HY16F3981

紅外線測溫應用說明書

Infrared Thermopile Measurement Application Note

Table of Contents

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1. 內容簡介

常見的紅外線感測器應用可分為醫療、工業、消費性用途，如耳溫槍、額溫槍、工業用溫度儀、紅外線溫度計…等。在耳溫槍應用中，需注意紅外線感測器進入耳中的升溫效應、導波管與感測器的連接方式…等。在紅外線溫度計應用中，需注意待測物距離、透鏡的聚焦距離…等。

HY16F3981 晶片內建儀表放大器(Instrumentation Amplifier)具有高輸入阻抗特性與 Sigma-delta 24 Bit ADC 具有高精度訊號量測特性，因此 HY16F3981 非常適用於高輸入阻抗與小電壓訊號(uV)的量測應用，典型的應用為紅外線測溫。本文介紹使用 HY16F3981 晶片搭配紅外線感測器(IR Sensor)完成紅外線測溫應用。

2. 原理說明

2.1. 紅外線波長介紹

依紅外線的波長範圍和紅外線輻射源可區分：

近紅外線(Near Infra-red, NIR)；700~2,000nm

中紅外線(Middle Infra-red, MIR)；3,000~5,000nm

遠紅外線(Far Infra-red, FIR)；8,000~14,000nm

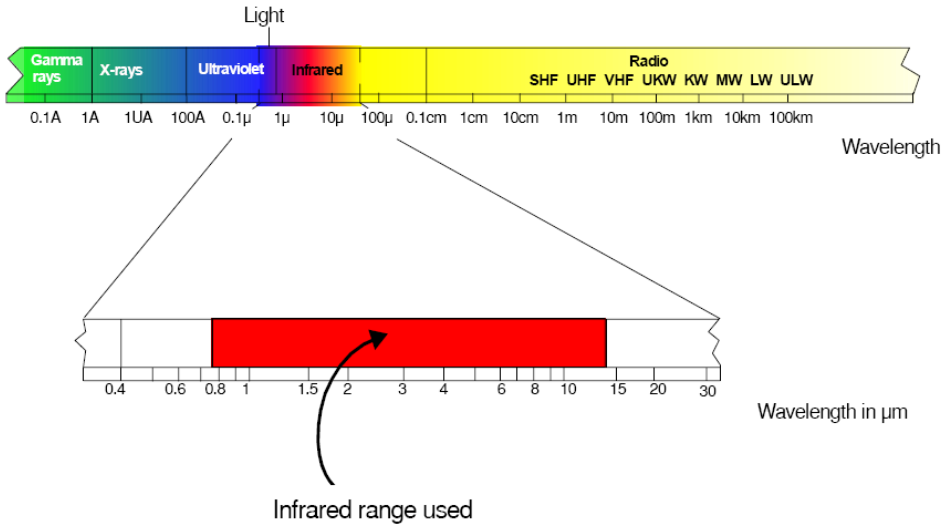


圖 1 波長頻譜圖，紅外線常用的量測波長範圍：700nm~14000nm

2.2. 量測光點與視窗

在光學系統中，量測目標物的能量唯一關鍵因素，因此目標物必須完全包含著光點，能量與量測的距離、光點面積大小存在著一定的關係，距離越遠偵測器接受到的能量越小，光點面積越大。

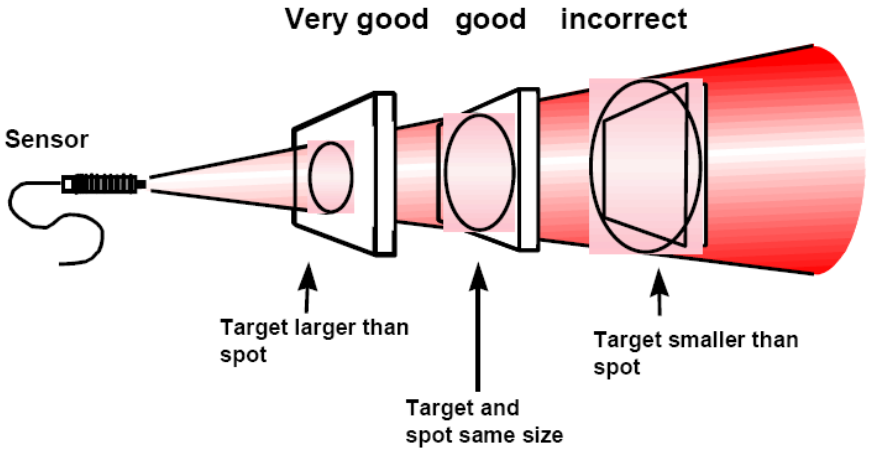


圖 2 目標物必須完全包含著光點，否則量測數據會錯誤

2.3. 感測器簡介

紅外線傳感器(IR sensor)簡介:

由兩個介面元件組成，分別為 Thermopile 及 Thermistor，兩者封裝如圖 。

圖 3 紅外線溫度傳感器

Thermopile：

輸出小電壓，其電壓值由目標物溫度及 Thermopile 所在環境溫度決定((圖))。建議解析度 0.01℃的精準度。使用於環溫 25℃校正時絕對誤差在±0.03℃內。其為半導體材料製作而成的感測器，故容易受溫度而影響其測量數值。良好的 IR Sensor 其 Thermopile 的數學模式如下

$$V_{out} = K \times [(T_t + 273.13)^4 - (T_a + 273.13)^4]$$
$$= K \times f(T_t, T_a) \quad \text{.....公式(1)}$$
$$= K \times [f(T_t, T_{ref}) - f(T_a, T_{ref})]$$

Vout：Thermopile 輸出電壓

K：Sensitivity of Thermopile

Tt：Target Temperature (℃)

Ta：Ambient Temperature (℃)

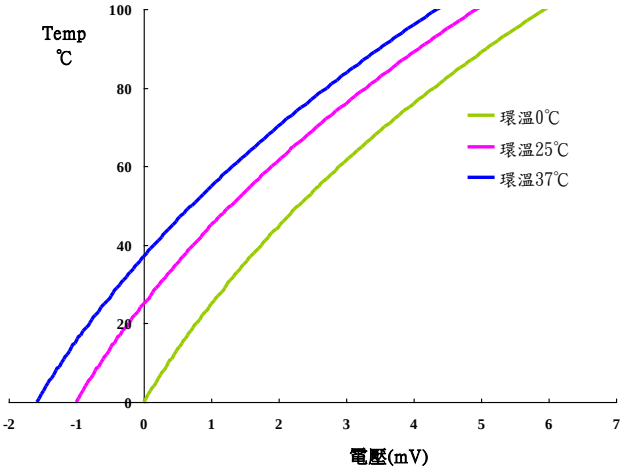


圖 4 Thermopile 電壓與溫度曲線

Good Thermopile 會有以下兩個特性

- Tt=Ta 時, Vout=0
- K 為常數, 不隨環境溫度而改變

Thermistor：

隨其所在之溫度改變而有電阻變化(圖)，用來監視 IR sensor 內部溫度。在此亦稱之為量測時的環境溫度。建議測量誤差及重複性< 0.05°C。

Thermistor 的數學模式如下

$$R_{th}(T) = R_{25} \times e^{\{B\times[(\frac{1}{T+273.13})-(\frac{1}{25+273.13})]\}} \quad \text{.....公式(2)}$$

$R_{th}(T)$：Thermistor 變化電阻值

B：Sensitivity of Thermistor

R_{25}：25℃電阻值

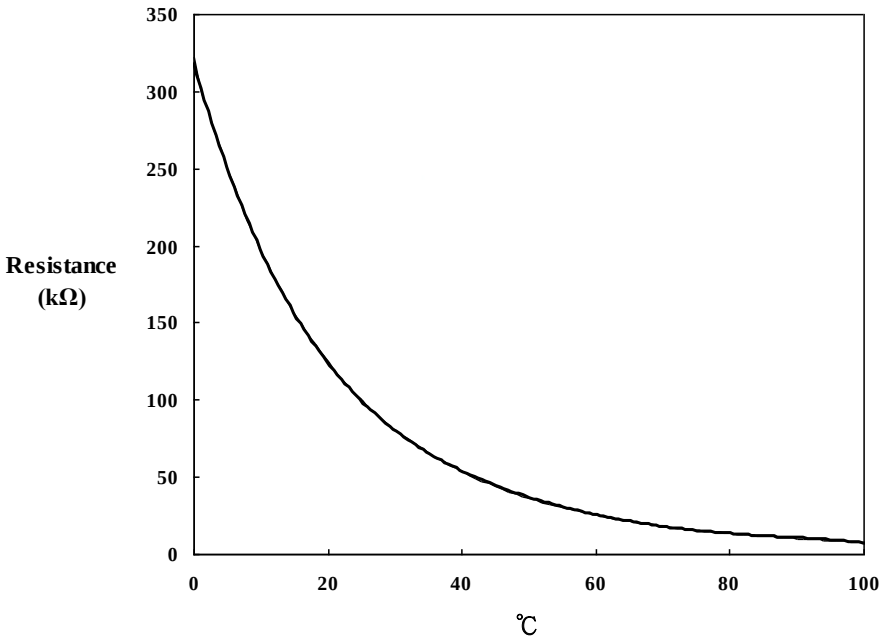


圖 5 Thermistor 電阻與溫度曲線

2.4. 控制晶片

利用紅外線傳感器(IR Sensor)做為溫度訊號的擷取來源，轉換為電阻與為小電壓訊號(uV)，經由 HYCON 的晶片 HY16F3981 量測訊號，做運算與數位訊號輸出，顯示目標溫度，以最少元件達成紅外線量測方案，(如下圖 6) 。

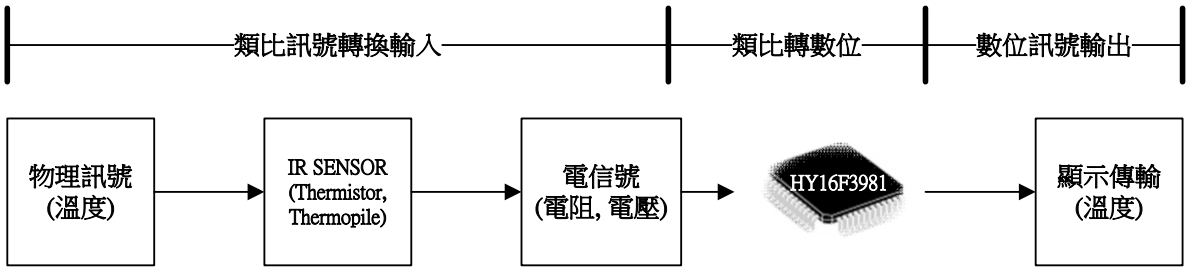


圖 6　HY16F3981 紅外線傳感器量測方案，類比與數位訊號轉換

HY16F3981 晶片簡介 ：

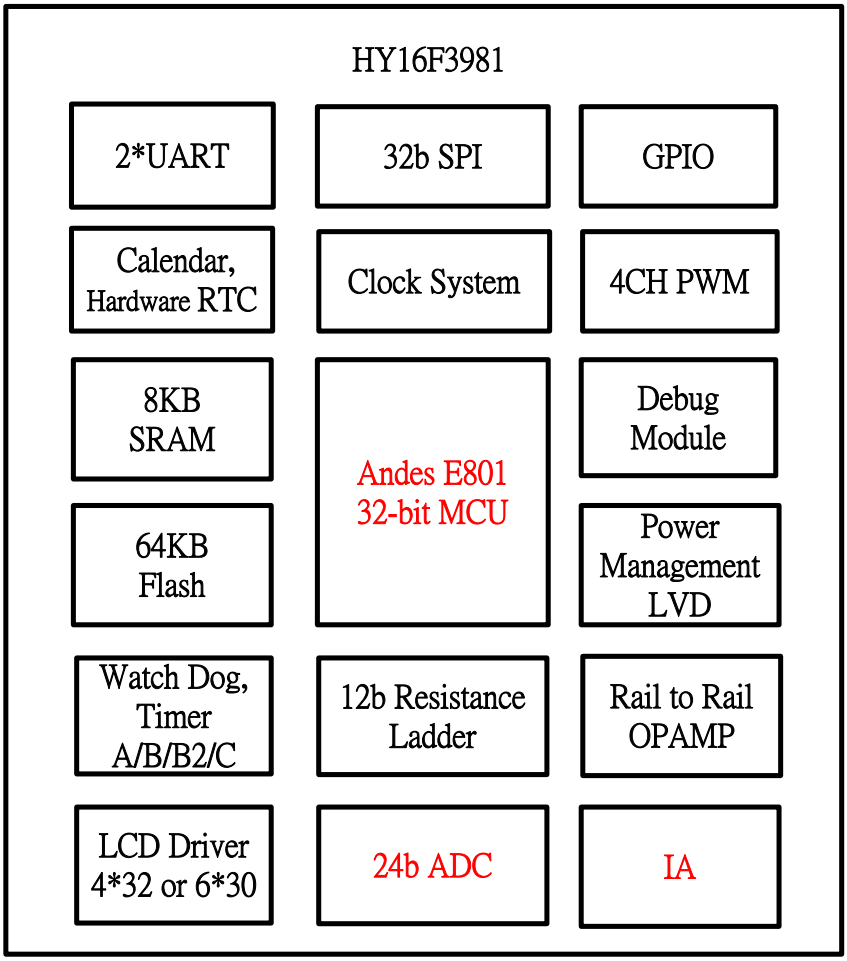


圖 7 HY16F3981 應用晶片方塊圖

(01)採用晶心科技 Andes 32 位元 CPU 核心 E801 處理器。

(02)電壓操作範圍 2.2~3.6V(類比電源沒開啟情況下)，以及-40℃~85℃工作溫度範圍。

(03)支援外部 16MHz 石英震盪器或內部 16MHz 高精度 RC 震盪器，

(04)程式記憶體 64K-Byte Flash ROM

(05)資料記憶體 8K-Byte SRAM。

(06)擁有 BOR and WDT 功能，可防止 CPU 死機。

(07)24-bit 高精準度 ΣΔADC 類比數位轉換器

(ADC Clock=1MHz@30sps, gain=256 (IA*ADGN), IA HW Chopper On, 0.1uV input RMS noise)

