



# SARA-R5 series

## Internet applications development guide

Application note



### Abstract

This document provides detailed examples of how to use AT commands to develop IP applications in SARA-R5 modules series.

# Document information

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# 1 Introduction

This document provides guidance for using IP related applications in SARA-R5 series modules. It includes examples of AT commands used to interface with the u-blox SARA-R5 series modules for network connectivity and IP protocols use. It reports examples for any applications relying on the IP stack (sockets, MQTT, MQTT-SN, HTTP, FTP, CoAP, SSL/TLS).

In the first section, the packet switched (PS) data connection is described with context definition and procedure to obtain a valid IP address from the network. Then, it provides information on security aspects useful to manage and configure a secure data connection.

Table 1 shows a summary of the documentation available for SARA-R5 series modules. We recommend, as a starting point, to read the application development guide app note [4] which reports extremely relevant information guidance for developing applications that interface with the u-blox SARA-R5 series modules. Moreover, it contains details to complete the network registration process, which is a mandatory precondition to activate a PS data connection and use any internet application.

	Document name	Notes
<b>Application integration</b>	Application development guide app note [4]	This should be the first document to read when working on an application for SARA-R5
	FW update app note [9]	FW update procedures (uFOTA, FOAT, FOTA, +UFWINSTALL, EasyFlash)
	IP applications development guide app note	<b>This document.</b>
	Security suite app note [8]	IoT-as-a-Service features (local encryption, E2E encryption, E2E symmetric KMS, Chip-to-Chip, Zero Touch Provisioning)
	GNSS implementation app note [11]	
	Mux implementation app note [17]	Usage of multiplexer with cellular modules
	EVK-R5 user guide [10]	Starting guide for the SARA-R5 evaluation kit
<b>Reference documentation</b>	Data sheet [1]	Use these documents as hardware integration and AT commands API reference
	System integration manual [2]	
	AT commands manual [3]	
<b>Product release documents</b>	Sample delivery note / Information note	Delivered with every FW release

**Table 1: SARA-R5 product documentation scheme**

Considering the growing interest in internet-related applications, the second part of this document provides complete examples and relevant notes to introduce the so-called “IP” applications that are built with our SARA-R5 series modules. The module structure of these applications is reported in Figure 1.

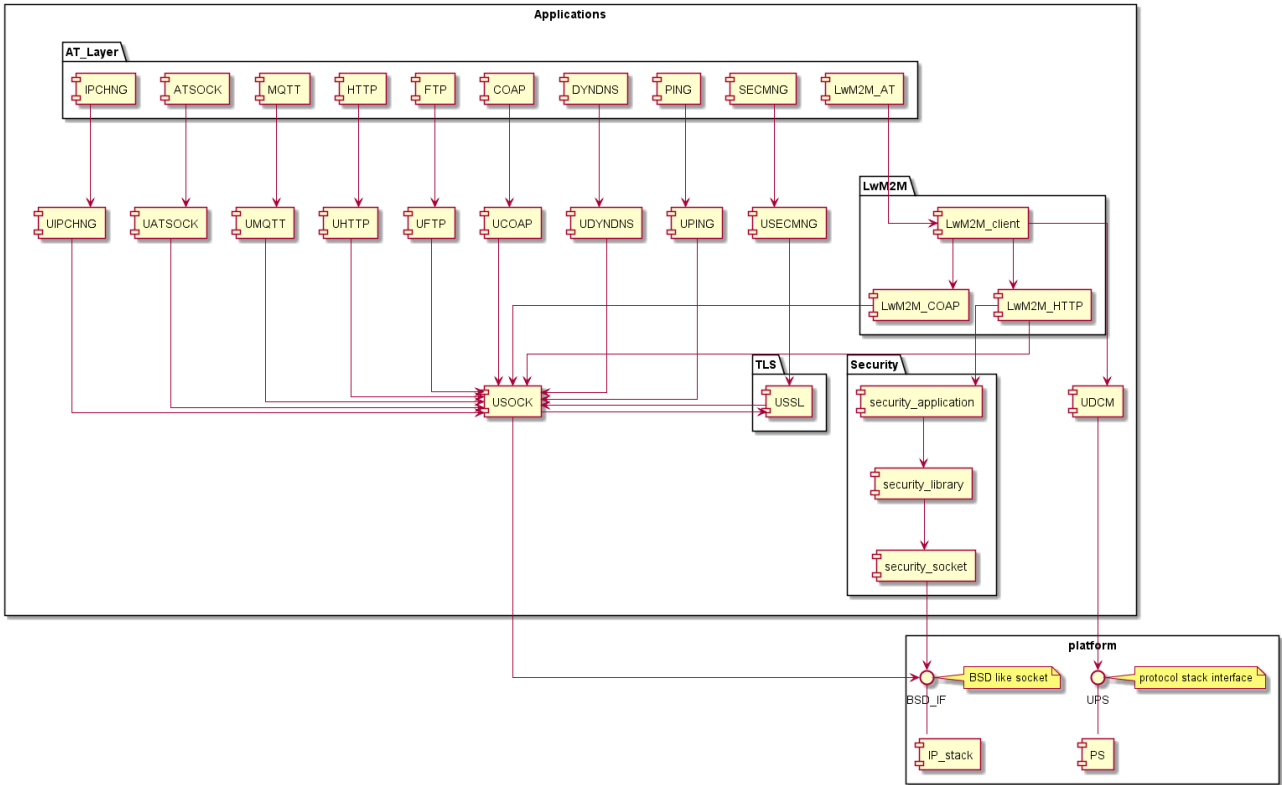




Figure 1: SARA-R5 “IP” applications

In conclusion, use as reference documentation the data sheet [1], the system integration manual [2], and the SARA-R5 series AT commands manual [3] for a detailed AT command descriptions.

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 PS data connection

Ensure the module is correctly registered to the network before executing all the procedures and examples reported in this document. Steps to complete the network registration operation can be found in the “Network registration” section of the SARA-R5 application development guide [4].

### 2.1 PDP contexts

Packet-switched services rely on the Packet Data Protocol (PDP). The PDP context is a data structure that contains the subscriber’s session information. Two types of PDP context are defined:

- “external” PDP context: IP packets are built by the Data Terminal Equipment (DTE), the module’s IP instance runs the IP relay function only.
- “internal” PDP context, or PSD profile: the PDP context (relying on the module’s embedded TCP/IP stack) is configured, established, and handled via the data connection management AT commands.

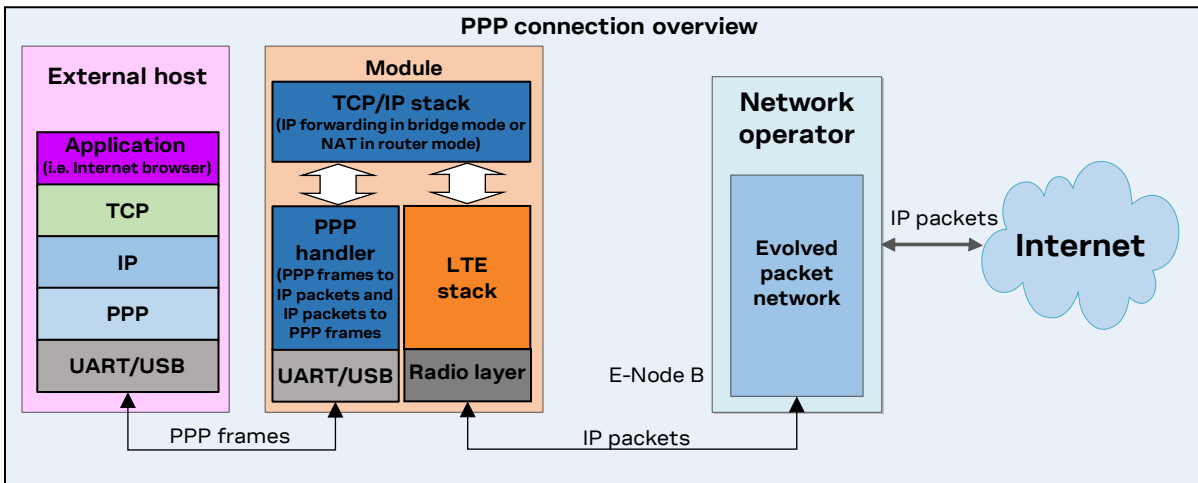


Figure 2: Example of external context structure

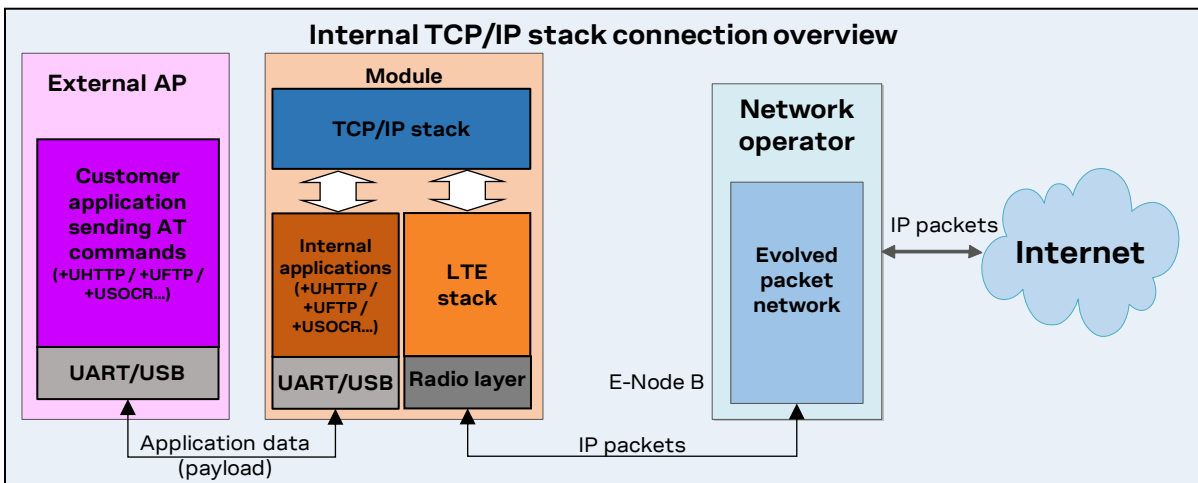



Figure 3: Example of internal context structure

Networks offer connectivity to different IP domains (internet or private intranet) selected by specifying the Access Point Name (APN) at PDP context activation.



 In LTE RAT, if the APN name is not specified, an anchor APN (e.g., “admin”) can be assigned by the network to the module, along with an IP address which may give no actual connectivity. Check the APN name to use with your mobile network operator.


For further details on the APN configuration, see the “Network registration” section of the SARA-R5 application development guide [4].

Each PDP context defined has a related identifier called “context ID” (cid). On SARA-R5 series it is possible to define up to 12 PDP contexts (<cid> from 0 to 11) where 7 of them can be active. <cid>=1 is mapped to the initial default EPS bearer (primary PDP context, established during the LTE attach procedure).



## 2.2 Socket and PDP context activation

The following example reports all the AT commands necessary to reach the activation of a PDP context at first then a data socket by starting from the power-up of the SARA-R5 module and the control of the pre-existing settings.

### Network settings verification

Command	Response	Description
AT+CFUN=0	OK	Turn off radio functionality.  While setting the network profile and parameters, the radio functionality must be turned off.
AT+UMNOPROF=100	OK	Set the MNO profile for usage in Europe (LTE bands 3, 8, 20). The MNO profiles are sets of modem configurations specific for MNO/regions and it can be done only at the first start-up of the module.
AT+CFUN=16	OK	Reboot of the module to make the new setting effective.
AT+UMNOPROF?	+UMNOPROF: 100 OK	Verifying that the new profile has been set.
AT+CFUN=0	OK	Turn off radio functionality.
AT+CGDCONT=1,"IPV4V6","apn_name"	OK	Define the PDP context 1 with PDP type "IPV4V6" and APN "apn_name" of the MNO.

