Off-chip Flash

This tutorial demonstrates: using **SPI (SPI2)** to control the external Flash (W25Q64) to read and write data, and print the data through the serial port (USART1)

1、Software-Hardware

- **STM32F103CubeIDE**
- **STM32 Robot Development board**

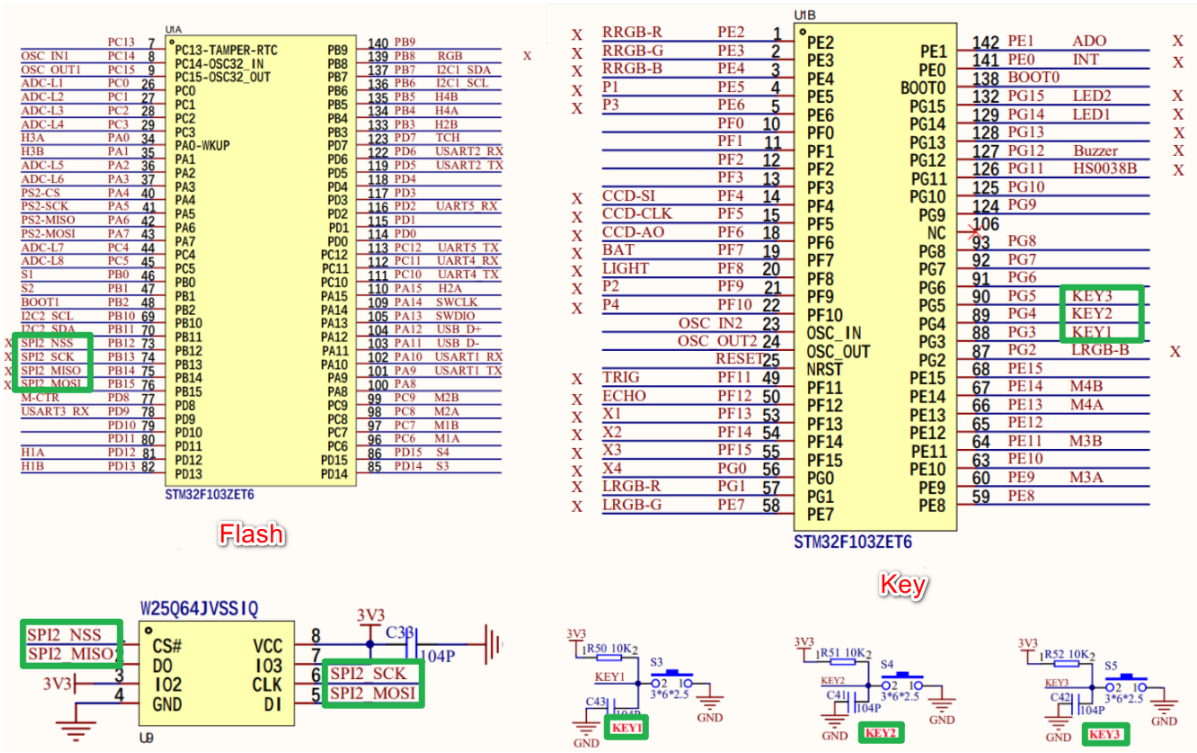
  USART: Chip internal peripheral

  Key, external Flash (W25Q64) : onboard
- **Type-C cable or ST-Link**

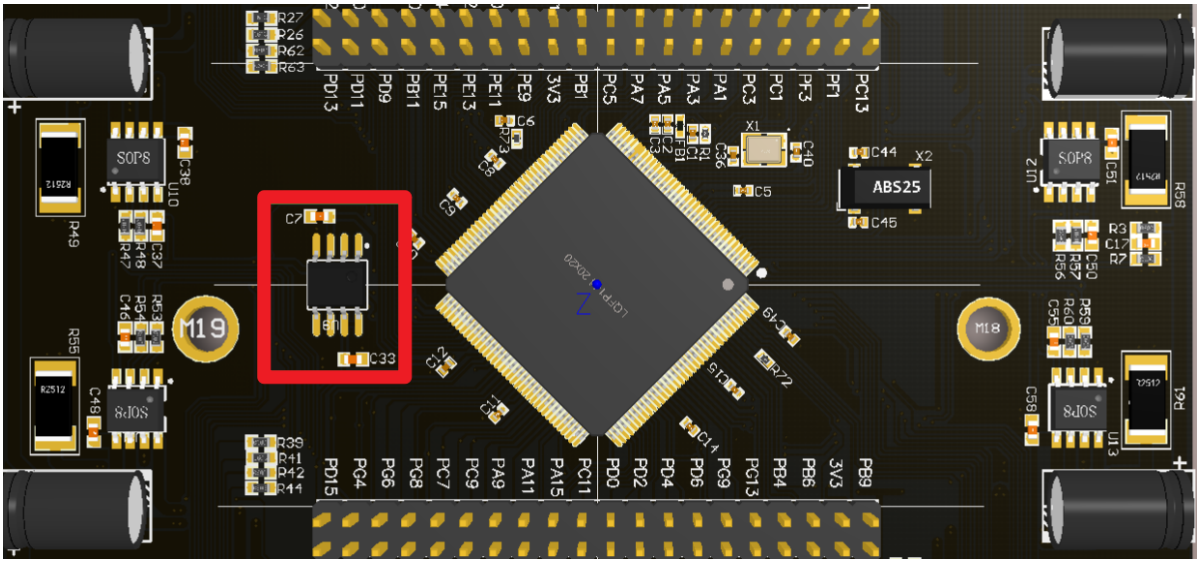
  Download or simulate the program of the development board

