



# **PY32T090 series**

## **32-bit ARM® Cortex®-M0+ microcontroller**

### **LL Library Sample Manual**

## 1 ADC

### 1.1 ADC\_AnalogWatchdog

此样例演示了 ADC 的模拟看门狗功能，当开启模拟看门狗通道的电压值超过上下限时，会进入看门狗中断。

This example demonstrates the analog watchdog function of ADC. When the voltage value of the analog watchdog channel exceeds the upper and lower limits, it will enter the watchdog interrupt.

### 1.2 ADC\_MulChannels\_TriggerTimer\_DMA

此样例演示了 ADC 的 DMA 多通道传输功能，在 DMA 完成中断中打印多通道的电压值。

This example demonstrates the DMA multi-channel transmission function of ADC, which prints the voltage values of multiple channels during the DMA completion interrupt.

### 1.3 ADC\_SingleConversion\_TriggerSW\_IT

此样例演示了 ADC 中断功能。

This sample demonstrates the Interrupt function of ADC

### 1.4 ADC\_TempSensor\_Polling

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\_Vrebuf

此样例演示了 ADC 的 Vrebuf 功能。

This example demonstrates the Vrebuf function of ADC.

### 1.6 ADC\_Vrefint

此样例演示了 ADC 的 Vrefint 功能，通过 Vrefint 的值，可以反推出 MCU 的供电电压值。

This example demonstrates the Vrefint function of ADC. By using the value of Vrefint, the power supply voltage value of MCU can be inferred



## 2 COMP

### 2.1 COMP\_CompareGpioVs1\_2VCC\_Polling\_Init

此样例演示了 COMP 比较器轮询功能，PD0 作为比较器正端输入，1/2VCC 作为比较器负端输入，当 PD0 的电压大于 1/2VCC 电压时，LED 灯亮，小于 1/2VCC 电压时，LED 灯灭。

This example demonstrates the interrupt function of the COMP comparator, with PD0 as the positive input and VREFINT as the negative input. When the voltage of PD0 is greater than 1/2 voltage, the LED lights up, and when it is less than 1/2VCC voltage, the LED lights up.

### 2.2 COMP\_CompareGpioVs1\_2VCC\_WakeUpFromStop

此样例演示了 COMP 比较器唤醒功能，PD0 作为比较器正端输入，1/2VCC 作为比较器负端输入，进入 stop 模式后，通过调整 PD0 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 PD0 as the positive input and 1/2VCC 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 PD0.

### 2.3 COMP\_CompareGpioVs1\_2VCC\_Window

此样例演示了 COMP 比较器的 window 功能，比较器 1 正端用比较器 2 的正端(PC4)作为输入，VREFCMP 作为比较器负端输入，当 PC4 的电压值小于 1.65V 时，LED 灯灭，大于 1.65V 时，LED 灯亮。

This example demonstrates the window function of the COMP. The positive terminal of the COMP1 is connected the positive terminal of the COMP2(PC4).VREFCMP used as the negative terminal of the COMP1.When the voltage value of PC4 is greater than 1.65V, the LED is on, and when it is less than 1.65V, the LED is off.

## 3 CRC

### 3.1 CRC\_CalculateAndCheck

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.

### 3.2 CRC\_UserDefinedPolynomial

该样例演示了 CRC (循环冗余校验)，计算单元根据用户定义的生成多项式为给定的数据缓冲区计算 8 位 CRC 代码。

This sample demonstrates CRC (Cyclic Redundancy Check), where the calculation unit calculates an 8-bit CRC code for a given data buffer based on a user-defined generating polynomial.

## 4 DAC

### 4.1 DAC\_GenerateConstantSignal\_TriggerSW

此样例演示了 DAC 的软件触发功能,通道 PC6 能够输出 1/2 的供电电压值。

This example demonstrates the software triggering function of DAC, where channel PC6 can output 1/2 of the supply voltage value.

