



# HY16F188 Voltage Current Meter Application Manual

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### 1. Content Introduction

Regarding to industrial application, voltage and current measurement are the most fundamental yet the most important factors. As to industrial measurement in pressure, temperature and humidity, sensor is applied to convert signals into voltage or current, which are in turn analyzed by electrical instrument before displaying on the meter. Therefore, there is a significant importance in measuring accurate voltage and current. This article mainly discusses about HYCON HY16F188 Series chip application in voltage and current measurement. HY16F188 chip is equipped with internal-integrated accurate display  $\Sigma\Delta$  ADC. In addition, ADC output frequency can reach a maximum of 10KHZ. Since IC HY2613B is driven by external LCD, HY16F188 possesses a relatively high accuracy in measuring voltage and current.

### 2. Theory Explanation

Voltage Measurement:

Electrical circuit chart is demonstrated in illustration 1. This circuit is a simple voltage division circuit, with a voltage division ratio being 20:1. Due to program setting relationship, maximum voltage difference between AIO0 and AIO1 is 1.2V. Therefore, upper limit to voltage measurement is 20V. Current measurement: electrical circuit chart is presented in illustration 2. Once current source flows through 10 $\Omega$  resistance, a voltage drop is generated. By measuring voltage drop, electrical current can be inferred.

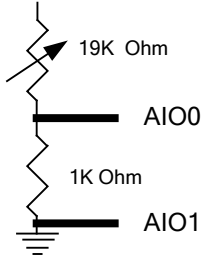
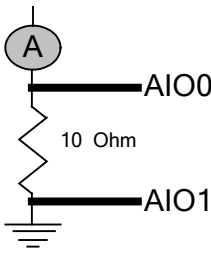
Resolution is separated into external resolution and internal resolution. External resolution is the voltage ratio between maximum output voltage and minimum voltage to be identified. Minimum measurement voltage in this application is 10mV.

Generally, internal resolution defined by our visual method refers to one grid rolling in LCD display after being processed by our software. Under this moment, full-range grid indicate internal resolution, with one grid representing a signal 2-3 times higher than RMS Noise. The smaller the resolution ratio between internal and external resolution, the higher the accuracy will be in voltage current meter. However, there is still limitation to resolution ratio between internal and external resolution. For example, full-range voltage difference is 1.1V. To reach 2000 count, voltage current meter with a 1:10 resolution ratio between internal and external resolution must process a minimum signal of  $1.1V/(2000 \times 10) = 55\mu V$ , if hasn't gone through signal amplification. SD24 can process a minimum signal value of 65nV. As a result, it is extremely easy to complete accurate measurement in this specification.

To test whether ADC performance can achieve the required specification, we apply RMS Noise to infer whether externality can stabilize internal resolution ratio. Regarding to development in electronic product, the bottle neck for HY16F188 chip to achieve the maximum internal resolution lies in Input RMS Noise rather than ADC resolution. After being amplified by PGA and AD multiplying regulator (PGA=32, ADGN=4), HY16F188 ADC signal is subjected to a condition where OSR=32768 outputs 10 ADC values per second, further leading to an Input RMS Noise being approximately 65nV. However, since Input Noise is primarily composed of Thermal Noise, we can further reduce Input Noise through average software processing.

If we apply 8 output software to evenly processing its Input RMS Noise, 40nV can be achieved after considering other noise factors, with 3 times RMS Noise representing approximately 1 grid rolling, or 120nV. After applying 2.4V drive voltage, 1mV/V full-range voltage difference can achieve 2.4mV. Under this situation, we can obtain a 20000 counts internal resolution.

### 2.1 Measurement Theory

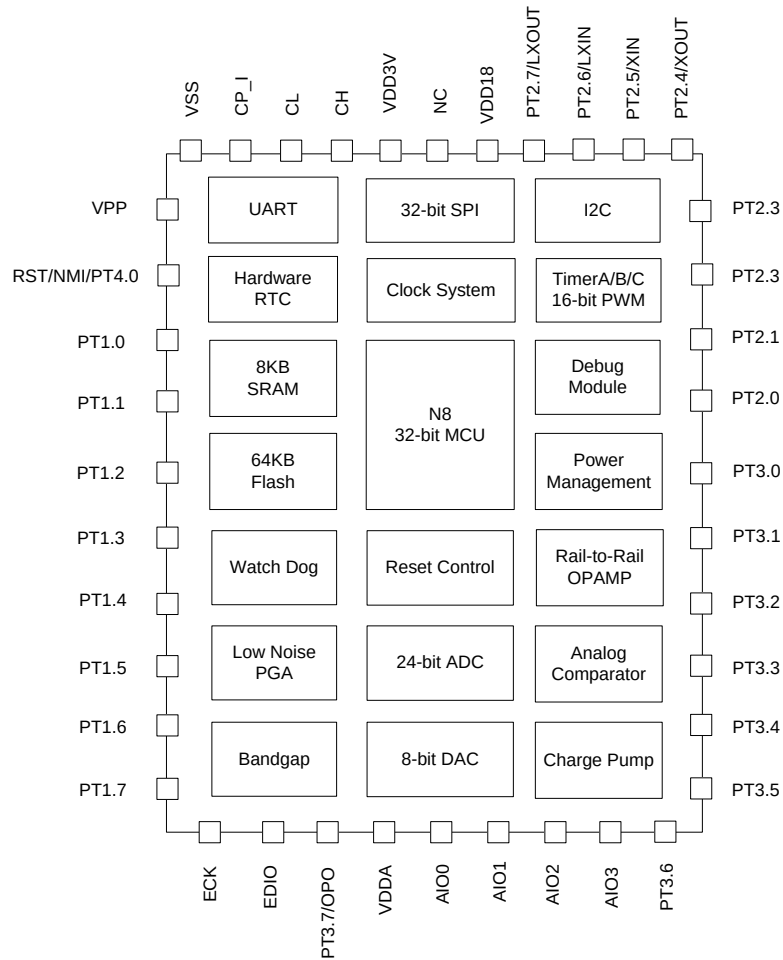
|                                                                                   |                                                                                    |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|  |  |
| Illustration 1: Voltage Measurement<br>Circuit Chart                              | Illustration 2: Current Measurement Circuit                                        |

### 2.2 Control Chip

single-chip microcomputer: HY16F Series 32 Bit High Performance Flash Single-Chip Microcomputer (HY16F188)

# HY16F188

## Voltage Current Meter



HYCON HY16F Series 32 Bit High Performance Flash Single-Chip Microcomputer  
(HY16F188)

