HOLTEK HT32 MCU UART Application Note User Manual

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Introduction

The Universal Asynchronous Receiver/Transmitter – UART is a widely used serial transmission interface that provides flexible asynchronous full-duplex data transmission. The “Module_UART” application code provided in this application note uses TX/RX interrupts with software ring buffers to implement simple UART transmit/receive functions through APIs, whose related functions are described below. This will simplify the entire data transmission process and allow users to quickly understand and implement UART communication applications.

- Transmit/receive functions: byte read, byte write, buffer read, buffer write, etc.
- Status functions: obtain the buffer length, TX status, etc.

This document will first introduce the UART communication protocol, which will help users to better understand the UART communication from principle to application. This is followed by the download and preparation of the resources required for the application code, including the firmware library, application code download, file and directory configuration as well as an introduction to the terminal software tool used in the application note. In the Functional Description chapter, the application code directory structure, parameter settings and API description will be introduced. The API usage will be described using the “Module_UART” application code and the Flash/RAM resource consumption required for the APIs will also be listed. The Instructions for Use chapter will guide the user through the steps of environmental preparation, compilation and test to confirm that the application code will work properly. It will then provide instructions explaining how to integrate the APIs into the user’s projects and finally provide a reference for modifications and common problems that may be encountered.

Abbreviations used:

- **UART:** Universal Asynchronous Receiver/Transmitter
- **API:** Application Programming Interface
- **LSB:** Least Significant Bit
- **MSB:** Most Significant Bit
- **PC:** Personal Computer
- **SK:** Starter Kit, HT32 development board
- **IDE:** Integrated Development Environment

UART Communication Protocol

The UART is a serial communication type of interface that implements parallel-to-serial data conversion at its transmitter and then communicates serially with a similar receiver. The receiver then performs a serial-to-parallel data conversion after data reception. Figure 1 shows a schematic diagram of serial communication showing how the data is transferred in a bitwise order. Therefore for bidirectional communication between transmitter and receiver, only two wires, TX and RX, are required to transfer data serially between each other. TX is the pin on which the UART transmits the serial data and is connected to the RX pin of the receiver. Therefore the transmitter and receiver devices need to cross-connect their TX and RX pins to perform UART two-way communication, as shown in **Figure 2**.

Figure 1. Serial Communication Diagram

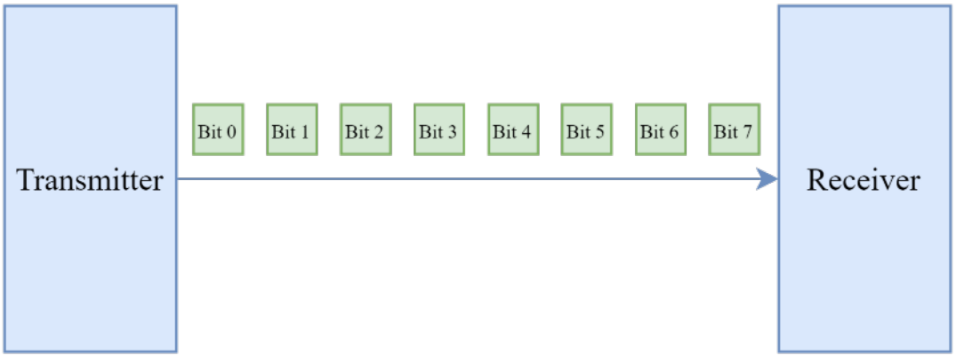
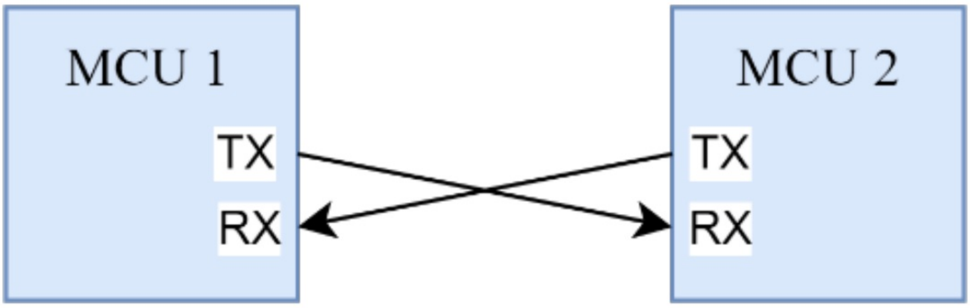


Figure 2. UART Circuit Diagram



During the UART serial communication, data transmission is asynchronous. This means that there is no clock or other synchronisation signal between the transmitter and receiver. Here a baud rate is used, which is the serial data transmitting/receiving speed and which is set by both sides in advance of data transfers. In addition, special bits such as start and stop bits are added to the beginning and end of the data packet to form a complete UART data packet. Figure 3 shows the UART data packet structure while Figure 4 shows a UART 8-bit data packet without a parity bit.

Figure 3. UART Data Packet Structure

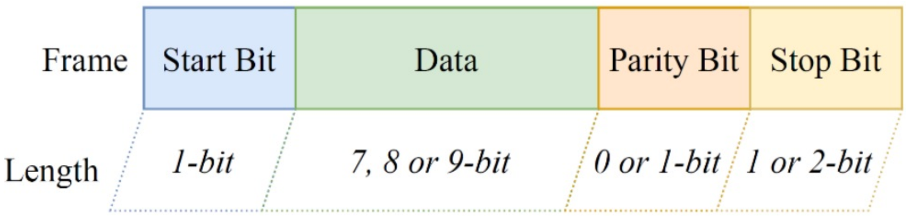
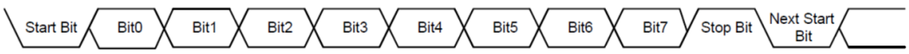


Figure 4. UART 8-bit Data Packet Format



Each part of the UART data packet is introduced in order below.

- **Start Bit:** This indicates the start of a data packet. The UART TX pin usually remains at a high logic level before transmission starts. If data transmission starts, the UART transmitter will pull the TX pin from high to low, i.e., from 1 to 0, and then hold it there for one clock cycle. The UART receiver will start reading data when a high to low transition has been detectedon the RX pin.
- **Data:** This is the actual data transferred, with a data length of 7, 8 or 9 bits. The data is usually transferred with the LSB first.
- **Parity Bit:** The number of logic "1" in the data is used to determine whether any data has changed during transmission. For even parity, the total number of logic "1" in the data should be an even number, conversely, the total number of logic "1" in the data should be an odd number for odd parity.

- **Stop Bit:** This indicates the end of a data packet, where the UART transmitter will pull the TX pin from low to high, i.e., from 0 to 1, and then hold it there for a 1 or 2-bit time period.

