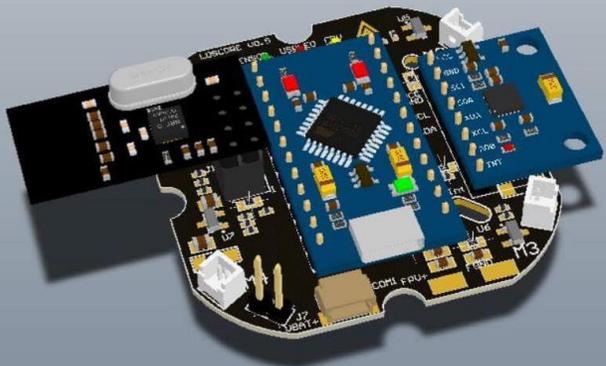




多軸旋翼機飛控實戰課程



★ PART 2 LD SLITE 旋翼機飛控程式實戰

ARDUINO 安裝與環境設定



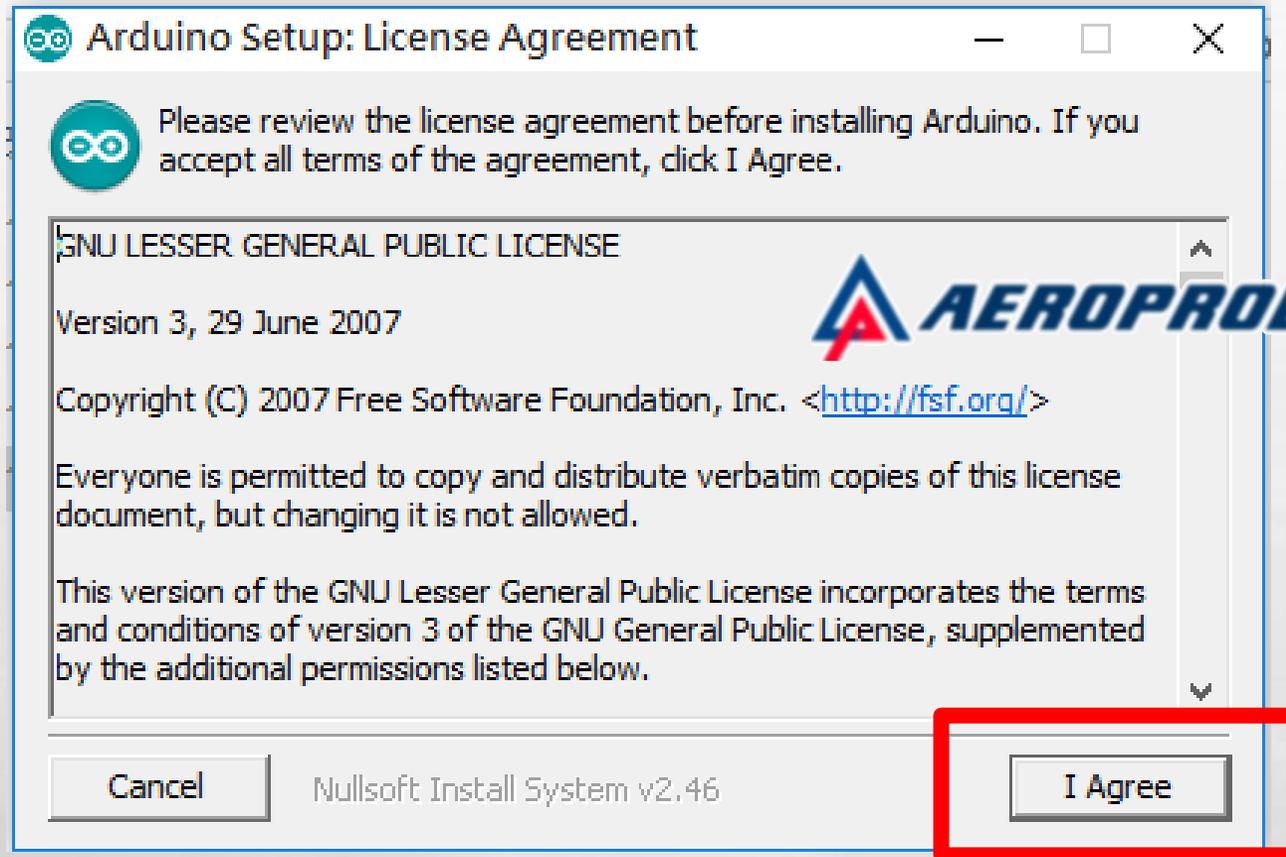
此安裝檔放在「**LDSLITE**飛控實戰課程安裝軟體」資料夾中

 XLoader	2016/11/14 下午 ...	檔案資料夾
 arduino-1.6.12-windows.exe	2016/11/14 上午 ...	應用程式
 npp.6.9.2.Installer.exe	2016/7/17 下午 0...	應用程式



