μ-blox GPS-MS1E
GPS Receiver Module based on SiRFstar I/LX™
-Datasheet-

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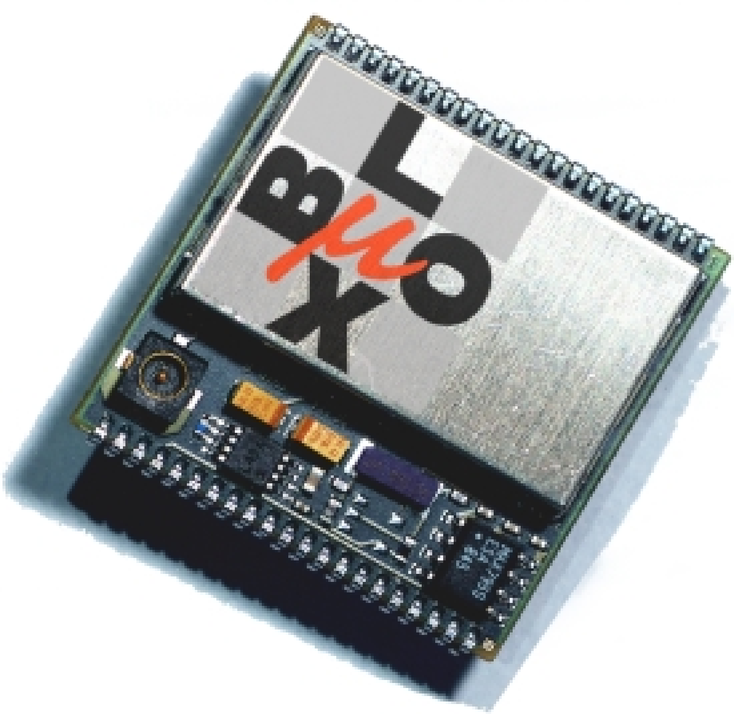

1 Features

- Full Implementation of the SiRFstar I/LX™ Architecture, Including:
  - GRF1/LX Low-power RF front-end IC
  - GSP1/LX Low-power GPS DSP with Integrated Real Time Clock (RTC)
  - Hitachi RISC CPU SH-7020
  - 1 MBit SRAM
  - 8 MBit FLASH memory
  - Low Noise Amplifier
  - Filter, Crystals, etc.
- SiRFstar I/LX™ TricklePower™ enhanced power management modes (3 stage)
- Differential GPS (RTCM-SC104) input
- PLCC-84 pinout compatible package, Dimensions: 30.2mm × 29.5mm × 7.55mm
- M/A-Com SSMT coax connector for RF-Input
- 12 General purpose I/Os and 4 bi-directional Serial Interfaces
- IRQ inputs plus NMI
- System clock output
- Operating voltage 3.3 Volts, 0.5 Watt (max.)
- Industrial operating temperature range (–40 - +85°C)
- External requirements:
  - 3.3 Volt power supply, 0.5 Watt
  - Backup battery for real time clock and SRAM
  - Serial interface for NMEA or SiRF binary data
  - Passive or active Antenna
  - Antenna bias voltage for active antenna
- Customer specific code can be implemented on the Hitachi SH-1 processor using the μ-blox Software Customization Kit.

Revision History		
Date	Section	Changes
3.5.00		Initial version
15.5.00	Section 4.1	Accuracy information (w/o SA) added
16.5.00	Section 8.2	Cleaning information added

Table 1: Revision History

2 Overview

GPS-MS1E is a fully self-contained receiver module for the Global Positioning System (GPS). Based on the SiRFstar I/LX™ chip set manufactured by SiRF Technology, Inc., the module supports all features, and maintains the technical specifications of the SiRFstar I/LX™ architecture.

