Rapid Response Body Thermometer

HY11P32 Application Note

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1 Introduction

One of the conventional methods to measure body temperature is by mercury thermometers. Heavy metal that leaked from broken mercury thermometers is harmful to the environment and human health; therefore electronic thermometers would be used to replace mercury thermometers gradually. The wide application of thermistor has created new direction for temperature measurement.

Based on the characteristic of different resistor value that Thermistor responses toward different temperature, we can easily realize temperature measurement. This article depicts how to apply HY11P32 of HYCON Technology to rapid response body temperature measurement.

2 Theory Description

2.1 Sensor

Thermistor is resistors that sense heat, which main function is to display resistor values that change with the environment. Thermistor is broadly divided into Positive Temperature Coefficient (PTC) and Negative Temperature Coefficient (NTC). NTC has high sensitivity and reasonable price, thus it was wildly applied.

Users need to list a table before measurement, in which data can precisely reflect the conditions of Thermistor with changing temperature. For example, when temperature increases from 32.1°C to 32.2°C, the value of 503ET (NTC thermistor) drops from 36.763KΩ to 36.605KΩ. The temperature change is very limited, thus the process can be deemed as linearity. We table the value within human body temperature ranges (in 0.1°C temperature change, its resistor value is almost linear)，using look-up-table method to gain its corresponding temperature.

NTC Thermistor 503ET equation is as follows:

Equation 2-1

$Rth(T)=R25 \times \exp \{ B \times [1/(T+273.13) - 1/(25+273.13)] \}$

Rth(T)：Thermistor change resistor value

B：Sensitivity of Thermistor

R25：25°C resistor value

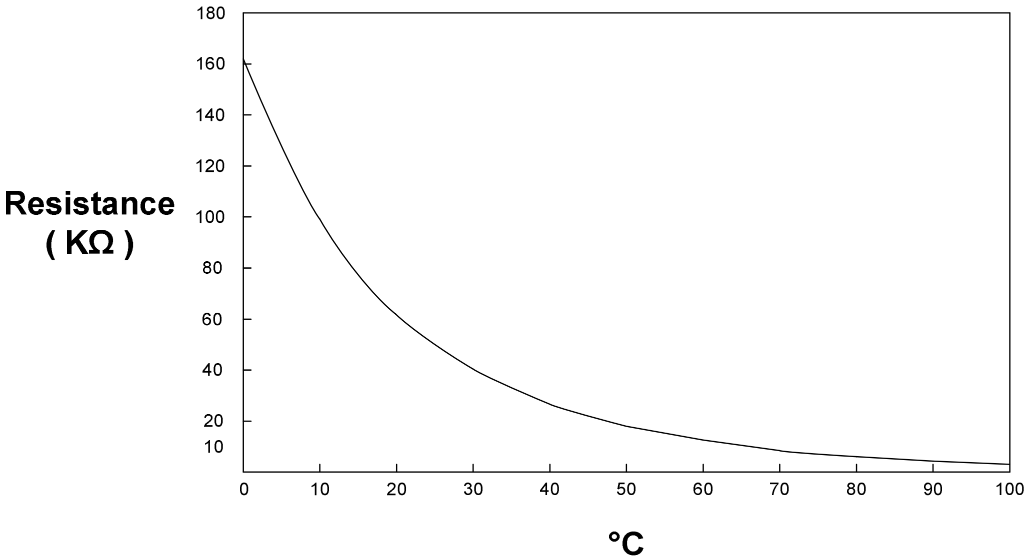

Figure 1 Thermistor Resistor and Temperature Curve

2.2 Control IC

HY11P32 IC Features:

8-bit RISC-like simplified instruction set, 46 instructions included.

2.2V to 3.6V operation voltage, -40~85°C operation temperature range

Internal high precision RC oscillator, users can plan the most power efficient solution by 4 types of CPU operation clock source options.

Operation mode: 300μA@2MHz

Standby mode: 3μA@28KHz

Sleep Mode: 1μA

2K Word OTP (One Time Programmable) Type program memory, 128 Byte data memory

Brownout detector and Watch dog Timer, preventing CPU from crashing

18-bit fully differential input ΣΔADC (analog-to-digital converter)

Built-in PGA (Programmable Gain Amplifier), 10 signal amplifications, selecting from 1/4, 1/2, 1…to 128.

Built-in input zero point adjustment can add measurement range to different applications.

