QUECTEL®
Build a Smarter World

BC66&BC66-NA-QuecOpen User Guide

NB-IoT Module Series

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About the Document

Revision History

Version	Date	Author	Description
1.0	2018-09-13	Lebron LIU/ Flame YANG	Initial
1.1	2020-02-06	Sheffer GU	1. Updated the term “OpenCPU” into “QuecOpen”. 2. Added the applicable module BC66-NA-QuecOpen. 3. Updated the number of GPIOs into 23. 4. Added “App version” as a customization item in Table 4. 5. Updated block storage space for backup data in Chapter 5.1.1.7. 6. Added FreeRTOS system APIs in Chapter 5.1.2. 7. Added microsecond timer APIs in Chapter 5.3.2. 8. Added power down, power supply voltage, wakeup reason and deep sleep APIs in Chapter 5.5.2. 9. Added two I/O pins for ADC functions and an ADC value read API in Chapter 5.7.5. 10. Added the SPI full-duplex communication API in Chapter 5.7.7.

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1 Introduction

QuecOpen® is an embedded development solution for M2M applications where Quectel modules can be designed as the main processor. It has been designed to facilitate the design and accelerate the application development. QuecOpen® makes it possible to create innovative applications and embed them directly into Quectel modules to run without any external MCU. It has been widely used in M2M field, such as smart home, smart city, tracker & tracing, automotive, energy, etc.

This document mainly introduces how to implement QuecOpen® solution on Quectel NB-IoT BC66 and BC66-NA modules.

2 QuecOpen® Platform

2.1. System Architecture

The following figure shows the fundamental principle of QuecOpen® software architecture.

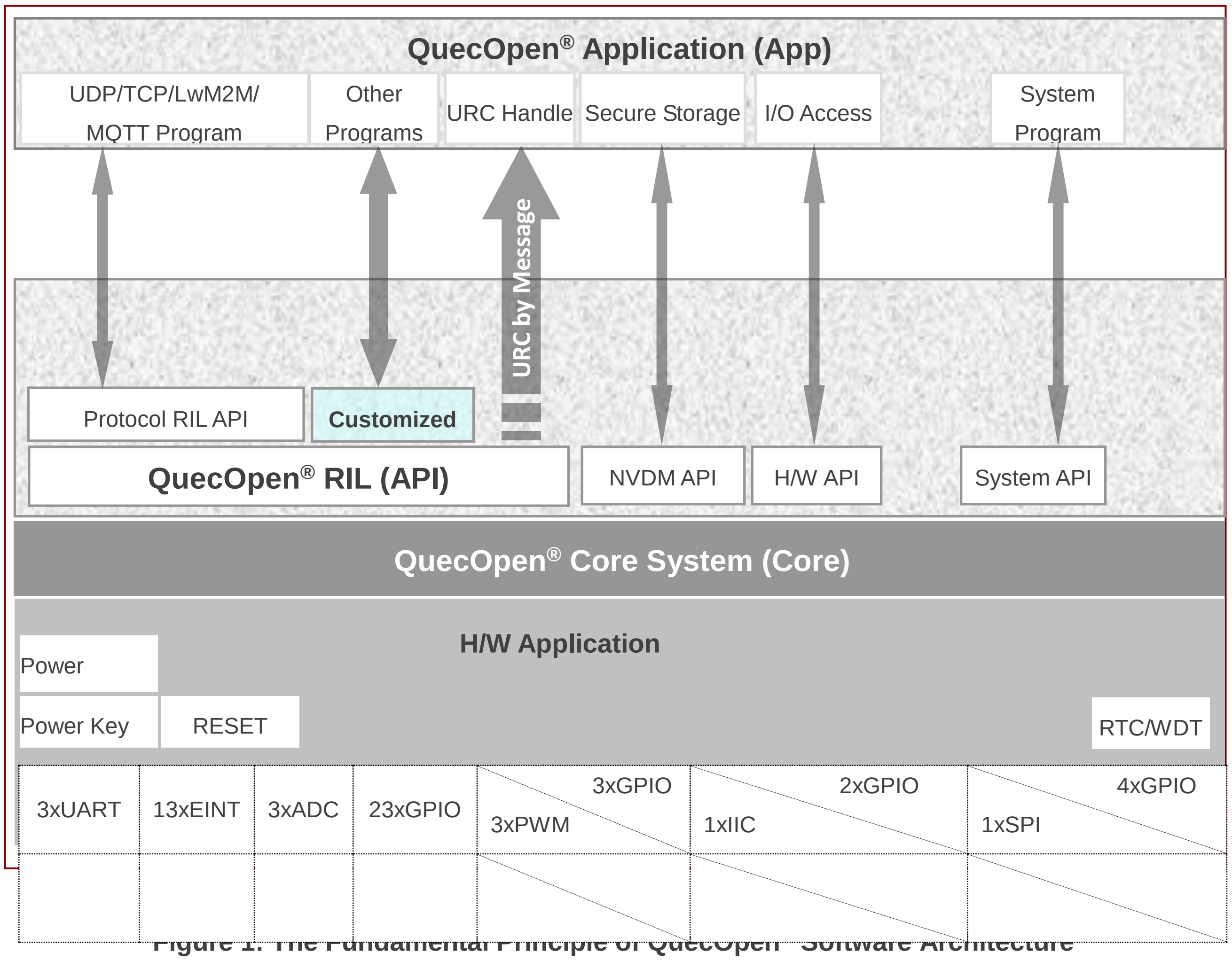


Figure 1: The Fundamental Principle of QuecOpen® Software Architecture

PWM, EINT, IIC, SPI and ADC are multiplexing interfaces with GPIOs.

QuecOpen® Core System is a combination of hardware and software of NB-IoT module. It has built-in ARM Cortex-M4 processor, and has been built over FreeRTOS operating system which has the characteristics of micro-kernel, real-time, multi-tasking, etc.

QuecOpen® user APIs are designed for accessing to hardware resources, radio communications resources, or external devices. All APIs are introduced in ***Chapter 5***.

QuecOpen® RIL is an open source layer, which enables developers to simply call API to send AT commands and get the response when API returns. Additionally, new APIs can be easily added to implement AT commands. For more details, please refer to ***document [3]***.

In QuecOpen® RIL, all URC messages of module have already been reinterpreted and the result is informed to App by system message. App will receive the message MSG_ID_URC_INDICATION when a URC arrives.

2.2. Open Resources

2.2.1. Processor

- BC66-QuecOpen: 32-bit ARM Cortext-M4 RISC 78 MHz.
- BC66-NA-QuecOpen: 32-bit ARM Cortext-M4 RISC 156 MHz.

2.2.2. Memory Scheme

BC66-QuecOpen/BC66-NA-QuecOpen builds in a 4 MB flash and a 4 MB RAM.

- User App Code Space: 200 KB space available for image bin
- RAM Space: 100 KB static memory and 300 KB dynamic memory

2.3. Interfaces

2.3.1. Serial Interfaces

BC66-QuecOpen/BC66-NA-QuecOpen provides 3 UART ports: UART0 (Main UART), UART1 (Auxiliary UART) and UART2 (Debug UART). Please refer to ***Chapter 5.7.1*** for software API functions.

UART1 and UART2 provide debug function to enable Core system debugging. And UART1 supports hardware flow control. For more details, please refer to ***Chapter 5.8***.

2.3.2. GPIO

There are 23 I/O pins that can be configured into general purpose I/Os. All pins are accessible through corresponding API functions. Please refer to ***Chapter 5.7.2*** for details.

2.3.3. EINT

BC66-QuecOpen/BC66-NA-QuecOpen supports external interrupt inputs. There are 13 I/O pins that can be configured into external interrupt inputs. Please don't use EINT pins for high-frequent interrupt detections so as to avoid instability of the module. The EINT pins can be accessed by APIs. Please refer to ***Chapter 5.7.3*** for details.

2.3.4. PWM

There are 3 I/O pins that can be configured into PWM pins. 32K and 13M clock sources are available. The PWM pins can be configured and controlled by APIs. Please refer to ***Chapter 5.7.4*** for details.

2.3.5. ADC

There are two I/O pins and one analogue input pin that can be configured into ADC. The ADC value can be read by *Ql_ADC_Read* interface. Please refer to ***Chapter 5.7.5*** for more details.

Please refer to ***document [2]*** or ***document [6]*** for the characteristics of ADC interface.

2.3.6. IIC

BC66-QuecOpen/BC66-NA-QuecOpen provides a hardware IIC interface. Please refer to ***Chapter 5.7.6*** for more details.

2.3.7. SPI

BC66-QuecOpen/BC66-NA-QuecOpen provides a hardware SPI interface. Please refer to ***Chapter 5.7.7*** for more details.

2.4. Development Environment

2.4.1. SDK

QuecOpen® SDK provides resources as follows for developers:

- Compiling environment
- Development guide and other related documents
- A set of header files that defines all API functions and type declaration
- Source code for examples
- Open source code for RIL

- Download tool for application image bin files

Please contact Quectel Technical Supports at support@quectel.com to obtain the latest SDK package.

2.5. Editor

Text editors are available for editing codes, such as Source Insight, Visual Studio and even Notepad.

The Source Insight tool is recommended to be used to edit and manage codes. It is an advanced code editor and browser with built-in analysis for C/C++ program, and provides syntax highlighting, code navigation and customizable keyboard shortcuts.

2.5.1. Compiler and Compiling

2.5.1.1. Complier

QuecOpen® uses GCC as the compiler, and the compiler edition is *arm-none-eabi-gcc v4.8.3*. The GCC compiler is provided under *tools* directory by default, and no additional installation is needed.

2.5.1.2. Compiling

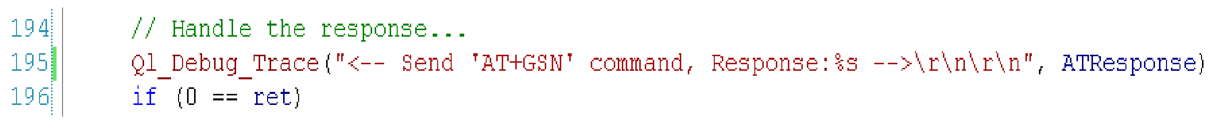
In QuecOpen® solution, compiling commands are executed in command lines. The clean and compiling commands are defined as below.

```
make clean
make new
```

2.5.1.3. Compiling Output

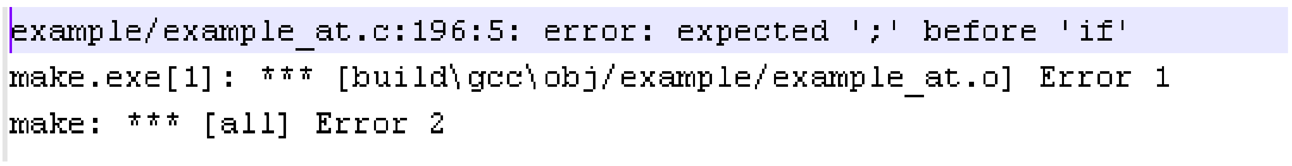
In a command-line, some compiler processing information will be output during compiling. All WARNINGs and ERRORs are recorded in *\SDK\build\gcc\build.log.* Therefore, if there exists any compilation error during compiling, please check *build.log* for the error line number and the error hints.

For example, in line 195 of the following code, the semicolon is missed intentionally.



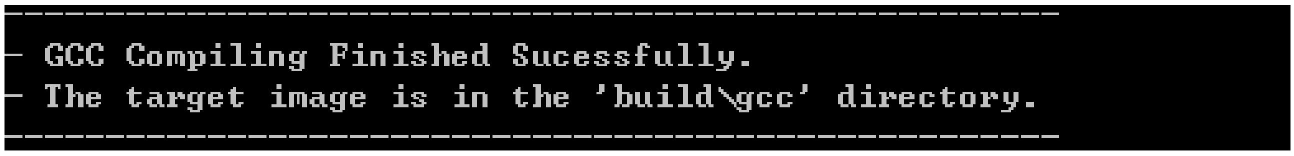
```
194        // Handle the response...
195        Ql_Debug_Trace("<-- Send 'AT+GSN' command, Response:%s -->\r\n\r\n", ATResponse)
196        if (0 == ret)
```

When compiling this example program, a compilation error will be shown in *build.log* as follows:



```
example/example_at.c:196:5: error: expected ';' before 'if'
make.exe[1]: *** [build\gcc\obj/example/example_at.o] Error 1
make: *** [all] Error 2
```

If there is no compilation error during compiling, the prompt for successful compiling will be given as below.



```
-----------------------------------------------------------------
- GCC Compiling Finished Sucessfully.
- The target image is in the 'build\gcc' directory.
-----------------------------------------------------------------
```

2.5.2. Download

QFlash tool is typically used to download the application bin. Please refer to ***document [4]*** for more details about the tool and its usage.

2.5.3. How to Program

By default, the *custom* directory has been designed to store developers' source code files in SDK.

2.5.3.1. Program Composition

The composition of QuecOpen® program is described as follows.

Table 1: QuecOpen® Program Composition

Item	Description
.h, .def files	Declarations for variables, functions and macros.
.c files	Source code implementations.
makefile	Define the destination object files and directories to be compiled.

2.5.3.2. Program Framework

The following codes are the least codes that comprise a QuecOpen® Embedded Application.

```
/**
 * The entrance of this application.
 */
void proc_main_task(s32 taskId)
{
    ST_MSG msg;

    //Start message loop of this task
    while (1)
    {
        Ql_OS_GetMessage(&msg);
        switch(msg.message)
        {
        case MSG_ID_RIL_READY:
            {
                Ql_Debug_Trace("<-- RIL is ready -->\r\n");

                //Before use the RIL feature, you must initialize it by calling the following API
                //After receive the 'MSG_ID_RIL_READY' message.
                Ql_RIL_Initialize();

                //Now you can start to send AT commands.
                Demo_SendATCmd();
                break;
            }
        case MSG_ID_URC_INDICATION:
        {
            //Ql_Debug_Trace("<-- Received URC: type: %d, -->\r\n", msg.param1);
            switch (msg.param1)
            {
            case URC_SYS_INIT_STATE_IND:
                Ql_Debug_Trace("<-- Sys Init Status %d -->\r\n", msg.param2);
                break;
            case URC_SIM_CARD_STATE_IND:
                Ql_Debug_Trace("<-- SIM Card Status:%d -->\r\n", msg.param2);
                break;
            case URC_EGPRS_NW_STATE_IND:
                Ql_Debug_Trace("<-- EGPRS Network Status:%d -->\r\n", msg.param2);
                break;
            case URC_CFUN_STATE_IND:
                Ql_Debug_Trace("<-- CFUN Status:%d -->\r\n", msg.param2);
                break;
            case URC_NEW_SMS_IND:
                Ql_Debug_Trace("<-- New SMS Arrives: index=%d\r\n", msg.param2);
                break;
            default:
                Ql_Debug_Trace("<-- Other URC: type=%d\r\n", msg.param1);
                break;
            }
            break;
        }
         //
         //Case other user message ID...
         //
        default:
            break;
        }
    }
 }
```

The *proc_main_task* function is the entrance of Embedded Application, just like the *main()* in C application.