### Check network registration




Command	Response	Description
AT+CFUN=1	OK	Turn on radio functionality.
AT+COPS?	+COPS: 0,0,"Nutaq Cat-M1 Network",7 OK	Verify if module is currently registered to the network.  Issue AT+COPS=0 if the +COPS? command returns +COPS: 2.
AT+CGDCONT?	+CGDCONT: 1,"IP","apn_name","100.108.232.233",0,0,0,0,0 OK	Return IPv4 address (in this case, only IPv4 address is assigned by the network).  When mapping the external context to an internal PSD profile, the application must make sure that the same protocol type is set (e.g., in this example, using command AT+UPSD=0,0,0).

## Socket activation

Command	Response	Description
AT+UPSD=0,100,1	OK	Profile #0 is mapped on CID=1.
AT+UPSD=0,0,0	OK	Set the PDP type to IPv4 referring to the output of the +CGDCONT read command.
AT+UPSDA=0,3	OK	Activate the PSD profile #0: the IPv4 address is already assigned by the network.
	+UUPSDA: 0, "100.108.232.233"	This URC indicates that the PSD profile #0 has been successfully activated and the IPv4 assigned to the activated PDP context.

### 2.2.1 Mapping IP protocol type

When an external context is mapped to an internal PSD profile (e.g., by using the +UPSD AT command option 100) make sure to set the same protocol type (either "IP", "IPV6", or "IPV4V6") both for the context and the profile before the PSD profile activation.

-  What matters is the protocol type set when issuing the +CGDCONT set command, and not what is provided as the response of the +CGDCONT read command, which could be different.
-  On SARA-R5 series the default protocol type for external contexts (defined by means of the +CGDCONT AT command) is IPV4V6, while for internal PSD profiles it is IP (v4).
-  If the network supports both IPv4 and IPv6, it is recommended to keep the IPV4V6 setting when defining a new PDN connection via AT commands. In this manner, when an LTE attach or PDP context activation is performed, both IPv4 and IPv6 will be assigned and all IP clients can connect to either IPv4 or IPv6 servers on the same context.

The following table shows all possible examples and the +UPSD AT command that need to be set to correctly map an external context to an internal PSD profile:

External context setting	+UPSD respective configuration
AT+CGDCONT=1, "IPV4V6", ...	AT+UPSD=0, 0, 2 or AT+UPSD=0, 0, 3
AT+CGDCONT=1, "IP", ...	AT+UPSD=0, 0, 0
AT+CGDCONT=1, "IPV6", ...	AT+UPSD=0, 0, 1

**Note that the mapping is always done with AT+UPSD=0,100,1 command.**

If the protocol mapping type is wrong, the profile activation will report the +CME ERROR: IP type configuration mismatch error result code.

## 2.3 Other relevant AT commands

### 2.3.1 UPING






The ping command is the common method to know if a remote host is reachable on the internet.

The ping functionality is based on the ICMP protocol. The ping command sends an ICMP echo request to the remote host and waits for its ICMP echo reply. If the echo reply packet is not received, it might mean that the remote host is not reachable. The ping command could be used also to measure e.g. the round trip time (RTT, the time needed by a packet to go to the remote host and come back) and the time to live (TTL, it is a value to understand how many gateways a packet has gone through).

The +UPING AT command allows the user to execute a ping command from the module to a remote peer. The results of the ping command execution are notified by means of these URCs:

- +UUPING: it reports the +UPING AT command result when no error occurred.
- +UUPINGER: it is raised if an error occurs while processing the +UPING AT command.

For further details on the +UPING AT command and its possible errors, see the SARA-R5 series AT commands manual [3].

-  Some network operators may disallow ICMP packets traffic on their network, this means that the +UPING AT command may not work.
-  Some remote hosts might not reply to ICMP echo requests for security reasons (e.g. firewall settings).
-  Some remote hosts might not reply to ICMP echo requests if the data size of the echo request is too big.
-  If a remote peer does not reply to an ICMP echo request, it does not mean that for sure the peer cannot be reached in another way.
-  The command is not supported in context using the IPv6 protocol type.

Command	Response	Description
AT+UPING="www.google.com"	OK	Ping request.
	+UUPING: 1, 32, "www.google.com" , "216.58.206.68", 115, 62	URC ping responses.
	+UUPING: 2, 32, "www.google.com" , "216.58.206.68", 115, 53	
	+UUPING: 3, 32, "www.google.com" , "216.58.206.68", 115, 53	
	+UUPING: 4, 32, "www.google.com" , "216.58.206.68", 115, 53	


### 2.3.1.1 Notes

- If the +UUPING URC reports <rtt>=-1 the timeout is elapsed (no response received).
- If the first +UUPING URC reports <rtt>=-2 the TTL used in the ping request is too low.
- Some network operators may return an ICMP time exceeded message when the remote host is not reachable. In these cases the first +UUPING URC reports <rtt>=-1 and the subsequent +UUPING URC reports <rtt>=-2.

### 2.3.2 DNS resolution

Using the +UDNSRN AT command it is possible to translate a domain name to an IP address or an IP address to a domain name by using an available DNS. There are two available DNSs, primary and secondary. The network usually provides them after a PS data activation. They are automatically used in the resolution process if available. The resolver will use first the primary DNS, otherwise if there is no answer, the second DNS will be involved.

Command	Response	Description
AT+UDNSRN=0, "www.google.com"	+UDNSRN: "216.239.59.147" OK	DNS resolution request.

-  In case the application is not subjected to low power consumption constraints, use either the +UPING or the +UDNSRN AT command to verify that the module is registered with the network, and a PS data connection is activated before start using any IP application.

## 3 Secure data

### 3.1 Certificates manager +USECMNG

The use of +USECMNG AT command permits to manage SSL/TLS certificates and private keys. Particularly, the command permits to:

- Import of certificates and private keys
- List and information retrieval of imported certificates and private keys
- Removal of certificates and private keys
- MD5 calculation of imported certificate or private key

For additional details on this AT command, the number and the format of the certificates, and the private keys accepted, see the SARA-R5 series AT commands manual [3].

In the following it is reported a complete example regarding the use of the +USECMNG AT command for performing a double authentication using certification authority (CA) certificate, client certificate and client private key.

Command	Response	Description
AT+USECMNG=1,0,"ca_cert","ca_cert.crt"	+USECMNG: 1,0,"ca_cert","d10137cee624f cee624418db5eaa" OK	Import the CA certificate from the file "ca_cert.crt" stored on the file system.
AT+USECMNG=1,1,"client_cert","client_cert.crt"	+USECMNG: 1,1,"client_cert","b137ce 137ce5edd6723d8b13" OK	Import the client certificate from the file "client_cert.crt" stored on the file system.
AT+USECMNG=1,2,"client_key","client_key.key"	+USECMNG: 1,2,"client_key","087ab34c9aa03fbce5edd6723d8b8e05" OK	Import the client private key from the file "client_key.key" stored on the file system.
AT+USECMNG=3	CA,"ca_cert","An MQTT broker","2032/10/18 08:23:32"  CC,"client_cert","A client certificate","2032/06/22 12:34:48"  PK,"client_key" OK	List all imported certificates or private keys.


### 3.2 Profile configuration +USECPRF

The +USECPRF AT command allows the configuration of USECMNG (u-blox SECURITY MaNaGement) profiles used for an SSL/TLS/DTLS connection.


In particular, the command manages security profiles for the configuration of the following SSL/TLS/DTLS connections properties:


- Certificate validation level
- Cipher suite to be configured
- Certificate to be used for server and mutual authentication
- Expected server hostname, when using certificate validation level 1, 2 or 3
- Password for the client private key, if it is password protected
- Pre-shared key used for connection
- Server name indication (SNI)
- Server certificate pinning
- Pre-shared key generated by Root of Trust (RoT)
- (D)TLS session resumption.

For additional details on this AT command and all the related configurations, see the SARA-R5 series AT commands manual [3].

Command	Response	Description
AT+USECPRF=0	OK	Reset (set to factory-programmed value) all the parameters of security profile #0.  We recommend issuing the reset as the first command to erase all previously stored values.
AT+USECPRF=0,0,1	OK	Enable certificate validation without URL integrity check for profile #0. The server certificate will be verified with a specific trusted certificate or with each of the imported trusted root certificates.
AT+USECPRF=0,2,3	OK	Select legacy cipher suite for profile #0.
AT+USECPRF=0,3,"ca_cert"	OK	Select trusted root certificate internal name for profile #0.
AT+USECPRF=0,5,"client_cert"	OK	Select trusted client certificate internal name for profile #0.
AT+USECPRF=0,6,"client_key"	OK	Select trusted client key internal name for profile #0.

### 3.3 Complete example

Command	Response	Description
<b>Step1: Import a trusted root certificate using the stream of byte similar to the +UDWFILE AT command</b>		
AT+USECMNG=0,0,"ThawteCA",1516 >		Start the data transfer using the stream of byte.  Differently from the example in section 3.1, in this case the certificate is transferred as a stream of byte and it is not stored in the SARA-R5 file system.
-----BEGIN CERTIFICATE----- MIIEIDCCAwigAwIBAgIQNE7VVyDV7e xJ9C/OjVaMaA== -----END CERTIFICATE-----	+USECMNG: 1,0,"ThawteCA", "8cca dc0b22cef5be72ac411a11a8d812" OK	Input PEM formatted trusted root certificate data bytes. Output MD5hash string of the stored trusted root certificate DER.
<b>Step 2: List all available certificates and private key</b>		
AT+USECMNG=3	CA, "ThawteCA", "thawte Primary Root CA", "2036/07/17" OK	List all available certificates and private keys.
<b>Step 3: Set the security profile 2 validation level to a trusted root</b>		
AT+USECPRF=2,0,1	OK	Security profile 2 has the validation level set to a trusted root.
<b>Step 4: Set the security profile 2 trusted root certificate to the CA certificate imported as "ThawteCA"</b>		
AT+USECPRF=2,3,"ThawteCA"	OK	Security profile 2 will use the CA certificate imported as "ThawteCA" for server certificate validation.
<b>Step 5: Use the configured USECMNG profile 2 with the UHTTP application</b>		
AT+UHTTP=0,1,"www.ssl_tls_test _server.com"	OK	Configure the UHTTP server name.
AT+UHTTP=0,6,1,2	OK	Enable the SSL/TLS for the UHTTP profile #0 and specify the SSL/TLS security profile #2.
AT+UHTTPC=0,1,"/", "https.resp"	OK	Execute the HTTP GET command.
	+UUHTTPCR: 0,1,1	HTTP GET URC response.

 Due to the significant memory fingerprint of an SSL/TLS connection, the number of concurrent SSL/TLS connections is limited. The +USECMNG AT command and the underlying SSL/TLS infrastructure allows 4 concurrent SSL/TLS connections (i.e., 4 HTTPS requests or 2 HTTPS and 2 FTPS requests).

### 3.4 (D)TLS session resumption

This section reports some details and examples on the use of the innovative (D)TLS session resumption feature, a new, useful approach that speeds up the handshake negotiation process.


The session resumption allows the caching of TLS/DTLS session information and hence can be used to shorten the handshake procedure when consequential sessions must be established with the same server. The RFC 5077 specification [18] of the session resumption provides 2 concepts:

- **Session ID:** the connection properties (IP address /port) in the resumed session need to be the same as in the suspended session. The server in this case has a cache where tracks the IP address /port /session ID. This concept is also called server-side stateful session resumption in the sense that the server should keep a per-client session state.
- **Session Ticket:** the connection properties (IP address /port) do not need to be the same. In this case, the module needs to keep the *session ticket* so for the server there is less work. This concept is also called server-side stateless session resumption and does not require the server to keep the per-client session state. This allows servers to handle a large number of transactions from different users, the sessions can be cached for a long time, load balancing of the requests can be performed across different servers, and the possibility to run server instances on an embedded platform with little memory.

The session resumption with session ID is performed within the following steps:

1. acquiring the session ID:
  - the client sends in the Client Hello message the session ID length equal to 0;
  - the server responds in the Server Hello message with the session ID and the session ID length (not equal to 0);
  - the client should store the session ID and the session ID length to reuse them;
  - the server should store the session information (session ID, session ID length, connection properties) to accept session resumption from the client.
2. reusing previous session:
  - the client sends in the Client Hello message the session ID and session ID length (not equal to 0);
  - the server responds in the Server Hello message with the same session ID and session ID length if it accepts the session resumption. In this case, no certificate or key information is exchanged during abbreviated TLS handshake and previously negotiated keys are re-used. If the previous session is not accepted the server replies in the Server Hello with a new session ID and session ID length, and then certificates and new session keys must be exchanged.