- (1) Apply the most advanced Andes 32 Bit CPU Kernel N801 Processor.
- (2) Voltage operation range is 2.4 – 3.6V, while working temperature range is -40 °C~ 85°C.
- (3) Support for external 20MHz quartz crystal resonator or internal 20MHz highly accurate RC oscillator, with various CPU working clock switching options, further enabling user to achieve the optimum power saving plan.
- (3.1) Operating Mode: 350uA @ 2MHz/2(3.2)Idle Mode: 10uA @ 32KHz/2(3.3)Sleep Mode: 2.5uA
- (4) Program Memory: 64KBytes Flash ROM
- (5) Data Memory: 08KBytes SRAM
- (6) Equipped with BOR and WDT, so as to prevent CPU crash.
- (7) 24-bit Highly Accurate  $\Sigma\Delta$ ADC Analog to Digital Converter
- (7.1) Installed with PGA (Programmable Gain Amplifier), capable of achieving a maximum of 128 times amplification.
- (7.2) Installed with temperature sensor.
- (8) Lowest Input Noise Operational Amplifier OPAMP.
- (9) 16-bit Timer A
- (10) 16-bit Timer B Module with PWM Generation Function
- (11) 16-Bit Timer C Module with Digital Capture/Compare Function
- (12) Hardware Series Communication SPI Module
- (13) Hardware Series Communication I2C Module
- (14) Hardware Series Communication UART Module
- (15) Hardware RTC Clock Function Module
- (16) Hardware Touch KEY Function Module



### 3. System Design

#### 3.1 Hardware Explanation

Regarding to voltage current measurement application, HY16F188 integral circuit includes S2 and S3 button and LCD display module, as demonstrated in illustration 3.

(A) Central Processing Unit (CPU):

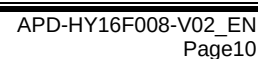
HY16F188 (Andes 32-bit MCU Core + HYCON 24-bit  $\Sigma\Delta$ ADC + UMC 64K Flash)

(B) Display Chip:HY2613 (HYCON LCD Driver LCD Segment 4X36)

(C) Power Supply Circuit: 5.0V convert to 3.3V Power Supply System

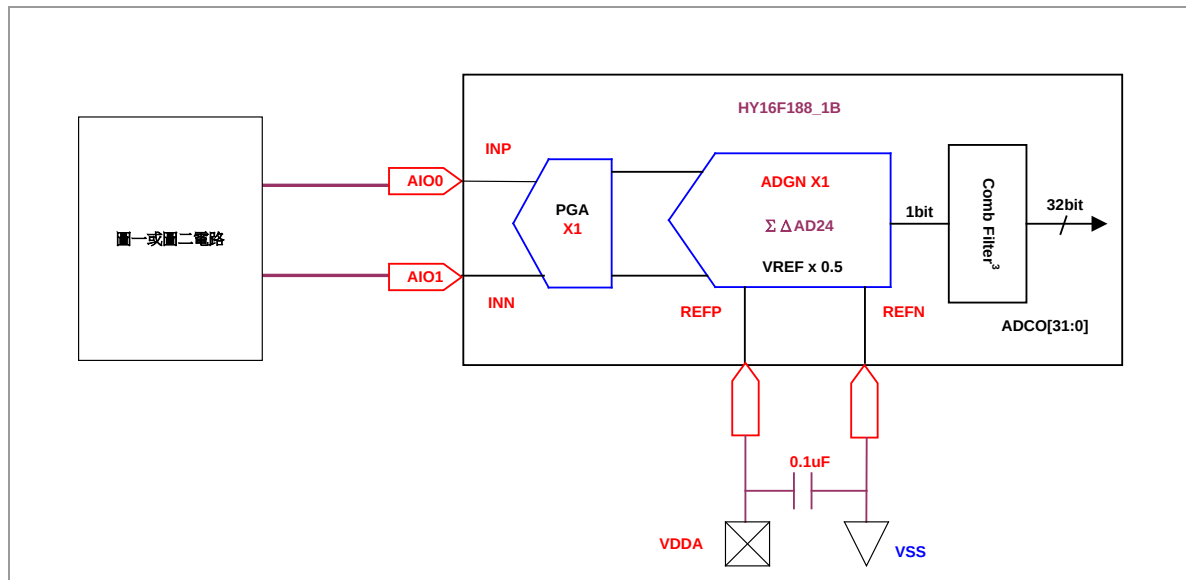
(D) Analog Sensory Module: Internal ADC

(E) Through EDM connection, online burning and ICE connection circuit can support for online burning simulation. It is equipped with a strong C Platform IDE, HYCON analog software analysis instrument and GUI support.



### 3.2 Function Explanation

ADC internal PGA amplifies for 1 time, while ADGN amplifies for 1 time as well. Referential voltage is provided through VDDA-VSS, resulting in  $\Delta VR_I = 1.2V$ .



#### 3.2.1 Voltage Measurement

Under voltage measurement mode, measurement range is between  $\pm 20V$ . While conducting measurement, please comply with circuit chart demonstrated in illustration 1. Display can reach 1mV, while accuracy can reach 10mV.

#### 3.2.2 Current Measurement

Current measurement range is between  $\pm 10A$ . While conducting measurement, please comply with circuit chart demonstrated in illustration 2. Display and measurement accuracy are both 0.1mA.

## 4. Operation Procedure

### 4.1 Operation Method

After starting up, initialization and HYCON display will be conducted in the first place.

