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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

Contents

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

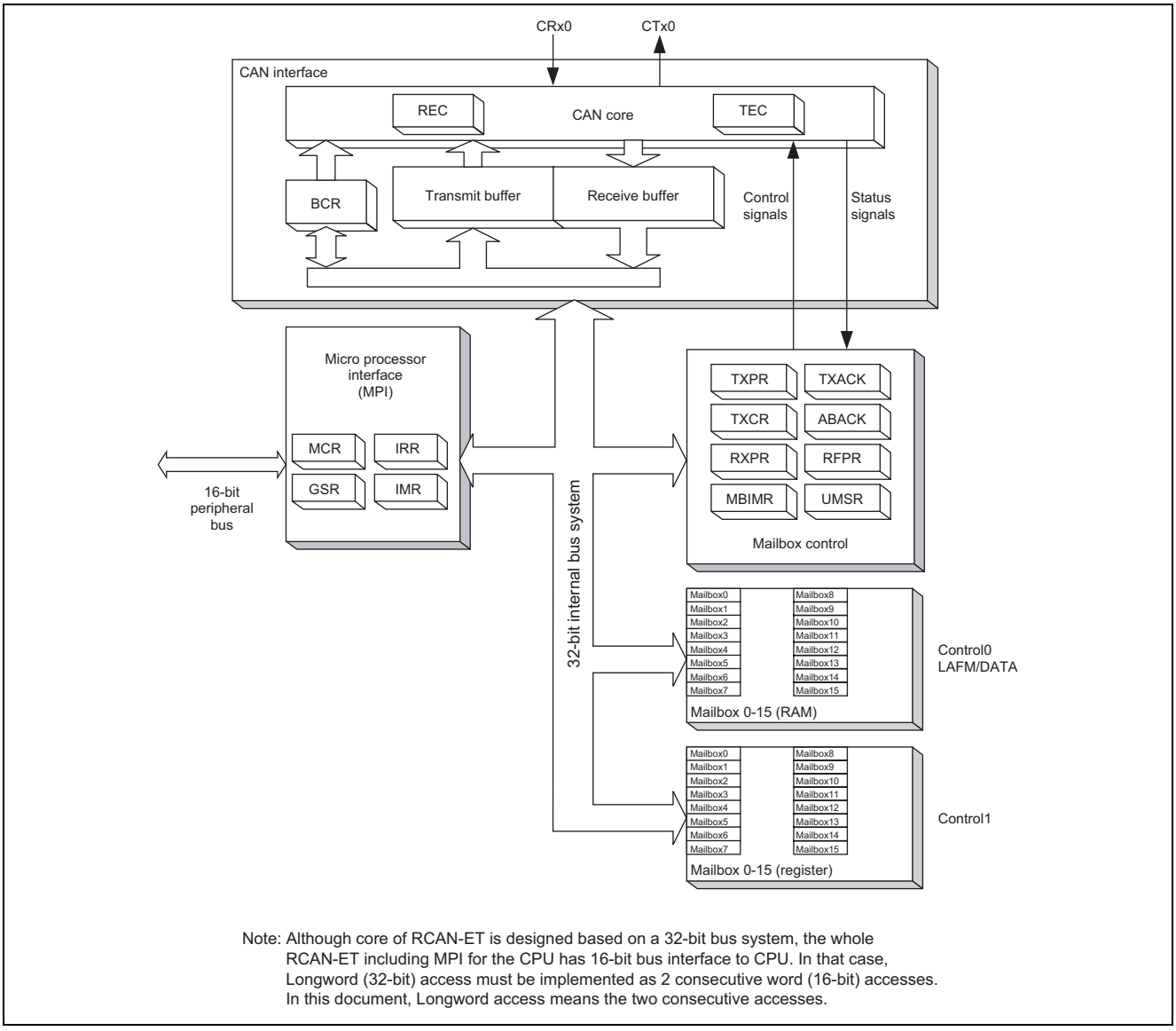
2. Description of the Sample Application

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*.



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 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*.

