Y70XX Series_Low Power Mode_Application Note

LPWA Module

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About document

Version History

Version	Date	Author	Discription
1.00	2021-11-26	Xinsheng Wu	New version

Scope

This document is suitable for SIMCom Y7025 series, Y7026 series and Y7012 series.

Contents

1 Introduction

1.1 Purpose of the document

This document focuses on three low-power mode business processes: PSM, eDRX, and sleep, based on the AT instruction manual extension. By referring to this application documentation, developers can quickly understand and develop relevant business processes.

1.2 Related documents

[1] Y70XX Series_AT Command Manual

1.3 Conventions and abbreviations

2 Lower Power Mode Introduction

NB-IoT supports three power saving modes: PSM (Power Saving Mode), DRX (Discontinuous Reception Mode), and eDRX (Extended DRX).

PSM (power saving mode) and eDRX (extended Discontinuous Reception) are used in NB-IOT to save power. In PSM mode, the terminal does not need to receive paging to detect whether there is downlinkservice, and eDRX mode has a longer paging detection period than DRX, which may result in a longer timedelay, which has an impact on the real-time performance of the data. Whether the PSM or the eDRX are used depends on the capabilities and configuration of the terminal and the network. In terms of capabilities, the capability network that the terminal does not support must not be configured, and the capabilities supported by the terminal may be different in different situations of the network.

2.1 PSM mode

In PSM mode, the terminal does not detect whether there is paging data in the downlink. As long as the TAU and uplink need to send data, the PSM state will be exited. T3412 is the time of TAU (Tracking Area Update), and T3324 is the timer that enters PSM in IDLE mode.

2.2 DRX

DRX can be considered that the downlink service can reach the terminal equipment at any time. In each DRX cycle (1.28s, 2.56s, 5.12s or 10.24s), the terminal will detect whether there is a downlink service arrival, which is applicable to services with high requirements for delay. Terminal equipment generally adopts a power supply method, such as a street light service.

- Since the DRX cycle is short (1.28s, 2.56s, 5.12s, or 10.24s, determined by the operator's network side setting), the downlink service can be considered to be reachable at any time with a small delay.
- Applicable to services with high latency requirements, but with relatively high power consumption. Terminal devices generally use power supply.

2.3 eDRX

eDRX has a longer paging cycle than DRX, which enables the terminal to save power and also causes longer downlink data delay (such as DRX value of 1.28s\2.56s, and eDRX value can be 20.48s, even 2.9h), so it is suitable for use in scenarios where time urgency is not very high.

2.4 The difference among three modes

No.	Method	Description
1	PSM	It may take a day or longer time to find the device
2	DRX	Can find devices anytime, anywhere
3	eDRX	It takes from few minutes to an hour or even longer time to find the device

3 PSM Mode

This section focuses on the PSM application characteristics of the Y70XX series modules.

3.1 Working Mode

The Y70XX module has the following operating modes to choose from, which are described below:

Function		Description
Working mode	Active	Active Mode: The system is currently not in low power mode and is instead in a state of cyclic waiting with a high power consumption.All functions are available as normal, and data can be sent and received without any issues. It is possible to switch the module to either Idle mode or PSM mode while in this state.
	Idle	Idle mode： The module is in a low-power sleep state, but the network remains connected, and any interruption can wake up the system. In this state, the module can receive paging messages, and it can be switched to either Active mode or PSM mode.
	PSM	Power saving mode: The module is currently in power-saving mode. In this mode, the CPU is powered down, leaving only the RTC functional. The network is also in a non-connected state, making it impossible to receive downlink data. However, the module can be woken up from this state by either the pre-set RTC timer or AT commands. Doing so will cause the module to exit from PSM mode and enter into Active mode.

Typical low-power modes include DEEPSLEEP and STANDBY modes.

3.1 DEEPSLEEP Mode

When the chip enters DEEPSLEEP mode, only the RST_WKUP pin, UTC, and retention memory (4KB) remain powered on, while all other modules, including peripherals, are powered off. During this time, the chip can only be externally woken up via the RST_WKUP pin. Once woken up, the Core will power up, the PLL will start, and the program will begin running from the boot stage. The wake-up process takes approximately 35ms, after which the AT response can be received.