(7.1)內置 IA (Instrumentation Amplifier), 最大輸入放大倍率高達 32*8=256 倍放大。

(7.2)內置溫度感測器 TPS。

(08)內建 1 組 R2ROPA 運算放大器。

(09)內建硬體 12-bit Resistance Ladder(DAC)。

(10)16-bit Timer A

(11)16-bit Timer B/B2 模組具 PWM 波形產生功能

(12)16-bit Timer C 模組具數位 Capture 功能

(13)硬體串列通訊 32-bit SPI /UART*2 模組

(14)硬體 RTC 時鐘功能模組

(15)LCD 驅動模組

3. 系統設計

3.1. 硬體說明

HY16F3981 在紅外線測溫應用方案提供完整開發套件，系統架構圖如下 ：

1. HW : HY16F3981 IR Demo Board.
2. FW : HY16F3981 IR Demo Code.
3. SW : HY16F3981-AM01-V00(UART) GUI

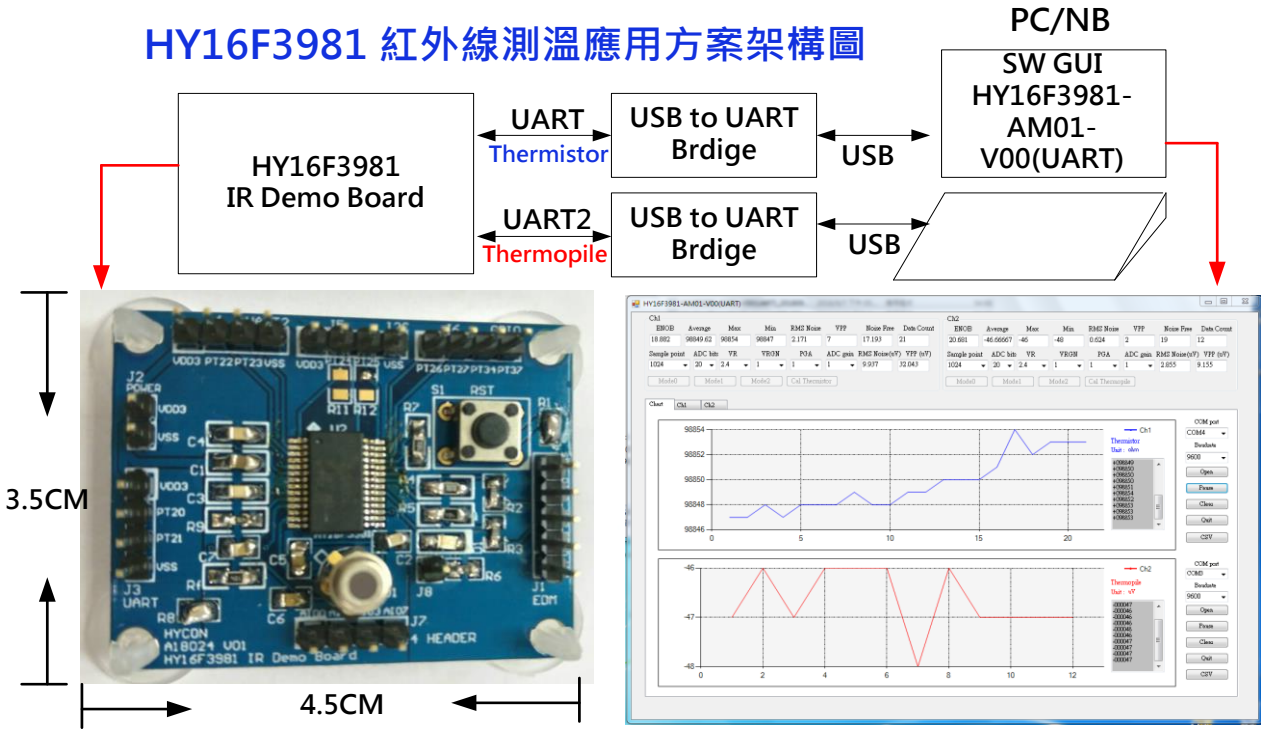


圖 8 HY16F3981 紅外線測溫應用方案架構圖

HY16F3981 IR Demo Board 硬體線路圖如下 ：

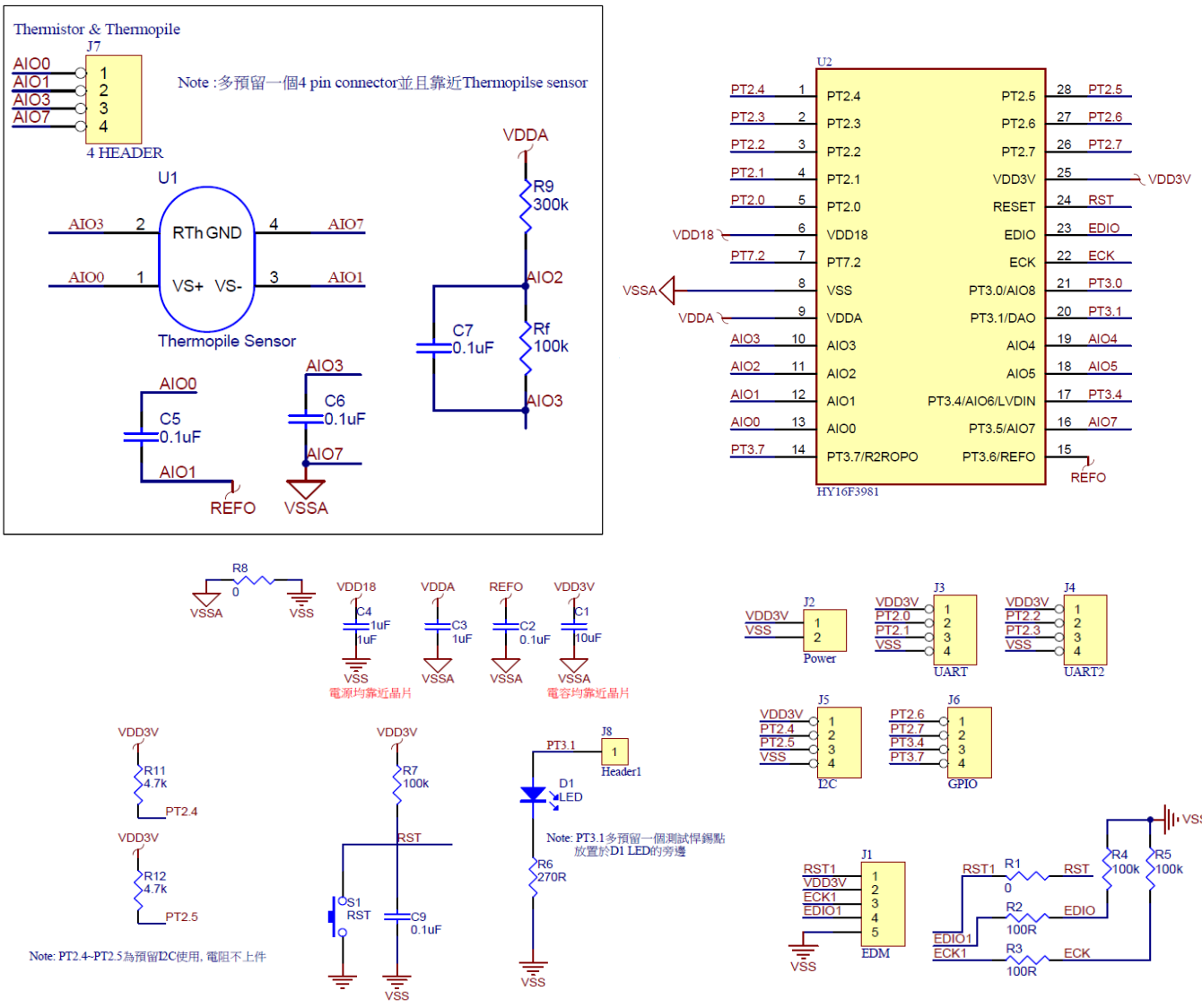


圖 9 HY16F3981 IR Demo Board 硬體線路連接圖

主要元件介紹 ：

(1)MCU:HY16F3981，Andes 32-bit MCU Core + HYCON 24-bit ΣΔADC & IA+ MCU 64K Flash 。

(2) J1 Port:連接 HY16F mini link，HY16F3981 程式開發與除錯使用。

(3) J3&J4 Port:負責把量測到的 Thermistor 與 Thermopile 數據透過 UART 與 UART2 傳輸。

(4) J5&J6 Port : I2C&GPIO 傳輸預留使用。

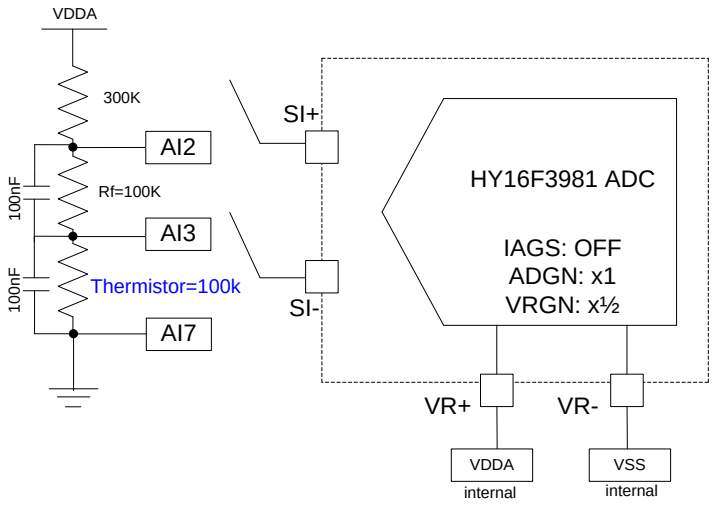
(5) J7 Port : 連接 Thermistor 與 Thermopile 傳感器。

(6) J8 Port : 利用 PT3.1 腳位做控制，得到一筆完整的 Thermistor & Thermopile 資料，PT3.1 會做 High/Low 變化，可做為資料傳輸輸出率的辨別。

(7) R9 分壓電阻 & RF 參考電阻 ： 分壓電路設計使用，主要是用於量測 Thermistor 通道資料。

(8)傳感器 Thermopile Sensor : AI0-AI1 通道連接 Thermopile，AI3-AI7 通道連接 Thermistor。

Thermistor 電阻量測 ：

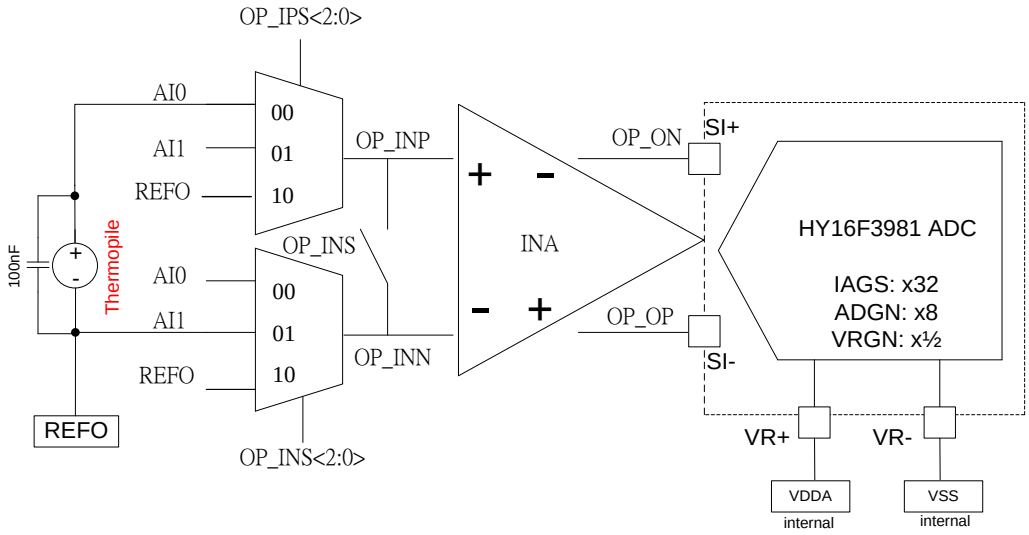


HY16F3981 的 VDDA 類比電源典型輸出為 2.4V，透過 300k 分壓電組，可讓 RF 參考電阻 100k 與 Thermistor 電組 100k 的電壓大小控制在 ADC 可量測的電壓訊號範圍內。利用 Thermistor 的電阻值查表換算出環境溫度， Thermistor 的電阻值可以利用與 RF 參考電組的比值來比出。 以下為 ADC 量測 RF 參考電阻與 Thermistor 電阻的 ADC RAW DATA 計算過程 ：

ADC_RF_P = AI2-AI3
Comb Filter Reset
ADC_RF_N =AI3-AI2
做 ADC Chopper 扣除 offset 雜訊運算
ADC_RF(100k)= (ADC_RF_P- ADC_RF_N)/2

Comb Filter Reset
ADC_RS_P= AI3-AI7
Comb Filter Reset
ADC_RS_N= AI7-AI3
做 ADC Chopper 扣除 offset 雜訊運算
ADC_RS(Thermistor)=(ADC_RS_P- ADC_RS_N)/2
先利用 ADC_RF 與 ADC_RS 的比值換算出電阻值，再利用電阻值查表算出環境溫度。

