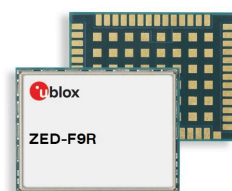**P**

ZED-F9R-04B

u-blox F9 high precision sensor fusion GNSS receiver
Professional grade

Data sheet

Abstract
This data sheet describes the ZED-F9R high precision sensor fusion module with 3D sensors and a multi-band GNSS receiver. It provides a reliable multi-band RTK turnkey solution with up to 30 Hz real-time position update rate and full GNSS carrier raw data.

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Document information

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Initial production	Early production information	Data from product verification. Revised and supplementary data may be published later.
Mass production / End of life	Production information	Document contains the final product specification.

This document applies to the following products:

Product name	Type number	Firmware version	PCN reference	Product status
ZED-F9R	ZED-F9R-04B-00	HPS 1.40	-	Initial production

Contents

1 Functional description

1.1 Overview

The ZED-F9R-04B module with the u-blox F9 multi-band GNSS receiver features rapid convergence time within seconds. This mass-market component combines high precision positioning with highest availability, while making use of all four GNSS constellations simultaneously. It is the first sensor fusion module with an integrated inertial measurement unit (IMU) capable of high precision positioning. The sophisticated built-in algorithms fuse the IMU data, GNSS measurements, wheel ticks, and a dedicated dynamic model to provide accurate positioning where GNSS alone would fail.

The module operates under open sky, sidewalks, roads, in the wooded countryside, in difficult multi-path environments, and even in tunnels and underground parking. For modern autonomous robotic applications such as unmanned ground vehicles where control and availability are the keys to success, ZED-F9R-04B is the ultimate solution.

The device is a turnkey solution eliminating the technical risk of integrating third-party libraries, precise positioning engines, and the multi-faceted hardware engineering aspects of radio frequency design and digital design. The u-blox approach provides a transparent evaluation of the positioning solution and clear lines of responsibility for design support while reducing supply chain complexity during production.

ZED-F9R-04B offers support for a range of correction services allowing each application to optimize performance according to the application's unique needs. ZED-F9R-04B comes with built-in support for RTCM-formatted corrections, enabling high precision navigation using internet or satellite data connectivity. From firmware version HPS 1.21 onwards, the product supports SSR-type correction services suitable for mass-market deployment. Finally, the full set of RAW data from IMU sensors and GNSS carriers are provided.

ZED-F9R-04B modules use GNSS chips qualified according to AEC-Q100 and are manufactured in ISO/TS 16949 certified sites. Qualification tests are performed as stipulated in the ISO16750 standard. The professional-grade ZED-F9R-04B module adheres to industrial standard quality specifications and production flow.

1.2 Performance

Parameter	Specification	
Receiver type	Multi-band GNSS high precision sensor fusion 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
Position error during GNSS loss[2]		2%

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[1] Assuming airborne 4 g platform

[2] 68% error incurred without GNSS as a percentage of distance of traveled 3000 m, applicable to four-wheel road vehicle

Parameter	Specification	
Max navigation update rate (RTK) [3]	Priority navigation mode	30 Hz
	Non-priority navigation mode	4 Hz
	Secondary output	4 Hz
Navigation latency	Priority navigation mode	15 ms
Velocity accuracy[4]		0.05 m/s
Dynamic attitude accuracy[4]	Heading	0.2 deg
	Pitch	0.3 deg
	Roll	0.5 deg
Max sensor measurement output rate		100 Hz

GNSS		GPS+GLO+GAL+BDS	GPS+GAL+BDS	GPS+GAL	GPS+BDS	BDS
Acquisition[5]	Cold start	23 s	28 s	32 s	29 s	33 s
	Hot start	2 s	2 s	2 s	2 s	2 s
	Aided starts[6]	2 s	2 s	2 s	2 s	3 s
Re-convergence time[7][8]	RTK	≤ 10 s	≤ 10 s	≤ 10 s	≤ 10 s	≤ 30 s
Sensitivity[9][10]	Tracking and nav.	-160 dBm	-160 dBm	-160 dBm	-160 dBm	-160 dBm
	Reacquisition	-159 dBm	-159 dBm	-158 dBm	-158 dBm	-158 dBm
	Cold start	-147 dBm	-147 dBm	-147 dBm	-147 dBm	-144 dBm
	Hot start	-158 dBm	-158 dBm	-158 dBm	-158 dBm	-158 dBm

Table 1: ZED-F9R-04B performance in different GNSS modes

GNSS		GPS+GLO+GAL+BDS	GPS+GLO+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Horizontal position accuracy (CEP)	PVT[11]	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m
	SBAS[11]	1.0 m	1.0 m	1.0 m	1.0 m	1.0 m	1.0 m
	RTK[12]	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)	RTK[12]	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 2: ZED-F9R-04B position accuracy in different GNSS modes

