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April 1st, 2010
Renesas Electronics Corporation

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SH7262/SH7264 Group

Controller Area Network, Configuration to Transmit Remote Frames

Summary

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

Target Device

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

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1. Introduction

1.1 Specifications

- Uses the Controller Area Network channel 0
- Transmission speed: 1 Mbps
- Receive mailbox: Mailbox 1
- Transmit mailbox: Mailbox 0
- Transmits a remote frame with following specifications
Identifier: 0; standard remote frame; DLC: 2
- Receives a 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 Internal clock: 144 MHz
Operating Frequencies	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 Default setting in the High-performance Embedded Workshop
Compiler Options	<code>(-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)</code>

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 Data 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 remote frame with identifier 0, DLC: 2. Then, it receives a standard data frame with identifier 0.

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

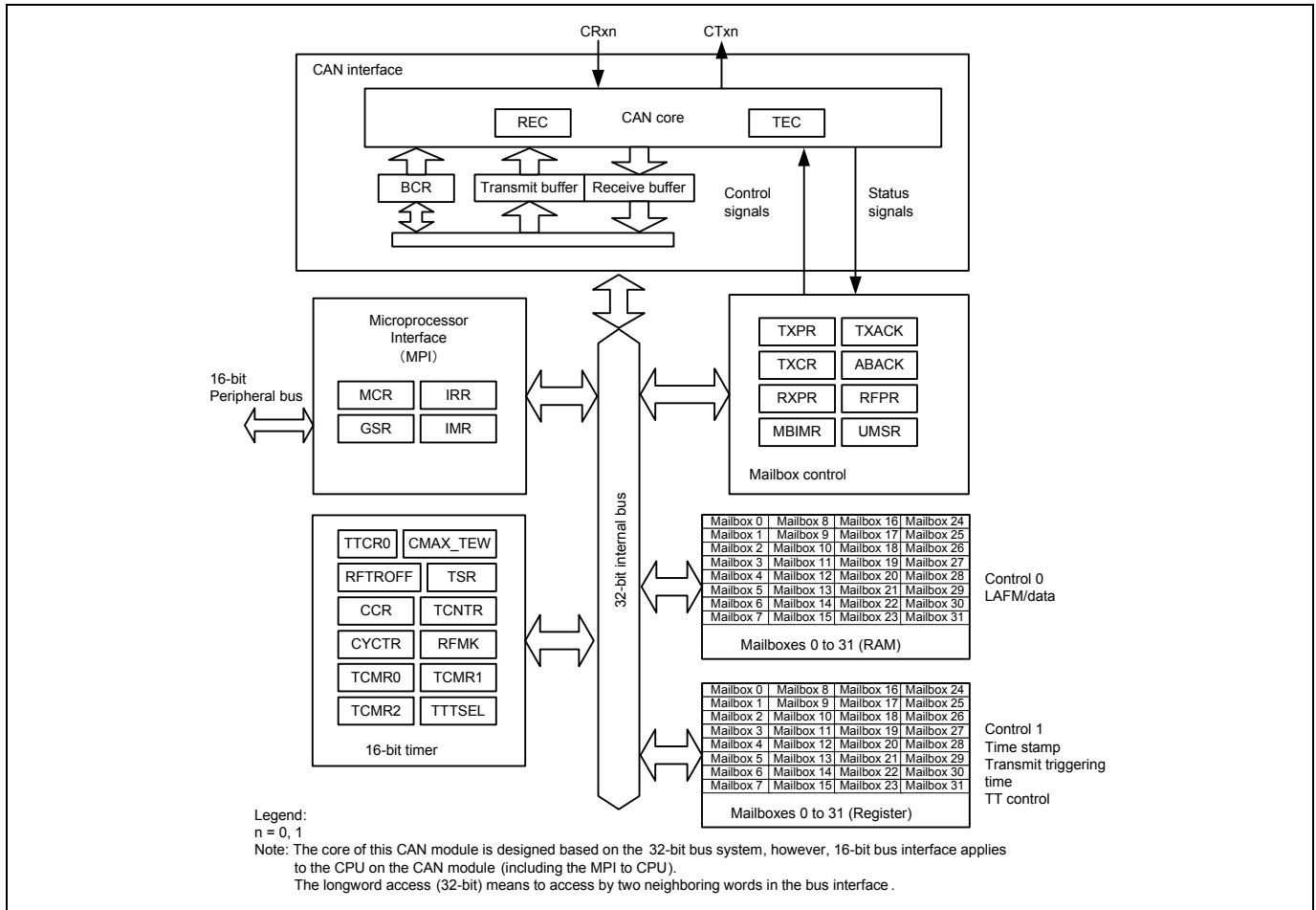


Figure 1 CAN Block Diagram (For One Channel)

