M3H Group(1)
Application Note
Asynchronous Serial Communication Circuit
(UART-C)
DMA

Outlines
This application note is a reference material for developing products using the asynchronous serial communication circuit (UART with DMA) functions of M3H Group(1). This document helps the user check operation of the product and develop its program.

Target sample program: UART_Echo_DMA
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1. Preface

This sample program is used to check the operation of the function of the UART communication with DMA. A command is input on the PC terminal and the echo-back of the command is done through the USB-UART interface.

Structure diagram of Sample program
2. Reference Document

- Datasheet
  TMPM3H group (1) datasheet Rev2.0 (Japanese edition)
- Reference manual
  Asynchronous serial communication circuit (UART-C) Rev2.0 (Japanese edition)
  DMA controller (DMAC-B) Rev1.2 (Japanese edition)
  Product Information (PINFO-M3H(1)) Rev2.0 (Japanese edition)
- Other reference document
  TMPM3H(1) 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>
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<tbody>
<tr>
<td>Asynchronous communication</td>
<td>ch0</td>
<td>PA1 (UT0TXDA) PA2 (UT0RXD)</td>
<td>UART mode</td>
</tr>
<tr>
<td>DMAC</td>
<td>ch10 ch11</td>
<td>-</td>
<td>Single normal transfer</td>
</tr>
</tbody>
</table>

4. Target Device

The target devices of application note are as follows.

<table>
<thead>
<tr>
<th>Device</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMPM3H6FWFG</td>
<td>TMPM3H6FUFG TMPM3H6FSFG</td>
</tr>
<tr>
<td>TMPM3H6FWDFG</td>
<td>TMPM3H6FUDFG TMPM3H6FSDFG</td>
</tr>
<tr>
<td>TMPM3H5FWFG</td>
<td>TMPM3H5FUFG TMPM3H5FSFG</td>
</tr>
<tr>
<td>TMPM3H5FWDFG</td>
<td>TMPM3H5FUDFG TMPM3H5FSDFG</td>
</tr>
<tr>
<td>TMPM3H4FWUG</td>
<td>TMPM3H4FUUG TMPM3H4FSUG</td>
</tr>
<tr>
<td>TMPM3H4FWFG</td>
<td>TMPM3H4FUFG TMPM3H4FSFG</td>
</tr>
<tr>
<td>TMPM3H3FWUG</td>
<td>TMPM3H3FUUG TMPM3H3FSUG</td>
</tr>
<tr>
<td>TMPM3H2FWUDUG</td>
<td>TMPM3H2FUDUG TMPM3H2FSDUG</td>
</tr>
<tr>
<td>TMPM3H2FWQG</td>
<td>TMPM3H2FUQG TMPM3H2FSQG</td>
</tr>
<tr>
<td>TMPM3H1FWUG</td>
<td>TMPM3H1FUUG TMPM3H1FSUG</td>
</tr>
<tr>
<td>TMPM3H1FPUG</td>
<td>TMPM3H0FSDUG 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

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>CN5</th>
<th>Use</th>
<th>Through-hole No.</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>UART (RXD)</td>
<td>9-10</td>
<td></td>
<td>Connection</td>
</tr>
<tr>
<td>UART (TXD)</td>
<td>11-12</td>
<td></td>
<td>Connection</td>
</tr>
</tbody>
</table>

7. Operation of Evaluation Board

The USB_UART pin on the evaluation board and the PC should be connected with a USB cable. After the PC starts up the terminal software (Tera Term), the communication settings should be done. The reset button should be pushed down on the evaluation board.

The following operations should be done on the PC terminal software (Tera Term).

1. Initial status display
   "Input =" on the display requests a user to input proper characters.
2. Character input
   User should input proper characters. Then, "Enter" should be pushed down.
3. Echo-back output
   After "Echo=" on the display, the input characters are displayed.
4. When the character count exceeds the maximum count;
   "Input Error !!" is displayed.

Used port

| TXD:PA1, RXD:PA2 |
8. Outline of UART Interface Function

The asynchronous serial communication circuit (UART) can operate as a transmission / reception circuit of 1 channel (UTxTXDA / UTxTXDB / UTxRXD) per unit. The following is a list of functions.