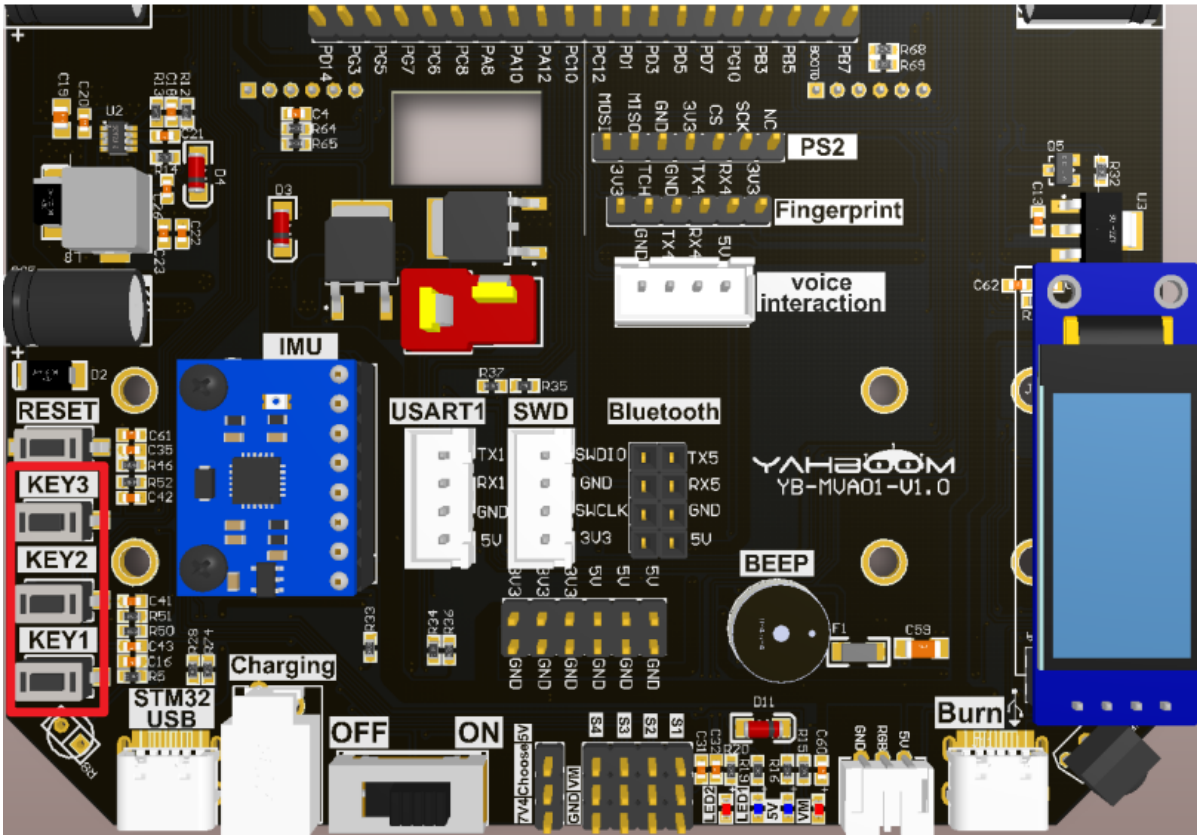
2、Brief principle

2.1、Hardware schematic diagram



2.2、Physical connection diagram





2.3、Principle of control

Write, read and erase the data of external flash by key control, and print the data through the serial port.

- **GPIO reading**

By defining different functions for the key, the read and write operation of data in W25Q64 is realized.

KEY（Schematic name)	Control pin	Function
KEY1	PG3	Add 1 to the count
KEY2	PG4	Reading count values
KEY3	PG5	Erasing data

- **External Flash**

W25Q64 divides the capacity of 8M bytes into 128 blocks of 64K bytes each, and each block is further divided into 16 sectors of 4K bytes each. The minimum erasing unit for W25Q64 is one sector, which means that 4K bytes must be erased at a time.

Instruction list（truncated）

Data Input Output	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Number of Clock(1-1-1)	**8**	**8**	**8**	**8**	**8**	**8**	**8**
Write Enable	**06h**						
Volatile SR Write Enable	**50h**						
Write Disable	**04h**						
Release Power-down / ID	**ABh**	Dummy	Dummy	Dummy	(ID7-ID0)(2)		
Manufacturer/Device ID	**90h**	Dummy	Dummy	00h	(MF7-MF0)	(ID7-ID0)	
JEDEC ID	**9Fh**	(MF7-MF0)	(ID15-ID8)	(ID7-ID0)			
Read Unique ID	**4Bh**	Dummy	Dummy	Dummy	Dummy	(UID63-0)	
Read Data	**03h**	A23-A16	A15-A8	A7-A0	(D7-D0)		
Fast Read	**0Bh**	A23-A16	A15-A8	A7-A0	Dummy	(D7-D0)	
Page Program	**02h**	A23-A16	A15-A8	A7-A0	D7-D0	D7-D0(3)	
Sector Erase (4KB)	**20h**	A23-A16	A15-A8	A7-A0			
Block Erase (32KB)	**52h**	A23-A16	A15-A8	A7-A0			
Block Erase (64KB)	**D8h**	A23-A16	A15-A8	A7-A0			
Chip Erase	**C7h/60h**						
Read Status Register-1	**05h**	(S7-S0)(2)					
Write Status Register-1(4)	**01h**	(S7-S0)(4)					
Read Status Register-2	**35h**	(S15-S8)(2)					
Write Status Register-2	**31h**	(S15-S8)					
Read Status Register-3	**15h**	(S23-S16)(2)					
Write Status Register-3	**11h**	(S23-S16)					

```
Instructions for detailed use of the reference [W25Q64JV_ English Reference Manual]
```

- **SPI**

Serial Peripheral Interface (SPI) is a high-speed, full-duplex, synchronous serial communication interface, which is often used to transfer data between microcontrollers, sensors and peripheral devices.