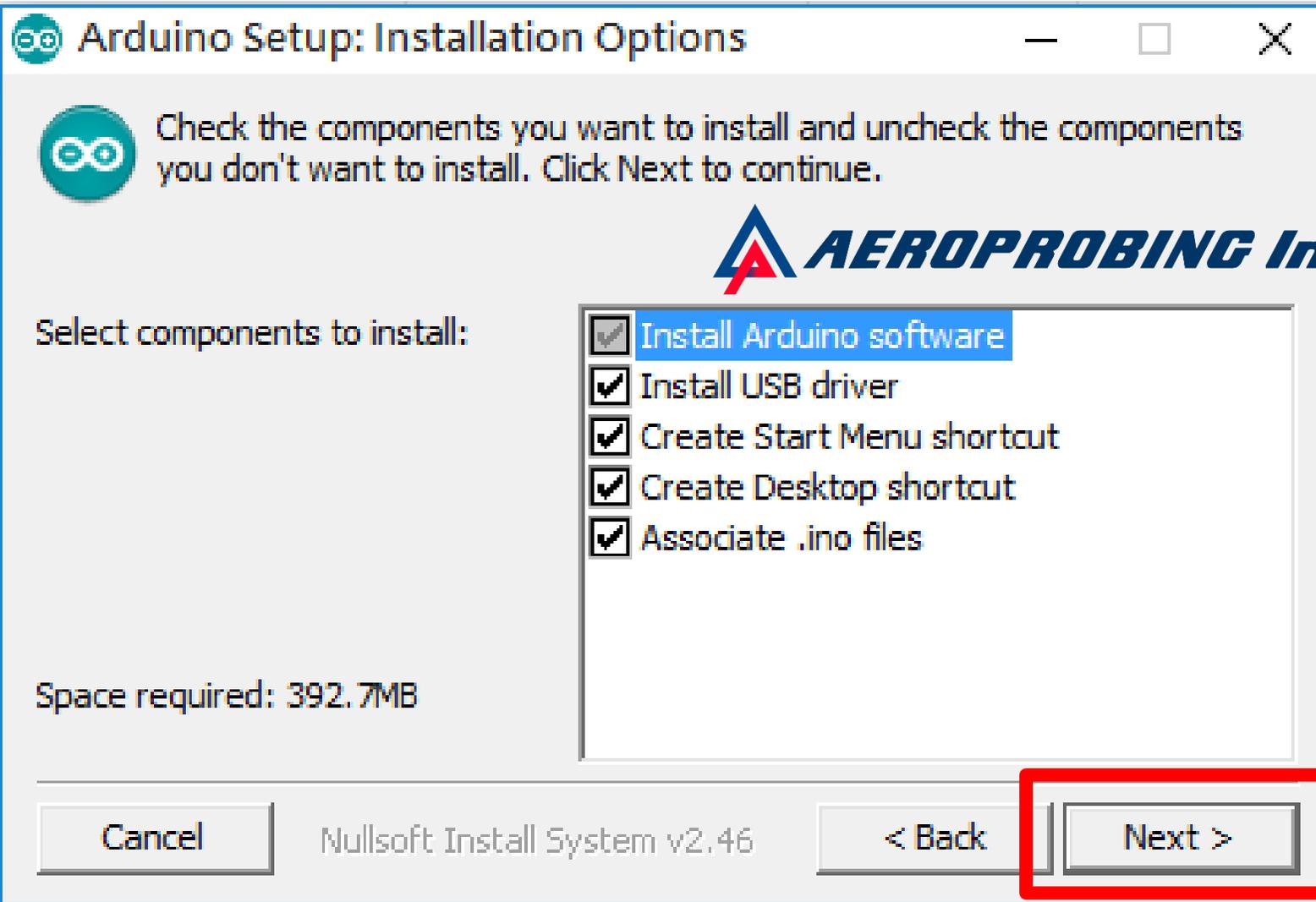
本次課程只接受**1.6.12**以上之版本，較早版本請移除並更新

ARDUINO 安裝與環境設定

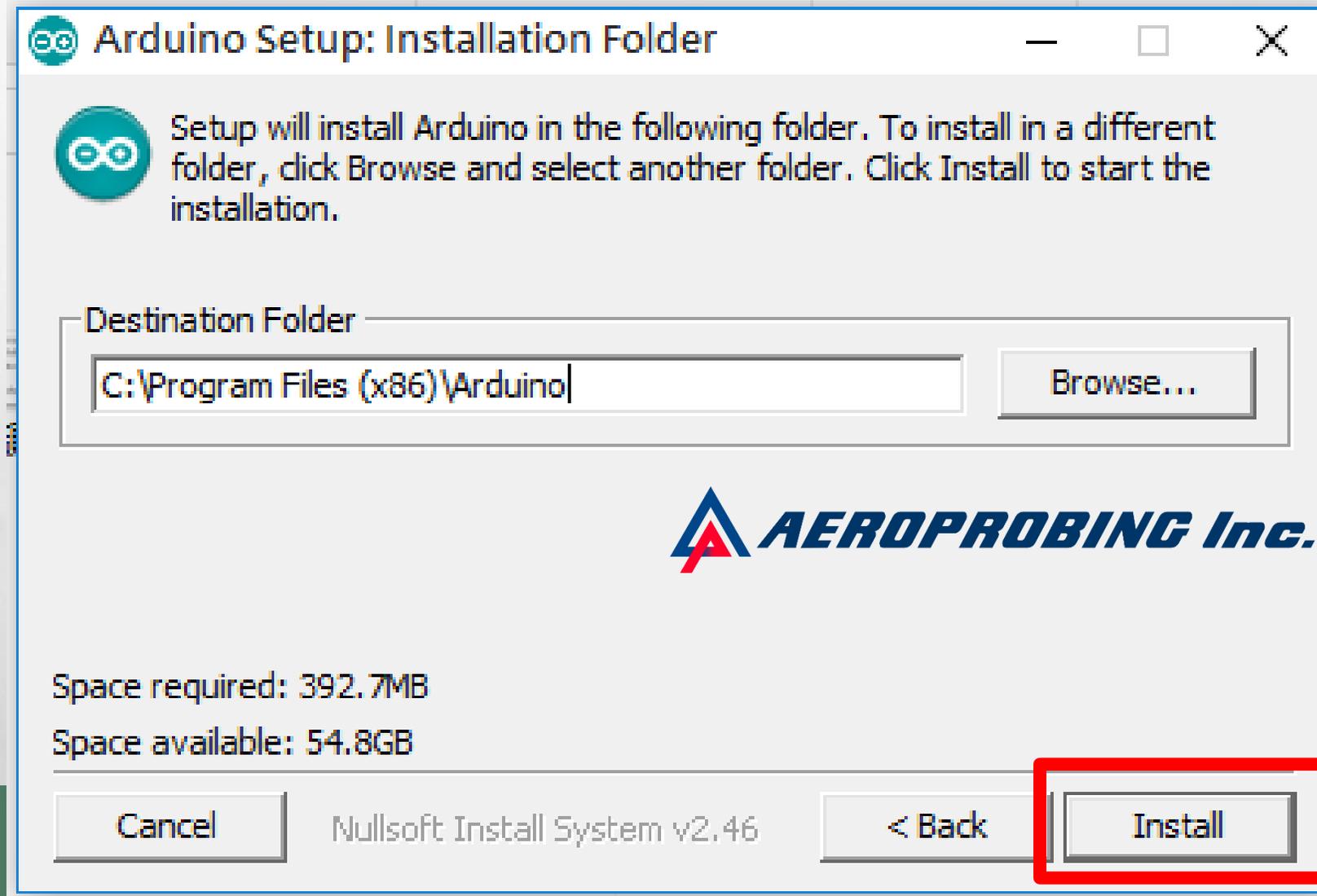


若有舊的非預設 **LIBRARY** 安裝前請先將檔案保存

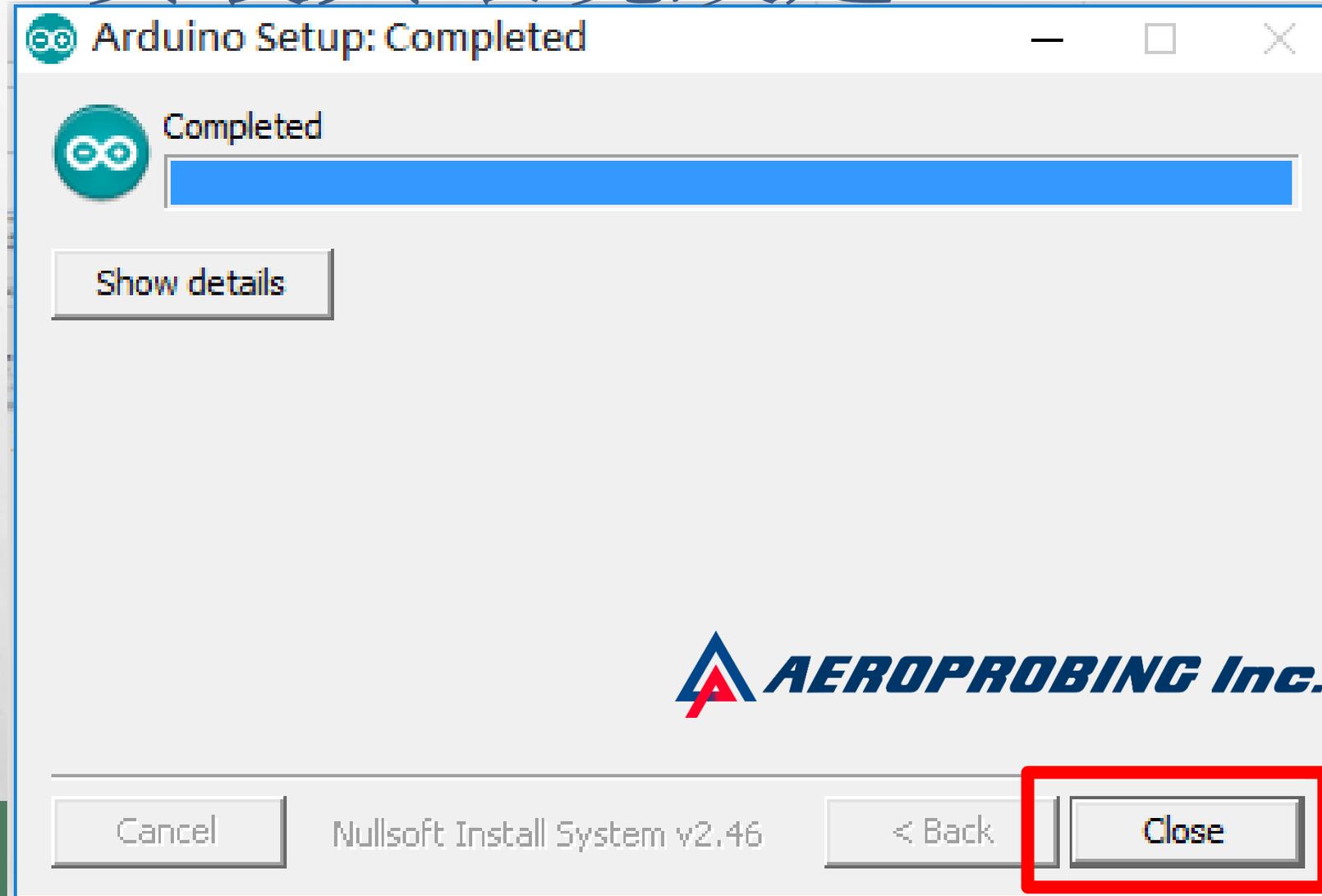
ARDUINO 安裝與環境設定



ARDUINO 安裝與環境設定



ARDUINO 安裝與環境設定





ARDUINO 安裝與環境設定

```
1 void setup()  
2 // put your code here  
3  
4 }  
5  
6 void loop() {  
7 // put your code here  
8  
9 }
```

序列埠監控視窗 Ctrl+Shift+M
Serial Plotter Ctrl+Shift+L
板子: "Arduino/Genuino Micro"
序列埠
燒錄器: "AVRISP mkII"
燒錄Bootloader

板子管理員...
Arduino AVR板
Arduino Yún
Arduino/Genuino Uno
Arduino Duemilanove or Diecimila
Arduino Nano
Arduino/Genuino Mega or Mega 2560
Arduino Mega ADK
Arduino Leonardo
● Arduino/Genuino Micro
Arduino Esplora
Arduino Mini
Arduino Ethernet
Arduino Fio
Arduino BT
LilyPad Arduino USB
LilyPad Arduino
Arduino Pro or Pro Mini
Arduino NG or older
Arduino Robot Control
Arduino Robot Motor
Arduino Gemma

選取此次上課所使用的**MICRO**板



AEROPROBING Inc.

