LEXI-R10 series

Application development guide

Application note

Abstract

This document provides detailed technology architecture and examples of how to use AT commands with u-blox LEXI-R10 series modules.

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Document information

Title	**LEXI-R10 series**	
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This document applies to the following products:

Product name
LEXI-R10 series

Contents

1 Getting Started

This document provides guidance for developing applications that interface with the u-blox LEXI-R10 series modules, including examples of AT command sequences for specific use cases.

Figure 1 shows the supporting documentation through the product design lifecycle.

Table 1 provides summary of the key information contained in each of them.

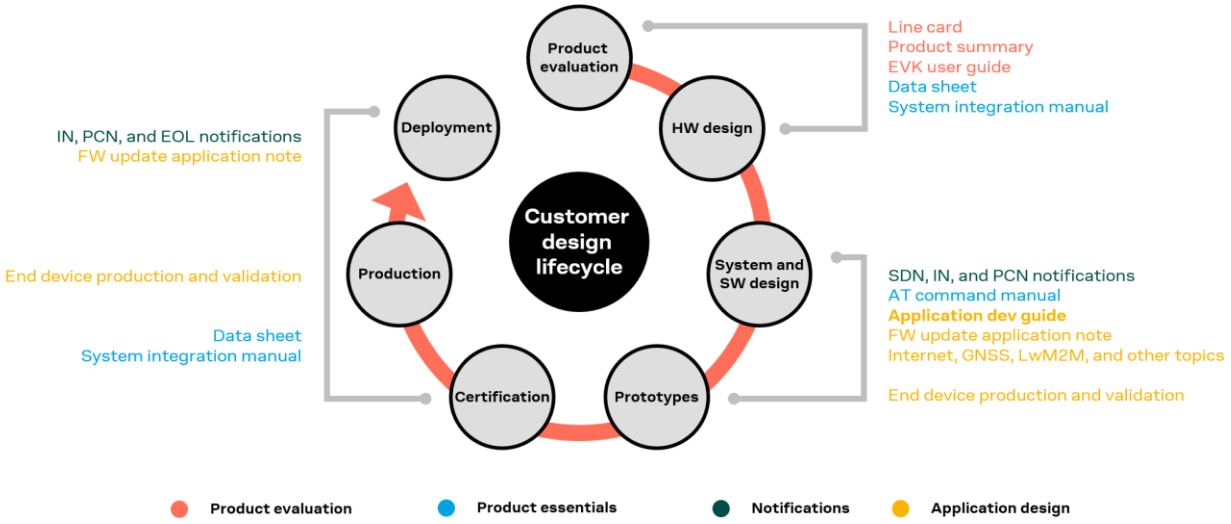

Figure 1: LEXI-R10 series documentation map

Document scope	Document name	Notes
Product evaluation	EVK-R10 user guide [4]	Starting guide for the LEXI-R10 evaluation kit.
Product essentials	Data sheet [2]	Performance and characteristics of a product (family)
	System integration manual [3]	Describes how to design a product (family) into a customer application
	AT commands manual [1]	Reference guide for protocols, detailed AT command descriptions. Refer to this manual for details of any AT command listed in this app note.
Notifications	Sample Delivery Note / Information Note / Product Change Note / End of Life	Notifications of SW / HW / Certification changes.
Application design	Application development guide	This document. **Start here!**
	FW update app note [5]	FW update procedures (FOAT, FOTA, and EasyFlash).
	Internet application app note [6]	Any applications relying on the IP stack (sockets, MQTT, HTTP, and TLS).
	Production and validation test app note [11]	Guidelines of OEM production test and validation test. Contact tech support for this document.
	Mux implementation [9]	Use of multiplexer with cellular modules.
Tools	m-center AT scripts collection	https://github.com/u-blox/m-center

Table 1: LEXI-R10 documentation overview

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

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

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

2 Application design and development

When designing a host application interfacing with a u-blox cellular module, consider the points depicted in Figure 2:

- Choose the module's features that the application needs and the ones that can be disabled.
- Split the application workflow into stages.
- Design the application to work in several modes, reflecting the lifecycle steps of the product.

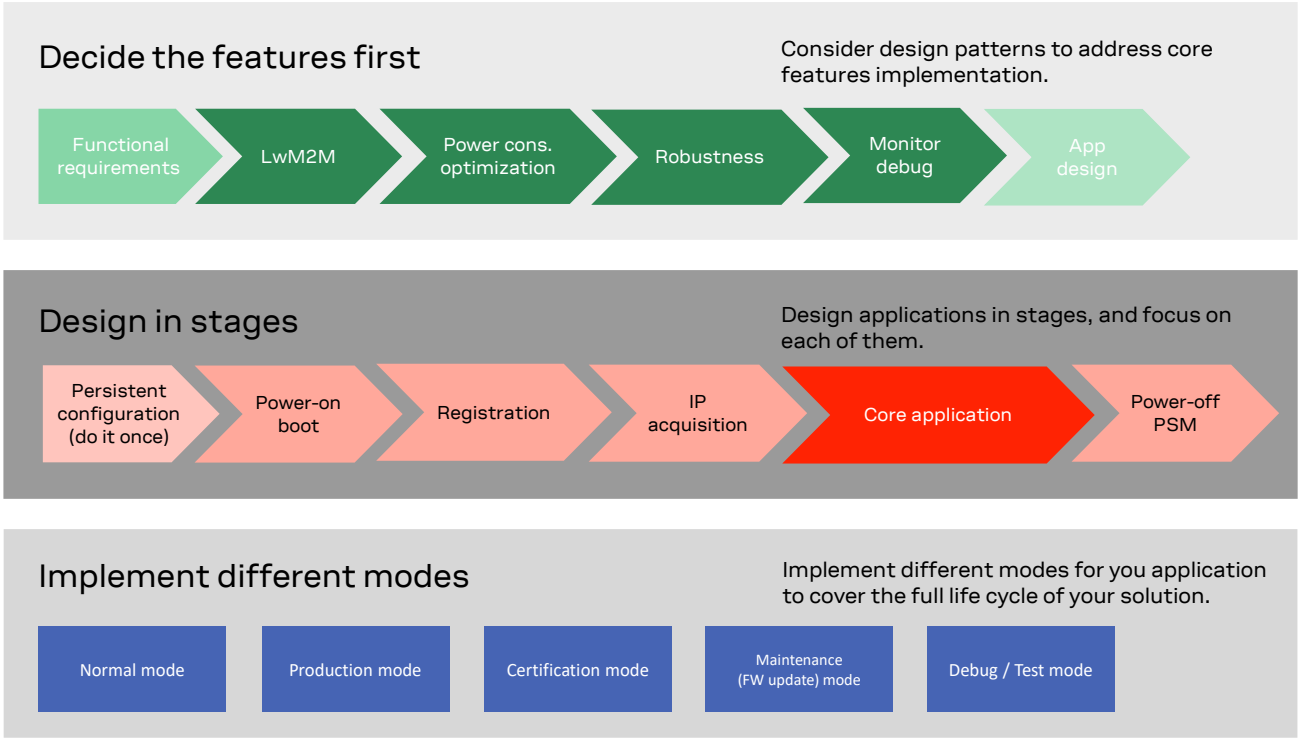

Figure 2: Application design guidelines

2.1 Initial design decisions and recommendations

If some features will never be used during the application lifetime, they should be disabled or properly configured to minimize their impact on the overall performance. These decisions should be carefully taken at design stage because any late change could cause much effort to adapt and validate the application.

These decisions concern:

- Usage of power saving
- SIM card/MNO selection
- SW/HW monitor and debug solutions
- SW/HW recovery modes

Power saving features (+UPSV, PSM, eDRX) shall be configured based on the target power consumption profile.

The MNO profile (section 6) to be used depends on the type of application and SIM card (regional or global roaming). If the SIM card belongs to an MNO for which the module has gained the type approval, the MNO profile is available in the FW and shall be used.

Debug-ability can be provided via test endpoints, access to the USB interface, and in general a prolific application log containing all AT commands strings exchanged with the module and diagnostic

information sent by the module with timing information. Monitoring the module status is a requirement to implement, via HW or SW, recovery procedures as described in section 9.

u-blox recommends properly designing and testing a module's firmware update mechanism that allows deployment of the latest cellular module FW in the field after the device production.

☞ For the LWM2M feature available only on Verizon MNO profile, see section 6.7.

2.2 Application stages

2.2.1 Persistent configurations

Some module settings are persistent, that is, they are stored in the module Non-Volatile Memory (NVM). Among these are the MNO profile (see section 6), APN for Internet connectivity, and active LTE bands, but also +IPR and +UPSV AT commands settings. In addition to NVM, several settings (e.g., +CMEE and +CEREG) are saved to the module profiles by AT&W command.

The host application shall implement a persistent configuration setting phase, performed once and then on an as-needed basis, where all AT commands related to the required settings are issued.

☞ See the FW update application note [5] for persistence of settings after a FW update. If settings are not retained, they shall be reapplied.

2.2.2 Power on/boot

In general, at each boot the application should read configurations and make sure they are correct. If not, persistent configurations can be reapplied.

Not all the module configurations are persistent. Therefore, the application, after each module boot, should again set these volatile configurations.

It is very important that the application has a robust mechanism to detect when the module is ready to communicate via AT commands at the power-on: a solution is to monitor the greeting message (+CSGT AT command factory-programmed value is "+UUSTATUS: READY"); alternatively, the host application can wait for a response to "AT" command.

The application should configure module time. Automatic update of local time with the network time information is the factory-programmed setting (+CTZU: 1), so after LTE attach, the time of the module is generally updated.

☞ Every time the module is powered on, it issues the message "^boot.rom'v'!\n" on the main UART interface at 115200 bit/s (8-n-1). This message shall be ignored, and the module shall be considered ready to receive AT commands only after the greeting text is returned.

When using power saving, at exiting from Sleep-2 or Hibernate deep-sleep modes the volatile settings as well as the current communication port mode (e.g., multiplexer protocol) shall be restored. Refer to section 8.3 for more details.

2.2.3 Network registration

For details about the network registration stage, see section 7.1.

2.2.4 IP acquisition

IP acquisition is done during the LTE network registration on the LEXI-R10 series. Therefore, no additional AT commands are required to start a data connection. For additional details and guidelines on this topic, see the LEXI-R10 Internet applications development guide application note [6].

2.2.5 Core application

For some details and guidelines on this topic, see the Internet applications development guide application note [6] and the AT command manual [1]. The application shall handle AT commands, responses and unsolicited indications as suggested in section 3. For diagnostic purposes, the application should rely on status AT commands, see section 9. For robustness purposes, the application should implement embedded watchdog procedures, see section 9.2.

2.2.6 Power-off

Both normal and emergency shutdown are described in the LEXI-R10 series system integration manual [3].

2.3 Application modes

An application is usually designed based on the main use cases in actual scenarios. This way of operation is what we call “normal mode”. In addition, the designer should provide a way to configure the application for more specific contexts, which can have different requirements with respect to normal mode and can help to perform other important steps in the product lifecycle.

2.3.1 Debug / test mode

In general, an application should always output a significant log, including the AT commands it issues and their responses, and implement monitoring strategies as described in section 9.

If a problem occurs related to the cellular module and more information is needed, it may be necessary to configure different verbosity levels for the host application and modules log. In extreme cases, it may be necessary to provide an AT interface passthrough to allow access to diagnostic AT commands.

If the cellular communication is tested against a network simulator, use a suitable test SIM card (usually provided by the network simulator manufacturer). If a test SIM card is not available, make sure to disable authentication and integrity checks on the tester side (by proper setting) and on the module (by using the AT+UDCONF=81,0 command, see AT commands manual [1]).