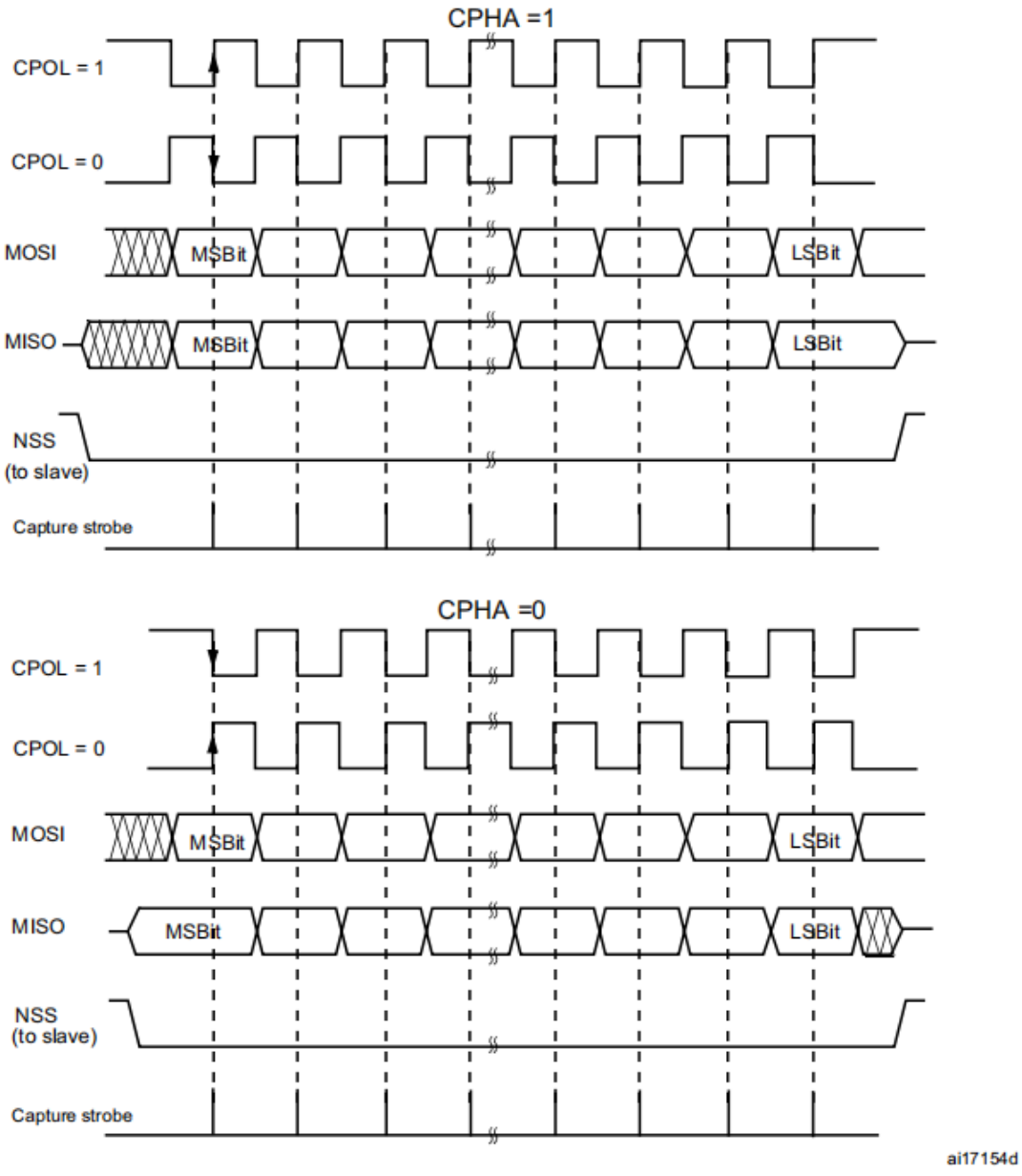
SPI pins	Function
MISO	Master device data output line, from the master device to the slave device to send data
MOSI	The master device data input line transfers data from the slave device to the master device
SCLK	Clock signal line for timing control of synchronous data transmission
CS	The slave selection line is used to select a specific slave device to communicate with the master device

- **SPI transmission mode**

Polarity of clock（CPOL）：Controls the idle and active states of the clock signal (0: idle low, 1: idle high)

Phase of clock（CPHA）：Sampling and transmission time of control data (0: sampling along odd hops, 1: sampling along even hops)

Polarity of clock (CPOL)	Phase of clock (CPHA)	
0	0	SCL idle state low level; The data is sampled on the rising edge and transmitted on the falling edge
0	1	SCL idle state low level; Data is sampled on the falling edge and data is transmitted on the rising edge
