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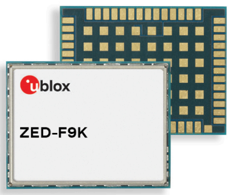
ZED-F9K-02A

High precision automotive DR GNSS receiver

Automotive grade

Data sheet



Abstract

This data sheet describes the ZED-F9K high precision module with 3D sensors and a multi-band GNSS receiver. The module provides lane-accurate positioning under the most challenging conditions, decimeter-level accuracy for automotive mass markets, and it is ideal for ADAS, V2X and head-up display. It provides a low-risk multi-band RTK turnkey solution with built-in inertial sensors and lag-free displays with up to 50 Hz real-time position update rate.

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This document applies to the following products:

Product name	Type number	Firmware version	PCN reference	Product status
ZED-F9K	ZED-F9K-02A-00	LAP 1.50	-	Initial production

Contents

1 Functional description

1.1 Overview

The ZED-F9K-02A module features the u-blox F9 GNSS platform, which provides continuous decimeter-level positioning accuracy for the most challenging automotive use cases. With LAP 1.50 , it supports both L1/L2/E5B and L1/L5 bands for maximum flexibility, satellite availability, and security.

The sophisticated built-in algorithms cleverly fuse the IMU data, GNSS measurements, wheel ticks, and vehicle dynamics model to identify driving lanes where GNSS alone would fail. The module natively supports the u-box PointPerfect GNSS augmentation service. It delivers multiple GNSS and IMU outputs in parallel to support all possible architectures, including a 50 Hz sensor-fused solution with very low latency. It also enables advanced real-time applications like augmented reality, while the optimized multi-band and multi constellation capability maximizes the number of visible satellites even in urban conditions.

The device is a self-contained solution, which provides the best possible system performance to address issues such as latency constraints, RF front-end design issues, or RTK algorithm integration. This eliminates the technical risk and effort of selecting and integrating RF components and third-party libraries, like positioning engines, which helps customers optimize time to market. The u-blox approach also dramatically reduces supply chain complexity during production.

The u-blox position engine incorporates a dependable protection level output and advanced security features including anti-spoofing and anti-jamming. Operation up to 105 °C makes it possible to integrate the product anywhere in the car without design constraints.

u-blox manufacturing partners use ISO/TS 16949 certified sites and adhere to the latest standards in the automotive industry. Qualification tests are performed as stipulated in the AEC-Q104 standard: “Failure mechanism based stress test qualification for multichip modules (MCM) in automotive applications

⚠ At the time of writing, the GPS L5 signals remain pre-operational and are set as unhealthy until sufficient monitoring capability is established. This is an operational issue concerning the satellites / space segment and not a limitation of u-blox products.

⚠ Due to the pre-operational status, the GPS L5 signals are not used for the navigation solution by default. However, it is possible to evaluate the GPS L5 signals before they become fully operational by changing the receiver configuration to override the GPS L5 health status. Contact u-blox support for more information.

1.2 Performance

Parameter	Specification	
Receiver type	Multi-band high precision DR GNSS receiver	
Accuracy of time pulse signal	RMS 99%	30 ns 60 ns
Frequency of time pulse signal		0.25 Hz to 10 MHz (configurable)

Parameter	Specification	
Operational limits[1]	Dynamics Altitude Velocity	≤ 4 g 80,000 m 500 m/s
Position error during GNSS loss[2]	3D Gyro + 3D accelerometer + speed pulse	1%
Max navigation update rate (RTK) [3] [4]	Priority navigation mode Non-priority navigation mode	50 Hz 4 Hz
Velocity accuracy[5]		0.05 m/s
Dynamic attitude accuracy[5]	Heading Pitch Roll	0.2 deg 0.3 deg 0.5 deg
Navigation latency	Priority navigation mode	15 ms
Raw sensor (IMU) data output rate		100 Hz