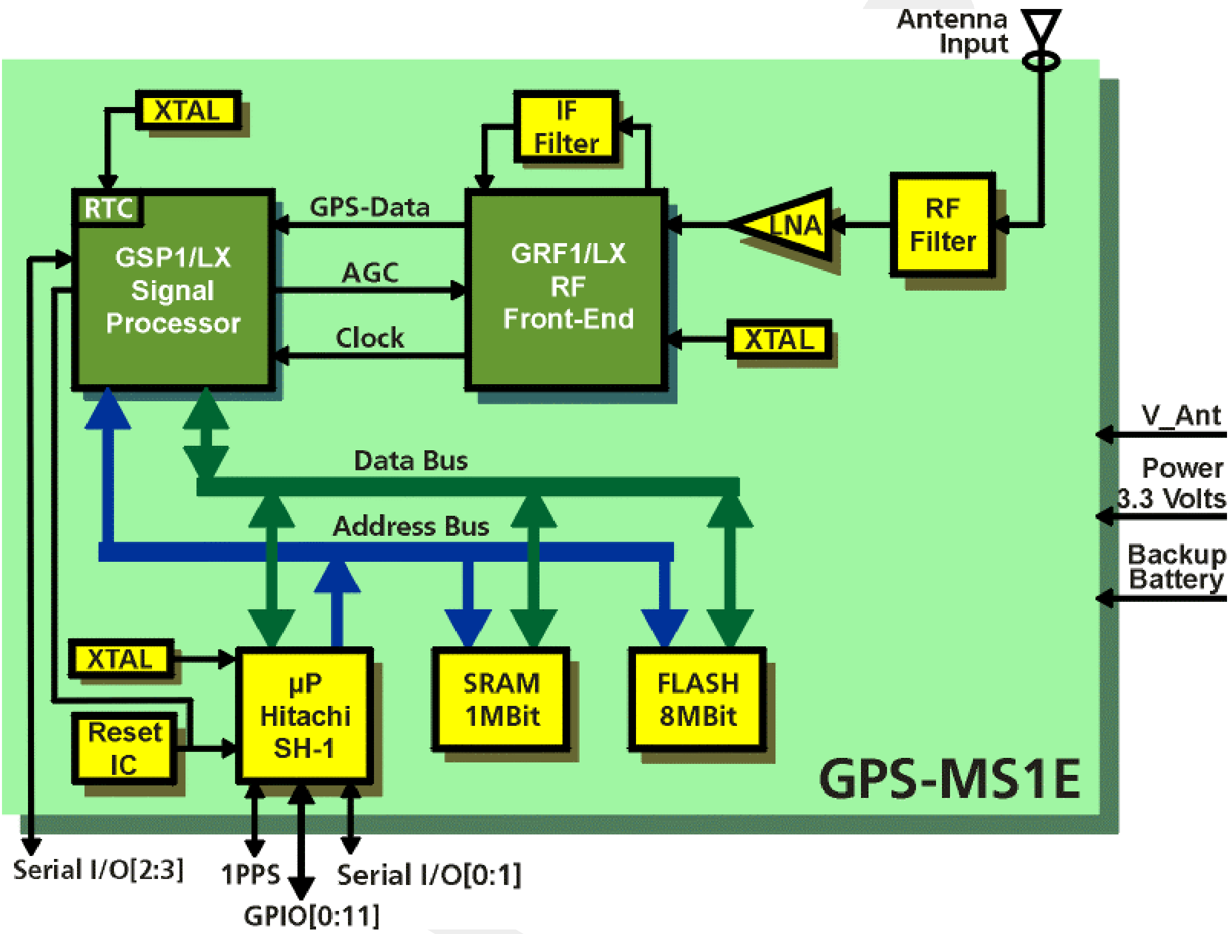

Figure 1: Blockdiagram of GPS-MS1E

Fitting the footprint of a PLCC-84 package (30.2mm × 29.5mm board area), the module provides complete GPS signal processing from antenna input to serial data output (NMEA or SiRF proprietary data format). A second serial port accepts differential GPS data (RTCM).

Operating at a nominal operating voltage of 3.3 Volts, the module consumes less than 0.5 Watts in continuous operation mode. The implementation of the patent pending TricklePower™ Mode allows an additional drastic reduction of power consumption for applications where power consumption is of primary concern (see also the *Low Power Mode Application Note*). Using a third crystal the GPS-MS1E offers extended TricklePower Mode capabilities. It can shut off the RF part and the signal processor of the chipset (GSP1/LX) independently from the processor. The GPS-MS1E is fully backward compatible to the GPS-MS1.

Featuring the GRF1/LX RF front-end chip and an integrated Low-Noise Amplifier (LNA), the module connects seamlessly to low-cost passive antennas. Active antennas can be connected to the GPS-MS1E as well, if the antenna bias voltage is supplied externally. General purpose I/Os and sufficient CPU power of the module's Hitachi SH-1 RISC CPU allow integration of additional customer specific functionality. For many applications, the functionality of an external micro-controller can be transferred to GPS-MS1E. The μ-blox Software Customization Kit is required to change the firmware or implement additional functionality on the on-board microprocessor.

3 Product Lineup

The GPS-MS1E is supplied in the following default start-up configuration:

- SiRF binary protocol
- 19'200 Baud
- 8 data bits, no parity, 1 stop bit

During a firmware up-date the default start-up configuration of the receiver can be set. Firmware up-dates as well as the up-date utility are available at the µ-blox homepage. See the *firmware up-date manual* for further information.

Refer to Table 2 for ordering information.

Option	Features
None	Standard version
DL	Adds datalogging capability

Table 2: Ordering Options

For the GPS-MS1E an integrated datalogger is available as an ordering option (GPS-MS1E-DL). This option enables the user to take advantage of the on-board FLASH memory to store position data. Further information on the capabilities of the datalogger is available on our homepage.

Ordering example:

GPS-MS1E-DL GPS-MS1E with datalogger.

4 GPS Performance Specification

4.1 GPS accuracy

GPS receiver accuracy is a function of GPS receiver performance, satellite constellation and Selective Availability (SA). GPS accuracy is not properly defined. Every manufacturer has his own means of defining, measuring and calculating position accuracy. On May 1, 2000 the US president decided to discontinue SA with with immediate effect. This improves GPS accuracy dramatically without any modification on the receivers.
We define commonly used measures and give the values for all of them in the *GPS receiver performance application note*. In Table 3 we focus on CEP, which gives the most intuitive feel for the accuracy of a GPS receiver.

Definition of Circular Error Probability: The radius of a circle, centered at the antenna's true position, containing 50 % of the fixes.

See *GPS receiver performance application note* for more details.

4.2 Start-up times

A GPS receiver has different start-up scenarios, which differs significantly in the Time-to-first-fix (TTFF). These start-up scenarios depend on the amount of knowledge the GPS receiver has regarding its positions and the availability of satellites. Just like GPS accuracy, startup times for GPS receivers are another field where every manufacturer has his own naming scheme, and therefore, comparison between receivers is difficult. In the following a short introduction in our definitions of start-up times (see Table 3 for specifications) is given. Please note that these numbers were measured with good visibility (open view to the sky). Obstructed view will result in longer start-up times.

