SARA-R5 series

CellTime

Application note

Abstract

This document describes the CellTime feature and the implementation of the timing functionalities with u-blox SARA-R5 series modules.

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Document information

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This document applies to the following products:

Product name
SARA-R500E
SARA-R500S
SARA-R510S
SARA-R510M8S
SARA-R520
SARA-R520M10

Contents

1 Introduction

1.1 Scope

This document describes how to use the timing functionalities provided by CellTime™ feature of u-blox SARA-R5 series modules. The cellular modules provide timing information obtained from the internal / external GNSS receiver or derived from the synchronization between the cellular module and the base station (BS).

1.2 AT commands

Table 1 lists the AT commands of the CellTime feature:

AT command	Description
Timing information configuration	
+UTIME	Provides timing information from cellular modem
+UTIMEIND	Timing information request status unsolicited indication
+UTIMECFG	Sets the CellTime configuration parameters
+UTIMECELLSELECT	Forces the module to synchronize on a specific cell of any MNO

Table 1: AT commands of CellTime feature

For AT commands examples of CellTime features, see section 6.

For a complete description of AT commands syntax, see the AT commands manual [2].

2 Timing information from cellular modules

The SARA-R5 series modules can produce a clock output and timing information.

Timing information is important for M2M devices, for

- Sensor information interpretation, including:
  - Detecting differences and changes
  - Interpreting sequences of events
  - Identifying "which alarm happened first?"
- Distributed applications synchronization, including:
  - Triggering actions in remote places to take place at particular times
  - To coordinate actions by multiple devices
  - For cross-device functions and applications
- Security:
  - Detection of attacks, for example by monitoring for disturbance of the local clock

For further details on timing technologies for wireless applications, see the u-blox Accurate timing for the IoT whitepaper [5].

2.1 Sources of timing information

The module may derive timing information from a GNSS receiver if fitted, or from the synchronization with the base station.

Source	Availability	Precision	Accuracy
GNSS	May be limited by weak signals (indoors) or interference (jamming)	Excellent [<50 ns]	Excellent [<50 ns]
LTE base station	Widely available	Excellent short-term stability [<1 µs], usually good long term stability [<10 µs/day]	Absolute timing may be undefined depending on network deployment. Drift specification is relaxed. Timing observed by modem depends on propagation distance.

Table 2: The characteristics of timing sources available to a modem

Use combination of the signals to achieve the required performance of different usage models (see section 3). Using a combination brings advantages of:

- Maintaining the ability of providing a timing output.
- Improving precision and accuracy.

The module may use timing from one source to calibrate or to assist in the generation of timing from another source.

2.2 Interface of timing information to the application

The input to CellTime is:

- Single interrupt input, with a message returned reporting the time of the input signal.

The outputs of CellTime are:

- A sequence of time pulses with configurable periodicity and pulse width[1].
- Single trigger output, with a message labelling the time of the output signal.

[1] SARA-R5 "00B" product versions do not allow configuring the pulse

The timing source and the accuracy are provided as part of the UART output, to enable appropriate interpretation and use by an application.

Figure 1 illustrates internal and external connections implemented for CellTime on SARA-R5 series modules:

- For SARA-R510M8S and SARA-R520M10, the **EXTINT** pin and the **TIMEPULSE** pin of the u-blox GNSS chipset are internally connected to the u-blox cellular chipset to provide GNSS timing functionalities.
- For SARA-R500E, SARA-R500S, SARA-R510S and SARA-R520, the **EXTINT** pin and the **TIMEPULSE** pin of the external u-blox GNSS system are respectively connected to the **GPIO4** pin and **SDIO_CMD** pin of the u-blox cellular module to provide GNSS timing functionalities.
- The **GPIO6** pin, the **EXT_INT**2 pin and UARTs interfaces of the modules represent the connections available to the external application for CellTime.