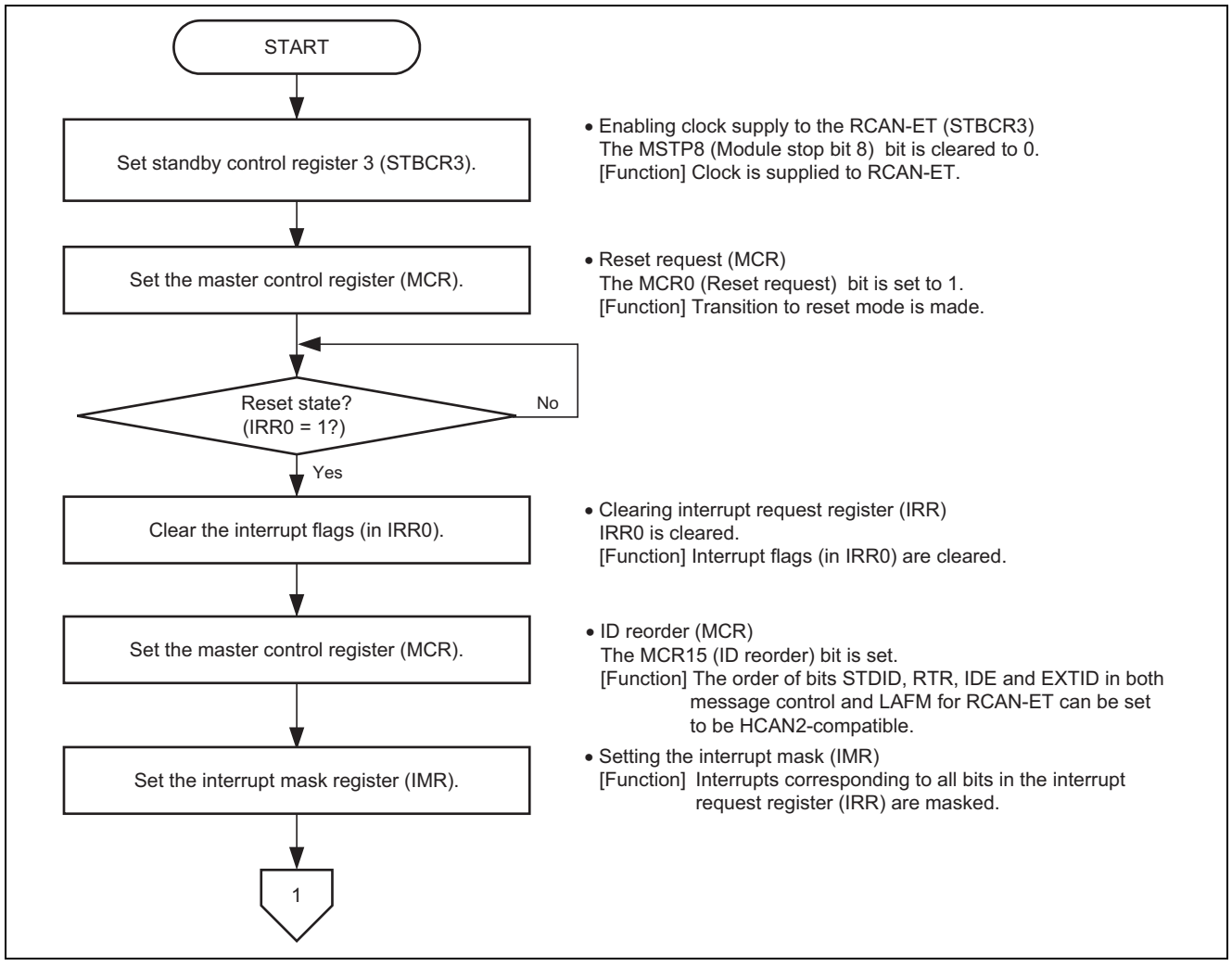
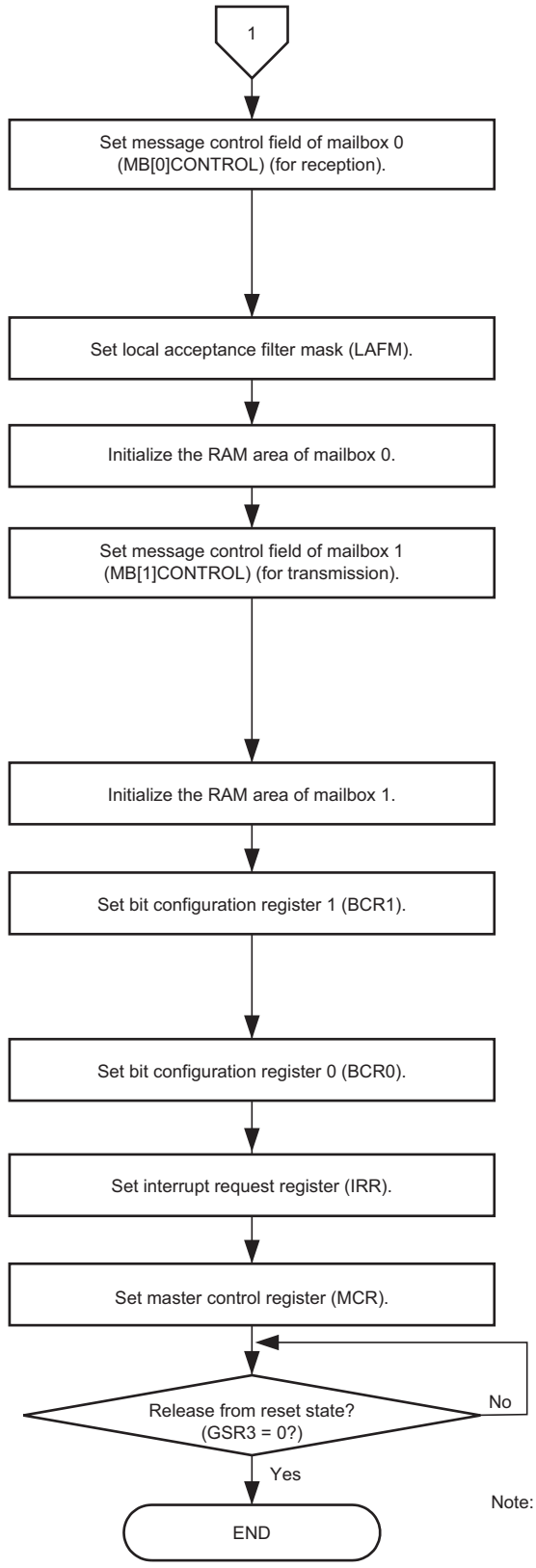


