HDSC 华大半导体 HUADA SEMICONDUCTOR

32-bit Microcontrollers

On-Chip Temperature Sensor OTS

for HC 32 F 460 Series

Applicable objects

Series	Product Model
HC32F460	HC32F460JEUA HC32F460JETA HC32F460KEUA HC32F460KETA HC32F460PETB

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1 Abstract

This application note introduces the features, usage and precautions of the on-chip temperature sensor OTS of HC32F460 series MCUs.

2 Introduction

The on-chip temperature sensor OTS of HC32F460 series MCU can obtain the internal temperature of the chip in real time to support the reliability design of the system. the OTS does not need the participation of ADC, it can just read the register directly when using and get the temperature value after arithmetic operation, and can be turned off to reduce the system power consumption when not in use, its functional block diagram is shown in Figure 2-1.

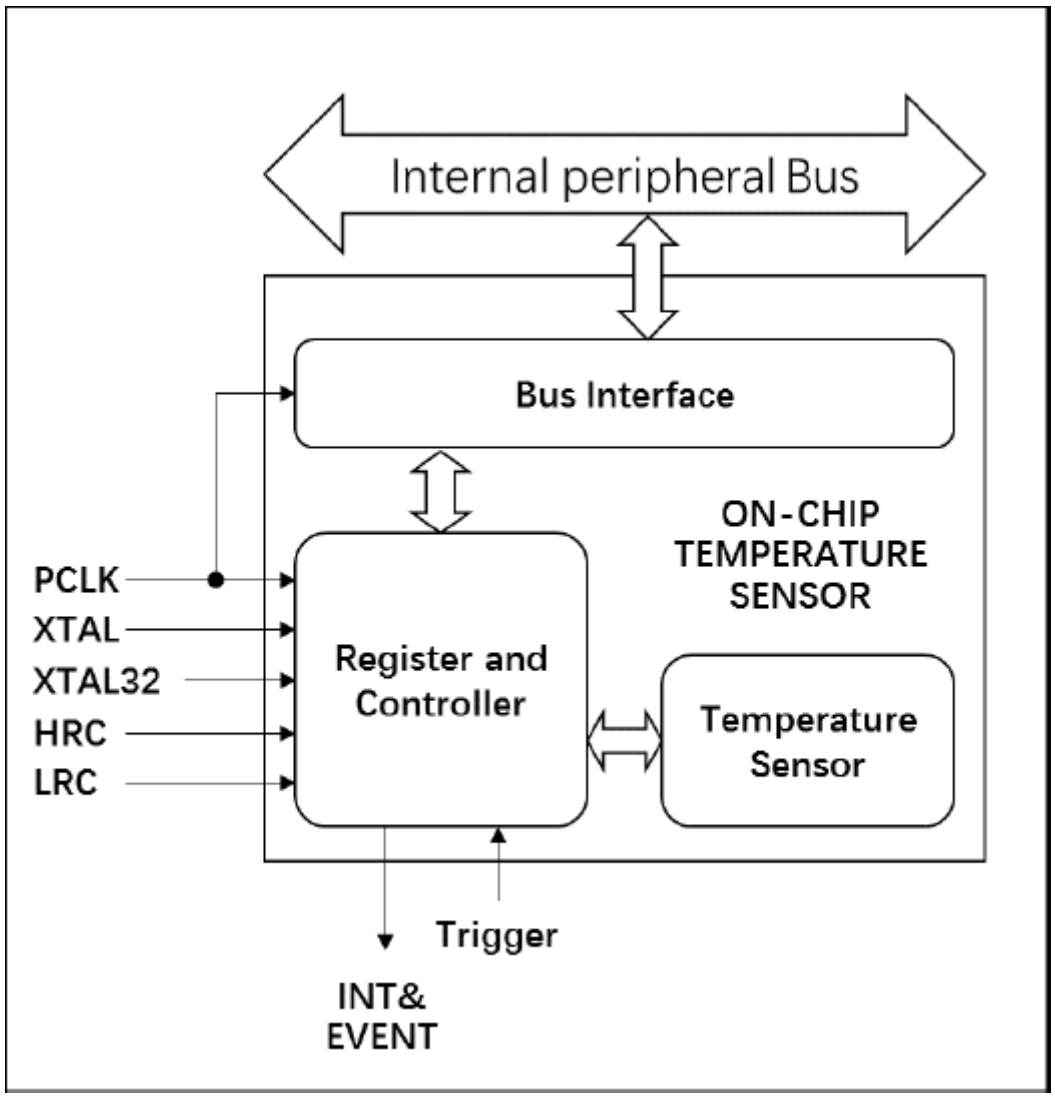

Figure 2-1 OTS Function Block Diagram

3 Calibration experiments

To obtain accurate temperature values, two parameters are very important, the temperature slope K and the temperature offset M. These two parameters need to be obtained by the user through calibration experiments and then saved for subsequent use. The parameters K and M are not universal, and each chip needs to do calibration experiments; OTS can choose either the external crystal XTAL or the internal high-speed crystal HRC, and the K and M measured by the two crystals are also not universal.

