# EVA-M8E

## u-blox M8 Miniature Untethered Dead Reckoning Module

Data Sheet





### Abstract

This data sheet describes the EVA-M8E SiP module, which is the industry's smallest UDR module form factor. EVA-M8E provides leading performance and continuous navigation even with poor GNSS signal conditions and functions independent of any electrical connection to the car.



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# Document Information

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This document applies to the following products:

| **Product name** | **Type number** | **Firmware version** | **PCN reference** |
|---|---|---|---|
| EVA-M8E | EVA-M8E-0-11 | ROM 3.01 / Flash FW 3.01 UDR 1.21 | N/A |

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# 1 Functional description

☞ For more details of many of the functions, see the u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [2].

## 1.1 Overview

The EVA-M8E module introduces u-blox's Untethered Dead Reckoning (UDR) technology in the ultra-compact EVA form factor. EVA offers the designer flexibility in the selection and placement of peripheral components: EVA-M8E only requires Flash memory, an inertial sensor, and an optional real-time clock (RTC) crystal. The EVA-M8E's sensor may be installed in any stable position within the vehicle without configuration.

UDR brings the benefits of Dead Reckoning (DR) without requiring speed information from the vehicle. This significantly reduces the cost of installation for after-market Dead Reckoning applications and brings DR performance to applications where previously only GNSS was possible. The strength of UDR compared with GNSS alone is particularly apparent under poor signal conditions in urban environments, where it brings continuous positioning even to devices with antennas installed within the vehicle. Useful positioning performance is also available during complete signal loss, for example in parking garages and short tunnels. UDR positioning starts as soon as power is applied to the module, even before the first GNSS fix is available. Inertial sensing enables vehicle yaw and pitch to be calculated and reported directly.

The intelligent combination of GNSS and sensor measurements enables accurate, real-time positioning at rates up to 30 Hz, as needed for smooth and responsive interactive applications. Native high-rate sensor data can be relayed to the host for applications such as driving behavior analysis or accident reconstruction.

The EVA-M8E includes u-blox's latest generation GNSS receiver, which adds Galileo to the multi-constellation reception that already includes GPS, GLONASS, BeiDou and QZSS. The module provides high sensitivity and fast GNSS signal acquisition and tracking. UART, USB, DDC (I2C compliant) and SSI interface options provide flexible connectivity and enable simple integration with most u-blox cellular modules.

EVA-M8E modules are qualified as stipulated in the JESD47 standard.

## 1.2 Product features

| Model | Category | | | | GNSS | | | | | Supply | Interfaces | | | | Features | | | | | | | | Grade | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard Precision GNSS | High Precision GNSS | Dead Reckoning | Timing | GPS / QZSS | GLONASS | Galileo | BeiDou | Number of concurrent GNSS | 2.7 V - 3.6 V | UART | USB | SPI | DDC (I²C compliant) | Programmable (flash) | Data logging | Additional SAW | Additional LNA | RTC crystal | Oscillator | Built-in sensor | Timepulse | Standard | Professional | Automotive |
| **EVA-M8E** | | | UDR | | • | • | • | • | 3 | • | • | • | • | • | E | E | | | o | T | | 1 | | • | |

ADR = Automotive Dead Reckoning / UDR = Untethered Dead Reckoning / E = External flash required / o = Optional, or requires external components / C = Crystal / T = TCXO

## 1.3 GNSS Performance

| Parameter | Specification | | | | | | |
|---|---|---|---|---|---|---|---|
| Receiver type | 72-channel u-blox M8 engine<br>GPS L1C/A, SBAS L1C/A, QZSS L1C/A, QZSS L1-SAIF, GLONASS L1OF, BeiDou B1I , Galileo E1B/C | | | | | | |
| Operational limits[1] | Dynamics | ≤ 4 g | | | | | |
| | Altitude | 50,000 m | | | | | |
| | Velocity | 500 m/s | | | | | |
| Velocity accuracy[2] | | 0.5 m/s typ. | | | | | |
| Heading accuracy[2] | | 1 degrees typ. | | | | | |
| Position error during GNSS loss[3] | < 60 s signal loss | typ. 10% distance travelled | | | | | |
| Max navigation update rate, High Navigation Rate output | | 30 Hz | | | | | |
| Max navigation update rate (PVT)[4] | | 2 Hz | | | | | |
| Navigation latency High Navigation Rate output | | <10 ms | | | | | |
| Max sensor measurement output rate | | 100 Hz | | | | | |
| **GNSS** | | **GPS & GLONASS** | **GPS** | **GLONASS** | **BeiDou** | **Galileo** | |
| Time-To-First-Fix[5] | Cold start | 26 s | 30 s | 31 s | 39 s | 57 s | |
| | Hot start | 1.5 s | 1.5 s | 1.5 s | 1.5 s | 1.5 s | |
| | Aided starts[6] | 3 s | 3 s | 3 s | 7 s | 7 s | |
| Sensitivity[7] | Tracking & Navigation | -160 dBm | -160 dBm | -160 dBm | -160 dBm | -154 dBm | |
| | Reacquisition | -160 dBm | -159 dBm | -156dBm | -155 dBm | -152 dBm | |
| | Cold start | -148 dBm | -147 dBm | -145 dBm | -143 dBm | -133 dBm | |
| | Hot start | -157 dBm | -156 dBm | -155 dBm | -155 dBm | -151 dBm | |
| Horizontal position accuracy | Autonomous[8] | 2.5 m | 2.5 m | 4.0 m | 3.0 m | TBC[9] | |
| | With SBAS[10] | 1.5m | 1.5m | - | - | - | |
| Altitude Accuracy | With SBAS[11] | 3.5m | 3.0 m | 7.0 m | 5.0 m | - | |

**Table 1: EVA-M8E performance in different GNSS modes (default: concurrent reception of GPS and GLONASS incl. QZSS, SBAS)**

[1] Configured for Airborne < 4g platform
[2] 50% @ 30 m/s
[3] Typical error incurred without GNSS as a percentage of distance travelled
[4] Rates with SBAS and QZSS enabled for > 98% fix report rate under typical conditions
[5] All satellites at -130 dBm, except Galileo at -127 dBm
[6] Dependent on aiding data connection speed and latency
[7] Demonstrated with a good external LNA
[8] CEP, 50%, 24 hours static, -130 dBm, > 6 SVs
[9] To be confirmed when Galileo reaches full operational capability

