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SH7262/SH7264 Group

Controller Area Network, Configuration to Transmit Data Frames

Summary

This application note describes the configuration example of the SH7264 microcomputers (MCUs) to transmit data frames using the Controller Area Network.

Target Device

SH7264 MCU (In this document, SH7262/SH7264 are described as "SH7264".)

Contents

1. Introduction

1.1 Specifications

- Uses the Controller Area Network channel 0
- 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	SH7262/SH7264
Operating Frequencies	Internal clock: 144 MHz Bus clock: 72 MHz Peripheral clock: 36 MHz
Integrated Development Environment	Renesas Technology Corp. High-performance Embedded Workshop Ver.4.07.00
C Compiler	Renesas Technology SuperH RISC engine Family C/C++ Compiler Package Ver.9.03 Release 00
Compiler Options	Default setting in the High-performance Embedded Workshop (-cpu=sh2afpu -fpu=single -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:

- SH7262/SH7264 Group Controller Area Network, Configuration to Receive Data Frames
- SH7262/SH7264 Group Controller Area Network, Configuration to Transmit Remote Frames
- SH7262/SH7264 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 SH7264 includes two channels of a CAN module which is compliant with the CAN protocol, version 2.0B active, and ISO 11898.

The CAN module has 31 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 SH7262 Group, SH7264 Group Hardware Manual.

