

校園發明大賽

INVENTION FOR SCHOOLS CONTEST

Intermediate Arduino Arduino進階

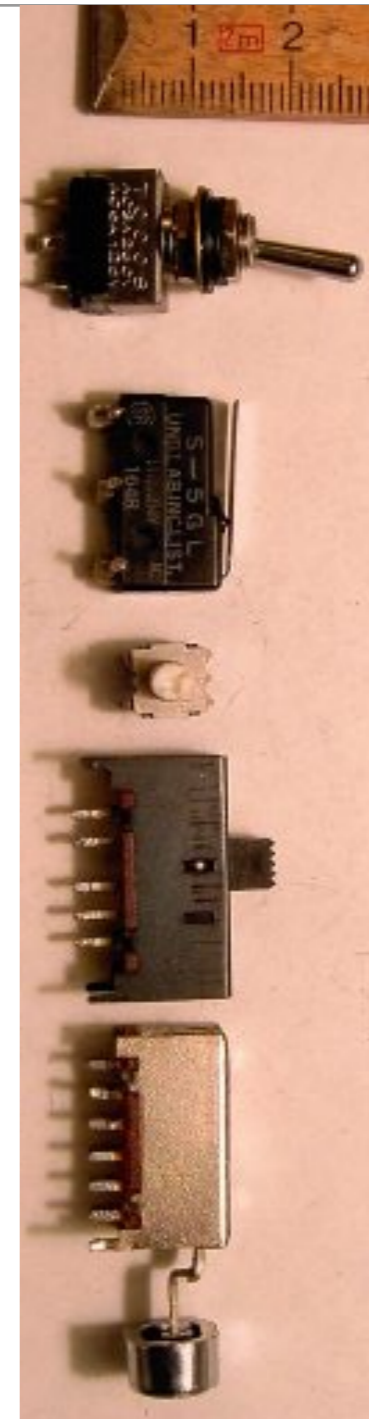
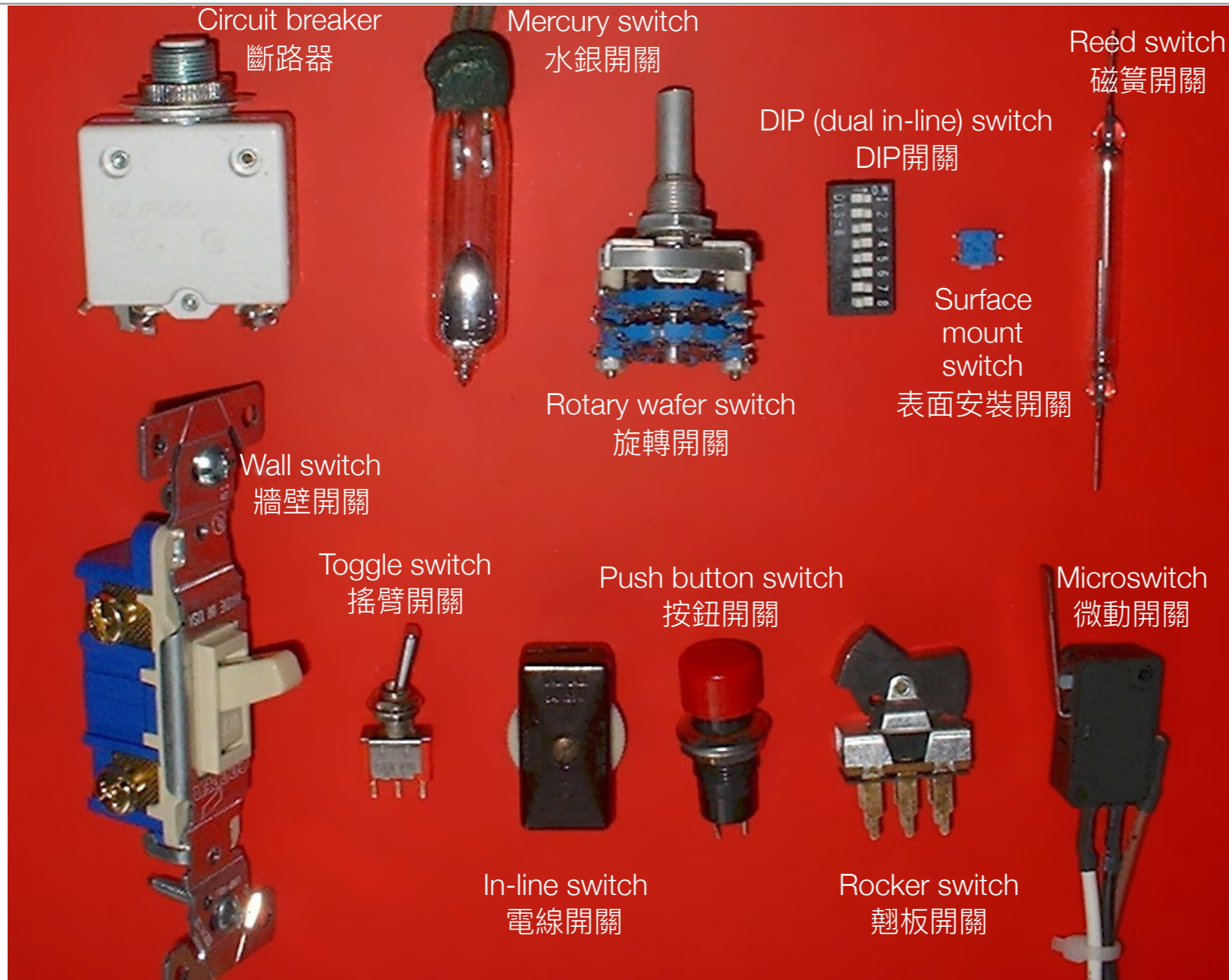
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Topics to cover...

內容...

- Switches 開關
- Relays 繼電器
- Some technical info about Arduino outputs
Arduino 輸出端子的一些技術資料
- Power MOSFET
- USB as power source USB 用作電源
- PIR (Passive Infra-Red) sensor module 被動紅外線傳感器
- The Halloween program 萬聖節程式

Switches 開關



SPDT toggle switch
單刀雙擲搖臂開關

SPDT microswitch
單刀雙擲微動開關

SPDT switch
單刀雙擲開關

1P4T switch
單刀四擲開關

4P2T switch
四刀雙擲開關

Image sources:

- Electrical switches. By ArnoldReinhold.
CC-BY-SA-3.0, GFDL. <https://commons.wikimedia.org/wiki/File:Switches-electrical.agr.jpg>
- Image of electrical changeover switches. By Glenn.
GFDL, CC-BY-SA-3.0 https://commons.wikimedia.org/wiki/File:Changeover_switches.jpg

Switches 開關

- Switches lets current through under some conditions.
開關在某些情況下允許電流通過。
- How can they be used 它們如何使用?
 - Key switch 鎖匙開關
 - Push button 按鈕開關
 - Tilt switch 傾斜開關
 - Float switch 浮控開關
- Sensors giving digital output and can be seen as switches conditionally connecting to the power or ground.
用數碼輸出傳感器可以看作是有條件地將輸出連接到電源或接地的開關。
 - Pressure switch 壓力開關
 - Passive InfraRed (PIR) sensor 被動紅外線傳感器
 - Bluetooth remote switch 藍芽遙控開關

