Mechanism and Application Reference for PSM and Sleep Mode of NB-IoT Module

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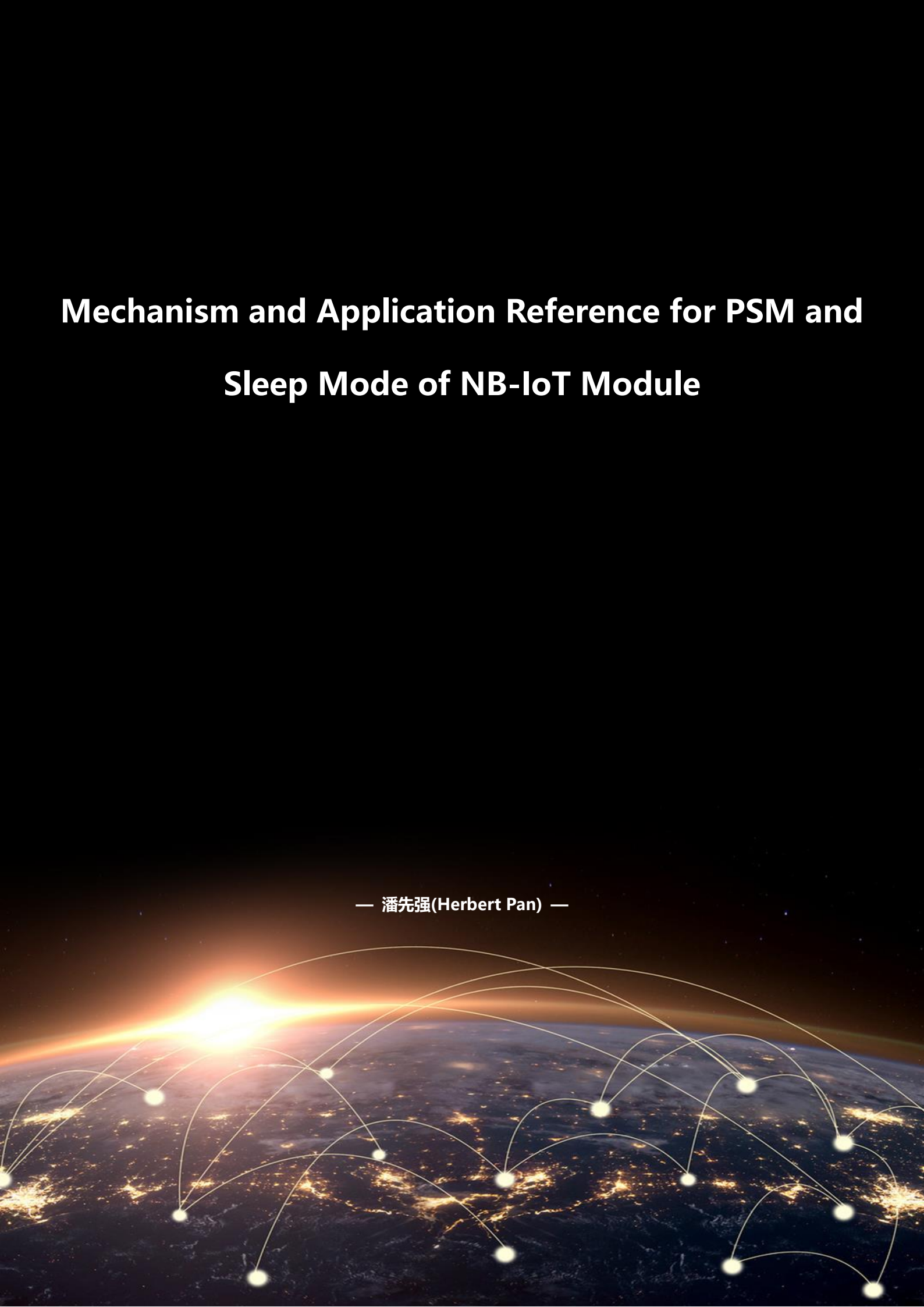

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一、Foreword

The NB-IoT module is often used in business such as low power consumption, long sustainable working time, and battery power. Widely used in industry of smart meter; However, in applications, developers may lack an in-depth understanding of the mechanism of PSM mode and sleep mode of NB-IoT modules, as well as how to enter PSM mode, how to quickly enter low power (sleep), and how to effectively control the module to enter low power and sleep. This document describes and explains the principle and mechanism of PSM mode and sleep mode of NB-IoT module. At the same time, how to effectively apply PSM mode and sleep mode of NB module is explained. In this way, developers can design NB modules with optimal low power consumption in development and application.