GNSS[13]		GPS+GLO+GAL+BDS	GPS+GLO+GAL
Horizontal position accuracy (CEP)	SPARTN	< 0.06 m	< 0.06 m
	CLAS	0.04 m	0.04 m

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3 Rates with QZSS enabled for > 98% fix report rate under typical conditions

4 68% at 30 m/s for dynamic operation

5 All satellites at -130 dBm

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

7 68% depending on atmospheric conditions, baseline length, GNSS antenna, multipath conditions, satellite visibility and geometry

8 Time to ambiguity fix after 20 s outage

9 Demonstrated with a good external LNA

10 Configured minCNO of 6 dBHz, limited by FW with minCNO of 20 dBHz for best performance

11 24 hours static

12 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.

13 GPS used in combination with QZSS and SBAS

GNSS[13]		GPS+GLO+GAL+BDS	GPS+GLO+GAL
Vertical position accuracy (Median)	SPARTN	< 0.12 m	< 0.12 m
	CLAS	0.08 m	0.08 m
Convergence time[7]	SPARTN[14]	< 45 s	< 45 s
	CLAS	< 70 s	< 70 s

Table 3: ZED-F9R-04B performance for PPP-RTK in different GNSS modes

☞ PPP-RTK performance with SPARTN 2.0.2 protocol varies amongst service providers and service definitions. Performance has been validated with SPARTN correction stream available at the time of firmware release in February 2025.

1.3 Supported GNSS constellations

The ZED-F9R-04B 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.

All satellites in view can be processed to provide an RTK navigation solution when used with correction data; the highest positioning accuracy will be achieved when the receiver is tracking signals on both bands from multiple satellites, and is provided with corresponding correction data.

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.

ZED-F9R-04B supports the GNSS and their signals as shown in Table 4 .

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

Table 4: Supported GNSS signals on ZED-F9R-04B

ZED-F9R-04B 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. ZED-F9R-04B 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.

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[13] GPS used in combination with QZSS and SBAS

[14] Measured for IP data stream only with low-latency communication link

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

1.4.2 Satellite-based augmentation system (SBAS)

The ZED-F9R-04B optionally supports SBAS (including WAAS in the US, EGNOS in Europe, MSAS 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.

☞   SBAS reception is disabled by default in ZED-F9R-04B.

1.4.3 Differential GNSS (DGNSS)

When operating in RTK mode, RTCM version 3.4 messages are required and the module supports DGNSS according to RTCM 10403.4. ZED-F9R-04B can decode the following RTCM 3.4 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
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

Table 5: Supported input RTCM 3.4 messages

Message type-subtype	Description
SM 0-0	GPS orbit, clock, bias (OCB)
SM 0-1	GLONASS orbit, clock, bias (OCB)
SM 0-2	Galileo orbit, clock, bias (OCB)
SM 0-3	BeiDou orbit, clock, bias (OCB)

Message type-subtype	Description
SM 0-4	QZSS orbit, clock, bias (OCB)
SM 1-0	GPS high-precision atmosphere correction (HPAC)
SM 1-1	GLONASS high-precision atmosphere correction (HPAC)
SM 1-2	Galileo high-precision atmosphere correction (HPAC)
SM 1-3	BeiDou high-precision atmosphere correction (HPAC)
SM 1-4	QZSS high-precision atmosphere correction (HPAC)
SM 2-0	Geographic area definition (GAD)
SM 3-0	Basic-precision atmosphere correction (BPAC)

Table 6: Supported input SPARTN version 2.0.2 messages

1.4.4 Centimeter level augmentation service (CLAS)

A ZED-F9R-04B can receive UBX-RXM-QZSSL6 message from a NEO-D9C on any communication interface. The message contains QZSS CLAS (centimeter-level augmentation service) corrections. The CLAS protocol provides corrections for in-view GPS, Galileo, and QZSS satellites in Japan.

1.5 Broadcast navigation data and satellite signal measurements

ZED-F9R-04B 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. For the UBX-RXM-SFRBX message specification, see the Interface description [2]. 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-F9R-04B 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 is available once the receiver has established data bit synchronization and time-of-week.

1.6 Supported protocols

ZED-F9R-04B supports the following protocols:

Protocol	Type
UBX	Input/output, binary, u-blox proprietary
NMEA 4.11 (default), 4.10, 4.0, 2.3, and 2.1	Input/output, ASCII
RTCM 3.4	Input, binary
SPARTN 2.0.2	Input, binary

Table 7: Supported protocols

For specification of the protocols, see the Interface description [2].

