PY32F040 series
32-bit ARM® Cortex®-M0+ microcontroller

HAL Library Sample Manual

1 ADC

1.1 ADC_AnalogWatchdog

此样例演示了 ADC 的模拟看门狗功能，当开启看门狗的通道的电压值不在设定的上下限中，会进入看门狗中断。

This example demonstrates the analog watchdog function of ADC. When the voltage value of the channel that opens the watchdog is not within the set upper or   lower limits,Will enter watchdog interrupt.

1.2 ADC_SingleConversion_TriggerSW_IT

此样例演示了 ADC 的中断功能，每隔 1s，软件触发 ADC 采样，在中断中通过串口打印通道 4 的 DR 值。

This example demonstrates the interrupt function of ADC. Every 1 second, the software triggers ADC sampling and prints the DR value of channel 4 through the serial port during the interrupt.

1.3 ADC_SingleConversion_TriggerTimer_DMA

此样例演示了 ADC 的多通道 DMA 传输的功能。

This example demonstrates the functionality of multi-channel DMA transmission in ADC.

1.4 ADC_TempSensor

此样例演示了 ADC 模块的 Tempsensor 功能，并通过串口打印出温度值。

This example demonstrates the Tempsensor function of the ADC module and prints   the temperature value through the serial port.

1.5 ADC_Vrefint

此样例演示了 ADC 模块的 VCC 采样功能，通过采样 VREFINT 的值，计算得出 VCC 的值，并通过串口打印出来。

This example demonstrates the VCC sampling function of the ADC module. By sampling the value of VREFINT, the VCC value is calculated and printed through the serial port.

1.6 ADC_VrefintAndVrefbuf

此样例演示了 ADC 模块的 Vrefbuf 和 Vrefint 采样功能，通过采样 VREFINT 的值，计算得出 VrefBuf 的值，并通过串口打印出来。

This example demonstrates the Vrefbuf and Vrefint sampling functions of the ADC module. By sampling the value of VREFINT, the VrefBuf value is calculated and printed through the serial port.

2 COMP

2.1 COMP_CompareGpioVsVrefint_IT

此样例演示了 COMP 比较器中断功能，PA00 作为比较器正端输入，VREFINT 作为比较器负端输入，当 PA0 的电压大于 Vref 电压时，LED 灯亮，小于 Vref 电压时,LED 灯灭。

This example demonstrates the interrupt function of the COMP comparator, with PA00 as the positive input and VREFINT as the negative input. When the voltage of PA0 is greater than Vref voltage, the LED lights up, and when it is less than Vref voltage, the LED lights out.

2.2 COMP_CompareGpioVsVrefint_Polling

此样例演示了 COMP 比较器轮询功能，PA00 作为比较器正端输入，VREFINT 作为比较器负端输入，当 PA0 的电压大于 Vref 电压时，LED 灯亮，小于 Vref 电压时,LED 灯灭。

This example demonstrates the COMP comparator polling function, with PA00 as the positive input and VREFINT as the negative input. When the voltage of PA0 is greater than Vref voltage, the LED lights up, and when it is less than Vref voltage, the LED lights up.

2.3 COMP_CompareGpioVsVrefint_WakeUpFromStop

此样例演示了 COMP 比较器唤醒功能，PA0 作为比较器正端输入，VREFINT 作为比较器负端输入，进入 stop 模式后，通过调整 PA0 上的输入电压，产生中断唤醒 stop 模式。

This example demonstrates the COMP comparator wake-up function, with PA0 as the positive input and VREFINT as the negative input of the comparator. After entering stop mode, the interrupt wake-up stop mode is generated by adjusting the input voltage on PA0.

3 CRC

3.1 CRC_CalculateCheckValue

此样例演示了 CRC 校验功能，通过对一个数组里的数据进行校验，得到的校验值与理论校验值进行比较，相等则 LED 灯亮，否则 LED 灯熄灭。

This example demonstrates the CRC verification function. By verifying the data in an array, the obtained verification value is compared with the theoretical verification value. If it is equal, the LED light will be on, otherwise the LED light will be off.

4 CTC

4.1 CTC_Autotrim

此样例演示了 CTC 使用 LSE 做参考时钟自动校准 HSI48M 时钟的功能。

This example demonstrates the function of CTC using LSE as a reference clock to automatically calibrate the HSI48M clock.

5 DIV

5.1 Division_signed

此样例演示了硬件除法器计算有符号除法。

This example demonstrates how a hardware divider calculates signed division.

5.2 Division_unsigned

此样例演示了硬件除法器计算无符号除法。

This example demonstrates how a hardware divider calculates unsigned division.

6 DMA

6.1 DMA_SramToSram

此样例演示了 DMA 从 SRAM 到 SRAM 传输数据的功能（SRAM 和外设之间传输的样例请参考相关外设样例工程）。

This example demonstrates the function of DMA transferring data from SRAM to SRAM (please refer to the relevant peripheral sample project for the example of transfer between SRAM and peripherals).

7　EXTI

7.1　EXTI_ToggleLed_IT

此样例演示了 GPIO 外部中断功能，按键 (PB0) 引脚上的每一个下降沿都会产生中断，中断函数中 LED 灯会翻转一次。

This example demonstrates the GPIO external interrupt function, where each falling edge on the key (PB0) pin generates an interrupt, and the LED light in the interrupt function flips once.

7.2　EXTI_WakeUp_Event

此样例演示了通过 PA6 引脚唤醒 MCU 的功能。下载程序并运行后，LED 灯处于常亮状态；按下用户按键后，LED 灯处于常暗状态，且 MCU 进入 STOP 模式；拉低 PA6 引脚后，MCU 唤醒，LED 灯处于闪烁状态。

This example demonstrates the function of waking up an MCU through the PA6 pin. After downloading the program and running it, the LED light is constantly on; After pressing the user button, the LED light is in a constant dark state and the MCU enters STOP mode; After pulling down the PA6 pin, the MCU wakes up and the LED light is in a flashing state.

