

AIOT智慧物聯網學習馬拉松

► 作業解答篇

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作業1



問題：

- 實際練習/sys/class/gpio啟動gpio，設定gpio接腳的狀態，並且卸載所啟動的gpio。同時觀察卸載之後的gpio接腳，繼續送設定狀態的資料，將會發生什麼樣的狀態。

作業1

- 透過linux週邊裝置的概念來操控GPIO，可以讓同學更了解Linux對於作業系統操控硬體週邊的設計概念，相對對於初學者，透過作業系統觀察GPIO週邊運作的過程，能夠建立作業系統支援硬體的概念，同時可以了解不用寫程式也可控制GPIO的操作方式。

作業1



- 首先開啟一個命令列視窗，之後切換至/sys/class/gpio的子目錄，並且按下ls -al觀察目前子目錄內包含的檔案。

```
shengan@ubuntu:/sys/class/gpio$ ls -al
total 0
drwxr-xr-x  2 root root    0 Oct  9 11:45 .
drwxr-xr-x 73 root root    0 Oct  9 11:44 ..
--w----- 1 root root 4096 Oct  5 12:28 export
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio10 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio10
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio11 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio11
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio12 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio12
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio13 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio13
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio16 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio16
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio17 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio17
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio18 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio18
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio19 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio19
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio20 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio20
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio21 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio21
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio22 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio22
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio23 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio23
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio24 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio24
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio25 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio25
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio26 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio26
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio5 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio5
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio6 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio6
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpio9 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio9
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpiochip0 -> ../../devices/platform/soc/fe200000.gpio/gpio/gpiochip0
lrwxrwxrwx 1 root root    0 Oct  9 11:45 gpiochip504 -> ../../devices/platform/soc/soc:firmware/soc:firmware:gpio/gpio/gpiochip504
--w----- 1 root root 4096 Oct  9 11:45 unexport
shengan@ubuntu:/sys/class/gpio$
```

- 請注意，這個時候的使用者身份是shengan，不是root。

作業1



- 使用一般使用者身份的時候，會發出權限不允許的狀態。需要使用sudo su切換身份為超級使用者，會發現出現了gpio4檔案。

```
shengan@ubuntu:/sys/class/gpio$ echo 4 > /sys/class/gpio/export
-bash: /sys/class/gpio/export: Permission denied
shengan@ubuntu:/sys/class/gpio$ sudo su
root@ubuntu:/sys/class/gpio# whoami
root
root@ubuntu:/sys/class/gpio# echo 4 > /sys/class/gpio/export
root@ubuntu:/sys/class/gpio# ls -al
total 0
drwxr-xr-x  2 root root    0 Oct  9 11:45 .
drwxr-xr-x 73 root root    0 Oct  9 11:44 ..
--w-----  1 root root 4096 Oct  9 11:53 export
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio10 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio10
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio11 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio11
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio12 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio12
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio13 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio13
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio16 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio16
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio17 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio17
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio18 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio18
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio19 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio19
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio20 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio20
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio21 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio21
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio22 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio22
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio23 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio23
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio24 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio24
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio25 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio25
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio26 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio26
lrwxrwxrwx  1 root root    0 Oct  9 11:53 gpio4 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio4
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio5 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio5
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio6 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio6
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpio9 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio9
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpiochip0 -> ../../devices/platform/soc/fe200000.gpio/gpio/gpiochip0
lrwxrwxrwx  1 root root    0 Oct  9 11:52 gpiochip504 -> ../../devices/platform/soc/soc:firmware/soc:firmware:gpio/gpio/gpiochip504
--w-----  1 root root 4096 Oct  9 11:52 unexport
root@ubuntu:/sys/class/gpio#
```

