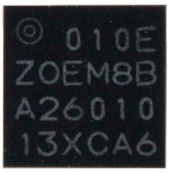
ZOE-M8B

Ultra-small, super low power u-blox M8 GNSS SiP module

System integration manual



Abstract

This manual provides hardware and system design instructions for the u-blox ZOE-M8B GNSS SiP module.

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Document information

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European Union regulatory compliance
ZOE-M8B complies with all relevant requirements for RED 2014/53/EU. The ZOE-M8 Declaration of Conformity (DoC) is available at www.u-blox.com within Support > Product resources > Conformity Declaration.

This document applies to the following products:

Product name	Type number	ROM version	PCN reference
ZOE-M8B	ZOE-M8B-0-11	ROM SPG 3.51	UBX- 21030535

Contents

1 Hardware description

1.1 Overview

The u-blox ZOE-M8B standard precision GNSS SiP module features the high-performance u-blox M8 GNSS engine. The ultra-miniature form factor integrates a complete GNSS receiver solution including SAW filter, LNA and TCXO.

The ZOE-M8B GNSS SiP is targeted for applications that require a small size without compromising the performance. It features the new Super-Efficient (Super-E) operation mode, providing a unique balance between power consumption and performance.

For RF optimization, the ZOE-M8B SiP integrates a front-end SAW filter and an additional front-end LNA for increased jamming immunity and easier antenna integration. The Super-E mode allows automatic LNA duty-cycling for reduced power consumption. A passive antenna can be used to provide a highly integrated system solution with minimal eBOM.

The ZOE-M8B optimizes the overall system power consumption by excluding the need for any heavy signal processing on the application processor. In the Super-E mode, the system can operate with absolute minimal current consumption during power-optimized periods. Navigation data can be stored internally while the application processor is in deep sleep (data batching). Super-E mode, LNA duty cycling, and intelligent power management are breakthroughs for low-power applications.

The ZOE-M8B GNSS SiP can be easily integrated in manufacturing thanks to the advanced S-LGA (Soldered Land Grid Array) packaging technology, which enables easier and more reliable soldering processes compared to a normal LGA (Land Grid Array) package.

☞ For product features see the ZOE-M8B 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 Low power operation

The ZOE-M8B GNSS SiP is designed for use in portable and wearable applications. It is intended to run in Super-E mode and defaults to this mode on power up. The Super-E mode provides the best balance between current consumption vs. performance. The Super-E mode also enables automatic duty cycling of both the internal and optional external LNA to further lower the total power consumption.

For specific power saving applications, the host processor has an option to put the receiver into backup state. All essential data for quick re-starting of navigation can be saved either on the receiver side or on the host processor side.

The data batching feature allows position fixes to be stored in the RAM of the GNSS receiver for later retrieval in one batch. Batching of position fixes happens independently of the host system, and can continue while the host is powered down with as many as 300 sets of position, accuracy estimate, speed, and time data.

Used in combination with multi-GNSS Assistance data, the ZOE-M8B GNSS SiP not only features fast TTFF and good sensitivity, but also ensures minimal power consumption, since A-GNSS enables the chip to maximize its power-optimized period.

1.2.1 Super-E mode overview

Super-E mode provides optimal power savings while maintaining good level of position and speed accuracy. ZOE-M8B defaults to Super-E mode on power up.

On receiver startup, the Super-E mode uses the acquisition engine until a sufficient number of satellites is acquired for reliable GNSS performance, and uses the tracking engine to track the satellites. By default, the acquisition engine is active at least for 5 minutes after the receiver startup to read the ephemeris of many satellites. The tracking engine is duty-cycled adaptively according to the signal strength in order to provide the best balance between power consumption and navigation performance.

Super-E mode offers choice of 1 Hz (default), 2 Hz, or 4 Hz operation. In addition, a slower operation rate with an interval of 1 – 10 s can be selected. The higher 2 Hz and 4 Hz navigation rates improve the navigation accuracy, but they also consume more power. The power mode can be selected with the configuration message UBX-CFG-PMS. Update periods longer than 1 s are set with the Extended Power Management configuration message UBX-CFG-PM2.

Super-E mode has two settings to tune the receiver operation. The "performance" (default) setting provides the best balance for power vs. performance. The "power save" setting provides up to an additional 15-20% power savings at the cost of position accuracy. The setting can be selected with the optTarget configuration option of the Extended Power Management configuration message UBX-CFG-PM2.

During the tracking phase of the Super-E mode, the satellite reception is duty-cycled and it is turned off most of the time. The receiver reads data from the satellite transmission only occasionally. Mostly it just checks where the tracked satellites are at that time, and then calculates the position. With strong enough signal strength, the active time is 1/12 of each navigation cycle. If signal level goes too low, the active time can go up to 1/3 of each navigation cycle.

Optimal efficiency of Super-E mode is achieved with a strong signal level. To ensure best efficiency, significant power savings, and good tracking performance, the signal strength of the strongest satellites should be at least -146 dBm to -144 dBm (C/N0 value of 28 dBHz to 30 dBHz). Super-E mode will still work if the signal level goes lower, but efficiency will then degrade.

Some satellites become obscured every now and then when the receiver moves. In Super-E mode, the receiver needs to be able to track at least 6 - 8 satellites constantly. If some of the currently used satellites are not in view, the receiver can start to use some other known satellite. If too many of the currently known satellites are obscured, the receiver must restart the acquisition engine and stop power-optimized tracking to read ephemeris data for the new satellites. This acquisition phase lasts only as long as minimally needed.

Navigation performance improves if ephemeris of many more satellites is known beforehand, because the receiver can then use new satellites even if several of the previously used satellites are out of view.

The five-minute (default) initial acquisition period on receiver startup helps to read the ephemeris of many satellites. Ephemeris data can be provided to the receiver also with AssistNow mechanism. If the ephemeris data for many satellites are known, then there is no need to read this data from the satellite transmission. Such preloading of data improves performance especially when the receiver is started in a low signal level environment (for example, indoors). The initial acquisition period can be adjusted with the Extended Power Management configuration message UBX-CFG-PM2. The minimum value for an initial acquisition period is 0 s, which can be used if, for example, valid AssistNow Online data or up to one-day old AssistNow Offline data are available. Depending on the age of the aiding data and GNSS signal conditions, an initial acquisition period up to two or three minutes may be beneficial.

1.2.2 Super-E mode power consumption

1.2.2.1 Super-E states

ZOE-M8B defaults to the Super-E mode on powerup. The receiver starts up in the full-power acquisition state to search for satellites. The acquisition state continues until there is a valid 3D fix and the receiver has enough information about available satellites. For the 3D fix, the receiver needs to receive data for current GNSS time and information of at least four satellites (red points in Figure 1). The receiver continues searching for more satellites in the acquisition state (yellow dots in Figure 1) until it has enough information for proper low-power operation. By default, this search lasts for five minutes after the receiver start-up, but can be adjusted if, for instance, AssistNow data is used.

After the initial acquisition state, the receiver enters the power-optimized tracking state (shown by the green dots in Figure 1). This is the low-power state of the Super-E mode. If the set of available satellites gets too small, the receiver again enters acquisition or tracking state for a short period until it has enough satellites to track. This is shown by the brief peaks in current consumption during the power-optimized tracking state in Figure 1.

The state of the receiver is given in the psmState field in the UBX-NAV-PVT message.

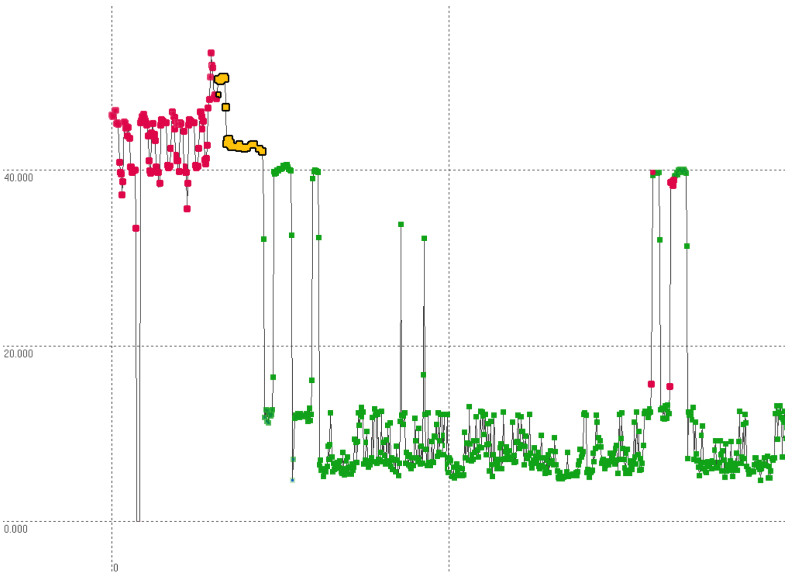


Figure 1: Current consumption in different states in Super-E mode.

1.2.2.2 Super-E power consumption examples

The sensitivity, accuracy, and power efficiency of a GNSS receiver depend heavily on the availability, strength and quality of the GNSS signal. If the signal is attenuated, blocked or reflected, the power consumption, acquisition speed, and positioning accuracy suffer. Application design, including antenna performance, also contributes to the signal quality. Use of assistance often helps to improve both performance and power consumption.

In the following examples, current consumption in Super-E mode is shown for open, forest and urban environment over a 30-minute period. The results are presented for the default mode, that is, 1 Hz Super-E “performance” setting with GPS, GLONASS and QZSS enabled. A wrist-worn sports watch with weak and constantly changing reception was used to receive the GNSS signal.

Current consumption in an open environment is shown in Figure 2 and Figure 3 for continuous and Super-E mode, respectively. The average tracking current in continuous mode is 45.7 mA whereas in Super-E mode the average current drops to 13.3 mA after the (adjustable) initial acquisition period. Use of assistance improves TTFF but also further reduces average current consumption by approximately 15% (Figure 4).

The effect of environment on current consumption can be seen in Figure 3 (open), Figure 5 (forest) and Figure 7 (urban). The power optimization in Super-E mode performs best in an open environment, with the current consumption increasing with deteriorating signal conditions. Under heavy multipath and blocking of satellites, the receiver may need to briefly exit power-optimized tracking to acquire new satellites. The use of assistance improves TTFF and reduces current consumption in all cases (as seen in Figure 4, Figure 6 and Figure 8).

