POSITIONING

NEO-M8P

u-blox M8 High Precision GNSS Modules

Hardware Integration Manual

Abstract

This document provides design-in and feature information for the high-accuracy NEO-M8P modules. Base and rover module variants together provide a high precision cm-level RTK position solution. Each module contains the u-blox M8 concurrent GNSS engine for concurrent reception of GPS, GLONASS and BeiDou signals.

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Objective Specification	Document contains target values. Revised and supplementary data will be published later.
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This document applies to the following products:

Product name	Type number	ROM/FLASH version	PCN reference
NEO-M8P	NEO-M8P-0-10	Flash FW 3.01 HPG 1.20	N/A
NEO-M8P	NEO-M8P-2-10	Flash FW 3.01 HPG 1.20	N/A

Contents

1 Hardware description

1.1 Overview

The NEO-M8P modules combine the high performance u-blox M8 positioning engine with u-blox's Real Time Kinematic (RTK) technology. The NEO-M8P provides cm-level GNSS performance designed to meet the needs of unmanned vehicles and other machine control applications requiring accurate guidance.

u-blox's RTK technology introduces the concept of a "rover" (NEO-M8P-0) and a "base" (NEO-M8P-2) on the M8 platform for stunning cm-level accuracy in clear sky environments. The base module sends corrections via the RTCM protocol to the rover module via a communication link enabling the rover to output its position relative to the base at cm level accuracies.

Available in industry standard form factors in leadless chip carrier (LCC) packages, the modules 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 all product features, see the NEO-M8P Data Sheet [1].

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 [2]. 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-M8P module, the configuration can be saved permanently in SQI flash.

1.3 Connecting power

The NEO-M8P high precision GNSS modules have up to three power supply pins: **VCC**, **V_BCK 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. For this reason, it is important that the supply circuitry be able to support the peak power for a short time (see the NEO-M8P Data Sheet [1] for specification).

☞ When switching from backup mode to normal operation or at start-up, u-blox M8 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/or 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 inductors 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 of hot or warm starts. If no backup battery is connected, the module performs a cold start at power up.

☞ 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**.

☞ While power is supplied to the NEO-M8P module 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.

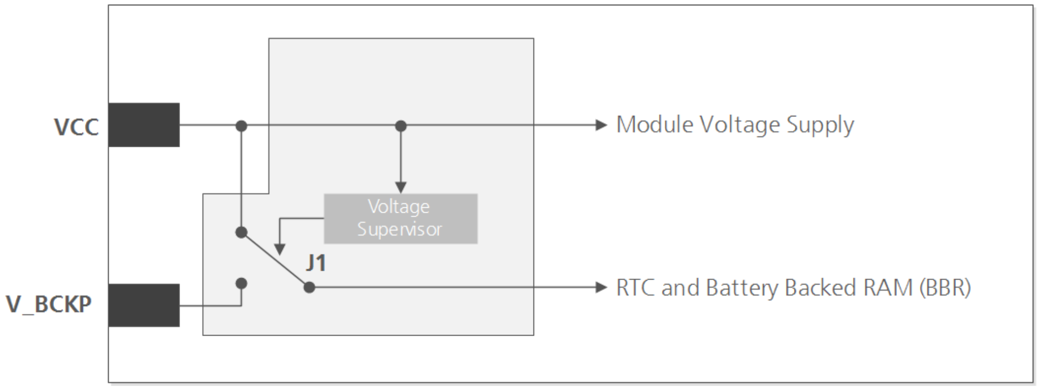


Figure 1: Backup battery and voltage (for exact pin orientation, see the *NEO-M8P Data Sheet* [1])

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 Communication interfaces

The following interfaces are used for command and control using the UBX proprietary binary protocol and for reception and transmission of a RTCM message stream when operating in RTK mode.

1.4.1 UART

NEO-M8P positioning modules include a Universal Asynchronous Receiver Transmitter (UART) serial interface **RXD/TXD** supporting configurable baud rates. The baud rates supported are specified in the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [2].

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 a Maxim MAX3232. Hardware handshake signals and synchronous operation are not supported.

1.4.2 USB

A USB version 2.0 FS (Full Speed, 12 Mb/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 operating systems (Vista, Windows 7, 8 and 10). These drivers are available for download from our website: www.u-blox.com

1.4.2.1 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 a 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 i.e. VBUS is not supplied.

☞ USB bus-powered mode is not supported.

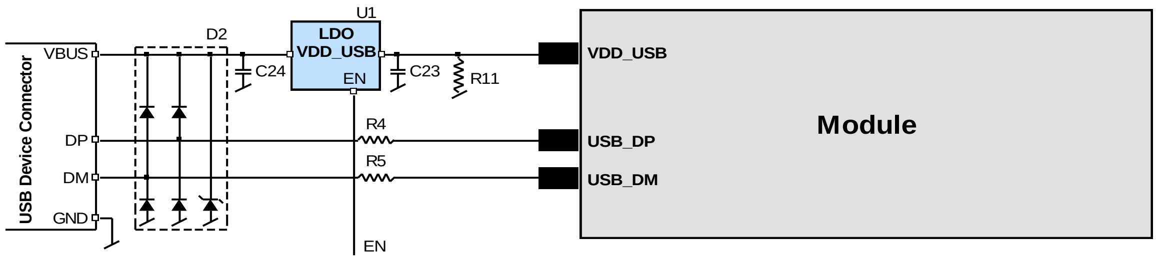


Figure 2: USB Interface

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.