作業1

- 可以比較第一頁使用一般身份時候，跟切換為超級使用者後，畫面上面增加了gpio4的檔案。
- 有gpio4檔案代表GPIO4接角已經被正確的啟動了。
- 接下來可以使用echo out > /sys/class/gpio/gpio4/direction設定GPIO4為輸出接腳，並且將設定接腳為高電位輸出。
- 然後使用cat /d/gpio觀察GPIO各接腳的電位狀態。

```
root@ubuntu:/sys/class/gpio# echo out > /sys/class/gpio/gpio4/direction
root@ubuntu:/sys/class/gpio# echo 1 > /sys/class/gpio/gpio4/value
root@ubuntu:/sys/class/gpio# mkdir /d
root@ubuntu:/sys/class/gpio# mount -t debugfs debug /d
root@ubuntu:/sys/class/gpio# cat /d/gpio
gpiochip0: GPIOs 0-53, parent: platform/fe200000.gpio, pinctrl-bcm2835:
gpio-4 ( ) sysfs ) out hi
gpio-5 ( ) sysfs ) out hi
gpio-6 ( ) sysfs ) out hi
gpio-7 ( ) spi0 CS1 ) out hi ACTIVE LOW
gpio-8 ( ) spi0 CS0 ) out hi ACTIVE LOW
gpio-9 ( ) sysfs ) out hi
gpio-10 ( ) sysfs ) out hi
gpio-11 ( ) sysfs ) out hi
gpio-12 ( ) sysfs ) out lo
gpio-13 ( ) sysfs ) out hi
gpio-16 ( ) sysfs ) out lo
gpio-17 ( ) sysfs ) in lo IRQ
gpio-18 ( ) sysfs ) out lo
gpio-19 ( ) sysfs ) out hi
gpio-20 ( ) sysfs ) out lo
gpio-21 ( ) sysfs ) out lo
gpio-22 ( ) sysfs ) in lo IRQ
gpio-23 ( ) sysfs ) out hi
gpio-24 ( ) sysfs ) out lo
gpio-25 ( ) sysfs ) out lo
gpio-26 ( ) sysfs ) out hi
gpio-42 ( ) lled0 ) out lo

gpiochip1: GPIOs 504-511, parent: platform/soc:firmware:gpio, raspberrypi-exp-gpio, can sleep:
gpio-504 (BT_ON )
gpio-505 (WL_ON )
gpio-506 (PWR_LED_OFF) lled1 ) out lo ACTIVE LOW
gpio-507 (GLOBAL_RESET)
gpio-508 (VDD_SD_IO_SEL) lvdd-sd-io ) out hi
gpio-509 (CAM_GPIO )
gpio-510 (SD_PWR_ON) sd_vcc_reg ) out hi
gpio-511 (SD_OC_N )
root@ubuntu:/sys/class/gpio#
```

作業1

- 使用 `echo 4 > /sys/class/gpio/unexport`，將GPIO4接腳釋放，可以發現gpio4檔案消失了，顯示GPIO4接腳釋放成功。

```
root@ubuntu:/sys/class/gpio# echo 4 > /sys/class/gpio/unexport
root@ubuntu:/sys/class/gpio# ls -al
total 0
drwxr-xr-x  2 root root    0 Oct  9 13:06 .
drwxr-xr-x 73 root root    0 Oct  9 13:05 ..
--w----- 1 root root 4096 Oct  9 13:06 export
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio10 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio10
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio11 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio11
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio12 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio12
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio13 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio13
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio16 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio16
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio17 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio17
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio18 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio18
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio19 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio19
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio20 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio20
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio21 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio21
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio22 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio22
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio23 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio23
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio24 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio24
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio25 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio25
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio26 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio26
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio5  -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio5
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio6  -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio6
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpio9  -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio9
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpiochip0 -> ../../devices/platform/soc/fe200000.gpio/gpio/gpiochip0
lrwxrwxrwx 1 root root    0 Oct  9 13:24 gpiochip504 -> ../../devices/platform/soc/soc:firmware/soc:firmware:gpio/gpio/gpiochip504
--w----- 1 root root 4096 Oct  9 13:24 unexport
root@ubuntu:/sys/class/gpio#
```

