NEO-8Q / NEO-M8

u-blox 8 / M8 GNSS modules

Hardware integration manual



Abstract

This document describes the features and specifications of u-blox NEO-8Q and NEO-M8 series modules.

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Document information

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

European Union regulatory compliance

NEO-8Q and NEO-M8J/N/M/Q/T modules comply with all relevant requirements for RED 2014/53/EU. The NEO-8Q and NEO-M8J/N/M/Q/T Declaration of Conformity (DoC) is available at www.u-blox.com in Support > Product resources > Conformity Declaration.

This document applies to the following products:

Product name	Type number	ROM/FLASH version	PCN reference
NEO-M8N	NEO-M8N-0-12	FLASH FW SPG 3.01	UBX-21015025
NEO-M8M	NEO-M8M-0-11	ROM SPG 3.01	UBX-21015022
NEO-M8Q	NEO-M8Q-0-12	ROM SPG 3.01	UBX-21015025
NEO-M8T	NEO-M8T-0-11	FLASH FW3.01 TIM 1.10	UBX-20013367
NEO-8Q	NEO-8Q-0-11	ROM SPG 3.01	UBX-20013367
NEO-M8J	NEO-M8J-0-11	Flash FW SPG 3.05	UBX-21015025

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1 Hardware description

1.1 Overview

u-blox NEO-8Q, NEO-M8N, NEO-M8Q, NEO-M8M and NEO-M8J standard precision GNSS modules, and the NEO-M8T timing GNSS module, all feature the high performance u-blox M8 GNSS engine. Available in the industry standard NEO form factor in a leadless chip carrier (LCC) package, they are easy to integrate and combine exceptional positioning performance with highly flexible power, design, and connectivity options. SMT pads allow fully automated assembly with standard pick & place and reflow-soldering equipment for cost-efficient, high-volume production enabling short time-to-market.

☞ For product features, see the corresponding product data sheet in the Related documents section.

☞ To determine which u-blox product best meets your needs, see the product selector tables on the u-blox website www.u-blox.com.

1.2 Configuration

The configuration settings can be modified using UBX protocol configuration messages, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [4]. The modified settings remain effective until power-down or reset. If these settings have been stored in BBR (Battery Backed RAM), then the modified configuration will be retained, as long as the backup battery supply is not interrupted.

For the NEO-M8N and NEO-M8J modules, configuration can be saved permanently in SQI flash.

1.3 Connecting power

The u-blox NEO-8Q and NEO-M8 series modules have three power supply pins: **VCC**, **V_BCKP, and VDD_USB**.

1.3.1 VCC: Main supply voltage

The **VCC** pin provides the main supply voltage. During operation, the current drawn by the module can vary by some orders of magnitude, especially if enabling low-power operation modes. For this reason, it is important that the supply circuitry be able to support the peak power for a short time (for the specifications, see the corresponding product data sheet in the Related documents section).

☞ When switching from backup mode to normal operation or at start-up, u-blox NEO-8Q and NEO-M8 series modules must charge the internal capacitors in the core domain. In certain situations, this can result in a significant current draw. For low power applications using Power Save and backup modes, it is important that the power supply or low ESR capacitors at the module input can deliver this current/charge.

☞ Use a proper GND concept. Do not use any resistors or coils in the power line.

1.3.2 V_BCKP: Backup supply voltage

If the module supply has a power failure, the **V_BCKP** pin supplies the real-time clock (RTC) and battery backed RAM (BBR). Use of valid time and the GNSS orbit data at start up will improve the GNSS performance, as with hot starts, warm starts, AssistNow Autonomous and AssistNow Offline. If no backup battery is connected, the module performs a cold start at power up.

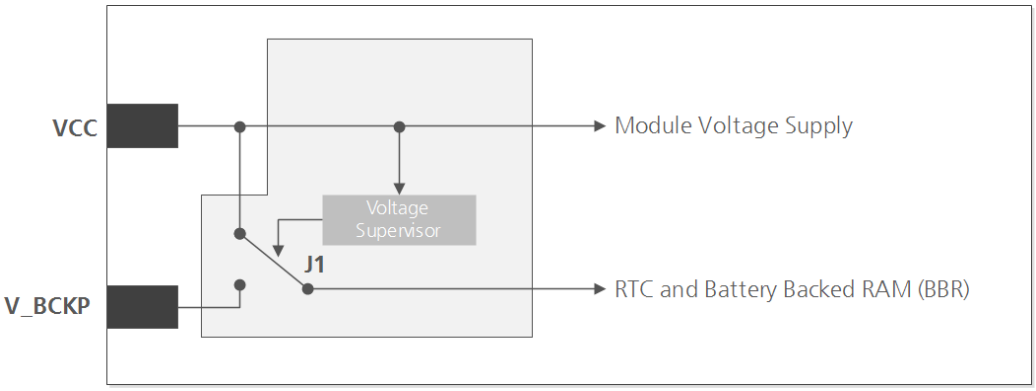


Figure 1: Backup battery and voltage (for exact pin orientation, see the corresponding product data sheet)

- Avoid high resistance on the **V_BCKP** line: During the switch from main supply to backup supply, a short current adjustment peak can cause high voltage drop on the pin with possible malfunctions.
- If no backup supply voltage is available, connect the **V_BCKP** pin to **VCC**.
- As long as power is supplied to the NEO-8Q and NEO-M8 series modules through the **VCC** pin, the backup battery is disconnected from the RTC and the BBR to avoid unnecessary battery drain (see Figure 1). In this case, **VCC** supplies power to the RTC and BBR.

Real-Time Clock (RTC)

The RTC is driven by a 32 kHz oscillator using an RTC crystal. If the main supply voltage fails, and a battery is connected to V_BCKP, parts of the receiver switch off, but the RTC still runs providing a timing reference for the receiver. This operating mode is called Hardware Backup Mode, which enables all relevant data to be saved in the backup RAM to allow a hot or warm start later.

1.3.3 VDD_USB: USB interface power supply

VDD_USB supplies the USB interface. If the USB interface is not used, the **VDD_USB** pin must be connected to GND. For more information about correctly handling the **VDD_USB** pin, see section 1.4.

1.3.4 VCC_RF: Output voltage RF

The **VCC_RF** pin can supply an active antenna or external LNA. For more information, see section 2.4.

1.4 Interfaces

1.4.1 UART

The NEO-8Q and NEO-M8 series modules include a Universal Asynchronous Receiver Transmitter (UART) serial interface **RXD/TXD** supporting configurable baud rates. The baud rates supported are specified in the corresponding product data sheet.

The signal output and input levels are 0 V to **VCC**. An interface based on RS232 standard levels (+/- 12 V) can be implemented using level shifters such as Maxim MAX3232. Hardware handshake signals and synchronous operation are not supported.

- Designs must allow access to the UART pin for future service and reconfiguration.

1.4.2 USB

A USB version 2.0 FS (Full Speed, 12 Mbit/s) compatible interface is available for communication as an alternative to the UART. The **USB_DP** integrates a pull-up resistor to signal a full-speed device to the host. The **VDD_USB** pin supplies the USB interface.

u-blox provides Microsoft® certified USB drivers for Windows 7, Windows 8 and Windows 10 operating systems. These drivers are available at our website at www.u-blox.com

USB external components

The USB interface requires some external components to implement the physical characteristics required by the USB 2.0 specification. These external components are shown in Figure 2 and listed in Table 1. To comply with USB specifications, VBUS must be connected through an LDO (U1) to pin **VDD_USB** on the module.

In USB self-powered mode, the power supply (**VCC**) can be turned off and the digital block is not powered. In this case, since VBUS is still available, the USB host would still receive the signal indicating that the device is present and ready to communicate. This should be avoided by disabling the LDO (U1) using the enable signal (EN) of the VCC-LDO or the output of a voltage supervisor. Depending on the characteristics of the LDO (U1) it is recommended to add a pull-down resistor (R11) at its output to ensure **VDD_USB** is not floating if the LDO (U1) is disabled or the USB cable is not connected, that is, VBUS is not supplied.

☞ USB bus-powered mode is not supported.