二、The Mechanism of PSM and Sleep

In general, NB module can be understood as composed of AP core and CP core. AP core is similar to mcu of modules, which is used to deal with communication protocols and task scheduling related transactions. CP core, which can be called modem, is used to handle baseband&RF and communication control, etc.

PSM usually means that the module enables the PSM function and completes network registration. According to the timer delivered by the network, the modem enters the PSM state after data interaction is completed.

Sleep generally means that the module can enter the sleep state under the following issues when the sleep function is enabled after the module is powered on and booted up:

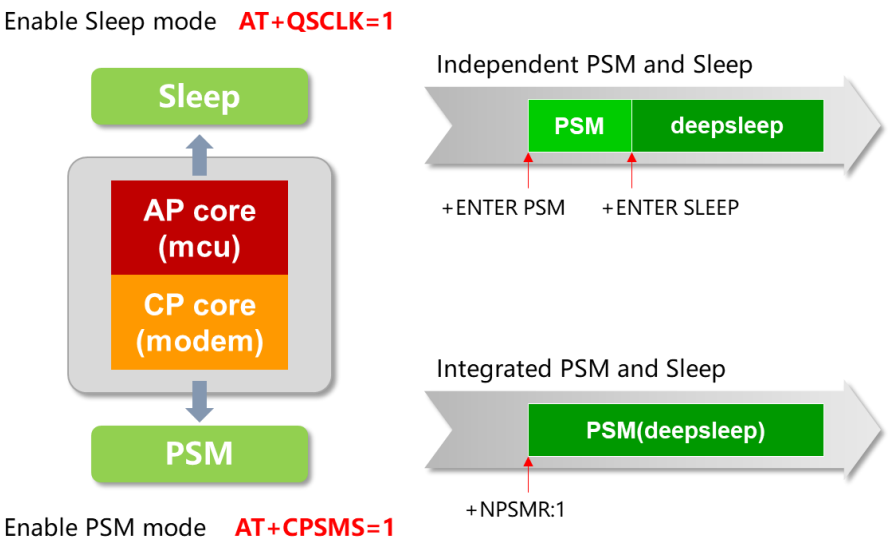
1) In PSM mode, the Modem has entered PSM state, and the AP core enters deepsleep state after completing relevant programs and tasks;
2) In eDRX mode, the Modem stops sending and receiving after PTW, and the AP core enters the deepsleep state;
3) After executing AT+CFUN=0, AP core enters deepsleep state after completing relevant programs and tasks.

PSM and Sleep functions are enabled by default in all NB modules.

Type1:the module of integrated PSM and Sleep function, no QSCLK, you don't need to execute AT+QSCLK=0/1;

Type2:the module of Independent PSM and Sleep function, support the AT+QSCLK, you should according to the actual application requirements, execute AT+QSCLK=1/0;

The NB module enters the low power state, commonly referred to as Sleep mode/state or Deepsleep mode/state; For the module of integrated PSM and Sleep, entering the low power state can also be called PSM mode/state.



Due to the differences in the design of NB chipsets by different chip manufacturers, different models of NB modules have greatly different mechanisms regarding the sleep state; currently they can be divided into two types:

Type 1: In PSM state, PSM Sleep and sleep sleep are merged/integrated, and the modules enter PSM state and at the same time to enter sleep and low power consumption;

Type 2: In PSM state, PSM Sleep and sleep sleep are controlled independently. QSCLK controls the sleep state of AP core. When the module enters PSM state normally, it then enters deepsleep state (sleep function is enabled by default). If AT+QSCLK=0, it will not be able to enter sleep state and deepsleep state, and low power state;

	Type1：Integrated PSM and Sleep	Type2：Independent PSM and Sleep
Domestic	BC28/BC95/BC28CNV/BC95CNV BC28F/BC95GF BC28CNS/BC95CNS	BC25/BC32/BC95B5R/BC95B8R/BC95GR/BC35GR BC260Y/BC300Y BC28CNX/BC95CNX
Overseas	BC68/BC95/BC68GV/BC95GV BC680Z	BC65/BC92 BC660K/BC950K
Notes	1. BC25/BC32/BC95B5R/BC95B8R/BC95GR/BC35GR/BC65/BC92 Deep sleep mode is not supported after executing AT+CFUN=0 2. BC25/BC32/BC95B5R/BC95B8R/BC95GR/BC35GR/BC65/BC92 the wake-up of main UART port is not supported. Only PSM_EINT pin is used for wake-up of sleep； 3. All the above modules support sleep mode without SIM card；	