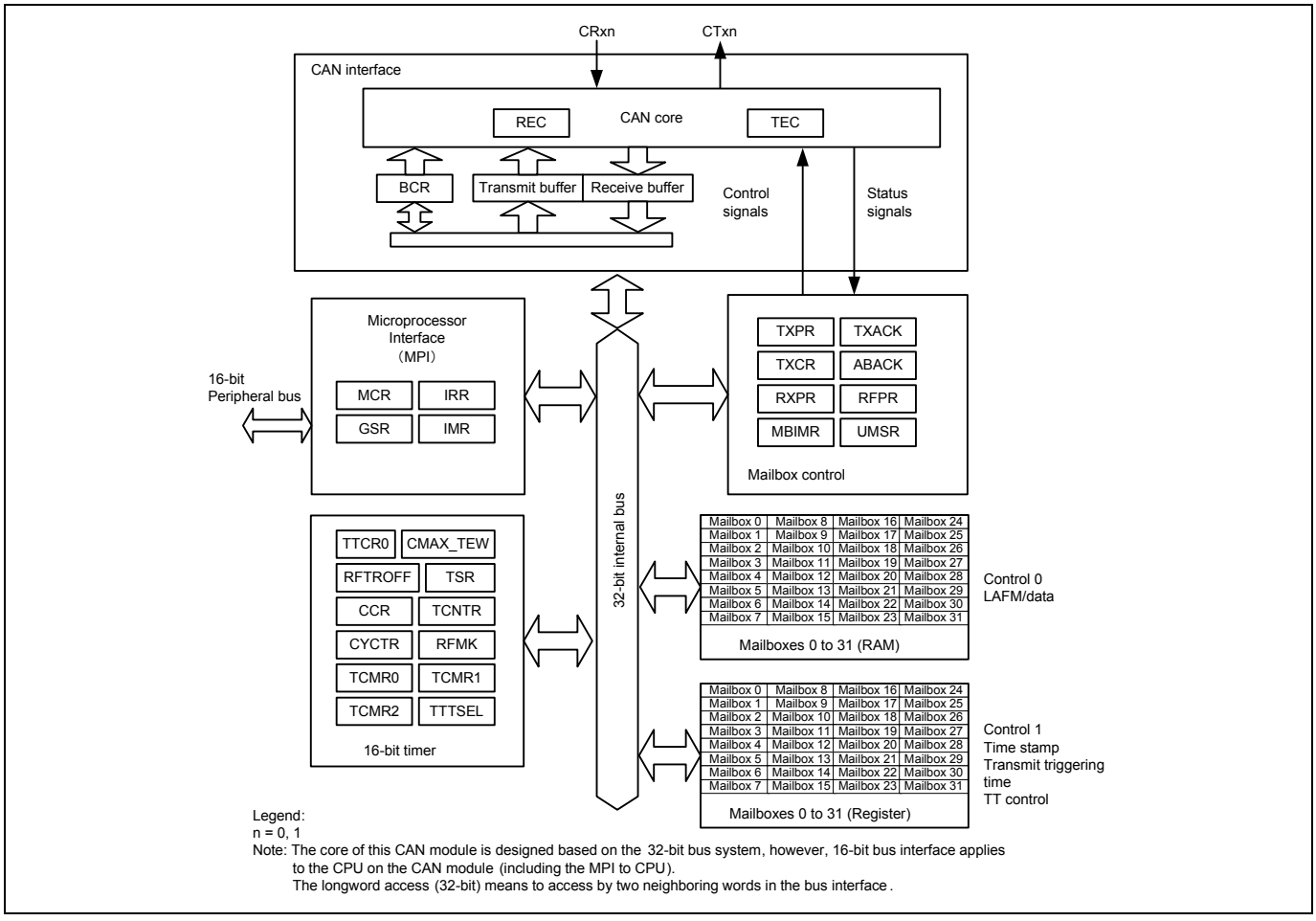


Figure 1 CAN Block Diagram (For One Channel)

2.2 Configuration Procedure

This section describes how to configure the SH7264 MCU to transmit data frames using the CAN module channel 0.

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 SH7264 - 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 Controller Area Network chapter in the SH7262 Group, SH7264 Group Hardware Manual.

