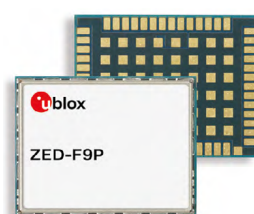


ZED-F9P-02B

High precision GNSS module
Professional grade

Data sheet



Abstract

This data sheet describes the ZED-F9P high precision module with multi-band GNSS receiver. The module provides multi-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.

Document information

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This document applies to the following products:

| Product name | Type number | FW version | IN/PCN reference | Product status |
|---------------------|--------------------|-------------------|-------------------------|------------------------|
| ZED-F9P | ZED-F9P-02B-00 | HPG 1.13 | UBX-23000084 | Production information |

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1 Functional description

1.1 Overview

The ZED-F9P-02B positioning module features the u-blox F9 receiver platform, which provides multi-band GNSS to high-volume industrial applications. The ZED-F9P-02B has integrated u-blox multi-band RTK technologies for centimeter-level accuracy. The module enables precise navigation and automation of moving machinery in industrial and consumer-grade products in a compact surface-mounted form factor of only 17.0 x 22.0 x 2.4 mm.

The ZED-F9P-02B includes moving base support, allowing both base and rover to move while computing the position between them. The moving base is ideal for UAV applications where the UAV is programmed to follow its owner or to land on a moving platform. It is also well suited to attitude sensing applications where both base and rover modules are mounted on the same moving platform and the relative position is used to derive attitude information for the vehicle or tool.

1.2 Performance

| Parameter | Specification | |
|---------------------------------------|-----------------------------------------|----------|
| Receiver type | Multi-band GNSS high precision receiver | |
| Accuracy of time pulse signal | RMS | 30 ns |
| | 99% | 60 ns |
| Frequency of time pulse signal | 0.25 Hz to 10 MHz (configurable) | |
| Operational limits ¹ | Dynamics | ≤ 4 g |
| | Altitude | 80,000 m |
| | Velocity | 500 m/s |
| Velocity accuracy ² | 0.05 m/s | |
| Dynamic heading accuracy ² | 0.3 deg | |

Table 1: ZED-F9P-02B specifications

| GNSS ³ | | GPS+GLO+GAL+BDS | GPS+GLO+GAL | GPS+GAL | GPS+GLO | GPS+BDS | GPS |
|-------------------------------|--------------------------|-----------------|-------------|---------|---------|---------|--------|
| Acquisition ⁴ | Cold start | 25 s | 25 s | 30 s | 25 s | 30 s | 30 s |
| | Hot start | 2 s | 2 s | 2 s | 2 s | 2 s | 2 s |
| | Aided start ⁵ | 2 s | 2 s | 2 s | 2 s | 2 s | 2 s |
| Max navigation update rate | RTK | 8 Hz | 10 Hz | 15 Hz | 15 Hz | 15 Hz | 20 Hz |
| | PVT | 10 Hz | 12 Hz | 20 Hz | 25 Hz | 25 Hz | 25 Hz |
| | RAW | 20 Hz | 20 Hz | 25 Hz | 25 Hz | 25 Hz | 25 Hz |
| Convergence time ⁶ | RTK | < 10 s | < 10 s | < 10 s | < 10 s | < 10 s | < 30 s |

Table 2: ZED-F9P-02B performance in different GNSS modes

¹ Assuming Airborne 4 g platform

² 50% at 30 m/s for dynamic operation

³ GPS used in combination with QZSS and SBAS

⁴ Commanded starts. All satellites at -130 dBm. Measured at room temperature.

⁵ Dependent on the speed and latency of the aiding data connection, commanded starts

⁶ Depends on atmospheric conditions, baseline length, GNSS antenna, multipath conditions, satellite visibility and geometry

| GNSS | | GPS+GLO+GAL+BDS | GPS+GLO+GAL | GPS+GAL | GPS+GLO | GPS+BDS | GPS |
|-------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Horizontal position accuracy (CEP) | PVT ⁷ | 1.5 m | 1.5 m | 1.5 m | 1.5 m | 1.5 m | 1.5 m |
| | SBAS ⁷ | 1.0 m | 1.0 m | 1.0 m | 1.0 m | 1.0 m | 1.0 m |
| | RTK ⁸ | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm |
| Vertical position accuracy (Median) | | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm | 0.01 m + 1 ppm |

Table 3: ZED-F9P-02B position accuracy in different GNSS modes

| GNSS ³ | | GPS+GLO+GAL+BDS |
|--------------------------|-------------------|-----------------|
| Sensitivity ⁹ | Tracking and nav. | -167 dBm |
| | Reacquisition | -160 dBm |
| | Cold start | -148 dBm |
| | Hot start | -157 dBm |

Table 4: ZED-F9P-02B sensitivity

| GNSS | | GPS+GLO+GAL+BDS | GPS+GLO+GAL | GPS+GAL | GPS+GLO | GPS+BDS | GPS |
|---------------------------------|--|-----------------|-------------|---------|---------|---------|---------|
| Max navigation update rate | | 8 Hz | 8 Hz | 10 Hz | 10 Hz | 10 Hz | 10 Hz |
| Baseline accuracy ¹⁰ | | 0.01 m | 0.01 m | 0.01 m | 0.01 m | 0.01 m | 0.01 m |
| Heading accuracy | | 0.4 deg | 0.4 deg | 0.4 deg | 0.4 deg | 0.4 deg | 0.4 deg |

Table 5: ZED-F9P-02B moving base RTK performance in different GNSS modes
⁷ 24 hours static

⁸ Measured using 1 km baseline and patch antennas with good ground planes. Does not account for possible antenna phase center offset errors. ppm limited to baselines up to 20 km.

⁹ Demonstrated with a good external LNA. Measured at room temperature.