Definitions:

Cold Start In Cold Start Scenario, the receiver has no knowledge on last position, approximate time or satellite constellation. The receiver starts to search for signals blindly. This is standard behavior, if no backup battery is connected.
Cold Start time is the longest startup time for μ -blox GPS receivers.

Warm Start In Warm Start Scenario, the receiver knows - due to a backup battery – his last position, approximate time and almanach. Thanks to this, it can quickly acquire satellites and get a position fix faster than in cold start mode.

Hot Start In Hot Start Scenario, the receiver was off for less than 2 hours. It uses its last Ephemeris data to calculate a position fix.

Reacquisition The reacquisition figure gives the time required to get lock on a satellite if the signal has been blocked for a short time (e.g. due to buildings). This is most important in urban areas. Reacquisition time is not related with TTFF.

All accuracy measurements were performed in a static scenario, with clear view to the sky.

Parameter	Specification	
Receiver Type		L1 frequency, C/A Code, 12-Channel
Max Up-date Rate		1Hz
Accuracy (SA off)	Position Time	5m CEP
Accuracy (SA on)	Position Time	21m CEP +/- 180ns
Accuracy (DGPS, SA on)	Position Time	2m CEP +/- 60ns
Acquisition (typical)	Cold Start Warm Start Hot Start	60 sec 45 sec 2 - 6 sec
Signal Reacquisition		100 ms
Dynamics		<= 4g
Operational Limits		Altitude <60000ft and velocity <1000 knots Either limit may be exceeded but not both (COCOM restrictions)

Table 3: GPS receiver specifications

5 Operating Modes

GPS-MS1E can be operated in different operating modes.

5.1 Normal Operation

In Normal Mode, the module is continuously running as long as the operating voltage Vcc is supplied. Position fixes are generated at the maximum update rate. Use of an external backup battery is recommended to reduce the system's startup time. If an external backup battery is connected the module keeps the internal Real Time Clock running and holds the SRAM data (ephemeris and almanac data) during power supply interruption, this enables Warm- and Hotstart. However, under good visibility conditions cold- and warm start times do not differ significantly.

5.2 TricklePower Operation

In TricklePower Mode, Vcc is continuously supplied to the module. A software configurable internal timer periodically forces the module to acquire a position fix. Between the fixes, the module remains in an ultra-low power sleep mode. This mode is recommended for applications where lowest power consumption and a periodical position up-date are of primary concern. A backup battery must be connected to enable the module to reduce startup times when recovering from a Vcc supply interruption. The GPS-MS1E supports a new enhanced TricklePower Mode. This enables to shut off the CPU independently from the RF part and the signal processor. So in TricklePower Mode operation there are 3 Modes: Track Mode (RF and CPU on), CPU Mode (CPU on) and Standby Mode (RF off, CPU in stand-by).

State	Current (typ.)
Track Mode	140 mA
CPU Mode	34 mA
Standby Mode	0.25 mA

Table 4 : TricklePower Mode states

The RF on time (Track Mode) depends on the length of the up-date period. The CPU on time (CPU Mode) depends also on the number of satellites in view. (See *Low Power Mode Application Note* for more details).

The currents during the different states are given in Table 4. This means that the power supply must be capable of delivering at least 140mA at 3.3V, regardless of the average current drawn by the module in TricklePower Mode.

During the TricklePower mode the firmware periodically schedules ephemeris collection and RTC calibration to insure that useable data is always available. Ephemeris collection occurs once within a 30 minutes period and whenever a new satellite rises above the horizon.

The power-on scenario in TricklePower Mode differs from the one in continuous Mode. If the module fails to acquire 3 satellites within a given time (due to bad visibility or very low signal levels) the module goes into an extended sleep phase. The length of this sleep phase is defined by the duty cycle (up-date rate). After this period the module wakes up and tries to acquire a position fix again.

For more detailed information on TricklePower Mode please check the *Low Power Mode Application Note*.

5.3 Push to Fix Mode

In Push to Fix mode the GPS-MS1E stays in sleep mode until an external request wakes it up and initiates a position fix. The TTFF[1] stays under 6 seconds. The receiver has the capability to wake itself up in order to check for new ephemeris data. Through this, low TTFF can be achieved virtually independent on the time the receiver was off. This mode is best used for application where no periodical position fixes and low power consumption is required. Push to Fix mode operation requires special external wiring, please refer to the *Low Power Mode Application Note* for more detailed information.

5.4 Customized Operation

The Hitachi SH-7020 RISC-CPU provides enough computational power to allow the implementation of additional customer specific software into the module. The current datasheet only provides basic information on the availability of I/O signals to the customer's application. In order to implement software on the on-board processor the Software Customization Kit (GPS-SCK) is required. The Software Customization Kit includes a development platform (compiler) and a sub-license of the firmware on the receiver. Contact μ-blox for a detailed discussion of the feasibility of implementing a particular application.

[1] Time to first fix

6 Technical Specifications

6.1 Electrical Specifications

6.1.1 Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Units
Power Supply Voltage	Vcc	-0.3	3.6	V
Input Pin Voltage	Vin	-0.3	Vcc + 0.3	V
Antenna Bias Current	Iant		300	mA
Storage Temperature	Tstg	-40	125	°C

Table 5: Absolute Maximum Ratings

Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only.

! GPS-MS1E is not protected against overvoltage or inverse voltages. If necessary, voltage spikes exceeding the power supply voltage specification, given in table above, must be reduced by using appropriate protection diodes.

