UC20 Power Management Application Note

UMTS/HSPA Module Series

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1 Introduction

When UC20 module is embedded into host system, it will increase the whole power consumption of the system. Therefore, Quectel provides several power management solutions on UC20 module for the host to lower the overall power consumption by managing module working mode.

UC20 power management solutions mainly consist of the following mechanisms:

- Host controls UC20 module to enter into power saving mode.
- Host wakes up UC20 module
- UC20 module wakes up host

This document illustrates hardware interface and the URC event in UC20 power management first, and then elaborates typical application scenarios about power saving solutions. In the end, it briefly describes the sleep and wakeup software mechanism of UC20 module.

2 Hardware Interface

The communication between UC20 and host is mainly realized through USB and UART port. Besides, UC20 module also provides other functional pins for host to manage power.

2.1. UC20 Pin Assignment

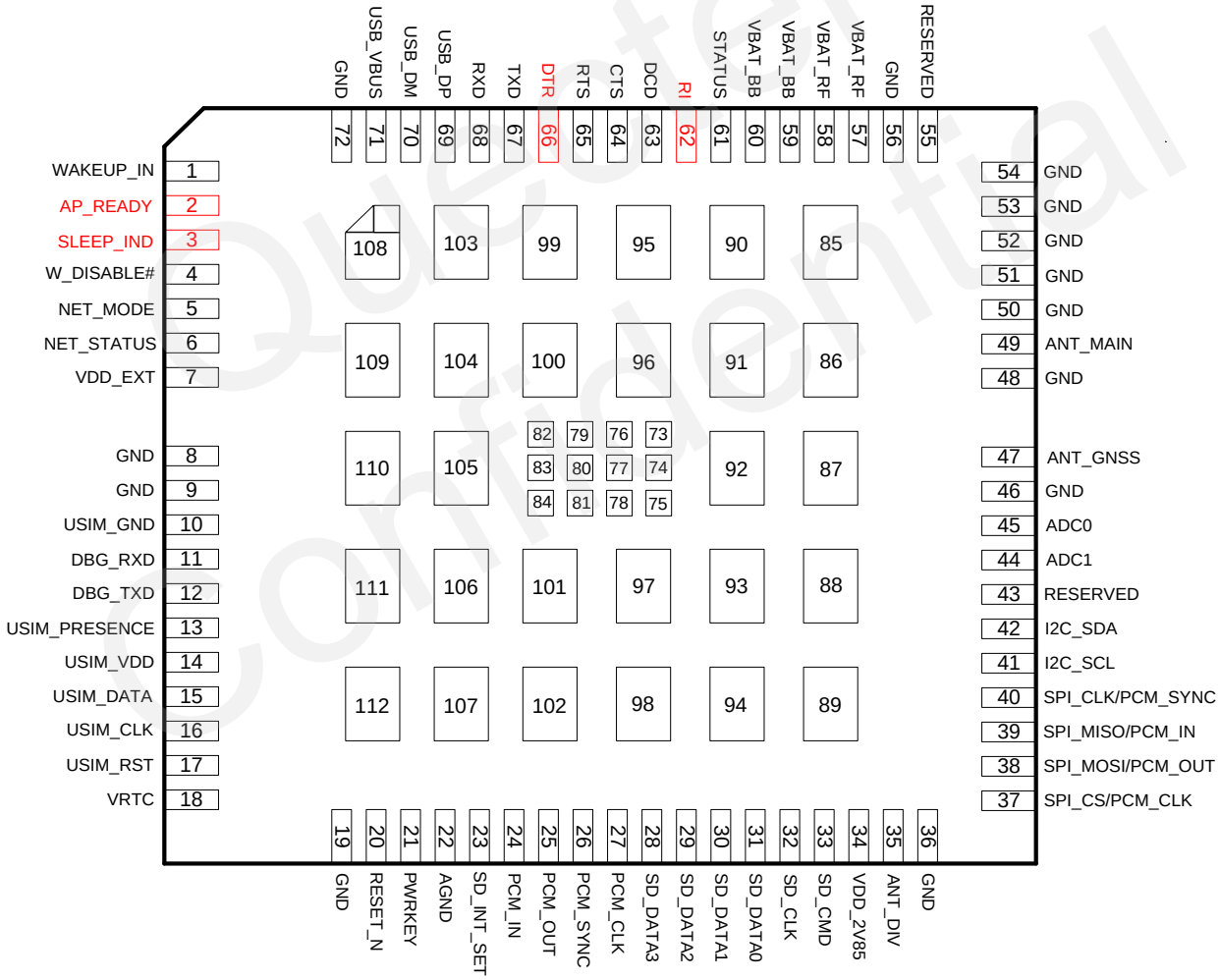

Figure 1: UC20 Pin Assignment (Top View)

