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SH7137 Group

Sample Application for the CAN Module (Remote Frame Transmission)

Introduction

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

Target Devices

SH7137

Contents

1. Preface

1.1 Specifications

- Transfer rate: 500 kbps
- Mailbox for transmission: Mailbox 0
- Received data frame 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

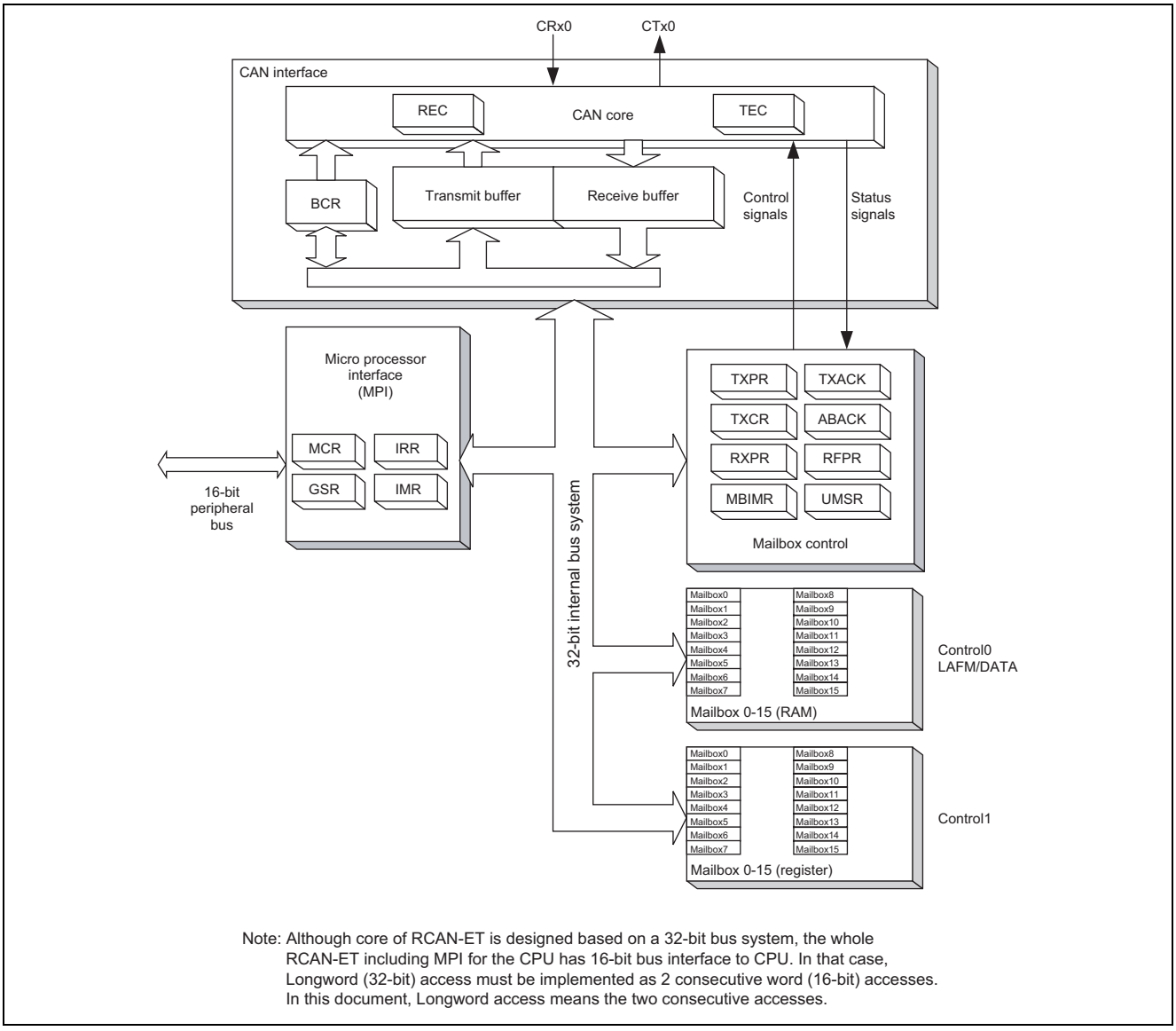
2. Description of the Sample Application

This sample program employs the RCAN-ET module to transmit a remote frame (DLC: 2) in standard format (ID: 0) and receive a data frame 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 transmission 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*.

