POSITIONING

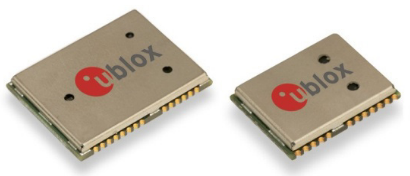
NEO/LEA-M8T

u-blox M8 concurrent GNSS timing modules

Data Sheet

Highlights:

- Concurrent reception of GPS/QZSS, GLONASS, BeiDou
- Market leading acquisition and tracking sensitivity
- Optimized accuracy and availability with Survey-in and single-satellite timing
- Minimized power consumption with low duty-cycle operation
- Maximized reliability with Integrity monitoring and alarms
- Multi-GNSS Raw data, IMES Message data
- Backward compatible with LEA-5T, LEA-6T and NEO-6T



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Document Information		
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Objective Specification	Document contains target values. Revised and supplementary data will be published later.
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Production Information	Document contains the final product specification.

This document applies to the following products:

Product name	Type number	ROM/FLASH version	PCN reference
NEO-M8T	NEO-M8T-0-00	ROM 2.01 / Flash FW 2.30 TIM RAW 1.01	N/A
LEA-M8T	LEA-M8T-0-00	ROM 2.01 / Flash FW 2.30 TIM RAW 1.01	N/A

Contents

1 Functional description

1.1 Overview

The NEO-M8T and LEA-M8T standalone concurrent GNSS modules are built on the exceptional performance of the u-blox M8 GNSS (GPS, GLONASS, BeiDou, QZSS, SBAS and Galileo-ready[1]) engine in the industry proven NEO and LEA form factors.

The u-blox M8 series of modules offers high sensitivity and rapid acquisition in applications requiring low system power. The NEO-M8T and LEA-M8T modules meet the requirements for GNSS timing applications (including fixed location, survey-in and RAIM). The modules deliver multi-GNSS, raw measurement data (code and carrier phase, Doppler) and multi-GNSS, QZSS L1S and IMES message data. Both modules offer easy design migration from previous generations adding BeiDou and concurrent multi-GNSS capability to existing products.

Sophisticated RF-architecture and interference suppression ensure maximum performance even in GNSS-hostile environments. The LEA-M8T includes a SAW filter and antenna power supervision and is perfect for use with active antennas or antenna signal distribution systems. The NEO-M8T includes an additional LNA, improving performance when connected directly to a passive antenna, and support for external antenna supply management if required. Both modules include Flash memory for field upgrade if required. UART, SPI and DDC (I^2C compatible) interfaces provide connectivity and enable synergies with most u-blox cellular modules.

u-blox M8 modules use GNSS chips qualified according to AEC-Q100, are manufactured in ISO/TS 16949 certified sites, and fully tested on a system level. Qualification tests are performed as stipulated in the ISO16750 standard: "Road vehicles – Environmental conditions and testing for electrical and electronic equipment".

u-blox' AssistNow Assistance services supply aiding information, such as ephemeris, almanac and time, reducing the time to first fix significantly and improving acquisition sensitivity. The u-blox M8 generation extends validities of AssistNow Offline data (up to 35 days) and AssistNow Autonomous data (up to 6 days), providing the benefits of faster acquisition for longer durations since last use.

☞ See section 1.6 for more information on AssistNow Assistance.

1.2 Product features

Model	Type								Supply			Interfaces				Features												
	GPS / QZSS	GLONASS	Galileo	BeiDou	Timing	Dead Reckoning	Precise Point Positioning	Raw Data	1.65 V – 3.6 V	2.7 V – 3.6 V	Lowest power (DC/DC)	UART	USB	SPI	DDC (I^2C compliant)	Programmable (Flash)	Data logging	Additional SAW	Additional LNA	RTC crystal	Internal oscillator	Active antenna / LNA supply	Active antenna / LNA control	Antenna short circuit detection / protection pin	Antenna open circuit detection pin	Timepulse output	Frequency output	External interrupt / Wakeup
NEO-M8T	•	•	R	•	•			•		•	•	•	•	Sel	•	•	•	•	•	•	T	o	o			•		•
LEA-M8T	•	•	R	•	•			•		•	•	•	•	Sel	•	•	•	•		•	T	•	•	•	o	•		•

o = Optional, not activated per default or requires external components
Sel = Select for either SPI or UART/DDC by HW configuration pin (D_SEL)
R = Galileo supported in future firmware version
C = Crystal / T = TCXO

[1] With future flash firmware update

1.3 Performance

Parameter	Specification			
Receiver type	72-channel u-blox M8 engine GPS L1C/A, QZSS L1C/A, SBAS L1C/A, GLONASS L1OF BeiDou B1 Galileo E1B/C[2]			
GNSS		**GPS & GLONASS**	**GPS & BeiDou**	**GPS**
Time-To-First-Fix[3]	Cold start	26 s	27 s	29 s
	Aided cold start[4]	2 s	3[5]	2 s
	Hot start	1.5 s	1.5 s	1.5 s
Sensitivity[6]	Tracking & Navigation	-167 dBm	-165 dBm	-166 dBm
	Aided acquisition[7]	-157 dBm	N/A[8]	--157 dBm
	Reacquisition	-160 dBm	-160 dBm	-160 dBm
	Cold start	-148 dBm	-148 dBm	-148 dBm
	Hot start	-156 dBm	-156 dBm	-156 dBm
Horizontal position accuracy[9]	Autonomous	2.5 m	2.5 m	2.5 m
	SBAS	2.0 m	2.0 m	2.0 m
Velocity accuracy[10]		0.05 m/s	0.05 m/s	0.05 m/s
Heading accuracy[10]		0.3 degrees	0.3 degrees	0.3 degrees
Max navigation update rate		5 Hz	5 Hz	10 Hz
Time pulse frequency		0.25 Hz…10 MHz		
Time pulse accuracy	Clear sky	≤ 20 ns		
	Indoor	≤ 500 ns		
Operational limits[11]	Dynamics	≤ 4 g		
	Altitude	50,000 m		
	Velocity	500 m/s		

Table 1: NEO/LEA-M8T performance in different GNSS modes (default: concurrent reception of GPS and GLONASS)

[2] Ready to support Galileo E1B/C when available via a flash firmware update
[3] All satellites at -130 dBm
[4] Dependent on aiding data connection speed and latency, time quoted is for fastest constellation
[5] BeiDou and Galileo assisted acquisitions are not available in this release
[6] Demonstrated with a good external LNA
[7] Time: 1s, Position: 1km, Almanac, Ephemeris
[8] GPS signals are acquired at -157 dBm, BeiDou and Galileo assisted acquisitions are not available in this release
[9] CEP, 50%, 24 hours static, -130 dBm, > 6 SVs
[10] 50% @ 30 m/s
[11] Assuming Airborne < 4 g platform

