SH7216 Group

Controller Area Network, Configuration to Transmit Data Frames

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Summary

This application note describes the configuration example of the SH7216 microcomputers (MCUs) to transmit data frames using the controller area network (RCAN-ET).

Target Device

SH7216 MCU

Contents

1. Introduction

1.1 Specifications

- Transmission speed: 1 Mbps
- Transmit mailbox: Mailbox 1
- Transmits the data frame with following specifications
  Identifier: 0; standard data frame; DLC: 2; Data: H'C1C2

1.2 Modules Used

- Controller Area Network (CAN) module

1.3 Applicable Conditions

MCU	SH7216
Operating Frequencies	Internal clock: 200 MHz Bus clock: 50 MHz Peripheral clock: 50 MHz
Integrated Development Environment	Renesas Electronics Corporation High-performance Embedded Workshop Ver.4.05.01
C compiler	Renesas Electronics SuperH RISC engine Family C/C++ Compiler Package Ver.9.03 Release 00
Compiler options	-cpu=sh2afpu -fpu=single -include="$(WORKSPDIR)\inc" -object="$(CONFIGDIR)\$(FILELEAF).obj" -debug -gbr=auto -chgincpath -errorpath -global_volatile=0 -opt_range=all -infinite_loop=0 -del_vacant_loop=0 -struct_alloc=1 -nologo

1.4 Related Application Notes

For more information, refer to the following application notes:

- SH7216 Group Controller Area Network, Configuration to Receive Data Frames
- SH7216 Group Controller Area Network, Configuration to Transmit Remote Frames
- SH7216 Group Controller Area Network, Configuration to Receive Remote Frames

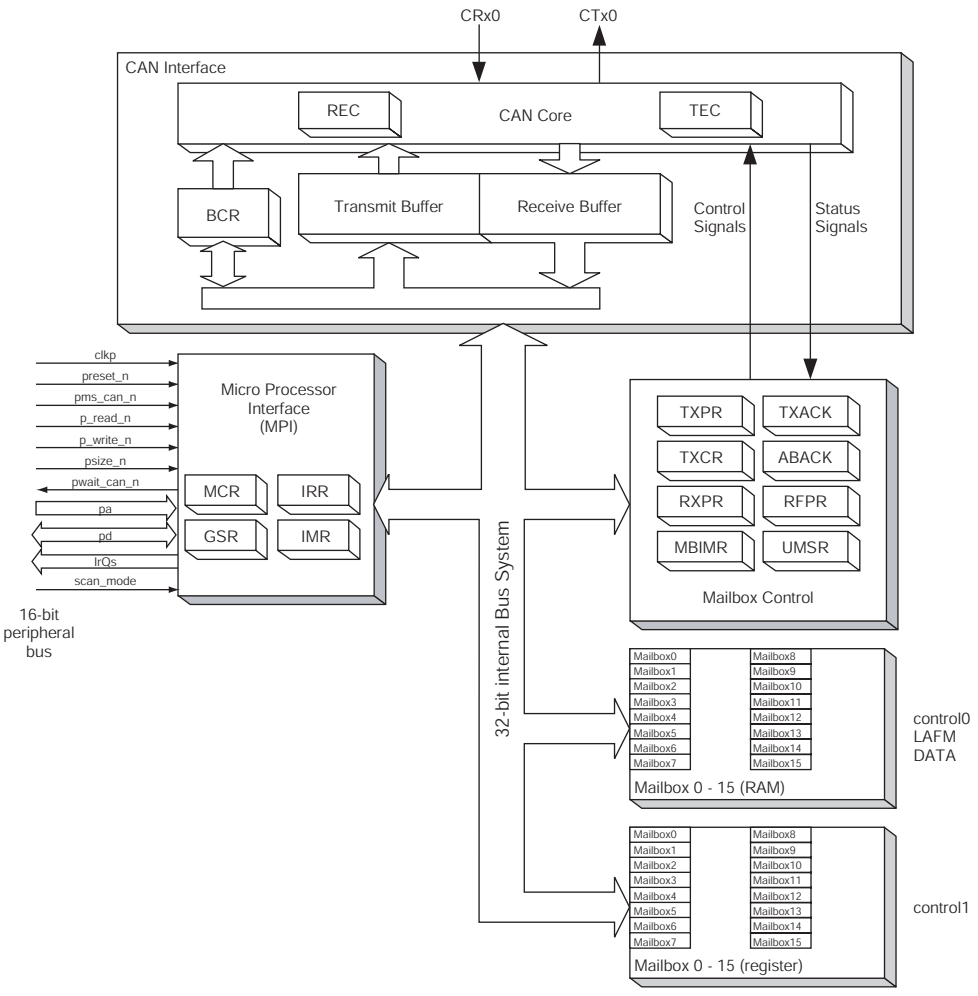
2. Applications

This application note uses the CAN module to transmit a standard data frame with identifier 0, DLC 2, and H'C1C2 data.

