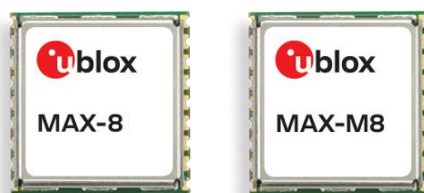


# MAX-8 / MAX-M8

**u-blox 8 / M8 GNSS modules**

Hardware integration manual



## Abstract

This document describes the features and specifications of the u-blox MAX-8 / MAX-M8 module series.

# Document information

<b>Title</b>	<b>MAX-8 / MAX-M8</b>	
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<b>Product status</b>	<b>Corresponding content status</b>	
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<b>Mass Production / End of Life</b>	Production Information	Document contains the final product specification.

This document applies to the following products:

#### European Union regulatory compliance

MAX-8 / MAX-M8 complies with all relevant requirements for RED 2014/53/EU. The MAX-8 / MAX-M8 Declaration of Conformity (DoC) is available at [www.u-blox.com](http://www.u-blox.com) within Support > Product resources > Conformity Declaration.

<b>Product name</b>	<b>Type number</b>	<b>Firmware version</b>	<b>PCN reference</b>
MAX-M8C	MAX-M8C-0-10	ROM SPG 3.01	UBX-16013125
MAX-M8W	MAX-M8W-0-10	ROM SPG 3.01	UBX-16013125
MAX-M8Q	MAX-M8Q-0-10	ROM SPG 3.01	UBX-16013125
MAX-8Q	MAX-8Q-0-10	ROM SPG 3.01	N/A
MAX-8C	MAX-8C-0-10	ROM SPG 3.01	N/A

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# 1 Hardware description


## 1.1 Overview

u-blox MAX-8 / MAX-M8 modules are standard precision GNSS positioning modules featuring the high-performance u-blox 8 / M8 positioning engine. Available in the industry standard MAX 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 and place and reflow-soldering equipment for cost-efficient, high-volume production enabling short time-to-market.

-  For product features see the data sheet for MAX-8 [1] or MAX-M8 [2] .
-  To determine which u-blox product best meets your needs, see the product selector tables on the u-blox website [www.u-blox.com](http://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 BBR (battery backed RAM), the modified configuration will be retained as long as the backup battery supply (**V\_BCKP**) is not interrupted.

-  eFuse is one-time-programmable; it cannot be changed if it has been programmed once.

In order to save backup current, a u-blox **MAX-8C / MAX-M8C** module configured in “single crystal” mode can have the single-crystal feature turned off by means of a SW command. Hot start performance will be degraded (no time information at startup).

Use the string in Table 1 to turn off the single-crystal feature. This is recommended for low-power applications, especially if time will be delivered by GSM or uC.

eFuse	String
turn-off single-crystal feature	B5 62 06 41 09 00 01 01 92 81 E6 39 93 2B EE 30 31



Table 1: String to turn off single-crystal feature

## 1.3 Connecting power

u-blox MAX-8 / MAX-M8 positioning modules have up to three power supply pins: **VCC**, **VCC\_IO**, and **V\_BCKP**.

### 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 data sheet for MAX-8 [1] or MAX-M8 [2] for specification).

-  When switching from backup mode to normal operation or at start-up, u-blox MAX-8 / MAX-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.

### 1.3.1 VCC\_IO: IO supply voltage

VCC\_IO from the host system supplies the digital I/Os. The wide range of VCC\_IO allows seamless interfacing to standard logic voltage levels independent of the VCC voltage level. In many applications, VCC\_IO is simply connected to the main supply voltage.

Without a VCC\_IO supply, the system will remain in reset state.

### 1.3.2 V\_BCKP: Backup supply voltage

If there is a power failure on the module supply (VCC\_IO), the real-time clock (RTC) and battery backed RAM (BBR) are supplied through the V\_BCKP pin. Thus orbit information and time can be maintained and will allow a hot or warm start. If no backup battery is connected, the module performs a cold start at every power up if no aiding data are sent to the receiver

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\_IO.

As long as power is supplied to the u-blox 8 / M8 modules through the VCC\_IO pin, the backup battery is disconnected from the RTC and the BBR to avoid unnecessary battery drain (see Figure 1). In this case, VCC\_IO supplies power to the RTC and BBR.

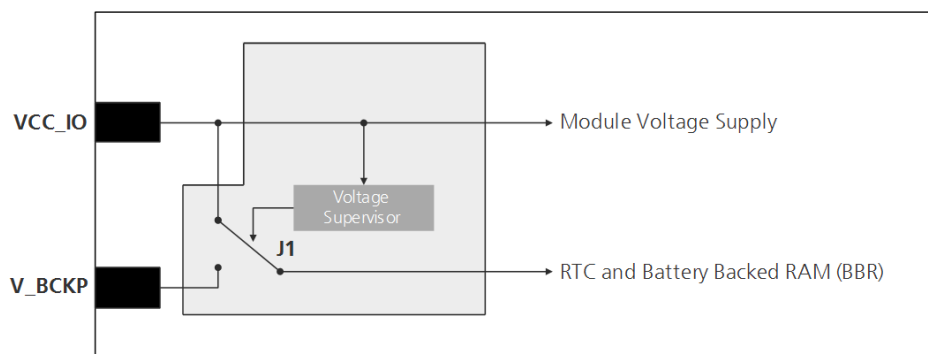


Figure 1: Backup battery and voltage (for exact pin orientation, see the data sheet for MAX-8 [1] or MAX-M8 [2])


#### Single-crystal feature on MAX-8C / MAX-M8C

On MAX-8C / MAX-M8C, the reference frequency for the RTC clock will be internally derived from the main clock frequency (26 MHz) when in backup mode (does not have a 32 kHz oscillator). This feature is called “single-crystal” operation. In the event of a power failure, the backup battery at V\_BCKP will supply the 26 MHz crystal oscillator, as needed to maintain the time. This makes MAX-8C / MAX-M8C a more cost-efficient solution at the expense of a higher backup current, as compared to other MAX-8 / MAX-M8 variants that use an ordinary RTC crystal. Therefore, the capacity of the backup battery at V\_BCKP must be increased if hardware backup mode is needed (see the data sheet for MAX-8 [1] or MAX-M8 [2] for specification).

If the battery used cannot provide the increased current consumption for the needed time on MAX-8C / MAX-M8C, the “single-crystal” feature can be permanently disabled. The backup current will be the same as on MAX-8 / MAX-M8 modules without the “single-crystal” feature. But the time information is not maintained during off time. So the customer either aides the time to the receiver at every startup, or the hot and warm start performance will be degraded because of missing time information.

Send this string to disable the “single-crystal” feature:

“B5 62 41 09 00 01 01 92 81 E6 39 93 2B EE 30 31”.

-  This string has to be sent once in production and will permanently turn off the single-crystal feature on MAX-8C / MAX-M8C. The hot start and warm start performance will be degraded if time information is not provided to the receiver at every startup.

### 1.3.3 VCC\_RF: Output voltage RF

The **VCC\_RF** pin can be used to supply an active antenna or an external LNA. For more information, see section 2.4.

### 1.3.4 V\_ANT: Antenna supply (MAX-M8W)

At **V\_ANT** pin an antenna supply voltage can be connected which will be provided at RF\_IN to supply an active antenna. For more information see section 2.4.3.

-  If not used, connect the **V\_ANT** pin to GND.

## 1.4 Interfaces


### 1.4.1 UART

u-blox MAX-8 / MAX-M8 positioning modules include a Universal Asynchronous Receiver Transmitter (UART) serial interface **RXD/TXD** that supports configurable baud rates. The UART output and input levels are 0 V to **VCC\_IO**. 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 Display data channel (DDC)


An I2C-compatible display data channel (DDC) interface is available with u-blox MAX-8 / MAX-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 I2C industry standard. DDC pins **SDA** and **SCL** have internal pull-up resistors to **VCC\_IO**.

