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.
## Document information

<table>
<thead>
<tr>
<th>Title</th>
<th>NEO-F9P-15B</th>
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<tbody>
<tr>
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<thead>
<tr>
<th>Product status</th>
<th>Corresponding content status</th>
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<tr>
<td>Functional Sample</td>
<td>Draft For functional testing. Revised and supplementary data will be published later.</td>
</tr>
<tr>
<td>In development / prototype</td>
<td>Objective specification Target values. Revised and supplementary data will be published later.</td>
</tr>
<tr>
<td>Engineering sample</td>
<td>Advance information Data based on early testing. Revised and supplementary data will be published later.</td>
</tr>
<tr>
<td>Initial production</td>
<td>Early production information Data from product verification. Revised and supplementary data may be published later.</td>
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This document applies to the following products:

<table>
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<th>Product name</th>
<th>Type number</th>
<th>FW version</th>
<th>IN/PCN reference</th>
<th>Product status</th>
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<td>NEO-F9P</td>
<td>NEO-F9P-15B-00</td>
<td>HPG L1L5 1.40</td>
<td>-</td>
<td>Engineering sample</td>
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</tbody>
</table>
# Contents

1 Functional description......................................................................................................... 4
   1.1 Overview........................................................................................................................................ 4
   1.2 Performance...................................................................................................................................... 4
   1.3 Supported GNSS constellations........................................................................................................ 5
   1.4 Supported GNSS augmentation systems.......................................................................................... 6
      1.4.1 Quasi-Zenith Satellite System (QZSS)...................................................................................... 6
      1.4.2 Satellite-based augmentation system (SBAS)........................................................................ 6
      1.4.3 Differential GNSS (DGNSS).......................................................................................................... 6
      1.4.4 Centimeter level augmentation service (CLAS)....................................................................... 7
   1.5 Broadcast navigation data and satellite signal measurements..................................................... 8
      1.5.1 Carrier-phase measurements...................................................................................................... 8
   1.6 Supported protocols....................................................................................................................... 8

2 System description............................................................................................................... 9
   2.1 Block diagram.................................................................................................................................. 9

3 Pin definition............................................................................................................................. 10
   3.1 Pin assignment.................................................................................................................................. 10
   3.2 Pin states.......................................................................................................................................... 11

4 Electrical specification............................................................................................................ 12
   4.1 Absolute maximum ratings.............................................................................................................. 12
   4.2 Operating conditions.......................................................................................................................... 12
   4.3 Indicative power requirements......................................................................................................... 13

5 Communications interfaces..................................................................................................... 14
   5.1 UART.................................................................................................................................................. 14
   5.2 SPI..................................................................................................................................................... 14
   5.3 I2C....................................................................................................................................................... 15
   5.4 USB.................................................................................................................................................... 17
   5.5 Default interface settings................................................................................................................... 17

6 Mechanical specification....................................................................................................... 18

7 Reliability tests and approvals............................................................................................... 20
   7.1 Approvals......................................................................................................................................... 20

8 Labeling and ordering information.......................................................................................... 21
   8.1 Product labeling.................................................................................................................................. 21
   8.2 Explanation of product codes........................................................................................................... 21
   8.3 Ordering codes................................................................................................................................. 21

Related documents.................................................................................................................. 22

Revision history.......................................................................................................................... 23
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. The 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).

1.2 Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver type</td>
<td>Multi-band GNSS high precision receiver</td>
</tr>
<tr>
<td>Accuracy of time pulse signal</td>
<td>RMS 99%</td>
</tr>
<tr>
<td></td>
<td>30 ns</td>
</tr>
<tr>
<td></td>
<td>60 ns</td>
</tr>
<tr>
<td>Frequency of time pulse signal</td>
<td>0.25 Hz to 10 MHz (configurable)</td>
</tr>
<tr>
<td>Operational limits(^2)</td>
<td>Dynamics</td>
</tr>
<tr>
<td></td>
<td>Altitude</td>
</tr>
<tr>
<td></td>
<td>Velocity</td>
</tr>
<tr>
<td></td>
<td>≤ 4 g</td>
</tr>
<tr>
<td></td>
<td>80,000 m</td>
</tr>
<tr>
<td></td>
<td>500 m/s</td>
</tr>
<tr>
<td>Velocity accuracy(^3)</td>
<td>0.05 m/s</td>
</tr>
<tr>
<td>Dynamic heading accuracy(^3)</td>
<td>0.3 deg</td>
</tr>
</tbody>
</table>