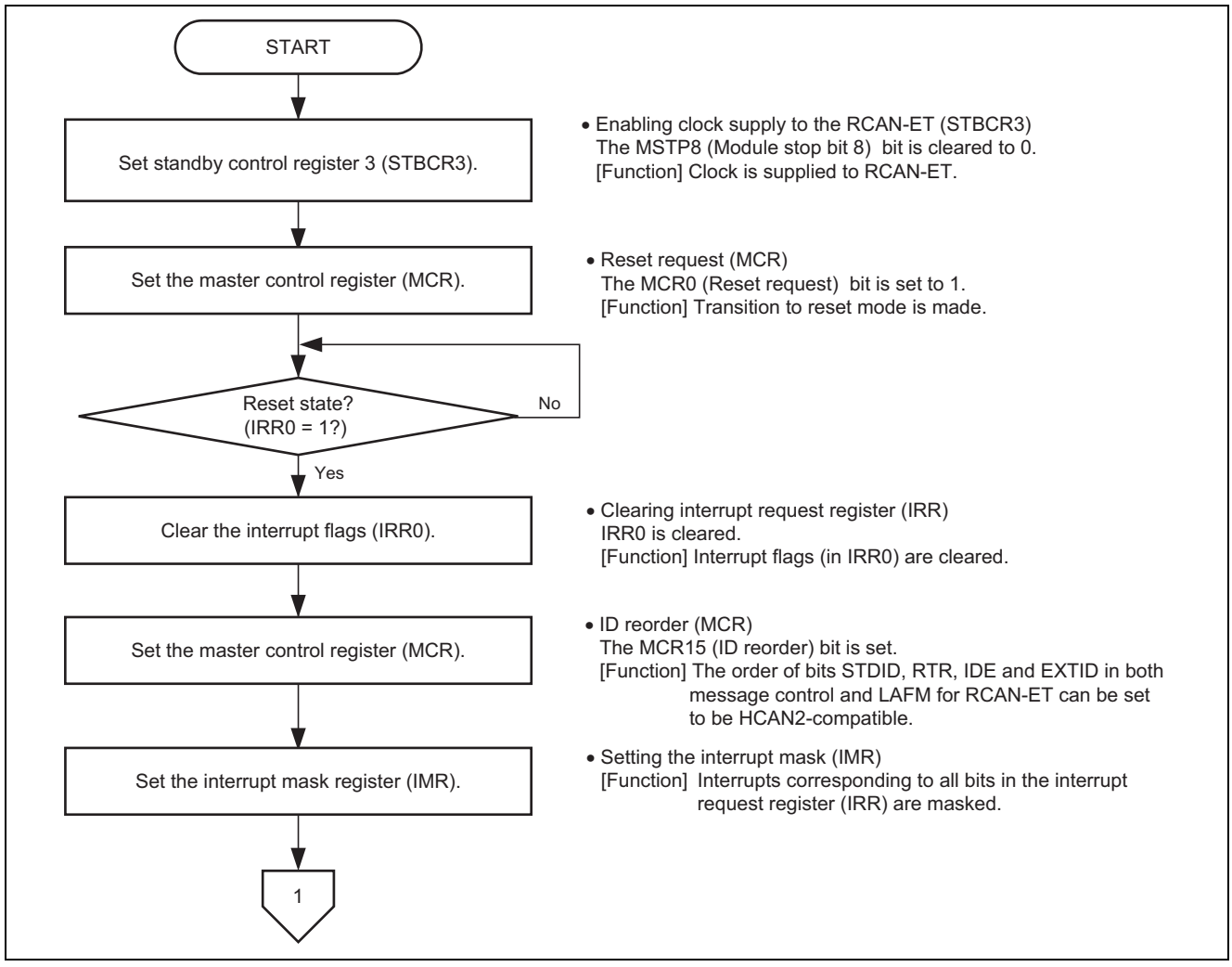


Figure 2 Example of Initialization Flow for the RCAN-ET Module (1)