As mentioned before, since there is no clock signal in the UART circuit, the same serial data transmitting/receiving speed, which is known as the baud rate, must be defined between the transmitter and receiver to implement error-free transmission. The baud rate is defined by the number of bits transferred per second, in bps (bit per second). Some standard and commonly used baud rates are 4800bps, 9600bps, 19200bps, 115200bps, etc. The corresponding time required for transferring a single data bit is shown below.

Table 1. Baud Rate vs. 1-Bit Transmission Time

Baud Rate	1-Bit Transmission Time
4800bps	208.33μs
9600bps	104.16μs
19200bps	52.08μs
115200bps	8.68μs

Resource Download and Preparation

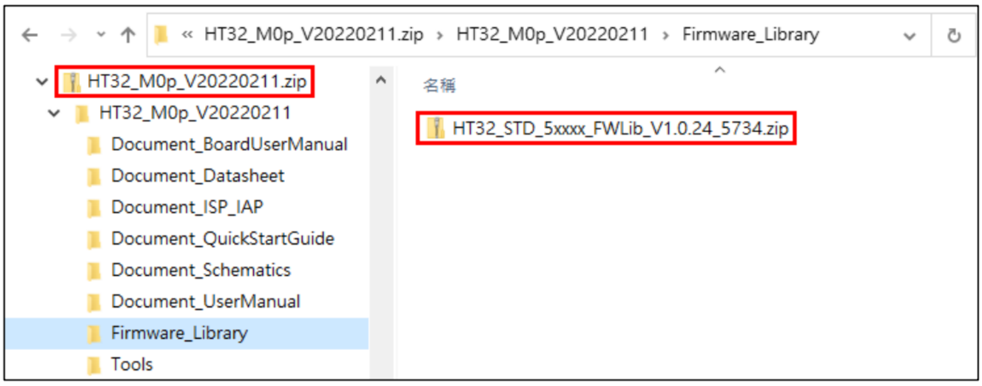
This chapter will introduce the application code and the software tool used, as well as how to configure the directory and file path.

Firmware Library

First, ensure that the Holtek HT32 firmware library has been downloaded before using the application code. The download link is shown below. Here there are two options, HT32_M0p_Vyyyymmdd.zip for the HT32F5xxxx series and HT32_M3_Vyyyymmdd.zip for the HT32F1xxxx series. Download and unzip the desired file.

The zip file contains several folders that can be classified as Document, Firmware Library, Tools and other items, the placement path of which is shown in Figure 5. The HT32 firmware library zip file with a file name of HT32_STD_xxxxx_FWLib_Vm.n.r_s.zip is located under the Firmware_Library folder.

Figure 5. HT32_M0p_Vyyyymmdd.zip Contents



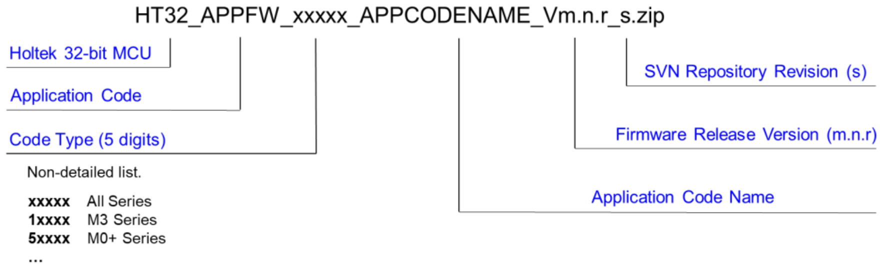
Application Code

Download the application code from the following link. The application code is packaged into a zip file with a file name of HT32_APPFW_xxxxx_APPCODENAME_Vm.n.r_s.zip. See **Figure 6** for the file name conventions.

Figure 6. Application Code File Name Introduction

Download link: https://mcu.holtek.com.tw/ht32/app.fw/Module_UART/

Download link: https://mcu.holtek.com.tw/ht32/app.fw/Module_UART/



File and Directory Configuration

As the application code does not contain the HT32 firmware library files, the application code and firmware library unzipped files should be placed in the correct path before starting the compilation. The application code zip file usually contains one or more folders, such as application and library, as shown in Figure 7. Place the application folder under the HT32 firmware library root directory to complete the file path configuration, as shown in Figure 8. Alternatively, unzip the application code and HT32 firmware library simultaneously into the same path to achieve the same configuration results.

Figure 7. HT32_APPFW_xxxxx_APPCODENAME_Vm.n.r_s.zip Contents

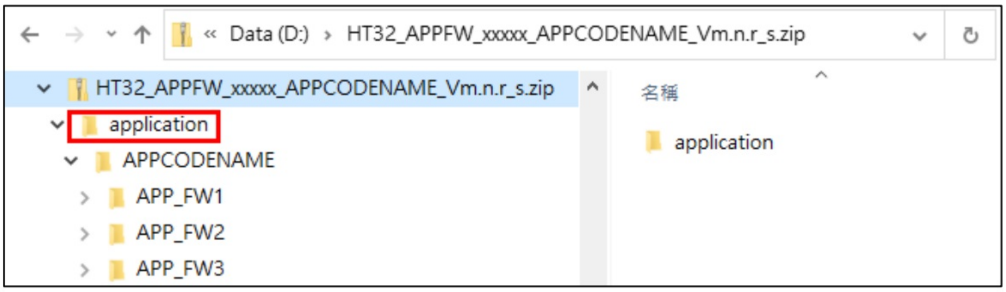
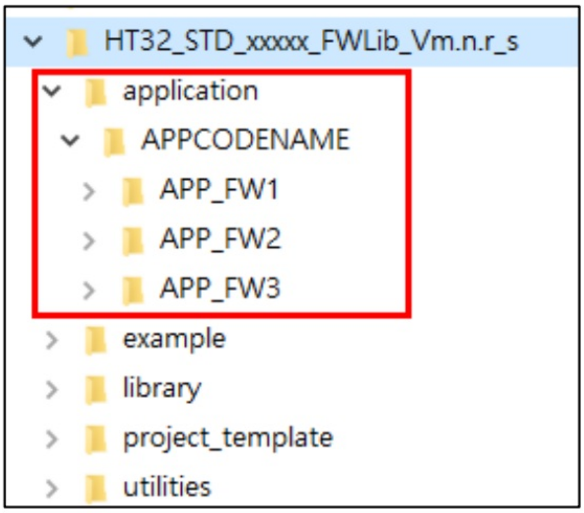


Figure 8. Decompression Path



Terminal Software

The application code can transfer messages through the COM port to implement function selection or status display. This requires the host side to have the terminal software installed in advance. Users can choose appropriate connection software, or use free licensed software such as Tera Term. In the application code, the UART channel is configured with a word length of 8-bits, no parity, 1 stop bit and a baud rate of 115200bps.

Functional Description

This chapter will provide a functional description for the application code, including information on the directory structure, API architecture, setting description, etc

Directory Structure

The application code file contains an application folder. The next layer is the “Module_UART” folder which contains two application programs, “UART_Module_Example” and “UART_Bridge”. The relevant files are listed and described below.

