BG95&BG77&BG600L Series
PSM Application Note

LPWA Module Series

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About the Document

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Contents

Table Index

Figure Index

1 Introduction

Power Saving Mode (PSM) is a key feature for eMTC/NB-IoT devices and applications with the following requirements:

- Infrequently active
- Short duration of active communication
- Data transmission is mainly originated by eMTC/NB-IoT devices, but also possible to engage in DL receiving during the active duration
- Power constraint, running on battery
- Require long battery life

PSM is to make an IoT device inactive or power-down most of the time to save power and wake up the device only for a short period of time for data transmission.

This document mainly introduces PSM feature and also describes how to use PSM function of Quectel BG95 series, BG77 and BG600L-M3 modules.

1.1. Applicable Modules

Table 1: Applicable Modules

Module Series	Model	Description
BG95	BG95-M1	Cat M1 only
	BG95-M2	Cat M1/Cat NB2
	BG95-M3	Cat M1/Cat NB2/EGPRS
	BG95-M4	Cat M1/Cat NB2, 450 MHz Supported
	BG95-M5	Cat M1/Cat NB2/EGPRS, Power Class 3
	BG95-M6	Cat M1/Cat NB2, Power Class 3
	BG95-MF	Cat M1/Cat NB2, Wi-Fi Positioning

	BG95-N1	Cat NB2 Only
BG77	BG77	Cat M1/Cat NB2
BG600L	BG600L-M3	Cat M1/Cat NB2/EGPRS

2 General Overview of PSM

PSM mode defined by 3GPP Release 12 is similar to power-off, but the UE (BG95 series, BG77 and BG600L-M3 modules) remains registered with the network and there is no need to re-attach or re-establish PDN connections. Therefore, the UE in PSM is not immediately reachable for mobile terminating services. The UE using PSM is available for mobile terminating services during the time it is in connected mode and for the period of an Active Time that is after the connected mode. The connected mode is caused by a mobile originated event like data transmission or signalling, e.g. after a periodic TAU/RAU procedure. PSM is therefore suitable for UE that is expecting only infrequent mobile originating and terminating services and that can accept a corresponding latency in the mobile terminating communication.

NOTE

For more detailed description of PSM mode defined by 3GPP Release 12, see *3GPP TS 23.682 clause 4.5.4 UE Power Saving Mode.*

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3 Description of PSM AT Commands

3.1. AT Command Syntax

3.1.1. Definitions

- **<CR>**   Carriage return character.
- **<LF>**   Line feed character.
- **<...>**   Parameter name. Angle brackets do not appear on command line.
- **[...]**   Optional parameter of a command or an optional part of TA information response. Square brackets do not appear on command line. When an optional parameter is omitted, the new value equals its previous value or its default setting, unless otherwise specified.
- **Underline**   Default setting of a parameter.

3.1.2. AT Command Syntax

The **AT** or **at** prefix must be added at the beginning of each command line. Entering **<CR>** will terminate a command line. Commands are usually followed by a response that includes **<CR><LF><response><CR><LF>**. Throughout this document, only the response **<response>** will be presented, **<CR><LF>** are omitted intentionally.

Table 2: Type of AT Commands and Responses

Test Command	**AT+<cmd>=?**	This command returns the list of parameters and value ranges set by the corresponding Write Command or internal processes.
Read Command	**AT+<cmd>?**	This command returns the currently set value of the parameter or parameters.
Write Command	**AT+<cmd>=<p1> [,<p2>[,<p3>[...]]]**	This command sets the user-definable parameter values.
Execution Command	**AT+<cmd>**	This command reads non-variable parameters affected by internal processes in the module.

3.2. Description of AT Commands

3.2.1. AT+CPSMS   Power Saving Mode Setting

The Write Command configures PSM parameters of the module. It controls whether the module wants to apply PSM or not, as well as the requested extended periodic RAU value and the requested GPRS READY timer value in GERAN, the requested extended periodic TAU value in E-UTRAN and the requested Active Time value. See the URCs provided by commands **AT+CGREG** for the Active Time value, the extended periodic RAU value and the GPRS READY timer value that are allocated to the module by the network in GERAN and **AT+CEREG** for the Active Time value and the extended periodic TAU value that are allocated to the module by the network in E-UTRAN.

A special form of the command can be given as **AT+CPSMS=** (with all parameters omitted). In this form, **<mode>** will be set to 0, the use of PSM will be disabled and data for all parameters in **AT+CPSMS** will be removed.

