32-bit microcontroller

HC32L110 / HC32F003 / HC32F005

A series of ADC error analysis and calibration methods

Suitable

series	Product number
HC32L110	HC32L110C6UA HC32L110C6PA HC32L110C4UA HC32L110C4PA HC32L110B6PA HC32L110B4PA
HC32F003	HC32F003C4UA HC32F003C4PA
HC32F005	HC32F005C6UA HC32F005C6PA HC32F005D6UA

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1 Summary

This application note mainly introduces the ADC error analysis and calibration method of HC32L110 / HC32F003 / HC32F005 series

Law.

This application note mainly includes:

ÿ ADC error

ÿ ADC calibration method

Notice:

- This application note is an application supplement for the HC32L110 / HC32F003 / HC32F005 series and is not intended to replace the user manual. Please refer to the user manual for specific functions and register operations.

2 Function introduction

This article mainly describes the ADC module of HC32L110 / HC32F003 / HC32F005 series MCU on the system board

Offset, Gain error and calibration method, according to the calibration method in this article, this chip can be applied to the ADC on the system board.

Calibration so that accurate ADC-converted values are available on the system board.

3 ADC Error Analysis and Calibration Method

3.1 Schematic diagram of ADC conversion error

This schematic depicts the difference between the ideal value and the actual value of the ADC, and the error of the ADC conversion can be seen from the figure.