Table 1: NEO-F9P-15B specifications

<table>
<thead>
<tr>
<th>GNSS(^4)</th>
<th>GPS+GLO+GAL+BDS</th>
<th>GPS+BDS+GAL</th>
<th>GPS+GAL</th>
<th>GPS+GLO</th>
<th>GPS+BDS</th>
<th>GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition(^5)</td>
<td>Cold start</td>
<td>27 s</td>
<td>28 s</td>
<td>29 s</td>
<td>30 s</td>
<td>27 s</td>
</tr>
<tr>
<td></td>
<td>Hot start</td>
<td>3 s</td>
<td>3 s</td>
<td>3 s</td>
<td>3 s</td>
<td>3 s</td>
</tr>
<tr>
<td></td>
<td>Aided start(^6)</td>
<td>4 s</td>
<td>4 s</td>
<td>4 s</td>
<td>4 s</td>
<td>5 s</td>
</tr>
<tr>
<td>Max navigation</td>
<td>RTK</td>
<td>7 Hz</td>
<td>8 Hz</td>
<td>15 Hz</td>
<td>25 Hz</td>
<td></td>
</tr>
<tr>
<td>update rate</td>
<td>PVT</td>
<td>7 Hz</td>
<td>8 Hz</td>
<td>18 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RAW</td>
<td>10 Hz</td>
<td>10 Hz</td>
<td>20 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convergence time(^8)</td>
<td>RTK</td>
<td>&lt; 12 s</td>
<td>&lt; 12 s</td>
<td>&lt; 12 s</td>
<td>&lt; 12 s</td>
<td></td>
</tr>
</tbody>
</table>

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

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
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
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.

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

---

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.

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

The 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)

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

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

<table>
<thead>
<tr>
<th>Message type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTCM 1005</td>
<td>Stationary RTK reference station ARP</td>
</tr>
<tr>
<td>RTCM 1006</td>
<td>Stationary RTK reference station ARP with antenna height</td>
</tr>
<tr>
<td>RTCM 1007</td>
<td>Antenna descriptor</td>
</tr>
<tr>
<td>RTCM 1033</td>
<td>Receiver and antenna description</td>
</tr>
<tr>
<td>RTCM 1074</td>
<td>GPS MSM4</td>
</tr>
<tr>
<td>RTCM 1075</td>
<td>GPS MSM5</td>
</tr>
<tr>
<td>RTCM 1077</td>
<td>GPS MSM7</td>
</tr>
<tr>
<td>RTCM 1084</td>
<td>GLONASS MSM4</td>
</tr>
<tr>
<td>RTCM 1085</td>
<td>GLONASS MSM5</td>
</tr>
<tr>
<td>RTCM 1087</td>
<td>GLONASS MSM7</td>
</tr>
</tbody>
</table>
Table 7: Supported input RTCM 3.3 messages

