

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.



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This document applies to the following products:

Product name	Type number	ROM/FLASH version	PCN reference
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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Preface

u-blox Technical Documentation

As part of our commitment to customer support, u-blox maintains an extensive volume of technical documentation for our products. In addition to our product-specific technical data sheets, the following manuals are available to assist u-blox customers in product design and development.

- **GPS Compendium:** This document, also known as the GPS book, provides a wealth of information regarding generic questions about GPS system functionalities and technology.
- **Receiver Description including Protocol Specification:** This document describes messages, configuration and functionalities of the MAX-8 / MAX-M8 software releases and receivers.
- **Hardware Integration Manuals:** These manuals provide hardware design instructions and information on how to set up production and final product tests.
- **Application Notes:** These documents provide general design instructions and information that applies to all u-blox GNSS positioning modules.

How to use this Manual

This manual has a modular structure. It is not necessary to read it from beginning to end.

The following symbols highlight important information within the manual:



An index finger points out key information pertaining to module integration and performance.



A warning symbol indicates actions that could negatively influence or damage the module.

Questions

If you have any questions about MAX-8 / MAX-M8 integration, please:

- Read this manual carefully.
- Contact our information service on the homepage <http://www.u-blox.com>.
- Read the questions and answers on our FAQ database on the homepage.

Technical Support

Worldwide Web

Our website (www.u-blox.com) is a rich pool of information. Product information, technical documents and helpful FAQ can be accessed 24 h a day.

By E-mail

If you have technical problems or cannot find the required information in the provided documents, contact the closest Technical Support office. To ensure that we process your request as soon as possible, use our service pool email addresses rather than personal staff email addresses. Contact details are at the end of the document.

Helpful Information when Contacting Technical Support

When contacting Technical Support please have the following information ready:

- Receiver type (e.g. MAX-M8C-0-10), Datacode (e.g. 181000.0800) and firmware version (e.g. ROM SPG 3.01)
- Receiver/module configuration
- Clear description of your question or the problem (may include a u-center logfile)
- A short description of the application
- Your complete contact details

Contents

Preface	3
Contents.....	4
1 Hardware description	6
1.1 Overview	6
1.2 Configuration	6
1.3 Connecting power.....	6
1.3.1 VCC_IO: IO Supply Voltage	7
1.3.2 V_BCKP: Backup supply voltage	7
Single Crystal feature on MAX-8C / MAX-M8C	7
1.3.3 VCC_RF: Output voltage RF.....	8
1.3.4 V_ANT: Antenna supply (MAX-M8W).....	8
1.4 Interfaces.....	8
1.4.1 UART.....	8
1.4.2 Display Data Channel (DDC)	8
1.4.3 TX_READY.....	8
1.5 I/O pins	9
1.5.1 RESET_N: Reset input	9
1.5.2 EXTINT: External interrupt.....	9
1.5.3 SAFEBOOT_N	9
1.5.4 TIMEPULSE	9
1.5.5 LNA_EN: LNA enable	9
1.5.6 ANT_DET: Open Circuit Detection (MAX-M8)	10
1.6 Electromagnetic interference on I/O lines	10
2 Design	11
2.1 Pin description	11
2.1.1 Pin name changes	11
2.2 Minimal design	12
2.3 Layout: Footprint and paste mask	12
2.4 Antenna and Antenna supervision	13
2.4.1 Antenna design with passive antenna	13
2.4.2 Antenna design with active antenna	14
2.4.3 Antenna design with active antenna using antenna supervisor (MAX-M8W)	15
2.4.4 Status reporting	16
2.4.5 Power and short detection antenna supervisor (MAX-M8W)	16
2.4.6 Power, short and open detection Antenna Supervisor (MAX-M8W).....	18
3 Migration to u-blox 8 / M8 modules.....	19
3.1 Migrating u-blox 7 designs to a u-blox 8 / M8 modules	19
3.2 Hardware migration from MAX-6 to MAX-8 / M8	19

3.3	Software migration	20
4	Product handling	21
4.1	Packaging, shipping, storage and moisture preconditioning	21
4.2	Soldering	21
4.3	EOS/ESD/EMI precautions	24
4.4	Applications with cellular modules	27
	Appendix	29
A	Glossary	29
	Recommended parts	30
	Related documents	31
	Revision history	31
	Contact	32

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 & place and reflow-soldering equipment for cost-efficient, high-volume production enabling short time-to-market.



For product features see the *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [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.

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), then 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 *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [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 not 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.

