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SH7137 Group
Sample Application for the CAN Module (Data Frame Transmission)

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

Target Devices
SH7137

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1. Preface

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

1.2 Module Used
- Controller area network (RCAN-ET)

1.3 Applicable Conditions
- MCU: SH7137
- Operating frequency:
  Internal clock: 80 MHz
  Bus clock: 40 MHz
  Peripheral clock: 40 MHz
- C compiler: SuperH RISC engine family C/C++ compiler package Ver.9.01 Release01 from Renesas Technology
- Compiler options: Default settings of the High-performance Embedded Workshop
  (-cpu = sh2 -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-ET module to transmit a single frame with two bytes of data.

2.1 Overview of Operations by the Module Used

The SH7137 CPU has an internal RCAN-ET module that support CAN2.0B and comply with ISO-11898.

The RCAN-ET module has 15 programmable transmit/receive mailboxes and one receive-only mailbox, each supporting a programmable reception filter mask, providing for highly flexible communications. Figure 1 shows the structure of the RCAN-ET module. For details on the module, refer to the section on the controller area network in the SH7137 Group Hardware Manual.

![Figure 1 Structure of the RCAN-ET Module](image_url)
2.2 Procedure for Setting the Module Used

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

Initial settings of the module are made in reset mode (configuration mode). On subsequent release from reset mode, the RCAN-ET 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-ET module. For details on the settings made to individual registers, refer to the SH7137 Group Hardware Manual.

![Flowchart of Initialization](Image)

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

Setting message control (MB[0].CONTROL) *1
MBC[2:0] (mailbox configuration) is set to B'010.
[Function] Receives remote/data frame.
IDE (identifier extension bit) is cleared to 0.
[Function] Standard format
RTR (remote transmission request bit) is cleared to 0.
[Function] Data frame
STDID[10:0] (standard identifier) is cleared 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 1

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

Setting bit configuration register 0 (BCR0)
BRP[7:0] (Baud rate pre-scale) is set to B'0000 0011.
[Function] One time quantum is set as 8 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).

Set interrupt request register (IRR).
IRR0 to IRR15 are cleared.
[Function] All interrupt flags are cleared.

Set 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.
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 = 1Tq, PRSEG = 3Tq, PHSEG1 = 3Tq, and PHSEG2 = 3Tq.

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

In the RCAN-ET, 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 SH7137 Group Hardware Manual.

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

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

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

\[
\begin{align*}
\text{TSEG1 (Min)} &> \text{TSEG2} \geq \text{SJW (Max)} & (\text{SJW} = 1 \text{ to } 4) \\
\text{SJW:} & \text{Jump width for resynchronization. This segment is used to correct phase errors by extending phase buffer segment 1 or shortening phase buffer segment 2.} \\
8 \leq \text{TSEG1 + TSEG2 + 1} &\leq 25 \text{ time quanta} \\
\text{TSEG2} \geq 2
\end{align*}
\]

Since the settings in this sample program are as follows: peripheral bus clock = 40 MHz, BRP = 3, TSEG1 = 5, TSEG2 = 2, the transfer rate is calculated with the following formula.

\[
\text{Transfer rate (bps)} = 40 \times (2 \times (3 + 1) \times ((5 + 1) + (2 + 1) + 1) = 500 \text{ k}
\]
2.4 Operation of the Sample Program

In this sample program, a data frame in standard format (ID = 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 waveforms for data frame transmission.

![Diagram of data frame transmission](image)

