# LTE Software eNodeB and NR Software gNB

Version: 2024-12-13

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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. Note that ciphering is subject to export rules depending on your country.
- 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.

## 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 4 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.
- PDSCH and PUSCH repetition support, including MSG3 repetitions.
- Small Data Transmission support (4-steps and 2-steps RA SDT)

## 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.

## 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 39 is the officially supported distribution.
  The following distributions are known as compatible:
  - Fedora 22 to 39
  - Cent OS 7
  - Ubuntu 14 to 22

  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 1.1.1w.
If your system does not have compatible version installed you may have this error message at startup:

```
error while loading shared libraries: libssl.so.1.1: cannot open shared object file: No su
```

To overcome this problem, you may:

- Copy libssl.so.1.1 and libcrypto.so.1.1 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 rxko 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. |
| `rxko` | Number of received uplink transport blocks with CRC errors. |
| `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

The monitor command `cell_gain` changes the relative DL power for a given cell. For example, use

```
cell_gain 1 -100
```

to mute the first cell (cell_id = 1). Use:

```
cell_gain 1 0
```

to restore the default output power.

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 URSP 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.
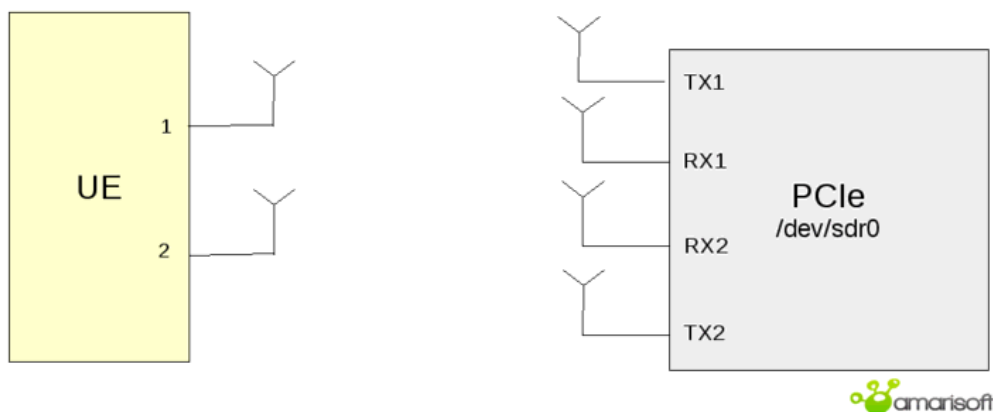


For TDD mode, you only need to connect antennas on the TX1 and TX2 connectors.

#### 7.9.1.2  N2x0 setup

To setup your MIMO environment with N2x0 device, here is a detailed diagram of how to proceed.
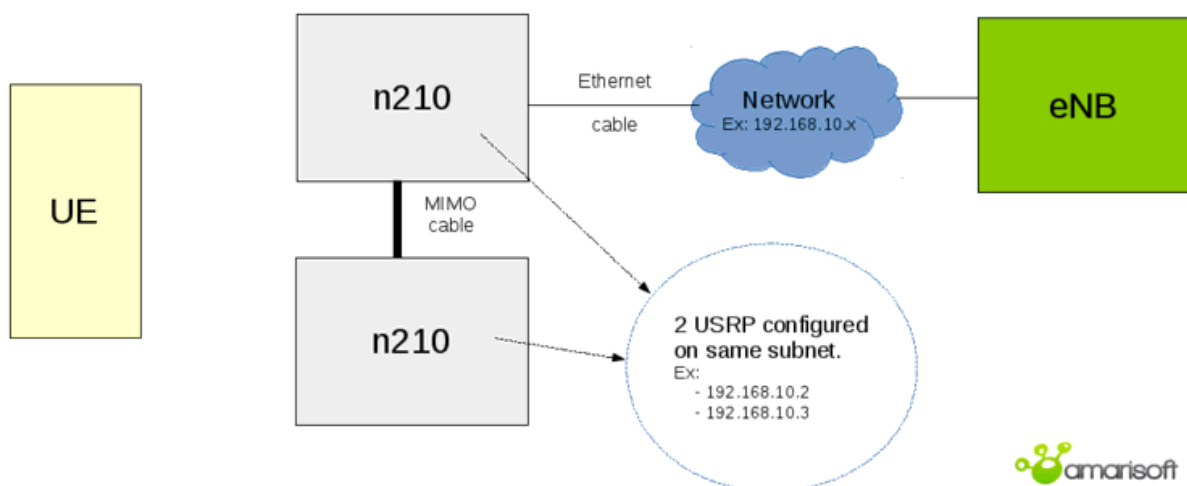
This configuration may have a bottle neck at ethernet side because USRP speed is limited to 1Gbps.