## 5 DMA

### 5.1 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).

## 6 EXTI

### 6.1 EXTI\_ToggleLed\_IT\_Init

此样例演示了 GPIO 外部中断功能，PA0 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 sample demonstrates the functionality of GPIO external interrupts. Whenever a falling edge is detected on pin PA0, an interrupt is triggered, and the interrupt handler toggles the state of the LED.

### 6.2 EXTI\_WakeUp\_Event

此样例演示了 stop0 模式下，GPIO 外部事件唤醒功能。

This sample demonstrates the GPIO external event wake-up feature in stop0 mode.



## **7 FLASH**

### **7.1 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 sample demonstrates the change of the RESET pin to a normal GPIO by software.

### **7.2 FLASH\_PageEraseAndWrite**

此样例演示了 flash page 擦除和 page 写功能。

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

### **7.3 FLASH\_SectorEraseAndWrite**

此样例演示了 flash sector 擦除和 page 写功能。

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

## 8 GPIO

### 8.1 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 sample demonstrates the FAST IO output functionality of GPIO, which can achieve a single-cycle toggling speed.

### 8.2 GPIO\_Toggle

此样例演示了 GPIO 输出模式，配置 LED 引脚为数字输出模式，并且每隔 500ms 翻转一次 LED 引脚电平，运行程序，可以看到 LED 灯闪烁。

This sample demonstrates GPIO output mode by configuring the LED pin as a digital output. The LED pin's level is toggled every 500ms, causing the LED to blink. Run the program to observe the LED blinking.

### 8.3 GPIO\_Toggle\_Init

此样例演示了 GPIO 输出模式，配置 LED 引脚为数字输出模式，并且每隔 500ms 翻转一次 LED 引脚电平，运行程序，可以看到 LED 灯闪烁。

This sample demonstrates GPIO output mode by configuring the LED pin as a digital output. The LED pin level is toggled every 500ms. When running the program, the LED will blink.

## 9 I2C

### 9.1 I2C\_TwoBoards\_Com\_DMA\_Init

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.

### 9.2 I2C\_TwoBoards\_Com\_IT\_Init

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 interrupt. 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.

### 9.3 I2C\_TwoBoards\_Com\_Pollig\_Init

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.

### 9.4 I2C\_TwoBoard\_Com\_DMA\_MEM\_Init

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。按下用户按键后，主机先向从机写入 15 字节的数据 (0x1-0xf)，然后从 EEPROM 中读取写入的数据。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 device and the slave device using I2C with DMA. The slave device uses the EEPROM peripheral chip P24C32. When the user button is pressed, the master device first writes 15 bytes of data (0x1-0xf) to the slave device, and then reads the written data from the EEPROM. Upon successful read, the LED on the master board remains continuously on.

## 9.5 I2C\_TwoBoard\_Com\_DualAddr\_IT\_Init

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 interrupt. 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.

## 9.6 I2C\_TwoBoard\_IndefiniteLengthData\_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 I2S

### 10.1 I2S\_TwoBoard\_Communication\_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.

### 10.2 I2S\_TwoBoard\_Communication\_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 interrupt. 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.

### 10.3 I2S\_TwoBoard\_Communication\_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 IWDG

### 11.1 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).

## 12 LCD

### 12.1 LCD\_Display

此样例是对单色无源液晶显示器(LCD)的演示，将偏置产生电路配置为内部电阻分压，使 LCD 全显，显示“88:88”字样。

This sample demonstrates the usage of a monochrome passive LCD (Liquid Crystal Display). The bias generation circuit is configured with internal resistor voltage division to achieve a fully displayed LCD showing the "88:88" characters.

## 13 LPTIM

### 13.1 LPTIM\_ContinuousMode\_WakeUp\_WFE

此样例演示了 LPTIM 连续模式事件唤醒 STOP 模式。

This example demonstrates the LPTIM continuous mode event wake-up STOP mode.

### 13.2 LPTIM\_ContinuousMode\_WakeUp\_WFI

此样例演示了 LPTIM 连续模式中断唤醒 STOP 模式。

This sample demonstrates waking up from stop mode by LPTIM(contiunus mode) interrupt request.