1.7 Firmware features

Feature	Description
Advanced calibration handling	Calibration information can be stored with the host

Feature	Description
Automotive dead reckoning	Combines satellite and sensor-based navigation (IMU and odometer input)
Automatic alignment	Automatic estimation of the alignment angles (automotive dynamic model only)
Backup modes	Hardware backup mode, software backup mode
Dual output	GNSS only and Fused (GNSS+DR) output
Geofencing	Up to 4 circular areas; GPIO for waking up external CPU
Protection level	Computed by the receiver in real-time, quantifies the reliability of the position information
Upgradeable firmware	Firmware in flash memory can be upgraded
Wake on motion	Wakes up the host while the receiver is in SW backup mode

Table 8: Firmware features

Feature	Description
Anti-jamming	RF interference and jamming detection and reporting
Anti-spoofing	Spoofing detection and reporting
Configuration lockdown	Receiver configuration can be locked by command
Message integrity	All messages signed with SHA-256
Secure boot	Only signed FW images executed

Table 9: Security features

1.8 High precision sensor fusion (HPS)

u-blox's proprietary high precision sensor fusion (HPS) solution uses a 3D inertial measurement unit (IMU) included within the module and speed pulses from the wheel sensors. Alternatively, the velocity data can be provided via software interface. Sensor data and GNSS signals are processed together, achieving 100% coverage, with highly accurate and continuous positioning even in GNSS-hostile environments (e.g. urban areas) or in case of GNSS signal absence (e.g. tunnels, multi-level parking structures).

Wheel or speed sensor rate variations and the 3D IMU sensors are calibrated automatically and continuously by the module, accommodating, for example, if wheel diameter changes.

☞ For more details, see the ZED-F9R-04B Integration manual [1].

The ZED-F9R-04B combines GNSS and sensor measurements and computes a position solution at rates of up to 4 Hz with non-priority navigation mode. In priority navigation mode the navigation rate can be increased using IMU-only data to deliver accurate, low-latency position measurements at rates up to 30 Hz. These solutions are reported in standard NMEA, UBX-NAV-PVT and similar messages.

⚠ The priority navigation mode works optimally when the IMU and WT sensors have been calibrated, and the alignment angles are correct.

The dead reckoning mode allows navigation to commence as soon as power is applied to the module (i.e. before a GNSS fix has been established) under the following conditions:

- the vehicle has not been moved while the module is switched off
- at least a dead reckoning (DR) fix was available when the vehicle was last used
- a backup supply has been available for the module since the vehicle was last used

☞ The save-on-shutdown feature can be used when no backup supply is available. All necessary information is saved to the flash and read from the flash upon restart.

ZED-F9R-04B's high precision sensor fusion algorithm is optimized for the following platforms.

- Automotive
- E-scooter
- Robotic lawn mower
- Rail vehicles

☞ For more information regarding the supported HPS dynamic models, see the ZED-F9R-04B Integration manual [1].