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:
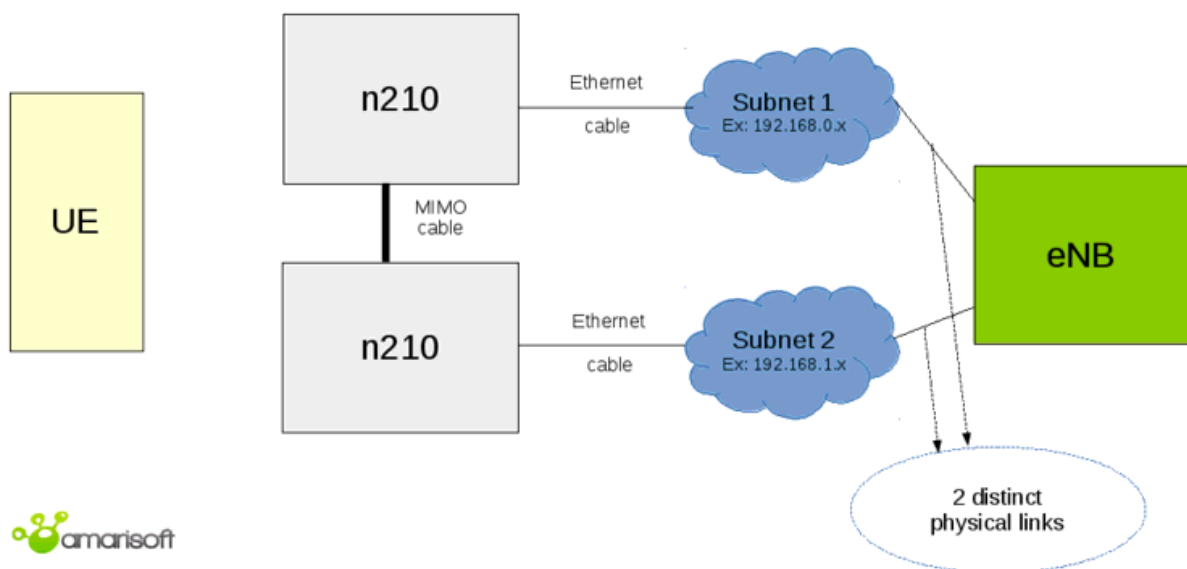


## 7.9.2  Using cable

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.
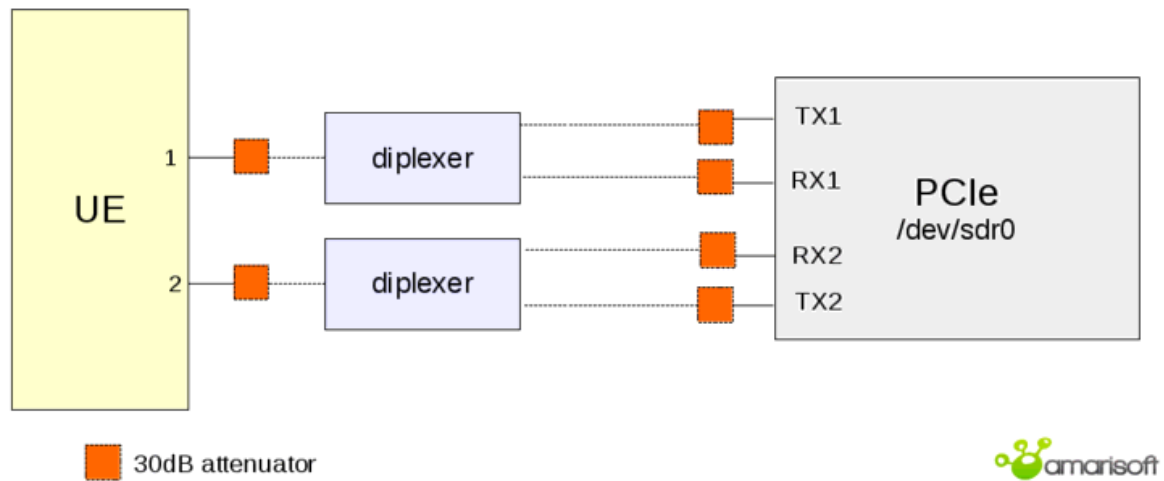
For TDD mode, you only need to connect TX1 and TX2.
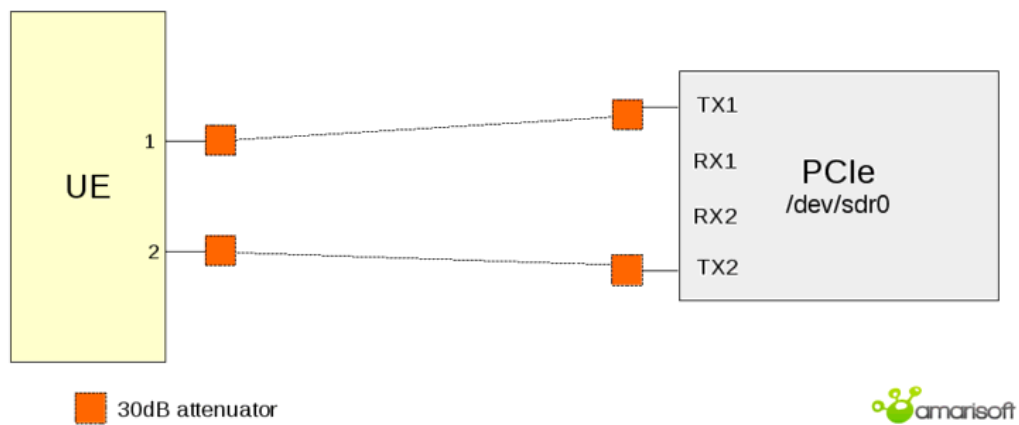
### 7.9.2.2 N2x0 setup