2.3.2 Production testing

This mode is to be used during the production tests of the end device. In this scenario the main application is usually inactive, and AT commands can be used to properly configure the module and use its end user testing features. For more details, contact technical support production and prototype validation guidelines application note.

2.3.3 Certification mode

Depending on the kind of certification, such as regulatory, conformance or for MNO type approval, the application might be disabled, and the module externally controlled (for example, for throughput testing). Specific MNO tests might require the application to be running in normal mode (for example, remote SIM provisioning, FOTA).

2.3.4 Firmware update mode

A module’s firmware update procedure shall be implemented when necessary, either over the air or tethered. Each update strategy has its requirements and correct implementation, which should be followed to guarantee the success of the operation. For more details, see the LEXI-R10 FW update application note [5].

3 AT commands response parser

It is important that the user implements a dedicated AT parser component in the host application.

Basic guidelines:

- When entering AT commands, spaces are ignored.
- The DTE shall handle the case of unexpected spaces or line endings, i.e., the <CR><LF> characters.
- As suggested in the AT commands manual [1], always wait for at least 20 ms following a final result code or a URC reception before issuing a new AT command.
- When the module has finished processing an AT command, it will output a final result code (either OK or ERROR) indicating that it is ready to accept a new AT command. The information text responses are issued before the final result code. Change the +CMEE AT command setting to numeric or verbose value (for example, AT+CMEE=1 or AT+CMEE=2).
- Asynchronous commands (for example, +UMQTTC) return an immediate final result code and final result via URC.
- Some AT commands return an intermediate result code (IRC) during command execution.

3.1 Operational modes of the AT interface

When implementing the AT parser, it is important to consider that the communication port, whether a virtual serial ports over USB interface, the main and auxiliary UART or a MUX virtual channels, enters different operational modes while processing AT commands.

In command mode, the module, called Data Communication Equipment (DCE), can receive AT commands. Once an AT command is detected on the AT interface, the DCE processes it and may return to command mode by issuing a success or error response. Special AT commands lead the AT interface into intermediate states where, for example, an SMS payload is expected, or raw/binary data is exchanged (for example, during file transfer), or PPP packets are exchanged. In the latter case, the PPP data mode can be temporarily exited by a special +++ packet or DTR line ON-to-OFF transition and the online command mode (OLCM) state is entered: from this state, which is similar to the command mode, the DCE can be moved back to PPP data mode via ATO command or can disconnect PPP via ATH command.

Figure 3 depicts the various modes in which the module can operate and shows the actions that cause transitions between the different modes. The transitions triggered by DTR line changes are configurable with the AT&D command.

For more details about the AT command interface settings, see the AT command settings section in the AT commands manual [1].

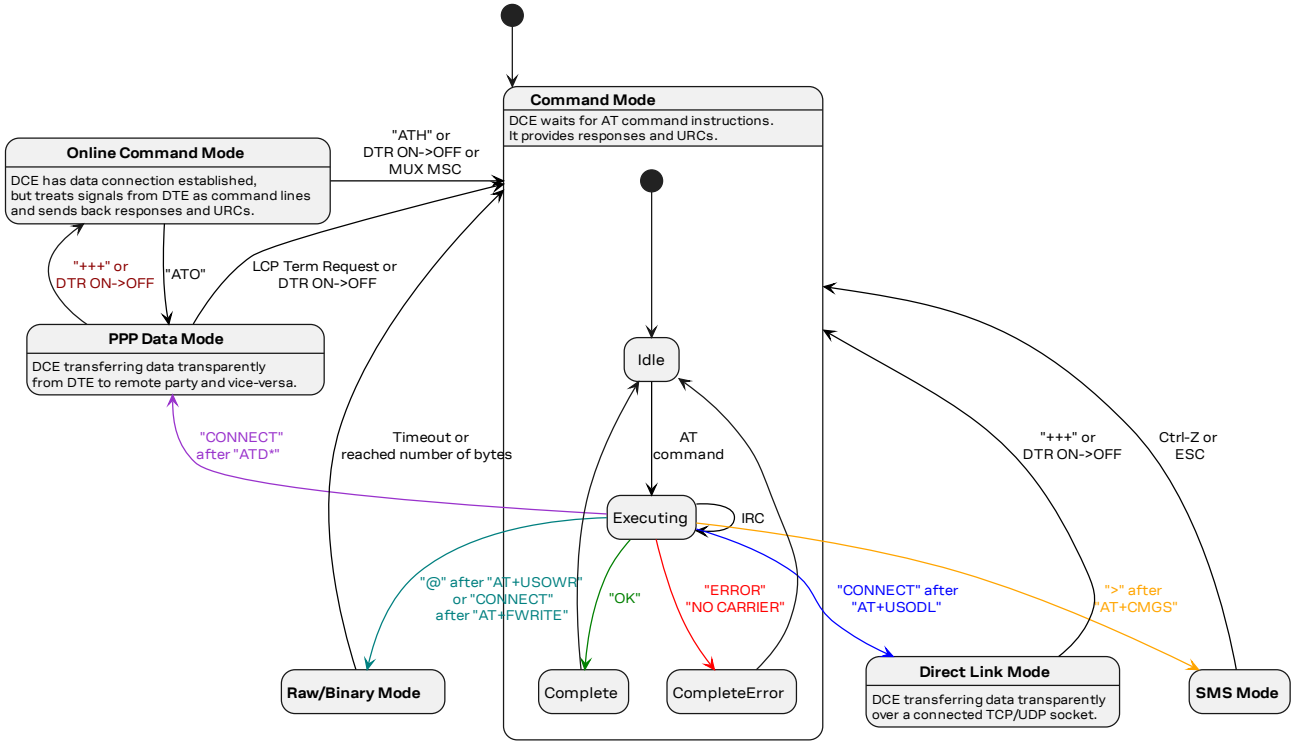

Figure 3: Module operating modes and actions causing mode transitions

3.2 Unsolicited result code

An unsolicited result code (URC) is a string message (provided by the DCE) that asynchronously indicates the occurrence of an event that might be related to a previous AT command or to the feature the user is currently using, or to the module's autonomous activity (for example, due to mobility).

When a specific URC has been enabled, it can be output on one or more AT ports, for further details see Appendix B of the AT commands manual [1]. Some URCs can be enabled in a persistent manner storing their configuration into the personal profile with AT&W command. Groups of diagnostic URCs can be enabled or disabled with the +UURCSTAT command, see more details in section 9.1.

If an AT port is busy, by default the URC presentation is deferred: up to 12 URCs are buffered on the USB ports and 7 on the UART ports, and are printed when the AT port returns into command mode. The application can discard +CGEV and SMS related URCs by configuring the related AT commands. For other URCs, caching and deferral can be customized with +UURCCFG AT command.

Due to race conditions in mode transitions, URCs can be received after an AT command has been transmitted by the host application.

Examples of some URCs are shown in Table 3.

URC	Description
`+CEREG: <stat>[,<tac>,<ci>,<AcT>]`	Network registration status or location has been updated
`+CGEV: ME PDN ACT <cid>`	The MT has activated a primary PDP context
`+UUSOCL: <socket>`	Socket has been closed

Table 2: URCs examples

4 Local connectivity

4.1 Serial interface configuration

By default, USB and UART interfaces are available simultaneously. It is possible to switch between 3 serial interface configuration variants, using the command +USIO AT command, as shown in Table 3.

Command	Response	Description
AT+USIO=0	OK	(Default configuration) AT on MAIN UART (8-wire: RXD, TXD, CTS, RTS, DTR, DSR, DCD, RI) AT on USB (x2) Diagnostic on USB1
AT+USIO=1	OK	AT on MAIN UART (4-wire: RX/TX, CTS, RTS) AT on AUX UART (4-wire: RX/TX, CTS, RTS) AT on USB (x2) Diagnostic on USB1
AT+USIO=5	OK	AT on MAIN UART (4-wire: RX/TX, CTS, RTS) AT on USB (x2) Diagnostic on AUX UART (4-wire: RX/TX, CTS, RTS) or USB1

Table 3: +USIO configuration variants

☞ Reboot the module to apply the new +USIO configuration.

4.2 AT interface on UART

AT commands can be issued to the module via UART interfaces, with default data rate set to 115.2 kbit/s (230.4 kbit/s, 460.8 kbit/s, 921.6 kbit/s and 3 Mbit/s are supported too). “Auto-bauding” is not supported by LEXI-R10 series modules.

☞ If only the UART interface is used and connected, it is required to disable the USB interface with +UUSBCONF=99 AT command for the proper device operation. Then, reboot is required to save the configuration.

4.2.1 Set a fixed baud rate

Use the +IPR AT command to set a different baud rate for the UART interface in which the command is sent, as shown in Table 4.

Command	Response	Description
AT+IPR=460800	OK	Set UART speed to fixed value 460800 bit/s. Cellular module response is sent at 115200 bit/s, i.e., at the original baud rate value.
☞ After the “OK” final result code, wait for at least 200 ms before issuing a new AT command, to guarantee proper baud rate reconfiguration. Then send commands at the speed just set (460800 bit/s in the example). The new selected baud rate is immediately applied.		
AT+IPR?	+IPR: 460800 OK	Check the current baud rate

Table 4: Setting a fixed baud rate example

☞ The baud rate configured for UART is persistent across power cycles.

☞ To show a greeting text at module boot (+CSGT AT command), set the desired fixed baud rate beforehand by using the +IPR AT command. If active, the greeting text is shown at boot once, on any AT interface, the first time the TE sets the DTR line to ON state.

4.2.2 Auxiliary (AUX) serial interface configuration

If the auxiliary UART interface is enabled via the +USIO AT command, then it may be necessary to configure this serial interface from the main UART interface, especially for the first use and when the factory-programmed configuration does not match the desired settings.

Table 5 shows how the +UUARTCONF AT command applies the desired settings. For additional details, see the AT commands manual [1].

Command	Response	Description
AT+UUARTCONF=1,115200,3	OK	Set the desired baud rate and flow control mode for the auxiliary UART interface.
AT+UUARTCONF?	+UUARTCONF: 0,115200,3 +UUARTCONF: 1,115200,3 OK	Check the current settings for both the main UART and the auxiliary UART interfaces.
AT+UUARTCONF=?	+UUARTCONF: 1,(115200,230400,460800,921600,3000000),(0-3) OK	Visualize the possible settings to be applied in the auxiliary UART handling.

Table 5: +UUARTCONF variants description

☞ Configuration changes performed by the +UUARTCONF AT command are stored in the NVM and applied to the auxiliary UART interface at the next module boot.

☞ AT+UUARTCONF can be used also for configuring main UART, but this is not the normal use case.

4.2.3 Configure flow control

The flow control can be configured by of the &K AT command for the main UART or by the +UUARTCONF for the auxiliary UART.

☞ The &K setting takes around two characters transmission time (with respect to the current baud rate) to reconfigure after the command has been issued.

4.2.4 Notification and URCs: Ring Indicator

The ring indicator line behavior can be customized by the +URING AT command. By default (+URING: 0), the line is asserted only on incoming call and incoming SMS but can be asserted also for all URCs (+URING: 1), for all incoming data (+URING: 2) and for all URCs and all incoming data (+URING: 3).

☞ The ring indicator line (RI) is not supported when main and auxiliary UARTs are both enabled in 4-wires mode (+USIO: 1). In these cases, it is necessary to configure one of the GPIO pins as a RI line (<gpio_mode> = 18) by the +UGPIOC AT commands. The same mapping is required when using power saving, because the RI line is powered off in deep-sleep mode.