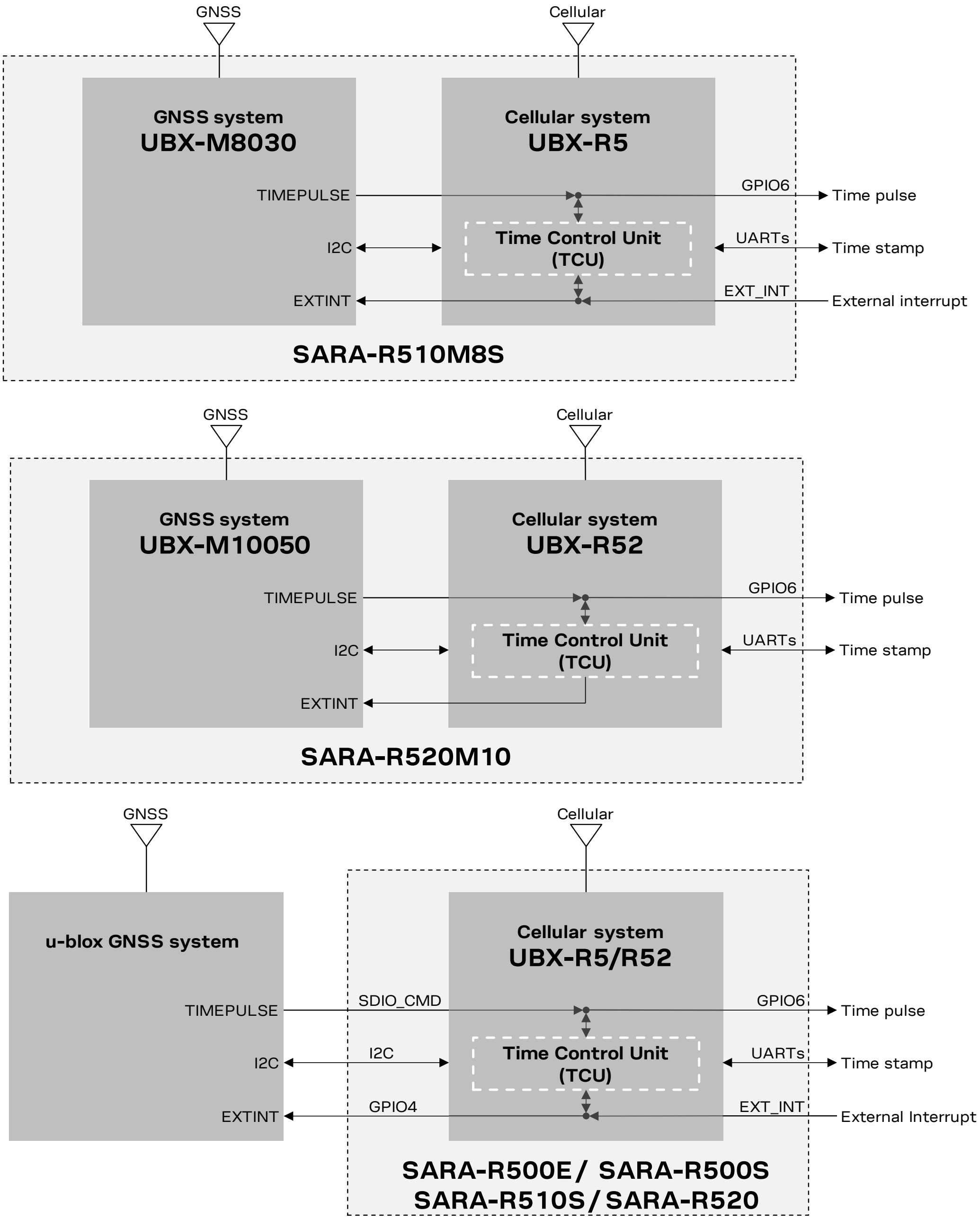

Figure 1: SARA-R5 series modules CellTime block diagram

[2] Not supported by SARA-R520M10 modules.

The time control unit (TCU) integrated into the u-blox UBX-R5/UBX-R52 cellular chipset is responsible for updating and distributing timing information within the module and to the AT interface. Moreover, the TCU keeps track and coordinates all the module's time sources, consisting of the GNSS system or in the LTE modem autonomous time propagation.

Timing information can be retrieved from the module by the +UTIME AT command in the form of:

- A time pulse
- Unsolicited result codes (URC) sent over AT interface, with the corresponding time information and an estimated time accuracy

The **GPIO6** pin of the SARA-R5 series modules can be configured to provide the "Time pulse output" functionality, consisting of a time reference available for the external application in the form of continuous PPS (pulse-per-second) output sequence, or single output pulse with time stamp sent as URC over UART AT interface containing the date and time when the pulse occurred and an estimation of the time accuracy. The time information may come from the GNSS system (using the connection illustrated in Figure 1), or from the LTE modem system.

The **EXT_INT**[3] pin can be configured to provide the "Time stamp of external interrupt" functionality, consisting of timing information available for the external application in the form of an URC sent over AT interface once triggered by a rising edge applied to the **EXT_INT** input pin. When an interrupt is received by the module at the **EXT_INT** input pin, it is timestamped by the TCU using the most accurate time source available, from the GNSS system (using the connection illustrated in Figure 1), or from the LTE system.

For SARA-R500E, SARA-R500S, SARA-R510S and SARA-R520 modules, to get the timing information from the external GNSS system, in addition to the I2C serial interface connection between the cellular and the GNSS systems, as illustrated in Figure 1:

- The **SDIO_CMD** pin of the cellular module must be connected to the TIMEPULSE pin of the external GNSS system, and it must be properly configured to the "External GNSS time pulse input" mode by the +UGPIOC AT command (<gpio_mode>=28) to receive the time pulse reference from the external GNSS system.
- The **GPIO4** pin of the cellular module must be connected to the EXTINT pin of the external GNSS system, and it has to be properly configured to the "External GNSS time stamp of external interrupt" mode by the +UGPIOC AT command (<gpio_mode>=29) to trigger via interrupt the generation of an URC timestamp from the external GNSS system.

Table 3 summarizes the pins available on the SARA-R5 series modules for timing functionalities.

Function	Description	Configurable GPIO	Notes
External GNSS time stamp of external Interrupt	Output to get an URC time stamp from an external u-blox GNSS system, triggered via interrupt	GPIO4	Not supported by SARA-R510M8S and SARA-R520M10
Time pulse output	Output providing accurate time reference, as a time pulse sequence with 1 PPS or as a single time pulse, based on the GNSS system or on the LTE system	GPIO6	
Timestamp of external interrupt	Input triggering via interrupt the generation of an URC time stamp over AT serial interface, using the time reference from the GNSS system or the LTE system	EXT_INT	Not supported by SARA-R520M10
External GNSS time pulse input	Input to receive an accurate time reference, as a time pulse sequence with 1 PPS or as a single time pulse, from an external u-blox GNSS system	SDIO_CMD	Not supported by SARA-R510M8S and SARA-R520M10

Table 3: Pins of SARA-R5 series modules supporting timing functionalities

☞ For further details of the +UTIME AT command, see section 4 and the AT commands manual [2].

[3] Not supported by SARA-R520M10 modules.

3 Usage models

This section provides a few usage models to illustrate the range of applications and configurations for the module hybrid timing feature.