8 FLASH

8.1 FLASH_BOR

此样例演示了修改 FLASH 的 BOR 功能。

This example demonstrates the BOR function of modifying FLASH.

8.2 FLASH_OptionByteWrite_RST

此样例演示了通过软件方式将 RESET 引脚改为普通 GPIO。

This example demonstrates changing the RESET pin to regular GPIO through software.

8.3 FLASH_PageEraseAndWrite

此样例演示了 flash page 擦除和 page 写功能。

This example demonstrates the flash page erase and page write functions.

8.4 FLASH_SectorEraseAndWrite

此样例演示了 flash sector 擦除和 Page 写功能。

This example demonstrates the flash sector erase and page write functions.

9 GPIO

9.1 GPIO_FastIO

本样例主要展示 GPIO 的 FAST IO 输出功能,FAST IO 速度可以达到单周期翻转速度。

This example mainly demonstrates the FAST IO output function of GPIO, which can achieve a single cycle flip speed.

9.2 GPIO_Toggle

此样例演示了 GPIO 输出模式，配置 LED 引脚(PB02)为数字输出模式，并且每隔 250ms 翻转一次 LED 引脚电平，运行程序，可以看到 LED 灯以 2Hz 的频率闪烁。

This example demonstrates the GPIO output mode, configuring the LED pin (PB02) to be in digital output mode, and flipping the LED pin level every 250ms. Running the program, you can see that the LED light flashes at a frequency of 2Hz.

10 I2C

10.1 I2C_TwoBoard_CommunicationMaster_10BitAddr_IT

此样例演示了 I2C 通过中断方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的 15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using interrupts. The master device   sends 15 bytes of data to the slave device and then receives 15 bytes of data   from the slave. When both the master and slave successfully transmit and   receive data, the LEDs on both boards will be constantly lit.

10.2 I2C_TwoBoard_CommunicationMaster_DMA

此样例演示了 I2C 通过 DMA 方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的 15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using DMA. The master device   sends 15 bytes of data to the slave device and then receives 15 bytes of   data from the slave. When both the master and slave successfully transmit   and receive data, the LEDs on both boards will be constantly lit.

10.3 I2C_TwoBoard_CommunicationMaster_DMA_MEM

此样例演示了主机 I2C 通过 DMA 方式进行通讯，从机使用 EEPROM 外设芯片 P24C32，按下 user 按键，主机先向从机写 15bytes 数据为 0x1~0xf, 然后再从 EEPROM 中将写入的数据读出，读取成功后，主机板上的小灯处于"常亮"状态。

This sample demonstrates communication between the master and slave using I2C   and DMA. The master device sends 15 bytes of data (0x1~0xf) to the slave device,   and then reads the data from the EEPROM. When the data is successfully read,   the LED on the master board will be constantly lit.

10.4 I2C_TwoBoard_CommunicationMaster_DualAddr_IT

此样例演示了 I2C 通过中断方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的 15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using interrupts. The master device   sends 15 bytes of data to the slave device and then receives 15 bytes of data   from the slave. When both the master and slave successfully transmit and receive   data, the LEDs on both boards will be constantly lit.

10.5 I2C_TwoBoard_CommunicationMaster_IT

此样例演示了 I2C 通过中断方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的

15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using interrupts. The master device   sends 15 bytes of data to the slave device and then receives 15 bytes of data   from the slave. When both the master and slave successfully transmit and   receive data, the LEDs on both boards will be constantly lit.

10.6 I2C_TwoBoard_CommunicationMaster_Polling

此样例演示了 I2C 通过轮询方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的

15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using polling. The master device   sends 15 bytes of data to the slave device and then receives 15 bytes of data   from the slave. When both the master and slave successfully transmit and   receive data, the LEDs on both boards will be constantly lit.

10.7 I2C_TwoBoard_CommunicationSlave_10BitAddr_IT

此样例演示了 I2C 通过中断方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的

15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using interrupts. The master device   sends 15 bytes of data to the slave device and then receives 15 bytes of data   from the slave. When both the master and slave successfully transmit and receive   data, the LEDs on both boards will be constantly lit.

10.8 I2C_TwoBoard_CommunicationSlave_DMA

此样例演示了 I2C 通过 DMA 方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的

15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using DMA (Direct Memory Access).   The master device sends 15 bytes of data to the slave device and then receives   15 bytes of data from the slave. When both the master and slave successfully   transmit and receive data, the LEDs on both boards will be constantly lit.

10.9 I2C_TwoBoard_CommunicationSlave_DualAddr_IT

此样例演示了 I2C 通过中断方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的

15byte 数据,主机、从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates I2C communication using interrupts. The master device   sends 15 bytes of data to the slave device and then receives 15 bytes of data   from the slave. When both the master and slave successfully transmit and receive   data, the LEDs on both boards will be constantly lit.

10.10 I2C_TwoBoard_CommunicationSlave_IT

此样例演示了 I2C 通过中断方式进行通讯，主机先向从机发送 15byte 数据，然后再接收从机发送的 15byte 数据，主机和从机接收数据成功后，主机和从机板上的小灯处于"常亮"状态。

This sample demonstrates the I2C communication using interrupt mode. The master   sends 15 bytes of data to the slave, and then receives 15 bytes of data from the   slave. When both the master and slave successfully receive the data, the LEDs on   the master and slave boards will be constantly on.

10.11 I2C_TwoBoard_MasterTxIndefiniteLengthData_IT_Init

此样例演示了通过中断方式，主机发送不定长数据，从机接收不定长数据。主机向从机发送 10 字节的数据（0~9），然后从机接收数据（0~9）并通过串口打印；主机向从机发送 100 字节数据（1~100），然后从机接收数据（1~100）并通过串口打印；主机向从机发送 10 字节的数据（0~9），然后从机接收数据（0~9）并通过串口打印。

This example demonstrates how the host sends variable length data and the slave receives variable length data through interrupt mode. The host sends 10 bytes of data (0-9) to the slave, and then the slave receives the data (0-9) and prints it through the serial port; The host sends 100 bytes of data (1-100) to the slave, and then the slave receives the data (1-100) and prints it through the serial port; The host sends 10 bytes of data (0-9) to the slave, and then the slave receives the data (0-9) and prints it through the serial port.

