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NEO-M8Q-01A

u-blox M8 concurrent GNSS module Automotive Grade

Hardware Integration Manual

Abstract

This document describes the features and specifications of u-blox automotive grade NEO-M8Q-01A module.

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Document Information

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Mass Production / End of Life	Production Information	Document contains the final product specification.

This document applies to the following products:

Product name	Type number	ROM/FLASH version	PCN reference
NEO-M8Q-01A	NEO-M8Q-01A-10	ROM SPG 3.01	N/A

Contents

1 Hardware description

1.1 Overview

The NEO-M8Q-01A is an Automotive Grade standard precision GNSS module featuring the high performance u-blox M8 positioning engine. With the high end of the operating temperature range extended from +85 °C to +105 °C, the NEO-M8Q-01A is optimized for automotive applications.

Available in the industry standard NEO form factor in a leadless chip carrier (LCC) package, they are easy to integrate and combine exceptional positioning performance with highly flexible power, design, and connectivity options. SMT pads allow fully automated assembly with standard pick & place and reflow-soldering equipment for cost-efficient, high-volume production enabling short time-to-market.

☞ For more about product features, see the *NEO-M8Q-01A 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.

1.3 Connecting power

The NEO-M8Q-01A positioning module has 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 *NEO-M8Q-01A Data Sheet* [1] for specification).

The NEO-M8Q-01A module integrates a DC/DC converter, allowing reduced power consumption especially when using a main supply voltage above 2.5 V.

☞ 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 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.

☞ The equipment must be supplied by an external limited power source in compliance with the clause 2.5 of the standard IEC 60950-1.

1.3.2 V_BCKP: Backup supply voltage

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

☞ Avoid high resistance on the **V_BCKP** line: During the switch from the 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-M8Q-01A 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.

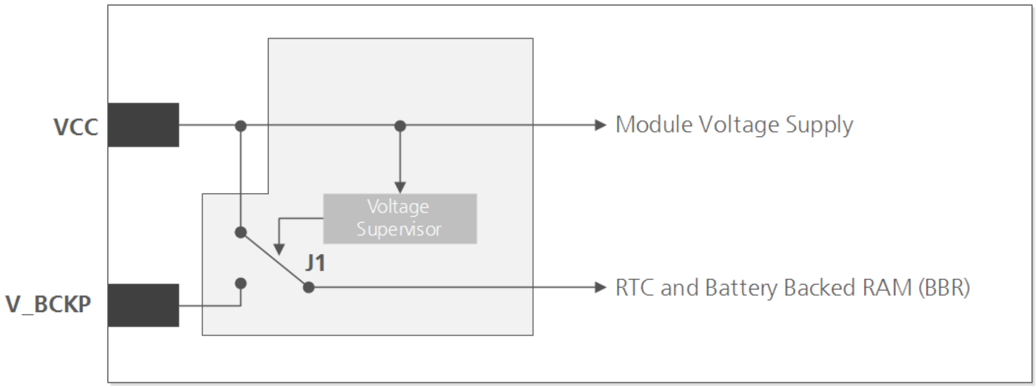

Figure 1: Backup battery and voltage (for exact pin orientation, see the NEO-M8Q-01A Data Sheet [1])

Real-Time Clock (RTC)

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

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.

1.3.3 VCC_RF: Output voltage RF

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

1.4 Interfaces

1.4.1 UART

The NEO-M8Q-01A positioning module includes a Universal Asynchronous Receiver Transmitter (UART) serial interface **RXD/TXD** supporting configurable baud rates. For the supported baud rates, see 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 Maxim MAX3232. Hardware handshake signals and synchronous operation are not supported.

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

1.4.2 USB

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

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

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

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

☞ USB bus-powered mode is not supported.

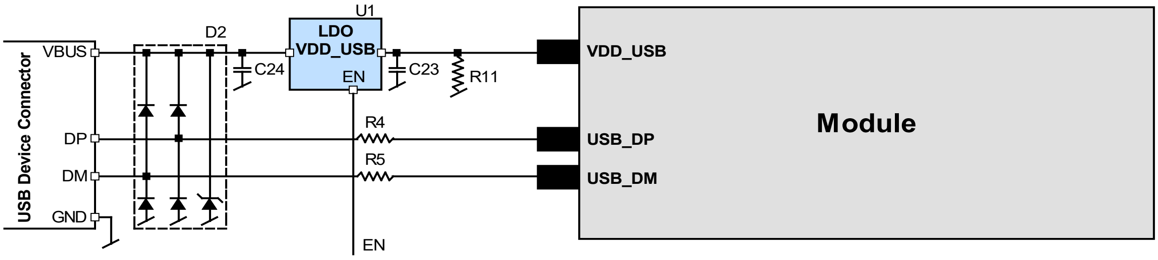

Figure 2: USB Interface

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, 24	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 I^{2}C compatible Display Data Channel (DDC) interface is available with u-blox M8 modules for serial communication with an external host CPU. The interface only supports operation in slave mode (master mode is not supported). The DDC protocol and electrical interface are fully compatible with the Fast-Mode of the I^{2}C 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-M8Q-01A Data Sheet* [1]. For timing, parameters consult the *I^{2}C-bus specification* [5].

☞ The u-blox M8 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.

☞ 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-M8Q-01A Data Sheet* [1].

1.4.5 TX_READY

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

☞ The **TX_READY** functionality can be enabled and configured by AT commands sent to the u-blox cellular module supporting the feature. For more information, see the *GPS Implementation and Aiding Features in u-blox wireless modules* [6].

1.5 I/O pins

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

1.5.1 RESET_N: Reset

Driving **RESET_N** low activates a hardware reset of the system. Use this pin only to reset the module. Do not use **RESET_N** to turn the module on and off, since the reset state increases power consumption. With the NEO-M8Q-01A module, **RESET_N** is an input only.

