第十六讲
元器件（II）
Lecture 16
Components (II)

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电机驱动模块
Motor Driver IC

- 我们已经讲了常见的电机如直流（减速）电机，伺服电机，步进电机。一般在实际使用时，常常需要相应的驱动模块驱动电机工作。常用的驱动模块一般由集成电路构成，满足电机工作时的功率与控制要求。

  We have introduced commonly-used motors such as DC (reduction) motor, servo motor, and stepper motor. Generally, when using them in practice, corresponding drive modules are often needed to drive the motors. The commonly used drive modules generally consist of integrated circuits (ICs) that handle the control and power requirements of the motor.

- 驱动芯片通常包括两个主要组成部分：电机控制器和功率驱动器。电机控制器从微控制器或另一个控制系统接收输入信号，并为电机生成必要的控制信号。它具有速度控制、方向控制和电机制动等功能。

  The IC typically includes two main components: a motor controller and a power driver. The motor controller receives input signals from a microcontroller or another control system and generates the necessary control signals for the motor. It manages functions such as speed control, direction control, and motor braking.

电机驱动模块
Motor Driver IC

- 功率驱动器通常被称为H桥，它是处理驱动电机所需的高电流的开关。它确保电流按所需方向流经电机，并且H桥配置允许通过反转电流极性实现电机的双向控制。

  The power driver, often referred to as an H-bridge, handles the high-current switching necessary to drive the motor. It ensures that the current flows through the motor in the desired direction. The H-bridge configuration allows bidirectional control of the motor by reversing the current polarity.

- 电机驱动芯片组有各种配置和规格，以适应不同的电机类型和功率要求。它们可以处理不同的电压范围和电流额定值，让用户可以根据电机的规格选择适当的芯片组。也有专门针对特定电机类型的电机驱动器芯片可用，例如刷式直流电机、无刷直流电机和步进电机。这些芯片针对各自的电机类型进行了优化，并提供更专业的控制和驱动能力。

  Motor driver chipsets are available in various configurations and specifications to accommodate different motor types and power requirements. They can handle different voltage ranges and current ratings, allowing you to select the appropriate chipset based on your motor's specifications. There are also dedicated motor driver ICs available for specific motor types, such as brushed DC motors, brushless DC motors, and stepper motors. These ICs are optimized for their respective motor types and provide more specialized control and drive capabilities.

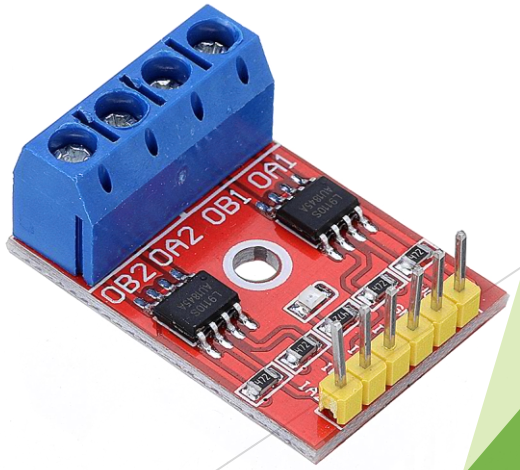
直流电机驱动模块
DC Motor Driver IC

- 一种常用的驱动低功率小型直流电机的驱动芯片为L9110S，其驱动的电机的电压范围为2.5V至12V，由于它能够双向驱动，这意味着它可以控制电机的正反转。同时，由于该芯片的低功耗操作设计，其适用于电池供电的应用。

  A popular driver IC used to drive small low-power DC motors is the L9110S. It is designed to drive two small DC motors with a voltage range of 2.5V to 12V bidirectionally, meaning it can control the motor‘s rotation in both forward and reverse directions. Meantime, since the IC is designed to operate with low power consumption, it is suitable for battery-powered applications.

- 通常，L9110S由两个独立的H桥电路组成，双H桥电机驱动器：既可以独立控制两个电机，也可将它们组合以驱动单个功率要求更高的电机。

  Genrally, the L9110S consists of two independent H-bridge circuits to form a dual H-bridge motor driver, which allows you to control two motors independently or combine them for driving a single motor with higher power requirements.