Since the session resumption is enabled, the URC will be displayed every time a secure connection is performed. Once the session data of the URC are not equal to the session data already set, it means that the server does not accept the session resumption. In this case, the complete handshake has been performed and the new session data has been displayed. The new session data needs to be set again.



 The session resumption feature configuration and secure session data are not stored in the NVM, and the session data is displayed via URC. Therefore, the session can be restored after waking up from PSM mode or a module reboot only if the session data is stored by the user application.

### 3.4.1 (D)TLS session resumption examples

The following session will present two examples of the use of the session resumption. In the first example the session data is not encrypted, while in the second example the session resumption data is encrypted with a local encryption feature provided by the RoT.

#### 3.4.1.1 Example: session data not encrypted

##### Phase 1: acquiring the session data

Command	Response	Description
<b>Step 1: Preparation steps</b>		
		AT command sequence to ensure Internet connectivity.
		Required +USECMGN AT commands to handle the certificates/keys.
		Required +USECPRF AT commands to configure the security profile <profile_id>.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP – HTTP client).
<b>Step 2: Enable the session resumption</b>		
AT+USECPRF=<profile_id>,13,0,1 OK		Enable the session resumption for the security profile <profile_id>.
<b>Step 3: Set the session resumption type</b>		
AT+USECPRF=<profile_id>,13,1,0 OK		Set the session resumption type for the security profile <profile_id>.
<b>Step 4: Associate the application profile to the security profile</b>		
AT+UHTTP=<app_profile>,6,1,<profile_id> OK		The application profile <app_profile> is associated to the security profile <profile_id>.
<b>Step 5: Execute HTTP GET request</b>		
AT+UHTTPC=<app_profile>,1,"/index.html","response_file"		Perform HTTP GET request.
	+UUSECPRF: <profile_id>,13,1,0	URC with session resumption type.  The session resumption type should be stored to be reused for the resumption on the next session.
	+UUSECPRF: <profile_id>,13,2,<session_id_base64>,<master_secret_base64>	URC with session resumption data.  The session resumption data should be stored to be reused for the resumption on the next session.
	+UUHTTPCR: <app_profile>,1,1	HTTP GET URC response.

##### Phase 2: reusing previous session

Command	Response	Description
<b>Step 1: Preparation steps</b>		
		AT command sequence to ensure Internet connectivity.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP).



Command	Response	Description
<b>Step 2: Enable the session resumption</b>		
AT+USECPRF=<profile_id>,13,0,1	OK	Enable the session resumption for the security profile <profile_id>.
<b>Step 3: Set the session resumption type</b>		
AT+USECPRF=<profile_id>,13,1,0	OK	Set the session resumption type for the security profile <profile_id>.
<b>Step 4: Set the session resumption data</b>		
AT+USECPRF=<profile_id>,13,2,<session_id_base64>,<master_sec_ret_base64>	OK	Set the session resumption data for the security profile <profile_id>.
<b>Step 5: Associate the application profile to the security profile</b>		
AT+UHTTP=<app_profile>,6,1,<profile_id>	OK	The application profile <app_profile> is associated to the security profile <profile_id>.
<b>Step 6: Execute HTTP GET request</b>		
AT+UHTTPC=<app_profile>,1,"/index.html","response_file"	OK	Perform HTTP GET request.
	+UUSECPRF: <profile_id>,13,1,0	URC with session resumption type.  If the displayed session type is not equal to the session type already set, the session has not been resumed. The new session type should be set.
	+UUSECPRF: <profile_id>,13,2,<session_id_base64>,<master_sec_ret_base64>	URC with session resumption data.  If the displayed session data is not equal to the session data already set, the session has not been resumed. The new session type should be set.
	+UUHTTPCR: <app_profile>,1,1	HTTP GET URC response.

### 3.4.1.2 Example: session data encrypted with local encryption



#### Phase 1: acquiring the session data

Command	Response	Description
<b>Step 1: Preparation steps</b>		
		AT command sequence to ensure Internet connectivity.
		Required +USECMGN AT commands to handle the certificates/keys.
		Required +USECPRF AT commands to configure the security profile <profile_id>.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP – HTTP client).
<b>Step 2: Enable the session resumption</b>		
AT+USECPRF=<profile_id>,13,0,1	OK	Enable the session resumption for the security profile <profile_id>.
<b>Step 3: Set the session resumption type</b>		
AT+USECPRF=<profile_id>,13,1,1	OK	Set the session resumption type for the security profile <profile_id>.
<b>Step 4: Associate the application profile to the security profile</b>		
AT+UHTTP=<app_profile>,6,1,<profile_id>	OK	The application profile <app_profile> is associated to the security profile <profile_id>.
<b>Step 5: Execute HTTP GET request</b>		
	OK	Perform HTTP GET request.



Command	Response	Description
AT+UHTTPC=<app_profile>,1,"/in dex.html","response_file"	+UUSECPRF: <profile_id>,13,1,1 0	URC with session resumption type.  The session resumption type should be stored to be reused for the resumption on the next session.
	+UUSECPRF: <profile_id>,13,12,<encrypted_session_data>,<enc_session_data_size>	URC with encrypted session resumption data.  The session resumption data should be stored to be reused for the resumption on the next session.
	+UUHTTPCR: <app_profile>,1,1	HTTP GET URC response.



## Phase 2: reusing previous session

Command	Response	Description
<b>Step 1: Preparation steps</b>		
		AT command sequence to ensure Internet connectivity.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP).
<b>Step 2: Enable the session resumption</b>		
AT+USECPRF=<profile_id>,13,0,1	OK	Enable the session resumption for the security profile <profile_id>.
<b>Step 3: Set the session resumption type</b>		
AT+USECPRF=<profile_id>,13,1,1	OK 0	Set the session resumption type for the security profile <profile_id>.
<b>Step 4: Set the encrypted session resumption data</b>		
AT+USECPRF=<profile_id>,13,12,<encrypted_session_data>,<enc_session_data_size>	OK	Set the encrypted session resumption data for the security profile <profile_id>.
<b>Step 5: Associate the application profile to the security profile</b>		
AT+UHTTPC=<app_profile>,6,1,<profile_id>	OK	The application profile <app_profile> is associated to the security profile <profile_id>.
<b>Step 6: Execute HTTP GET request</b>		
AT+UHTTPC=<app_profile>,1,"/in dex.html","response_file"	OK	Perform HTTP GET request.
	+UUSECPRF: <profile_id>,13,1,1 0	URC with session resumption type.  If the displayed session type is not equal to the session type already set, the session has not been resumed. The session type should be update.
	+UUSECPRF: <profile_id>,13,12,<encrypted_session_data>,<enc_session_data_size>	URC with encrypted session resumption data.  If the displayed session data is not equal to the session data already set, the session has not been resumed. The session data should be updated.
	+UUHTTPCR: <app_profile>,1,1	HTTP GET URC response.


## 4 Dial-up network (PPP)

The module can perform dial-up network (DUN) connections supporting the Point-to-Point Protocol (PPP). The PPP connection is established between the target (e.g., Windows device) and the DTE. In particular, the target performs as the PPP server, while the DTE performs as the PPP client.

When a data call is initiated by means of the D\* AT command, the module switches to the PPP mode just after the CONNECT intermediate result code.

-  After the module has attached to the network the host can control the PDP context APN, authentication and MTU (maximum transmission unit) sizes directly through PPP.
-  If the network throughput is less than the data sent from the host to the module (is limited by the uplink network resource/bandwidth), then a packet data loss may occur, even with hardware flow control enabled. To avoid this issue, do either or both:
  - Reduce the baud rate used
  - The host application can slow down data transfer by adding pauses between data payloads or breaking up their payload and adding delay.

### 4.1 Basic setup



-  The module must be attached to the network with an already active context before starting the dial-up.

Command	Response	Description
ATD*99***1#		Perform the dial-up on the PDP context on CID=1.

Using the dial command for establishing PPP connection, ATD\*99\*\*\*1#, the ‘1’ in this example refers to the first active PDP context returned by the +CGDCONT read command.

#### 4.1.1 PPP over multiple PDP contexts

Optionally, a second PDP context can be set up for PPP if used with multiplexer (multiplexing mode MUX) over the UART interface. In such a configuration, the socket type data calls established by AT commands and internal embedded calls are only routed through the default context CID 1.

-  If a MUX configuration is adopted, it is recommended to use two channels, one for the control by AT interface and URCs messages, and the second for the PPP itself. For additional details on the use of MUX, see the specific application note [\[17\]](#).
-  A different and unique APN is required per context.

In the below example there are two contexts defined and established. The second context on CID2 may be utilized by PPP. Do not activate the second context manually, instead establishing the PPP session will automatically activate and deactivate it. In the example the second context is activated by the PPP session.

Example of a second context for PPP dial-up connection:


```
+CGDCONT: 1,"IP","APN1","166.130.71.189",0,0,0,0
+CGDCONT: 2,"IPV4V6","APN2","10.117.32.103 38.0.3.128.178.65.129.209.0.0.0.74.87.68.176.1",0,0,0,0
```

For more details on multiple PDP contexts, see the SARA-R5 series AT command manual [\[3\]](#).


## 4.2 Terminate cellular packet data connection

The PPP data session can be terminated by one of the following events:

- via a DTR hardware transition of the pin from ON to OFF;
- sending an LCP “Terminated request”;
- sending the string “+++” in the AT interface (see the “Circuit 108/2 behavior &D” section of the SARA-R5 AT commands manual [\[3\]](#) for further details on “+++” different behaviors).

 When using MUX and PPP combined, toggling the DTR line does not terminate the PPP session and return the device to the command mode. In this configuration, it is recommended that the host terminates the PPP session, which can be done by sending LCP\_TERM REQ. Another method to terminate the PPP session is to send a MSC MUX frame for logical DTR de-assert.


## 5 TCP/UDP internal stack

 Verify that the module is registered with the network and a PS data connection is activated. Make sure to follow the steps in section 2 before using the AT commands in this section.

### 5.1 Socket connect

Command	Response	Description
AT+USOCR=6	+USOCR: 0 OK	TCP socket creation. In this example socket #0 is created. The information text response returns the created socket identifier (in this case #0). If a new socket is created (without closing the already existent), a new socket identifier will be returned.
AT+USOCR=17	+USOCR: 1 OK	Create another socket (in this case the socket is UDP and its identifier is 1).
AT+USOCL=1	OK	Close socket #1. The socket #1 is free.
AT+UDNSRN=0,"ftp.u-blox.com"	+UDNSRN: "195.34.89.241" OK	DNS resolution of the URL "ftp.u-blox.com".
AT+USOCO=0,"195.34.89.241",7	OK	Connect socket #0 to port 7 of a remote host with IP address 195.34.89.241. <b>The connection is now uniquely associated to the socket. The socket is now ready for read/write operations.</b>
AT+USOCO=0,"195.34.89.241",7	ERROR  +UUSOCL: 0	If the connection is not successfully performed, an error result code is returned and the socket used for the connection attempt <u>is closed</u> . The notification is provided by +UUSOCL URC.

### 5.2 Socket listening

Command	Response	Description
AT+USOCR=6	+USOCR: 0 OK	TCP socket creation with ID #0.
AT+USOLI=0,1099	OK	Set the socket in listening mode on port 1099.  The ability to reach the opened port on the server depends also on the network operator. Some network operators do not allow incoming connection on opened TCP/UDP port.
	+UUSOLI: 1,"151.9.34.66",399 12,0,"151.9.34.74",1099	When a connection request arrives from a remote host, a new socket is created with the first integer identifier available. In this example the socket ID is #1. The +UUSOLI URC indicates: <ul style="list-style-type: none"> <li>• <b>1</b>: the new socket created. Incoming data from the established connection will be received on this socket. Data to be sent must be written into this socket</li> <li>• <b>151.9.34.66</b>: IP of the remote server</li> <li>• <b>39912</b>: service port</li> <li>• <b>0</b>: listening socket. It is the socket identifier specified with the +USOLI AT command</li> <li>• <b>151.9.34.74</b>: module IP address</li> <li>• <b>1099</b>: listening port assigned to the connection. Configured with the +USOLI AT command</li> </ul>


Command	Response	Description
		Socket #1 is now ready for reading/writing data.
	+UUSORD: 1,18	18 bytes of incoming data over the previously established connection.  The incoming data will always be sent on the related socket.