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

1.5.2 EXTINT: External interrupt

EXTINT, PIO 13, is an external interrupt pin with fixed input voltage thresholds with respect to **VCC** (see the *NEO-M8Q-01A Data Sheet* [1] for more information). It can be used for wake-up functions in Power Save Mode and for aiding. Leave open if unused; the function is disabled by default.

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

Power Control

The power control feature allows overriding the automatic active/inactive cycle of Power Save Mode. The state of the receiver can be controlled through the **EXTINT** pin. The receiver can also be forced OFF using **EXTINT** when Power Save Mode is not active.

Frequency Aiding

The **EXTINT** pin can be used to supply time or frequency aiding data to the receiver.

For time aiding, hardware time synchronization can be achieved by connecting an accurate time pulse to the **EXTINT** pin.

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

1.5.3 SAFEBOOT_N

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

☞ Do not pull low during reset.

1.5.4 D_SEL: Interface select

The **D_SEL** pin selects the available interfaces. SPI cannot be used simultaneously with UART/DDC.

If open, UART and DDC are available. If pulled low, the SPI interface is available. See the *NEO-M8Q-01A Data Sheet* [1].

1.5.5 TIMEPULSE

The TIMEPULSE output generates configurable signal. By default, the time pulse signal is configured to one pulse per second. For more information, see the *u-blox 8 / u-blox M8 Receiver Description including Protocol Specification* [2].

1.5.6 Active Antenna Control (ANT_OFF)

Control signal to turn the antenna supply on and off. In Power Save Mode, the system can turn on/off an optional external LNA using the **ANT_OFF** signal on PIO16 in order to optimize power consumption, where "high" = Turn OFF antenna supply and "low" = Turn ON antenna supply. For more information, see section 2.4.

Antenna supervision is configurable using message UBX-CFG-ANT.

For common LNAs that come with an enable pin that has to be “low” to turn OFF, the ANT_OFF signal must be inverted to ANT_OFF_N.

☞ The function of the **ANT_OFF** signal can be inverted to **ANT_OFF_N** by sending the following sequence to the receiver: B5 62 06 41 0C 00 00 00 03 1F 90 47 4F B1 FF FF EA FF 33 98

Applying this sequence results in a permanent change and cannot be reversed. An unstable supply voltage at the VCC pin while applying this sequence can also damage the receiver.

A pull-down resistor (R7) is required to ensure correct operation of the **ANT_OFF** pin.

☞ Refer to the *u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification* [2] for information about further settings.

1.5.7 Short Circuit Detection (ANT_OK)

ANT_OK can be used as Short Circuit Detection, see section 2.4.

"high" = antenna is ok (e.g. no short); "low" = antenna not ok (e.g. short)

Antenna supervision is configurable using message UBX-CFG-ANT.

☞ Refer to the *u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification* [2] for information about further settings.

1.5.8 Open Circuit Detection (PIO14 / ANT_DET)

PIO14 / ANT_DET is an input pin used to report whether an external circuit has detected an external antenna or not. Antenna supervision is configurable using the message UBX-CFG-ANT.

- "high" = Antenna detected (antenna consumes current)
- "low" = Antenna not detected (no current drawn)

For more information, see section 2.4

☞ Refer to the *u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification* [2] for information about further settings.

1.6 Electromagnetic interference on I/O lines

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

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

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

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

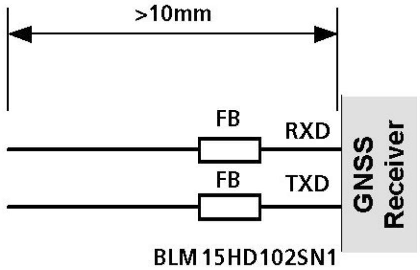

Figure 3: EMI Precautions

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

2 Design

2.1 Pin description

Function	PIN	No	I/O	Description	Remarks
Power	VCC	23		Supply Voltage	Provide clean and stable supply.
	GND	10, 12, 13, 24		Ground	Assure a good GND connection to all GND pins of the module, preferably with a large ground plane.
	V_BCKP	22		Backup Supply Voltage	It is recommended to connect a backup supply voltage to V_BCKP in order to enable warm and hot start features on the positioning modules. Otherwise, connect to VCC.
	VDD_USB	7		USB Power Supply	To use the USB interface, connect this pin to 3.0 V – 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	UART_TX/ SPI MISO	Communication interface,. Can be programmed as TX_READY for DDC interface. Serial Port if D_SEL =1(or open) SPI MISO if D_SEL = 0
	RXD / SPI MOSI	21	I	UART_RX / SPI MOSI	Serial input. Internal pull-up resistor to VCC. Leave open if not used. Serial Port if D_SEL =1(or open) SPI MOSI if D_SEL = 0
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 signal (one pulse per second by default). Leave open if not used.
	SAFEBOOT_N	1	I	Reserved	SAFEBOOT_N, leave OPEN
	EXTINT	4	I	External Interrupt	External Interrupt Pin. Internal pull-up resistor to VCC. Leave open if not used. Function is disabled by default.
	PIO14 / ANT_DET	15	I	ANT_DET	Open Circuit Detection (PIO14/ANT_DET)
	ANT_OK	16	I	ANT_OK	Short Circuit Detection (ANT_OK)
	ANT_OFF	14	O	ANT_OFF	Active Antenna Control (ANT_OFF)
	SDA / SPI CS_N	18	I/O	DDC Data / SPI CS_N	DDC Data if D_SEL =1 (or open) SPI Chip Select if D_SEL = 0.
	SCL / SPI CLK	19	I	DDC Clock / SPI SCK	DDC Clock if D_SEL =1(or open) SPI Clock if D_SEL = 0
	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-M8Q-01A Pinout

2.2 Minimal design

This is a minimal design for a NEO-M8Q-01A GNSS receiver.

