

GPS Implementation

GPS Implementation and Aiding Features in u-blox wireless modules

Application Note

Abstract

This document provides a brief overview of firmware aspects of GPS implementation in u-blox wireless modules.

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1 Introduction

1.1 Scope



This document applies to the following products:

- LEON-G100 series
- LEON-G200 series
- LISA-U1 series

1.2 Overview

This Application Note provides necessary information to successfully develop location based M2M applications exploiting the GPS control functionalities of u-blox wireless modules. A proprietary AT command set leverages the application from direct control of the GPS module providing an easy and abstracted interface.

The following chapters describe the hardware and software architecture implemented in the wireless module for connection with u-blox GPS receivers. A detailed description is then provided for aiding modes implemented to improve GPS performance.

Although GPS is a widespread technology, its reliance on the visibility of extremely weak GPS satellite signals means that positioning is not always possible. This limitation can be overcome with Hybrid positioning technology where cellular network information is used (CellLocate™) to complement GPS and provide positioning information even when GPS reception is degraded or absent. Hybrid positioning and CellLocate™ features are described in chapter 7.

The following symbols are used to highlight important information within the document:



An index finger points out key information pertaining to integration and performance.



A warning symbol indicates actions that could negatively impact or damage the module.

1.3 AT Commands

This document explains all allowed operations that can be performed with a u-blox wireless module connected to a u-blox GPS receiver by AT commands. Please refer to u-blox AT commands manual [1] for a complete description and syntax of the AT commands. The most important AT commands described in this document are listed as follows:

- GPS Power Management configuration +UGPS
- Assisted GPS unsolicited indication +UGIND
- GPS Profile configuration +UGPRF
- AssistNow Online configuration +UGAOP
- AssistNow Offline configuration +UGAOF
- GPS Aiding request command +UGAOS
- Ask for localization information +ULOC
- Configure GPS sensor +ULOCGNSS
- Configure cellular location sensor (CellLocate) +ULOCCELL

2 Hardware Architecture

2.1 General considerations

u-blox has implemented special features in its wireless modules to ease the design efforts required to integrate u-blox wireless modules and GPS receivers.

u-blox wireless modules feature embedded u-blox AssistNow A-GPS aiding software for faster and more accurate GPS performance. Combining a u-blox wireless module with a u-blox GPS receiver gives designers full access to the GPS receiver directly via the wireless module: control messages are relayed to the GPS receiver via a dedicated I²C compliant DDC interface, making a second interface connected to the GPS receiver unnecessary: AT commands via the wireless module's UART interface allow full control of the GPS receiver from the host processor.

The wireless module's DDC interface is exclusively dedicated for connection to u-blox GPS receivers and cannot be used to control other peripherals: the DDC interface is only enabled by the AT+UGPS command (for more details refer to u-blox AT Commands Manual [1]).



The u-blox wireless module's DDC interface pins (i.e. the **SDA** and **SCL** pins) must be properly connected to the DDC interface pins of the u-blox GPS receiver (i.e. the SDA2 and SCL2 pins) on the application board to take advantage of the embedded A-GPS features.

For compliance with the I²C bus specifications, the module pads of the bus interface are open drain output, therefore pull up resistors must be used. Since these pull-up resistors are not included within the module, they must be externally mounted and their values must conform to the I²C bus specifications [9]. The signal shape is defined by the pull-up resistors values and bus capacitance. Long wires on the bus will increase the capacitance: if this capacitance value is increased, pull-up resistors with nominal resistance value lower than 4.7 kΩ should be used to match the I²C bus specifications [9] regarding rise and fall times of the signals.



Pull-up resistors for the DDC lines must be connected to a proper supply voltage, which differs depending on the u-blox wireless module series.



Capacitance and series resistance must be limited on the bus to match the I²C specifications [9] (the maximum allowed rise time on the **SCL** and **SDA** lines is 1.0 μs): route connections must be kept as short as possible.

The GPIO pins of u-blox wireless module can configure additional functionalities of the GPS receiver: i.e. reduced power consumption and faster Time to First Fix (TTFF) performance.



The support of the different types of embedded GPS aiding features and of additional functionalities configured by the wireless module's GPIOs can vary depending on the u-blox wireless module series and version.

The following sections describe the hardware connection between different u-blox wireless module series and u-blox GPS receivers. For further details refer to LEON-G100 / LEON-G200 System Integration Manual [4] and LISA-U series System Integration Manual [5].

2.2 Hardware architecture with LEON-G100 / LEON-G200 series

2.2.1 Hardware architecture with LEON-Gx00-05 and LEON-Gx00-04

LEON-G100-05 / LEON-G200-05 and previous versions support these GPS aiding types:

- Local aiding
- AssistNow Online
- AssistNow Offline

The embedded GPS aiding features can only be used if the DDC (I²C) interface of the wireless module is connected to u-blox GPS receivers: the **SDA** and **SCL** pins of the u-blox wireless module must be properly connected to the SDA2 and SCL2 pins of the u-blox GPS receiver.



The pull-ups must be connected to a supply voltage of 3.0 V (typical), since this is the voltage domain of the DDC (I²C) pins of LEON-G100 / LEON-G200 series modules (for detailed electrical characteristics see LEON-G100/G200 Data Sheet [6]).

GPIO pins of LEON-G100-05 / LEON-G200-05 and previous versions can handle:

- GPS receiver power on/off (“GPS supply enable” function provided by **GPIO2**)



“GPS data ready” and “GPS RTC sharing” functions are not available on LEON-G100-05 / LEON-G200-05 and previous versions.



LEON-G100-05 / LEON-G200-05 and previous versions don't enter idle mode when the DDC (I²C) interface is enabled by the AT+UGPS command, even if power saving is enabled by the AT+UPSV command.

GPIO2 pin is by default configured to provide the “GPS supply enable” function (parameter <gpio_mode> of AT+UGPIOC command set to 3 by default), to enable or disable the supply of the u-blox GPS receiver connected to the wireless module by the AT+UGPS command. The pin is set as:

- Output / High, to switch on the u-blox GPS receiver, if the parameter <mode> of AT+UGPS command is set to 1
- Output / Low, to switch off the u-blox GPS receiver, if the parameter <mode> of AT+UGPS command is set to 0 (default setting)

The pin must be connected to the active-high enable pin (or the active-low shutdown pin) of the voltage regulator that supplies the u-blox GPS receiver on the application board.

The “GPS supply enable” function improves the power consumption of the GPS receiver. When GPS functionality is not required, the wireless module controlled by the application processor can completely switch off the GPS receiver using AT commands.

The application circuit for the connection of LEON-G100-05 / LEON-G200-05 and previous versions to a u-blox 3.0 V GPS receiver is illustrated in Figure 1 and the suggested components are listed in Table 1. A pull-down resistor is mounted on the **GPIO2** line to avoid a switch on of the GPS receiver when the wireless module is switched off and its digital pins are tri-stated.

The **V_BCKP** supply output of the LEON-G100-05 / LEON-G200-05 and previous versions is connected to the **V_BCKP** backup supply input pin of the GPS receiver to provide the supply for the GPS real time clock and backup RAM when the **VCC** supply of the wireless module is within its operating range and the **VCC** supply of the GPS receiver is disabled. This enables the u-blox GPS receiver to recover from a power breakdown with either a Hot start or a Warm start (depending on the duration of the GPS **VCC** outage) and to maintain the configuration settings saved in the backup RAM.

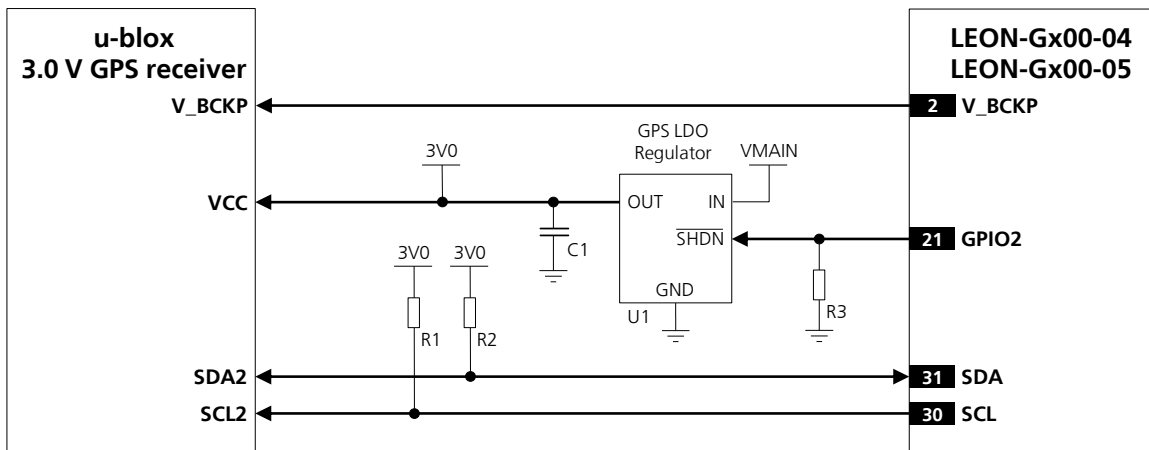


Figure 1: Application circuit for LEON-G100-05 / LEON-G200-05 modules and previous versions and u-blox 3.0 V GPS receivers

Reference	Description	Part Number - Manufacturer
R1, R2	4.7 kΩ Resistor 0402 5% 0.1 W	RC0402JR-074K7L - Yageo Phycomp
R3	47 kΩ Resistor 0402 5% 0.1 W	RC0402JR-0747KL - Yageo Phycomp
U1	Voltage Regulator for GPS Receiver	See GPS Receiver Hardware Integration Manual

Table 1: Components for LEON-G100-05 / LEON-G200-05 modules and previous versions and u-blox 3.0 V GPS receivers' application circuit

2.2.2 Hardware architecture with LEON-G100-06 / LEON-G200-06

LEON-G100-06 / LEON-G200-06 versions support these GPS aiding types:

- Local aiding
- AssistNow Online
- AssistNow Offline
- AssistNow Autonomous

The embedded GPS aiding features can only be used if the DDC (I²C) interface of the wireless module is connected to u-blox GPS receivers: the **SDA** and **SCL** pins of the u-blox wireless module must be properly connected to the SDA2 and SCL2 pins of the u-blox GPS receiver.



The pull-ups must be connected to a supply voltage of 3.0 V (typical), due to the voltage domain of the DDC (I²C) pins of LEON-G100 / LEON-G200 series modules (for detailed electrical characteristics see LEON-G100/G200 Data Sheet [7]).

GPIO pins of LEON-G100-06 / LEON-G200-06 can handle:

- GPS receiver power on/off ("GPS supply enable" function provided by **GPIO2**)
- Wake up from idle mode when the GPS receiver is ready to send data ("GPS data ready" function provided by **GPIO3**)
- The RTC synchronization signal to the GPS receiver ("GPS RTC sharing" function provided by **GPIO4**)

GPIO2 pin is by default configured to provide the “GPS supply enable” function (parameter <gpio_mode> of AT+UGPIOC command set to 3 by default), to enable or disable the supply of the u-blox GPS receiver connected to the wireless module by the AT+UGPS command. The pin is set as:

- Output / High, to switch on the u-blox GPS receiver, if the parameter <mode> of AT+UGPS command is set to 1
- Output / Low, to switch off the u-blox GPS receiver, if the parameter <mode> of AT+UGPS command is set to 0 (default setting)

The pin must be connected to the active-high enable pin (or the active-low shutdown pin) of the voltage regulator that supplies the u-blox GPS receiver on the application board.

The “GPS supply enable” function improves the GPS receiver’s power consumption. When GPS functionality is not required, the application processor can completely switch off the GPS receiver using AT commands via the wireless module.

GPIO3 pin is by default configured to provide the “GPS data ready” function (parameter <gpio_mode> of AT+UGPIOC command set to 4 by default), to detect when the u-blox GPS receiver is ready to send data via the DDC (I²C) interface. The pin is set as:

- Input, to detect the line status, waking up the wireless module from idle mode when the u-blox GPS receiver is ready to send data by the DDC (I²C) interface; this is possible if the <mode> parameter of +UGPS AT command is set to 1 and the parameter <GPS_IO_configuration> of +UGPRF AT command is set to 16; for more details on AT commands description refer to u-blox AT commands manual [1]
- Tri-state with an internal active pull-down enabled, otherwise (default setting)

The pin must be connected to the data ready output of the u-blox GPS receiver (i.e. TxD1) on the application board.

The “GPS data ready” function improves the wireless module’s power consumption. When power saving is enabled in the wireless module by the AT+UPSV command, the module automatically enters idle mode whenever possible when the GPS receiver doesn’t send data by the DDC (I²C) interface. The **GPIO3** pin can be used by the GPS receiver to indicate to the wireless module that it is ready to send data by the DDC (I²C) interface to wake up the wireless module if it is in idle mode, so that data sent by the GPS receiver will not be lost by the wireless module even if power saving is enabled.

GPIO4 pin is by default configured to provide the “GPS RTC sharing” function (parameter <gpio_mode> of AT+UGPIOC command set to 5 by default), to provide a synchronization timing signal at the power up of the u-blox GPS receiver connected to the wireless module. The pin is set as:

- Output, to provide a synchronization timing signal to the u-blox GPS receiver for RTC sharing if the parameter <mode> of AT+UGPS command is set to 1 and the parameter <GPS_IO_Configuration> of +UGPRF AT command is set to 32; for more details on AT commands description refer to u-blox AT commands manual [1]
- Output / Low, otherwise (default setting)

The pin must be connected to the synchronization timing input of the u-blox GPS receiver (i.e. the pin EXTINT0 of the u-blox GPS receiver) on the application board.

The “GPS RTC sharing” function improves the GPS receiver performance, decreasing the TTFF and increasing accuracy. When GPS local aiding is enabled, the wireless module automatically uploads data such as position, time, ephemeris, almanac, health and ionospheric parameter from the GPS receiver into its local memory, and restores this back to the GPS receiver at its next power up.