Poles and throws

刀數和擲數

- Switches are categorised by the number of poles and throws.
開關用刀數和擲數分類。
- Poles are the number of switches, and throws are the number of choices for each switch.
刀數即開關數目，擲數即每個開關有多少選擇。
- They are abbreviated as xPyT where x and y are numbers, or S for Single, and D for Double. 分類用 xPyT 表示，x 和 y 為數字，或以 S 代表單，D 代表雙。
- Examples, used in both relays and switches 用於繼電器和開關的例子：
 - SPST = Single Pole Single Throw 單刀單擲
 - SPDT = Single Pole Double Throw 單刀雙擲
 - DPST = Single Pole Single Throw 雙刀單擲
 - DPDT = Single Pole Double Throw 雙刀雙擲

Image source:

- Relay symbols; FDominec; https://commons.wikimedia.org/wiki/File:Relay_symbols.svg

About switches 關於開關

- 2P6T, etc. can be used for ganged rotary switches.
2P6T 等會用於開關旋轉開關。
- Some switches like push buttons has a normal state.
有些開關有常態，例如按鈕開關。
- A Normally Open (NO) switch has a normal state that does not conduct electricity.
常開 (NO) 開關常態為開路，即電流不能通過。
- A Normally Closed (NC) switch has a normal state that conducts electricity.
常閉或常關 (NC) 開關常態為閉路，即電流可以通過。
- Relay contacts can also be designated by NO and NC.
繼電器的接點亦能以 NO 和 NC 表示。

Electrical switches: Relay

電機開關：繼電器



TAKAMISAWA RY3W-K
Relay (2P2T, 3VDC, 18£
[1])

TAKAMISAWA RY5W-K
Relay (2P2T, 5VDC, 167£[1])

TAKAMISAWA RY6W-K
Relay (2P2T, 6VDC, 240£[1])

07-01-3003

07-01-3005

07-01-3006



TAKAMISAWA RY12W-K
Relay (2P2T, 12VDC, 960£[1])

TAKAMISAWA RY24W-K
Relay (2P2T, 24VDC, 2880£[1])

TAKAMISAWA SY-3-K
Relay (1P2T, 3VDC, 15£[1])



OMRON H3Y-2 Timer
Relay (24VDC, 3min)

OMRON MK2P-I Timer
Relay (2P2T, 12VDC, 7A)

OMRON MK2P-I Timer
Relay (2P2T, 24VDC, 7A)

07-20-2430

07-99-0012

07-99-0024



OMRON MK2P-I Timer
Relay (2P2T, 110VAC, 7A)




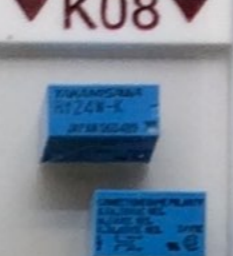
















OMRON LY2J Timer
Relay (2P2T, 12VDC, 10A)

OMRON LY2J Timer
Relay (2P2T, 24VDC, 10A)

Image source:

- http://www.weclonline.com/eng/productlist.asp?page=1&display=photo&mc_code=08&sc_code=012&s2c_code=0001&s3c_code=0010

	
07-10-1224 Dae Yang DYR-MY-4C 4P2T 3A/DC 24V Relay	07-10-1224 Dae Yang DYR-MY-4C 4P2T 3A/DC 24V Relay
▼ J11 ▼	▼ J12 ▼
	
07-10-1822 Dae Yang DYR-LY-2CMA 2P2T 10A/ AC220V Relay	07-10-1822 Dae Yang DYR-LY-2CMA 2P2T 10A/ AC220V Relay
▼ J15 ▼	▼ J16 ▼
	
07-08-3024 MASSUSE ME-13F-012-222 DC12V 2P2T 8 Pin Relay	07-08-3024 MASSUSE ME-13F-02-4 DC24V 2P1T 8 Pin Relay 650Ω
▼ J19 ▼	▼ J20 ▼
	
07-08-3024 MASSUSE ME-13F-012-121 DC12V 1P2T 8 Pin Relay, 160Ω	07-08-3024 MASSUSE ME-13F-012-121 DC12V 1P2T 8 Pin Relay, 160Ω
▼ J23 ▼	▼ J24 ▼
	
07-08-9003 MASSUSE ME-13F-A240-222 AC240V 8 Pin Relay	07-08-9003 MASSUSE ME-28A-012-1 DC12V 1P1T 4 Pin Relay

			
07-01-3005 TAKAMISAWA RY-5W-K DC5V/1A 2P2T 8 Pin Relay, 167Ω	07-01-3006 TAKAMISAWA RY-6WK DC6V/1A 2P2T 8 Pin Relay	07-01-3012 TAKAMISAWA RY-12WK DC12V/1A 2P2T 8 Pin Relay	07-01-3024 TAKAMISAWA RY-24W-K DC24V/1A 2P2T 8 Pin Relay
▼ K09 ▼	▼ K10 ▼	▼ K11 ▼	▼ K12 ▼
			
07-01-3205 TAKAMISAWA JY-5H-K DC5V/5A 1P1T 4 Pin Relay	07-01-3212 TAKAMISAWA JY-12H-K DC12V/5A 1P1T 4 Pin Relay	07-01-3224 TAKAMISAWA JY-24H-K DC24V/5A 1P1T 4 Pin Relay	07-01-3103 TAKAMISAWA SY-3K DC 3V/2A 1P2T 6 Pin Relay, 15Ω
▼ K13 ▼	▼ K14 ▼	▼ K15 ▼	▼ K16 ▼
			
07-01-3105 TAKAMISAWA SY-5-K DC 5V/2A 1P2T 6 Pin Relay, 167Ω	07-01-3109 TAKAMISAWA SY-9-K DC 9V/2A 1P2T 6 Pin Relay, 540Ω	07-01-3112 TAKAMISAWA SY-12K DC12V/2A 1P2T 6 Pin Relay	07-01-3124 TAKAMISAWA SY-24K DC24V/2A 1P2T 6 Pin Relay
▼ K17 ▼	▼ K18 ▼	▼ K19 ▼	▼ K20 ▼
			
07-01-4005 TAKAMISAWA A-5W-K DC 5V/2A 2P2T 10 Pin Relay, 178Ω	07-01-4012 TAKAMISAWA A-12W-K DC12V/2A 2P2T 10Pin Relay	07-01-3305 TAKAMISAWA NY-5W-K DC5V/5A 1P1T 4 Pin Relay	07-01-3312 TAKAMISAWA NY-12W-K DC12V/5A 1P1T 4 Pin Relay
▼ K21 ▼	▼ K22 ▼	▼ K23 ▼	▼ K24 ▼
			
07-01-3324 TAKAMISAWA NY-24W-K DC24V/5A 1P1T 4 Pin Relay	07-08-5303 MASSUSE ME-4-L1-3 DC3V 1 Coil Latch 2P2T 8 Pin Relay	07-08-5305 MASSUSE ME-4-L1-5B DC5V 1 Coil Latch 2P2T 8 Pin Relay, 1440Ω	07-08-5312 MASSUSE ME-4-L1-12B DC12V 1 Coil Latch 2P2T 8 Pin Relay, 1440Ω