10.12 I2C_TwoBoard_SlaveRxIndefiniteLengthData_IT_Init

此样例演示了通过中断方式，主机发送不定长数据，从机接收不定长数据。主机向从机发送 10 字节的数据（0~9），然后从机接收数据（0~9）并通过串口打印；主机向从机发送 100 字节数据（1~100），然后从机接收数据（1~100）并通过串口打印；主机向从机发送 10 字节的数据（0~9），然后从机接收数据（0~9）并通过串口打印。

This example demonstrates how the host sends variable length data and the slave receives variable length data through interrupt mode. The host sends 10 bytes of data (0-9) to the slave, and then the slave receives the data (0-9) and prints it through the serial port; The host sends 100 bytes of data (1-100) to the slave, and then the slave receives the data (1-100) and prints it through the serial port; The host sends 10 bytes of data (0-9) to the slave, and then the slave receives the data (0-9) and prints it through the serial port.

11 I2S

11.1 I2S_TwoBoard_CommunicationMaster_DMA

此样例是对I2S主机与I2S从机以DMA方式进行通信的演示,I2S主机先向I2S从机发送数据0x1~0x10，I2S 从机接收到数据后，再向 I2S 主机回发数据 0x1~0x10，当 I2S 主机和 I2S 从机成功接收数据时，小灯处于常亮状态；否则小灯处于闪烁状态。

This sample demonstrates communication between the I2S master and I2S slave   using DMA. The I2S master sends data 0x1 to 0x10 to the I2S slave. The I2S   slave receives the data and sends back data 0x1 to 0x10 to the I2S master.   When both the I2S master and I2S slave successfully receive the data, the   LED will be constantly on. Otherwise, the LED will be blinking.

11.2 I2S_TwoBoard_CommunicationMaster_IT

此样例是对I2S主机与I2S从机以中断方式进行通信的演示,I2S主机先向I2S从机发送数据0x1~0x10，I2S 从机接收到数据后，再向 I2S 主机回发数据 0x1~0x10，当 I2S 主机和 I2S 从机成功接收数据时，小灯处于常亮状态；否则小灯处于闪烁状态。

This sample demonstrates communication between the I2S master and I2S slave using   interrupts. The I2S master sends data 0x1 to 0x10 to the I2S slave. The I2S slave receives   the data and sends back data 0x1 to 0x10 to the I2S master. When both the I2S master and   I2S slave successfully receive the data, the LED will be constantly on. Otherwise, the   LED will be blinking.

11.3 I2S_TwoBoard_CommunicationMaster_Polling

此样例是对I2S主机与I2S从机以轮询方式进行通信的演示,I2S主机先向I2S从机发送数据0x1~0x10，I2S 从机接收到数据后，再向 I2S 主机回发数据 0x1~0x10，当 I2S 主机和 I2S 从机成功接收数据时，小灯处于常亮状态；否则小灯处于闪烁状态。

This sample demonstrates communication between the I2S master and I2S slave   using polling. The I2S master sends data 0x1 to 0x10 to the I2S slave. The I2S   slave receives the data and sends back data 0x1 to 0x10 to the I2S master. When   both the I2S master and I2S slave successfully receive the data, the LED will be   constantly on. Otherwise, the LED will be blinking.

11.4 I2S_TwoBoard_CommunicationSlave_DMA

此样例是对I2S主机与I2S从机以DMA方式进行通信的演示,I2S主机先向I2S从机发送数据0x1~0x10，I2S 从机接收到数据后，再向 I2S 主机回发数据 0x1~0x10。当 I2S 主机和 I2S 从机成功接收数据时，小灯处于常亮状态；否则，小灯处于闪烁状态。

This sample demonstrates communication between an I2S master and an I2S slave   using DMA. The I2S master sends data 0x1 to 0x10 to the I2S slave, and the I2S   slave receives the data and sends back data 0x1 to 0x10 to the I2S master. When   both the I2S master and I2S slave successfully receive

the data, the LED remains   constantly on. Otherwise, the LED blinks.

11.5 I2S_TwoBoard_CommunicationSlave_IT

此样例是对I2S主机与I2S从机以中断方式进行通信的演示，I2S主机先向I2S从机发送数据0x1~0x10，I2S 从机接收到数据后，再向 I2S 主机回发数据 0x1~0x10。当 I2S 主机和 I2S 从机成功接收数据时，小灯处于常亮状态；否则，小灯处于闪烁状态。

This sample demonstrates communication between an I2S master and an I2S slave   using interrupts. The I2S master sends data 0x1 to 0x10 to the I2S slave, and   the I2S slave receives the data and sends back data 0x1 to 0x10 to the I2S   master. When both the I2S master and I2S slave successfully receive the data,   the LED remains constantly on. Otherwise, the LED blinks.

11.6 I2S_TwoBoard_CommunicationSlave_Polling

此样例是对 I2S 主机与 I2S 从机以轮询方式进行通信的演示，I2S 主机先向 I2S 从机发送数据 0x1 到 0x10，I2S 从机接收到数据后，再向 I2S 主机回发数据 0x1 到 0x10。当 I2S 主机和 I2S 从机成功接收数据时，小灯保持常亮；否则，小灯闪烁。

This sample demonstrates communication between an I2S master and an I2S slave   using polling. The I2S master sends data 0x1 to 0x10 to the I2S slave, and the   I2S slave receives the data and sends back data 0x1 to 0x10 to the I2S master.   When both the I2S master and I2S slave successfully receive the data, the LED   remains constantly on. Otherwise, the LED blinks.