## 14 LPUART

### 14.1 LPUART\_HyperTerminal\_DMA

此样例演示了 LPUART 的 DMA 方式发送和接收数据，LPUART 配置为 9600，数据位 8，停止位 1，校验位 None，下载并运行程序后，打印提示信息，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，然后打印结束信息。

This example demonstrates how to use LPUART to send an amount of data in DMA mode. LPUART configuration is 9600 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message.

### 14.2 LPUART\_HyperTerminal\_IT

此样例演示了 LPUART 的中断方式发送和接收数据，LPUART 配置为 9600，数据位 8，停止位 1，校验位 None，下载并运行程序后，打印提示信息，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，然后打印结束信息。

This example demonstrates how to use LPUART to send an amount of data in interrupt mode. LPUART configuration is 9600 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message.

### 14.3 LPUART\_HyperTerminal\_Polling

此样例演示了 LPUART 的轮询方式发送和接收数据，LPUART 配置为 9600，数据位 8，停止位 1，校验位 None，下载并运行程序后，打印提示信息，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，然后打印结束信息。

This example demonstrates how to use LPUART to send an amount of data in polling mode. LPUART configuration is 9600 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message.

## 15 OPA

### 15.1 OPA\_VoltageFollow

此样例演示了 OPA 的电压跟随功能，PC2 为正端输入，PC1 为负端输入，PC8 为输出，PC8 会输出和 PC2 相同的电压值。

This sample demonstrates the voltage follower functionality of the OPA. PC2 is the positive input, PC1 is the negative input, and PC8 is the output. PC8 will output the same voltage as PC2.

## 16 PWM

### 16.1 PWM\_PWM\_Init

此样例演示了使用 PWM PWM2 模式输出三路频率为 10Hz 占空比分别为 25%、50%、75%的 PWM 波形。

This example demonstrates the use of PWM PWM2 mode to output three PWM waves with a frequency of 10Hz and a duty cycle of 25%, 50% and 75%, respectively.

## 17 PWR

### 17.1 PWR\_LPRUN

此样例演示了进入和退出 lprun 模式。

This example demonstrates entering and exiting the lprun mode.

### 17.2 PWR\_LPSLEEP\_WFI

此样例演示了 lpsleep 模式下，GPIO 外部中断唤醒功能。

This sample demonstrates the GPIO external interrupt wake-up feature in lpsleep mode.

### 17.3 PWR\_PVD

此样例演示了 PVD 电压检测功能。当供电电压低于 3.1V 时，LED 会点亮，高于 3.1V 时，LED 灯会熄灭。

This sample demonstrates the PVD (Programmable Voltage Detector) voltage detection functionality. When the supply voltage is lower than 3.1V, the LED will light up. When the supply voltage is higher than 3.1V, the LED will turn off.

### 17.4 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 GPIO external interrupt wake-up feature in sleep mode.

### 17.5 PWR\_STANDBY

此样例演示了 standby 模式下，通过 wakeuppín 唤醒功能。

This sample demonstrates the wake-up feature using the wakeup pin in standby mode.

### 17.6 PWR\_STOP0\_WFI

此样例演示了在 stop0 模式下，使用 GPIO 中断唤醒。

This sample demonstrates waking up from stop0 mode using GPIO interrupt.

## 17.7 PWR\_STOP1\_WFE

此样例演示了 stop1 模式下，GPIO 外部事件唤醒功能。

This sample demonstrates the GPIO external event wake-up feature in stop1 mode.

## 18 RCC

### 18.1 RCC\_HSE\_OUTPUT

此样例演示了时钟输出功能，可输出 HSE 波形。

This sample demonstrates the clock output function, which can output the HSE waveform.

### 18.2 RCC\_HSI\_OUTPUT

此样例演示了时钟输出功能，可输出 HSI 波形。

This sample demonstrates the clock output function, which can output the HSI waveform.

