NEO-M8L

u-blox M8 automotive dead reckoning modules including 3D sensors

Hardware integration manual



Abstract

This document describes the features and specifications of NEO-M8L, a high-performance automotive dead reckoning (ADR) module with 3D sensors. The module includes the u-blox M8 concurrent GNSS engine with reception of GPS, GLONASS, BeiDou, Galileo and QZSS signals.

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This document applies to the following products:

Product name	**Type number**	**ROM/FLASH version**	**PCN/IN reference**
NEO-M8L	NEO-M8L-0-12	Flash FW3.01 ADR 4.11	UBX-17049965
NEO-M8L-04B	NEO-M8L-04B-00	Flash FW3.01 ADR 4.21	N/A
NEO-M8L-05B	NEO-M8L-05B-00	Flash FW3.01 ADR 4.31	UBX-20014805
NEO-M8L-06B	NEO-M8L-06B-00	Flash FW3.01 ADR 4.50	UBX-20053641

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1 Hardware description

1.1 Overview

The NEO-M8L modules are 3D dead reckoning GNSS receivers for automotive applications using a built-in 6-axis sensor (3-axis gyroscope and 3-axis accelerometer) and featuring the high-performance u-blox M8 concurrent positioning engine. Available in the NEO industry standard leadless chip carrier (LCC) package, they are easy to integrate and they 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 more information about the product features, see the corresponding product data sheet [1], or [2] 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 [3]). The modified settings remain effective until power-down or reset. If these settings have been stored in battery-backed RAM (BBR), then the modified configuration will be retained, as long as the backup battery supply is not interrupted.

For NEO-M8L modules, the configuration can be saved permanently in SQI flash.

1.3 Connecting power

The NEO-M8L positioning modules have up to 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 (see the corresponding product data sheet in the Related documents section for the specifications).

☞ When switching from backup mode to normal operation or at start-up, the NEO-M8L 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 startup 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.

☞ A backup supply voltage should be provided to the NEO-M8L to enable navigation by dead reckoning before the first GNSS fix.

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- 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-M8L 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.

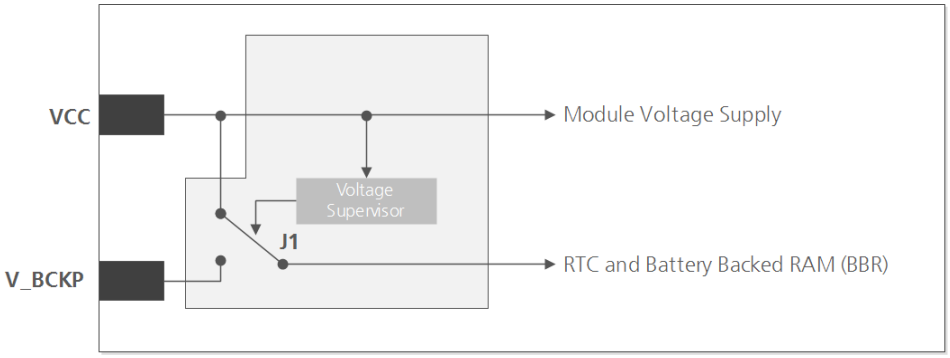


Figure 1: Backup battery and voltage (for exact pin orientation, see the corresponding product data sheet)

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

For more information about the interfaces (baud rates, bandwidth, speed and clock frequency, and so on), see the corresponding product data sheet [1], or [2] in the Related documents section.

1.4.1 UART

NEO-M8L 3D dead reckoning modules include a Universal Asynchronous Receiver Transmitter (UART) serial interface **RXD/TXD** supporting configurable baud rates.

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.

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 Vista, Windows 7, Windows 8 and Windows 10. These drivers are available at our website, 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

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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.

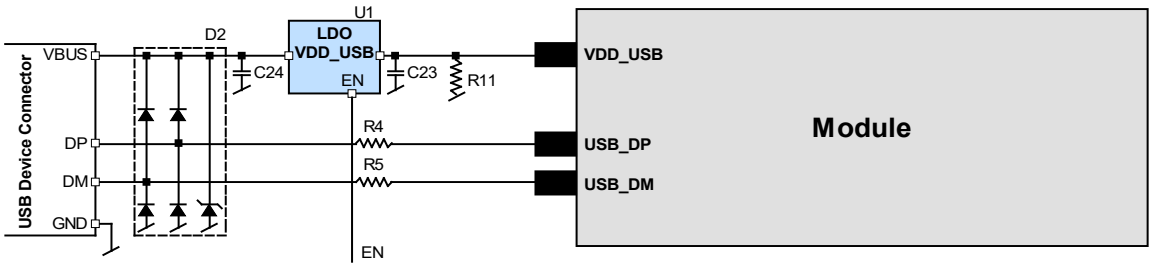


Figure 2: USB interface

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 with a NEO-M8L module 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 [3]. For timing, parameters consult the I2C-bus specification [8].

☞ The NEO-M8L 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 available for communication to a host CPU.