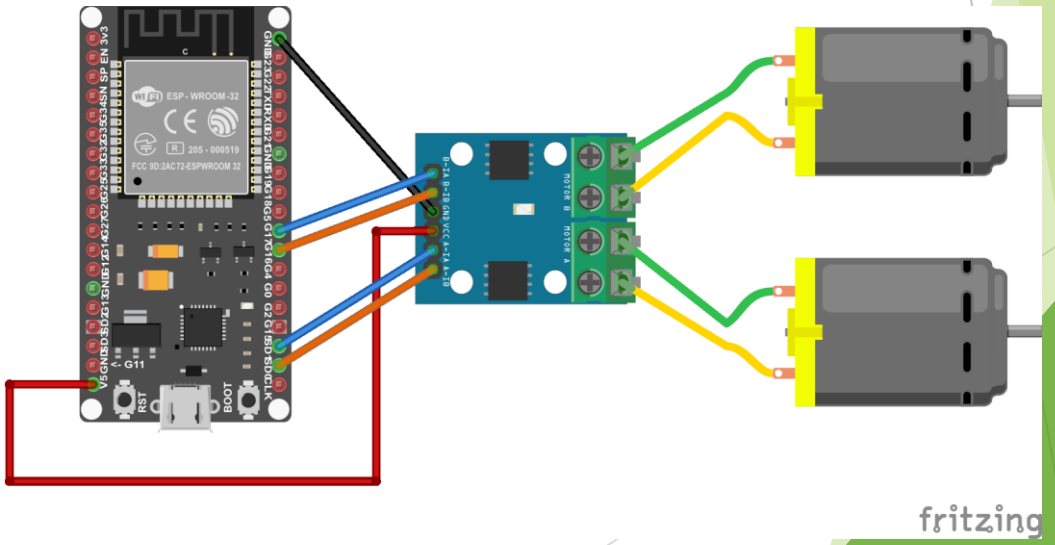
直流电机驱动模块
DC Motor Driver IC

- L9110S的控制接口较为简单，它通过使用对应于每个电机两个输入信号来控制电机的旋转方向（正转或反转），以及一个可选的使能引脚来打开或关闭电机。

  The L9110S typically uses two input signals per motor to control the motor's rotation direction (forward or reverse) and an optional enable pin to turn the motor on or off.

- 此外，该芯片集成了各种保护功能，包括过流保护和热关断，以保护电机和驱动器芯片免受损坏。

  In addition, the IC incorporates various protection features, including overcurrent protection and thermal shutdown, to safeguard the motor and the driver IC from damage.



直流电机驱动模块
DC Motor Driver IC

- L9110S的通常接法与操作逻辑如下表所示：

  The stereotypical wiring and logic operation of L9110S is as follows:

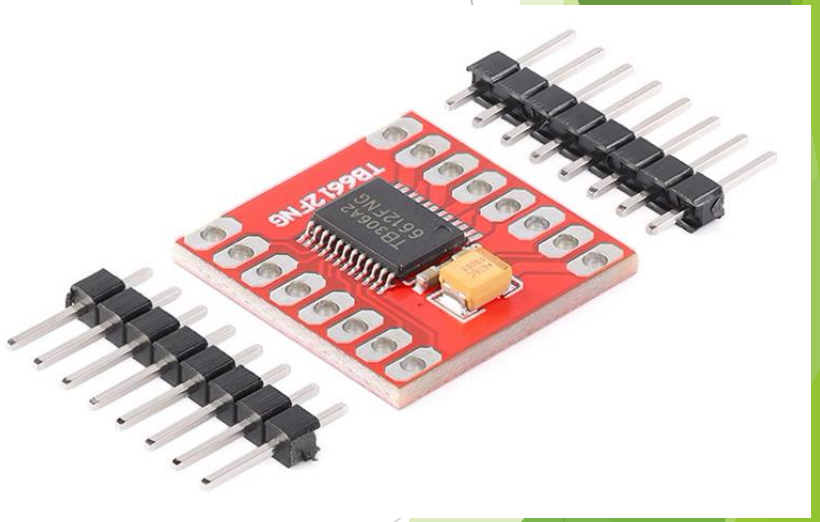
		IA1	IB1	IA2	IB2	VCC	GND
		接IO口	接IO口	接IO口	接IO口	电源正极	电源地
OA1	电机1一端	注意，由于L9110S常用来驱动如130等小型直流电机，因此，通常共用单片机的电源输出即可满足要求。但如果是用另外的电源供电的话，（即不是和单片机的电源共用），那么需要将单片机的GND和模块上的GND连接在一起，只有这样单片机上过来的逻辑信号才有参考0点。否则模块可能不能正常工作。					
OB1	电机1另一端						
OA2	电机2一端						
OB2	电机2另一端						

		IA1		IA2	
		高电平	低电平	高电平	低电平
IB1	高电平	电机正转	电机静止	/	/
	低电平	电机静止	电机反转	/	/
IB2	高电平	/	/	电机正转	电机静止
	低电平	/	/	电机静止	电机反转