1	0	SCL idle state high level; Data is sampled on the falling edge and data is transmitted on the rising edge
1	1	SCL idle state high level; The data is sampled on the rising edge and transmitted on the falling edge



3、Engineering configuration

Project Configuration: Prompts for configuration options in the STM32CubeIDE project configuration process

3.1、Notes

Omitted project configuration: **New project, chip selection, project configuration, SYS for pin configuration, RCC configuration, clock configuration, and project configuration** content

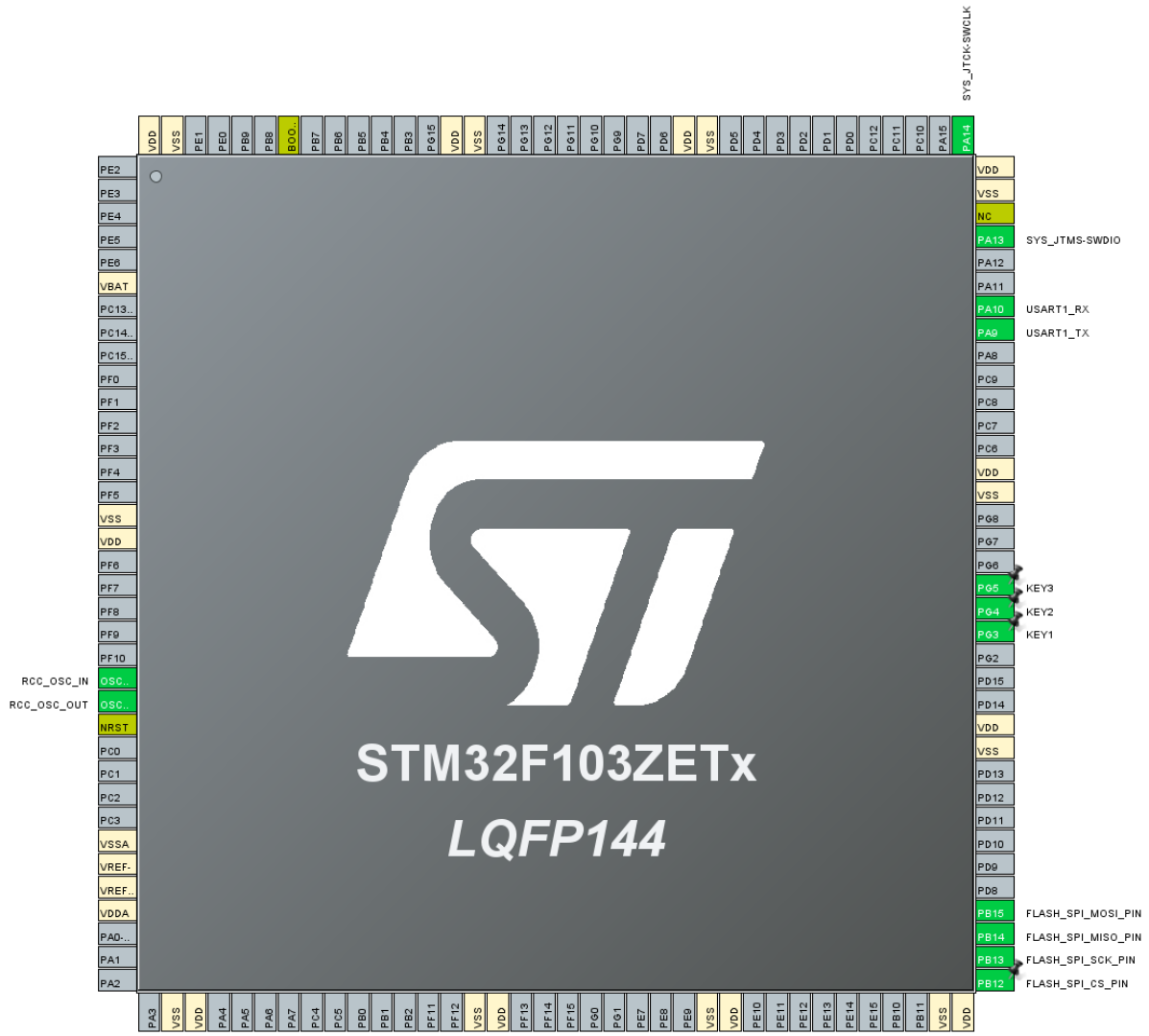
The project configuration part, which is not omitted, is the key point to configure in this tutorial.

```
Please refer to [2. Development environment construction and use: STM32CubeIDE
installation and use] to understand how to configure the omitted parts of the
project.
```