### 18.3 RCC\_LSE\_OUTPUT

此样例演示了将系统时钟设置为 LSE，并通过 MCO 引脚输出系统时钟。

This example demonstrates setting the system clock to LSE and outputting the system clock through the MCO pin.

### 18.4 RCC\_LSI\_OUTPUT

此样例演示了将系统时钟设置为 LSI，并通过 MCO 引脚输出系统时钟。

This example demonstrates setting the system clock to LSI and outputting the system clock through the MCO pin.

### 18.5 RCC\_PLL\_OUTPUT

此样例演示了时钟输出功能，可输出以 HSI 为源的 PLL 波形。

This sample demonstrates the clock output function, which can output PLL waveform with HSI as the source.

### 18.6 RCC\_Sysclock\_Switch

此样例演示了时钟切换，由 LSI 切换至 HSE。

This sample demonstrates clock switching from LSI to HSE.

## 19 RTC

### 19.1 RTC\_Alarm\_IT\_Init

此样例演示 RTC 的闹钟中断功能。在闹钟中断函数中会打印当前闹钟时间及字符“RTC\_IT\_ALARM”。

This sample demonstrates the RTC's alarm interrupt functionality. In the alarm interrupt function, the current alarm time and the character "RTC\_IT\_ALARM" will be printed.

### 19.2 RTC\_Calendar\_Init

此样例演示 RTC 的日历功能。当前时间和日期更新在全局变量 aShowTime 和 aShowDate 中。

This example demonstrates the calendar function of the RTC. The current time and date are updated in the global variables aShowTime and aShowDate.

### 19.3 RTC\_Tamper

此样例演示外部入侵事件擦除备份寄存器功能。在 TAMP\_IN 引脚(PA8)产生下降沿入侵事件可擦除备份寄存器中的数据。

This example demonstrates the function of erasing backup registers by external tamper events. A tamper event generated on the TAMP\_IN pin (PA8) with a falling edge can erase the data in the backup registers.

### 19.4 RTC\_TimeStamp

此样例演示 RTC 的时间戳功能。

This example demonstrates the timestamp function of RTC.

### 19.5 RTC\_WakeUpTimer

此样例演示通过 RTC 唤醒定时器中断每隔 1s 将 MCU 从 STOP0 模式下唤醒，每次唤醒会翻转 LED，LED 翻转间隔为 1s。

This example demonstrates waking up the MCU from STOP0 mode every 1 second using an RTC WakeUpTimer interrupt. Each wake-up will flip the LED, with an interval of 1 second between LED flips.

## 20 SPI

### 20.1 SPI\_TwoBoards\_FullDuplex\_DMA

此样例是利用 DMA 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, 主设备提供通信时钟 SCK, 通过 MOSI/MISO 引脚发送/接收数据。从设备通过 MOSI/MISO 引脚接收/发送数据。数据以主机提供的 SCK 沿同步被移位, 完成全双工通信。

This sample is a demonstration of using DMA to communicate with a serial peripheral interface (SPI) and an external device in full-duplex serial mode. The master device provides the communication clock SCK and sends/receives data through the MOSI/MISO pin. The slave device receives/transmits data through the MOSI/MISO pins. The data is shifted synchronously along the SCK provided by the master to complete full-duplex communication.

### 20.2 SPI\_TwoBoards\_FullDuplex\_IT

此样例是利用中断对串口外设接口 (SPI) 与外部设备以全双工串行方式进行通信的演示, 主设备提供通信时钟 SCK, 通过 MOSI/MISO 引脚发送/接收数据。从设备通过 MOSI/MISO 引脚接收/发送数据。数据以主机提供的 SCK 沿同步被移位, 完成全双工通信。

This sample is a demonstration of using interrupt to communicate with a serial peripheral interface (SPI) and an external device in full-duplex serial mode. The master device provides the communication clock SCK and sends/receives data through the MOSI/MISO pin. The slave device receives/transmits data through the MOSI/MISO pins. The data is shifted synchronously along the SCK provided by the master to complete full-duplex communication.