Table 2. Application Code Directory Structure

Folder / File Name	Description
application\Module_UART\UART_Module_Example[*1]	
_CreateProject.bat	Batch scripts for creating project files
_ProjectSource.ini	Initialisation file for adding source code to projects
ht32_board_config.h	Setup file related to IC peripheral I/O assignment
ht32fxxxxx_01_it.c	Interrupt service program file
main.c	Main program source code
application\Module_UART\UART_Bridge[*2]	
_CreateProject.bat	Batch scripts for creating project files
_ProjectSource.ini	Initialisation file for adding source code to projects
ht32_board_config.h	Setup file related to IC peripheral I/O assignment
ht32fxxxxx_01_it.c	Interrupt service program file
main.c	Source code of the main program
uart_bridge.h uart_bridge.c	UART bridge header file and source code file
utilities\middleware	
uart_module.h[*3] uart_module.c[*3]	API header file and source code file
utilities\common	
ringbuffer.h ring_buffer.c	Software ring buffer header file and source code file

Note:

1. In the “UART_Module_Example” application code, the API read and write operations are performed in a loopback manner, refer to the “API Usage Examples” section for more details.
2. In the “UART_Bridge” application code, two UART channels, UART CH0 and UART CH1, are activated, and custom communication protocol through the COMMAND structures are implemented between the two UART

devices. For more information, refer to the “API Usage Examples” section.

3. The application code needs to use the uart_module.c/h files which have a firmware library version requirement. The requirement may change time to time according to the update. To confirm the current firmware library version requirement, refer to the dependency check content by searching for keyword “Dependency check” in the main.c file. If the firmware library version does not meet the requirements, download the newest version from the link provided in the “Firmware Library” section.

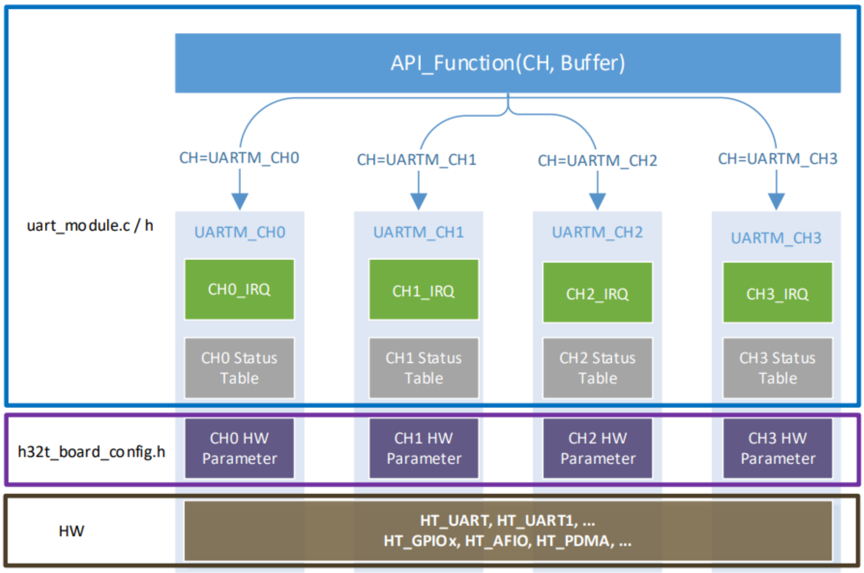
API Architecture

Each API has an important parameter CH, which is the UART Channel. This determines which UART channel is to be controlled. Currently up to four UART channels are supported and therefore four constant symbols are defined as follows. These are used as the parameter CH providing the APIs the basis for control.

- UARTM_CH0: input parameter – control or configure UART CH0
- UARTM_CH1: input parameter – control or configure UART CH1
- UARTM_CH2: input parameter – control or configure UART CH2
- UARTM_CH3: input parameter – control or configure UART CH3

Memory space will not be wasted if only one UART channel is used. This is because the number of the supported UART channels can be set and the unused UART channel code will be removed by the preprocessor to increase available memory space. The API architecture is shown in **Figure 9**.

Figure 9. API Architecture Block Diagram



Each API is composed of four groups of UART channel-related settings or controls so that users only need to input the desired CH parameter. To configure the relevant API, it is only required to have an additional UART basic configuration parameter table with the structure form, USART_InitTypeDef. The API will implement the UART basic configuration according to the parameter contents in the table. Refer to the “API Description” section for the UART basic configuration structure table.

The uart_module.c/.h files only contain the interrupt (CHx_IRQ) and status table (CHx Status) of each UART channel while all the settings required for UART communication is provided by ht32_board_config.h. The hardware relevant parameters in the ht32_board_config.h file are shown in the table below. More details are provided in the “Setting Description” section.

The hardware relevant parameters in the ht32_board_config.h include I/O settings and physical UART port settings, as follows.

Table 3. Definition Symbols in ht32_board_config.h

Symbol	Description
HTCFG_UARTM_CH0	Physical UART port name; Example: UART0, UART1…
HTCFG_UARTM0_TX_GPIO_PORT	Defines the port name of TX for CH0; Example: A, B, C…
HTCFG_UARTM0_TX_GPIO_PIN	Defines the pin number of TX for CH0; Example: 0~15
HTCFG_UARTM0_RX_GPIO_PORT	Defines the port name of RX for CH0; Example: A, B, C…
HTCFG_UARTM0_RX_GPIO_PIN	Defines the pin number of TX for CH0; Example: 0~15
HTCFG_UARTM0_TX_BUFFER_SIZE	Defines the TX buffer size for CH0; Example: 128
HTCFG_UARTM0_RX_BUFFER_SIZE	Defines the RX buffer size for CH0; Example: 128

To modify the UART channel AFIO configuration, refer to the relevant device datasheet. Currently only the I/O definitions for UART CH0 take effect as only UART CH0 has been configured in ht32_board_config.h. To add UART CH1~3, their I/O definitions need to be completed by referring to the UART CH0 definition or referring to the “Setting Modification and FAQs” section.

There are three API architecture main features:

1. Up to four UART channels are supported. Their input parameters are UARTM_CH0, UARTM_CH1, UARTM_CH2 and UARTM_CH3.
2. The number of UART channels can be set and unused channels will not reduce available memory space.
3. All the UART settings and I/O definitions are completely separated from the APIs. This increases the management convenience of setting values and reduces the possibility of incorrect or missing settings.

Setting Description

This section will introduce the parameter settings in the ht32_board_config.h and uart_module.h files.