2.2 Configuration Procedure

This section describes how to configure the SH7264 MCU to receive remote 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 configures mailbox 1 for both transmitting data frames and receiving remote frames. 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.

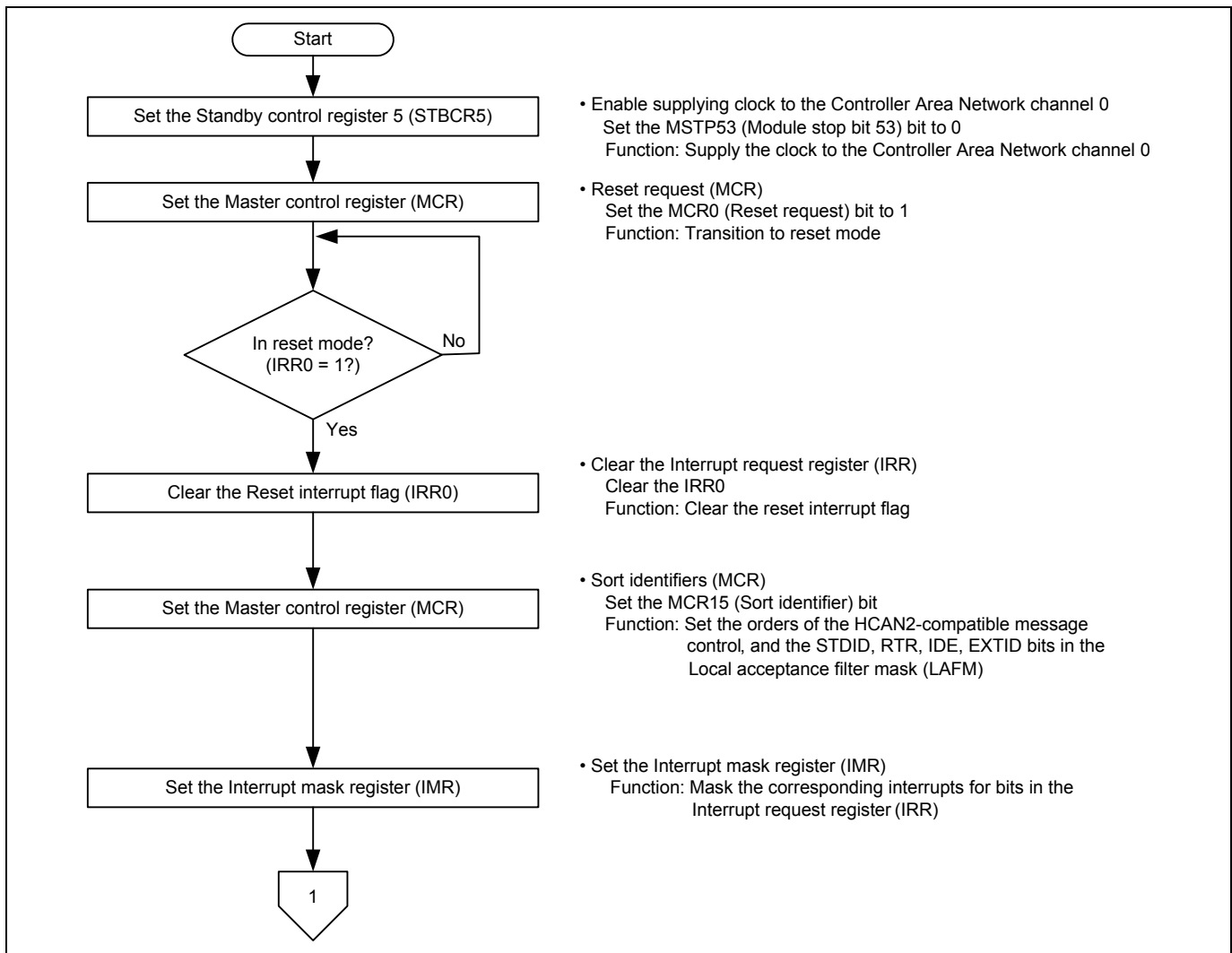


Figure 2 Flow Chart for Configuring the CAN Module (1/2)

