LTE Software eNodeB and NR Software gNB

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1 Introduction

LTEENB is a LTE/NR base station (eNodeB/ng-eNodeB/gNodeB) implemented entirely in software and running on a PC. The PC generates a baseband signal which is sent to a radio front end doing the digital to analog conversion. The reverse is done for the reception.

LTEENB interfaces with a LTE Core Network thru the standard S1 interface and with a 5GS Core Network thru the standard NG interface. In particular the Amarisoft Core Network software (LTEMME) can easily be connected to it to build a highly configurable LTE and/or NR test network.

LTEENB also supports NB-IoT.

2 Features

2.1 LTE PHY layer

- LTE release 16 compliant.
- FDD and TDD configurations.
- Supported bandwidths: 1.4, 3, 5, 10, 15 and 20 MHz.
- Handle several cells in intra-band or inter-band configurations.
- Transmission modes: 1 (single antenna) and 2 to 10 (MIMO 4x2).
- Wideband CQI/PMI reports.
- HARQ support.
- Timing measurement thru the PRACH.
- Closed-loop UE power control.
- Frequency based MMSE equalizer.
- Highly optimized software turbo decoder.
- PAPR reduction support.
- Support of other radio heads can be added with an external shared library.
- Positioning Reference Signals (PRS) support.
- CSI-RS support.
- Multi-cluster PUSCH allocation.
- PUCCH 3 and PUCCH channel selection support.
- Carrier Aggregation support with cross carrier scheduling (tested with 3 DL channels, supports up to 8 DL channels).
- Mixed FDD-TDD Carrier Aggregation support.
- CoMP testing features (DMRS scrambling identity and QCL parameters can be selected).
- 256QAM DL support for PDSCH and MBMS.
- 1024QAM DL support for PDSCH.
- 256QAM UL support for PUSCH.
- Support of release 11 TDD special subframe configurations 7 and 9.

2.2 LTE Protocol layer

- LTE release 17 compliant.
- Implements the MAC, RLC, PDCP and RRC layers.
- Proportionally fair MAC scheduler with QoS support.
- Support of full and half duplex UEs.
- DRX support.
- Number of active users only limited by the available bandwidth.
- Fully configurable System Information Blocks.
- Integrity check and encryption using AES, Snow3G and ZUC algorithms.
- Support of RRC measurement with measurement gap.
- Supports intra eNodeB, S1, X2 and EPS to 5GS handovers.
- QoS support with user selectable DRB configuration for each QCI.
- ROHC support (RTP, UDP and IP v1 profiles, unidirectional mode, no RTP CSRC, no IP extensions, no outer/inner IP).

- Public Warning System (CMAS/ETWS) support.
- MBMS support.
- Support of all ciphering and integrity protection algorithms including ZUC.
- Category 0 UE support.
- eDRX support.
- EN-DC support.
- RRC release with redirection to NR SA cell support.
- Semi-persistent scheduling (SPS) support.
- TTI bundling support.
- PDCCH order PRACH support.
- Satellite connection without UE-side NTN support (Direct-To-Cell).

2.3 LTE-M

- Release 16 compliant.
- Category M1 UE support.
- TM6 and TM9 support.
- FDD, HD-FDD and TDD support.
- Support of multiple CE levels (only CE-Mode A is supported).
- Support of message repetition for MPDCCH, PDSCH, PUCCH, PUSCH and PRACH.
- Support of localized and distributed MPDCCH transmission.
- No frequency hopping.
- Bandwidth must be >= 5 MHz for cells that also need to support Category 0 and above UEs and for TDD cells.
- DRX support.
- eDRX support.
- Group WUS support.

2.4 NB-IoT

- NB-IoT release 17 compliant.
- Single-tone and multi-tone category NB1 and NB2 UE support.
- 15 kHz and 3.75 kHz subcarrier spacing are supported.
- All operation modes (in-band, guard band and standalone) are supported.
- Multiple NB-IoT and LTE cells can be used at the same time in the same eNodeB.
- Support of multiple coverage levels.
- Support of all NPDCCH, NPDSCH, NPUSCH and NPRACH configurations, including NPRACH Format 2.
- Support of control plane CIoT optimization.
- Support of multi-DRB mode.
- Support of non-anchor carriers, including Release 14 NPRACH and paging on non-anchor carriers.
- Support of two HARQ processes.
- Support of interference randomisation.
- Support of SR with HARQ.

- DRX support.
- eDRX support.
- PDCCH order PRACH support.
- NTN support.
- Group WUS support.

2.5 NR

- NR release 18 compliant.
- FDD/TDD FR1 (<= 7.125 GHz) and FR2 (>= 24.25 GHz).
- Bandwidth: 3 to 100 MHz.
- Data subcarrier spacing: 15, 30, 60 or 120 kHz. SSB subcarrier spacing: 15, 30, 120 or 240 kHz. All SSB/data subcarrier spacing combinations are supported.
- Up to 8 layer downlink MIMO.
- Up to 4 layer uplink MIMO.
- 64QAMLowSE (DL/UL), 256QAM (DL/UL) and 1024QAM (DL).
- All PUCCH and PRACH formats.
- Two steps RACH procedure.
- PDCCH order PRACH procedure.
- Contention-free RACH procedure for PDCCH order and handover.
- PUSCH with and without transform precoding. PUSCH and PDSCH with user configurable DMRS, PT-RS and number of symbols.
- PUSCH codebook and non-codebook TX configuration.
- Uplink Tx Switching in CA and SUL.
- User configurable TDD UL/DL pattern. Automatic or custom setting for k0, k1 and k2 values.
- PDCCH with DCI 0_0, 0_1, 1_0 and 1_1.
- CSI-RS and TRS support with automatic configuration available.
- SRS support with automatic configuration available.
- UL Configured Grant Type1 and Type2 support.
- Scheduling Request support.
- DSS support.
- PHY test mode: support for continuous PDSCH and PUSCH transmission.
- EN-DC support with dynamic activation/deactivation based on events.
- FR1-FR1 and FR1-FR2 NR-DC support with dynamic activation/deactivation based on events.
- Dynamic LTE/NR DRB configuration.
- User selectable DRB configuration for each QCI/5QI.
- DRX support.
- RRC measurement with measurement gap support.
- PScell change support.
- Standalone support.
- Intra gNodeB, NG, Xn or 5GS to EPS handovers support.
- Public Warning System (CMAS/ETWS) support.
- Carrier aggregation support, both in NSA and SA operation.
- Multi-BWP support with RRC and DCI BWP switching.
- Supplementary Uplink support.
- RRC release with redirection to EUTRA cell support.
- RRC Inactive mode support.
- EPS fallback support.

- Network slicing support.
- Positioning Reference Signals (PRS) support.
- eDRX support.
- FDD, HD-FDD, TDD (e)RedCap support.
- NTN support in FR1 and FR2.
- Satellite connection without UE-side NTN support (Direct-To-Cell).
- PDSCH and PUSCH repetition support, including MSG3 repetitions.
- Small Data Transmission support (4-steps and 2-steps RA SDT and CG-SDT).
- MBS broadcast sessions support.

2.6 Downlink channel simulator

- Real time operation.
- High quality white Gaussian noise generator.
- Support the AWGN, EPA, EVA, ETU, TDL and MBSFN 3GPP channels.
- MIMO operation with the 3GPP correlation matrixes.
- User defined constant or Rayleigh paths with custom MIMO correlation matrixes.
- Dynamic satellite link simulator for all orbit types.

2.7 Network interface

- Standard S1AP, NGAP and GTP-U interfaces to the Core Network. Several PLMNs and S1 or NG interfaces can be used simultaneously.
- X2AP interface between eNodeBs and XnAP interface between gNodeBs and ng-eNodeBs.
- M1 and M2 interfaces for MBMS.
- IPv6 support.
- Support of LPPa procedures E-CID and OTDOA.
- Support of NRPPa procedures E-CID and OTDOA.

2.8 User interface

- Configurable logging system for all channels with built-in text decoders.
- Wireshark MAC-LTE capture.
- Plots for QAM constellations and channel response.
- Remote API using WebSocket.
- Command line monitor.
- Test commands to initiate handover and to dynamically change the power level of each cell.

3 Requirements

3.1 Hardware requirements

- A fast PC:
  - For best performances, a quad core Intel Core i5 or i7 CPU with AVX2 support (Haswell architecture or later) is recommended. Support of the SSE4.1 instruction set extension is required to run the software.
    ARM64 architecture is also supported with NEON support.
  - At least 1 Gigabit Ethernet ports.
  - At least 2 GB of RAM.
  - At least 1 GB of hard disk space.
  - The video adapter does not matter.
- Radio front end:
  - Amarisoft PCIe SDR
  - Ettus Research USRP N2x0 (SBX daughterboard). For MIMO 2x2, a second N2x0 with the SBX daughterboard and a USRP MIMO cable are needed.
  - Ettus Research USRP B2x0.
  - Ettus Research USRP X3x0.
  - Lime Microsystem LimeSDR
- Appropriate antennas for the intended LTE frequencies or cables and attenuators to connect to a UE.
- Any commercial UE compatible with LTE FDD or TDD. All LTE FDD and TDD frequency bands are supported. If you use the Amarisoft Core Network, the device must accept test USIM cards (sim locked devices may not accept them).
- A test USIM card. Test USIM cards from Anritsu are supported by the default configuration. Other test USIM cards should work as well provided their IMSI and secret key are known.

3.2 Software requirements

- A 64 bit Linux distribution. Fedora 42 is the officially supported distribution.
  The following distributions are known as compatible:
  - Fedora 22 to 42
  - Cent OS 7
  - Ubuntu 14 to 24

  Your system requires at least GLIBC 2.17.

  Other distributions can be used provided the radio frontend drivers are available for them.

- The Amarisoft LTE Core Network (another Core Network can be used, but we only explain here how to quickly set up the Amarisoft Core Network).

4 Off-The-Shelf package

If you ordered the OTS package, you don't need installation so you can skip next chapter.
When booting, MME and eNB are automatically started within a screen.
If you are not familiar with screen here is what you must know:

- To have access to consoles, log on the machine with root access, then type:

  `screen -r`
- To access MME monitor:

  `CTRL-A + 0`
- To access eNB monitor:

  `CTRL-A + 1`
- To exit screen:

  `CTRL-A + d`

5 Installation

The radio front end must be connected to one gigabit Ethernet port (don't use a switch to connect them to avoid potential packet losses). The other Ethernet port can be connected to the local network if necessary.

It is not recommended to run LTEENB in a virtual machine because it has hard real time constraints.

We also assume that you have some Linux and LTE knownledge.

5.1 Linux setup

5.1.1 Packages

LTEENB uses the SCTP protocol for which the necessary packages are not usually installed. In order to install them, do as root user:

- Fedora

    ```
    dnf install lksctp-tools kernel-modules-extra
    ```

- Ubuntu

    ```
    sudo apt-get install lksctp-tools linux-image-extra-3.13.0-24-generic
    ```

    Note that linux-image-extra package name may differ depending on your kernel version.

To verify that SCTP kernel module is running, do as root user:

```
checksctp
```

If it reports that the protocol is not supported,

- check if you have a /etc/modprobe.d/sctp-blacklist.conf file

- edit it to comment the 'blacklist sctp' line

Then reboot the PC in case the Linux kernel was upgraded too.

5.1.2 OpenSSL

LTEENB has been compiled against openssl version 3.5.4.
If your system does not have compatible version installed you may have this error message at startup:

```
error while loading shared libraries: libssl.so.3: cannot open shared object file: No such
```

To overcome this problem, you may:

- Copy libssl.so.3 and libcrypto.so.3 from `libs` subdirectory of your release tarball.
  If you have installed software with automatic install script, this should have been done automatically.

- Compile and install proper openssl version yourself

In case of persisting issue, raise a ticket from our support site at `https://support.amarisoft.com/` with the information provided by below commands executed in LTEENB directory:

```
uname -a
ls -l
ldd ./lteenb
openssl version
```

5.2 Linux setup for best performance

LTEENB requires a lot of CPU power and it has hard real time requirements (a maximum latency of 3 ms is required).

In order to get the lowest latency, it is recommended to set up the `performance` frequency governor for each CPU core. An example is included in the `lte_init.sh` script given with LTEENB.

Some buggy drivers are known to block the CPU during a few tens of ms. When it happens, LTEENB displays `UHD status: L=X U=Y S=Z`. One known problem is the DRM KMS cable polling. The script `lte_init.sh` disables it automatically.

Other drivers such as Wifi controllers can give the same problem. In order to avoid such problems, remove all unnecessary peripherals from the PC.

5.3 RRH setup

Please refer to sub section of your radio frontend to set it up.
When configured, you will have to select it (See [RRH selection], page 11).

5.3.1 Amarisoft PCIe SDR

Read the PCIe SDR documentation (`trx_sdr.pdf`).

5.3.2 Ettus Research USRP

Read the UHD Compatible RF frontends documentation (`trx_uhd.pdf`).

5.3.3 Lime Microsystems LimeSDR

Use LimeSuiteNG software suite located at `https://github.com/myriadrf/LimeSuiteNG`, which contains Amarisoft plugin. During build it creates the needed trx_limesuite.so (build directory) file, which can be sim linked or copy pasted.

5.4 UE setup

Insert the test USIM card in the device.
Enable data connection and roaming in the configuration of your device.

With LTE, no Access Point Name (APN) is necessary because a default one is always provided by the network.
However, some UEs insists on having the same APN name as the MME to enable IP connectivity.

As a result, start by removing any APN stored in the UE and manualy add APN (Only APN name is required) as defined in MME configuration file (Default is test123).

If possible, disable 2G (GSM) and 3G (WCDMA) access to have only LTE access system in order to speed up the network search.

If possible, limit the LTE frequency bands used by the device to the one you want to use in order to speed up the network search.

5.5 LTEENB installation

Decompress the LTEENB archive to a convenient place. The executable `lteenb` can be launched from this directory.

5.5.1 Basic LTEENB configuration

The main configuration file is `config/enb.cfg`. It uses a superset of the JSON syntax.

The default setup is for a 10 MHz LTE eNodeB. The main parameter you need to change right now is the actual frequency you want to use. You need to be sure that no interference is present on the frequency you are using and that you have the legal right to use it (in most countries it is illegal to transmit on LTE frequency bands without an explicit authorization).

In order to reduce interferences, it is recommended to use a high frequency band such as the 2600 MHz band (band 7) in Europe.

The parameter `dl_earfcn` gives the EARFCN of the center frequency for the downlink. The corresponding uplink frequency is automatically choosen. The center frequency can be arbitrarily choosen provided the transmitted spectrum fully lies inside the choosen band. So if `f` is the center frequency, `B` the LTE bandwidth, `f_min` and `f_max` the band limits, the following relation must hold:

```
f_min + 0.5 * B <= f <= f_max - 0.5 * B
```

The EARFCN is the frequency expressed in 100 kHz units starting from an offset depending on the selected band. You can have the band parameters and do convertions between EARFCNs and frequencies at `https://www.sqimway.com/lte_band.php` or by looking at the section 5.7.3 of 3GPP TS 36.101.

5.5.2 RRH selection

To select appropriate RF frontend to use, please execute following command:

```
./config/rf_select.sh <type>
```

Where `type` is your frontend type:

- sdr
- n2x0
- b2x0
- n3x0
- x3x0
- limeMini
- limeSDR

NB: you can lanch following command to see available frontends:

```
./config/rf_select.sh
```

5.5.3 License key installation

LTEENB needs a license key file to run. *It is associated to your PC, so if you replace it or change its hardware configuration you must contact Amarisoft to get a new license key.*

The following steps are needed to get this license file:

- Run LTEENB:

  ```
  ./lteenb config/enb.cfg
  ```

  It says that the license key is not present and prints a 16 digit hexadecimal code.

- Send by mail to `delivery@amarisoft.com` this hexadecimal code to your contact at Amarisoft. You will get back the `lteenb.key` license key file.

- Copy the `lteenb.key` file to the `${HOME}/.amarisoft/` directory (`${HOME}` is the home directory of the `root` user). You can use the shell variable `AMARISOFT_PATH` to change this path.

Once the license key is installed, lteenb should start normally.

5.6 Initial testing

Customize and start the `lte_init.sh` script as `root` user to configure the network and CPU governors.

Start the LTEMME software as `root` user. `root` priviledges are needed to set up the virtual network interface.

```
./ltemme config/mme.cfg
```

In another terminal, start the LTEENB software as `root` user. `root` priviledges are needed to use real time scheduling priority.

```
./lteenb config/enb.cfg
```

The base station is now running. Type `s1` in the command line monitor of LTEENB to verify that it is connected to LTEMME. If it is the case, type `t` to enable the MAC traces (the traces are automatically disabled once you press return).

Turn on the UE and keep it at a few meters of the eNodeB antenna. It starts scanning the LTE bandwidth. After a few minutes, it should detect the eNodeB signal and transmit its first PRACH signal to the base station. You should get a trace like:

```
PRACH: cell=01 seq=X ta=Y snr=Z dB
```

Then the UE will *attach* to the simulated LTE core network and get its IP address. If it works, then the device will indicate it is connected.

The core network maintains a persistent database storing all the parameters of the configured UEs. It is by default in `config/lte_ue.db`. If the initial connection is OK, you can get the IP address of the UE from this file. You can then try to ping it from the PC.

Then if the local network is correctly configured on the PC, the UE can access to your local network (and internet if your local network allows it).

6 Troubleshooting

There are many parameters in an LTE setup, so there are many cause of problems. Here are a few ones we noticed during our tests:

6.1 LTEENB does not start

LTEENB must be launched as root so that it can use real time scheduling.

If some librairies needed by LTEENB are not present, it means you need to use another Linux distribution or to upgrade it.

6.2 UHD library ABI compatibility mismatch

If you get this kind of message while starting *lteenb*:

```
'trx_uhd_3.4.0.so' does not exist
```

It means that current UHD version on your system is not supported.
Follow `trx_uhd.pdf` documentation to install proper version.

6.3 The license key file is not correct

You need to contact Amarisoft to get a valid license key and/or a USB dongle.

6.4 Many messages 'UHD status: L=X U=Y S=Z' or 'SDR u=x o=y' are displayed.

These messages indicate that there are underflows or overflows errors when communicating with the RF card. The most likely explanation is that not enough CPU time is available. You can launch

```
top -H
```

To see which processes and threads use the CPU time. Normally only 2 LTEENB threads should use about 50% of one CPU core time each when the eNodeB is idle. The following can be done to help:

- Remove unnecessary drivers and peripherals. See [Linux setup for best performance], page 9.
- Launch `lteenb` as `root` so that it can use real time scheduling.
- If you use a USRP device, don't connect it to the PC thru a switch to avoid packet losses.
- Ensure that your CPU is fast enough. It should be at least a 4 core i5 or i7 Haswell architecture or later.
- If your CPU is too slow, consider using a smaller LTE bandwidth (the CPU load is proportional to the bandwidth).
- If the errors happen during high traffic, be sure you have disabled the `debug` log output (`log_options` option). It generates a lot of data and takes some CPU time.
- If the errors happen during high traffic, consider limiting the eNodeB uplink bit rate. See [CPU load limitation], page 16.
- For more information, read the appnote_cpu document found in the doc/ folder or your LTEENB installation.

For best performance, you can also remove unused daemons or cron jobs, in particular:

- The automatic upgrade done by PackageKit or similar.
- The various scripts in `/etc/cron.{hourly|daily|weekly}` which take some time and which are not strictly needed: `mlocate`, `tmpwatch`, `man-db`, `prelink`.

If the PC is only used as server, it is better to boot the PC in text mode by default. If `systemd` is used by your Linux distribution (Fedora), it is done by changing the link `/etc/systemd/system/default.target` to `/lib/systemd/system/runlevel3.target`. If `init` is used, it is done by modifying `/etc/inittab` to use the run level 3 as the default run level:

```
id:3:initdefault:
```

6.5 The initial PRACH signal is not received.

This is the most critical step. If you don't get the initial PRACH signal, it indicates that something is wrong in your configuration. Here are a few important points:

- Check that your EARFCN is correct and in a band without interference. Warning: the EARFCN corresponds to the frequency of the *center* of the bandwidth. Use a cable and an attenuator if you want to avoid interfering with another network or if you don't have the authorization to transmit on the corresponding frequency.

- Check that your UE is correctly configured: LTE must be enabled on the right frequency band.

- The UE may not get a good enough signal or may saturate. Try to move it closer or further from the base station antenna. Some UE have better performance with some frequency bands, so try another frequency band supported by the UE.

- Only if you have problems after changing the frequency band, make sure that you use a different `cell_id` in `enb.cfg`. The UE memorizes the last parameters and won't search another frequency if the Cell Identity is not modified.

If none of the previous point helps, consider trying another frequency band (change the EARFCN and update `cell_id` in `enb.cfg`).

6.6 The initial PRACH is received, but the UE is never attached.

Look at the `/tmp/enb0.log` log file. There can be several problems. The normal steps are RRC connection, then NAS messages are exchanged to attach the UE and authenticate it.

The possible problems are:

- Radio problems. In this case, no NAS messages are seen in the logs. Try to lower the TX gain of the radio frontend ([tx_gain], page 34, parameter) to reduce the TX/RX interferences due to the lack of proper duplexer.

- Invalid IMSI configured. In this case, the dialog stops after the NAS attach request message.

- SIM authentication error. In this case, the dialog ends in the Authentication request/Authentication response NAS dialog. It means you don't have the correct secret key configured.

- Security configuration error. In the case, the dialog stops after the NAS security mode command. It indicates that the UE does not accept to be configured without integrity check and encryption. You need to find another UE which is more tolerant (we never hit this case, but it might happen).

- Immediate NAS detach after NAS attach complete. In this case, the UE does not accept something in the network configuration. It can happen if it requested IPv6 (we only support IPv4 in the default configuration) or if the APN is not correct. It can also happen because of an invalid UE database in the core network emulation. Try to turn off and on the device several times to see if the problem persists (there are various timeouts and number of NAS attempts which can be triggered and solve the issue).

- Unexpected `PDN connectivity request`. In this case, you see `PDN connectivity request` and `PDN connectivity reject` in the logs. Remove any explicit Access Point Name (APN) in the UE configuration (the core network emulation only supports configuring a default PDN in the initial attach).

6.7 The initial attach is OK but `ping` is not working.

If you get here, the device indicates that the LTE/4G connection is up but the ping to the UE from the PC does not work. You can also try a ping from the device to the PC (the PC can be pinged on 192.168.3.1).

Radio problems can still be the explication if the radio conditions are too bad. The symptom of this case is that you see many PRACH signals coming from the UE. Try to reduce the TX power with the [tx_gain], page 34, parameter.

Another explanation can be that the UE does not accept roaming. Try to enable it on the UE.

Another explanation can be bugs in the UE (or its PC driver if it is a USB dongle) in case you changed the LTE configuration (we noticed it in some cases). The symptom is that the IP packets are truncated when doing `tcpdump` on the UE side. In case of doubt, just turn off and on the UE (and the corresponding PC if it is a USB dongle) to start from a clean state.

6.8 The ping is working but no Internet access is possible from the UE.

The most likely explanation is that the IP forwarding/masquerading is not configured correctly on the PC. You need to look at the IP table configuration (/sbin/iptables -n -v -L) and correct it if the `lte_init.sh` configuration is not enough. Use of `tcpdump` or `wireshark` on the different interfaces can help to locate the problem.

Another possibility is that the DNS address given to the UE is not correct (try to ping using IP address instead of host names).

Verify that roaming is activated on the UE. The UE may not accept roaming and avoid IP access even if the ping is working.

7 Advanced Configuration

7.1 Logging

The eNodeB and the Core Network can output the messages of all the layers to log files. See the `log_options` option to select the layer to output and the level of verbosity. The log filenames are defined with the `log_filename` option.

You can also use Wireshark to monitor:

- S1 (S1AP with embedded NAS, GTP-U) link between the eNodeB and the Core Network.
- NG (NGAP with embedded NAS, GTP-U) link between the gNodeB/ng-eNodeB and the Core Network.
- M2 (M2AP, GTP-U) link between the eNodeB and MBMS Gateway.
- X2 (X2AP) link between eNodeBs.
- Xn (XnAP) link between gNodeBs/ng-eNodeBs.

7.2 Changing the LTE bandwidth

It is configured with the `n_rb_dl` parameter giving the number of resource blocks. To ease the bandwidth change, the enb.cfg configuration file has a define at the top named N_RB_DL that can be set to 6, 15, 25, 50, 75, 100 for the bandwiths 1.4, 3, 5, 10, 15, 20 MHz.

Notes:

- The CPU load is proportional to the LTE bandwidth.
- Not all LTE bands allow all LTE bandwidths. For example, bands 7 (2.6 GHz) and band 20 (Europe 800 EDD) do not support the bandwidths of 1.4 and 3 MHz.

7.3 CPU load limitation

In order to avoid using too much CPU time, it is possible to limit the uplink MCS (`pusch_max_mcs` for LTE cells, `max_mcs` in `pusch` object for NR cells) and the number of iterations of the LTE turbo decoder (`pusch_max_its`) or NR LPDC decoder (`ldpc_max_its`). Normally it is only critical for the larger LTE bandwidths (20 MHz). The symptom of too high CPU use are many messages `UHD status: L=X U=Y S=Z`.

7.4 UE connection traces

By default or when using the `t` monitor command, the eNodeB displays the status of the connection with the UEs. It stops displaying them when you press return.

```
              ----DL---------------------- ----UL--------------------------------------
   --------
   UE_ID  CL RNTI C cqi ri  mcs retx txok brate C  snr puc1  nl  mcs retx rxok brate    #its phr  pl  ta█
       1 001 003d 1  12  1 21.1    0  361 1.77M 1  9.1  8.5 1.0 14.7    3  779 2.06M 1/3.5/10  10 100  0.1█
```

UE_ID	S1 eNodeB or NG RAN UE identity, unique among all cells.
CL	Lower 7, 8 or 10 bits of the cell identity (hexadecimal).
RNTI	C-RNTI of the UE (hexadecimal).
C	Number of aggregated DL cells.
cqi	Channel Quality Indicator, between 0 (bad) and 15 (very good). If there are several aggregated DL cells, the minimum cqi is displayed.
ri	Rank Indicator (number of layers for MIMO). If there are several aggregated DL cells, the minimum rank indicator is displayed.

`mcs`	Average Modulation and Coding Scheme.
`retx`	Number of transport block retransmissions.
`txok`	Number of successfully transmitted transport blocks.
`brate`	Average bitrate (at the MAC layer), in bits per second.
`snr`	Is the measured Signal to Noise Ratio for the uplink from the PUSCH reference signals and the SRS.
`puc1`	Is the measured Signal to Noise Ratio for the last PUCCH1.
`nl`	Average number of UL layers.
`mcs`	Average Modulation and Coding Scheme.
`retx`	Number of transport block retransmissions.
`rxok`	Number of received uplink transport blocks without CRC error.
`#its`	Gives the minimum, average and maximum number of iterations of the turbo decoder or LDPC decoder.
`phr`	Is the content of the last Power Headroom MAC control element sent by the UE. It is expressed in dB. Negative values indicate that the UE could not transmit with the required power.
`pl`	Uplink Path Loss in dB. It is measured from the reported PHR and the measured uplink power level. It is meaningful only if the RF interface correctly reports the absolute received power level.
`ta`	Average of the uplink timing advance measured for the UE in TA units.

7.5 UE Power control

The eNodeB does dynamic UE power control (see the `dpc`) option. However, it is better to have a good initial UE power to avoid retransmissions or interferences. So it is important to correctly set the various power settings in the SIBs. In particular, to avoid generating too much interference and to limit the battery drain, the SIB1 `p-Max` parameter (maximum allowed power for the UE in dBm) should be set to a low enough value (a few dBm).

It is also useful to tune the value of `referenceSignalPower` (power per carrier of the reference signal in dBm) in SIB2 if the RF interface does not provides its transmit power thru the TRX driver. It is used by the UE to compute the path loss and to adjust its own transmit power.

7.6 Multi-cell support

The eNodeB/ng-eNodeB can run several LTE or NB-IoT cells and the gNodeB can run several NR cells. The cells can be configured individually and share the same S1 or NG interfaces with the Core Network.

7.6.1 Intra-band multi-cell

Constraints:

- The full transmitted spectrum must lie inside the maximum output bandwidth permitted by the radio head (hence 40 MHz for the USRP N2x0, 56 MHz for PCIe SDR50 card and 100MHz for PCIe SDR100 card).
- The difference of the center frequencies of each cell should be a multiple of 300 kHz to minimize the interferences and the CPU usage (hence the difference of their EARFCN must be a multiple of 3).

- The difference between the center frequency of each cell and the average of center frequencies must be a multiple of 15 kHz.

- The number of cells that could be configured in a frequency band depends on the total bandwidth of the lte band and the configured bandwidth of each cell + the offsets.

- The LTE cells must have the same `prach-ConfigIndex` (SIB2), i.e. their PRACH must have the same duration and transmitted in the same subframes.

- Multiple LTE cells can be set at the same frequency provided their physical cell identity (`n_id_cell` property) and PRACH rootSequenceIndex (`root_sequence_index` and `br_root_sequence_index` properties) are different to minimize the inter-cell interferences.

- Multiple NB-IoT cells can be set at the same frequency provided their physical cell identity (`n_id_ncell` property) are different and NPRACH `nprach-StartTime-r13` and/or `nprach-SubcarrierOffset-r13` (SIB2) do not overlap to minimize the inter-cell interferences.

- Multiple NR cells can be set at the same frequency provided their physical cell identity (`n_id_cell` property) and PRACH rootSequenceIndex (`root_sequence_index` property) are different to minimize the inter-cell interferences.

- In the current version, there is no resource reservation among the cells, so a performance degradation happens if they transmit at the same time in the same resource blocks. So it is currently better to use cells at different frequencies.

Let's take the following example to configure 3 cells in band 7:

```
cell 1 DL frequency: 2627 MHz
cell 2 DL frequency: 2642 MHz
cell 3 DL frequency: 2657 MHz
average_dl_freq  =  (2627 + 2642 + 2657)/3  =  2642 MHz
cell1_freq_offset  =  2627 − 2642  =  −15 MHz
cell2_freq_offset  =  2642 − 2642  =  0 MHz
cell3_freq_offset  =  2657 − 2642  =  15 MHz
```

```
cell 1 DL EARFCN: 2820
cell 2 DL EARFCN: 2970
cell 3 DL EARFCN: 3120
cell1_cell2_earfcn_offset  =  2820 − 2970  =  −150
cell1_cell3_earfcn_offset  =  2820 − 3120  =  −300
cell3_cell2_earfcn_offset  =  3120 − 2970  =  150
```

We can observe that the difference between the center frequency of each cell and the average of center frequencies is indeed a multiple of 15 kHz and the difference between the DL EARFCNs are a multiple of 3.

7.6.2 Inter-band multi-cell

A configuration example is given in `config/enb-2cc.cfg` for two SISO 5 MHz cells in bands 3 and 7. This configuration could be tested with:

- Two USRP N210 connected with a MIMO cable

- Two PCIe SDR cards synchronized with a USB cable

This configuration also enables carrier aggregation for release 10 UEs.

7.7 Handover support

Intra-eNodeB, Intra-gNodeB, S1, X2, NG, Xn, EPS to 5GS and 5GS to EPS handovers are supported. The handover can be manually initiated with the `handover` monitor command, the `handover` remote API, or automatically initiated based on UE measurement.

Test case for intra-eNodeB handover:

1. Start lteenb with the multi cell configuration `config/enb-2cell-ho.cfg`.

2. Wait until the UE connects to a cell (use the `t` command to active the MAC traces or use the monitor command `ue` to list the connected UEs).

3. Start a long network transfer or a ping to the UE.

4. Reduce the power by 10 dB on the serving cell. If the UE is on cell 1:

   ```
   cell_gain 1 -10
   ```

   After some time the UE will make a handover to cell 2 (check it with the `t` command by looking at the `CL` column).

5. Increase the power of cell 1 and reduce the power of cell 2:

   ```
   cell_gain 1 0 ; cell_gain 2 -10
   ```

   After some time the UE will make a handover to cell 1.

6. You can also force a handover with the `handover` monitor command by giving the UE ID and the Physical Cell Identity (and optionally the DL EARFCN) of the target cell.

The behavior is similar with S1, X2, NG or Xn handovers, but at least two eNodeBs or gNodeBs (and two radio heads) are needed to use it.

In all the cases, it is important to have a valid neighbour cell configuration for each cell (`ncell_list` property) so that the source eNodeB can deduce target the Cell Identity from the target Physical Cell Identity and DL EARFCN.

7.8 MIMO support

MIMO is currently supported with following radio frontends:

- USRP N2x0 with their SBX daughterboards (Two device are needed for MIMO).
- USRP B2x0.
- USRP X3x0 (Only up to 10Mhz bandwidth with gigabit Ethernet link).
- PCIe SDR.
- Lime Microsystems LimeSDR.

The configuration `mimo-2x2-5mhz.cfg` demonstrates a 5 MHz MIMO configuration using transmission mode 3 (large delay CDD).

The configuration `mimo-2x2-20mhz.cfg` demonstrates a 20 MHz MIMO configuration with transmission mode 3.

If you use N2x0 with this configuration, please note that there is only one N2x0 connected by ethernet (second is using MIMO cable).

Note: the current UHD driver uses a lot of CPU time when MIMO is enabled. If it is an issue in your tests, follow patched version installation inside your `trx_uhd.pdf` documentation.

7.9 MIMO environment setup

7.9.1 Over the air

7.9.1.1 PCIe SDR setup

The following diagram depicts how to set up your MIMO environment with antennas using one single PCIe SDR card in FDD. You can simplify the setup by removing the antenna connected to RX2 if there is no MIMO in UL.
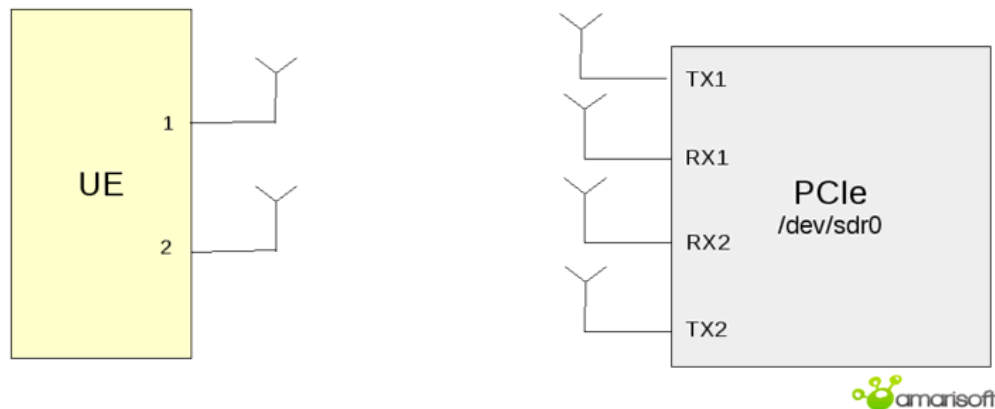
For TDD mode, you only need to connect antennas on the TX1 and TX2 connectors.

7.9.1.2 N2x0 setup

To setup your MIMO environment with N2x0 device, here is a detailed diagram of how to proceed.
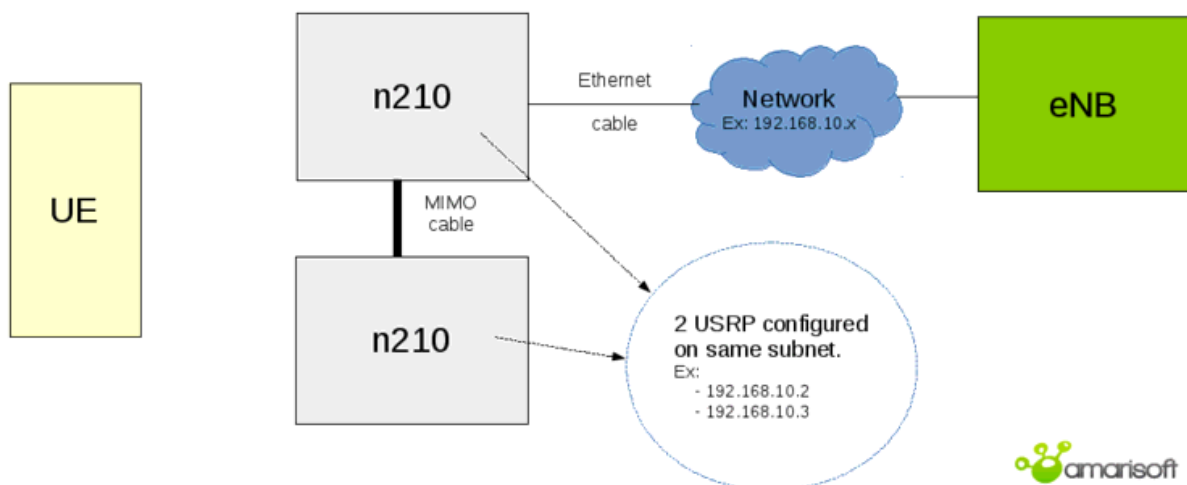
This configuration may have a bottle neck at ethernet side because USRP speed is limited to 1Gbps.
That's why for 20Mhz MIMO configuration, downlink sampling rate is limited to 8 (`dl_sample_`

bits parameter).

You can remove this constraint with the following diagram:
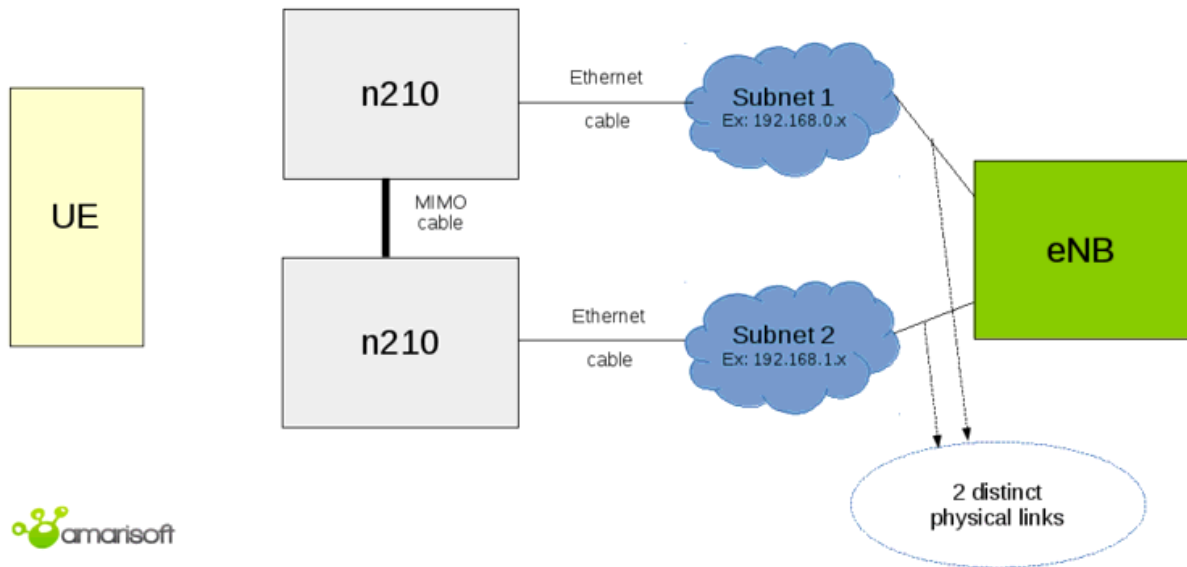
7.9.2 Using cable

Note that the diagrams provided below are only examples.

You may adapt depending on the UE.

7.9.2.1 PCIe SDR setup

If you are using FDD mode, the general case will be as follows. Note that if there is no MIMO in UL, you can simplify by removing the RX2 connection, thus connecting the TX2 directly to antenna 2 at UE side.
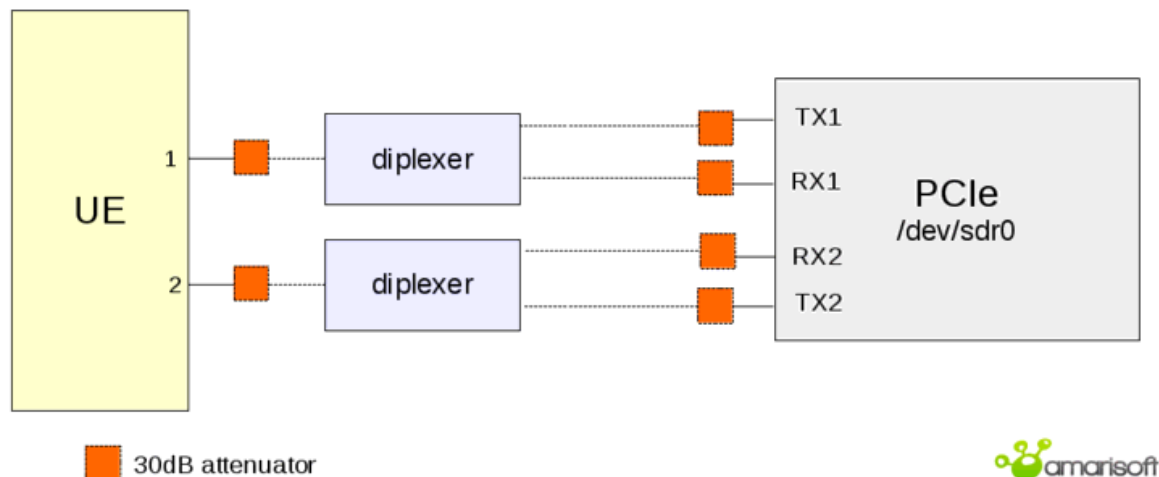
For TDD mode, you only need to connect TX1 and TX2.
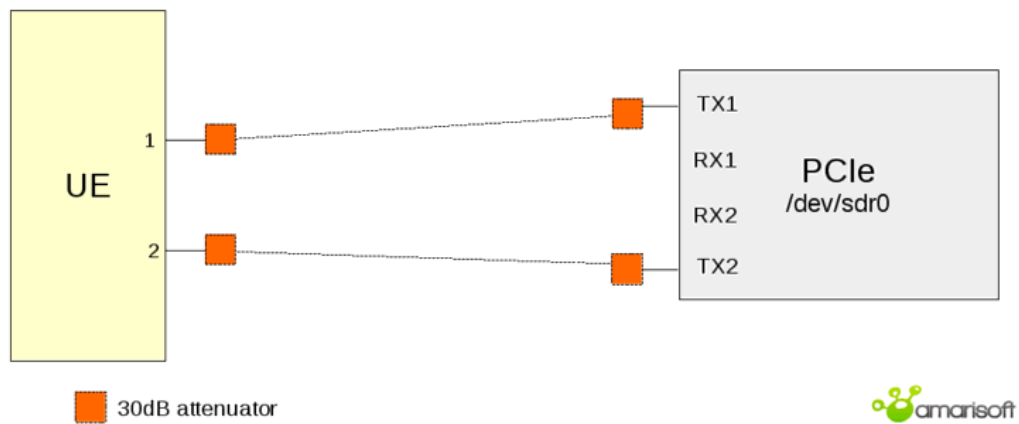
7.9.2.2 N2x0 setup

If you are using FDD mode, the general case will be:
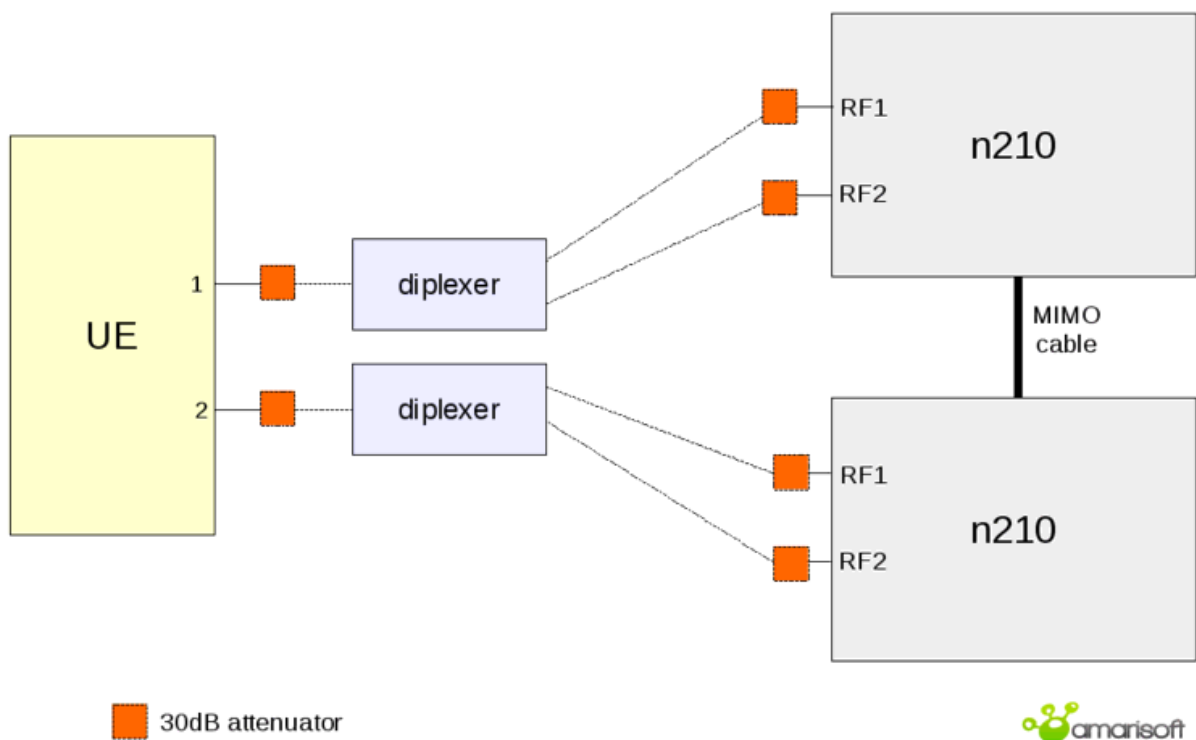
On most UE, second antenna is only used for RX so you can simplify with:
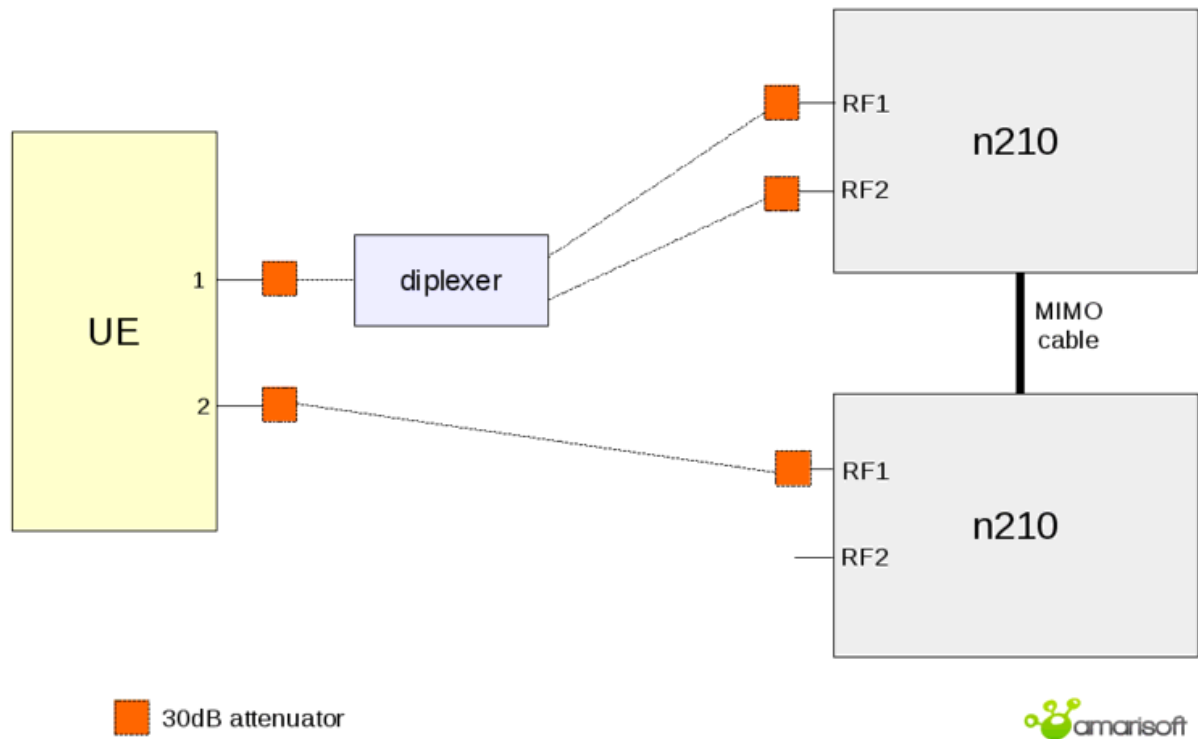
If your are using TDD mode, only one antenna is necessary per USRP.
Thus, you only need following diagram:
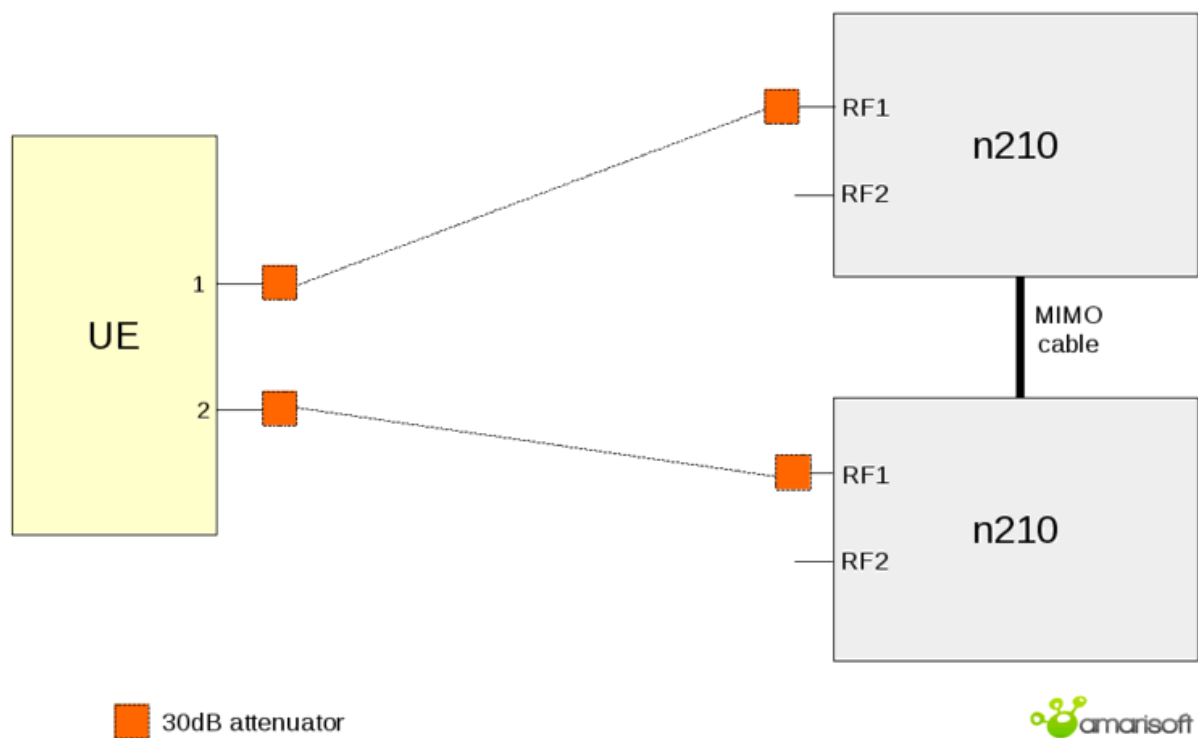
7.10 Carrier Aggregation support

CA is currently supported with PCIe SDR radio frontend. Intra-band CA could be handled with one single PCIe SDR card with the same constrains specified for intra-band multi-cell support, See [Intra-band multi-cell], page 17. For inter-band CA, one PCIe SDR card is required per band. The following diagram depicts the environment setup for DL inter-band CA with 2 carriers and MIMO in DL.
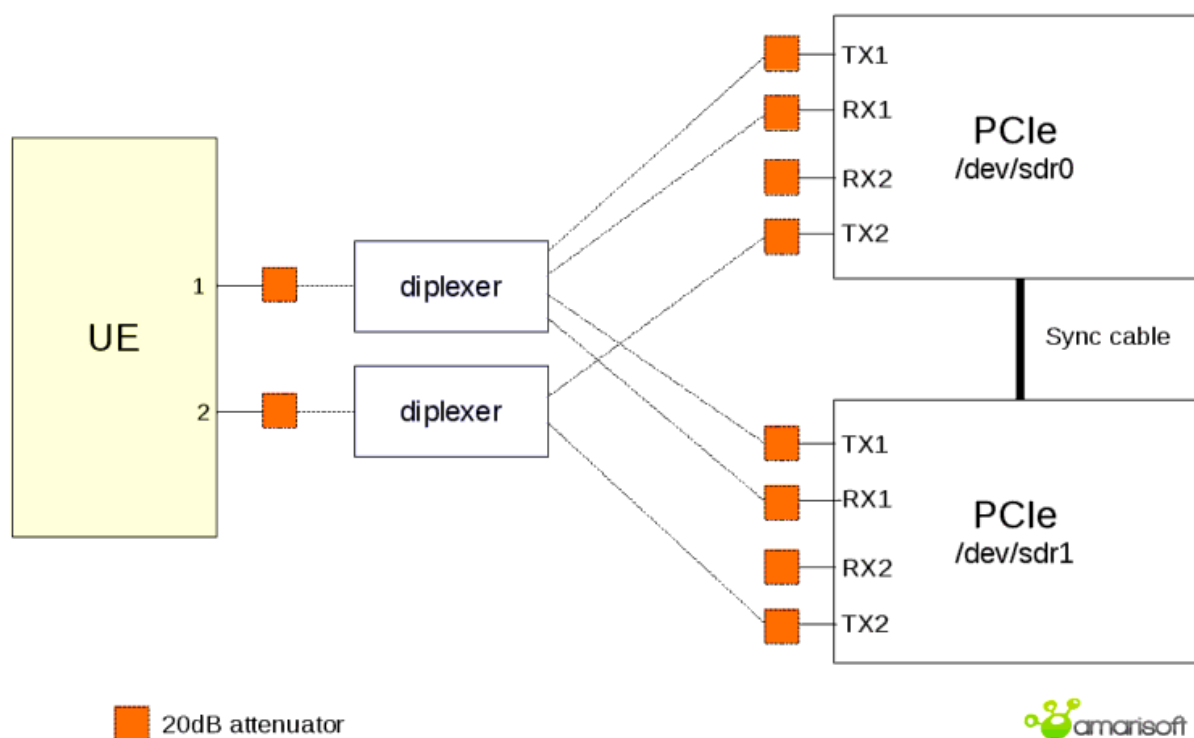
The configuration `enb-2cc.cfg` is an example of DL CA with 2 carriers in band 3 and band 7 (5+5 MHz). To use it in 2x2 DL MIMO 20MHz configuration, edit the file and change N_RB_DL to 100 and N_ANTENNA_DL to 2.

If you would like to enable CA in UL as well, you should connect the RX2 connectors as below.
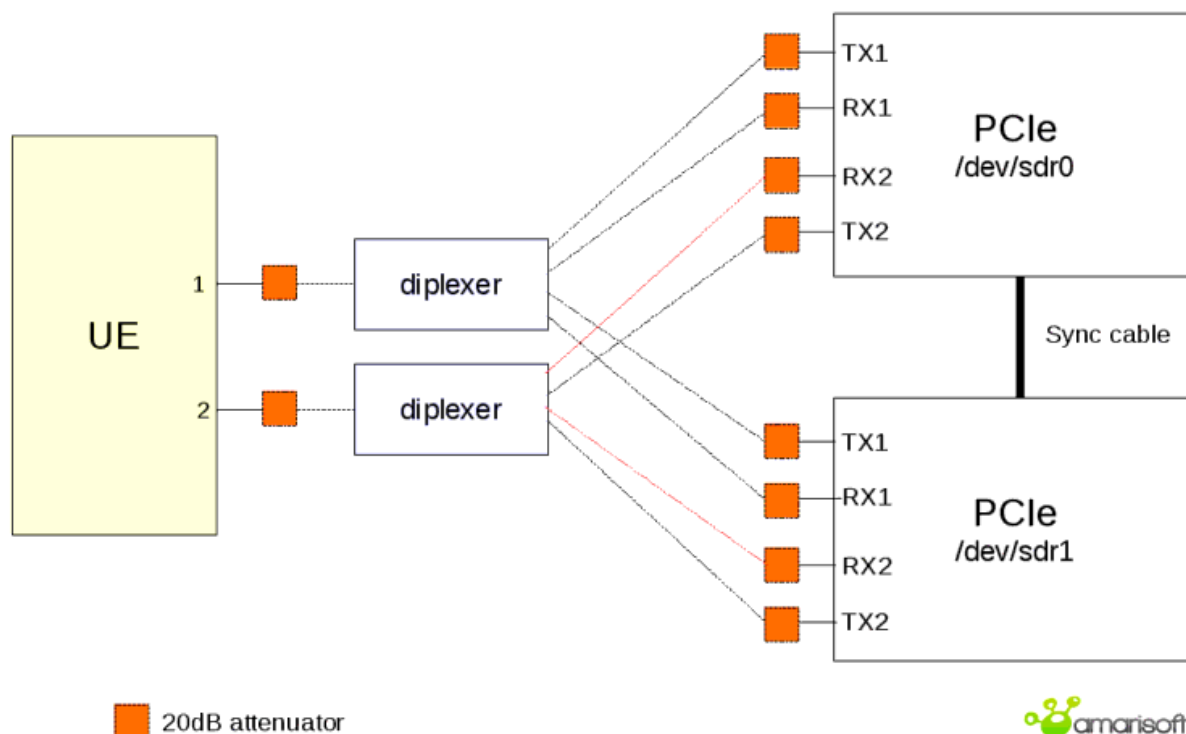
7.11 TDD support

The configuration file `enb.cfg` with the TDD define set to 1 at the top of the file is an example of TDD configuration. The eNodeB supports all 7 UL/DL TDD configurations.

7.12 Category M1

The eNodeB supports Category M1 UEs (Bandwidth Reduced UEs). They only receive or transmit on a 1.4 MHz bandwidth so they cannot use all the standard LTE signals. In particular, BR specific system information blocks are necessary. The configuration file `enb-catm1.cfg` is an example of Category M1 configuration. See [Bandwidth Reduced parameters], page 93.

7.13 NB-IoT

The eNodeB supports NB-IoT cells. They use a 200 kHz bandwidth which can be inside an existing LTE cell (in-band operation mode), at its edge (guard band mode) or completely independent (standalone mode). An example of standalone NB-IoT configuration is in file `enb-nbiot.cfg`. An example of in-band NB-IoT configuration is in file `enb-nbiot-inband.cfg`.

7.14 NR

The eNodeB/gNodeB supports NR cells.
When the MME requests the establishment of an ERAB for a UE supporting EN-DC, the eNB first checks if the corresponding QCI is declared in the NR cell definition. If this is the case, and if the `en_dc_setup` parameter is not set, the ERAB is established in the NR cell. Otherwise it is established in the LTE cell.
For EN-DC configuration, some exemples of eNodeB configuration are in files `gnb-nsa.cfg`, `gnb-2cc-nsa.cfg`, `gnb-pscell-change.cfg` and `gnb-nsa-ho-lte.cfg`.
When the AMF requests the establishment of a QoS flow for a UE supporting NR-DC, the gNB

first checks if the corresponding 5QI is declared in the FR2 cell definition. If this is the case, and if the `nr_dc_setup` parameter is not set, the QoS flow is established in the FR2 cell. Otherwise it is established in the FR1 cell.

For SA configuration, some examples of gNodeB configuration are in files `gnb-sa.cfg`, `gnb-sa-ho.cfg` and `gnb-sa-lte-ho.cfg`.

For NR-DC configuration, an example of gNodeB configuration is in file `gnb-nr-dc.cfg`.

7.15 (e)RedCap

The gNodeB supports RedCap and eRedCap UEs. See [Reduced Capability parameters], page 214.

8 Configuration reference

8.1 Configuration file syntax

The main configuration file uses a syntax very similar to the Javascript Object Notation (JSON) with few extensions.

1. Supported types:
   - Numbers (64 bit floating point). Notation: `13.4`
   - Complex numbers. Notation: `1.2+3*I`
   - Strings. Notation: `"string"`
   - Booleans. Notation: `true` or `false`.
   - Objects. Notation: `{ field1: value1, field2: value2, .... }`
   - Arrays. Notation: `[ value1, value2, .... ]`

2. The basic operations `+`, `-`, `*` and `/` are supported with numbers and complex numbers. `+` also concatenates strings. The operators `!`, `||`, `&&`, `==`, `!=`, `<`, `<=`, `>=`, `>` are supported too.

3. The numbers `0` and `1` are accepted as synonyms for the boolean values `false` and `true`.

4. `{}` at top level are optional.

5. `"` for property names are optional, unless the name starts with a number.

6. Properties can be duplicated.
   If properties are duplicated, they will be merged following [JSON merge rules], page 28, with overriding occuring in reading direction (last overrides previous).
   Ex:
   ```
   {
       value: "foo",
       value: "bar",
       sub: {
           value: "foo"
       },
       sub: {
           value: "bar"
       }
   }
   ```
   Will be equivalent to:
   ```
   {
       value: "bar",
       sub: {
           value: "bar"
       }
   }
   ```

7. Files can be included using *include* keyword (must not be quoted) followed by a string (without :) representing the file to include (path is relative to current file) and terminating by a comma.
   Arrays can't be included.
   Merge will be done as for duplicate properties.
   If *file1.cfg* is:
   ```
       value: "foo",
       include "file2.cfg",
       foo: "foo"
   ```

And *file2.cfg* is:

```
    value: "bar",
    foo: "bar"
```

Final config will be:

```
{
    value: "bar",
    foo: "foo"
}
```

8. A C like preprocessor is supported. The following preprocessor commands are available:

#define *var expr*
> Define a new variable with value *expr*. *expr* must be a valid JSON expression. Note that unlike the standard C preprocessor, *expr* is evaluated by the preprocessor.

#undef *var*
> Undefine the variable *var*.

#include *expr*
> Include the file whose filename is the evaluation of the string expression *expr*.

#if *expr*   Consider the following text if *expr* is true.

#else   Alternative of #if block.

#elif   Composition of #else and #if.

#endif   End of #if block.

#ifdef *var*
> Shortcut for #if defined(var)

#ifndef *var*
> Shortcut for #if !defined(var)

In the JSON source, every occurrence of a defined preprocessor variable is replaced by its value.

9. Backquote strings: JSON expression can be inserted in backquote delimited strings with the ${expr} syntax. Example: `abc${1+2}d` is evaluated as the string "abc3d". Preprocessor variables can be used inside the expression. Backquote strings may span several lines.

8.1.1 JSON merge rules

Merge overriding direction depends on context, i.e source may override destination or the opposite.
JSON merge is recursive for Objects and Arrays.

Example, merging

```
{
    foo: { value: "bar" },
    same: "one",
    one: 1
}
```

with

```
{
    foo: { value: "none", second: true },
```

```
    same: "two",
    two: 1
}
```

Will become:

```
{
    foo: { value: "bar", second: true },
    same: "one",
    one: 1
    two: 1
}
```

assuming first object overrides second one.

In case of Array merging, the final array length will be the maximum length of all merged arrays.
For each element of the final array, merge will be done considering defined elements only.
Ex:

```
{
    array: [0, 1, 2, { foo: "bar" } ],
    array: [3, 4],
    array: [5, 6, 7, { bar: "foo" }, 8 ]
}
```

Will be merged to:

```
{
    array: [5, 6, 7, { foo: "bar", bar: "foo" }, 8 ],
}
```

8.1.2 ASN.1

Some parameters refer to a ASN.1 description. Such parameter can be an object or a string.
In case of object, the following properties apply:

`content`   Object. ASN.1 definition in JSON format as defined in ITU X.697 (JER encoding).
              If defined, `filename` must not be set.

`filename`   String. Reference to a file containing the ASN.1 definition.
              If defined, `content` must not be set.

`content_type`

              Optional string. In case `filename` is set, defines the encoding format of the ASN.1
              file. Can be:

              `application/json`
                      JER encoding

              `application/octet-stream`
                      Binary

              `plain/text or not set`
                          GSER encoding as defined in RFC 3641 (Generic String Encoding Rules
                          for ASN.1 Types).

              In case content_type is not defined, file extension will be used to guess type. In case
              no matching is found, GSER decoding will be used.

In case of string, the parameter is assumed to be a filename refering to a GSER encoded content.

To create your ASN.1 files, you can use our ASN.1 editor (`https://tech-academy.amarisoft.com/web-gui/asn1.html`).

8.2 Global properties

`log_filename`
> String. Set the log filename. If no leading `/`, it is relative to the configuration file path. See [Log file format], page 302.

`log_options`
> String. Set the logging options as a comma separated list of assignments.
>
> - *layer*.level=*verbosity*. For each layer, the log verbosity can be set to `none`, `error`, `info` or `debug`. In debug level, the content of the transmitted data is logged.
> - *layer*.max_size=*n*. When dumping data content, at most `n` bytes are shown in hexa. For ASN.1, NAS or Diameter content, show the full content of the message if `n > 0`.
> - *layer*.payload=[0|1]. Dump ASN.1, NAS, SGsAP or Diameter payload in hexadecimal.
> - *layer*.key=[0|1]. Dump security keys (NAS and RRC layers).
> - *layer*.crypto=[0|1]. Dump plain and ciphered data (NAS and PCDP layers).
> - phy.signal=[0|1]. Dump binary received signal data of the physical layer to another file (*log_filename*.bin). The currently available data are QAM constellations and channel estimation for PDSCH, PUSCH and SRS. The GUI can be used to display them. Note: the size of the binary signal data is larger than the textual logs, so they should be enabled only when needed.
> - phy.rep=[0|1]. Log the NPUSCH/NPDCCH/NPDSCH allocations and repetitions in each subframe (NB-IoT eNodeB only).
> - phy.csi=[0|1]. Log the detailed CSI information from CSI reports (NR only).
> - phy.ntn=[0|1]. Log DL channel updates performed for NTN if `channel_sim_control` is enabled.
> - bcch=[0|1]. Enable or disable BCCH log. The BCCH is always transmitted, so it gives large logs when enabled.
> - mib=[0|1]. Enable or disable MIB log. The MIB is always transmitted, so it gives large logs when enabled.
> - time=[sec|short|full]. Display the time as seconds, time only or full date and time (default = time only).
> - time.us=[0|1]. Dump time with microseconds precision.
> - file=cut. Close current file log and open a new one.
> - file.rotate=now. Move and rename to the same directory or to the directory pointed by `file.path` and open a new log file (Headers are kept).
> - file.rotate=*size*. Every time log file size reaches *size* bytes, move and rename to the same directory or to the directory pointed by `file.path`, and open a new log file (Headers are kept).
>   Size is an integer and can be followed by K, M or G.
> - file.rotate=#*count*. Everytime number of logs in log file reaches *count*, move and rename to the same directory or to the directory pointed by `file.path`, and open a new log file (Headers are kept).
>   Size is an integer and can be followed by K, M or G.

- file.path=*path*. When log rotation is enabled (`file.rotate` set), rename and move current log to this path instead of initial log path.
- append=[0|1]. (default=0). If 0, truncate the log file when opening it. Otherwise, append to it.

Available layers are: `phy`, `mac`, `rlc`, `pdcp`, `rrc`, `nas`, `s1ap`, `ngap`, `x2ap`, `xnap`, `m2ap`, `lppa`, `nrppa`, `gtpu`

log_sync   Optional boolean (default = false). If true, logs will be synchronously dumped to file.
Warning, this may lead to performances decrease.

pcap   Optional object. Gives the Wireshark capture options. The `mac-lte-framed` protocol using link-layer type 147 is supported (`http://wiki.wireshark.org/MAC-LTE`). In order to enable it in Wireshark, go to the menu `Edit->Preferences->protocols->DLT_USER->Edit->New` and add the DLT type 147 (User 0) with payload protocol `mac-lte-framed`.
It works only with LTE cells.

    filename   String. Filename in which the capture is stored.

    bcch   Optional boolean (default = false). If true, the BCCH SI PDUs are logged. It is disabled by default because the capture size increases even when the eNodeB is idle.

    max_data_len
        Optional integer (default = 65536). Maximum captured MAC PDU length per packet.

    use_pipe   Optional boolean (default = false). Capture in a pipe instead of a regular pipe. This allow live capture with wireshark: `wireshark -k -i <filename>`. Note that it can be used only once as wireshark requires initial header.

description
    Optional string. Set informational description for `config_get` remote API.

enb_name
    Optional string. Set eNB name used in S1 connection setup request.

gnb_name
    Optional string. Set gNB name used in NG connection setup request.

gtp_addr
    String. Set the IP address (and optional port) on which the GTP-U packets are received. The default port is 2152. It is normally the IP address of the network interface connected to the core network.

gtp_payload_mtu
    Optional integer (range 68 to 16384, default = 1500). MTU in bytes for the GTP-U payload. Do not forget to update the network interface MTU accordingly for optimal performance. For example with a GTP MTU of 1500 bytes, interface should have a MTU of at least 1564 bytes.

gtp_use_packet_bundling
    Optional boolean (default = false). Concatenate multiple GTP-U PDUs within a single UDP datagram. Be careful, this is a non-standard option that must not be activated if the peer is not an Amarisoft MME/AMF with this option activated.

mme_list   Optional array of objects. It must be present when LTE or NB-IoT cells are declared. List of MME to which the eNodeB is connected. Each object contains the following properties:

> **mme_addr**
>
> > String. Set the IP address (and optional port) of S1AP SCTP connection to the MME. The default port is 36412.
> >
> > Syntax:
> > - "1.2.3.4" (use default port)
> > - "1.2.3.4:5678" (use explicit port)
> > - "2001:db8:0:85a3::ac1f:8001" (IPv6 address and default port)
> > - "[2001:db8:0:85a3::ac1f:8001]:5678" (IPv6 address and explicit port)
>
> **gtp_ext_addr**
>
> > Optional string. Set the IP address on which the Core Network should transmit the GTP-U packets. It is the same as gtp_addr by default. It can be different if the eNodeB is behind a NAT.
>
> **s1ap_bind_addr**
>
> > Optional string. IP address and optional port on which the S1AP SCTP connection is bound.
>
> **qci_dscp_mapping**
>
> > Optional array of objects. Allows to define a specific IP differentiated services code point for a given QCI. QCI not explicitly configured use the default DSCP value 0.
> >
> > Each object must contain the following properties:
> >
> > qci   Integer (range 1 to 254). QCI value.
> >
> > dscp   Integer (range 0 to 63). DSCP value.
>
> **backup_mme_addr**
>
> > Optional string. Defines the IP address (and optional port) of the backup MME to be used if the S1 connection is not established with the current MME. If the S1 connection is established, the backup MME will not be used. There must be a corresponding object for the backup MME in the mme_list array.
>
> priority   Optional integer (range 0 to 1, default 0). Defines the priority of a given MME. When performing MME selection, if no candidate is found with priority n, the candidates with priority n+1 are tested.
>
> **emergency_bearer_arp_priority_level**
>
> > Optional integer (range 0 to 15, default 1). Defines the ARP priority level used by EPS for emergency bearers. Set to 0 to have no emergency bearer identification based on the ARP priority level.

> For backward compatibility, if mme_list is omitted, then a single MME is assumed and the properties mme_addr, gtp_ext_addr and s1ap_bind_addr are expected at the top level.

amf_list   Optional array of objects. It must be present when NR SA cells or LTE/NB-IoT cells with 5GC connectivity are declared. List of AMF to which the gNodeB/ng-eNodeB is connected. Each object contains the following properties:

> **amf_addr**

String. Set the IP address (and optional port) of NGAP SCTP connection to the AMF. The default port is 38412.

gtp_ext_addr
Optional string. Set the IP address on which the Core Network should transmit the GTP-U packets. It is the same as gtp_addr by default. It can be different if the gNodeB/ng-eNodeB is behind a NAT.

ngap_bind_addr
Optional string. IP address and optional port on which the NGAP SCTP connection is bound.

5qi_dscp_mapping
Optional array of objects. Allows to define a specific IP differentiated services code point for a given 5QI. 5QI not explicitly configured use the default DSCP value 0.
Each object must contain the following properties:

5qi   Integer (range 1 to 254). 5QI value.

dscp   Integer (range 0 to 63). DSCP value.

backup_amf_addr
Optional string. Defines the IP address (and optional port) of the backup AMF to be used if the NG connection is not established with the current AMF. If the NG connection is established, the backup AMF will not be used. There must be a corresponding object for the backup AMF in the amf_list array.

priority   Optional integer (range 0 to 1, default 0). Defines the priority of a given AMF. When performing AMF selection, if no candidate is found with priority n, the candidates with priority n+1 are tested.

emergency_bearer_arp_priority_level
Optional integer (range 0 to 15, default 1). Defines the ARP priority level used by 5GS for emergency bearers. Set to 0 to have no emergency bearer identification based on the ARP priority level.

x2ap_bind_addr
Optional string. IP address and optional port on which the X2AP SCTP connection is bound.

x2_peers   Optional array of strings. IP addresses and optional port of other eNodeBs to establish X2 connections. The default port is 36422.

xnap_bind_addr
Optional string. IP address and optional port on which the XnAP SCTP connection is bound.

xn_peers   Optional array of strings. IP addresses and optional port of other eNodeBs to establish Xn connections. The default port is 38422.

m2ap_bind_addr
Optional string. IP address and optional port on which the M2AP SCTP connection is bound.

mbmsgw_addr
Optional string. Set the IP address (and optional port) of the MBMS Gateway for the M2 connection. The default port is 36443.

`mbms_gtp_u_port`
> Optional integer. GTP-U local port number used to receive the MBMS packets. The default port is 2152.

`mbs_gtp_u_port`
> Optional integer. GTP-U local port number used to receive the MBS packets. The default port is 2152.

`mcc`
> String. The MCC part of the PLMN (3 digits). This property is obsolete. Use `plmn_list` instead.

`mnc`
> String. The MNC part of the PLMN (2 or 3 digits). This property is obsolete. Use `plmn_list` instead.

`enb_type`
> Optional enumeration: macro, short_macro, long_macro or home (default = macro). Select between macro or home eNodeB.

`enb_id`
> Optional integer. The 18 bit (short macro), 20 bit (macro), 21 bits (long macro) or 28 bit (home) eNodeB global identifier. It must be present when LTE or NB-IoT cells are declared.

`gnb_id_bits`
> Optional integer (range 22 to 32). Number of bits for the gNodeB global identifier. It must be present when NR SA cells are declared.

`gnb_id`
> Optional integer. The gNodeB global identifier. It must be present when NR SA cells are declared.

`rf_driver`
> Object. Parameters of the radio driver. See [Radio driver configuration], page 45.

`tx_gain`
> Float or array of floats. Transmit gain in dB. The range is device dependent. For the PCIe SDR board, the range is between 0 and 89.75 dB. For the USRP N2x0 device with the SBX daughterboard, the range is 0 to 31.5 dB. With an array of floats a different gain is specified for each channel.

`rx_gain`
> Float or array of floats. Receive gain in dB. The range is device dependent. For the PCIe SDR board, the range is between -11 and 77 dB (the exact limits depend on the RX frequency). For the USRP N2x0 device with the SBX daughterboard, the range is 0 to 31.5 dB. With an array of floats a different gain is specified for each channel.

`com_addr`
> Optional string. Address of the WebSocket server remote API. See [Remote API], page 235.
> If set, the WebSocket server for remote API will be enabled and bound to this address.
> Default port is 9001.
> Setting IP address to [::] will make remote API reachable through all network interfaces.

`com_name`
> Optional string. Sets server name. ENB by default

`com_ssl_certificate`
> Optional string. If set, forces SSL for WebSockets. Defines CA certificate filename.

`com_ssl_key`
> Optional string. Mandatory if *com_ssl_certificate* is set. Defines CA private key filename.

`com_ssl_peer_verify`
> Optional boolean (default is false). If *true*, server will check client certificate.

com_ssl_ca

>   Optional string. Set CA certificate. In case of peer verification with self signed
>   certificate, you should use the client certificate.

com_log_lock

>   Optional boolean (default is false). If *true*, logs configuration can't be changed via
>   `config_set` remote API.

com_log_us

>   Optional boolean (default is false). If *true*, logs sent by `log_get` remote API re-
>   sponse will have a `timestamp_us` parameters instead of `timestamp`

com_auth   Optional object. If set, remote API access will require authentication.
Authentication mechanism is describe in [Remote API Startup], page 237, section.

> **passfile**   Optional string. Defines filename where password is stored (plaintext).
>   If not set, `password` must be set
>
> **password**   Optional string. Defines password.
>   If not set, `passfile` must be set.
>
> **unsecure**   Optional boolean (default false). If set, allow password to be sent plain-
>   text.
>   NB: you should set it to true if you access it from a Web Browser (Ex:
>   Amarisoft GUI) without SSL (https) as your Web Browser may prevent
>   secure access to work.

com_log_count

>   Optional number (Default = 8192). Defines number of logs to keep in memory
>   before dropping them.
>   Must be between 4096 and 2097152).

sim_events

>   Array of object. Each element defines a remote API request ([Remote API],
>   page 235) except that `message` field is replaced by `event`.

sim_events_loop_count

>   If set, will define `loop_count` for each event of `sim_events`, See [loop_count],
>   page 236.

sim_events_loop_delay

>   If set, will define `loop_delay` for each event of `sim_events`, See [loop_delay],
>   page 236.

license_server

>   Configuration of the Amarisoft license server to use.
>   Object with following properties:

> **server_addr**
>   String. IP address of the license server.
>
> **name**   Optional string. Text to be displayed inside server monitor or remote
>   API.
>
> **tag**   Optional string. If set, server will only allow license with same tag.
>
> Example:
>
> `license_server: {`

```
            server_addr: "192.168.0.20",
            name: "My license"
        }
```

cell_list

>Array of object. Each element gives the configuration of a cell. The property `cell_default` gives a default value for each property. See [Cell configuration], page 45.

cell_default

>Optional Object. Gives a default value for the LTE cell configuration.
>This object will be merged with each element of `cell_list` according to [JSON merge rules], page 28, rules (`cell_list` overrides `cell_default`).

nb_cell_list

>Optional array of object. Each element gives the configuration of a NB-IoT cell. The property `nb_cell_default` gives a default value for each property. See [NB-IoT cell configuration], page 103.

nb_cell_default

>Optional Object. Gives a default value for the NB-IoT cell configuration.
>This object will be merged with each element of `nb_cell_list` according to [JSON merge rules], page 28, rules (`nb_cell_list` overrides `nb_cell_default`).

en_dc_support

>Optional boolean (default = false). Set it to true to enable E-UTRA NR Dual Connectivity support.

nr_cell_list

>Optional array of object. Each element gives the configuration of a NR cell. See [NR cell configuration], page 125.

nr_cell_default

>Optional Object. Gives a default value for the NR cell configuration.
>This object will be merged with each element of `nr_cell_list` according to [JSON merge rules], page 28, rules (`nr_cell_list` overrides `nr_cell_default`).

8.3 Advanced properties

internal_time_ref

>Optional enumeration: os_clock or rf_frontend (default = os_clock). Selects the time source for the LTE SIB16 or NR SIB9. `rf_frontend` selects the time from the RF frontend. It is the normal choice when the RF frontend is time synchronized. `os_clock` uses the OS clock and derives the number leap seconds by using the `right/UTC` Unix time zone.

rf_frontend_time_offset

>Optional integer (default = 0). Gives the difference in ms between the time given by the rf frontend and the International Atomic Time (TAI).

frame_epoch

>Optional integer (default = 0). Gives the TAI time in ms at which the LTE frame 0 starts. Use 0 to have the frame 0 start at 1970-01-01 00:00:00 TAI. Use 315964819000 to have the frame 0 start at 1980-01-06 00:00:19 TAI (GPS time = 0).

rf_ports Optional array of objects. Each object contains the configuration of the corresponding RF port. In order to support legacy configuration files, if the `rf_ports` array is not present, the RF port parameters come from the top level and are identical for all the RF ports.

Each object contain the following properties:

dl_freq   Optional float. Tuning frequency in MHz for the downlink. It is automatically set to the average of the DL center frequency of each cell.

In the multi-cell case, if the radio head has a degraded output near the center of the transmitted spectrum (which is the case for zero IF TX or RX architectures), it is interesting to move the center of the transmitted spectrum outside the spectrum of every cell or in the middle of the spectrum of a given cell.

In this case, the dl_freq property can be used. It must be set so that for each cell dl_freq - dl_cell_freq is a multiple of 15 kHz (dl_freq_cell is assumed to be the center frequency of a cell).

Note: if you want to use non standard frequencies, use the custom_freq_band option.

ul_freq   Optional float. Tuning frequency in MHz for the uplink. It is automatically set to the average of the UL center frequency of each cell.

Same remark as dl_freq.

channel_dl

Optional object. Set the RF port specific channel simulator configuration. See [RF port specific channel simulator], page 220.

ul_freq_shift

Optional float. Add ul_freq_shift Hz to the nominal center uplink frequency. This parameter may be used to compensate a large simulated frequency offset when using the channel simulator.

n_antenna_dl

Optional integer. Set the number of DL antennas. Only useful if the channel simulator is used to set a different number of physical DL antennas at the output of the channel simulator. See [RF port specific channel simulator], page 220.

sample_rate

Optional float. Sample rate in MHz. It is normally automatically set depending on the radio head capabilities and selected cell bandwidth.

sample_rate_num

Optional integer. Main sample rate used for the LTE signal processing in 1.92 MHz units (hence 3 means 5.76 MHz). It is normally automatically set depending on the radio head capabilities and selected cell bandwidth. If the resulting rate is different from sample_rate, a fractional sample rate interpolator is used to convert the sample rate (this is only possible with a 15kHz SCS without ORAN split 7.2).

tx_gain_offset

Optional float. Set the TX digital gain. The default value is -14 dB. It should be set so that the digital signal level is as high as possible without saturation. The t spl monitor command displays the maximum digital signal level and the number of saturations.

When using the channel simulator with fading channels it is necessary to lower tx_gain_offset to reduce the likelihood of saturations.

tx_power_offset

Optional float. If set add an offset in dB to any TX signal power information such as 't spl' monitor command or referenceSignalPower/ss-

PBCH-BlockPower (if manual_ref_signal_power is false).
Useful when placing an attenuator (negative value) or a power amplifier (positive value) after the radio frontend TX output.

rf_dl_freq

Optional float. Override the tuning frequency in MHz for the downlink. This optional is only needed if there is a frequency translator after the SDR device.

rf_ul_freq

Optional float. Override the tuning frequency in MHz for the uplink. This optional is only needed if there is a frequency translator after the SDR device.

dl_bandwidth

Optional float. Force the DL RF bandwidth of the SDR device in MHz.

ul_bandwidth

Optional float. Force the UL RF bandwidth of the SDR device in MHz.

rx_to_tx_latency

Optional integer (range 2 to 4, default = 4). Minimum allowed latency in ms between RX and TX.
This parameter is deprecated. Please use cell `rx_to_tx_latency` cell parameter instead (See [Cell RX/TX latency], page 209).