Table 1: Summary of USB external components

1.4.3 Display Data Channel (DDC)

An I^2C compatible Display Data Channel (DDC) interface is available with NEO-M8P modules for serial communication with an external host CPU. The interface operates in slave mode only (master mode is not supported). The DDC protocol and electrical interface are fully compatible with the Fast-Mode of the I^2C 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 [2]. For bandwidth information, see the NEO-M8P Data Sheet [1]. For timing parameters consult the I^2C-bus specification [4].

☞ The NEO-M8P DDC interface supports serial communication with u-blox cellular modules. See the specification of the applicable cellular module to confirm compatibility.

1.4.4 SPI

An SPI interface is optionally 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 NEO-M8P Data Sheet [1].

1.4.5 TX Ready signal

The TX Ready signal indicates that 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 enables configuration of signal polarity and buffer threshold (in bytes) before the TX Ready signal goes active. The TX Ready signal can be mapped to UART 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 [5].

1.5 I/O pins

1.5.1 RESET_N: Reset input

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-M8P module **RESET_N** is an input only.

1.5.2 EXTINT: External interrupt input

EXTINT is an external interrupt pin with fixed input voltage thresholds with respect to **VCC** (see the NEO-M8P Data Sheet [1] for more information). It can be used for functions such as accurate external frequency aiding and ON/OFF control. Leave open if unused, this function is disabled by default.

1.5.3 SAFEBOOT_N: input

If the **SAFEBOOT_N** pin is "low" at power up, the NEO-M8P modules start in Safe Boot Mode and doesn't begin GNSS operation. The Safe Boot Mode can be used to recover from situations where the Flash has become corrupted.

1.5.4 D_SEL: input

The **D_SEL** pin selects the available interfaces between SPI and UART/DDC operation.

If open, the UART and DDC ports are active. If pulled low, the SPI interface is available. See the NEO-M8P Data Sheet [1].

1.5.5 LNA_EN: Antenna ON (LNA enable), output

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.

1.5.6 TIMEPULSE: output

A configurable time pulse signal is available with NEO-M8P modules. The time pulse signal is configured as one pulse per second by default. For more information on programming this function, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [2].

1.5.7 RTK_STAT: output

The **RTK_STAT** pin provides an indication of the RTK positioning status. At start up this pin is set high. When receiving a valid stream of RTCM 3 messages the pin alternates between high and low at the navigation rate, e.g. the default rate is 1Hz. It is set into a continuous low output when the receiver is operating in RTK fixed mode.

1.5.8 GEOFENCE_STAT: output

This pin indicates the current geofence status, if activated. The pin active polarity and geofence locations are preset using the UBX-NAV-GEOFENCE message allowing up to four circular areas to be defined. Once activated, the receiver continuously compares its current position with the preset geofenced areas. The pin state reflects the current Geofence status as to whether the receiver is inside any of the active areas. See the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [2] for more information.

1.5.9 Electromagnetic interference on I/O lines

Any I/O signal line with a length greater than a ~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, or lines close to the edges of the printed circuit board.

If, for example, a cellular signal radiates into an unshielded I/O line, it is possible to generate noise of the order of many volts which not only distort receiver operation but can also damage it permanently.

On the other hand, noise generated at the I/O pins will emit from unshielded I/O lines. Receiver performance can be degraded when this noise is coupled into the GNSS antenna (see Figure 14).

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

Figure 3 shows an example of EMI protection measures on the RX/TX line using a ferrite bead. More information is given in section 3.3.

Figure 3: EMI Precautions

2 Design

2.1 Pin description

Function	PIN	No	I/O	Description	Remarks
Power	**VCC**	23		Supply Voltage	Provide a 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 has to 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	Serial Port/ SPI MISO	Communication interface,. Can be programmed as TX Ready for DDC interface. If pin 2 low => SPI MISO.
	RXD / SPI MOSI	21	I	Serial Port / 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**	3	O	Timepulse Signal	Configurable Timepulse 1 signal (one pulse per second by default). Leave open if not used.
	SAFEBOOT_N	1	I		SAFEBOOT_N (for future service, updates and reconfiguration, normally leave OPEN)
	EXTINT	4	I	External Interrupt 0	External Interrupt Pin. Internal pull-up resistor to **VCC**. Leave open if not used. Function is disabled by default.
	RTK_STAT	15	O	RTK Status	Shows current RTK position status
	GEOFENCE_STAT	16	O	Geofence Status	Active if enabled, polarity programmable
	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	ANT_ON	LNA Enable can be used to turn on and off an optional external LNA or active antenna
	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	17	-	Reserved	Leave open.