		
07-08-1412 MASSUSE ME-15M-012-HTS DC12V 12A 1P1T 4 Pin Relay, 400Ω	07-08-1412 MASSUSE ME-15M-012-HTS DC12V 12A 1P1T 4 Pin Relay, 400Ω	07-08-9017 MASSUSE ME-25-012-HS DC12V (617Ω/ 8A 250V)
▼ L09 ▼	▼ L10 ▼	▼ L11 ▼
		
07-08-1506 MASSUSE ME-15M-006-TS DC5V 1P2T 5 Pin Relay, 300Ω	07-08-1509 MASSUSE ME-15M-009-TS DC9V 12A 1P2T 5 Pin Relay, 300Ω	07-08-1512 MASSUSE ME-15M-012-TS DC12V 12A 1P2T 5 Pin Relay, 400Ω
▼ L13 ▼	▼ L14 ▼	▼ L15 ▼
		
07-08-5005 MASSUSE ME-1A-05B DC12V 1P2T 5 Pin Relay, 700Ω	07-08-5012 MASSUSE ME-1A-12B DC12V 2A 1P2T 5 Pin Relay, 400Ω	07-08-5024 MASSUSE ME-1A-24B DC24V 2A 1P2T 5 Pin Relay, 1600Ω
▼ L17 ▼	▼ L18 ▼	▼ L19 ▼
		
07-08-6005 MASSUSE ME-3-005-12S DC12V 1P2T 6 Pin Relay, 720Ω	07-08-6012 MASSUSE ME-3-012-12S DC12V 1A 1P2T 6 Pin Relay, 720Ω	07-08-9007 MASSUSE ME-12-12 12V DC 2P2T 10 Pin Relay, 1028Ω
▼ L21 ▼	▼ L22 ▼	▼ L23 ▼
		
07-08-1100 MASSUSE ME-11-000-121 DC12V 1P2T 5 Pin Relay, 360Ω	07-08-1100 MASSUSE ME-11-012-121 DC12V 12A 1P2T 5 Pin Relay, 360Ω	07-08-1100 MASSUSE ME-11-024-121 DC24V 12A 1P2T 5 Pin Relay, 1440Ω

Relays 繼電器

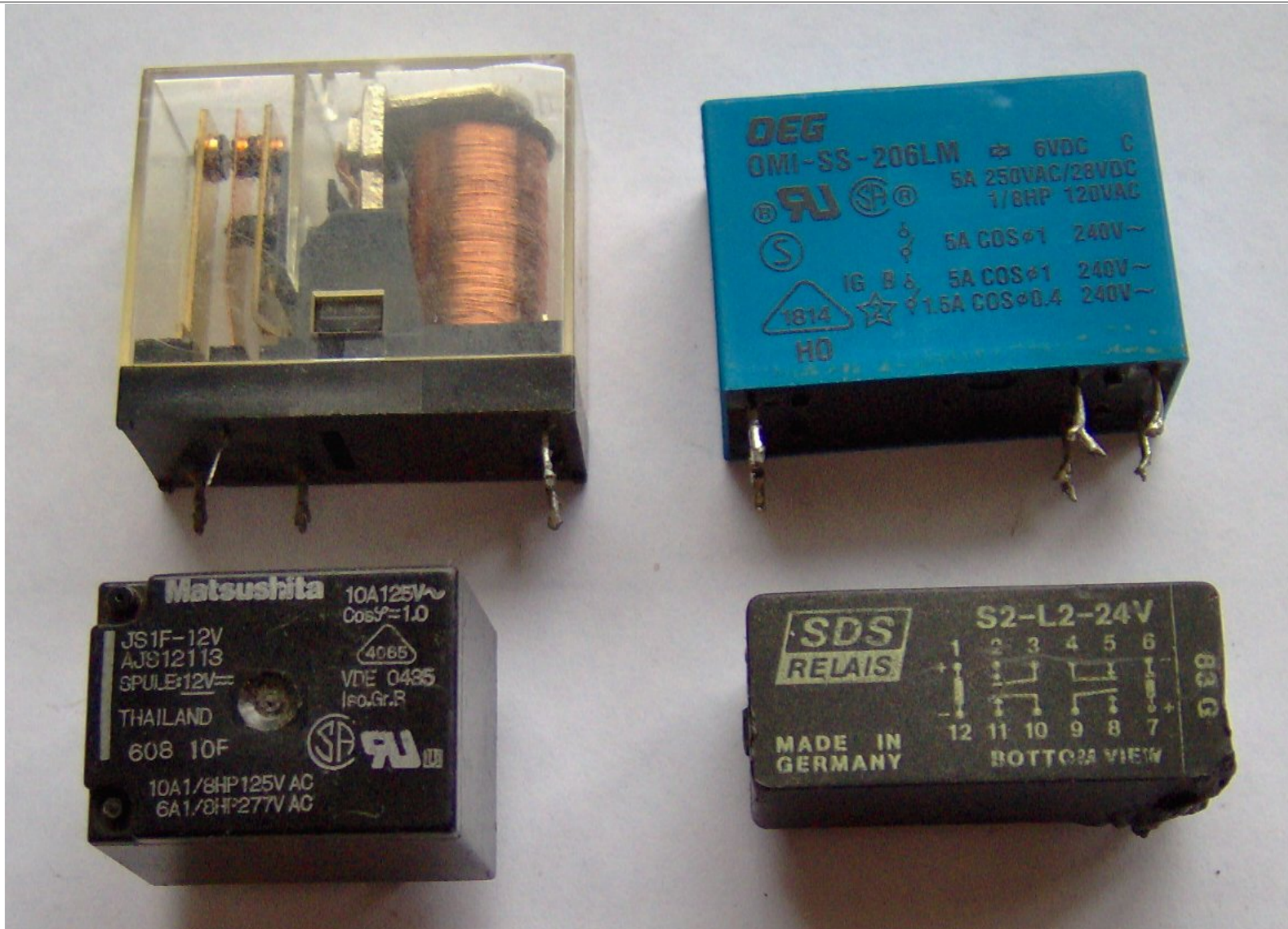
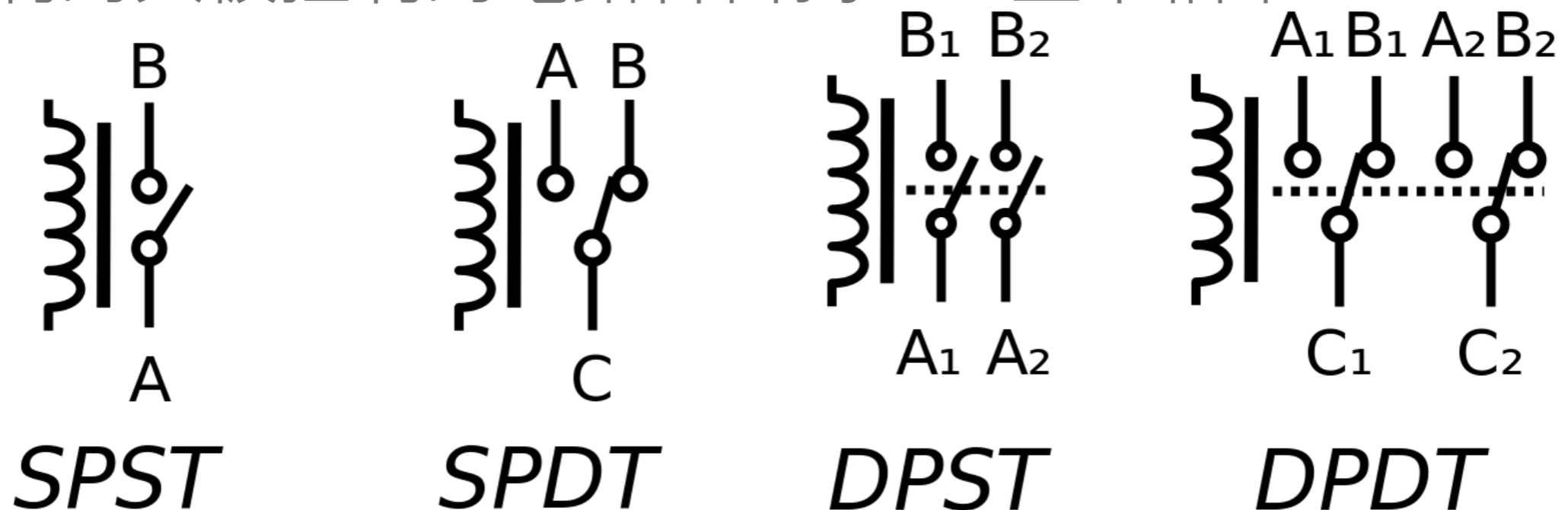


