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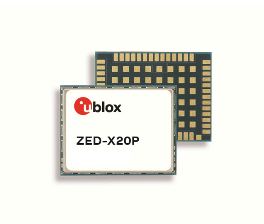
ZED-X20P

All-band high precision GNSS module

Professional grade

Integration manual



Abstract

This document describes the ZED-X20P high precision module with all-band GNSS receiver. The module provides all-band RTK with fast convergence times, reliable performance and easy integration of RTK for fast time-to-market. It has a high update rate for highly dynamic applications and centimeter-level accuracy in a small and energy-efficient module.

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Contents

1 System description

This document is an important source of information for all aspects of ZED-X20P software and hardware design. The purpose of this document is to provide guidelines for a successful integration of the receiver with the customer's end product.

1.1 Overview

ZED-X20P is an innovative all-band receiver module designed to revolutionize positioning technology in industrial applications. Built upon the u-blox new generation receiver platform, this module offers multi-band GNSS capability, supporting bands including L1, L2, L5, and L6. With its comprehensive coverage, ZED-X20P ensures precise and reliable positioning even in challenging environments, setting a new standard in accuracy.

Equipped with integrated u-blox multi-band real-time kinematic (RTK) and precise point positioning real-time kinematic (PPP-RTK) technologies, achieves centimeter-level accuracy, enabling precise navigation and automation in industrial and consumer-grade products. Despite its advanced capabilities, ZED-X20P maintains a compact surface-mounted form factor, measuring only 17.0 x 22.0 x 2.4 mm, ensuring seamless integration into various applications without compromising performance.

In this document, RTK refers to an observation state representation (OSR) based solution utilizing radio technical commission for maritime services (RTCM) corrections, while PPP-RTK refers to state space representation (SSR) based solution using safe position augmentation for real-time navigation (SPARTN). With its comprehensive features and advanced technologies, ZED-X20P offers unparalleled accuracy and reliability, making it the ideal choice for applications requiring high-performance positioning solutions.

1.2 Real time kinematic

u-blox ZED-X20P high precision receiver takes GNSS precision to the next level:

- Delivers accuracy down to the centimeter level: 0.01 m + 1 ppm CEP.
- Fast time to first fix and robust performance with multi-band, multi-constellation reception.
- Compatible with leading correction services for global coverage and versatility.

Some typical applications for the ZED-X20P are shown below:

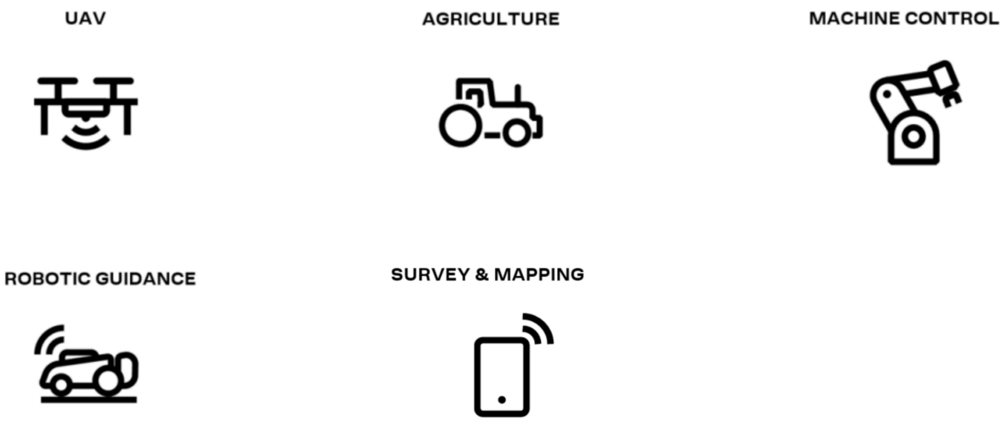

Figure 1: Typical applications for the ZED-X20P

1.2.1 RTK modes of operation

The ZED-X20P supports the following modes of operation:

1. ZED-X20P operating as a base: It provides RTCM correction data to a rover, or to a network of rovers.
2. ZED-X20P operating as a rover: It receives RTCM correction data from a ZED-X20P operating as a base, or from a VRS service provider operating a network of base receivers.

1.2.2 PPP-RTK modes of operation

The ZED-X20P operating as a rover supports the following additional operation modes:

- It can receive SPARTN correction data via internet from the service provider

1.2.3 NTRIP - networked transport of RTCM via internet protocol

Networked Transport of RTCM via internet protocol, or NTRIP, is an open standard protocol for streaming differential data and other kinds of GNSS streaming data over the internet in accordance with specifications published by RTCM.

The NTRIP protocol is also used by SSR correction service providers to stream SSR correction data over the internet (e.g. SPARTN corrections).

There are three major parts to the NTRIP system: The NTRIP client, the NTRIP server, and the NTRIP caster:

1. The NTRIP server is a PC or an on-board computer running NTRIP server software communicating directly with a GNSS reference station. The NTRIP server serves as the intermediary between the GNSS receiver (NTRIP Source) streaming correction data and the NTRIP caster.
2. The NTRIP caster is an HTTP server which receives streaming correction data from one or more NTRIP servers and in turn streams the correction data to one or more NTRIP clients via the internet.
3. The NTRIP client receives streaming correction data from the NTRIP caster to apply as real-time corrections to a GNSS receiver.

u-center 2 GNSS evaluation software provides a NTRIP client and server application that can be used to easily evaluate a ZED-X20P base or rover. Typically a u-center 2 NTRIP client connects to an NTRIP service provider over the internet. The u-center 2 NTRIP client then provides the corrections to a ZED-X20P rover connected to the local u-center 2 application. VRS service is also supported by the u-center 2 NTRIP client.

1.3 Typical ZED-X20P application setups

Two application examples are illustrated below as typical system implementations. Both are representative of a simple "short baseline" setup in which the base and rover receivers are within a few hundred meters of each other. In Figure 2 and Figure 3 ZED-X20P is used as a base station providing corrections to a ZED-X20P rover receiver.

Alternatively, the rover can use corrections provided over longer baselines from a correction stream distributed as a subscription service. This method can use a single fixed reference source which is local (within 50 km) to the rover receiver or via a VRS service in which corrections are synthesized based on the rover's location.

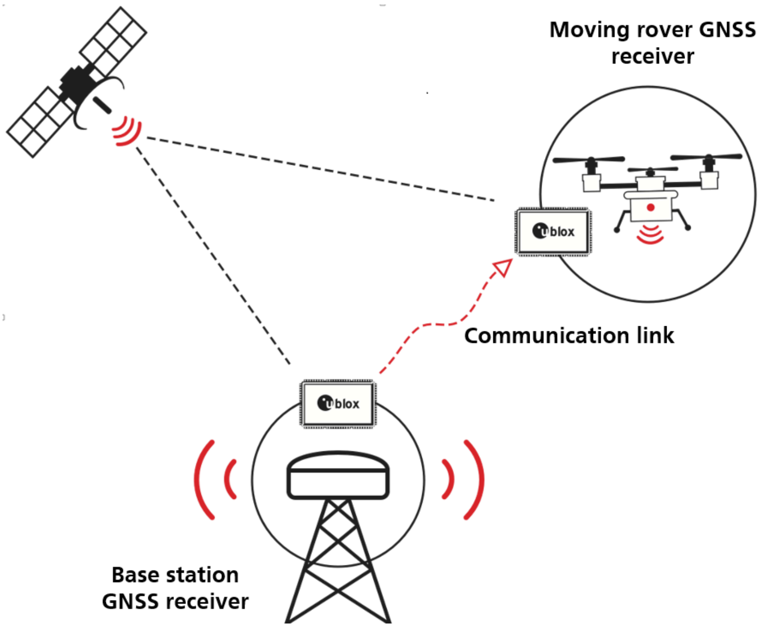

Figure 2: ZED-X20P base and rover in a short baseline drone application

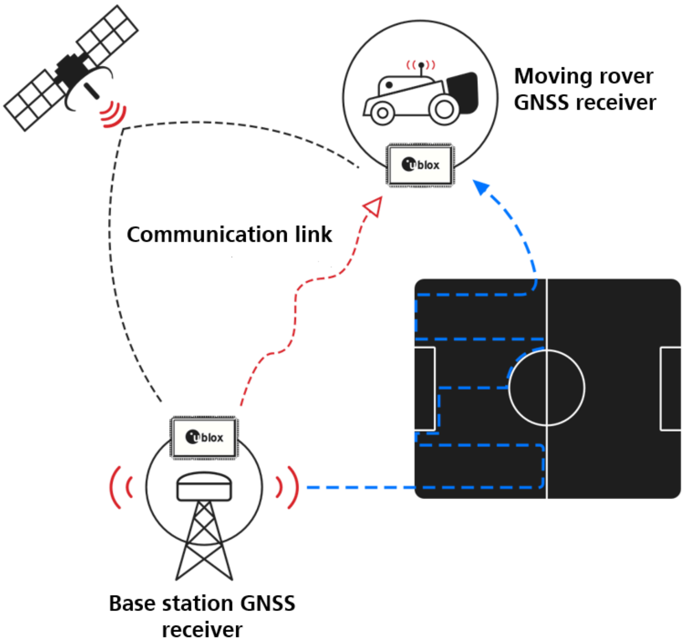

Figure 3: ZED-X20P base and rover in a short baseline robotic mower application

1.4 Block diagram

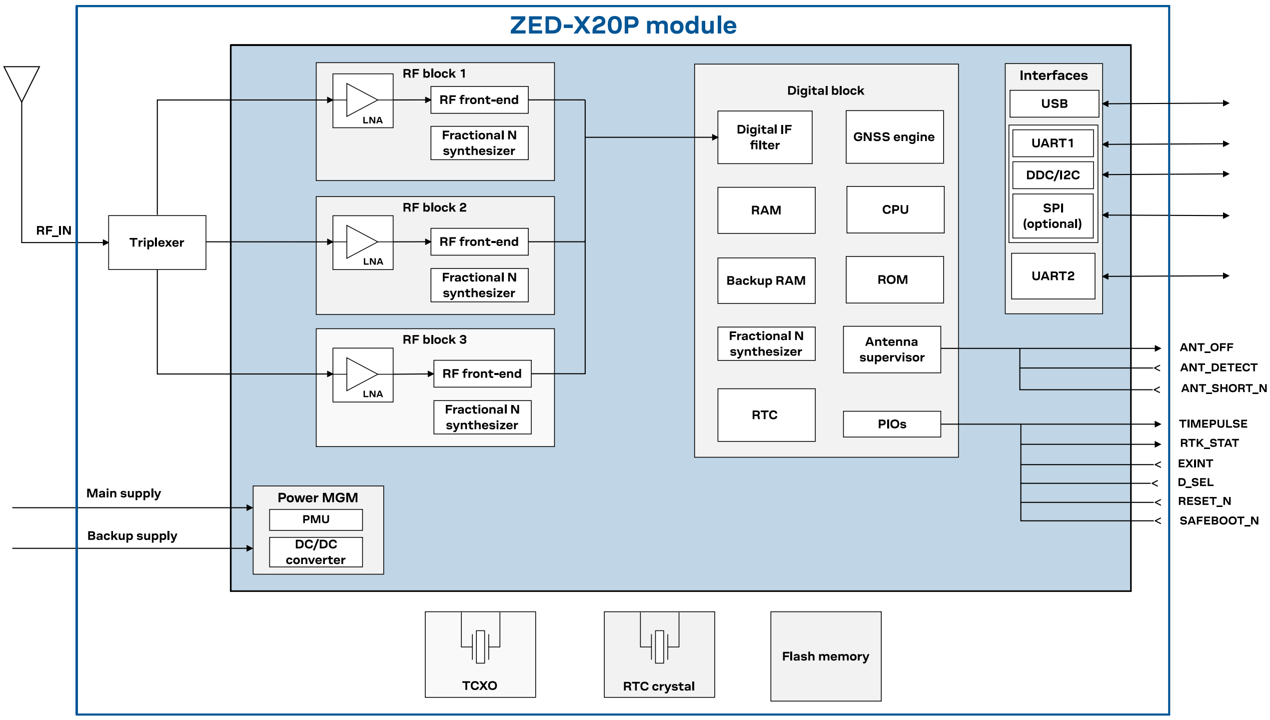

Figure 4: ZED-X20P block diagram

1.5 Pin assignment

The pin assignment of the ZED-X20P module is shown in Figure 5. The defined configuration of the PIOs is listed in Table 1.

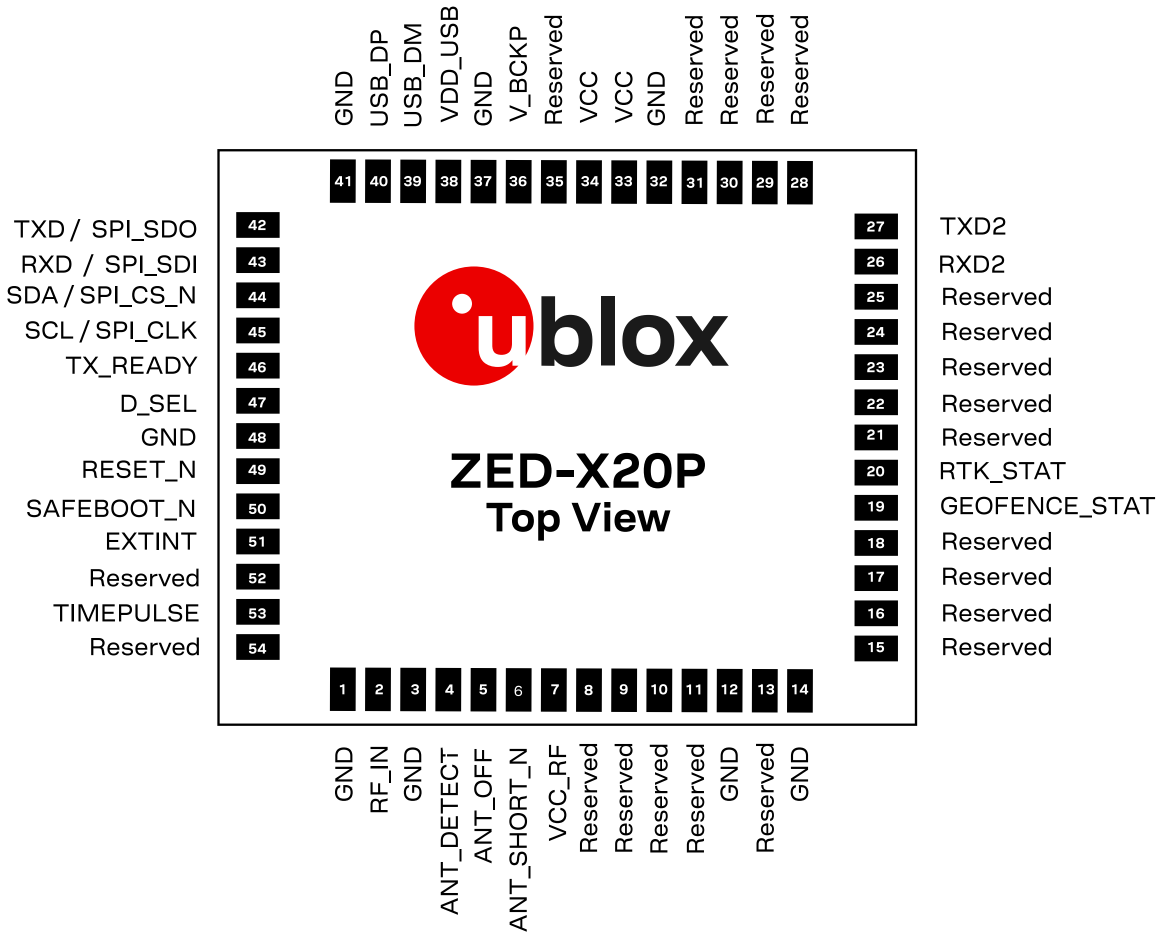

Figure 5: ZED-X20P pin assignment

Pin no.	Name	I/O	Description
1	GND	-	Ground
2	RF_IN	I	RF input
3	GND	-	Ground
4	ANT_DETECT	I	Active antenna detect - default active high
5	ANT_OFF	O	External LNA disable - default active high
6	ANT_SHORT_N	I	Active antenna short detect - default active low
7	VCC_RF	O	Voltage for external LNA
8	Reserved	-	Reserved
9	Reserved	-	Reserved
10	Reserved	-	Reserved
11	Reserved	-	Reserved
12	GND	-	Ground
13	Reserved	-	Reserved
14	GND	-	Ground
15	Reserved	-	Reserved
16	Reserved	-	Reserved
17	Reserved	-	Reserved

Pin no.	Name	I/O	Description
18	Reserved	-	Reserved
19	GEOFENCE_STAT	O	Geofence status, user defined
20	RTK_STAT	O	RTK status: 0 = RTK/PPP-RTK fixed blinking = receiving and using corrections 1 = no corrections
21	Reserved	-	Reserved
22	Reserved	-	Reserved
23	Reserved	-	Reserved
24	Reserved	-	Reserved
25	Reserved	-	Reserved
26	RXD2	I	Correction UART input
27	TXD2	O	Correction UART output
28	Reserved	-	Reserved
29	Reserved	-	Reserved
30	Reserved	-	Reserved
31	Reserved	-	Reserved
32	GND	-	Ground
33	VCC	I	Voltage supply
34	VCC	I	Voltage supply
35	Reserved	-	Reserved
36	V_BCKP	I	Backup supply voltage
37	GND	-	Ground
38	VDD_USB	I	USB supply
39	USB_DM	I/O	USB data
40	USB_DP	I/O	USB data
41	GND	-	Ground
42	TXD / SPI_SDO	O	Host UART output if D_SEL = 1 (or open). SPI_SDO if D_SEL = 0
43	RXD / SPI_SDI	I	Host UART input if D_SEL = 1 (or open). SPI_SDI if D_SEL = 0
44	SDA / SPI_CS_N	I/O	I2C Data if D_SEL = 1 (or open). SPI Chip Select if D_SEL = 0
45	SCL / SPI_CLK	I/O	I2C Clock if D_SEL = 1 (or open). SPI Clock if D_SEL = 0
46	TX_READY	O	TX_Buffer full and ready for TX of data
47	D_SEL	I	Interface select for pins 42-45
48	GND	-	Ground
49	RESET_N	I	RESET_N
50	SAFEBOOT_N	I	SAFEBOOT_N (for future service, updates and reconfiguration, leave OPEN)
51	EXTINT	I	External interrupt pin
52	Reserved	-	Reserved
53	TIMEPULSE	O	Time pulse
54	Reserved	-	Reserved

Table 1: ZED-X20P pin assignment

2 Receiver configuration

The configuration determines all aspects of the GNSS receiver operation and therefore, information in this section is essential for the successful integration of ZED-X20P.

ZED-X20P is configured using UBX configuration interface keys. The configuration database in the receiver's RAM holds the current configuration, which is used by the receiver at runtime. It is constructed at the receiver startup from several sources of configuration. For more information on the receiver configuration, see the Interface description [2].

The configuration can be stored in the RAM, battery-backed RAM (BBR), and flash memory. The permanence of the stored configuration and the actions to clear it in each memory are listed in Table 2.

Memory	Permanence of storage	Clearing actions
RAM	Settings remain effective until power-down	• Activating the RESET_N pin • A UBX-CFG-RST message excluding GNSS stop (resetMode 0x08) and GNSS start (resetMode 0x09) • Entering software standby mode
BBR	The receiver retains the settings stored as long as the backup power supply remains	• Activating the RESET_N pin • A UBX-CFG-RST message with reset mode set to a hardware reset (resetMode 0x00 and 0x04)
Flash	Permanent storage of the configuration settings	• A UBX-CFG-CFG message to erase the configuration on the flash layer

Table 2: Permanence of storage and clearing actions for each memory

It is recommended to apply runtime configuration on both RAM and BBR or flash memory layers. For more information about the UBX-CFG-RST message, refer to Forcing receiver reset.

The configuration interface settings are stored in a database consisting of separate configuration items. An item is made up of a pair consisting of a key ID and a value. Related items are grouped together and identified under a common group name: CFG-GROUP-*; a convention used in u-center 2 and within this document. Within u-center 2, a configuration group is identified as "Group name" and the configuration item is identified as the "item name" in the "Device configuration" window.

The UBX messages available to change or poll the configurations are the UBX-CFG-VALSET, UBX-CFG-VALGET, and UBX-CFG-VALDEL messages. For more information about these messages and the configuration keys, see the configuration interface section in the Interface description [2].

2.1 Basic receiver configuration

This section summarizes the most commonly used, basic receiver configurations.

2.1.1 Basic hardware configuration

The ZED-X20P receiver is configured with the default settings during the module production. The receiver starts up and is fully operational as soon as proper power supply, communication interfaces and antenna signal from the host application device are connected.

2.1.2 GNSS signal configuration

The GNSS constellations and signal bands are selected using keys from the CFG-SIGNAL-*. configuration group ZED-X20P is an all-band receiver that can concurrently select signals of all

GNSS bands.Each GNSS constellation can be enabled or disabled independently except for QZSS[1] and SBAS[2]. A GNSS constellation is considered to be enabled when the constellation enable key is set and at least one of the constellation's band keys is enabled.

ZED-X20P only supports certain combinations of constellations and bands. For all constellations L1 band is mandatory, a combination of L1 and L2 or L1 and L5 or L1,L2 and L5 must either be enabled or disabled. Unsupported combinations will be rejected with a UBX-ACK-NAK and the warning: "inv sig cfg" will be sent via UBX-INF and NMEA-TXT messages (if enabled).

The following table shows possible configuration key combinations for the Galileo constellation.

Constellation key CFG-SIGNAL-GAL_ENA	Band key CFG-SIGNAL-GAL_E1_ENA	Band key CFG-SIGNAL-GAL_E5A_ENA	Band key CFG-SIGNAL-GAL_E6_ENA	Constellation enabled?
true (1)	true (1)	true (1)	true (1)	**yes**
true (1)	true (1)	true (1)	false (0)	**yes**
true (1)	true (1)	false (0)	true (1)	**yes**
true (1)	true (1)	false (0)	false (0)	**yes**
true (1)	false (0)	true (1)	true (1)	**no**
true (1)	false (0)	false (0)	true (1)	**no**
true (1)	false (0)	true (1)	false (0)	**no**
true (1)	false (0)	false (0)	false (0)	**no**
false (0)	true (1)	true (1)	true (1)	**no**
false (0)	true (1)	true (1)	false (0)	**no**
false (0)	true (1)	false (0)	true (1)	**no**
false (0)	false (0)	true (1)	true (1)	**no**
false (0)	false (0)	false (0)	true (1)	**no**
false (0)	false (0)	true (1)	false (0)	**no**
false (0)	true (1)	false (0)	false (0)	**no**
false (0)	false (0)	false (0)	false (0)	**no**

Table 3: Example of possible values of configuration items for the Galileo constellation

2.1.2.1 Default GNSS configuration

The ZED-X20P default GNSS configuration is set as follows:

ZED-X20P-00B:

- GPS: L1C/A, L2C, L5[3]
- Galileo: E1B/C, E5a, E6
- BeiDou: B1I[4], B1C, B2a, B3I
- QZSS: L1C/A
- SBAS: L1C/A

1 QZSS can be enabled only if GPS is selected
2 SBAS can only be enabled with at least one of GPS, GAL and BDS
3 GPS L5 is tracked but not used in navigation by default
4 B1I is only used for acquisition

For more information about the default configuration, see the applicable Interface description [2].

