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SH7137 Group
Sample Application for the CAN Module (Remote Frame Reception)

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

Target Devices
SH7137

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2. Description of the Sample Application........................................................................... 3
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1. Preface

1.1 Specifications
- Transfer rate: 500 kbps
- Mailbox for transmission: Mailbox 1
- Mailbox for reception: Mailbox 0
- Remote frame for reception is as follows.
  - ID: 0 (standard format) and data length code (DLC): 2
- Data frame for transmission is as follows.
  - 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 receive a remote frame (ID: 0 and DLC: 2) and transmit a data frame (DLC: 2 and data: H'C1C2) in standard format (ID: 0).

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.

Note: Although core of RCAN-ET is designed based on a 32-bit bus system, the whole RCAN-ET including MPI for the CPU has 16-bit bus interface to CPU. In that case, Longword (32-bit) access must be implemented as 2 consecutive word (16-bit) accesses. In this document, Longword access means the two consecutive accesses.

Figure 1 Structure of the RCAN-ET Module
2.2 Procedure for Setting the Module Used

This section describes initial settings for the reception of remote 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. 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](image-url)

Figure 2 Example of Initialization Flow for the RCAN-ET Module (1)
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.

Releasing from reset state?
(GSR3 = 0?)
- Yes
- No

Set master control register (MCR).

Set interrupt request register (IRR).

Set 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 bit configuration register 1 (BCR1).
- TSG1[3:0] (Time segment 1) is set to B'0101 (6 time quanta).
- TSG2[2:0] (Time segment 2) is set to B'010 (3 time quanta).
- SJW[1:0] (Resynchronization jump width) is set to B'00 (1 time quantum).
- [Function] Prevention of substantial misalignment of the sampling points
  Set BSP (Bit sample point).
- [Function] Selects sampling at a single point or determination of each sample value
  from the majority value of three points.

Set local acceptance filter mask (LAFM).
- LAFM is set to H'0000 0000.
- [Function] Mask is not set.

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

Setting data for transmission in mailbox 1

Setting message control field of mailbox 1
- ATX (automatic transmission of data frame) is set to 1.
- MBC[2:0] (Mailbox configuration) is set to B'001.
- [Function] Transmission of remote/data frame is enabled,
  reception of remote frame is enabled.
- 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 1 (BCR1)

Setting bit configuration register 0 (BCR0).
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 \times \text{peripheral bus clock}/(2 \times (BRP[7:0] + 1) \times \text{the number of Tq in 1-bit time}) = \text{peripheral bus clock}/(2 \times (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.

TSEG1 (Min) > TSEG2 \geq SJW (Max) \quad (SJW = 1 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 TSEG1 + TSEG2 + 1 \leq 25 \text{ time quanta}

TSEG2 \geq 2

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.

Transfer rate (bps) = 40 \times 10^6 \times ((3 + 1) \times ((5 + 1) + (2 + 1) + 1) = 500 \text{ k}
2.4 Operation of the Sample Program

In this sample program, a remote frame (DLC: 2) in standard format (ID: 0) is received in mailbox 0 and a data frame (DLC: 2 and data: H’C1C2) in standard format (ID: 0) is transmitted from mailbox 1 at a transfer rate of 500 kbps. Figure 5 shows the waveform for remote frame reception.

![Waveform for Remote Frame Reception by the RCAN-ET](image)

**Figure 5** Waveform for Remote Frame Reception 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
- **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 (STBCR3)</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></td>
<td>H'1001</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[1].CONTROL1H)</td>
<td>H'FFFF D942</td>
<td>H'1100</td>
<td>• ATX = 1: Automatic transmission of data frame</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• MBC[2:0] = 001: Enables transmission of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>frames and remote frames, and reception of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>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].LAFM)</td>
<td>H'FFFF D904</td>
<td>H'0000 0000</td>
<td>• Clear: MASK is not set</td>
</tr>
<tr>
<td>Remote frame receive pending register 0 (RFPR0)</td>
<td>H'FFFF D84A</td>
<td>H'0000 0002</td>
<td>• Clears the remote frame receive pending flag</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

Setting of pin function controller (PFC): io_init_pfc();

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

Reception of remote frame: io_remote_receive();

Setting of pin function controller

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

END

Reception of remote frame

Reception completed (RFPR0 = 1)?

Yes

Store received data.

Clear the remote-frame reception completed flag (in RFPR_0).

Transmission completed (TXACK_0 = 1)?

Yes

Clear the transmission completed flag (in TXACK_0).

END

No

Figure 6   Example of Flow of Processing by the Sample Program
# Sample Application for the CAN Module (Remote Frame Reception)

## 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 (Remote Frame Receive)*/
/*       Version : 1.00.00*/
/*       Model : M3A-H537*/
/*       CPU : SH7137*/
/*       note : CAN bus speed 500 kbps*/
*/
/*       The mailbox 1 in CAN1 receives the remote frame (ID=0,DLC=2, standard format)*/
/*       to write the received frame in RAM.*/
/*       After receiving the remote frame, the data frame is automatically*/
/*       transmitted from the mailbox 1.*/

<Caution>

This sample program is for reference
and its operation is not guaranteed.