### 20.3 SPI\_TwoBoards\_FullDuplex\_Polling

此样例是利用轮询对串口外设接口 (SPI) 与外部设备以全双工串行方式进行通信的演示, 主设备提供通信时钟 SCK, 通过 MOSI/MISO 引脚发送/接收数据。从设备通过 MOSI/MISO 引脚接收/发送数据。数据以主机提供的 SCK 沿同步被移位, 完成全双工通信。

This sample is a demonstration of using polling to communicate with a serial peripheral interface (SPI) and an external device in full-duplex serial mode. The master device provides the communication clock SCK and sends/receives data through the MOSI/MISO pin. The slave device receives/transmits data through the MOSI/MISO pins. The data is shifted synchronously along the SCK provided by the master to complete full-duplex communication.



## 21 TIM

### 21.1 TIM1\_6Step\_Init

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。

This sample demonstrates advanced timer function 'six-step PWM generation', systick interrupt as COM commutation event trigger source to achieve commutation (brushless motor).

### 21.2 TIM1\_ComplementarySignals\_Init

此样例演示了使用 TIM1 输出三路频率为 10Hz 占空比分别为 25%、50%、75%的 PWM 波形以及他们的互补信号。

This sample demonstrates the generation of three PWM waveforms with frequencies of 10Hz and duty cycles of 25%, 50%, and 75% using TIM1. It also generates their complementary signals.

### 21.3 TIM1\_DmaBurst\_Init

此样例演示了 TIM1 的 DMA Burst 传输，配置 TIM1 为 PWM 模式，更新中断触发 DMA 传输请求。每次产生更新中断时将 TIM1DataBuff[]中的值按顺序写入 RCR 和 CCR1 寄存器，改变 PWM 脉冲的占空比和该占空比的脉冲数量。

This sample demonstrates the DMA Burst transfer of TIM1. It configures TIM1 in PWM mode and triggers DMA transfer requests on update interrupt. Each time an update interrupt occurs, the values in TIM1DataBuff[] are sequentially written to RCR and CCR1 registers, changing the duty cycle and the number of pulses for the PWM waveform.

### 21.4 TIM1\_EncoderTI2AndTI1\_Init

此样例演示了 TIM1 的编码器接口模式。TIM1 配置为编码器接口模式 3，PB12 和 PC13 配置为通道 1 和通道 2,当 PB12 输入信号的上升沿在前，PC13 输入信号上升沿在后时 TIM1 向上计数，反之向下计数。开启通道 1 和通道 2 的捕获中断，在中断中打印当前 CNT 值。

This sample demonstrates the encoder interface mode of TIM1. TIM1 is configured in encoder interface mode 3, with PB12 and PC13 configured as channel 1 and channel 2, respectively. When the rising edge of the input signal on PB12 occurs before the rising edge of the input signal on PC13, TIM1 counts up; otherwise, it counts down. The capture interrupts for channel 1 and channel 2 are enabled, and the current CNT value is printed in the interrupt.

## 21.5 TIM1\_InputCapture

此样例演示了 TIM1 的输入捕获功能。配置 PB12 为通道 1 的输入引脚,每当引脚电平出现上升沿时会触发捕获中断,并在中断处理中翻转 LED。

This sample demonstrates the input capture functionality of TIM1 . Configure PB12 as the input capture pin. Whenever an rising edge is detected on PB12, it triggers the capture interrupt and toggles the LED in the interrupt callback function.

## 21.6 TIM1\_InputCapture\_XORCh1Ch2Ch3

此样例演示了 TIM1 的三通道异或输入捕获功能。配置 PB12、PC13、PC5 为通道 1、通道 2、通道 3 的输入引脚。每当有一个引脚电平变化时会触发捕获中断，并在中断处理中翻转 LED。

This sample demonstrates the XOR input capture functionality of TIM1 using three channels: PB12, PC13, and PC5 as the input pins for channel 1, channel 2, and channel 3, respectively. Whenever there is a change in the level of any of the input pins, it triggers the capture interrupt and toggles the LED in the interrupt handler.

