

MAX-M8

u-blox M8 GNSS modules

Hardware Integration Manual

Abstract

This document describes the features and specifications of the cost effective and high-performance MAX-M8 modules, which feature the u-blox M8 concurrent GNSS engine with reception of GPS, GLONASS, BeiDou and QZSS signals.



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

| Name | Type number | ROM/FLASH version | PCN reference |
|-----------|--------------|-------------------|---------------|
| MAX-M8C-0 | MAX-M8C-0-00 | ROM 2.01 | N/A |
| MAX-M8W-0 | MAX-M8W-0-00 | ROM 2.01 | N/A |
| MAX-M8Q-0 | MAX-M8Q-0-00 | ROM 2.01 | N/A |

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1 Hardware description

1.1 Overview

u-blox M8 modules are standalone GNSS positioning modules featuring the high performance u-blox M8 positioning engine. Available in industry standard form factors in leadless chip carrier (LCC) packages, 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-M8 Data Sheet* [1].



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 M8-V15 Receiver Description Protocol Specification* [2]. The modified settings remain effective until power-down or reset. If these settings have been stored in BBR (Battery Backed RAM), then the modified configuration will be retained, as long as the backup battery supply is not interrupted.

Electrical Programmable Fuse (eFuse)

u-blox M8 modules include an integrated eFuse memory for permanently saving configuration settings.



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-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 M8 positioning modules have up to four power supply pins: **VCC**, **VCC_IO**, **V_BCKP** and **VDD_USB**.

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-M8 Data Sheet* [1] for specification).



When switching from backup mode to normal operation or at start-up, u-blox M8 modules must charge the internal capacitors in the core domain. In certain situations, this can result in a significant current draw. For low-power applications using Power Save and 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.

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.

V_BCKP: Backup supply voltage

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



Avoid high resistance on the **V_BCKP** line: During the switch from main supply to backup supply, a short current adjustment peak can cause high voltage drop on the pin with possible malfunctions.



If no backup supply voltage is available, connect the **V_BCKP** pin to **VCC**.



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

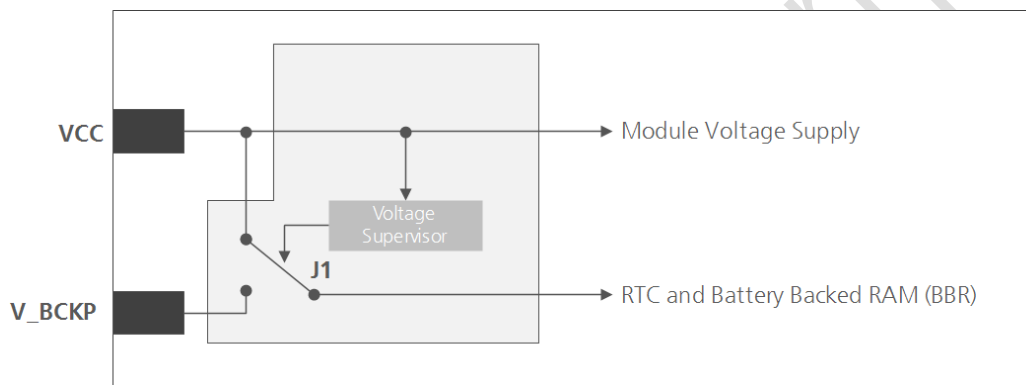


Figure 1: Backup battery and voltage (for exact pin orientation, see the *MAX-M8 Data Sheet* [1])

RTC derived from the system clock; "Single Crystal" feature (MAX-M8C)

On MAX-M8C, the reference frequency for the RTC clock will be internally derived from the crystal system clock frequency (26 MHz) when in Hardware Backup Mode. This feature is called "single crystal" operation. In the event of a power failure,, the crystal will be supplied by the backup battery at V_BCKP to derive and maintain the RTC clock. This makes MAX-M8C a more cost efficient solution at the expense of a higher backup current, as compared to other MAX-M8 variants that use an ordinary RTC crystal. The capacity of the backup battery at V_BCKP must therefore be increased accordingly if Hardware Backup Mode is needed. (See the *MAX-M8 Data Sheet* [1] for specification.)

In order to save backup current, a u-blox MAX-M8C module configured in "single crystal" mode can have the single-crystal feature turned off by means of a SW command, see section 1.2 and the *u-blox M8-V15 Receiver Description Protocol Specification* [2]. Hot start Performance will be degraded (no time information at startup).

VCC_RF: Output voltage RF

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

V_ANT: Antenna supply

The **V_ANT** pin is available to provide antenna bias voltage to supply an optional external active antenna. For more information, see section 2.4.



If not used, connect the **V_ANT** pin to GND.

1.4 Interfaces

UART

u-blox M8 positioning modules include a Universal Asynchronous Receiver Transmitter (UART) serial interface **RxD/TxD** that supports configurable baud rates. The baud rates supported are specified in the *MAX-M8 Data Sheet* [1]. The signal output and input levels are 0 V to **VCC**. An interface based on RS232 standard levels (+/- 12 V) can be implemented using level shifters such as Maxim MAX3232. Hardware handshake signals and synchronous operation are not supported.

Display Data Channel (DDC)

An I²C compatible Display Data Channel (DDC) interface is available with u-blox M8 modules for serial communication with an external host CPU. The interface only supports operation in slave mode (master mode is not supported). The DDC protocol and electrical interface are fully compatible with the Fast-Mode of the I²C industry standard. DDC pins **SDA** and **SCL** have internal pull-up resistors.