2 System description

2.1 Block diagram
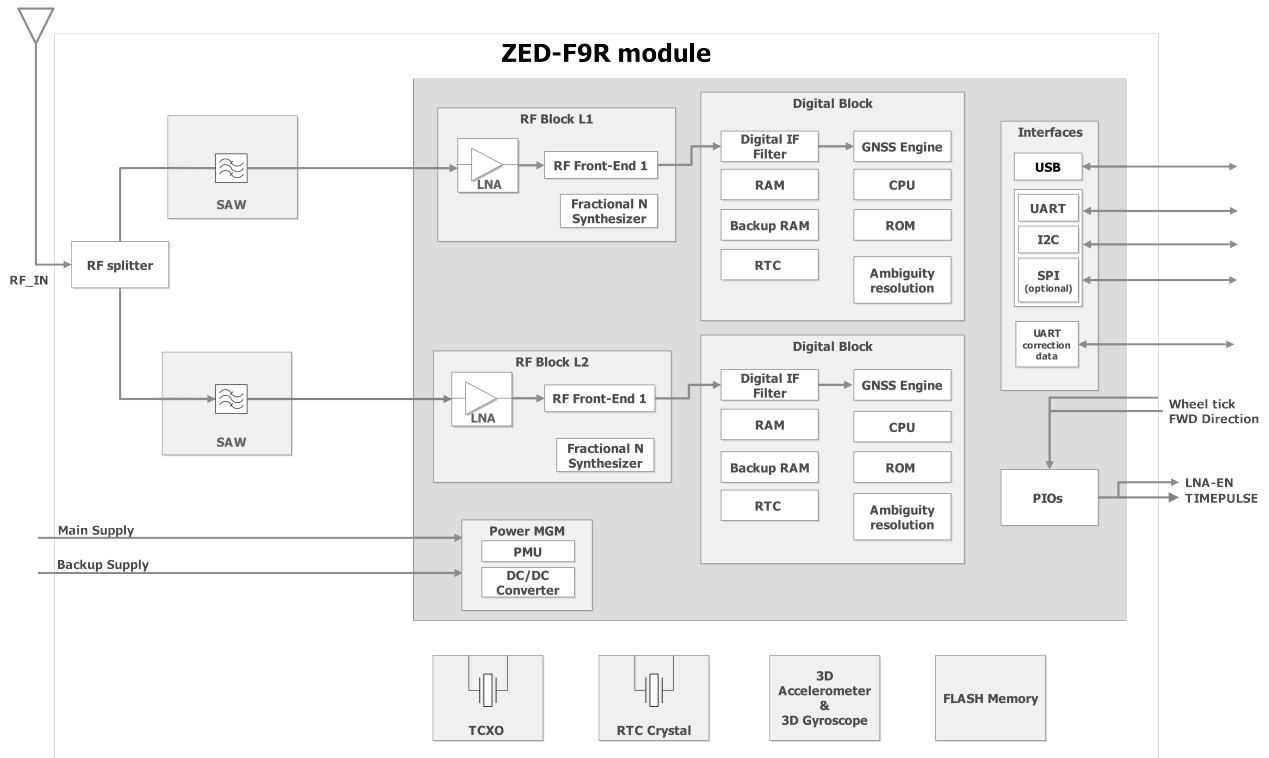
Figure 1: ZED-F9R-04B block diagram

3 Pin definition

3.1 Pin assignment

The pin assignment of the ZED-F9R-04B module is shown in Figure 2. The defined configuration of the PIOs is listed in Table 10.

☞ ZED-F9R-04B is an LGA package with the I/O on the outside edge and central ground pads.
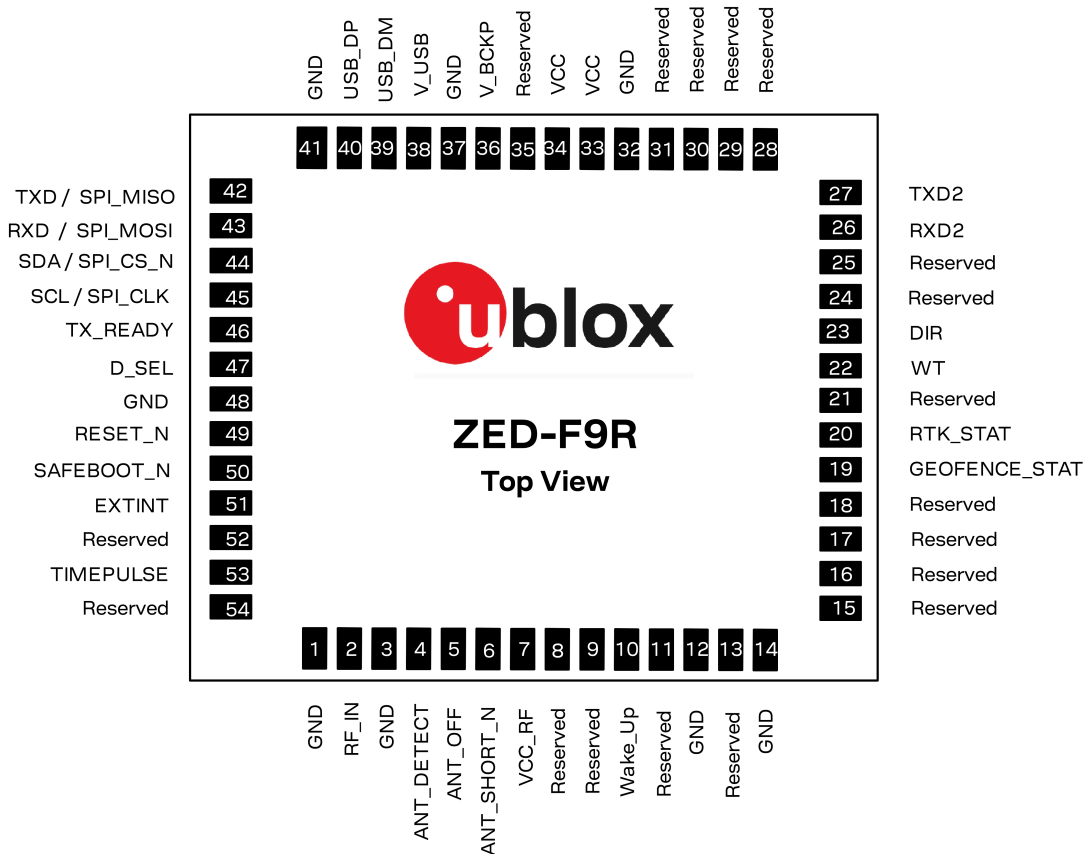
Figure 2: ZED-F9R-04B pin assignment