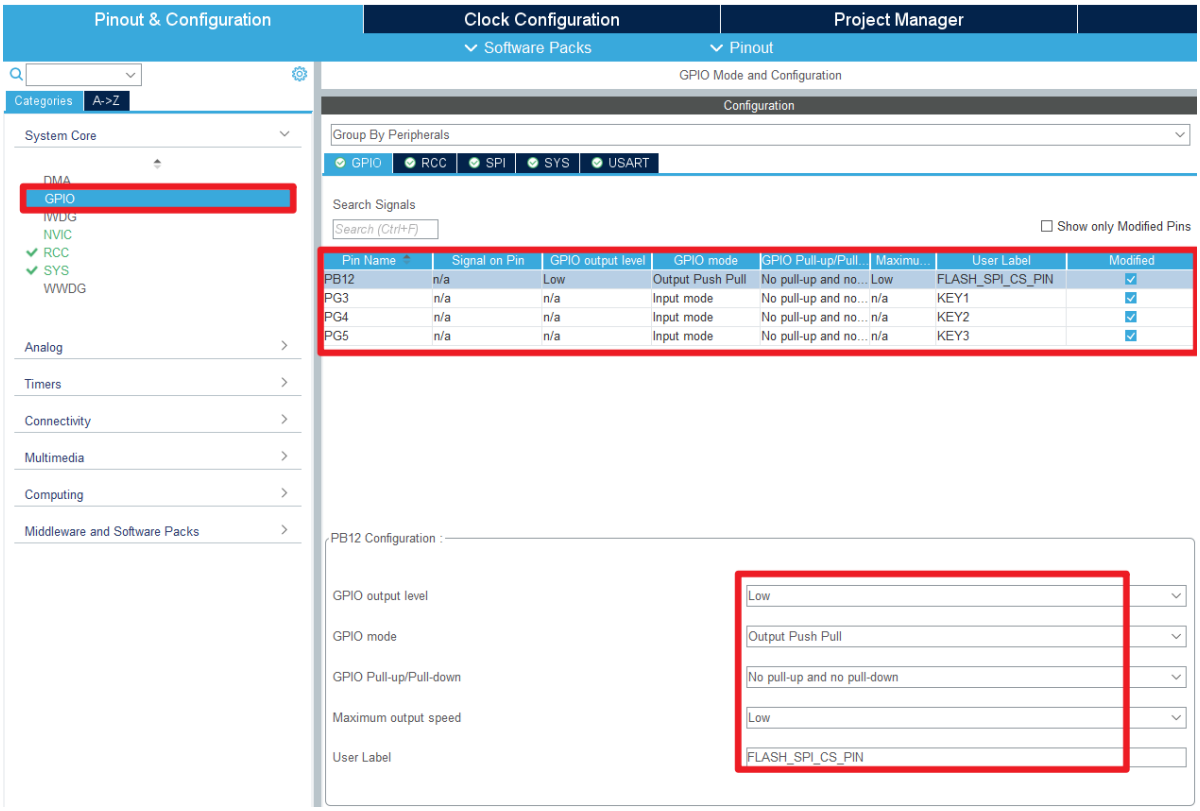
3.2、Pin configuration

- **Configure the specified pin function**

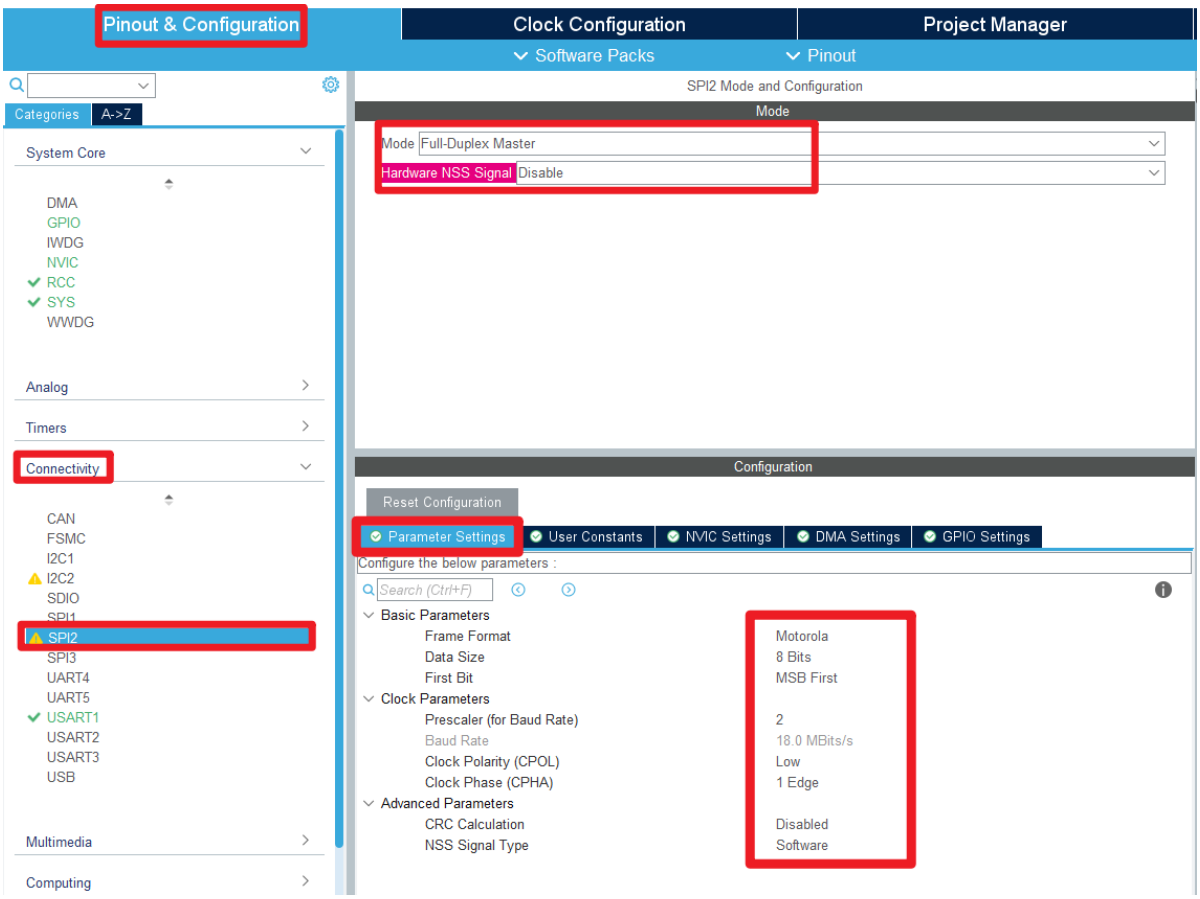
You can directly select the corresponding pin number in the pin view, and the corresponding option will appear when the mouse is left clicked



- **GPIO**


Pinout & Configuration
Clock Configuration
Project Manager
Software Packs
Pinout
Categories
A->Z
System Core
DMA
GPIO
IWDG
NVIC
RCC
SYS
WWDG
Analog
Timers
Connectivity
Multimedia
Computing
Middleware and Software Packs
GPIO Mode and Configuration
Configuration
Group By Peripherals
GPIO
RCC
SPI
SYS
USART
Search Signals
Search (Ctrl+F)
Show only Modified Pins
Pin Name
Signal on Pin
GPIO output level
GPIO mode
GPIO Pull-up/Pull...
Maximu...
User Label
Modified
PB12 n/a Low Output Push Pull No pull-up and no... Low FLASH_SPI_CS_PIN
PG3 n/a n/a Input mode No pull-up and no... n/a KEY1
PG4 n/a n/a Input mode No pull-up and no... n/a KEY2
PG5 n/a n/a Input mode No pull-up and no... n/a KEY3
PB12 Configuration :
GPIO output level Low
GPIO mode Output Push Pull
GPIO Pull-up/Pull-down No pull-up and no pull-down
Maximum output speed Low
User Label FLASH_SPI_CS_PIN