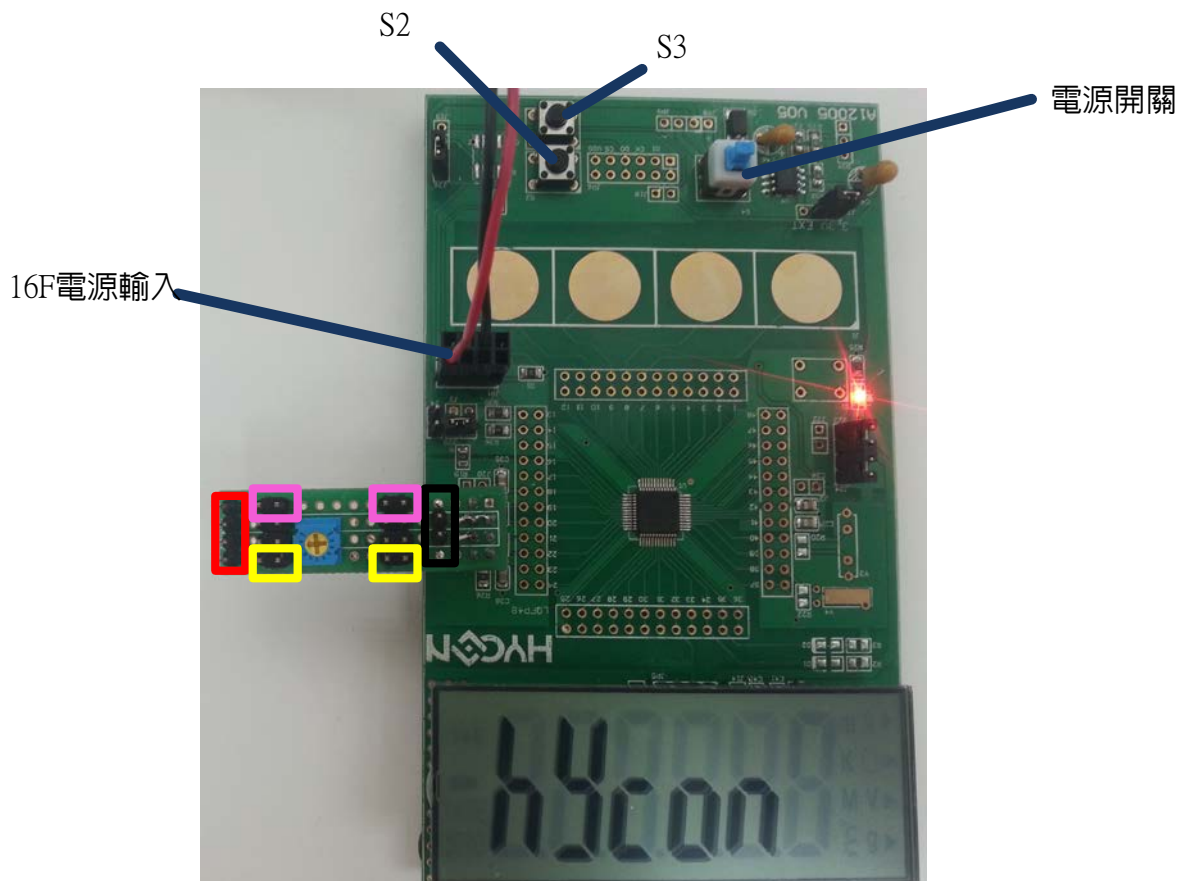
Through S3 button, measurement optional converting can be conducted, with S2 representing confirmation.

Selection Display:

20V stands for  $\pm 20V$  measurement, with a need to comply with the externality so as to implement appropriate short circuit.

10A stands for  $\pm 10A$  measurement, with a need to comply with the externality so as to implement appropriate short circuit.

Under measurement mode, please click S2 to leave for initial status.



## **HY16F188**

### **Voltage Current Meter**

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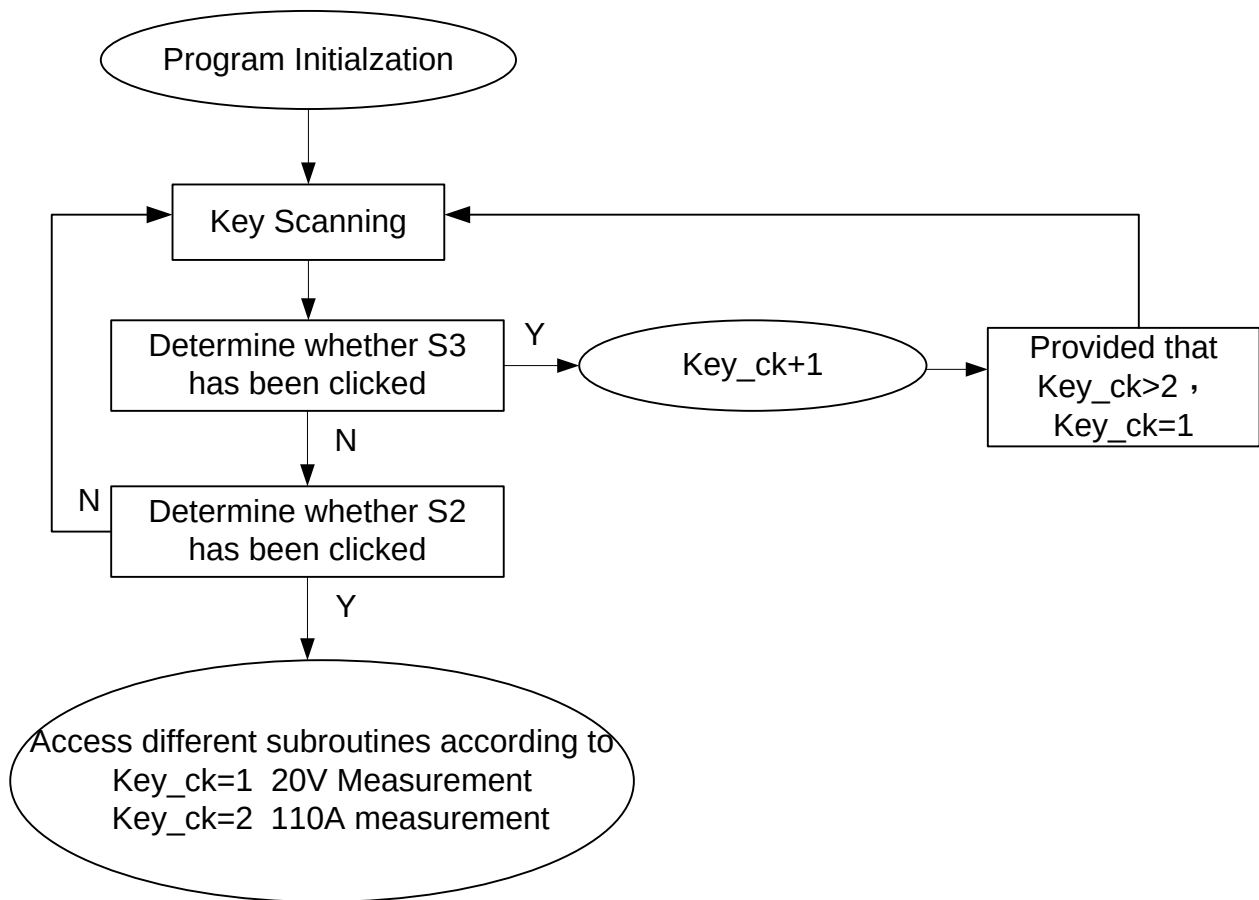
Portion within the red frame stands for measurement +.