直流电机驱动模块
DC Motor Driver IC

- 在某些情况下，我们不仅需要控制电机的转向，同时需要控制电机的转速，此时，我们需要使用具有相关功能的驱动IC。这里以TB6612为例，其是一款新型驱动器件，具有较高的集成度，独立双向控制2个直流电机的同时，能提供足够的输出能力。特别的，通过额外的PWM信号输入端，通过调整PWM信号的占空比，可以进一步控制电机的转速。

  In some scenarios, we need to control not only the direction of motor rotation, but also the speed of rotation, therefore, we need driver ICs which provide such a functionality. We introduce such ICs by exemplifying of TB6612, which is a new driver IC of high integration. It can control two DC motors independently without compromising the power of outputs. Specially, by providing extra PWM pins and by regulating the duty of cycle, it can control the rotation speed of motors.



直流电机驱动模块
DC Motor Driver IC

	引脚	定义
	VM	驱动电压输入端（4.5–10V）
	VCC	逻辑电平输入端（2.7–5.5V）
	GND	电源地端
	STBY	正常工作/待机状态控制输入端
1路电机	PWMA	PWM信号输入端
	AIN1	电机控制模式输入端
	AIN2	
	A01	电机驱动输出端
	A02	
2路电机	PWMB	PWM信号输入端
	BIN1	电机控制模式输入端
	BIN2	
	B01	电机驱动输出端
	B02	

- TB6612的通常接法与操作逻辑如下表所示：

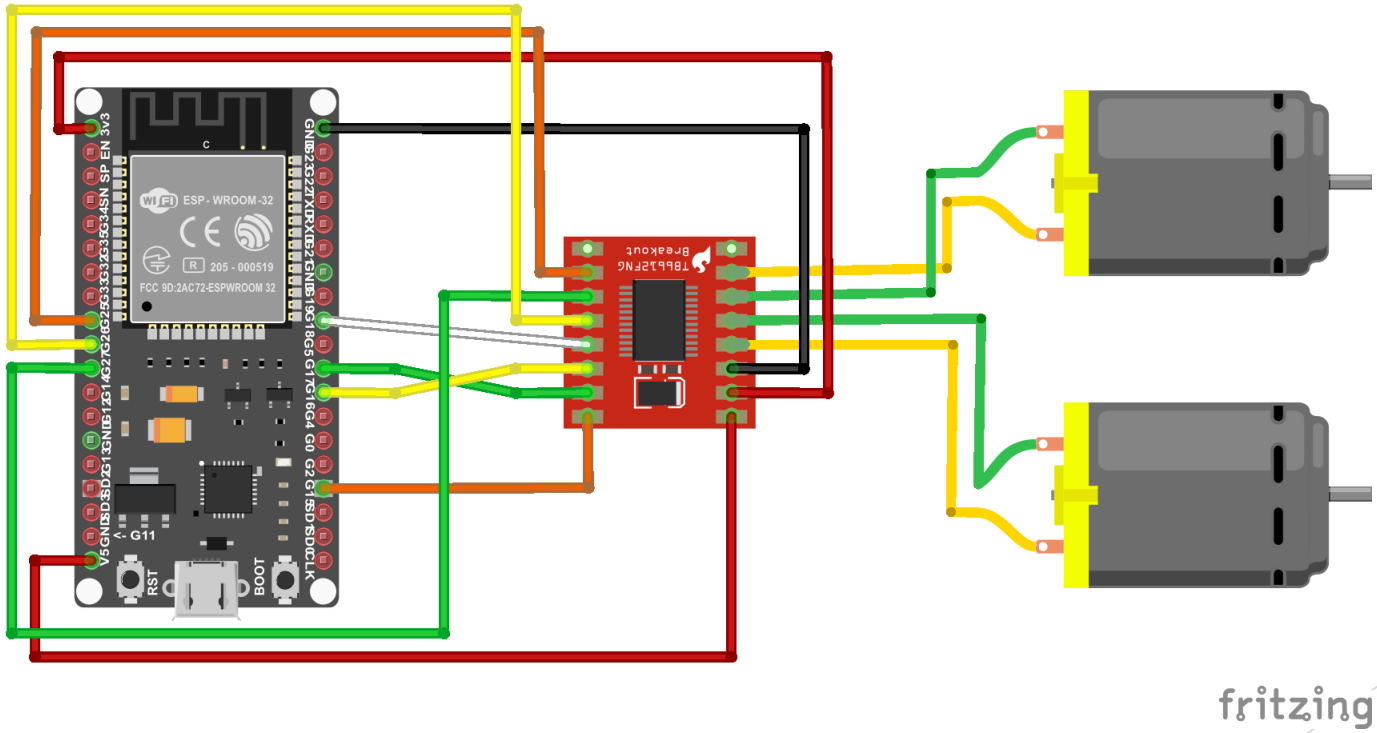
  The stereotypical wiring and logic operation of TB6612 is as follows:

输入				输出		
IN1	IN2	PWM	STBY	O1	O2	模式状态
H	H	H/L	H	L	L	制动
L	H	H	H	L	H	反转
L	H	L	H	L	L	制动
H	L	H	H	H	L	正转
H	L	L	H	L	L	制动
L	L	H	H	OFF		停止
H/L	H/L	H/L	L	OFF		待机

直流电机驱动模块
DC Motor Driver IC

- TB6612的基于ESP32的连接如下图所示：

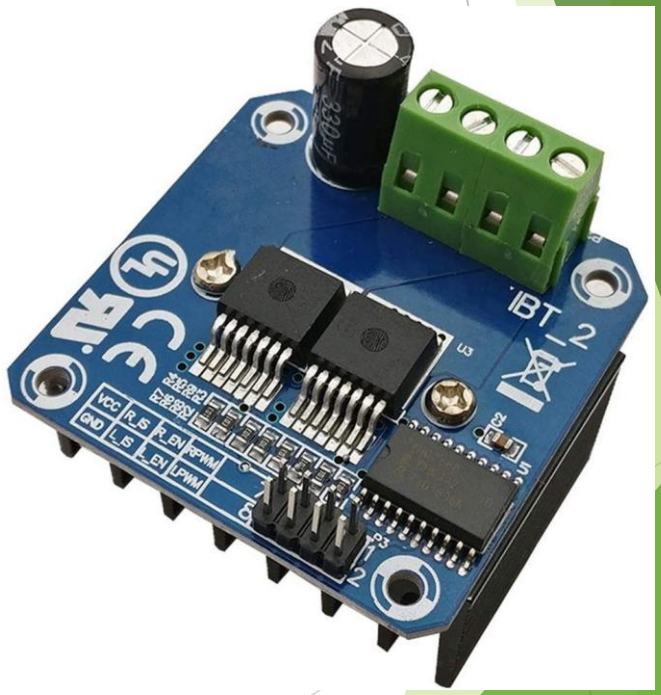
  The stereotypical wiring between TB6612 and ESP32 is as follows:



直流电机驱动模块
DC Motor Driver IC

- 在某些情况下，我们可能需要驱动功率较大的电机。此时，往往需要输出端由电压较高的独立电源供电。加上此时控制端与输出端对输入电源的电压要求往往不同，因此，这时我们需要大功率、具有信号隔离的驱动芯片，例如以BTS7960芯片为基础制成的驱动模块，如下图所示：

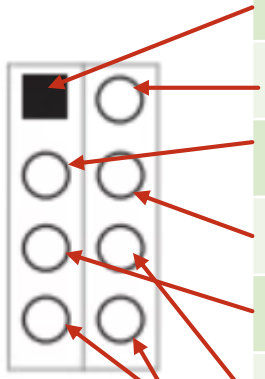
  In certain situations, we may need to drive motors require higher torque. In this case, it is often necessary to power the output terminals with an independent power supply of higher voltage. Additionally, the voltage requirements for the control terminals and output terminals with respect to the input power supply are often different. Therefore, in these situations, we need high-power drive chips with signal isolation. An example of such a drive module is one based on the BTS7960 chip, as shown in the diagram below:



直流电机驱动模块
DC Motor Driver IC

- BTS7960的通常接法与操作逻辑如下表所示：

  The stereotypical wiring and logic operation of TB6612 is as follows:

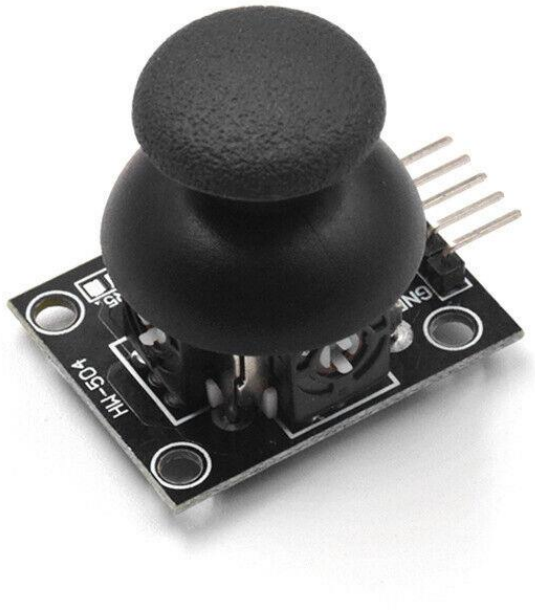


序号	名称	描述
1	RPWM	正转电平或PWM信号输入，高电平有效
2	LPWM	反转电平或PWM信号输入，高电平有效
3	R_EN	正转驱动器使能输入，高电平使能，低电平关闭
4	L_EN	转驱动器使能输入，高电平使能，低电平关闭
5	R_IS	正转驱动器边电流报警输出
6	L_IS	反转驱动器边电流报警输出
7	VCC	电源输入，与单片机5V电源连接
8	GND	信号公共地端

控制杆
Joystick

- 控制杆是一种输入设备，由基座和固定在上面作为枢轴的主控制杆组成，作用是向其控制的设备传递角度或方向信号。控制杆通常有一个或多个按钮，按钮的状态也可被电脑识别。控制杆在应用上有电子游戏机使用的模拟杆与电动车玩具的控制器。

- A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. A joystick usually has one or more than one push-buttons whose state can also be read by the computer. A popular variation of the joystick used on modern video game consoles is the analog stick. Other applications include the controllers for the toy cars.



控制杆
Joystick

- 通常控制杆模块至少有5个管脚，分别为电源VCC与GND，两路模拟量输出，一路数字量输出。其中，两路模拟输出为X、Y轴的两个电位器的输出，可以通过数模转换读出扭动角度；一路数字输出为摇杆向下按下与否的高低电平输出，根据设计时的上拉或下拉，按下时可能为高电平或低电平。

- Usually, a joystick module has at least 5 pins, namely, the VCC and GND pins, two pins for analog output, and one pin for digital output. Among them, the two analog outputs are the outputs of the two potentiometers for the X and Y axes. The twisting angle can be read via analog-to-digital conversion. The digital output represents the high or low level output when the joystick is pressed down, depending on the pull-up or pull-down configuration during design.

控制杆
Joystick

- 控制杆的使用通常都比较简单，但由于工艺的差异，模拟量的输出可能与规格书有差异；另外，进行数模转换之后，所得的量程范围可能需要重新转换之后才适配项目的逻辑。下面的示例代码显示了相关编程的范式。
- The use of a joystick is usually straightforward, but due to quality control, the analog output may vary from the specification. Additionally, the obtained value after analog-to-digital conversion may need to be recalibrated to fit the project's logic. The following code example demonstrates the programming paradigm.

```
int mapAndAdjustJoystickDeadBandValues(int value, bool reverse)
{
  if (value >= 2200)
  {
    value = map(value, 2200, 4095, 127, 254);
  }
  else if (value <= 1800)
  {
    value = map(value, 1800, 0, 127, 0);
  }
  else
  {
    value = 127;
  }

  if (reverse)
  {
    value = 254 - value;
  }
  return value;
}
```

```
mapAndAdjustJoystickDeadBandValues(analogRead(X_AXIS_PIN), false);
mapAndAdjustJoystickDeadBandValues(analogRead(Y_AXIS_PIN), false);
```

三轴加速度传感器
Three-axis Accelerometer

- 三轴加速度传感器是加速度传感器中用来测量空间加速度的传感器，即测量物体在空间中速度变化的快慢。通过将空间加速度在X、Y、Z三个轴上进行分解，得到在三个单轴上的数值。根据实现原理，目前三轴加速度传感器主要的类型有：压阻式、压电式、电容式三种，是将待测量物体的加速度转化为传感单元的电阻/电压/电容的变化，再通过转换电路将传感单元的变化数值转化为电压值，接着进行信号相应的放大以及滤波处理，将处理后的信号输出。

  The three-axis accelerometer is a sensor used to measure spatial acceleration in acceleration sensors, that is, to measure the speed of an object's velocity changes in space. By decomposing spatial acceleration into X, Y, and Z axes, values on the three single axes are obtained. According to the implementation principle, the main types of three-axis accelerometers currently are: resistive, piezoelectric, and capacitive. They convert the acceleration of the object to be measured into the resistance/voltage/capacitance changes of the sensing unit, and then convert the sensing unit's changing values into voltage values through a conversion circuit, followed by signal amplification and filtering processing, and outputting the processed signal.