GNSS		GPS+GLO+GAL+BDS	GPS+GAL+BDS	GPS+GAL	GPS+BDS	BDS
Acquisition[6]	Cold start	22 s	28 s	32 s	29 s	33 s
	Hot start	2 s	2 s	2 s	2 s	2 s
	Aided starts[7]	2 s	2 s	2 s	2 s	3 s
Re-convergence time[8] [9]	RTK	≤ 10 s	≤ 10 s	≤ 10 s	≤ 10 s	≤ 30 s
Sensitivity[10] [11]	Tracking and nav.	-159 dBm	-159 dBm	-159 dBm	-159 dBm	-158 dBm
	Reacquisition	-158 dBm	-158 dBm	-157 dBm	-158 dBm	-157 dBm
	Cold start	-147 dBm	-148 dBm	-147 dBm	-147 dBm	-144 dBm
	Hot start	-159 dBm	-159 dBm	-158 dBm	-158 dBm	-157 dBm
Position accuracy RTK[8] [12]	Along track	0.20 m	0.20 m	0.25 m	0.25 m	N/A
	Cross track	0.20 m	0.20 m	0.25 m	0.25 m	N/A
	2D CEP	0.30 m	0.30 m	0.40 m	0.40 m	N/A
	Vertical	0.30 m	0.30 m	0.40 m	0.40 m	N/A

Table 1: ZED-F9K-02A performance in different GNSS modes (L1L2 configuration)

1.3 Supported GNSS constellations

The ZED-F9K-02A 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

1 Assuming airborne 4 g platform, not supported by ADR
2 68% error incurred without GNSS as a percentage of distance of traveled 1000 m, applicable to four-wheel road vehicle
3 Rates with SBAS and QZSS enabled for > 98% fix report rate under typical conditions
4 Update rate depends on the GNSS configuration
5 68% at 30 m/s for dynamic operation
6 All satellites at -130 dBm
7 Dependent on the speed and latency of the aiding data connection, commanded starts
8 68% depending on atmospheric conditions, baseline length, GNSS antenna, multipath conditions, satellite visibility and geometry
9 Time to ambiguity fix after 20 s outage
10 Demonstrated with a good external LNA
11 Configured min C/N0 of 6 dBHz, limited by FW with min C/N0 of 20 dBHz for best performance
12 Measured using 1 km baseline and patch antennas with good ground planes. Does not account for possible antenna phase center offset errors.

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-F9K-02A supports the GNSS and their signals as shown in Table 2 .

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)	-
L5 (1176.450 MHz)	-	E5a (1176.450 MHz)	B2a (1176.450 MHz)	SPS-L5 (1176.450 MHz)

Table 2: Supported GNSS signals on ZED-F9K-02A

ZED-F9K-02A can use the u-blox AssistNow™ Online service which provides GNSS assistance information.

ZED-F9K-02A supports the following augmentation systems:

SBAS	QZSS	IMES	Differential GNSS
EGNOS, GAGAN, WAAS, MSAS and BDSBAS	Supported	Not supported	RTCM 3.4, SPARTN 2.0.2

Table 3: Supported augmentation systems of ZED-F9K-02A

☞ The SBAS and QZSS augmentation systems can be enabled only if the GPS operation is also enabled.

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-F9K-02A is able to receive and track QZSS L1 C/A and L2C or L1 C/A and L5 signals concurrently with GPS signals, resulting in better availability especially under challenging signal conditions, e.g. in urban canyons.

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

1.4.2 Satellite-based augmentation system (SBAS)

The ZED-F9K-02A 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 enabled by default in ZED-F9K-02A.

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-F9K-02A 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 4: 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)
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)

Message type-subtype	Description
SM 3-0	Basic-precision atmosphere correction (BPAC)

Table 5: Supported input SPARTN version 2.0.2 messages

1.5 Broadcast navigation data and satellite signal measurements

ZED-F9K-02A 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].

1.6 Supported protocols

ZED-F9K-02A 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 6: 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
Antenna supervisor[13]	Active antenna supervisor to detect short and open status
Assisted GNSS	AssistNow Online supported
Multiple GNSS assistance	MGA service proprietary implementation of an A-GNSS protocol
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
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 7: 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	Authentication of data output based on private/public key pair.

13 External components required

Feature	Description
Secure boot	Only signed FW images executed

Table 8: Security features

1.8 Automotive dead reckoning

u-blox's proprietary automotive dead reckoning (ADR) solution uses a 3D inertial measurement unit (IMU) included within the module, and speed pulses from the vehicle's wheel tick (WT) sensor. Alternatively, the vehicle speed data can be provided as messages via a serial interface. Sensor data and GNSS signals are processed together, achieving 100% coverage, with highly accurate and continuous positioning even in GNSS-hostile environments (for example in urban canyons) or in case of GNSS signal absence (for example in tunnels and parking garages).

WT or speed sensor rate variations and the 3D IMU sensors are calibrated automatically and continuously by the module, accommodating automatically for example to vehicle tire wear.