If the latency is too high, the gNB scheduler may not be able to use all the PDSCH transmission occasions with subcarrier spacings larger or equal to 30 kHz. Increasing the value will improve performances, especially in case of radio frontend underflows. If LTE and NB-IoT cells are present on the RF port, only the value 4 is allowed.

papr_reduction

Optional object. Define the parameters for Peak to Average Power Ratio (PAPR) reduction. It is only useful if you use a high power amplifier. In the current version it takes a significant amount of CPU time, so it is only usable for LTE bandwidth <= 10 MHz.
The following properties are available:

enabled   Boolean. If true, PAPR reduction is enabled.

a_max   Float. Set the cut-off level in dB relative to the Reference Signal power.

evm_max   Float. Set the maximum Error Vector Magnitude (EVM) for 64QAM.

oob_points

Array of floats. Each pair of number defines a point of the maximum allowed distorsion curve. The first number is the frequency offset in MHz from the edge of the LTE spectrum. The second number is the power level in dB. The actual curve is linearly interpolated between the points.

Typically, the PAPR CCDF at 10^-5 goes from 12.5 dB to 11.0 dB.

n_subband

Optional integer (default = 1). If larger than one, the RF port bandwidth is split into n_subband frequency parts. For example, it allows

to reach a 100 MHz bandwidth with two 50 MHz SDR boards. The number of channels of the RF port is `n_subband*n_ant` where `n_ant` is the number of selected antennas. The first `n_ant` channels correspond to the lowest frequency part, the next `n_ant` channels to next part, etc. It is only supported with NR cells. The PRACH and the SSB must always be in the first frequency part.

s72   Optional object. If set, this RF port will use ORAN split 7.2 TRX API to send data to the radio unit.

RF port must only have NR cells. This section has the following properties:

rtc_id   Integer. RTC id.

ud_comp_hdr

Optional integer (default = 0). Set User Data compression header configuration. Can be `0` for no compression, `0x81` for BF8, `0x91` for BF9, `0xc1` for BF12 or `0xe1` for BF14.

port_mapping

Optional array of integers. If set, allows to map UE antenna to different RU port.

Each number represents the RU port ID used for the antenna in ORAN packets.

This array must have same number of elements as the maximum between DL antenna count and UL antenna count. Each RU port must be set once in the array. Ex:

`port_mapping: [1, 2, 4, 0],`

Means UE will use RU port 1 for the first antenna, RU port 2 for the second antenna... By default, it is set to `[0, 1, 2, ... ]`

port_mapping_dl

Optional array of integers. Same as `port_mapping` except that it applies only for DL antenna and the array must have same number of elements as DL antenna count.

port_mapping_ul

Optional array of integers. Same as `port_mapping` except that it applies only for UL antenna and the array must have same number of elements as UL antenna count.

port_mapping_prach

Optional array of integers. Same as `port_mapping` except that it applies only for the PRACH ORAN packets.

gen_prb0   Optional boolean (default = false). If true, numPrbc of U-Plane ORAN section will be set to 0 when all ressources blocks are used and exceed 255.

If set to false and number of ressources blocks exceed 255, multiple ORAN sections will be generated.

cp_dl   Optional boolean (default = true). If false, LTEENB won't generate any DL-Control packet.

cp_ul   Optional boolean (default = true). If set to false, UL-C packet won't be generated. May be use with test mode to qualify DL signal.

relative_symbol
> Optional boolean (default = false). In case of section type 3, start symbol of both control and data packet will start at 0, i.e relative to time_offset

debug
> Optional boolean (default = false). If true, mode information will be displayed in logs. May have an impact on performances.

ul_ctrl_latency
> Optional integer (default = 1, between 1 and 2). Set how many slot in advance to send uplink control packets (Experimental).

Example:

```
rf_ports: [
  {
    s72: {
      rtc_id: 0x1000,
      gen_prb0: true,
    }
  }
],
```

udc_port   Optional integer. Selects the UDC port used for the cell. Cells aggregated with the same UDC device, will use the same udc_port number.

cpu_core_list
> Optional Array. Defines the core affinity of the digital signal processing engine (Physical layer) for both UL and DL of the cells associated to this rf_port (See [cpu_core_list], page 234).

cpu_core_list_ul
> Optional Array. Defines the core affinity of the digital signal processing engine (Physical layer) for UL of the associated cell(s). If set, overrides cpu_core_list.

cpu_core_list_dl
> Optional Array. Defines the core affinity of the digital signal processing engine (Physical layer) for DL of the associated cell(s). If set, overrides cpu_core_list.

nb_threads
> Optional number. If set, forces the number of threads used by the digital processing engine for DL or UL of the associated cell(s).

nb_threads_ul
> Optional number. If set, forces the number of threads used by the digital processing engine for UL of the associated cell(s). If set, overrides nb_threads.

nb_threads_dl
> Optional number. If set, forces the number of threads used by the digital processing engine for DL of the associated cell(s). If set, overrides nb_threads.

cpu_numa_list
> Optional array of integers. Each integer represent a NUMA node index. If set will, digital processing engine will use the list of defined NUMA

nodes for its memory usage.

If this field is not set but `cpu_core_list` is defined, LTEENB will select the NUMA nodes associated to the affected cores. This means that most of the time this parameter shouldn't be set. The only relevant case is when a NUMA node has no RAM bank connected, you may use this parameter to select the closest NUMA node with memory.

udc_ports

Optional array of objects. Each object contains the configuration of the corresponding UDC port.

Each object contains the following properties:

args   String. Set the UDC configuration parameters. Each parameter composing the string is separed by semicolon (See [args configuration], page 302).

cmd   String. Specifies the path to the script for the UDC configuration (See [UDC configuration reference], page 301). The script is called once for each configured `udc_port` with the following command line arguments:

- `args`: (See [args], page 41)
- `lo_freq`: (See [lo_freq], page 41)
- `min_freq`: automatically set by the software, spectrum minimum frequency for aggregated cells using the same `udc_port`
- `max_freq`: automatically set by the software, spectrum maximum frequency for aggregated cells using the same `udc_port`
- `freq`: automatically set by the software, FR2 cell central frequency, for each `rf_port` using the same `udc_port`
- `bandwidth`: automatically set by the software, FR2 cell bandwidth, for each `rf_port` using the same `udc_port`

lo_freq   Optional float. Specifies the UDC LO frequency in MHz to be configured. If not present, it will be automatically computed.

tx_power_offset

Optional float. Measured in dB, negative value. It corresponds to the amount of attenuation between the SDR and the UDC IF port.

The default value is 0, in case of aggregated cells with combiner the attenuation is computed as -10*log10(COMBINER_PORTS).

tx_pad_duration

Optional integer (default = 23). Duration (in 1/1.92 us units) of the zero sample burst sent before the start of the downlink burst in TDD. It corresponds to the power amplifier ramp up duration. The appropriate value depends on the radio head.

tx_time_offset

Optional integer (default = 0). Time offset (in samples) for the downlink. It may be needed to compensate internal delays in the radio head. In a normal setup, this value should be set to zero.

rx_ta_offset

Optional float (default = 2.0). Time offset (in 1/1.92 us) for the uplink. With a well calibrated radio head (i.e. where the TRX timestamps take into account the internal radio head delays), it gives the PRACH timing advance of a UE close to the eNodeB. A small non zero value (such as 2) is recommended.

tdd_legacy_timing

>   Optional boolean (default = false). If true, the LTE TDD downlink frame starts
>   39/1.92 us after the GPS origin. Otherwise, the LTE TDD downlink frame starts
>   at the GPS origin (default). For interoperability purposes with other eNodeBs, it
>   is better to keep it to false.

custom_freq_band

>   Optional object or array of objects. Define a non standard LTE or NR frequency
>   band. Standard bands can also be overriden by this option. If the uplink information
>   is not provided, it is assumed to be the same as the downlink (TDD band). Use an
>   array of objects if you want to define more than one custom band.
>
>   For LTE bands, the following parameters are available:

band   Range: 1 to 256.

dl_earfcn_min

>   Range: 0 to 262143.

dl_earfcn_max

>   Range: 0 to 262143.

dl_freq_min

>   Float. Low DL frequency in MHz.

ul_earfcn_min

>   Optional integer. Range: 0 to 262143.

ul_earfcn_max

>   Optional integer. Range: 0 to 262143.

ul_freq_min

>   Optional Float. Low UL frequency in MHz.

ntn   Optional boolean. True if this is a NTN band.

>   For NR bands, the following parameters are available:

band_nr   Range: 1 to 1024. NR band number.

dl_freq_min

>   Float. Range: 0 to 65535. Minimum DL frequency in MHz. Use 0 if no
>   DL.

dl_freq_max

>   Float. Range: 0 to 65535. Maximum DL frequency in MHz. Use 0 if
>   no DL.

ul_freq_min

>   Float. Range: 0 to 65535. Minimum UL frequency in MHz. Use 0 if no
>   UL. If not provided, use the same value as DL (TDD).

ul_freq_max

>   Float. Range: 0 to 65535. Maximum UL frequency in MHz. Use 0 if
>   no UL.

ssb_scs   Array of integers. List of allowed SSB subcarrier spacing for this band.
>   Allowed values: 15, 30, 120 or 240.

f_raster   Enumeration: 100, 15, 15_30, 15_30_100, 60_120, 100_enhanced. Fre-
>   quency raster in kHz.

ssb_case_c

>>Boolean. True if SSB case C is enabled on this band.

min_40mhz_bw

>>Boolean. True if the minimum allowed bandwidth on this band is at least 40 MHz. This information is used to select the CoReSet #0 table in standalone mode.

delta_gscn

>>Optional enumeration: 1, 3, 7, 16 (default = 1). GSCN step size.

ntn Optional boolean. True if this is a NTN band.

rate_bucket_duration

>Optional. Range 50 to 1000 (default = 100). Duration in ms for the average bit rate estimation. It is used to enforce the UE Aggregate Maximum Bit Rate and GBR ERAB Maximum Bit Rate.

sched_rate_duration

>Optional. Range 5 to 1000 (default = 50). Period in ms for the average bit rate estimation for the MAC scheduler.

sched_metric

>Optional enumeration: pf, rr, mt (default = pf). Set the MAC scheduler metric. Available possibilities:

Type	Description
pf	Proportionally fair
rr	Round-robin
mt	Maximum throughput

sched_latency_for_prb_max

>Optional. Range: 5 to 1000 (default = 50). Approximate maximum latency in ms. It is used to limit the maximum number of UEs per TTI.

automatic_ue_info_request

>Optional boolean (default = false). If set, the eNB will send a UE Information message if the UE indicates the availability of information in RRC signalling.

skip_smc_proc

>Optional boolean (default = false). If set to true, the eNB will not perform a RRC security mode control procedure. This needs to be supported on UE side also.

fifteen_bearers

>Optional boolean (default = true). If true, enable the use of 15 EUTRA data radio bearers (if supported by the UE).

automatic_eutra_cap_enquiry_params

>Optional boolean (default = true). If set to true, the eNB automatically sends the requestedFrequencyBands-r11, requestReducedFormat-r13, requestReducedIntNonContComb-r13 and requestedMaxCCsDL-r13 fields in the LTE RRC UE capability enquiry message for EUTRA RAT based on the LTE bands, neighbor cells and CA combinations defined in the configuration file.
>The cell specific `requested_eutra_freq_bands`, `requested_eutra_max_ccs_dl`, `request_reduced_format` or `request_eutra_reduced_int_non_cont_comb` parameters have precedence over this one.

cpu_core_list
> Optional array. Defines the list of CPU cores indexes on which LTEENB will run. If not set, LTEENB may use all cores, refer to [cpu_core_list], page 234, for syntax. Note that the number of cores depends on Linux scheduler and LTEENB configuration.

icic
> Optional object. If present, Inter Cell Interference Coordination (ICIC) is activated for all the LTE cells in the eNodeB. ICIC is used to mitigate interference between neighbor cells within a reuse 1 network. It is used to improve the coverage quality in DL and UL. It is currently only supported in LTE. Two ICIC methods can be used: Hard Frequency Reuse (HFR) and Fractionnal Frequency Reuse (FFR). In HFR, the band is split in a given number of portions (called reuse factor) and each cell uses one portion. FFR is an alternative where a portion of the band is shared between cells and used by UEs located in the cells' center. The rest of the band is used like in HFR. The method can be different in UL and DL. The different ICIC methods are only applied for data channels. PDCCH, PUCCH and PRACH are not impacted. This object contains the following fields (all the DL fields dl_xxx have their symmetrical UL field noted ul_xxx):

> reuse_factor
>> Optional integer (default = 3). Factor by which the total bandwidth is split between cells. Same for DL and UL.

> dl_icic   Optional boolean (default = false). Activate ICIC in DL. This field activates HFR by default.

> dl_cell_center_portions
>> Optional integer (default = 0). Number of band portions used for cell center UEs. It activates FFR. For example, if reuse_factor is 3 and dl_cell_center_portions is 1, then cell center UEs have $1/(3 + 1) = 1/4$ of the band and cell edge UEs also have 1/4 of the band. If reuse_factor is 3 and dl_cell_center_portions is 3, then cell center UEs have $3/(3 + 3) = 1/2$ of the band and cell edge UEs have 1/6 of the band. If FFR is activated, a measurement report must be configured to let the eNodeB know where the UE is located (cell edge or cell center). The object eutra_interference_intra must be configured within the object meas_config_desc.

> dl_schedule_cc_on_ce_band
>> Optional boolean (default = true). Allow the scheduling of cell center UEs on cell edge band in FFR. Setting it to false increases cell edge UEs throughput but decreases bandwidth usage.

> icic_bitmap_dynamic_update
>> Optional boolean (default = false). Add the ability to dynamically reallocate the band reserved for cell egde UEs of a cell to another cell when there is no active UEs in the cell. Cells are allowed to use the band reserved for a neighbor cell when this neighbor cell has no active UEs (in cell edge or cell center). Can be used with both HFR and FFR. When two cells belong to two different eNodeBs, the X2 interface is leveraged to share occupancy information between cells. We strongly advise to activate this parameter for bandwidth usage optimization.

> inter_enb_synchro
>> Optional boolean (default = false). Specify whether or not eNodeBs are synchronized in time (start of frame, frame and subframe number are

the same accross all the eNodeBs). Enables better bandwidth usage for inter-eNodeB ICIC.

`vrb_lib_path`

Optional string. Path to the `vrb_dpdk.so` dynamic library file located in the delivered tarball. If present, the gNodeB uses Intel vRANBoost device for LDPC decoding. The CPU must support vRANBoost, DPDK must be installed on the machine and the vRANBoost device must be configured properly before use. This mode enables faster LDPC decoding. It can be used to lower the CPU usage of the stack or to increase the number of LDPC decoding iterations in order to improve decoding sensitivity.

8.4 Radio driver configuration

`name`   Driver name. The corresponding DLL file name is `trx_name.so`. It is searched in the lteenb executable directory, in the path configured in the `path` property.
The following drivers are currently available:

dummy   Dummy driver. Can be used to measure the RX to TX latency.
sdr   Amarisoft PCIe SDR driver.
           Parameters are defined here:
           SDR50 (https: / / tech-academy . amarisoft . com / trx_sdr . doc # TRX-driver-configuration-options)
           SDR100 (https: / / tech-academy . amarisoft . com / trx_sdr100 . doc # TRX-driver-configuration-options)
           CPRI (https: / / tech-academy . amarisoft . com / trx_cpri . doc # TRX-driver-configuration-options)

uhd   Ettus Research UHD driver for USRP N2x0, B2x0 and X3x0 series.
           Please check Amarisoft UHD documentation delivered within package.
lms7002m   Lime MicroSystem LimeSDR platform driver.
           Please check Amarisoft SDR documentation delivered within package.

If you don't have and need one of these drivers, please contact `customer@amarisoft.com` and ask for it.

8.5 LTE cell configuration

8.5.1 Basic parameters

These parameters are the most important ones and must usually be modified when a new cell is added.

`plmn_list`

Array of objects or strings. List of PLMNs broadcasted by the eNodeB. At most 6 PLMNs are supported. Each element of the array is either a PLMN (5 or 6 digit string) or an object containing the following properties:

`plmn`   String. PLMN (5 or 6 digits).

`reserved` Boolean. True if the cell is reserved for operator use.

`cp_ciot_opt`
           Optional boolean (default = false). Indicates if PLMN supports CP-CIoT EPS optimisation.

> attach_without_pdn
>> Optional boolean (default = false). Indicates if PLMN supports attach without PDN connectivity.
>
> allow_upper_layer_ind
>> Optional boolean (default = true). Indicates if upperLayerIndication-r15 is allowed for this PLMN or not. If set to true and if NR cells are defined in `en_dc_scg_cell_list`, upperLayerIndication-r15 is set to true.

When `reserved` is not provided, its default value is `false`.

plmn_list_5gc
> Optional list of objects. List of PLMNs broadcasted by the ng-eNodeB. At most 6 PLMNs are supported. Each object contains the following properties:
>
> plmn_ids   Array of objects. The array can contain up to 6 PLMNs. Each object contains the following properties:
>
>> plmn   String. PLMN (5 or 6 digits).
>>
>> reserved   Boolean. True if the cell is reserved for operator use.
>>
>> cp_ciot_opt
>>> Optional boolean (default = false). Indicates if PLMN supports CP-CIoT 5GS optimisation.
>
> tac   Integer (range 1 to 0xFFFFFF, except 0xFFFFFE). Tracking Area Code of the cell.
>
> ranac   Optional integer (range 0 to 255). If present, sets the RAN Area Code.
>
> nssai   Optional array of objects. List of supported S-NSSAIs.
>   Default content is sst: 1 (eMBB).
>   Each object will set a S-NSSAI value as defined below:
>
>> sst   Integer (range 0 to 255). Slice Service Type.
>>
>> sd   Optional integer (range 0 to 0xFFFFFE). Slice Differentiator.

eutra_5gc_only
> Optional boolean (default = false). It `plmn_list_5gc` is present and if this parameter is set to true, EUTRA/EPC access is barred and only EUTRA/5GC access is allowed.

dl_earfcn
> Range: 0 to 262143. Set the DL EARFCN. See https://www.sqimway.com/lte_band.php to convert between the center frequency and EARFCN. When several cells share the same radio front end, the difference of their center DL frequency should be a mutiple of 300 kHz to minimize the interferences and the CPU usage (i.e. the difference of their DL EARFCN must be a multiple of 3). Also, the difference between the DL center frequency of each cell and the average of DL center frequencies must be a multiple of 15 kHz.

ul_earfcn
> Optional. Range: -1 to 262143. Set the UL EARFCN. -1 means that the cell is configured as DL only. If not provided, the default DL/UL gap is used. `ul-CarrierFreq` in SIB2 is automatically set to the corresponding value. When several cells share the same radio front end, the difference of their center UL frequency should be a

mutiple of 300 kHz to minimize the interferences and the CPU usage (i.e. the difference of their UL EARFCN must be a multiple of 3). Also, the difference between the UL center frequency of each cell and the average of UL center frequencies must be a multiple of 15 kHz.

n_antenna_dl

Enumeration: 1, 2, 4 or 8. Number of DL antennas. It must be the same for all NB-IoT and LTE cells sharing the same RF port. Currently 1 (SISO) 2 (MIMO 2x2) or 4 (MIMO 4x4) are supported.

n_antenna_ul

Enumeration: 1, 2, 4 or 8. Number of UL antennas. It must be the same for all NB-IoT and LTE cells sharing the same RF port.

n_antenna_pbch

Optional enumeration: 1, 2 or 4 (default = n_antenna_dl). Number of PBCH antennas. Must be <= n_antenna_dl.

rf_port Optional integer (default = 0). This parameter selects the RF port when several cells on different RF interfaces or RF bands are handled by the eNodeB. The number of supported RF ports depends on the radio head. For example, each PCIe card or N210 counts as one RF port.

multi_band_list

Optional array of integers. List the additional bands supported by the cell, in decreasing priority order (MFBI feature). The downlink and uplink frequency of the cell must exist in all these bands.

freq_band_indicator_priority

Optional boolean (default = false). Indicates the prioritization of the frequency bands in multiBandInfoList over the band in freqBandIndicator in SIB1. Only used when `multi_band_list` is set.

cell_id Range: 0 to 1023. 7 bit (long macro eNB), 8 bit (macro eNB) or 10 bit (short macro eNB) cell identifier. The 28 bit E-UTRAN cell identity is the concatenation of `enb_id` and `cell_id`.

tac Range: range 1 to 0xFFFF, except 0xFFFE. Tracking Area Code of the cell.

csg_indication

Optional boolean (default = false). SIB1 csg-Indication parameter.

csg_id Optional integer in range 0 to 0x7FFFFFF. Identity of the Closed Subscriber Group the cell belongs to. Must be present if `csg_indication` is set to true.

n_id_cell

Range: 0 to 503. Physical cell identifier. Each neighbour cell operating on the same frequency must have a different physical cell identifier modulo 3.

root_sequence_index

Range: 0 to 837. Set the PRACH root sequence index (SIB2.rootSequenceIndex field). It must be different for each neighbour cell operating on the same frequency and sharing the same PRACH configuration.

prach_config_index

Optional integer: Range: -1 to 63 (default = -1). Set the PRACH configuration index. The special value -1 indicates to take the value from the SIB2 (legacy case).

prach_freq_offset

>   Optional integer. Range: -2 to n_rb_ul - 6 (default = -2). Set the PRACH frequency
>   offset. The special value -2 indicates to take the value from the SIB2 (legacy case).
>   The special value -1 indicates to automatically set it.

ncell_list

>   Optional array of objects. List of neighbour EUTRA or NR cells. Used to convert
>   the physical cell identity and EARFCN or NR SSB ARFCN to a cell identity in
>   case of handover or cell redirection. Each neighbour cell is defined by the following
>   properties:

>   **rat**   Optional enumeration (eutra or nr, default = eutra). Radio access tech-
>   nology for this neighbor cell. If set to `nr` the other properties must match
>   a NR cell description. See [NR ncell_list], page 134.

>   **n_id_cell**

>   Integer. Range: 0 to 503. Physical cell identity.

>   **dl_earfcn**

>   Optional integer. Range 0 to 262143. DL EARFCN. If not present, it
>   is assumed to be the same as the current cell.

>   **plmn**   Optional string. PLMN of the Global eNodeB-ID and E-UTRAN Cell
>   Global Identifier (5 or 6 digits). The default is the same PLMN as the
>   eNB.

>   **cell_id**   Integer. 28 bit E-UTRAN cell identity. Concatenation of `enb_id` and
>   `cell_id`.

>   **tac**   Optional integer (range 1 to 0xFFFF, except 0xFFFE). Tracking Area
>   Code. Must be present if the neighbor cell belongs to an eNB. Can be
>   absent if `tac_5gc` is present.

>   **tac_plmn**   Optional string. PLMN of the target cell TAI. If not present, the current
>   UE PLMN is used.

>   **csg_id**   Optional integer in range 0 to 0x7FFFFFF. Identity of the Closed Sub-
>   scriber Group the cell belongs to.

>   **csg_hybrid**

>   Optional boolean (default = false). Indicates if the cell is a CSG hybrid
>   cell.

>   **tac_5gc**   Optional integer (range 1 to 0xFFFFFF, except 0xFFFFFE). Must be
>   present if the neighbor cell belongs to a ng-eNB.

>   **tac_5gc_plmn**

>   Optional string. PLMN of the target cell TAI if it belongs to a ng-eNB.
>   If not present, the current UE PLMN is used.

>   **type**   Optional string. Can be "macro" (default) for macro eNB,
>   "short_macro" for short macro eNB, "long_macro" for long macro eNB
>   or "home" for home eNB. Only used for S1 handover.

>   **allowed_meas_bandwidth**

>   Optional integer 6, 15, 25, 50, 75 or 100. Defines the allowed measure-
>   ment bandwidth to be used for this cell. If the field is not present, it
>   uses the serving cell downlink bandwidth.

antenna_port_1

>   Optional boolean. Indicates if antenna port 1 is used by the cell. If the
>   field is not present, it uses the serving cell configuration.

neigh_cell_config

>   Optional integer, range 0 to 3, default to 1 (means 'no MBSFN sub-
>   frames are present in all neighbour cells'). Sets the neighbour cell in-
>   formation as specified in 3GPP TS 36.331. It must be the same for all
>   cells belonging to the same frequency. The allowed values are:

Index	Description
0	Not all neighbour cells have the same MBSFN subframe allocation as the serving cell on this frequency, if configured, and as the PCell otherwise
1	No MBSFN subframes are present in all neighbour cells
2	The MBSFN subframe allocations of all neighbour cells are identical to or subsets of that in the serving cell on this frequency, if configured, and of that in the PCell otherwise
3	Different UL/DL allocation in neighbouring cells for TDD compared to the serving cell on this frequency, if configured, and compared to the PCell otherwise

individual_offset

>   Optional enumeration: -24, -22, -20, -18, -16, -14, -12, -10, -8, -6, -5,
>   -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20, 22 or 24.
>   Individual offset in dB given to the UE in the Measurement Object for
>   the corresponding cell.

multi_band_list

>   Optional array of integers. List the additional bands supported by the
>   cell, in decreasing priority order (MFBI feature). The downlink and
>   uplink frequency of the cell must exist in all these bands. If not present,
>   it will take the `multi_band_list` configuration from the LTE serving
>   cell if both cells are in the same band.

eps_fallback_target

>   Optional boolean (default = false). If set to true, this cell is considered
>   as the EUTRA target for NR EPS fallback procedure (handover or
>   redirection). Only one cell should be configured with true.

emergency_fallback_target

>   Optional boolean (default = false). If set to true, this cell is considered
>   as the EUTRA target for NR emergency fallback procedure (handover
>   or redirection). Only one cell should be configured with true.

handover_target

>   Optional boolean (default = true). If set to true, this cell is considered
>   for handover purpose. If set to false, no handover is triggered towards
>   this cell.

cell_redirect_target

>   Optional boolean (default = true). If set to true, this cell is considered
>   for redirection purpose. If set to false, no redirection is triggered towards
>   this cell.

direct_forwarding_available

Optional boolean (default = true). Defines if a direct path is available between eNBs for user data forwarding during a S1AP handover

n_rb_dl   Integer. Range: 6 to 100. Set the number of DL resource blocks. The corresponding LTE bandwidth can be deduced from the following table:

#	Bandwidth
6	1.4 MHz
15	3 MHz
25	5 MHz
50	10 MHz
75	15 MHz
100	20 MHz

Note: It is always necessary to modify the SIB2 when changing the LTE bandwidth.

n_rb_ul   Optional integer. Range: 6 to 100. Set the number of UL resource blocks. If not present, the value is retrieved from the SIB2 freqInfo/ul-Bandwidth field if present, and is set to **n_rb_dl** otherwise.

8.5.2 Advanced parameters

cell_gain

Optional float (default = 0). Downlink cell gain in dB. Must be between -200 and 0 (included). Note: it is not taken into account to set **SIB2.referenceSignalPower**.

rx_epre_in_dbfs

Optional boolean (default = false). In the logs, the EPRE (Energy Per Resource Element) is displayed in dBm if the RF interface provides its reference receive power and if rx_epre_in_dbfs = false. Otherwise it is displayed in dBFS (Decibels relative to Full Scale).

rx_epre_offset

Optional float (default = 0). Offset in dB applied to all the receive EPRE measurements.

manual_ref_signal_power

Optional boolean (default = false). If the RF interface provides its transmit power, then **SIB2.referenceSignalPower** is automatically set. If manual_ref_signal_power is true, then **SIB2.referenceSignalPower** is never automatically set by the eNodeB.

cyclic_prefix

Enumeration: normal or extended. Set the DL cyclic prefix.

uldl_config

(TDD only) Range: 0 to 6. TDD frame configuration.

sp_config

(TDD only) Range: 0 to 9. TDD special subframe configuration. The special subframe 7 (with extended cyclic prefix) and 9 (with normal cyclic prefix) from the release 11 are supported.

long_range

Optional boolean (default = false). If true, enable a proprietary Amarisoft extension to extend the cell range (modified UEs are necessary). Only FDD mode is supported. PRACH format 1 or 3 must be used and SIB2.zeroCorrelationZoneConfig must be set to zero. The HARQ round-trip time is increased from 8 to 10 ms.

subframe_offset

Optional integer (default = 0). Normally all cells have their subframe number temporally aligned. This parameters adds a cell specific subframe offset.

power_p_sync

Optional float (default = `p-a`). Set the relative power in dB of the Primary Synchronization Signal.

power_s_sync

Optional float (default = `p-a`). Set the relative power in dB of Secondary Synchronization Signal.

power_pcfich

Optional float (default = `p-a`). Set the relative power in dB of PCFICH.

power_pbch

Optional float (default = `p-a`). Set the relative power in dB of PBCH.

power_phich

Optional float (default = `p-a`). Set the relative power in dB of PHICH.

power_pdcch

Optional float (default = `p-a`). Set the relative power in dB of PDCCH.

power_pdsch_si

Optional float (default = `p-a`). Set the relative power in dB of PDSCH when transmitting SI/RA/P-RNTI information.

power_pmch

Optional float (default = `p-a`). Set the relative power in dB of PMCH (MBMS).

phich_duration

Enumeration: normal or extended. Set the PHICH duration.

phich_resource

Enumeration: 1/6, 1/2, 1 or 2. Set the PHICH resource.

sib1   Optional [ASN.1 property], page 29. SIB1 content. The fields `plmn-Identity`, `trackingAreaCode`, `cellIdentity` and `freqBandIndicator` are automatically modified by the eNodeB.
If the `sib1` property is not present, the SIB1 is built from the JSON configuration.

cell_barred

Boolean or string (true, false or "auto"). Value of SIB1.cellBarred. If set to "auto", the cell is barred when there is no connection with a core network for any of the PLMNs broadcast. Ignored if `sib1` is present.

intra_freq_reselection

Boolean. Value of SIB1.intraFreqReselection. Ignored if `sib1` is present.

q_rx_lev_min

Integer. Value of SIB1.q-RxLevMin. Ignored if `sib1` is present.

q_rx_lev_min_offset

Optional integer (default = 0). Value of SIB1.q-RxLevMinOffset. The value 0 disables the field. Ignored if `sib1` is present.

q_qual_min

Optional integer. Value of SIB1.cellSelectionInfo-v920.q-QualMin-r9. Ignored if `sib1` is present.

q_qual_min_offset

>Optional integer (default = 0). Value of SIB1.cellSelectionInfo-v920.q-QualMinOffset-r9. Only applicable when `q_qual_min` is present. The value 0 disables the field. Ignored if `sib1` is present.

p_max   Optional integer. Value of SIB1.p-Max. Ignored if `sib1` is present.

si_value_tag

>Range: 0 to 31. Increment modulo 32 if SI is modified. Ignored if `sib1` is present.

si_window_length

>Integer. SI window length in ms. Ignored if `sib1` is present.

sib25   Optional object used to configure the SIB 25. It contains the following fields:

>**si_periodicity**
>
>>Optional enumeration: 8, 16, 32, 64, 128, 256, 512 (default = 32). Sets the periodicity (in frames) of the transmission of SIB 25.
>
>**uac_barring_info**
>
>>Optional object containing the configuration of SIB25.
>>See [uac_barring_info], page 131.

sib_sched_list

>Array of [ASN.1 property], page 29. Each entry contains the content of one SI scheduling slot. The first entry must contain the SIB2. Each object contains the following properties:
>
>**filename, content, content_type**
>
>>See [ASN.1 property], page 29, `BCCH-DL-SCH-Message` RRC message type.
>
>**si_periodicity**
>
>>Enumeration: 8, 16, 32, 64, 128, 256, 512. SI periodicity in Radio Frames. This field should not be not present if the `sib1` property is present because the corresponding value comes from the SIB1 content.

si_coderate

>Float. Maximum code rate for System Information Blocks (SIBs).

rar_coderate

>Optional float. Maximum code rate for Random Access Response (RAR) (default = same as `si_coderate`).

paging_coderate

>Optional float. Maximum code rate for paging messages (default = same as `si_coderate`).

paging_cat0_coderate

>Optional float. Maximum code rate for paging messages for category 0 UEs (default = same as `paging_coderate`).

si_pdcch_format

>Range: 2 to 3. Log2 of the number of CCEs for PDCCH for SIBs.

rar_pdcch_format

>Optional. Range: 2 to 3. Log2 of the number of CCEs for PDCCH for RAR (default = same as `si_pdcch_format`).

paging_pdcch_format

>Optional. Range: 2 to 3. Log2 of the number of CCEs for PDCCH for paging (default = same as `si_pdcch_format`).

paging_cat0_pdcch_format

>   Optional. Range: 2 to 3. Log2 of the number of CCEs for PDCCH for paging for
>   category 0 UEs (default = same as `paging_pdcch_format`).

rar_backoff_index

>   Optional. Range: -1 to 15. If set to -1, no Backoff Indicator is sent in the Random
>   Access Response message. Values 0 to 15 refer to the index of table 7.2-1 found in
>   3GPP TS 36.321.

sib_sfn_offset

>   Optional array of integer. If present, set the offsets of the SIBs in the SI window.
>   At most 4 offsets are allowed. If it not present, the eNodeB uses default values.

n_symb_cch

>   Range: 0 to 4. Number of OFDM symbols for PDCCH. 0 means to automatically
>   adjust the number of OFDM symbols. 0 should not be used in a cell where cross
>   carrier PDCCH signalling is enabled.

half_duplex_ue

>   Optional boolean (default = false). If true, the support of HD-FDD UEs is enabled.
>   Because it introduces some restrictions in the choice of scheduling parameters and
>   because HD-FDD UEs are not commercially deployed, the feature is disabled by
>   default.

allow_cat0_ue

>   Optional boolean (default = false). If true, category 0 UEs (release 12) can connect
>   to the eNodeB. The corresponding SIB1 field is set and the scheduler takes the
>   category 0 UE scheduling restrictions into account.

edrx   Optional boolean (default = false). If true, extended idle mode DRX support is
>   activated in the cell, and Hyper System Frame Number value is scheduled in SIB1.

pdcch_order_prach

>   Optional enumeration (`none`, `cb_random`, `cf_given`, default = `none`). Defines
>   possibility to trigger a PDCCH order PRACH either with random preamble (ra-
>   PreambleIndex = 0), or dedicated contention-free preamble.
>   PDDCH order PRACH is currently not supported for BR UEs. PDCCH order
>   PRACH is triggered when a UE reaches `ul_max_consecutive_retx` or `dl_max_`
>   `consecutive_retx`, or via a call the `pdcch_order_prach` API or monitor command.

distributed_vrb

>   Optional boolean (default = false). If true, enable distributed VRB allocation for
>   PDSCH. It is supported only with transmission modes 1, 2, 5 or 6. It cannot be
>   used with BR UEs nor with in-band NB-IoT cells.

use_n_gap_2

>   Optional boolean (default = false). Force `n_gap_2` usage with distributed VRB
>   allocation. It is meaningful only if `distributed_vrb` is true and if `n_rb_dl >=` 50.

use_dci_1c

>   Optional boolean (default = false). Force the use of DCI 1C for SI information,
>   RAR and paging. It is allowed only if `distributed_vrb` is true.

pdsch_dedicated

>   Object. PDSCH dedicated configuration. Currently shared by all UEs. The follow-
>   ing properties are defined:

>   **p_a**   Optional enumeration: -6, -4.77, -3, -1.77, 0, 1, 2, 3. Set the `p_a`
>>   parameter which sets the PDSCH average power. The default value
>>   is set to 0 (resp. -3, -6) dB when `n_antenna_pbch` = 1 (resp. 2, 4).

p_b
: Optional integer. Range: -2 to 3 (default = -2). The special value -2 indicates to take the value from the SIB2 (legacy case). The special value -1 indicates to automatically set it depending on the number of contigured PBCH antennas.

dmrs
: Optional array of 2 integers. Range: 0 to 503. Specifies the DMRS scrambling identity when transmission mode 10 is used (release 11).

qcl_operation
: Optional enumeration: `typeA` or `typeB` (default = `typeB`). Select the PDSCH Quasi Co-Location parameter when transmission mode 10 is used (release 11). Note that this parameter does not modify the eNodeB behavior, it just changes the value of the corresponding RRC field.

tbs_index_alt
: Optional boolean (default = false). Enable TBS index 26A (64QAM) or 33A (256QAM/1024QAM) for DCI 2C/2D (TM9/10).

tbs_index_alt2
: Optional boolean (default = false). Enable TBS index 33B (256QAM/1024QAM) for DCI 1/1B/2/2A (TM0/1/2/3/4/6).

tbs_index_alt3
: Optional boolean (default = false). Enable TBS index 37A (1024QAM) for DCI 2C/2D (TM9/10).

pdcch_format
: Optional. Range: 0 to 3. If defined, force for number of CCEs for UE specific PDCCH to `2^pdcch_format`. Otherwise it is computed from the reported CQI.

initial_cqi
: Range: 1 to 15. This CQI value is assumed when none is received from the UE.

pucch_dedicated
: Optional object. PUCCH configuration.

cqi_pucch_n_rb
: Optional integer (default = -1). Number of resource blocks reserved for PUCCH 2 (periodic CQI). SIB2.nRB-CQI is automatically set from it. The special value -1 indicates to deduce `cqi_pucch_n_rb` from SIB2.nRB-CQI (legacy case).

n1_pucch_sr_count
: Optional integer (default = -1). Number of PUCCH 1 resources reserved for Scheduling Requests. They are mapped before the PUCCH 1 ack/nack resources. SIB2.n1PUCCH-AN is automatically computed from it. The special value -1 indicates to deduce `n1_pucch_sr_count` from SIB2.n1PUCCH-AN (legacy case).

tdd_ack_nack_feedback_mode
: (TDD only) Enumeration: `bundling` or `multiplexing`. Define the ACK/NACK feedback mode for TDD.

tdd_ack_nack_feedback_mode_r10
: (TDD only) Optional enumeration: `bundling`, `multiplexing`, `cs`, `pucch3`. Select the ACK/NACK feedback mode for release 10 TDD UE. `cs` means channel selection. By default it is set to `cs` if `tdd_ack_nack_feedback_mode` is set to `multiplexing` otherwise to `bundling`.

ack_nack_feedback_mode_ca
> Optional enumeration: `cs`, `pucch3`. Select the ACK/NACK feedback mode when two serving cells are enabled (carrier aggregation). When more than two serving cells are enabled, `pucch3` is always used.

ack_nack_r13
> Optional object to configure release 13 ACK NACK modes for CA, with the RRC IE PUCCH-ConfigDedicated-r13. If omitted, all the parameters are set to default, so release 13 configuration will be used when a UE has more than 5 serving cells. It contains the following parameters:

> n_scells_threshold
>> Optional integer (range: 2 to 6, default = 6). Number of serving cells at which release 13 ACK/NACK configuration is used.

> cbs_determination
>> Optional enumeration: `cc` or `dai` (default = `cc`). Sets the codebooksizeDetermination-r13 parameter.

> pucch_spatial_bundling
>> Optional boolean (default = true). Sets the spatialBundlingPUCCH-r13 parameter.

> pusch_spatial_bundling
>> Optional boolean (default = true). Sets the spatialBundlingPUSCH-r13 parameter.

n1_pucch_an_cs_count
> Optional integer (default = 0). Select the number of PUCCH 1 resources used for PUCCH 1B channel selection. It is only useful when `ack_nack_feedback_mode_ca` is set to `cs`. This value limits the number of UEs which can be scheduled in the same TTI while doing carrier aggregation.

n3_pucch_an_n_rb
> Optional integer (default = 0). Select the number of UL resources blocks reserved for PUCCH 3 signalling. It is only necessary if PUCCH 3 ACK/NACK feedback is selected for carrier aggregation or TDD.

n1_pucch_an_rep_count
> Optional integer (default = 0). Number of PUCCH 1 resources reserved for PUCCH ACK/NACK repetitions. If set to a non-zro value, `an_rep_ul_snr_threshold` and `an_rep_factor` are expected to configure the ACK/NACK repetition feature.

an_rep_ul_snr_threshold
> Optional float (range -6.0 to 40.0). Mandatory if `n1_pucch_an_rep_count` is set, ignored otherwise. UL SNR threshold below which an UE will be configured with PUCCH ACK/NACK repetition. The UL SNR is monitored only during the first instant of the RRC connection.

an_rep_factor
> Optional enumeration (2, 4 or 6). Mandatory if `n1_pucch_an_rep_count` is set, ignored otherwise. Repetition factor for ACK/NACK when ACK/NACK repetition is configured.

prach_detect_threshold
> Optional float. Set the PRACH SNR detection threshold in dB.

pucch1_sr_detect_threshold
> Optional float. SNR threshold in dB to filter Scheduling Request detection in PUCCH format 1/1A/1B.

pucch1_an_detect_threshold
> Optional float. SNR threshold in dB to filter HARQ ACK/NACK detection in PUCCH format 1/1A/1B.

pucch2_detect_threshold
> Optional float. SNR threshold in dB to filter PUCCH format 2/2A/2B.

pucch3_detect_threshold
> Optional float. SNR threshold in dB to filter PUCCH format 3.

pusch_dedicated
> Object. PUSCH dedicated configuration. Currently shared by all UEs. The following properties are defined:
>
> > **beta_offset_ack_index**
> > > Range: 0 to 15.
> >
> > **beta_offset_ri_index**
> > > Range: 0 to 12.
> >
> > **beta_offset_cqi_index**
> > > Range: 2 to 15.

pusch_msg3_delta_power
> Optional. Range: -6 to 8 (default = 0). Relative power for Msg3 (=CCCH RRC Connection Request) in dB. It is internally rounded to an even value.

pusch_hopping_offset
> Optional integer (default = -2). Set the value of SIB2.pusch-HoppingOffset. The special value -2 indicates to keep the value from the SIB2 (legacy case). The special value -1 indicates to compute it from the reserved PUCCH resources.

pusch_hopping_type
> Optional integer (default = 0). Range: 0 to 2. Use `0` for no PUSCH frequency hopping. `1` for hopping type 1, `2` for hopping type 2.

pusch_hopping_index
> Optional integer (default = 0). Select the hopping index transmitted in DCI 0. This parameter only matters for hopping type 1 with n_rb_ul >= 50.

pusch_msg3_mcs
> Range: 0 to 15. MCS for Msg3 (=CCCH RRC Connection Request).

pusch_mcs
> Integer or array of integers (range: -1 to 28). The length of the array must divide 10. Force the PUSCH MCS (test feature). If an array is provided, it provides the PUSCH MCS for each subframe. Use -1 not to force the MCS in a given subframe.

pusch_fixed_rb_alloc
> Optional boolean or array of booleans. The length of the array must divide 10. Force fixed PUSCH RB allocation in all or a selected set of subframes. If an array is provided, a value true at the index value i of the array indicates that a fixed PUSCH RB allocation is used in subframe number i.
>
> The parameters `pusch_fixed_rb_start` and `pusch_fixed_l_crb` are used for the fixed allocation. `pusch_fixed_l_crb` must be of the form `2^n1*3^n2*5^n3`.

PUSCH are allocated only if they don't overlap with PUCCH or PRACH, so care must be taken when defining the range. In some cases, PUSCH retranmissions may use other RBs.

pusch_fixed_rb_start

Optional integer or array of integers. The length of the array must divide 10. First RB for fixed PUSCH allocation. If an array is provided, it gives the first RB for each subframe (see pusch_fixed_rb_alloc).

For a cell configured for category M1 UEs, pusch_fixed_rb_start and pusch_fixed_l_crb give the allocation inside a narrow band (hence pusch_fixed_rb_start + pusch_fixed_l_crb <= 6).

pusch_fixed_l_crb

Optional integer or array of integers. The length of the array must divide 10. Number of consecutive RBs for fixed PUSCH allocation. If an array is provided, it gives the number of consecutive RBs for each subframe (see pusch_fixed_rb_alloc).

pusch_fixed_rb_forced

Optional boolean (default = false). If true, the eNodeB schedules the PUSCH with fixed RB allocation even if it collides with PUCCH/PRACH or another PUSCH.

pusch_multi_cluster

Optional boolean (default = false). If true, enable multi-cluster PUSCH resource allocation for the UEs supporting it (release 10). Note: this is a UE test feature, so the multi cluster allocation is not optimized by the scheduler.

pusch_max_mcs

Optional integer. Range: 0 to 28 (default = 28). CPU load limitation: maximum MCS allocated by the eNodeB for PUSCH. Smaller MCS give a smaller bitrate and a smaller CPU load. For LTE cells only.

pusch_max_its

Optional integer. Range 1 to 20 (default = 6). CPU load limitation: set the maximum number of iterations of the turbo decoder. A higher value gives a lower frame error rate but a higher CPU load. For LTE cells only.

force_adaptive_retransmission

Optional boolean (default = false). If set to true, the eNB will request a PUSCH retransmission using a DCI instead of PHICH.

force_full_bsr

Optional boolean (default = false). If true, the eNodeB considers the UE always indicates a full buffer size. Hence the UE is scheduled as often as possible for PUSCH transmission.

force_dl_schedule

Optional boolean (default = false). If true, the eNodeB considers there is always DL data waiting for transmission. Hence the UE is scheduled as often as possible for PDSCH transmission.

pdsch_mcs

Integer or array of integers (range: -1 to 28). The length of the array must divide 20. Force the PDSCH MCS (test feature). If an array is set, it provides the PDSCH MCS for each subframe. Use -1 not to force the MCS in a given subframe.

pdsch_mcs_from_cqi

Integer or array of 16 integers (range: -1 to 28). Force the PDSCH MCS (test feature).

If an array is set, it provides the PDSCH MCS according to the CQI reported by UE. Use -1 not to force the MCS for a given CQI.

pdsch_fixed_rb_alloc

Optional boolean or array of booleans. The length of the array must divide 20. Force fixed PDSCH RB allocation using the parameters `pdsch_fixed_rb_start` and `pdsch_fixed_l_crb`. If an array is provided, it selects the fixed PDSCH allocation for each subframe.

For a cell configured for category M1 UEs, fixed PDSCH RB allocation is only possible in subframes where the PDSCH MCS is fixed (see `pdsch_mcs`).

pdsch_fixed_rb_start

Optional integer or array of integers. The length of the array must divide 20. First RB for fixed PDSCH allocation (see `pdsch_fixed_rb_alloc`). If an array is provided, it provides the first RB for each subframe.

For a cell configured for category M1 UEs, `pdsch_fixed_rb_start` and `pdsch_fixed_l_crb` give the allocation inside a narrow band (hence `pdsch_fixed_rb_start + pdsch_fixed_l_crb <= 6`).

pdsch_fixed_l_crb

Optional integer or array of integers. The length of the array must divide 20. Number of consecutive RBs for fixed PDSCH allocation (see `pdsch_fixed_rb_alloc`). If an array is provided, it provides the consecutive RBs for each subframe.

sr_ignore_count

Optional integer. Indicates how many consecutive Scheduling Request are ignored by the eNB or gNB.

rach_ignore_count

Optional integer. Indicates how many consecutive RACH attempts are ignored by the eNB or gNB.

mac_crnti_ce_ignore_count

Optional integer. Indicates how many consecutive MAC C-RNTI control elements are ignored by the eNB or gNB.

dummy_ue_contention_resolution_id

Optional boolean. If set to true, a wrong MAC UE Contention Resolution Identity control element will be sent in the Msg4, rather than the one matching the UE Msg3 content.

rrc_procedure_filter

Optional object. Allows to define the eNB behavior for a list of RRC procedures. Each property name represents a RRC procedure. The ones currently supported are `rrc_connection_request`, `rrc_connection_reestablishment_request` and `scg_failure_information_nr`.

Each property value is an object containing the following fields:

action Enumeration (`treat` (UE message is processed), `ignore` (UE message is ignored) or `reject` (UE message is rejected))

ttl Optional integer. If set, the `reject` of `ignore` filter is applied `ttl` times. If not set, the filter is applied until it is modified.

By default all procedures are treated.

Example:

`rrc_procedure_filter: {`

```
        rrc_connection_request: {
            action: "treat"
        },
        rrc_connection_reestablishment_request: {
            action: "reject",
            ttl: 1
        }
    }
```

transmission_mode

Optional. Range: 1 to 6 (default = 1). Set the DL transmission mode (same for all UEs). The values of 1 and 2 are equivalent and automatically adjusted to 1 or 2 depending on the number of DL antennas. The corresponding transmission modes are:

Value	Description
1	Single antenna port.
2	Transmit diversity.
3	Large delay CDD.
4	Closed-loop spatial multiplexing.
5	Multi-user MIMO.
6	Closed-loop spatial multiplexing using single transmission layer.

Notes:

- Transmission modes 2 to 6 are only usable when `n_antenna_pbch >= 2` (more than one DL antenna).

- Transmission modes 3 and 4 need rank indicator reporting for proper operation (see the `m_ri` parameter).

- The current MAC scheduler does not schedule several UE at the same time when using transmission mode 5.

codebook_subset_restriction

Optional string. Bit string giving the allowed code book indexes for transmission modes 3, 4, 5, 6. The number of bits is given by TS.36 213 table 7.2-1b. The default value is all ones (i.e. all code book indexes are allowed).

transmission_mode_opt

Optional integer (default = 0). Range: 0 or 7 to 10. If the UE supports the indicated transmission mode, it is enabled with the first RRC connection reconfiguration. The value 0 is used to keep the initial transmission mode selected by `transmission_mode`. The available optional transmission modes are:

Value	Description
7	Antenna port 5 (UE specific, release 8).
8	Dual layers, antenna ports 7 and 8 (UE specific, release 9).
9	Up to 8 layers, antenna ports 7 to 14 (UE specific, release 10).
10	Up to 8 layers, antenna ports 7 to 14 (UE specific, CoMP, release 11).

The transmission modes 8, 9 and 10 require at least two DL antennas and need rank indicator reporting for proper operation (see the `m_ri` parameter). Moreover transmission modes 9 and 10 need a proper CSI-RS configuration.

codebook_subset_restriction_opt

Optional string. Bit string giving the allowed code book indexes for transmission modes 8, 9 or 10. The number of bits depends on the selected transmission mode and number of DL antennas:

Mode	Number of digits
tm8, 2 antennas:	6 bits
tm8, 4 antennas:	32 bits
tm9 or tm10, 2 antennas:	6 bits
tm9 or tm10, 4 antennas:	64 bits
tm9 or tm10, 8 antennas:	109 bits

n_scid Optional integer (default = 0). Range 0 to 1. Force the scrambling identifier when antenna ports 7 or 8 are used.

ue_specific_port

Optional integer (default = 7). Range 7 to 8. When single layer transmission is used with transmission mode 8, force the corresponding antenna port.

csi_rs_nzp

Optional object or array of objects. Specifies the Non-Zero Power Channel-State Information Reference Signals (CSI-RS) sent by the eNodeB for release 10 UEs. The following fields are defined:

period Enumeration: 5, 10, 20, 40, 80. Period (in ms) of the CSI-RS.

offset Range: 0 to period - 1. Offset (in ms) of the CSI-RS.

n_antenna

Integer: 1, 2, 4 or 8. Must be less than the number of DL antennas.

resource_config

Integer. Selected CSI-RS resource configuration. The exact range depends on the selected cyclic prefix and frame structure. See tables 6.10.5.2-1 and 6.10.5.2-2 from 3GPP TS 36.211.

scrambling_id

Optional integer (range: -1 to 503, default = -1). For release 11 UEs, specify the scrambling identity. -1 indicates to use n_id_cell.

p_c Range: -8 to 15. Relative power in dB compared to the cell specific reference signal.

When configuring transmission mode 10, a single CSI process is configured using the first NZP CSI-RS and the first CSI-IM. A single re-MappingQCLConfig is configured using the first ZP CSI-RS.

csi_rs_zp

Optional object or array of objects. Specifies the Zero Power Channel-State Information Reference Signals reserved by the eNodeB for release 10 UEs. The following fields are defined:

period Enumeration: 5, 10, 20, 40, 80. Period (in ms) of the CSI-RS ZP.

offset Range: 0 to period - 1. Offset (in ms) of the CSI-RS ZP.

resource_config_list

Range: 0 to 65535. Bit mask of the selected zero CSI-RS ZP configurations. The first configuration is in bit 15. The corresponding configurations are given in tables 6.10.5.2-1 and 6.10.5.2-2 from 3GPP TS 36.211 (column with 4 antennas).

csi_rs_im

> Optional object or array of objects. Specifies the Channel-State Information Reference Signals reserved by the eNodeB for Interference Measurement for release 11 UEs (CSI-RS IM). The following fields are defined:

> period   Enumeration: 5, 10, 20, 40, 80. Period (in ms) of the CSI-RS IM.

> offset   Range: 0 to period - 1. Offset (in ms) of the CSI-RS IM.

> resource_config

>> Integer. Selected CSI-RS IM resource configuration. The exact range depends on the selected cyclic prefix and frame structure. See tables 6.10.5.2-1 and 6.10.5.2-2 from 3GPP TS 36.211.

> The first CSI-RS IM must completely overlap with the first configured CSI-RS ZP.

dl_256qam

> Optional boolean (default = false). If true, allow 256QAM DL support for the UE supporting it (release 12).

ul_64qam   Optional boolean. If true, allow 64QAM UL support for the UE supporting it (release 12). The SIB2 is modified accordingly. If this property is not present, the values SIB2.enable64QAM and SIB2.enable64QAM-v1270 are used instead.

dl_1024qam

> Optional boolean (default = false). If true, allow 1024QAM DL support for the UE supporting it (release 15, UE DL category >= 20). If true, it also implicitely sets dl_256qam to true.

ul_256qam

> Optional boolean (default = false). If true, allow 256QAM UL support for the UE supporting it (release 14, UL category >= 16).

sr_period

> Enumeration: 5, 10, 20, 40, 80, 2, 1, 0. Scheduling Request period in ms. When allowing TypeA half-duplex UEs (i.e when half_duplex_ue is true and br_only is false), the value must be >= 40.
> For TypeB or Cat-M half-duplex UEs constraints, please refer to the parameter br_sr_period (See [Bandwidth Reduced parameters], page 93).
> The special value 0 means that no Scheduling Request resource is allocated hence the UE uses a PRACH instead.

forced_sr_offset

> Optional integer: range -1 to sr_period-1 (default = -1). Forces the scheduling request subframe offset sent to the UE. -1 means that the eNB allocates the value automatically.

dsr_trans_max

> Optional enumeration: 4, 8, 16, 32, 64 (default = 64). Set the dsr-TransMax parameter (maximum number of scheduling request transmissions).

cqi_period

> Optional enumeration: 2, 5, 10, 20, 40, 80, 160, 1, 32, 64, 128, 0 (default = 0). When allowing TypeA half-duplex UEs (i.e when half_duplex_ue is true and br_only is false), the value must be >= 32.
> For TypeB or Cat-M half-duplex UEs constraints, please refer to the parameter br_cqi_period (See [Bandwidth Reduced parameters], page 93).
> Value 0 indicates that periodic CQI reporting is disabled. Disabling both periodic and aperiodic CQI is not recommended unless radio conditions are known and forced_cqi/ri are set to suitable values.

m_ri   Optional enumeration: 0, 1, 2, 4, 8, 16, 32 (default = 0). If different from zero, Rank
                Indicator (RI) reporting is done every `m_ri` CQI/PMI reports. RI should only be
                used with transmission modes 3, 4, 8, 9 and 10.

subband_cqi_k
                Optional integer: 0, 1, 2, 3, 4 (default = 0). If different from zero, enables UE-
                selected subband CQI reporting and sets the value K for the number of cycles of
                subband reports between two wideband reports.

cqi_on_sf3_8
                Optional boolean (default = false). This parameter is used only for TDD cell with
                `uldl_config: 0`, and ignored otherwise. Allows to configure periodic CQI reporting
                on subframe 3 and subframe 8.

ap_cqi_period
                Optional integer (default = 0). Approximate period (in ms) for the aperiodic CQI
                reporting. 0 indicates that aperiodic CQI reporting is disabled. Disabling both
                periodic and aperiodic CQI is not recommended unless radio conditions are known
                and `forced_cqi/ri` are set to suitable values.

ap_cqi_rm
                Optional enumeration: rm12, rm20, rm22, rm30, rm31. Aperiodic CQI reporting
                mode when the transmission mode is less or equal to 6. Note: For BR UEs, the
                aperiodic CQI reporting mode will be forced to 'rm20' if aperiodic CQI reporting is
                enabled (`ap_cqi_period` $\neq 0$).

ap_cqi_rm_opt
                Optional enumeration: rm12, rm20, rm22, rm30, rm31. Aperiodic CQI reporting
                mode when the transmission mode is greater or equal to 7. Note: For BR UEs, the
                aperiodic CQI reporting mode will be forced to 'rm20' if aperiodic CQI reporting is
                enabled (`ap_cqi_period` $\neq 0$).

ap_cqi_trigger_list
                Optional array of array of integers. Allows to define up to 6 custom aperiodic CQI
                trigger. Each element is an array of serving cell indices. If absent, the eNB will
                group up to 4 serving cells per trigger.

simultaneousAckNackAndCQI
                Optional boolean (default = true). If true, enable simultaneous ACK/NACK and
                CQI reporting. With normal cyclic prefix, PUCCH format 2A/2B are used.

simultaneousAckNackAndCQI_format3
                Optional boolean (default = true). If true, enable simultaneous ACK/NACK and
                CQI reporting with PUCCH format 3 (release 11).

srs_dedicated
                Object. SRS configuration. Currently the same for all UEs except for
                `srs-ConfigIndex` and `freqDomainPosition` which are dynamically allocated for
                each UE. The following properties are defined:

                srs_bandwidth_config
                        Optional integer. Range: -1 to 7. Set the value of SIB2.srs-
                        BandwidthConfig. The special value -1 indicates to keep the value
                        from the SIB2 (legacy case).

                srs_subframe_config
                        Optional integer. Range: -1 to 15. Set the value of SIB2.srs-
                        SubframeConfig. The special value -1 indicates to keep the value from
                        the SIB2 (legacy case).

srs_period

>Enumeration: 2, 5, 10, 20, 40, 80, 160, 320. SRS period in ms. Currently
>when `half_duplex_ue` is true it must be `>= 40`.
>There is an additional constraint for TypeB or Cat-M half-duplex UEs,
>when SRS is enabled (`br_srs_enabled` set to `true`), similar to CQI
>or SR. Refer to `br_cqi_period` (See [Bandwidth Reduced parameters],
>page 93).

srs_bandwidth

>Range: 0 to 3. SRS bandwidth.

srs_hopping_bandwidth

>Range: 0 to 3. SRS hopping bandwidth.

srs_cyclic_shift

>Optional integer. Range: -1 to 7, default = -1. -1 indicates to choose a
>random per UE cyclic shift.

mac_config

>Object. MAC configuration. Currently the same for all UEs. The following prop-
>erties are defined:

ul_max_harq_tx

>Maximum number of HARQ transmissions for uplink.

dl_max_harq_tx

>Maximum number of HARQ transmissions for downlink.

ul_max_consecutive_retx

>Optional Integer (default = 30). Maximum number of UL retransmis-
>sions after which the UE is disconnected.

dl_max_consecutive_retx

>Optional Integer (default = 30). Maximum number of DL retransmis-
>sions after which the UE is disconnected.

time_alignment_tx_timer

>Optional integer from 0 to 10240 (default = 500). Transmit the UL
>time alignment information every `time_alignment_tx_timer` ms. The
>value 0 means infinity.

time_alignment_timer_dedicated

>Optional integer (default = 0). Time alignment timer dedicated. 0
>means infinity. Note: `time_alignment_tx_timer` must be used to set
>the UL time alignment transmission period.

periodic_bsr_timer

>Optional integer (default = 20). Periodic BSR timer value.

retx_bsr_timer

>Optional integer (default = 320). Retransmission BSR timer value.

periodic_phr_timer

>Optional integer (default = 500). Periodic PHR timer value.

prohibit_phr_timer

>Optional integer (default = 200). Prohibit PHR timer value.

dl_path_loss_change

Optional enumeration: `dB1`, `dB3`, `dB6`, `infinity` (default = `dB3`). DL path loss change value.

drx_config

Optional object. If present, configure the DRX parameters. The following properties are defined:

on_duration_timer

Range: 1 to 1600. DRX on duration timer (in PDCCH subframes). If the value is small, it may be necessary to disallow half duplex UE from connecting to the eNodeB (set `half_duplex_ue` to `false`) in order to relax the constraints on the allocation of SRS/CQI/SR.

drx_inactivity_timer

Range: 1 to 2560. DRX inactivity timer (in PDCCH subframes).

drx_retransmission_timer

Range: 1 to 320. DRX retransmission timer (in PDCCH subframes).

drx_ul_retransmission_timer

Optional. Range: 0 to 320. DRX UL retransmission timer (in PDCCH subframes) for BL/CE UEs.

long_drx_cycle

Range: 10 to 10240. Duration of the long DRX cycle (in subframes). Must be a multiple of `meas_gap_period`. Values 5120 and 10240 can only be used with UEs declaring the support of extended long DRX cycles. For UEs not declaring the support, value 2560 will be used instead.

short_drx_cycle

Optional. Range: 2 to 640. If present, configuration the duration of the short DRX cycle (in subframes). `long_drx_cycle` must be a multiple of `short_drx_cycle`.

drx_short_cycle_timer

Optional. Range: 1 to 16. If the short DRX cycle is configured, set the short DRX cycle timer.

forced_drx_start_offset

Optional integer (range -1 to long_drx_cycle, default = -1). If set to a positive value, it will force the DRX start offset of all the UEs. Beware that forcing the setting may no longer be compliant with other contraints like gap offset.

data_inactivity_timer

Optional integer (default = 0). Value in seconds of the data inactivity monitoring timer. 0 means that the timer is deactivated.

sr_prohibit_timer

Optional integer. Timer in number of SR periods used to delay the transmission of a Scheduling Request.

logical_channel_sr_prohibit_timer

Optional integer (default = 0). Timer in number of subframes used to delay the transmission of a Scheduling Request for logical channels

enabled by the `logicalChannelSR_Prohibit` parameter in `drb_config` object. 0 means that the timer is deactivated.

rai_support

Optional boolean (default = false). Activates MAC release assistance indication feature in the eNB. It will not be used if `rai_enh_support` is set and the UE supports R16 MAC rai-ActivationEnh feature.

rai_enh_support

Optional boolean (default = false). Activates R16 MAC rai-ActivationEnh feature in the eNB.

tti_bundling

Optional object. If present, configure the TTI bundling parameters. Since TTI bundling is a deep change in the MAC layer, the configuration/deconfiguration of TTI bundling is performed via an intra-cell handover. The following properties are defined:

snr_threshold

Float. Range: -6 to 40 dB. UL SNR value in dB (measured on PUSCH and SRS) below which TTI bundling will be configured.

phr_threshold

Optional float. Range: 0 to 40 dB (default 0 dB). UL PHR value (in dB for 1 RB allocation) below which TTI bundling will be configured. This condition is OR'ed with the `snr_threshold` trigger.

hysteresis

Optional float. Range 1 to 20 dB (default 6 dB). Hysteresis value to add to `snr_threshold` and `phr_threshold` when checking conditions to deconfigure TTI bundling.
TTI bundling is deconfigured when SNR is above `snr_threshold + hysteresis` AND PHR is above `phr_threshold + hysteresis`.

mcs_max   Optional integer. Range 0 to 10 (default 10). Maximum MCS of PUSCH allocation with TTI bundling.

l_crb_max

Optional integer. Range 1 to UL BW (default 6). Maximum number of RBs of PUSCH allocation with TTI bundling. If the UE does not support noResourceRestrictionForTTIBundling-r12, PUSCH allocation is limited to 3 RBs anyway.

e_harq_pattern

Optional boolean (default = false). FDD only. If set and if the UE supports e-HARQ-Pattern-FDD-r12, eNB configures the e-HARQ-Pattern-r12 parameter along with TTI bundling.

skip_uplink_tx_dynamic_support

Optional boolean (default = false). Activates R14 MAC skipUplinkTx-Dynamic feature in the eNB.

`skip_uplink_tx_sps_support`
> Optional boolean (default = false). Activates R14 MAC skipUplink-TxSPS feature in the eNB.

`sps`   Optional object. Contains the SPS configuration of the cell, currently the same for all UEs. SPS will be configured on the UE depending on the established radio bearers, see [DRB configuration], page 98. It contains the following properties:

> `dl`   Optional object. Defines the SPS DL configuration. It contains the following fields:
>
>> `rb_start`   Integer. PDSCH allocation starting position in number RBs.
>>
>> `l_crb`   Integer (range 1 to 6). PDSCH allocation length in number of RBs, limited to 6 RBs. SPS DL allocation uses a localized type2 PDSCH allocation. If the cell has a BR configuration, the SPS allocation shall be contained in one of the BR narrowband.
>>
>> `mcs`   Integer (range 0 to 15). MCS of the PDSCH allocation.
>>
>> `sched_interval`
>>> Enumeration (10, 20, 32, 40, 64, 80, 128, 160, 320, 640). SPS scheduling interval semiPersistSchedIntervalDL in subframes. In TDD, the value should be a multiple of 10 ms.
>
> `ul`   Optional object. Defines the SPS UL configuration. It contains the following fields:
>
>> `rb_start`   Integer. PUSCH grant starting position in number RBs.
>>
>> `l_crb`   Integer (range 1 to 6). PUSCH grant length in number of RBs, limited to 6 RBs. SPS UL allocation uses a type0 PUSCH allocation without hopping.
>>
>> `mcs`   Integer (range 0 to 15). MCS of the PUSCH grant.
>>
>> `sched_interval`
>>> Enumeration (10, 20, 32, 40, 64, 80, 128, 160, 320, 640, 1, 2, 3, 4, 5). SPS scheduling interval semiPersistSchedIntervalUL in subframes. In TDD, values 32, 64 and 128 are not supported.
>>
>> `implicit_release_after`
>>> Enumeration (2, 3, 4, 8). Number of empty SPS UL transmission before implicit release of the SPS UL grant, see implicitReleaseAfter in 3GPP TS 36.331.
>>
>> `skip_uplink_tx_snr_threshold`
>>> Optional float (default = -8.0). SNR threshold on the PUSCH for skip uplink detection on a SPS grant when `skip_uplink_tx_sps_support` is set to true. If the received signal is below the threshold, the grant is considered skipped by the UE and will not be requested for retransmission.

`cyclic_shift_dci`
> Optional. Range: 0 to 7 (default = 0). Set the DCI 0 cyclic_shift_dci parameter.

dpc   Optional boolean (default = false). Enable dynamic UE power control.

dpc_pusch_snr_target
            Optional float. Must be present if dpc is true. Set the PUSCH SNR target for the
            dynamic UE power control.

dpc_pusch_p_max
            Optional float (default = -15). Set the PUSCH maximum power in dBFS for the dy-
            namic power control. The corresponding maximum EPRE is computed by dividing
            it by the number of subcarriers.

dpc_pusch_epre_max
            Optional float. Set the PUSCH maximum EPRE in dBFS for the dynamic power
            control. If not present, dpc_pusch_p_max is used instead. See rx_epre_in_dbfs if
            you want to display the EPRE in dBFS instead of dBm in the logs.

dpc_pucch_snr_target
            Optional float. Must be present if dpc is true. Set the PUCCH SNR target for the
            dynamic UE power control.

dpc_pucch_p_max
            Optional float (default = -15). Set the PUCCH maximum power in dBFS for the dy-
            namic power control. The corresponding maximum EPRE is computed by dividing
            it by the number of subcarriers.

dpc_pucch_epre_max
            Optional float. Set the PUCCH maximum EPRE in dBFS for the dynamic power
            control. If not present, dpc_pucch_p_max is used instead. See rx_epre_in_dbfs if
            you want to display the EPRE in dBFS instead of dBm in the logs.

p_srs_offset
            Optional. Range 0 to 15 (default = 3). SRS power offset. The configured value is
            -10.5 + 1.5 * p_srs_offset dB.

pusch_dtx_snr_threshold
            Optional float (default = -8.0). SNR threshold on the PUSCH for DTX detection
            on a dynamic grant. When skip_uplink_tx_dynamic_support is set to true, if the
            received signal is below the threshold the grant is considered skipped by the UE and
            will not be requested for retransmission. Otherwise if the received signal is below
            the threshold, the eNB will request an adaptive retransmission using redundancy
            version 0.

snr_to_mcs_offset
            Optional float. This offset is added to the estimated uplink SNR to compute the
            PUSCH MCS. The default value depends on the eNodeB configuration.

ul_snr_adapt_fer
            Optional float (default = 0.1). This value defines the UL PER targeted by the eNB
            link adaptation algorithm. By default it applies an error rate of 10% for the initial
            HARQ transmission.

ul_snr_adapt_amp
            Optional float (default = 10). This values defines the maximum amplitude (in dB
            units) of the correction applied on top of the MCS selected from the UL SNR.

ul_snr_adapt_retx
            Optional float (default = 0.3). This value defines the correction step applied by the
            HARQ initial transmission decoding result within the ul_snr_adapt_amp range.

phr_link_adaptation

> Optional boolean (default = true). If set to true, the eNB will lower the UL MCS and/or resource blocks allocation if the UE sends negative MAC power headroom reports indicating it is power limited. If set to false, the power headroom value is not taken into account for the UL link adaptation mecanism.

cqi_adapt_fer

> Optional float (default = 0.1). This value defines the DL PER targeted by the eNB link adaptation algorithm. By default it applies an error rate of 10% for the initial HARQ transmission.

cqi_adapt_amp

> Optional float (default = 2). This values defines the maximum amplitude (in CQI units) of the correction applied on top of the MCS selected from the CQI report.

cqi_adapt_retx

> Optional float (default = 0.3). This value defines the correction step applied by the HARQ initial transmission decoding result within the `cqi_adapt_amp` range.

ri_adapt Optional boolean (default = false). Allows the link adaption algorithm to also apply a correction on the reported rank (RI) to schedule more or less layers than the UE reports.
> When enabled, the `cqi_adapt_amp` parameter has additional constraint and must be withing the [4, 8] range.

cipher_algo_pref

> Array of integers. Set the preferred algorithms for RRC and User Plane encryption in decreasing order of preference. If none match the UE capabilities, then EEA0 (no encryption) is selected.
>
> List of supported algorithms:

> | Value | Algorithm |
> |-------|-----------|
> | 1 | EEA1 (Snow 3G) |
> | 2 | EEA2 (128 bit AES) |
> | 3 | EEA3 (ZUC) |

> If encryption is necessary, for best performance use AES (EEA2) as first choice if your CPU supports the AES NI Intel instruction set (use the `hwcaps` monitor command and see if AES is displayed). Otherwise use Snow3G (EEA1) or ZUC (EEA3).

cipher_algo_null_allowed

> Optional boolean (default = true). If set to false, the use of NULL ciphering algorithm (EEA0) is forbidden unless the UE performs an emergency registration.

integ_algo_pref

> Array of integers. Set the preferred algorithms for RRC integrity check in decreasing order of preference. If none match the UE capabilities, then EIA0 (no integrity check) is selected.
>
> List of supported algorithms:

> | Value | Algorithm |
> |-------|-----------|
> | 1 | EIA1 (Snow 3G) |
> | 2 | EIA2 (128 bit AES) |
> | 3 | EIA3 (ZUC) |

For best performance, use AES (EIA2) as first choice if your CPU supports the AES NI Intel instruction set (use the `hwcaps` monitor command and see if AES is displayed). Otherwise use Snow3G (EIA1) or ZUC (EIA3).

`integ_algo_null_allowed`

Optional boolean (default = true). If set to false, the use of NULL integrity algorithm (EIA0) is forbidden unless the UE performs an emergency registration.

`inactivity_timer`

Integer. Send RRC connection release after this time (in ms) of network inactivity. Note that it is only used for the UE PCell.

`srb_config`

Optional array of objects. Allows to override some parameters of the default configuration specified in 3GPP TS 36.331 chapter 9.2.1. If unset, the eNB will already change maxRetxThreshold value to 32, t-Reordering value to 45 ms and t-PollRetransmit to 60 ms.

Each object contains the following fields:

`id`   Integer: 1 or 2. Contains the SRB identity.

`t_PollRetransmit`

Optional enumeration: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 2000, 4000 (default 60). t-PollRetransmit timer value in ms.

`pollPDU`   Enumeration: 4, 8, 16, 32, 64, 128, 256, 0 (default 0). pollPDU value. 0 means infinity.

`pollByte`   Enumeration: 25, 50, 75, 100, 125, 250, 375, 500, 750, 1000, 1250, 1500, 2000, 3000, 0 (default 0). pollByte value in kBytes. 0 means infinity.

`maxRetxThreshold`

Optional enumeration: 1, 2, 3, 4, 6, 8, 16, 32 (default 32). maxRetxThreshold value.

`t_Reordering`

Optional enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 1600 (default 45). t-Reordering timer value in ms.

`t_StatusProhibit`

Enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 1200, 1600, 2000, 2400 (default 0). t_StatusProhibit timer value in ms.

`drb_config`

String or Array. Array of objects containing the DRB configuration for each QCI value. If a string is given, the array is read from the corresponding filename. See [DRB configuration], page 98.

`unsupported_qci_fallback`

Optional boolean (default = true). If set to true and if the core network requests the establishment of an unsupported QCI value, the parameters from QCI 9 are used instead. Otherwise the establishment is rejected.

meas_config

>   Optional [ASN.1 property], page 29. ASN.1 content of the `measConfig` field of the
>   `RRCConnectionReconfiguration` message (see 3GPP TS 36.331). It is used to set
>   the parameters of the RRC measurements (not including the measGapConfig IE
>   that must be configured using the `meas_gap_config` object). If it is absent and if
>   `meas_config_desc` optional object is absent, no `measConfig` field is transmitted to
>   the UEs.
>
>   The object can optionally contain a `meas_report_action` array to define an ac-
>   tion when receiving a measurement report for an event trigger. An empty array is
>   allowed to ensure no action is performed. If the array is not defined, a handover
>   action is automatically defined for A3 and A5 events, and an en_dc_setup action is
>   automatically defined for B1-NR events.
>
>>   **meas_report_action**
>>
>>>   Optional array. Each object has the following fields:
>>>
>>>>   **report_config_id**
>>>>
>>>>>   Optional integer (range 1 to 32). Defines the reportConfigId
>>>>>   associated with the action. Must be present if `meas_id` is
>>>>>   absent.
>>>>
>>>>   **meas_id**   Optional integer (range 1 to 64). Defines the measId associ-
>>>>   ated with the action. Must be present if `report_config_id`
>>>>   is absent.
>>>>
>>>>   **action**   Optional   enumeration   (handover,   cell_redirect,
>>>>   en_dc_setup). Defines the action triggered when receiving
>>>>   the measurement report.

meas_config_desc

>   Optional object. If present, and if `meas_config` object is not present, the eNB will
>   dynamically build the measurement configuration sent to the UE based on the
>   content of this object and the list of neighbour cells defined in `ncell_list` object.
>   It will create A1 and A2 events for the serving cell (if inter frequencies neighbour
>   cells exist, or if intra frequency neighbour cells exist for a BR UE), and optionally
>   an A3 or A4 or A5 event for each neighbour frequencies. At the beginning, gaps
>   are not activated. When A2 event report is received and if `meas_gap_config` is
>   set to gp0 or gp1, gaps are activated. When A1 event report is received, gaps are
>   released.
>
>   If `eutra_interference_intra` is present, an A3 event is defined for interference
>   management pupose.
>
>   If `eutra_handover`, `eutra_handover_intra` or `eutra_handover_inter` are
>   present, an A3 or A4 or A5 event is defined for handover purpose.
>
>   If `eutra_cell_redirect`, `eutra_cell_redirect_intra` or `eutra_cell_`
>   `redirect_inter` are present, an A3 or A4 or A5 event is defined for cell redirection
>   purpose.
>
>   If `scell_config` is present with A2/A4 events and if some cells are defined in
>   `scell_list` with `rrc_configuration=measurement` (see [scell_list], page 85), the
>   eNB will also define A2 and A4 events respectively for SCell release and addition
>   and gaps will always be activated.
>
>   If `scell_config` is present with an A6 event and if some cells are defined in
>   `scell_list` with `a6_candidates` (see [scell_list], page 85), the eNB will also define
>   an A6 event for SCell handover.
>
>   If `eutra_periodical` is present, a periodical measurement report is defined for the
>   EUTRA primary cell, and optionally inter frequency neighbor cells.

If NR cells are defined in the `ncell_list` array, inter RAT B1 and B2 events can be defined to trigger a cell redirection during the RRC connection release procedure when `nr_cell_redirect` is set, or a handover when `nr_handover` is set. If `nr_periodical` is present, a periodical measurement report is defined for each NR cell defined in `ncell_list` or `en_dc_scg_cell_list` objects.

This object contains the following fields:

`a1_report_type`
> Enumeration, rsrp or rsrq. Defines the measurement type requested for the A1 report.

`a1_rsrp`   Integer, range from -140 to -43. RSRP threshold value in dBm. Used if `a1_report_type` is set to rsrp.

`a1_rsrq`   Integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. Used if `a1_report_type` is set to rsrq.

`a1_hysteresis`
> Integer, range from 0 to 30. A1 hysteresis in 0.5dB steps used for the measurement report triggering condition.

`a1_time_to_trigger`
> Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A1 event condition must be met before triggering the measurement report.

`a2_report_type`
> Enumeration, rsrp or rsrq. Defines the measurement type requested for the A2 report.

`a2_rsrp`   Integer, range from -140 to -43. RSRP threshold value in dBm. Used if `a2_report_type` is set to rsrp.

`a2_rsrq`   Integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. Used if `a2_report_type` is set to rsrq.

`a2_hysteresis`
> Integer, range from 0 to 30. A2 hysteresis in 0.5dB steps used for the measurement report triggering condition.

`a2_time_to_trigger`
> Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A2 event condition must be met before triggering the measurement report.

`eutra_interference_intra`
> Optional object used to describe the A3 event reporting criteria for ICIC. It is only used when FFR is activated in DL or UL. For further information about ICIC, please refer to [icic], page 44. It contains the following fields:
>
> > `a3_offset`
> > > Integer, range from -30 to 30. A3 offset in 0.5dB steps used for the measurement report triggering condition.
> >
> > `hysteresis`
> > > Integer, range from 0 to 30. A3 hysteresis in 0.5dB steps used for the measurement report triggering condition.

time_to_trigger

>>Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A3 event condition must be met before triggering the measurement report.

eutra_handover

>Optional object used to describe the A3, A4 or A5 reporting criteria for intra and inter frequency handover. If `eutra_handover_intra` or `eutra_handover_inter` objects are present, it is ignored. It contains the following fields:

a3_report_type

>>Optional enumeration, rsrp or rsrq. Defines the measurement type requested for the A3 report. If set, `a4_threshold_rsrp`, `a4_threshold_rsrq`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold2_rsrp` and `a5_threshold2_rsrq` are ignored.

a3_offset

>>Optional integer, range from -30 to 30. A3 offset in 0.5dB steps used for the measurement report triggering condition. Must be present if `a3_report_type` is set.

a4_threshold_rsrp

>>Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrq`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold2_rsrp` and `a5_threshold2_rsrq` are ignored.

a4_threshold_rsrq

>>Optional integer, from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold2_rsrp` and `a5_threshold2_rsrq` are ignored.

a5_threshold1_rsrp

>>Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold1_rsrq` are ignored.

a5_threshold1_rsrq

>>Optional integer, from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold1_rsrp` are ignored.

a5_threshold2_rsrp

>>Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold2_rsrq` are ignored.

a5_threshold2_rsrq

>>> Optional integer, from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold2_rsrp` are ignored.

hysteresis

>>> Integer, range from 0 to 30. A3/A4/A5 hysteresis in 0.5dB steps used for the measurement report triggering condition.

time_to_trigger

>>> Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A3/A4/A5 event condition must be met before triggering the measurement report.

force_meas_id_on_pcell_earfcn

>>> Optional boolean (default = false). Forces an A3 measurement identity for the primary cell even if no neighbour intra frequency cells are declared in `ncell_list` object.

eutra_handover_intra

>> Optional object used to describe the A3, A4 or A5 reporting criteria for intra frequency handover. It contains the same fields as `eutra_handover` object. See [eutra_handover], page 72,

eutra_handover_inter

>> Optional object used to describe the A3, A4 or A5 reporting criteria for inter frequency handover. It contains the same fields as `eutra_handover` object. See [eutra_handover], page 72,

eutra_cell_redirect

>> Optional object used to describe the A3, A4 or A5 reporting criteria for intra and inter frequency cell redirection. If `eutra_cell_redirect_intra` or `eutra_cell_redirect_inter` objects are present, it is ignored. It contains the following fields:

a3_report_type

>>> Optional enumeration, rsrp or rsrq. Defines the measurement type requested for the A3 report. If set, `a4_threshold_rsrp`, `a4_threshold_rsrq`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold2_rsrp` and `a5_threshold2_rsrq` are ignored.

a3_offset

>>> Optional integer, range from -30 to 30. A3 offset in 0.5dB steps used for the measurement report triggering condition. Must be present if `a3_report_type` is set.

a4_threshold_rsrp

>>> Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrq`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold2_rsrp` and `a5_threshold2_rsrq` are ignored.

a4_threshold_rsrq

>Optional integer, from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold2_rsrp` and `a5_threshold2_rsrq` are ignored.

a5_threshold1_rsrp

>Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold1_rsrq` are ignored.

a5_threshold1_rsrq

>Optional integer, from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold1_rsrp` are ignored.

a5_threshold2_rsrp

>Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold2_rsrq` are ignored.

a5_threshold2_rsrq

>Optional integer, from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a5_threshold2_rsrp` are ignored.

hysteresis

>Integer, range from 0 to 30. A3/A4/A5 hysteresis in 0.5dB steps used for the measurement report triggering condition. is set.

time_to_trigger

>Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A3/A4/A5 event condition must be met before triggering the measurement report.

eutra_cell_redirect_intra

>Optional object used to describe the A3, A4 or A5 reporting criteria for intra frequency cell redirection. It contains the same fields as `eutra_cell_redirect` object. See [eutra_cell_redirect], page 73,

eutra_cell_redirect_inter

>Optional object used to describe the A3, A4 or A5 reporting criteria for inter frequency cell redirection. It contains the same fields as `eutra_cell_redirect` object. See [eutra_cell_redirect], page 73,

scell_config

>Optional object used to describe the A2, A4 and A6 reporting criteria for SCell release/addition and handover. It contains the following fields:

a2_report_type

>Optional enumeration, rsrp or rsrq. Defines the measurement type requested for the A2 report. Must be present if `a4_report_type` is set.

a2_rsrp   Optional integer, range from -140 to -43. RSRP threshold value in dBm. Used if `a2_report_type` is set to rsrp.

a2_rsrq   Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. Used if `a2_report_type` is set to rsrq.

a2_hysteresis

>Optional integer, range from 0 to 30. A2 hysteresis in 0.5dB steps used for the measurement report triggering condition. Must be present if `a2_report_type` is set.

a2_time_to_trigger

>Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A2 event condition must be met before triggering the measurement report. Must be present if `a2_report_type` is set.

a4_report_type

>Optional enumeration, rsrp or rsrq. Defines the measurement type requested for the A4 report.

a4_rsrp   Optional integer, range from -140 to -43. RSRP threshold value in dBm. Used if `a4_report_type` is set to rsrp.

a4_rsrq   Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. Used if `a4_report_type` is set to rsrq.

a4_hysteresis

>Optional integer, range from 0 to 30. A4 hysteresis in 0.5dB steps used for the measurement report triggering condition. Must be present if `a4_report_type` is set.

a4_time_to_trigger

>Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A4 event condition must be met before triggering the measurement report. Must be present if `a4_report_type` is set.

gaps_required

>Optional boolean (default = true). If set to true, the eNB will activate measurement gaps if there is at least one cell with measurement-based scell addition in `scell_list`.

a6_report_type

>Optional enumeration, rsrp or rsrq. Defines the measurement type requested for the A6 report.

a6_offset

>Optional integer, range from -30 to 30. A6 offset in 0.5dB steps used for the measurement report triggering condition. Must be present if `a6_report_type` is set.

a6_hysteresis

>Optional integer, range from 0 to 30. A6 hysteresis in 0.5dB steps used for the measurement report triggering condition. Must be present if `a6_report_type` is set.

a6_time_to_trigger

>Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A6 event condition must be met before triggering the measurement report. Must be present if `a6_report_type` is set.

eutra_periodical

>Optional object used to describe an EUTRA periodical measurement report. It contains the following fields:

>trigger_quantity

>>Enumeration: rsrp, rsrq. Quantity triggering the report.