Ql_OS_GetMessage is an important system function which enables the Embedded Application to retrieve messages from message queue of the task.

MSG_ID_RIL_READY is a system message sent by the RIL module to the main task.

MSG_ID_URC_INDICATION is a system message that indicates a new URC is coming.

2.5.3.3. Makefile

In QuecOpen® solution, the compiler compiles programs according to the definitions in makefile. The profile of makefile has been pre-designed and is ready for use. However, it is necessary to change some settings before compiling programs according to native conditions, such as the compiler environment path.

\SDK\make\gcc\gcc_makefile\gcc_makefile needs to be maintained. This makefile mainly includes:

- Environment path definition of compiler
- Preprocessor definitions
- Definition of header fileSource code directories and files to be compiled
- Library files to link

2.5.3.4. How to Add .c File

Suppose that the new file is in *custom* directory, and the newly added .c files will be compiled automatically.

2.5.3.5. How to Add Directory

If a new directory needs to be added in *custom*, please follow the steps below.

1. Add the name of the new directory in variable "SRC_DIRS" in *\SDK\make\gcc\gcc_makefile\gcc_makefile*, and define the source code files to be compiled.

```
#-------------------------------------
# Configure source code dirctories
#-------------------------------------
SRC_DIRS=example     \
         custom      \
         custom\config      \
         ril\src     \
```

2. Define the source code files to be compiled in the new directory.

```
SRC_SYS=$(wildcard custom/config/*.c)
SRC_SYS_RIL=$(wildcard ril/src/*.c)
SRC_EXAMPLE=$(wildcard example/*.c)
SRC_CUS=$(wildcard custom/*.c)
```

```
OBJS=\
     $(patsubst %.c, $(OBJ_DIR)/%.o, $(SRC_SYS))         \
     $(patsubst %.c, $(OBJ_DIR)/%.o, $(SRC_SYS_RIL))     \
     $(patsubst %.c, $(OBJ_DIR)/%.o, $(SRC_CUS))         \
     $(patsubst %.c, $(OBJ_DIR)/%.o, $(SRC_EXAMPLE))     \
```

3 Basic Data Types

3.1. Required Header File

The base data types are defined in *ql_type.h* header file.

3.2. Base Data Type

Table 2: Base Data Type

Type	Description
bool	Boolean variable (should be TRUE or FALSE). This variable is declared as follows: `typedef unsigned char bool;`
s8	8-bit signed integer. This variable is declared as follows: `typedef signed char s8;`
u8	8-bit unsigned integer. This variable is declared as follows: `typedef unsigned char u8;`
s16	16-bit signed integer. This variable is declared as follows: `typedef signed short s16;`
u16	16-bit unsigned integer. This variable is declared as follows: `typedef unsigned short u16;`
s32	32-bit signed integer. This variable is declared as follows: `typedef int s32;`
u32	32-bit unsigned integer. This variable is declared as follows: `typedef unsigned int u32;`

u64	64-bit unsigned integer. This variable is declared as follows: typedef unsigned long lone u64;
float	Floating-point variable. This variable is declared in *math.h*.

4 System Configuration

In *\SDK\custom\config* directory, applications can be reconfigured according to specific requirements for tasks addition, task stack size configuration and GPIO initialization status. All configuration files are named with a prefix "custom_".

Table 3: List of System Configuration Files

Configuration File	Description
custom_feature_def.h	Enable QuecOpen® features, including RIL. Generally, there is no need to change this file.
custom_gpio_cfg.h	Configurations for GPIO initialization status
custom_task_cfg.h	Multitask configuration
custom_sys_cfg.c	Other system configurations, including configuration files for power key, specified GPIO pin for external watchdog, and configuration files for setting working mode of debug port.

4.1. Configuration of Tasks

QuecOpen® supports multitask processing. It is recommended to simply follow suit to add a record in *custom_task_cfg.h* file to define a new task. QuecOpen® supports one main task and maximum ten subtasks.

Functions *Ql_Delay_ms()*, *Ql_OS_TakeSemaphore()* and *Ql_OS_TakeMutex()* should be called cautionly, as they will block the task and thus will make the task unable to fetch message from the message queue. If the message queue is filled up, the system may reboot unexpectedly.

4.2. Configuration of GPIOs

There are two ways to initialize GPIOs. One is to configure initial GPIO list in *custom_gpio_cfg.h* and the other way is to call *Ql_GPIO_Init* (please refer to ***Chapter 5.7.2*** for details) to initialize GPIO after App starts. But the former is earlier than the latter on time sequence. The following figure shows the time sequence relationship.

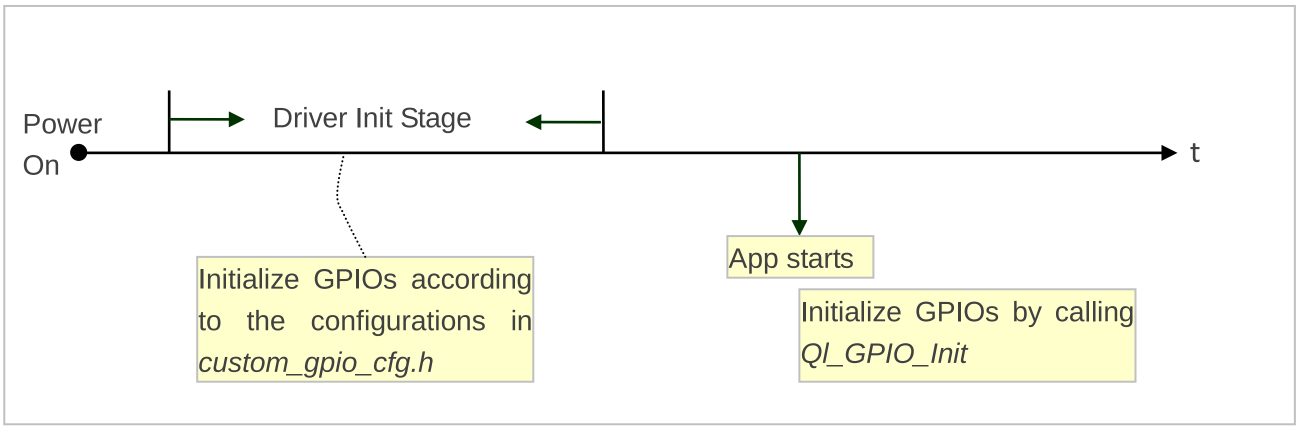

Power
On
Driver Init Stage
t
Initialize GPIOs according to the configurations in *custom_gpio_cfg.h*
App starts
Initialize GPIOs by calling *Ql_GPIO_Init*

Figure 2: Time Sequence for GPIO Initialization

4.3. Configuration of Customization Items

All customization items are configured in TLV (Type-Length-Value) in *custom_sys_cfg.c*. Please change the corresponding value to change App features. PWRKEY and Watchdog configuration features are currently not supported.

```
const ST_SystemConfig SystemCfg[] = {
    {SYS_CONFIG_APP_ENABLE_ID,          SYS_CONFIG_APPENABLE_DATA_SIZE,
(void*)&appEnableCfg},
    {SYS_CONFIG_WATCHDOG_DATA_ID,     SYS_CONFIG_WATCHDOG_DATA_SIZE,
(void*)&wtdCfg          },
    {SYS_CONFIG_DEBUG_MODE_ID,          SYS_CONFIG_DEBUGMODE_DATA_SIZE,
(void*)&debugPortCfg},
    {SYS_CONFIG_DEBUG_SET_ID,           SYS_CONFIG_DEBUGSET_DATA_SIZE,
(void*)&debugPortSet},
    {SYS_CONFIG_APP_VERSION_ID,      SYS_CONFIG_APPVERSION_DATA_SIZE,
(void*)&appvercfg},
    {SYS_CONFIG_END,                            0,
NULL                            }
};
```

Table 4: Customization Items

Item	Type(T)	Length (L)	Default Value	Possible Value	Description
App Enabling	SYS_CONFIG_APP_ENABLE_ID	4	APP_ENABLE	APP_ENABLE APP_DISABLE	App enable config
GPIO for WTD Config	SYS_CONFIG_WATCHDOG_DATA_ID	8	PINNAME_GPIO0	One value of Enum_PinName	GPIO for feeding WTD.
Working Mode for Debug Port	SYS_CONFIG_DEBUG_MODE_ID	4	BASIC_MODE	BASIC_MODE ADVANCE_MODE	Application mode or debug mode
App Version	SYS_CONFIG_APP_VERSION_ID	50	SDK_VERSION	Any string less than 50 bytes	App version config

4.3.1. GPIO for External Watchdog

When an external watchdog is adopted to monitor the App, the module has to feed the watchdog in the whole period of the module's power-on including the processes of startup, App activation and upgrade.

Table 5: Participants for Feeding External Watchdog

Period	Feeding Host
Booting	Core System
App Running	App
Upgrading App by DFOTA	Core System

Therefore, it is suggested to only specify which GPIO is designed to feed the external watchdog.

```
static const ST_ExtWatchdogCfg wtdCfg = {
PINNAME_CTS,        //Specify a pin or another GPIO to connect to the external watchdog.
PINNAME_END         //Specify another pin for watchdog if needed.
};
```

4.3.2. Debug Port Working Mode Configuration

The debug port (UART2) may work as a common serial port (BASIC_MODE), or a special debug port (ADVANCE_MODE) that can debug some issues underlay application.

Usually there is no need to use ADVANCE_MODE when there are no requirements from support engineers. If needed, please refer to ***document [5]*** for the usage of the special debug mode.

```
static const ST_DebugPortCfg debugPortCfg = {
BASIC_MODE          //Set the serial debug port (UART2) to a common serial port
//ADVANCE_MODE    //Set the serial debug port (UART2) to a special debug port
};
```

5 API Functions

5.1. System APIs

The header file *ql_system.h* declares system-related API functions. These functions are essential to customized applications. Please make sure the header file is included when using these functions.

QuecOpen® provides interfaces that support multitasking, message, mutex, semaphore and event mechanism functions. These interfaces are used for multitask programming. The example *example_multitask.c* in QuecOpen® SDK shows the proper usages of these API functions.

5.1.1. Usage

This chapter introduces some important operations and the API functions in system-level programming.

5.1.1.1. Receive Message

Please call *Ql_OS_GetMessage* to retrieve a message from the current task's message queue. The message can be a system message or a customized message.

5.1.1.2. Send Message

Please call *Ql_OS_SendMessage* or *Ql_OS_SendMessageFromISR* to send messages to other tasks. To send a message, a message ID has to be defined. In QuecOpen®, user message ID must be greater than 0x1000.

Step 1: Define a message ID.

```
#define        MSG_ID_USER_START       0x1000
#define        MSG_ID_MESSAGE1        (MSG_ID_USER_START + 1)
```

Step 2: Send the message.

```
Ql_OS_SendMessage(ql_subtask1, MSG_ID_MESSAGE1, 0, 0);
```

```
Ql_OS_SendMessageFromISR(ql_subtask1, MSG_ID_MESSAGE1, 0, 0);
```

5.1.1.3. Mutex

A mutex object is a synchronization object whose state is set to signaled when it is not owned by any task, while non-signaled when it is owned. A task can only own one mutex object at a time. For example, to prevent two tasks from being written to a shared memory at the same time, each task waits for ownership of a mutex object before executing the code for accessing the memory. After writing to the shared memory, the task releases the mutex object.

Step 1: Create a mutex. Please call *Ql_OS_CreateMutex* to create a mutex.
Step 2: Get a specified mutex. If mutex mechanism is to be used for programming, please call *Ql_OS_TakeMutex* to get a specified mutex ID.
Step 3: Release the specified mutex. Please can call *Ql_OS_GiveMutex* to release the specified mutex.

5.1.1.4. Semaphore

A semaphore object is a synchronization object that maintains a count between zero and a specified maximum value. The count is decremented each time when a task finishes waiting for the semaphore object and is incremented each time when a task releases the semaphore. When the count reaches zero, no more tasks can successfully wait for the semaphore object state to be signaled. The state of a semaphore is set as signaled when its count is greater than zero and non-signaled when its count is zero.

Step 1: Create a semaphore. Please call *Ql_OS_CreateSemaphore* to create a semaphore.
Step 2: Get a specified semaphore. If semaphore mechanism is to be used for programming, please call *Ql_OS_TakeSemaphore* to get a specified semaphore ID.
Step 3: Release the specified semaphore. Please call *Ql_OS_GiveSemaphore* to release the specified semaphore.

5.1.1.5. Event

An event object is a synchronization object, which is useful in sending a signal to a thread indicating that a particular event has occurred. A task uses *Ql_OS_CreateEvent* function to create an event object, whose state can be explicitly set as signaled by *Ql_OS_SetEvent* function.

5.1.1.6. Task

QuecOpen® provides 11 tasks: 1 main task and 10 subtasks. The task APIs can be used to suspend a spcified task, resume a spcified task and get information of the current task, such as handle, task ID, priority and left stack size.

5.1.1.7. Backup Critical Data

BC66-QuecOpen/BC66-NA-QuecOpen is designed with 2 blocks of system storage space to backup critical user data. Each block can store 2 Kbytes data.

Ql_Flash_Write can be called to backup data, and *Ql_Flash_Read* can be called to read the backup data from backup space.

5.1.2. API Functions

5.1.2.1. Ql_Reset

This function resets the system.

- **Prototype**

```
void Ql_Reset(s32 resetType)
```

- **Parameter**

resetType:
[In] Reset type. Must be 0.

- **Return Value**

None.

5.1.2.2. Ql_Delay_ms

This function suspends the execution of the current task until the time-out interval elapses.

- **Prototype**

```
void Ql_Delay_ms (u32 msec)
```

- **Parameter**

msec:
[In] The time interval for the execution to be suspended, in milliseconds.

- **Return Value**

None.

5.1.2.3. Ql_Delay_us

This function blocks the execution of the current task until the time-out interval elapses.

- **Prototype**

```
void Ql_Delay_us(u32 usec)
```

- **Parameter**

usec:
[In] The time interval for the execution to be blocked, in microseconds.

- **Return Value**

None.

5.1.2.4. Ql_GetSDKVer

This function gets the version ID of the SDK. The SDK version ID is a string with no more than 20 characters and ends with '\0'.

- **Prototype**

```
s32 Ql_GetSDKVer(u8* ptrVer, u32 len)
```

- **Parameter**

ptrVer:
[In] Pointer to the buffer which is used to store the SDK version ID. The buffer length needs to be at least 20 bytes.

len:
[In] Length of the parameter *ptrVer*. The value must be less than or equal to the size of the buffer that *ptrVer* points to.

- **Return Value**

The return value is the length of SDK version ID if this function is executed successfully. Otherwise, an error code will be returned. To get extended error information, please refer to ***Chapter 5.1.3***.

5.1.2.5. Ql_OS_GetMessage

This function retrieves a message from the message queue of current task. When there is no message in the queue, the task will be in waiting state.

- **Prototype**

```
s32 Ql_OS_GetMessage(ST_MSG* msg)
```

- **Parameter**

msg:
[In] Pointer to the *ST_MSG* object.

- **Return Value**

QL_RET_OK: Indicates the function is executed successfully.