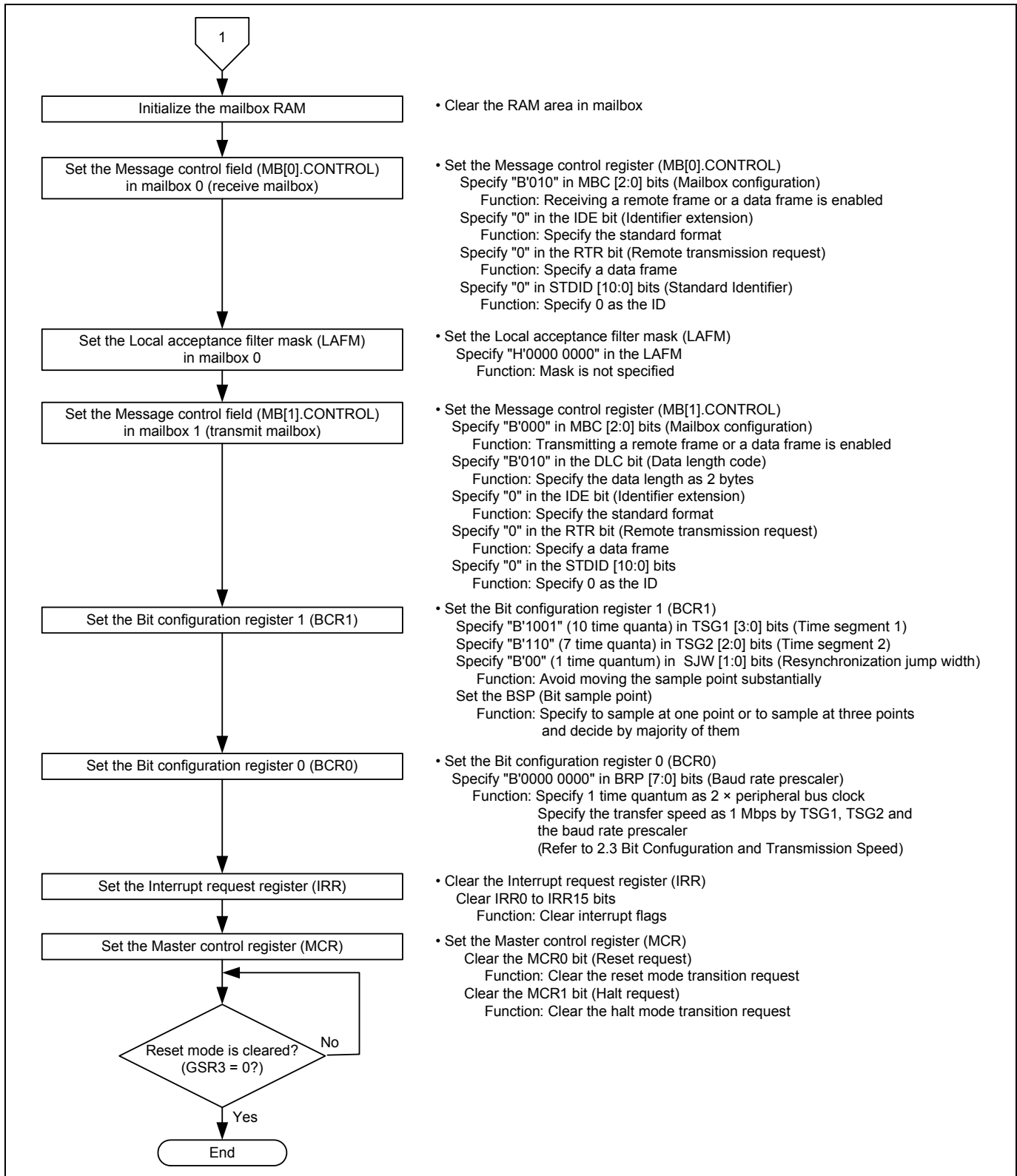


Figure 3 Flow Chart for Configuring the CAN Module (2/2)

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 T_q (time quanta). Figure 4 shows the bit configuration example when $SS = 1 T_q$, $PRSEG = 8 T_q$, $PHSEG1 = 8 T_q$, and $PHSEG2 = 8 T_q$.