1. A single device, for internal timekeeping, see section 3.1.
2. A device with GNSS timekeeping, with a fallback to an LTE time base in case of temporary loss of GNSS, see section 3.2.
3. Relative timing between a number of local devices, see section 3.3.
4. Relative timing between devices distributed over a wide area, see section 3.4.
5. Timing provision for a device deep indoors, with calibration by a reference anchor receiving GNSS, see section 3.5.

In all above use cases, the devices in consideration are stationary.

3.1 LTE for measuring timing intervals in a sensor

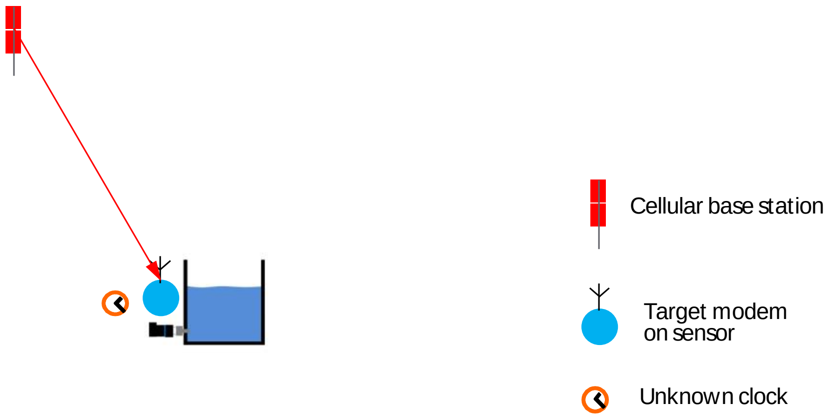

Figure 2: Using LTE to measure timing intervals

In Figure 2, the signal from an LTE base station is monitored and provides an accurate clock tick to measure time intervals precisely.

In addition, this synchronization allows distributing the LTE clock ticks (aligned to LTE frames) also to other sensors.

Two possible outputs are available with the setup above:

- Elapsed time between events in the module can be accurately (better than 1 µs) measured with reference to the LTE base station frame time.
- A PPS sequence, aligned with the LTE frame grid (better than 1 µs) is generated.

☞ Note that:

- The timekeeping is that of the base station.
- The device may select to synchronize with any of the visible base stations. By default, the device synchronizes with the serving cell.
- If the device moves, then the perceived time will change, as the propagation time from the base station changes.
- Time measured on the device relates only to the events at that device and cannot be compared to events on other devices.

3.2 LTE bridging GNSS as a temporary fallback

Using the LTE as a timing reference is particularly useful, to provide a fallback to measure time intervals within the device, when GNSS operation is temporarily limited. This will be illustrated considering the example of the synchronization of small cells.

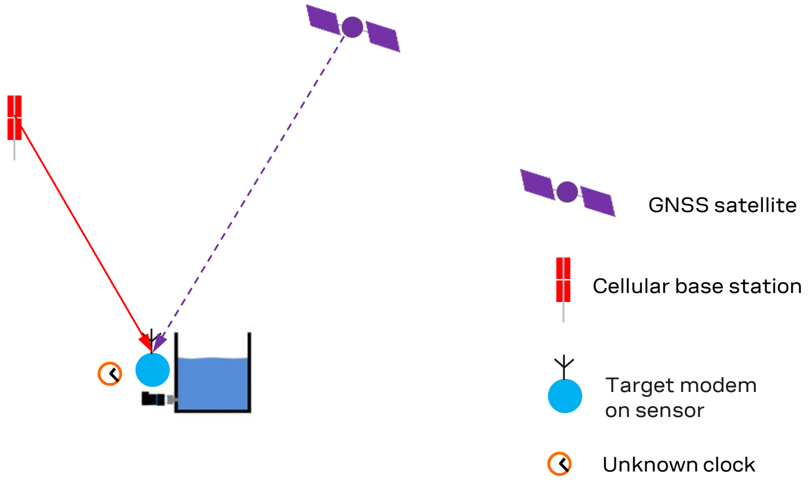

Figure 3: Using LTE as a fall back, if GNSS becomes unavailable

Figure 3 shows an example where the sensor is provided with a timing reference either from the GNSS receiver or, as a fallback, from LTE receiver.

The product may use the fallback if GNSS:

- Suffers a system failure, or
- Becomes unavailable because of difficult propagation (such as sunspot activity, or weaker indoor conditions), or
- Is accidentally or deliberately jammed.

As a result of the setup above:

- Initially the product obtains absolute UTC time from GNSS.
- This absolute time is then used to calibrate the signal received from the LTE base station, so that its absolute time is known.
- The timing of the signal received from the LTE base station then continues to be tracked.
- The timing reference obtained from LTE base station is used as a fallback option if the GNSS timing reference becomes unavailable.

☞ Note that for this use case:

- The same device is doing all the measurements, so the location of the base station does not matter and does not need to be known.
- It is assumed that the device is static.
- In the absence of GNSS the device remains locked to the timekeeping of the LTE base station. Therefore, the timekeeping will be determined by that of the LTE base station.

3.3 Relative timing between modules

In the example of Figure 4 several sensors are clustered together, with view of the same base station. The application shall establish the relative timing between events in a number of modules.

In this example it is assumed that:

- Modules are connected to the same LTE base station.
- The relative timing between modules can be precisely estimated (<1 µs), using the base station as a common reference.

As a result of the setup above:

- The signal from the LTE base station is used to establish a local clock.
- The timestamps by the different modules are compared to establish the relative timing of events at different modules.

