M3H Group(1)
Application Note

12-bit Analog to Digital Converter
(ADC-A)

Outlines
This application note is a reference material for developing products using the 12-bit analog to digital converter (ADC) function of M3H Group(1).
This document helps the user check operation of the product and develop its program

Target sample program: ADC_UART
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1. Preface

This sample program is used to measure the thermistor output voltage using the ADC, convert the ADC result to a temperature value using the CPU, and display it on the terminal software.

Structure diagram of Sample program

2. Reference Document

- Datasheet
  TMPM3H group (1) datasheet Rev2.0 (Japanese edition)
- Reference manual
  12-bit analog to digital converter (ADC-A) Rev2.0 (Japanese edition)
- Reference manual
  TMPM3H Group Peripheral Driver User Manual (Doxygen)

3. Function to Use

<table>
<thead>
<tr>
<th>IP</th>
<th>channel</th>
<th>port</th>
<th>Function / operation mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC</td>
<td>ch2</td>
<td>PD2 (AIN02)</td>
<td>Single conversion</td>
</tr>
<tr>
<td>Asynchronous serial communication circuit</td>
<td>ch0</td>
<td>PA1 (UT0TXDA)</td>
<td>Asynchronous communication with PC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PA2 (UT0RXD)</td>
<td></td>
</tr>
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4. Target Device

The target devices of application note are as follows.

<table>
<thead>
<tr>
<th>TMPM3H6FWFG</th>
<th>TMPM3H6FUFG</th>
<th>TMPM3H6FSFG</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPM3H6FWDFG</td>
<td>TMPM3H6FUDFG</td>
<td>TMPM3H6FSDFG</td>
</tr>
<tr>
<td>TMPM3H5FWFG</td>
<td>TMPM3H5FUFG</td>
<td>TMPM3H5FSFG</td>
</tr>
<tr>
<td>TMPM3H5FWDFG</td>
<td>TMPM3H5FUDFG</td>
<td>TMPM3H5FSDFG</td>
</tr>
<tr>
<td>TMPM3H4FWUG</td>
<td>TMPM3H4FUUG</td>
<td>TMPM3H4FSUG</td>
</tr>
<tr>
<td>TMPM3H4FWFG</td>
<td>TMPM3H4FUFG</td>
<td>TMPM3H4FSFG</td>
</tr>
<tr>
<td>TMPM3H3FWUG</td>
<td>TMPM3H3FUUG</td>
<td>TMPM3H3FSUG</td>
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<td>TMPM3H3FWDFG</td>
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</tr>
<tr>
<td>TMPM3H1FWUG</td>
<td>TMPM3H1FUUG</td>
<td>TMPM3H1FSUG</td>
</tr>
<tr>
<td>TMPM3H1FPUG</td>
<td>TMPM3H0FSDUG</td>
<td>TMPM3H0FMDUG</td>
</tr>
</tbody>
</table>

* This sample program operates on the evaluation board of TMPM3H6FWFG. If other function than the TMPM3H6 one is checked, it is necessary that CMSIS Core related files (C startup file and I/O header file) should be changed properly.

The BSP related file is dedicated to the evaluation board (TMPM3H6). If other function than the TMPM3H6 one is checked, the BSP related file should be changed properly.
5. Operation Confirmation Condition

Used microcontroller: TMPM3H6FWFG
Used board: TMPM3H6FWFG Evaluation Board (Product of Sensyst)
Unified development environment: IAR Embedded Workbench for ARM 8.11.2.13606
Unified development environment: μVision MDK Version 5.24.2.0
Terminal software: Tera Term V4.96
Sample program: V1100

Evaluation board (TMPM3H6FWFG Evaluation Board) (Top view)

For purchasing the board, refer to the following homepage. (http://www.chip1stop.com/)
6. Evaluation Board Setting

The following pin connections should be done on the evaluation board.