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

<table>
<thead>
<tr>
<th>Message type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTCM 1005</td>
<td>Stationary RTK reference station ARP</td>
</tr>
<tr>
<td>RTCM 1074</td>
<td>GPS MSM4</td>
</tr>
<tr>
<td>RTCM 1077</td>
<td>GPS MSM7</td>
</tr>
<tr>
<td>RTCM 1084</td>
<td>GLONASS MSM4</td>
</tr>
<tr>
<td>RTCM 1087</td>
<td>GLONASS MSM7</td>
</tr>
<tr>
<td>RTCM 1094</td>
<td>Galileo MSM4</td>
</tr>
<tr>
<td>RTCM 1097</td>
<td>Galileo MSM7</td>
</tr>
<tr>
<td>RTCM 1124</td>
<td>BeiDou MSM4</td>
</tr>
<tr>
<td>RTCM 1125</td>
<td>BeiDou MSM5</td>
</tr>
<tr>
<td>RTCM 1127</td>
<td>BeiDou MSM7</td>
</tr>
<tr>
<td>RTCM 1230</td>
<td>GLONASS code-phase biases</td>
</tr>
</tbody>
</table>

Table 8: Supported output RTCM 3.3 messages

A NEO-F9P-15B operating as a rover can decode the following SPARTN 2.0.1 messages:

<table>
<thead>
<tr>
<th>Message type-subtype</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM 0-0</td>
<td>GPS orbit, clock, bias (OCB)</td>
</tr>
<tr>
<td>SM 0-1</td>
<td>GLONASS orbit, clock, bias (OCB)</td>
</tr>
<tr>
<td>SM 0-2</td>
<td>Galileo orbit, clock, bias (OCB)</td>
</tr>
<tr>
<td>SM 0-3</td>
<td>BeiDou orbit, clock, bias (OCB)</td>
</tr>
<tr>
<td>SM 1-0</td>
<td>GPS high-precision atmosphere correction (HPAC)</td>
</tr>
<tr>
<td>SM 1-1</td>
<td>GLONASS high-precision atmosphere correction (HPAC)</td>
</tr>
<tr>
<td>SM 1-2</td>
<td>Galileo high-precision atmosphere correction (HPAC)</td>
</tr>
<tr>
<td>SM 1-3</td>
<td>BeiDou high-precision atmosphere correction (HPAC)</td>
</tr>
<tr>
<td>SM 2-0</td>
<td>Geographic area definition (GAD)</td>
</tr>
</tbody>
</table>

Table 9: Supported input SPARTN version 2.0.1 messages

1.4.4 Centimeter level augmentation service (CLAS)

A NEO-F9P-15B operating as a rover 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, 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 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 are available once the receiver has established data bit synchronization and time-of-week.

1.6 Supported protocols

The NEO-F9P-15B supports the following protocols:

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBX</td>
<td>Input/output, binary, u-blox proprietary</td>
</tr>
<tr>
<td>NMEA 4.11 (default), 4.10, 4.0, 2.3, and 2.1</td>
<td>Input/output, ASCII</td>
</tr>
<tr>
<td>RTCM 3.3</td>
<td>Input/output, binary</td>
</tr>
<tr>
<td>SPARTN 2.0.1</td>
<td>Input, binary</td>
</tr>
</tbody>
</table>

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.