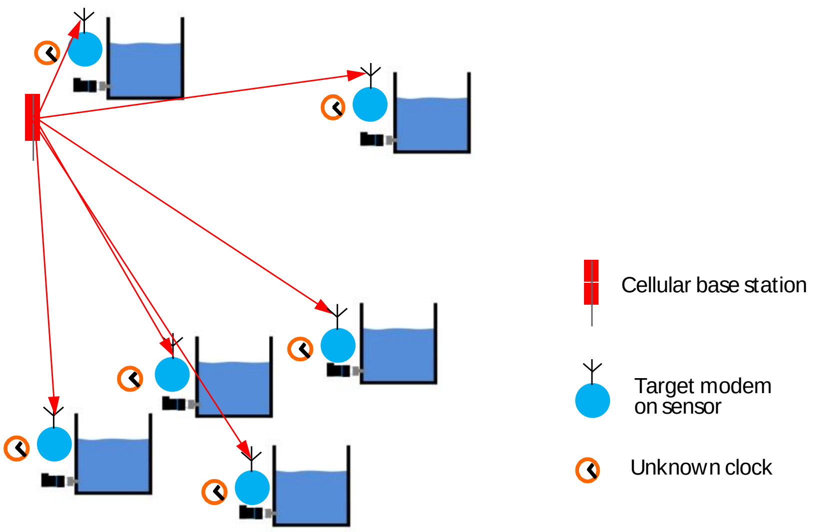

Figure 4: Relative timing between a cluster modems using a common LTE base station as a reference

The relative timing of the modules is affected by the relative separations of the different modules to the base station, as illustrated in Figure 5. The uncertainty is mitigated by using the Timing Advance (TA) information from the serving cell

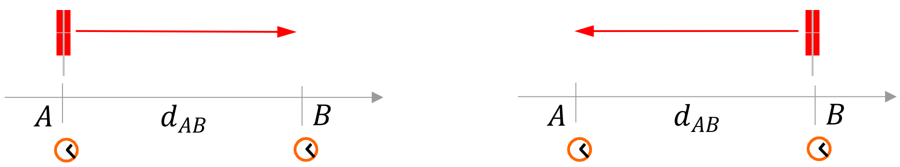

Figure 5: The effect on relative timing of uncertainty in the base station location

The location of the modules might be known, at least approximately, but the location of the serving cell base station used for timing is normally unknown. This will lead to uncertainty in the relative timing of the arrival of signals at the modules, and hence in the perceived relative timing at the modules. However, the Timing Advance (TA) information provided by the serving cell allows compensation of this geometry effect.

As illustrated in Figure 5 for the case of two modules at A and B separated by a distance d_{AB} if the base station is close to A then the signal from the base station arrives at the module at B after a delay of $t_B - t_A = d_{AB}/c$, where c is the speed of light. Two clocks synchronized by receiving this signal will therefore be running with an offset, with the clock at A running in advance of the clock at . Similarly, if the base station happens to be sited close to the location, then the use of the transmitted signal to synchronize the clocks will result in an offset of $t_B - t_A = -d_{AB}/c$. The uncertainty in the relative timing caused by these propagation delays thus depends on the separation between the modules, and on the relative location of the base station and the modules. As we have seen, in the worst case the error is

$$t_B - t_A = \pm d_{AB}/c$$

In principle, for module sensors separated by 300 m this gives a worst case error of ±1 µs. The TA information, made available to the cellular module by the serving cell, permits to compensate this geometric effect with the only limitation given by the granularity of TA of ~0.5 µs.

☞ Note that for this use case:

- The absolute UTC time is not known, but this is not needed for handling relative timing between the modules.
- Any disturbance or change in the LTE base station may also affect the relative time measurements by the module, if the measurements by the modules take place at different times. For example, care should be taken when accurately comparing a measurement in the morning by one module, with a measurement in the afternoon by a second module.
- No GNSS is involved or required.

3.4 Modules distributed over a wide area

In some applications sensors are widely distributed across an area. In this case the sensors do not all see the same serving cell or base station.

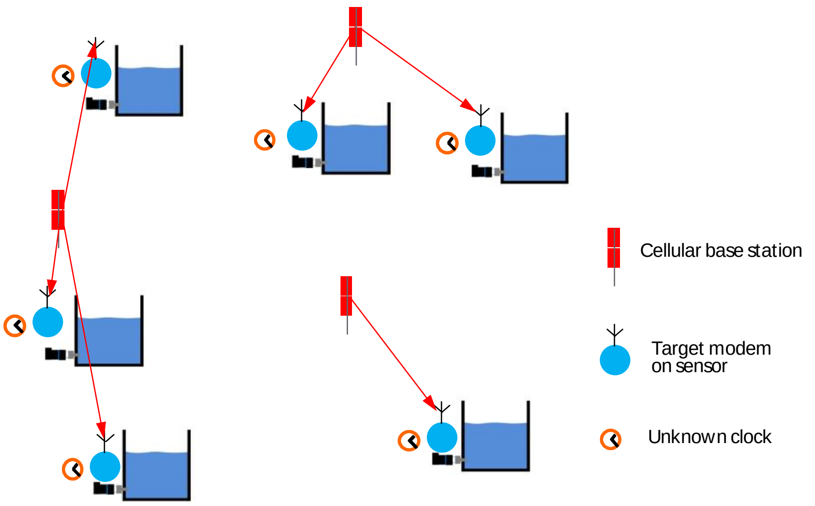

Figure 6: Timing for modems distributed over a wide area

In the example of Figure 6 the application wishes to establish the relative timing between events in a number of modules which are distributed over a wide area. The application may wish to coordinate activities in different areas, or to report measurements with knowledge of time.