Thermopile 小電壓量測 ：

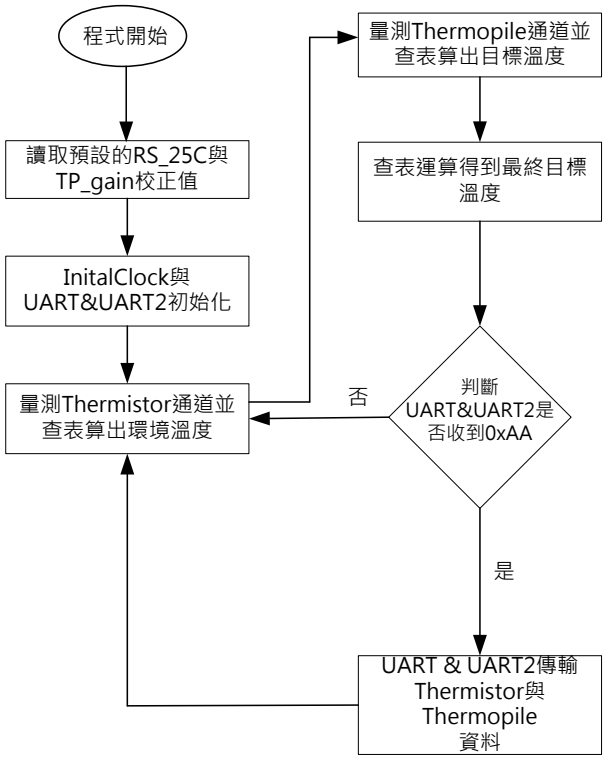


如果使用 IA chopper on 來做訊號測量，得到的每一筆 ADC 資料都已經是硬體 Chopper 處理過的 ADC 資料，所以不需再透過軟體的方式來做 Chopper，因此 Thermopile 的 ADC RAW DATA 資料量測過程如下 ：
ADC_TP=AI0-AI1 (IA chopper On)
但是在 IA chopper on 開啟的情況下，如果量測訊號源的輸入阻抗超過 10k 歐姆，會有 ADC 的精度衰減的問題發生，為了追求更高與更精準的 Thermopile 量測，在此提供 IA Chopper Off 的另一種選擇方式，需要透過軟體的方式處理來做 Chopper，也是利用速度來換取精度的方式。
ADC_TP_P=AI0-AI1
Comb Filter Reset
ADC_TP_N=AI1-AI0
ADC_TP=(ADC_TP_P-ADC_TP_N)/2, (IA chopper Off)

利用 ADC_TP，先換算出量測到的微小電壓值，再把得到的微小電壓值(uV)查表做查表換算出目標溫度。

3.2. 軟體說明

FW : HY16F3981 IR Demo Code 程式流程圖如下 ：



以下為 UART 傳輸通訊格式 ：

1. 當 UART 與 UART2 分別收到 0xAA 之後，會開始個別丟出 Thermistor 與 Thermopile 的通道資料到 Host 端

2. UART 與 UART2 傳輸模式 command 切換如下

UART Mode0 : 0xa9, 0xa2, 0x01, 0x0e, 0x01. RS resistance. unit : ohm
UART Mode1 : 0xa9, 0xa2, 0x01, 0x0e, 0x0B. TH temperatur. Unit : temp
UART Mode2 : 0xa9, 0xa2, 0x01, 0x0e, 0x0D. AIO3-AIO7 ADC Count
UART Cal Thermistor : 0xa9, 0xa2, 0x01, 0x0c, 0x05. Cal Thermistor

UART2 Mode0 : 0xa9, 0xa2, 0x01, 0xe0, 0xA1. TP voltage. unit : uV
UART2 Mode1 : 0xa9, 0xa2, 0x01, 0xe0, 0xAB. TP temperatur. Unit : temp
UART2 Mode2 : 0xa9, 0xa2, 0x01, 0xe0, 0xAD. AIO0-AIO1 ADC Count
UART2 Cal Thermopile : 0xa9, 0xa2, 0x01, 0xc0, 0xA5. Cal Thermopile

4. GUI 軟體操作

4.1. 硬體連接說明

SW : HY16F3981-AM01-V00(UART) GUI，需搭配 FW : HY16F3981_IR_DemoCode_V00 使用.

UART 傳輸 Thermistor 資料，UART2 傳輸 Thermoile 資料，HY16F3981 IR Demo Board 硬體實體連接如下圖。

在本文中使用 FTDI FT232R 這一顆 USB to UART Bridge 與 J3 Port 連接負責接收 Thermistor 資料，該晶片可以輸出 3.3V 電壓，直接供給 HY16F3981 晶片，J4 port 則連接第二組 USB to UART Bridge 負責接收 Thermopile 資料。

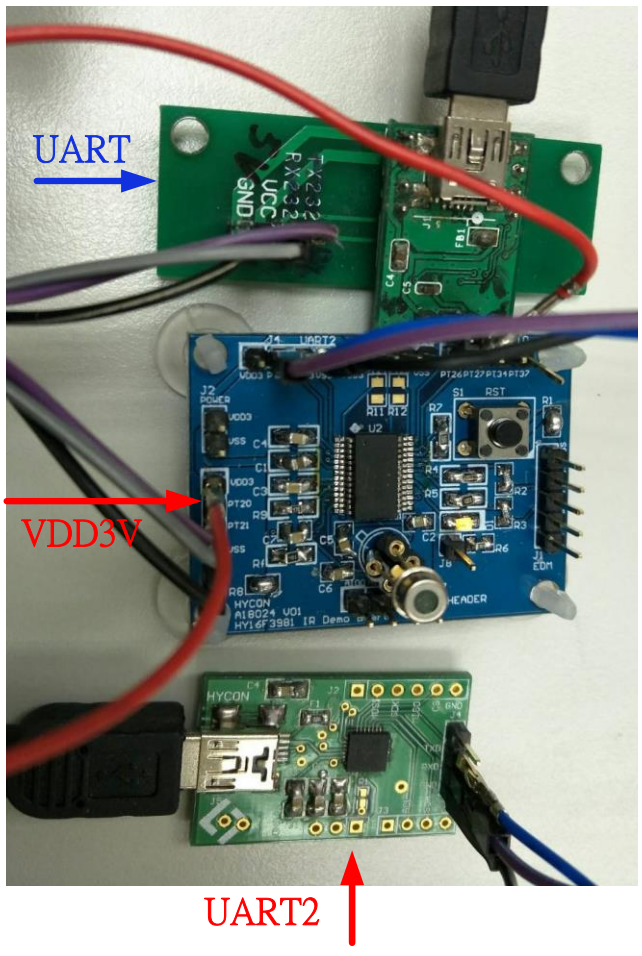


圖 10 HY16F3981 IR Demo Board 硬體實體連接圖

4.2. 軟體顯示介面

GUI 操作畫面如下圖，可同時掃描 Thermistor 與 Thermopile 共兩通道資料，圖形化界面做資料顯示。

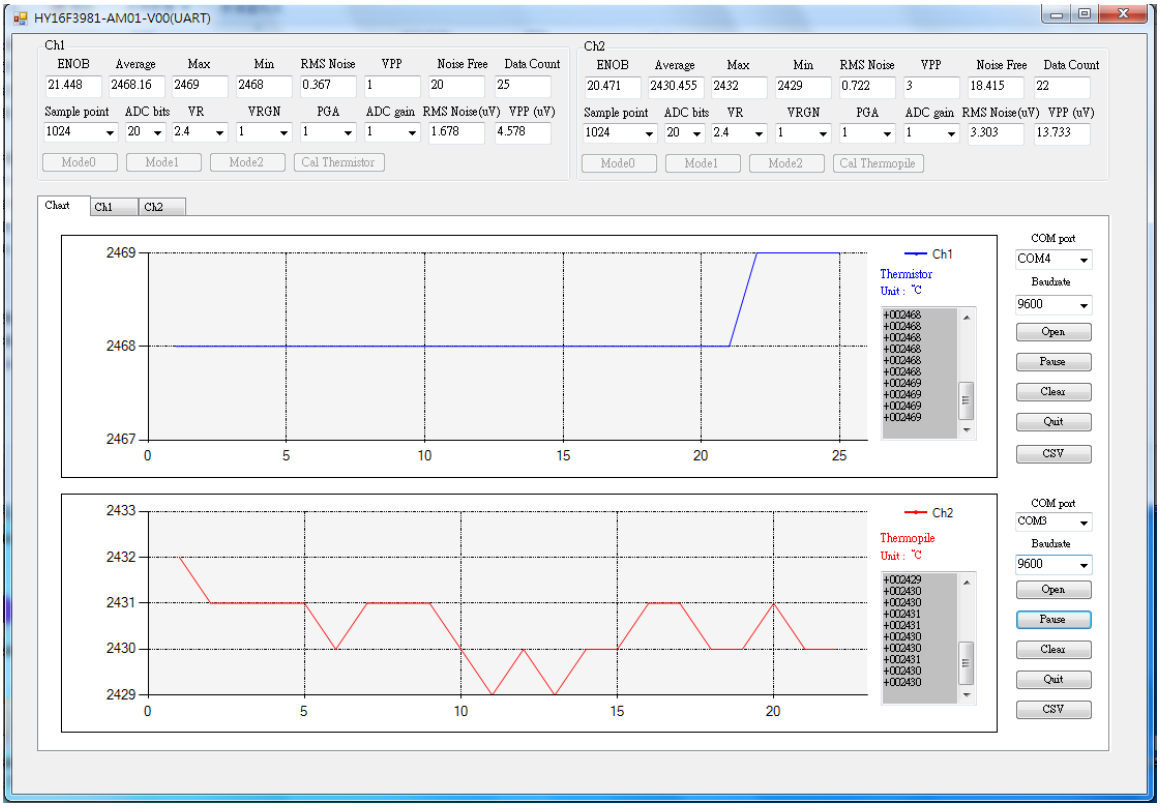


圖 11 GUI HY16F3981-AM01-V00(UART)操作畫面

注意 1:開啟 COM port 所對應到的 COM port 號碼需要是對應到 Thermistor 與 Thermopile 對應的 Port。以本文為例，從裝置管理員中可看到兩組 COM port，COM4 是連接到 UART，對應到 Thermistor 通道，COM3 是連接到 UART2，對應到 Thermopile 通道。

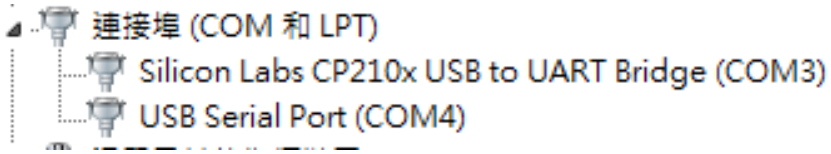


圖 12 電腦裝置管理員下觀察到的 COM Port 狀態

4.3. 軟體操作說明

HY16F3981-AM01-V00(UART) GUI 分別提供 Thermistor 與 Thermopile 通道在幾個不同 Mode 下的資料顯示，如下圖所示。

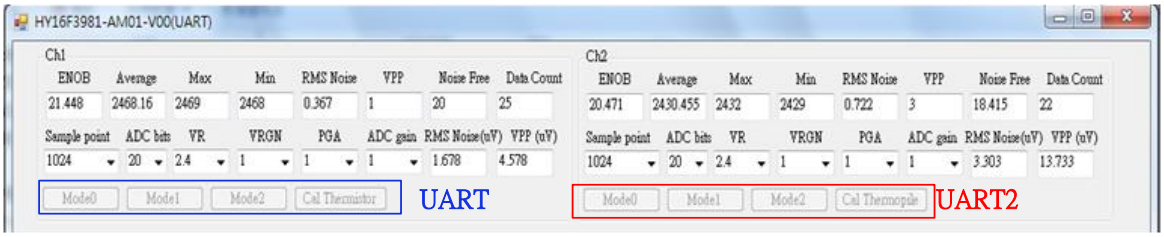


圖 13 Thermistor 與 Thermopile 切換不同 Mode 的模式

Thermistor(Ch1) 功能說明 ：

Mode0 ： 顯示測量到的 Thermistor 電阻. unit : ohm

Mode1 :顯示測量到的 Thermistor 環境溫度. unit : temp

Mode2 ： 顯示量測到的 AIO3-AIO7 ADC Count. unit : Count

Cal Thermistor ： 校正 Thermistor 電阻. (校正溫度 25C)

Thermopile(Ch2) 功能說明

Mode0:顯示測量到的 Thermopile 電壓. unit : uV

Mode1:顯示測量到的 Thermopile 目標溫度. unit : temp

Mode2:顯示量測到的 AIO0-AIO1 ADC Count. unit : Count

Cal Thermopile: 校正 Thermopile 電壓. (外部輸入電壓)

參考如下圖，使用者於傳輸資料中，設定 Thermistor 與 Thermopile 都工作於 Mode2，顯示溫度值. 顯示數值 2500 代表 25.00 度.

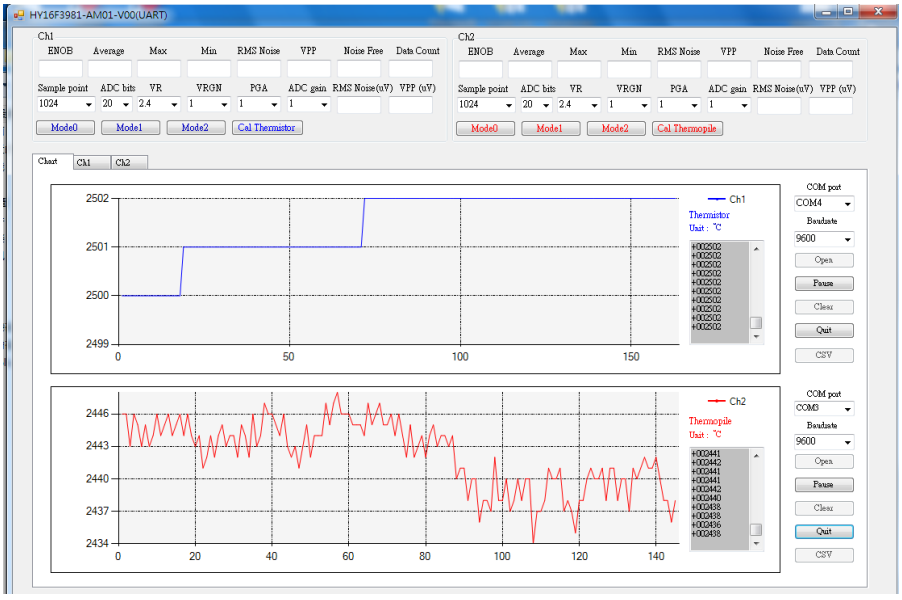


圖 14 Thermistor 通道與 Thermopile 通道顯示溫度(單位:度 C)

參考如下圖，使用者於傳輸資料中，手觸碰 IR Sensor，讓 IR Sensor 感受到溫度變化. 設定 Thermistor 與 Thermopile 都工作於 Mode0. Thermistor 通道顯示電阻值(單位: ohm), Thermopile 通道顯示電壓值(單位: uV).