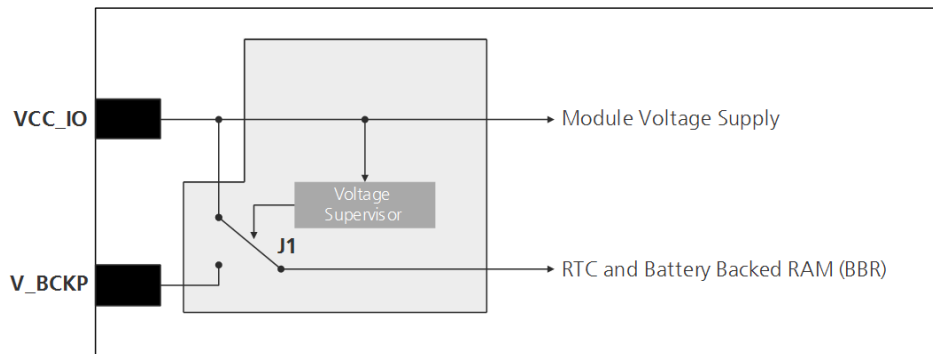


Figure 1: Backup battery and voltage (for exact pin orientation, see the *MAX-8 Data Sheet [1]* and *MAX-M8 Data Sheet [2]*)

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 an 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 *MAX-8 Data Sheet [1]* and *MAX-M8 Data Sheet [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. Then the backup current will be same as on MAX-8 / MAX-M8 modules without “single crystal” feature. But the time information is not maintained during off time. So the customer either aides the time at every startup to the receiver or the Hot and Warmstart 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 – and Warmstart 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

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 *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [2] for more information). It can be used for wake-up functions in Power Save Mode on all u-blox 8 / M8 modules and for aiding. Leave open if unused; the functions are disabled by default.

Power Control

The power control feature allows overriding the automatic active/inactive cycle of Power Save Mode. The state of the receiver can be controlled through the **EXTINT** 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.

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

On **MAX-M8Q**, **MAX-M8C**, **MAX-8C** and **MAX-8Q** modules, in Power Save Mode, the system can turn on/off an optional external LNA using the LNA_EN signal in order to optimize power consumption.

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

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 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 (e.g. $R > 20 \Omega$), 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 affect also the signal rise times.

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.

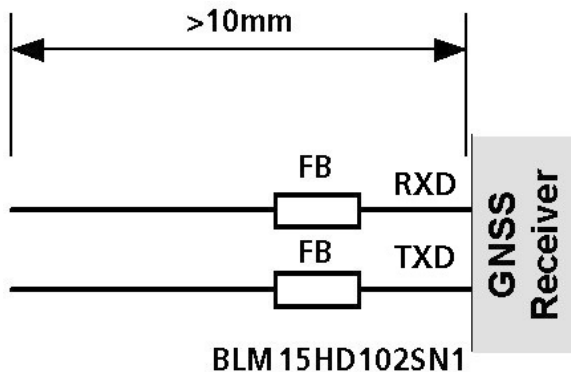


Figure 2: EMI Precautions

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 GND connection to all GND pins of the module, preferably with a large ground plane.
	V_BCKP	6	I	Backup Supply Voltage	Backup supply voltage input pin. Connect to VCC_IO 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 RF_IN 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. LNA_EN pin voltage level is VCC_IO
	Reserved (MAX-M8W)	-	-	Reserved	Leave open
UART	TXD	2	O	Serial Port	UART, leave open if not used, Voltage level referred VCC_IO . Can be configured as TX Ready indication for the DDC interface.
	RXD	3	I	Serial Port	UART, leave open if not used, Voltage level referred VCC_IO
System	TIMEPULSE	4	O	Timepulse Signal	Leave open if not used, Voltage level referred VCC_IO
	EXTINT	5	I	External Interrupt	Leave open if not used, Voltage level referred VCC_IO Can be programmed on MAX-M8W as Open Circuit Detection (ANT_DET)
	SDA	16	I/O	DDC Pins	DDC Data. Leave open, if not used.
	SCL	17	I	DDC Pins	DDC Clock. Leave open, if not used.
	VCC_IO	7	I	VCC_IO	IO supply voltage. Input must be always supplied. Usually connect to VCC Pin 8
	RESET_N	9	I	Reset	Reset
	V_ANT (MAX-M8W)	15	I	Antenna Bias Voltage	Connect to GND (or leave open) if passive antenna is used. If an active antenna is used, add a 10 Ω resistor in front of V_ANT input to the Antenna Bias Voltage or VCC_RF
	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 a common naming convention across u-blox modules. The pins have not changed their operation and are the same physical hardware but with updated names. The table below lists the pins that have changed name along with their old and new names.

No	Previous Name	New name
13	ANT_ON	LNA_EN

Table 3: Pin name changes

2.4 Antenna and Antenna supervision

The MAX-8 / MAX-M8 modules are 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 require 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, care should be taken to reduce electrical noise that may interfere with the antenna performance. Passive antennas do not require a DC bias voltage and can be directly connected to the RF input pin **RF_IN**. Sometimes they may also need a passive matching network to match the impedance to 50 Ω .