Image source:

- Electronic component relays; FDominec; GFDL, CC-BY-SA-3.0-migrated, CC-BY-SA-2.5,2.0,1.0 https://commons.wikimedia.org/wiki/File:Electronic_component_relays.jpg

Relays 繼電器

- Relays are switches controlled by electromagnets.
繼電器是用電磁鐵控制的開關。
- The controlling and controlled circuitries are isolated from each other.
控制的與被控制的電路各自獨立，互不相干。



Some technical info about Arduino outputs

Arduino 輸出端子的一些技術資料

- Some technical info about Arduino output pins:
Arduino UNO 輸出端子的技術資料：
<https://www.arduino.cc/en/Main/ArduinoBoardUno>
 - Maximum current drain is 20mA. 最大電流 20mA.
- i.e., The outputs cannot drive devices that take more than 20mA.
即是說輸出不能驅動要多於 20mA 電流的器件。
- The specification for other Arduino boards can be looked up at:
其他 Arduino 版的技術資料可在這裏找到：
<https://www.arduino.cc/en/Main/Products>

Type	Current
UNO	20mA
101	4mA
Pro	40mA
Pro Mini	40mA
MICRO	20mA
Nano	40mA
Mega	20mA
ZERO	7mA
Due	800mA
Yún	40mA

How much current is needed?

需要多少電流？

- LED 發光二極管：3 – 20mA
- Buzzer 蜂鳴器：10 – 200mA
- Miniature relays 微型繼電器, e.g., Fujitsu Takamisawa RY series:
150mW to 560mW at 3V to 5V, i.e., 33mA to 166mA
<http://www.weclonline.com/downloads/pdf/07-01-3005.pdf>
- Other electronic interfaces 其他電子界面：0.1 μ A – 5mA
- Some components like LEDs can work with smaller currents, while some, like motors and relays, have minimum current requirements.
有些零件如發光二極管用少些電流也可以運作，而有些零件如馬達和繼電器則有最低電流要求。
- What can be done if an Arduino output pin need to drive a high-current component?
Arduino 的輸出要驅動高電流的零件要怎辦？

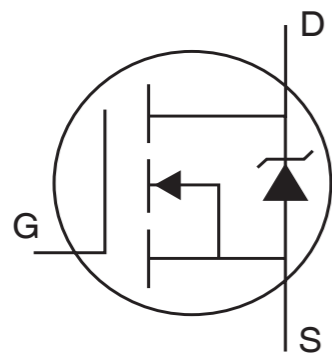
Driving high current components

驅動高電流的零件

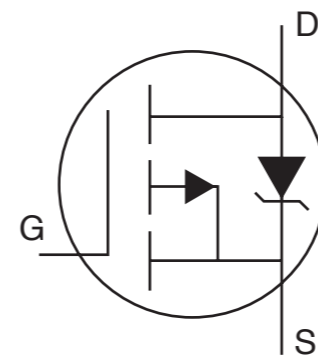
- For Arduino output pin to drive a high current component, a electronic switch is needed.
Arduino 的輸出要驅動高電流的零件，需要一個電子開關。
- This can be done using a Power Metal Oxide Semiconductor Field Effect Transistor (MOSFET).
可以用大功率金屬氧化半導體場效應晶體管 (Power MOSFET)。

Power MOSFET

- A MOSFET has three connections: Source (S), Drain (D), and Gate (G).
MOSFET 有三個接腳：源極 (S)、汲極 (D)、和閘極 (G)。
- There are two types: N-channel and P-channel.
分 N通道和 P通道兩種。
- They can be seen as voltage-controlled amplifiers which is often used as solid state switches.
它們可看成電壓控制的放大器，常用作固態開關。