1.4 Block diagram

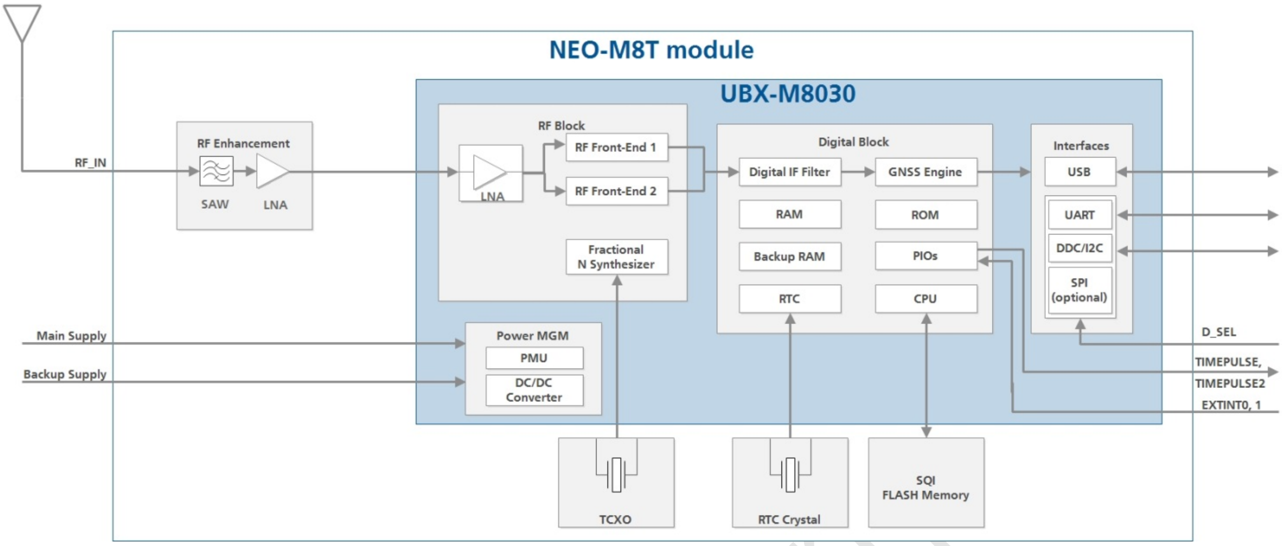


Figure 1: NEO-M8T block diagram

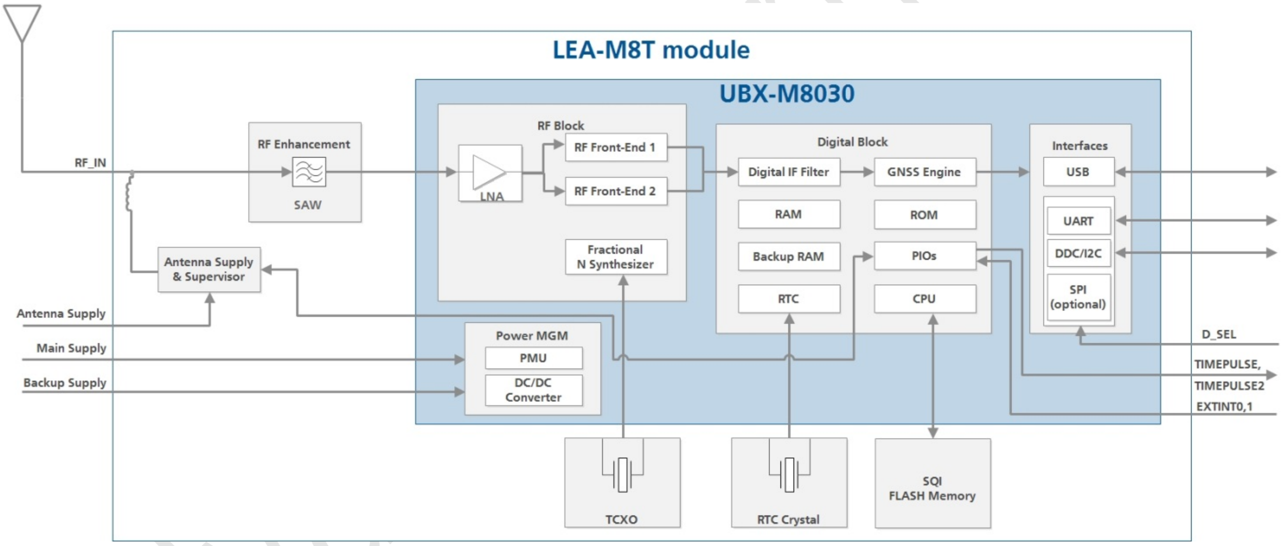


Figure 2: LEA-M8T block diagram

1.5 GNSS

The NEO-M8T and LEA-M8T modules are concurrent GNSS receivers and can receive and track multiple GNSS systems (e.g. GPS/QZSS, GLONASS, and BeiDou signals). Because of the dual-frequency RF front-end architecture, two of the three signals (GPS L1C/A, GLONASS L1OF, and BeiDou B1) can be received and processed concurrently. By default, NEO-M8T and LEA-M8T modules are configured with GPS/QZSS and GLONASS enabled. The NEO/LEA-M8T timing receivers can also be configured to use a single GNSS for the best possible consistency in clear-sky conditions.

☞ QZSS, SBAS and Galileo share the same frequency band as GPS and can be processed in conjunction with GPS (Galileo support is subject to a firmware upgrade).

1.5.1 GPS

The NEO/LEA-M8T receivers are designed to receive and track the L1C/A signals provided at 1575.42 MHz by the Global Positioning System.

☞ GPS can be received and processed concurrently with GLONASS or BeiDou.

1.5.2 GLONASS

The NEO/LEA-M8T receivers are designed to receive and track the L1OF signals provided at 1602 MHz + k*562.5 kHz by GLONASS, where k is the satellite's frequency channel number (k = –7, –6,...5, 6).

☞ GLONASS can be received and processed concurrently with GPS or BeiDou.

1.5.3 BeiDou

The NEO/LEA-M8T receivers are 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 improved performance within the coverage area. Global coverage is scheduled for 2020.

☞ BeiDou can be received and processed concurrently with GPS or GLONASS (BeiDou reception is disabled in the default configuration).

To take advantage of GPS, GLONASS and BeiDou frequencies, dedicated RF hardware preparation must be made during the design-in phase. See the respective *Hardware Integration Manual* [1] or [2] for u-blox design recommendations.

1.5.4 Galileo

A firmware upgrade would be required for the NEO/LEA-M8T receivers to use Galileo signals. The module hardware is ready to receive and track GPS and Galileo E1B/C signals concurrently.

1.5.5 QZSS

The Quasi-Zenith Satellite System (QZSS) is a regional navigation satellite system that transmits additional GPS L1C/A signals from high-elevation satellites over the Pacific region between Japan and Australia. NEO/LEA-M8T receivers are able to receive and track these signals concurrently with GPS resulting in better availability especially where sky-view is limited e.g. in urban canyons.

☞ L1-SAIF messages provided by QZSS are delivered as Raw data but not used in the receiver's navigation solution.

1.6 Assisted GNSS (A-GNSS)

Supply of aiding information, such as ephemeris, almanac, approximate position and time, will reduce the time to first fix significantly and improve the acquisition sensitivity. All u-blox M8 products support the u-blox AssistNow Online and AssistNow Offline A-GNSS services, support AssistNow Autonomous, and are OMA SUPL compliant.

1.6.1 AssistNow™ Online

With AssistNow Online, an internet-connected GNSS device downloads assistance data from u-blox' 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. AssistNow Online can improve initial acquisition sensitivity to -157 dBm for NEO/LEA-M8T.

1.6.2 AssistNow™ Offline

With AssistNow Offline, users download u-blox' long-term orbit data from the Internet at their convenience. The orbit data can be stored in the GNSS receiver's SQI flash memory or the memory of the application processor.

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 aiding information without the need for a host or external network connection. Based on previous broadcast satellite ephemeris data 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' 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.

☞ For more details see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.7 Augmentation systems

1.7.1 Satellite-Based Augmentation System (SBAS)

The NEO/LEA-M8T timing receivers optionally support SBAS (including WAAS in the US, EGNOS in Europe, MSAS in Japan and planned networks elsewhere) to deliver improved location accuracy within the regions covered. However, the additional inter-standard time calibration step used during SBAS reception results in degraded time accuracy overall.

☞ SBAS reception is disabled by default in NEO/LEA-M8T.

1.7.2 Differential GPS (D-GPS)

The NEO/LEA-M8T receivers support Differential-GPS data according 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 2: Supported RTCM 2.3 messages

☞ For more details see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.8 Odometer

The odometer provides information on travelled ground distance (in meter) using solely the position and Doppler-based velocity of the 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 details see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.9 Data logging

The u-blox NEO/LEA-M8T receivers 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 from 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 M8 Receiver Description Including Protocol Specification* [3].

1.10 EXTINT: External interrupt

The NEO/LEA-M8T receivers feature two EXTINT pins, each of which can be used to switch the receiver on and off or for aiding.