3.2 STANDBY Mode

When the chip enters STANDBY mode, the VDDIO1 power supply domain remains normal, but the VDDIO2 power supply (for SIM card and XO) is powered down, and the PLL clock stops. Once the chip wakes up, it waits for the crystal to stabilize and starts the PLL. It takes roughly 3ms for the PLL clock to stabilize, during which time the CSP and UART may receive lost characters if they are transmitting or receiving characters. It is important to note that the maximum baud rate of the AT serial port supporting STANDBY mode is only 9600, and that it supports GPI wake-up without the need for an RST_WKUP pin.

3.3 Selection of power saving level

The sleep levels provided by the chip are arranged in descending order of power consumption, with ACTIVE being the most power-intensive and DEEPSLEEP the least. While higher sleep levels are more power-efficient, they cause some hardware resources to shut down, affecting some scenarios. Moreover, the platform offers both static and dynamic ways to control the highest sleep level that can be entered.

DEEPSLEEP Enable: This factory NV parameter is used to switch the DEEPSLEEP level statically. Once set to 0, deep sleep is not possible, and the working lock becomes invalid. Usually, this NV parameter is switched at the same time as STANDBY. To query it, use AT+NV=GET,DEEPSLEEP, and to set it, use AT+NV=SET,DEEPSLEEP,1(0).

STANDBY Enable: This factory NV parameter is used to switch the STANDBY level statically. Once it is set to 0, STANDBY sleep is not available. This NV is usually switched at the same time as DEEPSLEEP. To query it, use AT+NV=GET,STANDBY, and to set it, use AT+NV=SET, STANDBY,1(0).

WFI Enable: This factory NV parameter is used to switch the IDLE level statically. Once it is set to 0, IDLE sleep is not available. However, it is not recommended for customer use. To query it, use AT+NV=GET,WFI, and to set it, use AT+NV=SET, WFI,1(0).

Work Lock/Unlock: This interface is used to switch the DEEPSLEEP sleep dynamically. It needs to be paired to ensure that the user will not enter deep sleep while working and cause process interruption. This parameter is valid only when DEEPSLEEP is enabled.

3.2 PSM Mode

The Y70XX module can activate the PSM function by sending the command "AT+CPSMS=1". Once the condition is met, the module will automatically enter the PSM mode, which is designed to reduce power consumption and extend battery life. In PSM mode, the module's power consumption drops to as low as

1uA. The power consumption of the module in different operating modes is shown in the table below.

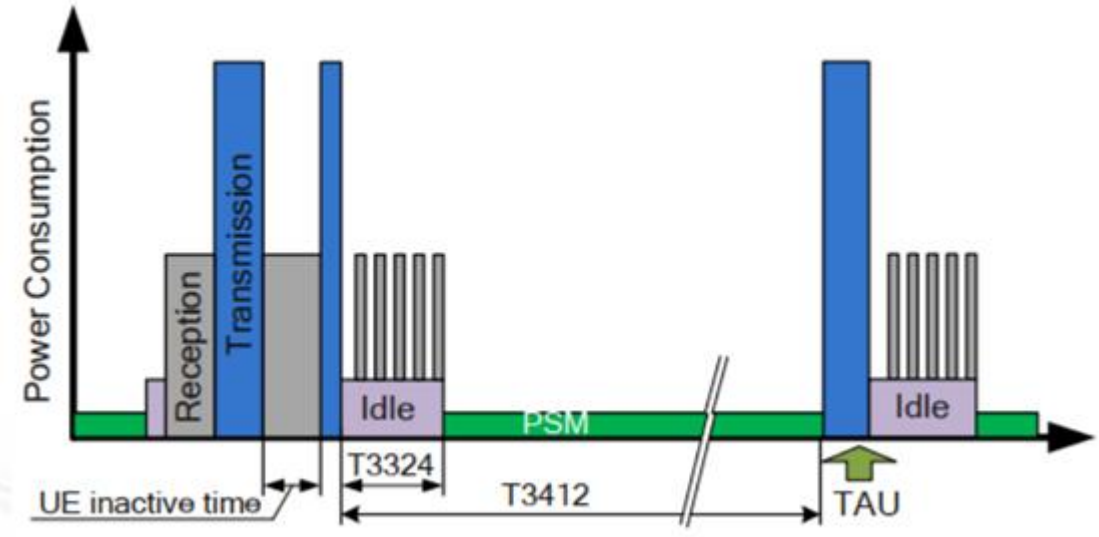

Figure 1 PSM process state diagram

To enter the Power Saving Mode (PSM), the module requests it when establishing a connection with the network or updating the Tracking Area (TAU). The network responds with the PSM timer value and starts the reachable timer. When the PSM timer times out, the module enters the PSM mode. However, it cannot apply for PSM when connecting to the network for emergency services or initializing the public data network.