Portion within the black frame stands for measurement -.

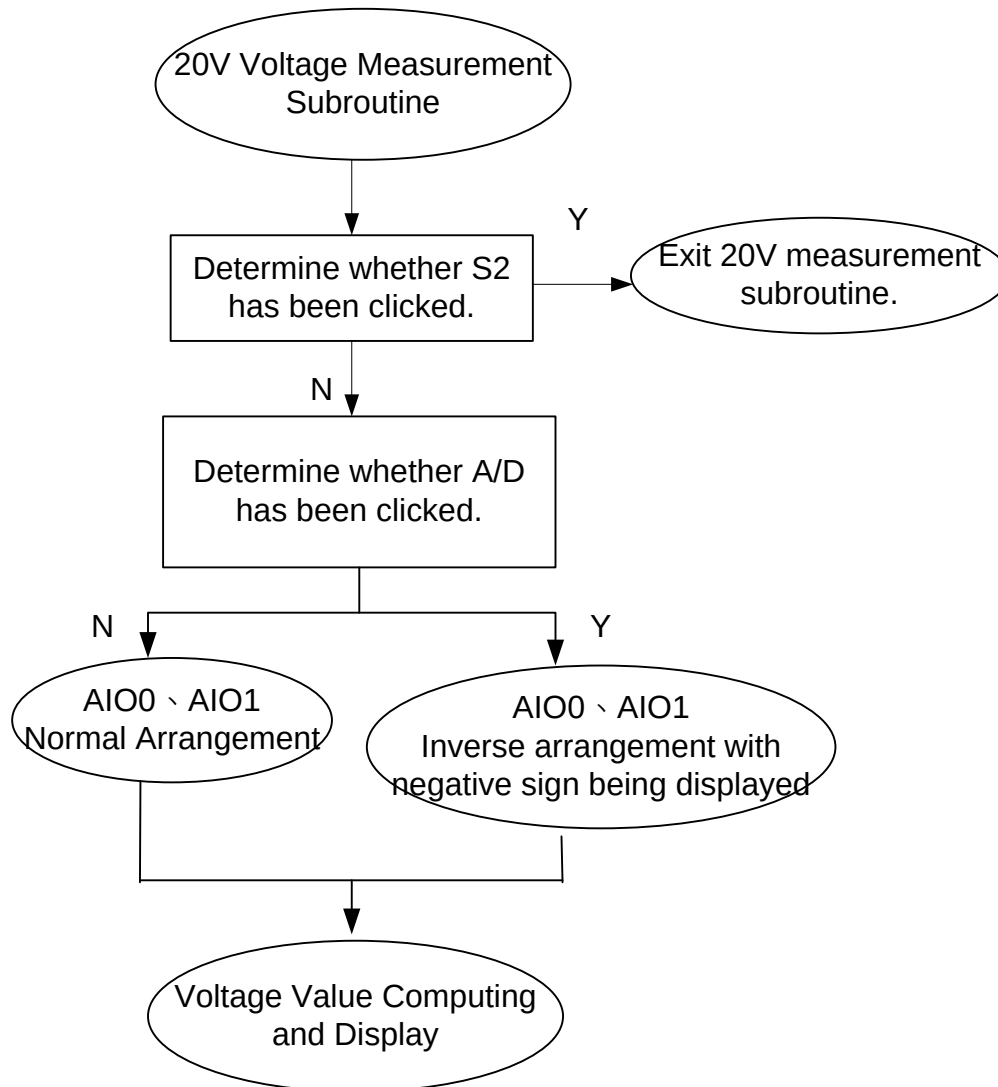
While selecting current measurement, make sure that portions within the two pink frames are short circuited.

While selecting voltage measurement, make sure that portions within the two yellow frames are short circuited.