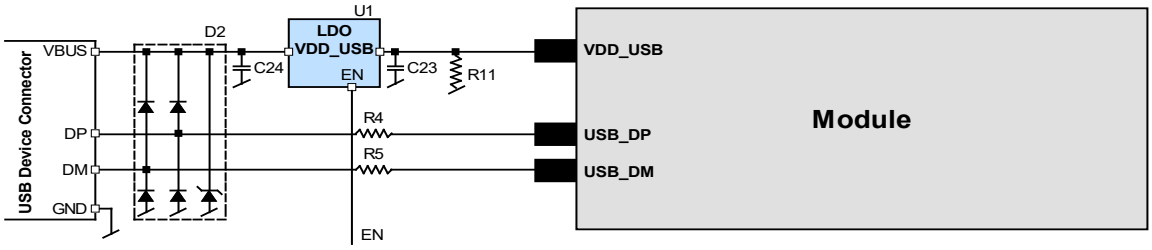


Figure 2: USB interface

Name	Component	Function	Comments
U1	LDO	Regulates VBUS (4.4 ...5.25 V) down to a voltage of 3.3 V.	Almost no current requirement (~1 mA) if the GNSS receiver is operated as a USB self-powered device.
C23, C24	Capacitors		Required according to the specification of LDO U1
D2	Protection diodes	Protect circuit from overvoltage / ESD when connecting.	Use low capacitance ESD protection such as ST Microelectronics USBLC6-2.
R4, R5	Serial termination resistors	Establish a full-speed driver impedance of 28...44 Ω	A value of 27 Ω is recommended.
R11	Resistor		100 kΩ is recommended for USB self-powered setup.

Table 1: Summary of USB external components

1.4.3 Display Data Channel (DDC)

An I2C compatible Display Data Channel (DDC) interface is available on NEO-8Q and NEO-M8 series modules for serial communication with an external host CPU. The interface only supports operation in slave mode (master mode is not supported). The DDC protocol and electrical interface are fully compatible with the Fast-Mode of the I2C industry standard. DDC pins **SDA** and **SCL** have internal pull-up resistors.

For more information about the DDC implementation, see the u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [4]. For bandwidth information, see the corresponding product data sheet. For timing parameters, consult the I2C-bus specification [7].

☞ The NEO-8Q and NEO-M8 series DDC interface supports serial communication with most u-blox cellular modules. See the specification of the applicable cellular module to confirm compatibility.

1.4.4 SPI

An SPI interface is available for communication to a host CPU.

☞ SPI is not available in the default configuration, because its pins are shared with the UART and DDC interfaces. The SPI interface can be enabled by connecting **D_SEL** to ground. For speed and clock frequency, see the corresponding product data sheet.

1.4.5 TX_READY

The **TX_READY** function is used to indicate when the receiver has data to transmit. A listener can wait on the **TX_READY** signal instead of polling the DDC or SPI interfaces. The UBX-CFG-PRT message lets you configure the polarity and the number of bytes in the buffer before the TX READY signal goes active. The **TX_READY** function can be mapped to **TXD** (PIO 06). The **TX_READY** function is disabled by default.

☞ The **TX_READY** functionality can be enabled and configured by AT commands sent to the u-blox cellular module supporting the feature. For more information, see the GPS Implementation and Aiding Features in u-blox wireless modules [8].

1.5 I/O pins

All I/O pins make use of internal pull-ups. Thus, there is no need to connect unused pins to VCC_IO.

1.5.1 RESET_N: Reset

Driving **RESET_N** low activates a hardware reset of the system. Use this pin only to reset the module. Do not use **RESET_N** to turn the module on and off, since the reset state increases power consumption. With NEO-8Q and NEO-M8 series modules **RESET_N** is an input only.

☞ The RTC time is also reset (but not BBR).

1.5.2 EXTINT: External interrupt

EXTINT (EXTINT0 on **NEO-M8T), PIO 13** is an external interrupt pin with fixed input voltage thresholds with respect to **VCC** (see the corresponding product data sheet for more information). It can be used for wake-up functions in power save mode on NEO-8Q and NEO-M8 series modules and for aiding. Leave open if unused. The function is disabled by default.

If the **EXTINT** is not used for an external interrupt function, it can be used for some other purpose. For example, as an output pin for the **TX_READY** feature to indicate that the receiver has data to transmit.

EXTINT1 is an external interrupt pin on **NEO-M8T** with fixed input voltage thresholds with respect to **VCC** (see the corresponding product data sheet for more information). It can be used for wake-up functions in Power Save Mode on NEO-M8T module and for aiding. Leave open if unused. The function is disabled by default.

Power control

The power control feature allows overriding the automatic active/inactive cycle of power save mode. The state of the receiver can be controlled through the **EXTINT (EXTINT0** on **NEO-M8T)** pin. The receiver can also be forced OFF using **EXTINT (EXTINT0** on **NEO-M8T)** when power save mode is not active.

Frequency aiding

The **EXTINT (EXTINT0** on **NEO-M8T)** pin can be used to supply time or frequency aiding data to the receiver.

For time aiding, hardware time synchronization can be achieved by connecting an accurate time pulse to the **EXTINT (EXTINT0** on **NEO-M8T)** pin.

Frequency aiding can be implemented by connecting a periodic rectangular signal with a frequency up to 500 kHz and arbitrary duty cycle (low/high phase duration must not be shorter than 50 ns) to the **EXTINT (EXTINT0** on **NEO-M8T)** pin. Provide the applied frequency value to the receiver using UBX messages.

1.5.3 SAFEBOOT_N

The **SAFEBOOT_N** pin is for future service, updates and reconfiguration.

On the NEO-M8T module, a configurable TIMEPULSE2 signal can be programmed on **TP2/SAFEBOOT_N**.

☞ Do not pull low during reset.

1.5.4 D_SEL: Interface select

The **D_SEL** pin selects the available interfaces. SPI cannot be used simultaneously with UART/DDC. If open, UART and DDC are available. If pulled low, the SPI interface is available. See the corresponding product data sheet.

1.5.5 TIMEPULSE (TIMEPULSE1 on NEO-M8T)

On NEO-8Q and NEO-M8 series modules, a configurable time pulse signal is available. By default, the time pulse signal is configured to one pulse per second. For more information, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [4].

1.5.6 TIMEPULSE2

On the **NEO-M8T** module, a configurable TIMEPULSE2 signal can be programmed on TP2/SAFEBOOT_N.

For more information, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [4].

☞ The TIMEPULSE2 output must **not** be held LOW during start-up.

1.5.7 LNA_EN: LNA enable

On **NEO-M8N, NEO-M8J, NEO-M8Q, NEO-M8T** and **NEO-8Q** modules, in power save mode, the system can turn on/off an optional external LNA using the **LNA_EN** signal in order to optimize power consumption.

Signals: "high" = Turn ON LNA, "low" = Turn OFF LNA

1.6 Electromagnetic interference on I/O lines

Any I/O signal line with a length greater than approximately 3 mm can act as an antenna and may pick up arbitrary RF signals transferring them as noise into the GNSS receiver. This specifically applies to unshielded lines, in which the corresponding GND layer is remote or missing entirely, and lines close to the edges of the printed circuit board.

If, for example, a cellular signal radiates into an unshielded high-impedance line, it is possible to generate noise in the order of volts and not only distort receiver operation but also damage it permanently.

On the other hand, noise generated at the I/O pins will emit from unshielded I/O lines. Receiver performance may be degraded when this noise is coupled into the GNSS antenna (see Figure 15).

To avoid interference by improperly shielded lines, it is recommended to use resistors (e.g. R>20 Ω), ferrite beads (e.g. BLM15HD102SN1) or inductors (e.g. LQG15HS47NJ02) on the I/O lines in series. These components should be chosen with care because they will also affect the signal rise times.

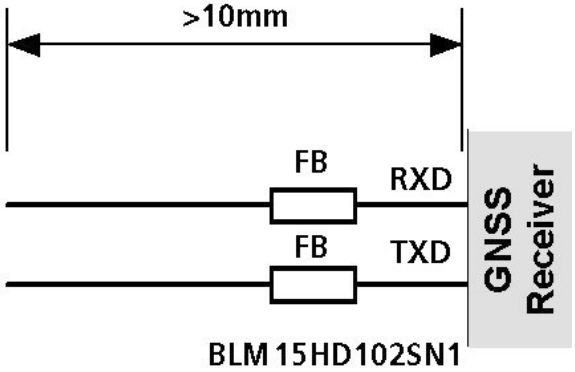


Figure 3 shows an example of EMI protection measures on the RXD/TXD line using a ferrite bead. For more information, see section 4.3.