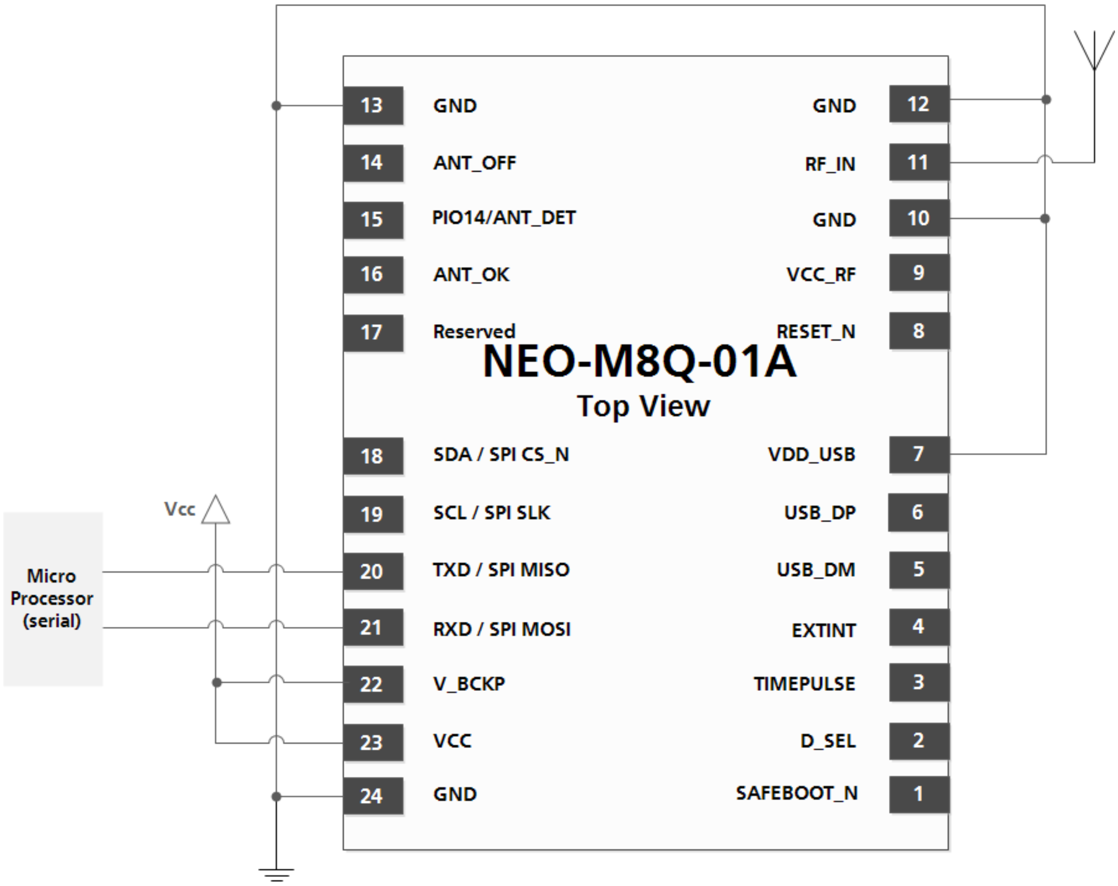

Figure 4: NEO-M8Q-01A passive antenna design

☞ A passive antenna can be used, but require for optimal operation an external SAW and LNA, see section 2.4.1.

2.3 Layout: Footprint and paste mask

Figure 5 describes the footprint and provides recommendations for the paste mask for NEO-M8Q-01A 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.

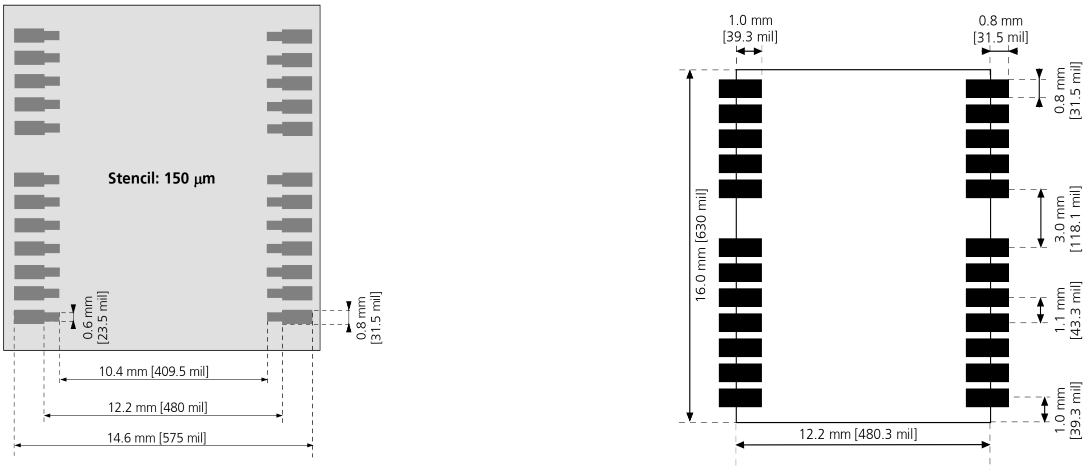

Figure 5: NEO-M8Q-01A paste mask and footprint

2.4 Antenna

The NEO-M8Q-01A module is designed for usage with an active antenna, see *section 2.4.2.* .

2.4.1 Antenna design with passive antenna

A passive antenna can be used, but requires an external LNA and SAW for best performance.

A design using a passive antenna requires some 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 design using an external LNA and SAW to increase the sensitivity for optimum performance with passive antenna.