The application circuit for the connection of LEON-G100-06 / LEON-G200-06 wireless modules to a u-blox 3.0 V GPS receiver is illustrated in Figure 2 and the suggested components are listed in Table 2. A pull-down resistor is mounted on the **GPIO2** line to avoid a switch on of the GPS receiver when the wireless module is switched off and its digital pins are tri-stated.

The **V_BCKP** supply output of the LEON-G100-06 / LEON-G200-06 wireless modules is connected to the **V_BCKP** backup supply input pin of the GPS receiver to provide the supply for the GPS real time clock and backup RAM when the **VCC** supply of the wireless module is within its operating range and the **VCC** supply of the GPS receiver is disabled. This enables the u-blox GPS receiver to recover from a power outage with either a Hot start or a Warm start (depending on the duration of the GPS **VCC** outage) and to maintain the configuration settings saved in the backup RAM.

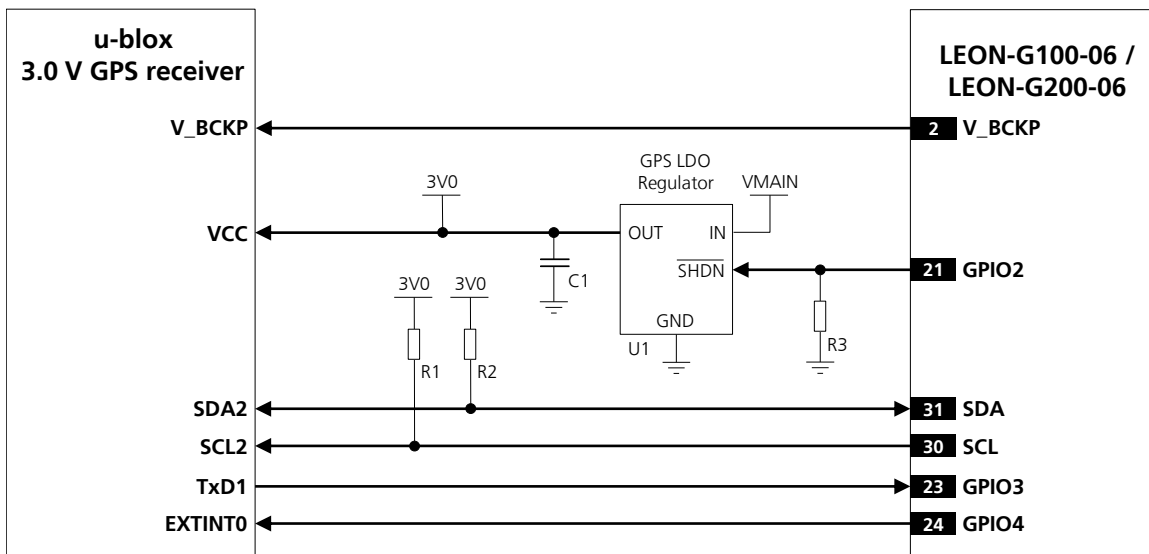


Figure 2: Application circuit for LEON-G100-06 / LEON-G200-06 wireless modules and u-blox 3.0 V GPS receivers

Reference	Description	Part Number – Manufacturer
R1, R2	4.7 kΩ Resistor 0402 5% 0.1 W	RC0402JR-074K7L – Yageo Phycomp
R3	47 kΩ Resistor 0402 5% 0.1 W	RC0402JR-0747KL - Yageo Phycomp
U1	Voltage Regulator for GPS Receiver	See GPS Receiver Hardware Integration Manual

Table 2: Components for LEON-G100-06 / LEON-G200-06 wireless modules and u-blox 3.0 V GPS receivers' application circuit

2.3 Hardware architecture with LISA-U1 series

LISA-U1 series modules support these GPS aiding types:

- Local aiding
- AssistNow Online
- AssistNow Offline
- AssistNow Autonomous



LISA-U1x0-00 versions don't support AssistNow Autonomous GPS aiding.

The embedded GPS aiding features can be only used if the DDC (I²C) interface of the wireless module is connected to u-blox GPS receivers: the **SDA** and **SCL** pins of the u-blox wireless module must be properly connected to the SDA2 and SCL2 pins of the u-blox GPS receiver.



The pull-ups must be connected to a supply voltage of 1.8 V (typical), due to the voltage domain of the DDC (I²C) pins of LISA-U1 series modules. **V_INT** digital interfaces supply output pin of the module can be used to provide the 1.8 V supply for the pull-ups (for detailed electrical characteristics see the LISA-U1 series Data Sheet [8]).

GPIO pins of LISA-U1 series modules can handle:

- GPS receiver power on/off (“GPS supply enable” function provided by **GPIO2**)
- Wake up from idle mode when the GPS receiver is ready to send data (“GPS data ready” function provided by **GPIO3**)
- The RTC synchronization signal to the GPS receiver (“GPS RTC sharing” function provided by **GPIO4**)



LISA-U1x0-00 modules versions don't support “GPS data ready” and “GPS RTC sharing” functions.



LISA-U1x0-00 modules versions don't enter idle mode when the DDC (I²C) interface is enabled by the AT+UGPS command, even if power saving is enabled by the AT+UPSV command.

The **GPIO2** pin is by default configured to provide the “GPS supply enable” function (parameter <gpio_mode> of AT+UGPIOC command set to 3 by default), to enable or disable the supply of the u-blox GPS receiver connected to the wireless module by the AT+UGPS command. The pin is set as:

- Output / High, to switch on the u-blox GPS receiver, if the parameter <mode> of AT+UGPS command is set to 1
- Output / Low, to switch off the u-blox GPS receiver, if the parameter <mode> of AT+UGPS command is set to 0 (default setting)

The pin must be connected to the active-high enable pin (or the active-low shutdown pin) of the voltage regulator that supplies the u-blox GPS receiver on the application board.

The “GPS supply enable” function improves the GPS receiver's power consumption. When the GPS functionality is not required, the application processor can completely switch off the GPS receiver using AT commands via the wireless module.

The **GPIO3** pin is by default configured to provide the “GPS data ready” function (parameter <gpio_mode> of AT+UGPIOC command set to 4 by default), to sense when the u-blox GPS receiver connected to the wireless module is ready to send data by the DDC (I²C) interface. The pin will be set as

- Input, to detect the line status, waking up the wireless module from idle mode when the u-blox GPS receiver is ready to send data by the DDC (I²C) interface, if the parameter <mode> of +UGPS AT command is set to 1 and the parameter <GPS_IO_Configuration> of +UGPRF AT command is set to 16; for more details on AT commands description refer to u-blox AT commands manual [1]
- Tri-state with an internal active pull-down enabled, otherwise (default setting)

The pin that provides the “GPS data ready” function must be connected to the data ready output of the u-blox GPS receiver (i.e. TxD1) on the application board.

The “GPS data ready” function improves the wireless module's power consumption. When power saving is enabled in the wireless module by the AT+UPSV command and the GPS receiver doesn't send data by the DDC (I²C) interface, the module automatically enters idle mode whenever possible. With the “GPS data ready” function the GPS receiver indicates to the wireless module that it is ready to send data by the DDC (I²C) interface: the GPS receiver can wake up the wireless module if it is in idle mode, so that data sent by the GPS receiver will not be lost by the wireless module even if power saving is enabled.

The **GPIO4** pin is by default configured to provide the “GPS RTC sharing” function (parameter <gpio_mode> of +UGPIOC AT command set to 5), to provide an RTC (Real Time Clock) synchronization signal at the power up of the u-blox GPS receiver connected to the wireless module. The pin will be set as:

- Output, to provide an RTC synchronization signal to the u-blox GPS receiver for RTC sharing if the parameter <mode> of AT+UGPS command is set to 1 and the parameter <GPS_IO_Configuration> of +UGPRF AT command is set to 32
- Output / Low, otherwise (default setting)

The pin that provides the “GPS RTC sharing” function must be connected to the RTC synchronization signal of the u-blox GPS receiver (i.e. EXTINT0) on the application board.

The “GPS RTC sharing” function provides improved GPS receiver performance, decreasing the TTFF and improving accuracy. When GPS local aiding is enabled, the wireless module automatically uploads data such as position, time, ephemeris, almanac, health and ionospheric parameter from the GPS receiver into its local memory, and restores this to the GPS receiver at its next power up.

The application circuit for the connection of a LISA-U1 series wireless module to a u-blox 1.8 V GPS receiver is illustrated in Figure 3 and the suggested components are listed in Table 3.

SDA and **SCL** pins of the LISA-U series wireless module are directly connected to the relative pins of the u-blox 1.8 V GPS receiver, with appropriate pull-up resistors.

GPIO3 and **GPIO4** pins are directly connected respectively to the **TxD1** and **EXTINT0** pins of the u-blox 1.8 V GPS receiver to provide “GPS data ready” and “GPS RTC sharing” functions.

A pull-down resistor is mounted on the **GPIO2** line to avoid a switch on of the GPS module when the LISA-U1 series module is in the internal reset state.

The **V_BCKP** supply output of the LISA-U series wireless module is connected to the **V_BCKP** backup supply input pin of the GPS receiver to provide the supply for the GPS real time clock and backup RAM when the **VCC** supply of the wireless module is within its operating range and the **VCC** supply of the GPS receiver is disabled. This enables the u-blox GPS receiver to recover from a power breakdown with either a Hot start or a Warm start (depending on the duration of the GPS **VCC** outage) and to maintain the configuration settings saved in the backup RAM.

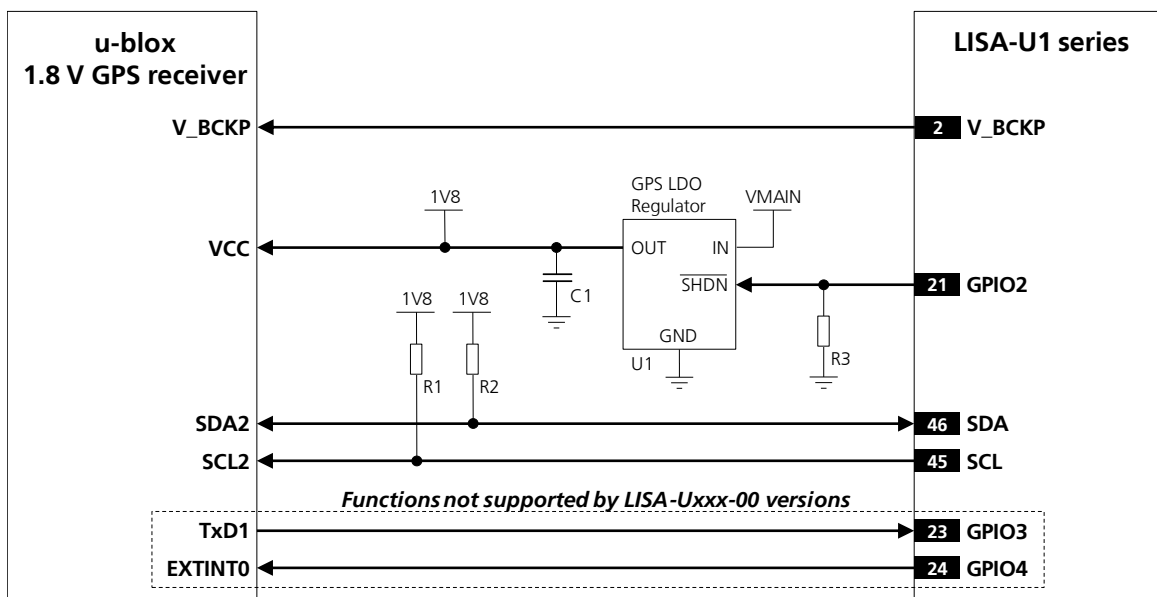


Figure 3: Application circuit for LISA-U1 series wireless modules and u-blox 1.8 V GPS receivers

Reference	Description	Part Number – Manufacturer
R1, R2	4.7 kΩ Resistor 0402 5% 0.1 W	RC0402JR-074K7L – Yageo Phycomp
R3	47 kΩ Resistor 0402 5% 0.1 W	RC0402JR-0747KL - Yageo Phycomp
U1	Voltage Regulator for GPS Receiver	See GPS Receiver Hardware Integration Manual

Table 3: Components for LISA-U1 series wireless modules and u-blox 1.8 V GPS receivers' application circuit



“GPS data ready” and “GPS RTC sharing” functions are not supported by all u-blox GPS receiver HW or ROM/FW versions. Refer to the Hardware Integration Manual of the u-blox GPS receivers for the supported functions.

If a 3 V u-blox GPS receiver is used, the **SDA**, **SCL**, **GPIO3** and **GPIO4** pins of the LISA-U1 series wireless module cannot be directly connected to the 3.0 V u-blox GPS receiver: a proper appropriate I²C-bus bidirectional voltage translator must be used for the **SDA** and **SCL** signals, and a general purpose voltage translator must be used for the **GPIO3** and **GPIO4** signals. The **V_BCKP** supply output of the wireless module can be directly connected to the **V_BCKP** backup supply input pin of the GPS receiver as in the application circuit for a u-blox 1.8 V GPS receiver.

An application circuit for the connection of a LISA-U1 series wireless module to a u-blox 3.0 V GPS receiver is illustrated in Figure 4 and the suggested components are listed in Table 4. A pull-down resistor is mounted on the **GPIO2** line to avoid a switch on of the GPS module when the LISA-U1 series module is in the internal reset state.