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

The ZED-F9K-02A combines GNSS and dead reckoning measurements and computes a position solution at rates of up to 4 Hz with the non-priority navigation mode. In the priority navigation mode, the navigation rate can be increased using IMU-only data to deliver accurate, low-latency position measurements at rates up to 50 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.

Dead reckoning allows navigation to commence as soon as power is applied to the module (that is, before a GNSS fix has been established) under the following conditions:

- The vehicle has not been moved while the module has been switched off.
- At least a dead reckoning 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.

☞ The advanced calibration handling feature can be used when no backup supply is available or the save-on-shutdown feature cannot be used. This feature allows the host to poll and later send the sensor initialization and calibration parameters to the receiver.

2 System description

2.1 Block diagram

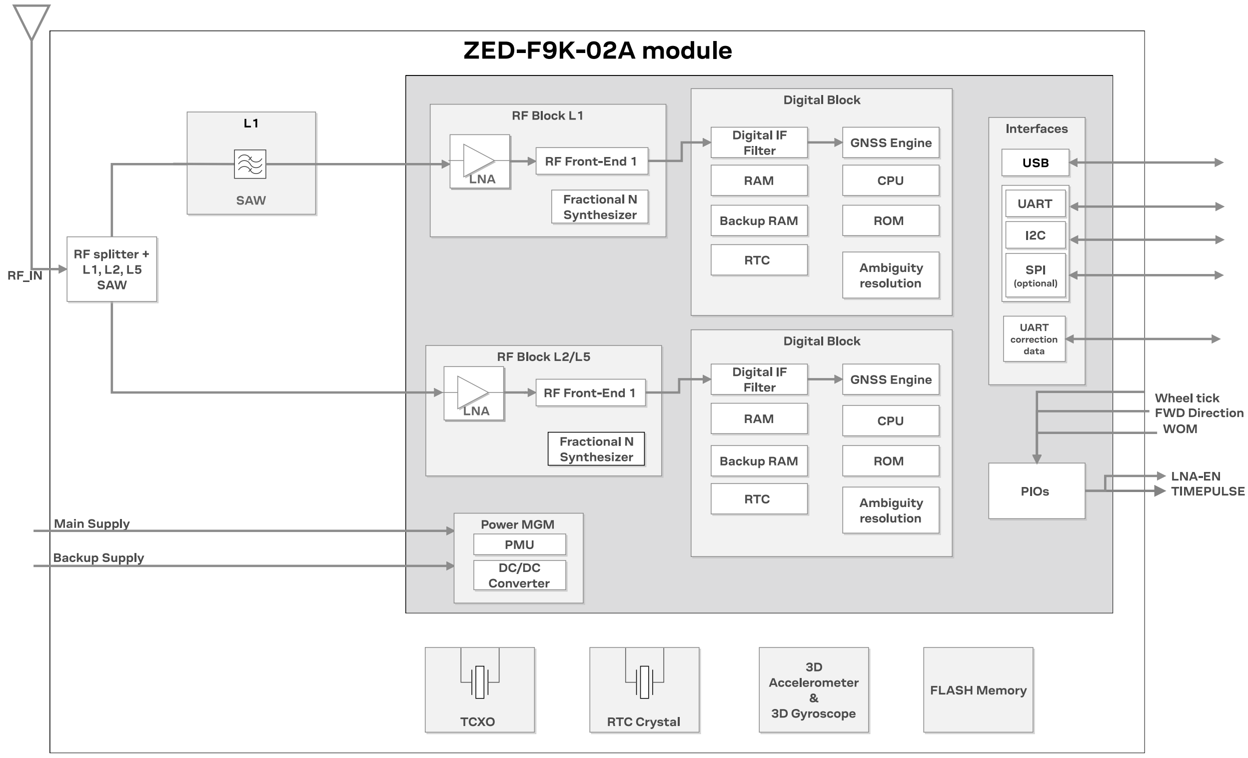

Figure 1: ZED-F9K-02A block diagram

3 Pin definition

3.1 Pin assignment

The pin assignment of the ZED-F9K-02A module is shown in Figure 2. The defined configuration of the PIOs is listed in Table 9.

☞ ZED-F9K-02A is an LGA package with the I/O on the outside edge and central ground pads.