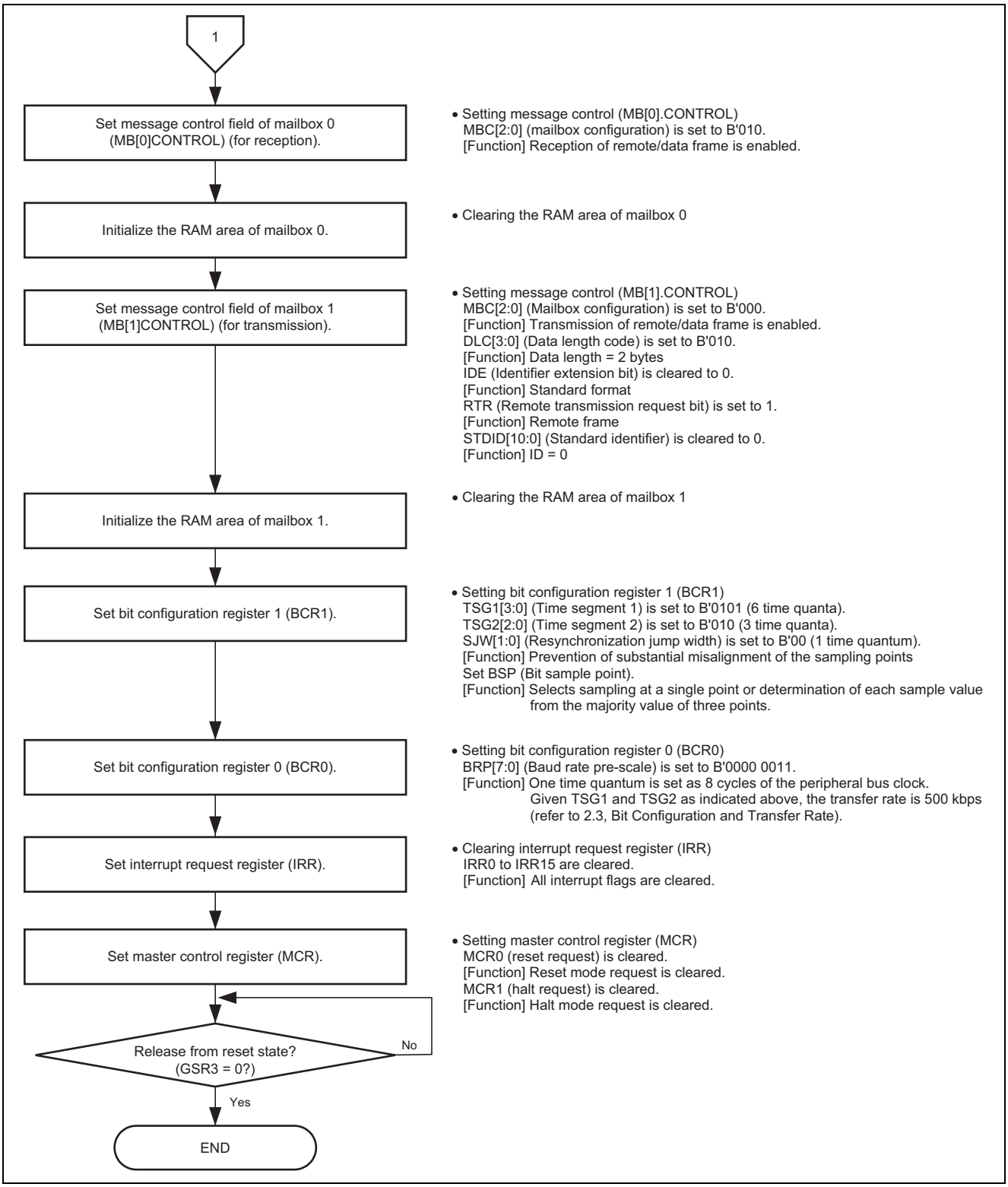


Figure 3 Example of Initialization Flow for the RCAN-ET Module (2)

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

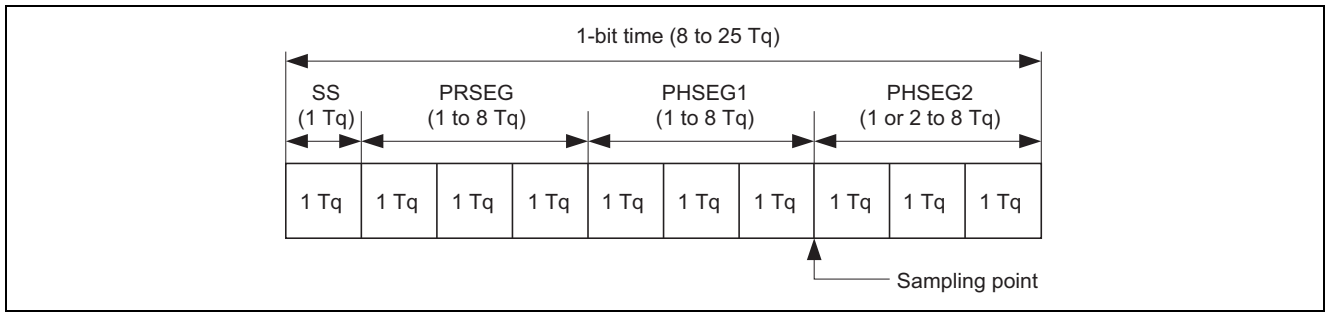


Figure 4 Configuration of One-Bit Time

In the RCAN-ET, the Tq of PRSEG + PHSEG1 is set to TSG1[3:0] in bit configuration register 1 (BCR1) and the Tq of PHSEG2 is set to TSG2[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], TSG1[3:0] and TSG2[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.