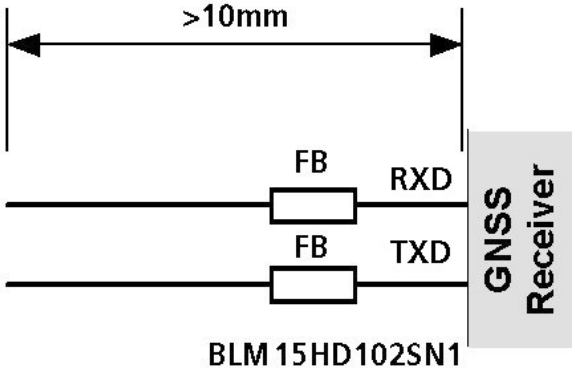


Figure 3: EMI precautions

2 Design

2.1 Pin description

Function	Pin	No.	I/O	Description	Remarks
Power	VCC	23		Supply voltage	Provide clean and stable supply.
	GND	10, 12, 13, 24		Ground	Assure a good GND connection to all GND pins of the module, preferably with a large ground plane.
	V_BCKP	22		Backup supply voltage	It is recommended to connect a backup supply voltage to V_BCKP in order to enable warm and hot start features on the positioning modules. Otherwise, connect to VCC.
	VDD_USB	7		USB power supply	To use the USB interface, connect this pin to 3.0 – 3.6 V. If no USB serial port used connect to GND.
Antenna	RF_IN	11	I	GNSS signal input from antenna	The connection to the antenna must be routed on the PCB. Use a controlled impedance of 50 Ω to connect RF_IN to the antenna or the antenna connector.
	VCC_RF	9	O	Output voltage RF section	VCC_RF can be used to power an external active antenna.
UART	TXD / SPI MISO	20	O	UART_TX/ SPI MISO	Communication interface, can be programmed as TX_READY for DDC interface. If pin 2 low => SPI MISO.
	RXD / SPI MOSI	21	I	UART_RX / SPI MOSI	Serial input. Internal pull-up resistor to VCC. Leave open if not used. If pin 2 low => SPI MOSI.
USB	USB_DM	5	I/O	USB I/O line	USB bidirectional communication pin. Leave open if unused.
	USB_DP	6	I/O	USB I/O line	
System	TIMEPULSE TIMEPULSE1 (NEO-M8T)	3	O	Timepulse signal	Configurable Timepulse signal (one pulse per second by default). Leave open if not used.
	SAFEBOOT_N TP2 / SAFEBOOT_N (NEO-M8T)	1	I	SAFEBOOT_N	SAFEBOOT_N, leave OPEN
			I/O	TP2 / SAFEBOOT_N	Configurable Timepulse2 signal SAFEBOOT_N, leave open if not used. Do not pull low during reset.
	EXTINT EXTINT0 (NEO-M8T)	4	I	External interrupt	External interrupt pin. Internal pull-up resistor to VCC. Leave open if not used. Function is disabled by default.
	RESERVED EXTINT1 (NEO-M8T)	15	-	Reserved	Leave open.
			I	External interrupt	External interrupt pin. Internal pull-up resistor to VCC. Leave open if not used. Function is disabled by default.
	SDA / SPI CS_N	18	I/O	DDC data / SPI CS_N	DDC data. If pin 2 low => SPI chip select.
	SCL / SPI CLK	19	I	DDC Clock / SPI SCK	DDC Clock. If pin 2 low => SPI clock.
	LNA_EN	14	O	LNA_EN	Antenna control can be used to turn on and off an optional external LNA.
	RESERVED (NEO-M8M)				
			-	Reserved	Leave open.
	RESET_N	8	I	Reset input	Reset input
	D_SEL	2	I	Selects the interface	Allow selecting UART/DDC or SPI open-> UART/DDC; low->SPI
	RESERVED	16, 17	-	Reserved	Leave open.

Table 2: NEO-8Q and NEO-M8 series pinout

2.1.1 Pin name changes

Selected pin names have been updated to agree with a common naming convention across u-blox modules. The pins have not changed their operation and are the same physical hardware but with updated names. The table below lists the pins that have a changed name along with their old and new names.

No.	Previous name	New name
14	ANT_ON	LNA_EN
20	TxD SPI MISO	TXD / SPI MISO
21	RxD SPI MOSI	RXD / SPI MOSI

Table 3: Pin name changes

2.2 Minimal design

This is a minimal design for a NEO-8Q and NEO-M8 series GNSS receiver.

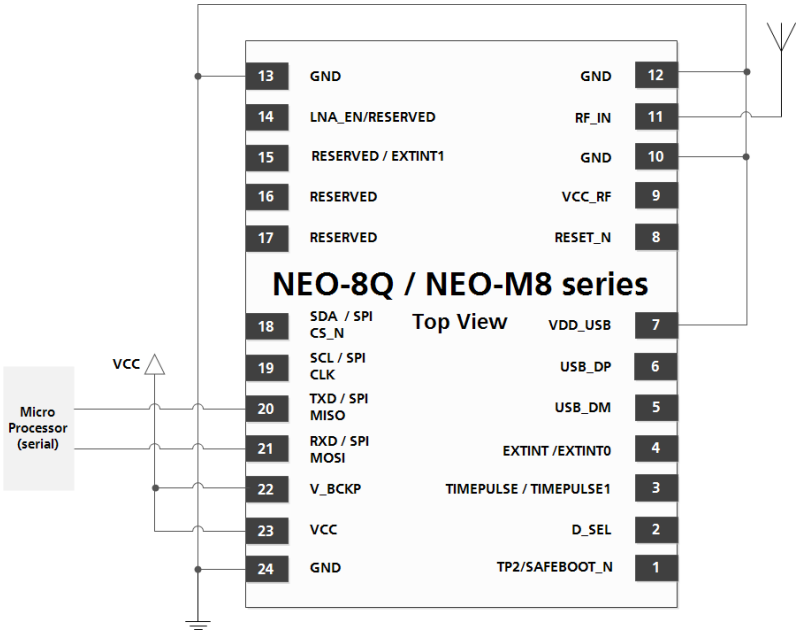


Figure 4: NEO-8Q / NEO-M8 passive antenna design

☞ NEO-M8M can support passive antenna, but for optimal operation it requires an external SAW and LNA, see Figure 7.

2.3 Layout: Footprint and paste mask

Figure 5 describes the footprint of the NEO-8Q and NEO-M8 series modules and provides recommendations (not specifications) for the paste mask Note that the copper and solder masks have the same size and position.

To improve the wetting of the half vias, reduce the amount of solder paste under the module and increase the volume outside of the module by defining the dimensions of the paste mask to form a T-shape (or equivalent) extending beyond the copper mask. For the stencil thickness, see section 4.2.

Consider the paste mask outline when defining the minimal distance to the next component. The exact geometry, distances, stencil thicknesses and solder paste volumes must be adapted to the specific production processes (e.g. soldering) of the customer.

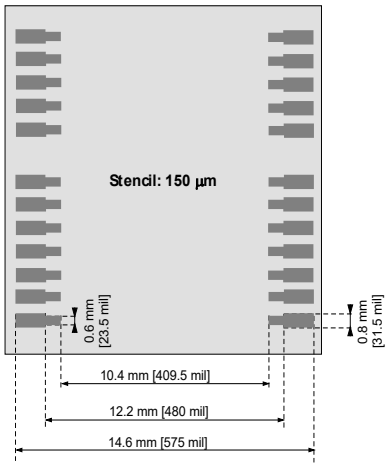
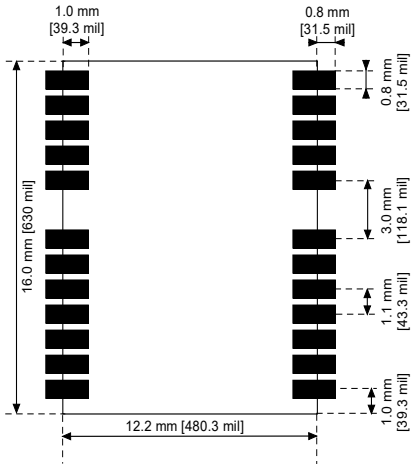


Figure 5: NEO-8Q and NEO-M8 series paste mask



NEO-8Q and NEO-M8 series footprint

2.4 Antenna

2.4.1 Antenna design with passive antenna

A design using a passive antenna requires more attention to the layout of the RF section. Typically, a passive antenna is located near electronic components; therefore, care should be taken to reduce electrical noise that may interfere with the antenna performance. Passive antennas do not require a DC bias voltage and can be directly connected to the RF input pin **RF_IN**. Sometimes, they may also need a passive matching network to match the impedance to 50 Ω.

Use an antenna that has sufficient bandwidth to receive all GNSS constellations. See the Appendix.

Figure 6 shows a minimal setup for a design with a good GNSS patch antenna. For exact pin orientation, see the corresponding product data sheet.

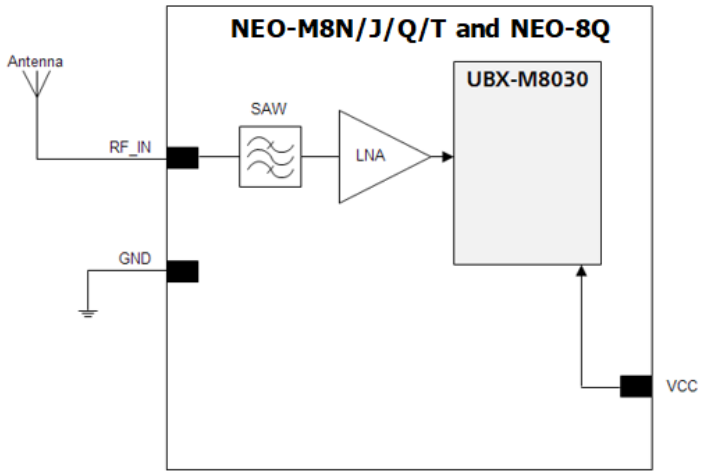


Figure 6: NEO-M8N/J/T/Q and NEO-8Q passive antenna design

Figure 7 and Figure 8 show designs using an external LNA and SAW to increase the sensitivity for optimum performance with passive antenna. For exact pin orientation, see the corresponding product data sheet.

