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Low Power Mode Application Note

GPS-MS1, GPS-MS1E and GPS-PS1E

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Abstract

Starting with Firmware Version 1.3 of the µ-blox GPS receiver firmware, additional functionality has been introduced that adds low power modes available to the user. This paper discusses these low power modes, gives figures on the power savings and explains the low power states.

Introduction

The GPS-MS1, GPS-MS1E and GPS-PS1E have the capability to shut down and wake up at a predefined time under software control. This hardware capability allows the module to implement various low power scenarios, resulting in significantly reduced power consumption.

Definitions

Throughout this document, we use the terms defined below.

Operating Strategy This term describes a strategy of a receiver that defines if and how the receiver will perform under certain conditions. An Operating Strategy consists of a sequence of Operating States. Operating Strategies on µ-blox GPS receivers are **Continuous Mode**, **Trickle Power Mode** and **Push To Fix Mode**.

Operating State This term describes a state that the receiver is in and where it performs a certain action. The following table lists the available Operating State on the µ-blox GPS receivers.

Receiver Model	Track Mode	CPU Mode	Standby Mode
GPS-PS1	x		
GPS-MS1	x	(1)	x
GPS-PS1E	x	x	x
GPS-MS1E	x	x	x

(1):Equivalent to Track Mode

Table 1: Operating States on µ-blox GPS receivers

Continuous Mode (Operating Strategy) A GPS receiver which is configured for permanent Track mode, thereby outputting position information at a 1 Hz rate. No Low Power strategies are applied.

Trickle Power Mode (Operating Strategy) A GPS receiver which periodically enters Standby Mode in order to save power. In Trickle Power Mode, the unit outputs position information at a user-defined rate. Trickle Power Mode is a repeating sequence of Track Mode, CPU Mode and Standby Mode.

Push To Fix Mode (Operating Strategy) A GPS receiver which is in Standby Mode, except for when it is woken up by an external signal in order to calculate a position fix. Push To Fix Mode is a sequence of Standby Mode, Track Mode and CPU Mode.

Track Mode (Operating State) This Mode is part of the sequence used in Continuous Mode, Trickle Power Mode and Push To Fix Mode. During Track Mode, every section of the receiver is running, thereby consuming full power $I_{running}$[1].

CPU Mode (Operating State) This mode is part of the sequence used in Trickle Power Mode and Push To Fix Mode. During that mode, only the micro controller is running and no GPS satellites are being tracked. The purpose of this mode is to calculate a position solution based upon measurements previously taken in Track Mode. During that Mode, the unit requires I_{RF_Off}[2] .

Standby Mode (Operating State) In this mode, both the RF and CPU section of the receiver are unpowered, thereby reducing current consumption to $I_{standby}$. Standby Mode is left by either an RTC-driven wakeup event, or through external request

Table 2 gives an overview of power consumption in all operating states.

State	Current (typ.)	
Track Mode	$I_{running}$	140 mA
CPU Mode	I_{RF_Off}	34 mA
Standby Mode	$I_{standby}$	250 µA

Table 2: GPS-MS1 and GPS-MS1E Current Consumption

Which Operating Strategy to use

The following table shows selection criteria for operating modes best suited to your needs.

- Periodic Position Fixes required
- Power Consumption of minor concern

→ Continuous Mode

[1] GPS-PS1E units additionally provide Antenna Bias Voltage during that Mode. $I_{running}$ does not include any current consumed by the antenna

[2] On GPS-MS1, I_{RF_Off} is equivalent to $I_{running}$ since GPS-MS1 can not power RF and CPU sections independently

• Periodic Position Fixes required (1 Hz to 1/10 Hz) • Power Consumption critical	→ *Trickle Power Mode*
• Position Fix required upon demand. • Time from request to Fix can be > 30 seconds	→ *Continuous Mode. Shut off supply voltage to module if no data required*
• Position Fix required upon external request • Time from request to Fix must be < 6 seconds • Time between requests always < 15 Minutes	→ *Continuous Mode. Shut off supply voltage to module if no data required*
• Position Fix required upon external request • Time from request to Fix must be < 6 seconds • Downtime can be > 15 Minutes	→ *Push To Fix Mode*

Pin Description

See table 3 for a pin description for GPS-MS1 and GPS-MS1E. Please note that pin LP_A is only available on GPS-MS1 and N/C on GPS-MS1E. Please see the datasheets for GPS-MS1 and GPS-MS1E for detailed wiring instructions for Push To Fix and Trickle Power Mode.
GPS-PS1E units fully support Trickle Power Mode. They don't need special external wiring. GPS-PS1E receivers running Push To Fix Mode are available upon request.

Note – *GPS-PS1 receivers do not support any of the low power modes.*

Continuous Mode

In this mode, the module is constantly running. It outputs position information at a 1 Hz rate. Please see the datasheet for recommended external wiring.
This mode uses an average current of $I_{running}$ mA.