2.1.3 GPS L5 signal health status configuration

ZED-X20P supports GPS L1 C/A, L2C and L5 signals. Broadcasting of Civil Navigation (CNAV) messages on the L5 signal began in April 2014. At the time of writing, GPS L5 signals remain pre-operational which are set unhealthy until sufficient monitoring capability is established.

To evaluate GPS L5 signals before they become fully operational, the receiver can be configured to ignore the GPS L5 health status by overriding it with the respective GPS L1 C/A signal status.

⚠ Do not use unhealthy, pre-operational GPS L5 signals for safety-of-life or other critical purposes. This is an operational issue concerning the satellites / space segment and not a limitation or specific configuration of u-blox products.

To ignore the GPS L5 signal health status and override it with the respective GPS L1 signal health status, send the configuration string given in Table 4. The configuration can be stored in RAM, battery-backed RAM (BBR), and flash layers. Stored in the RAM layer, the device returns the UBX-ACK-ACK message if the configuration is sent successfully and it is applied immediately without a configuration reset. To apply the configuration stored in the BBR and flash layers, send the UBX-CFG-RST message with resetMode 0x01.

To revert back to the default configuration, send the configuration string given in Table 5. The device returns the UBX-ACK-ACK message if the configuration is sent successfully and it is applied immediately without a reset in the RAM layer. To apply the configuration stored in the BBR and flash layers, send the UBX-CFG-RST message with resetMode 0x01.

⚠ Customers who choose to ignore the GPS L5 signal health status in their production system do so at their own risk and must be fully aware of the implications. The system should also include a mechanism to revert to the mode where the L5 signal health status is respected.

Configuration layer	Configuration string
RAM	B5 62 06 8A 09 00 01 01 00 00 01 00 32 10 01 DF F6
BBR	B5 62 06 8A 09 00 01 02 00 00 01 00 32 10 01 E0 FE
FLASH	B5 62 06 8A 09 00 01 04 00 00 01 00 32 10 01 E2 0E

Table 4: UBX binary string to override GPS L5 signal health status with GPS L1 health status

Configuration layer	Configuration string
RAM	B5 62 06 8A 09 00 01 01 00 00 01 00 32 10 00 DE F5
BBR	B5 62 06 8A 09 00 01 02 00 00 01 00 32 10 00 DF FD
FLASH	B5 62 06 8A 09 00 01 04 00 00 01 00 32 10 00 E1 0D

Table 5: UBX binary strings to revert the GPS L5 signal health status monitoring to default

2.1.4 Communication interface configuration

Several configuration groups allow operation mode configuration of the various communication interfaces. These include parameters for the data framing, transfer rate and enabled input/output protocols. The configuration groups available for each interface are:

Interface	Configuration groups
UART1	CFG-UART1-*, CFG-UART1INPROT-*, CFG-UART1OUTPROT-*
UART2	CFG-UART2-*, CFG-UART2INPROT-*, CFG-UART2OUTPROT-*
USB	CFG-USB-*, CFG-USBINPROT-*, CFG-USBOUTPROT-*
I2C	CFG-I2C-*, CFG-I2CINPROT-*, CFG-I2COUTPROT-*

Interface	Configuration groups
SPI	CFG-SPI-*, CFG-SPIINPROT-*, CFG-SPIOUTPROT-*

Table 6: Interface configurations

2.1.4.1 Default interface settings

Interface	Settings
UART1 output	38400 baud, 8 bits, no parity bit, 1 stop bit. NMEA protocol with **GGA, GLL, GSA, GSV, RMC, VTG, TXT** messages are output by default. UBX and RTCM 3.4 protocols are enabled by default but no output messages are enabled by default.
UART1 input	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX, NMEA and RTCM 3.4 input protocols are enabled by default.
UART2 output	38400 baud, 8 bits, no parity bit, 1 stop bit. RTCM 3.4 protocol is enabled by default but no output messages are enabled by default. NMEA protocol is disabled by default.
UART2 input	38400 baud, 8 bits, no parity bit, 1 stop bit. RTCM 3.4 protocol is enabled by default. SPARTN protocol is enabled by default. NMEA protocol is disabled by default.
USB	Default messages activated as in UART1. Input/output protocols available as in UART1.
I2C	Available for communication in the Fast-mode with an external host CPU in peripheral mode only. Default messages activated as in UART1. Input/output protocols available as in UART1. Maximum bit rate 400 kb/s.
SPI	Allow communication to a host CPU, operated in peripheral mode only. Default messages activated as in UART1. Input/output protocols available as in UART1. SPI is not available unless D_SEL pin is set to low

Table 7: Default interface settings

☞ Refer to the applicable Interface description for information about further settings.

☞ By default, ZED-X20P outputs NMEA messages that include satellite data for all GNSS bands being received. This results in a high NMEA output load for each navigation period.

2.1.5 Message output configuration

The receiver supports two protocols for output messages: industry-standard NMEA and u-blox UBX. Any message type can be enabled or disabled individually and the output rate is configurable.

The message output rate is related to the frequency of an event. For example, the output message UBX-NAV-PVT (position, velocity, and time solution) is related to the navigation event, which generates a navigation epoch. In this case, the rate for each navigation epoch is defined by the configuration keys CFG-RATE-MEAS and CFG-RATE-NAV. For example, a value of 1000 ms in CFG-RATE-MEAS indicates that a measurement is done every second. If CFG-RATE-NAV is set to one (1), the solution is calculated for every measurement. This means that a navigation epoch is calculated every 1000 ms. If the rate is set to two (2), only the second measurement is used and the navigation epoch is calculated every two seconds. The same result is obtained if CFG-RATE-MEAS is set to 2000 ms, and CFG-RATE-NAV is set to one (1). Every 2000 ms a measurement is done, and in every measurement, a navigation epoch is calculated. However, this second option demands fewer resources and is the correct procedure when the navigation rate is changed. Setting a navigation rate value higher than one (1) is only needed when it is required that the raw measurement data is output at a higher rate than the navigation data.

The output rate for each message is defined in the CFG-MSGOUT-* configuration group. If the output rate of the message is set to one (1) on the UART interface, CFG-MSGOUT-UBX_NAV_PVT_UART1 = 1, the message is output for every navigation epoch. If the rate is set to two (2), the message is output for every other navigation epoch. If the rate is zero (0), then corresponding message is not output. As seen in this example, the rates of the output messages are individually configurable per communication interface.

Some messages, such as UBX-MON-VER, are non-periodic and are only output as an answer to a poll request.

The UBX-INF-* and NMEA-Standard-TXT information messages are non-periodic output messages that do not have a message rate configuration. Instead they can be enabled for each communication interface via the CFG-INFMSG-* configuration group.

☞ All message output is additionally subject to the protocol configuration of the communication interfaces. Messages of a given protocol are not output unless the protocol is enabled for output on the interface. See Communication interface configuration for details.

2.1.6 Configuring raw doppler measurements for velocity

ZED-X20P can be configured to use raw doppler measurements for velocity by following below steps.

1. Reset the receiver to default configuration.
2. Make sure the receiver is set to portable model by default.If not, configure it using **CFG-NAVSPG-DYNMODEL**.
3. Enable use of raw doppler measurements using below hex command.
   - Ram layer:B5 62 06 8A 09 00 01 01 00 00 23 00 11 20 01 F0 5D
   - Flash layer:B5 62 06 8A 09 00 01 04 00 00 23 00 11 20 01 F3 75
4. Raw doppler measurements usage can be disabled by using below hex command.
   - Ram layer:B5 62 06 8A 09 00 01 01 00 00 23 00 11 20 00 EF 5C
   - Flash layer:B5 62 06 8A 09 00 01 04 00 00 23 00 11 20 00 F2 74

2.2 Navigation configuration

This section presents various configuration options related to the navigation engine. These options can be configured through CFG-NAVSPG-* configuration keys.

2.2.1 Dynamic platform

The dynamic platform model can be configured through the CFG-NAVSPG-DYNMODEL configuration item. For the supported dynamic platform models and their details, see Table 8 and Table 9.

Platform	Description
Portable	Applications with low acceleration, e.g. portable devices. Suitable for most situations.
Stationary	Used in timing applications (antenna must be stationary) or other stationary applications. Velocity restricted to 0 m/s. Zero dynamics assumed.
Pedestrian	Applications with low acceleration and speed, e.g. how a pedestrian would move. Low acceleration assumed.
Automotive	Used for applications with equivalent dynamics to those of a passenger car. Low vertical acceleration assumed.
At sea	Recommended for applications at sea, with zero vertical velocity. Zero vertical velocity assumed. Sea level assumed.
Airborne <1g	Used for applications with a higher dynamic range and greater vertical acceleration than a passenger car. No 2D position fixes supported.

Platform	Description
Airborne <2g	Recommended for typical airborne environments. No 2D position fixes supported.
Airborne <4g	Only recommended for extremely dynamic environments. No 2D position fixes supported.
Wrist	Only recommended for wrist-worn applications. Receiver will filter out arm motion.

Table 8: Dynamic platform models

Platform	Max altitude [m]	Max horizontal velocity [m/s]	Max vertical velocity [m/s]	Sanity check type	Max position deviation
Portable	12000	310	50	Altitude and velocity	Medium
Stationary	9000	10	6	Altitude and velocity	Small
Pedestrian	9000	30	20	Altitude and velocity	Small
Automotive	6000	100	15	Altitude and velocity	Medium
At sea	500	25	5	Altitude and velocity	Medium
Airborne <1g	80000	100	6400	Altitude	Large
Airborne <2g	80000	250	10000	Altitude	Large
Airborne <4g	80000	500	20000	Altitude	Large
Wrist	9000	30	20	Altitude and velocity	Medium

Table 9: Dynamic platform model details

Applying dynamic platform models designed for high acceleration systems (e.g. airborne <2g) can result in a higher standard deviation in the reported position.

If a sanity check against the limit of the dynamic platform model fails, the position solution becomes invalid. Table 9 shows the types of sanity checks which are applied for a particular dynamic platform model.

2.2.2 Navigation input filters

The navigation input filters in the CFG-NAVSPG-* configuration group control how the navigation engine handles the input data that comes from the satellite signal.

Configuration item	Description
CFG-NAVSPG-FIXMODE	By default, the receiver calculates a 3D position fix if possible but it reverts to 2D position if necessary (auto 2D/3D). The receiver can be configured to only calculate 2D (2D only) or 3D (3D only) positions.
CFG-NAVSPG-CONSTR_ALT, CFG-NAVSPG-CONSTR_ALTVAR	The fixed altitude is used if fixMode is set to 2D only. A variance greater than zero must also be supplied.
CFG-NAVSPG-INFIL_MINELEV	Minimum elevation of a satellite above the horizon to be used in the navigation solution. Low-elevation satellites may provide degraded accuracy, due to the long signal path through the atmosphere.
CFG-NAVSPG-INFIL_MINSVS, CFG-NAVSPG-INFIL_MAXSVS	Minimum and maximum number of satellites to use in the navigation solution. There is an absolute maximum limit of 32 satellites that can be used for navigation.
CFG-NAVSPG-INFIL_NCNOTHRS, CFG-NAVSPG-INFIL_CNOTHRS	A navigation solution will only be attempted if there is at least the given number of satellites with signals at least as strong as the given threshold.

Table 10: Navigation input filter parameters

If the receiver has only three satellites for calculating a position, the navigation algorithm uses a constant altitude to compensate for the missing fourth satellite. This is called a 2D fix. The constant altitude value is taken from the last successful 3D fix using a minimum of four available satellites.

2.2.3 Navigation output filters

The result of a navigation solution is initially classified by the fix type (as detailed in the `fixType` field of the UBX-NAV-PVT message). This distinguishes between failures to obtain a fix ("No Fix") and cases where a fix has been achieved, which are further subdivided into specific types of fixes (for example, 2D, 3D).

Where a fix has been achieved, the fix is checked to determine whether it is valid or not. A fix is only valid if it passes the navigation output filters as defined in CFG-NAVSPG-OUTFIL. In particular, both PDOP and accuracy values must be below the respective limits.

☞ Important: Users are recommended to check the `gnssFixOK` flag in the UBX-NAV-PVT or the NMEA valid flag. Fixes not marked as valid should not be used.

UBX-NAV-STATUS message also reports whether a fix is valid in the `gpsFixOK` flag. These messages have only been retained for backwards compatibility and it is recommended to use the UBX-NAV-PVT message.

2.3 RTK configuration

RTK technology introduces the concept of a base[5] and a rover. In such a setup, the base sends corrections (complying with the RTCM 3.4 protocol) to the rover via a communication link. This enables the rover to compute its position relative to the base with high accuracy.

When operating as a rover, the ZED-X20P can receive RTCM 3.4 corrections from another ZED-X20P operating as a base, or via NTRIP from a VRS service provider operating a network of base receivers.In this mode, the receiver coordinates will be expressed in the datum used by the RTCM correction provider. For more information refer to the Reference frames section in the Appendix.

After describing the RTCM protocol and corresponding supported message types, this section describes how to configure the ZED-X20P high precision receiver as a base or rover receiver.

2.3.1 RTCM corrections

RTCM is a standard-based binary protocol for the communication of GNSS correction information. The ZED-X20P high precision receiver supports RTCM as specified by RTCM 10403.4, Differential GNSS (Global Navigation Satellite Systems) Services – Version 4 (December 1, 2023).

The RTCM specification is currently at version 3.4 and RTCM version 2 messages are not supported by this standard.

To modify the RTCM input/output settings, see the configuration section in the applicable Interface description [2].

Users should be aware of the datum used by the correction source. The rover's reported position is in a coordinate system based on the correction service provider's reference frame. This may need

5 The terms base, base station, reference and reference station can be used interchangeably

to be taken into account when using the RTK rover position depending on the application. See the Reference frames section in the Appendix for more information.

2.3.2 List of supported RTCM input messages

Message type	Description
RTCM 1001	L1-only GPS RTK observables
RTCM 1002	Extended L1-only GPS RTK observables
RTCM 1003	L1/L2 GPS RTK observables
RTCM 1004	Extended L1/L2 GPS RTK observables
RTCM 1005	Stationary RTK reference station ARP
RTCM 1006	Stationary RTK reference station ARP with antenna height
RTCM 1007	Antenna descriptor
RTCM 1033	Receiver and Antenna Description
RTCM 1074	GPS MSM4
RTCM 1075	GPS MSM5
RTCM 1077	GPS MSM7
RTCM 1094	Galileo MSM4
RTCM 1095	Galileo MSM5
RTCM 1097	Galileo MSM7
RTCM 1124	BeiDou MSM4
RTCM 1125	BeiDou MSM5
RTCM 1127	BeiDou MSM7

Table 11: ZED-X20P supported input RTCM version 3.4 messages

2.3.3 List of supported RTCM output messages

Message type	Description
RTCM 1005	Stationary RTK reference station ARP
RTCM 1074	GPS MSM4
RTCM 1077	GPS MSM7
RTCM 1094	Galileo MSM4
RTCM 1097	Galileo MSM7
RTCM 1124	BeiDou MSM4
RTCM 1127	BeiDou MSM7
RTCM 4072.0	Reference station PVT (u-blox proprietary RTCM Message)

Table 12: ZED-X20P supported output RTCM version 3.4 messages

2.3.4 Rover operation

In its default configuration, the ZED-X20P will attempt to provide the best positioning accuracy depending on the received correction data. It will enter RTK float mode shortly after it starts receiving an input stream of RTCM correction messages. Once the rover has resolved the carrier phase ambiguities, it will enter RTK fixed mode. When in this mode, the relative position accuracy between base and rover can be expected to be cm-level accurate. The time period between RTK float and RTK fixed operation is referred to as the convergence time. Note that the convergence time is affected by the baseline length as well as by multipath and satellite visibility at both rover and base station.

The ZED-X20P should receive RTCM corrections matching its GNSS signal configuration to function optimally. The rover requires both base station observation (MSM4 or MSM7 messages) and position message (RTCM 1005 or RTCM 1006) in order to attempt ambiguity fixes. The rover will attempt to provide RTK fixed operation when sufficient number of ambiguities are resolved. If phase lock on sufficient number of signals cannot be maintained, the rover will drop back to RTK float mode. The rover will continue to attempt to resolve carrier ambiguities and revert to RTK fixed mode once the minimum number of signals has been restored.

The RTK mode that an RTK rover operates in can be configured through the CFG-NAVHPG-DGNSSMODE configuration item. The following two RTK modes are available:

- RTK fixed: The rover will attempt to fix ambiguities whenever possible.
- RTK float: The rover will estimate the ambiguities as float but will make no attempts at fixing them.

The rover will stop using RTCM corrections that are older than 60s (default value) and will drop back to a 3D or 3D/DGNSS mode. This is meant to prevent the computation of grossly misleading differential solutions. If desired, this value can be changed through the CFG-NAVSPG-CONSTR_DGNSSTO configuration item.

The received correction messages stream should comply with the following:

- The reference station ID in the reference station message (RTCM 1005 or RTCM 1006) must match that used in the MSM observation messages. Otherwise, the rover cannot compute RTK fixed position.

CFG-RTCM-DF003_IN can be used to configure the desired reference station ID and CFG-RTCM-DF003_IN_FILTER can be used to configure how strict the filtering should be (RELAXED is the recommended setting).

2.3.4.1 Message output in RTK mode

When operating in RTK rover mode users should take note of the modified information within the following NMEA and UBX messages:

- NMEA-GGA: The quality field is 4 for RTK fixed and 5 for RTK float (see NMEA position fix flags in interface description). The age of differential corrections and base station ID is set.
- NMEA-GLL, NMEA-VTG: The posMode indicator is D for RTK float and RTK fixed (see NMEA position fix flags in interface description).
- NMEA-RMC, NMEA-GNS: The posMode indicator is F for RTK float and R for RTK fixed (see NMEA position fix flags in interface description).
- UBX-NAV-PVT: The carrSoln flag is set to 1 for RTK float and 2 for RTK fixed. The age of differential corrections are reported.
- UBX-NAV-RELPOSNED
  - The diffSoln and relPosValid flags are set
  - The carrSoln flag is set to 1 for RTK float and 2 for RTK fixed
- UBX-NAV-SAT
  - The diffCorr flag is set for satellites with valid RTCM data
  - The rtcmCorrUsed, prCorrUsed, and crCorrUsed flags are set for satellites for which the RTCM corrections have been applied
- UBX-NAV-SIG
  - For signals to which the RTCM corrections have been applied, the correction source is set to RTCM3 OSR and the crUsed, prCorrUsed, and crCorrUsed flags are set
- UBX-NAV-STATUS
  - The diffSoln flag and the diffCorr flag is set

    - The carrSoln flag is set to 1 for RTK float and 2 for RTK fixed
- If the baseline exceeds 100 km, a UBX-INF-WARNING will be output, e.g. "WARNING: DGNSS long baseline: 102.7 km"

2.3.5 Stationary base operation

The ZED-X20P high precision receiver default operation begins without producing any RTCM messages. RTCM observation messages will be streamed as soon as they are configured for output. However, any stationary reference position messages are output only when the base station position has been initialized and is operating in time mode. Time mode sets the receiver to operate as a stationary base station in fixed position and only time is estimated.

The following procedures can be used to initialize the base station position:

- Use the built-in survey-in procedure to estimate the position.
- Enter coordinates independently generated or taken from an accurate position such as a survey marker.
- Use in rover mode while feeding the receiver corrections and then enter the resulting estimated position coordinates as above.

2.3.5.1 Survey-in

Survey-in is a procedure that is carried out prior to entering time mode. It estimates the receiver position by building a weighted mean of all valid 3D position solutions.

Two major parameters are required when configuring:

- A **minimum observation time** defines the minimum observation time independent of the actual number of 3D fixes used for the position estimate. Values can range from one day for high accuracy requirements to a few minutes for coarse position determination.
- A **3D position standard deviation** defines a limit on the spread of positions that contribute to the calculated mean.

Survey-in ends when both requirements are successfully met. The receiver begins operation in time mode and can output a base position message if configured. The survey-in status can be queried using the UBX-NAV-SVIN message.

☞ The base station receiver should not be fed RTCM corrections while it is in survey-in mode. If a corrected position is desired, the base station coordinates should be pre-surveyed using RTCM corrections; the resultant position can be used to set the base station in fixed mode.

To configure a base station into survey-in mode (CFG-TMODE-MODE=SURVEY_IN), the following items are required:

Configuration item	Description
CFG-TMODE-MODE	Receiver mode (disabled, survey-in or fixed)
CFG-TMODE-SVIN_MIN_DUR	Survey-in minimum duration
CFG-TMODE-SVIN_ACC_LIMIT	Survey-in position accuracy limit

Table 13: Configuration items used for setting a base station into survey-in mode

2.3.5.2 Fixed position

An alternative to the survey-in procedure is to manually enter the receiver's coordinates. Any error in the base station position will directly translate into rover position errors. The base station position accuracy should therefore match or exceed the desired rover absolute position accuracy.

To configure Fixed mode (CFG-TMODE-MODE=FIXED), the following items are relevant:

Configuration item	Description
CFG-TMODE-MODE	Receiver mode (disabled or survey-in or fixed)
CFG-TMODE-POS_TYPE	Determines whether the ARP position is given in ECEF or LAT/LON/HEIGHT
CFG-TMODE-ECEF_X	ECEF X coordinate of the ARP position
CFG-TMODE-ECEF_Y	ECEF Y coordinate of the ARP position
CFG-TMODE-ECEF_Z	ECEF Z coordinate of the ARP position
CFG-TMODE-LAT	Latitude of the ARP position
CFG-TMODE-LON	Longitude of the ARP position
CFG-TMODE-HEIGHT	Height of the ARP position
CFG-TMODE-ECEF_X_HP	High-precision ECEF X coordinate of the ARP position
CFG-TMODE-ECEF_Y_HP	High-precision ECEF Y coordinate of the ARP position
CFG-TMODE-ECEF_Z_HP	High-precision ECEF Z coordinate of the ARP position
CFG-TMODE-LAT_HP	High-precision latitude of the ARP position
CFG-TMODE-LON_HP	High-precision longitude of the ARP position
CFG-TMODE-HEIGHT_HP	High-precision height of the ARP position
CFG-TMODE-FIXED_POS_ACC	Fixed position 3D accuracy estimate

Table 14: Configuration items used for setting a base station into fixed mode

Once the receiver is set in fixed mode, select the position format to use: either LLH or ECEF with optional high precision (mm) coordinates compared to the default cm level precision.