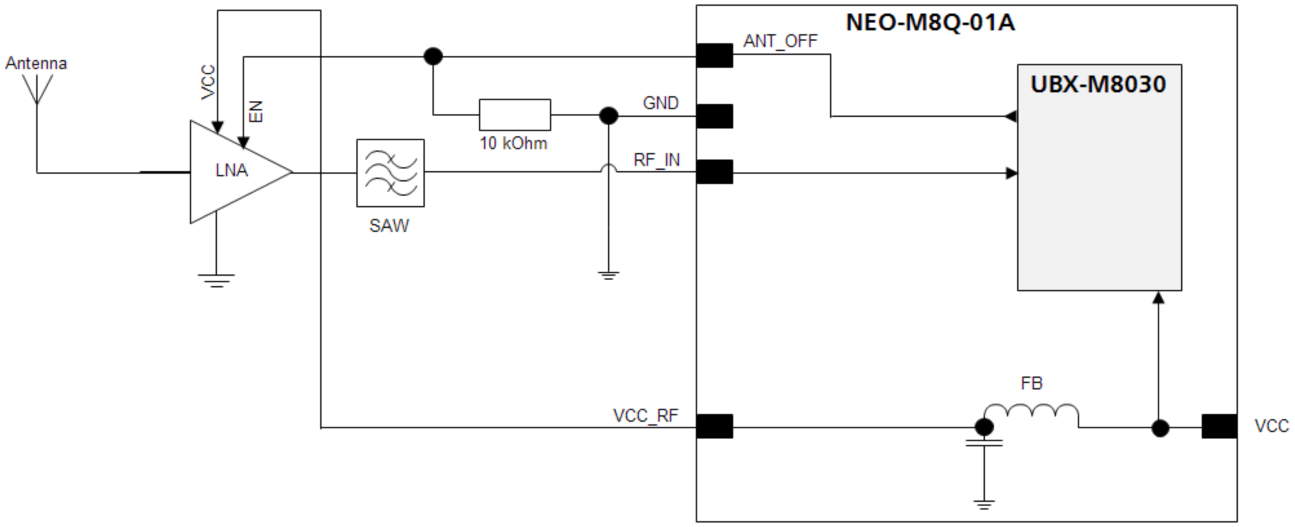

Figure 6: Module design with passive antenna and an external LNA and SAW (for exact pin orientation, see the *NEO-M8Q-01A Data Sheet* [1])

The Active Antenna Control (**ANT_OFF**) pin can be used to turn on and off an optional external LNA.

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

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

2.4.2 Active antenna design

Active antennas have an integrated low-noise amplifier and are connected over a coaxial cable with the module. Active antennas require a power supply that will contribute to the total GNSS system power consumption budget, typically with an additional 5 mA to 20 mA.

Active antenna design using VCC_RF pin to supply the active antenna

NEO-M8Q-01A module includes a built in antenna bias supply for nominal 3 V antennas enabled by linking the filtered **VCC_RF** supply output pin to the **V_ANT** antenna supply input pin with a 10 Ohm resistor in series.

If the supply voltage of the NEO-M8Q-01A 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 7.

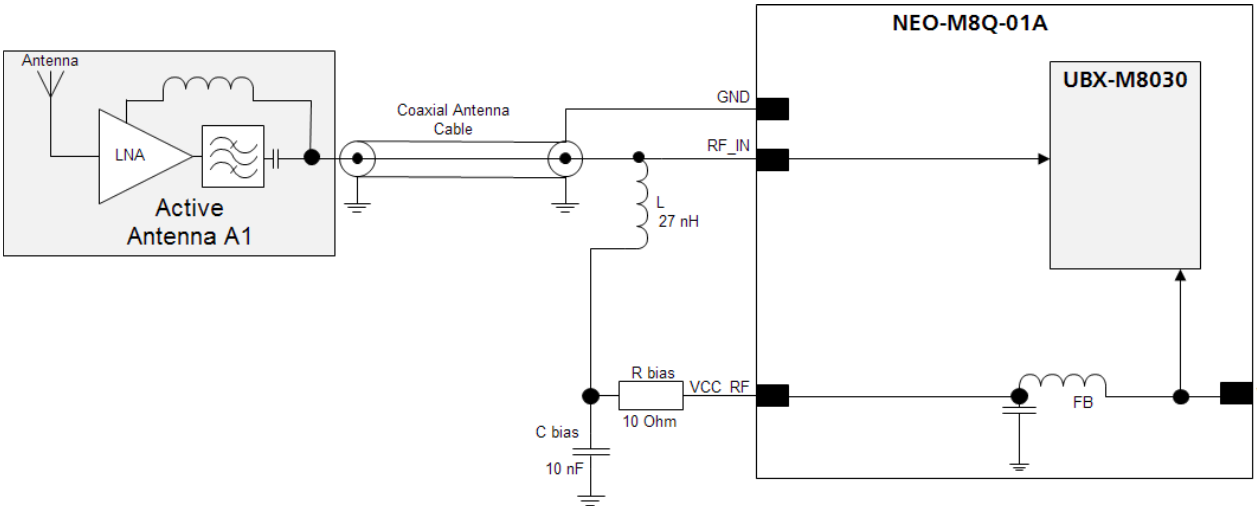

Figure 7: Active antenna design, external supply from VCC_RF (for exact pin orientation, see the *NEO-M8Q-01A Data Sheet* [1])

Active antenna design powered from external supply

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 8.