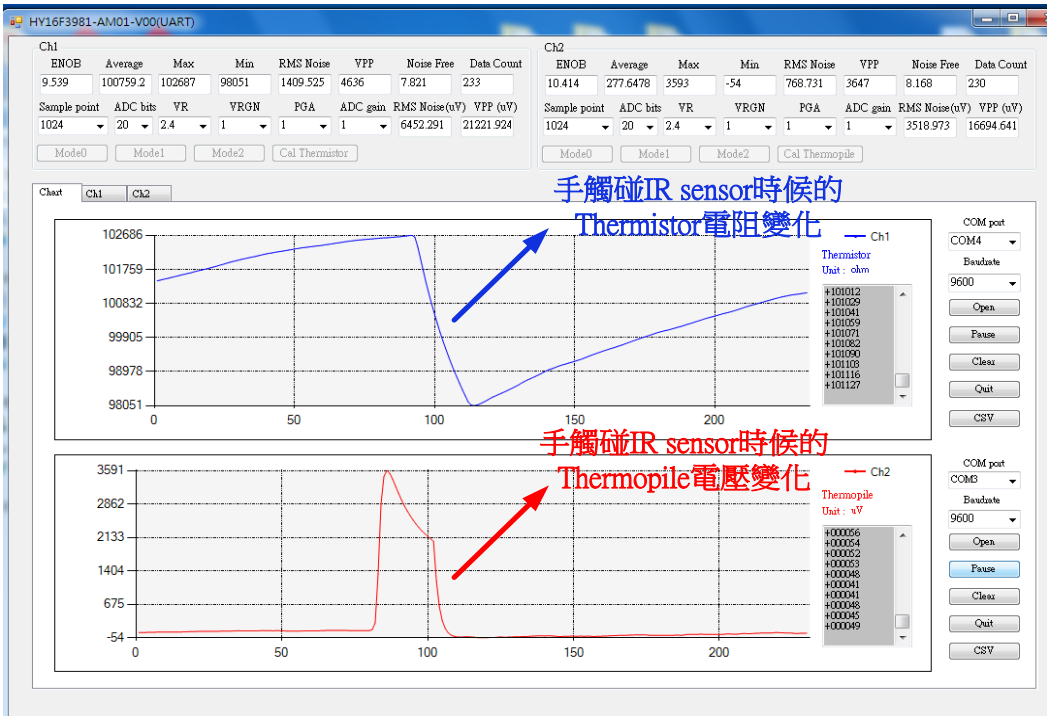


圖 15 當 IR Sensor 感受到溫度變化時候的 Thermistor 通道與 Thermopile 通道

使用者可以把擷取到的資料，可以儲存為 csv 檔案，由 Excel 開啟做資料分析。

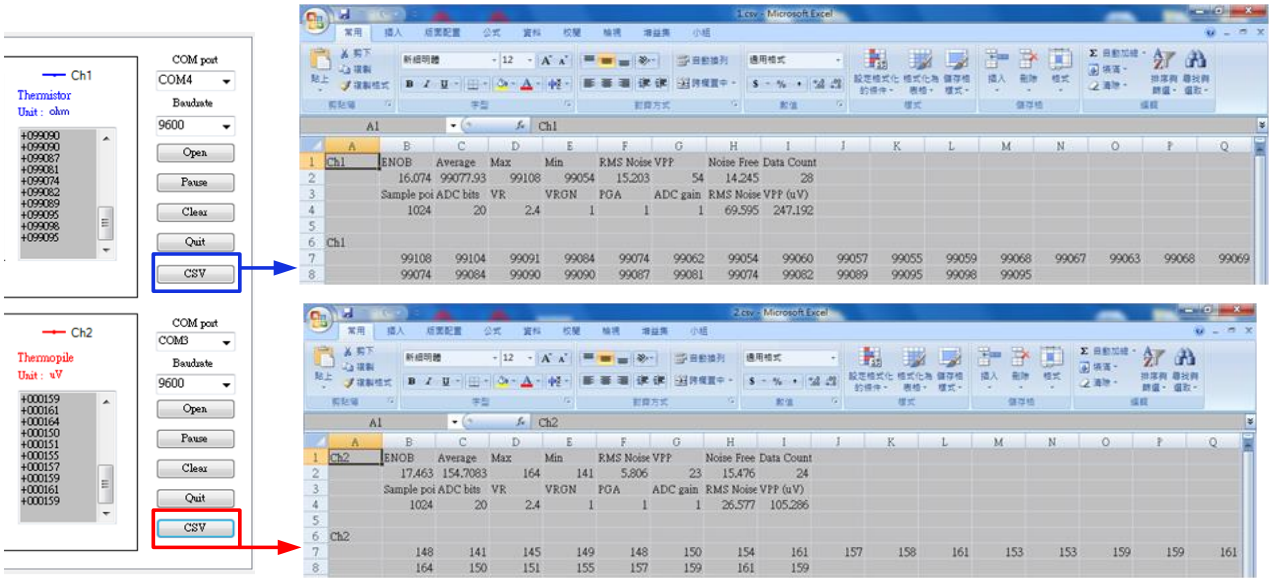


圖 16 Thermistor 與 Thermopile 通道儲存為 csv 檔案

4.4. 總結

在本文中，介紹與提供了完整的紅外線測溫應用的開發套件供使用者參考，使用者可以依據兩個通道 Thermistor 與 Thermopile 的 ADC Raw Data 變化量，透過 UART 傳輸到 Host PC 端來做即時動態資料顯示，以利後續在紅外線應用的程式開發與評估。