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

Figure 2: NEO-F9P-15B pin assignment
<table>
<thead>
<tr>
<th>Pin no.</th>
<th>Name</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>RTK_STAT</td>
<td>O</td>
<td>RTK status:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 = RTK/PPP-RTK fixed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>blinking = receiving and using corrections</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = no corrections</td>
</tr>
<tr>
<td>16</td>
<td>TXD2</td>
<td>O</td>
<td>UART 2 TXD</td>
</tr>
<tr>
<td>17</td>
<td>RXD2</td>
<td>I</td>
<td>UART 2 RXD</td>
</tr>
<tr>
<td>18</td>
<td>SDA / SPI CS_N</td>
<td>I/O</td>
<td>I2C data if D_SEL = VCC (or open); SPI chip select if D_SEL = GND</td>
</tr>
<tr>
<td>19</td>
<td>SCL / SPI SLK</td>
<td>I/O</td>
<td>I2C clock if D_SEL = VCC (or open); SPI clock if D_SEL = GND</td>
</tr>
<tr>
<td>20</td>
<td>TXD / SPI SDO</td>
<td>O</td>
<td>UART1 output if D_SEL = VCC (or open); SPI SDO if D_SEL = GND</td>
</tr>
<tr>
<td>21</td>
<td>RXD / SPI SDI</td>
<td>I</td>
<td>UART1 input if D_SEL = VCC (or open); SPI SDI if D_SEL = GND</td>
</tr>
<tr>
<td>22</td>
<td>V_BCKP</td>
<td>I</td>
<td>Backup voltage supply</td>
</tr>
<tr>
<td>23</td>
<td>VCC</td>
<td>I</td>
<td>Supply voltage</td>
</tr>
<tr>
<td>24</td>
<td>GND</td>
<td>I</td>
<td>Ground</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Pin no.</th>
<th>Default function</th>
<th>Continuous mode</th>
<th>Software backup mode</th>
<th>Safeboot mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>D_SEL = open</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
<tr>
<td></td>
<td>D_SEL = GND</td>
<td>High-Z</td>
<td>Input pull-down</td>
<td>High-Z</td>
</tr>
<tr>
<td>21</td>
<td>RXD</td>
<td>Input pull-up</td>
<td>Input pull-down</td>
<td>Input pull-up</td>
</tr>
<tr>
<td></td>
<td>SPI_SDO</td>
<td>High-Z</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
<tr>
<td>20</td>
<td>TXD</td>
<td>Output</td>
<td>Input pull-up</td>
<td>Output</td>
</tr>
<tr>
<td></td>
<td>SPI_SDI</td>
<td>Output&lt;sup&gt;13&lt;/sup&gt;</td>
<td>Input pull-up</td>
<td>Output&lt;sup&gt;13&lt;/sup&gt;</td>
</tr>
<tr>
<td>18</td>
<td>SDA</td>
<td>Input pull-up / Output</td>
<td>Input pull-up</td>
<td>Input pull-up / Output</td>
</tr>
<tr>
<td></td>
<td>SPI_CS_N</td>
<td>High-Z</td>
<td>Input pull-up</td>
<td>High-Z</td>
</tr>
<tr>
<td>19</td>
<td>SCL</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
<tr>
<td></td>
<td>SPI_SLK</td>
<td>High-Z</td>
<td>Input pull-up</td>
<td>High-Z</td>
</tr>
<tr>
<td>3</td>
<td>TIMEPULSE</td>
<td>Output</td>
<td>Input pull-up</td>
<td>Output low</td>
</tr>
<tr>
<td>14</td>
<td>LNA_EN</td>
<td>Output</td>
<td>Input pull-down</td>
<td>Input pull-up</td>
</tr>
<tr>
<td>15</td>
<td>RTK_STAT</td>
<td>Output</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
<tr>
<td>1</td>
<td>SAFEBOOT_N</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
<tr>
<td>4</td>
<td>EXTINT</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
<tr>
<td>17</td>
<td>RXD2</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
<tr>
<td>16</td>
<td>TXD2</td>
<td>Output</td>
<td>Input pull-up</td>
<td>Output</td>
</tr>
<tr>
<td>8</td>
<td>RESET_N</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
<td>Input pull-up</td>
</tr>
</tbody>
</table>

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

---

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage</td>
<td>VCC</td>
<td></td>
<td>-0.5</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Voltage ramp on VCC[^1]</td>
<td></td>
<td></td>
<td>20</td>
<td>8000</td>
<td>µs/V</td>
</tr>
<tr>
<td>Backup battery voltage</td>
<td>V_BCKP</td>
<td></td>
<td>-0.5</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>Voltage ramp on V_BCKP[^1]</td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td>µs/V</td>
</tr>
<tr>
<td>Input pin voltage</td>
<td>Vin</td>
<td>VCC ≤ 3.1 V</td>
<td>-0.5</td>
<td>VCC + 0.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCC &gt; 3.1 V</td>
<td>-0.5</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>VCC_RF output current</td>
<td>ICC_RF</td>
<td></td>
<td></td>
<td>300</td>
<td>mA</td>
</tr>
<tr>
<td>Supply voltage USB</td>
<td>V_USB</td>
<td></td>
<td>-0.5</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>USB signals</td>
<td>USB_DM,</td>
<td></td>
<td>-0.5</td>
<td>V_USB + 0.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>USB_DP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input power at RF_IN</td>
<td>Prfin</td>
<td>source impedance = 50 Ω, continuous wave</td>
<td>10</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>Tstg</td>
<td></td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
</tr>
</tbody>
</table>