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☞ 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 in the Related documents section.

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 lets you configure the polarity and the number of bytes in the buffer 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 [9].

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 to reset the module only. Do not use **RESET_N** to turn the module on and off, since the reset state increases power consumption. With the NEO-M8L modules the **RESET_N pin** is an input only.

☞ Use RESET_N in critical situations only to recover the system. RESET_N also resets the real-time clock which means that the receiver cannot perform hot start immediately after RESET_N.

1.5.2 WHEELTICK: Wheel tick input

The wheel tick input, also known as the HW interface, is used to provide speed pulse (wheel tick) information to the NEO-M8L modules. By default the wheel tick count is based on the rising edge of the wheel tick pulse signal. To improve performance with lower rate mechanically derived wheel-tick signals, the receiver may be configured to use both the rising and falling edges of the wheel tick signal on the condition that the wheel tick pulses have approximately 1:1 mark:space ratio regardless of speed. The minimum recommended pulse width is 10 us.

The pulse interval (WT resolution) should be less than 40 cm per tick over distance travelled. For best performance, less than 2 cm/tick is recommended. The wheel tick pulse output shall change linearly with the change in speed (navigation filter estimates only the linear scale factor). If the vehicle is standing still, there should be no wheel tick pulses. This is particularly important at system shut down and power up. If there is a dead-band (wheel tick pulse does not change or is not output below a certain speed), performance will be affected at low speed.

If the speed pulse is available from the host processor, then the information can also be provided by SW interface using the UBX-ESF-MEAS message. In this particular case, the wheel-tick pin can be configured as EXTINT1 and used to provide a time mark for the message. For more information, see the u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [3].

☞ Do not exceed the maximum voltage of 3.6 V at the input when using the HW interface.

1.5.3 FWD: Forward/reverse input

The forward/reverse input is used to indicate the moving direction by an external signal (HW interface). By default the wheel-tick direction pin polarity is automatically initialized once the vehicle has reached required minimum speed of 30 km/h. The forward/reverse input polarity can also be set manually. If the forward/reverse information is available from the host processor, the UBX-ESF-MEAS

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message can also be used to provide the direction of motion (SW interface). For more information, see the u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [3].

☞ Do not exceed the maximum voltage of 3.6 V at the input when using the HW interface. When using a SW interface this pin is not used and can be left open.

☞ No forward or reverse input will cause incorrect operation.

1.5.4 D_SEL: Interface select

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

1.5.5 LNA_EN: LNA enable

In power save mode, the system can turn on/off an optional external LNA using the LNA_EN signal to optimize power consumption.

1.5.6 TIMEPULSE

A configurable time pulse signal is available with the NEO-M8L modules. It generates pulse trains synchronized with GPS or UTC time grid with intervals configurable over a wide frequency range. For more information, see the u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [3].

☞ The NEO-M8L time-pulse output is configured using messages for “TIMEPULSE2”.

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

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 16).

To avoid interference by improperly shielded lines, it is recommended to use resistors (for example, R>20 Ω), ferrite beads (for example, BLM15HD102SN1) or inductors (for example, LQG15HS47NJ02) on the I/O lines in series. Choose these components carefully because they also affect the signal rise times.

Figure 3 shows an example of EMI protection measures on the RX/TX line using a ferrite bead.

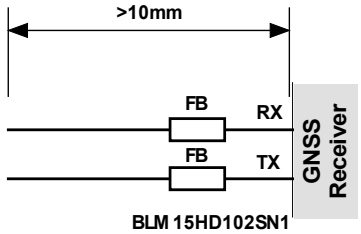


Figure 3: EMI precautions

More information is available in section 4.3.

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2 Design

2.1 Pin description

No.	Name	I/O	Description
1	SAFEBOOT_N	I	SAFEBOOT_N, test-point for service use (leave OPEN)
2	D_SEL	I	Interface select
3	TIMEPULSE	I/O	Time pulse (disabled by default). Do not pull low during reset. Note: configured using TIMEPULSE2 messages (see u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [3])
4	WHEELTICK	I	Wheel tick input
5	USB_DM	I/O	USB data
6	USB_DP	I/O	USB data
7	VDD_USB	I	USB supply
8	RESET_N	I	RESET_N
9	VCC_RF	O	Output voltage RF section
10	GND	I	Ground
11	RF_IN	I	GNSS signal input
12	GND	I	Ground
13	GND	I	Ground
14	LNA_EN	O	LNA enable
15	FWD	I	Forward/reverse input for speed pulse
16	RESERVED	-	Reserved
17	RESERVED	-	Reserved
18	SDA / SPI CS_N	I/O	DDC data if D_SEL =1 (or open) / SPI chip select if D_SEL = 0
19	SCL / SPI CLK	I/O	DDC clock if D_SEL =1 (or open) / SPI clock if D_SEL = 0
20	TXD / SPI MISO	O	Serial port if D_SEL =1 (or open) / SPI MISO if D_SEL = 0
21	RXD / SPI MOSI	I	Serial port if D_SEL =1 (or open) / SPI MOSI if D_SEL = 0
22	V_BCKP	I	Backup voltage supply
23	VCC	I	Supply voltage
24	GND	I	Ground

Table 2: Pinout of NEO-M8L modules

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
16	NC	RESERVED
17	NC	RESERVED
20	TxD / SPI MISO	TXD / SPI MISO
21	RxD / SPI MOSI	RXD / SPI MOSI

Table 3: Pin name changes in NEO-M8L-0 (Professional grade)

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2.2 Minimal design

This is a minimal design for a NEO-M8L GNSS receiver.