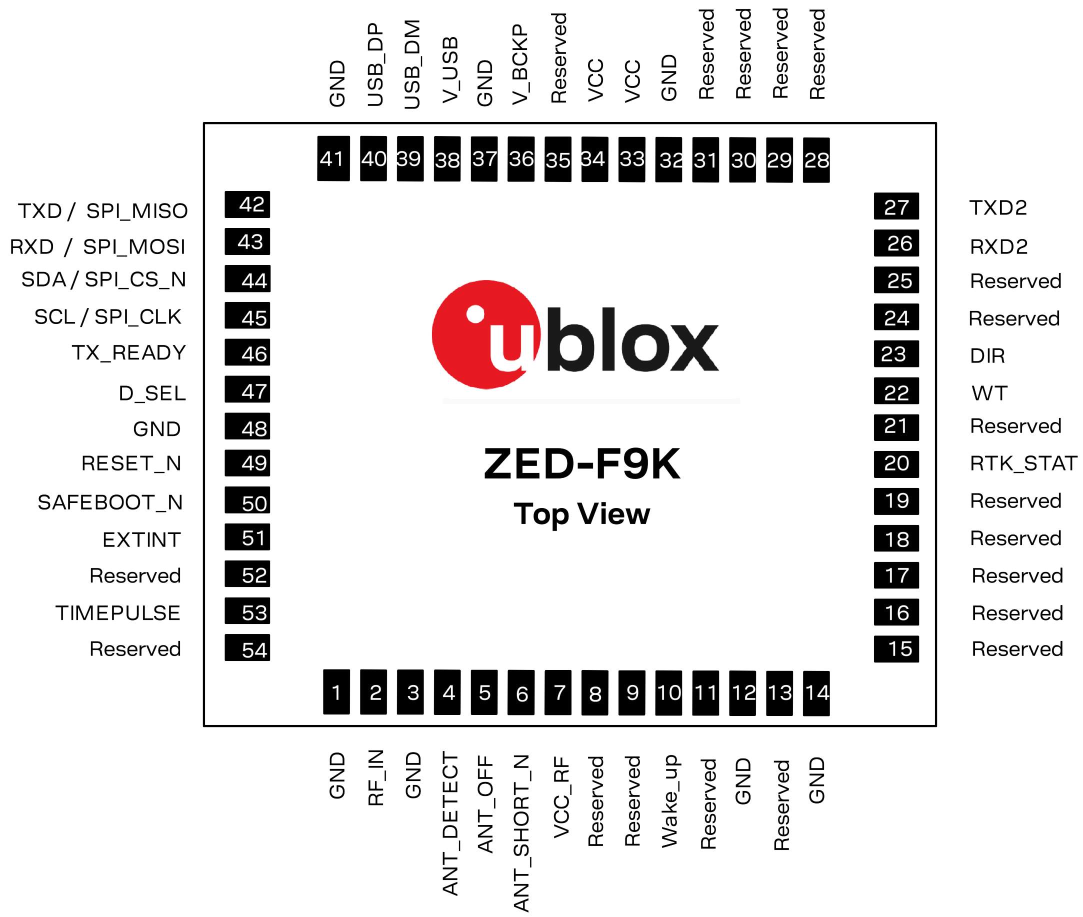

Figure 2: ZED-F9K-02A pin assignment

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

Pin no.	Name	I/O	Description
10	Wake_Up	O	Wake on motion
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	Reserved	-	Reserved
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

Pin no.	Name	I/O	Description
53	TIMEPULSE	O	Time pulse
54	Reserved	-	Reserved

Table 9: ZED-F9K-02A 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[14]			20	8000	µs/V
Backup battery voltage	V_BCKP		–0.5	3.6	V
Voltage ramp on V_BCKP[14]			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	+105	°C

Table 10: 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[15, 16]	I_BCKP		45		µA	V_BCKP = 3 V, VCC = 0 V
SW backup current[16]	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[17]

14 Exceeding the ramp speed may permanently damage the device

15 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.

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

17 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[17]
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[18]	NFtot		9.5		dB	
External gain (at RF_IN)	Ext_gain	17		50	dB	
Operating temperature	Topr	–40	+25	+105	°C	

Table 11: Operating conditions

4.3 Indicative power requirements

Table 12 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 12 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}[19]	VCC current	Acquisition	90	75	mA
I_{VCC}[19]	VCC current	Tracking	85	80	mA

Table 12: Currents to calculate the indicative power requirements

18 Only valid for GPS

19 Simulated GNSS signal

5 Communications interfaces

ZED-F9K-02A has several communications interfaces[20], 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 3.3 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 13: ZED-F9K-02A 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.