For more information about the DDC implementation, see the *u-blox M8-V15 Receiver Description Including Protocol Specification* [2]. For bandwidth information, see the *MAX-M8 Data Sheet* [1]. For timing, parameters consult the *I²C-bus specification* [5].



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

TX Ready signal

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



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

1.5 I/O pins

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 M8 modules, **RESET_N** is an input only.

EXTINT: External interrupt

EXTINT is an external interrupt pin with fixed input voltage thresholds with respect to **VCC** (see the *MAX-M8 Data Sheet* [1] for more information). It can be used for wake-up functions in Power Save Mode on all u-blox M8 modules and for aiding. Leave open if unused; the functions are disabled by default.

ANT_ON: Antenna ON (LNA enable) (MAX-M8Q, MAX-M8C)

In Power Save Mode, the system can turn on/off an optional external LNA using the **ANT_ON** signal in order to optimize power consumption.

Antenna Short circuit detection (MAX-M8W)

MAX-M8W modules include internal short circuit antenna detection. For more information, see section 2.5.2.

Antenna open circuit detection

Antenna open circuit detection (MAX-M8)

Antenna open circuit detection (OCD) is not activated by default on the MAX-M8 module. OCD can be mapped to PIO13 (**EXTINT**). For more information about how to implement OCD, see section 2.5.3. To learn how to configure OCD see the *u-blox M8-V15 Receiver Description Protocol Specification* [2].

TIMEPULSE

A configurable time pulse signal is available with all u-blox M8 modules. By default, the time pulse signal is configured to 1 pulse per second. For more information, see the *u-blox M8-V15 Receiver Description including Protocol Specification* [2].

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. |
| | ANT_ON (MAX-M8C/Q) | 13 | O | ANT_ON | Active antenna or ext. LNA control pin in power save mode. ANT_ON 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 |
| | 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) | - | - | Reserved | Leave open |
| | Reserved | 18 | - | Reserved | Leave open |

Table 2: Pinout MAX-M8

2.2 Minimal design

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

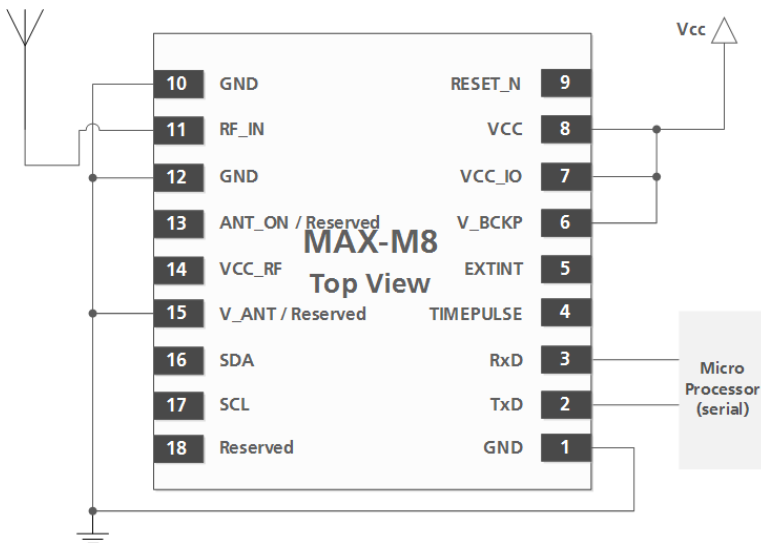


Figure 2: MAX-M8 passive antenna design



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

2.3 Layout: Footprint and paste mask

Figure 3 describes the footprint and provides recommendations for the paste mask for u-blox 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 specific production processes (e.g. soldering) of the customer.

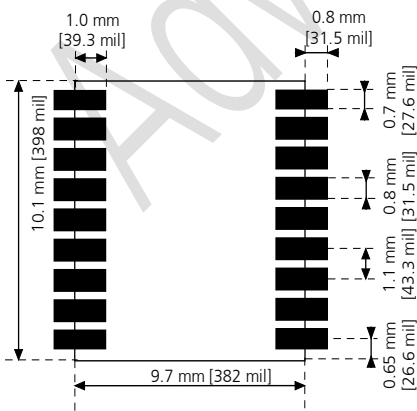


Figure 3: MAX-M8 footprint

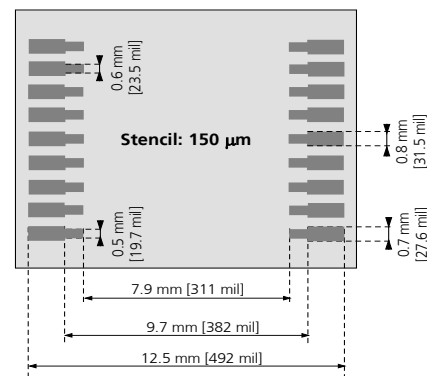


Figure 4: MAX-M8 paste mask



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

Antenna design with passive antenna

A design using a passive antenna requires more attention to the layout of the RF section. Typically, a passive antenna is located near electronic components; therefore, care should be taken to reduce electrical noise that may interfere with the antenna performance. Passive antennas do not require a DC bias voltage and can be directly connected to the RF input pin **RF_IN**. Sometimes they may also need a passive matching network to match the impedance to 50 Ω .

Figure 5 shows a minimal setup for a design with a good GNSS patch antenna.