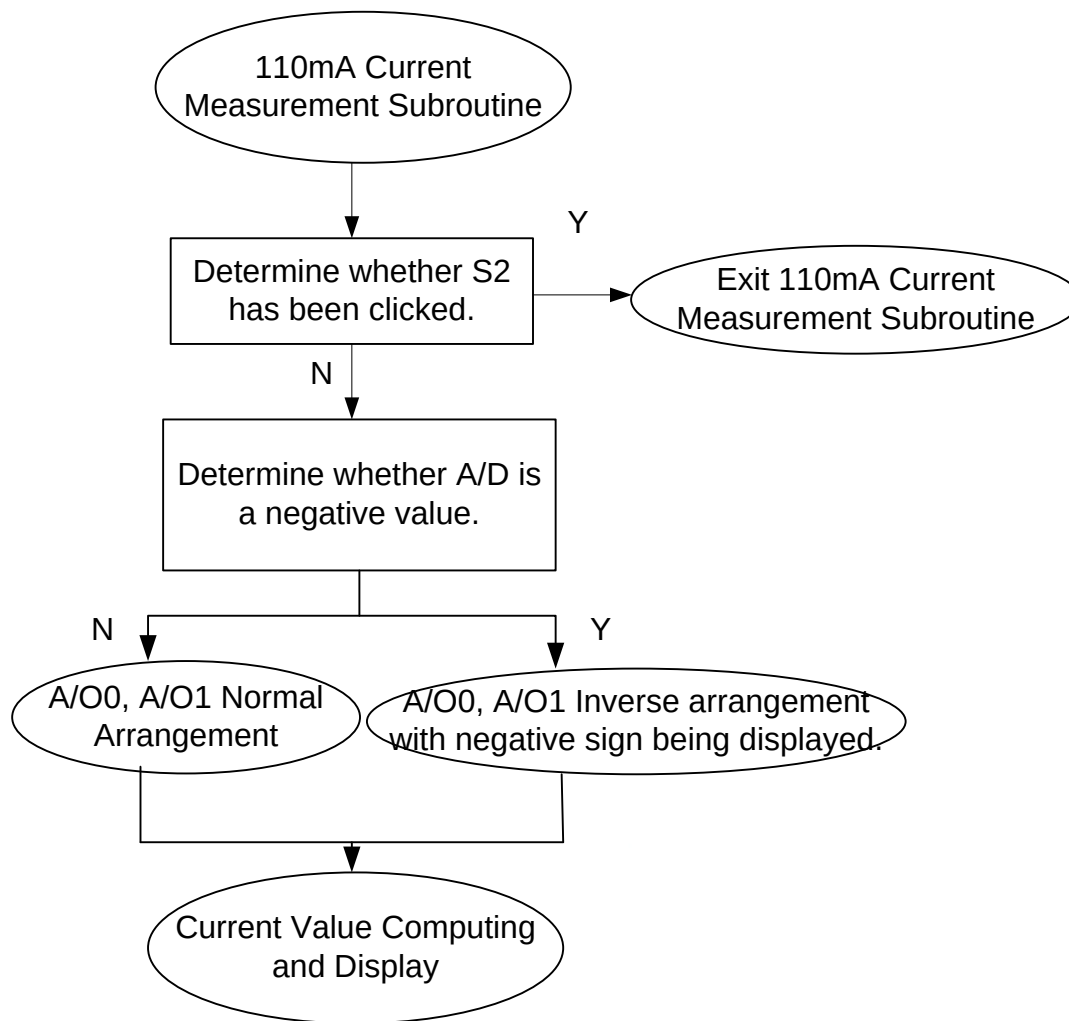
#### 4.2 Program Procedure



#### 4.3 Voltage Measurement Subroutine



4.4 Current Measurement Subroutine





## 5. Technical Specification

- (1) Power Supply Connecting Point: 3.0V
- (2) Power Consumption: Working Mode 1mA
- (3) Measurement Precision: Voltage: 10 (mV) and Current 0.1 (mA)
- (4) Applicable Range: Various Current Voltage Measurement
- (5) Working Temperature: -40°C ~ +85°C
- (6) Storage Temperature: -55°C ~ +125°C
- (7) Relative Humidity: < 95% (Under 20±5°C Condition)

### 5.1 Measurement Data

#### 20V Voltage Measurement

| Fluke Output Voltage | 16F188 Measured Voltage |      | Error % |        |
|----------------------|-------------------------|------|---------|--------|
| mV                   | +                       | -    | +       | -      |
| 10                   | 10                      | 10   | 0.0000  | 0.0000 |
| 20                   | 20                      | 20   | 0.0000  | 0.0000 |
| 30                   | 30                      | 30   | 0.0000  | 0.0000 |
| 40                   | 40                      | 40   | 0.0000  | 0.0000 |
| 50                   | 50                      | 50   | 0.0000  | 0.0000 |
| 60                   | 60                      | 60   | 0.0000  | 0.0000 |
| 70                   | 70                      | 70   | 0.0000  | 0.0000 |
| 80                   | 80                      | 80   | 0.0000  | 0.0000 |
| 90                   | 90                      | 90   | 0.0000  | 0.0000 |
| 100                  | 100                     | 100  | 0.0000  | 0.0000 |
| 200                  | 200                     | 200  | 0.0000  | 0.0000 |
| 300                  | 300                     | 300  | 0.0000  | 0.0000 |
| 400                  | 400                     | 400  | 0.0000  | 0.0000 |
| 500                  | 500                     | 500  | 0.0000  | 0.0000 |
| 600                  | 600                     | 600  | 0.0000  | 0.0000 |
| 700                  | 700                     | 700  | 0.0000  | 0.0000 |
| 800                  | 800                     | 800  | 0.0000  | 0.0000 |
| 900                  | 900                     | 900  | 0.0000  | 0.0000 |
| 1000                 | 1000                    | 1000 | 0.0000  | 0.0000 |
| 1500                 | 1500                    | 1500 | 0.0000  | 0.0000 |
| 1600                 | 1600                    | 1600 | 0.0000  | 0.0000 |
| 1700                 | 1700                    | 1700 | 0.0000  | 0.0000 |

# **HY16F188**

## **Voltage Current Meter**

|       |       |       |        |        |
|-------|-------|-------|--------|--------|
| 1800  | 1800  | 1800  | 0.0000 | 0.0000 |
| 1900  | 1900  | 1900  | 0.0000 | 0.0000 |
| 2000  | 2000  | 2000  | 0.0000 | 0.0000 |
| 2500  | 2500  | 2500  | 0.0000 | 0.0000 |
| 3000  | 3000  | 3000  | 0.0000 | 0.0000 |
| 3500  | 3500  | 3500  | 0.0000 | 0.0000 |
| 4000  | 4000  | 4000  | 0.0000 | 0.0000 |
| 4500  | 4500  | 4500  | 0.0000 | 0.0000 |
| 5000  | 5000  | 5000  | 0.0000 | 0.0000 |
| 6000  | 6000  | 6000  | 0.0000 | 0.0000 |
| 7000  | 7000  | 7000  | 0.0000 | 0.0000 |
| 8000  | 8000  | 8000  | 0.0000 | 0.0000 |
| 9000  | 9000  | 9000  | 0.0000 | 0.0000 |
| 10000 | 10000 | 10000 | 0.0000 | 0.0000 |
| 11000 | 11000 | 11000 | 0.0000 | 0.0000 |
| 12000 | 12000 | 12000 | 0.0000 | 0.0000 |
| 13000 | 13000 | 13000 | 0.0000 | 0.0000 |
| 14000 | 14000 | 14000 | 0.0000 | 0.0000 |
| 15000 | 15000 | 15000 | 0.0000 | 0.0000 |
| 16000 | 16000 | 16000 | 0.0000 | 0.0000 |
| 17000 | 17000 | 17000 | 0.0000 | 0.0000 |
| 18000 | 18000 | 18000 | 0.0000 | 0.0000 |
| 19000 | 19000 | 19000 | 0.0000 | 0.0000 |
| 20000 | 20000 | 20000 | 0.0000 | 0.0000 |