The Read Command returns the current parameter values.

The Test Command returns the supported **<mode>**s and the value ranges for the requested extended periodic RAU value and the requested GPRS READY timer value in GERAN, the requested extended periodic TAU value in E-UTRAN and the requested Active Time value as compound values.

AT+CPSMS Power Saving Mode Setting	
Test Command **AT+CPSMS=?**	Response **+CPSMS: (**list of supported **<mode>**s**),(**list of supported **<Requested_Periodic-RAU>**s**),(**list of supported **<Requested_GPRS-READY-timer>**s**),(**list of supported **<Requested_Periodic-TAU>**s**),(**list of supported **<Requested_Active-Time>**s**)** **OK**
Read Command **AT+CPSMS?**	Response **+CPSMS: <mode>,[<Requested_Periodic-RAU>],[<Requested_GPRS-READY-timer>],[<Requested_Periodic-TAU>],[<Requested_Active-Time>]** **OK**
Write Command **AT+CPSMS=[<mode>[,<Requested_Periodic-RAU>[,<Requested_GPRS-READY-timer>[,<Requested_Periodic-TAU>[,<Requested_Active-Time>]]]]]**	Response **OK** If there is any other error: **ERROR**
Maximum Response Time	300 ms

Characteristics	The command takes effect immediately. The configurations will be saved automatically.
Reference 3GPP TS 27.007	

Parameter

<mode>	Integer type. Disable or enable the use of PSM in the UE. <u>0</u> Disable the use of PSM 1 Enable the use of PSM

<Requested_Periodic-RAU>	String type. One byte in an 8-bit format. Requested extended periodic RAU value (T3312) to be allocated to the UE in GERAN. (e.g. "01000111" equals to 70 hours.)
	Bits 5 to 1 represent the binary coded timer value.
	Bits 6 to 8 define the timer value unit as follows:
	Bits 8 7 6
	    0 0 0 value is incremented in multiples of 10 minutes
	    0 0 1 value is incremented in multiples of 1 hour
	    0 1 0 value is incremented in multiples of 10 hours
	    0 1 1 value is incremented in multiples of 2 seconds
	    1 0 0 value is incremented in multiples of 30 seconds
	    1 0 1 value is incremented in multiples of 1 minute

<Requested_GPRS-READY-timer>	String type. One byte in an 8-bit format. Requested GPRS READY timer value (T3314) to be allocated to the UE in GERAN. (e.g. "01001010" equals to 1 hours.)
	Bits 5 to 1 represent the binary coded timer value.
	Bits 6 to 8 define the timer value unit as follows:
	Bits 8 7 6
	    0 0 0 value is incremented in multiples of 2 seconds
	    0 0 1 value is incremented in multiples of 1 minute
	    0 1 0 value is incremented in multiples of decihours
	    1 1 1 value indicates that the timer is deactivated

<Requested_Periodic-TAU>	String type. One byte in an 8-bit format. Requested extended periodic TAU value (T3412) to be allocated to the UE in E-UTRAN. (e.g. "00001010" equals to 100 minutes) In the Write Command, when <mode> is 1 and **<requested_periodicTAU>** is omitted, the value configured last time is used.
	Bits 5 to 1 represent the binary coded timer value.
	Bits 6 to 8 define the timer value unit as follows:
	Bits 8 7 6
	    0 0 0 value is incremented in multiples of 10 minutes
	    0 0 1 value is incremented in multiples of 1 hour
	    0 1 0 value is incremented in multiples of 10 hours

	0 1 1	value is incremented in multiples of 2 seconds
	1 0 0	value is incremented in multiples of 30 seconds
	1 0 1	value is incremented in multiples of 1 minute
<Requested_Active-Time>	String type. One byte in an 8-bit format. Requested Active Time value (T3324) to be allocated to the UE. (e.g. "00001111" equals to 1 minute)	
	Bits 5 to 1 represent the binary coded timer value.	
	Bits 6 to 8 define the timer value unit as follows:	
	Bits 8 7 6	
	0 0 0	value is incremented in multiples of 2 seconds
	0 0 1	value is incremented in multiples of 1 minute
	0 1 0	value is incremented in multiples of decihours
	1 1 1	value indicates that the timer is deactivated.

Example

AT+CPSMS=1,,,"00000100","00001111" **OK**	//Set the requested T3412 value to 40 minutes, and set the requested T3324 value to 30 seconds.