三、The Process of PSM and Sleep

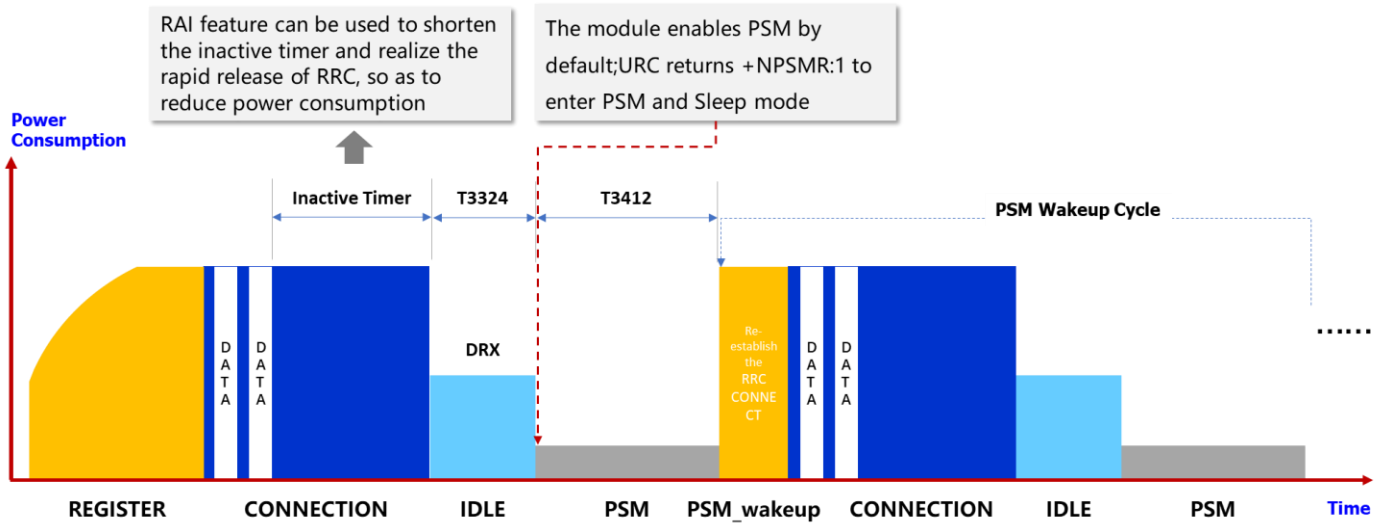
3.1 PSM and Sleep Processes for Type 1

As shown in the figure below, when both the network and SIM card support PSM function, after the type 1 module is powered on and booted up, the following process will be completed: initialization → search network → registration network → data interaction →(inactive timer)→ idle state →PSM state, and it will enter the sleep state (+NPSMR:1). PSM wake-up can be triggered in the following ways:

1) TAU update (i.e. T3412 timeout), the module takes the initiative to wake up PSM and returns +NPSMR:0; If there is no data interaction, the module then quickly enters the PSM state;
2) The host directly sends data to the main UART of the module (based on lwm2m or UDP protocol) and triggers PSM wake-up, and returns +NPSMR:0;
3) The host wakes up the PSM of the module by triggering the relevant protocol stack (such as PING) or updating the network status (such as AT+CPSMS=0/1, manually updating TAU) and returns +NPSMR:0.

After PSM wakes up, the module will complete the following process: Exit PSM(+NPSMR:0)→Re-establish the RRC

connection(+CSCON:1)→ Data interaction →(inactive timer)→ Idle state →PSM state.