In PSM mode, most of the networking activities are shut down, including cell message searches and reselection. Nevertheless, the periodic TAU update timer continues to operate.

Once the reachable timer times out, the network cannot page the module until the next time the module initiates the network presence procedure or TAU.

Two ways can exit the PSM. One is when the DTE sends uplink data, and the other is when the TAU is activated, and the T3412 timer times out, and the module exits the PSM.

3.4 PSM wake up

When the Y70XX module enters PSM mode, it terminates the network connection and becomes unresponsive to user requests. To send commands to the module through the serial port, the module needs to be woken up first using the relevant AT command.

There are different ways to exit the module from PSM mode:

- Wait for the network timer T3412 to time out, after which the module will automatically exit PSM mode.
- If the LPUART serial port (UART1) is used for communication, and the baud rate is fixed at 9600bps, AT commands can be sent directly to the module, which will automatically exit PSM mode upon receiving data at the RXD side.
- Pull down the PSM_ENIT pin to wake up the module. When the module detects a low level on the PSM_ENIT pin, it will wake up, and the relevant AT instruction needs to be sent to the module within

10ms. The module will execute the instruction after checking it at the RXD side.

- Pull down the RESET pin to wake up the module. This will cause the module to reboot, and it will re-register and find the network. However, some of the previously set information may be lost and will need to be reset.

NOTE

Pay attention to the time when RESET and PSM_ENIT are pulled low, different low level time corresponds to different functions.

3.5 ATC related PSM

Command	Description
AT+CPSMS	Power saving mode setting
AT+NPSMR	Setting up PSM for automatic reporting
AT+WORKLOCK	Economiser lock
AT+NUESTATS	Querying UE status information

3.6 Description of PSM parameters

The AT+CPSMS command can be used to set various PSM-related parameters. The parameters include <Requested_Periodic-RAU> and <Requested_GPRS-READY-timer>, which do not require any configuration. <Requested_Periodic-TAU> refers to T3412_ext, and <Requested_Active-Timer> refers to T3324. These parameters are expressed as eight-digit binary numbers. The higher three digits indicate the unit, while the lower five digits represent the value. Here's how you can convert the values:

<Requested_Periodic-TAU>

Unit	Base	Min. In Second	Max. in Second
0	10min	2400	18600
1	1h	21600	111600
2	10h	144000	1116000
3	2sec	0	62
4	30sec	90	930
5	1min	960	1860
6	320h	1152000	35712000
7	Timer deactivation	-	-

The default is 20 hours.

Table 1 Parameters of AT+CPSMS command <Requested_Periodic-TAU>

Then 01000111 represents a value of unit = 2(010), value = 7(00111), and the time is 70h (10h * 7).

<Requested_Active-Time>

Unit	Base	Min. In Second	Max. in Second
0	2sec	0	62
1	1min	120	1860
2	6min	2160	11160
7	Timer deactivation	-	-

The default is 5 minutes.

4 eDRX Mode

This section focuses on the eDRX application features of the Y70XX series modules.

4.1 eDRX introduction

4.1.1 eDRX Mode

The eDRX mode is a new feature in the Rel-13. Its main purpose is to support longer-cycle paging monitoring to save power. The traditional 2.56-second paging interval consumes a large amount of power for the UE, and the downlink data transmission frequency is small. Through the negotiation cooperation between the core network and the user terminal, the user terminal skips most of the paging monitoring, thereby achieving the purpose of power saving.

The power saving effect of the eDRX mode is worse than the PSM mode, but the accessibility of the downlink communication link is greatly improved relative to the PSM mode.

