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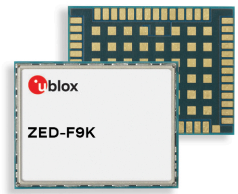
ZED-F9K-00B

High precision automotive DR GNSS receiver

Professional 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 30 Hz real-time position update rate.

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Product name	Type number	Firmware version	PCN reference	Product status
ZED-F9K	ZED-F9K-00B-02	LAP 1.20	-	Advance information

Contents

1 Functional description

1.1 Overview

The ZED-F9K-00B module features the u-blox F9 multi-band L1/L2 GNSS receiver with rapid convergence time within seconds. This mass-market component provides decimeter-level positioning with high availability, while making use of all four GNSS constellations simultaneously.

It is the first dead reckoning 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 vehicle dynamics model to provide lane-accurate positioning where GNSS alone would fail. The module operates under open-sky motorways, in the wooded countryside, in difficult urban environments, and even in tunnels and underground parking. In modern automotive applications, such as advanced driver assistance system (ADAS) where availability can improve the safety of our roads, ZED-F9K-00B 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-F9K-00B is ideal for innovative automotive architecture designs with limited space and power. The module provides accurate location services to the increasing number of intelligent electronic control units (ECU) such as telematics control unit, navigation system, infotainment and V2X safety systems.

In priority navigation mode the module reaches a navigation rate of up to 30 Hz. The on-board processor augments fused GNSS position with additional IMU-based position estimates. Drivers experience responsive, lag-free user interfaces. ZED-F9K-00B can output raw IMU and raw GNSS data for advanced applications.

ZED-F9K-00B modules are manufactured in ISO/TS 16949 certified sites and are fully tested on a system level. Qualification tests are performed as stipulated in the ISO 16750 standard: “Road vehicles–Environmental conditions and testing for electrical and electronic equipment”.

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)
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	2%

1 Assuming airborne 4 g platform, not supported by ADR

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] [4]	Priority navigation mode	30 Hz
	Non-priority navigation mode	2 Hz
Velocity accuracy[5]		0.05 m/s
Dynamic attitude accuracy[5]	Heading	0.2 deg
	Pitch	0.3 deg
	Roll	0.5 deg
Navigation latency[5]	Priority navigation mode	15 ms
Max sensor measurement output rate		100 Hz

GNSS		GPS+GLO+GAL +BDS	GPS+GLO+GAL	GPS+GAL	GPS+BDS	BDS
Acquisition[6]	Cold start	26 s	25 s	30 s	25 s	28 s
	Hot start	2 s	2 s	2 s	2 s	2 s
	Aided starts[7]	3 s	3 s	3 s	3 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.	-160 dBm	-160 dBm	-160 dBm	-160 dBm	-160 dBm
	Reacquisition	-157 dBm	-157 dBm	-157 dBm	-157 dBm	-157 dBm
	Cold start	-147 dBm	-147 dBm	-147 dBm	-147 dBm	-145 dBm
	Hot start	-158 dBm	-158 dBm	-158 dBm	-158 dBm	-158 dBm
Position accuracy RTK[8] [12]	Along track	0.20 m	0.20 m	0.25 m	0.25 m	0.60 m
	Cross track	0.20 m	0.20 m	0.25 m	0.25 m	0.60 m
	2D CEP	0.30 m	0.30 m	0.40 m	0.40 m	0.85 m
	Vertical	0.30 m	0.30 m	0.40 m	0.40 m	1.00 m

Table 1: ZED-F9K-00B performance in different GNSS modes

GNSS		GPS	GLONASS	BEIDOU	GALILEO
Acquisition[6]	Cold start	30 s	28 s	40 s	-
	Hot start	2 s	2 s	2 s	-
	Aided start[7]	3 s	3 s	3 s	-
Sensitivity[10] [11]	Tracking and nav.	-158 dBm	-158 dBm	-158 dBm	-156 dBm
	Reacquisition	-157 dBm	-155 dBm	-157 dBm	-153 dBm
	Cold start	-147 dBm	-147 dBm	-141 dBm	-137 dBm
	Hot start	-158 dBm	-157 dBm	-158 dBm	-155 dBm

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 dB/Hz, limited by FW with min C/N0 of 20 dB/Hz 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.

GNSS		GPS	GLONASS	BEIDOU	GALILEO
Position accuracy RTK[12]	2D CEP	0.80 m	1.00 m	-	1.50 m
	Vertical	1.00 m	1.50 m	-	2.00 m

Table 2: ZED-F9K-00B performance in single-GNSS modes

1.3 Supported GNSS constellations

The ZED-F9K-00B 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.