1.0V internal analog circuit common ground power source, equipped with Push-Pull drive power to provide driving voltage to sensors.

LVD low voltage detection function with 14 steps detection voltage configurations.

Analog power source, VDDA has 10mA regulated power output function.

4×12 LCD driver

1/4 Duty, 1/3 Bias

Built-in Charge Pump regulated circuit, providing 4 LCD bias.

8-bit Timer A

Build-In EPROM

2.3 Measurement Theory

Thermistor displays different value along with the change of temperature, it voltage changes accordingly. We can use Thermister to convert physical signal, temperature, to digital signal.

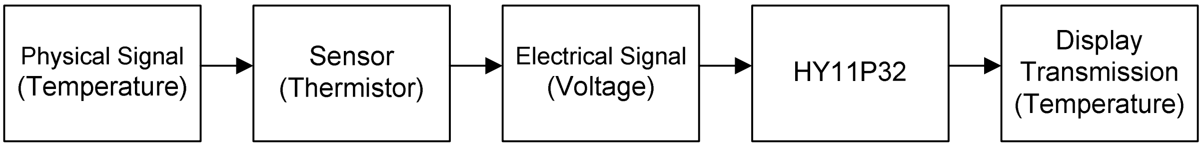

Figure 2 Analog and Digital Signal Conversion

Measure framework is shown as Figure 3, internal analog circuit common ground voltage source, ACM passes through Thermistor (RT1) and 100KΩ resistor divided signal to be measured and reference voltage. SD18 carries out analog to digital conversion; a resistor value will be gained from ADC. This resistor value can match with its corresponding temperature value by look-up-table. The rapid response body temperature measurement can be realized by minimum components.

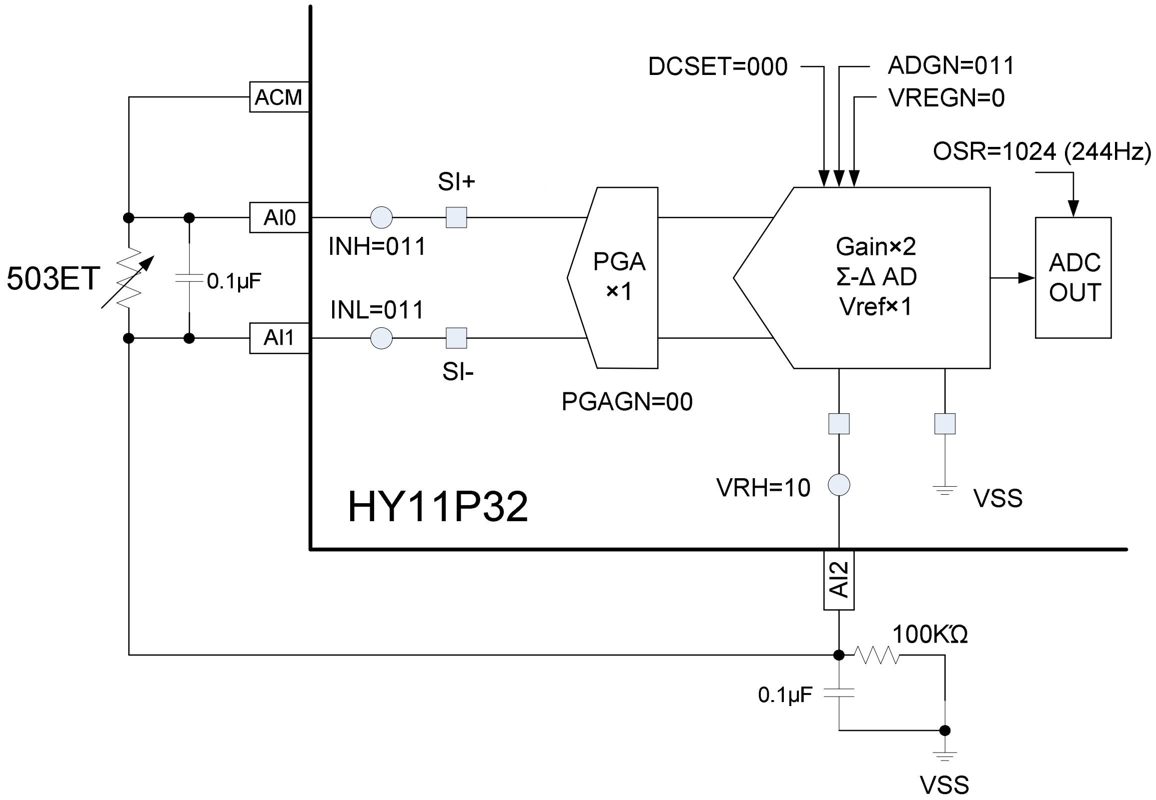

Figure 3 HY11P32 Measurement Framework

2.4 Output Rate

503ET heat stable time is 6-second. SD18 OSR samples 1024 data and 20 data per second will be filtered by software average. Only a few seconds needed to gain body temperature.