2.2. UC20 Power Management Pin

Table 1: UC20 Power Management Pin

Pin Name	Input/Output	Description
DTR	IN	Used for host to wake up UC20 from power saving mode or allow UC20 to enter into the power saving mode. When it is in high level, it means host allows UC20 to enter into power saving mode. When UC20 is in sleep mode, pulling down DTR will wake up UC20. DTR has been pulled up by default.
RI	OUT	Used for UC20 to inform the host there is URC to report. When UC20 has no URC to report, RI will keep in high level. When there is URC to report, RI will output a low pulse. If host is in sleep mode, it will be waked up and process URC.
AP_READY	IN	Used for module to detect whether the host is ready to receive URC or not. Make sure the host receives URC in the ready status to ensure outputted URC will not be lost. You can enable this function by AT+QCFG="apready" to configure the active level and detection interval.

2.3. DTR

You can configure the power saving mode and wakeup control function by AT+QCFG="pwrsavedtr" (This function has been enabled by default). When this function is enabled, pulling up DTR indicates UC20 is allowed to enter into power saving mode. If DTR is pulled down, UC20 would not enter into power saving mode.

2.4. RI

When module needs to send URC to host, RI pin of UC20 will generate a low pulse (It will last 120ms by default, and the time can be configured by AT command) to inform the host. When the host is in power saving mode, you can wake it up by detecting the low pulse. After the host is waked up, AP_READY pin can be used to indicate UC20 that host has been in wakeup mode.

2.5. AP_READY

In practical use, the time for host system to enter into sleep mode and wake up from sleep mode is uncertain. When the host is in light sleep, it can be waked up quickly; host application can quickly recover the AT communication with UC20, and read/write data normally from USB or UART port. When host is in deep sleep, it is slower to wake it up, and it needs more time to recover the communication with UC20,

then it begins to read and write date from USB or UART port. When host and UC20 are in sleep mode at the same time, if UC20 has URC to report, host cannot provide reliable guarantee for the integrity of data receiving during the whole procedure of sleep→wakeup→URC processing. Thus the data reported by module may not be processed effectively.

In order to enable the host to control the procedure of sleep→wakeup→URC processing, UC20 opens AP_READY functional pin and provides AT commands for host to configure. After host has enabled AP_READY pin, module will report the URC to host when the AP_READY pin is in active level, otherwise, URC will be cached in the module side.

2.5.1. Functional Description

When there is URC for UC20 to report, UC20 will detect whether the AP_READY pin is in active level first. After AP_READY function is enabled and AP AP_READY is in active level, UC20 will output the URC to host directly, otherwise, UC20 will cache the URC first, and detect it according to the detection intervals which you have set. And it will not output the URC until AP_READY pin is detected to be active, i.e. host has been waked up.

2.5.2. Example

```
…….

System software initialization
…….

AT+QCFG="apready",1,0,200          //Host enables AP_READY pin. When AP_READY pin is in low level, it indicates the host is in wakeup mode and the module will output the data to host directly If UC20 has URC to report. When AP_READY pin is in high level, it indicates the host is not ready and it will detect the pin at an interval of 200ms till AP_READY pin is in low level. When the AP_READY pin is in low level, the module will output URC to host if it has URC to report.
.
OK

Host and UC20 enter into sleep mode

……

When wakeup event has arrived at UC20, UC20 RI pin will produce a low pulse and report URC. UC20 will detect whether or not the host is waked up from the sleep mode and in ready mode by AP_READY pin first. If host is in ready mode, the module will output URC to host directly, otherwise, it will detect
```

AP_READY pin at an interval of 200ms until the system is in ready mode. As for host, after it has detected the low pulse on the UC20 RI pin, it will be waked up. After the host has been waked up completely, host should pull down AP_READY pin to inform UC20 to output URC. Host will process URC normally after receiving it.

3 Introduction to URC

In normal data interaction process, UC20 not only responds the request from host, but also takes the initiative to report external events to host, such as incoming call and short message. In general, the unsolicited information reported by the module is called URC (Unsolicited Result Code).

The processing of URC is embodied in two aspects: report event information to host actively and generate low pulse on RI pin. In UC20 power management, RI pin can inform the incoming URC to host in the form of pulse after the host enters into sleep mode. For UC20 supports several types of URC, frequent URC report will repeatedly wake up the host from the sleep mode, which will reduce the power management efficiency of the whole system and reduce the effect of power managing. In order to avoid this, host should select corresponding URCs based on its own needs.

3.1. Set URC Port

Generally, UC20 and host communicate with each other by UART or USB port, so the module only reports URC through one of the two ports.

Host can configure URC report port by "AT+QURCCFG", for example, UART port or USB AT port. In specific application scenarios, host can specify URC port according to the actual hardware connection ways. The default port is USB AT port.