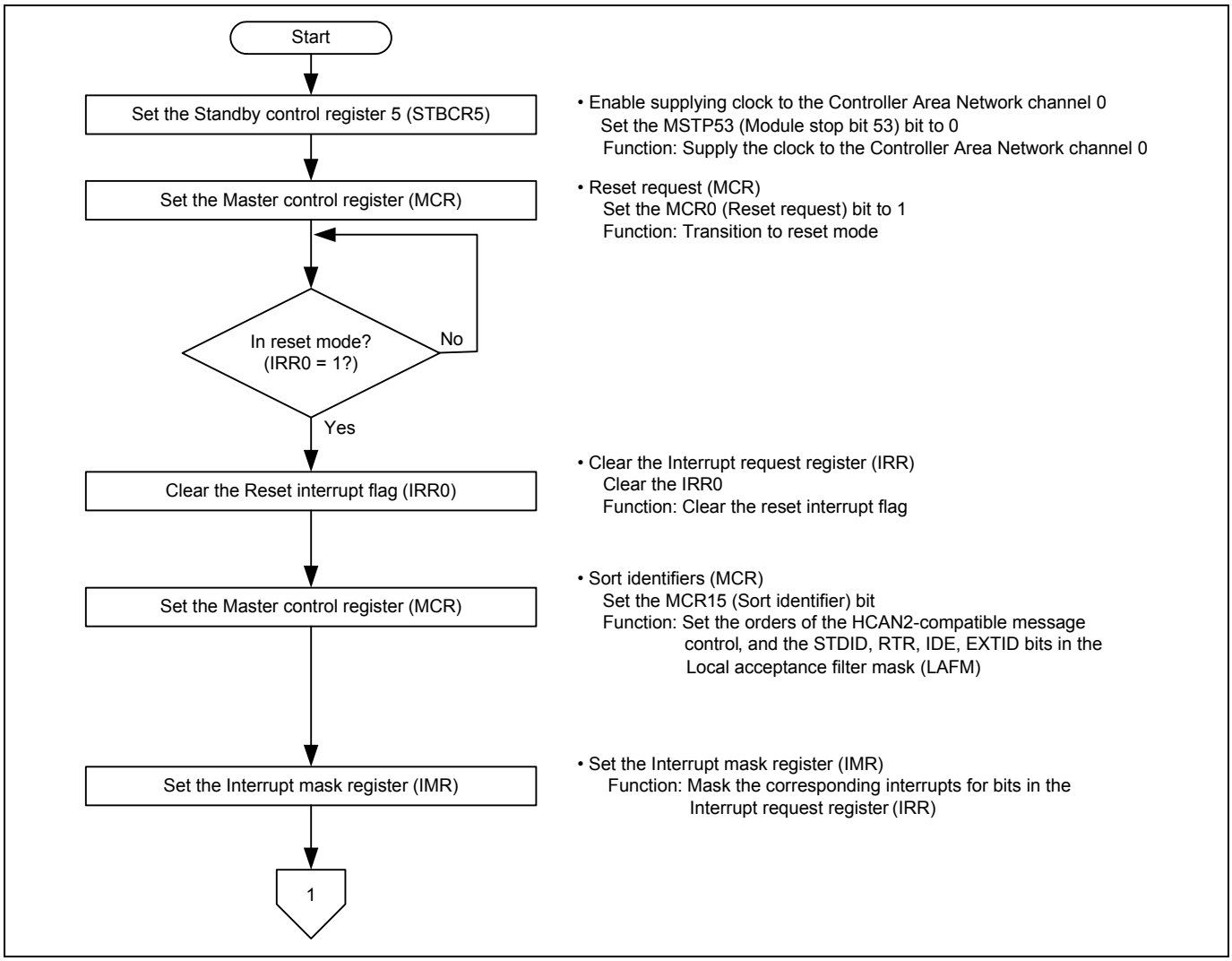
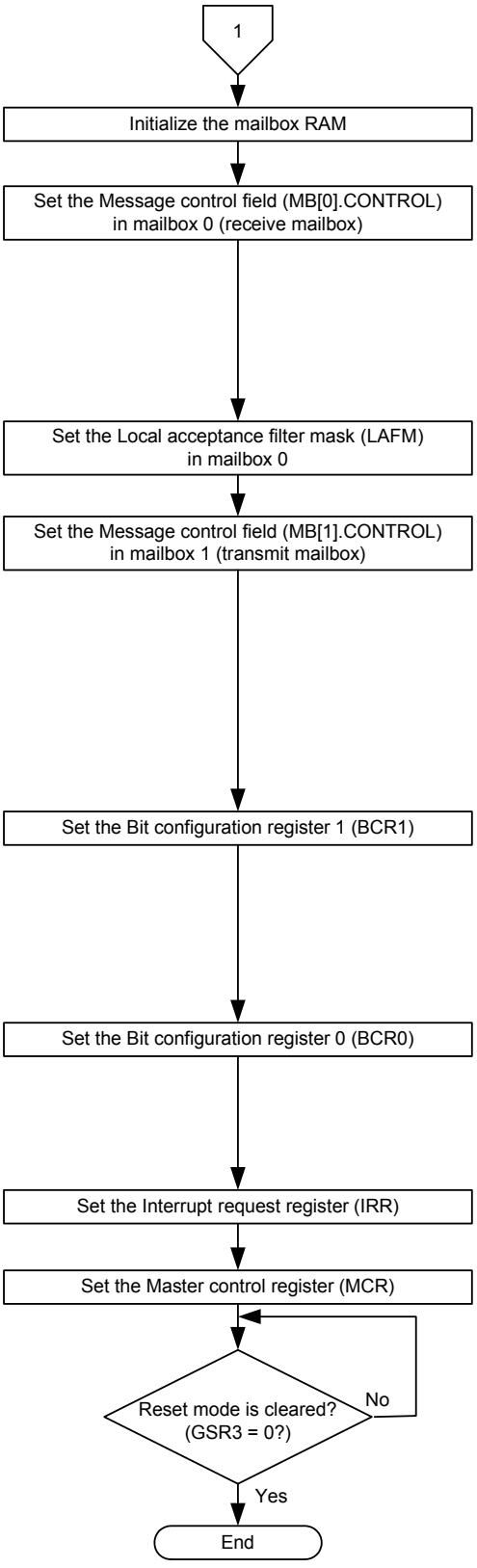


Figure 2 Flow Chart for Configuring the CAN Module (1/2)



• Clear the RAM area in mailbox

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

• Set the Bit configuration register 1 (BCR1)
Specify "B'1001" (10 time quanta) in TSG1 [3:0] bits (Time segment 1)
Specify "B'110" (7 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
Set the BSP (Bit sample point)
Function: Specify to sample at one point or to sample at three points and decide by majority of them

• 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 × peripheral bus clock
Specify the transfer speed as 1 Mbps by TSG1, TSG2 and the baud rate prescaler
(Refer to 2.3 Bit Confuguration and Transmission 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 = 1 Tq, PRSEG = 8 Tq, PHSEG1 = 8 Tq, and PHSEG2 = 8 Tq.