>report_quantity

>>Enumeration: same, both. Reporting quantity.

>max_report_cells

>>Integer (range 1 to 8). Maximum number of cells reported.

>report_interval

>>Enumeration: ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240, min1, min6, min12, min30, min60. Interval between each measurement report.

>report_amount

>>Enumeration: 1, 2, 4, 8, 16, 32, 64, infinity. Number of measurement reports.

>measure_neighbor_cells

>>Boolean. Defines if a measurement report must be configured for inter frequency neighbor cells on top of the primary cell.

rsrp_filter_coeff

>Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19 (default = 4). Coefficient used for the RSRP layer 3 filtering done in RRC (see 3GPP TS 36.331 chapter 5.5.3.2 for details).

rsrq_filter_coeff

>Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19 (default = 4). Coefficient used for the RSRQ layer 3 filtering done in RRC (see 3GPP TS 36.331 chapter 5.5.3.2 for details).

s_measure

>Optional integer (range -140 to -43). Defines the s-Measure threshold in dBm.

en_dc_setup

>Optional object. If set, it defines a B1 event to trigger EN-DC activation. It contains the following fields:

>b1_report_type

>>Optional enumeration: rsrp, rsrq, sinr. Defines the measurement type requested for the NR B1 report used to activate EN-DC.

b1_rsrp   Optional integer, range from -156 to -30. RSRP threshold value in dBm. Used if `b1_report_type` is set to rsrp.

b1_rsrq   Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. Used if `b1_report_type` is set to rsrq.

b1_sinr   Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps. Used if `b1_report_type` is set to sinr.

b1_hysteresis

Optional integer, range from 0 to 30. NR B1 hysteresis in 0.5dB steps used for the measurement report triggering condition. Must be present if `b1_report_type` is present.

b1_time_to_trigger

Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the NR B1 event condition must be met before triggering the measurement report. Must be present if `b1_report_type` is present.

nr_cell_redirect

Optional object. If set, it defines a B1 or B2 event for NR cell redirection procedure. It contains the following fields:

b1_threshold_rsrp

Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `b1_threshold_rsrq`, `b1_threshold_sinr`, `b2_threshold1_rsrp` and `b2_threshold1_rsrq` are ignored.

b1_threshold_rsrq

Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `b1_threshold_sinr`, `b2_threshold1_rsrp` and `b2_threshold1_rsrq` are ignored.

b1_threshold_sinr

Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps. If set, `b2_threshold1_rsrp` and `b2_threshold1_rsrq` are ignored.

b2_threshold1_rsrp

Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `b2_threshold1_rsrq` is ignored.

b2_threshold1_rsrq

Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps.

b2_threshold2_rsrp

Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `b2_threshold2_rsrq` and `b2_threshold2_sinr` are ignored.

b2_threshold2_rsrq

Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `b2_threshold2_sinr` is ignored.

b2_threshold2_sinr

> Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps.

hysteresis

> Integer, range from 0 to 30. NR B1 or B2 hysteresis in 0.5dB steps.

time_to_trigger

> Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the NR B1 or B2 event condition must be met before triggering the measurement report.

allowed_with_ims_dedicated_bearer

> Optional enum (auto, yes, no, default = auto). If set to no, the RRC measurement report is ignored and no NR cell redirection is triggered if a VoLTE call is ongoing (at least one DRB is established with a CQI having `ims_dedicated_bearer` set to true). If set to auto, the behavior depends on whether the UE declares ims-VoiceOverNR-FR1-r15 or ims-VoiceOverNR-FR2-r15 support in its EUTRA inter RAT capabilities.

nr_handover

> Optional object. If set, it defines a B1 or B2 event for NR handover procedure. It contains the following fields:

b1_threshold_rsrp

> Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `b1_threshold_rsrq`, `b1_threshold_sinr`, `b2_threshold1_rsrp` and `b2_threshold1_rsrq` are ignored.

b1_threshold_rsrq

> Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `b1_threshold_sinr`, `b2_threshold1_rsrp` and `b2_threshold1_rsrq` are ignored.

b1_threshold_sinr

> Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps. If set, `b2_threshold1_rsrp` and `b2_threshold1_rsrq` are ignored.

b2_threshold1_rsrp

> Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `b2_threshold1_rsrq` is ignored.

b2_threshold1_rsrq

> Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps.

b2_threshold2_rsrp

> Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `b2_threshold2_rsrq` and `b2_threshold2_sinr` are ignored.

b2_threshold2_rsrq

>Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `b2_threshold2_sinr` is ignored.

b2_threshold2_sinr

>Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps.

hysteresis

>Integer, range from 0 to 30. NR B1 or B2 hysteresis in 0.5dB steps.

time_to_trigger

>Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the NR B1 or B2 event condition must be met before triggering the measurement report.

allowed_with_ims_dedicated_bearer

>Optional enum (auto, yes, no, default = auto). If set to no, the RRC measurement report is ignored and no NR handover is triggered if a VoLTE call is ongoing (at least one DRB is established with a CQI having `ims_dedicated_bearer` set to true). If set to auto, the behavior depends on whether the UE declares ims-VoiceOverNR-FR1-r15 or ims-VoiceOverNR-FR2-r15 support in its EUTRA inter RAT capabilities.

nr_periodical

>Optional object used to describe a NR periodical measurement report. It contains the following fields:

report_quantity_ss_rsrp

>Boolean. Report SS-RSRP quantity.

report_quantity_ss_rsrq

>Boolean. Report SS-RSRQ quantity.

report_quantity_ss_sinr

>Boolean. Report SS-SINR quantity.

max_report_cells

>Integer (range 1 to 8). Maximum number of cells reported.

report_interval

>Enumeration: ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240, min1, min6, min12, min30, min60. Interval between each measurement report.

report_amount

>Enumeration: 1, 2, 4, 8, 16, 32, 64, infinity. Number of measurement reports.

nr_rsrp_filter_coeff

>Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13,15, 17 or 19 (default = 4). Coefficient used for the RSRP layer 3 filtering done in RRC for NR cells (see 3GPP TS 36.331 chapter 5.5.3.2 for details).

nr_rsrq_filter_coeff

>Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13,15, 17 or 19 (default = 4). Coefficient used for the RSRQ layer 3 filtering done in RRC for NR cells (see 3GPP TS 36.331 chapter 5.5.3.2 for details).

nr_sinr_filter_coeff

>Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13,15, 17 or 19 (default = 4). Coefficient used for the SINR layer 3 filtering done in RRC for NR cells (see 3GPP TS 36.331 chapter 5.5.3.2 for details).

nr_need_for_gaps

>Optional enumeration: auto, yes, no (default = auto). If set to auto, gaps are required depending on the EUTRA bandInfoNR-v1610 RRC capability. If set to yes, gaps are always required for NR mobility and EN-DC activation. If set to false, gaps are never required for NR mobility and EN-DC activation.

meas_gap_config

>Optional enumeration: none, gp0, gp1 (default = none). Configuration of the measurement gap.
>For Cat-M UEs in HD-FDD, it is recommended to use a period bigger than (`2*br_mpdcch_n_rep` + `br_pdsch_n_rep` + 3). See also the limitations on parameters `br_cqi_period` and `br_sr_period` (See [Bandwidth Reduced parameters], page 93).

forced_meas_gap_offset

>Optional integer. Forces the gap offset sent to the UE in the MeasGapConfig ASN.1 object. -1 means that the eNB allocates the value automatically.

br_meas_gap_sharing_config

>Optional integer (range: -1 to 3, default = -1). Sets the measurement gap sharing scheme sent to a BR UE in the measurement configuration when gaps are configured. -1 means that the measGapSharingConfig parameter is not present in the MeasConfig object.

ho_from_meas

>Optional boolean (default = true). If true, when `meas_config` is used the eNodeB triggers a handover when a measurement event with `action` set to "handover" is received from the UE; when `meas_config_desc` is used the eNodeB triggers a handover when the event defined in `eutra_handover`, `eutra_handover_intra`, `eutra_handover_inter` or `nr_handover` is reported.

ho_cfra   Optional boolean (default = false). If true, any handover towards this cell will use contention-free random access if there is a contention-free preamble still available. It is not used for Cat-M UEs.

ho_force_full_config

>Optional boolean (default = false). If true, any handover towards this cell will use full configuration.

ho_continue_rohc_context

>Optional boolean (default = false). If true, and if the UE supports the feature, the RoHC contexts are not reset during an intra eNB or ng-eNB handover towards this cell.

t304   Enumeration: 50, 100, 150, 200, 500, 1000, 2000 (default = 1000). T304 timer for handover.

sib1_delivery_during_ho
> Optional boolean (default = false). If set to true, the target cell SIB1 is sent in the RRC connection reconfiguration with mobilityControlInfo message. Note that it is always sent for Cat-M UEs.

pws_max_segment_len
> Optional integer (default = 32). Set the maximum CMAS/ETWS message segment length in bytes, including the WarningAreaCoordinate segment if any. It is needed in order to limit the size of the corresponding SIB messages.

pws_si_periodicity
> Enumeration: 8, 16, 32, 64, 128, 256, 512 (default = 16). Set the periodicity (in frames) of the transmission of the CMAS/ETWS SIB messages.

pws_emergency_area_id
> Optional integer (range 0 to 16777215). If set, defines the emergency area identity of the cell for CMAS/ETWS.

prs   Optional object. Contains the optional Positioning Reference Signals (PRS) configuration. If not present, no PRS are generated. PRS parameters are defined in 3GPP TS 36.211 and 3GPP TS 36.355.

> **prs_bandwidth**
>> Integer. Bandwidth (in Resource Blocks) of the PRS. From 6 to `n_rb_dl`.

> **prs_period**
>> Enumeration: 160, 320, 640, 1280. Give the periodicity (in subframes) of the PRS.

> **prs_offset**
>> Integer (0 to prs_period - 1). Give the time offset of the PRS.

> **numdl_frames**
>> Integer: 1, 2, 4 or 6. Number of consecutive subframes in which the PRS are sent.

> **prs_muting_info**
>> Optional string. Bit string containing the PRS muting pattern. Its length must be 2, 4, 8 or 16.

> **power_prs**
>> Optional float (default = 0). Relative power in dB of the PRS.

> **precoding_matrix**
>> Optional complex matrix. Precoding matrix of `n_antenna_dl` rows and 1 column.

access_point_position
> Optional object. Contains the geographical position of the access point (i.e. the cell antennas). If not present, the latitude is set to 48.8534, the longitude is set to 2.3488 and the altitude is set to 0.

> **latitude**   Float. Range -90 to 90. Degrees of latitude. Positive value = North, negative value = South.

> **longitude**
>> Float. Range -180 to 180. Degrees of longitude.

> **altitude**   Optional float (default = 0). Range -1000m to 20km. Altitude in meters.

antenna_azimuth

>   Optional float in range 0 to 360. Angle of arrival in degrees.

carrier_sense

>   Optional object. Allow to perform regular carrier sensing and cutoff eNB transmission if carrier is occupied. Activating this feature will bring contraints on `prach_config_index`, `sr_period`, `cqi_period` and `srs_period`. The feature is available only in TDD for now.
>   The object contains the following parameters :
>
>   **period**   Integer: 32, 64, 128, 256, 512 or 1024. Period for carrier sensing measurement, in frames. The measurement lasts one single frame during which eNB stops transmitting any signal. The eNB also takes care that no UE transmission can occur during the measurement. The maximum EPRE value across the ten subframes is retained as the measurement.
>
>   **threshold**
>
> >   Float. Range -140 to -30, in dBm. When the carrier sensing measurement is above the threshold, the cell will be cutoff at least until the next measurement period. When the cell is cutoff, the eNB stops transmitting any signal, the UEs are not longer scheduled and all the received PRACH are ignored. The cell is brought back on if the carrier sensing measurement gives an EPRE below (`threshold` - 3dB).

mbms   Optional object. MBMS configuration. See [MBMS configuration], page 102.

reserved_mbms_subframes

>   Optional object. Mark subframes as MBMS and transmit no data in them. The following properties are available:
>
>   **sf_alloc**   Array of objects. Each object has the following fields:
>
> >   **radio_frame_allocation_period**
> >   Range: 1 to 32, power of two. Allocation period (in 10 ms frames).
> >
> >   **radio_frame_allocation_offset**
> >   Range: 0 to 7. offset in the allocation period (in 10 ms frames).
> >
> >   **subframe_allocation**
> >   Bit string. Length = 6 (1 frame) or 24 (4 frames). In FDD, the bits correspond to subframes 1, 2, 3, 6, 7, 8. In TDD, the bits correspond to subframes 3, 4, 7, 8, 9.
>
>   **n_symb_cch**
>
> >   Integer. Range 1 to 2. Number of CCH symbols in the reserved MBMS subframes.

sib16_enable

>   Optional boolean (default = false). If true, enables SIB16 (time information broadcast). Note: the broadcasted UTC is currently taken from the eNB internal time (see `internal_time_ref` parameter), so it might not be GPS accurate. The time zone and daylight saving time are taken from the system time.

sib16_time_reference_info

>   Optional boolean (default = false). If true, adds the timeReferenceInfo-r15 IE to SIB16.

sib16_si_periodicity

> Enumeration: 8, 16, 32, 64, 128, 256, 512 (default = 32). Sets the periodicity (in frames) of the transmission of the SIB16 messages.

ueinfo_extension

> Optional boolean (default = false). If set, eNB will send UE information within S1AP initial UE message.
>
> The informations are presented as a S1AP-PROTOCOL-IES item in InitialUEMessage with an ID = 1000.
>
> Its ASN.1 definition is:

```
UEInformationExtension ::= SEQUENCE {
    timing-advance      INTEGER,
    snr                 INTEGER (0..255)
}
```

> Where:

timing-advance

> UE timing advance expressed in unit of TA

snr   8 bit value representing SNR in range of -63.5 to +64 dB by step of 0.5 dB (i.e 0 is -63.5 dB and 255 is 64 dB).

> Example of initial UE message:

```
initiatingMessage: {
  procedureCode id-initialUEMessage,
  criticality ignore,
  value {
    protocolIEs {
      {
        id id-eNB-UE-S1AP-ID,
        criticality reject,
        value 1
      },
      ...
      {
        id 1000,
        criticality ignore,
        value {
          timing-advance 1,
          snr 169
        }
      }
    }
  }
}
```

rrc_redirect

> Array of [ASN.1 property], page 29. Each entry is the ASN.1 content of a RedirectedCarrierInfo or RedirectedCarrierInfo-v9e0 redirection information.
>
> These will define the redirection parameter within RRC Connection Release sent by eNB to the UE (cf 3GPP TS 36.331)
>
> To send this redirection, you need to send to eNB a S1AP DownlinkNASTransport message and add a S1AP-PROTOCOL-IE item with an ID of 1001 (Please refer to

MME documentation and `attach_reject_filter` parameter to use it).
Its ASN.1 definition is:

```
UERedirectExtension ::= SEQUENCE {
    type                 INTEGER (0..255)
}
```

Where:

type   Index of the redirection configuration in the rrc_redirect array.

Here is an example of the incoming downlink NAS transport message (GSER encoding):

```
initiatingMessage: {
  procedureCode id-downlinkNASTransport,
  criticality ignore,
  value {
    protocolIEs {
      ...
      {
        id 1001,
        criticality ignore,
        value {
          type 0
        }
      }
    }
  }
}
```

If *rrc_redirect* is the following: `["redirect.asn"]`.
And *redirect.asn* is:

```
geran: {
    startingARFCN  10,
    bandIndicator  dcs1800,
    followingARFCNs explicitListOfARFCNs: {12, 42}
}
```

The UE will be sent the following RRC connection release message:

```
{
  message c1: rrcConnectionRelease: {
    rrc-TransactionIdentifier 0,
    criticalExtensions c1: rrcConnectionRelease-r8: {
      releaseCause other,
      redirectedCarrierInfo geran: {
        startingARFCN 10,
        bandIndicator dcs1800,
        followingARFCNs explicitListOfARFCNs: {
          12,
          42
        }
      }
    }
  }
}
```

Alternatively, *rrc_redirect* can be an array of objects. Each object contains the following fields:

`plmn`   String. PLMN of the location area.

`lac`   Range 0 to 0xffff. LAC of the location area.

`filename, content, content_type`
            String. [ASN.1 property], page 29,

The redirection is initiated with a CS fallback indication in the UE context modification request S1 message. The Location Area Information (PLMN and LAC) is used to select the redirection information sent in the RRC connection release. If the Location Area Information is not present, the first redirection is used.

`rrc_redirect_after_eps_fallback`
        Optional integer. If set, defines RRC redirection index (See [rrc_redirect], page 83) for the RRC connection release message after an EPS fallback handover.

`idle_mode_mobility_control`
        Optional object. If present, the RRC Connection Release message will contain the IdleModeMobilityControlInfo and optionally IdleModeMobilityControlInfo-v9e0 information. The object contains the following fields:

`info`   [ASN.1 property], page 29. IdleModeMobilityControlInfo ASN.1 content.

`info_v9e0`
            Optional [ASN.1 property], page 29. IdleModeMobilityControlInfo-v9e0 ASN.1 content.

Example of info file content (GSER):
```
{
  freqPriorityListEUTRA {
    {
      carrierFreq 2850,
      cellReselectionPriority 4
    },
    {
      carrierFreq 65535,
      cellReselectionPriority 3
    }
  }
}
```
Example of info_v9e0 file content:
```
{
  freqPriorityListEUTRA-v9e0 {
    {
    },
    {
      carrierFreq-v9e0 260000
    }
  }
}
```

`scell_list`
        Optional array of objects. List the cells of the same eNodeB which can be used for carrier aggregation. Each object contains the following fields:

cell_id   Range: 0 to 1023. Low 7 bit (long macro eNB), 8 bit (macro eNB) or
              10 bit (short macro eNB) of the cell identifier.

cross_carrier_scheduling
              Boolean. True if cross carrier scheduling is enabled for this cell.

scheduling_cell_id
              Range: 0 to 1023. If cross carrier scheduling is enabled, gives the cell
              id in which the corresponding PDCCH is sent.

ul_allowed
              Optional boolean (default = false). If true, enable uplink for this serving
              cell.

rrc_configuration
              Optional enumeration: `initial`, `measurement` or `api_only` (default =
              `initial`). Desscribes the conditions under which the SCell is config-
              ured.
              If set to `initial`, the SCell is added right away after the RRC connec-
              tion establishment.
              If set to `measurement`, the SCell can be dynamically added and released
              based on measurement reports configured in the `scell_config` element
              of the `meas_config_desc` object, see [meas_config_desc], page 70.
              If set to `api_only`, the SCell can only be added through the `rrc_cnx_`
              `reconf` API, see [rrc_cnx_reconf], page 281.
              Note that the `rrc_cnx_reconf` API can still add or release any SCell
              irrespective of its `rrc_configuration` value.

individual_offset
              Optional integer, in dB. Relevant only when `rrc_configuration` is set
              to `measurement`. Individual offset used in A4 criteria evaluation for
              SCell addition.

a6_candidates
              Optional array of integers. Defines the list of intra frequency cells candi-
              dates for SCell handover. Each entry of the array contains the `cell_id`
              value of the target cell that must also be defined in `scell_list` array.

scells_activation
      Optional enumeration: `mac_ce`, `direct` or `off` (default = `mac_ce`). Selects how the
      eNB activates the secondary cells once they are configured. When `off` is selected,
      cells won't be activated unless an API call to `scells_act_deact` is performed.
      When `mac_ce` is selected, all the SCells are activated right after their configuration
      using the MAC control element. When `direct` is selected, all the SCells are acti-
      vated during their configuration using RRC signalling if the feature is supported by
      the UE. Otherwise it uses the MAC control element.

ue_cap_rat_type
      Optional array of strings. List the RAT types (`eutra`, `utra`, `geran-cs`, `geran-ps`,
      `cdma2000-1XRTT`, `nr`, `eutra-nr`) for the RRC UE capability enquiry message. In the
      first UE capability enquiry message, `eutra` is always included whatever the array
      content.

requested_eutra_freq_bands
      Optional array of 1 to 16 integers. Defines the list of EUTRA bands the eNB will
      request in the UE Capability Enquiry message (via the requestedFrequencyBands-
      r11 information element).

requested_eutra_max_ccs_dl

>   Optional integer (range = 2 to 32). Sets the maximum number of EUTRA
>   DL CCs the eNB will request in the UE Capability Enquiry message (via the
>   requestedMaxCCsDL-r13 information element).

requested_eutra_max_ccs_ul

>   Optional integer (range = 2 to 32). Sets the maximum number of EUTRA
>   UL CCs the eNB will request in the UE Capability Enquiry message (via the
>   requestedMaxCCsUL-r13 information element).

request_reduced_format

>   Optional boolean. If set, the eNB will request the UE to provide EUTRA
>   CA Combinations using supportedBandCombinationReduced-r13 instead of
>   supportedBandCombination-r10 in the UE Capability Enquiry message (via the
>   requestReducedFormat-r13 information element).

request_eutra_reduced_int_non_cont_comb

>   Optional boolean. If set, the eNB will request an EUTRA reduced intra-band non-
>   contiguous CA band combination in the UE Capability Enquiry message (via the
>   requestReducedIntNonContComb-r13 information element).

requested_freq_bands_nr_mrdc

>   Optional array of objects of 0 to 1280 objects. If the array is present with at least
>   one element, the requestedFreqBandsNR-MRDC-r15 IE content will be based on
>   the content provided. Otherwise, the eNB will build the requestedFreqBandsNR-
>   MRDC-r15 IE content based on the LTE and NR cells configured and their neighbor
>   cells.
>
>   Each object contains the following parameters:
>
>   **rat**   Enumeration (eutra or nr). RAT type for this FreqBandInformation
>   item.
>
>   **band_eutra**
>
>   >   Optional integer (range 1 to 256). E-UTRA frequency band indicator.
>   >   Must be present if `rat` is set to "eutra".
>
>   **ca_bandwidth_class_dl**
>
>   >   Optional enumeration (a, b, c, d, e, f). E-UTRA DL CA bandwidth
>   >   class. Only used if `rat` is set to "eutra".
>
>   **ca_bandwidth_class_ul**
>
>   >   Optional enumeration (a, b, c, d, e, f). E-UTRA UL CA bandwidth
>   >   class. Only used if `rat` is set to "eutra".
>
>   **band_nr**   Optional integer (range 1 to 1024). NR frequency band indicator. Must
>   be present if `rat` is set to "nr".
>
>   **max_bandwidth_requested_dl**
>
>   >   Optional enumeration (50, 100, 150, 200, 250, 300, 350, 400, 450, 500,
>   >   550, 600, 650, 700, 750, 800). Maximum aggregated DL bandwidth.
>   >   Only used if `rat` is set to "nr".
>
>   **max_bandwidth_requested_ul**
>
>   >   Optional enumeration (50, 100, 150, 200, 250, 300, 350, 400, 450, 500,
>   >   550, 600, 650, 700, 750, 800). Maximum aggregated UL bandwidth.
>   >   Only used if `rat` is set to "nr".
>
>   **max_carriers_requested_dl**
>
>   >   Optional integer (range 1 to 32). Maximum number of DL carriers.
>   >   Only used if `rat` is set to "nr".

max_carriers_requested_ul

>Optional integer (range 1 to 32). Maximum number of UL carriers. Only used if `rat` is set to "nr".

mr_dc_request_nr_dc

>Optional boolean (default = false). If true, the includeNR-DC bit is set to true in the UE capability enquiry message so as to retrieve NR-DC band combinations. Note that it is automatically set if there is at least once cell configured for NR-DC.

rrc_ul_segmentation_support

>Optional boolean (default = true). If set to true, the eNB indicates that RRC UL segmentation is allowed in the RRC UE capability enquiry message.

single_ue_cap_enquiry

>Optional boolean (default = false). If set to true, and if the UE and eNB supports R16 uplink RRC segmentation feature, EUTRA, NR and MRDC capabilities are requested in a single message.

srs_switching_time_request

>Optional boolean (default = false). If set to true, the eNB sets the srs-SwitchingTimeRequest flag when requesting NR or EUTRA-NR UE capabilities.

uplink_tx_switch_request

>Optional boolean (default = true if a `uplink_tx_switch` configuration is present, false otherwise).
>
>If set to true, the eNB sets the uplinkTxSwitchRequest flag when requesting NR or EUTRA-NR UE capabilities.

gbr_ul_ratio

>Optional float (default = 0.8). Maximum ratio of the uplink resources that can be reserved for GBR ERABs.

gbr_dl_ratio

>Optional float (default = 0.8). Maximum ratio of the downlink resources that can be reserved for GBR ERABs.

gbr_init_ul_bits_per_re

>Optional float (default = 2.0). The GBR ERAB resources are measured in terms of resource elements (RE) per second. Each RE can be assigned a given number of bits depending on the exact radio conditions. This parameter gives the initial number of bits per uplink RE when the UE is connecting (in this case no reliable radio quality measurement is available).

gbr_init_dl_bits_per_re

>Optional float (default = 2.0). Same as `gbr_init_ul_bits_per_re` for downlink.

gbr_congested

>Optional boolean (default = false). Option that simulates a congestion once at least one GBR bearer is active in the cell. Any new GBR request will be rejected or will trigger a preemption depending on the ERAB ARP parameters.

ignore_gbr_congestion

>Optional boolean (default = false). If set to true, no GBR congestion check is performed.

ue_count_max

>Optional integer (default = 500). Maximum number of UEs (for this cell).

erab_count_max
>   Optional integer (default = 1500). Maximum number of ERABs (for this cell).

rrc_cnx_reject_waitTime
>   Optional integer (default = 10). RRC connection reject wait time in seconds.

rrc_cnx_reject_extWaitTime
>   Optional integer (default = 0). RRC connection reject extended wait time in seconds.

rrc_cnx_reject_deprioritisation
>   Optional object. If present, the deprioritisationReq-r11 field is added to the RRC Connection Reject message.
>   The object must contain the following fields:
>
>   type   Enumeration ("none", "frequency" or "e-utra").
>
>   timer   Optional enumeration (5, 10, 15 or 30). Timer in minutes. Required if type is not none.

rrc_cnx_release_extWaitTime
>   Optional integer (default = 0). RRC connection release extended wait time in seconds.

rrc_cnx_release_waitTime_5gc
>   Optional integer (default = 0). RRC connection release wait time in seconds when connected to 5GC.

ims_emergency_support
>   Optional boolean (default = false). If true, IMS emergency support is advertised in SIB1.

ecall_over_ims_support
>   Optional boolean (default = false). If true, eCall over IMS support is advertised in SIB1.

label   Optional string. Helper available in monitor (cell), remote API (config_get) and logs.

channel_dl
>   Optional object. Set the cell specific channel simulator configuration. See [Cell specific channel simulator], page 224.

eps_fallback_fast_return_preferred_method
>   Optional enumeration: none, handover, redirection (default = none). Set the preferred method for the EPS fallback fast return procedure. If the handover procedure fails a redirection is performed.
>   Note that the fast return can only be performed if the EPS fallback procedure was performed with a handover and if the NR SA source cell is in the LTE neighbor cell list.

ue_assistance_information
>   Optional object containing the UE assistance information procedure configuration. It can contain the following properties:
>
>   power_preference
>>   Optional object for the powerPrefIndicationConfig-r11 ASN.1 parameters.
>>   Note that no action will be taken by the eNB when receiving the powerPrefIndication-r11 information. Its purpose is only to test the

UE message sending.
It contains the following properties:

prohibit_timer
> Enumeration (0, 0.5, 1, 2, 5, 10, 20, 30, 60, 90, 120, 300, 600, -1). Sets the powerPrefIndicationConfig-r11 value. -1 means no powerPrefIndicationConfig-r11 is configured.

overheating_assistance
> Optional object for the overheatingAssistanceConfig-r14 ASN.1 parameters.
> Note that no action will be taken by the eNB when receiving the overheatingAssistance-r14 information. Its purpose is only to test the UE message sending.
> It contains the following properties:

prohibit_timer
> Enumeration (0, 0.5, 1, 2, 5, 10, 20, 30, 60, 90, 120, 300, 600, -1). Sets the overheatingAssistanceConfig-r14 value. -1 means no overheatingAssistanceConfig-r14 is configured.

empty_bsr_grant
> Optional object containing the empty BSR grant feature configuration.
> When a UE reports an empty BSR (Buffer Status Report) MAC control element, the eNB stops scheduling it in UL and the UE needs to transmit a scheduling request to resume the UL transmission, which adds delay. With this feature, the UE will still be scheduled in UL after the empty BSR report for the configured `duration` with `tb_len` UL grants if it has a bearer active using a QCI/5QI with the `use_empty_bsr_grant` parameter set to true.
> This feature is useful in case of an application being time sensitive but generating bursty UL traffic like a video live stream for example.
> It contains the following properties:

duration Integer. Duration in milliseconds.

tb_len Integer. Length in bytes.

ran_slicing
> Optional array of objects. Defines the the maximum number of resources blocks that can be allocated for a slice by the ng-eNodeB, sorted by decreasing order of priority (if a UE has PDU sessions established in different S-NSSAIs, the scheduling constraints applied are the one of the S-NSSAI with the smallest index in the array). If a S-NSSAI defined in the cell is not defined in this array, it can use all the cell resource blocks. Each object contains the following properties:

sst Integer (range 0 to 255). S-NSSAI Slice Service Type.

sd Optional integer (range 0 to 0xFFFFFE). S-NSSAI Slice Differentiator.

dl_max_l_crb
> Optional integer (range 1 to `n_rb_dl`, default = `n_rb_dl`). Maximum number of DL resource blocks that can be used by the S-NSSAI.

ul_max_l_crb
> Optional integer (range 1 to `n_rb_ul`, default = `n_rb_ul`). Maximum number of UL resource blocks that can be used by the S-NSSAI.

8.5.3 Test parameters

The following cell parameters are only useful when the eNodeB is connected to a specific measurement equipment. They cannot normally be used with normal UEs.

sib_enable

>Optional boolean (default = true). If false, disable the transmission of the SIBs.

pdcch_fill

>Optional boolean (default = false). If true, add dummy PDCCHs filling the available PDCCH resources. For 1.4 and 3 bandwidths, PDCCHs of 1 CCE are added. For the other bandwidths, PDCCHs of 2 CCEs are added.

phich_fill

>Optional boolean (default = false). If true, add dummy PHICH filling the available PHICH resources. 2 PHICH are added per group with HI=0 with sequence numbers 0 and 4 for normal cyclic and sequence numbers 0 and 2 for extended cyclic prefix.

boosted_prbs

>Optional string or array of array of integers. If present, specifies the list of boosted PRBs for each subframe. If a string is provided, it is `E-TM1.2`, `E-TM3.2` or `E-TM3.3` and the corresponding list of boosted PRBs is set as specified in 3GPP TS 36.141 section 6.1.1.

>Otherwise, an array of PRBs is given for each subframe. The number of subframes must divide 20.

boosted_power

>Optional float. If `boosted_prbs` is present, specifies the power in dB relative to the CRS of the resource elements in the boosted PRBs. In the subframes with boosted PRBs, the PRBs which are not boosted have a power so that the average relative power to the CRS is 0 dB.

deboosted_constellation

>Optional enumeration (qpsk, 16qam, 64qam, 256qam). If `boosted_prbs` is present, specify the constellation for the PRBs which are not boosted in the subframes where boosted PRBs are present.

forced_ri

>Optional integer. Range 0 to 8 (default = 0). If `>= 1`, use it as Rank Indicator (RI) returned by the UE.

forced_cqi

>Optional integer. Range -1 to 15. (default = -1). If `>= 0`, use it as Channel Quality Indicator (CQI) returned by the UE.

forced_pmi

>Optional integer. Range -1 to 15. (default = -1). If `>= 0`, use it as Precoding Matrix Indicator (PMI) returned by the UE.

pusch_fer

>Optional float. Range 0 to 1. Set the simulated PUSCH Frame Error Rate.

pdsch_fer

>Optional float. Range 0 to 1. Set the simulated PDSCH Frame Error Rate.

test_mode

>Optional object. Enable specific test modes where UE contexts are automatically created when starting the eNodeB. They are only useful when the eNodeB is con-

nected to a specific measurement equipment.

The `type` property selects the test mode:

pusch

>Enables continuous reception of PUSCH by the eNodeB. DCI 0 and PHICH are transmitted. The following additional properties are available:
>
>rnti   Integer. Range 0 to 65535. Select the PUSCH RNTI.
>
>pusch_retx
>>Boolean. If false, don't force the UE to retransmit in case of error.
>
>pusch_external_harq_ack
>>Optional boolean (default = false). If true, transmit the PUSCH HARQ ACK/NACK and timing advance information to the TRX driver so that it can be transmitted to an external signal generator. The HARQ ACK/NACK signal is transmitted at the same time as PHICH (hence at PUSCH TTI + 4 in FDD mode). The timing advance information is transmitted at the same time as the corresponding PDSCH. The timing advance transmission period is set with the `time_alignment_tx_timer` parameter.
>
>The cell properties `pdcch_format`, `pusch_fixed_rb_alloc`, `pusch_mcs` can be used to force specific PUSCH parameters.

pdsch

>Enables continuous transmission of PDSCH. The PDSCH payload contains valid data with PDCP packets of constant length. DCI are transmitted according to the selected transmission mode. PUCCH are received. The following additional properties are available:
>
>rnti   Integer. Range 0 to 65535. Select the PDSCH RNTI.
>
>pdsch_retx
>>Boolean. If false, don't retransmit the unacknowledged PDSCH (hence PUCCH ACK/NACK are ignored).
>
>random_data
>>Optional boolean (default = false). If true, send random data instead of zeros in the PDCP payload.
>
>The cell properties `pdcch_format`, `pdsch_mcs`, `forced_ri`, `forced_cqi`, `forced_pmi`, `transmission_mode`, `dl_256qam`, `pdsch_fer` can be used to force specific PDSCH parameters.

load

>CPU load test. Several UEs are instanciated and all are transmitting and receiving at the same time. The following additional properties are available:
>
>ue_count   Integer. Set the number of UE contexts. The upper bound is set to `ue_count_max` value.
>
>The cell properties `pusch_mcs`, `forced_ri`, `forced_cqi`, `forced_pmi`, `pusch_fer` can be used to set the simulated radio conditions.

For all test modes, the category of the fake UE created can be set with the following parameter:

ue_category
> Optional integer (-1 to 26, default = 4). Category of the fake UE created for the test mode. -1 corresponds to a category M1 UE.

8.5.4 Bandwidth Reduced parameters (Category M1)

The following parameters configure the cell to allow the connection of Bandwidth-Reduced UEs (category M1). All the parameters are in the `br_ue` object. Bandwidth-reduced specific SIB configuration files must be used except for SIB1.

br_only
> Optional boolean (default = false). If true, only category M1 UEs are allowed in this cell. The legacy LTE SIBs are disabled and no legacy LTE resources are allocated. 1.4 and 3 MHz category M1 cells must use `br_only=true`.

br_root_sequence_index
> Range: 0 to 837. Set the BR PRACH root sequence index. It must be different for each neighbour cell operating on the same frequency and sharing the same PRACH configuration.

br_prach_freq_offset
> Optional integer. Range: -2 to n_rb_ul - 6 (default = -2). Set the PRACH frequency offset. The special value -2 indicates to take the value from the SIB2 (legacy case). The special value -1 indicates to automatically set it.

br_r_sib1
> Enumeration: 1, 2 or 4. Number of SIB1 BR repetitions per 20 ms (1, 2 or 4).

br_tbs_sib1
> Optional enumeration: 26, 32, 41, 63, 89, 117. SIB1 BR size in bytes. If not set, the size is automatically computed by the eNB based on the SIBs defined in the configuration file. It can be useful to set it manually in case new SIBs are scheduled during runtime (like SIB10, 11, 12 or 14).

br_si_window_length
> Enumeration: 20, 40, 60, 80, 120, 160, 200. BR SI window length in ms.

br_si_repetition_pattern
> Enumeration: 1, 2, 4, 8. SI repetition pattern (one every n Radio Frames)

br_sib_sched_list
> Array of [ASN.1 property], page 29. Each entry contains the content of one SI scheduling slot (the first slot must contain the SIB2):
>
> si_periodicity
> > Enumeration: 8, 16, 32, 64, 128, 256, 512. SI periodicity in Radio Frames.
>
> filename, content, content_type
> > See [ASN.1 property], page 29,

br_si_nb_idx
> Optional integer (default = -1). Forces the narrow band index used for BR SIB scheduling. The value -1 means that the eNB selects the narrow band automatically.

q_rx_lev_min_ce
> Optional integer (default = -71). Range: -71 to -22. SIB1 Cell selection information. The special value -71 indicates that the parameter is not transmitted.

`q_qual_min_ce`

>	Optional integer (default = -35). Range: -35 to -3. SIB1 Cell selection information. The special value -35 indicates that the parameter is not transmitted.

`q_rx_lev_min_ce1`

>	Optional integer (default = -71). Range: -71 to -22. SIB1 Cell selection information. The special value -71 indicates that the parameter is not transmitted.

`q_qual_min_ce1`

>	Optional integer (default = -35). Range: -35 to -3. SIB1 Cell selection information. The special value -35 indicates that the parameter is not transmitted.

`delta_rx_lev_min_ce1`

>	Optional integer (default = 0). Range: -8 to 0. SIB1 Cell selection information. The special value 0 indicates that the parameter is not transmitted.

`power_class_14dbm_offset`

>	Optional enumeration (0, -6, -3, 3, 6, 9, 12). SIB1 powerClass14dBm-Offset-r15 parameter. The special value 0 indicates that the parameter is not transmitted. Only used if `q_rx_lev_min_ce` if not set to -71.

`br_distributed_mpdcch_precoding_matrix`

>	Optional complex matrix. Set the distributed MPDCCH precoding matrix. It has `n_antenna_dl` rows and 2 columns.

`br_coverage_levels`

>	Array of objects. Configuration of each coverage level. There must be the same number of coverage levels as PRACH configurations in the SIB2. Since only CE mode A is currently supported, at most 2 coverage levels can be specified. For each coverage level, the following parameters are available:

>	`br_rar_coderate`

>>		Float. Maximum code rate for the Random Access Response (RAR).

>	`br_mpdcch_css_ra_al`

>>		Enumeration: 8, 16, 24. MPDCCH aggregation level for the Common Search Space for the RAR message.

>	`br_mpdcch_css_n_rep`

>>		Integer. Range: 1 to 255. Number of repetitions for the Common Search Space MPDCCH.

>	`br_pusch_msg3_mcs`

>>		Range: 0 to 7. MCS for Msg3 (=CCCH RRC Connection Request).

>	`br_mpdcch_n_rb`

>>		Enumeration: 2, 4, 6. Number of PRBs for the UE specific MPDCCH.

>	`br_mpdcch_tm_type`

>>		Enumeration: distributed or localized. Set the UE specific MPDCCH transmission mode. The localized transmission mode relies on the PMI reports from the UE, so it is normally used only with transmission modes 6 or 9.

>	`br_mpdcch_al`

>>		Enumeration: 2, 4, 8, 16, 24. Aggregation level for the UE specific MPDCCH (it is currently statically configured).

>	`br_mpdcch_n_rep_max`

>>		Integer. Range: 1 to 256. Maximum number of repetitions for the UE specific MPDCCH.

br_mpdcch_n_rep
> Integer. Range: 1 to br_mpdcch_n_rep_max. Number of repetitions for the UE specific MPDCCH.

br_mpdcch_start_sf
> Float. Range: 1 to 10. Starting subframe value for the UE specific MPDCCH.

br_initial_cqi
> Range: 4 to 10. Initial CQI for BR UEs (used until the first CQI is received). It cannot currently be lower than 4 because no repetition is possible for CCCH.

br_pdsch_n_rep
> Integer. Range: 1 to 32. Number of repetitions for PDSCH (for normal UE data and RAR).

br_pusch_n_rep
> Integer. Range: 1 to 32. Number of repetitions for PUSCH (for normal UE data).

br_msg3_pusch_n_rep
> Integer. Range: 1 to 32. Number of repetitions for PUSCH (for MSG3).

br_pucch_fmt1_n_rep
> Enumeration: 1, 2, 4, 8. Number of repetitions for PUCCH format 1 or 1A (FDD and CE mode A only).

br_pucch_fmt2_n_rep
> Enumeration: 1, 2, 4, 8. Number of repetitions for PUCCH format 2 (FDD and CE mode A only).

inactivity_timer
> Optional integer. Send RRC connection release after this time (in ms) of network inactivity. Allows to override the value defined in the cell object for this coverage level. Note that it is only used for the UE PCell.

br_sr_period
> Optional enumeration of type `sr_period`. Overrides the scheduling request period set in the cell object by `sr_period` for this coverage level. For HD-FDD UEs, it is recommended to use a period bigger than (`2*br_mpdcch_n_rep + br_pdsch_n_rep + br_pucch_fmt1_n_rep + 3`). Note that the use of measurement gap (see parameter `meas_gap_config`) of same period may divide the effective period by two.

br_forced_sr_offset
> Optional integer: range -1 to `br_sr_period`-1 (default = -1). Forces the scheduling request subframe offset sent to the UE. -1 means that the eNB allocates the value automatically.

br_cqi_period
> Optional enumeration of type `cqi_period`. Overrides the period of periodic CQI reporting set in the cell object by `cqi_period` for this coverage level. The largest br_cqi_period defined among the coverage levels should also be the least common multiple. (i.e a mix of periods 32, 64 or 128 with periods of 10, 20, 40, 80 or 160 is not supported). For HD-FDD UEs, it is recommended to use a period bigger than (`2*br_mpdcch_n_rep + br_pdsch_n_rep + br_pucch_fmt2_n_rep + 3`). Note

that the use of measurement gap (see parameter `meas_gap_config`) of same period may divide the effective period by two.

br_pusch_n_rep_enh
Optional enumeration: 1, 2, 4, 8, 12, 16, 24, 32. Defaults to `br_pusch_n_rep` if absent. This field is used when `br_pdsch_pusch_enhancement` is set to `true` to set the number of PUSCH repetitions for UEs supporting the rel14 ce-pdsch-pusch-Enhancement feature.

br_pusch_force_qpsk
Optional boolean (default = false). Control the 'mod_override' bit in DCI 6-0A when `br_pdsch_pusch_enhancement` is set to `true`, for UEs supporting the rel14 ce-pdsch-pusch-Enhancement feature.

br_paging_mcs
Integer. Range: 0 to 7. Maximum MCS used for paging messages. The eNB will select a MCS lower or equal to this value depending on the number of UEs present in the paging record list.

br_mpdcch_paging_n_rep
Integer. Range: 1 to 256. Number of repetition for the paging MPDCCH.

br_paging_n_rep
Integer. Range: 1 to 32. Number of repetitions for the paging message (PDSCH).

br_paging_direct_indication
Optional boolean (default = false). When true, the eNB will send Direct Indication Information in DCI 6-2 instead of a full paging message, when applicable.

br_n1_pucch_sr_count
Range: 1 to 1000. Number of Scheduling Request PUCCH resources reserved for BR UE.

br_cqi_pucch_n_rb
Range: 0 to `n_rb_ul`. Number of resources blocks reserved for CQI reporting thru PUCCH for BR UE. Must be even. Value 0 is only supported if all the coverage levels have a CQI period of 0.

br_mpdcch_ue_count
Integer >= 1. Maximum number of UEs assigned to a single MPDCCH resource.

br_t304   Optional enumeration: 50, 100, 150, 200, 500, 1000, 2000, 10000 (default = `t304` value). T304 timer for handover.

br_srs_enabled
Optional boolean (default = false). Enable SRS for the BR UEs.

br_forced_mpdcch_nb_idx
Optional integer (default = -1). Forces the narrow band index used for MPDCCH. The value -1 means that the eNB selects the narrow band automatically.

br_forced_pdsch_nb_idx
Optional integer (default = -1). Forces the narrow band index used for PDSCH. The value -1 means that the eNB selects the narrow band automatically.

br_forced_pusch_nb_idx
Optional integer (default = -1). Forces the narrow band index used for PUSCH. The value -1 means that the eNB selects the narrow band automatically.

br_dl_sf_bitmap

>>Optional bit string to specify the BL/CE DL subframes in the cell. Parameter is a string of '0' and '1' of length 10 or 40. When present, it will set the SIB1 parameter `fdd-DownlinkOrTddSubframeBitmapBR-r13`.

br_pusch_nb_max_tbs

>>Optional boolean (default = false). Add support for the rel14 ce-PUSCH-NB-MaxTBS-r14 feature.

br_pdsch_pusch_enhancement

>>Optional boolean (default = false). Add support for the rel14 ce-pdsch-pusch-EnhancementConfig-r14 feature. See the coverage level parameters `br_pusch_n_rep_enh` and `br_pusch_force_qpsk` for further control enabled by this feature.

br_scheduling_enhancement

>>Optional integer, range 0-2 (default = 0). Add support for the rel14 ce-SchedulingEnhancement-r14 feature. Value 1 corresponds to range1, 2 to range2 and 0 means the feature is disabled.

>>Scheduling enhancement will be effectively used only when `br_mpdcch_n_rep`, `br_pdsch_n_rep` and `br_pucch_fmt1_n_rep` are all set to 1.

br_harq_ack_bundling

>>Optional boolean (default false). Add support for the rel14 ce-HARQ-AckBundling-r14 feature.

>>HARQ ACK bundling will be effectively used only when `br_mpdcch_n_rep`, `br_pdsch_n_rep` and `br_pucch_fmt1_n_rep` are all set to 1.

br_pdsch_ten_processes

>>Optional boolean (default = false). Add support for the rel14 ce-PDSCH-TenProcesses-r14 feature.

>>Note that 10 HARQ processes can only be used when at least one of `br_scheduling_enhancement` or `br_harq_ack_bundling` is set.

br_pdsch_flexible_start_prb

>>Optional boolean (default = false). Add support for the rel15 ce-PDSCH-FlexibleStartPRB-AllocConfig feature.

br_guess_guard_time

>>Optional boolean (default = false). Guess the presence of retuning PUSCH guard times. May improve the receive robustness in case the UE needs retuning guard times.

8.5.4.1 Wake-Up-Signal

wus_config

>>Optional object containing the wake up signal configuration.

>>**time_offset**

>>>>Optional enumeration: 0, 40, 80, 160, 240 (default = 0). Time offset (in ms) between the end of WUS transmission and beginning of paging occasion. If set to 0, WUS is not activated on the cell.

>>**freq_location**

>>>>Optional enumeration: 0, 2, 4 (default = 0). First RB used for first WUS resource within a narrow band.

max_num_rep
> Optional enumeration: 1, 2, 4, 8, 16, 32, 64 (default = 2). Maximum number of WUS repetitions (in subframes). Must be less than 0.5 x `mpdcch-NumRepetition-Paging-r13` defined in SIB23.

num_po
> Optional enumeration: 1, 2, 4 (default = 1). Number of consecutive paging occasions mapped to one WUS.

groups
> Optional array of objects containing group WUS config (two groups currently supported). If absent, group WUS is not enabled. The length of this array must be equal to 1.
>
> prob_threshold
> > Enumeration: 20, 30, 40, 50, 60, 70, 80, 90. Paging probability threshold (in percent), between the two WUS groups.

resources
> Optional enumeration: 1, 2 (default = 1). Number of WUS resources for group WUS.

8.5.5 E-UTRA NR Dual Connectivity parameters

The following parameters configure some EN-DC parameters controlled by the LTE cell, and the relationship between LTE and NR cells.

en_dc_scg_cell_list
> Optional array of objects. Defines the list of NR cells that can be used by the LTE cell for EN-DC (similar to the scell_list array).
> Each objet must contain the following parameters:
>
> cell_id Integer. cell_id as configured in the `nr_cell_list` object entry of the eNB configuration object.

nr_p_max_eutra
> Optional integer (range = -30 to 33). Value of p-MaxEUTRA-r15 in RRCConnectionReconfiguration-v1510-IEs/nr-Config-r15/setup IE.

8.5.6 DRB configuration

Array of objects giving the Data Radio Bearer configuration for each QCI (QoS Class Identifier). There must be at least one definition for QCI = 9 which is the default QCI.

Each object contains the following properties:

qci
Range: 1 to 255. The following parameters apply to DRBs of this QCI.

ims_dedicated_bearer
> Optional boolean (default = false). If set to true, it indicates that this QCI is used for IMS dedicated bearers (VoLTE, ...)

rlc_config
> Object. Gives the RLC configuration. If UM (Unacknowledged Mode) is used, the `ul_um` and `dl_um` objects must be present. If AM (Acknowledged Mode) is used, the `ul_am` and `dl_am` objects must be present.
>
> ul_um Object. Uplink RLC UM configuration.
>
> > sn_FieldLength
> > > Enumeration: 5, 10. Sequence number field length in bits.
>
> dl_um Object. Downlink RLC UM configuration.
>
> > sn_FieldLength
> > > Enumeration: 5, 10. Sequence number field length in bits.

t_Reordering
: Enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 1600. t_Reordering timer value in ms.

ul_am
: Object. Uplink RLC AM configuration.

t_PollRetransmit
: Enumeration: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 2000, 4000. t_PollRetransmit timer value in ms.

pollPDU
: Enumeration: 4, 8, 16, 32, 64, 128, 256, 0. pollPDU value. 0 means infinity.

pollByte
: Enumeration: 25, 50, 75, 100, 125, 250, 375, 500, 750, 1000, 1250, 1500, 2000, 3000, 0. pollByte value in kBytes. 0 means infinity.

maxRetxThreshold
: Enumeration: 1, 2, 3, 4, 6, 8, 16, 32. maxRetxThreshold value.

ul_extended_RLC_LI_Field_r12
: Optional boolean. If set to true and supported by the UE, a 15 bits LI will be used.

ul_extended_RLC_AM_SN_r13
: Optional boolean. If set to true and supported by the UE, a 16 bits SN and SO will be used.

pollPDU_v1310
: Optional enumeration: 512, 1024, 2048, 4096, 6144, 8192, 12288, 16384. pollPDU-v1310 value.

pollByte_r14
: Optional enumeration: 1, 2, 5, 8, 10, 15, 3500, 4000, 4500, 5000, 5500, 6000, 6500, 7000, 7500, 8000, 9000, 10000, 11000, 12000, 13000, 14000, 15000, 16000, 17000, 18000, 19000, 20000, 25000, 30000, 35000, 40000. pollByte-r14 value in kBytes. Sent if supported by the UE.

dl_am
: Object. Downlink RLC AM configuration.

t_Reordering
: Enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 1600. t_Reordering timer value in ms.

t_StatusProhibit
: Enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 1200, 1600, 2000, 2400. t_StatusProhibit timer value in ms.

dl_extended_RLC_LI_Field_r12
> Optional boolean. If set to true and supported by the UE, a 15 bits LI will be used.

dl_extended_RLC_AM_SN_r13
> Optional boolean. If set to true and supported by the UE, a 16 bits SN and SO will be used.

pdcp_config
Object. Gives the PDCP configuration.

discardTimer
> Integer. PDCP discardTimer variable (in ms). 0 means infinity.

pdcp_SN_Size
> (UM only) Enumeration: 7, 12. pdcp sequence number size in bits.

pdcp_SN_Size_v1130
> (AM only) Optional boolean. If set to true and supported by the UE, a 15 bits SN will be used.

pdcp_SN_Size_v1310
> (AM only) Optional boolean. If set to true and supported by the UE, a 18 bits SN will be used.

statusReportRequired
> (AM only) Boolean. PDCP statusReportRequired variable.

headerCompression
> Optional object. If not present or `null`, header compression is disabled.

maxCID   Range: 1 to 16383.

profile0x0001
> Boolean. If true, enable RTP v1 ROHC profile.

profile0x0002
> Boolean. If true, enable UDP v1 ROHC profile.

profile0x0004
> Boolean. If true, enable IP v1 ROHC profile.

nr_pdcp_config
Optional object. Gives the NR PDCP configuration. If set, and if the UE supports NR PDCP for EUTRA ERABs, the ERAB will be established with a NR PDCP entity instead of an EUTRA PDCP entity. Its presence is mandatory for a ng-eNB cell.

discardTimer
> Enumeration: 10, 20, 30, 40, 50, 60, 75, 100, 150, 200, 250, 300, 500, 750, 1500, 2000 or 0. Duration of the discard timer in ms. 0 means infinity.

pdcp_SN_SizeUL
> Enumeration: 12 or 18. Uplink SN size in bits.

pdcp_SN_SizeDL
> Enumeration: 12 or 18. Downlink SN size in bits.

headerCompression
> Optional object. If not present or `null`, header compression is disabled.

maxCID   Range: 1 to 16383.

profile0x0001
> Boolean. If true, enable RTP v1 ROHC profile.

profile0x0002
> Boolean. If true, enable UDP v1 ROHC profile.

profile0x0004
> Boolean. If true, enable IP v1 ROHC profile.

statusReportRequired
> (AM only) Boolean. Indicates if status reports must be generated or not.

outOfOrderDelivery
> Boolean. Indicates if out of order delivery must be activated or not.

t_Reordering
> Optional enumeration: 0, 1, 2, 4, 5, 8, 10, 15, 20, 30, 40, 50, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 500, 750, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 2750, 3000. Duration of the t-Reordering timer in ms.

restrict_to_ng_enb
> Optional boolean (default = false). If set to true, the nr_pdcp_config settings are only used for UEs connected to the ng-eNB.

en_dc_split
> Optional object. It defines if the current QCI can be used for EN-DC split bearers or not.
> It contains the following items:

type
> Enumeration: mcg, scg. Defines which cell group is the primary path. If set to mcg, `nr_pdcp_config` object must be defined also.
> The value mcg corresponds to option 3.
> The value scg corresponds to option 3x.
> The absence of the `en_dc_split` configuration object and the same QCI being defined in the NR cell DRB configuration object corresponds to option 3a.

ul_data_threshold
> Optional enumeration: 0, 100, 200, 400, 800, 1600, 3200, 6400, 12800, 25600, 51200, 102400, 204800, 409600, 819200, 1228800, 1638400, 2457600, 3276800, 4096000, 4915200, 5734400, 6553600, -1 (default = -1). Defines the PDCP ul-DataSplitThreshold parameter in bytes. -1 means infinity.

secondary_path_dl_ratio
> Optional number between 0 and 1 (default = -1). Experimental feature trying to force data ratio between both bearers, -1 disables it. Note that the ratio cannot be sustained if the `force_dl_schedule` option is activated in one of the cells used for the traffic, or if multiple bearers with different priorities are used, or if the traffic pushed is higher than the maximum physical bitrate.
> Example: if 10Mbps is sent and ratio is set to 0.75, primary path will schedule 2.5Mbps and secondary 7.5Mbps.

logical_channel_config
> Object. MAC Logical channel configuration. The downlink values are assumed to be the same as the uplink values.

priority Range: 1 to 16. logical channel priority. Lower value has more priority.

prioritisedBitRate

Enumeration: 0, 8, 16, 32, 64, 128, 256, -1, 512, 1024, 2048. Prioritised bit rate. -1 means infinity.

bucketSizeDuration

Enumeration: 50, 100, 150, 300, 500, 1000. Bucket size duration in ms.

logicalChannelGroup

Range: 0 to 3. Logical channel group to which this logical channel belongs.

logicalChannelSR_Mask

Optional boolean. Indicates whether this DRB should use SR masking or not.

logicalChannelSR_Prohibit

Optional boolean. Indicates whether this DRB will use the R12 logical channel SR prohibit timer or not. Note that it requires setting `logical_channel_sr_prohibit_timer` parameter in `mac_config` object.

need_sps Optional enumeration: `dl`, `ul`, `both` or `none` (default = none). If present, defines whether the radio bearer needs an SPS configuration for DL, UL or both directions.

If a corresponding configuration exists in the eNB (See [SPS configuration], page 66) and if the UE supports SPS, SPS will be configured when the bearer is established.

Further Activation/Release of the SPS allocations will be performed depending on the trafic on the radio bearer.

5qi_qos Optional object. Default 5QI QoS characteristics to be used for this 5QI by the ng-eNB. If not present, the ng-eNB tries to retrieve a default value based on 3GPP TS 23.501 table 5.7.4-1 and errors if the 5QI value is unknown.

priority_level

Integer (range 1 to 127).

averaging_window

Optional integer (range 1 to 4095). Averaging window for GBR bearers.

use_empty_bsr_grant

Optional boolean (default = false). Indicates if empty BSR grant feature must be used for this QCI. See [empty_bsr_grant LTE cell parameter], page 90.

tx_fifo_size

Optional integer (default = 10485760). Defines the maximum number of bytes that can be queued in the DL PDCP entity before dropping incoming DL packets.

8.5.7 MBMS configuration

The object `mbms` gives the eNB MBMS configuration. Other parameters previously present in this object are now configured in MBMS Gateway. Here are the properties of the object:

sib13_periodicity

Integer. Range: 8 to 512, power of two. Periodicity (in 10 ms frames) of the SIB13 retransmission. The SIB13 contain the parameters to find the MCCH for each MBSFN area.

synchronization_area_id

Integer. Range: 0 to 65535. MBSFN synchronization area identifier sent in the M2 Setup Request message.

`use_precise_timestamp`
> Optional boolean (default = false). If set to true, eNB and MBMSGW internal time (as seen by the `time` monitor command) are assumed to be synchronized. SYNC packets will be dropped in their time stamp is not ahead of 1 to `msp_fifo_size` number of times the MCH Scheduling Period compared to the current eNB internal time. If set to false, the eNB will not consider the SYNC packet timestamp.

`mbms_time_offset`
> Optional integer. Offset in ms applied to the eNB internal time (as retrieved by the `time` monitor command) so as to synchronize the eNB with the MBMSGW and ensure that they have a common time base for SYNC protocol. It is ignored if `use_precise_timestamp` option is set to false.

`msp_fifo_size`
> Optional integer. Range: 2 to 512, default set to 8. Size of the FIFO used by eNB to store SYNC packets based on their timestamp, ahead of the current MCH Scheduling Period (one entry per MCH Scheduling Period). Should be set to a relevant value according to the time_offset parameter set in MBMS Gateway.

`service_area_id_list`
> Array of integers. Range: 0 to 65535 per item. List of MBMS service areas for which the cell is subscribed. This list is sent in the M2 Setup Request message.

`notification_config`
> Object. Definition of the MCCH change notification parameters. Note: the MCCH parameters are currently static so that eNodeB never signals MCCH change.
>
> `notification_repetition_coeff`
> > Enumeration: 2, 4.
>
> `notification_offset`
> > Range: 0 to 10.
>
> `notification_sf_index`
> > Range: 1 to 6.

8.6 NB-IoT cell configuration

8.6.1 NB-IoT Frequency setting

NB-IoT carrier frequency position is not straightforward, especially for in-band and guard-band operation. The eNB provides two mutually exclusive ways to specify a NB-IoT carrier frequency:
- Either by specifying a PRB (for in-band and guard-band operation only)
- Either by specifying an EARFCN (and optionally an offset)

This is done with the parameters detailed below:

`dl_prb`   Optional integer, available only for in-band or guard-band operation. If the parameter is present, `dl_earfcn` and `dl_carrier_freq_offset` shall not be present. Range: -6 to `n_rb_dl`+5. If provided, it defines the DL PRB of the base LTE cell in which the NB-IoT carrier is deployed.
> - In-band operation: range 0 to `n_rb_dl`-1. For anchor carriers, not all PRB are suitable because the frequency needs to be in the 7.5kHz range around an NB EARFCN. Authorized PRB are given in 3GPP TS 36.213 chapter 16.8.
> - Guard-band operation: range [-6..-1] and [`n_rb_dl`..`n_rb_dl`+5]. The PRB is virtual and is not mapped by the base LTE cell.

> Not all PRB are suitable because the carrier shall fit inside the guardband interval.
>
> For anchor carriers, the PRB also needs to be in the 7.5 kHz range around an NB EARFCN.
>
> Note that this constraint make it impossible to have an anchor carrier in the guard-band of a 1.4 or 3 MHz LTE cell.

dl_earfcn

Optional integer, range: 0 to 262143. Set the NB DL EARFCN. This parameter is mandatory for standalone operation. For in-band and guard-band operation, `dl_prb` can be used instead.

For in-band operation and anchor carriers, the NB DL EARFCN must be in a range of 7.5 kHz around the center of a PRB of the base LTE cell. Such NB DL EARFCN are spaced by 900 kHz (5 resource blocks).

For in-band operation and non-anchor carriers, the NB DL EARFCN must be in a range of 50 kHz around the center of a PRB of the base LTE cell.

For in-band and guard-band operation, eNB will automatically compute a valid value for `dl_carrier_freq_offset` to fully specify the NB carrier position.

For guard-band operation, the NB carrier shall fit inside the guardband interval. Note that this constraint make it impossible to have an anchor carrier in the guard-band of a 1.4 or 3 MHz LTE cell.

dl_carrier_freq_offset

Optional integer, range: -10 to 9. Set the offset (also called raster offset in 3GPP TS 36.331 or M_{DL} in 3GPP TS 36.101) between the actual NB DL carrier position and the NB DL EARFCN. This parameter can only be used with a `dl_earfcn` setting and for in-band or guard-band operation.

For anchor carriers, it must be in the range -2 to 1.

Value in kHz is `5*dl_carrier_freq_offset + 2.5`.

Note that this parameter is truly necessary only for non-anchor carriers in guard-operation when several NB carriers can correspond to the same NB DL EARFCN. This parameter shall not be present for stand-alone operation.

ul_prb   Optional integer, available only for in-band or guard-band operation. If the parameter is present, `ul_earfcn` and `ul_carrier_freq_offset` shall not be present. Range: -6 to `n_rb_ul`+5. If provided, it defines the UL PRB of the base LTE cell in which the NB-IoT carrier is deployed.

- In-band operation: range 0 to `n_rb_dl`-1. The PRB shall not be used by PRACH or PUCCH on the base LTE cell. It is more efficient to set it at the edge of the PUSCH spectrum to have larger contiguous PUSCH allocations.

- Guard-band operation: range [-6..-1] and [`n_rb_dl`..`n_rb_dl`+5]. The PRB is virtual and is not mapped by the base LTE cell. Not all PRB are suitable because the carrier shall fit in the guardband interval, depending on the base LTE cell bandwidth.

ul_earfcn

Optional integer, range: 0 to 262143. Set the NB UL EARFCN. If neither `ul_earfcn` nor `ul_prb` are provided, the default DL/UL separation is used. For in-band and guard-band operation, `ul_prb` can be used instead.

For in-band operation, the NB UL EARFCN must be in a range of 50 kHz around the center of a UL PRB of the base LTE cell and this PRB must follow the restriction specified above for `ul_prb`.

For in-band and guard-band operation, eNB will automatically compute a valid value for `ul_carrier_freq_offset` to fully specify the NB carrier position.

ul_carrier_freq_offset

Optional integer, range: -10 to 9. Set the offset (also called raster offset or M_{UL} in 3GPP TS 36.101) between the actual NB UL carrier position and the NB UL EARFCN. This parameter can only be used with a `ul_earfcn` setting and for in-band or guard-band operation.

Value in kHz is `5*ul_carrier_freq_offset`.

It is only really mandatory to specify this value for guard-operation when several NB carriers can correspond to the same NB UL EARFCN. This parameter shall not be present for stand-alone operation.

8.6.2 Basic NB-IoT cell parameters

plmn_list

Array of objects or strings. List of PLMNs broadcasted by the eNodeB. At most 6 PLMNs are supported. Each element of the array is either a PLMN (5 or 6 digit string) or an object containing the following properties:

plmn   String. PLMN (5 or 6 digits).

reserved   Boolean. True if the cell is reserved for operator use.

attach_without_pdn
Optional boolean (default = false). Indicates if PLMN supports attach without PDN connectivity.

When `reserved` is not provided, its default value is `false`.

plmn_list_5gc

Optional list of objects. List of PLMNs broadcasted by the ng-eNodeB. At most 6 PLMNs are supported, only 1 object is supported. Each object contains the following properties:

plmn_ids   Array of objects. The array can contain up to 6 PLMNs. Each object contains the following properties:

plmn   String. PLMN (5 or 6 digits).

reserved   Boolean. True if the cell is reserved for operator use.

ng_u_data_transfer
Optional boolean (default = true). ng-U-DataTransfer-r16 parameter.

truncated_5g_s_tmsi
Optional object. Defines the parameters to rebuild the UE 5G-S-TMSI from the truncated 5G-S-TMSI. The object contains the following properties:

amf_set_id_upper_bits_len
Integer (range 0 to 9). Number of upper bits to rebuild the AMF Set ID.

amf_set_id_upper_bits
Integer. Upper bits AMF Set ID value.

amf_pointer_upper_bits_len
Integer (range 0 to 5). Number of upper bits to rebuild the AMF Pointer.

amf_pointer_upper_bits
> Integer. Upper bits AMF Pointer value.

fiveg_tmsi_upper_bits
> Integer. Upper bits 5G-TMSI value.

tac
> Integer (range 1 to 0xFFFFFF, except 0xFFFFFE). Tracking Area Code of the cell.

reserved
> Boolean. True if the cell is reserved for operator use.

nssai
> Optional array of objects. List of supported S-NSSAIs.
> Default content is sst: 1 (eMBB).
> Each object will set a S-NSSAI value as defined below:
>
> sst
> > Integer (range 0 to 255). Slice Service Type.
>
> sd
> > Optional integer (range 0 to 0xFFFFFE). Slice Differentiator.

eutra_5gc_only
> Optional boolean (default = false). It `plmn_list_5gc` is present and if this parameter is set to true, EUTRA/EPC access is barred and only EUTRA/5GC access is allowed.

operation_mode
> Enumeration: same_pci, diff_pci, guardband, standalone. Set the cell operation mode. `same_pci` and `diff_pci` are for in-band operation. `diff_pci` must be used in case of a LTE base cell with 4 PBCH antenna ports.
>
> For in-band operation, the eNodeB checks that the specified DL and UL EARFCN are consistent.

dl_prb
> See [NB-IoT frequency setting], page 103.

ul_prb
> See [NB-IoT frequency setting], page 103.

dl_earfcn
> See [NB-IoT frequency setting], page 103.

dl_carrier_freq_offset
> See [NB-IoT frequency setting], page 103.

ul_earfcn
> See [NB-IoT frequency setting], page 103.

ul_carrier_freq_offset
> See [NB-IoT frequency setting], page 103.

n_antenna_dl
> Enumeration: 1, 2, 4 or 8. Number of DL antennas. It must be the same for all NB-IoT and LTE cells sharing the same RF port.

n_antenna_ul
> Enumeration: 1, 2, 4 or 8. Number of UL antennas. It must be the same for all NB-IoT and LTE cells sharing the same RF port.

n_antenna_pbch
> Optional enumeration: 1, 2. Number of NPBCH antenna ports. It is automatically set to `min(2, number of PBCH antenna ports of the base cell)` for in-band operation. Otherwise its default value is `min(2, n_antenna_dl)`.

rf_port   Optional integer (default = 0). This parameter selects the RF port when several cells on different RF interfaces or RF bands are handled by the eNodeB. The number of supported RF ports depends on the radio head. For example, each PCIe card or N210 counts as one RF port.

multi_band_list

Optional array of integers. List the additional bands supported by the cell, in decreasing priority order (MFBI feature). The downlink and uplink frequency of the cell must exist in all these bands.

cell_id   Range: 0 to 1023. 7 bit (long macro eNB), 8 bit (macro eNB) or 10 bit (short macro eNB) cell identifier. The 28 bit E-UTRAN cell identity is the concatenation of `enb_id` and `cell_id`.

tac   Range 1 to 0xFFFF, except 0xFFFE. Tracking Area Code of the cell. Note: the NB-IoT and LTE tracking areas must be different.

base_cell_id

Integer. Only needed for in-band / guard band operation. 7, 8 or 10 bit cell identifier of the base cell in which the NB-IoT cell is mapped.

cell_gain

Optional float (default = 0). Downlink cell gain in dB. Must be between -200 and 0 (included). Note: it is not taken into account to set `SIB2.nrs-Power-r13`.

nrs_crs_power_offset

Optional float. Range: -6 to 9 (default = 0). Power offset in dB of the Narrow band Reference Signal with respect to the LTE Cell Reference Signal. This field is unused when the operation mode is `standalone`.

n_id_ncell

Range: 0 to 503. Physical cell identifier. It is not necessary if the operation mode is `same_pci`.

cipher_algo_pref

Array of integers. Set the preferred algorithms for RRC and User Plane encryption in decreasing order of preference (see corresponding LTE cell parameter).

cipher_algo_null_allowed

Optional boolean (default = true). If set to false, the use of NULL ciphering algorithm (EEA0) is forbidden unless the UE performs an emergency registration.

integ_algo_pref

Array of integers. Set the preferred algorithms for RRC integrity check in decreasing order of preference (see corresponding LTE cell parameter).

integ_algo_null_allowed

Optional boolean (default = true). If set to false, the use of NULL integrity algorithm (EIA0) is forbidden unless the UE performs an emergency registration.

inactivity_timer

Integer. Send RRC connection release after this time (in ms) of network inactivity.

rel13_5   Optional boolean (default = true). If true, enable incompatible physical layer changes for NPBCH/BCCH introduced in release 13.5.

8.6.3 System Information parameters

si_value_tag

Range: 0 to 31. Increment modulo 32 if SI is modified.

r_sib1   Enumeration: 4, 8, 16. Number of SIB1 repetitions for 256 radio frames.

tbs_sib1   Optional enumeration: 26, 41, 55, 85. SIB1 size in bytes. If not set, the size is automatically computed by the eNB based on the SIBs defined in the configuration file. It can be useful to set it manually in case new SIBs are scheduled during runtime (like SIB14).

cell_barred
Boolean or string (true, false or "auto"). Value of SIB1.cellBarred-r13. If set to "auto", the cell is barred when there is no connection with a core network for any of the PLMNs broadcast.

intra_freq_reselection
Boolean. Value of SIB1.intraFreqReselection-r13

q_rx_lev_min
Integer. Value of SIB1.q-RxLevMin.

delta_rx_lev_min
Optional integer (-8 to 0). Value of SIB1.nonCriticalExtension.cellSelectionInfo-v1350.delta-RxLevMin-v1350. If set to 0, the field is not transmitted.

q_qual_min
Integer. Value of SIB1.q-QualMin

power_class_14dbm_offset
Optional   enumeration   (0,   -6,   -3,   3,   6,   9,   12).   Value   of SIB1.nonCriticalExtension.nonCriticalExtension.cellSelectionInfo-v1430.powerClass14dBm-Offset-r14.   The   special   value   0   indicates   that the parameter is not transmitted.

ce_authorization_offset
Optional   enumeration   (0,   5,   10,   15,   20,   25,   30,   35).   Value   of SIB1.nonCriticalExtension.nonCriticalExtension.cellSelectionInfo-v1430.ce-authorisationOffset-r14.   The   special   value   0   indicates   that   the   parameter   is   not transmitted.

p_max   Optional integer. Value of SIB1.p-Max.

dl_bitmap
Optional bit string. Set the Downlink Subframe bitmap. It must contain 10 or 40 bits.

si_window_length
Integer. SI window length in ms.

si_radio_frame_offset
Integer. SI radio frame offset (in radio frames).

si_value_tag_list_enable
Boolean. If true, enables per SIB si_value_tag.

sib_sched_list
Array of [ASN.1 property], page 29. Each entry contains the content of one SI scheduling slot (the first slot must contain the SIB2):

> **si_periodicity**
> Integer. SI periodicity in Radio Frames.

> **si_repetition_pattern**
> Integer. The SI is present every **si_repetition_pattern** radio frames.

si_value_tag

>Optional integer. Range: 0 to 3. Must be present if `si_value_tag_list_enable` is true. Increment modulo 4 if the corresponding SIB is modified.

filename, content, content_type

>See [ASN.1 property], page 29,

si_tb_size

>Optional integer. Values: 7, 15, 26, 32, 41, 55, 69 or 85. Sets the TB size in bytes of this SIB message. If not set, the smallest TB size fitting the message is chosen.

sib16   Optional object. If present, the SIB16 message will be scheduled.

si_periodicity
si_repetition_pattern
si_value_tag

>It must contain the `si_periodicity`, `si_repetition_pattern` and `si_value_tag` objects described in `sib_sched_list`. See [sib_sched_list], page 108.

time_reference_info

>Optional boolean (default = false). If true, adds the timeReferenceInfo-r15 IE to SIB16.

sib22   Optional object. If present, the SIB22 message will be scheduled. SIB22 is necessary to enable NPRACH on non-anchor carriers. Configuration must contain the `si_periodicity`, `si_repetition_pattern` and `si_value_tag` objects described in `sib_sched_list`. See [sib_sched_list], page 108.

sib31   Optional object. If present, the SIB31 message will be scheduled. SIB31 is necessary to enable NTN functionnality in the cell. See [Non Terrestrial Network], page 224. It must contain the `si_periodicity`, `si_repetition_pattern` and `si_value_tag` objects described in `sib_sched_list`. See [sib_sched_list], page 108.

cp_Reestablishment_r14

>Optional boolean. If present, it overrides the cp-Reestablishment-r14 field in SIB2-NB message.

8.6.4 MAC configuration

mac_config

>Object. MAC configuration. Currently the same for all UEs. The following properties are defined:

msg3_max_harq_tx

>Integer. Maximum number of HARQ transmissions for MSG3.

ul_max_harq_tx

>Integer. Maximum number of HARQ transmissions for uplink.

dl_max_harq_tx

>Integer. Maximum number of HARQ transmissions for downlink.

ul_max_consecutive_retx

>Integer. Maximum number of UL retransmissions after which the UE is disconnected.
>If NPDCCH order NPRACH is defined for the current coverage level of the UE, the eNB will send a NPDCCH order.

dl_max_consecutive_retx

> Integer. Maximum number of DL retransmissions after which the UE is disconnected. If NPDCCH order NPRACH is defined for the current coverage level of the UE, the eNB will send a NPDCCH order.

time_alignment_timer_dedicated

> Integer. Time alignment timer dedicated in ms. 0 means infinity.

periodic_bsr_timer

> Integer. Periodic BSR timer value in NPDCCH periods.

retx_bsr_timer

> Integer. Retransmission BSR timer value in NPDCCH periods.

logical_channel_sr_prohibit_timer

> Optional integer (default = 0). Logical Channel SR prohibit timer value in NPDCCH periods. 0 means that the timer is deactivated.

data_inactivity_timer

> Optional integer (default = 0). Value in seconds of the data inactivity monitoring timer. 0 means that the timer is deactivated.

time_alignment_tx_timer

> Optional integer from 0 to 10240 (default = 0). Transmit the UL time alignment information every `time_alignment_tx_timer` ms. The value 0 means infinity. No actual UL time alignment measurement is done and a zero time alignment MAC control element is always sent. Hence this option is only useful for UE testing.

rai_support

> Optional boolean (default = false). Activates MAC release assistance indication feature in the eNB. It will not be used if `rai_enh_support` is set and the UE supports R16 MAC rai-ActivationEnh feature.

rai_enh_support

> Optional boolean (default = false). Activates R16 MAC rai-ActivationEnh feature in the eNB.

drx_config

> Optional object. DRX configuration. The following properties are defined:
>
> **on_duration_timer**
>
> > Enumeration: 1, 2, 3, 4, 8, 16, 32. onDurationTimer-r13 parameter, in NPDCCH periods.
>
> **drx_inactivity_timer**
>
> > Enumeration: 0, 1, 2, 3, 4, 8, 16, 32. drx-InactivityTimer-r13 parameter, in NPDCCH periods.
>
> **drx_retransmission_timer**
>
> > Enumeration: 0, 1, 2, 4, 6, 8, 16, 24, 33. drx-RetransmissionTimer-r13 parameter, in NPDCCH periods.
>
> **drx_ul_retransmission_timer**
>
> > Enumeration: 0, 1, 2, 4, 6, 8, 16, 24, 33, 40, 64, 80, 96, 112, 128, 160, 320. drx-ULRetransmissionTimer-r13 parameter, in NPDCCH periods.

drx_cycle

> Enumeration: 256, 512, 1024, 2048. drx-Cycle-r13 parameter, in subframes. Values not dividing 10240 are not yet supported.

8.6.5 PHY and L1 configuration

npusch_max_its

> Integer. Set the maximum number of turbo decoder iterations

coverage_levels

> Array of objects. Configuration of each coverage level. There must be the same number of coverage levels as NPRACH configurations in the SIB2.

> NPRACH additional parameters:

nprach_detect_threshold

> Optional float. Set the NPRACH SNR detection threshold in dB.

nprach_prob_anchor_denom

> Optional integer (default = 1). Set the denominator of the value nprach-ProbabilityAnchor-r14 in SIB22 for this coverage level. Value 0 means a probability of zero.

nprach_ta_min

> Optional integer (default = -16). The computed NPRACH timing advance ta is such that: nprach_ta_min <= ta < 512 + nprach_ta_min.

npdcch_order_nprach

> Optional enumeration (none, cb_random, cb_given, cf_given, default = none). Defines possibility to trigger a NPDCCH order NPRACH either with random preamble (ra-PreambleIndex = 0), dedicated contention-based preamble or dedicated contention-free preamble.
> NPDCCH order NPRACH is triggered when a UE reaches ul_max_consecutive_retx or dl_max_consecutive_retx, or via a call the pdcch_order_prach API or monitor command.

> RAR Parameters:

npdcch_ra_n_rep

> Integer. Number of RAR (Random Access Response) NPDCCH repetitions. It must be <= SIB2.npdcch-NumRepetitions-RA-r13.

npdsch_ra_n_rep

> Integer. Number of repetitions for RAR NPDSCH..

npdsch_ra_i_tbs

> Integer. Range 0 to 12. I_TBS for the RAR NPDSCH. For in-band cells, the maximum value is 10.

npdsch_ra_i_delay_min

> Optional Integer (default = 0). Range: 0 to 7. Minimum value for the RAR DCI N1 scheduling delay field.

ul_sc_spacing

> Enumeration: 0, 1. Select the subcarrier spacing used by the UE. 0 = 3.75 KHz subcarriers, 1 = 15 KHz subcarriers.

MSG3 parameters:

`msg3_n_sc`

Enumeration: 1, 3, 6, 12. Maximum number of subcarriers for MSG3. The eNodeB uses more than one subcarrier only if the UE supports it.

`msg3_single_tone_mcs`

Integer. Range: 0 to 2. MCS for single-tone MSG3.

`msg3_multi_tone_mcs`

Integer. Range 0 to 2. MCS for multi-one MSG3. Only needed if `msg3_n_sc > 1`.

`msg3_n_rep`

Integer. Range 1 to 128. Number of repetitions for MSG3.

`msg3_i_delay_min`

Optional Integer (default = 0). Range: 0 to 3. Minimum value for the RAR UL grant scheduling delay field.

Paging parameters:

`npdcch_paging_n_rep`

Integer. Range: 1 to 2048. Number of repetitions for the paging NPDCCH. It must be `<=` SIB2.npdcch-NumRepetitionPaging-r13.

`npdsch_paging_i_tbs`

Integer. Range: 0 to 12. I_TBS for the paging NPDSCH. For in-band cells, the maximum value is 10.

`npdsch_paging_n_rep`

Integer. Range: 1 to 2048. Number of repetitions for the paging NPDSCH.

UE dedicated parameters:

`npdcch_uss_n_rep_max`

Integer. Range: 1 to 2048. npdcch-NumRepetitions-r13 RRC parameter. Max number of NPDCCH repetitions for the User Search Space (USS).

`npdcch_uss_n_rep`

Optional Integer. Actual number of repetitions for the USS NPDCCH. The special value 0 means to use a single CCE (instead of 2) with a single transmission. If not present, the eNodeB link adaptation algorithm automatically chooses it.

`npdcch_uss_start_sf`

Enumeration: 1.5, 2, 4, 8, 16, 32, 48, 64. Used to compute of the period of the USS NPDCCH by multiplying it to `npdcch_uss_n_rep_max`.

`npdcch_uss_offset`

Integer. Range: 0 to 3. USS NPDCCH start offset in 8th of the USS NPDCCH period.

`npdsch_i_tbs`

Optional Integer (default = -1). Range: -1 to 13. I_TBS for NPDSCH. For in-band cells, the maximum value is 10. For category NB1 UEs, the value is limited to 12. -1 means that the eNodeB link adaptation algorithm automatically chooses it.

`npdsch_i_sf`

> Optional Integer (default = -1). Range: -1 to 7. I_SF value for NPDSCH. -1 means that the eNodeB scheduler automatically chooses it.

`npdsch_n_rep`

> Optional Integer. Range: 1 to 2048. Number of NPDSCH repetitions. If not present, the eNodeB link adaptation algorithm automatically chooses it.

`npdsch_i_delay_min`

> Optional Integer (default = 0). Range: 0 to 7. Minimum value for the DCI N1 scheduling delay field.

`dl_snr_adapt_fer`

> Optional float (default = 0.1). This value defines the DL PER targeted by the eNB link adaptation algorithm. By default it applies an error rate of 10% for the initial HARQ transmission.

`dl_snr_adapt_retx`

> Optional float (default = 1). Defines the correction step applied by the HARQ initial transmission decoding result.

`npusch_n_sc`

> Optional enumeration: 1, 3, 6, 12. Maximum number of subcarriers for NPUSCH. The eNodeB uses more than one subcarrier only if the UE supports it. If not present, the eNodeB link adaptation automatically chooses it.

`npusch_n_rep`

> Optional Integer. Range: 1 to 128. Number of NPUSCH repetitions. If not present, the eNodeB link adaptation algorithm automatically chooses it along with `i_tbs`.

`npusch_single_tone_i_tbs`

> Optional Integer. Range: 0 to 10. I_TBS for single-tone NPUSCH. Mandatory if `npusch_n_rep` is present, unused and optional otherwise.

`npusch_multi_tone_i_tbs`

> Optional Integer. Range: 0 to 13. I_TBS for multi-tone NPUSCH. For category NB1 UEs, the value is limited to 12. Mandatory if `npusch_n_rep` is present, unused and optional otherwise.

`npusch_i_ru`

> Optional Integer (default = -1). Range: -1 to 7. I_RU value for NPUSCH. -1 means that the eNodeB scheduler automatically chooses it.

`ul_snr_adapt_fer`

> Optional float (default = 0.1). This value defines the UL PER targeted by the eNB link adaptation algorithm. By default it applies an error rate of 10% for the initial HARQ transmission.

`ul_snr_adapt_retx`

> Optional float (default = 1). Defines the correction step applied by the HARQ initial transmission decoding result.