6.1.2 Operating Conditions

Parameter	Symbol	Min	Typ	Max	Units
Power Supply Voltage	Vcc	3.0	3.3	3.4	V
Power Supply Voltage Ripple	Vcc		50		mV
Backup Battery Voltage	Vbat	2.0		3.6	V
Input Pin Voltage	Vin	0		Vcc	V
Antenna bias voltage drop @50 mA	Vant_drop		0.45		V
Supply Current	Icc		140		mA
TricklePower Sleep Mode Supply Current	Itps		0.25		mA
Standby Battery Current @Vbat=3.6V (T=25°C)	Ibat		20		μA
Standby Battery Current @Vbat=3.3V (T=25°C)	Ibat		8		μA
Standby Battery Current @Vbat=3.0V (T=25°C)	Ibat		6		μA
Operating Temperature	Topr	-40		85	°C

Table 6: Operating Conditions

Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.

6.2 Pin Description

Figure 2 shows the pin identification.

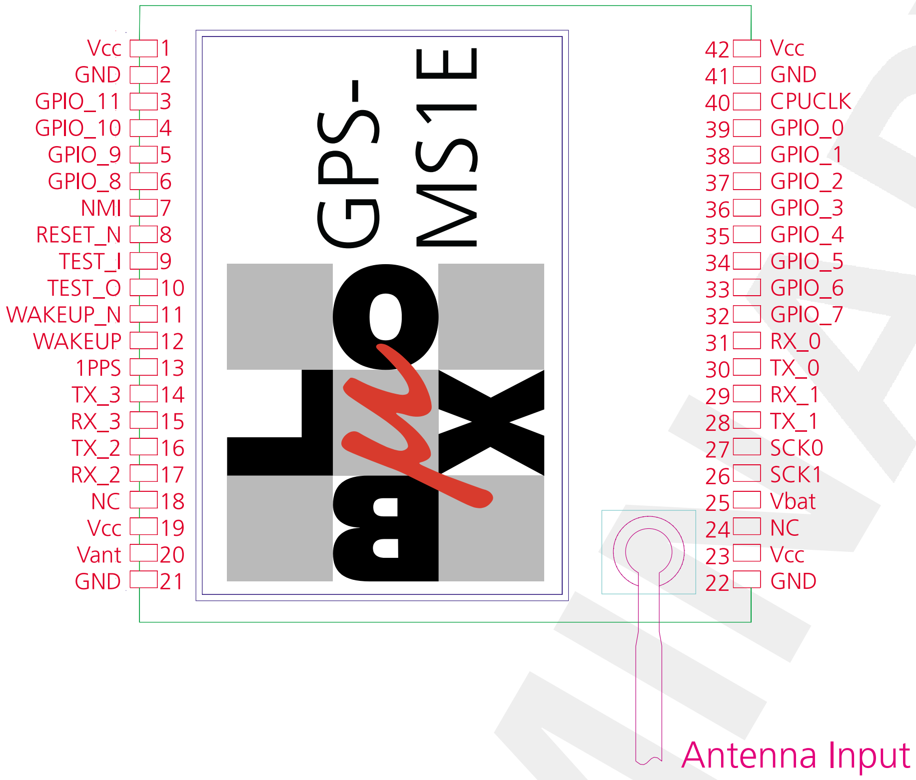

Figure 2 : Pin Identification

Please see Table 7 for the pin identification of the GPS-MS1E.

Pin	Type	Name
1	I	Vcc
2	I	GND
3	I/O	GPIO_11
4	I/O	GPIO_10
5	I/O	GPIO_9
6	I/O	GPIO_8
7	I	NMI
8	I/O	RESET_N
9	I	TEST_I
10	O	TEST_O
11	O	WAKEUP_N
12	O	WAKEUP
13	I/O	1PPS
14	O	TX_3

Pin	Type	Name
15	I	RX_3
16	O	TX_2
17	I	RX_2
18	I	NC
19	I	Vcc
20	I	Vant
21	I	GND
22	I	GND
23	I	Vcc
24	I	NC
25	I	Vbat
26	I/O	SCK1
27	I/O	SCK0
28	O	TX_1

Pin	Type	Name
29	I	RX_1
30	O	TX_0
31	I	RX_0
32	I/O	GPIO_7
33	I/O	GPIO_6
34	I/O	GPIO_5
35	I/O	GPIO_4
36	I/O	GPIO_3
37	I/O	GPIO_2
38	I/O	GPIO_1
39	I/O	GPIO_0
40	O	CPU_CLK
41	I	GND
42	I	Vcc

Table 7: Pin Identification

6.2.1 Serial Interface Signals

The GPS-MS1E (with Firmware Version V1.32 or higher) supports 4 serial IOs. All serial interface signals TX_[0:1], TX_[2:3], RX_[0:1], RX_[2:3] and SCK[0:1] operate on 3.3V CMOS compatible signal levels. If RS 232 compatible signal levels are required an external driver (e.g. MAX3232) must be provided.

! Connect unused RX_[0:1], RX_[2:3] to Vcc.

Default operation includes sending out SiRF binary data format compatible position data on Serial Port 0 and accepting RTCM SC-104 differential correction data on Serial Port 1. NMEA 0183 position data format can optionally be used instead of SiRF binary data format. See the *μ-blox GPS receiver protocol specifications* for detailed information on the serial protocols.

The configuration of the receiver can also be changed by using the SiRF binary communication protocol. In order to change the default start-up configuration of the receiver, the firmware on the receiver has to be up-dated. During this up-date the default start-up configuration is set.