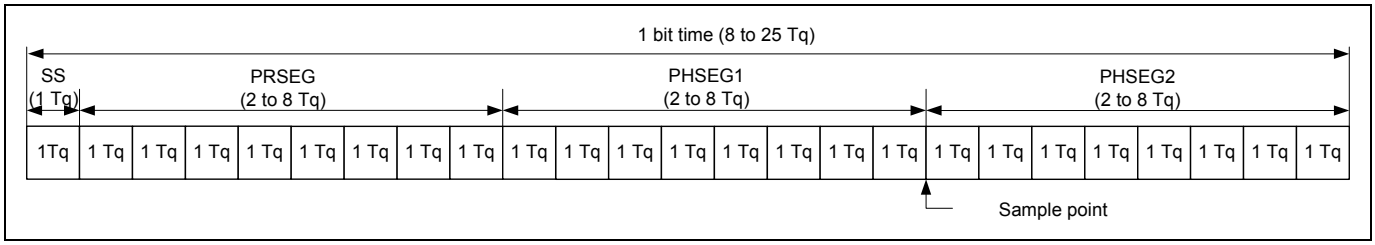


Figure 4 Bit Configuration

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 SH7262 Group, SH7264 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:

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

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

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

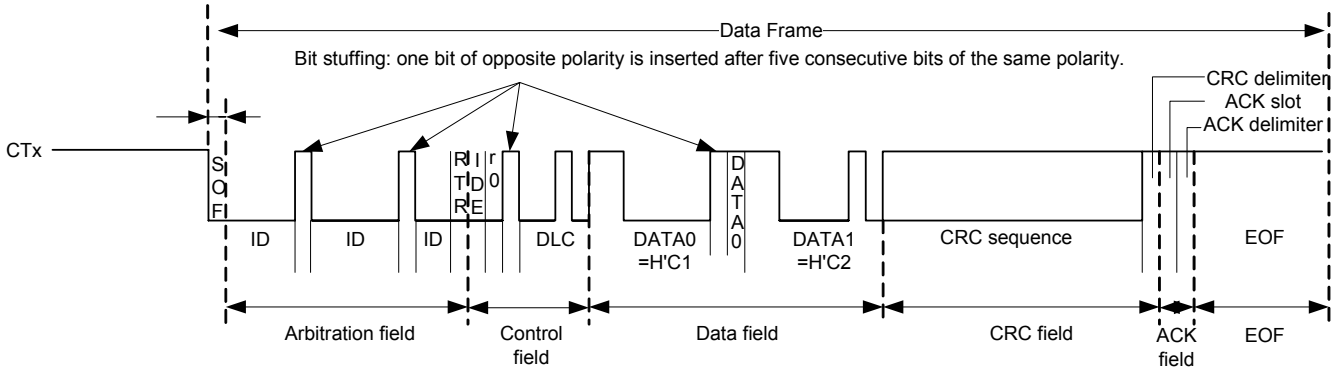
As this sample program specifies the peripheral bus clock as 36 MHz, BRP [7:0] = 0, TSEG 1 [3:0] = 9, and TSEG2 [2:0] = 6, the transmission speed is calculated as follows:

$$\text{Transmission speed} = \frac{36\mathrm{M}}{2\times(0+1)\times\{(9+1)+(6+1)+1\}} = 1\mathrm{M}\ldots.1\ \text{Mbps}$$

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.

Note: The sample program transmits and receives data frames, however, this application note describes only the transmission.



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.

Note: The sample program transmits and receives data frames, however, this application note describes only the transmission.

Table 1 Controller Area Network Settings

Register Name	Address	Setting	Description
Standby control register (STBCR5)	H'FFFE 0410	H'F7	MSTP53 = "0": Controller Area Network channel 0 is operating
Master control register (MCR)	H'FFFF 5000	H'0001	MCR0 = "1": Reset mode transition request
		H'8001	MCR15 = "1": The order of the RCAN message and of the HCAN2 message are different
		H'8000	MCR0 = "0": Reset mode is cleared
Interrupt mask register(IMR)	H'FFFF 500A	H'FFFF	All interrupts in the Controller Area Network are disabled
Bit configuration register 1 (BCR1)	H'FFFF 5004	H'9600	TSEG1 [3:0] = "B'1001": PRSEG + PHSEG1 = 10 Tq TSEG2 [2:0] = "B'110": PHSEG2 = 7 Tq SJW = "0": SJW = 1 Tq BSP = "0": Bit sampling at one point
Bit configuration register 0 (BCR0)	H'FFFF 5006	H'0000	BRP [7:0] = "0": 1 Tq = 2 × Pφ
Message control field in mailbox 0 (MB[0].CONTROL1)	H'FFFF 5110	H'0200	MBC [2:0] = "B'010": Receiving the data frame or remote frame is enabled
Message control field in mailbox 0 (MB[0].CONTROL0)	H'FFFE 5100	H'0000 0000	IDE = "0": Standard format RTR = "0": Data frame STDID [10:0] = "0": Standard identifier is 0
Message control field in mailbox 1 (MB[1].CONTROL1)	H'FFFF 5130	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
Message control field in mailbox 1 (MB[1].CONTROL0)	H'FFFF 5120	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].LAFM)	H'FFFF 5104	H'0000 0000	Clear: Mask is not specified
Message data field in mailbox 1 (MB[1].MSG_DATA_0)	H'FFFF 5128	H'C1C2	Specify "H'C1C2" as the transmit data
Transmit pending register (TXPR)	H'FFFF 5020	H'0000 0002	TXPR [31:0] = H'0000 0002: A transmission request occurred in Mailbox 1
Transmit acknowledge register 0 (TXACK0)	H'FFFF 5032	H'0002	Clear the transmit acknowledge flag