Transfer rate = peripheral bus clock/(2 × (BRP[7:0] + 1) × the number of Tq in 1-bit time) = peripheral bus clock/(2 × (BRP[7:0] + 1) × ((TSG1[3:0] + 1) + (TSG2[2:0] + 1) + 1)

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

TSEG1 (Min) > TSEG2 ≥ SJW (Max) (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.

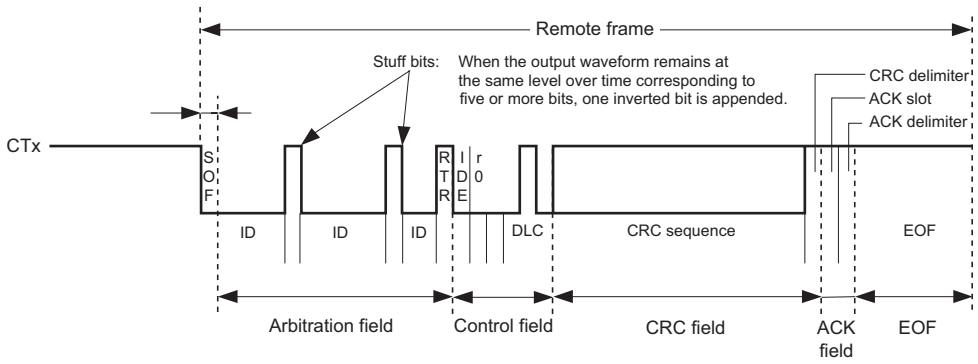
8 ≤ TSEG1 + TSEG2 + 1 ≤ 25 time quanta
TSEG2 ≥ 2

Since the settings in this sample program are as follows: peripheral bus clock = 40 MHz, BRP = 3, TSG1 = 5, TSG2 = 2, the transfer rate is calculated with the following formula.

Transfer rate (bps) = 40 M (2 × (3 + 1) × ((5 + 1) + (2 + 1) + 1) = 500 k

2.4 Operation of the Sample Program

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



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.

Figure 5 Waveform for Remote Frame Transmission by the RCAN-ET

2.5 Processing Procedure by the Sample Program

Table 1 gives an example of the settings for the controller area network (RCAN-ET). Figures 6 and 7 show an example of the flow of processing by this sample program.

Table 1 Register Settings for Controller Area Network (RCAN-ET)

Register Name	Address	Setting Value	Description
Standby control register 3 (STBCR3)	H'FFFF E806	H'F6	• MSTP8 = 0: RCAN-ET runs
Master control register (MCR)	H'FFFF D800	H'0001	• MCR0 = 1: Reset mode transition request
		H'1001	• MCR15 = 1: RCAN-ET is not the same as HCAN2
		H'1000	• MCR0 = 0: Release from reset mode
Interrupt mask register (IMR)	H'FFFF D80A	H'FFFF	• Disables all interrupts of RCAN
Bit configuration register 1 (BCR1)	H'FFFF D804	H'5200	• TSG1[3:0] = 0101: PRSEG + PHSEG1 = 6 Tq • TSG2[2:0] = 010: PHSEG2 = 3 Tq • SJW[1:0] = 00: SJW = 1 Tq • BSP = 0: Bit sampling at one point
Bit configuration register 0 (BCR0)	H'FFFF D806	H'0003	• BRP[7:0] = 3: 1 Tq = 8 × Pϕ
Message control field (MB[0].CONTROL1)	H'FFFF D910	H'0200	• MBC[2:0] = 010: Enables reception of data frames and remote frames
Message control field (MB[1].CONTROL1H)	H'FFFF D930	H'0002	• MBC[2:0] = 000: Enables transmission of data frames and remote frames. • DLC[3:0] = 0010: 2-byte data length
Message control field (MB[1].CONTROL0H)	H'FFFF D920	H'4000 0000	• IDE = 0: Standard format • RTR = 0: Remote frame • STDID[10:0] = 0: Standard ID = 0
Local acceptance filter mask (MB[0].LAFM)	H'FFFF D904	H'0000 0000	• Clear: MASK is not set
Transmit pending register (TXPR)	H'FFFF D820	H'0000 0002	• TXPR[31:0] = H'0000 0002: Generates a transmission request in mailbox 1
Transmit acknowledge register 0 (TXACK0)	H'FFFF D832	H'0002	• Clears the transmit acknowledge flag
Data frame receive pending register 0 (RXPR0)	H'FFFF D842	H'0001	• Clears the data frame receive pending flag