In this case we may be interested in:

- The interval of time between events on the same device
- The differences in time between events on different devices
- Synchronization of the clocks on the different devices

The most accurate way to do this is to use GNSS, but this is not always applicable, on the grounds of signal availability, or equipment cost. Timing can still be performed using the network, though naturally with some limitations on the accuracy.

As a result of the setup above:

- The signal from the LTE base station is used by the module to establish its local clock rate, for timing the intervals between events on the single module.
- It might also be that the relative time between different base stations is managed by the network operator within limits, for example to maintain connectivity specifications. In which case this can be used to support relative timing between clusters of modules listening to different base stations.

☞ Note that for this use case:

  - The relative timing of events on a single module is normally very precise, as it is determined by the timekeeping performance of the LTE system base station (This assumes that the module is stationary, as the absolute time reported by the module will change, if it is moved)
  - For relative timing within each cluster the absolute UTC time does not need to be known accurately
  - For relative timing between clusters, GNSS integrated in at least one sensor module in each cluster may be used to synchronize the different clusters together

3.5 Local anchor with GNSS giving accurate time

Figure 7 illustrates a further example, addressing applications in which the absolute time is important, but GNSS is not available – perhaps because the module is located deep indoors. In this case an additional module, with GNSS, is installed as a local reference anchor.

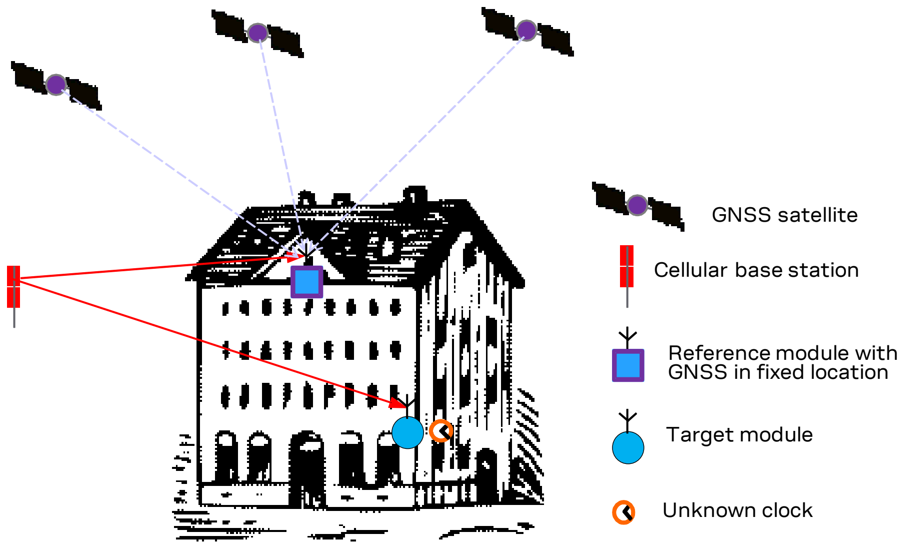

Figure 7: Using a local anchor with GNSS to calibrate the timing of a signal from an LTE base station

The anchor has good GNSS, and calibrates the timing of the signals from the cellular base station. The calibration information is shared with other modules which are listening to the cellular base station, so that they can use this as a timing reference.

As a result of the setup above:

- The anchor module performs a GNSS fix, establishing time at the anchor.
- The timing of the signal received by the anchor from the LTE base station is measured and calibrated against the GNSS time. This calibrates the timing of the LTE base station.
- The calibration information is communicated to the timing module.
- The timing module receives the signal from the LTE base station and measures its timing.
- The calibration information is then used to generate the correct absolute time at the timing module, which is then available for the application.

☞ For this use case:

- The anchor is assumed to be placed such that it has good GNSS reception, for the calibration of the signal from the base station
- If GNSS reception by the anchor is lost for some reason (such as interference) then timing continues to be provided to the modems by reference to the LTE base station

4 CellTime application interface

This section introduces the AT commands that provides and configures timing information to the user application.

4.1 Time information +UTIME

The +UTIME AT command can provide timing information from the SARA-R5 series modules via three operating modes:

- Configurable Pulse Per Second (PPS) output sequence from a GPIO pin
- Single time pulse output from a GPIO pin and a URC with the accurate time stamp of the pulse
- Time stamp of external interrupts (received in a dedicated GPIO pin)

Time pulses will be generated using one of the supported GPIO pins of the cellular module. Similarly, the external interrupts will be received using one of the supported GPIO pins of the cellular module. For further details on supported GPIO pins, see the SARA-R5 series system integration manual [3] and the positioning implementation application note [4].

PPS time pulse sequence can be configured both in periodicity (0.5 to 4 s) and width (10 ms to 990 ms).

The time information source may be GNSS or the autonomous time propagation (LTE module clock). In addition, URCs are output when the device changes the source of the timing – in particular when GNSS becomes unavailable, and available again (see the +UTIMEIND command in section 4.2). It is possible to configure which aiding types and GNSS systems are available to the GNSS sensor by the +ULOCGNSS command. For further details on aiding features, see the positioning implementation application note [4].

Two or more modules registered to the same base station (see usage model in section 3.3) can be synchronized if the +UTIME AT command is sent simultaneously (+/- 1 s) to both devices.

☞ The +UTIME AT command requires the exclusive access to the GNSS sensor. If the +UTIME AT command is enabled using GNSS sensor, when this is already in use (e.g. by +UGPS AT command), it will return an error result code.

If the GNSS is turned on using the +UTIME AT command, it cannot be turned off using another interface (e.g. AT+UGPS=0).

☞ The pulse configuration is not available in SARA-R5 “00B” product versions.

