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SH7263/SH7203 Group
Sample Application for the CAN Module (Data Frame Transmission)

Introduction
This application note describes the controller area network module (RCAN-TL1) and provides an example of its application to data frame transmission.

Target Devices
SH7263 and SH7203 Groups

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1. Introduction

1.1 Specifications
- Transfer rate: 500 kbps
- Mailbox for transmission: Mailbox 1
- A data frame as described below is transmitted once.
  IDE: 0 (standard format), data length code (DLC): 2, and data: H’C1C2

1.2 Module Used
- Controller area network (RCAN-TL1): 1

1.3 Applicable Conditions
- MCU SH7263/SH7203 (R5S72630/R5S72030)
- Clock operating mode: 3 (the input from the USB_X1 pin is in use as the clock source)
- Operating frequency:
  Internal clock: 192 MHz
  Bus clock: 48 MHz
  Peripheral clock: 24 MHz
- C compiler: SuperH RISC engine family C/C++ compiler package Ver.9.01Release01 from Renesas Technology
- Compiler options: Default settings of the High-performance Embedded Workshop
  -cpu=sh2a -debug -gbr=auto -global_volatile=0 -opt_range=all -infinite_loop=0
  -del_vacant_loop=0 -struct_alloc=1

1.4 Related Application Note
None
2. Description of the Sample Application

This sample program employs the RCAN-TL1 module to transmit a single frame with two bytes of data.

2.1 Overview of Operations by the Module Used

The SH7203 CPU has two internal RCAN-TL1 modules that support CAN2.0B and comply with ISO-11898.

The RCAN-TL1 module has 32 programmable mailboxes, each supporting a reception filter mask, and a 16-bit timer function, providing for highly flexible communications. Figure 1 shows the structure of the RCAN-TL1 module. For details on the module, refer to the section on the controller area network in the SH7203 Group Hardware Manual.
2.2 Procedure for Setting the Module Used

This section describes initial settings for the transmission of data frames by the RCAN-TL1 module.

Initial settings of the module are made in reset mode (configuration mode). On subsequent release from reset mode, the RCAN-TL1 module participates in CAN-bus activity. In initial settings in this sample program, one mailbox is set for transmission and reception respectively. Figures 2 and 3 show examples of the flow of initialization for the RCAN-TL1 module. For details on settings made to individual registers, refer to the SH7203 Group Hardware Manual.

---

**START**

- Set standby control register 5 (STBCR5).
  
- Set the master control register (MCR).
  
  Reset state? (GSR3 = 1?)
  
    No

    Set the master control register (MCR).

    Set the interrupt mask register (IMR).

    Set the master control register (MCR).

    Set the interrupt mask register (IMR).

    Set the master control register (MCR).

    Set standby control register 5 (STBCR5).

---

- Enabling clock supply to the RCAN (STBCR5)
  The MSTP52 (Module Stop 52) bit is set to 0.
  [Function] Clock is supplied to RCAN1.

- Reset request (MCR)
  The MCR0 (Reset Request) bit is set to 1.
  [Function] Transition to reset mode is made.

- ID reorder (MCR)
  The MCR15 (ID Reorder) bit is set.
  [Function] Configuration of bits: STDID, RTR, IDE, and EXTID of message control and local acceptance filter mask can be set up to the HCAN2-compatible configuration.

- Setting the interrupt mask (IMR)
  [Function] Interrupts corresponding to all bits in the interrupt request register (IRR) are masked.

- Setting bit configuration register 1 (BCR1)
  TSG1[3:0] (time segment 1) is set to 0110 (7 time quanta).
  TSG2[2:0] (time segment 2) is set to 011 (4 time quanta).
  SJW[1:0] (resynchronization jump width) is set to 00 (4 time quanta).
  [Function] Large-scale shifting of the sampling point is prevented.

  Setting BSP (Bit Sample Point)
  [Function] Selects sampling at a single point or determination of each sample value from the majority value for three points.

- Setting bit configuration register 0 (BCR0)
  BRP[7:0] (baud rate pre-scaler) is set to 0000 0001.
  [Function] One time quantum is set as 4 cycles of the peripheral bus clock. Given TSG1 and TSG2 as indicated above, the transfer rate is 500 kbps (refer to 2.3, Bit Configuration and Transfer Rate).