## 1.4 Block diagram

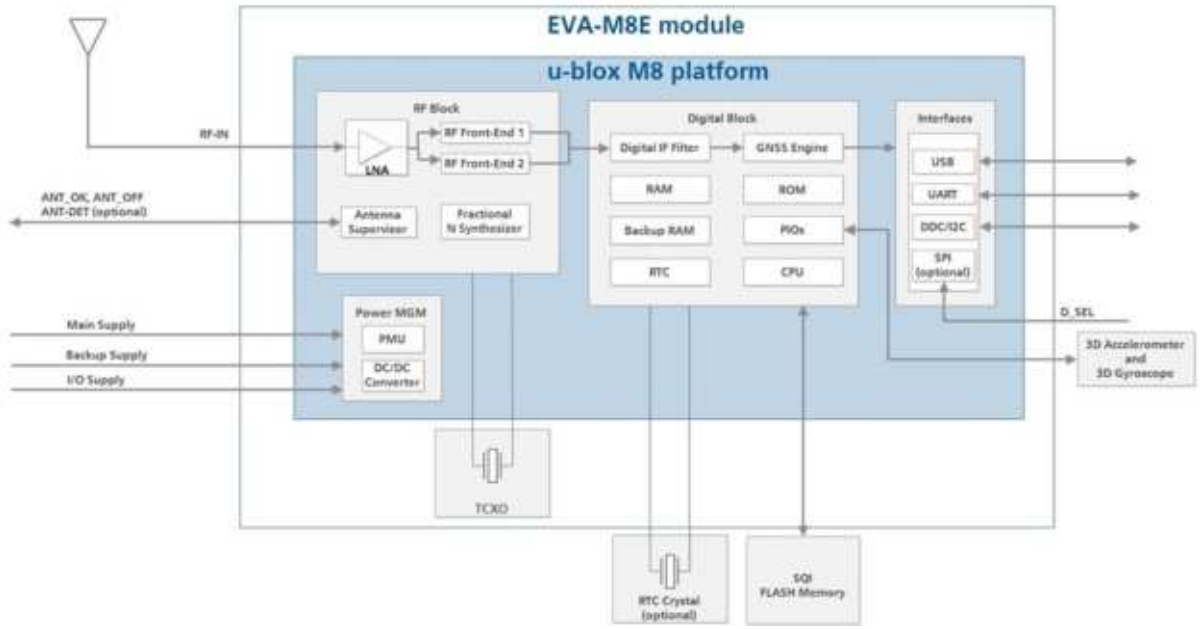



**Figure 1: EVA-M8E block diagram**

## 1.5 Supported GNSS Constellations

The EVA-M8E GNSS module is a concurrent GNSS receiver which can receive and track multiple GNSS systems: GPS, Galileo, GLONASS and BeiDou. Owing to the dual-frequency RF front-end architecture, either GLONASS or BeiDou can be processed concurrently with GPS and Galileo signals providing reception of three GNSS systems. By default the M8 receivers are configured for concurrent GPS and GLONASS, including SBAS and QZSS reception. If power consumption is a key factor, then the receiver should be configured for a single GNSS operation using GPS, Galileo, GLONASS or BeiDou and disabling QZSS and SBAS.

The QZSS, IMES and SBAS augmentation systems share the same frequency band as GPS and can always be processed in conjunction with the GPS.

The module can be configured to receive any single GNSS constellation or within the set of permissible combinations shown below.

| GPS | Galileo | GLONASS | BeiDou |
|---|---|---|---|
| • | • | – | – |
| • | • | • | – |
| • | • | – | • |
| • | – | • | – |
| • | – | – | • |
| – | • | • | – |
| – | • | – | • |
| – | – | • | • |

**Table 2: Permissible GNSS combinations (• = enabled)**

☞ The augmentation systems: SBAS and QZSS can be enabled only if GPS operation is configured

☞ Galileo is not enabled as the default configuration.

### 1.5.1 GPS

The EVA-M8E positioning module is designed to receive and track the L1C/A signals provided at 1575.42 MHz by the Global Positioning System (GPS). The EVA-M8E can receive and process GPS concurrently with GLONASS or BeiDou.

### 1.5.2 GLONASS

EVA-M8E can receive and process GLONASS concurrently with GPS or BeiDou. The Russian GLONASS satellite system is an alternative system to the US-based Global Positioning System (GPS). EVA-M8E is designed to receive and track the L1OF signals that GLONASS provides at 1602 MHz + k*562.5 kHz, where k is the satellite's frequency channel number (k = –7,..., 5, 6). The ability to receive and track GLONASS L1OF satellite signals enable the design of GLONASS receivers where required by regulations.

### 1.5.3 BeiDou

EVA-M8E can receive and process BeiDou concurrently with GPS or GLONASS. EVA-M8E is designed to receive and track the B1 signals provided at 1561.098 MHz by the BeiDou Navigation Satellite System. The ability to receive and track BeiDou B1 satellite signals in conjunction with GPS results in higher coverage, improved reliability and better accuracy. Global coverage is scheduled for 2020.

### 1.5.4 Galileo

The EVA-M8E positioning module can receive and track the E1-B/C signals centered on the GPS L1 frequency band. GPS and Galileo signals can be processed concurrently together with either BeiDou or GLONASS signals, enhancing coverage, reliability and accuracy. The SAR return link message (RLM) parameters for both short and long versions are decoded by the receiver and made available to users via UBX proprietary messages.

☞ Galileo has been implemented according to ICD release 1.3 (December 2016). Since the Galileo satellite system has only recently reached Initial Services (IS) and does not have Full Operational Capability (FOC) yet, changes to the Galileo signal specification (OS SIS ICD) remain theoretically possible. u-blox therefore recommends provision for Flash firmware update in designs utilizing Galileo signals in the unlikely event of a change to the Galileo signal specification (OS SIS ICD).

☞ Galileo reception is by default disabled, but can be enabled by sending a configuration message (UBX-CFG-GNSS) to the receiver. See the u-blox 8 / u-blox M8 Receiver Description / Protocol Specification [2] for more information.

## 1.6 Assisted GNSS (A-GNSS)

Supply of aiding information, such as ephemeris, almanac, or approximate position and time, will reduce the time-to-first-fix significantly and improve the acquisition sensitivity. EVA-M8E supports the u-blox AssistNow Online and AssistNow Offline A-GNSS services, AssistNow Autonomous, and is OMA SUPL compliant.

### 1.6.1 AssistNow™ Online

With AssistNow Online, an internet-connected GNSS device downloads assistance data from u-blox's AssistNow Online Service at system start-up. AssistNow Online is network-operator independent and globally available. Devices can be configured to request only ephemeris data for those satellites currently visible at their location, thus minimizing the amount of data transferred.

### 1.6.2 AssistNow™ Offline

With AssistNow Offline, users download u-blox's long-term orbit data from the Internet at their convenience. The orbit data can be stored in the NEO-M8L-04A GNSS receiver's SQI flash memory. Thus, the service requires no connectivity at system start-up, enabling a position fix within seconds, even when no network is available. AssistNow Offline offers augmentation for up to 35 days.

### 1.6.3 AssistNow™ Autonomous

AssistNow Autonomous provides information without the need for a host or external network connection. Based on previous broadcast satellite ephemeris data, which has been downloaded to and stored by the GNSS receiver, AssistNow Autonomous automatically generates accurate 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 basically repeated every 24 hours. By capturing strategic ephemeris data at specific times over several days, the receiver can predict accurate satellite ephemeris for up to six days after initial reception.

u-blox's AssistNow Autonomous benefits are:

- Faster fix in situations where GNSS satellite signals are weak
- No connectivity required
- Compatible with AssistNow Online and Offline (can work stand-alone, or in tandem with these services)
- No integration effort, calculations are done in the background, transparent to the user.

## 1.7 Augmentation Systems

### 1.7.1 Satellite-Based Augmentation System (SBAS)

EVA M8E supports SBAS. These systems supplement GPS data with additional GPS augmentation data within defined service areas. The systems broadcast augmentation data via satellite and this information can be used by GNSS receivers to improve the resulting precision. In some cases, the SBAS satellites can be used as additional satellites for ranging (navigation), further enhancing precision and availability.

☞ For more details, see the u-blox 8 / u-blox M8 Receiver Description / Protocol Specification [2].

### 1.7.2 QZSS

The Quasi-Zenith Satellite System (QZSS) is a regional navigation satellite system that transmits additional GPS L1 C/A signals for the Pacific region covering Japan and Australia. EVA-M8E positioning module is able to receive and track these signals concurrently with GPS signals, resulting in better availability especially under challenging signal conditions, e.g. in urban canyons.

### 1.7.3 QZSS L1S SLAS

QZSS SLAS (Sub-meter Level Augmentation Service) is an augmentation technology, which provides correction data for pseudoranges of GPS and QZSS satellites. With the QZSS SLAS enabled, u-blox receivers autonomously select the most suitable Ground monitoring stations (GMS) based on the user's location. The correction stream of this GMS will then be applied to the measurements in order to improve the position accuracy.