See further information on the URCs reception in section 3.2.

4.2.5 Recommendations when using Direct link mode with high baud rates

The combination of high baud rates and huge data transfer between the module and external host (uplink) may lead to data loss.

It is recommended to insert a pause of 1ms every 2048 bytes sent if the host application is sending via TCP direct link more than 1 Mbytes of data without any downlink incoming data in between.

The data loss can happen on the MAIN UART when using a baud rate of 3 Mbps or on the AUX UART when using baud rates equal or higher than 921600 bps.

In case both the UARTs are used, u-blox recommends using the MAIN UART for direct link / data and the AUX UART for control.

4.3 AT interface on USB

AT commands can be issued to the module via the AT enabled ports on the USB interface. The functionality of the two ports available over the USB interface can be modified by the +USIO AT command.

☞ If only the USB interface is used and connected it is required to disable the UART flow control with +UUARTCONF=0,115200,0 AT command for the proper functioning of the device. Then, reboot is required to save the configuration.

4.4 USB network modes

Packet switched connectivity over USB interface can be established in two different modes:

- **RNDIS** mode: Remote Network Driver Interface Specification is a Microsoft proprietary protocol used over a USB interface. RNDIS provides a virtual Ethernet link between a Remote NDIS device (LEXI-R10) and a host.
- **ECM** mode: ECM is a protocol used to send and receive Ethernet frames over a USB. It can be used in conjunction with AT command ports. The module used through ECM supports both bridge and router mode.

No additional drivers are required to correctly detect all the USB components.

A module can be switched to RNDIS or ECM mode issuing the following AT commands:

Command	Response	Description
AT+UUSBCONF=4,<network>	OK	Switch the module to USB net mode<network>: • "RNDIS" [1] • "ECM" [2]
AT+CFUN=16	OK	Reboot the module. At next reboot, the restore action previously set is applied.

Table 6: USB net mode set AT command usage example

In RNDIS and ECM mode the module exposes the following enumerated USB interfaces:

USB device order	Description
0	Diagnostic log port
1	AT commands
2	AT commands
3	RNDIS/ECM interface

4.4.1 Basic implementation

The host connection manager (CM) configures the DTE according to the status of each PDP context/EPS bearer, retrieved with +CGDCONT AT command.

The CM must properly set the IP, gateway and DNS addresses for the USB network interface aliases/virtual interfaces. Once the PDP context/EPS bearers are activated and the configuration is set, the CM must periodically poll the target to update the settings or to track state changes of the PDP contexts, caused, e.g., by the deactivation of PDP contexts commanded by the network due to roaming or temporary network issues.

Use the following instructions as reference for the implementation on IP based networks:

- To be performed once: set up NAT (bridge or router mode) with the +UNETCFG AT command.

[1] Available only in Windows OS
[2] Not available in Windows OS

- Verify if the module is attached to the network by the +CREG, +CGREG and +CEREG URCs.
- The default initial PDP context is automatically activated during the attach.
- Map the enabled PDN context with the associated network adapter using the +UNETDEVCTL AT command.
- If DHCP is not available in the host application, set up the OS with IP alias/virtual interfaces, routing rules and DNS configuration. Modem assigned IP, subnet mask and DNS configuration can be obtained with the +UIPADDR AT command.

4.5 Multiplexer (MUX)

LEXI-R10 series modules support the multiplexer functionality on the UART physical link as defined in the 3GPP TS 27.010 [7]. This makes it possible to have multiple simultaneous sessions (virtual channels) over the single UART interface.

The following virtual channels are defined:

- Channel 0: multiplexer control.
- Channels 1 to 3: AT commands / data connection.

For further details about the use of multiplexer, see the Mux implementation in cellular modules application note [9].

☞ The UART interface takes around 200 ms to reconfigure itself after the multiplexer configuration through the +CMUX AT command.

☞ It is recommended to open only the necessary and actively used virtual channels.

4.6 Point-to-point protocol (PPP)

Data (PSD) calls are possible over all interfaces. To select the PPP authentication method (directly to the module or via LCP procedure), use the +UNETCFG AT command.

☞ If the double UART configuration is used, the full V24 modem lines are not supported. In this configuration, entering in OLCM or disconnecting the PPP connection via DTR line de-assertion is not possible.

☞ PPP cannot be used alongside USB network modes.

Further information about PPP dial-up establishment can be found in the LEXI-R10 Internet applications development guide application note [6].

5 User settings persistence

5.1 Save user settings

Some AT commands executed in set mode automatically store the provided values in the non-volatile memory (NVM) and no other action is required. Other AT commands can be persistently configured by writing the personal profile with AT&W. Check where a AT command setting is saved, and what their factory-programmed values are, in the AT commands manual [1] appendix .

☞ To avoid flash memory wearing, it is strongly recommended to read the required user setting value before save the new user setting, instead of setting the new value directly.

☞ User settings listed by +UNVMCFG=? AT command implement “Smart Write”: A NVM item is created only if the provided setting is different from the factory-defined value. Any subsequent write to NVM is executed only if the new user setting is different from the current one.

6 MNO profiles

MNO profiles provide a powerful and flexible method to configure the LEXI-R10 series module to seamlessly work with the SIM of the selected network operator.

Using the MNO profiles the module is dynamically configured to use the proper bands, and the operator-dependent protocol stack settings needed to operate on the home network in full compliance with the mobile operator requirements.

With the MNO profiles, a customer application is not required to configure the module using complex and/or network-dependent parameters but benefits from a “out of the box” solution that provides seamless connectivity while abstracting the complexity of managing individual network configurations.

Use the +UMNOPROF AT command to select a profile for the network operator. For more details on the +UMNOPROF AT command and the MNO profile settings, see the AT commands manual [1].

6.1 Using MNO profiles

To configure the module to use an MNO profile, first make sure the module is de-registered from the network, then select the profile using the ID number and finally software-reset the module. When the module reboots, it will configure itself to use the parameters specified by the MNO.

☞ The default and factory-programmed MNO profile is 90 (global profile).

☞ Reboot the module by AT+CFUN=15 command (or the equivalent AT+CFUN=16) to make the MNO profile active.

6.2 Modifiable parameters

MNO profiles configure the module with a set of parameters. Some of these parameters can be overridden by using AT commands:

- +UBANDCONF allows to enable/disable the cellular bands;
- +CGDCONT allows to configure APN and PDP type.

If the host changes any of these parameters, they will be retained after a module reset; if the MNO profile is re-applied, after reboot the MNO profile specific settings will be restored to the factory-programmed setting.

After setting the MNO profile the application may want also to modify the bands to be enabled or disabled.

Possible reason for setting +UBANDCONF include:

- Usually, the APN will be accepted also when in roaming, but bands might need to be enabled to search for alternative PLMNs;
- The device is an area where it is interested in running on specific bands only;
- Band is not fully deployed by carrier in the area the device is intended to run.

6.3 MNO profile setting examples

De-register the module before setting MNO profile, then reboot it to apply the setting (Table 7).

Command	Response	Description
AT+CFUN=0	OK	Turn-off radio functionality, the module will de-register
AT+UMNOPROF=2	OK	Set MNO profile for AT&T.

Command	Response	Description
AT+CFUN=15	OK	Perform a module reset. After reboot, the MNO profile 2 settings are applied.

Table 7: Correct way of setting the MNO profile

6.4 Global profile (+UMNOPROF: 90)

This is the default profile for the LEXI-R10 series modules, with all supported bands set as enabled. No factory-programmed <APN> is available for the initial default EPS bearer mapped to <cid>=1, so the user shall configure it (+CGDCONT) based on the inserted SIM before usage.

This profile can be used also for certification and testing purposes.

6.5 AT&T profile (+UMNOPROF: 2)

☞ Profile supported only by the LEXI-R10401D product variant.

LEXI-R10 series in AT&T configuration (+UMNOPROF: 2) is factory-programmed with a predefined string for the <APN> of the initial default bearer on <cid>=1 per AT&T requirement. For more details, see the appendix related to MNO Profile in the AT command manual [1]. The user can set a custom APN, which might be different from M2M and consumer SIM cards, used for live AT&T network attach via the +CGDCONT set. This setting is persistent.

The module has the following APN configuration:

- <cid>=1: PDP type is Ipv4v6, APN is “broadband”

6.6 FirstNet profile (+UMNOPROF: 206)

☞ Profile supported only by the LEXI-R10401D product variant.

FirstNet is the AT&T nationwide high-speed wireless broadband network dedicated to public safety community. By setting the FirstNet profile (+UMNOPROF: 206) the interoperability with this network is optimized.

The module has the following APN configuration:

- <cid>=1: PDP type is Ipv4v6, APN is “firstnet-broadband”

6.7 Verizon profile (+UMNOPROF: 3)

☞ Profile supported only by the LEXI-R10401D product variant.

LEXI-R10 series in Verizon profile (+UMNOPROF: 3) is factory-programmed with predefined strings for the Class 2, Class 3 and Class 4 <APN>s, as defined in Verizon requirements. The Table 8 depicts the predefined mapping between Context IDs (<cid>s) and APN strings.

Context ID	APN	Description
1	VZWINTERNET	Verizon Wireless Internet PDN / Class 3 APN Initial EPS bearer
2	VZWADMIN	Verizon Wireless Administrative PDN / Class 2 APN Used by BIP and LwM2M
4	VZWAPP	Verizon Wireless Application PDN / Class 4 APN

Table 8: Context ID description in Verizon MNO profile

For more details on Verizon profile settings, see the appendix related to MNO Profile in the AT command manual [1].

According to Verizon specifications, devices which operate in LTE Cat 1bis radio access technology, are not required to support LTE IP multimedia system (IMS). Consequently, IMS less devices shall not specify the APN string for the Verizon Wireless Internet PDN / Class 3 APN, when performing the EPS network attach procedure (blank APN string is used). The device shall accept and use the APN string, typically a Class 3 APN string type, provided by the network. Moreover, IMS less devices shall send and receive SMS via SGs as for low power wide area (LPWA) devices.

☞ The AT+CGDCONT read command reports the factory-programmed predefined APN strings before the EPS network attach procedure. The network provisioned APN string for the Verizon Wireless Internet PDN / Class 3 APN is reported only after the EPS network attach completion.

☞ For LEXI-R10 series modules, in roaming condition, IPV4-only PDP type is used.

☞ The LwM2M client is enabled by default in the Verizon profile.

6.7.1 LWM2M client recommendations

Verizon requirements mandate LTE Cat 1bis devices to support LwM2M protocol and the presence of an active LwM2M client on-board. The bootstrap server SSID 100 and the diagnostic server SSID 101 are factory programmed in the LwM2M client and enabled by default. The bootstrap server SSID 100 is used only during the bootstrap process. The device management server SSID 102 is provisioned during the bootstrapping process and is enabled by default. The repository server SSID 1000 is optional and hence is neither provisioned nor enabled, unless specifically required to Verizon by customers. The table below summarizes the Verizon servers and their roles.

Server ID	Server URI	Server role	Server status
100	coaps://boot.lwm2m.vzwdm.com:5684	Bootstrap	Enabled by default No longer used after bootstrap
101	coaps://diag.lwm2m.vzwdm.com:5684	Diagnostic	Enabled by default Default lifetime is 1 day
102	Provisioned during bootstrap phase	Device management	Enabled by default Default lifetime is 30 days
1000	Provisioned during bootstrap phase	Repository	Not provisioned by default

Table 9 - LwM2M servers' description in Verizon MNO profile

The LwM2M client can have a significant impact on module resources availability, potentially affecting other on-board applications, like TCP/IP sockets, HTTP and MQTT clients. For this reason, it is strongly recommended to monitor LwM2M client activities, as described in section 6.7.1.1, in order to avoid resource allocation conflicts.