ARDUINO IDE 編譯測試



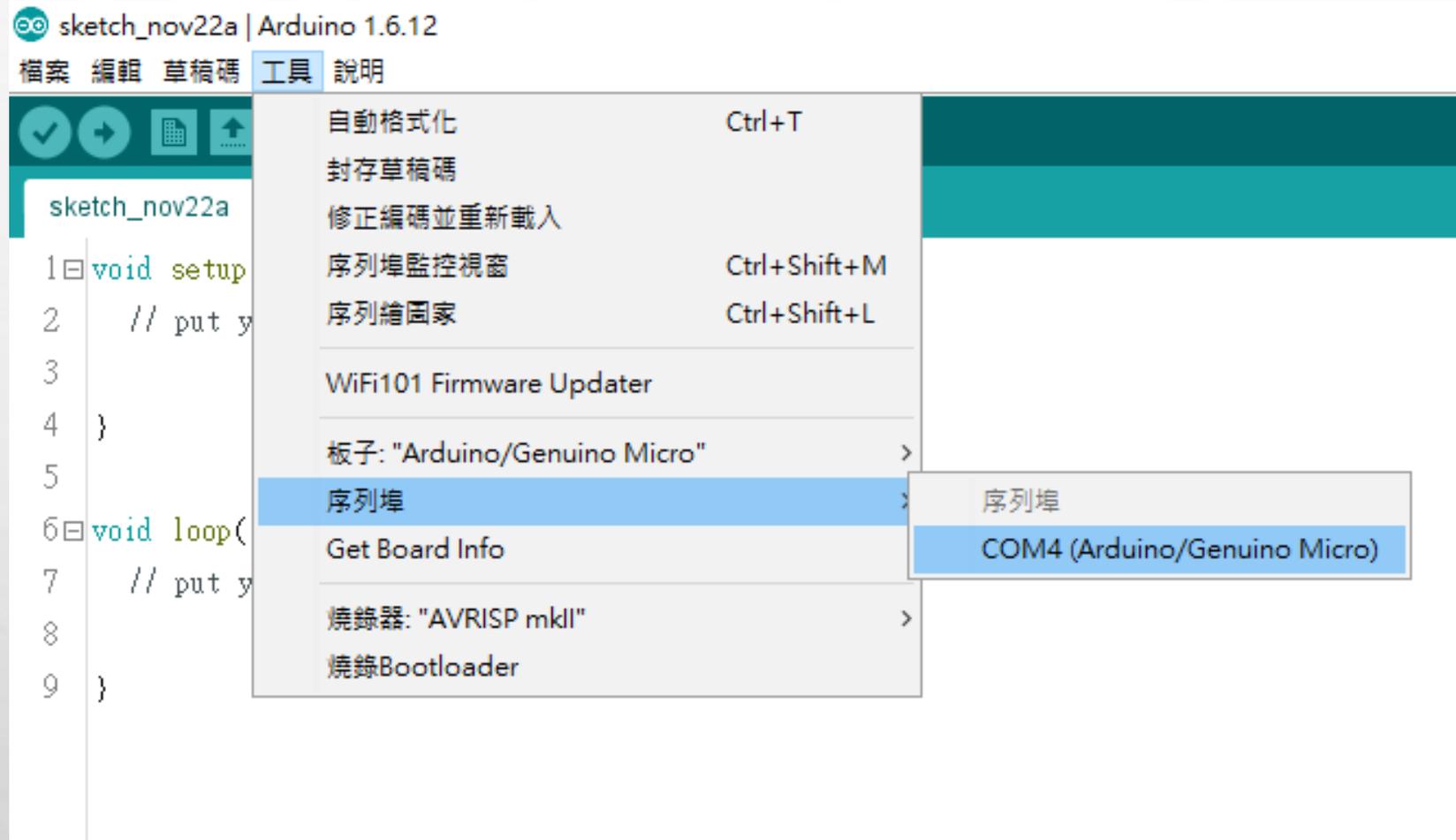
The screenshot shows the Arduino IDE window titled "sketch_jun15a | Arduino 1.6.7". The menu bar includes "檔案", "編輯", "草稿碼", "工具", and "說明". The toolbar contains icons for a checkmark, a play button, a document, an upload button, a download button, and a help icon. The sketch name "sketch_jun15a" is displayed in the top bar. The code editor contains the following code:

```
1 void setup() {  
2   // put your setup code here, to run once:  
3  
4 }  
5  
6 void loop() {  
7   // put your main code here, to run repeatedly:  
8  
9 }
```

At the bottom of the IDE, a status bar shows "草稿碼編譯中..." (Sketch compiling...) with a green progress bar. The bottom-most status bar indicates "9" and "Arduino/Genuino Micro on COM8".



ARDUINO IDE 編譯測試



上傳之前須先用**USB**接上**ARDUINO**並選擇要進行燒錄的序列埠



ARDUINO IDE上傳燒錄程式測試



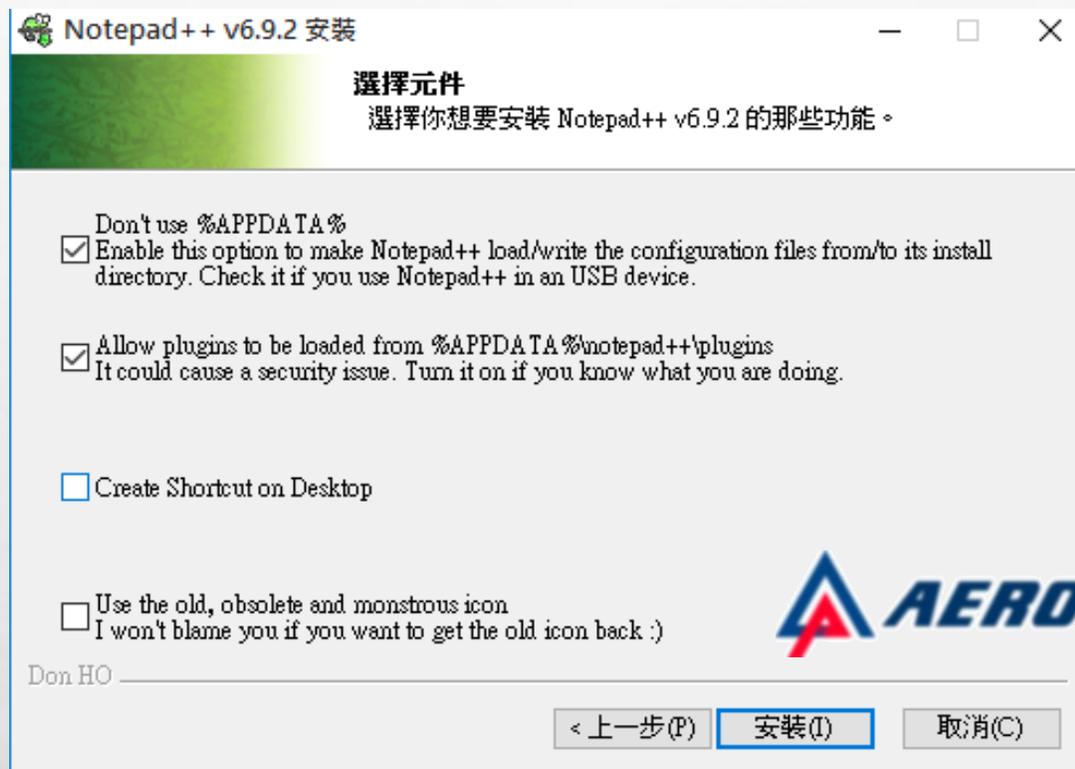
```
sketch_jun15a
1 void setup() {
2   // put your setup code here, to run once:
3
4 }
5
6 void loop() {
7   // put your main code here, to run repeatedly:
8
9 }
```

 **AEROPROBING Inc.**

草稿碼編譯中... 

9 Arduino/Genuino Micro on COM6

安裝NOTEPAD++





此**LIBRARY**資料夾位於「**LDSLITE**飛控實戰程式」資料夾中

- ✓ Aeroprobing LDS MUAUV 201
- ✓ Aeroprobing_PAUV 201
- ✓ Library 201
- ✓ MPU6050_calibration 201
- ✓ 練習題 201



ARDUINO IDE 客製函式庫設定



 I2Cdev	2016/6/15 下午 0...	檔案資料夾
 MPU6050	2016/6/15 下午 0...	檔案資料夾
 RF24-master	2016/6/15 下午 0...	檔案資料夾