For more information about how to implement and configure these features, see the *u-blox M8 Receiver Description including Protocol Specification* [3] and the *Hardware Integration Manual* [1] or [2].

1.10.1 Power control

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

The receiver can also be forced OFF using EXTINT when Power Save Mode is not active.

1.10.2 Aiding

An EXTINT pin can be used to supply time or frequency aiding data to the receiver.

For time aiding, hardware time synchronization can be achieved by connecting an accurate time pulse to the EXTINT pin.

Frequency aiding can be implemented by connecting a periodic rectangular signal with a frequency up to 500 kHz and arbitrary duty cycle (low/high phase duration must not be shorter than 50 ns) to an EXTINT pin. The applied frequency value is provided to the receiver using UBX messages.

☞ For more information see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.11 Precision timing, raw data and low duty-cycle operation

1.11.1 Time mode

NEO/LEA-M8T support:

- a special fixed-position mode improving timing stability in stationary applications
- optional single-SV time tracking for difficult RF environments (available in fixed-position mode only)
- Receiver Autonomous Integrity Monitoring (RAIM) indication for timing
- dual configurable 0.25 Hz to 10 MHz time-pulse outputs

Improved timing performance can be delivered by using the fixed-position mode in stationary applications. In this mode, positioning uncertainties are eliminated from calculation of time which reduces the error and variation in the phase of the TIMEPULSE signal outputs. The known position also reduces the minimum number of measurements and hence good satellite signals required to enable Receiver Autonomous Integrity Monitoring (RAIM), reported in message UBX-TIM-TP.

Operation with as few as one single satellite signal is supported in this mode, enabling continuity of timing in situations with extremely limited sky view. The minimum number of signals required may be increased using message UBX-CFG-NAV5.

Fixed-position mode is configured with the message CFG-TMODE2 according to Table 3 below either by initiating a survey-in process (which can take some time to complete accurately) or by entering the position of the antenna if known. In NEO/LEA-M8T modules, the survey-in process may be performed during discontinuous (low duty-cycle) operation if necessary. In this case the receiver should be allowed to make several fixes during each cycle to avoid excessive degradation of the survey-in accuracy.

Time Mode Settings	Description
Disabled	Standard PVT operation
Survey-In	The receiver computes the average position over an extended time period until a predefined standard deviation has been reached and the minimum observation time has passed by. Afterwards the receiver will be automatically set to Fixed Mode and the timing features will be activated. Progress during survey in can be monitored using the TIM-SVIN message.
Fixed Mode	Fixed Mode is initiated automatically at the completion of a survey-in process or when the receiver is configured with its 3D position (and standard deviation of uncertainty). Fixed position coordinates can be entered in ECEF (Earth Center Earth Fixed format) or as latitude, longitude and height.

Table 3: Time mode settings

The u-blox M8 multi-GNSS receiver employed in the NEO/LEA-M8T timing receivers can use one of three variants of Universal Coordinated Time (UTC) as the basis for its conversion from native GNSS time to UTC. The selection is explicitly specified in message CFG-NAV5. This is significant when the time-pulse output has been configured (CFG-TP5) to be aligned with UTC rather than a GNSS time. In this case, a version of UTC should be selected in CFG-NAV5 of which the receiver has knowledge (from aiding messages or from the GNSS signals themselves). Other selections may result in relatively large timing uncertainties until the offset between GNSS time and the selected UTC becomes available (from satellite signals or aiding messages).

☞ For more information see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.11.2 Timepulse and frequency outputs

The NEO/LEA-M8Tmodules provide two time pulse outputs that can be configured in rate from 0.25 Hz up to 10 MHz by message CFG-TP5. Time pulse alignment can be configured to UTC or GNSS time according to the standard used in signals being received or to an alternate standard where inter-standard calibration data is available (from the signals themselves or by aiding). The time pulses are generated on edges of an asynchronous clock; for pulse rates below 2 Hz, the exact phase of the TIMEPULSE output is reported before each pulse in the TIM-TP message.

☞ Times reported in navigation messages such as NAV-PVT report the time of the preceding pulse.

1.11.3 Time mark

The NEO/LEA-M8T modules can be used for precise time measurements with sub-microsecond resolution using the external interrupt pins (EXTINT0 and EXTINT1). Rising and falling edges of these signals are time-stamped to GNSS or UTC time, counted and the results reported in message TIM-TM2. The reference time is the same as set for TIMEPULSE with CFG-TP5. The Time Mark functionality can be enabled with the CFG-TM2 message

☞ For more information see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.11.4 Timing integrity and availability

The NEO/LEA-M8T modules include the following measures to support applications requiring excellent timing integrity:

- Time uncertainty estimation
  The receiver estimates the uncertainty of the time-pulse and time report. The time and uncertainties are reported together for each standards-specific time-base in messages NAV-TIMEBDS (BeiDou), NAV-TIMEGLO (GLONASS), NAV-TIMEGPS (GPS) and NAV-TIMEUTC (for the UTC standard selected in CFG-NAV5). Under poor signal conditions the estimate of uncertainty may include unresolved ambiguities; for example for GPS these might be Epoch (millisecond), Bit (20ms) and Sub-frame (6s). Where the output time-base standard is derived from a different constellation (e.g. GPS-time from GLONASS), the estimate of uncertainty includes inter-constellation offset uncertainties. The estimate of uncertainty is used to disable or modify the time-pulse output by comparison with the 'tAcc' parameter (after conversion to distance) configured in message CFG-NAV5.
- Multi-GNSS signal reception
  Particularly where sky-view is limited, the timing accuracy is improved by combining measurements from two constellations. Inter-GNSS timing offsets are derived locally by the receiver whenever a timing fix can be achieved independently from each constellation (locally derived offsets automatically account for antenna, filter and cable dispersion). These offsets are then used for subsequent combined fixes. Where inter-GNSS offsets cannot be derived locally, offsets broadcast by the constellation satellites are used where available.
- Fix redundancy (RAIM)
  The receiver automatically and continually adjusts the significance of individual signal measurements in the reported estimate of time according to its quality and consistency. This ensures that the integrity of the reported time is protected from individual faulty signals or measurements so long as there are more signals in use than the minimum required. The minimum number changes depending on the situation but whenever it is exceeded the 'raim' flag is set in message TIM-TP to indicate that this protection is active.
- Aiding
  While a GNSS receiver may be able to achieve a vernier (sub-microsecond) time-fix even under poor signal conditions it may be slow or unable to resolve higher order ambiguities (especially whole milliseconds for GPS). Sub-millisecond time aiding may be applied to u-blox NEO/LEA-M8T modules by means of a pulse to one of the EXTINT pins in conjunction with a MGA-INI-TIME message, enabling immediate resolution of ambiguities as well as accelerating time to fix.

1.11.5 Indoor messaging system (IMES)

The NEO/LEA-M8T modules are equipped to receive messages from indoor messaging system beacons licensed for use in Japan. The receivers track beacon signals within range (up to the number of receiver channels allocated to tracking IMES signals) and report their message data pay-load in RXM-SFRBX messages. IMES reception and the number of beacons tracked are configured by the CFG-GNSS message. The receivers support 50 bps and 250 bps signals automatically.

1.11.6 Raw data

The NEO/LEA-M8T modules provide raw measurement data for civil L1 band GPS, GLONASS and BeiDou signals including pseudo-range and carrier phase, Doppler and message payloads. The data contained in the RXM-RAWX message follows the conventions of a multi-GNSS RINEX 3 observation file and includes pseudo-range, carrier phase and Doppler measurements along with measurement quality data. The RXM-SFRBX message provides the demodulated, parity-checked navigation and signaling message bits for each satellite currently tracked by the receiver including GPS, GLONASS and BeiDou constellations, SBAS satellites, the QZSS L1S signal and IMES beacons.