5. Demo Code 及相關檔案

```
/*****************************************************************************
 *
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 *
 * HYCON reserves the right to amend this code without notice at any time.
 * HYCON assumes no responsibility for any errors appeared in the code,
 * and HYCON disclaims any express or implied warranty, relating to sale
 * and/or use of this code including liability or warranties relating
 * to fitness for a particular purpose, or infringement of any patent,
 * copyright or other intellectual property right.
 *
 * ---------------------------------------------------------------------------
 * Project Name : HY16F3981_IR_DemoCode_V00
 * IDE tooling    : AndeSight C/C++ IDE, version: 2.1.1 Build ID : 201608241332
 * Device Ver.    : HY16F_RDSp3_DeviceV0.2 crt0.o for HY16F3981 MCU.
 * Library Ver. : 0.2
 * MCU Device     :
 * Description    :
 * Created Date : 2018/9/11
 * Created by     : Robert.Wang
 *
 * Program Description:
 * --------------------
 * Thermistor(RS) : AIO3-AIO7,    min=97k, typ=100k, max=103k
 * RF : AIO2-AIO3, 100k
 * Thermopile(TP) : AIO0-AIO1
 * Environment Range(Thermistor) : 16~35C
 * Target Range(Thermopile) : 0~50C
 *
 *****************************************************************************/
/*----------------------------------------------------------------------------*/
/*    I n c l u d e s                                                         */
/*----------------------------------------------------------------------------*/
#include "DrvCLOCK.h"
#include "my define.h"
#include "DrvREG32.h"
#include "SpecialMacro.h"
#include "HY16F3981.h"
#include "System.h"
#include "DrvADC.h"
#include "DrvPMU.h"
#include "DrvIA.h"
#include "DrvGPIO.h"
#include "DrvUART.h"
#include "DrvFlash.h"
/*----------------------------------------------------------------------------*/
/*    S T R U C T U R E S                                                     */
/*----------------------------------------------------------------------------*/
/*----------------------------------------------------------------------------*/
volatile typedef union _MCUSTATUS
{
   char    _byte;
   struct
   {
```

```
      unsigned b_ADCdone:1;
      unsigned b_TMAdone:1;
      unsigned b_TMBdone:1;
      unsigned b_RTCdone:1;
      unsigned b_UART_TxDone:1;
      unsigned b_UART_RxDone:1;
      unsigned b_UART2_TxDone:1;
      unsigned b_UART2_RxDone:1;
   };
} MCUSTATUS;

volatile typedef union _PTINTSTATUS
{
   char    _byte;
   struct
   {
      unsigned b_PTINT0done:1;
      unsigned b_PTINT1done:1;
      unsigned b_PTINT2done:1;
      unsigned b_PTINT3done:1;
      unsigned b_PTINT4done:1;
      unsigned b_PTINT5done:1;
      unsigned b_PTINT6Done:1;
      unsigned b_PTINT7Done:1;
   };
} PTINTSTATUS;
/*-------------------------------------------------------------------------------*/
/*    D E F I N I T I O N S                                                      */
/*-------------------------------------------------------------------------------*/
//#define HAO_2MHZ
//#define HAO_4MHZ
#define HAO_10MHZ
//#define HAO_16MHZ

//#define IA_chopper_ON
#define IA_chopper_OFF

#define HSRC    //Internal HAO

//UART, Thermistor
#define    UART_PORT E_PT2
#define    UART_TXD    BIT0
#define    UART_RXD    BIT1
#define    Uart_RX_BufferSize 16
#define    Uart_TX_BufferSize 16

//UART2, Thermopile
#define    UART2_PORT E_PT2
#define    UART2_TXD    BIT2
#define    UART2_RXD    BIT3
#define    Uart2_RX_BufferSize 16
#define    Uart2_TX_BufferSize 16

//#define UART_AUTOBAUDRATE
/*-------------------------------------------------------------------------------*/
/*    G l o b a l    C O N S T A N T S                                          */
/*-------------------------------------------------------------------------------*/
MCUSTATUS    MCUSTATUSbits;

float RS_25C;
```

```
float RF_25C;
float RS_measure;
float RS_kth;
float ADC_RF, ADC_RS;
float ADC_RF_P, ADC_RS_P;
float ADC_RF_N, ADC_RS_N;
float Target_voltage;
int TP_gain;
int ADC_TP_P, ADC_TP_N;
int ADC_TP;
int ADCData;
int ADCData1;
int ADCData2;
int TP_voltage;
int     TH_temperature,J_voltage;
int     TP_temperature;
unsigned char display_count;
unsigned char display_count2;
unsigned char UartRxBuffer[Uart_RX_BufferSize]={0},UartTxBuffer[Uart_TX_BufferSize]={0};
unsigned char UartTxIndex,UartTxLength,UartRxIndex,UartRxLength;
unsigned char Uart2RxBuffer[Uart2_RX_BufferSize]={0},Uart2TxBuffer[Uart2_TX_BufferSize]={0};
unsigned char Uart2TxIndex,Uart2TxLength,Uart2RxIndex,Uart2RxLength;
unsigned char UART_command[3]=
{
0xa9,0xa2,0x01
};
//UART Mode0 : 0xa9, 0xa2, 0x01, 0x0e, 0x01. RS resistance. unit : ohm
//UART Mode1 : 0xa9, 0xa2, 0x01, 0x0e, 0x0B. TH temperatur. Unit : temp
//UART Mode2 : 0xa9, 0xa2, 0x01, 0x0e, 0x0D. AIO3-AIO7 ADC Count
//UART Cal Thermistor : 0xa9, 0xa2, 0x01, 0x0c, 0x05. Cal Thermistor

//UART2 Mode0 : 0xa9, 0xa2, 0x01, 0xe0, 0xA1. TP voltage. unit : uV
//UART2 Mode1 : 0xa9, 0xa2, 0x01, 0xe0, 0xAB. TP temperatur. Unit : temp
//UART2 Mode2 : 0xa9, 0xa2, 0x01, 0xe0, 0xAD. AIO0-AIO1 ADC Count
//UART2 Cal Thermopile : 0xa9, 0xa2, 0x01, 0xc0, 0xA5. Cal Thermopile

//Thermistor
//unit : temperature
int TH[20]={
16,17,18,19,20,
21,22,23,24,25,
26,27,28,29,30,
31,32,33,34,35
};

//Thermistor
//unit : ohm
int TH_ohm[20]={
148766,142183,135936,130012,124400,
119038,113928,109059,104420,100000,
95788,91775,87950,84305,80830,
77517,74357,71342,68466,65720
};

//Thermopile
//unit : temperature
int TP[51]={
0,1,2,3,4,
5,6,7,8,9,
10,11,12,13,14,
```

```
15,16,17,18,19,
20,21,22,23,24,
25,26,27,28,29,
30,31,32,33,34,
35,36,37,38,39,
40,41,42,43,44,
45,46,47,48,49,
50
};

//Thermopile
//unit : uV
//OTP-638D2, absolute 25C table
int TP_V[51]={
5,78,151,226,302,                    //0~4C
380,456,535,614,693,                 //5~9C
775,856,938,1022,1105,               //10~14C
1191,1277,1363,1451,1539,            //15~19C
1628,1722,1815,1909,2003,            //20~24C
2097,2191,2285,2379,2473,            //25~29C
2567,2665,2765,2865,2966,            //30~34C
3067,3170,3273,3378,3483,            //35~39C
3590,3696,3804,3912,4022,            //40~44C
4132,4243,4355,4468,4582,            //45~49C
4697                                 //50C
};

/*
//Thermopile
//unit : uV
//OTP-638D2, absolute 0C table
int TP_V[51]={
0,75,150,226,303,                //0~4C
381,460,540,620,702,             //5~9C
784,867,952,1037,1124,           //10~14C
1211,1299,1390,1482,1575,        //15~19C
1672,1757,1842,1927,2012,        //20~24C
2097,2182,2267,2353,2438,        //25~29C
2524,2628,2736,2837,2942,        //30~34C
3045,3149,3253,3359,3466,        //35~39C
3574,3681,3788,3897,4006,        //40~44C
4116,4227,4340,4453,4566,        //45~49C
4681}                            //50C
;
*/
unsigned char ACK_KEY,ACK_KEY2 ;
/*------------------------------------------------------------------------------*/
/*  Data  Flash                                                                 */
/*------------------------------------------------------------------------------*/
//Default calibration data RS_25C and TP_gain
const unsigned char DefaultData[8] __attribute__ ((section ("DATA_EARE0"))) =
{
0xE8, 0x7A, 0x01, 0x00, //97000=0x17AE8, Default calibration data RS_25C=97000
0x70, 0x00, 0x00, 0x00, //112=0x70, TP_gain, Default calibration data TP_gain=112, calibration at 4mV
(gain=256, VRGN=1/2, OSR=32768)
};


/*------------------------------------------------------------------------------*/
/*  Function  PROTOTYPES                                                        */
```

```
/*-------------------------------------------------------------------------------*/
void Delay(unsigned int num);
void InitalClock(void);
void InitalUart(void);
void InitalUart2(void);
void Inital_GPIO(void);
void Inital_ADC_TH(void);
void Inital_ADC_TP(void);
void Calibrate_ADC_TH(void);
void Calibrate_ADC_TP(void);    //input 4mV on AI0-AI1
void Measure_ADC_TH(void);
void Measure_ADC_TP(void);
void Temptable_TH(void);
void Temptable_TP(void);
void Cold_Junction(void);
void SendUART(int data);
void SendUART2(int data);
void InitalUart_AutoBaudRate(void);
unsigned int Handshake(void);
unsigned char ISP_UART_Read(unsigned char* ptr_data, unsigned int count);
void ISP_UART_Write(unsigned char* ptr_data, unsigned int count);
/*-------------------------------------------------------------------------------*/
/*  Main Function                                                                */
/*-------------------------------------------------------------------------------*/
int main(void)
{

   //ACK_KEY & ACK_KEY2
   ACK_KEY=0;
   ACK_KEY2=0;

   //Read Calibration data RS_25C and TP_gain
   unsigned char index=0;
   unsigned int BufferRx[32];
   for(index=0;index<32;index++)
   {
      BufferRx[index]=0xFFFFFFFF;      //to set BufferRx[0]=0xFFFFFFFF....BufferRx[31]=0xFFFFFFFF
   }
   ReadPage(0xF000,BufferRx);          //Read BufferRx to make sure BurnPage data
   RS_25C=BufferRx[0];                 //Read calibration data RS_25C
   TP_gain=BufferRx[1];                //Read calibration data TP_gain

   //Initial variable
   display_count=0;
   display_count2=0;
   RF_25C=100000;                      //Assume RF=100k

   //Initial IP
   InitalClock();
#if defined(UART_AUTOBAUDRATE)
   InitalUart_AutoBaudRate();
   InitalUart2();
#else
   InitalUart();
   InitalUart2();
#endif
   MCUSTATUSbits.b_UART_TxDone=ENABLE;
   MCUSTATUSbits.b_UART2_TxDone=ENABLE;
   DrvGPIO_Open(E_PT3,0x02,E_IO_OUTPUT);
   DrvGPIO_ClrPortBits(E_PT3,0x02);
```

```
    SYS_EnableGIE(4,0x3FF);

    for(UartRxLength=0;UartRxLength<=Uart_RX_BufferSize;UartRxLength++)
    {
      UartRxBuffer[UartRxLength]=0;
      UartRxIndex=0;
    }

    for(Uart2RxLength=0;Uart2RxLength<=Uart2_RX_BufferSize;Uart2RxLength++)
    {
      Uart2RxBuffer[Uart2RxLength]=0;
      Uart2RxIndex=0;
    }

    while(1)
    {

      DrvGPIO_SetPortBits(E_PT3,0x02);
      //Thermistor
      Inital_ADC_TH();
      Measure_ADC_TH();                    //ADC raw count to R, get RS_measure and RS_kth
( unit :R )
      Temptable_TH();                      //R to T, get TH_temperature
      Cold_Junction();                     //T to V, get J_voltage

      //Thermopile
      Inital_ADC_TP();
      Measure_ADC_TP();                    //ADC raw count to V, get TP_voltage=Thermopile
measure voltage( unit :uV )
      Target_voltage=TP_voltage+J_voltage;  //Target_voltage=TP_voltage+J_voltage
      Temptable_TP();                      //V to T, get TP_temperature Tempurature
      DrvGPIO_ClrPortBits(E_PT3,0x02);


     //Case if UART receive == 0xAA
     if(UartRxBuffer[0]==0xAA)
     {
         ACK_KEY=1;
         for(UartRxLength=0;UartRxLength<=Uart_RX_BufferSize;UartRxLength++)
         {
           UartRxBuffer[UartRxLength]=0;
           UartRxIndex=0;
         }
     }


     //Case if UART receive == Mode0
     //0xa9, 0xa2, 0x01, 0x0e, 0x01
     if
        (
        (UartRxBuffer[4]==0x01) &&
        (UartRxBuffer[3]==0x0e && UartRxBuffer[2]==UART_command[2]) &&
        (UartRxBuffer[1]==UART_command[1] && UartRxBuffer[0]==UART_command[0])
        )
     {
         display_count=0;
         for(UartRxLength=0;UartRxLength<=Uart_RX_BufferSize;UartRxLength++)
         {
           UartRxBuffer[UartRxLength]=0;
           UartRxIndex=0;
```

```
    }
}

//Case if UART receive == Mode1
//0xa9, 0xa2, 0x01, 0x0e, 0x0B
if
   (
   (UartRxBuffer[4]==0x0B) &&
   (UartRxBuffer[3]==0x0e && UartRxBuffer[2]==UART_command[2]) &&
   (UartRxBuffer[1]==UART_command[1] && UartRxBuffer[0]==UART_command[0])
   )
{
    display_count=1;
    for(UartRxLength=0;UartRxLength<=Uart_RX_BufferSize;UartRxLength++)
    {
       UartRxBuffer[UartRxLength]=0;
       UartRxIndex=0;
    }
}

//Case if UART receive == Mode2
//0xa9, 0xa2, 0x01, 0x0e, 0x0D
if
   (
   (UartRxBuffer[4]==0x0D) &&
   (UartRxBuffer[3]==0x0e && UartRxBuffer[2]==UART_command[2]) &&
   (UartRxBuffer[1]==UART_command[1] && UartRxBuffer[0]==UART_command[0])
   )
{
    display_count=2;
    for(UartRxLength=0;UartRxLength<=Uart_RX_BufferSize;UartRxLength++)
    {
       UartRxBuffer[UartRxLength]=0;
       UartRxIndex=0;
    }
}

//Case if UART receive == Cal Thermistor
//0xa9, 0xa2, 0x01, 0x0c, 0x05
if
   (
   (UartRxBuffer[4]==0x05) &&
   (UartRxBuffer[3]==0x0c && UartRxBuffer[2]==UART_command[2]) &&
   (UartRxBuffer[1]==UART_command[1] && UartRxBuffer[0]==UART_command[0])
   )
{
     Inital_ADC_TH();
    Calibrate_ADC_TH();
    SYS_DisableGIE();
    DrvFlash_Burn_Word(0xF000,0x2000,RS_25C);
    Delay(100000);
    SYS_EnableGIE(4,0x3FF);
    for(UartRxLength=0;UartRxLength<=Uart_RX_BufferSize;UartRxLength++)
    {
       UartRxBuffer[UartRxLength]=0;
       UartRxIndex=0;
    }
}
```

```
//Case if UART2 receive == 0xAA
if(Uart2RxBuffer[0]==0xAA)
{
    ACK_KEY2=1;
    for(Uart2RxLength=0;Uart2RxLength<=Uart2_RX_BufferSize;Uart2RxLength++)
    {
      Uart2RxBuffer[Uart2RxLength]=0;
      Uart2RxIndex=0;
    }
}

//Case if UART2 receive == Mode0
// 0xa9, 0xa2, 0x01, 0xe0, 0xA1
if
   (
   (Uart2RxBuffer[4]==0xA1) &&
   (Uart2RxBuffer[3]==0xe0 && Uart2RxBuffer[2]==UART_command[2]) &&
   (Uart2RxBuffer[1]==UART_command[1] && Uart2RxBuffer[0]==UART_command[0])
   )
{
    display_count2=0;
    for(Uart2RxLength=0;Uart2RxLength<=Uart2_RX_BufferSize;Uart2RxLength++)
    {
      Uart2RxBuffer[Uart2RxLength]=0;
      Uart2RxIndex=0;
    }
}


//Case if UART2 receive == Mode1
//0xa9, 0xa2, 0x01, 0xe0, 0xAB
if
   (
   (Uart2RxBuffer[4]==0xAB) &&
   (Uart2RxBuffer[3]==0xe0 && Uart2RxBuffer[2]==UART_command[2]) &&
   (Uart2RxBuffer[1]==UART_command[1] && Uart2RxBuffer[0]==UART_command[0])
   )
{
    display_count2=1;
    for(Uart2RxLength=0;Uart2RxLength<=Uart2_RX_BufferSize;Uart2RxLength++)
    {
      Uart2RxBuffer[Uart2RxLength]=0;
      Uart2RxIndex=0;
    }
}

//Case if UART2 receive == Mode2
//0xa9, 0xa2, 0x01, 0xe0, 0xAD
if
   (
   (Uart2RxBuffer[4]==0xAD) &&
   (Uart2RxBuffer[3]==0xe0 && Uart2RxBuffer[2]==UART_command[2]) &&
   (Uart2RxBuffer[1]==UART_command[1] && Uart2RxBuffer[0]==UART_command[0])
   )
{
    display_count2=2;
    for(Uart2RxLength=0;Uart2RxLength<=Uart2_RX_BufferSize;Uart2RxLength++)
    {
      Uart2RxBuffer[Uart2RxLength]=0;
      Uart2RxIndex=0;
```

```
        }
    }


    //Case if UART2 receive == Cal Thermopile
    //0xa9, 0xa2, 0x01, 0xc0, 0xA5