4.2 Time information request status +UTIMEIND

The +UTIMEIND AT command enables the sending of URCs during +UTIME operations. The URC provides the status of the timekeeping in the module and informs the user about:

- The operation in progress
- The source used for timekeeping
- Whether time is in UTC or on an arbitrary time scale
- Generic results of intermediate operation steps

☞ In case of alignment with UTC time (by GNSS), it also returns the discontinuity in the local time (offset between the local time and UTC time). The knowledge of this discontinuity is needed to compare in time two events occurred before and after the re-synchronization.

4.3 CellTime configuration +UTIMECFG

This command sets the CellTime configuration parameters.

The user can configure a time offset to correct the local time scale or align it with the UTC time.

For example, considering the usage model in section 3.5 when the anchor module calibrates the timing of the LTE base station against the GNSS time, it returns a URC (+UTIMEIND) providing the discontinuity in the local time. This calibration information can be used to generate the correct absolute time at the timing module (without GNSS) by the `+UTIMECFG` AT command.

4.4 Synchronization on a specific cell of any MNO +UTIMECELLSELECT

This command forces the module to synchronize and lock on a specific LTE-M/NB-IoT cell of any specific MNO.

The user only sets the PLMN and the EARFCN, P-CID pairs to make the module locked and camped on a specific cell.

In section 3.1, a user case is described where the local time in the modem is aligned with the LTE frame grid of a base station. The reference base station may be any LTE-M/NB-IoT cell in view of any MNO. A SIM card is not needed by the modem to operate under these conditions.

The synchronization with the base station is affected by the time of flight of the signal, this can be compensated using the Timing Advance (TA).

The purpose of `+UTIMECELLSELECT` is to achieve a successful Cell Selection (IDLE-state) and obtain the TA information from RACH process. Then, the UE attach procedure is aborted before Msg3 (RRC Connection Request). Optionally, the user can choose to skip the RACH procedure and provide the TA value as input, if known.

The obtained TA value will be automatically compensated during the PPS output generation (e.g. `AT+UTIME=1,2`) which will result aligned with the LTE frame.

The feature can work only if cellular functionality is switched off by the `AT+CFUN=0` or `AT+CFUN=4` AT command. So, connectivity is not supported, and reselections are inhibited.

5 Expected performance

Table 4 shows the target specifications for the hybrid timing function of SARA-R5 series modules.

Timing	GNSS	LTE
Relative between events[4]	< 0.1µs	< 1 µs for a limited period[5]
Relative between modems	< 1µs	< 1 µs
Timing relative to base station[6]		< 0.5 µs[7]
Absolute, UTC[8]	< 0.1µs for timestamp < 0.5µs for 1pps output	~10 µs for one day[9]
		< 1 µs for a limited period[5]
Anchor Assisted absolute UTC		< 1 µs

Table 4: Expected timing accuracy for CellTime hybrid timing

[4] Relative timestamp of two events on the same (stationary) module

[5] The measured timing interval will become less accurate over time, depending on the drift of the LTE base station, and whether the base station timing is controlled using reference GNSS receivers by MNOs.

[6] The timekeeping from a stationary module, relative to the timekeeping of the local LTE base station, over a period of time. If the LTE base station drifts, so will the timekeeping and output of the module. This assumes that there is no calibration (which actually would introduce additional errors into the measurement of relative timing)

[7] There will also be a time offset, depending on the separation of the module from the base station

[8] Strictly speaking this is GNSS time, not UTC. Assuming the base station signal is not calibrated using a GNSS receiver, and that the GNSS receiver has visibility of at least 4 GNSS satellites

[9] Worst case scenario if base station clock is not controlled using a reference GNSS receiver by MNOs.

6 AT commands examples

6.1 Activation of CellTime - PPS mode

Command	Response	Description
AT+UTIMEIND=1	OK	Enable the timing information request status.
AT+UTIMECFG=0,0	OK	Reset the time offset configuration
AT+UGPIOC=19,22	OK	Configure the output pin for the PPS.
AT+UTIME=1,1,1,200	OK	Request PPS output generation enabling GNSS/LTE (best effort) with 1 s period and 200 ms width. Period/width parameters are optional and have 1 s/100 ms as default values[10]
	+UUTIMEIND: 1,0,0,0	Initialization of sensors after starting UTIME operations (PPS mode).
	+UUTIMEIND: 4,2,0,0	Synchronized with LTE BS (local time scale): start PPS output.
	+UUTIMEIND: 4,1,1,0	Synchronized with GNSS TP (UTC time): align PPS output.
	+UUTIMEIND: 4,1,1,1,295045451,0	Alignment with UTC time: offset compared to local time scale.
	+UUTIMEIND: 4,2,1,0	GNSS fix lost. Synchronized with LTE BS: keep PPS output aligned to UTC time.
AT+UTIMECFG=3000,0	OK	Configure a time offset of 3000 ns: re-align PPS output.
AT+UTIME=0	OK	Turn off the UTIME operations.
	+UUTIMEIND: 0,3,1,0	UTIME operations are off.