If you are using FDD mode, the general case will be:
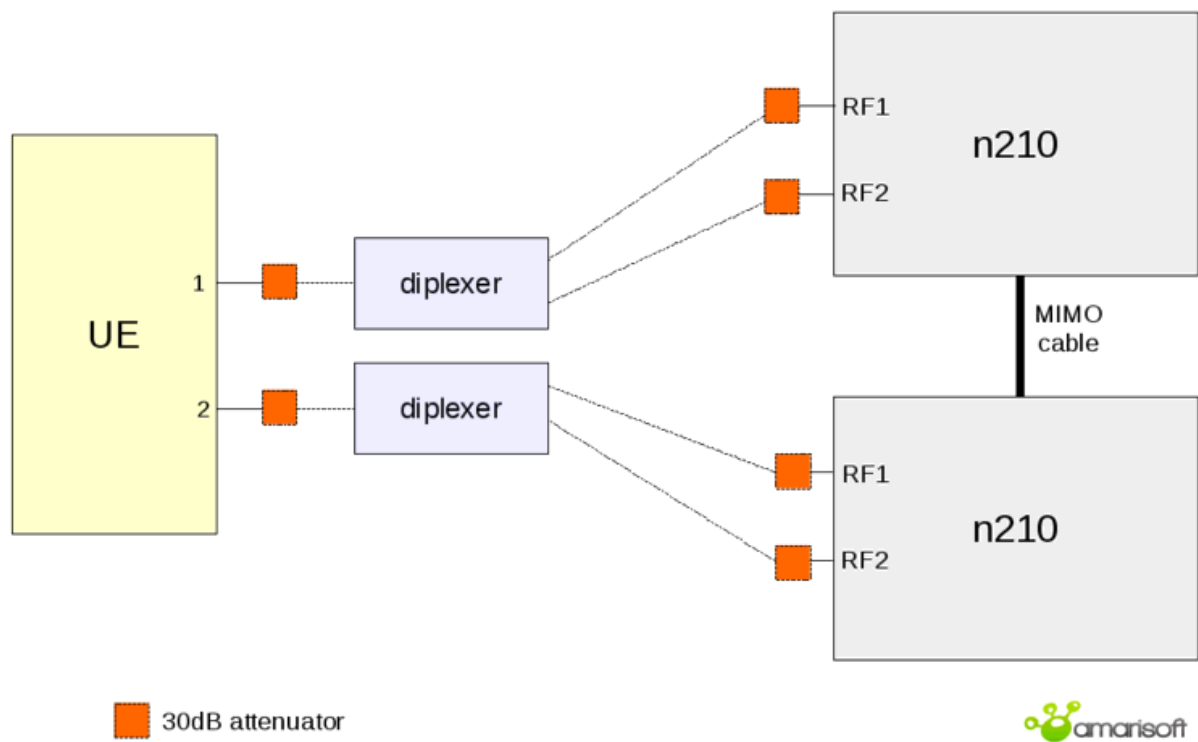


On most UE, second antenna is only used for RX so you can simplify with:
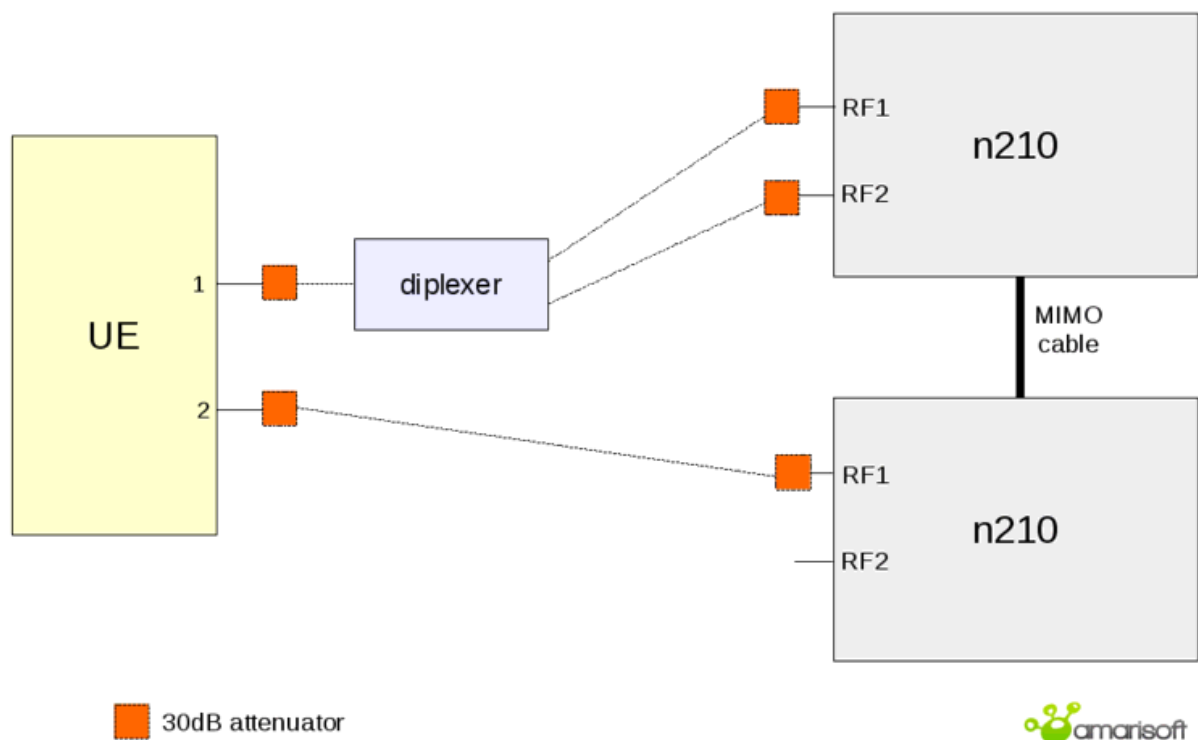
If your are using TDD mode, only one antenna is necessary per USRP.
Thus, you only need following diagram:
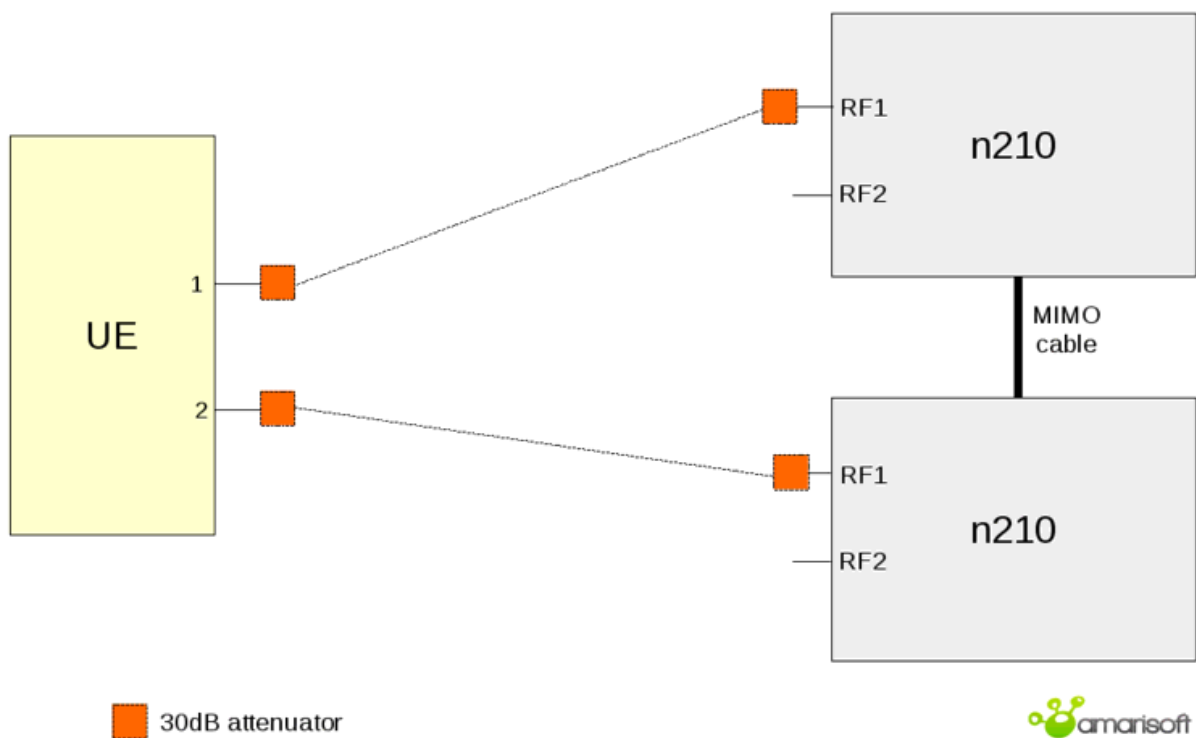