¹⁰ 50%, measured with 1 m baseline and patch antennas with good ground plane

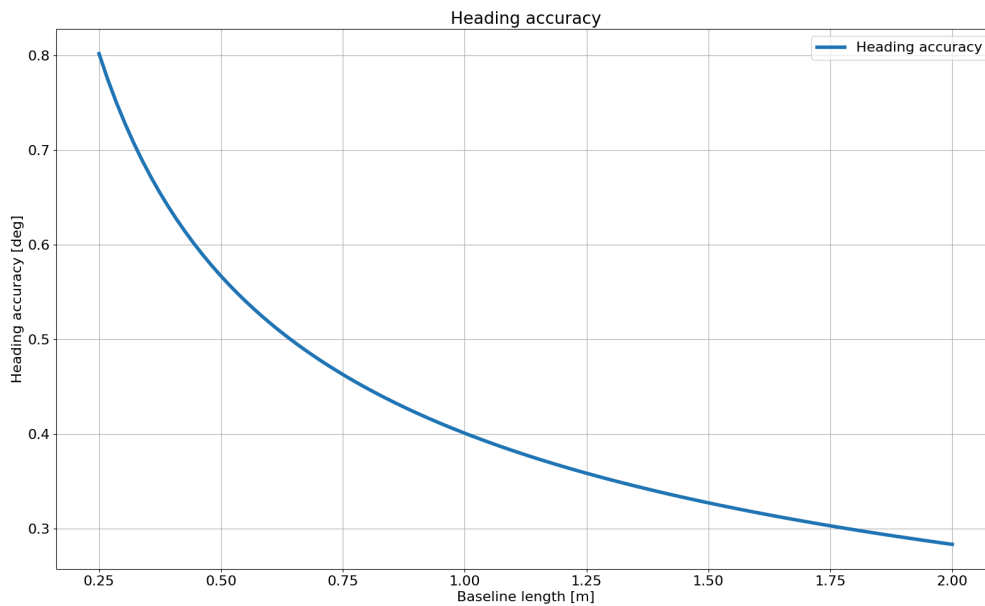


Figure 1: ZED-F9P-02B moving base RTK heading accuracy versus baseline length



In a moving base application, and especially when the antennas are mounted on the same platform, it is recommended to use identical antennas. Furthermore it is recommended these antennas are mounted with identical orientation, as this will minimize effects of phase center variation.

1.3 Supported GNSS constellations

The ZED-F9P-02B GNSS modules are concurrent GNSS receivers that can receive and track multiple GNSS constellations. Owing to the multi-band RF front-end architecture, all four major GNSS constellations (GPS, GLONASS, Galileo and BeiDou) plus SBAS and QZSS satellites can be received concurrently. All satellites in view can be processed to provide an RTK navigation solution when used with correction data. If power consumption is a key factor, the receiver can be configured for a subset of GNSS constellations.

The QZSS system shares the same frequency bands with GPS and can only be processed in conjunction with GPS.

To benefit from multi-band signal reception, dedicated hardware preparation must be made during the design-in phase. See the Integration manual [1] for u-blox design recommendations.

The ZED-F9P-02B supports the GNSS and their signals as shown in Table 6.

| GPS / QZSS | GLONASS | Galileo | BeiDou | NavIC |
|----------------------|------------------------------------------------------------|-----------------------|--------------------|-------|
| L1C/A (1575.420 MHz) | L1OF (1602 MHz + $k \cdot 562.5$ kHz, $k = -7, \dots, 6$) | E1-B/C (1575.420 MHz) | B1I (1561.098 MHz) | - |
| L2C (1227.600 MHz) | L2OF (1246 MHz + $k \cdot 437.5$ kHz, $k = -7, \dots, 6$) | E5b (1207.140 MHz) | B2I (1207.140 MHz) | - |

Table 6: Supported GNSS signals on ZED-F9P-02B

The ZED-F9P-02B can use the u-blox AssistNow™ Online service which provides GNSS assistance information.

1.4 Supported GNSS augmentation systems

1.4.1 Quasi-Zenith Satellite System (QZSS)

The Quasi-Zenith Satellite System (QZSS) is a regional navigation satellite system that provides positioning services for the Pacific region covering Japan and Australia. The ZED-F9P-02B is able to receive and track QZSS L1 C/A and L2C signals concurrently with GPS signals, resulting in better availability especially under challenging signal conditions, e.g. in urban canyons.

The ZED-F9P-02B is also able to receive the QZSS L1S signal in order to use the SLAS (Sub-meter Level Augmentation Service) which is an augmentation technology that provides correction data for pseudoranges. Ground monitoring stations positioned in Japan calculate separate corrections for each visible satellite and broadcast this data to the user via QZSS satellites. The correction stream is transmitted on the L1 frequency (1575.42 MHz).



QZSS can be enabled only if GPS operation is also configured.

1.4.2 Satellite-based augmentation system (SBAS)

The ZED-F9P-02B supports SBAS (including WAAS in the US, EGNOS in Europe, L1Sb(QZSS SBAS) in Japan and GAGAN in India) to deliver improved location accuracy within the regions covered. However, the additional inter-standard time calibration step used during SBAS reception results in degraded time accuracy overall.

1.4.3 Differential GNSS (DGNSS)

When operating in RTK mode, RTCM version 3 messages are required and the module supports DGNSS according to RTCM 10403.3.

A ZED-F9P-02B operating as a rover can decode the following RTCM 3.3 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 1009 | L1-only GLONASS RTK observables |
| RTCM 1010 | Extended L1-only GLONASS RTK observables |
| RTCM 1011 | L1/L2 GLONASS RTK observables |
| RTCM 1012 | Extended L1/L2 GLONASS RTK observables |
| RTCM 1033 | Receiver and antenna description |
| RTCM 1074 | GPS MSM4 |
| RTCM 1075 | GPS MSM5 |
| RTCM 1077 | GPS MSM7 |
| RTCM 1084 | GLONASS MSM4 |
| RTCM 1085 | GLONASS MSM5 |
| RTCM 1087 | GLONASS MSM7 |
| RTCM 1094 | Galileo MSM4 |

| Message type | Description |
|--------------|---------------------------------------------------------|
| RTCM 1095 | Galileo MSM5 |
| RTCM 1097 | Galileo MSM7 |
| RTCM 1124 | BeiDou MSM4 |
| RTCM 1125 | BeiDou MSM5 |
| RTCM 1127 | BeiDou MSM7 |
| RTCM 1230 | GLONASS code-phase biases |
| RTCM 4072.0 | Reference station PVT (u-blox proprietary RTCM Message) |