6.2 Activation of CellTime – One shot mode

Command	Response	Description
AT+UTIMEIND=1	OK	Enable the timing information request status.
AT+UTIMECFG=0,0	OK	Reset the time offset configuration.
AT+UGPIOC=19,22	OK	Configure the output pin for the time pulse.
AT+UTIME=2,1	OK	Request single output pulse with time stamp enabling GNSS/LTE (best effort).
	+UUTIMEIND: 2,0,0,0	Initialization of sensors after starting UTIME operations (one shot mode).
	+UUTIMEIND: 4,2,0,0	Synchronized with LTE BS (local time scale): generate single output pulse with timestamp (default time origin: 1st of January 2018).
	+UUTIME: 01/01/2018,00:00:03,123.456789,0.000000000,0	Timestamp of a single pulse (local time scale).
	+UUTIMEIND: 4,1,1,0	Synchronized with GNSS TP (UTC time): align timestamps to UTC time.
	+UUTIMEIND: 4,1,1,1,22962682,74774978	Alignment with UTC time: offset compared to local time scale.
AT+UTIME=2,1	OK	Request single output pulse with time stamp (UTIME already initialized).
	+UUTIME: 15/05/2020,10:12:34,12	Timestamp of a single pulse (UTC time scale).

[10] The pulse period and width are not configurable in SARA-R5 "00B" product versions

Command	Response	Description
	3.456789,0.000001234,1	
AT+UTIMECFG=3000,60	OK	Configure a time offset of 3000 ns and 60 s: re-align timestamps.
AT+UTIME=0	OK	Turn off the UTIME operations.
	+UUTIMEIND: 0,3,1,0	UTIME operations are off.

6.3 Activation of CellTime – Timestamping of external interrupts mode

Command	Response	Description
AT+UTIMEIND=1	OK	Enable the timing information request status.
AT+UTIMECFG=0,0	OK	Reset the time offset configuration.
AT+UGPIOC=33,23	OK	Configure the input pin for the external interrupts.
AT+UTIME=3,1	OK	Request timestamping of external interrupts enabling GNSS/LTE (best effort).
	+UUTIMEIND: 3,0,0,0	Initialization of sensors after starting UTIME operations (timestamp of ext-int mode).
	+UUTIMEIND: 4,2,0,0	Synchronized with LTE BS (local time scale): start timestamping external interrupts (default time origin: 1st of January 2018).
	+UUTIME: 01/01/2018,00:00:03,123.456789,0.000000000,0	Timestamp of an external interrupt (local time scale).
	+UUTIMEIND: 4,1,1,0	Synchronized with GNSS TP (UTC time): align timestamps to UTC time.
	+UUTIMEIND: 4,1,1,1,22962682,74774978	Alignment with UTC time: offset compared to local time scale.
	+UUTIME: 15/05/2020,10:12:34,123.456789,0.000001234,1	Timestamp of an external interrupt (UTC time scale).
	+UUTIMEIND: 4,2,1,0	GNSS fix lost. Synchronized with LTE BS: keep timestamps aligned to UTC time.
AT+UTIMECFG=3000,60	OK	Configure a time offset of 3000 ns and 60 s: re-align timestamps.
AT+UTIME=0	OK	Turn off the UTIME operations.
	+UUTIMEIND: 0,3,1,0	UTIME operations are off.

6.4 Synchronize two modules using LTE frame

Two modules registered to the same Base Station (see use case in section 3.3) can be synchronized if the `+UTIME` AT command is sent simultaneously (+/- 1 s) to both devices.

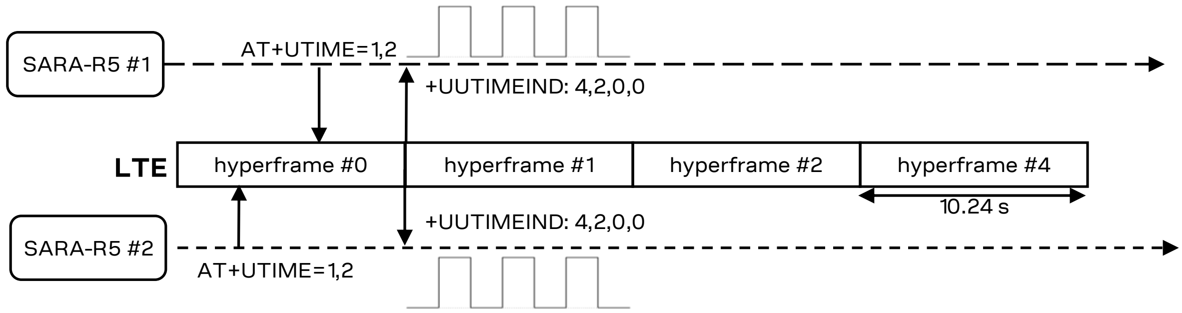

Figure 8: Example of time synchronization between two modules registered to the same base station

6.5 Synchronization on a specific cell (+UTIMECELLSELECT) and activate +UTIME- PPS mode

Command	Response	Description
`AT+CFUN=0`	`OK`	Switch off cellular functionality.
`AT+UTIMECELLSELECT=1,"123456",2450,1`	`OK`	Sync on a specific cell: • MCC: 123 • MNC: 456 • EARFCN: 2450 • P-CID: 1
	`+UUTIMECELLSELECT: 1,160`	Synchronization enabled and successful, camped on the requested cell with TA=160Ts (~5208 ns).
`AT+UGPIOC=19,22`	`OK`	Configure the output pin for the PPS.
`AT+UTIMEIND=1`	`OK`	Enable the timing information request status indications.
`AT+UTIME=1,2`	`OK`	Request PPS output generation (LTE source).
	`+UUTIMEIND: 1,0,0,0`	Initialization of sensors after starting UTIME operations (PPS mode).
	`+UUTIMEIND: 4,2,0,0`	Synchronized with LTE BS (local time scale): start PPS output.
`AT+UTIMECFG=3000,0`	`OK`	Configure a time offset of 3000 ns: re-align PPS output.
`AT+UTIME=0`	`OK`	Turn off the UTIME operations.
	`+UUTIMEIND: 0,3,0,0`	UTIME operations are off.