# HY16F188

## Voltage Current Meter

### 110mA Current Measurement

| Fluke Output Current | 16F188 Measured Current |       | Error % |       |
|----------------------|-------------------------|-------|---------|-------|
| mA                   | +                       | -     | +       | -     |
| 0                    | 0                       | 0     | 0       | 0     |
| 1                    | 1                       | 1     | 0       | 0     |
| 2                    | 2                       | 2     | 0       | 0     |
| 3                    | 3                       | 3     | 0       | 0     |
| 4                    | 4                       | 4     | 0       | 0     |
| 5                    | 5                       | 5     | 0       | 0     |
| 6                    | 6                       | 6     | 0       | 0     |
| 7                    | 7                       | 7     | 0       | 0     |
| 8                    | 8                       | 8     | 0       | 0     |
| 9                    | 9                       | 9     | 0       | 0     |
| 10                   | 10                      | 10    | 0       | 0     |
| 11                   | 11                      | 11    | 0       | 0     |
| 12                   | 12                      | 12    | 0       | 0     |
| 13                   | 13                      | 13    | 0       | 0     |
| 14                   | 14                      | 14    | 0       | 0     |
| 15                   | 15                      | 15    | 0       | 0     |
| 16                   | 16                      | 16    | 0       | 0     |
| 17                   | 17                      | 17    | 0       | 0     |
| 18                   | 18                      | 18    | 0       | 0     |
| 19                   | 19                      | 19    | 0       | 0     |
| 20                   | 20                      | 20    | 0       | 0     |
| 25                   | 25                      | 25    | 0       | 0     |
| 30                   | 30                      | 30    | 0       | 0     |
| 40                   | 40                      | 40    | 0       | 0     |
| 50                   | 50                      | 50    | 0       | 0     |
| 60                   | 60                      | 60    | 0       | 0     |
| 70                   | 70                      | 70    | 0       | 0     |
| 80                   | 80                      | 80    | 0       | 0     |
| 90                   | 90                      | 90.1  | 0       | 0.111 |
| 100                  | 100                     | 100.1 | 0       | 0.1   |
| 110                  | 110.1                   | 110.1 | 0.09    | 0.09  |

### 6. Result Conclusion

HY16F188 combines internal highly accurate, multi-channel input, and speedy ADC measurement. Compared to other meters sold in the market, our current and voltage measurement meter consumes lower power and exhibit outstanding measurement accuracy in voltage or current measurement. HY16F188 internal ADC is not only applied in voltage and current measurement, but can also be connected to external sensors, so as to conduct other measurement. All measurements conducted by our meter exhibit satisfactory performance.

### 7. Attached Document



HY16F008V03.zip

### 8. Referential Literature

- (1)HYCON HY16F188 Series Data Sheet
- (2)HYCON HY16F188 Series User's Guide

### 9. Amendment Record

Greater differences in the document are presented below, with variation in punctuation and font excluded.

| Version | Page Number | Amendment Summary           | Date       |
|---------|-------------|-----------------------------|------------|
| V1.0    | ALL         | Initial Version Publication | 2013/10/30 |
| V2.0    | ALL         | Procedure Amendment         | 2014/12/17 |