<table>
<thead>
<tr>
<th>Function classification</th>
<th>Function</th>
<th>Operation explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baud rate control</strong></td>
<td>Frequency dividing of prescaler</td>
<td>Selectable from 1/1 to 1/512 of the ΦT0 frequency.</td>
</tr>
<tr>
<td></td>
<td>Baud rate generator</td>
<td>N dividing or N + (64 - K) / 64 (N = 1 to 65535 and K = 0 to 63) dividing of the source clock frequency are possible.</td>
</tr>
<tr>
<td><strong>Data format</strong></td>
<td>Data length</td>
<td>Selectable 7, 8, or 9-bit.</td>
</tr>
<tr>
<td></td>
<td>Parity</td>
<td>Parity control: Enable or disable selection. Parity type: Even or odd parity is selectable.</td>
</tr>
<tr>
<td></td>
<td>Stop bit length</td>
<td>Selectable 1-bit or 2-bit.</td>
</tr>
<tr>
<td></td>
<td>Data transfer order</td>
<td>Selectable LSB first or MSB first.</td>
</tr>
<tr>
<td></td>
<td>Data signal inversion</td>
<td>Inversion control of the input and output data signal. Selectable disabled or enabled.</td>
</tr>
<tr>
<td><strong>Transmission / reception control</strong></td>
<td>FIFO storage stages</td>
<td>Reception: 8 stages. Transmission: 8 stages.</td>
</tr>
<tr>
<td></td>
<td>Noise cancelling function</td>
<td>Reception: Noise cancelling function is enabled or disabled for UTxRXD.</td>
</tr>
<tr>
<td></td>
<td>Error detection</td>
<td>Reception: Parity error, Framing error, Break error, Overrun error. Transmission: Break error, Trigger transmission error.</td>
</tr>
<tr>
<td></td>
<td>Handshake function</td>
<td>Transmission / reception control by handshake with UTxCTS_N / UTxRTS_N signal is possible.</td>
</tr>
<tr>
<td></td>
<td>Wake-up function</td>
<td>Serial link operation using the wakeup function in the 9-bit mode is possible.</td>
</tr>
<tr>
<td><strong>Interlocking control</strong></td>
<td>Interrupt</td>
<td>Reception interrupt, Transmission interrupt, and Error interrupt.</td>
</tr>
<tr>
<td></td>
<td>DMA request</td>
<td>Reception DMA request: Burst transfer or Single transfer. Transmission DMA request: Burst transfer or Single transfer.</td>
</tr>
<tr>
<td><strong>Special control</strong></td>
<td>Half clock mode (Transmission / reception)</td>
<td>Transmission and reception with half width of &quot;0&quot; width of the normal UART waveform is possible.</td>
</tr>
<tr>
<td></td>
<td>Loopback function (Test function)</td>
<td>The transmission data is connected to the reception data and the loopback test is possible.</td>
</tr>
<tr>
<td></td>
<td>Software reset</td>
<td>Initialization can be done by software.</td>
</tr>
</tbody>
</table>

UTxTXDA can be exchanged for UTxRXD and UTxCTS_N can be exchanged for UTxRTS_N, too. This is done by a port setting. Refer to “Input/Output Ports” of the reference manual.

8.1. Clock Supply

When you use UART, please set an applicable clock enable bit to "1" (clock supply) in fsys supply stop register A and B ([CGFSYSENA], [CGFSYSENB]), fsys supply stop register ([CGFCEN]). Please refer to “Clock Control and Operation Mode” of the reference manual for the details. When attempting to stop supplying the clock, make sure to check whether the UART is stopping. Note that when the MCU enters STOP mode, make sure to check whether the UART is stopping as well.
9. Sample Program

The data transferred from the terminal software is echoed back.

9.1. Initialization

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

9.2. Sample program main operation

Each clock setting and the PORT setting are executed as the initialization of BSP (Board Support Package).
The DMA clear procedure is done after the clock and PORT settings.
The timer interrupt setting and the DMA setting are done as the initialization of the driver.
After those settings complete, the UART setting is done for the DMA.
DMAC ch10 is assigned to the data reception channel, and DMAC ch11 is assigned to the data transmission
channel.

After all settings complete, the timer starts. Then the DMA operation starts.
The DMAC receives the input data after “Input =” on the terminal software through the UART interface. The
data is stored to a memory.
After that, the data stored in this memory is transferred by DMAC control and data is output to the terminal
software.
For DMA transfer, reception is single transfer and transmission is burst transfer.