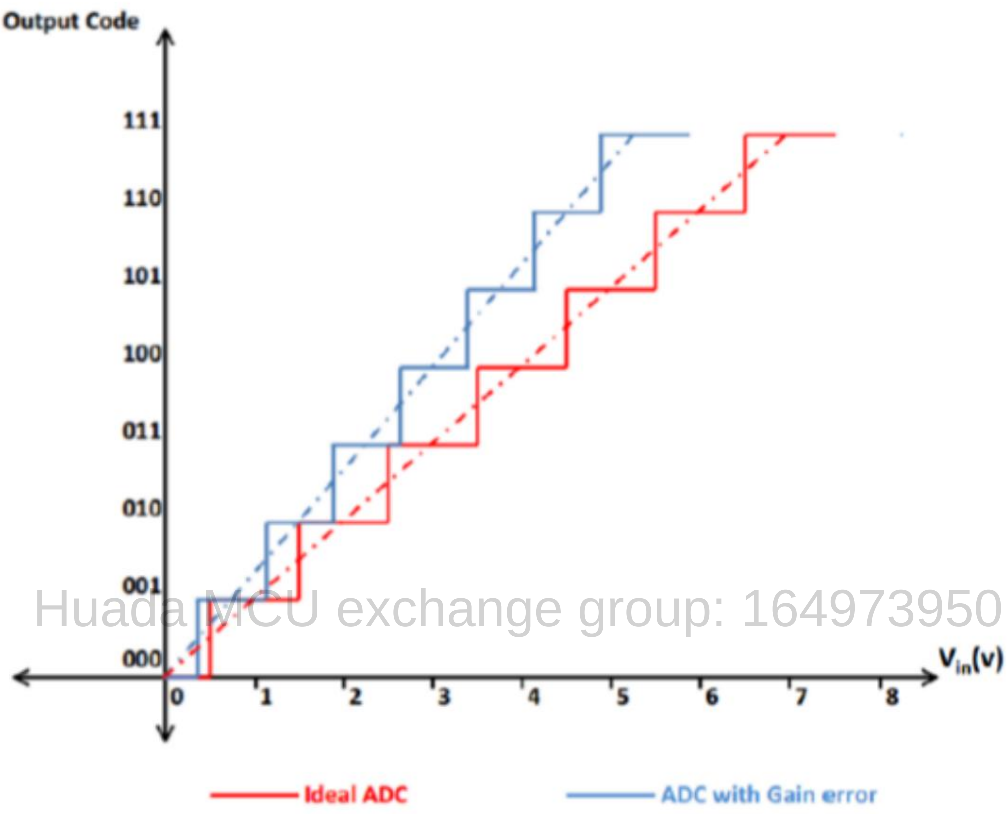

Figure 1 Schematic diagram of ADC ideal error

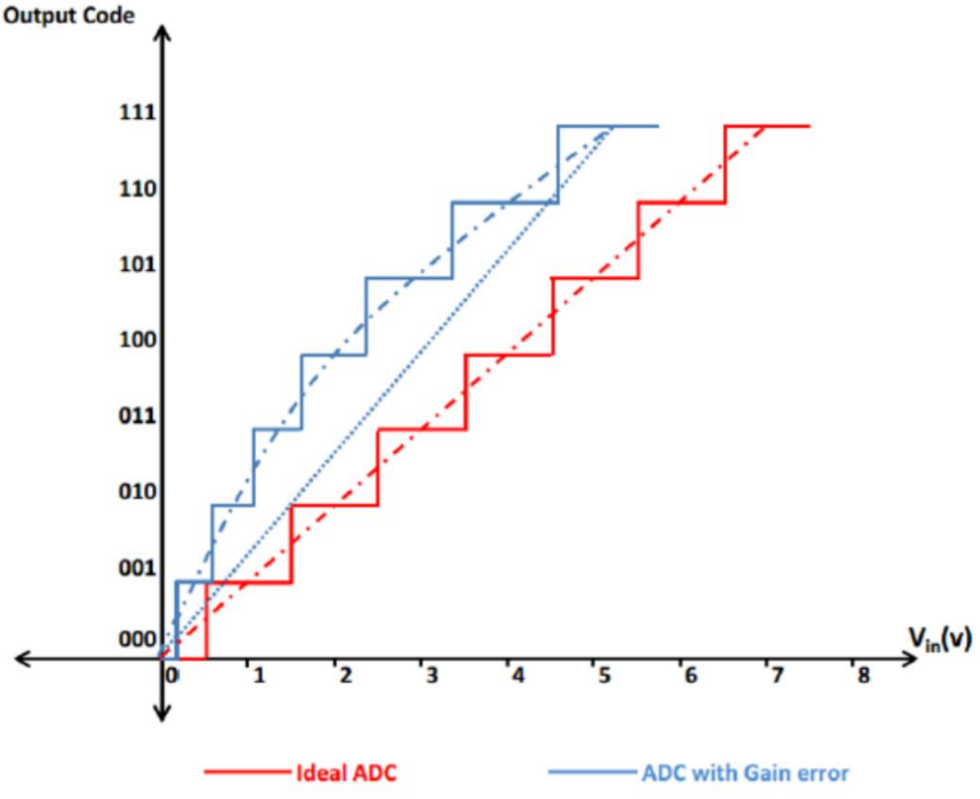

Figure 2 Schematic diagram of the actual error of the ADC

3.2 Introduction to ADC Error

The difference between the ideal output of the device and the actual output is defined as the offset error, which is present in all digital codes. in reality, Offset error causes a fixed offset between the transfer function or analog input voltage and the corresponding numerical output code. Usually counted Offset error is calculated by measuring the voltage of the first digital code transition or "zero" transition and comparing it to the theoretical zero voltage. Compare.

Gain error is the difference between the estimated transfer function and the actual slope, and the gain error is usually at the end or the last pass of the analog-to-digital converter. Input code conversion point calculation.

3.3 ADC Calibration Method

As shown in Figure 1, the red line is the transfer characteristic curve of the ideal ADC, and the blue line is the transfer characteristic curve of the actual ADC.

For an ideal ADC, if the analog input and digital output are in equal increments on the X and Y axes, the transfer between them

The characteristic is then shown by the red dotted line in Figure 1 (k=1). However, the actual ADC transfer characteristic is not the case, the blue dotted line

The increment factor is not equal to 1. The difference between the red and blue dotted lines is the Gain error. Therefore, calibration is required to minimize or

Eliminate value-added errors. Regarding the method of elimination, two-point calibration can be used.