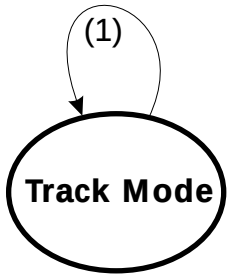

Figure 1: Continuous Mode State

The condition for (1) is ALWAYS

Trickle Power Mode

Trickle Power Mode is a term describing an operating strategy where the receiver periodically wakes up in track mode to receive GPS data , calculates a position fix in CPU mode, and returns to standby mode. The period of a full cycle is software adjustable in the range of one second up to ten seconds.

WAKEUP	Pin# 12, Output	This pin comes from the real-time clock. A 1 to 0 transition is performed after a time programmed from the firmware, indicating a standby to wakeup transition. A transition from 0 to 1 indicates the beginning of standby mode.
WAKEUP_N	Pin# 11, Output	This pin is the inverted equivalent of the pin WAKEUP
NMI	Pin# 7, Input	This is the NMI (non-maskable interrupt) pin to the SH-1 microprocessor. A 0 to 1 transition wakes up the SH-1 and restarts the firmware after a maximum of 100 ms.
LP_A	Pin#18, Input	**GPS-MS1:** This pin controls RF power. A high level powers the RF circuitry and therefore provides the cpu clock to the SH-1. A low level powers down the RF part. **GPS-MS1E:** This pin is N/C on GPS-MS1E

Table 3: GPS-MS1/GPS-MS1E Low-Power related pins

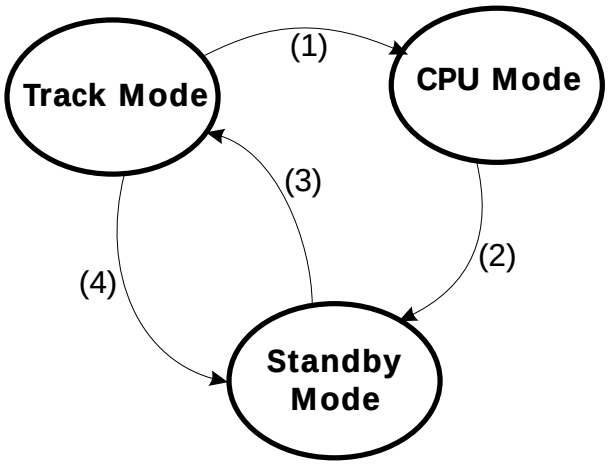

Figure 2: Trickle Power Mode State

The conditions for the state transitions above are:

(1) Ephemeris is available, RTC is calibrated and RF-On Time – as given by the user – has elapsed. If Ephemeris is not available, they receiver will stay in track mode. If the RTC is not calibrated, the receiver will stay in track mode.

(2) The receiver has finished calculating a position fix.

(3) The wakeup event – as given through duty cycle and RF-On Time – has occurred.

(4) No GPS signal coverage or unable to calibrate the RTC.

Besides this periodicity, the receiver has to receive and decode the navigation message to check for new ephemeris. This is done at most twice an hour or whenever a new SV rises above the horizon. It takes 18 seconds to update ephemeris. During that time, the unit is temporarily returning to Track Mode.
The following tables give an overview over recommended settings and expected power consumption.

Average Current I_{avg} $[mA]$				
D $[\%]$				
T_{RF_On} $[ms]$				
	1 s	200 ms	20.0 %	48 mA
Position	2 s	200 ms	10.0 %	25 mA
Update	3 s	300 ms	10.0 %	22 mA
Rate	4 s	300 ms	7.5 %	17 mA
T_{cycle}	6 s	300 ms	5.0 %	12 mA
$[s]$	8 s	300 ms	3.8 %	10 mA

*GPS-MS1E (labeled 9079-**C**00x)*

Average Current I_{avg} $[mA]$				
D $[\%]$				
T_{RF_On} $[ms]$				
	1 s	200 ms	20.0 %	114 mA
Position	2 s	200 ms	10.0 %	57 mA
Update	3 s	300 ms	10.0 %	43 mA
Rate	4 s	300 ms	7.5 %	33 mA
T_{cycle}	6 s	300 ms	5.0 %	22 mA
$[s]$	8 s	300 ms	3.8 %	17 mA

*GPS-MS1 4.3 (labeled 9079-**B**00x)*

Average Current I_{avg} $[mA]$				
D $[\%]$				
T_{RF_On} $[ms]$				
	1 s	300 ms	30.0 %	127 mA
Position	2 s	300 ms	15.0 %	71 mA
Update	3 s	400 ms	13.3 %	48 mA
Rate	4 s	400 ms	10.0 %	37 mA
T_{cycle}	6 s	400 ms	6.7 %	25 mA
$[s]$	8 s	400 ms	5.0 %	19 mA

*GPS-MS1 < 4.3 (labeled 9079-**A**00x)*

Longer Update periods (>10s) can be achieved by increasing the RF-On Time and Lowering the duty cycle.
The Average Current figures above include all power required to update ephemeris. These are long-term average current measurements.
The relation between Position Update Rate T_{cycle}, the Duty Cycle D and the RF-On Time T_{RF_On} is as follows:

$$D = \frac{T_{RF\_On}}{T_{cycle}}$$

For the *GPS-MS1*, the average power consumption I_{avg} can be estimate with:

$$\begin{aligned} I_{avg} &= \left(\frac{T_{RF\_On}+0.6}{T_{cycle}}+0.01\right) I_{running} \\ &+ \left(1-\frac{T_{RF\_On}+0.6}{T_{cycle}}\right) I_{standby} \end{aligned}$$