`npusch_i_delay_min`

> Optional Integer (default = 0). Range: 0 to 3. Minimum value for the DCI N0 scheduling delay field.

npusch_an_n_rep

>Optional Integer. Range: 1 to 128. Number of NPUSCH Format 2 repetitions for ACK/NACK. If not present or equal to the value of `ack-NACK-NumRepetitions-Msg4-r13` from the SIB2, no `ack-NACK-NumRepetitions-r13 parameter` will be sent in the RRC connection setup message, unless `dedicated_ack_nack_num_rep_enabled` is set to true.

inactivity_timer

>Optional integer. Send RRC connection release after this time (in ms) of network inactivity. Allows to override the value defined in the cell object for this coverage level.

harq_disabled

>Optional boolean (default = false). In NTN operation, enables DCI-based DL HARQ disabling feature to improve DL throughput when the UE-eNB RTT is large.
>Note that the UE capability should be known at RRC connection establishment so the feature will not be activated during UE initial attach.

ul_harq_mode_b

>Optional boolean (default = false). In NTN operation, enables UL HARQ mode B to improve UL throughput when the UE-eNB RTT is large.
>Note that the UE capability should be known at RRC connection establishment so the feature will not be activated during UE initial attach.

paging_direct_indication

>Optional boolean (default = false). When true, the eNB will send Direct Indication Information in DCI N2 instead of a full paging message, when applicable.

npusch_all_symbols

>Optional boolean. If true, NPUSCH symbols are transmitted in the SRS symbols. The field must be present if SRS is enabled on the base cell for in-band operation.

group_hopping_disabled

>Optional boolean (default = false). If true, disable group hopping in the UE RRC dedicated signaling.

dedicated_ack_nack_num_rep_enabled

>Optional boolean (default = false). If true, force the `ack-NACK-NumRepetitions-r13` parameter in the RRC connection setup message, even if its value should be identical (depending on `npusch_an_n_rep` parameter) to the `ack-NACK-NumRepetitions-Msg4-r13` from the SIB2. Note: this parameter is only useful for UE testing.

two_harq_support

>Optional boolean (default = false). If true, the eNB will use two HARQ processes in UL and DL for UE declaring two HARQ process support (UE category NB2 only). Note that the UE capability should be known at RRC connection establishment so the feature will not be activated during UE initial attach.

two_harq_force

>Optional boolean (default = false). If true, and if two HARQ processes are enabled, the scheduler will use the two HARQ processes, even if it is less efficient than single-HARQ process scheduling.

two_harq_interleaved_dl_ul

>Optional boolean (default = false). If true and if two HARQ processes are enabled, the scheduler will interleave DL and UL transmission if necessary.
>
>Note that this scheduling is very efficient but not compliant with 3GPP specification (see 3GPP TS 36.321 - 5.7).

interf_rnd_support

>Optional boolean (default = false). If true, the eNB will enable the interference randomisation feature for UE declaring its support (release 14 only). Note that the UE capability should be known at RRC connection establishment so the feature will not be activated during UE initial attach. Note that a UE accessing the eNB through NPRACH on a non-anchor carrier will always be configured with interference randomisation.

sr_with_harq

>Optional boolean (default = false). If true, the eNB will enable the sr-WithHARQ-ACK-Config feature for UEs declaring its support (release 15 only). Note that the UE capability should be known at RRC connection establishment so the feature will not be activated during UE initial attach.

sr_grant_size

>Optional integer (range 3-125, default = 11). UL grant size in bytes scheduled after reception of a Scheduling Request from a UE. This parameter is used only if `sr_with_harq` is set to true.

nprach_format2

>Optional array of objects. If set, the eNB will support NPRACH Format 2 and broadcast the relevant configuration in SIB2 via the IE *fmt2-Parameters-r15*.
>
>The array must contain the same number of elements as NPRACH configurations in SIB2 and as `coverage_levels` in the NB cell.
>
>An empty element {} indicates that there is no Format 2 resource for this coverage level.
>
>If at least one parameter is present, a Format 2 resource is defined. Unless stated otherwise, all optional parameters default to the value of the corresponding field in SIB2.
>
>For a correct behaviour, it is mandatory to set specific values for the NPRACH Format 2 resources so that they dont't overlap with the regular NPRACH resources defined in SIB2. It can be done in the time domain by adjusting the `start_time/period` and/or in the frequency domain by adjusting `subcarrier_offset/num_subcarriers`.

>**period** Optional enumeration: 40, 80, 160, 320, 640, 1280, 2560, 5120. NPRACH periodicity in ms.

>**start_time**
>
>>Optional enumeration: 8, 16, 32, 64, 128, 256, 512, 1024. NPRACH start time in ms.

>**subcarrier_offset**
>
>>Enumeration: 0, 36, 72, 108, 6, 54, 102, 42, 78, 90, 12, 24, 48, 84, 60, 18. NPRACH sub-carriers offset, in 1.25 kHz subcarriers

>**num_subcarriers**
>
>>Enumeration: 36, 72, 108, 144. Number of sub-carriers in a NPRACH resource, in 1.25 kHZ subcarriers.

sc_msg3_range_start
> Optional enumeration: 0, 1, 2, 3. Fraction in multiple of 1/3 for calculating the range reserved for indication of multi-tone MSG3 support.

npdcch_num_repetitions
> Optional enumeration: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048. Maximum number of repetitions for NPDCCH common search space for RAR, Msg3 retransmission and Msg4.

npdcch_start_sf_css
> Optional enumeration: 1, 2, 4, 8, 16, 32, 48, 64 Starting subframe configuration for NPDCCH common search space. The value 1 actually conveys the value 1.5 (v1dot5).

npdcch_offset
> Optional enumeration: 0, 1, 2, 3 Fractional period offset of starting subframe for NPDCCH common search space. Expressed in number of eighths.

num_cbra_start_sc
> Optional enumeration: 24, 30, 33, 36, 60, 66, 69, 72, 96, 102, 105, 108, 120, 132, 138, 144. Default is num_subcarriers. The number of 1.25kHz subcarriers from which a UE can randomly select a start subcarrier for contention based random access.

npusch_an_threshold
> Optional float. SNR threshold in dB to filter HARQ ACK/NACK detection in NPUSCH format 2.

subframe_offset
> Optional integer (default = 0). Normally all cells have their subframe number temporally aligned. This parameters adds a cell specific subframe offset.

8.6.6 Non-anchor carriers

non_anchor_list
> Optional array of objects. List of non-anchor carriers for this NB-IoT cell.

> dl_prb   See [NB-IoT frequency setting], page 103. Note that the non-anchor carrier has always the same base LTE cell as the anchor carrier.

> dl_earfcn
> > See [NB-IoT frequency setting], page 103. The center frequency of the non-anchor carrier shall be within a 20 MHz range around the anchor carrier.

> dl_carrier_freq_offset
> > See [NB-IoT frequency setting], page 103.

> ul_prb   See [NB-IoT frequency setting], page 103. If neither ul_prb nor ul_earfcn are provided, the DL/UL separation of the anchor carrier is used, as per 3GPP TS 36.331 chapter 6.7.3.2.

> ul_earfcn
> > See [NB-IoT frequency setting], page 103. If neither ul_prb nor ul_earfcn are provided, the DL/UL separation of the anchor carrier is used, as per 3GPP TS 36.331 chapter 6.7.3.2.

> ul_carrier_freq_offset
> > See [NB-IoT frequency setting], page 103.

operation_mode
> Enumeration: `same_pci`, `diff_pci`, `guardband`, `standalone`. Set the carrier operation mode. If the anchor carrier uses in-band or guard-band operation, non-anchor carrier can only use in-band or guard-band operation. If the anchor uses standalone operation, non-anchor carrier can only operate in standalone mode. See 3GPP TS 36.300 chapter 5.5a.

cell_id   Integer. Range: 0 to 1023. Internal identifier for this carrier. The value should be unique and distinct from the `cell_id` of the other cells (LTE and NB-IoT) and non-anchor carriers.

cell_gain
> Optional float (default = 0). Additional downlink cell gain in dB. Must be between -200 and 0 (included). Note: it is not taken into account to set `SIB2.nrs-Power-r13`.

nrs_power_offset_non_anchor
> Optional enumeration: -12, -10, -8, -6, -4, -2, 0, 3 (default = 0). Power offset in dB between the non-anchor carrier and the anchor carrier.

dl_bitmap
> Optional string: 'anchor, 'no' or a 10/40 bits bitstring (default = 'no'). Defines the DL bitmap pattern to use on the non-anchor carrier.

dl_gap   Optional string: 'anchor', 'no' or 'explicit' (default = 'no'). Defines the DL gap configuration of the non-anchor carrier. If set to 'explicit', the following parameters can be used:

> **dl_gap_threshold**
> > Optional enumeration: 32, 64, 128 or 256 (default = value for anchor carrier if present or 32). Threshold on the maximum number of repetitions configured for NPDCCH before application of DL transmission gap.

> **dl_gap_period**
> > Optional enumeration: 64, 128, 256, 512 (default = value for anchor carrier if present or 64). Periodicity of a DL transmission gap in number of subframes.

> **dl_gap_duration_coeff**
> > Optional enumeration: 1, 2, 3, 4 (default = value for anchor carrier if present or 1) Coefficient to calculate the gap duration of a DL transmission, measured in eighths of `dl_gap_period`.

non_anchor_ue_max
> Optional integer (default = 500). Maximum number of UE to schedule on this non-anchor carrier unless no other non-anchor carriers are available. Non-anchor carriers are filled up in the order of their definition.

nrs_always_on
> Optional boolean (default = `true`). If set to `false`, eNB will turn off the NRS of this non-anchor carrier when no UEs are scheduled on it. In case of in-band operation, the occupied DL and UL PRB become available for scheduling on the base cell.

nprach_support

> Optional boolean (default = `false`). If set to `true`, eNB will add this non-anchor carrier to SIB22 and allow NPRACH access on it. Note that SIB22 scheduling must be configured. See [sib22_nb], page 109. Note that `nprach_prob_anchor_denom` must be different from 1 to effectively allow UEs to use the non-anchor carrier for NPRACH on a given coverage level. NPRACH configuration of the non-anchor carrier is the same as the anchor carrier.

paging_support

> Optional boolean (default = `false`). If set to `true`, eNB will add this non-anchor carrier to SIB22 and use it for paging according to its `paging_weight`, see below. Note that SIB22 scheduling must be configured. See [sib22_nb], page 109. NPDCCH configuration for paging on the non-anchor carrier is the same as the anchor carrier.

paging_weight

> Optional integer. Range 1 to 16 (default = 1). Specifies the paging weight to use for this carrier when `paging_support` is enabled.

anchor_ue_max

> Optional integer (default = 0). Maximum number of UE to schedule on the anchor carrier before using the non-anchor carriers, if at least one non-anchor carrier is defined and if the UE supports multi-carrier. Value 0 means that all the multi-carrier UEs will be scheduled on the non-anchor carriers, if any.

anchor_paging_weight

> Optional integer. Range 0 to 16 (default = 0). Paging weight of the anchor carrier broadcasted in SIB22. A value of 0 means that a UE supporting paging on non-anchor carrier will never be paged on the anchor carrier.

8.6.7 Advanced parameters

rx_epre_in_dbfs

> Optional boolean (default = false). In the logs, the EPRE (Energy Per Resource Element) is displayed in dBm if the RF interface provides its reference receive power and if rx_epre_in_dbfs = false. Otherwise it is displayed in dBFS (Decibels relative to Full Scale).

manual_ref_signal_power

> Optional boolean (default = false). If the RF interface provides its transmit power, then `SIB2.nrs-Power-r13` is automatically set. If manual_ref_signal_power is true, then `SIB2.nrs-Power-r13` is never automatically set by the eNodeB.

rrc_cnx_reject_extWaitTime

> Optional integer. Range: 1 to 1800 (default = 10). Set the wait time in seconds in the RRC connection reject message.

rrc_cnx_release_extWaitTime

> Optional integer. Range: 0 to 1800 (default = 0). RRC connection release extended wait time in seconds.

rrc_cnx_release_extWaitTime_CPdata

> Optional integer. Range: 0 to 1800 (default = 0). RRC connection release extended wait time for Control Plane CIoT EPS optimisation in seconds.

power_npss

> Option float (default = 0 for n_antenna_pbch = 1, -3 for n_antenna_pbch = 2). Set the NPSS power level (in dB) relative to the NRS power level.

power_nsss

>Option float (default = 0 for n_antenna_pbch = 1, -3 for n_antenna_pbch = 2). Set the NSSS power level (in dB) relative to the NRS power level.

force_full_bsr

>Optional boolean (default = false). If true, the eNodeB considers the UE always indicates a full buffer size. Hence the UE is scheduled as often as possible for NPUSCH transmission.

force_dl_schedule

>Optional boolean (default = false). If true, the eNodeB considers there is always DL data waiting for transmission. Hence the UE is scheduled as often as possible for NPDSCH transmission.

rrc_procedure_filter

>Optional object. Allows to define the eNB behavior for a list of RRC procedures. Each property name represents a RRC procedure. The ones currently supported are `rrc_connection_request`, `rrc_connection_reestablishment_request` and `early_data_request`.
>
>Each property value is an object containing the following fields:

>action   Enumeration (`treat` (UE message is processed), `ignore` (UE message is ignored) or `reject` (UE message is rejected))

>ttl   Optional integer. If set, the `reject` of `ignore` filter is applied `ttl` times. If not set, the filter is applied until it is modified.

>By default all procedures are treated.
>
>Example:

```
rrc_procedure_filter: {
    rrc_connection_request: {
        action: "treat"
    },
    rrc_connection_reestablishment_request: {
        action: "reject",
        ttl: 1
    }
}
```

rach_ignore_count

>Optional integer. Indicates how many consecutive RACH attempts are ignored by the eNB.

mac_crnti_ce_ignore_count

>Optional integer. Indicates how many consecutive MAC C-RNTI control elements are ignored by the eNB.

dummy_ue_contention_resolution_id

>Optional boolean. If set to true, a wrong MAC UE Contention Resolution Identity control element will be sent in the Msg4, rather than the one matching the UE Msg3 content.

srb_config

>Optional object. Allows to override some parameters of the default configuration specified in 3GPP TS 36.331 chapter 9.2.1. If unset, the eNB will configure maxRetx-Threshold value to 32, t-PollRetransmit value to 25 s and logicalChannelSR-Prohibit

to true if `logical_channel_sr_prohibit_timer` is not set to 0.
The object contains the following fields:

maxRetxThreshold

>Optional enumeration: 1, 2, 3, 4, 6, 8, 16, 32 (default 32). maxRetx-Threshold value on UE side.

enb_maxRetxThreshold

>Optional enumeration: 1, 2, 3, 4, 6, 8, 16, 32 (default 32). maxRetx-Threshold value on eNB side.

t_PollRetransmit

>Optional enumeration: 250, 500, 1000, 2000, 3000, 4000, 6000, 10000, 15000, 25000, 40000, 60000, 90000, 120000, 180000 (default 25000). t-PollRetransmit timer value in ms on UE side.

enb_t_PollRetransmit

>Optional enumeration: 250, 500, 1000, 2000, 3000, 4000, 6000, 10000, 15000, 25000, 40000, 60000, 90000, 120000, 180000 (default 25000). t-PollRetransmit timer value in ms on eNB side.

logical_channel_sr_prohibit

>Optional boolean (default true if `logical_channel_sr_prohibit_timer` is not set to 0, false otherwise). logicalChannelSR-Prohibit for SRB1/SRB1bis.

t_Reordering

>Optional enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 1600 (default 60). Duration of the t-Reordering timer in ms, applicable only when UE is configured with two HARQ processes.

enableStatusReportSN_Gap

>Optional boolean (default false). enableStatusReportSN-Gap-r13 for SRB1/SRB1bis.

use_periodic_ul_grant

>Optional boolean (default = false). Indicates if periodic UL grant feature must be used for SRB1/SRB1bis. See [periodic_ul_grant NB-IoT cell parameter], page 123.

drb_config

>String. Filename for the DRB configuration. See the file `drb_nb.cfg` to have a description of its fields. Note that the DRB configuration is ignored when Control Plane CIoT optimization is used.

unsupported_qci_fallback

>Optional boolean (default = true). If set to true and if the core network requests the establishment of an unsupported QCI value, the parameters from QCI 9 are used instead. Otherwise the establishment is rejected.

ue_count_max

>Optional integer (default = 500). Maximum number of UEs (for this cell).

erab_count_max

>Optional integer (default = 1500). Maximum number of ERABs (for this cell).

rar_backoff_index

>Optional. Range: -1 to 15. If set to -1, no Backoff Indicator is sent in the Random Access Response message. Values 0 to 15 refer to the index of table 7.2-2 found in 3GPP TS 36.321.

npdcch_uss_half_rb_cce

> Optional Integer (default = 0). Range: 0 to 1. Set the first CCE index used for half RB NPDCCH allocation.

npdsch_fer

> Optional float. Range 0 to 1. Set the simulated NPDSCH Frame Error Rate.

npusch_fer

> Optional float. Range 0 to 1. Set the simulated NPUSCH Frame Error Rate.

test_mode

> Optional object. Enable specific test modes where UE contexts are automatically created when starting the eNodeB. They are only useful when the eNodeB is connected to a specific measurement equipment.
>
> The `type` property selects the test mode:
>
> **npusch**
>
>> Enables continuous reception of NPUSCH by the eNodeB. DCI N0 is transmitted. The following additional properties are available:
>>
>> **rnti**   Integer. Range 0 to 65535. Select the NPUSCH RNTI.
>>
>> **npusch_retx**
>>> Boolean. If false, don't force the UE to retransmit in case of error.
>
> **npdsch**
>
>> Enables continuous transmission of NPDSCH. The NPDSCH payload contains valid data with PDCP packets of constant length. DCI are transmitted. NPUSCH ACK/NACK are received. The following additional properties are available:
>>
>> **rnti**   Integer. Range 0 to 65535. Select the PDSCH RNTI.
>>
>> **npdsch_retx**
>>> Boolean. If false, don't retransmit the unacknowledged NPDSCH (hence NPUSCH ACK/NACK are ignored).
>>
>> **random_data**
>>> Optional boolean (default = false). If true, send random data instead of zeros in the PDCP payload.
>
> **load**
>
>> Creates `ue_count` virtual UEs in connected mode and force bidirectionnal trafic. If `two_harq_support` is set to true in the cell, the UEs allocated on CE level 0 will use two harq processes. The following additional properties are available:
>>
>> **ue_count**   Integer. Number of UEs to instantiate. The upper bound is set to `ue_count_max` value.
>>
>> **random_ce_level**
>>> Optional boolean (default = false). If true, the UEs are affected randomly to the coverage levels defined in the cell. If false, all UEs are affected to CE level 0.
>
> **n_tm**
>
>> Enables transmission based on the NB-IoT Test Model specified in 3GPP TS 36.141-6.1.3:

NPSS/NSSS and NPBCH are transmitted normally.
NPDCCH is transmitted in subframe 1 with content set to 0.
NPDSCH is transmitted in other NB DL subframes, starting with subframe 2, with content set to 0. NPDSCH transmission can be customized with parameters `npdsch_i_tbs` and `npdsch_i_sf` of the first coverage level but NPDSCH transmission cannot be longer than 6 subframes. The additional property `random_data` of this `test_mode` object will set random data instead of zeros in the NPDSCH payload. NPDSCH is scrambled with RNTI=1000.
SIB1 and other SIBs are not transmitted.

`preemptive_ul_grant`

Optional boolean (default = true). When set to true, the eNB can send a DCIN0 grant before the UE explicitly request an allocation via the random access procedure.

`rrc_redirect`

Array of objects. Each object can contain the following properties:

`r13`   [ASN.1 property], page 29. RedirectedCarrierInfo-NB-r13 redirection information. These will define the redirection parameter within RRC Connection Release sent by eNB to the UE (cf 3GPP TS 36.331).
Below is an example of the ASN.1 file content:

```
{
    carrierFreq-r13 2859,
    carrierFreqOffset-r13 v0
}
```

`v1430`   Optional [ASN.1 property], page 29. RedirectedCarrierInfo-NB-v1430 redirection information

`label`   Optional string. Helper available in monitor (`cell`), remote API (`config_get`) and logs.

`channel_dl`

Optional object. Set the cell specific channel simulator configuration. See [Cell specific channel simulator], page 224.

`sib14`   Optional object used to configure the SIB 14. Contains the parameters defined for SIB 14 modification (See [sib14], page 289).
The following additional parameters may be present:

`si_periodicity`

Integer. SI periodicity in Radio Frames.

`si_repetition_pattern`

Integer. The SI is present every `si_repetition_pattern` radio frames.

`si_value_tag`

Optional integer. Range: 0 to 3. Must be present if `si_value_tag_list_enable` is true. Increment modulo 4 if the corresponding SIB is modified.

`si_tb_size`

Optional integer. Values: 7, 15, 26, 32, 41, 55, 69 or 85. Sets the TB size in bytes of this SIB message. If not set, the smallest TB size fitting the message is chosen.

`periodic_ul_grant`

Optional object containing the periodic UL grant configuration.

Once defined, when the UE activates a bearer (either SRB or DRB) with the `use_periodic_ul_grant` parameter set to true, the eNB periodically schedules new UL grants of the size configured in this object without the need for the UE to send a Buffer Status Report. It acts roughly as a UL Semi Persistent Scheduling feature. When used in combination with the `logical_channel_sr_prohibit` parameter, it can prevent the UE from triggering an extra random access procedure to report its BSR and send UL data. It can be useful when the UL traffic pattern is known and you want to avoid the random access procedure overhead.

It contains the following properties:

`periodicity`

Integer. Periodicity in milliseconds.

`size`   Integer. Number of bytes to grant to the UE. Note that the value does not necessarily needs to be high as the UE will also report its Buffer Status Report that will be taken into account by the scheduler.

8.6.8 CP-EDT

`edt`   Optional object. Only applicable to NB-IoT cells.

`cp_edt_support`

Optional boolean (default = false). Indicates if CP-EDT is supported.

`parameters`

Array of 1 to 3 set of EDT parameters. Significant only if CP-EDT is supported.

It corresponds to the EDT specific parameters for each coverage level, and must contain the same number of elements as NPRACH configurations in SIB2 and as `coverage_levels` in the NB cell.

All parameters are optional and default to the value of their non-EDT counterpart (either found in SIB2 or in `coverage_levels`).

For a correct behaviour, it is mandatory to set specific values for the NPRACH resources so that they don't overlap with the non-EDT NPRACH resources. It can be done in the time domain by adjusting the `start_time`/`period` and/or in the frequency domain by adjusting `subcarrier_offset`/`num_subcarriers`.

`edt_tbs`   Optional enumeration: 41, 51, 63, 73, 85, 101, 117, 125. Default value is 125. Largest TBS for Msg3 in bytes.

`msg3_mcs` Optional integer (range 3 to 7). MCS for Msg3 RrcEarlyDataRequest. Default value is 7.

`period`   Optional enumeration: 40, 80, 160, 240, 320, 640, 1280, 2560. NPRACH periodicity in ms.

`start_time`

Optional enumeration: 8, 16, 32, 64, 128, 256, 512, 1024. NPRACH start time in ms.

`subcarrier_offset`

Optional enumeration: 0, 2, 12, 18, 24, 34, 36. NPRACH sub-carriers offset.

num_subcarriers

>Optional enumeration: 12, 24, 36, 48. Number of subcarriers in a NPRACH resource.

sc_msg3_range_start

>Optional enumeration: 0, 1, 2, 3. Fraction in multiple of 1/3 for calculating the starting subcarrier index.

npdcch_num_repetitions

>Optional enumeration: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048. Maximum number of repetitions for NPDCCH common search space for RAR, Msg3 retransmission and Msg4.

npdcch_start_sf_css

>Optional enumeration: 1, 2, 4, 8, 16, 32, 48, 64 Starting subframe configuration for NPDCCH common search space. The value 1 actually conveys the value 1.5 (v1dot5).

npdcch_offset

>Optional enumeration: 0, 1, 2, 3 Fractional period offset of starting subframe for NPDCCH common search space. Expressed in number of eighths.

num_cbra_start_sc

>Optional enumeration: 8, 10, 11, 12, 20, 22, 23, 24, 32, 34, 35, 36, 40, 44, 46, 48. The number of start subcarriers from which a UE can randomly select a start subcarrier.

mac_cr_timer

>Optional enumeration: 1, 2, 3, 4, 8, 16, 32, 64. Timer for contention resolution in number PDCCH periods.

8.6.9 Wake-Up-Signal

wus_config

>Optional object containing the wake up signal configuration.

time_offset

>Optional enumeration: 0, 40, 80, 160, 240 (default = 0). Time offset (in ms) between the end of WUS transmission and beginning of paging occasion. If set to 0, WUS is not activated on the cell.

max_num_rep

>Optional enumeration: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 (default = 2). Maximum number of WUS repetitions (in subframes). Must be less than 0.5 x `npdcch-NumRepetitionPaging-r13` defined in SIB2.

num_po Optional enumeration: 1, 2, 4 (default = 1). Number of consecutive paging occasions mapped to one WUS.

num_drx_cycles_relaxed

>Optional enumeration: 1, 2, 4, 8 (default = 1). Maximum number of consecutive DRX cycles during which the UE may use WUS for synchronisation and skip serving cell measurements.

groups Optional array of objects containing group WUS config (two groups currently supported). If absent, group WUS is not enabled. The length of this array must be equal to 1.

prob_threshold
> Enumeration: 20, 30, 40, 50, 60, 70, 80, 90. Paging probability threshold (in percent), between the two WUS groups.

resources
> Optional enumeration: 1, 2 (default = 1). Number of WUS resources for group WUS.

8.7 NR cell configuration

To configure NR cells, add an array of objects named `nr_cell_list` to your eNB configuration object.

8.7.1 Basic NR cell parameters

cell_id
> Integer (range 0 to 1023, depending on the `gnb_id_bits` value). Internal cell identity. It must be different for each cell configured in the eNB.

band
> Integer or array of integers. NR bands. Use an array in case of multi frequency band list.

dl_nr_arfcn
> Integer. Downlink NR absolute radio frequency channel number. See `https://www.sqimway.com/nr_band.php` to convert between the center frequency and NR-ARFCN.

ul_nr_arfcn
> Optional integer. Uplink NR absolute radio frequency channel number. If not present, the default UL NR ARFCN associated with `dl_nr_arfcn` is configured.

n_antenna_dl
> Enumeration: 1, 2, 4 or 8. Number of DL antennas.

n_antenna_ul
> Enumeration: 1, 2, 4 or 8. Number of UL antennas.

rf_port
> Integer. Selects the RF port used for the NR cell. The number of supported RF ports depends on the radio head. For example, each PCIe card or N210 counts as one RF port.

subcarrier_spacing
> Integer (15, 30, 60, 120). Subcarrier spacing in kHz for the data. Currently the same subcarrier spacing is used for downlink and uplink. Note that 60 Khz is not supported for NR SA cells operating in FR1.

bandwidth
> Integer (3, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100) for frequencies <= 7.125 GHz (FR1) or (50, 100, 200, 400) for frequencies >= 24.25 GHz (FR2). Bandwidth in MHz. The number of downlink and uplink resource blocks is deduced from it.

n_rb_dl
> Optional integer (range 11 to 275). Number of resource blocks for downlink. It is ignored if `bandwidth` is provided.

n_rb_ul
> Optional integer (range 11 to 275) (default = same as n_rb_dl). Number of resource blocks for uplink. By default it is set to `n_rb_dl` value.

n_id_cell
> Integer (range 0 to 1007). NR cell physical cell identity (PCI).

enhanced_channel_raster
> Optional boolean (default = false). Allow release 18 enhanced channel raster.

8.7.2 MAC parameters

`mac_config`

>   Object. MAC configuration. Currently the same for all UEs. The following properties are defined:

>   `msg3_max_harq_tx`

>>   Integer (range 1 to 255). Maximum number of HARQ transmissions for Msg3 PUSCH.

>   `ul_max_harq_tx`

>>   Integer (range 1 to 255). Maximum number of HARQ transmissions for PUSCH.

>   `dl_max_harq_tx`

>>   Integer (range 1 to 255). Maximum number of HARQ transmissions for PDSCH.

>   `ul_max_consecutive_retx`

>>   Integer. Maximum number of UL retransmissions after which the UE is disconnected.

>   `dl_max_consecutive_retx`

>>   Integer. Maximum number of DL retransmissions after which the UE is disconnected.

>   `periodic_bsr_timer`

>>   Enumeration: 1, 5, 10, 16, 20, 32, 40, 64, 80, 128, 160, 320, 640, 1280, 2560, 0. periodicBSR-Timer parameter. 0 means infinity.

>   `retx_bsr_timer`

>>   Enumeration: 10, 20, 40, 80, 160, 320, 640, 1280, 2560, 5120, 10240. retxBSR-Timer parameter.

>   `logical_channel_sr_delay_timer`

>>   Optional enumeration: 20, 40, 64, 128, 512, 1024, 2560. logicalChannelSR-DelayTimer parameter.

>   `periodic_phr_timer`

>>   Enumeration: 10, 20, 50, 100, 200, 500, 1000, 0. phr-PeriodicTimer parameter. 0 means infinity.

>   `prohibit_phr_timer`

>>   Enumeration: 0, 10, 20, 50, 100, 200, 500, 1000. phr-ProhibitTimer parameter.

>   `phr_tx_power_factor_change`

>>   Enumeration: dB1, dB3, dB6, infinity. phr-Tx-PowerFactorChange parameter.

>   `sr_prohibit_timer`

>>   Optional enumeration: 0, 1, 2, 4, 8, 16, 32, 64, 128, 192, 256, 320, 384, 448, 512, 576, 640, 1082. sr-ProhibitTimer parameter. 0 means deactivated. Must be present if `sr_period` is not 0.

>   `sr_trans_max`

>>   Optional enumeration: 4, 8, 16, 32, 64. sr-TransMax parameter. Must be present if `sr_period` is not 0.

tag_id   Optional integer (range 0 to 7, default = 0). Defines a MAC Timing
              Advance Group ID local to the configuration file used to group cells in
              separate timing advance groups. If the UE does not indicate supporting
              enough MAC TAGs in its RRC capabilities, the carrier aggregation
              secondary cells won't have UL added if the maximum number of TAGs
              supported has been reached.
              Note that SCells configured with another `tag_id` than the PCell must
              have the `pdcch_order_prach` parameter set to "cf_given".

time_alignment_tx_timer
              Optional integer from 0 to 10240 (default = 500). Transmit the UL
              time alignment information every `time_alignment_tx_timer` ms. The
              value 0 means infinity.

time_alignment_timer_dedicated
              Optional integer (default = 0). Time alignment timer dedicated. 0
              means infinity. Note: `time_alignment_tx_timer` must be used to set
              the UL time alignment transmission period.

data_inactivity_timer
              Optional integer (default = 0). Value in seconds of the data inactivity
              monitoring timer. 0 means that the timer is deactivated.

drx_config
              Optional object. DRX configuration. The following properties are de-
              fined:

              drx_on_duration_timer_sub_ms
                          Optional integer (range 1 to 31). drx-onDurationTimer pa-
                          rameter in 1/32th ms when the value is less than 1 ms. The
                          value should be a multiple of the DL slot duration. Must
                          be present if `drx_on_duration_timer_ms` is absent.

              drx_on_duration_timer_ms
                          Optional enumeration: 1, 2, 3, 4, 5, 6, 8, 10, 20, 30, 40, 50,
                          60, 80, 100, 200, 300, 400, 500, 600, 800, 1000, 1200, 1600.
                          drx-onDurationTimer parameter in ms when the value is
                          greater or equal than 1 ms. Must be present if `drx_on_`
                          `duration_timer_sub_ms` if absent.

              drx_inactivity_timer
                          Enumeration: 0, 1, 2, 3, 4, 5, 6, 8, 10, 20, 30, 40, 50,
                          60, 80, 100, 200, 300, 500, 750, 1280, 1920, 2560. drx-
                          InactivityTimer parameter, in ms.

              drx_harq_rtt_dl
                          Optional integer (range 0 to 56, default 56). drx-HARQ-
                          RTT-TimerDL parameter in symbols. The value should be
                          a multiple of 14 symbols.

              drx_harq_rtt_ul
                          Optional integer (range 0 to 56, default 56). drx-HARQ-
                          RTT-TimerUL parameter in symbols. The value should be
                          a multiple of 14 symbols.

drx_retransmission_timer_dl

Enumeration: 0, 1, 2, 4, 6, 8, 16, 24, 33, 40, 64, 80, 96, 112, 128, 160, 320. drx-RetransmissionTimerDL parameter, in slots.

drx_retransmission_timer_ul

Enumeration: 0, 1, 2, 4, 6, 8, 16, 24, 33, 40, 64, 80, 96, 112, 128, 160, 320. drx-RetransmissionTimerUL parameter, in slots.

long_drx_cycle

Enumeration: 10, 20, 32, 40, 60, 64, 70, 80, 128, 160, 256, 320, 512, 640, 1024, 1280, 2048, 2560, 5120, 10240. drx-LongCycle parameter, in ms. drx-StartOffset is chosen dynamically per UE, unless `forced_drx_start_offset` is set.

short_drx_cycle

Optional enumeration: 2, 3, 4, 5, 6, 7, 8, 10, 14, 16, 20, 30, 32, 35, 40, 64, 80, 128, 160, 256, 320, 512, 640. drx-ShortCycle parameter, in ms.

drx_short_cycle_timer

Optional integer (range 1 to 16). drx-ShortCycleTimer, in number of short DRX cycles. Must be present if `short_drx_cycle` is present.

forced_drx_start_offset

Optional integer (range -1 to long_drx_cycle, default = -1). If set to a positive value, it will force the drx-StartOffset of all the UEs. Beware that forcing the setting may no longer be compliant with other contraints (gap offset, TDD pattern, ...).

forced_drx_slot_offset

Optional integer (range 0 to $2^{\mu}-1$, default = 0). If `forced_drx_start_offset` is set, this parameter given in slots will force the drx-SlotOffset value, based on the slot duration in 32th of ms.

drx_last_transmission_ul

Optional boolean (default = false). If set and if the UE supports it, drx-LastTransmissionUL-r17 is configured.

enhanced_skip_uplink_tx_dynamic_enabled

Optional boolean (default = false). If set, and if the UE supports it, enhancedSkipUplinkTxDynamic-r16 is activated.

enhanced_skip_uplink_tx_configured_enabled

Optional boolean (default = true). If set, and if the UE supports it, enhancedSkipUplinkTxConfigured-r16 is activated.

8.7.3 RRC parameters

8.7.3.1 MIB/SIB contents

The parameters in this section must be present for a SA cell:

plmn_list

List of objects. List of PLMNs broadcasted by the gNodeB. The total number of PLMNs (identified by a PLMN identity in plmn), SNPNs (identified by a PLMN

identity and a NID in snpn) and PNI-NPNs (identified by a PLMN identity and a CAG-ID in cag_info_list) shall not exceed 12. Each object contains the following properties:

plmn   Optional string or array of strings. PLMN (5 or 6 digits). The array can contain up to 12 PLMNs.

snpn   Optional array of 1 to 12 objects. List of Stand-Alone Non-Public Network.
            Restriction: shall not be present if cag_info_list or plmn is present. Each element contains the following parameters:

    plmn   PLMN string (5 or 6 digits).

    nid_list   Array of NID as defined in 23.003 12.7 Stand-Alone Non-Public Network Identifier an contains the following parameters. Each element contains the following parameters:

        nid_value
                    String (10 hexadecimal digits). NID value.

        assignment_mode
                    Optional enumeration ("self", "coordinated_1", "coordinated_2"). Default value is "self". Each combination of a PLMN and NID identifies a Stand-Alone Non-Public Network.

    network_name
                Optional array of strings. The n-th entry in the array gives the hrnn (human readable network name) of the n-th SNPN in nid_list. The hrnn in the corresponding entry is empty if there is no HRNN associated with the given NPN.

cag_info_list
            Optional array of objects. List of PNI-NPNs with CAG. Restriction: shall not be present if snpn or plmn is present. Each element of the array contains:

    plmn   PLMN string (5 or 6 digits).

    cag_id_list
                Array of 1 to 12 integers (range 0 to 4294967295) giving the CAG-Identifiers.

    network_name
                Optional array of strings. The n-th entry in the array gives the hrnn (human readable network name) of the n-th PNI-NPN in the cag_id_list. The hrnn in the corresponding entry is empty if there is no HRNN associated with the given NPN.

tac   Integer (range 1 to 0xFFFFFF, except 0xFFFFFE). Tracking Area Code of the cell.

ranac   Optional integer (range 0 to 255). If present, sets the RAN Area Code.

reserved   Boolean. True if the cell is reserved for operator use.

nssai   Optional array of objects. List of supported S-NSSAIs.
            Default content is sst: 1 (eMBB).
            Each object will set a S-NSSAI value as defined below:

    sst   Integer (range 0 to 255). Slice Service Type.

sd   Optional integer (range 0 to 0xFFFFFE). Slice Differentia-
                     tor.

cell_barred
       Boolean or string (true, false or "auto"). Value of MIB.cellBarred. If set to "auto",
       the cell is barred when there is no connection with a core network for any of the
       PLMNs broadcast.

intra_freq_reselection
       Boolean. Value of MIB.intraFreqReselection.

q_rx_lev_min
       Integer. Value of SIB1.cellSelectionInfo.q-RxLevMin.

delta_rx_lev_min
       Optional integer (default = 0). Value of SIB1.cellSelectionInfo.q-RxLevMinOffset.
       The value 0 disables the field.

q_qual_min
       Optional integer. Value of SIB1.cellSelectionInfo.q-QualMin.

delta_qual_min
       Optional integer (default = 0). Value of SIB1.cellSelectionInfo.q-QualMinOffset.
       Only applicable when `q_qual_min` is present. The value 0 disables the field.

p_max   Optional integer or array of integers (range -30 to 33 or -127). p-NR-FR1 (in Physi-
                     calCellGroupConfig IE) and p-Max (in FrequencyInfoUL and FrequencyInfoUL-SIB
                     IEs) value in dB. The value -127 means that the parameter is not broadcast. If the
                     object is an array, it should have the same size as the `band` array.

additional_spectrum_emission
       Optional integer or array of integer (range -1 to 39). Additional spectrum emission
       value for the cell. The value -1 means that the parameter is not broadcast. If the
       object is an array, it should have the same size as the `band` array.

sib1_repetition_period
       Optional integer (20, 40, 80 or 160, default = 20). SIB1 repetition period in ms.

sib_sched_list
       Optional array of [ASN.1 property], page 29. Must be present if SIBs other than
       SIB1 should be transmitted. Each object contains the content of one SI scheduling
       slot. Each object contains the following properties:

       filename, content, content_type
              See [ASN.1 property], page 29, `BCCH-DL-SCH-Message` RRC message
              type.

       si_periodicity
              Enumeration: 8, 16, 32, 64, 128, 256, 512. SI periodicity in Radio
              Frames.

       si_value_tag
              Optional integer. Range: 0 to 31 (default = 0). Initial `valueTag` RRC
              field.

       area_scope
              Optional boolean (default = false). `areaScope` RRC field.

si_window_length
       Enumeration: 5, 10, 20, 40, 80, 160, 320, 640, 1280. SI window length in slots. Must
       be present for a SA cell.

bcch_modification_period_coeff

>Optional enumeration: 2, 4, 8, 16 (default = 4). BCCH modification period coefficient.

paging   Optional object containing the paging configuration (PCCH-Config) broadcast in SIB1.

>If absent, all the parameters take their default value.
>
>It contains the following fields:

>**cycle**   Optional enumeration: 32, 64, 128, 256 (default = 128). Default paging cycle, in radio frames.

>**n_frac**   Optional enumeration: 1, 2, 4, 8, 16 (default = 1). Denominator of fraction N/T, ratio of paging frames in the paging cycle.

>**pf_offset**
>>Optional integer: range 0 to **n_frac**-1 (default = 0). Paging frame offset. In TDD, the paging frame must match the start of TDD period.

>**ns**   Optional enumeration: 4, 2, 1 (default = 1). Ns parameter, number of paging occasion inside a paging frame.

>**first_pdcch_mo_of_po**
>>Optional array of integer of size ns. firstPDCCH-MonitoringOccasionOfPO parameter, force the starting position of the PO inside the PF.

>**pei_frame_offset**
>>Optional integer. Range: -1 to 16 (default = -1). pei-FrameOffset parameter. If set to -1, PEI is disabled.

>**pei_n_subgroups**
>>Optional integer. Range: 1 to 8 (default = 1). subgroupsNumPerPO parameter. Number of subgroups used for PEI. Ignored if **pei_frame_offset** is set to -1.

>**n_po_per_pei**
>>Optional integer. Range: 1 to **ns** (default = 1). Must be a power of two. po-NumPerPEI parameter. Number of PO per PEI. Ignored if **pei_frame_offset** is set to -1.

edrx   Optional boolean (default = false). If true, extended idle mode DRX support is activated in the cell, and Hyper Frame Number value is scheduled in SIB1.

uac_barring_info

>Optional object containing the configuration for ASN.1 uac-BarringInfo object in SIB1.
>
>It contains the following fields:

>**info_set_list**
>>Array of objects to configure the UAC-BarringInfoSetList and the UAC-BarringInfoSet-v1700.
>>
>>Each object contains the following fields:

>>**barring_factor**
>>>Enumeration: 0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 90, 95. uac-BarringFactor value.

>>**barring_time**
>>>Enumeration: 4, 8, 16, 32, 64, 128, 256, 512. uac-BarringTime value.

barring_for_access_id
> 7 bits bit string (a string of '0' and '1'). uac-BarringForAccessIdentity value.

ai3_barring_factor
> Optional enumeration: 0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 90, 95. uac-BarringFactorForAI3-r17 value.

for_common_list
> Optional array of objects to configure the uac-BarringForCommon object of type UAC-BarringPerCatList.
> Each object contains the following fields:

access_category
> Integer (range = 1 to 63). accessCategory value.

info_set_index
> Integer (range = 1 to number of items in `info_set_list`). uac-BarringInfoSetIndex value.

per_plmn_list
> Optional array of objects to configure the uac-BarringPerPLMNList. Each object contains the following fields:

plmn_index
> Integer (range = 1 to number of items in the `plmn_list`). plmn-IdentityIndex value.

explicit_barring_list
> Optional array of objects with the same syntax than `for_common_list`. Content of the uac-ExplicitACBarringList. Only one of explicit_barring_list and implicit_barring_list may be present.

implicit_barring_list
> Optional array of 63 `uac_BarringInfoSetIndex`. Content of the uac-ImplicitACBarringList. Only one of explicit_barring_list and implicit_barring_list may be present.

ims_emergency_support
> Optional boolean (default = false). If true, IMS emergency support is advertised in SIB1.

ecall_over_ims_support
> Optional boolean (default = false). If true, IMS emergency support is advertised in SIB1.

timers_and_constants
> Optional object containing the configuration for ASN.1 UE-TimersAndConstants and RLF-TimersAndConstants objects.
> It contains the following fields:

t300 Optional enumeration: 100, 200, 300, 400, 600, 1000, 1500, 2000 (default = 1000). T300 timer value.

t301 Optional enumeration: 100, 200, 300, 400, 600, 1000, 1500, 2000 (default = 1000). T301 timer value.

t310 Optional enumeration: 0, 50, 100, 200, 500, 1000, 2000, 4000, 6000 (default = 1000). T310 timer value. Note that values 4000 and 6000

are only applicable to RLF-TimersAndConstants object, and will be capped to 2000 in the UE-TimersAndConstants object.

n310   Optional enumeration: 1, 2, 3, 4, 6, 8, 10, 20 (default = 1). N310 counter value.

t311   Optional enumeration: 1000, 3000, 5000, 10000, 15000, 20000, 30000 (default = 30000). T311 timer value.

n311   Optional enumeration: 1, 2, 3, 4, 5, 6, 8, 10 (default = 1). N311 counter value.

t319   Optional enumeration: 100, 200, 300, 400, 600, 1000, 1500, 2000 (default = 1000). T319 timer value.

hsdn   Optional boolean (default = false). If true, HSDN cell is advertised in SIB1.

conn_est_failure_control
        Optional object containing the configuration for ASN.1 connEstFailureControl object in SIB1.
        It contains the following fields:

        count   Optional integer (1 to 4). Value of SIB1.connEstFailureControl.connEstFailCount. If not present, connEstFailureControl is not transmitted in SIB1.

        offset_validity
                 Enumeration (30, 60, 12, 240, 300, 420, 600, 900). Value of SIB1.connEstFailureControl.connEstFailOffsetValidity.

        offset   Optional integer (range 0 to 15). Value of SIB1.connEstFailureControl.connEstFailOffset. If not present, connEstFailOffset is not transmitted in SIB1.

idle_mode_measurement_eutra
        Optional boolean (default = false). If true, idleModeMeasurementsEUTRA-r16 is advertized in SIB1.

idle_mode_measurement_nr
        Optional boolean (default = false). If true, idleModeMeasurementsNR-r16 is advertized in SIB1.

pws_max_segment_len
        Optional integer (default = 32). Set the maximum CMAS/ETWS message segment length in bytes, including the WarningAreaCoordinate segment if any. It is needed in order to limit the size of the corresponding SIB messages.

pws_si_periodicity
        Enumeration: 8, 16, 32, 64, 128, 256, 512 (default = 16). Set the periodicity (in frames) of the transmission of the CMAS/ETWS SIB messages

pws_emergency_area_id
        Optional integer (range 0 to 16777215). If set, defines the emergency area identity of the cell for CMAS/ETWS.

sib9   Optional object. If present, the SIB9 message will be scheduled.

        si_periodicity
        si_value_tag
        area_scope
                 It must contain the si_periodicity, si_value_tag and area_scope objects described in sib_sched_list. See [NR sib_sched_list], page 130.

reference_time_info
> Optional boolean (default = false). If true, adds the referenceTimeInfo-r16 IE to SIB9

sib10   Optional object. If present, the SIB10 message will be scheduled if NPN network names are configured in the plmn_list object. It must contain the `si_periodicity`, `si_value_tag` and `area_scope` objects described in `sib_sched_list`. See [NR sib_sched_list], page 130.

sib19   Optional object. If present, the SIB19 message will be scheduled. SIB19 is necessary to enable NTN functionnality in the cell. See [Non Terrestrial Network], page 224. It must contain the `si_periodicity`, `si_value_tag` and `area_scope` objects described in `sib_sched_list`. See [NR sib_sched_list], page 130.

8.7.3.2 Mobility and Measurements

ncell_list
> Optional array of objects. List of neighbour NR or EUTRA cells. Used to convert the physical cell identity and NR SSB ARFCN or EARFCN to a cell identity in case of handover or cell redirection. Each neighbour cell is defined by the following properties. The `cell_id` parameter can be used for cells internal to the gNB to ease the configuration. For cells belonging to another gNB, all the parameters must be set manually.

> rat   Optional enumeration (eutra or nr, default = nr). Radio access technology for this neighbor cell. If set to `eutra` the other properties must match an EUTRA cell description. See [LTE ncell_list], page 48.

> cell_id   Optional integer. `cell_id` as configured in the `nr_cell_list` object entry of the gNB configuration object.

> ssb_nr_arfcn
> > Optional integer. NR ARFCN of the SSB carrier. Must be present if `cell_id` is not set.

> dl_nr_arfcn
> > Optional integer. NR ARFCN of the SSB carrier. Must be present if `cell_id` is not set.

> ul_nr_arfcn
> > Optional integer. NR ARFCN of the SSB carrier. Must be present if `cell_id` is not set.

> n_id_cell
> > Optional integer: 0 to 1007. Physical cell identity. Must be present if `cell_id` is not set.

> gnb_id_bits
> > Optional integer: 22 to 32. gNB ID length in bits. Must be present if `cell_id` is not set.

> plmn   Optional string. PLMN of the Global RAN Node ID and NR Cell Global Identity (5 or 6 digits). The default is the same PLMN as the gNB.

> nr_cell_id
> > Optional integer. 36 bits NR cell identity. Concatenation of `gnb_id` and `cell_id`. Must be present if `cell_id` is not set.

> tac   Optional integer (range 1 to 0xFFFFFF, except 0xFFFFFFE). Tracking area code. Must be present if `cell_id` is not set.

tac_plmn   Optional string. PLMN of the target cell TAI. If not present, the current UE PLMN is used.

band   Optional integer or array of integers. NR bands. Use an array in case of multi frequency band list. Must be present if `cell_id` is not set.

ssb_subcarrier_spacing
Optional enumeration: 15, 30, 120, 240. SSB subcarrier spacing. Must be present if `cell_id` is not set.

ssb_period
Optional enumeration: 5, 10, 20, 40, 80, 160. Periodicity of the SSB. Must be present if `cell_id` is not set.

ssb_offset
Optional integer: 0 to `ssb_period`-1. SSB offset. Must be present if `cell_id` is not set.

ssb_duration
Optional integer: 1 to 5. SSB duration. Must be present if `cell_id` is not set.

reference_location
Optional object. Reference location of the neighbor cell provided via NTN quasi-Earth fixed system. Only used if `band` parameter defines a NTN band. It contains the following parameters:

latitude   Float value. Range -90 to 90. Degrees of latitude.

longitude
Float value. Range -180 to 180. Degrees of longitude.

ssb_rsrp_individual_offset
Optional enumeration: -24, -22, -20, -18, -16, -14, -12, -10, -8, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20, 22 or 24. Individual SSB RSRP offset in dB given to the UE in the Measurement Object for the corresponding cell.

ssb_rsrq_individual_offset
Optional enumeration: -24, -22, -20, -18, -16, -14, -12, -10, -8, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20, 22 or 24. Individual SSB RSRQ offset in dB given to the UE in the Measurement Object for the corresponding cell.

ssb_sinr_individual_offset
Optional enumeration: -24, -22, -20, -18, -16, -14, -12, -10, -8, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20, 22 or 24. Individual SSB SINR offset in dB given to the UE in the Measurement Object for the corresponding cell.

handover_target
Optional boolean (default = true). If set to true, this cell is considered for handover purpose. If set to false, no handover is triggered towards this cell.

conditional_handover_target
Optional boolean (default = false). If set to true, this cell is considered for conditional handover purpose. If set to false, no conditional handover is configured towards this cell. Only one cell should be configured with

true. This parameter is only applicable for cells declared with the `cell_id` parameter.

`cell_redirect_target`

Optional boolean (default = true). If set to true, this cell is considered for redirection purpose. If set to false, no redirection is triggered towards this cell.

`allowed_during_eps_fallback`

Optional boolean (default = false). If set to true, this cell is considered for inter RAT handover or cell redirection during an ongoing EPS fallback procedure

`direct_forwarding_available`

Optional boolean (default = true). Defines if a direct path is available between gNBs or ng-eNBs for user data forwarding during a NGAP handover

`eps_fallback_preferred_method`

Optional enumeration: handover, redirection (default = handover). Set the preferred method for the EPS fallback procedure. If the handover procedure fails a redirection is performed.

`emergency_fallback_preferred_method`

Optional enumeration: handover, redirection (default = redirection). Set the preferred method for the emergency fallback procedure. If the handover procedure fails a redirection is performed.

`meas_config`

Optional [ASN.1 property], page 29. ASN.1 content of the `measConfig` field of the `RRCReconfiguration` message (see 3GPP TS 38.331). It is used to set the parameters of the RRC measurements (not including the measGapConfig IE that must be configured using the `meas_gap_config` object). The first measurement object should correspond to the PCell. If it is absent and if `meas_config_desc` optional object is absent, no `measConfig` field is transmitted to the UEs.

The object can optionally contain a `meas_report_action` array to define an action when receiving a measurement report for an event trigger. An empty array is allowed to ensure no action is performed. If the array is not defined, a handover action is automatically defined for A3 and A5 events.

`meas_report_action`

Optional array. Each object has the following fields:

`report_config_id`

Optional integer (range 1 to 64). Defines the reportConfigId associated with the action. Must be present if `meas_id` is absent.

`meas_id`   Optional integer (range 1 to 64). Defines the measId associated with the action. Must be present if `report_config_id` is absent.

`action`   Optional enumeration (handover, cell_redirect, nr_dc_setup, mr_dc_release). Defines the action triggered when receiving the measurement report.

`meas_config_desc`

Optional object. If present, and if `meas_config` object is not present, the gNB will dynamically build the measurement configuration sent to the UE based on the

content of this object and the list of neighbour cells defined in `ncell_list` object. It will create A1 and A2 events for the serving cell (if inter frequencies neighbour cells exist), and optionally an A3 or A4 or A5 event for each serving and neighbour frequencies. At the beginning, gaps are not activated. When A2 event report is received and if `meas_gap_config` is configured, gaps are activated. When A1 event report is received, gaps are released.

If `nr_handover`, `nr_handover_intra` or `nr_handover_inter` are present, an A3 or A4 or A5 event is defined for handover (for SA) or NR PSCell change (for MR-DC) purpose.

If `nr_handover_location_based` is present and if the UE declares the supporting the eventD1-MeasReportTrigger-r17 NR capability, a D1 event is defined for NTN cells with the `reference_location` parameter set both in the serving cell and neighbour cell definition. In that case no A3 or A4 or A5 event is defined for this neighbour cell.

If `nr_conditional_handover` is present and if the UE declares the supporting the feature, a measurement based and/or a location/time based event are defined for the neighbor cell with `conditional_handover_target` set to true.

If `nr_cell_redirect`, `nr_cell_redirect_intra` or `nr_cell_redirect_inter` are present, an A3 or A4 or A5 event is defined for cell redirection purpose.

An extra A2 event can be added to release EN-DC or NR-DC configuration.

If `scell_config` is present with A2/A4 events and if some cells are defined in `scell_list` with `rrc_configuration=measurement` (see [scell_list_nr], page 151), the gNB will also define A2 and A4 events respectively for SCell release and addition and gaps will always be activated.

If `scell_config` is present with an A6 event and if some cells are defined in `scell_list` with `a6_candidates` (see [scell_list], page 85), the gNB will also define an A6 event for SCell handover.

If `nr_periodical` is present, a periodical measurement report is defined for the NR primary cell, and optionally inter frequency neighbor cells.

If EUTRA cells are defined in the `ncell_list` array, inter RAT B1 and B2 events can be defined to trigger a cell redirection during the RRC release procedure when `eutra_cell_redirect` is set, or a handover when `eutra_handover` is set.

If `eutra_periodical` is present, a periodical measurement report is defined for each EUTRA cell defined in `ncell_list` object.

This object contains the following fields:

`a1_report_type`
> Enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A1 report.

`a1_rsrp`   Integer, range from -156 to -30. RSRP threshold value in dBm. Used if `a1_report_type` is set to rsrp.

`a1_rsrq`   Integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. Used if `a1_report_type` is set to rsrq.

`a1_sinr`   Integer, range from -46 to 81. SINR threshold value in 0.5dB steps. Used if `a1_report_type` is set to sinr.

`a1_hysteresis`
> Integer, range from 0 to 30. A2 hysteresis in 0.5dB steps used for the measurement report triggering condition.

`a1_time_to_trigger`
> Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A1 event condition must be met before triggering the measurement report.

`a2_report_type`
> Enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A2 report.

`a2_rsrp`   Integer, range from -156 to -30. RSRP threshold value in dBm. Used if `a2_report_type` is set to rsrp.

`a2_rsrq`   Integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. Used if `a2_report_type` is set to rsrq.

`a2_sinr`   Integer, range from -46 to 81. SINR threshold value in 0.5dB steps. Used if `a2_report_type` is set to sinr.

`a2_hysteresis`
> Integer, range from 0 to 30. A2 hysteresis in 0.5dB steps used for the measurement report triggering condition.

`a2_time_to_trigger`
> Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A2 event condition must be met before triggering the measurement report.

`nr_handover`
> Optional object used to describe the A3, A4 or A5 reporting criteria for intra and inter frequency handover. If `nr_handover_intra` or `nr_handover_inter` objects are present, it is ignored. It contains the following fields:

> > `a3_report_type`
> > > Optional enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A3 report. If set, `a4_threshold_rsrp`, `a4_threshold_rsrq`, `a4_threshold_sinr`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold1_sinr`, `a5_threshold2_rsrp`, `a5_threshold2_rsrq` and `a5_threshold2_sinr` are ignored.

> > `a3_offset`
> > > Optional integer, range from -30 to 30. A3 offset in 0.5dB steps used for the measurement report triggering condition. Must be present if `a3_report_type` is set.

> > `a4_threshold_rsrp`
> > > Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrq`, `a4_threshold_sinr`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold1_sinr`, `a5_threshold2_rsrp`, `a5_threshold2_rsrq` and `a5_threshold2_sinr` are ignored.

> > `a4_threshold_rsrq`
> > > Optional integer, from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`,

a3_offset, a4_threshold_rsrp, a4_threshold_ sinr, a5_threshold1_rsrp, a5_threshold1_rsrq, a5_threshold1_sinr, a5_threshold2_rsrp, a5_ threshold2_rsrq and a5_threshold2_sinr are ignored.

a4_threshold_sinr
> Optional integer, from -46 to 81. SINR threshold value in 0.5dB steps. If set, a3_report_type, a3_offset, a4_threshold_rsrp, a4_threshold_ rsrq, a5_threshold1_rsrp, a5_threshold1_rsrq, a5_threshold1_sinr, a5_threshold2_rsrp, a5_ threshold2_rsrq and a5_threshold2_sinr are ignored.

a5_threshold1_rsrp
> Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, a3_report_type, a3_offset, a4_threshold_rsrp, a4_threshold_rsrq, a4_threshold_ sinr, a5_threshold1_rsrq and a5_threshold1_sinr are ignored.

a5_threshold1_rsrq
> Optional integer, from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, a3_report_type, a3_offset, a4_threshold_rsrp, a4_threshold_rsrq, a4_threshold_sinr, a5_threshold1_rsrp and a5_threshold1_sinr are ignored.

a5_threshold1_sinr
> Optional integer, from -46 to 81. SINR threshold value in 0.5dB steps. If set, a3_report_type, a3_offset, a4_threshold_rsrp, a4_threshold_rsrq, a4_threshold_sinr, a5_threshold1_rsrp and a5_threshold1_rsrq are ignored.

a5_threshold2_rsrp
> Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, a3_report_type, a3_offset, a4_threshold_rsrp, a4_threshold_rsrq, a4_threshold_ sinr, a5_threshold2_rsrq and a5_threshold2_sinr are ignored.

a5_threshold2_rsrq
> Optional integer, from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, a3_report_type, a3_offset, a4_threshold_rsrp, a4_threshold_rsrq, a4_threshold_sinr, a5_threshold2_rsrp and a5_threshold2_sinr are ignored.

a5_threshold2_sinr
> Optional integer, from -46 to 81. SINR threshold value in 0.5dB steps. If set, a3_report_type, a3_offset, a4_threshold_rsrp, a4_threshold_rsrq, a4_threshold_sinr, a5_threshold2_rsrp and a5_threshold2_rsrq are ignored.

hysteresis

>Integer, range from 0 to 30. A3/A4/A5 hysteresis in 0.5dB steps used for the measurement report triggering condition. is set.

time_to_trigger

>Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A3/A4/A5 event condition must be met before triggering the measurement report.

nr_handover_intra

Optional object used to describe the A3, A4 or A5 reporting criteria for intra frequency handover. It contains the same fields as `nr_handover` object. See [nr_handover], page 138,

nr_handover_inter

Optional object used to describe the A3, A4 or A5 reporting criteria for inter frequency handover. It contains the same fields as `nr_handover` object. See [nr_handover], page 138,

nr_handover_location_based

Optional object used to describe the D1 reporting criteria for handover. It contains the following fields:

distance_threshold_from_ref1

>Integer, range from 0 to 65525. Distance from reference location 1 in 50m steps.

distance_threshold_from_ref2

>Integer, range from 0 to 65525. Distance from reference location 2 in 50m steps.

hysteresis

>Integer, range from 0 to 32768. D1 hysteresis in 10m steps used for the measurement report triggering condition.

time_to_trigger

>Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the D1 event condition must be met before triggering the measurement report.

nr_conditional_handover

Optional object used to describe the conditional handover configuration. It contains the following fields:

activation_trigger

>Optional object. If present, an A2 or D1 event is defined to delay the conditional handover configuration to the UE. If it is not present, the configuration is sent as soon as the UE capabilities are retrieved. It contains the following fields:

a2_report_type

>>Optional enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A2 report. Must be present for an A2 event.

a2_rsrp   Optional integer, range from -156 to -30. RSRP
              threshold value in dBm. Used if `a2_report_type` is set to rsrp. Must be present for an A2
              event.

a2_rsrq   Optional integer, range from -87 to 40. RSRQ
              threshold value in 0.5dB steps. Used if `a2_report_type` is set to rsrq. Must be present
              for an A2 event.

a2_sinr   Optional integer, range from -46 to 81. SINR
              threshold value in 0.5dB steps. Used if `a2_report_type` is set to sinr. Must be present
              for an A2 event.

a2_hysteresis

              Optional integer, range from 0 to 30. A2 hysteresis in 0.5dB steps used for the measurement
              report triggering condition. Must be present for
              an A2 event.

a2_time_to_trigger

              Optional enumeration: 0, 40, 64, 80, 100, 128,
              160, 256, 320, 480, 512, 640, 1024, 1280, 2560
              or 5120. Time in ms during which the A2 event
              condition must be met before triggering the
              measurement report. Must be present for an
              A2 event.

distance_threshold_from_ref1

              Optional integer, range from 0 to 65525. Distance from reference location 1 in 50m steps.
              Must be present for a D1 event.

distance_threshold_from_ref2

              Optional integer, range from 0 to 65525. Distance from reference location 2 in 50m steps.
              Must be present for a D1 event.

hysteresis

              Optional integer, range from 0 to 32768. D1
              hysteresis in 10m steps used for the measurement report triggering condition. Must be
              present for a D1 event.

time_to_trigger

              Optional enumeration: 0, 40, 64, 80, 100, 128,
              160, 256, 320, 480, 512, 640, 1024, 1280, 2560
              or 5120. Time in ms during which the D1 event
              condition must be met before triggering the
              measurement report. Must be present for a D1
              event.

measurement_trigger

              Optional object defining a measurement based condition.
              It contains the same fields as `nr_handover` object. See
              [nr_handover], page 138. Note that an A4 event can only
              be defined in a NTN cell.

location_or_time_trigger

Optional object defining a location or time based condition. It contains the following fields:

distance_threshold_from_ref1

Optional integer, range from 0 to 65525. Distance from reference location 1 in 50m steps. Must be present for a D1 event.

distance_threshold_from_ref2

Optional integer, range from 0 to 65525. Distance from reference location 2 in 50m steps. Must be present for a D1 event.

hysteresis

Optional integer, range from 0 to 32768. D1 hysteresis in 10m steps used for the measurement report triggering condition. Must be present for a D1 event.

time_to_trigger

Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the D1 event condition must be met before triggering the measurement report. Must be present for a D1 event.

time_threshold

Optional string, format "below_elevation" or "YYYY-MM-DDTHH:MM:SS[.mmm]". UTC time for the T1 event entering condition. Must be present for a T1 event. If set to "below_elevation", the UTC time sent in the report configuration is the time where the current serving cell satellite elevation is below the `time_satellite_elevation` parameter.

time_satellite_elevation

Optional integer, range from 10 to 80. Defines the serving cell satellite elevation that will be used to compute the T1 event threshold when `time_threshold` is set to "below_elevation".

time_duration

Optional integer, range from 0 to 6000. Time used to define the T1 event leaving condition in 100ms steps. Must be present for a T1 event.

single_trigger_allowed

Optional boolean, default = false. Indicates if the gNB can configure a location or time based condition only if supported by the UE.

nr_cell_redirect

Optional object used to describe the A3, A4 or A5 reporting criteria for intra and inter frequency cell redirection. If `nr_cell_redirect_`

`intra` or `nr_cell_redirect_inter` objects are present, it is ignored. It contains the following fields:

`a3_report_type`

>Optional enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A3 report. If set, `a4_threshold_rsrp`, `a4_threshold_rsrq`, `a4_threshold_sinr`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold1_sinr`, `a5_threshold2_rsrp`, `a5_threshold2_rsrq` and `a5_threshold2_sinr` are ignored.

`a3_offset`

>Optional integer, range from -30 to 30. A3 offset in 0.5dB steps used for the measurement report triggering condition. Must be present if `a3_report_type` is set.

`a4_threshold_rsrp`

>Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrq`, `a4_threshold_sinr`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold1_sinr`, `a5_threshold2_rsrp`, `a5_threshold2_rsrq` and `a5_threshold2_sinr` are ignored.

`a4_threshold_rsrq`

>Optional integer, from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_sinr`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold1_sinr`, `a5_threshold2_rsrp`, `a5_threshold2_rsrq` and `a5_threshold2_sinr` are ignored.

`a4_threshold_sinr`

>Optional integer, from -46 to 81. SINR threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq`, `a5_threshold1_rsrp`, `a5_threshold1_rsrq`, `a5_threshold1_sinr`, `a5_threshold2_rsrp`, `a5_threshold2_rsrq` and `a5_threshold2_sinr` are ignored.

`a5_threshold1_rsrp`

>Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq`, `a4_threshold_sinr`, `a5_threshold1_rsrq` and `a5_threshold1_sinr` are ignored.

`a5_threshold1_rsrq`

>Optional integer, from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `a3_report_type`, `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq`,

> > `a4_threshold_sinr`, `a5_threshold1_rsrp` and
> > `a5_threshold1_sinr` are ignored.

> `a5_threshold1_sinr`
> > Optional integer, from -46 to 81. SINR threshold
> > value in 0.5dB steps. If set, `a3_report_type`,
> > `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq`,
> > `a4_threshold_sinr`, `a5_threshold1_rsrp` and
> > `a5_threshold1_rsrq` are ignored.

> `a5_threshold2_rsrp`
> > Optional integer, range from -156 to -30. RSRP thresh-
> > old value in dBm. If set, `a3_report_type`, `a3_offset`,
> > `a4_threshold_rsrp`, `a4_threshold_rsrq`, `a4_threshold_`
> > `sinr`, `a5_threshold2_rsrq` and `a5_threshold2_sinr` are
> > ignored.

> `a5_threshold2_rsrq`
> > Optional integer, from -87 to 40. RSRQ threshold
> > value in 0.5dB steps. If set, `a3_report_type`,
> > `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq`,
> > `a4_threshold_sinr`, `a5_threshold2_rsrp` and
> > `a5_threshold2_sinr` are ignored.

> `a5_threshold2_sinr`
> > Optional integer, from -46 to 81. SINR threshold
> > value in 0.5dB steps. If set, `a3_report_type`,
> > `a3_offset`, `a4_threshold_rsrp`, `a4_threshold_rsrq`,
> > `a4_threshold_sinr`, `a5_threshold2_rsrp` and
> > `a5_threshold2_rsrq` are ignored.

> `hysteresis`
> > Integer, range from 0 to 30. A3/A4/A5 hysteresis in 0.5dB
> > steps used for the measurement report triggering condition.
> > is set.

> `time_to_trigger`
> > Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480,
> > 512, 640, 1024, 1280, 2560 or 5120. Time in ms during
> > which the A3/A4/A5 event condition must be met before
> > triggering the measurement report.

`nr_cell_redirect_intra`
> Optional object used to describe the A3, A4 or A5 reporting criteria for
> intra frequency cell redirection. It contains the same fields as `nr_cell_`
> `redirect` object. See [nr_cell_redirect], page 142,

`nr_cell_redirect_inter`
> Optional object used to describe the A3, A4 or A5 reporting criteria for
> inter frequency cell redirection. It contains the same fields as `nr_cell_`
> `redirect` object. See [nr_cell_redirect], page 142,

`ssb_rsrp_filter_coeff`
> Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19
> (default = 4). Coefficient used for the SSB RSRP layer 3 filtering done
> in RRC (see 3GPP TS 38.331 chapter 5.5.3.2 for details).

ssb_rsrq_filter_coeff

> Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19 (default = 4). Coefficient used for the SSB RSRQ layer 3 filtering done in RRC (see 3GPP TS 38.331 chapter 5.5.3.2 for details).

ssb_sinr_filter_coeff

> Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19 (default = 4). Coefficient used for the SSB SINR layer 3 filtering done in RRC (see 3GPP TS 38.331 chapter 5.5.3.2 for details).

s_measure

> Optional object. Defines the s-MeasureConfig parameters. It contains the following fields:

> **type**   Enumeration (ssb or csi). RSRP measurement type.

> **threshold**
> > Integer (range -156 to -29). RSRP threshold in dBm. -29 means infinity.

scell_config

> Optional object used to describe the A2, A4 and A6 reporting criteria for SCell release/addition and handover. It contains the following fields:

> **a2_report_type**
> > Optional enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A2 report. Must be present if **a4_report_type** is set.

> **a2_rsrp**   Optional integer, range from -156 to -30. RSRP threshold value in dBm. Used if **a2_report_type** is set to rsrp.

> **a2_rsrq**   Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. Used if **a2_report_type** is set to rsrq.

> **a2_sinr**   Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps. Used if **a2_report_type** is set to sinr.

> **a2_hysteresis**
> > Optional integer, range from 0 to 30. A2 hysteresis in 0.5dB steps used for the measurement report triggering condition. Must be present if **a2_report_type** is set.

> **a2_time_to_trigger**
> > Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A2 event condition must be met before triggering the measurement report. Must be present if **a2_report_type** is set.

> **a4_report_type**
> > Optional enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A4 report.

> **a4_rsrp**   Optional integer, range from -156 to -30. RSRP threshold value in dBm. Used if **a4_report_type** is set to rsrp.

a4_rsrq   Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. Used if `a4_report_type` is set to rsrq.

a4_sinr   Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps. Used if `a4_report_type` is set to sinr.

a4_hysteresis

Optional integer, range from 0 to 30. A4 hysteresis in 0.5dB steps used for the measurement report triggering condition. Must be present if `a4_report_type` is set.

a4_time_to_trigger

Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A4 event condition must be met before triggering the measurement report. Must be present if `a4_report_type` is set.

gaps_required

Optional boolean (default = true). If set to true, the gNB will activate measurement gaps if there is at least one cell with measurement-based scell addition in `scell_list`.

a6_report_type

Optional enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A6 report.

a6_offset

Optional integer, range from -30 to 30. A6 offset in 0.5dB steps used for the measurement report triggering condition. Must be present if `a6_report_type` is set.

a6_hysteresis

Integer, range from 0 to 30. A6 hysteresis in 0.5dB steps used for the measurement report triggering condition. Must be present if `a6_report_type` is set.

a6_time_to_trigger

Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A6 event condition must be met before triggering the measurement report. Must be present if `a6_report_type` is set.

nr_periodical

Optional object used to describe a NR periodical measurement report. It contains the following fields:

report_interval

Enumeration: ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240, min1, min6, min12, min30. Interval between each measurement report.

report_amount

Enumeration: 1, 2, 4, 8, 16, 32, 64, infinity. Number of measurement reports.

report_quantity_rsrp

> Boolean. Report RSRP quantity.

report_quantity_rsrq

> Boolean. Report RSRQ quantity.

report_quantity_sinr

> Boolean. Report SINR quantity.

max_report_cells

> Integer (range 1 to 8). Maximum number of cells reported.

measure_neighbor_cells

> Boolean. Defines if a measurement report must be configured for inter frequency neighbor cells on top of the primary cell.

eutra_cell_redirect

Optional object. If set, it defines a B1 or B2 event for EUTRA cell redirection procedure. It contains the following fields:

b1_threshold_rsrp

> Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `b1_threshold_rsrq`, `b1_threshold_sinr`, `b2_threshold1_rsrp`, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b1_threshold_rsrq

> Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `b1_threshold_sinr`, `b2_threshold1_rsrp`, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b1_threshold_sinr

> Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps. If set, `b2_threshold1_rsrp`, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b2_threshold1_rsrp

> Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b2_threshold1_rsrq

> Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `b2_threshold1_sinr` is ignored.

b2_threshold1_sinr

> Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps.

b2_threshold2_rsrp

> Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `b2_threshold2_rsrq` and `b2_threshold2_sinr` are ignored.

b2_threshold2_rsrq

> Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `b2_threshold2_sinr` is ignored.

b2_threshold2_sinr

>   Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps.

hysteresis

>   Integer, range from 0 to 30. B1 or B2 hysteresis in 0.5dB steps.

time_to_trigger

>   Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the B1 or B2 event condition must be met before triggering the measurement report.

eutra_handover

Optional object. If set, it defines a B1 or B2 event for EUTRA handover procedure. It contains the following fields:

b1_threshold_rsrp

>   Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `b1_threshold_rsrq`, `b1_threshold_sinr`, `b2_threshold1_rsrp`, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b1_threshold_rsrq

>   Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `b1_threshold_sinr`, `b2_threshold1_rsrp`, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b1_threshold_sinr

>   Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps. If set, `b2_threshold1_rsrp`, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b2_threshold1_rsrp

>   Optional integer, range from -156 to -30. RSRP threshold value in dBm. If set, `b2_threshold1_rsrq` and `b2_threshold1_sinr` are ignored.

b2_threshold1_rsrq

>   Optional integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. If set, `b2_threshold1_sinr` is ignored.

b2_threshold1_sinr

>   Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps.

b2_threshold2_rsrp

>   Optional integer, range from -140 to -43. RSRP threshold value in dBm. If set, `b2_threshold2_rsrq` and `b2_threshold2_sinr` are ignored.

b2_threshold2_rsrq

>   Optional integer, range from -40 to -6. RSRQ threshold value in 0.5dB steps. If set, `b2_threshold2_sinr` is ignored.

b2_threshold2_sinr
> Optional integer, range from -46 to 81. SINR threshold value in 0.5dB steps.

hysteresis
> Integer, range from 0 to 30. B1 or B2 hysteresis in 0.5dB steps.

time_to_trigger
> Optional enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the B1 or B2 event condition must be met before triggering the measurement report.

eutra_periodical
> Optional object used to describe an EUTRA periodical measurement report. It contains the following fields:

report_interval
> Enumeration: ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240, min1, min6, min12, min30. Interval between each measurement report.

report_amount
> Enumeration: 1, 2, 4, 8, 16, 32, 64, infinity. Number of measurement reports.

report_quantity_rsrp
> Boolean. Report RSRP quantity.

report_quantity_rsrq
> Boolean. Report RSRQ quantity.

report_quantity_sinr
> Boolean. Report SINR quantity.

max_report_cells
> Integer (range 1 to 8). Maximum number of cells reported.

measure_neighbor_cells
> Boolean. Defines if a measurement report must be configured for inter frequency neighbor cells on top of the primary cell.

eutra_rsrp_filter_coeff
> Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19 (default = 4). Coefficient used for the RSRP layer 3 filtering done in RRC (see 3GPP TS 38.331 chapter 5.5.3.2 for details).

eutra_rsrq_filter_coeff
> Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19 (default = 4). Coefficient used for the RSRQ layer 3 filtering done in RRC (see 3GPP TS 38.331 chapter 5.5.3.2 for details).

eutra_sinr_filter_coeff
> Optional enumeration: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17 or 19 (default = 4). Coefficient used for the SINR layer 3 filtering done in RRC (see 3GPP TS 38.331 chapter 5.5.3.2 for details).

nr_dc_setup

>Optional object. If set, it defines an A4 event to trigger NR-DC activation. It contains the following fields:

>>**a4_report_type**
>>>Enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A4 report.

>>**a4_rsrp**   Integer, range from -156 to -30. RSRP threshold value in dBm. Used if `a4_report_type` is set to rsrp.

>>**a4_rsrq**   Integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. Used if `a4_report_type` is set to rsrq.

>>**a4_sinr**   Integer, range from -46 to 81. SINR threshold value in 0.5dB steps. Used if `a4_report_type` is set to sinr.

>>**a4_hysteresis**
>>>Integer, range from 0 to 30. A4 hysteresis in 0.5dB steps used for the measurement report triggering condition.

>>**a4_time_to_trigger**
>>>Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A4 event condition must be met before triggering the measurement report.

mr_dc_release

>Optional object. Defines the A2 event configuration for the EN-DC or NR-DC release trigger. This object contains the following fields:

>>**a2_report_type**
>>>Enumeration, rsrp, rsrq or sinr. Defines the measurement type requested for the A2 report.

>>**a2_rsrp**   Integer, range from -156 to -30. RSRP threshold value in dBm. Used if `a2_report_type` is set to rsrp.

>>**a2_rsrq**   Integer, range from -87 to 40. RSRQ threshold value in 0.5dB steps. Used if `a2_report_type` is set to rsrq.

>>**a2_sinr**   Integer, range from -46 to 81. SINR threshold value in 0.5dB steps. Used if `a2_report_type` is set to sinr.

>>**a2_hysteresis**
>>>Integer, range from 0 to 30. A2 hysteresis in 0.5dB steps used for the measurement report triggering condition.

>>**a2_time_to_trigger**
>>>Enumeration: 0, 40, 64, 80, 100, 128, 160, 256, 320, 480, 512, 640, 1024, 1280, 2560 or 5120. Time in ms during which the A2 event condition must be met before triggering the measurement report.

meas_gap_config

>Optional object allowing to configure gaps for a SA UE (MR-DC UE uses the measurement gap configuration coming from MCG). If the object it not present, no measurement gap is defined.
>It contains the following fields:

pattern_id

Integer, range 0 to 23. Measurement gap pattern identity as defined in 3GPP TS 38.133 table 9.1.2-1.

use_gap_fr

Optional boolean (default = false). If set to true, the gNB tries to use gapFR1 or gapFR2 instead of gapUE if the UE is having only FR1 or FR2 serving and neighbor cells and is not using NR-DC.

forced_meas_gap_offset

Optional integer. Forces the gap offset sent to the UE in the GapConfig ASN.1 object. -1 means that the gNB allocates the value automatically.

ho_from_meas

Optional boolean (default = true). If true, when `meas_config` is used the gNodeB triggers a handover (for SA) or a NR PSCell change (for MR-DC) when a measurement event with `action` set to "handover" is received from the UE; when `meas_config_desc` is used the gNodeB triggers a handover or NR PSCell change when the event defined in `nr_handover`, `nr_handover_intra` or `nr_handover_inter` is reported. It is also used for the event defined in `eutra_handover` triggering an inter RAT handover towards a LTE cell.

reconf_sync_cfra

Optional boolean (default = false). If true, any reconfiguration with sync towards this cell (e.g SCG configuration in MR-DC or handover in SA) will use contention-free random access if there is a contention-free preamble still available.

ho_force_full_config

Optional boolean (default = false). If true, any handover towards this cell will use full configuration.

ho_continue_rohc_context

Optional boolean (default = false). If true, and if the UE supports the feature, the RoHC contexts are not reset during an intra gNB handover towards this cell.

t304   Optional enumeration: 50, 100, 150, 200, 500, 1000, 2000, 10000 (default = 1000). T304 timer for reconfiguration with sync.

sib1_delivery_during_ho

Optional boolean (default = false). If set to true, the target cell SIB1 is sent in the RRC reconfiguration with sync message.

8.7.3.3 Carrier Aggregation

scell_list

Optional array of objects. List the cells of the same gNB which can be used for carrier aggregation. There is no restriction concerning TDD/FDD mode, UL/DL configuration or subcarrier spacing across the serving cells. Each object contains the following fields:

cell_id   Range: 0 to 1023 (depending on the `gnb_id_bits` value). Cell identifier

ul_allowed

Optional boolean (default = false). If true, enable uplink for this serving cell for PUSCH only. PUCCH on SCell is not supported.

rrc_configuration

Optional enumeration: `initial`, `measurement` or `api_only` (default = `initial`). Desscribes the conditions under which the SCell is configured.

If set to `initial`, the SCell is added right away after the RRC connection establishment.

If set to `measurement`, the SCell can be dynamically added and released based on measurement reports configured in the `scell_config` element of the `meas_config_desc` object, see [meas_config_desc_nr], page 136.

If set to `api_only`, the SCell can only be added through the `rrc_cnx_reconf` API, see [rrc_cnx_reconf], page 281.

Note that the `rrc_cnx_reconf` API can still add or release any SCell irrespective of its `rrc_configuration` value.

individual_offset

Optional integer, in dB. Relevant only when `rrc_configuration` is set to `measurement`. Individual offset used in A4 criteria evaluation for SCell addition.

a6_candidates

Optional array of integers. Defines the list of intra frequency cells candidates for SCell handover. Each entry of the array contains the `cell_id` value of the target cell that must also be defined in `scell_list` array.

scells_activation

Optional enumeration: `mac_ce`, `direct` or `off` (default = `mac_ce`). Selects how the gNB activates the secondary cells once they are configured. When `off` is selected, cells won't be activated unless an API call to `scells_act_deact` is performed. When `mac_ce` is selected, all the SCells are activated right after their configuration using the MAC control element. When `direct` is selected, all the SCells are activated during their configuration using RRC signalling if the feature is supported by the UE. Otherwise it uses the MAC control element.

nr_dc_scg_cell_list

Optional array of objects. Defines the list of other NR cells that can be used by the current NR cell for NR-DC (similar to the scell_list array).

Each objet must contain the following parameters:

cell_id   Integer. cell_id as configured in the `nr_cell_list` object entry of the gNB configuration object.

8.7.3.4 Radio bearers

srb_config

Optional array of objects. Allows to override some parameters of the default configuration specified in 3GPP TS 38.331 chapter 9.2.1.

Each object contains the following fields:

id   Integer: 1, 2 or 3. Contains the SRB identity.

t_PollRetransmit

Optional enumeration: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 2000, 4000 (default 45). t-PollRetransmit timer value in ms.

pollPDU   Optional enumeration: 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 6144, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 40960, 49152, 57344, 65536, 0 (default 0). pollPDU parameter. 0 means infinity.

pollByte   Optional enumeration: 1, 2, 5, 8, 10, 15, 25, 50, 75, 100, 125, 250, 375,
             500, 750, 1000, 1250, 1500, 2000, 3000, 4000, 4500, 5000, 5500, 6000,
             6500, 7000, 7500, 8000, 9000, 10000, 11000, 12000, 13000, 14000, 15000,
             16000, 17000, 18000, 20000, 25000, 30000, 40000, 0 (default 0). pollByte
             parameter in kBytes. 0 means infinity.

maxRetxThreshold
             Optional enumeration: 1, 2, 3, 4, 6, 8, 16, 32 (default 8). maxRetx-
             Threshold value.

t_Reassembly
             Optional enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65,
             70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190,
             200, 210, 220, 340, 350, 550, 1100, 1650, 2200 (default 35). t-Reassembly
             timer value in ms.

t_StatusProhibit
             Optional enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65,
             70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145,
             150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220,
             225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 1200,
             1600, 2000, 2400 (default 0). Duration of the t-StatusProhibit timer in
             ms.

sdt_allowed
             Optional boolean (default = false). If set to true, and if the UE supports
             SDT for SRBs, SRB2 will be configured for SDT upon the suspension
             of the RRC connection. See [rrc_inactive], page 159. Only applicable to
             SRB2.

drb_config
        String or Array. Array of objects containing the DRB configuration for each
        QCI/5QI value. There must be at least one definition for QCI = 9 which is the
        default QCI/5QI. If a string is given, the array is read from the corresponding
        filename. If must contain the following parameters.

        qci   Integer (range 0 to 255). QCI/5QI value.

        use_for_mr_dc_scg
                     Optional boolean (default = true). If set to false, this QCI/5QI value
                     is not used for the SCG of a MR-DC UE.

        ims_dedicated_bearer
                     Optional boolean (default = false). If set to true, it indicates that this
                     QCI/5QI is used for IMS dedicated bearers (VoNR, ...)

        trigger_eps_fallback
                     Optional boolean (default = false). If set to true and if EPS fallback
                     is indicated as supported by the 5GC, trying to establish this 5QI will
                     trigger an EPS fallback procedure.
                     Note that an EPS fallback procedure is also triggered if the UE does
                     not declare supporting voice over NR in its NR capability and the 5QI
                     has ims_dedicated_bearer set to true.

        pdcp_config
                     Object. PDCP configuration. It must contain the following parameters.

discardTimer

Enumeration: 10, 20, 30, 40, 50, 60, 75, 100, 150, 200, 250, 300, 500, 750, 1500, 2000 or 0. Duration of the discard timer in ms. 0 means infinity.

discardTimerExt_r16

Optional enumeration: 0.5, 1, 2, 4, 6, 8 or 0 (default = 0). Duration of the extended discard timer. 0 means disabled.

pdcp_SN_SizeUL

Enumeration: 12 or 18. Uplink SN size in bits.

pdcp_SN_SizeDL

Enumeration: 12 or 18. Downlink SN size in bits.

headerCompression

Optional object. If not present or `null`, header compression is disabled.

maxCID   Range: 1 to 16383.

profile0x0001

Boolean. If true, enable RTP v1 ROHC profile.

profile0x0002

Boolean. If true, enable UDP v1 ROHC profile.

profile0x0004

Boolean. If true, enable IP v1 ROHC profile.

statusReportRequired

(AM only) Boolean. Indicates if status reports must be generated or not.

outOfOrderDelivery

Boolean. Indicates if out of order delivery must be activated or not.

t_Reordering

Optional enumeration: 0, 1, 2, 4, 5, 8, 10, 15, 20, 30, 40, 50, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 500, 750, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 2750, 3000. Duration of the t-Reordering timer in ms.

sn_GapReport_r18

Optional boolean (default = FALSE). Indicates if SN gap report feature must be activated if the UE supports it.

nr_dc_split

Optional object. It defines if the current 5QI can be used for NR-DC split bearers or not.
It contains the following items:

type   Enumeration: mcg, scg. Defines which cell group is the primary path.
If the `nr_dc_split` configuration object is absent or if the same 5QI is not defined in the SCG cell DRB configuration object, the bearer will not be split.

ul_data_threshold

>>> Optional enumeration: 0, 100, 200, 400, 800, 1600, 3200, 6400, 12800, 25600, 51200, 102400, 204800, 409600, 819200, 1228800, 1638400, 2457600, 3276800, 4096000, 4915200, 5734400, 6553600, -1 (default = -1). Defines the PDCP ul-DataSplitThreshold parameter in bytes. -1 means infinity.

secondary_path_dl_ratio

>>> Optional number between 0 and 1 (default = -1). Experimental feature trying to force data ratio between both bearers, -1 disables it. Note that the ratio cannot be sustained if the `force_dl_schedule` option is activated in one of the cells used for the traffic, or if multiple bearers with different priorities are used, or if the traffic pushed is higher than the maximum physical bitrate.
>>> Example: if 10Mbps is sent and ratio is set to 0.75, primary path will schedule 2.5Mbps and secondary 7.5Mbps.

rlc_config

> Object. RLC configuration. If UM (Unacknowledged Mode) is used, the ul_um and/or dl_um objects must be present. If AM (Acknowledged Mode) is used, ul_am and dl_am objects must be present.