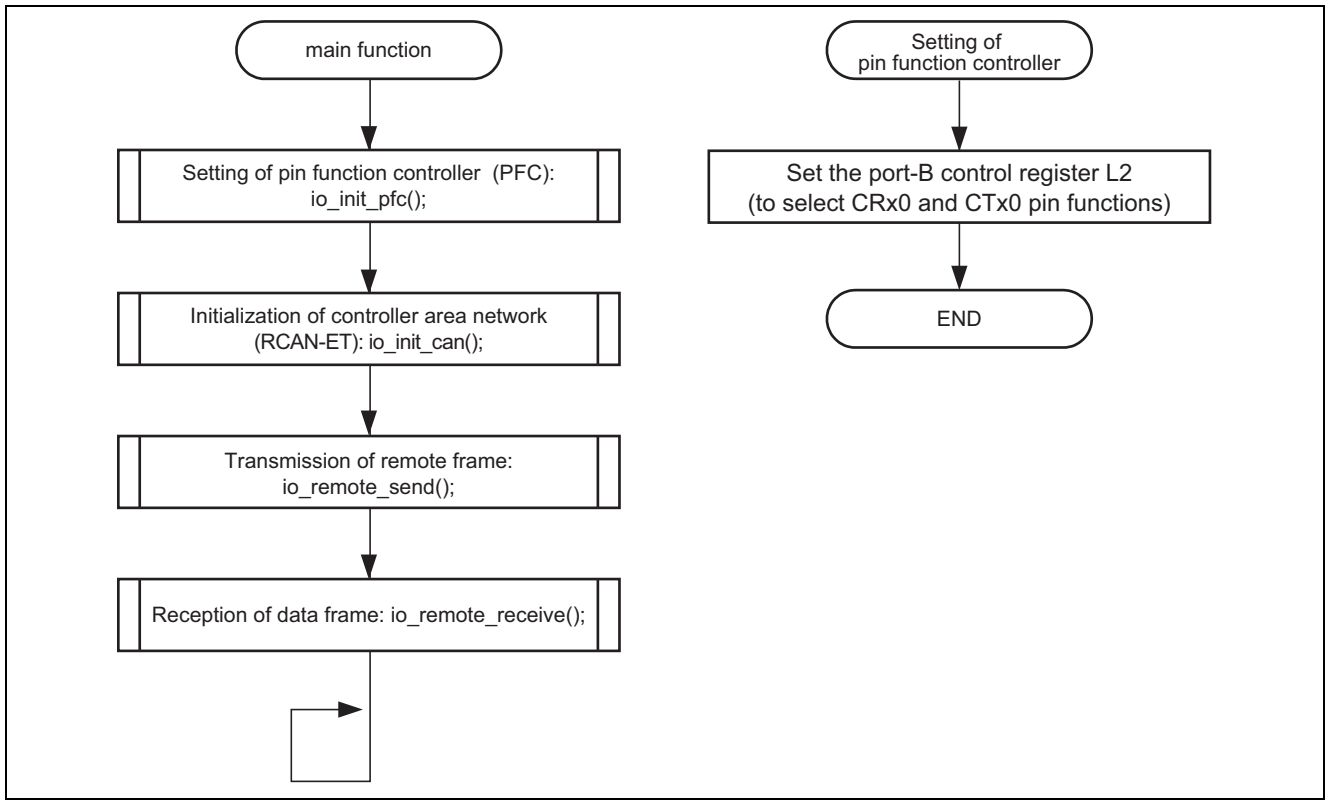


Figure 6 Example of Flow of Processing by the Sample Program (1)