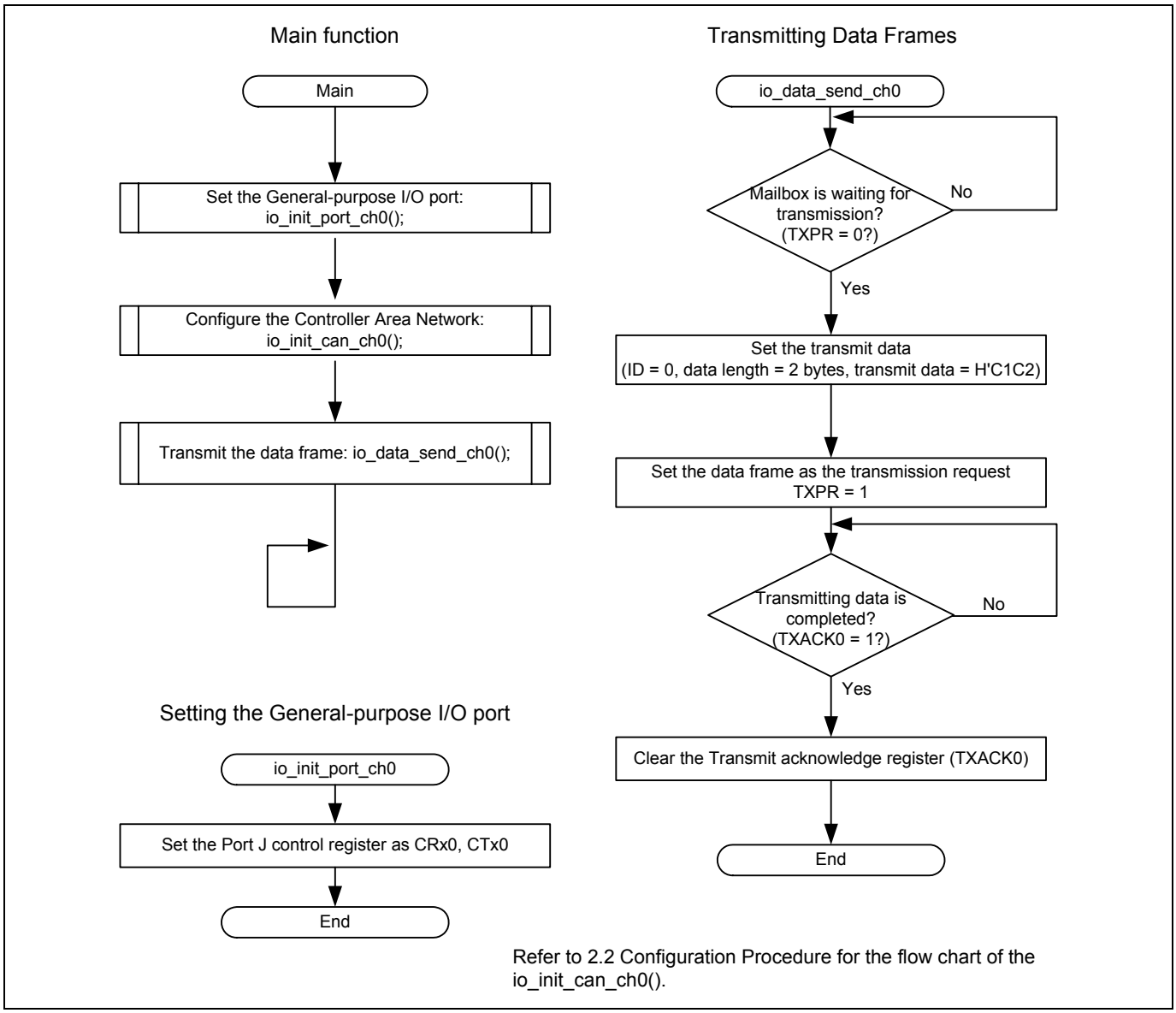


Figure 6 Sample Program Flow Chart

3. Sample Program Listing

3.1 Supplement to the Sample Program

As the capacity of the SH7264 large-capacity internal RAM varies as 1 MB or 640 KB, depending on the MCU type, the section alignment and register setting must be partly altered. To support both MCU types, this application note provides two types of sample programs (workspaces) for 1-MB RAM and 640-KB RAM.

As the MCU with 640-KB RAM must be write-enabled before writing data in the data-retention RAM, the System control register 5 (SYSCR5) is set to write-enable the RAM in the sample program for 640-KB RAM.

Review your product and use the appropriate workspace.

3.2 Sample Program Listing "main.c" (1/2)

```
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3       *
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26      *   http://www.renesas.com/disclaimer
27      ***********************************************************************
28      *   Copyright (C) 2009. Renesas Technology Corp., All Rights Reserved.
29      *""FILE COMMENT""*********** Technical reference data *************************
30      *   System Name : SH7264 Sample Program
31      *   File Name   : main.c
32      *   Abstract    : CAN Module Application (Data Frame Transmit and Receive)
33      *   Version     : 1.00.00
34      *   Device      : SH7262/SH7264
35      *   Tool-Chain  : High-performance Embedded Workshop (Ver.4.07.00).
36      *               : C/C++ compiler package for the SuperH RISC engine family
37      *               :                             (Ver.9.03 Release00).
38      *   OS          : None
39      *   H/W Platform: M3A-HS64G50 (CPU board) + M3A-HS64G02 (IO board)
40      *   Description :
41      ***********************************************************************
42      *   History     : Nov.20,2009 ver.1.00.00
43      *""FILE COMMENT END""*****************************************************/
44      #include "iodefine.h"       /* SH7264 iodefine  */