3.2. URC Event

In order to avoid host being waked up frequently by URC, host can choose necessary URC events by AT+QINDCFG based on its own needs to optimize power consumption of the whole system.

UC20 contains various URCs. For example, network status URC is used to report the current network status to host. Short message URC is used to report the new incoming short messages. And phone call URC is used to report the call state. For most URCs, you can configure whether to report them or not by AT command. So host can open or close URC report in different system status according to its own needs. For instance, when you first start the system, you can set to actively report the URC relevant to network, short message and phone call by AT command. Before the host enters into sleep mode, you can forbid the report of URC related to network via AT command, but only report the URC relevant to short message and phone call. After the host has entered into sleep mode, it will only be waked up by URC relevant to short message and phone call. In this way, the basic requirements of the host have been met, and the power management efficiency of whole system has been improved as well.

3.3. Example of URC Configuration

```
//The following example shows how to configure the relevant URCs:
AT+CREG=1 or AT+CREG=2          //Enable to actively report the CS network registration status (Disabled by default)
OK
AT+CREG=0                       //Disable to actively report the CS network registration status
OK
AT+CGREG=1 or AT+CGREG=2        //Enable to actively report the PS network registration status (Disabled by default)
OK
AT+CGREG=0                      //Disable to actively report the PS network registration status
OK
AT+QINDCFG="csq",1              //Enable to actively report the value of CSQ signals (Disabled by default)
OK
AT+QINDCFG="csq",0              //Disable to actively report the value of CSQ signals
OK
AT+QINDCFG="ring",1             //Enable to actively report the RING of incoming call (Disabled by default)
OK
AT+QINDCFG="ring",0             //Enable to actively report the RING of incoming call
OK
AT+QINDCFG="smsincoming",1      //Enable to actively report the incoming of new short messages (Disabled by default)
OK
AT+QINDCFG="smsincoming",0      //Disable to actively report the incoming of new short messages
OK
```

NOTE

For more details about AT commands configuration, please refer to *UC20_ATC_Commands_Manual*.

4 Application Scenarios for Power Saving Solutions

4.1. Power Saving Solutions Based on UART Port

4.1.1. Requirements

When the device is implementing power saving solutions, it is required that both host and UC20 are able to enter into power saving mode. Host is communicated with UC20 by UART port, not by USB port. This chapter illustrates the detailed implementation method based on these requirements.

4.1.2. Hardware Connection Configuration

1. Host is connected with UC20 by UART port.
2. Host I/O is connected with UC20 RI pin, and the pin connected with the host must be able to wake up.
3. Host I/O is connected with UC20 DTR pin.
4. Host specifies AP_READY pin of UC20, and host I/O is connected with this pin. (optional, URCs may be lost if AP_READY function is disabled.)

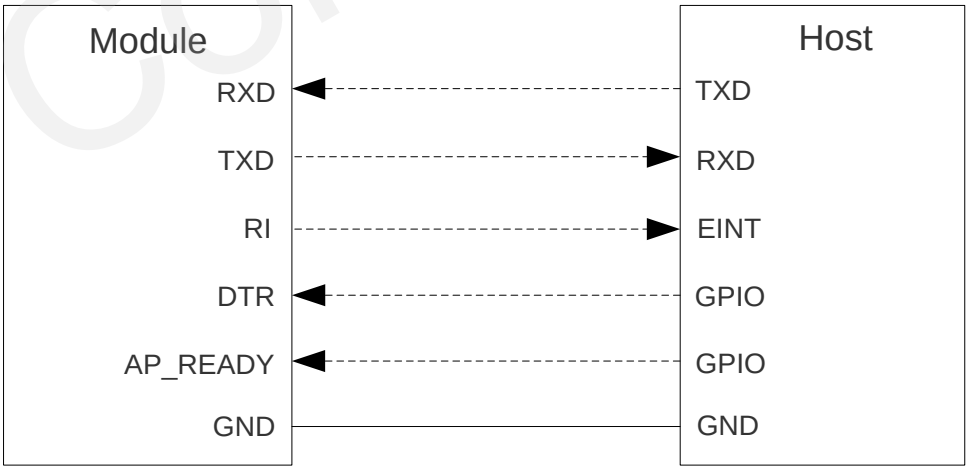

Figure 2: Connection Diagram Based on UART

UART port is an important channel for the communication between UC20 and host. Through reusing the

DTR functional pin in UART port, host can manage the UC20 power easily. Host can enable DTR power management by AT+QCFG="pwrsavedtr",1. When DTR is in high level, the module will be allowed to enter into power saving mode. When DTR is in low level, the module cannot enter into power saving mode.

