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SH7263/SH7203 Group

Sample Application for the CAN Module (Remote Frame Transmission)

Introduction

This application note describes the controller area network module (RCAN-TL1) and provides an example of its application to remote frame transmission.

Target Devices

SH7263 and SH7203 Groups

Contents

1. Introduction

1.1 Specifications

- Transfer rate: 500 kbps
- Mailbox for transmission: Mailbox 1
- Mailbox for reception: Mailbox 0
- Remote frame for transmission is as follows.
  IDE: 0 (standard format) and data length code (DLC): 2
- Received data frame is as follows.
  IDE: 0 (standard format), data length code (DLC): 2, and data: H'C1C2

1.2 Module Used

- Controller area network (RCAN-TL1): 1

1.3 Applicable Conditions

• MCU	SH7263/SH7203 (R5S72630/R5S72030)
• Clock operating mode	3 (the input from the USB_X1 pin is in use as the clock source)
• Operating frequency	Internal clock: 192 MHz Bus clock: 48 MHz Peripheral clock: 24 MHz
• C compiler:	SuperH RISC engine family C/C++ compiler package Ver.9.01Release01 from Renesas Technology
• Compiler options:	Default settings of the High-performance Embedded Workshop -cpu=sh2a -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-TL1 module to transmit a remote frame (DLC: 2) in standard format (IDE: 0) and receive a data frame in standard format (IDE: 0).

2.1 Overview of Operations by the Module Used

The SH7203 CPU has two internal RCAN-TL1 modules that support CAN2.0B and comply with ISO-11898.

The RCAN-TL1 module has 32 programmable mailboxes, each supporting a reception filter mask, and a 16-bit timer function, providing for highly flexible communications. Figure 1 shows the structure of the RCAN-TL1 module. For details on the module, refer to the section on the controller area network in the *SH7203 Group Hardware Manual*.