## 21.7 TIM1\_OC\_Toggle

此样例演示了 TIM1 的输出比较模式。将捕获/比较通道 1(CH1)的输出映射到 PB12，开启捕获/比较通道 1(CH1)并设置为比较输出翻转模式

This sample demonstrates the output compare mode of TIM1. The output of capture/compare channel 1 (CH1) is mapped to pin PB12. Capture/compare channel 1 (CH1) is enabled and set to compare output toggle mode.

## 21.8 TIM1\_OnePulseOutput

此样例演示了 TIM1 的单脉冲模式。配置 TIM1 为从模式触发模式，触发源为 TI2FP2，通道 1 为 PWM2 模式，映射到 PB12，通道 2 为输入模式，映射到 PC13。当 PC13 上检测到一个上升沿时，PB12 延迟 20ms 后产生一个宽度为 80ms 的脉冲。

This sample demonstrates the single pulse mode of TIM1. TIM1 is configured in slave mode trigger mode with TI2FP2 as the trigger source. Channel 1 is configured as PWM mode 2 and mapped to pin PB12, while channel 2 is configured as input mode and mapped to pin PC13. When an rising edge is detected on PC13, a 20ms delay is applied, and then PB12 will output a pulse with a width of 80ms.

## 21.9 TIM1\_PWM\_Init

此样例演示了使用 TIM1 PWM2 模式输出三路频率为 10Hz 占空比分别为 25%、50%、75%的 PWM 波形。

This example demonstrates the use of TIM1 PWM2 mode to output three PWM waves with a frequency of 10Hz and a duty cycle of 25%, 50% and 75%, respectively.

## 21.10 TIM1\_TIM2\_Cascade

此样例演示了 TIM1 和 TIM2 级联成 48 位计数器，TIM2 做主机，TIM2 的溢出信号作为 TIM1 的输入时钟。TIM2 每 1ms 计数一次，计数 1000 次后产生溢出，TIM1 计数一次。

This sample demonstrates the cascading of TIM1 and TIM2 as a 48-bit counter, with TIM2 as the master and the overflow signal of TIM2 as the input clock of TIM1. TIM2 counts every 1ms, and after counting 1000 times, it overflows and TIM1 counts once.

## 21.11 TIM1\_TimeBase\_Init

此样例演示了 TIM1 的更新中断功能，在更新中断中翻转 LED。

This sample demonstrates the update interrupt function of TIM1, and toggle the LED in update interrupt

## 21.12 TIM1\_Update\_DMA\_Init

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 更新周期变化,TIM1 第一次溢出后 LED 会翻转,此次翻转时间间隔为 1000ms,DMA 将数据搬运到 TIM1\_ARR,第二次 LED 翻转间隔为 900ms,以此类推,最后 LED 翻转间隔为 100msDMA 搬运结束,LED 保持 100ms 的翻转间隔闪烁。

This sample demonstrates the use of DMA to transfer data in TIM1, copying data from SRAM to the ARR register to achieve varying update periods for TIM1. After the first overflow of TIM1, the LED will toggle, with a time interval of 1000ms. After the data is transferred to TIM1\_ARR using DMA, the LED toggling interval gradually decreases: 900ms, 800ms, 700ms, 600ms, 500ms, 400ms, 300ms, 200ms, 100ms. Finally, the LED will blink with a constant toggling interval of 100ms.

## 22 UART

### 22.1 UART\_HyperTerminal\_DMA

此样例演示了 UART 的 DMA 方式发送和接收数据，UART 配置为 115200，数据位 8，停止位 1，校验位 None，下载并运行程序后，打印提示信息，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，然后打印结束信息。

This example demonstrates how to use UART to send an amount of data in DMA mode. UART configuration is 115200 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message

### 22.2 UART\_HyperTerminal\_IndefiniteLengthData\_IT

此样例演示了 UART 的中断方式发送和接收不定长数据，UART 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 128bytes），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 UART to send and receive variable length data. UART 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 128bytes) through the upper computer, such as 0x1~0xC. The MCU will send the received data to the upper computer again.

