µ-blox GPS-MS1
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™ power management modes
- 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 2 bi-directional Serial Interfaces
- IRQ inputs plus NMI
- System clock output
- Operating voltage 3.3 Volts, 0.5 Watt
- Industrial operating temperature range (–40 - +85°C)
- Minimum 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
- Customer specific code can be implemented on the Hitachi SH-1 processor using the µ-blox Software Customization Kit.

Revision History		
Date	Section	Changes
Oct. 19, 97		Initial Version
Oct. 20, 97	Section 3 Table Table 7: GPS-MS1 Signal Description	Ordering example GPMS1-BT replaced with GPS-MS1-BT PA[11:8] replaced with PA[8:11] 'Connect to the NMI input of SH-7020. Connect to Vcc if this pin is not used' replaced with 'NMI input of SH-7020. Connect to Vcc for normal operation.'
Oct. 23, 97		New µ-blox logo inserted
Nov. 16, 97	Mechannical Dimensions Section 6	Shield dimensions changed Default serial port operation changed, Lower Baud Rates added for Ports 0 and 1
Dec. 19, 97	Section 1.1.1	Details on Serial Port Operation added
Jan. 9, 98	Table 5.2	'Connect TEST_I to Vcc and leave TEST_O unconnected.' Replaced with 'Connect TEST_I to GND and leave TEST_O unconnected.'
Feb. 4, 98	Section 1.1.1	'Default operation includes sending out NMEA compatible position data on Serial Port 2 and accepting RTCM differential correction data on Serial Port 3.' Replaced with 'Default operation includes sending out NMEA compatible position data on Serial Port 0 and accepting RTCM differential correction data on Serial Port 1.'
Mar. 16,98	 Section 8 Section 5.2, Table 7: GPS-MS1 Signal Description Section 6 Section 3 Section 5.2.3	Product name changed from GPSMS1 to GPS-MS1 Contact information updated TricklePower Mode related Pin information updated Protocol selection information extended Order information extended 1PPS function information extended
Mar. 17, 98	Section 5.2.3, Table 7	TEST_I FLASH programming note added.
Mar. 18, 98	Section 6 Table 7	Complete section added. Vbat connection specification for unused case added.
Apr. 15, 98	Section 6	Weight Specification added
May 14, 98	Section 4.1 Table 5: Pin Identification & Table 7: GPS-MS1 Signal Description Sections 5.2.2 & 5.2.3 Section 4.2 Section 4.2 Table 2: Ordering Options Table 5: Pin Identification Section 6 Section 1 & Table 4: Operating Conditions	'However, under good visibility condions cold- and warmstart times do not differ significantly.' Pinname GPIO_12 changed to 1PPS. Pinname TIMEMARK changed to WAKEUP. 1PPS signal specification clarified. Sentence added: 'Pin WAKEUP outputs an inverted version of signal WAKEUP_N.' Sentence deleted: ¨Important: A 1PPS signal is not available if the module features TricklePower Mode operation.'' Pintype of pin 11 WAKEUP_N changed from I to O. Pintype of pin 40 CPU_CLK changed from O to I/O. Option P removed, 1PPS signal is now available on all modules Sentence changed: 'Leave pins 11 (WAKEUP_N) and 12 (WAKEUP) open.' 1PPS item added. Operating voltage specification changed to 3.3V±5\%
May 22, 98	Section 5.1.1	Power supply voltage warning Regarding input voltage spikes added.
July 30, 98	Layout Section 3 & Table 2: Ordering Options	New Font, all tables small font Options changed
Nov. 5, 98	Figure Section 4.2 Table 7: GPS-MS1 Signal Description	New Mech Drawing Mode description up-dated Description of pin changed
Nov.26, 98	Figure	Changed Specs
Apr.26, 98	Table 8: Matching Connectors Table 4: Operating Conditions	Murata Connector information removed Voltage Specs changed
June 15, 99	Version GPS-DS-0699	new Layout, Flash size up-dated, Ordering options added, Figure External wiring added

Table 1: Revision History

2 Overview

GPS-MS1 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.