12 IWDG

12.1 IWDG_Reset

此样例演示了 IWDG 看门狗功能。配置看门狗的重载计数值为 1 秒，当计数达到 1 秒后，系统会被复位。通过调整每次喂狗的时间（main 函数 while 循环中的代码），可以观察到以下情况：如果每次喂狗时间小于 1 秒，程序能够正常运行（LED 灯闪烁）；如果喂狗时间超过 1 秒，程序会一直被复位（LED 灯熄灭）。

This sample demonstrates the IWDG (Independent Watchdog) functionality. The watchdog is configured with a reload value of 1 second. Once the watchdog timer reaches 1 second, the system will be reset. By adjusting the time for feeding the watchdog (code in the main loop), the following observations can be made:If the feeding time is less than 1 second, the program can run normally (LED blinks);If the feeding time exceeds 1 second, the program will be continuously reset (LED turns off).

13 LCD

13.1 LCD_Display

此样例演示了对单色无源液晶显示器（LCD）的操作。将偏置产生电路配置为内部电阻分压，以使 LCD 全显，并显示"88:88"字样。

This sample demonstrates the operation of a monochrome passive liquid crystal   display (LCD). The biasing circuit is configured with internal resistor division   to ensure full display on the LCD, showing the text "88:88".

14 LPTIM

14.1 LPTIM_Wakeup

此样例演示了使用 LPTIM 连续模式事件唤醒 STOP 模式。

This sample demonstrates the use of LPTIM continuous mode to wake up from STOP mode.

15 OPA

15.1 OPA_VoltageFollow

此样例演示了 OPA 的电压跟随功能，PA7 为正端输入，PA5 为负端输入，PA6 为输出，PA6 会输出和 PA7 相同的电压值。

This sample demonstrates the voltage follower functionality of the OPA. PA7　is the positive input, PA5 is the negative input, and PA6 is the output. PA6　will output the same voltage as PA7.

16 PWR

16.1 PVD

此样例演示了 PVD 电压检测功能。样例中配置 PB07 引脚的电压与 VREF（1.2V）进行比较。当 PB07 引脚的电压高于 VREF 时，LED 灯灭；当低于 VREF 时，LED 灯亮。

This sample demonstrates the PVD (Programmable Voltage Detector) voltage monitoring functionality. In this example, PB07 pin is configured to compare its voltage with VREF (1.2V). When the voltage at PB07 is higher than VREF, the LED light turns off. When it is lower than VREF, the LED light turns on.

16.2 PWR_SLEEP_WFE

此样例演示了 sleep 模式下，通过 GPIO 事件唤醒功能。

This sample demonstrates the sleep mode with GPIO event wake-up feature.

16.3 PWR_SLEEP_WFI

此样例演示了 sleep 模式下，GPIO 外部中断唤醒功能。

This sample demonstrates the sleep mode with GPIO external interrupt wake-up feature.

16.4 PWR_STOP_WFE

此样例演示了 stop 模式下，通过 GPIO 事件唤醒功能。

This sample demonstrates the stop mode with GPIO event wake-up feature.

16.5 PWR_STOP_WFI

此样例演示了 stop 模式下，通过 GPIO 中断唤醒功能。

This sample demonstrates the stop mode with GPIO interrupt wake-up feature.

17 RCC

17.1 RCC_HSEDiv

此样例配置系统时钟为 HSE，并通过 MCO（PA08）引脚输出。

This sample configures the system clock as HSE and outputs it through the MCO (PA08) pin.

17.2 RCC_HSIOutput

此样例配置系统时钟为 HSI，并通过 MCO（PA08）引脚输出。

This sample configures the system clock as HSI and outputs it through the MCO (PA08) pin.

17.3 RCC_LSEOutput

此样例配置系统时钟为 LSE，并通过 MCO（PA08）引脚输出。注意系统时钟切换为 LSE 之前，要求把 SysTick 中断关闭掉，因为 SysTick 中断默认是 1ms 一次中断，由于 LSE 时钟频率过低，SysTick 中断会导致程序无法正常运行。

This sample configures the system clock as LSE and outputs it through the MCO (PA08) pin. Note that before switching the system clock to LSE, it is required to disable the SysTick interrupt. This is because the SysTick interrupt defaults to occur every 1ms, and due to the low frequency of LSE, the SysTick interrupt can disrupt the normal operation of the program.

17.4 RCC_LSIOutput

此样例配置系统时钟为 LSI，并通过 MCO（PA08）引脚输出。注意系统时钟切换为 LSI 之前，要求把 SysTick 中断关闭掉，因为 SysTick 中断默认是 1ms 一次中断，由于 LSI 时钟频率过低，SysTick 中断会导致程序无法正常运行。

This sample configures the system clock as LSI and outputs it through the MCO (PA08) pin. Note that before switching the system clock to LSI, it is required to disable the SysTick interrupt. This is because the SysTick interrupt defaults to occur every 1ms, and due to the low frequency of LSI, the SysTick interrupt can disrupt the normal operation of the program.

17.5 RCC_PLLOutput

此样例配置系统时钟为 PLL，并通过 MCO（PA08）引脚输出。PLL 的输入时钟源选择 HSI。

This sample configures the system clock as PLL and outputs it through the MCO (PA08) pin. The PLL input clock source is set to HSI.

17.6 RCC_SysclockSwitch

此样例演示系统时钟切换功能。样例中配置系统时钟从 LSI 切换到 HSE，并通过 MCO（PA08）引脚输出系统时钟。

This sample demonstrates the system clock switching functionality. The sample   configures the system clock to switch from LSI to HSE and outputs the system   clock through the MCO (PA08) pin.

18 RTC

18.1 RTC_AlarmSecond_IT

此样例演示 RTC 的秒中断和闹钟中断功能。每次秒中断，在中断函数中会打印字符"RTC_IT_SEC"并输出实时时间。

This sample demonstrates the RTC's second interrupt and alarm interrupt functionality. Each time the second interrupt occurs, the interrupt function prints the string "RTC_IT_SEC" and outputs the current RTC count time.