For example, with CFG-TMODE-POS_TYPE=ECEF the base antenna position can be entered with cm precision using CFG-TMODE-ECEF_X, CFG-TMODE-ECEF_Y, CFGTMODE-ECEF_Z. For high precision (mm) coordinates use CFG-TMODEECEF_X_HP, CFG-TMODE-ECEF_Y_HP, CFG-TMODE-ECEF_Z_HP. The same applies with corresponding coordinates used with CFG-TMODE-POS_TYPE=LLH.

The "3D accuracy estimate" in "Fixed Position" and the "Position accuracy limit" in "Survey-in" will affects the rover absolute position accuracy. Note that the availability of the position accuracy does not mitigate the error in the rover position, but only accounts for it when calculating the resulting positioning accuracy.

☞ In stationary base station mode a current position check is made with respect to the fixed coordinates. If the result indicates the fixed position coordinates are incorrect, a UBX-INF-WARNING message "Base station position seems incorrect" is issued. The message is output when the coordinates are incorrect by more than ~50 m up to 25 km.

⚠ If the base station is moved during operation then new position coordinates must be configured.

2.3.5.3 Base station: RTCM output configuration

The desired RTCM messages must be selected and configured for the corresponding GNSS constellations received. The recommended list of RTCM output messages for a base operating in default GNSS configuration are:

- RTCM 1005 Stationary RTK reference station ARP
- RTCM 1074 GPS MSM4
- RTCM 1094 Galileo MSM4
- RTCM 1124 BeiDou MSM4

The configuration messages for these are shown in the Table 15.

The following configuration items output the recommended messages for a default satellite constellation setting. Note that these are given for the UART1 interface:

Configuration item	Description
CFG-MSGOUT-RTCM_3X_TYPE1005_UART1	Output rate of the RTCM-3X-TYPE1005 message on port UART1: RTCM base station message
CFG-MSGOUT-RTCM_3X_TYPE1074_UART1	Output rate of the RTCM-3X-TYPE1074 message on port UART1: RTCM GPS MSM4 message
CFG-MSGOUT-RTCM_3X_TYPE1094_UART1	Output rate of the RTCM-3X-TYPE1094 message on port UART1: RTCM Galileo MSM4 message
CFG-MSGOUT-RTCM_3X_TYPE1124_UART1	Output rate of the RTCM-3X-TYPE1124 message on port UART1: RTCM BeiDou MSM4 message

Table 15: Configuration items used for typical RTCM output configuration on UART1

CFG-RTCM-DF003_OUT can be used to configure the reference station ID that will be reported in all RTCM messages containing the RTCM DF003 data field.

The configuration of the RTCM 3.4 correction stream must be made with the following guidance:

- All observation messages must be broadcast at the same rate.
- The static reference station message (RTCM 1005 or RTCM 1006) does not need to be broadcast at the same rate as the observation messages, however, a rover will not be able to compute its position until it has received a valid reference station message.
- The correction stream should only contain one type of observation messages per constellation. When using a multi-constellation configuration, all constellations should use the same type of observation messages. Mixing MSM4 and MSM7 messages will possibly lead to incorrect setting of the multiple message bit.
- If the receiver is configured to output RTCM messages on several ports, they must all have the same RTCM configuration, otherwise, the MSM multiple message bit might not be set properly.

2.4 PPP-RTK configuration

2.4.1 SPARTN corrections

When operating as a rover, the ZED-X20P can receive SPARTN corrections:

- via the internet from a service provider
- via a host application that receives L-band satellite data. For more information, see section Multiple SPARTN sources.

☞ If you choose PointPerfect service, contact your local u-blox technical support

2.4.1.1 SPARTN protocol

SPARTN is a binary protocol for the communication of SSR correction information.

ZED-X20P supports SPARTN as specified by SPARTN Interface Control Document – Version 2.0.2 (February, 2022).

To modify the SPARTN input/output settings, see the configuration section in the applicable Interface description [2].

2.4.1.2 List of supported SPARTN 2.0.2 input messages

Message type-subtype	Description
SM 0-0	GPS orbit, clock, bias (OCB)
SM 0-2	Galileo orbit, clock, bias (OCB)
SM 0-3	BeiDou orbit, clock, bias (OCB)
SM 1-0	GPS high-precision atmosphere correction (HPAC)
SM 1-2	Galileo high-precision atmosphere correction (HPAC)

Message type-subtype	Description
SM 1-3	BeiDou high-precision atmosphere correction (HPAC)
SM 2-0	Geographic area definition (GAD)

Table 16: ZED-X20P supported input SPARTN version 2.0.2 messages

- Only the messages in Table 16 are supported. The implementation recognizes unsupported correction messages but they are not applied for the RTK solution such as QZSS correction messages, for instance.
- Group and embedded authentication messages are not supported.
- SM1 messages must contain tropospheric model for the receiver to reach an RTK fixed solution.

Application designs using ZED-X20P and SPARTN correction streams should provide firmware upgrade capability; upcoming firmware versions will implement further SPARTN messages and functionalities.

☞ Some SPARTN correction service providers broadcast different sets of messages in different regions and support different signals or satellites. These variations may affect the accuracy of the ZED-X20P.

2.4.2 Multiple SPARTN sources

ZED-X20P supports multiple SPARTN correction stream sources. It can support a SPARTN correction stream received over the internet (SPARTN message formatted IP stream).

Only one source can be configured to be used at a time by ZED-X20P. The configuration item CFG-SPARTN-USE_SOURCE can be configured to select which source will be used. Alternatively, the input protocol configuration items of a physical port can be configured to block input support for the UBX or the SPARTN protocols on the desired ports, for example CFG-UART1INPROT-UBX, CFG-USBINPROT-SPARTN, etc.

Source	Description	CFG-SPARTN-USE_SOURCE
SPARTN IP stream	This refers to corrections received in a SPARTN message format by any interface of the ZED-X20P. The SPARTN corrections must follow the SPARTN protocol specification and the source can be any SPARTN service provider.	IP (default)

Table 17: ZED-X20P supported SPARTN correction stream sources

ZED-X20P provides additional monitoring information in the form of UBX-RXM-COR messages to help identify what is the current stream status in order to assist the host application in deciding which stream to use. UBX-RXM-COR reports, among other information:

- What is the type/subtype of the received SPARTN messages.
- Which is the source of the received SPARTN message (IP or L-band) and if it is used by ZED-X20P.

Additionally some SPARTN input status information is also available in other UBX messages, such as UBX-MON-COMMS. For the full message specification, see ZED-X20P Interface description [2].

☞ If the selected SPARTN source contains encrypted SPARTN corrections, then extra monitoring information are reported through UBX-RXM-COR, such as if the message is encrypted and if it got decrypted.

2.4.3 Encrypted SPARTN support

SPARTN messages may be encrypted as indicated by SPARTN field TF004 (Encryption and authentication flag). ZED-X20P supports both encrypted and unencrypted SPARTN messages. Unencrypted SPARTN messages can be utilized as is by ZED-X20P without any special setup. Encrypted SPARTN messages can be decrypted and utilized by ZED-X20P once the appropriate dynamic keys are set and managed by the host application.

☞ The rest of this section describes the steps needed to enable encrypted SPARTN support for the u-blox PointPerfect service only

☞ Different dynamic keys apply for IP-only stream. The type of service available to a user is specified by u-blox Terms and Services.

Step	Description	Example/notes
Obtain PointPerfect dynamic key	Request by any means available a PointPerfect dynamic key lease. It should come in a json structure containing two dynamic keys; the current key and the next key. The request can be postponed if the host application already holds such a json structure obtained earlier and the current time falls within the current key validity time.	current: • Key: current key in byte array format • Expires: current key expiring date next: • Key: next key in byte array format • Expires: next key expiring date
Check if current and next dynamic keys are currently available	At every power cycle of ZED-X20P or whenever the host application needs to decrypt encrypted SPARTN messages for the first time, poll UBX-RXM-SPARTNKEY to see what are the current and next keys saved in the ZED-X20P. If no key is saved or both keys have expired, then no keys are reported. If one key is available and/or one key has expired, then only one current key is reported. If two keys are available and no key has expired, then both current and next keys are reported.	See description of UBX-RXM-SPARTNKEY message in the applicable interface description [2].
Set current and next dynamic keys	Convert the json structure into a UBX-RXM-SPARTNKEY to set the current and next dynamic keys. This process should be repeated at every power cycle of ZED-X20P, or whenever the host application needs to decrypt encrypted SPARTN messages for the first time, or when the dynamic keys are close to expiring (e.g. only one key is available and is close to expire), or when no dynamic keys are saved.	This will load the current and next dynamic keys in this sequence. See the description of UBX-RXM-SPARTNKEY in the applicable interface description [2]. Although setting the current key only is sufficient, it is recommended that both current and next keys are set.
Forward or relay SPARTN corrections	The host application and design should be such that SPARTN corrections arrive to the ZED-X20P interfaces, either as SPARTN format messages (over an IP stream). In case of multiple SPARTN sources only the one selected by the configuration item CFG-SPARTN-USE_SOURCE will be attempted to be decrypted/used. The other available SPARTN source will not be decrypted and will be reported as such.	
Monitor decryption status	UBX-RXM-COR reports info on the stream selected, if it is encrypted and if the decryption was performed. Further key status information are reported by the UBX-RXM-SPARTNKEY message.	Decryption success cannot be verified in SPARTN messages
Monitor key status	UBX-RXM-SPARTNKEY reports info on the current and next key and if both, or one, or no keys are available.	See description of UBX-RXM-SPARTNKEY message in the applicable interface description [2].

Step	Description	Example/notes
Key switching from current to next	The host application does not need to handle the key switching form current to next, as long as both keys have been saved in the ZED-X20P. Once a current key expires, it gets removed and replaced by the next key (if available). Then only the next key will be available and reported as current. If no next key is available to become current, then the decryption stops and the above steps need to be repeated.	

Table 18: PointPerfect dynamic key handling

2.4.4 Rover operation

The rover operation and configuration, when using SPARTN corrections, is similar to the setup when using RTCM corrections (see RTCM rover operation).

The float/fix carrier phase ambiguities resolution concept is maintained and, where relevant, the NMEA and UBX output contents are updated accordingly. Small adjustments are made where necessary, for example the correction source field in UBX messages will be set to SPARTN instead of RTCM.

In order to verify that the rover is receiving and using SPARTN or corrections, the following messages can be observed:

- UBX-MON-COMMS message reports which data are received on which port
- UBX-NAV-SIG message reports which type of corrections is applied for each signal in the field "corrSource"
- UBX-RXM-COR message reports the received SPARTN messages and if they were used

For further details see the the applicable interface description [2].

Users should be aware of the datum used by the correction source. The rover position will provide coordinates in the correction source reference frame. This may need to be taken into account when using the PPP-RTK rover position.

☞ If the rover switches between different correction types (SPARTN RTCM) it is recommended to reset the receiver before using a new type of correction

2.5 OTP memory configuration

ZED-X20P contains a one-time programmable (OTP) memory. This is a non-volatile memory for storing configuration settings and ROM patches permanently in the device. The stored data cannot be modified after it has been initially programmed. The device applies the settings and ROM patches on the device startup.

As the space in the OTP memory is limited, only essential system configuration settings should be stored. The total space used for device configuration and ROM patches in the OTP memory must not exceed 150 bytes. Other settings can be stored in the BBR or sent from the host to the device on each device startup.

☞ Ensure that the final configuration stored and optional ROM patches do not require more than 150 bytes of OTP memory space.

3 Receiver functionality

This chapter describes the ZED-X20P operational features and their configuration.

3.1 Augmentation systems

3.1.1 SBAS

ZED-X20P is capable of receiving multiple Satellite Based Augmentation System (SBAS) signals concurrently, even from different SBAS systems (WAAS, EGNOS, BDSBAS, GAGAN, etc.).

For receiving correction data, ZED-X20P automatically chooses the best SBAS satellite as its primary source. It selects only one satellite since the information received from other SBAS satellites is redundant and could be inconsistent. The selection strategy is determined by the proximity of the satellites, the services offered by the satellite, the configuration of the receiver (test mode allowed/disallowed, integrity enabled/disabled) and the signal link quality to the satellite.

If corrections are available from the chosen SBAS satellite and used in the navigation calculation, the differential status is indicated in several output messages such as UBX-NAV-PVT, UBX-NAV-STATUS, UBX-NAV-SAT, NMEA-GGA, NMEA-GLL, NMEA-RMC, and NMEA-GNS. The UBX-NAV-SBAS message provides detailed information about the corrections being available and applied. Refer to the Interface description [2] for a detailed description of the messages.

The most important SBAS feature for accuracy improvement is the ionosphere correction parameters. The measured data from regional Ranging and Integrity Monitoring Stations (RIMS) are combined to make a Total Electron Content (TEC) map. This map is transferred to the receiver via SBAS satellites to correct for ionospheric delays of each received signal.

Message type	Message content	Source
0(0/2)	Test mode	All
1	PRN mask assignment	Primary
2, 3, 4, 5	Fast corrections	Primary
6	Integrity	Primary
7	Fast correction degradation	Primary
9	Satellite navigation (ephemeris)	All
10	Degradation	Primary
12	Time offset	Primary
17	Satellite almanac	All
18	Ionosphere grid point assignment	Primary
24	Mixed fast / long-term corrections	Primary
25	Long-term corrections	Primary
26	Ionosphere delays	Primary

Table 19: Supported SBAS messages

To configure the SBAS functionality, use the CFG-SBAS-* configuration group.

Parameter	Description
CFG-SIGNAL-SBAS_ENA	Enabled/disabled status of the SBAS subsystem
CFG-SBAS-USE_TESTMODE	Allow/disallow SBAS usage from satellites in test mode (enable when BDSBAS is used)
CFG-SBAS-USE_RANGING	Use the SBAS satellites for navigation (ranging)

Parameter	Description
CFG-SBAS-USE_DIFFCORR	Combined enable/disable switch for fast, long-term, and ionosphere corrections
CFG-SBAS-USE_INTEGRITY	Apply integrity information data
CFG-SBAS-ACCEPT_NOT_IN_PRNMASK	Allow usage of SBAS data even when SBAS SV is not included in PRN MASK (Compatible only with BDSBAS, enable BDSBAS is used)
CFG-SBAS-USE_IONOONLY	Allow/disallow usage of SBAS ionospheric corrections only (enabled by default)
CFG-SBAS-PRNSCANMASK	Allows selectively enabling/disabling SBAS satellites (BDSBAS disabled by default)

Table 20: SBAS configuration parameters

☞ When SBAS integrity data is applied, the navigation engine stops using all signals for which no integrity data is available (including all non-GPS signals). It is not recommended to enable SBAS integrity on borders of SBAS service regions in order not to inadvertently restrict the number of available signals.

☞ SBAS integrity information is required for at least five GPS satellites. If this condition is not met, SBAS integrity data will not be applied.

☞ SBAS is only used if no correction services are available. If the connection stream is lost during the operation, the receiver will switch to using the SBAS corrections after the time set in CFG-NAVSPG-CONSTR_DGNSSTO (60 s by default) has elapsed.

☞ When the receiver switches from a solution using correction data to a standard position solution, the reference frame of the output position switches as well. For an SBAS solution, the reference frame is aligned within a few centimeters of WGS84 (and modern ITRF realizations).

☞ Although u-blox receivers try to select the best available SBAS correction data, it is recommended to configure them to exclude the unwanted SBAS satellites.

Each satellite serves a specific region and its correction signal is only useful within that region. Planning is crucial to determine the best possible configuration, especially in areas where signals from different SBAS systems can be received:

- **Example 1 - SBAS receiver in North America:** In eastern parts of North America, make sure that EGNOS satellites do not take preference over WAAS satellites. The satellite signals from the EGNOS system should be disallowed by using the PRN scan mask (configuration key CFG-SBAS-PRNSCANMASK).
- **Example 2 - SBAS receiver in Europe:** Some WAAS satellite signals can be received in some parts of western Europe and GAGAN SBAS satellites in other parts of Europe. Therefore, it is recommended that satellites from all but the EGNOS system are disabled using the PRN scan mask.

3.2 Communication interfaces and PIOs

u-blox receivers are equipped with a communication interface which is multi-protocol capable. The interface ports can be used to transmit GNSS measurements, monitor status information and configure the receiver.

A protocol (e.g. UBX, NMEA) can be assigned to several ports simultaneously, each configured with individual settings (e.g. baud rate, message rates, etc.). More than one protocol (e.g. UBX protocol and NMEA) can be assigned to a single port (multi-protocol capability), which is particularly useful for debugging purposes.

The ZED-X20P provides UART1, UART2, SPI, I2C and USB interfaces for communication with a host CPU. The interfaces are configured via the configuration methods described in the applicable interface description [2].

6 The signal names and related terms have been replaced with new terminology in this document.

The following table shows the port numbers reported in the UBX-MON-COMMS messages.

Port no.	UBX-MON-COMMS portId	Electrical interface
0	0x0000	I2C
1	0x0100	UART1
2	0x0200	UART2
3	0x0300	USB
4	0x0400	SPI

Table 21: Port number assignment

☞ It is important to isolate interface pins when VCC is removed. They can be allowed to float or they can be connected to a high impedance.

3.2.1 UART

ZED-X20P supports a Universal Asynchronous Receiver/Transmitter (UART) port consisting of an RX and a TX line. The UART can be used as a host interface which supports a configurable baud rate and protocol selection.

☞ The UART interface does not support handshaking signals or hardware flow control signals.

The UART baud rate can be configured for selected speeds. Different rates than these speeds are not supported for transmission and reception.

☞ The UART RX interface is disabled when more than 100 frame errors are detected during a one-second period. This can happen if the wrong baud rate is used or the UART RX pin is grounded. An error message appears when the UART RX interface is re-enabled at the end of the one-second period.

Baud rate	Data bits	Parity	Stop bits
4800	8	none	1
9600	8	none	1
19200	8	none	1
38400	8	none	1
57600	8	none	1
115200	8	none	1
230400	8	none	1
460800	8	none	1
921600	8	none	1
2000000	8	none	1
4000000	8	none	1
8000000	8	none	1

Table 22: Possible UART interface configurations

Allow a short time delay of typically 100 ms between sending a baud rate change message and providing input data at the new rate. Otherwise some input characters may be ignored or the port could be disabled until the interface is able to process the new baud rate.

If there is too much data for the interface's bandwidth, the output buffer may overflow. Once the buffer space is exceeded, new messages to be sent will be dropped. To prevent message loss, the baud rate and the number of enabled messages should be selected carefully.

3.2.2 I2C

An I2C interface is available for communication with an external host CPU in the I2C Fast-mode. Backwards compatibility with the Standard-mode I2C bus operation is not supported. The interface can be operated only in the peripheral mode with the maximum bit rate of 400 kbit/s. The interface can make use of clock stretching by holding the SCL line LOW to pause a transaction. In this case, the bit transfer rate is reduced. The maximum clock stretching time is 20 ms.

The SCL and SDA pins have internal pull-up resistors which should be sufficient for most applications. However, depending on the clock speed of the host and the capacitive load on the I2C lines, additional external pull-up resistors may be necessary. The higher the speed and the capacitance load, the lower the pull-up resistor needs to be.

To poll or set the I2C address, use the CFG-I2C-ADDRESS configuration item. Refer to Interface description [2] for details. The CFG-I2C-ADDRESS configuration item is an 8-bit value containing the I2C address in the 7 most significant bits plus a 0 as the least significant bit. Thus, the default address becomes 0x84(1000 0100).

☞ In designs where the host uses the same I2C bus to communicate with more than one u-blox receiver, each receiver's I2C address must be configured with a different value.

3.2.2.1 I2C register layout

As shown in Figure 6, there are 256 registers. The data registers 0 to 252, at addresses 0x00 to 0xFC, contain reserved information and must not be used. Hence, only the last three registers are left for communication. The registers 0xFD and 0xFE contain the currently available number of bytes to be read, while the register 0xFF buffers the message stream. The 0xFF address delivers a 0xFF byte value if there is no data awaiting for transmission, or all the bytes have been read.

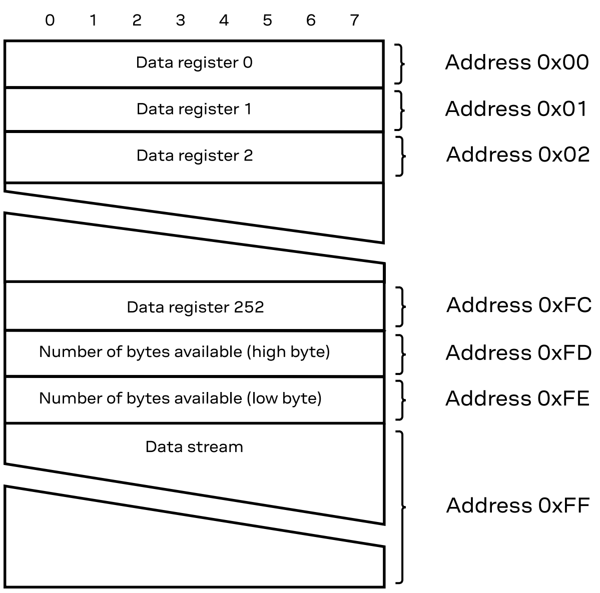

Figure 6: I2C register layout

3.2.2.2 Read access types

The host can choose one of the following two modes:

- Random read access: the controller first reads the number of available bytes at the 0xFD and 0xFE before accessing the data at 0xFF.
- Current address read access: the controller directly reads the data at the register 0xFF, without knowing first if there is any data waiting. If there is no data, the read result is a 0xFF byte value. This mode basically skips the first step of the "random read access", as it does not address to any particular register.

Figure 7 shows the format of the "random access" form of the request.

Following the start condition from the controller, the 7-bit device address and the RW bit (which is a logic low for write access) are clocked onto the bus by the controller transmitter. The receiver answers with an acknowledge (logic low) to indicate that it recognizes the address.

Next, the 8-bit address of the register to be read must be written to the bus (0xFD for u-blox receivers). Following the receiver's acknowledgment, the controller again triggers a start condition and writes the device address, but this time the RW bit is a logic high to initiate the read access. Now, the controller can read 1 to N bytes from the receiver. The receiver will first deliver the byte value at 0xFD, followed by the value at 0xFE. At this point the controller knows the number of bytes waiting at the 0xFF register, and by acknowledging again, the data stream follows. The data transfer will stop once the controller emits a not-acknowledge response or a stop condition is triggered after the last byte has been read.