>> **ul_um**   Optional object. UL UM configuration. It must contain the following parameters.

>>> **sn_FieldLength**

>>>> Enumeration: 6 or 12. Uplink SN size in bits.

>> **dl_um**   Optional object. DL UM configuration. It must contain the following parameters.

>>> **sn_FieldLength**

>>>> Enumeration: 6 or 12. Downlink SN size in bits.

>>> **t_Reassembly**

>>>> Enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 340, 350, 550, 1100, 1650, 2200. Duration of the t-Reassembly timer in ms.

>> **ul_am**   Optional object. UL AM configuration. It must contain the following parameters.

>>> **sn_FieldLength**

>>>> Enumeration: 12 or 18. Uplink SN size in bits.

>>> **t_PollRetransmit**

>>>> Enumeration: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 2000, 4000. Duration of the t-PollRetransmit timer in ms.

`t_PollRetransmit_v1610`

Optional enumeration: 0, 1, 2, 3, 4 (default = 0). Duration of the t-PollRetransmit timer in ms when using v1610 extension. 0 means deactivated.

`pollPDU` Enumeration: 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 6144, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 40960, 49152, 57344, 65536, 0. pollPDU parameter. 0 means infinity.

`pollByte` Enumeration: 1, 2, 5, 8, 10, 15, 25, 50, 75, 100, 125, 250, 375, 500, 750, 1000, 1250, 1500, 2000, 3000, 4000, 4500, 5000, 5500, 6000, 6500, 7000, 7500, 8000, 9000, 10000, 11000, 12000, 13000, 14000, 15000, 16000, 17000, 18000, 20000, 25000, 30000, 40000, 0. pollByte parameter in kBytes. 0 means infinity.

`maxRetxThreshold`

Enumeration: 1, 2, 3, 4, 6, 8, 16, 32. maxRetx-Threshold parameter.

`dl_am` Optional object. DL AM configuration. It must contain the following parameters.

`sn_FieldLength`

Enumeration: 12 or 18. Downlink SN size in bits.

`t_Reassembly`

Enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 340, 350, 550, 1100, 1650, 2200. Duration of the t-Reassembly timer in ms.

`t_StatusProhibit`

Enumeration: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 300, 350, 400, 450, 500, 800, 1000, 1200, 1600, 2000, 2400. Duration of the t-StatusProhibit timer in ms.

`t_StatusProhibit_v1610`

Optional enumeration: 0, 1, 2, 3, 4 (default = 0). Duration of the t-StatusProhibit-v1610 timer in ms. 0 means deactivated.

`logical_channel_config`

Object. Logical channel configuration. It must contain the following parameters.

`priority` Integer (range 1 to 16). Logical channel priority.

prioritisedBitRate

> Enumeration: 0, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384, 32768, 65536, -1. Prioritised bit rate in kBps. -1 means infinity.

bucketSizeDuration

> Enumeration: 5, 10, 20, 50, 100, 150, 300, 500, 1000. Duration of the bucket in ms.

logicalChannelGroup

> Integer (range 0 to 7). Logical channel group.

logicalChannelSR_Mask

> Optional boolean (default = false). Activates SR masking for this logical channel.

logicalChannelSR_DelayTimerApplied

> Optional boolean (default = false). The `logical_channel_sr_delay_timer` parameter must also be configured.

need_sps   Optional enumeration: `dl`, `ul`, `both` or `none` (default = none). If present, defines whether the radio bearer needs a SPS/CG configuration. Currently only UL CG are supported, so the value `dl` has no effect.

harq_mode

> Optional enumeration: `enabled_only`, `disabled_only` and `both` (default = both). In NTN cells and if supported by the UE, configures whether this DRB will use HARQ enabled processes only, HARQ disabled processes only, or all HARQ processes.
>
> If a corresponding configuration exists in the gNB (See [Configured Grant], page 205) and if the UE supports CG, a CG will be configured when the bearer is established.

sdt_allowed

> Optional boolean (default = false). If set to true, and if the UE supports SDT, the corresponding bearer will be configured for SDT upon the suspension of the RRC connection. See [rrc_inactive], page 159.

5qi_qos   Optional object. Default 5QI QoS characteristics to be used for this 5QI. If not present, the gNB tries to retrieve a default value based on 3GPP TS 23.501 table 5.7.4-1 and errors if the 5QI value is unknown.

priority_level

> Integer (range 1 to 127).

averaging_window

> Optional integer (range 1 to 4095). Averaging window for GBR bearers.

use_empty_bsr_grant

> Optional boolean (default = false). Indicates if empty BSR grant feature must be used for this 5QI. See [empty_bsr_grant NR cell parameter], page 220.

tx_fifo_size

> Optional integer (default = 10485760). Defines the maximum number of bytes that can be queued in the DL PDCP entity before dropping incoming DL packets.

unsupported_5qi_fallback

>   Optional boolean (default = true). If set to true and if the core network requests
>   the establishment of un unsupported 5QI value, the parameters from 5QI 9 are used
>   instead. Otherwise the establishment is rejected.

srb3_support

>   Optional boolean (default = false). If true, and if the UE supports SRB3, the
>   gNodeB will activate it.

gbr_ul_ratio

>   Optional float (default = 0.8). Maximum ratio of the uplink resources that can be
>   reserved for GBR QoS flows.

gbr_dl_ratio

>   Optional float (default = 0.8). Maximum ratio of the downlink resources that can
>   be reserved for GBR QoS flows.

gbr_init_ul_bits_per_re

>   Optional float (default = 2.0). The GBR QoS flow resources are measured in terms
>   of resource elements (RE) per second. Each RE can be assigned a given number
>   of bits depending on the exact radio conditions. This parameter gives the initial
>   number of bits per uplink RE when the UE is connecting (in this case no reliable
>   radio quality measurement is available).

gbr_init_dl_bits_per_re

>   Optional float (default = 2.0). Same as `gbr_init_ul_bits_per_re` for downlink.

gbr_congested

>   Optional boolean (default = false). Option that simulates a congestion once at least
>   one GBR bearer is active in the cell. Any new GBR request will be rejected or will
>   trigger a preemption depending on the QoS flow ARP parameters.

ignore_gbr_congestion

>   Optional boolean (default = false). If set to true, no GBR congestion check is
>   performed.

drb_count_max

>   Optional integer (default = 1500). Maximum number of DRBs (for this cell).

8.7.3.5 Other RRC parameters

inactivity_timer

>   Integer. Send RRC connection release after this time (in ms) of network inactivity.
>   Note that it is only used for the UE PCell.

scg_failure_information_behavior

>   Optional enum (auto, release, reestablish, default = auto). Defines the behavior
>   when the MCG primary cell receives a RRC SCG failure information message for
>   this SCG primary cell.
>   If set to `auto`, the SCG is released if the cause is set to T310 expiry or synchRecon-
>   figFailure and a measurement reporting configuration is defined to trigger the SCG
>   addition. Otherwise the SCG is reestablished.
>   If set to `release`, SCG is always released.
>   If set to `reestablish`, a RRC message is always sent to reestablish SCG.

cipher_algo_pref

>   Array of integers. Set the preferred algorithms for RRC and User Plane encryption
>   in decreasing order of preference. If none match the UE capabilities, then NEA0
>   (no encryption) is selected. List of supported algorithms:

Value	Algorithm
1	NEA1 (Snow 3G)
2	NEA2 (128 bit AES)
3	NEA3 (ZUC)

If encryption is necessary, for best performance use AES (NEA2) as first choice if your CPU supports the AES NI Intel instruction set (use the `hwcaps` monitor command and see if AES is displayed). Otherwise use Snow3G (NEA1) or ZUC (NEA3).

cipher_algo_null_allowed

Optional boolean (default = true). If set to false, the use of NULL ciphering algorithm (NEA0) is forbidden unless the UE performs an emergency registration.

integ_algo_pref

Array of integers. Set the preferred algorithms for RRC integrity (and optionally User Plane integrity) check in decreasing order of preference. If none match the UE capabilities, then NIA0 (no integrity check) is selected. List of supported algorithms:

Value	Algorithm
1	NIA1 (Snow 3G)
2	NIA2 (128 bit AES)
3	NIA3 (ZUC)

For best performance, use AES (NIA2) as first choice if your CPU supports the AES NI Intel instruction set (use the `hwcaps` monitor command and see if AES is displayed). Otherwise use Snow3G (NIA1) or ZUC (NIA3).

integ_algo_null_allowed

Optional boolean (default = true). If set to false, the use of NULL integrity algorithm (NIA0) is forbidden unless the UE performs an emergency registration.

rrc_inactive

Optional object. If present, the cell will support UEs in RRC Inactive mode and will be able to suspend/resume RRC connection and perform RAN paging.

Note that RRC connection suspend is possible only if the 5GC sends the 'Core Network Assistance Information For Inactive' during initial context setup of the UE.

RAN paging and RRC resume procedure is currently limited to cells belonging to the same gNB.

use_full_resume_id

Optional boolean (default = false). Sets the useFullResumeId flag in SIB1.

rna_cell_list

Optional array of objects.

If absent, the ran-NotificationAreaInfo of the SuspendConfig will be set as a PLMN-RAN-AreaConfigList covering the full registration area given by the 5GC in the Core Network Assistance Information, unless `rna_ranac_list` is present.

If present, sets the ran-NotificationAreaInfo of the SuspendConfig as a PLMN-RAN-AreaCellList.

Each element has the following parameters:

plmn   String. PLMN (5 or 6 digits).

cell_id_list

>Array of integer. Each value is a full 28 bits cell identity, concatenation of `enb_id` and `cell_id`.

rna_ranac_list

>Optional array of objects.
>If present, the list or RAN Area Code defined for the Tracking Area Code will be sent in the RAN-AreaConfig field of the PLMN-RAN-AreaConfig item.
>Each element has the following parameters:

>tac   Integer. Tracking Area Code.

>ranac_list

>>Array of 1 to 32 integers. List of RAN Area Code.

ran_paging_cycle

>Enumeration (32, 64, 128, 256). RAN paging cycle, in frames.

t380_mins

>Optional enumeration (5, 10, 20, 30, 60, 120, 360, 720). Value for T380 (Periodic RNA update timer) in minutes.
>If absent, the timer will take the value of the periodic registration update timer given by the 5GC in the Core Network Assistance Information.

inactivity_timer

>Optional integer. Overrides the top-level value of `inactivity_timer` for UEs supporting RRC Inactive mode. Note that it is only used for the UE PCell.

release_timer_mins

>Optional integer (range 0 to 1440, default 0). Duration of total UE inactivity after which the UE will be actually released and no longer suspended. The expiry is evaluated during each RNA update procedure. If 0, the UE won't be released due to UE inactivity but will keep being suspended.

continue_rohc_context

>Optional boolean (default = false). If true, and if the UE supports the feature, the RoHC contexts are not reset during the RRC connection resume procedure.

sdt   Optional object. If present, it configures the Small Data Transmission feature.
>Both CG-SDT and RA-SDT are supported. For RA-SDT, the `prach_feature_preambles_list` should contain at least one preamble with `sdt`. See [prach_feature_preambles], page 188.
>SDT shall also be enabled per DRB basis. See [NR DRB configuration], page 153.
>It contains the following parameters:

>rsrp_threshold

>>Optional integer (range -156 to -29, default = -29). sdt-RSRP-Threshold-r17 parameter: RSRP threshold above which a UE can initiate a SDT session. Value -29 means the threshold is not advertised in SIB1.

logical_channel_sr_delay_timer

>Optional enumeration (20, 40, 64, 128, 512, 1024, 2560, 0, default = 0). sdt-LogicalChannelSR-DelayTimer-r17: logicalChannelSR-DelayTimer applied during SDT for logical channels configured with SDT. Value 0 means the timer is not advertised in SIB1.

ul_data_volume_threshold

>Enumeration (32, 100, 200, 400, 600, 800, 1000, 2000, 4000, 8000, 9000, 10000, 12000, 24000, 48000, 96000). sdt-DataVolumeThreshold-r17 parameter: maximum number of bytes pending for transmission on the SDT bearers to initiate a SDT session.

t319a   Enumeration (100, 200, 300, 400, 600, 1000, 2000, 3000, 4000). t319a-r17 parameter: value in ms for the T319a timer.

session_inactivity_timer

>Optional integer (range 10ms to 80% of T319A, default = 20% T319A). Inactivity timer for the SDT session. If there is no transmission during this value, the eNB will suspend the RRC connection.

session_max_duration

>Optional integer (range 10ms to 80% of T319A, default = 80% T319A). If the SDT session lasts longer than this value, the eNB will resume the RRC connection.

continue_rohc_context

>Optional enum ("none", "cell", default = "none"). If set to "cell", and if the UE supports the feature, the RoHC contexts are not reset during the SDT procedure.

configured_grant

>Optional object to add CG-SDT support. It contains the following parameters:

>**rsrp_threshold_ssb**

>>Optional integer (range -156 to -29, default to sdt.rsrp_threshold). Configures cg-SDT-RSRP-ThresholdSSB-r17.

>**time_alignment_timer**

>>Integer (500, 750, 1280, 1920, 2560, 5120 or 10240). Configures cg-SDT-TimeAlignmentTimer-r17.

>**ta_valid_rsrp_change_threshold**

>>Optional integer (2, 4, 6, 8, 10, 14, 18, 22, 26, 30, 34). Configures cg-SDT-RSRP-ChangeThreshold-r17. If absent, CG-SDT-TA-ValidationConfig-r17 is disabled

>>**grant**   Optional object defining the UL grant parameters in the initial BWP. It contains the same parameters than the `configured_grant`

object of the `pusch` configuration, See
[Configured Grant], page 205, with the
following changes:
`dynamic_beta_offsets, beta_offset_ack_`
`index, beta_offset_ack_index1, n_layer`
are ignored because they are not applicable.
`configuration_type` is ignored because it is
forced to "type1"
`periodicity` should be larger than 5
milliseconds

grant_redcap
        Optional object defining the UL grant parameters in the RedCap specific initial BWP.

ssb_subset_bitmap
        Optional bitstring (same length as `ssb_pos_bitmap`, defaults to `ssb_pos_bitmap`). Configures sdt-SSB-Subset-r17. See [ssb_pos_bitmap], page 166,

ssb_per_cg_pusch
        Enumeration (1/8, 1/4, 1/2, 1, 2, 4, 8, 16). Configures sdt-SSB-PerCG-PUSCH-r17.

dmrs_ports_bitmap
        Optional bitstring (length 4, 8, 6 or 12 based on `dmrs_type` and `dmrs_max_len` defined in `grant.dmrs`, defaults to all the ports allowed by the DMRS configuration). Configures sdt-DMRS-Ports-r17

rrc_reject_waitTime
        Optional integer (range 1 to 16). RRC reject wait time in seconds.

rrc_release_waitTime
        Optional integer (range 1 to 16). RRC release wait time in seconds.

rrc_release_deprioritisation
        Optional object. If present, the deprioritisationReq field is added to the RRC Release message.
        The object must contain the following fields:

type   Enumeration ("none", "frequency" or "nr").

timer   Optional enumeration (5, 10, 15 or 30). Timer in minutes. Required if `type` is not none.

rrc_redirect
        Array of [ASN.1 property], page 29. Each entry is the ASN.1 content of a RedirectedCarrierInfo redirection information.
        These will define the redirection parameter within the RRC Release sent by the gNB to the UE (cf 3GPP TS 38.331).
        Below is an example of the ASN.1 file content:

```
nr: {
  carrierFreq 518910,
  ssbSubcarrierSpacing kHz15
}
```

`rrc_release_cell_reselection_priorities`

>   Optional [ASN.1 property], page 29. ASN.1 content of a cellReselectionPriorities
>   information. It will define the cellReselectionPriorities parameter within the RRC
>   Release sent by the gNB to the UE (cf 3GPP TS 38.331).
>
>   Below is an example of the ASN.1 file content:

```
{
  freqPriorityListNR {
    {
      carrierFreq 391970,
      cellReselectionPriority 3
    },
    {
      carrierFreq 427970,
      cellReselectionPriority 7
    }
  },
  t320 min10
}
```

`rrc_procedure_filter`

>   Optional object. Allows to define the eNB behavior for a list of RRC procedures.
>   Each property name represents a RRC procedure. The ones currently supported are
>   `rrc_setup_request`, `rrc_reestablishment_request`, `rrc_resume_request` and
>   `scg_failure_information`.
>
>   Each property value is an object containing the following fields:

>   action   Enumeration (`treat` (UE message is processed), `ignore` (UE message
>   is ignored) or `reject` (UE message is rejected))

>   ttl   Optional integer. If set, the `reject` of `ignore` filter is applied `ttl` times.
>   If not set, the filter is applied until it is modified.

>   By default all procedures are treated.
>
>   Example:

```
rrc_procedure_filter: {
    rrc_setup_request: {
        action: "treat"
    },
    rrc_reestablishment_request: {
        action: "reject",
        ttl: 1
    }
}
```

`ue_cap_rat_type`

>   Optional array of strings. List the RAT types (`nr`, `eutra-nr`, `eutra`, `utra-fdd`)
>   for the RRC UE capability enquiry message. In the first UE capability enquiry
>   message, `nr` is always included whatever the array content.

`requested_freq_bands_nr`

>   Optional array of objects of the same type than `requested_freq_bands_nr_mrdc`,
>   See [requested_freq_bands_nr_mrdc], page 87.
>
>   Force the frequencyBandListFilter element of the UE-CapabilityRequestFilterNR
>   when requesting UE capabilities in SA mode.

By default, the frequencyBandListFilter contains the bands of all the NR cells defined in `nr_cell_list` and EUTRA cells defined in `cell_list`.

`requested_eutra_freq_bands`

Optional array of 1 to 16 integers. Defines the list of EUTRA bands the gNB will request in the UE Capability Enquiry message (via the requestedFrequencyBands-r11 information element).

`requested_eutra_max_ccs_dl`

Optional integer (range = 2 to 32). Sets the maximum number of EUTRA DL CCs the gNB will request in the UE Capability Enquiry message (via the requestedMaxCCsDL-r13 information element).

`requested_eutra_max_ccs_ul`

Optional integer (range = 2 to 32). Sets the maximum number of UL CCs the gNB will request in the UE Capability Enquiry message (via the requestedMaxCCsUL-r13 information element).

`request_reduced_format`

Optional boolean. If set, the gNB will request the UE to provide EUTRA CA combinations using supportedBandCombinationReduced-r13 instead of supportedBandCombination-r10 in the UE Capability Enquiry message (via the requestReducedFormat-r13 information element).

`request_eutra_reduced_int_non_cont_comb`

Optional boolean. If set, the gNB will request an EUTRA reduced intra-band non-contiguous CA band combination in the UE Capability Enquiry message (via the requestReducedIntNonContComb-r13 information element).

`mr_dc_request_nr_dc`

Optional boolean (default = false). If true, the includeNR-DC bit is set to true in the UE capability enquiry message so as to retrieve NR-DC band combinations. Note that it is automatically set if there is at least once cell configured for NR-DC.

`rrc_ul_segmentation_support`

Optional boolean (default = true). If set to true, the gNB indicates that RRC UL segmentation is allowed in the RRC UE capability enquiry message.

`single_ue_cap_enquiry`

Optional boolean (default = false). If set to true, and if the UE and gNB supports R16 uplink RRC segmentation feature, NR, EUTRA and MRDC capabilities are requested in a single message.

`srs_switching_time_request`

Optional boolean (default = false). If set to true, the gNB sets the srs-SwitchingTimeRequest flag when requesting NR or EUTRA-NR UE capabilities.

`uplink_tx_switch_request`

Optional boolean (default = false). If set to true, the gNB sets the uplink-TxSwitchRequest flag when requesting NR or EUTRA-NR UE capabilities.

`ue_assistance_information`

Optional object containing the UE assistance information procedure configuration. It can contain the following properties:

`overheating_assistance`

Optional object for the overheatingAssistanceConfig ASN.1 parameters. Note that no action will be taken by the gNB when receiving the over-

heatingAssistance information. Its purpose is only to test the UE message sending.

It contains the following properties:

prohibit_timer
> Enumeration (0, 0.5, 1, 2, 5, 10, 20, 30, 60, 90, 120, 300, 600, -1). Sets the overheatingAssistanceConfig value. -1 means no overheatingAssistanceConfig is configured.

max_bw_preference
Optional object for the maxBW-PreferenceConfig-r16 ASN.1 parameters.

Note that no action will be taken by the gNB when receiving the maxBW-Preference-r16 information. Its purpose is only to test the UE message sending.

It contains the following properties:

prohibit_timer
> Enumeration (0, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, -1). Sets the maxBW-PreferenceConfig-r16 value. -1 means no maxBW-PreferenceConfig-r16 is configured.

max_cc_preference
Optional object for the maxCC-PreferenceConfig-r16 ASN.1 parameters.

It contains the following properties:

prohibit_timer
> Enumeration (0, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, -1). Sets the maxCC-PreferenceConfig-r16 value. -1 means no maxCC-PreferenceConfig-r16 is configured.

max_mimo_layer_preference
Optional object for the maxMIMO-LayerPreferenceConfig-r16 ASN.1 parameters.

It contains the following properties:

prohibit_timer
> Enumeration (0, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, -1). Sets the maxMIMO-LayerPreferenceConfig-r16 value. -1 means no maxMIMO-LayerPreferenceConfig-r16 is configured.

release_preference
Optional object for the releasePreferenceConfig-r16 ASN.1 parameters.
It contains the following properties:

prohibit_timer
> Enumeration (0, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, infinity, -1). Sets the releasePreferenceProhibitTimer-r16 value. -1 means no releasePreferenceConfig-r16 is configured.

delay_timer
> Optional integer (default = 0). Defines the delay between releasePreference-r16 reception and its treatment. If the value is greater than 0, connectedReporting ASN.1 parameter is set to true.

rrm_meas_relaxation_reporting
> Optional object for the rrm-MeasRelaxationReportingConfig-r17 ASN.1 parameters.
> Note that no action will be taken by the gNB when receiving the rrm-MeasRelaxationFulfilment-r17 information. Its purpose is only to test the UE message sending.
> It contains the following properties:

> s_search_delta_p_stationary
>> Enumeration (2, 3, 6, 9, 12, 15). Sets the s-SearchDeltaP-Stationary-r17 value.

> t_search_delta_p_stationary
>> Enumeration (5, 10, 20, 30, 60, 120, 180, 240, 300). Sets the t-SearchDeltaP-Stationary-r17 value.

prop_delay_diff_report
> Optional object for the propDelayDiffReportConfig-r17 ASN.1 parameters.
> Note that no action will be taken by the gNB when receiving the propagationDelayDifference-r17 information. Its purpose is only to test the UE message sending.
> It contains the following properties:

> thresh_prop_delay_diff
>> Enumeration (0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10). Sets the threshPropDelayDiff-r17 value.

high_speed_config
> Optional object. If present, it should contain the following configuration parameters.

> high_speed_meas_flag
>> Boolean. If true, highSpeedMeasFlag is advertised in the cell.

8.7.4 PHY/L1 - Downlink parameters

8.7.4.1 SSB

ssb_pos_bitmap
> String or Object. SSB position bitmap in bits (4, 8 or 64 bits depending on the DL frequency). For convenience, an object with the same fields as the SIB1 is accepted too. It contains the following fields:

> in_one_group
>> String. 4 or 8 bits depending on the DL frequency.

> group_presence
>> Optional string. 8 bits. Only present in FR2.

ssb_period
> Enumeration (5, 10, 20, 40, 80, 160). SSB periodicity in ms.

ssb_subcarrier_spacing
> Optional integer (15, 30, 120, 240). Set the SSB subcarrier spacing in kHz. By default it is the same as subcarrier_spacing.

ssb_nr_arfcn
> Optional integer. Set the NR ARFCN of the SSB carrier. If not set, its value depends on gscn.

gscn   Optional integer (default = 0). Set the SSB GSCN (=SSB carrier frequency). The
            special default value 0 indicates to automatically set it. It is computed so that the
            SSB is at the lowest possible frequency in the cell bandwidth.

ssb_precoding
            Optional complex matrix. Array of N vectors of `n_antenna_dl` elements where N is
            the number of '1' bits in `ssb_pos_bitmap`. Set the precoding vector for each SSB.
            By default all the elements are set to one.

ssb_power_offset
            Optional float (default = 0). Power offset (in dB) added to the SS PBCH block
            power in SIB1.

ssb_offset
            Optional integer (default = 0). Offset in ms of the start of the SSB half-frame in
            the SSB period. It must be a multiple of 5 and less than the SSB period.

ssb_case_c
            Optional boolean. For the 30 kHz subcarrier spacing, select between SSB block
            pattern case B (false) or case C (true). The default value depends on the selected
            frequency band (see 3GPP TS 38.101-1 table 5.4.3.3-1).

8.7.4.2 PDCCH

pdcch   Object. Contains the PDCCH parameters defined below.

            common_coreset
                        Optional object. Define the common CoReSet. For backward compati-
                        bility, the common CoReSet properties can be in the `pdcch` object if no
                        dedicated CoReSet is defined.

                        The CoReSet definition accepts the following properties:

                        coreset_id
                                    Optional integer. Force the CoReSet ID. If the parameter
                                    is absent, the CoReSet IDs are automatically assigned.

                        rb_start   Optional integer (default = -1). PDCCH start position in
                                    number of RBs relative to the start of the BWP. rb_start +
                                    BWP_rb_start must be a multiple of 6. -1 means to select
                                    the value to maximize the bandwidth based on the BWP
                                    and CoReSet #0 configurations.

                        l_crb   Optional integer (default = -1). PDCCH length in num-
                                    ber of RBs. Must be a multiple of 6 or -1. -1 means to
                                    use the maximum number of RBs compatible with the DL
                                    bandwidth.

                        rb_list   Optional array of objects. If present, a list of resource blocks
                                    is provided instead of `rb_start` and `l_crb`. The syntax
                                    of the list is similar to the rate match pattern `resource_`
                                    `blocks` parameter.

                        duration   Optional integer (0 to `dmrs_type_a_pos` value, default =
                                    0). PDCCH duration. The special value 0 indicates to
                                    automatically set it from the CoReSet bandwidth.

                        interleaved
                                    Optional boolean (default = false). If true, enable inter-
                                    leaved mapping.

reg_bundle_size
> Optional enumeration: 2, 3, 6. Must be present for interleaved mapping.

interleaver_size
> Optional enumeration: 2, 3, 6. Must be present for interleaved mapping.

shift_index
> Optional integer. Range: -1 to 274. Must be present for interleaved mapping. -1 is a shortcut for the physical cell ID.

precoder_granularity
> Optional enum (sameAsREG_bundle, allContiguousRBs, default = sameAsREG_bundle).

dmrs_scid
> Optional integer (default = -1). Range: -1 to 65535. DMRS scrambling ID. -1 is a shortcut for the physical cell ID.

tci_states_pdcch
> Optional array of integers. TCI state IDs for the PDCCH.

dedicated_coreset
Optional object or array of objects. Define UE dedicated CoReSets. At least one should be defined for best performance in standalone mode. The properties are the same as for `common_coreset`.

css
Object or array of objects. PDCCH common search space configuration defined in RRC `PDCCH-ConfigCommon`. Each object defines a search space with the parameters defined below.

search_space_id
> Optional integer. Force the Search space ID. If not present, IDs are assigned in BWP order and then search space definition order.

n_candidates
> Optional array of 5 integers, mandatory for the DL BWP #0. Enumeration: 0, 1, 2, 3, 4, 5, 6, 8. nrofCandidates parameters for each aggregation level (1, 2, 4, 8, 16).

pei_n_candidates
> Optional array of 3 integers. Enumeration. nrofCandidates parameters for each PEI aggregation level (4, 8, 16). Allowed values are for AL 4: 0, 1, 2, 3, 4, for AL 8: 0, 1, 2 and for AL 16: 0, 1. When PEI is activated, default value is set to 4, 2, 1.

start_symb
> Optional integer (default = 0). range: 0 to 3. First symbol of the search space.

coreset_id
> Optional integer to force the CoReSet ID. If the parameter is absent and if the cell has a CoReSet 0, CoReSet 0 is used. Otherwise, the default CoReSet is the one defined by `common_coreset`.

uss   Object or array of objects. PDCCH UE dedicated search space configuration defined in RRC `PDCCH-Config`. Each object defines a search space with the parameters defined below.

    search_space_id
        Optional integer. Force the Search space ID. If not present, IDs are assigned in BWP order and then search space definition order.

    n_candidates
        Optional array of 5 integers, mandatory for the DL BWP #0. Enumeration: 0, 1, 2, 3, 4, 5, 6, 8. nrofCandidates parameters for each aggregation level (1, 2, 4, 8, 16).

    start_symb
        Optional integer (default = 0). range: 0 to 3. First symbol of the search space.

    coreset_id
        Optional integer to force the CoReSet ID. It is set by default to the first UE dedicated CoReSet ID if present otherwise to the first common CoReSet ID.

    css   Optional boolean (default = false). If true, a common search space is defined. Otherwise a UE specific search space is defined.

    dci_0_1_and_1_1
        Optional boolean (default = true). It defines whether DCI 0_1 and 1_1 are used for PDCCH in the search space. It is relevant only if `css` is false.

    slot_period
        Optional enumeration: 1, 2, 4, 5, 8, 10, 16, 20, 40, 80, 160, 320, 640, 1280, 2560 (default = 1). Monitoring periodicity of the search space, in slots.

    slot_duration
        Optional integer, 1 to slot_period-1 (default = 1). Monitoring duration of the search space, in slots.

    force_cce0
        Optional boolean (default = false). Force the CCE index 0 (only useful to implement test models).

rar_search_space
    Optional integer. Set the RAR search space ID. It is set by default to the first common search space of the BWP.

rar_al_index
    Integer (range 0 to 4). Aggregation level for Random Access Response.

dl_search_space
    Optional integer (default = -1). If >= 0, force the search space ID used when scheduling DL data. If set to -1, the first UE dedicated search space compatible with the `force_dci_1_0` parameter is used. If no suitable UE dedicated search space is found, then the first common search space is used.

force_dci_1_0

>Optional boolean (default = false). Force the use of DCI 1_0 if both DCI 0_1 and 1_1 are possible. It is relevant only if `dl_search_space` is set to -1.

ul_search_space

>Optional integer (default = -1). If `>= 0`, force the search space ID used when scheduling UL data. If set to -1, the first UE dedicated search space compatible with the `force_dci_0_0` parameter is used. If no suitable UE dedicated search space is found, then the first common search space is used.

force_dci_0_0

>Optional boolean (default = false). Force the use of DCI 0_0 if both DCI 0_1 and 1_1 are possible. It is relevant only if `ul_search_space` is set to -1.

al_index   Integer (range 0 to 4). Aggregation level for PDCCH.

precoding_from_csi

>Optional boolean (default = false). If true, precode the UE specific PDCCH using the CSI reports. Otherwise, use the SSB precoding.

other_si_search_space

>Optional integer. Set the other SI search space ID. It is set by default to the first common search space of the BWP. It is relevant in the initial BWPs of a SA cell.

paging_search_space

>Optional integer. Set the paging search space ID. It is set by default to the first common search space of the BWP. It is relevant in the initial BWPs of a SA cell. It is not possible to have several initial BWPs mixing `paging_search_space` set to zero and not set to zero.

mcch_search_space

>Optional integer. Sets the MCCH search space ID. It is set by default to the `other_si_search_space` value.

mtch_search_space

>Optional integer. Sets the MTCH search space ID. It is set by default to the `mcch_si_search_space` value.

The following parameters must be present in the DL BWP#0 for a SA cell:

coreset0_index

>Optional integer (range 0 to 15). CORESET0 index.

n_rb_coreset0

>Optional integer (12, 15, 20, 24, 48 or 96). Number of resource blocks for CORESET0. Only meaningful if `coreset0_index` is absent. The default value is set from the DL bandwidth.

n_symb_coreset0

>Optional integer (range 1 to 3). Number of symbols for CORESET0. Only meaningful if `coreset0_index` is absent. The default value is set from the DL bandwidth.

offset_rbs_coreset0

>Optional integer (range -42 to 97). Recource block offset for CORESET0. Used if present and if `coreset0_index` is absent.

search_space0_index
> Integer (range 0 to 15). Search space index for SIBs.

si_al_index
> Integer (range 2 to 4). Aggregation level for SIBs.

paging_al_index
> Optional integer (range 2 to 4, default = 2). Aggregation level for paging.

pei_al_index
> Optional integer (range 2 to 4, default = 2). Aggregation level for PEI.

8.7.4.3 PDSCH

pdsch_harq_ack_max
> Optional integer. Set the maximum number of PDSCH scheduled having their HARQ ACK information in a given uplink slot.

pdsch   Object. Contains the PDSCH parameters defined below.

mapping_type
> Enumeration (typeA or typeB). Select the mapping type.

start_symb
> Optional Integer (range 0 to 3 for mapping type A, 0 to 13 for mapping type B). PDSCH start symbol. If not provided it is set the maximum CoReSet duration.

n_symb   Optional Integer. Number of symbols for PDSCH. If not provided it is set to 14 - start_symb for mapping type A.

dmrs_mapping_type_a
dmrs_mapping_type_b
> Optional object. Set the DMRS mapping type A and/or type B configuration. If neither the dmrs_mapping_type_a nor the dmrs_mapping_type_b objects are present, the DMRS configuration properties are directly in the pdsch object and the DMRS mapping is determined by mapping_type. The DMRS parameters are the following:

dmrs_add_pos
> > Otional integer (range 0 to 3, default = 2). dmrs-AdditionalPosition parameter.

dmrs_max_len
> > Optional integer (range 1 to 2, default = 1). DMRS maxLength parameter.

dmrs_type
> > Optional integer (1 or 2, default = 1). dmrs-Type parameter.

dmrs_scid0
> > Optional integer (-1 to 65535, default = -1). DMRS for scrambling ID 0. -1 means default value (PCI).

dmrs_scid1
> > Optional integer (-1 to 65535, default = -1). DMRS for scrambling ID 1. -1 means default value (PCI).

dmrs_low_papr
> Optional boolean (default = false). Enable low PAPR downlink DMRS.

ptrs   Optional object. PDSCH PT-RS parameters. If the object is present, the PT-RS are enabled regardless of the UE capabilities. The following PT-RS parameters are available:

> frequency_density
>> Optional array of integers (range: 1 to 276) of 2 elements.
>
> time_density
>> Optional array of integers (range: 0 to 29) of 3 elements.
>
> epre_ratio
>> Optional integer (range: 0 to 1, default = 0).
>
> resource_element_offset
>> Optional integer (range: 0 to 3, default = 0).

When `n_layer` is forced, the following additional DMRS parameters are available:

dmrs_len Optional integer (range 1 to dmrs_max_len, default = 1). Set the DMRS length (only used in DCI 1_1).

n_dmrs_cdm_groups
> Optional integer (range 1 to 3, default = 1). Number of DMRS CDM groups (only used in DCI 1_1).

dmrs_ports
> Optional array of integers. DMRS port for each layer. By default `dmrs_ports[i] = i`.

k0   Optional integer (0 to 3, default = 0). Delay in slots from DCI to PDSCH. Support for k0 != 0 is experimental.

bwp_switch_k0
> Optional integer (range -1 to $3 * 2^\mu$, default = 0). Delay in slots from DCI 1_1 to PDSCH when doing a DCI downlink BWP switch. DCI downlink BWP switch is only possible if `bwp_switch_k0` is non zero. When set to -1, the eNB will adjust the value based on UE capability (bwp-SwitchingDelay type1 or type2).

k1   Optional integer or array of integers (range `k_min` to 15 or -1). Delay in slots from PDSCH to ACK/NACK. In FDD a single value is provided. In TDD, an array is provided with one entry per downlink slot in the TDD period. At least one slot must have a k1 value <= 8 to allow the use of DCI 1_0. The special value -1 indicates that no acknowledged PDSCH is scheduled in the slot (but PDSCH for SI, RAR or paging can still be scheduled).
> If the field is absent, and if `k2` in the PUSCH configuration (See [pusch], page 197) is also absent, the gNB automatically computes valid values.

slot_enable
> Optional array of booleans. Enable (true) or disable (false) the scheduling on a given slot. Each element corresponds to a slot number modulo

the array length. The array length must divide the number of slots in
20 ms.

n_harq_process

Optional enumeration: 2, 4, 6, 8, 10, 12, 16, 32 (default = 16).
nrofHARQ-ProcessesForPDSCH parameter. The value 32 will be ap-
plied only on NTN cells and if the UE supports it, and will default to
16 otherwise.

harq_process_disabled

Optional boolean or string (default = false). Controls the NTN HARQ
disabling feature.

If set to true, it disables HARQ feedback on all processes except process
0.

If set to a string, it should be a 32 bits bitmap of the HARQ processes to
disable. Like the RRC IE DownlinkHARQ-FeedbackDisabled-r17, a bit
set to '1' disables HARQ feedback and HARQ process 0 is represented
by the first/leftmost bit. You must always leave at least one process
with HARQ process enabled for SRBs and DRBs with `harq_mode` set
to enabled_only.

The boolean value `true` is equivalent to the bitstring with the first bit
set to 0 and all others to 1.

mcs_table

Optional enum (`qam64`, `qam256`, `qam64LowSE`, `qam1024`, default =
`qam64`). Selected MCS table.

If set to `1024qam`, and if a UE doesn't support it, the configuration will
fallback to 256QAM for this UE.

two_codewords

Optional boolean (default = false). Enable two codewords in DCI 1_1.
Two codewords are necessary to use more than 4 MIMO layers.

n_layer Optional integer (0 to 8, default = 0). The default value 0 indicates
that the number of layers in DCI 1_1 is computed from the CSI reports.
Otherwise, the number of layers is forced and the following additional
parameter may be provided:

> **precoding_matrix**
>
> > Optional complex matrix with `n_antenna_dl` rows and `n_layer` columns. Force the PDSCH precoding matrix.

Additional DMRS parameters may be provided too.

fixed_rb_alloc

Optional boolean or array of booleans (default = false). Allows to force
the PDSCH allocations. If an array is provided, its length must divide
$20 * 2^\mu$ and each element corresponds to a slot modulo the length of the
array.

rb_start Optional integer or array of integers. PDSCH allocation starting posi-
tion in number of RBs. Must be present if `fixed_rb_alloc` is true.

l_crb Optional integer or array of integers. PDSCH allocation length in num-
ber of RBs. Must be present if `fixed_rb_alloc` is true. If set to 0,
PDSCH scheduling is disabled on the slot.

mcs Optional integer or array of integers (range -1 to 28, default = -1).
PDSCH MCS. -1 means autonomous DL MCS adaptation by the gNB

scheduler. If an array is provided, its length must divide $20 * 2^{\mu}$ and each element corresponds to a slot modulo the length of the array.

data_scid
> Optional integer (range -1 to 1023, default = -1). PDSCH data scrambling ID. -1 means default value (PCI).

n_scid
> Optional integer (range 0 to 1, default = 0). Forces the DMRS sequence scrambling ID (only used in DCI 1_1).

x_overhead
> Optional enumeration (0, 6, 12, 18, default = 0). Corresponds to the xOverhead RRC parameter.

max_mimo_layers_enabled
> Optional boolean (default = true). If enabled, the RRC serving cell parameter maxMIMO_Layers is set.

max_mimo_layers_r16
> Optional integer (default = 0). If the UE declares supporting maxLayersMIMO-Indication and a value other than 0 is set, this value is sent in the maxMIMO-Layers-r16 field.

ra_type
> Optional enumeration (type0, type1, dynamic_switch, default = type1). Set the RB resource allocation type. Note: fixed_rb_alloc = true cannot be used with resource allocation type 0.

rbg_size
> Optional enumeration (config1, config2, default = config1). Set the RBG size configuration for resource allocation type 0.

vrb_to_prb_interleaver
> Optional enumeration (0, 2, 4, default = 0). Set the VRB to PRB interleaver size or 0 to disable it.

prb_bundling
> Optional object. If not present, the PRB bundling size is set to static wideband. Otherwise, one of the following properties must be present:
>
> > static   enumeration: 2, 4, wideband. Set the static PRB bundling size.
> >
> > dynamic   Object containing the following properties:
> >
> > > set1   enumeration: 2, 4, wideband, n2_wideband, n4_wideband. Dynamic PRB bundling size set1.
> > >
> > > set2   enumeration: 2, 4, wideband. Dynamic PRB bundling size set2.

prb_bundling_size_indicator
> Optional integer (range 0 to 1, default = 0). Set the value of the DCI PRB bundling size indicator field. It is used to select the dynamic PRB bundling size set.

prg_precoding_test
> Optional boolean (default = false). If true, one PRG every two has its precoding matrix multiplied by -1. The PRG size is computed according to the configured PRB bundling parameters.

rar_mcs
> Integer (range 0 to 9). MCS used for RAR.

rar_tb_scaling
> Optional integer (range 0 to 2, default = 0).

fer Optional float (range 0 to 1). If present, simulates a PDSCH Frame Error Rate of `fer`. It is mainly useful in test mode (see the `test_mode` parameter).

cqi_adapt_fer
> Optional float (range 0 to 1, default = 0.1). DL FER target for the initial HARQ transmission used by the gNB DL MCS adaptation algorithm, enabled when `mcs` is absent or set to -1. Applied for all MCS tables but 64QAMLowSE.

cqi_adapt_fer_lowse
> Optional float (range 0 to 1, default = 0.00001). DL FER target for the initial HARQ transmission used by the gNB DL MCS adaptation algorithm, enabled when `mcs` is absent or set to -1. Applied for MCS table 64QAMLowSE.

cqi_adapt_amp
> Optional float (default = 2). This values defines the maximum amplitude (in CQI units) of the correction applied on top of the MCS selected from the CQI report.

cqi_adapt_retx
> Optional float (default = 0.3). Defines the correction step applied by the HARQ initial transmission decoding result within the `cqi_adapt_amp` range.

power_256qam
> Optional float (default = 0). PDSCH power offset in dB when using 256QAM.

power_1024qam
> Optional float (default = 0). PDSCH power offset in dB when using 1024QAM.

initial_cqi
> Optional integer (range 1 to 15, default = 5). This CQI value is assumed when none has been received from the UE.

tci_states
> Optional array of objects. If not present, a single TCI state of ID 0 is defined with the first SSB index as reference signal and QCL type D. Otherwise, the following parameters must be present:
>
> **tci_state_id**
> > Integer (range 0 to 127).
>
> **qcl_type1**
> > Object. The following parameters are available:
> >
> > **reference_signal**
> > > Enumeration: csi_rs, ssb.
> >
> > **csi_rs_index**
> > > Integer. Must be present if `reference_signal` is csi_rs.

ssb_index

> Integer. Must be present if `reference_signal` is ssb. The special value -1 selects the SSB that the UE is listening to.

qcl_type   Enumeration: typeA, typeB, typeC, typeD.

qcl_type2

> Optional object. Same parameters as `qcl_type1`.

rate_match_pattern

> Optional array of objects. BWP level PDSCH rate match patterns (see `cell_rate_match_pattern` for cell level rate match patterns). Each object has the following properties:

rate_match_pattern_id

> Optional integer (range: 0 to 3). Rate match pattern ID. They are assigned by default by using consecutive integers starting from 0.

coreset_id

> Optional integer. If set, the rate match pattern consists in the corresponding Control Resource Set and the associated search spaces. In this case, the following properties are disabled. This property is only valid for BWP level rate match patterns.

resource_blocks

> Array of objects. Each object defines a range of resource blocks with the following properties:

start   Integer. Index of the first resource block.

len   Optional integer. Number of resource blocks. Either `len` or `end` must be present.

end   Optional integer. Ending resource block hence the number of resource blocks is `end` - `start`.

> The ranges must be non overlapping and sorted by increasing resource block indexes.

symbols_in_resource_block

> Array of array of integers (range: 0 to 13). Each array provides the rate matched symbols in the even (resp. odd) slots. The symbols for one or two slots are provided.

period   Integer (range: 1 to 40). period in slots (or double slots if symbols_in_resource_block contains the symbols for two slots).

pattern   Array of integer (range: 0 to `period` - 1). Corresponding slot offsets (in slot or double slot unit) in the period.

subcarrier_spacing

> Optional integer (default = cell subcarrier spacing). Only applies to cell level rate match patterns. The rate match pattern only applies to the BWP using this subcarrier spacing.

rate_match_pattern_group1
rate_match_pattern_group2

>Optional array of objects. Definition of the rate match pattern groups. Each object contains either the integer property `cell_level` or `bwp_level` giving the corresponding rate match pattern ID.

rate_match_pattern_dci

>Optional integer (range: 0 to 3, default = 0). When rate match pattern groups are defined, this property forces the `rate_match` DCI 1_1 field to select the rate match pattern groups.

aggregation_factor

>Optional enumeration (1, 2, 4, 8, default = 1). If greater than 1 and if the UE supports it, pdsch-AggregationFactor will be configured for PDSCH in this BWP.
>
>If `repetition_scheme` is also configured and if the UE supports both features, the parameter is ignored.

repetition_scheme

>Optional object to define the Rel-16 repetitionSchemeConfig-r16 IE. Contains the following parameters:

>>slot_based_repetition

>>>Optional enumeration (2, 3, 4, 5, 6, 7, 8, 16). Configures a slot based repetition scheme for PDSCH if the UE supports it and sets the value for the repetitionNumber field in the TimeDomain resource allocation.

The following parameters must be present for a SA cell:

si_mcs   Integer (range 0 to 9). MCS used for SIBs.

paging_mcs

>Optional integer (range 0 to 9, default = 3). MCS used for paging.

paging_tb_scaling

>Optional integer (range 0 to 2, default = 0). Transport block scaling for paging.

8.7.4.4 CSI-RS - PRS

csi_rs   Optional Object. Allows to define CSI-RS resources and CSI reporting. CSI-RS resources can be configured:

- either automatically with the `resource_auto` parameter,
- either explicitly with the `nzp_csi_rs_resource`, `nzp_csi_rs_resource_set`, `csi_im_resource`, `csi_im_resource_set`, `zp_csi_rs_resource`, `p_zp_csi_rs_resource_set` and `csi_resource_config` parameters. In that case, the parameters are directly mapped to the corresponding RRC parameters, unless otherwise specified.

resource_auto

>Optional object. Contains the following parameters:

>>nzp_csi_rs_period

>>>Integer. Period for NZP CSI-RS resources, in slots.

>>n_ports   Optional integer (defaults to the value of `n_antenna_dl`). Number of ports for NZP CSI-RS.

trs_presence

>Optional boolean (default = true). Add NZP CSI-RS resources for TRS.

trs_period

>Optional integer (defaults to the value of `nzp_csi_rs_period`). Period of TRS resources when present, in slots.

exclude_slots

>Optional array of booleans. Excludes CSI-RS presence in slots set to true. The array length must divide $20 * 2^{\mu}$ and each element corresponds to a slot modulo the length of the array.

exclude_slot_sib1

>Optional boolean (defaults to false when `n_ports <= 2`, true otherwise). Excludes CSI-RS presence in slots used for SIB1 scheduling.

exclude_slot_ssb

>Optional boolean (defaults to true). Excludes CSI-RS presence in slots where SSB is present.

power_control_offset

>Optional integer (range -8 to 15, default = 0). Power control offset value for NZP CSI-RS.

dl_bwp_list

>Optional array of integer. List of IDs of the DL BWPs on which CSI RS resources are configured. When absent, CSI RS resources are configured on all DL BWPs.

nzp_csi_rs_resource

Optional array of objects. Mandatory if `resource_auto` is not present. NZP CSI-RS resource definitions. Each object contains the following parameters:

csi_rs_id

>Integer.

n_ports   Integer.

frequency_domain_allocation

>Enumeration: row1, row2, row4, other.

bitmap   Bit string.

cdm_type   Enumeration: no_cdm,   fd_cdm2,   cdm4_fd2_td2, cdm8_fd2_td4.

density   Enumeration: 0.5, 1, 3.

odd_prbs   Optional integer.

first_symb

>Integer.

first_symb2

>Optional Integer.

rb_start   Integer.

l_crb   Integer. -1 means the whole bandwidth.

power_control_offset
        Integer.

power_control_offset_ss
        Optional integer.

scrambling_id
        Optional integer (-1 to 1023, default = -1). -1 indicates to use n_id_cell.

period   Integer.

offset   Integer.

qcl_info_periodic_csi_rs
        Integer.

precoding_matrix
        Optional complex matrix with **n_antenna_dl** rows and **n_ports** columns. Set the NZP CSI-RS precoding matrix. Otherwise, the antenna i is associated with the NZP CSI-RS port $i \pmod{n_{ports}}$.

nzp_csi_rs_resource_set
        Optional array of objects. Mandatory if **resource_auto** is not present. NZP CSI-RS resource set definitions. Each object contains the following parameters:

csi_rs_set_id
        Integer.

nzp_csi_rs_resources
        Array of integers.

repetition
        Boolean.

trs_info   Boolean.

csi_im_resource
        Optional array of objects. Mandatory if **resource_auto** is not present. CSI-IM resource definitions. Each object contains the following parameters:

csi_im_id
        Integer.

pattern   Integer.

subcarrier_location
        Integer.

symbol_location
        Integer.

rb_start   Integer.

l_crb   Integer. -1 means the whole bandwidth.

period   Integer.

offset   Integer.

csi_im_resource_set
> Optional array of objects. Mandatory if `resource_auto` is not present. CSI-IM resource set definitions. Each object contains the following parameters:
>
> **csi_im_set_id**
> > Integer
>
> **csi_im_resources**
> > Array of integer.

csi_ssb_resource_set
> Optional array of objects. CSI-SSB resource set definitions. Each object contains the following parameters:
>
> **csi_ssb_set_id**
> > Integer
>
> **csi_ssb_resources**
> > Array of integer. Each element is a SSB index.

zp_csi_rs_resource
> Optional array of objects. Mandatory if `resource_auto` is not present. ZP CSI-RS resource definitions. Each object contains the following parameters:
>
> **csi_rs_id**
> > Integer.
>
> **frequency_domain_allocation**
> > Enumeration: row1, row2, row4, other.
>
> **bitmap**   Bit string.
>
> **n_ports**   Integer.
>
> **cdm_type** Enumeration: no_cdm,   fd_cdm2,   cdm4_fd2_td2, cdm8_fd2_td4.
>
> **density**   Enumeration: 0.5, 1, 3.
>
> **odd_prbs** Optional integer.
>
> **first_symb**
> > Integer.
>
> **first_symb2**
> > Optional Integer.
>
> **rb_start** Integer.
>
> **l_crb**   Integer. -1 means the whole bandwidth.
>
> **period**   Integer. For aperiodic ZP CSI-RS resources, the period must also be provided and is used by the gNB to generate the corresponding DCI 1_1 ZP CSI-RS trigger bits.
>
> **offset**   Integer.

p_zp_csi_rs_resource_set
> Optional array of objects. ZP CSI-RS resource set definitions. At most one element must be present. Each object contains the following parameters:
>
> **csi_rs_set_id**
> > Optional integer. Range: 0 to 15 (default = 0).

zp_csi_rs_resources
> Array of integers.

aperiodic_zp_csi_rs_resource_set
> Optional array of objects. Aperiodic ZP CSI-RS resource sets. At most 3 objects must be present. Each object contains the following parameters:

> **csi_rs_set_id**
> > Optional integer. Range: 0 to 15. It is set by default to (i + 1) where i is the object index in the `aperiodic_zp_csi_rs_resource_set` array.

> **zp_csi_rs_resources**
> > Array of integers.

csi_resource_config
> Optional array of objects. Mandatory if `resource_auto` is not present. CSI resource configuration definitions. Each object contains the following parameters:

> **csi_rsc_config_id**
> > Integer.

> **nzp_csi_rs_resource_set_list**
> > Optional array of integer.

> **csi_ssb_resource_set_list**
> > Optional array of integer.

> **csi_im_resource_set_list**
> > Optional array of integer.

> **resource_type**
> > Enumeration: aperiodic, semi_persistent, periodic. Only periodic is currently supported.

> **bwp_id** Optional integer (default = 0). Cell downlink BWP ID for the CSI resources. Mandatory if several downlink BWPs are defined.

csi_report_config
> Array of objects. CSI report definitions. Each object contains the following parameters:

> **resources_for_channel_measurement**
> > Optional integer, mandatory if `resource_auto` is not present.

> **csi_im_resources_for_interference**
> > Optional integer, mandatory if `resource_auto` is not present.

> **nzp_csi_rs_resources_for_interference**
> > Optional integer.

> **dl_bwp_id**
> > Optional integer (default = 0). Specifies the cell DL BWP for the resources to use, when `resource_auto` is configured.

> **report_config_type**
> > Enumeration: periodic, aperiodic.

period
:   Integer. Period in UL slots of periodic reports. For aperiodic reports, gives approximately the period (in UL slots) at which the gNB will schedule CSI requests, as long as DL traffic is ongoing.

ul_bwp_id
:   Optional integer (default = 0). ID of the cell uplink BWP containing the periodic CSI reports. When carrier aggregation is configured, it refers to the uplink BWP of the primary cell.

report_quantity
:   Optional enumeration (default = CRI_RI_PMI_CQI): none, CRI_RI_PMI_CQI, CRI_RI_i1, CRI_RI_i1_CQI, CRI_RI_CQI, CRI_RSRP, ssb_Index_RSRP, CRI_RI_LI_PMI_CQI. none is not supported.

codebook_config
:   Optional object. A default configuration matching the number of ports of the CSI RS will be provided if absent. The object contains the following properties:

    codebook_type
    :   Optional enumeration (default = type1): type1.

    sub_type
    :   Optional enumeration (default = typeI_SinglePanel): typeI_SinglePanel.

    n1
    :   Optional integer, mandatory for more than 2 CSI RS ports.

    n2
    :   Optional integer, mandatory for more than 2 CSI RS ports.

    codebook_mode
    :   Optional integer (range 1 or 2, default = 1).

    ri_restriction
    :   Optional bit string.

    subset_restriction
    :   Optional bit string.

    subset_restriction_i2
    :   Optional bit string.

non_pmi_port_indication
:   Optional array of array of array of integers. May be present only if report_quantity is set to CRI_RI_CQI. Indicate the port indexes for each possible rank. The first dimension corresponds to the NZP-CSI-RS resource. The second to the rank. The third to the layer for a given rank. The third array can be null if no ports are defined for a given rank.

cqi_table
:   Optional integer (range 1 to 4, default is based on the pdsch.mcs_table of the BWP where the resources belong to).

subband_size

> Optional enumeration (default = value1): value1, value2.

Only wideband CQI and PMI reports are currently supported.

prs   Optional object. Contains the Positioning Reference Signals (PRS) configuration. PRS parameters are defined in 3GPP TS 38.211 section 7.4.1.7, 3GPP TS 38.214 section 5.1.6.5 and 3GPP TS 37.355 section 6.4.3.

prs_resource_set

> Array of objects. Each object corresponds to one PRS resource set:

> period   Enumeration. Periodicity in slots. The allowed periods correspond to 2^μ multiplied by [4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 160, 320, 640, 1280, 2560, 5120, 10240].

> offset   Integer (0 to period - 1). Offset in slots inside the PRS period.

> time_gap   Integer: 1, 2, 4, 8, 16, 32. dl-PRS-ResourceTimeGap parameter.

> repetition_factor
>> Integer: 1, 2, 4, 6, 8, 16, 32. dl-PRS-ResourceRepetitionFactor parameter.

> prs_muting_option1
>> Optional bit string. dl-PRS-MutingOption1 parameter.

> muting_bit_repetition_factor
>> Optional integer. Must be present when prs_muting_option1 is present. dl-prs-MutingBitRepetitionFactor parameter.

> prs_muting_option2
>> Optional bit string. dl-PRS-MutingOption2 parameter.

> rb_start   Optional Integer (default = 0). First PRB index of the PRS. The origin is the same as the carrier data. The SCS is the same as the carrier data SCS.

> l_crb   Optional Integer (default = -1). Number of PRBs of the PRS. -1 indicates to use the largest possible value.

> comb_size
>> Integer: 2, 4, 6, 12. PRS comb size. part of the dl-PRS-CombSizeN-AndReOffset parameter.

> n_symb   Integer: 2, 4, 6, 12. dl-PRS-NumSymbols parameter.

> power_prs
>> Optional float (default = 0). Power of the PRS relative to the SSB in dB.

> precoding_matrix
>> Optional complex matrix. Precoding matrix of n_antenna_dl rows and 1 column.

> prs_resource
>> Array of objects. Each object corresponds to one PRS resource:

sequence_id

>Optional integer (0 to 4095, default = physical cell ID). `dl-PRS-SequenceID` parameter.

re_offset

>Integer (0 to `comb_size` - 1). part of the `dl-PRS-CombSizeN-AndReOffset` parameter.

slot_offset

>Integer (0 to `period` - 1). `dl-PRS-ResourceSlotOffset` parameter.

start_symb

>Integer (0 to 12). `dl-PRS-ResourceSymbolOffset` parameter.

8.7.4.5 Other downlink parameters

dmrs_type_a_pos

>Enumeration: 2 or 3. dmrs-TypeA-Position parameter.

channel_dl

>Optional object. Set the cell specific channel simulator configuration. See [Cell specific channel simulator], page 224.

lte_crs   Optional object or string. If present, the RRC element lte-CRS-ToMatchAround is added and the PDSCH data is rate matched against the LTE CRS. The string value `auto` automatically sets the configuration from the LTE cell having the same center frequency as the NR cell. Otherwise, the following properties are available:

carrier_freq_dl

>Integer. `carrierFreqDL` RRC field.

carrier_bandwidth_dl

>Enumeration: 6, 15, 25, 50, 75, 100. `carrierBandwidthDL` RRC field.

nr_of_crs_ports

>Enumeration: 1, 2, 4. `nrofCRS-Ports` RRC field.

v_shift   Integer. Range: 0 to 5. `v-Shift` RRC field.

mbsfn_subframe_config_list

>Optional array of object. `mbsfn-SubframeConfigList` RRC field. Each object has the following properties:

radio_frame_allocation_period

>Integer. `radioframeAllocationPeriod` RRC field.

radio_frame_allocation_offset

>Integer. `radioframeAllocationOffset` RRC field.

subframe_allocation1

>Bit string of length 6 or 24. `subframeAllocation1` RRC field.

subframe_allocation2

>Optional bit string of length 2 or 8. `subframeAllocation2` RRC field.

cell_rate_match_pattern

>Optional array of objects. Cell level PDSCH rate match patterns. See the `rate_match_pattern` description.

`reserved_dl_prbs`

>Optional array of integers containing the RB indices where PDCCH and PDSCH allocations are strongly restricted. To allow the cell to run correctly even with a relatively large amount of reserved RBs, only the following allocations are allowed on the `reserved_dl_prbs` :

>- PDCCH allocations of aggregation level greater than or equal to 4
>- If necessary, PDSCH allocations for SIBs and MSG4

`blanked_scs`

>Optional array of integers. List of blanked DL subcarrier ranges. Each range is defined by a pair of integers. The first integer gives the subcarrier index (starting from 0). The second integer gives the number of subcarriers. The SSB subcarriers are not blanked if the SSB subcarrier spacing is not the same as the data subcarrier spacing.

8.7.5 PHY/L1 - Uplink parameters

8.7.5.1 PRACH

`prach`   Object. Contains the PRACH parameters defined below.

>`prach_config_index`
>
>>Integer (range 0 to 262). prach-ConfigurationIndex parameter.

>`msg1_subcarrier_spacing`
>
>>Optional integer. msg1-SubcarrierSpacing parameter. Must be present for PRACH format above 3.

>`l_ra`   Optional enumeration: 139, 571, 1151 (default = 139). For PRACH format above 3, select the length of the root sequence. Only `139` is available for release 15 UEs.

>`msg1_fdm`   Enumeration: 1, 2, 4, 8. msg1-FDM parameter.

>`msg1_frequency_start`
>
>>Integer. msg1-FrequencyStart parameter. The special value -1 indicates to automatically select the PRACH frequency.

>`zero_correlation_zone_config`
>
>>Integer (range 0 to 15). zeroCorrelationZoneConfig parameter.

>`preamble_received_target_power`
>
>>Integer (range -202 to -60). preambleReceivedTargetPower parameter, in dBm.

>`preamble_trans_max`
>
>>Enumeration: 3, 4, 5, 6, 7, 8, 10, 20, 50, 100, 200. preambleTransMax parameter.

>`power_ramping_step`
>
>>Enumeration: 0, 2, 4, 6. powerRampingStep parameter.

>`ra_response_window`
>
>>Enumeration: 1, 2, 4, 8, 10, 20, 40, 80. ra-ResponseWindow parameter.

>`restricted_set_config`
>
>>Enumeration: unrestricted_set, restricted_set_type_a, restricted_set_type_b. restrictedSetConfig parameter.

ra_contention_resolution_timer

>   Enumeration: 8,   16,   24,   32,   40,   48,   56,   64.   ra-
>   ContentionResolutionTimer parameter.

ssb_per_prach_occasion

>   Enumeration: 1/8 1/4 1/2 1 2 4 8 16. ssb-perRACH-OccasionAndCB-
>   PreamblesPerSSB parameter.

cb_preambles_per_ssb

>   Integer (1 to 64). ssb-perRACH-OccasionAndCB-PreamblesPerSSB pa-
>   rameter.

total_number_of_ra_preambles

>   Optional integer (1 to 64, default = 64). totalNumberOfRA-Preambles
>   parameter.

prach_detect_threshold

>   Optional float. Set the PRACH SNR detection threshold in dB. The
>   default value depends on the cell and PRACH parameters.

sul_prach

>   Optional array of objects. Each object of the array defines a PRACH resource to
>   be used for supplementary uplink PRACH by other cells.
>   The array is only relevant when **serve_as_sul** is set to true. See [serve_as_sul],
>   page 207.
>   Each object of the array contains the following parameters:

msg1_frequency_start

>   Optional integer. msg1-FrequencyStart parameter

msg1_fdm   Optional enumeration: 1, 2, 4, 8. msg1-FDM parameter.

root_sequence_index

>   Optional integer (range 0 to 837 for PRACH format up to 3, 0 to 137
>   otherwise). prach-RootSequenceIndex parameter.

zero_correlation_zone_config

>   Optional integer (range 0 to 15). zeroCorrelationZoneConfig parameter.

restricted_set_config

>   Optional   enumeration: unrestricted_set,   restricted_set_type_a,
>   restricted_set_type_b. restrictedSetConfig parameter.

>   When they are not present, the parameters defaults to the value defined in the
>   cell's **prach** configuration. However, each SUL PRACH resource should not overlap
>   with the cell PRACH resource, either through frequency separation or sequence
>   separation or both.

two_steps_prach

>   Optional object for the support of two-steps (or type2) RACH procedure.
>   The current version only supports shared RACH occasions with the 4-steps RACH.
>   It contains the following parameters:

shared_ro

>   Object for the configuration for shared RACH occasions. It contains
>   the following parameters:

>   **cb_preambles_per_ssb_per_sro**

>   Integer (range 1 to 60).   msgA-CB-PreamblesPerSSB-
>   PerSharedRO-r16 parameter.   Actual range will depend

on `cb_preambles_per_ssb`, `ssb_per_prach_occasion` and `total_number_of_ra_preambles` parameters of the 4-steps RACH

ssb_mask_index

Optional integer (range 0 to 15). msgA-SSB-SharedRO-MaskIndex-r16 parameter. The value is ignored if `ssb_per_rach_occasion` is greater or equal than "1".

msga_rsrp_threshold

Integer (range -156 to -30). Value in dB for parameter msgA-RSRP-Threshold-r16.

msga_pusch

Object containing configuration of the PUSCH of the MSGA.
Time multiplexing of MsgA PO is not supported, i.e. nrofMsgA-PO-PerSlot-r16 and nrofSlotsMsgA-PUSCH-r16 are set to '1'.
It contains the following parameters:

time_domain_offset

Integer (range 4 to 32). msgA-PUSCH-TimeDomainOffset-r16 parameter. Values shorter than 4 are not supported.

mcs   Integer (range 0 to 15). msgA-MCS-r16 parameter.

l_crb   Integer (range 1 to 32). nrofPRBs-PerMsgA-PO-r16 parameter.

guard_band

Optional integer (range 0 to 1, default 0). guardBandMsgA-PUSCH-r16 parameter.

po_fdm   Optional enumeration (1, 2, 4, 8, default = 1). nrofMsgA-PO-FDM-r16 parameter.

rb_start   Optional integer (range -1 to UL BWP bandwidth, default = -1). frequencyStartMsgA-PUSCH-r16 parameter. If omitted or set to -1, it is automatically allocated by the eNB.

mapping_type

Optional enumeration (typeA, typeB, default = `mapping_type` of the `pusch` configuration). mappingTypeMsgA-PUSCH-r16 parameter.

n_symb   Optional integer (range 1 to 14). Number of symbols for a MsgA PO.

start_symb

Optional integer (range 0 to 14-n_symb). Mandatory if `mapping_type` is set to `typeB`, ignored otherwise. Starting symbol of the MsgA PO in a slot.

data_scrambling_index

Optional integer (range -1 to 1023, default = -1). msgA-DataScramblingIndex-r16 parameter. Value -1 conveys the absence of the parameter.

tf_precoding

> Optional boolean (default = `msg3_tf_precoding` of the `pusch` configuration). msgA-TransformPrecoder-r16 parameter.

dmrs_scrambling_id_0

> Optional integer (range -1 to 65535, default = -1). msgA-ScramblingID0-r16 parameter if not set to -1.
> Only a single DMRS sequence is supported.

dmrs_add_pos

> Optional integer (range 0 to 3, default = 2). msgA-DMRS-AdditionalPosition-r16 parameter.

dmrs_max_len

> Optional integer (range 1 to 2, default = 1). msgA-MaxLength-r16 parameter.

dmrs_cdm_group

> Optional enumeration (0, 1, "both", default = "both"). msgA-PUSCH-DMRS-CDM-Group-r16 parameter.

dmrs_n_ports

> Optional enumeration (1, 2, 4, default = 2 or 4). msgA-PUSCH-NrofPorts parameter. Value 4 is possible only if `dmrs_max_len` is set to 2.

msgb_response_window

> Enumeration (1, 2, 4, 8, 10, 20, 40, 80, 160, 320). msgB-ResponseWindow-r16 parameter in slots. Cannot represent a duration bigger than 40 ms.

msgb_mcs   Optional integer (range 0 to 16, default = `rar_mcs`). MCS used for MSGB transmission.

msgb_tb_scaling

> Optional integer (range 0 to 2, default = `rar_tb_scaling`). TB scaling to apply to MSGB to reduce coderate.

prach_feature_preambles_list

> Optional array to configure one or several partitions of the PRACH preambles corresponding to a combination of features. AdditionalRACH-Config is not supported. Each element of the array contains the following parameters :

feature_combination

> Array of enumeration (`redcap`, `msg3_rep`, `sdt` or `eredcap`). The combination of features associated to this PRACH preambles partition.

preamble_start

> Optional integer (range 0 to 64, defaults to cb_preambles_per_ssb + two_steps_rach.cb_preambles_per_ssb_per_sro). Starting preamble of the partition. Overriding the default value can be useful when the whole PRACH resource can be reserved to a certain feature, typically (e)RedCap in a (e)RedCap-only BWP.

preambles_per_ssb

> Integer (actual range depends on preamble_start and total_number_of_ra_preambles). Number of preambles per SSB in this partition.

rsrp_threshold

>>Optional integer (range -156 to -30). rsrp-ThresholdSSB to restrict beam selection when using this partition.

two_steps_prach

>>Optional object. If present, this PRACH partition will be configured with two-steps RACH and will inherit the configuration of the `two_steps_prach` object of this UL BWP. See [two_steps_prach], page 186. The object contains the following parameters :

>>msga_pusch

>>>Optional object with the same parameters than `msga_pusch` of the main `two_steps_prach` configuration. All parameters are optional and default to the value given by the two-steps RACH configuration of this UL BWP.
To avoid MSGA collision, it is preferable to separate (in time, frequency or code) this MSGA configuration from the other MSGA configurations.

sul_prach_index_list

>>Optional array of integers. If the cell defines SUL PRACH resources with `sul_prach`, this PRACH preamble partition will also apply to the SUL PRACH resources of the given indices. See [sul_prach], page 186. The source cells refering to those SUL PRACH resource indices need to have a configuration suitable for the `feature_combination`.

sul_prach_only

>>Optional boolean (default = false). When set to true, this PRACH preamble partition doesn't apply to the cell's own PRACH, but only to the SUL PRACH resources.

feature_priorities

>Optional object to configure the feature priorities. The object is mandatory when at least one of the BWP contains a `prach_feature_preambles_list`. It contains the following parameters:

redcap   Optional integer (range 0 to 7). Priority for the RedCap feature.

msg3_rep Optional integer (range 0 to 7). Priority for the MSG3 repetition feature.

sdt   Optional integer (range 0 to 7). Priority for the SDT feature.

eredcap   Optional integer (range 0 to 7). Priority for the eRedCap feature.

pdcch_order_prach

>Optional object to support PDCCH order PRACH.
PDCCH order is triggered when a UE reaches `ul_max_consecutive_retx` or `dl_max_consecutive_retx`, or via a call the `pdcch_order_prach` API or monitor command.
It contains the following parameters:

preamble_type

>>Enumeration (`cb_random, cf_given`). Defines the type of RACH triggered by the gNB: random contention-based preamble chosen by UE (ra-PreambleIndex = 0) or dedicated contention-free preamble. If set to `cb_random`, all the other parameters are irrelevant.

sul_ind Optional enumeration (`last, normal_ul, sul`, default = `normal_ul`). Defines on which UL carrier is performed the access. `last` corresponds to the UL carrier used by the UE for the last random access.

ssb_index

Optional integer (range -1 to length of `ssb_pos_bitmap` minus 1, default = -1). The index should correspond to a 'one' bit in `ssb_pos_bitmap`. SSB index used by the UE to determine RACH occasion. The special value -1 selects the SSB that the UE is listening to.

prach_mask_index

Optional integer (range 0 to 15, default = 0). PRACH mask index to further restrict PRACH occasions.

root_sequence_index

Integer (range 0 to 837 for PRACH format up to 3, 0 to 137 otherwise). prach-RootSequenceIndex parameter. It must be different for each neighbour cell operating on the same frequency and sharing the same PRACH configuration.

rar_backoff_index

Optional integer (range -1 to 15, default = -1). Sets the backoff indicator sent in the RAR message. -1 means that the BI is not transmitted.

8.7.5.2 PUCCH

pucch Object. Contains the PUCCH parameters defined below. PUCCH can be defined either automatically with the `resource_auto` parameter or explicitely.
For an explicit configuration, either the `pucch0` or `pucch1` object must be defined and either the `pucch2`, `pucch3` or `pucch4` object must be defined.

p0_nominal

Integer (range -202 to 24). p0-nominal parameter.

resource_auto

Optional object. Contains high level configuration to generate automatically the PUCCH resources. When set, the following parameters are ignored: `n_rb_max, short_pucch_an_rsc_count, long_pucch_an_rsc_count, ue_short_pucch_an_rsc_count, ue_long_pucch_an_rsc_count, pucch02_min_start_symb, pucch134_auto_n_symb, pucch0, pucch1, pucch2, pucch3` and `pucch4`. It contains the following :

ue_count Optional integer (default = dependent on the UL BWP bandwidth): Estimation of the number of simultaneous users on this BWP.

formats Optional enumeration: automatic, format_0_and_2, format_1_and_3, format_1_and_4 (default = automatic). Force the formats for the short and long PUCCH. In automatic mode, the format is chosen based on the maximum number of available symbols in UL slots.

robustness

Optional enumeration: low, medium, high (default = medium). Configure the wanted robustness of the PUCCH signal.

freq_hopping

> Optional boolean (default = false). Configure intra-slot frequency hopping for the PUCCH whenever possible.

pucch_resource_common

> Optional integer (range -1 to 15, default = -1). pucch_ResourceCommon parameter, -1 if not present. This parameter is normally not needed for NSA. For SA, -1 means that it is automatically set.

pucch_group_hopping

> Optional enumeration: neither, enable, disable (default = neither). pucch-GroupHopping parameter.

hopping_id

> Optional integer (range -1 to 1023, default = -1). hoppingId parameter. -1 means disabled.

dpc_snr_target

> Optional float (range -10 to 40). When set, closed-loop power control is enabled for PUCCH and gNB will send TPC commands in DCI 1_0/1_1 to make the PUCCH SNR converge to the specified value.

dpc_p_max

> Optional float (default = -15). Set the PUCCH maximum power in dBFS for the dynamic power control. The corresponding maximum EPRE is computed by dividing it by the number of subcarriers. Only used when dpc_snr_target is present.

dpc_epre_max

> Optional float. Set the PUCCH maximum EPRE in dBFS for the dynamic power control. If not present, dpc_p_max is used instead. See rx_epre_in_dbfs if you want to display the EPRE in dBFS instead of dBm in the logs. Only used when dpc_snr_target is present.

n_rb_max   Optional integer (range 2 to n_rb_ul). Set the maximum number of resource blocks which can be allocated for PUCCH.

short_pucch_an_rsc_count

> Optional integer (range 1 to 1024, default = 8). Number of short PUCCH (format 0 or 1) allocated for HARQ/ACK in the cell.

long_pucch_an_rsc_count

> Optional integer (range 0 to 1024, default = 4). Number of long PUCCH (format 2, 3 or 4) allocated for HARQ/ACK in the cell.

ue_short_pucch_an_rsc_count

> Optional integer (range 1 to 8, default = min(8, short_pucch_an_rsc_count)). Number of short PUCCH for HARQ/ACK per UE.

ue_long_pucch_an_rsc_count

> Optional integer (range 0 to 8, default = min(8, long_pucch_an_rsc_count)). Number of long PUCCH for HARQ/ACK per UE.

pucch02_min_start_symb

> Optional integer (range 0 to 13, default = 0). Force the PUCCH format 0 and 2 to be allocated in symbols starting from pucch02_min_start_symb.

pucch134_auto_n_symb

> Optional boolean (default = true). When set to true, the eNB overrides the value of n_symb for PUCCH formats 1, 3 or 4 based on SRS configuration to lower the risk of PUCCH allocation issues.

multi_csi

> Optional boolean (default = false). When set to true, the eNB uses the same PUCCH resource for all the CSI reports and configures multi-CSI-PUCCH-ResourceList.

dmrs_tf_precoding

> Optional boolean (default = false). When set to true, enable DMRS transform precoding for PUCCH 3 and 4 when the BPSK modulation is used. Warning: the feature is enabled regardless of the UE capabilities.

pucch0   Object. Contains the parameters for PUCCH 0 and enable its use for short ACK/NACK/SR report.

> **initial_cyclic_shift**
>
> > Integer (range 0 to 11). Initial cyclic shift.
>
> **n_symb**   Integer (range 1 to 2). Number of symbols.
>
> **freq_hopping**
>
> > Optional boolean (default = true when n_symb = 2). Enable intra slot frequency hopping (only possible with n_symb = 2).
>
> **sr_detect_threshold**
>
> > Optional float. Scheduling Request detection threshold in dB.

pucch1   Object. Contains the parameters for PUCCH 1 and enable its use for short ACK/NACK/SR report.

> **n_cs**   Integer (range 2 to 4). Cyclic shift.
>
> **n_occ**   Integer (range 2 to 4). Number of time orthogonal codes.
>
> **freq_hopping**
>
> > Optional boolean (default = true). Enable intra slot frequency hopping.
>
> **start_symb**
>
> > Optional integer (range 0 to 10, default = 0). Starting symbol.
>
> **n_symb**   Optional integer (range 4 to 14, default = 14). Number of symbols.
>
> **sr_detect_threshold**
>
> > Optional float. Scheduling Request detection threshold in dB.

pucch2   Object. Contains the parameters for PUCCH 2 and enable its use for long ACK/NACK report.

> **n_symb**   Integer (range 1 to 2). Number of symbols.
>
> **freq_hopping**
>
> > Optional boolean (default = true when n_symb = 2). Enable intra slot frequency hopping (only possible with n_symb = 2).

max_code_rate
> Optional enumeration: 0.08, 0.15, 0.25, 0.35, 0.45, 0.6, 0.8. (default = 0.25). Set the maxCodeRate PUCCH RRC parameter.

simultaneous_harq_ack_csi
> Optional boolean (default = false).

n_prb
> Integer (range 1 to 16). Maximum number of PRBs for HARQ-ACK PUCCH. It must be of the form $2^a 3^b 5^c$.

n_prb_csi
> Optional integer (range 0 to 16, default = 0). Number of PRBs for CSI reports. The default value 0 indicates that it is automatically computed from the number of estimated CSI bits and max_code_rate.

pucch3
> Object. Contains the parameters for PUCCH 3 and enable its use for long ACK/NACK report.

bpsk
> Boolean. Use BPSK instead of QPSK.

additional_dmrs
> Boolean. Use additional DMRS symbols.

freq_hopping
> Boolean. Enable intra slot frequency hopping.

start_symb
> Optional integer (range 0 to 10, default = 0). Starting symbol.

n_symb
> Optional integer (range 4 to 14, default = 14). Number of symbols.

max_code_rate
> Optional enumeration: 0.08, 0.15, 0.25, 0.35, 0.45, 0.6, 0.8. (default = 0.25). Set the maxCodeRate PUCCH RRC parameter.

simultaneous_harq_ack_csi
> Optional boolean (default = true).

n_prb
> Integer (range 1 to 16). Maximum number of PRBs for HARQ-ACK PUCCH. It must be of the form $2^a 3^b 5^c$.

n_prb_csi
> Optional integer (range 0 to 16, default = 0). Number of PRBs for CSI reports. The default value 0 indicates that it is automatically computed from the number of estimated CSI bits and max_code_rate.

pucch4
> Object. Contains the parameters for PUCCH 4 and enable its use for long ACK/NACK report.

bpsk
> Boolean. Use BPSK instead of QPSK.

additional_dmrs
> Boolean. Use additional DMRS symbols.

occ_len
> Integer (2 or 4). Select the orthogonal code length.

freq_hopping
> Boolean. Enable intra slot frequency hopping.

start_symb
> Optional integer (range 0 to 10, default = 0). Starting symbol.

n_symb   Optional integer (range 4 to 14, default = 14). Number of symbols.

max_code_rate
> Optional enumeration: 0.08, 0.15, 0.25, 0.35, 0.45, 0.6, 0.8. (default = 0.25). Set the maxCodeRate PUCCH RRC parameter.

simultaneous_harq_ack_csi
> Optional boolean (default = true).

sr_period
> Enumeration: 0, 1, 2, 4, 5, 8, 10, 16, 20, 40, 80, 160, 320, 640. Scheduling Request periodicity. 0 means no Sheduling Request configuration.

forced_sr_offset
> Optional integer: range -1 to sr_period-1 (default = -1). Forces the scheduling request slot offset sent to the UE. -1 means that the gNB allocates the value automatically.