作業1

- 最後使用echo 1 > /sys/class/gpio/gpio4/value，會發現因為gpio4已經消失，會出現No such file or directory的訊息，無法繼續使用GPIO4進行任何操作。

```
drwxr-xr-x 2 root root 0 Oct 9 13:06 .
drwxr-xr-x 73 root root 0 Oct 9 13:05 ..
--w----- 1 root root 4096 Oct 9 13:06 export
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio0 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio0
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio1 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio1
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio2 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio2
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio3 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio3
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio6 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio6
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio17 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio17
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio18 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio18
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio19 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio19
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio20 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio20
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio21 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio21
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio22 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio22
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio23 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio23
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio24 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio24
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio25 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio25
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio26 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio26
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio5 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio5
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio6 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio6
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpio9 -> ../../devices/platform/soc/fe200000.gpio/gpiochip0/gpio/gpio9
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpiochip0 -> ../../devices/platform/soc/fe200000.gpio/gpio/gpiochip0
lrwxrwxrwx 1 root root 0 Oct 9 13:24 gpiochip504 -> ../../devices/platform/soc/soc.firmware/soc.firmware:gpio/gpio/gpiochip504
--w----- 1 root root 4096 Oct 9 13:24 unexport
root@ubuntu:/sys/class/gpio# echo 1 > /sys/class/gpio/gpio4/value
bash: /sys/class/gpio/gpio4/value: No such file or directory
root@ubuntu:/sys/class/gpio# echo out > /sys/class/gpio/gpio4/direction
bash: /sys/class/gpio/gpio4/direction: No such file or directory
```


作業2



問題：

- 使用raspi-config啟動i2c，觀察gpio2以及gpio3的變化，透過 `/sys/kernel/debug/gpio` 觀察改變的情形，嘗試重新做一次作業1，針對gpio2以及gpio3操作，觀察在i2c啟動的狀態下，gpio2以及gpio3相對gpio4有何不同。

作業2



- 在啟動i2c之後，將會使用gpio2作為SDA與gpio3作為SCL的接腳，在使用的概念上，要注意的是否會發生軟體衝突的現象，實務上如果需要用到gpio2與gpio3接腳時，建議透過raspi-config將i2c關掉。

作業2

- 本題在i2c已經打開的狀態下，透過/sys/class/gpio/export將gpio2與gpio3設定為out的狀態，並且分別輸出0與1的狀態，此時觀察並無設定輸出失敗的現象。因此可以觀察到並不會有啟動i2c開啟之後，阻止其他軟體存取gpio2與gpio3的情形。

```
root@raspberrypi:/sys/class/gpio# echo 2 > /sys/class/gpio/export
root@raspberrypi:/sys/class/gpio# echo 3 > /sys/class/gpio/export
root@raspberrypi:/sys/class/gpio# cat gpio
cat: gpio: No such file or directory
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (                |sysfs                ) in  hi
gpio-3 (                |sysfs                ) in  hi
gpio-5 (                |sysfs                ) out hi
gpio-6 (                |sysfs                ) out hi
gpio-7 (                |sysfs                ) out lo
gpio-8 (                |sysfs                ) out lo
gpio-9 (                |sysfs                ) out hi
gpio-10 (               |sysfs                ) out hi
gpio-11 (               |sysfs                ) out hi
gpio-12 (               |sysfs                ) out hi
gpio-13 (               |sysfs                ) out hi
gpio-16 (               |sysfs                ) out hi
gpio-17 (               |sysfs                ) in  lo IRQ
gpio-19 (               |sysfs                ) out hi
gpio-20 (               |sysfs                ) out hi
gpio-21 (               |sysfs                ) out hi
gpio-22 (               |sysfs                ) in  lo IRQ
gpio-23 (               |sysfs                ) out lo
gpio-24 (               |sysfs                ) out lo
gpio-25 (               |sysfs                ) out lo
gpio-26 (               |sysfs                ) out hi
gpio-29 (               |lled0                ) out lo
```

作業2

- 進一步的設定gpio4接腳為啟動，會發現內定為輸入，並呈現高電位輸入狀態。因為gpio2、gpio3、gpio4是完全獨立的狀態，不會發生互相影響的情形。

```
root@raspberrypi:/sys/class/gpio# echo 4 > export
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (          |sysfs          ) in  hi
gpio-3 (          |sysfs          ) in  hi
gpio-4 (          |sysfs          ) in  hi
gpio-5 (          |sysfs          ) out hi
```