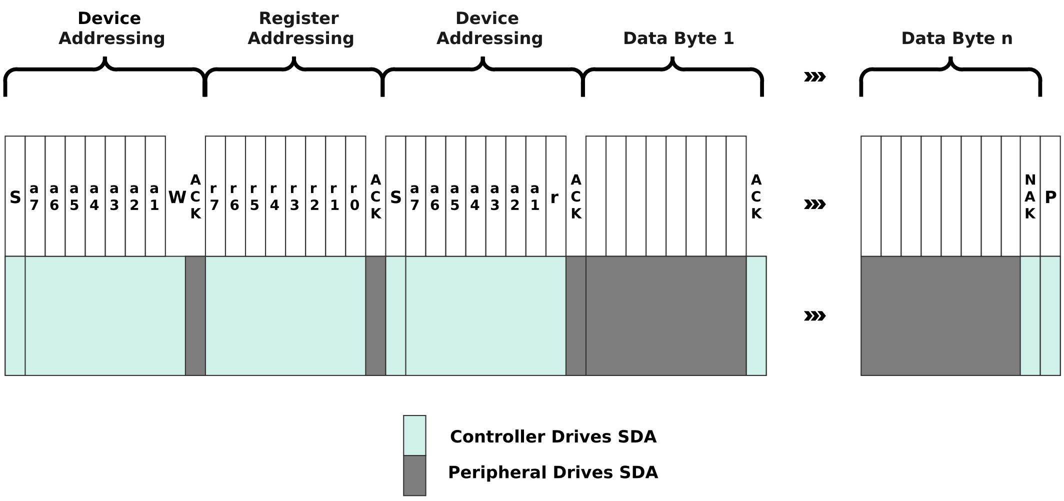

Figure 7: I2C random read access

If "current address" is used, an address pointer in the receiver is used to determine which register to read. This address pointer will increment after each read operation unless it is already pointing at register 0xFF, the highest addressable register, in which case it remains unaltered.

The initial value of this address pointer at startup is 0xFF, so by default all current address read operations will repeatedly read register 0xFF and receive the next byte of message data (or 0xFF value if no message data is waiting).

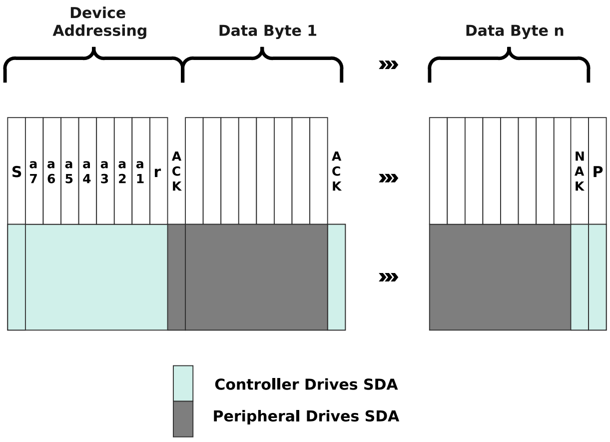

Figure 8: I2C current address read access

Only after addressing the peripheral, the receiver starts the data stream. If the controller does not read data from the receiver for a certain timeout, the receiver assumes that the communication is broken and stops the data stream, preventing an overflow of the output buffer. This timeout is 1.5 seconds by default. However, it can be extended by setting the CFG-I2C-EXTENDEDTIMEOUT configuration item to true. Refer to the Interface description [2] for details. By disabling the timeout, the receiver will only interrupt the data stream when the buffer is full. The buffer can store up to 4 kB and the time for an overflow event depends on the number of messages enabled.

3.2.2.3 Write access

The receiver does not provide any write access except for writing UBX and NMEA messages to the receiver, such as configuration or aiding data. Therefore, the register set mentioned in section I2C register layout is not writeable.

Following the start condition from the controller, the 7-bit device address and the RW bit (which is a logic low for write access) are clocked onto the bus by the controller. The receiver answers with an acknowledge (logic low) response to indicate that it is responsible for the given address.

The controller can write 2 to N bytes to the receiver, generating a stop condition after the last byte being written. To properly distinguish from the write access to set the address counter in random read accesses, the number of data bytes must be at least 2.

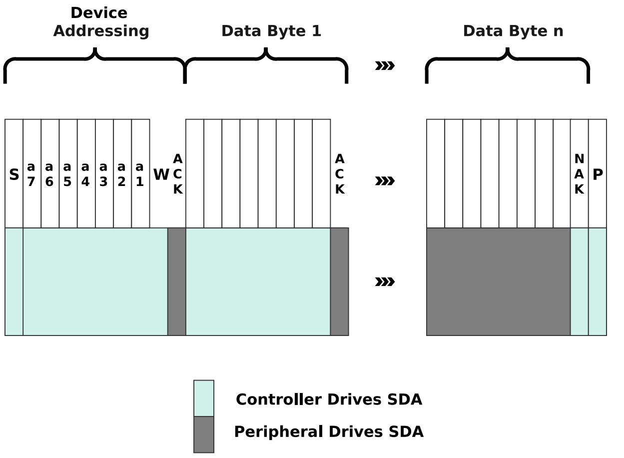

Figure 9: I2C write access

3.2.3 SPI

The ZED-X20Phas an SPI peripheral interface that can be selected by setting D_SEL = 0. The SPI peripheral interface is shared with UART1 and I2C port, the physical pins are same. The SPI pins available are:

- SPI_SDO (TXD)
- SPI_SDI (RXD)
- SPI_CS_N
- SPI_CLK

For more information about the communication interface selection, see D_SEL.

☞ The SPI interface is designed to allow communication to a host CPU and thus, the interface can only be operated in peripheral mode.

3.2.3.1 Read access

The register mode is not implemented for the SPI interface and thus, the NMEA and UBX message stream is accessible using the Back-to-back read and write access implementation. When no data is available to be written to the receiver, `SDI` should be held logic high, i.e., all bytes written to the receiver are set to 0xFF.

To prevent the receiver from being busy parsing incoming data, the parsing process is stopped after 50 subsequent bytes containing 0xFF. The parsing process is re-enabled with the first byte not equal to 0xFF.

If the receiver has no more data to send, it sets `SDO` to logic high, i.e. all bytes transmitted decode to 0xFF. An efficient parser in the host will ignore all 0xFF bytes which are not part of a message and will resume data processing as soon as the first byte not equal to 0xFF is received.

3.2.3.2 Back-to-back read and write access

The receiver does not provide any write access except for writing UBX and NMEA messages to the receiver, such as configuration or aiding data. For every byte written to the receiver, a byte will simultaneously be read from the receiver. While the controller writes to `SDI` of the peripheral, at the same time it needs to read from `SDO` of the peripheral, as any pending data will be output by the receiver with this access. The data on `SDO` represents the results from a current address read, returning 0xFF when no more data is available.

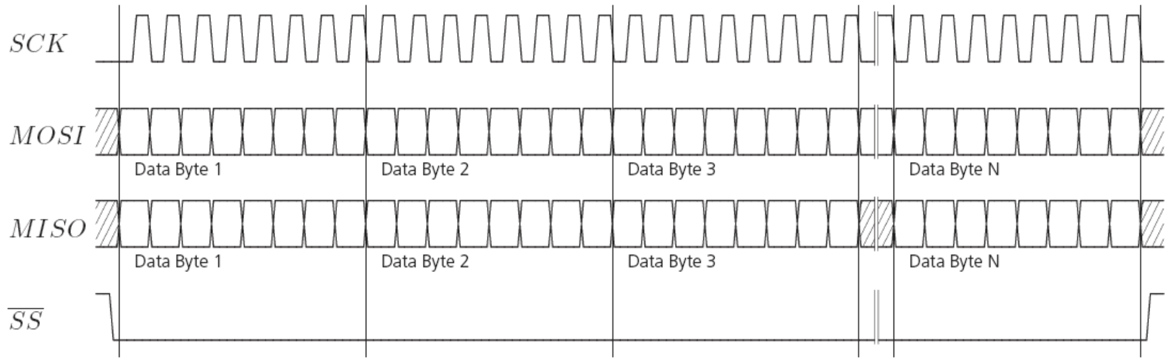

Figure 10: SPI back-to-back read/write access

3.2.4 USB

A single USB port is provided for host communication purposes.

The USB 2.0 FS (Full speed, 12 Mbit/s) interface can be used for host communication. Due to the hardware implementation, it may not be possible to certify the USB interface.

If the receiver executes code from internal ROM (i.e. when a valid flash firmware image is not detected), the USB behavior can differ compared to executing a firmware image from flash memory. USB host compatibility testing is thus recommended in this scenario.

The ZED-X20P receiver supports only self-powered mode operation in which the receiver is supplied from its own power supply. The V_USB pin is used to detect the availability of the USB port, i.e. whether the receiver is connected to a USB host.

☞ USB suspend mode is not supported.

☞ USB bus-powered mode is not supported.

☞ It is important to connect V_USB to ground and leave data lines open when the USB interface is not used in an application.

☞ The voltage range for V_USB is specified from 3.0 V to 3.6 V, which differs slightly from the specification for VCC.

☞ The boot screen is retransmitted on the USB port after enumeration. However, messages generated between receiver startup and USB enumeration are not visible on the USB port.

There are additional hardware requirements if USB is used:

- V_USB requires 1 uF capacitor mounted adjacent to the pin to ensure correct V_USB voltage detection
- The V_USB voltage should be sourced from an LDO enabled by the module VCC and supplied from the USB host
- A pull-down resistor is required on the output of this V_USB LDO
- Apply USB_DM and USB_DP series resistors; typically 27 Ω

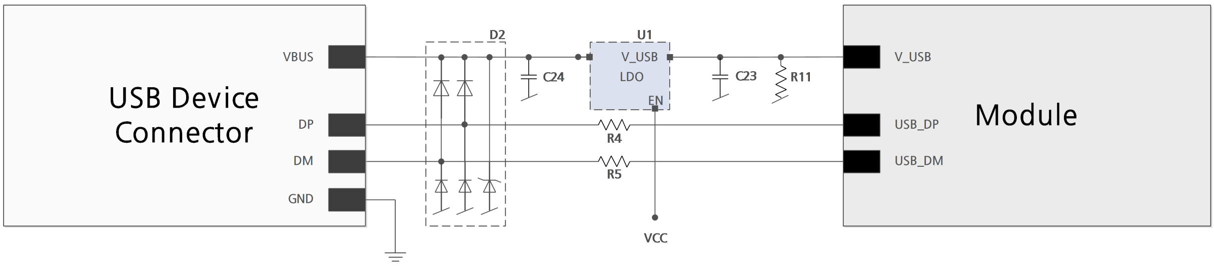

Figure 11: ZED-X20P example circuit for USB interface

R11 = 100 k Ω is recommended

R4, R5 = 27 Ω is recommended

3.2.5 Predefined PIOs

This section describes the PIOs supported by ZED-X20P. All PIO active voltage levels are related to the VCC supply voltage. All the inputs have internal pull-up resistors in normal operation and can be left open if unused.

3.2.5.1 D_SEL

The D_SEL pin can be used to configure the functionality of the combined UART1, I2C, and SPI pins. It is possible to configure the pins as UART1 + I2C, or as SPI. SPI is not available unless D_SEL pin is set to low. See Table 23 below.

Pin no.	D_SEL == 0	D_SEL == 1
42	SPI_SDO	UART1 TXD
43	SPI_SDI	UART1 RXD
44	SPI_CS_N	I2C SDA
45	SPI_CLK	I2C SCL

Table 23: D_SEL configuration

3.2.5.2 RESET_N

The ZED-X20P provides a RESET_N pin to reset the receiver. The RESET_N pin is input-only with an internal pull-up resistor and can be left open for normal operation. Driving RESET_N low for at least 100 ms will trigger a reset of the receiver. The RESET_N complies with the VCC level and can be actively driven high.

☞ The RESET_N pin will delete all information and trigger a cold start. It should only be used as a recovery option.

☞ No capacitor should be placed at RESET_N to GND, otherwise it could trigger a reset on every startup.

3.2.5.3 SAFEBOOT_N

The ZED-X20P provides a SAFEBOOT_N pin that is used to command the receiver safeboot mode.

If this pin is low at power up, the receiver starts in safeboot mode and GNSS operation is disabled.

The safeboot mode can be used to recover from situations where the flash content has become corrupted and needs to be restored.

In safeboot mode the receiver runs from a passive oscillator circuit with less accurate timing and hence the receiver is unable to communicate via USB.

In this mode UART1, I2C or SPI communication is possible. For communication via UART1 in safeboot mode, the host must send a training sequence (0x55 0x55 at 9600 baud) to the receiver in order to begin communication. After this the host must wait at least 2 ms before sending any data.

Safeboot mode is used in production to program the flash and to set the low level configuration in the eFuse.

It is recommended to have the possibility to pull the SAFEBOOT_N pin low in the application. This can be provided using an externally connected test point or a host I/O port.

3.2.5.4 TIMEPULSE

The ZED-X20P features one time pulse output at the TIMEPULSE pin.

More information about the time pulse feature and its configuration can be found in the Time pulse section.

3.2.5.5 TX_READY

This feature enables each port to define a corresponding pin, which indicates if bytes are ready to be transmitted. A listener can wait on the TX-READY signal instead of polling the I2C or SPI interfaces. The CFG-TXREADY message lets you configure the polarity and the number of bytes in the buffer before the TX-READY signal goes active. By default, this feature is disabled. For USB, this feature is configurable but might not behave as described below due to a different internal transmission mechanism. If the number of pending bytes reaches the threshold configured for this port, the corresponding pin will become active (configurable active-low or active-high), and stay active until the last bytes have been transferred from software to hardware.

☞ This is not necessarily equal to all bytes transmitted, i.e. after the pin has become inactive, up to 16 bytes might still need to be transferred to the host.

The TX_READY pin can be selected from all PIOs which are not in use (see UBX-MON-HW3 in the applicable interface description [2] for a list of the PIOs and their mapping). Each TX_READY pin is exclusively associated to one port and cannot be shared. If PIO is invalid or already in use, only the configuration for the specific TX_READY pin is ignored, the rest of the port configuration is applied if valid. The acknowledge message does not indicate if the TX-READY configuration is successfully set, it only indicates the successful configuration of the port. To validate successful configuration of the TX_READY pin, the port configuration should be read back and the settings of TX-READY feature verified (will be set to disabled/all zero if the settings are invalid).

The threshold when TX_READY is asserted should not be set above 2 kB as it is possible that the internal message buffer limit is reached before this. This results in the TX_READY pin never being set as the messages are discarded before the threshold is reached.

3.2.5.5.1 Extended TX timeout

If the host does not communicate over SPI or I2C for more than approximately 2 seconds, the device assumes that the host is no longer using this interface and no more packets are scheduled for this port. This mechanism can be changed by enabling "extended TX timeouts", in which case the receiver delays idling the port until the allocated and undelivered bytes for this port reach 4 kB. This feature is especially useful when using the TX-READY feature with a message output rate of less than once per second, and polling data only when data is available, determined by the TX_READY pin becoming active.

3.2.5.6 EXTINT

EXTINT is an external interrupt pin with fixed input voltage thresholds with respect to VCC. It can be used for functions such as accurate external frequency aiding and on/off control. The external frequency aiding can be used to calibrate the clock. This enables faster fix of satellite signals (UBX-MGA-INI-FREQ or UBX-MGA-INI-TIME_XXX) and can be used during normal operation or during the production test. Another possibility to use the extint feature is to wake up the receiver after putting it into backup mode; this can be set up with UBX-RXM-PMREQ. Leave open if unused, this function is disabled by default.

3.2.5.7 GEOFENCE_STAT pin

The ZED-X20P provides a GEOFENCE_STAT pin that indicates the current geofence status as to whether the receiver is inside any of the active areas.

This feature can be used for example to wake up a sleeping host when a defined geofence condition is reached. It is possible to configure up to four circular areas as geofence locations. Once configured, the receiver continuously compares its current position with the preset geofenced areas.

The receiver toggles the assigned pin according to the combined geofence state.

There are three possible outcomes for each geofence:

- *Inside* - The position is inside the geofence with the configured confidence level
- *Outside* - The position lies outside of the geofence with the configured confidence level
- *Unknown* - There is no valid position solution or the position uncertainty does not allow for unambiguous state evaluation

The GEOFENCE_STAT pin is always set to high level when the combine geofence state is unknown. The low level can either represent the inside state or the outside state according to the value set in the CFG-GEOFENCE-PINPOL configuration item. If the receiver is in software backup or in a reset, the pin will go to high accordingly.

☞ The GEOFENCE_STAT pin is the module pin 19 and it is assigned to PIO3.

3.2.5.8 RTK_STAT pin

The ZED-X20P provides an RTK_STAT pin that provides an indication of the RTK positioning status. It can be used to confirm if a valid stream of correction messages is being received. As valid correction messages we only consider the correction messages that are supported and used by the receiver.

The RTK_STAT pin status can be mapped to the `carrSoln` field of the UBX-NAV-PVT and interpreted as follows:

- An active low pin level indicates that RTK fixed mode has been achieved
- Alternating (blinking) pin level, indicates that a valid stream of correction messages is being received and utilized but no RTK fixed mode has been achieved
- An active high pin level indicates that no carrier phase solution is available

3.3 Antenna supervisor

An active antenna supervisor provides the means to check the antenna for open and short circuits and to shut off the antenna supply if a short circuit is detected. Once enabled, the active antenna supervisor produces status messages, reporting in NMEA and/or UBX protocol.

The antenna supervisor can be configured through the CFG-HW-ANT_* configuration items. The current configuration of the active antenna supervisor can also be checked by polling the related CFG-HW_ANT_* configuration items.

The current active antenna status can be determined by polling the UBX-MON-RF message. If an antenna is connected, the initial state after power-up is “Active Antenna OK" in the UBX-MON-RF message in the u-center "Message View".

The Antenna supervisor circuit section details the required circuit.

3.3.1 Antenna voltage control - ANT_OFF

☞ Antenna status (as reported in UBX-MON-RF and UBX-INF-NOTICE messages) is not reported unless the antenna voltage control has been enabled.

Enable the antenna voltage control by setting the configuration item CFG-HW-ANT_CFG_VOLTCTRL to true (1).

Result:

- UBX-MON-RF in u-center "Message View": Antenna status = OK. Antenna power status = ON
- ANT_OFF pin = active high to turn antenna off therefore the pin is low to enable an external antenna.

Start-up message at power up if configuration stored:

`$GNTXT,01,01,02,ANTSUPERV=AC *00`

`$GNTXT,01,01,02,ANTSTATUS=INIT*3B`

`$GNTXT,01,01,02,ANTSTATUS=OK*25`

`ANTSUPERV=AC` indicates antenna control is activated

3.3.2 Antenna short detection - ANT_SHORT_N

Enable the antenna short detection by setting the configuration item CFG-HW-ANT_CFG_SHORTDET to true (1).

Result:

- UBX-MON-RF in u-center "Message View": Antenna status = OK. Antenna power status = ON
- ANT_OFF = active high to disable an external antenna therefore the pin is low to enable an external antenna.
- ANT_SHORT_N = active low to detect a short therefore the pin is high (PIO pull up enabled to be pulled low if shorted)

Start-up message at power up if configuration is stored:

`$GNTXT,01,01,02,ANTSUPERV=AC SD *37`

`$GNTXT,01,01,02,ANTSTATUS=INIT*3B`

`$GNTXT,01,01,02,ANTSTATUS=OK*25`

`ANTSUPERV=AC SD` (Antenna control and short detection activated)

Then if shorted (ANT_SHORT_N pulled low):

- UBX-MON-RF in u-center "Message View": Antenna status = SHORT. Antenna power status = ON (Antenna power control power down when short has not been enabled = off by default).

`$GNTXT,01,01,02,ANTSTATUS=SHORT*73`

- ANT_OFF = active high therefore still low (still enabled as auto power down is not enabled)

☞ After a detected antenna short, the reported antenna status will keep on being reported as shorted. If the antenna short detection auto recovery is enabled, then the antenna status can recover after a timeout. To recover the antenna status immediately, a power cycle is required or configuring the antenna short detection functionality off and on.

3.3.3 Antenna short detection auto recovery

Enable the antenna short detection auto recovery by setting the configuration item CFG-HW-ANT_CFG_RECOVER to true (1).

Result:

- UBX-MON-RF in u-center "Message View": Antenna status = OK. Antenna power status = ON
- ANT_OFF = active high there for the PIO is low to enable an external antenna
- ANT_SHORT_N = high (PIO pull up enabled to be pulled low if shorted)

Start-up message at power up if configuration is stored:

`$GNTXT,01,01,02,ANTSUPERV=AC SD PDoS SR*3E`

`$GNTXT,01,01,02,ANTSTATUS=INIT*3B`

`$GNTXT,01,01,02,ANTSTATUS=OK*25`

`ANTSUPERV=AC SD PDoS SR` (indicates short circuit recovery added - SR)

Then if antenna is shorted (ANT_SHORT_N pulled low):

- `$GNTXT,01,01,02,ANTSTATUS=SHORT*73`
- UBX-MON-RF in u-center "Message View": Antenna status = SHORT. Antenna power status = OFF
- ANT_OFF = high (to disable - active high)

After a time out period receiver will retest the short condition by enabling ANT_OFF = LOW

If a short is not present it will report antenna condition is OK:

`$GNTXT,01,01,02,ANTSTATUS=OK*25`

UBX-MON-RF in u-center "Message View": Antenna status = OK. Antenna power status = ON

3.3.4 Antenna open circuit detection - ANT_DETECT

Enable the antenna open circuit detection by setting the configuration item CFG-HW-ANT_CFG_OPENDET to true (1).

Result:

- UBX-MON-RF in u-center "Message View": Antenna status = OK. Antenna power status = ON
- ANT_OFF = active high therefore PIO is low to enable external antenna
- ANT_SHORT_N = active low therefore PIO is high (PIO pull up enabled to be pulled low if shorted)
- ANT_DETECT = active high therefore PIO is high (PIO pull up enabled to be pulled low if antenna not detected)

Start-up message at power up if configuration is stored:

`$GNTXT,01,01,02,ANTSUPERV=AC SD OD PDoS SR*15`

`$GNTXT,01,01,02,ANTSTATUS=INIT*3B`

`$GNTXT,01,01,02,ANTSTATUS=OK*25`

`ANTSUPERV=AC SD OD PDoS SR` (indicates open circuit detection added - OD)

Then if ANT_DETECT is pulled low to indicate no antenna:

`$GNTXT,01,01,02,ANTSTATUS=OPEN*35`

Then if ANT_DETECT is left floating or it is pulled high to indicate antenna connected:

`$GNTXT,01,01,02,ANTSTATUS=OK*25`

3.4 Forcing receiver reset

GNSS receivers typically make a distinction between cold, warm, and hot start based on the type of valid information the receiver has during the restart.

- **Cold start:** in the cold start mode, the receiver has no information from the last position (e.g. time, velocity, frequency etc.) at startup. Therefore, the receiver must search the full time and frequency space, and all possible satellite numbers. If a satellite signal is found, it is tracked to decode the ephemeris (18-36 seconds under strong signal conditions), while the other channels continue to search satellites. Once there is a sufficient number of satellites with valid ephemeris, the receiver can calculate position and velocity data. Other GNSS receiver manufacturers call this the Factory startup mode.
- **Warm start:** in the warm start mode, the receiver has approximate information for time, position, and coarse satellite position data (Almanac). In this mode, the receiver normally needs to download ephemeris after power-up before it can calculate position and velocity data. As the ephemeris data is usually outdated after 4 hours, the receiver typically starts with a warm start if it has been powered down for more than 4 hours. In this scenario, several augmentations are possible. See Multiple GNSS assistance.
- **Hot start:** in the hot start mode, the receiver has been powered down only for a short time (4 hours or less), so that its ephemeris is still valid. Since the receiver does not need to download ephemeris again, this is the fastest startup method.