Table 7: Supported input RTCM 3.3 messages

A ZED-F9P-02B operating as a base station can generate the following RTCM 3.3 output messages:

| Message type | Description |
|--------------|----------------------------------------------------------------------------|
| RTCM 1005 | Stationary RTK reference station ARP |
| RTCM 1074 | GPS MSM4 |
| RTCM 1077 | GPS MSM7 |
| RTCM 1084 | GLONASS MSM4 |
| RTCM 1087 | GLONASS MSM7 |
| RTCM 1094 | Galileo MSM4 |
| RTCM 1097 | Galileo MSM7 |
| RTCM 1124 | BeiDou MSM4 |
| RTCM 1127 | BeiDou MSM7 |
| RTCM 1230 | GLONASS code-phase biases |
| RTCM 4072.0 | Reference station PVT (u-blox proprietary RTCM Message) |
| RTCM 4072.1 | Additional reference station information (u-blox proprietary RTCM Message) |

Table 8: Supported output RTCM 3.3 messages

1.5 Broadcast navigation data and satellite signal measurements

The ZED-F9P-02B can output all the GNSS broadcast data upon reception from tracked satellites. This includes all the supported GNSS signals as well as the QZSS and SBAS augmentation services. The UBX-RXM-SFRBX message provides this information, see the Interface description [2] for the UBX-RXM-SFRBX message specification. The receiver can provide satellite signal information in a form compatible with the Radio Resource LCS Protocol (RRLP) [4].

1.5.1 Carrier-phase measurements

The ZED-F9P-02B modules provide raw carrier-phase data for all supported signals, along with pseudorange, Doppler and measurement quality information. The data contained in the UBX-RXM-RAWX message follows the conventions of a multi-GNSS RINEX 3 observation file. For the UBX-RXM-RAWX message specification, see Interface description [2].



Raw measurement data are available once the receiver has established data bit synchronization and time-of-week.

1.6 Supported protocols

The ZED-F9P-02B supports the following protocols:

| Protocol | Type |
|----------------------------------------------|------------------------------------------|
| UBX | Input/output, binary, u-blox proprietary |
| NMEA 4.11, 4.10 (default), 4.0, 2.3, and 2.1 | Input/output, ASCII |
| RTCM 3.3 | Input/output, binary |

Table 9: Supported protocols

For specification of the protocols, see the Interface description [\[2\]](#).

2 System description

2.1 Block diagram

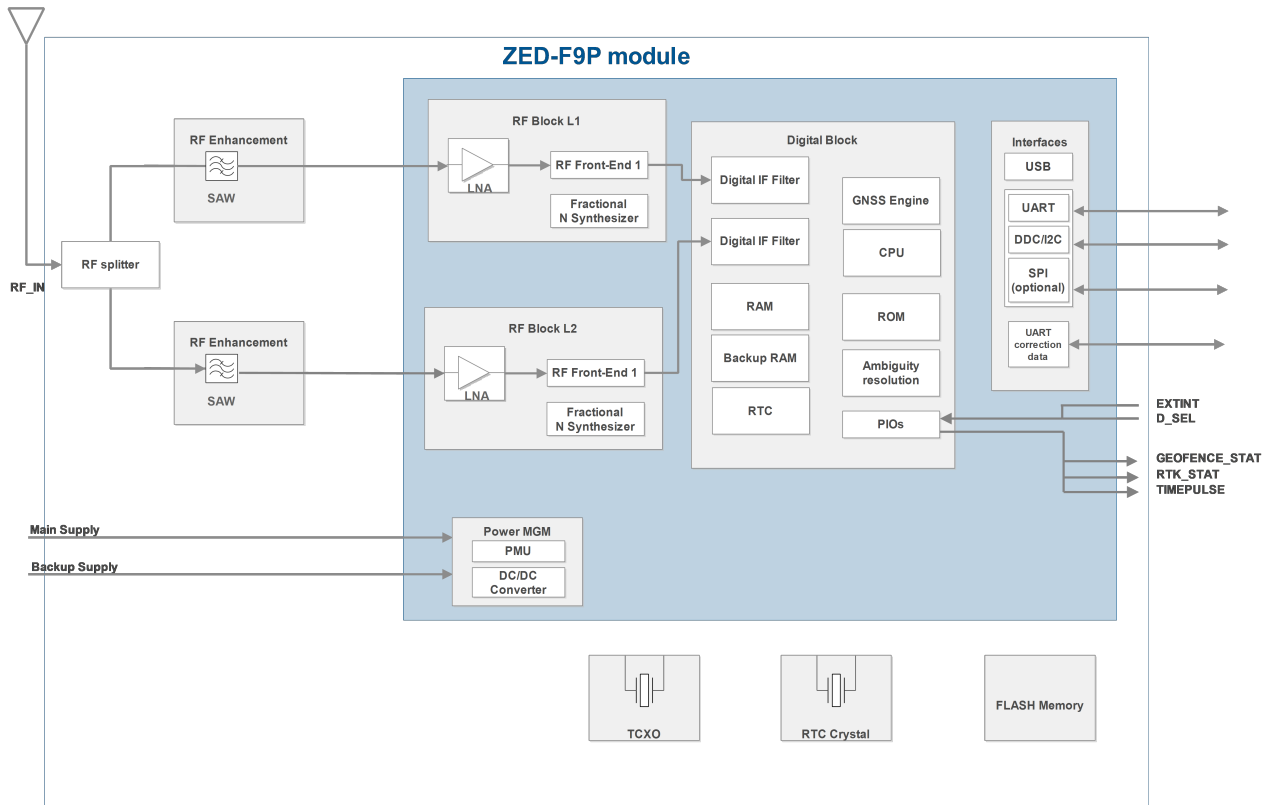


Figure 2: ZED-F9P-02B block diagram



An active antenna is mandatory with the ZED-F9P-02B. For more information, see the Integration manual [1].