N-channel MOSFET
e.g., IRF520

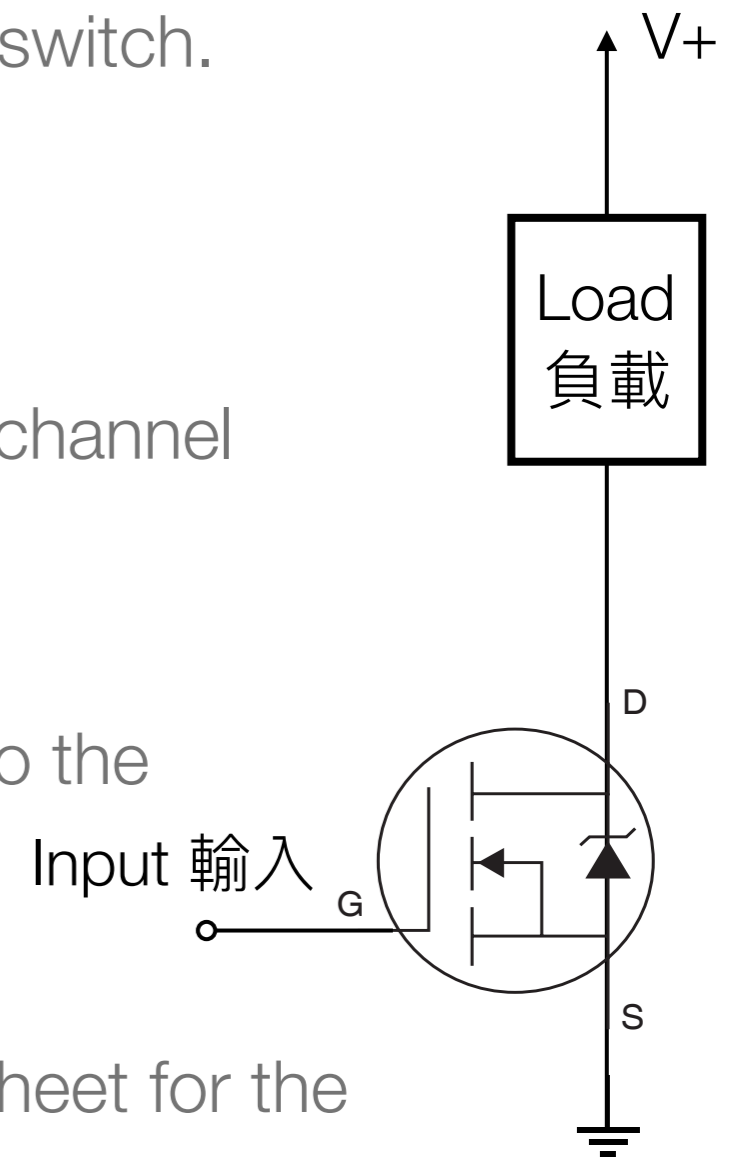


P-channel MOSFET
e.g., IRF5210

Power MOSFET as electronic switch

大功率 MOSFET 用作電子開關

- Sample use of an N-channel MOSFET as an electronic switch.
N通道 MOSFET 作電子開關的應用。
 - Connect the Source to ground. 源極接地。
 - A positive voltage applied at the Gate opens up the channel from Drain to Source.
對地為正的閘極電壓開通汲極至源極的通道。
 - A load can be serially connected through the Drain to the ground via the Power MOSFET.
負載可由電源經 MOSFET 串聯至地。
- Again, actually it is more complicated. Read the data sheet for the MOSFET for details.
實際上比這裏複雜，要知細節，請讀所選 MOSFET 的數據資料。



Power MOSFET references 參考資料

- IRF520
Product info 產品資料 : <http://hken.rs-online.com/web/p/mosfet-transistors/5411180/>
Data sheet 技術資料 : <http://docs-asia.electrocomponents.com/webdocs/0791/0900766b807910f4.pdf>
- IRF5210
Product info 產品資料 : <http://hken.rs-online.com/web/p/mosfet-transistors/5411720/>
Data sheet 技術資料 : <http://docs-asia.electrocomponents.com/webdocs/0791/0900766b807910f5.pdf>
- Application Note 558: Introduction to Power MOSFETs and their Applications; Ralph Locher; Fairchild October 1998.
<https://www.fairchildsemi.com/application-notes/AN/AN-558.pdf>
- Application Note 7500: Understanding Power MOSFETs; Fairchild October 1999.
<https://www.fairchildsemi.com/application-notes/AN/AN-7500.pdf>
- AN11158: Understanding power MOSFET data sheet parameters; Rev. 4; NXP Semiconductors 2014-02-04.
http://www.nxp.com/documents/application_note/AN11158.pdf

How to use a MOSFET to drive a relay?

如何利用 MOSFET 驅動繼電器？

Using MOSFET to drive a relay

利用 MOSFET 驅動繼電器

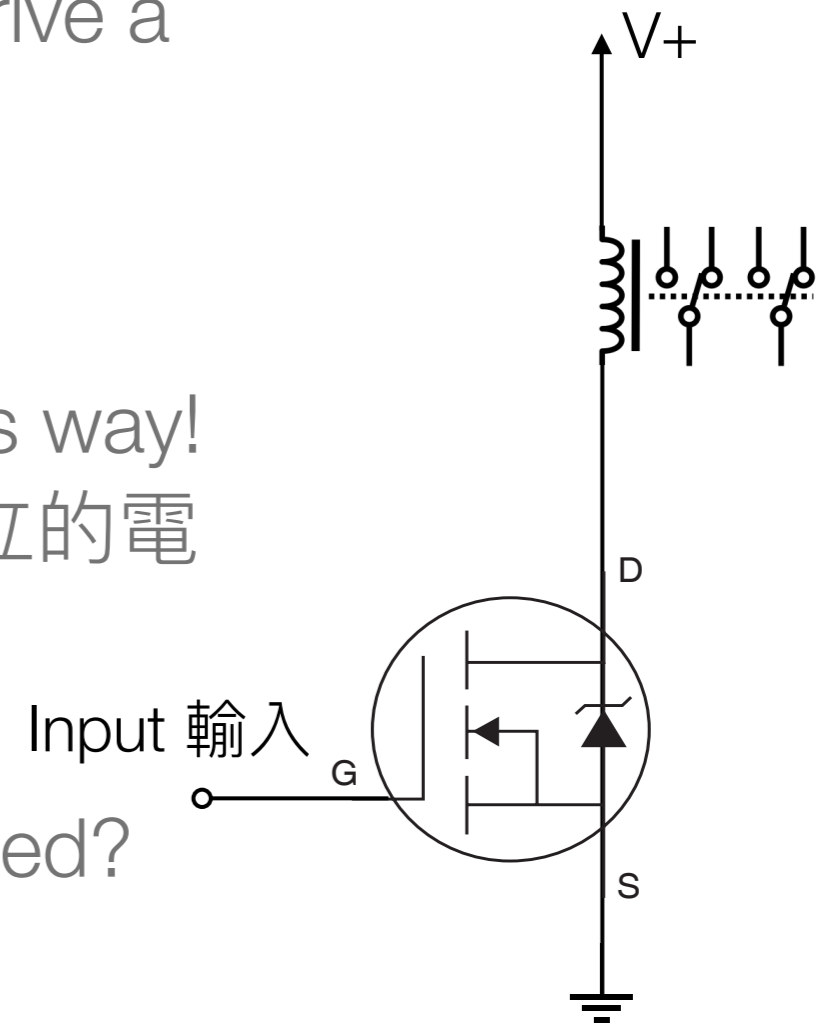
- The circuit schematic for using MOSFET to drive a relay is as shown on the right.

利用 MOSFET 驅動繼電器的電路圖如右。

- We have built a electrically isolated switch this way!
我們設計了一個用 Arduino 來控制，互相獨立的電路！

- How can the two sets of relay contacts be used?
繼電器的兩組開關可以用來控制甚麼？

- Let's try controlling USB power!
試試控制 USB 的電源吧！



USB as power source

USB 用作電源

- USB = Universal Serial Bus 通用序列匯流排 / 通用串行總線
<http://www.usb.org/>
- Many USB devices like fans, cup heaters, lights use the USB connection as a 5V power source only. The USB data connections are not used.
許多USB設備如風扇、暖杯器、燈都使用 USB 連接，只因為它是個5V電源，而沒有使用 USB 的數據線。
- There are four pins in a USB connector, two for power, two for data.
USB 連接器有四個接點，兩點為電源，兩點作資料傳送。

USB extension cable

USB 延長線

- On bottom left is part of the technical specification of a USB extension cable.

左下為一條 USB 延長線的部分技術資料。

Product info 產品資料：<http://hken.rs-online.com/web/p/usb-cable-assemblies/7587510/>

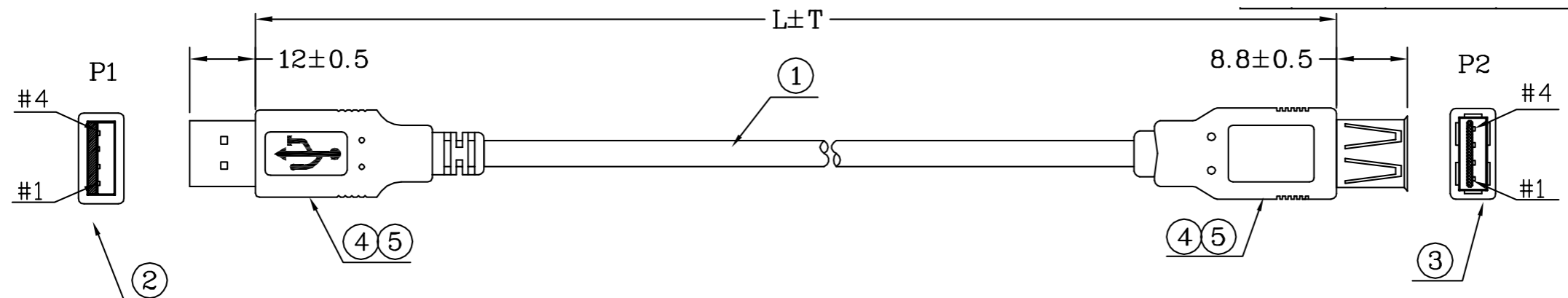
Data sheet 技術資料：<http://docs-asia.electrocomponents.com/webdocs/1145/0900766b811456a2.pdf>

- From the USB specification (bottom right), pin 1 is the bus power, and pin 4 is the ground. Pins 2 and 3 are for data.