45
```

3.3 Sample Program Listing "main.c" (2/2)

```
46    /* ---- prototype declaration ---- */
47    void main(void);
48    extern void io_init_port_ch0(void);
49    extern void io_init_port_ch1(void);
50    extern void io_init_can_ch0(void);
51    extern void io_init_can_ch1(void);
52    extern void io_data_send_ch0(void);
53    extern void io_data_receive_ch1(void);
54
55    /*""FUNC COMMENT""*****************************************************************
56     * ID            :
57     * Outline       : Sample program main
58     *-------------------------------------------------------------------------------
59     * Include       : "iodefine.h"
60     *-------------------------------------------------------------------------------
61     * Declaration   : void main(void);
62     *-------------------------------------------------------------------------------
63     * Description   : After configuring the Controller Area Network (RCAN), channel 0
64     *               : transmits the data frame, and channel 1 receives the data frame.
65     *-------------------------------------------------------------------------------
66     * Argument      : void
67     *-------------------------------------------------------------------------------
68     * Return Value  : void
69     *-------------------------------------------------------------------------------
70     * Note          :
71     *""FUNC COMMENT END""*************************************************************/
72    void main(void)
73    {
74        /* ==== Initializing port ==== */
75        io_init_port_ch1();
76        io_init_port_ch0();
77
78        /* ==== Initializing CAN module ==== */
79        io_init_can_ch1();
80        io_init_can_ch0();
81
82        /* ==== CAN data frame transmission ==== */
83        io_data_send_ch0();
84
85        /* ==== CAN data frame reception ==== */
86      io_data_receive_ch1();
87
88        while(1){
89            /* loop */
90        }
91    }
92
93    /* End of File */
```

