HY11P12 Thermocouple Measurement

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1：Introduction

In modern industrial fields, thermocouple is commonly used to measure high temperature. The Test result was sent to master end or displayed by digital displaying devices.

This article introduces the solution of adopting HY11P12 to realize thermocouple temperature measurement.

2：Theory Description of Thermocouple Measurement

2.1 Overview

Thermocouple is one of the most widely used temperature sensors in the engineering application. It has simple mechanism and easy-use feature. Thermocouple possesses the advantages of accurate, thermal inertia, high repeatability and wide measurement range. Therefore, it plays an important role in temperature measurement for its capability for long distance signal transmission, auto record and centralized control.

There are three main advantages:

1. High precision measurement: thermocouple was directly contacted to the measurement object, avoiding the affection of intermediate substances.
2. Wide measurement range. The thermocouple usually conducts continuous measurement of -50~+1600℃. Some special thermocouple can measure -269℃ to +2800℃.
3. Simple mechanism and easy use. Thermocouple usually composed by two different metal wires and does not influence by the restriction of size and opening. It is very convenient to use as it covered by a protection tube.

2.2：Thermocouple Theory

The measurement theory of thermocouple is based on thermoelectric effect. That is to connect conductor A and B of different material to form a close circuit. When two connector 1 and 2 has different temperature, thermoelectric force will occur in the circuit if T>T0 (as shown in Figure 2-1), a certain amount of current will be generated in the circuit, this phenomenon is called thermoelectric effect.

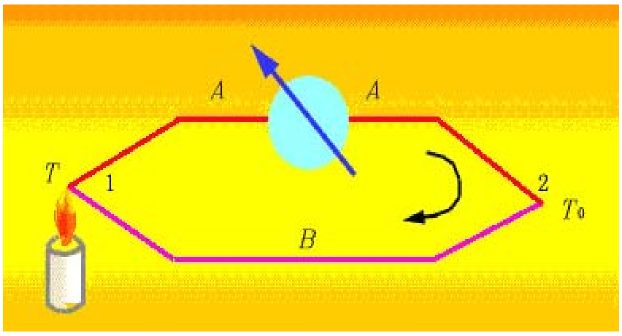


Figure 2-1 Thermoelectric effect (T>To)

Thermoelectric force is marked as EAB while conductor A & B was called thermal electrode. Connector 1 usually is soldered together. It is usually being placed in the temperature measurement field to measure the temperature; therefore, it is called the measurement end (or hot junction). Connector 2 is required to have constant temperature; it is called reference end (or cold junction).

2.3 Measurement and Cold Junction Compensation Theory

In practical measurement system, cold junction is not always constant; therefore, we need to measurement the temperature of cold junction to compensate hot junction temperature.

Practical measurement equation:

Actual temperature = corresponding temperature of hot junction thermoelectric force + cold junction temperature

Hence, we need to use thermoelectric force of thermocouple and cold junction temperature to calculate real temperature by the above equation in measurement system.

3: System Structure and Theory Description

HYCON HY11P series are high integrated and high resolution Σ-Δ ADC single chip embedded with absolute temperature sensor. Through communication signal converter, short circuit or cross measurement can be implemented.