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

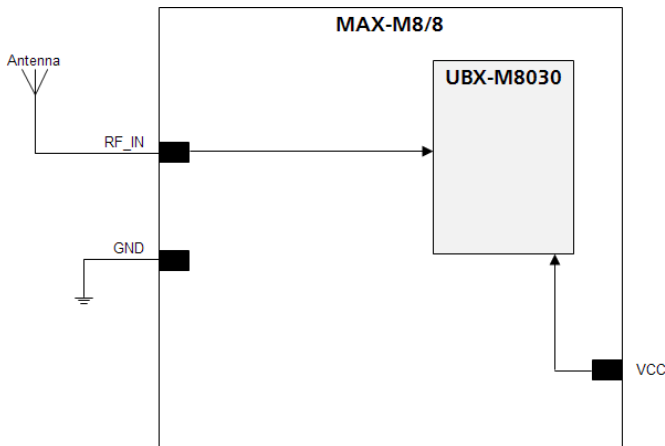


Figure 6: Module design with passive antenna (for exact pin orientation see *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [2])



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

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

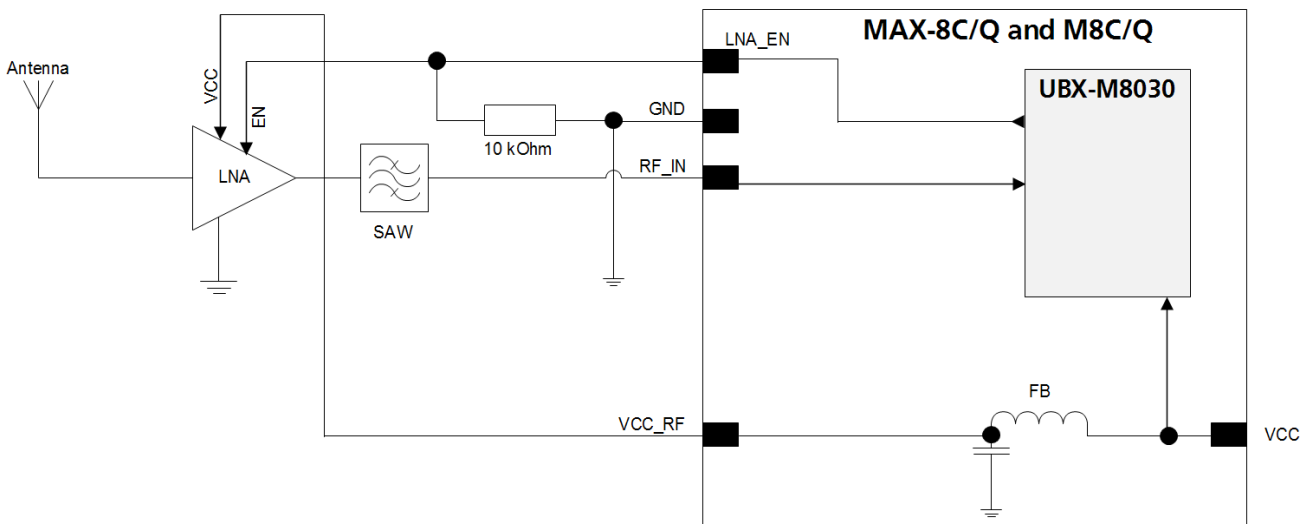


Figure 7: MAX-8C/Q and M8C/Q modules design with passive antenna and an external LNA and SAW (for exact pin orientation see the *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [2])

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.

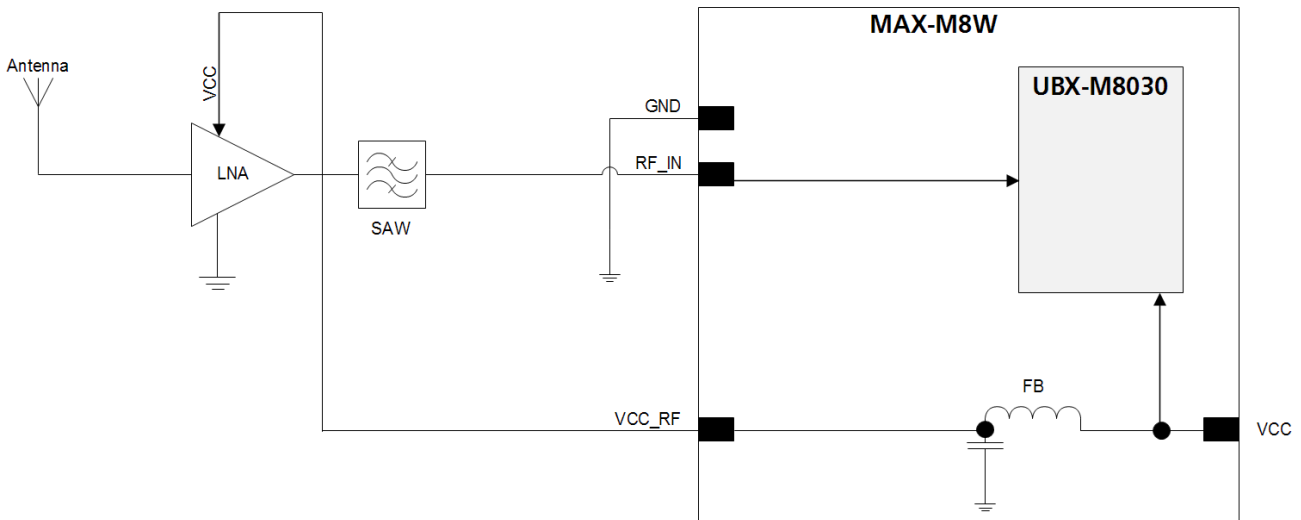


Figure 8: MAX-M8W Module design with passive antenna and an external LNA and SAW (for exact pin orientation see the *MAX-M8 Data Sheet [2]*)