9.3. Output Example of Sample Program

When you run the sample program, the result of the command is output as follows.

![Output Example](image_url)
9.3.1. Setting Example of Terminal Software

The operation of the terminal software (Tera Term) has been checked with the following settings.
9.4. Operating Flow of Sample Program

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

Main

- **Creation and Initialization**

loop

- **Start-up**

[No procedure errors]

- **Output**
  - "Input = " Display data output

- **Input**
  - Wait for data input

- **Output**
  - Echo-back data output

- **Stop**

- **End and Deletion**
Creation and Initialization

RAM initialization

BSP initialization

Driver initialization

Application initialization
Driver initialization

- T32A Driver initialization
- DMA Driver initialization

DMA Driver initialization

- Assignment of Register address for DMA
- Generation of DMA Driver setting values
  - Work area
- dma_init(DMA instance address)
Although initialization setting of 32-bit timer event counter of TMPM3H is done, it is not used in actual operation of this sample program.

**T32A Driver initialization**

- **BSP (Application)**
  - `bsp_get_timer_ch(BSPTimer)`
  - `Channel number = bsp_get_timer_ch(-)`
  - `t32a_mode_init(Instance address)`
  - `result = t32a_mode_init(-):Successful`
  - `result = t32a_timer_init(-):Successful`
  - `timer_initialize(Timer instance address)`
  - `result = timer_initialize(-):Successful`

**Application initialization**

- **ref** UART Application initialization
- **ref** Timer Application initialization
UART Application initialization

BSP (Application)

Generation of UART IO initial setting

bsp_get_usb_uart_tx_ch

Acquisition of Channel for USB UART

uart_io_dma_initialize (Storage destination of UART IO initial setting)

Assignment of Address to Specified UART CH register

UART (Driver)

Generation of UART Driver initial setting

- uart_initial_setting_t
- uart_dma_initial_setting_t

Registration of UART Driver event handler

- Transmission event handler
- Reception event handler

uart_dma_init(UART instance address)

UART IO instance address=uart_io_dma_initialize(-)
DMA Driver end

DMA (Driver)

dma_deinit (DMA instance address)

Release of assignment of Register address for DMA

T32A Driver end

T32A (Driver)

Release register address assignment for 1-ms timer channel
### Start-up

**Exception enable**
- INTDMACTC_IRQn
- INTDMACERR_IRQn

**Timer Application**

**start-up**

### Stop

**Exception stop**
- INTDMACTC_IRQn
- INTDMACERR_IRQn

**Timer Application**

**stop**
"printf" is retargeted to "putc", and
the characters are output one by one.

Generation of Transmission setting information

uart_dma_transmitIt
(UART DMA instance address,
Storage destination of Transmission setting information)

The handler is called when the data
of the specified count is transmitted.

Transmit data = fputc(-)
loop

Transmission result = Successful.

uart_get_status
(UART instance address,
Storage destination of Status)

For the transmission result, refer to
"Transmission" sequence.

Transmission result = Failure
break

[(Status = Transmission stop) && (FIFO level = 0)]
break

"printf" is retargeted to "fputc", and
the characters are output one by one.

The handler is called when the data
of the specified count is transmitted.
"getchar" is retargeted to "getc", and the characters are input one by one.

For the reception result and the reception information, refer to "Reception" sequence.

The handler is called when the data of the specified count is received.
Transmission

- dma_irq_handler (DMA instance handle, Target DMA channel)

- Registered transfer end handler (UART Driver user ID, Transmission result)

- Registered transmission handler (User ID, Transmission result)

- Transmission result is stored

- Registered transmission handler (-)

- dma_irq_handler (-)

- Registered transfer end handler (-)
Reception

- irq_dmac_done
  - dma_irq_handler
    (DMA instance handle, Target DMA channel)

uart_io
(Application)

- Reception result is stored.
  - Registered reception handler
    (User ID, reception result)

- Registered transfer end handler
  (UART Driver user ID, reception result)

UART
(Driver)

DMA
(Driver)

- Registered transfer end handler(-)
  - dma_irq_handler(-)
  - Registered reception handler(-)
10. Precaution

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

11. Revision History

<table>
<thead>
<tr>
<th>Rev</th>
<th>Date</th>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2018-03-15</td>
<td>-</td>
<td>First release</td>
</tr>
</tbody>
</table>
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