8.7.5.3 SRS

srs
> Optional object. Contains the SRS configuration.
>
> If not present a default aperiodic SRS configuration with one antenna port is selected if use_dci_0_1_and_1_1 is set to true, and no SRS configuration is selected otherwise.
>
> SRS can be configured:
>
> - either automatically with the resource_auto parameter. The object takes a high level description and the actual SRS configuration will depend on the UE capabilities.
>
> - either explicitly with the srs_symbols, srs_resource and srs_resource_set parameters.
>
> The following parameters are available:
>
> resource_auto
> > Optional object. Contains high level configuration for one or two SRS resource sets, based on their usage. At least one of codebook, non_codebook or antenna_switching set needs to be defined. codebook and non_codebook shall not be defined simultaneously.
> >
> > codebook   Optional object. Configures the SRS resource set for codebook usage. It contains the following parameters:
> >
> > > resource_type
> > > > Optional enumeration: aperiodic, periodic (default = aperiodic).
> > >
> > > period   Integer (range 1 to 2560). SRS period in slots. For an aperiodic resource, it indicates the approximate period for SRS scheduling via DCI.

wideband   Optional boolean (default = false). Whether the SRS resource is wideband or not. The cell can accomodate less UEs with wideband resources.

n_ports   Optional enumeration: 1, 2, 4, default = 4. Maximum number of SRS antenna ports allowed. The actual number of ports will depend on UE capability.

p0   Optional integer (range -202 to 24). If not provided the p0_nominal_with_grant and alpha values from the PUSCH configuration are used.

alpha   Optional enumeration: 0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, default = 1.

non_codebook

Optional object. Configured the SRS resource set for non-codebook usage. It contains the same parameters than codebook object, except that n_ports is forced to 1. It also contains the following additional parameter:

rsc_count

Optional integer (range 1 to 4, default = 4). Maximum number of SRS resources in the non-codebook set. For aeriodic resources, the value is limited to 2. The actual number of resources will depend on UE capability.
If pusch.ncb_sri_bitmap is set, it will also adapt based on UE capability.

antenna_switching

Optional object. Configures the SRS resource sets for antenna switching usage. It contains the same parameters than codebook object plus the following additional parameter:

allow_xTyR

Optional boolean (default = true). Set to true when UE with antena switching capabilities like xTyR (with $x \neq y$) are expected. It reserves more slots and symbols for SRS resources in the cell.

n_symb   Optional integer (range 1 to 4). Force the number of symbols reserved for SRS. If the parameter is absent, a default value is chosen depending on cell bandwidth and allow_xTyR value.

srs_symbols

Optional array of integer. Each element gives the number of trailing symbols reserved for SRS in the corresponding slot. The length of the array must divide $20 * 2^{\mu}$. PUSCH in slots with reserved SRS symbols are automatically shortened. PUCCH format 0 and 2 are allocated so that they don't collide with the SRS Symbols. The number of symbols for PUCCH formats 1, 3 and 4 must be chosen so that they don't overlap with SRS.

srs_resource
> Array of objects. Each object defines a SRS resource:
>
> **srs_resource_id**
> > Integer: 0 to 63. RRC SRS resource ID.
>
> **n_ports** Optional enumeration: 1, 2, 4, default = 1. Select the number of SRS antenna ports. The maximum rank for PUSCH cannot be larger.
>
> **transmission_comb**
> > Optional enumeration: 2, 4, default = 2.
>
> **cyclic_shift**
> > Optional integer: -1 to 11, default = -1. -1 indicates a random per UE cyclic shift.
>
> **n_symb** Optional enumeration: 1, 2, 4, default = 1.
>
> **repetition_factor**
> > Optional enumeration: 1, 2, 4, default = 1.
>
> **c_srs** Optional integer (range 0 to 63). SRS bandwidth configuration index. The default value is chosen depending on the BWP bandwidth.
>
> **freq_domain_shift**
> > Optional integer (range 0 to 268). The default value is chosen so that the SRS bandwidth is centered in the BWP bandwidth.
>
> **b_srs** Optional integer (range 0 to 3, default = 2).
>
> **b_hop** Optional integer (range 0 to 3, default = 0).
>
> **group_or_sequence_hopping**
> > Optional enumeration: neither, group, sequence (default = neither).
>
> **n_id** Optional integer (range 0 to 1023, default = n_id_cell).
>
> **resource_type**
> > Optional enumeration: aperiodic, periodic (default = aperiodic).
>
> **period** Integer (range 1 to 2560). SRS period in slots.
> > When `resource_type` is `periodic`, the parameter is mandatory.
> > When `resource_type` is `aperiodic`, the parameter is optional and indicates the approximate period for SRS scheduling via DCI. If the parameter is absent or set to 0, the aperiodic SRS is still configured but never scheduled.

srs_resource_set
> Array of objects. Each object defines a SRS resource set:
>
> **srs_resource_set_id**
> > Optional integer (range 0 to 15). The default value is set to the array element index.

srs_resource_id_list

> Array of integer. Each element must be a valid SRS resource ID. All the SRS resources must have the same `resource_type`.

aperiodic_srs_trigger

> Optional integer (range 1 to 3, default = 1). Aperiodic SRS parameter.

slot_offset

> Optional integer (range 0 to 32, default = 7). Aperiodic SRS parameter.

usage
> Optional enumeration: beam_management, codebook, non_codebook, antenna_switching, default = codebook.

p0
> Optional integer (range -202 to 24). If not provided the `p0_nominal_with_grant` and `alpha` values from the PUSCH configuration are used.

alpha
> Optional enumeration: 0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, default = 1.

srs_carrier_switching

> Optional boolean (default = false). If true, enable SRS carrier switching when the containing cell is used as primary cell. It can be used when SRS is configured explicitly or with `resource_auto`. The SRS resources sets with `usage` set as `antenna_switching` are configured on the secondary cells with no uplink.

8.7.5.4 PUSCH

pusch   Object. Contains the PUSCH parameters defined below.

mapping_type

> Optional enumeration (typeA or typeB, default = typeA). Select the mapping type for the full UL slots

n_symb   Optional integer (range 4 to 14 for mapping type A, 1 to 14 for mapping type B). Number of symbols for PUSCH. Defaults to the maximum possible.

start_symb

> Optional integer. Only required for mapping type B as it is set to 0 for mapping type A. Defaults to the smallest possible.

partial_slots

> Optional boolean. (default = false). If set to true, partial UL slots will also be allocated if they have more than 2 symbols not taken by SRS.

dmrs_mapping_type_a
dmrs_mapping_type_b

> Optional object. Set the DMRS mapping type A and/or type B configuration. If neither the `dmrs_mapping_type_a` nor the `dmrs_mapping_type_b` objects are present, the DMRS configuration properties are directly in the `pusch` object and the DMRS mapping is determined by `mapping_type`. The DMRS parameters are the following:

dmrs_add_pos

> Optional integer (range 0 to 3, default = 2). dmrs-AdditionalPosition parameter.

dmrs_max_len

> Optional integer (range 1 to 2, default = 1). maxLength parameter.

dmrs_type

> Optional integer (1 or 2, default = 1). dmrs-Type parameter.

dmrs_scid0

> Optional integer (-1 to 65535, default = -1). DMRS for scrambling ID 0. -1 means default value (PCI).

dmrs_scid1

> Optional integer (-1 to 65535, default = -1). DMRS for scrambling ID 1. -1 means default value (PCI).

dmrs_low_papr

> Optional boolean (default = false). Enable low PAPR uplink DMRS without transform precoding.

dmrs_tf_precoding

> Optional object (default = null). Enable low PAPR uplink DMRS with transform precoding. The object contains the following paramters:
>
> pi2_bpsk_scid0
>
> > Optional integer (default = -1). Set the pi/2 BPSK DMRS scrambling ID 0. -1 means default value (PCI).
>
> pi2_bpsk_scid1
>
> > Optional integer (default = -1). Set the pi/2 BPSK DMRS scrambling ID 1. -1 means default value (PCI).

n_id_rs   Optional integer (range -1 to 1024, default = -1). PUSCH identity for transform precoding. -1 means default value (PCI).

group_hopping_disabled

> Optional boolean (default = false). If true, set uplink DMRS transformPrecodingEnabled.sequenceGroupHopping to disabled.

sequence_hopping

> Optional boolean (default = false).

ptrs   Optional object. PUSCH PT-RS parameters. If the object is present, the PT-RS are enabled regardless of the UE capabilities. The following PT-RS parameters are available:

> frequency_density
>
> > Optional array of integers (range: 1 to 276) of 2 elements.
>
> time_density
>
> > Optional array of integers (range: 0 to 29) of 3 elements.
>
> power   Optional integer (range: 0 to 3, default = 0).

resource_element_offset
Optional integer (range: 0 to 3, default = 0).

ptrs_dmrs_assoc
Optional integer (range: 0 to 3, default = 0). Force the value of the PTRS-DMRS association DCI 0_1 field when present.

sample_density_tp
Optional array of integers (range: 1 to 276) of 5 elements. If present, PT-RS with transform precoding are enabled.

time_density_tp
Option integer (range: 1 to 2, default = 1).

When n_layer is forced, the following additional DMRS parameters are available:

dmrs_len   Optional integer (range 1 to dmrs_max_len, default = 1) (only used in DCI 0_1).

n_dmrs_cdm_groups
Optional integer (range 1 to 3, default = 1) (only used in DCI 0_1).

dmrs_ports
Optional array of integers. DMRS port for each layer. By default dmrs_ports[i] = i.

tf_precoding
Optional boolean (default = false). Enable transform precoding for PUSCH (only used in DCI 0_1).

msg3_tf_precoding
Optional boolean (default = tf_precoding value). msg3-transformPrecoder parameter.

group_hopping
Optional boolean (default = false). Corresponds to pusch-ConfigCommon.groupHoppingEnabledTransformPrecoding.

mcs_table
Enumeration (qam64, qam256, qam64LowSE). Select the MCS Table when transform precoding is disabled.

mcs_table_tp
Enumeration (qam64, qam256, qam64LowSE). Select the MCS Table when transform precoding is enabled.

tp_pi2_bpsk
Optional boolean (default = false). If true, the UE uses pi/2 BPSK for some MCS when transform precoding is enabled (only used in DCI 0_1).

ldpc_max_its
Optional integer (range 1 to 50, default = 5). Maximum number of iterations for the LDPC decoder.

ra_type   Optional enumeration (type0, type1, dynamic_switch, default = type1).
              Set the RB resource allocation type. Note: `fixed_rb_alloc` = true or
              transform precoding cannot be used with resource allocation type 0.

rbg_size   Optional enumeration (config1, config2, default = config1). Set the
              RBG size configuration for resource allocation type 0.

fixed_rb_alloc
              Optional boolean or array of booleans (default = false). Allows to force
              the PUSCH allocations. If an array is provided, its length must divide
              $20 * 2^{\mu}$ and each element corresponds to a slot modulo the length of the
              array.

rb_start   Optional integer or array of integers. PUSCH allocation starting posi-
              tion in number of RBs. Must be present if `fixed_rb_alloc` is true.

l_crb   Optional integer or array of integers. PUSCH allocation length in num-
              ber of RBs. Must be present if `fixed_rb_alloc` is true.
              If set to 0, PUSCH scheduling is disabled on the slot.

tx_config
              Optional enumeration: codebook, non_codebook (default = codebook).
              PUSCH TX configuration.

codebook_subset
              Optional   enumeration: fully_and_partial_and_non_coherent,
              partial_and_non_coherent, non_coherent (default = non_coherent).
              Codebook subset when `tx_config` = `codebook`. Warning: this
              parameter is set regardless of the UE capabilities.

ul_full_power_transmission
              Optional enumeration: none, full_power, full_power_mode1,
              full_power_mode2 (default = none). ul-FullPowerTransmission
              configuration when `tx_config` = `codebook`. Warning: this parameter
              is set regardless of the UE capabilities.

max_rank   Optional integer (default = 1). Maximum rank for DCI 0_1. For
              `codebook` configuration, the maximum value is the number of SRS an-
              tenna ports of the SRS resource with codebook usage.
              For `non_codebook` configuration, the maximum value is the number of
              SRS resources in the SRS set with non-codebook usage.

n_layer   Optional integer (range 0 to `max_rank`, default = 0). The default value
              0 indicates that the number of layers in DCI 0_1 is computed from the
              SRS reports. Otherwise, the number of layers is forced and the following
              additional parameter may be provided:

              tpmi   Optional integer (default = 0). Forced TPMI for PUSCH
                         in `codebook` configuration. Only meaningful if `tx_config`
                         = `codebook` and if more than one SRS antenna port.

              ncb_sri_bitmap
                         Optional string of '0' or '1'. Mandatory if `tx_config` =
                         `non_codebook`, ignored otherwise. The length of the bit-
                         string should equal the number of SRS resources in the
                         SRS set with non-codebook usage. Indicates the SRS re-
                         sources to use for PUSCH transmission in `non_codebook`
                         configuration, there should be `n_layer` bits set to 1.

Additional DMRS parameters may be provided too.

mcs   Optional integer or array of integers (range -1 to 28, default = -1). PUSCH MCS. -1 means autonomous UL MCS adaptation by the gNB scheduler. If an array is provided, its length must divide $20 * 2^\mu$ and each element corresponds to a slot modulo the length of the array.

max_mcs   Optional. Range: 0 to 28 (default = 28). CPU load limitation: maximum MCS allocated by the gNodeB for PUSCH. Smaller MCS give a smaller bitrate and a smaller CPU load.

k2   Optional integer or array of integer (range k_min to 32). Delay in slots from DCI to PUSCH. In FDD a single value is provided. In TDD, an array is provided with one entry per uplink slot in the TDD period. The k2 value for a given UL slot must be less or equal than all k1 values leading to a HARQ ACK/NACK in this slot.
                If the field is absent, and if k1 is also absent in the PDSCH configuration, the gNB automatically computes valid values.

msg3_k2   Optional integer (range k_min to 32). Delay in slots from DCI to Msg3 PUSCH. If the field is absent, and if k1 and k2 are absent, the gNB automatically computes a valid value.

msg3_delta_power
                Integer (range -6 to 8). TPC command for Msg3 PUSCH.

msg3_mcs   Integer (range 0 to 15). MCS for Msg3 PUSCH.

msg3_alpha
                Optional enumeration (0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, default = 1). Power control alpha value for Msg3.

p0_nominal_with_grant
                Integer (range -202 to 24). p0-NominalWithGrant parameter.

alpha   Optional enumeration (0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, default = 1). Power control alpha value.

dpc_snr_target
                Optional float (range -5 to 40). When set, closed-loop power control is enabled for PUSCH and gNB will send TPC commands in DCI 0_0/0_1 to make the PUSCH SNR converge to the specified value.

dpc_p_max
                Optional float (default = -15). Set the PUSCH maximum power in dBFS for the dynamic power control. The corresponding maximum EPRE is computed by dividing it by the number of subcarriers. Only used when dpc_snr_target is present.

dpc_epre_max
                Optional float. Set the PUSCH maximum EPRE in dBFS for the dynamic power control. If not present, dpc_p_max is used instead. See rx_epre_in_dbfs if you want to display the EPRE in dBFS instead of dBm in the logs. Only used when dpc_snr_target is present.

data_scid
                Optional integer (range -1 to 1023, default = -1). dataScramblingIdentityPUSCH parameter. -1 means disabled.

n_scid   Optional integer (range 0 to 1, default = 0). Allows to force the DMRS for scrambling ID used (only used in DCI 0_1).

x_overhead
           Optional enumeration (0, 6, 12, 18, default = 0). Corresponds to the x0verhead RRC parameter.

dynamic_beta_offsets
           Optional array of 4 objects. If present, enable the dynamic beta offsets. Each object contains the following properties:

           beta_offset_ack_index
                   Optional integer (range 0 to 15). Set the 3 fields beta_offset_ack_index1, beta_offset_ack_index2, beta_offset_ack_index3 to the same value. Otherwise, each field must be set separately.

           beta_offset_ack_index1
                   Optional integer (range 0 to 15).

           beta_offset_ack_index2
                   Optional integer (range 0 to 15).

           beta_offset_ack_index3
                   Optional integer (range 0 to 15).

           beta_offset_csi_part1_index
                   Optional integer (range 0 to 18). Set beta_offset_csi_part1_index1 and beta_offset_csi_part1_index2 to the same value.

           beta_offset_csi_part1_index1
                   Optional integer (range 0 to 18, default = beta_offset_csi_part1_index).

           beta_offset_csi_part1_index2
                   Optional integer (range 0 to 18, default = beta_offset_csi_part1_index).

           beta_offset_csi_part2_index
                   Optional integer (range 0 to 18). Set beta_offset_csi_part2_index1 and beta_offset_csi_part2_index2 to the same value.

           beta_offset_csi_part2_index1
                   Optional integer (range 0 to 18, default = beta_offset_csi_part2_index).

           beta_offset_csi_part2_index2
                   Optional integer (range 0 to 18, default = beta_offset_csi_part2_index).

           The semi-static beta offset index properties are directly set in the pusch object.

dci_beta_offset_indicator
           Optional integer (range 0 to 3, default = 0). When dynamic beta offsets are enabled, set the value of the DCI 0_1 beta_offset_indicator field.

uci_scaling

Optional enumeration (0.5, 0.65, 0.8, 1, default = 1). Set the RRC UCI-OnPUSCH scaling field value.

fer   Optional float (range 0 to 1). If present, simulates a PUSCH Frame Error Rate of `fer`. It is mainly useful in test mode (see the `test_mode` parameter).

ul_snr_adapt_fer

Optional float (range 0 to 1, default = 0.1). UL FER target for the initial HARQ transmission used by the gNB UL MCS adaptation algorithm, enabled when `mcs` is absent or set to -1. Applied for all MCS tables but 64QAMLowSE.

ul_snr_adapt_fer_lowse

Optional float (range 0 to 1, default = 0.00001). UL FER target for the initial HARQ transmission used by the gNB UL MCS adaptation algorithm, enabled when `mcs` is absent or set to -1. Applied for MCS table 64QAMLowSE.

ul_snr_adapt_amp

Optional float (default = 10). This values defines the maximum amplitude (in dB units) of the correction applied on top of the MCS selected from the UL SNR.

ul_snr_adapt_retx

Optional float (default = 0.3). Defines the correction step applied by the HARQ initial transmission decoding result within the `ul_snr_adapt_amp` range.

phr_link_adaptation

Optional boolean (default = true). If set to true, the gNB will lower the UL MCS and/or resource blocks allocation if the UE sends negative MAC power headroom reports indicating it is power limited. If set to false, the power headroom value is not taken into account for the UL link adaptation mecanism.

dtx_snr_threshold

Optional float (default = -8.0). SNR threshold on the PUSCH for DTX detection on a dynamic grant. When `enhanced_skip_uplink_tx_dynamic_enabled` is set to true, if the received signal is below the threshold the grant is considered skipped by the UE and will not be requested for retransmission. Otherwise if the received signal is below the threshold, the gNB will request a retransmission using the same redundancy version as the previous transmission.

aggregation_factor

Optional enumeration (1, 2, 4, 8, default = 1). If greater than 1 and if the UE supports it, pusch-AggregationFactor will be configured for PUSCH multi-slots transmission in this BWP.
If `tdra_repetition_number` is also configured and if the UE supports both features, the parameter is ignored.

tdra_repetition_number

Optional enumeration (1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32, default = 1). Configure TDRA based PUSCH multi-slots transmission via the field numberOfRepetitions-r16 if the value is less or equal than 16 or numberOfRepetitionsExt-r17 otherwise, if the UE supports it.

available_slot_counting

>Optional boolean (default = false). Enables availableSlotCounting-r17 if the UE supports it, to change how the UE counts the DL-only slots for the repetition mapping.

dmrs_bundling

>Optional boolean (default = false). Enables pusch-DMRS-Bundling-r17 if the UE supports it and if PUSCH repetition are configured

dmrs_bundling_tdw_length

>Optional integer (0 or range 2 to 8, default = 0). Controls the pusch-TimeDomainWindowLength-r17 field for PUSCH DMRS bundling. If set to 0, the value will not be configured and UE will apply a default value. If set to a value between 2 and 8, the value will be configured by also taking into account UE capability.

dmrs_bundling_window_restart

>Optional boolean (default = false). Enables pusch-WindowRestart-r17 if the UE supports it.

msg3_repetition_number

>Optional enumeration (1, 2, 3, 4, 7, 8, 12, 16, default = 1). If set to 1, the gNB will not use msg3 repetitions. Number of repetitions for MSG3 if the UE uses a PRACH preamble for the `msg3_rep` feature. See [prach_feature_preambles], page 188.

msg3_repetition_mcs

>Optional integer (range 0 to 15, default is `msg3_mcs`). MCS for MSG3 PUSCH with repetitions.

msg3_repetition_rsrp_threshold

>Optional integer (range -156 to -130, default is -110). RSRP threshold below which a capable UE will try to use the MSG3 repetition feature.

n_harq_process

>Optional enumeration: 16, 32 (default = 16). nrofHARQ-ProcessesForPUSCH parameter. The value 32 will be applied only on NTN cells and if the UE supports it, and will default to 16 otherwise.

harq_mode_b

>Optional boolean or string (default = false). Controls the NTN HARQ mode B feature.
>If set to true, all HARQ processes except process 0 are set to HARQ mode B. If set to false, all the processes are HARQ mode A.
>If set to a string, it should be a 32 bits bitmap of the HARQ processes to disable. HARQ process 0 is represented by the first/leftmost bit.
>You must always leave at least one process in mode A since the SRBs and DRBs with `harq_mode` set to enabled_only will only be allowed on processes mode A.
>Note : *Unlike* the RRC IE uplinkHARQ-mode-r17, a bit set to '1' sets the process in mode B and a bit value of '0' corresponds to HARQ mode A.

freq_hopping

>Optional boolean (default = false). Enables PUSCH frequency hopping with an hopping offset of half the UL BWP.

freq_hopping_offsets
> Optional array of integers. Frequency hopping offsets list transmitted to UE.

freq_hopping_index
> Optional integer. Index in `freq_hopping_offsets` of the actually used frequency offset, which must be equal to the half of the UL BWP.

configured_grant
> Optional object. Defines UL configured grant parameters used when at least one bearer with `need_sps` equal to `ul` or `both` is established and if the UE supports Configured Grant. See [NR DRB configuration], page 153.
>
> Both Configured Grant Type 1 and Type 2 are supported.
>
> It contains a subset of parameters defined in the `pusch` object, with the same meaning. See [pusch], page 197.
>
> All those parameters are optional and default to the value defined in the `pusch` object of the same BWP, unless stated otherwise.
>
> Those PUSCH parameters are:

tf_precoding
> Optional boolean

mcs_table
> Optional enumeration (qam64, qam256, qam64LowSE).

rbg_size   Optional enumeration (config1, config2)

ra_type   Optional enumeration (type0, type1, dynamic_switch)

dynamic_beta_offsets
> Optional array of 4 objects.

dmrs   Optional object

tpmi   Optional integer.

mcs   Optional integer (range 0 to 28). If absent and if the corresponding value is set to -1 in the `pusch` object (dynamic behaviour), the value defaults to 4.

n_layer   Optional integer (range 1 to `pusch.max_rank`). If absent and if the corresponding value is set to 0 in the `pusch` object (dynamic behaviour), the value defaults to 1.

skip_uplink_tx_snr_threshold
> Optional float (default = -8.0). SNR threshold on the PUSCH for skip uplink detection on a configured grant if `enhanced_skip_uplink_tx_configured_enabled` is set to true. If the received signal is below the threshold, the grant is considered skipped by the UE and will not be requested for retransmission.

In addition to the above parameters, the `configured_grant` contains the following additional parameters:

l_crb   Integer. Configured Grant size in number of RBs. Must be a multiple of the RBG size if `ra_type` is set to `type0`.

periodicity
> Integer. Periodicity of the CG in slots

configuration_type
> Enumeration (type1, type2_immediate, type2_dynamic). Configuration type1 is a semi-static grant configured via RRC while type2 is activated/released by an UL DCI.
> `type2_immediate` will send an activation DCI right after RRC configuration.
> `type2_dynamic` will send activation/release DCI based on the UL trafic on the bearers flagged with `need_sps`.

type2_deact_no_data_threshold
> Optional integer (default = 3). Number of consecutive Configured Grants without any UL data on bearers flagged with `need_sps` after which CG will be released via DCI. This parameter is only meaningful when `configuration_type` is set to `type2_dynamic`.

max_retrans
> Optional integer (range 0 to 3, default = 1). Maximum number of HARQ retransmission for a Configured Grant.

rep_k
> Optional integer (1, 2, 4 or 8, default = 1). Number of repetitions for the Configured Grant.

l_crb_max
> Optional integer (defaults to 1/4 of available bandwidth in the BWP). Maximum number of RBs used for Configured Grants in a slot.

rb_start
> Optional integer (defaults to -1). Start RB for Configured Grants allocation. If absent or set to -1, Configured Grants are placed automatically in the high part of the BWP bandwidth.

p0_nominal_without_grant
> Optional integer (range -202 to 24). p0-NominalWithoutGrant parameter. If not present, the value `p0_nominal_with_grant` in the `pusch` object is used.

8.7.5.5 Other uplink parameters

ul_frequency_shift_7p5_khz
> Optional boolean (default = false). If true, a 7.5 kHz offset is added to the NR UL frequency.

reserved_ul_prbs
> Optional array of integers. List of PRB indexes in which no PUSCH and PUCCH will be allocated. In TDD, it is set by default to the same as `reserved_dl_prbs`.

ul_blanked_scs
> Optional array of integers. List of blanked UL subcarrier ranges. Each range is defined by a pair of integers. The first integer gives the subcarrier index (starting from 0). The second integer gives the number of subcarriers.

sul
> Optional object. Controls the configuration of Supplementary Uplink (SUL) for this cell.
> The supplementary uplink uses the uplink of another NR cell that should have set the `serve_as_sul` parameter and belong to a band compatible with SUL operation. See [serve_as_sul], page 207.
> Note that SUL will only be enabled for the primary cell and that SUL configuration is currently performed before the reception of UE capabilities, based solely on the

cell configuration and on which uplink carrier the PRACH access is performed. The object contains the following properties:

`cell_id`   Integer. Cell identifier of the cell which uplink will be used as SUL.

`q_rx_lev_min`

    Optional integer. Value of SIB1.cellSelectionInfo.q-RxLevMinSUL.

`prach_index`

    Optional integer, default -1. Index of the PRACH configuration in SUL cell's `sul_prach` array. If set to -1, there is no setting for PRACH in SUL configuration.

`prach_rsrp_threshold`

    Optional integer, mandatory if `prach_index >= 0`. Parameter rsrp-ThresholdSSB-SUL, in dB.

`channels`   Object. Describes how the PUCCH, PUSCH and SRS are configured for UEs accessing the cell via NUL PRACH or in NSA.
It contains the following properties:

    `pucch`   Optional enumeration: normal_only, sul_only (default = normal_only). Choose if PUCCH is configured in the uplinkConfig or in supplementaryUplink.

    `pusch`   Optional enumeration: normal_only, sul_only, both (default = normal_only). Choose if PUSCH is configured in the uplinkConfig, or in supplementaryUplink, or in both. When set to `both`, the choice to schedule on NUL or SUL is based on the received SNR and the configuration of `pusch_switch_snr_threshold` or based on uplink Tx switching rules (see `uplink_tx_switch` below).

    `srs`   Optional enumeration: normal_only, sul_only, both (default = normal_only). Choose if SRS is configured in the uplinkConfig or in supplementaryUplink, or in both.
SRS should be configured in all the possible UL carriers for PUSCH.

`channels_prach_on_sul`

    Optional object. Describes how the channels are configured for UEs accessing the cell via a SUL PRACH resource. If the object is not defined, it defaults to the same configuration than `channels`.
It contains the same properties than `channels`.

`pusch_switch_snr_threshold`

    Float (range -6.0 to 50.0). Mandatory if at least one of `channels.pusch` or `channels_prach_on_sul.pusch` is set to `both`, unused otherwise. If the received SNR for the PUSCH is below the threshold, PUSCH will be scheduled on SUL. If Uplink Tx Switch is configured (see `uplink_tx_switch` below), the parameter is no longer used.

`pusch_switch_hysteresis`

    Optional float (range 1.0 to 20.0, default 9.0). Hysteresis used when comparing SNR to `pusch_switch_snr_threshold`.

`serve_as_sul`

Optional boolean (default = false). When set to true, and if the cell belong to a suitable band (namely band 1, 3, 5, 8, 20, 24, 28, 34, 39, 40 or 66), the cell's uplink

can be used as supplementary uplink by other cells. To do so, the other cells need to have a `sul` configuration referencing this cell.

If the cell's uplink is also to be used for supplementary PRACH, the `sul_prach` array needs to be specified. See [sul_prach], page 186.

uplink_tx_switch

Optional object. Controls the configuration of the Uplink Tx Switch feature for this cell.

Uplink Tx Switch feature is rel18 compliant for CA and SUL, with up to 4 different bands. Each cell involved in the Uplink Tx Switch operation shall have an `uplink_tx_switch` object.

For SUL operation, the `pusch` channel setting also need to be set to `both` in the `sul` configuration (see above). The object contains the following properties:

priority   Optional integer (range 0 to 15, default 15). Priority of this band in the UL Tx switching operation. Lower values means higher priority.

For any given slot, the UL will be scheduled on the band (or the two bands in case of dualUL) with the highest priority within their `active_slots` and when the `activation` is triggered.

With 2 cells operation, `priority: 15` is equivalent to set the cell as carrier1 and `priority: 0` to carrier2.

active_slots

Optional array of booleans (default = true for all UL slots). Specifies the slots where the UL can be scheduled in this cell during Uplink Tx switching operation.

The array length must divide $20 * 2^\mu$ and each element corresponds to a slot modulo the length of the array.

preferred_option

Optional enumeration: dualUL, switchedUL (default = dualUL). Chooses the UL Tx switching option when the UE reports the support for both options in a band pair. This setting should be identical in the cells of the concerned band pair.

two_tx   Optional boolean (default = true). Activates twoT mode if the UE supports it. This setting should be identical in the cells of the concerned band pair.

activation

Optional enumeration : immediate, ul_quality (default = immediate). Specifies when the UL Tx Switching operation will become effective on this cell.

immediate

UL Tx Switching will be activated whenever the SCell is activated

ul_quality

UL Tx Switching will be activated when the signal on carrier 2 (as measured by SRS) has an UL rank greater than 1 and an UL CQI above `ul_quality_ri2_cqi_threshold`

ul_quality_ri2_cqi_threshold

Optional integer (range 1 to 15, default = 5). UL CQI value measured on SRS of carrier 2 above wich UL Tx switching will be activated, if UL rank is greater than 1 and `activation` is set to `ul_quality`.

max_allowed_period

>   Optional enumeration : 35, 140, 210 (default = 210 for 15kHz SCS, 140 for 30kHz SCS). Gives a limit on the length of the allowed UL Tx Switching period to avoid cropping too much PUSCH allocations and PUCCH resources.

8.7.6 PHY/L1 - Other parameters

tdd_ul_dl_config

>   Optional object. Define the TDD UL/DL configuration. If present, it contains the following properties:

>   **ref_subcarrier_spacing**
>
>>   Optional integer. Reference subcarrier spacing for pattern1 and pattern2. The default value is the same as the data subcarrier spacing.

>   **pattern1**   Object. Definition of the first TDD pattern. The following properties must be present:

>>   **period**   Enumeration: 0.5, 0.625, 1, 1.25, 2, 2.5, 3, 4, 5, 10. DL/UL transmission periodicity in ms.

>>   **dl_slots**   Integer. Number of downlink slots.

>>   **ul_slots**   Integer. Number of uplink slots.

>>   **dl_symbols**
>>
>>>   Integer (0-13). Number of downlink symbols after the last complete downlink slot.

>>   **ul_symbols**
>>
>>>   Integer (0-13). Number of uplink symbols before the first complete uplink slot.

>   **pattern2**   Optional object. Optional second TDD pattern. It contains the same properties as **pattern1**.

n_timing_advance_offset

>   Optional enumeration: 0, 25600, 39936. UL/DL timing advance offset in multiples of $T=1/(16*64*1920000)$ seconds for FR1. The default timing advance offset is 25600. The RRC field n-TimingAdvanceOffset is updated accordingly.

subframe_offset

>   Optional integer (default = 0). Normally all cells have their subframe number temporally aligned. This parameters adds a cell specific subframe offset. It is useful to align the LTE and NR TDD patterns while keeping the uplink slots at the end of the NR TDD pattern.

k_min   Optional integer (range 1 to 16, default = 4). Minimum value for PDSCH k1 and PUSCH k2 and msg3_k2.

rx_to_tx_latency

>   Optional integer. Minimum allowed latency in slots between RX and TX.
>   Its range is from 2 slots to 4ms (The default value depends on subcarrier spacing). If the latency is too high, the gNB scheduler may not be able to use all the PDSCH transmission occasions with subcarrier spacings larger or equal to 30 kHz. Increasing the value will improve performances, especially in case of radio frontend underflows. If LTE and NB-IoT cells are present on the RF port, only 4ms is allowed.

alternate_retx_scheme

>   Optional boolean (default = false). If set to true, the gNB always perform HARQ
>   retransmissions using MCS >= 29. Otherwise it indicates the initial MCS in the
>   DCI if possible.

8.7.7 Bandwidth parts (BWP)

dl_bwp_rb_start

>   Optional integer (default = 0) First PRB of the initial downlink BWP (DL BWP
>   #0).

dl_bwp_l_crb

>   Optional integer (default = all the carrier bandwidth) Number of PRBs of the initial
>   downlink BWP.

ul_bwp_rb_start

>   Optional integer (default = 0) First PRB of the initial uplink BWP (UL BWP #0).

ul_bwp_l_crb

>   Optional integer (default = all the carrier bandwidth) Number of PRBs of the initial
>   uplink BWP.

first_active_dl_bwp_id

>   Optional integer (default = 0). Set the ID of the first active cell downlink BWP.
>   This parameter is ignored if the UE cannot be configured with this BWP by `dl_bwp_access`.

first_active_ul_bwp_id

>   Optional integer (default = 0). Set the ID of the first active cell uplink BWP. This
>   parameter is ignored if the UE cannot be configured with this BWP by `ul_bwp_access`.

dl_bwp_access

>   Optional enumeration `all_ue`, `normal_only` or `redcap_only` (default = `all_ue` or
>   `normal_only` based on `dl_bwp_l_crb`). Restrict configuration and access to this
>   DL BWP depending on UE type.
>   The initial BWP cannot be `redcap_only`.

ul_bwp_access

>   Optional enumeration `all_ue`, `normal_only` or `redcap_only` (default = `all_ue` or
>   `normal_only` based on `ul_bwp_l_crb`). Restrict configuration and access to this
>   UL BWP depending on UE type.
>   The initial BWP cannot be `redcap_only`.

bwp_inactivity_timer

>   Optional enumeration. If present, set the value of the BWP inactivity timer.

default_dl_bwp_id

>   Optional integer (default = 0). Set the ID of the default cell downlink BWP.

allow_rrc_bwp_switch

>   Optional boolean (default = true if several non-redcap BWPs are defined). Allows
>   a robust operation of RRC-based BWP switch. The requirements on the source and
>   destination BWP for a RRC-based BWP switch in a SA cell are:
>   - BWP access is `all_ue` or `normal_only`.
>   - UL BWPs must have some RBs in common on one edge of the cell spectrum.
>   - DL BWPs must share the same common search space.

ran_slicing

Optional array of objects. Defines the the maximum number of resources blocks that can be allocated for a slice by the gNodeB, sorted by decreasing order of priority (if a UE has PDU sessions established in different S-NSSAIs, the scheduling constraints applied are the one of the S-NSSAI with the smallest index in the array). If a S-NSSAI defined in the cell is not defined in this array, it can use all the cell resource blocks. Each object contains the following properties:

`sst`   Integer (range 0 to 255). S-NSSAI Slice Service Type.

`sd`   Optional integer (range 0 to 0xFFFFFE). S-NSSAI Slice Differentiator.

`dl_max_l_crb`
Optional integer (range 1 to `n_rb_dl`, default = `n_rb_dl`). Maximum number of DL resource blocks that can be used by the S-NSSAI.

`ul_max_l_crb`
Optional integer (range 1 to `n_rb_ul`, default = `n_rb_ul`). Maximum number of UL resource blocks that can be used by the S-NSSAI.

dl_bwp   Optional array of objects. If present, downlink BWPs are defined in addition to the initial downlink BWP. Each object contains the following properties:

`bwp_id`   Optional integer. Set the ID to identify the BWP in the cell. Note that the BWP ID sent to the UE might differ from the one set here.

`dl_bwp_rb_start`
`dl_bwp_l_crb`
`dl_bwp_access`
Same meaning as for the initial BWP.

`ssb_nr_arfcn`
Optional integer. Specify the NCD-SSB ARFCN. Available only if BWP does not contain CD-SSB.
If set to -1, NCD-SSB is not activated.
If set to 0, NCD-SSB is placed automatically at the lowest position of the BWP.
If set to a positive value, specify the NCD-SSB ARFCN.
Default value is 0 when `dl_bwp_access` is `redcap_only` and -1 when `dl_bwp_access` is `all_ue`.

`pdcch`   Object. Contains a subset of the `pdcch` object properties in the initial BWP. The contents of the `css`, `uss` objects and `rar_al_index`, `al_index` parameters defaults to those of DL BWP #0.
The following properties are available only in the initial BWP: `coreset0_index`, `n_rb_coreset0`, `n_symb_coreset0`, `offset_rbs_coreset0`, `search_space0_index`, `si_al_index` and `paging_al_index`.

`pdsch`   Object. Contains a subset of the `pdsch` object properties in the initial BWP.
The following properties are available only in the initial BWP: `mapping_type`, `start_symb`, `n_symb`, `k0`, `bwp_switch_k0`, `k1`, `slot_enable`, `n_harq_process`, `rar_mcs`, `si_mcs`, `paging_mcs`, `paging_tb_scaling`, `x_overhead`, `initial_cqi`, `cqi_adapt_fer`, `cqi_adapt_fer_lowse`, `cqi_adapt_amp`, `cqi_adapt_retx`, `tci_states`, `max_mimo_layers_enabled`.

All the other properties can be redefined and defaults to the value of those of DL BWP #0.

ran_slicing
Optional array of objects. If not present, the configuration is inherited from the cell `ran_slicing` object. Each object contains the following properties:

sst   Integer (range 0 to 255). S-NSSAI Slice Service Type.

sd   Optional integer (range 0 to 0xFFFFFE). S-NSSAI Slice Differentiator.

dl_max_l_crb
Optional integer (1 to `n_rb_dl`, default = `n_rb_dl`). Maximum number of DL resource blocks that can be used by the S-NSSAI.

ul_bwp   Optional array of objects. If present, uplink BWPs are defined in addition to the initial uplink BWP. Each object contains the following properties:

bwp_id   Optional integer. Set the ID to identify the BWP in the cell. Note that the BWP ID sent to the UE might differ from the one set here.

ul_bwp_rb_start
ul_bwp_l_crb
ul_bwp_access
Same meaning as for the initial BWP. In TDD, each uplink BWP is paired with the downlink BWP of identical ID. They must have the same center frequency and same access restriction.

pucch

Object. Contains a subset of the `pucch` object properties in the initial BWP. Each property is optional and defaults to the value defined in the `pucch` of the initial BWP.
The following properties are available:
`pucch_group_hopping`, `hopping_id`, `n_rb_max`, `short_pucch_an_rsc_count`, `long_pucch_an_rsc_count`, `ue_short_pucch_an_rsc_count`, `ue_long_pucch_an_rsc_count`.

pusch

Object. Contains a subset of the `pusch` object properties in the initial BWP.
The following properties are available only in the initial BWP: `mapping_type`, `n_symb`, `ldpc_max_its`, `x_overhead`, `msg3_k2`, `k2`, `p0_nominal_with_grant`, `alpha`, `msg3_alpha`, `dpc_snr_target`, `dpc_p_max`, `dpc_epre_max`, `msg3_delta_power`, `ul_snr_adapt_fer`,`ul_snr_adapt_fer_lowse`, `ul_snr_adapt_amp`, `ul_snr_adapt_retx`, `n_harq_process`.
All the other properties can be redefined and defaults to the value of those of UL BWP #0.

prach

Optional object. Contains a subset of the `prach` object properties in the initial BWP. Each property is optional and defaults to the value defined in the `prach` of the initial BWP. However, at least one property should differ so that the PRACH defined in this BWP doesn't overlap

the PRACH of the initial BWP, either through frequency separation or sequence separation or both.

The following properties are available:

`msg1_frequency_start`, `msg1_fdm`, `root_sequence_index`, `zero_correlation_zone_config`, `restricted_set_config`.

`two_steps_prach`

Optional object to configure two-steps RACH procedure on this BWP. The initial UL BWP must also have a valid `two_steps_prach` object. See [two_steps_prach], page 186.

It contains the following parameters :

`msga_pusch`

Object with the same parameters than `msga_pusch` of the main `two_steps_prach` configuration. To avoid MSGA collision, it is preferable to separate (in time, frequency or code) this MSGA configuration from other MSGA configurations.

All the other two-steps PRACH related parameters will be inherited from the `two_steps_prach` of the initial UL BWP.

`prach_feature_preambles_list`

Optional object, valid only if a `prach` object is present in the BWP. Contains the same properties than the `prach_feature_preamble_list` list in the initial BWP.

`srs`

Object. Contains a subset of the `srs` object properties in the initial BWP. The following property is available only in the initial BWP: `srs_symbols`.

`configured_grant`

Optional object. Contains the same properties than the `configured_grant` object in the initial BWP.

`ran_slicing`

Optional array of objects. If not present, the configuration is inherited from the cell `ran_slicing` object. Each object contains the following properties:

`sst`　　　　Integer (range 0 to 255). S-NSSAI Slice Service Type.

`sd`　　　　Optional integer (range 0 to 0xFFFFFE). S-NSSAI Slice Differentiator.

`ul_max_l_crb`

Optional integer (1 to `n_rb_ul`, default = `n_rb_ul`). Maximum number of UL resource blocks that can be used by the S-NSSAI.

`bwp_dynamic_switch`

Optional object. Provide parameters to configure the dynamic BWP switching based on bit rate. In TDD, both the DL and UL BWP are switched using DCI 0_1. In FDD, the DL and UL BWP switch are independent. The DL BWP is switched using DCI 1_1 and UL BWP is switched using DCI 0_1. Note that the UE must be in the `bwp_id_low` or `bwp_id_high` BWP to trigger the dynamic switch. The object contains the following properties:

`dl_high_rate_threshold`
> Integer. DL high bit rate threshold in bit/s to switch to the high BWP.

`dl_low_rate_threshold`
> Optional integer. DL low bit rate threshold in bit/s to switch to the low BWP. It is set by default to `dl_high_rate_threshold / 2`.

`ul_high_rate_threshold`
> Optional integer, defaults to `dl_high_rate_threshold`. UL high bit rate threshold in bit/s to switch to the high BWP. In TDD, since DL and UL BWP are coupled, the switch is performed when one of the DL or UL bit rate is above the high threshold.

`ul_low_rate_threshold`
> Optional integer. UL low bit rate threshold in bit/s to switch to the low BWP. It is set by default to `ul_high_rate_threshold / 2`. In TDD, the switch is performed when both the DL and UL bit rate are below the low threshold.

`bwp_id_high`
`bwp_id_low`
> Integer. Cell BWP ID for the high (resp. low) BWP.

`probe_interval`
> Optional integer (default = 50). Probe interval for the bit rate in ms.

`probe_counter_threshold`
> Optional integer (default = 3). The BWP switching is initiated if the bit rate is higher (resp. lower) than the selected thresholds over `probe_counter_threshold` consecutive probe intervals.

`rrc_based_bwp_switch`
> Optional boolean (default = false). If true and if `allow_rrc_bwp_switch` is set and the constraints on the BWP are respected, the BWP switching will be performed via RRC reconfiguration.

8.7.8 Reduced Capability parameters ((e)RedCap)

The following parameters configure the cell to allow the connection of Reduced Capability UEs (RedCap) and enhanced Reduced Capability UEs (eRedCap). All the parameters must be put in a `redcap_ue` object in the NR cell object.

`allow`
> Optional boolean (default = true). Defines if RedCap UEs are allowed in the cell or not.

`allow_1rx_ue`
> Optional boolean (default = true). Defines if RedCap 1Rx UE access is allowed in the cell or not.

`allow_2rx_ue`
> Optional boolean (default = true). Defines if RedCap 2Rx UE access is allowed in the cell or not.

`eredcap_ue`
> Optional object. If present, eRedCap UEs are allowed in the cell. If contains the following properties:
>
> `allow_1rx_ue`
> > Optional boolean (default = true). Defines if eRedCap 1Rx UE access is allowed in the cell or not.

>> `allow_2rx_ue`
>>> Optional boolean (default = true). Defines if eRedCap 2Rx UE access is allowed in the cell or not.

> `half_duplex`
>> Optional object. If present, half duplex support is activated in the cell. For each BWPs where half duplex is enabled, the DCI format 0_1/1_1 will be larger. It contains the following properties. The gNB defines default values that can be over-written if needed:

>> `dl_k1_max`
>>> Optional integer (range `k_min` to min between `k_min+7` and PDSCH `n_harq_process`). Maximum k1 value for half duplex PDSCH.

>> `dl_k2_max`
>>> Optional integer (range `k_min` to min `k_min+6`). Maximum k2 value for half duplex PUSCH.

>> `dl_ul_guard_symb`
>>> Optional integer (range 1 to 6, default = 1). Number of guard symbols when switching from DL to UL.

>> `ul_dl_guard_symb`
>>> Optional integer (range 0 to 6, default = 1). Number of guard symbols when switching from UL to DL.

>> `dl_bwp_list`
>>> Optional array of integers. List of the DL BWP IDs where half duplex is enabled. If the parameter is absent, half duplex is supported on all DL BWPs.

>> `ul_bwp_list`
>>> Optional array of integers. List of the UL BWP IDs where half duplex is enabled. If the parameter is absent, half duplex is supported on all UL BWPs.

`initial_dl_bwp_id`
> Optional integer (default = 0). Defines a (e)RedCap specific initial cell DL BWP. This DL BWP should contain CoReSet #0 and its common search space should use CoReSet #0.
> This DL BWP should also have a bandwidth smaller than 20MHz and `dl_bwp_access` set to `all_ue` or `redcap_only`.
> If different from the DL BWP #0, the DL BWP#0 must be unsuitable for (e)RedCap UE.

`initial_ul_bwp_id`
> Optional integer (default = 0). Defines a (e)RedCap specific initial cell UL BWP. This UL BWP should feature a PRACH configuration, have a bandwidth smaller than 20MHz and `ul_bwp_access` set to `all_ue` or `redcap_only`.
> If different from the UL BWP #0, the UL BWP#0 must be unsuitable for (e)RedCap UE.

8.7.9 Multicast/Broadcast Service parameters (MBS)

The following parameters configure the support of MBS feature in the cell. They must be put in a `mbs` object in the NR cell object.

broadcast

        Optional object. Defines the MBS broadcast parameters. It contains the following properties:

        mcch   Object. Defines the parameters for MCCH scheduling.

            repetition_period

                Enumeration (1, 2, 4, 8, 16, 32, 64, 128, 256). MCCH repetition period in radio frames.

            repetition_offset

                Optional integer. MCCH repetition radio frame offset.

            window_start_slot

                Optional integer (default = 1). MCCH transmission window start slot.

            window_duration

                Optional enumeration (2, 4, 8, 10, 20, 40, 80, 160). MCCH transmission window duration in slots.

            modification_period

                Optional enumeration (2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 82192, 16384, 32768, 65536; default = 128). MCCH modification period in radio frames.

            mcs   Integer (range 0 to 28). MCS used for the MCCH DL transport blocks.

            al_index Integer (range 0 to 4). Aggregation level for MCCH.

        mtch   Object. Defines the parameters for MTCH scheduling.

            ssb_mapping_window_duration

                Optional enumeration (10, 20, 32, 64, 128, 256). MTCH SSB mapping window.

            sessions Optional array of objects. Allows to define a specific MCS for a given MBS session ID. Each object contains the following properties:

                tmgi   Object. Session TMGI. It contains the following properties:

                    plmn   String. PLMN.

                    service_id

                        Integer. 24 bits service identity.

                nid   Optional object. See [nid], page 129.

                mcs   Integer (range 0 to 28). MCS used by this MBS session for MTCH DL transport blocks.

                al_index Integer (range 0 to 4). Aggregation level used by this MBS session for MTCH DL transport blocks.

            default_mcs

                Integer (range 0 to 28). Default MCS used for MTCH DL transport blocks if no specific value is defined in the `sessions` array.

default_al_index
:   Integer (range 0 to 4). Default aggregation level for MTCH DL transport blocks if no specific value is defined in the `sessions` array.

max_l_crb
:   Optional integer (range 1 to `n_rb_dl`, default = `n_rb_dl`). Maximum number of DL resource blocks that can be used by MTCH.

sib20
:   Object. Defines the parameters for SIB20 scheduling.

si_periodicity
si_value_tag
:   It must contain the `si_periodicity` and `si_value_tag` objects described in `sib_sched_list`. See [NR sib_sched_list], page 130.

mrb
:   Array of objects containing the MRB configuration for each 5QI value. If the 5QI value requested by the core network is not defined, the MRB is not created. Each object contains the following properties:

5qi
:   Integer. 5QI value.

pdcp_config
:   Object. Defines the PDCP parameters:

    pdcp_SN_SizeDL
    :   Enumeration (12 or 18). Number of bits for the PDCP sequence number.

    headerCompression
    :   Optional object. If not present or `null`, header compression is disabled.

        maxCID
        :   Range: 1 to 16.

        profile0x0001
        :   Boolean. If true, enable RTP v1 ROHC profile.

        profile0x0002
        :   Boolean. If true, enable UDP v1 ROHC profile.

    t_Reordering
    :   Optional enumeration (1, 10, 40, 160, 500, 1000, 1250, 2750). PDCP t-Reordering timer duration in ms. If not present, the timer is set to 0 ms.

rlc_config
:   Object. Defines the RLC parameters:

    sn_FieldLength
    :   Enumeration (6 or 12). Number of bits for the RLC sequence number.

    t_Reassembly
    :   Optional enumeration (0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95,

100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200). RLC t-Reassembly timer duration in ms. If not present, the timer is set to 0 ms.

5qi_qos   Optional object. Default 5QI QoS characteristics to be used for this 5QI. If not present, the gNB tries to retrieve a default value based on 3GPP TS 23.501 table 5.7.4-1 and errors if the 5QI value is unknown.

priority_level
Integer (range 1 to 127).

averaging_window
Optional integer (range 1 to 4095). Averaging window for GBR bearers.

8.7.10 Miscellaneous and Test parameters

cell_gain
Optional float (default = 0). Downlink cell gain in dB. Must be between -200 and 0 (included). Note: it is not taken into account to set the SS PBCH block power in SIB1.

manual_ref_signal_power
Optional boolean (default = false). If set to true, the SS PBCH block power must be set manually. Otherwise it is computed automatically if the RF interface provides its transmit power.

ss_pbch_block_power
Optional integer (range -60 to 50). Must be present if manual_ref_signal_power is set to true.

rx_epre_in_dbfs
Optional boolean (default = false). In the logs, the EPRE (Energy Per Resource Element) is displayed in dBm if the RF interface provides its reference receive power and if rx_epre_in_dbfs = false. Otherwise it is displayed in dBFS (Decibels relative to Full Scale).

rx_epre_offset
Optional float (default = 0). Offset in dB applied to all the receive EPRE measurements.

force_full_bsr
Optional boolean (default = false). If true, the gNodeB considers the UE always indicates a full buffer size. Hence the UE is scheduled as often as possible for PUSCH transmission.

force_dl_schedule
Optional boolean (default = false). If true, the gNodeB considers there is always DL data waiting for transmission. Hence the UE is scheduled as often as possible for PDSCH transmission.

sr_ignore_count
Optional integer. Indicates how many consecutive Scheduling Request are ignored by the gNB.

rach_ignore_count
Optional integer. Indicates how many consecutive RACH attempts are ignored by the gNB.

`mac_crnti_ce_ignore_count`

>Optional integer. Indicates how many consecutive MAC C-RNTI control elements are ignored by the gNB.

`dummy_ue_contention_resolution_id`

>Optional boolean. If set to true, a wrong MAC UE Contention Resolution Identity control element will be sent in the Msg4, rather than the one matching the UE Msg3 content.

`ue_count_max`

>Optional integer (default = 500). Maximum number of UEs (for this cell).

`label`   Optional string. Helper available in monitor (`cell`), remote API (`config_get`) and logs.

The following cell parameters are only useful when the gNodeB is connected to a specific measurement equipment. They cannot normally be used with normal UEs.

`test_mode`

>Optional object. Enable specific test modes where UE contexts are automatically created when starting the gNodeB. They are only useful when the gNodeB is connected to a specific measurement equipment.
>The `type` property selects the test mode:

>`pusch`

>>Enables continuous reception of PUSCH. DCI are transmitted. The following additional properties are available:

>>`rnti`   Integer. Range 0 to 65535. Select the PUSCH RNTI.

>`pdsch`

>>Enables continuous transmission of PDSCH. The PDSCH payload contains valid data with PDCP packets of constant length. DCI are transmitted according to the selected transmission mode. PUCCH are received. The following additional properties are available:

>>`rnti`   Integer. Range 0 to 65535. Select the PDSCH RNTI.

>>`pdsch_harq_ack_disable`
>>>Optional boolean (default = false). If true, no HARQ ACK/NACK is received for the PDSCH. It is useful to make sure a PDSCH is sent in all DL slots in case the gNodeB is latency limited.

>>`random_data`
>>>Optional boolean (default = false). If true, send random data instead of zeros in the PDCP payload.

>`load`

>>CPU load test. Several UEs are instanciated and all are transmitting and receiving at the same time. The following additional properties are available:

>>`ue_count`   Integer. Set the number of UE contexts. The upper bound is set to `ue_count_max` value.

>>`pdsch_harq_ack_disable`
>>>Optional boolean (default = false). If true, no HARQ ACK/NACK is received for the PDSCH. It is useful to make

sure a PDSCH is sent in all DL slots in case the gNodeB is latency limited.

random_data

Optional boolean (default = false). If true, send random data instead of zeros in the PDCP payload.

no_ssb_allowed

Optional boolean (default = false). If true, allow a zero SSB bitmap for the cell (can be used to implement test models from 3GPP TS 38.141).

tm_pdsch Optional object. Define one or two additional PDSCHs using a fixed configuration to implement test models from 3GPP TS 38.141-1 section 4.9.2.2. The following properties are available:

rb_start Integer. Position of the first resource block.

l_crb Optional integer. Number of contiguous resource blocks. The default value corresponds to the whole carrier.

mcs Integer. MCS using the MCS table from the initial BWP.

boosted_ratio

Optional float (default = 0). If non zero, boost the power of some of the resource block groups inside the PRB range by adding a second PDSCH.

boosted_power

Optional float. Specify the relative power in dB of the boosted PRBs.

deboosted_mcs

Optional integer. Set the MCS of the PRBs which are not power boosted.

sib_enable

Optional boolean (default = true). If false, disable the transmission of the SIBs.

empty_bsr_grant

Optional object containing the empty BSR grant feature configuration.

When a UE reports an empty BSR (Buffer Status Report) MAC control element, the eNB stops scheduling it in UL and the UE needs to transmit a scheduling request to resume the UL transmission, which adds delay. With this feature, the UE will still be scheduled in UL after the empty BSR report for the configured `duration` with `tb_len` UL grants if it has a bearer active using a 5QI with the `use_empty_bsr_grant` parameter set to true.

This feature is useful in case of an application being time sensitive but generating bursty UL traffic like a video live stream for example.

It contains the following properties:

duration Integer. Duration in milliseconds.
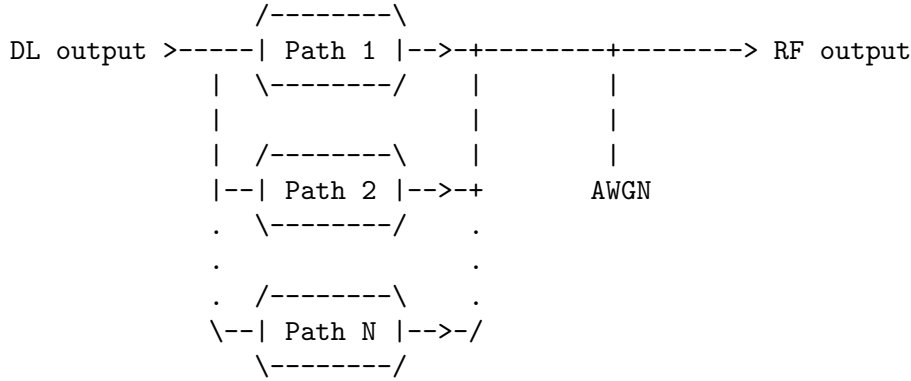
tb_len Integer. Length in bytes.

8.8 Channel simulator

8.8.1 RF port specific channel simulator

The channel simulator applies after the DL modulator(s) on each RF port using the configured sample rate. It takes `cell.n_antenna_dl` channels as inputs (*n_input*) and may output a different number of channels (*n_output*) (see the global `n_antenna_dl` parameter).

It applies a number of delay paths with a configurable gain and phase for each *n_input* x *n_output* antenna combination. Each path can also appply a Rayleigh fading (Jakes or Gaussian fading model). In case of MIMO channels, a configurable MIMO correlation matrix is applied for each path. Then a white Gaussian noise is added (AWGN).

```
                /--------\
DL output >-----| Path 1 |-->-+--------+--------> RF output
             |  \-------/     |        |
             |                |        |
             |  /--------\    |        |
             |--| Path 2 |-->-+       AWGN
             .  \-------/     .
             .                .
             .  /--------\    .
             \--| Path N |-->-/
                \-------/
```

Preconfigured path configurations are available for common 3GPP channel models. Preconfigured 3GPP MIMO correlation matrixes are also available.

When the channel simulator is enabled with fading channels, it may be necessary to lower `tx_gain_offset` (digital gain) to allow a larger dynamic range without saturation. Use the `t spl` monitor command to check that no overflow is present at the RF output. The `tx_gain_offset` value of -21 dB should be safe for all channel types.

The CPU usage of the channel simulator increases with the sample rate, number of MIMO channels and the number of paths. If the CPU load is too high (see the `t cpu` monitor command to estimate it), you can reduce the RF bandwidth (i.e. `n_rb_dl`), reduce the number of MIMO channels or use a simpler channel model with a smaller number of paths.

The `channel_dl` object contains the downlink channel simulator parameters:

type   Optional. Must be present if no `paths` property. Set the predefined channel type:

Type	Description
awgn	Additive White Gaussian Noise channel. It is equivalent to specifying a single zero delay unit gain constant path:

```
paths: [{
    type: "constant",
    gain: 0.0,
    delay: 0,
    channel_matrix: [[ 1 ]],
}]
```

When there are more than one input or output antennas, the channel matrix $a_{i,j}$ is set such as $a_{i,i \bmod n_{tx}} = 1$. In this case, it is usually better to manually specify a `paths` configuration to select an explicit channel matrix.

Type	Description
static	Static channel model from 3GPP TS 36.101 and TS 38.101-4.
epa	Extended Pedestrian A model from 3GPP TS 36.101.
eva	Extended Vehicular A model from 3GPP TS 36.101.
etu	Extended Typical Urban model from 3GPP TS 36.101.
mbsfn	MBSFN channel from 3GPP TS 36.101.

tdla30	TDLA30 channel from 3GPP TS 38.141 (TDLA with 30 ns delay spread).
tdlb100	TDLB100 channel from 3GPP TS 38.141 (TDLB with 100 ns delay spread).
tdlc300	TDLC300 channel from 3GPP TS 38.141 (TDLC with 300 ns delay spread).
tdld30	TDLD30 channel from 3GPP TS 38.141 (TDLD with 30 ns delay spread).
ntn_tdla100	NTN-TDLA100 channel from 3GPP TS 38.101-5.
ntn_tdlc5	NTN-TDLC5 channel from 3GPP TS 38.101-5.
tdla, tdlb, tdlc, tdld or tdle	TDL channels from 3GPP TS 38.901 section 7.7.2. Note that the TDL channels from 3GPP TS 38.141 slightly differ from the ones defined in 3GPP TS 38.901 when using the same delay spread.
ntn_tdla, ntn_tdlb, ntn_tdlc, ntn_tdld	NTN TDL channels from 3GPP TS 38.811 section 6.9.2.

freq_doppler

For non AWGN channels, sets the doppler frequency, in Hz.

delay_spread

Set the delay spread in ns for the TDL channels (`tdla`, `tdlb`, `tdlc`, `tdld`, `tdle`, `ntn_tdla`, `ntn_tdlb`, `ntn_tdlc` and `ntn_tdld`).

mimo_correlation

Optional enumeration or matrix. The default value is `low`.

MIMO correlation matrix. Allowed values:

low	Low correlation matrix (identity matrix) (3GPP TS 36.101 section B.2.3.2).
medium	Medium correlation matrix with uniform linear array (3GPP TS 36.101 section B.2.3.2).
high	High correlation matrix with uniform linear array (3GPP TS 36.101 section B.2.3.2).

cross_pol_medium

Medium correlation matrix with cross polarized antennas (3GPP TS 38.101-4 section B.2.3.2).

cross_pol_high

High correlation matrix with cross polarized antennas (3GPP TS 38.101-4 section B.2.3.2).

Alternatively, an explicit complex matrix of `n` rows and `n` columns can be provided where `n` is the product of the number *n_input* and *n_output* antennas. The matrix must be Hermitian positive.

paths Optional array of objects. Set user defined paths. If present the `type` parameter is ignored. Each path has the following fields:

type

Enumeration. Type of path. `constant` for constant path, `rayleigh` for Rayleigh fading with the Jakes model, `rayleigh_gauss` for Rayleigh fading with the Gaussian model.

gain   Relative path gain, in dB.

delay   Path delay, in ns. Note: the delay is internally rounded to an integer number of samples.

channel_matrix
                Only necessary for `constant` path. Complex matrix of n_output rows and n_input columns giving the channel coefficients.

freq_shift
                Provides an optional frequency shift in Hz for `constant` paths. A `constant` path with frequency shift coupled with a `rayleigh` path can be used to implement Ricean fading.

freq_doppler
                Only needed for Rayleigh paths. Doppler frequency in Hz.

mimo_correlation
                Only needed for Rayleigh paths. Path specific correlation matrix (same definition as the global `channel.mimo_correlation` property). If not present, the global `channel.mimo_correlation` matrix is used for this path.

freq_shift
                Optional float (default = 0). Apply a global frequency shift (in Hz) after the paths.

delay   Optional float (default = 0). Apply an additional global delay (in ns) to all the paths.

gain   Optional float (default = 0). Apply a global gain (in dB) after the paths.

high_speed_train
                Optional object. Parameters for the high speed train model (see 3GPP TS 36.141 section B.3 or 3GPP TS 38.141 section G.3). This model applies a variable global frequency shift after the paths. In this case the `freq_shift` parameter is ignored.

    d_s   Float. $d_s/2$ is the initial distance of the train from BS in meters.

    d_min   Float. BS - railway track distance in meters.

    v   Float. Speed of the train in km/h.

    f_d   Float. Maximum Doppler frequency in Hz.

noise_level
                Float or array of floats. Set the noise level in dB relative to the PDSCH data level. If an array is provided, each element sets the noise level for the corresponding output antenna. Otherwise the same noise level is applied to all the output antennas. The Gaussian noise is generated with a constant power density over the whole generated bandwidth. A large negative value such as -200 can be used to completely suppress the noise generation.

                Note: the `noise_level` corresponds to the SNR measured on the PDSCH data RE on OFDM symbols without Cell Reference Signal. For LTE, there is no need to take `p-a` into account as in the previous releases of the software.

                The noise level can be interactively modified with the `noise_level` monitor command.

                Warning: the reference signal level is not modified when the `cell_gain` monitor command is used. So you can monitor the noise level on a spectrum analyzer by suppressing the DL signal with a near zero cell gain (e.g. `cell_gain 1 -200`).

snr   Float or array of floats. Deprecated. Set the SNR defined as the opposite of `noise_level`.

dump_paths

         Optional boolean (default = false). Print on the standard output the path delays and relative powers.

         It only applies when the `paths` property is not set.

max_paths

         Optional integer. Set the maximum number of paths. The paths with the smallest power are removed. It can be used to reduce the CPU load at the expense of the precision of the simulated impulse response. The default value depends on the sample rate.

         It only applies when the `paths` property is not set.

normalize

         Optional boolean (default = true). If true, the Rayleigh fading channel matrices are normalized with respect to the number of TX antennas. Set `normalize` to false to restore the previous behavior.

8.8.2 Cell specific channel simulator

In addition to the RF port specific channel simulator, it is possible to set cell specific channel simulators. They are useful to have a different channel model for cells sharing the same RF port. They are also faster so they can be used with a larger number of antennas or larger bandwidths.

The cell specific channel simulator assumes a constant channel impulse response during each OFDM symbol, so it is less accurate than the RF port specific channel simulator when the Doppler frequency becomes non negligible compared to the OFDM symbol frequency. For example, for LTE, Doppler frequencies up to 200 Hz give a negligible loss of accuracy.

The cell specific channel simulator uses the same parameters as the RF port specific channel simulator with the following modifications:

- When specifying explicit paths, the delay should be smaller than the cyclic prefix duration. Moreover, the `rayleigh_gauss` path type is not supported.
- Global `freq_shift`, `delay`, `gain` and high speed train model are not supported. The corresponding per-path `freq_shift`, `delay` and `gain` parameters are supported.
- `noise_level` and `snr` are not supported. The Gaussian noise should be added with the RF port specific channel simulator. If a different SNR is required for the different cells, the cell levels should be modified with `cell_gain`.

8.9 Non Terrestrial Network

This eNB supports the Release-18 NTN feature for NB-IoT cells and NR cells. It supports all the orbit configuration (LEO, MEO and GEO).
Direct-To-Cell operation supporting pre-Release 17 UEs without any NTN specific signalling is also supported on non-NTN NR bands and non-NTN LTE bands.
The following `ntn` configuration object allows the cell to operate a NTN/Direct-To-Cell configuration.
To simulate the large RTT delay and Optionally doppler shift and large attenuation induced by NTN operation, the RF port channel simulator `channel_dl` may be used. See [RF port specific channel simulator], page 220.
The satellite ephemeris can be configured either with a TLE file, a StateVector file or with explicit orbital elements. If nothing is specified, a default ephemeris is generated according to the `default_ephemeris` parameter.

Regenerative mode (ie if the eNB is on-board the satellite) is supported by setting `n_ta_common` to 0.

ntn   Optional object to describe the NTN configuration. Contains the following parameters:

    `sv_filename`

        Optional string to configure satellite state vectors from a file according to the file format specified with `sv_filetype`.

        Real time satellite position determination will depend on the `sv_interpolation` parameter. When the parameter is present, `tle_filename` and `ephemeris` are ignored, and `use_state_vectors` is forced to true.

    `sv_filetype`

        Optional enumeration: `ccsds-oem`, `custom-1`. Default is `custom-1`.

        Describe the file format used to parse the state vectors file defined by `sv_filename`.

        `ccsds-oem` corresponds to the ORBIT EPHEMERIS MESSAGE specified by The Consultative Committee for Space Data Systems (CCSDS) in document CCSDS 502.0-B-2.

        `custom-1` is a proprietary format.

    `sv_interpolation`

        Optional enumeration: `none`, `linear` or `integration`. Default is `integration`. Describes how satellite is interpolated between the datapoints of the state vectors file by `sv_filename`.

        When set to `none`, the eNB fetches the last datapoint of the file timestamped before the current time and consider the satellite as stationary until the next datapoint timestamp is reached.

        When set to `linear`, satellite position and velocity is linearly interpolated between the current datapoint and the next one (if present).

        When set to `integration`, the eNB propagates the satellite position and velocity from the current datapoint with its internal gravitational model.

    `tle_filename`

        Optional string to configure satellite ephemeris from a Two Line Elements (TLE) file.

        The file shall contain only the two lines of data and optionally a title line.

        When the parameter is present, `ephemeris` is ignored.

    `default_ephemeris`

        Optional enumeration: `geo`, `meo`, `leo`. Default is `geo`.

        If `ephemeris` is absent, a default satellite ephemeris is generated so that the satellite is overhead the eNB ground position at eNB startup. The GEO and MEO satellite will be placed on the equatorial plane (zero inclination) at the longitude of the eNB ground position.

        The LEO satellite will be initially placed at the zenith of the eNB position.

    `default_sma`

        Optional float, range 6500e3 to 42300e3. If `default_ephemeris` is used and set to `meo` or `leo`, this parameter (in meters) allows to override the

semi-major axis of the chosen orbit.

The parameter is ignored otherwise. The default values are 6928e3 (altitude 650km) for `leo` and 14441e3 for `meo`.

default_elevation_offset

Optional float, range -90 to 90, default = 0. If `default_ephemeris` is used and set to `leo`, this parameter (in degrees) allows to adjust the initial elevation of the satellite compared to the zenith position.

The parameter is ignored otherwise. Negative values will place the satellite before its zenith pass and positive values after the zenith.

ephemeris

Optional object to configure satellite ephemeris in the form of orbital parameters.

The epehemeris configuration is understood in a fixed ECI reference frame aligned with the J2000 vernal equinox, like a TLE configuration, irrespective of the `eci_reference` parameter. If absent and if `tle_filename` and `sv_filename` are also absent, a default ephemeris is generated.

Contains the following parameters:

eccentricity

Float value. Range 0 to 0.99. Eccentricity, unitless

inclination

Float value. Range 0 to π. Inclination, in radians. Value between $\pi/2$ and π will be encoded as $-\pi/2$ to -1 in RRC ASN.1 representation.

semi_major_axis

Float value. Semi-major axis, in meters.

longitude

Float value. Range 0 to 2π. Longitude of the ascending node, in radians.

periapsis

Float value. Range 0 to 2π. Argument of periapsis, in radians.

anomaly   Float value. Range 0 to 2π. Mean anomaly of the satellite on its orbit at `epoch`, in radians.

epoch   Optional integer or string. Epoch for the `anomaly` parameter, given as UTC time.

If given as an integer, it represents a timestamp in 10ms unit of Unix time (UTC time since 1970-01-01).

If given as a string, it should be a date with the following format: `"YYYY/MM/DD HH:MM:SS.mmm"`.

If absent, the eNB startup time is used.

use_state_vectors

Optional boolean (default = false). If true, the satellite position is converted to ECEF coordinates and broadcast as EphemerisStateVectors-r17 in SIB31. If false, EphemerisOrbitalParameters-r17 is used.

eci_reference

Optional enumeration: `vernal_point`, `ecef_greenwich`. Default is `vernal_point`.

Defines the ECI reference frame X axis when broadcasting the orbital parameters, which serves as origin for the longitude of ascending node measurement.

`vernal_point` corresponds to the standard J2000 vernal equinox.

`ecef_greenwich` corresponds to the Greenwich meridian at epoch, so that the ECI and ECEF reference frame coincide.

`ground_position`

Optional object to configure the geographical ground position of the eNB in order to automatically compute NTA-Common, NTA-CommonDrift and NTA-CommonDriftVariation for transparent mode.

In case the `ephemeris` parameter is absent, the default geostationary satellite will be instantiated at the configured `longitude`. Contains the following parameters:

`same_as_ap_position`

Optional boolean (default = false). If true, the position configured by `access_point_position` is used and `latitude`, `longitude` and `altitude` are ignored.

If false, `latitude` and `longitude` are mandatory.

`latitude` Float value. Range -90 to 90. Degrees of latitude.

`longitude`

Float value. Range -180 to 180. Degrees of longitude.

`altitude` Optional float value (default = 0). Range -1000m to 20km. Altitude in meters.

`n_ta_common`

Optional float value, mandatory if `ground_position` is absent. Force the value of NTA-Common, in us. Setting this to 0 effectively emulates a regenerative architecture where the eNB is on-board the satellite, without any feeder link.

If the parameter is absent, then the NTA-Common value is automatically computed based on `ground_position` and current satellite position.

`n_ta_drift`

Optional float value (default = 0). Force the value of NTA-CommonDrift, in us/s. `n_ta_common` must be present if set.

`n_ta_drift_var`

Optional float value (default = 0). Force the value of NTA-CommonDriftVariation, in us/s/s. `n_ta_common` must be present if set.

`n_ta_common_offset`

Optional float value (default = 0). Adds a constant to the NTA-common broadcast in SIB. It can be used to reflect fixed delays occuring in the system independently of satellite position. This offset will *not* be simulated in the channel simulator.

feeder_doppler_compensation

> Optional boolean (default = false). If true, the eNB will precompensate the doppler effect present on the feeder link. This parameters needs `ground_position` to be set.

feeder_dl_freq

> Optional integer (default = cell *UL* frequency). Sets the actual frequency in Hz of the satellite DL feeder link (from satellite to eNB) to compute an accurate doppler compensation. Unused if `feeder_doppler_compensation` is false.

feeder_ul_freq

> Optional integer (default = cell *DL* frequency). Sets the actual frequency in Hz of the satellite UL feeder link (from eNB to satellite) to compute an accurate doppler compensation. Unused if `feeder_doppler_compensation` is false.

large_freq_shift

> Optional object to add a 'calibration' phase where the eNB measures the received PRACH (without handling them) in order to compensate a large and unforeseen frequency error. The frequency error is also constantly tracked and adjusted on subsequent UL signals. This option is available for NR and LTE only.
>
> This feature is compatible with all PRACH formats except format 0 and C0. The eNB parameter `compute_freq_shift` also needs to be set.
>
> The object contains the following parameters:
>
> **prach_range_sc**
>
> > Integer. Range 0 to 768. Range of frequency error detection in PRACH subcarrier units. If set below 12, PRACH frequency detection is effectively disabled and the remaining parameters of `large_freq_shift` will allow for simple frequency tracking.
>
> **prach_n_acc**
>
> > Integer. Range 1 to 11. Number of PRACH to accumulate before deciding on a frequency measurement.
>
> **ta_tolerance**
>
> > Integer. Range 0 to 32, in TA units. Range in TA units below which the received PRACH will be assumed coming from the same UE.
>
> **average_mode**
>
> > Optional boolean (default false). Defines how the frequency error is determined. When true, the error is the average of the frequency measurements performed on the `prach_nacc` PRACH sharing the same TA (in the `ta_tolerance` range). When false, the error is the mode of the frequency measurements.

large_time_shift_symbols

> Optional integer. Range 0 to 4 (default 0). If set, the eNB will add a 'calibration' phase to compensate for large and unforeseen timing errors when operating in FR2 with short PRACH preambles.
>
> Upon a PRACH reception, the eNB will add an offset of n symbols to

the measured TA before sending the RAR, with n ranging from 0 to `large_time_shift_symbols` or until RACH procedure is successful. The best results will be obtained with preamble format C2 where the timing estimation range of the PRACH corresponds to one symbol.

`direct_to_cell`

Optional object to configure Direct-To-Cell operation. This setting is possible only on NR FDD and LTE FDD non-NTN bands.

When configured, the following NTN parameters are ignored or have no effect: `k_mac`, `k_offset`, `use_state_vectors`, `eci_reference`, `ul_sync_validity`, `dynamic_k_offset`, `t_service`, `neighbour_cells`, `rat_type`.

Direct-To-Cell operation also brings some constraints on the PRACH configuration. The eNB will display an comprehensive error message when those constraints are not met.

The object contains the following parameters:

`cell_center`

Object, configures the center position of the served cell on the ground used as a reference point for timing and doppler precompensation. It contains the following parameters:

`latitude`   Float value. Range -90 to 90. Degrees of latitude.

`longitude`

Float value. Range -180 to 180. Degrees of longitude.

`altitude`   Optional float value (default = 0). Range -1000m to 20km. Altitude in meters.

`channel_sim_control`

Optional object to automatically adjust the global delay of the channel simulator.

If `ue_doppler_shift` and/or `feeder_doppler_shift` is true, the values of `freq_shift` and `ul_freq_shift` will be automatically updated.

If `ue_dl_attenuation` is true, the global gain of the channel simulator is also updated.

If the `channel_sim_control` object is absent, channel simulator control is disabled.

Contains the following parameters:

`type`   Enumeration: `disabled, auto_feeder_link, auto_feeder_service_link`. Sets the type of control of the channel simulator.
`auto_feeder_link` updates the delay with only the feeder link, based on satellite ephemeris and `ground_position`.
`auto_feeder_service_link` updates the delay with the feeder link plus the service link to simulate the overall round-trip time of a NTN system. In that mode, an estimation of the UE position needs to be configured with `ue_position`.
If `ground_position` is not present (typically in a regenerative architecture), feeder link simulation is based

on explicit `ta_common` setting.

ue_position

Optional object, needed only when type is set to `auto_feeder_service_link`. Configures the expected geographical position of the UEs to simulate the global round-trip time. Contains the following parameters:

latitude Float value. Range -90 to 90. Degrees of latitude.

longitude

Float value. Range -180 to 180. Degrees of longitude.

altitude Optional float value (default = 0). Range -1000m to 20km. Altitude in meters.

ue_doppler_shift

Optional boolean (default = false). If true, the doppler frequency shift of the service link is added to the channel simulator in DL and in UL.

This parameter is used only if the control type is set to `auto_feeder_service_link`.

ue_dl_freq

Optional integer (default = cell DL freq). Sets the actual DL frequency in Hz of the satellite service link to simulate accurate doppler shifts when `ue_doppler_shift` is true.

ue_ul_freq

Optional integer (default = cell UL freq). Sets the actual UL frequency in Hz of the satellite service link to simulate accurate doppler shifts when `ue_doppler_shift` is true.

feeder_doppler_shift

Optional boolean (default = false). If true, the doppler frequency shift of the feeder link is added to the channel simulator in DL and in UL.

The frequencies used for the simulation of feeder link doppler are the same than the one used for `feeder_doppler_compensation`.

ue_dl_attenuation

Optional boolean (default = false). If true, the DL attenuation of the service link is set in the DL channel simulator. The attenuation takes into account the free space loss and the atmospheric absorption for frequencies up to 50GHz. This parameter is used only if the control type is set to `auto_feeder_service_link`.

ue_dl_gain_offset

Optional float, range 0 to 100 (default = 0). Offsets the attenuation calculated by `ue_dl_attenuation` by a constant value. Typical free space loss from a satellite will range

from 70 to 90 dB, so setting a value around 80 dB in a cabled setup environment is recommended. This parameter is used only if `ue_dl_attenuation` is set to true.

`ul_sync_validity`
Enumeration 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 120, 180, 240 or 900. ul-SyncValidationDuration in seconds.

`k_offset` Optional integer. Range 0 to 1023. k-Offset value in ms. Default value is calculated based on satellite altitude.

`k_mac` Optional integer. Range 0 to 512 (default 0). k-Mac value in ms.

`dynamic_k_offset`
Optional boolean (default = false). If true, enables UE-specific k_offset adjustment based on UE TA Report.

`reference_location`
Optional object. Reference location of the serving cell provided via NTN quasi-Earth fixed system. It contains the following parameters:

`latitude` Float value. Range -90 to 90. Degrees of latitude.

`longitude`
Float value. Range -180 to 180. Degrees of longitude.

`t_service`
Optional integer or string. This parameters is suitable for NR only to send the corresponding end of service for the current cell, given as UTC time.
If set to 0, it is automatically computed by the eNB based on satellite ephemeris.

`neighbour_cells`
Optional boolean (default = false). This parameter is suitable for NR only. If set to true, intra-gNB neighbour cells defined in the `ncell_list` via the `cell_id` parameter (See [NR ncell_list], page 134) which have also a NTN config will be used to populate the ntn-NeighCellConfigList-r17 in SIB19.

`rat_type` Optional enumeration: `leo, meo, geo, othersat`. RAT Type advertised to the core network for the Tracking Area to which the cell belong. Default value is based on satellite altitude defined by `semi_major_axis`.

`t318` Optional enumeration: 0, 200, 500, 1000, 2000, 4000, 8000, default = 2000. T318 value. Only applicable to NB-IoT cells.

8.9.1 NB-IoT cell

For NB-IoT, the `ntn` object shall be placed inside a cell item of the `nb_cell_list` or in the `nb_cell_default`. See [NB-IoT cell configuration], page 103.
`neighbour_cells` and `direct_to_cell` parameters are not available.
The `sib31` scheduling information also needs to be configured in the cell. See [NB-IoT sib31], page 109.

8.9.2 LTE cell

For LTE, the `ntn` object shall be placed inside a cell item of the `cell_list` or in the `cell_default`. See [Cell configuration], page 45. `direct_to_cell` configuration is mandatory and `k_mac, k_offset, use_state_vectors, eci_reference, ul_sync_validity, dynamic_k_offset, t_service, neighbour_cells, rat_type` are not available.

8.9.3 NR cell

For NR, the `ntn` object shall be placed inside a cell item of the `nr_cell_list` or in the `nr_cell_default`. See [NR cell configuration], page 125. The `sib19` scheduling information also needs to be configured in the cell, See [NR sib19], page 134, unless `direct_to_cell` is configured.

8.10 DL synchronization

This feature allows eNB/gNB to listen to neighbour cells on same frequency to synchronize its clock in time.
The feature is only available for NR and LTE TDD cells and is subject to license limitation.
To enable it, please contact `sales@amarisoft.com`.

When enabled, the eNB/gNB will search for cells at same frequency and will synchronize in time its signal to the strongest cell found. This cell will be noted as remote cell.

Inside your LTE or NR cell configuration, place a `dl_sync` object with following parameters:

`snr_threshold`
> Optional number (default = 2). SNR in dB below which the synchronization is considered as lost.
> When this threshold is reached, a `dl_sync/lost` event will be sent via remote API.

`snr_seq` Optional number (default = 20). Defines number of consecutive low SNR found before generating unsync event.

`pbch_error_threshold`
> Optional number (default = 5). Number of consecutive MIB decoding failure before the synchronization is considered as lost.
> Applies to NR cells only.
> When this threshold is reached, a `dl_sync/lost` event will be sent via remote API.

`info_delay`
> Optional number (default = 5). Delay in seconds between two `dl_sync/info` event sent via remote API.

`sync_timeout`
> Optional number (default = 5). Maximum time in seconds for cell search. During this period, no signal will be transmitted. When a cell is found, a `dl_sync/sync` event is sent and cell signal will be sent again. If the timeout is reached, signal will be back and a `dl_sync/timeout` event will be sent via remote API.

`pci_blacklist`
> Optional integer or array of integers. Each integer represents a Physical Cell ID that can't be used for synchronization.

8.10.1 LTE cell

To work with a LTE cell, DL synchronization requires MBMS to be enabled.
Please refer to [reserved_mbms_subframes], page 82, to do it.

8.10.2 NR cell

For NR cell, `dl_sync` configuration object has following additional parameters:

`ssb_period`
> Enumeration (5, 10, 20, 40, 80, 160). SSB periodicity in ms of the remote cell.
> Should be lesser or equal to the real remote cell periodicity.
> Note that gNB will stop sending signal when listening to remote cell SSB.

gscn   Optional integer (default = 0). Set the SSB GSCN of the remote (=SSB carrier frequency). The special default value 0 indicates to automatically set it. It is computed so that the SSB is at the lowest possible frequency in the cell bandwidth.

ssb_nr_arfcn

    Optional integer. If set, forces remote cell SSB arfcn.

Note that [ssb_pos_bitmap], page 166, of the cell should be defined to avoid collision with remote cell SSB.

9 CPU/Cores configuration

For optimal performances LTEENB will use multiple cores. Those cores can be spread on multiple CPUs (Multi socket) as long as Linux operating system makes them available.

By default, LTEENB will try to find the most suitable amount of necessary cores depending on the total number of available cores and the desired radio configuration (Mainly depending on number of cells, on their bandwidth and number of antenna).

For optimization purpose, this can be manually defined as explained in this chapter.

9.1 Hyperthreading

We strongly recommend to disable CPU hyperthreading.
The main reason is that LTEENB is memory intensive and any process running on a twin of a core used by the process may steal its cache resources, leading to performance degradation.

If you use Amarisoft automatic installation, you should disable it during the installation process.
For optimal performances, you may disable hyperthreading in the BIOS.

If you want to keep hyperthreading on for other processes, you may configure Linux to avoid scheduling other processes on the twin of the cores used by LTEENB using core isolation.

9.2 Core restriction cores

LTEENB will restrict its core usage to the list of cores affected to the process by the OS at startup.

If the process is launch with a dedicated core list, such as what `tasket` program will do, the software relies on it and will tries to use only specified cores.

In the case where cores would have been isolated by kernel at boot time, those cores won't be used by default.
If you want to use them, you will need to use `taskset` program (or equivalent) to prevent this restriction.

9.3 Affinity

You can force core affinity of the process externaly (Ex: using taskset program) or use `cpu_core_list` array.

Each element will represent cores to use or not, with following syntax:

Number   Represent the core index to use (Same as processor information in /proc/cpuinfo).

String

String	Description
<a>	where <a> is a number, represents the core index to use.
*	all cores (excluding hyperthreaded twins) will be added to the list.
numa<n>	all cores related to NUMA node <n> will be added

`<a>-<b>`	all cores between core index `<a>` and core index `<b>` (included) will be added. `<b>` can be "last" representing the index of the last core.
`!<cores>`	remove all the cores defined by `<core>` where `<code>` can have the other string syntax defined above.

By default, only non hyperthreaded cores will be used. To select hyperthreaded core twins, use number syntax or start string by `"ht:"`.
Ex: `"ht:*"` will select all cores including hyperthreaded twins.