18.2 RTC_WakeUpAlarm

此样例演示通过 RTC 闹钟中断每隔 1 秒将 MCU 从 STOP 模式下唤醒，并且每次唤醒会翻转 LED，LED 翻转间隔为 1 秒。

This sample demonstrates waking up the MCU from STOP mode every 1 second using RTC alarm interrupt. Each time the MCU wakes up, the LED will toggle its state. The LED toggling interval is 1 second.

18.3 RTC_WakeUpSecond

此样例演示了通过 RTC 的秒中断唤醒 MCU 的功能。下载程序并运行后，LED 灯处于常亮状态；按下用户按键后，LED 灯处于常暗状态，且 MCU 进入 STOP 模式；RTC 秒中断唤醒 MCU 后，LED 灯处于闪烁状态。

This sample demonstrates waking up the MCU using RTC second interrupt. After downloading and running the program, the LED is continuously on. Pressing the user button turns off the LED and puts the MCU into STOP mode. When the RTC second interrupt wakes up the MCU, the LED starts blinking.

19 SPI

19.1 SPI_TwoBoards_FullDuplexMaster_DMA

此样例是对串口外设接口（SPI）与外部设备以全双工串行方式进行通信的演示,此接口设置为主模式,

为外部从设备提供通信时钟 SCK。主机通过 MOSI 引脚发送数据,从 MISO 引脚接收从机的数据，数据

以主机提供的 SCK 沿同步被移位，完成全双工通信。

This example demonstrates that SPI communicates with external devices in full duplex serial mode.This interface is set in master mode to provide communication   clock SCK for external and slave devices.The host sends data through the MOSI   pin, receives data from the MISO pin, and the data is shifted synchronously   along the SCK provided by the host, completing the full-duplex communication.

19.2 SPI_TwoBoards_FullDuplexMaster_IT

此样例是对串口外设接口（SPI）与外部设备以全双工串行方式进行通信的演示,此接口设置为主模式,

为外部从设备提供通信时钟 SCK。主机通过 MOSI 引脚发送数据,从 MISO 引脚接收从机的数据，数据

以主机提供的 SCK 沿同步被移位，完成全双工通信。

This example demonstrates that SPI communicates with external devices in full duplex serial mode.This interface is set in master mode to provide communication   clock SCK for external and slave devices.The host sends data through the MOSI   pin, receives data from the MISO pin, and the data is shifted synchronously   along the SCK provided by the host, completing the full-duplex communication.

19.3 SPI_TwoBoards_FullDuplexMaster_Polling

此样例是对串口外设接口（SPI）与外部设备以全双工串行方式进行通信的演示,此接口设置为主模式,

为外部从设备提供通信时钟 SCK。主机通过 MOSI 引脚发送数据,从 MISO 引脚接收从机的数据，数据

以主机提供的 SCK 沿同步被移位，完成全双工通信。

This example demonstrates that SPI communicates with external devices in full duplex serial mode.This interface is set in master mode to provide communication   clock SCK for external and slave devices.The host sends data through the MOSI   pin, receives data from the MISO pin, and the data is shifted synchronously   along the SCK provided by the host, completing the full-duplex communication.

19.4 SPI_TwoBoards_FullDuplexSlave_DMA

此样例是对串口外设接口（SPI）与外部设备以全双工串行方式进行通信的演示,此接口设置为主模式,

为外部从设备提供通信时钟 SCK。主机通过 MOSI 引脚发送数据,从 MISO 引脚接收从机的数据，数据

以主机提供的 SCK 沿同步被移位，完成全双工通信。

This example demonstrates that SPI communicates with external devices in full duplex serial mode.This interface is set in master mode to provide communication clock SCK for external and slave devices.The host sends data through the MOSI pin, receives data from the MISO pin, and the data is shifted synchronously along the SCK provided by the host, completing the full-duplex communication.

19.5 SPI_TwoBoards_FullDuplexSlave_IT

此样例是对串口外设接口（SPI）与外部设备以全双工串行方式进行通信的演示,此接口设置为主模式, 为外部从设备提供通信时钟 SCK。主机通过 MOSI 引脚发送数据,从 MISO 引脚接收从机的数据，数据 以主机提供的 SCK 沿同步被移位，完成全双工通信。

This example demonstrates that SPI communicates with external devices in full duplex serial mode.This interface is set in master mode to provide communication clock SCK for external and slave devices.The host sends data through the MOSI pin, receives data from the MISO pin, and the data is shifted synchronously along the SCK provided by the host, completing the full-duplex communication.

19.6 SPI_TwoBoards_FullDuplexSlave_Polling

此样例是对串口外设接口（SPI）与外部设备以全双工串行方式进行通信的演示,此接口设置为主模式, 为外部从设备提供通信时钟 SCK。主机通过 MOSI 引脚发送数据,从 MISO 引脚接收从机的数据，数据 以主机提供的 SCK 沿同步被移位，完成全双工通信。

This example demonstrates that SPI communicates with external devices in full duplex serial mode.This interface is set in master mode to provide communication clock SCK for external and slave devices.The host sends data through the MOSI pin, receives data from the MISO pin, and the data is shifted synchronously along the SCK provided by the host, completing the full-duplex communication.

20 TIM

20.1 TIM14_LSICalibrate

此样例配置 LSI 时钟从 MCO (PA8) 输出并将 TIM14 的通道 1 连接到 MCO。将系统时钟配置为 32MHz（HSI 16MHz，PLL 配置 2 倍频），TIM14 时钟为 320KHz，设置重载值为 10001，使能 TIM14 的输入捕获功能，调整 LSI trimming 值，LED 亮起表示校准完成。

This example configures the LSI clock to output from MCO (PA8) and connects channel 1 of TIM14 to MCO. Set the system clock to 32MHz (HSI 16MHz, PLL frequency doubling), set the clock of TIM14 to 320KHz, set the overload value to 10001, enable the input capture function of TIM14, adjust the value of LSI trimming, and the LED ON indicates that calibration is complete.