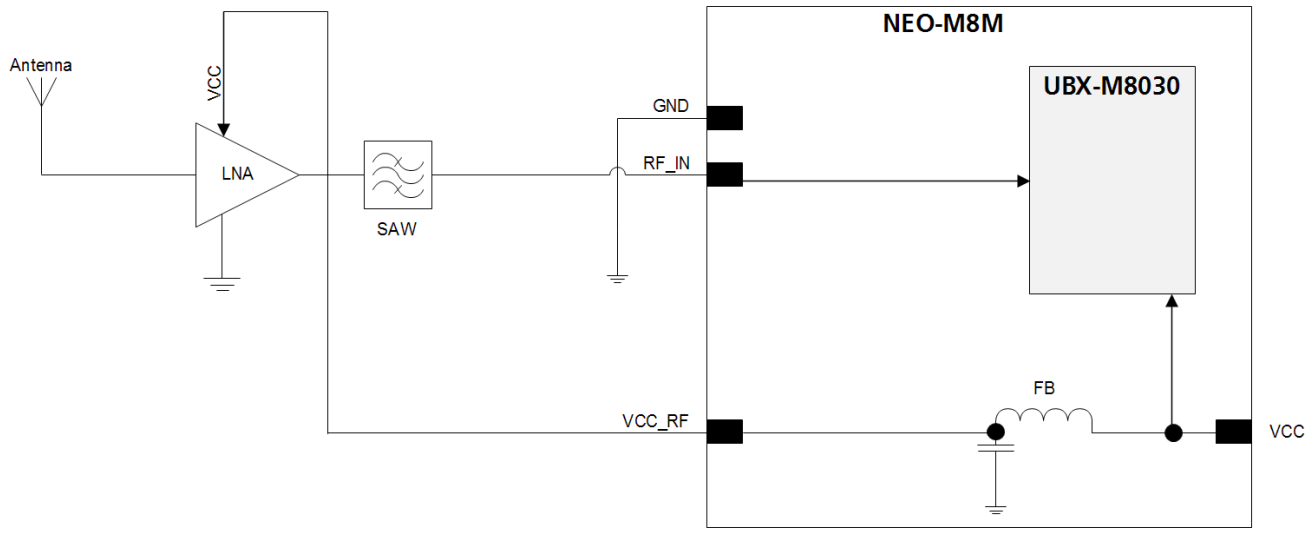


Figure 7: NEO-M8M module design with passive antenna, external LNA and SAW filter

The **VCC_RF** output can be used to supply the LNA with a filtered supply voltage.

An external LNA is only required if the antenna is far away. In that case, the LNA must be placed close to the passive antenna.

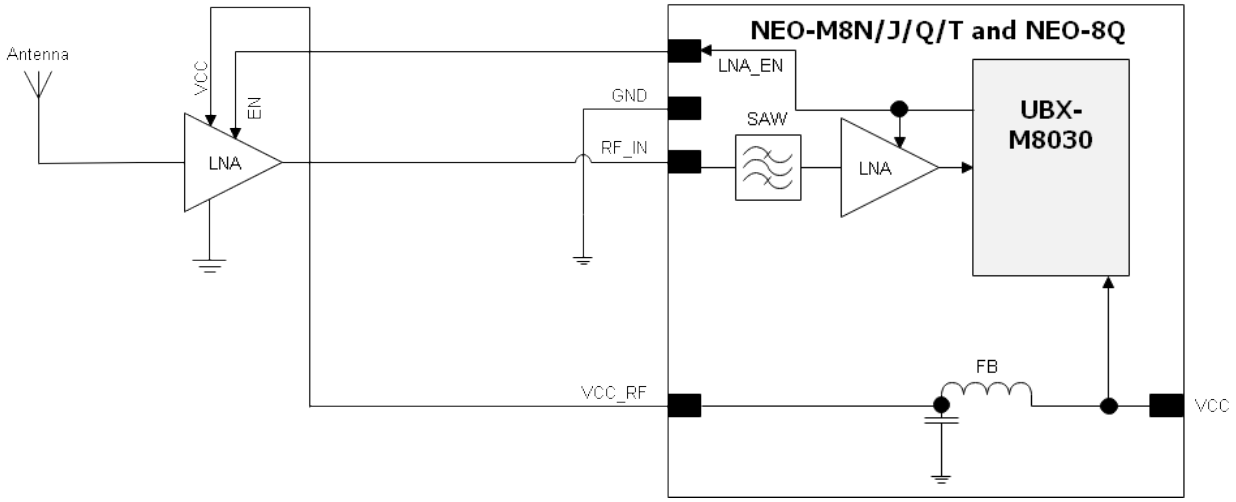


Figure 8: NEO-M8N/J/T/Q and NEO-8Q module design with passive antenna and an external LNA

The **LNA_EN** pin (LNA enable) can be used to turn on and off an optional external LNA.

The **VCC_RF** output can be used to supply the LNA with a filtered supply voltage.

A standard GNSS LNA has enough bandwidth to amplify GPS/GLONASS/Galileo/BeiDou signals.

An external LNA is only required if the antenna is far away. In that case the LNA must be placed close to the passive antenna.

2.4.2 Active antenna design

Active antennas have an integrated low-noise amplifier. Active antennas require a power supply that will contribute to the total GNSS system power consumption budget with additional 5 to 20 mA typically.

For maximum external gain see the corresponding product data sheet.

If the supply voltage of the NEO-8Q / NEO-M8 receiver matches the supply voltage of the antenna (e.g. 3.0 V), use the filtered supply voltage available at pin **VCC_RF** as shown in Figure 9. For exact pin orientation, see the corresponding product data sheet.

Active antenna design using VCC_RF pin to supply the active antenna

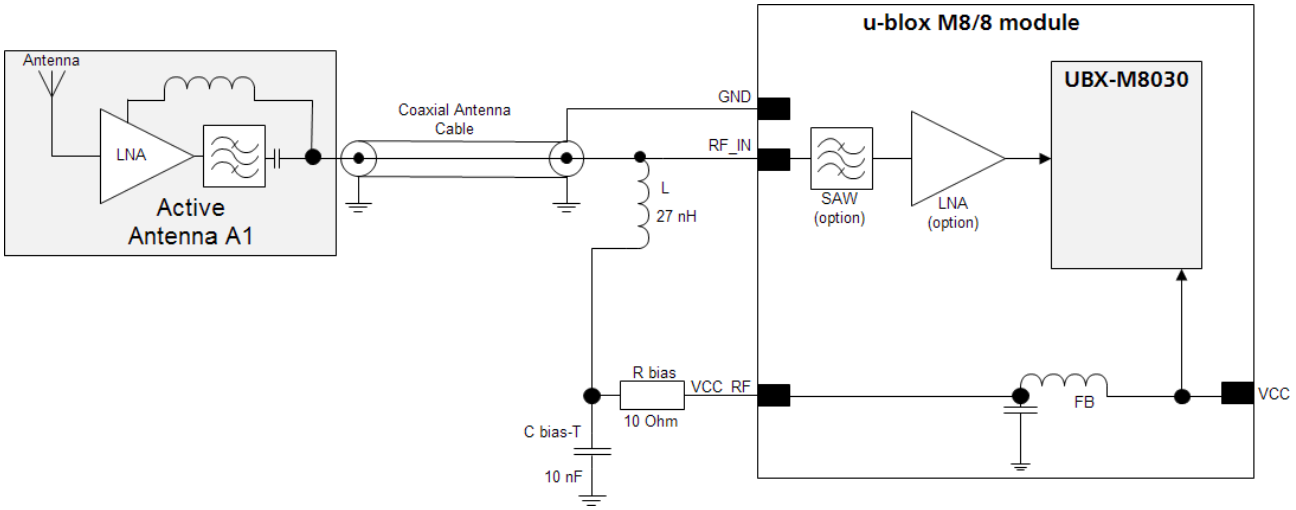


Figure 9: Active antenna design, external supply from VCC_RF

If the **VCC_RF** voltage does not match the supply voltage of the active antenna, use a filtered external supply, as shown in Figure 10. For the exact pin orientation, see the corresponding product data sheet.