Table 13: 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Units</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage</td>
<td>VCC</td>
<td>2.7</td>
<td>3.0</td>
<td>3.6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Backup battery voltage</td>
<td>V_BCKP</td>
<td>1.65</td>
<td>3.6</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backup battery current[^15]</td>
<td>I_BCKP</td>
<td>45</td>
<td>µA</td>
<td>V_BCKP = 3 V, VCC = 0 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW backup current</td>
<td>I_SWBCKP</td>
<td>0.8</td>
<td>mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input pin voltage range</td>
<td>Vin</td>
<td>0</td>
<td>VCC</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital IO pin low level input voltage</td>
<td>Vii</td>
<td>0.4</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital IO pin high level input voltage</td>
<td>Vih</td>
<td>0.8 * VCC</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[^1\] 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.
### Table 14: Operating conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Units</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital IO pin low level output voltage</td>
<td>Vol</td>
<td>0.4</td>
<td></td>
<td>0.4</td>
<td>V</td>
<td>lol = 2 mA⁶</td>
</tr>
<tr>
<td>Digital IO pin high level output voltage</td>
<td>Voh</td>
<td>VCC</td>
<td>-0.4</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>DC current through any digital I/O pin (except supplies)</td>
<td>lpin</td>
<td>5</td>
<td></td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Pull-up resistance for SCL, SDA</td>
<td>Rpu</td>
<td>7</td>
<td>15</td>
<td>30</td>
<td>kΩ</td>
<td></td>
</tr>
<tr>
<td>Pull-up resistance for D_SEL, RXD, TXD, SAFEBOOT_N, EXTINT</td>
<td>Rpu</td>
<td>30</td>
<td>75</td>
<td>130</td>
<td>kΩ</td>
<td></td>
</tr>
<tr>
<td>Pull-up resistance for RESET_N</td>
<td>Rpu</td>
<td>7</td>
<td>10</td>
<td>13</td>
<td>kΩ</td>
<td></td>
</tr>
<tr>
<td>Voltage at USB pins</td>
<td>V_USBIO</td>
<td>0</td>
<td>V_USB</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VCC_RF voltage</td>
<td>VCC_RF</td>
<td></td>
<td>VCC - 0.1</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VCC_RF output current</td>
<td>ICC_RF</td>
<td></td>
<td>50</td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Receiver chain noise figure</td>
<td>NFtot</td>
<td>3</td>
<td></td>
<td></td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>External gain (at RF_IN)</td>
<td>Ext_gain</td>
<td>0</td>
<td>30</td>
<td></td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Topr</td>
<td>-40</td>
<td>+25</td>
<td>+85</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

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

### 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.

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.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>GPS+GLO+GAL+BDS</th>
<th>GPS</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPeak</td>
<td>Peak current</td>
<td>Acquisition</td>
<td>135</td>
<td>125</td>
<td>mA</td>
</tr>
<tr>
<td>I_{VCC}¹⁸</td>
<td>VCC current</td>
<td>Acquisition</td>
<td>98</td>
<td>80</td>
<td>mA</td>
</tr>
<tr>
<td>I_{VCC}¹⁸</td>
<td>VCC current</td>
<td>Tracking</td>
<td>95</td>
<td>78</td>
<td>mA</td>
</tr>
</tbody>
</table>

Table 15: Currents to calculate the indicative power requirements

All values in Table 15 are measured at 25 °C ambient temperature.