Raw measurement data are available once the receiver has established data bit synchronization and time-of-week. Message data are available for all signals tracked at a sufficient level to achieve data bit and frame synchronization. For more information see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.11.7 Low duty cycle operation

The NEO/LEA-M8T low power timing modules support energy-saving automatic low duty-cycle operation in conjunction with their precision timing features. Currently this support is available for GPS signals only. Low duty-cycle operation is enabled with the 'Power Save Mode' setting in message CFG-RXM and 'on/off' mode in message CFG-PM2. Through a set of period and time-out parameters defined in the CFG-PM2 message the receiver can be configured to deliver a new time fix at intervals with a limit on total energy consumed for searches if no fix can be achieved. The duty-cycle of operation may be reduced significantly by:

- provision of sub-millisecond time-aiding to accelerate ambiguity resolution (see 1.11.4 above),
- provision of ephemeris aiding (message MGA-GPS-EPH) to avoid the need to receive new data transmissions from the satellites themselves.

Survey-in is supported in conjunction with low duty cycle operation providing the accuracy benefits of a long observation interval without the need to keep the receiver continuously powered. To achieve the best sensitivity on first deployment at a new site, the receiver should be allowed to operate continuously until the first fix is achieved (up to 20 minutes in very poor signal conditions) before engaging low duty cycle operation.

For more information see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.12 TIMEPULSE

Two configurable time pulse signals (TIMEPULSE, TIMPULSE2) are available with u-blox NEO/LEA-M8T timing modules.

The TIMEPULSE outputs generate pulse trains synchronized with GNSS 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 TIMEPULSE2 pin should not be held LO during start-up.

By default the primary time pulse signal is enabled and configured to 1 pulse per second. For more information see the *u-blox M8 Receiver Description including Protocol Specification* [3].

1.13 Protocols and interfaces

Protocol	Type
NMEA 0183, version 4.0 (V2.3 or V4.1 configurable)	Input/output, ASCII, 0183, version 4.0
UBX	Input/output, binary, u-blox proprietary
RTCM	Input message, 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 M8 Receiver Description Including Protocol Specification* [3].

1.14 Interfaces

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

1.14.1 UART

The NEO/LEA-M8T modules include one UART interface, which can be used for communication to a host. It supports configurable baud rates. For supported baud rates see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

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

1.14.2 USB

A USB version 2.0 FS compatible interface 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.

u-blox USB (CDC-ACM) driver supports Windows Vista and Windows 7 and Windows 8 operating systems.

1.14.3 SPI

The SPI interface is designed to allow communication with a host CPU. The interface can be operated in slave mode only. The maximum sustained transfer rate using SPI is 1 Mbit/s (the interface hardware supports clock rates up to 5.5 MHz).

☞ SPI is not enabled in the default configuration because its pins are shared with the UART and DDC interfaces. The SPI interface can be enabled by connecting DSEL to ground (details see the *Hardware Integration Manual* [1] or [2]); in this case the DDC and UART interfaces for data communication are no longer available.

1.14.4 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.

1.15 Clock generation

1.15.1 Oscillators

NEO/LEA-M8TGNSS timing modules incorporate TCXOs for accelerated weak signal acquisition and stable timing output. These TCXOs are carefully selected and screened for stability and against frequency perturbations across the full operating range (–40° to +85°C).

1.15.2 Real-Time Clock (RTC) and Hardware Backup mode

The RTC can be maintained by a secondary 32 kHz oscillator using an RTC crystal. If the main supply voltage is removed, a battery connected to V_BCKP allows the RTC to continue to run with very low power consumption. The same supply also maintains a static back-up memory for current configuration information, recent ephemeris, location and auxiliary data necessary to ensure the fastest re-acquisition when the primary power supply is restored.

1.16 Power management

u-blox NEO/LEA-M8T technology offers a power-optimized architecture with built-in autonomous power saving functions to minimize power consumption at any given time. Furthermore, the receivers can be used in three operating modes: Continuous mode for best performance or one of two Power Save Modes for optimized power consumption. A high efficiency DC/DC converter is integrated to minimize power consumption and dissipation across the range of supported power supply voltages.

1.16.1 Operating modes

NEO/LEA-M8Tmodules have two operating modes:

- Continuous Mode for best GNSS performance
- On/off duty-cycle Mode to reduce energy-use in discontinuous operation

☞ Timing and raw data features are not fully supported in Cyclic Power Save Mode. There is limited support for GLONASS and BeiDou signals in On/off duty-cycle mode, notably in efficient reception and use of ephemeris data.

1.16.1.1 Continuous Mode

Continuous Mode uses the acquisition engine at full performance resulting in the shortest possible TTFF and the highest sensitivity. It searches for all possible satellites until the Almanac is completely downloaded. The receiver then switches to the tracking engine to lower power consumption.

Thus, a lower tracking current consumption level will be achieved when:

- A valid GNSS position is obtained
- The entire Almanac has been downloaded
- The Ephemeris for each satellite in view is valid

1.16.1.2 On/off duty-cycle Power Save Mode

Where an application requires only intermittent navigation or timing information an On/off low duty-cycle power save mode can be employed. In this mode the receiver starts at intervals configurable between a few seconds and several hours. Alternatively the receiver can be re-started on demand by a hardware signal applied to either EXTINT input or activity on the UART. An EXTINT pin can also be configured (by CFG-PM2) to define durations when the receiver should be held on or off by hardware control.

With each start, the receiver stays on for long enough to deliver a new fix or down-load new ephemeris if necessary to make a fix. The receiver makes use of one or more of the following sources of aiding to reduce the duration of each fix and thereby minimize overall energy use:

- built-in RTC (time-aiding)
- fine time-aiding delivered to an EXTINT pin (see MGA-INI-TIME messages)
- last known or fixed position (see MGA-INI and CFG-TMODE2 messages)
- ephemeris and auxiliary aiding data messages (see MGA-GPS, MGA-GLO and MGA-BDS messages)

☞ On/off duty-cycle Power Save Mode may not provide the minimum energy use when GLONASS or BeiDou signal reception is enabled without ephemeris aiding.

☞ For more information about power management strategies, see the *u-blox M8 Receiver Description Including Protocol Specification* [3].

1.17 Antenna

1.17.1 Antenna type

The NEO-M8T includes a SAW filter and an additional LNA and is suitable for use with both passive[12] and active[13] antennas. The LEA-M8T includes a SAW filter and is suitable for use with active antennas and antenna distribution systems. Within the recommended range below, lower overall gain can improve immunity to interference in most situations; higher gain offers slightly better sensitivity.

Parameter	Specification	
Antenna Type		Passive and active antenna
Active Antenna Recommendations	Minimum gain Maximum gain Maximum noise figure	5 dB (at module input) 20 dB (at module input) 1.5 dB

Table 5: Antenna Specifications

1.17.2 Antenna supervision

The LEA-M8T includes a built in antenna bias supply for nominal 3V antennas enabled by linking the filtered VCC_RF supply output pin to the V_ANT antenna supply input pin with a series resistor. The module then controls the power supply to the antenna, applying power whenever the receiver is active and removing power during power-save idle times and if a short-circuit is detected. Short-circuit is detected if the voltage at the antenna supply falls close to zero and is indicated as an alarm in message MON-HW.

Optionally the EXTINT1 pin may be reassigned to antenna supervision, allowing an external circuit to indicate to the module that the antenna is open-circuit. This condition is then reported by the module in message MON-HW.

The NEO-M8T provides a control output for an external antenna supply switch. Antenna supervision is configurable in both modules using message CFG-ANT.

☞ For more details on antenna supervision in NEO-M8T or LEA-M8T see the relevant *Hardware Integration Manual* [1] or [2].

[12] For integration of u-blox M8 modules with Cellular products, see the *NEO-M8 Hardware Integration Manual* [1].
[13] For information on using active antennas with NEO-M8T modules, see the *NEO-M8 Hardware Integration Manual* [1].