The ZED-F9K-00B supports the GNSS and their signals as shown in Table 3.

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 3: Supported GNSS signals on ZED-F9K-00B

The ZED-F9K-00B can use the u-blox AssistNow™ Online service which provides GNSS assistance information.

ZED-F9K-00B supports the following augmentation systems:

SBAS	QZSS	IMES	Differential GNSS
EGNOS, GAGAN, WAAS and MSAS supported	Supported	Not supported	RTCM 3.3

Table 4: Supported augmentation systems of ZED-F9K-00B

☞ The augmentation systems SBAS and QZSS can be enabled only if 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. The ZED-F9K-00B 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-F9K-00B 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-F9K-00B 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-00B.

1.4.3 Differential GNSS (DGNSS)

When operating in RTK mode, RTCM version 3.3 messages are required and the module supports DGNSS according to RTCM 10403.3. ZED-F9K-00B 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
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 3.3 messages

1.5 Broadcast navigation data and satellite signal measurements

The ZED-F9K-00B can output all the GNSS broadcast data upon reception from tracked satellites. This includes all the supported GNSS signals as well as the QZSS augmentation service. 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) [3].

1.5.1 Carrier-phase measurements

The ZED-F9K-00B 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.

☞ Only available with an optional license for an additional cost.

1.6 Supported protocols

The ZED-F9K-00B 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, binary

Table 6: Supported protocols

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

1.7 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, urban canyons) or in case of GNSS signal absence (for example, 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 to, for example, vehicle tire wear.

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

The ZED-F9K-00B combines GNSS and dead reckoning measurements and computes a position solution at rates of up to 5 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 ZED-F9K-00B will work optimally in priority navigation mode when the IMU and WT sensors are 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 information necessary will be saved to the flash and read from the flash upon restart.