3.1 Measurement Network

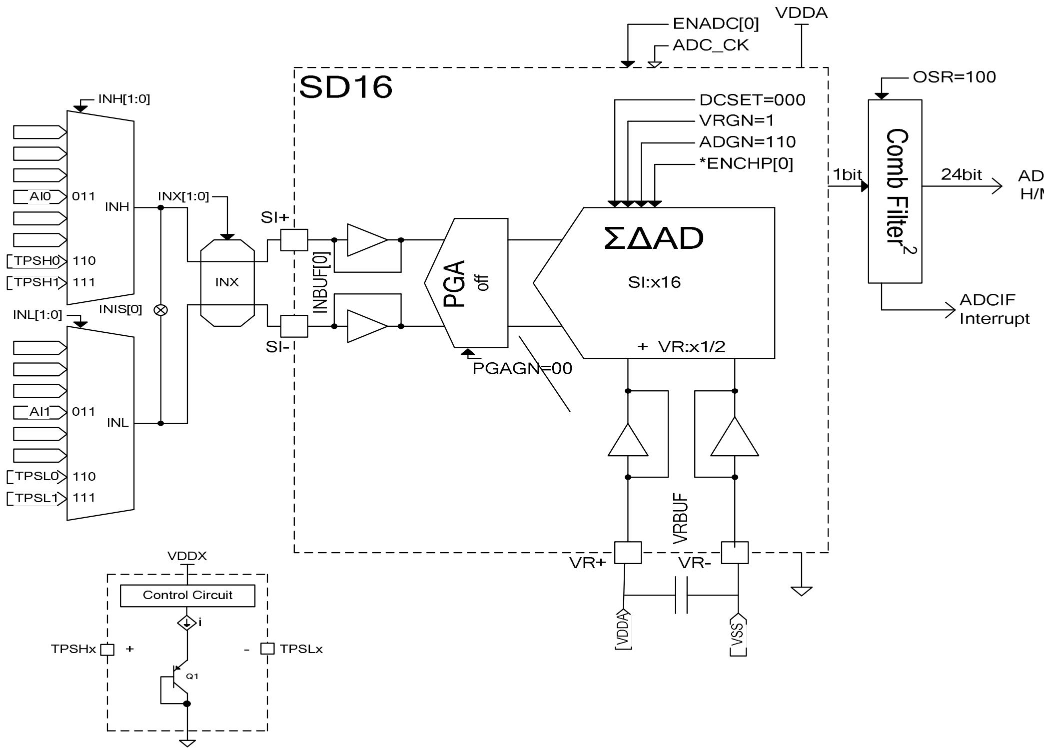


Figure 1 Measurement Network

3.2 ADC Network Configuration

Reference voltage：

VR+： VDDA

VR-： VSS

Thermocouple signal input：

S+： AIN0

S-： AIN1

3.3 Measurement Theory and Calculation

3.3.1 Far-end Measurement

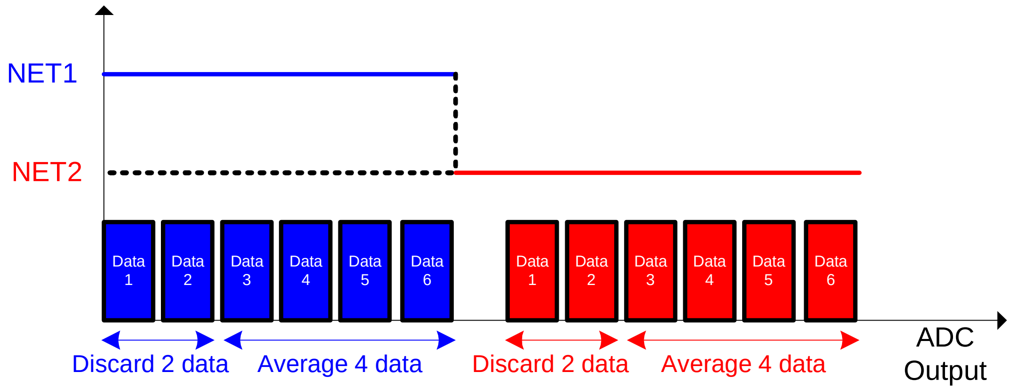
ADC input signal adopts crossed measurement to deduct OFFSET, the equation is as follows：

Vin=VADC2+VADOffset……(1)

-(Vin)=VADC1+VADOffset……(2)

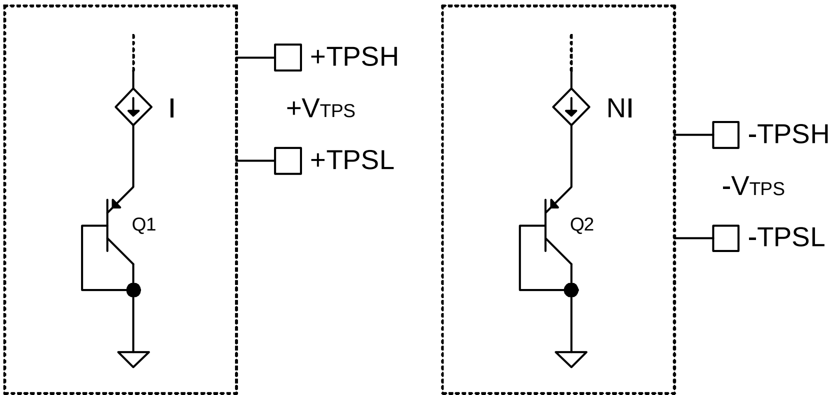
Vin=[(1)-(2)]/2=[VADC2-VADC1]/2

（PS：through crossed measurement, the OFFSET of signal wire）



3.3.2：Cold Junction Measurement

Clod junction primarily is used to measure temperature by internal TPS, the way of measurement is as follows：



TPS calculation：

$$V_{BE1} = V_{+TPS} = V_{ADC1} + V_{ADOffset}$$

$$V_{BE2} = V_{-TPS} = V_{ADC2} + V_{ADOffset}$$

$$\Delta V_{BE} = V_{BE1} - V_{BE2} = V_{+TPS} - V_{-TPS} = V_{ADC1} - V_{ADC2}$$

(Note：V_{BE1} is TPS0 ADC output, V_{BE2} is TPS1 ADC output, ΔV_{BE} is ADC value of TPS, V_{ADC1} is ADC output of TPS0 signal, V_{ADC2} is ADC output of TPS1 signal,