### 1.7.4 IMES

The Japanese Indoor MEssaging System (IMES) system is used for indoor position reporting using low-power transmitters which broadcast a GPS–like signal. EVA-M8E module can be configured to receive and demodulate the signal to provide an in-door location estimate.

☞ This service is authorized and available only in Japan.

☞ IMES reception is disabled by default.

### 1.7.5 Differential GPS (D-GPS)

EVA-M8E supports Differential-GPS data according to RTCM 10402.3: "RECOMMENDED STANDARDS FOR DIFFERENTIAL GNSS". The use of Differential-GPS data improves GPS position accuracy. RTCM cannot be used together with SBAS. The RTCM implementation supports the following RTCM 2.3 messages.

| Message Type | Description |
|---|---|
| 1 | Differential GPS Corrections |
| 2 | Delta Differential GPS Corrections |
| 3 | GPS Reference Station Parameters |
| 9 | GPS Partial Correction Set |

**Table 3: Supported RTCM 2.3 messages**

☞ RTCM corrections cannot be used together with SBAS.

## 1.8 Untethered Dead Reckoning (UDR)

u-blox's proprietary Untethered Dead Reckoning (UDR) solution relies on information from inertial 3D accelerometer and gyroscope sensors deployed outside the module. The module provides a dedicated DDC ($I^2C$ compatible) interface for directly connected integrated IMUs.

IMU data and GNSS signals are processed together, achieving accurate and continuous positioning in GNSS-hostile environments (e.g. urban canyons) and useful positioning even in case of complete GNSS signal absence (e.g. tunnels and parking garages).

The EVA-M8E combines GNSS and IMU measurements and reports a fused navigation solution at rates of up to 2 Hz. In addition, a navigation solution utilizing sensor data is output with low latency at rates of up to 30 Hz.

Dead reckoning allows navigation to commence as soon as power is applied to the module (i.e. before a GNSS fix has been established) when all of the following conditions are fulfilled:

- the vehicle has not moved unpowered since the previous operation of the module
- at least a dead-reckoning fix was available when the vehicle was last used
- last navigation solution is available by loading from BBR or provided by the host

For post-processing applications, time tagged sensor data is available from message UBX-ESF-MEAS at rates of 10 Hz and from UBX-ESF-RAW at rates of up to 100 Hz.

## 1.9 Broadcast navigation data and satellite signal measurements

The EVA-M8E can output all the GNSS broadcast data upon reception from tracked satellites. This includes all the supported GNSS signals plus the augmentation services SBAS, QZSS and IMES.

## 1.10 Data logging

The u-blox NEO-M8L-04A receiver can be used in data logging applications. The data logging feature enables continuous storage of position, velocity and time information to an onboard SQI flash memory. It can also log the distance reported by the odometer. The information can be downloaded from the receiver later for further analysis or for conversion to a mapping tool. For more information, see the *u-blox 8 / u-blox M8 Receiver Description / Protocol Specification* [2].

## 1.11 Odometer

The odometer provides information on travelled ground distance (in meters) using solely the position and velocity measurements from the combined GNSS/DR navigation solution. For each computed travelled distance since the last odometer reset, the odometer estimates a 1-sigma accuracy value. The total cumulative ground distance is maintained and saved in the BBR memory.

The odometer feature is disabled by default. For more information, see the u-blox 8 / u-blox M8 Receiver Description / Protocol Specification [2].

## 1.12 Geofencing

The u-blox EVA-M8E module supports up to four circular Geofencing areas defined on the Earth's surface using a 2D model. Geofencing is active when at least one Geo-fence is defined, the current status can be found by polling the receiver. A PIO pin can be nominated to indicate status to e.g. wake up a host on activation.

## 1.13 Message Integrity Protection

EVA-M8E provides a function to prevent a third party interfering with the UBX message steam sent from receiver to host. The security mechanism essentially 'signs' nominated messages with a following message containing an MD5-generated hash of the nominated message. This message signature is then compared with the one generated by the host to determine if the message data has been altered.

## 1.14 Spoofing Detection

Spoofing is a process whereby a malicious third party tries to control the reported position via a 'fake' GNSS broadcast signal. This may result in the form of reporting incorrect position, velocity or time. To combat against this, the EVA-M8E module includes spoofing detection measures to alert the host when signals appear to be suspicious. The receiver combines a number of checks on the received signals looking for inconsistencies across several parameters.

☞ This feature does not guarantee to detect all spoofing attacks.

## 1.15 TIMEPULSE

A configurable time pulse signal is available with the u-blox EVA-M8E module.

The **TIMEPULSE** output generates pulse trains synchronized with GPS or UTC time grid with intervals configurable over a wide frequency range. Thus it may be used as a low frequency time synchronization pulse or as a high frequency reference signal.

☞ The EVA-M8E TIMEPULSE output is configured using TIMEPULSE2 messages. This pin has a secondary function during start-up (initiation of "SAFEBOOT" mode for firmware recovery) and should not normally be held LO during start-up.

By default, the time pulse signal is disabled. For more information, see the u-blox 8 / u-blox M8 Receiver Description / Protocol Specification [2].

## 1.16 Protocols and interfaces

| Protocol | Type |
|---|---|
| NMEA 0183 V4.0<br>(V2.1, V2.3 and V4.1 configurable) | Input/output, ASCII |
| UBX | Input/output, binary, u-blox proprietary |
| RTCM | Input, messages 1, 2, 3, 9 |

**Table 4: Available Protocols**

All protocols are available on UART, USB, DDC ($I^2C$ compliant) and SPI. For specification of the various protocols see the *u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification[2]*.

## 1.17 Interfaces

A number of interfaces are provided either for data communication or memory access. The embedded firmware uses these interfaces according to their respective protocol specifications.

### 1.17.1 UART

The EVA-M8E module makes use of a UART interface, which can be used for communication to a host. It supports configurable baud rates. For supported transfer rates see the *u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification [2]*.

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

### 1.17.2 USB

A USB interface, which is compatible to USB version 2.0 FS (Full Speed, 12 Mbit/s), can be used for communication as an alternative to the UART. The pull-up resistor on pin **USB_DP** is integrated to signal a full-speed device to the host. The **VDD_USB** pin supplies the USB interface. The u-blox USB (CDC-ACM) driver supports Windows Vista plus Windows 7 and 8 operating systems. A separate driver (CDC-ACM) is not required for Windows 10 which has a built-in USB-serial driver. However, plugging initially into an internet connected Windows 10 PC, will down-load the u-blox combined sensor and VCP driver package.

USB drivers can be down-loaded from the u-blox web site, www.u-blox.com.

### 1.17.3 SPI

The SPI interface is designed to allow communication to a host CPU. The interface can be operated in slave mode only. The maximum transfer rate using SPI is 125 kB/s and the maximum SPI clock frequency is 5.5 MHz, see Figure 3. Note that SPI is not available in the default configuration, because its pins are shared with the UART and DDC interfaces. The SPI interface can be enabled by connecting **D_SEL** to ground (see section 1.17.7).

### 1.17.4 Display Data Channel (DDC)

An $I^2C$ compliant DDC interface is available for communication with an external host CPU or u-blox cellular modules. The interface can be operated in slave mode only. The DDC protocol and electrical interface are fully compatible with Fast-Mode of the $I^2C$ industry standard. Since the maximum SCL clock frequency is 400 kHz, the maximum transfer rate is 400 kb/s.