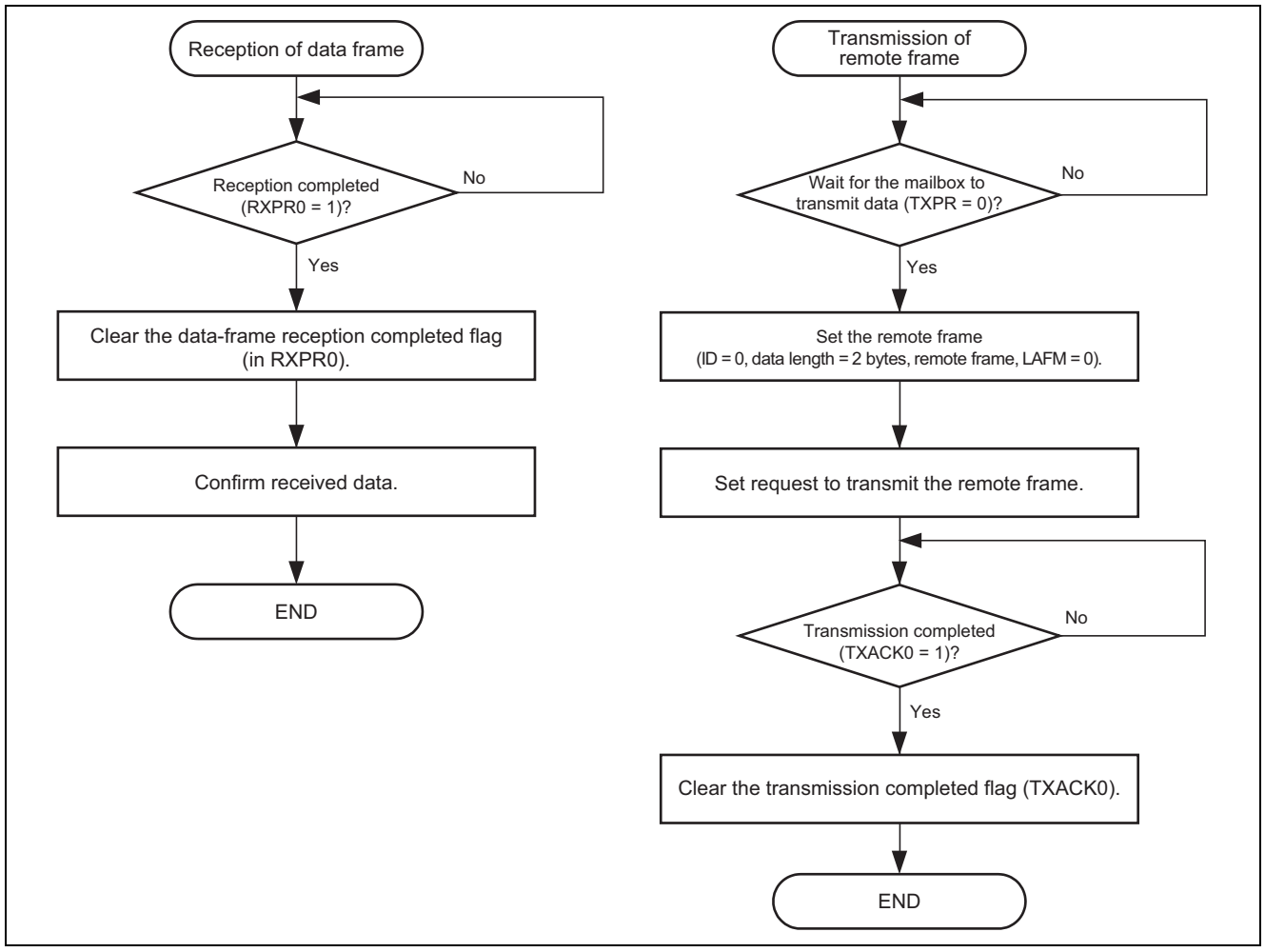


Figure 7 Example of Flow of Processing by the Sample Program (2)

3. Listing of the Sample Program

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

```
/*""FILE COMMENT""*****************************************************************
*
*       System Name : SH7137 Sample Program
*       File Name   : main.c
*       Contents    : CAN Module Application (Remote Frame Transmit)
*       Version     : 1.00.00
*       Model       : M3A-HS37
*       CPU         : SH7137
*       Compiler    : SHC9.1.1.0
*       note        : The module transmits a remote frame (DLC: 2) in standard format
*                     (ID: 0) from mailbox 1 of CAN at a 500-kbps transfer rate over the
*                     CAN bus once. After transmission, it receives a data frame from
*                     mailbox 0 of CAN1 and writes the received frame to RAM.
*
*                     <Caution>
*                     This sample program is for reference
*                     and its operation is not guaranteed.
*                     Customers should use this sample program for technical reference
*                     in software development.
*
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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_send(void);
void io_data_receive(void);

/* ---- symbol definition ---- */
#define CAN_GSR3 0x0008
#define CAN_IRR0 0x0001
#define CAN_MB0  0x0001
#define CAN_MB1  0x0002
#define CAN_MB01 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   gRcv_data[8];       /* data of message */
```