2 Pin definition

2.1 NEO-M8T pin assignment

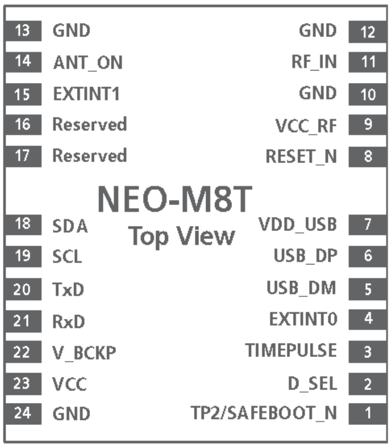


Figure 3: NEO-M8T Pin Assignment

No	Name	I/O	Description
1	TP2/SAFEBOOT_N	I/O	Timepulse 2/SAFEBOOT_N (must not be held LO during start-up)
2	D_SEL	I	Interface select
3	TIMEPULSE	O	Time pulse (1PPS)
4	EXTINT0	I	External Interrupt Pin 0
5	USB_DM	I/O	USB Data
6	USB_DP	I/O	USB Data
7	VDD_USB	I	USB Supply
8	RESET_N	I	RESET_N
9	VCC_RF	O	Output Voltage RF section
10	GND	I	Ground
11	RF_IN	I	GNSS signal input
12	GND	I	Ground
13	GND	I	Ground
14	ANT_ON	O	Antenna control
15	EXTINT1	I	External Interrupt Pin 1
16	Reserved	-	Reserved
17	Reserved	-	Reserved
18	SDA SPI CS_N	I/O	DDC Data if D_SEL =1 (or open) SPI Chip Select if D_SEL = 0
19	SCL SPI CLK	I/O	DDC Clock if D_SEL =1(or open) SPI Clock if D_SEL = 0
20	TxD SPI MISO	O	Serial Port if D_SEL =1(or open) SPI MISO if D_SEL = 0
21	RxD SPI MOSI	I	Serial Port if D_SEL =1(or open) SPI MOSI if D_SEL = 0
22	V_BCKP	I	Backup voltage supply
23	VCC	I	Supply voltage
24	GND	I	Ground

Table 6: NEO-M8T Pinout

☞ Pins designated Reserved should not be used. For more information about Pinouts see the *NEO-M8 Hardware Integration Manual* [1].

2.2 LEA-M8T pin assignment

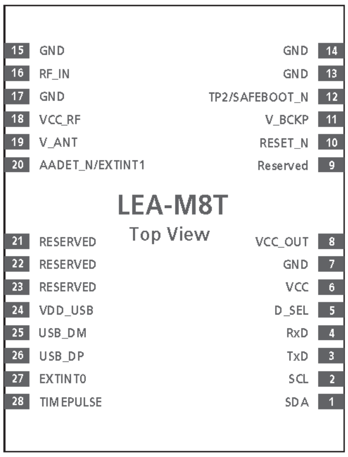


Figure 4: LEA-M8T Pin Assignment

No	Name	I/O	Description
1	SDA SPI CS_N	I/O	DDC Data if D_SEL =1 (or open) SPI Chip Select if D_SEL = 0
2	SCL SPI CLK	I/O	DDC Clock if D_SEL =1(or open) SPI Clock if D_SEL = 0
3	TxD SPI MISO	O	Serial Port if D_SEL =1(or open) SPI MISO if D_SEL = 0
4	RxD SPI MOSI	I	Serial Port if D_SEL =1(or open) SPI MOSI if D_SEL = 0
5	DSEL	I	Interface Select
6	VCC	I	Supply voltage
7	GND	-	Ground
8	VCC_OUT	O	Output Voltage (VCC)
9	Reserved	-	Reserved
10	RESET_N	I	RESET_N
11	V_BCKP	I	Backup voltage supply
12	TP2/SAFEBOOT_N	I/O	Timepulse 2/SAFEBOOT_N (must not be held LO during start-up)
13	GND	-	Ground
14	GND	-	Ground
15	GND	-	Ground
16	RF_IN	I	GPS signal input
17	GND	-	Ground
18	VCC_RF	O	Output Voltage RF section
19	V_ANT	I	Active Antenna Voltage Supply
20	AADET_N/EXTINT1	I	Active Antenna Detection/External Interrupt Pin 1
21	Reserved	-	Reserved
22	Reserved	-	Reserved
23	Reserved	-	Reserved
24	VDD_USB	I	USB Supply
25	USB_DM	I/O	USB Data
26	USB_DP	I/O	USB Data
27	EXTINT0	I	External Interrupt Pin 0
28	TIMEPULSE	O	Timepulse (1 PPS)

Table 7: LEA-M8T Pinout

☞ Pins designated Reserved should not be used. For more information about Pinouts see the *LEA-M8S / M8T Hardware Integration Manual* [1].

3 Configuration management

Configuration settings can be modified with UBX configuration messages. The modified settings remain effective until power-down or reset. Settings can also be saved in battery-backed RAM, Flash or both using the UBX-CFG-CFG message. If settings have been stored in battery-backed RAM then the modified configuration will be retained as long as the backup battery supply is not interrupted. Settings stored in Flash memory will remain effective even after power-down and do not require backup battery supply.

3.1 Interface selection (D_SEL)

At startup, the D_SEL pin determines which data interfaces are used for communication. If D_SEL is set high or left open, UART and DDC become available. If D_SEL is set low, i.e. connected to ground, the modules can communicate to a host via SPI.

PIN NUMBER NEO-M8T	PIN NUMBER LEA-M8T	D_SEL="1" (left open)	D_SEL ="0" (connected to GND)
20	3	UART TX	SPI MISO
21	4	UART RX	SPI MOSI
19	2	DDC SCL	SPI CLK
18	1	DDC SDA	SPI CS_N

Table 8: Data interface selection by D_SEL

4 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 these limits 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 see the *Hardware Integration Manual* [1] or [2].

4.1 Absolute maximum rating

Parameter	Symbol	Module	Condition	Min	Max	Units
Power supply voltage	VCC	All		–0.5	3.6	V
Backup battery voltage	V_BCKP	All		–0.5	3.6	V
USB supply voltage	VDD_USB	All		–0.5	3.6	V
Input pin voltage	Vin	All		–0.5	3.6	V
	Vin_usb	All		–0.5	VDD_USB	V
	Vrfin	NEO-M8T LEA-M8T[14]		0 -	0 -	V
DC current trough any digital I/O pin (except supplies)	Ipin				10	mA
VCC_RF output current	ICC_RF	All			100	mA
Input power at RF_IN	Prfin	All	source impedance = 50 Ω, continuous wave		13	dBm
Antenna bias voltage	V_ANT				6	V
Antenna bias current	I_ANT				100	mA
Storage temperature	Tstg	All		–40	85	°C

Table 9: 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.

[14] Antenna bias is supplied by LEA-M8T module

4.2 Operating 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.

Parameter	Symbol	Module	Min	Typical	Max	Units	Condition
Power supply voltage	VCC	All	2.7	3.0	3.6	V	
Supply voltage USB	VDDUSB	All	3.0	3.3	3.6	V	
Backup battery voltage	V_BCKP	All	1.4		3.6	V	
Input pin voltage range	Vin	All	0		VCC	V	
Digital IO Pin Low level input voltage	Vil	All	0		0.2*VCC	V	
Digital IO Pin High level input voltage	Vih	All	0.7*VCC		VCC	V	
Digital IO Pin Low level output voltage	Vol	All			0.4	V	Iol = 4 mA
Digital IO Pin High level output voltage	Voh	All	VCC–0.4			V	Ioh = 4 mA
USB_DM, USB_DP	VinU	All	Compatible with USB with 27 Ω series resistance				
V_ANT antenna bias voltage	V_ANT	LEA-M8T	2.7		5.5	V	I_{ANT} < –50 mA
Antenna bias voltage drop	V_ANT_DROP	LEA-M8T		0.1		V	ICC_RF =50 mA
VCC_RF voltage	VCC_RF	All		VCC–0.1		V	
VCC_RF output current	ICC_RF	All			50	mA	
Receiver Chain Noise Figure[15]	NFtot	NEO-M8T		2.5		dB	
		LEA-M8T		4.7		dB	
Operating temperature	Topr	All	–40		85	°C	

Table 10: Operating conditions

☞ Operation beyond the specified operating conditions can affect device reliability.