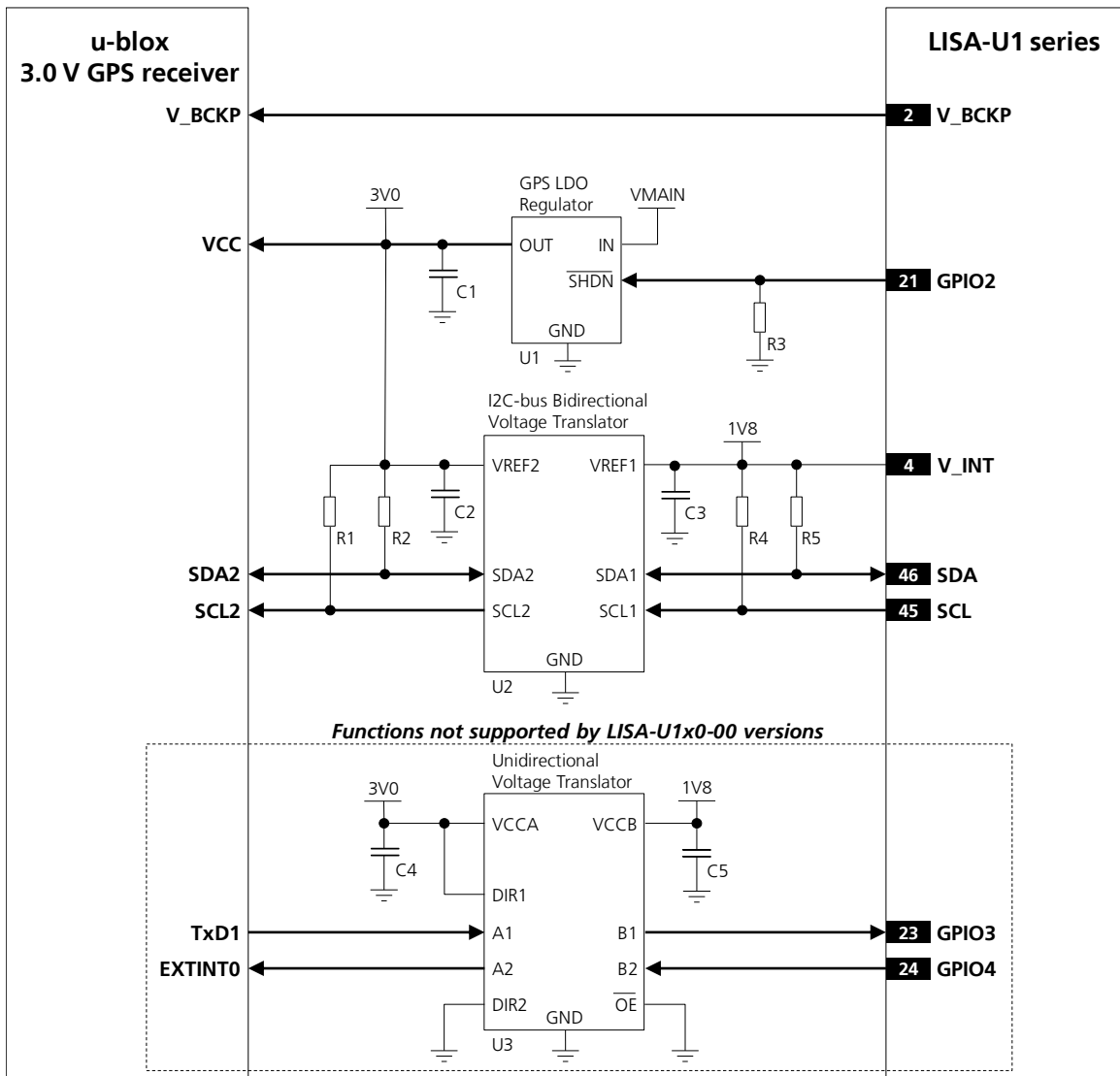



Figure 4: Application circuit for LISA-U1 series wireless modules and u-blox 3.0 V GPS receivers

Reference	Description	Part Number – Manufacturer
R1, R2, R4, R5	4.7 kΩ Resistor 0402 5% 0.1 W	RC0402JR-074K7L – Yageo Phycomp
R3	47 kΩ Resistor 0402 5% 0.1 W	RC0402JR-0747KL - Yageo Phycomp
C2, C3, C4, C5	100 nF Capacitor Ceramic X5R 0402 10% 10V	GRM155R71C104KA01 - Murata
U1	Voltage Regulator for GPS Receiver	See GPS Receiver Hardware Integration Manual
U2	I2C-bus Bidirectional Voltage Translator	PCA9306DCURG4 - Texas Instruments
U3	Generic Bidirectional Voltage Translator	TXB0104PWR - Texas Instruments

Table 4: Components for LISA-U1 series wireless modules and u-blox 3.0 V GPS receivers' application circuit

3 Software architecture







The u-blox wireless module has full control over the GPS receiver and can power it on and off, send and receive commands using proprietary UBX protocol and receive positioning information through NMEA strings.

 **To avoid I²C interface lock in case of an external reset of the GPS receiver during I²C communication an automatic recovery mechanism is implemented, in case this system fails as well, a power-cycle of the wireless module is required to restore normal functionality.**

3.1 “GPS data ready” function

On LISA-U1x0-00 versions and LEON-G100-05 / LEON-G200-05 (and previous versions), data is read from the I²C interface by polling the bus every 200 ms. The “GPS data ready” function is implemented to avoid polling the I²C bus when no data is available.




To enable this function, AT+UGPRF command must be used (please refer to u-blox AT commands manual [1] for more details).

-  With u-blox 6 GPS receivers, when the GPS is powered on, the GPS UART1 is disabled and TxD1 pin is used to handle interrupts when data is available.
-  “GPS data ready” function is not supported by LEON-Gx00-05 and previous versions or by LISA-U1x0-00 versions.
-  The function is supported in u-blox 6 GPS receivers with FW version 7 or higher.
-  Polling mode is automatically used when the GPS receiver does not support this function.
-  If the “GPS data ready” function is not working (e.g. line not connected, wrong configuration, etc) the wireless module will automatically switch back to polling mode.
-  On LEON-G100 / LEON-G200 series if “GPS data ready” function is enabled but the pin is not physically connected, the wireless module will not be able to read data from the GPS receiver.

3.2 Sending UBX strings via AT commands

It is possible to send commands to the GPS receiver in proprietary UBX format through the AT interface: UBX strings are encapsulated into AT+UGUBX command (for more details please refer to the command description in u-blox AT Commands Manual [1]).

The UBX message must be in hexadecimal format: spacing bytes is not mandatory although messages can include spaces to simplify copy/paste from u-center, e.g. AT+UGUBX=“B5 62 06 01 08 00 01 06 00 01 00 00 00 00 17 DA” is equivalent to: AT+UGUBX=“B56206010800010600010000000017DA”.

-  The total length of the command AT+UGUBX shall not exceed 108 bytes (including spaces inserted in the UBX string). If the message length is exceeded or if the command is wrong, the generic ERROR message will be sent as a command answer.
-  The use of UBX CFG-PRT command is not recommended since the wireless module can lose communication with the GPS receiver. In this case, even if the command is correctly executed, it’s possible to receive an error indication due to the missing GPS receiver answer.
-  The UBX checksum is automatically calculated by the wireless module before sending the message to the GPS receiver.

When the GPS receiver is off or used for Hybrid Positioning the UBX string is saved in RAM and passed to the GPS receiver as configuration for “GPS data ready” function when the GPS receiver is used. This message is only

used if the GPS receiver HW is unknown to the wireless module FW (i.e. newer the GPS receiver is newer than the wireless FW).



On LEON-G100 / LEON-G200 series and LISA-U1x0-00 module versions use the command AT+UGUBX can be only used when the GPS is used from the AT interface (power on by AT+UGPS=1,x). External configuration for "GPS data ready" function is not supported.

4 GPS Basic Operation

4.1 Aiding support

Standard GPS can't always provide instant position information because it is necessary to receive signals from at least four satellites to derive their precise orbital position data, called ephemeris. Under adverse signal conditions, data download from the satellites to the receiver can take minutes, hours or even fail altogether. Assisted GPS (A-GPS) boosts acquisition performance by providing data such as ephemeris, almanac, accurate time and satellite status to the GPS receiver via mobile networks or previously stored information. Aiding data enables the receiver to compute a position within seconds, even under poor signal conditions. For timings scenarios, please refer to the u-blox Receiver Description [10].

4.2 Using GPS without aiding support

The typical operating mode has the GPS receiver activated via wireless module without any aiding mode. This is equivalent to switching on the GPS as a stand-alone, sending commands and receiving data using the AT commands port of the wireless module. A command sequence can be found below.

The answer to the AT+UGPS=1,x command will be "OK" if the GPS receiver responds within 5 s, otherwise an error message is reported.

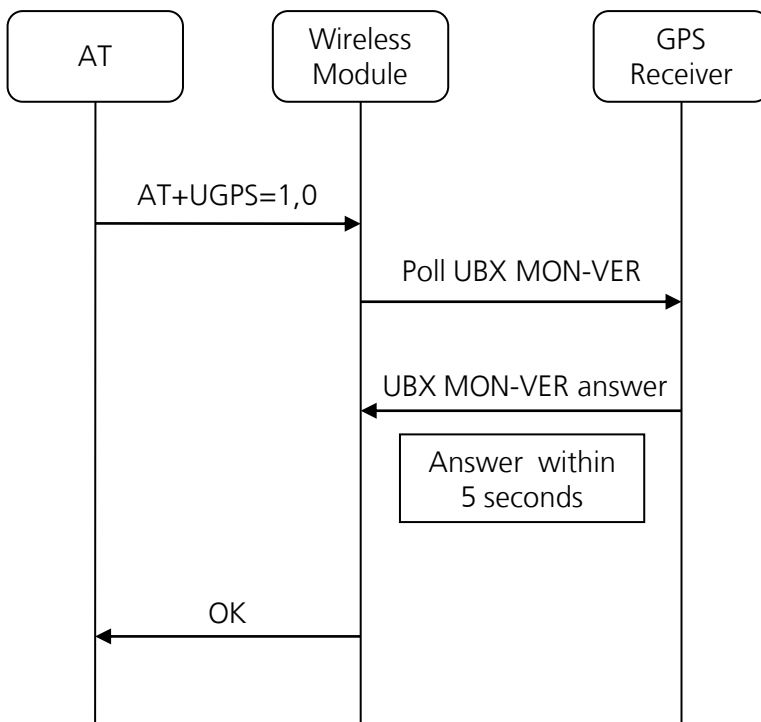


Figure 5: Interaction between the wireless module and GPS receiver without aiding support

Command	Response	Description
AT+UGRMC=1	OK	Enable storing of the last value NMEA \$RMC string
AT+UGPS=1,0	OK	Start up the GPS
		Allow the GPS enough time to perform a fix

Command	Response	Description
AT+UGRMC?	+UGRMC : 1, \$GPRMC,,V,,,,,,,,,N*53 OK	Read the last stored value of the NMEA \$RMC string
AT+UGPS=0	OK	Stop the GPS

Table 5: AT command example without aiding support

4.3 Reading NMEA strings

u-blox wireless modules support reading NMEA strings from the GPS receiver through the AT command port. Before being able to read a specific NMEA string, it is necessary to activate storage of the last value of that particular NMEA string.

If storing a particular NMEA string was not activated, the response to the query will be "0, Not available".

The last value of a specific NMEA string is stored in RAM and is made available even after GPS switch off.



For a complete list of supported NMEA strings as well as the related commands description refer to u-blox AT commands manual [1], +UGZDA, +UGGGA, +UGGLL, +UGGSV, +UGRMC, +UGVTG, +UGGSA commands.

Command	Response	Description
AT+UGRMC=1	OK	Activate storing of the last value of \$RMC NMEA string
AT+UGZDA=1	OK	Activate storing of the last value of \$ZDA NMEA string
AT+UGPS=1, 1	OK	Start the GPS with local aiding
	+UUGIND: 1, 0	URC reporting GPS mode "Local Aiding" ('1') and "No error" ('0')
AT+UGRMC?	+UGRMC : 1, \$GPRMC,,V,,,,,,,,,N*53 OK	Read the last stored value of the NMEA \$RMC string
AT+UGZDA?	+UGZDA: 1, \$GPZDA, ... OK	Read the last stored value of the NMEA \$ZDA string
AT+UGPS=0	OK	Stop the GPS
AT+UGRMC?	+UGRMC: 1, \$GPRMC, ... OK	Read the last string of the NMEA \$RMC string
		The GPS is switched off, this string is the last one saved while the GPS was active.
AT+UGGGA?	+UGZDA: 0, NULL OK	If storing of the last value of the \$GGA string was not activated before, its value cannot be read.

Table 6: NMEA string reading

5 Aiding features

The basic command used to activate and deactivate the GPS receiver from the wireless module is AT+UGPS. The first parameter allows switching on (value = 1) or switching off (value = 0).

When the GPS receiver is switched on by AT+UGPS command the aiding mode must be configured through the second parameter of the same command. GPS Aiding is a set of specific features developed by u-blox to enhance GPS performance, decreasing the TTFF and increasing accuracy. For more details refer to u-blox Receiver Description [10].

u-blox wireless modules support 4 different types of GPS aiding:

- Local aiding
- AssistNow Offline
- AssistNow Online
- AssistNow Autonomous

The second parameter of AT+UGPS command allows configuration of one or more assistance modes (e.g. '4' for AssistNow Online), or '0' if no aiding mode is required. For more details refer to u-blox AT commands manual [1], +UGPS AT command.



On LEON-G100-05 / LEON-G200-05 and previous version, it is not possible to switch aiding mode while the GPS receiver is active.

Each aiding mode is briefly described in the following paragraphs. For additional information, please refer to u-blox Receiver Description [10]. Some common points:

- No aiding mode is enabled by default: when switching on the GPS receiver, it is necessary to specify the desired aiding mode(s)
- GPS aiding modes can be combined to further increase performance, additional details are provided below (available from LEON-G100-06 / LEON-G200-06)
- Some assistance modes require a packet data connection to exchange information with u-blox servers
- When the GPS receiver is switched on through the wireless module, "OK" is returned on the serial port once the communication is established. If the GPS does not respond within 5 s, an error message is returned: in this case check the I²C interface and the power supply pin connection
- Once the communication between wireless module and GPS receiver is established on the I²C interface, the wireless module will try to perform the requested aiding type. In case of aiding failure (e.g. no network coverage, no GPRS connection active, expired alp file etc.) the GPS receiver will operate without aiding



The aiding notification is provided by +UUGIND URC. The allowed aiding results are available in chapter 5.6. The feature is disabled by default and is enabled via the dedicated command AT+UGIND=1 (for more details refer to u-blox AT Commands Manual [1]).