2.1 CAN Overview

The SH7216 includes a CAN module which is compliant with the CAN protocol, version 2.0B active, and ISO 11898.

The CAN module has 15 programmable mailboxes for transmission/reception, one mailbox for reception, and a programmable receive filtering mask to provide flexible communication procedure. **Figure 1** shows the CAN block diagram. For more details, refer to Controller Area Network chapter in the SH7216 Group Hardware Manual.



Note: RCAN-ET core is designed based on the 32-bit bus system, however, 16-bit bus interface applies to CPU on the RCAN-ET (including the MPI to CPU). Therefore, execute the longword (32-bit) access using two neighboring words (16-bit). The longword access explained in the Hardware Manual means to access by such two neighboring words.

Figure 1 CAN Block Diagram

2.2 Configuration Procedure

This section describes how to configure the SH7216 MCU to transmit data frames using the CAN module.

Configure the CAN module in reset mode (configuration mode). After configuration is complete, clear the reset mode to join the CAN bus activity. The sample program sets two mailboxes in SH7216 - one transmit mailbox and one receive mailbox. **Figure 2** and **Figure 3** show the flow charts for configuring the CAN module. For details on register settings, refer to the SH7216 Group Hardware Manual.

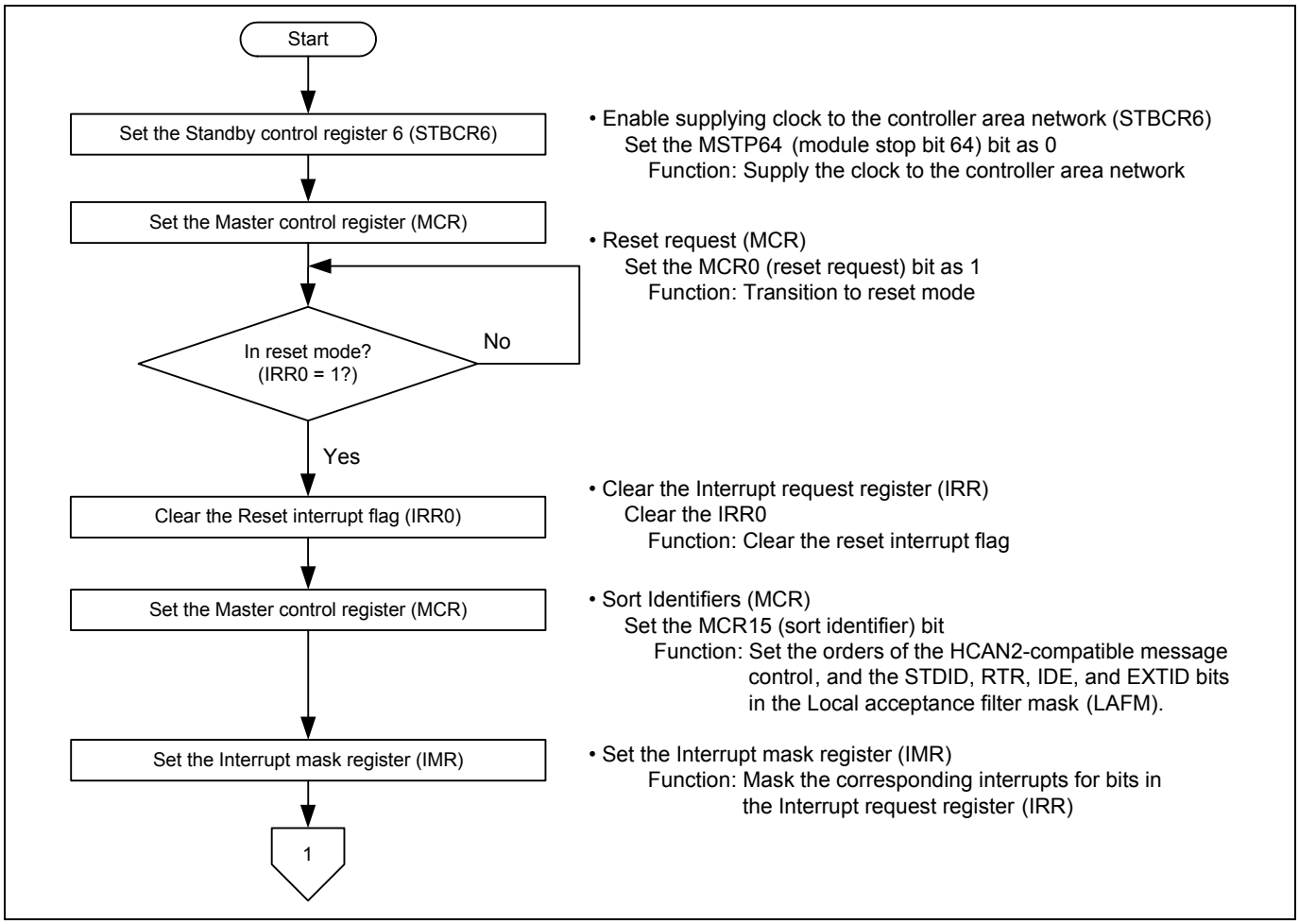
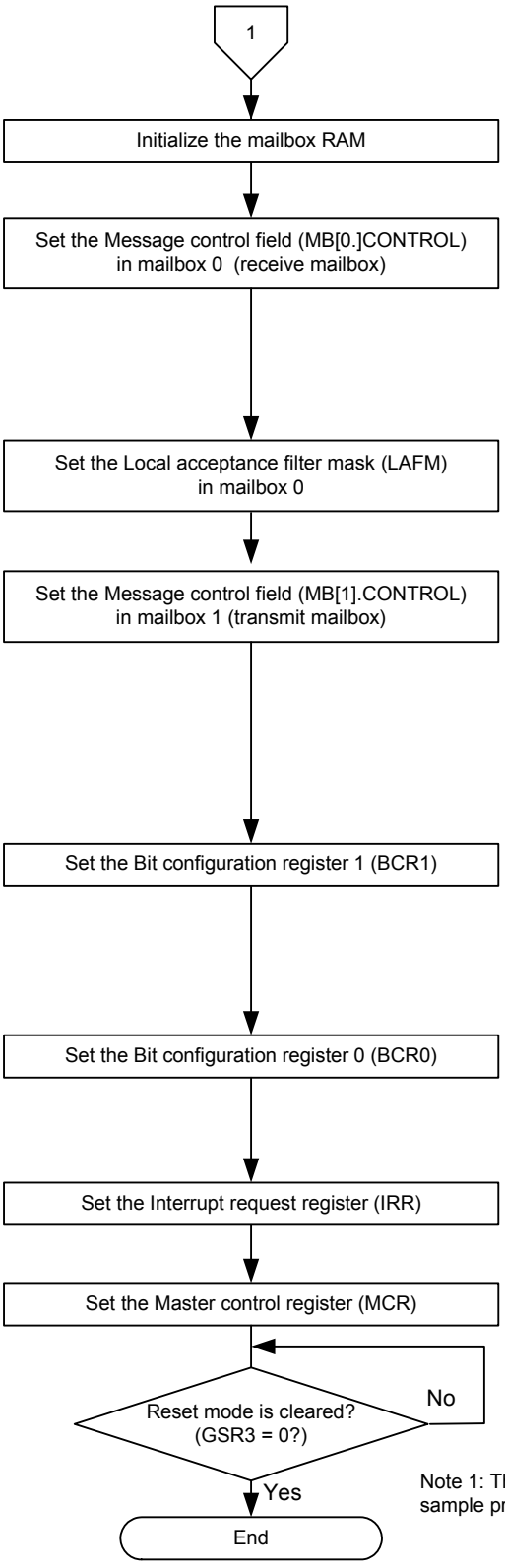