三轴加速度传感器
Three-axis Accelerometer

- 三轴加速度传感器可以将测得的模拟量转为合适的输出信号，如电压值，直接输出，也可以通过模数转换器，转换为数字信号再输出。因此，加速度传感器根据输出信号的不同，可分为模拟式和数字式两种。

  The three-axis accelerometer can convert the measured analog quantity into a suitable output signal, such as the voltage, to directly output. Or it can convert the value into a digital signal through an analog-to-digital converter and then outputting it. Therefore, according to the different output signals, the accelerometer can be divided into two types: analog and digital.

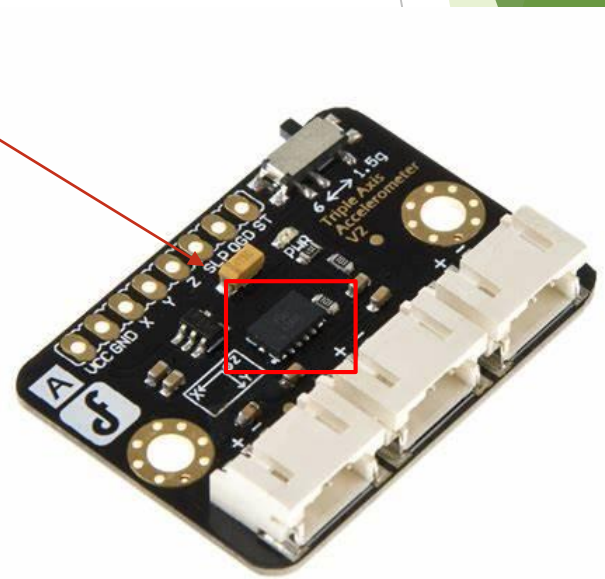
- 在具体应用中，模拟式传感器还需要加入数模转换器，而数字式则已经集成了ADC电路，可直接通过通讯接口（SPI、I2C等）进行数据传输。注意，在智能程度上数字式明显优于模拟式，但是高质量的ADC转换器价格昂贵甚至可能超出传感器部分的售格 。

  In practical applications, analog sensors also need to be equipped with analog-to-digital converters, while digital sensors have already integrated ADC circuits and can directly output data through communication interfaces such as SPI and I2C. In terms of intelligence, digital sensors are clearly superior to analog sensors, but high-quality ADC converters are expensive and may even exceed the price of the sensor itself.

三轴加速度传感器
Three-axis Accelerometer

- 模拟型三轴传感器的一个例子是来自Freescale的MMA7361，其具有易于使用的模拟接口。MMA7361为3.3V供电的元件，每个输出都输出一个模拟电压。这个电压与测量的加速度和供电电压成比例。它具有可选的灵敏度，可以通过编程进行自动选择或通过开关进行手动选择。当然，需要微控制器上具有ADC接口以便将模拟信号转换为数字信号。

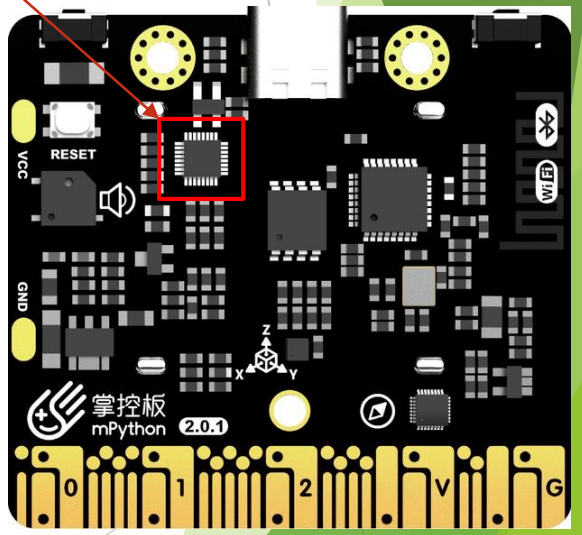
  One example of analog accelerometer is the MMA7361 from Freescale, with a very nice sensor with easy analog interface. The MMA7361 is a 3.3V part and outputs an analog voltage for each of the three outputs. This voltage is in ratio to the measured acceleration and to the supply voltage. It has selectable sensitivity by programming or by manually switching. Obvious, the MCU need to come up with ADC interface to convert this analog signal to a digital one.