3.2.2. AT+QPSMS   Extended Power Saving Mode Setting

This is an extended AT command developed by Quectel for PSM setting. A special form of the command can be given as **AT+QPSMS=** (with all parameters omitted). In this form, **<mode>** will be set to 0, the use of PSM will be disabled and data for all parameters in **AT+QPSMS** will be removed. It is similar with **AT+CPSMS**.

AT+QPSMS Extended Power Saving Mode Setting	
Test Command **AT+QPSMS=?**	Response **+QPSMS: (**list of supported **<mode>**s**),(**list of supported **<Requested_Periodic-RAU>**s**),(**list of supported **<Requested_GPRS-READY-timer>**s**),(**list of supported **<Requested_Periodic-TAU>**s**),(**list of supported **<Requested_Active-Time>**s**) **OK**
Read Command **AT+QPSMS?**	Response **+QPSMS: <mode>,[<Network_Periodic-RAU>],[<Network_GPRS-READY-timer>],[<Network_Periodic-TAU>],[<Network_Active-Time>]** **OK**
Write Command **AT+QPSMS=[<mode>[,<Requested_P**	Response **OK**

eriodic-RAU>[,<Requested_GPRS-READY-timer>[,<Requested_Periodic-TAU>[,<Requested_Active-Time>]]]]]	If there is any other error: **ERROR**
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configurations will be saved automatically.
Reference 3GPP TS 27.007	

Parameter

<mode>	Integer type. Disable or enable the use of PSM in the UE.
	<u>0</u> Disable the use of PSM
	1 Enable the use of PSM
<Requested_Periodic-RAU>	String type. One byte in an 8-bit format. Requested extended periodic RAU value (T3312) to be allocated to the UE in GERAN. (e.g. "01000111" equals to 70 hours.)
	Bits 5 to 1 represent the binary coded timer value.
	Bits 6 to 8 define the timer value unit as follows:
	Bits 8 7 6
	0 0 0 value is incremented in multiples of 10 minutes
	0 0 1 value is incremented in multiples of 1 hour
	0 1 0 value is incremented in multiples of 10 hours
	0 1 1 value is incremented in multiples of 2 seconds
	1 0 0 value is incremented in multiples of 30 seconds
	1 0 1 value is incremented in multiples of 1 minute
<Requested_GPRS-READY-timer>	String type. One byte in an 8-bit format. Requested GPRS READY timer value (T3314) to be allocated to the UE in GERAN. (e.g. "01001010" equals to 1 hours.)
	Bits 5 to 1 represent the binary coded timer value.
	Bits 6 to 8 define the timer value unit as follows:
	Bits 8 7 6
	0 0 0 value is incremented in multiples of 2 seconds
	0 0 1 value is incremented in multiples of 1 minute
	0 1 0 value is incremented in multiples of decihours
	1 1 1 value indicates that the timer is deactivated.
<Requested_Periodic-TAU>	String type. One byte in an 8-bit format. Requested extended periodic TAU value (T3412) to be allocated to the UE in E-UTRAN. (e.g. "00001010" equals to 100 minutes.)
	Bits 5 to 1 represent the binary coded timer value.
	Bits 6 to 8 define the timer value unit as follows:
	Bits 8 7 6
	0 0 0 value is incremented in multiples of 10 minutes

	0 0 1 value is incremented in multiples of 1 hour
	0 1 0 value is incremented in multiples of 10 hours
	0 1 1 value is incremented in multiples of 2 seconds
	1 0 0 value is incremented in multiples of 30 seconds
	1 0 1 value is incremented in multiples of 1 minute
<Requested_Active-Time>	String type. One byte in an 8-bit format. Requested Active Time value (T3324) to be allocated to the UE. (e.g. "00001111" equals to 1 minute.) Bits 5 to 1 represent the binary coded timer value. Bits 6 to 8 define the timer value unit as follows: **Bits 8 7 6** 0 0 0 value is incremented in multiples of 2 seconds 0 0 1 value is incremented in multiples of 1 minute 0 1 0 value is incremented in multiples of decihours 1 1 1 value indicates that the timer is deactivated.
<Network_Periodic-RAU>	Integer type. Extended periodic RAU value (T3312) to be allocated to the UE in GERAN, and the value is specified by network.
<Network_GPRS-READY-timer>	Integer type. GPRS READY timer value (T3314) to be allocated to the UE in GERAN, and the value is specified by network.
<Network_Periodic-TAU>	Integer type. Extended periodic TAU value (T3412) to be allocated to the UE in E-UTRAN, and the value is specified by network.
<Network_Active-Time>	Integer type. Active timer value (T3324) to be allocated to the UE in E-UTRAN, and the value is specified by network.