Table 2: NEO-M8P 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 changed name along with their old and new names.

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

Table 3: NEO-M8P Module Pin renaming

2.2 Minimal design

This is a minimal design for a NEO-M8P GNSS receiver.

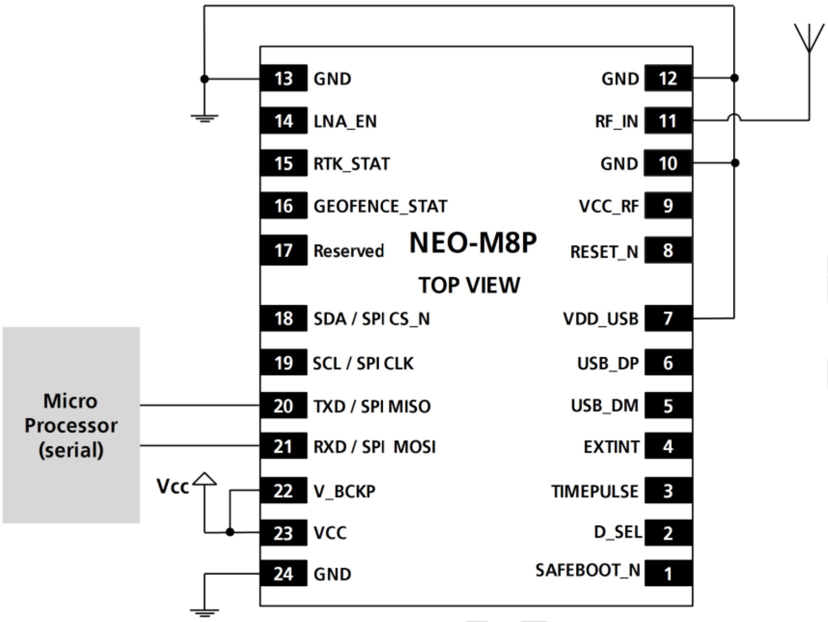


Figure 4: NEO-M8P passive antenna design

2.3 Layout: Footprint and paste mask

Figure 5 describes the footprint and provides recommendations for the paste mask for NEO-M8P LCC modules. These are recommendations only and not specifications. 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 3.2.

☞ 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.

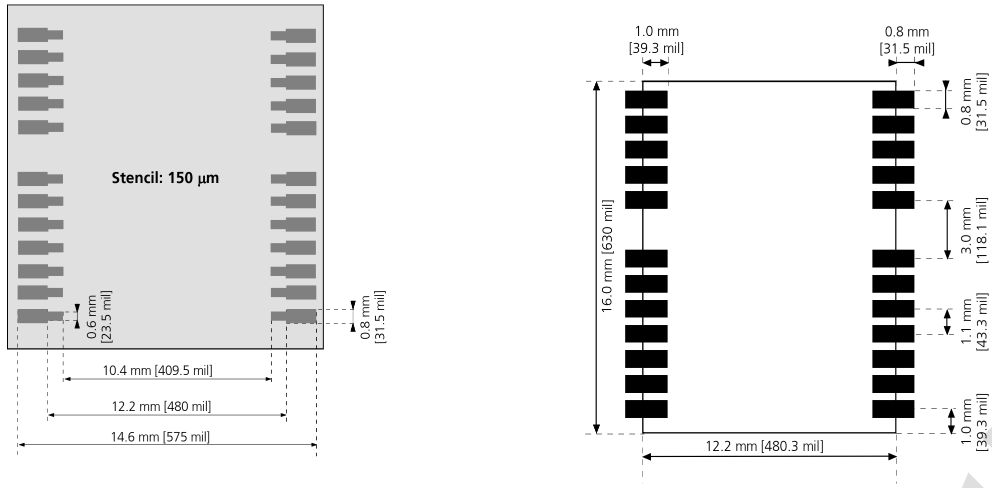


Figure 5: NEO-M8P footprint / NEO-M8P paste mask

2.4 Antenna

With RTK operation, the antenna and its placement are critical system factors, both for the Base and Rover. The minimum receiver signal strengths to track the signal phase are higher than conventional GNSS receivers, at about 34 dBHz, and require good antenna efficiency with a stable phase center. Hence, use of a relatively large ceramic patch, i.e. 25 mm square or greater will provide reasonable performance in terms of efficiency and accuracy vs. cost. For a Base station antenna installation, users should try to mitigate the effects of multi-path reception from nearby objects or buildings. Use of a ground plane will minimize the effects of ground reflections and enhance the antenna efficiency. For the Rover, use of a ground plane with a minimum diameter of 10 centimeter is recommended. It is also recommended that the Rover antenna is positioned away from any potential reflectors on the vehicle will give the best overall results. Exercise care with Rover vehicles that emit RF energy from motors etc. as interference may extend into the GNSS band and couple into the GNSS antenna suppressing the wanted signal.