Figure 2 Flow Chart for Configuring the CAN Module (1/2)



• Clear the RAM area in the mailbox

• Set the Message control register (MB[0].CONTROL) (1)
Set "B'010" in the MBC [2:0] bits (Mailbox configuration)
Function: Receiving a remote frame or a data frame is enabled
Set "0" in the IDE bit (Identifier extension)
Function: Specify the standard format
Set "0" in the RTR bit (Remote transmission request)
Function: Specify a data frame
Set "0" in the STDID [10:0] bits (standard Identifier)
Function: Specify 0 as the ID

• Set the Local acceptance filter mask (LAFM) (1)
Set H'0000 0000 in the LAFM
Function: Mask is not specified

• Set the Message control register (MB[1].CONTROL)
Specify "B'000" in MBC [2:0] bits (Mailbox configuration)
Function: Transmitting a remote frame or a data frame is enabled
Specify "B'010" in DLC bit (Data length code)
Function: Specify the data length as 2 bytes
Specify "0" in IDE bit (Identifier extension)
Function: Specify the standard format
Specify "0" in RTR bit (Remote transmission request)
Function: Specify a data frame
Specify "0" in STDID [10:0] bits (Standard Identifier)
Function: Specify 0 as the ID

• Set the Bit configuration register 1 (BCR1)
Specify "B'1111" (16 time quanta) in TSG1 [3:0] bits (Time segment 1)
Specify "B'111" (8 time quanta) in TSG2 [2:0] bits (Time segment 2)
Specify "B'00" (1 time quantum) in SJW [1:0] bits (Resynchronization jump width)
Function: Avoid moving the sample point substantially
Specify the BSP (Bit sample point)
Function: Specify to sample at one point

• Set the Bit configuration register 0 (BCR0)
Specify "B'0000 0000" in BRP [7:0] bits (Baud rate prescaler)
Function: Specify 1 time quantum as 2 x peripheral bus clock
Transfer speed is 1 Mbps by TSG1, TSG2, and baud rate prescaler.
(Refer to 2.3 Bit configuration and transfer speed.)