3 Pin definition

3.1 Pin assignment

The pin assignment of the ZED-F9P-02B module is shown in [Figure 3](#). The defined configuration of the PIOs is listed in [Table 10](#).

For detailed information on pin functions and characteristics, see the Integration manual [\[1\]](#).



The ZED-F9P-02B is an LGA package with the I/O on the outside edge and central ground pads.

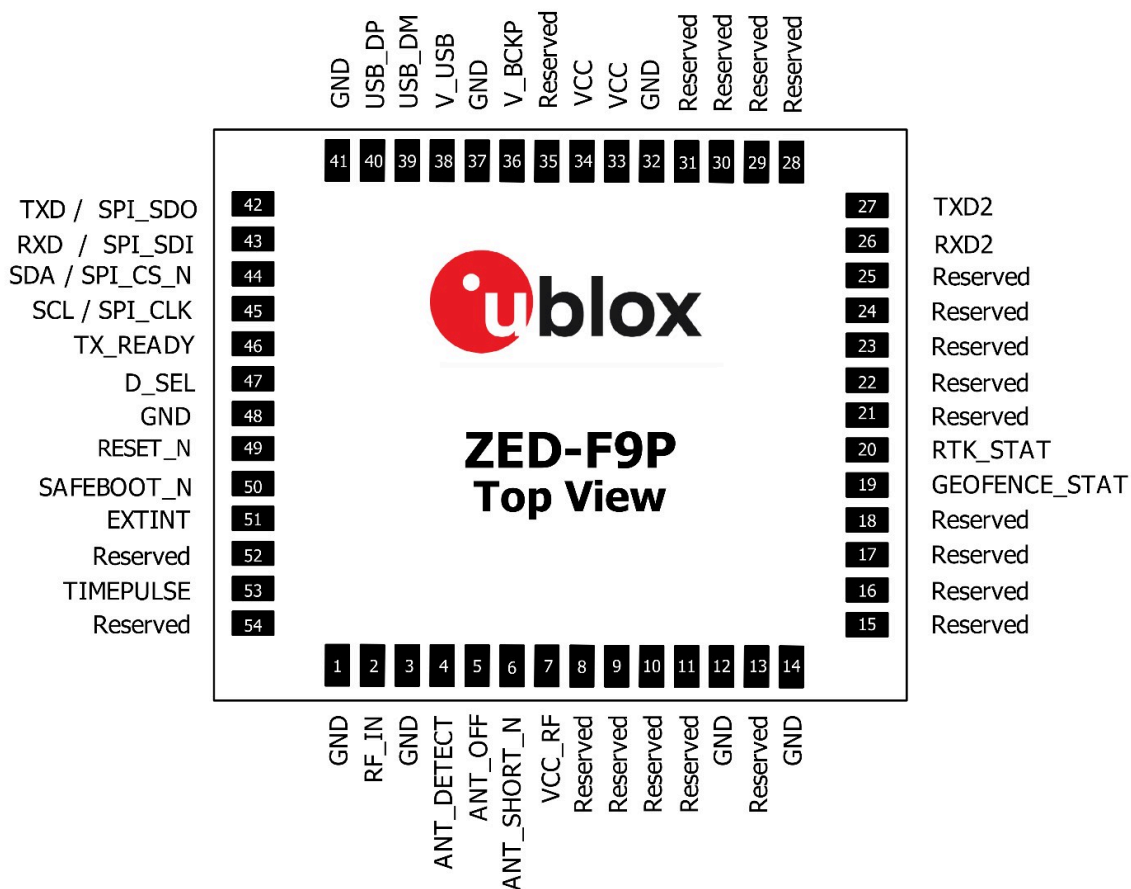


Figure 3: ZED-F9P-02B pin assignment

| 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 |



| Pin no. | Name | I/O | Description |
|---------|----------------|-----|--------------------------------------------------------------------------------------------------|
| 10 | Reserved | - | Reserved |
| 11 | Reserved | - | Reserved |
| 12 | GND | - | Ground |
| 13 | Reserved | - | Reserved |
| 14 | GND | - | Ground |
| 15 | Reserved | - | Reserved |
| 16 | Reserved | - | Reserved |
| 17 | Reserved | - | Reserved |
| 18 | Reserved | - | Reserved |
| 19 | GEOFENCE_STAT | O | Geofence status, user defined |
| 20 | RTK_STAT | O | RTK status: 0 = 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 | V_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) |

| Pin no. | Name | I/O | Description |
|---------|-----------|-----|------------------------|
| 51 | EXTINT | I | External interrupt pin |
| 52 | Reserved | - | Reserved |
| 53 | TIMEPULSE | O | Time pulse |
| 54 | Reserved | - | Reserved |

Table 10: ZED-F9P-02B pin assignment

4 Electrical specification


4.1 Absolute maximum ratings

-  CAUTION. Risk of device damage. Exceeding the absolute maximum ratings may affect the lifetime and reliability of the device or permanently damage it. Do not exceed the absolute maximum ratings.
-  This product is not protected against overvoltage or reversed voltages. Use appropriate protection to avoid device damage from voltage spikes exceeding the specified boundaries.

| Parameter | Symbol | Condition | Min | Max | Units |
|--------------------------------------|-------------------|---------------------------------------------|------|---------------|-------|
| Power supply voltage | VCC | | -0.5 | 3.6 | V |
| Voltage ramp on VCC ¹¹ | | | 20 | 8000 | µs/V |
| Backup battery voltage | V_BCKP | | -0.5 | 3.6 | V |
| Voltage ramp on V_BCKP ¹¹ | | | 20 | | µs/V |
| Input pin voltage | Vin | VCC ≤ 3.1 V | -0.5 | VCC + 0.5 | V |
| | | VCC > 3.1 V | -0.5 | 3.6 | V |
| VCC_RF output current | ICC_RF | | | 200 | mA |
| Supply voltage USB | V_USB | | -0.5 | 3.6 | V |
| USB signals | USB_DM, USB_DP | | -0.5 | V_USB + 0.5 V | |
| Input power at RF_IN | Prfin | source impedance = 50 Ω, continuous wave | | 10 | dBm |
| Storage temperature | Tstg | | -40 | +85 | °C |