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.

Figure 6 shows a minimal setup for a design with a good GNSS patch antenna.

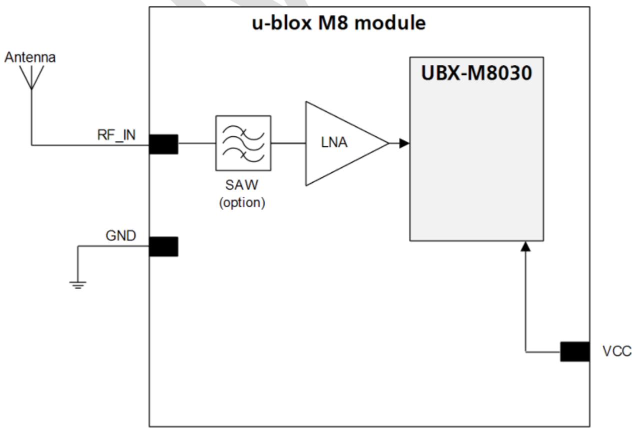


Figure 6: Module design with passive antenna (for exact pin orientation see the *NEO-M8P Data Sheet* [1])

☞ Use an antenna that has sufficient bandwidth to receive all GNSS constellations. See Appendix A.1.

Figure 7 shows a design using an external LNA to increase the sensitivity for best performance with passive antenna.

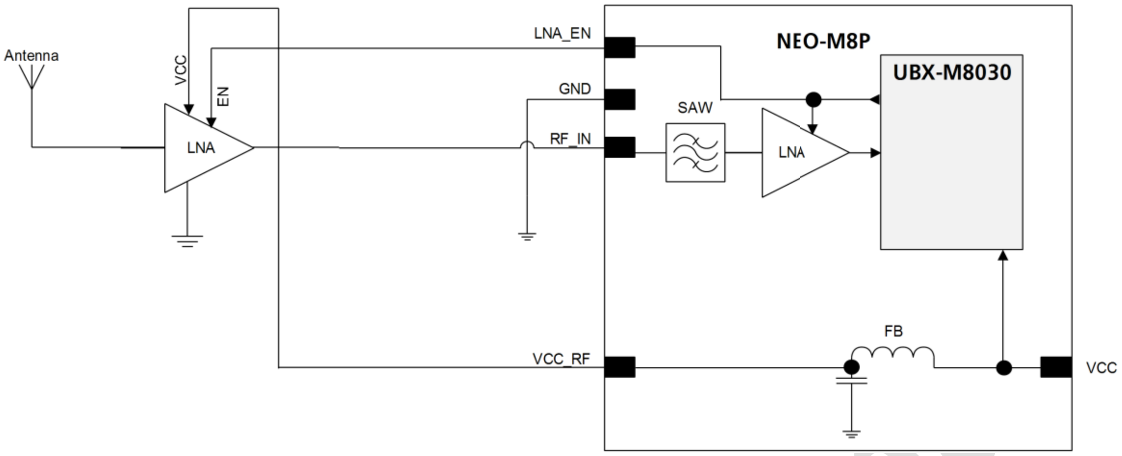


Figure 7: Module design with passive antenna and an external LNA (for exact pin orientation see the *NEO-M8P Data Sheet* [1])

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.

☞ Ensure the LNA has enough bandwidth to amplify all the required satellite signals.

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

☞ Add a SAW filter before or after the LNA to prevent any blocking issues from out-of-band signals

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.

If the supply voltage of the 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 8.