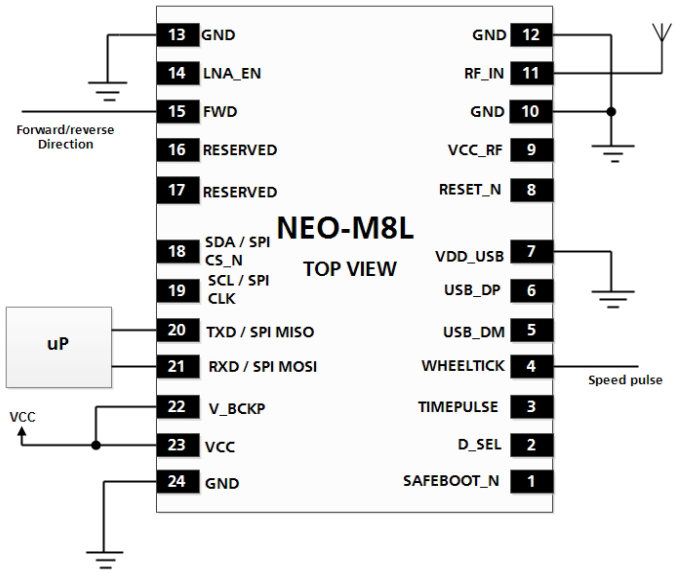


Figure 4: NEO-M8L passive antenna design

2.3 Layout: Footprint and paste mask

Figure 5 describes the footprint and provides recommendations for the paste mask for NEO-M8L 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 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.

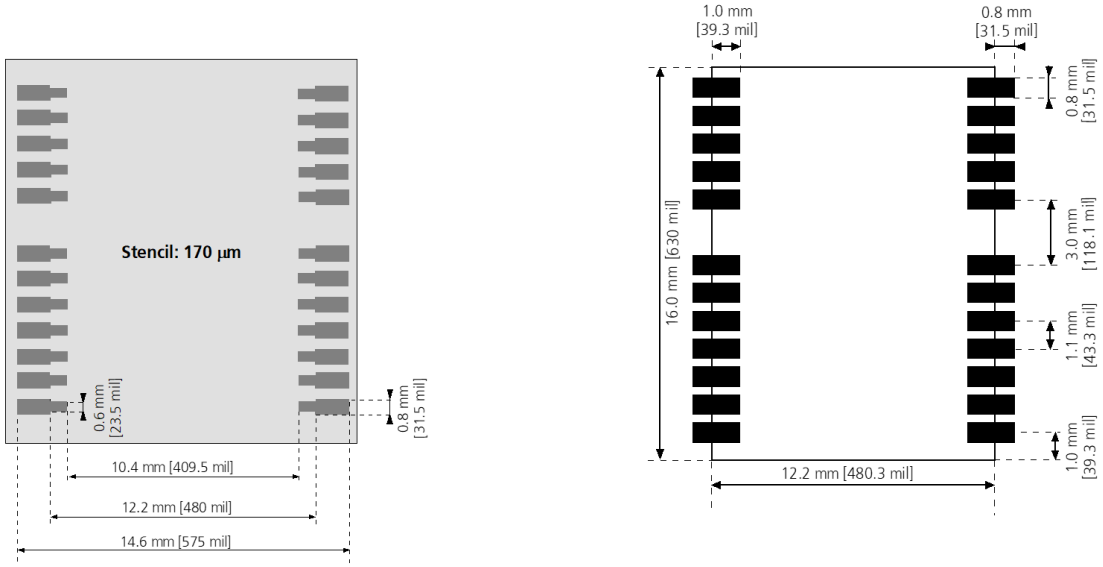


Figure 5: NEO-M8L paste mask / footprint

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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.

Figure 6 shows a minimal setup for a design with a good GNSS patch antenna. For exact pin orientation, see the Appendix and the corresponding product Data sheet [1], or [2] in the Related documents section.