---

⁶ TIMEPULSE has 4 mA current drive/sink capability
⁷ Only valid for GPS
⁸ Simulated GNSS signal
5 Communications interfaces

The NEO-F9P-15B has several communications interfaces\(^\text{\textsuperscript{19}}\), including UART, SPI, I2C and USB.

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

5.1 UART

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

Hardware flow control is not supported.

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_u )</td>
<td>Baud rate</td>
<td>9600</td>
<td>921600</td>
<td>bit/s</td>
</tr>
<tr>
<td>( \Delta_{\text{Tx}} )</td>
<td>Tx baud rate accuracy</td>
<td>-1%</td>
<td>+1%</td>
<td>-</td>
</tr>
<tr>
<td>( \Delta_{\text{Rx}} )</td>
<td>Rx baud rate tolerance</td>
<td>-2.5%</td>
<td>+2.5%</td>
<td>-</td>
</tr>
</tbody>
</table>

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](image)

\(^{19}\) The signal names and related terms have been replaced with new terminology in this document.
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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>I2C Fast-mode</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_{SCL}$</td>
<td>SCL clock frequency</td>
<td></td>
<td>0</td>
<td>400</td>
<td>kHz</td>
</tr>
<tr>
<td>$t_{HD,STA}$</td>
<td>Hold time (repeated) START condition</td>
<td></td>
<td>0.6</td>
<td>-</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{LOW}$</td>
<td>Low period of the SCL clock</td>
<td></td>
<td>1.3</td>
<td>-</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{HIGH}$</td>
<td>High period of the SCL clock</td>
<td></td>
<td>0.6</td>
<td>-</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{SU,STA}$</td>
<td>Setup time for a repeated START condition</td>
<td></td>
<td>0.6</td>
<td>-</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{HD,DAT}$</td>
<td>Data hold time</td>
<td></td>
<td>0</td>
<td>-21</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{SU,DAT}$</td>
<td>Data setup time</td>
<td></td>
<td>100</td>
<td>0</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{BUF}$</td>
<td>Bus-free time between a STOP and START condition</td>
<td></td>
<td>1.3</td>
<td>-</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{VD,DAT}$</td>
<td>Data valid time</td>
<td></td>
<td>-</td>
<td>0.9</td>
<td>µs</td>
</tr>
<tr>
<td>$t_{VD,ACK}$</td>
<td>Data valid acknowledge time</td>
<td></td>
<td>-</td>
<td>0.9</td>
<td>µs</td>
</tr>
<tr>
<td>$V_{NL}$</td>
<td>Noise margin at the low level</td>
<td></td>
<td>0.1</td>
<td>VCC</td>
<td>V</td>
</tr>
<tr>
<td>$V_{NH}$</td>
<td>Noise margin at the high level</td>
<td></td>
<td>0.2</td>
<td>VCC</td>
<td>V</td>
</tr>
</tbody>
</table>

Table 21: NEO-F9P-15B I2C peripheral timings and specifications

- 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.
- The maximum $t_{HD,DAT}$ must be less than the maximum $t_{VD,DAT}$ or $t_{VD,ACK}$ with a maximum of 0.9 µs by a transition time. This maximum must only be met if the device does not stretch the LOW period ($t_{LOW}$) of the SCL signal. If the clock stretches the SCL, the data must be valid by the set-up time before it releases the clock.
- When the I2C peripheral is stretching the clock, the $t_{SU,DAT}$ of the first bit of the next byte is 62.5 ns.
The I2C interface is only available with the UART default mode. If the SPI interface is selected by using D_SEL = 0, the I2C interface is not available.

5.4 USB
The USB 2.0 FS (full speed, 12 Mbit/s) interface can be used for host communication. Due to the hardware implementation, it may not be possible to certify the USB interface. The V_USB pin supplies the USB interface.

