M451 Temperature Sensor

Example Code Introduction for 32-bit NuMicro® Family

Information

Application	This code uses EADC to measure internal temperature sensor voltage.
BSP Version	M451 Series BSP CMSIS V3.01.003
Hardware	NuEdu-SDK-M451 v2.0

1 Function Description

1.1 Introduction

This code uses EADC to measure the voltage of the M451's internal temperature sensor. User could monitor the temperature of the chip to avoid errors caused by excessive temperature.

1.2 Principle

In this example code, the internal temperature sensor function of the EADC is implemented. For the internal temperature sensor specifications, please refer to Section 8.4.6 of the M451 Datasheet. The example code uses two EADCs together. One EADC is for the band-gap voltage. It can estimate the actual voltage value of VREF to avoid the external reference voltage instability. Then, the other EADC measures the internal temperature sensor voltage. According to the following table, the output voltage can be converted into the actual temperature.

$$\text{Temperature} = (748 - (\frac{\text{ADC}_{\text{TMP}}}{4095} \times \text{V}_{\text{REF}})) / 1.672;$$

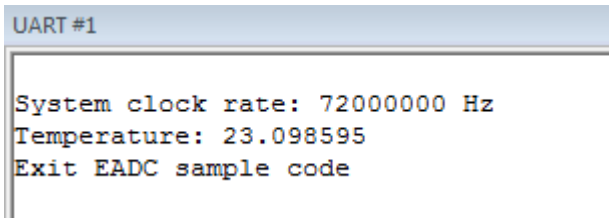
8.4.6 Temperature Sensor

Symbol	Parameter	Min	Typ	Max	Unit	Test Condition
T_A	Temperature	-40	-	105	℃	
I_{TEMP}	Current Consumption	-	16	-	μA	
-	Gain	-1.55	-1.672	-1.75	mV/℃	
-	Offset	735	748	755	mV	T_A = 0 ℃

Note:

1. The temperature sensor formula for the output voltage (Vtemp) is as below equation.
2. Vtemp (mV) = Gain (mV/℃) x Temperature (℃) + Offset (mV)

1.3 Demo Result


UART #1
System clock rate: 72000000 Hz
Temperature: 23.098595
Exit EADC sample code

2 Code Description

Set ADC and start the A/D conversion：

```
void EADC_FunctionTest()
{
    /* Enable channel 16 and select internal band-gap voltage as input source */
    EADC_Open(EADC, EADC_CTL_DIFFEN_SINGLE_END);
    /* Set sample module 16 & 17 external sampling time to 0xF */
    EADC_SetExtendSampleTime(EADC, 16, 0xF);
    EADC_SetExtendSampleTime(EADC, 17, 0xF);

    EADC_ConfigSampleModule(EADC, 16, EADC_SOFTWARE_TRIGGER, 0);
    EADC_ConfigSampleModule(EADC, 17, EADC_SOFTWARE_TRIGGER, 0);
    SYS->IVSCTL |= SYS_IVSCTL_VTEMPEN_Msk;
    /* Clear the A/D ADINT0 interrupt flag for safe */
    EADC_CLR_INT_FLAG(EADC, EADC_STATUS2_ADIF0_Msk);
    /* Enable the sample module 17 interrupt.  */
    EADC_ENABLE_INT(EADC, BIT0);
    EADC_ENABLE_SAMPLE_MODULE_INT(EADC, 0, BIT17);
    NVIC_EnableIRQ(ADC00_IRQn);

    u8ADCStop = 0;
    u8ConvertTimes = 0;
    u32ConvertResVgap = 0;
    u32ConvertResVtemp = 0;

    /* Trigger ADC conversion */
    while(1) {
        if(!(EADC_IS_BUSY(EADC))) {
            EADC_START_CONV(EADC, BIT16|BIT17);
        }
        if(u8ADCStop) break;
    }

    /* Disable the ADINT0 interrupt */
    EADC_DISABLE_INT(EADC, BIT0);
    NVIC_DisableIRQ(ADC00_IRQn);

    /* Calculate average value of ADC result */
    u32AverageValueVgap = u32ConvertResVgap/ADC_AVERAGE_TIMES;
```

```
    u32AverageValueVtemp = u32ConvertResVtemp/ADC_AVERAGE_TIMES;

    /* The equation of converting to real temperature is as below
     * (748-(i32ConversionData*ADCVREF/4095))/(1.672)),
     * ADCVREF means the VREF voltage get from Band-gap 1.2V
     */
    fVDD=(1.2f*4095*1000/u32AverageValueVgap);
    Check=(double)(748-(u32AverageValueVtemp*fVDD/4095))/1.672;

    printf("Temperature: %f\n",Check);
}
```

3 Software and Hardware Environment

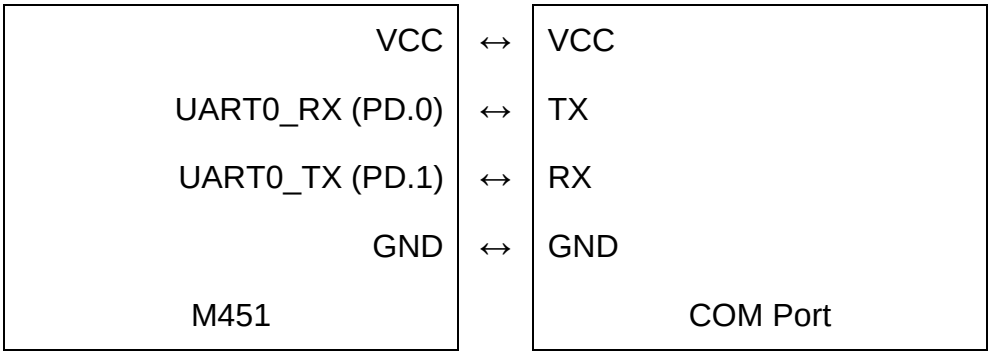
Software Environment

- BSP version
  - M451 Series BSP CMSIS V3.01.003
- IDE version
  - Keil uVersion 5.26

Hardware Environment

- Circuit components
  - NuEdu-SDK-M451 v2.0
- Diagram

Using printf function to output message and the UART0 TX RX pin are PD.1 and PD.0 respectively.



4 Directory Information

- EC_M451_Temperature_Sensor _V1.00
  - Library — Sample code header and source files
    - CMSIS — Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
    - Device — CMSIS compliant device header file
    - NuEdu — Library for NuEdu-SDK-xxxx board
    - StdDriver — All peripheral driver header and source files
  - SampleCode
    - ExampleCode — Source file of example code

5 How to Execute Example Code

1. Browsing into sample code folder by Directory Information (section 4) and double click M451_Temperature_Sensor.uvproj.
2. Enter Keil compile mode
   a. Build
   b. Download
   c. Start/Stop debug session
3. Enter debug mode
   a. Run

6 Revision History

Date	Revision	Description
Jul. 11, 2019	1.00	1. Initially issued.

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