20.2 TIM1_6Step

此样例是对高级定时器功能"六步 PWM 的产生"的演示，通过 systick 中断作为 COM commutation 事件的触发源，实现（无刷电机的）换向下表是换向步骤，比如第一步中的 CH1 和 CH3N 为 1，即设置打开这两个通道的 PWM 输出。

This sample demonstrates advanced timer function 'six-step PWM generation', systick interrupt as COM commutation event trigger source to achieve commutation (brushless motor). The following table shows the commutating steps. For example, CH1 and CH3N in the first step are set to 1, that mean the PWM output of these two channels is set to start

20.3 TIM1_AutoReloadPreload

此样例实现了定时器的基本计数功能，以及演示了 ARR 自动重载功能，样例在定时器重载中断中翻转 LED 灯修改 main.c 中的第 56 行配置 TimHandle.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_ENABLE;使能自动重载功能，新的 ARR 值在第四次进中断时生效，配置 TimHandle.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_DISABLE;禁止自动重载功能，新的 ARR 值在第三次进中断时生效,生效后，LED 灯以 2.5HZ 的频率翻转

This sample demonstrates base count function of the timer,and show ARR register autoreload function.Example toggle LED in timer update interrupt. Modify line 56 in main.c. Set TimHandle.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_ENABLE to enable autoreload,and new ARR value will takes effect on the fourth interrupt generate. Set TimHandle.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_DISABLE to disable autoreload,and new ARR value will takes effect on the third interrupt generate. After taking effect, the LED lights blinked at a frequency of 2.5HZ.

20.4 TIM1_ComplementarySignals

此样例实现了定时器的互补输出功能，三组互补共六路 pwm 输出，此样例没有实现死区功能 CH1 -> PA8CH1N -> PA7CH2 -> PA9CH2N -> PB0CH3 -> PA10CH3N -> PB1

This sample demonstrates complementary output function of the timer,Three sets of complementary outputs total six pwm outputs, this example does not implement the dead zone function

20.5 TIM1_ComplementarySignals_break

此样例实现了定时器的刹车功能，CH1 和 CH1N 互补 pwm 输出，接收到外部 IO 口的刹车信号（低电平）后，PWM 信号关闭，由于 BDTR.AOE 置位，所以刹车信号取消（高电平）后，继续 pwm 输出，此样例实现了死区功能。CH1 -> PA8CH1N -> PA7 刹车输入 -> PA6 通过调整 OCxE,CCxP,OISx,CCxNE,CCxNP,OISxN 的配置，可实现刹车功能的各种应用

This sample demonstrates brake function of the timer,the CH1 and CH1N complementary pwm outputs.After receiving the brake signal (low level)from the external IO port, the PWM signal is turned off. Because BDTR.AOE is set, the pwm output continues after the brake signal is cancelled (high level). This example realizes the dead zone function CH1 -> PA8 CH1N -> PA7 Brake input -> PA6 By adjusting the OCxE, CCxP, OISx, CCxNE, CCxNP, OISxN configuration, which can realize the brake function of a variety of applications

20.6 TIM1_ComplementarySignals_break_it

此样例实现了定时器的刹车功能，CH1 和 CH1N 互补 pwm 输出，接收到外部 IO 口的刹车信号（低电平）后，PWM 信号关闭，由于 BDTR.AOE 置位，所以刹车信号取消（高电平）后，继续 pwm 输出，此样例实现了死区功能。本样例开启了刹车中断，并在刹车中断里翻转 LED 灯通过调整 OCxE,CCxP,OISx,CCxNE,CCxNP,OISxN 的配置，可实现刹车功能的各种应用

This sample demonstrates brake function of the timer,the CH1 and CH1N complementary pwm outputs.After receiving the brake signal (low level)from the external IO port, the PWM signal is turned off. Because BDTR.AOE is set, the pwm output continues after the brake signal is cancelled (high level). This example realizes the dead zone function. This example turns on the brake interrupt and toggle the LED light in the brake interrupt. By adjusting the OCxE, CCxP, OISx, CCxNE, CCxNP, OISxN configuration, which can realize the brake function of a variety of applications

20.7 TIM1_ComplementarySignals_DeadTime

此样例实现了定时器的刹车功能，CH1 和 CH1N 互补 pwm 输出，接收到外部 IO 口的刹车信号（低电平）后，PWM 信号关闭，由于 BDTR.AOE 置位，所以刹车信号取消（高电平）后，继续 pwm 输出，此样例实现了死区功能。通过调整 OCxE,CCxP,OISx,CCxNE,CCxNP,OISxN 的配置，可实现刹车功能的各种应用

This sample demonstrates brake function of the timer,the CH1 and CH1N complementary pwm outputs.After receiving the brake signal (low level)from the external IO port, the PWM signal is turned off. Because BDTR.AOE is set, the pwm output continues after the brake signal is cancelled (high level). This example realizes the dead zone function. By adjusting the OCxE, CCxP, OISx, CCxNE, CCxNP, OISxN configuration, which can realize the brake function of a variety of applications

20.8 TIM1_DmaBurst_twice

此样例演示了在 TIM1 中使用 DMA 连续两次 burst 传输数据的功能,burst 每传输一次更新三个寄存器，PSC,ARR,RCR，在更新事件中断中，PA0 会进行翻转，通过逻辑分析仪监测，可看到 PA0 的翻转间隔会从第一次的 400ms，第二次 400ms，第三次 20ms,第四次及后续变为 200us，此时两次 burst 传输完成，并且 PCS,ARR,RCR 均更新完毕。

This sample demonstrates the function to transfer data in TIM1 using DMA in two consecutive bursts.burst updates three registers(PSC,ARR,RCR) per transfer.In the interruption of update event, PA0 will be flipped. Through the monitoring of logic analyzer, it can be seen that the flipping interval of PA0 will change from 400ms for the first time, 400ms for the second time, 20ms for the third time, and 200us for the fourth and subsequent times. At this time, the two burst transmission is completed, and PCS,ARR and RCR are all updated.