### 1.17.5 Integrated IMU Sensor Interface

A dedicated I²C compliant DDC interface is available and reserved for communication with an external Inertial Measurement Unit, which employs 3D accelerometer and 3D gyroscope sensors. The interface can be operated in master mode only. The DDC protocol and electrical interface are fully compatible with Fast-Mode of the I²C industry standard. Since the maximum SCL clock frequency is 400 kHz, thus the maximum transfer rate is 400 kbit/s.

The DDC interface is I²C Fast Mode compliant. For timing parameters consult the I²C standard.

☞ The maximum bit rate is 400 kb/s. The interface stretches the clock when slowed down while serving interrupts, so real bit rates may be slightly lower.

☞ For more information see the *EVA-M8E Hardware Integration Manual[1]*

### 1.17.6 Serial Quad Interface (SQI)

An SQI is available in the EVA-M8E module for connecting the module with a mandatory external flash memory. The flash memory is required for firmware updates and for data logging. In addition, it can be used to store configurations and to save AssistNow Offline and AssistNow Autonomous data.

☞ For more information see the *EVA-M8E Hardware Integration Manual* [1].

### 1.17.7 Interface selection (D_SEL)

At startup the **D_SEL** pin determines which data interfaces are used for communication. If **D_SEL** is set to logical “1” or is not connected, UART and DDC become available. If **D_SEL** is set to logical “0”, i.e. connected to **GND**, the EVA-M8E module can communicate to a host via SPI.

| Pin # | (D_SEL)=”1” (left open) | (D_SEL)=”0” (connected to GND) |
|---|---|---|
| 16 | UART TX | SPI MISO |
| 15 | UART RX | SPI MOSI |
| 29 | DDC SCL | SPI CLK |
| 30 | DDC SDA | SPI CS_N |

**Table 5: Data interface selection by D_SEL**

## 1.18 Configurable Input Output pins

Configuration settings can be modified for several Input/Output pins with either UBX configuration messages or pin selection. This flexible configuration options allow the receivers to be optimally configured for specific applications requirements. The modified settings remain either permanent or effective until power-down or reset depending on the case. Customer can activate or remap the following pins on an EVA-M8E module:

1. Selection of either SPI or DDC and UART TX/RX pins interface using **D_SEL** pin. See section *1.17.7.*
2. Selection of antenna supervision pins. See section *1.23*.
3. Configuration of Timepulse. See section *1.12*.

☞ For more information see the *EVA-M8E Hardware Integration Manual[1]*.

## 1.19 Safe Boot Mode

If Pin33 (**SAFEBOOT_N**) is set to logical “0” at startup, the EVA-M8E receiver enters Safe Boot Mode. In this mode the receiver does not calculate positioning data, but is in a defined state that allows such actions as programming the flash memory in production, or recovering a corrupted flash memory.

☞ For more information about Safe Boot Mode see the *EVA-M8E Hardware Integration Manual[1].*

## 1.20 System reset

The EVA-M8E receiver provides a **RESET_N** pin to reset the system and Real-Time Clock (RTC). The **RESET_N** pin should be only used in critical situations to recover the system.

## 1.21 Clock generation

### 1.21.1 Oscillator

The EVA-M8E module has a Temperature Compensated Crystal Oscillator (TCXO). The TCXO allows accelerated weak signal acquisition, improving start and reacquisition times during temperature changes typical of vehicle applications. Like other u-blox GNSS modules, the EVA-M8E module uses components selected for functioning reliably in the field over the full operating temperature range.

### 1.21.2 Real-Time Clock (RTC)

The use of the RTC Clock may be optionally used to maintain time in the event of power failure at **VCC_IO**. The RTC is required for hot start, warm start, AssistNow Autonomous, AssistNow Offline and some Power Save Mode operations.

The use of the RTC is optional. The time information can be generated in one of these ways:

- by connecting to an external RTC crystal (for lower battery current – default mode)
- by sharing from another RTC oscillator used within the application (for lowest system costs and smallest size)

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

☞ For more information about crystal operation and configuration, see the *EVA-M8E Hardware Integration Manual* [1].

☞ If neither backup RAM nor RTC are used, the backup battery is not needed and **V_BCKP** should be connected to **VCC_IO**.

## 1.22 Power Management

u-blox M8 technology offers a power-optimized architecture with built-in autonomous power saving functions to minimize power consumption at any given time. In addition, a high efficiency DC/DC converter is integrated to allow low power consumption even for higher main supply voltages.

### 1.22.1 Power control

A separate battery backup voltage may be applied to the module to retain the current state of the receiver and sustain a low power real time clock (RTC) while the main supply is removed. This enables fast acquisition and navigation based on dead-reckoning before the first GNSS-based fix.

Alternatively, a configuration command (UBX-CFG-PWR) can be issued to stop the receiver in a similar way to Hardware Backup Mode (see *1.21.2* above) while the main supply remains active. This mode is referred to as Software backup mode; current consumption in this mode is slightly higher than in Hardware Backup Mode. The receiver will then restart on the next edge received at its UART interface (there will be a delay before any communications are possible). See

| Parameter | Symbol | Typ<br>GPS & GLONASS | Typ<br>GPS / QZSS / SBAS | Max | Units | Condition |
|---|---|---|---|---|---|---|
| Max. supply current | Iccp | | | 67 | mA | |
| Average supply current | Icc | 29 | 23 | | mA | Estimated at 3 V |
| Backup battery current | I_BCKP<br>using the RTC crystal | 15 | | | µA | HW Backup mode,<br>VCC_IO = VCC = 0 V |
| SW Backup current | I_SWBCKP<br>using the RTC crystal | 20 | | | µA | SW Backup mode,<br>VCC_IO = VCC = 3 V |

Table 14 for current consumption in backup mode.

## 1.23 Antenna

The EVA-M8E module is designed for use with passive[10] and active[11] antennas.

| Parameter | Specification | |
|---|---|---|
| Antenna Type | Passive and active antenna | For Passive antenna, an external LNA is mandatory to achieve the performance specified in this document |
| Active Antenna Recommendations | Minimum gain<br>Maximum gain<br>Maximum noise figure | 10 dB (to compensate signal loss in RF cable)<br>50 dB<br>1.5 dB |

**Table 6: Antenna recommendations and specifications for EVA-M8E module**

### 1.23.1 Active antenna control (ANT_OFF)

The **ANT_OFF** pin can be used to turn on and off an external LNA or an active antenna. This reduces power consumption in Power Save Mode (Backup mode). This pin is available in an EVA-M8E module.

☞ **ANT_OFF** pin polarity can be changed. For more information about active antenna control, see the EVA-M8E Hardware Integration Manual [1].

### 1.23.2 Active Antenna supervisor and short circuit detection

An antenna supervisor is available with the EVA-M8E module and requires external components. The antenna supervisor enables the receiver to detect short circuits at the active antenna using the **ANT_OFF** and **ANT_OK** pins (activated per default) and to shut down the voltage bias immediately. The antenna supervisor can be extended to also detect condition of open circuit by activating the **ANT_DET** pin and including external components for antenna open circuit detection. UBX and NMEA messages are provided to report the condition of the antenna supply. Open circuit detection can also be supported.

[10] For integrate an EVA-M8E module with Cellular products, see the *EVA-M8E Hardware Integration Manual* [1]
[11] For information on using active antennas with EVA-M8E module, see the *EVA-M8E Hardware Integration Manual* [1].

# 2 Pin definition

## 2.1 Pin assignment

This section shows the pin assignments. Most PIOs are configurable and have shared functions. Use special care when designing with these pins since the overall function of the device can be affected.

The default configuration of the PIOs is listed in Table 7 below.