# HY16F188

## Voltage Current Meter

```
/*-----*/
/*****
*HY16F188
* main.c
* Created on:2013/12/08
* Maintenance:2014/10/01
* -----
* Release 1.0.0
* Program Description:
* -----
*
* -----
*      | -----
* PT2.0 | SDA ---> SDA | LCD Drive HY2613 |
* PT2.1 | SCK ---> SCK -----
*      GND |
*      |
* -----
*****/
/*-----*/
/* Includes                                     */
/*-----*/
#include "HY16F188.h"
#include "System.h"
#include "DrvGPIO.h"
#include "DrvI2C.h"
#include "DrvHWI2C.h"
#include "DrvCLOCK.h"
#include "DrvADC.h"
#include "DrvPMU.h"
#include "HY2613.h"
#include "my define.h"

/*-----*/
/* STRUCTURES
*/
/*-----*/
typedef union _MCUSTATUS
```

```
{
    char _byte;
    struct
    {
        unsigned b_ADCdone:1;
        unsigned b_TMAdone:1;
        unsigned b_TMBdone:1;
        unsigned b_TMC0done:1;
        unsigned b_TMC1done:1;
        unsigned b_RTCdone:1;
        unsigned b_UART_TxDone:1;
        unsigned b_UART_RxDone:1;
    };
} MCUSTATUS;

/*-----*/
/* DEFINITIONS                                     */
/*-----*/

/*-----*/
/* Global CONSTANTS
*/
/*-----*/
MCUSTATUS  MCUSTATUSbits;
extern unsigned char seg[16];
#define  Disable 0
#define  Enable  1
int key_ck,b,c,pb6,pb7;                //button
signed int ADtemp10,ADCDData,sum,ADtemp101,ADtemp100,average;//AD use
signed int ADtemp20n,ADtemp20p,ADtemp200,ADtemp110n,ADtemp110p,ADtemp1100;
//use by calculate & display
int nu,tn,ch,ok;
int value_buf[9];
/*-----*/
/* Function PROTOTYPES
*/
/*-----*/
void Delay(unsigned int num);
```

```
void InitalADC(void);
void Initial_ALL(void);
void Pb_6();
void Pb_7();
void AD3(void);
void Test1(void);
void Test2(void);
void AD01(void);
/*-----*/
/* Main Function */
/*-----*/
int main(void)
{
    InitalI2C();
    SYS_EnableGIE(7,0x3F); // Enable GIE(Global Interrupt)

    Ini_Display();
    ClearLCDframe();

    InitalADC();
    Initial_ALL();

    MCUSTATUSbits._byte = 0;
    while(1)
    {
        pb7=0;
        LCD_DATA_DISPLAY2(key_ck);
        if(b==0) Pb_6();
        if(pb6==1)
        {
            pb6=0;
            key_ck++;
            Delay(0x2000);
            if(key_ck>=3) key_ck=1;
        }
        if(c==0) Pb_7();
        if(pb7==1)
        {
            pb7=0;
```

```
        switch(key_ck)
        {
            case 0x01:Test1();break;/**  
            case 0x02:Test2();break;/**  
        }
    }
}

return 0;
}
void Test1(void)
{
    while(DrvGPIO_GetBit(E_PT1,7))
    {
        AD3();
        key_ck=0;
        if(nu==0)
        {
            AD01();
            if(sum<7010)
            {sum=sum-1;
            ADtemp101=100*(sum-ADtemp200)/(ADtemp20n-ADtemp200);
            ADtemp100=ADtemp101%100;
            if(ADtemp100>70) ADtemp101+=100;
            ADtemp101=ADtemp101/100;
            ADtemp101=ADtemp101*10;
            LCD_DATA_DISPLAY(ADtemp101);
            }
            else
            {
                if(sum<10507)
                {
                    sum-=1;

ADtemp101=(sum-ADtemp200)/(ADtemp20n-ADtemp200);
                    ADtemp101*=10;
                }
            }
        }
    }
}
```



```
        {
            sum-=3;

ADtemp101=(sum-ADtemp200)/(ADtemp20n-ADtemp200);
            ADtemp101*=10;
        }
        LCD_DATA_DISPLAY(ADtemp101);
    }
}
if(nu==1)
{
    AD01();
    if(sum<7010)
    {sum=sum-1;

ADtemp101=100*(sum+ADtemp200)/(ADtemp20n+ADtemp200);
        ADtemp100=ADtemp101%100;
        if(ADtemp100>70) ADtemp101+=100;
        ADtemp101=ADtemp101/100;
        ADtemp101=ADtemp101*10;
        LCD_DATA_DISPLAY(ADtemp101);
    }
    else
    {
        if(sum<10507)
        {
            sum-=1;

ADtemp101=(sum+ADtemp200)/(ADtemp20n+ADtemp200);
            ADtemp101*=10;
        }
        else
        {
            sum-=3;

ADtemp101=(sum+ADtemp200)/(ADtemp20n+ADtemp200);
            ADtemp101*=10;
        }
        LCD_DATA_DISPLAY(ADtemp101);
```

```
        }
    }
}
Delay(0x2000);
}
/*-----*/
void Test2(void)
{
    while(DrvGPIO_GetBit(E_PT1,7))
    {
        AD3();
        key_ck=0;
        if(nu==0)
        {
            AD01();
            ADtemp101=100*(sum+1)/(ADtemp110n-ADtemp1100);
            LCD_DATA_DISPLAY1(ADtemp101);
        }
        if(nu==1)
        {
            AD01();
            ADtemp101=100*(sum+1)/(ADtemp110n-ADtemp1100);
            LCD_DATA_DISPLAY1(ADtemp101);
        }
    }
    Delay(0x2000);
}
/*-----*/

void AD01(void)
    //ADC sub-program
{
    unsigned char t;
    while(ok)                                //ADC after Interrupt OK=1
    {
        ok=0;
        ADtemp10=(ADCDData>>17);
    }
}
```

```
        value_buf[8]=value_buf[7];           // sliding filtering average
        value_buf[7]=value_buf[6];
        value_buf[6]=value_buf[5];
        value_buf[5]=value_buf[4];
        value_buf[4]=value_buf[3];
        value_buf[3]=value_buf[2];
        value_buf[2]=value_buf[1];
        value_buf[1]=ADtemp10;
        sum=0;
        for(t=4;t>0;t--)
        {
            sum+=value_buf[t];
        }
        average=sum>>2;
    }
    if(average<0) average*=-1;
    sum=average;
}

/*
void AD01(void)
{
    int t;
    sum=0;
    for(t=0;t<8;t++)
    {
        ADtemp10=(ADCDData>>17);
        sum=sum+ADtemp10;
    }
    sum=sum>>3;
    if(sum<0)
    {
        sum*=-1;
    }
}
*/

/*-----*/
void AD3(void)
{
```

```
int t;
sum=0;
for(t=0;t<8;t++)
{
    ADtemp10=(ADCDData>>18);
    sum+=ADtemp10;
}
if(sum>=-30)
{
    if(ch==0)
    {
        nu=0;
        ch=0;

        DrvADC_SetADCInputChannel(ADC_Input_AIO1,ADC_Input_AIO0);//AIO0、 AIO1
Normal configuration
        goto by;
    }
    if(ch==1)
    {
        nu=1;
        ch=1;

        DrvADC_SetADCInputChannel(ADC_Input_AIO0,ADC_Input_AIO1);//AIO0、
AIO1Reversed
        goto by;
    }
}
if(sum<0)
{
    if(ch==0)
    {
        nu=1;
        ch=1;

        DrvADC_SetADCInputChannel(ADC_Input_AIO0,ADC_Input_AIO1);//AIO0、
AIO1Reversed configuration
        goto by;
    }
}
```

```
        if(ch==1)
        {
            nu=0;
            ch=0;

            DrvADC_SetADCInputChannel(ADC_Input_AIO1,ADC_Input_AIO0);//AIO0、 AIO1
Normal configuration

            goto by;
        }
    }
    by:asm("NOP");
    Delay(0x8000);
}
/*-----*/
/* Hardware Communication Interrupt */
/* UART/SPI/I2C Interrupt Service Routines */
/*-----*/
void HW0_ISR(void)
{
    unsigned char I2C_Status;

    if(DrvI2C_ReadIntFlag()==E_DRVI2C_INT) // Get I2C Interrupt Flag
    {
        I2C_Status=DrvI2C_GetStatusFlag(); // Get I2C Status Flag
        switch(I2C_Status)
        {
            case 0x90: //MACTFlag+RWFlag
                { /* START has been transmitted */
                    DrvI2C_WriteData(I2C_TARGET); //Send Slave Address & R/W Bit
                    DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
                    break;
                }
            case 0x84: //MACTFlag+ACKFlag
                { /* Slave A + W has been transmitted. ACK has been received. */
                    DrvI2C_WriteData(Sendbuf[DataTxIndex++]); //Send Data to Slave
                    DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
                    break;
                }
            case 0x80: //MACTFlag
```

```
        { /* Slave A + W has been transmitted. ACK has been received. */
            DrvI2C_WriteData(Sendbuf[DataTxIndex++]); //Send Data to Slave
            DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
            break;
        };
case 0x30:
    {
        DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
        EndFlag=1;
        break;
    };
case 0x8C: // MACTFlag+DFFlag+ACKFlag
    { /* DATA has been transmitted and ACK has been received */
        if(DataTxIndex<DataTxLen)
        {
            DrvI2C_WriteData(Sendbuf[DataTxIndex++]); //Send Data to Slave
            DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
        }
        else
        {
            if(I2C_RW == WRITE)
            {
                DrvI2C_Ctrl(0,1,0,0); // I2C as master sends STOP signal
                EndFlag=1;
            }
            else if(I2C_RW == READ)
                DrvI2C_Ctrl(1,0,0,0); // I2C as master sends START signal
            DataTxIndex=0;
        }
        break;
    };
case 0x88: //MACTFlag+DFFlag
    { /* DATA has been transmitted and NACK has been received */
        DrvI2C_Ctrl(0,1,0,0); // I2C as master sends STOP signal
        DataTxIndex=0;
        EndFlag=1;
        break;
    };
case 0xB0:
```

```
        { /* A repeated START has been transmitted. */
            DrvI2C_WriteData(I2C_TARGET | READ); //Send Slave Address & R/W Bit
            DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
            break;
        }
    case 0x94: //MACTFlag+RWFlag
        { /* Slave A + R has been transmitted. ACK has been received. */
            DrvI2C_Ctrl(0,0,0,1); // Set ACK bit
            break;
        };
    case 0x9C: //MACTFlag+RWFlag+DFFlag+ACKFlag
        { /* Data byte has been received. ACK has been transmitted. */
            if(DataRxLen>DataRxIndex)
            {
                Recbuf[DataRxIndex++]=DrvI2C_ReadData();
                DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
            }
            else
            {
                Recbuf[DataRxIndex++]=DrvI2C_ReadData();
                DrvI2C_Ctrl(0,1,0,0); // I2C as master sends STOP signal
                EndFlag=1;
            }
            break;
        };
    case 0x98: //MACTFlag+RWFlag+DFFlag
        { /* Data byte has been received. NACK has been transmitted. */
            DrvI2C_Ctrl(0,1,0,0); // I2C as master sends STOP signal
            EndFlag=1;
            break;
        };
    default:
        {
            DrvI2C_Ctrl(0,0,0,0); // Clear all I2C flag
            EndFlag=1;
            break;
        };
}
DrvI2C_ClearEIRQ();
```

```
    DrvI2C_ClearIntFlag(2); // Clear I2C Interrupt Flag(I2CIF)
    SYS_EnableGIE(7,0x3F);      // Enable GIE(Global Interrupt)
}
if(DrvI2C_ReadIntFlag()==E_DRVI2C_ERROR_INT) //Get I2C Error Interrupt Flag
{
    EndFlag=1;
    DrvI2C_ClearIRQ();
    DrvI2C_ClearIntFlag(2); // Clear I2C Interrupt Flag(I2CEIF)
    DrvI2C_Ctrl(0,1,0,0);    // I2C as master sends STOP signal
    SYS_EnableGIE(7,0x3F);      // Enable GIE(Global Interrupt)
}
}
```