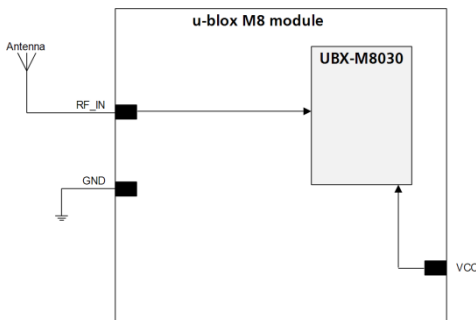


Figure 5: Module design with passive antenna (for exact pin orientation see the *MAX-M8 Data Sheet* [1])



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

Figure 6 shows a design using an external LNA to increase the sensitivity for best performance with passive antenna.

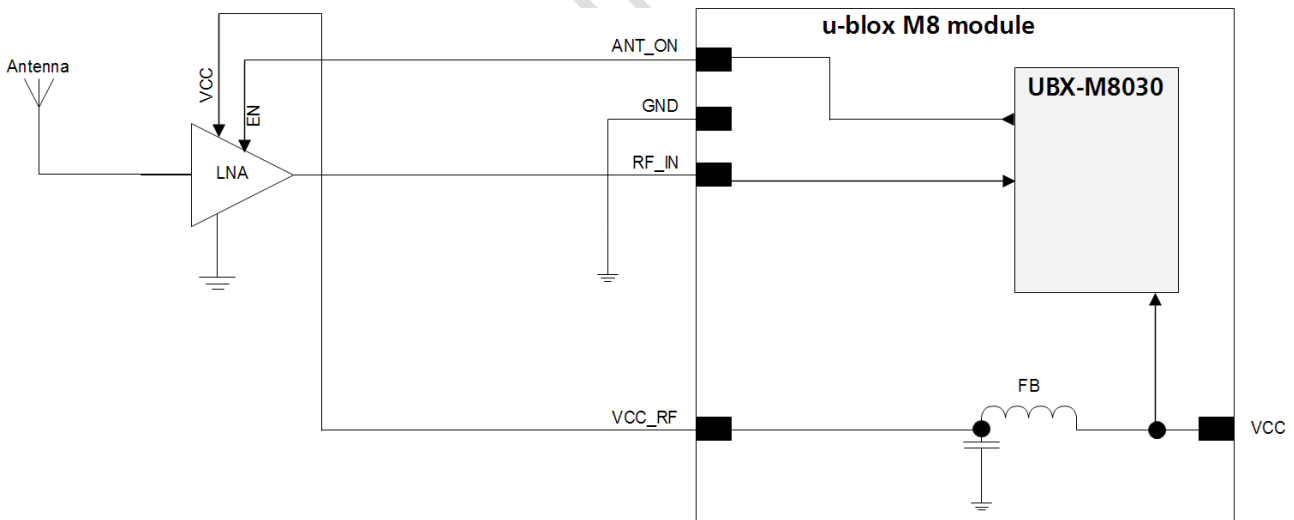


Figure 6: Module design with passive antenna and an external LNA (for exact pin orientation see the *MAX-M8 Data Sheet* [1])

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

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



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



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

Active antenna design

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

If the supply voltage of the u-blox M8 receiver matches the supply voltage of the antenna (e.g. 3.0 V), use the filtered supply voltage **VCC_RF** output to supply the antenna. See section 2.4. This design is used for modules in combination with active antenna.

In case of different supply voltage, use a filtered external supply as shown in section 2.4

Active antenna design using VCC_RF pin to supply the active antenna

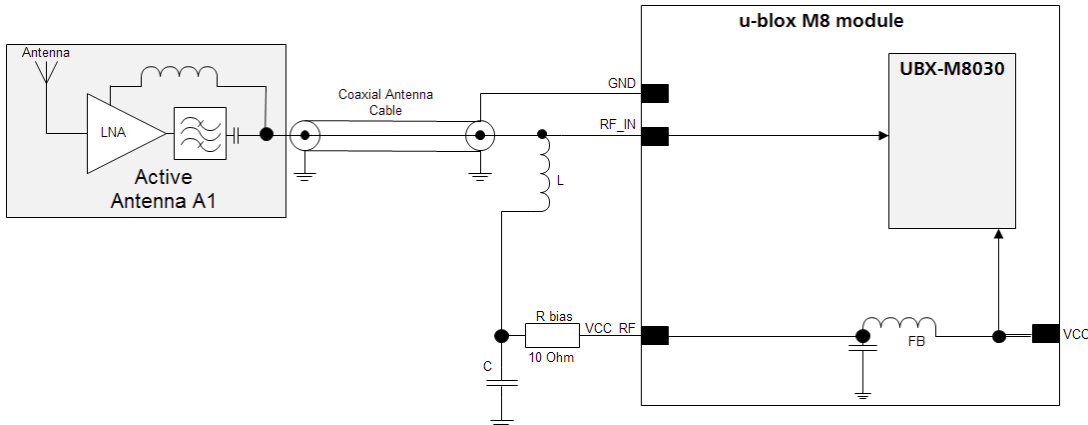


Figure 7: Active antenna design, external supply from VCC_RF (for exact pin orientation see the *MAX-M8 Data Sheet* [1])