The bootstrap process, triggered only after the first EPS network attach to Verizon network, is the most critical process, from the module resource usage standpoint. During this process, the MNO default configuration is provisioned by the bootstrap server SSID 100 into the LwM2M client and persisted in the module's NVM. The next step, after a successful bootstrap, is the initial full registration phase with the enabled servers. A specific delay time is configured for each server, by default 30 seconds for the device management server SSID 102 and 180 seconds for the diagnostic server SSID 101. The delay times are meant to avoid servers' initial full registrations running in parallel, to limit resources usage.

☞ The bootstrap process, after being successfully completed, is no longer required, unless the module is factory reset.

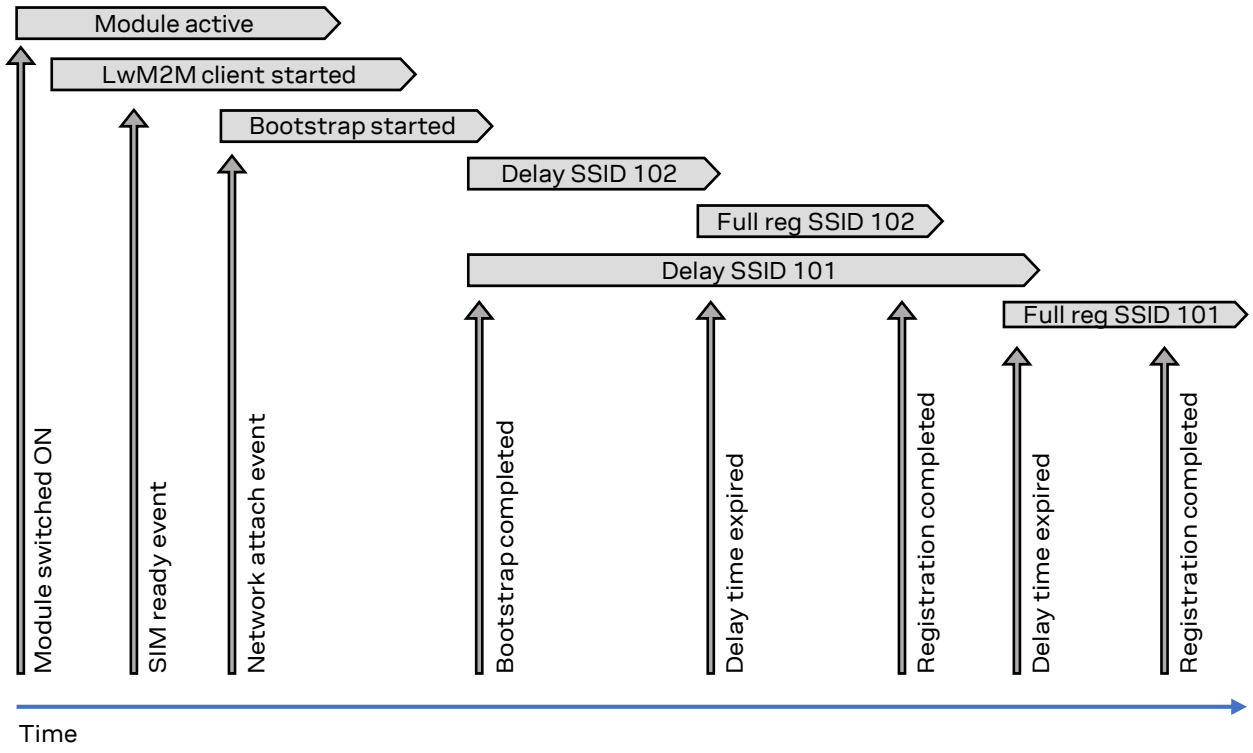

Figure 4 – LwM2M client bootstrap process overview

Event	LwM2M client action	Description
Module switched ON	LwM2M client started	The LwM2M client waits until the SIM Ready event is received
SIM detected		The LwM2M client waits until the network attach event is received
EPS network attach	Bootstrap started	The LwM2M client connects to bootstrap server SSID 100 and fetches the data for device management server SSID 102
Bootstrap completed	Delay timers started	The LwM2M client starts the delay timer for device management server SSID 102 (30 seconds) and for the diagnostic server SSID 101 (180 seconds)
Delay time expired	Registration started	The LwM2M client performs the registration with device management server SSID 102
Registration completed		The LwM2M client waits for the expiration of diagnostic server SSID 101 delay time
Delay time expired	Registration started	The LwM2M client performs the registration with diagnostic server SSID 101

Table 10 - LwM2M client bootstrap process events description

The second most impacting activity performed by the LwM2M client, is the registration update, performed with configured servers, when the lifetime period is close to the expiration time. The lifetime period for each Verizon servers is reported in the Table 9.

It is recommended to schedule resources intensive tasks while the LwM2M client is not performing the two aforementioned activities. Alternatively, it is possible to temporarily pause the LwM2M client activities, as described in section 6.7.1.2.

6.7.1.1 Monitoring LwM2M activity

The LwM2M client activity can be monitored by the means of the URC messages made available by the +ULWM2MSTAT AT command. The command supports several categories of reported events, limiting the category of URC messages issued. The settings are retained between module reboots.

To disable the URC messages generation, it is necessary to issue the +ULWM2MSTAT=0 AT command. The table below shows the most common URC messages generated by the module, when the highest level of verbosity is used, together with a short explanation.

Command	Response	Description
AT+ULWM2MSTAT=1,7	OK	Enable the LwM2M client URC messages with all event categories available.
	+ULWM2MSTAT: 5,1 +ULWM2MSTAT: 5,2	The LwM2M client has completed its initialization. This message is emitted every time the LwM2M client is started, like at end of module boot.
	+ULWM2MSTAT: 0,100,10 +ULWM2MSTAT: 6,100,0,"boot.lwm2m.vzwdm.com:5684" +ULWM2MSTAT: 0,100,11 +ULWM2MSTAT: 0,100,14	The LwM2M client has successfully connected with the server SSID 100 (URL is also displayed) and performed the bootstrap procedure. This procedure is necessary at module first boot or after the LwM2M client factory reset.
	+ULWM2MSTAT: 6,102,0,"gvzwcdp.vzw.motive.com:5684" +ULWM2MSTAT: 1,102,2 +ULWM2MSTAT: 1,102,3	The LwM2M client successfully connected with the server SSID 102 (URL is also displayed) and performed a registration update / full registration. Registration updates are performed periodically near the server lifetime expiration.
	+ULWM2MSTAT: 6,101,0,"diag.lwm2m.vzwdm.com:5684" +ULWM2MSTAT: 1,101,2 +ULWM2MSTAT: 1,101,3	The LwM2M client successfully connected with the server SSID 101 (URL is also displayed) and performed a registration update / full registration. Registration updates are performed periodically near the server lifetime expiration.
	+ULWM2MSTAT: 2,101,86383 +ULWM2MSTAT: 2,102,2591999	These messages report the time left before lifetime expiration for server SSID 101 and 102 and are emitted periodically by the LwM2M client.
	+ULWM2MSTAT: 6,101,3 +ULWM2MSTAT: 6,102,3	These messages report the closure of the connections used to reach the server SSID 101 and 102 due to inactivity.
AT+ULWM2MSTAT=0	OK	Disable the LwM2M client URC messages

Table 11 - Usage of +ULWM2MSTAT command

For more details see the +ULWM2MSTAT section in the AT command manual [1].

6.7.1.2 Mitigation of LwM2M activity

If the end application requires to perform an intensive task, it is possible to temporarily limit the LwM2M client activity, mitigating its impact on module resources. The AT+ULWM2M=3 command prevents the LwM2M client from establishing a connection to any server, even if the lifetime is close to its expiration time, until the AT+ULWM2M=0 command is issued or the module is powered off.

Command	Response	Description
AT+ULWM2M=3	OK	The LwM2M client prevents to establish a connection to all Verizon servers
☞ If the module is rebooted or power cycled, the LwM2M client will behave as in normal operation.		
AT+ULWM2M=0	OK	

Table 12 - Usage of +ULWM2M command

For more details see the +ULWM2M section in the AT command manual [1].

Furthermore, it is possible to disable independently any servers reported in Table 9, by the means of +ULWM2MCONFIG AT command, issued with <server_disabled> parameter set to 1. To make the setting effective, it is required a reboot or a power cycle of the module. The setting is retained until the +ULWM2MCONFIG AT command is executed with <server_disabled> parameter set to 0.

☞ The disabling via the +ULWM2MCONFIG AT command is meant only for test purpose: Verizon authorization is strictly mandatory before disabling any server with module camped to Verizon network.

For more details see the +ULWM2MCONFIG section in the AT command manual [1].

7 Cellular modem

7.1 Network registration

At power-on the module reads the information in the currently selected MNO profile. It will use this information to configure which bands to scan, and other attach parameters like APN. Once the module has found a suitable cell it can camp on, it will start the registration process.

A new SIM can be activated after its first registration on a real network: its “profile” (e.g., contents of the SIM files) can be remotely provisioned over the air and a registration cycle is triggered at the end of the SIM OTA procedure via BIP.

It is important to set the operator profile first because this operation will configure the bands for that corresponding profile. The module is programmed with auto-cops, so no AT command is required to trigger the network registration.

The MNO profile to be selected shall match the SIM card provider and not the MNO on which the module is going to register, that is, with an AT&T SIM card the AT&T MNO profile shall be selected, with a Verizon SIM card the Verizon MNO profile shall be selected, and so on. If there is no MNO profile matching the SIM card provider, then it is recommended to select a generic MNO profile (e.g., the global profile).

Be aware that the settings of each MNO profile are aligned to the requirements of that MNO, so if the module will move to roaming MNOs, it might happen that some bands are disabled and need to be enabled. E.g., the AT&T MNO profile has the European (EU) bands disabled and if the device will roam in Europe, then the related EU bands shall be enabled manually.

7.1.1 LTE Initial default bearer

LTE networks are all-IP networks, meaning all services available to the end-user rely on IP protocols.

LTE devices are always connected, i.e., an IP address is always assigned to the device when it is registered to an LTE network. There is always an IP connection between the device and a PDN, therefore one PDP context must always be active.

The initial default EPS bearer is the PDP context enabled during the EPS attach (i.e., the network registration phase).

If no APN has been specified by the device, the network will assign a default one, the so-called anchor APN: in this way a PDP context is active, and the module has an IP address.

☞ The PDP context with the anchor APN guarantees the LTE signaling but does not assure IP connectivity to the Internet. It depends on MNO policies, e.g., it might be used by BIP or OMA-DM clients only for administrative purposes.

☞ It is strongly recommended to use a proper APN for the initial default bearer. The APN value shall be provided by the SIM card provider.

The APN for the initial default bearer must be set when the module is in the de-registered state.

7.1.2 Band configuration

The module can scan over several bands to find a network to attach to. The host application can limit the scanning to specific bands to shorten the time to find a network e.g., for testing purposes.

Use the +UBANDCONF AT command to specify the bands to use within the list of the supported bands: the sequence in which the bands are specified corresponds to their relative priority in the PLMN search procedure.

☞ The band configuration can be changed runtime, also in registered state: in this case the module automatically performs an LTE detach and LTE attach with updated capabilities.