2 System description

2.1 Block diagram

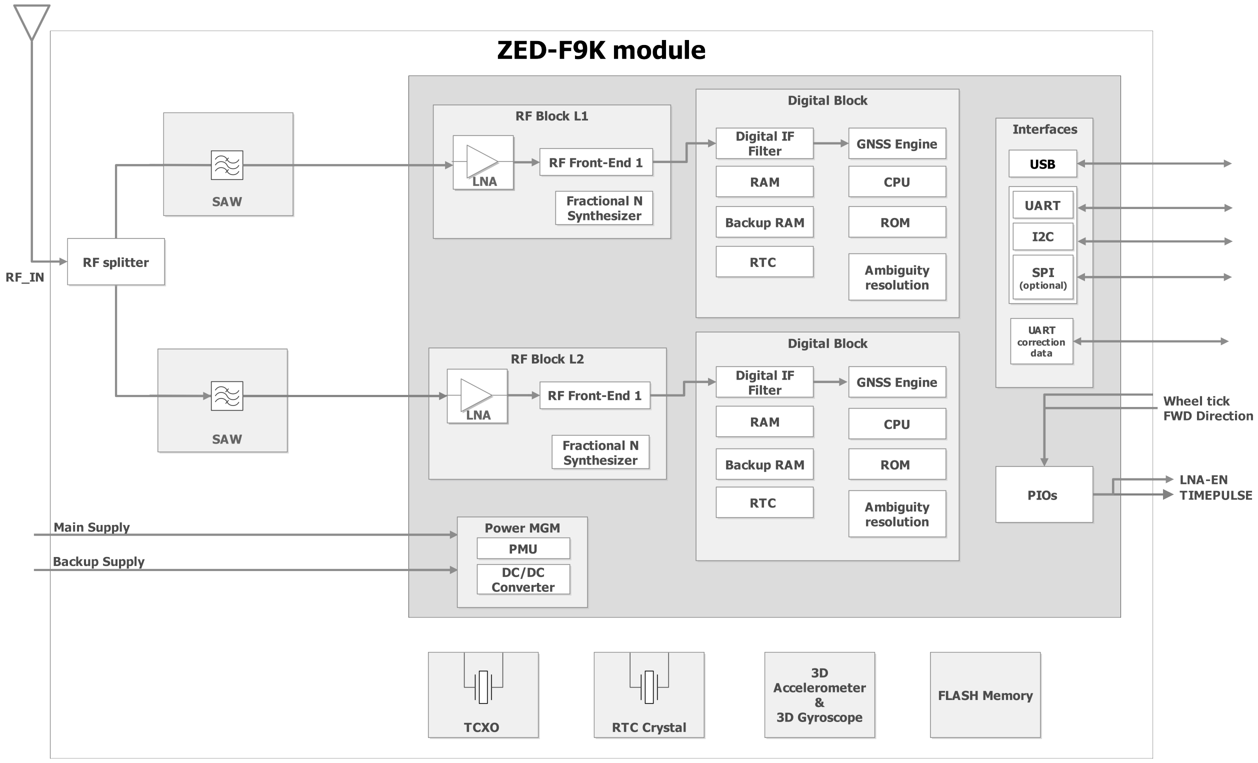


Figure 1: ZED-F9K-00B block diagram

3 Pin definition

3.1 Pin assignment

The pin assignment of the ZED-F9K-00B module is shown in Figure 2. The defined configuration of the PIOs is listed in Table 7.

☞ The ZED-F9K-00B is an LGA package with the I/O on the outside edge and central ground pads.

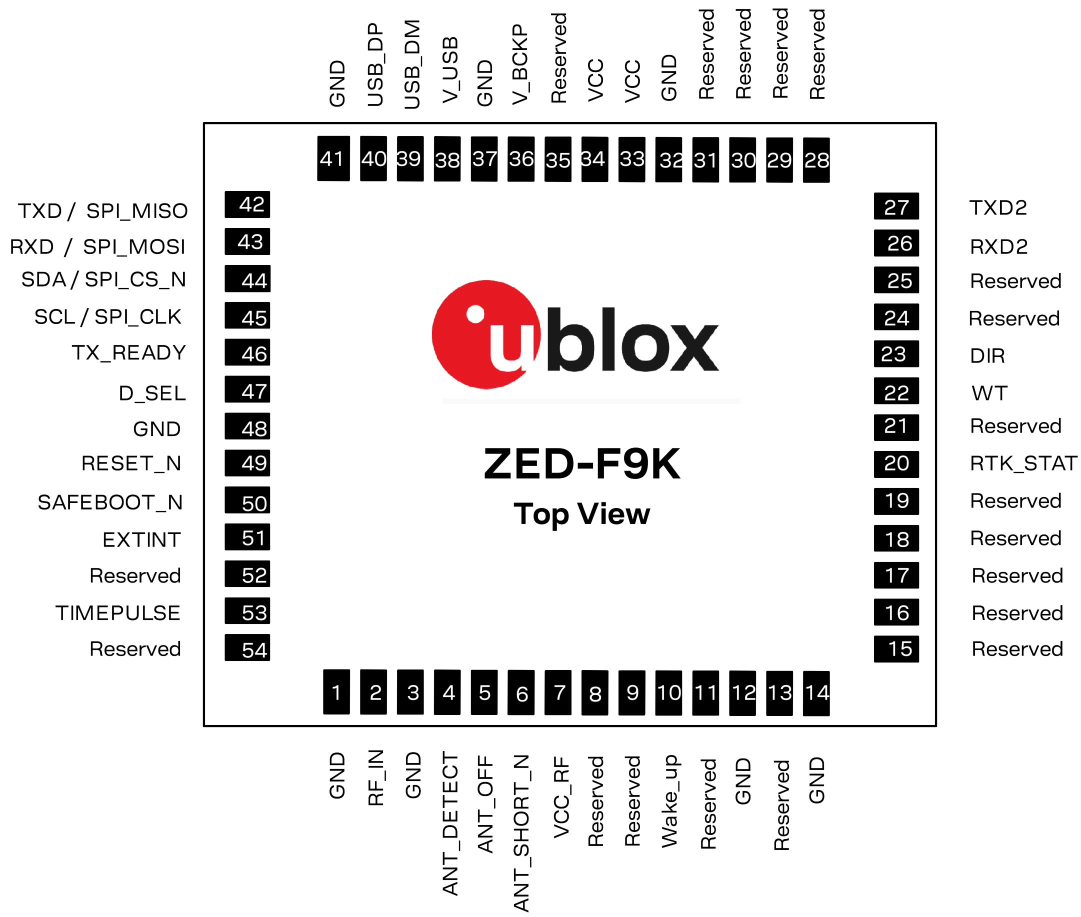


Figure 2: ZED-F9K-00B pin assignment

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	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 – 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_MISO	O	Serial port if D_SEL =1(or open). SPI MISO if D_SEL = 0
43	RXD / SPI_MOSI	I	Serial port if D_SEL =1(or open). SPI MOSI 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 7: ZED-F9K-00B pin assignment

4 Electrical specification

⚠ **CAUTION** Operating the device above one or more of the limiting values may cause permanent damage to the device. The values provided in this chapter are stress ratings. Extended exposure to the values outside the limits may effect the device reliability.