- 針對gpio2操作設定為out輸出，會發現內定的輸出為lo低電位。

```
root@raspberrypi:/sys/class/gpio# echo out > gpio2/direction
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (          |sysfs          ) out lo
gpio-3 (          |sysfs          ) in  hi
gpio-4 (          |sysfs          ) in  hi
```

- 可以再將gpio2設定hi，echo 1 > gpio2/value可設定新的值。

```
root@raspberrypi:/sys/class/gpio# echo 1 > gpio2/value
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (          |sysfs          ) out hi
gpio-3 (          |sysfs          ) in  hi
gpio-4 (          |sysfs          ) in  hi
gpio-5 (          |sysfs          ) out hi
```

作業2

- 進一步針對gpio3設定輸出為out。底下是針對gpio3操作狀態，會發現內定的輸出為lo低電位。

```
root@raspberrypi:/sys/class/gpio# echo out > gpio3/direction
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2  (                |sysfs                ) out hi
gpio-3  (                |sysfs                ) out lo
gpio-4  (                |sysfs                ) in  hi
```

- 可以再將gpio3設定hi，echo 1 > gpio3/value可設定新的值。

```
root@raspberrypi:/sys/class/gpio# echo 1 > gpio3/value
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2  (                |sysfs                ) out hi
gpio-3  (                |sysfs                ) out hi
gpio-4  (                |sysfs                ) in  hi
```

- 最後同學可以自行練習將GPIO4設定為out之後，設定為高電位輸出。

作業3



問題：

- 使用raspi-config啟動spi，觀察gpio各接腳的變化狀態，嘗試將spi關閉之後，透過/sys/kernel/debug/gpio，觀察可以使用gpio數量的變化情形

作業3



- 本題目希望同學觀察spi啟動以後，gpio接腳的變化情形，因為spi占用非常多的gpio接腳，在沒有使用spi的狀況下，建議透過raspi-config關閉spi，避免接腳之間的佔用狀態發生。

作業3

- 首先透過raspi-config將spi開啟，在開啟之前可以先透過cat /sys/kernel/debug/gpio觀察各個GPIO接腳的狀態值(輸出入、電位狀態)。

```
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2  (                |sysfs                ) out hi
gpio-3  (                |sysfs                ) out hi
gpio-4  (                |sysfs                ) in  hi
gpio-5  (                |sysfs                ) out hi
gpio-6  (                |sysfs                ) out hi
gpio-7  (                |sysfs                ) out lo
gpio-8  (                |sysfs                ) out lo
gpio-9  (                |sysfs                ) out hi
gpio-10 (                |sysfs                ) out hi
gpio-11 (                |sysfs                ) out hi
gpio-12 (                |sysfs                ) out hi
gpio-13 (                |sysfs                ) out hi
gpio-16 (                |sysfs                ) out hi
gpio-17 (                |sysfs                ) in  lo  IRQ
gpio-19 (                |sysfs                ) out hi
gpio-20 (                |sysfs                ) out hi
gpio-21 (                |sysfs                ) out hi
gpio-22 (                |sysfs                ) in  lo  IRQ
gpio-23 (                |sysfs                ) out lo
gpio-24 (                |sysfs                ) out lo
gpio-25 (                |sysfs                ) out lo
gpio-26 (                |sysfs                ) out hi
gpio-29 (                |led0                 ) out lo
```


作業3

- 透過raspi-config的Interfacing Options把spi的開關打開。

```
Raspberry Pi Software Configuration Tool (raspi-config)

1 Change User Password Change password for the 'pi' user
2 Network Options      Configure network settings
3 Boot Options         Configure options for start-up
4 Localisation Options Set up language and regional settings to match your location
5 Interfacing Options  Configure connections to peripherals
6 Overclock            Configure overclocking for your Pi
7 Advanced Options     Configure advanced settings
8 Update              Update this tool to the latest version
9 About raspi-config   Information about this configuration tool

<Select>                                <Finish>
```