Figure 2 Example of Initialization Flow for the RCAN-ET Module (1)



- Setting message control (MB[0].CONTROL) *1
  MBC[2:0] (mailbox configuration) is set to B'010.
  [Function] Reception of remote/data 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 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 *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'010.
  [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
- Clearing the RAM area of mailbox 1
- Setting 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.
- 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).
- Clearing interrupt request register (IRR)
  IRR0 to IRR15 are cleared.
  [Function] All interrupt flags are cleared.
- 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-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.

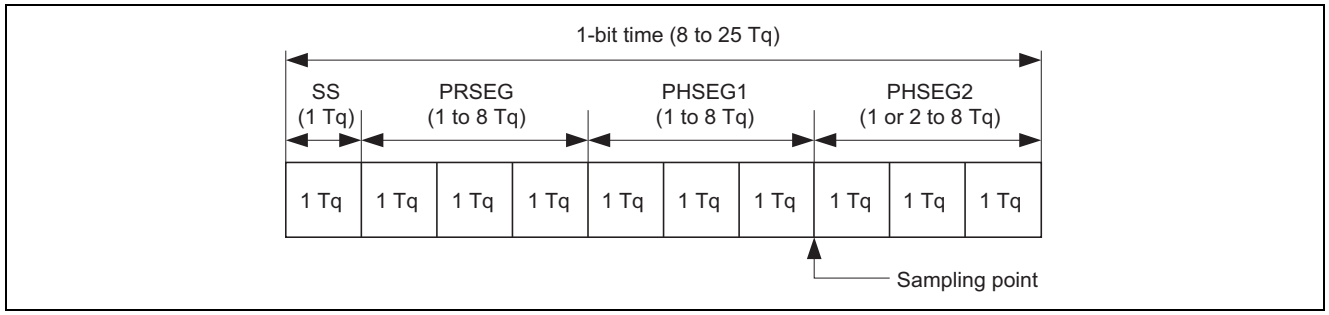


Figure 4 Configuration of One-Bit Time

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.