3.4 Sample Program Listing "can0.c" (1/5)

```
1     /***********************************************************************
2     *   DISCLAIMER
3     *
4     *   This software is supplied by Renesas Technology Corp. and is only
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27    ************************************************************************
28    *   Copyright (C) 2009. Renesas Technology Corp., All Rights Reserved.
29    *""FILE COMMENT""*********** Technical reference data *********************
30    *   System Name : SH7264 Sample Program
31    *   File Name   : can0.c
32    *   Abstract    : CAN Module Application (Data Frame Transmit)
33    *   Version     : 1.00.00
34    *   Device      : SH7262/SH7264
35    *   Tool-Chain  : High-performance Embedded Workshop (Ver.4.07.00).
36    *               : C/C++ compiler package for the SuperH RISC engine family
37    *               :                             (Ver.9.03 Release00).
38    *   OS          : None
39    *   H/W Platform: M3A-HS64G50 (CPU board) + M3A-HS64G02 (IO board)
40    *   Description :
41    ************************************************************************
42    *   History     : Nov.20,2009 ver.1.00.00
43    *""FILE COMMENT END""*****************************************************/
44    #include "iodefine.h"       /* SH7264 iodefine  */
45
```

3.5 Sample Program Listing "can0.c" (2/5)

```
46    /* ---- prototype declaration ---- */
47    void io_init_port_ch0(void);
48    void io_init_can_ch0(void);
49    void io_data_send_ch0(void);
50
51    /* ---- symbol definition ---- */
52    #define CAN_GSR3 0x0008
53    #define CAN_IRR0 0x0001
54    #define CAN_MB0  0x0001
55    #define CAN_MB1  0x0002
56    #define CAN_MB01 0x00000002
57
58    /*""FUNC COMMENT""*****************************************************************
59     * ID            :
60     * Outline       : PORT setting
61     *-----------------------------------------------------------------------------
62     * Include       : "iodefine.h"
63     *-----------------------------------------------------------------------------
64     * Declaration   : void io_init_port_ch0(void);
65     *-----------------------------------------------------------------------------
66     * Description   : Set pin functions (CRx0 input, and CTx0 output).
67     *-----------------------------------------------------------------------------
68     * Argument      : void
69     *-----------------------------------------------------------------------------
70     * Return Value  : void
71     *-----------------------------------------------------------------------------
72     * Note          :
73     *""FUNC COMMENT END""*************************************************************/
74    void io_init_port_ch0(void)
75    {
76        /* ==== Setting of PORT ==== */
77        PORT.PJCR0.BIT.PJ0MD = 0x1;     /* Set CTx0 */
78        PORT.PJCR0.BIT.PJ1MD = 0x1;     /* Set CRx0 */
79    }
80
```

3.6 Sample Program Listing "can0.c" (3/5)

```
81    /*""FUNC COMMENT""*****************************************************************
82     * ID            :
83     * Outline       : RCAN setting
84     *-------------------------------------------------------------------------------
85     * Include       : "iodefine.h"
86     *-------------------------------------------------------------------------------
87     * Declaration   : void io_init_can_ch0(void);
88     *-------------------------------------------------------------------------------
89     * Description   : Configure the Controller Area Network (RCAN) channel 0.
90     *               : Transfer rate is set as 1 Mbps.
91     *-------------------------------------------------------------------------------
92     * Argument      : void
93     *-------------------------------------------------------------------------------
94     * Return Value  : void
95     *-------------------------------------------------------------------------------
96     * Note          :
97     *""FUNC COMMENT END""*************************************************************/
98    void io_init_can_ch0(void)
99    {
100       int i, j;
101
102     /* ==== Setting of power down mode(RCAN) ==== */
103     CPG.STBCR5.BIT.MSTP53 = 0;                /* Module Standby Clear (RCAN0)*/
104
105     /* ==== Initializing CAN module ==== */
106       RCAN0.MCR.WORD |= 0x0001;          /* CAN Interface reset mode */
107       while((RCAN0.IRR.WORD & CAN_IRR0) != CAN_IRR0){
108           /* Reset state waiting */
109       }
110       /* ==== IRR = 1, GSR = 1 (Auto SET) ==== */
111
112       /* ---- Clear IRR0 ---- */
113       RCAN0.IRR.WORD = 0x0001;
114
115       /* ---- RCAN mode selection(MCR15) ---- */
116       RCAN0.MCR.WORD |= 0x8000;          /* RCAN is not same as HCAN2 */
117
118       /* ---- Disable all can interrupt ---- */
119       RCAN0.IMR.WORD  = 0xffff;
120
```