- 選擇P4 SPI，啟動SPI在kernel中掛入模組。

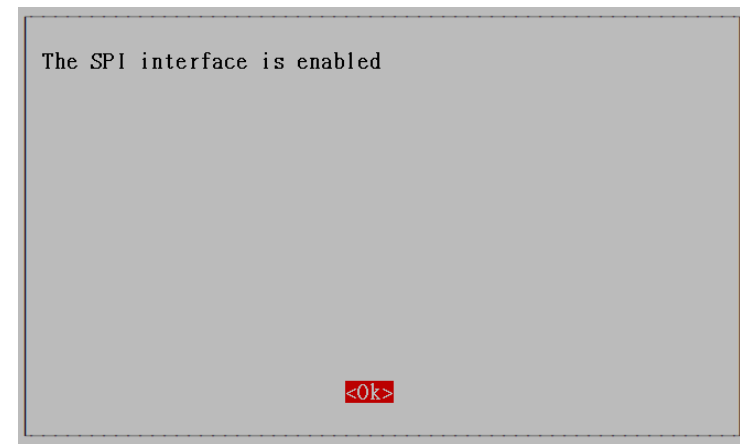
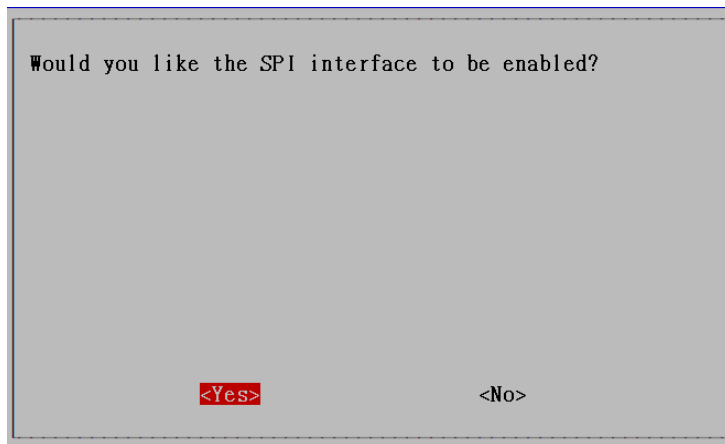
```
Raspberry Pi Software Configuration Tool (raspi-config)

P1 Camera      Enable/Disable connection to the Raspberry Pi Camera
P2 SSH         Enable/Disable remote command line access to your Pi using SSH
P3 VNC         Enable/Disable graphical remote access to your Pi using RealVNC
P4 SPI         Enable/Disable automatic loading of SPI kernel module
P5 I2C         Enable/Disable automatic loading of I2C kernel module
P6 Serial      Enable/Disable shell and kernel messages on the serial connection
P7 I-Wire      Enable/Disable one-wire interface
P8 Remote GPIO Enable/Disable remote access to GPIO pins

<Select>                                <Back>
```

作業3

- 方向鍵選擇YES，按下Enter啟動SPI，最後按下Enter啟動。



- 啟動SPI之後觀察與啟動SPI前，GPIO的狀態有什麼不同？

作業3

- 開啟之後透過`cat /sys/kernel/debug/gpio`觀察各個GPIO接腳的狀態值(輸出入、電位狀態)。比較跟開啟之前有什麼不同。

```
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (                ) out hi
gpio-3 (                ) out hi
gpio-4 (                ) in  hi
gpio-5 (                ) out hi
gpio-6 (                ) out hi
gpio-7 (                ) out lo
gpio-8 (                ) out lo
gpio-9 (                ) out hi
gpio-10 (               ) out hi
gpio-11 (               ) out hi
gpio-12 (               ) out hi
gpio-13 (               ) out hi
gpio-16 (               ) out hi
gpio-17 (               ) in  lo IRQ
gpio-19 (               ) out hi
gpio-20 (               ) out hi
gpio-21 (               ) out hi
gpio-22 (               ) in  lo IRQ
gpio-23 (               ) out lo
gpio-24 (               ) out lo
gpio-25 (               ) out lo
gpio-26 (               ) out hi
gpio-29 (               ) out lo
```

```
root@raspberrypi:/sys/class/gpio# raspi-config
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (                ) out hi
gpio-3 (                ) out hi
gpio-4 (                ) in  hi
gpio-5 (                ) out hi
gpio-6 (                ) out hi
gpio-7 (                ) out hi
gpio-8 (                ) out hi
gpio-9 (                ) out lo
gpio-10 (               ) out lo
gpio-11 (               ) out lo
gpio-12 (               ) out hi
gpio-13 (               ) out hi
gpio-16 (               ) out hi
gpio-17 (               ) in  lo IRQ
gpio-19 (               ) out hi
gpio-20 (               ) out hi
gpio-21 (               ) out hi
gpio-22 (               ) in  lo IRQ
gpio-23 (               ) out lo
gpio-24 (               ) out lo
gpio-25 (               ) out lo
gpio-26 (               ) out hi
gpio-29 (               ) out lo
```