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 (e.g. 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

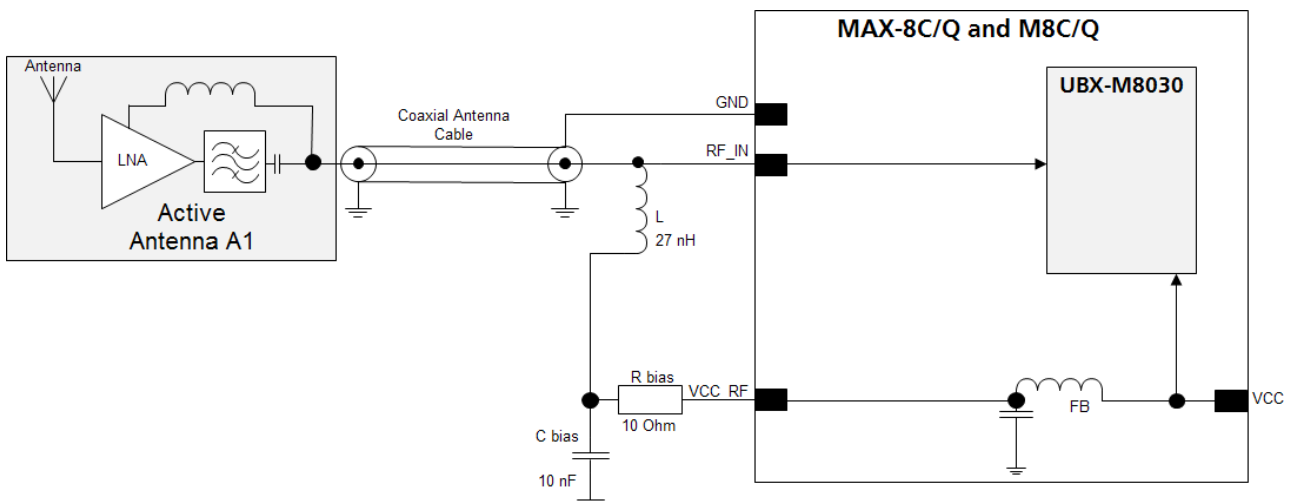


Figure 9: MAX-8C/Q and M8C/Q active antenna design, external supply from VCC_RF (for exact pin orientation see the *MAX-8 Data Sheet [1]* and *MAX-M8 Data Sheet [2]*)

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 (i.e. the 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.

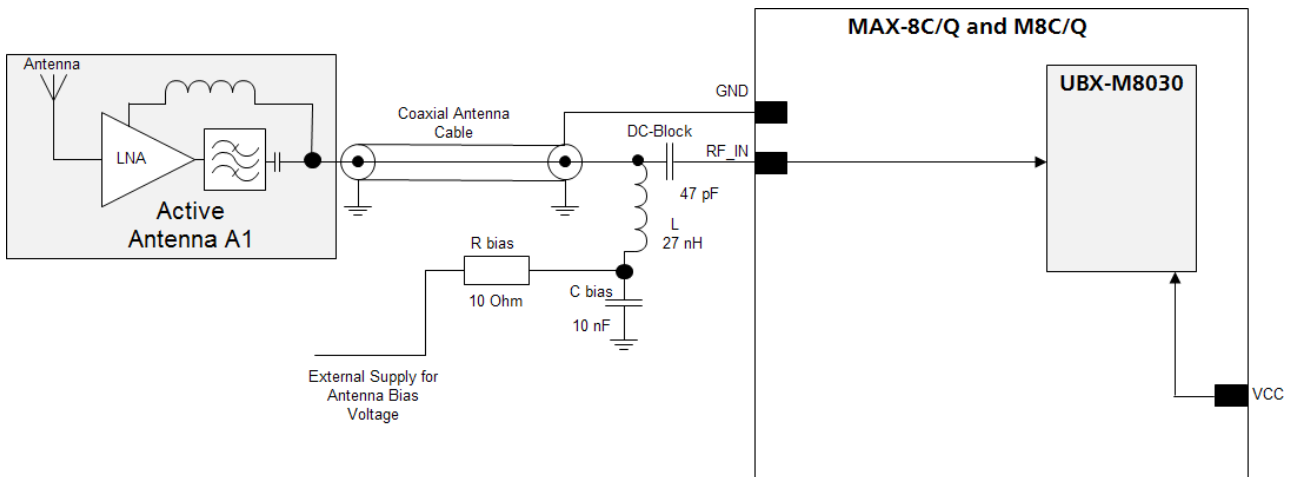


Figure 10: MAX-8C/Q and M8C/Q active antenna design, direct external supply (for exact pin orientation see the *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [2])



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 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 on 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 start-up 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 which, 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 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, 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 (e.g. 3.0 V).