20.9 TIM1_EncoderTI2AndTI1

此样例实现了 TIM1 中的编码器计数功能，TI1(PA8)和 TI2(PA9)作为编码器输入引脚，通过 CNT 寄存器可观察到计数器变化，通过 uwDirection 变量可观察到计数器的计数方向，通过打印数据也可观察计数方向和 CNT 寄存器计数值，打印数据 Direction = 0 为向上计数，Direction = 1 为向下计数。

This sample demonstrates encoder count function of the TIM1,TI1(PA8) and TI2(PA9) configured as encoder input pins.The change of the counter can be observed through the CNT register, and the counting direction of the counter can be observed through the uwDirection variable.The counting Direction and CNT register can also be observed by printing data. The printed data Direction = 0 indicates CounterMode:Up, and direction = 1 indicates CounterMode:down.

20.10 TIM1_ExternalClockMode1

此样例演示了 TIM1 的外部时钟模式 1 功能, 选择 ETR(PA12)引脚作为外部时钟输入源，并使能更新中断，在中断中翻转 LED 灯

This sample demonstrates external clock mode 1 function of the TIM1.Select the ETR(PA12) pin as the external clock input source and enable the update interrupt to flip the LED light in the interrupt.

20.11 TIM1_ExternalClockMode1_TI1F

此样例演示了 TIM1 的外部时钟模式 1 功能, 选择 TI1FD(PA8)引脚作为外部时钟输入源，并使能更新中断，在中断中翻转 LED 灯

This sample demonstrates the external clock mode 1 function of TIM1, selects the TI1FD(PA8) pin as the external clock input source, and enables the update interrupt and toggle the LED light in the interrupt

20.12 TIM1_ExternalClockMode2

此样例演示了 TIM1 的外部时钟模式 2 功能，选择 ETR(PA12)引脚作为外部时钟输入源，并使能更新中断，在中断中翻转 LED 灯。

This sample demonstrates the external clock mode 2 function of TIM1, selects the ETR(PA12) pin as the external clock input source, and enables the update interrupt and toggle the LED light in the interrupt

20.13 TIM1_InputCapture_TI1FP1

此样例演示了在 TIM1(PA8)输入捕获功能，PA8 输入时钟信号，TIM1 捕获成功后，会进入捕获中断，每进一次中断，翻转一次 LED

This sample demonstrates the input capture function of TIM1(PA8), PA8 input clock signal, when TIM1 capture success, will enter the capture interrupt,and toggle the LED in the interrupt

20.14 TIM1_InputCapture_XORCh1Ch2Ch3

此样例演示了在 TIM1 输入捕获功能，PA8 或 PA9 或 PA10 输入时钟信号，TIM1 捕获成功后，会进入捕获中断，每进一次中断，翻转一次 LED

This sample demonstrates the input capture function of TIM1, input clock signal into PA8 or PA9 or PA10 will generate the capture interrupt after TIM1 capture successfully.Toggle the LED once per interruption

20.15 TIM1_OCToggle

此样例演示了 TIM1 比较模式下的 OC 翻转输出功能，使能 CH1(PA08),CH2(PA09),CH3(PA10),CH4(PA11)四个通道的输出功能，并且当计数器 TIMx_CNT 与 TIMx_CCRx 匹配时输出信号翻转，频率为 400KHz

This sample demonstrates the OC toggle output function in TIM1 comparison mode, enabling CH1(PA08),CH2(PA09),CH3(PA10),CH4(PA11) four channel output function, then the output signal toggle when the counter TIMx_CNT matches TIMx_CCRx. The frequency is 400KHz

20.16 TIM1_OCToggle_IT

此样例演示了 TIM1 比较模式下的中断功能，在中断中翻转 GPIO。

This sample demonstrates the interrupt function in TIM1 comparison mode, toggle the GPIO in an interrupt.

20.17 TIM1_OnePulseOutput

此样例演示了 TIM1 的单脉冲模式，CH2(PA09)引脚上的上升沿，触发计数器开始计数，当计数值与 CCR1 匹配时，CH1(PA08)输出高电平，直到计数器溢出，CH1 再次输出低电平，计数器溢出后，定时器停止工作，本例程脉冲宽度计算 (TIM1_ARR-TI1_CCR1)/CLK= (65535-16383) /32000000=1.536ms

This sample demonstrates the one pulse mode of TIM1.The rising edge on the   CH2(PA09) pin triggers the counter to start counting. when the count value   matches CCR1,CH1(PA08) outputs a high level. When the counter overflows ,CH1   outputs the low level again. After the counter overflows, the timer stops   working. This example pulse width calculation   (TIM1_ARR-TI1_CCR1)/CLK= (65,535-16383)/ 32,000,000 =1.536ms

20.18 TIM1_PWM

本例程输出 4 路 PWM，通道 1 的占空比为 20%，通道 2 为 40%，通道 3 为 60%，通道 4 为 80%，本例程周期为 8000000/(50+1)/800=196Hz

This sample outputs 4 channels PWM, the duty cycle of channel 1 is 20%,channel 2 is 40%, channel 3 is 60%,channel 4 is 80%.The period is 8000000/(50+1)/800=196Hz

20.19 TIM1_SynchronizationEnable

定时器 1 的使能由定时器 3 控制，当定时器 3 计数时，LED 会常亮，当定时器 3 发生更新事件时，更新事件会触发定时器 1，定时器 1 开始计数后，LED 会以 5Hz 的频率进行翻转

The enable of TIM1 is controlled by TIM3. When TIM3 counts, the LED will be   steady on. The update event generated by TIM3 will triggers TIM1, and when TIM1   starts counting, the LED is toggled at a frequency of 5Hz

20.20 TIM1_TIM3_Cascade

此样例实现了 TIM1 和 TIM3 级联成 32 位计数器，TIM3 做主机，TIM3 的计数溢出信号作为 TIM1 的输入时钟，通过配置 TIM1 和 TIM3 的重载寄存器值，(在 TIM1 中断回调函数中) 实现 LED 灯以 0.5Hz 频率闪烁。

This example realizes the cascade of TIM1 and TIM3 into a 32-bit counter, with   TIM3 as the host.The count overflow signal of TIM3 acts as the input clock of   TIM1.By configuring the reloaded register values of TIM1 and TIM3, the LED   is toggled at 0.5Hz (in the TIM1 interrupt callback function).