Port	Baud Rate
0 and 1	4800 9600 19200 (default) 38400

Table 8: Available Baud rates

Using SiRF binary protocol, the lowest baud rate that can be achieved is 9600. Because of the limited bandwidth with 9600 baud development data and raw data can only be transmitted at 19200 baud. NMEA protocol allows using baud rates down to 4800, depending on the messages used. In firmware version 1.32 (or higher) Port 2 and port 3 are supported (only in continuous mode).

6.2.2 General Purpose I/O Signals

A total of 12 port signals (GPIO_[0:11]) of the SH-7020 are connected to the module's pins. Alternatively, GPIO_[0:7] can be used as I/Os for the SH-7020's Timing Pattern Controller (TPC) or for the Integrated Timer Pulse Unit (ITU).

1PPS is a freely configurable general purpose I/O pin of GSP1/LX. In standard software configuration a 1PPS signal (<100ms positive pulse) is output on this pin. This signal is 3.3V CMOS and 5V TTL compatible.

All these pins are available to customized applications. For standard operation, the GPIO pins should be left unconnected.

6.2.3 Special Function Signals

TEST_I, **TEST_O** are used for factory test of the module. They can also be used for interrupt input. Please contact μ-blox for further details if your application requires external interrupts. TEST_I must be connected to GND for normal operation. TEST_O must be left unconnected.

! For re-programming the FLASH memory, it must be possible to pull TEST_I to Vcc.

RESET_N is an open drain output with internal pull-up resistor. This signal is an internally generated system reset signal. After power-up this signal goes to a high level. An external reset is initiated by pulling RESET_N low.

6.2.4 Special Power Pins

A DC-bias voltage can be supplied to an active antenna via pin **Vant**. Typically, the voltage required by an active antenna is 4.5V. The bias voltage is applied to the inner conductor of the antenna's coaxial cable. If a passive antenna is used, no bias voltage needs to be provided and this pin should be left open.

! Noise on the antenna bias voltage will degrade the GPS performance of the GPS-MS1E.

An external backup battery must be connected to pin **Vbat** to enable RTC operation and SRAM backup and to allow GPS warm or hot starts after power supply interruption. If no battery is connectedt to VBAT, VBAT should be connected to GND.

6.2.5 Trickle Power Mode Pins

In TricklePower Mode an active (High) **WAKEUP_N** pin indicates that the module is running. WAKEUP_N pin low indicates that the module is in sleep mode. To enable TricklePower Mode the module pins **NMI** and **WAKEUP_N** must be connected. Pin **WAKEUP** outputs the inverted version of signal WAKEUP_N.

Pin	Signals	Description
Serial I/O		
26-31	TX_[0:1], RX_[0:1], SCK[0:1]	Serial interface of SH-7020. In default configuration, GPS data is output on interface 0, DGPS data is input on interface 1. SCK[0:1] can also be used as interrupt signal inputs. Unused RX pins have to be pulled high.
14-17	TX_[2:3], RX_[2:3]	Serial interface of GSP1/LX. Unused RX pins have to be pulled high.
General Purpose I/O		
32-39	GPIO_[0:7]	PB[0:7] of SH-7020, available to users applications
3-6	GPIO_[8:11]	PA[8:11] of SH-7020, available to users applications
13	1PPS	Connects to GPIO_0 of GSP1/LX, used for output of the 1PPS signal
Special Functions		
7	NMI	NMI input of SH-7020. Connect to Vcc for normal operation. Connect to WAKEUP_N, if TricklePower Mode will be used.
8	RESET_N	Active-Low system reset. Open-drain output with internal pull-up resistor.
11	WAKEUP_N	Wakeup signal output. A low WAKEUP_N pin indicates that the module is in sleep mode.
12	WAKEUP	Inverted Wakeup signal output. A high WAKEUP pin indicates that the module is in sleep mode.
40	CPU_CLK	12.288MHz system clock signal
9-10	TEST_I, TEST_O	Pins used for factory test. Connect TEST_I to GND and leave TEST_O unconnected. TEST_I and TEST_O can also be used as interrupt inputs to SH-7020. For re-programming of the FLASH memory, it must be possible to pull TEST_I to Vcc.
Power Pins		
1,19,23,42	Vcc	3.3V Supply Voltage
2,21,22,41	GND	Module Ground
20	Vant	Bias voltage for active antenna power supply. Do not connect if not used.
25	Vbat	Backup voltage supply for RTC and SRAM. Connect to GND, if not used.
Not Connected		
18, 24	N/C	Leave open

Table 9: GPS-MS1E Signal Description

7 How to Make it Run

The following are the minimum outside connections one has to provide to allow basic operation of GPS-MS1E. If you plan to use more of GPS-MS1E's functionality within your application, please contact μ-blox support.

1. **Antenna** Use a cable fitted with M/A-Com SSMT coaxial connector to connect the antenna to the module (see Table 10).

2. **Power** Connect Vcc pins 1, 19, 23, and 42 to 3.3V. And, connect GND pins 2, 21, 22, and 41 to ground. No special decoupling capacitors are necessary. The power supply should be capable of delivering a sustained current of at least 140mA. A proper RESET signal is internally generated and available at pin 8 (RESET_N).

3. **Configuration Pins** Tie pins 7 and 11 (NMI and WAKEUP_N) together. Do not connect them to Vcc. This external wiring allows to run the module in Continuous as well as in Trickle Power mode. If you intend to use Continuous Mode exclusively, tie 7 (NMI) to Vcc and leave pins 11 (WAKEUP_N) and 12 (WAKEUP) open.