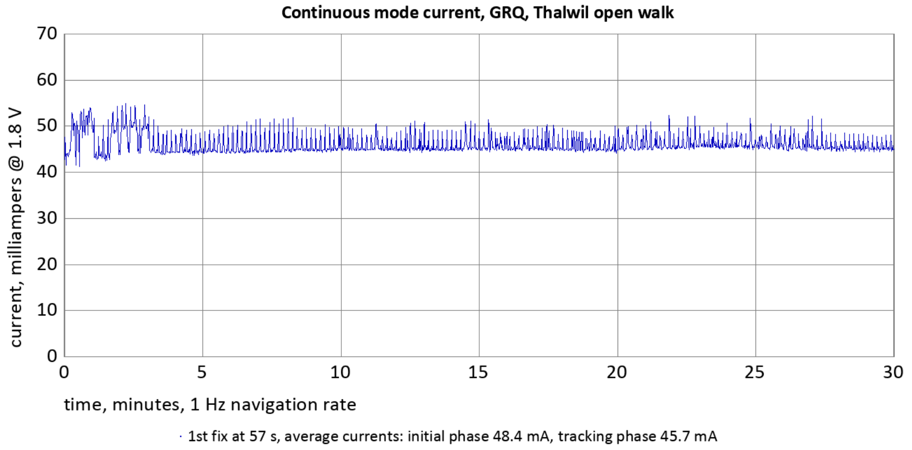


Figure 2: ZOE-M8B continuous mode current consumption in open environment

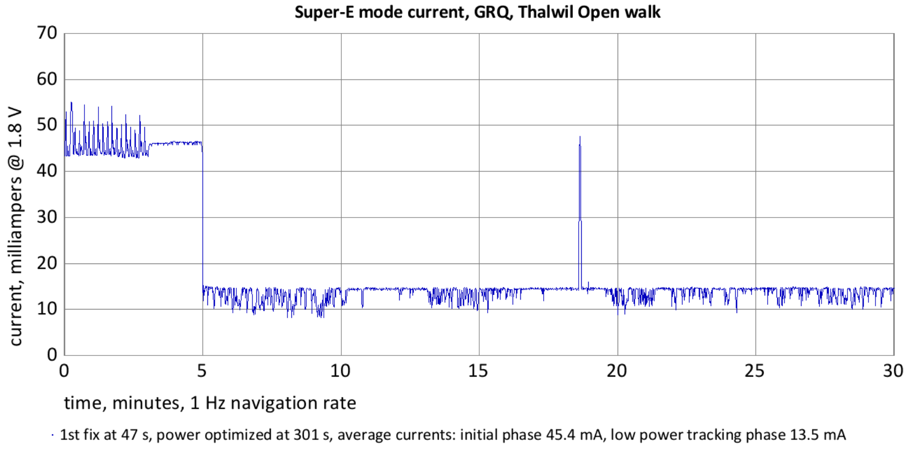


Figure 3: ZOE-M8B Super-E mode current consumption in open environment

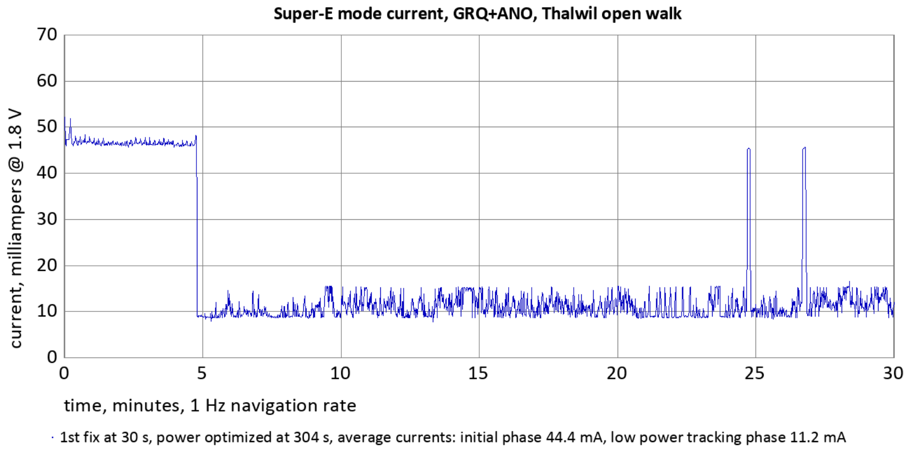


Figure 4: ZOE-M8B Super-E mode current consumption in open environment with AssistNow Offline

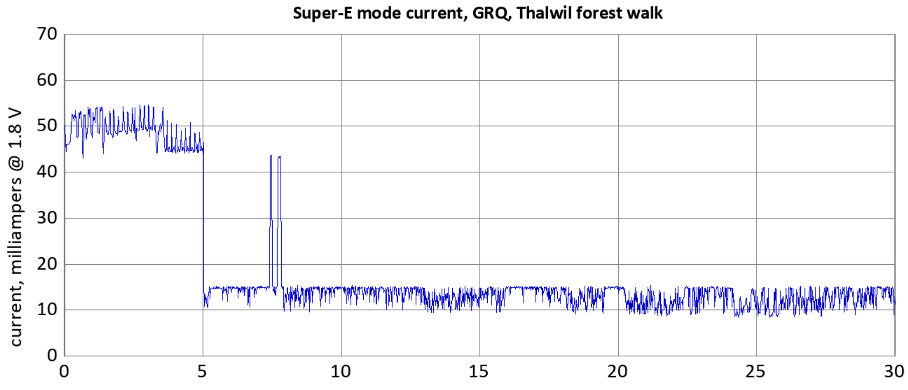


Figure 5: ZOE-M8B Super-E mode current consumption in obstructed environment (forest)

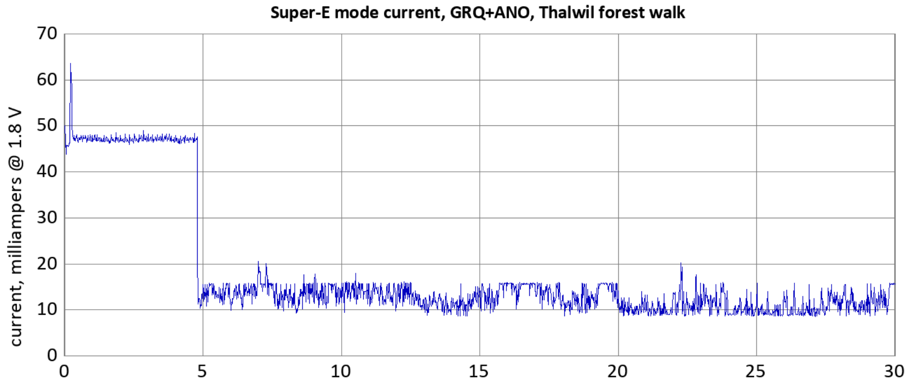


Figure 6: ZOE-M8B Super-E mode current consumption in obstructed environment (forest) with AssistNow Offline

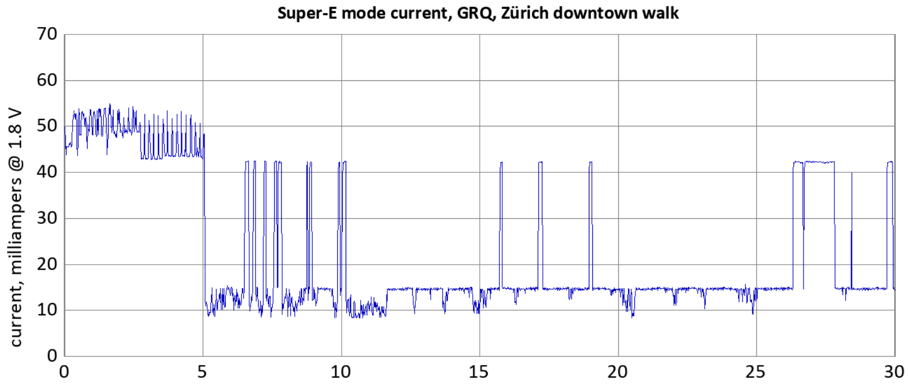


Figure 7: ZOE-M8B Super-E mode current consumption in urban environment

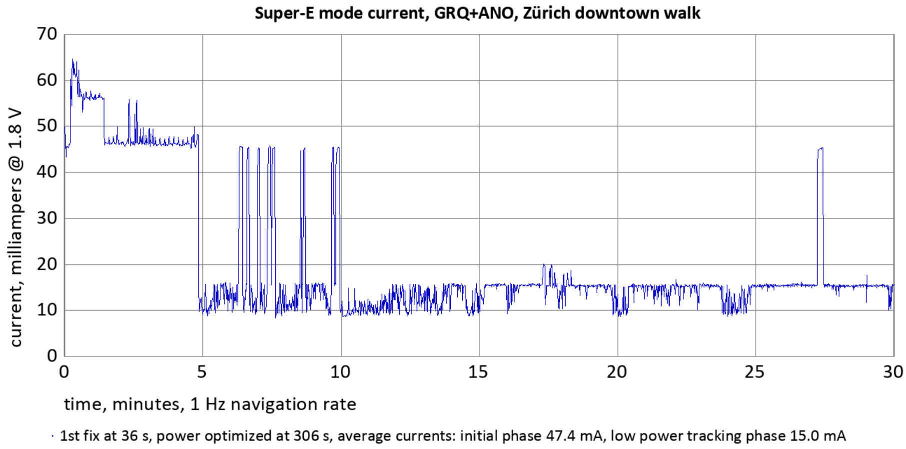


Figure 8: ZOE-M8B Super-E mode current consumption in urban environment with AssistNow Offline

2 Design-in

To obtain good performance with the ZOE-M8B GNSS SiP, there are a number of issues requiring careful attention during the design-in. These include:

- **Power supply**: Good performance requires a clean and stable power supply.
- **Interfaces**: Ensure correct wiring, rate and message setup on the SiP and your host system.
- **Antenna interface**: For optimal performance, seek short routing, matched impedance and no stubs.

2.1 Power management

2.1.1 Overview

The ZOE-M8B GNSS SiP provides two supply pins: **VCC** and **V_BCKP**. They can be supplied independently or tied together, depending on the intended application.

2.1.1.1 Main supply voltage (VCC)

During operation, the ZOE-M8B GNSS SiP receives power through the **VCC** pin. Built-in LDOs generate stabilized voltages for the core and RF domains of the chip. The current at **VCC** depends heavily on the current state of the system and is in general very dynamic.

☞ Do not add any series resistance (< 0.1 Ω) to the **VCC** supply, as it will generate input voltage noise due to the dynamic current conditions.

The digital I/Os of the ZOE-M8B GNSS SiP are supplied by the **VCC** voltage.

2.1.1.2 Backup power supply (V_BCKP)

In the case of a power failure at main supply **VCC**, the backup domain and optional RTC oscillator are supplied by **V_BCKP**. Providing a **V_BCKP** supply maintains the time (RTC) and the GNSS orbit data in backup RAM. This ensures that any subsequent re-starts after a **VCC** power failure will benefit from the stored data, providing a faster TTFF.

The GNSS satellite ephemeris data is typically valid for up to 4 hours. To enable hot starts, ensure that the battery or capacitor at **V_BCKP** is able to supply the backup current for at least 4 hours. For warm starts or when using the AssistNow Autonomous, the **V_BCKP** source must be able to supply current for up to a few days

☞ If no backup supply is available, **V_BCKP** can be connected to reserved neighbor pin G9.

☞ 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.

☞ For description of the different power operating modes see the ZOE-M8B Data sheet [1].

2.1.2 Power modes

The ZOE-M8B GNSS SiP can operate in two power modes:

- Super-E Mode to optimize power consumption (default mode)
- Continuous mode for best GNSS reception

The available power modes are illustrated in Figure 9. The Super-E Mode has three predefined settings for 1 Hz (default), 2 Hz and 4 Hz update rates. In addition, Super-E mode supports longer user-defined update periods from 1 s up to 10 s. The continuous mode has two predefined settings, full power and balanced.

For specific power saving applications, the host system has an option to put the receiver into backup state. All essential data for quick re-starting of navigation can be saved either on the receiver or on the host processor side.

☞ Unlike some other u-blox M8 receivers, the ZOE-M8B GNSS SiP does not support self-managed ON/OFF power saving mode, in which the receiver periodically puts itself into backup state when an operation interval longer than 10 s is selected.