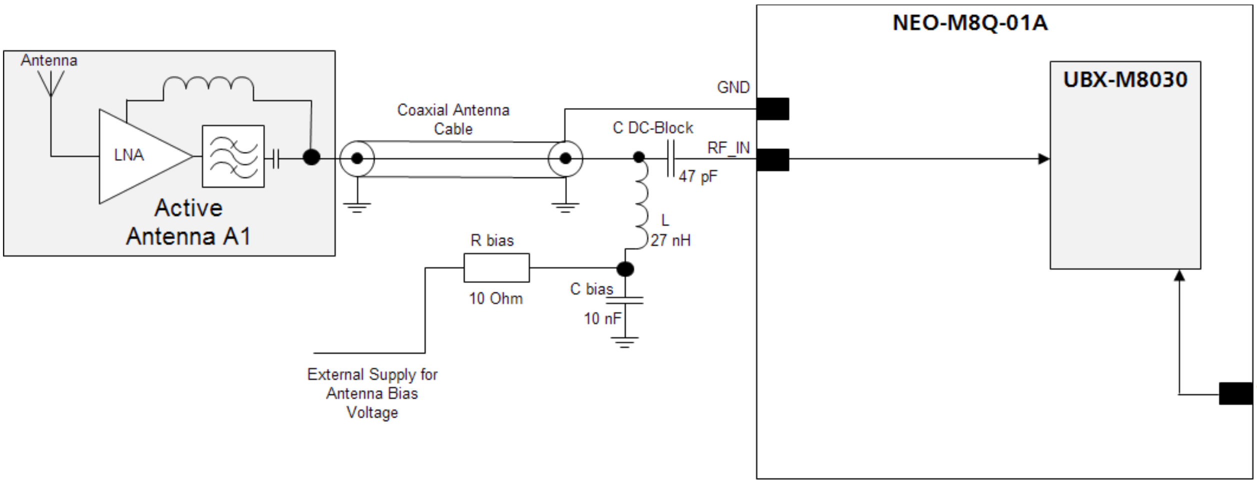

Figure 8: Active antenna design, direct external supply (for exact pin orientation, see the NEO-M8Q-01A Data Sheet [1]

Active antenna design using antenna supervisor

An active antenna supervisor provides the means to check the antenna for open and short circuits and to shut off the antenna supply if a short circuit is detected. The Antenna Supervisor is configured using a serial port UBX binary protocol message. Once enabled, the active antenna supervisor produces status messages, reporting in NMEA and/or UBX binary protocol. These indicate the particular state of the antenna supervisor shown in the state diagram.

The current active antenna status can be determined by polling the UBX-MON-HW monitor command.

The module firmware supports an active antenna supervisor circuit, which is connected to **PIO14 / ANT_DET**.

Status reporting

At start-up, and on every change of the antenna supervisor configuration, the NEO-M8Q-01A module will output an NMEA (**$GPTXT**) or UBX (**INF-NOTICE**) message with the internal status of the antenna supervisor (disabled, short detection only, enabled).

Abbreviation	Description
AC	Active Antenna Control enabled
SD	Short Circuit Detection Enabled
OD	Open Circuit Detection enabled
PDoS	Short Circuit Power Down Logic enabled
SR	Automatic Recovery from Short state

Table 3: Active Antenna Supervisor Message on start-up (UBX binary protocol)

☞ To activate the antenna supervisor, use the UBX-CFG-ANT message. For further information, refer to the *u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification* [2].

Similar to the antenna supervisor configuration, the status of the antenna supervisor will be reported in an NMEA (**$GPTXT**) or UBX (**INF-NOTICE**) message at start-up and on every change.

Power and short detection antenna supervisor

Figure 9 shows an active antenna supervisor circuit.

A short circuit can be detected in the antenna supply, after which the antenna supply voltage will be immediately shut down. Afterwards, periodic attempts to re-establish antenna power are made by default.

An internal switch (under control of the receiver) can turn off the supply to the external antenna whenever it is not needed. This feature helps to reduce power consumption in power save mode.

☞ To configure the antenna supervisor, use the UBX-CFG-ANT message. For further information, see the *u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification* [2].

⚠ Short circuits on the antenna input without limitation (R_BIAS) of the current can result in permanent damage to the receiver! Therefore, it is mandatory to implement an R_BIAS in all risk applications, such as situations where the antenna can be disconnected by the end-user or that have long antenna cables.

If **VCC_RF** voltage does not match with the antenna supply voltage, use a filtered external supply.

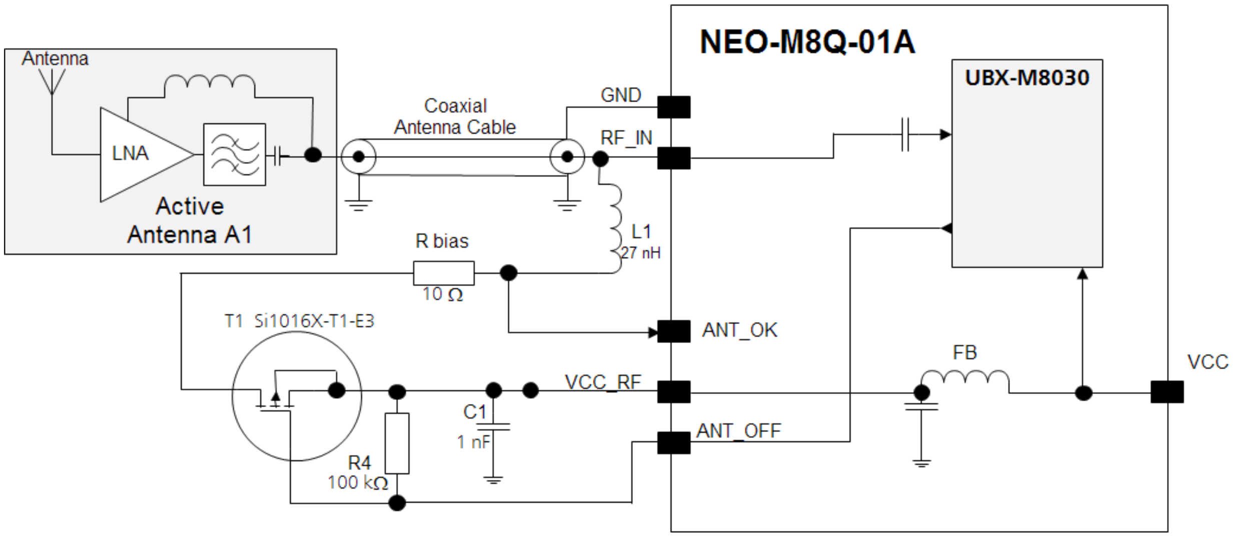

Figure 9: Power and short detection Antenna Supervisor

Power, short and open detection Antenna Supervisor

Figure 10 shows an active antenna supervisor circuit. A short circuit can be detected in the antenna supply, after which the antenna supply voltage will be immediately shut down. Afterwards, periodic attempts to re-establish antenna power are made by default.