Example

AT+QPSMS=1,,,"00000100","00001111"	//Set the requested T3412 value to 40 minutes, and set the requested T3324 value to 30 seconds.
OK	
AT+QPSMS?	//Query the PSM mode and the periodic-TAU and active time specified by the network. .
+QPSMS:1,,,"86400","2"	
OK	

3.2.3. AT+QPSMCFG PSM Feature and Minimum Threshold Value Setting

The Write Command enables or disables PSM feature and sets the minimum threshold value to enter PSM. A special form of the command can be given as **AT+QPSMCFG=** (with all parameters omitted). In this form, **<threshold>** will be set to 20 and **<PSM_version>** will be set to 4.

AT+QPSMCFG PSM Feature and Minimum Threshold Value Setting	
Test Command **AT+QPSMCFG=?**	Response **+QPSMCFG: (**list of supported **<threshold>**s**),(**list of supported **<PSM_version>**s**)** **OK**
Write Command **AT+QPSMCFG=[<threshold>[,<PSM_ version>]]**	Response **OK** If there is any error: **ERROR**
Read Command **AT+QPSMCFG?**	Response **+QPSMCFG: <threshold>,<PSM_version>** **OK**
Maximum Response Time	300 ms
Characteristics	The command takes effect after rebooting. The configurations will be saved automatically.

Parameter

<threshold>	Integer type. Minimum threshold value to enter PSM. Range: 20-4294967295. Unit: second.
<PSM_version>	Integer type. Bitmask to indicate PSM feature (1: Enable; 0: Disable). Each bit is configured independently. Range: 0-4-15.
	Bit 0 PSM without network coordination
	Bit 1 Rel-12 PSM without context retention
	Bit 2 Rel-12 PSM with context retention
	Bit 3 PSM in between eDRX cycles

Example

AT+QPSMCFG=100	//Set the threshold to 100 seconds.
OK	
AT+QPSMCFG?	//Query the threshold value and PSM version.
+QPSMCFG: 100,4	
OK	

3.2.4. AT+QPSMEXTCFG   Modem Optimization

This command is used to set extended parameters for modem optimizations. A special form of the command can be given as **AT+QPSMEXTCFG=** (with all parameters omitted). In this form, **<PSM_opt_mask>** will be set to 14, and data for all parameters in **AT+QPSMEXTCFG** will be removed or, if available, set to default values. In the Write Command, any parameter before the one that needs to be configured should be added or, if it is set as a default value, can be omitted and separated by a comma.

AT+QPSMEXTCFG Modem Optimization	
Test Command **AT+QPSMEXTCFG=?**	Response **+QPSMEXTCFG: (**list of supported **<PSM_opt_mask>**s**),(**list of supported **<max_oos_full_scans>**s**),(**list of supported **<PSM_duration_due_to_oos>**s**),(**list of supported **<PSM_randomization_window>**s**),(**list of supported **<max_oos_time>**s**),(**list of supported **<early_wakeup_time>**s**)** **OK**
Read Command **AT+QPSMEXTCFG?**	Response **+QPSMEXTCFG: <PSM_opt_mask>,<max_oos_full_scans>,<PSM_duration_due_to_oos>,<PSM_randomization_window>,<max_oos_time>,<early_wakeup_time>** **OK**
Write Command **AT+QPSMEXTCFG=[<PSM_opt_mask>[,<max_oos_full_scans>[,<PSM_duration_due_to_oos>[,<PSM_randomization_window>[,<max_oos_time>[,<early_wakeup_time>]]]]]]**	Response **OK** If there is any error: **ERROR**
Maximum Response Time	300 ms
Characteristics	The command takes effect after rebooting. The configurations will be saved automatically.

Parameter

<PSM_opt_mask>	Integer type. Range: 0-14-15. 1st bit of the parameter is used to enable/disable (0: disable; 1: enable) PSM ENTER request without sending PSM_READY_REQ to NAS. This is a quick PSM operation. 2nd bit of the parameter is used to enable/disable (0: disable; 1: enable) Out of Service (OoS) status indication from Modem to AP.

