

32-bit microcontrollers

On-Chip Temperature Sensor OTS

for HC 32F 460 Series

Applicable objects

F Series	HC 32F460
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1 Abstract

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

2 Introduction

The on-chip temperature sensor OTS of HC32F460 series MCUs can obtain the internal temperature of the chip in real time to support the reliability design of the system, and the OTS does not need the involvement of ADC, it only needs to read the register directly when it is used, and the temperature value can be obtained after arithmetic operation, and it can be turned off when it is not used to reduce the system power consumption.

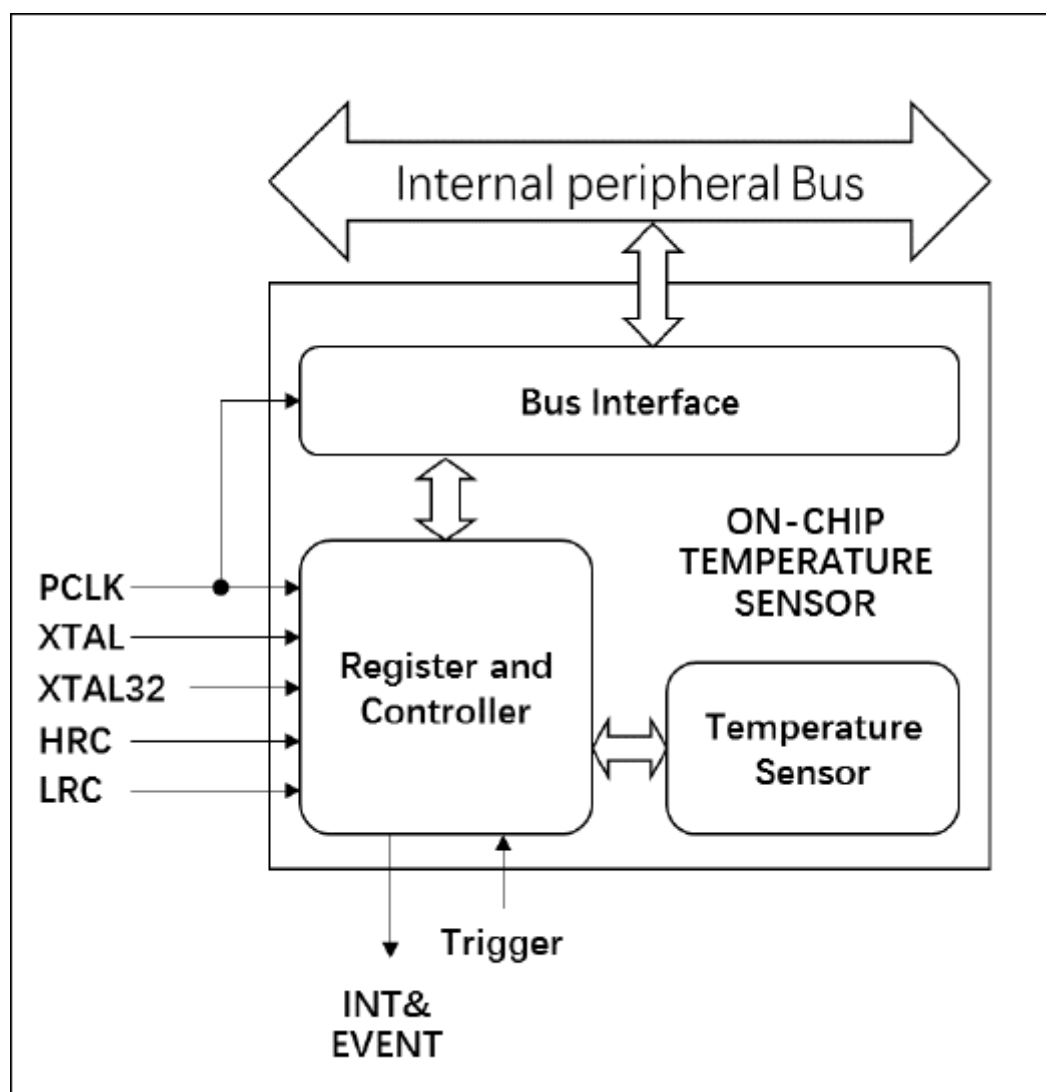


Figure 2-1 OTS Function Block Diagram

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, each chip needs to do calibration experiments; OTS can choose external crystal XTAL or 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 the keypad (Pin PC1) pressed and released as the trigger method, the reason for setting the trigger method 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. Recompile the project and download it to the target board after modifying the trigger method;
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, noted 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:

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

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

This 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 routine ots_01_base;

```
#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, and several OTS routines are briefly described here:

1. Example `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. Example `ots_03_aos_base` implements the configuration and basic usage of triggering 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 practical 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
2020/8/28	Rev1.1	Update supported models



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