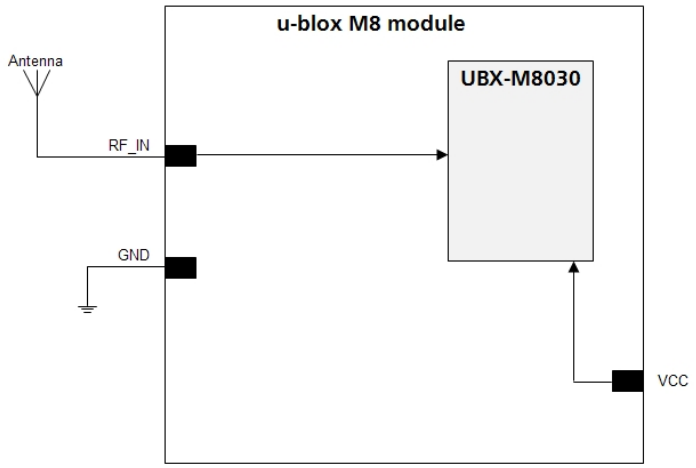


Figure 6: Module design with passive antenna

☞ Use an antenna that has sufficient bandwidth to receive all GNSS constellations. For more information, see and the GPS Antenna Application Note [5].

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

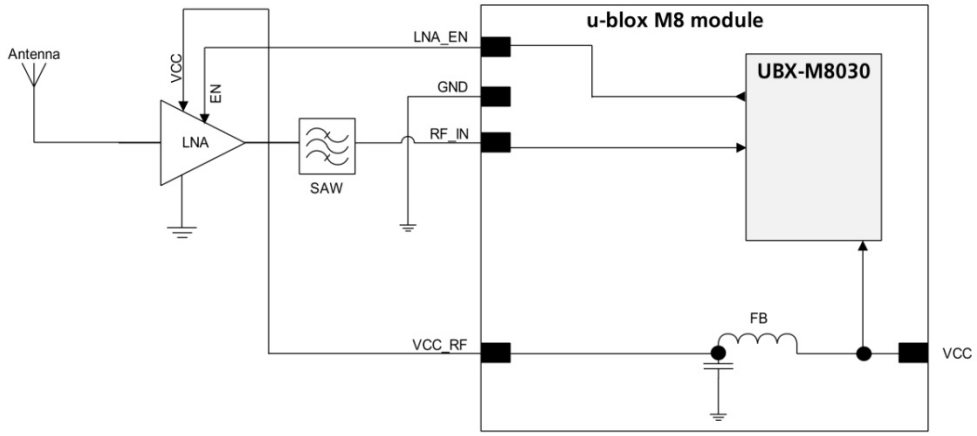


Figure 7: Module design with passive antenna and an external LNA and SAW

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

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/BeiDou/Galileo signals.

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

2.4.2 Active antenna design

An active antenna makes use of an integrated low-noise amplifier, which requires 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-M8L module matches the supply voltage of the active antenna (for example, 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

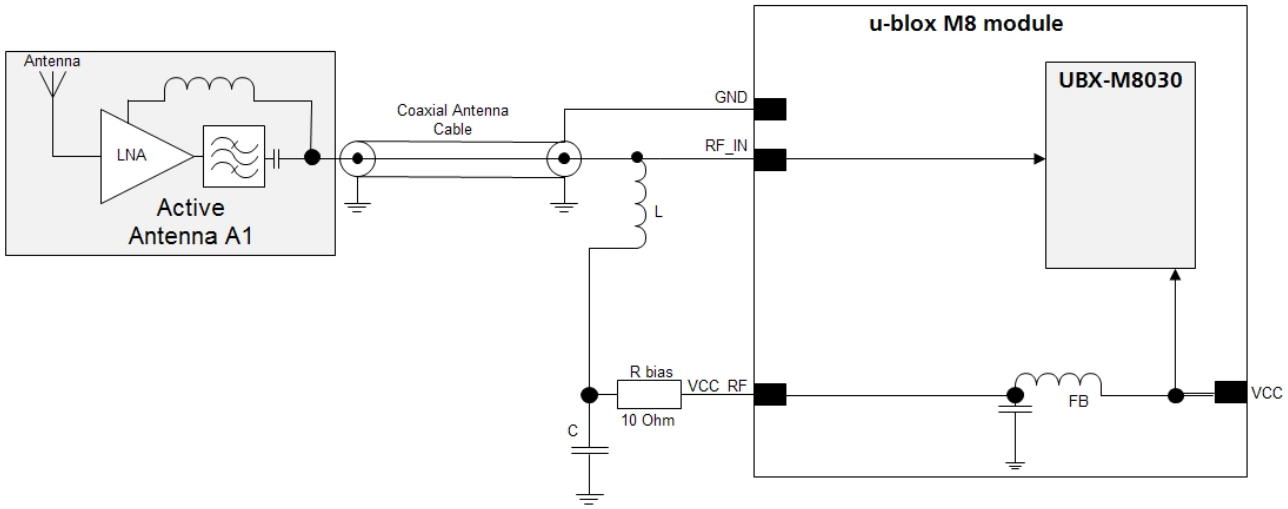


Figure 8: Active antenna design, external supply from VCC_RF

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.

For exact pin orientation, see the corresponding product Data sheet [1], or [2] in the Related documents section.