4.3 Indicative current requirements

Table 11 lists examples of the total system supply current for a possible application.

☞ Values in Table 11 are provided for customer information only as an example of typical power requirements. 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.

Parameter	Symbol	Module	Typ GPS & GLONASS	Typ GPS / QZSS / SBAS	Max	Units	Condition
Max. supply current [16]	Iccp	All			67	mA	
Average supply current [17, 18]	Icc	NEO-M8T	34	27		mA	Estimated at 3 V
		LEA-M8T	30	23		mA	
Backup battery current	I_BCKP	NEO-M8T		15		µA	V_BCKP = 1.8 V, VCC = 0 V
		LEA-M8T		17		µA	
SW backup current	I_SWBCKP	NEO-M8T		30		µA	VCC = 3 V
		LEA-M8T		50		µA	

Table 11: Indicative power requirements at VCC = 3.0 V

☞ For more information about power requirements, see the *Hardware Integration Manual* [1] or [2].

[15] Only valid for the GPS band
[16] Use this figure to dimension maximum current capability of power supply. Measurement of this parameter with 1 Hz bandwidth.
[17] Use this figure to determine required battery capacity.
[18] Simulated GNSS constellation using power levels of -130 dBm. VCC = 3.0 V

☞ For more information on how to noticeably reduce current consumption, see the *Power Management Application Note* [5].

4.4 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 12: Symbol description

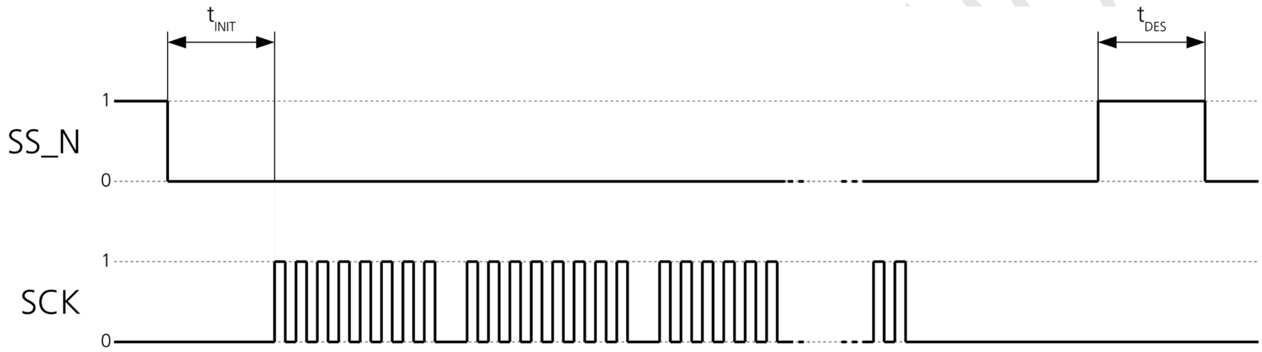


Figure 5: SPI timing diagram

4.4.1 Timing recommendations

Parameter	Description	Recommendation
t_{INIT}	Initialization Time	500 µs
t_{DES}	Deselect Time	1 ms.
Bit rate		1 Mb/s

Table 13: 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.

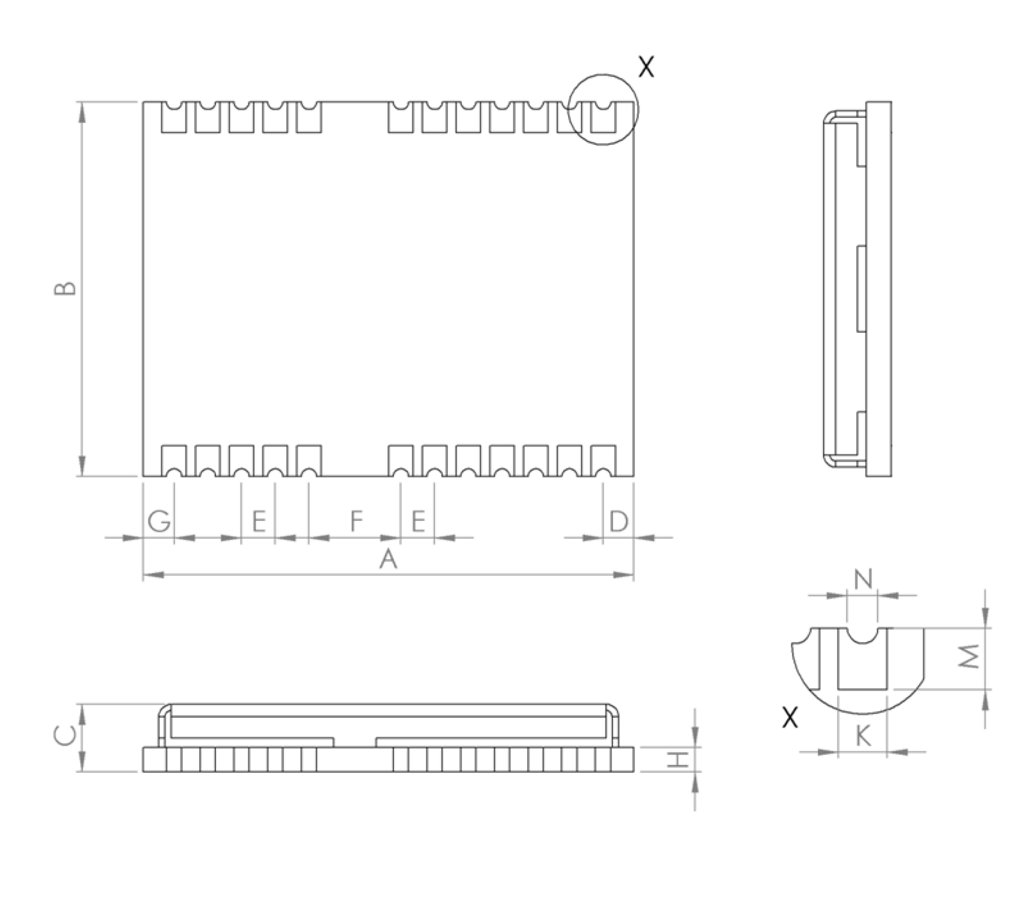
4.5 DDC timing diagrams

The DDC interface is I^2C Fast Mode compliant. For timing parameters consult the I^2C standard.