3.1 Experimental conditions

The calibration experiment requires a high and low temperature chamber, a digital thermometer (used to obtain the exact temperature value inside the high and low temperature chamber, not needed if the temperature of the high and low temperature chamber is accurate enough), and a serial debugging tool (used to observe the experimental data). It is recommended that users do calibration experiments at the two temperature values of 25°C and 105°C.

3.2 Experimental steps

The calibration experiment routine ots_05_scaling_experiment has a trigger method for the calibration experiment, and the routine uses a keystroke.
(Pin PC1) press and release as the trigger mode, the reason why the trigger mode is set is to make the experiment is controllable. Users can modify the trigger method according to their actual needs. The specific experimental steps are as follows.

1. Recompiling the project after modifying the trigger method and downloading it to the target board;
2. Put the target board and digital thermometer into the high and low temperature chamber, set the temperature of the high and low temperature chamber to 25°C and start the high and low temperature chamber;
3. After the temperature of the high and low temperature chamber has stabilized at 25°C for about 5 minutes, trigger the calibration experiment to run;
4. A parameter A can be obtained through the serial debugging assistant, recorded as A1, and the actual temperature of the current high and low temperature chamber is recorded as T1;

5. Set the high and low temperature chamber temperature to 105 °C and run it;
6. After the temperature of the high and low temperature chamber has stabilized at 105°C for about 5 minutes, trigger the calibration experiment to run;
7. A parameter A can be obtained through the serial debugging assistant, recorded as A2, and the actual temperature of the current high and low temperature chamber is recorded as T2;
8. K and M can be obtained by the following two equations:

$$K = (T2 - T1) / (A2 - A1).$$

$$M = T1 - K \times A1 = T2 - K \times A2 ;;$$

The experiment routine will output the parameters A corresponding to XTAL and HRC, and the user can calculate the corresponding K and HRC according to the actual demand. M. Figure 3-1 shows a possible set of experimental data:

	A	B	C	D	E	F	G
1		T1	T2	A1	A2	K	M
2	HRC16M	24.6	105.7	-0.001105	0.025905	3002.591633	27.91786375
3	HRC20M	24.6	105.7	-0.001108	0.025878	3005.261988	27.92983028
4	XTAL	24.6	105.7	-0.000004	0.000106	737272.7273	27.54909091

Figure 3-1 A set of possible calibration experimental data

9. Modify the values of K and M in hc32f46x_ots.c (see program listing 3-1, K and M are common for HRC20M and HRC16M), and verify the accuracy of the parameters using the ots_01_base routine;

```
#define OTS_XTAL_K      737272.73f
#define OTS_XTAL_M      27.55f
#define OTS_HRC_K       3002.59f
#define OTS_HRC_M       27.92f
```

Program List 3-1 OTS Parameter Setting

10. the user can save K and M to Flash for subsequent use;

11. The calibration experiment was completed.

4 Applications

The application of OTS is relatively simple, so here is a brief description of several OTS routines:

1. The routine ots_01_base describes the configuration and basic usage of OTS;
2. Example ots_02_interrupt describes the configuration and use of the OTS interrupt application;
3. The routine ots_03_aos_base implements the configuration and basic usage of triggering the OTS with internal events to obtain temperature values;
4. The routine, ots_04_aos_interrupt, implements the use of Timer0 to generate an event EVT_TMR02_GCMA every second to trigger the OTS for the purpose of obtaining the temperature value once per second.

5 Summary

This application note introduces the calibration experiments of on-chip temperature sensor OTS of HC32F460 series MCU, and gives a set of possible calibration experimental data and its verification method. In real projects, users need to do calibration experiments for each chip to get more accurate temperature values.

6 Version Information & Contact

Date	Versions	Modify records
2019/3/13	Rev1.0	Initial Release

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Email: mcu@hdsc.com.cn

Website: http://www.hdsc.com.cn/mcu.htm

Address: 39, Lane 572, Bibo Road, Zhangjiang Hi-Tech Park, Shanghai, 201203, P.R. China