Command	Response	Description
AT+UBANDCONF?	+UBANDCONF: 1,3,5,7,8,20,28 OK	Query the currently set bands. Currently selected bands are: LTE bands 1, 3, 5, 7, 8, 20, and 28.

Table 13: +UBANDCONF AT command example

7.1.3 PLMN selection rules

The module usually tries to register on the HPLMN, or on any of the equivalent HPLMNs optionally listed in the SIM card.

In international roaming, in automatic PLMN selection mode (+COPS: 0), the lists of PLMNs returned by the +CPOL command (the so-called user preferred PLMNs and operator preferred PLMNs, depending on the +CPLS value) have higher precedence with respect to a visitor PLMN with the same MCC not present in such list: in case the module registers on a VPLMN not present in the +CPOL lists but with the same MCC as one or more entries in the +CPOL lists, a periodic higher priority PLMN search is triggered (in idle state). In national roaming, the HPLMN will be looked for with the same procedure, periodically or when performing a AT+COPS=2/AT+COPS=0 cycles.

To assess the current SIM configuration and PLMN selection rules, the following commands can be issued:

Command	Response	Description
AT+CIMI	123010123456063 OK	Query the IMSI, whose first 5-6 digits (define the HPLMN, 123-01 in this case.
AT+CRSM=176,28633,0,0,0	+CRSM: 144,0,"FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF" OK	Check if Equivalent HPLMN file is present in SIM card.
AT+CPLS=1	OK	Select operator preferred PLMN.
AT+CPOL?	+CPOL: 1,2,"32101",1,0,1,1 +CPOL: 2,2,"43201",1,0,1,1 +CPOL: 3,2,"54301",1,0,1,1 OK	List of operator higher priority PLMN available in SIM card. If some entry with the same MCC as current registered PLMN is available, and the PLMN has higher priority or the current VPLMN is not present in SIM card, higher priority PLMN scan will be triggered.
AT+CPLS=0	OK	Select user preferred PLMN.
AT+CPOL?	OK	List of user higher priority PLMN currently configured in SIM card, empty in the example. The file might be not present in the SIM card.
AT+CEREG?;+CREG?	+CEREG: 0,5 +CREG: 0,5 OK	Module is in roaming in LTE. In case current VPLMN is equivalent to the HPLMN, +CEREG/+CREG read commands would return 1.
AT+COPS?	+COPS: 0,2,"32102",7 OK	The current VPLMN is lower priority than high priority PLMN 32101 reported by AT+CPOL?.
AT+CPOL=1,2,"32102",1,0,1,1	OK	User can edit the user high priority PLMN list, so that the current VPLMN is given higher priority.

Table 14: Example of how to check and edit the SIM PLMN preferences

7.1.4 PLMN selection at startup

The last registered PLMN stored in LOCI files (CS/PS/EPS LOCI EF in SIM card, EPS can be stored in NVM if SIM card does not contain the file) will be selected at registration cycles (e.g., AT+CFUN=0/1).

To trigger the search of HPLMN at registration cycle, LOCI files shall be cleaned with +CSIM command (EPS LOCI info in NVM cannot be cleaned), or AT+UUSERSCAN shall be used to trigger higher priority PLMN scan, provided that +COPS lists have at least a higher priority PLMN of the same MCC as the current registered VPLMN.

☞ Both AT+CFUN=0/1 and AT+COPS=2/0 can be used to trigger a registration cycle with switch-off detach (which does not need the DETACH_ACCEPT message from the network).

7.2 Network attach and PDN connections

During the LTE registration procedure, an IP address is assigned to the initial default EPS bearer, which is mapped on <cid>=1 and usually devoted to data/Internet connectivity.

In general, given that IP embedded applications (such as BIP, or LwM2M) may activate the Internet PDP context and de-activate it after usage without synchronization with the user application that shares the same PDN connection, it is advisable to always activate it with AT+CGACT=1,<cid> before usage to “reserve” the packet data connectivity service.

☞ In case of “reserving” the packet data connectivity service, the AT+CGACT=1,<cid> command will return the OK final result code, even if the +CGDCONT AT command reports that the context is already active with a valid IP address.

☞ The modules counts the number of AT+CGACT=1,<cid> commands received, so the same number of AT+CGACT=0,<cid> shall be entered before the EPS bearer associated to <cid> is deactivated.

If allowed by the MNO and by the SIM card subscription, it is possible to activate more PDN connections with the same or different APNs at the same time in the module. This configuration is useful for applications that require to use simultaneously more IP addresses in possibly different service domains.

7.2.1 PDN settings (APN name and PDP type)

To change the PDN settings for the initial default EPS bearer established during LTE attach, edit the <cid>=1 PDN by the +CGDCONT AT command, as shown in Table 15.

Command	Response	Description
AT+CFUN=0	OK	Turn off the modem radio so to de-register the module.
AT+CEREG=3;+CGEREP=1	OK	Enable a set of registration URCs.
AT+CGDCONT?	+CGDCONT: 1,"IPV4V6","","0.0.0.0 0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,2,0,0,0,0,0,0 OK	Read IP type and APN for EPS attach bearer.
AT+CGDCONT=1,"IPV4V6","custom_APN"	OK	Set APN name ("custom_APN" for example) and the PDP type ("IPV4V6" for example) for EPS attach bearer.
AT+CFUN=1	OK +CEREG: 1,"0001","01a2d001",7 +CGEV: ME PDN ACT 1	Turn on the modem radio. URCs indicate the registration status change.
AT+CGCONTRDP=1	+CGDCONTRDP: 1,5,"IP", "custom_APN2", "10.197.24.57","10.105.16.254","10.105.144.254",,,,,1430	The assigned PDN (if different from the requested one) is returned by +CGDCONTRDP

Table 15: Change of PDN settings

For additional details on the PDN connectivity topic, see the Internet applications development guide application note [6].

7.2.2 Authentication settings

If PAP or CHAP authentication is to be configured, the +CGAUTH AT command shall be used. If the authentication is required on the initial default bearer, the setting shall be entered in de-registered state.

7.3 Radio Policy Manager

LEXI-R10 series modules implement the Radio Policy Manager (RPM) feature according to GSMA connection efficiency TS 34 [8]. RPM aims to prevent cellular devices to aggressively try registration or PDP context activation procedures in case of permanent failures (e.g., “invalid UE” or “EPS services not allowed”), which are usually due to subscription restrictions, in addition to standard 3GPP retry algorithms. Since these aggressive behaviors can cause network overload and service outage, some MNOs require to have RPM active by default and provide in the SIM card the RPM settings that the module shall adopt; if RPM is not activated in the SIM card, it can be enabled via +URPMPARAM AT command.

Even if RPM is not active, it is recommended to limit the number of registration and power cycles per hour (20 at most is a good rule of thumb) to avoid network unfriendly behaviors.

7.4 Mobility scenarios

Devices used in non-static installations can move out of range of the currently serving cell. This means entering another cell of the RPLMN (registered PLMN) or of a different PLMN or moving into an area where there is no cellular coverage or no roaming agreement for the device.

If the module loses synchronization with the serving cell but finds another cell to camp on, any PDP context and open sockets will be kept. This holds in particular for seamless change of serving cell with cell reselection or handover procedures.

If mobility implies crossing national borders or simply changing the PLMN, it is likely that the new PLMN will force the module to reattach.

7.4.1 RRC procedures in mobility

In LTE, the UE is instructed by the network to provide measurement reports on neighbor cells so that the network can decide if and when the radio resource control (RRC) connection has to be handed over to another cell via RRC Connection Reconfiguration message.

- The network will allocate gaps in the downlink transmission to allow the device to perform the intra-band or inter-band measurements.
- +CSCON will return the status of the RRC connection.

7.5 PSM, eDRX and deep-sleep modes

The modules support the 3GPP power saving features PSM and eDRX. PSM and eDRX are disabled by default and can be enabled separately or simultaneously. After enabling the PSM and eDRX features, to enter deep-sleep modes the AT+UPSV command shall be properly configured (see section 8.1).

In particular, eDRX is used when the host application must be reachable: the eDRX cycle shall be selected based on the maximum tolerated delay in receiving short messages or IP data, and the optimal power consumption in Sleep-2 or Hibernate deep sleep states. In mobility, where very likely a new cell shall be selected at every wake-up, usually Hibernate starts to be convenient for larger eDRX cycles than in static conditions.

PSM is used when the host application uses only mobile originated traffic and does not need to be reachable: the optimal setting for the maximum deep-sleep level in +UPSV depends on the mobility profile and on the frequency of the data sessions.

It is also possible to enable the "PSM without network coordination" feature by specifying a user-defined PSM active timer duration (+UPSCONFIG AT command, "T3324MaxValueS" key): in case PSM is not granted by the network, the UE enters PSM <T3324MaxValueS> seconds after each RRC connection release; if the PSM active timer is assigned by the network, the shorter of the two timer values will be used.

Refer to the SARA-R42 series application development guide application note [10] for an accurate description of the 3GPP PSM and eDRX features: for the LTE Cat 1bis technology, LTE Cat-M1 timer values shall be considered.

Refer to the AT commands manual [1] for supported AT commands and default PSM and eDRX values.

7.5.1 Deep-sleep modes and modem activity

The maximum deep-sleep level that can be entered depends also on the modem activity.

In airplane mode (+CFUN:0/4/19) the module can enter Hibernate.

In out of service conditions the module can enter all deep-sleep modes and periodically wake up to perform PLMN scan according to the periodicity configured in the protocol stack (see +UPSCONFIG, “PlmnSearchPowerLevel” key).

In idle mode, even if DRX cycles are large enough for the modem to enter Sleep-2 (e.g. 2560 ms), usually only Sleep-1 is entered because the module has to perform measurements on neighbor cells for cell reselection procedures. To increase the chances to enter Sleep-2, DRX periods can be extended with +UPSCONFIG command (“UserDrxCycle” key).

Similarly, when eDRX is used, even if the eDRX cycle is very large and Hibernate is expected, only Sleep-2 can be entered if measurements shall be performed on neighbor cells candidate for cell reselection.

In static conditions the frequency of the measurements can be tailored with +UPSCONFIG command (“RelaxMonitorDeltaP” key) or locking the module on a specific frequency with +UFREQLOCK command: this can help to enter more efficient deep-sleep modes and reduce the average power consumption.

In connected mode, entrance in deep-sleep modes is allowed only if CDRX is configured: for CDRX cycles longer than 100ms the module can enter Sleep-1 mode. This is reflected by the flow control CTS line, which toggles frequently.

7.6 SIM

7.6.1 SIM communication

Module and SIM card communicate through a serial interface. The module automatically starts a communication with the SIM at boot for cellular protocol stack operations. The host application can interact with applets and services residing in the SIM card using a set of AT commands. Based on capabilities these commands can be divided in two groups:

- Commands for restricted access.
- Commands for generic access.

7.6.1.1 Commands for restricted access

Commands for restricted access are a set of high-level commands that allow simple but limited interactions with the SIM and its contents. The handling of all the steps required by communication protocol used by module - SIM interface is managed internally by the module, and therefore not a concern for the host application.

This subset includes the +CRSM AT commands.

7.6.1.1.1 Examples of UICC communication

Below are examples of commands for restricted access.