Active antenna design using VCC_RF pin to supply the active antenna

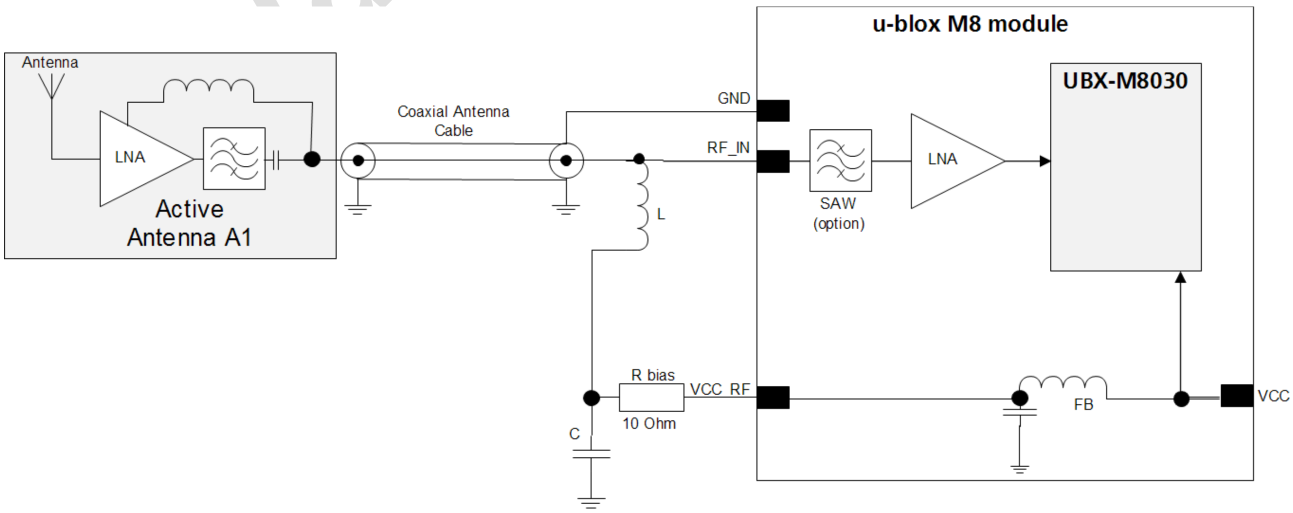


Figure 8: Active antenna design, external supply from VCC_RF (for exact pin orientation see the *NEO-M8P Data Sheet* [1])

The L,C passive component values and recommended types are given in Appendix A.1. If the **VCC_RF** voltage does not match with the supply voltage of the active antenna, use a filtered external supply as shown in Figure 9. To ensure that the maximum DC input voltage at the LNA input is not exceeded use a DC blocking capacitor (value C).

Active antenna design powered from external supply

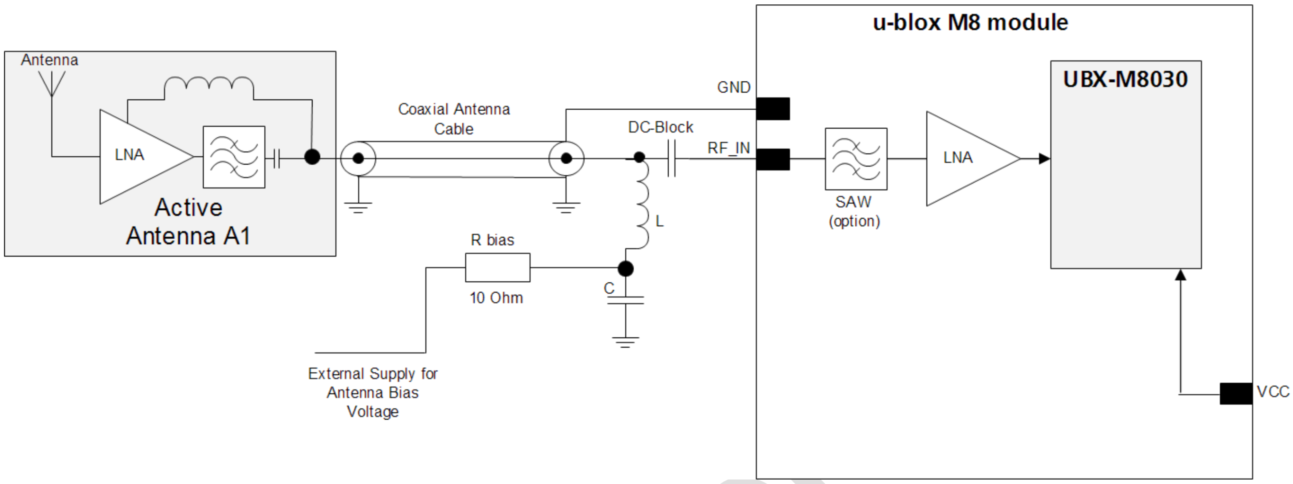


Figure 9: Active antenna design, direct external supply (for exact pin orientation see the *NEO-M8P Data Sheet* [1])

☞ The circuit shown in Figure 9 works with all u-blox M8 modules, also with modules without **VCC_RF** output.

3 Product handling

3.1 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 NEO-M8P Data Sheet [1]**.**

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.

3.2 Soldering

Soldering paste

Use of "No Clean" soldering paste is highly recommended, as it does not require cleaning after the soldering process has taken place. The paste listed 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 (solder becomes more brittle) of the solder 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, the NEO-M8P modules should be placed 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, etc. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

