AN10769

How to use the P89LPC9351 temperature sensor

Rev. 01 — 2 December 2008 Application note

Document information

Info	Content
Keywords	P89LPC9351, temperature sensor
Abstract	This application note describes how to use the P89LPC9351 temperature sensor. Demo code is also provided.

Revision history

Rev	Date	Description
01	20081202	Initial version

Contact information

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1. Introduction

The P89LPC9351 has two 8-bit, 4-channel multiplexed successive approximation analog-to-digital converter modules. An on-chip wide range temperature sensor is integrated in the ADC0 module. It provides temperature sensing capability in the range of -40°C ~ 85°C.

This application note provides example code, which enables the user to get a jump-start into using the on-chip temperature sensor. The code was tested on the KEIL MCB900 evaluation board. For more information about MCB900, please refer to: http://www.nxp.com/redirect/keil.com/mcb900.

2. Temperature sensor

2.1 ADC block diagram

A block diagram of the A/D converter is shown in Figure 1. The on-chip temperature sensor is integrated with ADC0 module. The Temperature sensor, the internal reference voltage $V_{ref(bg)}$ (1.23 V ± 10 %) and analog input channel AD03 are multiplexed on the same input channel to PGA0. Selecting the temperature sensor, the internal reference voltage or AD03 input pin is achieved by configuring the TSEL1 and TSEL0 bits in the register PGACON0.

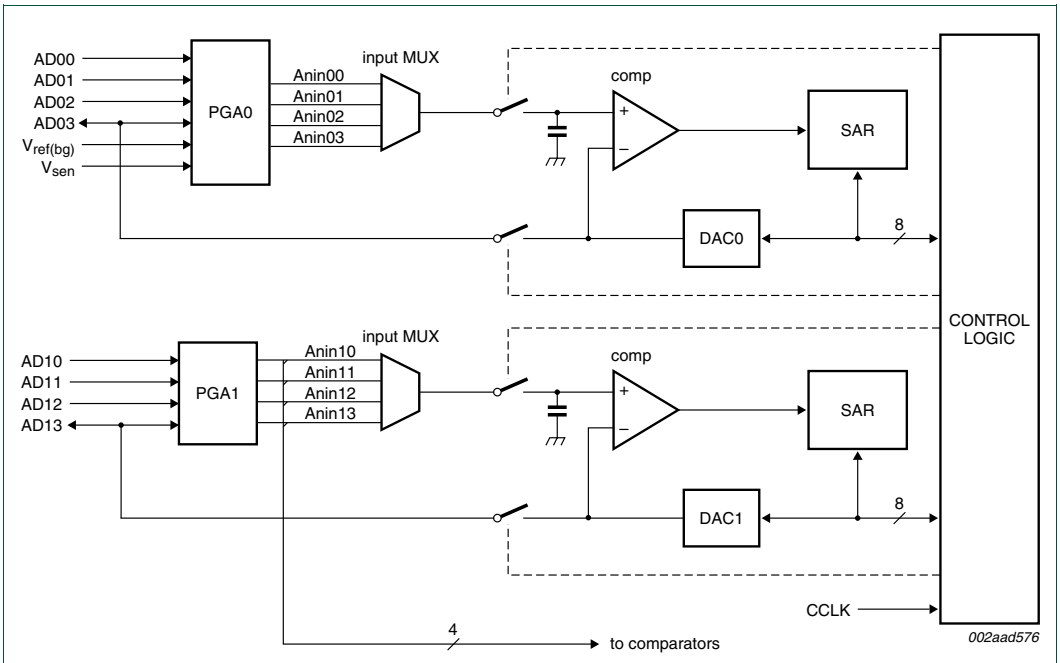

Fig 1. ADC block diagram

2.2 Temperature sensor usage steps

To get an accurate temperature value, it is necessary to firstly measure the internal reference voltage $V_{ref(bg)}$.The Temperature sensor voltage can be calculated using the following formula:

$$V_{sen} = A_{sen} * V_{ref(bg)} / A_{ref(bg)} \quad (1)$$

In the formula (1), $A_{ref(bg)}$ is the A/D converting result of $V_{ref(bg)}$ and A_{sen} is the A/D converting result of V_{sen}.

The Temperature Sensor transfer function can be shown in the following formula:

$V_{sen} = m * Temp + b$ (where m=11.3mV/°C, b=890mV) (2)

Temperature Sensor usage steps:

1. Setting PGASEL01 and PGASEL00 bits to choose AD03 channel.
2. Configure TSEL1 and TSEL0 as “01” to select the internal reference voltage.
3. Use ADC to get conversion result as A_{ref}.
4. Configure TSEL1 and TSEL0 as “10” to select temperature sensor.
5. Wait at least 200us to allow the sensor to stabilize. Then use the ADC to measure A_{sen}.
6. Calculate V_{sen} with the formula (1).
7. Calculate Temperature with the formula (2).

2.3 Demo introduction

In this demo, the temperature is measured and the calculated temperature is sent to UART0.