- 紅色框線為SPI0所使用的接腳，分別為GPIO 7,8,9,10,11
- 藍色框線為SPI1所使用的接腳，分別為GPIO16,17,18,19,20,21

作業3

- 可以觀察到GPIO7,8,9,10,11的腳位電位值改變了，在此次的結果剛好反向(hi變lo、lo變hi)。
- 左邊是尚未啟動spi，右邊是啟動spi之後。

```
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (      ) out hi
gpio-3 (      ) out hi
gpio-4 (      ) in hi
gpio-5 (      ) out hi
gpio-6 (      ) out hi
gpio-7 (      ) out lo
gpio-8 (      ) out lo
gpio-9 (      ) out hi
gpio-10 (     ) out hi
gpio-11 (     ) out hi
gpio-12 (     ) out hi
gpio-13 (     ) out hi
gpio-16 (     ) out hi
gpio-17 (     ) in lo IRQ
gpio-19 (     ) out hi
gpio-20 (     ) out hi
gpio-21 (     ) out hi
gpio-22 (     ) in lo IRQ
gpio-23 (     ) out lo
gpio-24 (     ) out lo
gpio-25 (     ) out lo
gpio-26 (     ) out hi
gpio-29 (     ) out lo
```

```
root@raspberrypi:/sys/class/gpio# raspi-config
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (      ) out hi
gpio-3 (      ) out hi
gpio-4 (      ) in hi
gpio-5 (      ) out hi
gpio-6 (      ) out hi
gpio-7 (      ) out hi
gpio-8 (      ) out hi
gpio-9 (      ) out lo
gpio-10 (     ) out lo
gpio-11 (     ) out lo
gpio-12 (     ) out hi
gpio-13 (     ) out hi
gpio-16 (     ) out hi
gpio-17 (     ) in lo IRQ
gpio-19 (     ) out hi
gpio-20 (     ) out hi
gpio-21 (     ) out hi
gpio-22 (     ) in lo IRQ
gpio-23 (     ) out lo
gpio-24 (     ) out lo
gpio-25 (     ) out lo
gpio-26 (     ) out hi
gpio-29 (     ) out lo
```

作業3

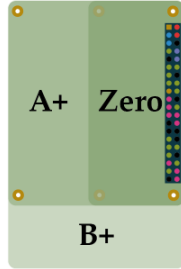
- 需要注意的是，透過資料查詢，SPI0與SPI1會使用到許多的接腳，特別是當不需要使用SPI的時候，記得把SPI關掉。

Raspberry Pi Pinout	
3v3 Power	2 5v Power
GPIO 2 (I2C1 SDA)	4 5v Power
GPIO 3 (I2C1 SCL)	5 6 Ground
GPIO 4 (GCLK0)	7 8 GPIO 14 (UART TX)
Ground	9 10 GPIO 15 (UART RX)
GPIO 17 (SPI1 CE1)	11 12 GPIO 18 (SPI1 CE0)
GPIO 27	13 14 Ground
GPIO 22	15 16 GPIO 23
3v3 Power	17 18 GPIO 24
GPIO 10 (SPI0 MOSI)	19 20 Ground
GPIO 9 (SPI0 MISO)	21 22 GPIO 25
GPIO 11 (SPI0 SCLK)	23 24 GPIO 8 (SPI0 CE0)
Ground	25 26 GPIO 7 (SPI0 CE1)
GPIO 0 (EEPROM SDA)	27 28 GPIO 1 (EEPROM SCL)
GPIO 5	29 30 Ground
GPIO 6	31 32 GPIO 12 (PWM0)
GPIO 13 (PWM1)	33 34 Ground
GPIO 19 (SPI1 MISO)	35 36 GPIO 16 (SPI1 CE2)
GPIO 26	37 38 GPIO 20 (SPI1 MOSI)
Ground	39 40 GPIO 21 (SPI1 SCLK)

Legend

Orientate your Pi with the GPIO on the right and the HDMI port on the left.