---

**Figure 2  Example of Initialization Flow for the RCAN-TL1 Module (1)**
Clearing the RAM area of mailbox 0

- Setting message control field of mailbox 0 (MB[0].CONTROL) (for reception).
  - Setting message control (MB[0].CONTROL)*1
    MBC[2:0] (mailbox configuration) is set to 010.
    [Function] Reception of remote/data frame is enabled.
    IDE (identifier extension bit) is set to 0.
    [Function] Standard format
    RTR (remote transmission request bit) is set to 0.
    [Function] Data frame
    STDID[10:0] (standard identifier) is set to 0.
    [Function] ID = 0

- Setting local acceptance filter mask (LAFM)*1
  LAFM is set to H’0000 0000.
  [Function] Mask is not set.

Clearing the RAM area of mailbox 0

- Setting message control field of mailbox 1 (MB[1].CONTROL) (for transmission).
  - Setting message control (MB[1].CONTROL)
    MBC[2:0] (mailbox configuration) is set to 000.
    [Function] Transmission of remote/data frame is enabled.
    DLC[3:0] (data length code) is set to 0010.
    [Function] Data length = 2 bytes
    IDE (identifier extension bit) is set to 0.
    [Function] Standard format
    RTR (remote transmission request bit) is set to 0.
    [Function] Data frame
    STDID[10:0] (standard identifier) is set to 0.
    [Function] ID = 0

- Setting master control register (MCR)
  MCR0 (reset request) is cleared.
  [Function] Reset mode request is cleared.
  MCR1 (halt request) is cleared.
  [Function] Halt mode request is cleared.

Note: 1. This processing is not required for transmission alone, but descriptions in this sample program are on the assumption that both transmission and reception are performed.

**Figure 3** Example of Initialization Flow for the RCAN-TL1 Module (2)
2.3 Bit Configuration and Transfer Rate

One-bit time for the CAN module has the four segments indicated below.

1) Synchronization segment (SS)
2) Propagation time segment (PRSEG)
3) Phase buffer segment 1 (PHSEG1)
4) Phase buffer segment 2 (PHSEG2)

Furthermore, the individual segments are structured in units of a base time called the time quantum (Tq). Figure 4 shows an example of the configuration of a bit in the case where SS = Tq, PRSEG = 3Tq, PHSEG1 = 4Tq, and PHSEG2 = 4Tq.

![Figure 4 Configuration of One-Bit Time](image)

In the RCAN-TL1, the Tq of PRSEG + PHSEG1 is set to TSEG1[3:0] in bit configuration register 1 (BCR1) and the Tq of PHSEG2 is set to TSEG2[2:0] (Tq = set value + 1). Additionally, the number of cycles of the peripheral-bus clock corresponding to 1Tq is set in BRP[7:0] of bit configuration register 0 (BCR0).

In the following description, BRP[7:0], TSEG1[3:0] and TSEG2[2:0] indicate the register settings, and BRP, TSEG1, TSEG2, and SJW indicate the values that correspond to these register settings. For the values corresponding to the values set in registers, refer to the section on the controller area network in the SH7203 Group Hardware Manual.

By definition, Tq for the RCAN-TL1 module is 1Tq = 2 × (BRP[7:0] + 1)/peripheral bus clock, and the transfer rate is calculated as follows.

\[
\text{Transfer rate} = \frac{\text{peripheral bus clock}}{(2 \times (\text{BRP}[7:0] + 1) \times \text{the number of Tq in 1-bit time})} = \frac{\text{peripheral bus clock}}{(2 \times (\text{BRP}[7:0] + 1) \times ((TSEG1[3:0] + 1) + (TSEG2[2:0] + 1) + 1)}
\]

The following restrictions apply to settings of the bit-configuration registers.

\[
\text{TSEG1 (Min)} > \text{TSEG2} \geq \text{SJW (Max)} \quad (\text{SJW} = 1 \text{ to } 4)
\]