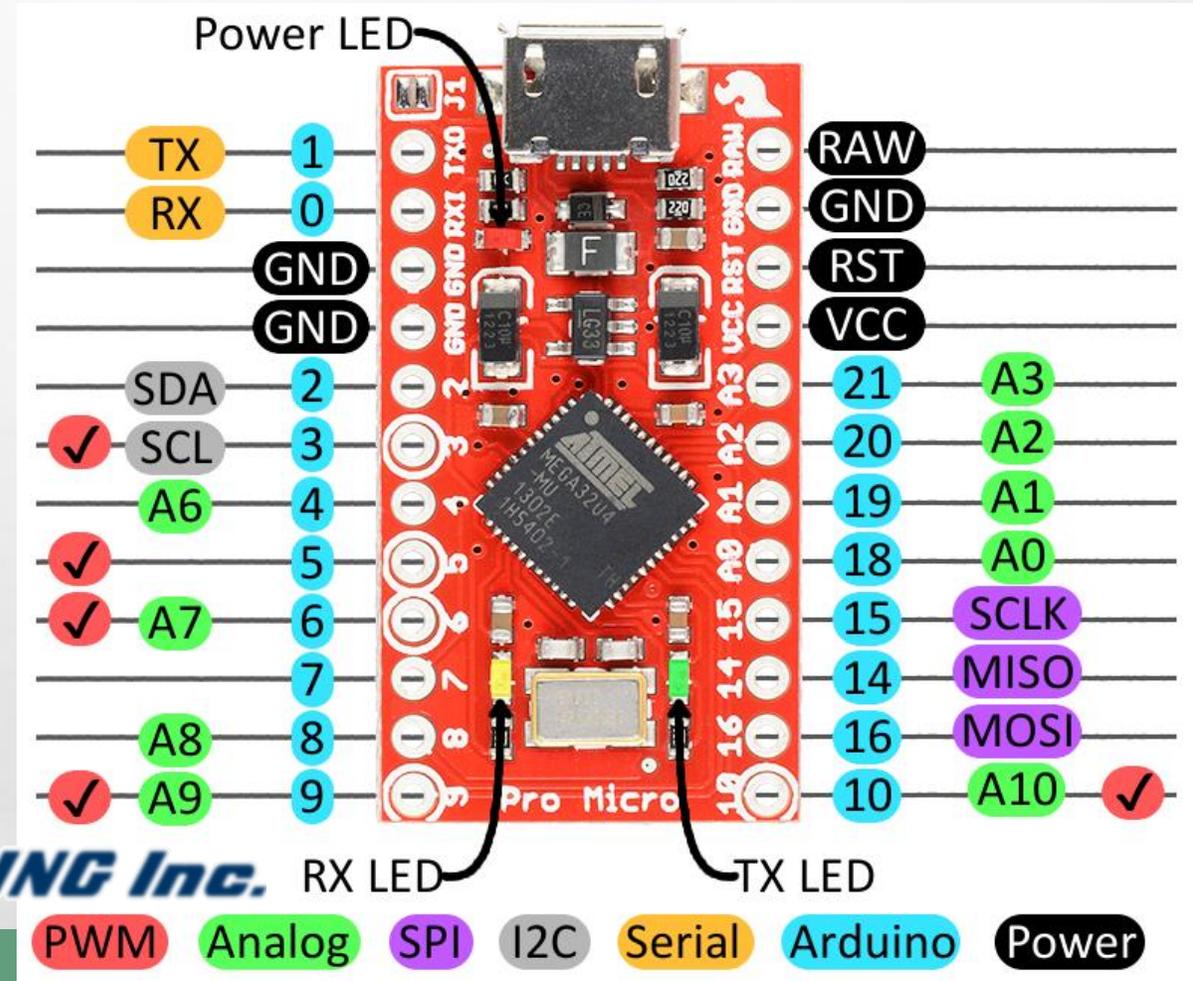
進入 **LIBRARY** 資料夾，將此三個檔案複製至

C:\PROGRAM FILES (X86)\ARDUINO\LIBRARIES

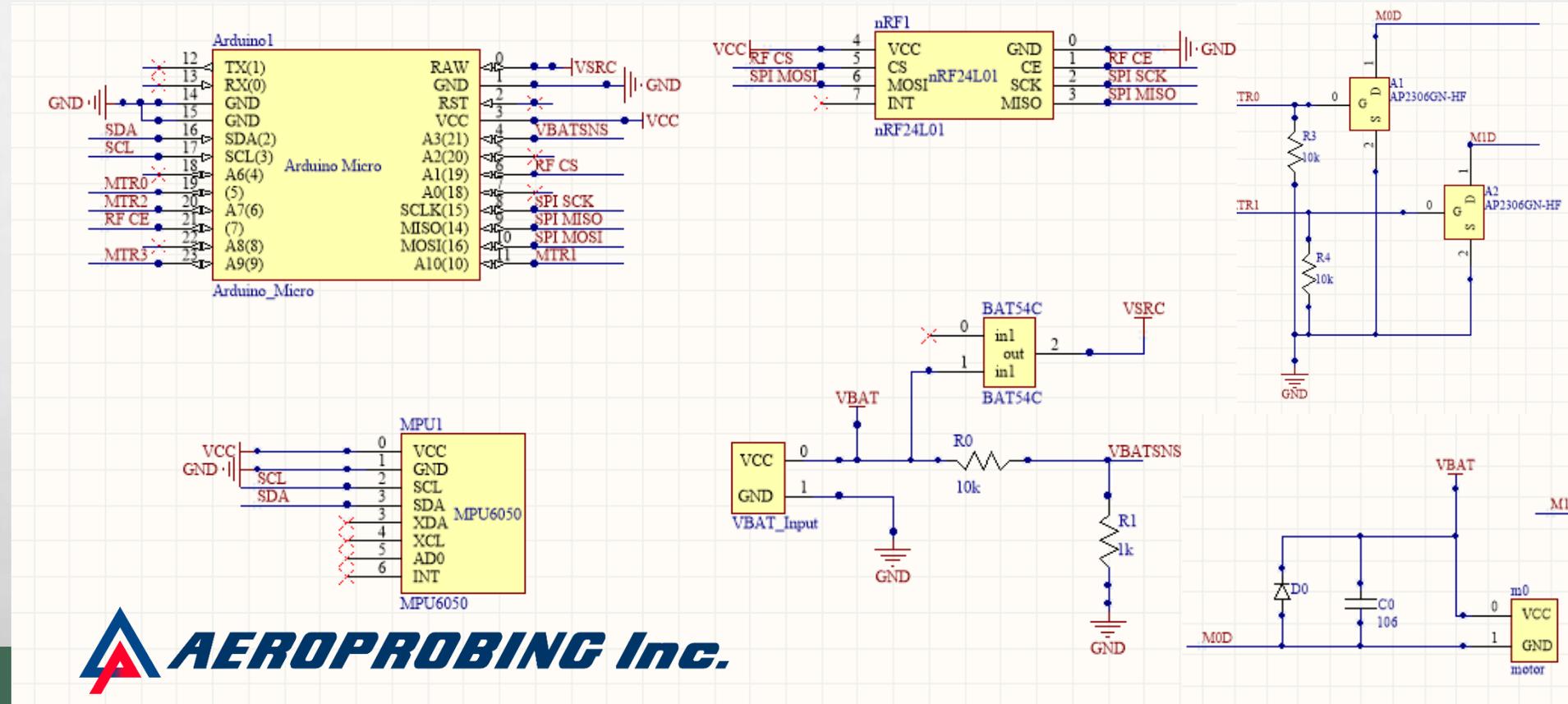
ARDUINO I/O 講解



- 控制器：**ATmega32u4**
- 工作頻率：**16 MHz**
- 工作電壓：**5V**
- 輸入電壓（推薦）：**7-12V**
- 數位I/O接腳：**20**個
- 硬體PWM通道：**5**個
- 類比I/O：**9**個
- **5V**數位/類比接腳最大允許電流：**40 mA**
- **3.3V**數位/類比接腳最大允許電流：**50 mA**



LDSLITE 四軸飛行器飛控系統硬體架構





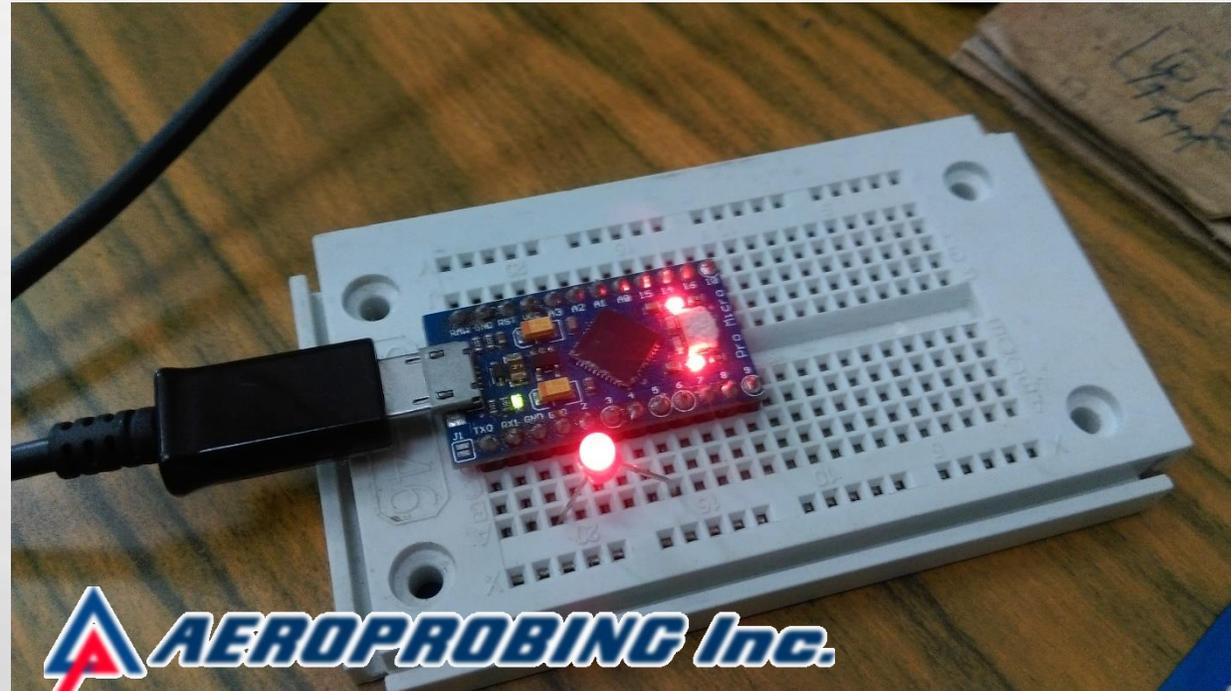
ARDUINO 語法講解與練習

```
void setup() {  
  // put your setup code here, to run once:  
  
}  
  
void loop() {  
  // put your main code here, to run repeatedly:  
  
}
```





練習一：LED控制





練習一：LED控制

```
LEDblink | Arduino 1.6.12
檔案 編輯 草稿碼 工具 說明

LEDblink
1 #define LED 4 //LED腳位設定
2 bool Flag = true; //遞增與遞減旗標
3 byte Count = 0; //LED PWM輸出
4 /*****
5     腳位I/O設定
6     *****/
7 void ioPinSetup()
8 {
9     pinMode(LED, OUTPUT); //LED腳位輸出設定
10 }
```

```
12 void setup() { //初始設定
13     ioPinSetup();
14 }
```



```
void loop() { //主迴圈
    if (Flag)
    {
        Count++; //輸出遞增
        digitalWrite(LED, HIGH);
        if (Count == 255) //當輸出為255時切換成遞減模式
            Flag = false;
    }
    else if (!Flag)
    {
        Count--; //輸出遞減
        digitalWrite(LED, LOW);
        if (Count == 0) //當輸出為0時切換成遞增模式
            Flag = true;
    }
    delay(10); //延遲10ms
}
```