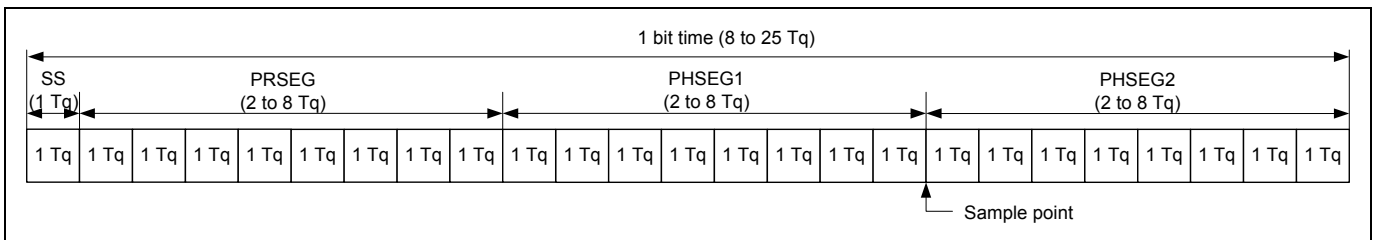


Figure 4 Bit Configuration

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

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

$$\begin{aligned} \text{Transmission speed} &= \frac{\text{Peripheral bus clock}}{2 \times (BRP[7:0] + 1) \times \text{the number of } T_q\text{/bit}} \\ &= \frac{\text{Peripheral bus clock}}{2 \times (BRP[7:0] + 1) \times \{(TSEG1[3:0] + 1) + (TSEG2[2:0] + 1) + 1\}} \end{aligned}$$

Following is the restriction on setting the bit configuration register.

$$TSEG1 (\text{Min.}) > TSEG2 \geq SJW (\text{Max.}) \quad (SJW = 1 \text{ to } 4)$$

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.

$$\begin{aligned} 8 &\leq TSEG1 + TSEG2 + 1 \leq 25 \text{ time quanta} \\ TSEG2 &\geq 2 \end{aligned}$$

As this sample program specifies the peripheral bus clock as 36 MHz, $BRP [7:0] = 0$, $TSEG1 [3:0] = 9$, and $TSEG2 [2:0] = 6$, the transmission speed is calculated as follows:

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

2.4 Sample Program Operation

This sample program transmits a standard remote frame with identifier 0, DLC: 2 from mailbox 1 at 1 Mbps. Then it receives a standard data frame with identifier 0 in mailbox 0. Figure 5 shows the transmission waveform of a remote frame.