## 5.3 Socket write (+USOWR)

### 5.3.1 Binary mode

Command	Response	Description
AT+USOWR=0,2	@	Request to write 2 data bytes into socket #0. Wait "@" symbol indicating the data prompt is now open (AT commands are not allowed in data prompt). After the @ prompt reception, wait for a minimum of 50ms before sending data.
12	+USOWR: 0,2 OK	Write data bytes. It is not allowed to write fewer bytes than previously specified with AT+USOWR command. If more bytes are written with respect to the threshold, the remaining bytes will be truncated. The interface is blocked until all bytes are written. If the final result code is returned then the data is sent to a lower level of the protocol stack. <b>This is not a notification of an acknowledgment received from the remote host data bytes that have been sent to.</b>

### 5.3.2 Base syntax


Command	Response	Description
AT+USOWR=0,2,"12"	+USOWR: 0,2 OK	Write 2 data bytes data on socket #0. If the final result code is returned then the data is sent to a lower level of the protocol stack. <b>This is not an acknowledgment from the remote host where the data bytes were sent.</b>  Some characters are not allowed in base syntax mode. For the allowed characters, see the SARA-R5 series AT commands manual [3].

### 5.3.3 Queue FULL

Command	Response	Description
AT+USOWR=0,2,"12"	ERROR	If the socket buffer is full, then the data bytes inserted in data prompt will be discarded: this may happen if the network is congested or if network coverage is lost. <b>In this case an error result code is returned.</b>
AT+USOCTL=0,10	+USOCTL: 0,10,4 OK	In case of an error result code, it is recommended to query the state of TCP connection associated to the socket to verify the socket is still connected.

Command	Response	Description
		The third parameter of the information text response is the state; if its value is 4, it means the connection is established.
AT+USOCTL=0,11	+USOCTL: 0,11,0 OK	It is also possible to query for TCP outgoing unacknowledged data of the socket (this command is valid only for TCP socket). In this case, 0 bytes of data is unacknowledged.

## 5.4 Socket operations with "Keep Alive" option

 In "Keep Alive" mode, the module periodically sends dummy TCP packets to prevent the network from closing the inactive context. The network operator may close inactive TCP connections without notification to the module.

Command	Response	Description
AT+USOCR=6	+USOCR: 0 OK	Create a TCP socket #0.
AT+USOSO=0,65535,8,1	OK	Enable the "keep alive" option. This socket option enables the module to send dummy IP packets to keep the connection alive. <ul style="list-style-type: none"> <li>• <b>0</b>: socket number to be set to enable keep alive option</li> <li>• <b>65535</b>: specifies socket level option</li> <li>• <b>8</b>: specify the "Keep Alive" option</li> <li>• <b>1</b>: enable the keep alive (set to 0 to disable it)</li> </ul>
AT+USOSO=0,6,2,30000	OK	Set the inactivity timeout after which the module will start to send "keep alive" packets. <ul style="list-style-type: none"> <li>• <b>0</b>: socket number to be set to enable keep alive option</li> <li>• <b>6</b>: specifies TCP level option</li> <li>• <b>2</b>: specifies option TCP "keep alive" timer option</li> <li>• <b>30000</b>: the module will send dummy TCP packets every 30000 ms</li> </ul>

## 5.5 Socket read (+USORD)

### First scenario

Command	Response	Description
	+UUSORD: 0,2	The remote server sends 2 data bytes on socket #0. A URC is returned indicating the socket on which the data is received and the total amount of data received.
AT+USORD=0,2	+USORD: 0,2,"ar" OK	Read data. The data is returned between quotation marks.

### Second scenario

Command	Response	Description
		The remote server sends 30 data bytes on socket #0.
	+UUSORD: 0,30	If a socket buffer is empty, the +UUSORD URC indicates a TCP packet has been received



Command	Response	Description
		from the remote host the socket is connected to and the amount of data bytes of the packet.
AT+USORD=0,10	+USORD: 0,10,"hfgyrhgfty" OK	Read only part of data (in this example 10 bytes of data are read). Data is returned between quotation marks.
	+UUSORD: 0,20	The +UUSORD URC indicates the total amount of data bytes stored in the buffer after the last +USORD AT command execution. In this example 20 bytes are stored in the buffer.

### Third scenario

Command	Response	Description
		The remote server sends 30 data bytes on socket #0.
	+UUSORD: 0,30	If a socket buffer is empty +UUSORD URC indicates a TCP packet has been received from the remote host the socket is connected to and the amount of data bytes of the packet.
AT+USORD=0,10	+USORD: 0,10,"hfgyrhgfty" OK	Only part of the data bytes (10 bytes in this example) is read. The data is returned between quotation marks.
	+UUSORD: 0,25	The remote server sent more data after the first part was received. The +UUSORD URC indicates the total amount of data bytes stored the buffer after the last +USORD AT command execution. In this example 25 bytes are stored in the buffer.
AT+USORD=0,10	+USORD: 0,10,"hfgbchs7[o" OK	Only part of the data bytes (10 bytes in this example) is read. Data is returned between quotation marks.
	+UUSORD: 0,34	The remote server sent more data. The +UUSORD URC indicates the total amount of data bytes stored the buffer after the last +USORD AT command execution. In this example 34 bytes are stored in the buffer.
AT+USORD=0,34	+USORD: 0,34,"jghfbv74ksHDFU Eçpjè0'@èpyujfnvhfyù" OK	All the bytes are read.
AT+USORD=0,0	+USORD: 0,0 OK	Verifies how much unread data is in the buffer. In this example 0 bytes are in socket #0.

### Fourth scenario



Command	Response	Description
		The remote host sends 30 bytes of data on the socket #0.
	+UUSORD: 0,30	If a socket buffer is empty the +UUSORD URC indicates a TCP packet has been received from the remote host the socket is connected to and the amount of data bytes of the packet.

Command	Response	Description
AT+USORD=0,10	+USORD: 0,10,"hfgyrhgfty" OK	Only part of the data bytes (10 bytes in this example) is read. Data is returned between quotation marks.
	+UUSORD: 0,25	The remote server sent other data after the first data bytes had been received. The +UUSORD URC indicates the total amount of data bytes stored the buffer after the last +USORD AT command execution. In this example 25 bytes are in the buffer.
		The remote host closes the TCP connection associated to socket #0.
AT+USOWR=0,3	@	Request to write 3 data bytes into the socket #0. Wait for "@" symbol indicating the data prompt is now open. After the @ prompt reception, wait for a minimum of 50 ms before sending data.
123	+USOWR: 0,0 OK	Write data. After the last byte the data prompt is closed.  It is not allowed to write fewer bytes than previously specified with +USOWR AT command.  If more bytes are written with respect to the threshold, the remaining bytes will be truncated. The interface is blocked until all bytes are written. The +USOWR: 0,0 URC indicates 0 bytes have been sent to the remote host. <b>This means the TCP connection is now closed.</b>
AT+USORD=0,25	+USORD: 0,25,"23dfgt5uhj89ik dftevlpazwe" OK	Read the remaining data bytes still stored in the buffer of socket #0.
	+UUSOCL: 0	The URC indicates the TCP connection associated to socket #0 is now closed and socket #0 is cleared.


## 5.6 Socket write (+USOST)


Command	Response	Description
AT+USOCR=17	+USOCR: 0 OK	UDP socket creation. In this example the socket #0 is created. The information text response returns the new socket identifier (in this example #0). If a new socket is created, a new socket identifier will be returned.
AT+USOCR=17,12000	+USOCR: 0,12000 OK	The local port to be used for data sending can be configured during the UDP socket creation. In this example the socket #0 is created and bound with port 12000. Data written on socket #0 will be sent from this specific port.
AT+UDNSRN=0,"ftp.u-blox.com"	+UDNSRN: "195.34.89.241" OK	DNS resolution of the URL "ftp.u-blox.com".
AT+USOST=0,"195.34.89.241",7,2 @		Request to write 2 bytes of data into socket #0 specifying IP address and UDP port of the remote host UDP packet has to be sent to. Wait for "@" symbol indicating the data prompt is now open (AT commands are not allowed in data prompt).



Command	Response	Description
12	+USOST: 0,2 OK	<p>Write data. After the last data byte is written, the prompt is closed.</p> <p> It is not allowed to write fewer bytes than previously specified with +USOST AT command.</p> <p> If more bytes are written with respect to the threshold, the remaining bytes will be truncated.</p> <p>The interface is blocked until all bytes are written The final result code is returned. This means the data is sent to a lower level of the protocol stack. This is not an acknowledgment, UDP is a connectionless protocol.</p>

## 5.7 Socket read (+USORF)

Command	Response	Description
	+UUSORD: 0,2	A UDP packet with 2 data bytes has been received.
AT+USORF=0,2	+USORF: 0,"195.34.89.241",7,2,"12" OK	<p>Read data. The information text response indicates:</p> <ul style="list-style-type: none"> <li>• Read socket identifier</li> <li>• Remote IP address</li> <li>• Remote UDP port</li> <li>• Number of read data bytes</li> <li>• Read data bytes (between quotation marks)</li> </ul>
	+UUSORD: 0,20	UDP packet with 20 data bytes has been received from the remote server.
AT+USORF=0,10	+USORF: 0,"195.34.89.241",7,2,"1234567890" OK	Read 10 data bytes.
	+UUSORD: 0,10	The +UUSORD URC indicates that 10 bytes are still unread.
		The remote host sends a UDP packet with 20 data bytes.
AT+USORF=0,10	+USORF: 0,"195.34.89.241",7,2,"1234567890" OK	Read the remaining 10 data bytes of the previous packet. The URC indicates 20 data bytes have been received and are still stored in the socket buffer.
	+UUSORD: 0,20	<p> After the first URC has been returned, a second URC is returned (only after a reading operation) indicating:</p> <ul style="list-style-type: none"> <li>• If a reading operation of a packet is not finished it will provide the remaining data of the specific packet</li> <li>• Otherwise it will provide the number of data bytes of packets stored in the socket buffer</li> </ul>

 For UDP it is highly recommended to use +USOST and +USORF AT commands instead of +USOCO, +USOWR and +USORD AT commands.


## 5.8 Socket state

For a detailed description of TCP socket states, see the +USOCTL AT command description in SARA-R5 series AT commands manual [3].


Command	Response	Description
AT+USOCTL=0,0	+USOCTL: 0,0,6 OK	Query the socket type of the socket #0. The socket type information is provided by the third parameter (in this case 6 – TCP).
AT+USOCTL=0,10	+USOCTL: 0,10,4 OK	It is possible to query the state of TCP connection associated with the socket; in this example the socket #0 (this command is valid only for TCP socket). The third parameter of information text response provides the socket status (in this case 4 - the socket is in ESTABLISHED status).
AT+USOCTL=0,10	+USOCTL: 0,10,7 OK	The third parameter of the information text response provides the socket status (in this case 7 - a TCP connection termination procedure is being performed).
AT+USOCTL=0,11	+USOCTL: 0,11,0 OK	Query for TCP outgoing unacknowledged data of the socket #0 (this command is valid only for TCP socket). In this case 0 bytes of data are unacknowledged.
AT+USOCTL=0,1	+USOCTL: 0,1,0 OK	Query for the last socket error for socket #0. If there are no errors the value is 0.

## 5.9 Socket close

### By remote server

Command	Response	Description
	+UUSOCL: 1	The URC indicates the connection associated to socket 1 is closed. The socket #1 is cleared.  After this indication has been received the socket buffer is cleared.



### By the module

Command	Response	Description
AT+USOCL=0	OK	The socket is closed by the module (socket #0).  No +UUSOCL URC returned.


## 5.10 Secure socket

Use the +USOSEC AT command to enable or disable the use of SSL/TLS/DTLS connection (where supported) on a TCP socket.

A secure manager profile must be configured before starting a secure socket session. See section 3 for more details on this aspect.

-  The command is applicable only with TCP sockets.
-  The enable or disable operation can be performed only after the socket has been created with +USOCR AT command.


## 6 MQTT

 Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using MQTT AT commands.