1. ht32_board_config.h: This file is used for pin definitions and development board relevant settings, which include the UART IP channel (UART0, UART1, USART0…) used by the Starter Kit (SK), corresponding TX/RX pin locations and TX/RX buffer size. Figure 10 shows the setting contents of the HT32F52352 Starter Kit. Depending on the functional integration of the development, users can refer to the “Pin Assignment” section of the datasheet of the used device to implement the pin definitions. More details about setting modification will be described in the “Setting modification and FAQs” section.
   Figure 10. ht32_board_config.h Settings (HT32F52352)

```
#if defined(USE_HT32F52352_SK)
  #define HTCFG_UARTM_CH0                 USART1
  #define HTCFG_UARTM0_TX_GPIO_PORT       A
  #define HTCFG_UARTM0_TX_GPIO_PIN        4
  #define HTCFG_UARTM0_RX_GPIO_PORT       A
  #define HTCFG_UARTM0_RX_GPIO_PIN        5
  #define HTCFG_UARTM0_TX_BUFFER_SIZE     128
  #define HTCFG_UARTM0_RX_BUFFER_SIZE     128

  //#define HTCFG_UARTM_CH1                 USART0
  //#define HTCFG_UARTM1_TX_GPIO_PORT       A
  //#define HTCFG_UARTM1_TX_GPIO_PIN        2
  //#define HTCFG_UARTM1_RX_GPIO_PORT       A
  //#define HTCFG_UARTM1_RX_GPIO_PIN        3
  //#define HTCFG_UARTM1_TX_BUFFER_SIZE     128
  //#define HTCFG_UARTM1_RX_BUFFER_SIZE     128
#endif
```

2. **uart_module.h:** This is the API header file used by the application code, which includes the relevant default settings, function definitions, etc. As shown in Figure 11, the default setting contents can be overwritten by external configurations, such as the settings in the ht32_board_config.h file.
   Figure 11. Default Settings in uart_module.h

```
#ifndef HTCFG_UARTM_CH0
  /* !!! NOTICE !!!
     Default Setting which will be override by configuration outside (such as "ht32_board_config.h"),
     shall be modified according to the device you are using.
  */
  #define HTCFG_UARTM_CH0                 USART0
  #define HTCFG_UARTM0_TX_GPIO_PORT       A
  #define HTCFG_UARTM0_TX_GPIO_PIN        4
  #define HTCFG_UARTM0_RX_GPIO_PORT       A
  #define HTCFG_UARTM0_RX_GPIO_PIN        5
  #define HTCFG_UARTM0_TX_BUFFER_SIZE     128
  #define HTCFG_UARTM0_RX_BUFFER_SIZE     128
#endif
```

API Description

1. Application code data type description.
   - **USART_InitTypeDef**
     This is the UART basic configuration structure which is composed of BaudRate, WordLength, StopBits, Parity and Mode configurations, as shown below.

Variable Name	Type	Description
USART_BaudRate	u32	UART communication baud rate
USART_WordLength	u16	UART communication word length: 7, 8 or 9 bits
USART_StopBits	u16	UART communication stop bit length: 1 or 2 bits
USART_Parity	u16	UART communication parity: even, odd, mark, space or no parity
USART_Mode	u16	UART communication mode; the APIs only support normal mode

2. Before using the API functions, complete the UART basic configuration in the main program. The UART basic configuration for this application code is shown in Figure 12. Here the baud rate is 115200bps, word length is 8-bit, stop bit length is 1-bit, and there is no parity.
   Figure 12. UART Basic Configuration

```
USART_InitTypeDef USART_InitStructure;
USART_InitStructure.USART_BaudRate = 115200;
USART_InitStructure.USART_WordLength = USART_WORDLENGTH_8B;
USART_InitStructure.USART_StopBits = USART_STOPBITS_1;
USART_InitStructure.USART_Parity = USART_PARITY_NO;
USART_InitStructure.USART_Mode = USART_MODE_NORMAL;
```

3. Figure 13 shows the API functions declared in the uart_module.h file. The following tables explain the function, input parameters and usage of the API functions.

Figure 13. API Function Declarations in uart_module.h

```
/* Exported functions ------------------------------------------------------------
void UARTM_Init(u32 CH, USART_InitTypeDef *pUART_Init, u32 uRxTimeOutValue);

u32 UARTM_WriteByte(u32 CH, u8 uData);
u32 UARTM_Write(u32 CH, u8 *pBuffer, u32 uLength);

u32 UARTM_ReadByte(u32 CH, u8 *pData);
u32 UARTM_Read(u32 CH, u8 *pBuffer, u32 uLength);

u32 UARTM_GetReadBufferLength(u32 CH);
u32 UARTM_GetWriteBufferLength(u32 CH);

u8 UARTM_IsTxFinished(u32 CH);

void UARTM_DiscardReadBuffer(u32 CH);
```

Name	**void UARTM_Init(u32 CH, USART_InitTypeDef *pUART_Init, u32 uRxTimeOutValue)**	
Function	UART module initialisation	
Input	CH	UART channel
	pUART_Init	UART basic configuration structure pointer
	uRxTimeOutValue	UART RX FIFO time-out value. When the RX FIFO receives new data the counter will reset and restart. Once the counter reaches the preset time-out value and the corresponding time-out interrupt has been enabled, a time-out interrupt will be generated.
Usage	UARTM_Init(UARTM_CH0, &USART_InitStructure, 40);//Execute UART basic configuration//Refer to Figure 12 for USART_InitStructure configuration	

Name	**u32 UARTM_WriteByte(u32 CH, u8 uData)**	
Function	UART module write byte operation (TX)	
Input	CH	UART channel
	uData	The data to be written
Output	SUCCESS	Successful
	ERROR	Failed
Usage	UARTM_WriteByte(UARTM_CH0, ‘A’); //UART writes 1 byte – ‘A’	

Name	**u32 UARTM_Write(u32 CH, u8 *pBuffer, u32 uLength)**	
Function	UART module write operation (TX)	
Input	CH	UART channel
	pBuffer	Buffer pointer
	uLength	The length of the data to be written
Output	SUCCESS	Successful
	ERROR	Failed
Usage	u8 Test[] = “This is test!\r\n”; UARTM_Write(UARTM_CH0, Test, sizeof(Test) - 1); //UART writes pBuffer data	

Name	**u32 UARTM_ReadByte(u32 CH, u8 *pData)**	
Function	UART module read byte operation (RX)	
Input	CH	UART channel
	pData	The address to place the read data
Output	SUCCESS	Successful
	ERROR	Failed (no data)
Usage	u8 TempData; if (UARTM_ReadByte(UARTM_CH0, &TempData) == SUCCESS){UARTM_WriteByte(UARTM_CH0, TempData);}//If UARTM_ReadByte() returns SUCCESS then UART writes this data byte	

Name	**u32 UARTM_Read(u32 CH, u8 *pBuffer, u32 uLength)**	
Function	UART module read operation (RX)	
Input	CH	UART channel
	pBuffer	Buffer pointer
	uLength	The length of the data to be read
Output	Read count	The length of the data has been read
Usage	u8 Test2[10]; u32 Len; Len = UARTM_Read(UARTM_CH0, Test2, 5);if (Len > 0){UARTM_Write(UARTM_CH0, Test2, Len);}//UARTM_Read() reads 5 bytes of data and stores data into Test2, and assigns the read byte count to Len//Write the data sourced from Test2	