For more information about the DDC implementation, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3]. For bandwidth information, see the MAX-8 Data sheet [1] and MAX-M8 Data sheet [2]. For timing, parameters consult the I2C-bus specification [6].

-  The u-blox MAX-8 / MAX-M8 DDC interface supports serial communication with u-blox cellular modules. See the specification of the applicable cellular module to confirm compatibility.

### 1.4.3 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 [7].

## 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 input

Driving **RESET\_N** low activates a hardware reset of the system. Use this pin only to reset the module. Do not use **RESET\_N** to turn the module on and off, since the reset state increases power consumption. In u-blox MAX-8 / MAX-M8 modules, **RESET\_N** is an input only.

### 1.5.2 EXTINT: External interrupt

**EXTINT** is an external interrupt pin with fixed input voltage thresholds with respect to **VCC\_IO** (see the data sheet for MAX-8 [1] and MAX-M8 [2] for more information). It can be used for wake-up functions in power save mode in all u-blox 8 / M8 modules and for aiding. Leave open if unused; the functions are disabled by default.

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

#### 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 an 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.

### 1.5.4 TIMEPULSE

A configurable time pulse signal is available with all u-blox 8 / u-blox M8 modules. By default, the time pulse signal is configured to 1 pulse per second. For more information, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].

### 1.5.5 LNA\_EN: LNA enable

In the power save mode in **MAX-M8Q**, **MAX-M8C**, **MAX-8C** and **MAX-8Q** modules, the system can turn on/off an optional external LNA using the LNA\_EN signal to optimize power consumption.

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

#### Antenna short circuit detection (ANT\_OK) (MAX-M8W)

MAX-M8W module includes internal short circuit antenna detection. For more information, see section 2.4.5.

- "high" = Antenna is OK (e.g. no short)



- "low" = Antenna is 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 [3] for information about further settings.

### 1.5.6 ANT\_DET: Open circuit detection (MAX-M8)

Antenna open circuit detection (**ANT\_DET**) is not activated by default on the MAX-8 / MAX-M8 modules. **ANT\_DET** can be mapped to PIO13 (**EXTINT**).

**ANT\_DET** is an input used to report whether an external circuit has detected an external antenna or not.

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

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

Refer to the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3] 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 19).

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

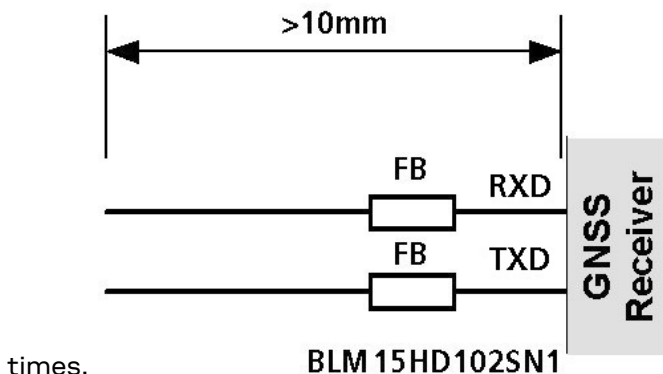


Figure 2 shows an example of EMI protection measures on the RX/TX line using a ferrite bead. More information can be found in section 4.3.

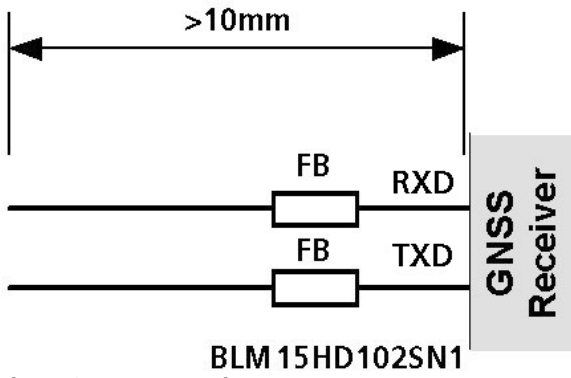


Figure 2: EMI precautions

## 2 Design

### 2.1 Pin description

Function	Pin	No.	I/O	Description	Remarks
Power	VCC	8	I	Supply voltage	Provide clean and stable supply.
	GND	1,10,12	I	Ground	Assure a good <b>GND</b> connection to all <b>GND</b> pins of the module, preferably with a large ground plane.
	V_BCKP	6	I	Backup supply voltage	Backup supply voltage input pin. Connect to <b>VCC_IO</b> if not used.
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 <b>RF_IN</b> to the antenna or the antenna connector. DC block inside.
	VCC_RF	14	O	Output voltage RF section	Can be used for active antenna or external LNA supply.
	LNA_EN (MAX-M8C/Q MAX-8C/Q)	13	O	Active antenna control	Ext. LNA control pin in power save mode. <b>LNA_EN</b> pin voltage level is <b>VCC_IO</b>
	Reserved (MAX-M8W)	-	-	Reserved	Leave open
UART	TXD	2	O	Serial port	UART, leave open if not used, voltage level referred <b>VCC_IO</b> . Can be configured as TX ready indication for the DDC interface.
	RXD	3	I	Serial port	<b>UART, leave open if not used, voltage level referred VCC_IO</b>
System	TIMEPULSE	4	O	Timepulse signal	Leave open if not used, voltage level referred <b>VCC_IO</b>
	PIO13/EXTINT	5	I	External interrupt	Leave open if not used, voltage level referred <b>VCC_IO</b> . Can be programmed on MAX-M8W as open circuit detection ( <b>ANT_DET</b> )
	SDA	16	I/O	DDC pins	DDC data. Leave open, if not used.
	SCL	17	I	DDC pins	<b>DDC clock. Leave open, if not used.</b>
	VCC_IO	7	I	VCC_IO	IO supply voltage. Input must always be supplied. Usually connect to VCC pin 8.
	RESET_N	9	I	Reset	Reset
	V_ANT (MAX-M8W ) Reserved (MAX-M8C/Q MAX-8C/Q)	15	I	Antenna bias voltage	Connect to <b>GND</b> (or leave open) if passive antenna is used. If an active antenna is used, add a 10 Ω resistor in front of <b>V_ANT</b> input to the antenna bias voltage or <b>VCC_RF</b> .
	Reserved (MAX-M8C/Q MAX-8C/Q)	-	-	Reserved	Leave open
SAFEBOOT_N	18	I	SAFEBOOT_N	For future service, leave open	

Table 2: Pinout MAX-8 / MAX-M8

#### 2.1.1 Pin name changes

Selected pin names have been updated to agree with the 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
13	ANT_ON	LNA_EN

Table 3: Pin name changes

## 2.2 Minimal design

This is a minimal setup for a MAX-8 / M8 GNSS receiver:

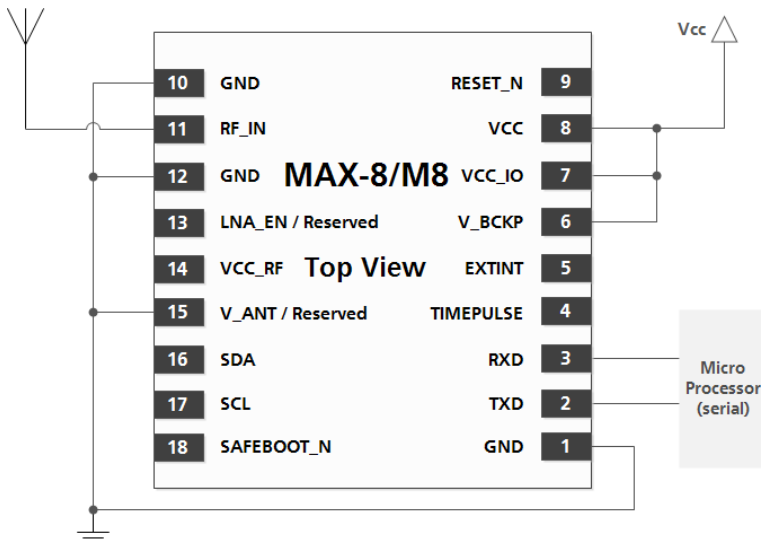


Figure 3: MAX-8 / MAX-M8 passive antenna design

For information on increasing immunity to jammers such as GSM, see section 4.3.