練習二：串列輸入

```
1 #define LED 4//LED腳位設定
2 bool Flag = true;//遞增與遞減旗標
3 int ch = 0;
4 /*****
5     腳位I/O設定
6     *****/
7 void ioPinSetup()
8 {
9     pinMode(LED, OUTPUT); //LED腳位輸出設定
10 }
11 void setup() {
12     Serial.begin(115200);//baud 設定
13     ioPinSetup();
14 }
```

```
16 void loop() {
17     ch = Serial.read();//讀取鍵盤輸入
18     if (ch == '0')
19     {
20         Serial.println("Serial Input : 0");//輸出文字
21     }
22     else if (ch == '1')
23     {
24         Flag = !Flag;
25         Serial.println("Serial Input : 1");
26         Serial.println("LED blink");
27         digitalWrite(LED, Flag); //outputValue 0~255
28     }
29 }
```



練習三：馬達控制

```
1 #define motorLB 5
2 #define motorRF 9
3 #define motorLF 10
4 #define motorRB 6
5 int input;
6 int EXinput;
7 int sum = 0;
8 void setup() {
9     Serial.begin(115200);
10    pinMode(motorLF, OUTPUT);
11    pinMode(motorRB, OUTPUT);
12    pinMode(motorRF, OUTPUT);
13    pinMode(motorLB, OUTPUT);
14 }
```



```
void loop() {
    if (Serial.available() > 0)
    {
        input = Serial.read();
        switch (input)
        {
            case '1':
                Serial.print("motorLB = "); Serial.println(sum);
                break;
            case '3':
                Serial.print("motorRB = "); Serial.println(sum);
                break;
            case '7':
                Serial.print("motorLF = "); Serial.println(sum);
                break;
            case '9':
                Serial.print("motorRF = "); Serial.println(sum);
                break;
            case '5':
                Serial.print("ALL = "); Serial.println(sum);
                break;
            case '0':
                Serial.print("ALL = "); Serial.println(0);
                break;
        }
    }
}
```



練習三：馬達控制

```
39     case 43:
40         if (sum != 255)
41             sum += 17;
42         Serial.print("sum = "); Serial.println(sum);
43         break;
44     case 45:
45         if (sum != 0)
46             sum -= 17;
47         Serial.print("sum = "); Serial.println(sum);
48         break;
49     }
50     if (input == 43 || input == 45)
51     {
52         input = EXinput;
53     }
54 }
```

```
55     switch (input)
56     {
57         case '1':
58             analogWrite(motorLB, sum);
59             analogWrite(motorRB, 0);
60             analogWrite(motorLF, 0);
61             analogWrite(motorRF, 0);
62             break;
63         case '3':
64             analogWrite(motorLB, 0);
65             analogWrite(motorRB, sum);
66             analogWrite(motorLF, 0);
67             analogWrite(motorRF, 0);
68             break;
69         case '7':
70             analogWrite(motorLB, 0);
71             analogWrite(motorRB, 0);
72             analogWrite(motorLF, sum);
73             analogWrite(motorRF, 0);
74             break;
```

練習三：馬達控制



```
75     case '9':
76         analogWrite(motorLB, 0);
77         analogWrite(motorRB, 0);
78         analogWrite(motorLF, 0);
79         analogWrite(motorRF, sum);
80         break;
81     case '0':
82         digitalWrite(motorLB, LOW);
83         digitalWrite(motorRB, LOW);
84         digitalWrite(motorLF, LOW);
85         digitalWrite(motorRF, LOW);
86         sum = 0;
87         input = 0;
88         break;
89     case '5':
90         analogWrite(motorLB, sum);
91         analogWrite(motorRB, sum);
92         analogWrite(motorLF, sum);
93         analogWrite(motorRF, sum);
94         break;
95     }
96     EXinput = input;
97 }
```





練習四：MPU6050讀取

加速度

角速度



ax : -794	ay : -364	az : 15504	gx : -116	gy : -20	gz : 10
ax : -794	ay : -364	az : 15504	gx : -116	gy : -20	gz : 10
ax : -816	ay : -352	az : 15484	gx : -119	gy : -30	gz : 8
ax : -772	ay : -366	az : 15490	gx : -114	gy : -32	gz : 7
ax : -772	ay : -366	az : 15490	gx : -114	gy : -32	gz : 7
ax : -796	ay : -378	az : 15490	gx : -114	gy : -31	gz : 11



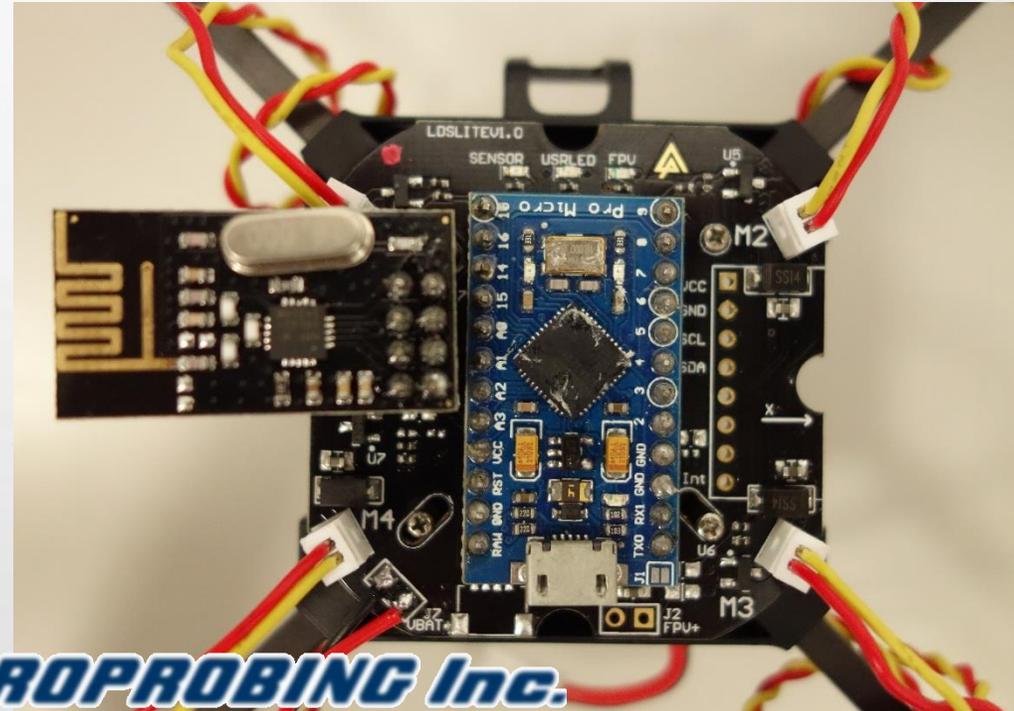
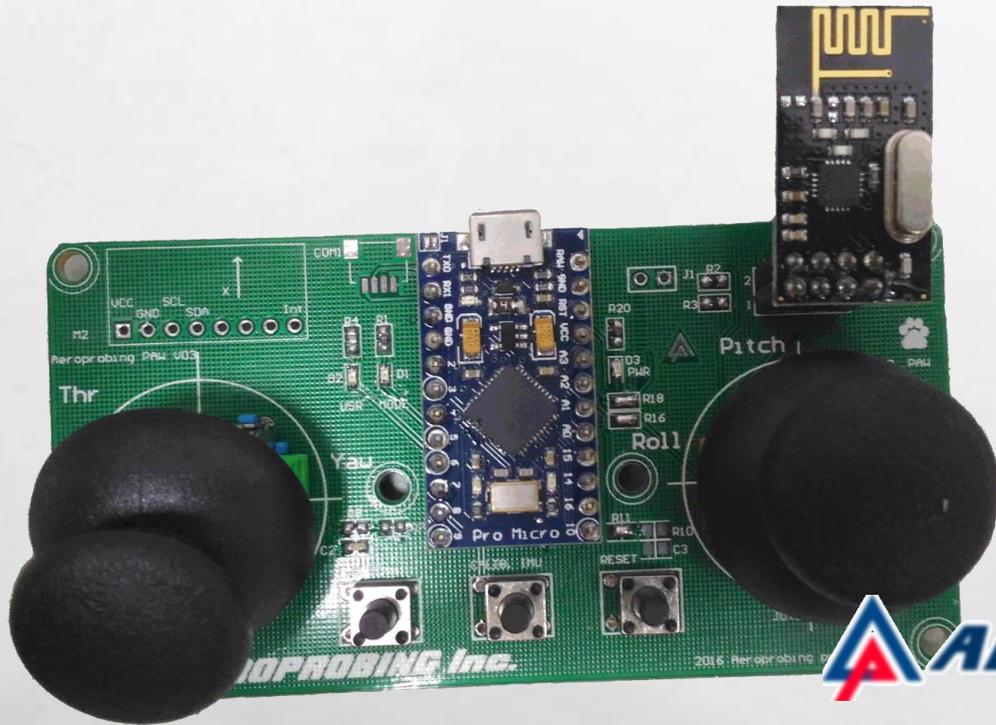
練習四：MPU6050讀取



	Yaw	Pitch	Roll
ypr	59.61	-4.05	4.51
ypr	59.60	-4.03	4.48
ypr	59.61	-4.01	4.44
ypr	59.61	-3.98	4.41
ypr	59.61	-3.96	4.37



練習五：NRF24L01通訊





練習五：NRF24L01通訊

```
RF-master$ 
1 #include <SPI.h>
2 #include "Wire.h"
3 #include "nRF24L01.h"
4 #include "RF24.h"
5 RF24 radio(7, 19); //RF建構子與腳位設定(ce,csn)
6 #define UserChannel 41|
7 const uint64_t pipes[2] = { 0x4080, 0x8040 }; //RF傳輸位址設定
```



練習五：NRF24L01通訊

傳送端

接收端

mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90
mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90
mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90
mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90
mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90
mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90
mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90
mode : 37	Throttle : 0	Yaw :90	Pitch :90	Roll :90	mode 37	Throttle 0	Yaw 90	Pitch 90	Roll 90