- **SPI**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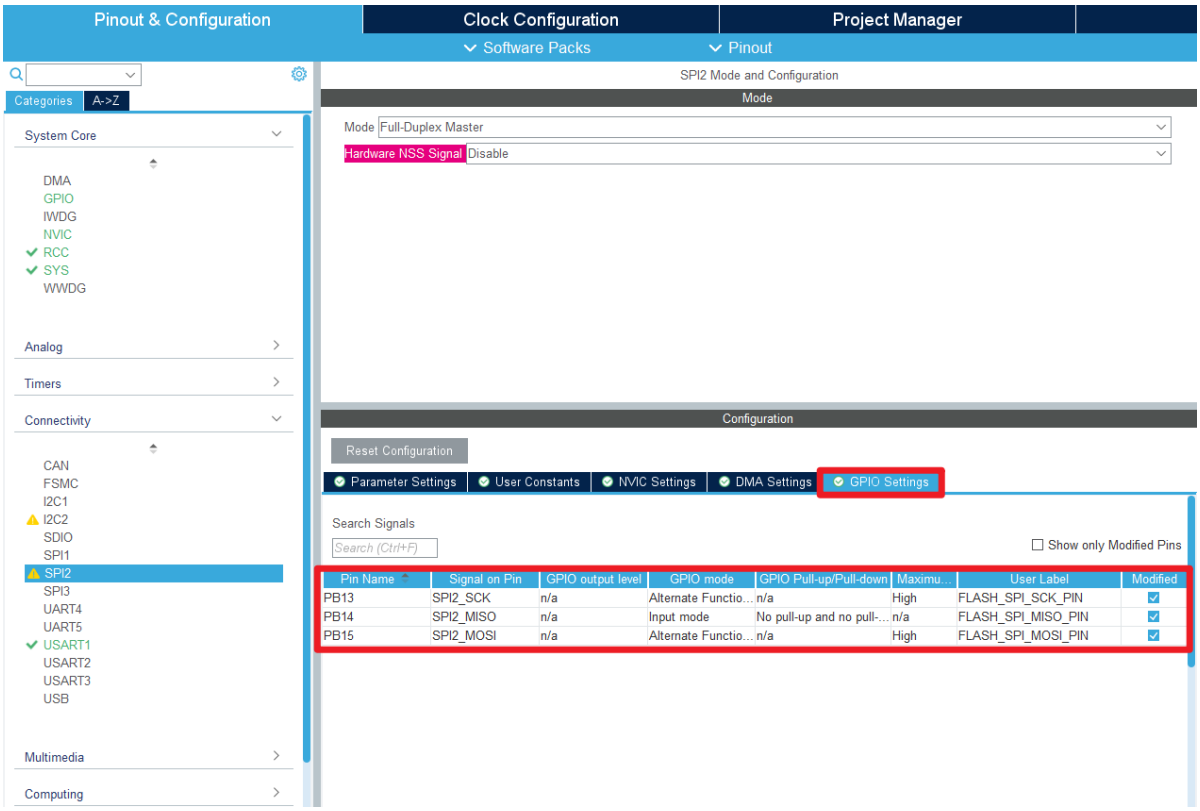
NVIC
RCC
SYS
WWDG
Analog
Timers
Connectivity
CAN
FSMC
I2C1
I2C2
SDIO
SPI1
SPI2
SPI3
UART4
UART5
USART1
USART2
USART3
USB
Multimedia
Computing
SPI2 Mode and Configuration
Mode
Mode Full-Duplex Master
Hardware NSS Signal Disable
Configuration
Reset Configuration
Parameter Settings
User Constants
NVIC Settings
DMA Settings
GPIO Settings
Configure the below parameters :
Search (Ctrl+F)
Basic Parameters
Frame Format Motorola
Data Size 8 Bits
First Bit MSB First
Clock Parameters
Prescaler (for Baud Rate) 2
Baud Rate 18.0 MBits/s
Clock Polarity (CPOL) Low
Clock Phase (CPHA) 1 Edge
Advanced Parameters
CRC Calculation Disabled
NSS Signal Type Software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Hardware NSS Signal Disable
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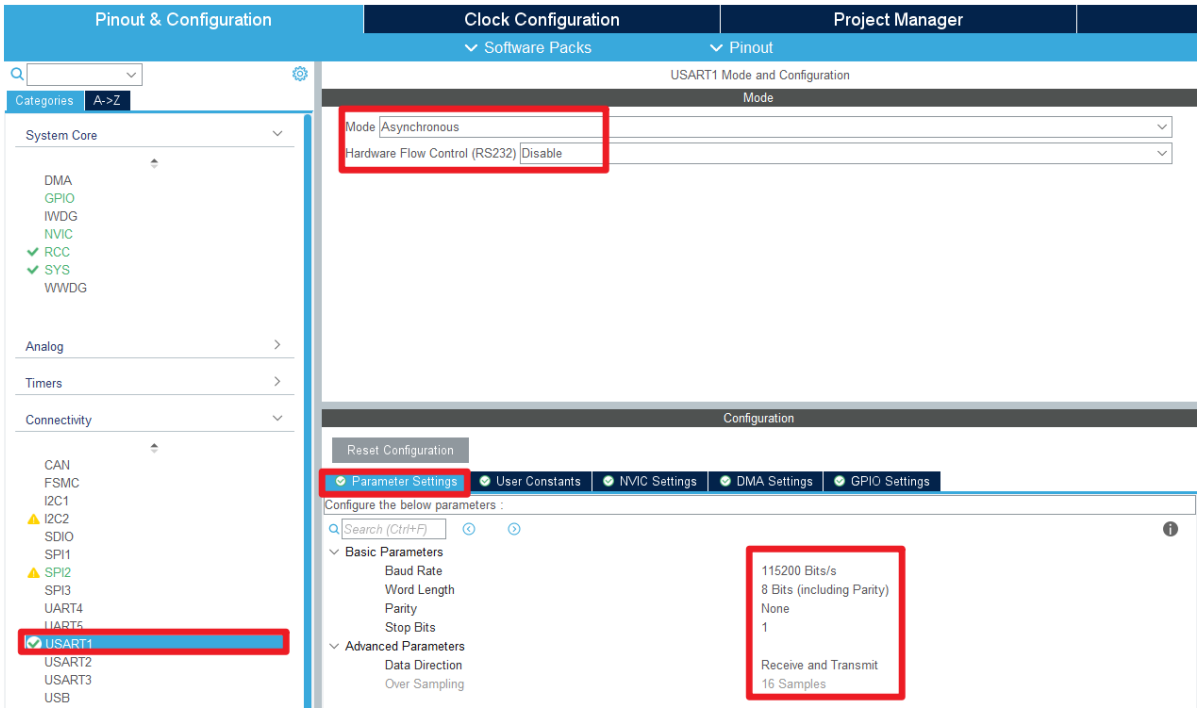
Reset Configuration
Parameter Settings
User Constants
NVIC Settings
DMA Settings
GPIO Settings
Search Signals
Search (Ctrl+F)
Show only Modified Pins
Pin Name
Signal on Pin
GPIO output level
GPIO mode
GPIO Pull-up/Pull-down
Maximu...
User Label
Modified
PB13
SPI2_SCK
n/a
Alternate Functio...
n/a
High
FLASH_SPI_SCK_PIN
PB14
SPI2_MISO
n/a
Input mode
No pull-up and no pull-...
n/a
FLASH_SPI_MISO_PIN
PB15
SPI2_MOSI
n/a
Alternate Functio...
n/a
High
FLASH_SPI_MOSI_PIN