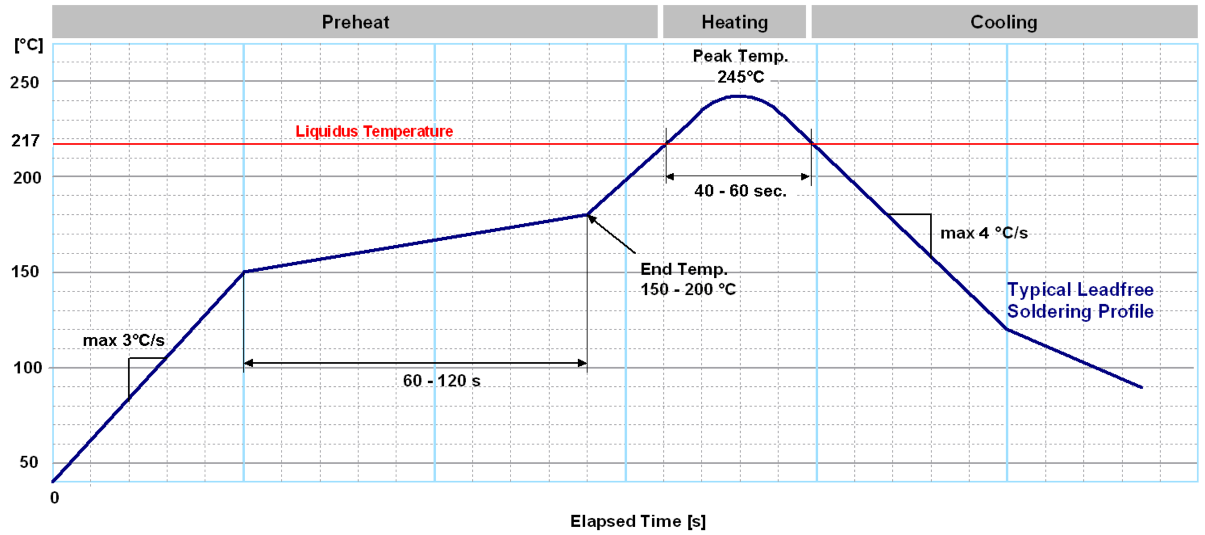


Figure 10: Recommended soldering profile

☞ NEO-M8P modules **must not** be soldered with a damp heat process.

Optical inspection

After soldering the NEO-M8P 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 in 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 NEO-M8P modules. NEO-M8P modules should not be submitted to two reflow cycles on a board populated with components on both sides in order to avoid upside down orientation during the second reflow cycle. In this case, the module should always be placed on that side of the board, which is submitted into the last reflow cycle. The reason for this (besides others) is 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 this section..

☞ 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 NEO-M8P 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 (e.g. pins 1 and 15), and then continue from left to right.

Rework

The NEO-M8P 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, e.g. 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; therefore, care is required in applying the coating.

☞ 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 NEO-M8P 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 makes no warranty for damages to the NEO-M8P module 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 NEO-M8P module are sensitive to Ultrasonic Waves. Use of any Ultrasonic Processes (cleaning, welding etc.) may cause damage to the GNSS Receiver.

☞ u-blox offers no warranty against damages to the NEO-M8P module caused by any Ultrasonic Processes.

3.3 EOS/ESD/EMI precautions

When integrating GNSS positioning modules into wireless systems, careful consideration must be given to electromagnetic and voltage susceptibility issues. 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 are provided to help in designing robust yet cost effective solutions.

⚠ **To avoid overstress damage during production or in the field it is essential to 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 *NEO-M8P Data Sheet* [1]).**

Electrostatic discharge (ESD)

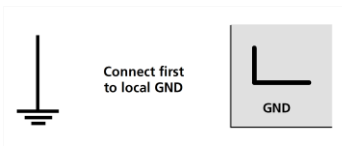
Electrostatic discharge (ESD) is the sudden and momentary electric current that flows between two objects at different electrical potentials caused by direct contact or induced by an electrostatic field. The term is usually used in the electronics and other industries to describe momentary unwanted currents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

ESD handling precautions

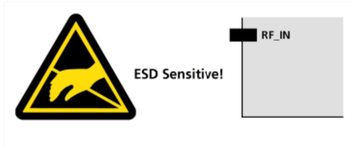
ESD prevention is based on establishing an Electrostatic Protective Area (EPA). The EPA can be a small work station or a large manufacturing area. The main principle of an EPA is that there are no highly charged materials near ESD sensitive electronics, all conductive materials are grounded, workers 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 the International Electrotechnical Commission (IEC) or American National Standards Institute (ANSI).

GNSS positioning modules are sensitive to ESD and require special precautions when handling. Particular care must be exercised when handling patch antennas, due to the risk of electrostatic charges. In addition to standard ESD safety practices, the following measures should be taken 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, then the first point of contact when handling the PCB must always be between the local GND and PCB GND.
- Ground a patch antenna before mounting.



- 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 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, then additional ESD measures can also avoid failures in the field as shown in Figure 11.

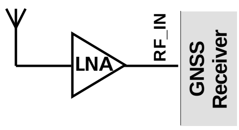
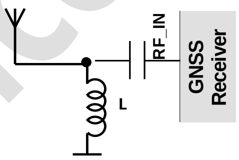
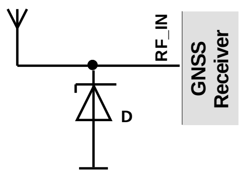
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas**
A  LNA with appropriate ESD rating	B 	C 

Figure 11: 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 when 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 circuitry 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 transceivers (e.g. GSM/GPRS) in close proximity, ensure sufficient isolation between the wireless and GNSS antennas. If the 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 12 are recommended for designs combining wireless communication transceivers (e.g. GSM, GPRS) and GNSS in the same design or in close proximity.