☞ Where application information is given, it is advisory only and does not form part of the specification.

4.1 Absolute maximum ratings

Parameter	Symbol	Condition	Min	Max	Units
Power supply voltage	VCC		-0.5	3.6	V
Voltage ramp on VCC[13]			20	8000	µs/V
Backup battery voltage	V_BCKP		-0.5	3.6	V
Voltage ramp on V_BCKP[13]			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 8: Absolute maximum ratings

⚠ **CAUTION** Risk of equipment damage. This product is not protected against overvoltage or reversed voltages. Use appropriate protection diodes to avoid voltage spikes exceeding the specified boundaries damaging the equipment.

4.2 Operating conditions

☞ The values for the following operating conditions have been specified at 25°C ambient temperature. 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[14]	I_BCKP		45		µA	V_BCKP = 3 V, VCC = 0 V
SW backup current	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	

13 Exceeding the ramp speed may permanently damage the device

14 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.

Parameter	Symbol	Min	Typical	Max	Units	Condition
Digital IO pin low level output voltage	Vol			0.4	V	Iol = 2 mA[15]
Digital IO pin high level output voltage	Voh	VCC – 0.4			V	Ioh = 2 mA[15]
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[16]	NFtot		9.5		dB	
External gain (at RF_IN)	Ext_gain	17		50	dB	
Operating temperature	Topr	-40	+25	+85	°C	

Table 9: Operating conditions

☞ Operation beyond the specified operating conditions can affect the device reliability.

4.3 Indicative power requirements

Table 10 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.

☞ 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}[17]	VCC current	Acquisition	90	75	mA
I_{VCC}[17]	VCC current	Tracking	85	68	mA

Table 10: Currents to calculate the indicative power requirements

All values in Table 10 are measured at 25 °C ambient temperature.

15 TIMEPULSE has 4 mA current drive/sink capability

16 Only valid for GPS

17 Simulated GNSS signal

5 Communications interfaces

The ZED-F9K-00B has several communications interfaces, 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.

UART1 is the primary host communications interface while UART2 is dedicated for RTCM 3.3 corrections and NMEA. No UBX protocol is supported on UART 2.

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 11: ZED-F9K-00B 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 slave 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 slave operation are defined in Figure 3. Default SPI configuration is CPOL = 0 and CPHA = 0.