    if
       (
       (Uart2RxBuffer[4]==0xA5) &&
       (Uart2RxBuffer[3]==0xc0 && Uart2RxBuffer[2]==UART_command[2]) &&
       (Uart2RxBuffer[1]==UART_command[1] && Uart2RxBuffer[0]==UART_command[0])
       )
    {
        Inital_ADC_TP();
        Calibrate_ADC_TP();
        SYS_DisableGIE();
        DrvFlash_Burn_Word(0xF004,0x2000,TP_gain);
        Delay(100000);
        SYS_EnableGIE(4,0x3FF);
        for(Uart2RxLength=0;Uart2RxLength<=Uart2_RX_BufferSize;Uart2RxLength++)
        {
           Uart2RxBuffer[Uart2RxLength]=0;     //clear RX buffer
           Uart2RxIndex=0;
        }
    }

if(ACK_KEY==1)
{
     //UART Mode0
     if(display_count==0)
     {
        DrvADC_DisableInt();
        SendUART(RS_measure);                    //RS resistance. unit : ohm
        DrvADC_EnableInt();
     }
     //UART Mode1
     if(display_count==1)
     {
        DrvADC_DisableInt();
        SendUART(TH_temperature);                //TH temperature. Unit : temp
        DrvADC_EnableInt();
     }
     //UART Mode2
     if(display_count==2)
     {
        DrvADC_DisableInt();
        SendUART(ADC_RF);                        //AIO3-AIO7 ADC Count
        DrvADC_EnableInt();
     }
}

if(ACK_KEY2==1)
{
     //UART2 Mode0
     if(display_count2==0)
     {
        DrvADC_DisableInt();
        SendUART2(TP_voltage);                   //TP voltage. unit : uV
        DrvADC_EnableInt();
     }
```

```
      //UART2 Mode1
      if(display_count2==1)
      {
         DrvADC_DisableInt();
         SendUART2(TP_temperature);              //TP temperatur. Unit : temp
         DrvADC_EnableInt();
      }
      //UART2 Mode2
      if(display_count2==2)
      {
         DrvADC_DisableInt();
         SendUART2(ADC_TP);                      //AIO0-AIO1 ADC Count
         DrvADC_EnableInt();
      }
}


   } //while(1) end



}

/*-------------------------------------------------------------------------------------------*/
/* Function Name: HW0_ISR()                                                                  */
/* Description  : I2C/UART/SPI interrupt Service Routine (HW0).                              */
/* Arguments    : None.                                                                      */
/* Return Value : None.                                                                      */
/* Remark       :                                                                            */
/*-------------------------------------------------------------------------------------------*/
void HW0_ISR(void)
{
   if(DrvUART_GetRxFlag())
   {
      UartRxBuffer[UartRxIndex]=DrvUART_Read();
      UartRxIndex++;
      if(UartRxIndex>=Uart_RX_BufferSize)
      {
         UartRxIndex=0;
         MCUSTATUSbits.b_UART_RxDone=ENABLE;
      }
         DrvUART_ClrRxFlag();
   }

   if(DrvUART_GetTxFlag())
   {
      if(MCUSTATUSbits.b_UART_TxDone==DISABLE)
      {
         DrvUART_Write(UartTxBuffer[UartTxIndex++]);
         DrvUART_ClrTxFlag();
         if(UartTxIndex>=UartTxLength)
         {
            DrvUART_EnableInt(ENABLE,ENABLE);   //ENABLE UART Tx Interrupt, ENABLE UART Rx
Interrupt
            MCUSTATUSbits.b_UART_TxDone=ENABLE;
            UartTxIndex=0;
         }
      }
      if(MCUSTATUSbits.b_UART_TxDone==ENABLE)
      {
```

```
        DrvUART_EnableInt(DISABLE,ENABLE);   //DISABLE UART Tx Interrupt, ENABLE UART Rx
Interrupt
        DrvUART_ClrTxFlag();
      }
    }
}
/*-------------------------------------------------------------------------------------------*/
/* Function Name: HW1_ISR()                                                                  */
/* Description  : WDT & RTC & Timer A/B/C interrupt Service Routine (HW1).                   */
/* Arguments    : None.                                                                      */
/* Return Value : None.                                                                      */
/* Remark       :                                                                            */
/*-------------------------------------------------------------------------------------------*/
void HW1_ISR(void)
{

}
/*-------------------------------------------------------------------------------------------*/
/* Function Name: HW2_ISR()                                                                  */
/* Description  : ADC interrupt Service Routine (HW2).                                       */
/* Arguments    : None.                                                                      */
/* Return Value : None.                                                                      */
/* Remark       :                                                                            */
/*-------------------------------------------------------------------------------------------*/
void HW2_ISR(void)
{
  if(DrvADC_ReadIntFlag())                    //Read ADC Flag
  {
    ADCData=DrvADC_GetConversionData()>>12;   //@ ADC get 20bit, +/- 19bit
    MCUSTATUSbits.b_ADCdone=1;
  }
}
/*-------------------------------------------------------------------------------------------*/
/* Function Name: HW4_ISR()                                                                  */
/* Description  : PT3 interrupt Service Routine (HW4).                                       */
/* Arguments    : None.                                                                      */
/* Return Value : None.                                                                      */
/* Remark       :                                                                            */
/*-------------------------------------------------------------------------------------------*/
void HW4_ISR(void)
{

}
/*-------------------------------------------------------------------------------------------*/
/* Function Name: HW5_ISR()                                                                  */
/* Description  : PT2 interrupt Service Routine (HW5).                                       */
/* Arguments    : None.                                                                      */
/* Return Value : None.                                                                      */
/* Remark       :                                                                            */
/*-------------------------------------------------------------------------------------------*/
void HW5_ISR(void)
{

}
/*-------------------------------------------------------------------------------------------*/
/* Function Name: HW7_ISR()                                                                  */
/* Description  : UART2 interrupt Service Routine (HW7).                                     */
/* Arguments    : None.                                                                      */
/* Return Value : None.                                                                      */
/* Remark       :                                                                            */
```

```
/*---------------------------------------------------------------------------------------------------*/
void HW7_ISR(void)
{

  if(DrvUART2_GetRxFlag())
  {
    Uart2RxBuffer[Uart2RxIndex]=DrvUART2_Read();
    Uart2RxIndex++;
    if(Uart2RxIndex>=Uart2_RX_BufferSize)
    {
      Uart2RxIndex=0;
      MCUSTATUSbits.b_UART2_RxDone=ENABLE;
    }
      DrvUART2_ClrRxFlag();
  }

  if(DrvUART2_GetTxFlag())
  {
    if(MCUSTATUSbits.b_UART2_TxDone==DISABLE)
    {
      DrvUART2_Write(Uart2TxBuffer[Uart2TxIndex++]);
      DrvUART2_ClrTxFlag();
      if(Uart2TxIndex>=Uart2TxLength)
      {
        DrvUART2_EnableInt(ENABLE,ENABLE);   //ENABLE UART2 Tx Interrupt, ENABLE UART2 Rx
Interrupt
        MCUSTATUSbits.b_UART2_TxDone=ENABLE;
        Uart2TxIndex=0;
      }
    }
      if(MCUSTATUSbits.b_UART2_TxDone==ENABLE)
      {
        DrvUART2_EnableInt(DISABLE,ENABLE);   //DISABLE UART2 Tx Interrupt, ENABLE UART2 Rx
Interrupt
        DrvUART2_ClrTxFlag();
      }

  }
}
/*---------------------------------------------------------------------------------------------------*/
/* Function Name: HW8_ISR()                                                                          */
/* Description  : TMB2 interrupt Service Routine (HW8).                                              */
/* Arguments    : None.                                                                              */
/* Return Value : None.                                                                              */
/* Remark       :                                                                                    */
/*---------------------------------------------------------------------------------------------------*/
void HW8_ISR(void)
{

}
/*---------------------------------------------------------------------------------------------------*/
/* Function Name: HW9_ISR()                                                                          */
/* Description  : OPA interrupt Service Routine (HW9).                                               */
/* Arguments    : None.                                                                              */
/* Return Value : None.                                                                              */
/* Remark       :                                                                                    */
/*---------------------------------------------------------------------------------------------------*/
void HW9_ISR(void)
{
```

```
}
/*---------------------------------------------------------------------------*/
/* Function Name: tlb_exception_handler()                                    */
/* Description  : Exception Service Routines.                                */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void tlb_exception_handler()
{

   long long Exception_link_pointer_temp, Exception_link_pointer;
   Exception_link_pointer_temp=0, Exception_link_pointer=0;
   //可以從變數 Exception_link_pointer 找出進入 expection 的程式段
   asm volatile("add %0, %1, $lp":"=&r"(Exception_link_pointer):"r"(Exception_link_pointer_temp));

   int   Exception_ITYPE;
   Exception_ITYPE=0;
   //以下語句可以將 ITYPE(ir6)資料從暫存器中搬出到 C 環境中.
   asm volatile("mfsr %0,$ITYPE":"=&r"(Exception_ITYPE)); //ITYPE 資料存放在變數 Exception_ITYPE.

   while(1);

}
/*---------------------------------------------------------------------------*/
/* Software Delay Subroutines                                                */
/*---------------------------------------------------------------------------*/
void Delay(unsigned int num)
{
   for(;num>0;num--)
   asm("NOP");
}

/*---------------------------------------------------------------------------*/
/* Function Name: Inital_ADC_TH()                                            */
/* Description  : ADC thermistor channel Initialization Subroutines.         */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void Inital_ADC_TH(void)
{
   //Set ADC Clock
#if defined(HAO_2MHZ)
   DrvCLOCK_EnableHighOSC(E_INTERNAL,10);    //Select HSRC
   DrvCLOCK_SelectIHOSC(0);                   //Select internal 2MHZ=HS_CK
   DrvADC_ClkEnable(2);                      //Setting ADC CLOCK ADCK=HS_CK/4
#endif
#if defined(HAO_4MHZ)
   DrvCLOCK_EnableHighOSC(E_INTERNAL,10);    //Select HSRC
   DrvCLOCK_SelectIHOSC(1);                   //Select internal 4MHZ=HS_CK
   DrvADC_ClkEnable(2);                      //Setting ADC CLOCK ADCK=HS_CK/4
#endif
#if defined(HAO_10MHZ)
   DrvCLOCK_EnableHighOSC(E_INTERNAL,10);    //Select HSRC
   DrvCLOCK_SelectIHOSC(2);                   //Select internal 10MHZ=HS_CK
   DrvADC_ClkEnable(3);                      //Setting ADC CLOCK ADCK=HS_CK/8
#endif
#if defined(HAO_16MHZ)
```

```
   DrvCLOCK_EnableHighOSC(E_INTERNAL,10);     //Select HSRC
   DrvCLOCK_SelectIHOSC(3);                    //Select internal 16MHZ=HS_CK
   DrvADC_ClkEnable(4);                        //Setting ADC CLOCK ADCK=HS_CK/16
#endif

   //Set VDDA voltage
   DrvPMU_VDDA_LDO_Ctrl(E_LDO);
   DrvPMU_VDDA_Voltage(E_VDDA2_4);
   DrvPMU_BandgapEnable();
   DrvPMU_REFO_Enable();
   Delay(0x1000);
   DrvPMU_AnalogGround(ENABLE);                //ADC analog ground source selection.
                                               //1 : Enable buffer and use internal source(need to
work with ADC)

   //Set ADC input pin
   DrvADC_SetADCInputChannel(ADC_Input_AIO3,ADC_Input_AIO7); //Set the ADC positive/negative input
voltage source.
   DrvADC_InputSwitch(OPEN);                   //ADC signal input (positive and negative) short(VISHR)
control.
   DrvADC_RefInputShort(OPEN);                 //Set the ADC reference input (positive and negative)
short(VRSHR) control.
   DrvADC_ADGain(0);
   DrvADC_DCoffset(0);                         //DC offset input voltage selection (VREF=REFP-REFN)
   DrvADC_RefVoltage(0,0);                     //Set the ADC reference voltage. VDDA-VSSA
   DrvADC_FullRefRange(1);                     //Set the ADC full reference range select.
   DrvADC_OSR(2);                              //2 : 120sps

   //Set ADC interrupt
   DrvADC_EnableInt();
   DrvADC_Enable();
   DrvADC_CombFilter(ENABLE);                  //Enable comb filter
}

/*---------------------------------------------------------------------------*/
/* Function Name: Calibrate_ADC_TH()                                         */
/* Description  : ADC thermistor channel calibration.                        */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void Calibrate_ADC_TH(void)
{

   DrvADC_SetADCInputChannel(ADC_Input_AIO3,ADC_Input_AIO7);
   DrvADC_CombFilter(DISABLE);
   DrvADC_CombFilter(ENABLE);
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_RS_P=ADCData;
   MCUSTATUSbits.b_ADCdone=0;

   DrvADC_SetADCInputChannel(ADC_Input_AIO7,ADC_Input_AIO3);
   DrvADC_CombFilter(DISABLE);
   DrvADC_CombFilter(ENABLE);
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_RS_N=ADCData;
   MCUSTATUSbits.b_ADCdone=0;
```

```
    ADC_RS=(ADC_RS_P-ADC_RS_N)/2;    //get ADC Raw count on Thermistor(RS)

    DrvADC_SetADCInputChannel(ADC_Input_AIO2,ADC_Input_AIO3);
    DrvADC_CombFilter(DISABLE);
    DrvADC_CombFilter(ENABLE);
    MCUSTATUSbits.b_ADCdone=0;
    while(MCUSTATUSbits.b_ADCdone==0);
    ADC_RF_P=ADCData;
    MCUSTATUSbits.b_ADCdone=0;

    DrvADC_SetADCInputChannel(ADC_Input_AIO3,ADC_Input_AIO2);
    DrvADC_CombFilter(DISABLE);
    DrvADC_CombFilter(ENABLE);
    MCUSTATUSbits.b_ADCdone=0;