三轴加速度传感器
Three-axis Accelerometer

- 数字式三轴传感器的一个例子是来自国产的矽睿公司的QMI8658A。实际上，QMI8658A包含3轴陀螺仪和3轴加速度计，是一款完整的6维MEMS惯性测量单元，具有9轴传感器融合和指定的系统级定向精度，界面支持I3C、I2C和3线或4线SPI，非常适合高性能消费者和工业应用。同时，QMI8658A还集成了一个先进的矢量数字信号处理器运动协处理器，以减轻主机处理器上的数据处理和中断负载。

  One example of digital accelerometer is the QMI8658A from QST. The QMI8658A incorporates a 3-axis gyroscope and a 3- axis accelerometer, to form a complete 6D MEMS inertial measurement unit (IMU) with 9-axis sensor fusion and specified system level orientation accuracy. Its interface supports I3C, I2C and 3-wire or 4-wire SPI, makes it ideal for high performance consumer and for industrial applications. The QMI8658A also incorporates an advanced vector digital signal processor (DSP) motion co-processor called the AttitudeEngine, which reduces the data processing and interrupt load on a host processor with no compromises in 3D motion tracking accuracy.



三轴加速度传感器
Three-axis Accelerometer

- 对于模拟型的三轴传感器，编程时只需要按常规的模拟量进行读取处理即可：

  For analog accelerometer, the paradigm of programming is just treat it as analog device:

```
const int xPin = A0; // X-axis analog input
const int yPin = A1; // Y-axis analog input
int xValue = analogRead(xPin);
int yValue = analogRead(yPin);
```

- 对于数字型的三轴传感器，编程时可选择I2C或SPI进行通信读取处理即可：

  For analog accelerometer, the paradigm of programming is just treat it as I2C or SPI device:

```
Wire.beginTransmission(MPU_addr);
Wire.write(0x3B); // starting with register 0x3B (ACCEL_XOUT_H)
Wire.endTransmission(false);
Wire.requestFrom(MPU_addr,6,true); // request 6 bytes from MPU-6050
accelerometer_x=Wire.read()<<8|Wire.read(); // 0x3B (ACCEL_XOUT_H) & 0x3C (ACCEL_XOUT_L)
accelerometer_y=Wire.read()<<8|Wire.read(); // 0x3D (ACCEL_YOUT_H) & 0x3E (ACCEL_YOUT_L)
accelerometer_z=Wire.read()<<8|Wire.read(); // 0x3F (ACCEL_ZOUT_H) & 0x40 (ACCEL_ZOUT_L)
```

显示屏
Display

- 显示屏或显示模块是物联网项目中常用的元件之一，用于信息的显示以方便用户进行交互。由于技术的发展，屏幕材质正在以传统的LCD向IPS、TFT以及OLED转变。由于屏幕尺寸往往较小，从小的0.96寸到大的4.8寸不等，显示的信息也较为有限，因此接口常采用SPI接口或I2C接口。

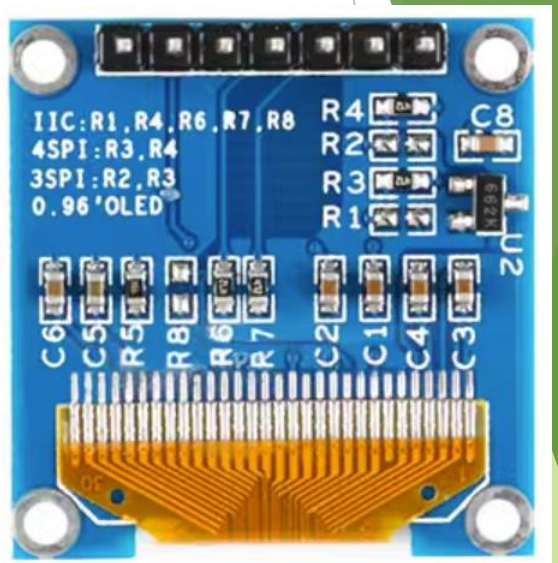
  Display or display module is one of the commonly used electronic components in IoT projects, to display information for users' interaction. Due to technology evolvement, materials to make the screen are transitioning from the traditional LCD to IPS, TFT, and OLED. As the screen size is often small, ranging from 0.96 inches to 4.8 inches, plus the displayed information is also limited, the interface commonly used are SPI or I2C interfaces.