Name	**u32 UARTM_GetReadBufferLength(u32 CH)**	
Function	Obtain the read buffer length (RX)	
Input	CH	UART channel
Output	uLength	Read buffer length
Usage	UARTM_Init(UARTM_CH0, &USART_InitStructure, 40); //UART module initialisation while (UARTM_GetReadBufferLength(UARTM_CH0) < 5);//Wait until UARTM_ReadBuffer has received 5 bytes of data	

Name	**u32 UARTM_GetWriteBufferLength(u32 CH)**	
Function	Obtain the write buffer length (TX)	
Input	CH	UART channel
Output	uLength	Write buffer length

Name	**u8 UARTM_IsTxFinished(u32 CH)**	
Function	Obtain the TX status	
Input	CH	UART channel
Output	TRUE	TX status: finished
	FALSE	TX status: not finished
Usage	UARTM_WriteByte(UARTM_CH0, ‘O’); #if 1 // “uart_module.c” SVN >= 525 requiredwhile (UARTM_IsTxFinished(UARTM_CH0) == FALSE) #elsewhile (1) #endif //This API can be used to check the TX status, as shown above; wait until the UARTM_WriteByte() API has finished, i.e., TX status is TRUE, and then continue the subsequent actions.//A restriction is added because this function has not been added until the SVN version number in uart_module.c is 525.	

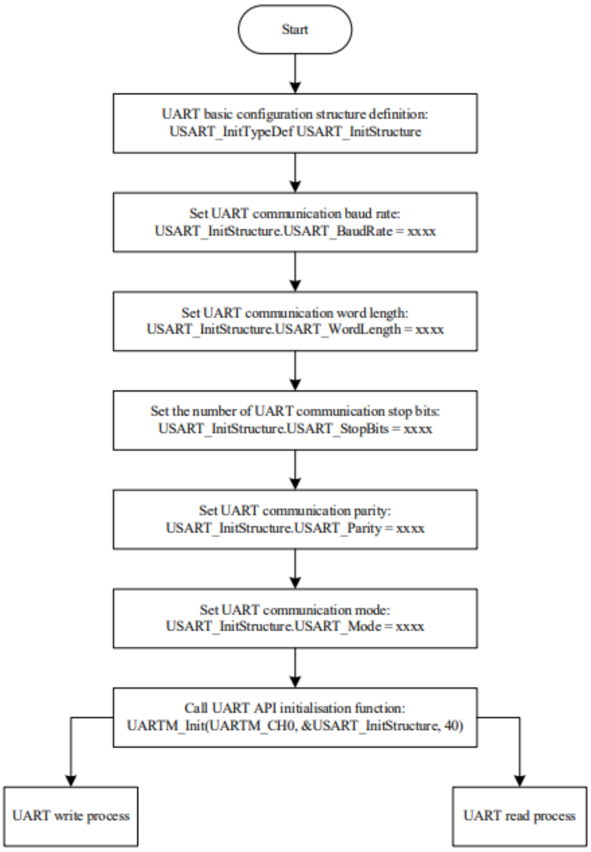
Name	**void UARTM_DiscardReadBuffer(u32 CH)**	
Function	Discard the data in the read buffer	
Input	CH	UART channel

API Usage Examples

This section will demonstrate API write and read examples of the “Module_UART” application code using the initialisation process and the “UART_Module_Example” application code process. Before using the APIs, users need to include the API header file into the main program source code file (#include “middleware/uart_module.h”).

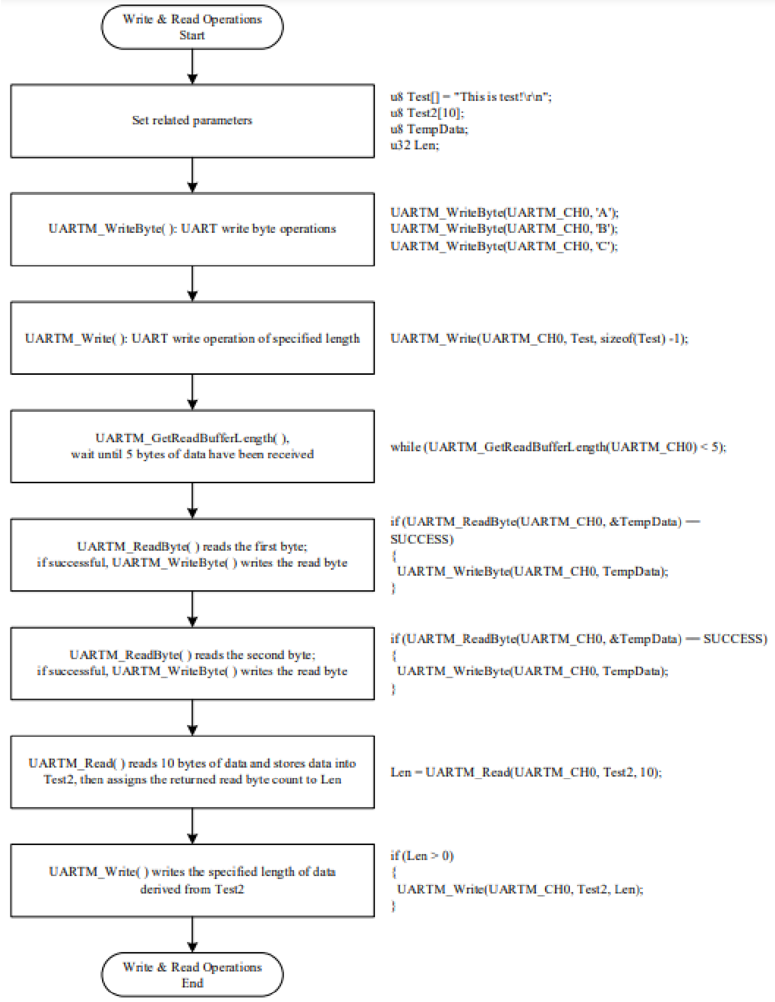
As shown in Figure 14, when entering the initialisation process, first define theUART basic configuration structure. Then configure the UART basic configuration structure members including BaudRate, WordLength, StopBits, Parity and Mode. Finally, call the API initialisation function, the completion of which indicates the end of the initialisation process. After this userscan continue the write and read operations based on the preset UART basic configuration.

Figure 14. Initialisation Flowchart



The “UART_Module_Example” application code demonstrates the API read and write operations in a loopback manner. The flowchart for this is shown in Figure 15. The API functions used include UARTM_WriteByte(), UARTM_Write(), UARTM_ReadByte(), UARTM_Read() and UARTM_GetReadBufferLength(). Their description are provided in the “API Description” section.