NOTES

1. The default value of AT+QCFG="pwrsavedtr" is 1, which means DTR power management has been enabled.
2. The connection in dotted line in Figure 2 indicates that the level match between the two systems should be paid attention to in actual application. The connection in solid line means they can be connected directly. Same as the lines in the following connection diagrams of this chapter.

4.1.3. Software Initialization Configuration

1. Configure **AT+QSCLK** control variables to enable UC20 to enter into power saving mode by **AT+QSCLK=1**;
2. Specify UART port to report UC20 URC by **AT+QURCCFG="urcport","uart1"**;
3. Enable DTR pin to control whether or not UC20 enters into power saving mode by **AT+QCFG="pwrsavedtr",1**;
4. Enable UC20 AP_READY function by **AT+QCFG="apready",<enable>[,<level>,[<interval>]]**; (optional)
5. Configure URC needed for UC20 to report by **AT+QINDCFG**;
6. Configure RI pin by AT+QCFG="risignaltype","physical" to pull up/down physical RI on UART1 when reporting URC.

4.1.4. Implementation Method

4.1.4.1. Module Enters into Power Saving Mode

When host enters into sleep mode, pulling up DTR pin enables the module to enter into power saving mode, and setting the AP_READY pin as inactive indicates that host is not in ready mode (If AP_READY function is enabled).

4.1.4.2. Host Wakes up Module

Host pulls down DTR pin, and sets AP_READY pin as active to indicate host is in ready mode now (If AP_READY function is enabled).

4.1.4.3. Module Wakes up Host

When UC20 has URC to report, its RI pin will generate a low pulse (Duration time is 120ms by default, and it can be configured by AT command) to inform the host that URC is coming. When the host is in sleep mode, it is required to ensure that the change of RI pin level can wake up the host itself. After host is waked up, AP_READY pin should be set as active to indicate the host is in ready mode (If AP_READY function is enabled).

4.2. Power Saving Solutions Based on USB Remote Wakeup

4.2.1. Requirements

When the device is implementing power saving solution, it is required that both host and UC20 are able to enter into power saving mode, and host should support USB suspend/resume and remote wakeup functionality. This chapter illustrates detailed implementation method based on these requirements.

4.2.2. Hardware Connection Configuration

1. Connect host with UC20 via USB.
2. Host specifies UC20 AP_READY functional pin, and I/O of host is connected with this pin (optional, URCs may be lost if AT_READY function is disabled).

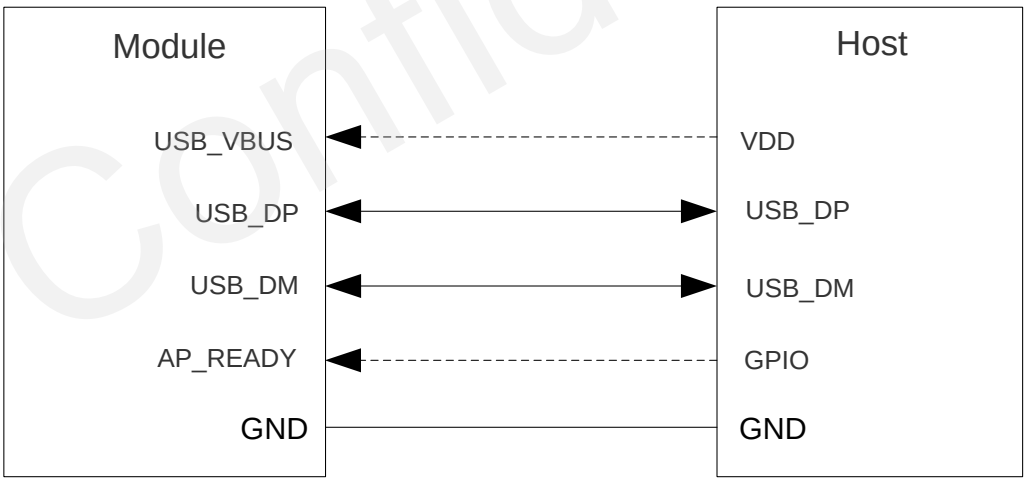

Figure 3: Connection Diagram Based on USB Remote Wakeup

4.2.3. Software Initialization Configuration

1. Configure **AT+QSCLK** control variables to to enable UC20 to enter into power saving mode by **AT+QSCLK=1**;
2. Specify USB AT port to report URC by **AT+QURCCFG="urcport","usbat"**;

3. Enable AP_READY function of UC20 by **AT+QCFG="apready",<enable>[,<level>,[<interval>]]** (optional);
4. Configure URC needed for UC20 to report via A**T+QINDCFG**;
5. Configure the corresponding system and driver settings in host system. (For details, please contact Quectel technical support.)

4.2.4. Implementation Method

4.2.4.1. Module Enters into Power Saving Mode

Host sets the AP_READY pin as inactive (If AP_READY function is enabled) and sends suspend command to module on USB BUS, thus module enters into power saving mode.