The eDRX cycle is shown in Figure 3. The user can check the eDRX cycle by consulting the relevant AT command (AT+CEDRXS)

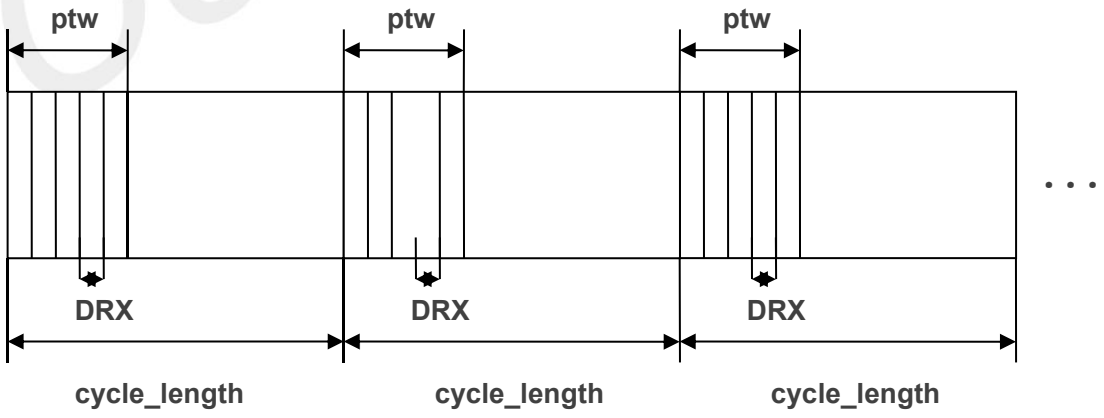

Figure 2 eDRX Schematic

4.1.2 PTW

During each eDRX cycle, there is a Paging Time Window (PTW). The UE can only listen to the paging channel according to the DRX cycle in the PTW to receive downlink traffic. The time outside the PTW is in a sleep state and does not monitor. The paging channel cannot receive downlink traffic.

The PTW cycle is shown in Figure 3. The user can perform the PTW cycle setting by consulting the relevant AT command (AT+CEDRX).

※ NOTE

The user terminal and the core network negotiate the length of the eDRX through the attach and TAU procedures.

4.1.3 eDRX cycle length

eDRX value, octet 3 (bit 4 to 1)
The octet contains the eDRX value field. The values are listed in table3.

4	3	2	1	eDRX cycle length duration
0	0	0	0	5.12 seconds
0	0	0	1	10.24 seconds
0	0	1	0	20.48 seconds
0	0	1	1	40.96 seconds
0	1	0	0	61.44 seconds
0	1	0	1	81.92 seconds
0	1	1	0	102.4 seconds
0	1	1	1	122.88 seconds
1	0	0	0	143.36 seconds
1	0	0	1	163.84 seconds
1	0	1	0	327.68 seconds
1	0	1	1	655.36 seconds
1	1	0	0	1310.72 seconds
1	1	0	1	2621.44 seconds
1	1	1	0	5242.88 seconds
1	1	1	1	10485.76 seconds

Table 3 eDRX cycle length

4.2 ATC related eDRX

Command	Description
AT+CEDRXS	Entended-DRX Setting
AT+NPTWEDRXS	Paging time window set in eDRX
AT+CEDRXRDP	Read Extended DRX Dynamic Parameters

For detailed explanation of AT commands, please refer to the Y70XX Series AT Command Manual.

4.3 Instruction

1. The AT+CEDRXS command can be used to enable or disable the EDRX feature of the module. If the module is already registered with the network, executing this command will initiate a TAU (Tracking Area Update) process. If the network approves the request, the new parameters will apply immediately.

2. The AT+CEDRXRDP command can be used to check if the EDRX request sent by the module is accepted by the network. A response of "+CEDRXRDP: 0" implies that the EDRX request was not accepted by the operator's network.

3. The AT+CEDRX command configures the paging period and PTW (Periodic TAU Timer Window) parameters of the EDRX. However, to apply the new PTW parameters, the module requires a reboot. This command can be used for modifying the PTW parameters.

5 Network Bearer Settings

The PDN is activated and PS service address obtained automatically upon module switch-on, provided that the data card and antenna are functioning properly.