5.5 Default interface settings

<table>
<thead>
<tr>
<th>Interface</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>UART1 output</td>
<td>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.</td>
</tr>
<tr>
<td>UART1 input</td>
<td>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.</td>
</tr>
<tr>
<td>UART2 output</td>
<td>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.</td>
</tr>
<tr>
<td>UART2 input</td>
<td>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.</td>
</tr>
<tr>
<td>USB</td>
<td>Default messages activated as in UART1. Input/output protocols available as in UART1.</td>
</tr>
<tr>
<td>I2C</td>
<td>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.</td>
</tr>
<tr>
<td>SPI</td>
<td>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]).</td>
</tr>
</tbody>
</table>

Table 22: Default interface settings

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

By default, the 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 specification

![Figure 5: NEO-F9P-15B mechanical drawing](image)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Min (mm)</th>
<th>Typical (mm)</th>
<th>Max (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15.9</td>
<td>16.0</td>
<td>16.1</td>
</tr>
<tr>
<td>B</td>
<td>12.1</td>
<td>12.2</td>
<td>12.3</td>
</tr>
<tr>
<td>C</td>
<td>3.12</td>
<td>3.42</td>
<td>3.72</td>
</tr>
<tr>
<td>D</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>E</td>
<td>1.0</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>F</td>
<td>2.9</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>G</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>H1</td>
<td>1.22</td>
<td>1.32</td>
<td>1.42</td>
</tr>
<tr>
<td>H2</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>K</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>M</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>N</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>P*</td>
<td>0.0</td>
<td>-</td>
<td>0.5</td>
</tr>
</tbody>
</table>

| Weight | 1.25 g |

*There are 2 de-paneling residual tabs on the left and 1 on the right, or vice versa.*

**Table 23: NEO-F9P-15B mechanical dimensions**
The mechanical picture of the de-paneling residual tabs (P*) is an approximate representation, shape and position may vary.

Component keep-out area must consider the presence of the de-paneling residual tabs.
7 Reliability tests and approvals

NEO-F9P-15B 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


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 NEO-F9P-15B 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 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 24 below details these three formats.

<table>
<thead>
<tr>
<th>Format</th>
<th>Structure</th>
<th>Product code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product name</td>
<td>PPP-TGV</td>
<td>NEO-F9P</td>
</tr>
<tr>
<td>Ordering code</td>
<td>PPP-TGV-NNQ</td>
<td>NEO-F9P-15B</td>
</tr>
<tr>
<td>Type number</td>
<td>PPP-TGV-NNQ-XX</td>
<td>NEO-F9P-15B-00</td>
</tr>
</tbody>
</table>

Table 24: Product code formats

The parts of the product code are explained in Table 25.

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPP</td>
<td>Product family</td>
<td>NEO</td>
</tr>
<tr>
<td>TG</td>
<td>Platform</td>
<td>F9 = u-blox F9</td>
</tr>
<tr>
<td>V</td>
<td>Variant</td>
<td>P = High precision</td>
</tr>
<tr>
<td>NNQ</td>
<td>Option / Quality grade</td>
<td>NN: Option [00...99]</td>
</tr>
<tr>
<td>Q</td>
<td>Grade</td>
<td>A = Automotive</td>
</tr>
<tr>
<td>XX</td>
<td>Product detail</td>
<td>Describes hardware and firmware versions</td>
</tr>
</tbody>
</table>

Table 25: Part identification code

8.3 Ordering codes

<table>
<thead>
<tr>
<th>Ordering code</th>
<th>Product</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEO-F9P-15B</td>
<td>NEO-F9P</td>
<td>Shipped with firmware FW 1.00 HPG L1L5 1.40</td>
</tr>
</tbody>
</table>

Table 26: 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

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

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Name</th>
<th>Status / comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>14-Oct-2022</td>
<td>dama</td>
<td>Objective specification</td>
</tr>
<tr>
<td>R02</td>
<td>21-Jun-2023</td>
<td>dbhu</td>
<td>Advance information</td>
</tr>
</tbody>
</table>
Contact

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

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

u-blox:
NEO-F9P-15B