An internal switch (under control of the receiver) can turn off the supply to the external antenna whenever it is not needed. This feature helps to reduce power consumption in power save mode.

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In case **VCC_RF** voltage does not match with the antenna supply voltage, use a filtered external supply.

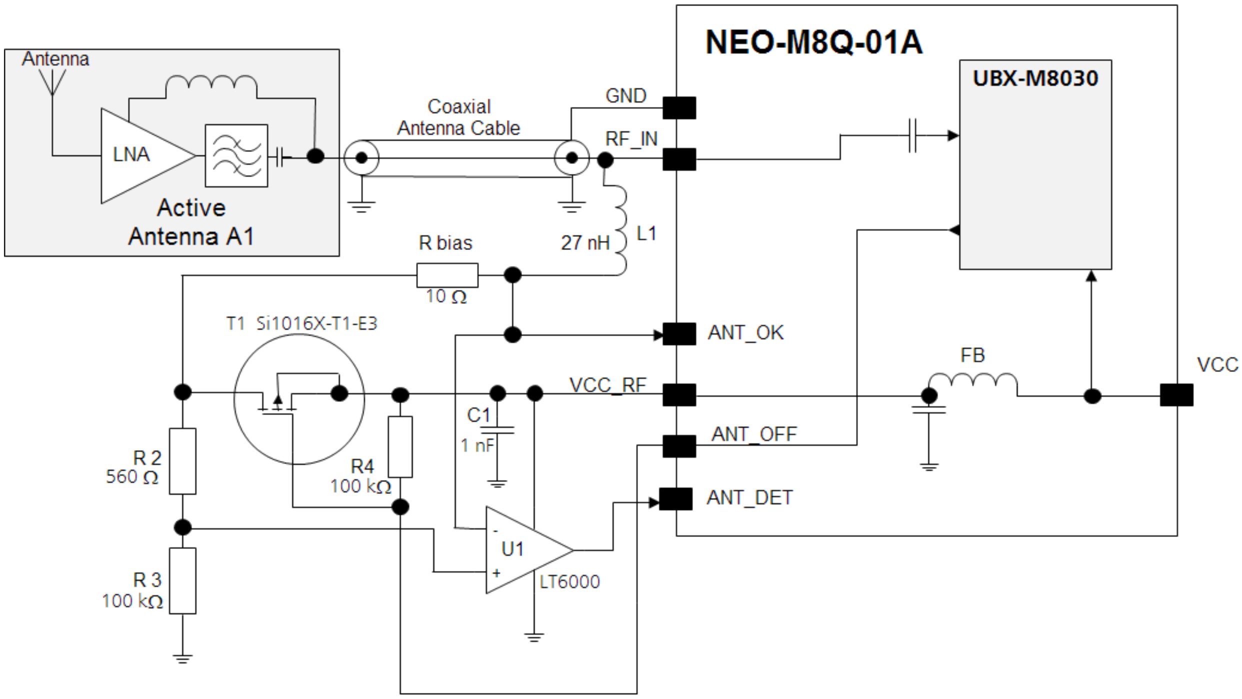


Figure 10: Power, short and open detection Antenna Supervisor

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-M8Q-01A 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 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.

The recommended soldering process is described below. This recommended process follows the IPC/JEDEC J-STD-020 specification for a Pb-Free assembly. When necessary, a different soldering process may be chosen as long as the selected process is also compliant with the IPC/JEDEC J-STD-020 specification. Please note that the thickness and volume of the NEO-M8Q-01A module limit the peak reflow temperature to +250 °C.

As a reference, see the IPC/JEDEC J-STD-020E, December 2014 [7].

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: 60-150 seconds
- Peak reflow temperature: 250 °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 6 °C/second

☞ To avoid falling off, the u-blox M8 GNSS 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, etc. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