Active antenna design powered from external supply

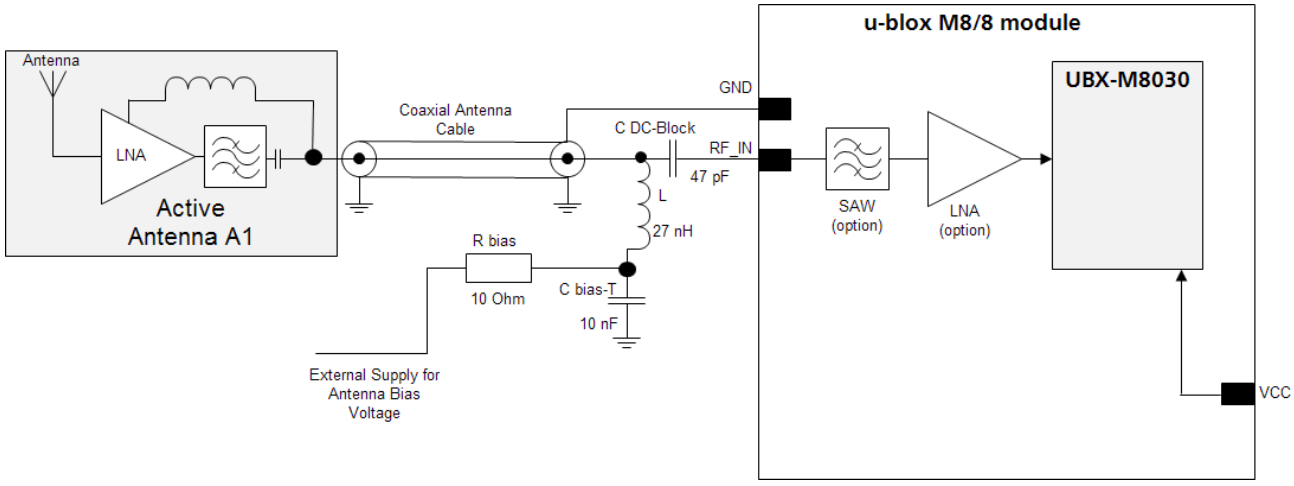


Figure 10: Active antenna design, direct external supply

☞ The circuit shown in **Figure 10** works with all u-blox M8 modules, and with modules without **VCC_RF** output.

2.5 Layout design-in: Thermal management

During design-in, do not place the module near sources of heating or cooling. The receiver oscillator is sensitive to sudden changes in ambient temperature which can adversely impact satellite signal tracking. Sources can include co-located power devices, cooling fans or thermal conduction via the PCB. Consider the following questions when designing in the module.

- Is the receiver placed away from heat sources?
- Is the receiver placed away from air-cooling sources?
- Is the receiver shielded by a cover/case to prevent the effects of air currents and rapid environmental temperature changes?

⚠ High temperature drift and air vents can affect the GNSS performance. For best performance, avoid high temperature drift and air vents near the module.

3 Migration to u-blox 8 / M8 modules

3.1 Migrating u-blox 7 designs to NEO-8Q and NEO-M8 series modules

u-blox is committed to ensuring that products in the same form factor are backwards compatible over several technology generations. Utmost care has been taken to ensure there is no negative impact on function or performance and to make NEO-8Q and NEO-M8 series modules as fully compatible as possible with u-blox 7 modules. If using BeiDou, check the bandwidth of the external RF components and the antenna. For information about power consumption, see the corresponding product data sheet.

It is highly advisable that customers consider a design review with the u-blox support team to ensure the compatibility of key functionalities.

☞ Selected pin names have been updated to agree with a common naming convention across u-blox modules. The pins have not changed their operation and are the same physical hardware but with updated names.

3.2 Hardware migration of NEO-6 to NEO-8Q and NEO-M8 series

Pin	NEO-6		NEO-8Q and NEO-M8 series		Remarks for migration
	Pin name	Typical assignment	Pin name	Typical assignment	
1	SAFEBOOT_N	Leave open	SAFEBOOT_N	Leave open	No difference
2	SS_N	SPI slave select	D_SEL	Selects the interface	-> Various functions, compatible only when not using SPI for communication.
3	TIMEPULSE 1	Timepulse 1 (1PPS)	TIMEPULSE/ TIMEPULSE1	Timepulse1	No difference
4	EXTINT0	External interrupt pin	EXTINT/ EXTINT0	External interrupt	No difference
5	USB_DM	USB data	USB_DM	USB data	No difference
6	USB_DP	USB data	USB_DP	USB data	No difference
7	VDD_USB	USB supply	VDD_USB	USB supply	No difference
8	RESERVED	Pin 8 and 9 must be connected	RESET_N	Reset	If pin 8 is connected directly to pin 9, the RESET_N function is not available. If the RESET_N function shall be used, a 3k3 resistor from pin 8 to pin 9 in conjunction with an open drain buffer is required for u-blox 6. For NEO-8Q / NEO-M8 modules pin 8 can be connected to pin 9 or can be left open. Do not populate the 3k3 resistor. Behavior of RESET_N has changed; For u-blox 7 and M8, a RESET_N will erase the time information in the BBR, which was maintained in u-blox 6. Therefore, with u-blox 7 and M8 a RESET_N will not result in a hot start, etc.
9	VCC_RF	Can be used for active antenna or external LNA supply	VCC_RF	Can be used for active antenna or external LNA supply	No difference
10	GND	GND	GND	GND	No difference

Pin	NEO-6		NEO-8Q and NEO-M8 series		Remarks for migration
	Pin name	Typical assignment	Pin name	Typical assignment	
11	RF_IN	GNSS signal input	RF_IN	GNSS signal input	No difference
12	GND	GND	GND	GND	No difference
13	GND	GND	GND	GND	No difference
14	MOSI/ CFG_COM0	SPI MOSI / configuration pin. Leave open if not used.	LNA_EN	Used to turn an optional external LNA on and off	LNA_EN (Active Antenna Control) can be used to turn an optional external LNA on and off. -> Different functions, no SPI MOSI and configuration pins with NEO-8Q / NEO-M8. If not used as default configuration, it must be set using software command! It is not possible to migrate from NEO-6 to NEO-8Q / NEO-M8 if NEO-6 pin 14 is connected to GND. In this case, migrate to NEO-M8M!
15	MISO/ CFG_COM1	SPI MISO / configuration pin. Leave open if not used.	RESERVED	Leave open	
16	CFG_GPS0/ SCK	Power mode configuration pin / SPI clock. Leave open if not used.	RESERVED	Leave open	
17	RESERVED	Leave open	RESERVED	Leave open	No difference
18	SDA	DDC data	SDA	DDC data / SPI CS_N	No difference for DDC. If pin 2 low = SPI chip select
19	SCL	DDC clock	SCL	DDC clock / SPI SCK	No difference for DDC. If pin 2 low = SPI clock
20	TxD	Serial port	TXD	UART_TX / SPI MISO	No difference for UART. If pin 2 low = SPI MISO
21	RxD	Serial port	RXD	UART_RX / SPI MOSI	No difference for UART. If pin 2 low = SPI MOSI
22	V_BCKP	Backup supply voltage	V_BCKP	Backup supply voltage	Check current in Data sheet. If in u-blox 6 module this was connected to GND, you can do the same in u-blox M8/8.
23	VCC	Supply voltage NEO-6Q / M/P/V/T: 2.7 – 3.6 V NEO-6G: 1.75 – 1.95 V	VCC	Supply voltage NEO-8Q / NEO-M8N/Q/J: 2.7 – 3.6 V NEO-M8M: 1.65 – 3.6 V	No difference for NEO-8Q / NEO-M8J/N/Q Extended supply voltage range for NEO-M8M
24	GND	GND	GND	GND	No difference

Table 4: Pin-out comparison NEO-6 vs. NEO-8Q and NEO-M8 series

Make sure that the RF path (antenna and filtering) matches that of the GNSS constellations used.

3.3 Software migration

☞ For an overall description of the module software operation, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [4].

☞ For migration, see the u-blox M8 FW SPG3.01 Migration Guide [9].

4 Product handling

4.1 Packaging, shipping, storage and moisture preconditioning

For information pertaining to reels and tapes, moisture sensitivity levels (MSL), shipment and storage information, as well as drying for preconditioning see the corresponding product data sheet.

Population of modules

☞ When populating the modules, make sure that the pick and place machine is aligned to the copper pins of the module and not on the module edge.

4.2 Soldering

Soldering paste

Use of "No Clean" soldering paste is highly recommended, as it does not require cleaning after the soldering process. The paste in the example below meets these criteria.

Soldering paste:	OM338 SAC405 / Nr.143714 (Cookson Electronics)
Alloy specification:	Sn 95.5/ Ag 4/ Cu 0.5 (95.5% tin/ 4% silver/ 0.5% copper)
Melting temperature:	+217 °C
Stencil thickness:	see section 2.3

The final choice of the soldering paste depends on the approved manufacturing procedures.