• Clear the Interrupt request register (IRR)
Clear IRR0 to IRR15 bits
Function: Clear interrupt flags

• Set the Master control register (MCR)
Clear the MCR0 bit (reset request)
Function: Clear the reset mode transition request
Clear the MCR1 bit (halt request)
Function: Clear the halt mode transition request

Note 1: This operation is not required in transmitting data, however, this sample program assumes both transmission and reception.

Figure 3 Flow Chart for Configuring the CAN Module (2/2)

2.3 Bit Configuration and Transmission Speed

One bit in the CAN module consists of the following four segments:

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

Each segment is composed of the reference time Tq (time quanta). **Figure 4** shows the bit configuration example when SS = Tq, PRSEG = 8 Tq, PHSEG1 = 8 Tq, and PHSEG2 = 8 Tq.

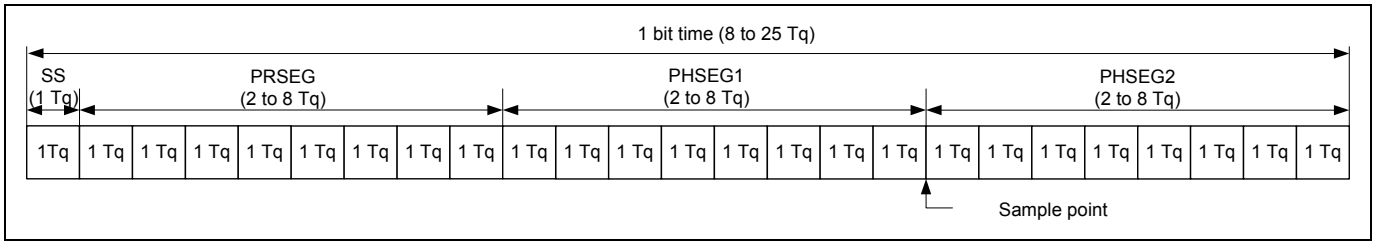


Figure 4 Bit Configuration

The CAN module sets the number of Tqs of PRSEG + PHSEG1 to bits TSG1 [3:0] in the BCR1 register, and the number of Tqs of PSEG2 to bits TSG2 [2:0] in this register (Value + 1 is the number of Tqs). Also, the number of peripheral bus clocks for 1 Tq is set to bits BRP [7:0] in the BCR0 register.

In the following description, bits BRP [7:0], TSEG1 [3:0], and TSEG2 [2:0] are register values, and bits BRP, TSEG1, TSEG2, and SJW are the corresponding values for the register values. For the corresponding values for register values, refer to the Controller Area Network chapter in the SH7216 Group Hardware Manual.

The CAN module defines $1\,\mathrm{Tq} = \frac{2\times(\mathrm{BRP}[7:0]+1)}{\text{Peripheral bus clock}}$ By this formula, the transmission speed is calculated as follows:

$$\text{Transmission speed} = \frac{\text{Peripheral bus clock}}{(2\times(\mathrm{BRP}[7:0]+1)\times \text{the number of Tqs/bit})}$$

$$= \frac{\text{Peripheral bus clock}}{\langle\{2\times(\mathrm{BRP}[7:0]+1)\}\times\{(\mathrm{TSEG}[3:0]+1)+(\mathrm{TSEG2}[2:0]+1)+1\}\rangle}$$

Following is the restrictions on setting the bit configuration register.

TSEG1 (Min.) > TSEG2 ≥ SJW (Max.) (SJW = 1 to 4)
SJW is the resynchronization jump width. It is a segment that lengthens phase buffer segment 1 or shortens phase buffer segment 2 to correct the phase difference.

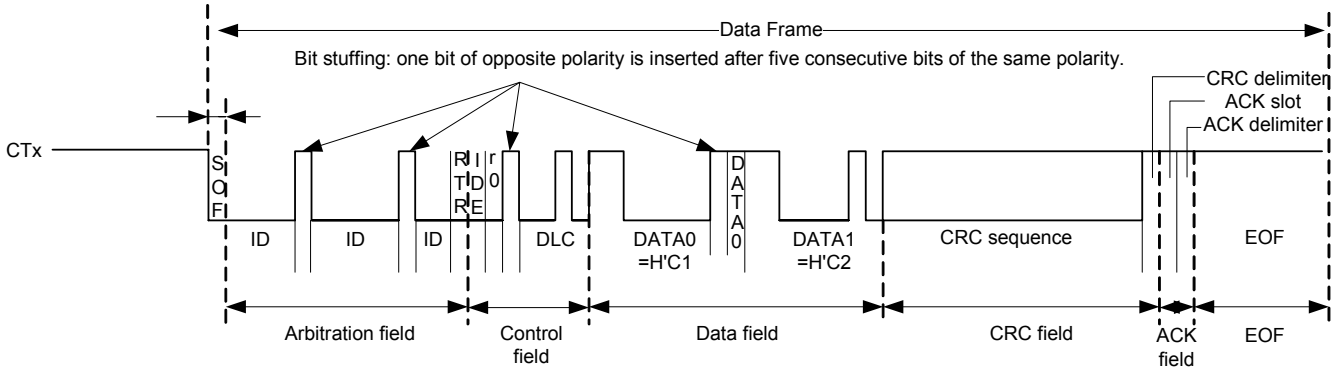
8 ≤ TSEG1 + TSEG2 + 1 ≤ 25 time quanta
TSEG2 ≥ 2