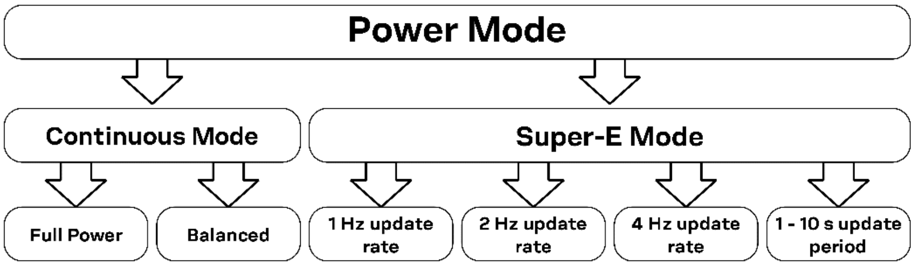


Figure 9: ZOE-M8B power modes

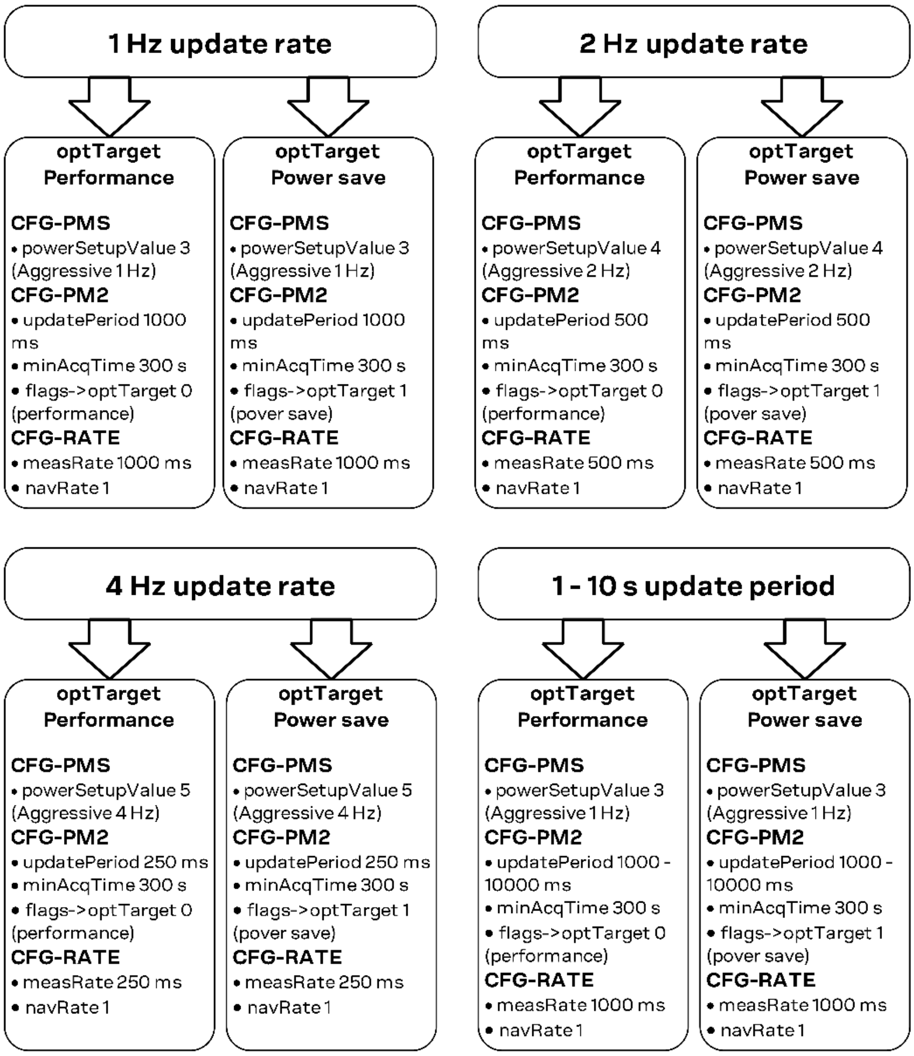


Figure 10: ZOE-M8B Super-E mode configuration options

2.1.2.1 Super-E mode

The available configuration options for Super-E mode are described in more detail in Figure 10. The relevant configuration messages and message fields with required values are also given.

The power mode can be selected with the Power mode setup message UBX-CFG-PMS. Super-E mode offers the choice of 1 Hz (default), 2 Hz, or 4 Hz operation. A slower update rate with an interval of 1–10 s can be set with the Extended Power Management configuration message UBX-CFG-PM2.

Super-E mode has two settings for tuning the receiver operation. The selection is done with the optTarget configuration option in the Extended Power Management configuration message UBX-CFG-PM2. The "performance" (default) setting provides the best balance for power vs. performance. The "power save" setting provides additional power savings up to 15-20% at the cost of position accuracy.

☞ To ensure a consistent receiver configuration, always first send UBX-CFG-PMS message followed by UBX-CFG-PM2 message.

☞ For update rates from 1 Hz to 4 Hz, the update rate in UBX-CFG-PMS message and the field updatePeriod in UBX-CFG-PM2 must match. For example, for 2 Hz update rate selected with the UBX-CFG-PMS message, set the updatePeriod in UBX-CFG-PM2 to 500 ms.

☞ For update periods longer than 1 s (up to 10 s), first select 1 Hz update rate with UBX-CFG-PMS message, followed by UBX-CFG-PM2 message with the desired value for updatePeriod between 1–10 s.

The messages UBX-CFG-PMS and UBX-CFG-PM2 only affect the navigation update rate in the power-optimized tracking state. The update rate for acquisition and tracking states is set with the UBX-CFG-RATE message. For a uniform update rate regardless of the Super-E state, the same update rate need to be set with UBX-CFG-PMS/UBX-CFG-PM2 as well as UBX-CFG-RATE messages.

☞ For update rates from 1 Hz to 4 Hz, it is recommended to use a uniform update rate for all Super-E states.

☞ For longer update periods up to 10 s, it is recommended to set the acquisition and tracking state update rate to 1 Hz with the UBX-CFG-RATE message. This may speed up the return to the power-optimized tracking state in case the receiver needs to enter acquisition or tracking state to decode satellite information.

The UBX-CFG-PMS and UBX-CFG-PM2 message strings for typical Super-E configurations are given in Table 1. For more information, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].

Power mode	UBX-CFG-PMS	UBX-CFG-PM2
Super-E 2 Hz performance	B5 62 06 86 08 00 00 04 00 00 00 00 00 00 98 76	B5 62 06 3B 30 00 02 06 00 00 00 00 43 01 F4 01 00 00 10 27 00 00 00 00 00 00 00 00 2C 01 2C 01 00 00 CF 41 00 00 88 6A A4 46 FE 00 00 00 40 00 00 00 00 00 00 00 6D C1
Super-E 1 Hz performance	B5 62 06 86 08 00 00 03 00 00 00 00 00 00 97 6F	B5 62 06 3B 30 00 02 06 00 00 00 00 43 01 E8 03 00 00 10 27 00 00 00 00 00 00 00 00 2C 01 2C 01 00 00 CF 41 00 00 88 6A A4 46 FE 00 00 00 40 00 00 00 00 00 00 00 63 2F
Super-E 1 Hz power save	B5 62 06 86 08 00 00 03 00 00 00 00 00 00 97 6F	B5 62 06 3B 30 00 02 06 00 00 02 00 43 01 E8 03 00 00 10 27 00 00 00 00 00 00 00 00 2C 01 2C 01 00 00 CF 40 00 00 87 5A A4 46 FE 00 00 00 20 00 00 00 00 00 00 00 33 74
Super-E 3 s power save	B5 62 06 86 08 00 00 03 00 00 00 00 00 00 97 6F	B5 62 06 3B 30 00 02 06 00 00 02 00 43 01 B8 0B 00 00 10 27 00 00 00 00 00 00 00 00 2C 01 2C 01 00 00 CF 40 00 00 87 5A A4 46 FE 00 00 00 20 00 00 00 00 00 00 00 0B 2C
Super-E 10 s power save	B5 62 06 86 08 00 00 03 00 00 00 00 00 00 97 6F	B5 62 06 3B 30 00 02 06 00 00 02 00 43 01 10 27 00 00 10 27 00 00 00 00 00 00 00 00 2C 01 2C 01 00 00 CF 40 00 00 87 5A A4 46 FE 00 00 00 20 00 00 00 00 00 00 00 7F 30

Table 1: Required UBX-CFG-PMS and UBX-CFG-PM2 message strings for typical Super-E configurations

2.1.2.2 Continuous mode

Continuous mode provides the best performance in terms of tracking sensitivity and navigation performance by acquiring all satellites that are visible in the sky. Continuous mode uses the acquisition engine until all visible satellites are acquired, and uses the tracking engine to track the satellites.

To achieve the best navigation performance, the tracking engine is not duty-cycled.

If balanced operation is selected for the continuous mode, some GNSS RF operations are optimized. This reduces the power consumption slightly for the tracking phase.

The navigation update rate in the continuous mode is set with the UBX-CFG-RATE message.

2.2 Communication interfaces

The ZOE-M8B GNSS SiP provides UART, SPI and DDC (I2C-compatible) interfaces for communication with a host CPU. Additionally, an SQI interface is available for connecting the ZOE-M8B GNSS SiP with an optional external flash memory.

The UART, SPI and DDC pins are supplied by **VCC** and operate at this voltage level.

Four dedicated pins can be configured as either 1 x UART and 1 x DDC or a single SPI interface selectable by **D_SEL** pin. Table 2 below provides the port mapping details.

Pin #	Pin D4 (D_SEL) = "high" (left open)	Pin D4 (D_SEL) = "Low" (connected to GND)
J5	UART TXD	SPI MISO
J4	UART RXD	SPI MOSI
B1	DDC SCL	SPI CLK
A2	DDC SDA	SPI CS_N

Table 2: Communication interfaces overview

☞ It is not possible to use the SPI interface simultaneously with the DDC or UART interface.

☞ For debugging purposes, it is recommended to have a second interface, for example, DDC available that is independent from the application and accessible via test-points.

For each interface, a dedicated pin can be defined to indicate that data is ready to be transmitted. The TXD Ready signal indicates that the receiver has data to transmit. Each TXD Ready signal is associated with a particular interface and cannot be shared. A listener can wait on the TXD 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 TXD Ready signal goes active. The TX Ready signal can be mapped, for example, to UART TX. The TXD Ready function is disabled by default.

☞ The TXD Ready functionality can be enabled and configured by proper AT commands sent to the involved u-blox cellular module supporting the feature. For more information see the GPS Implementation and Aiding Features in u-blox wireless modules [2].

☞ The TXD Ready feature is supported on several u-blox cellular module products.

2.2.1 UART interface

A UART interface is available for serial communication to a host CPU. The UART interface supports configurable data rates with the default at 9600 baud. Signal levels are related to the **VCC** supply voltage. An interface based on RS232 standard levels (+/- 7 V) can be realized using level shifter ICs such as the Maxim MAX3232.

Hardware handshake signals and synchronous operation are not supported.

A signal change on the UART RXD pin can also be used to wake up the receiver in power save mode (see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3]).

☞ Designs must allow access to the UART and the **SAFEBOOT_N** pin for future service, updates, and reconfiguration.

2.2.2 Display data channel (DDC) interface

An I2C compatible display data channel (DDC) interface is available for serial communication with a host CPU.

☞ The SCL and SDA pins have internal pull-up resistors sufficient for most applications. However, depending on the speed of the host and the load on the DDC lines additional external pull-up resistors might be necessary. For speed and clock frequency see the ZOE-M8B Data sheet [1].

☞ To make use of DDC interface the **D_SEL** pin has to be left open.

☞ The ZOE-M8B DDC interface provides serial communication with u-blox cellular modules. See the specification of the applicable cellular module to confirm compatibility.

2.2.3 SPI interface

The SPI interface can be used to provide a serial communication with a host CPU. If the SPI interface is used, UART and DDC are deactivated, because they share the same pins.

☞ To make use of the SPI interface, the **D_SEL** pin has to be connected to GND.

2.2.4 SQI interface

An external SQI (Serial Quad Interface) flash memory can be connected to the ZOE-M8B GNSS SiP. The SQI interface provides the following options:

- Store the current configuration permanently
- Save data logging results
- Hold AssistNow Offline and AssistNow Autonomous data

☞ The voltage level of the SQI interface follows the **VCC** level. Therefore, the SQI flash must be supplied with the same voltage as **VCC** of the ZOE-M8B GNSS SiP. It is recommended to place a decoupling capacitor (C4) close to the supply pin of the SQI Flash.