PAW 2.4GHZ 遙控器 程式檔燒錄方法



 XLoader	2016/11/14 下午 ...	檔案資料夾
 arduino-1.6.12-windows.exe	2016/11/14 上午 ...	應用程式
 npp.6.9.2.Installer.exe	2016/7/17 下午 0...	應用程式



此安裝檔放在「**LDSLITE**飛控實戰課程安裝軟體」資料夾中

PAW 2.4GHZ 遙控器 程式檔燒錄方法



 avrdude.conf	2016/8/18 上午 1...	CONF 檔案	453 KB
 avrdude.exe	2015/4/16 上午 0...	應用程式	398 KB
 devices.txt	2016/9/14 下午 0...	文字文件	1 KB
 libusb0.dll	2012/3/18 下午 0...	應用程式擴充	43 KB
 license.txt	2012/3/18 下午 0...	文字文件	1 KB
 XLoader.exe	2012/3/18 下午 0...	應用程式	271 KB



開啟**XLOADER**目錄之內容

到ARDUINO 安裝路徑底下搜尋此兩個檔案 並且取代XLOADER.EXE旁原有的兩個檔案



 avrdude.conf	2016/8/18 上午 1...	CONF 檔案	453 KB
 avrdude.exe	2015/4/16 上午 0...	應用程式	398 KB
 devices.txt	2016/9/14 下午 0...	文字文件	1 KB
 libusb0.dll	2012/3/18 下午 0...	應用程式擴充	43 KB
 license.txt	2012/3/18 下午 0...	文字文件	1 KB
 XLoader.exe	2012/3/18 下午 0...	應用程式	271 KB





修改燒錄程式組態檔方法

- **AVRDUDE.CONF**檔案位置：
C:\PROGRAM FILES (X86)\ARDUINO\HARDWARE\ARDUINO\AVR\BOOTLOADERS\GEMMA
- **AVRDUDE.EXE**檔案位置：
C:\PROGRAM FILES (X86)\ARDUINO\HARDWARE\TOOLS\AVR\BIN



開啟**XLOADER.EXE**並選擇**LEONARDO(32U4)**，並設定**BAUD**為**57600**、以及**HEX**檔案位置**COM**不需要設定

The screenshot shows the Xloader v... application window. At the top right is the AeroProbing Inc. logo. The interface includes the following fields and controls:

- Hex file:** A text box containing the path `C:\Users\StevenHsu\Desktop\A...` with a browse button (...).
- Device:** A dropdown menu currently showing `Leonardo(32U4)`.
- COM port:** A dropdown menu currently showing `COM6`.
- Baud rate:** A text box containing the value `57600`.
- Buttons:** `Upload` and `About` buttons.
- Status:** A message at the bottom left reads `Upload failed`.

Red boxes highlight the Hex file path, the Device dropdown, and the Baud rate field. A blue box highlights the COM port dropdown.

HEX檔案位置: 「LDSLITE飛控實戰程\AEROPROBING_PAW」



【學員編號】 通訊位址 通訊CHANNEL



✓ (01)0x1611_0x1116	Channel 1	2016/11/14 下午 ...	檔案資料夾
✓ (02)0x1774_0x7417	Channel 5	2016/11/14 下午 ...	檔案資料夾
✓ (03)0x1971_0x7119	Channel 9	2016/11/2 上午 1...	檔案資料夾
✓ (04)0x2420_0x2024	Channel 13	2016/11/2 上午 1...	檔案資料夾
✓ (05)0x2548_0x4825	Channel 17	2016/11/2 上午 1...	檔案資料夾
✓ (06)0x2573_0x7325	Channel 21	2016/11/2 上午 1...	檔案資料夾
✓ (07)0x2587_0x8725	Channel 25	2016/11/2 上午 1...	檔案資料夾
✓ (08)0x2641_0x4126	Channel 29	2016/11/2 上午 1...	檔案資料夾
✓ (09)0x2710_0x1027	Channel 33	2016/11/2 上午 1...	檔案資料夾
✓ (10)0x3128_0x2831	Channel 37	2016/11/2 上午 1...	檔案資料夾
✓ (11)0x4080_0x8040	Channel 41	2016/11/2 上午 1...	檔案資料夾
✓ (12)0x4090_0x9040	Channel 45	2016/11/2 上午 1...	檔案資料夾
✓ (13)0x4341_0x4143	Channel 49	2016/11/2 上午 1...	檔案資料夾



將**PAW** 搖控器重置 **(RESET)** 便能夠進入 **BOOTLOADER** 模式



按下此按鈕便能夠將重置 **(RESET)** 系統



回到XLOADER重新選擇COM

Xloader v... — □ ×

 **AEROPROBING Inc.**

Hex file
C:\Users\StevenHsu\Desktop\A... ..