	3rd bit of the parameter is used to enable/disable (0: disable; 1: enable) limited service status indication from Modem to AP.
	4th bit of the parameter is used to enable/disable (0: disable; 1: enable) deep-sleep mode if PSM cycle is less than the threshold value. If enabled, the device will be in deep-sleep mode before it enters PSM because of reaching the threshold value.
<max_oos_full_scans>	Integer type. Maximum number of full scans to wait before modem declares SYS_PSM_STATUS_OOS to clients. Range: 1-2-100.
<PSM_duration_due_to_oos>	Integer type. PSM cycle used by PSM daemon upon OOS/Limited Service indication, due to service outage. Range: 120-4294967295. Unit: second.
<PSM_randomization_window>	Integer type. PSM wakeup randomization window which avoids network congestion caused by simultaneous wake-up of all the PSM devices. Range: 1-5-1000. Unit: second.
<max_oos_time>	Integer type. Maximum time in seconds to wait before declaring SYS_PSM_STATUS_OOS to clients. Range: 1-120-65535. Unit: second.
<early_wakeup_time>	Integer type. The time that the device wakes up in advance to account for boot-up and acquisition delay. While programming PMIC, PSM daemon reduces PSM cycle by this duration. Range: 1-3-1000. Unit: second.

Example

```
AT+QPSMEXTCFG=14,2,120
OK
AT+QPSMEXTCFG?
+QPSMEXTCFG: 14,2,120,5,120,3

OK
```

3.2.5. AT+QCFG="psm/urc" Enable/Disable PSM Entering Indication

The command enables/disables the output of URC **+QPSMTIMER: <TAU_timer>,<T3324_timer>** which is used to indicate the TAU duration and active time duration for the module's PSM.

When PSM function is enabled and RRC connection release is received, the active timer (T3324) will be started, and the indication URC will be reported.

AT+QCFG="psm/urc" Enable/Disable PSM Entering Indication	
Write Command **AT+QCFG="psm/urc"[,<enable>]**	Response If the optional parameter is omitted, query the current setting: **+QCFG: "psm/urc",<enable>**

	OK
	If the optional parameter is specified, set whether to enable PSM entering indication. **OK**
	If there is an error related to ME functionality: **+CME ERROR: <err>**
	If there is any other error: **ERROR**
Maximum Response Time	300 ms
Characteristics	The command takes effect immediately. The configurations will be saved automatically.

Parameter

<enable>	Integer type. Enable/disable the output of URC **+QPSMTIMER: <TAU_timer>,<T3324_timer>**. If enabled, the URC will be reported when RRC connection release is received.
	<u>0</u> Disable
	1 Enable
<err>	Integer type. Error code. See **Appendix B**.

3.3. Description of URC

3.3.1. +QPSMTIMER Indicate the TAU Duration and Active Time Duration

The URC is used to indicate the TAU duration and active time duration of PSM. The URC is disabled by default, and can be enabled with **AT+QCFG="psm/urc",1**.

+QPSMTIMER Indicate the TAU Duration and Active Time Duration	
+QPSMTIMER: <TAU_timer>,<T3324_timer>	Indicate the TAU duration and active time duration of UE's PSM.

Parameter

<TAU_timer>	Integer type. TAU duration of PSM. Unit: second.
<T3324_timer>	Integer type. Active time duration of PSM. Unit: second.

Example

```
AT+QCFG="psm/urc"
+QCFG: "psm/urc",0

OK
AT+QCFG="psm/urc",1
OK

+QPSMTIMER: 86400,2                    //TAU timer and active timer value of PSM.
```

4 Wake up from PSM

Either of the following methods wakes up the module from PSM:

1. Give PON_TRIG a rising edge to wake up the module (**recommended**).
2. Drive PWRKEY low to wake up the module.
3. When the T3412 timer expires, the module will be automatically woken up.

4.1. Wake up from PSM with PON_TRIG (Recommended)

Through the following steps, the module can be woken up from PSM to realize communication between the module and the network.