☞ Make sure that the SQI flash supply range matches the voltage supplied at **VCC**.

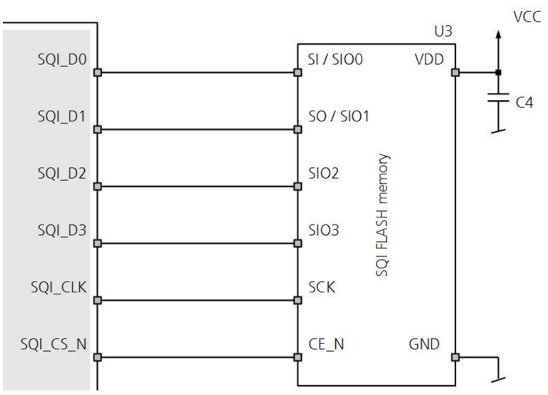


Figure 11 : Connecting an external SQI flash memory

SQI flash size of 4 Mbit is sufficient to save AssistNow Offline and AssistNow Autonomous information, current configuration data as well as space for data logging results. A larger SQI flash size may be required for large amounts of log data.

☞ For more information about supported SQI flash devices see section B.3.

2.3 I/O pins

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

2.3.1 External interrupt

EXTINT is an external interrupt pin with fixed input voltage thresholds with respect to **VCC** (see the ZOE-M8B 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. By default, the external interrupt is disabled. If **EXTINT** is not used for an external interrupt function, the pin can be used as a generic PIO (PIO13).

For further information, see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].

☞ If the **EXTINT** is configured for on/off switching of the ZOE-M8B GNSS SiP, the internal pull-up becomes disabled. Thus make sure the **EXTINT** input is always driven within the defined voltage level by the host.

2.3.2 External LNA enable

LNA_EN pin can be used to turn on and off an external LNA. The external LNA can be automatically duty cycled in Super-E mode or turned off in software backup mode.

2.3.3 Electromagnetic interference and I/O lines

Any I/O signal line (length > ~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, lines where 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 22).

In case of improper shielding, it is recommended to use resistors or ferrite beads (see Appendix B.6) on the I/O lines in series. Choose these components with care because they also affect the signal rise times. Alternatively, feed-through capacitors with good GND connection close to the GNSS receiver can be used (see Appendix B.7).

EMI protection measures are particularly useful when RF emitting devices are placed next to the GNSS receiver and/or to minimize the risk of EMI degradation due to self-jamming. An adequate layout with a robust grounding concept is essential in order to protect against EMI. More information can be found in section 2.14.6.3.

2.4 Real-time clock (RTC)

The use of the RTC is optional to maintain time in the event of power failure at **VCC**. It requires **V_BCKP** to be supplied in case of power failure at **VCC**. The RTC is required for hot start, warm start, AssistNow Autonomous, AssistNow Offline and in some power save mode operations.

The time information can either be generated by connecting an external RTC crystal to the SiP, by connecting an external 32.768 kHz signal to the RTC input, or by time aiding of the GNSS receiver at every startup.

2.4.1 RTC using a crystal

The easiest way to provide time information to the receiver is to connect an RTC crystal to the corresponding pins of the RTC oscillator, **RTC_I** and **RTC_O**. There is no need to add load capacitors to the crystal for frequency tuning, because they are already integrated in the chip. Using an RTC crystal will provide the lowest current consumption to **V_BCKP** in case of a power failure. On the other hand, it will increase the BOM costs and requires space for the RTC crystal.

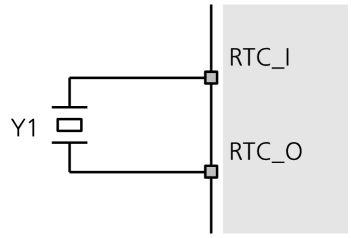


Figure 12: RTC crystal

2.4.2 RTC using an external clock

Some applications can provide a suitable 32.768 kHz external reference to drive the SiP RTC. The external reference can simply be connected to the **RTC_I** pin. Make sure that the 32.768 kHz reference signal is always turned on and the voltage at the **RTC_I** pin does not exceed 350 mVpp. Adjusting of the voltage level (typically 200 mVpp) can be achieved with a resistive voltage divider followed by a DC blocking capacitor in the range of 1 nF to 10 nF. Also make sure the frequency versus temperature behavior of the external clock is within the recommended crystal specification shown in section B.1.

2.4.3 Time aiding

Time can also be sent by UBX message at every startup of the ZOE-M8B GNSS SiP to enable warm starts, AssistNow Autonomous and AssistNow Offline. This can be done when no RTC is maintained.

To enable hot starts correctly, the time information must be known accurately and thus the TimeMark feature has to be used.

For more information about time aiding or timemark see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].

☞ For information of this use case, it is mandatory to contact u-blox support team.

2.5 RF input

The ZOE-M8B GNSS SiP RF input is already matched to 50 Ω and has an internal DC block. The ZOE-M8B SiP is optimized to work with a passive antenna.

The ZOE-M8B GNSS SiP can receive and track multiple GNSS systems (for example, GPS, Galileo, GLONASS, BeiDou and QZSS signals). Because of the dual-frequency RF front-end architecture, two GNSS signals (GPS L1C/A, GLONASS L1OF, Galileo E1B/C and BeiDou B1) can be received and processed concurrently. In continuous mode, this concurrent operation is extended to three GNSS when GPS and Galileo are used in addition to GLONASS or BeiDou.

2.5.1 Passive antenna

ZOE-M8B GNSS SiP is optimized to work with passive antennas. The internal SAW filter inside followed by an LNA is a good solution for most applications from jamming and performance point of view.

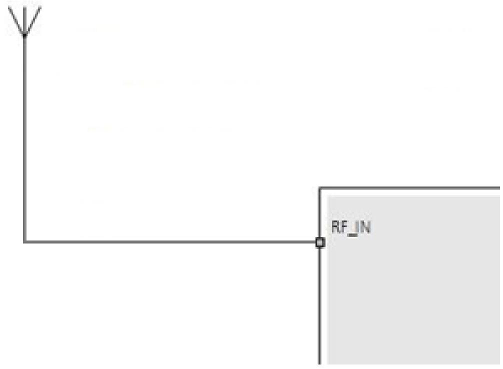


Figure 13: Typical circuit with passive antennas

Where best performance has to be achieved and there are no jamming sources, an additional external LNA (U1) can be placed close to the antenna.

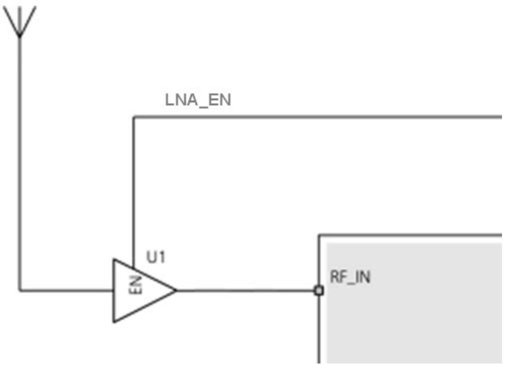


Figure 14: Circuit for best performance

The LNA (U1) can be selected to deliver the performance needed by the application in terms of:

- Noise figure (sensitivity)
- Selectivity and linearity (robustness against jamming)
- Robustness against RF power and ESD

☞ The external LNA (U1) must be placed close to the passive antenna to get best performance.

If power save mode is used and the minimum current consumption has to be achieved, the external LNA should also be turned off. The **LNA_EN** pin can be used to turn off the external LNA.

ESD discharge into the RF input cannot always be avoided during assembly and / or field use with this approach! To provide additional robustness an ESD protection diode can be placed in front of the LNA to GND (see Appendix B.5).

☞ If VCC supply is also used to supply the external LNA, make sure some good filtering is in place for the external LNA supply because of the noise on the VCC. This means a series ferrite bead FB1 and a decoupling capacitor to GND has to be used (see section B.6).

2.5.2 Active antenna

In case an active antenna is used, the active antenna supply circuit has to be added right in front of the SiP RF input.

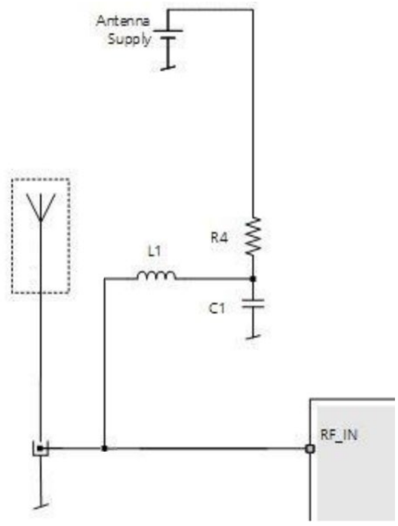


Figure 15: Active antenna supply circuit

2.6 Safe boot mode (SAFEBOOT_N)

If the **SAFEBOOT_N** pin is "low" at start up, the ZOE-M8B GNSS SiP starts in safe boot mode and does not begin GNSS operation. In safe boot mode the SiP runs from an internal LC oscillator and starts regardless of any configuration provided by the configuration pins. Thus, it can be used to recover from situations where the SQI flash has become corrupted.

For communication by UART in safe boot mode, a training sequence (0x 55 55 at 9600 baud) can be sent by the host to the ZOE-M8B GNSS SiP in order to enable communication. After sending the training sequence, the host has to wait for at least 2 ms before sending messages to the receiver. For further information see the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].

Safe boot mode is used in production to program the SQI flash. It is recommended to have the possibility to pull the **SAFEBOOT_N** pin "low" when the SiP starts up. This can be provided using an externally connected test point or via a host CPUs digital I/O port.

2.7 System reset (RESET_N)

The ZOE-M8B GNSS SiP provides a RESET_N pin to reset the system. The RESET_N is input-only with internal pull-up resistor. It must be at low level for at least 10 ms to make sure RESET_N is detected. It is used to reset the system. Leave RESET_N open for normal operation. The RESET_N complies with the **VCC** level and can be actively driven high.

☞ Use **RESET_N** in critical situations only to recover the system. The real-time clock (RTC) will also be reset and thus immediately afterwards the receiver cannot perform a hot start.