Table 11: Absolute maximum ratings

4.2 Operating conditions

-  Extreme operating temperatures can significantly impact the specified values. If an application operates near the min or max temperature limits, ensure the specified values are not exceeded.

| Parameter | Symbol | Min | Typical | Max | Units | Condition |
|------------------------------------------|----------|-----------|---------|-----|-------|----------------------------|
| Power supply voltage | VCC | 2.7 | 3.0 | 3.6 | V | |
| Backup battery voltage | V_BCKP | 1.65 | | 3.6 | V | |
| Backup battery current ^{12, 13} | I_BCKP | | 45 | | µA | V_BCKP = 3 V, VCC = 0 V |
| SW backup current ¹³ | I_SWBCKP | | 1.4 | | mA | |
| Input pin voltage range | Vin | 0 | | VCC | V | |
| Digital IO pin low level input voltage | Vil | | | 0.4 | V | |
| Digital IO pin high level input voltage | Vih | 0.8 * VCC | | | V | |
| Digital IO pin low level output voltage | Vol | | | 0.4 | V | Iol = 2 mA ¹⁴ |
| Digital IO pin high level output voltage | Voh | VCC - 0.4 | | | V | Ioh = 2 mA ¹⁴ |

¹¹ Exceeding the ramp speed may permanently damage the device

¹² To measure the I_BCKP the receiver should first be switched on, i.e. VCC and V_BCKP is available. Then set VCC to 0 V while the V_BCKP remains available. Afterward measure the current consumption at the V_BCKP.

¹³ The value has been characterized at 25 °C ambient temperature.

¹⁴ TIMEPULSE has 4 mA current drive/sink capability

| Parameter | Symbol | Min | Typical | Max | Units | Condition |
|------------------------------------------------------------|-------------------|-----|-----------|-------|-------|-----------|
| DC current through any digital I/O pin (except supplies) | I _{pin} | | | 5 | mA | |
| Pull-up resistance for SCL, SDA | R _{pu} | 7 | 15 | 30 | kΩ | |
| Pull-up resistance for D_SEL, RXD, TXD, SAFEBOOT_N, EXTINT | R _{pu} | 30 | 75 | 130 | kΩ | |
| Pull-up resistance for RESET_N | R _{pu} | 7 | 10 | 13 | kΩ | |
| Voltage at USB pins | V_USBIO | 0 | | V_USB | V | |
| VCC_RF voltage | VCC_RF | | VCC - 0.1 | | V | |
| VCC_RF output current | ICC_RF | | | 50 | mA | |
| Receiver chain noise figure ¹⁵ | NF _{tot} | | 9.5 | | dB | |
| External gain (at RF_IN) | Ext_gain | 17 | | 50 | dB | |
| Operating temperature | Topr | -40 | +25 | +85 | °C | |

Table 12: Operating conditions

4.3 Indicative power requirements

Table 13 provides examples of typical current requirements when using a cold start command. The given values are total system supply current for a possible application including RF and baseband sections.

All values in **Table 13** have been measured at 25 °C ambient temperature.



The actual power requirements vary depending on the FW version used, external circuitry, number of satellites tracked, signal strength, type and time of start, duration, and conditions of test.

| Symbol | Parameter | Conditions | GPS+GLO +GAL+BDS | GPS | Unit |
|--------------------------------|--------------|-------------|---------------------|-----|------|
| I _{PEAK} | Peak current | Acquisition | 130 | 120 | mA |
| I _{VCC} ¹⁶ | VCC current | Acquisition | 90 | 75 | mA |
| I _{VCC} ¹⁶ | VCC current | Tracking | 85 | 70 | mA |

Table 13: Currents to calculate the indicative power requirements

¹⁵ Only valid for GPS

¹⁶ Simulated GNSS signal

5 Communications interfaces

The ZED-F9P-02B has several communications interfaces¹⁷, including UART, SPI, I2C and USB.

All the inputs have internal pull-up resistors in normal operation and can be left open if not used. All the PIOs are supplied by VCC, therefore all the voltage levels of the PIO pins are related to VCC supply voltage.

5.1 UART

The UART interfaces support configurable baud rates. See the Integration manual [1].

Hardware flow control is not supported.

The UART1 is enabled if D_SEL pin of the module is left open or "high".

| Symbol | Parameter | Min | Max | Unit |
|---------------|------------------------|-------|--------|-------|
| R_U | Baud rate | 9600 | 921600 | bit/s |
| Δ_{Tx} | Tx baud rate accuracy | -1% | +1% | - |
| Δ_{Rx} | Rx baud rate tolerance | -2.5% | +2.5% | - |

Table 14: ZED-F9P-02B UART specifications

5.2 SPI

The SPI interface is disabled by default. The SPI interface shares pins with UART and I2C and can be selected by setting D_SEL = 0. The SPI interface can be operated in peripheral mode only. The maximum transfer rate using SPI is 125 kB/s and the maximum SPI clock frequency is 5.5 MHz.

The SPI timing parameters for peripheral operation are defined in Figure 4. Default SPI configuration is CPOL = 0 and CPHA = 0.