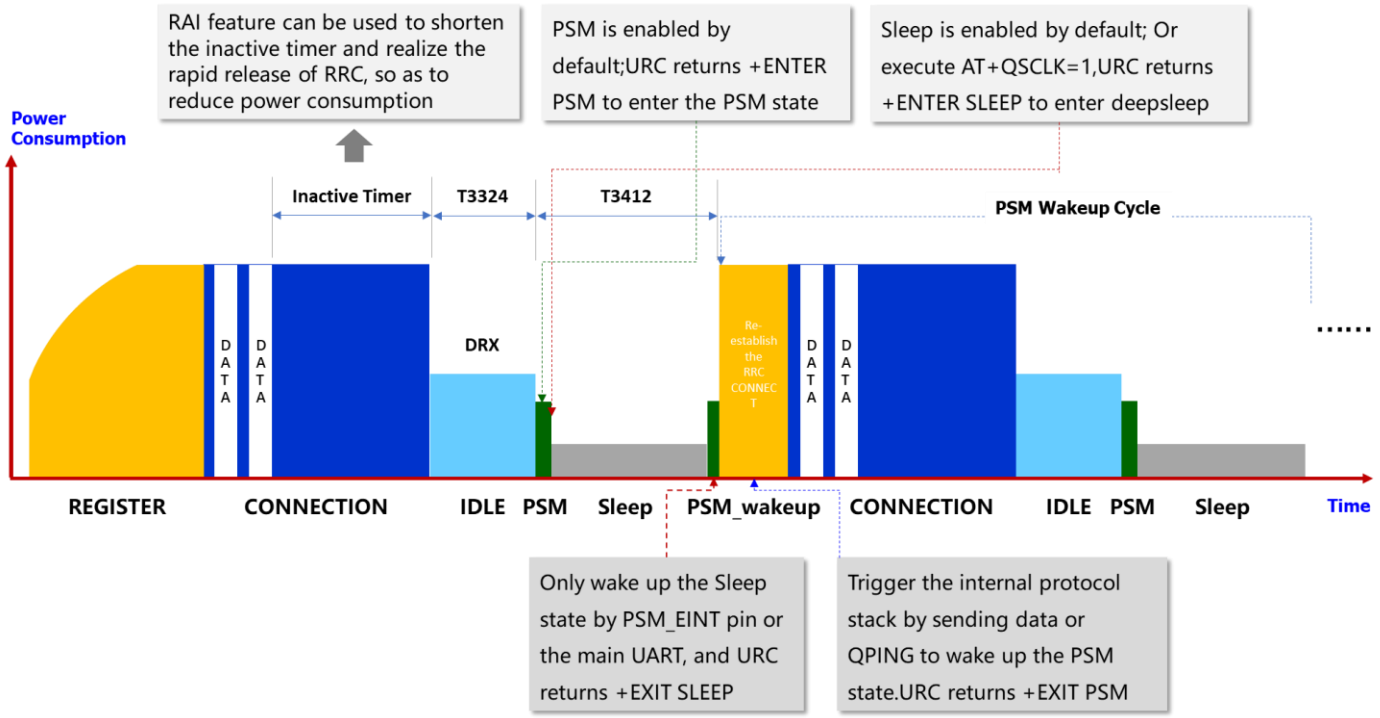
The module of type 1 supports the main UART wake-up. In the PSM sleep state, if you only run AT or other static AT Commands for query, only AP core is awakened and +NPSMR:0 is not returned.

3.2 PSM and Sleep Processes for Type 2

As shown in the figure below, in the case that both the network and SIM card support PSM function, after the type 2 module is powered on and booted up,the following process will be completed: initialization → search network → registration network → data interaction →(inactive timer)→ idle state →PSM state (+ENTER PSM). If AT+QSCLK=1(enabled by default) has been executed, then it immediately enters deepsleep (+ENTER SLEEP); PSM wake-up can be triggered in the following ways:

1) TAU update (i.e. T3412 timeout), the module takes the initiative to wake up PSM and returns +NPSMR:0; If there is no data interaction, the module then quickly enters the PSM and deepsleep state;
2) The host directly sends data to the main UART of module (based on lwm2m or UDP protocol) and triggers PSM wake-up, and returns +EXIT SLEEP,+EXIT PSM;
3) The host wakes up the PSM of the module by triggering the relevant protocol stack (such as PING) or updating the network status (such as AT+CPSMS=0/1, manually updating TAU) and returns +EXIT SLEEP,+EXIT PSM.

After PSM wakes up, the module will complete the following process: EXIT sleep state (+EXIT SLEEP)→ Exit PSM state (+ Exit PSM)→Re-establish the RRC connection(+CSCON:1)→ Data interaction →(inactive timer)→ Idle →PSM (+ENTER PSM)→Sleep (+ENTER SLEEP).



The module of type 1 supports the main UART and PSM_EINT pin wake-up. In the deepsleep state, if you only run AT or other static AT Commands for query, only AP core is awakened and and returns only +EXIT SLEEP, but not +EXIT PSM. Then enter deepsleep again (+ENTER SLEEP); Its re-entry time is controlled by the sleeplock.