- **USART**


Pinout & Configuration
Clock Configuration
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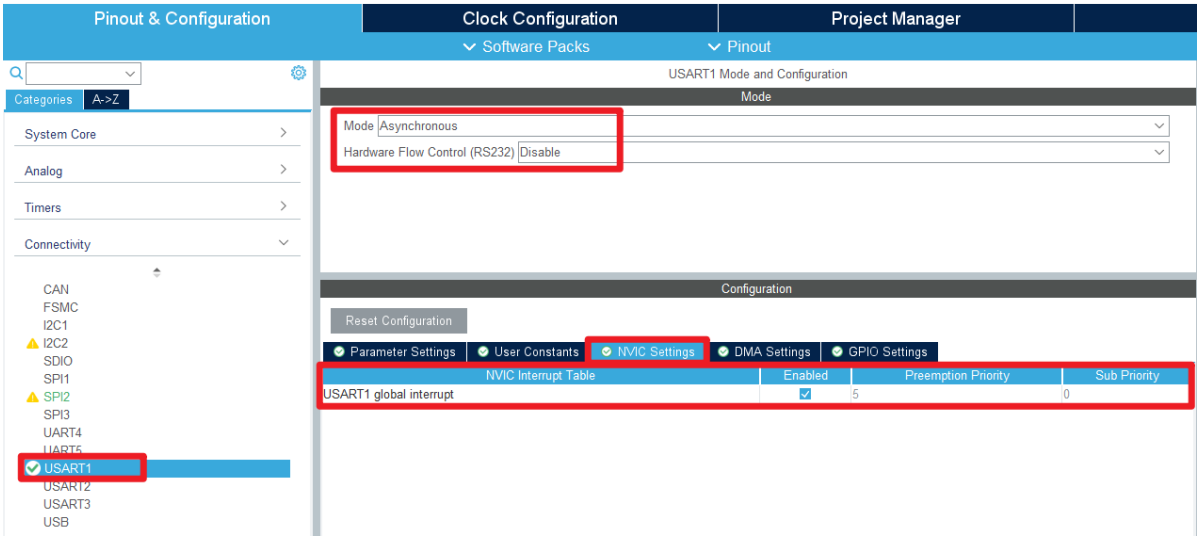
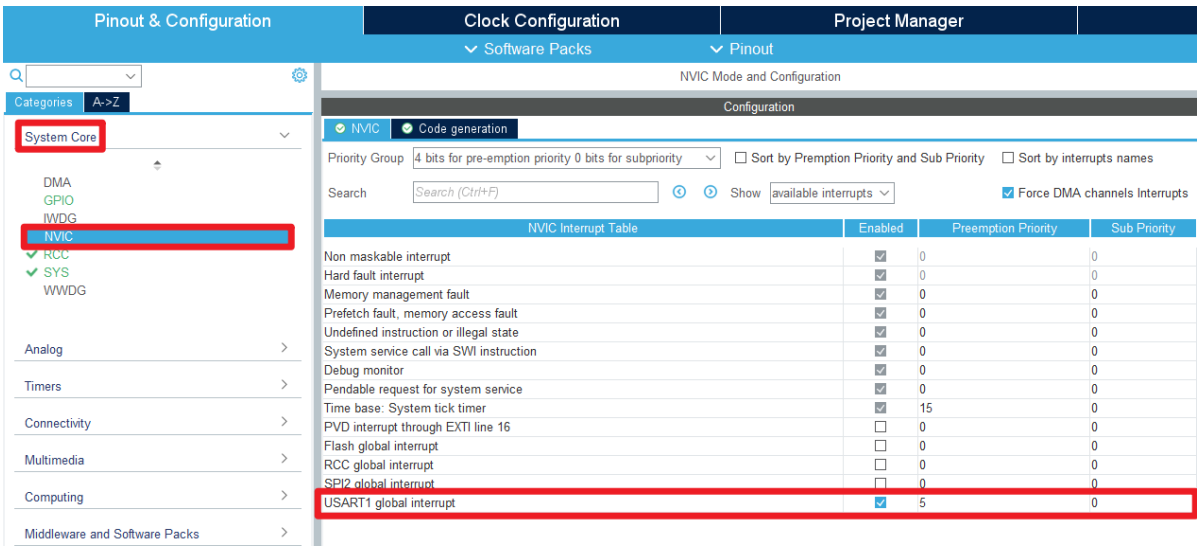
FSMC
I2C1
I2C2
SDIO
SPI1
SPI2
SPI3
UART4
UART5
USART1
USART2
USART3
USB
USART1 Mode and Configuration
Mode
Mode Asynchronous
Hardware Flow Control (RS232) Disable
Configuration
Reset Configuration
Parameter Settings
User Constants
NVIC Settings
DMA Settings
GPIO Settings
Configure the below parameters :
Search (Ctrl+F)
Basic Parameters
Baud Rate
Word Length
Parity
Stop Bits
Advanced Parameters
Data Direction
Over Sampling
115200 Bits/s
8 Bits (including Parity)
None
1
Receive and Transmit
16 Samples

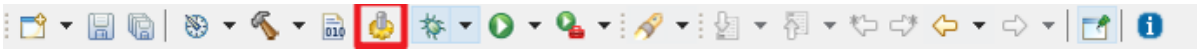


- **NVIC**

  NVIC可修改中断优先级



- **Generating code**



4、Main function

This section mainly introduces the functional code written by users. ** Detailed code can be opened by yourself in the project file we provide, and enter the Bsp folder to view the source code. **

4.1、User function

> **function：Spi_Flash_ReadID**

Function prototypes	**u16 Spi_Flash_ReadID(void)**
Functional Description	Read the W25Q64 chip ID
Input parameters	None
Return value	ID number

> **function：Spi_Flash_Erase_Sector**

Function prototypes	void Spi_Flash_Erase_Sector(u32 Dst_Addr)
Functional Description	Erases a sector
Input parameters	Sector address
Return value	None

> function：Spi_Flash_Write

Function prototypes	void Spi_Flash_Write(u8 *pBuffer, u32 WriteAddr, u16 NumByteToWrite)
Functional Description	Writes data of the specified length starting at the specified address
Input parameters1	Data storage area
Input parameters2	Address to write to
Input parameters3	Number of bytes written
Return value	None

> function：Spi_Flash_Read

Function prototypes	void Spi_Flash_Read(u8 *pBuffer, u32 ReadAddr, u16 NumByteToRead)
Functional Description	Reads data of the specified length starting at the specified address
Input parameters1	Data storage area
Input parameters2	Read address
Input parameters3	The number of bytes read
Return value	None

4.2、HAL library function parsing

The HAL library functions that were covered in the previous tutorial will not be covered

```
If you want to find the HAL library and LL library function analysis involved in the entire tutorial, you can view the documents in the folder [8. STM32 Manual: STM32F1_HAL Library and LL Library_User Manual]
```

> function：HAL_SPI_Init

Function prototypes	HAL_StatusTypeDef HAL_SPI_Init(SPI_HandleTypeDef *hspi)
Functional Description	Initialize the SPI parameters
Input parameters	**hspi**：SPI handle address
Return value	**HAL status value**：HAL_OK、HAL_ERROR、HAL_BUSY、HAL_TIMEOUT

> **function：HAL_SPI_MspInit**

Function prototypes	void HAL_SPI_MspInit(SPI_HandleTypeDef *hspi)
Functional Description	**Initialize the peripheral clock, GPIO, and NVIC of SPI**
Input parameters	**hspi**：SPI handle address
Return value	None