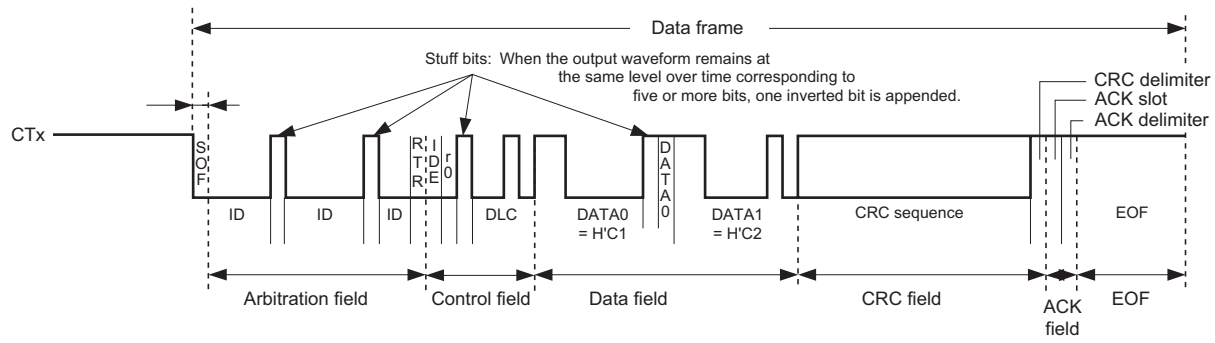
8 ≤ TSEG1 + TSEG2 + 1 ≤ 25 time quanta
TSEG2 ≥ 2

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 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.



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.

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

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

Register Name	Address	Setting Value	Description
Standby control register 3 (STBCR 3)	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].CONTROL1H)	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'0000 0000	• IDE = 0: Standard format • RTR = 0: Data frame • STDID[10:0] = 0: Standard ID = 0
Local acceptance filter mask (MB[0].LAFMH)	H'FFFF D904	H'0000 0000	• Clear: MASK is not set
Message data field_1 (MB[1].MSG_DATA_0)	H'FFFF D928	H'C1C2	• H'C1C2 is set as data for transmission.
Transmit pending register (TXPR)	H'FFFF D820	H'0000 0002	• TXPR[31:0] = H'0000 0002: Generates a transmission request for mailbox 1
Transmit acknowledge register 0 (TXACK0)	H'FFFF D832	H'0002	• Clears the transmit acknowledge flag