   Tie pin 9 (TEST_I) to GND. If you want to allow re-programming of the internal FLASH memory for firmware upgrade, it must be possible to switch this pin to Vcc. A jumper will do the job (see Figure 4). Or, you can use a 100k pull-down resistor to GND and provide a testpoint to set TEST_I to Vcc during re-programming. If a re-programming of the internal flash memory should be possible in the target system, the serial port 1 should be available externally (see also *Firmware Update Manual*).

4. **Serial Interface** Pins 28-31 (RX_[0:1] and TX_[0:1]) are 3.3V CMOS compatible. The RX inputs are NOT 5V TOLERANT. However the TX outputs are 5V TTL compatible. If you need different voltage levels, use appropriate level shifters. E.g. in order to obtain RS-232 compatible levels use the 3V compatible MAX3232 from Maxim or equivalent. GPS data will come out of port 0. You can use port 1 to feed in DGPS correction data. Connect the RX pin of any unused serial interface to Vcc, this is in most of the applications pin 15 and 17 (RX_2 and RX_3). If not used also connect pin 29 and 31 (RX_0 and RX_1) to Vcc.

5. **Active Antenna Bias Voltage** If you intend to use an active antenna, supply the required bias voltage (up to 12V, according to your antenna specifications) to pin 20 (V_ANT). Make sure that this voltage is properly filtered to avoid injection of noise into the RF-frontend. If your environment is very noisy, a low-noise voltage regulator such as National LP2988, LP2982 or Analog Devices ADP 3307 might be needed to reduce voltage ripple. For maximum power savings in TricklePower mode also the antenna bias voltage should be switched. The WAKEUP_N signal can be used to control the voltage regulator for the antenna bias voltage.

6. **Backup Battery** Connect a backup battery to pin 25 (Vbat) if you intend to use this feature. You can also use a supercap. The voltage at this pin can be anywhere between 2.0V and 3.6V. For charging of the supercap, connect its positive pole through a diode to Vcc. If you don't intend to use a backup battery, connect this pin to GND.

7. **1PPS Signal** On pin 13 (1PPS), a one-pulse-per-second signal is available.

Leave all unused pins open, if not specified else.

That's all!

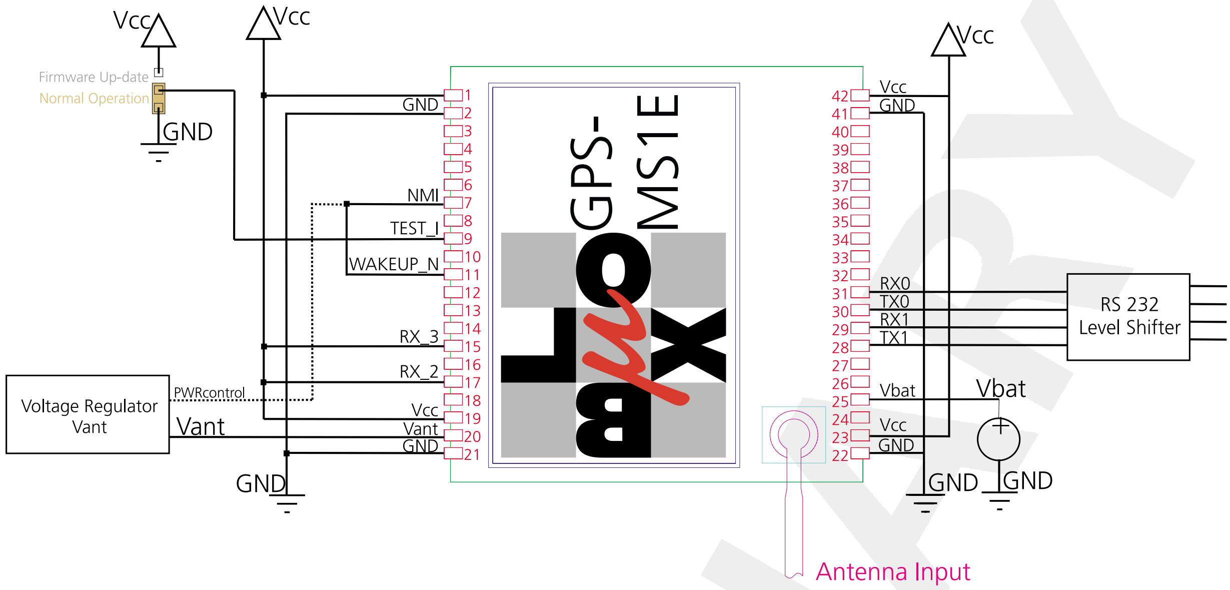

Figure 3: External wiring (Continuous and TPM mode)

Figure 3 shows a draft of the minimal external wiring for the GPS-MS1E, that enables TricklePower and Continuous operation. External wiring for Push to Fix needs an additional OR gate (see Figure 4). If an active antenna is used, a voltage regulator for the antenna bias voltage is strongly recommended. This also enables a switching of the antenna bias voltage in TricklePower mode (controlled by the WAKEUP_N of the GPS-MS1E).