## 7.10 Carrier Aggregation support

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.
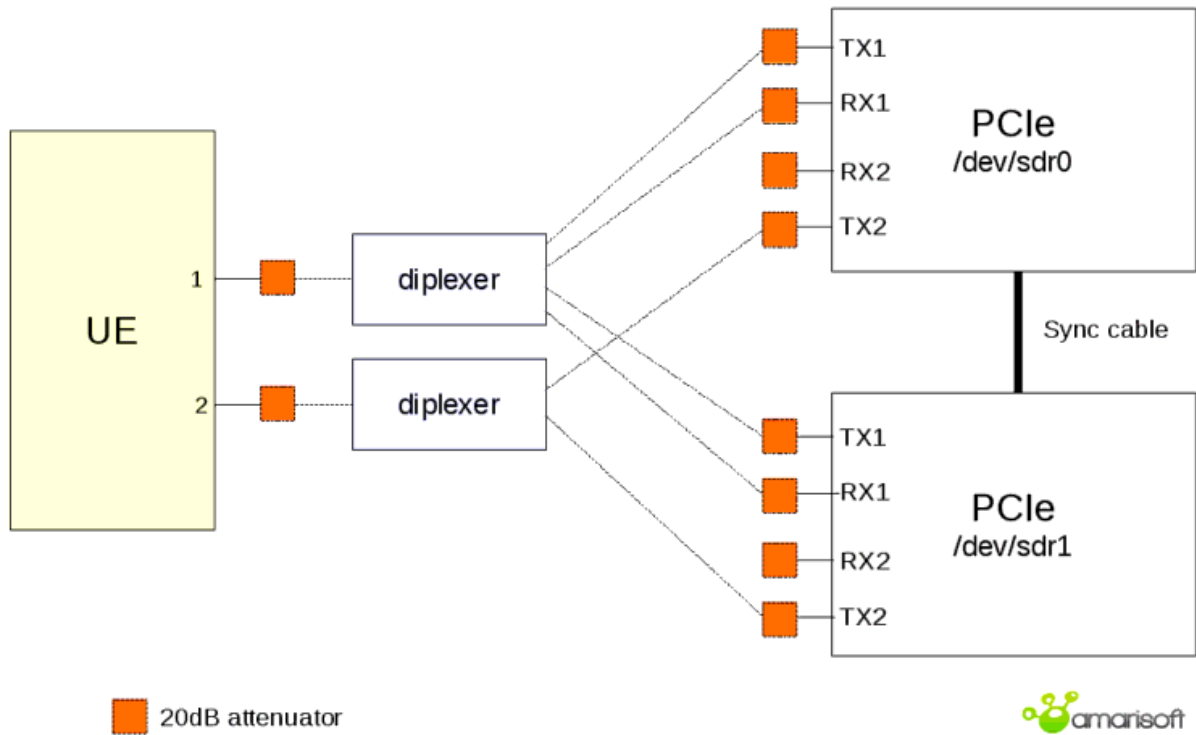


The configuration `enb-2cc.cfg` is an example of DL CA with 2 carriers in band 3 and band 7 (5+5 MHz). To use it in 2x2 DL MIMO 20MHz configuration, edit the file and change N_RB_DL to 100 and N_ANTENNA_DL to 2.