3 Operation Description

1. Before countdown completed, enter into calibration mode by press PT1.0.
2. First WORD of EPROM is blank, entering into auto calibration mode.
3. Take 10 data and compare to the first data. If the difference falls in the range of 96H, start to judge. 10 data in successive falls in the range of 96H, then the last data would be deemed as calibration value to write EPROM otherwise, re-judge is needed.
4. When comparing, ADO is the judge of [(+) - (-)]/2 shift. Only when H=02H, M=01111XXXH will it enter into auto calibration judge mode to read value and store to EPROM.
5. If VPP does not connect to external 6V, then WAVPP message will show up when entering into calibration mode.
6. Using 37C reference resistor, 29938.5R to execute calibration, measurement will be restarted after calibration completed.
7. Temperature under 32C displays OVRL; higher than 43C display OVRH
8. Under measurement mode, pressing PT1.0 to start TIMERA, maximum value will be locked for around 4~5 seconds and display H xxxx, BZ ON
9. Then presses PT1.0 back to normal measurement mode
10. Under measurement mode, pressing PT1.1, displaying the maximum temperature value and display r xxxx
11. Then presses PT1.1, back to measurement mode
12. PT1.0/PT1.1 display maximum value and history maximum value does not function under OVRL/OVRH.
13. Under measurement mode, pressing PT1.2 to enter Sleep Mode, then press PT1.0 back to normal measurement mode