The paste-mask geometry for applying soldering paste should meet the recommendations.

☞ The quality of the solder joints on the connectors ('half vias') should meet the appropriate IPC specification.

Reflow soldering

A convection type-soldering oven is highly recommended over the infrared type radiation oven. Convection-heated ovens allow precise control of the temperature, and all parts will heat up evenly, regardless of material properties, thickness of components and surface color.

As a reference, see the "IPC-7530 Guidelines for temperature profiling for mass soldering (reflow and wave) processes", published in 2001.

Preheat phase

During the initial heating of component leads and balls, residual humidity will be dried out. Note that this preheat phase will not replace prior baking procedures.

- Temperature rise rate: max. 3 °C/s. If the temperature rise is too rapid in the preheat phase, it may cause excessive slumping.
- Time: 60 – 120 s. If the preheat is insufficient, rather large solder balls tend to be generated. Conversely, if performed excessively, fine balls and large balls will be generated in clusters.
- End temperature: 150 – 200 °C. If the temperature is too low, non-melting tends to be caused in areas containing large heat capacity.

Heating/ Reflow phase

The temperature rises above the liquidus temperature of 217 °C. Avoid a sudden rise in temperature as the slump of the paste could become worse.

- Limit time above 217 °C liquidus temperature: 40 – 60 s

- Peak reflow temperature: 245 °C

Cooling phase

A controlled cooling avoids negative metallurgical effects of the solder (solder becomes more brittle) and possible mechanical tensions in the products. Controlled cooling helps to achieve bright solder fillets with a good shape and low contact angle.

- Temperature fall rate: max 4 °C/s

☞ To avoid falling off, place the u-blox module on the topside of the motherboard during soldering.

The final soldering temperature chosen at the factory depends on additional external factors like choice of soldering paste, size, thickness and properties of the base board. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

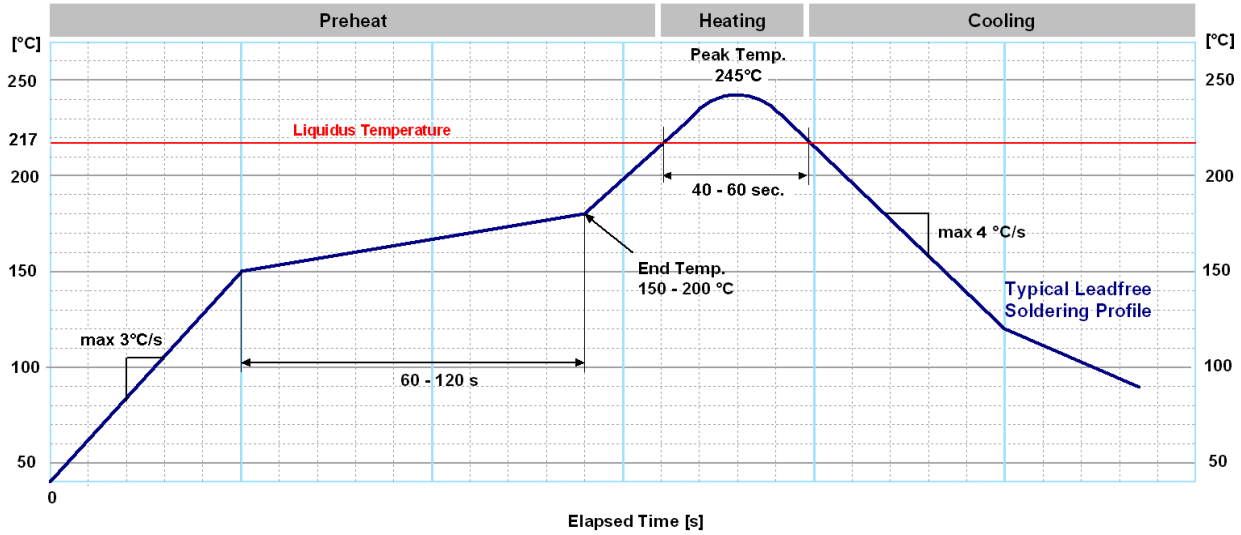


Figure 11: Recommended soldering profile

☞ u-blox modules **must not** be soldered with a damp heat process.

Optical inspection

After soldering the u-blox module, consider an optical inspection step to check whether:

- The module is properly aligned and centered over the pads
- All pads are properly soldered
- No excess solder has created contacts to neighboring pads, or possibly to pad stacks and vias nearby

Cleaning

In general, cleaning the populated modules is strongly discouraged. Residues underneath the modules cannot be easily removed with a washing process.

- Cleaning with water will lead to capillary effects where water is absorbed into the gap between the baseboard and the module. The combination of residues of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pads.
- Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into the two housings, areas that are not accessible for post-wash inspections. The solvent will also damage the sticker and the ink-jet printed text.
- Ultrasonic cleaning will permanently damage the module, in particular the quartz oscillators.

The best approach is to use a “no clean” soldering paste and eliminate the cleaning step after the soldering.

Repeated reflow soldering

Only single reflow soldering processes are recommended for boards populated with u-blox modules. To avoid upside down orientation during the second reflow cycle, do not submit u-blox modules to two reflow cycles on a board populated with components on both sides. In such a case, place the module on the side of the board which is submitted into the last reflow cycle. This is because of the risk of the module falling off due to the significantly higher weight in relation to other components.

Two reflow cycles can be considered by excluding the above described upside down scenario and taking into account the rework conditions described in section Product handling.

☞ Repeated reflow soldering processes and soldering the module upside down are not recommended.

Wave soldering

Base boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices require wave soldering to solder the THT components. Only a single wave soldering process is encouraged for boards populated with u-blox modules.

Hand soldering

Hand soldering is allowed. Use a soldering iron temperature setting equivalent to 350 °C. Place the module precisely on the pads. Start with a cross-diagonal fixture soldering (for example, pins 1 and 15), and continue from left to right.

Rework

The u-blox module can be unsoldered from the baseboard using a hot air gun. When using a hot air gun for unsoldering the module, a maximum of one reflow cycle is allowed. In general, we do not recommend using a hot air gun because this is an uncontrolled process and might damage the module.

⚠ Attention: use of a hot air gun can lead to overheating and severely damage the module. Always avoid overheating the module.

After the module is removed, clean the pads before placing and hand soldering a new module.

⚠ Never attempt a rework on the module itself, for example, replacing individual components. Such actions immediately terminate the warranty.

In addition to the two reflow cycles, manual rework on particular pins by using a soldering iron is allowed. Manual rework steps on the module can be done several times.

Conformal coating

Certain applications employ a conformal coating of the PCB using HumiSeal® or other related coating products. These materials affect the HF properties of the GNSS module and it is important to prevent them from flowing into the module. The RF shields do not provide 100% protection for the module from coating liquids with low viscosity; apply the coating carefully.

☞ Conformal coating of the module will void the warranty.

Casting

If casting is required, use viscose or another type of silicon pottant. The OEM is strongly advised to qualify such processes in combination with the u-blox module before implementing this in the production.

☞ Casting will void the warranty.

Grounding metal covers

Attempts to improve grounding by soldering ground cables, wick or other forms of metal strips directly onto the EMI covers is done at the customer's own risk. The numerous ground pins should be sufficient to provide optimum immunity to interferences and noise.

☞ u-blox offers no warranty for damages to the modules caused by soldering metal cables or any other forms of metal strips directly onto the EMI covers.

Use of ultrasonic processes

Some components on the modules are sensitive to ultrasonic waves. Use of any ultrasonic processes (cleaning, welding, and so on) may cause damage to the GNSS receiver.

☞ u-blox offers no warranty against damages to the modules caused by any ultrasonic processes.

4.3 EOS/ESD/EMI precautions

When integrating GNSS positioning modules into wireless systems, consider electromagnetic and voltage susceptibility issues carefully. Wireless systems include components that can produce electrical overstress (EOS) and electro-magnetic interference (EMI). CMOS devices are more sensitive to such influences because their failure mechanism is defined by the applied voltage, whereas bipolar semiconductors are more susceptible to thermal overstress. The following design guidelines help in designing robust yet cost-effective solutions.

⚠ To avoid overstress damage during production or in the field, observe strict EOS/ESD/EMI handling and protection measures.

⚠ To prevent overstress damage at the RF_IN of your receiver, never exceed the maximum input power (see the corresponding product data sheet).

Electrostatic discharge (ESD)

Electrostatic discharge (ESD) is the sudden and momentary electric current that flows between two objects at different electrical potentials caused by direct contact or induced by an electrostatic field. The term is usually used in the electronics and other industries to describe momentary unwanted currents that may cause damage to electronic equipment.