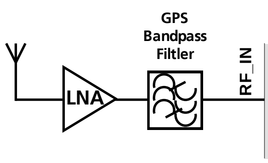
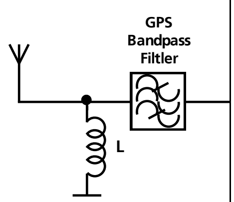
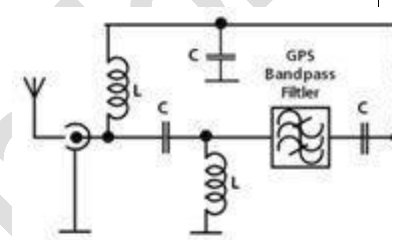
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas** (without internal filter which need the module antenna supervisor circuits)
D  	**3.3.1.1.1.1.1.1** E  3.3.1.1.1.1.1.2	3.3.1.1.1.1.2.1 F  3.3.1.1.1.1.2.2
LNA with appropriate ESD rating and maximum input power	GNSS Band pass Filter: SAW or Ceramic with low insertion loss and appropriate ESD rating	

Figure 12: 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 (e.g. pin rows etc.)
- Weakly shielded lines on PCB (e.g. on top or bottom layer and especially at the border of a PCB)
- Weak GND concept (e.g. 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 4) into any unshielded PCB lines connected to the GNSS receiver. Place the resistor as close as possible to the GNSS receiver pin.

Alternatively, feed-thru capacitors with good GND connection can be used to protect e.g. the **VCC** supply pin against EMI. A selection of feed-thru capacitors are listed in Table 4.

3.4 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 in Related documents for the absolute maximum power input at the GNSS receiver.

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [5].

Isolation between GNSS and GSM antenna

In a handheld design, an antenna isolation of approximately 20 dB can be reached with careful placement of the antennas. If this isolation factor cannot be achieved, e.g. in the case of an integrated GSM/GNSS antenna, an additional input filter is required on the GNSS side to reduce the energy coupled from the GSM transmitter. Examples of these filters are 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, e.g. GPS frequency of 1575 MHz (see Figure 13). Such interference signals are typically caused by harmonics emitted from displays, micro-controller, data-bus systems, etc.

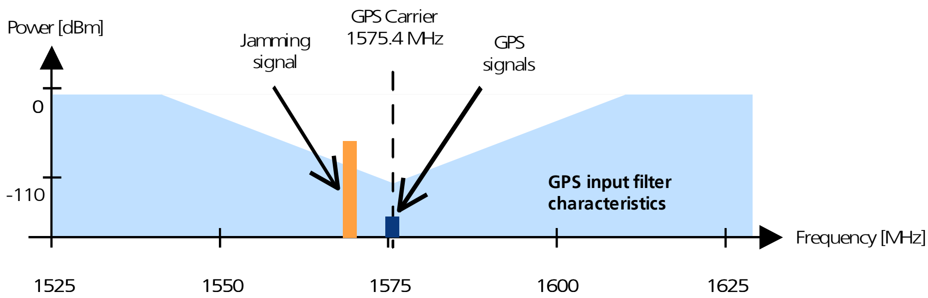


Figure 13: In-band interference signals

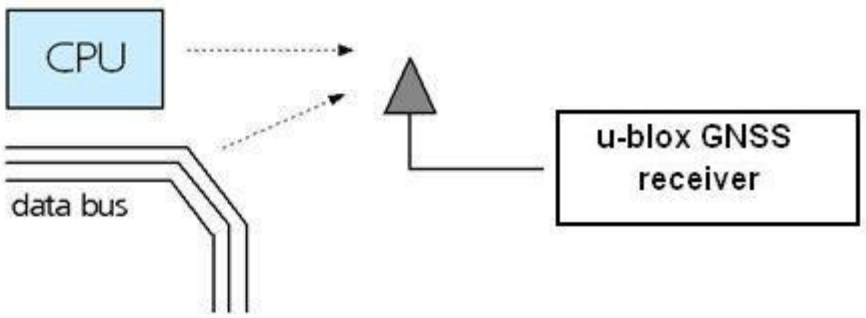


Figure 14: In-band interference sources

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, GSM, 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 15). The main sources are wireless communication systems such as GSM, CDMA, WCDMA, Wi-Fi, BT, etc.

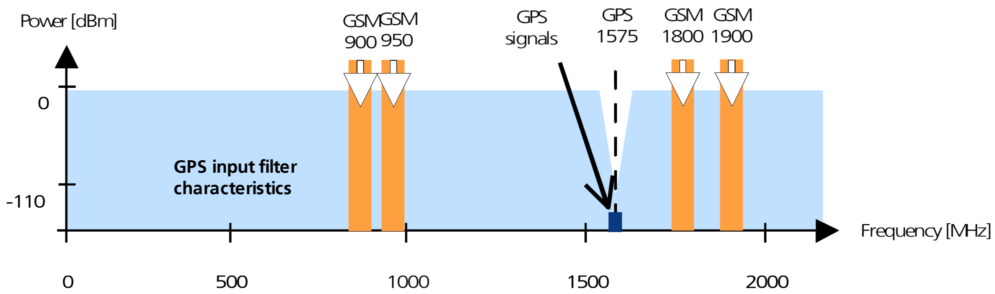


Figure 15: Out-band interference signals

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 3) into the antenna input line to the GNSS receiver (see Figure 16).