$V_{ADOffset}$ is ADC OFFSET)

3.4: Calibration and Its Calculation

DEMO adopts 2-point calibration. Make sure the ambient temperature of cold junction of 2-point during calibration procedures are consistent. ADC calibration point is : VIN50, VIN250. Take 50° & 250° as calibration points for example:

250° = GAIN*VIN250+{ (ΔV_{BE} / TPSGAIN)-289}……………….(1)

50° = GAIN*VIN50+ {(ΔV_{BE} / TPSGAIN)-289}…………………(2)

(Note: GAIN is calibration coefficient of thermocouple measurement temperature, VIN250 is ADC output inner code of 250° C calibration point, VIN50 is ADC output inner code of 50° C calibration point, TPGAIN is slope constant of internal TPS)

Solve equation (1) & (2), then GAIN is conceived.

Take GAIN into (1) and current ambient temperature TEMP, will be calculated;

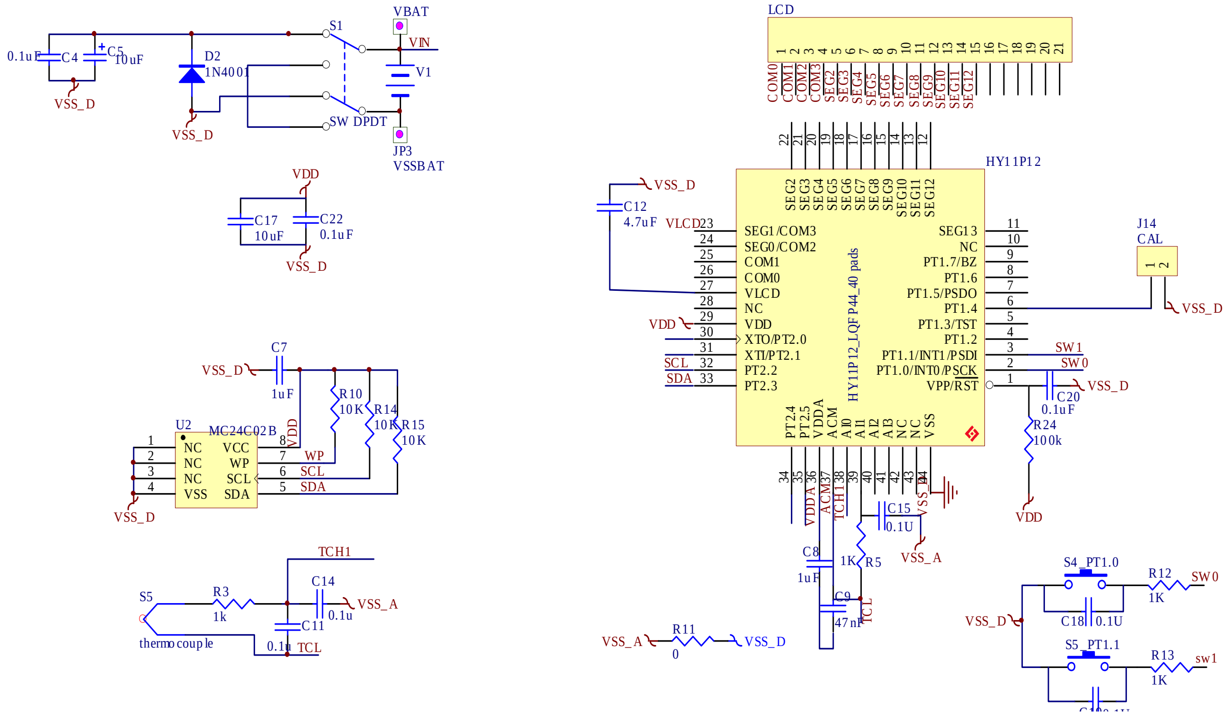
Take TEMP into (3), then TPS slope will be answered:

TPSGAIN= ΔV_{BE} /(289+TEMP)……………………………………….(3)