ADC0 is configured as below.

```
1    void ad03_init(void)
2    {
3          // select ADC03
4          ADINS = 0x08;
5          // single conversion mode
6          ADMODA  = 0x01;
7          // configure clock divider
8          ADMODB |= 0x40;
9    }
```

According to the aforementioned temperature sensor usage steps, the internal reference voltage $V_{ref(bg)}$ is measured first.

```
10   ……
11   // measure internal reference voltage
12         PGACON0 = 0x64 ;
13         delay (100);
14
15         temp = 0 ;
16
17         // read VREF
18         for(i=0;i<N;i++)
19         {
20               temp += get_ad();
21         }
22         aref = temp / N ;
23   ……
```

Every time configure TSEL1 and TSEL0 as “10” to choose temperature sensor, settling time of 200us is required before getting ADC conversion result.

```
24    ……
25    // choose temperature sensor
26          PGACON0 = 0x68 ;
27          // Wait sometime to let the sensor work stably
28          delay (200);
29    ……
30
```

The temperature is calculated as below.

```
31    #define VREFBG              12300L                  // Vrefbg * 10000
32    #define VT(at,ar)           ((at)*VREFBG/(ar))
33
34    #define M                   113L                    // M * 10000
35    #define B                   8900L                   // b * 10000
36    #define T(v)                (((v)-B) / M)
37
38    ……
39    // Calculate the real temperature
40    temperature = T(VT(atemp,aref));
41    ……
42
```

2.3.1 Demo setup

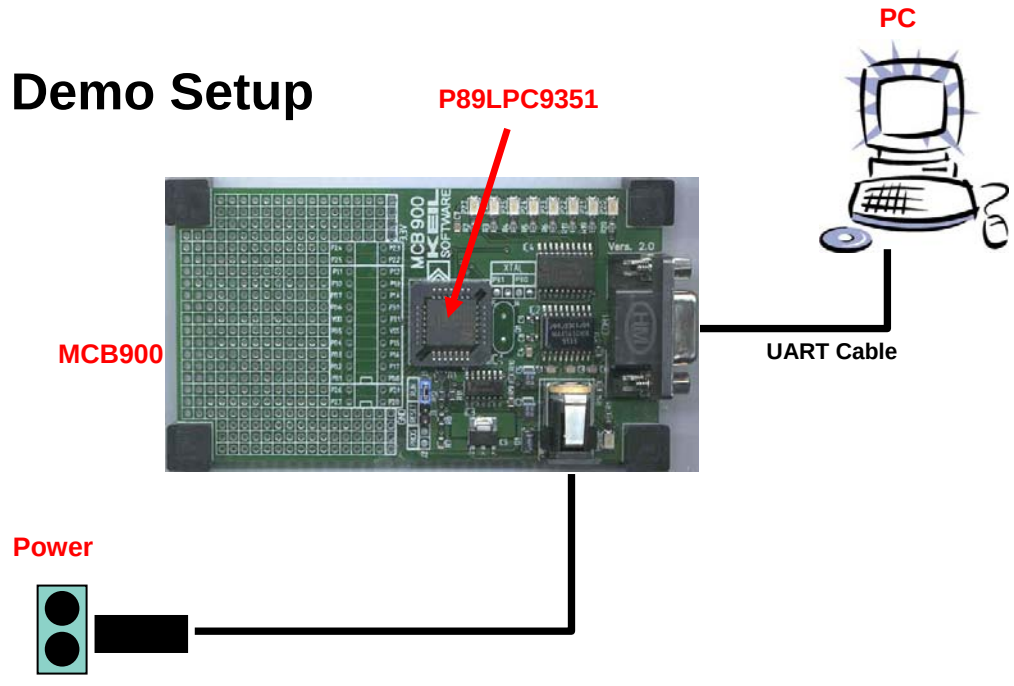

Fig 2. Demo setup

2.3.2 Output information using P89LPC9351 – Temperature sensor

The temperature is measured at regular intervals and the calculated result will be sent to UART0.

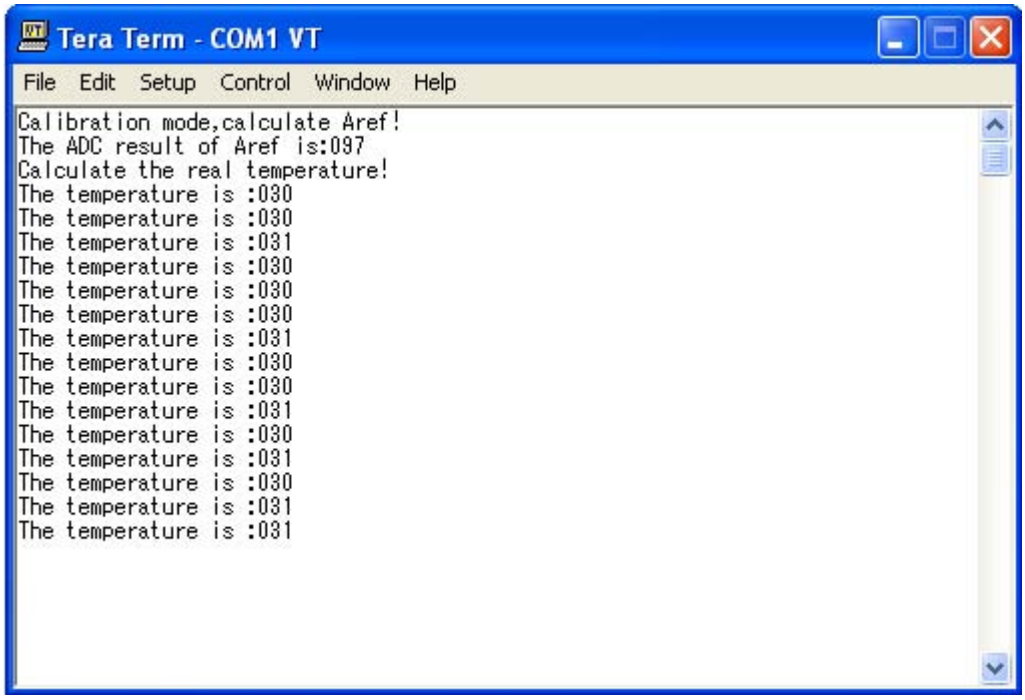

Fig 3. Print information

3. Reference

[1] P89LPC9351 User Manual (UM10308) – Rev. 01

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