4.2.4.2. Host wakes up Module

Host sending data to UC20 through USB will change USB bus from suspend status to resume status to wake up the module. And host also should set AP_READY pin as active (if AP_READY function is enabled).

4.2.4.3. Module Wakes up Host

When UC20 has URC to report, module will send remote wake-up signals to host on USB BUS. Host USB should be able to be waked up through these signals, and then set AP_READY pin as active (If AP_READY function is enabled).

4.3. Power Saving Solutions Based on USB Disconnection

4.3.1. Requirements

When the device is implementing power saving solution, it is required that both host and UC20 are able to enter into power saving mode, and host should not support USB suspend/resume and remote wakeup functionality. So host should disconnect the USB when the device enters into power saving mode. This chapter illustrates detailed implementation method based on these requirements.

4.3.2. Hardware Connection Configuration

1. Connect host with UC20 module via USB;
2. Host specifies UC20 AP_READY pin, and host I/O is connected with this pin (optional, URCs may be lost if AP_READY function is disabled);

3. Host I/O is connected with UC20 RI pin, and the pin must be able to suspend wakeup.

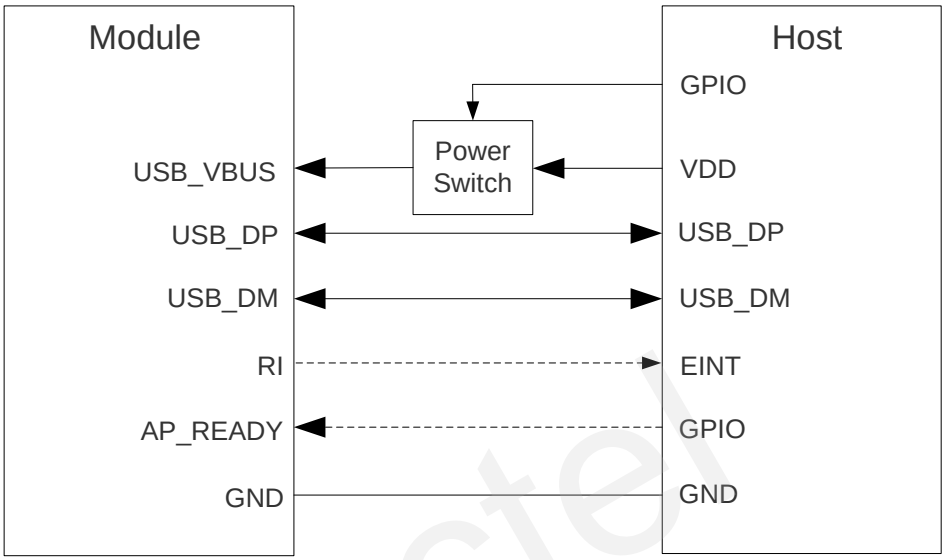

Figure 4: Connection Diagram Based on USB Disconnection

4.3.3. Software Initialization Configuration

1. Configure **AT+QSCLK** control variables to enable UC20 to enter into power saving mode by **AT+QSCLK=1**;
2. Specify USB AT port to report URC by **AT+QURCCFG="urcport","usbat"**;
   Enable the UC20 AP_READY function by **AT+QCFG="apready",<enable>[,<level>,[<interval>]]** (optional);
3. Configure the URC needed for UC20 to report through **AT+QINDCFG**;
4. Configure RI pin by AT+QCFG="risignaltype","physical" to pull up/down physical RI on UART1 when reporting URC.

4.3.4. Implementation Method

4.3.4.1. Module Enters into Power Saving Mode

Host pulls down UC20 USB_VBUS and sets AP_READY as inactive (If AP_READY function is enabled).

4.3.4.2. Host Wakes up Module

Host pulls up UC20 USB_VBUS to wake up the module then sets AP_READY as active (If AP_READY function is enabled). After that, host begins to send data to the module.

4.3.4.3. Module Wakes up Host

When UC20 has URC to report, RI pin will generate a low pulse (Duration time is 120ms by default, and it can be set by AT command). Host must be able to be waked up by RI pin. After the host has been waked up, pull up UC20 UAB_VBUS and set AP_READY as active (If AP_READY function is enabled) to indicate the module outputs URC to host.

4.4. Power Saving Solutions Based on USB Suspend/Resume and RI Pin

4.4.1. Requirements

When the device is implementing power saving solution, it is required that both host and UC20 are able to enter into power saving mode. Meanwhile, host should support USB suspend/resume, but need not support USB remote wakeup functionality, and UC20 RI pin should be the external wakeup source of the host. So, host should disconnect the USB when the device enters into power saving mode. This chapter illustrates detailed implementation method based on these requirements.