Figure 15. Flowchart of Write and Read Examples



There is another “UART_Bridge” application code under the “Module_UART” folder whose related file description is introduced in the “Directory Structure” section. The “UART_Bridge” application code activates two UART channels, UART CH0 and UART CH1, and then customises the communication protocol between the two UART devices through COMMAND structures, gCMD1 and gCMD2. These are defined in uart_bridge.c, as shown below. UARTBridge_CMD1TypeDef gCMD1:

Variable Name	Type	Description
uHeader	u8	Header
uCmd	u8	Command
uData[3]	u8	Data

UARTBridge_CMD2TypeDef gCMD2:

Variable Name	Type	Description
uHeader	u8	Header
uCmdA	u8	Command A
uCmdB	u8	Command B
uData[3]	u8	Data

In the “UART_Bridge” application code, use gCMD1 to receive data as a command packet and then analyse it. Then according to the customised communication protocol, set gCMD2 as a response packet and transmit it. The following is an example of a command packet gCMD1) and a response packet (gCMD2). Command Packet (UARTBridge_CMD1TypeDef gCMD1):

Byte 0	Byte 1	Byte 2 ~ Byte 4
uHeader	uCmd	uData [3]
“A”	“1”	“x, y, z”

Response Packet (UARTBridge_CMD2TypeDef gCMD2):

Byte 0	Byte 1	Byte 2	Byte 3 ~ Byte 5
uHeader	uCmdA	uCmdB	uData [3]
“B”	“a”	“1”	“x, y, z”

Resource Occupation
Taking the HT32F52352 as an example, the resources occupied by the UART module is shown below.

	HT32F52352
ROM Size	946 Bytes
RAM Size	40*1 + 256*2 Bytes

Note:

1. Global variables including flags and status for a single channel occupy 40 bytes of RAM.
2. This is for a condition where a single channel is used and the TX/RX buffer size is 128/128 bytes. The buffer size can be set according to the application requirements.

Table 4. Application Code Resource Occupation

- **Compilation environment:** MDK-Arm V5.36, ARMCC V5.06 update 7 (build 960)
- **Optimise option:** Level 2 (-O2)

Instructions for Use

This chapter will introduce the environmental preparation for the “Module_UART” application code, as well as the compilation and test steps.

Environmental Preparation
The hardware and software required for the “Module_UART” application code are listed below.
Table 5. Hardware/Software Environmental Preparation

Hardware/Software	**Count**	**Note**
Starter Kit	1	This application note uses the HT32F52352 Starter Kit as an example
USB Cable	1	Micro USB, connected to PC
Application Code	—	The download path, file and directory configuration are introduced in the “Resource Download and Preparation” section.Path: “\\application\Module_UART\UART_Module_Example”
Tera Term	—	Refer to the “Terminal Software” section
Keil IDE	—	Keil uVision V5.xx

First, use the HT32F52352 Starter Kit combined with the Virtual COM Port (VCP) function of e-Link32 Lite for the UART application introduction. This requires the following environmental preparation to be implemented:

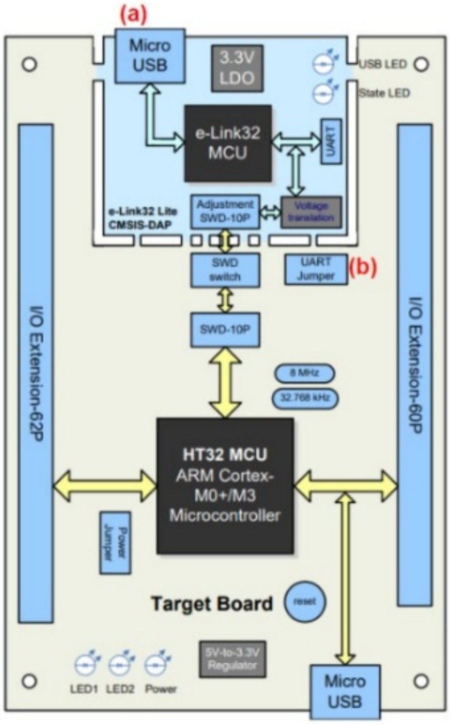
1. There are two USB interfaces on the board. Use the USB cable to connect the PC and the eLink32 Lite interface on the board as shown in Figure 16-(a).
2. As the application code needs to use the e-Link32 Lite Virtual COM Port (VCP) function, ensurethat the PAx*2 and DAP_Tx of UART Jumper-J2*1 has been shorted using a jumper. The J2 location is indicated by Figure 16-

(b).

Note

1. J2 on the Starter Kit has two options, PAx and DAP_Tx shorted or PAx and RS232_Tx shorted. Refer to the Starter Kit user manual for the detailed setting functions.
2. The MCU UART RX pin location on different Starter Kits are different. This example uses PAx to indicate the RX pin.

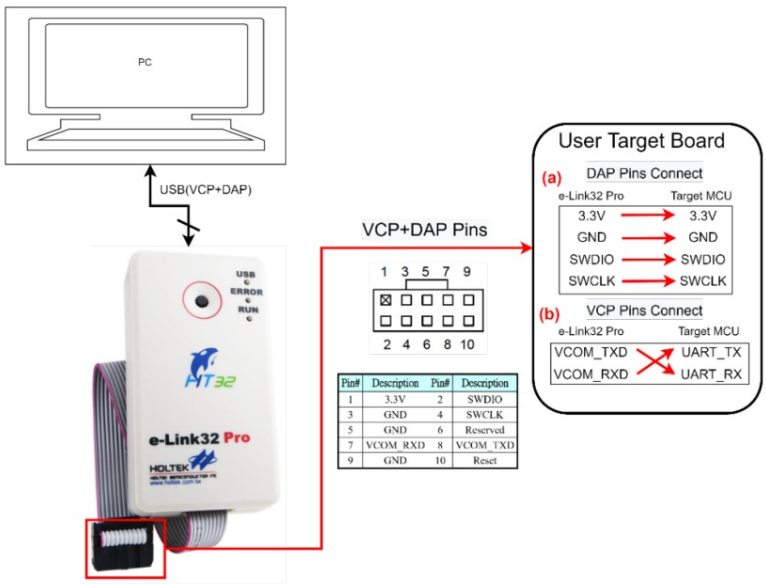
Figure 16. HT32 Starter Kit Block Diagram



Now use the user target board combined with the Virtual COM Port (VCP) function of the e-Link32 Pro for the UART application introduction. This requires the following environmental preparation to be implemented:

1. One side of e-Link32 Pro is connected to a PC using a Mini USB cable and the other side is connected to the user target board through its 10-bit grey cable. The connection between the SWD interfaces of the cable and target board is implemented using Dupont lines, as shown in Figure 17-(a).
2. The serial communication pins of the e-Link32 Pro are Pin#7 VCOM_RXD and Pin#8- VCOM_TXD. These should be connected to the TX and RX pins of the user target board, as shown in Figure 17-(b).