    while(MCUSTATUSbits.b_ADCdone==0);
    ADC_RF_N=ADCData;
    MCUSTATUSbits.b_ADCdone=0;

    ADC_RF=(ADC_RF_P-ADC_RS_N)/2;    //get ADC Raw count on RF

    RS_25C = (ADC_RS*RF_25C)/ADC_RF;

}
/*-------------------------------------------------------------------------*/
/* Function Name: Measure_ADC_TH()                                         */
/* Description  : ADC thermistor channel measurement.                      */
/* Arguments    : None.                                                    */
/* Return Value : None.                                                    */
/* Remark       :                                                          */
/*-------------------------------------------------------------------------*/
void Measure_ADC_TH(void)
{

    DrvADC_SetADCInputChannel(ADC_Input_AIO3,ADC_Input_AIO7);
    DrvADC_CombFilter(DISABLE);
    DrvADC_CombFilter(ENABLE);
    MCUSTATUSbits.b_ADCdone=0;
    while(MCUSTATUSbits.b_ADCdone==0);
    ADC_RS_P=ADCData;
    MCUSTATUSbits.b_ADCdone=0;

    DrvADC_SetADCInputChannel(ADC_Input_AIO7,ADC_Input_AIO3);
    DrvADC_CombFilter(DISABLE);
    DrvADC_CombFilter(ENABLE);
    MCUSTATUSbits.b_ADCdone=0;
    while(MCUSTATUSbits.b_ADCdone==0);
    ADC_RS_N=ADCData;
    MCUSTATUSbits.b_ADCdone=0;

    ADC_RS=(ADC_RS_P-ADC_RS_N)/2;    //get ADC Raw count on Thermistor(RS)

    DrvADC_SetADCInputChannel(ADC_Input_AIO2,ADC_Input_AIO3);
    DrvADC_CombFilter(DISABLE);
    DrvADC_CombFilter(ENABLE);
    MCUSTATUSbits.b_ADCdone=0;
    while(MCUSTATUSbits.b_ADCdone==0);
    ADC_RF_P=ADCData;
    MCUSTATUSbits.b_ADCdone=0;

    DrvADC_SetADCInputChannel(ADC_Input_AIO3,ADC_Input_AIO2);
```

```
    DrvADC_CombFilter(DISABLE);
    DrvADC_CombFilter(ENABLE);
    MCUSTATUSbits.b_ADCdone=0;
    while(MCUSTATUSbits.b_ADCdone==0);
    ADC_RF_N=ADCData;
    MCUSTATUSbits.b_ADCdone=0;

    ADC_RF=(ADC_RF_P-ADC_RS_N)/2;    //get ADC Raw count on RF

    RS_measure=(ADC_RS*RF_25C)/ADC_RF;
    RS_kth = RS_measure*RF_25C/RS_25C;

}


/*-------------------------------------------------------------------------*/
/* Function Name: Inital_ADC_TP()                                          */
/* Description  : ADC Thermopile Initialization Subroutines.               */
/* Arguments    : None.                                                    */
/* Return Value : None.                                                    */
/* Remark       :                                                          */
/*-------------------------------------------------------------------------*/
void Inital_ADC_TP(void)
{
    //Set ADC Clock
#if defined(HAO_2MHZ)
    DrvCLOCK_EnableHighOSC(E_INTERNAL,10);     //Select HSRC
    DrvCLOCK_SelectIHOSC(0);                    //Select internal 2MHZ=HS_CK
    DrvADC_ClkEnable(2);                       //Setting ADC CLOCK ADCK=HS_CK/4
#endif
#if defined(HAO_4MHZ)
    DrvCLOCK_EnableHighOSC(E_INTERNAL,10);     //Select HSRC
    DrvCLOCK_SelectIHOSC(1);                    //Select internal 4MHZ=HS_CK
    DrvADC_ClkEnable(2);                       //Setting ADC CLOCK ADCK=HS_CK/4
#endif
#if defined(HAO_10MHZ)
    DrvCLOCK_EnableHighOSC(E_INTERNAL,10);     //Select HSRC
    DrvCLOCK_SelectIHOSC(2);                    //Select internal 10MHZ=HS_CK
    DrvADC_ClkEnable(3);                       //Setting ADC CLOCK ADCK=HS_CK/8
#endif
#if defined(HAO_16MHZ)
    DrvCLOCK_EnableHighOSC(E_INTERNAL,10);     //Select HSRC
    DrvCLOCK_SelectIHOSC(3);                    //Select internal 16MHZ=HS_CK
    DrvADC_ClkEnable(4);                       //Setting ADC CLOCK ADCK=HS_CK/16
#endif

    //Set VDDA voltage
    DrvPMU_VDDA_LDO_Ctrl(E_LDO);
    DrvPMU_VDDA_Voltage(E_VDDA2_4);
    DrvPMU_BandgapEnable();
    DrvPMU_REFO_Enable();
    Delay(0x1000);
    DrvPMU_AnalogGround(ENABLE);               //ADC analog ground source selection.
                                               //1 : Enable buffer and use internal source(need to
work with ADC)
#if defined(IA_chopper_OFF)
    //Set ADC input pin
    DrvADC_SetADCInputChannel(OP_OP,OP_ON);    //Set the ADC positive/negative input voltage source.
    DrvADC_InputSwitch(OPEN);                  //ADC signal input (positive and negative) short(VISHR)
control.
```

```
   DrvADC_RefInputShort(OPEN);                  //Set the ADC reference input (positive and negative)
short(VRSHR) control.
   DrvADC_ADGain(7);                            //ADC gain=8
   DrvADC_DCoffset(0);                          //DC offset input voltage selection (VREF=REFP-REFN)
   DrvADC_RefVoltage(0,0);                      //Set the ADC reference voltage. VDDA-VSSA
   DrvADC_FullRefRange(1);                      //Set the ADC full reference range select.
                                                //0: Full reference range input
                                                //1: 1/2 reference range input
   DrvADC_OSR(2);                               //2 : 120sps
   //Set IA
   DrvIA_SetIAInputChannel(IA_Input_AIO0,IA_Input_AIO1);   //ADC positive=AIO0, negative=AIO1
   DrvIA_IAGain(IA_IAGain_32);                  //IA gain=32
   DrvIA_IACHM(IA_IACHM_NoChopper);             //IA Chopper OFF
   DrvIA_IAIS(0);                               //Input control=open
   DrvIA_ENIA(0);                               //Disable IA
   DrvIA_ENIA(1);

   //Set ADC interrupt
   DrvADC_EnableInt();
   DrvADC_Enable();
   DrvADC_CombFilter(ENABLE);                   //Enable comb filter
#endif

#if defined(IA_chopper_ON)
   //Set ADC input pin
   DrvADC_SetADCInputChannel(OP_OP,OP_ON);   //Set the ADC positive/negative input voltage source.
   DrvADC_InputSwitch(OPEN);                    //ADC signal input (positive and negative) short(VISHR)
control.
   DrvADC_RefInputShort(OPEN);                  //Set the ADC reference input (positive and negative)
short(VRSHR) control.
   DrvADC_ADGain(7);                            //ADC gain=8
   DrvADC_DCoffset(0);                          //DC offset input voltage selection
(VREF=REFP-REFN)
   DrvADC_RefVoltage(0,0);                      //Set the ADC reference voltage. VDDA-VSSA
   DrvADC_FullRefRange(1);                      //Set the ADC full reference range select.
                                                //0: Full reference range input
                                                //1: 1/2 reference range input
   DrvADC_OSR(0);                               //0 : OSR=32768
   //Set IA
   DrvIA_SetIAInputChannel(IA_Input_AIO0,IA_Input_AIO1);   //ADC positive=AIO0, negative=AIO1
   DrvIA_IAGain(IA_IAGain_32);                  //IA Gain=32
   DrvIA_IACHM(IA_IACHM_Both);                  //IA Chopper On
   DrvIA_IAIS(0);                               //Input control=open
   DrvIA_ENIA(0);                               //Disable IA
   DrvIA_ENIA(1);                               //Enable IA

   //Set ADC interrupt
   DrvADC_EnableInt();
   DrvADC_Enable();
   DrvADC_CombFilter(ENABLE);                   //Enable comb filter
#endif

}

/*---------------------------------------------------------------------------*/
/* Function Name: Measure_ADC_TP()                                           */
/* Description  : ADC Thermopile measurement.                                */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
```

```
/*-------------------------------------------------------------------------------*/
void Measure_ADC_TP(void)
{

#if defined(IA_chopper_OFF)
   //positive measure
   DrvIA_SetIAInputChannel(IA_Input_AIO0,IA_Input_AIO1);
   DrvADC_CombFilter(DISABLE);
   DrvADC_CombFilter(ENABLE);
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_TP_P=ADCData;
   MCUSTATUSbits.b_ADCdone=0;
   //negative measure
   DrvIA_SetIAInputChannel(IA_Input_AIO1,IA_Input_AIO0);
   DrvADC_CombFilter(DISABLE);
   DrvADC_CombFilter(ENABLE);
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_TP_N=ADCData;
   MCUSTATUSbits.b_ADCdone=0;
   ADC_TP=(ADC_TP_P-ADC_TP_N)/2;
   TP_voltage=(ADC_TP_P-ADC_TP_N)/2/TP_gain;
#endif

#if defined(IA_chopper_ON)
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_TP=ADCData;
   TP_voltage=ADCData/TP_gain;
   MCUSTATUSbits.b_ADCdone=0;
#endif

}

/*-------------------------------------------------------------------------------*/
/* Function Name: Calibrate_ADC_TP()                                             */
/* Description  :                                                                */
/* Arguments    : None.                                                          */
/* Return Value : None.                                                          */
/* Remark       :                                                                */
/*-------------------------------------------------------------------------------*/
void Calibrate_ADC_TP(void)
{

#if defined(IA_chopper_OFF)
   DrvIA_SetIAInputChannel(IA_Input_AIO0,IA_Input_AIO1);
   DrvADC_CombFilter(DISABLE);
   DrvADC_CombFilter(ENABLE);
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_TP_P=ADCData;
   MCUSTATUSbits.b_ADCdone=0;
   DrvIA_SetIAInputChannel(IA_Input_AIO1,IA_Input_AIO0);
   DrvADC_CombFilter(DISABLE);
   DrvADC_CombFilter(ENABLE);
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_TP_N=ADCData;
   MCUSTATUSbits.b_ADCdone=0;
```

```
   ADC_TP=(ADC_TP_P-ADC_TP_N)/2;
   TP_gain=(ADC_TP_P-ADC_TP_N)/2/4000; //4mV=4000, assume ADC count=0 at 0mV, calibration at 4mV
#endif

#if defined(IA_chopper_ON)
   MCUSTATUSbits.b_ADCdone=0;
   while(MCUSTATUSbits.b_ADCdone==0);
   ADC_TP=ADCData;
   TP_gain=ADCData/4000;
   MCUSTATUSbits.b_ADCdone=0;
#endif
}

/*---------------------------------------------------------------------------*/
/* Function Name: Temptable_TH()                                             */
/* Description  : Thermistor temperature table searching                     */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void Temptable_TH(void)
{
      float count1;
      float tempH,tempL;
      char count2;
      unsigned char a=0;
      unsigned char b=0;
      unsigned char max=19,min=0;
      a=(max+min)/2;
      b=a+1;
      while(1)
      {
            tempH=TH_ohm[a+1];
            tempL=TH_ohm[a];
            if(RS_kth>tempH&&RS_kth<=tempL)
                  break;
            else
            {
                  b=b/2;
                  if(b==0)
                        b=1;
                  if(RS_kth>tempL)
                        a=a-b;
                  else if(RS_kth<=tempH)
                        a=a+b;
                  if(a<min||a>max)
                        break;
            }

      }
      count1=(tempL-tempH)/100;              //Note : /100  代表兩個點之間分成 100 階數, count1 代表每
一階的數值大小
      count2=(RS_kth-tempL)/count1;          //count2  代表總共的階數為多少
      TH_temperature=TH[a]*100-count2;       //Note : *100  代表兩個點之間分成 100 階數, 十位數與個位
數代表小數點後兩位
      if(a==255)                             //a=a-b, but a=0 and b=1, a will be 255
     (TH_temperature=TH[min]*100);           //to show TH[min]
      if(a>max && a!=255)
```

```
    (TH_temperature=TH[max]*100-count2);     //to show TH[max]
}

/*-------------------------------------------------------------------------*/
/* Function Name: Temptable_TP()                                           */
/* Description  : Thermopile temperature table searching                   */
/* Arguments    : None.                                                    */
/* Return Value : None.                                                    */
/* Remark       :                                                          */
/*-------------------------------------------------------------------------*/
void Temptable_TP(void)
{
    float count1;
    float tempH,tempL;
    char count2;
    unsigned char a=0;
    unsigned char b=0;
    unsigned char max=50,min=0;
    a=(max+min)/2;
    b=a+1;
    while(1)
    {
        tempH=TP_V[a+1];
        tempL=TP_V[a];
        if(Target_voltage<tempH&&Target_voltage>=tempL)
            break;
        else
        {
            b=b/2;
            if(b==0)
                b=1;
            if(Target_voltage<tempL)
                a=a-b;
            else if(Target_voltage>=tempH)
                a=a+b;
            if(a<min||a>max)
                break;
        }

    }

    count1=(tempH-tempL)/100;
    count2=(Target_voltage-tempL)/count1;
    TP_temperature=TP[a]*100+count2+6;   //+6=rounding
    if(a==255)                           //a=a-b, but a=0 and b=1, a will be 255
    (TP_temperature=TP[min]*100);        //to show TP[min]
    if(a>max && a!=255)
    (TP_temperature=TP[max]*100);        //to show TP[max]
}


/*-------------------------------------------------------------------------*/
/* Function Name: Cold_Junction()                                          */
/* Description  :                                                          */
/* Arguments    : None.                                                    */
/* Return Value : None.                                                    */
/* Remark       :                                                          */
/*-------------------------------------------------------------------------*/
void Cold_Junction(void)
{
```

```
    int tempH,tempL;
    float Temp_remain;
    unsigned char a=0;
    unsigned char b=0;
    unsigned char max=50,min=0;
    a=(max+min)/2;
    b=a+1;
    while(1)
    {
        tempH=TP[a+1];
        tempL=TP[a];
        if((TH_temperature/100)<tempH&&(TH_temperature/100)>=tempL)
            break;
        else
        {
            b=b/2;
            if(b==0)
                b=1;
            if((TH_temperature/100)<tempL)
                a=a-b;
            else if((TH_temperature/100)>=tempH)
                a=a+b;
            if(a<min||a>max)
                break;
        }
    }
    Temp_remain=(TH_temperature%100)*(TP_V[a+1]-TP_V[a])/100;
    J_voltage=TP_V[a]+Temp_remain;
    if(a==255)                                  //a=a-b, but a=0 and b=1, a will be 255
    (J_voltage=TP_V[min]);                      //to show TP_V[min]
    if(a>max && a!=255)
    (J_voltage=TP_V[max]+Temp_remain);          //to show TP_V[max]
}


/*---------------------------------------------------------------------------*/
/* Function Name: InitalClock()                                              */
/* Description  : CLOCK Initial Subroutines.                                 */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void InitalClock(void)