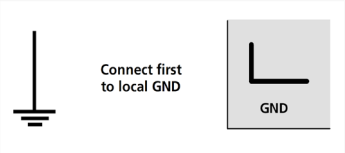


ESD handling precautions

ESD prevention is based on establishing an electrostatic protective area (EPA). The EPA can be a small working station or a large manufacturing area. The main principle of the EPA is that there are no highly charging materials near ESD-sensitive electronics, all conductive materials are grounded, workers are grounded, and charge build-up on ESD sensitive electronics is prevented. International standards are used to define typical EPA and can be obtained, for example, from International Electrotechnical Commission (IEC) or American National Standards Institute (ANSI).

GNSS positioning modules are sensitive to ESD and require special precautions when handling. Due to the risk of electrostatic charges, take particular care when handling patch antennas. In addition to standard ESD safety practices, take the following measures into account whenever handling the receiver.

- Unless there is a galvanic coupling between the local GND (i.e. the work table) and the PCB GND, the first point of contact when handling the PCB must always be between the local GND and PCB GND.



- Before mounting an antenna patch, connect ground of the device.
- When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges (e.g. patch antenna ~10 pF, coax cable ~50 – 80 pF/m, soldering iron).
- To prevent electrostatic discharge through the RF input, do not touch any exposed antenna area. If there is any risk that such exposed antenna area is touched in a non-ESD protected work area, implement proper ESD protection measures in the design.
- When soldering RF connectors and patch antennas to the receiver's RF pin, make sure to use an ESD safe soldering iron (tip).



⚠ Failure to observe these precautions can result in severe damage to the GNSS module!

ESD protection measures

⚠ GNSS positioning modules are sensitive to electrostatic discharge (ESD). Special precautions are required when handling.

☞ For more robust designs, employ additional ESD protection measures. Using an LNA with appropriate ESD rating can provide enhanced GNSS performance with passive antennas and increases ESD protection.

Most defects caused by ESD can be prevented by following strict ESD protection rules for production and handling. When implementing passive antenna patches or external antenna connection points, additional ESD measures can also avoid failures in the field as shown in Figure 12.

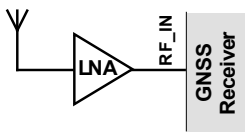
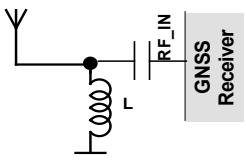
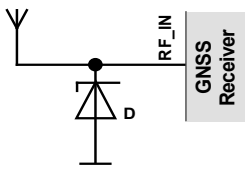
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas**
A  LNA with appropriate ESD rating	B 	C 

Figure 12: ESD precautions

☞ Protection measure A is preferred because it offers the best GNSS performance and best level of ESD protection.

Electrical Overstress (EOS)

Electrical overstress (EOS) usually describes situations where the maximum input power exceeds the maximum specified ratings. EOS failure can happen if RF emitters are close to a GNSS receiver or its antenna. EOS causes damage to the chip structures. If the RF_IN is damaged by EOS, it is hard to determine whether the chip structures have been damaged by ESD or EOS.

EOS protection measures

☞ For designs with GNSS positioning modules and wireless (for example, cellular) transceivers in close proximity, ensure sufficient isolation between the wireless and GNSS antennas. If wireless power output causes the specified maximum power input at the GNSS RF_IN to be exceeded, employ EOS protection measures to prevent overstress damage.

For robustness, EOS protection measures as shown in Figure 13 are recommended for designs combining wireless communication transceivers (for example, cellular) and GNSS in the same design or in close proximity.

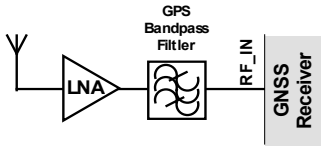
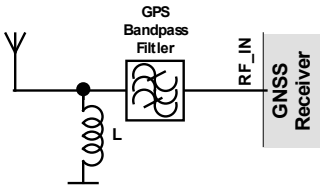
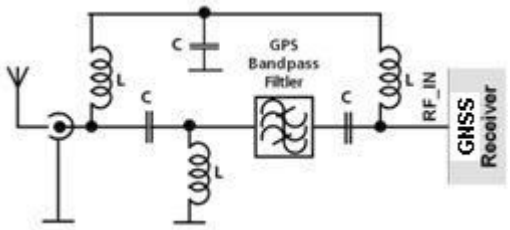
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas** (without internal filter which need the module antenna supervisor circuits)
D 	E 	F 
LNA with appropriate ESD rating and maximum input power	GNSS band pass filter: SAW or ceramic with low insertion loss and appropriate ESD rating	

Figure 13: EOS and ESD precautions

Electromagnetic interference (EMI)

Electromagnetic interference (EMI) is the addition or coupling of energy causing a spontaneous reset of the GNSS receiver or resulting in unstable performance. In addition to EMI degradation due to self-jamming (see section 1.5) any electronic device near the GNSS receiver can emit noise that can lead to EMI disturbances or damage.

The following elements are critical regarding EMI:

- Unshielded connectors (for example, pin rows)
- Weakly shielded lines on PCB (for example, on top or bottom layer and especially at the border of a PCB)
- Weak GND concept (for example, small and/or long ground line connections)

EMI protection measures are recommended when RF emitting devices are near the GNSS receiver. To minimize the effect of EMI a robust grounding concept is essential. To achieve electromagnetic robustness, follow the standard EMI suppression techniques.

http://www.murata.com/products/emc/knowhow/index.html

http://www.murata.com/products/emc/knowhow/pdf/4to5e.pdf

Improved EMI protection can be achieved by inserting a resistor or, better yet, a ferrite bead or an inductor (see Table 6) into any unshielded PCB lines connected to the GNSS receiver. Place the resistor as close to the GNSS receiver pin as possible.

Alternatively, feed-through capacitors with good GND connection can be used to protect, for example, the **VCC** supply pin against EMI. A selection of feed-through capacitors is listed in Table 6.

Intended use

☞ To mitigate any performance degradation of a radio equipment under EMC disturbance, system integration shall adopt appropriate EMC design practice and not contain cables over three meters on signal and supply ports.

4.4 Applications with cellular modules

GSM terminals transmit power levels up to 2 W (+33 dBm) peak, 3G and LTE up to 250 mW continuous. Consult the corresponding product data sheet for the absolute maximum power input at the GNSS receiver.

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [8].

Isolation between GNSS and cellular antenna

In a handheld type design, an isolation of approximately 20 dB can be reached with careful placement of the antennas. If such isolation cannot be achieved, for example, in the case of an integrated cellular /GNSS antenna, an additional input filter is needed on the GNSS side to block the high energy emitted by the cellular transmitter. Examples of these kinds of filters are the SAW Filters from Epcos (B9444 or B7839) or Murata.

Increasing interference immunity

Interference signals come from in-band and out-band frequency sources.

In-band interference

With in-band interference, the signal frequency is very close to the GNSS constellation frequency used, for example, GPS frequency of 1575 MHz (see Figure 14). Such interference signals are typically caused by harmonics from displays, micro-controller, bus systems, and so on.

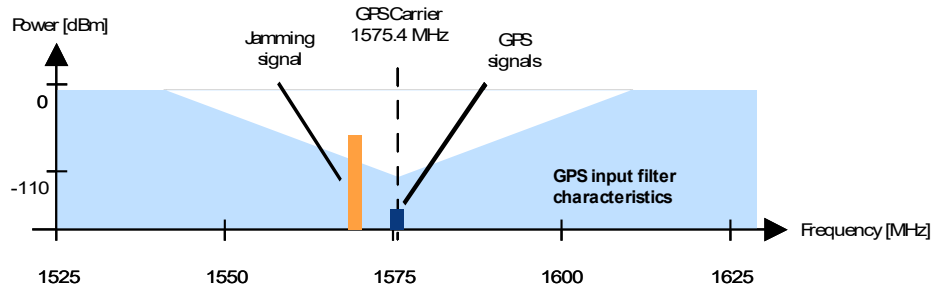


Figure 14: In-band interference signals

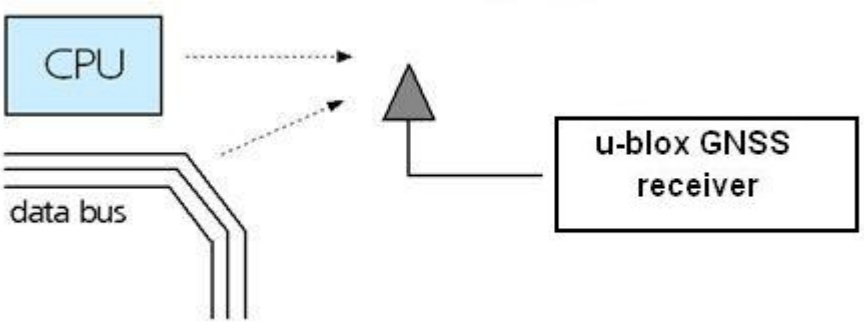


Figure 15: In-band interference sources

Measures against in-band interference include:

- Maintaining a good grounding concept in the design
- Shielding
- Layout optimization
- Filtering
- Placement of the GNSS antenna
- Adding a CDMA, cellular, WCDMA band pass filter before handset antenna

Out-band interference

Out-band interference is caused by signal frequencies that are different from the GNSS carrier (see Figure 16). The main sources are wireless communication systems such as cellular, CDMA, WCDMA, Wi-Fi, BT, etc.