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
5	ANT_OFF	O	External LNA disable
6	ANT_SHORT_N	I	Active antenna short detect
7	VCC_RF	O	Voltage for external LNA
8	Reserved	-	Reserved
9	Reserved	-	Reserved
10	Wake_Up	O	Wake on motion
11	Reserved	-	Reserved

Pin no.	Name	I/O	Description
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 – fixed, blinking – receiving and using corrections, 1 – no corrections
21	Reserved	-	Reserved
22	WT	I	Wheel ticks
23	DIR	I	Direction
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 power input
39	USB_DM	I/O	USB data
40	USB_DP	I/O	USB data
41	GND	-	Ground
42	TXD / SPI_SDO	O	Serial port if D_SEL =1(or open). SPI SDO if D_SEL = 0
43	RXD / SPI_SDI	I	Serial port 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
48	GND	-	Ground
49	RESET_N	I	RESET_N
50	SAFEBOOT_N	I	SAFEBOOT_N (for future service, updates and reconfiguration, leave OPEN)
51	EXT_INT	I	External interrupt pin
52	Reserved	-	Reserved
53	TIMEPULSE	O	Time pulse

Pin no.	Name	I/O	Description
54	Reserved	-	Reserved

Table 10: ZED-F9R-04B pin assignment

4 Electrical specifications

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[15]			20	8000	µs/V
Backup battery voltage	V_BCKP		–0.5	3.6	V
Voltage ramp on V_BCKP[15]			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			300	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	
Supply voltage for USB interface	V_USB	3.0		3.6	V	
V_USB current	I_USB		2.0		mA	
Backup battery voltage	V_BCKP	1.65		3.6	V	
Backup battery current[16, 17]	I_BCKP		45		µA	V_BCKP = 3 V, VCC = 0 V
SW backup current[17]	I_SWBCKP		1.5		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[18]

---

[15] Exceeding the ramp speed may permanently damage the device

[16] 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.

[17] The value has been characterized at 25 °C ambient temperature.

[18] TIMEPULSE has 4 mA current drive/sink capability

Parameter	Symbol	Min	Typical	Max	Units	Condition
Digital IO pin high level output voltage	Voh	VCC – 0.4			V	Ioh = 2 mA [18]
DC current through any digital I/O pin (except supplies)	Ipin			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	
VCC_RF voltage	VCC_RF		VCC – 0.1		V	
VCC_RF output current	ICC_RF			50	mA	
Receiver chain noise figure[19]	NFtot		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}[20]	VCC current	Acquisition	90	75	mA
I_{VCC}[20]	VCC current	Tracking	85	70	mA

Table 13: Currents to calculate the indicative power requirements

---

[19] Only valid for GPS

[20] Simulated GNSS signal

5 Communications interfaces

ZED-F9R-04B has several communications interfaces[21], 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. For further information, see the Integration manual [1].

Hardware flow control is not supported.

UART1 is the primary host communications interface while UART2 is dedicated to the DCS-correction interface, RTCM 3.4 corrections, and NMEA. The UBX protocol is supported on UART2 but disabled by default.

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-F9R-04B 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 3. Default SPI configuration is CPOL = 0 and CPHA = 0.

---

21 The signal names and related terms have been replaced with new terminology in this document.
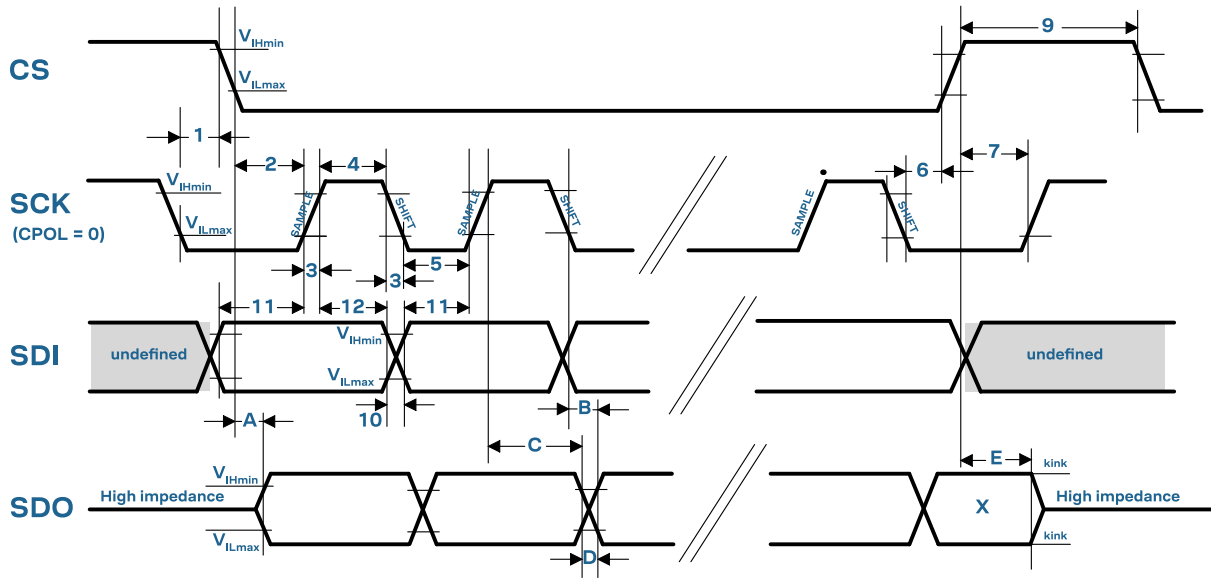
Figure 3: ZED-F9R-04B SPI specification mode 1: CPHA=0 SCK = 5.33 MHz

