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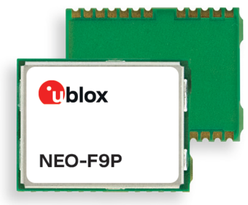
NEO-F9P-15B

High precision GNSS module

Professional grade

Data sheet



Abstract

This data sheet describes the NEO-F9P high precision module with multi-band GNSS receiver. The module provides multi-band RTK with fast convergence times, reliable performance and easy integration of RTK for fast time-to-market. It has a high update rate for highly dynamic applications and centimeter-level accuracy in a small and energy-efficient module.

Note! GPS L5 signals are pre-operational and not used by default. Refer to the Overview section for more information.

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This document applies to the following products:

Product name	Type number	FW version	IN/PCN reference	Product status
NEO-F9P	NEO-F9P-15B-00	HPG L1L5 1.40	UBXDOC-963802114-12773	Mass production

Contents

1 Functional description

1.1 Overview

The NEO-F9P-15B positioning module features the u-blox F9 receiver platform, which provides multi-band GNSS to high-volume industrial applications. NEO-F9P-15B has integrated u-blox multi-band RTK and PPP-RTK[1] technologies for centimeter-level accuracy. The module enables precise navigation and automation of moving machinery in industrial and consumer-grade products in a compact surface-mounted form factor of only 16.0 x 12.2 x 3.4 mm.

In this document, RTK refers to an OSR-based solution (using RTCM corrections), while PPP-RTK refers to an SSR-based solution (using SPARTN or CLAS corrections).

⚠ 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.

⚠ It is the responsibility of the designer to decide whether the application may use the GPS L5 signals and make the tradeoff between performance and application suitability. Alternatively, the designer may assess the performance in the future when the L5 signals are deemed healthy. Both of these goals can be achieved by configuring the receiver to apply the health status of L1 signals to L5 signals. For details on u-blox GPS L5 configuration, see the Application note [5] for u-blox GPS L5 configuration.

1.2 Performance

Parameter	Specification	
Receiver type	Multi-band GNSS high precision 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[2]	Dynamics Altitude Velocity	≤ 4 g 80,000 m 500 m/s
Velocity accuracy[3]		0.05 m/s
Dynamic heading accuracy[3]		0.3 deg

Table 1: NEO-F9P-15B specifications

GNSS[4]		GPS+GLO+GAL+BDS	GPS+BDS+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Acquisition[5]	Cold start	27 s	28 s	29 s	30 s	27 s	37 s
	Hot start	3 s	3 s	3 s	3 s	3 s	3 s
	Aided start[6]	4 s	4 s	4 s	4 s	4 s	5 s

1 PPP-RTK position accuracy depends on the quality of the SSR service used, high-quality SSR services can perform similarly to RTK
2 Assuming Airborne 4 g platform
3 50% at 30 m/s for dynamic operation
4 GPS used in combination with QZSS and SBAS
5 Commanded starts. All satellites at -130 dBm. Measured at room temperature.
6 Dependent on the speed and latency of the aiding data connection, commanded starts

GNSS[4]		GPS+GLO+GAL+BDS	GPS+BDS+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Max navigation update rate[7]	RTK	7 Hz	8 Hz	14 Hz	15 Hz	10 Hz	25 Hz
	PVT	7 Hz	8 Hz	14 Hz	20 Hz	11 Hz	25 Hz
	RAW	10 Hz	10 Hz	20 Hz	25 Hz	20 Hz	25 Hz
Convergence time[8]	RTK	< 12 s	< 12 s	< 12 s	< 12 s	< 12 s	< 30 s

Table 2: NEO-F9P-15B performance in different GNSS modes

GNSS		GPS+GLO+GAL+BDS	GPS+BDS+GAL	GPS+GAL	GPS+GLO	GPS+BDS	GPS
Horizontal position accuracy (CEP)	PVT[9]	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m
	SBAS[9]	1.0 m	1.0 m	1.0 m	1.0 m	1.0 m	1.0 m
	RTK[10]	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)	PVT[9]	2.0 m	2.0 m	2.0 m	2.0 m	2.0 m	2.0 m
	SBAS[9]	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m
	RTK[10]	0.01 m + 1 ppm	0.01 m + 1 ppm	0.01 m + 1 ppm	0.01 m + 1 ppm	0.01 m + 1 ppm	0.01 m + 1 ppm