Command	Response	Description
Read IMSI (International Mobile Subscriber Identity)		
AT+CRSM=176,28423,0,0,0	+CRSM: 144,0,"082922107840836055" OK	Read the IMSI using the Restricted SIM access command. • 176 is the read command for EF in binary format. • 28423 is the ID for EF_IMSI, the SIM elementary file where IMSI is stored by SIM manufacturer. The <response> parameter in +CRSM answer contains few prefix bytes followed by the IMSI value with swapped nibbles.
AT+CIMI	222018704380655 OK	Read the IMSI. The response is the readable serial number. This example is for reference only, as an alternative AT command to read IMSI.
LOCI management		
AT+CRSM=176,28542,0,0,0	+CRSM: 144,0,"623C50A322F210D5BD0000" OK	Read EF_LOCI, the SIM elementary file where information about last CS location is stored
AT+CRSM=214,28542,0,0,11,"FFFFFFFFFFFFFFFFFFFFFF"	+CRSM: 144,0,"" OK	Erase EF_LOCI content. This command is useful to start a registration procedure from scratch. For this scope, the below EF shall have to be erased as well: • EF_PSLOCI (28531) • EF_EPSLOCI (28643)

7.6.1.2 Commands for generic access

Commands for generic access are a subset of low-level commands that allow the direct control of messages sent to the SIM and received from it; the full knowledge of APDU protocol syntax and procedures is therefore needed.

This subset includes the +CSIM and +CGLA AT commands.

7.6.1.3 SIM logical channels

The exchange of messages (APDU) between SIM card and module occurs through "logical channels" that work on the physical SIM serial interface.

7.6.1.3.1 Basic logical channel

At module boot, the “basic logical channel” (logical channel 0) is automatically opened, and it is used for cellular protocol stack operations.

This channel is owned by the module, and the host application is not allowed to close it. For the same reason, internal module commands have the priority, and AT commands that do not coordinate (e.g., +CSIM) will not disrupt the module functionality but might be disturbed by the module.

7.6.1.3.2 Supplementary logical channels

To allow interactions with applets and services residing in the SIM card, cellular SIM cards support supplementary logical channels (up to 3).

These channels shall be explicitly activated by the module and the SIM card assigns them a progressive number from 1 to 3. The user or host application can manage logical channels using proper AT commands. It is recommended to use an independent supplementary channel for each different applet/service and to close them at the end for reuse.

Command	Response	Description
Generic SIM access		
`AT+CSIM=10,"0070000000"`	`+CSIM: 6,"029000"` `OK`	Open a new supplementary logical channel. As per ISO/IEC 7816-4, <response> parameter contains • the number assigned to the opened channel: “02”. This means that channel “01” is already active • the action result: “9000” (means ‘Command successfully executed’)
`AT+CSIM=10,"0270800200"`	`+CSIM: 4,"9000"` `OK`	Close the supplementary ch2 (indicated in the 4th byte), using the same ch (indicated in the 1st byte)

7.7 SMS

7.7.1 Commands for SMS handling

In addition to the 3GPP AT commands, LEXI-R10 series modules support AT commands for handling concatenated messages (see +UCMGS and +UCMGR), and +USMSSEND AT command to send short messages without the need to enter SMS input mode; see the AT command manual for details [1].

7.7.2 Preferred message storage

The factory-programmed value for LEXI-R10 series modules is "ME" for the three memory parameters <mem1>, <mem2> and <mem3>. The setting can be set or read by the +CPMS AT command.

This is an example regarding the configuration of the +CPMS storage parameter for all memory parameters to the same value.

Command	Response	Description
`AT+CPMS="ME","ME","ME"`	`+CPMS: 0,255,0,255,0,255` `OK`	Set all three memory storage parameters to “ME” memory storage.
`AT+CPMS?`	`+CPMS: "ME",0,255,"ME",0,255,"ME",0,255` `OK`	Read the storage setting back.

Table 16: preferred message storage

8 Low Power

The power saving is disabled by default. The host can enable and configure the power saving by the +UPSV AT command, including define the maximum deep-sleep modes. Once power saving is enabled, the module automatically enters the low power idle mode whenever possible.

8.1 Deep-sleep modes

The different deep-sleep modes are:

- Minimum deep-sleep (Sleep-1): The mode for higher module reactivity to external events (e.g., wake-up PIN), but lacks power consumption reduction.
- Medium deep-sleep (Sleep-2): The mode for medium power consumption, much lower than in Sleep-1. The module is less responsive (longer wake-up time) and any module volatile setting and state is lost, since most of the RAM is switched off. Only "always-on" (AoN) configurations are held because they are retained in the AoN RAM[3]. For more details of AoN settings, see section 8.3.
- Maximum deep-sleep (Hibernate): The mode for the lowest power consumption. The module has a slightly longer wake-up time and any module volatile setting and state is lost, since all the RAM is switched off. Only "always-on" configurations are retained because saved in NVM.

All the deep-sleep modes cause loss of communication between the DTE and the module, and a module wake-up via a wake-up source must be forced if the DTE cannot wait for a programmed module wake-up (due to paging).

If the module is registered or attached to a network, the power saving periods are interleaved by wake-up phases in which the module monitors the paging channels, according to LTE system requirements.

Deep-sleep modes can be used via UART but also via USB. Deep-sleep modes via USB require the host to implement USB suspend/resume and the power consumption is higher than via UART.

During an application design phase, consider the following points:

- Multiplexer protocol session (i.e., a MUX session) over UART shall be re-established, if Sleep-2 mode was allowed and entered during a multiplexer session. For details see the AT+UDCONF=201 command in AT commands manual [1].
- If the multiplexer protocol is used, at exit form Sleep-2 or Hibernate early issued URCs (e.g., MT SMS or MT data notifications upon a paging) would be lost, since there is no buffering for them until multiplexer protocol session is re-established; URCs shall hence be enabled on UART and received on UART, before MUX is restarted.
- Any volatile setting not stored in NVM before entering Sleep-2 / Hibernate will be lost and shall be restored. The only exception is "always-on" settings, which are retained.
- Settings stored in the module profiles are automatically restored, even if they were not saved via AT&W command. They are part of "always-on" configurations.
- USB diagnostic port can be used and will not change deep-sleep entrance timings, provided that AT+UUSBSLPCONF with <usb_allow_sleep>=1 setting is used.

☞ "Always-on" configurations include also other settings, related to networking and protocol stack configuration, which are restored automatically at exit from Sleep-2 / Hibernate.

☞ At exit from Sleep-2 / Hibernate, the host application must restore module applications state. See section 8.3 for the correct handling.

☞ At exit from Sleep-2 / Hibernate state, the setting of the diagnostic commands (e.g., +UCGED and +UPSSTAT) are not persistent (i.e., default values are applied).

[3] The AoN RAM is a RAM portion not switched off when Sleep-2 is entered. Used to keep the so-called AoN configurations.

8.2 Interfaces specifications

8.2.1 USB interface

The USB interface adds some limitations to power saving entering. The module supports the USB suspend / resume and remote wake up functionalities regardless the actual +UPSV value configured, and the host is required to properly manage it to reduce the overall module power consumption.

In the factory programmed case (see AT+UUSBSLPCONF, <usb_allow_sleep>=0), module entering a deep-sleep mode requires either the DTE suspend the USB (in this case the deep-sleep mode is limited to Sleep-1) or disable USB by AT+UUSBCONF=99 command.

In other cases, module power saving is allowed even if USB is not suspended by the DTE. The use of this configuration is not recommended because it could cause recurrent USB re-enumerations. Consider it only if the DTE does not support the USB suspend or in case of long sleep period (e.g., in conjunction with PSM and eDRX).

Based on host characteristics about USB suspend/resume, the following points shall be considered:

- If the host does not support USB suspend/resume, you must use AT+UUSBSLPCONF with <usb_allow_sleep>=1 to allow module power saving. This only works if the USB composition (USB profile selected using AT+UUSBCONF) does not include a USB network interface.
  If a USB network interface (RNDIS or ECM) is used in the application, USB suspend is still required, even using the <usb_allow_sleep>=1 configuration; the only alternative is the USB disconnection by host when module power saving entering is required.
- If the host supports USB suspend / resume but does not support the remote wakeup function, the ring line (RI) must be configured for being asserted upon incoming data or URCs, in this way the host know when to resume USB.
- If both the module and the host enter a low power mode, the RI line shall be configured to wake up the host (see section 4.2.4), when needed (for URCs or data sending).

8.2.2 UART interface

The +UPSV AT command can be configured in three different modes:

- **Power saving is disabled** (+UPSV: 0)
  The UART interfaces are always enabled, and the module does not enter in power save mode.
- **Power saving is enabled** (+UPSV: 1)
  The UART is re-enabled from time to time to allow the DTE to transmit, and the module switches from idle to active mode in a cyclic way. If during the active mode any data is received, the module remains active for the specified timeout.
  In this mode, if both main and auxiliary UART interfaces are active, the flow control shall be configured the same on both ports.
- **Power saving is controlled by the GPIO** (+UPSV: 5)
  Power saving is allowed and controlled by the GPIO pin configured with <GPIO_mode>=34 using the +UGPIOC AT command. With this mode the <timeout> parameter is not used, even if it is included in the set command.

If the power saving feature is active (+UPSV: 1 or +UPSV: 5), and the hardware flow control is enabled on the UART interface, and the RTS line is de-asserted by the DTE, then the URCs generated are buffered by the DCE, and the DCE power saving mode is inhibited until the DTE asserts the RTS line and receives the buffered URCs.

☞ The scenario above is also valid when the DCE is in MUX mode, where physical RTS line must be handled for receiving buffered URCs.

☞ If only the UART interface is used (that is the USB interface is not connected and not used by the host application), it is recommended to disable the USB interface via the AT+UUSBCONF=99 command to avoid any impact on power saving.

At exit from a deep-sleep mode, if the wake-up is not triggered by the host and the host application receives some MT SMS or data notifications on UART, it shall react on time to avoid data loss or deep-sleep re-entering. It shall either:

- De-assert the UART RTS line to block any data transmission from the module (this assumes that hardware flow control is enabled); as said, this also blocks deep-sleep re-entering.

☞ Use AT+USLPVOTE command to block deep-sleep re-entering (see section 8.3.3).

8.3 Configuration and handling

Power saving and deep-sleep modes are essential for applications that operate with limited energy budget. For such use cases u-blox recommends carefully proceeding with the application design decision and testing the design based on the +UPSV configuration that will be adopted.

The +UPSV command allows specifying the deep-sleep levels the module can enter. Depending on such configuration, the module can reach different values of current consumption while different retention mechanisms applied.

The RAM memory contents are kept only for Sleep-1 mode, which is therefore transparent to the host application. When exiting Sleep-2 and Hibernate modes, the application must implement recovery mechanisms to restore its status (e.g. the connection to the server). A solution offered by the module is to use always-on (AoN) sockets, or to temporarily prevent the entrance into the deeper sleep modes with +USLPVOTE AT command. Both features are described in the following sections.

8.3.1 GPIO always-on

Always-on (AoN) GPIOs are GPIO pins that maintain their function also when the module is in Sleep-2 or Hibernate deep-sleep modes, with the generic digital interface supply (**V_INT**) switched off. Those are **GPIO2**, **GPIO3**, **GPIO4** and **GPIO6** pins.

See further information on the AoN GPIO configuration in the system integration manual [3].

8.3.2 Sockets always-on

TCP and UDP sockets support the always-on (AoN) functionality, so that the socket configuration and state are kept between deep-sleep cycles. Such functionality allows the host to save time and power by having a data pipe ready to send data. The AoN socket attribute can be retrieved with +USOCR read command.

☞ Secure sockets cannot be configured as AoN sockets.

☞ Any socket not configured as AoN prevents the module from entering Sleep-2 and Hibernate deep-sleep states.

See further information on how to use this functionality in the internet application note [6].