> **function：HAL_SPI_MspDeInit**

Function prototypes	void HAL_SPI_MspDeInit(SPI_HandleTypeDef *hspi)
Functional Description	**Uninitialize the SPI peripheral clock, GPIO, and NVIC**
Input parameters	**hspi**：SPI handle address
Return value	None

5、Experimental phenomenon

After downloading the program successfully, press the RESET button of the development board to open the serial debugging assistant to observe the phenomenon

```
For program download, please refer to [2. Development environment construction and use: program download and simulation]
```

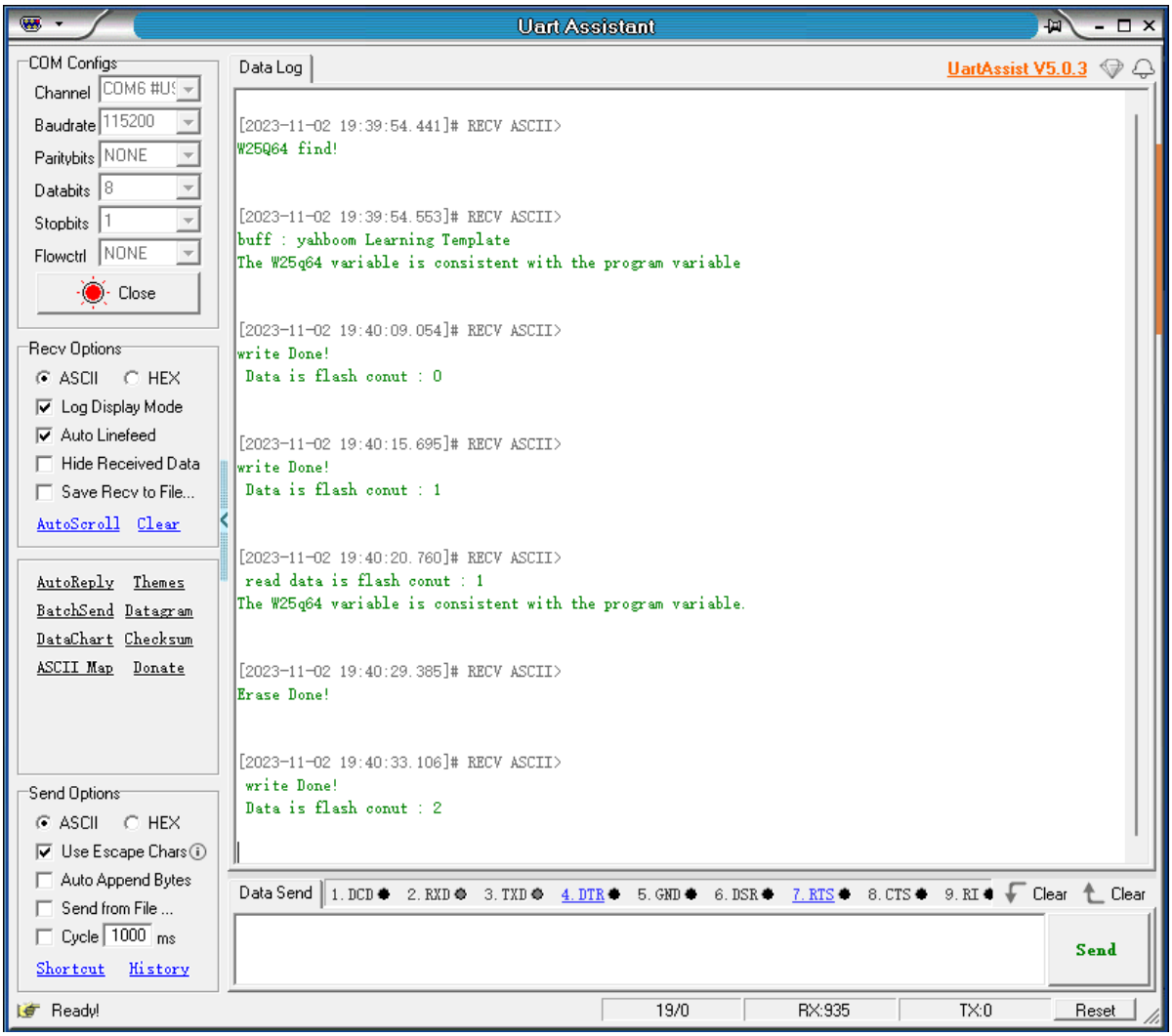
phenomenon：

Press RESET button: the serial debugging assistant will print the detection status of the external Flash chip;

Press KEY1: The serial debugging assistant will add 1 to the count value and write the value to the external Flash chip;

Press KEY2: The serial debugging assistant will output the numerical value stored in the specified sector of the external Flash chip;

Press KEY3: The serial debugging assistant will erase the specified sector data.


Uart Assistant
COM Configs
Channel COM6 #US
Baudrate 115200
Paritybits NONE
Databits 8
Stopbits 1
Flowctrl NONE
Close
Recv Options
ASCII HEX
Log Display Mode
Auto Linefeed
Hide Received Data
Save Recv to File...
AutoScroll Clear
AutoReply Themes
BatchSend Datagram
DataChart Checksum
ASCII Map Donate
Send Options
ASCII HEX
Use Escape Chars
Auto Append Bytes
Send from File ...
Cycle 1000 ms
Shortcut History
Data Log
UartAssist V5.0.3
[2023-11-02 19:39:54.441]# RECV ASCII>
W25Q64 find!
[2023-11-02 19:39:54.553]# RECV ASCII>
buff : yahboom Learning Template
The W25q64 variable is consistent with the program variable
[2023-11-02 19:40:09.054]# RECV ASCII>
write Done!
Data is flash conut : 0
[2023-11-02 19:40:15.695]# RECV ASCII>
write Done!
Data is flash conut : 1
[2023-11-02 19:40:20.760]# RECV ASCII>
read data is flash conut : 1
The W25q64 variable is consistent with the program variable.
[2023-11-02 19:40:29.385]# RECV ASCII>
Erase Done!
[2023-11-02 19:40:33.106]# RECV ASCII>
write Done!
Data is flash conut : 2
Data Send
1. DCD 2. RXD 3. TXD 4. DTR 5. GND 6. DSR 7. RTS 8. CTS 9. RI
Clear
Clear
Send
Ready!
19/0
RX:935
TX:0
Reset