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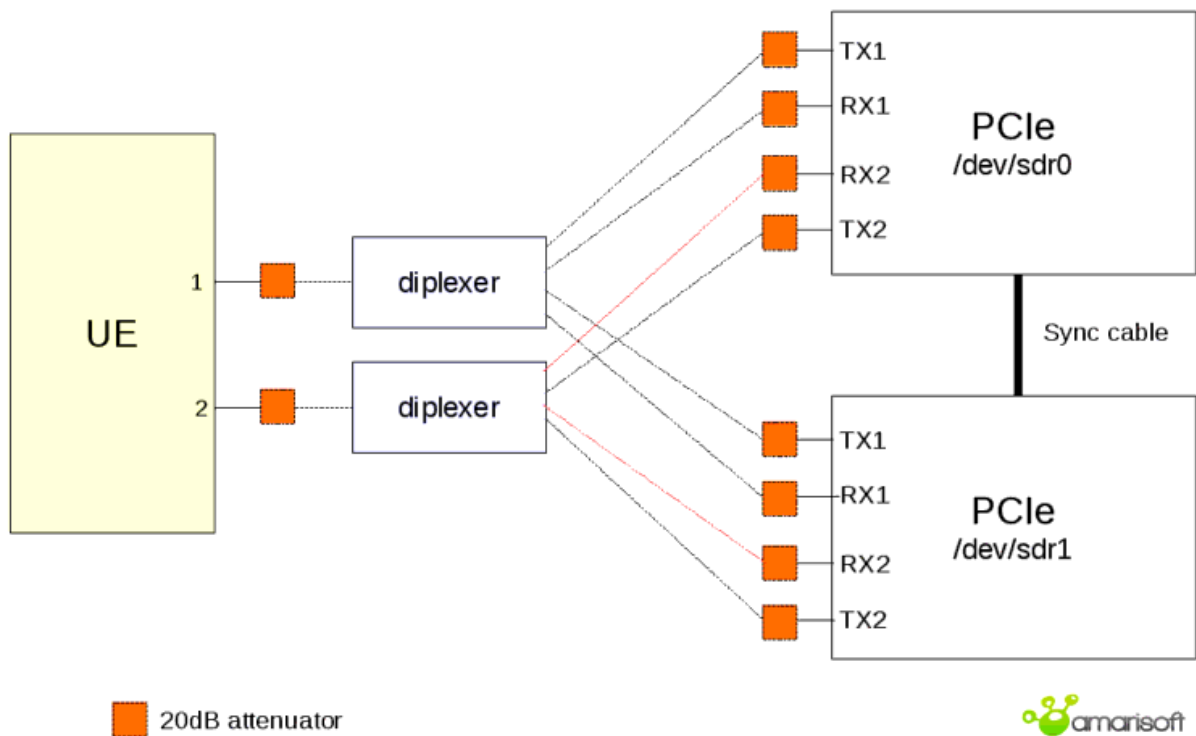
## 7.11 TDD support

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 90.

## 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 201.

# 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 280.

`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 hex-
>   adecimal.
> - *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 constel-
>   lations 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 repeti-
>   tions 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. Rename current log with timestamp and open new one.
> - file.rotate=*size*. Rename current log every time it reaches *size* bytes open new
>   one. Size is an integer and can be followed by K, M or G.
> - file.path=*path*. When log rotation is enabled, 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. Other-
>   wise, 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.

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

**mcc**        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 44.

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 218.
            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 220, 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 gives an event configuration to execute for this UE.
            Event configuration is exactly the same as for [Remote API], page 218, messages
            except that message field must be event.

sim_events_loop_count
            If set, will define `loop_count` for each event of `sim_events`, See [loop_count],
            page 219.

sim_events_loop_delay
            If set, will define `loop_delay` for each event of `sim_events`, See [loop_delay],
            page 219.

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 100.

`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 121.

`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 205.

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 205.

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.

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 197).
>
> 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.