8.3.3 Deep-sleep control (+USLPVOTE)

The +USLPVOTE command allows the application to control how to enter the deep-sleep states. The command can be used to implement a voting mechanism that prevents a specific deep-sleep state depending on the task the application is running. Every task or interface can vote independently.

It is recommended to use this command in the configuration phase, when several consecutive AT commands are issued to configure the module. In this case, the voting allows the application to

properly configure the module (e.g., waiting also for URCs – if necessary) and to avoid entering into a deep-sleep state in case of e.g. not immediate responses or late URCs. Once the configuration phase is completed, all votes can be reset with this AT command and the module is allowed to enter to deep-sleep.

An example of +USLPVOTE AT command:

Command	Response	Description
AT+UPSV=1,1000,4	OK	Application configures the deep-sleep. Module is allowed to enter into deep-sleep after 1 second of inactivity. Hibernate is the maximum deep-sleep level configured.
AT+USLPVOTE=1,2	OK	Within 1 second the host application configures the +USLPVOTE to block Sleep-1 state (and also lower deep-sleep levels). Command needed only for the first configuration.
AT+USLPVOTE=0,0	OK	Within 1 second the host application must configure the vote down option so to start the module configuration.
Workflow used the check the network registration and coverage.		
AT+CEREG?	+CEREG: 2,1,"4079","0AB56A3D",7 OK	
AT+COPS?	+COPS: 0,2,"22201",7 OK	
AT+CGDCONT?	+CGDCONT: 1,"IP","ibox.tim.it","10.33.180 .108",0,0,,0 OK	
AT+CESQ	+CESQ: 99,99,255,255,18,35 OK	
Workflow sequence completed.		
AT+USLPVOTE=0,1	OK	Vote-up, the module is allowed to enter in the deep-sleep state.

☞ The +USLPVOTE setting is not stored in NVM. Therefore, the votes are lost during a power cyc

9 Monitoring module status

The module registration status can be retrieved by using the following URCs:

- **+CEREG** monitors the LTE registration status;
- **+CREG** monitors the status of non EPS services (e.g., SMS).

It is recommended to enable +CREG and +CEREG URCs with <n>=3, because in this way information about the cause of rejection is reported when registration is rejected by the network. Using a logical OR between these URCs to know all registration statuses.

The **+UCGED** AT command can be used to retrieve information details on the current cell where the module is registered.

The **+CGEV** URC, enabled via +CGEREP, provides information about the PDP context status.

For monitoring and debuggability purpose an example of commands to use is available in the m-center script repository: debug_lexiR10_basic.atl.

9.1 Retrieve and interpret diagnostic information

It is recommended to track the module status in the host application. Such diagnostic information allows detection of specific scenarios and implementation of proper handling and countermeasures in the host application.

The module status can be returned by AT command responses and unsolicited result codes (URCs). Depending on the host application architecture, URCs, periodic polling, or both, can be used. URCs provide the most updated information and, in some cases, diagnostic information which is not available via polling. For AT commands that enable URCs, they might also return the same information when polled, as indicated below.

Some commands store the setting of the URC reporting in NVM or in the personal profile, so they are referred to as persistent settings.

Some AT commands provide a choice on how to handle the URCs when the AT interface is busy; for all other AT commands, URC is issued at the return into command mode, as explained in the AT command manual [1], in the “URCs presentation deferring” section.

9.1.1 Diagnostic information via URCs

Command	URC	Description	Can be polled
AT+CSCON=1	+CSCON: 1	In LTE, it returns the status of the RRC connection (idle or connected). Persistent setting (AT&W).	Yes
AT+CREG=2	+CREG: <stat>[,[<lac>],[<ci>][,[<AcTStatus>]]]	Enable registration status URC for non EPS services in LTE. Persistent setting (AT&W)	Yes
AT+CEREG=3	+CEREG: <stat>[,[<tac>],[<ci>],[<AcT>][,[<cause_type>],[<reject_cause>]]]]	Enable registration status URC for EPS services, reject cause in case of unavailability of such services (AT&W)	Yes
AT+CGEREP=1	+CGEV: NW PDN DEACT <cid>	Report all registration and PDN connectivity status events. The URC in the example is reported when the device enters out of coverage condition, in particular after a radio link failure	No
AT+CTZR=1	+CTZV: <tz>	Enable reporting of changes in time zone. Usually, time zone information is provided by the network at LTE attach only. Persistent setting (AT&W).	No
AT+CNMI=2,1	+CMTI: <mem>,<index>	Report the index in current selected memory (can be the factory-programmed setting ME or SIM, see +CPMS read command) where the mobile	No

Command	URC	Description	Can be polled
		terminated SMS has been stored. The first parameter set to 2 indicates that URC are buffered in case of busy AT interface. Persistent setting (AT&W).	
AT+UCESQS=1,2	+CESQ: 99,99,255,255,19,36	At RSRP and RSRQ variation greater than 2, a +CESQ (or +UCESQ if the first parameter is set to 2) URC is issued	No
AT+USIMSTAT=1	+UUSIMSTAT:0	Reports SIM status. Persistent setting (AT&W)	No
AT+UURCSTAT= “ALL”,1	+UURCSTAT: "CREG":1,"CEREG":1, "CEDRXP":1,"CCIOTOPTI":1, "CSCON":1,"CTZEU":1, "UCESQ":1,"CGEV":1,"UPSMR":1, "UUSIMSTAT":1,”UUBIP:1”, "UPDPADDR":1,"UPCFUN":1, "USMSFULL":1,"CNEC":1 OK	It enables all (or a subsets of) the following URCs: +CREG, +CEREG, +CEDRXP, +CSCON, +CTZEU, +UCESQ, +CGEV, +UUPSMR, +USIMSTAT, +UBIP, +UPDPADDR, +USMSFULL, +CNEC). The persistent attribute is specific for each URC.	No
AT+CNEC=8	+CNEC_EMM: 11	URCs reporting of error result codes sent by the network in numeric format. ☞ The same network error causes can be obtained by polling +CEER command.	No

Table 17: Diagnostic information via URCs

9.1.2 Diagnostic information via polling

Command	Response (omitting OK)	Description	Suggested usage
ATI ATI9	LEXI-R10801D-00B-00 01.01.A00.01	Return the model and FW identification, useful for tracking purposes.	Module initialization
AT+CGSN	358110420002839	Return the IMEI.	Module initialization
AT+CIMI AT+CCID	001010123456789 +CCID: 89860000502000180722	Return the SIM identities for tracking purposes. They can change after a SIM refresh event that can be reported by +UUSIMSTAT URC.	Module initialization
AT+UBANDCONF?	+UBANDCONF: 1,3,5,7,8,20,28 OK	Return band mask selection.	Module initialization
AT+UMNOPROF?	+UMNOPROF: 90	Return MNO profile set.	Module initialization
AT+UCGED=2;+UCGED?	+UCGED: 2 6 <svc>,<MCC>,<MNC> <EARFCN>,<Lband>,<ul_BW> ,<dl_BW>,<TAC>,<LcellId> ,<P- CID>,<mTmsi>,<mmeGrId>, mmeCode>,<RSRP>,<RSRQ>, Lsinr>,<LTE_rrc>,<RI>,<C QI>,<avg_rsrp>,<totalPus chPwr>,<avgPucchPwr>,<dr x>,<l2w>,<volte_mode>, <ul_BLER>,<dl_BLER> [N1: <MCC>,<MNC>,<EARFCN>,<P- CID>,<RSRP>,<RSRQ> [N2: <MCC>,<MNC>,<EARFCN>,<P- CID>,<RSRP>,<RSRQ>..]]	Return several cell parameters as measured by the module or provided by the network. Some values are not supported and provided for syntax compatibility. Useful when the module seems not registered as, in combination with +CESQ, can show current cell.	Low periodicity
AT+UCGED=8;+UCGED?	+UCGED: 8,<urc_reporting> [[<timer_name>,<timer_va lue>]	Returns active NAS timers; NAS backoff timers might inhibit registration attempts.	Periodically (30 s) and when detecting problems

Command	Response (omitting OK)	Description	Suggested usage
AT+CESQ?	+CESQ: <rxlev>,<ber>,<rscp>,<ecn0>,<rsrq>,<rsrp>	Return signal quality and level, and it is more precise than +CSQ. It is subjected to transitions due to local reset of values at changes in RRC state (idle, connected) so the host application should average the values.	Periodically (for example, every 50 to 10 s)
AT+COPS?	+COPS: <mode>[,<format>,<oper>[,<AcT>]]	It returns the current registered PLMN in the configured format, RAT is fixed to 7 (LTE), numeric format only is usually returned.	Periodically (30 s) and when detecting problems
AT+CGDCONT?	+CGDCONT: <cid>,<PDP_type>,<APN>,<PDP_addr>,<d_comp>,<h_comp>[,<IPv4AddrAlloc>,<request_type>,<P-CSCF_discovery>,<IM_CN_Signalling_Flag_Ind>[,<NSLPI>[,<secure_PCO>[,<IPv4_MTU_discovery>[,<Local_Addr_Ind>]]]]]	Return the active and defined EPS bearers with the requested APN and other flags, and the assigned IP type and addresses.	Periodically (30 s) and when detecting problems
AT+CGCONTRDP=1	+CGCONTRDP: <cid>,<bearer_id>,<APN>[,<local_addr_and_subnet_mask>[,<gw_addr>[,<DNS_prim_addr>[,<DNS_sec_addr>[,<P-CSCF_prim_addr>[,<P-CSCF_sec_addr>[,<IM_CN_Signalling_Flag_Ind>[,<LIPA_indication>[,<IPv4_MTU>[,<WLAN_offload>[,<Local_Addr_Ind>[,<Non_IP_MTU>]]]]]]]]]]]]]	Return the assigned APN and other addresses and parameters.	Periodically (30 s) and when detecting problems
AT+CPOL?	+CPOL: <index1>,<format>,<oper1>[,<GSM_AcT1>,<GSM_Compact_AcT1>,<UTRAN_AcT1>[,<E-UTRAN_AcT>]]	Return the high priority PLMN list, which might change at SIM refresh. Check it both in AT+CPLS=0 and AT+CPLS=1	Module initialization and SIM refresh, only in debug/test mode
AT+UPSSTAT?	+UPSSTAT: 1 RRC, ConEstSucc:13, ConEstFail:0 EMM, AttachSucc:1, AttachFail:0, TAUSucc:3, TAUFail:0, SRSucc:8, SRFail:0, AuthFail:0, DetachNum:1 PLMN, OOS:0	Return modem statistics and counters	Periodically (30 s) and when detecting problems
AT+CEER	+CEER: "EMM cause ESM failure",33,"Requested service option not subscribed",222,10	Report the error result code sent by the network and the network's MCC and MNC. In the example, an error cause returned attaching with wrong APN. ☞ The same network error causes can be obtained with +CNEC URC command.	In case of difficulties in network registration.

Table 18: Diagnostic information via polling

9.2 Full-stack watchdog: how to react to unexpected conditions

The application shall properly handle communication or connectivity problems that can arise when using the module in the cellular mobile environment.

When a problem at a specific level is encountered, the countermeasure for that level should be tried and, if that does not resolve the issue, then proceed with the solutions for the lower levels. Table 19 shows a full-stack watchdog for monitoring LEXI-R10 series modules.