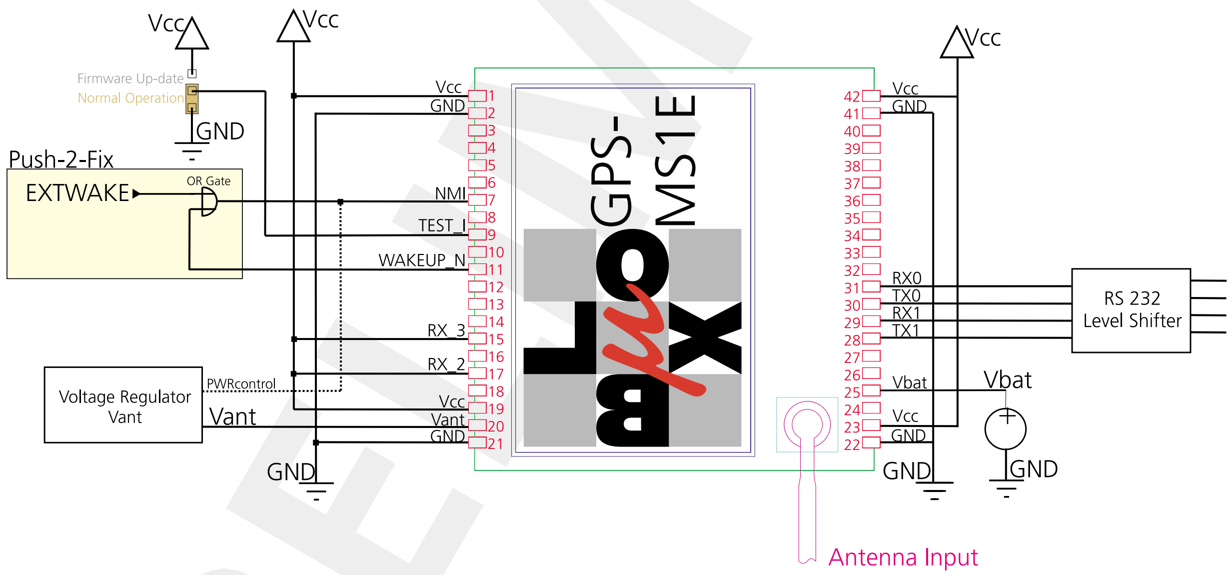

Figure 4: External wiring for Push to Fix mode

8 Processing of the GPS-MS1E

8.1 Handling

The GPS-MS1E is designed and packaged to be processed in an automatic assembly line. However due to the fact that the GPS-MS1 is a specially packaged subsystem, there are some requirements that differ from the handling of single packaged parts.

The GPS-MS1E is shipped in blister trays (30pcs per tray) that are specially designed to protect the module from Electro-static discharge (ESD) as well as from mechanical damages. The module contains highly sensitive electronic circuitry. Handling the GPS-MS1E without proper ESD protection may destroy or damage the module. The trays can be fed in most of the pick-place equipment.
The blister trays should not be exposed to temperatures higher than 75°C.

8.2 Cleaning

Ultrasonic cleaning will damage the GPS-MS1E permanently.

8.3 Soldering

Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

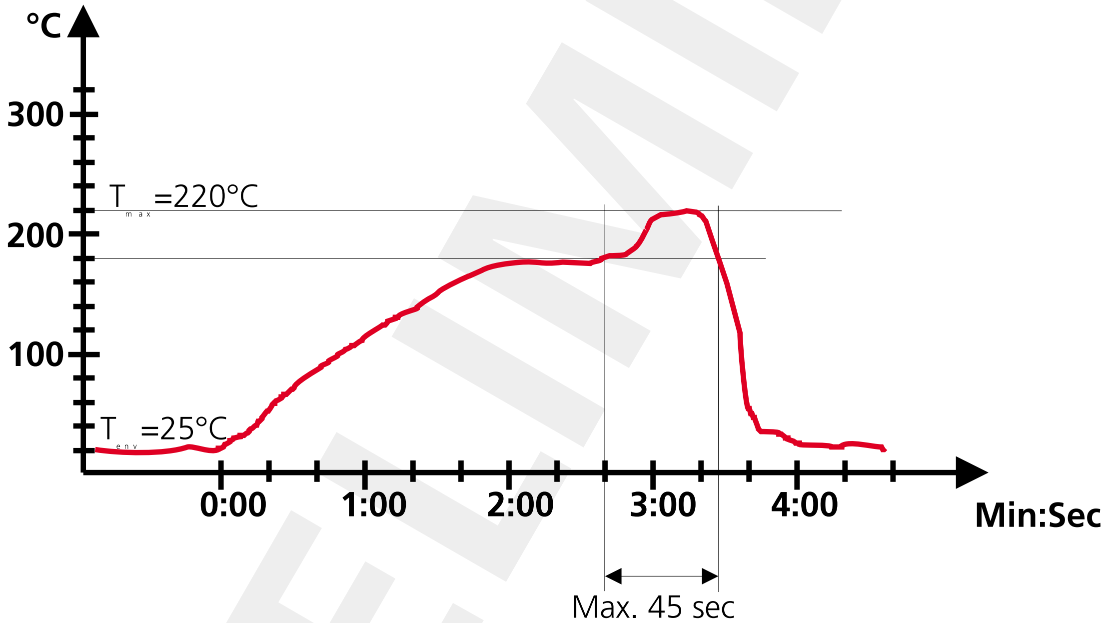

Figure 5: Recommended Soldering Profile

The following points should be carefully considered:

- Maximum Temperature should not exceed 220°C (measured on the PCB of the module).
- The temperature should not remain over the liquidus temperature (180°C) for longer than 40-50 sec.
- The temperature ramp up from the environmental temperature to liquidus temperature (180°C) should be equal or less than in the recommended soldering profile.

! The specified soldering profile is measured on the module (on the PCB). See Figure 6 for the location of the temperature sensors on the module.