Active antenna design powered from an external supply

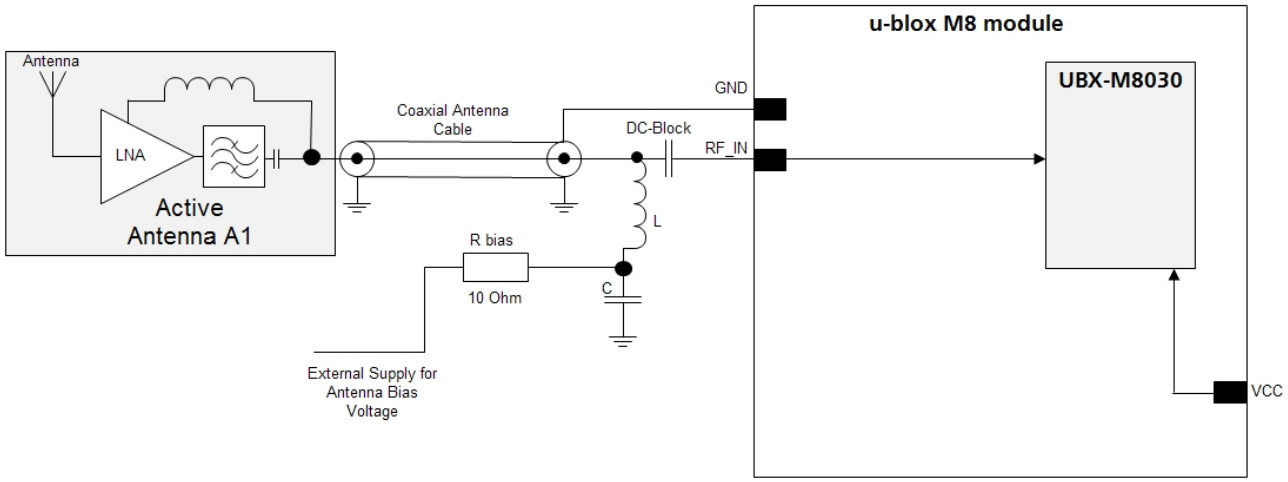


Figure 9: Active antenna design, direct external supply

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

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3 Automotive dead reckoning

3.1 Implementation

The NEO-M8L 3D dead reckoning modules make use of an internal 6-axis sensor (3-axis gyroscope and 3-axis accelerometer), meaning that only speed pulse and forward/reverse information must be provided externally. This can be done by applying speed pulse and forward/reverse signals directly at the dedicated HW interface pins of the NEO-M8L (see section 1.5) or by transmitting the same information to the module in UBX-ESF-MEAS messages (SW interface) sent from a host processor to the module. Where the software interface is used, the customer can re-configure the hardware wheel tick pin (as EXTINT) to indicate the reference time of the speed and forward/reverse information in the following UBX message from the processor. Figure 10 shows the orientation of the IMU frame.

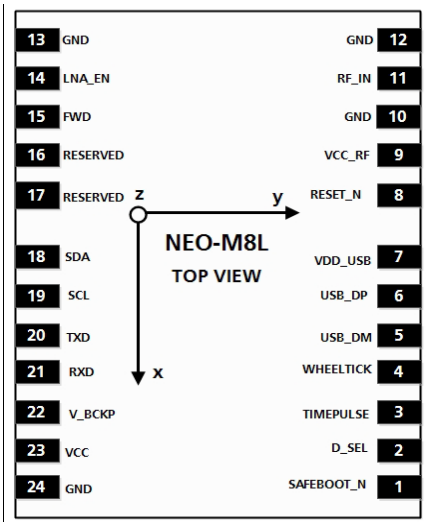


Figure 10: NEO-M8L with IMU sensor frame

☞ More information about the ADR functionality can be found in the u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [3].

3.2 Sensor calibration

The availability of “Sensor Fusion Mode” dead reckoning depends on the configuration of some mandatory sensor characteristic data and optional parameter refinements. If only the mandatory data are provided at installation, the navigation quality may be degraded on first use. The receiver continuously refines sensor calibration to account for tire wear, temperature, and aging. Data from continuous calibration are stored for future use in non-volatile memory.

☞ For more information about mandatory, calibration and optional configuration parameters, refer to the ADR configuration section of u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [3].

☞ Note that the performance of the ADR solution relies on stable sensor location and orientation with respect to the vehicle frame. The module must be mounted securely within the vehicle.

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 [3].

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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 [1], or [2] or the u-blox Package Information guide [4] in the Related documents section.

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. Note that a MEMS device is present internally.

4.2 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 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 for the professional grade NEO-M8L, see the IPC-7530 Guidelines for temperature profiling for mass soldering (reflow and wave) processes, published in 2001. For the Automotive Grade NEO-M8L-01A module, see the IPC/JEDEC J-STD-020E, December 2014.

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.

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- For the professional grade NEO-M8L, limit time above 217 °C liquidus temperature to 40 - 60 s. For the NEO-M8L-01A (automotive grade), the time above 217 °C should be limited to 60-150 seconds.
- Peak reflow temperature for professional grade NEO-M8L is 245 °C, and for NEO-M8L-01A it is 250 °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 for the NEO-M8L, max 6 °C/s for the NEO-M8L-01A.