{

#if defined(HSRC)
  #if defined(HAO_2MHZ)
  //Clock INIT 2MHZ
  DrvCLOCK_EnableHighOSC(E_INTERNAL,10);        //Select HSRC
  DrvCLOCK_SelectIHOSC(0);                      //Select internal 2MHZ
  DrvCLOCK_SelectMCUClock(0,0);                 //CPU CLOCK IS 'hs_ck/1'
  DrvCLOCK_CalibrateHAO(0);                     //Calibration 1.843MHz
  #endif
  #if defined(HAO_4MHZ)
  //Clock INIT 4MHZ
  DrvCLOCK_EnableHighOSC(E_INTERNAL,10);        //Select HSRC
  DrvCLOCK_SelectIHOSC(1);                      //Select internal 4MHZ
  DrvCLOCK_SelectMCUClock(0,0);                 //CPU CLOCK IS 'hs_ck/1'
  DrvCLOCK_CalibrateHAO(1);                     //Calibration 4.147MHz
  #endif
```

```
   #if defined(HAO_10MHZ)
   //Clock INIT 10MHZ
   DrvCLOCK_EnableHighOSC(E_INTERNAL,10);        //Select HSRC
   DrvCLOCK_SelectIHOSC(2);                       //Select internal 10MHZ
   DrvCLOCK_SelectMCUClock(0,0);                  //CPU CLOCK IS 'hs_ck/1'
   DrvCLOCK_CalibrateHAO(2);                     //Calibration 9.216MHz
   #endif
   #if defined(HAO_16MHZ)
   //Clock INIT 16MHZ
   DrvCLOCK_EnableHighOSC(E_INTERNAL,10);        //Select HSRC
   DrvCLOCK_SelectIHOSC(3);                       //Select internal 16MHZ
   DrvCLOCK_SelectMCUClock(0,0);                  //CPU CLOCK IS 'hs_ck/1'
   DrvCLOCK_CalibrateHAO(3);                      //Calibration 15.667MHz
   #endif
#endif

}

/*---------------------------------------------------------------------------*/
/* Function Name: InitalUart()                                               */
/* Description  : UART Initial Subroutines.                                  */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void InitalUart(void)
{

#if defined(HSRC)
      DrvUART_ClkEnable(1,0);              //Choose the internal HAO as clock source
      #if defined(HAO_2MHZ)

DrvUART_Open(1843,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBITS
_1,2);
      #endif
      #if defined(HAO_4MHZ)

DrvUART_Open(4147,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBITS
_1,2);
      #endif
      #if defined(HAO_10MHZ)

DrvUART_Open(9216,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBITS
_1,2);
      #endif
      #if defined(HAO_16MHZ)

DrvUART_Open(15667,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBIT
S_1,2);
      #endif
#endif

   //1843 : oscillator frequency 2MHz Unit After Calibration HAO = 1843kHz
   //4147 : oscillator frequency 4MHz Unit After Calibration HAO = 4147kHz
   //9216 : oscillator frequency 10MHz Unit After Calibration HAO = 9216kHz
   //15667 : oscillator frequency 16MHz Unit After Calibration HAO = 15667kHz
   //None parity
   //8 data bits.
   //2 : Port 2.0 =TX, Port 2.1 =RX
```

```
    DrvGPIO_Open(UART_PORT,UART_TXD,E_IO_OUTPUT);
    DrvGPIO_Open(UART_PORT,UART_RXD,E_IO_INPUT);
    DrvGPIO_Open(UART_PORT,UART_RXD|UART_TXD,E_IO_PullHigh);
    DrvGPIO_ClkGenerator(E_HS_CK,1);
    DrvUART_EnableInt(ENABLE,ENABLE); //Enable UART Tx Interrupt, Enable UART Rx Interrupt
    DrvUART_Disable_AutoBaudrate();
    DrvUART_Close();
    DrvUART_Enable();
}


/*---------------------------------------------------------------------------*/
/* Function Name: InitalUart2()                                              */
/* Description  : UART2 Initial Subroutines.                                 */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void InitalUart2(void)
{
#if defined(HSRC)
      DrvUART2_ClkEnable(1,0);              //Choose the internal HAO as clock source
      #if defined(HAO_2MHZ)

DrvUART2_Open(1843,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBIT
S_1,2);
      #endif
      #if defined(HAO_4MHZ)

DrvUART2_Open(4147,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBIT
S_1,2);
      #endif
      #if defined(HAO_10MHZ)

DrvUART2_Open(9216,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBIT
S_1,2);
      #endif
      #if defined(HAO_16MHZ)

DrvUART2_Open(15667,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBI
TS_1,2);
      #endif
#endif
    //1843 : oscillator frequency 4MHz Unit After Calibration HAO = 1843kHz
    //4147 : oscillator frequency 4MHz Unit After Calibration HAO = 4147kHz
    //9216 : oscillator frequency 4MHz Unit After Calibration HAO = 9216kHz
    //15667 : oscillator frequency 4MHz Unit After Calibration HAO = 15667kHz
    //None parity
    //8 data bits.
    //2 : Port 2.2 =TX, Port 2.3 =RX
    DrvGPIO_Open(UART2_PORT,UART2_TXD,E_IO_OUTPUT);
    DrvGPIO_Open(UART2_PORT,UART2_RXD,E_IO_INPUT);
    DrvGPIO_Open(UART2_PORT,UART2_RXD|UART2_TXD,E_IO_PullHigh);
    DrvUART2_EnableInt(ENABLE,ENABLE); //ENABLE UART2 Tx Interrupt, ENABLE UART2 Rx Interrupt
    DrvUART2_Disable_AutoBaudrate();
    DrvUART2_Close();
    DrvUART2_Enable();
}

/*---------------------------------------------------------------------------*/
```

```
/* Function Name: void SendUART(int data)                                    */
/* Description  : UART send data.                                            */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void SendUART(int data)
{
  ADCData1=data;
  if((ADCData1<0)||(ADCData1>0x80000000))   // plus-minus sign judgment
  {
     ADCData1=~ADCData1;
     ADCData1++;
    UartTxBuffer[0]='-';
  }
  else
  {
    UartTxBuffer[0]='+';
  }
  UartTxBuffer[6]=ADCData1%10 | '0';   //unit
  ADCData1=ADCData1/10;
  UartTxBuffer[5]=ADCData1%10 | '0';   //ten
  ADCData1=ADCData1/10;
  UartTxBuffer[4]=ADCData1%10 | '0';   //hundred
  ADCData1=ADCData1/10;
  UartTxBuffer[3]=ADCData1%10 | '0';   //thousand
  ADCData1=ADCData1/10;
  UartTxBuffer[2]=ADCData1%10 | '0';   //ten thousand
  ADCData1=ADCData1/10;
  UartTxBuffer[1]=ADCData1%10 | '0';   //hundred thousand
  ADCData1=ADCData1/10;
  UartTxBuffer[7]='\r';
  UartTxBuffer[8]='\n';
  MCUSTATUSbits.b_UART_TxDone=DISABLE;
  UartTxLength=9;
  UartTxIndex=0;
  DrvUART_EnableInt(ENABLE,ENABLE);       //Enable UART Tx Interrupt;Enable UART Rx Interrupt
  while(!MCUSTATUSbits.b_UART_TxDone);   //If   MCUSTATUSbits.b_UART_TxDone=DISABLE, stop at
here
}

/*---------------------------------------------------------------------------*/
/* Function Name: void SendUART2(int data)                                   */
/* Description  : UART send data.                                            */
/* Arguments    : None.                                                      */
/* Return Value : None.                                                      */
/* Remark       :                                                            */
/*---------------------------------------------------------------------------*/
void SendUART2(int data)
{
  ADCData2=data;
  if((ADCData2<0)||(ADCData2>0x80000000))   // plus-minus sign judgment
  {
     ADCData2=~ADCData2;
     ADCData2++;
    Uart2TxBuffer[0]='-';
  }
  else
  {
    Uart2TxBuffer[0]='+';
```

```
    }

    Uart2TxBuffer[6]=ADCData2%10 | '0';    //unit
    ADCData2=ADCData2/10;
    Uart2TxBuffer[5]=ADCData2%10 | '0';    //ten
    ADCData2=ADCData2/10;
    Uart2TxBuffer[4]=ADCData2%10 | '0';    //hundred
    ADCData2=ADCData2/10;
    Uart2TxBuffer[3]=ADCData2%10 | '0';    //thousand
    ADCData2=ADCData2/10;
    Uart2TxBuffer[2]=ADCData2%10 | '0';    //ten thousand
    ADCData2=ADCData2/10;
    Uart2TxBuffer[1]=ADCData2%10 | '0';    //hundred thousand
    ADCData2=ADCData2/10;
    Uart2TxBuffer[7]='\r';
    Uart2TxBuffer[8]='\n';
    MCUSTATUSbits.b_UART2_TxDone=DISABLE;
    Uart2TxLength=9;
    Uart2TxIndex=0;
    DrvUART2_EnableInt(ENABLE,ENABLE);         //Enable UART Tx Interrupt;Enable UART Rx Interrupt
    while(!MCUSTATUSbits.b_UART2_TxDone);    //If    MCUSTATUSbits.b_UART_TxDone=DISABLE, stop
at here
}

/*-------------------------------------------------------------------------*/
/* UART AutoBaud Rate Initial Subroutines                                  */
/*-------------------------------------------------------------------------*/
void InitalUart_AutoBaudRate(void)
{

    //Step0. UART clock and UART open
#if defined(HSRC)
    #if defined(HAO_2MHZ)
    //Clock INIT 2MHZ
    DrvCLOCK_EnableHighOSC(E_INTERNAL,10);          //Select HSRC
    DrvCLOCK_SelectIHOSC(0);                        //Select internal 2MHZ
    DrvCLOCK_SelectMCUClock(0,0);                   //CPU CLOCK IS 'hs_ck/1'
    DrvCLOCK_CalibrateHAO(0);                       //Calibration 1.843MHz

DrvUART_Open(1843,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBITS
_1,2);
    #endif
    #if defined(HAO_4MHZ)
    //Clock INIT 4MHZ
    DrvCLOCK_EnableHighOSC(E_INTERNAL,10);          //Select HSRC
    DrvCLOCK_SelectIHOSC(1);                        //Select internal 4MHZ
    DrvCLOCK_SelectMCUClock(0,0);                   //CPU CLOCK IS 'hs_ck/1'
    DrvCLOCK_CalibrateHAO(1);                       //Calibration 4.147MHz

DrvUART_Open(4147,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBITS
_1,2);
    #endif
    #if defined(HAO_10MHZ)
    //Clock INIT 10MHZ
    DrvCLOCK_EnableHighOSC(E_INTERNAL,10);          //Select HSRC
    DrvCLOCK_SelectIHOSC(2);                        //Select internal 10MHZ
    DrvCLOCK_SelectMCUClock(0,0);                   //CPU CLOCK IS 'hs_ck/1'
    DrvCLOCK_CalibrateHAO(2);                       //Calibration 9.216MHz

DrvUART_Open(9216,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBITS
```

```
_1,2);
   #endif
   #if defined(HAO_16MHZ)
   //Clock INIT 16MHZ
   DrvCLOCK_EnableHighOSC(E_INTERNAL,10);          //Select HSRC
   DrvCLOCK_SelectIHOSC(3);                        //Select internal 16MHZ
   DrvCLOCK_SelectMCUClock(0,0);                   //CPU CLOCK IS 'hs_ck/1'
   DrvCLOCK_CalibrateHAO(3);                       //Calibration 15.667MHz

DrvUART_Open(15667,B9600,DRVUART_PARITY_NONE,DRVUART_DATABITS_8,DRVUART_STOPBIT
S_1,2);
   #endif
#endif

   DrvGPIO_Open(UART_PORT,UART_TXD,E_IO_OUTPUT);
   DrvGPIO_Open(UART_PORT,UART_RXD,E_IO_INPUT);
   DrvGPIO_Open(UART_PORT,UART_RXD|UART_TXD,E_IO_PullHigh);
   int_00=0x00000c00;                          //Clear UTxIF,URxIF
   clk_08=0x20200000;                          //First, setting TUCKS=1b
   clk_08=0x1F100000;                          //Second, setting ENUD=1b
   ur_00=0xff00ff65;

   //Step1.   Specific Configuration Before Auto Baud Rate
   ur_08 = 0x0;                                // Clear BRG
   DrvGPIO_Close(E_PT2,UART_RXD,E_IO_INPUT);
   while(!(int_00 & 0x4));                     // Wait for RX IRQ
   DrvGPIO_Open(UART_PORT,UART_RXD,E_IO_INPUT);
   ur_00 = 0xff000000;                         // clear UART Flags
   Delay(1000);                                // Delay about 1000 NOP. OR less
   int_00 = 0x00000400;                        // Clear UART Rx Interrupt flag


   //Step2.   Auto-Baud rate Enable and Detection Handshake
   ur_04 =0xff08;                              // Enable Auto-Baud rate detection
   while(1)                                    // break only when Auto Baud Rate and Handshake Complete
   {
      while(!(int_00 & 0x4))                   // Wait for RX IRQ. Wait Master to send 0x55
      int_00 = 0x00000400;                     // Clear UART Rx Interrupt flag
      if(Handshake())                          // If Handshake process(user defined) was completed
      {
          break;
      }
      ur_04 =0xff08;                           // Retry and Enable Auto-Baud rate detection
   }

}

/*-------------------------------------------------------------------------*/
/* Handshake                                                               */
/*-------------------------------------------------------------------------*/
unsigned int Handshake(void)
{
    unsigned char ACK_MASTER = 0xa1;
    unsigned char ACK_SLAVE = 0xa2;
    unsigned char ACK_HANDSHAKE = 0xa3;
    unsigned char read_data;
    unsigned int Handshake_timeout = 1000;

    while(Handshake_timeout--)
    {
```

```
        ISP_UART_Write(&ACK_SLAVE,1);                // Slave sends Handshake signal as a slave
        if(!(ISP_UART_Read(&read_data,1)))           // If UART READ was completed
        {
            if(read_data==ACK_MASTER)                // Host sends back Handshake
Character(ACK_MASTER)
            {
              ISP_UART_Write(&ACK_HANDSHAKE,1); // Handshake is completed
              return 1;
            }
        }
    }
    return 0;
}
/*---------------------------------------------------------------------------*/
/*  ISP_UART_Read                                                            */
/*---------------------------------------------------------------------------*/
unsigned char ISP_UART_Read(unsigned char* ptr_data, unsigned int count)
{
    unsigned int Timeout=1000;
    while(Timeout && count)                      // while(timeout!=0 && count !=0)
    {
        if(int_00 & 0x4)
        {
            *ptr_data = ur_0c;                   // get data
            Timeout=1000;                        // reset timeout
            ptr_data++;
            count--;
            int_00 = 0x00000400;                 // clear interrupt flag
        }
        else
        {
            Timeout--;
       }
    }
    return count;                                // return 0: UART read was completed
                                                 // return !=0: UART read timeout
}
/*---------------------------------------------------------------------------*/
/*  ISP_UART_Write                                                           */
/*---------------------------------------------------------------------------*/
void ISP_UART_Write(unsigned char* ptr_data, unsigned int count)
{

    while(count)
    {
        if(int_00 & 0x8)
        {
            ur_0c=*ptr_data<<16;
            ptr_data++;
            count--;
            Delay(1000);                         // delay some NOP. for Master Rx to receive correct data if
need
        }
    }
}



/*---------------------------------------------------------------------------*/
/*  End  Of  File                                                            */
```

/ * - * /

HY16F3981_IR_DemoCode_V00_UART.zip   HY16F3981_AM01_V00.zip

6. 參考文獻

[1] http://www.hycontek.com/wp-content/uploads/APD-SD18009_TC.pdf，紘康科技 HY11P13 紅外線感測器應用說明書

[2] http://www.hycontek.com/hy_mcu/DS-HY16F3981_TC.pdf，紘康科技 HY16F3981 Datasheet.

[3] http://www.hycontek.com/hy_mcu/UG-HY16F3981_TC.pdf，紘康科技 HY16F3981 User Guide.

7. 修訂記錄

以下描述本文件差異較大的地方，而標點符號與字形的改變不在此描述範圍。

文件版次	頁次	日期	摘要
V01	All	2018/11/02	初版發行