Active antenna design powered from external supply

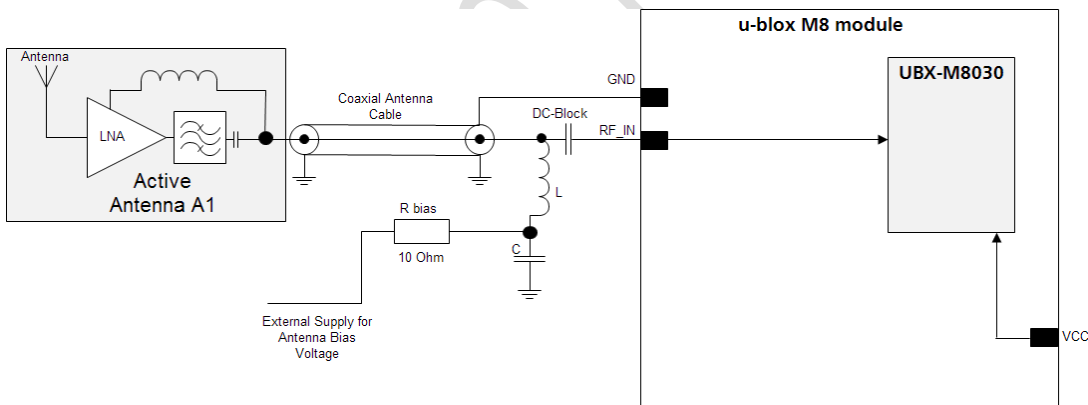


Figure 8: Active antenna design, direct external supply (for exact pin orientation see the *MAX-M8 Data Sheet* [1])

Figure 8 shows a design with direct externally powered active antenna. This circuit works with all u-blox M8 modules, also with modules without **VCC_RF** output.



In case **VCC_RF** voltage does not match with the antenna supply voltage, use a filtered external supply as shown in Figure 8.

2.5 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 2.5.1). These indicate the particular state of the antenna supervisor shown in the state diagram below (Figure 9).

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."

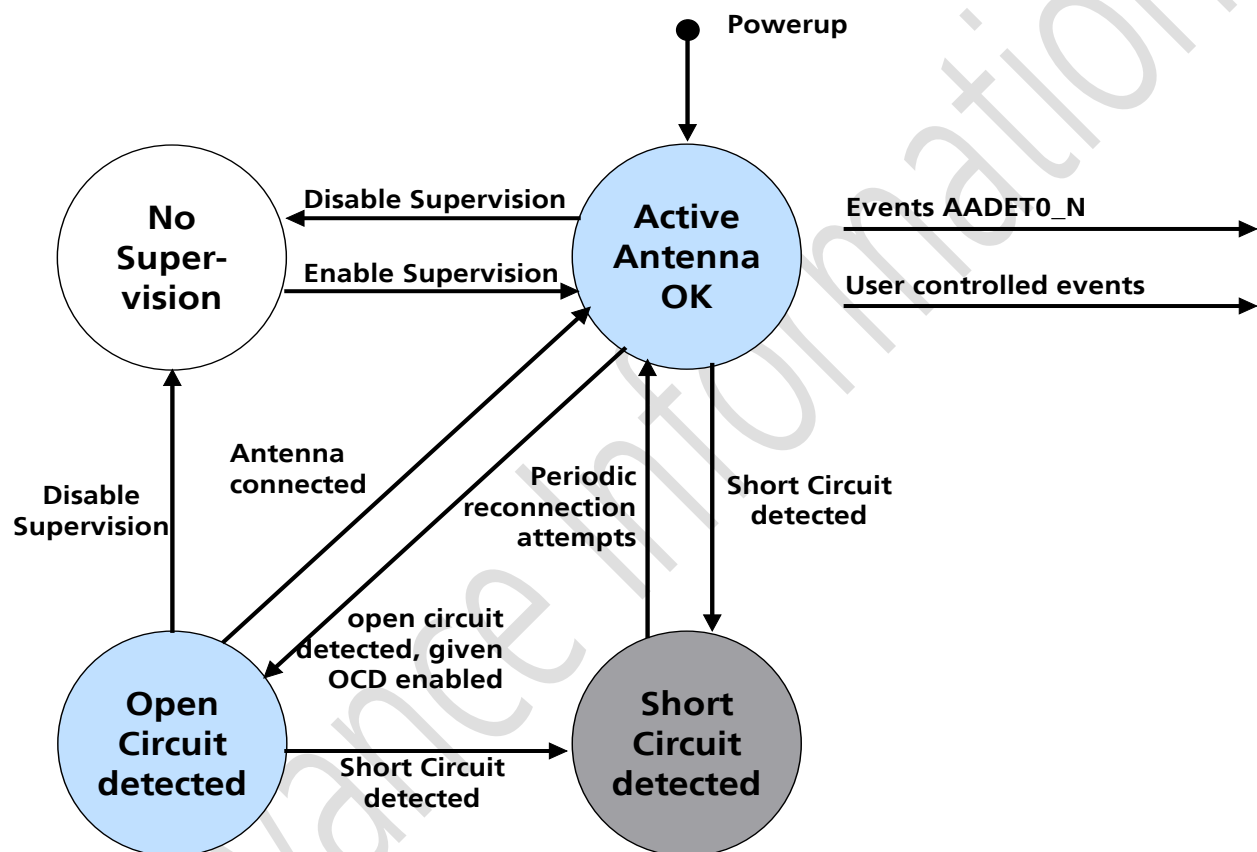


Figure 9: State diagram of active antenna supervisor

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 12. High on EXTINT means that an external antenna is not connected.



Antenna open circuit detection (OCD) is not activated by default on the MAX-M8 module. 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 M8-V15 Receiver Description Protocol Specification* [2].



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

2.5.1 Status reporting

At startup and on every change of the antenna supervisor configuration the u-blox M8 GPS/GALILEO module will output an NMEA (**\$GPTXT**) or UBX (**INF-NOTICE**) message with the internal status of the antenna supervisor (disabled, short detection only, enabled).

| Abbreviation | Description |
|--------------|--|
| AC | Antenna Control (e.g. the antenna will be switched on/ off controlled by the GPS receiver) |
| SD | Short Circuit Detection Enabled |
| SR | Short Circuit Recovery Enabled |
| OD | Open Circuit Detection Enabled |
| PdoS | Power Down on short |

Table 3: Active Antenna Supervisor Message on startup (UBX binary protocol)



To activate the antenna supervisor use the UBX-CFG-ANT message. For further information refer to the *u-blox M8-V15 Receiver Description Protocol Specification* [2].