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

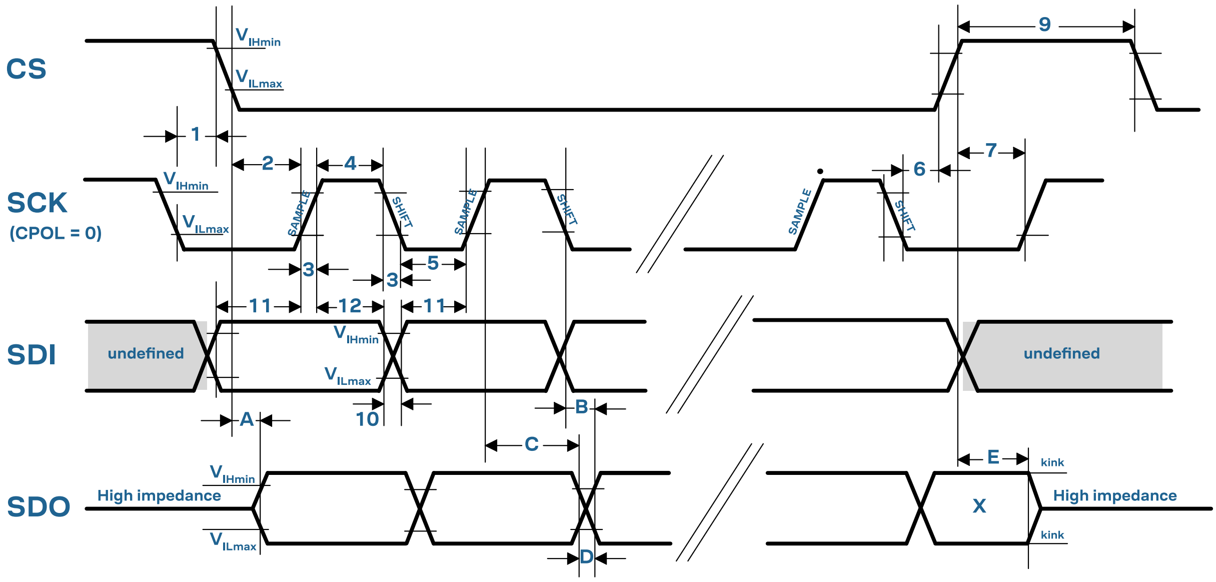

Figure 3: ZED-F9K-02A SPI specification mode 1: CPHA=0 SCK = 5.33 MHz

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 14: 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 15: 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 16: 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 17: 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.