☞ To avoid falling off, the NEO-M8L module 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, and so on. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

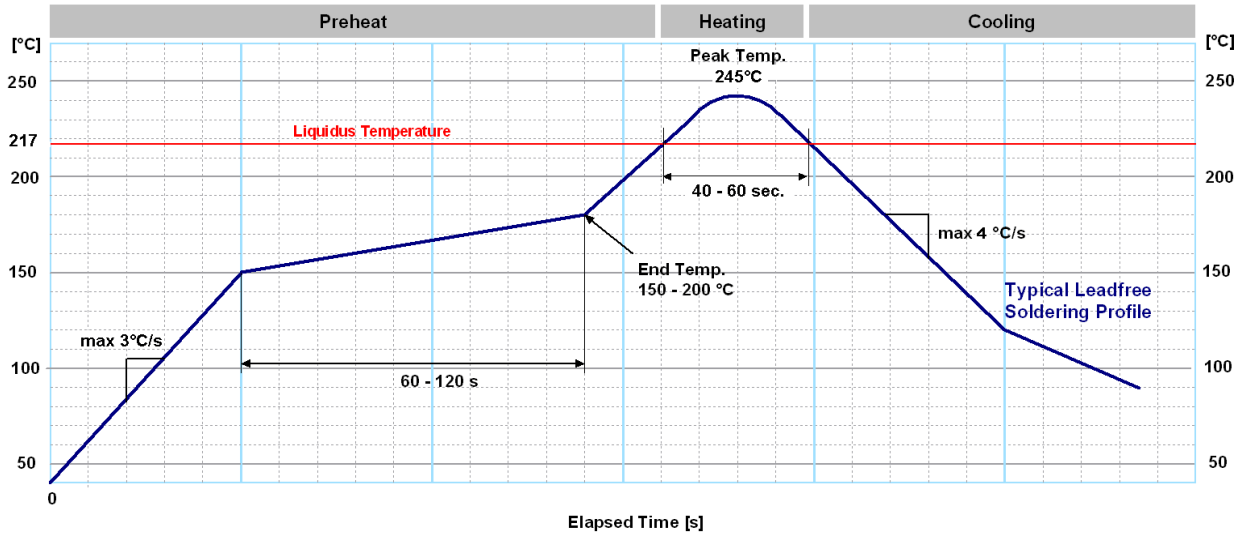


Figure 11: Recommended soldering profile for the professional grade NEO-M8L

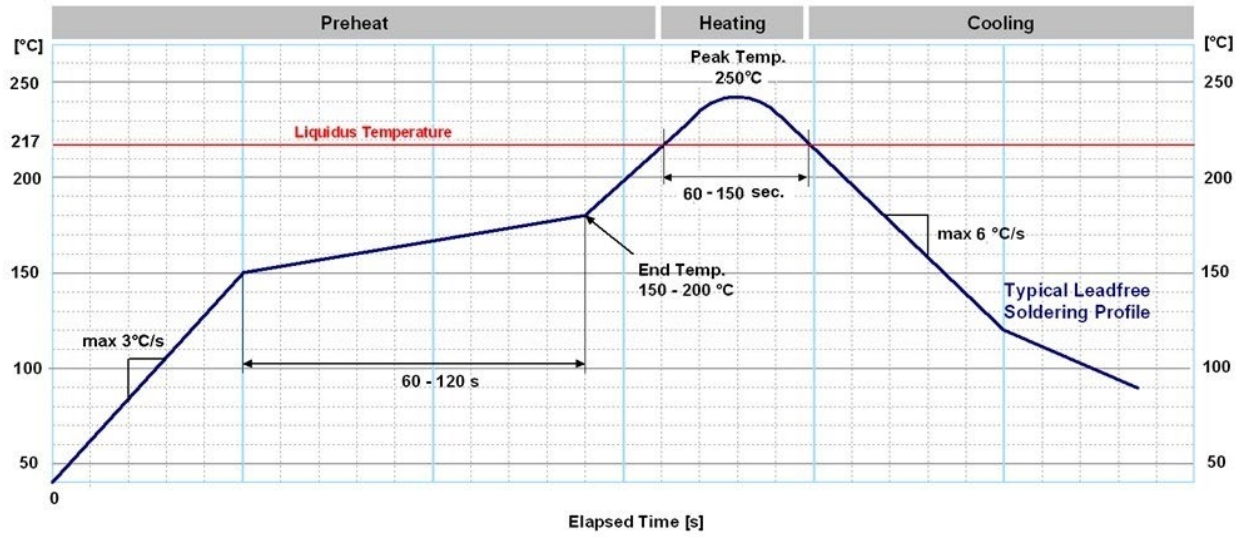


Figure 12: Recommended soldering profile for the automotive grade NEO-M8L-01A

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☞ NEO-M8L modules **must not** be soldered with a damp heat process.