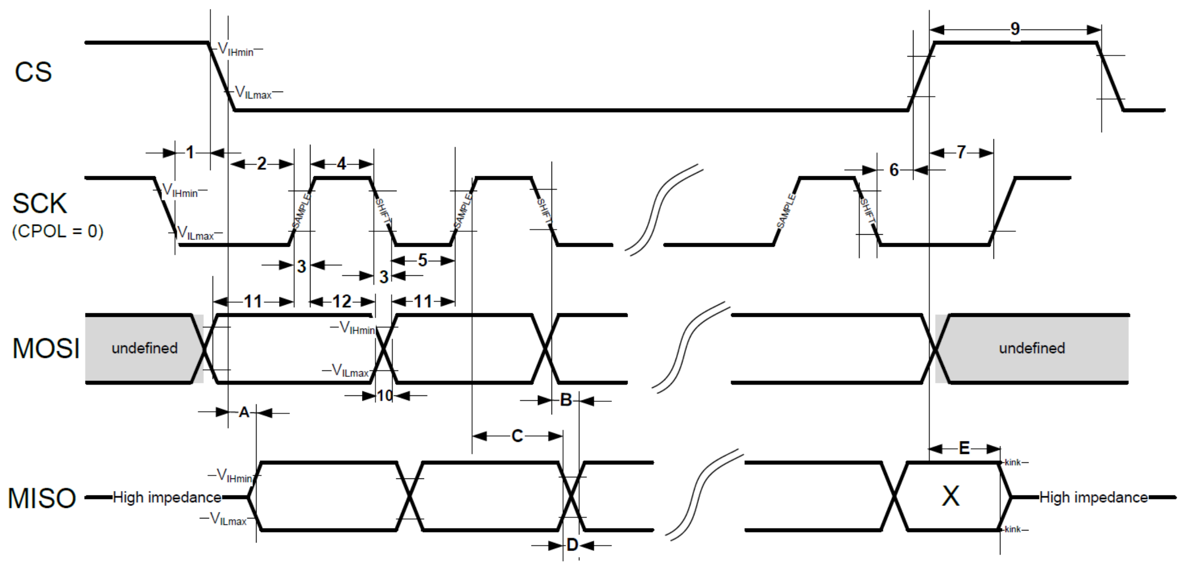


Figure 3: ZED-F9K-00B SPI specification mode 1: CPHA=0 SCK = 5.33 MHz

Symbol	Parameter	Min	Max	Unit
1	CS deassertion hold time	23	-	ns
2	Slave 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	Slave deselect time (SCK falling to CS)	30	-	ns
7	Slave deselect time (CS to SCK)	30	-	ns
9	CS high time	32	-	ns
10	MOSI transition time	-	7	ns
11	MOSI setup time	16	-	ns
12	MOSI hold time	24	-	ns

Table 12: SPI slave input timing parameters 1 - 12

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

Table 13: SPI slave timing parameters A - E, 2 pF load capacitance

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

Table 14: SPI slave timing parameters A - E, 20 pF load capacitance

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

Table 15: SPI slave 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 slave 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.

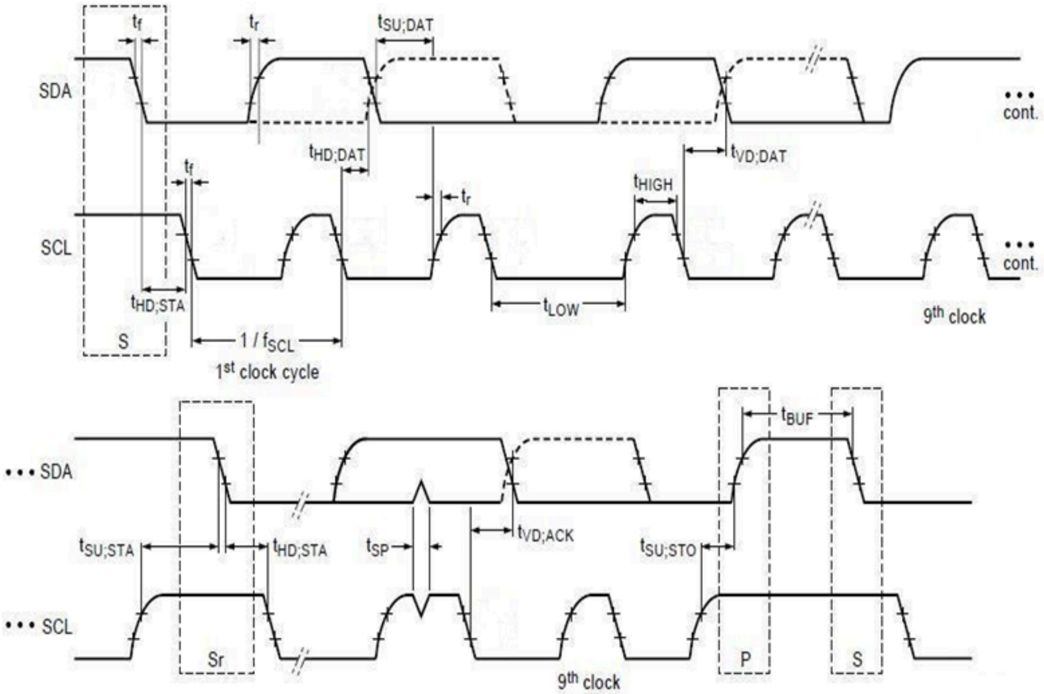


Figure 4: ZED-F9K-00B I2C slave specification

Symbol	Parameter	I2C Fast-mode Min	I2C Fast-mode 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
$t_{HD;DAT}$	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 16: ZED-F9K-00B I2C slave 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 Vih 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 (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.

20 When the I2C slave 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 WT (wheel tick) and DIR (forward/reverse indication)

ZED-F9K-00B 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].