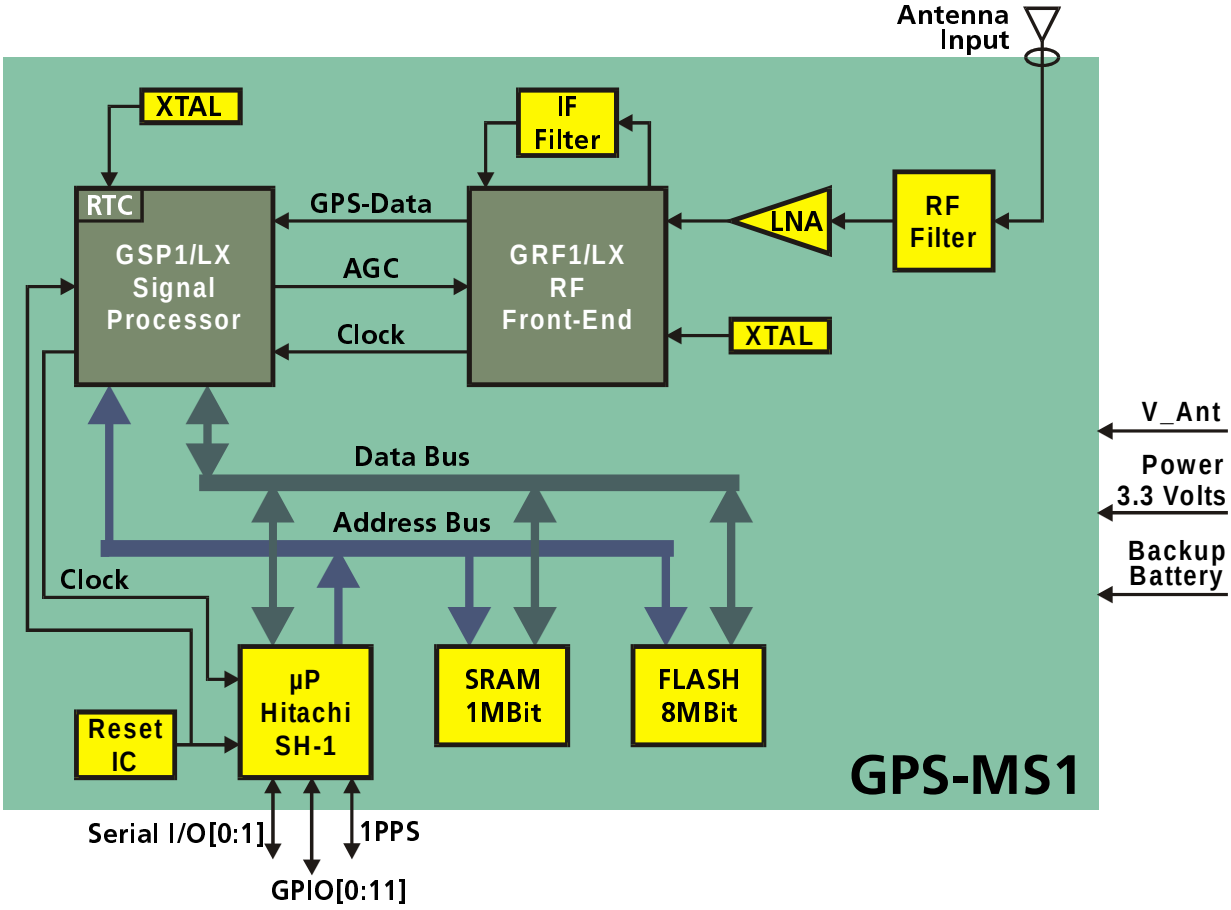

Figure 1: Blockdiagram of GPS-MS1

Fitting into the form factor 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 µ-blox Trickle Power Mode application note).

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-MS1 as well, provided an external antenna bias voltage is applied. 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-MS1. The µ-blox Software Customization Kit is required to change the firmware or implement additional functionality on the on-board microprocessor.

3 Product Lineup

For the GPS-MS1 a integrated datalogger is available as an ordering option. 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.

The GPS-MS1 is supplied in the following default start-up configuration:

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

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

Ordering example:

GPS-MS1-DL GPS-MS1 with datalogger.

4 Operating Modes

GPS-MS1 can be operated in different operating modes.

4.1 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. An external backup battery must be connected to enable the module to keep the internal Real Time Clock running and to hold the SRAM data (ephemeris and almanac data) during power supply interruption. Use of an external backup battery is recommended to reduce the system's startup time. However, under good visibility conditions cold- and warm start times do not differ significantly.

4.2 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. For more detailed information on TricklePower Mode please check the GPS-MS1 Low Power Mode Application Note.

The peak current during run time is Icc as given in Section 5.1.2. This means that the power supply must be capable of delivering at least 150mA 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. Collecting ephemeris data every 30 minutes for 18 seconds is equivalent to running the full receiver (150mA) for an extra 10ms for once per second fix rate.

4.3 Push-to-Fix Mode

In Push-to-Fix mode the GPS-MS1 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.

4.4 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.