3.7 Sample Program Listing "can0.c" (4/5)

```
121       /* ----All mailbox init ---- */
122       for(i = 0; i < 32; i++){
123           RCAN0.MB[i].CONTROL0.LONG = 0x00000000;
124           RCAN0.MB[i].LAFM.LONG = 0x00000000;
125           for(j = 0; j < 8; j++){
126               RCAN0.MB[i].MSG_DATA[j] =  0x00;
127           }
128       }
129
130       /* ---- Config mailbox0 as reception slot ---- */
131       RCAN0.MB[0].CONTROL1.WORD = 0x0200;       /* CAN receive data and remote frame */
132       RCAN0.MB[0].CONTROL0.LONG = 0x00000000;   /* Initialize the Message Control Field */
133       RCAN0.MB[0].LAFM.LONG = 0x00000000;
134       for(i = 0; i < 8; i++){                 /* data clear */
135           RCAN0.MB[0].MSG_DATA[i] =  0x00;
136       }
137       /* ---- Config mailbox1 as transmission slot ---- */
138       RCAN0.MB[1].CONTROL1.WORD = 0x0002;       /* CAN send data or remote frame, dlc=2 */
139       RCAN0.MB[1].CONTROL0.LONG = 0x00000000;   /* standard data frame, id=0x000 */
140       RCAN0.MB[1].LAFM.LONG = 0x00000000;
141       for(i = 0; i < 8; i++){                 /* data clear */
142           RCAN0.MB[1].MSG_DATA[i] =  0x00;
143       }
144
145       /* ---- Config baudrate ---- */
146       RCAN0.BCR1.WORD = 0x9600;      /* tsg1=9(10bit),tsg2=6(7bit),sjw=0(1bit),bsp=0 */
147       RCAN0.BCR0.WORD = 0x0000;      /*   1 Mbps */
148   //  RCAN0.BCR0.WORD = 0x0001;      /* 500 Kbps */
149   //  RCAN0.BCR0.WORD = 0x0003;      /* 250 Kbps */
150   //  RCAN0.BCR0.WORD = 0x0007;      /* 125 Kbps */
151
152       /* ---- Clear interrupt flags ---- */
153       RCAN0.IRR.WORD = 0xffff;
154
155       /* ---- Clear reset and halt ---- */
156       RCAN0.MCR.WORD &= 0xf8fc;      /* MCR0, MCR1 clear */
157       while( (RCAN0.GSR.WORD & CAN_GSR3) != 0x0000 ){
158           /* Reset state is end */
159       }
160   }
161
```

3.8 Sample Program Listing "can0.c" (5/5)

```
/*""FUNC COMMENT""*****************************************************************
 * ID            :
 * Outline       : Data frame transmit
 *-----------------------------------------------------------------------------
 * Include       : "iodefine.h"
 *-----------------------------------------------------------------------------
 * Declaration   : void io_data_send_ch0(void);
 *-----------------------------------------------------------------------------
 * Description   : Transmit 2-byte data stored in mailbox 1.
 *-----------------------------------------------------------------------------
 * Argument      : void
 *-----------------------------------------------------------------------------
 * Return Value  : void
 *-----------------------------------------------------------------------------
 * Note          :
 *""FUNC COMMENT END""*************************************************************/
void io_data_send_ch0(void)
{
    /* ---- Transmission waiting ---- */
    while((RCAN0.TXPR0.LONG & CAN_MB01) == CAN_MB01){
    }

    /* ---- Transmission data set ---- */
    RCAN0.MB[1].CONTROL1.WORD = 0x0002;       /* CAN send data or remote frame, dlc=2 */
    RCAN0.MB[1].CONTROL0.LONG = 0x00000000;   /* standard data frame, id=0x000 */
    RCAN0.MB[1].MSG_DATA[0] = 0xc1;
    RCAN0.MB[1].MSG_DATA[1] = 0xc2;

    /* ---- Transmit the data ---- */
    RCAN0.TXPR0.LONG = CAN_MB01;

    /* ---- Transmission completion waiting ---- */
    while((RCAN0.TXACK0.WORD & CAN_MB1) != CAN_MB1){
    }

    /* ---- Transmission completion flag clear ---- */
    RCAN0.TXACK0.WORD = CAN_MB1;
}

/* End of File */
```

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
  SH7262 Group, SH7264 Group Hardware Manual Rev. 2.00
  The latest version of the hardware manual can be downloaded from the Renesas website.

Website and Support

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

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
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