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

```
 55  /*""FUNC COMMENT""*****************************************************
 56   * Outline     : Sample program main
 57   *-------------------------------------------------------------------------
 58   * Include     : non
 59   *-------------------------------------------------------------------------
 60   * Declaration : void main(void);
 61   *-------------------------------------------------------------------------
 62   * Function    : Sample program main
 63   *-------------------------------------------------------------------------
 64   * Argument    : void
 65   *-------------------------------------------------------------------------
 66   * Return Value: void
 67   *-------------------------------------------------------------------------
 68   * Notice      : non
 69   *""FUNC COMMENT END""*************************************************/
 70  void main(void)
 71  {
 72      /* ==== Setting of PFC ==== */
 73      io_init_pfc();
 74
 75      /* ==== Initializing CAN module ==== */
 76      io_init_can();
 77
 78      /* ==== CAN remote frame transmission ==== */
 79      io_remote_send();
 80
 81      /* ==== CAN data frame reception ==== */
 82      io_data_receive();
 83
 84      while(1){
 85              /* loop */
 86      }
 87  }
 88
 89  /*""FUNC COMMENT""*****************************************************
 90   * Outline     : PFC setting
 91   *-------------------------------------------------------------------------
 92   * Include     : #include "iodefine.h"
 93   *-------------------------------------------------------------------------
 94   * Declaration : void io_init_pfc(void);
 95   *-------------------------------------------------------------------------
 96   * Function    : Pin function controller (PFC) setting
 97   *-------------------------------------------------------------------------
 98   * Argument    : void
 99   *-------------------------------------------------------------------------
100   * Return Value: void
101   *-------------------------------------------------------------------------
102   * Notice      : non
103   *""FUNC COMMENT END""*************************************************/
104  void io_init_pfc(void)
105  {
106      /* ==== Setting of PFC ==== */
107      /* ---- Port B control register L2 ---- */
108      PFC.PBCRL2.BIT.PB7MD = 0x6;   /* Set CRx0 */
109      PFC.PBCRL2.BIT.PB6MD = 0x6;   /* Set CTx0 */
110      PFC.PBIORL.BIT.B7    = 0;     /* PB7(CRX0) input */
111      PFC.PBIORL.BIT.B6    = 1;     /* PB6(CTX0) output */
112  }
113
```

3. Sample Program Listing: main.c (3)

```
114    /*""FUNC COMMENT""*****************************************************
115     * Outline     : RCAN setting
116     *-------------------------------------------------------------------------
117     * Include     : #include "iodefine.h"
118     *-------------------------------------------------------------------------
119     * Declaration : void io_init_can(void);
120     *-------------------------------------------------------------------------
121     * Function    : Controller area network (RCAN) setting
122     *-------------------------------------------------------------------------
123     * Argument    : void
124     *-------------------------------------------------------------------------
125     * Return Value: void
126     *-------------------------------------------------------------------------
127     * Notice      : non
128     *""FUNC COMMENT END""*************************************************/
129    void io_init_can(void)
130    {
131        int i;
132        int j;
133
134        /* ==== Setting of power down mode(RCAN) ==== */
135        STB.CR3.BYTE = 0xf6;                /* Module Standby Clear */
136                                            /* RCAN */
137        /* ==== Initializing CAN module ==== */
138        RCANET.MCR.WORD |= 0x0001;          /* CAN Interface reset mode */
139        while((RCANET.IRR.WORD & CAN_IRR0) != CAN_IRR0){
140                /* Reset state waiting */
141        }
142        /* ==== IRR = 1, GSR = 1 (Auto SET) ==== */
143
144        /* ---- Clear IRR0 ---- */
145        RCANET.IRR.WORD = 0x0001;
146
147        /* ---- RCAN mode selection(MCR15) ---- */
148        RCANET.MCR.WORD |= 0x8000;          /* RCAN-ET is not same as HCAN2 */
149
150        /* ---- Disable all can interrupt ---- */
151        RCANET.IMR.WORD  = 0xffff;
152
153        /* ----All mailbox init ---- */
154        for(i = 0; i < 16; i++){
155                RCANET.MB[i].CTRL0.LONG = 0x00000000;
156                RCANET.MB[i].LAFM.LONG = 0x00000000;
157                for(j = 0; j < 8; j++){
158                        RCANET.MB[i].MSG_DATA[j] =  0x00;
159                }
160        }
161
162        /* ---- Config mailbox0 as reception slot ---- */
163        RCANET.MB[0].CTRL1.WORD = 0x0200;       /* can receive data and remote frame */
164        RCANET.MB[0].CTRL0.LONG = 0x00000000;   /* Initialize the Message CTRL Field */
165        RCANET.MB[0].LAFM.LONG = 0x00000000;
166        for(i = 0; i < 8; i++){                 /* data clear */
167                RCANET.MB[0].MSG_DATA[i] =  0x00;
168        }
```