5.1 PDN Auto-activation

//Example of PDN Auto-activation

AT+CPIN?	//Check SIM card status
+CPIN: READY	
OK	
AT+CSQ	//Check RF signal
+CSQ: 13,99	
OK	
AT+CGATT?	//Check PS service. 1 indicates PS has attached
+CGATT: 1	
OK	
AT+CGACT?	//PDN active successfully
+CGACT: 0,1	
OK	
AT+COPS?	//Query Network information, operator and network.
+COPS: 0,2,"46000",9	//9: NB-IOT network
OK	
AT+CGCONTRDP=0	//Query the APN issued by the network after successful registration in CAT-M or NB-IOT network.
+CGCONTRDP:0,5,"ctnb.MNC004.MCC460.GPRS", "100.85.237.178.255.0.0.0","","","","","",,,,,,,	

```
OK
```

5.2 Manually changing the APN configuration

If there are scenarios where you need to change the APN configuration, refer to the following steps.

```
//APN Configuration Example.

AT+CFUN=0                          //Close RF
+CPIN: NOT READY

OK
AT+CGDCONT=0,"IP","ctnb"           //Configure the APN. some carrier network
                                   registration needs to set the APN first
OK
AT+CFUN=1                          //Open RF
OK

+CPIN: READY
AT+CGATT?                          //Check whether the PS service has been
                                   successfully registered. 1 means it has been
                                   successfully registered.
+CGATT: 1

OK
```

6 Examples of PSM applications

6.1 PSM Mode

6.1.1 Enable PSM mode

```
//Enable PSM Mode Example.

AT+NPSMR=1                                  //Enable PSM event reporting
OK
AT+CEREG=4
OK
AT+CEREG?

OK
AT+CPSMS=1,,,"01011111","00000001"          //Enable PSM mode and set T3412_ext and
                                            T3324.
OK

+CEREG:1,2A6E,025C173F,9,,,"00000001","010
11111"

AT+NV=SAVE
REBOOTING

+NPSMR:0
+CEREG:1,2A6E,025C173F,9,,,"00000001","010
11111"
+CTZEU:+32,0,2021/08/23,11:26:51

AT+CEREG?                                   // Query timer for network configuration
+CEREG:
+CEREG:4,1,2A6E,025C173F,9,,,"00000001","0
1011111"
```

```
OK

+NPSMR:1
```

6.1.2 Disable PSM mode

```
//Disable PSM Mode Example.

AT+CEREG=0                          // Disable network registration URC
OK
AT+CPSMS=0                          // Close PSM
OK
```

6.2 eDRX mode

6.2.1 Enable eDRX mode

```
//Enable eDRX Mode Example

AT+COPS?                            // Query network information, operator and network
                                    type

                                    //9 i.e. NB-IOT network
+COPS:0,2,"46000",9

OK
AT+CEDRXS=1,5,"0101","1111"         //Enable eDRX
OK
AT+NV=SAVE                          //Save settings
OK
AT+CEDRXS?                          //Query edrx setting status
+CEDRXS:5,"0101","1111"

OK
AT+CEDRXRDP                         //If supported by eDRX.
                                    // Cycle length of the first "0101" request.
```

```
                                        //Cycle length for the second "0101" network.
                                        //3rd "1111" network issued PTWs
+CEDRXRDP:5,"0101","0101","1111"

OK
AT+CEDRXRDP                             //If eDRX is not supported, return 0.
+CEDRXRDP: 0

OK
```

6.2.2 Disable eDRX mode

```
//Disable eDRX mode

AT+CEDRXS=0                             //Disable eDRX function
OK
AT+NV=SAVE                              //Save settings
OK
AT+CEDRXRDP
+CEDRXRDP: 0

OK
```

6.3 Working with Chip Locks

```
// Use job locks to disable entry into deep sleep mode to ensure that user processes are not interrupted.

AT+WORKLOCK=1                           //Disable the chip from entering deep sleep mode
OK

AT+NSOCR="STREAM",6,1235,1,AF_INET      // Perform socket or other operations
OK

……

                                        //Operational completion
```

```
AT+WORKLOCK=0                    // Execute PSM sleep process after completion to enter deep sleep mode

OK
+NPSMR:1
```