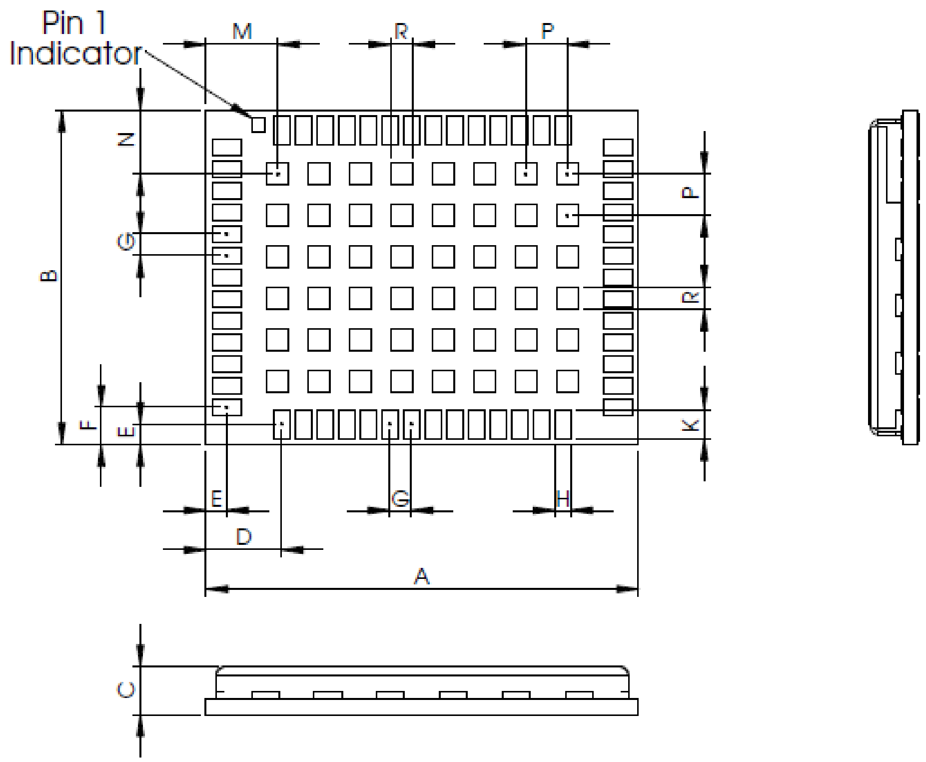
5.6 Default interface settings

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.
UART2 output	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX protocol cannot be enabled. 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 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 or u-blox cellular modules in slave 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 slave 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 17: Default interface settings

☞ By default, the ZED-F9K-00B 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



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
A	21.80	22.00	22.35
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
R	0.88	1.10	1.32
Weight		1.85g	

Figure 5: ZED-F9K-00B mechanical drawing

7 Reliability tests and approvals

ZED-F9K-00B modules are based on AEC-Q100 qualified GNSS chips.

Tests for product family qualifications comply with ISO 16750 "Road vehicles – environmental conditions and testing for electrical and electronic equipment", and appropriate standards.

7.1 Approvals

ZED-F9K-00B complies with the essential requirements and other relevant provisions of the Radio Equipment Directive (RED) 2014/53/EU.

ZED-F9K-00B complies with the Directive 2011/65/EU (EU RoHS 2) and its amendment Directive (EU) 2015/863 (EU RoHS 3).

The Declaration of Conformity (DoC) is available on the u-blox website.

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-F9K-00B 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-F9K-00B 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 18 below details these three formats.

Format	Structure	Product code
Product name	PPP-TGV	ZED-F9K
Ordering code	PPP-TGV-NNQ	ZED-F9K-00B
Type number	PPP-TGV-NNQ-XX	ZED-F9K-00B-02

Table 18: Product code formats

The parts of the product code are explained in Table 19.

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

Table 19: Part identification code

8.3 Ordering codes

Ordering code	Product	Remark
ZED-F9K-00B	u-blox ZED-F9K	

Table 20: 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-F9K Integration manual, UBX-20046189
[2] LAP 1.20 Interface description, UBX-20046191
[3] 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	Name	Status / comments
R01	19-Feb-2019	ssid	Objective specification
R02	24-Sep-2019	ssid	Advance information Priority/non-priority navigation mode
R03	15-Jan-2020	ssid	Early production information - optional license information for carrier-phase measurements, aided starts performance numbers revised
R04	10-Sep-2020	ssid	Advance information - LAP 1.20 update - ZED-F9K-00B-01 update - Added ZED-F9K performance in different single GNSS modes - Performance in different GNSS modes revised - SBAS support added - Communication interfaces section updated - Re-convergence time performance numbers revised
R05	06-Nov-2020	ssid	Early production information - ZED-F9K-00B-01 - Public
R06	24-Aug-2021	ssid	Advance information - ZED-F9K-00B-02
R07	23-Mar-2023	ssid	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 details in table Operating conditions

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