Table 3: NEO-F9P-15B position accuracy in different GNSS modes

GNSS[4]		GPS+GLO+GAL+BDS	GPS+BDS+GAL
Horizontal position accuracy (CEP)	SPARTN	< 0.10 m	< 0.10 m
	CLAS	0.04 m	0.04 m
Vertical position accuracy (Median)	SPARTN	< 0.20 m	< 0.20 m
	CLAS	0.08 m	0.08 m
Convergence time[8]	SPARTN[11]	< 65 s	< 65 s
	CLAS	< 90 s	< 90 s

Table 4: NEO-F9P-15B performance for PPP-RTK in different GNSS modes

GNSS[4]		GPS+GLO+GAL+BDS
Sensitivity[12]	Tracking and nav.	-167 dBm
	Reacquisition	-160 dBm
	Cold start	-148 dBm
	Hot start	-157 dBm

Table 5: NEO-F9P-15B sensitivity

☞ Performance values include the use of GPS L5 signals. Refer to the Application Note UBX-21038688 for u-blox GPS L5 configuration details.

4 GPS used in combination with QZSS and SBAS
7 Measured with primary output only, secondary output disabled (default)
8 Depends on atmospheric conditions, baseline length, GNSS antenna, multipath conditions, satellite visibility and geometry
9 24 hours static
10 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.
11 Measured for IP data stream only with low-latency communication link
12 Demonstrated with a good external LNA. Measured at room temperature.

1.3 Supported GNSS constellations

The NEO-F9P-15B GNSS modules are concurrent GNSS receivers that can receive and track multiple GNSS constellations. Owing to the multi-band RF front-end architecture, all four major GNSS constellations (GPS, GLONASS, Galileo and BeiDou) plus SBAS and QZSS satellites can be received concurrently. All satellites in view can be processed to provide an RTK navigation solution when used with correction data. If power consumption is a key factor, the receiver can be configured for a subset of GNSS constellations.

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

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

NEO-F9P-15B supports the GNSS and their signals as shown in Table 6.

GPS / QZSS	GLONASS	Galileo	BeiDou	NavIC
L1C/A (1575.420 MHz)	L1OF (1602 MHz + k*562.5 kHz, k = –7,..,6)	E1-B/C (1575.420 MHz)	B1I (1561.098 MHz)	-
L5 (1176.450 MHz)	-	E5a (1176.450 MHz)	B2a (1176.450 MHz)	SPS-L5 (1176.450 MHz)

Table 6: Supported GNSS signals on NEO-F9P-15B

NEO-F9P-15B 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. NEO-F9P-15B is able to receive and track QZSS L1 C/A and L5 signals concurrently with GPS signals, resulting in better availability especially under challenging signal conditions, e.g. in urban canyons.

NEO-F9P-15B 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)

NEO-F9P-15B supports SBAS (including WAAS in the US, EGNOS in Europe, L1Sb(QZSS SBAS) in Japan and GAGAN in India) to deliver improved location accuracy within the regions covered. However, the additional inter-standard time calibration step used during SBAS reception results in degraded time accuracy overall.

1.4.3 Differential GNSS (DGNSS)

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

Operating as a rover, NEO-F9P-15B can decode the following RTCM 3.3 messages:

Message type	Description
RTCM 1005	Stationary RTK reference station ARP
RTCM 1006	Stationary RTK reference station ARP with antenna height
RTCM 1007	Antenna descriptor
RTCM 1033	Receiver and antenna description
RTCM 1074	GPS MSM4
RTCM 1075	GPS MSM5
RTCM 1077	GPS MSM7
RTCM 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 7: Supported input RTCM 3.3 messages

Operating as a base station, NEO-F9P-15B can generate the following RTCM 3.3 output messages:

Message type	Description
RTCM 1005	Stationary RTK reference station ARP
RTCM 1074	GPS MSM4
RTCM 1077	GPS MSM7
RTCM 1084	GLONASS MSM4
RTCM 1087	GLONASS MSM7
RTCM 1094	Galileo MSM4
RTCM 1097	Galileo MSM7
RTCM 1124	BeiDou MSM4
RTCM 1127	BeiDou MSM7
RTCM 1230	GLONASS code-phase biases

Table 8: Supported output RTCM 3.3 messages

Operating as a rover, NEO-F9P-15B can decode the following SPARTN 2.0.1 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 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)

Message type-subtype	Description
SM 2-0	Geographic area definition (GAD)

Table 9: Supported input SPARTN version 2.0.1 messages

1.4.4 Centimeter level augmentation service (CLAS)

Operating as a rover, NEO-F9P-15B 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

The NEO-F9P-15B 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] for the UBX-RXM-SFRBX message specification. The receiver can provide satellite signal information in a form compatible with the Radio Resource LCS Protocol (RRLP) [4].

1.5.1 Carrier-phase measurements

The NEO-F9P-15B 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

NEO-F9P-15B 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 3.3	Input/output, binary
SPARTN 2.0.1	Input, binary

Table 10: Supported protocols

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

2 System description

2.1 Block diagram

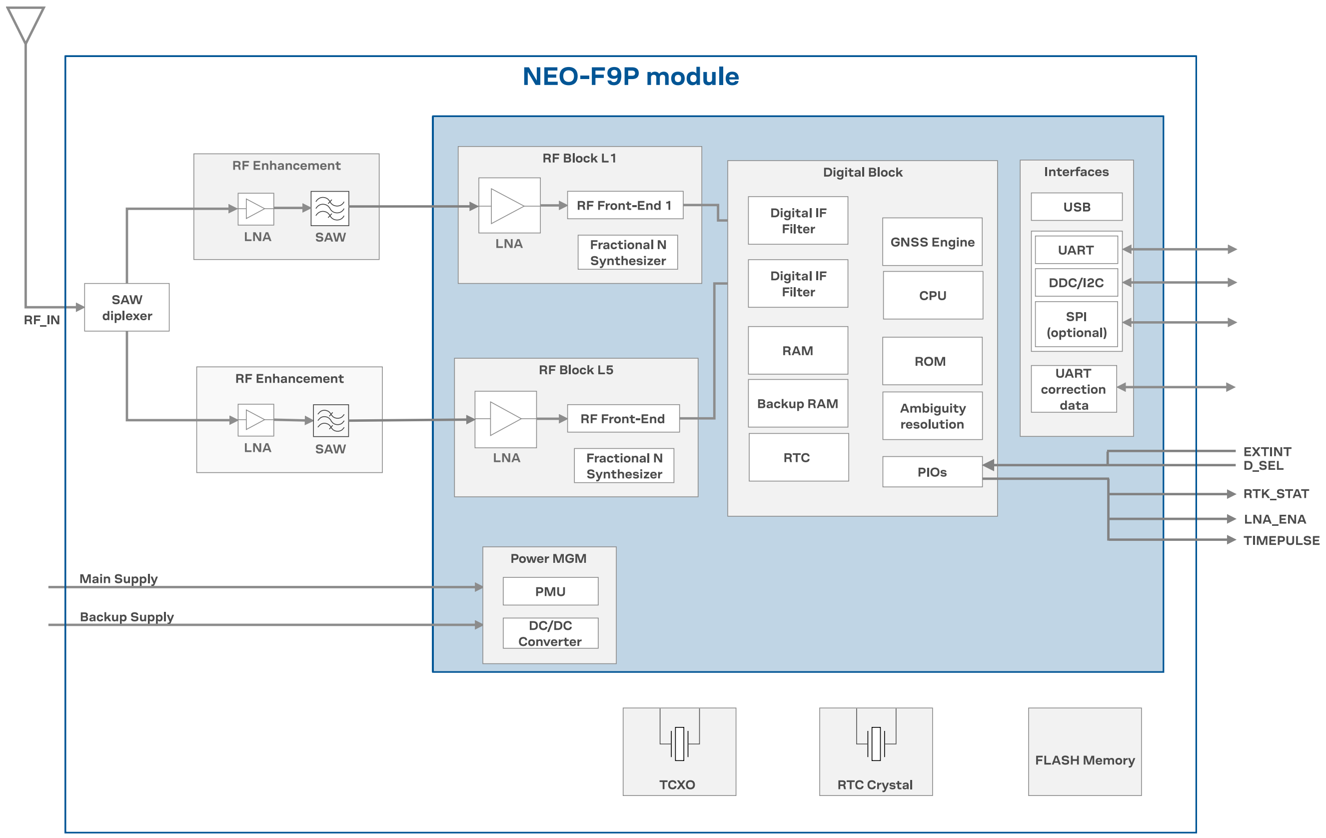

Figure 1: NEO-F9P-15B block diagram

3 Pin definition

3.1 Pin assignment

The pin assignment of the NEO-F9P-15B module is shown in Figure 2. The defined configuration of the PIOs is listed in Table 11.

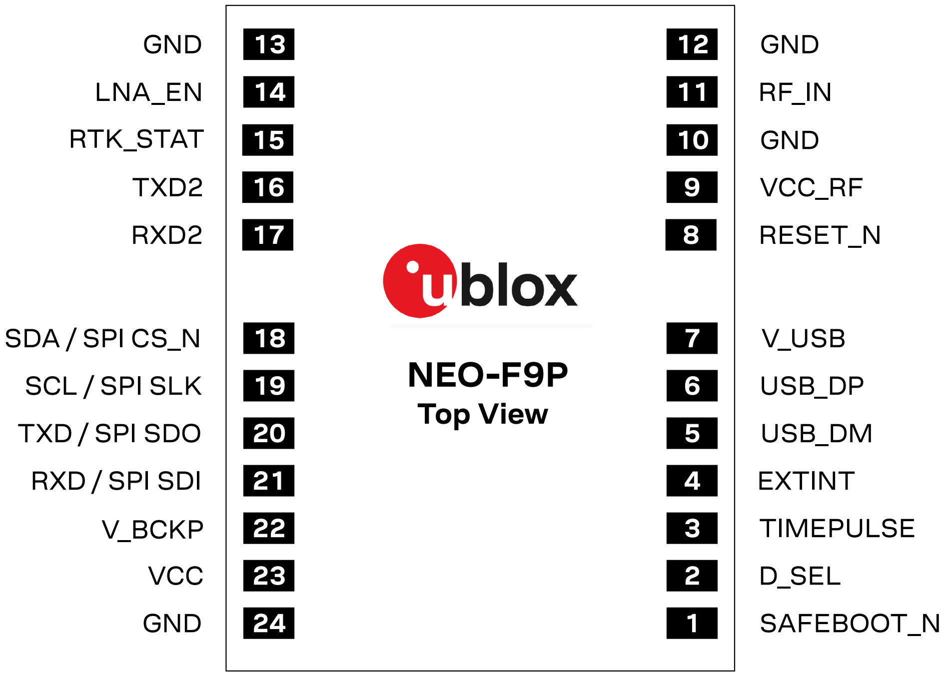

Figure 2: NEO-F9P-15B pin assignment

Pin no.	Name	I/O	Description
1	SAFEBOOT_N	I	SAFEBOOT_N (used for FW updates and reconfiguration, leave open)
2	D_SEL	I	Interface select (open or VCC = UART + I2C; GND = SPI)
3	TIMEPULSE	O	TIMEPULSE (1 PPS)
4	EXTINT	I	EXTINT (PIO 7)
5	USB_DM	I/O	USB data (DM)
6	USB_DP	I/O	USB data (DP)
7	V_USB	I	USB supply
8	RESET_N	I	RESET (active low)
9	VCC_RF	O	Voltage for external LNA
10	GND	I	Ground
11	RF_IN	I	GNSS signal input
12	GND	I	Ground
13	GND	I	Ground
14	LNA_EN	O	Antenna/LNA control