AssistNow Autonomous is not available on LEON-G100-05 / LEON-G200-05 and previous versions or on LISA-U1x0-00 versions.

Applications should enable GPS-related URCs. Once the application has activated GPS-related URCs and started the GPS with the required aiding mode, URCs should be monitored to verify successful completion. An example of AT command sequence is shown below:

Command	Response	Description
AT+UGRMC=1	OK	Activate storing of \$RMC NMEA string

Command	Response	Description
AT+UGIND=1	OK	Enable GPS-related URCs
AT+UGPS=1, 1	OK	Start the GPS with local aiding
	+UUGIND: 1, 0	URC reporting GPS mode "Local Aiding" ('1') and "No error" ('0')
AT+UGRMC?	+UGRMC : 1, \$GPRMC,,V,,,,,,,,,N*53 OK	Read the last stored value of the NMEA \$RMC string
AT+UGPS=0	OK	Stop the GPS

Table 7: GPS aiding modes AT command sequence

5.1 Using GPS with Local Aiding support

When local aiding is enabled, the wireless module automatically saves GPS-related data (position, time, ephemerides, almanac, health and ionosphere parameters) and GSM/WCDMA Cell ID on which the wireless module is camping before GPS shut down. No data connection over the cellular network is required for local aiding. Local aiding is activated setting the second parameter of AT+UGPS to 1 (AT+UGPS=1,1). For more details refer to u-blox AT commands manual [1].

Assistance Data is stored in a dedicated area within the wireless module's file system and is not visible or accessible to the user. At subsequent GPS start up, location data is uploaded from the wireless module to the GPS receiver. The total data size is about 2 kB.



In LEON-G100 / LEON-G200 series the space in the file system is reserved.



In LISA-U1 series the common file system space is used.

Local Aiding algorithm uses the last known position and adjusts its accuracy according to the elapsed time. However, if the Cell ID has not changed, the last known position is used with an accuracy figure of a maximum cell coverage radius (35 km).

In case no information regarding the previous position is available, a central position of the network is used (e.g. Rome for Italian networks) with the accuracy figure reflecting the uncertainty (e.g. 700 km in the case of Italy).

Aiding data can be manually saved at any time from the GPS to the wireless module by sending the command AT+UGAOS=0. This operation is automatically performed when local aiding is enabled and the GPS is switched off with AT+UGPS=0.

If local aiding is enabled and the stored aiding data is obsolete (more than 2 hours), the GPS receiver ignores it. When the GPS connection is closed, local aiding data is saved, overwriting the old. This operation requires a few seconds.

If the GPS has been switched on without aiding (or with aiding mode other than Local Aiding), when the GPS is active and a fix has been calculated, the application can trigger aiding data saving by sending AT+UGAOS=0. Similarly, usage of local aiding can be forced after GPS startup either by sending AT+UGAOS=1. If GPS-related URC responses are activated (by sending AT+UGIND=1), the command AT+UGAOS=1 will trigger a response type "+UUGIND=1,x", confirming that assistance data has been passed to the GPS receiver.



When the GPS receiver is calculating a fix, forcing the use of old files could decrease the GPS performance.

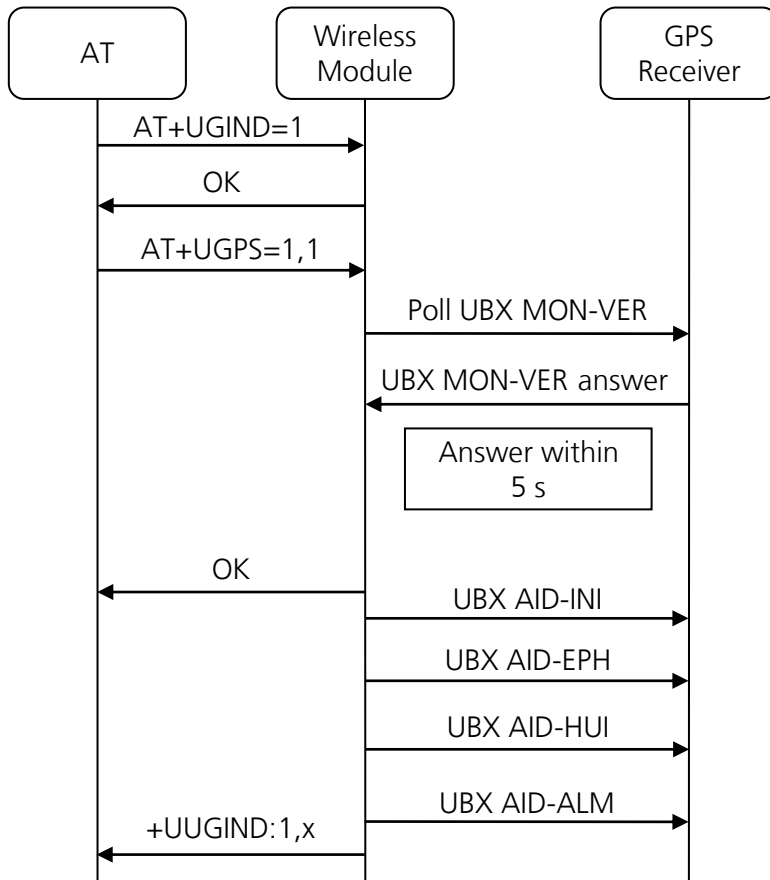


Figure 6: Interaction between the wireless module and GPS receiver with local aiding support

If an error occurs it will be notified through +UUGIND URC; for instance if there is no space available in the file system after having sent AT+UGPS=0 command the local aiding will try to save the data from the GPS receiver and will report an error for each failed writing on the Flash File System (FFS). For more details on aiding error refer to chapter 5.6.

Command	Response	Description
AT+COPS?	+COPS: 0,0,"vodafone IT" OK	Check if the module is registered to a GSM network (GPS local aiding will use GSM information to reduce TTFF)
AT+UGRMC=1	OK	Activate storing of the last value of \$RMC NMEA string
AT+UGIND=1	OK	Activate unsolicited aiding result
AT+UGPS=1,1	OK	Start up GPS with local aiding (it will download orbits, time and position to GPS if available in FFS, otherwise it will use country code information for a rough localization)
	+UUGIND: 1,0	URC reporting GPS mode "Local Aiding" ('1') and "No error" ('0')
AT+UGRMC?	+UGRMC: 1,\$GPRMC,102140.00,A,4542.85211,N,01344.44959,E,0.356,34.92,261009,,A*57 OK	Wait at least 15' for ephemerides download
AT+UGPS=0	OK	Stop the GPS. Module automatically creates some files hidden to the user: ubx_aid_ini.dat, ubx_aid_eph.dat, ubx_aid_hui.dat, ubx_aid_alm.dat and local_aid_info.bin (contains GPS coordinate, GPS time, fix accuracy, system time, GSM cell information)

Table 8: Local Aiding AT command sequence

5.1.1 “GPS RTC sharing” function

“GPS RTC sharing” function provides a better time accuracy in the UBX message AID-INI.



“GPS RTC sharing” function is not available on LEON-G100-05 / LEON-G200-05 and previous versions or on LISA-U1x0-00 versions.

Through the “RTC calibration” process the wireless module can characterize its own RTC using the GPS time, basically sending two pulses to the GPS EXTINT0 pin and reading the GPS time reported by the GPS (using the UBX message TIM-TM2) it is possible to calculate the RTC bias and drift.

Knowing the RTC characteristics (vary with time and temperature), it is possible to estimate with high precision the time elapsed between two GPS power cycles.

The RTC calibration is performed at GPS power off (or when AT+UGAOS=0 is triggered). At subsequent GPS power on, if RTC calibration was successful and RTC clock has not been changed, a new pulse is sent to the EXTINT0 pin and in the AID-INI message the pulse time is provided.

To only enable the “GPS RTC sharing” function the first parameter of AT+UGPRF command must be set to 32. For more details on GPS RTC sharing enabling and AT+UGPRF command description refer to u-blox AT commands manual [1]. If the RTC out pin of the wireless module and EXTINT0 of the GPS are not connected, the RTC calibration procedure will fail and time pulse is not sent with the UBX message AID-INI.



The calibration procedure requires more than 7 s, so the GPS power off sequence takes more time when the RTC sharing function is enabled. The whole procedure could take up to 15 s.



If the RTC time is modified between the RTC calibration procedure and subsequent GPS power on a wrong time and accuracy is passed to the GPS receiver and this could decrease GPS performance, to avoid this modify the RTC when the GPS is on or do not use local aiding right after RTC modification.

5.2 Using GPS with AssistNow Offline support

GPS AssistNow Offline stores the GPS almanac within the wireless module’s Flash File System (FFS). If there is no almanac file saved within the FFS the wireless module will try to download it from the dedicated server using an existing packet data connection (GPRS or HSPA).



If assistance data needs to be downloaded, the application must activate a data connection (e.g. using AT+UPSDA) to allow the wireless module to establish a connection to the server.

After the file has been downloaded from the server, it is renamed with the “.alp” extension and passed to the GPS receiver.



On LEON-G100 / LEON-G200 series the file name is composed by the number of minutes elapsed from 01/01/2004 while on LISA-U1 series is composed by the date and time.

If there is more than one Differential Almanac Correction Data file on the file system, all files, except the newest one, will be automatically deleted.

If the almanac file is downloaded from the u-blox server, the validity period of the Differential Almanac Correction data is determined by URL configured through +UGAOF command: on u-blox server the last characters of the filename indicates the validity of the almanac expressed in days. Differential Almanac Correction files made available on the u-blox server and their approximate size are listed below:

File Name	Validity	Approximate Size
current_1d.alp	1 day	10 kB
current_2d.alp	2 days	20 kB
current_3d.alp	3 days	25 kB
current_5d.alp	5 days	40 kB
current_7d.alp	1 week	50 kB
current_10d.alp	10 days	70 kB
current_14d.alp	2 weeks	100 kB

Table 9: Differential Almanac Correction files information

If file download from the server fails, the system will automatically retry the operation according to parameters specified through the AT+UGAOF command. In case of error, the GPS is started anyway but no aiding is performed.

The external application processor controlling the module should verify the validity period (detailed procedure is described below) and download a new Differential Almanac Correction data when needed. This can be achieved by sending AT+UGAOS=2 or simply deleting the .alp file before starting the GPS receiver by means of the AT+UDELFIL command.

It is also possible to manually store the almanac file on FFS with the AT+UDWNFILE command. For more details on AT commands description refer to u-blox AT commands manual [1].

The application processor can also decide to download a new Differential Almanac Correction data to increase performance, e.g. substitute a 14 days validity file with a new one with 1 day validity after 5 days.



Time and the date within the wireless module are set using the following AT commands: +CCLK, +CTZU and +UGMTR. Refer to u-blox commands manual [1] for the commands description.



To automatically download a new file from the server the following conditions need to be satisfied.

- Active packet data connection
- GPS receiver on
- AssistNow Offline aiding enabled
- The almanac file is expired or nearing expiration (less than 10% of validity time left)

On LEON-G100-05 / LEON-G200-05 and previous versions it is not possible to automatically download the file from the server.

The external application processor should perform the command sequence as follows:

1. Decide a validity period of n days and store somewhere the current date (it is also possible to use the renamed file in the FFS to derive the assistance file validity)
2. Use AT+UGAOF command to select the file to download by setting the appropriate URL, i.e. "http://alp.u-blox.com/current_14d.alp" for two weeks or "http://alp.u-blox.com/current_1d.alp" for one day
3. Start the GPS in AssistNow Offline mode (e.g. AT+UGPS=1,2, for more details refer to u-blox AT commands manual [1])
4. Before each subsequent GPS start up in AssistNow offline mode check if the Differential Almanac Correction data file is still valid (actual_date – download_date < validity period)
5. If the file is no longer valid, delete it from FFS using the command AT+UDELFIL
6. Start the GPS in AssistNow Offline mode (AT+UGPS=1,2)

Command	Response	Description
AT+UGAOF?	+UGAOF: "http://alp.u-blox.com/current_14d.alp",0,1,3 OK	Check the AssistNow Offline configuration (needed only if there is no almanac file in FFS). Note that the validity of the assistance data is given by the file name.
AT+UGIND=1	OK	Enable GPS-related URC

Command	Response	Description
AT+UPSD=0,1,"web.omnitel.it"	OK	Set up the connection profile with the APN specified by the Network Operator
AT+UPSDA=0,3	OK	Activate the GPRS connection (needed only if there is no valid almanac file in FFS)
AT+UGPS=1,2	OK	Start up the GPS with AssistNow Offline aiding. If there is no valid almanac file on FFS, it will be downloaded from the specified server)
	+UUGIND: 2,0	URC reporting GPS mode "AssistNow Offline" ('2') and "No error" ('0')
AT+UGPS=0	OK	Stop the GPS

Table 10: AssistNow Offline AT command sequence



The AT+UGAOS=2 command triggers the Differential Almanac Correction data file download when the GPS receiver is switched on, but the new file will be used only when the GPS receiver is restarted with AT+UGPS=1,2.



The longer the validity of the almanac file chosen, the larger the .alp file will be. If the FFS is used for other applications, it is necessary to verify that there is enough space to store the assistance data. If space saving is an issue, it is recommended to use the almanac with the shortest validity.