BC25/BC32 BC95B5R/BC95B8R/BC95GR/BC35GR BC65/BC92	URC output that enables PSM status AT+QNBIOTEVENT=1,1	URC output of enter PSM state +QNBIOTEVENT: ENTER PSM URC output of PSM status wake-up +QNBIOTEVENT: EXIT PSM
	URC output that enables Sleep state AT+QATWAKEUP=1	URC output of enter Sleep state +QATSLEEP URC output of Sleep status wake-up +QATWAKEUP
BC260Y/BC300Y/BC660K/BC950K	URC output that enables PSM status AT+QNBIOTEVENT=1,1	URC output of enter PSM state +QNBIOTEVENT: "ENTER PSM" URC output of PSM status wake-up +QNBIOTEVENT: "EXIT PSM"
	URC output that enables Sleep state AT+QCFG= "dsevent",1	URC output of enter Sleep state +QNBIOTEVENT: "ENTER DEEPSLEEP" URC output of Sleep status wake-up +QNBIOTEVENT: "EXIT DEEPSLEEP"
BC28CNX/BC95CNX	URC output that enables PSM status AT+QNBIOTEVENT=1,1	URC output of enter PSM state +QNBIOTEVENT: "ENTER PSM" URC output of PSM status wake-up +QNBIOTEVENT: "EXIT PSM"
	URC output that enables Sleep state AT+NPSMR=1	URC output of enter Sleep state +NPSMR:1 URC output of Sleep status wake-up +NPSMR:0

四、The Application of PSM and Sleep mode

The NB-IoT module is often used in business such as low power consumption, long sustainable working time, and battery power. Widely used in industry of smart meter; Current NB terminal application design commonly uses "power-off mode" or "PSM mode"; The “power-off mode” is suitable for scenarios with low frequency of terminal data reporting and simple program logic. The “PSM mode” is suitable for scenarios where terminal data reporting frequency is high, the design program logic is relatively complex, and power consumption is saved compared with power-off mode. For specific application process design, I suggest you refer to “Quectel_For BC660K&BC950K Development and Application Process in Power-off and PSM Mode”.

Power off mode	advantage	The logic of the development program is simple, it is suitable for terminals with low data reporting frequency, and easy to control
	shortcoming	Every time the terminal is powered on and booted up, it needs to search and register the network again
PSM mode	advantage	It is suitable for high frequency of data reporting. In general, PSM does not need to register the network again after waking up, saving power consumption compared with power-off mode
	shortcoming	The logic of the development program is relatively complex, and it needs to control and monitor to the PSM and sleep states, as well as the related exception interrupt handling
Notes	1) Based on power off mode or PSM mode, in application development, you need to add procedures to clear historical frequency points when the search network fails within the planned time 2) When the program or mcu performs hardware reset or power-off directly, you need to execute AT+CFUN=0 first, and return OK， then control hardware reset or power-off; But software reset or reboot does not run AT+CFUN=0.	

4.1 Key Points of the PSM

1) PSM and sleep functions are enabled by default in the NB module. If the current NB network and SIM card(related to APN) support PSM mode, the module of terminal will enter PSM and sleep states after data interaction is completed.
2) If your terminal uses PSM mode, and you want to control the power consumption as low as possible, I suggest that you need to add RAI feature to the program; You can also ask your SIM card provider to configure fixed T3324 and T3412 timer, Or you can request the configuration value to the network by AT+CPSMS=1,,, "<T3412>", "<T3324>", but the real values are provided by the radio network and can query via AT+CEREG=5,AT+CEREG? ;Generally, the network of overseas carriers support T3324=0;
3) Based on PSM mode, when the terminal uses UDP or lwm2m protocol in application development, data can be directly sent after sleep wake-up; However, when you use the TCP or MQTT, the TCP or MQTT needs to re-connect after sleep wake-up.

4.2 Key Points of the Sleep

1) In Type 2 modules, the sleep function is enabled by default. Usually, after the module is powered on in the development design, you need to execute AT+QSCLK=0 to disable the sleep mode, so as to avoid the module entering the deepsleep state in special events. It is generally recommended that you need to execute AT+QSCLK=1 again to start sleep mode after the completion of network registration or data interaction.
2) During terminal application development, if the NB module is powered on and booted up, but does not need network communication at present, you can execute AT+CFUN=0 to enter sleep state to reduce power consumption; When network communication is required, execute AT+CFUN=1 or AT+CFUN=1/AT+CGATT=1 to initiate a network connection.