## 2.3 Layout: Footprint and paste mask

Figure 4 describes the footprint and provides recommendations for the paste mask for MAX-8 / MAX-M8 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 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 customer's specific production processes (for example, soldering).

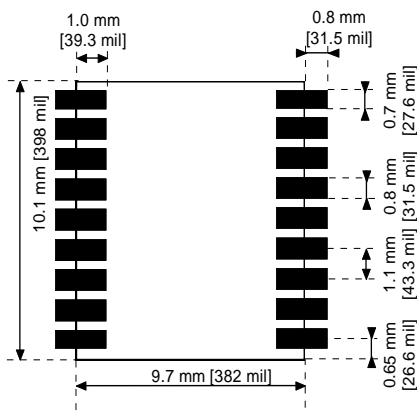


Figure 4: MAX-8 / MAX-M8 footprint

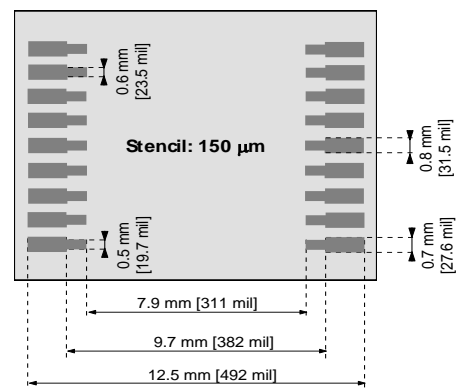


Figure 5: MAX-8 / MAX-M8 paste mask

MAX form factor (10.1 x 9.7 x 2.5): same pitch as NEO for all pins: 1.1 mm, but 4 pads in each corner (pin 1, 9, 10 and 18) only 0.7 mm wide instead of 0.8 mm.

## 2.4 Antenna and antenna supervision

The MAX-8 / MAX-M8 modules are designed for use with an active antenna, see section 2.4.2.

### 2.4.1 Antenna design with passive antenna

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

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, take care 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  $\Omega$ .

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

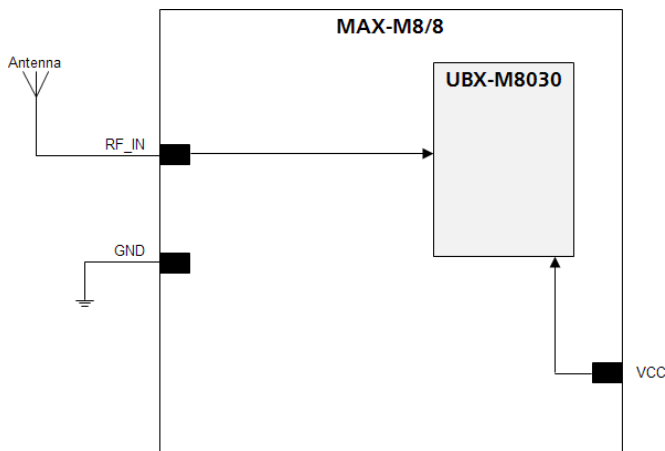


Figure 6: Module design with passive antenna (for exact pin orientation see data sheet for MAX-8 [1] and MAX-M8 [2])

Use an antenna that has sufficient bandwidth to receive all GNSS constellations. See **Error! eference source not found..**

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

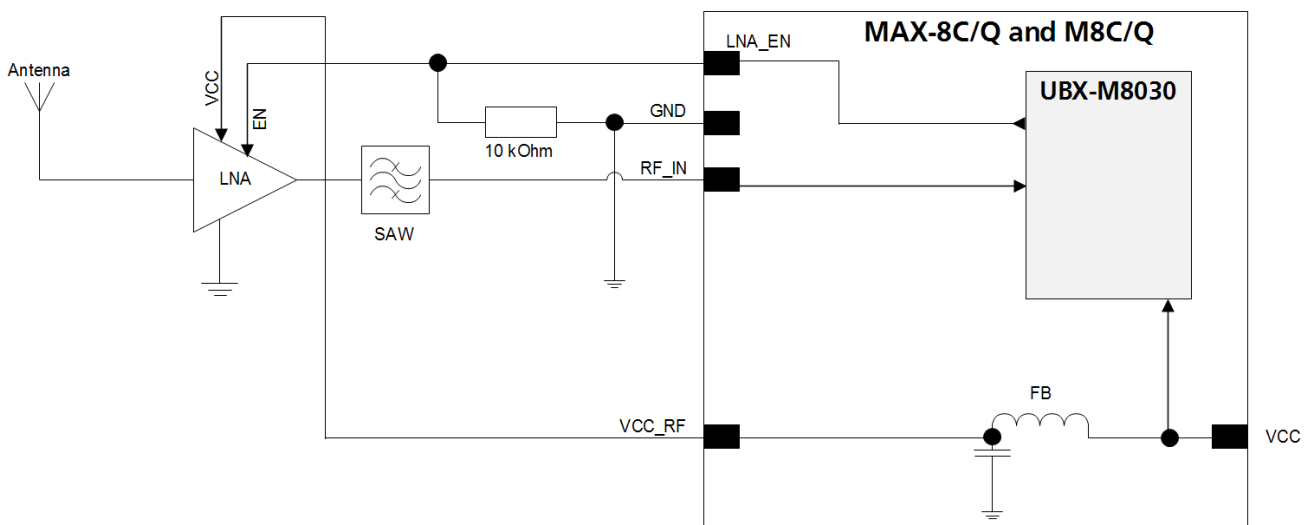


Figure 7: MAX-8C/Q and M8C/Q module design with passive antenna and an external LNA and SAW (for exact pin orientation see data sheet for MAX-8 [1] and MAX-M8 [2])

The **LNA\_EN** pin (LNA enable) can be used to turn on and off an optional external LNA in power save mode in on/off operation.

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 signals.

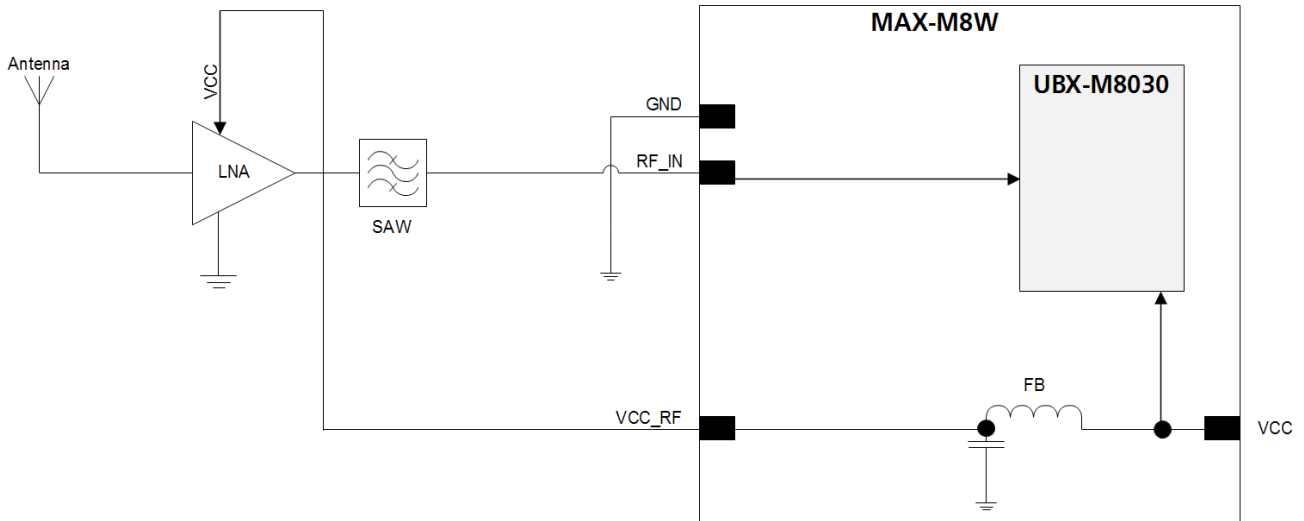


Figure 8: MAX-M8W module design with passive antenna and an external LNA and SAW (for exact pin orientation see the MAX-M8 Data sheet [2])

## 2.4.2 Antenna design with active antenna

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

If the supply voltage of the MAX-8 / M8 receivers matches the supply voltage of the antenna (for example, 3.0 V), use the filtered supply voltage available at pin **VCC\_RF** as shown in Figure 9.