**Figure 5** Waveform for Data Frame Transmission by the RCAN-ET

- **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

Table 1 gives an example of the settings for the controller area network (RCAN-ET). Figure 6 shows an example of the flow of processing by this sample program.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Address</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standby control register 3 (STBCR 3)</td>
<td>H'FFFF E806</td>
<td>H'F6</td>
<td>• MSTP8 = 0: RCAN-ET runs</td>
</tr>
<tr>
<td>Master control register (MCR)</td>
<td>H'FFFF D800</td>
<td>H'0001</td>
<td>• MCR0 = 1: Reset mode transition request</td>
</tr>
<tr>
<td></td>
<td>H'1001</td>
<td></td>
<td>• MCR15 = 1: RCAN-ET is not the same as HCAN2</td>
</tr>
<tr>
<td>Interrupt mask register (IMR)</td>
<td>H'FFFF D80A</td>
<td>H'FFFF</td>
<td>• Disables all interrupts of RCAN</td>
</tr>
<tr>
<td>Bit configuration register 1 (BCR1)</td>
<td>H'FFFF D804</td>
<td>H'5200</td>
<td>• TSG1[3:0] = 0101: PRSEG + PHSEG1 = 6 Tq</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• TSG2[2:0] = 010: PHSEG2 = 3 Tq</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• SJW[1:0] = 00: SJW = 1 Tq</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• BSP = 0: Bit sampling at one point</td>
</tr>
<tr>
<td>Bit configuration register 0 (BCR0)</td>
<td>H'FFFF D806</td>
<td>H'0003</td>
<td>• BRP[7:0] = 3: 1 Tq = 8 × Pφ</td>
</tr>
<tr>
<td>Message control field (MB[0].CONTROL1H)</td>
<td>H'FFFF D910</td>
<td>H'0200</td>
<td>• MBC[2:0] = 010: Enables reception of data frames and remote frames</td>
</tr>
<tr>
<td>Message control field (MB[1].CONTROL1H)</td>
<td>H'FFFF D930</td>
<td>H'0002</td>
<td>• MBC[2:0] = 000: Enables transmission of data frames and remote frames</td>
</tr>
<tr>
<td>Message control field (MB[1].CONTROL0H)</td>
<td>H'FFFF D920</td>
<td>H'0000 0000</td>
<td>• IDE = 0: Standard format</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• RTR = 0: Data frame</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• STDID[10:0] = 0: Standard ID = 0</td>
</tr>
<tr>
<td>Local acceptance filter mask (MB[0].LAFMH)</td>
<td>H'FFFF D904</td>
<td>H'0000 0000</td>
<td>• Clear: MASK is not set</td>
</tr>
<tr>
<td>Message data field_1 (MB[1].MSG_DATA_0)</td>
<td>H'FFFF D928</td>
<td>H'C1C2</td>
<td>• H'C1C2 is set as data for transmission.</td>
</tr>
<tr>
<td>Transmit pending register (TXPR)</td>
<td>H'FFFF D820</td>
<td>H'0000 0002</td>
<td>• TXPR[31:0] = H'0000 0002:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Generates a transmission request for mailbox 1</td>
</tr>
<tr>
<td>Transmit acknowledge register 0 (TXACK0)</td>
<td>H'FFFF D832</td>
<td>H'0002</td>
<td>• Clears the transmit acknowledge flag</td>
</tr>
</tbody>
</table>
main function

Pin function controller (PFC): io_init_pfc();

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

Transmission of data frame: io_data_send();

Setting of pin function controller

Set the port-B control register L2 (to select CRx0 and CTx0 pin functions)

END

Transmission of data frame

Wait for the mailbox to transmit data (TXPR = 0)?

No

Yes

Set up data for transmission (ID = 0, data length = 2 bytes, data = H’C1C2).

Set request to transmit the remote frame (TXPR = 1).

Transmission completed (TXACK0 = 1)?

No

Yes

Clear transmission completed flag (in TXACK0).

END

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

1. Sample Program Listing: main.c (1)

```c
/*FILE COMMENT***********************************************************************/
/*
*       System Name : SH7137 Sample Program
*       File Name   : main.c
*       Contents    : CAN Module Application (Data Frame Transmit)
*       Version     : 1.00.00
*       Model       : M3A-HS37
*       CPU         : SH7137
*       Compiler    : SHC9.1.1.0
*       note        : CAN bus speed 500 kbps
*                The mailbox1 in CAN transmits the data frame (ID=0,DLC=2,
*                DATA=2-byte (0xC1C2), standard format) once.
*                <Caution>
*                This sample program is for reference
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*                history : 2008.03.24 ver.1.00.00
**FILE COMMENT END***************************************************************************/
#include "iodefine.h" /* SH7137 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_IRR0 0x0001
#define CAN_MB0  0x0001
#define CAN_MB1  0x0002
#define CAN_MB01 0x00000002
```