Calibrating the ADC gain error requires an accurate reference (usually Band gap Ref). For an actual ADC to

That said, the transfer characteristic curve is not a straight line, that is, the ADC output and input are not linear. as shown in picture 2.

One of the most commonly used calibration methods - two-point calibration method:

This method assumes that the ADC transfer characteristic is a straight line. This method is a good choice for low input and can be effective

significantly reduce calibration costs. In the two-point calibration, one point can be selected at the lowest point of the AD input, and the other can be selected near the highest point.

point.

For example, a single-ended input ADC, the input range is 0-2.2V, we can use a reference as Vref1=0V

and one for Vref2=2.049 for calibration.

The calibration formula is:

Gain factor = (actual output at Vref2 - actual output at Vref1)/(ideal output at Vref2 - ideal output at Vref1)

For example, the actual output of one output for one Vref is 99, and the second gain factor is calculated to be 0.008, then the actual output is

The output is 99*1.008=99.792.

Offset calibration can be obtained by inputting 0V voltage and subtracting 0 from the actual output to obtain the Offset value. The client code can put each

The ADC sampling value can be obtained by subtracting the Offset value from the value collected for the second time.

3.4 Notes

The conversion accuracy of the ADC is related to the stability of the reference voltage. A stable reference voltage can significantly improve the conversion accuracy of the ADC. The ADC of this series of microcontrollers can choose from 4 reference voltages: power supply voltage, ExRef pin, built-in 1.5v parameter Test voltage, built-in 2.5v reference voltage. The power supply voltage will be affected by the digital circuit inside the chip, and it has a certain amount of digital noise. Voice. The built-in 1.5v reference voltage and the built-in 2.5v reference voltage are generated by the power supply voltage through the BGR module, and also have a certain digital noise. The reference voltage of the external ExRef pin can be adjusted by appropriate circuit (parallel decoupling capacitor) to The ADC provides a stable reference voltage, and the ADC has the highest conversion accuracy under this operating condition. Second, if you choose When selecting AVCC / internal 1.5V / internal 2.5V as the reference voltage of the ADC, it is recommended to set the ExRef pin to the analog function And an external decoupling capacitor.

When using the ADC module, the priority for selecting the reference voltage is as follows:

Superior serial number	reference voltage	ExRef pin configuration
1	Exref	Analog Pin + Decoupling Capacitor
2	VCC	Analog Pin + Decoupling Capacitor
3	Internal 1.5V / 2.5V analog pin + decoupling capacitor	
4	Internal 1.5V / 2.5V digital pins	
5	VCC	digital pin

4 Reference samples and drivers

Through the above introduction, together with the user manual of HC32L110 / HC32F003 / HC32F005 series, we

The ADC function and operation method of MCU have been further mastered.

Huada Semiconductor (HDC) officially provides the application sample and driver library of this module at the same time. Users can open the sample by opening the

The project is further intuitively familiar with the application of the module and the driver library, and can also directly refer to the sample and use in the actual development

Driver library to quickly implement the operation of this module.

ÿ Example reference: ~/HC32L110_DDL/example/adc

~/HC32F003_DDL/example/adc

~/HC32F005_DDL/example/adc

ÿ Driver library reference: ~/HC32L110_DDL/driver/…/adc

~/HC32F003_DDL/driver/…/adc

~/HC32F005_DDL/driver/…/adc

5 Summary

The above chapters briefly introduce the HC32L110 / HC32F003 / HC32F005 series ADC errors and calibration methods.

Understand the error and calibration method of the ADC. In the actual application development process, if the user needs to have a deeper understanding of the ADC

For the usage and operation of the block, please refer to the corresponding user manual. The samples and driver libraries mentioned in this article can either

As a user's further experiment and learning, it can also be directly applied in actual development.

6 Other information

Technical support information: www.hdsc.com.cn

7 Version Information & Contact Information

date	Version revision record
2018/5/31	The first version of Rev1.0 is released.
2018/6/6	Rev1.1 adds 3.4 Notes.

If you have any comments or suggestions in the process of purchasing and using, please feel free to contact us.

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