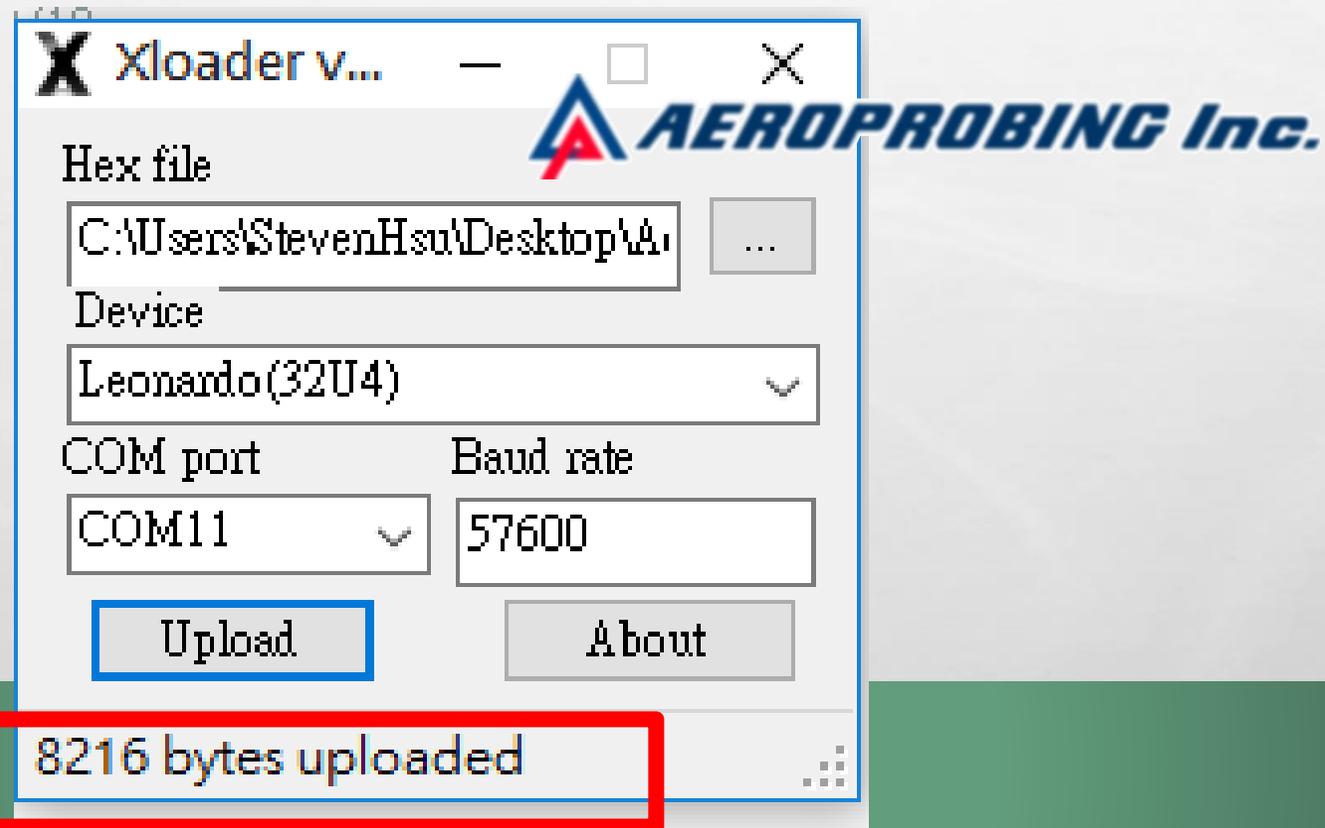
Device
Leonardo (32U4) ▾

COM port Baud rate
COM6 57600
COM11

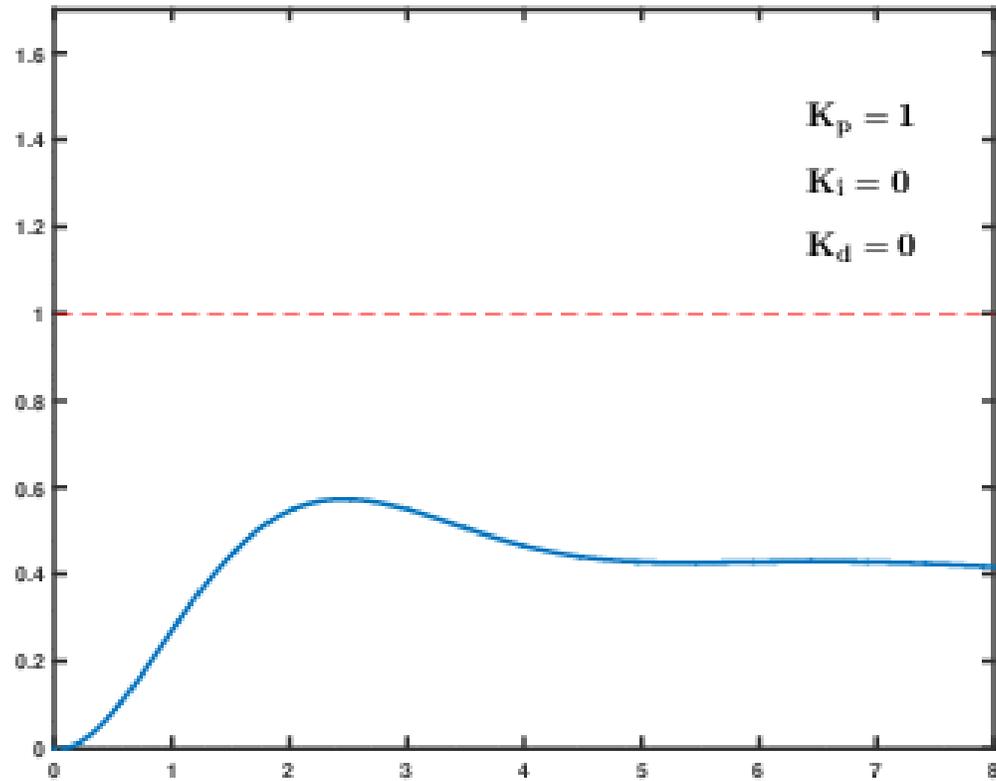
Upload About

Upload failed

按下按鈕之後馬上**UPLOAD** 因為 **BOOTLOADER** 模式只維持**5**秒左右，上傳的動作要快速，完成後會顯示上傳的資料量

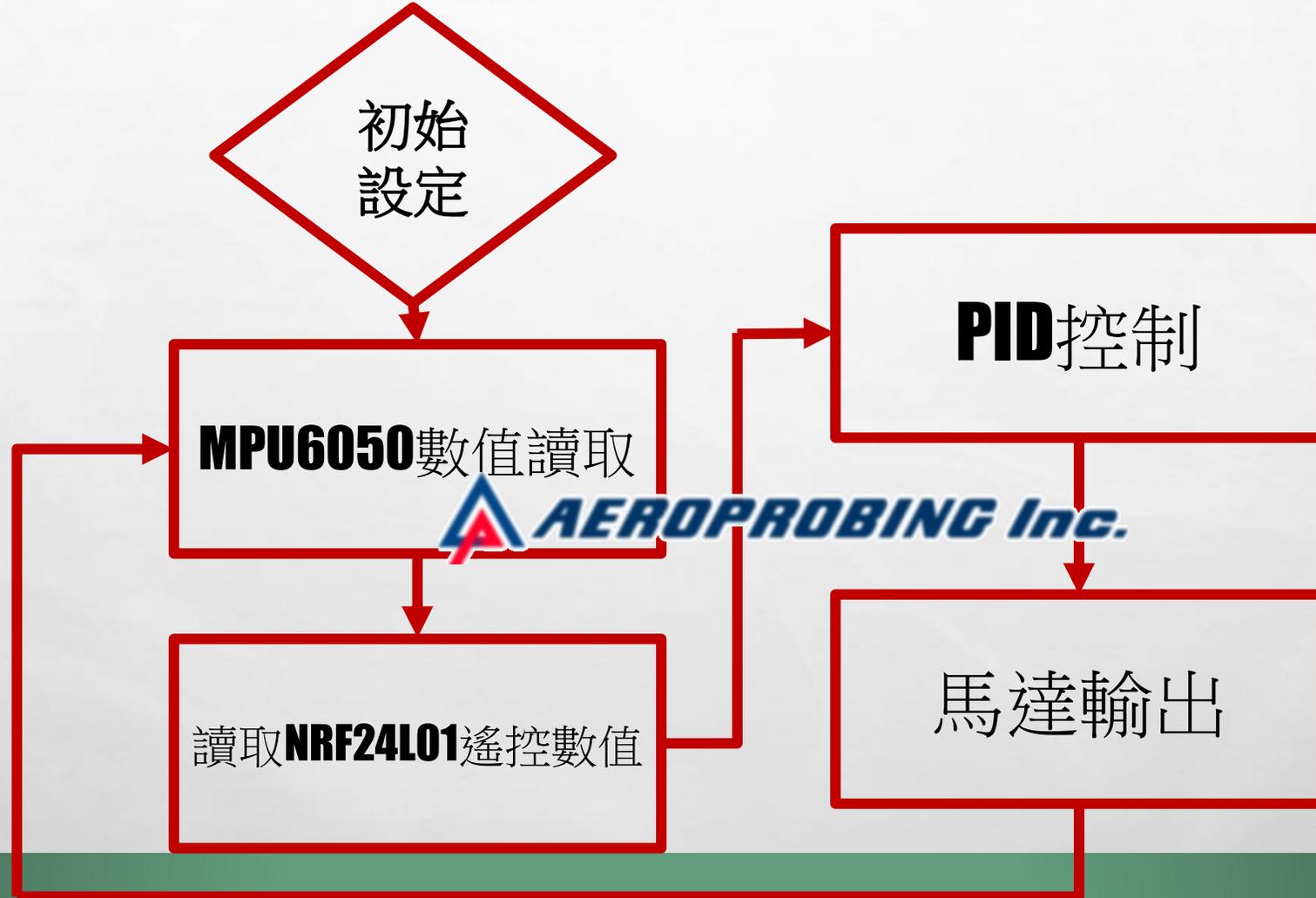


飛控軟體整合實作



$$u(t) = MV(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t)$$

LDSLITE 飛控流程講解



LDSLITE 飛控流程講解

```
70 void loop()
71 {
72   accelgyro.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);
73   yprGetValue(); //角度轉換取得Yaw,Pitch,Roll
74   APB_allSetToZero();//YPRT歸零與積分器歸零
75   APB_throttleLock();
76   if (radio.available() && !channelReadFlag)
77   {
78     APB_rfReadData();//讀取資料
79     readDataBuffer = readData;
80   }
81   else if (!radio.available() && !channelReadFlag)
82   {
83     readData = readDataBuffer;
84     APB_rfLost();//掉線時遞減油門
85   }
```

```
if (!PIDFlag) //不調整PID
{
  APB_SetBalance();//YPRT歸零與積分器歸零或是矯正陀螺儀
  APB_getYPRT(); //取得飛行數據
  APB_pidCalculate();//PID計算
  APB_motorOutput();//馬達輸出
}
else if (PIDFlag)//調整PID
{
  APB_pidSetting(); //取得Kp in,Ki in,Kd in數值
}
APB_LEDblink();
```



LDSLITE 飛控軟體整合實作



 Aeroprobing LDS MUAV	2016/8/6 上午 08...	檔案資料夾
 Library	2016/7/7 下午 04...	檔案資料夾
 MPU6050_calibration	2016/9/7 下午 02...	檔案資料夾
 練習題	2016/6/29 下午 0...	檔案資料夾
 arduino-1.6.11-windows.exe	2016/9/7 下午 01...	應用程式
 npp.6.9.2.Installer.exe	2016/7/17 下午 0...	應用程式





複製資料夾位置

貼簿 組合管理 新增 開啟 選取

C:\Users\StevenHsu\Desktop\Class\中階課程教案\全天課程\中階課程軟體\Aeroprobing LDS MUAV\MUAV

名稱	修改日期	類型	大小
 AeroprobingLDS.a	2016/7/17 下午 1...	A 檔案	656 KB
 AeroprobingLDS.h	2016/7/13 下午 0...	H 檔案	3 KB
 MUAV.ino	2016/7/15 上午 1...	Arduino file	4 KB

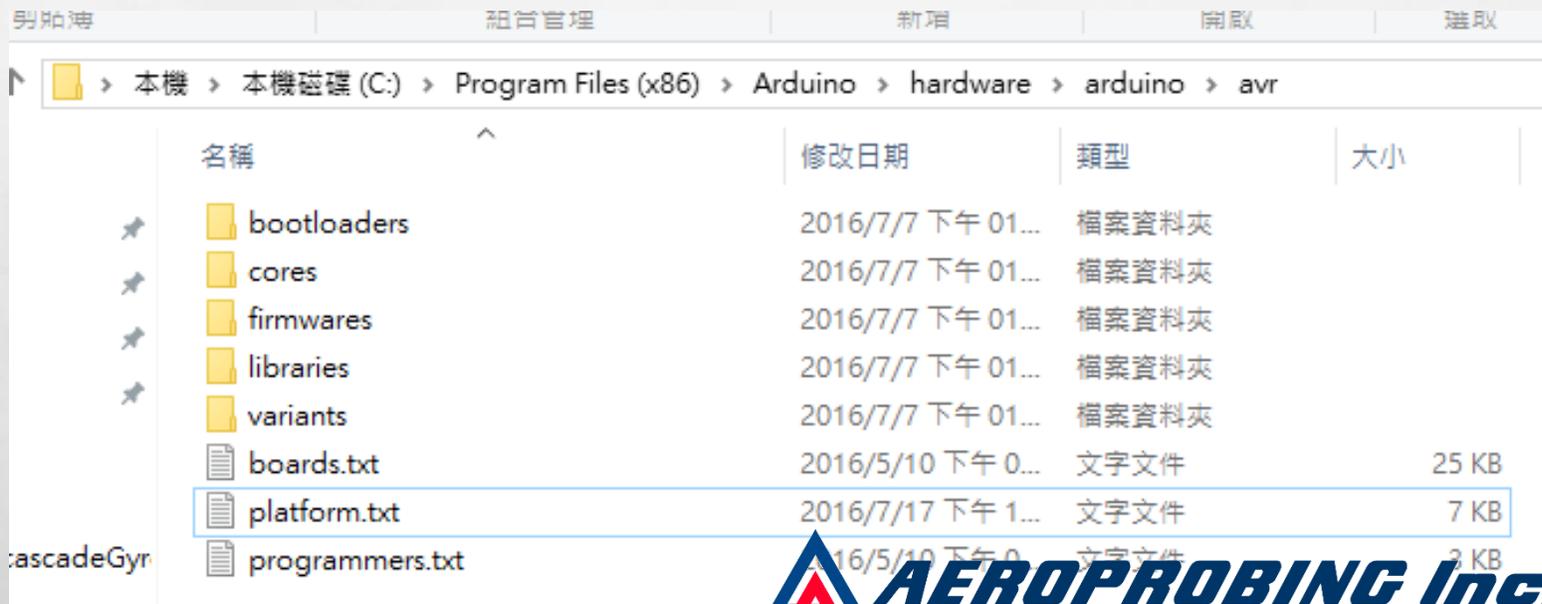
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進入下列位置並使用**NOTEPAD++**開啟**PLATFORM.TXT**