☞ For more information see the EVA-M8E Hardware Integration Manual [1].

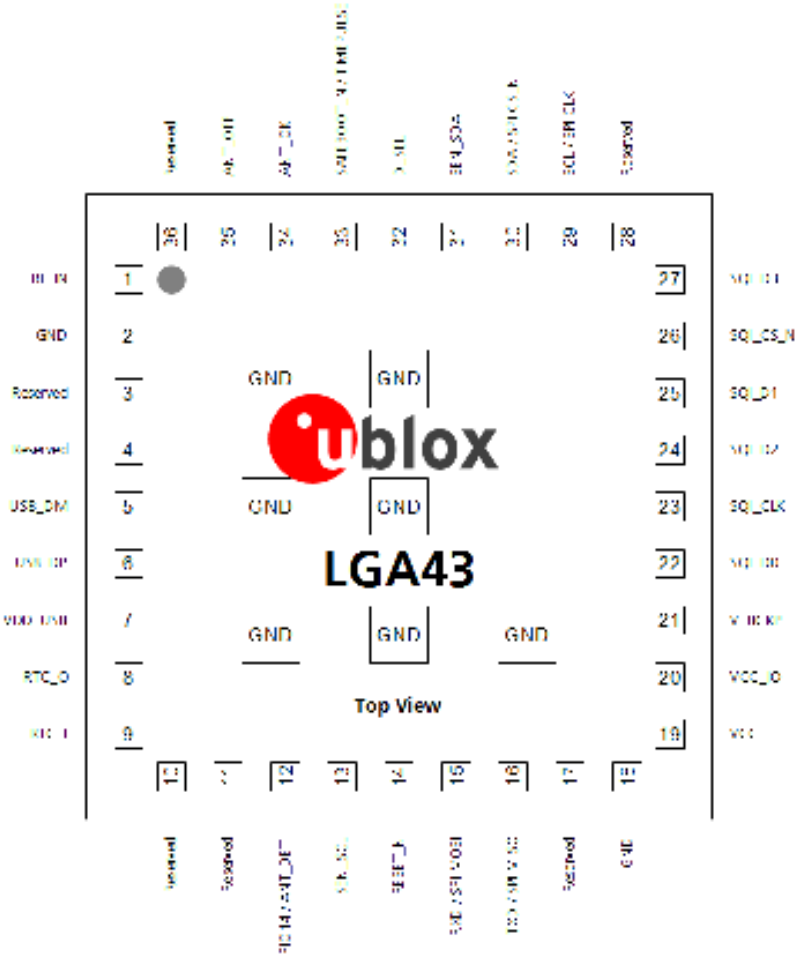



**Figure 2: Pin assignment of EVA-M8E (LGA43)**

☞ For multiple function PIOs, select the specific signal by sending the specific configuration message or by e-fusing.

| Pin # | Name | I/O | Description | Remark |
|---|---|---|---|---|
| **1** | RF_IN | I | RF Input | Add external LNA and SAW if no active antenna used. |
| **2** | GND | I | Ground | |
| **3** | Reserved | I/O | Reserved | Do not connect. Must be left open! |
| **4** | Reserved | I/O | Reserved | Do not connect. Must be left open! |
| **5** | USB_DM | I/O | USB data | Leave open if not used. |

| Pin # | Name | I/O | Description | Remark |
|---|---|---|---|---|
| **6** | USB_DP | I/O | USB data | Leave open if not used. |
| **7** | VDD_USB | I | USB Interface power | Connect to GND if not used. |
| **8** | RTC_O | O | RTC Output | Leave open if no RTC Crystal attached. |
| **9** | RTC_I | I | RTC Input | Connect to GND if no RTC Crystal attached. |
| **10** | Reserved | I/O | Reserved | Do not connect. Must be left open! |
| **11** | Reserved | I/O | Reserved | Do not connect. Must be left open! |
| **12** | PIO14 / ANT_DET | I | Normal PIO; Or antenna detection | Leave open if not used. |
| **13** | SEN_SCL | I/O | I2C clock for external IMU | Leave open if not used. |
| **14** | RESET_N | I | System reset | See section *1.19*. |
| **15** | RXD / SPI MOSI | I | Serial interface | See section *1.17.7*. |
| **16** | TXD / SPI MISO | O | Serial interface | See section *1.17.7*. |
| **17** | Reserved | I/O | Reserved | Do not connect. Must be left open! |
| **18** | GND | I | Ground | |
| **19** | VCC | I | Main supply | |
| **20** | VCC_IO | I | I/O Supply | |
| **21** | V_BCKP | I | Backup supply | |
| **22** | SQI_D0 | I/O | Data line 0 to external SQI flash memory or reserved configuration pin. | Leave open if not used. |
| **23** | SQI_CLK | I/O | Clock for external SQI flash memory or configuration pin. | Leave open if not used. |
| **24** | SQI_D2 | I/O | Data line 2 to external SQI flash memory or reserved configuration pin. | Leave open if not used. |
| **25** | SQI_D1 | I/O | Data line 1 to external SQI flash memory or reserved configuration pin. | Leave open if not used. |
| **26** | SQI_CS_N | I/O | Chip select for external SQI flash memory or configuration enable pin. | Leave open if not used. |
| **27** | SQI_D3 | I/O | Data line 3 to external SQI flash memory or reserved configuration pin. | Leave open if not used. |
| **28** | Reserved | I/O | Reserved | Do not connect. Must be left open! |
| **29** | SCL / SPI SCK | I | Serial interface | See section *1.17.7*. |
| **30** | SDA / SPI CS_N | I/O | Serial interface | See section *1.17.7*. |
| **31** | SEN_SDA | I/O | I2C data line for external IMU | Leave open if not used. |
| **32** | D_SEL | I | Interface selector | See section *1.17.7*. |
| **33** | SAFEBOOT_N / TIMEPULSE | I | Used for programming the SQI flash memory and testing purposes, or time pulse output. | Leave open if not used. |
| **34** | ANT_OK | I | Antenna status | Leave open if not used. |
| **35** | ANT_OFF | O | Antenna control | Leave open if not used. |
| **36** | Reserved | I/O | Reserved | Do not connect. Must be left open! |
| **37** | GND | I | Ground | Inner ground pins |
| **38** | GND | I | Ground | Inner ground pins |
| **39** | GND | I | Ground | Inner ground pins |
| **40** | GND | I | Ground | Inner ground pins |
| **41** | GND | I | Ground | Inner ground pins |
| **42** | GND | I | Ground | Inner ground pins |
| **43** | GND | I | Ground | Inner ground pins |

**Table 7: EVA-M8E pinout**

# 3 Electrical specification

The limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only, and operation of the device at these or at any other conditions above those given in the characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

Where application information is given, it is advisory only and does not form part of the specification. For more information regarding power management see the *EVA-M8E Hardware Integration Manual[1].*

## 3.1 Absolute maximum rating

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| VCC | Supply voltage | –0.5 | 3.6 | V |
| VCC_IO | Supply voltage I/O ring | –0.5 | 3.6 | V |
| VDD_USB | Supply voltage USB | –0.5 | 3.6 | V |
| V_BCKP | Supply voltage baseband backup core | –0.5 | 3.6 | V |
| $Vi_{RTC}$ | Input voltage on RTC_I | –0.5 | 1.6 | V |
| $Vi_{DIG}$ | Input voltage on Configurable Inputs , RESET_N | –0.5 | VCC_IO+0.5 | V |
| Prfin | RF Input power on RF_IN | | +15 | dBm |
| Ptot | Total power dissipation | | 500 | mW |
| Ts | Storage temperature | –40 | +105 | °C |

**Table 8: Absolute maximum ratings**

Stressing the device beyond the “Absolute Maximum Ratings” may cause permanent damage. These are stress ratings only. The product is not protected against overvoltage or reversed voltages. If necessary, voltage spikes exceeding the power supply voltage specification, given in table above, must be limited to values within the specified boundaries by using appropriate protection diodes.