- GPIO (General Purpose IO)
- SPI (Serial Peripheral Interface)
- I²C (Inter-integrated Circuit)
- UART (Universal Asynchronous Receiver/Transmitter)
- PCM (Pulse Code Modulation)
- Ground
- 5v (Power)
- 3.3v (Power)



5v Power | SDIO | JTAG | 3v3 Power | UART | DPI | PCM | 1-WIRE | WiringPi | GPClk

Ground | I2C | PWM | SPI

Browse pinouts for HATs, pHATs and add-ons »

SPI - Serial Peripheral Interface

SPI0 pins are GPIO 7, 8, 9, 10, 11

SPI1 pins are GPIO 16, 17, 18, 19, 20, 21

Known as the four-wire serial bus, SPI lets you attach multiple compatible devices to a single set of pins by assigning them different chip-select pins.

To talk to an SPI device, you assert its corresponding chip-select pin.

By default the Pi allows you to use SPI0 with chip select pins on CE0 on GPIO 8 and CE1 on GPIO 7.

You can enable SPI1 with a dtoverlay configured in "/boot/config.txt", for example:

```
1. dtoverlay=spi1-3cs
```

For full details of the SPI dtoverlays (and others) see [the Raspberry_Pi_dtoverlay_README](#)

Details

- [More Information](#)

資料來源：<https://pinout.xyz/pinout/spi>

作業3

- 最後透過raspi-config關掉spi。再觀察一次gpio接腳的變化。
- 左邊是啟動spi之後，右邊是關閉spi後的gpio值。
- 可以發現關閉spi時，GPIO7,8,9,10,11變為一般的GPIO了。

```
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (          ) out hi
gpio-3 (          ) out hi
gpio-4 (          ) in  hi
gpio-5 (          ) out hi
gpio-6 (          ) out hi
gpio-7 (          ) out lo
gpio-8 (          ) out lo
gpio-9 (          ) out hi
gpio-10 (         ) out hi
gpio-11 (         ) out hi
gpio-12 (         ) out hi
gpio-13 (         ) out hi
gpio-16 (         ) out hi
gpio-17 (         ) in  lo IRQ
gpio-19 (         ) out hi
gpio-20 (         ) out hi
gpio-21 (         ) out hi
gpio-22 (         ) in  lo IRQ
gpio-23 (         ) out lo
gpio-24 (         ) out lo
gpio-25 (         ) out lo
gpio-26 (         ) out hi
gpio-29 (         ) out lo
```

```
root@raspberrypi:/sys/class/gpio# raspi-config
root@raspberrypi:/sys/class/gpio# cat /sys/kernel/debug/gpio
gpiochip0: GPIOs 0-53, parent: platform/3f200000.gpio, pinctrl-bcm2835:
gpio-2 (          ) out hi
gpio-3 (          ) out hi
gpio-4 (          ) in  hi
gpio-5 (          ) out hi
gpio-6 (          ) out hi
gpio-7 (          ) out hi
gpio-8 (          ) out hi
gpio-9 (          ) out lo
gpio-10 (         ) out lo
gpio-11 (         ) out lo
gpio-12 (         ) out hi
gpio-13 (         ) out hi
gpio-16 (         ) out hi
gpio-17 (         ) in  lo IRQ
gpio-19 (         ) out hi
gpio-20 (         ) out hi
gpio-21 (         ) out hi
gpio-22 (         ) in  lo IRQ
gpio-23 (         ) out lo
gpio-24 (         ) out lo
gpio-25 (         ) out lo
gpio-26 (         ) out hi
gpio-29 (         ) out lo
```