Step 1: Give PON_TRIG a rising edge, and then check whether the module has been woken up from PSM.
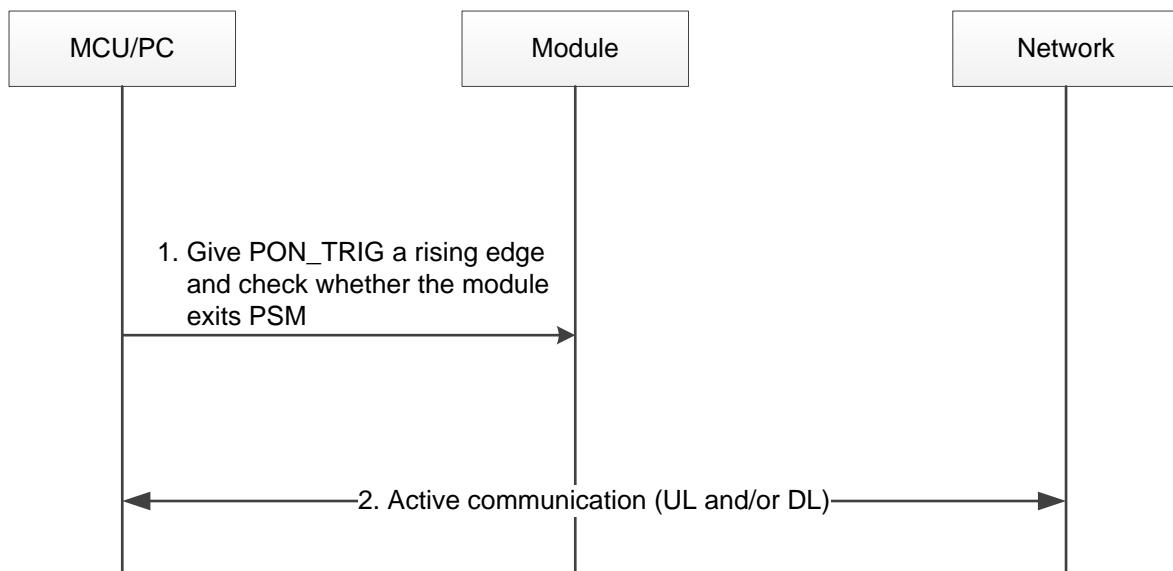
Step 2: Perform UL and/or DL communication actively.

Figure 1: Wake up Module from PSM with PON_TRIG

4.2. Wake up from PSM with PWRKEY

Similar to the PON_TRIG solution, the module can be woken up from PSM through steps below to realize communication between the module and the network.

Step 1: Drive PWRKEY low and then check whether the module has been woken up from PSM.

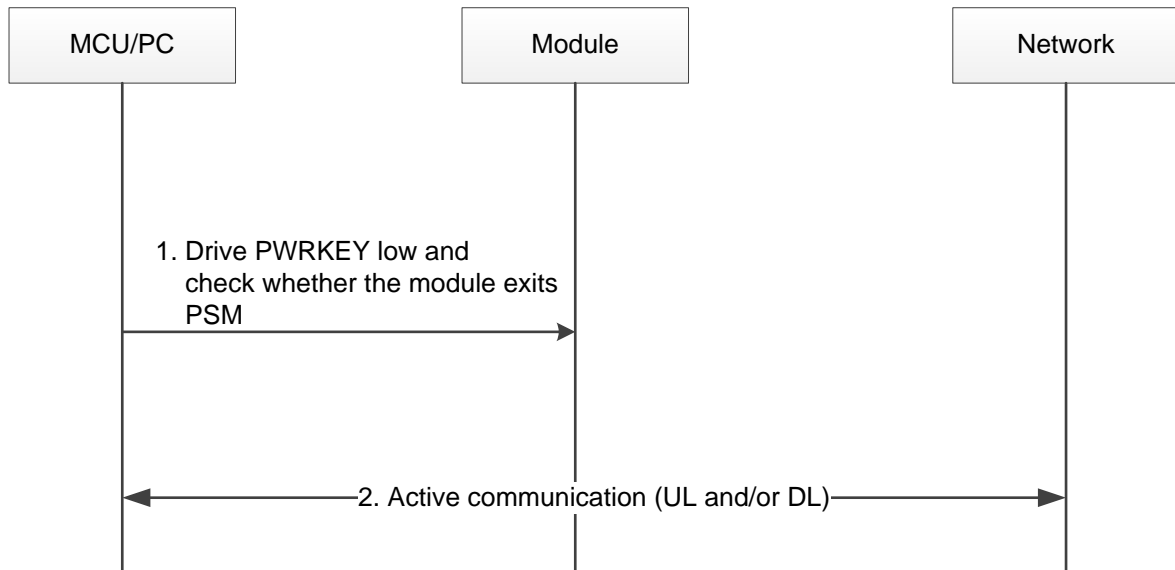**Step 2:** Perform UL and/or DL communication actively.