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

| Message | Description |
|---------------------------|--|
| ANTSTATUS=DONTKNOW | Active antenna supervisor is not configured and deactivated. |
| ANTSTATUS=OK | Active antenna connected and powered |
| ANTSTATUS=SHORT | Antenna short |
| ANTSTATUS=OPEN | Antenna not connected or antenna defective |

Table 4: Active antenna supervisor message on startup (NMEA protocol)

2.5.2 Module design with active antenna, short circuit protection/detection (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 M8 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 *u-blox M8-V15 Receiver Description Protocol Specification* [2].



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



In case VCC_RF voltage does not match with the antenna supply voltage, use a filtered external supply as shown in Figure 11.

Supply from VCC_RF (MAX-M8W)

Figure 10 shows an active antenna supplied from the u-blox M8 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), see Figure 10

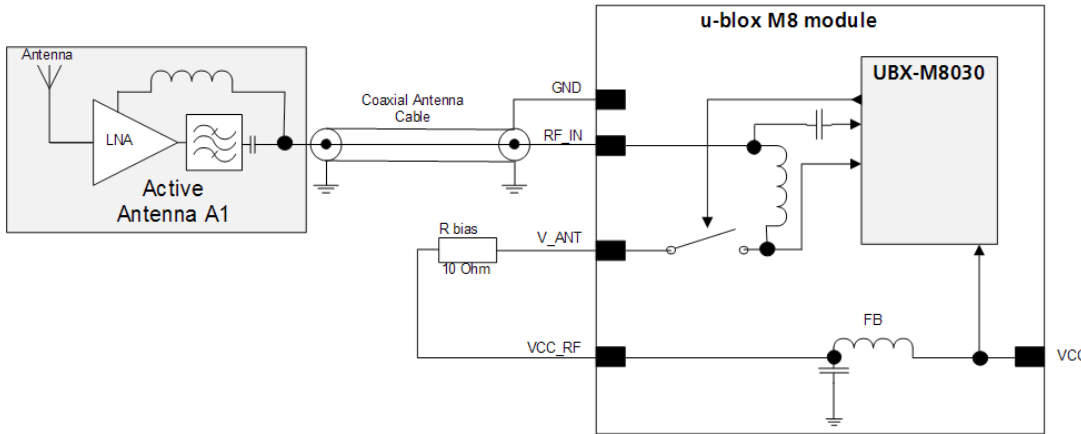


Figure 10: Module design with active antenna, internal supply from VCC_RF (for exact pin orientation, see data sheet)

External supply (MAX-M8W)

Figure 11 shows an externally powered active antenna design.

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. Therefore, it is not recommended to use digital supply nets to feed the **V_ANT** pin.

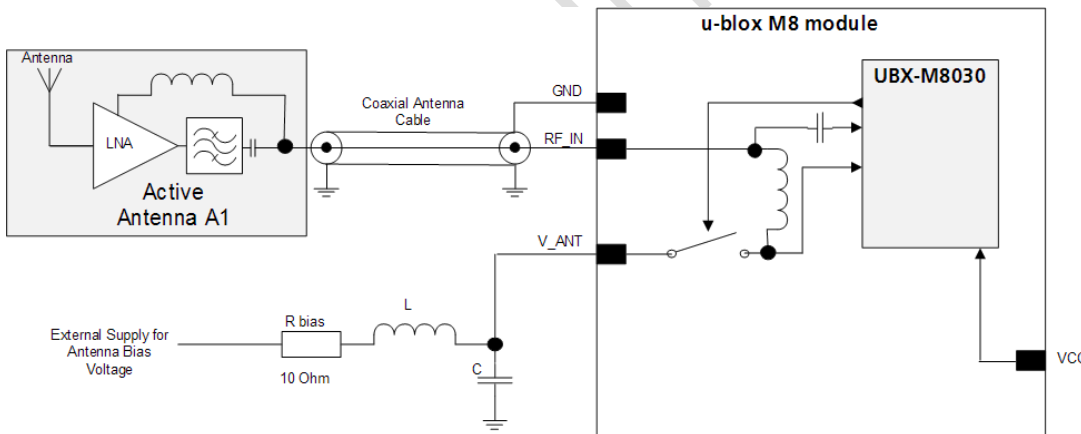


Figure 11: Module design with active antenna, external supply (for exact pin orientation, see data sheet)

2.5.3 Antenna supervision open circuit detection (OCD) (MAX-M8W)

The open circuit detection circuit uses the current flow to detect an open circuit in the antenna. Calculate the threshold current using Equation 1.