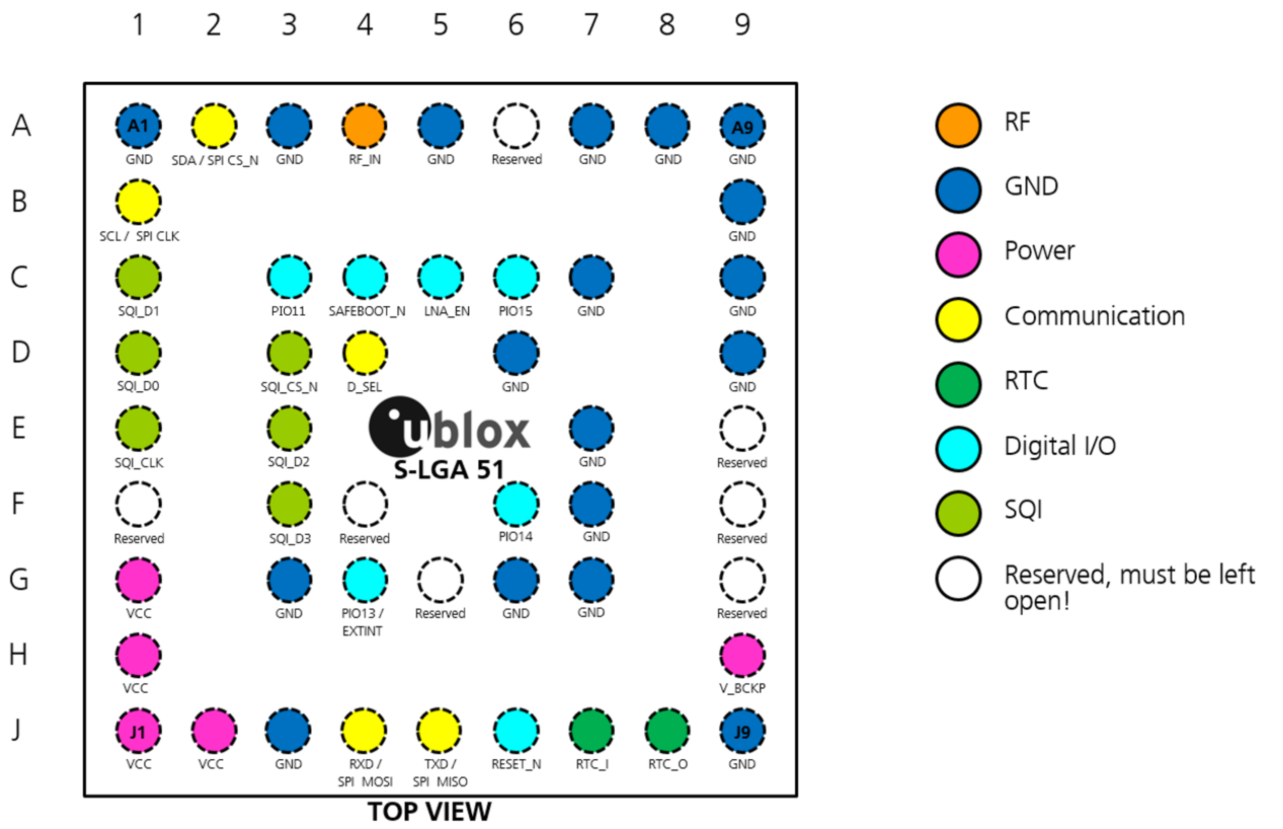
☞ In reset state, the SiP consumes a significant amount of current. It is therefore recommended to use **RESET_N** only as a reset signal and not as an enable/disable.

2.8 Pin description

Pin #	Name	I/O	Description	Remark
A1	GND		Ground	Ensure good GND connection
A2	SDA / SPI CS_N	I/O	Serial interface.	See section 2.2
A3	GND		Ground	Ensure good GND connection
A4	RF_IN	I	GNSS signal input	See section 2.5
A5	GND		Ground	Ensure good GND connection
A6	Reserved	I/O	Reserved. Do not connect.	Must be left open!
A7	GND		Ground	Ensure good GND connection
A8	GND		Ground	Ensure good GND connection
A9	GND		Ground	Ensure good GND connection
B1	SCL / SPI CLK	I	Serial interface.	See section 2.2
B9	GND		Ground	Ensure good GND connection
C1	SQI_D1	I	Data line 1 to external SQI flash memory or reserved configuration pin.	Leave open if not used.
C3	PIO11	I/O	Digital I/O	Leave open if not used.
C4	SAFEBOOT_N	I	Used for programming the SQI flash memory and testing purposes.	Leave open if not used.
C5	LNA_EN	O	LNA on/off signal connected to internal LNA	Leave open if not used.
C6	PIO15	I/O	Digital I/O	Leave open if not used.
C7	GND		Ground	Ensure good GND connection
C9	GND		Ground	Ensure good GND connection
D1	SQI_D0	I/O	Data line 0 to external SQI flash memory or reserved configuration pin.	Leave open if not used.
D3	SQI_CS_N	I/O	Chip select for external SQI flash memory or configuration enable pin.	Leave open if not used.
D4	D_SEL	I	Interface selector	See section 2.2
D6	GND		Ground	Ensure good GND connection
D9	GND		Ground	Ensure good GND connection
E1	SQI_CLK	I/O	Clock for external SQI flash memory or configuration pin.	Leave open if not used.
E3	SQI_D2	I/O	Data line 2 to external SQI flash memory or reserved configuration pin.	Leave open if not used.
E7	GND		Ground	Ensure good GND connection
E9	Reserved	I/O	Reserved	Do not connect. Must be left open!
F1	Reserved	I/O	Reserved	Do not connect. Must be left open!
F3	SQI_D3	I/O	Data line 3 to external SQI flash memory or reserved configuration pin.	Leave open if not used.
F4	Reserved	I/O	Reserved	Do not connect. Must be left open!
F6	PIO14	I/O	Digital I/O	Leave open if not used.
F7	GND		Ground	Ensure good GND connection
F9	Reserved	I/O	Reserved	Do not connect. Must be left open!
G1	VCC	I	Supply voltage	Clean and stable supply needed
G3	GND		Ground	Ensure good GND connection
G4	PIO13 / EXTINT	I	External interrupt	Leave open if not used.
G5	Reserved	I/O	Reserved	Do not connect. Must be left open!
G6	GND		Ground	Ensure good GND connection
G7	GND		Ground	Ensure good GND connection

Pin #	Name	I/O	Description	Remark
G9	Reserved	I/O	Reserved	Do not connect. Must be left open! The only exception is connection to pin H9 (V_BCKP). Pin G9 is internally connected to VCC, and can be used to supply V_BCKP if external supply is not used.
H1	VCC	I	Supply voltage	Clean and stable supply needed
H9	V_BCKP	I	Backup supply	
J1	VCC	I	Supply voltage	Clean and stable supply needed
J2	VCC	I	Supply voltage	Clean and stable supply needed
J3	GND		Ground	Ensure good GND connection
J4	RXD/SPI MOSI	I	Serial interface	See section 2.2
J5	TXD/SPI MISO	O	Serial interface	See section 2.2.
J6	RESET_N	I	System reset	See section 2.7
J7	RTC_I	I	RTC Input	Connect to GND if no RTC Crystal attached.
J8	RTC_O	O	RTC output	Leave open if no RTC crystal attached.
J9	GND		Ground	Ensure good GND connection

Table 3: Pinout



☞ For more information about pin assignment see the ZOE-M8B Data sheet [1].

2.9 Typical schematic

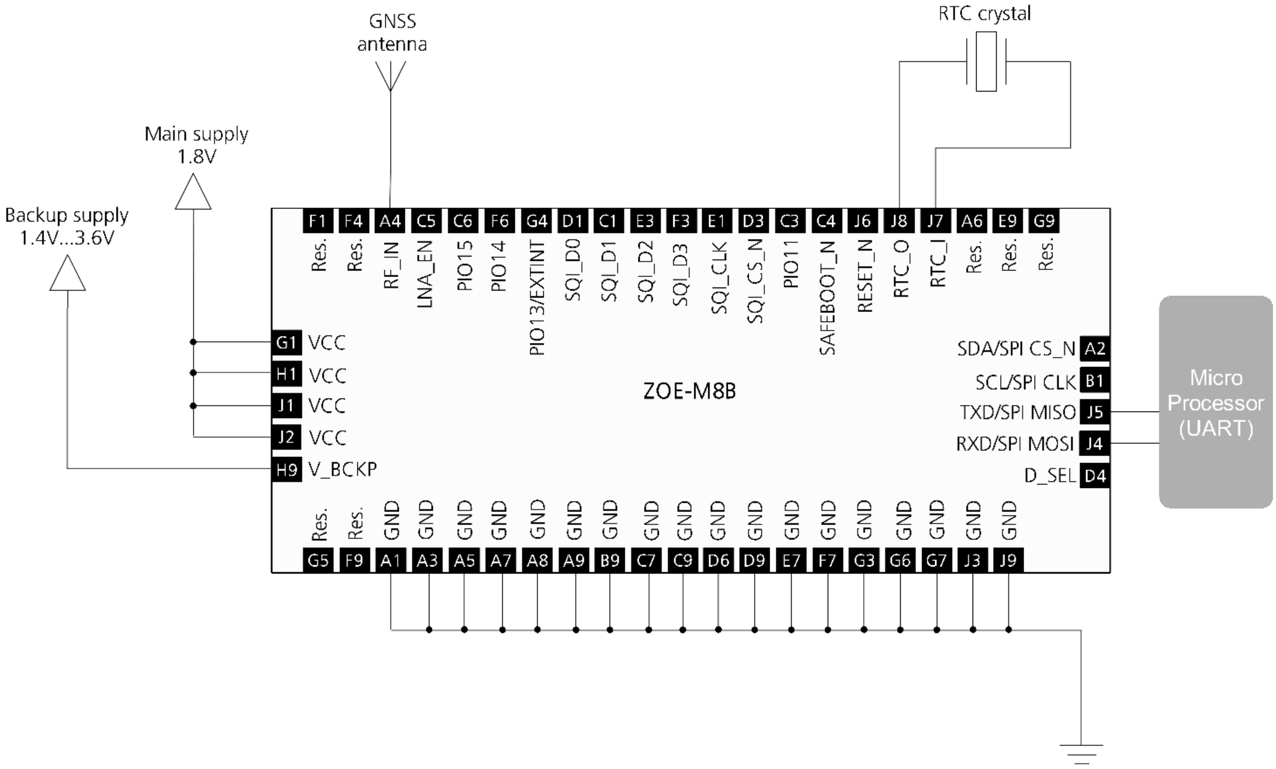


Figure 17: Typical schematic for ZOE-M8B

2.10 Migration from ZOE-M8G to ZOE-M8B

The ZOE-M8B GNSS SiP is optimized for low power use – for example in portable and wrist-worn applications – and features Super-E mode and data batching, which are not available in the ZOE-M8G. In addition, the ZOE-M8B supports all essential u-blox M8 features, including message integrity protection, anti-jamming and anti-spoofing, integrated odometer, geofencing, and optional data logging. Optimization for low-power operation introduces differences in the ZOE-M8B feature set that need to be considered for migration from ZOE-M8G to ZOE-M8B.

The ZOE-M8B is pin and feature compatible with ZOE-M8G with minor differences. Designs based on ZOE-M8G can be migrated to ZOE-M8B with minimum or even no changes, provided the following differences are considered:

- At start-up, the ZOE-M8B defaults to Super-E mode whereas ZOE-M8G defaults to continuous mode.
- Galileo operation is supported only in continuous mode. Galileo should be disabled in Super-E mode.
- Time pulse is not supported in ZOE-M8B.
- In ZOE-M8B, time mark is supported only in continuous mode and in acquisition phase of Super-E mode. It is not supported in the low power tracking phase of Super-E mode.
- Communication interfaces such as SPI and I2C have limited maximum communication speed in ZOE-M8B. The I2C bus speed is limited to up to 100 kbit/s (that is, the fast mode is not supported). The SPI bus speed is limited to up to 1 Mbits/s.
- Maximum navigation rate in Super-E mode is 4 Hz, and the longest supported fix interval is 10 s.
- Only host-controlled on/off operation is supported in ZOE-M8B. Managed on/off operation, that is, power save mode with long intervals, is not supported.
- In Super-E mode, the integrated LNA is automatically duty-cycled in order to save power. With the external LNA control LNA_EN, an optional external LNA can also be automatically duty-cycled.

2.11 Design-in checklist

2.11.1 General considerations

Check power supply requirements and schematic:

- ☐ Is the power supply voltage within the specified range? See how to connect power in section 2.1.
- ☐ Compare the peak current consumption of ZOE-M8B GNSS SiP with the specification of your power supply.
- ☐ GNSS receivers require a stable power supply. Avoid series resistance in your power supply line (the line to **VCC**) to minimize the voltage ripple on **VCC**.

Backup battery

- ☐ For achieving a minimal time-to-first-fix (TTFF) after a power down (warm starts, hot starts), make sure to connect a backup battery to **V_BCKP**, and use an RTC. If not used, make sure **V_BCKP** is connected to neighbor pin G9.