5.1.2.6. Ql_OS_SendMessageFromISR

This function sends messages from interrupt routine. The destination task receives messages with *Ql_OS_GetMessage.*

- **Prototype**

```
s32 Ql_OS_SendMessageFromISR(s32 destTaskId, u32 msgId, u32 param1, u32 param2)
```

- **Parameter**

destTaskId:
[In] The maximum value is 10. The destination task is main task if the value is 0. The destination task is subtask if the value is between 1 and 10.

msgId:
[In] User message ID, must bigger than 0xFF.

param1:
[In] User data.

param2:
[In] User data.

- **Return Value**

OS_SUCCESS: The data has been sent to the target task successfully.
OS_INVALID_ID: The task ID is invalid.
OS_NOT_INITIALIZED: The target task is invalid.
OS_Q_FULL: The message queue of target task is full.

5.1.2.7. Ql_OS_SendMessage

This function sends messages between tasks. The destination task receives messages with *Ql_OS_GetMessage.*

- **Prototype**

```
s32 Ql_OS_SendMessage (s32 destTaskId, u32 msgId, u32 param1, u32 param2)
```

- **Parameter**

destTaskId:
[In] The maximum value is 10. The destination task is main task if the value is 0. The destination task is subtask if the value is between 1 and 10.

msgId:
[In] User message ID, must bigger than 0xFF.

param1:
[In] User data.

param2:
[In] User data.

- **Return Value**

OS_SUCCESS: The data has been sent to the target task successfully.
OS_INVALID_ID: The task ID is invalid.
OS_NOT_INITIALIZED: The target task is invalid.
OS_Q_FULL: The message queue of target task is full.

5.1.2.8. Ql_OS_CreateMutex

This function creates a mutex. A handle of created mutex will be returned if creation succeeds. 0 indicates failure. If the same mutex has already been created, this function may also return a valid handle but the *Ql_GetLastError* function returns *ERROR_ALREADY_EXISTS*.

- **Prototype**

```
u32 Ql_OS_CreateMutex(void)
```

- **Return Value**

A handle of created mutex, 0 indicates failure.

5.1.2.9. Ql_OS_TakeMutex

This function obtains an instance of a specified mutex. If the mutex ID is invalid, the system may crush.

- **Prototype**

```
void Ql_OS_TakeMutex(u32 mutexId,u32 block_time)
```

- **Parameter**

mutexid:
[In] Destination mutex to be taken.

block_time:
[In] The time to be blocked for waiting to take specified mutex.

- **Return Value**

None.

5.1.2.10. Ql_OS_GiveMutex

This function releases an instance of a specified mutex.

- **Prototype**

```
void Ql_OS_GiveMutex(u32 mutexId)
```

- **Parameter**

mutexid:
[In] Destination mutex to be given.

- **Return Value**

None.

5.1.2.11. Ql_OS_TakeMutexFromISR

This function enables calling from an ISR to obtain an instance of a specified mutex.

- **Prototype**

```
bool Ql_OS_TakeMutexFromISR(u32 mutexId)
```

- **Parameter**

mutexId:
[In] Destination mutex to be taken.

- **Return Value**

TRUE: Successful execution of the function.
FALSE: Failed execution of the function.

5.1.2.12. Ql_OS_GiveMutexFromISR

This function enables calling from an ISR to realease an instance of a specified mutex.

- **Prototype**

```
bool Ql_OS_GiveMutexFromISR(u32 mutexId)
```

- **Parameter**

mutexId:
[In] Destination mutex to be given.

- **Return Value**

TRUE: Successful execution of the function.
FALSE: Failed execution of the function.

5.1.2.13. Ql_OS_DeleteMutex

This function deletes an instance of a specified mutex.

- **Prototype**

```
void Ql_OS_DeleteMutex(u32 mutexId)
```

- **Parameter**

mutexId:
[In] Destination mutex to be deleted.

- **Return Value**

None.

5.1.2.14. Ql_OS_CreateSemaphore

This function creates a counting semaphore. A handle of created semaphore will be returned, if creation succeeds. 0 indicates failure. If the same semaphore has already been created, this function may also return a valid handle, but the *Ql_GetLastError* function returns *ERROR_ALREADY_EXISTS*.

- **Prototype**

```
u32 Ql_OS_CreateSemaphore(u32 maxCount,u32 InitialCount)
```

- **Parameter**

maxCount:
[In] The max count of semaphore.

InitialCount:
[In] The initial count of a specified semaphore.

- **Return Value**

A handle of created semaphore. 0 indicates failure.

5.1.2.15. Ql_OS_TakeSemaphore

This function obtains an instance of a specified semaphore. If the mutex ID is invalid, the system may be crushed.

- **Prototype**

```
u32 Ql_OS_TakeSemaphore(u32 semId, u32 block_time)
```

- **Parameter**

semId:
[In] The destination semaphore to be taken.

block_time:
[In] The time to be blocked for waiting to take specified semaphore.

- **Return Value**

OS_SUCCESS: Indicates the function is executed successfully.
OS_SEM_NOT_AVAILABLE: The semaphore is unavailable immediately.

5.1.2.16. Ql_OS_GiveSemaphore

This function releases an instance of a specified semaphore.

- **Prototype**

```
void Ql_OS_GiveSemaphore (u32 semId)
```

- **Parameter**

semId:
[In] Destination semaphore to be given.

- **Return Value**

None.

5.1.2.17. Ql_OS_TakeSemaphoreFromISR

This function enables calling from an ISR to obtain an instance of a specified semaphore.

- **Prototype**

```
bool Ql_OS_TakeSemaphoreFromISR(u32 semId)
```

- **Parameter**

semId:
[In] A handle to the semaphore to be taken - obtained when the semaphore was created.

- **Return Value**

TRUE: Indicates the function is executed successfully.
FALSE: Indicates the semaphore is unavailable.

5.1.2.18. Ql_OS_GiveSemaphoreFromISR

This function enables calling from an ISR to release an instance of a specified semaphore.

- **Prototype**

```
void Ql_OS_GiveSemaphoreFromISR(u32 semId)
```

- **Parameter**

semId:
[In] A handle to the semaphore to be given - obtained when the semaphore was created.

- **Return Value**

TRUE: Successful execution of the function.
FALSE: Failed execution of the function.

5.1.2.19. Ql_OS_CreateEvent

This function creates a specified type of event.

- **Prototype**

```
u32 Ql_OS_CreateEvent(void);
```

- **Return Value**

An event ID that identifies this event is unique.

5.1.2.20. Ql_OS_WaitEvent

This function waits until a specified type of event is in signaled state. Different types of events can be specified for different purposes. The event flags are defined in *Enum_EventFlag*.

- **Prototype**

```
s32 Ql_OS_WaitEvent(u32 evtId, u32 evtFlag,u32 block_time);
```

- **Parameter**

evtId:
[In] Event ID that is returned by calling *Ql_OS_CreateEvent()*.

evtFlag:
[In] Event flag type.

block_time:
[In] The time to be blocked for waiting a specified event.

- **Return Value**

0 indicates the function is executed successfully and other values indicate execution failure.

5.1.2.21. Ql_OS_SetEvent

This function sets a specified event flag. Any task waiting on the event, whose event flag request is satisfied, is resumed.

- **Prototype**

```
s32 Ql_OS_SetEvent(u32 evtId, u32 evtFlag);
```

- **Parameter**

evtId:
[In] Event ID that is returned by calling *Ql_OS_CreateEvent()*.

evtFlag:
[In] Event flag type.

- **Return Value**

0 indicates the function is executed successfully and other values indicate execution failure.

5.1.2.22. Ql_OS_WaitEventFromISR

This function enables calling from an ISR to wait unitl the specified type of event is in the singaled state.

- **Prototype**

```
bool Ql_OS_WaitEventFromISR(u32 evtId)
```

- **Parameter**

evtId:
[In] Event ID that is returned by calling *Ql_OS_CreateEvent()*.

- **Return Value**

pdPASS: The message has been sent to the RTOS daemon task.
pdFAIL: The timer service queue is full.

5.1.2.23. Ql_OS_SetEventFromISR

This function enables calling from an ISR to set a specified event flag.

- **Prototype**

```
s32 Ql_OS_SetEventFromISR(u32 evtId, u32 evtFlag)
```

- **Parameter**

evtId:
[In] Event ID that is returned by calling *Ql_OS_CreateEvent()*.

evtFlag:
[In] Event flag type.

- **Return Value**

Returns the current event flag group value.

5.1.2.24. Ql_OS_DeleteEvent

This function deletes an event group that was previously created by calling *Ql_OS_CreateEvent()*.

- **Prototype**

```
void Ql_OS_DeleteEvent(u32 evtId)
```

- **Parameter**

evtId:
[In] Event ID that is returned by calling *Ql_OS_CreateEvent().*

- **Return Value**

None.

5.1.2.25. Ql_OS_GetCurrentTaskHandle

This function gets the handle ID of the current task.

- **Prototype**

```
TaskHandle_t Ql_OS_GetCurrentTaskHandle(void)
```

- **Parameter**

None.

- **Return Value**

If a task has been created then the handle of the task is returned, otherwise NULL is returned.

5.1.2.26. Ql_OS_TaskSuspend

This function suspends a task. When suspended, the task will never get any microcontroller processing time, no matter what priority it is.

- **Prototype**

```
void Ql_OS_TaskSuspend(TaskHandle_t task_handle)
```

- **Parameter**

task_handle:
[In] Handle to the task to be suspended.

- **Return Value**

None.

5.1.2.27. Ql_OS_TaskResume

This function resumes a suspended task.

- **Prototype**

```
void Ql_OS_TaskResume(TaskHandle_t task_handle)
```

- **Parameter**

task_handle:
[In] Handle to the task to be resumed.

- **Return Value**

None.

5.1.2.28. Ql_OS_TaskResumeFromISR

This function enables calling from an ISR to resume a suspended task.

- **Prototype**

```
void Ql_OS_TaskResumeFromISR(TaskHandle_t task_handle)
```

- **Parameter**

task_handle:
[In] Handle to the task to be resumed.

- **Return Value**

None.

5.1.2.29. Ql_OS_GetCurrentTaskPriority

This function gets the priority of the current task.

- **Prototype**

```
u32 Ql_OS_GetCurrentTaskPriority(void)
```

- **Parameter**

None

- **Return Value**

Task priority. The default value is 4.

5.1.2.30. Ql_OS_GetCurrenTaskLeftStackSize

This function gets the remaining bytes in the current task stack.

- **Prototype**

```
u32 Ql_OS_GetCurrenTaskLeftStackSize(void)
```

- **Parameter**

None

- **Return Value**

Number of bytes, ranging from 1024 to 10240 Kbytes.

5.1.2.31. Ql_OS_GetActiveTaskId

This function returns the task ID of the current task.

- **Prototype**

```
s32 Ql_OS_GetActiveTaskId(void)
```

- **Parameter**

None.

- **Return Value**

The current task ID.

5.1.2.32. Ql_OS_GetTaskTickCount

This function returns the task tick number since the task starts scheduler. 1 tick equals 10 ms.

- **Prototype**

```
u32 Ql_OS_GetTaskTickCount(void)
```

- **Parameter**

None.

- **Return Value**

The count of ticks.

5.1.2.33. Ql_OS_GetTaskTickCountFromISR

This function enables calling from an ISR to get the task tick number since the task starts scheduler. 1 tick equals 10 ms.

- **Prototype**

```
u32 Ql_OS_GetTaskTickCountFromISR(void)
```

- **Parameter**

None.

- **Return Value**

The count of ticks.

5.1.2.34. Ql_SetLastErrorCode

This function sets an error code.

- **Prototype**

```
s32 Ql_SetLastErrorCode(s32 errCode)
```

- **Parameter**

errCode:
[In] Error code.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_FATAL: Indicates failed to set error code.

5.1.2.35. Ql_GetLastErrorCode

This function retrieves the calling task's last-error code value.

- **Prototype**

```
s32 Ql_GetLastErrorCode(void)
```

- **Parameter**

None.

- **Return Value**

The return value is the calling task's last error code.

5.1.2.36. Ql_Flash_Write

This function is used to write user data to flash.

- **Prototype**

```
s32 Ql_Flash_Write(u8 index ,u16 addr, u8* pBuffer, u32 len)
```

- **Parameter**

index:
[In] The index of the secure data block. The range is 1-2, and every block supports max 2048 bytes data.

addr:
[In] The start address to write. The range is 0x0000-0x07FF(2KB).

pBuffer:
[In] The data to be written.

len:
[In] The length of the data to be written. The maximum value is 2048 bytes.

- **Return Value**

0 indicates successful execution, and other values indicate execution failure.

5.1.2.37. Ql_Flash_Read

This function reads flash data which is previously writtened by *Ql_Flash_Write*.

- **Prototype**

```
s32 Ql_Flash_Read(u8 index,u16 addr, u8* pBuffer, u32 len)
```

- **Parameter**

index:
[In] The index of the secure data block. The range is 1-2.

addr:
[In] The start address to read. The range is 0x0000-0x07FF(2KB).

pBuffer:
[Out] The data to be read.

len:
[In] The length of the data to be read. The maximum value is 2048 bytes.

- **Return Value**

0 indicates successful execution, and other values indicates execution failure.

5.1.3. Possible Error Codes

The frequent error codes, which could be returned by APIs in multitask programming, are enumerated in the *Enum_OS_ErrCode*.

```
/************************************************************
* Error Code Definition
 ************************************************************/
typedef enum {
      OS_SUCCESS,
      OS_ERROR,
      OS_Q_FULL,
      OS_Q_EMPTY,
      OS_SEM_NOT_AVAILABLE,
      OS_WOULD_BLOCK,
      OS_MESSAGE_TOO_BIG,
      OS_INVALID_ID,
      OS_NOT_INITIALIZED,
      OS_INVALID_LENGHT,
      OS_NULL_ADDRESS,
      OS_NOT_RECEIVE,
      OS_NOT_SEND,
      OS_MEMORY_NOT_VALID,
      OS_NOT_PRESENT,
      OS_MEMORY_NOT_RELEASE
} Enum_OS_ErrCode;
```

5.1.4. Examples

1. Mutex Example

```
static int   s_iMutexId = 0;

//Create the mutex first
s_iMutexId = Ql_OS_CreateMutex();

void MutextTest(int iTaskId)   //Two task Run this function at the same time
{

       //Get the mutex
      Ql_OS_TakeMutex(s_iMutexId,0xFFFFFFFF);

       //Another Caller prints this sentence after 3 seconds
       Ql_Delay_ms(3000);

      //3 seconds later release the mutex.
      Ql_OS_GiveMutex(s_iMutexId);
}
```

2. Semaphore Example

```
static int s_iTestSemInitial = 3; //Set the initial value of semaphore is 3
static int s_iTestSemMaxNum =4; //Set the maximum semaphore number is 4

//Create a semaphore first.
s_iSemaphoreId = Ql_OS_CreateSemaphore(s_iTestSemMaxNum, s_iTestSemInitial);
void SemaphoreTest(int iTaskId)
{
    int iRet = -1;

    //Get the mutex
    iRet = Ql_OS_TakeSemaphore(s_iSemaphoreId, 0xFFFFFFFF);//TRUE or FLASE indicate the task
    should wait infinitely or return immediately.
    Ql_OS_TakeMutex(s_iSemMutex);
    s_iTestSemNum--; //One semaphore is be used
    Ql_OS_GiveMutex(s_iSemMutex);

    Ql_Delay_ms(3000);

    //3 seconds later release the semaphore.
    Ql_OS_GiveSemaphore(s_iSemaphoreId);
    s_iTestSemNum++;// one semaphore is released.
    Ql_Debug_Trace("\r\n<--=========Task[%d]: s_iTestSemNum=%d-->", iTaskId, s_iTestSemNum);
}
```

5.2. Time APIs

BC66-QuecOpen/BC66-NA-QuecOpen provides time-related APIs including setting or getting local time, conversion between seconds and calendar time.