Pin no.	Name	I/O	Description
15	RTK_STAT	O	RTK status: 0 = RTK/PPP-RTK fixed blinking = receiving and using corrections 1 = no corrections
16	TXD2	O	UART 2 TXD
17	RXD2	I	UART 2 RXD
18	SDA / SPI CS_N	I/O	I2C data if D_SEL = VCC (or open); SPI chip select if D_SEL = GND
19	SCL / SPI SLK	I/O	I2C clock if D_SEL = VCC (or open); SPI clock if D_SEL = GND
20	TXD / SPI SDO	O	UART1 output if D_SEL = VCC (or open); SPI SDO if D_SEL = GND
21	RXD / SPI SDI	I	UART1 input if D_SEL = VCC (or open); SPI SDI if D_SEL = GND
22	V_BCKP	I	Backup voltage supply
23	VCC	I	Supply voltage
24	GND	I	Ground

Table 11: NEO-F9P-15B pin assignment

3.2 Pin states

Table 12 defines the state of some NEO-F9P-15B pins in different modes. The functions for the NEO-F9P-15B pins are as defined in the default configuration.

Pin no.	Default function	Continuous mode	Software backup mode	Safeboot mode
2	D_SEL = open	Input pull-up	Input pull-up	Input pull-up
	D_SEL = GND	High-Z	Input pull-down	High-Z
21	RXD	Input pull-up	Input pull-up	Input pull-up
	SPI_SDO	High-Z	Input pull-up	Input pull-up
20	TXD	Output	Input pull-up	Output
	SPI_SDI	Output[13]	Input pull-up	Output[13]
18	SDA	Input pull-up / Output	Input pull-up	Input pull-up / Output
	SPI_CS_N	High-Z	High-Z	High-Z
19	SCL	Input pull-up	Input pull-up	Input pull-up
	SPI_SLK	High-Z	High-Z	High-Z
3	TIMEPULSE	Output	Input pull-up	Output low
14	LNA_EN	Output	Input pull-down	Input pull-up
15	RTK_STAT	Output	Input pull-up	Input pull-up
1	SAFEBOOT_N	Input pull-up	Input pull-up	Input pull-up
4	EXTINT	Input pull-up	Input pull-up	Input pull-up
17	RXD2	Input pull-up	Input pull-up	Input pull-up
16	TXD2	Output	Input pull-up	Output
8	RESET_N	Input pull-up	Input pull-up	Input pull-up

Table 12: NEO-F9P-15B pin states in different operational modes

13 If SPI CS = low. Otherwise it is configured as an input pull-up.

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	+85	°C

Table 13: Absolute maximum ratings

4.2 Operating conditions

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

Parameter	Symbol	Min	Typical	Max	Units	Condition
Power supply voltage	VCC	2.7	3.0	3.6	V	
Backup battery voltage	V_BCKP	1.65		3.6	V	
Backup battery current[15, 16]	I_BCKP		45		µA	V_BCKP = 3 V, VCC = 0 V
SW backup current[16]	I_SWBCKP		0.8		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]
Digital IO pin high level output voltage	Voh	VCC – 0.4			V	Ioh = 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
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	
Voltage at USB pins	V_USBIO	0		V_USB	V	
VCC_RF voltage	VCC_RF		VCC – 0.1		V	
VCC_RF output current	ICC_RF			50	mA	
Receiver chain noise figure[18]	NFtot		3		dB	
External gain (at RF_IN)	Ext_gain	0		30	dB	
Operating temperature	Topr	–40	+25	+85	°C	

Table 14: Operating conditions

4.3 Indicative power requirements

Table 15 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 15 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	135	125	mA
I_{VCC}[19]	VCC current	Acquisition	98	80	mA
I_{VCC}[19]	VCC current	Tracking	95	78	mA

Table 15: Currents to calculate the indicative power requirements

18 Only valid for GPS
19 Simulated GNSS signal

5 Communications interfaces

The NEO-F9P-15B 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.

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 16: NEO-F9P-15B 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.