4 Design Scheme

4.1 Hardware Description

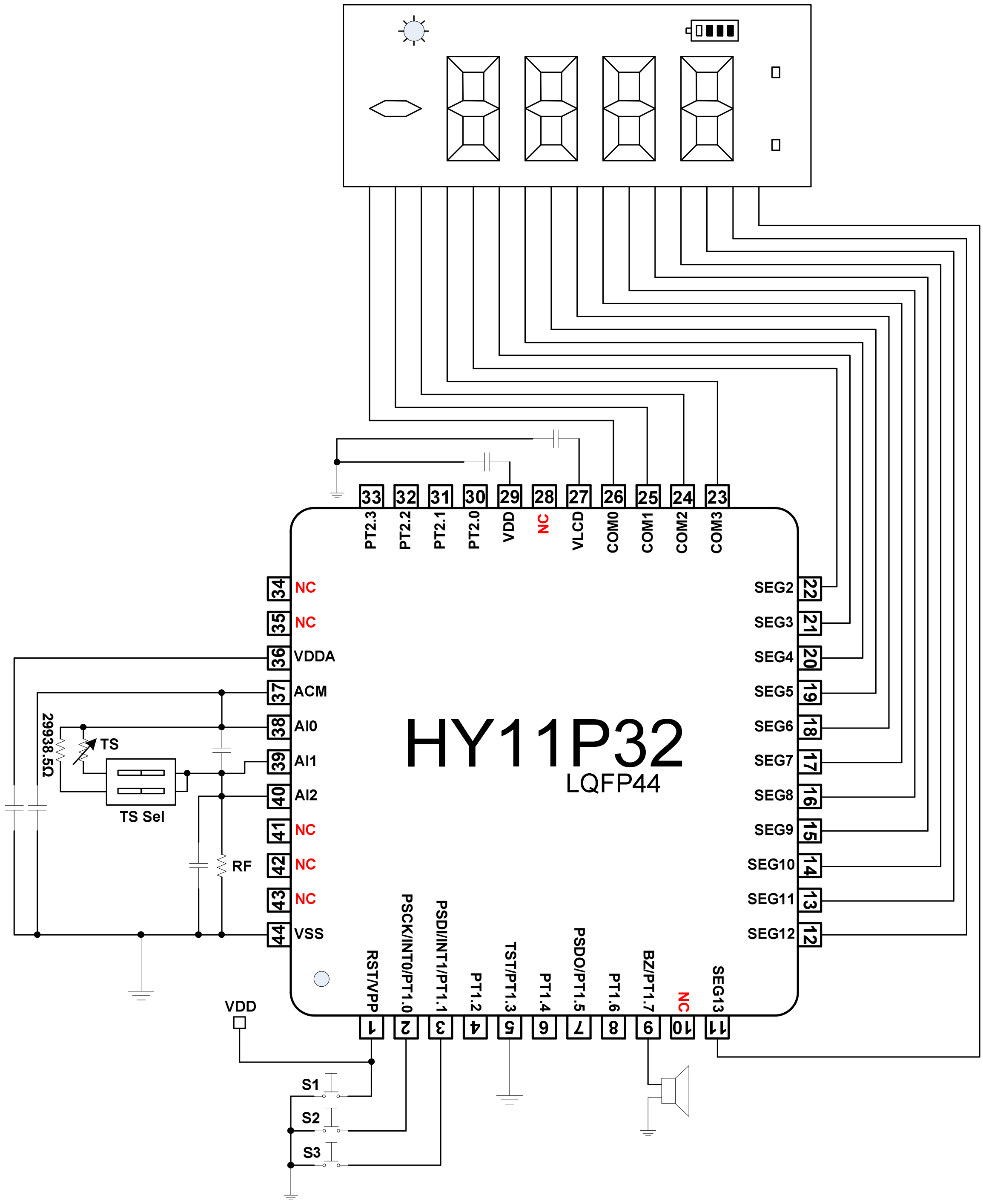

Figure 4 HY11P32 Simple Application Circuit

Main components:

1. MCU: HY11P32, main function is to measure electrical signal, control, operate and display
2. Sensor (TS): 503ET, to convert temperature and electrical signal
3. Reference resistance (RF): Reference resistor (precision resistor)

4.2 Circuit Description

Measuring temperature change by measuring the voltage change of Thermistor.

Reference resistor, RF, is used to divide voltage. SD18 passes though RF to gain a reference voltage. Accuracy of the measured resistor value relates to that of reference resistor. It is important to assure the accuracy of the reference resistor.

Calibration resistor, 29938.5Ω is the resistor value of Sensor 503ET under 37°C ambient temperature. When designing program, this value can be used for calibration.

BZ function is enabled after completion of locking max. value.

S0 has awakening IC function.

S1 has calibration, awakening IC and lock max. value function.

Press PT1.0 to enter calibration mode before the end of countdown when switched on.

Press PT1.0 to lock the max. value under measurement mode.

Press PT1.0 to awake the IC after entering into Sleep Mode.