### Active antenna design using VCC\_RF pin to supply the active antenna

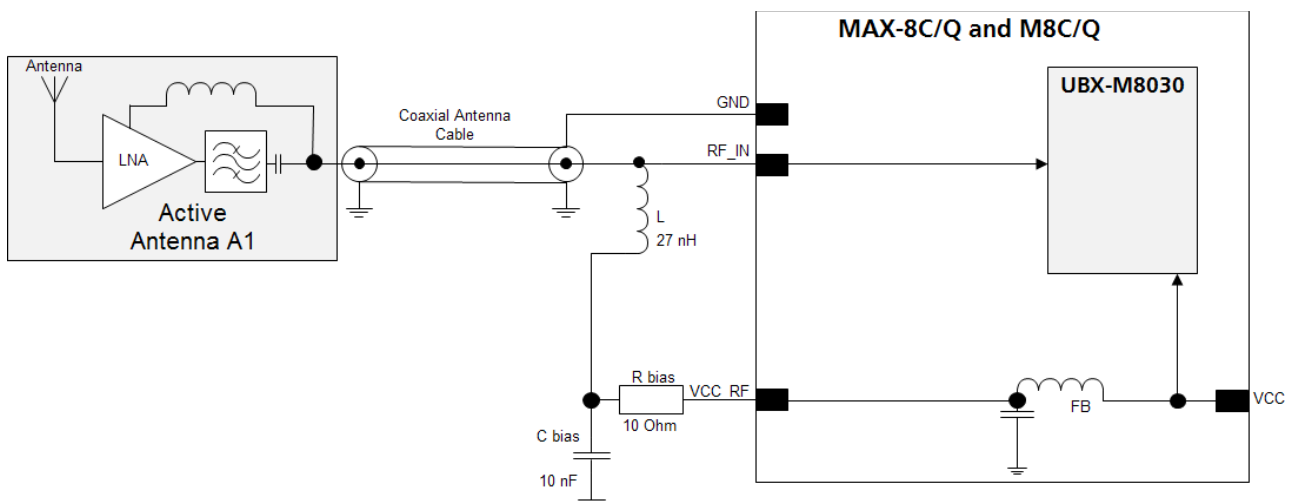


Figure 9: MAX-8C/Q and M8C/Q active antenna design, external supply from VCC\_RF (for exact pin orientation see data sheet for MAX-8 [1] and MAX-M8 [2])

For the MAX-M8W active antenna design with external supply from VCC\_RF, see Figure 11.

In case the **VCC\_RF** voltage does not match with the supply voltage of the active antenna, use a filtered external supply as shown in Figure 10.

### Active antenna design powered from external supply

Since the external bias voltage is fed into the most sensitive part of the receiver (RF input), this supply should be free of noise. Usually, low frequency analog noise is less critical than digital noise of spurious frequencies with harmonics up to the GNSS frequency.

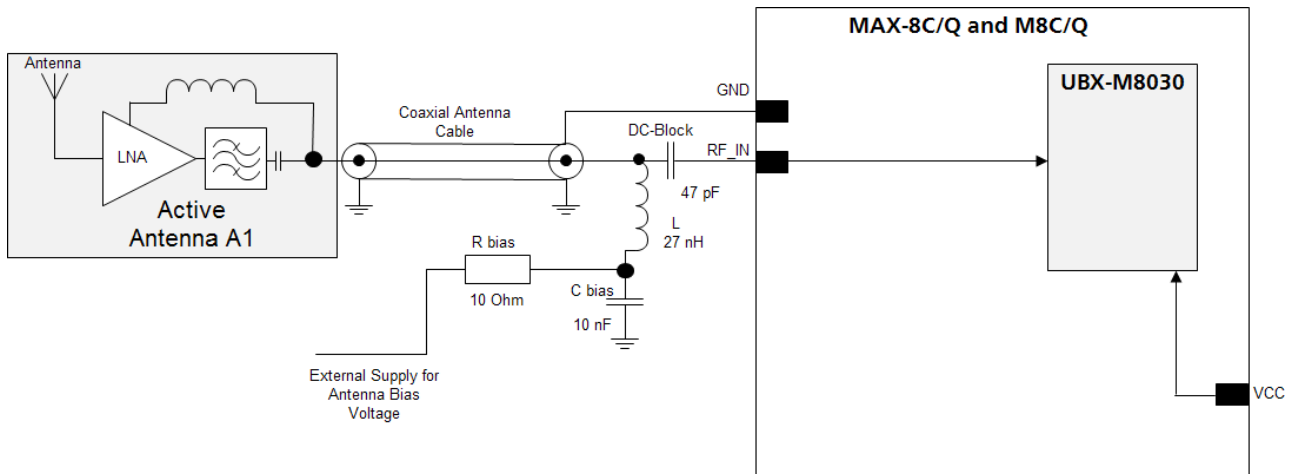


Figure 10: MAX-8C/Q and M8C/Q active antenna design, direct external supply (for exact pin orientation see data sheet for MAX-8 [1] and MAX-M8 [2])

The circuit shown in Figure 10 works with all u-blox 8 / M8 modules, also with modules without **VCC\_RF** output.

#### External supply (MAX-M8W)

For the module design with active antenna with external supply, see Figure 13.

### 2.4.3 Antenna design with active antenna using antenna supervisor (MAX-M8W)

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 (see section 2.4.4).

The current active antenna status can be determined by polling the UBX-MON-HW monitor command. If an antenna is connected, the initial state after power-up is “Active Antenna OK.”

The module firmware supports an active antenna supervisor circuit, which is connected to the pin **EXTINT**. For an example of an open circuit detection circuit, see Figure 14. High on **EXTINT** means that an external antenna is not connected.

Antenna open circuit detection (OCD) is not activated by default in the MAX-8/M8 modules. OCD can be mapped to **PIO13 (EXTINT)**. To activate the antenna supervisor, use the UBX-CFG-ANT message. For more information about how to implement and configure OCD, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].


For recommended parts for the designs that follow, see the Appendix.

## 2.4.4 Status reporting

At startup, and on every change of the antenna supervisor configuration, the MAX-8/M8 modules 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 4: Active antenna supervisor message on startup (UBX binary protocol)**


 To activate 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 [3].


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 startup and on every change.


## 2.4.5 Power and short detection antenna supervisor (MAX-M8W)

If a suitably dimensioned series resistor **R\_BIAS** is placed in front of pin **V\_ANT**, a short circuit can be detected in the antenna supply. This is detected inside the u-blox MAX-M8W module and the antenna supply voltage will be immediately shut down. After this, 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 [3].

 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 in situations where the antenna can be disconnected by the end-user, or where long antenna cables are used.

 If VCC\_RF voltage does not match with the antenna supply voltage, use a filtered external supply, as shown in Figure 13.

### Supply from VCC\_RF (MAX-M8W)

Figure 11 shows an active antenna supplied from the u-blox MAX-M8W module.

The **VCC\_RF** pin can be connected with **V\_ANT** to supply the antenna. Note that the voltage specification of the antenna has to match the actual supply voltage of the u-blox module (for example, 3.0 V).