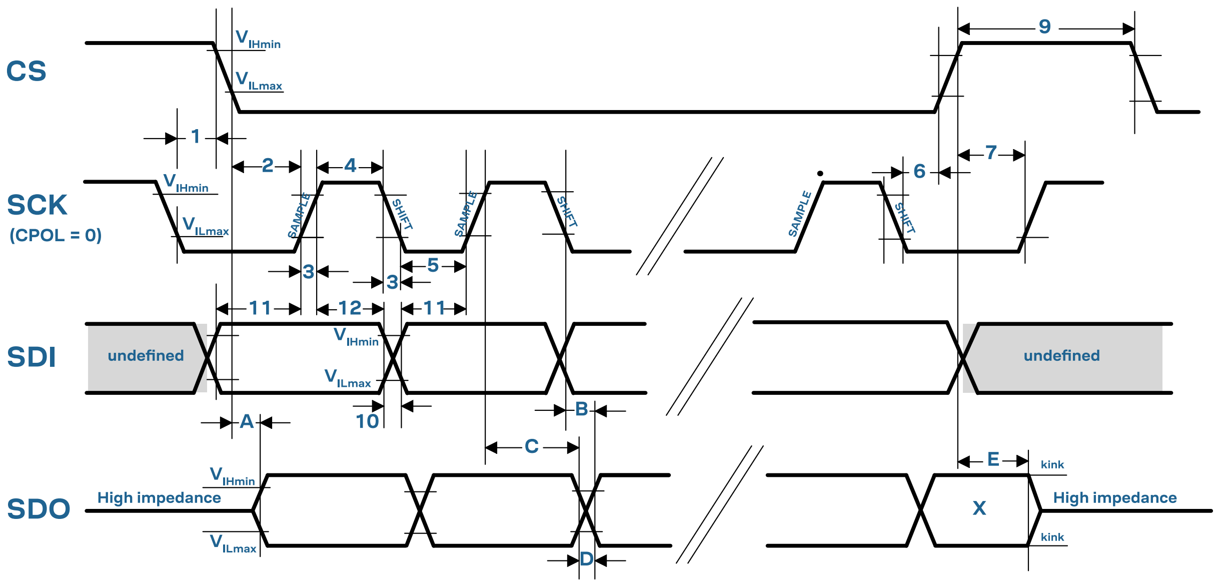

Figure 3: NEO-F9P-15B SPI specification mode 1: CPHA=0 SCK = 5.33 MHz

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

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

Table 17: 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 18: 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 19: 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 20: 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.