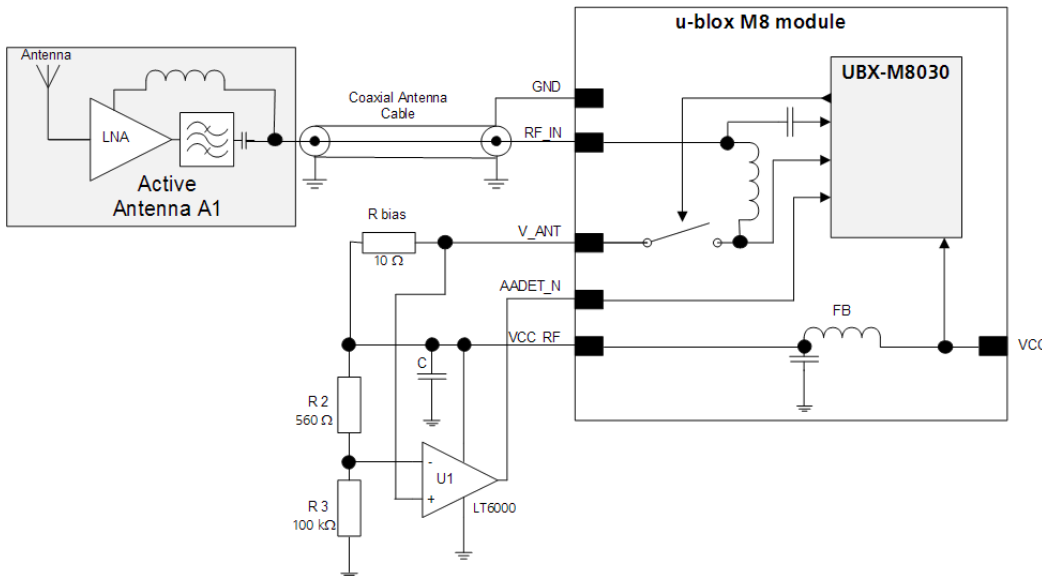


Figure 12: Schematic of open circuit detection (for exact pin orientation, see data sheet)

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

Equation 1: Calculation of threshold current for open circuit detection

Antenna open circuit detection (OCD) is not activated by default on the MAX-M8 module. 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 M8 Receiver Description including Protocol Specification* [1].

If the antenna supply voltage is not derived from VCC_RF, do not exceed the maximum voltage rating of AADET_N.

3 Migration to u-blox M8 modules

3.1 Migrating u-blox 7 designs to a u-blox M8 module

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 M8 modules as fully compatible as possible with u-blox 7 versions. No limitations of the standard features have resulted. If using BeiDou, check the bandwidth of the external RF components and the antenna. For power consumption information, see the *MAX-M8 Data Sheet* [1].

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

3.2 Hardware migration from MAX-6 to MAX-M8

| Pin | MAX-6 | | MAX-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 | EXTINT0 | 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 M8. (MAX-M8C: Higher backup current, see 0 Single Crystal) |
| 7 | VCC_IO | IO supply voltage Input must be always supplied. Usually connect to VCC Pin 8 | VCC_IO | IO supply voltage Input must be always 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-M8C: 1.65 – 3.6V MAX-M8Q: 2.7 – 3.6V | |
| 9 | VRESET | connect to pin 8 | RESET_N | Reset input | With MAX-6, if Reset input is used, it implements the 3k3 resistor from pin 9 to pin 8. This also works with MAX-M8. If used with MAX-M8, do not populate the pull-up resistor. |
| 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) | ANT_ON | Active antenna or ext. LNA control pin in power save mode. ANT_ON 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-M8 to VCC_IO (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 | RESERVED | Leave open. | RESERVED | Leave open. | No difference |

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

3.3 Software migration



For an overall description of the module software operation, see the *u-blox M8-V15 Receiver Description including Protocol Specification* [2].



For migration, see *u-blox 7 to u-blox M8 Software Migration Guide* [7].

Advance Information

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-M8 Data Sheet* [1].

Population of Modules



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

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 M8 GNSS module should be placed on the topside of the motherboard during soldering.

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

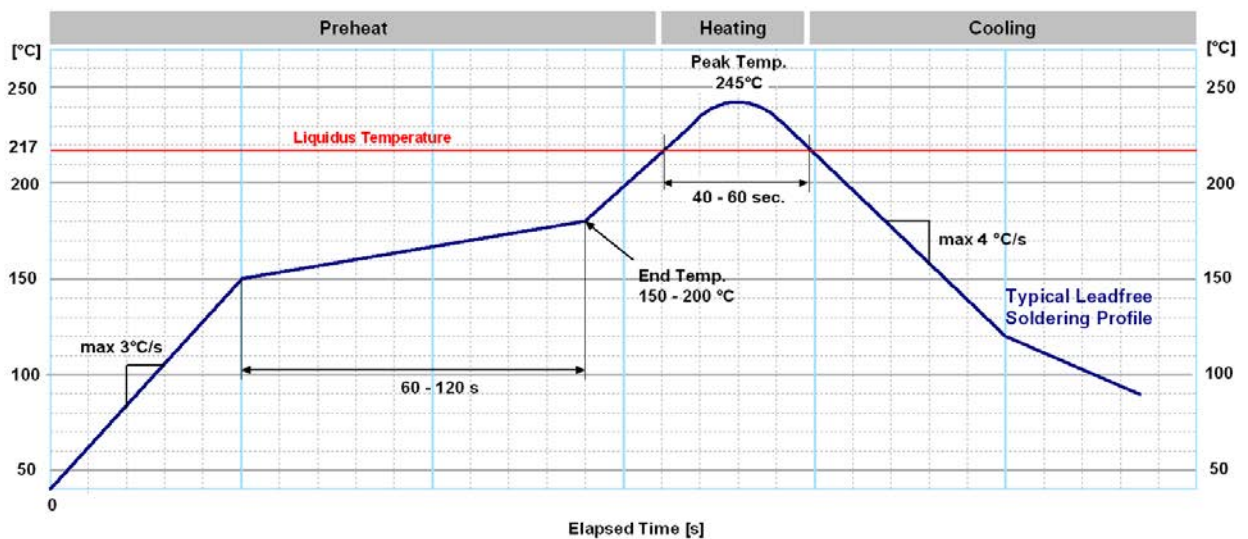


Figure 15: Recommended soldering profile



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

Optical inspection

After soldering the u-blox M8 module, consider an optical inspection step to check whether:

- The module is properly aligned and centered over the pads
- All pads are properly soldered
- No excess solder has created contacts to neighboring pads, or possibly to pad stacks and vias nearby

Cleaning

In general, cleaning the populated modules is strongly discouraged. Residues underneath the modules cannot be easily removed with a washing process.