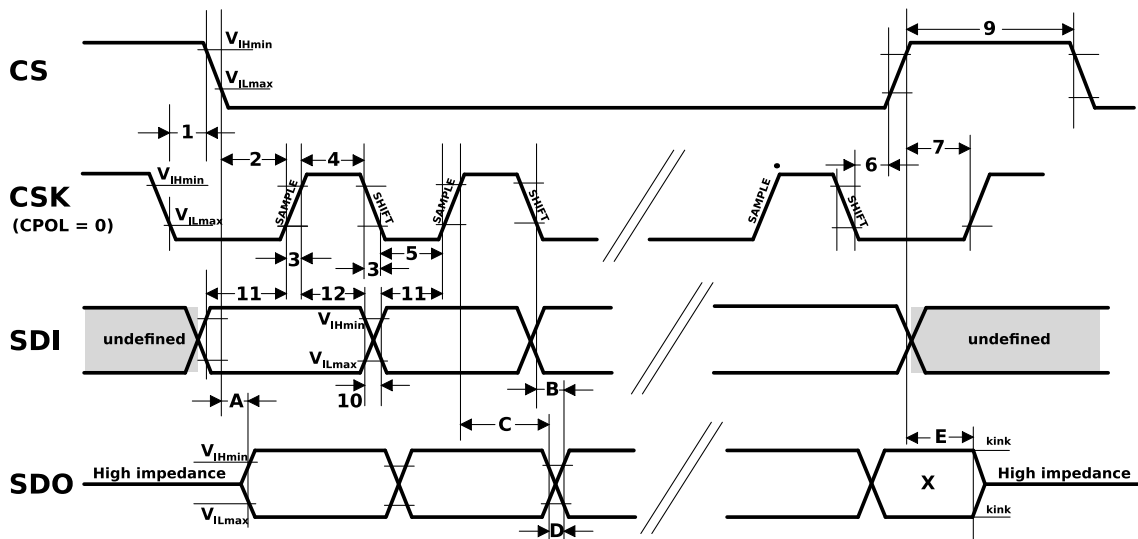


Figure 4: ZED-F9P-02B SPI specification mode 1: CPHA=0 SCK = 5.33 MHz

¹⁷ The signal names and related terms have been replaced with new terminology in this document.

| Symbol | Parameter | Min | Max | Unit |
|--------|----------------------------------------|-----|-----|------|
| 1 | CS deassertion hold time | 23 | - | ns |
| 2 | Chip select time (CS to SCK) | 20 | - | ns |
| 3 | SCK rise/fall time | - | 7 | ns |
| 4 | SCK high time | 24 | - | ns |
| 5 | SCK low time | 24 | - | ns |
| 6 | Chip deselect time (SCK falling to CS) | 30 | - | ns |
| 7 | Chip deselect time (CS to SCK) | 30 | - | ns |
| 9 | CS high time | 32 | - | ns |
| 10 | SDI transition time | - | 7 | ns |
| 11 | SDI setup time | 16 | - | ns |
| 12 | SDI hold time | 24 | - | ns |

Table 15: SPI peripheral input timing parameters 1 - 12

| Symbol | Parameter | Min | Max | Unit |
|--------|---------------------------------------------|-----|-----|------|
| A | SDO data valid time (CS) | 12 | 40 | ns |
| B | SDO data valid time (SCK), weak driver mode | 15 | 40 | ns |
| C | SDO data hold time | 100 | 140 | ns |
| D | SDO rise/fall time, weak driver mode | 0 | 5 | ns |
| E | SDO data disable lag time | 15 | 35 | ns |

Table 16: SPI peripheral timing parameters A - E, 2 pF load capacitance

| Symbol | Parameter | Min | Max | Unit |
|--------|---------------------------------------------|-----|-----|------|
| A | SDO data valid time (CS) | 16 | 55 | ns |
| B | SDO data valid time (SCK), weak driver mode | 20 | 55 | ns |
| C | SDO data hold time | 100 | 150 | ns |
| D | SDO rise/fall time, weak driver mode | 3 | 20 | ns |
| E | SDO data disable lag time | 15 | 35 | ns |

Table 17: SPI peripheral timing parameters A - E, 20 pF load capacitance

| Symbol | Parameter | Min | Max | Unit |
|--------|---------------------------------------------|-----|-----|------|
| A | SDO data valid time (CS) | 26 | 85 | ns |
| B | SDO data valid time (SCK), weak driver mode | 30 | 85 | ns |
| C | SDO data hold time | 110 | 160 | ns |
| D | SDO rise/fall time, weak driver mode | 13 | 45 | ns |
| E | SDO data disable lag time | 15 | 35 | ns |

Table 18: SPI peripheral timing parameters A - E, 60 pF load capacitance

5.3 I2C

An I2C interface is available for communication with an external host CPU in I2C Fast-mode. Backwards compatibility with Standard-mode I2C bus operation is not supported. The interface can be operated only in peripheral mode with a 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.