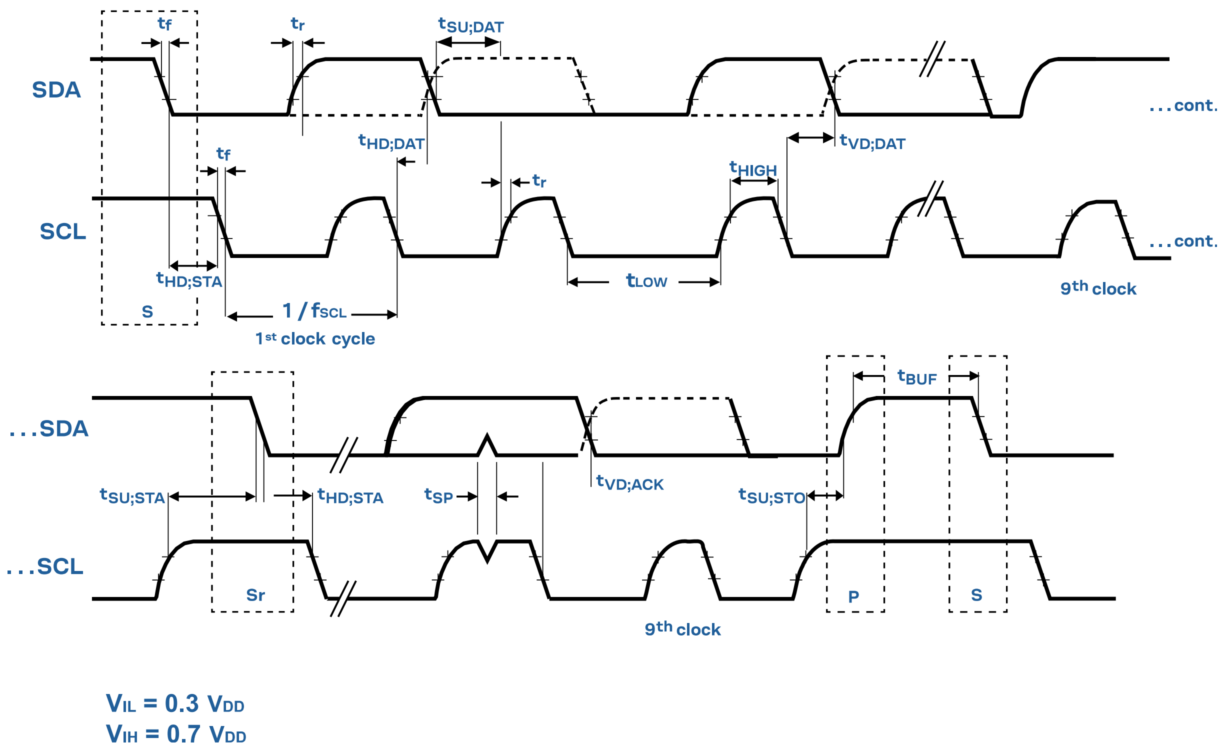

Figure 4: NEO-F9P-15B I2C peripheral specification

		I2C Fast-mode		
Symbol	**Parameter**	**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
$t_{HD;DAT}$	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

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.

Symbol	Parameter	I2C Fast-mode Min	Max	Unit
V_{nH}	Noise margin at the high level	0.2 VCC	-	V

Table 21: NEO-F9P-15B 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 Default interface settings

Interface	Settings
UART1 output	38400 baud, 8 bits, no parity bit, 1 stop bit. NMEA protocol with **GGA, GLL, GSA, GSV, RMC, VTG, TXT** messages are output by default. UBX and RTCM 3.3 protocols are enabled by default but no output messages are enabled by default.
UART1 input	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX, NMEA and RTCM 3.3 input protocols are enabled by default. 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. RTCM 3.3 protocol is enabled by default but no output messages are enabled by default. NMEA protocol is disabled by default.
UART2 input	38400 baud, 8 bits, no parity bit, 1 stop bit. UBX protocol is enabled by default. 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 22: Default interface settings