Antenna/ RF input

- ☐ Make sure the antenna is not placed close to noisy parts of the circuitry and not facing noisy parts. (such as micro-controller, display)
- ☐ Make sure your RF front end is chosen according to your design, see section 2.5.

☞ For more information dealing with interference issues see the GPS Antenna Application Note [4].

2.11.2 Schematic design-in for ZOE-M8B GNSS SiP

For a minimal design with the ZOE-M8B GNSS SiP, the following functions and pins need to be considered:

- Connect the power supply to **VCC** and **V_BCKP**.
- Ensure an optimal ground connection to all ground pins of the ZOE-M8B GNSS SiP.
- Choose the required serial communication interfaces (UART, SPI or DDC) and connect the appropriate pins to your application.
- If you need hot or warm start in your application, connect a backup battery to **V_BCKP** and add RTC circuit.

2.12 Layout design-in checklist

Follow this checklist for the layout design to get an optimal GNSS performance.

Layout optimizations (see section 2.13):

- ☐ Is the ZOE-M8B GNSS SiP placed according to the recommendation in section 2.13.3?
- ☐ Is the grounding concept optimal?
- ☐ Are all the GND pins well connected with GND?
- ☐ Has the 50 Ω line from antenna to SiP (micro strip / coplanar waveguide) as short as possible?
- ☐ Assure low serial resistance in **VCC** power supply line (choose a line width > 400 µm).
- ☐ Assure all VCC pins are well-connected with power supply line.
- ☐ Keep the power supply line as short as possible.
- ☐ Design a GND guard ring around the optional RTC crystal lines and GND below the RTC circuit.
- ☐ Add a ground plane underneath the GNSS SiP to reduce interference. This is especially important for the RF input line.
- ☐ For improved shielding, add as many vias as possible around the micro strip/coplanar waveguide, around the serial communication lines, underneath the GNSS SiP, etc.

Calculation of the micro strip for RF input

- ☐ The micro strip / coplanar waveguide must be 50 Ω and be routed in a section of the PCB where minimal interference from noise sources can be expected. Make sure around the RF line is only GND as well as under the RF line.
- ☐ In case of a multi-layer PCB, use the thickness of the dielectric between the signal and the 1st GND layer (typically the 2nd layer) for the micro strip / coplanar waveguide calculation.
- ☐ If the distance between the micro strip and the adjacent GND area (on the same layer) does not exceed 5 times the track width of the micro strip, use the "Coplanar Waveguide" model in AppCad to calculate the micro strip and not the "micro strip" model.

2.13 Layout

This section provides important information for designing a reliable and sensitive GNSS system.

GNSS signals at the surface of the earth are about 15 dB below the thermal noise floor. Signal loss at the antenna and the RF connection must be minimized as much as possible. When defining a GNSS receiver layout, the placement of the antenna with respect to the receiver, as well as grounding, shielding and jamming from other digital devices are crucial issues and need to be considered very carefully.

2.13.1 Footprint

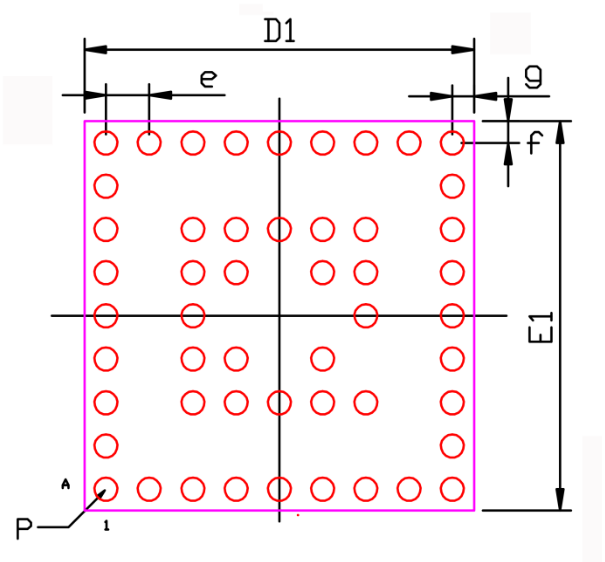


Figure 18: Recommended footprint (bottom view)

Symbol	Typical [mm]
e	0.50
g	0.25
f	0.25
D1	4.50
E1	4.50
P	0.27 diameter

Table 4: Footprint dimensions

2.13.2 Paste mask

The paste mask shall be same as the copper pads with a paste thickness of 80 µm.

☞ These are recommendations only and not specifications. The exact geometry, distances, stencil thicknesses and solder paste volumes must be adapted to the customer's specific production processes.

2.13.3 Placement

A very important factor in achieving maximum GNSS performance is the placement of the receiver on the PCB. The connection to the antenna must be as short as possible to avoid jamming into the very sensitive RF section.

Make sure that RF critical circuits are clearly separated from any other digital circuits on the system board. To achieve this, position the receiver digital part towards your digital section of the system PCB.

2.13.4 Layout design-in: Thermal management

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

- Is the receiver placed away from heat sources?
- Is the receiver placed away from air-cooling sources?
- Is the receiver shielded by a cover/case to prevent the effects of air currents and rapid environmental temperature changes?

⚠ High temperature drift and air vents can affect the GNSS performance. For best performance avoid high temperature drift and air vents near the SiP.

2.14 EOS/ESD/EMI precautions

When integrating GNSS receivers into wireless systems, consider electromagnetic and voltage susceptibility issues carefully. Wireless systems include components which can produce electrostatic discharge (ESD), 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 as specified in the ZOE-M8B Data sheet [1].

2.14.1 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.

2.14.2 ESD protection measures

⚠ GNSS receivers are sensitive to electrostatic discharge (ESD). Special precautions are required when handling.

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, additional ESD measures as shown in Figure 19 can also avoid failures in the field.

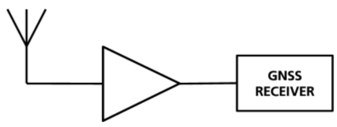
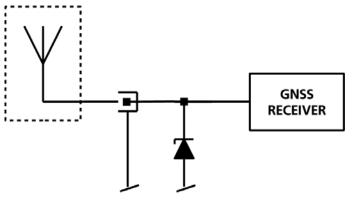
Passive antennas	Active antennas
A  LNA with appropriate ESD rating	B  RF ESD protection diode

Figure 19: ESD precautions

2.14.3 Electrical overstress (EOS)

Electrical overstress (EOS) usually describes situations where the maximum input power exceeds the maximum specified ratings. EOS failure can happen if RF emitters are close to a GNSS receiver or its antenna. EOS causes damage to the chip structures.

If the **RF_IN** is damaged by EOS, it is hard to determine whether the chip structures have been damaged by ESD or EOS.

2.14.4 EOS protection measures

EOS protection measures as shown in Figure 20 are recommended for any designs combining wireless communication transceivers (for example, GSM, GPRS) and GNSS in the same design or in close proximity.

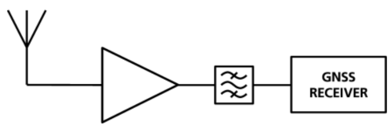
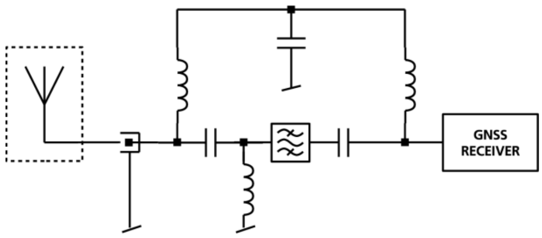
Passive antennas	Active antennas
C  LNA with appropriate ESD rating and maximum input power.	D 

Figure 20: EOS and ESD Precautions

2.14.5 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 2.3.3), 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 (such as pin rows)
- Weakly shielded lines on PCB (for example, on top or bottom layer and especially at the border of a PCB)
- Weak GND concept (for example, small and/or long ground line connections)

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

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

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

Improved EMI protection can be achieved by inserting a resistor or, better yet, a ferrite bead or an inductor (see Table 15) into any unshielded PCB lines connected to the GNSS receiver. Place the resistor as close to the GNSS receiver pin as possible.

Alternatively, feed-through capacitors with good GND connection can be used to protect, for example, the VCC supply pin against EMI. A selection of feed-through capacitors is listed in Table 15.

Intended use

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

2.14.6 Applications with cellular modules

GSM terminals transmit power levels up to 2 W (+33 dBm) peak, 3G and LTE up to 250 mW continuous. Consult the ZOE-M8B Data sheet [1] for the absolute maximum power input at the GNSS receiver. Make sure that absolute maximum input power level of the GNSS receiver is not exceeded.

☞ See the GPS Implementation and Aiding Features in u-blox wireless modules [4].

2.14.6.1 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, for example, 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.

2.14.6.2 Increasing interference immunity

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

2.14.6.3 In-band interference

With in-band interference, the signal frequency is very close to the GPS frequency of 1575 MHz (see Figure 21). Such interference signals are typically caused by harmonics from displays, micro-controller, bus systems.

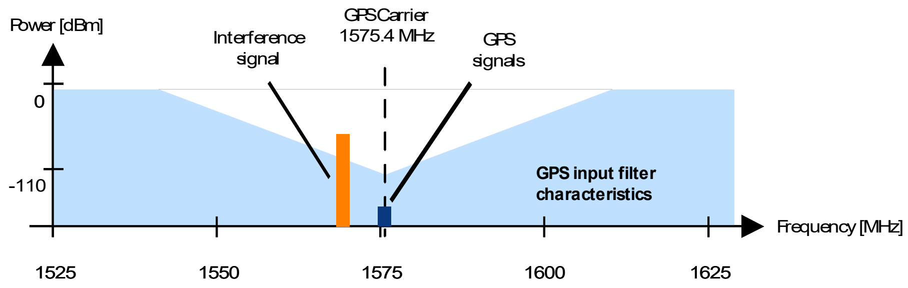


Figure 21: In-band interference signals

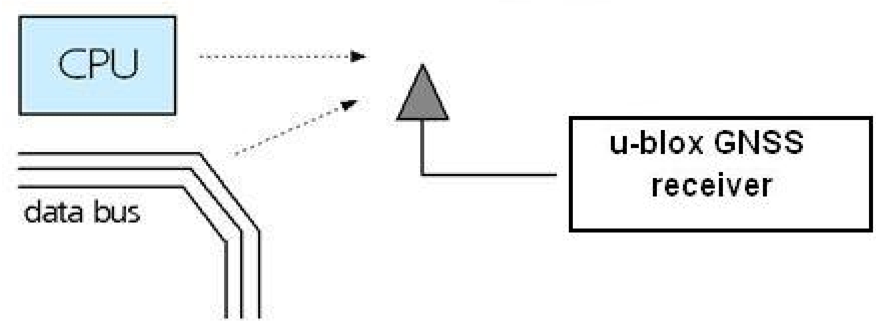


Figure 22: In-band interference sources

Measures against in-band interference include:

- Maintaining a good grounding concept in the design
- Shielding
- Layout optimization
- Filtering for example resistors and ferrite beads
- Placement of the GNSS antenna
- Adding a CDMA, GSM, WCDMA bandpass filter before handset antenna

2.14.6.4 Out-band interference

Out-band interference is caused by signal frequencies that are different from the GNSS carrier (see Figure 23). The main sources are wireless communication systems such as GSM, CDMA, HSPA, Wi-Fi, Bluetooth.