Using the UBX-CFG-RST message, you can force the receiver to reset and clear data, in order to see the effects of maintaining/losing such data between restarts. For this purpose, use the `navBbrMask` field in the UBX-CFG-RST message to initiate hot, warm, and cold starts, or a combination of startup modes.

The reset type can also be specified. This is not related to GNSS, but to the way the software restarts the system.

- **Hardware reset** uses the on-chip watchdog to electrically reset the chip. This is an immediate asynchronous reset. No stop events are generated.
- **Controlled software reset** terminates all running processes in an orderly manner. Once the system is idle, restarts the receiver operation, reloads its configuration and starts to acquire and track GNSS satellites.
- **Controlled software reset (GNSS only)** only restarts the GNSS tasks, without reinitializing the full system or reloading any stored configuration.
- **Hardware reset (after shutdown)** uses the on-chip watchdog to reset the receiver after shutdown.
- **Controlled GNSS stop** stops all GNSS tasks. The receiver is not restarted, but stops any GNSS-related processing.
- **Controlled GNSS start** starts all GNSS tasks.

Table 24 below contains an overview of the different reset types and the data that is cleared.

Reset type	Clears RAM	Clears BBR	Clears Flash
0x00 - Hardware reset (immediately), 0x04 - Hardware reset (after shutdown)	Yes	Yes	No
0x01 - Controlled Software reset	Yes	No	No
0x02 - Controlled Software reset (GNSS only), 0x08 - Controlled GNSS stop, 0x09 - Controlled GNSS start	No	No	No
RESET_N pin	Yes	Yes	No

Table 24: Overview of the available reset types

3.5 Time

Maintaining receiver local time and keeping it synchronized with GNSS time is essential for proper timing and positioning functionality. This section explains how the receiver maintains local time and introduces the supported GNSS time bases.

3.5.1 Receiver local time

The receiver is dependent on a local oscillator for both the operation of its radio parts and also for timing within its signal processing. No matter what nominal frequency the local oscillator has, u-blox receivers subdivide the oscillator signal to provide a 1-kHz reference clock signal, which is used to drive many of the receiver's processes. In particular, the measurement of satellite signals is arranged to be synchronized with the "ticking" of this 1-kHz clock signal.

When the receiver first starts, it has no information about how these clock ticks relate to other time systems; it can only count time in 1 millisecond steps. However, as the receiver derives information from the satellites it is tracking or from aiding messages, it estimates the time that each 1-kHz clock tick takes in the time base of the chosen GNSS system. This estimate of GNSS time based on the local 1-kHz clock is called receiver local time.

As receiver local time is a mapping of the local 1-kHz reference onto a GNSS time base, it may experience occasional discontinuities, especially when the receiver first starts up and the information it has about the time base is changing. Indeed, after a cold start, the receiver local time initially indicates the length of time that the receiver has been running. However, when the receiver obtains some credible timing information from a satellite or an aiding message, it jumps to an estimate of GNSS time.

3.5.2 GNSS time bases

GNSS receivers must handle a variety of different time bases as each GNSS has its own reference system time. What is more, although each GNSS provides a model for converting their system time into UTC, they all support a slightly different variant of UTC. So, for example, GPS supports a variant of UTC as defined by the US National Observatory, while BeiDou uses UTC from the National Time Service Center (NTSC) of China. While the different UTC variants are normally closely aligned, they can differ by as much as a few hundreds of nanoseconds.

Although u-blox receivers can combine a variety of different GNSS times internally, the user must choose a single source of GNSS time and, separately, a single type of UTC for input (on EXTINT pins) and output (via the TIMEPULSE pin) and the parameters reported in corresponding messages.

The CFG-TP-TIMEGRID_TP* configuration item allows the user to choose between any of the supported GNSS (GPS, BeiDou, etc.) time bases and UTC. Also, the CFG-NAVSPG-UTCSTANDARD configuration item allows the user to select which variant of UTC the receiver should use. This includes an "automatic" option which causes the receiver to select an appropriate UTC version itself, based on the GNSS configuration, using, in order of preference, USNO if GPS is enabled, NTSC if BeiDou is enabled,

The receiver assumes that an input time pulse uses the same GNSS time base as specified for the time pulse output. Where UTC is selected for time pulse output, any GNSS time pulse input will be assumed to be aligned to GPS time.

☞ The receiver allows users to independently choose GNSS signals used in the receiver (using CFG-SIGNAL-*) and the input/output time base (using CFG-TP-*). For example it is possible to instruct the receiver to use GPS satellite signals to generate BeiDou time. This practice compromises time pulse accuracy if the receiver cannot measure the timing difference between the constellations directly and is therefore not recommended.

☞ The information that allows GNSS times to be converted to the associated UTC times is only transmitted by the GNSS at relatively infrequent periods. For example GPS transmits UTC(USNO) information only once every 12.5 minutes. Therefore, if a time pulse is configured to use a variant of UTC time, after a cold start, substantial delays before the receiver has sufficient information to start outputting the time pulse can be expected.

Each GNSS has its own time reference for which detailed and reliable information is provided in the messages listed in the table below.

Time reference	Message
GPS time	UBX-NAV-TIMEGPS
BeiDou time	UBX-NAV-TIMEBDS
Galileo time	UBX-NAV-TIMEGAL
QZSS time	UBX-NAV-TIMEQZSS
UTC time	UBX-NAV-TIMEUTC

Table 25: GNSS time messages

3.5.3 Navigation epochs

Each navigation solution is triggered by the tick of the 1 kHz clock nearest to the desired navigation solution time. This tick is referred to as a navigation epoch. If the navigation solution attempt is successful, one of the results is an accurate measurement of time in the time base of the chosen GNSS system, called GNSS system time. The difference between the calculated GNSS system time and receiver local time is called the clock bias (and the clock drift is the rate at which this bias is changing).

In practice the receiver's local oscillator is not as stable as the atomic clocks to which GNSS systems are referenced and consequently clock bias tends to accumulate. However, when selecting the next navigation epoch, the receiver always tries to use the 1 kHz clock tick which it estimates to be closest to the desired fix period as measured in GNSS system time. Consequently, the number of 1 kHz clock ticks between fixes occasionally varies. This means that when producing one fix per second, there are normally 1000 clock ticks between fixes, but sometimes, to correct drift away from the GNSS system time, there are 999 or 1001 ticks.

The GNSS system time calculated in the navigation solution is always converted to a time in both the GPS and UTC time bases for output.

Clearly when the receiver has chosen to use the GPS time base for its GNSS system time, conversion to GPS time requires no work at all, but conversion to UTC requires knowledge of the number of leap seconds since GPS time started (and other minor correction terms). The relevant GPS-to-UTC conversion parameters are transmitted periodically (every 12.5 minutes) by GPS satellites, but can also be supplied to the receiver via the UBX-MGA-GPS-UTC aiding message.

When insufficient information is available for the receiver to perform any of these time base conversions precisely, predefined default offsets are used. Consequently, plausible times are nearly always generated, but they may be wrong by a few seconds (especially shortly after receiver start). Depending on the configuration of the receiver, such "invalid" times may well be output, but with flags indicating their state (e.g. the "valid" flags in UBX-NAV-PVT).

3.5.4 iTow timestamps

All the main UBX-NAV messages (and some other messages) contain an iTOW field which indicates the GPS time at which the navigation epoch occurred. Messages with the same iTOW value can be assumed to have come from the same navigation solution.

Note that iTOW values may not be valid (i.e. they may have been generated with insufficient conversion data) and therefore it is not recommended to use the iTOW field for any other purpose.

☞ The original designers of GPS chose to express time/date as an integer week number (starting with the first full week in January 1980) and a time of week (often abbreviated to TOW) expressed in seconds. Manipulating time/date in this form is far easier for digital systems than the more conventional year/month/day, hour/minute/second representation. Consequently, most GNSS receivers use this representation internally, only converting to a more conventional form at external interfaces. The iTOW field is the most obvious externally visible consequence of this internal representation.

If reliable absolute time information is required, it is recommended to use the UBX-NAV-PVT navigation solution message which also contains additional fields that indicate the validity (and accuracy in UBX-NAV-PVT) of the calculated times (see also the GNSS times section below for further messages containing time information).

3.5.5 Time validity

Information about the validity of the time solution is given in the following form:

- **Time validity**: Information about time validity is provided in the `valid` flags (e.g. `validDate` and `validTime` flags in the UBX-NAV-PVT message). If these flags are set, the time is known and considered valid for use. These flags are shown in table GNSS times in section GNSS times above as well as in the UBX-NAV-PVT message.
- **Time validity confirmation**: Information about confirmed validity is provided in the `confirmedDate` and `confirmedTime` flags in the UBX-NAV-PVT message. If these flags are set, the time validity can be confirmed by using an additional independent source, meaning that the probability of the time to be correct is very high. Note that information about time validity confirmation is only available if the `confirmedAvai` bit in the UBX-NAV-PVT message is set.

☞ `validDate` means that the receiver has knowledge of the current date. However, it must be noted that this date might be wrong for various reasons. Only when the `confirmedDate` flag is set, the probability of the incorrect date information drops significantly.

☞ `validTime` means that the receiver has knowledge of the current time. However, it must be noted that this time might be wrong for various reasons. Only when the `confirmedTime` flag is set, the probability of incorrect time information drops significantly.

☞ `fullyResolved` means that the UTC time is known without full seconds ambiguity. When deriving UTC time from GNSS time the number of leap seconds must be known. It might take several minutes to obtain such information from the GNSS payload. When the one second ambiguity has not been resolved, the time accuracy is usually in the range of ~20s.

3.5.6 UTC representation

UTC time is used in many NMEA and UBX messages. In NMEA messages, time is always rounded to the nearest hundredth of a second and it is normally reported with two decimal places (e.g. 124923.52). When using NMEA compatibility mode (selected using CFG-NMEA-COMPAT) where the output must have three decimal places, the third digit is always zero since the underlying time is rounded to the nearest hundredth of a second.

UTC time is also reported within some UBX messages, such as UBX-NAV-TIMEUTC and UBX-NAV-PVT. In these messages date and time are separated into seven distinct integer fields. Six of these (year, month, day, hour, min. and sec.) have fairly obvious meanings and are all guaranteed to match the corresponding values in NMEA messages generated by the same navigation epoch. This facilitates simple synchronization between associated UBX and NMEA messages.

The seventh field is called nano and it contains the number of nanoseconds by which the rest of the time and date fields need to be corrected to get the precise time. So, for example, the UTC time 12:49:23.521 would be reported as: hour: 12, min: 49, sec: 23, nano: 521000000.

It is however important to note that the first six fields are the result of rounding to the nearest hundredth of a second. Consequently the nano value can range from -5000000 (i.e. -5 ms) to +994999999 (i.e. nearly 995 ms).

When the nano field is negative, the number of seconds (and maybe minutes, hours, days, months or even years) have been rounded up. Therefore, some or all of them must be adjusted to get the correct time and date. Thus in an extreme example, the UTC time 23:59:59.9993 on 31st December 2011 would be reported as: year: 2012, month: 1, day: 1, hour: 0, min: 0, sec: 0, nano: -700000.

If a resolution of one hundredth of a second is adequate, negative nano values can simply be rounded up to 0 and effectively ignored.

The UBX-NAV-TIMEUTC message gives information about the UTC time reference clock.

The preferred variant of UTC time can be specified using the CFG-NAVSPG-UTCSTANDARD configuration item. The UTC time variant configured must correspond to a GNSS that is currently enabled. Otherwise the reported UTC time is inaccurate.

3.5.7 Leap seconds

Due to the slightly uneven spin rate of the Earth, UTC time gradually moves out of alignment with the mean solar time (that is, the sun no longer appears directly overhead at 0 longitude at midday). Occasionally, a "leap second" is announced to bring UTC back into close alignment with the mean solar time. Usually this means adding an extra second to the last minute of the year, but this can also happen on 30th June. When this happens, UTC clocks are expected to go from 23:59:59 to 23:59:60, and only then on to 00:00:00.

It is also possible to have a negative leap second, in which case there will only be 59 seconds in a minute and 23:59:58 will be followed by 00:00:00.

u-blox receivers are designed to handle leap seconds in their UTC output and consequently applications processing UTC times from either NMEA or UBX messages should be prepared to handle minutes that are either 59 or 61 seconds long.

Leap second information can be polled from the receiver with the message UBX-NAV-TIMELS.

3.5.8 Date ambiguity

Each navigation satellite transmits information about the current date and time in the data message. The time of week (TOW) indicates the elapsed number of seconds since the start of the week (midnight Saturday/Sunday). The week number (WN) indicates the elapsed number of weeks since the particular GNSS system was started. By combining these two values the current date and time can be known. Modern GPS satellites use a 13-bit value for the week number. As GPS system was started in 1980, it allows the week number to represent dates up to year 2137. Unfortunately, at the time when the commonly used GPS L1C/A data message was designed the signal had only 10 bits available for the week number. The top bits of the full week number had to be left out. The 10 bottom bits of the week number are not sufficient to yield a completely unambiguous date as every 1024 weeks (a bit less than 20 years), the transmitted week number value "rolls over" back to zero. Consequently, the information in GPS L1 message does not differentiate between, for example, 1980, 1999, or 2019. GPS L1 receivers must thus use additional methods to calculate the full week number.

Although BeiDou and Galileo have similar representations of time, they still transmit sufficient bits for the week number to be unambiguous for the foreseeable future (the first ambiguity will be in 2078 for Galileo, and not until 2163 for BeiDou). Therefore, the receiver regards the date information transmitted by BeiDou, and Galileo to be unambiguous and, where necessary, uses this information to resolve any ambiguity in the GPS date.

☞ If the receiver is connected to a simulator, note that GPS time is referenced to 6th January 1980, Galileo to 22 August 1999 and BeiDou to 1 January 2006. The receiver doesn't work reliably with signals simulated before these dates.

3.5.8.1 GPS-only date resolution

If only GPS L1C/A signals are available, the receiver establishes the date by assuming that all week numbers must be at least as large as the reference rollover week number. The default value for the reference rollover week number is selected at the compile time of the receiver firmware and is normally set to a value of a few weeks before the software is completed. The value can be overridden by CFG-NAVSPG-WKNROLLOVER configuration item.

The following example illustrates how this works:

Assume that the reference rollover week number set in the firmware at compile time is 2148 (which corresponds to a week in calendar year 2021, but is transmitted by the satellites as 100). In this case, if the receiver sees transmissions containing week numbers in the range of 100 ... 1023, they are interpreted as week numbers 2148 ... 3071 (calendar years 2021 ... 2038), whereas transmissions with week numbers from 0 to 99 are interpreted as week numbers 3072 ... 3171 (calendar years 2038 ... 2040).

☞ It is important to set the reference rollover week number correctly when supplying the receiver with simulated signals, especially when the scenarios are in the past.

3.6 Time mark

The receiver can be used to provide an accurate measurement of the time at which a pulse was detected on the external interrupt pin. The reference time can be chosen by setting the time source parameter to UTC, GPS, BeiDou, Galileo, NAVIC or local time in the CFG-TP-* configuration group. The UTC standard can be set in the CFG-NAVSPG-* configuration group. The delay figures defined with CFG-TP-* are also applied to the results output in the UBX-TIM-TM2 message.

A UBX-TIM-TM2 message is output at the next epoch if

- The UBX-TIM-TM2 message is enabled, and
- a rising or falling edge was triggered since last epoch on the EXTINT pin.

The UBX-TIM-TM2 messages includes the time of the last time mark, new rising/falling edge indicator, time source, validity, number of marks and an accuracy estimate.

☞ Only the last rising and falling edge detected between two epochs is reported since the output rate of the UBX-TIM-TM2 message corresponds to the measurement rate configured with CFG-RATE-MEAS (see Figure 12 below).

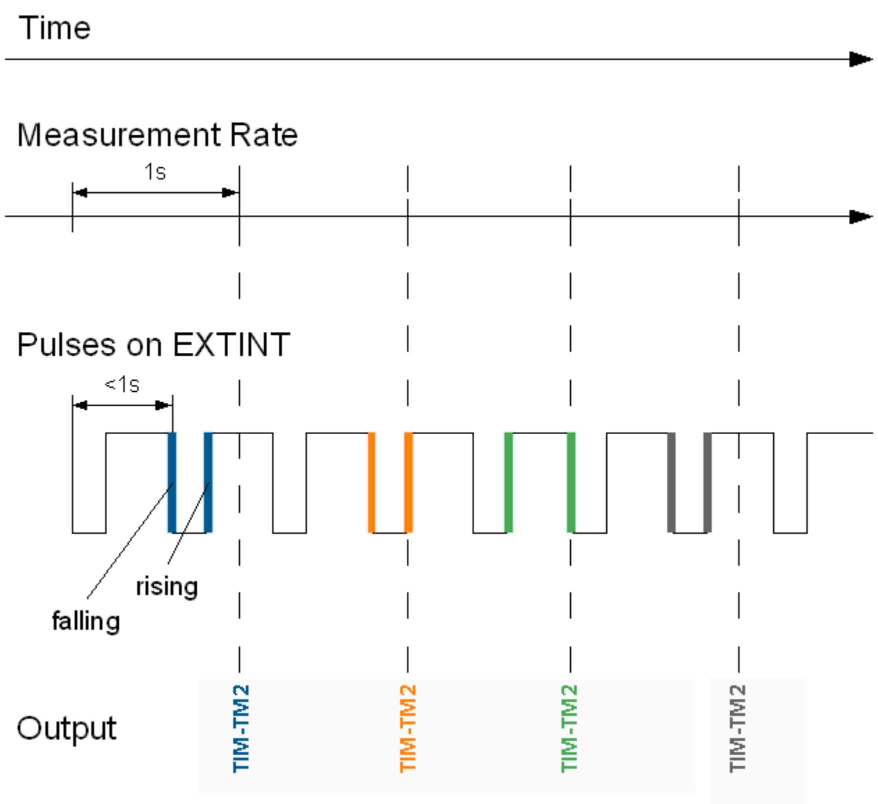

Figure 12: Time mark

3.7 Time pulse

The receiver includes a time pulse feature providing clock pulses with configurable duration and frequency. The time pulse function can be configured using the CFG-TP-* configuration group. The UBX-TIM-TP message provides time information for the next pulse and the time source.

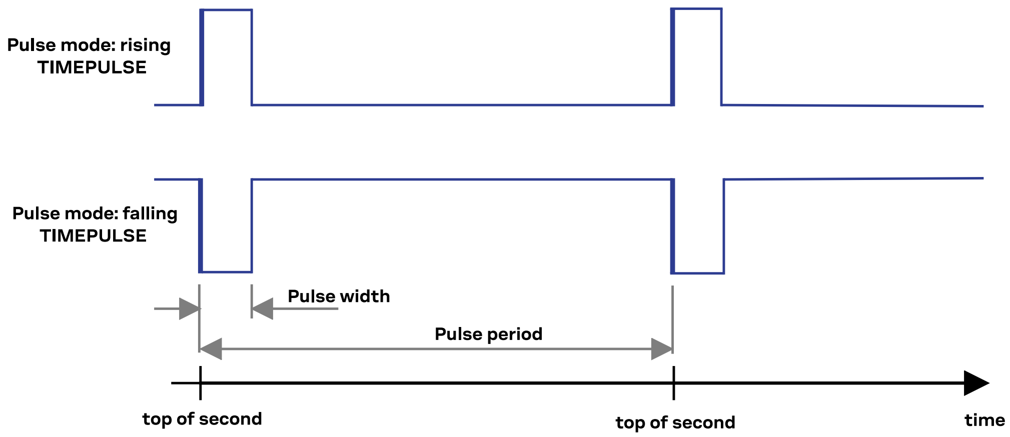

Figure 13: Time pulse

3.7.1 Recommendations

- The time pulse can be aligned to a wide variety of GNSS times or to variants of UTC derived from them. For further information, see GNSS time bases. However, it is strongly recommended that the choice of time base is aligned with the available GNSS signals (for example, to produce GPS time or UTC(USNO), ensure GPS signals are available). This involves coordinating the setting of CFG-SIGNAL-* configuration group with the choice of time pulse time base.
- When using time pulse for precision timing applications it is recommended to calibrate the antenna cable delay against a reference timing source.
- To get the best timing accuracy with the antenna, a fixed and accurate position is needed.
- If relative time accuracy between multiple receivers is required, do not mix receivers of different product families. If this is required, the receivers must be calibrated accordingly, by setting cable delay and user delay.
- The recommended configuration when using the UBX-TIM-TP message is to set both the measurement rate (CFG-RATE-MEAS) and the time pulse frequency (CFG-TP-*) to 1 Hz.

The sequential order of the signal present at the TIMEPULSE pin and the respective output message for the simple case of 1 pulse per second (1PPS) is shown in the following figure.

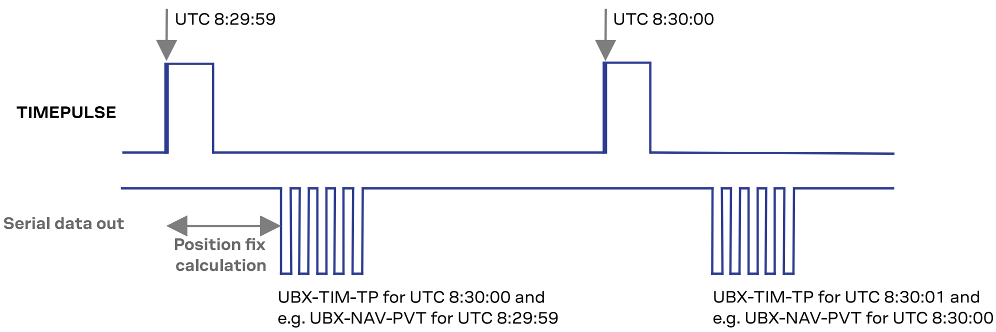

Figure 14: Time pulse and TIM-TP

3.7.2 Time pulse configuration

The time pulse (TIMEPULSE) signal has configurable pulse period, length and polarity (rising or falling edge).

It is possible to define different signal behavior (i.e. output frequency and pulse length) depending on whether or not the receiver is locked to reliable time source.

The configuration group CFG-TP-* can be used to change the time pulse settings, and includes the following parameters defining the pulse:

- **time pulse enable** - If this item is set, the time pulse is active.
- **frequency/period type** - Determines whether the time pulse is interpreted as frequency or period.
- **length/ratio type** - Determines whether the time pulse length is interpreted as length [us] or pulse ratio [%].
- **antenna cable delay** - Signal delay due to the cable between the antenna and the receiver.
- **pulse frequency/period** - Frequency or pulse time period when locked mode is not configured or not active.
- **pulse frequency/period lock** - Frequency or pulse time period for locked mode. In use as soon as the receiver has calculated a valid time from a received signal. Only used if the corresponding item is set to use another setting in locked mode.
- **pulse length/ratio** - Length or duty cycle of the generated pulse, specifies either time or ratio for the pulse to be on/off.
- **pulse length/ratio lock** - Length or duty cycle of the generated pulse for locked mode. In use as soon as the receiver has calculated a valid time from a received signal. Only used if the corresponding item is set to use another setting in locked mode.
- **user delay** - The cable delay from the receiver to the user device plus signal delay of any user application.
- **lock to GNSS freq** - If this item is set, uses the frequency gained from the GNSS signal information rather than the local oscillator's frequency.
- **locked other setting** - If this item is set, the alternative setting is used as soon as the receiver can calculate a valid time. This mode can be used, for example, to disable time pulse if the time is not locked, or to indicate a lock with different duty cycles.
- **align to TOW** - If this item is set, pulses are aligned to the top of a second.
- **polarity** - If set, the first edge of the pulse is a rising edge (pulse polarity: rising).
- **grid UTC/GNSS** - Selection between UTC (0), GPS (1), BeiDou (3), (4) Galileo and NAVIC (5) time grid. Also affects the time output by UBX-TIM-TP message.