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

5 Mechanical specifications

5.1 NEO-M8T

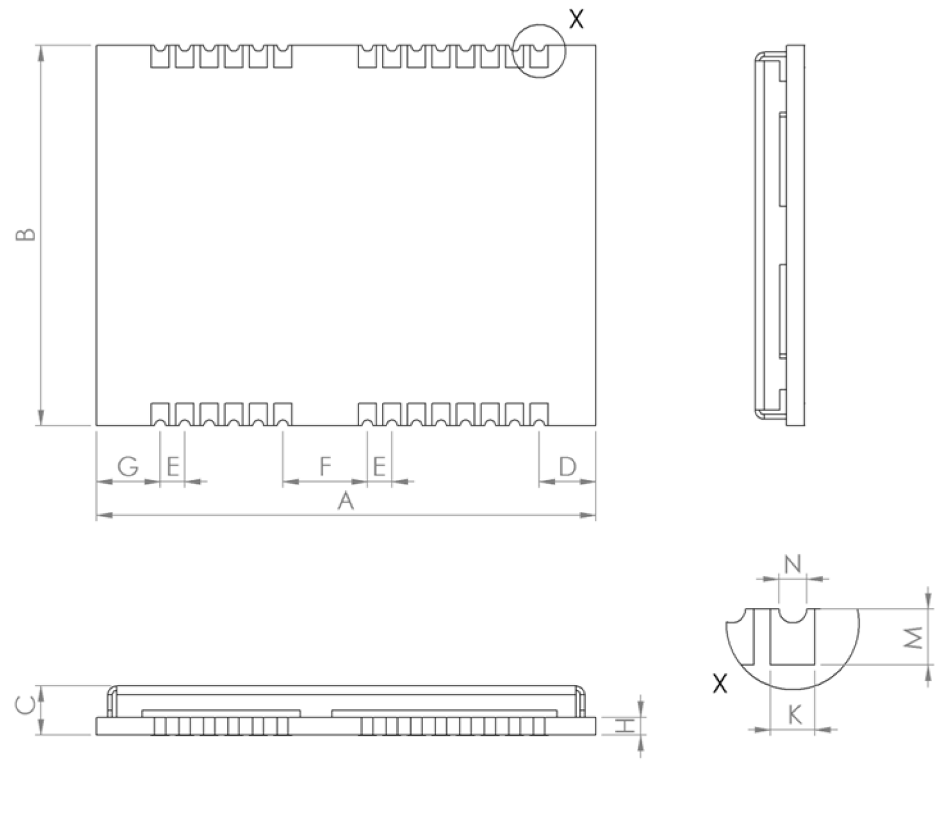


Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
A	15.9	16.0	16.6
B	12.1	12.2	12.3
C	2.2	2.4	2.6
D	0.9	1.0	1.3
E	1.0	1.1	1.2
F	2.9	3.0	3.1
G	0.9	1.0	1.3
H		0.82	
K	0.7	0.8	0.9
M	0.8	0.9	1.0
N	0.4	0.5	0.6
Weight		1.6g	

Figure 6: Dimensions

☞ For information about the paste mask and footprint, see the *NEO-M8 Hardware Integration Manual* [1].

5.2 LEA-M8T



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
A	22.1	22.4	23.0
B	16.9	17.0	17.1
C	2.1	2.4	2.7
D	2.45	2.55	2.85
E	1.0	1.1	1.2
F	3.7	3.8	3.9
G	2.75	2.85	3.15
H		0.82	
K	0.7	0.8	0.9
M	0.9	1.0	1.1
N	0.4	0.5	0.6
Weight		2.1g	

Figure 7: Dimensions

☞ For information about the paste mask and footprint, see the *LEA-M8S / M8T Hardware Integration Manual* [2].

6 Reliability tests and approvals

6.1 Reliability tests

NEO/LEA-M8Tmodules are based on AEC-Q100 qualified GNSS chips.

Tests for product family qualifications are according to ISO 16750 "Road vehicles – environmental conditions and testing for electrical and electronic equipment”, and appropriate standards.

6.2 Approvals

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

All u-blox M8 GNSS modules are RoHS compliant.

7 Product handling & soldering

7.1 Packaging

The NEO/LEA-M8T GNSS modules are delivered as hermetically sealed, reeled tapes in order to enable efficient production, production lot set-up and tear-down. For more information see the *u-blox Package Information Guide* [4].

7.1.1 Reels

NEO/LEA-M8T GNSS modules are both deliverable in quantities of 250 pcs on a reel. NEO/LEA-M8T receivers are shipped on Reel Type B, as specified in the *u-blox Package Information Guide* [4].

7.1.2 NEO-M8T tapes

The dimensions and orientations of the tapes for NEO-M8T modules are specified in Figure 8.

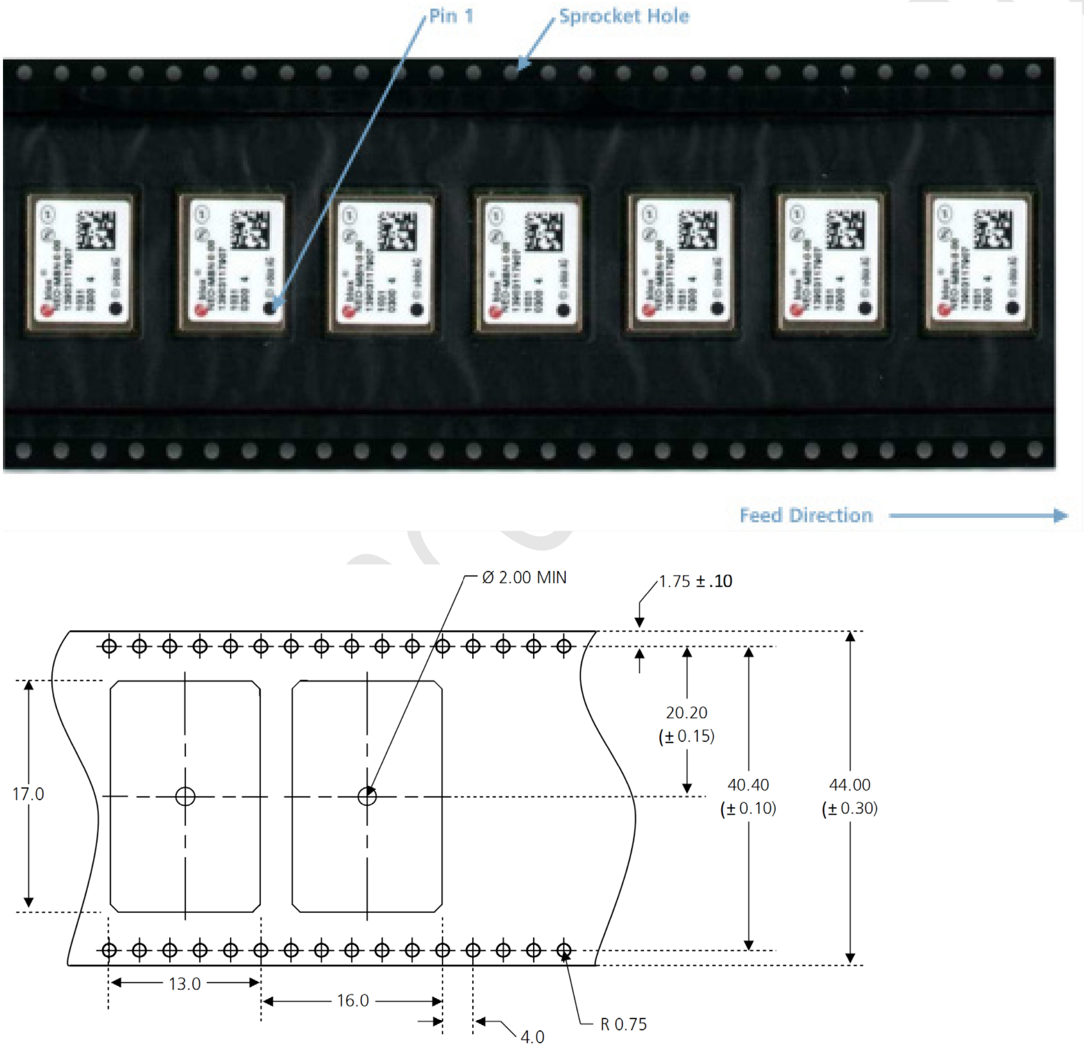


Figure 8: Dimensions and orientation for NEO-M8T modules on tape

7.1.3 LEA-M8T tapes

The dimensions and orientations of the tapes for LEA-M8T modules are specified in Figure 9.