4.4.2. Hardware Connection Configuration

1. Connect host with UC20 module via USB;
2. Host specifies UC20 AP_READY pin, and host I/O is connected with this pin (optional, URCs may be lost if AP_READY function is disabled);
3. Host I/O is connected with UC20 RI pin, and the pin must be able to suspend wakeup.

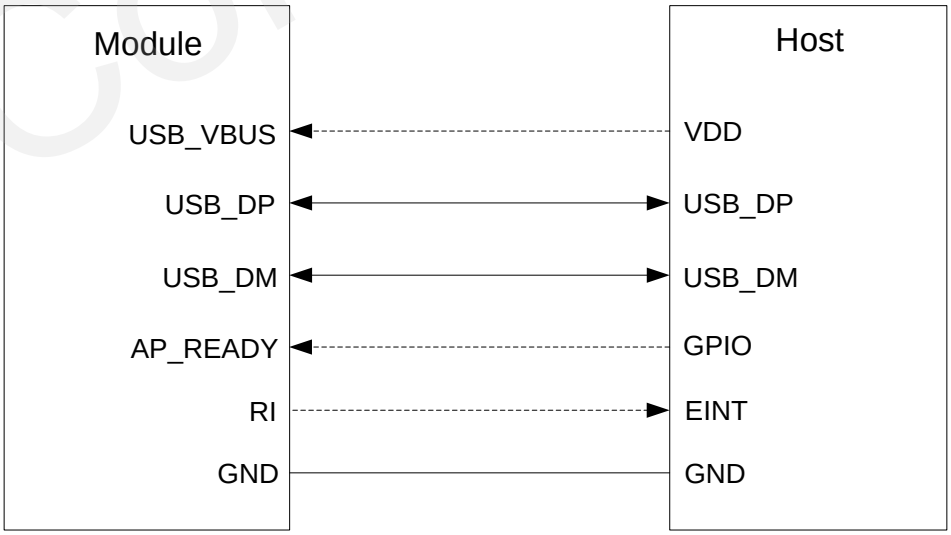

Figure 5: Connection Diagram Based on USB Suspend/Resume and RI Pin

4.4.3. Software Initialization Configuration

1. Configure **AT+QSCLK** control variables to enable UC20 to enter into powering saving mode by **AT+QSCLK=1**;
2. Specify USB AT port to report URC by **AT+QURCCFG="urcport","usbat"**;
3. Enable the UC20 AP_READY function by **AT+QCFG="apready",<enable>[,<level>,[<interval>]]** (optional);
4. Configure the URC needed for UC20 to report through **AT+QINDCFG**;
5. Configure RI pin by AT+QCFG="risignaltype","physical" to pull up/down physical RI on UART1 when reporting URC.

4.4.4. Implementation Method

4.4.4.1. Module Enters into Power Saving Mode

Host sets AP_READY pin as inactive (If AP_READY function is enable), and sends suspend command to module on USB BUS to make module enter into powering saving mode.

4.4.4.2. Host Wakes up Module

Host sends resume command to module through USB BUS to wake up the module and then host needs to set AP_READY pin as active (If AP_READY function is enabled).

4.4.4.3. Module Wakes up Host

When UC20 has URC to report, RI pin will generate a low pulse (Duration time is 120ms by default, and the time can be set by AT command). Host must be able to be waked up by RI pin. After host has been waked up, host sets AP_READY as active (If AP_READY function is enable) to indicate the module can output URC to host.

5 AT Command

5.1. AT+QCFG="pwrsavedtr" Enable/Disable DTR to Control Power Saving Mode

AT+QCFG="pwrsavedtr" can be used to enable or disable physical DTR pin to control whether or not module can enter into power saving mode.

AT+QCFG="pwrsavedtr" Enable/Disable DTR to Control Power Saving Mode	
Write Command **AT+QCFG="pwrsavedtr"[,<value>]**	Response If configuration parameters are omitted (**+QCFG="pwrsavedtr"**), return current configuration: **+QCFG: "pwrsavedtr",<value>** **OK** If configuration parameters are entered: **OK** **ERROR** If error is related to ME functionality: **+CME ERROR: <err>**
Maximum Response Time	300ms

Parameter

<value>	Number format, enable/disable DTR to control power save state. While **<value>** is enabled, pulling up DTR pin can trigger module to enter into power saving mode and pulling down DTR pin can wake up module. This option is only valid for non-mux mode, and cannot be saved. After module is restarted, it will return to default value. 0 Disable 1 Enable

5.2. AT+QCFG="apready" Extension Configuration

AT+QCFG="apready" is used to set status detection for AP_READY pin. AP_READY (PIN2) is the default indicator pin. MCU could change the level indicator pin according to its actual demands.