### 6.1 Basic setup

#### 6.1.1 Default and minimal configuration

The configuration required to start a MQTT session depends on the broker (server) configuration, the most important is the MQTT remote server information. Get the broker configuration in order to correctly set up the module, before starting a session.

Command	Response	Description
AT+CMEE=2	OK	Set verbose error result codes.
AT+UMQTT?	+UMQTT: 0, "357862090033897" +UMQTT: 2, "", 1883 +UMQTT: 3, "", 1883 +UMQTT: 4, "" +UMQTT: 6, 0 +UMQTT: 7, 0 +UMQTT: 8, "" +UMQTT: 9, 0, "" +UMQTT: 10, 0 +UMQTT: 11, 0 OK	Read the current profile configuration. All the reported values can be modified, see the SARA-R5 series AT commands manual [3] for a detailed description.  The default client id value is the IMEI of the module because it guarantees the uniqueness of the client to the server.
AT+UMQTT=2, "192.168.105.30", 1883	OK	Set the remote MQTT server's IP address and port. Alternatively, the server name can be set with the AT+UMQTT=3 command.

#### 6.1.2 Last will configuration

The "last will" parameters configure the message that the MQTT clients connected to the broker will receive in case of SARA-R5 disconnection due to an error. Following is an example of setup.

Command	Response	Description
AT+UMQTT=6, 1	OK	Set the last will quality of service (QoS) level to 1.
AT+UMQTT=8, "u-blox/publish"	OK	Set the last will topic.
AT+UMQTT=9, "Unrequested disconnect."	OK	Set the last will message.

#### 6.1.3 Profile management

Command	Response	Description
AT+UMQTTNV=2	OK	Store the current MQTT client profile parameters to the NVM.
AT+UMQTTNV=0	OK	Restore MQTT client profile parameters to the factory-programmed setting.
AT+UMQTT?	+UMQTT: 0, "357862090033897" +UMQTT: 2, "", 1883 +UMQTT: 3, "", 1883 +UMQTT: 4, "" +UMQTT: 6, 0 +UMQTT: 7, 0 +UMQTT: 8, "" +UMQTT: 9, 0, "" +UMQTT: 10, 0	Read the current profile configuration.

Command	Response	Description
	+UMQTT: 11,0 OK	
AT+UMQTTNV=1	OK	Set MQTT client profile parameters to values previously stored in the NVM.
AT+UMQTT?	+UMQTT: 0,"357862090033897" +UMQTT: 2,"185.215.193.15",1883 +UMQTT: 3,"",1883 +UMQTT: 4,"" +UMQTT: 6,0 +UMQTT: 7,0 +UMQTT: 8,"" +UMQTT: 9,0,"" +UMQTT: 10,0 +UMQTT: 11,0 OK	Read the current profile configuration.

## 6.2 Start and end a MQTT session

See the section [6.1](#) to configure the MQTT profile before starting a connection.

Command	Response	Description
AT+UMQTTC=1	OK	Connect to the broker.
	+UUMQTTC: 1,1	The MQTT session request is successfully performed. The MQTT session can start. The +UUMQTTC URC provides the result of the requested action from the MQTT broker
AT+UMQTTC=0	OK	Disconnect from the broker, end of the MQTT session.
	+UUMQTTC: 0,1	The disconnection is successfully performed.

## 6.3 Subscribe to a topic and publish a message to the same topic

The following example is a demonstration of the main functionalities that can be performed with the SARA-R5 series AT commands. In this MQTT session the module subscribes to a topic, publishes a message to the topic and receives the published message (since it is subscribed to topic of the published message).

Command	Response	Description
AT+UMQTTC=4,0,"module/lights"	OK	Subscribe to a topic.
	+UUMQTTC: 4,1,0,"module/light"	The broker granted QoS level is 0.
AT+UMQTTC=2,0,0,0,"module/lights","light_1 is red"	OK	Publish "light_1 is red " message to the "module/lights" topic with requested QoS level and retain value set to 0.
	+UUMQTTC: 2,1	
	+UUMQTTC: 6,1	Notification of the received publish message.
AT+UMQTTC=6,1	+UMQTTC: 6,0,27,13,"module/lights",14,"light_1 is red" OK	Read the received publish message.
AT+UMQTTC=5,"module/lights"	OK	Unsubscribe from the previously subscribed topic.
	+UUMQTTC: 5,1	

## 6.4 Publish a message with hexadecimal mode set

The following example shows how to publish a message whose payload is composed of hexadecimal bytes instead of ASCII characters. Two possibilities can be adopted, the first one is the publishing in "ASCII mode" of the "ABCD3031" string while the second is the publishing of the same string in "HEX mode".

Command	Response	Description
AT+UMQTTTC=4,0,"module/ascii"	OK +UUMQTTTC: 4,1,0,"module/ascii"	Subscribe to the "module/ascii" topic.
AT+UMQTTTC=2,0,0,0,"module/ascii","ABCD3031"	OK +UUMQTTTC: 2,1 +UUMQTTTC: 6,1	Send a Publish message, the "ABCD3031" payload is encoded with ASCII characters (the 4 <sup>th</sup> parameter value (<hex_mode>) is 0). Notification of the received publish message.
AT+UMQTTTC=6,1	+UMQTTTC: 6,0,20,12,"module/ascii", 8,"ABCD3031" OK	Read the received publish message, the payload is displayed in ASCII, so the received string is same as the one sent: 8 characters. The payload bytes in the MQTT packet are: 41 42 43 44 33 30 33 31
AT+UMQTTTC=4,0,"module/hex"	OK +UUMQTTTC: 4,1,0,"module/hex"	Subscribe to the "module/hex" topic.
AT+UMQTTTC=2,0,0,1,"module/hex","ABCD3031"	OK +UUMQTTTC: 2,1 +UUMQTTTC: 6,1	Send a Publish message with the same payload encoded as hexadecimal (the 4 <sup>th</sup> parameter value (<hex_mode>) is 1). Notification of the received publish message.
AT+UMQTTTC=6,1	+UMQTTTC: 6,0,14,10,"module/hex", 4,"«í01" OK	Read the received publish message, the payload length is 4 because each pair of characters is considered as one byte. The payload bytes in the MQTT packet are: AB CD 30 31  Since "AB" and "CD" are not strict ASCII characters their output depends on the interface of the terminal application used to communicate with the module. In this example, the m-center is used: the "AB" and "CD" bytes are respectively displayed as "«" and "í" characters. The other 2 bytes "30" and "31" are respectively the standard ASCII characters "0" and "1".

## 6.5 Publish a binary message to a topic

If the message payload contains special characters like quotation marks (""), carriage return (<CR>), etc., the AT+UMQTT=9 command should be used.

Command	Response	Description
AT+UMQTT=4,0,"module/special"	OK	Subscribe to the "module/special" topic.
	+UUMQTT: 4,1,0,"u-blox/specia l"	
AT+UMQTT=9,1,0,"module/specia l",21	>	Send a Publish message with special characters in the payload.
"this is an example"<CR>	OK	
	+UUMQTT: 2,1	
	+UUMQTT: 6,1	Notification of the received publish message.
AT+UMQTT=6,1	+UMQTT: 6,0,35, 14,"module/sp ecial",21,""this is an example" " OK	Read the received publish message, the quotation marks and the carriage return are displayed.

## 6.6 Ping the MQTT broker

The ping command starts a session of ping requests to the broker server. The ping requests are sent at intervals, the length of the interval depends on the inactivity timeout (keep-alive time) set when configuring the MQTT profile.

Command	Response	Description
AT+UMQTT=10,30	OK	Configure the inactivity timeout as 30 s.
AT+UMQTT=1	OK	Connect to the broker and start a MQTT session.
	+UUMQTT: 1,1	
AT+UMQTT=8,1	OK	Start a "ping loop". A PINGREQ packet is sent to the broker when there is no activity with the broker, in this example after 24 s of inactivity a PINGREQ packet is sent and PINGRESP is received. The ping request is approximately triggered after 80% of the keep alive time.
	+UUMQTT: 8,0	Notification of a ping failure, the broker is not responding.

## 6.7 Last will packet

To see the last will publish message, two modules shall start a MQTT session with the same gateway. For the first module, before starting a MQTT session, the last will parameter shall be configured, see section 6.1.2. The second module shall subscribe to the last will topic of the first module.

Command	Response	Description
<b>Module #1</b>		
AT+UMQTT=1	OK	Connect to the broker and start a MQTT session.
	+UUMQTT: 1,1	
<b>Module #2</b>		
AT+UMQTT=1	OK	Connect to the same broker and start a MQTT session.
	+UUMQTT: 1,1	

Command	Response	Description
AT+UMQTTTC=4,0,"u-blox/publish"	OK +UUMQTTTC: 4,1,0,"u-blox/publish"	Subscribe to the last will topic "u-blox/publish".
<b>Module #1</b>		
AT+UPSDA=0,4	OK +UUMQTTTC: 0,101	Simulate a network error. The URC notifies that the network connection is lost.
<b>Module #2</b>		
	+UUMQTTTC: 6,1	Notification of the received publish message.
AT+UMQTTTC=6,1	+UMQTTTC: 6,0,37,14,"u-blox/publish",23,"Unrequested disconnect." OK	Read the received last will publish message.

## 6.8 Debug

In case of errors returned by the broker with the +UUMQTTTC: x,0 URC, it is possible to investigate the type of error using the +UMQTTER AT command.

Command	Response	Description
AT+UMQTTTC=1	OK +UUMQTTTC: 1,0	Unsuccessful session start.
AT+UMQTTER	+UMQTTER: 13,50 OK	Error code 50 is "PSD or CSD connection not established", that means the context is not active.

## 6.9 Secure MQTT

Configure a secure manager profile before starting a secure MQTT session (using the TLS encryption protocol). For more details, see section 3.

The following example show to configure the MQTT profile before starting a secure session with the broker. Only the secure manager profile and the remote port must be configured, the other MQTT commands will behave as in the case of unencrypted session.

Command	Response	Description
AT+UMQTT=11,1,2	OK	Enable the secure MQTT option using the USECMNG profile 2.
AT+UMQTT=2,"192.168.105.30",8883	OK	Set the remote MQTT broker IP address and port. The default port for secure MQTT is 8883.
AT+UMQTTTC=1	OK +UUMQTTTC: 1,1	Connect to the broker and start a secure MQTT session.

## 7 MQTT-SN

Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using MQTT-SN AT commands.

### 7.1 Basic setup

#### 7.1.1 Default and minimal configuration

The configuration required to start a MQTT-SN session depends on the gateway configuration, most importantly, the MQTT-SN remote server information. Before starting a session, be sure to correctly set up the module with the gateway configuration.

Command	Response	Description
AT+CMEE=2	OK	Set verbose error result codes.
AT+UMQTTSN?	+UMQTTSN: 0, "357862090033897" +UMQTTSN: 1, "", 1883 +UMQTTSN: 2, "", 1883 +UMQTTSN: 4, 0 +UMQTTSN: 5, 0 +UMQTTSN: 6, "" +UMQTTSN: 7, 0, "" +UMQTTSN: 8, 0 +UMQTTSN: 9, 0 OK	Read the current profile configuration All the reported values can be modified, see the SARA-R5 AT commands manual [3] for a detailed description. The default client id value is the IMEI of the module because it guarantees the uniqueness of the client to the server.
AT+UMQTTSN=2, "192.168.105.30", 10000	OK	Set the IP address and port of the remote MQTTSN gateway. Alternatively, the gateway's server name can be set with the AT+UMQTTSN=1 command.

#### 7.1.2 Last will configuration

The “last will” parameters configure the message that the MQTT-SN clients connected to the gateway will receive in case of SARA-R5 disconnection due to an error. Following is a set up example.

Command	Response	Description
AT+UMQTTSN=4, 1	OK	Set the last will QoS level to 1.
AT+UMQTTSN=6, "u-blox/publish"	OK	Set the last will topic.
AT+UMQTTSN=7, "Unrequested disconnect."	OK	Set the last will message.