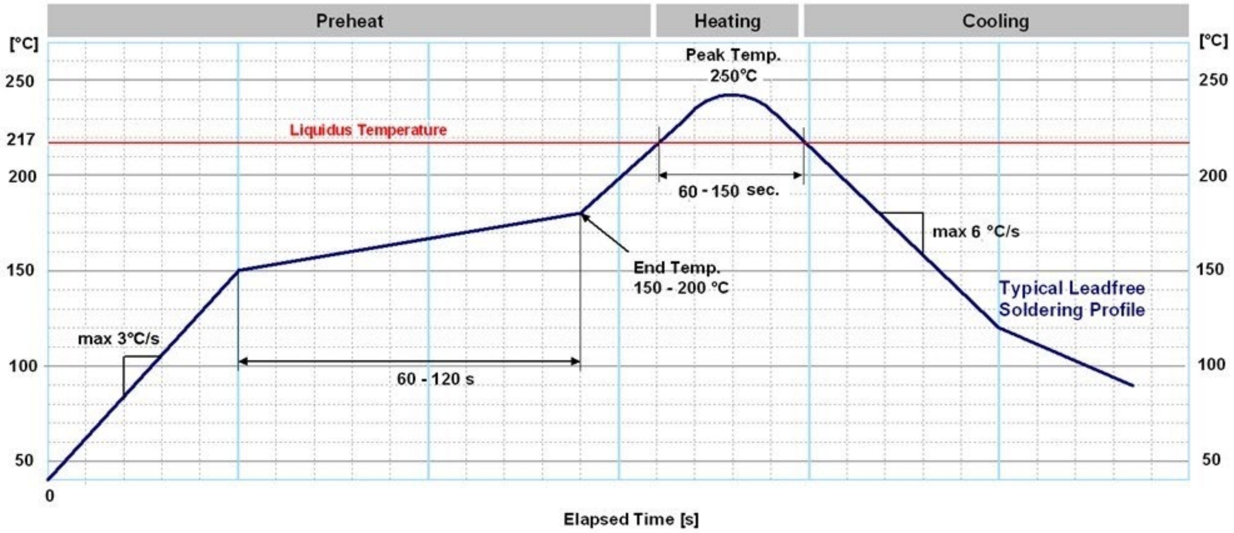


Figure 11: Recommended soldering profile

⚠ u-blox M8 modules must not be soldered with a damp heat process.

Optical inspection

After soldering the u-blox M8 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 a NEO-M8Q-01A module. The NEO-M8Q-01A module 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 key 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 the section about Product handling.

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

Wave soldering

Base boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices require wave soldering to solder the THT components. Only a single wave soldering process is encouraged for boards populated with NEO-M8Q-01A module.

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 u-blox M8 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-M8Q-01A 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-M8Q-01A 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-M8Q-01A 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-N8Q-01A 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 Electromagnetic 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-M8Q-01A 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

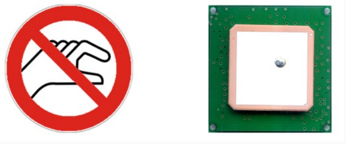
ESD prevention is based on establishing an Electrostatic Protective Area (EPA). The EPA can be a small working station or a large manufacturing area. The main principle of an EPA is that there are no highly charging materials near ESD sensitive electronics, all conductive materials are grounded, workers 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. 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.
- 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, 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 12.

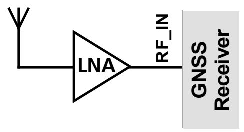
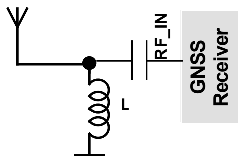
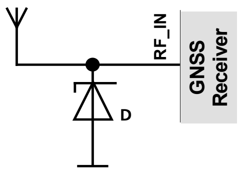
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas**
A  LNA with appropriate ESD rating	B 	C 

Figure 12: ESD Precautions

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

Electrical Overstress (EOS)

Electrical Overstress (EOS) usually describes situations 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 13 are recommended for designs combining wireless communication transceivers (e.g. GSM, GPRS) and GNSS in the same design or in close proximity.

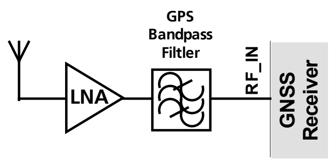
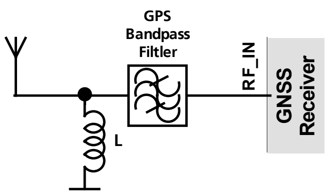
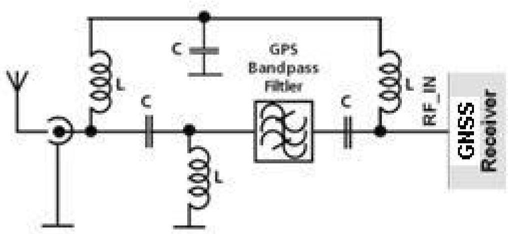
Small passive antennas (<2 dBic and performance critical)	**Passive antennas** (>2 dBic or performance sufficient)	**Active antennas** (without internal filter which need the module antenna supervisor circuits)
D 	E 	F 
LNA with appropriate ESD rating and maximum input power	GNSS Band pass Filter: SAW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

Figure 13: EOS and ESD Precautions

Electromagnetic interference (EMI)

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

The following elements are critical regarding EMI:

- Unshielded connectors (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 5) 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 connections can be used to protect e.g. the **VCC** supply pin against EMI. A selection of feed-through capacitors are listed in Table 5.

Intended use

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

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

☞ For more information, see *GPS Implementation and Aiding Features in u-blox wireless modules* [6].

Isolation between GNSS and GSM antenna

In a handheld-type design, an isolation of approximately 20 dB can be reached with careful placement of the antennas. If such isolation cannot be achieved, e.g. in the case of an integrated cellular /GNSS antenna, an additional input filter is needed on the GNSS side to block the high energy emitted by the cellular transmitter. Examples of these kinds of filters 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 14*). Such interference signals are typically caused by harmonics from displays, micro-controller, bus systems, etc.