The `cpu_core_list` can be defined at top level of your configuration file to force the global affinity of the process or for dedicated sections.

Examples:
Let's assume we have a CPU with 8 hyperthreaded cores (16 logical cores).

```
cpu_core_list: ["*", "!4"]
```

Will assign cores 0, 1, 2, 3, 5, 6 and 7

```
cpu_core_list: ["5-last", "ht:12-last"]
```

Will assign cores 5, 6, 7, 12, 13, 14, 15

9.4 Memory

On NUMA (Non Uniform Memory Access) CPU architecture, you may improve performances by assigning NUMA nodes to different digital processing engines.
This is the case when you have multiple sockets on your motherboard or with AMD processor.
Note that by default NUMA nodes are hidden by BIOS to the OS so you may change your BIOS configuration to use them.

For each digital processing engine, you should assign NUMA nodes for memory and for core affinity that has the shortest path.
In other words, when you affect cores to a DSP engine, you should ensure that the assigned cores are located on the fewest NUMA nodes possible and if needed select manually your NUMA node for memory (See [cpu_numa_list], page 40).

As the DSP engine communicates huge amount of memory to the radio frontend, you may select same NUMA nodes as your radio frontend.
If you use Amarisoft PCIe radio frontends, you can check which NUMA node is used by checking kernel traces (dmesg) when inserting kernel driver.
Ex:

```
sdr PCI device 6c:00.0 assigned to minor 5, type=RF_SDR100_Slave (rev 1) numa=1 dma:1ch 64b
```

10 Remote API

You can access LTEENB via a remote API.
Protocol used is WebSocket as defined in RFC 6455 (`https://tools.ietf.org/html/rfc6455`).

Note that Origin header is mandatory for the server to accept connections.
This behavior is determined by the use of `nopoll` library.
Any value will be accepted.

To learn how to use it, you can refer to our the following tutorial (`https://tech-academy.amarisoft.com/RemoteAPI.html`).

10.1 Messages

Messages exchanged between client and LTEENB server are in strict JSON format.

Each message is represented by an object. Multiple message can be sent to server using an array of message objects.

Time and delay values are floating number in seconds.

There are 4 types of messages:

- Request

    Message sent by client.
    Common definition:

    message String. Represent type of message. This parameter is mandatory and depending on its value, other parameters will apply.

    message_id

        Optional any type. If set, response sent by the server to this message will have same message_id. This is used to identify response as WebSocket does not provide such a concept.

    start_time

        Optional float. Represent the delay before executing the message.
    If not set, the message is executed when received.

    absolute_time

        Optional boolean (default = false). If set, `start_time` is interpreted as absolute.
    You can get current clock of system using `time` member of any response.

    standalone

        Optional boolean (default = false). If set, message will survive WebSocket disconnection, else, if socket is disconnected before end of processing, the message will be cancelled.

    loop_count

        Optional integer (default = 0, max = 1000000). If set, message will be repeated `loop_count` time(s) after `loop_delay` (From message beginning of event).
    Response will have a `loop_index` to indicate iteration number.

loop_delay

>Optional number (min = 0.1, max = 86400). Delay in seconds to repeat message from its `start_time`. Mandatory when `loop_count` is set > 0.

- Notification

  For some API, intermediate message may be sent by server before reception of response.
  Common definition:

  message   String. Same as request.

  message_id

  >Optional any type. Same as in request.

  time   Number representing time in seconds of the message start, relative to the beginning of the process.
  >Useful to send command with absolute time.

  notification

  >String. Notification purpose

  utc   Number representing UTC seconds (local clock) when the response has been generated.

- Response

  Message sent by server after any request message has been processed.
  Common definition:

  message   String. Same as request.

  message_id

  >Optional any type. Same as in request.

  time   Number representing time in seconds of the message start, relative to the beginning of the process.
  >Useful to send command with absolute time.

  utc   Number representing UTC seconds (local clock) when the response has been generated.

  absolute_time

  >Optional string. If `absolute_time` has been set and message is reaching LTEENB too late, this field is present and set to `late`.

- Events

  Message sent by server on its own initiative.
  Common definition:

  message   String. Event name.

  time   Number representing time in seconds.
  >Useful to send command with absolute time.

10.2 Startup

When WebSocket connections is setup, LTEENB will send a first message with name set to `com_name` and type set to ENB.

If authentication is not set, message will be `ready`:

```
{
    "message": "ready",
```

```
    "type": "ENB",
    "name": <com_name>,
    "version": <software version>,
    "product": <Amarisoft product name (optional)>
}
```

If authentication is set, message will be `authenticate` :

```
{
    "message": "authenticate",
    "type": "ENB",
    "name": <com_name>,
    "challenge": <random challenge>
}
```

To authenticate, the client must answer with a `authenticate` message and a `res` parameter where:

```
res = HMAC-SHA256( "<type>:<password>:<name>", "<challenge>" )
```

`res` is a string and HMAC-SHA256 refers to the standard algorithm (`https://en.wikipedia.org/wiki/HMAC`)

If the authentication succeeds, the response will have a `ready` field set to `true`.

```
{
    "message": "authenticate",
    "message_id": <message id>,
    "ready": true
}
```

If authentication fails, the response will have an `error` field and will provide a new challenge.

```
{
    "message": "authenticate",
    "message_id": <message id>,
    "error": <error message>,
    "type": "ENB",
    "name: <name>,
    "challenge": <new random challenge>
}
```

If any other message is sent before authentication succeeds, the error `"Authentication not done"` will be sent as a response.

10.3 Errors

If a message produces an error, response will have an error string field representing the error.

10.4 Sample nodejs program

You will find in this documentation a sample program: `ws.js`.
It is located in `doc` subdirectory.
This is a nodejs program that allow to send message to LTEENB.
It requires nodejs to be installed:

```
dnf install nodejs npm
npm install nodejs-websocket
```

Use relevant package manager instead of NPM depending on your Linux distribution.

Then simply start it with server name and message you want to send:

```
./ws.js 127.0.0.1:9001 '{"message": "config_get"}'
```

10.5 Common messages

`config_get`

Retrieve current config.

Response definition:

type   Always "ENB"

name   String representing server name.

logs   Object representing log configuration.
           With following elements:

           layers   Object. Each member of the object represent a log layer
                      configuration:

                      layer name
                                 Object. The member name represent log layer
                                 name and parameters are:

                                 level   See [log_options], page 30,

                                 max_size   See [log_options], page 30,

                                 key   See [log_options], page 30,

                                 crypto   See [log_options], page 30,

                                 payload   See [log_options], page 30,

                                 rep   Optional   boolean.   See
                                            [log_options], page 30,

                                 csi   Optional   boolean.   See
                                            [log_options], page 30,

                                 ntn   Optional   boolean.   See
                                            [log_options], page 30,

                                 signal   Optional   boolean.   See
                                            [log_options], page 30,

           count   Number. Number of bufferizer logs.

           rotate   Optional number. Max log file size before rotation.

           rotate_count
                      Optional number. Max log count before rotation.

           path   Optional string. Log rotation path.

           bcch   Boolean. True if BCCH dump is enabled (eNB only).

           mib   Boolean. True if MIB dump is enabled (eNB only).

locked   Optional boolean. If true, logs configuration can't be changed with
           config_set API.

tai   Number. Absolute TAI time in s corresponding to time of this response.
           Can be used to retrieve SFN.

global_enb_id

Optional object (present if LTE or NB-IoT cells are declared) containing the following members:

plmn   String. PLMN identity part of the global eNB ID.

enb_id_type

String. eNB type (short_macro, macro, long_macro, home).

enb_id   Integer. eNB identity part of the global eNB ID.

enb_name   String. eNB name

global_gnb_id

Optional object (present if NR SA cells are declared) containing the following members:

plmn   String. PLMN identity part of the global gNB ID.

gnb_id_bits

Integer. Number of bits for the `gnb_id`.

gnb_id   Integer. gNB identity part of the global gNB ID.

gnb_name   String. gNB name

cells   Object. Each member name/value represents the LTE cell ID/cell definition:

n_antenna_dl

Integer. Downlink antenna count.

n_antenna_ul

Integer. Uplink antenna count.

n_layer_dl

Integer. Downlink layer count.

n_layer_ul

Integer. Uplink layer count.

gain   Float. Cell gain in dB.

ul_disabled

Boolean. UL state.

rf_port   Integer. RF port number index.

label   Optional string. Label set in configuration file.

dl_qam   Enumeration: 64, 256, 1024. Maximum QAM size used in downlink.

ul_qam   Enumeration: 16, 64, 256. Maximum QAM size used in uplink.

ecgi   Object containing the following information:

plmn   String. E-UTRAN Cell Identity PLMN.

eci   Integer. E-UTRAN Cell Identity (28 bits).

cell_barred

Boolean. Cell barred status.

cell_barred_5gc
> Optional boolean. Cell barred status for EUTRA/5GC.

n_id_cell
> Integer. Physical cell ID.

n_rb_dl   Integer. Number of downlink resource blocks.

n_rb_ul   Integer. Number of uplink resource blocks.

dl_earfcn
> Integer. Downlink EARFCN.

ul_earfcn
> Integer. Uplink EARFCN.

band   Integer. LTE frequency band indicator.

dl_freq   Integer. Downlink frequency in Hz.

ul_freq   Integer. Uplink frequency in Hz.

mode   Enumeration: FDD, TDD. Operation mode.

uldl_config
> Optional integer. TDD subframe assignment. Only present if `mode` is "TDD".

sp_config
> Optional integer. TDD special subframe pattern. Only present if `mode` is "TDD".

prach_sequence_index
> Integer. Cell PRACH sequence index.

dl_cyclic_prefix
> Enumeration: normal, extended. Downlink cyclic prefix.

ul_cyclic_prefix
> Enumeration: normal, extended. Uplink cyclic prefix.

prach_config_index
> Integer. PRACH configuration index.

prach_freq_offset
> Integer. PRACH frequency offset.

delta_pucch_shift
> Integer. deltaPUCCH-Shift.

nrb_cqi   Integer. nRB-CQI.

n_cs_an   Integer. nCS-AN.

pucch_allocation
> Array of objects. Each object contains:
>
> > **type**   Enumeration: 2/2a/2b, 3.
> >
> > **rbs**   Integer. Number of resource blocks for this type.
> >
> > **n**   Integer. Number of PUCCH for this type.

pucch_ack_nack_start
> Integer. n1PUCCH-AN.

pucch_reserved_rbs
> Array of 10 integers. Each entry gives the number of resource blocks reserved for PUCCH in the corresponding subframe.

sr_resource_count
> Integer. Number of Scheduling Request resources.

cqi_resource_count
> Integer. Number of Channel Quality Indicator resources.

br_sr_resource_count
> Optional integer. Number of Bandwidth Reduced Scheduling Request resources.

br_cqi_resource_count
> Optional integer. Number of Bandwidth Reduced Channel Quality Indicator resources.

srs_resources
> Array containing the SRS related information:
>
> **offsets**   Integer. Number of possible offsets.
>
> **freqs**   Integer. Number of possible frequencies.
>
> **total**   Integer. Total number of resources.

gbr   Object containing the GBR related information:
> **dl_limit**   Integer. Downlink limit in number of resource elements per second.
>
> **ul_limit**   Integer. Uplink limit in number of resource elements per second.

connected_mobility
> Optional object. Present if `meas_config_desc` configuration object is defined for this cell. It contains the following information:
>
> **scell_config_a4_a2**
>> Boolean. Set to true if A2/A4 events are defined in `scell_config`.
>
> **scell_config_a6**
>> Boolean. Set to true if an A6 event is defined in `scell_config`.
>
> **eutra_handover_intra**
>> Boolean. Set to true if `eutra_handover` or `eutra_handover_intra` and `ho_from_meas` are true. Only applicable to EUTRA cells.
>
> **eutra_handover_inter**
>> Boolean. Set to true if `eutra_handover` or `eutra_handover_inter` and `ho_from_meas` are true. Only applicable to EUTRA cells.
>
> **eutra_handover**
>> Boolean. Set to true if `eutra_handover` and `ho_from_meas` are true. Only applicable to NR cells.

eutra_cell_redirect_intra
> Boolean. Set to true if `eutra_cell_redirect` or `eutra_cell_redirect_intra` is true. Only applicable to EUTRA cells.

eutra_cell_redirect_inter
> Boolean. Set to true if `eutra_cell_redirect` or `eutra_cell_redirect_inter` is true. Only applicable to EUTRA cells.

eutra_cell_redirect
> Boolean. Set to true if `eutra_cell_redirect` is true. Only applicable to NR cells.

nr_handover_intra
> Boolean. Set to true if `nr_handover` or `nr_handover_intra` and `ho_from_meas` are true. Only applicable to NR cells.

nr_handover_inter
> Boolean. Set to true if `nr_handover` or `nr_handover_inter` and `ho_from_meas` are true. Only applicable to NR cells.

nr_handover_d1
> Boolean. Set to true if `nr_handover_d1` and `ho_from_meas` are true. Only applicable to NR cells.

nr_conditional_handover
> Boolean. Set to true if `nr_conditional_handover` is true. Only applicable to NR cells.

nr_handover
> Boolean. Set to true if `nr_handover` and `ho_from_meas` are true. Only applicable to EUTRA cells.

nr_cell_redirect_intra
> Boolean. Set to true if `nr_cell_redirect` or `nr_cell_redirect_intra` is true. Only applicable to NR cells.

nr_cell_redirect_inter
> Boolean. Set to true if `nr_cell_redirect` or `nr_cell_redirect_inter` is true. Only applicable to NR cells.

nr_cell_redirect
> Boolean. Set to true if `nr_cell_redirect` is true. Only applicable to EUTRA cells.

en_dc_setup
> Boolean. Set to true if `en_dc_setup` is true.

scell_list
> Optional array of objects listing the configured LTE secondary cells. Each object of the array contains the following information:

cell_id   Integer. Cell identifier.

ul_allowed

        Boolean. Indicates if PUSCH transmission is allowed.

cross_carrier_scheduling

        Boolean. True if cross carrier scheduling is enabled for this cell.

ncell_list

Optional array of objects listing the configured E-UTRA or NR cells. Each object of the array contains the following information:

rat   String ("nr" or "eutra"). Cell type.

dl_earfcn

        Optional integer. Cell DL E-ARFCN. Only applicable to E-UTRA cells.

n_id_cell

        Optional integer. Cell PCI. Only applicable to E-UTRA cells.

ecgi   Optional object containing the following information. Only applicable to E-UTRA cells.

        plmn   String. E-UTRAN Cell Identity PLMN.

        eci   Integer. E-UTRAN Cell Identity (28 bits).

ssb_nr_arfcn

        Optional integer. SSB DL NR-ARFCN. Only applicable to NR cells.

n_id_nrcell

        Optional integer. Cell PCI. Only applicable to NR cells.

ncgi   Optional object containing the following information. Only applicable to NR cells.

        plmn   String. NR Cell Identity PLMN.

        nci   Integer. NR Cell Identity (36 bits).

handover_target

        Boolean. handover_target parameter value for this neighbor cell.

conditional_handover_target

        Boolean. conditional_handover_target parameter value for this neighbor cell. Only applicable to NR cells.

cell_redirect_target

        Boolean. cell_redirect_target parameter value for this neighbor cell.

eps_fallback_target

> Boolean. `eps_fallback_target` parameter value for this neighbor cell. Only applicable to E-UTRA cells.

emergency_fallback_target

> Boolean. `emergency_fallback_target` parameter value for this neighbor cell. Only applicable to E-UTRA cells.

en_dc_scg_cell_list

> Optional array of objects listing the configured NR primary secondary cells (EN-DC). Each object of the array contains the following information:
>
> cell_id   Integer. Cell identifier.

tac   Integer. Tracking Area Code.

plmn_list

> Array of objects. Each object contains the following information:
>
> plmn   String. PLMN.
>
> reserved   Boolean. Reserved flag.

plmn_list_5gc

> Optional array of objects. Each object contains the following information:
>
> plmn_ids   Array of objects. List of PLMNs for this TAC. Each object contains the following information:
>
> > plmn   String. PLMN.
> >
> > reserved   Boolean. Reserved flag.
>
> tac   Integer. Tracking Area Code.
>
> ranac   Optional integer. RAN Area Code.
>
> nssai   Array of objects. Each object contains the following information:
>
> > sst   Integer (range 0-255). Slice Service Type.
> >
> > sd   Optional integer (range 0-0xFFFFFE). Slice Differentiator.

eutra_5gc_only

> Optional boolean. If set to true, the cell is barred for EUTRA/EPC and only allows EUTRA/5GC access.

manual_ref_signal_power

> Integer. Tells if `SIB2.referenceSignalPower` is set from TRX driver or manually set via configuration file or `config_set` remote API.

ref_signal_power

> Integer. `SIB2.referenceSignalPower` current value

carrier_sense
> Optional object. Present if carrier sensing is enabled on that cell. Contains following informations:
>
> epre
> > Number. Last measured energy in dB.
>
> cutoff
> > Bollean; Cutoff state.

nb_cells Object. Each member name/value represents the NB-IoT cell ID/cell definition:

n_antenna_dl
> Integer. Downlink antenna count.

n_antenna_ul
> Integer. Uplink antenna count.

n_layer_dl
> Integer. Downlink layer count.

n_layer_ul
> Integer. Uplink layer count.

gain   Float. Cell gain in dB.

ul_disabled
> Boolean. UL state.

rf_port   Integer. RF port number index.

label   Optional string. Label set in configuration file.

dl_qam   Enumeration: 4. Maximum QAM size used in downlink.

ul_qam   Enumeration: 4. Maximum QAM size used in uplink.

ecgi   Object containing the following information:

> plmn
> > String. E-UTRAN Cell Identity PLMN.
>
> eci
> > Integer. E-UTRAN Cell Identity (28 bits).

cell_barred
> Boolean. Cell barred status.

cell_barred_5gc
> Optional boolean. Cell barred status for EUTRA/5GC.

cell_barred_ntn
> Optional boolean. Cell barred status for NTN.

n_id_ncell
> Integer. Physical cell ID.

dl_earfcn
> Integer. Downlink EARFCN.

ul_earfcn
> Integer. Uplink EARFCN.

band   Integer. LTE frequency band indicator.

operation_mode
> Enumeration: same_pci, diff_pci, guardband, standalone.

tac   Integer. Tracking Area Code.

plmn_list
Array of objects. Each object contains the following information:

plmn   String. PLMN.

reserved Boolean. Reserved flag.

plmn_list_5gc
Optional array of objects. Each object contains the following information:

plmn_ids Array of objects. List of PLMNs for this TAC. Each object contains the following information:

plmn   String. PLMN.

reserved Boolean. Reserved flag.

tac   Integer. Tracking Area Code.

nssai   Array of objects. Each object contains the following information:

sst   Integer (range 0-255). Slice Service Type.

sd   Optional integer (range 0-0xFFFFFE). Slice Differentiator.

eutra_5gc_only
Optional boolean. If set to true, the cell is barred for EUTRA/EPC and only allows EUTRA/5GC access.

manual_ref_signal_power
Optional integer. Tells if SIB2.nrs-Power-r13 is set from TRX driver or manually set via configuration file or config_set remote API.

nrs_power_r13
Optional integer. SIB2.nrs-Power-r13 current value

nr_cells Object. Each member name/value represents the NR cell ID/cell definition:

n_antenna_dl
Integer. Downlink antenna count.

n_antenna_ul
Integer. Uplink antenna count.

n_layer_dl
Integer. Downlink layer count.

n_layer_ul
Integer. Uplink layer count.

gain   Float. Cell gain in dB.

ul_disabled
Boolean. UL state.

rf_port   Integer. RF port number index.

label   Optional string. Label set in configuration file.

dl_qam   Enumeration: 64, 256. Maximum QAM size used in down-
            link.

ul_qam   Enumeration: 64, 256. Maximum QAM size used in uplink.

ncgi   Object containing the following information:

    plmn   String. NR Cell Identity PLMN.

    nci   Integer. NR Cell Identity (36 bits).

cell_barred
            Boolean. Cell barred status.

cell_barred_redcap_1rx
            Optional boolean. Cell barred status for RedCap UEs with
            1 Rx branch.

cell_barred_redcap_2rx
            Optional boolean. Cell barred status for RedCap UEs with
            2 Rx branches.

cell_barred_eredcap_1rx
            Optional boolean. Cell barred status for eRedCap UEs with
            1 Rx branch.

cell_barred_eredcap_2rx
            Optional boolean. Cell barred status for eRedCap UEs with
            2 Rx branches.

cell_barred_ntn
            Optional boolean. Cell barred status for NTN.

n_id_nrcell
            Integer. Physical cell ID.

band   Integer. NR frequency band indicator.

dl_nr_arfcn
            Integer. Downlink ARFCN.

ul_nr_arfcn
            Integer. Uplink ARFCN.

n_rb_dl   Integer. Number of downlink resource blocks.

n_rb_ul   Integer. Number of uplink resource blocks.

ssb_nr_arfcn
            Integer. SSB ARFCN.

dl_mu   Integer. Downlink sub carrier spacing ($15 * 2 \char`\^ mu$ in KHz).

ul_mu   Integer. Uplink sub carrier spacing ($15 * 2 \char`\^ mu$ in KHz).

ssb_mu   Integer. SSB sub carrier spacing ($15 * 2 \char`\^ mu$ in KHz).

mode   Enumeration: FDD, TDD. Operation mode.

prach_sequence_index
            Integer. Cell PRACH sequence index.

connected_mobility

> Optional object. Present if `meas_config_desc` configuration object is defined for this cell. It contains the following information:

> scell_config
>
> > Boolean. Set to true if `scell_config` is defined.

> nr_handover
>
> > Boolean. Set to true if `nr_handover` is defined.

> nr_cell_redirect
>
> > Boolean. Set to true if `nr_cell_redirect` is defined.

> eutra_handover
>
> > Boolean. Set to true if `eutra_handover` is defined.

> eutra_cell_redirect
>
> > Boolean. Set to true if `eutra_cell_redirect` is defined.

> nr_dc_setup
>
> > Boolean. Set to true if `nr_dc_setup` is defined.

> mr_dc_release
>
> > Boolean. Set to true if `mr_dc_release` is defined.

scell_list

> Optional array of objects listing the configured NR secondary cells. Each object of the array contains the following information:

> cell_id   Integer. Cell identifier.

> ul_allowed
>
> > Boolean. Indicates if PUSCH transmission is allowed.

ncell_list

> Optional array of objects listing the configured E-UTRA or NR cells. Each object of the array contains the following information:

> rat   String ("nr" or "eutra"). Cell type.

> dl_earfcn
>
> > Optional integer. Cell DL E-ARFCN. Only applicable to E-UTRA cells.

> n_id_cell
>
> > Optional integer. Cell PCI. Only applicable to E-UTRA cells.

> ecgi   Optional object containing the following information. Only applicable to E-UTRA cells.
>
> > plmn   String. E-UTRAN Cell Identity PLMN.

<div style="margin-left:2em">

            `eci`   Integer. E-UTRAN Cell Identity (28 bits).

      `ssb_nr_arfcn`

            Optional integer. SSB DL NR-ARFCN. Only applicable to NR cells.

      `n_id_nrcell`

            Optional integer. Cell PCI. Only applicable to NR cells.

      `ncgi`   Optional object containing the following information. Only applicable to NR cells.

            `plmn`   String. NR Cell Identity PLMN.

            `nci`   Integer. NR Cell Identity (36 bits).

      `handover_target`

            Boolean. `handover_target` parameter value for this neighbor cell.

      `cell_redirect_target`

            Boolean. `cell_redirect_target` parameter value for this neighbor cell.

      `eps_fallback_target`

            Boolean. `eps_fallback_target` parameter value for this neighbor cell. Only applicable to E-UTRA cells.

      `emergency_fallback_target`

            Boolean. `emergency_fallback_target` parameter value for this neighbor cell. Only applicable to E-UTRA cells.

`nr_dc_scg_cell_list`

    Optional array of objects listing the configured NR primary secondary cells (NR-DC). Each object of the array contains the following information:

    `cell_id`   Integer. Cell identifier.

`plmn_list`

    Array of objects. Each object contains the following information:

    `plmn_ids` Array of strings. List of PLMNs for this TAC.

    `reserved` Boolean. Reserved flag.

    `tac`   Integer. Tracking Area Code.

    `ranac`   Optional integer. RAN Area Code.

    `nssai`   Array of objects. Each object contains the following information:

            `sst`   Integer (range 0-255). Slice Service Type.

            `sd`   Optional integer (range 0-0xFFFFFE). Slice Differentiator.

</div>

manual_ref_signal_power
> Optional integer. Tells if `SIB1.ss-PBCH-BlockPower` is set from TRX driver or manually set via configuration file or `config_set` remote API.

ss_pbch_block_power
> Optional integer. `SIB1.ss-PBCH-BlockPower` current value

rx_channels
> Array of objects. Each object contains the following members:

> **gain**   Float. RF reception gain, in dB.

> **freq**   Float. RF reception frequency, in MHz.

tx_channels
> Array of objects. Each object contains the following members:

> **gain**   Float. RF transmission gain, in dB.

> **freq**   Float. RF transmission frequency, in MHz.

> **port**   Integer. RF port index.

rf_ports   Array of objects. Each object represents the channel simulator parameters per RF port if channel simulator is enabled.

> **channel_dl**
> > Object. Each object contains the following members:

> > **noise_level**
> > > Array of float. Noise level table, in dB.

> > **freq_shift**
> > > Float. Global frequency shift in Hz.

> > **paths**   Array of objects. Each object contains the parameters of a path:

> > > **type**   Enumeration: constant, rayleigh, rayleigh_gauss. Type of path array. `constant` for constant path, `rayleigh` for Rayleigh fading with the Jakes model, `rayleigh_gauss` for Rayleigh fading with the Gaussian model.

> > > **delay**   Float. Path delay in ns.

> > > **gain**   Float. Path gain in dB.

> > > **freq_shift**
> > > > Float. Frequency shift in Hz (only for constant paths).

> > > **freq_doppler**
> > > > Float. Doppler frequency in Hz (only for paths with Rayleigh fading).

> **ul_freq_shift**
> > Float. Uplink frequency shift in Hz.

sample_rate

>Float. Sample rate in Hz.

config_set

>Change current config.
>Each member is optional.
>Message definition:

logs
>Optional object. Represent logs configuration. Same structure as config_get (See [config_get logs member], page 239).
>All elements are optional.
>Layer name can be set to `all` to set same configuration for all layers.
>If set and logs are locked, response will have `logs` property set to `locked`.

cells
>Optional object used to configure cells individually. Each configured cell must be a new object inside the `cells` object, using its cell id as key and containing the following fields:
>
>Example:
>
>```
>"cells": {
>  "1": {
>    ...
>  },
>  "2": {
>    ...
>  }
>}
>```
>
>tech-academy tutorial : Remote API for Cell Specific Configurations (`https://tech-academy.amarisoft.com/RemoteAPI.html#enb_Remote_API_under_cells`).
>
>pusch_mcs
>
>>Integer or array of integers (range: -1 to 28). The length of the array must divide 10 for LTE cells and $20 * 2^\mu$ for NR cells. Force the PUSCH MCS (test feature). If an array is provided, it provides the PUSCH MCS for each subframe. Use -1 not to force the MCS in a given subframe.
>
>pusch_fixed_rb_alloc
>
>>Optional boolean or array of booleans. The length of the array must divide 10 for LTE cells and $20 * 2^\mu$ for NR cells. Force fixed PUSCH RB allocation in all or a selected set of subframes. If an array is provided, a value true at the index value i of the array indicates that a fixed PUSCH RB allocation is used in subframe number i.
>>
>>The parameters `pusch_fixed_rb_start` and `pusch_fixed_l_crb` are used for the fixed allocation. `pusch_fixed_l_crb` must be of the form `2^n1*3^n2*5^n3`. PUSCH are allocated only if they don't overlap with PUCCH or PRACH, so care must be taken when defining the range. In some cases, PUSCH retranmissions may use other RBs.

pusch_fixed_rb_start

Optional integer or array of integers. The length of the array must divide 10 for LTE cells and $20 * 2^{\mu}$ for NR cells. First RB for fixed PUSCH allocation. If an array is provided, it gives the first RB for each subframe (see `pusch_fixed_rb_alloc`).

For a cell configured for category M1 UEs, `pusch_fixed_rb_start` and `pusch_fixed_l_crb` give the allocation inside a narrow band (hence `pusch_fixed_rb_start + pusch_fixed_l_crb <= 6`).

pusch_fixed_l_crb

Optional integer or array of integers. The length of the array must divide 10 for LTE cells and $20 * 2^{\mu}$ for NR cells. Number of consecutive RBs for fixed PUSCH allocation. If an array is provided, it gives the number of consecutive RBs for each subframe (see `pusch_fixed_rb_alloc`).

pusch_fixed_rb_forced

Optional boolean (default = false). If true, the eNodeB schedules the PUSCH with fixed RB allocation even if it collides with PUCCH/PRACH or another PUSCH.

pusch_multi_cluster

Optional boolean (default = false). If true, enable multi-cluster PUSCH resource allocation for the UEs supporting it (release 10). Note: this is a UE test feature, so the multi cluster allocation is not optimized by the scheduler.

pusch_max_mcs

Optional integer. Range: 0 to 28 (default = 28). CPU load limitation: maximum MCS allocated by the eNodeB for PUSCH. Smaller MCS give a smaller bitrate and a smaller CPU load. For LTE cells only.

pusch_max_its

Optional integer. Range 1 to 20 (default = 6). CPU load limitation: set the maximum number of iterations of the turbo decoder. A higher value gives a lower frame error rate but a higher CPU load. For LTE cells only.

force_adaptive_retransmission

Optional boolean (default = false). If set to true, the eNB will request a PUSCH retransmission using a DCI instead of PHICH.

force_full_bsr

Optional boolean (default = false). If true, the eNodeB considers the UE always indicates a full buffer size. Hence the UE is scheduled as often as possible for PUSCH transmission.

force_dl_schedule

Optional boolean (default = false). If true, the eNodeB considers there is always DL data waiting for transmission. Hence the UE is scheduled as often as possible for PDSCH transmission.

pdsch_mcs

Integer or array of integers (range: -1 to 28). The length of the array must divide 20 for LTE cells and $20 * 2^\mu$ for NR cells. Force the PDSCH MCS (test feature). If an array is set, it provides the PDSCH MCS for each subframe. Use -1 not to force the MCS in a given subframe.

pdsch_mcs_from_cqi

Integer or array of 16 integers (range: -1 to 28). Force the PDSCH MCS (test feature).
If an array is set, it provides the PDSCH MCS according to the CQI reported by UE. Use -1 not to force the MCS for a given CQI.

pdsch_fixed_rb_alloc

Optional boolean or array of booleans. The length of the array must divide 20 for LTE cells and $20 * 2^\mu$ for NR cells. Force fixed PDSCH RB allocation using the parameters pdsch_fixed_rb_start and pdsch_fixed_l_crb. If an array is provided, it selects the fixed PDSCH allocation for each subframe.

For a cell configured for category M1 UEs, fixed PDSCH RB allocation is only possible in subframes where the PDSCH MCS is fixed (see pdsch_mcs).

pdsch_fixed_rb_start

Optional integer or array of integers. The length of the array must divide 20 for LTE cells and $20 * 2^\mu$ for NR cells. First RB for fixed PDSCH allocation (see pdsch_fixed_rb_alloc). If an array is provided, it provides the first RB for each subframe.

For a cell configured for category M1 UEs, pdsch_fixed_rb_start and pdsch_fixed_l_crb give the allocation inside a narrow band (hence pdsch_fixed_rb_start + pdsch_fixed_l_crb <= 6).

pdsch_fixed_l_crb

Optional integer or array of integers. The length of the array must divide 20 for LTE cells and $20 * 2^\mu$ for NR cells. Number of consecutive RBs for fixed PDSCH allocation (see pdsch_fixed_rb_alloc). If an array is provided, it provides the consecutive RBs for each subframe.

sr_ignore_count

Optional integer. Indicates how many consecutive Scheduling Request are ignored by the eNB or gNB.

rach_ignore_count

Optional integer. Indicates how many consecutive RACH attempts are ignored by the eNB or gNB.

mac_crnti_ce_ignore_count

Optional integer. Indicates how many consecutive MAC C-RNTI control elements are ignored by the eNB or gNB.

dummy_ue_contention_resolution_id
> Optional boolean. If set to true, a wrong MAC UE Contention Resolution Identity control element will be sent in the Msg4, rather than the one matching the UE Msg3 content.

ho_from_meas
> Optional boolean. If true, a measurement report can trigger a handover procedure. See [LTE cell ho_from_meas], page 80. See [NR cell ho_from_meas], page 151.

ho_force_full_config
> Optional boolean. If true, any handover towards this cell will use full configuration.

ho_continue_rohc_context
> Optional boolean. If true, and if the UE supports the feature, the RoHC contexts are not reset during an intra eNB or ng-eNB or gNb handover towards this cell.

sib1_delivery_during_ho
> Optional boolean. If set to true, the target cell SIB1 is sent during an intra eNB or ng-eNB or gNb handover towards this cell.

dl_bwp   Optional array of objects (NR cells only). Each object contains configuration parameters for one DL BWP:

> **bwp_id**   Optional integer (range 0 to 4, default = 0). BWP ID.
>
> **pdsch**   Optional object. PDSCH configuration parameters. The following parameters can be specified: `n_layer`, `dmrs_mapping_type_a`, `dmrs_mapping_type_b`, `fixed_rb_alloc`, `rb_start`, `l_crb`, `mcs`, `fer`, `n_scid` with the same definition as in the PDSCH NR cell configuration. In the DMRS configuration objects, the following parameters can be specified: `dmrs_len`, `n_dmrs_cdm_groups` and `dmrs_ports`.

ul_bwp   Optional array of objects (NR cells only). Each object contains configuration parameters for one UL BWP:

> **bwp_id**   Optional integer (range 0 to 4, default = 0). BWP ID.
>
> **pusch**   Optional object. PUSCH configuration parameters. The following parameters can be specified: `n_layer`, `tpmi`, `ncb_sri_bitmap`, `dmrs_mapping_type_a`, `dmrs_mapping_type_b`, `fixed_rb_alloc`, `rb_start`, `l_crb`, `mcs`, `fer`, `n_scid`, `dci_beta_offset_indicator`, `max_mcs` with the same definition as in the PUSCH NR cell configuration. In the DMRS configuration objects, the following parameters can be specified: `dmrs_len`, `n_dmrs_cdm_groups` and `dmrs_ports`.

rrc_procedure_filter

Optional object. Allows to define the eNB/ng-eNB/gNB behavior for a list of RRC procedures.

Each property name represents a RRC procedure. The ones currently supported are `rrc_connection_request`, `rrc_connection_reestablishment_request` and `scg_failure_information_nr` for LTE cells, `rrc_connection_request`, `rrc_connection_reestablishment_request` and `early_data_request` for NB-IoT cells, `rrc_setup_request` and `rrc_reestablishment_request` for NR cells.

Each property value is an object containing the following fields:

`action`   Enumeration (`treat` (UE message is processed), `ignore` (UE message is ignored) or `reject` (UE message is rejected))

`ttl`   Optional integer. If set, the `reject` of `ignore` filter is applied `ttl` times. If not set, the filter is applied until it is modified.

Example:

```
"cells": {
  "1": {
    rrc_procedure_filter: {
      rrc_connection_request: {
        action: "treat"
      },
      rrc_connection_reestablishment_request: {
        action: "reject",
        ttl: 1
      }
    }
  }
}
```

rrc_cnx_reject_waitTime

Optional integer (range: 1 to 16). RRC connection reject wait time in seconds. Only applicable to LTE cells.

rrc_cnx_reject_extWaitTime

Optional integer (range: 0 to 1800 for LTE cells, 1 to 1800 for NB-IoT cells). RRC connection reject extended wait time in seconds. Not applicable to NR cells.

rrc_cnx_reject_deprioritisation

Optional object. If present, the deprioritisationReq-r11 field is added to the RRC Connection Reject message. Only applicable to LTE cells.

The object must contain the following fields:

`type`   Enumeration ("none", "frequency" or "e-utra").

`timer`   Optional enumeration (5, 10, 15 or 30). Timer in minutes. Required if `type` is not none.

rrc_cnx_release_extWaitTime

>   Optional integer (range: 0 to 1800). RRC connection release extended wait time in seconds. Not applicable to NR cells.

rrc_cnx_release_waitTime_5gc

>   Optional integer (default = 0). RRC connection release wait time in seconds when connected to 5GC. Only applicable to LTE cells.

rrc_cnx_release_extWaitTime_CPdata

>   Optional integer (range: 0 to 1800). RRC connection release extended wait time for Control Plane CIoT EPS optimisation in seconds. Only applicable to NB-IoT cells.

rrc_reject_waitTime

>   Optional integer (range 1 to 16). RRC reject wait time in seconds. Only applicable to NR cells.

rrc_release_waitTime

>   Optional integer (range 1 to 16). RRC release wait time in seconds. Only applicable to NR cells.

rrc_release_deprioritisation

>   Optional object. If present, the deprioritisationReq field is added to the RRC Release message. Only applicable to NR cells.
>   The object must contain the following fields:

>   **type**   Enumeration ("none", "frequency" or "nr").

>   **timer**   Optional enumeration (5, 10, 15 or 30). Timer in minutes. Required if `type` is not none.

gbr_congested

>   Optional boolean. Option that simulates a congestion once at least one GBR bearer is active in the cell. Any new GBR request will be rejected or will trigger a preemption depending on the ERAB or QoS flow ARP parameters.

ignore_gbr_congestion

>   Optional boolean (default = false). If set to true, no GBR congestion check is performed.

ue_cap_rat_type

>   Optional array of strings.
>   In LTE, list the RAT types (`eutra`, `utra`, `geran-cs`, `geran-ps`, `cdma2000-1XRTT`, `nr`, `eutra-nr`) for the RRC UE capability enquiry message. In the first UE capability enquiry message, `eutra` is always included whatever the array content.
>   In NR, list the RAT types (`nr`, `eutra-nr`, `eutra`, `utra-fdd`) for the RRC UE capability enquiry message. In the first UE capability enquiry message, `nr` is always included whatever the array content.

requested_eutra_freq_bands

>   Optional array of 0 to 16 integers. Defines the list of EUTRA bands the eNB or gNB will request in the UE Capa-

bility Enquiry message (via the requestedFrequencyBands-r11 information element). Use an array without any integer to remove a previously configured `requested_eutra_freq_bands` array.

requested_eutra_max_ccs_dl

Optional integer (range = 2 to 32, or 0). Sets the maximum number of EUTRA DL CCs the eNB or gNB will request in the UE Capability Enquiry message (via the requestedMaxCCsDL-r13 information element). Set to 0 to remove the field from the message.

requested_eutra_max_ccs_ul

Optional integer (range = 2 to 32, or 0). Sets the maximum number of EUTRA UL CCs the eNB or gNB will request in the UE Capability Enquiry message (via the requestedMaxCCsUL-r13 information element). Set to 0 to remove the field from the message.

request_reduced_format

Optional boolean. If set, the eNB or gNB will request the UE to provide EUTRA CA combinations using supportedBandCombinationReduced-r13 instead of supportedBandCombination-r10 in the UE Capability Enquiry message (via the requestReducedFormat-r13 information element).

request_eutra_reduced_int_non_cont_comb

Optional boolean. If set, the eNB or gNB will request an EUTRA reduced intra-band non-contiguous CA band combination in the UE Capability Enquiry message (via the requestReducedIntNonContComb-r13 information element).

requested_freq_bands_nr_mrdc

Optional array of objects of 0 to 1280 objects. If the array is present with at least one element, the requestedFreqBandsNR-MRDC-r15 IE content will be based on the content provided. Otherwise, the eNB will build the requestedFreqBandsNR-MRDC-r15 IE content based on the LTE and NR cells configured.
Each object contains the following parameters:

rat   Enumeration (eutra or nr). RAT type for this FreqBandInformation item.

band_eutra

Optional integer (range 1 to 256). E-UTRA frequency band indicator. Must be present if `rat` is set to "eutra".

ca_bandwidth_class_dl

Optional enumeration (a, b, c, d, e, f). E-UTRA DL CA bandwidth class. Only used if `rat` is set to "eutra".

ca_bandwidth_class_ul
> Optional enumeration (a, b, c, d, e, f). E-UTRA UL CA bandwidth class. Only used if `rat` is set to "eutra".

band_nr
> Optional integer (range 1 to 1024). NR frequency band indicator. Must be present if `rat` is set to "nr".

max_bandwidth_requested_dl
> Optional enumeration (50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800). Maximum aggregated DL bandwidth. Only used if `rat` is set to "nr".

max_bandwidth_requested_ul
> Optional enumeration (50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800). Maximum aggregated UL bandwidth. Only used if `rat` is set to "nr".

max_carriers_requested_dl
> Optional integer (range 1 to 32). Maximum number of DL carriers. Only used if `rat` is set to "nr".

max_carriers_requested_ul
> Optional integer (range 1 to 32). Maximum number of UL carriers. Only used if `rat` is set to "nr".

requested_freq_bands_nr
> Optional array of objects of the same type than `requested_freq_bands_nr_mrdc`.
> Force the frequencyBandListFilter element of the UE-CapabilityRequestFilterNR when requesting UE capabilities in SA mode.
> By default, the frequencyBandListFilter contains the bands of all the NR cells defined in `nr_cell_list` and EUTRA cells defined in `cell_list`.

mr_dc_request_nr_dc
> Optional boolean (default = false). If true, the includeNR-DC bit is set to true in the UE capability enquiry message so as to retrieve NR-DC band combinations. Note that it is automatically set if there is at least once cell configured for NR-DC.

rrc_ul_segmentation_support
> Optional boolean (default = true). If set to true, the eNB or gNB indicates that RRC UL segmentation is allowed in the RRC UE capability enquiry message.

single_ue_cap_enquiry
> Optional boolean (default = false). If set to true, and if the UE and eNB or gNB supports R16 uplink RRC segmentation feature, EUTRA, NR and MRDC capabilities are requested in a single message.

srs_switching_time_request
> Optional boolean (default = false). If set to true, the eNB or gNb sets the srs-SwitchingTimeRequest flag when requesting NR or EUTRA-NR UE capabilities.

uplink_tx_switch_request
> Optional boolean (default = false). If set to true, the eNB or gNB sets the uplinkTxSwitchRequest flag when requesting NR or EUTRA-NR UE capabilities.

inactivity_timer
> Optional integer. Send RRC connection release after this time (in ms) of network inactivity. It only impacts LTE (not Bandwidth-Reduced) or NR UEs. Note that it is only used for the UE PCell.

br_ue   Optional object only applicable to cells supporting Bandwidth-Reduced UEs. It can contain the following objects:

> **br_forced_mpdcch_nb_idx**
>> Optional integer. Forces the narrow band index used for MPDCCH. The value -1 means that the eNB selects the narrow band automatically.

> **br_forced_pdsch_nb_idx**
>> Optional integer. Forces the narrow band index used for PDSCH. The value -1 means that the eNB selects the narrow band automatically.

> **br_forced_pusch_nb_idx**
>> Optional integer. Forces the narrow band index used for PUSCH. The value -1 means that the eNB selects the narrow band automatically.

> **br_coverage_levels**
>> Optional array of objects. There must be the same number of coverage levels as PRACH configurations in the SIB2. Since only CE mode A is currently supported, at most 2 coverage levels can be specified. It can contain the following objects:

>> **inactivity_timer**
>>> Optional integer. Send RRC connection release after this time (in ms) of network inactivity. Note that it is only used for the UE PCell.

>> **br_forced_sr_offset**
>>> Optional integer: range -1 to `br_sr_period`-1. Forces the scheduling request subframe offset sent to the UE. -1 means that the eNB allocates the value automatically.

coverage_levels

Optional array of objects. Only applicable to NB-IoT cells. There must be the same number of coverage levels as NPRACH configurations in the SIB2. It can contain the following objects:

npdcch_paging_n_rep

Optional nteger. Range: 1 to 2048. Number of repetitions for the paging NPDCCH. It must be <= SIB2.npdcch-NumRepetitionPaging-r13.

npdsch_paging_i_tbs

Optional integer. Range: 0 to 12. I_TBS for the paging NPDSCH. For in-band cells, the maximum value is 10.

npdsch_paging_n_rep

Optional integer. Range: 1 to 2048. Number of repetitions for the paging NPDSCH.

npdcch_uss_n_rep

Optional Integer. Actual number of repetitions for the USS NPDCCH. The special value 0 means to use a single CCE (instead of 2) with a single transmission.

npdsch_i_tbs

Optional integer. Range: 0 to 13. I_TBS for NPDSCH. For in-band cells, the maximum value is 10. For category NB1 UEs, the value is limited to 12.

npdsch_i_sf

Optional Integer. Range: -1 to 7. I_SF value for NPDSCH. -1 means that the eNodeB scheduler automatically chooses it.

npdsch_n_rep

Optional integer. Range: 1 to 2048. Number of NPDSCH repetitions.

npdsch_i_delay_min

Optional Integer. Range: 0 to 7. Minimum value for the DCI N1 scheduling delay field.

npusch_single_tone_i_tbs

Optional integer. Range: 0 to 10. I_TBS for single-tone NPUSCH.

npusch_multi_tone_i_tbs

Optional integer. Range: 0 to 13. I_TBS for multi-tone NPUSCH. For category NB1 UEs, the value is limited to 12.

npusch_i_ru

Optional Integer. Range: -1 to 7. I_RU value for NPUSCH. -1 means that the eNodeB scheduler automatically chooses it.

npusch_n_sc

>Optional enumeration: 1, 3, 6, 12. Maximum number of subcarriers for NPUSCH. The eNodeB uses more than one subcarrier only if the UE supports it. If not present, the eNodeB link adaptation automatically chooses it.

npusch_n_rep

>Optional integer. Range: 1 to 128. Number of NPUSCH repetitions.

npusch_i_delay_min

>Optional Integer. Range: 0 to 3. Minimum value for the DCI N0 scheduling delay field.

inactivity_timer

>Optional integer. Send RRC connection release after this time (in ms) of network inactivity.

preemptive_ul_grant

>Optional boolean, only applicable to NB-IoT cells. When set to true, the eNB can send a DCIN0 grant before the UE explicitly request an allocation via the random access procedure.

forced_ri

>Optional integer, only applicable to LTE and NR cells. Range 0 to 8. If >= 1, use it as Rank Indicator (RI) returned by the UE.

forced_cqi

>Optional integer, only applicable to LTE and NR cells. Range -1 to 15. If >= 0, use it as Channel Quality Indicator (CQI) returned by the UE.

forced_pmi

>Optional integer, only applicable to LTE cells. Range -1 to 15. If >= 0, use it as Precoding Matrix Indicator (PMI) returned by the UE.

forced_meas_gap_offset

>Optional integer. Forces the gap offset sent to the UE in the LTE MeasGapConfig or NR GapConfig ASN.1 object. -1 means that the eNB/gNB allocates the value automatically. Only applicable to LTE and NR cells.

forced_sr_offset

>Optional integer: range -1 to sr_period-1, only applicable to LTE and NR cells. Forces the scheduling request offset sent to the UE. -1 means that the value is allocated automatically.

pusch_fer

>Optional float, only applicable to LTE and NR cells. Range 0 to 1. Set the simulated PUSCH Frame Error Rate.

pdsch_fer

>Optional float, only applicable to LTE and NR cells. Range 0 to 1. Set the simulated PDSCH Frame Error Rate.

npusch_fer

>Optional float, only applicable to NB-IoT cells. Range 0 to 1. Set the simulated NPUSCH Frame Error Rate.

npdsch_fer

>Optional float, only applicable to NB-IoT cells. Range 0 to 1. Set the simulated NPDSCH Frame Error Rate.

eps_fallback_preferred_method

>Optional enumeration: handover, redirection (default = handover). Only applicable to NR cells. Set the preferred method for the EPS fallback procedure. If the handover procedure fails a redirection is performed.

eps_fallback_fast_return_preferred_method

>Optional enumeration: none, handover, redirection (default = none). Only applicable to LTE cells. Set the preferred method for the EPS fallback fast return procedure. If the handover procedure fails a redirection is performed.
>Note that the fast return can only be performed if the EPS fallback procedure was performed with a handover and if the NR SA source cell is in the LTE neighbor cell list.

emergency_fallback_preferred_method

>Optional enumeration: handover, redirection (default = redirection). Only applicable to NR cells. Set the preferred method for the emergency fallback procedure. If the handover procedure fails a redirection is performed.

srb3_support

>Optional boolean (default = false). If true, and if the UE supports SRB3, the gNodeB will activate it.

scg_failure_information_behavior

>Optional enum (auto, release, reestablish, default = auto). Defines the behavior when the MCG primary cell receives a RRC SCG failure information message for this SCG primary cell.
>If set to `auto`, the SCG is released if the cause is set to T310 expiry and a measurement reporting configuration is defined to trigger the SCG addition. Otherwise the SCG is reestablished.
>If set to `release`, SCG is always released.
>If set to `reestablish`, a RRC message is always sent to reestablish SCG.

cell_barred

>Optional boolean or string (true, false or "auto"). Indicates if the cell should be barred or not. If set to "auto", the cell is barred when there is no connection with a core network for any of the PLMNs broadcast. Only applicable to NR cells. For LTE or NB-IoT cells, see `sib_set` remote API.

carrier_sense

>Optional object. If carrier sensing is enabled on cell, allow to change its configuration with following properties:

threshold
> Number. Cutoff threshild in dB.

rf_ports

Optional array of objects used to configure the RF ports. Each object contains the following fields:

channel_dl

Optional object to dynamically change the configuration of the downlink channel simulator. It contains the following fields:

noise_level
> Optional array of float or float: set the noise level in dB for each port.

freq_shift
> Optional float. Set the global frequency shift in Hz.

delay
> Optional float. Apply an additional global delay (in ns) to all the paths.

gain
> Optional float. Apply a global gain (in dB) after the paths.

freq_doppler
> Optional float. Set the Doppler frequency in Hz of all the paths with Rayleigh fading. When this parameter is modified, the internal state of the paths is reset so a discontinuity may happen in the simulated channel.

paths
> Optional array of objects. Each object contains the following fields:
>
> delay
> > Optional float. Set the path delay in ns.
>
> gain
> > Optional float. Set the path gain in dB. When this parameter is modified, the internal state of the paths is reset so a discontinuity may happen in the simulated channel.
>
> freq_shift
> > Optional float. Set the frequency shift in Hz of constant paths. When this parameter is modified, the internal state of the paths is reset so a discontinuity may happen in the simulated channel.
>
> freq_doppler
> > Optional float. Set the Doppler frequency in Hz of paths with Rayleigh fading. When this parameter is modified, the internal

state of the paths is reset so a discontinuity may happen in the simulated channel.

ul_freq_shift
Optional float. Set the uplink frequency shift in Hz.

log_get   Get logs.
This API has a per connection behavior. This means that the response will depend on previous calls to this API within the same WebSocket connection.
In practice, logs that have been provided in a response won't be part of subsequent request unless connection is reestablished. To keep on receiving logs, client should send a new log_get request as soon as the previous response has been received.
If a request is sent before previous request has been replied, previous request will be replied right now without considering specific min/max/timeout conditions.
Message definition:

min   Optional number (default = 1). Minimum amount of logs to retrieve. Response won't be sent until this limit is reached (Unless timeout occurs).

max   Optional number (default = 4096). Maximum logs sent in a response.

timeout   Optional number (default = 1). If at least 1 log is available and no more logs have been generated for this time, response will be sent.

allow_empty
Optional boolean (default = false). If set, response will be sent after timeout, event if no logs are available.

rnti   Optional number. If set, send only logs matching rnti.

ue_id   Optional number. If set, send only logs with matching ue_id.

layers   Optional Object. Each member name represents a log layer and values must be string representing maximum level. See [log_options], page 30. If *layers* is not set, all layers level will be set to *debug*, else it will be set to *none*.
Note also the logs is also limited by general log level. See [log_options], page 30.

short   Optional boolean (default = false). If set, only first line of logs will be dumped.

headers   Optional boolean. If set, send log file headers.

start_timestamp
Optional number. Is set, filter logs older than this value in milliseconds.

end_timestamp
Optional number. Is set, filter logs more recent than this value in milliseconds.

max_size   Optional number (default = 1048576, i.e. 1MB). Maximum size in bytes of the generated JSON message. If the response exceeds this size, the sending of logs will be forced independently from other parameters.

Response definition:

logs   Array. List of logs. Each item is a an object with following members:

            data   Array. Each item is a string representing a line of log.

timestamp
> Number. Milliseconds since January 1st 1970. Not present if `com_log_us` is set in configuration.

timestamp_us
> Number. Microseconds since January 1st 1970. Only present if `com_log_us` is set in configuration.

`layer`	String. Log layer.
`level`	String. Log level: *error*, *warn*, *info* or *debug*.
`dir`	Optional string. Log direction: *UL*, *DL*, *FROM* or *TO*.
`ue_id`	Optional number. UE_ID.
`cell`	Optional number (only for PHY layer logs). Cell ID.
`rnti`	Optional number (only for PHY layer logs). RNTI.
`frame`	Optional number (only for PHY layer logs). Frame number (Subframe is decimal part).
`channel`	Optional string (only for PHY layer logs). Channel name.
`src`	String. Server name.
`idx`	Integer. Log index.
`headers`	Optional array. Array of strings.

discontinuity
> Optional number. If set, this means some logs have been discarded due to log buffer overflow.

microseconds
> Optional boolean. Present and set to true if `com_log_us` is set in configuration file.

log_set   Add log.
Message definition:

`log`	Optional string. Log message to add. If set, *layer* and *level* are mandatory.
`layer`	String. Layer name. Only mandatory if *log* is set.
`level`	String. Log level: *error*, *warn*, *info* or *debug*. Only mandatory if *log* is set.
`dir`	Optional string. Log direction: *UL*, *DL*, *FROM* or *TO*.
`ue_id`	Optional number. UE_ID.
`flush`	Optional boolean (default = false). If set, flushes fog file.
`rotate`	Optional boolean (default = false). If set, forces log file rotation.
`cut`	Optional boolean (default = false). If set, forces log file reset.

log_reset
> Resets logs buffer.

license   Retrieves license file information.
          Response definition:

          products   String. List of products, separated by commas.

          user   String. License username.

          validity   String. License end of validity date.

          id   Optional string. License ID.

          id_type   Optional string. License ID type. Can be `host_id` or `dongle_id`

          uid   Optional string. License unique ID.

          filename   Optional string. License filename.

          server   Optional string. License server URL.

          server_id
                     Optional string. License server ID.

quit   Terminates lteenb.

help   Provides list of available messages in *messages* array of strings and events to register
          in *events* array of strings.

stats   Report statistics for LTEENB.
          The statistics sampling time is defined by delay between two calls within the same
          connection.
          To get relevant statistics, you may let the WebSocket connected and call this API
          regularly.
          The sampling time for the first request is defined by `initial_delay` parameter.
          Message definition:

          samples   Optional boolean (default = false). Provide information similar to the
                     't spl' monitor command.

          rf   Optional boolean (default = false). Provide information similar to the
                     't cpu' monitor command.

          initial_delay
                     Optional number (default = 0.4). Only relevant for first call within a
                     WebSocket connection.
                     Defines the sampling time in seconds of the first call.
                     If set to 0, the first call won't report most of statistics.

          Response definition:

          cpu   Object. Each member name defines a type and its value cpu load in %
                     of one core.

          instance_id
                     Number. Constant over process lifetime. Changes on process restart.

          counters   Object. List of counters, with following sub members:

                     messages   Object. Each member name is the message name and its
                                value is its occurence.
                                To get list of message, type *cevent help msg* in LTEENB
                                monitor.

errors   Object. Each member name is the error name and its value is its occurence.
To get list of message, type *cevent help error* in LTEENB monitor.

cells   Object. Each member name is the cell ID and each value is an object representing statistics as follow:

dl_bitrate
> Number. Downlink bitrate in bits per seconds at PHY layer level (Counts acknowledged transmissions).

ul_bitrate
> Number. Uplink bitrate in bits per seconds at PHY layer level (Counts successful transmissions).

mbms_bitrate
> Number. eMBMS MTCH downlink RLC PDU bitrate in bits per seconds.

mbs_broadcast_bitrate
> Number. MBS broadcast MTCH downlink PHY bitrate in bits per seconds (accumulated on all SSBs).

dl_tx   Integer. Number of downlink transmitted transport blocks (without retransmissions).

ul_tx   Integer. Number of received uplink transport blocks (without CRC error).

dl_err   Integer. Number of downlink non transmitted transport blocks (after retransmissions).

ul_err   Integer. Number of non received uplink transport blocks (after retransmissions).

dl_retx   Integer. Number of downlink retransmitted transport blocks.

ul_retx   Integer. Number of received uplink transport blocks with CRC errors.

dl_sched_users_min
> Number. Minimum downlink scheduled users per TTI. Note that in NB-IoT cells, a factor 1000 is applied.

dl_sched_users_avg
> Number. Average downlink scheduled users per TTI. Note that in NB-IoT cells, a factor 1000 is applied.

dl_sched_users_max
> Number. Maximum downlink scheduled users per TTI. Note that in NB-IoT cells, a factor 1000 is applied.

ul_sched_users_min
> Number. Minimum uplink scheduled users per TTI. Note that in NB-IoT cells, a factor 1000 is applied.

ul_sched_users_avg
> Number. Average uplink scheduled users per TTI. Note that in NB-IoT cells, a factor 1000 is applied.

`ul_sched_users_max`

>Number. Maximum uplink scheduled users per TTI. Note that in NB-IoT cells, a factor 1000 is applied.

`dl_use_min`

>Number between 0 and 1. Minimum downlink usage ratio, based on number of allocated resource blocks.

`dl_use_avg`

>Number between 0 and 1. Average downlink usage ratio, based on number of allocated resource blocks.

`dl_use_max`

>Number between 0 and 1. Maximum downlink usage ratio, based on number of allocated resource blocks.

`ul_use_min`

>Number between 0 and 1. Minimum uplink usage ratio, based on number of allocated resource blocks.

`ul_use_avg`

>Number between 0 and 1. Average uplink usage ratio, based on number of allocated resource blocks.

`ul_use_max`

>Number between 0 and 1. Maximum uplink usage ratio, based on number of allocated resource blocks.

`ctrl_use_min`

>Number between 0 and 1. Minimum control usage ratio, based on number of used CCE.

`ctrl_use_avg`

>Number between 0 and 1. Average control usage ratio, based on number of used CCE.

`ctrl_use_max`

>Number between 0 and 1. Maximum control usage ratio, based on number of used CCE.

`ue_count_min`

>Integer. Minimum number of UE contexts.

`ue_count_max`

>Integer. Maximum number of UE contexts.

`ue_count_avg`

>Integer. Average number of UE contexts.

`ue_active_count_min`

>Integer. Minimum number of active UE contexts. Active RRC state is when all UE resources are still allocated.

`ue_active_count_max`

>Integer. Maximum number of active UE contexts.

`ue_active_count_avg`

>Integer. Average number of active UE contexts.

`ue_inactive_count_min`

>Integer. Minimum number of inactive UE contexts. Inactive RRC state is when all UE resources are freed but the UE data is stil kept.

ue_inactive_count_max

Integer. Maximum number of inactive UE contexts.

ue_inactive_count_avg

Integer. Average number of inactive UE contexts.

erab_count_min

Integer. Minimum number of established radio bearer. Applicable to LTE or NB-IoT cells.

erab_count_max

Integer. Maximum number of established radio bearer. Applicable to LTE or NB-IoT cells.

erab_count_avg

Integer. Average number of established radio bearer. Applicable to LTE or NB-IoT cells.

drb_count_max

Integer. Minimum number of established radio bearer. Applicable to NR cells.

drb_count_max

Integer. Maximum number of established radio bearer. Applicable to NR cells.

drb_count_max

Integer. Average number of established radio bearer. Applicable to NR cells.

dl_gbr_use_min

Optional number. Minimum downlink GBR usage ratio. Not present for NB-IoT cells.

dl_gbr_use_avg

Optional number. Average downlink GBR usage ratio. Not present for NB-IoT cells.

dl_gbr_use_max

Optional number. Maximum downlink GBR usage ratio. Not present for NB-IoT cells.

ul_gbr_use_min

Optional number. Minimum uplink GBR usage ratio. Not present for NB-IoT cells.

ul_gbr_use_avg

Optional number. Average uplink GBR usage ratio. Not present for NB-IoT cells.

ul_gbr_use_max

Optional number. Maximum uplink GBR usage ratio. Not present for NB-IoT cells.

counters   Object. List of counters, with following sub members:

messages   Object. Each member name is the message name and its value is its occurence.

To get list of message, type *cevent help msg* in LTEENB monitor.

errors   Object. Each member name is the error name and its value is its occurence.

To get list of message, type *cevent help error* in LTEENB monitor.

gtp_tx_bitrate

Optional number. This field will be filled when multiple calls on the same socket are done and represents the GTP payload bitrate (bits/seconds) sent to core network and is equivalent to IP traffic.

The bitrate is computed using the delay between two calls.

gtp_rx_bitrate

Optional number. This field will be filled when multiple calls on the same socket are done and represents the GTP payload bitrate (bits/seconds) received from core network and is equivalent to IP traffic. It does not include MBMS traffic.

The bitrate is computed using the delay between two calls.

rf_ports Object. Each member name is the RF port ID and each value is an object representing the TX-RX latency statistics (average, max and min values).

samples Object. Set if `samples` has been set to true in request.

This object has the following properties:

tx   Array of objects. Each object represents samples statistics of the antenna port.

rms   Number. RMS of the signal in dBFS

max   Number. Maximum sample value in dBFS

sat   Number. Number of saturation events

count Number of IQ samples analyzed

rms_dbm Number. RMS of the signal in dBm

rx   Array of objects. Each object represents samples statistics of the antenna port.

rms   Number. RMS of the signal in dBFS

max   Number. Maximum sample value in dBFS

sat   Number. Number of saturation events

count Number of IQ samples analyzed

rms_db Number. RMS of the signal in dBm.

duration Number. Time elapsed in seconds since the last call to the `stats` API. Equals to `initial_delay` on first call.

register Register client for messages generated by LTEENB. Message definition:

register Optional string or array of string. List of messages to register to.

Can be `ue_measurement_report`, `srs`, `pusch`, `npusch`, `carrier_sense`.

unregister

Optional string or array of string. List of messages to unregister.

Can be `ue_measurement_report`, `srs`, `pusch`, `npusch`, `carrier_sense`.

10.6 LTE messages

ue_get   Get ue list.
            Message definition:

    ue_id   Optional integer. If set, will filter on UE_ID.

    stats   Optional boolean (default is false). If true, will display stats for each cell

    Response definition:

    ue_list   Array of object, representing current connected UEs.
            Each element has following definition:

        time   Time in seconds since eNB starting.

        enb_ue_id
            Optional integer. eNB UE id. Present for LTE or NB-IoT UEs.

        ran_ue_id
            Optional integer. RAN UE id. Present for NR UEs.

        mme_ue_id
            Optional integer. MME UE id. It is present when the UE-associated logical S1-connection is setup.

        amf_ue_id
            Optional integer. AMF UE id. It is present when the UE-associated logical NG-connection is setup.

        linked_enb_ue_id
            Optional integer. eNB UE id associated with the current NR UE for NSA.

        linked_ran_ue_id
            Optional integer. RAN UE id associated with the current LTE UE for NSA.

        catm   Optional boolean. True for Cat-M1 UEs, absent otherwise.

        redcap   Optional boolean. True for RedCap UEs, absent otherwise.

        eredcap   Optional boolean. True for eRedCap UEs, absent otherwise.

        rnti   Integer. RNTI.

        cells   Array of object. Each object represent a cell.
            First entry is primary cell.
            Only *cell_id* is displayed for each cell unless *stats* is set to true.

            cell_id   Number. Cell ID.

            cqi   Number. Last reported cqi.

            ri   Number. Last reported rank indicator.

            ul_rank   Optional number. Last uplink rank computed by the gNB in NR cells.

dl_bitrate

Number. Downlink bitrate in bits per seconds at PHY layer level (Counts acknowledged transmissions).

ul_bitrate

Number. Uplink bitrate in bits per seconds at PHY layer level (Counts successful transmissions).

dl_tx   Integer. Number of downlink transmitted transport blocks (without retransmissions).

ul_tx   Integer. Number of received uplink transport blocks (without CRC error).

dl_err   Integer. Number of downlink non transmitted transport blocks (after retransmissions).

ul_err   Integer. Number of non received uplink transport blocks (after retransmissions).

dl_retx   Integer. Number of downlink retransmitted transport blocks.

ul_retx   Integer. Number of received uplink transport blocks with CRC errors.

dl_mcs   Number. Average downlink MCS.

ul_mcs   Number. Average uplink MCS.

ul_n_layer

Number. Average number of uplink layers.

ue_dl_bwp_id

Optional number. Current active UE DL BWP Id in RRC signalling (NR cells only).

dl_bwp_id

Optional number. Current active UE DL BWP Id in cell configuration object (NR cells only).

ue_ul_bwp_id

Optional number. Current active UE UL BWP Id in RRC signalling (NR cells only).

ul_bwp_id

Optional number. Current active UE UL BWP Id in cell configuration object (NR cells only).

turbo_decoder_min

Optional number. Minimum turbo/ldpc decoder pass.

turbo_decoder_avg

Optional number. Average turbo/ldpc decoder pass.

turbo_decoder_max

Optional number. Maximum turbo/ldpc decoder pass.

pucch1_snr

>Optional number. PUCCH snr.

pusch_snr

>Optional number. Last received PUSCH snr.

epre   Optional number. Last received EPRE in dBm.

ul_phr   Optional number. Last received power head-
           room report. To retrieve the value in dB, refer
           to 3GPP TS 36.133 table 9.1.8.4.

ul_path_loss

>Optional number. Last computed UL path loss
>in dB, estimated from PHR.

p_ue   Optional number. UE transmission power in
           dB, estimated from PHR and Pmax set in the
           cell and reported by UE.

initial_ta

>Optional number. Last timing advance mea-
>sured with PRACH, expressed in unit of TA.

erabs   Array of object. Set for LTE and NB-IoT UEs. Each object
           represent a radio bearer with the following properties:

erab_id   Number. Radio bearer ID.

qci   Number. Radio beader QCI.

dl_total_bytes

>Integer. Total downlink PDCP SDU byte
>count.

ul_total_bytes

>Integer. Total uplink PDCP SDU byte count.

qos_flows

>Array of object. Set for NR UEs. Each object represent a
>QoS flow with the following properties:

pdu_session_id

>Integer. PDU session ID.

sst   Integer. Slice Service Type.

dl_total_bytes

>Integer. Total downlink PDCP SDU byte
>count.

ul_total_bytes

>Integer. Total uplink PDCP SDU byte count.

erab_get   Get EPS radio bearer list.
           Response definition:

timestamp

>Integer. Timestamp in milliseconds.

erab_list
> Array of object, representing radio bearers.
> Each element has following definition:
>
> **enb_ue_id**
>> Integer. eNB UE id.
>
> **erab_id**   Integer. Radio bearer ID.
>
> **qci**   Integer. Bearer QCI.
>
> **dl_mbr**   Optional integer. Downlink maximum bitrate (only if erab is GBR).
>
> **dl_gbr**   Optional integer. Downlink guaranteed bitrate (only if erab is GBR).
>
> **dl_gbr_re**
>> Optional integer. Downlink GBR per RE per second (only if erab is GBR).
>
> **ul_mbr**   Optional integer. Uplink maximum bitrate (only if erab is GBR).
>
> **ul_gbr**   Optional integer. Uplink guaranteed bitrate (only if erab is GBR).
>
> **ul_gbr_re**
>> Optional integer. Uplink GBR per RE per second (only if erab is GBR).
>
> **dl_total_bytes**
>> Integer. Total downlink PDCP SDU byte count.
>
> **ul_total_bytes**
>> Integer. Total uplink PDCP SDU byte count.

qos_flow_get
> Get 5GS radio bearer list.
> Response definition:
>
> **timestamp**
>> Integer. Timestamp in milliseconds.
>
> **qos_flow_list**
>> Array of object, representing radio bearers.
>> Each element has following definition:
>>
>> **ran_ue_id**
>>> Integer. RAN UE id.
>>
>> **pdu_session_id**
>>> Integer. PDU session ID.
>>
>> **sst**   Integer. Slice Service Type.
>>
>> **sd**   Optional integer. Slice Differentiator.
>>
>> **qfi_list**   Array of objects. List of QoS Flows associated with this bearer.
>>> Each object contains the following entries:
>>>
>>> **qfi**   Integer. QoS Flow ID.

	5qi	Integer. 5QI.
	dl_mbr	Optional integer. Downlink maximum bitrate (only if QoS Flow is GBR).
	dl_gbr	Optional integer. Downlink guaranteed bitrate (only if QoS Flow is GBR).
	ul_mbr	Optional integer. Uplink maximum bitrate (only if QoS Flow is GBR).
	ul_gbr	Optional integer. Uplink guaranteed bitrate (only if QoS Flow is GBR).

dl_total_bytes
> Integer. Total downlink PDCP SDU byte count.

ul_total_bytes
> Integer. Total uplink PDCP SDU byte count.

cell_gain

> Set cell DL RF signal gain. See [cell_gain], page 299.
> Message definition:

cell_id   Integer. Cell ID.

gain   Float. Gain in dB. Must be between -200 and 0 (included).

rf   Set radio frontend channels gain.
            Message definition:

tx_gain   Optional number or array of numbers. Set TX gain.
            Same definition as the [tx_gain], page 34, property.

tx_channel_index
> Optional number. If set, apply gain to specified channel only.

rx_gain   Optional number or array of numbers. Set RX gain.
            Same definition as the [rx_gain], page 34, property.

rx_channel_index
> Optional number. If set, apply gain to specified channel only.

Response definition:

tx_gain   Array. List of TX gain per channel.

rx_gain   Array. List of RX gain per channel.

rf_info   Optional string. RF driver information (depends on radio frontend).

trx_iq_dump

> Dump baseband IQ samples (time domain) to files.
> The IQ samples are stored as little endian 32 bit floating point numbers.
> Real and imaginary part are interleaved: the real part (I) is written first, the imaginary one (Q) next:
> I(0) [0 ... 31]
> Q(0) [32 ... 63]
> I(1) [64 ... 95]
> Q(1) [96 ... 127]
> ...
> I(n) [n*64 ... n*64+31]

Q(n) `[n*64+32 ... n*64+63]`

Message definition:

duration   Optional value (default = 1s, max = 30s). Sets dump duration in milliseconds.

rf_port   Optional integer or array of integer. If set, dump only the related RF port channels.

rx_filename

Optional string. If set defines the file where the received IQ samples will be dumped.

May contain *%d* to differentiate antenna streams (printf style).

If not set, no RX data will be dumped.

tx_filename

Optional string. If set defines the file where the transmitted IQ samples will be dumped.

May contain *%d* to differentiate antenna streams (printf style).

If not set, no TX data will be dumped.

rx_channels

Optional array of integer. Selects channel to dump. Each integer represents the global index of the channel.

tx_channels

Optional array of integer. Selects channel to dump. Each integer represents the global index of the channel.

rx_header

Optional boolean (Default = false). Set the dump mode.

If not set, only the IQ samples are written to the files. If set, add a header for each TRX read or write operation. It is followed by the corresponding IQ samples.

Header:

timestamp

64 bit TRX timestamp, in samples.

count   32 bit integer: number of following IQ samples before next header.

tx_header

Optional boolean (Default = false). Same as *rx_header* for TX.

Notification:
As IQ dump initialization may take some time (Memory allocation, file creation...), dumping of IQs may start some time before the command is being executed.
A notification message is sent when the IQ dump is really starting. You can base on its `time` parameter to synchronize any subsequent message.
Its notification property is `started`.

Message response:

dump_utc   Integer. UTC time in milliseconds of the capture start

rf_ports   Array of object representing information on each rf port capture. Defined as follow:

> sample_rate
>> Integer. IQ sample rate in samples per seconds
>
> index   Integer. RF port index
>
> timestamp
>> Integer. Timestamp (in IQ sample) associated with `frame`/`slot` start.
>
> frame   Integer. Frame number of slot starting at `timestamp`
>
> slot   Integer. Slot number of slot starting at `timestamp`
>
> mu   Integer. Subcarrier spacing (0, 1...)
>
> rx_files   Array of string representing IQ files for RX.
>
> tx_files   Array of string representing IQ files for TX.
>
> rx_overflows
>> Optional integer. Number of RX lost data during catpure process
>
> tx_overflows
>> Optional integer. Number of TX lost data during catpure process
>
> rx_timestamp0
>> Integer. If `rx_header` mode not set, timestamp of first IQ sample in RX files.
>
> tx_timestamp0
>> Integer. If `tx_header` mode not set, timestamp of first IQ sample in TX files.

cell_ul_disable
>Enable/disable UL on cell.
>Message definition:
>
>cell_id   Integer. Cell ID.
>
>disabled   Boolean. Set state

handover   Triggers a handover.
Message definition:

> ran_ue_id
>> Integer. eNB or RAN UE id.
>
> pci   Integer. Physical Cell ID.
>
> dl_earfcn
>> Optional integer. If set look for cell with this EARFCN, else use LTE UE current EARFCN.
>
> ssb_nr_arfcn
>> Optional integer. If set look for cell with this SSB NR-ARFCN, else use NR UE current SSB NR-ARFCN.

type   Optional string. Can be `auto` (default), `intra`, `s1`, `x2`, `xn`, `ng`.
For an EPS to 5GS handover, the type parameter must be present and set to `s1`. For a 5GS to EPS handover, the type parameter must be present and set to `ng`.

rrc_cnx_release

Forces a RRC Connection release.
Message definition:

ran_ue_id

Integer. eNB or RAN UE id.

redirect   Optional integer. If set, defines RRC redirection index (See [rrc_redirect], page 83).

redirected_carrier_info

Optional [ASN.1 property], page 29. ASN.1 content of a Redirected-CarrierInfo, RedirectedCarrierInfo-v9e0 or RedirectedCarrierInfo-NB-r13 redirection information.

redirected_carrier_info_nb_v1430

Optional [ASN.1 property], page 29. ASN.1 content of a RedirectedCarrierInfo-NB-v1430 redirection information. Only applicable if `redirected_carrier_info` contains a RedirectedCarrierInfo-NB-r13 redirection information.

idle_mode_mobility_control

Optional [IdleModeMobilityControlInfo], page 85.

cell_reselection_priorities

Optional [ASN.1 property], page 29. ASN.1 content of a CellReselectionPriorities information.

suspend   Optional boolean (default = false). If true, and if the UE is suitable for RRC inactive mode, RRC connection will be suspended instead of released (See [rrc_inactive], page 159).

mps_priority_indication

Optional boolean (default = false). If true, if the `redirected_carrier_info` is present and if the UE supports the feature, the mpsPriorityIndication-r16 flag is sent in the release message.

rrc_ue_info_req

Sends a UE Information Request message.
Message definition:

enb_ue_id

Integer. eNB or RAN UE id.

req_mask   Integer. Bitmap of the information to request (bits: 0:RACH, 1:RLF, 2:LogMeas, 3:ConnEst, 4:MobHist, 5:IdleModeMeas, 6:ANR, 7:CoarseLocation, 8:SuccessHO-Report).
RACH: applicable to LTE, NB-IoT and NR UEs.
RLF: applicable to LTE, NB-IoT and NR UEs.
LogMeas: applicable to LTE and NR UEs.
ConnEst: applicable to LTE and NR UEs.
MobHist: applicable to LTE and NR UEs.
IdleModeMeas: applicable to LTE and NR UEs.
ANR: applicable to NB-IoT UEs.

CoarseLocation: applicable to LTE and NR UEs.

SuccessHO-Report: applicable to NR UEs.

`rrc_logged_meas_config`

Sends a Logged Measurement Configuration message.

Message definition:

`ran_ue_id`

Integer. eNB or RAN UE id.

`trace_reference`

Object. Trace Reference as specified in 3GPP TS 32.422. It contains the following fields:

`plmn`   String. PLMN.

`trace_id` Integer. Trace Identifier.

`trace_recording_session_ref`

Integer. Trace Recording Session Reference as specified in 3GPP TS 32.422.

`tce_id`   Integer. Trace Collection Entity Id as specified in 3GPP TS 32.422.

`logging_duration`

Enumeration (10, 20, 40, 60, 90, 120). Logging duration in minutes.

`logging_interval`

Enumeration (LTE cells: 1280, 2560, 5120, 10240, 20480, 30720, 40960, 61440; NR cells: 320, 640, 1280, 2560, 5120, 10240, 20480, 30720, 40960, 61440, 0). Loggin interval in milliseconds. 0 means infinity.

`type`   Enumeration (periodical, out_of_coverage, l1). Report type.

`rsrp_threshold`

Optional Integer. RSRP threshold for l1 report type.

`rsrq_threshold`

Optional Integer. RSRQ threshold for l1 report type.

`sinr_threshold`

Optional Integer. SINR threshold for l1 report type. Only applicable to NR cells.

`hysteresis`

Optional Integer. Hysteresis for l1 report type.

`time_to_trigger`

Optional Integer. Time to trigger for l1 report type.

`early_meas_indication`

Optional boolean (default = false). Log measurements on early measurement related frequencies. Only applicable to NR cells.

`rrc_ue_cap_enquiry`

Sends a UE Capability Enquiry message.

Message definition:

`ran_ue_id`

Integer. eNB or RAN UE id.

`payload`   Optional boolean. Adds the UL DCCH payload dump in hexadecimal to the response.

text   Optional boolean. Adds the UL DCCH payload decoding in text to the response.

Response definition:

`ran_ue_id`
            Integer. eNB or RAN UE id.

`payload`   Optional string. UL DCCH payload dump in hexadecimal.

`text`   Optional string. UL DCCH payload decoding in text.

`rrc_cnx_reconf`
Sends a RRC Connection reconfiguration.
Message definition:

`enb_ue_id`
            Integer. eNB or RAN UE id.

`eutra_secondary_cell_list`
            Optional array of objects. Objects are the same type than the one included in the `scell_list` of a LTE cell, see [scell_list], page 85. The array shall contain a subset of the objects defined in the `scell_list` of the UE's PCell. The `rrc_configuration`, `individual_offset` and `a6_candidates` fields are unused in this case. An empty list releases all the secondary cells.

`nr_secondary_cell_list`
            Optional array of objects. Objects are the same type than the one included in the `scell_list` of a NR cell, see [scell_list_nr], page 151. The array shall contain a subset of the objects defined in the `scell_list` of the UE's PCell (in SA) or PSCell (in MR-DC). The `rrc_configuration`, `individual_offset` and `a6_candidates` fields are unused in this case. An empty list releases all the secondary cells.
            A single API call cannot contain both `eutra_secondary_cell_list` and `nr_secondary_cell_list` parameters.

`reconf_pucch_srs`
            Optional boolean, LTE only. If set to true, forces a reconfiguration of the PUCCH (CSI, SR) and SRS parameters for all the LTE serving cells. A single API call cannot contain both `reconf_pucch_srs` and `eutra_secondary_cell_list`.

`dl_bwp_id`
`ul_bwp_id`
            Optional integers (default = -1), NR only. If provided, initiates a RRC BWP switch for the SA PCell or EN-DC PSCell. -1 indicates to keep the current BWP. These properties cannot be combined with the `eutra_secondary_cell_list` or `nr_secondary_cell_list` properties.
            BWP switch in SA mode on the PCell requires that `allow_rrc_bwp_switch` is set to true and that BWP constraints are respected.

`bwp_scell_id`
            Optional integer (default = -1), NR only. Can be used along with `dl/ul_bwp_id` to specify the cell id of the SCell on which the BWP switch is performed. When absent or set to -1, BWP switch is performed on PCell.

cell_group

> Optional enumeration (master or secondary). Defines for which cell group the RRC reconfiguration is.

rlc_drop_rate

> Defines a percentage of uplink RLC PDUs dropped. Note that in case of handover or reestablishment, the drop rate is reset to 0.
> Message definition:

ran_ue_id

> Integer. eNB or RAN UE id.

rb_id   Integer. Bearer identity.

srb   Boolean. Indicates if the bearer is for signalling or data.

percentage

> Integer (range 0 to 100). Drop percentage.

pdcch_order_prach

> Sends a PDCCH order for PRACH to the UE. Supported for all UE types except BR UEs.
> Message definition:

enb_ue_id

> Integer. S1AP eNB UE id or NGAP RAN UE id.

dci_bwp_switch

> Initiate a BWP switch thru DCI 0_1 or 1_1.
> Message definition:

enb_ue_id

> Integer. eNB (NSA) or RAN (SA) UE id.

dl_bwp_id
ul_bwp_id

> Optional integers. Either `dl_bwp_id` or `ul_bwp_id` must be set. If `dl_bwp_id` is provided, a DL BWP switch is initiated thru DCI 1_1. If `ul_bwp_id` is provided, a UL BWP switch is initiated thru DCI 0_1. DL BWP switch thru DCI 1_1 is experimental and requires the configuration of `bwp_switch_k0`. In TDD, both DL and UL BWPs are switched at the same time so it is recommended to switch BWPs thru DCI 0_1.

scell_id   Optional integer. Cell id of the SCell on which BWP switch should be triggered. If absent or set to -1, the BWP switch is performed on PCell.

x2   Get X2 peers state.
Response definition:

peers   Array of object. One for each peer.
            Each element has the following definition:

state   String. Can be `connecting`, `connected` or `setup_done`.

addr   String. Address of peer

cells   Array of object. One for each cell. Each element has the following definition:

cell_id   Integer. Cell ID.

tac   Integer. TAC.

| | dl_earfcn | | Integer. Downlink cell EARFCN. |
| | pci | | Integer. Physical Cell ID |

x2connect
Forces connection to a X2 peer.
Message definition

    addr   String. X2 peer address.

x2disconnect
Forces disconnection from a X2 peer.
Message definition

    addr   String. X2 peer address.

s1   Get MME link state.
Response definition:

    s1_list   Array of object. One for each MME connection defined as follow:

        state   Link state: *disconnected*, *connecting*, *connected*, *inactive* or *setup_done*.

        address   MME address.

        name   Optional MME name.