## 3.2 Operating conditions

☞ The test conditions specified in Table 9 apply to all characteristics defined in this section.

| Symbol | Parameter | Min | Typical | Max | Unit | Remarks |
|---|---|---|---|---|---|---|
| Tamb | Ambient temperature | -40 | +25 | +85 | °C | |
| GND | Ground | | 0 | | V | |
| VCC | Core supply voltage | | 3.3 | | V | |
| V_BCKP | Backup battery supply voltage | | 3.3 | | V | |
| VCC_IO | Supply voltage I/O ring | | 3.3 | | V | |
| VDD_USB | Supply voltage USB | | 3.3 | | V | |
| NFtot | Receiver Chain Noise Figure | | 5.0 | | dB | |

**Table 9: Test conditions**

☞ All specifications are at an ambient temperature of 25°C. Extreme operating temperatures can significantly impact specification values. Applications operating near the temperature limits should be tested to ensure the specification.

### 3.2.1 DC electrical characteristic

☞ For Power Management Unit (PMU) block diagrams, see the *EVA-M8E Hardware Integration Manual [1]*.

| Symbol | Parameter | Min | Typical | Max | Unit |
|---|---|---|---|---|---|
| VCC_IO | Supply voltage for PIOs and input voltage for LDO_B and LDO_X | 2.7 | 3.3 | 3.6 | V |
| VDD_USB | Supply voltage USB | 3.0 | 3.3 | 3.6 | V |
| V_BCKP | Input voltage for LDO_B and LDO_X (backup mode) | 1.4 | | 3.6 | V |
| VCC | Input voltage | 2.7 | | 3.6 | V |

**Table 10: Power supply pins**

| Symbol | Parameter | Condition | Min | Typical | Max | Unit |
|---|---|---|---|---|---|---|
| Ileak | Leakage current input pins | | | < 1 | | nA |
| Vil | Low level input voltage | | 0 | | 0.2*VCC_IO | V |
| Vih | High level input voltage | | 0.7*VCC_IO | | VCC_IO+0.5 | V |
| Vol | Low level output voltage for TX/MISO, RX/MOSI , SDA/CS_N, SCL/SCK, D_SEL, TIMEPULSE, PIO13/EXTINT, PIO14/ANT_DET, ANT_OK, ANT_OFF | Iol = 4 mA | | | 0.4 | V |
| Voh | High level output voltage for TX/MISO, RX/MOSI , SDA/CS_N, SCL/SCK, D_SEL, TIMEPULSE, PIO13/EXTINT, PIO14/ANT_DET, ANT_OK, ANT_OFF | Ioh = 4 mA | VCC_IO-0.4 | | | V |
| Rpu | Pull-up resistor for SDA/CS_N, SCL/SCK, TIMEPULSE, PIO13/EXTINT, PIO14/ANT_DET, RESET_N | | | 11 | | kΩ |
| Rpu | Pull-up resistor for TX/MISO, RX/MOSI, D_SEL, ANT_OK, ANT_OFF | | | 115 | | kΩ |

**Table 11: Digital IO pins**

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Ileak | Leakage current input pins | | | | 1 | µA |
| Vil | Low level input voltage | VDD_USB >= 3.0 V | 0 | | 0.8 | V |
| Vih | High level input voltage | VDD_USB >= 3.0 V | 2.0 | | VDD_USB | V |
| Vol | Low level output voltage | $R_L$ = 1.425 kΩ to VDD_USB, VDD_USB >= 3.0 V, 22 Ω external series resistor | | | 0.3 | V |
| Voh | High level output voltage | $R_L$ = 14.25 kΩ to GND, VDD_USB >= 3.0, 22 Ω external series resistor | 2.8 | | | V |
| Rpui | Pull-up resistor, Idle State | | 870 | 900 | 950 | Ω |
| Rpuo | Pull-up resistor, Operational State | | 1400 | 1490 | 1600 | Ω |

**Table 12: USB pins**

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| RTC_CL | RTC integrated load capacitance | ESR = 80 kΩ | 4 | 7 | 12 | pF |
| DCDC_eff | DC/DC efficiency | 3.3 V @ input, 4 mA - 80 mA,<br>External components:<br>L = 2.2 uH, C = 4.7 pF | | 85 | | % |
| V_DCDC_out | DC/DC output voltage | DC/DC enabled, bypass inactive | | 1.4 | | V |

**Table 13: RTC pin**

## 3.3 Indicative power requirements

Table 14 lists examples of the total system supply current for a possible application.

For more information about power requirements, see the *EVA-M8E Hardware Integration Manual* [1].

| Parameter | Symbol | Typ<br>GPS & GLONASS | Typ<br>GPS / QZSS / SBAS | Max | Units | Condition |
|---|---|---|---|---|---|---|
| Max. supply current [12] | Iccp | | | 67 | mA | |
| Average supply current [13, 14] | Icc | 29 | 23 | | mA | Estimated at 3 V |
| Backup battery current [15] | I_BCKP<br>using the RTC crystal | 15 | | | µA | HW Backup mode, VCC_IO = VCC = 0 V |
| SW Backup current | I_SWBCKP<br>using the RTC crystal | 20 | | | µA | SW Backup mode, VCC_IO = VCC = 3 V |

**Table 14: Indicative power requirements at 3.0 V**

☞ The values in Table 14 are provided for customer information only as an example of typical current requirements. The values are characterized on samples; actual power requirements can vary depending on FW version used, external circuitry, number of SVs tracked, signal strength, type of start as well as time, duration and conditions of test.

☞ All values in Table 14 are measured at 25°C ambient temperature.

[12] Use this figure to determine maximum current capability of power supply. Measurement of this parameter with 1 Hz bandwidth.

[13] Acquisition and tracking use this figure to determine required battery capacity.

[14] Simulated GNSS constellation using power levels of -130 dBm. VCC = 3.0 V

[15] Use this figure to determine required battery capacity.

## 3.4 SPI timing diagrams

In order to avoid incorrect operation of the SPI, the user needs to comply with certain timing conditions. The following signals need to be considered for timing constraints:

| Symbol | Description |
|---|---|
| **SPI CS_N (SS_N)** | Slave select signal |
| **SPI CLK (SCK)** | Slave clock signal |

**Table 15: Symbol description**

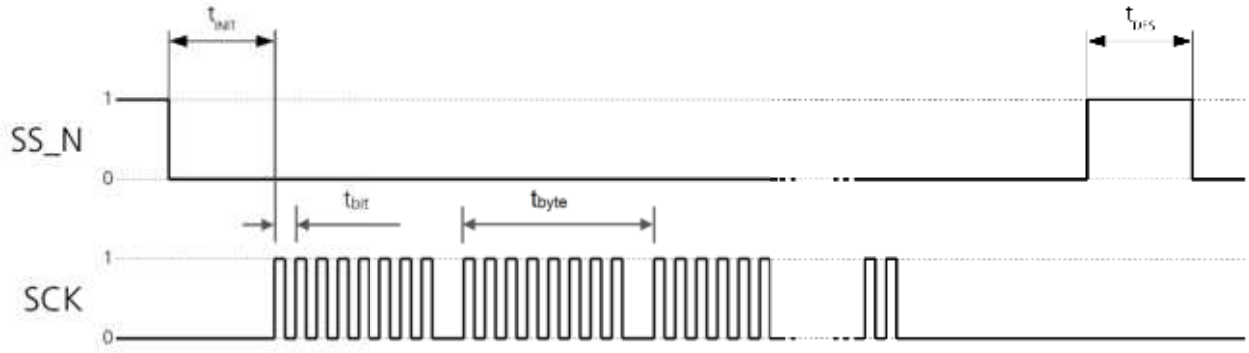



**Figure 3: SPI timing diagram**

### 3.4.1 Timing recommendations

The recommendations below are based on a firmware running from SQI flash memory.

| Parameter | Description | Recommendation |
|---|---|---|
| $t_{INIT}$ | Initialization Time | 10 µs |
| $t_{DES}$ | Deselect Time | 1 ms. |
| $t_{bit}$ | Minimum bit time | 180 ns (5.5 MHz max bit frequency) |
| $t_{byte}$ | Minimum byte period | 8 µs (125 kHz max byte frequency) |

**Table 16: SPI timing recommendations**

☞ The values in the above table result from the requirement of an error-free transmission. By allowing just a few errors and disabling the glitch filter, the bit rate can be increased considerably.