☞ The maximum pulse length cannot exceed the pulse period.

☞ The high and the low period of the output cannot be less than 50 ns, otherwise pulses can be lost.

3.7.2.1 Example

The example below shows the 1PPS TIMEPULSE signal generated on the time pulse output according to the specific parameters of the CFG-TP-* configuration group:

- **CFG-TP-TP1_ENA** = 1
- **CFG-TP-PERIOD_TP1** = 1 000 000 μs
- **CFG-TP-LEN_TP1** = 100 000 μs
- **CFG-TP-TIMEGRID_TP1** = 1 (GPS)
- **CFG-TP-PULSE_LENGTH_DEF** = 0 (Period)
- **CFG-TP-ALIGN_TO_TOW_TP1** = 1
- **CFG-TP-USE_LOCKED_TP1** = 1
- **CFG-TP-POL_TP1** = 1
- **CFG-TP-PERIOD_LOCK_TP1** = 1 000 000 μs
- **CFG-TP-LEN_LOCK_TP1** = 100 000 μs

The 1 Hz output is maintained whether or not the receiver is locked to GPS time. The alignment to TOW can only be maintained when GPS time is locked.

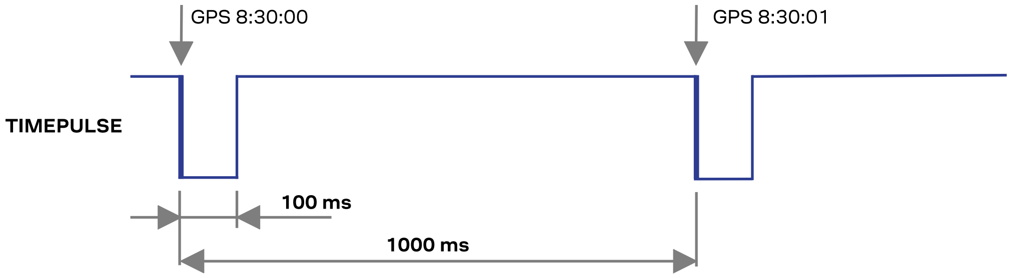

Figure 15: Time pulse signal with the example parameters

3.8 Security

The security concept of ZED-X20P covers:

- the integrity of the receiver
- communication between the receiver and the GNSS satellites
- the interface to the host system

Some security functions monitor and detect threats and report them to the host system. Other functions mitigate threats and allow the receiver to operate normally.

The table below gives an overview about possible threats and which functionality is available to detect and/or mitigate it.

Threat	u-blox solution
Over air signal integrity	Spoofing detection and monitoring Jamming interference detection and monitoring
GNSS receiver integrity	Secure boot
	Secure firmware update
	Receiver configuration lock
	Compliance with DHS allow list
Secure interface to host	Message authentication

Table 26: u-blox security options

3.8.1 Spoofing detection and monitoring

Spoofing is the process where a counterfeit GNSS signal is transmitted locally to deceive the receiver/user and produce an erroneous position fix and/or time solution. The detection algorithm monitors GNSS signals for implausible changes or inconsistencies. These are evaluated with regards to spoofing.

A detection is successful when a signal is observed to transition from an initially genuine one to a spoofed version. Hence detection is not possible if the receiver is started under spoofing conditions. The detection algorithms also rely on availability of signals from multiple GNSS constellations to improve the spoofing detection capabilities.

3.8.2 Jamming and interference detection and monitoring

Intentional and/or unintentional jamming of GNSS receivers can degrade the quality of GNSS signals and receiver performance. All u-blox receivers can detect and monitor jamming and report it to the user. The monitoring function is always enabled to inform the user about interference in the GNSS RF bands.

☞ In case of excessive false jamming alerts, the jamming detector sensitivity can be configured with the CFG-SEC-JAMDET_SENSITIVITY_HI configuration.

3.8.3 Spoofing and jamming indication

The UBX-SEC-SIG message provides a direct method for monitoring the current security status at each navigation epoch to alert the host about potential jamming or spoofing events.

The UBX-SEC-SIGLOG message provides a log of past events triggered by jamming or spoofing detection.

Each event is a combination of a detection type and an event type, where the event type 'indication started' and 'indication stopped' and also the event type 'indication triggered' and 'indication timeout' form a pair.

A maximum of 16 events are logged and new events take precedence over the past events in the log. Power cycles and restarts of the receiver reset the log, deleting its content.

See the applicable Interface description [2].

3.8.4 GNSS receiver security

3.8.4.1 Secure boot

The ZED-X20P boots only with firmware images that are signed by u-blox. This prevents the execution of non-genuine firmware images on the receiver.

3.8.4.2 Secure firmware update

The firmware image is signed by u-blox. The ZED-X20P verifies the signature during the firmware update.

3.8.4.3 Receiver configuration lock

The receiver configuration lock feature ensures that no configuration changes are possible once the feature is enabled. The configuration lock is enabled by setting the configuration item CFG-SEC-CFG_LOCK to "true".

The configuration lock can be applied to different configuration layers including the RAM, BBR, and flash memory. At startup, the receiver constructs the configuration database from different configuration layers and maintains it in the run-time RAM memory. When the configuration lock is set in the run-time RAM, the receiver configuration cannot be changed on any configuration layer.

☞ For more information on the configuration layers including the order of priority they are applied in, see the applicable Interface description [2].

The configuration lock set on a configuration layer in volatile memory (RAM, BBR) is removed when the memory is cleared. However, the configuration lock set in non-volatile memory (flash memory) is permanent apart from one exception: during firmware upload to flash memory, the flash is erased during the process causing the configuration lock to be cleared. Refer to Firmware update to flash for more information on firmware update.

The configuration lock can also be applied to the OTP layer. The configuration lock on OTP layer is permanent and cannot be reversed. However, patches can still be applied to the OTP memory.

To test the lock functionality, set it on the RAM configuration layer. After a power cycle, the information on RAM layer is cleared and the lock is no longer set.

☞ It is recommended to apply the configuration lock on the same layer the configuration is stored.

An example of use case is that the host application locks the receiver configuration. A user communicating with the ZED-X20P through any of the available interfaces can poll, enable or send messages, but cannot change the configuration by sending UBX configuration messages.

3.8.4.4 Compliance with DHS allow list

The GPS allow list is a list of checks that have been implemented in the ZED-X20P receiver firmware in order to validate LNAV navigation input data downloaded from the GPS satellites. These checks will improve the reliability of the receiver, blocking unreliable data from entering in the navigation solution or warning the user about issues in the navigation message.

The official DHS allow list guide DHS - GPS Receiver Allow List Development Guide provides an example of an allow list, and guidelines on building a series of rules to validate the input data. To ensure product security and minimize vulnerabilities, a significant number of checks have been added to the ZED-X20P firmware.

3.9 Multiple GNSS assistance (MGA)

The u-blox AssistNow services provide a proprietary implementation of an A-GNSS protocol compatible with u-blox GNSS receivers. The MGA services consist of AssistNow Online and Offline variants delivered by HTTP or HTTPS protocol.

When a client device makes an AssistNow request, the service responds with the requested data using standard UBX protocol MGA messages. These messages are ready for direct transmission from the client to the receiver port without requiring any modification.

AssistNow Online optionally provides immediate satellite ephemerides, health information and time aiding data suitable for GNSS receiver systems with direct internet access.

☞ The ZED-X20P supports AssistNow Online only.

Refer to the ZED-X20P datasheet for the supported GNSS signals by each MGA service [1].

3.9.1 Authorization

To use the AssistNow services, customers will need to obtain an authorization token from u-blox. Go to https://www.u-blox.com/en/solution/services/assistnow or contact your local technical support to get more information and to request access to the service.

3.9.2 Preserving MGA and operational data during power-off

The time-to-fix after a receiver power interruption is dependent on the amount of operational data available at startup. Satellite broadcast information and an estimate of accurate time can be fetched form the AssistNow service. In addition, the following techniques can restore the data that was stored prior to powering down.

- **Battery-backed RAM:**The receiver operational state stored in this RAM can be maintained during power outages by connecting the V_BCKP pin to an independent supply, e.g. a battery. This is a recommended method as it will maintain all MGA-related information, any user configuration, calibration data, and an estimate of time via the real-time clock. See V_BCKP for more information.

3.10 Firmware update

ZED-X20P is supplied with firmware. u-blox may release updated images containing, for example, security fixes, enhancements, bug fixes, etc. Therefore it is important that customers implement a firmware update mechanism in their system.

A firmware image is a binary file containing the software to be run by the GNSS receiver. A firmware update is the process of transferring a firmware image to the receiver and storing it in non-volatile flash memory.

Contact u-blox for more information on firmware update.

4 Hardware integration

This chapter explains how the receiver can be integrated into an application design.

4.1 Power supply

The ZED-X20P has the following power supply pins: VCC and V_BCKP.

A power supply at VCC must be present for normal operation. A supply at V_BCKP is optional. If present, it enables the hardware backup mode when the VCC supply is off.

Refer to the ZED-X20P Data sheet [1] for absolute maximum ratings, operating conditions, and power requirements.

4.1.1 VCC

The **VCC** pin is connected to the main supply voltage. During operation, the current drawn by the module can vary by some orders of magnitude. For this reason, it is important that the supply circuitry be able to support the peak power for a short time (see the applicable data sheet [1] for specification).

The module integrates a DC/DC converter, which allows reduced power consumption.

☞ When switching from backup mode to normal operation or at startup, u-blox ZED-X20P modules must charge the internal capacitors in the core domain. In certain situations, this can result in a significant current draw. For low-power applications using backup mode, it is important that the power supply or low ESR capacitors at the module input be able to deliver this current/charge.

☞ To reduce peak current during power on, users can employ an LDO that has a built-in current limiter.

☞ Do not add any series resistance greater than 0.2 Ω to the VCC supply as it will generate input voltage noise due to dynamic current conditions.

☞ For the ZED-X20P module the equipment must be supplied by an external limited power source in compliance with the clause 2.5 of the standard IEC 60950-1.

4.1.2 V_BCKP

The V_BCKP pin can be used to provide power to maintain the real-time clock (RTC) and battery-backed RAM (BBR) when VCC is removed.

If the module supply has a power failure, the **V_BCKP** pin supplies the real-time clock (RTC) and battery-backed RAM (BBR). Use of valid time and the GNSS orbit data at start up will improve the GNSS performance, as with hot starts and warm starts.

If V_BCKP is not provided, the module performs a cold start at power up.

If a host is connected to ZED-X20P, V_BCKP can be partially emulated by using UBX-UPD-SOS functionality. BBR data can saved to the host and restored at startup. See the applicable Interface description for more information.

☞ Avoid high resistance on the **V_BCKP** line: During the switch from main supply to backup supply, a short current adjustment peak can cause a high voltage drop on the pin with possible malfunctions.

☞ Add a 2 uF capacitor on the V_BCKP pin to absorb the current adjustment peak when switching from VCC to V_BCKP supply.

☞ If no backup supply voltage is available, connect the **V_BCKP** pin to **VCC**.

☞ Allow all I/O including UART and other interfaces to float or connect to a high impedance in HW backup mode (V_BCKP supplied when VCC is removed). See the Interfaces section.

Real-time clock (RTC)

The real-time clock (RTC) is driven by a 32-kHz oscillator using an RTC crystal. If VCC is removed while a battery is connected to **V_BCKP**, most of the receiver is switched off leaving the RTC and BBR powered. This operating mode is called Hardware Backup Mode which enables time keeping and all relevant data to be saved to allow a hot or warm start.

4.1.3 ZED-X20P power supply

The ZED-X20P requires a low-noise, low-dropout voltage, and a very low source impedance power supply of 3.3 V typically. No inductors or ferrite beads should be used from LDO to the module VCC pin. The peak currents need to be taken into account for the source supplying the LDO for the module.

A power supply fed by 5 V is shown in the figure below. This example circuit is intended only for the module supply.

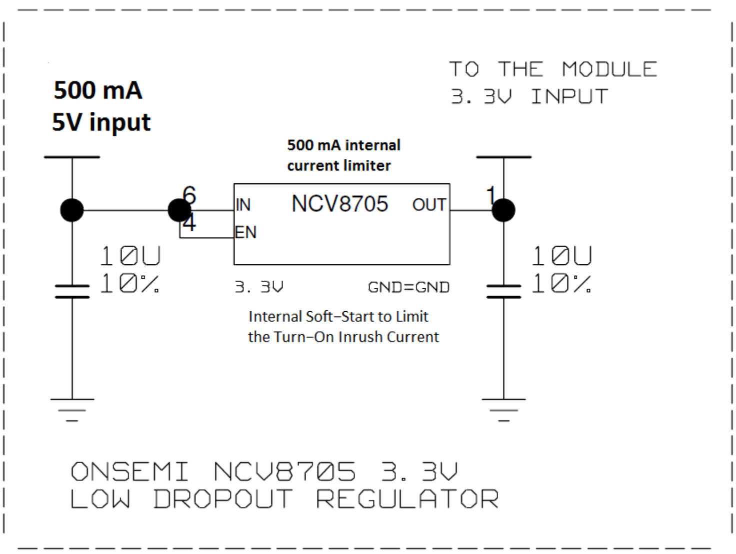

Figure 16: ZED-X20P power supply

4.2 RF interference

The GNSS signal power received at the antenna is very low compared to other wireless communication signals. The received nominal –130 dBm GNSS signal strength makes the GNSS receiver susceptible to interference from many kinds of nearby RF sources.

As an example, cellular applications emit signals with power levels of approximately +30 dBm, while the GNSS signal is less than –130 dBm when reaching the antenna. By simply comparing these numbers, it is obvious that interference issues must be seriously considered during the design phase.

4.2.1 In-band interference

Although the radio communications standards prevent intentional RF signal sources from interfering the GNSS frequencies, many devices emit RF power into the GNSS band at levels much higher than the GNSS signal itself.

One reason is that the frequency band above 1 GHz is not well regulated with regards to EMI, and even if permitted, signal levels are much higher than the GNSS signal power. In particular, all types of digital equipment, such as PCs, digital cameras, LCD screens, etc. tend to emit a broad frequency spectrum up to several GHz of frequency. Also wireless transmitters may generate spurious emissions that fall into the GNSS band.

☞ The section defines measures against in-band interference during the design phase of the application.

4.2.2 Out-of-band interference

Out-of-band interference is caused by signal frequencies that are different from the GNSS carrier frequency. The main sources are wireless communication systems such as LTE, GSM, CDMA, WCDMA, Wi-Fi, BT, etc. Typically, these systems may emit their specified maximum transmit power in close proximity to the GNSS receiving antenna, especially if such a system is integrated with the GNSS receiver. Even at reasonable antenna selectivity, destructive power levels may reach the RF input of the GNSS receiver. In addition, larger signal interferers may generate intermodulation products inside the GNSS receiver front-end that fall into the GNSS band and contribute to in-band interference.

4.2.3 Spectrum analyzer

The UBX-MON-SPAN message can be enabled in u-center 2 to provide a low-resolution spectrum analyzer sufficient to identify noise or jammers in the reception band. Once enabled, u-center 2 includes a real-time chart that is updated once per second with the message data. See Figure 17 for an example.

The design or device environment can generate interference at the in-band that can be analyzed from the spectrum in the UBX-MON-SPAN message. Hence, the shape of the spectrum as well as visible peaks help to identify in-band interference. Out-of-band interference can also cause peaks that appear in the in-band. However, there can be out-of-band interference that is not visible within the span of the spectrum. The presence of out-of-band interference may be seen as reduction in the PGA (Programmable Gain Amplifier) value.

The vertical axis compares the power level in dB for each frequency. A good spectrum shape is characterized by an even noise floor along with the GNSS band. For example, if any unwanted interference peak stands out, the vertical axis gives a rough approximation of the power level in dB compared to the noise floor.

Next to the chart, the center frequency, span, and resolution values set for the spectrum, and the PGA value are also displayed. The PGA value represents the internal gain set by the receiver, which depends on the external amplification of the GNSS input signal.

The vertical discontinuous lines in the chart area represent the offset to the center frequency in MHz. This helps to estimate the frequency of any spurious emission seen.

In addition, u-center 2 includes three functions commonly found in any spectrum analyzer. These features support the RF front-end design and help to spot out any jammer present during the application operation.

- Hold: if selected, the current spectrum shape freezes in a colored line. This allows for a comparison between the time the spectrum was frozen and the real-time spectrum. This is particularly helpful in assessing the impact of running other onboard components.
- Average: if selected, a colored line shows the averaged spectrum for each frequency. This supports the analysis over time and obtaining a less noisy shape.

- Max hold: if selected, a colored line shows the maximum amplitude measured at each frequency. This option helps to spot out any jammer over a period of time.

Figure 17 shows the spectrum view in u-center 2 with the hold, average and max hold options selected. The green, yellow and red lines represent the frozen hold, average and max hold spectrums, while the blue line represents the current continuous spectrum.

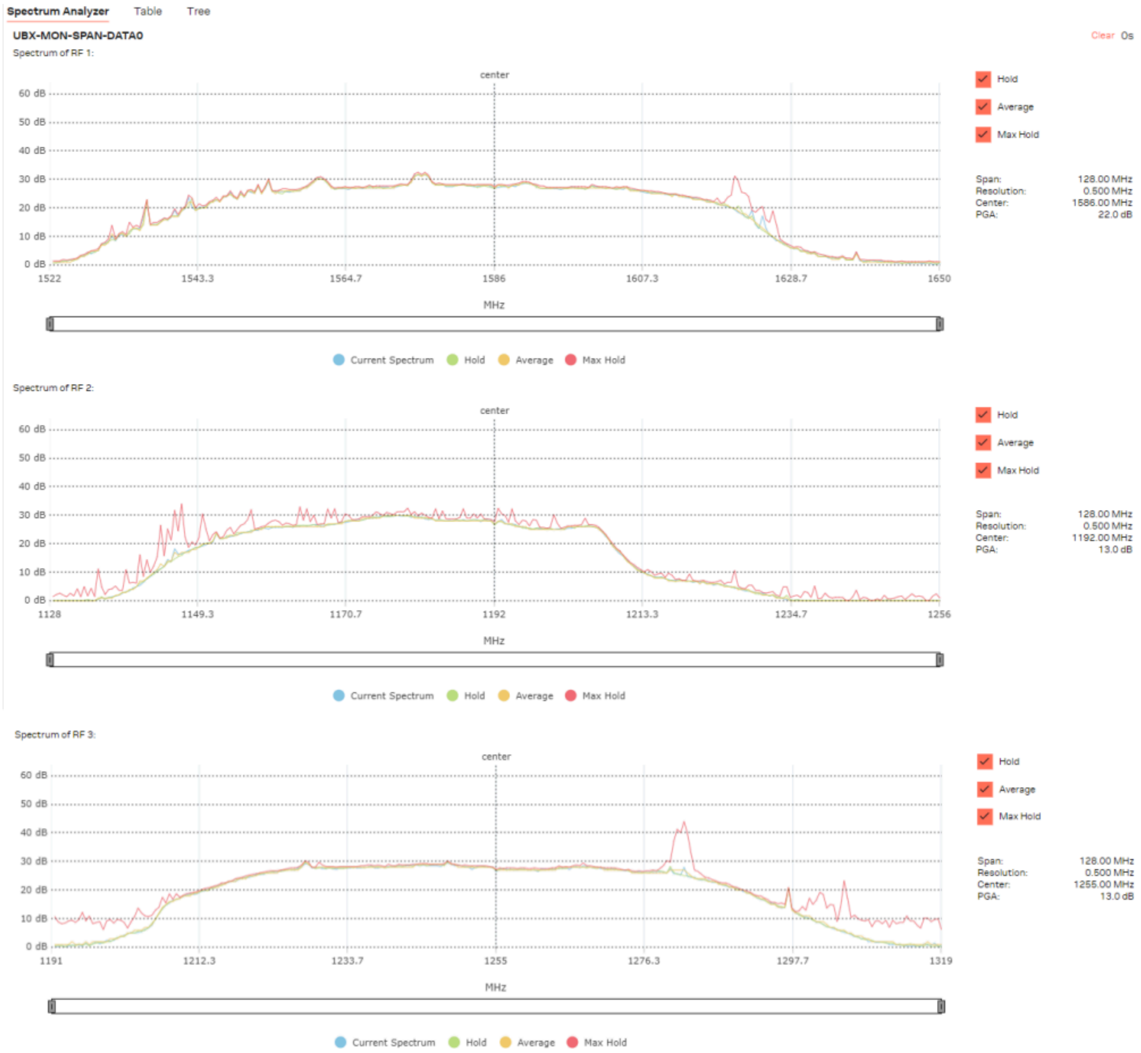

Figure 17: Spectrum analyzer view in u-center 2

☞ By changing the enabled GNSS constellations, the span widens or narrows. This has a direct impact on the spectrum resolution, since the number of measured values is fixed at 256 bins. For further details about this message and how to calculate each frequency, see the Interface description [2].

☞ A peak may be visible around the center frequency. The signal comes internally from the receiver and it does not cause any degradation in the performance.

4.3 RF front-end

GNSS receivers operate with very low signal levels, ranging from –130 dBm to approximately –167 dBm. This alone is a challenge for the GNSS application design. Out-of-band sources of interference such as GSM, CDMA, WCDMA, LTE, Wi-Fi, or Bluetooth wireless systems with a much higher signal level require additional specific measures. The goal of the RF front-end design is to receive the in-band signal with minimum loss and added noise while suppressing the out-of-band interference.

Refer to the Block diagram for an overview of the RF front-end.

4.3.1 Out-of-band blocking immunity

Out-of-band RF interference may degrade the quality and availability of the navigation solution. Out-of-band immunity limit describes the maximum power allowed at the receiver RF input with no degradation in performance. Minor violation of the immunity limit may reduce C/N0 of the received signals but does not necessarily affect the overall receiver performance. However, a significant violation may reduce receiver sensitivity or cause a complete loss of signal reception. The severity of the interference depends on the repetition rate, frequency, signal level, modulation, and bandwidth of the signal.

The immunity decreases closer to the GNSS in-band. The limit is defined at room temperature using a test signal with 64QAM modulation and 10 MHz bandwidth similar to an LTE signal.

☞ If the out-of-band immunity limit is exceeded, it is recommended to verify that the receiver performance is not affected or is at an acceptable level in the presence of interference.