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

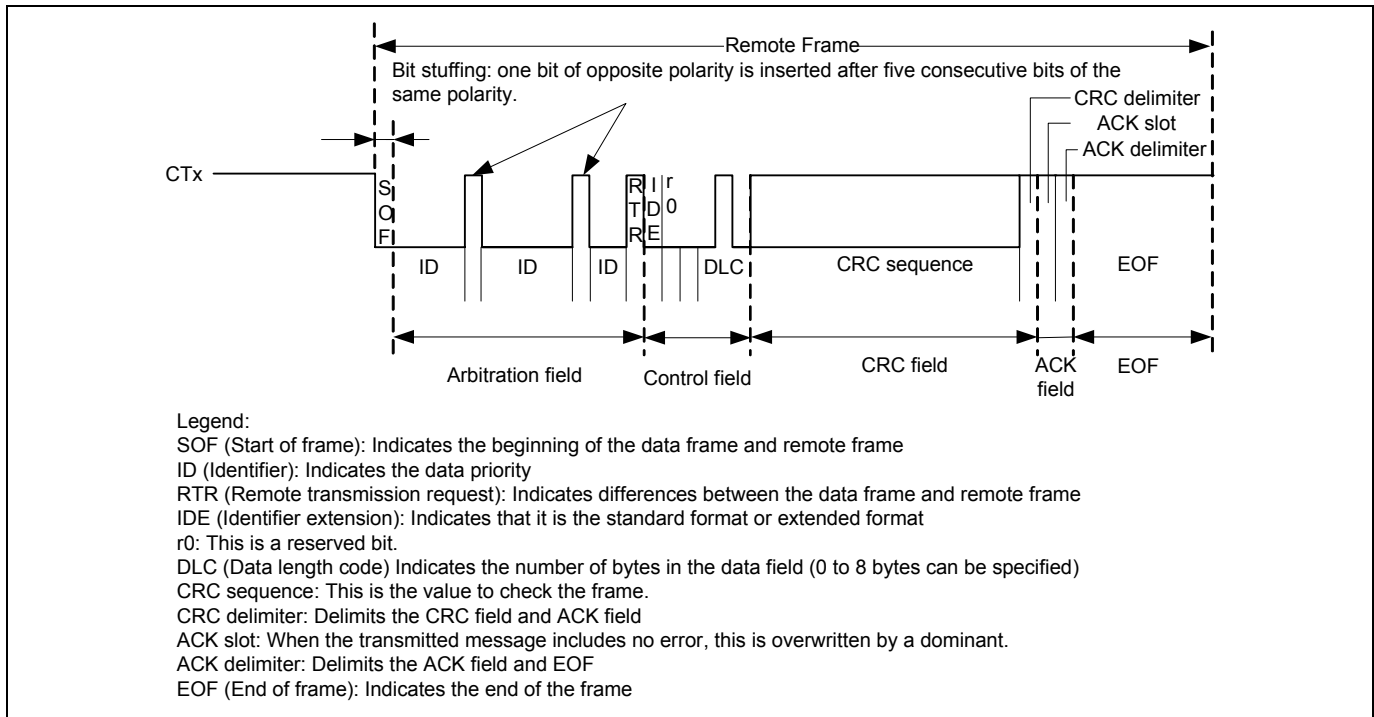


Figure 5 CAN Transmission Waveform

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 remote 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 T _q TSEG2 [2:0] = "B'110": PHSEG2 = 7 T _q SJW="0": SJW = 1 T _q BSP = "0": Bit sampling at one point
Bit configuration register 0 (BCR0)	H'FFFF D006	H'0000	BRP [7:0] = "0": 1 T _q = 2 × P _φ
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'4000 0000	IDE = "0": Standard format RTR = "1": Remote 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
Transmit pending register 1 (TXPR1)	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
Data frame receive pending register (RxPR0)	H'FFFF 5042	H'0001	Clear the data frame receive pending flag