從右下 USB 規格得知，第一腳為匯流排電源，第四腳為地，第二三腳則是資料線。

Universal Serial Bus, Power Delivery Specification, Revision 2.0, V1.1. 2015-05-07.

<http://www.usb.org/developers/docs/>



PIN ASSIGNMENT	
P1	P2
1 ——— RED ———	1
2 ——— WHITE ———	2
3 ——— GREEN ———	3
4 ——— BLACK ———	4
S ——— BRAID+DRAIN ———	S

Table 3-2 USB 2.0 PD Standard-A Connector Pin Assignments

Pin Number ¹	Signal Name	Description	Mating Sequence
1	V _{BUS}	Power	Third
2	D-	Differential pair as defined in [USB 2.0]	Fourth
3	D+		
4	GND	Ground for power return	Third
10 ²	PD DETECT 1	Contact in PD receptacle to detect a PD plug	Last
11 ²	PD DETECT 2	Contact in PD receptacle to detect a PD plug	Last
12 ³ ,13	INSERTION DETECT	Receptacle only. Detects	Second

How to switch USB power on and off
using the MOSFET-controlled relay?

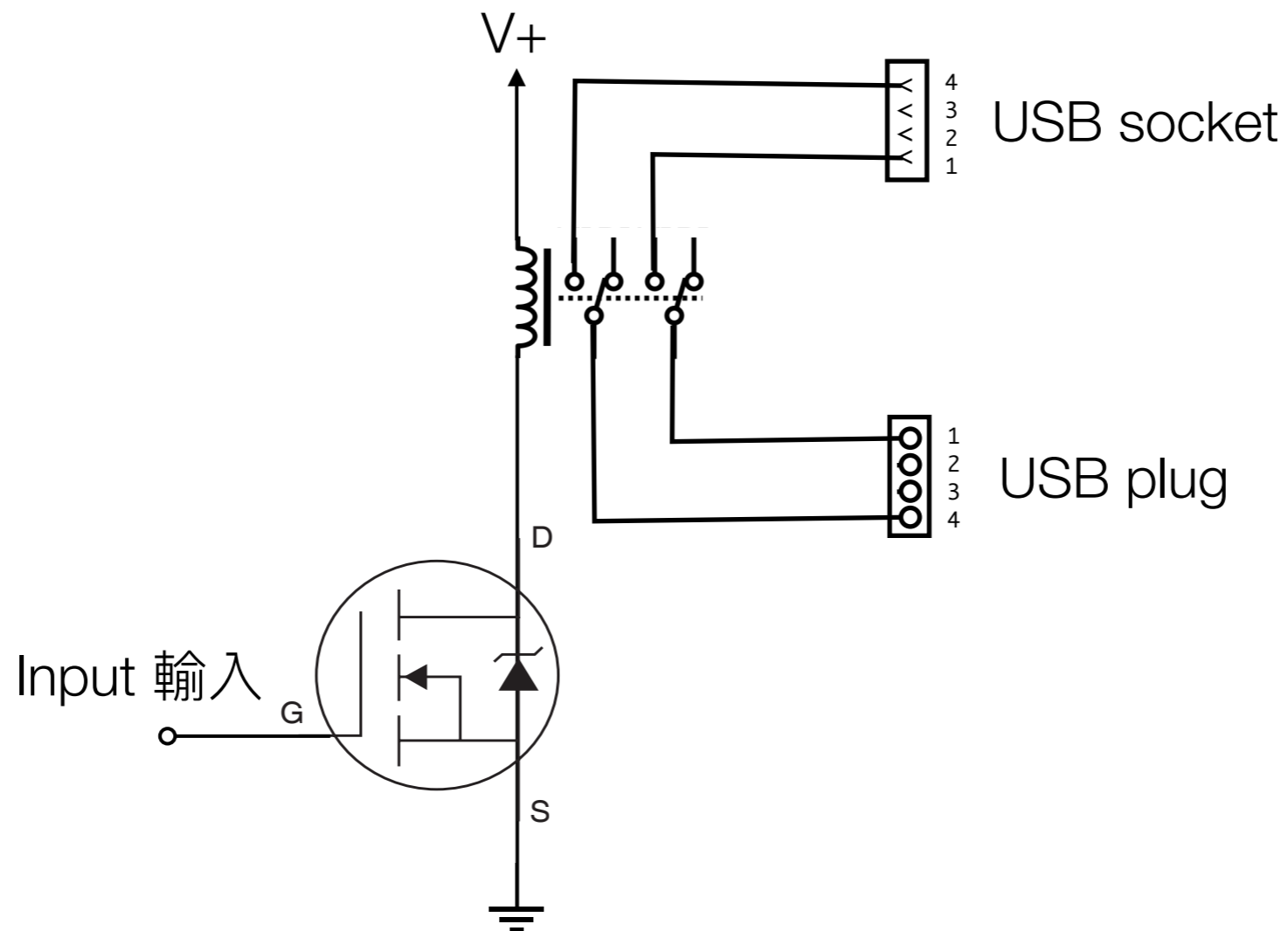
如何利用 MOSFET 控制的繼電器
開關 USB 電源？

Using MOSFET to drive a relay

利用 MOSFET 驅動繼電器

- The circuit schematic for using MOSFET to drive a relay to switch USB power is as shown.