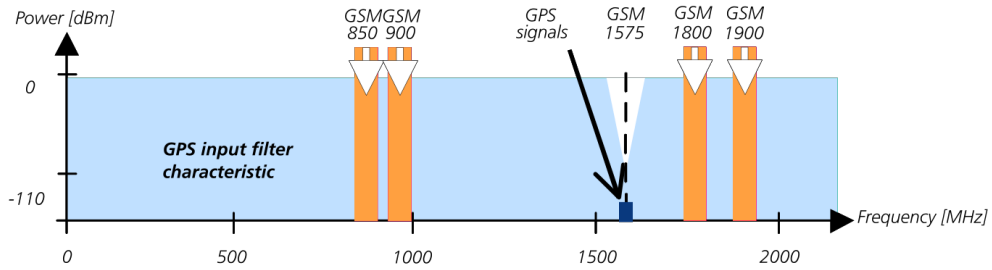


Figure 16: Out-band interference signals

Measures against out-band interference include maintaining a good grounding concept in the design and adding a SAW or band pass ceramic filter (as recommend in section 4) into the antenna input line to the GNSS receiver (see Figure 17).



Figure 17: Measures against out-band interference

For design-in recommendations in combination to cellular operation see the Appendix.

See the GPS Implementation and Aiding Features in u-blox wireless modules [8].

Appendix

A Glossary

Abbreviation	Definition
ANSI	American National Standards Institute
BeiDou	Chinese navigation satellite system
CDMA	Code Division Multiple Access
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EOS	Electrical Overstress
EPA	Electrostatic Protective Area
ESD	Electrostatic discharge
Galileo	European navigation system
GLONASS	Russian satellite system
GND	Ground
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
IEC	International Electrotechnical Commission
PCB	Printed circuit board
QZSS	Quasi-Zenith Satellite System

Table 5: Explanation of the abbreviations and terms used

B Recommended parts

Recommended parts are selected on data sheet basis only. Other components may also be used.

Part	Manufacturer	Part ID	Remarks	Parameters to consider
Diode	ON Semiconductor	ESD9R3.3ST5G	Standoff voltage>3.3 V	Low capacitance < 0.5 pF
		ESD9L3.3ST5G	Standoff voltage>3.3 V	Standoff voltage > Voltage for active antenna
		ESD9L5.0ST5G	Standoff voltage>5 V	Low inductance
SAW	TDK/ EPCOS	B8401: B39162B8401P810	GPS+GLONASS	High attenuation
	TDK/ EPCOS	B3913: B39162B3913U410	GPS+GLONASS+BeiDou	For automotive application
	TDK/ EPCOS	B4310: B39162B4310P810	GPS+GLONASS	Compliant to the AEC-Q200 standard
	ReyConns	NDF9169	GPS+BeiDou	Low insertion loss, only for mobile application
	Murata	SAFFB1G56KB0F0A	GPS+GLONASS+BeiDou	Low insertion loss, only for mobile application
	Murata	SAFEA1G58KB0F00	GPS+GLONASS	Low insertion loss, only for mobile application
	Murata	SAFEA1G58KA0F00	GPS+GLONASS	High attenuation, only for mobile application
	Murata	SAFFB1G58KA0F0A	GPS+GLONASS	High attenuation, only for mobile application

Part	Manufacturer	Part ID	Remarks	Parameters to consider
	Murata	SAFFB1G58KB0F0A	GPS+GLONASS	Low insertion loss, only for mobile application
	TAI-SAW	TA1573A	GPS+GLONASS	Low insertion loss
	TAI-SAW	TA1343A	GPS+GLONASS+BeiDou	Low insertion loss
	TAI-SAW	TA0638A	GPS+GLONASS+BeiDou	Low insertion loss
LNA	JRC	NJG1143UA2	LNA	Low noise figure, up to 15 dBm RF input power
Inductor	Murata	LQG15HS27NJ02	L, 27 nH	Impedance at freq. GPS > 500 Ω, rated current > 300mA
Capacitor	Murata	GRM1555C1E470JZ01	$C_{DC-block}$, 47 pF	DC-block
	Murata	X7R 10N 10% 16V	C_{Bias}, 10nF	Bias-T
Ferrite bead	Murata	BLM15HD102SN1	FB	High IZI @ fGSM
Feed-through capacitor for signal	Murata	NFL18SP157X1A3	Monolithic type	For data signals, 34 pF load capacitance
		NFA18SL307V1A45	Array type	For data signals, 4 circuits in 1 package
Feed-through Capacitor	Murata	NFM18PC .... NFM21P....	0603 2A 0805 4A	Rs < 0.5 Ω
Resistor		10 Ω ± 10%, min 0.250 W	R_{bias}	
		560 Ω ± 5%	R2	
		100 kΩ ± 5%	R3, R4	

Table 6: Recommended parts

Recommended antennas

Manufacturer	Order no.	Comments
Hirschmann (www.hirschmann-car.com)	GLONASS 9 M	GPS+GLONASS active
Taoglas (www.taoglas.com)	AA.160.301111	36 x 36 x 4 mm, 3-5 V 30 mA active
Taoglas (www.taoglas.com)	AA.161.301111	36 x 36 x 3 mm, 1.8 to 5.5 V / 10 mA at 3 V active
INPAQ (www.inpaq.com.tw)	B3G02G-S3-01-A	2.7 to 3.9 V / 10 mA active
Amotech (www.amotech.co.kr)	B35-3556920-2J2	35 x 35 x 3 mm GPS+GLONASS passive
Amotech (www.amotech.co.kr)	A25-4102920-2J3	25 x 25 x 4 mm GPS+GLONASS passive
Amotech (www.amotech.co.kr)	A18-4135920-AMT04	18 x 18 x 4 mm GPS+GLONASS passive
Amotech (www.amotech.co.kr)	Amotech AGA363913-S0-A1	GPS+GLONASS+ BeiDou active
INPAQ (www.inpaq.com.tw)	ACM4-5036-A1-CC-S	5.2 x 3.7 x 0.7 mm GPS+GLONASS passive
Additional antenna manufacturer: Allis Communications, 2J, Tallysman Wireless		

Table 7: Recommended antennas

Related documents

[1] NEO-M8 Data sheet (FW3), UBX-15031086
[2] NEO-8Q Data sheet, UBX-15031913
[3] NEO / LEA-M8T Data sheet (FW3), UBX-15025193
[4] u-blox 8 / u-blox M8 Receiver Description including Protocol Specification (Public version), UBX-13003221
[5] GPS Antenna Application note, GPS-X-08014
[6] GPS Compendium, GPS-X-02007
[7] I2C-bus specification, Rev. 6 - 4 April 2014, http://www.nxp.com/documents/user_manual/UM10204.pdf
[8] GPS Implementation and Aiding Features in u-blox wireless modules, GSM.G1-CS-09007
[9] u-blox M8 FW SPG3.01 Migration Guide, UBX-15028330

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Revision history

Revision	Date	Name	Comments
R01	28-Jan-2016	jfur	Advance Information
R02	17-May-2016	jfur	Pin name updated (Table 2 and Table 4, section 1.5.2, section 1.5.5 and section 1.5.7), added NEO-M8M, NEO-M8Q, NEO-M8T and NEO-8Q variants.
R03	08-Aug-2016	jfur	Production Information
R04	11-Nov-2017	msul	Added Information on RED DoC in the European Union regulatory compliance section (page 2); added Intended use case for EMI in section 4.3 EOS/ESD/EMI precautions; updated legal statement on the cover page and added Documentation feedback e-mail address in contacts page.
R05	10-Jul-2019	jesk	Clarified use of internal pull-ups in section 1.5. Clarified alternative uses for the EXTINT pin in section 1.5.2. Updated parameters for the recommended inductor in appendix B.
R06	24-Jan-2020	rmak	Updated section 3.2 Hardware migration (NEO-M8M supply voltage)
R07	26-May-2020	msul	Updated type number and PCN reference for NEO-M8N, NEO-M8Q, NEO-M8T, and NEO-8Q in page 2, added thermal management statement in section 2.5.
R08	05-May-2021	oola	Added NEO-M8J variant information, updated NEO-M8M type number and PCN reference on page 2.
R09	02-Jun-2021	imar	Updated type number and PCN reference for NEO-M8N, NEO-M8Q, and NEO-M8J in page 2.

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