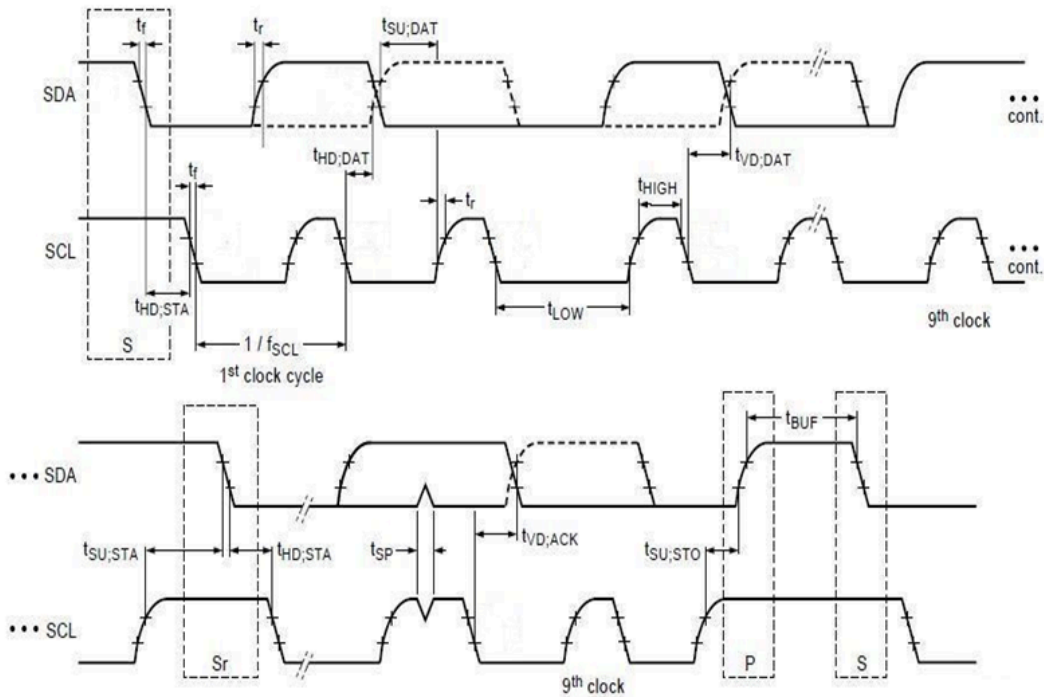


Figure 5: ZED-F9P-02B I2C peripheral specification

| Symbol | Parameter | I2C Fast-mode | | Unit |
|--------------|--------------------------------------------------|-------------------|---------------------|---------|
| | | Min | Max | |
| f_{SCL} | SCL clock frequency | 0 | 400 | kHz |
| $t_{HD;STA}$ | Hold time (repeated) START condition | 0.6 | - | μs |
| t_{LOW} | Low period of the SCL clock | 1.3 | - | μs |
| t_{HIGH} | High period of the SCL clock | 0.6 | - | μs |
| $t_{SU;STA}$ | Setup time for a repeated START condition | 0.6 | - | μs |
| $t_{HD;DAT}$ | Data hold time | 0 ¹⁸ | - ¹⁹ | μs |
| $t_{SU;DAT}$ | Data setup time | 100 ²⁰ | - | ns |
| t_r | Rise time of both SDA and SCL signals | - | 300 (for C = 400pF) | ns |
| t_f | Fall time of both SDA and SCL signals | - | 300 (for C = 400pF) | ns |
| $t_{SU;STO}$ | Setup time for STOP condition | 0.6 | - | μs |
| t_{BUF} | Bus-free time between a STOP and START condition | 1.3 | - | μs |
| $t_{VD;DAT}$ | Data valid time | - | 0.9 ¹⁹ | μs |
| $t_{VD;ACK}$ | Data valid acknowledge time | - | 0.9 ¹⁹ | μs |
| V_{nL} | Noise margin at the low level | 0.1 VCC | - | V |
| V_{nH} | Noise margin at the high level | 0.2 VCC | - | V |

Table 19: ZED-F9P-02B I2C peripheral timings and specifications

¹⁸ External device must provide a hold time of at least one transition time (max 300 ns) for the SDA signal (with respect to the min V_{ih} of the SCL signal) to bridge the undefined region of the falling edge of SCL.

¹⁹ The maximum $t_{HD;DAT}$ must be less than the maximum $t_{VD;DAT}$ or $t_{VD;ACK}$ with a maximum of 0.9 μs by a transition time. This maximum must only be met if the device does not stretch the LOW period (t_{LOW}) of the SCL signal. If the clock stretches the SCL, the data must be valid by the set-up time before it releases the clock.

²⁰ When the I2C peripheral is stretching the clock, the $t_{SU;DAT}$ of the first bit of the next byte is 62.5 ns.



The I2C interface is only available with the UART default mode. If the SPI interface is selected by using D_SEL = 0, the I2C interface is not available.

5.4 USB

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. The V_USB pin supplies the USB interface.

5.5 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 3.3 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 3.3 input protocols are enabled by default. |
| UART2 output | 38400 baud, 8 bits, no parity bit, 1 stop bit. UBX protocol cannot be enabled. RTCM 3.3 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. UBX protocol cannot be enabled and will not receive UBX input messages. RTCM 3.3 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 (see section D_SEL interface in Integration manual [1]). |

Table 20: Default interface settings



Refer to the applicable Interface description [2] for information about further settings.



By default, the ZED-F9P-02B 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. Make sure the UART baud rate used is sufficient for the selected navigation rate and the number of GNSS signals being received.