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.
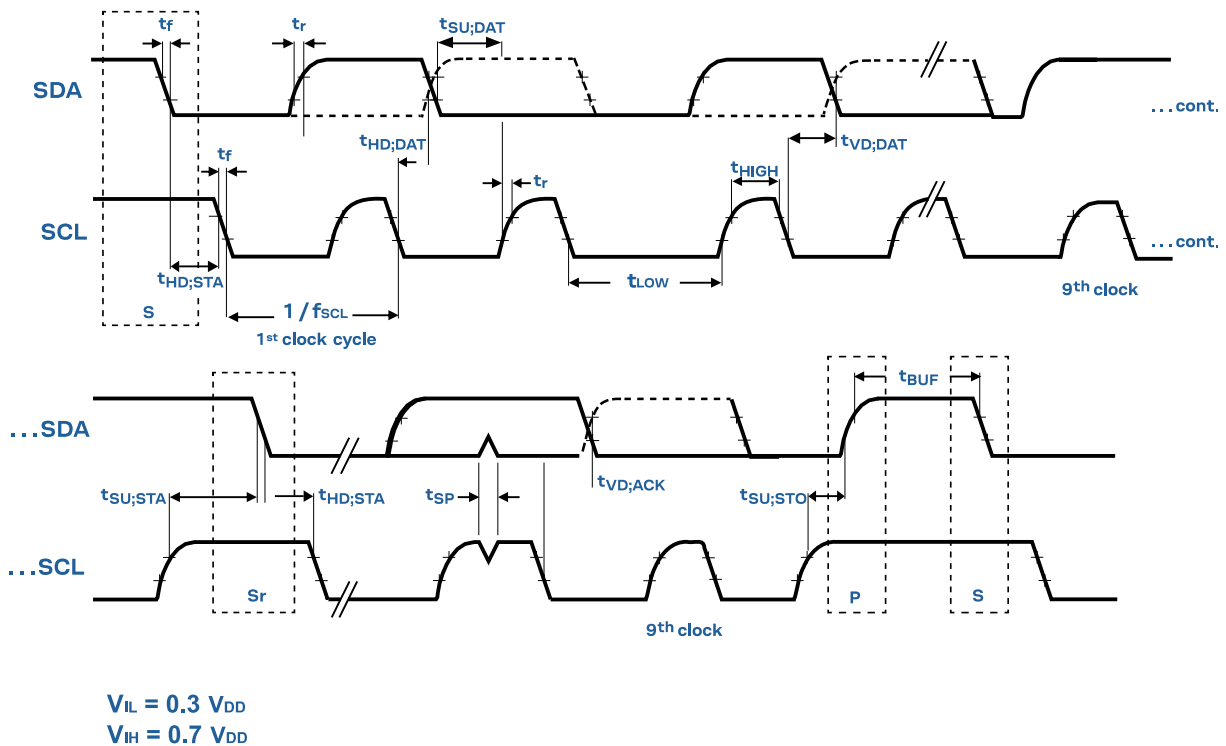

$V_{IL} = 0.3\ V_{DD}$
$V_{IH} = 0.7\ V_{DD}$

Figure 4: ZED-F9R-04B I2C peripheral specification

Symbol	Parameter	I2C Fast-mode		
		Min	Max	Unit
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

Symbol	Parameter	I2C Fast-mode		Unit
		Min	Max	
$t_{HD;DAT}$	Data hold time	0 [22]	- [23]	µs
$t_{SU;DAT}$	Data setup time	100 [24]		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 [23]	µs
$t_{VD;ACK}$	Data valid acknowledge time	-	0.9 [23]	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-F9R-04B I2C peripheral timings and specifications

☞ 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 WT (wheel tick) and DIR (forward/reverse indication)

ZED-F9R-04B pin 22 (WT) is available as a wheel-tick input. The pin 23 (DIR) is available as a direction input (forward/reverse indication).

