M3H Group(2)
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 (2).
This document helps the user check operation of the product and develop its program

Target sample program: ADC_UART_DMA
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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. And the program also displays the digital value to which an analog voltage is converted by the ADC.

Structure diagram of Sample program
2. Reference Document

- Datasheet
  TMPM3H group (2) datasheet Rev2.0 (Japanese edition)
- Reference manual
  12-bit analog to digital converter (ADC-A) Rev2.0 (Japanese edition)
- Other reference document
  TMPM3H(2) 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>ch0</td>
<td>PE0 (AINA04)</td>
<td>Continuous conversion</td>
</tr>
<tr>
<td></td>
<td>ch1</td>
<td>PD4 (AINA19)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ch2</td>
<td>PD5 (AINA20)</td>
<td></td>
</tr>
<tr>
<td>Asynchronous serial</td>
<td>ch0</td>
<td>PA1 (UT0TXDA)</td>
<td>Asynchronous communication with PC</td>
</tr>
<tr>
<td>communication circuit</td>
<td></td>
<td>PA2 (UT0RXD)</td>
<td></td>
</tr>
<tr>
<td>DMAC</td>
<td>ch14</td>
<td>-</td>
<td>Continuous normal transfer</td>
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</tbody>
</table>

4. Target Device

The target devices of application note are as follows.

<table>
<thead>
<tr>
<th>TMPM3HQFDFG</th>
<th>TMPM3HQFZFG</th>
<th>TMPM3HQFYFG</th>
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<tbody>
<tr>
<td>TMPM3HPFDFG</td>
<td>TMPM3HPFZFG</td>
<td>TMPM3HPFYFG</td>
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<tr>
<td>TMPM3HNFDFFG</td>
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<tr>
<td>TMPM3HMFDFG</td>
<td>TMPM3HMFZFG</td>
<td>TMPM3HMFYFG</td>
</tr>
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</table>

* This sample program operates on the evaluation board of TMPM3HQFDFG.
If other function than the TMPM3HQ 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 (TMPM3HQ). If other function than the TMPM3HQ one is checked, the BSP related file should be changed properly.
5. Operation confirmation condition

- Used microcontroller: TMPM3HQFDFG
- Used board: TMPM3HQFDFG 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

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>CN12</th>
<th>Board function</th>
<th>Through hole No.</th>
<th>Through hole No.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>USB UART conversion</td>
<td>53 : PA1</td>
<td>54 : USB_TXD</td>
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<tr>
<td></td>
<td>USB UART conversion</td>
<td>55 : PA2</td>
<td>56 : USB_RXD</td>
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<table>
<thead>
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<th>CN9</th>
<th>Board function</th>
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<tbody>
<tr>
<td></td>
<td>Thermistor</td>
<td>21 : AIN_NTC</td>
<td>22 : PE0</td>
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<table>
<thead>
<tr>
<th>CN5</th>
<th>Board function</th>
<th>Through hole No.</th>
<th>Through hole No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Variable resistance</td>
<td>57 : PORT_AIN1</td>
<td>58 : PD5</td>
</tr>
<tr>
<td></td>
<td>Variable resistance</td>
<td>59 : PORT_AIN0</td>
<td>60 : PD4</td>
</tr>
</tbody>
</table>
7. Outline of 12-bit Analog to Digital Converter Function

The ADC is triggered to start the conversion by the software start-up (Software trigger) or the trigger signal from PMD, a timer, and others. 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 thermistor output voltage is measured using the ADC. The ADC result is converted to a temperature value by the CPU, and the value is displayed on the terminal software. The ADC converts the output voltage value of a variable resistor, and the result value is displayed on the terminal software.

8.1. Initialization

The following initialization is done after power is supplied. The initialization of each clock setting and the initialization of the watchdog timer setting.

8.2. Sample program main operation

After the initialization operation, shift to the main function and do the following initialization.
1. BSP (Board Support Package) initialization
2. Driver initialization
3. Application initialization

The timer setting, the UART setting, the DMA setting, the ADC setting, and the thermistor setting are done by executing the above operation. The AINA04, AINA19, and AINA20 pins are used as the AD input pins. 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

Display temperature and voltage digital value.

Results are displayed at intervals of 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.

static const uint32_t thermistorsTbl[BSP_THERMISTORS_MAX][5] =
{
    {(uint32_t)GPIO_PORT_E, (uint32_t)GPIO_PORT_0, (uint32_t)(4), (uint32_t)(0), (uint32_t)(14) },
    {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_4, (uint32_t)(19), (uint32_t)(1), (uint32_t)(14) },
    {(uint32_t)GPIO_PORT_D, (uint32_t)GPIO_PORT_5, (uint32_t)(20), (uint32_t)(2), (uint32_t)(14) }
};

The above settings define Group of the ADC, PORT number, ADIN, AD channel, 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 in the following;
Creation and Initialization

- BSP initialization
- RAM initialization
- Driver initialization
- Application initialization

Driver initialization

- T32A Driver initialization
- DMA Driver initialization
- ADC Driver initialization
T32A Driver initialization

bsp_get_timer_ch(BSPTimer)

Channel number = bsp_get_timer_ch(-)

t32a_mode_init(Instance address)

timer_initialize (Timer instance address)

result = timer_initialize(-): Successful

result = t32a_mode_init(-): Successful

t32a_timer_init(Instance address)

result = t32a_timer_init(-): Successful
ADC Driver initialization

Assignment of ADC register address

`adc_init`

DMA Driver initialization

Assignment of DMA register address

`dma_init(DMA Instance address)`

Create DMA Driver setting value
- Work area
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

- adc_dma_start
  (Instance address, Storage address)
- dma_normal_int_startIt
  (Instance address, channel, Burst, config information)
- dma_sw_request
  (Instance address, channel)
- dma_sw_request()
- Conversion state =CONVERSION_SUCCESS done_handler()
- dma_irq_handler(DMA instance handle, target DMA channel)
- Transfer status =DMA_SUCCESS dma_done_handler()
- Acquisition of ADC channel for Thermistor
- bsp_get_thermistors_ch
- bsp_get_thermistors_degC
- ADC value → temperature conversion
- print(Display data of Temperature)
Thermistor (ADC channel) setting clear

Remote Control (Application)

adc_channel_clear
Driver end

ADC Driver end

T32A Driver end

DMA Driver end

dma_deinit(DMA Instance address)

Release of assignment of DMA register address

DMA (Driver)
ADC Driver end

- ADC (Driver)
- adc_deinit
- Release of assignment of ADC register address

T32A Driver end

- T32A (Driver)
- Release of assignment of Register address for 1-ms timer channel
9. Precaution

When using the sample program with CPU other than TMPM3HQ, please check operation sufficiently.

10. Revision History

<table>
<thead>
<tr>
<th>Rev</th>
<th>Date</th>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
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<tr>
<td>1.0</td>
<td>2018-05-14</td>
<td>-</td>
<td>First release</td>
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TOSHIBA ELECTRONIC DEVICES & STORAGE CORPORATION

2018-05-14 22 / 22 Rev 1.0

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