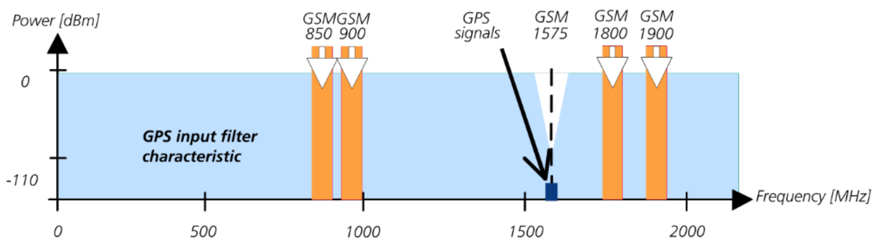


Figure 23: Out-band interference signals

Measures against out-band interference include maintaining a good grounding concept in the design and adding a SAW or bandpass ceramic filter (as recommend in section 2.14.6) into the antenna input line to the GNSS receiver (see Figure 24).

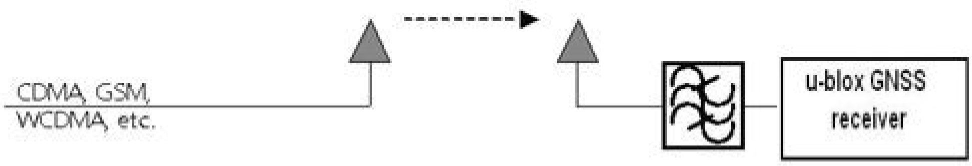


Figure 24: Measures against out-band interference

3 System integration

This section presents system integration methods for achieving low power and high performance.

Many aspects affect the system performance and power consumption of the ZOE-M8B GNSS SiP:

- The ZOE-M8B is intended to be run in Super-E mode and defaults to this mode on power up. The Super-E mode provides the best balance between low current consumption vs. performance.
- Using multi-GNSS Assistance data on receiver start-up can improve the start-up performance. Multi-GNSS Assistance data ensures minimal power consumption since A-GNSS enables the chip to maximize its power-optimized period.
- For specific power saving applications, the host processor has an option to set the receiver into backup state. All essential data for quick re-starting of navigation can be saved either on the receiver side or on the host processor side.
- The data batching feature allows position fixes to be stored in the RAM of the receiver to be retrieved later in one batch. Batching of position fixes happens independently of the host system, and can continue while the host is powered down.

Running the receiver in continuous mode gives the best GNSS performance for sensitivity and accuracy during acquisition and tracking phases. However, the ZOE-M8B GNSS SiP is intended to be run in the Super-E mode and defaults to this mode on power-up. The operating mode must be either explicitly changed with an UBX message after receiver startup or stored as part of current configuration to an external SQI flash.

3.1 Backup and time aiding for power off

By default, the receiver does not have information about GNSS time or satellite navigation data when it starts up. Receiving this information from the satellite broadcasts takes a long time and requires a high GNSS signal level.

Using a backup mode is a way to turn off the receiver while maintaining the knowledge about satellite navigation data. Additionally, RTC or time aiding can be used to maintain the information about GNSS time. Using these methods leads to better acquisition sensitivity and TTFF for the receiver start-up.

When using HW backup mode or SW backup mode the navigation data (GNSS orbit data) is maintained in receiver backup memory while the backup supply powers the backup power domain.

The difference between these two modes is that the receiver enters HW backup mode automatically when the main power supply is no longer powered. It enters SW backup mode when the host directs the receiver to go to backup mode with a UBX message.

The backup power domain must be supplied during HW or SW backup state. This also enables the use of an external RTC oscillator to maintain the GNSS time.

If the receiver is completely turned off so that the backup power domain also has no power, the navigation data can be stored on host or on the SQI flash. In this case, the receiver also no longer has knowledge of the GNSS time. Thus, the host processor must provide the time to the receiver on start-up, or the receiver must get this information directly from the satellite broadcast signals.

Impact on backup duration and time accuracy:

- Backup-state duration from 0 to ~15 min: the GNSS time accuracy after restart is still better than 1 ms and all ephemerides are still valid. The acquisition sensitivity and TTFF are improved (due to better search windows).
- Backup-state duration from ~15 min to ~2–4 hours: the GNSS time accuracy after restart is worse than 1 ms but all ephemerides are still likely to be valid. The TTFF is still improved (the receiver does full window searches but can do a fix before data decoding).

- Higher backup-state durations: the ephemerides and GNSS time information has expired. For this case AssistNow Offline data will still provide the benefits on acquisition sensitivity and TTFF.

If RTC is replaced by using time-assistance from the host, the benefits on TTFF are still applicable, but the benefits on acquisition sensitivity are reduced.

If neither an RTC nor time-assistance is used, only the navigation database is restored upon startup, but the receiver starts up with an unknown time. For this case, both the benefits on TTFF and acquisition sensitivity are reduced. However, the performance is still better than without using backup.

3.2 Using multi-GNSS Assistance (MGA)

u-blox multi-GNSS Assistance (MGA) service provides Assisted GNSS (A-GNSS) functionality with support for multiple constellations. Supply of GNSS receiver assistance information greatly improves performance of position calculation and tracking by delivering satellite data such as ephemeris, almanac, accurate time and satellite status to the GNSS receiver. The host processor fetches this aiding data from u-blox's multi-GNSS Assistance server via a wireless network or the internet, and sends the data to the GNSS receiver. Any of the receivers communication interfaces can be used for this.

All u-blox M8 GNSS receiver chips support the u-blox AssistNow Online and AssistNow Offline A-GNSS services. They also support AssistNow Autonomous feature, and are OMA SUPL-compliant.

When using the AssistNow Online, Offline or Autonomous data, the ZOE-M8B GNSS SiP reaches minimal power consumption, since A-GNSS enables the receiver to maximize its power-optimized period. The A-GNSS assistance data also improves tracking accuracy in Super-E mode because the receiver can optimize the set of satellites used in power-optimized tracking.

Performance of the GNSS operation is improved in several aspects:

- The TTFF can be reduced down to a couple of seconds.
- The signal acquisition before entering the power-optimized tracking is improved. Thus, more satellites can be tracked to improve the tracking accuracy.
- The receiver switches less often from power-optimized tracking back to full power mode. This leads to more optimal power saving in Super-E mode.
- Performance is improved also in weak-signal environments like urban canyons or forests.

AssistNow Online and AssistNow Offline can be used either alone or in combination. AssistNow Autonomous is an embedded feature of the receiver. GNSS orbit predictions are directly calculated by the GNSS receiver and no external aiding data or connectivity is required. AssistNow Autonomous can be used alone, or together with AssistNow Online. However, the AssistNow Offline and AssistNow Autonomous features are exclusive and should not be used at the same time. Every satellite will be ignored by AssistNow Autonomous if there is AssistNow Offline data available for it.

For more information on the Multiple GNSS Assistance Services and the related communication protocol, see the Multiple GNSS Assistance Services For u-blox GNSS receivers [5] and the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [3].

3.2.1 AssistNow™ Online

With AssistNow Online, an internet-connected host downloads assistance data from the u-blox AssistNow Online service to the receiver at system start-up. The multi-GNSS Assistance (MGA) service is an HTTP protocol-based service that is independent of network operators. The service works on all standard mobile communication networks that support Internet access, including GPRS, UMTS and Wireless LAN u-blox only sends ephemeris data for those satellites currently visible to the mobile device requesting the data, thus minimizing the amount of data transferred.

The AssistNow Online service provides data for GPS, GLONASS, BeiDou, Galileo and QZSS.

3.2.2 AssistNow™ Offline (ANO)

With AssistNow Offline (ANO), users can download long-term orbit data from the internet at their convenience. The orbit data can be stored in the u-blox M8 GNSS receiver's external SQI flash memory (if available) or in the memory of the application processor. Thus, the function requires no connectivity at system start-up and enables the GNSS performance and power consumption improvement even when no network is available.

The long term-orbit data is based on differential almanac correction data. Because this system utilizes the almanac data on the receiver, the current almanac should also be available.

Almanac data can be loaded separately or alongside with the ANO data.

☞ AssistNow Offline offers augmentation for up to 35 days.

☞ AssistNow Offline service provides data for GPS and GLONASS only; BeiDou and Galileo are not currently supported.

☞ AssistNow Offline cannot be used at the same time with AssistNow Autonomous.

3.2.3 AssistNow™ Autonomous

AssistNow Autonomous provides aiding information without the need for any external network connection. It is based on broadcast satellite ephemeris data that the receiver has previously downloaded. AssistNow Autonomous automatically generates accurate predictions of satellite orbital data ("AssistNow Autonomous data") that is usable for future GNSS position fixes. The concept capitalizes on the periodic nature of GNSS satellites: their position in the sky is repeated every 24 hours. By capturing strategic ephemeris data at specific times of the day, the receiver can predict accurate satellite ephemeris for up to six days after initial reception. The use of an SQI flash memory is recommended when using AssistNow Autonomous, otherwise only GPS satellites are used and the prediction time decreases to three days.

u-blox's AssistNow Autonomous benefits are:

- No connectivity required
- Can work stand-alone or concurrently with AssistNow Online
- No integration effort; calculations are done in the background, operation is transparent to the user

3.3 Data batching

The data batching feature allows position fixes to be stored in the RAM of the receiver to be retrieved later in one batch. Batching of position fixes happens independently of the host system, and can continue while the host is powered down.

The RAM available in the chip limits the size of the buffer. With the default 1 Hz navigation rate, up to five minutes of data can be stored to the buffer. To make the best use of the available space, only a minimum set of data is stored for each navigation epoch by default. More detailed information can be stored on the position fixes; however, this reduces the number of fixes that can be batched.

It is possible that the host is not able to retrieve the batched fixes before the buffer fills up. In such cases, the oldest fix will be dropped and replaced with the newest. The host can request batching status information to see if fixes have been dropped.

Data batching is disabled by default. To utilize this feature, the batching operation must be enabled and the buffer size must be set. It is also possible to set up a PIO as a flag to indicate when the buffer is close to filling up.

☞ The buffer size or the level of detail for the buffered data must not be changed while the receiver already has some data in the buffer. The previous data in the buffer must be retrieved before making any adjustments to the buffering.

Retrieval of the buffered data may take longer that one navigation cycle. For example, retrieving a buffer of 300 position fixes over UART at 115200 baud takes slightly over 3 seconds. (This is longer than 300*108*10/115200 = 2.8 seconds, because the messages are not transferred gap-free. There may be occasional gaps of up to 10 milliseconds.) If new position fixes arrive during retrieval operation, the new data will not be included in the currently ongoing retrieval operation, but it will be available for a new retrieval operation. See the u-blox 8 / M8 Receiver Description including Protocol Specification [3] for more information.

4 Product handling and soldering

4.1 Packaging, shipping, storage and moisture preconditioning

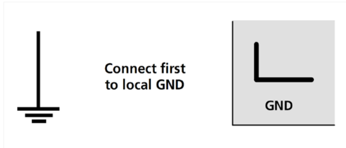
For information pertaining to reels and tapes, moisture sensitivity levels (MSD), shipment and storage information, as well as drying for preconditioning see the ZOE-M8B Data sheet [1].

4.2 ESD handling precautions

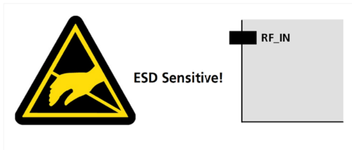
ESD prevention is based on establishing an electrostatic protective area (EPA). The EPA can be a small working station or a large manufacturing area. The main principle of an EPA is that there are no highly charging materials in the vicinity of ESD-sensitive electronics, all conductive materials are 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 receivers are sensitive to ESD and require special precautions when handling. Exercise particular care when handling patch antennas, due to the risk of electrostatic charges. In addition to standard ESD safety practices, take the following measures into account whenever handling the receiver.

- Unless there is a galvanic coupling between the local GND (i.e. the work table) and the PCB GND, the first point of contact when handling the PCB shall 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 the mounted patch antenna.