By default the wheel tick count is derived from the rising edges of the WT input.

For optimal performance the wheel tick resolution should be less than 5 cm. With the maximum supported wheel tick resolution is 40 cm.

The DIR input shall indicate whether the vehicle is moving forwards or backwards.

Alternatively, the vehicle WT (or speed) and DIR inputs can be provided via one of the communication interfaces with UBX-ESF-MEAS messages.

☞ For more details, see the integration manual [1].

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[22] 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 Vih of the SCL signal) to bridge the undefined region of the falling edge of SCL.

[23] 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 (tLOW) 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.

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

5.6 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 protocol is enabled by default but no output messages are enabled by default.
	RTCM 3.4 protocol output is not supported.
UART1 input	38400 baud, 8 bits, no parity bit, 1 stop bit.
	UBX, NMEA and RTCM 3.4 input protocols are enabled by default.
	SPARTN input protocol is enabled by default.
UART2 output	38400 baud, 8 bits, no parity bit, 1 stop bit.
	UBX protocol is disabled by default. It can be enabled as an output protocol from firmware version HPS 1.30 onwards. It cannot be enabled as an output protocol on any of the previous firmware versions and will not output UBX messages.
	RTCM 3.4 protocol output is not supported.
	NMEA protocol is disabled by default.
UART2 input	38400 baud, 8 bits, no parity bit, 1 stop bit.
	UBX protocol is disabled by default from firmware version HPS 1.30 onwards. It can be enabled as an input protocol on firmware version 1.30. It cannot be enabled as an input protocol on any of the previous firmware versions and will not receive UBX input messages.
	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 (see section D_SEL interface in Integration manual [1]).

Table 20: Default interface settings

UART2 can be configured as an RTCM interface. RTCM 3.4 is the default input protocol. UART2 may also be configured for NMEA output. NMEA GGA output is typically used with virtual reference service correction services.

☞ By default, ZED-F9R-04B 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.

⚠ Do not use UART2 as the only one interface to the host. Not all UBX functionality is available on UART2, such as firmware upgrade, safeboot or backup modes functionalities. No start-up boot screen is sent out from UART2.
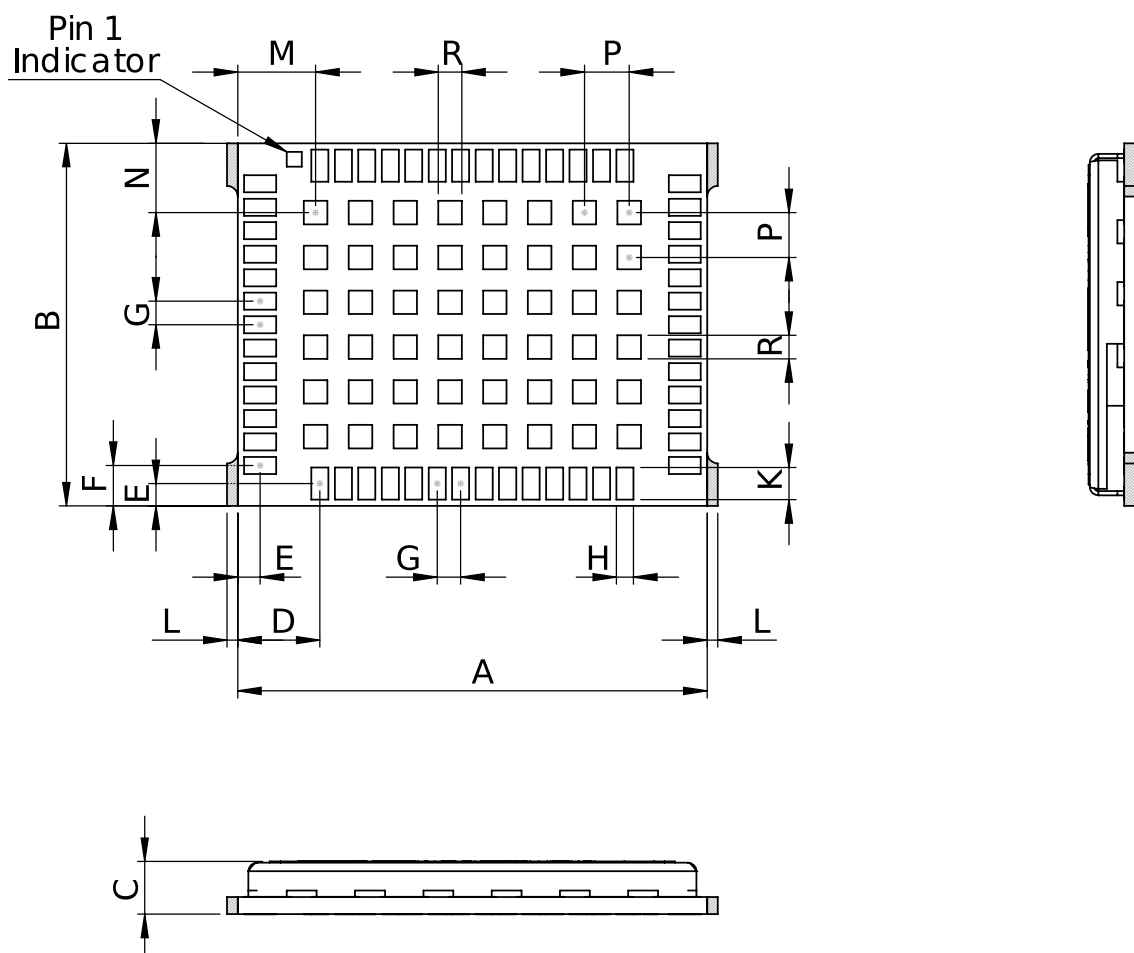
6 Mechanical specifications