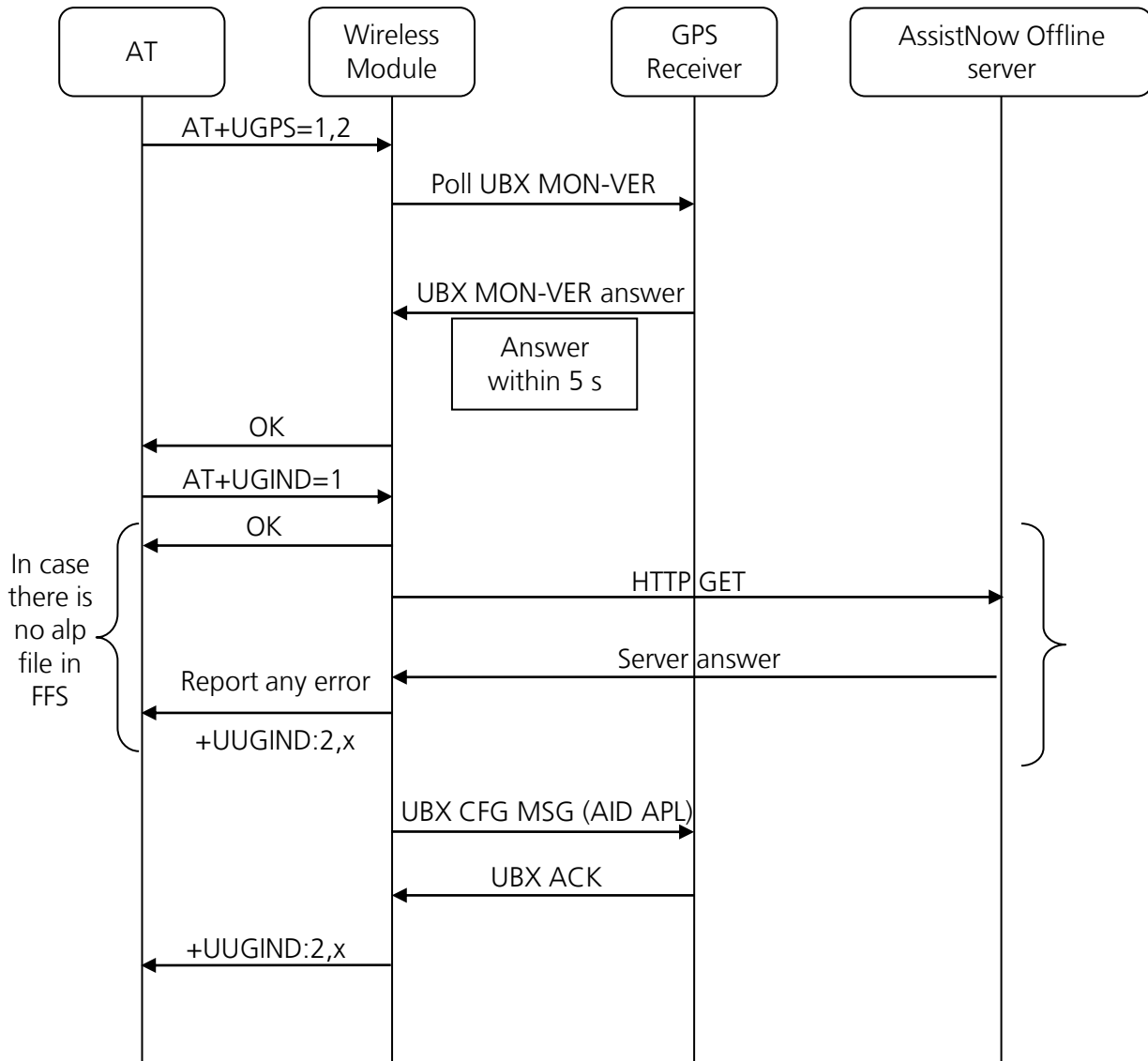


Figure 7: Interaction between the wireless module and GPS receiver with AssistNow Offline support



The wireless module does not perform checks on the almanac file: it just notifies the GPS that an alp file is available on the wireless module file system. If the file is corrupted or out of date the GPS determines if it will not use it and, in this case, no error notification is provided.

5.3 Using GPS with AssistNow Online support

AssistNow Online is the assistance mode ensuring the fastest TTFF. Assistance data is downloaded from the wireless module and then passed to the GPS receiver.



An active packet data connection is required to exchange data between the wireless module and u-blox dedicated server.

At GPS start up, a UDP connection is created either to u-blox AssistNow Online Server (eval1-les.services.u-blox.com) or to a configurable proxy server (the UDP socket is created when GSM cell information is available). The wireless module will pass the server the Network Cell ID, either GSM or WCDMA, and the server will return the ephemerides data only for those satellites visible by the GPS receiver at a given time.



The u-blox AssistNow Online Server at the address agps.u-blox.com has been replaced by eval1-les.services.u-blox.com also supporting CellLocate requests.

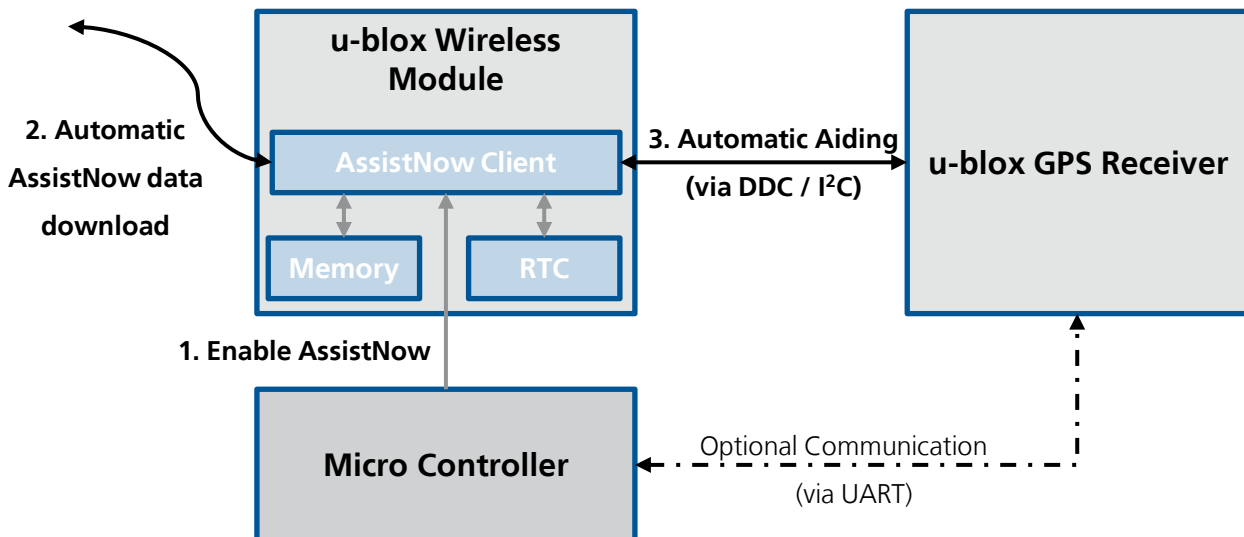


Figure 8: AssistNow Online flow

If no data socket is available, then the GPS receiver will start without aiding and an error message is reported by the URC.

In case of no response from AssistNow Online, the wireless module will make three repeated attempts (at intervals of 10 s, 30 s and 60 s respectively).

Authentication for the u-blox AssistNow Online Server (eval1-les.services.u-blox.com) is performed at the beginning of each access to the u-blox AssistNow server by sending the information listed below:

- Exclusive OR of IMSI and IMEI
- Home network code
- MCC, MNC, LAC, CI, TA of cell used by the wireless module and neighboring cells
- Latency

After a successful access and download of assistance data when a fix is available, the wireless module provides the following information to the server for quality monitoring purposes:

- Exclusive OR of IMSI and IMEI
- Calculated position after aiding
- Position accuracy
- Number of SVs used
- TTFF

The data payload sent from the module to the server during the AssistNow Online procedure is about 54 bytes during the authentication phase and about 35 bytes during the confirmation phase. Amount of aiding data downloaded from the server is variable.

Command	Response	Description
AT+UGAOP?	+UGAOP: `eval1-les.services.u-blox.com",46434,1000,0 OK	Check if AssistNow Online is configured
AT+UPSDA=0,3	OK	Activate the GPRS connection using the +UPSDA AT command
AT+UGPS=1,4	OK	Start up the GPS with AssistNow Online aiding (it will send network cell information to the server and receives aiding data for the GPS)
AT+UGPS=0	OK	Stop the GPS

Table 11: AssistNow Online AT command sequence

If URCs are enabled with AT+UGIND=1, an unsolicited response is sent when the AssistNow Online procedure is complete, so the indication is provided after the GPS fix and the notification to the server. If an error is encountered during AssistNow procedure, the appropriate URC will report it. Please refer to the AT+UGIND command description within the u-blox AT Commands Manual [1].

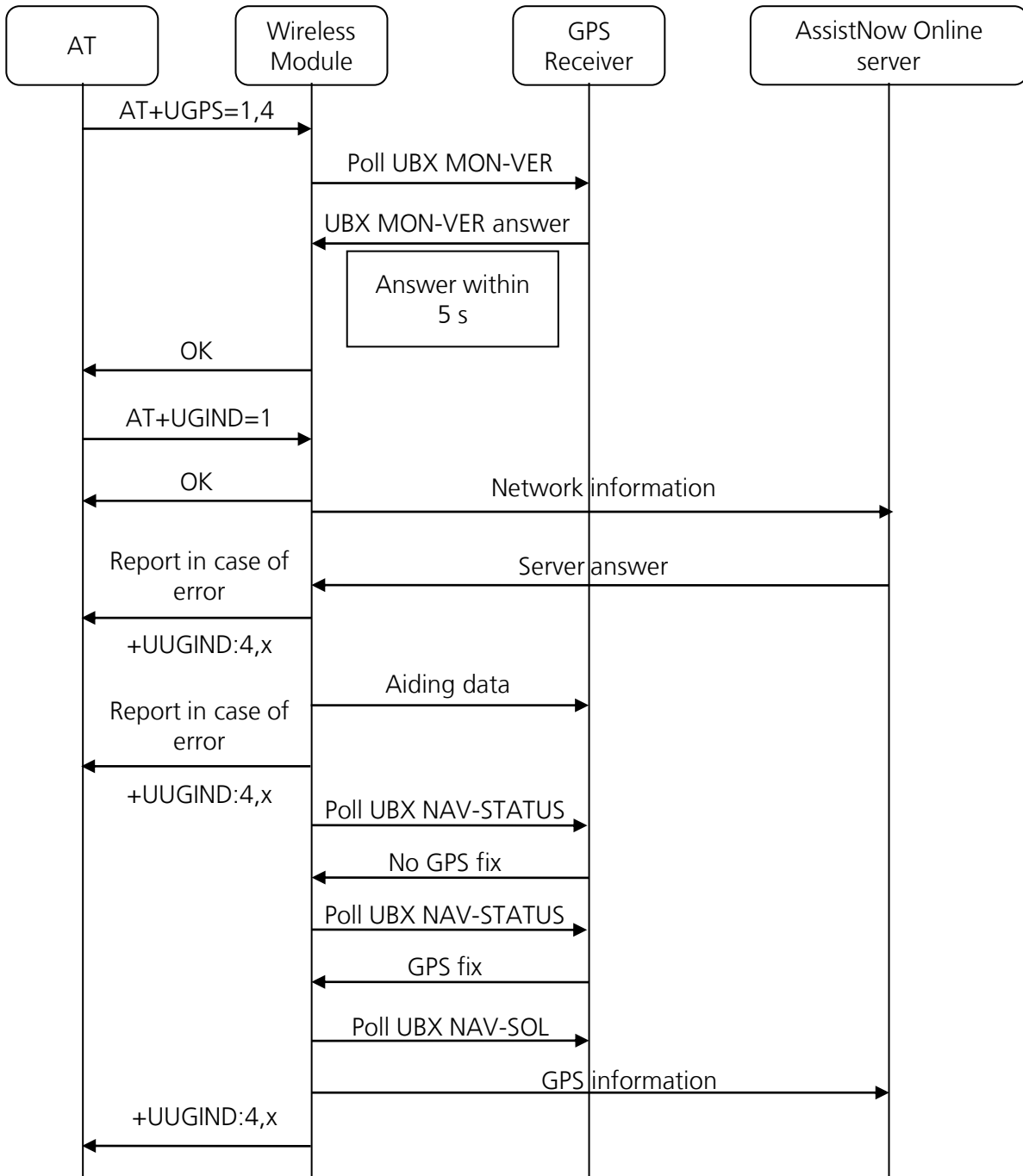


Figure 9: Interaction between the wireless module and GPS receiver with AssistNow Online support

5.3.1 Latency

The latency parameter is the expected time for data to arrive at the GPS receiver from the server. If there is a significant latency between the instant when the wireless module receives AssistNow data and when it is received by the GPS receiver, this should also be added to the latency parameter.

If latency excessively varies from the predicted value, the wireless module will send a new aiding request with an adjusted latency.

The server sets the time accuracy field within the AssistNow data to half of the reported latency. For example, with a latency of 500 ms, the AssistNow server adjusts the time in the data by 500 ms and sets the accuracy value in the AssistNow UBX data to 250 ms.

With this value, the GPS receiver assumes that the given time is accurate to +/-250 ms. Thus, in this example, if the measured latency between GSMREQ and AssistNow data received by the wireless module is between 500 ms and 1500 ms no new request is required.