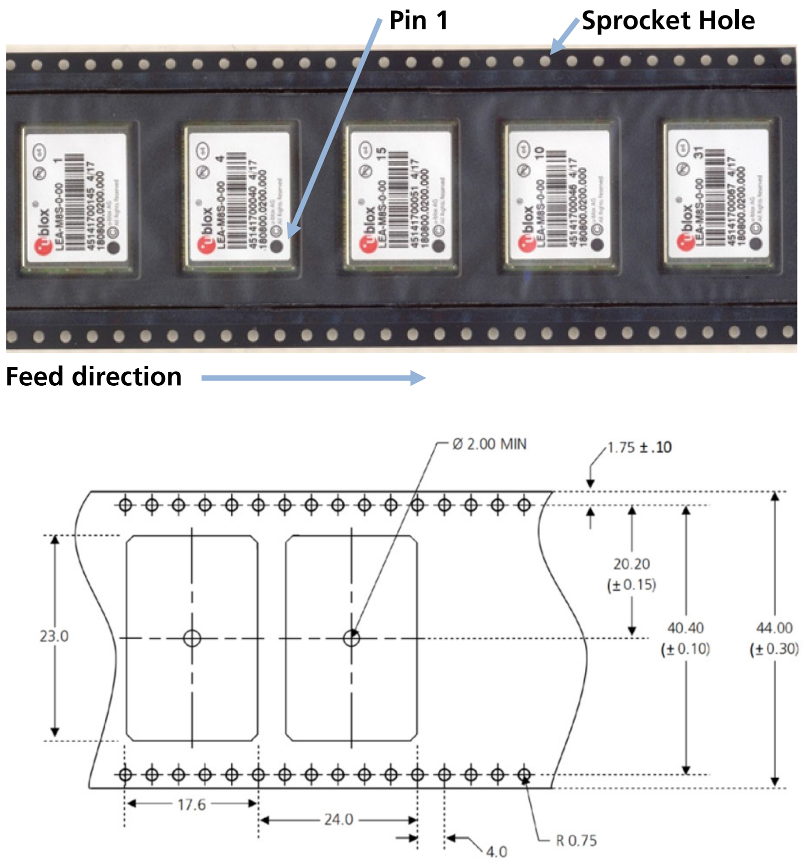


Figure 9: Dimensions and orientation for LEA-M8T modules on tape

7.2 Shipment, storage and handling

For important information regarding shipment, storage and handling see the *u-blox Package Information Guide* [4].

7.2.1 Moisture sensitivity levels

The Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions required. The NEO/LEA-M8T modules are rated at MSL level 4.

☞ 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* [4].

7.2.2 Reflow soldering

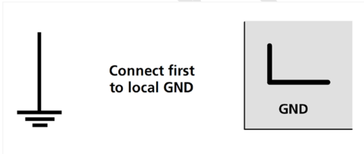
Reflow profiles are to be selected according u-blox recommendations (see the *Hardware Integration Manual* [1] or [2]).

7.2.3 ESD handling precautions

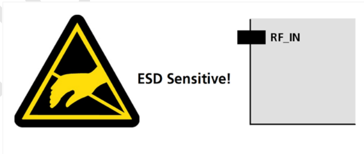
NEO/LEA-M8T modules are Electrostatic Sensitive Devices (ESD). Observe precautions for handling! Failure to observe these precautions can result in severe damage to the GNSS receiver!

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, then the first point of contact when handling the PCB must always be between the local GND and PCB GND.



- Before mounting an antenna patch, connect ground of the device
- When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges (e.g. patch antenna ~10 pF, coax cable ~50-80 pF/m, soldering iron, …)



- To prevent electrostatic discharge through the RF input, do not touch any exposed antenna area. If there is any risk that such exposed antenna area is touched in non ESD protected work area, implement proper ESD protection measures in the design.

- When soldering RF connectors and patch antennas to the receiver's RF pin, make sure to use an ESD safe soldering iron (tip).

8 Default messages

Interface	Settings
UART Output	9600 Baud, 8 bits, no parity bit, 1 stop bit Configured to transmit both NMEA and UBX protocols, but only the following NMEA (and no UBX) messages have been activated at start-up: **GGA, GLL, GSA, GSV, RMC, VTG, TXT, ZDA**
USB Output	Configured to transmit both NMEA and UBX protocols, but only the following NMEA (and no UBX) messages have been activated at start-up: **GGA, GLL, GSA, GSV, RMC, VTG, TXT, ZDA** USB Power Mode: Bus Powered
UART Input	9600 Baud, 8 bits, no parity bit, 1 stop bit, Autobauding disabled Automatically accepts following protocols without need of explicit configuration: UBX, NMEA, RTCM The GNSS receiver supports interleaved UBX and NMEA messages.
USB Input	Automatically accepts following protocols without need of explicit configuration: UBX, NMEA The GPS receiver supports interleaved UBX and NMEA messages. USB Power Mode: Bus Powered
DDC	Fully compatible with the I^2C industry standard, available for communication with an external host CPU or u-blox cellular modules, operated in slave mode only. Default messages activated. NMEA and UBX are enabled as input messages, only NMEA as output messages. 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.
TIMEPULSE (1Hz Nav)	1 pulse per second, synchronized at rising edge, pulse length 100 ms

Table 14: Default messages

☞ Refer to the *u-blox M8 Receiver Description Including Protocol Specification V15* [3] for information about further settings.

9 Labeling and ordering information

9.1 NEO-M8T product labeling

The labeling of u-blox M8 GNSS modules includes important product information. The location of the NEO-M8T product type number is shown in Figure 10.

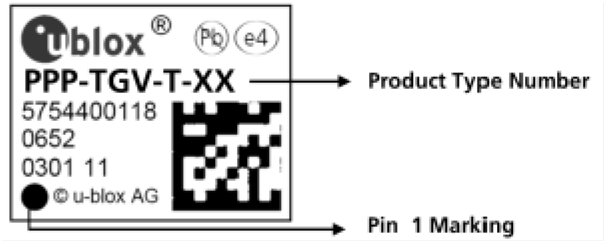


Figure 10: Location of product type number on u-blox NEO-M8T module label

9.2 LEA-M8T product labeling

The labeling of u-blox M8 GNSS modules includes important product information. The location of the LEA-M8T product type number is shown in Figure 11.

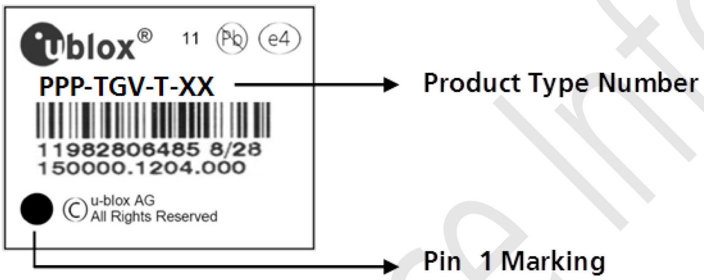


Figure 11: Location of product type number on u-blox LEA-M8T module label

9.3 Explanation of 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 options and quality, while the **Type Number** includes the hardware and firmware versions. Table 15 shows the structure of these three different formats.

Format	Structure
Product Name	PPP-TGV
Ordering Code	PPP-TGV-T
Type Number	PPP-TGV-T-XX

Table 15: Product Code Formats

The parts of the product code are explained in Table 16.

Code	Meaning	Example
PPP	Product Family	NEO
TG	Platform	M8 = u-blox M8
V	Variant	Function set (A-Z), T = Timing, R = DR, etc.
T	Option / Quality Grade	Describes standardized functional element or quality grade 0 = Default variant, A = Automotive
XX	Product Detail	Describes product details or options such as hard- and software revision, cable length, etc.

Table 16: part identification code

9.4 Ordering codes

Ordering No.	Product
NEO-M8T-0	u-blox M8 GNSS Module, Timing, TCXO, flash, SAW, LNA, 12.2x16 mm, 250 pcs/reel
LEA-M8T-0	u-blox M8 GNSS Module, Timing, TCXO, flash, SAW, 17x22.4 mm, 250 pcs/reel

Table 17: Product ordering codes

☞ Product changes affecting form, fit or function are documented by u-blox. For a list of Product Change Notifications (PCNs) see our website.

Related documents

[1] NEO-M8 Hardware Integration Manual, Docu. No. UBX-13003557
[2] LEA-M8S/M8T Hardware Integration Manual, Docu. No. UBX-13003140
[3] u-blox M8 Receiver Description Including Protocol Specification (Public version), Docu. No. UBX-13003221
[4] u-blox Package Information Guide, Docu. No. UBX-14001652
[5] Power Management Application Note, Docu. No. UBX-13005162

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

Revision history

Revision	Date	Name	Status / Comments
R01	16-Jul-2014	amil	Objective Specification
R02	29-Oct-2014	amil	Advance Information

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