### 22.3 UART\_HyperTerminal\_IT

此样例演示了 UART 的中断方式发送和接收数据，UART 配置为 115200，数据位 8，停止位 1，校验位 None，下载并运行程序后，打印提示信息，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，然后打印结束信息。

This example demonstrates how to use UART to send an amount of data in interrupt mode. UART configuration is 115200 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message

### 22.4 UART\_HyperTerminal\_Polling

此样例演示了 UART 的轮询方式发送和接收数据，UART 配置为 115200，数据位 8，停止位 1，校验位 None，下载并运行程序后，打印提示信息，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，然后打印结束信息。

This example demonstrates how to use UART to send an amount of data in polling mode. UART

configuration is 115200 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message

## 23 USART

### 23.1 SCI\_HyperTerminal\_AutoBaud\_IT

此样例演示了 SCI 的自动波特率检测功能,上位机发送 1 字节的波特率检测字符 0x55, 如果 MCU 检测成功, 则返回字符: Auto BaudRate Test。

This example demonstrates the automatic baud rate detection function of SCI. If the MCU detects successfully after the upper computer sends 1 byte baud rate detection character 0x55, it will returns the string: Auto BaudRate Test.

### 23.2 SCI\_HyperTerminal\_DMA

此样例演示了 SCI 的 DMA 方式发送和接收数据, SCI 配置为 115200, 数据位 8, 停止位 1, 校验位 None, 下载并运行程序后, 打印提示信息, 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, 然后打印结束信息。

This example demonstrates how to use SCI to send an amount of data in DMA mode. SCI configuration is 115200 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message

### 23.3 SCI\_HyperTerminal\_IndefiniteLengthData\_IT

此样例演示了 SCI 的中断方式发送和接收不定长数据, SCI 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 128bytes), 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 SCI to send and receive variable length data. SCI 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 128bytes) through the upper computer, such as 0x1~0xC. The MCU will send the received data to the upper computer again.

### 23.4 SCI\_HyperTerminal\_IT

此样例演示了 SCI 的中断方式发送和接收数据, SCI 配置为 115200, 数据位 8, 停止位 1, 校验位 None, 下载并运行程序后, 打印提示信息, 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, 然后打印结束信息。

This example demonstrates how to use SCI to send an amount of data in interrupt mode. SCI configuration is 115200 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message

## 23.5 SCI\_HyperTerminal\_Polling

此样例演示了 SCI 的轮询方式发送和接收数据, SCI 配置为 115200, 数据位 8, 停止位 1, 校验位 None, 下载并运行程序后, 打印提示信息, 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, 然后打印结束信息。

This example demonstrates how to use SCI to send an amount of data in polling mode. SCI configuration is 115200 baud rate, data bit 8, stop bit 1, check bit None. After download and run the program, Print the prompt message, and then send 12 data through the upper computer, such as 0x1~0xC, the MCU will send the received data to the upper computer again, Then print the end message

## 23.6 USART\_SyncCommunication\_FullDuplex\_Polling

此样例演示了 USART 同步通信功能, USART 设备作为主机、SPI 设备作为从机, 采用轮询方式通信。在 USART 设备提供同步时钟下, 主从机完成全双工通信。

This sample demonstrates USART synchronous communication, with USART devices as masters and SPI devices as slaves, communicating in polling mode. With synchronous clock provided by USART equipment, master and slave complete full duplex communication.

## 24 UTILS

### 24.1 UTILS\_ConfigureSystemClock

本样例主要演示如何配置 SYSCLK(系统时钟), HCLK(AHB 时钟), PCLK(APB 时钟)。通过 MCO 输出系统时钟 48MHz。

This sample demonstrates how to configure SYSCLK (system clock), HCLK (AHB clock), and PCLK (APB clock), and outputs the system clock of 48MHz through MCO.



## 25 WWDG

### 25.1 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.

### 25.2 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.