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

☞ By default, NEO-F9P-15B 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

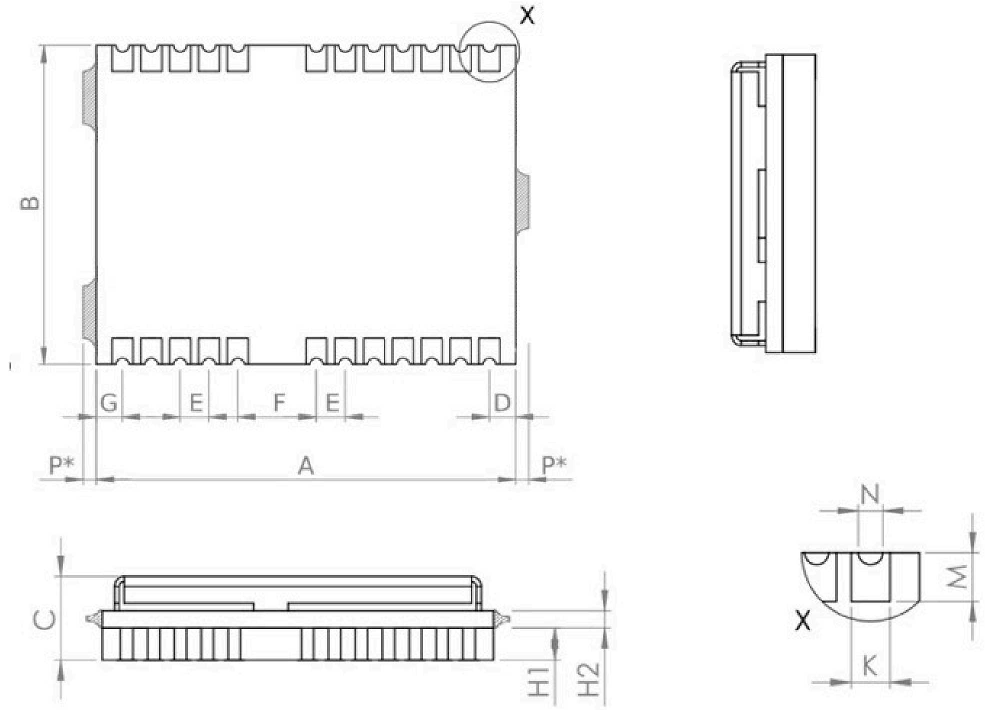

Figure 5: NEO-F9P-15B mechanical drawing

Symbol	Min (mm)	Typical (mm)	Max (mm)	
A	15.9	16.0	16.1	
B	12.1	12.2	12.4	
C	3.40	3.58	3.76	
D	0.9	1.0	1.1	
E	1.0	1.1	1.2	
F	2.9	3.0	3.1	
G	0.9	1.0	1.1	
H1	1.22	1.32	1.42	
H2	0.6	0.7	0.8	
K	0.7	0.8	0.9	
M	0.8	0.9	1.0	
N	0.4	0.5	0.6	
P*	0.0	-	0.5	There are 2 de-paneling residual tabs on the left and 1 on the right, or vice versa.
Weight		1.25 g		

Table 23: NEO-F9P-15B mechanical dimensions

☞ The mechanical picture of the de-paneling residual tabs (P*) 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 u-blox qualification policy, based on a subset of 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]	4
Type approvals	
European RED certification (CE)	Declaration of Conformity (DoC) is available on the u-blox website.
UK conformity assessment (UKCA)	Yes

Table 24: 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 Labeling and ordering information

This section provides information about product labeling and ordering. For information about product handling and soldering, see the Integration manual [1].

8.1 Product labeling

The labeling of the NEO-F9P-15B modules provides product information and revision information. For more information, contact u-blox sales.

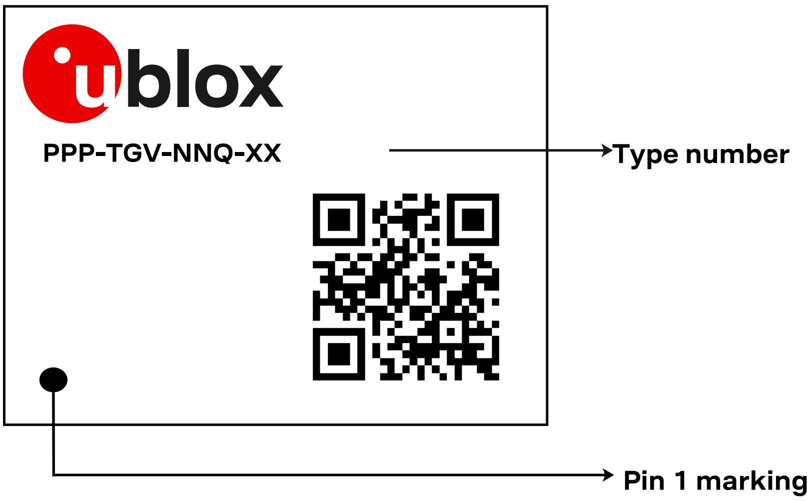

Figure 6: Example of NEO-F9P-15B label

8.2 Explanation of product codes

Three product code formats are used in the NEO-F9P-15B 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 25 below details these three formats.

Format	Structure	Product code
Product name	PPP-TGV	NEO-F9P
Ordering code	PPP-TGV-NNQ	NEO-F9P-15B
Type number	PPP-TGV-NNQ-XX	NEO-F9P-15B-00

Table 25: Product code formats

The parts of the product code are explained in Table 26.

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

Table 26: Part identification code

8.3 Ordering codes

Ordering code	Product	Remark
NEO-F9P-15B	NEO-F9P	Shipped with firmware FW 1.00 HPG L1L5 1.40

Table 27: 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] NEO-F9P Integration manual UBX-22028362
[2] HPG L1L5 1.40 Interface description UBX-23006991
[3] Product packaging reference guide UBX-14001652
[4] Radio Resource LCS Protocol (RRLP), (3GPP TS 44.031 version 11.0.0 Release 11)
[5] GPS L5 configuration, Application note, UBX-21038688

☞ 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	14-Oct-2022	Objective specification
R02	21-Jun-2023	Advance information
R03	19-Sep-2023	Early production information Update in mechanical dimensions table and the performance section
R04	06-Jun-2024	Mass production Change in document structure • Moisture sensitivity level (MSL) is included in chapter Qualifications and approvals

Contact

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