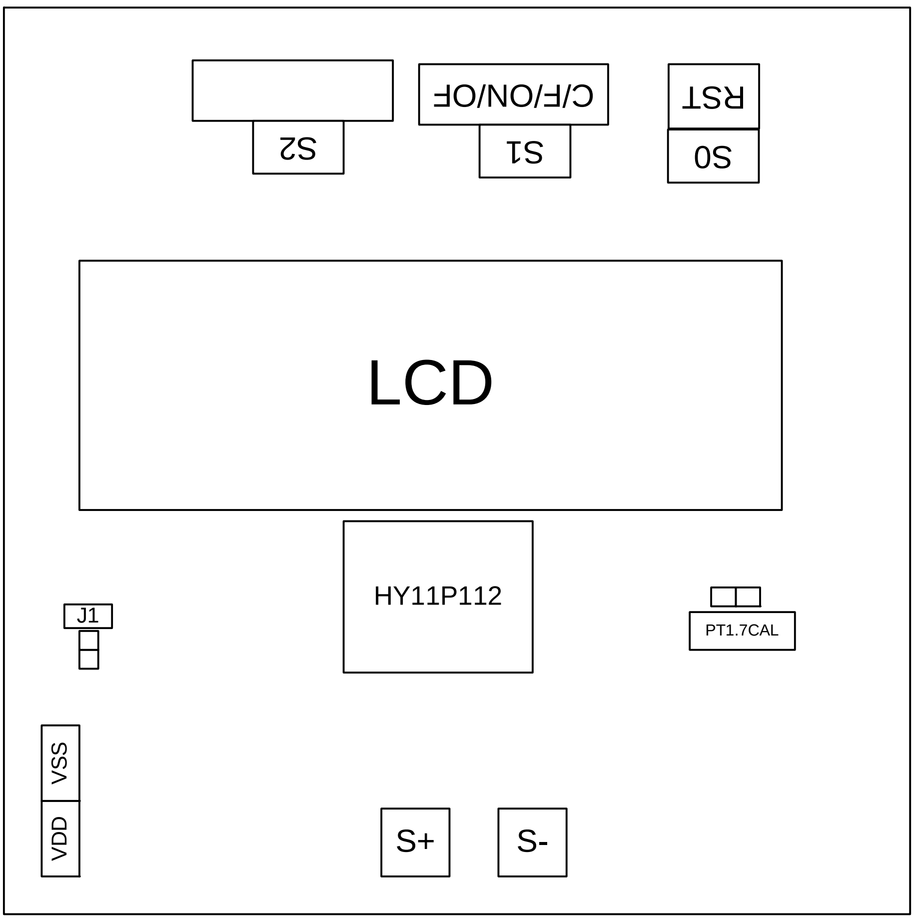
Actual measurement temp.= GAIN* VIN + {(ΔV_{BE} / TPSGAIN) -289}

（Note: VIN is ADC value of thermocouple input signal）

3.5: Circuit Diagram



3.6： DEMO Board Placement



3.7：Calibration Description

When power on, it determines PT1.7 and enters into calibration mode after grounding.

2-point calibration adopts different ambient temperature; the temperature coefficient of cold junction will be calculated by auto program operation.

Calibration flow:

1）When power on, short PT1.7 , LCD displays CAL;

2）Press SW1 to enable calibration flow, LCD displays 50℃;

3）Press SW1 will show ADC value of 50℃;

4）Press SW1 to make sure 50℃ is completed and save ADC value, shows 250℃;

5）Then press SW1 to show ADC value of 250℃;

6）Press SW1 to save ADC value of 250℃ and calculate thermocouple and TPS GAIN (calibration value) to 24C02;

7）After calibration complete, LCD show PAS.

3.8: DEMO Operation Description

1：Power on (auto turn on), press SW1 until it enters into power down status. Press SW0 to turn on the system.

2：Under run mode, SW1 is unit C/F switch button；

3：DEMO measurement range is 0° C～550° C. It shows LO when temp. is lower than 0° C; higher than 550° C, it shows HI.

4：HY11P12 Specification

4.1：Operation:

Digital voltage of the chip: 2.2V to 3.6V@±0.1V

Analog voltage of the chip: 2.4Vto 3.6V@±0.1V

Operation current of the chip: (VDDA not Load)

800uA@ ADC, no buffer

350uA@Analog off

Sleep current: 0.8uA

Operation temperature range: –40°C to +85°C

4.2：Analog SD18

Resolution/RMS noise

15 bit Noise-Free/100nV @ 8Hz, Gain=128, ACM=1.2V
18 bit Noise-Free/1.6uV @ 8Hz, Gain=1, ACM= 1.2V

4.3：Input Signal

Signal measurement: Thermocouple input and the cold junction adopts built-in TPS (temp. sensor)

5：Conclusion

Use HY11P12 to complete thermocouple temperature measurement system has the following features:

- Simple circuit that equips with high precision and low temperature drift coefficient.
- Use built-in TPS (temp. sensor) to easily accomplish cold junction.

6：DEMO CODE

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7：Reference

1：HY11P12 Datasheet: http://www.hycontek.com/page2.html
2：User’s Guide: http://www.hycontek.com/page2.html