As this sample program specifies the peripheral bus clock as 50 MHz, BRP = 0, TSEG 1 = 15, and TSEG2 = 7, the transmission speed is calculated as follows:

$$\text{Transmission speed} = \frac{50\mathrm{M}}{(2\times(0+1)\times(15+1)+(7+1)+1)} = 1\mathrm{M}....1\ \text{Mbps}$$

2.4 Sample Program Operation

This sample program transmits a standard data frame from mailbox 1 with identifier 2, DLC 2, and H'C1C2 data at 1 Mbps. **Figure 5** shows the transmission waveform.



Legend:

SOF (Start of frame): Indicates the beginning of a data frame or a remote frame
ID (Identifier): Indicates the data priority
RTR (Remote transmission request): Indicates differences between a data frame and a remote frame
IDE (Identifier extension): Indicates that it is the standard format or extended format
R0: This is a reserved bit.
DLC (Data length code): Indicates the number of bytes in the Data field (0 to 8 bytes can be specified.)
DATA: This is the data to transfer. Number of bytes DATA specified by the DLC is transferred.
CRC sequence: This is the value for frame check.
CRC delimiter: Delimits the CRC field and ACK field
ACK slot: When the transmitted message includes no error, this is overwritten by a dominant.
ACK delimiter: Delimits the ACK field and EOF
EOF (End of frame): Indicates the end of a frame

Figure 5 CAN Transmission Waveform

2.5 Sample Program Procedure

The following table lists setting example of the CAN. **Figure 6** shows the configuration flow chart of this sample program.

Table 1 Controller Area Network Setting

Register Name	Address	Setting	Description
Standby control register (STBCR6)	H'FFFE 041C	H'8F	MSTP64 = "0": CAN is operating
Master control register (MCR)	H'FFFF D000	H'0001	MCR0 = "1": Reset mode transition request
		H'8001	MCR15 = "1": The order of the RCAN-ET message and of the HCAN2 message are different
		H'8000	MCR0 = "0": Reset mode is cleared
Interrupt mask register(IMR)	H'FFFF D00A	H'FFFF	All interrupts in the CAN are disabled
Bit configuration register 1 (BCR1)	H'FFFF D004	H'F700	TSEG1[3:0] = "B'1111": PRSEG + PHSEG1 = 16 Tq TSEG2[2:0] = "B'111": PHSEG2 = 8 Tq SJW="0": 0: SJW = 1 Tq BSP = "0": Bit sampling at one point
Bit configuration register 0 (BCR0)	H'FFFF D006	H'0000	BRP[7:0] = "0": 1 Tq = 2 x Pφ
Message control field in mailbox 0 (MB[0].CONTROL1H)	H'FFFF D110	H'0200	MBC[2:0] = "B'010": Receiving the data frame or remote frame is enabled
Message control field in mailbox 1 (MB[1].CONTROL1H)	H'FFFF D130	H'0002	MBC[2:0] = "B'000": Transmitting the data frame or remote frame is enabled DLC[3:0] = "B'0010": Data length is 2 bytes
Mailbox 1 control field in mailbox 0 (MB[1].CONTROL0H)	H'FFFF D120	H'0000 0000	IDE = "0": Standard format RTR = "0": Data frame STDID[10:0] = "0": Standard identifier is 0
Local acceptance filter mask in mailbox 0 (MB[0].LAFMH)	H'FFFF D104	H'0000 0000	Clear: Mask is not specified
Message data field in mailbox 1 (MB[1].MSG_DATA_0)	H'FFFF D128	H'0000	Specify "H'C1C2" as the transmit data
Transmit pending register (TXPR1)	H'FFFF D020	H'0000 0002	TXPR [31:0] = H'0000 0002: A transmission request occurred in Mailbox 1
Transmit acknowledge register 0 (TXACK0)	H'FFFF D032	H'0002	Clear the transmit acknowledge flag