**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,
    }
  }
],
```

**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 217).

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 280).

cmd

> String. Specifies the path to the script for the UDC configuration (See [UDC configuration reference], page 279). The script is called once for each configured `udc_port` with the following command line arguments:
>
> - `args`: (See [args], page 40)
> - `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. Frequency 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 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 217, 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 eNodeB 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 0 to 16777215). 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. |

**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 (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 (1 to `n_rb_dl`, default = `n_rb_dl`). Maximum number of UL resource blocks that can be used by the S-NSSAI.

**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: 0 to 65535. 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 technology for this neighbor cell. If set to `nr` the other properties must match a NR cell description. See [NR ncell_list], page 129.
>
> **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
: Integer. Range: 0 to 65535. Tracking Area Code.

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 Subscriber 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 0 to 16777215. 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 measurement 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 subframes are present in all neighbour cells'). Sets the neighbour cell information 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.

## 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 127.

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 following 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.

**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 10 integers (range: -1 to 28). 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.

**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.

**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 Infor-
mation 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 con-
figurations. 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 Ref-
erence 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 implicitly 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 90).

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 90).

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 90).

> 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 properties 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 retransmissions after which the UE is disconnected.

dl_max_consecutive_retx
> Optional Integer (default = 30). Maximum number of DL retransmissions 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. 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. 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.

**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 95. 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 semiPersistSchedInterval-valUL 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 dynamic 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 dynamic 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.

**skip_uplink_tx_snr_threshold**

>    Optional float (default = -8.0). SNR threshold on the PUSCH for skip uplink
>    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.

**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.

**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.

**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).
>    Note that ciphering is subject to export rules depending on your country.

**cipher_algo_null_allowed**

>    Optional boolean (default = true). If set to false, the use of NULL ciphering algo-
>    rithm (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 95.

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 string. Filename of the textual ASN.1 context (GSER syntax) 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 no filename is given and if meas_config_desc optional object is absent, no measConfig field is transmitted to the UEs.

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 83), 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 83), the eNB will also define an A6 event for SCell handover.

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. 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 43. 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 70,

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 70,

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 72,

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 72,

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 measure-
ment 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.

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.

> > **b1_gaps_required**
> >
> > > Optional boolean (default = true). Defines if gaps must be activated for the NR B1 measurement report.

**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_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).

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 90).

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 an A3 or A5 RRC measurement event is received from the UE, or when a periodical measurement indicates a neighbour cell RSRP higher than or equal to the serving cell RSRP; when `meas_config_desc` is used the eNodeB triggers a handover when the event defined in `eutra_handover` is reported. It is also used for the event defined in `nr_handover` triggering an inter RAT handover towards a NR cell.

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.

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.

**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. 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.

**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 99.

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 TS

`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 EU initial 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 modi-
fication 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 81)
                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 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], page 69.

If set to `api_only`, the SCell can only be added through the `rrc_cnx_reconf` API, see [rrc_cnx_reconf], page 261.

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: `always` or `off` (default = `always`). Selects how the eNB activates (with MAC Control element) 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 `always` is selected, all the SCells are activated right after their configuration.

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.
>
> 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 208.

**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.

## 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 connected 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.

**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". 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 65) 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. Required for a ng-eNB.

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 88.

### 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 0 to 16777215). 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.

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 100.

ul_prb
: See [NB-IoT frequency setting], page 100.

dl_earfcn
: See [NB-IoT frequency setting], page 100.

dl_carrier_freq_offset
: See [NB-IoT frequency setting], page 100.

ul_earfcn
: See [NB-IoT frequency setting], page 100.

ul_carrier_freq_offset
: See [NB-IoT frequency setting], page 100.

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: 0 to 65535. 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

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 105.

`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 105.

`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 209. It must contain the `si_periodicity`, `si_repetition_pattern` and `si_value_tag` objects described in `sib_sched_list`. See [sib_sched_list], page 105.

`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**

>  Integer. Logical Channel SR prohibit timer value in NPDCCH periods.
>  0 means that the timer is released.

**data_inactivity_timer**

>  Optional integer. 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 de-
>  fined:

>  **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 param-
>  >  eter, 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.

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 re-
>      sources 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 calcu-
>      >           lating 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.

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 100. 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 100. 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 100.

ul_prb      See [NB-IoT frequency setting], page 100. 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 100. 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 100.

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 106. 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 106. 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 false.
>
> 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 false). 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.

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 208.

sib14      Optional object used to configure the SIB 14. Contains the parameters defined for SIB 14 modification (See [sib14], page 269).
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.

## 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 sub-
carriers 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.

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.

**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. 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 defined:
>
> **drx_on_duration_timer_sub_ms**
>
> > Optional integer (range 1 to 31). drx-onDurationTimer parameter 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_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.

**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 0 to 16777215). 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 Differentiator.

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 PhysicalCellGroupConfig 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**
>        Integer. SI window length in slots. Must be present for a SA cell.

**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.

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

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 126.

             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 126.

sib19        Optional object. If present, the SIB19 message will be scheduled. SIB19 is nec-
             essary to enable NTN functionnality in the cell. See [Non Terrestrial Network],
             page 209. It must contain the si_periodicity, si_value_tag and area_scope
             objects described in sib_sched_list. See [NR sib_sched_list], page 126.