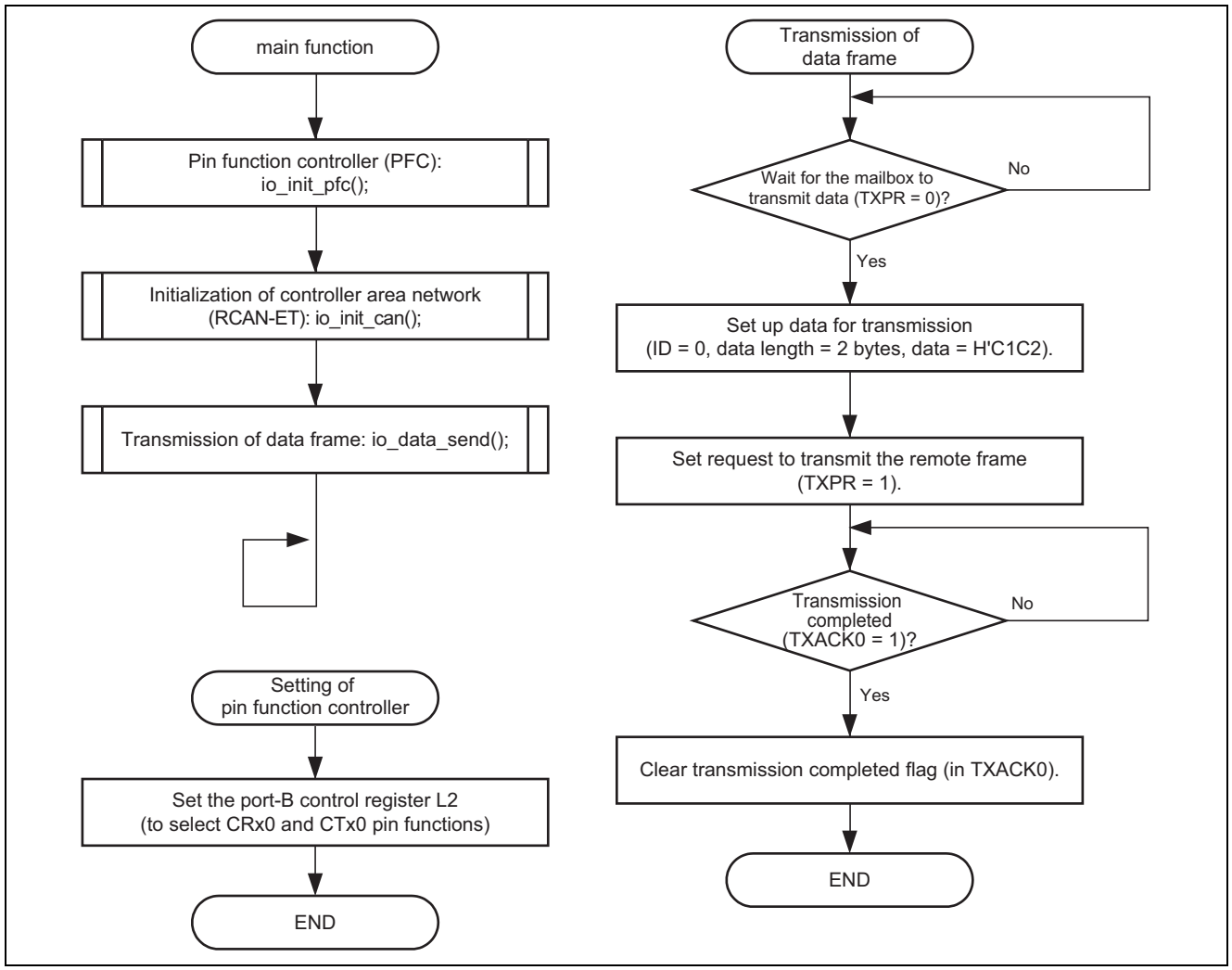


Figure 6 Example of Flow of Processing by the Sample Program

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 (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
*               and its operation is not guaranteed.
*               Customers should use this sample program for technical 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)

```
 45  /*""FUNC COMMENT""*****************************************************
 46   * Outline     : Sample program main
 47   *-------------------------------------------------------------------------
 48   * Include     : non
 49   *-------------------------------------------------------------------------
 50   * Declaration : void main(void);
 51   *-------------------------------------------------------------------------
 52   * Function    : Sample program main
 53   *-------------------------------------------------------------------------
 54   * Argument    : void
 55   *-------------------------------------------------------------------------
 56   * Return Value: void
 57   *-------------------------------------------------------------------------
 58   * Notice      : non
 59   *""FUNC COMMENT END""*************************************************/
 60  void main(void)
 61  {
 62
 63      /* ==== Setting of PFC ==== */
 64      io_init_pfc();
 65
 66      /* ==== Initializing CAN module ==== */
 67      io_init_can();
 68
 69      /* ==== CAN data frame transmission ==== */
 70      io_data_send();
 71
 72      while(1){
 73              /* loop */
 74      }
 75
 76  }
 77
 78  /*""FUNC COMMENT""*****************************************************
 79   * Outline     : PFC setting
 80   *-------------------------------------------------------------------------
 81   * Include     : #include "iodefine.h"
 82   *-------------------------------------------------------------------------
 83   * Declaration : void io_init_pfc(void);
 84   *-------------------------------------------------------------------------
 85   * Function    : Pin function controller (PFC) setting
 86   *-------------------------------------------------------------------------
 87   * Argument    : void
 88   *-------------------------------------------------------------------------
 89   * Return Value: void
 90   *-------------------------------------------------------------------------
 91   * Notice      : non
 92   *""FUNC COMMENT END""*************************************************/
 93  void io_init_pfc(void)
 94  {
 95      /* ==== Setting of PFC ==== */
 96      /* ---- Port B control register L2 ---- */
 97      PFC.PBCRL2.BIT.PB7MD = 0x6;   /* Set CRx0 */
 98      PFC.PBCRL2.BIT.PB6MD = 0x6;   /* Set CTx0 */
 99      PFC.PBIORL.BIT.B7    = 0;     /* PB7(CRX0) input */
100      PFC.PBIORL.BIT.B6    = 1;     /* PB6(CTX0) output */
101  }
102
```