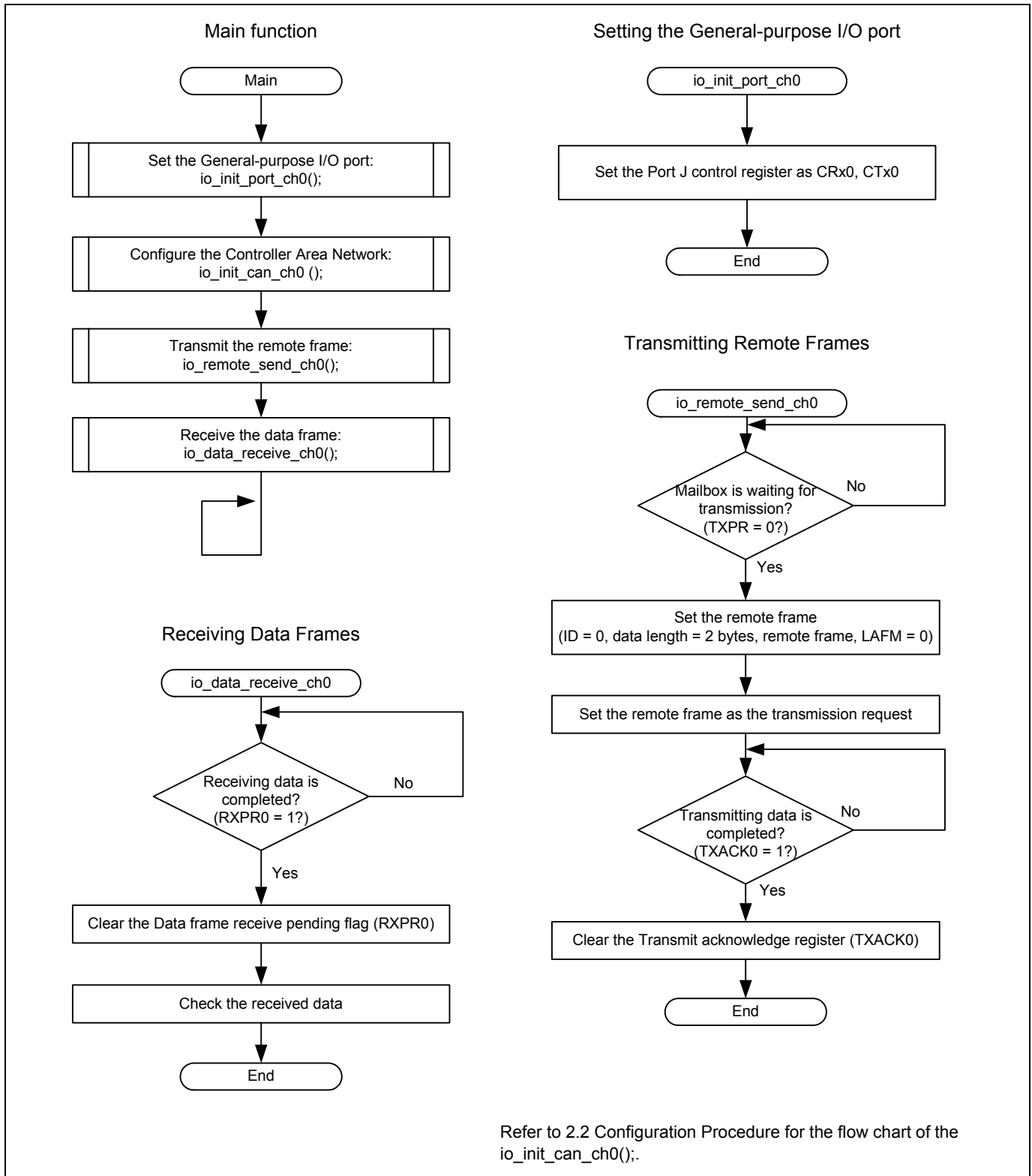


Figure 6 Sample Program Flow Chart

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" (1/3)

```

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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    : main.c
32     *   Abstract     : CAN Module Application (Remote 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" (2/3)

```

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_remote_send_ch0(void);
53  extern void io_remote_receive_ch1(void);
54  extern void io_data_receive_ch0(void);
55
56  /*"FUNC COMMENT"*****
57  * ID          :
58  * Outline     : Sample program main
59  *-----
60  * Include     : "iodefine.h"
61  *-----
62  * Declaration : void main(void);
63  *-----
64  * Description : After configuring the Controller Area Network (RCAN), channel 0
65  *              : transmits a remote frame, and receives a data frame.
66  *              : When channel 1 receives a remote frame, it automatically
67  *              : transmits a data frame.
68  *-----
69  * Argument    : void
70  *-----
71  * Return Value : void
72  *-----
73  * Note        :
74  *"FUNC COMMENT END"*****/
75  void main(void)
76  {
77      /* ==== Initializing port ==== */
78      io_init_port_ch1();
79      io_init_port_ch0();
80
81      /* ==== Initializing CAN module ==== */
82      io_init_can_ch1();
83      io_init_can_ch0();

```

3.4 Sample Program Listing "main.c" (3/3)

```
84
85     /* ==== CAN remote frame transmission ==== */
86     io_remote_send_ch0();
87
88     /* ==== CAN remote frame reception ==== */
89     io_remote_receive_ch1();
90
91     /* ==== CAN data frame reception ==== */
92     io_data_receive_ch0();
93
94     while(1){
95         /* loop */
96     }
97 }
98
99 /* End of File */
```

3.5 Sample Program Listing "can0.c" (1/6)

```

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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 (Remote 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

```

3.6 Sample Program Listing "can0.c" (2/6)