S2 can display max. value in measurement history

S3 can enter into Sleep Mode

4.3 Software Description

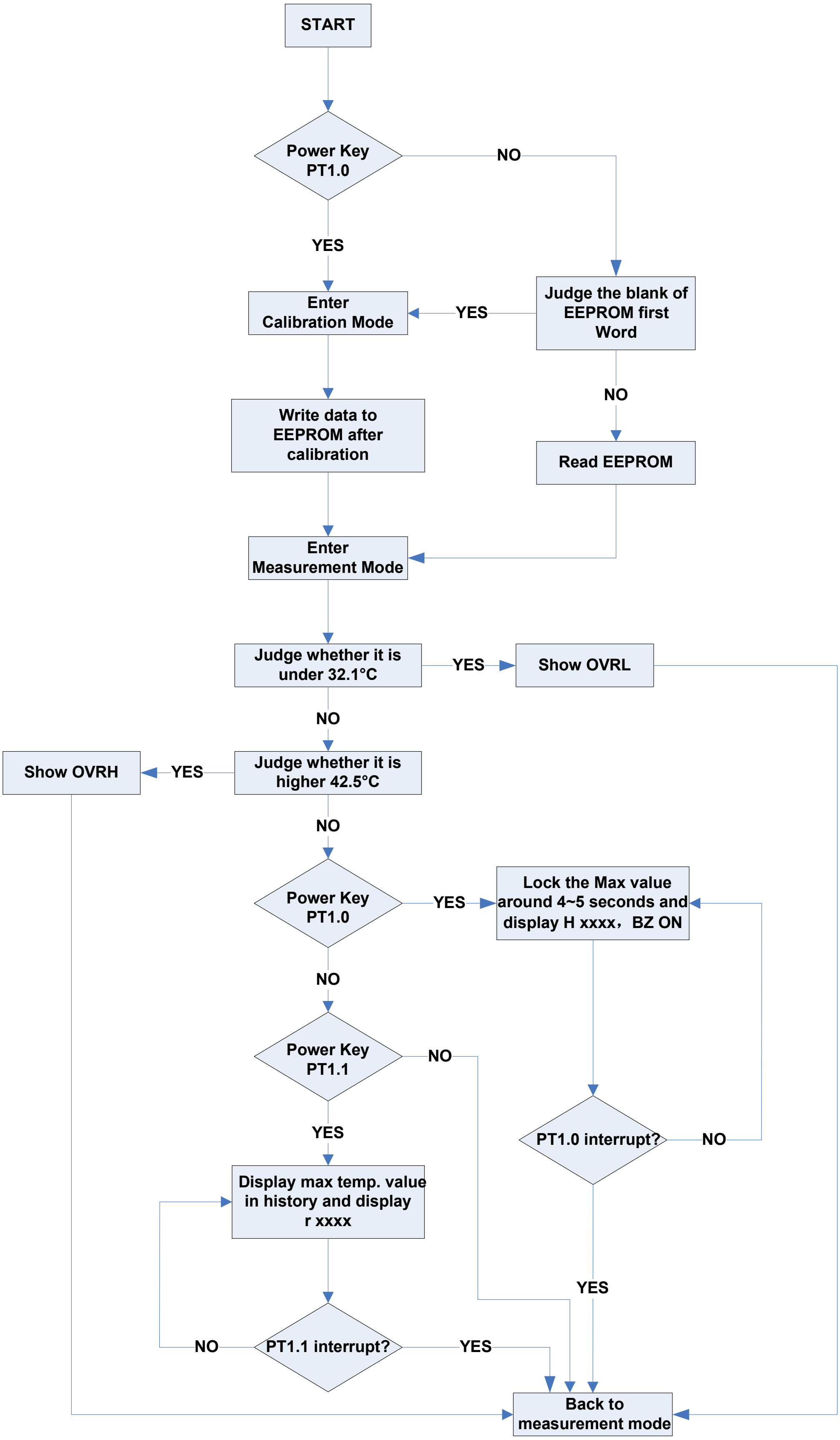

Figure 5 Program Flow

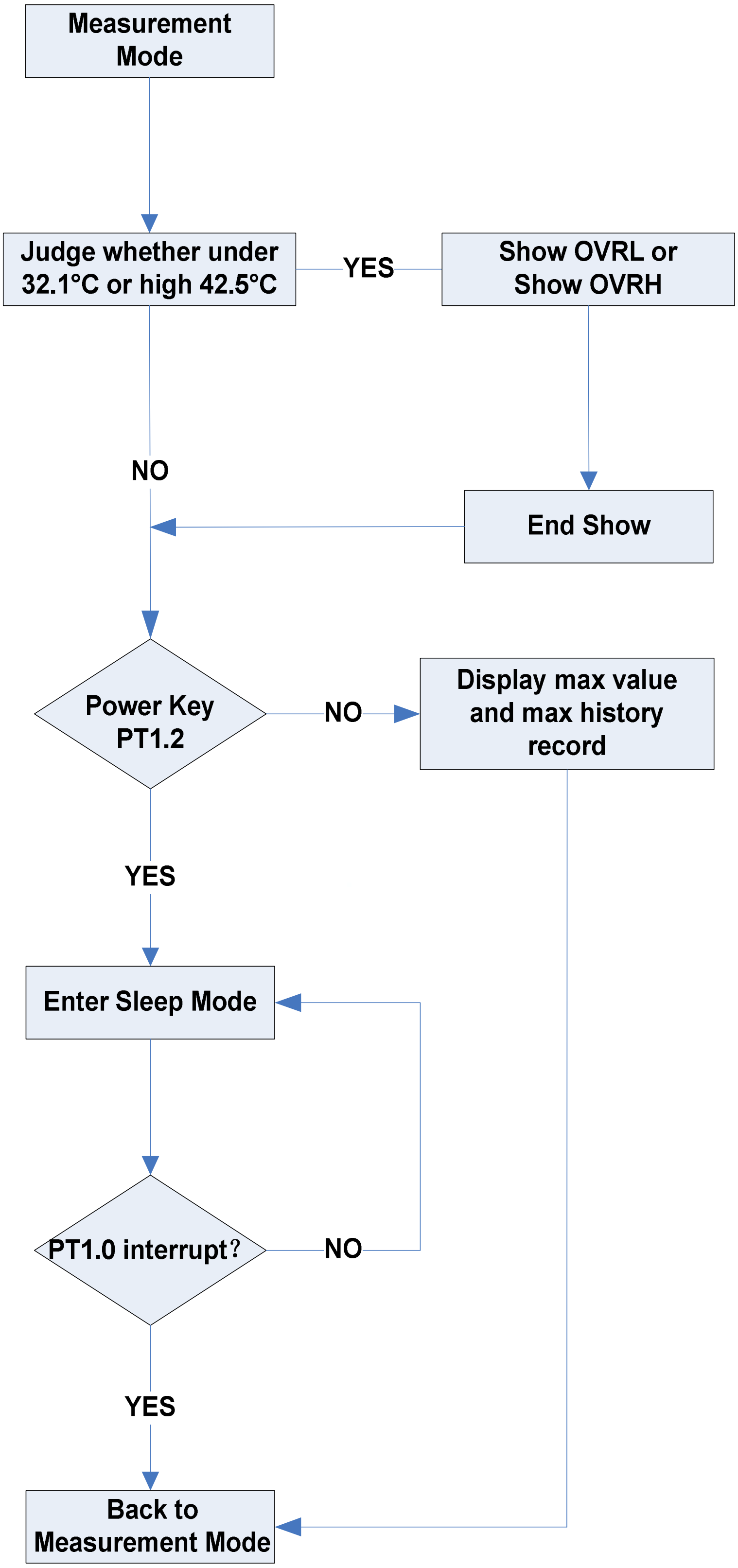

Figure 6 Enter into Sleep Mode and Awaken Flow

5 Technical Specification

5.1 Hardware Technical Specification

Digital operation voltage: 2.2~3.6V
Analog operation voltage: 2.6~3.6V
Operation mode current (Measure Temperature 34.5°C): 404μA
Sleep mode current: 0.7μA

Temperature range: 32.1~42.5°C
Resolution: 0.01°C
Accuracy: 0.05°C
Data convert: 20Hz

5.2 Software Technical Specification

ADC configuration
ADC sampling rate: 250KHz
PGAGN: by pass PGA amplifier
ADGN: ×2
OSR: 1024
ADC output rate: 250KHz/1024
Close SI± input buffer
Channel configuration
Senor signal
SI+: AI0
SI-: AI1
INH→SI+, INL→SI-
Voltage reference signal
VR+: AI2
VR-: VSS

Close VR± input Buffer
VREGN: ×1
Power consumption control mode
Under measurement mode, if measurement temperature is within temperature range, press PT1.0 and enter to Standby mode.
Under measurement mode, if measurement temperature is within temperature range, press PT1.1 and enter to Standby mode.
Under measurement mode, press PT1.2 and enter to Sleep mode.
Under Sleep mode, press PT1.0 to awake IC