Figure 5: ZED-F9R-04B 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-F9R-04B 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) [25] [26]	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

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

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

8 Product marking and ordering information

This section provides information about product marking and ordering.

8.1 Product marking

The product marking provides information on ZED-F9R-04B and its revision, as in Figure 6. For a description of the product marking, see Table 23.
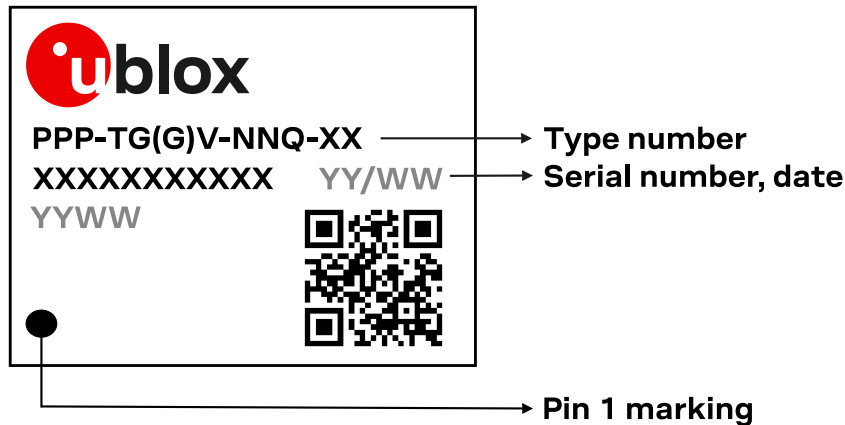

Figure 6: Example of ZED-F9R-04B product marking

Code	Meaning	Example
PPP	Form factor	ZED
TG(G)	Platform	F9 = u-blox F9
V	Variant	R = High precision sensor fusion
NN	Major product version	00, 01, …, 99
Q	Product grade	A = Automotive, B = Professional, C= Standard
XX	Revision	Hardware and firmware revisions
YY/WW or YYWW	Production date	Year/week, e.g. 24/04 or 2404
XXXXXXXXXX	Serial number	Alphanumeric characters, e.g. BN600001181
Other information	QR code	For internal/technical use.

Table 23: Description of product marking

8.2 Product identifiers

The ZED-F9R-04B label features three product identifiers: product name, ordering code, and type number. The product name identifies all u-blox products. It is used in documentation such as this Data sheet and is independent of packaging and product grade. The ordering code indicates the major product version and product grade, and the type number additionally specifies the hardware and firmware revisions.

Table 24 describes the three different product identifiers used in the ZED-F9R-04B label

Identifier	Format	Example
Product name	PPP-TG(G)V	ZED-F9R
Ordering code	PPP-TG(G)V-NNQ	ZED-F9R-04B
Type number	PPP-TG(G)V-NNQ-XX	ZED-F9R-04B-00

Table 24: Product identifiers

8.3 Ordering codes

Ordering code	Product	Remark
ZED-F9R-04B	u-blox ZED-F9R-04B	Product shipped with firmware FW HPS 1.40

Table 25: Product ordering codes

u-blox provides information on product changes affecting the form factor, size or function of the product. For the Product change notifications (PCNs), see our website at https://www.u-blox.com/en/product-resources.

Related documents

[1] ZED-F9R Integration manual, UBX-20039643
[2] HPS 1.40 Interface description, UBXDOC-963802114-13138
[3] Product packaging reference guide, UBX-14001652
[4] Radio Resource LCS Protocol (RRLP), (3GPP TS 44.031 version 11.0.0 Release 11)

☞ 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	21-Feb-2025	Engineering sample - ZED-F9R-04B
R02	04-Apr-2025	Initial production - ZED-F9R-04B

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For further support and contact information, visit us at www.u-blox.com/support.