   Figure 17. e-Link32 Pro + User Target Board Block Diagram



Compilation and Test

This section will take the "application\Module_UART\UART_Module_Example" as an example to introduce the compilation and test processes. Before this, ensure that all the preparations described in the previous section have been implemented and that the Tera Term terminal software has been downloaded.

The detailed operation steps are summarised below.

Step 1. Power-on test

Set up the hardware environment as described in the previous section. After power-on, the D9 power LED on the lower left of the Starter Kit will be illuminated. The D1 USB LED on the e-Link32 Lite on the upper right will be illuminated after the USB enumeration has completed. If D1 is not illuminated after a long period of time, confirm whether the USB cable is able to communicate. If not then remove it and re-insert it again.

Step 2. Generate a project

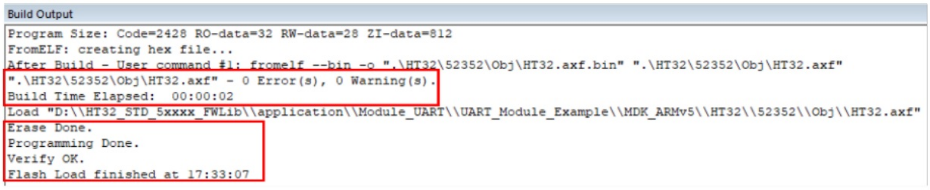
Open the application\Module_UART\UART_Module_Example folder, click on the _CreateProject.bat file to generate a project, as shown in Figure 18. Since this application note uses the HT32F52352 Starter Kit, open the Keil IDE project "Project_52352.uvprojx" located under the MDK_ARMv5 folder.

Figure 18. Execute _CreateProject.bat to Generate Project

Step 3. Compile and program

After the project has been opened, first click on "Build" (or use shortcut "F7"), then click on "Download" (or use shortcut "F8"). After this, the build and download results will be displayed in the Build Output window. See Figure 19.

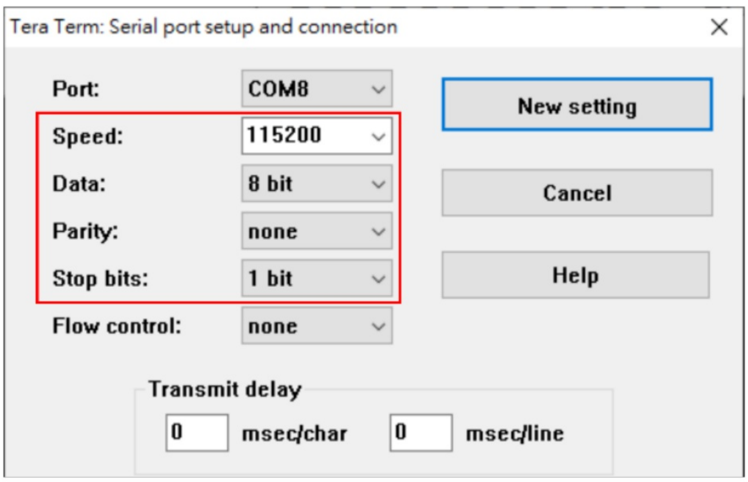
Figure 19. Build and Download Results



Step 4. Open the Tera Term software and configure the serial port

Open the Tera Term software and the COM port. Pay attention to whether the COM port number generated by the Starter Kit is correct or not. Then click on "Setup >> Serial Port" to enter the configuration interface. The UART interface configuration of the "Module_UART" application code is described in the "Terminal Software" section. The setup result is shown in Figure 20.

Figure 20. Tera Term Serial Port Setup Result



Step 5. Reset the system and test

Press the SK reset key – B1 Reset. After this, a “ABCThis is test!” message will be transmitted through the API and will be displayed in the Tera Term window, as shown inFigure 21. Regarding the receive function, when entering data into the Tera Term window, the relevant API will be used to determine the receive buffer length. When the data received by PC reaches 5 bytes, the received 5 bytes of data will be sent out sequentially. As shown in Figure 22, the data sequentially entered is “1, 2, 3, 4, 5”, which is received and determined through the API. After this, the data “1, 2, 3, 4, 5” will be printed after the five inputs.

Figure 21. “Module_UART” Application Code Functional Test – Transmit

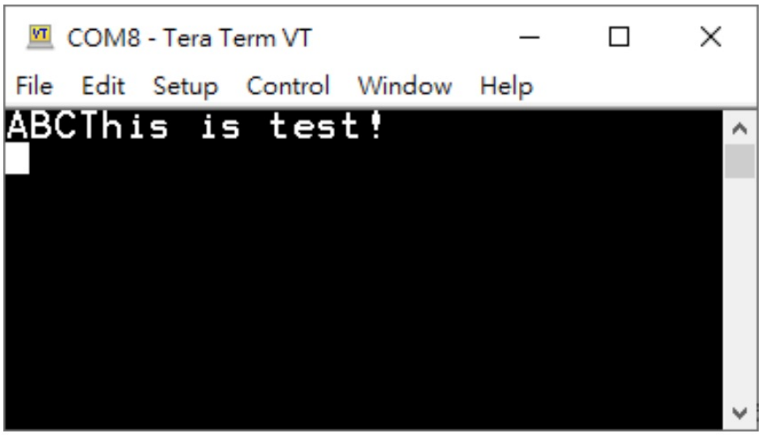
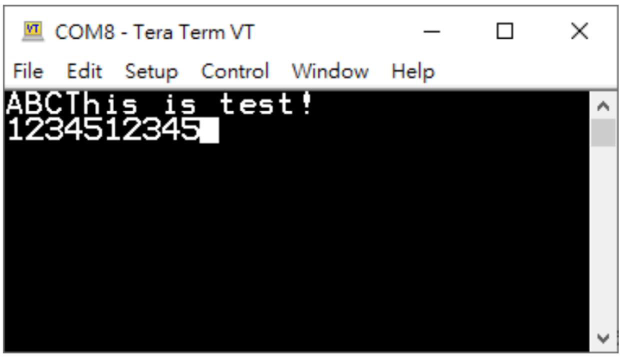


Figure 22. “Module_UART” Application Code Functional Test – Receive

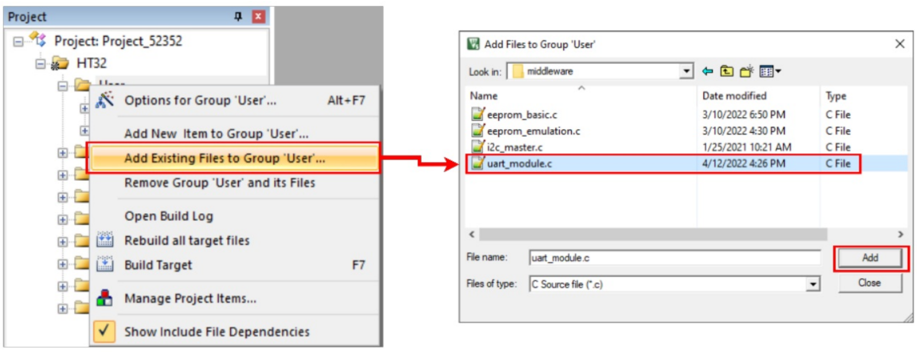


Transplant Instructions

This section will introduce how to integrate the APIs into the user’s projects.