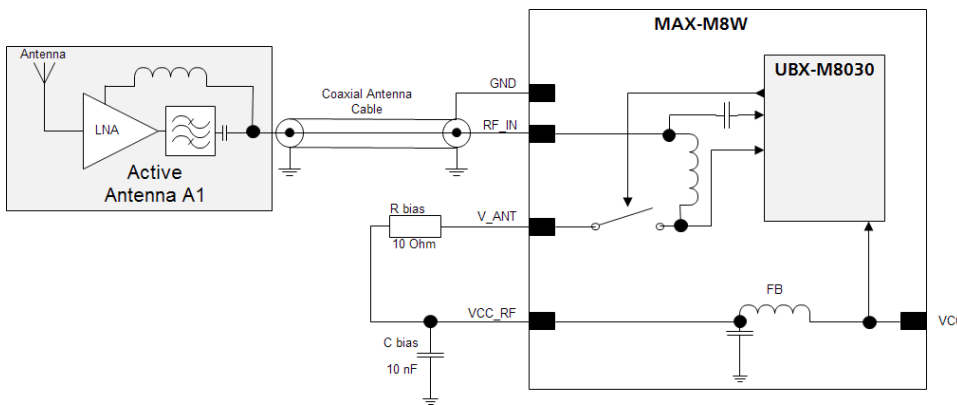


Figure 11: MAX-M8W module design with active antenna, internal supply from VCC\_RF (for exact pin orientation, see the MAX-M8 Data sheet [2])

The LNA\_EN signal can be used to turn an external active antenna on and off. This reduces power consumption in power save mode (backup mode).

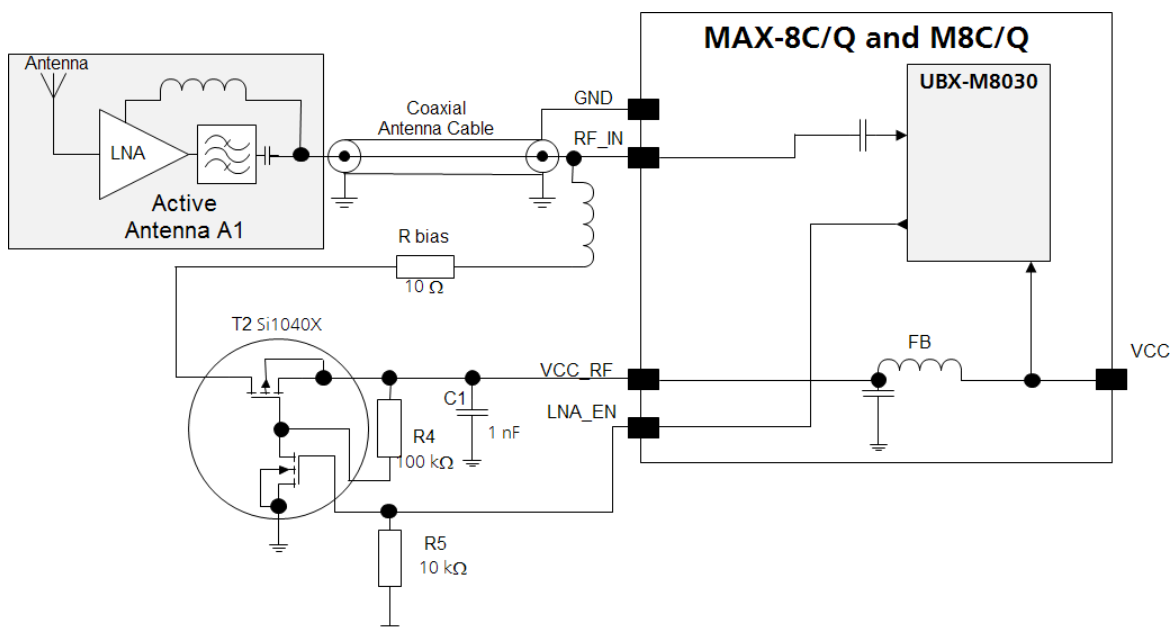


Figure 12: External active antenna control (MAX-8C/Q and M8C/Q)

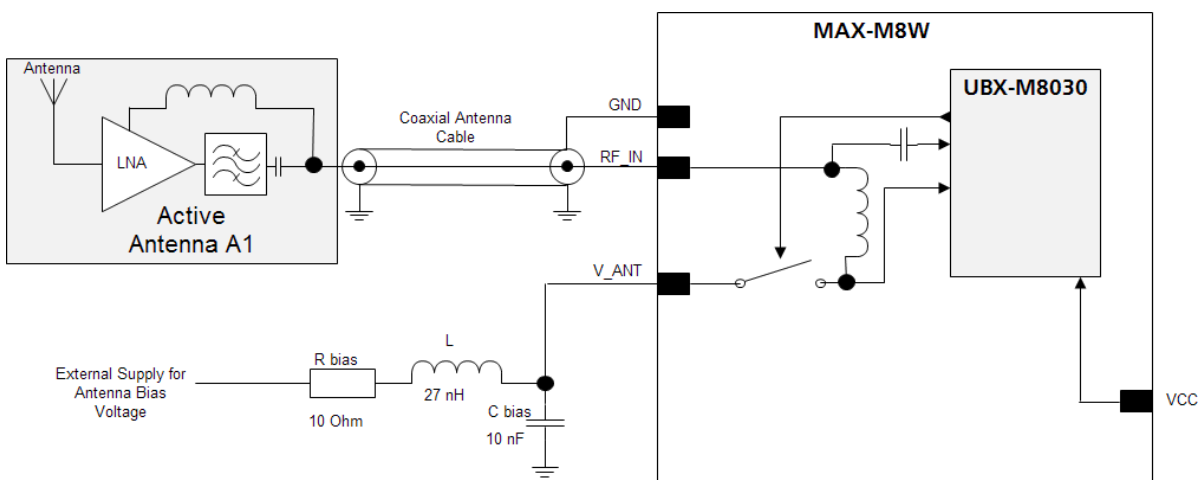


Figure 13: MAX-M8W module design with external supply, active antenna (for exact pin orientation, see the MAX-M8 Data sheet [2])

## 2.4.6 Power, short and open detection antenna supervisor (MAX-M8W)

The open circuit detection (**ANT\_DET**) circuit uses the current flow to detect an open circuit in the antenna. Calculate the threshold current using Equation 1.

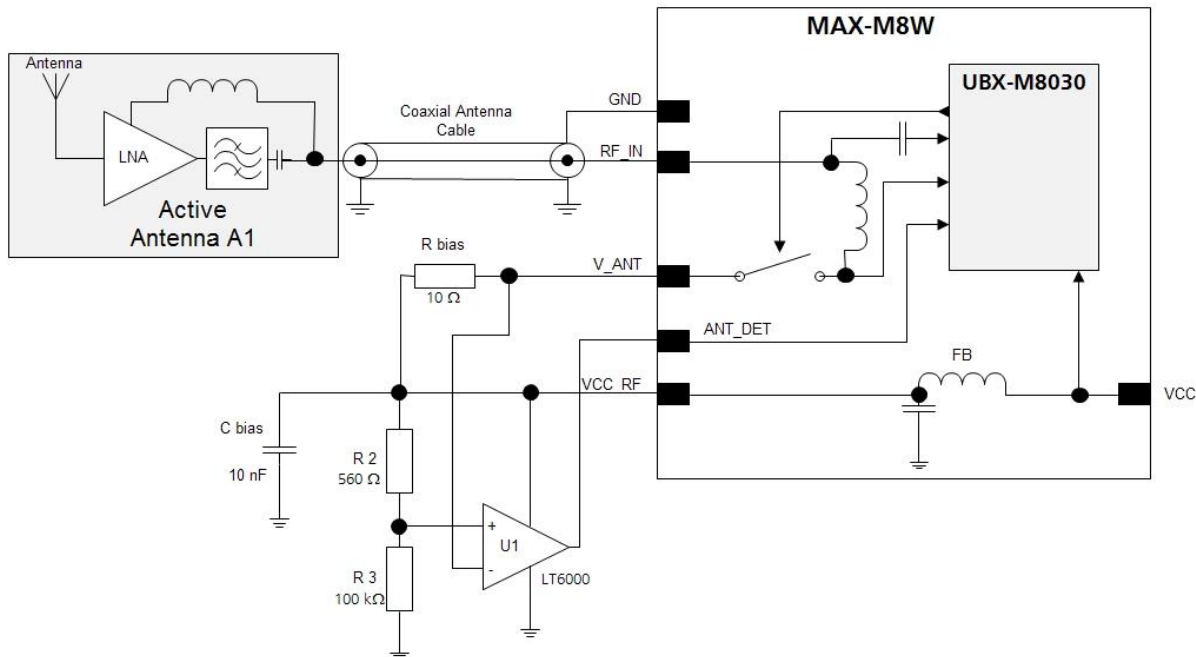


Figure 14: Schematic of open circuit detection (for exact pin orientation, see the MAX-M8 Data sheet [2])

$$I = \left( \frac{R2}{R2 + R3} \right) \cdot V_{cc\_RF}$$

Equation 1: Calculation of threshold current for open circuit detection

Antenna open circuit detection (**ANT\_DET**) is not activated by default. It can be enabled by the UBX-CFG-ANT message. This configuration must be sent to the receiver at every startup.