## 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 tech-
                          nology for this neighbor cell. If set to eutra the other properties must
                          match an EUTRA cell description. See [LTE ncell_list], page 47.

             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. 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.

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 no filename is given and if meas_config_desc optional object is absent, no measConfig field is transmitted to the UEs.

**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_d1` 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_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 143), 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 83), the gNB will also define an A6 event for SCell handover.

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.

This object contains the following fields:

**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.

**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 133,

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 133,

nr_handover_d1

> 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_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 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_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 136,

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 136,

**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.

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_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.

**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 an A3 or A5 RRC measurement event 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` 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 NSA 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 131.

If set to **api_only**, the SCell can only be added through the **rrc_cnx_reconf** API, see [rrc_cnx_reconf], page 261.

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: `always` or `off` (default = `always`). Selects how the gNB activates (with MAC Control element) 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 `always` is selected, all the SCells are activated right after their configuration.

**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 150. 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.

`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. maxRetxThreshold 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. Du-
> ration 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` or `both`. 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.
>
> If a corresponding configuration exists in the eNB (See [Configured
> Grant], page 192) and if the UE supports CG, a CG will be config-
> ured 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 150.

5qi_qos     Object. Default 5QI QoS characteristics to be used for this 5QI.

> 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 205.

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 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).
>
> Note that ciphering is subject to export rules depending on your country.

`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.
               Only RA-SDT is currently supported. For RA-SDT, the `prach_`
               `feature_preambles_list` should contain at least one preamble with
               `sdt`. See [prach_feature_preambles], page 178.
               SDT shall also be enabled per DRB basis. See [NR DRB configuration],
               page 145.
               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 logi-
                       cal channels configured with SDT. Value 0 means the timer
                       is not advertized 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.

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 85.

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 overheatingAssistance 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:

<blockquote>
<blockquote>
<blockquote>

`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.

</blockquote>

`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.

</blockquote>
</blockquote>

`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. SSB position bitmap in bits (4, 8 or 64 bits depending on the DL frequency).

`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.

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 (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).
>>
>> **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 186) 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 applied 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.

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 MSB.

The boolean value `true` is equivalent to the bitstring with 32 1's.

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.

n_layer  Optional integer (0 to `n_antenna_dl`, 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 position 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 number 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 (range -1 to 28, default = -1). PDSCH MCS. -1 means autonomous DL MCS adaptation by the gNB scheduler.

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 re-
                  sources 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 pres-
                  ence 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 $2^\mu$ 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_tap 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 208.

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. List of PRB indexes in which no PDSCH and PDCCH will be allocated.

**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,    re-
            stricted_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 195.
        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 cor-
>   responding 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 com-
>   bination 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   to-
>   tal_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 176.
>   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 parame-
>   >   ters 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 175.
>   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`, `cb_given`, `cf_given`). Defines the type of RACH triggered by the eNB: random contention-based preamble chosen by UE (ra-PreambleIndex = 0), dedicated contention-based preamble 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. Either the `pucch0` or `pucch1` object must be defined. Either the `pucch2`, `pucch3` or `pucch4` object must be defined.

> `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.

**p0_nominal**
> Integer (range -202 to 24). p0-nominal parameter.

**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`.

**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.

**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 paramer.

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).

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      transformPrecodingEn-
          abled.sequenceGroupHopping to disabled.

sequence_hopping
          Optional boolean (default = false).

ptrs      Optional object. PUSCH PT-RS parameters. If the ob-
          ject 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 position 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 number 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 antenna 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 bitstring should equal the number of SRS resources in the SRS set with non-codebook usage. Indicates the SRS resources 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 (range -1 to 28, default = -1). PUSCH MCS. -1 means autonomous UL MCS adaptation by the gNB scheduler.

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 `xOverhead` 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.

**skip_uplink_tx_snr_threshold**
> Optional float (default = -8.0). SNR threshold on the PUSCH for skip uplink 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.

**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.

`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 178.

`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.

`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 145.

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 186.

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.

`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 alloca-
           tion. 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 param-
           eter. 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`.

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 195.
           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 up-
                               linkConfig or in supplementaryUplink.

                     pusch     Optional enumeration: normal_only, sul_only, both (de-
                               fault = 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 up-
                               linkConfig 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 175.

uplink_tx_switch

Optional object. Controls the configuration of the R16 Uplink Tx Switch feature for this cell.

Uplink Tx Switch is supported in CA configuration with exactly two serving cells and in SUL configuration. Uplink Tx Switch will be enabled if the two cells have an `uplink_tx_switch` configuration with opposite `role` and `period_location`, and if the UE supports it.

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:

role        Enumeration: carrier1, carrier2. Determines the role of this cell for UL Tx Switching operation.

The cell chosen as `carrier2` needs to have at least 2 UL antennas.

period_location

Optional boolean (default = true if `role` is `carrier1`). Determines wether the UL Tx Switching period is located on this carrier.

If the cell is configured as `carrier2`, the following additional properties are available:

carrier2_slots

Optional array of booleans (default = true for all UL slots of a TDD cell, mandatory for FDD cells). Specifies the slots where UL will be fully switched to carrier 2.

The array length must divide $20 * 2^\mu$ and each element corresponds to a slot modulo the length of the array.

activation

Optional enumeration : immediate, ul_quality (default = immediate). Specifies when the UL Tx Switching operation will become effective.

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`.

If the cell is configured with `period_location` set to `true`, the following additional property is available:

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 (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 (1 to `n_rb_dl`, default = `n_rb_dl`). 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 migth 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 migth 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 176.

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_dl`, default = `n_rb_dl`). 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 overwritten 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 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 |-->-/
                 \--------/
```
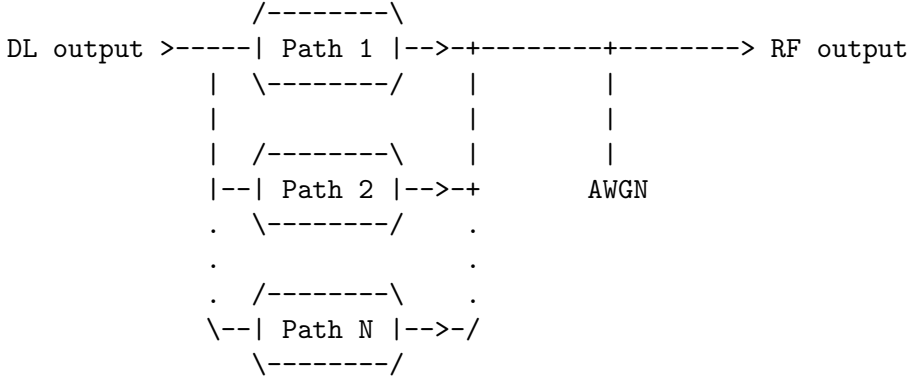
Preconfigured path configurations are available for common 3GPP channel models. Preconfigured 3GPP MIMO correlation matrixes are also available.