When URC is reported and the level of indicator pin is invalid, this module will store the reported URC and periodically detect indicator pin's level until it turns to be valid, and then stored URC will be reported. When the reported URC is stored, RI pin status will still change according to your configuration.

AT+QCFG="apready" Extension Configuration	
Test Command **AT+QCFG=?**	Response **……** **+QCFG: "apready",(0,1),(0,1),(100-3000)** **……** **OK**
Read Command **AT+ QCFG="apready"**	**+QCFG:"apready",<enable>,<level>,<interval>** **OK**
Set Command **AT+QCFG="apready",<enable >[,<level>,[<interval>]]**	Response **OK** **ERROR**

Parameter

<enable> Enable/disable status detection of AP ready
0 Disable status detection of AP ready
1 Enable status detection of AP ready

<level> Indicator pin's valid level. The parameter is only effective when indicator pin's detection is running.
0 Low level
1 High level

<interval> Detection period, unit is ms. The parameter is only effective when indicator pin's detection is running. When indicator pin's level is invalid and URC is reported, this parameter will be used as detection interval to check indicator pin's level until it is valid. The default value is 500ms.

NOTES

1. The configuration will be saved to NV automatically.
2. The maximum size to store URC is 15. Module will clear the earliest URC to store new one when exceeds 15.
3. When AP ready is running, module only stores one "RING" during call.

4. The default level of AP_READY depends on parameter <level>.

Example

```
AT+QCFG="apready",1,0,800          //Set configuration
OK
AT+QCFG="apready "
+QCFG: “apready”,0,0,300           //Read configuration

OK
```

5.3. AT+QCFG="risignaltype" Ring Line Signal Outputting Carrier

AT+QCFG="risignaltype" specifies the carrier of ring line signal outputting.

AT+ QCFG="risignaltype" Ring Line Signal Outputting Carrier	
Write Command **AT+QCFG="risignaltype",[<risignatype>]**	Response If configuration parameters are omitted (**+QCFG="urc/ri/other"**), return current configuration: **+QCFG: "risignaltype",<risignatype>** **OK** If configuration parameters are entered: **OK** **ERROR** If error is related to ME functionality: **+CME ERROR: <err>**
Maximum Response Time	300ms

Parameter

<risignatype>	The carrier of ring line signal output	
	"respective"	The ring line behaves on the port which URC is presented. For example, if URC is presented on UART port, it is physical ring line. If URC is presented on USB modem port, it is virtual ring line. If URC is presented on USB AT port, for USB AT port does not support ring signal, there will no ring signal on the USB AT port. **+QURCCFG=”urcport”** can get the port which URC is presented.

	"physical"	No matter which port URC is presented on, URC invariably causes pull-up/down of the physical ring line.

5.4. AT+QURCCFG Configure URC Indication Option

This command is used to configure the output port of URC.

AT+QURCCFG Configure URC Indication Option	
Test Command **AT+QURCCFG=?**	Response **+QURCCFG: "urcport",("usbat","usbmodem","uart1")** **OK**
Write Command **AT+QURCCFG="urcport"[,<urcportvalue>]**	If configuration parameters are omitted, return current configuration: **+QURCCFG: "urcport",<urcportvalue>** **OK** If configuration parameters are entered, response **OK** **ERROR**
Read Command **AT+QURCCFG?**	Response Return current configurations: **+QURCCFG: "urcport",<urcportvalue>** **OK**
Maximum Response Time	300ms

Parameter

<urcportvalue>	Set URC output port	
	"usbat"	USB AT port
	"usbmodem"	USB modem port
	"uart1"	Main UART

NOTES

1. Configuration of URC output port will be saved to NV immediately by default.
2. After configuration of URC output port is set successfully, it will take effect immediately.

Example

```
AT+QURCCFG=?
+QURCCFG: "urcport",("usbat","usbmodem","uart1")

OK
AT+QURCCFG?
+QURCCFG: "urcport","usbat"

OK
AT+QURCCFG="urcport","uart1"
OK
AT+QURCCFG?
+QURCCFG: "urcport","uart1"

OK
```

6 Software Mechanism

6.1. UC20 Power Saving Mechanism

There is a lower-priority sleep mission within UC20, which is used to detect whether UC20 can enter into power saving mode or not. Other service missions (such as RF/USB/UART and so on) and power saving control variables have rights to vote on the power saving mission to decide whether or not the module can enter into power saving mode. When other service missions and power saving control variables both agree UC20 to enter into power saving mode, power saving mission will be executed and UC20 will enter into power saving mode. It should be noted that when UC20 enters into power saving mode, RF will not be shut down but enter into DRX mode.