        PLMN   If connection complete, PLMN.

s1connect
Forces connection to a MME.
Message definition

    address   Optional string. If not set, will try to connect to all registered MME, else will try with the specified address.

s1disconnect
Forces disconnection from a MME.
Message definition

    address   Optional string. If not set, will to disconnect from all registered MME, else will try with the specified address.

s1add   Adds a new MME to the list of S1AP connections.
Message definition
The message must contain the same parameters as one of the object defined in mme_list array. See [mme_list], page 31.

s1delete Removes a MME address from the list of S1AP connections.
Message definition

    addr   String. MME address to be removed from the list.

xn   Get Xn peers state.
Response definition:

    peers   Array of object. One for each peer.
Each element has the following definition:

        ng_enb   Optional boolean. If the Xn connection is for a ng-eNB, the boolean is present and set to true.

	state	String. Can be `connecting`, `connected` or `setup_done`.
	addr	String. Address of peer
	cells	Array of object. One for each cell. Each element has the following definition:

	cell_id	Integer. Cell ID.
	tac	Integer. TAC.
	ssb_nr_arfcn	Integer. SSB NR ARFCN.
	pci	Integer. Physical Cell ID

xnconnect

Forces connection to a Xn peer.
Message definition

addr   String. Xn peer address.

xndisconnect

Forces disconnection from a Xn peer.
Message definition

addr   String. Xn peer address.

ng   Get AMF link state.
Response definition:

ng_list   Array of object. One for each AMF connection defined as follow:

	ng_enb	Optional boolean. If the NG connection is for a ng-eNB, the boolean is present and set to true.
	state	Link state: *disconnected*, *connecting*, *connected*, *inactive* or *setup_done*.
	address	AMF address.
	name	AMF name.
	PLMN	If connection complete, PLMN.

ngconnect

Forces connection to an AMF.
Message definition

address   Optional string. If not set, will try to connect to all registered AMF, else will try with the specified address.

ngdisconnect

Forces disconnection from an AMF.
Message definition

address   Optional string. If not set, will to disconnect from all registered AMF, else will try with the specified address.

ngadd   Adds a new AMF to the list of NGAP connections.
Message definition
The message must contain the same parameters as one of the object defined in amf_list array. See [amf_list], page 32.

ngdelete   Removes a AMF address from the list of NGAP connections.
           Message definition

           addr   String. AMF address to be removed from the list.

m2   Get M2AP link state.
           Response definition:

           state   Link state: *disconnected*, *waiting*, *connecting*, *connected*.

           address   MBMSGW address.

m2connect
           Forces connection to a MBMSGW.
           Message definition

           addr   Optional string. If not set, the eNB will try to connect to the previously
                       configured address.

m2disconnect
           Releases connection to a MBMSGW.

sib_set   Modify SIB content and advertise BCCH system information modification in paging
           messages.
           Message definition

           cells   Object used to configure cells individually. Each cell configured must
                       be a new object inside cells object, named with the cell_id value and
                       containing the following fields:

                       sib1   Optional object used to modify SIB 1. It can contain the
                                   following fields:

                                   cell_barred
                                               Optional boolean or string (true, false or
                                               "auto"). Indicates if the cell should be barred
                                               or not. If set to "auto", the cell is barred when
                                               there is no connection with a core network for
                                               any of the PLMNs broadcast. Only applicable
                                               to LTE or NB-IoT cells. For NR cells, see
                                               config_set remote API.

                                   reserved   Optional array of booleans. Allows to config-
                                               ure if the cell is reserved for operator use. The
                                               array must contain as many entries as the num-
                                               ber of PLMN-IdentityList configured in EU-
                                               TRA and NB-IoT cells, or the number of plmn-
                                               IdentityInfoList configured in NR cells.

                                   reserved_5gc
                                               Optional array of booleans. Allows to configure
                                               if the cell is reserved for operator use. The array
                                               must contain as many entries as the number of
                                               PLMN configured in EUTRA and NB-IoT cells
                                               connected to a 5GC.

                                   p_max   Optional integer or array of integers. New p-
                                               Max value.

timers_and_constants
> Optional object. See [timers_and_constants],
> page 132. Only applicable to NR cells.

uac_barring_info
> Optional object. See [uac_barring_info],
> page 131. Only applicable to NR cells.
> `info_set_list, for_common_list` and
> `per_plmn_list` are optional. When not
> present, the corresponding element is not
> modified. When present, the whole element is
> replaced. It is up to the user to make sure
> that the configuration is valid at any time.
> Setting the `info_set_list` to en empty array
> `[ ]` will release the whole UAC barring info
> configuration.

ss_pbch_block_power
> Optional integer (range -60 to 50) or string
> "auto". Only applicable to NR cells.
> If set to integer, forces `manual_ref_signal_`
> `power` to true.
> If set to "auto", forces `manual_ref_signal_`
> `power` to true and value will be taken from TRX
> driver.

ims_emergency_support
> Optional boolean. IMS emergency support.
> Only applicable to LTE and NR cells.

ecall_over_ims_support
> Optional boolean. eCall over IMS support.
> Only applicable to LTE and NR cells.

conn_est_failure_control
> Optional object. See [conn_est_failure_control],
> page 133. Only applicable to NR cells. To
> stop transmitting connEstFailureControl, send
> an empty conn_est_failure_control object.

use_full_resume_id
> Optional boolean. Sets the useFullResumeId
> flag. Only applicable to NR cells where `rrc_`
> `inactive` configuration object is defined.

sib2   Optional object used to modify SIB 2. It can contain the
following fields:

barring_info
> Optional object allowing to configure the ac-
> cess class barring related fields. If one the field
> below is not present, the corresponding field is
> removed from SIB2. Only applicable to LTE
> cells.

> ac_BarringForEmergency
> > Optional boolean.

ac_BarringForMO_Signalling

>Optional object. It contains the following fields:

>>ac_BarringFactor

>>>Enumeration: 0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 90, 95. Access barring factor in percentage.

>>ac_BarringTime

>>>Enumeration: 4, 8, 16, 32, 64, 128, 256, 512. Access barring time in seconds.

>>ac_BarringForSpecialAC

>>>String. Bit string for AC 11-15.

ac_BarringForMO_Data

>Optional object. It contains the same fields as ac_BarringForMO_Signalling. Only applicable to LTE cells.

ssac_BarringForMMTEL_Voice_r9

>Optional object. It contains the same fields as ac_BarringForMO_Signalling. Only applicable to LTE cells.

ssac_BarringForMMTEL_Video_r9

>Optional object. It contains the same fields as ac_BarringForMO_Signalling. Only applicable to LTE cells.

ac_BarringForCSFB_r10

>Optional object. It contains the same fields as ac_BarringForMO_Signalling. Only applicable to LTE cells.

ac_BarringSkipForMMTELVoice_r12

>Optional boolean. Only applicable to LTE cells.

ac_BarringSkipForMMTELVideo_r12

>Optional boolean. Only applicable to LTE cells.

ac_BarringSkipForSMS_r12

>Optional boolean. Only applicable to LTE cells.

reference_signal_power

>Optional integer (range -60 to 50) or string "auto". Only applicable to LTE cells. If set to integer, forces manual_ref_signal_power to true.

If set to "auto", forces `manual_ref_signal_power` to true and value will be taken from TRX driver.

`cp_Reestablishment_r14`
Optional boolean. Only applicable to NB-IoT cells.

`nrs_power_r13`
Optional integer (range -60 to 50) or string "auto". Only applicable to NB-IoT cells. If set to integer, forces `manual_ref_signal_power` to true.
If set to "auto", forces `manual_ref_signal_power` to true and value will be taken from TRX driver.

`type`   Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter. Only applicable to NR cells.

`payload` Optional string or object. NR SIB2 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter. Only applicable to NR cells.

`sib3`   Optional object used to modify SIB 3.

`type`   Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter.

`payload` Optional string or object. EU-TRA SystemInformationBlockType3, SystemInformationBlockType3-NB-r13 or NR SIB3 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter.

tech-academy tutorial : Changing the payload(whole contents) of a SIB3 (`https://tech-academy.amarisoft.com/RemoteAPI_SIB.html#Test_2`).

`sib4`   Optional object used to modify SIB 4.

`type`   Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter.

`payload` Optional string or object. EU-TRA SystemInformationBlockType4, SystemInformationBlockType4-NB-r13 or NR SIB4 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter.

sib5 Optional object used to modify SIB 5.

    type   Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter.

    payload   Optional string or object. EUTRA SystemInformationBlockType5, SystemInformationBlockType5-NB-r13 or NR SIB5 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter.

sib6 Optional object used to modify SIB 6.

    type   Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter.

    payload   Optional string or object. EUTRA SystemInformationBlockType6 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter. Only applicable to LTE cells.

sib7 Optional object used to modify SIB 7.

    type   Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter.

    payload   Optional string or object. EUTRA SystemInformationBlockType7 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter. Only applicable to LTE cells.

sib14 Optional object used to modify SIB 14. For NB-IoT cells, dynamic SIB scheduling is not supported so SIB14-NB must be present in the initial configuration, even if empty.
It can contain the following fields:

    enabled   Boolean. If set to true, SIB14 is scheduled.

    si_periodicity
        Optional enumeration: 8, 16, 32, 64, 128, 256, 512 for LTE cells. Not supported for NB-IoT cells. Sets the periodicity (in frames) of the transmission of SIB 14. Required for LTE cells if `enabled` is set to true.

    config   Optional object or array of object.
If `config` is an object, SIB14 contains a common AB configuration.
If `config` is an array, SIB14 contains a per PLMN AB configuration and you must define

as many objects as the number of PLMNs defined in SIB1.

Each object contains the following fields (see 3GPP TS 36.331 for details):

category   Enumeration: "a", "b", or "c".

barring_bitmap
        String. Bit string of 10 bits.

barring_for_exception_data
        Optional boolean. Only used for NB-IoT cells.

barring_for_special_ac
        Optional string. Bit string of 5 bits, mandatory for NB-IoT cells.

eab_per_rsrp
        Optional integer in range 0-3 (see eab-PerRSRP-r15 in 3GPP TS 36.331).

uac_config
        Optional object or array of object. Only applicable to NB-IoT cells.

        If `uac_config` is an object, SIB14 contains an UAC common configuration.

        If `uac_config` is an array, SIB14 contains an UAC per PLMN configuration and you must define as many objects as the number of 5GC PLMNs defined in SIB1.

        Each object contains the following fields (see 3GPP TS 36.331 for details):

        barring_per_cat_list
                Optional array of objects. Each object contains the following fields:

                access_category
                        Integer (range 1 to 63). uac-accessCategory-r16 value.

                barring_factor
                        Enumeration: 0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 90, 95. uac-BarringFactor-r16 value.

                barring_time
                        Enumeration: 4, 8, 16, 32, 64, 128, 256, 512. uac-BarringTime-r16 value.

	barring_for_access_id		
			String. Bit string of 7 bits. uac-BarringForAccessIdentity-r16 value.

sib24	Optional object used to modify SIB 24.		
	type		Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter.
	payload		Optional string or object. EUTRA SystemInformationBlockType24-r15 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter. Only applicable to LTE cells.

sib25   Optional object used to modify SIB 25. See [sib25], page 52. `info_set_list`, `for_common_list` and `per_plmn_list` are optional. When not present, the corresponding element is not modified. When present, the whole element is replaced. It is up to the user to make sure that the configuration is valid at any time.

Setting the `info_set_list` to en empty array `[ ]` will release the whole UAC barring info configuration.

sib27	Optional object used to modify SIB 27.		
	type		Optional enumeration (gser, hex or jer). Defines the format of the `payload` parameter.
	payload		Optional string or object. EUTRA SystemInformationBlockType27-r16 or SystemInformationBlockType27-NB-r16 ASN.1 description either in GSER format (string), hexadecimal representation of the unaligned PER encoding (string) or JER format (object) according to the `type` parameter. Only applicable to LTE or NB-IoT cells.

page_ue   Sends a paging message for a UE in RRC idle state on a list of cells.
Message definition

type   Enumeration ("normal", "cat0", "ce", "nb-iot" or "nr"). Defines the type of UE to be paged.

cn_domain
    Optional enumeration ("cs" or "ps"). Not required for NB-IoT or NR UEs.

imsi   Optional string. IMSI of the UE to be paged. Not required for NR UEs.

s-tmsi   Optional object. S-TMSI to be used for the paging identity. If the object is not present, the UE is paged by its IMSI. Not required for UEs registered to 5GC.
    The object must contain the following fields:

    mmec   Integer.

m-tmsi   Integer.

5g-s-tmsi

Optional objet. 5G-S-TMSI to be used for the paging identity. Not required for UEs registered to EPC.
The object must contain the following fields:

amf_set_id
              Integer. 10 bits length.

amf_pointer
              Integer. 6 bits length.

5g-tmsi   Integer. 32 bits length.

edrx   Optional object. eDRX configuration for the UE.
              The object must contain the following fields:

edrx_cycle
              Enumeration. eDRX cycle in hyper frames.
              For an EUTRA UE, the allowed values are hfhalf, hf1, hf2, hf4, hf6, hf8, hf10, hf12, hf14, hf16, hf32, hf64 and hf128.
              For a NB-IoT UE, the allowed values are hf2, hf4, hf6, hf8, hf10, hf12, hf14, hf16, hf32, hf64, hf128, hf512 and hf1024.
              For a NR UE, the allowed values are hfquarter, hfhalf, hf1, hf2, hf4, hf8, hf16, hf32, hf64, hf128, hf256, hf512 and hf1024.

paging_time_window
              Optional integer. Paging time window.
              For an EUTRA UE the allowed range is 1 to 16 (in units of 1.28 seconds).
              For a NB-IoT UE the allowed range is 1 to 16 (in units of 2.56 seconds).
              For a NR UE the allowed range is 1 to 32 (in units of 1.28 seconds).

cell_id   Array of integers. The array contains the cell_id of the cells on which the paging message must be transmitted.

noise_level
        Sets the noise level (relative to the CRS level) when the channel simulator is enabled.
        Message definition

noise_level
              Float. Defines the noise level value to be set.

channel   Optional integer. Defines the TX channel number on which the the new noise level value is applied. If not present, the new noise level value is applied on all TX channels.

ncell_list_add
        Add a new neighbour cell to the ncell_list object.
        Message definition

cell_id   Integer. Cell ID.

ncell   Object. Contains the same parameters as those defined for ncell_list object of the LTE or NR cell. See [LTE ncell_list], page 48. See [NR ncell_list], page 134.

ncell_list_del

Remove a neighbour cell from the `ncell_list` object.
Message definition

cell_id   Integer. Cell ID.

n_id_cell

Integer (range 0 to 503 for LTE, 0 to 1007 for NR). Physical cell identity.

dl_arfcn   Optional integer (range 0 to 262143 for LTE, 0 to 3279165 for NR). DL
EARFCN or SSB NR-ARFCN. If not present, it is assumed to be the
same as the current cell.

scells_act_deact

Activate or deactivate configured secondary cells for a given UE, through MAC
Control Element. Returns the status of the SCells for the UE.
Message definition

enb_ue_id

Integer. eNB or RAN UE id.

activate   Optional array of integers containing the cell id of the SCell to activate.
No effect if a cell is not part of the configured SCells for the UE.

deactivate

Optional array of integers containing the cell id of the SCell to deacti-
vate.

Response definition

scells   Array of integer containing the list of the cell ids of the configured SCells

activated

Array of integer containing the list of the cell ids of the activated SCells,
after execution of the command.

mr_dc_scg_release

Trigger a release of the SCG for an EN-DC or NR-DC UE. The is only allowed if
the UE PCell contains a `meas_config_desc` object defining a SCG addition based
on a NR B1 (`en_dc_setup`) or A4 (`nr_dc_setup`) measurement report.
Message definition

ran_ue_id

Integer. eNB or RAN UE id.

nr_pscell_change

Trigger a NR PSCell change procedure for an EN-DC or NR-DC UE.
Message definition

ran_ue_id

Integer. MCG UE eNB UE id.

cell_id   Integer. NR target cell id.

mr_dc_split_dl_ratio_change

Change the DL ratio for a MR-DC split data radio bearer.
Message definition

ran_ue_id

Integer. MCG UE RAN UE id.

drb_id   Integer. DRB id.

secondary_path_dl_ratio

>>> Integer. A value between 0 and 1 tries to force the data ratio between both bearers, -1 disables it. Note that the ratio cannot be sustained if the `force_dl_schedule` option is activated in one of the cells use for the traffic, or if multiple bearers with different priorities are used, or if the traffic pushed is higher than the maximum physical bitrate.
>>> Example: if 10Mbps is sent and ratio is set to 0.75, primary path will schedule 2.5Mbps and secondary 7.5Mbps.

ntn_satellite_update

> Update the satellite information and/or channel simulator behaviour for a NTN cell (NR or NB-IoT).
> Similarly to the `ntn` object (See [Non Terrestrial Network], page 224) satellite information is described either with `sv_filename`, `tle_filename` or explicit `ephemeris` configuration.
> Message definition

cell_id Integer. Cell ID.

sv_filename

>> Optional string. Update the State Vectors file. The file format is expected to be the same than the original file.

tle_filename

>> Optional string. Update the satellite ephemeris from a TLE file.

ephemeris

>> Optional object, containing the same parameters than its counterpart described in the `ntn` object.

channel_sim_control

>> Optional object. Update the channel simulator behaviour. This object contains all the parameters available to the `channel_sim_control` object of the `ntn` configuration, except for `type` which cannot be changed. Note that a sudden change in the channel simulator will likely result in sycnhronization loss for the connected UEs.

mbs_session_info

> Get MBS session info per cell. Response definition:

cells Array of objects. Each Each object contains the following properties:

>> cell_id Integer. cell_id as configured in the `nr_cell_list` object entry of the gNB configuration object.

>> broadcast

>>> Array of objects. Each object contains the following properties:

>>> session_id

>>>> Object. MBS session identity. It contains the following properties:

>>>>> tmgi Object. Temporary Mobile Group Identity. It contains the following properties:

>>>>>> plmn String. PLMN.

<div style="text-align: right">

service_id
            Integer. Service ID.

</div>

nid	Optional integer. Network Identifier.

snssai   Object. It contains the following properties:

        sst   Integer. Slice Service Type.

        sd   Optional integer. Slice Differentiator.

qos_flows
         Array of objects. Each object contains the following properties:

        qfi   Integer. QoS Flow identifier.

        pdcp_sdu_bytes
            Integer. Number of PDCP SDU bytes transmitted on the first SSB.

10.7 Remote events

Some messages (events) may be sent by LTEENB without client sollicitation.
To receive them, you need to register to those events via [remote event registration], page 271.
The received JSON will have a `message` property with the events name.

   Ex:
Register to `<event name>` event:

```
{
  message: "register",
  register: "<event name>"
}
```

   Message received:

```
{
  message: "<event name>",
  ...
}
```

   Here is the list of events generated by LTEENB:

ue_measurement_report
         Generated each time a LTE or NR RRC Measurement Report message is received. Message definition:

        ran_ue_id
            Integer. eNB UE S1AP ID or RAN UE NGAP ID.

        cn_ue_id   Optional integer. MME UE S1AP ID or AMF UE NGAP ID.

        cell_id   Integer. Identity of the cell that received the Measurement report message.

        c_rnti   Integer. UE C-RNTI.

        meas_config
            Optional string. Decoding of the UE current measurement configuration (if available). It corresponds to the MeasConfig ASN.1 field in GSER format.

        `meas_results`

             String. Decoding of the UE measurement results. It corresponds to the MeasResults ASN.1 field in GSER format.

`carrier_sense`

        Generated each time a LTE cell `carrier sensing` cutoff state changes.
        Message definition:

        `cell_id`   Integer. Identity of the cell that received the Measurement report message.

        `epre`   Number. Last measured energy in dB.

        `cutoff`   Boolean. Cutoff state

`srs`   Generated for each SRS decoding, [Signal events], page 296,

`pusch`   Generated for each PUSCH decoding, [Signal events], page 296,

`npusch`   Generated for each NPUSCH decoding, [Signal events], page 296,

10.8 Signal events

Generated each time such a channel is decoded by the physical layer. This message is in binary format and includes a JSON structure and signal data as followed:

First 4 bytes are an 32 bit integer representing the length in bytes of the serialized JSON, followed by the serialized JSON itself.

Next 4 bytes are the length of the signal data in bytes followed by the data itself.

Note that the message can include several signal data. In this case, the pattern length/signal is repeated.

    JSON data represent the associated log ([JSON log], page 265) and has following additional properties:

`label`   String. Can be `rs` or `re`

`binary`   Boolean. Always true

    Signal data bytes are defined this way:

- Bytes 0...3: integer representing data length in bytes of the subsequent information.
- Bytes 4...7: integer representing data element size where:
    - 0: 32 bits floats
    - 1: 16 bits integer.
- Bytes 8..11: number of elements in data
- Remaining bytes are for data.

    Note that <data length> = <# of elements> * <element size in bytes> + 8

    For more information about signal data, please check `signals.js` code inside `ltewww` software package.

10.9 Examples

1. Config
    1. Client sends
        ```
        {
            "message": "config_get",
            "message_id": "foo"
        }
        ```

2. Server replies

```
{
    "message_id": "foo",
    "message": "config_get",
    "name": "UE",
    "logs": {
        "phy": {
            "level": "error",
            "max_size": 0
        },
        ...
        "rrc": {
            "level": "debug",
            "max_size": 1
        }
    }
}
```

2. Error

    1. Client sends

```
{
    "message": "bar",
    "message_id": "foo"
}
```

    2. Server replies

```
{
    "message_id": "foo",
    "message": "bar",
    "error": "Unknown message: bar"
}
```

10.10 DL synchronization

For more details about this feature, please read [DL synchronization], page 232.

10.10.1 Events

Events may be sent during `DL synchronization` lifetime. All events `message` value is `dl_sync` and their meaning will be identified by their `event` parameter value as defined below:

lost   Synchronization to remote cell has been lost.

timeout   No remote cell have been found.

restart   A new cell search has been asked.

info   Periodically sent to provide following remote cell information:

    ss_snr   Object. Statistics for received remote cell synchronization signal. Includes `min`, `max`, `avg` and `sd` (Standard deviation) numbers in dB.

    drift   Number. Time drift between cell and remote cell in ppm.

    low_snr   How many consecutive times low snr threshold has been reached. If this counter reaches configured `snr_seq`, signal will be considered as lost.

pbch_error_count_max
> NR cells only.
> Maximum number of consecutive MIB decoding failures.
> If this counter reaches `pbch_error_threshold`, signal will be considered as lost.

sync   Sent when cell search is being successful and cell is now synchronized with remote cell. The event have the following members:

pci   Integer. Physical Cell ID of the remote cell.

ssb_index
> Integer (NR only). Index of the SSB the cell is listening to on remote cell.

10.10.2 Messages

dl_sync   Message definition:

action   Optional string (default = start). Defines action to perform.
> If set to `start`, forces a remote cell search.
> If set to `info`, replies with current state informations.

cell_id   Integer. Cell ID on which to retart DL `synchronization` procedure.

timeout   Optional number (default = last used value). Timeout in seconds for DL `synchronization` procedure.

11 Command line monitor reference

The following commands are available:

help   Display the help. Use `help command` to have a more detailed help about a command.

`t [ue|g|cpu|spl] [period]`

Activate various traces on the console. The display is stopped when typing return. The default trace is `ue`. An optional display period (in seconds) is accepted.

Available traces:

`ue [ue=<id>] [cell=<id>]`

UE MAC and PRACH traces. If `n` is provided, only display the UE ID `n`.

g   Show global eNodeB statistics.

`cpu [rf_ports=p0[,p1...]]`

Display the CPU usage from the TRX (transceiver) API and the TX-RX latency statistics.

If `pn` is set, only display statistics for rf port `pn`.

`spl [rf_ports=p0[,p1...]] [dbm]`

Display various statistics about the sent and received complex samples (at the TRX API level). For the TX side, the RMS and maximum sample value are displayed. The number of saturation events (`abs(sample) > 1`) are displayed too. For the RX side the RMS and maximum sample value are displayed. The unit is dB FS (dB Full Scale) or absolute dbm if set. 0 dB FS is reached with a square signal of amplitude 1.

If `pn` is set, only display statistics for rf port `pn`.

`log [log_options]`

Display the current log state. If *log_options* are given, change the log options. The syntax is the same as the `log_options` configuration property.

`cell [main|phy|ntn]`

List the available cells with information. Available information are :

main   It is the default display, prints some basic information of the cell (PCI, DL ARFCN, TAC, PLMN, ...)

phy   Prints more detailed information on the PHY layer (bandwidth, UL and DL ARFCN, number of antennas, ...)

ntn   For NTN cells, prints detailed information on the serving satellite (range, azimuth, elevation, doppler, ...)

`cell_gain cell_id gain`

Set the DL gain of the cell *cell_id*. The gain is in dB and must be `<= 0`. The gain of the other cells is not modified.

`cell_ul_disable cell_id flag`

Disable the uplink of the cell *cell_id* if *flag* = 1.

`noise_level level [channel]`

Change the noise level. If `channel` is not provided, the same noise level is set for all the TX channels. This command only applies if the channel simulator is configured. See [RF port specific channel simulator], page 220.

ue   List connected UEs.

`handover RAN_UE_ID pci [arfcn]`

Initiate a handover of UE *RAN_UE_ID* to the cell of physical identifier *pci* at EAR-FCN / SSB NR-ARFCN *arfcn*. If *arfcn* is not given, it is assumed to be the same as the source cell. The target cell must be defined in the source cell neighbour list. Note that this command line cannot be used for inter system handover. Instead you should use the handover remote API.

`pcap [-w filename] [-l data_len] [-b] [-d ms] [-p]`

Record packet data in the pcap format used by Wireshark. It works only with LTE cells.

By default data are written until a `pcap_stop` request is made.

To record for a fixed period of time the *-d* can be used to specify the number of milliseconds to capture data.

The remaining command line options mimic the control found in the config file:

- the *-w* option can be use to specify an output file name (default is */tmp/enb.pcap*)
- the *-l* option specifies the maximum length for packet data written (default is 65535)
- the *-b* option enables capture of broadcast packets on the BCCH channel
- the *-p* option can be set to capture into a pipe instead of a file

`pcap_stop`

Stop recording pcap packet data.

`rf_info`   Get RF driver informations

`tx_gain gain channel`

Set the TX gain in dB of the radio driver. If no channel is specified, all cells are affected. Same definition as the [tx_gain], page 34, property.

`rx_gain gain channel`

Set the RX gain in dB of the radio driver. If no channel is specified, all cells are affected. Same definition as the [rx_gain], page 34, property.

`s1`   Dump the S1 connection state. It is useful to see if the eNodeB is connected to the MME.

`s1connect [mme_addr]`

Force a S1 (re)connection to the MME. The MME IP address and optional port can be given as an optional parameter.

`s1disconnect`

Force a S1 disconnect from the MME.

`ng`   Dump the NG connection state. It is useful to see if the gNodeB/ng-eNodeB is connected to the AMF.

`ngconnect [amf_addr]`

Force a NG (re)connection to the AMF. The AMF IP address and optional port can be given as an optional parameter.

`ngdisconnect`

Force a NG disconnect from the AMF.

`x2`   Display the state of the X2 connections and the associated cell parameters.

`x2connect peer_addr`

Force a X2 connection to eNodeB *peer_addr*.

x2disconnect *peer_addr*
> Force a X2 disconnection from the eNodeB *peer_addr*.

xn   Display the state of the Xn connections and the associated cell parameters.

xnconnect *peer_addr*
> Force a Xn connection to gNodeB/ng-eNodeB *peer_addr*.

xndisconnect *peer_addr*
> Force a Xn disconnection from the gNodeB/ng-eNodeB *peer_addr*.

m2   Display the state of the M2 connection.

m2connect [*server_addr*]
> Force a M2 connection to MBMSGW *server_addr*. If *server_addr* is not present, it uses the previous address.

m2disconnect
> Force a M2 disconnection from the MBMSGW.

hwcaps   Show the CPU capabilities. Useful to see if AES acceleration is supported.

mbms   Show the MBMS status. It is useful to see packet losses, the instantaneous bitrate of each session and the maximum bitrate allowed for each PMCH.

erab [-a] Show the allocated EPS radio bearers (only GBR bearers by default, all the bearers with the -a option).

qos_flow [-a]
> Show the allocated 5GS QoS flows (only GBR bearers by default, all the bearers with the -a option).

rrc_ue_info_req *UE_ID* req_mask
> Send a RRC UE Information Request to UE *UE_ID*. 'req_mask' is a bitmask: 0:RACH, 1:RLF, 2:LogMeas, 3:ConnEst, 4:MobHist, 5:IdleModeMeas, 6:ANR, 7:CoarseLocation, 8:SuccessHO-Report.
> RACH: applicable to LTE, NB-IoT and NR UEs.
> RLF: applicable to LTE, NB-IoT and NR UEs.
> LogMeas: applicable to LTE and NR UEs.
> ConnEst: applicable to LTE and NR UEs.
> MobHist: applicable to LTE and NR UEs.
> IdleModeMeas: applicable to LTE and NR UEs.
> ANR: applicable to NB-IoT UEs.
> CoarseLocation: applicable to LTE and NR UEs.
> SuccessHO-Report: applicable to NR UEs.

rrc_cnx_release *UE_ID* [*redirect_type*]
> Forces a RRC connection release. See [rrc_cnx_release], page 279, in remote API.

rlc_drop_rate *UE_ID* rb_id rate [*is_srb*]
> Define a *rate* percentage of uplink RLC PDUs dropped. Note that in case of handover or reestablishment, the drop rate is reset to 0.

pdcch_order_prach *UE_ID*
> Forces the sending of a PDCCH order for PRACH to the UE. Supported for all UE types except BR UEs.

mbs_session_info
> Get MBS session info per cell.

12 UDC configuration reference

The UDC configuration is made by the script `udc-auto-cfg.sh`. For the input parameters See [cmd], page 41. The script needs to ouput on stdout the following lines:

- `LO_FREQ`: LO frequency confgured for the UDC devices belonging to the same `udc_port`
- `TX_POWER_OFFSET`: UDC up conversion gain [dB]. This quantity is used by the software to estimate the value of `ss-PBCH-BlockPower`
- `TX_POWER_MAXn`: it corresponds to the maximum power level [dBm] tolerated by the UDC IF port equally divided by the number of aggregated carriers using the same `udc_port`. `n` line output, one for each `rf_port`. This quantity is used by the software to find the maximum allowed `tx_gain` for each `rf_port` in order to avoid the UDC device IF port saturation.
- `IFn`: it corresponds to the intermediate frequency at which each SDR is configured. `n` line output, one for each `rf_port`.
- `TX_GAIN_MARGINn`: it corresponds to the `tx_gain` reduction [dB] from the maximum allowed value. It is automatically applied by the software by `rf_port` during the startup. `n` line output, one for each `rf_port`.

12.1 args Configuration

This section specifies how to configure the parameter `args` (See [args], page 41). The only mandatory string parameter is the UDC device enumeration, it specifies how the UDC has been mounted at Linux level. UDCB2 and UDCB4 are mounted as /dev/ttyUSBx and UDCA2 as /dev/ttyACMx. The other string parameters are optional, if not specified, they are configured with the default value. Supported parameters:

Clock configuration:
- A2: default(ingored). Any possibility to send clock configuration command for this UDC
- B2: internal,external,default(master=internal,slave=external). If only one UDC B2 in the setup default=internal.
- B4: internal,external,gps,default(internal)

TX port configuration:
- A2: 1,2,default(1). 1=port IF1, 2=port IF2
- B2: 1,2,3,4,default(2). 1=port IF1A, 2=port IF1B, 3=port IF2A, 4=port IF2B
- B4: 1,2,3,4,default(1,3). 1=port IF1, 2=port IF2, 3=port IF3, 4=port IF4

RX port configuration:
- A2: 1,2,default(2). 1=port IF1, 2=port IF2
- B2: 1,3,default(3). 1=port IF1A, 3=port IF2A
- B4: 1,2,3,4,default(2,4). 1=port IF1, 2=port IF2, 3=port IF3, 4=port IF4

Example: "/dev/ttyUSB0;clock=default;tx=default;rx=default"

12.2 Debug

To enable the `udc-auto-cfg.sh` debug logs it is required to enable the `trx` log level in debug mode in the configuration file. Example:

```
log_options: "all.level=error,all.max_size=0,nas.level=debug,nas.max_size=1,
s1ap.level=debug,s1ap.max_size=1,x2ap.level=debug,x2ap.max_size=1,
rrc.level=debug,rrc.max_size=1,trx.level=debug,trx.max_size=1",
```

13 Log file format

13.1 PHY layer

When a PHY message is dumped (debug level), the format is:

```
time layer dir ue_id cell rnti frame.subframe channel:short_content
        long_content
```

time   Time using the selected format.

layer   Layer ([PHY] here).

dir   UL (uplink) or DL (downlink).

ue_id   eNodeB UE identifier (hexadecimal, unique among all cells).

cell   Low 8 bits of the cell identifier (hexadecimal).

rnti   Associated RNTI (hexadecimal) or - if none.

frame.subframe
          Frame number (0-1023) and either subframe number (0-9) for LTE and NB-IoT cells
          or slot number for NR cells.

channel   PHY channel name (e.g. PUSCH, PUCCH, PRACH, SRS, PSS, PBCH, PDSCH,
          PHICH, PDCCH, EPDCCH, ...).

short_content
          Single line content.

long_content
          Hexadecimal dump of the message if phy.max_size > 0.

13.2 MAC and RRC layers

When a message is dumped, the format is:

```
time layer - ue_id message
```

When a PDU is dumped (debug level), the format is:

```
time layer dir ue_id short_content
        long_content
```

time   Time using the selected format

layer   Layer ([MAC] or [RRC] here).

dir   UL (uplink) or DL (downlink).

ue_id   eNodeB UE identifier (hexadecimal, unique among all cells).

cell_id   Primary cell identifier. See [cell_id], page 47,

short_content
          Single line content.

long_content
          - MAC: hexadecimal dump of the message if layer.max_size > 0.
          - RRC: full ASN.1 content of the RRC message if layer.max_size > 0.

long_content
          - MAC, RLC, PDCP: hexadecimal dump of the message if layer.max_size > 0.
          - RRC: full ASN.1 content of the RRC message if layer.max_size > 0.

13.3 RLC, PDCP and NAS layers

When a message is dumped, the format is:

```
time layer - ue_id message
```

When a PDU is dumped (debug level), the format is:

```
time layer dir ue_id short_content
        long_content
```

time   Time using the selected format

layer   Layer ([RLC], [PDCP], or [NAS] here).

dir   UL (uplink) or DL (downlink).

ue_id   eNodeB UE identifier (hexadecimal, unique among all cells).

short_content
            Single line content.

            • RLC, PDCP: preceded by the SRB or DRB identifier.

long_content
            • NAS: full content of the NAS message if layer.max_size > 0.

13.4 S1AP, NGAP, X2AP, XnAP, M2AP and GTP-U layers

When a message is dumped, the format is:

```
time layer - message
```

When a PDU is dumped (debug level), the format is:

```
time layer dir ip_address short_content
        long_content
```

time   Time using the selected format.

layer   Layer (e.g. [S1AP]).

dir   Direction: TO or FROM.

ip_address
            Source or destination IP address, depending on the dir field.

short_content
            Single line content.

long_content
            • S1AP, NGAP, X2AP, XnAP, M2AP: full ASN.1 content of the message if
              layer.max_size > 0.
            • GTPU: hexadecimal dump of the message if layer.max_size > 0.

14 Change history

14.1 Version 2025-12-12

- OpenSSL library is upgraded to 3.5.4
- improved satellite propagation algorithm for NTN
- added LTE bands 111, 112, 113 and 252 definition
- added NR bands 68, 87, 88, 110 and 252 definition
- added `ri_adapt` parameter in LTE cells
- added configurable actions when using `meas_config` object in LTE and NR cells:
  - `meas_report_action` parameter is added in `meas_config` object
  - handover based on `meas_config` periodical measurement reports are no more supported
- `nr_handover_d1` parameter is renamed to `nr_handover_location_based` in NR cells. `nr_handover_d1` is still supported for backward compatibility
- `nr_handover_location_based` parameter is added in `config_get` remote API
- added conditional handover in NR cells
  - added `nr_conditional_handover` parameter in `meas_config_desc` object
  - added `conditional_handover_target` parameter in `ncell_list` object
  - adde `nr_conditional_handover` and `conditional_handover_target` parameters in `config_get` remote API
- added `pws_emergency_area_id` parameter to LTE and NR cells
- added `prop_delay_diff_report` parameter to the `ue_assistance_information` configuration object in NR cells
- added `cp_dl` and `cp_ul` parameters for split 7.2
- removed `cb_given` option from `pdcch_order_prach` configuration object in NR cells
- added `pucch2_detect_threshold` and `pucch3_detect_threshold` parameters to LTE cells
- reworked `uplink_tx_switch` configuration object of NR cells to support Rel18
  - `role` parameter is replaced by the more generic `priority` parameter
  - `period_location` is removed
  - `carrier2_slots` is renamed to `active_slots`
- added `delay` and `gain` parameters to the RF port specific channel simulator object
- added the `static`, `tdld30`, `ntn_tdla100`, `ntn_tdlc5`, `ntn_tdla`, `ntn_tdlb`, `ntn_tdlc` and `ntn_tdld` channel models to the channel simulator
- added the `normalize` parameter to the RF port specific channel simulator. The Rayleigh fading channel matrices are now normalized by default. Set `normalize` to false to restore the previous behavior
- added multiple NR MAC Timing Advance Groups support
  - `tag_id` parameter is added in `mac_config` configuration object in NR cells
- added 16 bits float support for TRX driver

14.2 Version 2025-09-19

- updated NR RRC ASN.1 to release 18.6.0
- added NTN HARQ disabling in NB-IoT cells
  - `harq_disabled` and `ul_harq_mode_b` parameters are added to objects of `coverage_levels` list

- `logical_channel_sr_prohibit` default value is now true in `srb_config` and `drb_config` configuration object for NB-IoT cells
- `reserved` and `reserved_5gc` parameters are added to `sib_set` remote API
- `reserved_dl_prbs` parameter effect is changed in NR cells
- NTN HARQ disabling enhancements in NR cells
  - `harq_process_disabled` parameter meaning changed when set to true in `pdsch` object of NR cells
  - `harq_mode` parameter added in `drb_config` object of NR cells
- `drx_last_transmission_ul`, `drx_harq_rtt_dl` and `drx_harq_rtt_ul` parameters are added in `drx_config` configuration object of NR cells
- `b1_gaps_required` parameter is removed from `en_dc_setup` configuration object and is replaced by `nr_need_for_gaps` in `meas_config_desc` configuration object of LTE cells
- `eutra_5gc_only` parameter is added in LTE and NB-IoT cells and in `config_get` remote API
- `tac` parameter range is updated to forbid reserved values specified in 3GPP 23.003
- Clarify `sul` activation behaviour for NR cells
- `rep_k` parameter added in `configured_grant` and `sdt.configured_grant.grant` objects of NR cells
- `dmrs_bundling`, `dmrs_bundling_tdw_length` and `dmrs_bundling_window_restart` parameters are added for PUSCH in NR cells
- `preferred_option` and `two_tx` parameters are added in the `uplink_tx_switch` configuration of NR cells
- `pusch.max_mcs` added to `config_set` remote API for NR cells
- `tx_fifo_size` parameter documentation added in DRB configuration objects
- `sv_interpolation` parameter is added to `ntn` configuration to define how interpolation is performed between data points when `sv_filename` is set
- periodic UL grant feature in NB-IoT cells
  - `periodic_ul_grant` parameter is added in NB-IoT cells
  - `use_periodic_ul_grant` parameter is added in `srb_config` and `drb_config` configuration objects of NB-IoT cells
- `antenna_azimuth` is added to `nr_cell_list` and `cell_list` objects to define the angle of arrival used in location procedures
- `phr_link_adaptation` parameter is added in LTE cells and in the `pusch` object of NR cells
- DCSP values for GTP-U tunnels are set to Expedited Forwarding for QCI/5QI 1 and 65 in the configuration files delivered
- added ORAN 7.2 support for LTE cells
- added `gen_prb0` parameter

14.3 Version 2025-06-13

- updated RRC ASN.1 to release 18.5.0
- updated NR RRC ASN.1 to release 18.5.1
- updated NRPPa ASN.1 to release 18.5.0
- updated LPPa ASN.1 to release 18.1.0
- added DECOR support

- added MBS broadcast support
  - `mbs_gtp_u_port`, `mcch_search_space`, `mtch_search_space` and `mbs` parameters are added
  - `mbs_broadcast_bitrate` parameter is added to `stats` remote API
  - `mbs_session_info` remote API and monitor commands are added
  - added a gnb-sa-mbs.cfg sample configuration file
- added positioning related gaps support based on RRC inter-frequency RSTD measurement indication or NR RRC location measurement indication message
- added Direct-To-Cell support for LTE cells
  - `ntn` configuration is supported for LTE only with `direct_to_cell` setting
- allow array of integers for NR PDSCH and PUSCH `mcs` parameter
- CoarseLocation and SuccessHO-Report are added to `rrc_ue_info_req` remote API and `rrc_ue_info_req` monitor command
- `dmrs_low_papr` parameter is added for PDSCH and PUSCH in NR cells
- `dmrs_tf_precoding` parameter is added for PUSCH and PUCCH in NR cells
- `bcch_modification_period_coeff` parameter is added in NR cells
- added NTN UL HARQ disabled in NR cells
  - `harq_mode_b` parameter is added for PUSCH in NR NTN cells
- interpolation is performed between data points when `sv_filename` is set in the `ntn` configuration
- `large_time_shift_symbols` parameter is added to the `ntn` configuration for NR cells
- `feeder_doppler_compensation` parameter in `ntn` configuration is now supported for NB-IoT
- `freq_hopping` parameter in the `pucch.resource_auto` configuration of NR cells defaults to `false`
- added periodical measurement to dynamic measurement configuration
  - `eutra_periodical` and `nr_periodical` parameters are added to `meas_config_desc` object in LTE and NR cells

14.4 Version 2025-03-14

- updated NR RRC ASN.1 to release 18.4.0
- updated NGAP ASN.1 to release 18.4.0
- added NR DL MIMO 8x8
- added S1AP and NGAP overload support
- added NR RRC Location Measurement Indication support
- the crc=KO log is renamed to crc=FAIL
- `power_class_14dbm_offset` parameter is added to LTE and NB-IoT cells
- `ce_authorization_offset` parameter is added to NB-IoT cells
- `pucch134_auto_n_symb` parameter is added to the `pucch` object of NR cells
- `two_codewords` parameter is added to the `pdsch` object of NR cells
- `skip_uplink_tx_snr_threshold` parameter is renamed to `pusch_dtx_snr_threshold` in LTE cells. `skip_uplink_tx_snr_threshold` is still supported for backward compatibility
- `skip_uplink_tx_snr_threshold` parameter is renamed to `dtx_snr_threshold` in NR cells. `skip_uplink_tx_snr_threshold` is still supported for backward compatibility

- `configured_grant` parameter is added to `sdt` configuration object of NR cells
- `npusch_an_threshold` parameter description is added to NB-IoT cells
- `resource_auto` parameter is added to `pucch` in NR cells to perform automatic PUCCH configuration
- `mps_priority_indication` parameter is added to the `rrc_cnx_release` remote API
- `idle_mode_measurement_eutra` and `idle_mode_measurement_nr` parameters are added to NR cells
- `direct` value is added to `scells_activation` parameter in LTE and NR cells
- `always` value in `scells_activation` parameter is renamed to `mac_ce`. `always` is still supported for backward compatibility
- `direct_to_cell` parameter is added to `ntn` configuration object of NR cells for Direct-To-Cell operation
- `ul_blanked_scs` parameter is added to NR cells
- `sib1_delivery_during_ho` parameter is added to LTE cells and `config_set` remote API
- `n_rb_ul` parameter is added to LTE cells
- `ssb_pos_bitmap` can be an object in NR cells
- `carrier_sense` remote API event is added
- `carrier_sense` parameter is added to `config_get` and `config_set` remote APIs
- `sn_GapReport_r18` parameter is added to `drb_config` in NR cells

14.5 Version 2024-12-13

- updated RRC ASN.1 to release 18.3.0
- updated S1AP ASN.1 to v18.2.0
- updated X2AP ASN.1 to v18.2.0
- updated NR RRC ASN.1 to release 18.3.0
- updated NGAP ASN.1 to release 18.3.0
- updated XnAP ASN.1 to release 18.3.0
- added R18 3MHz cell bandwidth support for NR cells
- added NR band 106 definition
- added NR FR2 NTN
- `tbs_index_alt`, `tbs_index_alt2` and `tbs_index_alt3` parameters are added to LTE cells
- `q_rx_lev_min` parameter is added to `sul` configuration object
- `skip_uplink_tx_dynamic_support` and `skip_uplink_tx_sps_support` parameters are added to `mac_config` configuration object in LTE cells
- `skip_uplink_tx_snr_threshold` parameter is added to LTE cells
- `prb_bundling`, `prb_bundling_size_indicator`, `prg_precoding_test` parameters are added to `pdsch` object of NR cells
- `rar_search_space` is now set by default in all DL BWPs
- `ssb_nr_arfcn` parameter in `dl_bwp` configuration object can be set whatever the `dl_bwp_access` value
- `sched_interval` parameter in `sps/ul` configuration object in LTE cells accepts new values
- `ul_full_power_transmission` parameter is added to `pusch` object of NR cells
- `allow` and `eredcap_ue` parameters are added to `redcap_ue` configuration object for eRed-Cap support

- `eredcap` parameter is added to `prach_feature_preambles` and `feature_priorities` configuration objects
- `eredcap` parameter is added to `ue_get` remote API
- `cell_barred_eredcap_1rx` and `cell_barred_eredcap_2rx` parameters are added to `config_get` remote API
- `early_data_request` parameter is added to `rrc_procedure_filter` configuration object in NB-IoT cells
- `ttl` parameter is added to `rrc_procedure_filter` configuration object. The previous syntax is still supported for backward compatibility
- `band` parameter in NR cells and in NR `ncell_list` configuration object can be an array of integers
- `p_max` parameter in NR cells and in NR `sib_set` remote API can be an array of integers
- `additional_spectrum_emission` parameter in NR cells can be an array of integers
- `channel_sim_control` parameter is added to `ntn_satellite_update` remote API
- `vrb_lib_path` parameter is added to the gNodeB configuration for Intel vRANBoost support
- `ran_slicing` parameter is added to NR and LTE cells
- `forced_drx_slot_offset` parameter is added to the `drx_config` for NR cells
- `ul_snr_adapt_amp`, `ul_snr_adapt_retx`, `cqi_adapt_amp`, `cqi_adapt_retx` and `dl_snr_adapt_retx` parameters description is added
- `ul_snr_adapt_retx` default value is changed from 0.1 to 0.3 in NR cells
- `force_adaptive_retransmission` parameter is added to LTE cells and `config_set` remote API
- `rrc_logged_meas_config` remote API is added
- `use_full_resume_id` parameter is added to `sib_set` remote API
- `ho_from_meas` parameter is added to `config_set` remote API

14.6 Version 2024-09-13

- added LTE bands 107 and 108 definition
- added reflective QoS support
- added split 7.2 multi cell support
- added NR bands 510, 511 and 512 definition
- `continue_rohc_context` parameter is added to `rrc_inactive` and `sdt` objects
- `pei_frame_offset`, `pei_n_subgroups`, `n_po_per_pei`, `pei_n_candidates` and `pei_al_index` parameters are added in `paging` object of NR cells
- `rrm_meas_relaxation_reporting` parameter is added to `ue_assistance_information` object of NR cells
- `license` remote API is added
- `n_rb_dl` and `n_rb_ul` parameters range is updated for NR cells
- `ntn` option is added to the `cell` monitor command
- `n_ta_common_offset` parameter is added to the `ntn` configuration object
- `br_guess_guard_time` parameter is added
- `sr_ignore_count` parameter is added to LTE and NR cell objects and `config_set` remote API
- `ul_earfcn` parameter range is updated for LTE cells

- `emergency_bearer_arp_priority_level` parameter is added to `mme_list` and `amf_list` objects
- `cipher_algo_null_allowed` and `integ_algo_null_allowed` parameters are added
- `enhanced_channel_raster` parameter is added for NR Cells
- `f_raster` parameter supports the value 100_enhanced
- `exclude_slots` parameter is added in `resource_auto` configuration object for NR CSI-RS
- `com_logs_lock` parameter is renamed to `com_log_lock`. `com_logs_lock` is still supported for backward compatibility
- `com_log_us` parameter is added
- `inter_enb_synchro` parameter is added to `icic` configuration object
- `pbch_error_threshold` parameter is added to `dl_sync` configuration object
- `pbch_error_count_max` parameter is added to dl_sync info event
- `eab_per_rsrp` parameter is added to `sib_set` remote API
- `ntn` parameter is added to the `cell` monitor command
- added `pbch_error_threshold` to detect `DL sync` lost on PBCH decoding failure

14.7 Version 2024-06-14

- OpenSSL library is upgraded to 1.1.1w
- added NR band 54 definition
- improved UDC configuration for FR2
- allowed to configure up to 5 BWP per NR UE type (normal or RedCap)
- added RRC UE information procedure for NB-IoT and NR UEs
- `ue_dl_bwp_id` and `ue_ul_bwp_id` parameters are added in `ue_get` remote API
- `precoding_matrix` parameter is added in the `prs` object of LTE cells
- `edrx` parameter is added to `page_ue` remote API
- `sul_prach_index_list` and `sul_prach_only` parameters are added to the elements of `prach_feature_preamble_list` for NR cells
- `ho_force_full_config` parameter is added to LTE and NR cells, and `config_set` remote API
- `n_harq_process` parameter is added to the `pusch` object for NR NTN cells
- `scell_id` parameter is added to the `dci_bwp_switch` remote API for NR cells
- `bwp_scell_id` parameter is added to the `rrc_cnx_reconf` remote API for NR cells
- `large_freq_shift` object is added to the `ntn` configuration for NR cells
- `backup_mme_addr` and `priority` parameters are added to `mme_list` object
- `backup_amf_addr` and `priority` parameters are added to `amf_list` object
- changed the semantic of `n_ta_common` parameter of `ntn` configuration for NR and NB-IoT cells
- `direct_forwarding_available` parameter is added in the `ncell_list` object of LTE and NR cells
- `rsrp_threshold` parameter in the `sdt` object is now optional
- `logical_channel_sr_delay_timer` parameter is added in the `sdt` object
- `t318` parameter is added in `ntn` object of NB-IoT cells
- `ai3_barring_factor` and `implicit_barring_list` are added to the `uac_barring_info` object

- `sdt_allowed` parameter is added to the NR SRB2 configuration object
- `icic` object and `eutra_interference_intra` parameter are added to the LTE eNodeB configuration object for interference management
- `conn_est_failure_control` parameter is added to NR cells and `sib_set` remote API
- `k_mac` parameter is added to the `ntn` configuration for NR and NB-IoT cells
- `sib25` object is added to the LTE cell configuration
- `reference_signal_power`, `ss_pbch_block_power` and `nrs_power_r13` are added to `config_get` remote API and are now applicable on `sib_set` remote API without `manual_ref_signal_power` set to true
- `two_steps_prach` parameter is added to items of the `ul_bwp` array
- `sib14` added to the NB-IoT cell configuration
- `uplink_tx_switch` parameter can also be used in a SUL configuration
- `empty_bsr_grant` parameter is added in LTE and NR cells configuration
- `use_empty_bsr_grant` parameter is added to `drb_config` object in LTE and NR cells
- `ho_continue_rohc_context` parameter is added in LTE and NR cells configuration
- `cqi_on_sf3_8` parameter is added to LTE cell configuration

14.8 Version 2024-03-15

- updated NR RRC ASN.1 to release 17.6.0
- added LTE bands 106, 253 and 254 definition
- added NR bands 31, 72, 105, 109 and 254 definition
- allowed concurrent ETWS and CMAS notifications
- `cell_group` parameter is added to `rrc_cnx_reconf` remote API
- `additional_spectrum_emission` parameter is added for NR cells
- `redirected_carrier_info`, `redirected_carrier_info_nb_v1430`, `idle_mode_mobility_control` and `cell_reselection_priorities` are added to `rrc_cnx_release` remote API
- `first_pdcch_mo_of_po` parameter is added in the `paging` config of NR cells
- added jer format to `sib_set` remote API
- `rlc_drop_rate` remote API is added
- `5qi_qos` parameter is added to DRB configuration in LTE, NB-IOT and NR cells
- `uplink_tx_switch` parameter is added in NR cells
- `two_steps_prach` parameter is added to the elements of `prach_feature_preambles_list` for NR cells
- `forced_pmi` parameter is added in LTE cells
- `dl_bwp_id`, `ul_bwp_id`, `catm` and `redcap` fields are added to the response of the `ue_get` API command
- `multi_csi` added to the `pucch` object in NR cells
- use `trx_get_numa_nodes2` TRX API instead of `trx_get_numa_nodes`
- MME and AMF names added to `s1` and `ng` remote APIs and monitor commands
- added R17 values to `tdra_repetition_number` parameter of `pusch` object in NR cells

14.9 Version 2023-12-15

- X2AP ASN.1 is updated to v17.6.0
- added EPS user plane integrity protection
- added NGAP AMF status indication support
- added extended measurement identities and measurement objects support
- added support of TRX multi-thread API
- LTE PUCCH/PUSCH default p0-Nominal power is aligned with NR in the delivered configuration files
- allowed more CoReSet and PDCCH search spaces in NR cells. Added explicit parameters to select the search spaces. The `force_dci_0_0` and `force_dci_1_0` parameters were moved from the `uss` to the `pdcch` object
- `sdt` object is added to the `rrc_inactive` object for NR cells
- `sdt` value is added to the `prach_feature_preambles_list` array and `sdt` parameter to the `feature_priorities` object for NR cells
- `sdt_allowed` parameter is added to the NR DRB configuration objects
- `forced_sr_offset` parameter is added to the configuration of LTE and NR cells
- `br_forced_sr_offset` parameter is added to the `br_coverage_levels` array of LTE cells
- `power_256qam` and `power_1024qam` parameters are added to the `pdsch` object in NR cells
- `loop_count` and `loop_delay` parameters are added to remote API messages
- `sim_events_loop_count` and `sim_events_loop_delay` parameters are added
- `harq_process_disabled` parameter is added to the `pdsch` object for NR NTN cells
- `default_sma` and `default_elevation_offset` parameters are added to the `ntn` object for NB-IoT and NR cells
- `ue_dl_attenuation` and `ue_dl_gain_offset` parameters are added to the `ntn.channel_sim_control` object
- `a6_candidates` parameter is added in the `scell_list` object for LTE and NR cells
- `a6_report_type`, `a6_offset`, `a6_hysteresis` and `a6_time_to_trigger` parameters are added in the `scell_config` object for LTE and NR cells
- `scell_config` field is renamed to `scell_config_a4_a2` in `config_get` remote API
- `scell_config_a6` field is added in `config_get` remote API
- `ntn` parameter is added to `custom_freq_band` object
- `t_service` and `neigbour_cells` parameters are added to the `ntn` object for NR cells
- `cell_barred`, `cell_barred_5gc`, `cell_barred_redcap_1rx`, `cell_barred_redcap_2rx` and `cell_barred_ntn` parameters are added to `config_get` remote API
- `ims_emergency_support` and `ecall_over_ims_support` parameters are added to `sib_set` remote API
- `max_cc_preference` and `max_mimo_layer_preference` from `ue_assistance_information` can now change the NR cell behaviour if the UE reports them
- `altitude` parameter in `access_point_position`, `ground_position` and `ue_position` and `ntn_ground_position` parameters is now optional
- `reference_location` parameter is added to the `ntn` and `ncell_list` objects for NR cells
- `ul_snr_adapt_fer`, `cqi_adapt_fer` and `dl_snr_adapt_fer` parameters are now set to 0.1 by default
- `ul_snr_adapt_fer_lowse` and `cqi_adapt_fer_lowse` parameters are added for NR cells

- `ue_dl_freq`, `ue_ul_freq` and `feeder_doppler_shift` parameters are added to the `ntn.channel_sim_control` object
- `feeder_doppler_compensation`, `feeder_dl_freq` and `feeder_ul_freq` parameters are added to the `ntn` object for NR cells
- `unsupported_qci_fallback` and `unsupported_5qi_fallback` parameters are added
- `allow_rrc_bwp_switch` parameter is added to the NR cell configuration
- `rrc_based_bwp_switch` parameter is added to the `bwp_dynamic_switch` configuration
- `dl_bwp` and `ul_bwp` parameters are added to the `config_set` remote API
- `l_crb` parameter in `pdsch` configuration object in NR cells now accepts value 0
- `nr_handover_d1` parameter is added to `meas_config_desc` configuration object for NR cells
- `csg_indication` and `csg_id` parameters are added to LTE cells
- `csg_id` and `csg_hybrid` parameters are added to the `ncell_list` object for LTE cells
- `max_mimo_layers_r16` parameter is added to the `pdsch` object for NR cells
- `com_ssl_ca` parameter is added for SSL verification
- `s_measure` parameter is added to `meas_config_desc` object for LTE and NR cells

14.10 Version 2023-09-08

- NGAP ASN.1 is updated to v17.5.0
- XnAP ASN.1 is updated to v17.5.0
- Ethernet PDU session and PDN connectivity support is added
- default LTE aperiodic CQI reporting mode is changed to rm30 in the sample configuration files delivered to improve compatibility with UEs
- ALL_CE_LEVELS define is added to the enb-nbiot-standalone.cfg to test several CE levels
- the number of USS candidates in NR cells is increased in the sample configuration files delivered
- UDCB4 frequency shifter support is added in FR2 sample configuration files
- `x2disconnect` and `xndisconnect` remote APIs are added
- `ack_nack_r13` object is added to the `pucch_dedicated` configuration in LTE cells
- `ap_cqi_trigger_list` object is added to the configuration of LTE cells
- `subband_cqi_k` parameter is added to the configuration of LTE cells
- `sib16_time_reference_info` parameter is added in LTE cells
- `time_reference_info` parameter is added to `sib16` object in NB-IoT cells
- `reference_time_info` parameter is added to `sib9` object in NR cells
- `inclination` parameter in `ntn` object has now a more conventional range for NB-IoT or NR NTN configuration
- `tx_power_offset` parameter is added to RF port configuration
- `cpu_core_list` parameter is added to RF port configuration to control the list of cores used for multi threading
- `bwp_switch_k0` parameter of the `pdsch` object for NR cells has now a special value -1
- `srs_switching_time_request` and `uplink_tx_switch_request` parameters are added to LTE and NR cells
- `gtp_use_packet_bundling` parameter is added for GTP-U PDUs bundling support
- `epoch` parameter of the `ephemeris` configuration for NTN now accepts a formatted date input as string

- NUMA configuration automatically uses RF frontend driver information
- `n_harq_process` of the `pdsch` object for NR cell now supports the value 32
- the `prach-Config-v1430` SIB2 LTE RRC parameter is supported
- `forced_drx_start_offset` parameter is added to the DRX configuration for LTE and NR cells
- `eutra_handover_intra`, `eutra_handover_inter`, `eutra_cell_redirect_intra` and `eutra_cell_redirect_inter` parameters are added to LTE cells
- `nr_handover_intra`, `nr_handover_inter`, `nr_cell_redirect_intra` and `nr_cell_redirect_inter` parameters are added to NR cells
- ASN.1 content can be JER encoded (external file or directly inside configuration file)
- `prach_feature_preambles_list` parameter is added to NR cells and UL BWPs
- `feature_priorities` parameter is added to NR cells
- `msg3_repetition_number`, `msg3_repetition_mcs` and `msg3_repetition_rsrp_threshold` parameters are added to the `pusch` object of NR cells
- the `aperiodic_zp_csi_rs_resource_set` parameter is added to the `csi_rs` object in NR cells
- `n1_pucch_an_rep_count`, `an_rep_ul_snr_threshold` and `an_rep_factor` parameters are added to LTE cells
- `ntn_sv_file_update` remote API is deprecated
- `ntn_satellite_update` remote API is added
- `wus_config` configuration object is added for Cat-M1 cells
- `use_gap_fr` parameter is added to `meas_gap_config` object in NR cells

14.11 Version 2023-06-10

- NGAP ASN.1 is updated to v17.4.0
- added split 7.2 TRX API
- added LTE band 73 definition
- `sib1_delivery_during_ho` default value is changed from true to false
- `discardTimer`, `sr_prohibit_timer` and `t_Reassembly` in NR cells have new values
- `sib_enable` parameter is added to NR cells
- the `ssb_Index_RSRP` report quantity is supported with the `csi_ssb_resource_set` and `csi_ssb_resource_set_list` parameters
- `eci_reference` parameter is added to NTN configuration
- `default_ephemeris` parameter is added to NTN configuration
- `sib19` parameter is added to NR cell
- `ntn` configuration moved outside if the NB-IoT configuration and is now referenced by NB-IoT and NR
- `cell_id` parameter range is linked to the `gnb_id_bits` parameter for NR cells
- `dl_bwp_access` and `ul_bwp_access` parameters are added to restrict BWP configuration based on UE type
- `allow_1rx_ue` and `allow_2rx_ue` parameters are added to `redcap_ue` object
- `pollPDU`, `pollByte` and `t_StatusProhibit` parameters are added to `srb_config` object in LTE and NR cells
- `freq_hopping`, `freq_hopping_offsets` and `freq_hopping_index` parameters are added to NR PUSCH parameters for frequency hopping support

- `rrc_ul_segmentation_support` parameter is added to LTE and NR cells
- phy related logging parameters are moved in the phy layer object of `config_set/config_get` remote APIs
- `cell_gain` is not taken into account to compute the reference signal power
- `qam1024` value is added to the `mcs_table` parameter of the `pdsch` object
- 4 value is added to the `cqi_table` parameter of the `csi_report_config` items and default parameter value has changed
- `ssb_nr_arfcn` parameter is added to the `dl_bwp` object for RedCap BWPs
- `carrier_sense` object is added to LTE cell
- `ul_high_rate_threshold` and `ul_low_rate_threshold` parameters for `bwp_dynamic_switch` are also available in FDD
- `emergency_fallback_target` and `emergency_fallback_preferred_method` parameters are added to NR cells
- `emergency_fallback_preferred_method` parameter is added to `config_set` remote API
- `emergency_fallback_target` parameter is added to `config_get` remote API
- `tx_config` parameter of the `pusch` object in a NR cell can now take the value `non_codebook`
- `ncb_sri_bitmap` parameter is added to the `pusch` object in a NR cell
- `non_codebook` object is added to the `resource_auto` configuration for `srs` in a NR cell
- `q_qual_min` parameter is now optional in NR cells
- `delta_qual_min` parameter is added in NR cells
- `q_qual_min` and `q_qual_min_offset` parameters are added to LTE cells
- `com_logs_lock` parameter added to disable logs configuration change via remote API
- `pdsch_harq_ack_disable` and `random_data` parameters are added to load `test_mode` in NR cells
- `prach_detect_threshold` missing parameter description is added in LTE cells

14.12 Version 2023-03-17

- `com_addr` parameter now uses [::] address instead of 0.0.0.0 in the delivered configuration files to allow IPv6 connection
- added `config/gnb-sa-redcap.cfg` gNB sample configuration file for RedCap UEs
- updated RRC ASN.1 to release 17.3.0
- updated NR RRC ASN.1 to release 17.3.0
- added UL number of layers to t monitor command
- added LTE bands 54, 255 and 256 definition
- added NR bands 100, 101, 102, 104, 255 and 256 definition
- added FR1-FR1 NR-DC support
- added QCI10 definition to config/drb.cfg, config/drb_nb.cfg and config/drb_nr.cfg files
- number of UL layers used is added to the `t` monitor command
- NR cell configuration overhaul in a more organized presentation
- `wus_config` parameter is added to NB-IoT cells
- `cag_info_list` parameter description is fixed
- `ul_n_layer` and `ul_rank` parameters are added to `ue_get` remote API
- `rms_dbm` parameter is added to `stats` remote API
- `sv_filename` and `sv_filetype` parameters are added to the `ntn` object if NB-IoT cells

- `ntn_sv_file_update` remote API added
- `aggregation_factor` and `repetition_scheme` are added to the `pdsch` object in NR cells
- `aggregation_factor`, `tdra_repetition_number` and `available_slot_counting` are added to the `pusch` object in NR cells.
- `coreset_id` parameter is added to the `css` object of NR cells
- `csi_rs_nzp`, `csi_rs_zp` and `csi_rs_im` can now be arrays of objects in LTE cells. The field `scrambling_id` is added to `csi_rs_nzp`
- `prach` parameter is added to the objects of the `ul_bwp` array in NR cells
- `initial_dl_bwp_id` and `initial_ul_bwp_id` are added to the `redcap_ue` object in NR cells
- `dl_bwp_list` and `ul_bwp_list` are added to the `half_duplex` object in NR cells
- `n_symb` is added to the `resource_auto` object of `srs` object in NR cells
- `f_raster` parameter supports the value 15_30_100
- `delta_gscn` parameter supports the value 7
- `pdsch` object in `dl_bwp` items has all of its content optional and inherits from initial DL BWP
- `pusch` object in `ul_bwp` items has all of its content optional and inherits from initial UL BWP
- `sib3`, `sib4`, `sib5`, `sib6`, `sib7`, `sib24` and `sib27` parameters are added to sib_set remote API
- `hsdn` and `high_speed_config` parameters are added to NR cells
- `allowed_during_eps_fallback` parameter is added to NR `ncell_list` object
- `sib1_delivery_during_ho` parameter is added to NR cells
- `ignore_gbr_congestion` parameter is added to LTE and NR cells
- `alternate_retx_scheme` parameter is added to NR cells
- `tdd_ack_nack_feedback_mode_r10` default value is changed
- `sib1_repetition_period` parameter is added to NR cells
- `type2_immediate` and `type2_dynamic` are added to the `configuration_type` enumeration of the `configured_grant` object in NR cells for Type2 Configured Grant
- `rat_type` parameter values in `ntn` object are renamed. Older values are still supported for backward compatibility

14.13 Version 2022-12-16

- RRC ASN.1 is updated to v17.2.0
- S1AP ASN.1 is updated to v17.2.0
- NR RRC ASN.1 is updated to v17.2.0
- NGAP ASN.1 is updated to v17.2.0
- XnAP ASN.1 is updated to v17.2.0
- UE specific DRX cycle support is added in NR cells
- NGAP UE radio capability check procedure support is added
- `ul_freq_shift` is added to the RF port parameters
- `boosted_prbs` can be a string to automatically set the list of boosted PRBs
- `dynamic_k_offset`, `use_state_vectors`, `tle_filename`, `ground_position` and `channel_sim_control` parameters are added to the `ntn` object of NB-IoT cells

- `phy.ntn` log option is added
- `sr_with_harq` and `sr_grant_size` parameters are added to NB-IoT cells
- `snpn` and `cag_info_list` are added to `plmn_list` in the `nr_cell_list` object (NPN support)
- `sib10` object is added
- `dl_err` and `ul_err` added to `stats` remote API to count non transmitted transport blocks
- `configured_grant` is added to NR cells for UL Configured Grant
- `edrx` parameter is added to NR cells
- `automatic_requested_eutra_freq_bands` parameter is renamed to `automatic_eutra_cap_enquiry_params`. `automatic_requested_eutra_freq_bands` is still supported for backward compatibility
- `request_reduced_format` parameter is added to LTE cells
- `requested_eutra_freq_bands`, `requested_eutra_max_ccs_dl`, `requested_eutra_max_ccs_ul`, `request_reduced_format` and `request_eutra_reduced_int_non_cont_comb` parameters are added to NR cells
- `sib25` parameter added to `sib_set` remote API
- `ssb_offset` is documented for NR cells
- `uac_config` parameter added to `sib14` parameter
- `enhanced_skip_uplink_tx_dynamic_enabled`, `enhanced_skip_uplink_tx_configured_enabled` and `skip_uplink_tx_snr_threshold` parameters are added to NR cells
- `redcap_ue` parameter added for RedCap UE support
- `dpc_pucch_p_max`, `dpc_pucch_epre_max`, `dpc_pusch_p_max`, `dpc_pusch_epre_max` parameters added for LTE cells. `dpc_p_max` and `dpc_epre_max` parameters added for NR cells
- `tac_plmn` and `tac_5gc_plmn` parameters are added to `ncell_list` object
- defined a t-Reordering value for QCI/5QI using a NR PDCP with RLC AM to workaround a bug in some UEs locally dropping SN values without discard timer
- updated FR2 configuration files
- `utc` parameter is added to remote API response messages
- control usage statistics added to `stats` remote API

14.14 Version 2022-09-16

- RRC ASN.1 is updated to v17.1.0
- S1AP ASN.1 is updated to v17.1.0
- NR RRC ASN.1 is updated to v17.1.0
- NGAP ASN.1 is updated to v17.1.1
- added NUMA architecture support
- `distributed_vrb`, `use_n_gap_2` and `use_dci_1c` parameters are added for LTE cells
- cell id filter is added to `t` ue monitor command
- new filters are added to `t` monitor command
- the number of UL carriers is added to `t` monitor command
- `precoding_matrix` is added to `nzp_csi_rs_resource`
- `resource_auto` is added for automatic and responsive NR SRS configuration
- LTE band 103 definition is added
- `rai_enh_support` parameter is added to LTE and NB-IoT `mac_config` object

- `mr_dc_scg_release` remote API is added
- `subframe_offset` parameter is added to LTE and NB-IoT cells
- `mr_dc_request_nr_dc` parameter is added to LTE and NR cells
- `single_ue_cap_enquiry` parameter is added to LTE and NR cells
- `report_quantity` now supports CRI_RI_LI_PMI_CQI for NR CSI reporting configuration
- `ho_cfra` parameter is added to LTE cells
- `allowed_with_ims_dedicated_bearer` parameter is changed from a boolean to an enum. Backward compatibility is ensured
- `ue_assistance_information` parameter is added to NR cells
- `rrc_release_cell_reselection_priorities` parameter is added to NR cells
- `precoding_from_csi` parameter is added to NR `pdcch` object
- `two_harq_force` and `two_harq_interleaved_dl_ul` parameters are added to NB-IoT cells
- `br_scheduling_enhancement`, `br_pdsch_ten_processes` and `br_harq_ack_bundling` are added to `br_ue` objects of LTE cells
- `ntn` and `sib31` parameters are added for NTN support in NB-IoT cells
- `eutra_handover` parameter is added to LTE cells. It replaces `a3_report_type`, `a3_offset`, `a3_hysteresis`, `a3_time_to_trigger` and `a3_force_meas_id_on_pcell_earfcn` that are still supported for backward compatibility
- `nr_handover` parameter is added to NR cells. It replaces `a3_report_type`, `a3_offset`, `a3_hysteresis` and `a3_time_to_trigger` that are still supported for backward compatibility
- `a4_threshold_rsrp` and `a4_threshold_rsrq` parameters are added to `eutra_cell_redirect` object in LTE cells
- `a4_threshold_rsrp`, `a4_threshold_rsrq` and `a4_threshold_sinr` parameters are added to `nr_cell_redirect` object in NR cells
- `en_dc_setup` parameter is added to LTE cells. It replaces `nr_b1_report_type`, `nr_b1_rsrp`, `nr_b1_rsrq`, `nr_b1_sinr`, `nr_b1_hysteresis`, `nr_b1_time_to_trigger` and `nr_b1_gaps_required` that are still supported for backward compatibility
- renamed the `unrestricted_set_type_a` and `unrestricted_set_type_b` NR PRACH parameters to `restricted_set_type_a` and `restricted_set_type_b`
- values 35 and 45 are added to `bandwidth` parameter in NR cells
- added `mib` logging option
- `freq_shift` and `freq_doppler` are added to the `config_get` and `config_set` remote APIs
- `gtp_tx_bitrate` and `gtp_rx_bitrate` are added to the `stats` remote API
- `cross_pol_medium` and `cross_pol_high` MIMO correlation matrixes are added to channel simulator
- `erabs` and `qos_flows` objects are added to `ue_get` remote API

14.15 Version 2022-06-17

- OpenSSL library is upgraded to 1.1.1n
- added various speed improvements to the scheduler and GTP-U processing
- added a check to ensure that the cell configured fits in the band definition
- `m2ap_bind_addr` parameter description is added
- `cell_barred` parameter is added to `config_set` remote API for NR cells
- `pusch_switch_snr_threshold` and `pusch_switch_hysteresis` parameters are added
- `mac_crnti_ce_ignore_count` parameter is added

- `cell_rate_match_pattern`, `rate_match_pattern`, `rate_match_pattern_group1`, `rate_match_pattern_group2` and `rate_match_pattern_dci` parameters are added to specify PDSCH rate match patterns
- `stats` remote API is changed to use `drb_count` instead of `erab_count` for NR cells
- `freq_shift` parameter is added to the channel simulator paths
- `high_speed_train` parameter is added to the channel simulator
- `delay_spread` channel simulator parameter is added for the new `tdla`, `tdlb`, `tdlc`, `tdld` and `tdle` channel types
- `rb_list` parameter is added in the CoReSet definitions
- `start_timestamp` and `end_timestamp` are added to `log_get` API
- `phy.csi=1` log level is added for detailed NR CSI information from CSI reports
- `resource_auto` is added for automatic and easy NR CSI configuration
- `data_inactivity_timer` parameter is added to NR cell `mac_config` object
- missing `scells_activation` parameter description is added to NR cell
- `t_PollRetransmit_v1610` and `t_StatusProhibit_v1610` parameters are added to NR DRB configuration
- `discardTimerExt_r16` parameter is added to NR DRB configuration
- `dmrs_mapping_type_a` and `dmrs_mapping_type_b` are added in `pdsch` and `pusch` objects in NR cell
- `ptrs` object is added in PDSCH and PUSCH DMRS configuration
- `allowed_with_ims_dedicated_bearer` is added to LTE cell `nr_cell_redirect` and `nr_handover` objects
- S1AP ASN.1 is updated to v16.9.0

14.16 Version 2022-03-18

- NR-DC is supported (see `nr_dc_split`, `nr_dc_setup` and `nr_dc_scg_cell_list` parameters)
- `scg_failure_information` filter is added to `rrc_procedure_filter` in NR cells
- `ap_cqi_rm_opt` parameter is added to set the aperiodic CQI reporting mode when the transmission mode is greater or equal to 7
- `ho_cfra` parameter is renamed to `reconf_sync_cfra`. `ho_cfra` is still supported for backward compatibility
- `pucch_group_hopping` and `hopping_id` are now optional and configurable for each BWP
- `group_hopping_disabled` is added in NR cell `pusch` object
- `ecgi`, `ncgi`, `connected_mobility` and `ncell_list` objects are added to `config_get` remote API
- there is no more restriction with TDD PCell for NR CA
- `load` is added to the NB-IoT `test_mode`
- `rrc_ue_cap_enquiry` remote API can be used before the eNB has acquired the UE capabilities by its own, and adds the `ran_ue_id` parameter to the response
- added the `blanked_scs` NR cell parameter
- added the `max_mimo_layers_enabled` PDSCH NR cell parameter
- the gNB configuration files found in config folder are changed to use a cell SCS of 15kHz in FDD to improve the compatibility with the commercial UEs
- `p_ue` parameter is added to `ue_get` remote API

- `ran_ue_id` parameter is added to `rrc_ue_cap_enquiry` remote API response
- added channel estimation signal log for NR PUSCH and SRS
- added `scg_failure_information_behavior` configuration parameter
- added S1AP and NGAP reroute NAS request procedure
- improved NB-IoT scheduler
- added DL synchronization feature

14.17 Version 2021-12-17

- `npdcch_start_sf` in NB-IoT CP-EDT parameters replaces `npdcch_startSF_CSS_RA` and takes integer values
- `nprach_format2` parameter is added to support NPRACH format 2
- `dl_gap` parameter can now take an `explicit` value
- `reserved_dl_prbs` and `reserved_ul_prbs` parameters are added to reserve resources in a NR cell
- when `use_dci_0_1_and_1_1` parameter is set to false, no aperiodic SRS configuration is sent by default
- LPPa support for OTDOA and ECID is added
- NRPPa support for ECID is added
- `access_point_position` is added to give the coordinates of a cell (used for LPPa or NRPPa)
- NR CA can use up to 8 cells
- `two_steps_prach` object introduced for 2-steps RACH procedure support
- `npdcch_order_nprach` parameter introduced for PDCCH order in NB-IoT
- `pdcch_order_prach` object introduced for PDCCH order in NR
- `pdcch_order_prach` parameter introduced for PDCCH order in LTE
- `pdcch_order_prach` remote API and monitor command is added
- `k_min` parameter introduced to allow smaller k1/k2 value in NR
- `ho_cfra` parameter introduced to allow CFRA during SA handover
- `license` monitor command is added
- `rx_to_tx_latency` parameter in slot added to NR cell configuration
- `rx_to_tx_latency` RF port parameter is deprecated and should be replaced by `rx_to_tx_latency` parameter in NR cell configuration (note that this new parameter is in slot and not ms)
- `long_drx_cycle` NB-IoT configuration parameter now supports values 5120 and 10240
- `nr_support` parameter is renamed to `en_dc_support`. `nr_support` is still supported for backward compatibility
- `use_for_en_dc` parameter is renamed to `use_for_mr_dc_scg`. `use_for_en_dc` is still supported for backward compatibility
- `nr_scell_list` parameter is renamed to `en_dc_scg_cell_list`. `nr_scell_list` is still supported for backward compatibility
- `en_dc_release` parameter is renamed to `mr_dc_release`. `en_dc_release` is still supported for backward compatibility
- `en_dc_split_dl_ratio_change` monitor command is renamed to `mr_dc_split_dl_ratio_change`. `mr_dc_split_dl_ratio_change` is still supported for backward compatibility

- `p0_nominal_with_grant` value is changed from -76 to -84 in the delivered configuration files
- `p_max` is no more forced to 10dB in the NR cells of the delivered configuration files
- `sib23.asn`, `sib23_br.asn`, `sib23_br_ce.asn` and `sib23_nosrs.asn` files were renamed to `sib2_3.asn`, `sib2_3_br.asn`, `sib2_3_br_ce.asn` and `sib2_3_nosrs.asn` to make it obvious they contain a SIB2 and SIB3, not a SIB23
- NR cells now use 4 PDCCH candidates for CSS instead of 1 previously in the delivered configuration files
- a new gnb-sa-tdd-low-latency.cfg configuration file is delivered
- `config_get`/`config_set` remote APIs are updated to handle more logging options
- `srs_carrier_switching` parameter is added
- `max_mcs` parameter is added in NR cell `pusch` object
- `initial_ta` parameter is added to `ue_get` remote API
- `payload` and `text` parameters are added to `rrc_ue_cap_enquiry` remote API
- `handover_target` and `cell_redirect_target` parameters are added to exclude a neighbor cell from the corresponding procedures
- `eutra_cell_redirect` and `nr_cell_redirect` parameters are added to trigger measurement based intra RAT cell redirection procedures
- `mapping_type`, `start_symb` and `n_symb` parameters are now optional in the `pusch` configuration for NR.
- `partial_slots` parameters introduced in the `pusch` configuration to allow PUSCH scheduling on partial slots.
- aperiodic SRS is supported in NR
- `prs` object introduced for NR PRS support
- `long_pucch_an_rsc_count` default value is changed from 8 to 4
- `ecall_over_ims_support` parameter is added
- eNB automatically sends the requestedFrequencyBands-r11 field in the LTE RRC UE capability enquiry message for EUTRA RAT. The previous behavior can be restored by setting the `automatic_requested_eutra_freq_bands` parameter to false.
- S1AP ASN.1 is updated to v16.7.0
- X2AP ASN.1 is updated to v16.7.0

14.18 Version 2021-09-17

- the minimum GLIBC version is now 2.17
- ng-eNB functionality (LTE/LTE-M/NB-IoT UEs connected to a 5GC) is added. It requires a NR enabled license. See the config/enb.cfg or config/enb-2cell-ho.cfg files for a configuration example
- `cpu_core_list` parameter is added to control the list of cores used for multi threading
- logs can be displayed with microseconds precision
- PRACH repetitions in LTE-M are added
- `k0`, `k1`, `k2` and `msg3_k2` are computed automatically if they are ommited from the configuration file. The corresponding parameters can still be set manually if required
- `sul_prach`, `sul` and `serve_as_sul` parameters are added to support NR supplementary uplink
- `f_raster` parameter supports the value 15

- `fifteen_bearers` parameter is added to deactivate the 15 DRBs support in the eNB
- `freq_band_indicator_priority` parameter is added to support MFBI frequency band prioritization
- `pusch_hopping_type` and `pusch_hopping_index` parameters are added to control LTE PUSCH frequency hopping
- `scg_failure_information_nr` filter is added to `rrc_procedure_filter`
- `rrc_cnx_release_waitTime_5gc` parameter is added for the ng-eNB
- `idle_mode_mobility_control` parameter is added to control the mobility information sent to the UE in the LTE RRC connection release message
- `rrc_redirect_after_eps_fallback` parameter is added to manually set a redirection info after an EPS fallback procedure
- `eps_fallback_fast_return_preferred_method` parameter is added to trigger a return to the source NR cell (if present in the LTE neighbor cell list) after an EPS fallback procedure when the last IMS dedicated bearer is released
- `br_pdsch_flexible_start_prb` parameter is added to support R15 ce-PDSCH-FlexibleStartPRB-AllocConfig
- `ims_dedicated_bearer` parameter is added to indicate which QCI/5QI is used for IMS. The config/drb.cfg and config/drb_nr.cfg files set it for QCI/5QI 1, 2, 65, 66 and 67
- `restrict_to_ng_enb` parameter is added to indicate if the NR PDCP configuration of a given QCI if for the ng-eNB only, or if it is applicable to the eNB also. The config/drb.cfg file set if for all QCI except 9
- `truncated_5g_s_tmsi` parameter is added for NB-IoT control plane CIoT 5GS reestablishment
- `nprach_ta_min` parameter is added to control the NPRACH timing advance computation window
- UEs can experimentally connect to a cell with test mode activated. Test mode pdsch, pusch or load can be used to simulate a loaded cell
- NR_LONG_PUCCH_FORMAT define is added in the gNB configuration files found in config folder to easily switch between NR PUCCH format 2, 3 and 4
- S1AP ASN.1 is updated to v16.6.0
- X2AP ASN.1 is updated to v16.6.0
- RRC ASN.1 is updated to v16.4.0
- NGAP ASN.1 is updated to v16.6.0
- NGAP ASN.1 is updated to v16.6.0
- XnAP ASN.1 is updated to v16.6.0
- NR RRA ASN.1 is updated to v16.4.1

15 License

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Abbreviations

APN	Access Point Name
BWP	Bandwidth Part
CA	Carrier Aggregation
CIoT	Cellular Internet of Things
CQI	Channel Quality Indication
DL	Downlink
DRB	Data Radio Bearer
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
EN-DC	E-UTRA NR Dual Connectivity
ERAB	E-UTRA Radio Access Bearer
eRedCap	enhanced Reduced Capability
EPRE	Energy Per Resource Element
E-UTRA	Evolved UMTS Terrestrial Radio Access
FDD	Frequency Division Duplexing
HARQ	Hybrid Automatic Repeat reQuest
HSS	Home Subscriber Server
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
LTE	Long Term Evolution
MAC	Media Access Control
MBSFN	Multicast-Broadcast Single-Frequency Network
MBMS	Multimedia Broadcast Multicast Service
MBS	Multicast Broadcast Service
MCC	Mobile Country Code
MCG	Master Cell Group
MIMO	Multiple-Input Multiple-Output
MME	Mobility Management Entity
MNC	Mobile Network Code
MR-DC	Multi Radio Dual Connectivity
NAS	Non Access Stratum
NB-IoT	Narrow Band Internet of Things
NR	New Radio
NR-DC	NR Dual Connectivity
NSA	Non Stand Alone
NTN	Non Terrestrial Network

PAPR	Peak to Average Power Ratio
PCell	Primary serving cell
PDCP	Packet Data Convergence Protocol
PDN	Packet Data Network
PEI	Paging Early Indication
PLMN	Public Land Mobile Network
PMI	Precoding Matrix Indicator
PRG	Precoding Resource block Group
PRS	Positioning Reference Signals
QCI	QoS Class Identifier
QoS	Quality of Service
RAT	Radio Access Technology
RB	Resource Block
RedCap	Reduced Capability
RI	Rank Indicator
RLC	Radio Link Control
RMS	Root Mean Square
ROHC	Robust Header Compression
RRC	Radio Resource Control
SA	Stand Alone
SCG	Secondary Cell Group
SIB	System Information Block
SISO	Single-Input Single-Output
TDD	Time Division Duplexing
TMSI	Temporary Mobile Subscriber Identity
UE	User Equipment
UL	Uplink
USIM	Universal Subscriber Identity Module