6 Mechanical specification

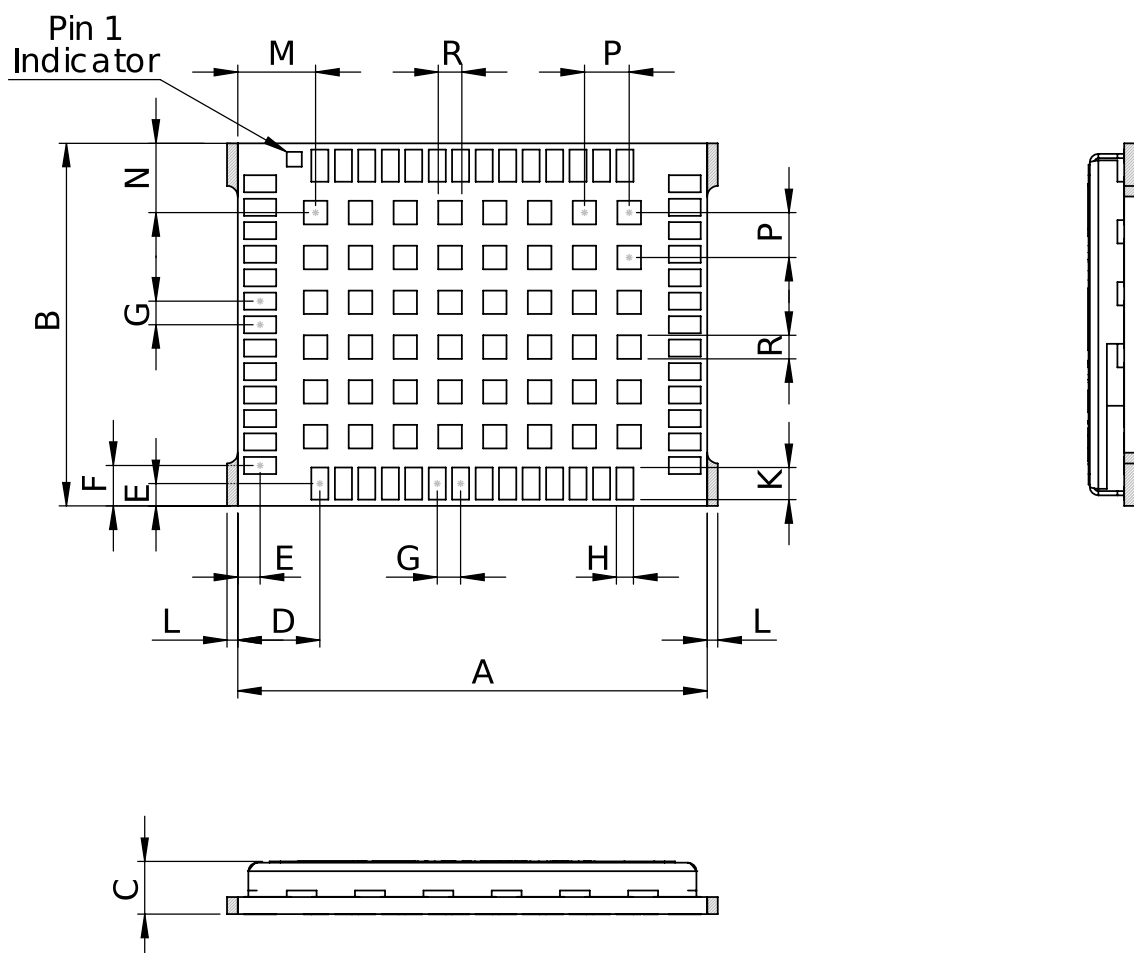


Figure 6: ZED-F9P-02B mechanical drawing

| Symbol | Min (mm) | Typical (mm) | Max (mm) |
|--------|----------|--------------|----------|
| A | 21.80 | 22.00 | 22.20 |
| B | 16.80 | 17.00 | 17.20 |
| C | 2.20 | 2.40 | 2.60 |
| D | 3.65 | 3.85 | 4.05 |
| E | 0.85 | 1.05 | 1.25 |
| F | 1.70 | 1.90 | 2.10 |
| G | 1.05 | 1.10 | 1.15 |
| H | 0.70 | 0.80 | 0.96 |
| K | 1.20 | 1.50 | 1.80 |
| M | 3.45 | 3.65 | 3.85 |
| N | 3.05 | 3.25 | 3.45 |
| P | 2.05 | 2.10 | 2.15 |

| Symbol | Min (mm) | Typical (mm) | Max (mm) |
|--------|----------|--------------|----------|
| R | 0.88 | 1.10 | 1.32 |
| L | 0.00 | | 0.30 |
| Weight | | 1.8 g | |

Table 21: ZED-F9P-02B mechanical dimensions


The mechanical picture of the de-paneling residual tabs (L) is an approximate representation. The shape and position may vary.



Take the size of the de-paneling residual tabs into account when designing the component keep-out area.

7 Qualifications and approvals

| | |
|---------------------------------------------------|--------------------------------------------------------------------------------------|
| Quality and reliability | |
| Product qualification | Qualified according to ISO 16750 |
| Chip qualification | Modules are based on AEC-Q100 qualified GNSS chips |
| Manufacturing | Manufactured at ISO/TS 16949 certified sites |
| Environmental | |
| RoHS compliance | Yes |
| Moisture sensitivity level (MSL) ^{21 22} | 4 |
| Type approvals | |
| European RED certification (CE) | Declaration of Conformity (DoC) is available on the u-blox website . |
| UK conformity assessment (UKCA) | Yes |

Table 22: Qualifications and approvals

²¹ For the MSL standard, see IPC/JEDEC J-STD-020 and J-STD-033, available on www.jedec.org

²² For more information regarding moisture sensitivity levels, labelling, storage and drying, see the Product packaging reference guide [3]

8 Labeling and ordering information

This section provides information about product labeling and ordering. For information about moisture sensitivity level (MSL), product handling and soldering see the Integration manual [1].

8.1 Product labeling

The labeling of the ZED-F9P-02B modules provides product information and revision information. For more information contact u-blox sales.

8.2 Explanation of product codes

Three product code formats are used in the ZED-F9P-02B labels. The **Product name** used in documentation such as this data sheet identifies all u-blox products, independent of packaging and quality grade. The **Ordering code** includes options and quality, while the **Type number** includes the hardware and firmware versions.

Table 23 below details these three formats.

| Format | Structure | Product code |
|---------------|----------------|----------------|
| Product name | PPP-TGV | ZED-F9P |
| Ordering code | PPP-TGV-NNQ | ZED-F9P-02B |
| Type number | PPP-TGV-NNQ-XX | ZED-F9P-02B-00 |

Table 23: Product code formats

The parts of the product code are explained in Table 24.

| Code | Meaning | Example |
|------|------------------------|--------------------------------------------------------------------|
| PPP | Product family | ZED |
| TG | Platform | F9 = u-blox F9 |
| V | Variant | P = High precision |
| NNQ | Option / Quality grade | NN: Option [00...99] Q: Grade, A = Automotive, B = Professional |
| XX | Product detail | Describes hardware and firmware versions |

Table 24: Part identification code

8.3 Ordering codes

| Ordering code | Product | Remark |
|---------------|---------|----------------------------------------|
| ZED-F9P-02B | ZED-F9P | Shipped with firmware FW 1.00 HPG 1.13 |

Table 25: Product ordering codes



Product changes affecting form, fit or function are documented by u-blox. For a list of Product Change Notifications (PCNs) see our website at: <https://www.u-blox.com/en/product-resources>.

Related documents

- [1] ZED-F9P Integration manual [UBX-18010802](#)
- [2] HPG 1.13 Interface description [UBX-21023318](#)
- [3] Product packaging reference guide [UBX-14001652](#)
- [4] Radio Resource LCS Protocol (RRLP), (3GPP TS 44.031 version 11.0.0 Release 11)
- [5] ZED-F9P Moving Base application note, [UBX-19009093](#)



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 | Status / comments |
|----------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R01 | 02-Jun-2020 | Early production information For document legacy revisions see UBX-17051259 |
| R02 | 25-Jun-2021 | Production information Overall text improvement and typo corrections plus: 5.1 UART interface section updated, 5.4 USB interface section updated |
| R03 | 24-Mar-2023 | Updated I2C and SPI timing specifications in section Communications interfaces Updated VCC_RF output current in table Absolute maximum ratings Updated backup current in table Operating conditions Added timepulse footnote in table Operating conditions |
| R04 | 21-Mar-2024 | Updated sections: <ul style="list-style-type: none">• Performance• Mechanical specifications updated with information on de-paneling residual tabs• Qualifications and approvals• Information on moisture sensitivity level has been moved from the Integration manual to chapter Qualifications and approvals• Editorial changes throughout the document |

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