Optical inspection

After soldering the NEO-M8L modules, 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-M8L modules. To avoid upside down orientation during the second reflow cycle, the NEO-M8L module should not be submitted to two reflow cycles on a board populated with components on both sides. 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 upside down scenario described above and taking into account the rework conditions described in section 4.

☞ 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-M8L 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 then continue from left to right.

Rework

The NEO-M8L modules 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, using a hot air gun is not recommended because this is an uncontrolled process and might damage the module.

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⚠ 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 NEO-M8L modules 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 potant. The OEM is strongly advised to qualify such processes in combination with the NEO-M8L modules 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 NEO-M8L 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 u-blox M8 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-M8L modules caused by any ultrasonic processes.

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4.3 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.

⚠ Only Separated or Safety Extra-Low Voltage (SELV) circuits are to be connected to the module including interfaces and antennas.

⚠ 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 receiver RF_IN, never exceed the maximum input power.

Electrostatic discharge (ESD)



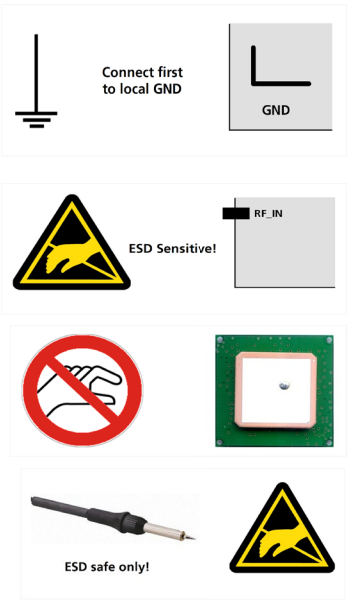
Electrostatic discharge (ESD) is the sudden and momentary electric current that flows between two objects at different electrical potentials caused by direct contact or induced by an electrostatic field. The term is usually used in the electronics and other industries to describe momentary unwanted currents 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 an 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. Exercize particular care when handling patch antennas, due to the risk of electrostatic charges. 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 (that is, the work desk) and the PCB GND, then 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 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, be sure to use an ESD-safe soldering iron (tip).



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

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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 13.

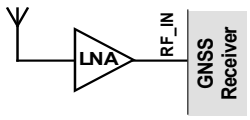
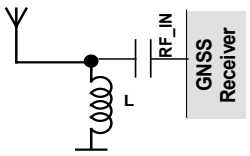
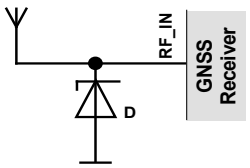
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas**
A  LNA with appropriate ESD rating	B 	C 

Figure 13: 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 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 (e.g. GSM/GPRS) 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 14 are recommended for designs combining wireless communication transceivers (e.g. GSM, GPRS) and GNSS in the same design or in close proximity.

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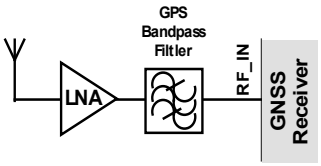
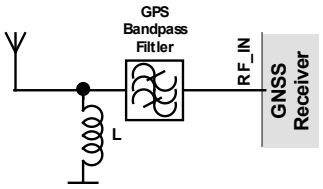
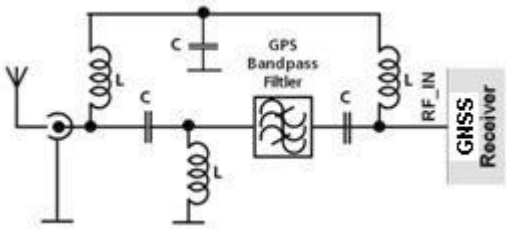
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas** (without internal filter which need the module antenna supervisor circuits)
D 	E 	F 
LNA with appropriate ESD rating and maximum input power	GNSS Band pass Filter: SAW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

Figure 14: 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)
- 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-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 4.

4.4 Safety precautions

The automotive grade NEO-M8L-01A modules must be supplied by an external limited power source in compliance with the clause 2.5 of the standard IEC 60950-1. In addition to external limited power source, only Separated or Safety Extra-Low Voltage (SELV) circuits are to be connected to the module including interfaces and antennas.

☞ For more information about SELV circuits see section 2.2 in Safety standard IEC 60950-1 0.

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4.5 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 data sheet for the absolute maximum power input at the GNSS receiver.

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [9].

Isolation between GNSS and cellular antennas

In multi-antenna designs, 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 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 would be 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, e.g. GPS frequency of 1575 MHz (see Figure 15). Such interference signals are typically caused by harmonics from displays, micro-controller, bus systems, and so on.