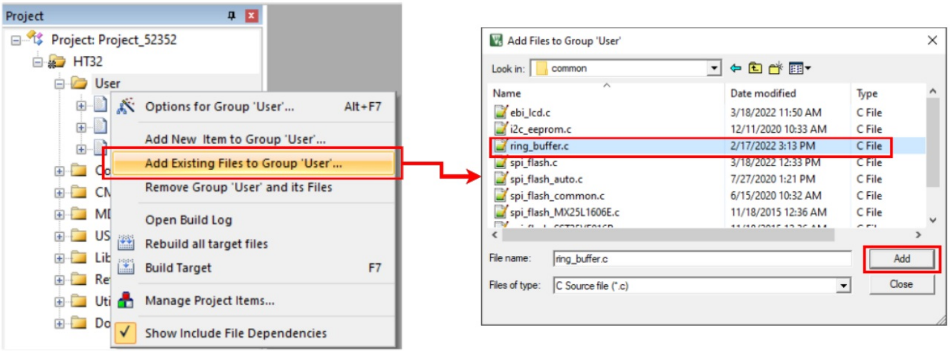
Step 1. Add the uart_module.c file into the project. Right-click on the User folder. Select “Add Existing Files to Group ‘User’…”, then select the uart_module.c file and click on “Add”, as shown in Figure 23. Refer to the “Directory Structure” section for the file path description.

Figure 23. Add uart_module.c File to Project



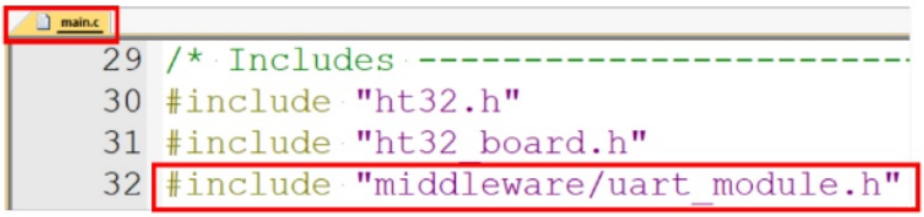
Step 2. Add the ring_buffer.c file into the project. Right-click on the User folder. Select “Add Existing Files to Group ‘User’…”, then select the ring_buffer.c file and click on “Add”, as shown in Figure 24.\ Refer to the “Directory Structure” section for the file path description.

Figure 24. Add ring_buffer.c File to Project



Step 3. Include the API header file into the beginning of main.c, as shown in Figure 25. (Ext: #include "middleware/uart_module.h")

Figure 25. Include API Header File to main.c



Step 4. Implement the settings required for the UART communication using the ht32_board_config.h file. This is introduced in detail in the "Setting Description" and "Setting Modification and FAQs" sections.

Setting Modification and FAQs

This section will introduce how to modify the UART settings and explain some common questions encountered during use.

Change UART Pin Assignment

1. Referring to the HT32F52352 Datasheet "Pin Assignment" chapter, look up the Alternate Function Mapping table which lists the AFIO functions of the device type. For the UART relevant pins, refer to the "AF6 USART/UART" column, as shown in Figure 26.
   Figure 26. HT32F52352 Alternate Function Mapping Table
2. This step will guide users to locate the corresponding UART pins using the above table. The HT32F52352 example uses USART1 as the default channel. Here, the TX and RX pins are USR1_TX and USR1_RX and are located on PA4 and PA5 respectively. Figure 27 shows the pin correspondence as well as the pin definitions in "ht32_board_config.h". The empty fields of "Package" in the pin assignment table means that there are no relevant GPIOs in this package. To modify the UART pins, find the target pin locations and re-define the pins using the "ht32_board_config.h" file.
   Figure 27. Pin Correspondence and Setting Modification

Add a UART Channel

Taking the HT32F52352 HTCFG_UARTM_CH1 as an example, here it is described how to add a new UART channel.

Modify the ht32_board_config.h file

Referring to the HT32F52352 Datasheet "Pin Assignment" chapter, look up the Alternate Function Mapping table which lists the AFIO functions of the device type. As USART1 has been used as HTCFG_UARTM_CH0, the newly added HTCFG_UARTM_CH1 can choose USART0. Here, the TX and RX pins are located on PA2 and PA3 respectively, as shown in the upper half of Figure 28. The corresponding modifications are implemented using code lines 120~126 in ht32_board_config.h, as shown by the red dotted box in Figure 28.

Figure 28. Add a UART Channel

FAQs

Q: In step 5 of the Compilation and Test section, the transmit functional test is normal. Here, the "ABCThis is test!" message has been displayed successfully, however for the receive function, why the five input values are not returned and displayed?

A: Check whether the MCU UART RX and DAP_Tx pins of UART Jumper-J2 have been shorted using a jumper. As the "Module_UART" application code needs to use the Virtual COM Port (VCP) of e-Link32 Lite, the short-circuit setting should be applied to the left two pins of UART Jumper-J2, as shown in Figure 29.

Figure 29. UART Jumper-J2 Setting

After executing "Build"(or shortcut "F7"), an error message appears indicating that the firmware library version is older than the one that is required? See Figure 30.
A: The implementation of the "Module_UART" application code needs to include the uart_module.c/h files which has a requirement for a certain firmware library version. When such an error message appears, it means the currently used firmware library is an older version. Therefore it is necessary to download the newest version through the link provided in the "Firmware Library" section.

Figure 30. Firmware Library Version Error Message

Conclusion

This document has provided a basic introduction to assist users with a better understanding of the "Module_UART" application code and UART communication protocol. This was followed by the resource download and preparation. The Functional Description chapter introduced the file directory structure, the API architecture, API description and API usage examples. The Instructions for Use chapter demonstrated the environmental preparation, compilation and testing of the "Module_UART" application code. It also provided instructions for code transplant and modification setting as well as explaining some common problems that may be encountered. All of this combined will allow users to quickly understand how to use the APIs and subsequently reduce the amount of time to get started.

Reference Material

For more information, refer to the Holtek website: www.holtek.com

Versions and Modification Information

Documents / Resources


HT32 MCU UART Application Note

Introduction

HOLTEK HT32 MCU UART Application Note [pdf] User Manual
HT32 MCU, UART Application Note, HT32 MCU UART, Application Note, HT32, MCU UART Application Note, HT32 MCU UART Application Note

References

- HT32 Application Firmware - Module_UART
- HT32 Development Resource Download