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

```
/* WDT & RTC & Timer A/B/C Interrupt Service Routines
```

```
*/
```

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

```
void HW1_ISR(void)
```

```
{
```

```
}
```

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

```
/* HW2 ADC Interrupt Subroutines
```

```
*/
```

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

```
void HW2_ISR(void)
```

```
{
```

```
    DrvADC_ClearIntFlag();
```

```
    ADCData=adc_08;
```

```
    ok=1;
```

```
}
```

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

```
/* CMP/OPA Interrupt Service Routines
```

```
*/
```

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

```
void HW3_ISR(void)
```

```
{
```

```
}
```



```
/*-----*/
/* PT1 Interrupt Service Routines                                     */
/*-----*/
void HW4_ISR(void)
{
    DrvGPIO_ClearIntFlag(E_PT1,0xc0);          //Clear PT1 interrupt flag
    b=DrvGPIO_GetBit(E_PT1,6);
    c=DrvGPIO_GetBit(E_PT1,7);

    asm volatile("sethi $r0, 0xc0000");
    asm volatile("ori  $r0, $r0, 0x003f");
    asm volatile("mtsr $r0, $INT_MASK");
    asm volatile("movi $r0, 0x70009");
    asm volatile("mtsr $r0, $PSW");
}

/*-----*/
/* PT2 Interrupt Service Routines                                     */
/*-----*/
void HW5_ISR(void)
{
}

/*-----*/
/* Software Delay Subroutines                                       */
/*-----*/
void Delay(unsigned int num)
{
    for(;num>0;num--)
        asm("NOP");
}
void InitalADC(void)
{
    //Set ADC input pin
    DrvADC_SetADCInputChannel(ADC_Input_AIO1,ADC_Input_AIO0);//ADC Input
    DrvADC_InputSwitch(OPEN);
    DrvADC_RefInputShort(OPEN);
}
```

```
DrvADC_Gain(0,0);           //Set the ADC Gain
DrvADC_DCOffset(0);         //DC offset input voltage selection
DrvADC_RefVoltage(VDDA,0);  //Set the ADC reference voltage.
DrvADC_FullRefRange(1);     //Set the ADC reference range select.
                             //0:Full reference range input
                             //1:1/2 reference range input

DrvADC_OSR(0);              //0:OSR=32768
DrvADC_CombFilter(Enable);
DrvADC_ClkEnable(0,1);      //Setting ADC CLOCK ADCK=HS_CK/6
DrvPMU_VDDA_Voltage(E_VDDA2_4);
DrvPMU_VDDA_LDO_Ctrl(E_LDO);
DrvPMU_BandgapEnable();
DrvPMU_REFO_Enable();
DrvPMU_AnalogGround(Enable); //ADC analog ground source selection.
                             //1:Enable buffer and use internal source

DrvPMU_LDO_LowPower(0);     //VDD LDO with low power control.
                             //0 : Normal;1 : Low power

Delay(0x1000);
//Set ADC interrupt
DrvADC_EnableInt();
DrvADC_ClearIntFlag();
DrvADC_Enable();
}
void Initial_ALL(void)
{
    pio_00=0xff00ff00;        //close all the IO
    pio_04=0xff00ff00;
    pio_08=0x00;
    pio_10=0xff00ff03;
    pio_14=0xff00ff03;
    DrvGPIO_Open(E_PT1,0xc0,E_IO_INPUT);    //PT_6-7 is input
    DrvGPIO_Open(E_PT1,0xc0,E_IO_PullHigh); //enable PT1_6-7 pull high R

    SYS_EnableGIE(7,0x3f);    //Enable GIE (Global Interrupt Enable)
    DrvGPIO_ClearIntFlag(E_PT1,0xc0);    //clear PT1.6~7 interrupt flag

    DrvGPIO_ClkGenerator(E_HS_CK,1);      //GPIO CLK enable
    DrvGPIO_Open(E_PT1,0xc0,E_IO_IntEnable); //PT1.6~7 interrupt enable
    //PT1.6~7 interrupt trigger method is negative edge
```

```
    DrvGPIO_IntTrigger(E_PT1,0xc0,E_N_Edge);
    DrvCLOCK_EnableHighOSC(E_INTERNAL,50);           // Select HAO 4MHz
    ADtemp200=0;
    ADtemp1100=0;
    ADtemp110n=1405;
    ADtemp110p=1405;
    ADtemp20n=7;
    ADtemp20p=7;
    nu=0;
    key_ck=0;
    tn=2;
    ch=0;

}
void Pb_7()                                           // Sub-program button
{
    if(c==0)
    {
        pb7=1;
        c=1;
        while(1)                                     //If continue put the button, may not sign out
        {
            c=DrvGPIO_GetBit(E_PT1,7);
            if(c==1)break;
        }
    }
}
/*-----*/
void Pb_6()
{
    if(b==0)
    {
        pb6=1;
        b=1;
        while(1) // If continue put the button, may not sign out
        {
            b=DrvGPIO_GetBit(E_PT1,6);
            if(b==1)break;
        }
    }
}
```

}

}

}

/\*-----\*/

/\* End Of File

\*/

/\*-----\*/

/\*-----\*/