5.2.1. Usage

Calendar time is measured from a standard point in time to the current time elapsed in seconds, and generally 00:00:00 on January 1st, 1970 is set as the standard point in time.

5.2.2. API Functions

Time struct is defined as below:

```
typedef struct {
    s32 year;           //Range: 2000~2127
    s32 month;
    s32 day;
    s32 hour;            //In 24-hour time system
    s32 minute;
    s32 second;
    s32 timezone;        //Range: -47~48
}ST_Time;
```

The field *timezone* defines the time zone. A negative number indicates the Western time zone, and a positive number indicates the Eastern time zone. For example: the time zone of Beijing is East Area 8 and the timezone range is 32 to 35; the time zone of Washington is West Zone 5 and the timezone range is -19 to -16.

5.2.2.1. Ql_SetLocalTime

This function sets the current local date and time.

- **Prototype**

```
s32 Ql_SetLocalTime(ST_Time* dateTime)
```

- **Parameter**

dateTime:
[In] Pointer to the ST_Time object.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates parameter error.

5.2.2.2. Ql_GetLocalTime

This function gets the current local date and time.

- **Prototype**

```
ST_Time* Ql_GetLocalTime(ST_Time* dateTime)
```

- **Parameter**

dateTime:
[Out] Pointer to the ST_Time object.

- **Return Value**

If the function is executed successfully, the current local date and time will be returned. NULL means failure.

5.2.2.3. Ql_Mktime

This function gets the total seconds elapsed since 00:00:00 on January 1st, 1970.

- **Prototype**

```
u64 Ql_Mktime(ST_Time* dateTime)
```

- **Parameter**

dateTime:
[In] Pointer to the ST_Time object.

- **Return Value**

Return the total seconds.

5.2.2.4. Ql_MKTime2CalendarTime

This function converts the seconds elapsed since 00:00:00 on January 1st, 1970 to the local date and time.

- **Prototype**

```
ST_Time* Ql_MKTime2CalendarTime(u64 seconds, ST_Time* pOutDateTime)
```

- **Parameter**

seconds:
[In] The seconds elapsed since 00:00:00 on January 1st, 1970.

pOutDateTime:
[Out] Pointer to the ST_Time object.

- **Return Value**

If the function is executed successfully, the current local date and time are returned. NULL indicates operation failure.

5.2.3. Example

The following codes show how to use the time-related APIs.

```
s32 ret;
u64 sec;
ST_Time datetime, *tm;
datetime.year=2013;
datetime.month=6;
datetime.day=12;
datetime.hour=18;
datetime.minute=12;
datetime.second=13;
datetime.timezone=32;

//Set local time
ret=Ql_SetLocalTime(&datetime);
Ql_Debug_Trace("\r\n<--Ql_SetLocalTime,ret=%d -->\r\n",ret);
Ql_Delay_ms(5000);

//Get local time
tm=Ql_GetLocalTime(&datetime);
Ql_Debug_Trace("<--%d/%d/%d %d:%d:%d %d -->\r\n",tm->year, tm->month, tm->day, tm->hour, tm
->minute, tm->second, tm->timezone);

//Get total seconds elapsed since 00:00:00 on January 1st, 1970.
sec=Ql_Mktime(tm);
Ql_Debug_Trace("\r\n<--Ql_Mktime,sec=%lld -->\r\n",sec);

//Convert the seconds elapsed since 00:00:00 on January 1st, 1970 to local date and time
tm=Ql_MKTime2CalendarTime(sec, & datetime);
Ql_Debug_Trace("<--%d/%d/%d %d:%d:%d %d -->\r\n",tm->year, tm->month, tm->day, tm->hour, tm
->minute, tm->second, tm->timezone);
```

5.3. Timer APIs

BC66-QuecOpen/BC66-NA-QuecOpen provides two kinds of timers. One is Common Timer and the other is Fast Timer. QuecOpen® system allows maximum 90 Common Timers running at the same time. The system provides only 6 Fast Timers for application. The accuracy of the Fast Timer is relatively higher than a common timer.

5.3.1. Usage

Ql_Timer_Register() can be used to create a common timer, and register an interrupt handler. And a timer ID, which is an unsigned integer, must be specified. *Ql_Timer_Start()* can start the created timer while *Ql_Timer_Stop()* can stop the running timer.

Ql_Timer_RegisterFast() can be called to create the Fast Timer, and register an interrupt handler. *Ql_Timer_Start()* can start the created timer while *Ql_Timer_Stop()* can stop the running timer. The minimum interval for Fast Timer should be an integer multiple of 10ms.

Ql_Timer_Register_us() can be called to create the Fast Timer, and register an interrupt handler. *Ql_Timer_Start_us()* can start the created timer while *Ql_Timer_Stop_us()* can stop the running timer. The microsecond timer should be 0x01 only and the minimum interval for microsecond timer can be 1 μs.

5.3.2. API Functions

5.3.2.1. Ql_Timer_Register

This function registers a Common Timer. The whole project supports 90 timers running at the same time. One timer can be operated by different tasks.

- **Prototype**

```
s32 Ql_Timer_Register(u32 timerId, Callback_Timer_OnTimer callback_onTimer, void* param)typedef
void(*Callback_Timer_OnTimer)(u32 timerId, void* param)
```

- **Parameter**

timerId:
[In] Timer ID. It must be ensured that the ID is the only one under QuecOpen® task. It should also differ from the ID registered by *Ql_Timer_RegisterFast*.

callback_onTimer:
[Out] Give notifications when the timer arrives.

param:
[In] One customized parameter that can be passed into the callback functions.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.

QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates an invalid timer.
QL_RET_ERR_TIMER_FULL: Indicates all timers are used up.

5.3.2.2. Ql_Timer_RegisterFast

This function registers a Fast Timer. It supports 6 Fast Timer for App. Please do not add any task schedule in the interrupt handler of the Fast Timer.

- **Prototype**

```
s32 Ql_Timer_RegisterFast(u32 timerId, Callback_Timer_OnTimer callback_onTimer, void* param)typedef void(*Callback_Timer_OnTimer)(u32 timerId, void* param)
```

- **Parameter**

timerId:
[In] Timer ID. It should not be the same as the one that is registered by *Ql_Timer_Register*.

callback_onTimer:
[Out] Give notifications when the timer arrives.

param:
[In] One customized parameter that can be passed into the callback functions.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates an invalid timer.
QL_RET_ERR_TIMER_FULL: Indicates all timers are used up.

5.3.2.3. Ql_Timer_Start

This function starts up a specified timer.

- **Prototype**

```
s32 Ql_Timer_Start(u32 timerId, u32 interval, bool autoRepeat)
```

- **Parameter**

timerId:
[In] Timer ID, which must be registered.

interval:
[In] Set the interval of the timer. Unit: ms. If a Common Timer is started, the interval must be greater than or equal to 1 ms. If a Fast Timer is started, the interval must be an integer multiple of 10 ms.

autoRepeat:
[In] TRUE or FALSE. FALSE indicates the timer is executed once; TRUE indicates the timer is executed repeatedly.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates an invalid timer.
QL_RET_ERR_INVALID_TASK_ID: Indicates the current task is not the one that registers the timer.

5.3.2.4. Ql_Timer_Stop

This function stops a specified timer.

- **Prototype**

```
s32 Ql_Timer_Stop(u32 timerId)
```

- **Parameter**

timerId:
[In] Timer ID. The timer has been started by calling *Ql_Timer_Start* previously.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates an invalid timer.
QL_RET_ERR_INVALID_TASK_ID: Indicates the current task is not the one that registers the timer.

5.3.2.5. Ql_Timer_Delete

This function deletes a specified timer. It can be used if the current timer ID needs to be re-registered or released.

- **Prototype**

```
s32 Ql_Timer_Delete(u32 timerId)
```

- **Parameter**

timerId:
[In] The timer ID that has been started by calling *Ql_Timer_Start* previously*.*

- **Return Value**

QL_RET_OK: Indicates the function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is already being used.
QL_RET_ERR_TIMER_FULL: Indicates all timers are used up.
QL_RET_ERR_INVALID_TASK_ID: Indicates the task is invalid.

5.3.2.6. Ql_Timer_Register_us

This function registers a general purpose timer, and only one timer is supported under QuecOpen® project currently.

- **Prototype**

```
s32 Ql_Timer_Register_us(u32 timerId, Callback_Timer_OnTimer callback_onTimer, void* param)
```

- **Parameter**

timerId:
[In] The timer ID, and the value can only be 0x01.

callback_onTimer:
[Out] Notify the application when the time set by timer is up.

param:
[In] Used to pass customized parameters.

- **Return Value**

QL_RET_OK: Indicates the function is executed successfully.
QL_RET_ERR_PARAM: Indicates the parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is already being used.
QL_RET_ERR_TIMER_FULL: Indicates all timers are used up.
QL_RET_ERR_ERROR: Indicates other errors.

5.3.2.7. Ql_Timer_Start_us

This function starts up a specified timer.

- **Prototype**

```
s32 Ql_Timer_Start_us(u32 timerId, u32 interval, bool autoRepeat)
```

- **Parameter**

timerId:
[In] The timer ID. This value can only be 0x01;

interval:
[In] The timer interval. Unit: μs. The interval must be greater than or equal to 1 μs.

autoRepeat:
[In] TRUE indicates that the timer is executed repeatedly. FALSE indicates only once.

- **Return Value**

QL_RET_OK: Indicates the function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is already being used.
QL_RET_ERR_TIMER_FULL: Indicates all timers are used up.
QL_RET_ERR_ERROR: Indicates other errors.

5.3.2.8. Ql_Timer_Stop_us

This function stops a specified timer.

- **Prototype**

```
s32 Ql_Timer_Stop_us(u32 timerId)
```

- **Parameter**

timerId:
[In] The timer ID. The value can only be 0x01.

- **Return Value**

QL_RET_OK: Indicates the function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.

QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is already being used.
QL_RET_ERR_TIMER_FULL: Indicates all timers are used up.
QL_RET_ERR_ERROR: Indicates other errors.

5.3.2.9. Ql_Timer_Delete_us

This function deletes a specified timer. This function can be used if the current timer ID needs to be re-registered or released.

- **Prototype**

```
s32 Ql_Timer_Delete_us(u32 timerId)
```

- **Parameter**

timerId:
[In] The timer ID. This value can only be 0x01.

- **Return Value**

QL_RET_OK: Indicates the function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is already being used.
QL_RET_ERR_TIMER_FULL: Indicates all timers are used up.
QL_RET_ERR_ERROR: Indicates other errors.

5.3.3. Example

The following codes show how to register and how to start a Common Timer.

```
s32 ret;
u32 timerId=999;    //Timer ID is 999
u32 interval=2 * 1000; //2 seconds
bool autoRepeat=TRUE;
u32 param=555;

//Callback function
void Callback_Timer(u32 timerId, void* param)
{
    ret=Ql_Timer_Stop(timerId);
    Ql_Debug_Trace("\r\n<--Stop: timerId=%d,ret = %d -->\r\n", timerId ,ret);
}

//Register timer
```

```
ret=Ql_Timer_Register(timerId, Callback_Timer, &param);
Ql_Debug_Trace("\r\n<--Register: timerId=%d, param=%d,ret=%d -->\r\n", timerId ,param,ret);

//Start timer
ret=Ql_Timer_Start(timerId, interval, autoRepeat);
Ql_Debug_Trace("\r\n<--Start: timerId=%d,repeat=%d,ret=%d -->\r\n", timerId , autoRepeat,ret);
```

5.4. RTC/PSM_EINT APIs

RTC/PSM_EINT can be used to wake up the module from deep sleep mode. When RTC/PSM_EINT event occurred, the registered callback will be called to notify users.

5.4.1. Usage

5.4.1.1. RTC/PSM_EINT Control

Ql_Rtc_RegisterFast function is used to register an RTC event callback.
Ql_Rtc_Start function is used to start an RTC timer.
Ql_Rtc_Stop function is used to stop an RTC timer.
Ql_Psm_Eint_Register function is used to register a PSM_EINT event callback.

5.4.2. API Functions

5.4.2.1. Ql_Rtc_RegisterFast

This function registers an RTC timer with a dedicated ID. When the RTC timer expires, the registered callback will be called.

- **Prototype**

```
s32 Ql_Rtc_RegisterFast(u32 rtcId, Callback_Rtc_Func callback_onTimer, void* param)
```

- **Parameter**

rtcId:
[In] RTC timer ID. It must be greater than 0x200. It should also differ from the ID registered by *Ql_Rtc_RegisterFast*.

callback_onTimer:
[Out] Notify the application when the RTC timer expires.

param:
[In] One customized parameter that can be passed into the callback functions.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is invalid.
QL_RET_ERR_FATAL: Indicates this function is failed.

5.4.2.2. Ql_Rtc_Start

This function starts an RTC timer.

- **Prototype**

```
s32 Ql_Rtc_Start(u32 rtcId, u32 interval, bool autoRepeat)
```

- **Parameter**

rtcId:
[In] RTC timer ID, which must be registered.

interval:
[In] Set the interval of the timer. Unit: ms. This value must be a multiple of 100 ms.

autoRepeat:
[In] TRUE or FALSE. FALSE indicates the timer is executed once; TRUE indicates the timer is executed repeatedly.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is invalid.
QL_RET_ERR_FATAL: Indicates this function is failed.

5.4.2.3. Ql_Rtc_Stop

This function stops an RTC timer.

- **Prototype**

```
s32 Ql_Rtc_Stop(u32 rtcId)
```

- **Parameter**

rtcId:
[In] RTC timer ID, which must be registered.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is invalid.
QL_RET_ERR_FATAL: Indicates this function is failed.

5.4.2.4. Ql_Psm_Eint_Register

This function registers a PSM_EINT event notification. When PSM_EINT is triggered (falling edge), the registered callback will be called.

- **Prototype**

```
s32 Ql_Psm_Eint_Register(Callback_Psm_Eint_Func    callback_psm_eint,void* param);
```

- **Parameter**

callback_psm_eint:
[Out] Notify the application when the PSM_EINT pin is triggered.

param:
[In] One customized parameter that can be passed into the callback functions.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_INVALID_TIMER: Indicates that the timer ID is invalid.
QL_RET_ERR_FATAL: Indicates this function is failed.