20.21 TIM1_Update_DMA

此样例演示了在 TIM1 中使用 DMA 传输数据的功能，通过 DMA 从 SRAM 中搬运数据到 ARR 寄存器，实现 TIM1 周期变化，在 TIM1 第一次溢出后，PA0 会翻转，此时翻转间隔为 400ms，DMA 开始搬运数

据到 TIM1_ARR,第一次 PA0 翻转间隔为 400ms,第二次翻转间隔为 100ms,第三次翻转间隔为 200ms,第四次翻转间隔为 300ms，此时 DMA 搬运结束，后续翻转间隔均为 300ms

This sample demonstrates the function of using DMA to transfer data in TIM1, carrying data from SRAM to ARR register by DMA to achieve TIM1 cycle change. After the first overflow of TIM1, PA0 will toggle, at this time the toggle interval is 400ms. DMA starts to carry data to TIM1_ARR, the first PA0 toggle interval is 400ms, the second toggle interval is 100ms, the third toggle interval is 200ms, the fourth toggle interval is 300ms, at this time the DMA carrying ends, the subsequent toggle interval are 300ms

20.22 TIM1_Update_IT

此样例演示了在 TIM1 中基本计数功能，并使能了更新中断，每次重装 ARR 值时会产生一次更新中断，并在中断中翻转 LED 灯，LED 灯会以 5Hz 的频率进行翻转。

This sample demonstrates basic count function of the TIM1 and enable update interrupt.Each time an update interrupt is generated, the ARR value is reloaded and the LED light is toggled in the interrupt.The LED light is toggled at a frequency of 5Hz.

21 USART

21.1 USART_HyperTerminal_AutoBaund_IT

此样例演示了 USART 的自动波特率检测功能，调试助手发送一个字符 0x7F，MCU 反馈字符串：Auto BaudRate Test。

This sample demonstrates automatic baud rate detection function of the USART. The serial assistant sends a character 0x7F, the MCU feedback character string: Auto BaudRate Test.

21.2 USART_HyperTerminal_DMA

此样例演示了 USART 的 DMA 方式发送和接收数据，USART 配置为 115200，数据位 8，停止位 1，校验位 None,下载并运行程序后，然后通过上位机下发 12 个数据，例如 0x1~0xC,则，MCU 会把接收到的数据再次发送。

This example demonstrates how to use USART to send an amount of data in DMA mode USART configuration is 115200 baud rate, data bit 8, stop bit 1, check bit None. Download and run the program, and send 12 data(such as 0x1~0xC) by the host   computer, then the MCU will send the received data again.

21.3 USART_HyperTerminal_IndefiniteLengthData_IT

此样例演示了 USART 的中断方式发送和接收不定长数据，USART 配置为 115200，数据位 8，停止位 1，校验位 None,下载并运行程序后，然后通过上位机下发任意长度个数据（不超过 200byte），例如 0x1~0xC,则 MCU 会把接收到的数据再次发送到上位机。

This example demonstrates the interrupt method of USART to send and receive variable length data. USART is configured as 115200, with data bit 8, stop bit 1, and check bit None. After downloading and running the program, the MCU will send any length of data (not exceeding 200bytes) through the upper computer, such as 0x1~0xC. The MCU will send the received data to the upper computer again.

21.4 USART_HyperTerminal_IT

此样例演示了 USART 的中断方式发送和接收数据，USART 配置为 115200，数据位 8，停止位 1，校验位 None,下载并运行程序后,上位机通过 USART 会接收到 0x1-0xC,然后通过上位机下发 12 个数据，例如 0x1~0xC,则，MCU 会把接收到的数据再次发送到上位机。

This example demonstrates how to use USART to send an amount of data in interrupt mode USART configuration is 115200 baud rate, data bit 8, stop bit 1, check bit   None. After download and run the program,the upper computer will receive 0x1-0xC Then send 12 data(such as 0x1~0xC)by the host computer,and the MCU will send the   received data again.

21.5 USART_HyperTerminal_Polling

此样例演示了 USART 的 POLLING 方式发送和接收数据，USART 配置为 115200，数据位 8，停止位 1，校验位 None,下载并运行程序后，通过 USART 会接收到 0x1-0xC,然后通过上位机下发 12 个数据，例如 0x1~0xC,MCU 会把接收到的数据再次发送。

This example demonstrates how to use USART to send an amount of data in polling mode USART configuration is 115200 baud rate, data bit 8, stop bit 1, check bit   None. After download and run the program,the upper computer will receive 0x1-0xC Then send 12 data(such as 0x1~0xC)by the host computer,and the MCU will send the   received data again.

22 WWDG

22.1 WWDG_IT

此样例演示了 WWDG 的提前唤醒中断功能,看门狗计数器向下计数到 0x40 时产生中断,中断中喂狗,可以确保看门狗不会复位。

This example demonstrates early wake up interrupt function of the WWDG.When the watchdog counter counts down to 0x40 will generates an interrupt.Refresh the WWDG in interrupt to ensure that the WWDG does not reset.

22.2 WWDG_Window

此样例演示了 WWDG 的 窗口看门狗功能,配置 WWDG 的窗口上限(下限固定是 0x3F),程序中通过 delay 延时函数,确保程序是在 WWDG 计数窗口内进行喂狗动作,通过 LED 灯闪烁,可以判断窗口内喂狗并未产生复位。

This example demonstrates the window watchdog function of WWDG. Set the upper limit of the window of WWDG (the lower limit is fixed at 0x3F).The program ensures that the WWDG is refreshed in the WWDG counting window through the delay function, and can judge that the WWDG is refreshed in the window without resetting through the LED light blinking.