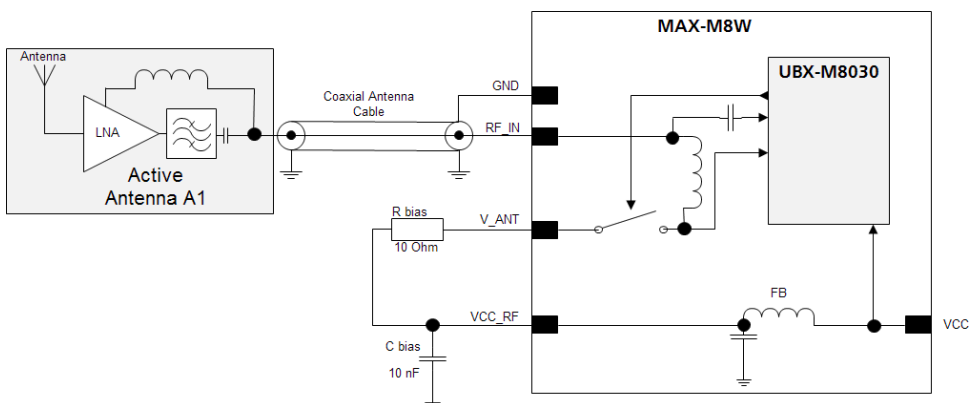


Figure 11: MAX-M8W module design with active antenna, internal supply from VCC_RF (for exact pin orientation, see the *MAX-M8 Data Sheet* [2])

The LNA_EN signal can be used to turn on and off an external active Antenna. This reduces power consumption in Power Save Mode (Backup mode).

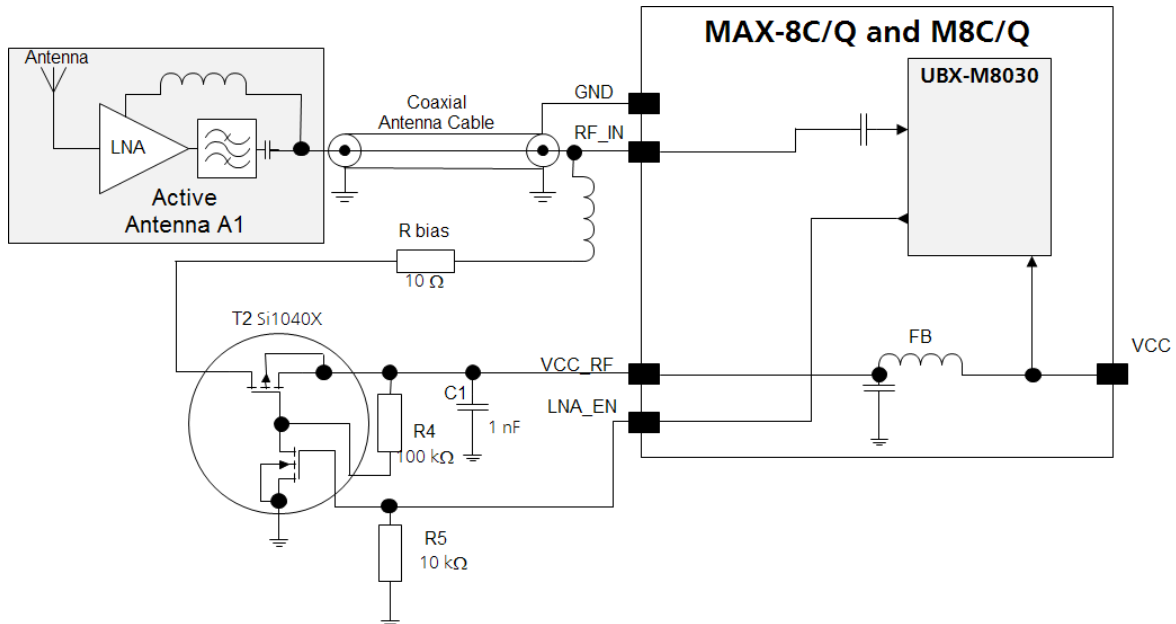


Figure 12: External active antenna control (MAX-8C/Q and M8C/Q)

