NL-SW-LTE-QBG96

Skywire® LTE CAT-M1

Power Save Mode

Application Note

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1. Introduction

1.1 Scope

This document serves as a guide for implementing Power Save Mode (PSM) on the NL-SW-LTE-QBG96 Skywire modem.

1.2 Overview

LTE CAT-M1 brings additional power saving features to cellular modems that were not previously available. PSM allows a Skywire to drastically reduce its power consumption by entering a low power state, while maintaining its registered status on the cellular network.

This application note explains the basics of PSM, and describes the procedure for implementing PSM on the NL-SW-LTE-QBG96 Skywire modem.

1.3 Orderable Part Numbers

Orderable Device	Description	Carrier	Network Type
NL-SWDK	Skywire Development Kit	Any	Any
NL-SW-LTE-QBG96	LTE CAT M1	Any	LTE

1.4 Prerequisites

This document assumes you have completed the initial setup of your modem and development kit using the Skywire Development Kit User Manual:

Skywire Development Kit User Manual

If you have not completed those steps, refer to the link above and complete the modem setup before proceeding.

If you wish to enable Power Save Mode on a Skywire Development Kit, additional UART setup may be required.

2. Power Save Mode Overview

2.1 A Primer on PSM

PSM allows a modem to remain registered on a cellular network while idling in a low power state and periodically waking to transmit and receive data.

In PSM, modems utilize internal timers to implement a cycle of waking and idling that allows the device to connect to the network periodically. During the woken state, the modem can send and receive data to and from the network, as if it was operating normally. Once the woken state expires, the modem can then return to the idle state without losing its registered status on the network.

The ability for the Skywire to retain its registered status on the network is advantageous in that it eliminates the need for the modem to constantly have to re-register on the network each time it exits a low power state. This in turn reduces the overall on-time of the modem, and thus reduces overall power consumption. This reduction in power consumption is ideal for IoT applications, where minimizing power consumption is a crucial requirement.

Specifics and regulations surrounding PSM implementations are governed by cellular carriers, who ultimately have the final say in how a device can and cannot use PSM. Furthermore, most cellular carriers comply with GSMA standards for LTE-M1 networks. As such, it is important to familiarize oneself with the PSM process and the associated regulations when choosing a configuration for a Skywire modem.

For reference, see the document linked below, which contains useful information regarding GSMA standards for LTE-M networks. Specifically, Section 6.1 of that document contains important details about PSM:

https://www.gsma.com/iot/wp-content/uploads/2018/04/LTE-M_Deployment_Guide_v2_5Apr2018.pdf

After reviewing the document above, proceed to Section 2.2, which contains information about the timers that control PSM.

2.2 PSM Timers

The NL-SW-LTE-QBG96 Skywire modem has two internal timers that control the duration of each stage of PSM mode. The bulleted list on the next page describes each of the two relevant timers.

- **"Requested Periodic TAU" timer (T3412)**
  - This timer dictates how long the Skywire will remain in the low power state of the PSM cycle.
  - This timer is also called the "T3412" timer, which is derived from the 3GPP TS 24.008.

- **"Requested Active Time" timer (T3324)**
  - This timer dictates how long the Skywire remains active during the wake period of the PSM cycle.
  - This timer is also called the "T3324" timer, which is derived from the 3GPP TS 24.008.

The values of these timers are encoded using a specification detailed in the 3GPP TS 24.008. This specification utilizes an 8-bit binary number to control the period of each of the timers. The table below details the encoding for each of the two relevant timers.

Requested Periodic TAU (T3412)		Requested Active Time (T3324)	
xxx….. (bits 7-5)	**Base Duration:** **000:** 10 minutes **001:** 1 hour **010:** 10 hours **011:** 2 seconds **100:** 30 seconds **101:** 1 minute **111:** Timer disabled	**xxx…..** (bits 7-5)	**Base Duration:** **000:** 2 seconds **001:** 1 minute **010:** decihours (6 minutes) **111:** Timer disabled
...xxxxx (bits 4-0)	Base duration multiplier, from 0 to 31	**...xxxxx** (bits 4-0)	Base duration multiplier, from 0 to 31

The three most significant bits serve as a base duration for the timer period. This base duration ranges from 2 seconds to 10 hours for the T3412 timer, and from 2 seconds to 1 decihour (6 minutes) for the T3324 timer. The 5 remaining bits contain a number between 0 and 31, which is used as a multiplier for the base duration.

Thus, the total period for the timer is calculated by multiplying the base duration of the timer by the 5-bit multiplier. In other words, the value of the period is calculated using the following equation:

$$Timer\ Period\ =\ (base\ duration\ given\ by\ bits\ 7-5)\ *\ (decimal\ value\ of\ bits\ 4-0)$$

For example, to obtain a value of 12 hours for the "Requested Periodic TAU" timer, the configuration of the 8 bits would be:

---

001 01100

'001' selects a base duration of 1 hour
'01100' in binary is equal to 12 in decimal

Thus, the timer period = 1 hour * 12 = 12 hours

For the "Requested Active Time" timer, a period of 30 minutes would be:

---

010 00011

'010' selects a base duration of 10 minutes
'00011' in binary is equal to 3 in decimal

Thus, the timer period = 10 mins * 3 = 30 mins

The process for calculating PSM timer periods is as simple as the examples above. Use the table on the last page, and the methods above to generate desired timer values.

However, there is one caveat regarding timer period selection: cellular carriers enforce minimum values for PSM timer periods. As such, some requested timer values will be rejected and overwritten by the network. In general, most networks enforce the following minimum timer periods:

- **Requested Periodic TAU:** minimum of 4 hours (sometimes slightly less)

- **Requested Active Time:** minimum of 16 seconds.