6 Conclusion

Main features of using HY11P32 chip to realize rapid response temperature measurement solution:

1. Low current consumption
2. Fast output rate, 20 data/sec
3. Simple circuit and higher measurement precision
4. Reduce production line rework cost that caused by inaccurate temperature measurement
5. Gain better measurement data and stronger anti-interference performance in the same cost level.

Measurement precision and data is shown in below table:

IDEAL		ACTUAL		
TA(°C)	R(Ω)	TA(°C)	Rolling Counts	Deviation
42.5	24048	42.46	+/-1 count	-0.09%
42.0	24539	41.97	+/-1 count	-0.07%
41.0	25503	40.98	1 count	-0.05%
40.0	26517	39.99	1 count	-0.02%
39.0	27646	38.99	1 count	-0.03%
38.5	28186	38.49	1 count	-0.03%
38.0	28746	38.00	1 count	0.00%
37.5	29363	37.50	1 count	0.00%
37.0	29938	37.00	1 count	Calibration point
36.5	30573	36.50	1 count	0.00%
36.0	31194	36.01	1 count	0.03%
35.0	32557	35.01	1 count	0.03%
34.0	33924	34.02	1 count	0.06%
33.0	35386	33.02	1 count	0.06%
32.1	36763	32.13	1 count	0.09%
OSR:1024(244Hz); positive/negative network crosses to 12 data; equivalent output rate is around 20Hz				

Table 1 Measurement Deviation Table

7 Reference

[1] http:www.hycontek.com/ HYCON Technology Corporation

8 Demon Code

HY11P32-Electronic Thermometer.rar