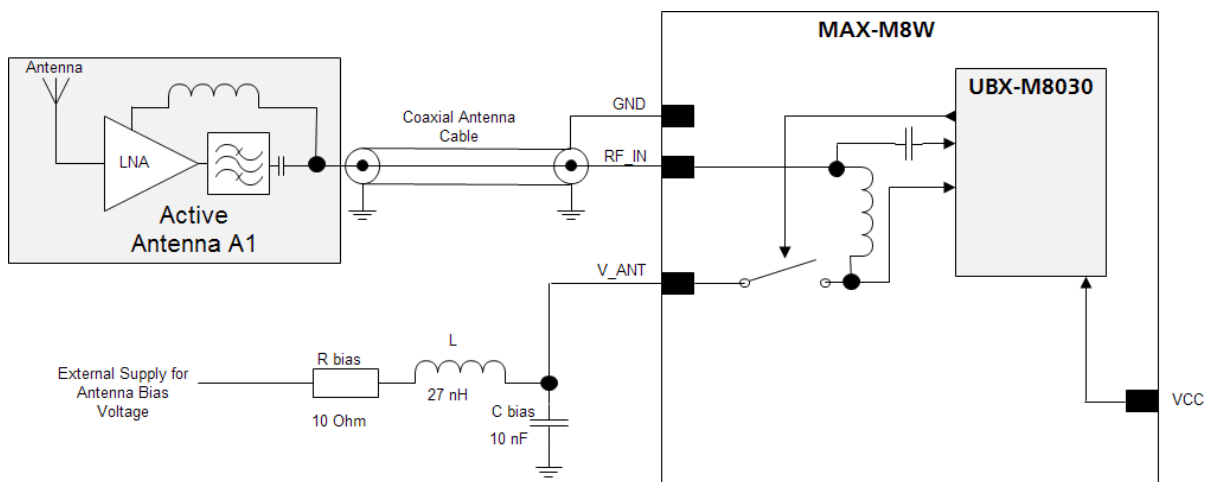


Figure 13: MAX-M8W module design with external supply, active antenna (for exact pin orientation, see the MAX-M8 Data Sheet [2])

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.

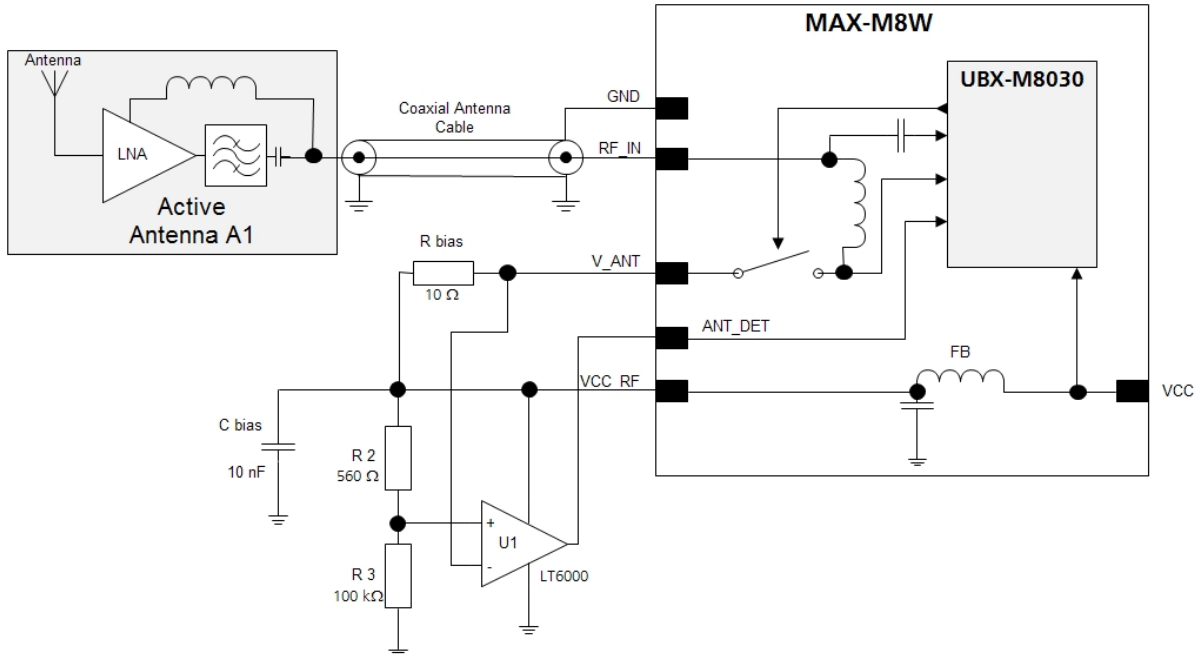


Figure 14: Schematic of open circuit detection (for exact pin orientation, see the *MAX-M8 Data Sheet* [2])

$$I = \frac{\left(\frac{R2}{R2 + R3} \right)}{R_{bias}} \cdot V_{CC_RF}$$

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**.

3 Migration to u-blox 8 / M8 modules

3.1 Migrating u-blox 7 designs to a 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 *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [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 a common naming convention across u-blox modules. The pins have not changed their operation and are the same physical hardware but with updated names.

3.2 Hardware migration 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, 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	Module power supply MAX-6G 1.75 – 2.0V MAX-6Q/C: 2.7 – 3.6V	VCC	Module power supply MAX-8C/M8C: 1.65 – 3.6V MAX-8Q/M8Q: 2.7 – 3.6V	
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; For u-blox 7 and 8 / M8 , a RESET will erase the time information in the BBR, which was maintained in u-blox 6. Therefore, with u-blox 7 and 8 / M8 a RESET will not result in a hot start, etc.
10	GND	GND	GND	GND	No difference
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. ANT_ON pin voltage level: MAX-6 -> VCC_RF (pull-up)	LNA_EN	Ext. LNA control pin in power save mode. LNA_EN pin voltage level: MAX-M8 -> VCC_IO (push-pull)	On MAX-6, ANT_ON pin voltage level is with respect to VCC_RF, on MAX-8 / M8 to VCC_IO (only relevant when VCC_IO does not share the same supply with VCC)

Pin	MAX-6		MAX-8/M8		Remarks for Migration
	Pin Name	Typical Assignment	Pin Name	Typical Assignment	
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 *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [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 listed in the example below meets these criteria.