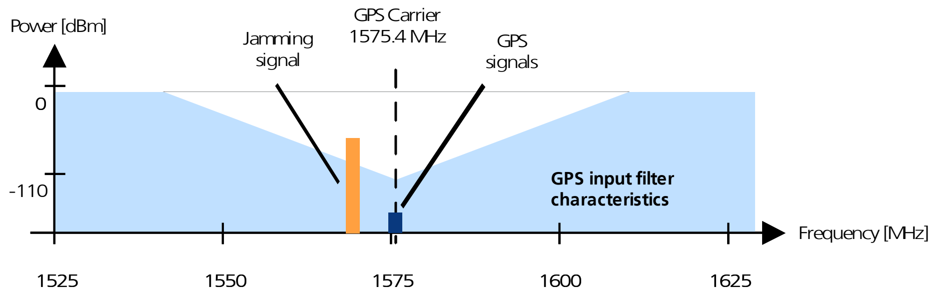


Figure 14: In-band interference signals

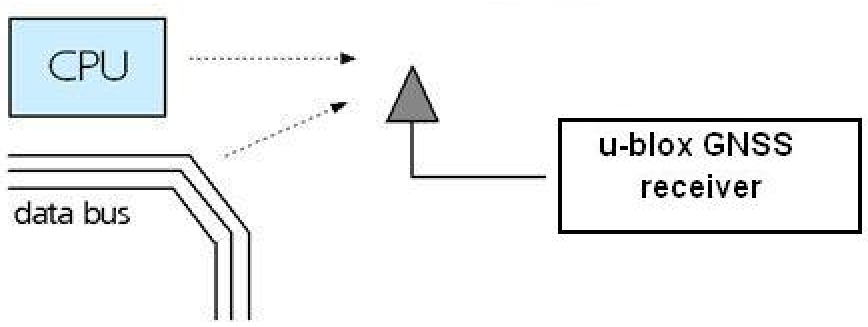


Figure 15: In-band interference sources

Measures against in-band interference include:

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

Out-band interference

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

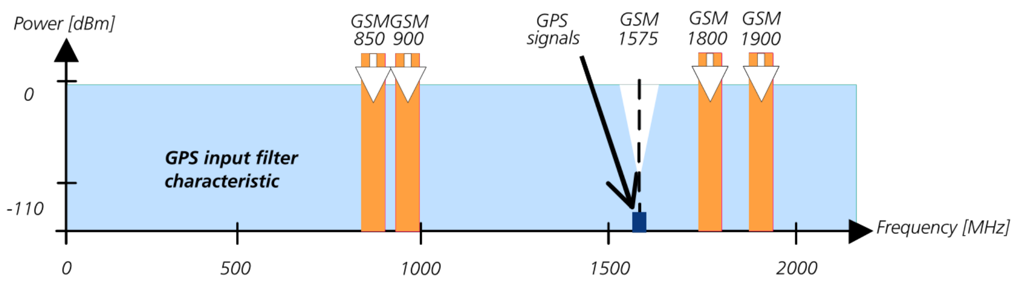


Figure 16: Out-band interference signals

Measures against out-band interference include maintaining a good grounding concept in the design and adding a SAW or band pass ceramic filter (as recommend in section 3) into the antenna input line to the GNSS receiver (see *Figure 17*).

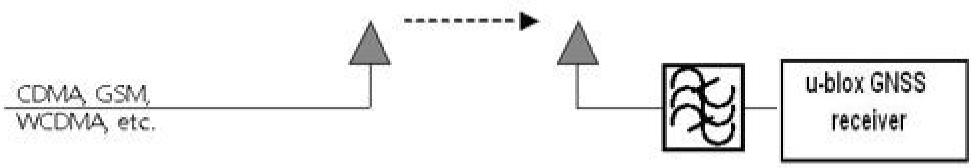


Figure 17: Measures against out-band interference

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

☞ For more information, see the *GPS Implementation and Aiding Features in u-blox wireless modules* [6].

Appendix

A Glossary

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

Table 4: Explanation of the abbreviations and terms used

B Recommended parts

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

If automotive grade components are required, ask directly the appropriate manufacturer.

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	AEC-Q200 standard –45 °C/+125 °C
	TDK/ EPCOS	B4310: B39162B4310P810	GPS+GLONASS	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

Part	Manufacturer	Part ID	Remarks	Parameters to consider
	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, rated current > 300mA
Capacitor	Murata	GRM1555C1E470JZ01	$C_{DC\text{-}block}$, 47 pF	DC-block
	Murata	X7R 10N 10% 16V	C_{Bias}, 10nF	Bias-T
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 5: Recommended parts

Recommended antennas

Manufacturer	Order No.	Comments
Hirschmann (www.hirschmann-car.com)	GLONASS 9 M	GPS+GLONASS active
Taoglas (www.taoglas.com)	AA.160.301111	36*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
Amotech (www.amotech.co.kr)	A18-4135920-AMT04	18x18x4 mm GPS+GLONASS passive
Amotech (www.amotech.co.kr)	Amotech AGA363913-S0-A1	GPS+GLONASS+ BeiDou active
INPAQ (www.inpaq.com.tw)	ACM4-5036-A1-CC-S	5.2 x 3.7 x 0.7 mm GPS+GLONASS passive
Additional antenna Manufacturer: Allis Communications, 2J, Tallysman Wireless		

Table 6: Recommend antennas

Related documents

[1] NEO-M8Q-01A Data Sheet, Doc. No. UBX-15013820
[2] u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification (Public version), Doc. No. UBX-13003221
[3] GPS Antenna Application Note, Doc. No. GPS-X-08014
[4] GPS Compendium, Doc. No. GPS-X-02007
[5] I2C-bus specification, Rev. 6 — 4 April 2014, http://www.nxp.com/documents/user_manual/UM10204.pdf
[6] GPS Implementation and Aiding Features in u-blox wireless modules, Doc. No. GSM.G1-CS-09007
[7] IPC/JEDEC J-STD-020E, December 2014

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

Revision history

Revision	Date	Name	Comments
R01	01-Jun-2016	jfur	Objective Specification
R02	08-Sep-2016	jfur	Advance Information, updated Figure 2: USB Interface.
R03	16-Jan-2017	jesk	Early Production Information, updated Figure 5: paste mask and footprint explanation. Updated section 3.2 recommended soldering process description
R04	23-Oct-2017	msul	Added information on RED DoC in European Union regulatory compliance (page 2), added Intended use statement in section 3.3 EOS/ESD/EMI precautions, updated legal statement in cover page and added Documentation feedback e-mail address in contacts page.
R05	05-Dec-2017	rmak	Production Information
R06	27-May-2019	jesk	Clarified use of internal pull-ups in section 1.5. Clarified alternative uses for the EXTINT pin in section 1.5.2. Updated parameters for the recommended inductor in appendix B.

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