5.4.3. Example

The following sample codes show how to register an RTC timer and PSM_EINT event callback.

```
    ret = Ql_Psm_Eint_Register(callback_psm_eint,NULL);
    APP_DEBUG("psm_eint register , ret=%d\r\n",ret);
      // Register & open UART port
    ret = Ql_GetPowerOnReason();

    APP_DEBUG("power on reason, ret=%d\r\n",ret);
    if(ret == QL_SYS_RESET)
    {
       ret = Ql_Rtc_RegisterFast(RTC_ID_USER_START,rtc_callback,NULL);
       if (ret < QL_RET_OK)
       {
             APP_DEBUG("RTC register failed, ret=%d\r\n");
       }
       ret = Ql_Rtc_Start(RTC_ID_USER_START, 30*1000, TRUE);
       if (ret < QL_RET_OK)
       {
             APP_DEBUG("RTC start failed, ret=%d\r\n",ret);
       }
    }
```

5.5. Power Management APIs

Power management contains the power-related operations, such as power-down, power key control and low power consumption mode enablement/disablement.

5.5.1. Usage

5.5.1.1. Sleep Mode

Ql_ SleepEnable is used to enable the sleep mode of module. The module enters sleep mode when it is idle.

Ql_SleepDisable is used to disable the sleep mode when the module is woken up.

5.5.2. API Functions

5.5.2.1. Ql_SleepEnable

This function enables the sleep mode of module. The module will enter sleep mode when it is under idle state.

- **Prototype**

```
s32 Ql_SleepEnable(void)
```

- **Parameter**

None.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
Ql_RET_NOT_SUPPORT: Indicates the function is not supported in the current SDK version.

5.5.2.2. Ql_SleepDisable

This function disables the sleep mode of the module.

- **Prototype**

```
s32 Ql_SleepDisable(void)
```

- **Parameter**

None.

- **Return Value**

QL_RET_OK: Indicates this function is executed successfully.
Ql_RET_NOT_SUPPORT: This function is not supported.

5.5.2.3. Ql_GetPowerOnReason

This function is used to query the module’s power-on reason (reset or wake up from deep sleep).

- **Prototype**

```
s32 Ql_GetPowerOnReason(void)
```

- **Parameter**

None.

- **Return Value**

QL_SYS_RESET: Indicates system reset occurring.
QL_DEEP_SLEEP: Indicates waking up from deep sleep.

5.5.2.4. Ql_PowerDown

This function is used to power down the module.

- **Prototype**

```
void Ql_PowerDown(u8 mode)
```

- **Parameter**

mode:
[In] Must be 0.

- **Return Value**

None.

5.5.2.5. Ql_GetPowerVol

This function querys the voltage value of power supply.

- **Prototype**

```
s32 Ql_GetPowerVol(u32* voltage)
```

- **Parameter**

voltage:
[Out] The buffer to store the voltage value of power supply.

- **Return Value**

QL_RET_OK: indicates this function is executed successfully.
Others indicate execution failure.

5.5.2.6. Ql_GetWakeUpReason

This function gets the reason of module waking up.

- **Prototype**

```
Enum_Ql_Wake_Up_Result_t Ql_GetWakeUpReason(void)
```

- **Parameter**

None.

- **Return Value**

Ql_RESULT_NOT_WAKEUP: The module is not woken up from deep sleep.
Ql_RTC_TC_WAKEUP: Woken up by RTC ticking clock.
Ql_PSM_EINT_WAKEUP: Woken up by PSM_EINT pin.
Ql_RTC_AlARM_WAKEUP: Woken up by RTC timer.
Ql_POWER_KEY_WAKEUP: Woken up by PWRKEY.

5.5.2.7. Ql_DeepSleep_Register

This function registers a callback handler of UCR **ENTER DEEPSLEEP**.

The callback will be called when the module enters Deep Sleep mode.

- **Prototype**

```
typedef void (*Callback_DeepSleep_Func)(void *param);
s32 Ql_DeepSleep_Register(Callback_DeepSleep_Func callback_ds_event,void * param);
```

- **Parameter**

callback_ds_event:
[out] Notify the application when the module enters Deep Sleep.

param:
[in] User data.

- **Return Value**

QL_RET_OK indicates registered successfully.
QL_RET_ERR_PARAM indicates a parameter error.

5.5.3. Example

The following sample codes show how to enter and exit sleep mode in the interrupt handler.

```
void Eint_CallBack _Hdlr (Enum_PinName eintPinName, Enum_PinLevel pinLevel, void* customParam)
{
If (0==pinLevel)
{
SYS_DEBUG( DBG_Buffer,"DTR set to low=%d wake !!\r\n", level);
Ql_SleepDisable(); //Enter sleep mode
}else{
SYS_DEBUG( DBG_Buffer,"DTR set to high=%d Sleep \r\n", level);
Ql_SleepEnable(); //Exit sleep mode
}
}
```

5.6. Memory APIs

QuecOpen® operating system supports dynamic memory management. *Ql_MEM_Alloc* and *QL_MEM_Free* functions are used to allocate and release the dynamic memory, respectively.

The dynamic memory is system heap space. And the maximum available system heap of application is 300 KB.

Ql_MEM_Alloc and *QL_MEM_Free* must be present in pairs. Otherwise, memory leakage occurs.

5.6.1. Usage

Step 1: Call *Ql_MEM_Alloc()* to apply for a block of memory with a specified size. The memory allocated by *Ql_MEM_Alloc()* is from system heap.

Step 2: If the memory block is not needed anymore, please call *Ql_MEM_Free()* to free the memory block that is previously allocated by calling *Ql_MEM_Alloc()*.

5.6.2. API Functions

5.6.2.1. Ql_MEM_Alloc

This function allocates memory with a specified size in memory heap.

- **Prototype**

```
void* Ql_MEM_Alloc (u32 size)
```

- **Parameter**

size:
[In] Number of memory bytes to be allocated.

- **Return Value**

A pointer of void type to the address of allocated memory. NULL will be returned if the allocation fails.

5.6.2.2. Ql_MEM_Free

This function frees the memory that is allocated by *Ql_MEM_Alloc*.

- **Prototype**

```
void Ql_MEM_Free (void *ptr);
```

- **Parameter**

ptr:
[In] Previously allocated memory block to be freed.

- **Return Value**

None.

5.6.3. Example

The following codes show how to allocate and free a specified size memory.

```
char *pch=NULL;

//Allocate the memory
pch=(char*)Ql_MEM_Alloc(1024);
if (pch !=NULL)
{
    Ql_Debug_Trace("Successfully apply for memory, pch=0x%x\r\n", pch);
}else{
    Ql_Debug_Trace("Fail to apply for memory, size=%d\r\n", 1024);
}
```

```
//Free the memory
Ql_MEM_Free(pch);
pch=NULL;
```

5.7. Hardware Interface APIs

5.7.1. UART

5.7.1.1. UART Overview

In QuecOpen®, the physical UART ports can be applied to connect to external devices. The working chart of UARTs is shown below:

5.7.1.2. UART Usage

The following illustrates a few simple steps for physical UART usage:

Step 1: Call *Ql_UART_Register* to register callback function of the UART.
Step 2: Call *Ql_UART_Open* to open a specified UART port.
Step 3: Call *Ql_UART_Write* to write data to a specified UART port. When the number of bytes actually sent is less than that to be sent, the application should stop sending data and will receive an event EVENT_UART_READY_TO_WRITE later in callback function. After receiving this event, the application can continue to send data, and the previously unsent data should be resent.
Step 4: Deal with the UART's notification in the callback function. If the notification type is EVENT_UART_READY_TO_READ, then all data in the UART RX buffer should be read out. Otherwise, there will not be such notification to be reported to application when new data comes to UART RX buffer later.

5.7.1.3. API Functions

5.7.1.3.1. Ql_UART_Register

This function registers the callback function for a specified serial port. UART callback function is used to receive the UART notification from core system.

- **Prototype**

```
s32 Ql_UART_Register(Enum_SerialPort port, CallBack_UART_Notify callback_uart,void *
customizePara)
typedef void (*CallBack_UART_Notify)( Enum_SerialPort port, Enum_UARTEventType event, bool
pinLevel,void *customizePara)
```

- **Parameter**

port:
[In] Port name.

callback_uart:
[In] Pointer of the UART callback function.

event:
[Out] Indication of the event type of UART callback.

pinLevel:
[Out] If the event type is EVENT_UART_RI_IND, EVENT_UART_DCD_IND or EVENT_UART_DTR_IND, *pinLevel* indicates the related pin's current level. Otherwise this parameter is meaningless and can be ignored.

customizePara:
[In] Customized parameter. If not used, just set it to NULL.

- **Return Value**

The return value is *QL_RET_OK* if this function is executed successfully. Otherwise, the return value is an error code. To get extended error information, please refer to ERROR CODES.

5.7.1.3.2. Ql_UART_Open

This function opens a specified UART port with the specified flow control mode. The task that calls this function will own the specified UART port.

- **Prototype**

```
s32 Ql_UART_Open(Enum_SerialPort port,u32 baudrate, Enum_FlowCtrl flowCtrl)
```

- **Parameter**

port:
[In] Port name.

baudrate:
[In] The baud rates of the UART to be opened.
The physical UART supports baud rates in unit of bps as follows: 75, 150, 300, 600, 1200, 2400, 4800, 7200, 9600, 14400, 19200, 28800, 38400, 57600, 115200, 230400, 460800, 921600.

flowCtrl:
[In] Please refer to *Enum_flowCtrl* for the physical UART ports. Only UART_PORT1 supports hardware flow control (FC_HW).

- **Return Value**

The return value is *QL_RET_OK* if this function is executed successfully. Otherwise, the return value is an error code. To get extended error information, please refer to ERROR CODES.

5.7.1.3.3. Ql_UART_OpenEx

This function opens a specified UART port with the specified DCB parameters. The task that calls this function will own the specified UART port.

- **Prototype**

```
s32 Ql_UART_OpenEx(Enum_SerialPort port, ST_UARTDCB *dcb)
```

- **Parameter**

port:
[In] Port name.

dcb:
[In] Pointer to the UART DCB settings, including baud rates, data bits, stop bits, parity, and flow control. Only UART_PORT1 supports hardware flow control.

- **Return Value**

The return value is *QL_RET_OK* if this function is executed successfully. Otherwise, the return value is an error *code*. To get extended error information, please refer to ERROR CODES.

5.7.1.3.4. Ql_UART_Write

This function is used to send data to a specified UART port. When the number of bytes actually sent is less than that to be sent, the application should stop sending data, and then it (in callback function) will receive an event EVENT_UART_READY_TO_WRITE later. After receiving this event, the application can continue to send data, and the previously unsent data should be resent.

- **Prototype**

```
s32 Ql_UART_Write(Enum_SerialPort port, u8* data, u32 writeLen)
```

- **Parameter**

port:
[In] Port name.

data:
[In] Pointer to data to be written.

writeLen:
[In] The length of the data to be written. The maximum data length of the receive buffer for physical UART port is 2048 bytes.

- **Return Value**

Number of bytes actually written. If this function fails to write data, a negative number will be returned. To get extended error information, please refer to ERROR CODES.

5.7.1.3.5. Ql_UART_Read

This function reads data from a specified UART port. When the UART callback is invoked, and the notification is EVENT_UART_READY_TO_READ, all data in the UART RX buffer should be read out by calling this function in loop. Otherwise, there will not be such notification to be reported to the application when new data comes to UART RX buffer later.

- **Prototype**

```
s32 Ql_UART_Read(Enum_SerialPort port, u8* data, u32 readLen)
```

- **Parameter**

port:
[In] Port name

data:
[In] Pointer to the buffer for the read data.

readLen:
[In] The length of the data to be read. The maximum data length of the receive buffer for physical UART port is 1024 bytes. And the buffer size cannot be modified programmatically in applications.

- **Return Value**

Number of bytes actually read. If *readLen* equals to the actual read length, please continue reading the UART until the actual read length is less than the *readLen*. To get extended information please refer to ERROR CODES.

5.7.1.3.6. Ql_UART_Close

This function closes a specified UART port.

- **Prototype**

```
void Ql_UART_Close(Enum_SerialPort port)
```

- **Parameter**

port:
[In] Port name.

- **Return Value**

None.

5.7.1.4. Example

This chapter gives an example to illustrate how to use the UART port.

```
//Write the call back function, for deal with the UART notifications.
static void CallBack_UART_Hdlr(Enum_SerialPort port, Enum_UARTEventType msg, bool level, void*
customizedPara);    //Call back
{
        switch(msg)
        case EVENT_UART_READ_TO_READ：
          //Read data from the UART port
                Ql_UART_Read (port,buffer,rlen);
                break;
        case EVENT_UART_READ_TO_WRITE:
          //Resume the operation of write data to UART
                QL_UART_Write(port,buffer,wlen);
                break;
        default:
                break;
}
//Register the call back function
```

```
s32 Ql_UART_Register(UART_PORT1, CallBack_UART_Hdlr,NULL)
//Open the specified uart port
Ql_UART_Open(UART_PORT1);
//Write data to uart port
QL_UART_Write(UART_PORT1,buffer,len)
```

5.7.2. GPIO

5.7.2.1. GPIO Overview

There are 23 I/O pins that can be designed as general purpose I/Os. All these pins can be accessed by corresponding API functions.

5.7.2.2. GPIO List

Table 6: Multiplexing Pins

Pin No.	Pin Name	RESET	MODE1	MODE2	MODE3	MODE4	MODE5
3	PINNAME_SPI_MISO	I/PD	SPI_MST0_MISO	GPIO	EINT		
4	PINNAME_SPI_MOSI	I/PD	SPI_MST0_MOSI	GPIO	EINT		
5	PINNAME_SPI_SCLK	I/PD	SPI_MST0_SCLK	GPIO	EINT		
6	PINNAME_SPI_CS	I/PD	SPI_MST0_CS	GPIO	EINT		
16	PINNAME_NETLIGHT	I/PU	PWM	GPIO	EINT		
20	PINNAME_RI	I/PD	IIC0_SCL	GPIO	EINT		
21	PINNAME_DCD	I/PD	IIC0_SDA	GPIO	EINT		
22	PINNAME_CTS_AUX	I/PD		GPIO	EINT		
23	PINNAME_RTS_AUX	I/PD	PWM	GPIO	EINT		
26	PINNAME_GPIO1	I/PD		GPIO	EINT		
28	PINNAME_RXD_AUX	I/PD		GPIO	EINT		
29	PINNAME_TXD_AUX	I/PD		GPIO	EINT		

30	PINNAME_GPIO2	I/PD		GPIO	EINT		
31	PINNAME_GPIO3	I/PD	PWM	GPIO	EINT		
32	PINNAME_GPIO4	I/PD		GPIO	EINT		
33	PINNAME_GPIO5	I/PD		GPIO	EINT		
38	PINNAME_RX_DBG	I/PD		GPIO	EINT		
39	PINNAME_TX_DBG	I/PD		GPIO	EINT		
47	PINNAME_USB_MODE	I/PD		GPIO	EINT		
8	PINNAME_GPIO0	I/PD		GPIO	EINT		
52	PINNAME_GPIO6	I/High-Z		GPIO	EINT		
53	PINNAME_GPIO7	I/High-Z		GPIO	EINT		ADC1
54	PINNAME_GPIO8	I/High-Z		GPIO	EINT		ADC2

- **MODE1** defines the original status of pins in standard module.
- **RESET** column defines the default status of every pin after system powers on.
- **I** means input.
- **O** means output.
- **HO** means high output.
- **PU** means internal pull-up circuit.
- **PD** means internal pull-down circuit.
- **EINT** means external interrupt input.
- **PWM** means PWM output function.
- **ADC** means ADC sample function.