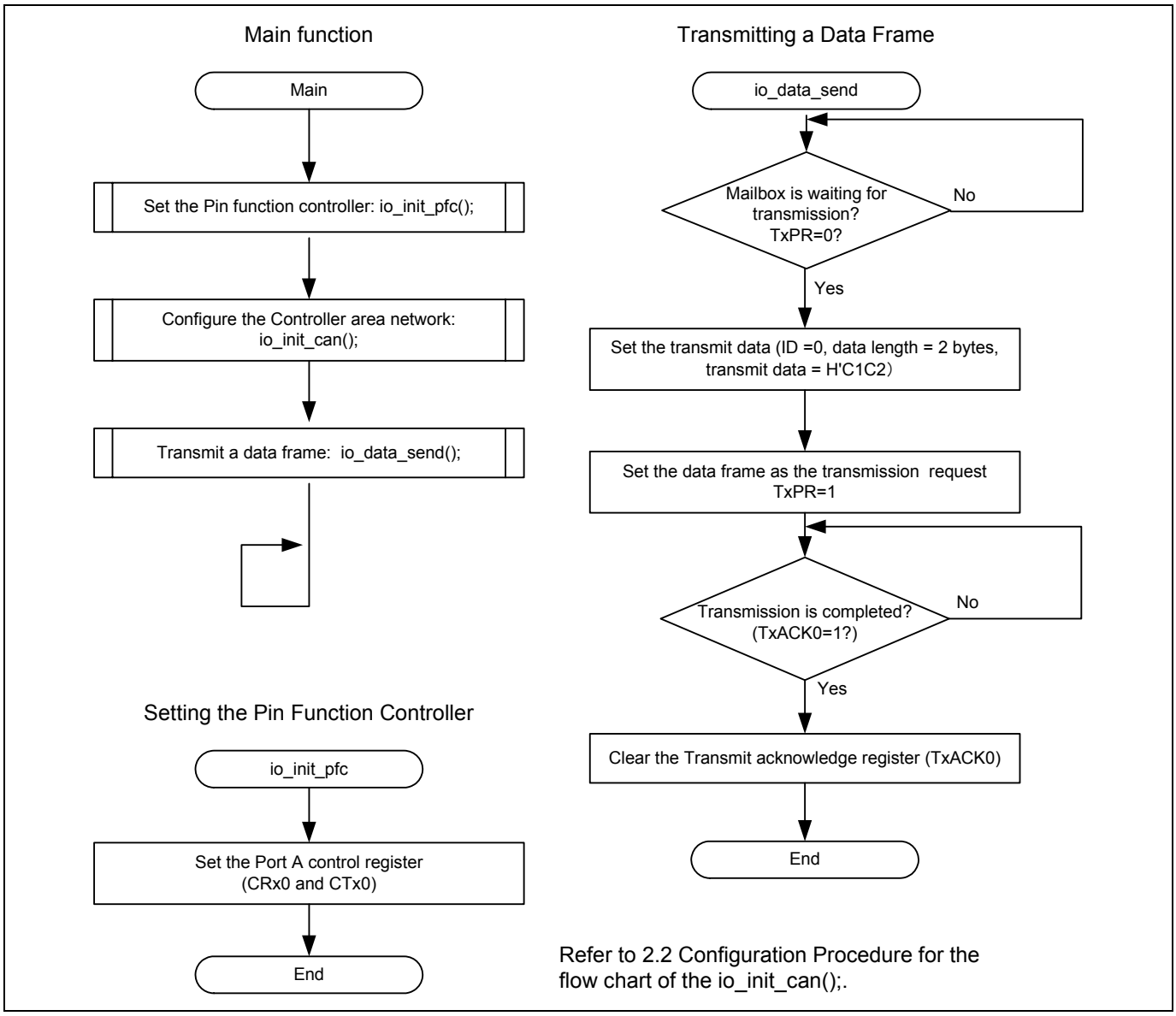


Figure 6 Sample Program Flow Chart

3. Sample Program Listing

3.1 Sample Program Listing "main.c" (1/6)

```
/***********************************************************************
*   DISCLAIMER
*
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*   intended for use with Renesas products.  No other uses are authorized.
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*   http://www.renesas.com/disclaimer
***********************************************************************
*   Copyright (C) 2009(2010) Renesas Electronics Corporation.
*   All rights reserved.
*""FILE COMMENT""************ Technical reference data *************************
*   System Name : SH7216 Sample Program
*   File Name   : main.c
*   Abstract    : CAN Module Application (Data Frame Transmit).
*   Version     : 1.01.00
*   Device      : SH7216
*   Tool-Chain  : High-performance Embedded Workshop (Ver.4.07.00).
*               : C/C++ compiler package for the SuperH RISC engine family
*               :                               (Ver.9.03 Release00).
*   OS          : None
*   H/W Platform: R0K572167 (CPU board)
*   Description :
***********************************************************************
*   History     : Jun.29,2009 Ver.1.00.00
*               : Jun.21,2010 Ver.1.01.00  Changing the corporate name and
*               :                           the copyright format
*               :                          - Dividing FRQCR setting into
*               :                             subroutine "io_set_cpg_frqcr"
*               :                             which is allocated to on-chip RAM
*               :                          - Adding processing of section copy
*               :                             function "_seccpy"
```