To enable the antenna open circuit detection feature, the following command must be sent to the receiver at every startup:

“B5 62 06 13 04 00 1F 00 F0 B5 E1 DE”.

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


For more information about how to implement and configure OCD, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].

If the antenna supply voltage is not derived from VCC\_RF, do not exceed the maximum voltage rating of **ANT\_DET**.

## 2.5 Layout design-in: Thermal management

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

- Is the receiver placed away from heat sources?
- Is the receiver placed away from air-cooling sources?


- Is the receiver shielded by a cover/case to prevent the effects of air currents and rapid environmental temperature changes?
-  High temperature drift and air vents can affect the GNSS performance. For best performance, avoid high temperature drift and air vents near the module.

## 3 Migration to u-blox 8 / M8 modules

### 3.1 Migrating u-blox 7 designs to u-blox 8 / M8 modules

u-blox is committed to ensuring that products in the same form factor are backwards compatible over several technology generations. Utmost care has been taken to ensure there is no negative impact on function or performance and to make u-blox 8 / M8 modules as fully compatible as possible with u-blox 7 versions. If using BeiDou, check the bandwidth of the external RF components and the antenna. For power consumption information, see the data sheet for MAX-8 [1] and MAX-M8 [2].

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

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



### 3.2 Hardware migration from MAX-6 to MAX-8 / M8

Pin	MAX-6		MAX-8/M8		Remarks for migration
	Pin name	Typical assignment	Pin name	Typical assignment	
1	GND	GND	GND	GND	No difference
2	TxD	Serial port	TXD	Serial port	No difference
3	RxD	Serial port	RXD	Serial port	No difference
4	TIMEPULSE	Timepulse (1PPS)	TIMEPULSE	Timepulse (1PPS)	No difference
5	EXTINT0	External interrupt pin	EXTINT	External interrupt pin	No difference
6	V_BCKP	Backup supply voltage	V_BCKP	Backup supply voltage	If this was connected to GND on u-blox 6 module, it is OK to do the same in u-blox 8 / M8. (MAX-8C / M8C: Higher backup current, see single crystal)
7	VCC_IO	IO supply voltage Input must always be supplied. Usually connect to VCC pin 8.	VCC_IO	IO supply voltage input must always be supplied. Usually connect to VCC pin 8.	No difference
8	VCC	<b>Module power supply</b> MAX-6G 1.75 – 2.0 V MAX-6Q/C: 2.7 – 3.6 V	VCC	<b>Module power supply</b> MAX-8C/M8C: 1.65 – 3.6 V MAX-8Q/M8Q: 2.7 – 3.6 V	
9	VRESET	Connect to pin 8	RESET_N	Reset input	If pin 9 is connected directly to pin 8, the RESET function is not available. If the RESET function shall be used, a 3k3 resistor from pin 9 to pin 8 in conjunction with an open drain buffer is required for u-blox 6. For MAX-8 / M8 modules, pin 8 can be connected to pin 9 or can be left open. Do not populate the 3k3 resistor. Behavior of RESET_N has changed; in u-blox 7 / 8 / M8, a RESET erases the time information in the BBR, which was maintained in u-blox 6. Therefore, in u-blox 7 / 8 / M8 a RESET will not result in a hot start, etc.
10	GND	GND	GND	GND	No difference

Pin	MAX-6		MAX-8/M8		Remarks for migration
	Pin name	Typical assignment	Pin name	Typical assignment	
11	RF_IN	Matched RF-Input, DC block inside.	RF_IN	Matched RF-Input, DC block inside.	No difference
12	GND	GND	GND	GND	No difference
13	ANT_ON	Active antenna or ext. LNA control pin in power save mode. <b>ANT_ON pin voltage level: MAX-6 -&gt; VCC_RF (pull-up)</b>	LNA_EN	Ext. LNA control pin in power save mode. <b>LNA_EN pin voltage level: MAX-M8 -&gt; VCC_IO (push-pull)</b>	<b>On MAX-6, ANT_ON pin voltage level is with respect to VCC_RF, on MAX-8 / M8 to VCC_IO</b> (only relevant when VCC_IO does not share the same supply with VCC)
14	VCC_RF	Can be used for active antenna or external LNA supply.	VCC_RF	Can be used for active antenna or external LNA supply.	No difference
15	RESERVED	Leave open.	RESERVED (MAX-M8W: V_ANT )	Leave open.	No difference
16	SDA	DDC data	SDA	DDC data	No difference
17	SCL	DDC clock	SCL	DDC clock	No difference
18	SAFEBOOT_N	Leave open.	SAFEBOOT_N	Leave open.	No difference

Table 5: Pin-out comparison MAX-6 vs. MAX-8 / MAX-M8

### 3.3 Software migration


-  For an overall description of the module software operation, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].
-  For migration, see u-blox M8 FW SPG3.01 Migration Guide [8].

## 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 data sheet for MAX-8 [1] and MAX-M8 [2].

#### Population of Modules

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

### 4.2 Soldering

#### Soldering paste

Use of “No Clean” soldering paste is strongly 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 be heated up evenly, regardless of material properties, thickness of components and surface color.

Consider the IPC-7530 Guidelines for temperature profiling for mass soldering (reflow and wave) processes, published 2001.

#### Preheat phase

Initial heating of component leads and balls. Residual humidity will be dried out. Note that this preheat phase will not replace prior baking procedures.

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

#### Heating/ Reflow phase

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

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

- Peak reflow temperature: 245 °C

### Cooling phase

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

- Temperature fall rate: max 4 °C/s

To avoid falling off, place the u-blox 8 / M8 GNSS modules 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 baseboard, and so on. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

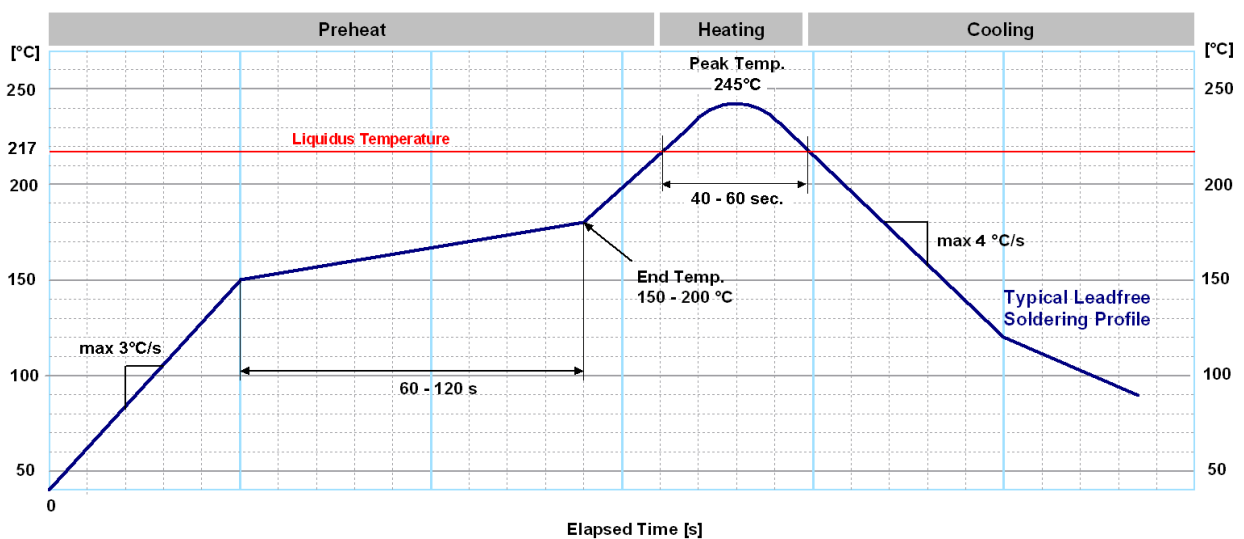


Figure 15: Recommended soldering profile

u-blox 8 / M8 modules **must not** be soldered with a damp heat process.