6.6 Synchronization on a specific cell without RACH request (+UTIMECELLSELECT) and activate +UTIME – PPS mode

Command	Response	Description
`AT+CFUN=0`	`OK`	Enable the airplane mode.
`AT+UTIMECELLSELECT=2,"123456",2450,1,80`	`OK`	Sync on a specific cell: • MCC: 123 • MNC: 456 • EARFCN: 2450 • P-CID: 1 TA (known): 80
	`+UUTIMECELLSELECT: 1,80`	Synchronization enabled and successful, camped on the requested cell with known TA=80Ts (~2604 ns).
`AT+UGPIOC=19,22`	`OK`	Configure the output pin for the PPS.
`AT+UTIMEIND=1`	`OK`	Enable the timing information request status indications.
`AT+UTIME=1,2`	`OK`	Request PPS output generation (LTE source).
	`+UUTIMEIND: 1,0,0,0`	Initialization of sensors after starting UTIME operations (PPS mode).
	`+UUTIMEIND: 4,2,0,0`	Synchronized with LTE BS (local time scale): start PPS output.
`AT+UTIMECFG=3000,0`	`OK`	Configure a time offset of 3000 ns: re-align PPS output.
`AT+UTIME=0`	`OK`	Turn off the UTIME operations.
	`+UUTIMEIND: 0,3,0,0`	UTIME operations are off.

7 Best practices for time information

Below is a list of the best practices of receiving the most accurate time information from the SARA-R5 series modules:

- The `+UUTIMEIND` URC reports which sensor provides the time information:
  - GNSS clock (from the GNSS fix)
  - LTE base station
- Once the `+UTIME` AT command is issued, the user/application shall wait for the `+UUTIMEIND: 4,2,0,0` indication (synchronized to LTE base station).
- The use of the `+UTIME` AT command could require a data connection, e.g., for GNSS aiding (AssistNow Online, AssistNow Offline) for faster and more accurate GNSS performance.
  - The user shall set the APN parameters of the network provider (`AT+UPSD=0,1,"apn.name"`) and activate the PDP context (`AT+UPSDA=0,3`)
  - The user shall configure the servers that provide time information using the `+UGSRV` AT command, e.g., `AT+UGSRV="cell-live1.services.u-blox.com","cell-live2.services.u-blox.com","token".`
  - GNSS constellations of interest can be set with the `+ULOCGNSS` AT command
- Configure the output pin (GPIO6) for the time pulse output by the `AT+UGPIOC=19,22` command
- Configure the input pin (**EXT_INT**) for the time stamp of external interrupts by the `AT+UGPIOC=33,23` command
- In case of SARA-R500S / SARA-R510S / SARA-R500E with an external GNSS, the user must configure two additional pins to allow calibration and interaction with the external GNSS:
  - Connect the SDIO_CMD pin of SARA-R500S / SARA-R510S / SARA-R500E with the PPS pin of the external GNSS
  - Configure the input pin (**SDIO_CMD**) for the external GNSS time pulse input (input to receive an accurate time reference, as a sequence with 1 PPS from an external GNSS system) by the `AT+UGPIOC=46,28` command
  - Connect the GPIO4 pin of SARA-R500S / SARA-R510S / SARA-R500E with the EXT-INT pin of the external GNSS
  - Configure the output pin (**GPIO4**) for the external GNSS time stamp of external interrupt (output triggering via interrupt the generation of an URC timestamp from an external GNSS system) by the `AT+UGPIOC=25,29` command
- To get time information from the GNSS, the application waits for a valid fully resolved fix and time. This could last from some tens of seconds to up to 2 minutes, depending on the environment and satellites in view.
- `+UTIMECELLSELECT` is intended only for CellTime purpose, to allow synchronization with any LTE-M/NB-IoT cell:
  - SIM card is not needed.
  - `+UTIMECELLSELECT` can work only if cellular functionality is switched off (`+CFUN: 0` or `+CFUN: 4`). Connectivity is not supported, and reselections are inhibited.
  - The `AT+COPS=5` command can be used to determine the available EARFCN and P-CID numbers.
  - The `AT+COPS=5` command and the test command shall not be used when the lock is enabled, because the results would be inconsistent.
  - Once the Timing Advance (TA) value is obtained, it will be automatically compensated during the PPS output generation (e. g., `+UTIME: 1,2`)

Appendix

A Glossary

Abbreviation	Definition
AT	AT Command Interpreter Software Subsystem, or attention
BS	Base Station
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input/Output
LTE	Long-Term Evolution
LTE-M	Long-Tem Evolution – enhanced Machine type communication
M2M	Machine to Machine
MCC	Mobile Country Code
MNC	Mobile Network Code
NB-IoT	Narrowband Internet of Things
P-CID	Physical Cell ID
PLMN	Public Land Mobile Network
PPS	Pulse Per Second
RACH	Random Access Channel
RRC	Radio Resource Control
SIM	Subscriber Identity Module
TA	Timing Advance
TP	Time Pulse
URC	Unsolicited Result Code
UTC	Universal Time Coordinated

Related documentation

[1] u-blox SARA-R5 series data sheet, UBX-19016638
[2] u-blox LEXI-R520 / SARA-R5 series AT commands manual, UBX-19047455
[3] u-blox SARA-R5 series system integration manual, UBX-19041356
[4] u-blox Positioning implementation application note, UBXDOC-686885345-1826
[5] u-blox Accurate timing for the IoT whitepaper, https://www.u-blox.com/en/publication/white-paper/accurate-timing-iot

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

Revision history

Revision	Date	Name	Comments
R01	15-May-2024	fvid	Initial release

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