Figure 16: Measures against out-band interference

☞ For design-in recommendations in combination to Cellular operation see Appendix

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [5]

Appendix

A.1 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: B39162-B8401-P810	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
	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 @ freq GPS > 500 Ω
Capacitor	Murata	GRM1555C1E470JZ01	C, 47 pF	DC-block
Ferrite Bead	Murata	BLM15HD102SN1	FB	High IZI @ fGSM
Feed thru 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 thru 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 4: Recommended parts

Recommended antennas

Manufacturer	Order No.	Comments
Tallysman (www.tallysman.com)	TW3400/TW3402	GPS+GLONASS, 2.5-16V active, good phase center variation
Tallysman (www.tallysman.com)	TW3710	GPS+BeiDou+GLONASS, 2.5-16V active, good phase center variation
Taoglas (www.taoglas.com)	A.40.A.301111	GPS+GLONASS, 2.5-5.5V active, good axial ratio
Hirschmann (www.hirschmann-car.com)	GLONASS 9 M	GPS+GLONASS active
Taoglas (www.taoglas.com)	AA.160.301111	36*36*4 mm, 3-5V 30mA active
Taoglas (www.taoglas.com)	AA.161.301111	36*36*3 mm, 1.8 to 5.5V / 10mA at 3V 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	35x35x3 mm GPS+GLONASS passive
Amotech (www.amotech.co.kr)	A25-4102920-2J3	25x25x4 mm GPS+GLONASS passive
Additional antenna Manufacturer: Allis Communications		

Table 5: Recommend antenna

A.2 Design-in recommendations in combination with cellular operation

Product		Receiver Chain					Cellular and GNSS Simultaneous operation			
							Passive GNSS Antenna		Active GNSS Antenna	
Family	Variant	Antenna	SAW LNA	SAW	On-chip LNA	SAW	2G cellular	3G/4G cellular	2G/3G/4G cellular	
MAX-6	Any				•	•	✓		✓	✓
NEO-6	Any				•	•	✓		✓	✓
LEA-6	Any				•	•	✓		✓	✓
EVA-7	M				•				✓	✓
MAX-7	C				•		✓		✓	✓
	W				•		✓		✓	✓
	Q				•		✓		✓	✓
NEO-7	N		•		•		✓	✓	✓	✓
	M				•		✓		✓	✓
	P			•	•		✓	✓	✓	✓
EVA-M8	M				•				✓	✓
MAX-M8	C				•		✓		✓	✓
	W				•		✓		✓	✓
	Q				•		✓		✓	✓
NEO-M8	N		•		•		✓	✓	✓	✓
	M				•		✓		✓	✓
	Q		•		•		✓	✓	✓	✓
	T		•		•		✓	✓	✓	✓
	P		•		•		✓	✓	✓	✓
LEA-M8	S			•	•		✓	✓	✓	✓
	T			•	•		✓	✓	✓	✓
PAM-7	Q	•	•	•	•		✓	✓	✓	✓
CAM-M8	C	•	•		•		✓	✓	✓	✓
	Q	•	•		•		✓	✓	✓	✓

• = integrated **✓ = optimal performance**

Table 6: Combinations of u-blox GNSS modules with different cellular technologies (2G/3G/4G).

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [5]

Related documents

[1] NEO-M8P Data Sheet, Doc. No. UBX-15016656

[2] u-blox 8 / u-blox M8 Receiver Description including Protocol Specification (Public version), Doc. No. UBX-13003221, HPG 1.20 Protocol Specification Addendum, Doc. No. UBX-16004304

[3] GPS Antenna Application Note, Doc. No. GPS-X-08014

[4] I^{2}C-bus specification, Version 2.1, Jan 2000, http://www.nxp.com/acrobat_download/literature/9398/39340011_21.pdf

[5] GPS Implementation and Aiding Features in u-blox wireless modules, Doc. No. GSM.G1-CS-09007

[6] u-blox 7 to u-blox 8 / M8 Software Migration Guide, Doc. No. UBX-15031124

☞ For regular updates to u-blox documentation and to receive product change notifications, register on our homepage (http://www.u-blox.com)

Revision history

Revision	Date	Name	Status / Comments
R01	25-Feb-2016	byou	Advance Information (ES phase I)
R02	07-June-2016	byou	Advance Information for Flash FW 3.01 HPG 1.11 (ES phase II)
R03	27-Sept-2016	Byou	Advance Information for Flash FW3.01 HPG 1.20 (ES Phase III)

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