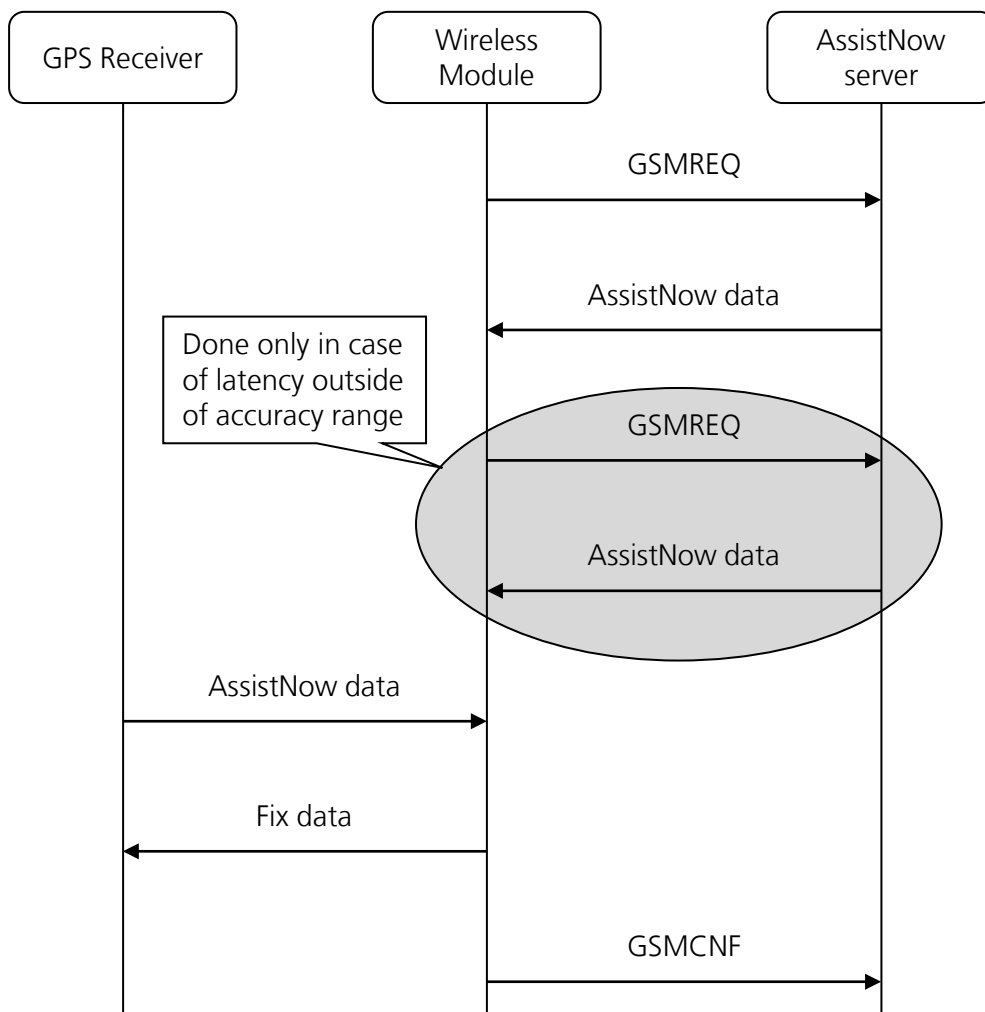


Figure 10: AssistNow message flow between the wireless module and the server

5.4 Using GPS with AssistNow Autonomous Support



Refer to chapter A.3 for more details about the availability of AssistNow Autonomous on u-blox GPS receiver.



AssistNow Autonomous is not supported by LEON-G100-05 / LEON-G200-05 and previous versions or LISA-U1x0-00 versions.

The AssistNow Autonomous feature provides functionality similar to AssistNow without the need for a host and a connection. Based on known ephemeris, the GPS receiver can autonomously generate an accurate satellite orbit representation that is usable for navigation much longer than the underlying broadcast ephemeris was intended for. It, therefore, renders the need to download or assist new ephemerides data for the first fix unnecessary for subsequent receiver start ups.

The AssistNow Autonomous data is automatically and autonomously generated from downloaded (or assisted) broadcast ephemerides. Data for the full constellation (32 satellites) is stored on the host file system.

The AssistNow Autonomous subsystem will not produce any data and orbits while AssistNow Offline data is available.

As with Local Aiding, data related to AssistNow Autonomous is saved within the wireless module FFS but the file is not accessible or visible to the user.

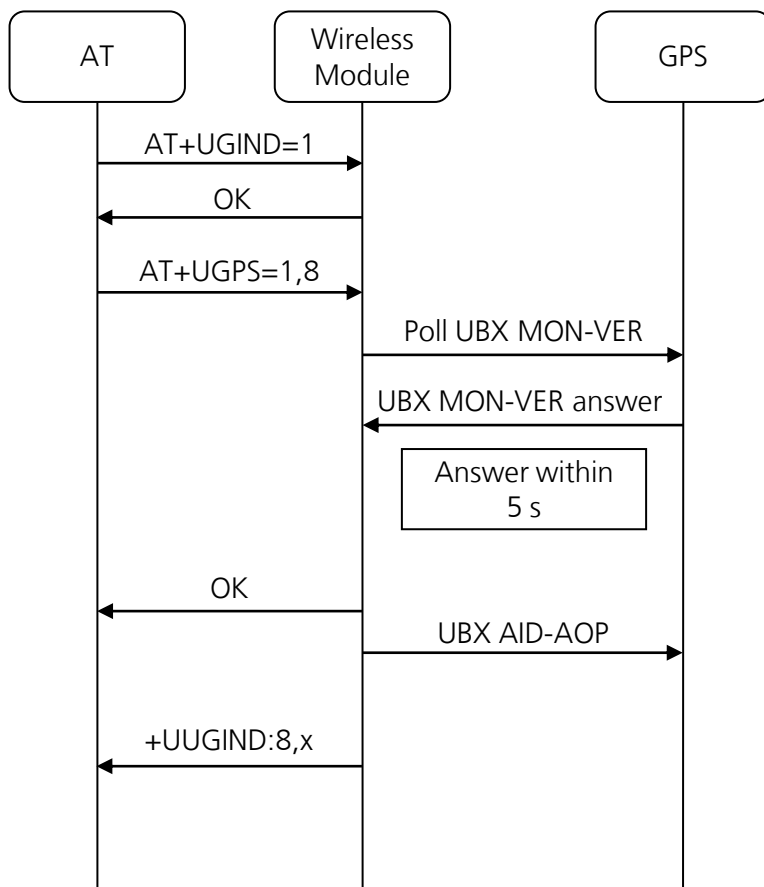


Figure 11: Typical interaction between the wireless module and GPS receiver with AssistNow Autonomous support

+UUGIND URC is reported for each error/result; for instance if there is no space available in the FFS after having sent AT+UGPS=0 command the local aiding will try to save the data from the GPS receiver and will report an error for each failure about the writing on FFS.

Command	Response	Description
AT+UGRMC=1	OK	Activate storing of the last value of \$RMC NMEA string
AT+UGIND=1	OK	Activate GPS aiding URC
AT+UGPS=1, 8	OK	Start up GPS receiver with local aiding (it will download AOP data to GPS receiver if available in FFS, otherwise it will enable the AssistNow Autonomous in the GPS receiver)
	+UUGIND: 8, 0	URC reporting GPS mode "AssistNow Autonomous" ('8') and "No error" ('0'). Data has been passed to the GPS
AT+UGRMC?	+UGRMC: 1, \$GPRMC, 102140.00, A, 4542.852 11, N, 01344.44959, E, 0.356, 34.9 2, 261009, , , A*57 OK	
AT+UGPS=0		Stop the GPS. Module automatically creates a file hidden to the user: ubx_aid_aop.dat.
	+UUGIND: 8, 0	URC reporting GPS mode "AssistNow Autonomous" ('8') and "No error" ('0'). Data saved on FFS
	OK	Answer to the AT+UGPS=0 command

Table 12: AssistNow Autonomous AT command sequence

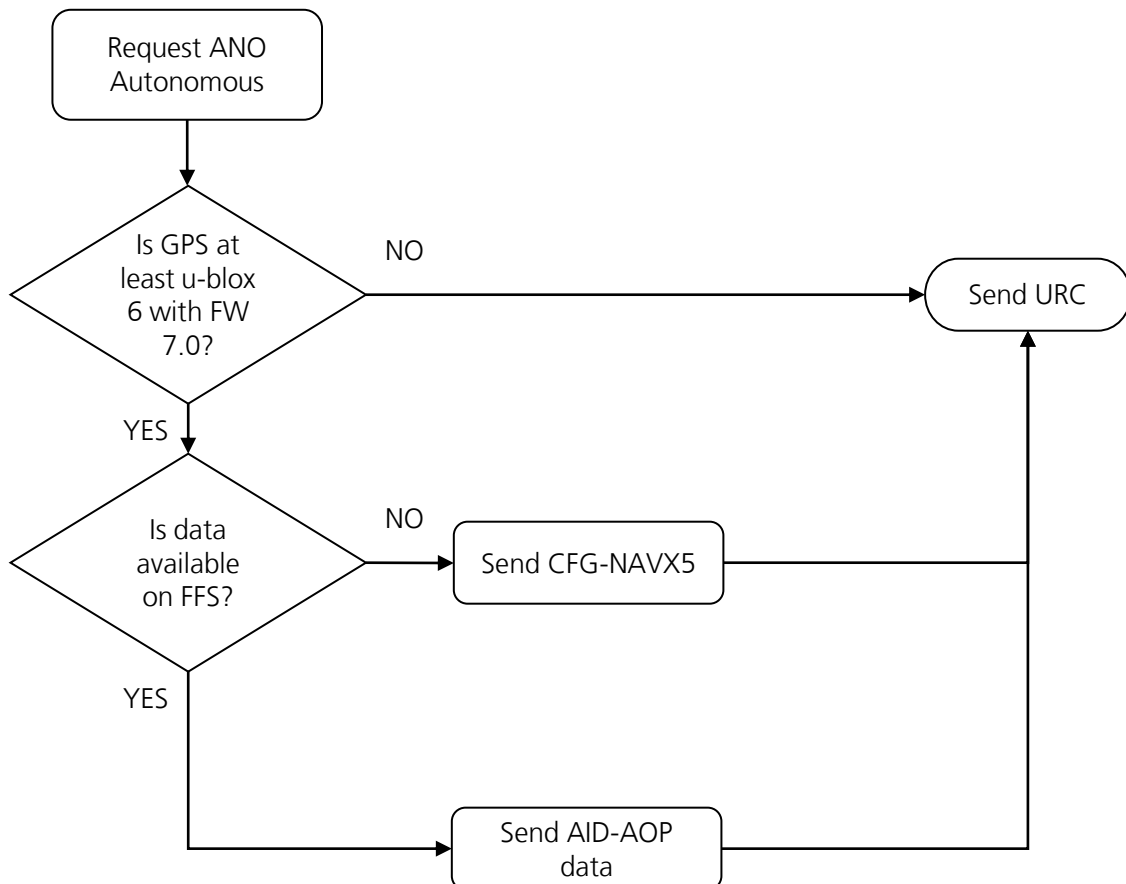


Figure 12: Detailed AssistNow Autonomous start sequence

5.5 Using GPS with combined aiding modes



This feature is not available on LEON-G100-04 / LEON-G200-04 versions.

The GPS aiding modes previously described can be enabled at the same time when the GPS receiver is switched on.

To enable more than one assistance mode, simply switch on the GPS with the command `AT+UGPS=1,x` passing as second parameter the algebraic sum of the codes of each assistance mode desired. For example, to activate Local Aiding (normally activate `AT+UGPS=1,1`) and AssistNow Autonomous (`AT+UGPS=1,8`), simply send `AT+UGPS=1,9`.

If URCs are enabled, there will be an unsolicited response for each mode activated.

Command	Response	Description
<code>AT+UGIND=1</code>	OK	Activate GPS-related URCs
<code>AT+UGPS=1, 9</code>	OK	Activate GPS with AssistNow Autonomous (<code>AT+UGPS=1,8</code>) and Local aiding (<code>AT+UGPS=1,1</code>)
	+UUGIND: 1, 0	
	+UUGIND: 8, 0	
<code>AT+UGPS=0</code>		Stop the GPS. Module automatically creates files hidden to the user
	+UUGIND: 1, 0	Data saved on FFS (<code>ubx_aid_ini.dat</code> , <code>ubx_aid_hui.dat</code> , <code>ubx_aid_eph.dat</code> , <code>ubx_aid_alp.dat</code>)
	+UUGIND: 8, 0	Data saved on FFS (<code>ubx_aid_aop.dat</code>)
	OK	Answer to the <code>AT+UGPS=0</code> command

Table 13: Combined aiding modes AT command sequence

5.6 Aiding result codes

+UUGIND URC provides the aiding result; the list of the allowed aiding results is reported as follows:

- 0: No error, this message is sent when the aiding procedure is complete. With AssistNow Online the procedure is complete when the position information is sent back to the server. Local aiding and AssistNow Autonomous also perform aiding action during power off sequence, therefore they also provide URC in this phase
- 1: The URL provided with +UGAOF command for AssistNow Offline is not valid
- 2: The HTTP GET request for AssistNow Offline file has failed
- 3: UDP socket creation for AssistNow Online failed
- 4: During AssistNow Online procedure the UDP socket closure returned an error
- 5: It was not possible to send AssistNow Online information to the server
- 6: There was an error while receiving for AssistNow Online data from the server
- 7: It was not possible to connect to the AssistNow Online server or to resolve its DNS error
- 8: Error writing data in the file system
- 9: Generic error
- 10: No answer from GPS after a data request (for local aiding and AssistNow Autonomous)
- 11: Data collection already in progress (for local aiding)
- 12: GPS activation of AssistNow Autonomous failed
- 13: RTC calibration procedure has not been completed (for local aiding)
- 14: Feature not supported by GPS receiver (for AssistNow Autonomous)

6 GPS input/output

Communication and data redirection between the GPS receiver and wireless module can be configured using AT+UGPRF command. Apart from enabling "GPS Data Ready" and "GPS RTC sharing", GPS data can be redirected from the DDC interface in the following modes:

- to a USB channel
- to a multiplexer virtual channel
- to a file in Flash File System (FFS)
- over the air (OTA)



On LEON-G100 / LEON-G200 the GPS data cannot be redirected to a USB channel.

The modes can be combined. The configuration can be only done when the GPS receiver is off. For more details, refer to u-blox AT commands manual [1], AT+UGPRF command.