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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_remote_receive(void);

/* ---- symbol definition ---- */
#define CAN_GSR3 0x0008
#define CAN_IRR0 0x0001
#define CAN_MB0  0x0000
#define CAN_MB1  0x0001
#define CAN_MB10 0x0002
#define CAN_MB01 0x0000
#define CAN_MB010 0x00000002

/* ---- RAM allocation variable declaration ---- */
unsigned char nIDE = 0; /* ide */
unsigned char nRTR = 0; /* rtr */
unsigned char nDLC = 0; /* dlc */
unsigned int nSID = 0; /* sid */
unsigned int nEID = 0; /* eid */
unsigned char gSnd_data[8] = {0xc1, 0xc2, 0xc3, 0xc4, 0xc5, 0xc6, 0xc7, 0xc8};
```
2. Sample Program Listing: main.c (2)

```c
/*""FUNC COMMENT"*******************************************************
* Outline     : Sample program main
*-----------------------------------------------------------------------
* Include     : non
*-----------------------------------------------------------------------
* Declaration : void main(void);
*-----------------------------------------------------------------------
* Function    : Sample program main
*-----------------------------------------------------------------------
* Argument    : non
*-----------------------------------------------------------------------
* Return Value: non
*-----------------------------------------------------------------------
* Notice      : non
**""FUNC COMMENT END"***************************************************/

void main(void)
{
    /* ==== Setting of PFC ==== */
    io_init_pfc();
    /* ==== Initializing CAN module ==== */
    io_init_can();
    /* ==== CAN remote frame reception ==== */
    io_remote_receive();
    while(1){
        /* loop */
    }
}

/*""FUNC COMMENT"*******************************************************
* Outline     : PFC setting
*-----------------------------------------------------------------------
* Include     : #include "iodefine.h"
*-----------------------------------------------------------------------
* Declaration : void io_init_pfc(void);
*-----------------------------------------------------------------------
* Function    : Pin function controller (PFC) setting
*-----------------------------------------------------------------------
* Argument    : non
*-----------------------------------------------------------------------
* Return Value: non
*-----------------------------------------------------------------------
* Notice      : non
**""FUNC COMMENT END"***************************************************/

void io_init_pfc(void)
{
    /* ==== Setting of PFC ==== */
    /* ---- Port B control register L2 ---- */
    PFC.PBCRL2.BIT.PB7MD = 0x6; /* Set CRx0 */
    PFC.PBCRL2.BIT.PB6MD = 0x6; /* Set CTx0 */
    PFC.PBIORL.BIT.B7    = 0;  /* PB7(CRX0) input */
    PFC.PBIORL.BIT.B6    = 1;  /* PB6(CTX0) output */
}
```
3. 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    : non
*-----------------------------------------------------------------------
* Return Value: non
*-----------------------------------------------------------------------
* 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++){
            if(j < 8) RCANET.MB[i].MSG_DATA[j] = 0x00;
        }
    }
    /* ==== Config mailbox1 as transmission/reception slot ==== */
    RCANET.MB[1].CTRL1.WORD = 0x1100;    /* Auto dataframe transmission, 
Can send data or remote frame, receive remote frame, dlc=0 */
    RCANET.MB[1].CTRL0.LONG = 0x00000000;    /* standard data frame, id=0x00 */
    for(i = 0; i < 8; i++){
        RCANET.MB[1].MSG_DATA[i] = gSnd_data[i];
    }
}
```
4. Sample Program Listing: main.c (4)

```c
/* ---- Config baudrate ---- */
RCANET.BCR1.WORD = 0x5200; /* tsg1=5(6 bits), tsg2=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;
while( (RCANET.GSR.WORD & CAN_GSR3) != 0x0000 ){
    /* reset state is end */
}

/**FUNC COMMENT**********
Outline : Remote frame receive
*-----------------------------------------------------------------------
* Include : #include "iodefine.h"
*-----------------------------------------------------------------------
* Declaration : void io_remote_receive(void);
*-----------------------------------------------------------------------
* Function : Receives the data frame by using RCANET
*-----------------------------------------------------------------------
* Argument : non
*-----------------------------------------------------------------------
* Return Value: non
*-----------------------------------------------------------------------
* Notice : non
**FUNC COMMENT END**********

void io_remote_receive(void)
{
    /* ---- Reception completion waiting ---- */
    while((RCANET.RFPR0.WORD & CAN_MB1) != CAN_MB1){
        
        /* ---- Receive data storage ---- */
        nIDE = RCANET.MB[0].CTRL0.BIT.IDE;
        nRTR = RCANET.MB[0].CTRL0.BIT.RTR;
        nDLC = RCANET.MB[0].CTRL1.BIT.DLC;
        nSID = RCANET.MB[0].CTRL0.BIT.STDID;
        nEID = RCANET.MB[0].CTRL0.BIT.EXDID;

        /* ---- Reception completion flag clear ---- */
        RCANET.RXPR0.WORD = CAN_MB1;

        /* ---- 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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<table>
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<th>Rev.</th>
<th>Date</th>
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