### Optical inspection

After soldering the u-blox 8 / M8 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 into the gap between the baseboard and the module. The combination of residues of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pads.
- Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into the two housings, areas that are not accessible for post-wash inspections. The solvent will also damage the sticker and the ink-jet printed text.
- Ultrasonic cleaning will permanently damage the module, in particular the quartz oscillators.

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

### Repeated reflow soldering

Only single reflow soldering processes are recommended for boards populated with u-blox 8 / M8 modules. To avoid upside down orientation during the second reflow cycle, u-blox 8 / M8 modules should not be submitted to two reflow cycles on a board populated with components on both sides. In such a case, the module should always be placed on the side of the board which is submitted into the last reflow cycle. This is because of the risk of the module falling off due to the significantly higher weight in relation to other components.

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

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

### Wave soldering


Base boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices require wave soldering to solder the THT components. Only a single wave soldering process is encouraged for boards populated with u-blox 8 / M8 modules.

### Hand soldering


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

### Rework

The u-blox 8 / 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, using a hot air gun is not recommended because this is an uncontrolled process and might damage the module.

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


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

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

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

### Conformal coating

Certain applications employ a conformal coating of the PCB using HumiSeal® or other related coating products. These materials affect the HF properties of the GNSS module and it is important to prevent them from flowing into the module. The RF shields do not provide 100% protection for the module from coating liquids with low viscosity; therefore, be careful when 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 u-blox 8 / M8 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 u-blox 8 / M8 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 u-blox 8 / M8 module are sensitive to ultrasonic waves. Use of any ultrasonic processes (cleaning, welding, and so on) may cause damage to the GNSS receiver.

 u-blox makes no warranty against damages to the u-blox 8 / M8 module caused by any ultrasonic processes.

### 4.3 EOS/ESD/EMI precautions

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

-  To avoid overstress damage during production or in the field, 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 data sheet for MAX-8 [1] and MAX-M8 [2]).

#### 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.

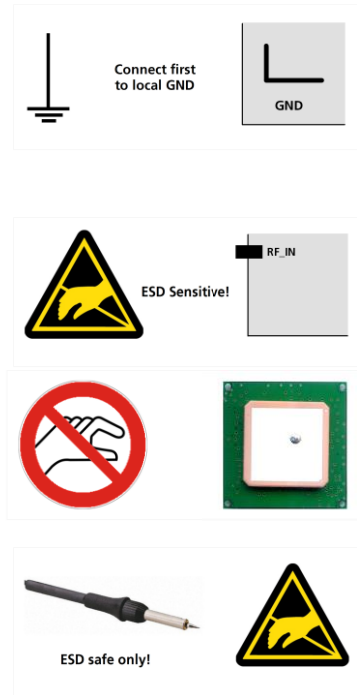


#### ESD handling precautions

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



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

### ESD protection measures

- GNSS positioning modules are sensitive to electrostatic discharge (ESD). Special precautions are required when handling.
- For more robust designs, employ additional ESD protection measures. Using an LNA with appropriate ESD rating can provide enhanced GNSS performance with passive antennas and increases ESD protection.

Most defects caused by ESD can be prevented by following strict ESD protection rules for production and handling. When implementing passive antenna patches or external antenna connection points, then additional ESD measures can also avoid failures in the field as shown in Figure 16.

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

Figure 16: ESD precautions

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

### Electrical overstress (EOS)

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

## EOS protection measures

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

For robustness, EOS protection measures as shown in Figure 17 are recommended for designs combining wireless communication transceivers (for example, cellular) and GNSS in the same design or in close proximity.

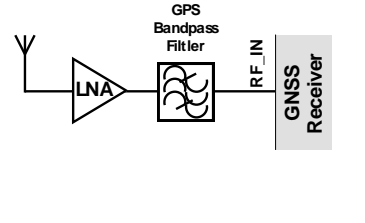
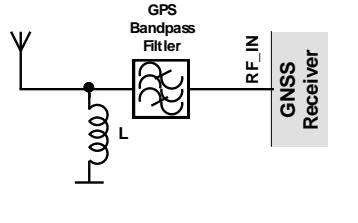
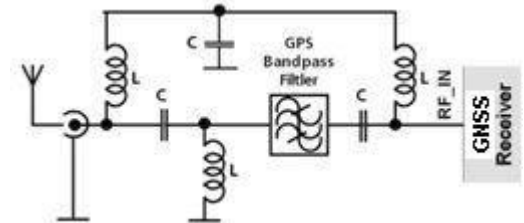
Small passive antennas (<2 dBic and performance critical)	Passive antennas (>2 dBic or performance sufficient)	Active antennas (without internal filter which need the module antenna supervisor circuits)
<p><b>D</b></p> 	<p><b>E</b></p> 	<p><b>F</b></p> 
LNA with appropriate ESD rating and maximum input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

Figure 17: EOS and ESD precautions

## Electromagnetic interference (EMI)

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

The following elements are critical regarding EMI:

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

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

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

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

Improved EMI protection can be achieved by inserting a resistor or, better yet, a ferrite bead or an inductor (see **Error! Reference source not found.**) into any unshielded PCB lines connected to the NSS receiver. Place the resistor as close to the GNSS receiver pin as possible.

Alternatively, feed-through capacitors with good GND connection can be used to protect, for example, the **VCC** supply pin against EMI. A selection of feed-through capacitors is listed in **Error! Reference source not found.**

## Intended use

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

## 4.4 Applications with cellular modules

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

See the GPS Implementation and Aiding Features in u-blox wireless modules [7].

### Isolation between GNSS and cellular antenna

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

### Increasing interference immunity

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

#### In-band interference

With in-band jamming, the signal frequency is very close to the GNSS constellation frequency used, for example, GPS frequency of 1575 MHz (see Figure 18). Such interference signals are typically caused by harmonics from displays, micro-controller, bus systems.

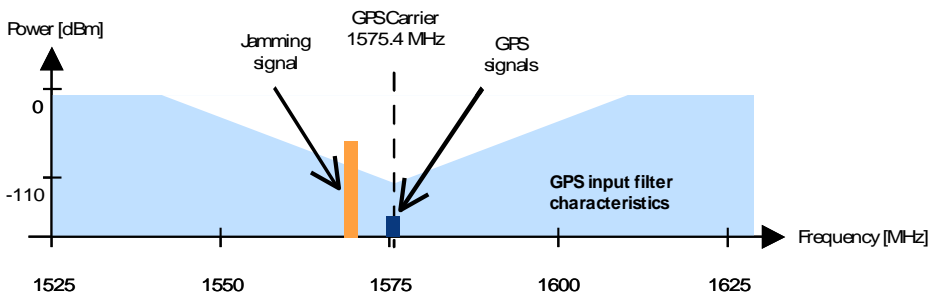


Figure 18: In-band interference signals

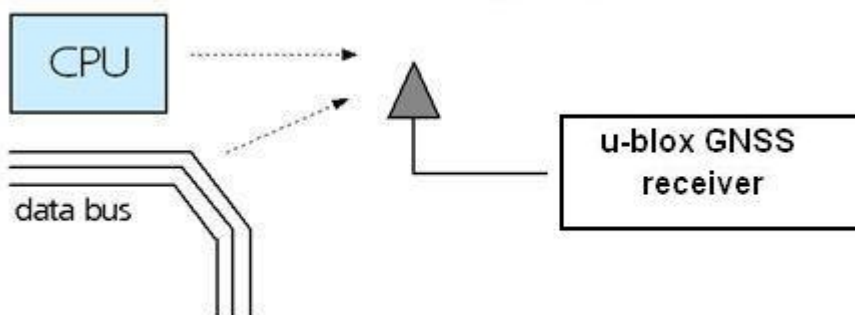


Figure 19: In-band interference sources

Measures against in-band interference include:

- Maintaining a good grounding concept in the design
- Shielding

- Layout optimization
- Filtering
- Placement of the GNSS antenna
- Adding a CDMA, GSM, WCDMA band pass filter before handset antenna

### Out-band interference

Out-band interference is caused by signal frequencies that are different from the GNSS carrier (see Figure 20). The main sources are wireless communication systems such as GSM, CDMA, WCDMA, Wi-Fi, BT.