6.2. UC20 Power Saving Process

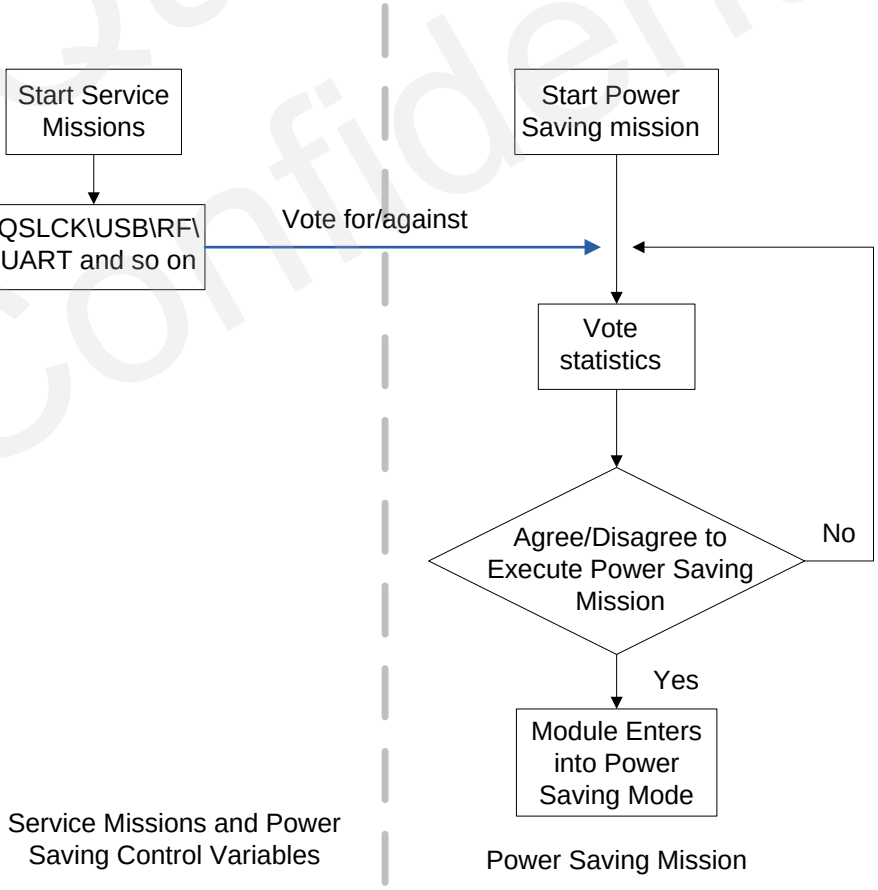

Figure 6: UC20 Power Saving Process

6.3. USB Power Saving Mechanism

When USB is working normally, root hub in hub or HCD will send SOF package periodically (full speed USB sends one package at an interval of 1ms, high speed USB sends one package at an interval of 125μs). At this time, USB on UC20 will vote against the module entering into power saving mode.

According to the description of suspend in USB standard protocol, when the host system sets the port attached with USB device in hub or root hub as suspend, hub or root hub will stop sending SOF package and USB bus will enter into suspend mode. Then USB on UC20 will enter into suspend mode, and vote for the module to enter into power saving mode.

NOTES

1. Quectel provides USB suspend solutions of UC20 for different host systems. You can control UC20 to enter into power saving mode on host system by these solutions.
2. If you use the USB driver developed by your own, the driver should support both global suspend and selective suspend functions.

6.4. Module Wakes up Host

6.4.1. Host Wake-up Event

Host wake-up event is the event that UC20 takes the initiative to report information to host and wake up host when host is in sleep mode. Host wakeup event is also called URC.

6.4.2. USB Remote Wakeup

When host enters into sleep mode, and host USB bus is in suspend mode, if UC20 has URC to report, it will send remote wakeup signals (duration time>3ms) to inform the host to resume USB.

The key points of UC20 remote wakeup are listed as follows:

- Host USB controller must support remote wakeup, and it can wake up host. If USB controller does not support remote wakeup, it will not process remote wakeup signals received from UC20 module. Similarly, if USB controller cannot wake up the host, then host will not be waked up from sleep mode by USB remote wakeup.

- As for host, UC20 remote wakeup function can be set by USB standard request. Host can enable remote wakeup function by "SET_FEATURE" and disable it by "CLEAR_FEATURE". Before host enters into sleep mode, UC20 remote wakeup function must be enabled.

- When UC20 sends remote wakeup signals to host, host must keep resume signals for at least 20ms. After that, USB bus will enter into idle state. And before USB bus enters into idle state, USB controller must retrieve to send SOF package on USB bus within 3s. Otherwise, UC20 would enter into suspend mode again.

7 Appendix A Reference

Table 2: Terms and Abbreviations

Abbreviation	Description
USB	Universal Serial Bus
URC	Unsolicited Result Code
DRX	Discontinuous Reception
AP	Application
I/O	Input/output