- 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 receiver!

4.3 Safety precautions

The ZOE-M8B GNSS SiP must be supplied by an external limited power source in compliance with the clause 2.5 of the standard IEC 60950-1. In addition to external limited power source, only separated or safety extra-low voltage (SELV) circuits are to be connected to the SiP including interfaces and antennas.

☞ For more information about SELV circuits see section 2.2 in *S*afety standard IEC 60950-1 [6].

4.4 Soldering

4.4.1 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-mask geometry for applying soldering paste should meet the recommendations given in section 2.13.2.

4.4.2 Reflow soldering

Preheat/ Soak temperature min. Preheat/ Soak temperature max. Preheat/ Soak time from T_{smin} to T_{smax}	T_{smin} T_{smax} T_s (T_{smin} to T_{smax})	150 °C 180 °C 90 to 110 seconds
Liquidus temperature Time maintained above T_L	T_L t_L	217 °C 40 to 60 seconds
Peak package body temperature	T_P	250 °C
Average ramp up rate (T_{smax} to T_P)		0.8 °C/ second max.
Time within +5 °C…-5 °C of T_P		20 to 40 seconds
Ramp down rate (T_P to T_L)		6 °C/ second max.
Time 25 °C to T_P		8 minutes max.

Table 5: Recommended conditions for reflow process

The peak temperature must not exceed 255 °C. The time above 245 °C must not exceed 40 seconds.

☞ The ZOE-M8B GNSS SiP **must not** be soldered with a damp heat process.

4.4.3 Optical inspection

After soldering the SiP, consider an optical inspection step to check whether:

- The SiP is properly aligned and centered over the pads.

4.4.4 Repeated reflow soldering

Only single reflow soldering process is recommended.

4.4.5 Wave soldering

Baseboards 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 ZOE-M8B GNSS SiPs.

4.4.6 Rework

Not recommended.

4.4.7 Use of ultrasonic processes

Some components on the ZOE-M8B GNSS SiP are sensitive to ultrasonic waves. Use of any ultrasonic processes (cleaning, welding) may cause damage to the GNSS receiver.

☞ u-blox offers no warranty against damages to the ZOE-M8B GNSS SiP caused by any ultrasonic processes.

5 Product testing

5.1 Test parameters for OEM manufacturer

Because of the testing done by u-blox, an OEM manufacturer does not need to repeat firmware tests or measurements of the GNSS parameters/characteristics (such as TTFF) in their production test.

An OEM manufacturer should focus on:

- Overall sensitivity of the device (including antenna, if applicable)
- Communication to a host controller

5.2 System sensitivity test

The best way to test the sensitivity of a GNSS device is with the use of a multi-GNSS generator. It assures reliable and constant signals at every measurement.

u-blox recommends the following Multi-GNSS generator:

- Spirent GSS6300: Spirent Communications Positioning Technology www.positioningtechnology.co.uk

Figure 25: Multi-GNSS generator

5.2.1 Guidelines for sensitivity tests

1. Connect a multi-GNSS generator to the OEM product.
2. Choose the power level in a way that the “Golden Device” would report a C/No ratio of 38-40 dBHz.
3. Power up the Device Under Test (DUT) and allow enough time for the acquisition.
4. Read the C/N0 value from the NMEA GSV or the UBX-NAV-SVINFO message (using, for example, u-center).
5. Compare the results to a “Golden Device” or the u-blox EVK-M8GZOE Evaluation Kit.

5.2.2 “Go/No go” tests for integrated devices

The best test is to bring the device to an outdoor position **with excellent sky view** (HDOP < 3.0). Let the receiver acquire satellites and compare the signal strength with a “Golden Device”.

☞ As the electro-magnetic field of a redistribution antenna is not homogenous, indoor tests are in most cases not reliable. These kind of tests may be useful as a ‘go/no go’ test but not as sensitivity measurements

.

Appendix

A Glossary

Abbreviation	Definition
ANSI	American National Standards Institute
BeiDou	Chinese satellite navigation system
CDMA	Code Division Multiple Access
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
LGA	Land Grid Array
PCB	Printed circuit board
SBAS	Satellite-Based Augmentation System
S-LGA	Soldered Land Grid Array
QZSS	Quasi-Zenith Satellite System
WCDMA	Wideband Code Division Multiple Access

Table 6: Explanation of the abbreviations and terms used

B Recommended components

This section provides information about components that are critical for ZOE-M8B GNSS SiP performance. Recommended parts are selected on a data sheet basis only. Temperature range specifications need only be as wide as required by a particular application. For the purpose of this document, specifications are for an industrial temperature range (-40 C … +85 C).

B.1 External RTC (Y1)

ID	Parameter	Value
1	**Frequency specifications**	
1.1	Oscillation mode	Fundamental mode
1.2	Nominal frequency at 25 °C	32.768 kHz
1.3	Frequency calibration tolerance at 25 °C	< ±100 ppm
2	**Electrical specifications**	
2.1	Load capacitance C_L	7 pF
2.2	Equivalent series resistance R_S	< 100 kΩ

Table 7: RTC crystal specifications

Manufacturer	Order no.
Micro Crystal	CC7V-T1A 32.768 kHz 7.0 pF +/- 100 ppm
Micro Crystal	CM7V-T1A 32.768 kHz 7.0 pF +/- 100 ppm
Micro Crystal	CM8V-T1A 32.768 kHz 7.0 pF +/- 100 ppm

Table 8: Recommended parts list for RTC crystal

B.2 RF bandpass filter (F1)

Depending on the application circuit, consult manufacturer data sheet for DC, ESD and RF power ratings!

Manufacturer	Order no.	System supported	Comments
TDK/ EPCOS	B8401: B39162B8401P810	GPS+GLONASS	High attenuation
TDK/ EPCOS	B3913: B39162B3913U410	GPS+GLONASS+BeiDou	For automotive application
TDK/ EPCOS	B9416: B39162B9416K610	GPS	High input power
TDK/ EPCOS	B4310: B39162B4310P810	GPS+GLONASS	Compliant to the AEC-Q200 standard
TDK/ EPCOS	B4327: B39162B4327P810	GPS+GLONASS+BeiDou	Low insertion loss
TDK/ EPCOS	B9482: B39162B9482P810	GPS+GLONASS	Low insertion loss
TDK/ EPCOS	B9850: B39162B9850P810	GPS	Low insertion loss
TDK/ EPCOS	B8400: B39162B8400P810	GPS	ESD-protected and high input power
Murata	SAFFB1G56KB0F0A	GPS+GLONASS+BeiDou	Low insertion loss, only for mobile application
Murata	SAFEA1G58KA0F00	GPS+GLONASS	Only for mobile application
Murata	SAFFB1G58KA0F0A	GPS+GLONASS	High attenuation, only for mobile application
Murata	SAFEA1G58KB0F00	GPS+GLONASS	Low insertion loss, only for mobile application
Murata	SAFFB1G58KB0F0A	GPS+GLONASS	Low insertion loss, only for mobile application
Triquint	856561	GPS	Compliant to the AEC-Q200 standard
TAI-SAW	TA1573A	GPS+GLONASS	Low insertion loss
TAI-SAW	TA1343A	GPS+GLONASS+BeiDou	Low insertion loss
CTS	CER0032A	GPS	Ceramic filter also offers robust ESD protection

Table 9: Recommended parts list for RF bandpass filter

B.3 Optional SQI flash (U3)

Manufacturer	Order no.	Comments
Macronix	MX25R1635FxxxH1	1.8 V, 16 Mbit, several package/temperature options
Macronix	MX25R8035Fxxxx1	1.8 V, 8 Mbit, several package/temperature options
Macronix	MX25R8035Fxxxx3	1.8 V, 8 Mbit, several package/temperature options
Winbond	W25Q16FW	1.8 V, 16 Mbit, several package/temperature options
Adesto	AT25SL641	1.8 V, 64 Mbit (only 32 Mbit used), several package/temperature options
ISSI	IS25WP016D	1.8 V, 16 Mbit, several package/temperature options
ISSI	IS25WP032D	1.8 V, 32 Mbit, several package/temperature options
ISSI	IS25WP064A	1.8 V, 64 Mbit (only 32 Mbit used), several package/temperature options

Table 10: Recommended parts list for optional SQI flash

B.4 External LNA (U1)

ID	Parameter	Value
1	**Gain and noise figure at 1.575 GHz**	
1.1	Gain	> 17 dB
1.2	Noise figure	< 2 dB

Table 11: External LNA specifications

Manufacturer	Order no.	Comments
Maxim	MAX2659ELT+	Low noise figure, up to 10 dBm RF input power
JRC New Japan Radio	NJG1143UA2	Low noise figure, up to 15 dBm RF input power
NXP	BGU8006	Low noise figure, very small package size (WL-CSP)
Infineon	BGA524N6	Low noise figure, small package size

Table 12: Recommended parts list for external LNA

B.5 RF ESD protection diode

Manufacturer	Order no.
ON Semiconductor	ESD9R3.3ST5G
Infineon	ESD5V3U1U-02LS

Table 13: Recommended parts list for RF ESD protection diode

B.6 Ferrite beads (FB1)

Manufacturer	Order no.	Comments
Murata	BLM15HD102SN1	High impedance at 1.575 GHz
Murata	BLM15HD182SN1	High impedance at 1.575 GHz
TDK	MMZ1005F121E	High impedance at 1.575 GHz
TDK	MMZ1005A121E	High impedance at 1.575 GHz

Table 14: Recommended parts list for ferrite beads FB1

B.7 Feed-through capacitors

Manufacturer	Order no.	Comments
Murata	NFL18SP157X1A3	For data signals, 34 pF load capacitance
Murata	NFA18SL307V1A45	For data signals, 4 circuits in 1 package
Murata	NFM18PC474R0J3	For power supply < 2 A, size 0603
Murata	NFM21PC474R1C3	For power supply < 4 A, size 0805

Table 15: Recommended parts list for feed-through capacitors

B.8 Standard capacitors

Name	Use	Type / Value
C4	Decoupling VCC at SQI flash supply pin	X5R 1U0 10% 6.3 V

Table 16: Standard capacitors

Related documents

[1] ZOE-M8B Data Sheet, UBX-17035164
[2] GPS Implementation and Aiding Features in u-blox wireless modules, GSM.G1-CS-09007
[3] u-blox 8 / u-blox M8 Receiver Description including Protocol Specification, UBX-13003221
[4] GPS Antenna Application Note, GPS-X-08014
[5] Multiple GNSS Assistance Services for u-blox GNSS receivers, UBX-13004360
[6] Information technology equipment – Safety Standard IEC 60950-1 https://webstore.iec.ch/publication/4024

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

Revision history

Revision	Date	Name	Comments
R01	12-Oct-2017	rmak	Objective Specification
R02	31-Jan-2018	rmak	Early Production Information. Updated Sections 1.2.2, 2.1.2.1, 2.10, 3.2.2, 3.3 and B.3. Added DoC statement on page 2.
R03	12-Mar-2018	rmak	Production Information. Updated Section 2.10 the I^2C bus speed.
R04	13-Dec-2018	rmak	Updated Super-E description in 1.2 and power mode description in 2.1.2. Corrected Pin C3 information (PIO11) in Sections 2.8 and 2.9. Added info on option to use use EXTINT pin as a generic PIO13 in 2.3.1. Updated supported SQI flash list in B.3.
R05	28-Jun-2019	rmak	Updated Figure 15 (active antenna supply circuit).
R06	08-May-2020	mala	Added section 2.13.4 Layout design-in: Thermal management. Grammar corrections, added some missing links, editorial changes to reflect the latest style guide updates.
R07	14-Oct-2021	mala	Updated product type number and PCN reference in page 2.

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