5 Technical Specifications

5.1 Electrical Specifications

5.1.1 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
Storage Temperature	Tstg	-55	125	°C

Table 3: Absolute Maximum Ratings

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

! GPS-MS1 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.

5.1.2 Operating Conditions

Parameter	Symbol	Min	Typ	Max	Units
Power Supply Voltage	Vcc	3.15	3.3	3.6	V
Power Supply Voltage Ripple	Vcc		50		mV
Backup Battery Voltage	Vbat	2.0		3.6	V
Input Pin Voltage	Vin	0		Vcc	V
Supply Current	Icc		150		mA
TricklePower Sleep Mode Supply Current	Itps		0.5		mA
Standby Battery Current	Ibat		20		µA
Operating Temperature	Topr	-40		85	°C

Table 4: Operating Conditions

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

[1] Time to first fix

5.2 Pin Description

Please see Table 5 for the pin identification of the GPS-MS1.

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	LP_A
19	I	Vcc
20	I	Vant
21	I	GND
22	I	GND
23	I	Vcc
24	I	TEST_D
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 5: Pin Identification

5.2.1 Serial Interface Signals

All serial interface signals TX_[0:1], RX_[0:1], 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.

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.

Unused Serial Input Ports should be pulled-down.

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

Table 6: Available Baud rates

Using SiRF binary protocol, the lowest baud rate that can be achieved is 9600. NMEA protocol allows using baud rates down to 4800, depending on the messages used. In the current firmware version Port 2 and port 3 are not supported.

5.2.2 General Purpose I/O Signals

A total of 12 port signals 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.

5.2.3 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 of 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.

5.2.4 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.

An external backup battery must be connected to pin **Vbat**. This enables RTC operation and SRAM backup and allows GPS warm or hot starts after power supply interruption.

5.2.5 Trickle Power Mode Pins

In TricklePower Mode enabled modules an active (High) **WAKEUP_N** pin indicates that the module is running. A low WAKEUP_N pin indicates that the module is in sleep mode. To enable TricklePower Mode the module pins **NMI**, **WAKEUP_N**, and **LP_A** must be connected. Pin WAKEUP outputs 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.
14-17	TX_[2:3], RX_[2:3]	Serial interface of GSP1/LX
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 GPIO0 of GSP1/LX, used for output of the 1PPS signal

Pin	Signals	Description
Special Functions		
7	NMI	NMI input of SH-7020. Connect to Vcc for normal operation. Connect to WAKEUP_N on TricklePower Mode enabled modules.
8	RESET_N	Low-active 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. Connect to pin 7 (NMI) and pin 18 (LP_A) for TricklePower Mode.
12	WAKEUP	Inverted Wakeup signal output. A high WAKEUP pin indicates that the module is in sleep mode.
18	LP_A	Pin used for TricklePower Mode. Connect to Vcc for normal operation. Connect to WAKEUP_N on TricklePower Mode enabled modules.
40	CPU_CLK	12.277MHz system clock signal
9-10, 24	TEST_I, TEST_O, TEST_D	Pins used for factory test. Connect TEST_I to GND and leave TEST_O unconnected. Connect TEST_D to Vcc. 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.

Table 7: GPS-MS1 Signal Description

6 How to Make it Run

The following are the minimum outside connections one has to provide to allow basic operation of GPS-MS1. If you plan to use more of GPS-MS1'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 8).
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 150mA. A proper RESET signal is internally generated and available at pin 8 (RESET_N).
3. **Configuration Pins** Tie pins 7, 11, and 18 (NMI, WAKEUP_N and LP_A) together. Do not connect them to Vcc. This external wiring allows to run the module in Continuous as well as inTrickle Power mode. If you intend to use Continuous Mode exclusively, tie 7 and 18 (NMI and LP_A) 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 2). 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).

   Tie pin 24 (TEST_D) to Vcc.
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 GND, 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 GND.
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!