4.3.2 Interference coupling

RF interference is typically first coupled into the antenna and subsequently conducted into the receiver input. Typical out-of-band interference sources include transmitting antennas of other radio systems. Estimation of the RF interference level coupled into the receiver antenna is a starting point for RF front-end design.

For designs with other radio systems, the maximum power coupled into the antenna can be estimated from the maximum transmission power and the isolation between the antennas. Practical values for antenna isolation can range from 15–20 dB down to 6–10 dB for very small devices. RF interference may also couple from external sources such as nearby mobile devices or base stations.

☞ A simplified test board can be used to estimate the isolation between two antennas. The size of the board and the placement of the antennas must match the final design. Connect the RF cables to the antenna inputs and measure S21 over the frequency band of interest with a vector network analyzer (VNA).

It is more difficult to estimate RF interference from other parts of the design. One option is to measure the interference level at the receiver input using a spectrum analyzer. Interference within the design is primarily a problem at the receiver in-band, where it cannot be addressed by filtering on the RF path. Outside the GNSS band, the required filtering is determined by the estimated interference level and the immunity of the receiver.

The maximum power coupled into the receiver RF input is compared against the immunity limit of the receiver defined in Out-of-band blocking immunity.

4.4 Antenna

The ZED-X20P requires an active antenna with an integrated LNA to ensure good performance under nominal signal reception.

When implementing a custom antenna installation, it is recommended that an OEM active antenna module be used that meets our specification. Implementing a custom active antenna design is an important exercise to meet the required bandwidths and group delay specifications compared to previous L1-only designs.

A typical all-band antenna design block diagram is shown below taken from the u-blox ANN-MB2 active antenna product.

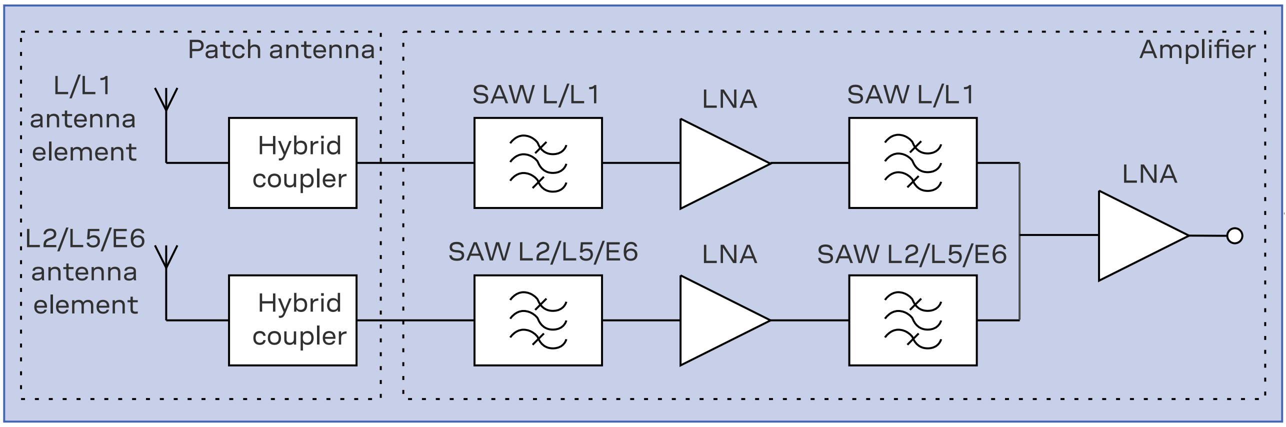

Figure 18: u-blox low cost all-band antenna internal structure

☞ A suitable ground plane is required for the antenna to achieve good performance.

☞ Location of the antenna is critical to reach the stated performance. Unsuitable locations within a vehicle could include, under vehicle dash, rear-view mirror location, etc.

A set of recommended specifications for an all-band active antenna is given below.

Parameter	Specification	
Active antenna recommendations	Minimum gain[7]	17 dB
	Maximum gain[7]	50 dB
	Noise figure	<4 dB
Group delay variation in-band[8]	TBD	
Out-of-band rejection	40 dB typ.	
Antenna element specification	L1 band antenna gain [9] (1559 - 1578 MHz)	5 dBic typ.
	L5/L2/B3/E6 band antenna gain[9] (1166 - 1285 MHz)	4.5 dBic typ.
	L1 band axial ratio (1559 - 1578 MHz)	1.5 dB max, at Zenith
	L5/L2/B3/E6 band axial ratio (1166 - 1285 MHz)	3 dB max, at Zenith
	Polarization	RHCP
	Phase center variation	<TBD
EMI immunity out-of-band[10]	30 V/m	

7 Including passive losses (filters, cables, connectors etc.)

8 GNSS system bandwidths: B1I 1559…1563 MHz; L1,E1,B1C 1573…1578 MHz; L2C 1223…1231 MHz; L5,E5a,E6,B2a,B3I 1166…1285MHz

9 Measured with a ground plane d=120 mm

10 Exception GNSS system band +/- 200 MHz, emphasis on cellular bands

Parameter	Specification
ESD circuit protection	15 kV human body model air discharge

Table 27: Antenna specifications for ZED-X20P modules

The antenna system should include filtering to ensure adequate protection from nearby transmitters. Take care in the selection of antennas placed close to cellular or Wi-Fi transmitting antennas.

4.4.1 Active Antenna Power Supply

The antenna power supply is typically used to power GNSS active antennas. The power supply should be able to provide the correct voltage and current to the antenna to ensure optimal performance of ZED-X20P.

To power and limit the current to the antenna, you have the following options:

- External power supply
- External power supply and current limiting
- VCC_RF power supply

The diagram shows the Z impedance of the antenna bias L4 inductor. This inductor is found in all the reference circuits mentioned in the subsequent sections. It is important for the Z impedance to be greater than 500 Ω within the 1–1.8 GHz frequency range. This impedance ensures efficient blocking of RF signals from reaching the power supply.

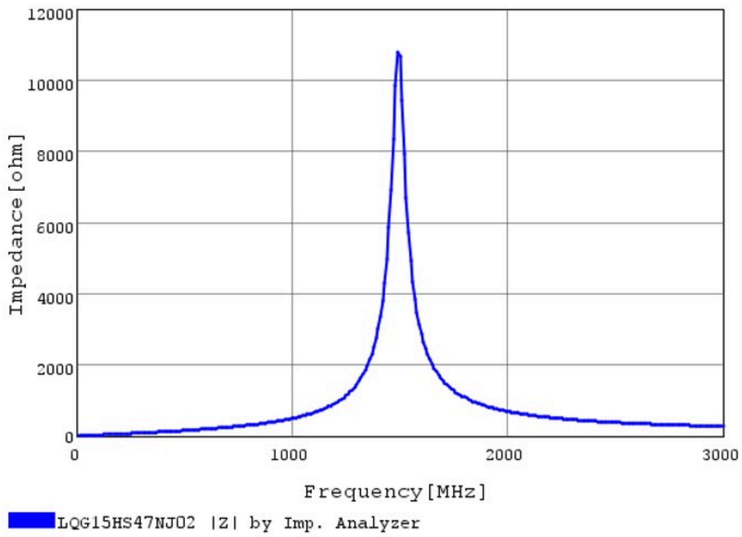

Figure 19: ZED-X20P antenna bias inductor impedance

4.4.1.1 External power supply

Figure 20 shows an example with an external filtered supply V_ANT 3.3 V. Consider the power dissipation in both the resistor and inductor based on the supply voltage and short circuit current. Calculate the current capacity of the bias-T inductor and the value of the bias resistor. Include the supply voltage and its current capacity for the bias-T in the calculation.

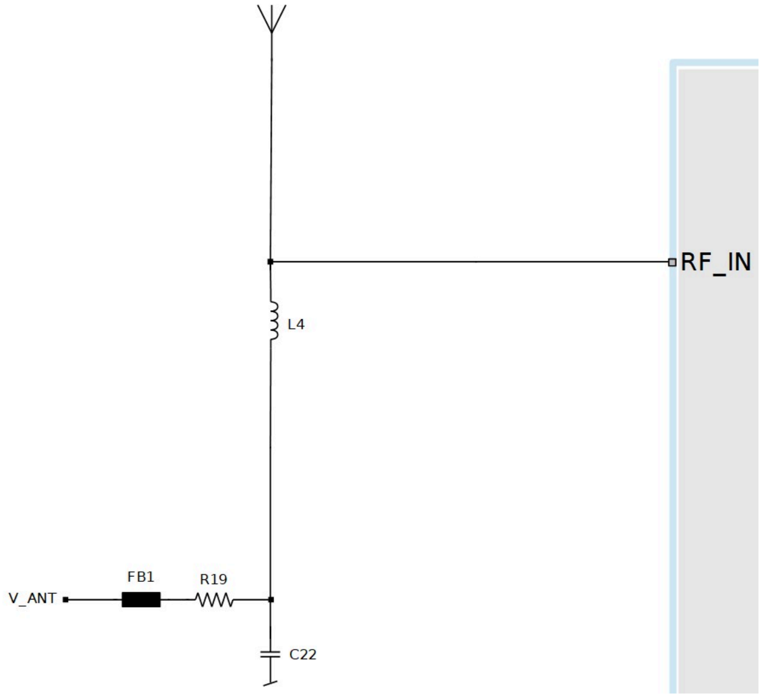

Figure 20: ZED-X20P with external voltage antenna bias

Part	Specifications	Values
C22	Filtering capacitor	100 nF, 16 V
FB1	Ferrite bead	BLM15HB121SH1
L4	Minimum Current of 300 mA or more impedance >500 Ω at GNSS frequencies	LQG15HS47NJ02
R19	Current limit resistor	10 Ω

Table 28: ZED-X20P external voltage antenna bias components

4.4.1.2 External power supply and current limiting

Figure 21 shows an example with an external voltage V_ANT 3.3 V. In this example, the current limiting threshold is set at 60 mA and the use of ferrite bead is recommended.

☞ Note that active antennas typically draw 5–20 mA current, contributing to the overall power consumption of the system.

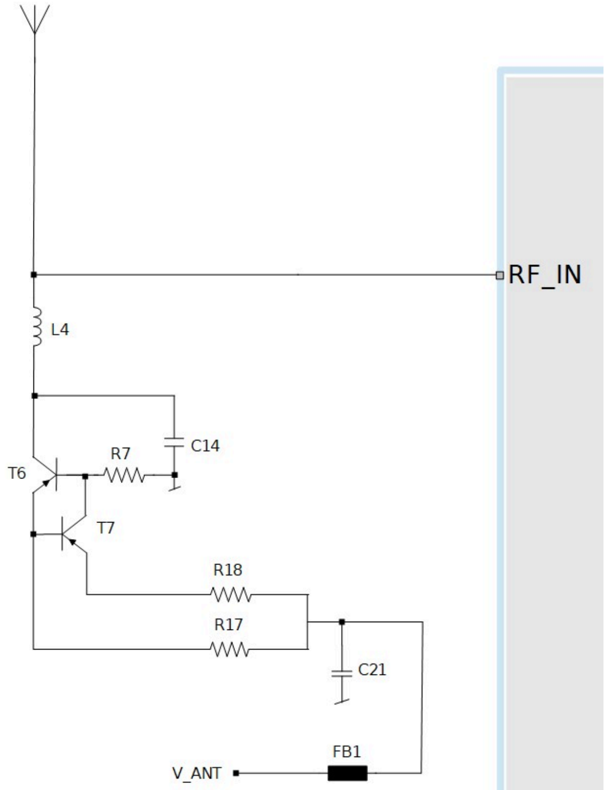

Figure 21: ZED-X20P with external voltage antenna bias and current limit circuit

Part	Specifications	Values
C14	Filtering capacitor	10n, Bias-T, X7R 10N 10% 16 V
C21	Filtering capacitor	100 nF, 16 V
FB1	Ferrite bead	BLM15HB121SH1
L4	Minimum Current of 300 mA or more impedance >500 Ω at GNSS frequencies	LQG15HS47NJ02
R7	Passive pull-up to control T6	PNP off 2.2 kΩ
R18	Defines the threshold of the comparator	220 Ω
R17	Defines the threshold of the comparator	10 Ω
T6, T7	BJT PNP transistors	PNP

Table 29: ZED-X20P antenna bias components

4.4.1.3 VCC_RF power supply

When using the VCC_RF supply pin from ZED-X20P:

- Limit the current to a maximum of 300 mA at the module supply voltage under short circuit conditions, requiring a 10 Ω resistor for a 3 V module supply.
- The bias-T inductor's DC resistance is assumed to be 1–2 Ω, and the module's internal feed inductor is assumed to be 1.2 Ω.

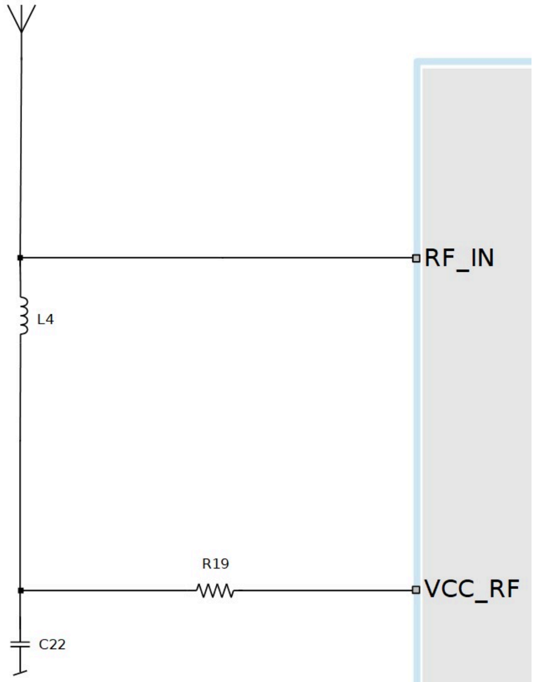

Figure 22: ZED-X20P VCC_RF antenna bias

Part	Specifications	Values
C22	Filtering capacitor	100 nF, 16 V
FB1	Ferrite bead	BLM15HB121SH1
L4	Minimum Current of 300 mA or more impedance >500 Ω at GNSS frequencies	LQG15HS47NJ02
R19	Current limit resistor	10 Ω

Table 30: ZED-X20P VCC_RF antenna bias components

4.4.2 Antenna supervisor circuit

The active antenna supervisor circuit connects to three ZED-X20P pins:

- ANT_OFF
- ANT_DETECT
- ANT_SHORT_N

For example the antenna open circuit detection is made using ANT_DET pin. A "high" at ANT_DET pin indicates an antenna is detected (antenna consumes current) and a "low" at ANT_DET pin indicates an antenna is not detected (no current drawn).

The following schematic details the required circuit:

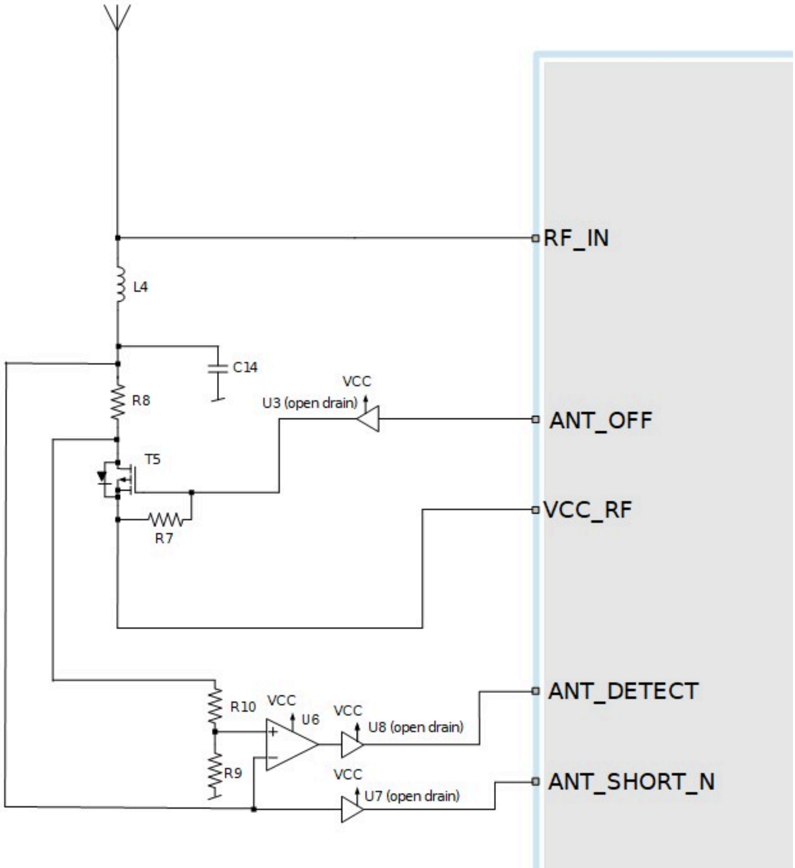

Figure 23: ZED-X20P antenna supervisor circuit

☞ The bias-T inductor L4 should support multi-band operation within the 1–1.8 GHz frequency range. For additional information, see Active Antenna Power Supply section.

Part	Specifications
C14	Filtering capacitor
L4	Minimum Current of 300 mA or more. Impedance >500 Ω at GNSS frequencies
R7	Passive pull-up to control T5
R8	Current limiter in the event of a short circuit
R9	Defines the threshold of the comparator
R10	Defines the threshold of the comparator
T5	P-FET transistor acting as a switch to control the antenna supply
U3, U7, U8	Open drain buffer to shift voltage levels
U6	Comparator (op-amp)

Table 31: Antenna supervisor components

☞ Buffers U3, U7 and U8 are optional depending on the application.They are not needed if the VCC_RF pin is used.

☞ An open drain buffer is recommended in case the antenna is supplied while the module is not, since IO pins must not be driven. If the antenna operates at a higher voltage like 5 V or 12 V, use of the buffer is also recommended.

4.5 Layout

This section details layout and placement requirements of the ZED-X20P high precision receiver.

4.5.1 Placement

GNSS signals at the surface of the Earth are below the thermal noise floor. A very important factor in achieving maximum GNSS performance is the placement of the receiver on the PCB. The placement used may affect RF signal loss from antenna to receiver input and enable interference into the sensitive parts of the receiver chain, including the antenna itself. When defining a GNSS receiver layout, the placement of the antenna with respect to the receiver, as well as grounding, shielding and interference from other digital devices are crucial issues and need to be considered very carefully.

Signal loss on the RF connection from antenna to receiver input must be minimized as much as possible. Hence, the connection to the antenna must be kept as short as possible.

Ensure that RF critical circuits are clearly separated from any other digital circuits on the system board. To achieve this, position digital part of the receiver close to the digital section of the system PCB and place the RF section and antenna as far away from the other digital circuits on the board as possible.

A proper GND concept shall be followed: the RF section shall not be subject to noisy digital supply currents running through its GND plane.

4.5.2 Thermal management

During the design-in, do not place the receiver near sources of heating or cooling. The receiver oscillator is sensitive to sudden changes in ambient temperature which can adversely impact satellite signal tracking. Sources can include co-located power devices, cooling fans or thermal conduction via the PCB. Take the following questions into account when designing in the receiver.

- Is the receiver placed away from heat sources?
- Is the receiver placed away from air-cooling sources?
- Is the receiver shielded by a cover/case to prevent the effects of air currents and rapid environmental temperature changes?

⚠ High temperature drift and air vents can affect the GNSS performance. For best performance, avoid high temperature drift and air vents near the receiver.

4.5.3 Package footprint, copper and paste mask

This section provides recommendations for copper and solder mask dimensioning for the ZED-X20P module packages.

☞ These are recommendations only and not specifications. The exact copper, solder and paste mask geometries, distances, stencil thickness and solder paste volumes must be adapted to the specific production processes (e.g. soldering etc.).

⚠ PIN 1 indicator is the ground opening, do not route any signal below this pad.

Refer to the applicable Data sheet [1] for the mechanical dimensions.

4.5.3.1 Footprint

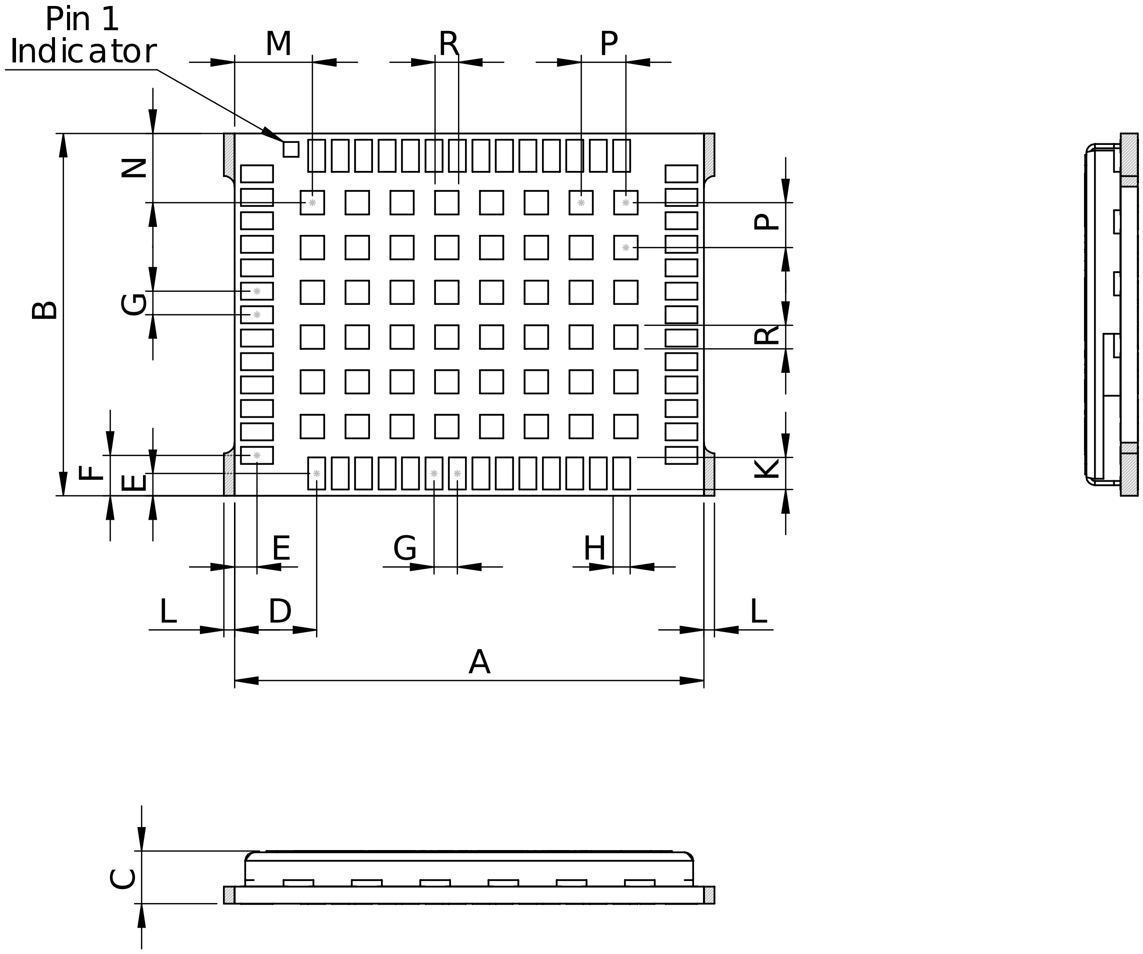

Figure 24: ZED-X20P suggested footprint (i.e. copper mask)

4.5.3.2 Paste mask

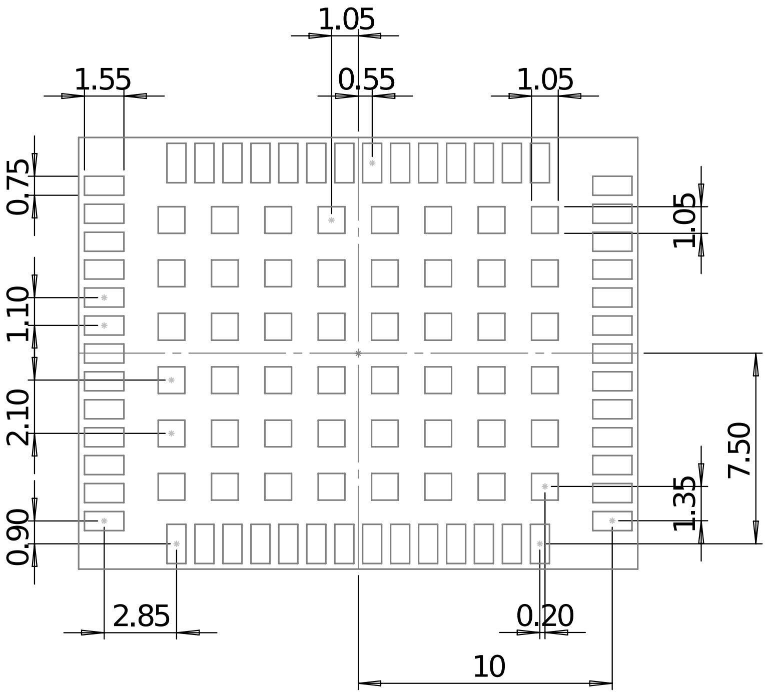

Figure 25: ZED-X20P suggested paste mask

4.5.4 Layout guidance

The presented layout guidance reduces the risk of performance issues at design level.