#### 7.1.3 Profile management

Command	Response	Description
AT+UMQTTSNNV=2	OK	Store the current MQTT-SN client profile parameters to the NVM.
AT+UMQTTSNNV=0	OK	Restore MQTT-SN client profile parameters to the factory-programmed setting.
AT+UMQTTSN?	+UMQTTSN: 0, "357862090033897" +UMQTTSN: 1, "", 1883 +UMQTTSN: 2, "", 1883 +UMQTTSN: 4, 0 +UMQTTSN: 5, 0 +UMQTTSN: 6, "" +UMQTTSN: 7, 0, "" +UMQTTSN: 8, 0	



Command	Response	Description
	+UMQTTSN: 9,0 OK	
AT+UMQTTSNV=1	OK	Set MQTT-SN client profile parameters to values previously stored in the NVM.
AT+UMQTTSN?	+UMQTTSN: 0, "357862090033897" +UMQTTSN: 1, "", 1883 +UMQTTSN: 2, "192.168.105.30", 1883 +UMQTTSN: 4, 0 +UMQTTSN: 5, 0 +UMQTTSN: 6, "" +UMQTTSN: 7, 0, "" +UMQTTSN: 8, 0 +UMQTTSN: 9, 0 OK	

## 7.2 Start and end a MQTT-SN session

See the default and minimal configuration described in section 7.1.1, to configure the MQTT-SN profile before starting a connection.

Command	Response	Description
AT+UMQTTSNV=1	OK +UUMQTTSNV: 1, 1	Connect to the gateway and start a MQTT-SN session.
AT+UMQTTSNV=0	OK +UUMQTTSNV: 0, 1	Disconnect from the gateway, end of the MQTT-SN session.

## 7.3 Subscribe to a normal topic and publish a message to the same topic

The following example is a demonstration of the main functionalities that can be performed with the SARA-R5 AT commands. In this MQTT-SN session the module subscribes to a topic, publishes a message to the topic and receives the published message (since it is subscribed to topic of the published message).

Command	Response	Description
AT+UMQTTSNV=5,0,0,"room/temperature"	OK +UUMQTTSNV: 5,1,0,1	Subscribe to a normal topic (0) with requested QoS level set to 0. The gateway granted QoS level is 0 and the topic ID for "room/temperature" is 1.
AT+UMQTTSNV=4,0,0,0,0,"1","20 degrees Celsius"	OK +UUMQTTSNV: 4,1 +UUMQTTSNV: 9,1	Publish the "20 degrees Celsius" message to the topic ID 1 with requested QoS level and retain value set to 0. Notification of the received publish message.
AT+UMQTTSNV=9,1	+UMQTTSNV: 9,1,0,19,1,"1",18,"20 degrees Celsius" OK	Read the received publish message.
AT+UMQTTSNV=6,0,"1"	OK +UUMQTTSNV: 6,1	Unsubscribe from the previously subscribed topic.

## 7.4 Register to a topic and publish a message to the same topic

The following example differs from the previous one only for the non-receipt of publish message since the module is not subscribed to the topic.

Command	Response	Description
AT+UMQTTTNSNC=2,"kitchen/temperature"	OK +UUMQTTTNSNC: 2,1,2	Register to a normal topic. The returned topic ID for "room/temperature" is 2.
AT+UMQTTTNSNC=4,1,0,0,0,"2","25 degrees Celsius"	OK +UUMQTTTNSNC: 4,1	Publish the "25 degrees Celsius" message to the "kitchen/temperature" topic using the above topic ID.

## 7.5 Subscribe to a short topic name and publish a message to the same topic

The short topic is composed of only 2 characters.

Command	Response	Description
AT+UMQTTTNSNC=5,0,2,"aa"	OK +UUMQTTTNSNC: 5,1,2,0	Subscribe to a short topic (2) with requested QoS level set to 0. The gateway granted QoS level is 0
AT+UMQTTTNSNC=4,1,0,0,2,"aa","test"	OK +UUMQTTTNSNC: 4,1	Publish the "test" message to the "aa" topic with requested QoS level and retain value set to 0.
	+UUMQTTTNSNC: 9,1	Notification of the received publish message.
AT+UMQTTTNSNC=9,1	+UMQTTTNSNC: 9,0,2,6,2,"aa",4,"test" OK	Read the received publish message.
AT+UMQTTTNSNC=6,2,"aa"	OK +UUMQTTTNSNC: 6,1	Unsubscribe from the previously subscribed topic.

## 7.6 Last will

To see the last will publish message, two modules shall start a MQTT-SN session with the same gateway. For the first module, before starting a MQTT-SN session, the last will parameter shall be configured; see last will configuration in section 7.1.2. The second module shall subscribe to the last will topic of the first module.

Command	Response	Description
<b>Module #1</b>		
AT+UMQTTTNSNC=1	OK +UUMQTTTNSNC: 1,1	Connect to the gateway and start a MQTT-SN session.
<b>Module #2</b>		
AT+UMQTTTNSNC=1	OK +UUMQTTTNSNC: 1,1	Connect to the same gateway and start a MQTT-SN session.
AT+UMQTTTNSNC=5,0,0,"u-blox/publish"	OK +UUMQTTTNSNC: 5,1,0,1	Subscribe to the last will topic "u-blox/publish".

Command	Response	Description
<b>Module #1</b>		
AT+UPSDA=0,4	OK	Simulate a network error.
	+UUMQTTSNCR: 0,101	The URC notifies that the network connection is lost.
<b>Module #2</b>		
	+UUMQTTSNCR: 9,1	Notification of the received publish message.
AT+UMQTTSNCR=9,1	UMQTTSNCR: 9,0,0,24,1,"1",23,"Unrequested disconnect." OK	Read the received last will publish message.

## 7.7 Error handling

In case of errors returned by the gateway with the +UUMQTTSNCR: x,0 URC, it is possible to investigate the type of error using the +UMQTTSNCR AT command.

Command	Response	Description
AT+UMQTTSNCR=5,1,0,"kitchen/temperature"	OK +UUMQTTSNCR: 5,0	Unsuccessful subscribe.
AT+UMQTTSNCR	+UMQTTSNCR: 14,21 OK	Error code 21 is "Timeout error" that means the gateway did not replay to the subscribe request.

## 7.8 Secure MQTT-SN

Configure a secure manager profile before starting a secure MQTT-SN session (using the DTLS encryption protocol). For further details, see the section 3.

The following example shows how to configure the MQTT-SN profile before starting a secure session with the gateway. Only the secure manager profile and the remote port must be configured; the other MQTT-SN commands will behave as in the case of an unencrypted session.

Command	Response	Description
AT+UMQTTSN=9,1,2	OK	Enable the secure MQTT-SN option using the USECMNG profile 2.
AT+UMQTTSN=2,"192.168.105.30",10001	OK	Set the remote MQTT-SN gateway IP address and port.
AT+UMQTTSNCR=1	OK +UMQTTSNCR: 1,1	Connect to the gateway and start a secure MQTT-SN session.

## 8 CoAP

CoAP is an application layer protocol based on UDP for resource-constrained internet devices described into RFC 7252 [13].

Main CoAP features are:

- Web protocol fulfilling M2M requirements in constrained environments.
- UDP (RFC 768 [9]) binding with optional reliability supporting unicast and multicast requests.
- Asynchronous message exchanges.
- Low header overhead and parsing complexity.
- URI and Content-type support.
- Simple proxy and caching capabilities.
- A stateless HTTP mapping, allowing proxies to be built providing access to CoAP resources via HTTP in a uniform way or for HTTP simple interfaces to be realized alternatively over CoAP.
- Security binding to Datagram Transport Layer Security (DTLS) [14].
- Transfer block-wise as described into RFC 7959 [15].
- Transmission over TCP and TLS: described into RFC 8323 [16].

Implementation details:

- Maximum URI length is 783 characters. URI\_HOST, URI\_PATH and URI\_QUERY are limited to 255 characters as per RFC 7252 [13].
- Maximum supported payload in uplink is 512 bytes. Use block transfer for data block greater than 512 bytes.
- In DTLS and TLS connection, the OK final result code will be returned only after the security connection handshake is completed successfully.
- It is allowed only one CoAP transmission until it is completed.
- Only 4 profiles can be stored.

### 8.1 Good practices on writing CoAP application

To create a good CoAP application keep the following in mind:

- **Register the module to the network and establish a data connection:** the module should be connected to the network and have a data connection to send CoAP commands. This is a mandatory step.
- **Configure a profile and store it:** create a basic configuration that can be stored for further restart.
- **Restore the profile:** this can be used to avoid to trigger always the same commands at the module boot and it can be used to verify if the current configuration is aligned with one expected.
- **Configure and send CoAP commands:** change the configuration parameter in order to send CoAP commands.
- **Wait and parse URCs:** wait until final +UCOAPCR is received and store then parse +UCOAPCD to be parsed to have a complete reply from the server.
- **Error handling:** procedure that can be used to debug errors from the server or from configuration.

This flow is described in the [Figure 4](#).

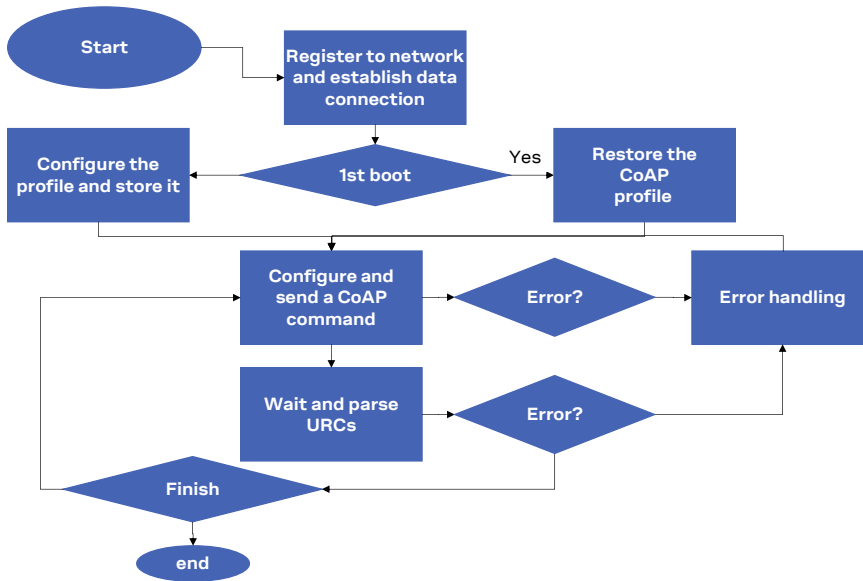


Figure 4: CoAP workflow

## 8.2 Basic setup

Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using CoAP AT commands.

### 8.2.1 Current configuration

Command	Response	Description
AT+CMEE=2	OK	Set verbose error result codes.
AT+UCOAP=4, 1	OK	Set current profile as valid.
AT+UCOAP=2, 0, 1	OK	Enable automatic recognition of URI_HOST, URI_PORT, URI_PATH and URI_QUERY directly from URI.
AT+UCOAP=2, 1, 1	OK	
AT+UCOAP=2, 2, 1	OK	
AT+UCOAP=2, 3, 1	OK	
AT+UCOAP=2, 4, 1	OK	Set content format for PUT/POST as "Plain/Text".

### 8.2.2 Profile management

Command	Response	Description
AT+UCOAP=6, 0	OK	Store current profile to be stored as profile number 0.
AT+UCOAP=7	+UCOAP: "URI_STR", "<server_uri >" +UCOAP: "OPT_MASK", 7 +UCOAP: "PROFILE_NUM", 0 +UCOAP: "STATUS_FLAG", 1 +UCOAP: "USECMNG PROFILE", 0 +UCOAP: "RAI FLAG", 0 +UCOAP: INVALID PROFILE NUMBER 1 +UCOAP: INVALID PROFILE NUMBER 2 +UCOAP: INVALID PROFILE NUMBER 3 OK	Check all stored profile configuration. In this configuration only profile 0 is a valid profile that can be used.

Command	Response	Description
AT+UCOAP=5,0	OK	Restore profile number 0 as current profile.
AT+UCOAP?	+UCOAP: "URI_STR", "<server_uri>" +UCOAP: "OPT_MASK", 7 +UCOAP: "PROFILE_NUM", 0 +UCOAP: "STATUS_FLAG", 1 +UCOAP: "USECMNG PROFILE", 0 +UCOAP: "RAI_FLAG", 0 OK	Verify that current profile is configured as expected.