SJW: Jump width for resynchronization. This segment is used to correct phase errors by extending phase buffer segment 1 or shortening phase buffer segment 2.

\[
8 \leq \text{TSEG1} + \text{TSEG2} + 1 \leq 25 \text{ time quanta}
\]

\[
\text{TSEG2} \geq 2
\]

Since the settings in this sample program are as follows: peripheral bus clock = 24 MHz, BRP[7:0] = 1, TSEG1[3:0] = 6, TSEG2[2:0] = 3, the transfer rate is calculated with the following formula.

\[
\text{Transfer rate (bps)} = 24 \text{ M (2 } \times (1+1) \times ((6 + 1) + (3 + 1) + 1) = 500 k}
\]
2.4 Operation of the Sample Program

In this sample program, a data frame in standard format (IDE = 0) with DLC = 2 and H'C1C2 as the data is transmitted once from mailbox 1 at a transfer rate of 500 kbps. Figure 5 shows the waveform for data frame transmission.

![Figure 5 Waveform for Data Frame Transmission by the RCAN-TL1](image)

- **SOF (Start of frame)**: Indicates start of data frame and remote frame.
- **ID (Identifier)**: Indicates priority of data.
- **RTR (Request for remote transmission)**: Indicates distinction between data frame and remote frame.
- **IDE (Identifier extension)**: Indicates distinction between standard format and extended format.
- **r0**: Reserved bit.
- **DLC (Data length code)**: Indicates the number of bytes in the data field. Setting range: 0 to 8 bytes.
- **DATA**: Data for transfer. The number of bytes transferred is the number set in the DLC field.
- **CRC sequence**: This value is used to check frames.
- **CRC delimiter**: This bit is used to delimit the CRC field and ACK field.
- **ACK slot**: The receiving unit is dominant, and overwrites this when no errors are detected in a transmitted message.
- **ACK delimiter**: This bit is used to delimit the ACK field and EOF.
- **EOF (End of frame)**: Indicates the end of the frame.
2.5 Procedure of Processing by the Sample Program

Tables 1 and 2 give an example of the settings for the controller area network (RCAN-TL1). Figure 6 shows an example of the flow of processing by this sample program.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Register Settings for Controller Area Network (RCAN-TL1) (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Register Name</strong></td>
<td><strong>Address</strong></td>
</tr>
<tr>
<td>Standby control register (STBCR5)</td>
<td>H'FFFF 0410</td>
</tr>
<tr>
<td>Master control register_1 (MCR_1)</td>
<td>H'FFFF 0800</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Interrupt mask register_1 (IMR_1)</td>
<td>H'FFFF 080A</td>
</tr>
<tr>
<td>Bit configuration register 1_1 (BCR1_1)</td>
<td>H'FFFF 0804</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Bit configuration register 0_1 (BCR0_1)</td>
<td>H'FFFF 0806</td>
</tr>
<tr>
<td>Message control field (MB[0].CONTROL1_1)</td>
<td>H'FFFF 0910</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Register Settings for Controller Area Network (RCAN-TL1) (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Register Name</strong></td>
<td><strong>Address</strong></td>
</tr>
<tr>
<td>Message control field (MB[1].CONTROL1_1)</td>
<td>H'FFFF 0942</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Message control field (MB[1].CONTROL0_1)</td>
<td>H'FFFF 0932</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Local acceptance filter mask_1 (MB[0].LAFM_1)</td>
<td>H'FFFF 0904</td>
</tr>
<tr>
<td>Local acceptance filter mask_1 (MB[1].LAFM_1)</td>
<td>H'FFFF 0936</td>
</tr>
<tr>
<td>Message data field_1 (MB[0].MSG_DATA01 to 67)</td>
<td>H'FFFF 0908 to H'FFFF 090F</td>
</tr>
<tr>
<td>Message data field_1 (MB[1].MSG_DATA01 to 67)</td>
<td>H'FFFF 093A to H'FFFF 0941</td>
</tr>
<tr>
<td>Transmit pending register_1 (TXPR_1)</td>
<td>H'FFFF 0820</td>
</tr>
<tr>
<td>Transmit acknowledge register 0_1 (TXACK0)</td>
<td>H'FFFF 0832</td>
</tr>
</tbody>
</table>
Transmission of data frame

Set up data for transmission (IDE = 0, data length = 2 bytes, data = H'C1C2)

Set the transmission request for the data frame. TXPR = 1

Completion of transmission? (TXACK0 = 1?)