# 4 Mechanical specification

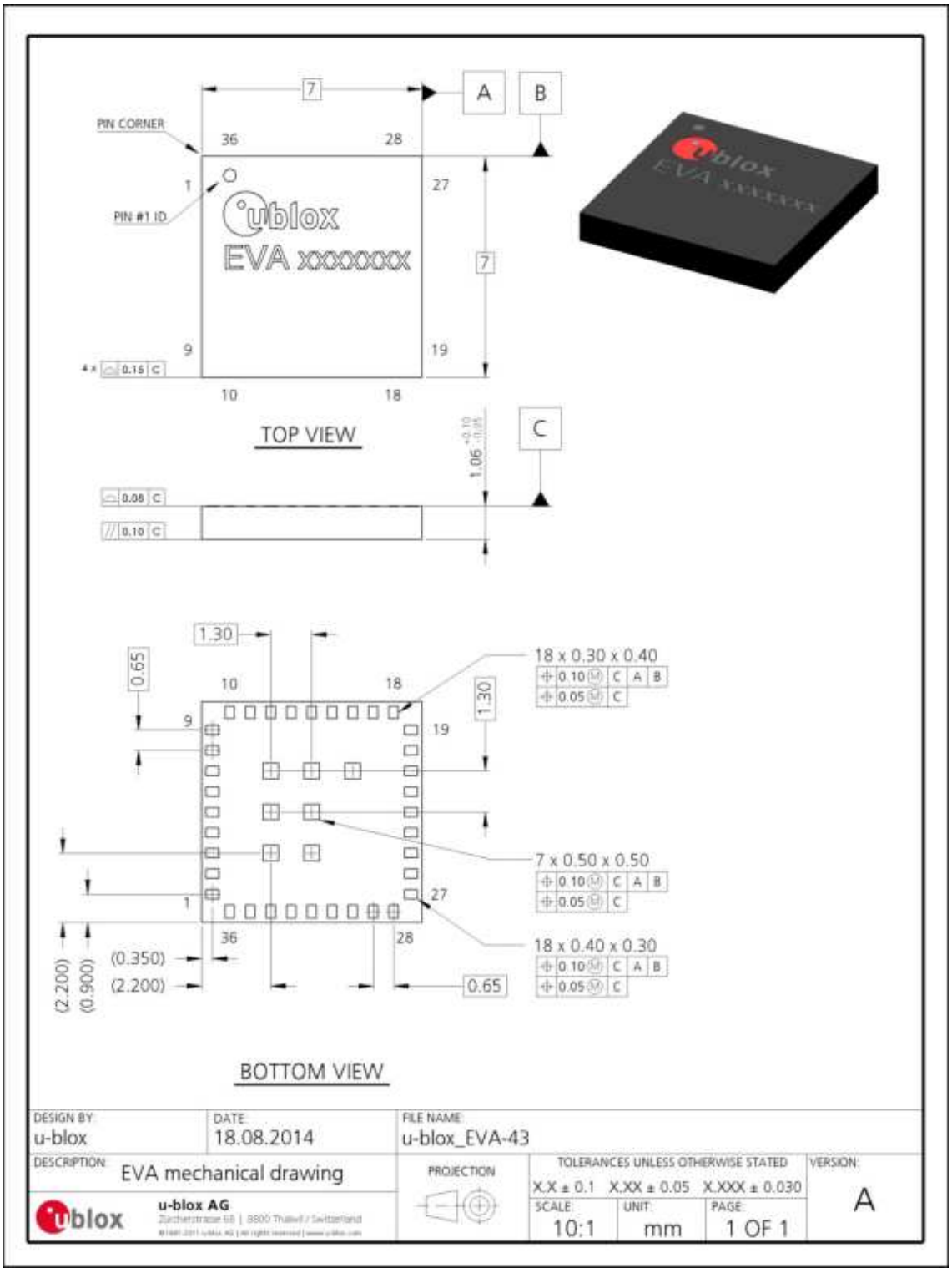



**Figure 4: Mechanical drawing for EVA-M8E (LGA43)**

# 5 Reliability tests and approvals

## 5.1 Reliability tests

Qualification requirements are according to JEDEC standards JESD47 "*Stress-Test-Driven Qualification of Integrated Circuits*".

## 5.2 Approvals




Products marked with this lead-free symbol on the product label comply with the "Directive 2002/95/EC and Directive 2011/65/EU of the European Parliament and the Council on the Restriction of Use of certain Hazardous Substances in Electrical and Electronic Equipment" (RoHS).

EVA-M8E modules are RoHS compliant and green (no halogens).

# 6 Product handling

## 6.1 Packaging

EVA-M8E module is delivered as hermetically sealed, reeled tapes in order to enable efficient production, production lot set-up and tear-down. For more information about packaging, see the *u-blox Package Information Guide* [1].

### 6.1.1 Reels

EVA-M8E module is deliverable in quantities of 500 pcs on a reel. The EVA-M8E module is shipped on Reel Type D, as described in the *u-blox Package Information Guide* [1].

### 6.1.2 Tapes

Figure 5 shows the feed direction and the orientation of the EVA-M8E positioning module on the tape. The positioning modules are placed such that the pin 1 is at the upper right for the LGA43. The dimensions of the tapes are specified in Figure 6.