For the *GPS-MS1E*, the average power consumption I_{avg} can be estimated with:

$$\begin{aligned} I_{avg} &= \left(\frac{T_{RF\_On}}{T_{cycle}}+0.01\right) I_{running} \\ &+ \frac{0.6}{T_{cycle}} I_{RF\_Off} \\ &+ \left(1-\frac{T_{RF\_On}+0.6}{T_{cycle}}\right) I_{standby} \end{aligned}$$

Note – *When designing a system with* Trickle Power *enabled modules, keep in mind that serial communication with the receiver can only take place during the running state. In SiRF Binary protocol, the unit transmits synchronization messages to allow the receiving unit to synchronize data transmission with the On/Off sequence of the receiver.*

Trickle Power Mode is backward compatible with Continuous Mode, i.e. a Trickle Power capable module can also run in Continuous Mode (by changing the operating mode under software control).

Push to Fix Mode

Push To Fix is used for applications requiring fast startup times (TTFF < 6 seconds) whilst minimizing power consumption. 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.
The cycle time for ephemeris check is software adjustable and in the order of 300 seconds to 1800 seconds. Table 4 shows TTFF as a function of the Off Period.

Off Time [s]	$TTFF_{avg}$	$TTFF_{max}$
60	1.42	2.4
120	2.48	5.4
240	4.80	5.8
600	4.80	5.8

Table 4: TTFF in Push to Fix mode

When the surrounding system has the need for new position data, an additional external signal EXTWAKE can be made available (see the GPS-MS1 and GPS-MS1E datasheets for wiring of the required external OR-gate). As soon as this signal is applied, the receiver will start up, calculating a position fix as fast as possible.

Note –

- *EXTWAKE must be pulled high for at least 100ms.*
- *EXTWAKE must be glitch-free*
- *The rise time on the output of the OR gate must be < 100ns*

The receiver will then calculate a fix, recalibrate the RTC, possibly collect ephemeris and return to the Standby Mode afterwards.

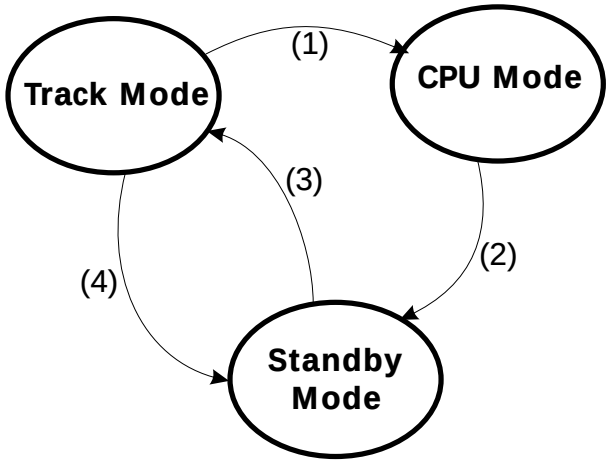

Figure 3: Push To Fix Mode States

The conditions for the state transitions above are:

(1) Position Fix is available and RTC calibrated.

(2) Finished last position fix calculation.

(3) The wakeup event – as given through the duty cycle – has occurred or EXTWAKE has been activated.

(4) No GPS signal coverage or unable to calibrate the RTC.

When designing a system with *Push to fix* enabled modules, keep in mind that serial communication with the module can only take place during the running state. In SiRF Binary protocol, the unit transmits synchronization messages to allow the receiving unit to synchronize data transmission with the On/Off sequence of the receiver.
Push to fix Mode is backward compatible with *Trickle Power Mode* and Continuous Mode.
In case there is no GPS signal coverage, the unit will go to sleep after 18 seconds of unsuccessful acquisition. It will retry according to the programmed duty cycle (default 30 minutes).

Important Considerations

- When designing a system with either Trickle Power Mode or Push-To-Fix mode, keep in mind that the power supply must be capable of delivering at least 140 mA peak, although the average power consumption will be much lower. This makes it difficult to develop devices that should be powered through an RS232 interface or from solar panels.
- If you are using an active antenna with GPS-MS1 or GPS-MS1E, you can use the WAKEUP_N signal for the shutdown input of the external antenna voltage regulator, so that in low-power state, the antenna is powered off, too. GPS-PS1E units control power to the antenna directly.

Related Documents

Related documents can be found at
`http://www.u-blox.ch/restricted`.

Revision History		
Date	**Revision**	**Changes**
Feb. 2000	1.0	Tables for Average Current Consumption, Added GPS-MS1E, New Power Estimation formulae, New Low-Power State Machine.
Nov. 20, 1998	0.91	Note on Power Supply Considerations
Nov. 10, 1998	0.90	Initial Version