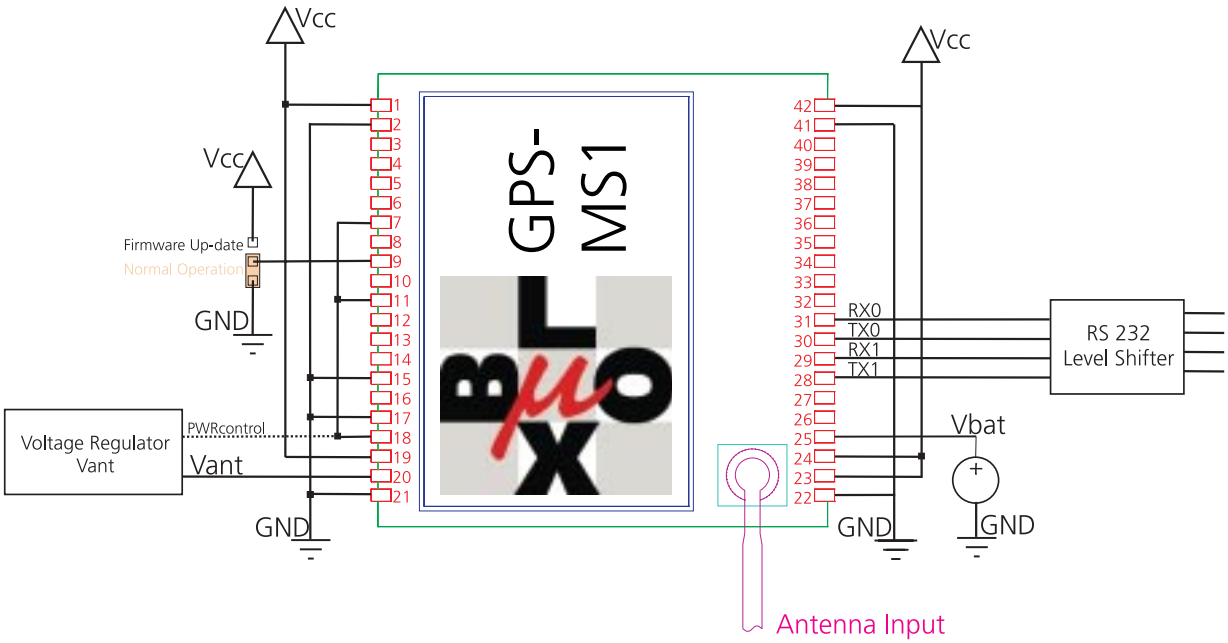

Figure 2: Minimal external wiring (for Continuous and TricklePower Mode operation)

Figure 2 shows a draft of the minimal external wiring for the GPS-MS1, that enables TricklePower and Continuous operation. 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-MS1).

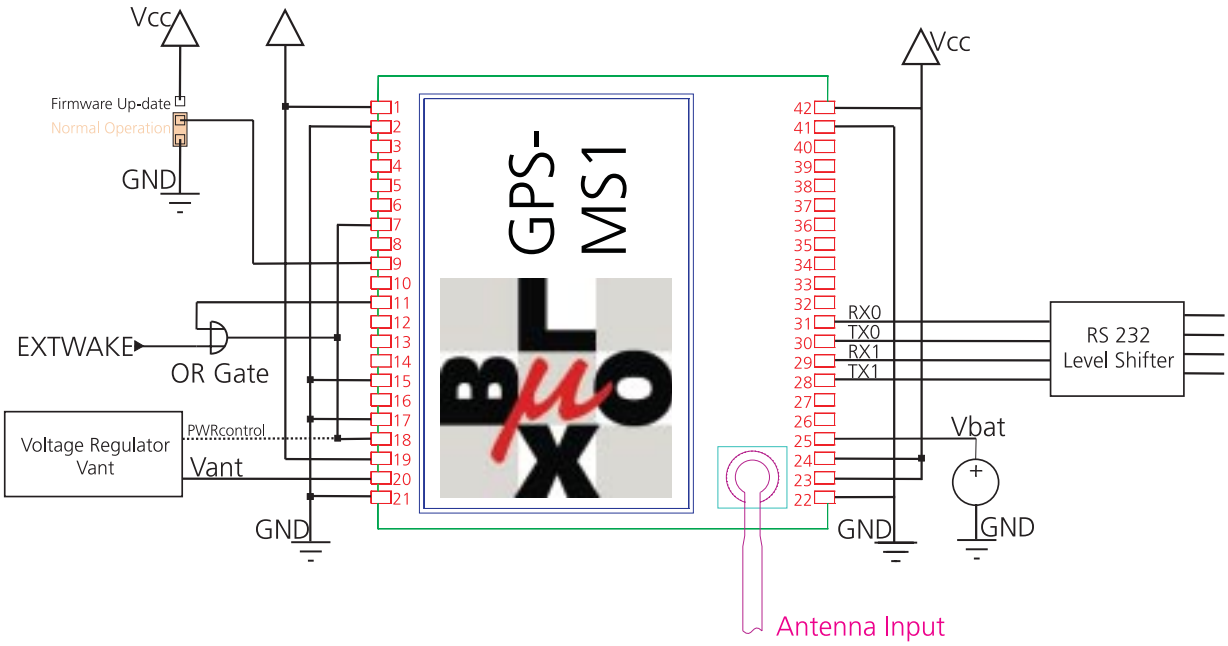

Figure 3: Minimal external wiring (for Push-to-Fix mode)

7 Mechanical Specifications

Figure 4 shows the mechanical dimensions of the module. The recommended pad-layout reflects a standard PLCC-84 footprint with only two rows of pins.