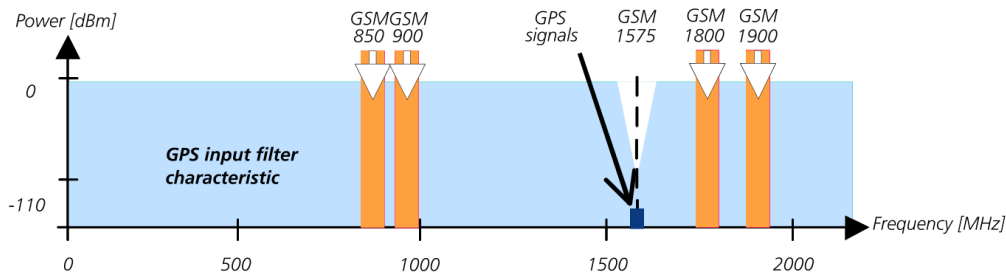


Figure 20: Out-band interference signals

Measures against out-band interference include maintaining a good grounding concept in the design and adding a SAW or band pass ceramic filter (as recommend in section 4) into the antenna input line to the GNSS receiver (see Figure 21).

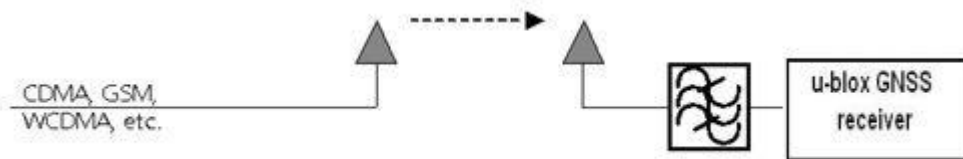


Figure 21: Measures against out-band interference

- For design-in recommendations in combination to cellular operation see **Error! Reference source not found..**
- See the GPS Implementation and Aiding Features in u-blox wireless modules [7].

# Appendix

## A Glossary

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

Table 6: Explanation of the abbreviations and terms used

## B Recommended components

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

Part	Manufacturer	Parts ID	Remarks	Parameters to consider
Diode semi-conductor	ON	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
		B3913: B39162B3913U410	GPS+GLONASS+BeiDou	For automotive application
		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
		SAFEA1G58KB0F00	GPS+GLONASS	Low insertion loss, only for mobile application
		SAFEA1G58KA0F00	GPS+GLONASS	High attenuation, only for mobile application
		SAFFB1G58KA0F0A	GPS+GLONASS	High attenuation, only for mobile application

Part	Manufacturer	Parts ID	Remarks	Parameters to consider
		SAFFB1G58KB0F0A	GPS+GLONASS	Low insertion loss, only for mobile application
	TAI-SAW	TA1573A	GPS+GLONASS	Low insertion loss
		TA1343A	GPS+GLONASS+BeiDou	Low insertion loss
		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 <sub>DC-block</sub> , 47 pF	DC-block
	Murata	X7R 10N 10% 16 V	C <sub>Bias</sub> , 10nF	Bias-T
Ferrite bead	Murata	BLM15HD102SN1	FB	High IZI at fGSM
Feed-through capacitor for signal	Murata	NFL18SP157X1A3	Monolithic type	For data signals, 34 pF load capacitance
		NFA18SL307V1A45	Array Type	For data signals, 4 circuits in 1 package
Feed-through capacitor	Murata	NFM18PC ....	0603 2A	Rs < 0.5 Ω
		NFM21P....	0805 4A	
Resistor		10 Ω ± 10%, min 0.250 W	R <sub>bias</sub>	
		560 Ω ± 5%	R2	
		100 kΩ ± 5%	R3, R4	

**Table 7: Explanation of the abbreviations and terms used**

### Recommended antennas


Manufacturer	Order no.	Comments
Hirschmann ( <a href="http://www.hirschmann-car.com">www.hirschmann-car.com</a> )	GLONASS 9 M	GPS+GLONASS active
Taoglas ( <a href="http://www.taoglas.com">www.taoglas.com</a> )	AA.160.301111	36 x 36 x 4 mm, 3-5 V 30 mA active
Taoglas ( <a href="http://www.taoglas.com">www.taoglas.com</a> )	AA.161.301111	36 x 36 x 3 mm, 1.8 to 5.5 V / 10 mA at 3 V active
INPAQ ( <a href="http://www.inpaq.com.tw">www.inpaq.com.tw</a> )	B3G02G-S3-01-A	2.7 to 3.9 V / 10 mA active
Amotech ( <a href="http://www.amotech.co.kr">www.amotech.co.kr</a> )	B35-3556920-2J2	35 x 35 x 3 mm GPS+GLONASS passive
Amotech ( <a href="http://www.amotech.co.kr">www.amotech.co.kr</a> )	A25-4102920-2J3	25 x 25 x 4 mm GPS+GLONASS passive
Amotech ( <a href="http://www.amotech.co.kr">www.amotech.co.kr</a> )	A18-4135920-AMT04	18 x 18 x 4 mm GPS+GLONASS passive
Amotech ( <a href="http://www.amotech.co.kr">www.amotech.co.kr</a> )	AGA363913-S0-A1	GPS+GLONASS+BeiDou active
INPAQ ( <a href="http://www.inpaq.com.tw">www.inpaq.com.tw</a> )	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 8: Recommended antennas**

## Related documents

- [1] MAX-8 Data sheet, [UBX-16000093](#)
- [2] MAX-M8 (FW3) Data sheet, [UBX-15031506](#)
- [3] u-blox 8 / u-blox M8 Receiver Description including Protocol Specification (Public version), [UBX-13003221](#)
- [4] GPS Antenna Application Note, GPS-X-08014
- [5] GPS Compendium, GPS-X-02007
- [6] I2C-bus specification, Rev. 6 — 4 April 2014,  
[http://www.nxp.com/documents/user\\_manual/UM10204.pdf](http://www.nxp.com/documents/user_manual/UM10204.pdf)
- [7] GPS Implementation and Aiding Features in u-blox wireless modules, GSM.G1-CS-09007
- [8] u-blox M8 FW SPG3.01 Migration Guide, [UBX-15028330](#)

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

## Revision history

Revision	Date	Name	Comments
R01	16-May-2016	jfur	Advance Information
R02	08-Aug-2016	jfur	Production Information
R03	30-Jan-2017	mdur	Update Figure 14 and relevant content in section 2.4.6.
R04	06-Oct-2017	msul	Added information on RED DoC in European Union regulatory compliance (page 2), added Intended use statement in section 0 Electromagnetic interference (EMI), updated legal statement in cover page and added Documentation feedback e-mail address in contacts page.
R05	07-Feb-2019	yzha	Clarified use of internal pull-ups in section 1.5. Clarified alternative uses for the EXTINT pin in section 1.5.2.
R06	27-May-2020	mala	Added section 2.5 Layout design-in: Thermal management. Minor editorial changes to reflect the latest style guide changes.



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