3.2 Sample Program Listing "main.c" (2/6)

```
51    *""FILE COMMENT END""**********************************************************/
52    #include "iodefine.h"
53
54    /* ---- prototype declaration ---- */
55    void main(void);
56    void io_init_pfc(void);
57    void io_init_can(void);
58    void io_data_send(void);
59
60    /* ---- symbol definition ---- */
61    #define CAN_GSR3 0x0008
62    #define CAN_IRR0 0x0001
63    #define CAN_MB0  0x0001
64    #define CAN_MB1  0x0002
65    #define CAN_MB01 0x00000002
66
67    /*""FUNC COMMENT""*****************************************************************
68     * ID            :
69     * Outline       : Sample program main
70     *-------------------------------------------------------------------------------
71     * Include       : "iodefine.h"
72     *-------------------------------------------------------------------------------
73     * Declaration   : void main(void);
74     *-------------------------------------------------------------------------------
75     * Description   : Set the PFC, and configure the RCAN to transmit the data frame.
76     *-------------------------------------------------------------------------------
77     * Argument      : void
78     *-------------------------------------------------------------------------------
79     * Return Value  : void
80     *-------------------------------------------------------------------------------
81     * Note          :
82     *""FUNC COMMENT END""*************************************************************/
83    void main(void)
84    {
85        /* ==== Setting of PFC ==== */
86        io_init_pfc();
87
88        /* ==== Initializing CAN module ==== */
89        io_init_can();
90
91        /* ==== Transmits a CAN data frame ==== */
92        io_data_send();
93
94        while(1){
95            /* loop */
96        }
97    }
98
```

3.3 Sample Program Listing "main.c" (3/6)

```
99    /*""FUNC COMMENT""*****************************************************************
100    * ID            :
101    * Outline       : PFC setting
102    *-------------------------------------------------------------------------------
103    * Include       : "iodefine.h"
104    *-------------------------------------------------------------------------------
105    * Declaration   : void io_init_pfc(void);
106    *-------------------------------------------------------------------------------
107    * Description   : Set the pin functions.
108    *               : CRx0 input, CTx0 output
109    *-------------------------------------------------------------------------------
110    * Argument      : void
111    *-------------------------------------------------------------------------------
112    * Return Value  : void
113    *-------------------------------------------------------------------------------
114    * Note          :
115    *""FUNC COMMENT END""*************************************************************/
116   void io_init_pfc(void)
117   {
118       /* ==== Setting of PFC ==== */
119       /* ---- Port A control register L2 ---- */
120       PFC.PACRL1.BIT.PA0MD = 0x5;     /* Set CRx0 */
121       PFC.PACRL1.BIT.PA1MD = 0x5;     /* Set CTx0 */
122   }
123
124   /*""FUNC COMMENT""*****************************************************************
125    * ID            :
126    * Outline       : RCAN setting
127    *-------------------------------------------------------------------------------
128    * Include       : "iodefine.h"
129    *-------------------------------------------------------------------------------
130    * Declaration   : void io_init_can(void);
131    *-------------------------------------------------------------------------------
132    * Description   : Configure the Controller area network (RCAN).
133    *               : Transfer rate is at 1 Mbps.
134    *-------------------------------------------------------------------------------
135    * Argument      : void
136    *-------------------------------------------------------------------------------
137    * Return Value  : void
138    *-------------------------------------------------------------------------------
139    * Note          :
140    *""FUNC COMMENT END""*************************************************************/
141   void io_init_can(void)
142   {
143       int i, j;
144
```

3.4 Sample Program Listing "main.c" (4/6)

```
145       /* ==== Setting of power down mode(RCAN) ==== */
146       STB.CR6.BYTE = 0x8f;               /* Module Standby Clear */
147                                          /* RCAN */
148       /* ==== Initializing CAN module ==== */
149       RCANET.MCR.WORD |= 0x0001;         /* CAN Interface reset mode */
150       while((RCANET.IRR.WORD & CAN_IRR0) != CAN_IRR0){
151           /* Reset state waiting */
152       }
153       /* ==== IRR = 1, GSR = 1 (Auto SET) ==== */
154
155       /* ---- Clear IRR0 ---- */
156       RCANET.IRR.WORD = 0x0001;
157
158       /* ---- RCAN mode selection(MCR15) ---- */
159       RCANET.MCR.WORD |= 0x8000;         /* RCAN-ET is not same as HCAN2 */
160
161       /* ---- Disable all CAN interrupts ---- */
162       RCANET.IMR.WORD  = 0xffff;
163
164       /* ----All mailbox init ---- */
165       for(i = 0; i < 16; i++){
166           RCANET.MB[i].CTRL0.LONG = 0x00000000;
167           RCANET.MB[i].LAFM.LONG = 0x00000000;
168           for(j = 0; j < 8; j++){
169               RCANET.MB[i].MSG_DATA[j] =  0x00;
170           }
171       }
172
173       /* ---- Config mailbox0 as reception slot ---- */
174       RCANET.MB[0].CTRL1.WORD = 0x0200;       /* Receiving a data or a remote frame /*
175                                               /* is enabled */
176       RCANET.MB[0].CTRL0.LONG = 0x00000000;   /* Initialize the Message Control Field */
177       RCANET.MB[0].LAFM.LONG = 0x00000000;
178       for(i = 0; i < 8; i++){                 /* Data clear */
179           RCANET.MB[0].MSG_DATA[i] =  0x00;
```