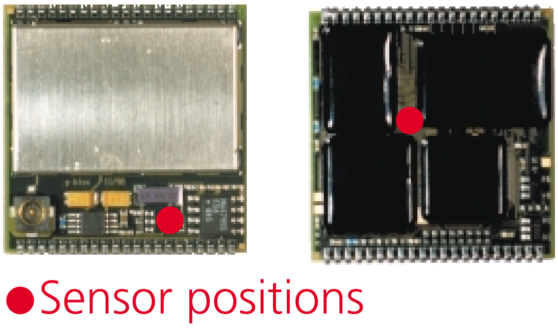

Figure 6: Sensor Position

9 Mechanical Specifications

Figure 7 shows the mechanical dimensions of the module. The recommended pad-layout reflects a standard PLCC-84 footprint with only two rows of pins.

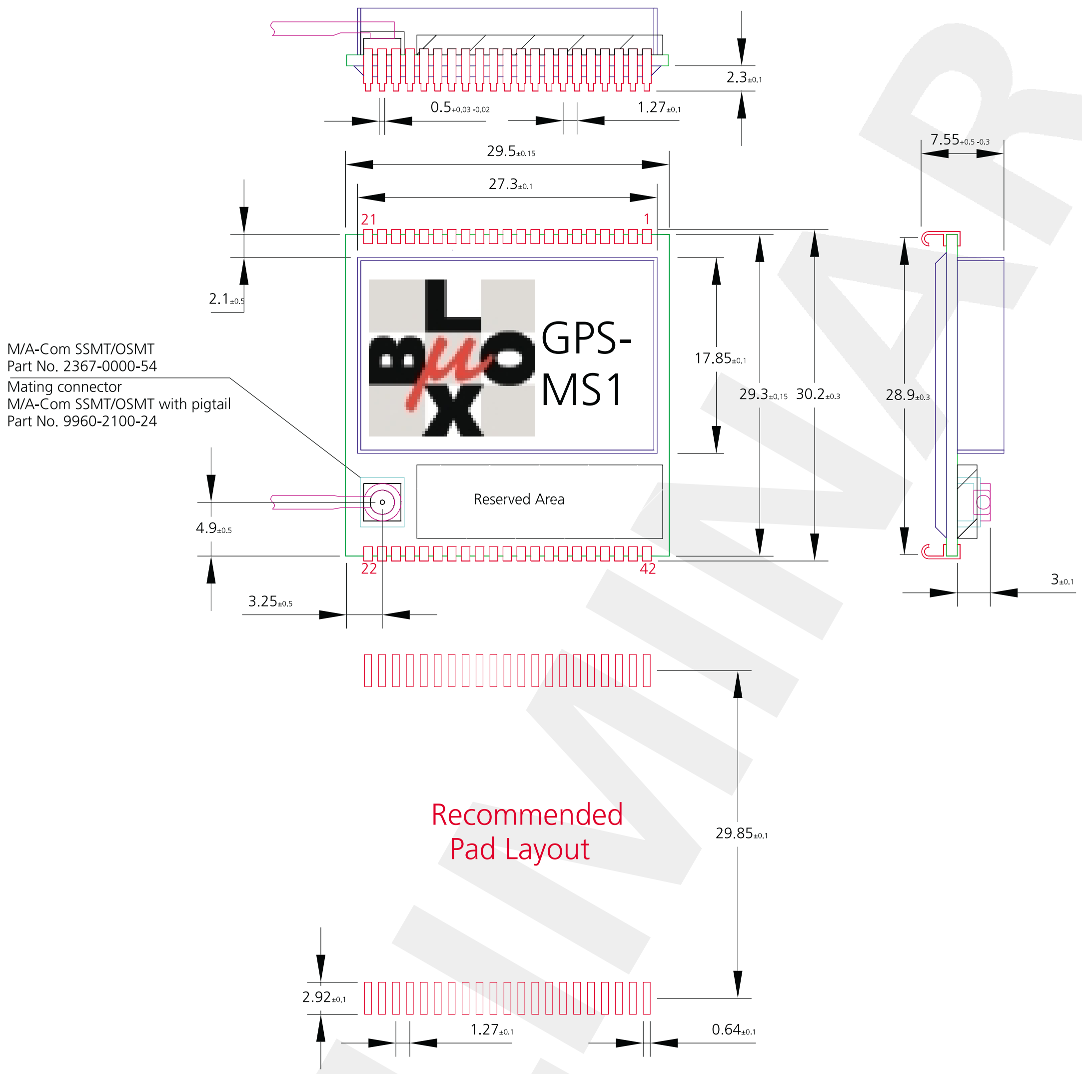

Figure 7: Mechanical Dimensions

The weight of the module is approximately 8 grams including the metal shield. The RF connector on the GPS-MS1E is a M/A-Com connector (see Table 10 for matching connectors). The overall height of the module is 7.55mm.

Connector on module	Matching Connector
M/A-COM SSMT plug receptable	M/A-COM SSMT/OSMT Right Angle Jack Pigtail P/No 9960-2xxx-24 (xxx defines the length in mm)
M/A-Com SSMT plug receptable	M/A-COM SSMT/OSMT to SMA cable assembly (100mm) P/No 9960-4100-02

Table 10: Matching Connectors

This table shows the matching connector for the RF-Connector. Check URL below for more information:

M/A-COM RF-Connectors: WWW: http://www.macom.com

10 Related Documents

- GPS-MS1E/GPS-PS1E Protocol Specification
- Low Power Mode Application Note
- Logging Option on μ-blox GPS receivers
- Performance of μ-blox GPS receivers Application Note
- GPS-xS1 Firmware Update Manual

All these documents are available on our homepage (http://www.u -blox.ch).

11 Contact

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