Due to these restrictions, it is best to select values higher than the minimums, so as to avoid any confusion caused by the network overwriting values that are shorter than the carrier's minimum PSM timer values. Either way, be sure to check the timer values that the network assigned after registering on the network. Section 3.4 explains how to perform this check.

3. Configuring and Enabling PSM

3.1 Overview

Section 3 describes how to enable PSM on an NL-SW-LTE-QBG96. This section assumes that the reader has read Section 2, and has familiarized themself with PSM, and the relevant PSM timers.

3.2 Firmware Check

PSM functionality is available on firmware BG96MAR02A07M1G and newer. To check the firmware version, issue the following command:

AT+CGMR

The modem should respond with something similar to:

BG96MAR02A07M1G

OK

If the reported firmware version is older than the version listed above, please contact NimbeLink at product.support@nimbelink.com. Otherwise, continue to Section 3.3.

3.3 Configure and Activate PDP Context

Next, configure and activate a PDP context to allow the Skywire to connect to the network. Instructions on how to do this are not explicitly provided in this document, but are available in the NL-SWDK User Manual. A link to this document is below:

https://nimbelink.com/Documentation/Development_Kits/NL-SWDK/30005_NL-SWDK_UserManual.pdf

After the PDP context has been configured and activated, check the network registration status using:

AT+CEREG?

The modem should respond with something similar to:

+CEREG: 0,1

The above response indicates that the modem is currently registered on the network.

Next, enable the highest level of verbosity for the "**+CEREG:**" URC by issuing the following command:

AT+CEREG=4

This extra level of verbosity allows the Skywire to print out the values of the PSM timers after registering on the network. Since the network has the final say in the timer values, it is helpful to enable this URC to check if the network altered the requested PSM timer periods.

3.4 Configure PSM Timer Periods

Before configuring PSM, it is necessary to ensure that the modem has cellular functionality disabled. Issue the following command to disable cellular functionality:

AT+CFUN=0

Next, issue the following command to configure the PSM timer values:

AT+CPSMS=0,,,<T3412>,<T3324>

Where "**0**" specifies to disable PSM mode (for now), "**<T3412>**" and "**<T3412>**" are replaced with custom timer periods.

For example, to request an active time of 1 minute, and an idle time of 12 hours, issue the following command:

AT+CPSMS=0,,,"00101100","00100001"

After issuing some form of the above command, the PSM timer values must be officially requested by re-registering on the network. To do this, issue the following command, which will re-enable cellular functionality and cause the modem to re-register on the network.

AT+CFUN=1

If the "**+CEREG**" URC is enabled, and the highest level of verbosity is selected, the modem will issue the following URC after the Skywire registers on the network:

+CEREG: 4,1,"BE43","BF","2E7BA01",8,,,"00100001","00101100"

The 8-bit binary numbers towards the end of this URC are the PSM timer values that were assigned to the user equipment by the network. The first of these numbers is the "Requested Active Time" value, and the second is the "Requested Periodic Tau" value.

Once the modem has re-registered on the network, proceed to Section 3.5.

3.5 Begin PSM Timer Countdown

After configuring the PSM timers, and registering on the network, start the PSM countdown by issuing the following command:

AT+CPSMS=1

The modem will now wait until the "Requested Active Time" timer expires, before entering PSM idle. Additionally, the modem will not enter PSM if there is an active socket connection, or an active PPP session, for instance. To enter PSM, any active data connections must be closed.

Once in PSM mode, the cycles of waking and idling will continue to occur on the time intervals specified by the network in the "**+CEREG**" URC.

3.6 Disabling PSM

To wake the Skywire from a PSM idle state, temporarily ground the ON_OFF pin of the Skywire, or press the ON_OFF button on the SWDK for a few seconds. This will wake the modem up, and after a short while the AT command interface will become responsive again.

However, this will not disable PSM. The Skywire will continue to return to PSM idle after the "Requested Active Time" timer expires. As such, PSM must be disabled by issuing the following command:

AT+CPSMS=0

This will disable PSM indefinitely until it is re-enabled using the **"AT+CPSMS=1"** command.

3.7 Example PSM AT Command Log

The table below contains a sample AT command log for configuring PSM on the NL-SW-LTE-QBG96.

```
// Verify firmware version
AT+CGMR
BG96MAR02A07M1G


OK


// Enable cellular functionality
AT+CFUN=1
OK


// Configure PDP context
AT+CGDCONT=1,"IPV4V6","[APN]"


OK


// Verify PDP context
AT+CGDCONT?
+CGDCONT:
1,"IPV4V6","[APN]","0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0",0,0,0,0


OK


// Activate PDP context
AT+CGACT=1,1
OK
```

```
// Verify network registration status
AT+CEREG?
+CEREG: 0,1

OK


// Enable +CEREG URC with maximum verbosity
AT+CEREG=4
OK


// Disable cellular functionality
AT+CFUN=0
OK


// Configure PSM timer values, but don't enable PSM yet
AT+CPSMS=0,,,"00011111","10110100"
OK


// Re-enable cellular functionality
AT+CFUN=1
OK

+CEREG: 1,"BE43","BF","2E7BA01",8,,,"00010100","00011111"


// Note: The network overwrote the "Requested Periodic TAU" value
// because it was too short in duration.


// Enable PSM
AT+CPSMS=1
OK

+CEREG: 1,"BE43","BF","2E7BA01",8,,,"00010100","00011111"


POWERED DOWN  // After 31 seconds, the Skywire entered PSM.


RDY // The module woke up from PSM idle after 200 minutes


// Disable PSM
AT+CPSMS=0
OK
```