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

```
/*""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;     /* Initialize the Message Control Field */
    RCANET.MB[0].LAFM.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;     /* standard data frame, id=0x000 */
    RCANET.MB[1].LAFM.LONG = 0x00000000;
    for(i = 0; i < 8; i++){                   /* data clear */
            RCANET.MB[1].MSG_DATA[i] =  0x00;
    }
```

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

```
166         /* ---- Config baudrate ---- */
167         RCANET.BCR1.WORD = 0x5200;    /* tsg1=5(6 bits), tsg2=2(3 bits), sjw=0(1 bit), bsp=0 */
168         RCANET.BCR0.WORD = 0x0003;    /* 500 kbps */
169     //  RCANET.BCR0.WORD = 0x0007;    /* 250 kbps */
170     //  RCANET.BCR0.WORD = 0x000f;    /* 125 kbps */
171
172         /* ---- Clear interrupt flags ---- */
173         RCANET.IRR.WORD = 0xffff;
174
175         /* ---- Clear reset and halt ---- */
176         RCANET.MCR.WORD &= 0xf8fc;    /* MCR0, MCR1 clear */
177         while( (RCANET.GSR.WORD & CAN_GSR3) != 0x0000 ){
178                 /* reset state is end */
179         }
180     }
181
182     /*""FUNC COMMENT""*****************************************************
183      * Outline     : Data frame transmit
184      *-------------------------------------------------------------------
185      * Include     : #include "iodefine.h"
186      *-------------------------------------------------------------------
187      * Declaration : void io_data_send(void);
188      *-------------------------------------------------------------------
189      * Function    : Transmits the data frame by using RCANET
190      *-------------------------------------------------------------------
191      * Argument    : void
192      *-------------------------------------------------------------------
193      * Return Value: void
194      *-------------------------------------------------------------------
195      * Notice      : non
196      *""FUNC COMMENT END""*************************************************/
197     void io_data_send(void)
198     {
199         /* ---- Transmission waiting ---- */
200         while((RCANET.TXPR10.LONG & CAN_MB01) == CAN_MB01){
201         }
202
203         /* ---- transmission data set ---- */
204         RCANET.MB[1].CTRL1.WORD = 0x0002;     /* Can send data or remote frame, dlc=2 */
205         RCANET.MB[1].CTRL0.LONG = 0x00000000; /* standard data frame, id=0x000 */
206         RCANET.MB[1].MSG_DATA[0] = 0xc1;
207         RCANET.MB[1].MSG_DATA[1] = 0xc2;
208
209         /* ---- Transmit the data ---- */
210         RCANET.TXPR10.LONG = CAN_MB01;
211
212         /* ---- Transmission completion waiting ---- */
213         while((RCANET.TXACK0.WORD & CAN_MB1) != CAN_MB1){
214         }
215
216         /* ---- Transmission completion flag clear ---- */
217         RCANET.TXACK0.WORD = CAN_MB1;
218
219     }
220
221     /* End of File */
```

4. Documents for Reference

- Software Manual
  SH-1/SH2/SH-DSP Software Manual (REJ09B0171)
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Hardware Manuals
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Revision Record

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

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