Soldering Paste: OM338 SAC405 / Nr. 143714 (Cookson Electronics)
 Alloy specification: Sn 95.5/ Ag 4/ Cu 0.5 (95.5% Tin/ 4% Silver/ 0.5% Copper)
 Melting Temperature: 217° C
 Stencil Thickness: See section 2.3

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

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



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

Reflow soldering

A convection type-soldering oven is highly recommended over the infrared type radiation oven. Convection heated ovens allow precise control of the temperature and all parts will 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 (solder becomes more brittle) of the solder and possible mechanical tensions in the products. Controlled cooling helps to achieve bright solder fillets with a good shape and low contact angle.

- Temperature fall rate: max 4° C/s



To avoid falling off, the u-blox 8 / M8 GNSS modules should be placed on the topside of the motherboard during soldering.

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

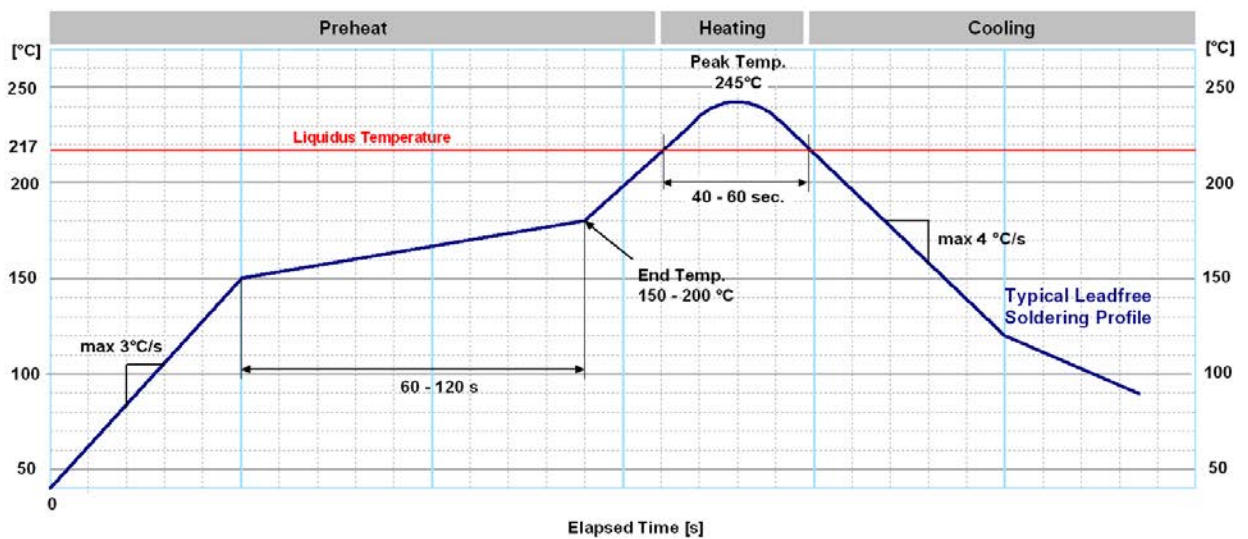


Figure 15: Recommended soldering profile



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 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 u-blox 8 / M8 modules. u-blox 8 / M8 modules should not be submitted to two reflow cycles on a board populated with components on both sides in order to avoid upside down orientation during the second reflow cycle. In this case, the module should always be placed on that side of the board, which is submitted into the last reflow cycle. The reason for this (besides others) is the risk of the module falling off due to the significantly higher weight in relation to other components.

Two reflow cycles can be considered by excluding the above described upside down scenario and taking into account the rework conditions described in 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 (e.g. pins 1 and 15), and then 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, 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 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 etc.) may cause damage to the GNSS Receiver.



u-blox offers 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, careful consideration must be given to electromagnetic and voltage susceptibility issues. 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 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 *MAX-8 Data Sheet* [1] and *MAX-M8 Data Sheet* [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. 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 16.

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

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

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

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 (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 7) into any unshielded PCB lines connected to the GNSS receiver. Place the resistor as close as possible to the GNSS receiver pin.

Alternatively, feed-thru capacitors with good GND connection can be used to protect e.g. the **VCC** supply pin against EMI. A selection of feed-thru capacitors are listed in Table 7.

4.4 Applications with cellular modules

GSM terminals transmit power levels up to 2 W (+33 dBm) peak, 3G and LTE up to 250mW 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, 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

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, e.g. GPS frequency of 1575 MHz (see Figure 18). Such interference signals are typically caused by harmonics from displays, micro-controller, bus systems, etc.