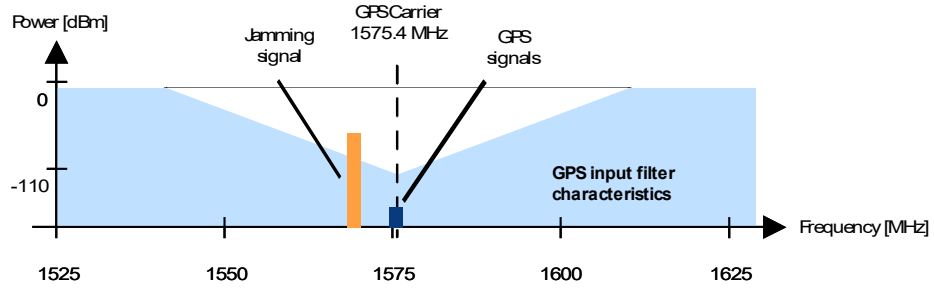


Figure 15: In-band interference signals

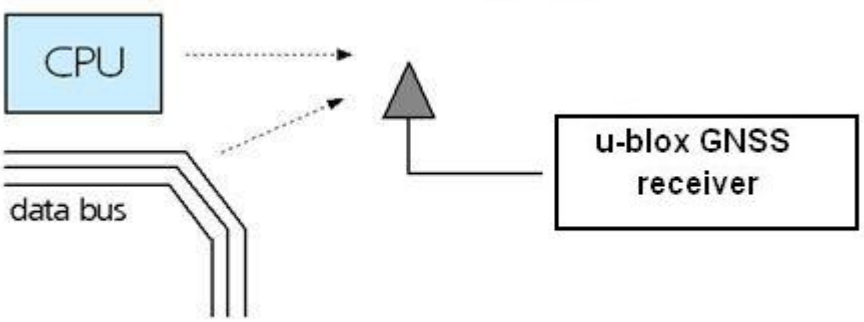


Figure 16: In-band interference sources

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

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Out-of-band interference

Out-of-band interference is caused by signal frequencies that are different from the GNSS carrier (see Figure 17). The main sources are wireless communication systems such as GSM, CDMA, WCDMA, Wi-Fi, BT.

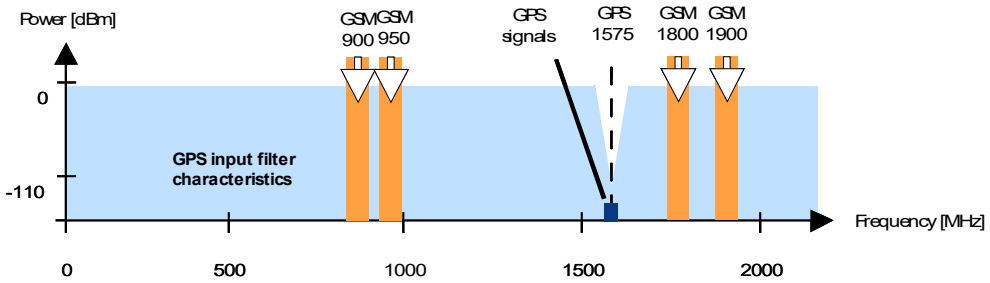


Figure 17: Out-of-band interference signals

Measures against out-of-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 18).



Figure 18: 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 [9].

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Appendix

A 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
	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
Capacitor	Murata	GRM1555C1E470JZ01	C, 47 pF	DC-block
Ferrite bead	Murata	BLM15HD102SN1	FB	High IZI at fGSM
Feed through capacitor for signal	Murata	NFL18SP157X1A3	Monolithic type Array type	Load capacitance appropriate to baud rate CL < xxx pF
		NFA18SL307V1A45		
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 4: Recommended parts

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B 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
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 5: Recommend antennas

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Related documents

[1] NEO-M8L-0 (ADR4) Data sheet, UBX-15028320
[2] NEO-M8L-06B (ADR4) Data sheet, UBX-20058645
[3] u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification, UBX-13002887
[4] u-blox Package information reference guide, UBX-14001652
[5] GPS Antenna Application Note, UBX-15030289
[6] NEO-M8L, NEO-M8U Information Note, UBX-20053641
[7] GPS Compendium, GPS-X-02007
[8] http://www.nxp.com/documents/user_manual/UM10204.pdf – I2C-bus specification and user manual, Revision 6, 20140404
[9] GPS Implementation and Aiding Features in u-blox wireless modules, GSM.G1-CS-09007
https://webstore.iec.ch/publication/4024 – Information technology equipment, Safety Standard IEC 60950-1

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

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Revision history

Revision	Date	Name	Comments
R01	13-May-2016	ghun/mpel	Advance Information
R02	28-Jun-2016	mpel	Early production Information
R03	09-Nov-2016	njaf	Production Information, added NEO-M8L-01A Data Sheet reference.
R04	28-Feb-2017	njaf	Firmware update for NEO-M8L-0-12.
R05	09-Sep-2017	njaf	Firmware version update for NEO-M8L-0-12, new PCN added.
R06	12-Sep-2018	njaf	Added information about the new product type, NEO-M8L-04B.
R07	20-Mar-2020	ssid	Advance information for NEO-M8L-05B
R08	23-Jun-2020	mala	Early production information. Added information on NEO-M8L, NEO-M8U information note in Document information and Related documents. Added disclosure restriction C1-Public.
R09	12-Feb-2021	njaf	Added information about new product type number, NEO-M8L-06B . Firmware version update for NEO-M8L-06B.

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