4.5.4.1 RF In trace

The RF in trace has to work in the combined GNSS signal bands.

For FR-4 PCB material with a dielectric permittivity of for example 4.7, the trace width for the 50 Ω line impedance can be calculated.

A grounded co-planar RF trace is recommended as it provides the maximum shielding from noise with adequate vias to the ground layer.

The RF trace must be shielded by vias to ground along the entire length of the trace and the ZED-X20P RF_IN pad should be surrounded by vias as shown in the figure below.

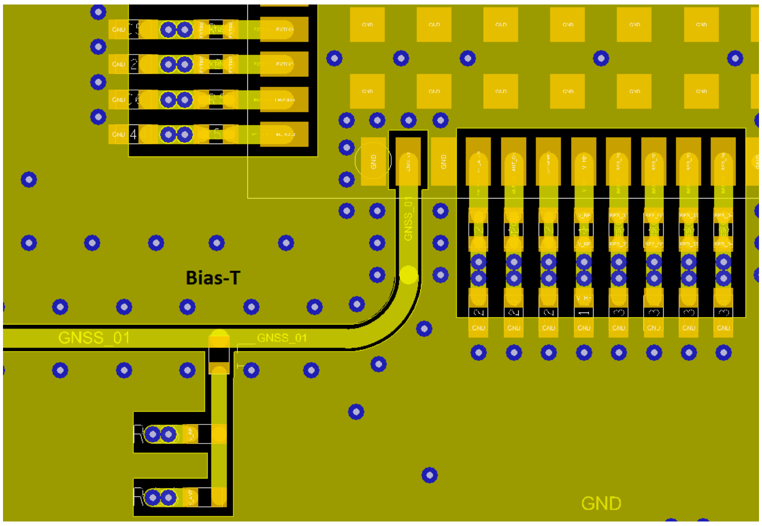

Figure 26: RF input trace

The RF_IN trace on the top layer should be referenced to a suitable ground layer.

4.5.4.2 Vias for the ground pads

The ground pads under the ZED-X20P high precision receiver need to be grounded with vias to the lower ground layer of the PCB. A solid ground layer fill on the top layer of the PCB is recommended. This is shown in the figure below.

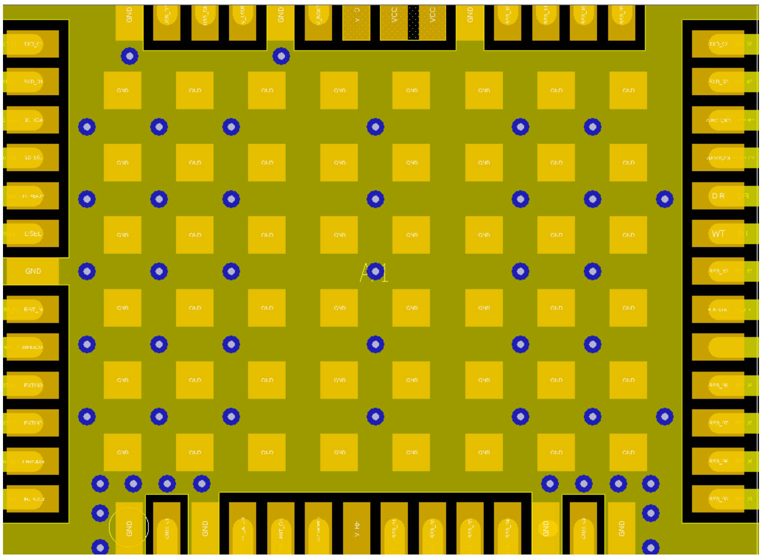

Figure 27: Top layer fill and vias

4.5.4.3 VCC pads

The VCC pads for the ZED-X20P high precision receiver must have as low impedance as possible with large vias to the lower power layer of the PCB. The VCC pads need a large combined pad and the de-coupling capacitors must be placed as close as possible. This is shown in the figure below.

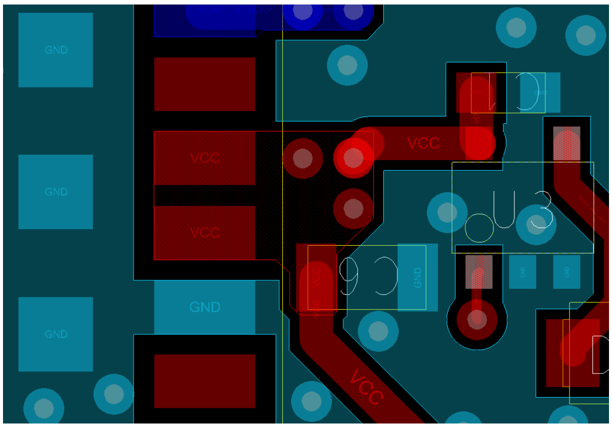

Figure 28: VCC pads

5 Production test

u-blox delivers products of the highest quality to its customers. To achieve this, we only supply fully tested units. At the end of the production process, every unit is tested. Defective units are analyzed in detail to continuously improve the production quality.

This is achieved with automatic test equipment, which delivers a detailed test report for each unit. The following measurements are done:

- Digital self-test (software download, verification of FLASH firmware, etc.)
- Measurement of voltages and currents
- Measurement of RF characteristics (e.g. C/No)

Thanks to the 100 % test coverage done by u-blox, the OEM manufacturer doesn't need to repeat firmware tests or measurements of the GNSS parameters/characteristics (e.g. TTFF) in the production test.

The OEM manufacturer can focus on testing:

- Overall sensitivity of the device (including antenna, if applicable)
- Communication to a host controller

5.1 Connected sensitivity test

The best way to test the sensitivity of a positioning device is with the use of a GNSS simulator. It assures reliable and constant signals at every measurement.

Guidelines for sensitivity tests:

- Connect a GNSS simulator to the OEM product
- Choose the power level in a way that the "Golden Device" would report a C/No ratio of 38-40 dBHz
- Power up the DUT (Device Under Test) and allow enough time for the acquisition
- Read the C/No value from the NMEA GSV or the UBX-NAV-SAT message (e.g. with u-center)
- Compare the results to a "Golden Device", a u-blox Evaluation Kit or Application Board.

5.2 Go/No go tests for integrated devices

- For best results, place the device in an outdoor position with excellent sky view (HDOP < 3.0).
- Let the receiver acquire satellites and compare the signal strength with a "Golden Device". As the electro-magnetic field of a signal repeaters is not homogenous, indoor tests are not reliable in most cases.

These kinds of tests are useful as a go/no go test but not for sensitivity measurements.

6 Product handling

6.1 ESD precautions

⚠ CAUTION! Risk of electrostatic discharge (ESD) damage. u-blox chips and modules are electrostatic sensitive devices containing highly sensitive electronic circuitry. A discharge of static electricity may damage the device or reduce the life expectancy of the device. To avoid ESD damage, adhere to the standard guidelines for handling ESD devices.

Consider the following:

Preventing electrostatic discharge

- Keep components in their original packages during transport.
- Open the package within an ESD-protected area (EPA), as in Figure 29.
- At a workstation, store components in an EPA.
- Place ESD sensitive devices inside of shielding packaging or containers when transported outside of an EPA.
- Use protective clothing and proper personnel grounding at all necessary points when touching electrostatic sensitivedevice or assembly. For instance, wear ESD-safe clothing and shoes and wear an ESD wrist strap connected to a groundedworkstation. Use heel straps when standing on conductive floors or dissipating floor mats.
- Hold the devices by the edges and avoid touching component contacts, pins, or circuitry

Product handling

- When handling RF transceivers and patch antennas, work in an EPA.
- When connecting test equipment or any other electronics to the module (as a standalone or PCB-mounted device), the first point of contact must always be between the local ground and the PCB ground.
- Before mounting a ceramic patch antenna, connect the device to ground.
- When handling the RF pin, do not touch any charged capacitors. Be especially careful when handling materials likepatch antennas (~10 pF), coaxial cables (~50-80 pF/m), soldering irons, or any other materials that can develop charges.
- If there is any risk of touching an exposed antenna area in a non-ESD protected work area, implement proper ESDprotection measures in the design.
- When soldering RF connectors and patch antennas to the receiver's RF pin, use an ESD-safe soldering iron (tip)

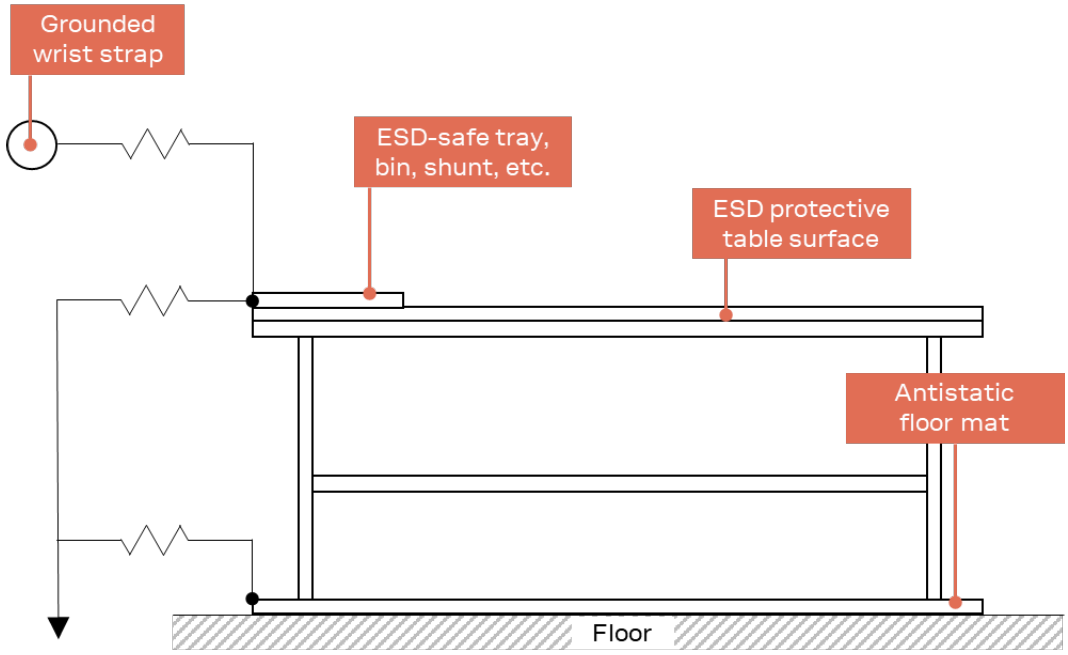

Figure 29: Standard workstation setup for safe handling of ESD-sensitive devices

6.2 Safety precautions

The ZED-X20P modules must be supplied by an external limited power source in compliance with the clause 2.5 of the standard IEC 60950-1. In addition to external limited power source, only Separated or Safety Extra-Low Voltage (SELV) circuits are to be connected to the module including interfaces and antennas.

☞ For more information about SELV circuits see section 2.2 in Safety standard IEC 60950-1.

6.3 Soldering

Reflow soldering procedures are described in the IPC/JEDEC J-STD-020 standard.

☞ When populating the modules, make sure that the pick and place machine is aligned to the copper pins of the module instead of the module edge.

Soldering paste

Use of “no clean” soldering paste is highly recommended, as it does not require cleaning after the soldering process. For instance, the following paste meets these criteria.

- Soldering paste: OM338 SAC405 / Nr.143714 (Cookson Electronics)
- Alloy specification: Sn 95.5/ Ag 4/ Cu 0.5 (95.5% tin/ 4% silver/ 0.5% copper)
- Melting temperature: 217 °C
- Stencil: The exact geometry, distances, stencil thicknesses and solder paste volumes must be adapted to the customer's specific production processes.

Reflow soldering

⚠ CAUTION. Risk of device damage. Exceeding the peak temperature of the recommended soldering profile may permanently damage the device.

The final soldering temperature chosen at the factory depends on additional external factors such as the choice of soldering paste, size, thickness and properties of the base board, etc.

As a reference, see “IPC-7530 Guidelines for temperature profiling for mass soldering (reflow and wave) processes”, published in 2001.

A convection-type soldering oven is highly recommended over the infrared-type radiation oven. Convection-heated ovens allow precise control of the temperature, and all parts will heat up evenly, regardless of material properties, thickness of components and surface color.

⚠ CAUTION. Risk of device damage. Modules must not be soldered with a damp heat process.

☞ To avoid falling off, the modules should be placed on the topside of the board during soldering.

For the recommended soldering profile and conditions, see Figure 30 and Table 32

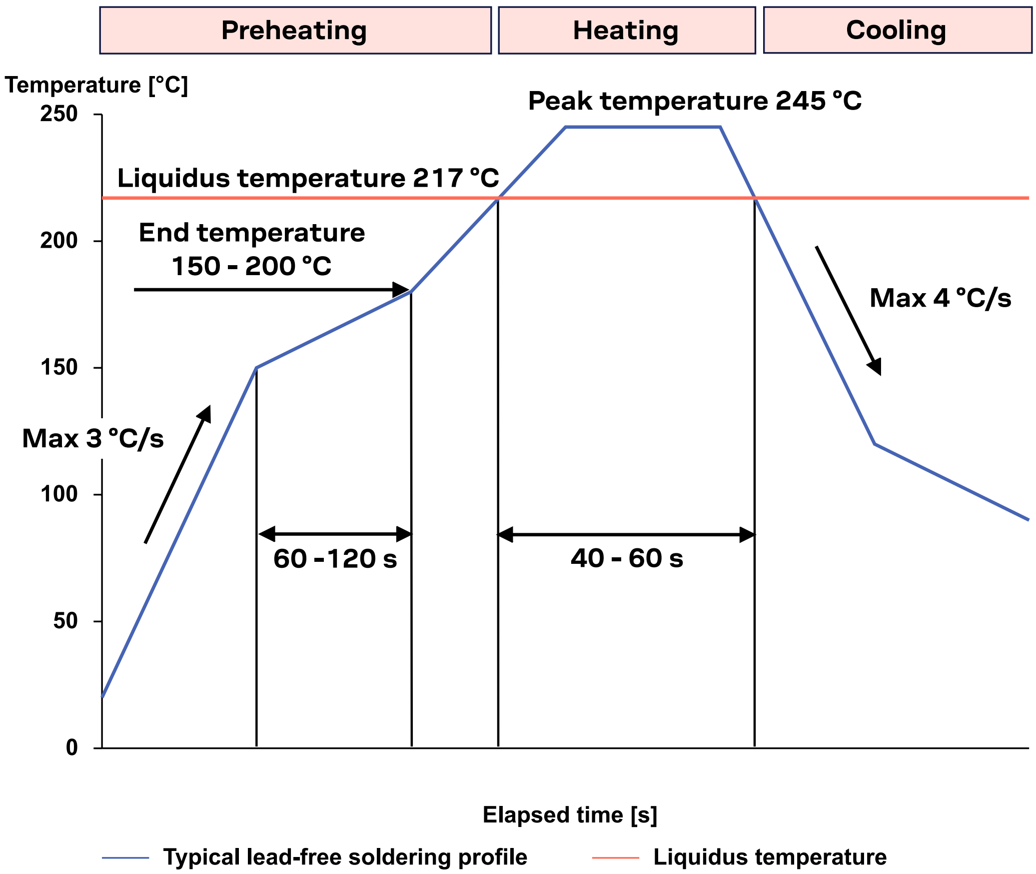

Figure 30: Recommended soldering profile

Phase	Value	Details
Preheating		During the initial heating of component leads and balls, residual humidity is dried out. Note that the preheating phase does not replace prior baking procedures.
Temperature rise rate	Max 3 °C/s	If the temperature rise is too rapid in the preheat phase, excessive slumping may be caused.
Time	60 – 120 s	If the preheating is insufficient, rather large solder balls tend to be generated. Conversely, if performed excessively, fine balls and large balls will be generated in clusters.
End temperature	150 – 200 °C	If the temperature is too low, non-melting tends to be caused in areas containing large heat capacity.
Heating - reflow		

Phase	Value	Details
Time limit above 217 °C liquidus temperature	40 – 60 s	The temperature rises above the liquidus temperature of 217 °C. Avoid a sudden rise in temperature as the slump of the paste could become worse.
Peak reflow temperature	245 °C	
Cooling		
Temperature fall rate	Max 4 °C/s	A controlled cooling prevents negative metallurgical effects of the solder (solder becomes more brittle) and possible mechanical tensions in the products. Controlled cooling helps to achieve bright solder fillets with a good shape and low contact angle.

Table 32: Recommended conditions for reflow soldering

Optical inspection

After soldering the module, consider optical inspection.

Cleaning

☞ Do not clean with water, solvent, or ultrasonic cleaner:

- Cleaning with water leads to capillary effects where water is absorbed into the gap between the baseboard and the module. The combination of residues of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pins.
- Cleaning with alcohol or other organic solvents can result in soldering flux residues flowing underneath the module, into areas that are not accessible for post-cleaning inspections. The solvent also damages the sticker and the printed text on the module.

⚠ CAUTION. Risk of device damage. Ultrasonic cleaning permanently damages the module, in particular the quartz oscillators.

The best approach is to use a “no clean” soldering paste to eliminate the cleaning step after the soldering.

Repeated reflow soldering

☞ Repeated reflow soldering processes or soldering the module upside down are not recommended.

A board that is populated with components on both sides may require more than one reflow soldering cycle. In such a case, the process should ensure the module is only placed on the board submitted for a single final upright reflow cycle. A module placed on the underside of the board may detach during a reflow soldering cycle due to lack of adhesion.

The module can also tolerate an additional reflow cycle for rework purposes.

Wave soldering

Base boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices require wave soldering to solder the THT components. Only a single wave soldering process is encouraged for boards populated with modules.

Rework

⚠ CAUTION. Risk of device damage. Using a hot air gun is an uncontrolled process. It can lead to overheating and severely damage the module. Always avoid overheating the module.

After the module is removed from the oven, clean the pins before reapplying the solder paste, placing the module in the oven and proceeding with the reflow soldering of a new module.

☞ Never attempt to alter the module itself, e.g. by replacing individual components. Such actions immediately void the warranty.

Conformal coating

Certain applications employ a conformal coating of the PCB using HumiSeal® or other related coating products. These materials affect the RF properties of the GNSS module

☞ Conformal coating of the module voids the warranty.

☞ Casting voids the warranty.

Use of ultrasonic processes

Some components on the module are sensitive to ultrasonic waves.

⚠ CAUTION. Risk of device damage. Use of any ultrasonic processes (cleaning, welding etc.) may cause damage to the receiver.

☞ u-blox provides no warranty against damages to the module caused by ultrasonic processes.

Appendix

A Reference frames

Real time kinematic (RTK) is a differential system where the rover uses the corrections from a reference station or a reference station network. The rover receiver will calculate its position in the reference frame used by the service provider in its correction stream. If the output is required in a different reference frame, then a (custom) datum transformation is required.

For example, if an application requires the position in the ITRF14 reference frame but the correction service is using the ETRF14 reference frame - to which the RTK solution will also be referring - then this reference frame offset needs to be compensated. For example if utilizing a truth system which is using corrections referring to different reference frame, it is important to compensate for the reference frame offset to avoid systematic errors in the analysis.

Terrestrial reference system is a coordinate reference system which is rotating in space with the rotation of the Earth. The reference system is an abstract concept that is realized by obtaining coordinates for some points on the surface of the Earth. This kind of realization is called a reference frame. For more details, see for example the ITRF webpage. Commonly used reference systems include International Terrestrial Reference System (ITRS) and European Terrestrial Reference System 1989 (ETRS89).

Widely used reference frames include for example International Terrestrial Reference Frame (ITRF) and European Terrestrial Reference Frame (ETRF). ITRF is a realization of ITRS, done every few years. Latest realizations of ITRF are ITRF2008 and ITRF2014. ETRF is a realization of ETRS89, done every few years. Latest realizations are ITRF2005 and ETRF2014.

For example, the EUREF is used to realize the ETRS89. For information, see their homepage: EUREF.

See the ITRF website for more information and an online transform calculator: ITRF.

Another online tool for transformations is available on the EUREF network page: EUREF Transformation.

Reference frames can have constant offsets between each other but, in addition to that, they can also drift and rotate with respect to each other. One major reason for this is that the tectonic plates move constantly and the reference frames that are attached to the tectonic plates move along with the plates.

☞ The ZED-X20P stores the EGM96 geoid model with limited resolution, leading to degraded precision of the reported mean sea level height and geoid separation. If the user application needs higher geoid separation accuracy, it is required to apply its own adjustment to the ellipsoidal height output from the ZED-X20P.

Related documents

[1] ZED-X20P-0B Data sheet, [UBXDOC-963802114-12690]

[2] HPG 2.00 Interface description, [UBXDOC-963802114-12858]

[3] Product packaging reference guide UBX-14001652

☞ For regular updates to u-blox documentation and to receive product change notifications please register on our homepage https://www.u-blox.com.

Revision history

Revision	Date	Comments
R01	03-Sept-2024	Prototype release

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