3.5 Sample Program Listing "main.c" (5/6)

```
180       }
181       /* ---- Config mailbox1 as transmission slot ---- */
182       RCANET.MB[1].CTRL1.WORD = 0x0002;       /* Transmitting data or remote frame
183                                               with dlc=2 is enabled */
184       RCANET.MB[1].CTRL0.LONG = 0x00000000;   /* Standard data frame, id=0x000 */
185       RCANET.MB[1].LAFM.LONG = 0x00000000;
186       for(i = 0; i < 8; i++){                 /* Data clear */
187           RCANET.MB[1].MSG_DATA[i] =  0x00;
188       }
189
190       /* ---- Config baudrate ---- */
191       RCANET.BCR1.WORD = 0xf700;      /* tsg1=15(16-bit),tsg2=7(8-bit),sjw=0(1-bit),bsp=0 */
192       RCANET.BCR0.WORD = 0x0000;      /*   1 Mbps */
193   //  RCANET.BCR0.WORD = 0x0001;      /* 500 Kbps */
194   //  RCANET.BCR0.WORD = 0x0003;      /* 250 Kbps */
195   //  RCANET.BCR0.WORD = 0x0007;      /* 125 Kbps */
196
197       /* ---- Clear interrupt flags ---- */
198       RCANET.IRR.WORD = 0xffff;
199
200       /* ---- Clear reset and halt ---- */
201       RCANET.MCR.WORD &= 0xf8fc;      /* MCR0,MCR1 clear */
202       while( (RCANET.GSR.WORD & CAN_GSR3) != 0x0000 ){
203           /* Reset state is end */
204       }
205   }
206
```

3.6 Sample Program Listing "main.c" (6/6)

```
207    /*""FUNC COMMENT""*****************************************************************
208     * ID           :
209     * Outline      : Data frame transmit
210     *-------------------------------------------------------------------------------
211     * Include      : "iodefine.h"
212     *-------------------------------------------------------------------------------
213     * Declaration  : void io_data_send(void);
214     *-------------------------------------------------------------------------------
215     * Description  : Transmit 2-byte data stored in mailbox 1.
216     *-------------------------------------------------------------------------------
217     * Argument     : void
218     *-------------------------------------------------------------------------------
219     * Return Value : void
220     *-------------------------------------------------------------------------------
221     * Note         : None
222     *""FUNC COMMENT END""*************************************************************/
223    void io_data_send(void)
224    {
225      /* ---- Transmission waiting ---- */
226      while((RCANET.TXPR10.LONG & CAN_MB01) == CAN_MB01){
227      }
228
229      /* ---- Transmission data set ---- */
230      RCANET.MB[1].CTRL1.WORD = 0x0002;       /* Transmitting data or remote frame is */
231                                             /* enabled, dlc=2 */
232      RCANET.MB[1].CTRL0.LONG = 0x00000000;   /* Standard data frame, id=0x000 */
233      RCANET.MB[1].MSG_DATA[0] = 0xc1;
234      RCANET.MB[1].MSG_DATA[1] = 0xc2;
235
236      /* ---- Transmit the data ---- */
237      RCANET.TXPR10.LONG = CAN_MB01;
238
239      /* ---- Waits for completing to transmit data ---- */
240      while((RCANET.TXACK0.WORD & CAN_MB1) != CAN_MB1){
241      }
242
243      /* ---- Transmission pending flag clear ---- */
244      RCANET.TXACK0.WORD = CAN_MB1;
245    }
246
247    /* End of File */
248
```

4. References

- Software Manual
  SH-2A/SH2A-FPU Software Manual Rev. 3.00
  The latest version of the software manual can be downloaded from the Renesas website.

- Hardware Manual
  SH7216 Group Hardware Manual Rev. 3.00
  The latest version of the hardware manual can be downloaded from the Renesas website.

Website and Support

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Inquiries
http://www.renesas.com/contact

Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Jul 24, 2009	—	First edition issued
1.01	Jul.24, 2010	—	Changing the corporate name and the copyright format
1.02	Jan.16, 2012	—	Changing the R-number and the copyright format.

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins
   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.
   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.
2. Processing at Power-on
   The state of the product is undefined at the moment when power is supplied.
   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.
3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.
4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.
   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.
5. Differences between Products
   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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