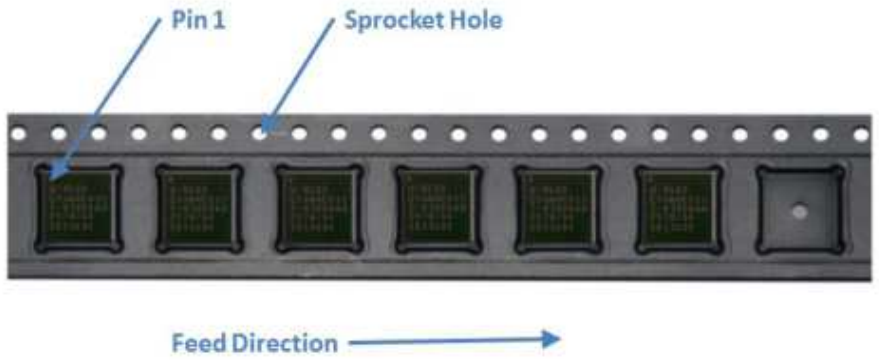



**Figure 5: Orientation of EVA-M8E modules on the tape**

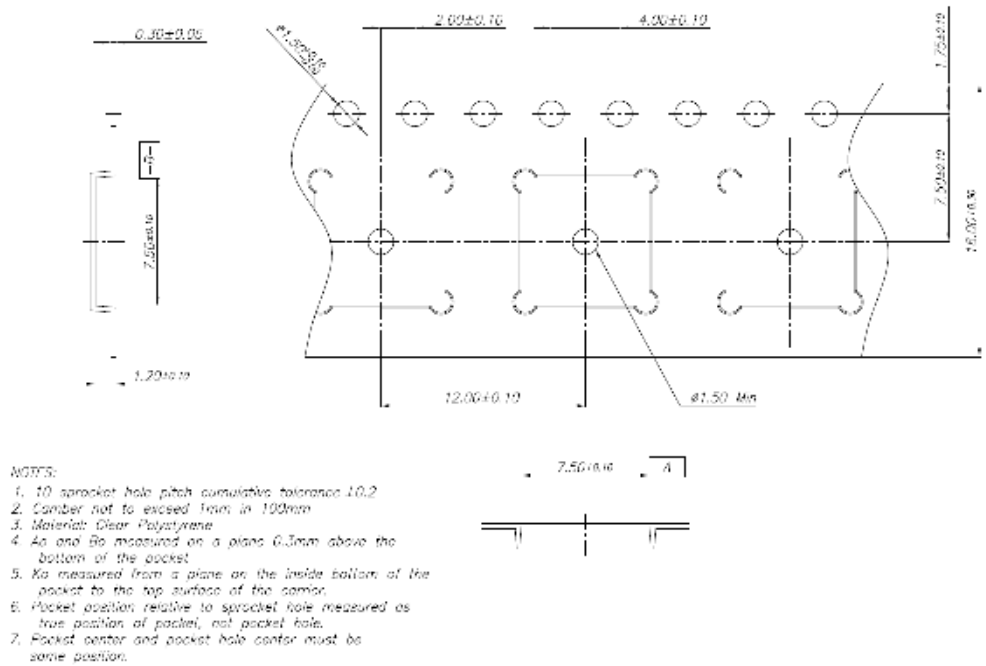



**Figure 6: EVA-M8E tape dimensions**

## 6.2 Shipment, storage and handling

For important information regarding shipment, storage and handling see the *u-blox Package Information Guide[3]*. The absolute maximum rating of the storage temperature specified in section 3.1 apply to the storage of the module both before and after soldering. Required storage conditions for modules in reeled tapes and for naked modules before soldering are described in the *u-blox Package Information Guide [3]*.

### 6.2.1 Moisture Sensitivity Levels

The Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions required. EVA-M8E[16] module is rated at MSL level 3.

☞ For MSL standard see IPC/JEDEC J-STD-020, which can be downloaded from www.jedec.org.

☞ For more information regarding MSL see the *u-blox Package Information Guide* [3].

### 6.2.2 ESD handling precautions

⚠ EVA-M8E positioning module contains highly sensitive electronic circuitry and is Electrostatic Sensitive Devices (ESD). Observe precautions for handling! Failure to observe these precautions can result in severe damage to the GNSS receiver!

GNSS receivers are Electrostatic Sensitive Devices (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, 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 ~10pF, 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).












[16] only two reflow soldering processes are done in MSL qualification due to internal component limitation.

# 7 Default messages

| Interface | Settings |
|---|---|
| UART Output | 9600 Baud, 8 bits, no parity bit, 1 stop bit<br>Configured to transmit both NMEA and UBX protocols, but only the following NMEA (no UBX) messages have been activated at start-up:<br>**GGA, GLL, GSA, GSV, RMC, VTG, TXT** |
| USB Output | Configured to transmit both NMEA and UBX protocols, but only the following NMEA (no UBX) messages have been activated at start-up:<br>**GGA, GLL, GSA, GSV, RMC, VTG, TXT**<br>USB Power Mode: Bus Powered |
| UART Input | 9600 Baud, 8 bits, no parity bit, 1 stop bit, Autobauding disabled<br>Automatically accepts following protocols without need of explicit configuration:<br>UBX, NMEA, RTCM<br>The GNSS receiver supports interleaved UBX and NMEA messages. |
| USB Input | Automatically accepts following protocols without need of explicit configuration:<br>UBX, NMEA, RTCM<br>The GNSS receiver supports interleaved UBX and NMEA messages.<br>USB Power Mode: Bus Powered |
| DDC | Fully compatible with the I²C industry standard, available for communication with an external host CPU or u-blox cellular modules, operated in slave mode only. Default messages activated.<br>NMEA and UBX are enabled as input messages, only NMEA as output messages.<br>Maximum bit rate 400 kb/s. |
| SPI | Allow communication to a host CPU, operated in slave mode only. Default messages activated. SPI is not available in the default configuration. |

**Table 17: Default messages**

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

# 8 Labeling and ordering information

## 8.1 Product labeling

The labeling of u-blox M8 GNSS modules includes important product information. The location of the EVA-M8E product type number is shown in Figure 7.




**Pin 1 Marking**

**U-BLOX**
**EVAM8E011** = Product identification
EVAM8E010 stands for product type number: EVA-M8E-0-11
**T-Rff00SS** = Revision
**LLLLLLL** = Lot number
**YYWWZZX** = Production date code

**Figure 7: Description of EVA-M8E product label**

## 8.2 Explanation of product codes

Three different product code formats are used. The **Product Name** is used in documentation such as this data sheet and identifies all u-blox M8 products, independent of packaging and quality grade. The **Ordering Code** includes packaging and quality, while the **Type Number** includes the hardware and firmware versions. Table 18 below details these three different formats:

| Format | Structure |
|---|---|
| **Product Name** | PPP-TGV-N |
| **Ordering Code** | PPP-TGV-N |
| **Type Number** | PPP-TGV-N-XX |

**Table 18: Product code formats**

The parts of the product code are explained in Table 19.

| Code | Meaning | Example |
|---|---|---|
| PPP | Product Family | EVA |
| TG | Technology & Generation | M8 = u-blox M8 |
| V | Variant | Function set (A-Z) |
| N | Option/ Quality Grade | Describes standardized functional element or quality grade<br>0 = Default variant |
| XX | Product Detail | Describes product details or options such as hardware and software revision, cable length, etc. |

**Table 19: Part identification code**

## 8.3 Ordering codes

| Ordering No. | Product |
|---|---|
| EVA-M8E-0 | u-blox M8 GNSS Module, Untethered Dead Reckoning, LGA43, 7x7 mm, 500 pcs/reel |

**Table 20: Product ordering codes for professional grade positioning modules**

☞ Product changes affecting form, fit or function are documented by u-blox. For a list of Product Change Notifications (PCNs) see our website at: http://www.u-blox.com/en/notifications.html.

# Related documents

[1] EVA-M8E Hardware Integration Manual, Docu. No. UBX-15028542
[2] u-blox 8 / u-blox M8 Receiver Description Including Protocol Specification (Public version), Docu. No. UBX 13003221
[3] u-blox Package Information Guide, Docu. No. UBX-14001652
[4] RTCM 10402.3 Recommended Standards for Differential GNSS, Ver. 2.3, RTCM AUG. 20, 2001
[5] Radio Resource LCS Protocol (RRLP), (3GPP TS 44.031 version 11.0.0 Release 11)

☞ 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 | 06-Jue-2016 | yzha | Advance Information |
| R02 | 19-Oct-2016 | njaf | Changed product type number to EVA-M8E-0-11 (TCXO based), TCXO-based design update. |
| R03 | 19-Jan-2017 | njaf | Early Production Information, added storage temperature related statement in section 6.2 |
| R04 | 30-Jan-2019 | pmcm | Updated for UDR 1.21 |
| R05 | 28-Jun-2019 | pmcm | Status changed to Production Information |

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