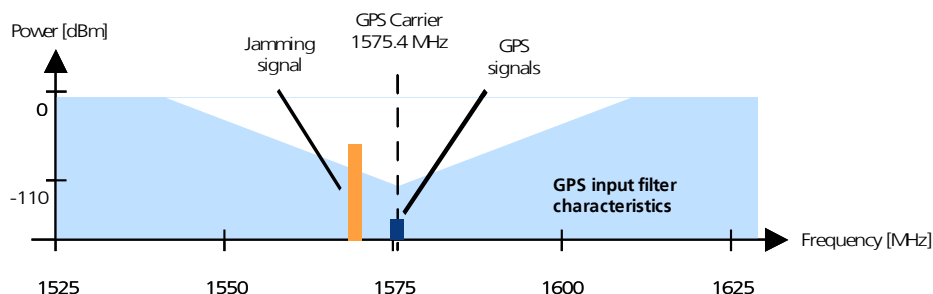


Figure 18: In-band interference signals

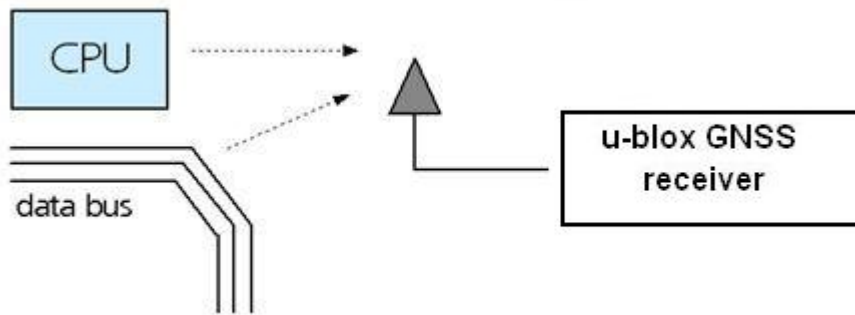


Figure 19: In-band interference sources

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, etc.

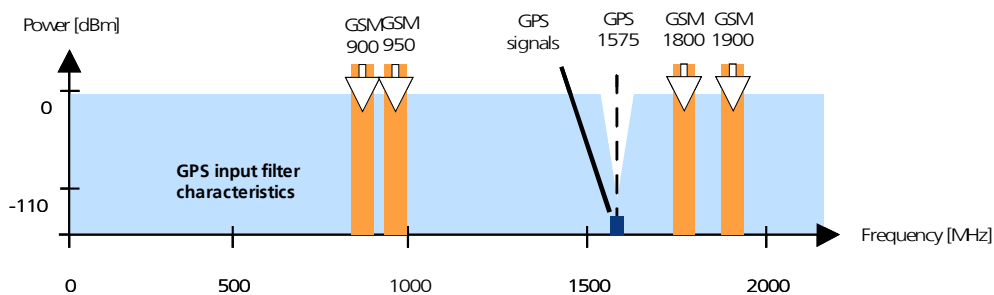


Figure 20: Out-band interference signals

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 Appendix



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

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 6: Explanation of abbreviations used

Recommended parts

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

Part	Manufacturer	Part ID	Remarks	Parameters to consider
Diode 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
	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
		SAFFB1G58KB0F0A	GPS+GLONASS	Low insertion loss, only for mobile application
	TAI-SAW	TA1573A	GPS+GLONASS	Low insertion loss
		TA0638A	GPS+GLONASS+BeiDou	Low insertion loss
		TA1343A	GPS+GLONASS+BeiDou	Low insertion loss
LNA	JRC	NJG1143UA2	LNA	Low noise figure, up to 15 dBm RF input power
Inductor	Murata	LQG15HS27NJ02	L, 27 nH	Impedance @ freq GPS > 500 Ω
Capacitor	Murata	GRM1555C1E470JZ01	C _{DC-block} 47 pF	DC-block
	Murata	X7R 10N 10% 16V	C _{Bias} 10nF	Bias-T
Ferrite Bead	Murata	BLM15HD102SN1	FB	High IZI @ fGSM
Feed 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	0603 2A	Rs < 0.5 Ω
		NFM21P....	0805 4A	
Resistor		10 $\Omega \pm 10\%$, min 0.250 W	R _{bias}	
		560 $\Omega \pm 5\%$	R2	
		100 k $\Omega \pm 5\%$	R3, R4	

Table 7: 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	GPS/GLONASS/BeiDou 36*36*4 mm, 3-5 V 30 mA active
Taoglas (www.taoglas.com)	AA.161.301111	36*36*3 mm, 1.8 to 5.5V / 10 mA at 3 V active
INPAQ (www.inpaq.com.tw)	B3G02G-S3-01-A	GPS/GLONASS/BeiDou 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)	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 8: Recommend antennas

Related documents

- [1] MAX-8 Data Sheet, Docu. No. UBX-16000093
- [2] MAX-M8 (FW3) Data Sheet, Docu. No. UBX-15031506
- [3] u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification (Public version), Docu. No. UBX-13003221
- [4] GPS Antenna Application Note, Docu. No. GPS-X-08014
- [5] GPS Compendium, Docu. No. GPS-X-02007
- [6] I2C-bus specification, Rev. 6 — 4 April 2014,
http://www.nxp.com/documents/user_manual/UM10204.pdf
- [7] GPS Implementation and Aiding Features in u-blox wireless modules, Docu. No. GSM.G1-CS-09007
- [8] u-blox M8 FW SPG3.01 Migration Guide, Docu. No. UBX-15028330



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Revision history

Revision	Date	Name	Status / Comments
R01	16-May-2016	jfur	Advance Information
R02	08-Aug-2016	jfur	Production Information
R03	30-Jan-2017	mdur	Updated Figure 14 and relevant content in section 2.4.6.

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