```

46  /* ---- prototype declaration ---- */
47  void io_init_port_ch0(void);
48  void io_init_can_ch0(void);
49  void io_remote_send_ch0(void);
50  void io_data_receive_ch0(void);
51
52  /* ---- symbol definition ---- */
53  #define CAN_GSR3 0x0008
54  #define CAN_IRR0 0x0001
55  #define CAN_MB0 0x0001
56  #define CAN_MB1 0x0002
57  #define CAN_MB01 0x00000002
58
59  /* ---- RAM allocation variable declaration ---- */
60  static unsigned char  nIDE = 0;          /* ide */
61  static unsigned char  nRTR = 0;         /* rtr */
62  static unsigned char  nDLC = 0;         /* dlc */
63  static unsigned int   nSID = 0;         /* sid */
64  static unsigned int   nEID = 0;         /* eid */
65  unsigned char  gRcv_data[8];           /* data of message */
66
67  /*"FUNC COMMENT"*****
68  * ID          :
69  * Outline     : PORT setting
70  *-----
71  * Include     : "iodefine.h"
72  *-----
73  * Declaration : void io_init_port_ch0(void);
74  *-----
75  * Description : Set pin functions (CRx0 input, CTx0 output).
76  *-----
77  * Argument    : void
78  *-----
79  * Return Value : void
80  *-----
81  * Note        :
82  *"FUNC COMMENT END"*****/
83  void io_init_port_ch0(void)
84  {
85      /* ==== Setting of PORT ==== */
86      PORT.PJCR0.BIT.PJ0MD = 0x1;        /* Set CTx0 */
87      PORT.PJCR0.BIT.PJ1MD = 0x1;        /* Set CRx0 */
88  }
89

```

3.7 Sample Program Listing "can0.c" (3/6)

```

90  /*"FUNC COMMENT"*****
91  * ID          :
92  * Outline     : RCAN setting
93  *-----
94  * Include     : "iodefine.h"
95  *-----
96  * Declaration : void io_init_can_ch0(void);
97  *-----
98  * Description : Configure the Controller Area Network channel 0.
99  *             : Transfer rate is set as 1 Mbps.
100 *-----
101 * Argument    : void
102 *-----
103 * Return Value : void
104 *-----
105 * Note        :
106  /*"FUNC COMMENT END"*****/
107 void io_init_can_ch0(void)
108 {
109     int i, j;
110
111     /* ==== Setting of power down mode(RCAN) ==== */
112     CPG.STBCR5.BIT.MSTP53 = 0;          /* Module Standby Clear (RCAN0)*/
113
114     /* ==== Initializing CAN module ==== */
115     RCAN0.MCR.WORD |= 0x0001;          /* CAN Interface reset mode */
116     while((RCAN0.IRR.WORD & CAN_IRR0) != CAN_IRR0){
117         /* Reset state waiting */
118     }
119     /* ==== IRR = 1, GSR = 1 (Auto SET) ==== */
120
121     /* ---- Clear IRR0 ---- */
122     RCAN0.IRR.WORD = 0x0001;
123
124     /* ---- RCAN mode selection(MCR15) ---- */
125     RCAN0.MCR.WORD |= 0x8000;          /* RCAN is not same as HCAN2 */
126
127     /* ---- Disable all can interrupt ---- */
128     RCAN0.IMR.WORD = 0xffff;
129
130     /* ----All mailbox init ---- */
131     for(i = 0; i < 32; i++){
132         RCAN0.MB[i].CONTROL0.LONG = 0x00000000;
133         RCAN0.MB[i].LAFM.LONG = 0x00000000;
134         for(j = 0; j < 8; j++){
135             RCAN0.MB[i].MSG_DATA[j] = 0x00;
136         }
137     }
138

```

3.8 Sample Program Listing "can0.c" (4/6)