Command	Response	Description
AT+UGPRF=4	OK	Enable GPS I/O configuration on FFS
AT+UPSDA=0, 3	OK	Activate the GPRS connection using the +UPSDA command
AT+UGPS=1, 0	OK	Start up the GPS receiver without aiding
AT+UGAOS=4	OK	Force AssistNow Online and wait some minutes
AT+UGPS=0	OK	Stop the GPS receiver
AT+ULSTFILE=	"gps_profile", "GPS_20040101_001" OK	Check if trace file has been generated
AT+UGPRF=6	OK	Start the multiplexer driver on host and then enable GPS communication on multiplexer and trace on FFS
AT+UGPS=1, 0	OK	Start up the GPS receiver without aiding, the GPS output will be visible on DLC1 (1 st multiplexer channel)
AT+UGAOS=0	OK	Force local aiding data download
AT+UGPS=0	OK	Stop the GPS receiver
AT+ULSTFILE=	"gps_profile", "GPS_20040101_002", "GPS_20040101_001" OK	Check if trace file has been generated

Table 14: GPS Data redirection AT command sequence

The multiplexer and the USB are Input/Output channels, while the FFS and network are only output channels.

6.1 USB I/O

The USB CDC 4 is reserved for GPS tunneling; this means that it is possible to directly communicate with the GPS using the UBX protocol.



Tunneling through USB is not available on LEON-G100 / LEON-G200 series and is mutually exclusive with the multiplexer channel.

6.2 MUX I/O

The wireless module FW supports the 3GPP 27.010 multiplexer protocol (for more details please refer to 3GPP 27.010 specifications [2]) to emulate several virtual connection channels on a single physical interface to concurrently access the module (e.g. it is possible to read a phonebook contact while receiving GPS data).



For more details on multiplexer implementation on wireless module, refer to GSM 3GPP 27.010 Mux implementation in Wireless Modules Application Note [2].



The last virtual channel has been dedicated to GPS tunnel data to the host.

The mux virtual channels are used as follows:

- DLC0: control channel
- DLC1 – DLC5: AT commands / data connection
- DLC6: GPS tunnelling

6.3 FFS output

A single log file saved on FFS is limited to 500 kB, while the total FFS usage for log files is limited to 750 kB. In case of FFS nearing its maximum capacity, the file is closed and no other log file is created and no indication is sent. However “--file truncated –” string is appended to the end of log file. In case the GPS receiver is restarted a new file will be created if the total FFS usage is not exceeded.

GPS log files are visible within the user space and their name has the following format: GPS_YYYYMMDDHHMM. YYYYMMDDHHMM is the date and time obtained from the system. A log file generated overwrites any existing file with the same filename. This may happen if the system time has been changed or the GPS log is started twice in the same minute.

GPS data is stored as it is received, no data compression is performed.



On LEON-G100 / LEON-G200 series, the log file names have the following format: GPS_YYYYMMDD_nnn (YYYYMMDD is the date while nnn is an incremental index).



On LEON-G100 / LEON-G200 series, there is no limit on the total FFS usage for log files.



On LEON-G100 / LEON-G200 series, a truncated log files is not ended with “--file truncated –” string.

6.4 OTA output

The GPS output can be redirected to a server via a data connection, this communication is mono-directional, so it is not possible to send UBX commands to the GPS receiver. The TCP protocol is used to transport data.



Before starting this transfer mode, a packet data connection must be properly set up.

7 Hybrid positioning and CellLocate™

Although GPS is a widespread technology, reliance on the visibility of extremely weak GPS satellite signals means positioning is not always possible, particularly in shielded environments such as indoors and enclosed park houses, or when a GPS jamming signal is present. The situation can be improved by augmenting GPS receiver data with mobile network cell information to provide a level of redundancy that can benefit numerous applications.

Hybrid location provides a set of features allowing the user to query the device position using a single AT command (AT+ULOC) which triggers the position calculation based on the GPS receiver and/or the position estimated from the visible GSM cells (CellLocate™).

The two sensors (GPS and CellLocate™) are configured using AT commands (sensor configurations are explained later) and, when triggered via +ULOC AT command, the wireless module drives the position calculation process and provides the position estimate based on the sensor combination which best fulfill the user requirements previously configured.



Hybrid positioning and communication with the GPS receiver through the wireless module (see chapter 6) features are mutually exclusive and the activation of one of them requires the previous deactivation of the other one via AT+UGPRF command.

AT+ULOC command configures both the target accuracy and the timeout within which a position must be returned. When one or both conditions are satisfied (timeout has expired or required position accuracy is satisfied), the position together with its accuracy is returned by a URC (refer to the u-blox AT command manual [1] for the complete list of configuration supported by +ULOC command).

When Hybrid positioning is used, before starting up the allowed sensors (GPS and/or cellular), the wireless module calculates a rough position by degrading the last known position (if available) as a function of elapsed time (the more time passed since the last fix, the more the accuracy will be decreased); if such accuracy is higher than the target accuracy, this position is output without starting up the allowed sensors. If the accuracy is lower than the target one or if no last known position is available the wireless module powers up the allowed sensors, transparently drives the position calculation process and outputs the position based on the sensors combination which better fulfills the +ULOC configuration (refer to Figure 13 for the description of the position calculation state machine).

The configuration of mobile network cells does not remain static (e.g. new cells are continuously added or existing cells are reconfigured by the network operators). For this reason, when a Hybrid positioning method has been triggered and the GPS receiver calculates the position, a database self-learning mechanism has been implemented so that these positions are sent to the server to update the database and maintain its accuracy.

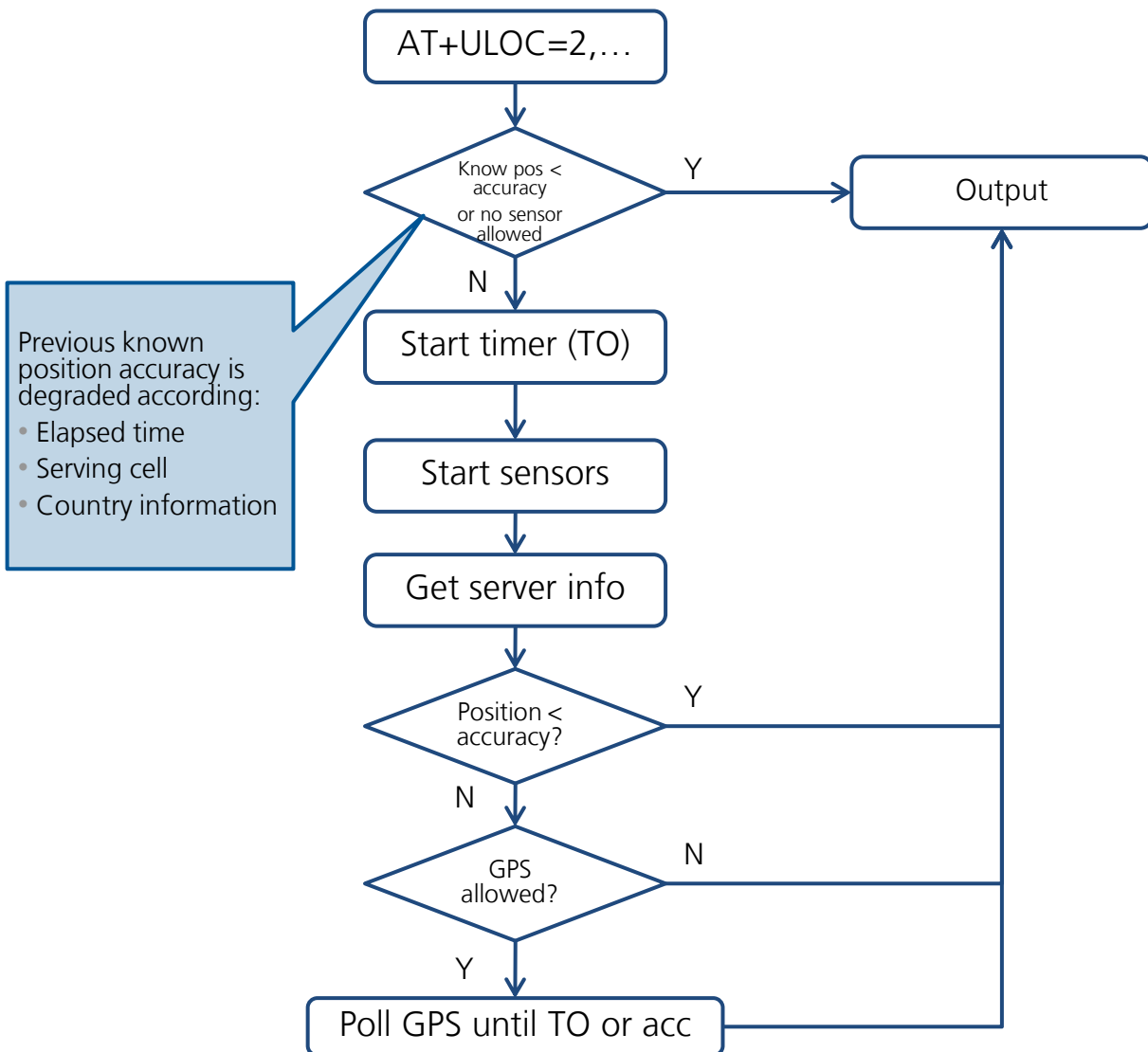


Figure 13: Hybrid positioning flow diagram



u-blox is extremely mindful of user privacy. When a position is sent to the CellLocate server u-blox is unable to track the SIM used or the specific device.



Hybrid Location and CellLocate feature are not available on LEON from LEON-G100-05 / LEON-G200-05 and previous version or on LISA-U1x0-00 version.



For the syntax description of AT+ULOC, AT+ULOCCELL and AT+ULOCNSS commands refer to u-blox AT Commands Manual [1].

7.1 Positioning sensors

Two positioning sensors are supported:

- **GPS receiver sensor:** the GPS receiver is connected to the wireless module as described in previous chapters and is configured by AT+ULOCNSS command (the configuration includes the set of GPS aiding modes allowed to optimize the GPS position calculation process)

- Cellular sensor:** CellLocate™ provides an estimated location based on visible network cell information reported by the wireless module and is configured by AT+ULOCCELL command. When CellLocate is activated a data connection to the CellLocate server is established and the network cell information is passed to the server which provides an estimation of the device position based on the cell information. When using CellLocate™, position accuracy is not predictable and is determined by the availability in the database of previous observations within the same area. CellLocate does not require a GPS receiver

Once the sensors are configured and a position request is triggered the sensors are fully controlled by the wireless module. The wireless module automatically switches the sensors on, optimizes the power consumption, drives the position estimate methods and aiding modes and outputs the estimated position together with its accuracy.

Figure 14 and Figure 15 show the sequence of the exchanged messages between involved elements when Hybrid positioning or stand-alone CellLocate methods are used.

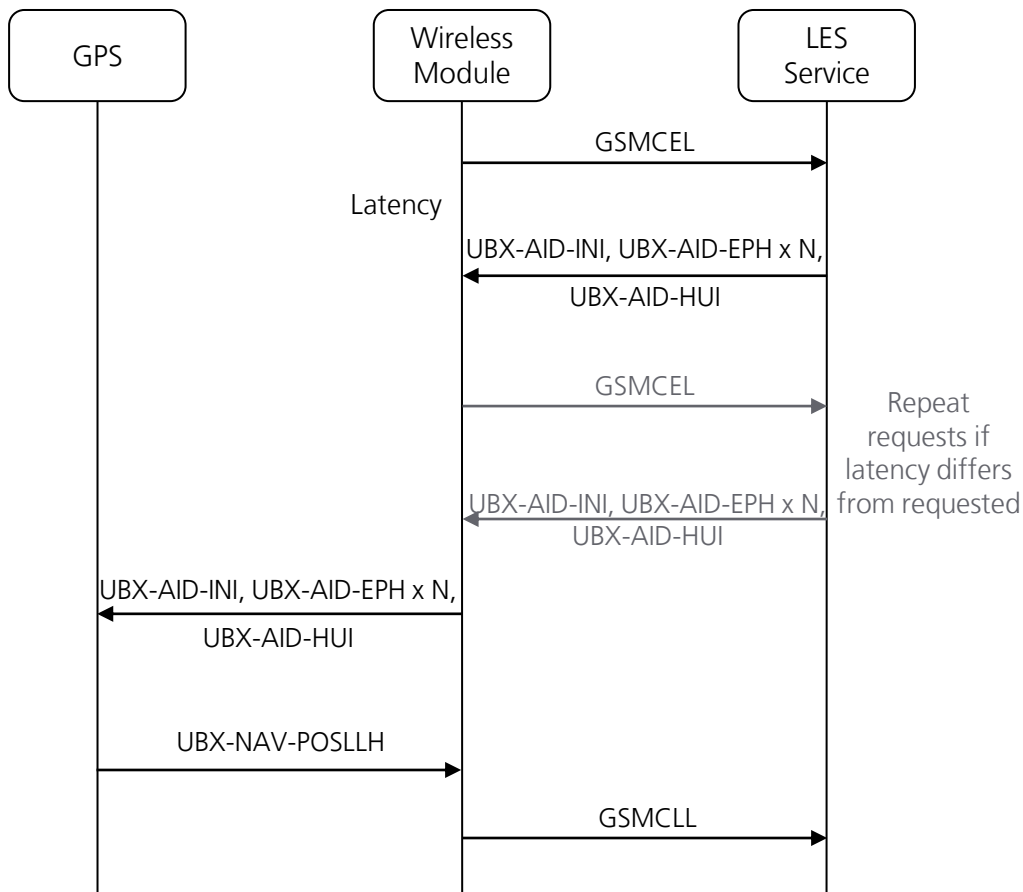


Figure 14: Hybrid positioning message sequence

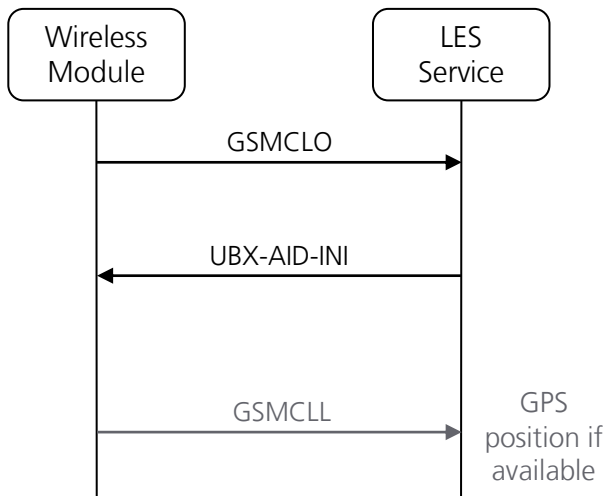


Figure 15: Stand-alone CellLocate message sequence



Stand-alone CellLocate does not require a GPS receiver and therefore is suitable for applications which do not require high positioning accuracy but where current consumption, compactness and cost reduction must be reduced to a bare minimum. Being cellular localization based on the cell(s) seen by the wireless module, the position estimation cannot be derived if the reported cell(s) information is not available in the database.