5.7.2.3. GPIO Initial Configuration`

There are two ways to initialize GPIOs. One is to configure initial GPIO list in *custom_gpio_cfg.h*, and please refer to ***Chapter 4.3*** for details. The other way is to call GPIO related API to initialize GPIOs after App starts.

The following codes show the initial configuration of PINNAME_NETLIGHT, PINNAME_STATUS and PINNAME_GPIO0 pins in *custom_gpio_cfg.h* file.

```
/*----------------------------------------------------------------------------------------------------------------------------------
{ Pin Name              |          Direction          |          Level          |     Pull Selection          }
*----------------------------------------------------------------------------------------------------------------------------------*/
```

```
#if 1// If needed, config GPIOs here
GPIO_ITEM(PINNAME_NETLIGHT,         PINDIRECTION_OUT,     PINLEVEL_LOW,   PINPULLSEL_PULLDOWN)
GPIO_ITEM(PINNAME_PCM_IN,           PINDIRECTION_OUT,     PINLEVEL_LOW,   PINPULLSEL_PULLDOWN)
GPIO_ITEM(PINNAME_PCM_OUT,          PINDIRECTION_OUT,     PINLEVEL_LOW,   PINPULLSEL_PULLUP)
#else if 0
…
#endif
```

5.7.2.4. GPIO Usage

The following shows how to use the multifunctional GPIOs:

Step 1: GPIO initialization. Call *Ql_GPIO_Init* function, and set a specified pin as the GPIO function and then initialize configurations such as direction, level and pull selection.
Step 2: GPIO control. When the pin is initialized as a GPIO, GPIO-related APIs can be called to change the GPIO level.
Step 3: Release the pin. If this pin is intended to be used for other purposes (such as EINT), please call *Ql_GPIO_Uninit* to release the pin first. This step is optional.

5.7.2.5. API Functions

5.7.2.5.1. Ql_GPIO_Init

This function enables the GPIO function of a specified pin, and initializes configurations such as direction, level and pull selection.

- **Prototype**

```
s32 Ql_GPIO_Init(Enum_ PinName pinName, Enum_ PinDirection dir, Enum_ PinLevel level , Enum_
PinPullSel pullsel)
```

- **Parameter**

pinName:
[In] Pin name.

dir:
[In] The initial direction of GPIO.

level:
[In] The initial level of GPIO.

pullsel:
[In] Pull selection.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.2.5.2. Ql_GPIO_GetLevel

This function gets the level of a specified GPIO.

- **Prototype**

```
s32 Ql_GPIO_GetLevel(Enum_ PinName pinName)
```

- **Parameter**

pinName:
[In] Pin name.

- **Return Value**

Return the level of the specified GPIO. 1 indicates high level, and 0 indicates low level.

5.7.2.5.3. Ql_GPIO_SetLevel

This function sets the level of a specified GPIO.

- **Prototype**

```
s32 Ql_GPIO_SetLevel(Enum_ PinName pinName, Enum_ PinLevel level)
```

- **Parameter**

pinName:
[In] Pin name.

level:
[In] The initial level of GPIO.

- **Return Value**

QL_RET_OK: indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.2.5.4. Ql_GPIO_GetDirection

This function gets the direction of a specified GPIO.

- **Prototype**

```
s32 Ql_GPIO_GetDirection(Enum_ PinName pinName)
```

- **Parameter**

pinName:
[In] Pin name.

- **Return Value**

Return the direction of the specified GPIO. 1 indicates output, and 0 indicates input.

5.7.2.5.5. Ql_GPIO_SetDirection

This function sets the direction of a specified GPIO.

- **Prototype**

```
s32 Ql_GPIO_SetDirection(Enum_ PinName pinName, Enum_ PinDirection dir)
```

- **Parameter**

pinName:
[In] Pin name.

dir:
[In] The initial direction of GPIO.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.2.5.6. Ql_GPIO_SetPullSelection

This function sets the pull selection of a specified GPIO.

- **Prototype**

```
s32 Ql_GPIO_SetPullSelection (Enum_ PinName pinName, Enum_ PinPullSel pullSel)
```

- **Parameter**

pinName:
[In] Pin name.

pullSel:
[In] Pull selection.

- **Return Value**

QL_RET_OK: indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.2.5.7. Ql_GPIO_Uninit

This function releases a specified GPIO that has been initialized by calling *Ql_GPIO_Init* previously. After releasing, the GPIO can be used for other purposes.

- **Prototype**

```
s32 Ql_GPIO_Uninit(Enum_ PinName pinName)
```

- **Parameter**

pinName:
[In] Pin name.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.2.6. Example

This chapter gives an example to illustrate how to use the GPIOs.

```
void API_TEST_gpio(void)
{
    s32 ret;
    Ql_Debug_Trace("\r\n<***********    GPIO API Test    ***********>\r\n");

    ret=Ql_GPIO_Init(PINNAME_NETLIGHT, PINDIRECTION_OUT, PINLEVEL_HIGH,
PINPULLSEL_PULLUP);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_Init ret=%d-->\r\n",PINNAME_NETLIGHT,ret);

    ret=Ql_GPIO_SetLevel(PINNAME_NETLIGHT,PINLEVEL_HIGH);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_SetLevel =%d ret=%d-->\r\n",
                                PINNAME_NETLIGHT,PINLEVEL_HIGH,ret);

    ret=Ql_GPIO_SetDirection(PINNAME_NETLIGHT,PINDIRECTION_IN);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_SetDirection =%d ret=%d-->\r\n",
                               PINNAME_NETLIGHT,PINDIRECTION_IN,ret);

    ret=Ql_GPIO_GetLevel(PINNAME_NETLIGHT);
   Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_GetLevel =%d ret=%d-->\r\n",
                              PINNAME_NETLIGHT,ret,ret);

    ret=Ql_GPIO_GetDirection(PINNAME_NETLIGHT);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_GetDirection =%d ret=%d-->\r\n",
                                PINNAME_NETLIGHT,ret,ret);

    ret=Ql_GPIO_SetPullSelection(PINNAME_NETLIGHT,PINPULLSEL_PULLDOWN);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_SetPullSelection =%d ret=%d-->\r\n",
                               PINNAME_NETLIGHT,PINPULLSEL_PULLDOWN,ret);

    ret=Ql_GPIO_GetPullSelection(PINNAME_NETLIGHT);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_GetPullSelection =%d ret=%d-->\r\n",
                               PINNAME_NETLIGHT,ret,ret);

    ret=Ql_GPIO_Uninit(PINNAME_NETLIGHT);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_GPIO_Uninit ret=%d-->\r\n",PINNAME_NETLIGHT,ret);
}
```

5.7.3. EINT

5.7.3.1. EINT Overview

BC66-QuecOpen/BC66-NA-QuecOpen has 13 I/O pins supporting external interrupt function, and please refer to ***Chapter 5.7.2.2*** for details. The external interrupt enjoys higher priority, so frequent interrupt is not allowed. It is strongly recommended that the interrupt frequency should be no more than 2, and too frequent interrupt will prevent other tasks from being scheduled, which probably leads unexpected exception.

NOTE

The interrupt response time is 50 ms by default, and can be re-programmed to a greater value. However, it is strongly recommended that the interrupt frequency should not be more than 3 Hz so as to ensure stable working of the module.

5.7.3.2. EINT Usage

The following steps show how to use the external interrupt function:

Step 1: Register an external interrupt function. Please choose one external interrupt pin and use *Ql_EINT_Register* (or *Ql_EINT_RegisterFast*) to register an interrupt handler function.
Step 2: Initialize the interrupt configurations. Call *Ql_EINT_Init* function to configure the software debounce time and set the level-triggered interrupt mode.
Step 3: Interrupt handle. The interrupt callback function will be called if the level has changed. It can also be processed in the handler.
Step 4: Mask the interrupt. When external interrupt is not needed, please call *Ql_EINT_Mask* function to disable it. When it is needed afterwards, please call *Ql_EINT_Unmask* function to enable it again.
Step 5: Release the specified EINT pin. Call *Ql_EINT_Uninit* function to release the specified EINT pin, and the pin can be used for other purposes after it is released. This step is optional.

5.7.3.3. API Functions

5.7.3.3.1. Ql_EINT_Register

This function registers an EINT I/O, and specifies the interrupt handler.

● **Prototype**

```
s32 Ql_EINT_Register(Enum_PinName eintPinName, Callback_EINT_Handle callback_eint,void* c
ustomParam) typedef void (*Callback_EINT_Handle)( Enum_PinName eintPinName, Enum_PinLe
vel pinLevel, void* customParam)
```

● **Parameter**

eintPinName:
[In] EINT pin name.

callback_eint:
[In] The interrupt handler.

pinLevel:
[In] The EINT pin level value.

customParam:
[In] Customized parameter. If not used, just set it to NULL.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.3.3.2. Ql_EINT_RegisterFast

This function registers an EINT I/O, and specifies the interrupt handler. The EINT that is registered by calling this function is a top half interrupt. The response to interrupt request is timelier. Please do not add any task schedule in the interrupt handler which cannot consume much CPU time. Otherwise it may lead to system exception or resetting.

- **Prototype**

```
s32 Ql_EINT_RegisterFast(Enum_PinName eintPinName, Callback_EINT_Handle callback_eint, v
oid* customParam)
```

- **Parameter**

eintPinName:
[In] EINT pin name.

callback_eint:
[In] The interrupt handler.

pinLevel:
[In] The EINT pin level value.

customParam:
[In] Customized parameter. If not used, just set it to NULL.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.3.3.3. Ql_EINT_Init

This function initializes an external interrupt function.

- **Prototype**

```
s32 Ql_EINT_Init(Enum_PinName eintPinName, Enum_EintType eintType,u32 hwDebounce,u32
swDebounce, bool autoMask)
```

- **Parameter**

eintPinName:
[In] EINT pin name.

eintType:
[In] Interrupt type: level-triggered or edge-triggered. Now, only level-triggered interrupt is supported.

hwDebounce:
[In] Hardware debounce.

swDebounce:
[In] Software debounce. Not supported currently.

autoMask:
[In] Whether automatically mask the external interrupt after the interrupt happens. 0 indicates no, and 1 indicates yes.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.3.3.4. Ql_EINT_Uninit

This function releases a specified EINT pin.

- **Prototype**

```
s32 Ql_EINT_Uninit(Enum_PinName eintPinName)
```

- **Parameter**

eintPinName:
[In] EINT pin name.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.3.3.5. Ql_EINT_GetLevel

This function gets the level of a specified EINT pin.

- **Prototype**

```
s32 Ql_EINT_GetLevel(Enum_PinName eintPinName)
```

- **Parameter**

eintPinName:
[In] EINT pin name.

- **Return Value**

1 indicates high level, and 0 indicates low level.

5.7.3.3.6. Ql_EINT_Mask

This function masks a specified EINT pin.

- **Prototype**

```
void Ql_EINT_Mask(Enum_PinName eintPinName)
```

- **Parameter**

eintPinName:
[In] EINT pin name.

- **Return Value**

None.

5.7.3.3.7. Ql_EINT_Unmask

This function unmasks a specified EINT pin.

- **Prototype**

```
void Ql_EINT_Unmask(Enum_PinName eintPinName)
```

- **Parameter**

eintPinName:
[In] EINT pin name.

- **Return Value**

None.

5.7.3.4. Example

The following sample codes show how to use the EINT function.

```
void eint_callback_handle(Enum_PinName eintPinName, Enum_PinLevel pinLevel, void* customParam)
{
    s32 ret;
    if(PINNAME_DTR==eintPinName) //Extern interrupt from which pin
    {
        ret=Ql_EINT_GetLevel(eintPinName); //Get the pin level if you need.

        //Developers need to unmask the interrupt again, because PINNAME_DTR pin interrupt is
initialized as auto mask.
        Ql_EINT_Unmask(eintPinName);
        if(*((s32*)customParam) >= 3)
        {
            //If developers do not want the interrupt, mask it now!!!
            Ql_EINT_Mask(eintPinName);
        }
    }
    else if(PINNAME_SIM_PRESENCE==eintPinName)
    {
        ret=Ql_EINT_GetLevel(eintPinName);
        Ql_Debug_Trace("\r\n<--Ql_EINT_GetLevel pin(%d) levle(%d)-->\r\n",eintPinName,ret);

        //Ql_EINT_Unmask(eintPinName); not need, initialization this interrupt is not auto mask.
        if(*((s32*)customParam) >= 3)
        {
            //If developers do not want the interrupt, mask it now!!!
            Ql_EINT_Mask(PINNAME_SIM_PRESENCE);
       }
    }
    *((s32*)customParam) +=1;
}

void API_TEST_eint(void)
```

```
{
    s32 ret;

     //Register PINNAME_SIM_PRESENCE pin for a top half external interrupt pin.
    ret=Ql_EINT_RegisterFast(PINNAME_SIM_PRESENCE,eint_callback_handle,(void
*)&EintcustomParam);

    //Initialize some parameters and set auto mask to FALSE.
    ret=Ql_EINT_Init(PINNAME_SIM_PRESENCE, EINT_LEVEL_TRIGGERED, 0,5,0);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_EINT_Init ret=%d-->\r\n",PINNAME_SIM_PRESENCE,ret);

    //Register PINNAME_DTR pin for an external interrupt pin.
    ret=Ql_EINT_Register(PINNAME_DTR,eint_callback_handle, (void *)&fastEintcustomParam);

    //Initialize some parameters and set auto mask to TRUE.
    ret=Ql_EINT_Init( PINNAME_DTR, EINT_LEVEL_TRIGGERED, 0, 5,1);
}
```

5.7.4. PWM

5.7.4.1. PWM Overview

BC66-QuecOpen/BC66-NA-QuecOpen has 3 PWM pins, and please refer to ***Chapter 5.7.2.2*** for details. The PWM pin has two clock sources: one is 32 KHz (the exact value is 32768 Hz) and the other is 13 MHz.

5.7.4.2. PWM Usage

The following steps illustrate how to use the PWM function:

Step 1: Initialize a PWM pin. Call *Ql_PWM_Init* function to configure the PWM duty cycle and frequency.
Step 2: PWM waveform control. Call *Ql_PWM_Output* to switch on/off the PWM waveform output.
Step 3: Release the PWM pin. Call *Ql_PWM_Uninit* to release the PWM pin. This step is optional.

5.7.4.3. API Functions

5.7.4.3.1. Ql_PWM_Init

This function initializes a PWM pin.