Level	Problem	Countermeasure	AT commands / actions	Notes

Socket/dial-up	Cannot send/receive data	Close and re-open socket	`AT+USOCL=<socket_id>`
			`AT+USOCR=<protocol>`
			`AT+USOCO=…`	

		Disconnect and re-connect dial-up	Send `+++` / Move DTR `ATD*99***<cid>#`	
IP/PDP	Cannot get an IP address; cannot establish dial-up	Detach/re-attach	`AT+CFUN=0` `AT+CFUN=1`	Consider possible restrictions to multiple <cid>s active for APN. If IPv6-only PDN is set in Verizon Wireless MNO setting, detach/deactivation may be caused by failing IPv6 acquire by SLAAC. The retry is managed automatically based on VZW Data Retry logic.
		Deactivate/re-activate context (<cid> != 1)	`AT+CGACT=0,<cid>` `AT+CGACT=1,<cid>`	
Network registration	Cannot register	Detach/re-attach	`AT+CFUN=0` `AT+CFUN=1`	AT+CFUN=0/1 must be preferred for registration cycles.
RF	Cannot register	Disable/re-enable RF functionality	`AT+CFUN=0` `AT+CFUN=1`	AT+CFUN=4 is NVM persistent, better to use AT+CFUN=0.
Module FW	Cannot register	Soft reset	`AT+CFUN=15`	
AT interface	No response from module	HW switch off	GPIO power control	See the LEXI-R10 series system integration manual [3] for details and alternatives.

Table 19: Full-stack watchdog for LEXI-R10 series modules

10 Backup & Restore

Backup & restore is a unique feature that may extend the lifetime of the modules in the field.

Due to the nature of flash memory, the module memory content stored in the embedded file system (EFS) may incur memory corruption if the safe and graceful shutdown procedure is not followed. It is possible that memory corruption may result in the device being inoperable or may impact specific device data information.

For a fatal memory corruption, the EFS backup & restore feature allows the module to autonomously restore the EFS using the last backup stored in the module itself.

Backup of device's unique parameters (e.g., RF calibration data, IMEI, etc.) is performed at the u-blox factory and is stored on the module as the first backup copy for the device. If an EFS corruption is detected, then the restore is triggered autonomously at the device boot-up process to restore the device with the single backup copy stored on the device.

⚠ It is critical that the host application follows the proper safe and graceful shutdown procedure outlined in the system integration manual [3]. The backup & restore feature is intended only as an additional backup mechanism if, on the potential rare occasion, the host application shutdown does not conform to the graceful power-down guidelines.

Item	LEXI-R10 series
Personalization data for security, calibrations, and unique data	Restored.
Files in user file system	Not applicable.
MNO profiles	Back to the factory-programmed settings.
User NVM settings (i.e. +IPR)	Restored.
User certificate and private keys	Not applicable.

10.1 Backup

Most of EFS backup is done automatically by the module and no external action is required by the application.

☞ Only the last backup is kept in the module.

10.1.1 Backup initiated with AT command

For the +UUARTCONF, +IPR, AT&K, AT&K0, +ICF, +IFC user NVM settings the backup is not done automatically to avoid excessive flash wear.

Command	Response	Description
`AT+UNVMW="aonnvmbckp"`	`OK`	Initiate a manual backup
`AT+UNVMR="aonnvmbckp"`	`OK`	Manual restore from backup
Unsolicited response	`+UUNVM: <id>,[<item_name>]`	Issued in case of corruption detection and automatic restoration of the item(s) on next boot or at the next NVM read operation.

10.2 Restore

The restore function allows a module to automatically recover from a fatal file system corruption if it should detect such a corruption from a previous improper shutdown at the next module boot-up.

When an automatic restore is triggered, the device will immediately restore the module memory settings (this may interrupt any running processes). After the restore procedure is completed, no

further action is required, except some settings may need to be restored manually by the user, if they were modified since the last backup.

11 Migration guide

This table list major software changes between the other u-blox cellular modules to the LEXI-R10 series and may help in migrating a host application between modules. For details of the commands below, see the AT commands manual [1].

Feature	SARA-R42	SARA-R5	LARA-R6	LEXI-R10
3GPP Release	Rel. 13 LTE Cat M1 and NB1 Rel. 14 LTE Cat M1	Rel. 13 LTE Cat M1 and NB1 Rel. 14 LTE Cat M1	Rel. 10 LTE Cat 1	Rel. 14 LTE Cat 1bis
Local connectivity peripherals	+USIO	+USIO	+USIO, +UUARTCONF, +UUSBCONF	+USIO, +UUARTCONF, +UUSBCONF
USB device class	N.A.	N.A.	Vendor specific class (CDC-ACM like)	Standard CDC-ACM
AT command execution and URC	AT command processing blocked if AT command ongoing on a different interface, URC issued on all ports (+UURCCONF to configure)	Parallel execution on each AT interface, URC usually issued on same port where enabled	AT command processing blocked if AT command ongoing on a different interface, URC issued on all ports (+UURCCONF to configure)	Parallel execution on each AT interface, URC usually issued on same port where enabled and stored to personal profile
Settings persistence	In NVM	In NVM and personal profile	In NVM	In NVM and personal profile
+CFUN syntax	+CFUN: (0,1,4,10,15,16,19)	+CFUN: (0,1,4,7,8,10,16)	+CFUN: (0,1,4,10,15,16,19)	+CFUN: (0,1,4,10,11,15,16,19)
PDP authentication parameters configuration	+UAUTHREQ with parameters in the following order: <username>, <password>.	+UAUTHREQ with parameters in the following order: <username>, <password>.	+UAUTHREQ with inverted parameters, thus: <password>, <username>.	+CGAUTH. If <cid>=1 is used, +CGDCONT must be configured with <secure_PCO> set to 1.
Band configuration	+UBANDMASK	+UBANDMASK	+UBANDMASK	+UBANDCONF, configures also the band priority
PLMN operator selection commands	+COPS=0 triggers a full PLMN scan, with possible loss of coverage at RAT change due to LPWA technology limits	+COPS=0 triggers a full PLMN scan if not on HPLMN or Higher priority PLMN	+COPS=0 triggers a full PLMN scan	+COPS=0 and COPS=1 returns immediate OK, +CEREG or COPS? shall be monitored for the registration result.
Higher priority PLMN scan configuration	+UHPPLMN	+UHPPLMN	+UHPPLMN	+UNASTCFG
Simple modem diagnostic	+CMER, +CIND, +UCIND supported	+CMER, +CIND, +UCIND supported	+CMER, +CIND, +UCIND supported	+CIND, +UCIND not supported, see 9.1 for alternative diagnostic.
Cell deep scan	+UCFSCAN	+COPS=5	+UCFSCAN	Not available yet.
PDN sharing between dial-up and Internet applications/Socket	Supported, use +UEMBPF to reserve port range for embedded applications.	Not supported, dial-up has exclusive usage of PDN connection.	Supported, use +UEMBPF to reserve port range for embedded applications.	Supported.
HTTP	Up to four different profiles	Up to four different profiles	Up to four different profiles	Only a single profile is available

Feature	SARA-R42	SARA-R5	LARA-R6	LEXI-R10
FOTA	uFOTA, FTP, HTTP	uFOTA, FTP, HTTP	uFOTA, FTP, HTTP	HTTP
PPP	No constraints on DTR (virtual and physical) line to start PPP connection. LCP Configure-Request must be initialized by DCE.	No constraints on DTR (virtual and physical) line to start PPP connection. LCP Configure-Request must be initialized by DCE.	DTR (virtual and physical) line must be asserted to start a PPP connection. LCP Configure-Request must be initialized by the DTE.	No constraints on DTR (virtual and physical) line to start PPP connection. LCP Configure-Request must be initialized by DCE.
Call hang up	ATH	ATH	+CHUP (for speech calls) and ATH	ATH
+UPSV (options)	+UPSV: (0,3,4)	+UPSV: (0,1,2,3,4)	+UPSV: (0,1,2,3,4)	+UPSV: (0,1,5)
+UFACTORY	Available	Available	Available	Not available
Antenna Dynamic Tunner	+UTEST=4	+UTEST=4	+UTEST=4	+UATUN
File system commands and handling	+URDFILE: to read an entire file +UDWNFILE: to write a file +UDELFILE: to delete the file +ULSTFILE: to list all the file +UDWNBLOCK to write a file in chunks	+URDFILE: to read an entire file +UDWNFILE: to write a file +UDELFILE: to delete the file +ULSTFILE: to list all the file +UDWNBLOCK to write a file in chunks.	+URDFILE: to read an entire file +UDWNFILE: to write a file +UDELFILE: to delete the file +ULSTFILE: to list all the file +UDWNBLOCK to write a file in chunks.	New file handling with open and close procedure. Commands are: +FOPEN: to open a file for operation +FREAD: to read bytes from the file +FWRITE: to write bytes to the file +FWRITEHEX: to write HEX data to the file +FDELETE: to close and delete the file +FCLOSE: to close the file +ULSTFILE: to list all the file ☞ Simultaneous operation on different interfaces of +FWRITE or +FREAD commands are not supported.
Reads the UEs PSM parameters assigned by the network.	AT+UCPSMS	AT+UCPSMS	AT+UCPSMS	AT+CEREG=4

Table 20: Software migration guide from previous u-blox products to LEXI-R10 series module

A Glossary

Abbreviation	Definition
BIP	Bearer Independent Protocol
CHAP	Challenge handshake authentication protocol
CSFB	Circuit Switched Fallback
DCE	Data Communication Equipment
DHCP	Dynamic Host Configuration Protocol
DL	Down Link (Reception)
DRX	Discontinuous Reception
DTE	Data Terminal Equipment
eDRX	Extended DRX
EFS	Embedded File System
FW	Firmware
HW	Hardware
LwM2M	Lightweight M2M
MNO	Mobile Network Operator
MO	Mobile Originated
MT	Mobile Terminated
NAT	Network Address Translation
NVM	Non-Volatile Memory
NW	Network
OPLMN	Operator Public Land Mobile Network
PAP	Password authentication protocol
PLMN	Public Land Mobile Network
PPP	Point-to-Point Protocol
RAT	Radio access technology
RNDIS	Remote Network Driver Interface Specification
RPLMN	Registered Public Land Mobile Network
SW	Software
TAU	Tracking Area Update
UE	User Equipment
URC	Unsolicited Result Code

Related documentation

[1] u-blox LEXI-R10 series AT commands manual, UBXDOC-686885345-1786
[2] u-blox LEXI-R10 series data sheet, UBX-23007594
[3] u-blox LEXI-R10 series system integration manual, UBX-23008149
[4] u-blox EVK-R10 user guide, UBXDOC-686885345-1985
[5] u-blox LEXI-R10 FW update application note, UBXDOC-686885345-2005
[6] u-blox LEXI-R10 Internet applications development guide app note, UBXDOC-686885345-2004
[7] 3GPP TS 27.010 V3.4.0 - Terminal Equipment to User Equipment (TE-UE) multiplexer protocol (Release 1999)
[8] GSMA TS.34 - IoT Device Connection Efficiency Guidelines (Version 4)
[9] u-blox Mux implementation in cellular modules application note, UBX-13001887
[10] u-blox SARA-R422 / LEXI R422 application development guide application note, UBX-20050829
[11] u-blox LEXI-L10 production and prototype validation guidelines application note. UBXDOC-686885345-2043. Contact tech support for this document.

☞ For product change notifications and regular updates of u-blox documentation, register on our website, www.u-blox.com.

Revision history

Revision	Date	Name	Comments
R01	29-Mar-2024	mreb	Initial release
R02	14-Jun-2024	mreb	Added section: Low power. Updated sections: Monitoring module status, Backup & restore and Migration guide.
R03	06-Aug-2024	mreb	Updated sections: Low power and Verizon profile.

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