利用 MOSFET 驅動繼電器開關 USB 電源的電路圖。



PIR (Passive Infra-Red) sensor module 被動紅外線傳感器

- A pyroelectric device that detects motion by sensing changes in the infrared (radiant heat) levels emitted by surrounding objects.
以熱電原理，感應周圍物體發出的紅外線（熱輻射）水平變化，來偵測物體移動的傳感器。
- Example 例：
Parallax PIR Sensor #555-28027
<http://hken.rs-online.com/web/p/interface-development-kits/7813024/>
 - Supply voltage 3 to 6V DC, digital output, high=movement.
電源電壓直流 3V 至 6V，數位輸出，高代表有移動。

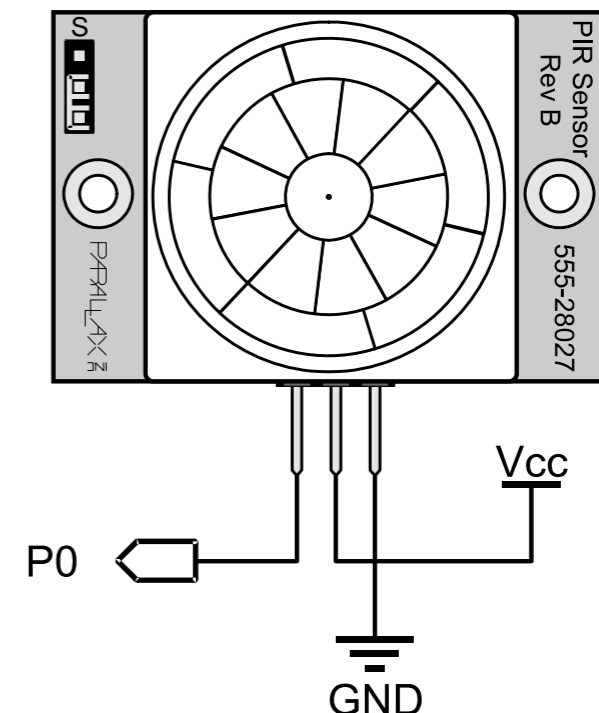
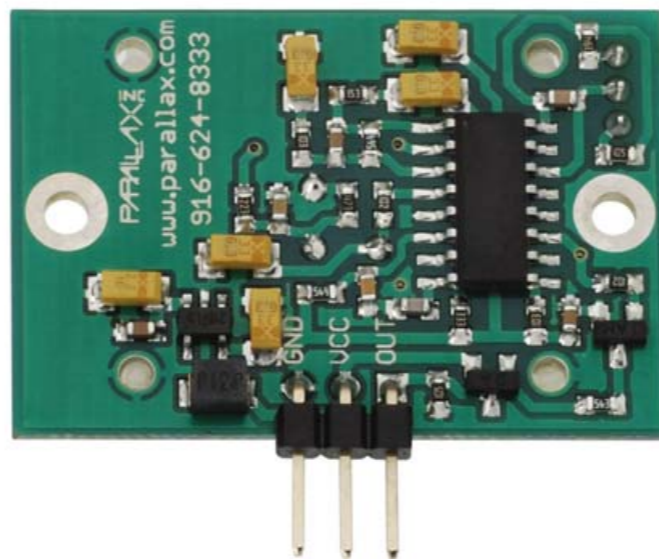
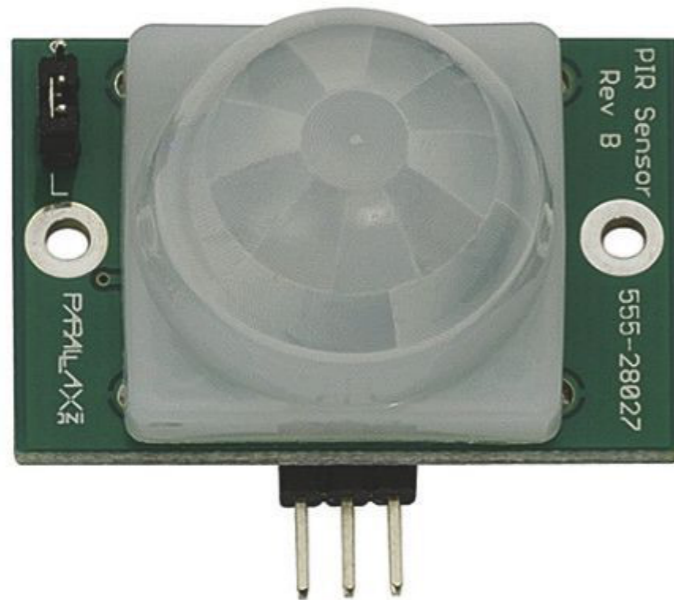


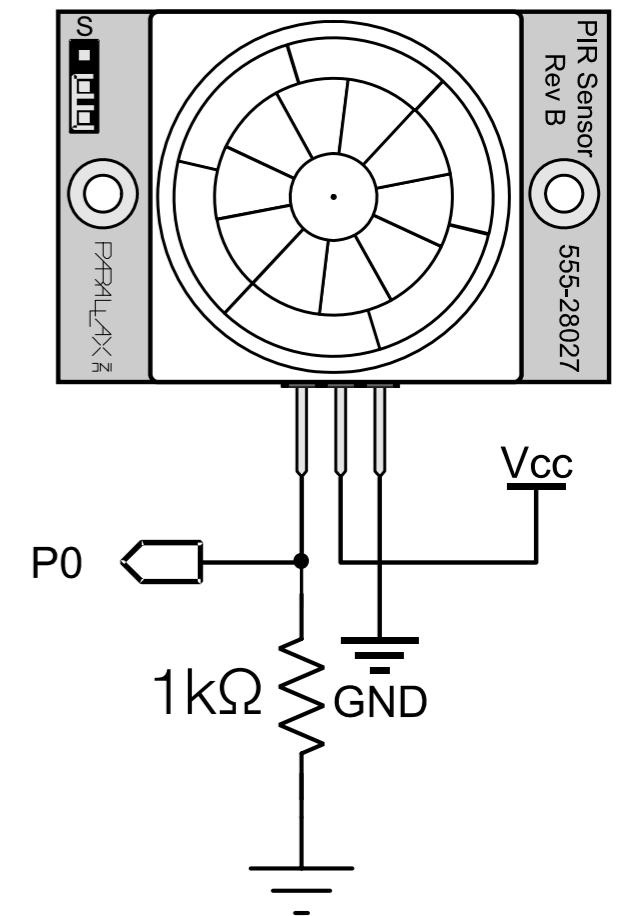
Image source:

- <http://hken.rs-online.com/web/p/interface-development-kits/7813024/>
- <http://docs-asia.electrocomponents.com/webdocs/125a/0900766b8125a3ed.pdf>

Interfacing the PIR sensor with Arduino

連接 Arduino 至被動紅外線傳感器

- Connect Vcc of the PIR sensor module to a 3.3V pin of Arduino. Also connect the Ground pin.
將被動紅外線傳感器的 Vcc 連接至 Arduino 的 3.3V 腳位，亦將其接地。
- The output of the PIR sensor module can be connected to a input pin of Arduino.
被動紅外線傳感器的輸出可以直接接到 Arduino 的輸入接口。
- If the Arduino cannot detect its low level output, connect a pull down resistor of about 1k Ω , as in the schematic on the right.
如 Arduino 檢則不到被動紅外線傳感器的低輸出，可將其輸出腳用約 1k Ω 的下拉電阻，如右電路圖。