- **Prototype**

```
s32 Ql_PWM_Init(Enum_PinName pwmPinName, Enum_PwmSource pwmSrcClk,
Enum_PwmSourceDiv pwmDiv,u32 lowPulseNum,u32 highPulseNum)
```

- **Parameter**

pwmPinName:
[In] PWM pin name, and it can be PINNAME_NETLIGHT, PINNAME_RTS_AUX or PINNAME_GPIO3.

pwmSrcClk:
[In] PWM clock source.

pwmDiv:
[In] Clock source division.

lowPulseNum:
[In] Set the number of clock cycles to stay at low level. The result of *lowPulseNum* plus *highPulseNum* is less than 8193.

highPulseNum:
[In] Set the number of clock cycles to stay at high level. The result of *lowPulseNum* plus *highPulseNum* is less than 8193.

NOTES

1. PWM Duty cycle = *highPulseNum* / (*lowPulseNum* + *highPulseNum*)
2. PWM frequency = (*pwmSrcClk* / *pwmDiv*) / (*lowPulseNum* + *highPulseNum*)

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.4.3.2. Ql_PWM_Uninit

This function releases a PWM pin.

- **Prototype**

```
s32 Ql_PWM_Uninit (Enum_PinName pwmPinName)
```

- **Parameter**

pwmPinName:
[In] PWM pin name. It can be PINNAME_NETLIGHT, PINNAME_RTS_AUX or PINNAME_GPIO3.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.4.3.3. Ql_PWM_Output

This function switches on/off the PWM waveform output.

- **Prototype**

```
s32 Ql_PWM_Output(Enum_PinName pwmPinName,bool pwmOnOff)
```

- **Parameter**

pwmPinName:
[In] PWM pin name. It can be PINNAME_NETLIGHT, PINNAME_RTS_AUX or PINNAME_GPIO3.

pwmOnOff:
[In] PWM waveform output enable/disable control.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.4.4. Example

This following sample codes show how to use the PWM.

```
void API_TEST_pwm(void)
{
    s32 ret;

    //Initialize some parameters.
    ret=Ql_PWM_Init(PINNAME_NETLIGHT, PWMSOURCE_32K, PWMSOURCE_DIV4, 500, 500);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_PWM_Init ret=%d-->\r\n",PINNAME_NETLIGHT,ret);

    //Enable PWM waveform output.
    ret=Ql_PWM_Output(PINNAME_NETLIGHT, 1);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_PWM_Output start ret=%d-->\r\n",PINNAME_NETLIGHT,ret);

    Ql_Delay_ms(3000);
        //Disable PWM waveform output.
    ret=Ql_PWM_Output(PINNAME_NETLIGHT, 0);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_PWM_Output stop ret=%d-->\r\n",PINNAME_NETLIGHT,ret);

    //Release the pin if it is no longer needed.
    ret=Ql_PWM_Uninit(PINNAME_NETLIGHT);
    Ql_Debug_Trace("\r\n<--pin(%d) Ql_PWM_Uninit stop ret=%d-->\r\n",PINNAME_NETLIGHT,ret);
}
```

5.7.5. ADC

5.7.5.1. ADC Overview

BC66-QuecOpen/BC66-NA-QuecOpen provides two I/O pins and one analogue input pin that can be configured into ADC function. Please refer to ***document [2]*** or ***document [6]*** for the pin definitions and ADC hardware characteristics. The voltage range that can be detected is 0 to 1400 mV.

5.7.5.2. ADC Usage

The following steps tell the use of the ADC function:

Step 1: Register an ADC sampling function. Call *Ql_ADC_Register* function to register an ADC callback function which will be invoked after ADC has sampled count times.

Step 2: ADC sampling parameter initialization. Call *Ql_ADC_Init* function to set the sampling count and the interval of each sampling.

Step 3: Start/stop ADC sampling. Use *Ql_ADC_Sampling* function with an enable parameter to start ADC sampling, and then ADC callback function will be invoked cyclically to report the ADC value. Call this API function again with a disabling parameter may stop the ADC sampling.

5.7.5.3. API Functions

5.7.5.3.1. Ql_ADC_Register

This function registers an ADC callback function. The callback function will be called when the module outputs the ADC value.

- **Prototype**

```
s32 Ql_ADC_Register(Enum_ADCPin adcPin,Callback_ADC callback_adc,void *customParam)
typedef void (*Callback_ADC)( Enum_ADCPin adcPin, u32 adcValue, void *customParam)
```

- **Parameter**

adcPin:
[In] ADC pin name. Only supports ADC0.

callback_adc:
[In] Callback function, which will be called when the module outputs the ADC value.

customParam:
[In] Customize parameter. If not used, set it to NULL.

adcValue:
[In] The average value of ADC sampling. The range is 0-1400 mV.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.5.3.2. Ql_ADC_Init

This function initializes the configurations for ADC, including sampling count and the interval of each sampling. The ADC callback function will be called when the module outputs the ADC value, and the value is the average of the sampling value.

- **Prototype**

```
s32 Ql_ADC_Init(Enum_ADCPin adcPin,u32 count,u32 interval)
```

- **Parameter**

adcpin:
[In] ADC pin name. Only ADC0 is supported.

count:
[In] Internal sampling times for each reporting ADC value. The minimum value is 1.

interval:
[In] Interval of each internal sampling. Unit: ms. The minimum value is 200 and this means the ADC report frequency must be less than 1 Hz.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.5.3.3. Ql_ADC_Sampling

This function switches on/off ADC sampling.

- **Prototype**

```
s32 Ql_ADC_Sampling(Enum_ADCPin adcPin,bool enable)
```

- **Parameter**

adcPin:
[In] ADC pin name. Only ADC0 is supported.

enable:
[In] Sampling control. 1 means start sampling, and 0 means stop sampling.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.5.3.4. Ql_ADC_Read

This function is used to read ADC values.

- **Prototype**

```
s32 Ql_ADC_Read(Enum_ADCPin adcPin, u32 *adc_vol)
```

- **Parameter**

adcPin:
[In] PIN_ADC0, PIN_ADC1 and PIN_ADC2 are supported.

adc_vol:
[Out] ADC value. The range is 0-1400 mV.

- **Return Value**

Refer to the enumeration of *ql_adc_status_t.*

5.7.5.4. Example

The following example demonstrates the use of ADC sampling.

```
void ADC_callback_handle(Enum_ADCPin adcPin, u32 adcValue, void *customParam)
{
        s32 ret;
        if (PIN_ADC0==adcPin )
        {
                if( *((s32*)customParam) >= 4)
                {
                        //Stop ADC0 to sample, if you not need
                        ret=Ql_ADC_Sampling(PIN_ADC0, 0);
                }
        }
    *((s32*)customParam) +=1;
}
void API_TEST_adc(void)
{
        s32 ret;
        s32 voltage=0;
ret = Ql_ADC_Read(ADC0, &voltage);        //Register ADC0 callback function.
        ret=Ql_ADC_Register(PIN_ADC0, ADC_callback_handle, (void * )&ADC0customParam);

        //Set the internal sampling times, the each internal sampling interval
        ret=Ql_ADC_Init(PIN_ADC0, 5, 200);//So the ADC0 report the ADC value frequency 1 Hz.(5*200ms).
        ret=Ql_ADC_Sampling(PIN_ADC0, 1); //Start to sample
}
```

5.7.6. IIC

5.7.6.1. IIC Overview

BC66-QuecOpen/BC66-NA-QuecOpen provides a hardware IIC interface. The IIC interface can be simulated by GPIO pins, which can be any two GPIOs in the GPIO list in ***Chapter 5.7.2.2***. Therefore, one or more IIC interfaces are possible.

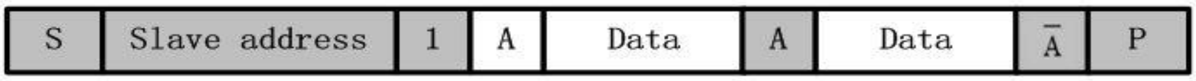
5.7.6.2. IIC Usage

The following steps tell how to work with IIC function:

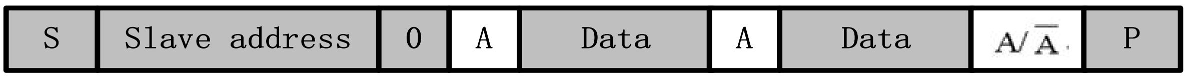
Step 1: Initialize IIC interface. Call *Ql_IIC_Init* function to initialize an IIC channel, including the specified GPIO pins for IIC and an IIC channel number.

Step 2: Configure IIC interface. Call *Ql_IIC_Config* to configure parameters that the slave device needs. Please refer to the API description for extended information.

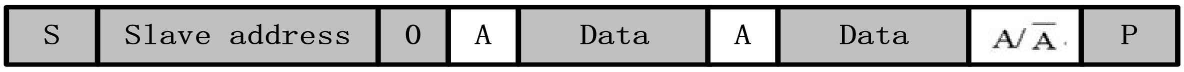
Step 3: Read data from slave. Call *Ql_IIC_Read* function to read data from the specified slave. The following figure shows the data exchange direction.



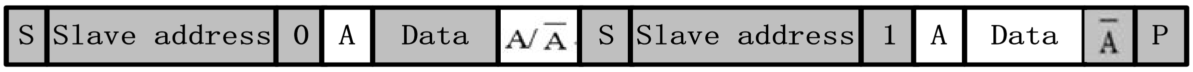
Step 4: Write data to slave. Call *Ql_IIC_Write* function to write data to the specified slave. The following figure shows the data exchange direction.



Step 5: Write the data to the register (or the specified address) of the slave. Call *Ql_IIC_Write* function to write the data to a register of the slave. The following figure shows the data exchange direction.



Step 6: Read the data from the register (or the specified address) of the slave. Call *Ql_IIC_Write_Read* function to read the data from a register of the slave. The following figure shows the data exchange direction.



Step 7: Release the IIC channel. Call *Ql_IIC_Uninit* function to release the specified IIC channel.

5.7.6.3. API Functions

5.7.6.3.1. Ql_IIC_Init

This function initializes the configurations for an IIC channel, including the specified pins for IIC, IIC type, and IIC channel number.

- **Prototype**

```
s32 Ql_IIC_Init(u32 chnnlNo, Enum_PinName pinSCL, Enum_PinName pinSDA, bool IICtype)
```

- **Parameter**

chnnlNo:
[In] IIC channel number. The range is 0-254.

pinSCL:
[In] IIC SCL pin.

pinSDA:
[In] IIC SDA pin.

IICtype:
[In] IIC type. 0 means the IIC communication is simulated by pins, while 1 means IIC controller.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.6.3.2. Ql_IIC_Config

This function configures the IIC interface for one slave.

- **Prototype**

```
s32 Ql_IIC_Config(u32 chnnlNo, bool isHost, u8 slaveAddr, u32 Iicspeed)
```

- **Parameter**

chnnlNo:
[In] IIC channel number. It is specified by *Ql_IIC_Init* function.

isHost:
[In] Whether to use host mode or not. It must be TRUE and only supports host mode.

slaveAddr:
[In] Slave address.

Iicspeed:
[In] Just for IIC controller, and the parameter can be ignored if simulated IIC is used.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.6.3.3. Ql_IIC_Write

This function writes data to a specified slave through IIC interface.

- **Prototype**

```
s32 Ql_IIC_Write(u32 chnnlNo,u8 slaveAddr,u8 *pData,u32 len)
```

- **Parameter**

chnnlNo:
[In] IIC channel number. It is specified by *Ql_IIC_Init* function.

slaveAddr:
[In] Slave address.

pData:
[In] Setting value to be written to the slave.

len:
[In] Number of bytes to be written. If *IICtype*=1, then 1<*len*<8 because the IIC controller supports 8 bytes at most for transmission at a time.

- **Return Value**

If no error occurs, the length of the written data will be returned. Negative integer indicates this function fails.

5.7.6.3.4. Ql_IIC_Read

This function reads data from a specified slave through IIC interface.

- **Prototype**

```
s32 Ql_IIC_Read(u32 chnnlNo,u8 slaveAddr,u8 *pBuffer,u32 len)
```

- **Parameter**

chnnlNo:
[In] IIC channel number. It is specified by *Ql_IIC_Init* function.

slaveAddr:
[In] Slave address.

pBuffer:
[Out] The buffer that stores the data read from a specific slave.

len:
[Out] Number of bytes to be read. If *IICtype*=1, then 1<*len*<8 because the IIC controller supports 8 bytes at most for transmission at a time.

- **Return Value**

If no error occurs, the length of the read data will be returned. Negative integer indicates this function fails.

5.7.6.3.5. Ql_IIC_Write_Read

This function reads data from a specified register (or address) of a specified slave.

- **Prototype**

```
s32 Ql_IIC_Write_Read(u32 chnnlNo,u8 slaveAddr,u8 * pData,u32 wrtLen,u8 * pBuffer,u32 rdLen)
```

- **Parameter**

chnnlNo:
[In] IIC channel number. It is specified by *Ql_IIC_Init* function.

slaveAddr:
[In] Slave address.

pData:
[In] Setting values of the specified register of the slave.

wrtLen:
[In] Number of bytes to be written. If *IICtype*=1, then 1<*wrtLen*<8.
pBuffer:
[Out] The buffer that stores the data read from a specific slave.

rdLen:
[Out] Number of bytes to be read. If *IICtype*=1, then 1<*wrtLen*<8.

- **Return Value**

If no error occurs, the length of the read data will be returned. Negative integer indicates this function fails.

5.7.6.3.6. Ql_IIC_Uninit

This function releases specified IIC pins.

- **Prototype**

```
s32 Ql_IIC_Uninit(u32 chnnlNo)
```

- **Parameter**

chnnlNo:
[In] IIC channel number. It is specified by *Ql_IIC_Init* function.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.6.4. Example

The following example code demonstrates the use of IIC interface.

```
void API_TEST_iic(void)
{
    s32 ret;
    u8 write_buffer[4]={0x10,0x02,0x50,0x0a};
    u8 read_buffer[6]={0x14,0x22,0x33,0x44,0x55,0x66};
    u8 registerAdrr[2]={0x01,0x45};
    Ql_Debug_Trace("\r\n<***********    IIC API Test    ***********>\r\n");

    //Simulate IIC test
    ret=Ql_IIC_Init(0,PINNAME_GPIO0,PINNAME_GPIO1,0);

    //Simulate IIC interface. The IIC speed can be ignored.
    ret=Ql_IIC_Config(0, TRUE,0x07, 0);

    ret=Ql_IIC_Write(0, 0x07, write_buffer, sizeof(write_buffer));
    ret=Ql_IIC_Read(0, 0x07, read_buffer, sizeof(read_buffer));
    ret=Ql_IIC_Write_Read(0, 0x07, registerAdrr, sizeof(registerAdrr),read_buffer, sizeof(read_buffer));

    //IIC controller test
    ret=Ql_IIC_Init(1,PINNAME_GPIO8,PINNAME_GPIO9,1);

    //IIC controller speed setting is necessary
    ret=Ql_IIC_Config(1, TRUE, 0x07, 300);

    ret=Ql_IIC_Write(1, 0x07, write_buffer, sizeof(write_buffer));
    ret=Ql_IIC_Read(1, 0x07, read_buffer, sizeof(read_buffer));
    ret=Ql_IIC_Write_Read(1, 0x07, registerAdrr, sizeof(registerAdrr),read_buffer, sizeof(read_buffer));
    ret=Ql_IIC_Uninit(1);
}
```

5.7.7. SPI

5.7.7.1. SPI Overview

The module provides a hardware SPI interface. The interface can also be simulated by GPIO pins, which can be any GPIO in the GPIO list in ***Chapter 5.7.2.2***.