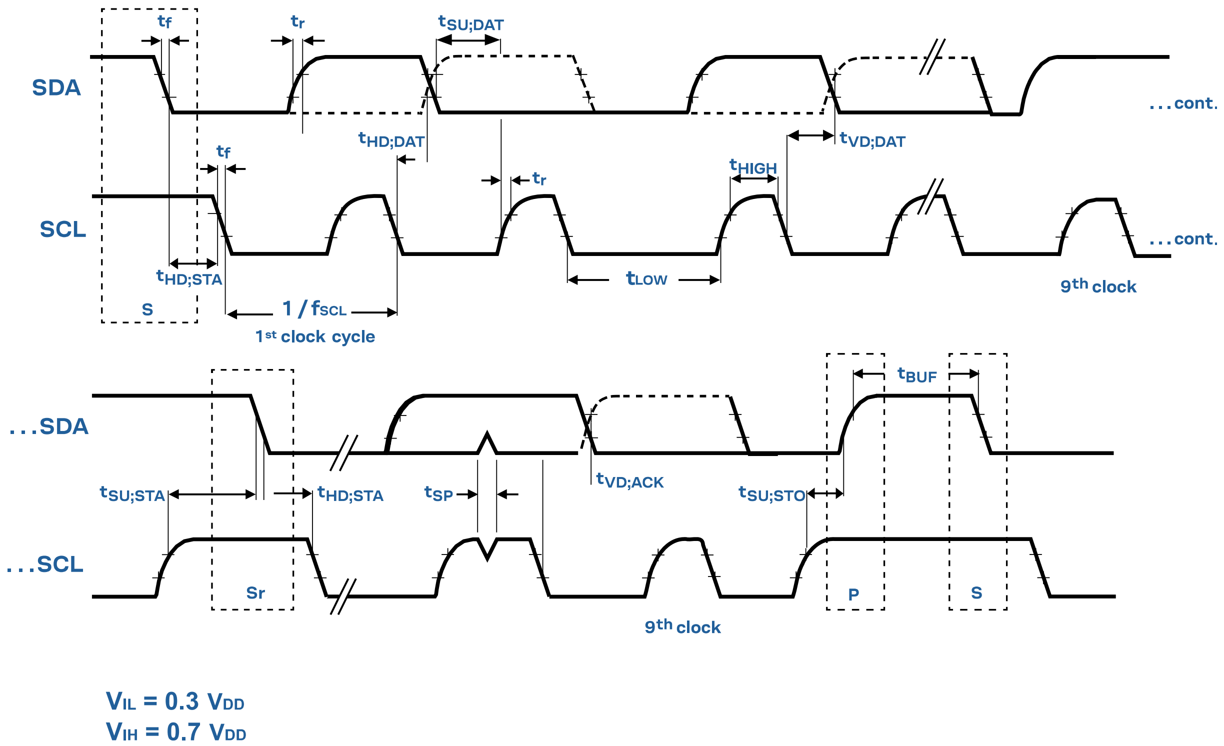

Figure 4: ZED-F9K-02A I2C peripheral specification

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

		I2C Fast-mode		
Symbol	**Parameter**	**Min**	**Max**	**Unit**
$t_{HD;DAT}$	Data hold time	0 [21]	- [22]	µs
$t_{SU;DAT}$	Data setup time	100 [23]		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 [22]	µs
$t_{VD;ACK}$	Data valid acknowledge time	-	0.9 [22]	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 18: ZED-F9K-02A 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-F9K-02A 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].

21 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.

22 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.

23 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 3.3 protocol output is not supported.
UART1 input	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX, NMEA and RTCM 3.3 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 LAP 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 3.3 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 LAP 1.30 onwards. It can be enabled as an input protocol on firmware version LAP1.30. It cannot be enabled as an input protocol on any of the previous firmware versions and will not receive UBX input messages. RTCM 3.3 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 19: Default interface settings

UART2 can be configured as an RTCM interface. RTCM 3.3 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-F9K-02A 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