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

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

Repeated reflow soldering

Only single reflow soldering processes are recommended for boards populated with u-blox M8 modules. u-blox 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 M8 modules.

Hand soldering

Hand soldering is allowed. Use a soldering iron temperature setting equivalent to 350° C and carry out the hand soldering according to the IPC recommendations / reference documents IPC7711. Place the module precisely on the pads. Start with a cross-diagonal fixture soldering (e.g. pins 1 and 15), and then continue from left to right.

Rework

The u-blox M8 module can be unsoldered from the baseboard using a hot air gun. When using a hot air gun for unsoldering the module, a maximum of one reflow cycle is allowed. In general, we do not recommend using a hot air gun because this is an uncontrolled process and might damage the module.



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

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



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

In addition to the two reflow cycles, manual rework on particular pins by using a soldering iron is allowed. For hand soldering the recommendations in IPC 7711 should be followed. 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 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 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 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 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-M8 Data Sheet* [1]).

Electrostatic discharge (ESD)

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



ESD handling precautions

ESD prevention is based on establishing an Electrostatic Protective Area (EPA). The EPA can be a small working station or a large manufacturing area. The main principle of an EPA is that there are no highly charging materials near ESD sensitive electronics, all conductive materials are grounded, workers are grounded, and charge build-up on ESD sensitive electronics is prevented. International standards are used to define typical EPA and can be obtained for example from International Electrotechnical Commission (IEC) or American National Standards Institute (ANSI).

GNSS positioning modules are sensitive to ESD and require special precautions when handling. Particular care must be exercised when handling patch antennas, due to the risk of electrostatic charges. In addition to standard ESD safety practices, the following measures should be taken into account whenever handling the receiver.

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



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

ESD protection measures



GNSS positioning modules are sensitive to Electrostatic Discharge (ESD). Special precautions are required when handling.



For more robust designs, employ additional ESD protection measures. Using an LNA with appropriate ESD rating can provide enhanced GNSS performance with passive antennas and increases ESD protection.

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

| Small passive antennas (<2 dBic and performance critical) | Passive antennas (>2 dBic or performance sufficient) | Active antennas |
|---|--|-----------------|
| <p>A</p> <p>LNA with appropriate ESD rating</p> | <p>B</p> | <p>C</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 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 cellular (e.g. GSM/GPRS) transceivers in close proximity, ensure sufficient isolation between the cellular and GNSS antennas. If cellular 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 cellular communication transceivers (e.g. GSM, GPRS) and GNSS in the same design or in close proximity.

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

Figure 17: EOS and ESD Precautions

Electromagnetic interference (EMI)

Electromagnetic interference (EMI) is the addition or coupling of energy originating from any RF emitting device. This can cause a spontaneous reset of the GNSS receiver or result in unstable performance. Any unshielded line or segment (>3mm) connected to the GNSS receiver can effectively act as antenna and 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 (e.g. $R > 20 \Omega$) or better yet a ferrite bead (BLM15HD102SN1) or an inductor (LQG15HS47NJ02) into any unshielded PCB lines connected to the GNSS receiver. Place the resistor as close as possible to the GNSS receiver pin.

Example of EMI protection measures on the RX/TX line using a ferrite bead:

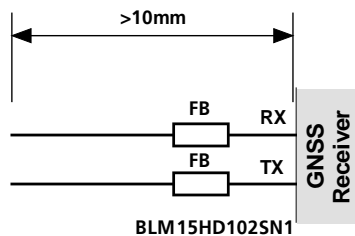


Figure 18: EMI Precautions

VCC can be protected by using a feed thru capacitor.

4.4 Applications with cellular modules LEON / LISA

GSM uses power levels up to 2 W (+33 dBm). Consult the data sheet for the absolute maximum power input at the GNSS receiver.

See *GPS Implementation and Aiding Features in u-blox wireless modules* [6].

Isolation between GNSS and GSM antenna

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

Increasing jamming immunity

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

In-band jamming

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 19). Such jamming signals are typically caused by harmonics from displays, micro-controller, bus systems, etc.

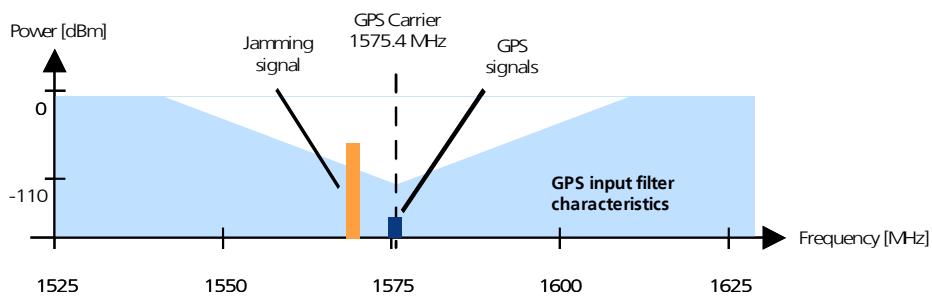


Figure 19: In-band jamming signals

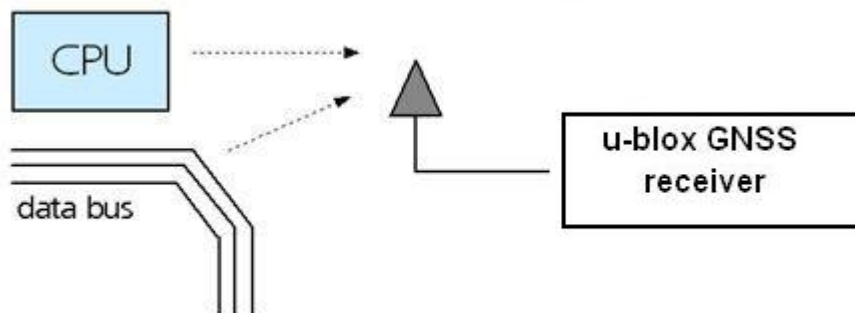


Figure 20: In-band jamming sources

Measures against in-band jamming 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 jamming