4. Sample Program Listing: main.c (4)

```
169         /* ---- Config mailbox1 as transmission slot ---- */
170         RCANET.MB[1].CTRL1.WORD = 0x0002;         /* Can send data or remote frame, dlc=2 */
171         RCANET.MB[1].CTRL0.LONG = 0x00000000;     /* standard data frame, id=0x000 */
172         RCANET.MB[1].LAFM.LONG = 0x00000000;
173         for(i = 0; i < 8; i++){                   /* data clear */
174                 RCANET.MB[1].MSG_DATA[i] =  0x00;
175         }
176
177         /* ---- Config baudrate ---- */
178         RCANET.BCR1.WORD = 0x5200;        /* tsg1=6(7 bits),tsg2=3(4 bits),sjw=0(1bit),bsp=0 */
179         RCANET.BCR0.WORD = 0x0003;        /* 500 kbps */
180     //  RCANET.BCR0.WORD = 0x0007;        /* 250 kbps */
181     //  RCANET.BCR0.WORD = 0x000f;        /* 125 kbps */
182
183         /* ---- Clear interrupt flags ---- */
184         RCANET.IRR.WORD = 0xffff;
185
186         /* ---- Clear reset and halt ---- */
187         RCANET.MCR.WORD &= 0xf8fc;
188
189         while( (RCANET.GSR.WORD & CAN_GSR3) != 0x0000 ){
190                 /* reset state is end */
191         }
192     }
193
194     /*""FUNC COMMENT""*************************************************
195      * Outline     : Remote frame transmit
196      *-----------------------------------------------------------------
197      * Include     : #include "iodefine.h"
198      *-----------------------------------------------------------------
199      * Declaration : void io_remote_send(void);
200      *-----------------------------------------------------------------
201      * Function    : Transmits the remote frame by using RCANET
202      *-----------------------------------------------------------------
203      * Argument    : void
204      *-----------------------------------------------------------------
205      * Return Value: void
206      *-----------------------------------------------------------------
207      * Notice      : non
208      *""FUNC COMMENT END""*************************************************/
209     void io_remote_send(void)
210     {
211         /* ---- Transmission waiting ---- */
212         while((RCANET.TXPR10.LONG & CAN_MB01) == CAN_MB01){
213         }
214
215         /* ---- Transmission data set ---- */
216         RCANET.MB[1].CTRL1.WORD = 0x0002;     /* Can send data or remote frame, dlc=2 */
217         RCANET.MB[1].CTRL0.LONG = 0x40000000; /* standard remote frame, id=0x000 */
218
219         /* ---- Transmit the data ---- */
220         RCANET.TXPR10.LONG = CAN_MB01;
221
222         /* ---- Transmission completion waiting ---- */
223         while((RCANET.TXACK0.WORD & CAN_MB1) != CAN_MB1){
224         }
225
226         /* ---- Transmission completion flag clear ---- */
227         RCANET.TXACK0.WORD = CAN_MB1;
228     }
229
```

5. Sample Program Listing: main.c (5)

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

    /* ---- Reception completion waiting ---- */
    while((RCANET.RXPR0.WORD & CAN_MB0) != CAN_MB0){
    }

    /* ---- 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;
    if(nDLC > 8){
            nDLC = 8;
    }
    for(i = 0; i < nDLC; i++){
            gRcv_data[i] = RCANET.MB[0].MSG_DATA[i];
    }

  /* ---- Reception completion flag clear ---- */
  RCANET.RXPR0.WORD = CAN_MB0;
}

/* 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 Manual
  SH7137 Group Hardware Manual (REJ09B0402)
  The most up-to-date versions of the documents are available on the Renesas Technology Website.

Website and Support

Renesas Technology Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/inquiry
csc@renesas.com

Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	Nov.19.08	—	First edition issued

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