2. Sample Program Listing: main.c (2)

```c
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 */
    }
}
```

```c
void io_init_pfc(void)
{
    /* ==== Setting of PFC ==== */
    /* ---- Port B control register L2 ---- */
    /* Port B control register L2 ---- */
    PFC.PBCTRL.BIT.PB7MD = 0x6; /* Set CRx0 */
    PFC.PBCTRL.BIT.PB6MD = 0x6; /* Set CTx0 */
    PFC.PBIORL.BIT.B7    = 0;  /* PB7(CRX0) input */
    PFC.PBIORL.BIT.B6    = 1;  /* PB6(CTX0) output */
}
```
### Sample Program Listing: main.c (3)

```c
/*""FUNC COMMENT"******************************************************
* Outline     : RCAN setting
*-----------------------------------------------------------------------
* Include     : #include "iodefine.h"
*-----------------------------------------------------------------------
* Declaration : void io_init_can(void);
*-----------------------------------------------------------------------
* Function    : Controller area network (RCAN) setting
*-----------------------------------------------------------------------
* Argument    : void
*-----------------------------------------------------------------------
* Return Value: void
*-----------------------------------------------------------------------
* Notice      : non
""FUNC COMMENT END"**************************************************/

void io_init_can(void)
{
    int i;
    int j;
    /* ==== Setting of power down mode(RCAN) ==== */
    STB.CR3.BYTE = 0xf6;    /* Module Standby Clear */
    /* RCAN */
    /* ==== Initializing CAN module ==== */
    RCANET.MCR.WORD |= 0x0001; /* CAN Interface reset mode */
    while((RCANET.IRR.WORD & CAN_IRR0) != CAN_IRR0){
        /* Reset state waiting */
    }
    /* ==== IRR = 1, GSR = 1 (Auto SET) ==== */
    /* ---- Clear IRR0 ---- */
    RCANET.IRR.WORD = 0x0001;
    /* ---- RCAN mode selection(MCR15) ---- */
    RCANET.MCR.WORD |= 0x8000; /* RCAN-ET is not same as HCAN2 */
    /* ---- Disable all can interrupt ---- */
    RCANET.IMR.WORD = 0xffff;
    /* ----All mailbox init ---- */
    for(i = 0; i < 16; i++){
        RCANET.MB[i].CTRL0.LONG = 0x00000000;
        RCANET.MB[i].LAFM.LONG = 0x00000000;
        for(j = 0; j < 8; j++){
            RCANET.MB[i].MSG_DATA[j] = 0x00;
        }
    }
    /* ---- Config mailbox0 as reception slot ---- */
    RCANET.MB[0].CTRL1.WORD = 0x0200;   /* Can receive data and remote frame */
    RCANET.MB[0].CTRL0.LONG = 0x00000000;
    for(i = 0; i < 8; i++){
        /* data clear */
        RCANET.MB[0].MSG_DATA[i] = 0x00;
    }
    /* ---- Config mailbox1 as transmission slot ---- */
    RCANET.MB[1].CTRL1.WORD = 0x0002; /* Can send data or remote frame, dlc=2 */
    RCANET.MB[1].CTRL0.LONG = 0x00000000;
    for(i = 0; i < 8; i++){
        /* data clear */
        RCANET.MB[1].MSG_DATA[i] = 0x00;
    }
}
```
/* ---- Config baudrate ---- */
RCANET.BCR1.WORD = 0x5200; /* tsgl=5(6 bits), tsgr2=2(3 bits), sjw=0(1 bit), bsp=0 */
RCANET.BCR0.WORD = 0x0003; /* 500 kbps */
    // RCANET.BCR0.WORD = 0x0007; /* 250 kbps */
    // RCANET.BCR0.WORD = 0x000f; /* 125 kbps */
/* ---- Clear interrupt flags ---- */
RCANET.IRR.WORD = 0xffff;
/* ---- Clear reset and halt ---- */
RCANET.MCR.WORD &= 0xf8fc; /* MCR0, MCR1 clear */
    while((RCANET.GSR.WORD & CAN_GSR3) != 0x0000){
        /* reset state is end */
    }

/**FUNC COMMENT**%%%%%%%%%%%%%%%%%%%%%%%%%%=%.==============================
Outline : Data frame transmit
* Include : #include "iodefine.h"
* Declaration : void io_data_send(void);
* Func: Transmits the data frame by using RCANET
* Argument : void
* Return Value : void
**FUNC COMMENT END**%%%%%%%%%%%%%%%%%%%%%%%%%%=%.==============================
void io_data_send(void)
{
    /* ---- Transmission waiting ---- */
    while((RCANET.TXPR10.LONG & CAN_MB01) == CAN_MB01){

    }

    /* ---- transmission data set ---- */
    RCANET.MB[1].CTRL1.WORD = 0x0002; /* Can send data or remote frame, dl=2 */
    RCANET.MB[1].CTRL0.LONG = 0x00000000; /* standard data frame, id=0x000 */
    RCANET.MB[1].MSG_DATA[0] = 0xc1;
    RCANET.MB[1].MSG_DATA[1] = 0xc2;

    /* ---- Transmit the data ---- */
    RCANET.TXPR10.LONG = CAN_MB01;

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

    }

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

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

- Software Manual
  SH-1/SH2/SH-DSP Software Manual (REJ09B0171)
  The most up-to-date version of this document is available on the Renesas Technology Website.

Hardware Manuals
SH7137 Group Hardware Manual (REJ09B0402)
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