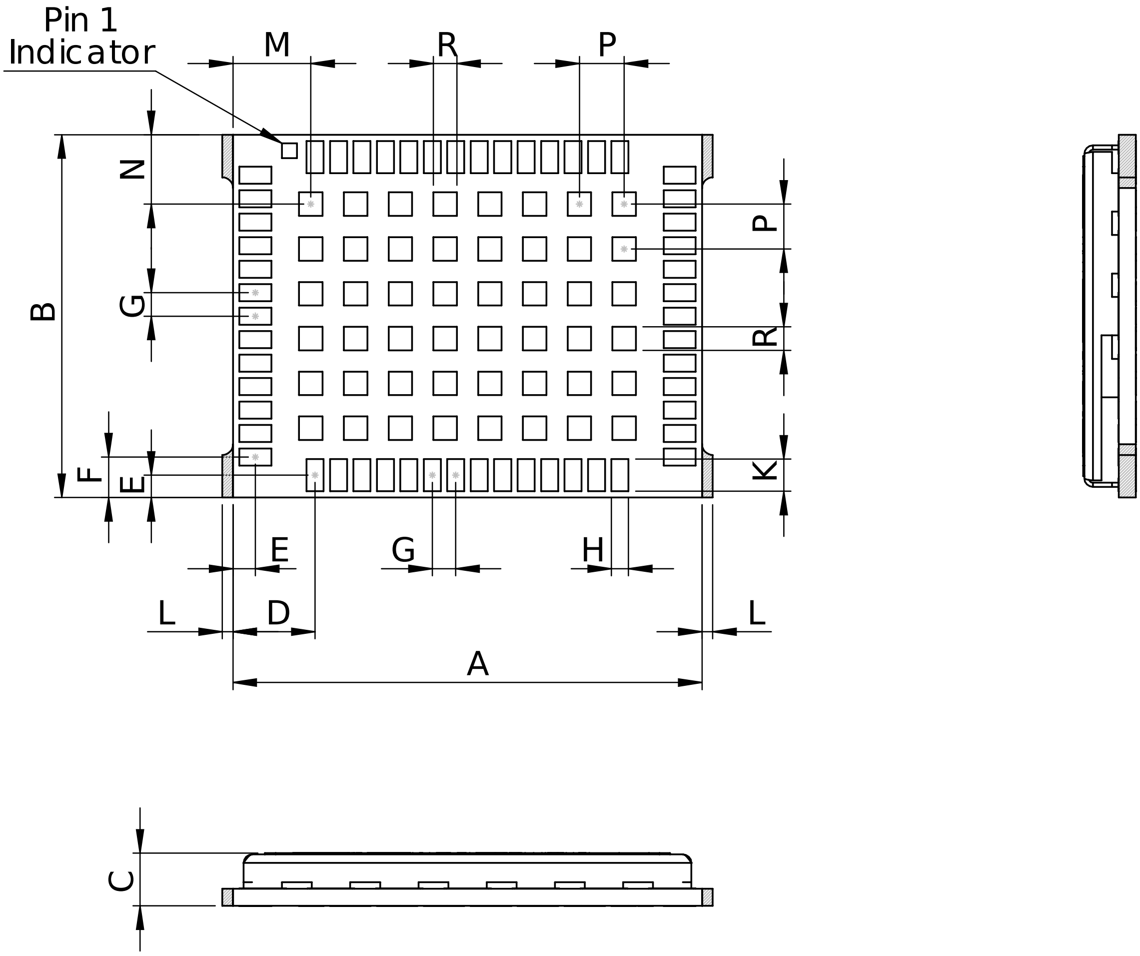

Figure 5: ZED-F9K-02A mechanical drawing

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 20: ZED-F9K-02A 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 AEC-Q104
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) [24] [25]	3
Type approvals	
European RED certification (CE)	Declaration of Conformity (DoC) is available on the u-blox website.
UK conformity assessment (UKCA)	Yes

Table 21: Qualifications and approvals

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

25 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-F9K-02A and its revision, as in Figure 6. For a description of the product marking, see Table 22.

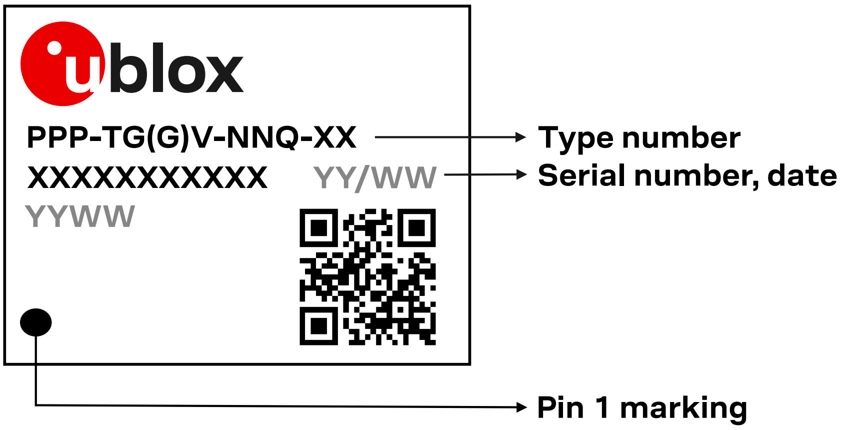

Figure 6: Example of ZED-F9K-02A product marking

Code	Meaning	Example
PPP	Form factor	ZED
TG(G)	Platform	F9 = u-blox F9
V	Variant	K = High precision + ADR
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
XXXXXXXXXXX	Serial number	Alphanumeric characters, e.g. BN600001181
Other information	QR code	For internal/technical use.

Table 22: Description of product marking

8.2 Product identifiers

The ZED-F9K-02A 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 23 describes the three different product identifiers used in the ZED-F9K-02A label

Identifier	Format	Example
Product name	PPP-TG(G)V	ZED-F9K
Ordering code	PPP-TG(G)V-NNQ	ZED-F9K-02A
Type number	PPP-TG(G)V-NNQ-XX	ZED-F9K-02A-00

Table 23: Product identifiers

8.3 Ordering codes

Ordering code	Product	Remark
ZED-F9K-02A	u-blox ZED-F9K, automotive grade	Product shipped with firmware FW 1.00 LAP 1.50

Table 24: 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-F9K Integration manual, UBXDOC-963802114-10912

[2] LAP 1.50 Interface description, UBXDOC-963802114-13052

[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-F9K-02A with LAP 1.50
R02	04-Apr-2025	Initial production of ZED-F9K-02A with LAP 1.50 Added section: Default interface settings

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