## 8.3 Basic operation

### 8.3.1 GET

Command	Response	Description
AT+UCOAP=1, "<server_uri>"	OK	Set URI to be used in GET request. In this example we use coap.me server. Reply can be different in the future.
AT+UCOAP=2, 5, 1	OK	Set message to be NON confirmable
AT+UCOAPC=1	OK +UCOAPCD: 2, 0, "776F726C64", 0 +UCOAPCR: 1, 1	Command trigger reply from the server in hexadecimal format that corresponds to "world".

### 8.3.2 PUT/POST

Command	Response	Description
AT+UCOAP=1, "<server_uri>"	OK	Set URI to be used in PUT/POST request. In this example we use coap.me server. Reply can be different in the future.
AT+UCOAP=2, 5, 0	OK	Set message to be CONFIRMABLE, so server should reply with an ACK
AT+UCOAPC=3, "736f6d655f74657874", 0	OK +UCOAPCD: 2, 0, "505554204F4B", 0 +UCOAPCR: 3, 1	Server replied in hex that correspond to "PUT OK" when PUT command is triggered.
AT+UCOAPC=4, "736f6d655f74657874", 0	OK +UCOAPCD: 2, 0, "504F5354204F4B", 0 +UCOAPCR: 4, 1	Server replied in hex that correspond to "POST OK" when POST command is triggered.

### 8.3.3 Block transfer

Command	Response	Description
AT+UCOAP=1,"<server_uri>"	OK	Set URI to be used in PUT request. In this example we use coap.me server. Reply can be different in the future.
AT+UCOAPC=3,"4d657373616765206e756d6265722030206669727374206d657373616765206666207365726965207375626469766964656420696e746f203634206279746573",0,0,1	OK +UCOAPCD: 2,0,"",0 +UCOAPCR: 3,1	Send data separated into two messages. First message is 64 bytes and is set that more block will be transmitted, so the server can be prepared for adding other data.
AT+UCOAPC=3,"4d657373616765206e756d6265722031206669727374206d657373616765206666207365726965207375626469766964656420696e746f203634206279746573",0,1,0	OK +UCOAPCD: 2,0,"",0,1,64 +UCOAPCR: 3,1	Second message (about 64 bytes) and the message number is different. No more block will be transmitted after.

### 8.3.4 TCP connection

Command	Response	Description
AT+UCOAP=1,"<server_uri>"	OK	Set URI to be used in GET request. In this example we use a local server that supports CoAP over TCP.
AT+UCOAPC=1	OK +UCOAPCD: 2,0,"5468697320697320661207465737420736572766572206D6164652077697468206C6962636F617020287365652068747470733A2F2F6C6962636F61702E6E6574290A436F707972696768742028432920323031302D2D32303230204F6C616620426572676D616E6E203C626572676D616E6E40747A692E6F72673E20616E64206F74686572730A0A",0 +UCOAPCR: 1,1	Command trigger reply from server in hex that corresponds to "This is a test server made with libcoap (see <a href="https://libcoap.net">https://libcoap.net</a> ) Copyright (C) 2010–2020 Olaf Bergmann <bergmann@tzi.org> and others".

## 8.4 Error handling

### 8.4.1 Configuration error

Command	Response	Description
AT+UCOAPC=1	+CME ERROR: operation not allowed	The connection is started but some configuration parameters are not configured properly.
AT+UCOAPER	+UCOAPER: 15,17 OK	Using this command and checking SARA-R5 series AT command manual [3] it is possible to retrieve the error result code (in this case "Current profile invalid"). It means that the profile is not configured properly.

### 8.4.2 Error on server reply

Command	Response	Description
AT+UCOAPC=3,"736f6d655f74657874",0	OK +UCOAPCD: 4,0,"4572726F7220342E30353A204D6574686F64206E6F7420737570706F727465642068657265",0 +UCOAPCR: 3,1	Command is executed successfully. The server replies with <error_code> and <error_description> that is reported here as "Error 4.05: Method not supported here".

## 8.5 Secure connection

### 8.5.1 Basic configuration

Configure a secure manager profile before trigger a CoAP command with secure connection. For further details, see section 3.


Command	Response	Description
AT+UCOAP=8,0	OK	Profile 0 will be used in a secure connection.

### 8.5.2 DTLS connection

Command	Response	Description
AT+UCOAP=1,"<server_uri>"	OK	Set the URI to be used in GET request. In this example it is used a server configured with proper security setup.
AT+UCOAPC=1	OK  +UCOAPCD: 2,0,"546869732069732061207465737420736572766572206D6164652077697468206C6962636F617020287365652068747470733A2F2F6C6962636F61702E6E6574290A436F707972696768742028432920323031302D2D32303230204F6C616620426572676D616E6E203C626572676D616E6E40747A692E6F72673E20616E64206F74686572730A0A",0  +UCOAPCR: 1,1	Command trigger reply from server in hex that corresponds to "This is a test server made with libcoap (see <a href="https://libcoap.net">https://libcoap.net</a> ) Copyright (C) 2010--2020 Olaf Bergmann <bergmann@tzi.org> and others".

### 8.5.3 TLS connection


Even if AT commands are the same, unlike the DTLS connection reported in the previous example, the TLS connection uses TCP protocol and therefore, a dedicated URI must be used for security using TCP (TLS).


 Ensure the CoAP server is supporting the TCP extension. This is not guaranteed because the native protocol is UDP. For this reason, a dedicated URI should be used, and the user must verify also that the server supports TLS connections.



Command	Response	Description
AT+UCOAP=1,"<server_uri>"	OK	Set the URI to be used in GET request. In this example we use a server that is configured with proper security setup.
AT+UCOAPC=1	OK  +UCOAPCD: 2,0,"546869732069732061207465737420736572766572206D6164652077697468206C6962636F617020287365652068747470733A2F2F6C6962636F61702E6E6574290A436F707972696768742028432920323031302D2D32303230204F6C616620426572676D616E6E203C626572676D616E6E40747A692E6F72673E20616E64206F74686572730A0A",0  +UCOAPCR: 1,1	Command trigger reply from server in hexadecimal format that corresponds to "This is a test server made with libcoap (see <a href="https://libcoap.net">https://libcoap.net</a> ) Copyright (C) 2010--2020 Olaf Bergmann <bergmann@tzi.org> and others".



## 9 FTP

 Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using FTP AT commands.


Command	Response	Description
AT+UFTP=1, "ftp.u-blox.com"	OK	Parameter configuration for FTP server connection. These parameters will be set: <ul style="list-style-type: none"> <li>• FTP server hostname</li> <li>• FTP username</li> <li>• FTP password</li> </ul>
AT+UFTP=2, "anonymous"	OK	
AT+UFTP=3, "user@somedomain.com"	OK	
AT+UFTP=6, 1	OK	
AT+UDNSRN=0, "ftp.u-blox.com"	+UDNSRN: "195.34.89.241" OK	Hostname resolution.
AT+UFTPC=1	OK +UFTPCR: 1,1	Connect to the server and manage the FTP connection using the +UFTPC AT command. Let's start connecting to the server. The +UFTPCR URC provides the FTP command result (the last parameter provides the result, 1 if is successfully performed).
AT+UFTPC=13	OK +UFTPCD: 13,194, "-rw-r--r-- 1 ftp ftp 1037 Aug 5 09:45 dat_000 -rw-r--r-- 1 ftp ftp 21041 Aug 5 09:12 data.zip -rw-r--r-- 1 ftp ftp 12 Aug 5 09:42 xlog.zip " +UFTPCR: 13,1	Request the file list on the server. The +UFTPCD URC provides the FTP data.
AT+UFTPC=10, "uploads"	OK +UFTPCR: 10,1	Directory creation on the FTP server.
AT+UFTPC=13	OK +UFTPCD: 13,258, "-rw-r--r-- 1 ftp ftp 1037 Aug 5 09:45 dat_000 -rw-r--r-- 1 ftp ftp 21041 Aug 5 09:12 data.zip drwxr-xr-x 2 ftp ftp 4096 Aug 5 09:48 uploads -rw-r--r-- 1 ftp ftp 12 Aug 5 09:42 xlog.zip " +UFTPCR: 13,1	Request again the file list.
AT+UFTPC=8, "uploads"	OK +UFTPCR: 8,1	Change directory to directory name "uploads".  Use AT+UFTPC=8, ".." to return back in the parent directory.
AT+UFTPC=5, "gps_positions", "gps_positions"	OK +UFTPCR: 5,1	Upload a file from the module to the FTP server from the local file system of the module (in this example filename "gps_positions").
AT+UFTPC=5, "gps_positions", "gps_positions", 250	OK +UFTPCR: 5,1	Restart the upload file from the module to FTP server from the local module file system (in this

Command	Response	Description
		example filename "gps_positions"), starting from byte 250.  The FTP server should support the REST command to support these functionalities. The server should write the file starting from byte indicated.
AT+UFTPC=13	OK +UUFTPCD: 13,70,"-rw-r--r-- 1 ftp ftp 176673 Aug 5 10:03 gps_positions" +UUFTPCR: 13,1	File list request.
AT+UFTPC=8,".."	OK +UUFTPCR: 8,1	Return to the parent directory.
AT+UFTPC=4,"data.zip","data.zip"	OK +UUFTPCR: 4,1	Download a file from the FTP server to the local file system of the module.
AT+UFTPC=4,"data.zip","data.zip",1	OK +UUFTPCR: 4,1	Restart the file download from the FTP server to the local module file system from the latest byte saved on the file system (this is automatically calculated). The data received is written after the latest byte available on the file system.
AT+UFTPC=0	OK +UUFTPCR: 0,1	FTP server disconnection.
AT+UPSDA=0,4	OK	PS data connection detachment with the +UPSDA AT command.  Only the specified profile will be deactivated.

## 9.1 Direct link

### 9.1.1 Retrieve a file from FTP server

Command	Response	Description
		Parameter configuration for FTP server connection. These parameters will be set:
AT+UFTP=1,"ftp.u-blox.com"	OK	• FTP server hostname
AT+UFTP=2,"anonymous"	OK	• FTP username
AT+UFTP=3,"user@somedomain.com"	OK	• FTP password
AT+UFTP=6,1	OK	• FTP connection mode (PASSIVE connection)
AT+UDNSRN=0,"ftp.u-blox.com"	+UDNSRN: "195.34.89.241" OK	Hostname resolution.
		Connect to the server and manage the FTP connection using the +UFTPC AT command.
AT+UFTPC=1	OK +UUFTPCR: 1,1	The +UUFTPCR URC is returned when the connection is established.
AT+UFTPC=6,"file_to_retrieve"	CONNECT	Send to the FTP server a RETRIEVE file request for file_to_retrieve.  The CONNECT intermediate result code means the direct link mode is activated: the data received from FTP connection will be redirected to the serial port.
AT+UFTPC=6,"file_to_retrieve",250	CONNECT	Restart a RETRIEVE file request for file_to_retrieve file from byte 250.

Command	Response	Description
		The CONNECT intermediate result code means the direct link mode activation: the data received from FTP connection is redirected to the serial port. The data reception begins with the byte indicated.
+++	DISCONNECT OK	 When the file has entirely been retrieved the module does not exit from the direct link mode. It is necessary to manually exit using the "+++" escape sequence.
	+UUFTPCR: 6,1	The +UUFTPCR URC notifies how the retrieve operation has been concluded (1 means success).

### 9.1.2 Aborting retrieve file request

Command	Response	Description
+++	DISCONNECT OK	If entering "+++" escape sequence before the requested file has been entirely retrieved from FTP server, the module exits from the direct link.
	+UUFTPCR: 6,0	The +UUFTPCR URC notifies that the retrieve operation has not been concluded successfully (0 means fail).