```

139     /* ---- Config mailbox0 as reception slot ---- */
140     RCAN0.MB[0].CONTROL1.WORD = 0x0200;      /* CAN receive data and remote frame */
141     RCAN0.MB[0].CONTROL0.LONG = 0x00000000; /* Initialize the Message Control Field */
142     RCAN0.MB[0].LAFM.LONG = 0x00000000;
143     for(i = 0; i < 8; i++){                  /* data clear */
144         RCAN0.MB[0].MSG_DATA[i] = 0x00;
145     }
146     /* ---- Config mailbox1 as transmission slot ---- */
147     RCAN0.MB[1].CONTROL1.WORD = 0x0002;      /* CAN send data or remote frame, dlc=2 */
148     RCAN0.MB[1].CONTROL0.LONG = 0x00000000; /* standard data frame, id=0x000 */
149     RCAN0.MB[1].LAFM.LONG = 0x00000000;
150     for(i = 0; i < 8; i++){                  /* data clear */
151         RCAN0.MB[1].MSG_DATA[i] = 0x00;
152     }
153
154     /* ---- Config baudrate ---- */
155     RCAN0.BCR1.WORD = 0x9600;                /* tsg1=9(10bit),tsg2=6(7bit),sjw=0(1bit),bsp=0 */
156     RCAN0.BCR0.WORD = 0x0000;                /* 1 Mbps */
157     // RCAN0.BCR0.WORD = 0x0001;            /* 500 Kbps */
158     // RCAN0.BCR0.WORD = 0x0003;            /* 250 Kbps */
159     // RCAN0.BCR0.WORD = 0x0007;            /* 125 Kbps */
160
161     /* ---- Clear interrupt flags ---- */
162     RCAN0.IRR.WORD = 0xffff;
163
164     /* ---- Clear reset and halt ---- */
165     RCAN0.MCR.WORD &= 0xf8fc;                /* MCR0, MCR1 clear */
166     while( (RCAN0.GSR.WORD & CAN_GSR3) != 0x0000 ){
167         /* Reset state is end */
168     }
169 }
170

```

3.9 Sample Program Listing "can0.c" (5/6)

```

171  /*"FUNC COMMENT"*****
172  * ID          :
173  * Outline     : Remote frame transmit
174  *-----
175  * Include     : "iodefine.h"
176  *-----
177  * Declaration : void io_remote_send_ch0(void);
178  *-----
179  * Description : Transmit a remote frame.
180  *-----
181  * Argument    : void
182  *-----
183  * Return Value : void
184  *-----
185  * Note        :
186  *"FUNC COMMENT END"*****/
187 void io_remote_send_ch0(void)
188 {
189     /* ---- Transmission waiting ---- */
190     while((RCAN0.TXPR0.LONG & CAN_MB01) == CAN_MB01){
191     }
192
193     /* ---- Transmission data set ---- */
194     RCAN0.MB[1].CONTROL1.WORD = 0x0002;    /* CAN send data or remote frame, dlc=2 */
195     RCAN0.MB[1].CONTROL0.LONG = 0x40000000; /* standard remote frame, id=0x000 */
196
197     /* ---- Transmit the data ---- */
198     RCAN0.TXPR0.LONG = CAN_MB01;
199
200     /* ---- Transmission completion waiting ---- */
201     while((RCAN0.TXACK0.WORD & CAN_MB1) != CAN_MB1){
202     }
203
204     /* ---- Transmission completion flag clear ---- */
205     RCAN0.TXACK0.WORD = CAN_MB1;
206 }
207

```

3.10 Sample Program Listing "can0.c" (6/6)

```

208  /*"FUNC COMMENT"*****
209  * ID          :
210  * Outline     : Data frame receive
211  *-----
212  * Include     : "iodef.h"
213  *-----
214  * Declaration : void io_data_receive_ch0(void);
215  *-----
216  * Description : Receive a data frame.
217  *-----
218  * Argument    : void
219  *-----
220  * Return Value : void
221  *-----
222  * Note       :
223  *"FUNC COMMENT END"*****/
224  void io_data_receive_ch0(void)
225  {
226      int i;
227
228      /* ---- Reception completion waiting ---- */
229      while((RCAN0.RXPR0.WORD & CAN_MB0) != CAN_MB0){
230      }
231
232      /* ---- Receive data storage ---- */
233      nIDE = RCAN0.MB[0].CONTROL0.BIT.IDE;
234      nRTR = RCAN0.MB[0].CONTROL0.BIT.RTR;
235      nDLC = RCAN0.MB[0].CONTROL1.BIT.DLC;
236      nSID = RCAN0.MB[0].CONTROL0.BIT.STDID;
237      nEID = RCAN0.MB[0].CONTROL0.BIT.EXTID;
238      if(nDLC > 8){
239          nDLC = 8;
240      }
241      for(i = 0; i < nDLC; i++){
242          gRcv_data[i] = RCAN0.MB[0].MSG_DATA[i];
243      }
244
245      /* ---- Reception completion flag clear ---- */
246      RCAN0.RXPR0.WORD = CAN_MB0;
247  }
248  /* 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.

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Revision History

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		Page	Summary
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