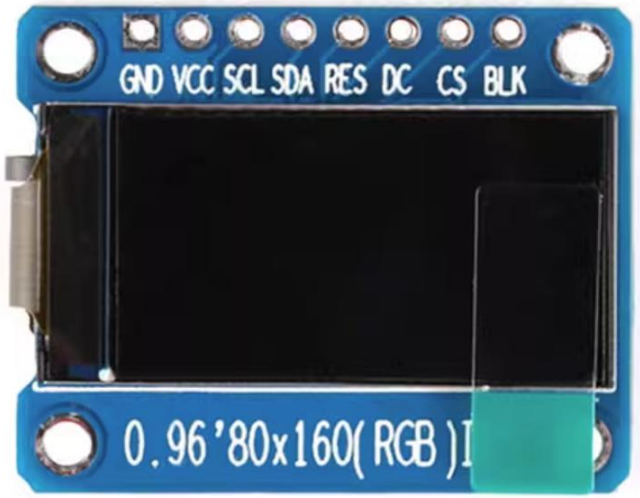
名称	描述	备注
LCD	Liquid Crystal Displays	In market, LCD defaults to "Passive Matrix LCD"
TFT	Thin Film Transistor	In market, TFT defaults to "Active-Matrix TN type TFT LCD
IPS	In-Plane Switching	In market, IPS defaults to "High-end Full Color LCD"
LED	Light Emitting Diode	In market, LED TV actually is a TFT TV but with LED backlights
OLED	Organic Light Emitting Diode	It is a display but not an LCD shown above

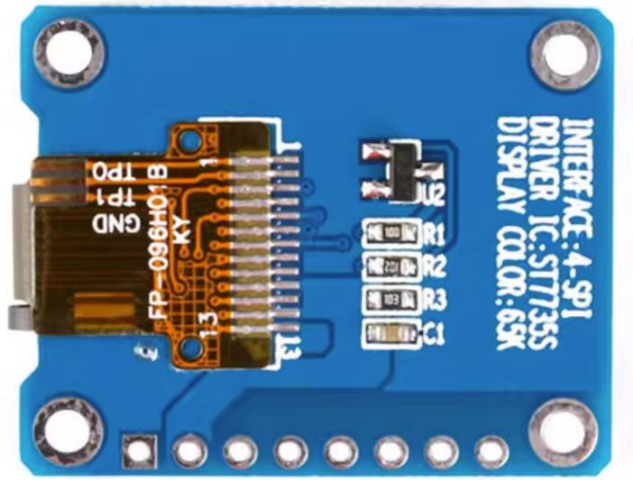
显示屏
Display

- 下面是一些显示屏的示例，有些显示屏的驱动可以支持输出在I2C与SPI之间切换，有的显示屏仅支持I2C接口，有些仅支持SPI接口。

  Here are some examples of displays. Some display drivers can support switching between I2C and SPI interfaces, while some display screens only support I2C interface, and some only support SPI interface.







显示屏
Display

- 显示屏驱动芯片根据屏幕类型，TFT类型的屏幕主要有ST7335、ST7735S、ST7789等，OLED类型的屏幕主要有SH1106、CH115、SSD1306、SSD1331等。下表列出了常见的引脚及定义。

  Display screen driver chips vary according to the screen type. For TFT screens, common driver chips include ST7335, ST7735S, ST7789, etc. For OLED screens, common driver chips include SH1106, CH115, SSD1306, SSD1331, etc. The following table shows the name and description of the commonly-used pins.

模块引脚	引脚说明
RST/RES	液晶屏复位控制信号（低电平复位）
S/CS	液晶屏片选控制信号（低电平使能）
D/C	液晶屏寄存器/数据选择控制信号（高电平：数据，低电平：寄存器）
DIN/SDA/D1	液晶屏SPI/I2C总线写数据信号
CLK/SCL/D0	液晶屏SPI总线时钟信号
VCC	液晶屏电源正（3.3V~5V）
BL	液晶屏背光控制信号（高电平点亮，如不需要控制，请接3.3V）
GND	液晶屏电源地

显示屏
Display

- 显示屏的使用往往根据驱动芯片，直接调用相应的库实现。

  Programing of display module is usually by taking advantage of the library.

```
#include <Adafruit_GFX.h>
#include <Adafruit_ST7735.h>

// initialize the display
Adafruit_ST7735 tft = Adafruit_ST7735(15, 27, 14);

void setup() {
  tft.initR(INITR_BLACKTAB); // initialize the display with black tab
  tft.fillScreen(ST7735_BLACK); // fill the screen with black color
  tft.setRotation(1); // set the display rotation to 90 degrees
  tft.setTextColor(ST7735_WHITE); // set the text color to white
  tft.setTextSize(2); // set the text size to 2
}

void loop() {
  tft.setCursor(0, 0); // set the cursor to the top-left corner
  tft.println("Hello, world!"); // print the text "Hello, world!"
  delay(1000); // wait for 1 second
}
```