Figure 2: Wake up Module from PSM with PWRKEY

4.3. Wake up from PSM When T3412 Timer Expires

When the T3412 (extended TAU timer) expires, the module will be automatically woken up from PSM.

The following figure illustrates the automatic procedure for waking up a module from PSM.

Module   Network

<Attach Request>
T3324 and/or T3412 Extended Value

<RRC Setup>

<Authentication/Security>

Attach Accept
T3324 and/or T3412 Extended Value

RRC Release

T3324

T3412

PSM

Tracking Area Update Request
T3324 and/or T3412 Extended Value

<RRC Setup>

Tracking Area Update Accept
T3324 and/or T3412 Extended Value
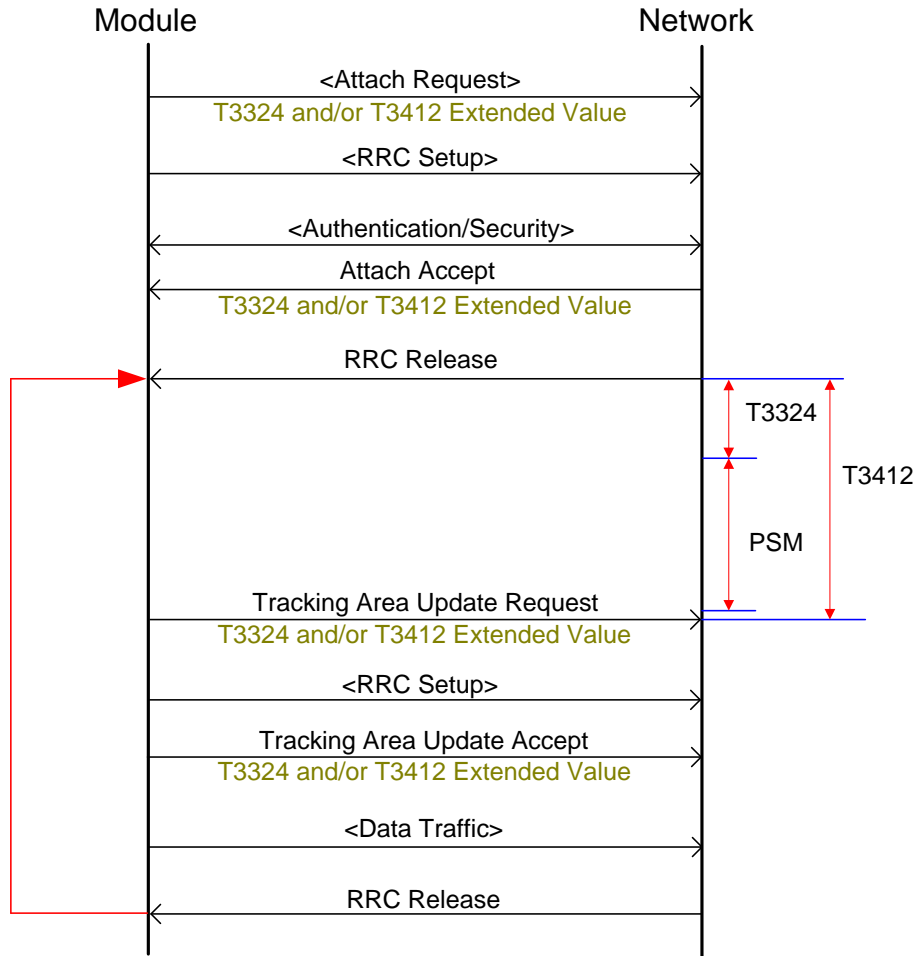
<Data Traffic>