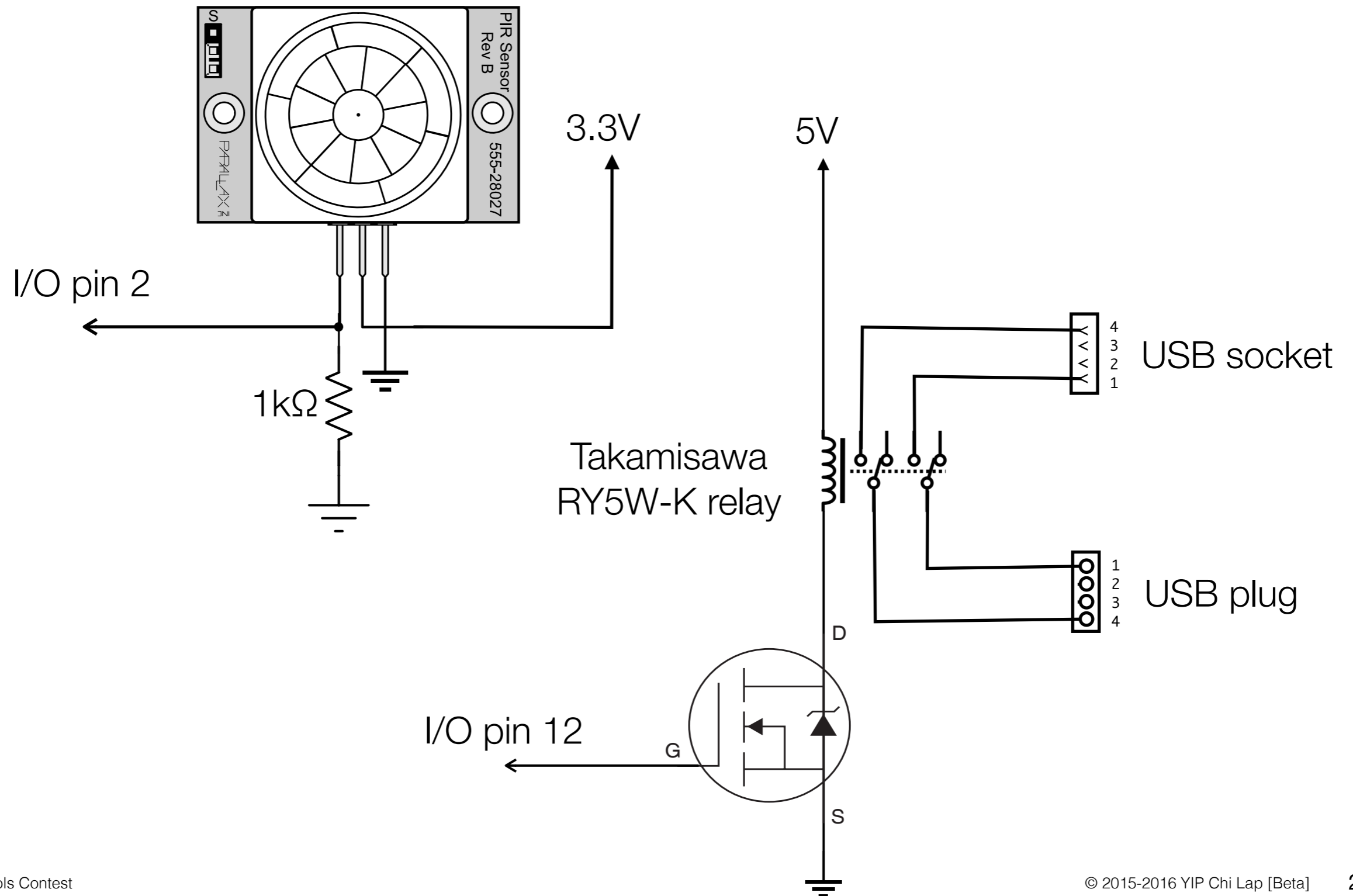


How to control USB power
using PIR sensor?

如何用被動紅外線傳感器
控制 USB 電源開關？

The circuit schematic

電路圖



How about the program? 程式呢？

```
const int inpin = 2;
const int outpin = 12;

void setup() {
  pinMode(inpin, INPUT);
  pinMode(outpin, OUTPUT);
}

void loop() {
  digitalWrite(outpin, digitalRead(inpin));
}
```

Input pin number for PIR sensor module.
接被動紅外線傳感器的輸入腳號。

Output pin number for relay.
接繼電器的輸出腳號。

This pin is for input.
此腳用作輸入。

This pin is for output.
此腳用作輸出。

The input value read is written to the output pin.
讀到的輸入數值 寫到 輸出腳。

How to turn off the USB power
only after some time there is no motion?

如何在感知到沒有移動一陣子後
才關閉 USB 電源？

Here's one of the ways. 這是其中一種方法。

```
const int inpin = 2;  
const int outpin = 12;  
int count = 0;
```

Counter for creating delay.
用以產生延時的計數器。

Initialize the counter to zero when run to indicate there is no delay.

計數器起始時設零，代表不延時。

```
void setup() {  
  count = 0;  
  pinMode(inpin, INPUT);  
  pinMode(outpin, OUTPUT);  
  Serial.begin(9600);  
}
```

Set the serial communication rate to 9600 baud.
串流速度為 9600 baud

When there is motion... 當測到移動時……

Output is set to high. 輸出高。

```
void loop() {  
  if (digitalRead(inpin)) {  
    digitalWrite(outpin, HIGH);  
    count = 10000;  
  } else {  
    if (count > 0) {  
      --count;  
      Serial.println(count);  
    } else {  
      digitalWrite(outpin, LOW);  
    }  
  }  
}
```

Counter is set to non-zero to indicate there should be delay.
計數器設至非零數，代表有延時。

When there is no motion... 當沒有移動時……

If counter is non-zero, i.e., there should be delay....
如計數器非零，即需要延時……

Decrement the counter. 將計數器數目減一。

Do something that takes time, in this case print the counter value to serial output.

做些要用時間的東西，這裏將計數器的數目輸出至串流輸出。

Counter is already zero, set output to low.
計數器已達零，輸出低。

The Halloween program

萬聖節程式

```
// Constants don't change when the program is run
const int buttonPin = 2;
const int buzzerPin = 11;
const int ledPin = 12;
```

Pin numbers for button, buzzer and LED.
開關、蜂鳴器、和發光二極管的腳號。

```
// variables will change:
int buttonState = LOW;
int lastButtonState = LOW;
int freq = 220;
```

The current and previous states of the button.
現在和之前的開關狀態。

```
void setup() {
  pinMode(ledPin, OUTPUT);
  pinMode(buzzerPin, OUTPUT);
  pinMode(buttonPin, INPUT);
}
```

Initial sound frequency. 起始聲音頻率。

Input/output pin assignment.
分配輸入和輸出腳。

```
void loop() {
  // Read the state of the pushbutton value:
  buttonState = digitalRead(buttonPin);
  // Check if the pushbutton is pressed.
```

Read the current button state. 讀取現在的開關狀態。

If button is pressed now... 如果現在按了鍵……

```
if (buttonState == HIGH) {
  if (lastButtonState == LOW) {
```

If previously the button is not pressed, this is a new button press.
如果之前沒按鍵，這次是新按。

```
    lastButtonState = HIGH;
    freq = (int)(freq * 1.0594630943592953);
    if (freq > 7040) { freq = 110; }
```

Update last button state. 更新之前的開關狀態。

Update frequency. 更新頻率。

```
  }
  digitalWrite(ledPin, HIGH);
  tone(buzzerPin, freq);
```

Light up the LED. 點亮發光二極管。

Play sound at the frequency on the buzzer. 指示蜂鳴器發聲頻率。

```
} else {
  lastButtonState = LOW;
  digitalWrite(ledPin, LOW);
  noTone(buzzerPin);
```

Button is not pressed now. 現在沒按鍵。

Update last button state. 更新之前的開關狀態。

Extinguish the LEDs. 熄滅發光二極管。

Stop playing sound on the buzzer. 指示蜂鳴器勿發聲。

Thank you 謝謝

Questions? 問題?