Yes

Clear transmission-completed flag (TXACK0).

No

Wait for transmission from mailbox (TXPR = 0)?

Yes

No

Set the port-B control register (to select CRx1 and CTx1 pin functions)

Setting of pin function controller

End

Pin function controller (PFC): io_init_pfc();

Initialization of controller area network (RCAN-TL1): io_init_can();

Transmission of data frame: io_data_send();

main function

Figure 6 Example of Flow of Processing by the Sample Program
3. Sample Program

```c
/*""FILE COMMENT""******************************************************************************
* System Name : SH7203 Sample Program
* File Name   : main.c
* Contents    : Application of CAN Module (Data Frame Transmission)
* Version     : 1.00.00
* Model       : M3A-HS30
* CPU         : SH7203
* Compiler    : SHC9.0.3.0
* note : The module transmits a single data frame in standard format (IDE = 0)
  with DLC = 2 and DATA = 0xC1C2, from mailbox 1 of CAN1 at a 500-kbps
  transfer rate over the CAN bus.
/*
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* history : 2007.06.26 ver.1.00.00
""FILE COMMENT END""******************************************************************************/
#include <machine.h>
#include "iodefine.h" /* SH7203 iodefine */

/* ---- prototype declaration ---- */
void main(void);
void io_init_pfc(void);
void io_init_can(void);
void io_data_send(void);

/* ---- symbol definition ---- */
#define CAN_GSR3 0x0008
#define CAN_MB1  0x0002

/* ---- prototype declaration ---- */
void main(void);
void io_init_pfc(void);
void io_init_can(void);
void io_data_send(void);

/* ---- symbol definition ---- */
#define CAN_GSR3 0x0008
#define CAN_MB1  0x0002
```

Figure 7  Sample Program Listing: "main.c" (1)
/*"FUNC COMMENT"***********************
* Outline     : Sample Program main
*-----------------------------------------------------------------------
* Include     : none
*-----------------------------------------------------------------------
* Declaration : void main(void);
*-----------------------------------------------------------------------
* Function    : Sample Program main
*-----------------------------------------------------------------------
* Argument    : none
*-----------------------------------------------------------------------
* Return Value: none
*-----------------------------------------------------------------------
* Notice      : none
**"FUNC COMMENT END"***************************/
void main(void)
{
    /* ---- Setting of PFC ---- */
    io_init_pfc();

    /* ---- Initializing CAN module ---- */
    io_init_can();

    /* ---- CAN data frame transmission ---- */
    io_data_send();
    while(1){
        /* loop */
    }
}

/*"FUNC COMMENT"***********************
* Outline     : Setting of PFC
*-----------------------------------------------------------------------
* Include     : #include "iodefine.h"
*-----------------------------------------------------------------------
* Declaration : void io_init_pfc(void);
*-----------------------------------------------------------------------
* Function    : Setting of Pin Function Controller(PFC)
*-----------------------------------------------------------------------
* Argument    : none
*-----------------------------------------------------------------------
* Return Value: none
*-----------------------------------------------------------------------
* Notice      : none
**"FUNC COMMENT END"***************************/
void io_init_pfc(void)
{
    /* ---- Setting of PFC ---- */
    /* ---- Port B control register L3 ---- */
    PORT.PBCRL3.BIT.PB10MD = 0x1;   /* Set CRx1 */
    PORT.PBCRL3.BIT.PB11MD = 0x1;   /* Set CTx1 */
}