C:\PROGRAM FILES

(X86)\ARDUINO\HARDWARE\ARDUINO\AVR





在**COMBINE GCC-SECTIONS, ARCHIVES, AND OBJECTS**[第**68**行]底下加上**AEROPROBINGLDS.A**的檔案[必須儲存才有效]



```
"-L{build.path}" "C:\Users\StevenHsu\Desktop\Class\中階課程教案\全天課程\中階課程軟體\Aeroprobing LDS MUAV\MUAV\AeroprobingLDS.a" -lm
```

開啟MUAV.INO



```
14 float Kpout[3] = { //Kp{ Yaw , Pitch , Roll }  
15     0.08, 2.2, 2.2  
16 };  
17 float Kiout[3] = { //Ki{ Yaw , Pitch , Roll }  
18     0.003, 0.003, 0.003  
19 };  
20 float Kdout[3] = { //Kd{ Yaw , Pitch , Roll }  
21     0.06, 0.029, 0.029  
22 };
```



更改自己的傳輸位址

```
3 #endif  
4 const uint64_t pipes[2] = { 0x1611, 0x1161 }; //RF傳輸位址設定
```

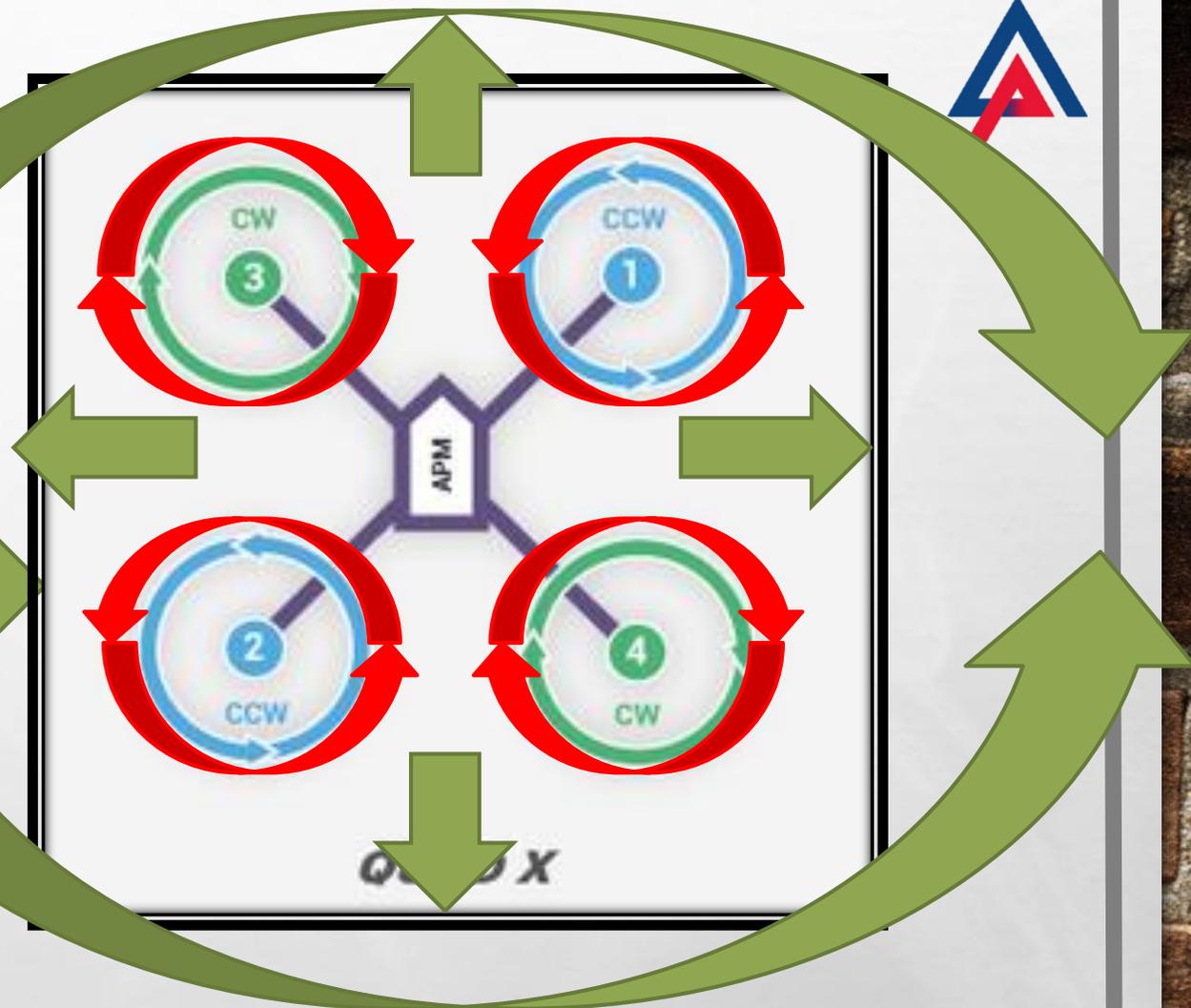
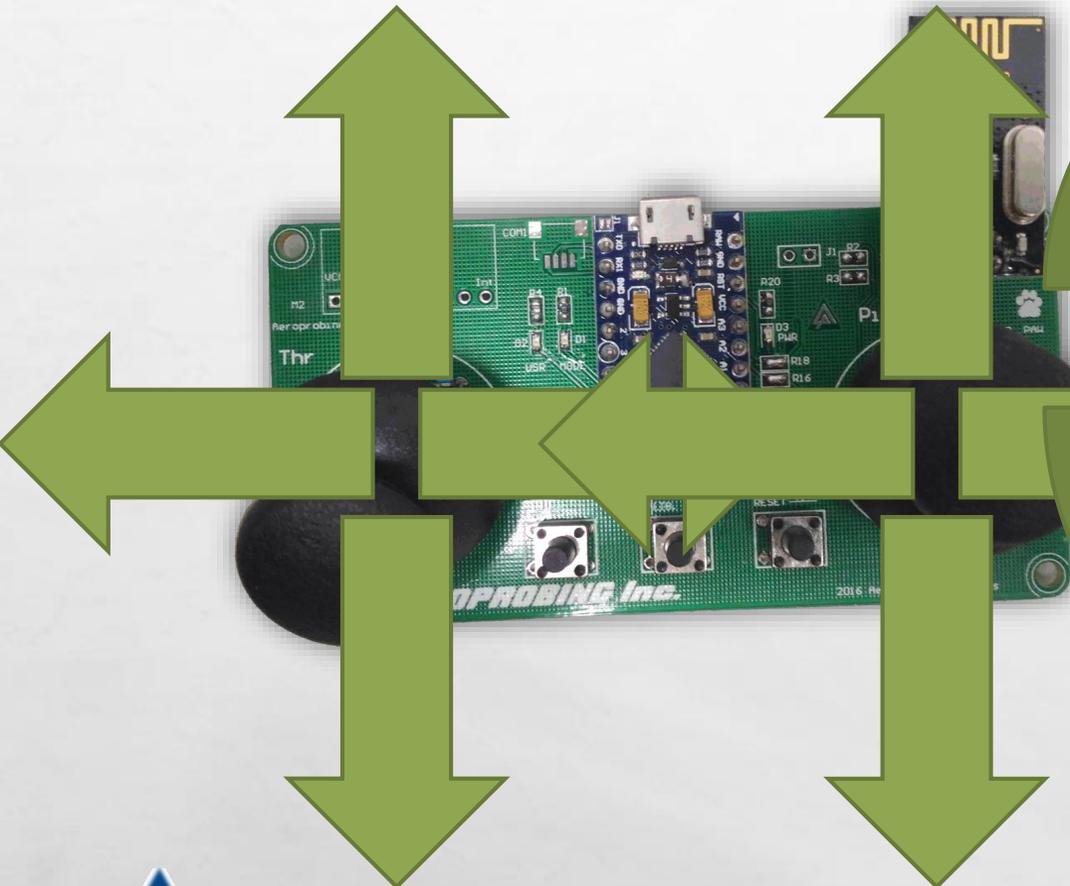


開啟AEROPROBINGLDS.H



```
85  **/  
86  #define UserChannel 110  
87  #define readDataSize 6  
88  #define sendDataSize 4  
89  extern bool AllSetToZero;  
90  extern float RF_YPR[3];
```

更改自己的傳輸**CHANNEL**



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遙控器操作教學



CALIB. IMU 按鈕可以校正陀螺儀
F.MODE 按鈕可以調整控制幅度





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