<table>
<thead>
<tr>
<th></th>
<th>Use</th>
<th>Through-hole No.</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN5</td>
<td>UART</td>
<td>9-10</td>
<td>Connection</td>
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<tr>
<td></td>
<td>UART</td>
<td>11-12</td>
<td>Connection</td>
</tr>
<tr>
<td>CN12</td>
<td>ADC Input</td>
<td>13-14</td>
<td>Connection</td>
</tr>
</tbody>
</table>
7. Outline of 12-bit Analog to Digital Converter (ADC) Function

The ADC is a successive-approximation analog-to-digital converter. It supports maximum 16 analog inputs. When you use ADC, please set an applicable clock enable bit to “1” (clock supply) in fsys supply stop register A or B ([CGFSYSENA], [CGFSYSENB]), fc supply stop registers ([CGFCEN]), and Clock Supply for ADC and TRACE register([CGSPCLKEN]). Please refer to “Clock Control and Operation Mode” of the reference manual for the clock enable bit.
8. Sample Program

The ADC measures the thermistor output voltage. The ADC result is converted to a temperature value by the CPU, and the value is displayed on the terminal software.

8.1. Initialization

The following initialization is done after power is supplied. The PORT setting is executed after the initialization of each clock setting and the clock setting.

8.2. Sample program main operation

This sample program executes the setting of the ADC driver after the initialization settings. The timer setting, the UART setting, and the thermistor setting are done to execute the operation. ADIN02 pin is used as the AD input pin. The application starts to operate after every setting completes. The sample program works with single conversion of ADC.

The ADC result is converted to a temperature value by the CPU, and the value is displayed on the terminal software. The interval of the output to the terminal software is defined by timer_interval_handler. The output interval is set by the macro definition CFG_OUTPUT_INTERVAL, and the initial value is 5 seconds.
8.3. Output Example of Sample Program

The data from the ADC is converted to a temperature value. Then the value is displayed.

The updated temperature value is displayed every 5 seconds.

8.3.1. Setting Example of Terminal Software

The operation of the terminal software (Tera Term) has been checked with the following settings.
8.4. ADC Setting Change

The ADC is initialized depending on the evaluation board. The channel of the ADC can be changed by bps.c.

```c
static const uint32_t thermistorsTbl[BSP_THERMISTORS_MAX][5] =
{
  {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_2, (uint32_t)(2), (uint32_t)(2), (uint32_t)(16)},
  {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_1, (uint32_t)(1), (uint32_t)(1), (uint32_t)(16)},
  {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_0, (uint32_t)(0), (uint32_t)(0), (uint32_t)(16)}
};
```

The above settings define Group of the ADC, PORT number, ADIN, AD ch, and the channel of DMAC. The used ADC can be changed by the update of the above settings. The third item sets the AD input channel. The fourth item sets the AD channel.
8.5. Operating Flow of Sample Program

The operating flows of the sample program are shown as follows.
Creation and Initialization

- **BSP initialization**
- **RAM initialization**
- **Driver initialization**
  - **T32A Driver initialization**
  - **ADC Driver initialization**

Application initialization
T32A Driver initialization

BSP (Application)

bsp_get_timer_ch(BSPTimer)

Channel number = bsp_get_timer_ch()

result = timer_initialize():Successful

result = t32a_mode_init():Successful

t32a_timer_init()

result = t32a_timer_init():Successful

T32A (Driver)

ADC Driver initialization

Assignment of ADC register address

adc_init

ADC (Driver)
Application initialization

- Timer Application initialization
- UART Application initialization
- Thermistor (ADC channel) setting

Thermistor (ADC channel) setting

- bsp_get_thermistors_adin
  Acquisition of ADIN channel for Thermistor
- bsp_get_thermistors_ch
  Acquisition of ADC channel for Thermistor
- adc_channel_setting
Acquisition of Temperature

```
[Conversion state == CONVERSION_SUCCESS]
loop
  bsp_get_thermistors_ch
  adc_channel_get_value
  bsp_get_thermistors_degC
  adc_continuity_irq_handler()
  Conversion state = CONVERSION_SUCCESS done_handler()
```

- **BSP (Application)**
- **UART IO (Application)**
- **ADC (Driver)**
End and Deletion

ref Application end

ref Driver end

ref BSP end

Application end

ref Thermistor (ADC channel) setting clear

ref UART Application end

ref Timer Application end
ADC Driver end

Release of assignment of ADC register address

T32A Driver end

Release of assignment of Register address for 1-ms timer channel
9. Precaution

When using the sample program with CPU other than TMPM3H6, please check operation sufficiently.

10. Revision History

<table>
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<tr>
<th>Rev</th>
<th>Date</th>
<th>Page</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2018-03-22</td>
<td>-</td>
<td>First release</td>
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