5.7.7.2. SPI Usage

The following steps illustrate how to use the SPI function:

Step 1: Initialize SPI Interface. Call *Ql_SPI_Init* function to initialize the configurations for a SPI channel, including the specified pins for SPI, SPI type, and SPI channel number.
Step 2: Configure parameters. Call *Ql_SPI_Config* function to configure parameters for the SPI interface, including the clock polarity and clock phase.
Step 3: Write data. Call *Ql_SPI_Write* function to write bytes to the specified slave bus.
Step 4: Read data. Call *Ql_SPI_Read* function to read bytes from the specified slave bus.
Step 5: Write and read. Call *Ql_SPI_WriteRead* function for SPI full-duplex communication, that is, read and write data at the same time.
Step 6: Release SPI interface. Invoke *Ql_SPI_Uniti* function to release the SPI pins. This step is optional.

5.7.7.3. API Functions

5.7.7.3.1. Ql_SPI_Init

This function initializes the configurations for a SPI channel, including the SPI channel number and the specified GPIO pins for SPI.

- **Prototype**

```
s32 Ql_SPI_Init(u32 chnnlNo, Enum_PinName pinClk, Enum_PinName pinMiso, Enum_PinName
pinMosi, Enum_PinName pinCs,bool spiType)
```

- **Parameter**

chnnlNo:
[In] SPI channel number. The range is 0~254.

pinClk:
[In] SPI CLK pin.

pinMiso:
[In] SPI MISO pin.

pinMosi:
[In] SPI MOSI pin.

pinCs:
[In] SPI CS pin.

spiType:
[In] SPI type. It must be zero.

- **Return Value**

QL_RET_OK indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.7.3.2. Ql_SPI_Config

This function configures the SPI interface.

- **Prototype**

```
s32 Ql_SPI_Config (u32 chnnlNo, bool isHost, bool cpol, bool cpha, u32 clkSpeed)
```

- **Parameter**

chnnlNo:
[In] SPI channel number. It is specified by *Ql_SPI_Init* function.

isHost:
[In] Whether to use host mode or not. It must be TRUE and only supports host mode.

cpol:
[In] Clock polarity. Please refer to the SPI standard protocol for more information.

cpha:
[In] Clock phase. Please refer to the SPI standard protocol for more information.

clkSpeed:
[In] SPI speed. It is not supported currently, so the input argument will be ignored.

- **Return Value**

If no error occurs, the length of the write data will be returned. Negative integer indicates this function fails.

5.7.7.3.3. Ql_SPI_Write

This function writes data to the specified slave through SPI interface.

- **Prototype**

```
s32 Ql_SPI_Write(u32 chnnlNo,u8 * pData,u32 len)
```

- **Parameter**

chnnlNo:
[In] SPI channel number. It is specified by *Ql_SPI_Init* function.

pData:
[In] Setting value to be written to the slave.

len:
[In] Number of bytes to be written.

- **Return Value**

If no error occurs, the length of the write data will be returned. Negative integer indicates this function fails.

5.7.7.3.4. Ql_SPI_WriteRead

This function is used for SPI half-duplex communication.

- **Prototype**

```
s32 Ql_SPI_WriteRead(u32 chnnlNo,u8 *pData,u32 wrtLen,u8 * pBuffer,u32 rdLen)
```

- **Parameter**

chnnlNo:
[In] SPI channel number. It is specified by *Ql_SPI_Init* function.

pData:
[In] Setting value to be written to the slave.

wrtLen:
[In] Number of bytes to be written.

pBuffer:
[Out] The buffer that stores the data read from a specific slave.

rdLen:
[Out] Number of bytes to be read.

NOTES

1. If *wrtLen* > *rdLen*, the other read buffer data will be 0xFF.
2. If *rdLen* > *wrtLen*, the other write buffer data will be 0xFF.

- **Return Value**

If no error occurs, the length of the read data will be returned. Negative integer indicates this function fails.

5.7.7.3.5. Ql_SPI_WriteRead_Ex

This function is used for SPI full-duplex communication.

- **Prototype**

```
s32 Ql_SPI_WriteRead_Ex(u32 chnnlNo,u8 *pData,u32 wrtLen,u8 * pBuffer,u32 rdLen)
```

- **Parameter**

chnnlNo:
[In] SPI channel number. It is specified by *Ql_SPI_Init* function.

pData:
[In] Setting value to be written to the slave.

wrtLen:
[In] Number of bytes to be written.

pBuffer:
[Out] The buffer that stores the data that read from the slave device.

rdLen:
[In] Number of bytes to be read.

NOTES

1. If *wrtLen* > *rdLen*, the other read buffer data will be 0xFF.
2. If *rdLen* > *wrtLen*, the other write buffer data will be 0xFF.

- **Return Value**

If no error, the length of the read data will be returned.
QL_RET_ERR_PARAM: Indicates a parameter error.
QL_RET_ERR_CHANNEL_NOT_FOUND: Indicates that the SPI channel cannot be found. It is recommended to make sure the SPI channel is initialized.

5.7.7.3.6. Ql_SPI_Uninit

This function releases the SPI pins.

- **Prototype**

```
s32 Ql_SPI_Uninit(u32 chnnlNo)
```

- **Parameter**

chnnlNo:
[In] SPI channel number. It is specified by *Ql_SPI_Init* function.

- **Return Value**

QL_RET_OK: indicates this function is executed successfully. Negative integer indicates this function fails.

5.7.7.4. Example

The following example shows the use of the SPI interface.

```
void API_TEST_spi(void)
{
    s32 ret;
    u32 rdLen=0;
    u32 wdLen=0;
    u8   spi_write_buffer[]={0x01,0x02,0x03,0x0a,0x11,0xaa};
    u8    spi_read_buffer[100];
    Ql_Debug_Trace("\r\n<***********    TEST API Test    ***********>\r\n");

    ret=Ql_SPI_Init(1,PINNAME_KBR0,PINNAME_KBR1,PINNAME_KBR2,0);
    Ql_Debug_Trace("\r\n<--SPI channel 1 Ql_SPI_Init ret=%d-->\r\n",ret);

    ret=Ql_SPI_Config(1,1,1,1,0);// isHost=1, cpol=1, cpha=1,
    Ql_Debug_Trace("<--Ql_SPI_Config(), SPI channel 1, ret=%d-->",ret);

    wdLen=Ql_SPI_Write(1,spi_write_buffer,6);
    Ql_Debug_Trace("\r\n<--SPI channel 1 Ql_SPI_Write data len =%d-->\r\n",wdLen);

    rdLen=Ql_SPI_WriteRead(1,spi_write_buffer,6,spi_read_buffer,3);
    Ql_Debug_Trace("\r\n<--SPI channel 1 Ql_SPI_WriteRead Read data len =%d-->\r\n",rdLen);

    ret=Ql_SPI_Uninit(1);
    Ql_Debug_Trace("\r\n<--SPI channel 1 Ql_SPI_Uninit ret =%d-->\r\n",ret);
}
```

5.8. Debug APIs

The head file *ql_trace.h* must be included so that the debug functions can be called. All examples in QuecOpen® SDK show the proper usages of these APIs.

5.8.1. Usage

There are two working modes for UART2 (DEBUG port): BASE MODE and ADVANCE MODE. The working mode of UART2 can be configured by the *debugPortCfg* variable in the *custom_sys_cfg.c* file.

```
static const ST_DebugPortCfg debugPortCfg = {
BASIC_MODE            //Set the serial debug port (UART2) to a common serial port
    //ADVANCE_MODE    //Set the serial debug port (UART2) to a special debug port
};
```

In basic mode, application debug messages will be outputted as text through UART2 port. And the UART2 port works as common serial port with RX, TX and GND. In such case, UART2 can be used as common serial port for application.

In advance mode, both application debug messages and system debug messages will be outputted through UART2 port in a special format. The Genie Tool provided by Quectel can be used to capture and analyze these messages. Usually there is no need to use ADVANCE_MODE without the requirements from support engineers. If needed, please refer to ***document*** **[7]** for the usage of the special debug mode.

5.8.2. API Functions

5.8.2.1. Ql_Debug_Trace

This function formats and prints a series of characters and values through the debug serial port (UART2). Its function is the same as that of standard "sprintf".

- **Prototype**

```
extern s32    (*Ql_Debug_Trace)(char* fmt, ...)
```

- **Parameter**

fmt:
[In] Pointer to a null-terminated multibyte string that specifies how to interpret the data. The maximum string length is 512 bytes. Format-control string. A format specification has the following form:

%type
[In] A character that determines whether the associated argument is interpreted as a character, a string, or a number.

Table 7: Format Specification for String Print

Character	Type	Output Format
c	int	Specifies a single-byte character.
d	int	Signed decimal integer.
o	int	Unsigned octal integer.
x	int	Unsigned hexadecimal integer, using "abcdef."
f	double	Float point digit.
p	Pointer to void	Prints the address of the argument in hexadecimal digits.

- **Return Value**

Number of characters printed.

NOTES

1. The string to be printed must not be larger than the maximum number of bytes allowed in buffer. Otherwise, a buffer overrun can occur.
2. The maximum allowed number of characters to be outputted is 512.
3. To print a 64-bit integer, please first convert it to characters using *Ql_sprintf()*.

5.9. RIL APIs

QuecOpen® RIL-related API functions respectively implement the corresponding AT command's function. RIL APIs can be called to send AT commands and get the response when APIs return. Please refer to ***document [3]*** for QuecOpen® RIL mechanism.

NOTE

The APIs defined in this chapter work normally only after calling *Ql_RIL_Initialize()*, and *Ql_RIL_Initialize()* is used to initialize RIL option after App receives the message *MSG_ID_RIL_READY*.

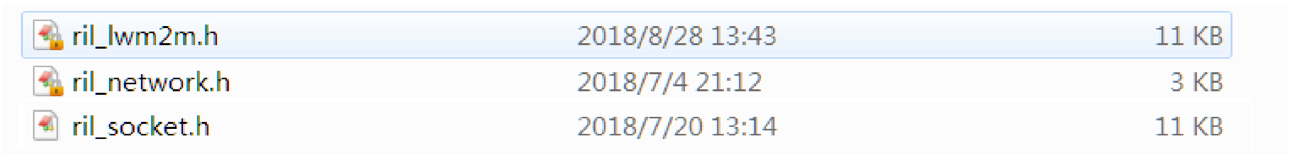
5.9.1. AT APIs

The API functions in this chapter are declared in header file *ril.h*.

5.9.1.1. Ql_RIL_SendATCmd

This function is used to send AT command with the result being returned synchronously. Before this function returns, the responses for AT command will be handled in the callback function *atRsp_callback*, and the paring results of AT responses can be stored in the space that the parameter *userData points* to. All AT responses string will be passed into the callback line by line. So the callback function may be called for times.

Network/UDP/TCP/LwM2M demos based on RIL API are available in *ril_xxx.h* files in *ril\inc* directory.



ril_lwm2m.h	2018/8/28 13:43	11 KB
ril_network.h	2018/7/4 21:12	3 KB
ril_socket.h	2018/7/20 13:14	11 KB

- **Prototype**

```
s32 Ql_RIL_SendATCmd(char*   atCmd,
                                u32 atCmdLen,
                                Callback_ATResponse atRsp_callback,
                                void* userData,
                                u32 timeout
                                );
typedef s32 (*Callback_ATResponse)(char* line, u32 len, void* userdata);
```

- **Parameter**

atCmd:
[In] AT command string.

atCmdLen:
[In] The length of AT command string.

atRsp_callBack:
[In] Callback function for handling the response of AT command.

userData:
[Out] Used to transfer user parameters.

timeout:
[In] Timeout for the AT command. Unit: ms. If it is set to 0, RIL uses the default timeout time (3 min).

- **Return Value**

RIL_AT_SUCCESS: Indicates the AT command is executed successfully, and the response is OK.
RIL_AT_FAILED: Indicates failed to execute the AT command or the response is ERROR.
RIL_AT_TIMEOUT: Indicates AT command sending times out.
RIL_AT_BUSY: Indicates the AT command is being sent.
RIL_AT_INVALID_PARAM: Indicates invalid input parameter.
RIL_AT_UNINITIALIZED: Indicates RIL is not ready and the module has to wait for MSG_ID_RIL_READY and then call *Ql_RIL_Initialize()* to initialize RIL.

- **Default Callback Function**

If this callback parameter is set to NULL, a default callback function will be called. But the default callback function only handles the simple AT response. Please refer to *Default_atRsp_callback* in *ril_atResponse.c*.

The following codes are the implementation for default callback function.

```
s32 Default_atRsp_callback(char* line, u32 len, void* userdata)
{
    if (Ql_RIL_FindLine(line, len, "OK")) //Find <CR><LF>OK<CR><LF>, <CR>OK<CR>，<LF>OK<LF>
    {
        return   RIL_ATRSP_SUCCESS;
    }
    else if (Ql_RIL_FindLine(line, len, "ERROR") //Find <CR><LF>ERROR<CR><LF>,
<CR>ERROR<CR>,<LF>ERROR<LF>
            || Ql_RIL_FindString(line, len, "+CME ERROR:") //Fail
            || Ql_RIL_FindString(line, len, "+CMS ERROR:")) //Fail
    {
        return   RIL_ATRSP_FAILED;
    }
    return RIL_ATRSP_CONTINUE;   //Continue to wait
}
```

6 Appendix A References

Table 8: Reference Documents

SN	Document Name
[1]	Quectel_BC66&BC66-NA_AT_Commands_Manual
[2]	Quectel_BC66-QuecOpen_Hardware_Design
[3]	Quectel_QuecOpen_RIL_Application_Note
[4]	Quectel_QFlash_User_Guide
[5]	Quectel_Genie_Tool_User_Guide
[6]	Quectel_BC66-NA-QuecOpen_Hardware_Design
[7]	*Quectel_* BC66&BC66-NA-*QuecOpen_Genie_Tool_User_Guide*

Table 9: Abbreviations

Abbreviation	Description
ADC	Analog-to-digital Converter
API	Application Programming Interface
APN	Access Point Name
App	Application
Core	Core System; QuecOpen® Operating System
CPU	Central Processing Unit
DCB	Data Center Bridging
DFOTA	Delta Firmware Upgrade Over-The-Air
EINT	External Interrupt Input
GCC	GNU Compiler Collection

GPIO	General Purpose Input Output
I/O	Input/Output
IIC	Inter-Integrated Circuit
KB	Kilobytes
M2M	Machine-to-Machine
MB	Megabytes
MCU	Micro Control Unit
NB-IoT	Narrowband Internet of Things
RAM	Random-Access Memory
RIL	Radio Interface Layer
RTC	Real Time Clock
SDK	Software Development Kit
SMS	Short Messaging Service
SPI	Serial Peripheral Interface
TCP	Transfer Control Protocol
TLV	Type-Length-Value
UART	Universal Asynchronous Receiver and Transmitter
UDP	User Datagram Protocol
URC	Unsolicited Result Code
WTD	Watchdog