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 |
|------|-------------|
| 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).              |
| 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. |

**freq_doppler**

> For non AWGN channels, sets the doppler frequency, in Hz.

**delay_spread**

> Set the delay spread in ns for TDL channels (`tdla`, `tdlb`, `tdlc`, `tdld` and `tdle`).

**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.

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.

### 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` and high speed train model are not supported. Per-path `freq_shift` is 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).
The following `ntn` configuration object allows the cell in a NTN band to operate a NTN 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 205.
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.

`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`.
        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.

    `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 $\pi$. Inclination, in radians. Value between $\pi/2$ and $\pi$ 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 $2\pi$. Longitude of the ascending node, in radians.

**periapsis**

Float value. Range 0 to $2\pi$. Argument of periapsis, in radians.

**anomaly**    Float value. Range 0 to $2\pi$. 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.

In case the `ephemeris` parameter is absent, the default geostationnary 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. 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_drift_var

Optional float value (default = 0). Force the value of NTA-CommonDriftVariation, in us/s/s.

**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. This option is available for NR cells only.

**feeder_dl_freq**

> Optional integer (default = cell *UL* frequency). Sets the actual frequency 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 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 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.

`channel_sim_control`

> Optional object to automatically adjust the delay (and optionally the doppler shift) of the channel simulator.
>
> The channel simulator needs to be configured with only one `path` of `type:"constant"`.
>
> In the `path` object, only the value for `delay` will be updated, other values will stays as initially configured. 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 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`.

> `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 129) 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 100. The `sib31` scheduling information also needs to be configured in the cell. See [NB-IoT sib31], page 106.

## 8.9.2 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 121. The `sib19` scheduling information also needs to be configured in the cell. See [NR sib19], page 129.

# 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 80, 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 156, 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.

## 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 3 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.

- Response

  Message sent by server after any request message as been processed.
  Common definition:

  `message`    String. Same as request.

  `message_id`
          Optional any type. Same as in request.

  `time`    Number representing time in seconds since start of the process.
          Usefull to send command with absolute time.

  `utc`    Number representing UTC seconds.

- Events

  Message sent by server on its own initiative.
  Common definition:

  `message`    String. Event name.

  `time`    Number representing time in seconds.
          Usefull 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.

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.

`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
>
> > 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.
>
> **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. |

**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

**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.

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 downlink.

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.

> > > 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.

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 221).
> 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 10 integers (range: -1 to 28). 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 pro-
>  vided, 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.

`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.

`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 trans-
>  mission.

`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 78. See [NR cell ho_from_meas], page 142.

ho_force_full_config

> Optional boolean. If true, any handover towards this cell will use full configuration.

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` 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 Capability 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 sched-
>    uler 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 sched-
>    uler automatically chooses it.

`npusch_n_sc`

>    Optional enumeration: 1, 3, 6, 12. Maximum
>    number of subcarriers for NPUSCH. The eN-
>    odeB 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.

**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.

                  `freq_doppler`

                        Optional float. Set the Doppler frequency in Hz of all the paths with Rayleigh fading.

                  `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.

                        `freq_shift`

                              Optional float. Set the frequency shift in Hz of constant paths.

                        `freq_doppler`

                              Optional float. Set the Doppler frequency in Hz of paths with Rayleigh fading.

              `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.

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.

<table>
<tr><td></td><td>To get list of message, type <em>cevent help msg</em> in LTEENB monitor.</td></tr>
</table>

**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. Broadcast downlink bitrate in bits per seconds.

**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.

**dl_sched_users_avg**
Number. Average downlink scheduled users per TTI.

**dl_sched_users_max**
Number. Maximum downlink scheduled users per TTI.

**ul_sched_users_min**
Number. Minimum uplink scheduled users per TTI.

**ul_sched_users_avg**
Number. Average uplink scheduled users per TTI.

**ul_sched_users_max**
Number. Maximum uplink scheduled users per TTI.

**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 to message generated by server. Message definition:

register String or array of string. List of message to register to. Can be `ue_measurement_report`, `srs`, `pusch`, `npusch`.

unregister

> String or array of string. List of message to unregister. Can be `ue_measurement_report`, `srs`, `pusch`, `npusch`.

## 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 headroom 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 measured with PRACH, expressed in unit of TS.

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 277.
> 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). 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.

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 81).

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 82.

cell_reselection_priorities

    Optional [ASN.1 property], page 29. ASN.1 content of a CellReselec-
    tionPriorities 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 150).

**rrc_ue_info_req**

    Sends a UE Information Request message.
    Message definition:

enb_ue_id

    Integer. eNB 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).

**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 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 83. 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 143. 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.
      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 UE id (SA or NSA mode)

`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 configura-
        tion 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.

>    p_max           Optional integer or array of integers. New p-
>                    Max value.

>    timers_and_constants
>                            Optional object. See [timers_and_constants],
>                            page 128. Only applicable to NR cells.

>    uac_barring_info
>                            Optional object. See [uac_barring_info],
>                            page 127. 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 128. 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 access 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. EUTRA 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. EUTRA 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 System-InformationBlockType6 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 System-InformationBlockType7 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 51. `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 47. See [NR ncell_list], page 129.

`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 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 deactivate.

        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 209) 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.

## 10.7  LTE events

Following events are sent by eNB/ng-eNB/gNB if they have been registered on WebSocket.

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.

srs, pusch, npusch
          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 itslef.
          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 has the following definition:

label      String. Can be `rs` or `re`

> data        Array of string. Information related to the signal being decoded.
>             Check `log_get` API.

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 `signal.js` code inside `ltewww` software package.

## 10.8 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"
    }
```

## 10.9 DL synchronization

For more details about this feature, please read [DL synchronization], page 215.

### 10.9.1 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. In-
                        cludes 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.

### 10.9.2 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 205.

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

rrc_cnx_release *UE_ID* [*redirect_type*]
: Forces a RRC connection release. See [rrc_cnx_release], page 259, in remote API.

rlc_drop_rate *UE_ID* *rb_id* *rate* [*is_srb*]
: Define a *rate* percentage of uplink RLC PDUs dropped.

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.

# 12 UDC configuration reference

The UDC configuration is made by the script `udc-auto-cfg.sh`. For the input parameters See [cmd], page 40. 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 40). 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, PCFICH,
            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 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 eRedCap 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

## 14.2 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

## 14.3  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

## 14.4 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

## 14.5 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

## 14.6 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

## 14.7 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

## 14.8  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

## 14.9 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

## 14.10   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

## 14.11  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

## 14.12 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

## 14.13 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

## 14.14  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 |
| 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 |