### 9.1.3 Store a file on FTP server

Command	Response	Description
		Parameter configuration for FTP server connection. These parameters will be set:
AT+UFTP=1,"ftp.u-blox.com"	OK	• FTP server hostname;
AT+UFTP=2,"anonymous"	OK	• FTP username;
AT+UFTP=3,"user@somedomain.com"	OK	• FTP password;
AT+UFTP=6,1	OK	• FTP connection mode (PASSIVE connection).
AT+UDNSRN=0,"ftp.u-blox.com"	+UDNSRN: "195.34.89.241" OK	Hostname resolution.
		Connect to the server and manage the FTP. Connection using the +UFTPC command. Let's start connecting to the server.
AT+UFTPC=1	OK +UUFTPCR: 1,1	The +UUFTPCR URC is returned when the connection is established.
AT+UFTPC=7,"file_to_store"	CONNECT	Send to FTP server a STORE file request for file_to_store.  The CONNECT intermediate result code means the direct link mode is activated: the data sent through the serial port will be redirected to the FTP server through the FTP connection.
AT+UFTPC=7,"file_to_store",250	CONNECT	Restart the STORE file request for file_to_store from byte 250. The CONNECT intermediate result code means the direct link mode activation: the data sent through the serial port is redirected to the FTP server through the FTP connection. The data is written on the FTP server starting from byte indicated.

Command	Response	Description
		The FTP server should support REST command to support this functionality.
+++	DISCONNECT OK	When the data upload is completed use the "+++\" escape sequence for exiting from the direct link mode.
	+UUFTPCR: 7,1	The +UUFTPCR URC notifies if the STORE operation has been concluded successfully.

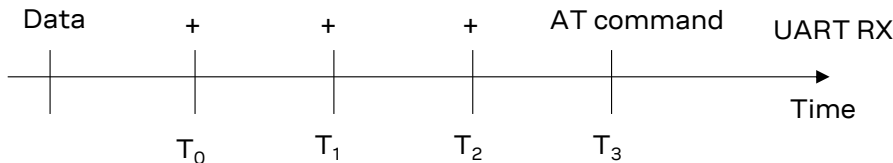
### 9.1.4 About "+++" escape sequence usage

To switch from the data mode to the command mode, the application shall send a proper escape sequence to the module. The application can configure the escape sequence by means of the following commands:

- ATS2: this command sets the character used as the escape character (by default it is "+")
- ATS12: this command sets the escape prompt delay (TEPD) timer (by default it is 1 s)

For more details on the AT commands, see the SARA-R5 series AT commands manual [3].

The escape sequence must follow certain timing constraints to be distinguished from generic data.



- T0 > TEPD: there must be at least TEPD seconds after the last data byte and the first escape character
- T1 < TEPD: the second escape character must be sent within TEPD seconds after the first escape character
- T2 < TEPD: the third escape character must be sent within TEPD seconds after the second escape character
- T3 > TEPD: There must be at least TEPD seconds after the last escape character and the first AT command

## 9.2 Using secure option

Command	Response	Description
		Parameters configuration for the FTP server connection in secure mode. These parameters are set:
AT+UFTP=0, "123.213.132.231"	OK	• FTP server address
AT+UFTP=2, "myname"	OK	• FTP username
AT+UFTP=3, "mypwd"	OK	• FTP password
AT+UFTP=8, 1	OK	• FTP SSL encryption control channel enabled
AT+YFTP=12, 1	OK	• FTP SSL encryption data channel enabled
AT+UFTPC=1		FTP login.
	OK	Connect to the server and manage the FTP connection using the +UFTPC AT command. Let's start connecting to the server.
	+UUFTPCR: 1, 1	The +UUFTPCR URC provides the FTP command result (the second parameter provides the result, 1 if is successfully performed).


Command	Response	Description
		Some operators may not accept a secure FTP connection:
AT+UFTPC=1	OK +UFTPCR: 1,0	The URC provides the FTP command result: the second parameter is 0, an error has occurred.
AT+UFTPER	+UFTPER: 8,63 OK	Retrieving of error class and code: <ul style="list-style-type: none"> <li>• Error class 8: "Wrong FTP API usage"</li> <li>• Error code 63: "Cannot set secure socket"</li> </ul>

### 9.3 Error handling

In case of errors returned in the last FTP operation, it is possible to investigate the type of error using the +UFTPER AT command.


Command	Response	Description
AT+UFTPC=1	OK +UFTPCR: 1,0	Unsuccessful login.
AT+UFTPER	+UFTPER: 1,1 OK	Error code 1 is "User missing".

# 10 HTTP

 Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using HTTP AT commands.

## 10.1 Basic setup

This section shows an example use of the u-blox proprietary +UHTTP and +UHTTPC AT commands. These commands are used for sending requests to a remote HTTP server, receiving the server responses, and transparently storing them in the file system. The supported methods are: HEAD, GET, DELETE, PUT, POST file, and POST data. For detailed AT command descriptions, see the SARA-R5 AT commands manual [3].

Command	Response	Description
AT+CMEE=2	OK	Set verbose error result codes.
AT+UHTTP=0	OK	Reset the HTTP profile #0.
AT+UHTTP=0,1,"httpbin.org"	OK	Set the server domain name and port.
AT+UHTTP=0,5,80	OK	 HTTP server name (e.g., "httpbin.org"). The factory-programmed value is an empty text string.
AT+UDNSRN=0,"httpbin.org"	+UDNSRN: "54.72.52.58" OK	DNS resolution of httpbin.org.
AT+UHTTPC=0,0,"/","head.ffs"	OK +UHTTPCR: 0,0,1	HEAD request of the default page and store the result into the "head.ffs" file on the local file system of the module. The +UHTTPCR URC notifies the success/failure of the operation (in this example: success).
AT+UHTTPC=0,1,"/","get.ffs"	OK +UHTTPCR: 0,1,1	GET request of the default page and store the result into the "get.ffs" file on the local file system of the module. The +UHTTPCR URC notifies the success/failure of the operation (in this example: success).
AT+UHTTPC=0,5,"/post","post.ffs","name_post=MyName&age_post=30",0	OK +UHTTPCR: 0,5,1	POST request sending data using content-type application/x-www-form-urlencoded. The result is saved in the "post.ffs" file on the local file system of the module. The +UHTTPCR notifies the success/failure of the operation (in this example: success).
AT+UHTTP=0,2,"test_user"	OK	Set the authentication for the HTTP server: HTTP server username.
AT+UHTTP=0,3,"P455w0rd"	OK	HTTP server password.
AT+UHTTP=0,4,1	OK	HTTP server authentication method (basic authentication).
AT+UHTTPC=0,1," /basic-auth/test_user/P455w0rd","get_auth.ffs"	OK +UHTTPCR: 0,1,1	GET request returning information on authenticated user. The page requires basic authentication. The result is saved in "get_auth.ffs" file on the local file system of the module. The +UHTTPCR URC notifies the success/failure of the operation (in this example: success).

## 10.2 HTTP POST

Command	Response	Description
AT+CMEE=2	OK	Set the verbose error result codes.
AT+UPSD=0,1,"click"	OK	Set the APN.
AT+UPSDA=0,3	OK	PS data attach.
AT+UPSND=0,0	+UPSND: 0,0,"10.130.31.65" OK	Check whether the IP address is assigned.
AT+UDWNFILE="postdata.txt",11	>hello world OK	Write some data in the file to send.
AT+URDFILE="postdata.txt"	+URDFILE: postdata.txt,11,"hello world" OK	Optionally check whether the data is present.
AT+UHTTP=0	OK	Reset the HTTP profile #0.
AT+UHTTP=0,1,"httpbin.org"	OK	Set up a connection to an echo server (httpbin.org) that checks and echoes post commands.
AT+UHTTP=0,5,80	OK	Set the port of the HTTP request to 80
AT+UHTTPC=0,4,"/post","result.txt","postdata.txt",1	OK +UUHTTPCR: 0,4,1	Submit a post command in text format and store the answer in result.txt.
AT+URDFILE="result.txt"	+URDFILE: result.txt,498, "HTTP/1.1 200 OK Content-Type: application/json Date: Tue, 15 Jan 2013 16:06:11 GMT Server: gunicorn/0.16.1 Content-Length: 345 Connection: Close  { "headers": { "Content-Length": "11", "Host": "httpbin.org", "Content-Type": "text/plain", "User-Agent": "UBlox Leon G200/1.0 (N7/HTTP 1.0)", "Connection": "keep-alive" }, "args": {}, "data": "hello world", "url": "http://httpbin.org/post", "files": {}, "json": null, "form": {}, "origin": "10.82.21.198" } OK"	Check the server's reply.

### 10.3 Error handling


In case of errors returned in the last HTTP operation of a specified HTTP profile, it is possible to investigate the type of error using the +UHTTPER AT command.

Command	Response	Description
AT+UHTTPCR=0,4,"/post","result.txt","postdata.txt",1	OK +UUHTTPCR: 0,4,1	Successfully submit a post command in text format and store the answer in result.txt.
AT+UHTTPER=1	+UHTTPER: 1,0,0 OK	In HTTP profile 1 the error code 0 is "No error".

### 10.4 Secure HTTP

Configure a secure manager profile before starting a secure HTTP. See section 3 for further details on this.

The following example reports how to configure the secure HTTP. Only the secure manager profile must be configured, the other HTTP commands will behave as in the case of unencrypted session.

Command	Response	Description
AT+UHTTTP=0,6,1	OK	Enable secure HTTP. HTTPS (SSL encryption) enabled and the HTTP server port set to 443.  The port number is set automatically to 443 (standard value for HTTPS). If the application is turning back to HTTP (using AT+UHTTTP=0,6,0 command), the port number is changed automatically to 80. Differently, if the port number is changed manually (e.g., using AT+UHTTTP=0,5,9000 command), a change in the security option (e.g., with +UHTTTP=0,6,1) will not modify the port manually selected.

## 11 LwM2M

LwM2M application examples are available into the LwM2M objects and commands application note [5].



# Appendix


## A Glossary

Abbreviation	Definition
ASCII	American Standard Code for Information Interchange
APN	Access Point Name
ARM	Arm (Advanced RISC Machines) Holdings
AEC	Automotive Electronics Council
BBR	Battery Backed RAM
BER	Bit Error Rate
CoAP	Constrained Application Protocol
CPU	Central Processing Unit
CUT	Coordinated Universal Time
CSD	Circuit-Switched Data
DCE	Data Circuit-terminating Equipment* / Data Communication Equipment*
DTE	Data Terminal Equipment
DTLS	Datagram Transport Layer Security
DC	Direct Current
DRX	Discontinuous Reception
DDC	Display Data Channel
DL	Down Link (Reception)
FOTA	Firmware updates Over-The-Air
ICMP	Internet Control Message Protocol
IoT	Internet of Things
LPWA	Low-Power Wide-Area
LPWAN	Low-Power Wide-Area Network
M2M	Machine to Machine
MTU	Maximum transmission unit
NVM	Non-Volatile Memory
PS	Packet switched
PSD	Packet-Switched Data
RAT	Radio Access Technologies
RFC	Request for Comments
RoT	Root of Trust
SAO	Socket Always On
TLS	Transport Layer Security
WAN	Wide Area Network

**Table 2: Explanation of the abbreviations and terms used**

## Related documentation

- [1] u-blox SARA-R5 series data sheet, [UBX-19016638](#)
- [2] u-blox SARA-R5 series system integration manual, [UBX-19041356](#)
- [3] u-blox SARA-R5 AT commands manual, [UBX-19047455](#)
- [4] u-blox SARA-R5 application development guide, [UBX-20009652](#)
- [5] u-blox LwM2M objects and commands application note, [UBX-18068860](#)
- [6] u-blox SARA-R4 application development guide, [UBX-18019856](#)
- [7] u-blox AT commands examples application note, [UBX-13001820](#)
- [8] u-blox security suite application note, [UBX-19030037](#)
- [9] SARA-R5 FW update application note, [UBX-20033314](#)
- [10] u-blox EVK-R5 user guide, [UBX-19042592](#)
- [11] u-blox SARA-R5 series GNSS implementation application note, [UBX-20012413](#)
- [12] RFC 768 - User Datagram Protocol (UDP)
- [13] RFC 7252 - Constrained Application Protocol (CoAP)
- [14] RFC 6347 - Datagram Transport Layer Security Version 1.2
- [15] RFC 7959 - Block-Wise Transfers in the Constrained Application Protocol (CoAP)
- [16] RFC 8323 - Constrained Application Protocol (CoAP) over TCP, TLS, and WebSockets
- [17] u-blox Multiplexer implementation application note, [UBX-13001887](#)
- [18] RFC 5077 - Transport Layer Security (TLS) Session Resumption without Server-Side State

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## Revision history

Revision	Date	Name	Comments
R01	26-Oct-2020	mreb	Initial release

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