Out-band jamming is caused by signal frequencies that are different from the GNSS carrier (see Figure 21). The main sources are wireless communication systems such as GSM, CDMA, WCDMA, Wi-Fi, BT, etc.

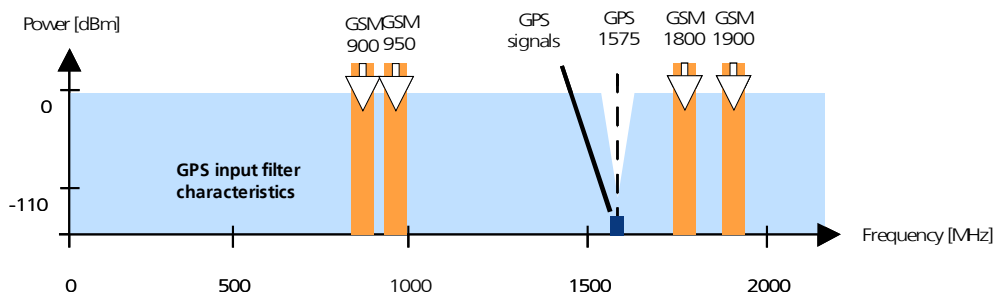


Figure 21: Out-band jamming signals

Measures against out-band jamming 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 22).



Figure 22: Measures against in-band jamming

Appendix

Recommended parts

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

| | Manufacturer | Part ID | Remarks | Parameters to consider |
|--------------------------------|--------------|------------------------------------|--------------------------|---|
| Diode Semiconductor | 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 |
| | TDK/ EPCOS | B3913: B39162B3913U410 | GPS+GLONASS+BeiDou | For automotive application |
| | TDK/ EPCOS | B4310: B39162B4310P810 | GPS+GLONASS | Compliant to the AEC-Q200 standard |
| | ReyConns | NDF9169 | GPS+GLONASS+BeiDou | Low insertion loss, only for mobile application |
| | muRata | SAFFB1G56KB0F0A | GPS+GLONASS+BeiDou | Low insertion loss, only for mobile application |
| | muRata | SAFEA1G58KB0F00 | GPS+GLONASS | Low insertion loss, only for mobile application |
| | muRata | SAFEA1G58KA0F00 | GPS+GLONASS | High attenuation, only for mobile application |
| | muRata | SAFFB1G58KA0F0A | GPS+GLONASS | High attenuation, only for mobile application |
| | muRata | SAFFB1G58KB0F0A | GPS+GLONASS | Low insertion loss, only for mobile application |
| | TAI-SAW | TA1573A | GPS+GLONASS | Low insertion loss |
| | TAI-SAW | TA0638A | GPS+GLONASS+BeiDou | Low insertion loss |
| | TAI-SAW | 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, 47 pF | DC-block |
| Ferrite Bead | Murata | BLM15HD102SN1 | FB | High IZI @ fGSM |
| Feed thru Capacitor for Signal | Murata | NFL18SP157X1A3 | Monolithic Type | Load Capacitance appropriate to Baud rate |
| | | NFA18SL307V1A45 | Array Type | CL < xxx pF |
| Feed thru Capacitor | Murata | NFM18PC | 0603 2A | Rs < 0.5 Ω |
| | | NFM21P.... | 0805 4A | |
| Resistor | | 10 Ω \pm 10%, min 0.250 W | R _{bias} | |
| | | 560 Ω \pm 5% | R2 | |
| | | 100 k Ω \pm 5% | R3, R4 | |

Table 6: 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, 3-5V 30mA active |
| Taoglas (www.taoglas.com) | AA.161.301111 | 36*36*3 mm, 1.8 to 5.5V / 10mA at 3V active |
| INPAQ (www.inpaq.com.tw) | B3G02G-S3-01-A | 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 |
| 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 7: Recommend antennas

Related documents

- [1] MAX-M8 Data Sheet, Docu. No. UBX-13004644
- [2] u-blox M8-V15 Receiver Description Protocol Specification, Docu. No. UBX-13003221
- [3] GPS Antenna Application Note, Docu. No. GPS-X-08014
- [4] GPS Compendium, Docu. No. GPS-X-02007
- [5] I²C-bus specification, Version 2.1, Jan 2000,
http://www.nxp.com/acrobat_download/literature/9398/39340011_21.pdf
- [6] GPS Implementation and Aiding Features in u-blox wireless modules, Docu. No. GSM.G1-CS-09007
- [7] u-blox 7 to u-blox M8 Software Migration Guide, Docu. No. UBX-13003254



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

Revision history

| Revision | Date | Name | Status / Comments |
|----------|--------------|------|-------------------------|
| R01 | 30-Jan-2014 | jfur | Objective Specification |
| R02 | 26-Feb- 2014 | jfur | Advance Information |

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