Figure 8   Sample Program Listing: "main.c" (2)
```c
void io_init_can(void)
{
    int i;

    /* ---- Setting of power down mode(RCAN) ---- */
    CPG.STBCR5.BIT.MSTP52 = 0;

    /* ---- Initializing CAN module ---- */
    RCAN1.MCR.WORD |= 0x0001;       /* CAN Interface reset mode */
    while((RCAN1.GSR.WORD & CAN_GSR3) != CAN_GSR3){
        /* Reset state waiting */
    }

    /* ---- RCAN mode selection ---- */
    RCAN1.MCR.WORD |= 0x8000;       /* RCAN-TL1 is not same as HCAN2 */

    /* ---- Disable all can interrupt ---- */
    RCAN1.IMR.WORD  = 0xFFFF;

    /* ---- Config baudrate ---- */
    RCAN1.BCR1.WORD = 0x6300;       /* ts2=6(7bit),ts2=3(4bit),sjw=0(1bit),bsp=0 */
    RCAN1.BCR0.WORD = 0x0001;       /* 500K bps */
    RCAN1.BCR0.WORD = 0x0003;       /* 250K bps */
    RCAN1.BCR0.WORD = 0x0007;       /* 125K bps */

    /* ---- Config mailbox0 as reception slot ---- */
    RCAN1.MB[0].CONTROL1.WORD = 0x0200;     /* can receive data and remote frame */
    RCAN1.MB[0].CONTROL0.LONG = 0x00000000; /* Initialize the Message Control Field */
    for(i = 0; i < 8; i++){
        RCAN1.MB[0].MSG_DATA[i] = 0x00;    /* data clear */
    }

    /* ---- Config mailbox1 as transmission slot ---- */
    RCAN1.MB[1].CONTROL1.WORD = 0x0002;     /* Can send data or remote frame, dlc=2 */
    RCAN1.MB[1].CONTROL0.LONG = 0x00000000; /* standard data frame, id=0x000 */
    RCAN1.MB[1].LAFM.LONG = 0x00000000;
    for(i = 0; i < 8; i++){
        RCAN1.MB[1].MSG_DATA[i] = 0x00;    /* data clear */
    }

    /* ---- Clear interrupt flags ---- */
    RCAN1.IRR.WORD = 0xffff;

    /* ---- Clear reset and halt ---- */
    RCAN1.MCR.WORD &= 0xfffc;
    while((RCAN1.GSR.WORD & CAN_GSR3) != 0x0000 ){
        /* reset state is end */
    }
}
```

Figure 9 Sample Program Listing: "main.c" (3)
/*"FUNC COMMENT"***************************************************************
* Outline     : Data Frame Transmission
*-----------------------------------------------------------------------
* Include     : #include "iodefine.h"
*-----------------------------------------------------------------------
* Declaration : void io_data_send(void);
*-----------------------------------------------------------------------
* Function    : RCAN1 is used to transmit a data frame.
*-----------------------------------------------------------------------
* Argument    : none
*-----------------------------------------------------------------------
* Return Value: none
*-----------------------------------------------------------------------
* Notice      : none
**"FUNC COMMENT END"************************************************************/

void io_data_send(void)
{
    /* ---- Transmission waiting ---- */
    while((RCAN1.TXPR0.LONG & CAN_MB1) == CAN_MB1){
        }

    /* ---- transmission data set ---- */
    RCAN1.MB[1].CONTROL1.WORD = 0x0002;     /* Can send data or remote frame, dlc=2 */
    RCAN1.MB[1].CONTROL0.LONG = 0x00000000; /* standard data frame, id=0x000 */
    RCAN1.MB[1].MSG_DATA[0] = 0xc1;
    RCAN1.MB[1].MSG_DATA[1] = 0xc2;

    /* ---- tramsmit the data ---- */
    RCAN1.TXPR0.LONG = CAN_MB1;

    /* ---- Transmission completion waiting ---- */
    while((RCAN1.TXACK0.WORD & CAN_MB1) != CAN_MB1){
        }

    /* ---- Transmission completion flag clear ---- */
    RCAN1.TXACK0.WORD = CAN_MB1;
}

/* End of File */
4. Documents for Reference

- Software Manual
  The most up-to-date version of this document is available on the Renesas Technology Website.

- Hardware Manuals
  SH7263 Group Hardware Manual
  SH7203 Group Hardware Manual
  The most up-to-date versions of the documents are available on the Renesas Technology Website.
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