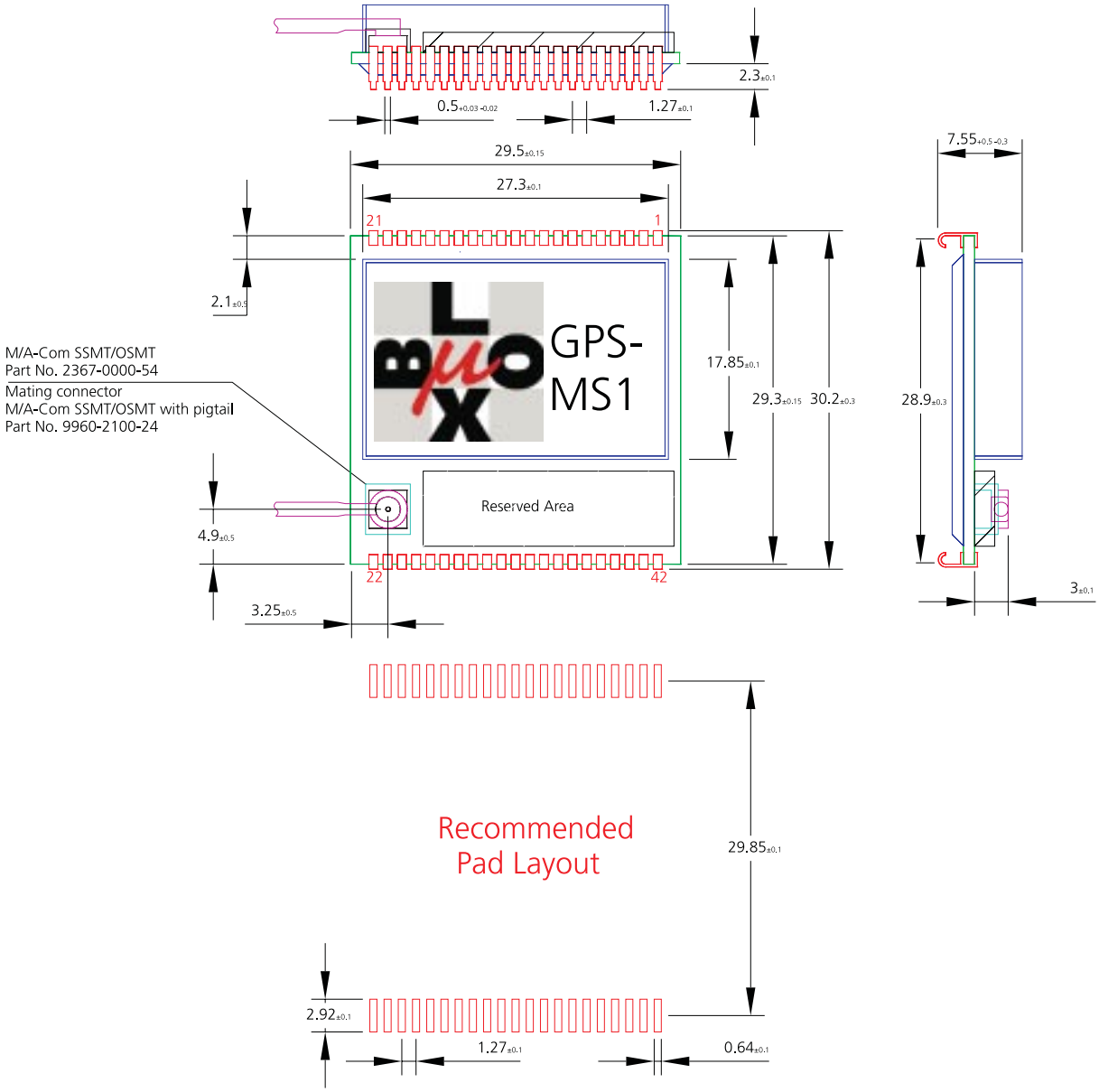

Figure 4: Mechanical Dimensions

The weight of the module is approximately 8 grams including the metal shield. The RF connector on the GPS-MS1 is a M/A-Com connector (see Table 8). 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 Part Number 9960-2100-24

Table 8: 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

8 Related Documents

- GPS-MS1/GPS-PS1 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).

9 Contact

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