If the CellLocate server, for whatever reason, cannot be reached during the +ULOC command execution, then the position will be calculated only using GPS sensor with possibly reduced accuracy.

7.2 GPS sensor setup

AT+ULOCGNSS command sets up the GPS sensor for hybrid positioning: it is possible to configure which aiding types (refer to chapter 5) are available to the GPS sensor. Moreover, additional parameters are available for modifying the GPS receiver behavior; below values are strictly related to the GPS receiver, the parameters are sent at GPS power on and are not saved within the receiver, the default values are the same of the GPS receiver. For values and additional details about their effect refer to u-blox Receiver Description [10]:

- UBX-CFG-PM2 message configures the power save mode of the GPS by setting the optimization target flag in power consumption or in default mode
- UBX-CFG-NAVX5 message configures the minimum number of satellites for navigation, minimum satellite signal level for navigation and if the initial fix must be 3D
- UBX-CFG-NAV5 configures the static hold mode: allows the navigation algorithms to decrease the noise in the position output when the velocity is below a pre-defined 'Static Hold Threshold'. This reduces the position wander caused by environmental issues such as multi-path and improves position accuracy especially in stationary applications. By default, static hold mode is disabled
- UBX-CFG-SBAS enable/disable: SBAS (Satellite Based Augmentation Systems) is an augmentation technology for GPS, which calculates GPS integrity and correction data with RIMS (Ranging and Integrity Monitoring Stations) on the ground and uses geostationary satellites (GEOs) to broadcast GPS integrity and correction data to GPS users. The correction data is transmitted on the GPS L1 frequency (1575.42 MHz), and therefore no additional receiver is required to make use of the correction and integrity data
- UBX-CFG-ITFM configures Jamming/Interference monitor: enables/disables the indicator, sets the antenna type, broadband jamming detection threshold and continuous wave jamming detection threshold

7.3 Cellular sensor setup

AT+ULOCCELL command configures which cell information must be reported to the CellLocate server for the position estimation as follows:

- “normal scan”: the wireless module only reports the parameters of the visible cells of the serving network operator
- “deep scan”: the wireless module reports not only the parameters of the visible cells of the serving network operators, but also the cells of all other available network operators, thus improving location accuracy. The drawbacks are that more data is sent to the server (9 bytes for each cell), power consumption will be increased and more time is needed to gather a position (approx 30 s is needed to perform a deep scan of all the available network operators)

7.4 Sequence examples

Command	Response	Description
AT+UGAOP="eval1-les.services.u-blox.com",46434,1000,0	OK	Configure LES
AT+UPSDA=0,3	OK	Activate the GPRS connection
AT+ULOCCELL=1	OK	Configure for full network scan
AT+ULOCGNSS=15	OK	Enable all GPS aiding modes
AT+ULOC=2,3,0,120,10	OK	Start hybrid positioning enabling both GPS and cellular sensor with a timeout of 2 minutes and a desired accuracy of 1 m. The answer mode is short
	+UULOC: 13/04/2011,09:54:51.000,45.63 3452,13.061862,49,1 OK	Output when the desired accuracy is reached

Command	Response	Description
AT+CCLK="11/05/23,14:00:00+00"	OK	Set date and time (previous fix information is not valid, because it is not possible to know elapsed time)
AT+ULOC=2,0,1,100,10	OK	Perform hybrid positioning without using sensor
	+UULOC: 00/00/0000,00:00:00.000,42.83 3299,12.833299,0,734000,0,000 ,0,0,0,0,0 OK	No information about time, center of the country and its radius is returned
AT+UPSDA=0,3	OK	Activate the GPRS connection
AT+ULOC=2,2,1,100,10	OK	Perform a CellLocate
	+UULOC: 23/05/2011,12:20:40.116,45.71 4102,13.740958,0,35000,0,000, 0,2,0,0,0 OK	Data is retrieved from the server, the accuracy is 35 km
AT+ULOC=2,3,1,100,10	OK	Start hybrid positioning enabling both GPS and cellular sensor.
AT+ULOC=2,3,1,100,20	OK	Start hybrid positioning enabling both GPS and cellular sensor. The command is provided before the URC of the previous command
	+UULOC: 23/05/2011,12:23:48.000,45.71 4115,13.740867,292,333,0,000, 19,1,7,3,5 OK	Best calculated position is returned and a new hybrid position is started

Command	Response	Description
	+UULOC: 23/05/2011,12:24:30.000,45.71 4127,13.740846,288,15,0,000,1 2,1,7,3,5 OK	Accuracy is reached
AT+UULOC=2,0,1,100,10	OK	New position request with no sensor allowed
	+UULOC: 23/05/2011,12:24:30.000,45.71 4127,13.740846,288,3849,0,000 ,12,1,7,3,5 OK	Previous position with degraded accuracy is reported

8 GPS impact on module performance

8.2 Power consumption for LEON-G100 / LEON-G200 series

Communication between the wireless module and GPS receiver requires the wireless module to exit idle mode (minimum power consumption) and enter active mode to be able to read data on the DDC interface: this means an increment in power consumption. This extra power consumption is negligible in case the power saving configuration of LEON module is disabled.



In case the GPS information is transmitted over the air (e.g. GPRS connection), the data transmission significantly increases the wireless module power consumption.

To evaluate the current consumption for LEON-G100 / LEON-G200 series (current consumption is only related to the wireless module, not including the GPS receiver) the GPS update rate has been set to 1 s and the GPS task has been configured for no data output (e.g. writing on FFS); two different GPS message configurations have been used:

1. Standard configuration
2. Only UBX-NAV-SOL and UBX-NAV-SVINFO messages

It is possible to perform a rough estimate of power consumption due to GPS-DDC communication based on the amount of data sent by the GPS:

- The DDC is configured to 100 kHz, this means that the LEON module will read about 60 bytes during each GSM frame
- LEON-G100/G200 reads the GPS registry every 200 ms (~40 frames)

In the previous cases in the standard configuration the GPS receiver sends ~476 bytes and in the second configuration it sends ~264 bytes, so 8 and 5 GSM frames respectively are needed for data transfer. This means that LEON will be kept out of power saving for an extra 20% (8/40) and 12,5% (5/40).

Appendix

A Compatibility matrix

A.1 “GPS data ready” compatibility matrix

Hardware	HW code	Status
Antaris	40	Not supported
Antaris 4	40001	Not supported
u-blox 5	40005	Not supported
u-blox 6	40007	Supported from FW 7 and above
Future HW	NA	Supported (the configuration must be passed using AT+UGUBX command)

A.2 “GPS RTC sharing” compatibility matrix

Hardware	HW code	Status
Antaris	40	Not supported
Antaris 4	40001	Not supported
u-blox 5	40005	Not supported
u-blox 6	40007	Supported from FW 7 and above
Future HW	NA	Supported

A.3 AssistNow Autonomous compatibility matrix

Hardware	HW code	Status
Antaris	40	Not supported
Antaris 4	40001	Not supported
u-blox 5	40005	Not supported
u-blox 6	40007	Supported from FW 7 and above
Future HW	NA	Supported

B Wireless module and GPS receiver compatibility matrix

Wireless module	GPS receiver	GPS receiver Flash version	Remarks
LEON-G100 / LEON-G200 series	u-blox 5	5.00	"GPS data ready" not supported
		6.02	"GPS data ready" not supported
	u-blox 6	6.02	"GPS data ready" not supported
		7.01	
		7.03	
LISA-U1 series	u-blox 6	6.02	
		7.01	
		7.03	

C List of Acronyms

Abbreviation / Term	Explanation / Definition
3GPP	3rd Generation Partnership Project
AT	AT Command Interpreter Software Subsystem, or attention
CI	Cell Identity
DDC	Display Data Channel
DLC	Data Link Connection
FFS	Flash File System
FW	Firmware
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
HTTP	HyperText Transfer Protocol
I ² C	Inter-Integrated Circuit
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Station Identity
LAC	Location Area Code
MCC	Mobile Country Code
MNC	Mobile Network Code
NMEA	National Marine Electronics Association
SV	Satellite Vehicle
TA	Timing Advance
TTF	Time To First Fix
UART	Universal Asynchronous Receiver-Transmitter
UBX	u-blox
UDP	User Datagram Protocol
URC	Unsolicited Result Code

Related documents

- [1] u-blox AT Commands Manual, Docu No WLS-SW-11000
- [2] u-blox GSM 3GPP 27.010 Mux implementation in Wireless Modules Application Note, Docu No WLS-CS-11002
- [3] 3GPP TS 27.010 – Terminal Equipment to User Equipment (TE-UE) multiplexer protocol (Release 1999)
- [4] u-blox LEON-G100/LEON-G200 series System Integration Manual, Docu No GSM.G1-HW-09002
- [5] u-blox LISA-U series System Integration Manual, Docu No 3G.G2-HW-10002
- [6] u-blox LEON-G100/LEON-G200 series Data Sheet, Docu No GSM.G1-HW-09001
- [7] u-blox LEON-G100/LEON-G200 series Data Sheet for LEON-06, Docu No GSM.G1-HW-10004
- [8] u-blox LISA-U1 series Data Sheet, Docu No 3G.G2-HW-10001
- [9] I²C-bus specification, Version 2.1, Jan 2000,
http://www.nxp.com/acrobat_download/literature/9398/39340011_21.pdf
- [10] u-blox Receiver Description, Protocol Specification, Docu No GPS.G6-SW-10018



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Revision history

Revision	Date	Name	Status / Comments
-	20/01/2010	mice	Initial release
P1	26/01/2010	mice	Inserted Table 1 - AssistNow data request format and Table 2 - AssistNow data confirm format. Added 5.3.1 Modified 6.3 Replaced BB chipset with LEON
2	11/02/2010	mice	Removed 2.1 - Details on GPS connections in the EVA-KIT Removed Table 1 - AssistNow data request format and Table 2 - AssistNow data confirm format.
3	08/03/2010		Abstract updated Chapter 5.1: WAS: In case no information of the previous position is available, a central position of the network should be BECOME: In case no information of the previous position is available, a central position of the network is used
4	01/07/2010	mice/lpah	Added 3.2 Modified 4: added some details about handling with different firmware Modified 5.2: added info about almanacplus data and inserted the information about the command sequence for the application processor Added GPS start diagrams Updated the subtitle: WAS: GPS Implementation and Aiding Features on LEON-G100/G200, BECOME: GPS Implementation and Aiding Features in u-blox wireless modules Added the reference to 3.5G HSDPA AT Commands Manual Chapter 1: added the applicability of the document to the products Chapter 8.1: WAS: Power consumption; BECOME: Power consumption for LEON modules Added note on multiple +UUGIND in 5.1 Modified 5.2: case of multiple almanac plus file Add description about +UUGIND in 5.3 Modified Figure 9: Interaction between the wireless module and GPS receiver with AssistNow Online support

Revision	Date	Name	Status / Comments
4	25/08/2010	fves	Chapter 5.1 - Updated the maximum cell coverage radius (WAS: 30 km, BECOME: 35 km)
A	09/06/2011	lpah	LISA-U1/LISA-H1 series and LEON-G100-06x/LEON-G200-06x supported Added description for AssistNowAutonomous, GPS Tx Data Ready, GPS RTC sharing, CellLocate and Hybrid Positioning sharing
A1	02/08/2011	lpah	Removed LISA-H1 series
A2	16/01/2012	mcel / lpah	Extended to include functionalities description LISA-U1 series GPS Data Ready, GPS RTC sharing and AssistNow Autonomous supported by LISA-U1 series (except for LISA-U1x0-00 versions) Corrected the example where the "OK" was missing and aligned the example structure to AT examples commands application note

Contact

For complete contact information visit us at www.u-blox.com

u-blox Offices

North, Central and South America

u-blox America, Inc.

Phone: +1 (703) 483 3180
E-mail: info_us@u-blox.com

Regional Office West Coast:

Phone: +1 (703) 483 3184
E-mail: info_us@u-blox.com

Technical Support:

Phone: +1 (703) 483 3185
E-mail: support_us@u-blox.com

Headquarters Europe, Middle East, Africa

u-blox AG

Phone: +41 44 722 74 44
E-mail: info@u-blox.com
Support: support@u-blox.com

Asia, Australia, Pacific

u-blox Singapore Pte. Ltd.

Phone: +65 6734 3811
E-mail: info_ap@u-blox.com
Support: support_ap@u-blox.com

Regional Office China:

Phone: +86 10 68 133 545
E-mail: info_cn@u-blox.com
Support: support_cn@u-blox.com

Regional Office Japan:

Phone: +81 03 5775 3850
E-mail: info_jp@u-blox.com
Support: support_jp@u-blox.com

Regional Office Korea:

Phone: +82 2 542 0861
E-mail: info_kr@u-blox.com
Support: support_kr@u-blox.com

Regional Office Taiwan:

Phone: +886 2 2657 1090
E-mail: info_tw@u-blox.com
Support: support_tw@u-blox.com