RRC Release

Figure 3: Automatically Wake up Module from PSM When T3412 Expires

5 Typical Power Consumption Cycle

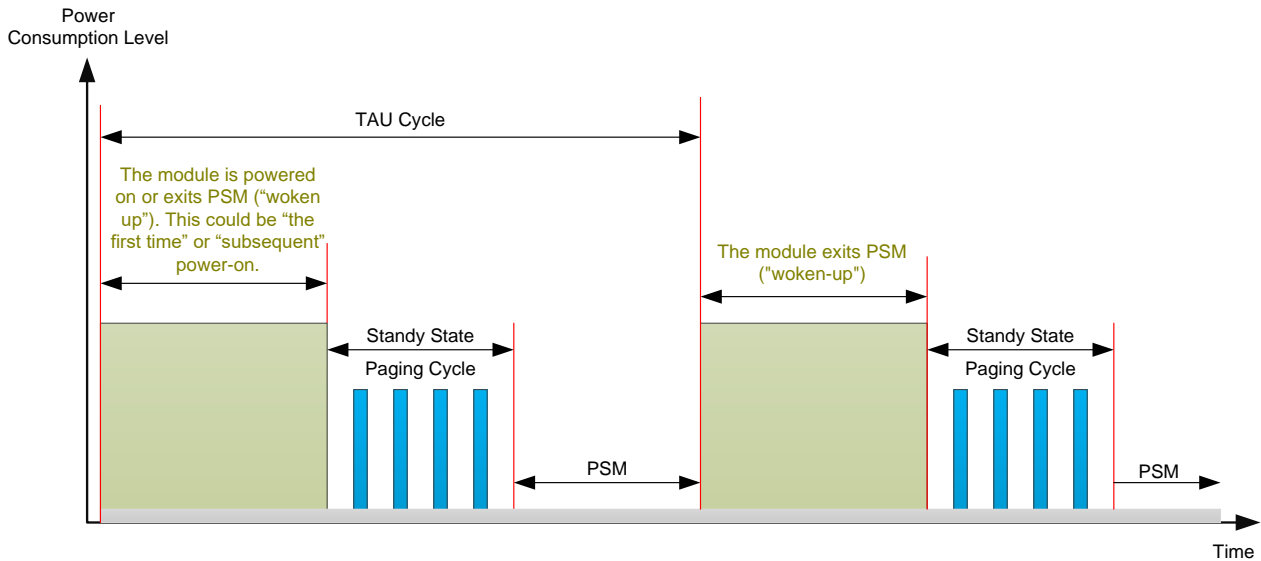The following figure shows the typical power consumption cycle of the module.

Figure 4: Typical Power Consumption Cycle

6 Appendix A References

Table 3: Related Documents

SN	Document Name	Remark
[1]	Quectel_BG95&BG77_AT_Commands_ Manual	AT commands manual of BG95 series and BG77 modules
[2]	3GPP TS 23.401	3GPP specification
[3]	3GPP TS 23.682	3GPP specification

Table 4: Terms and Abbreviations

Abbreviation	Description
3GPP	3rd Generation Partnership Project
AP	Application Processor
DL	Downlink
DRX	Discontinuous Reception
eDRX	Extended Discontinuous Reception
eMTC	enhanced Machine-Type Communication
E-UTRAN	Evolved UMTS Terrestrial Radio Access Network
GERAN	GSM EDGE Radio Access Network
GPRS	General Packet Radio Service
NB-IoT	Narrow Band Internet of Things
PDN	Packet Data Network Gateway
PMIC	Power Management IC
PSM	Power Saving Mode

RAU	Routing Area Update
RRC	Radio Resource Control
TAU	Tracking Area Update
UE	User Equipment (typically the module)
UL	Uplink
URC	Unsolicited Result Code

7 Appendix B Summary of CME ERROR Codes

Final result code **+CME ERROR: <err>** indicates an error related to mobile equipment or network. The operation is similar to **ERROR** result code. None of the following commands in the same command line is executed. Neither **ERROR** nor **OK** result code shall be returned.

<err> values are mostly used by common message commands. The following table lists most of general and GRPS related **ERROR** codes. For some GSM protocol failure cause described in GSM specifications, the corresponding **ERROR** codes are not included.

Table 5: Summary of CME ERROR Codes

Code of <err>	Meaning
0	Phone failure
1	No connection to phone
2	Phone-adaptor link reserved
3	Operation not allowed
4	Operation not supported
5	PH-SIM PIN required
6	PH-FSIM PIN required
7	PH-FSIM PUK required
10	(U)SIM not inserted
11	(U)SIM PIN required
12	(U)SIM PUK required
13	(U)SIM failure

14	(U)SIM busy
15	(U)SIM wrong
16	Incorrect password
17	(U)SIM PIN2 required
18	(U)SIM PUK2 required
20	Memory full
21	Invalid index
22	Not found
23	Memory failure
24	Text string too long
25	Invalid characters in text string
26	Dial string too long
27	Invalid characters in dial string
30	No network service
31	Network timeout
32	Network not allowed - emergency calls only
40	Network personalization PIN required
41	Network personalization PUK required
42	Network subset personalization PIN required
43	Network subset personalization PUK required
44	Service provider personalization PIN required
45	Service provider personalization PUK required
46	Corporate personalization PIN required
47	Corporate personalization PUK required