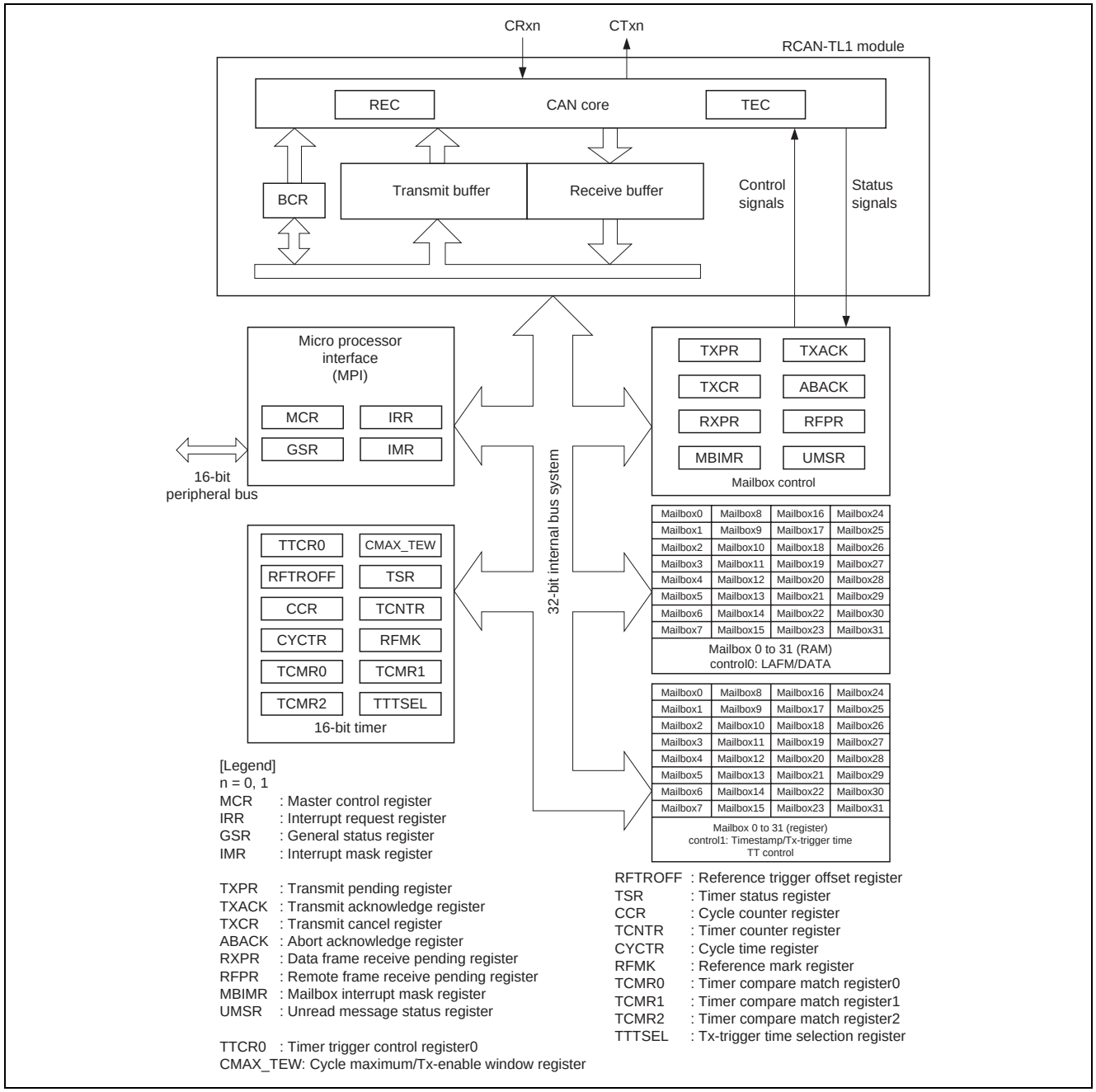


Figure 1 Structure of the RCAN-TL1 Module

2.2 Procedure for Setting the Module Used

This section describes initial settings for the transmission of remote frames by the RCAN-TL1 module.

Initial settings of the module are made in reset mode (configuration mode). On subsequent release from reset mode, the RCAN-TL1 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-TL1 module. For details on settings made to individual registers, refer to the *SH7203 Group Hardware Manual*.

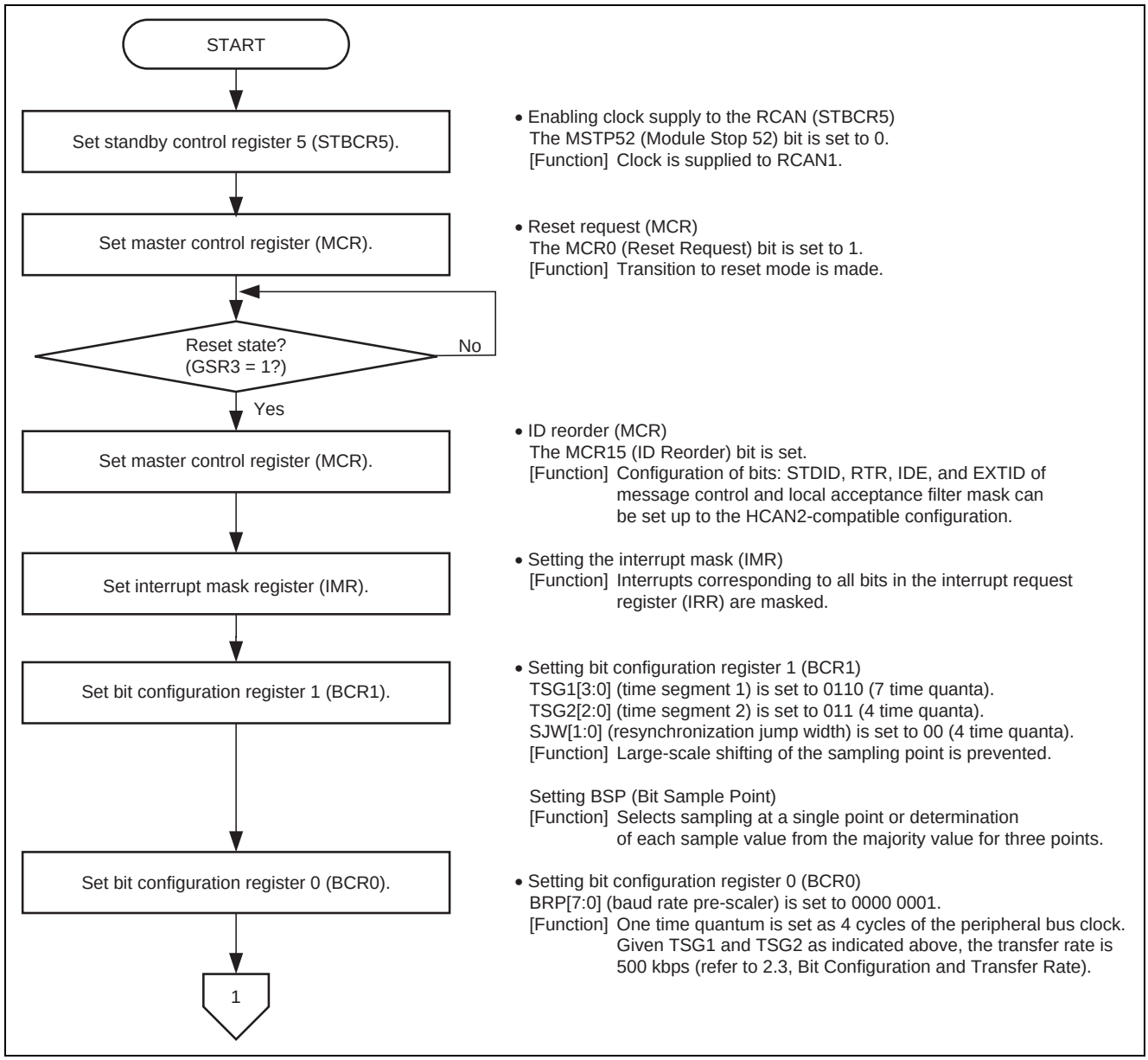


Figure 2 Example of Initialization Flow for the RCAN-TL1 Module (1)

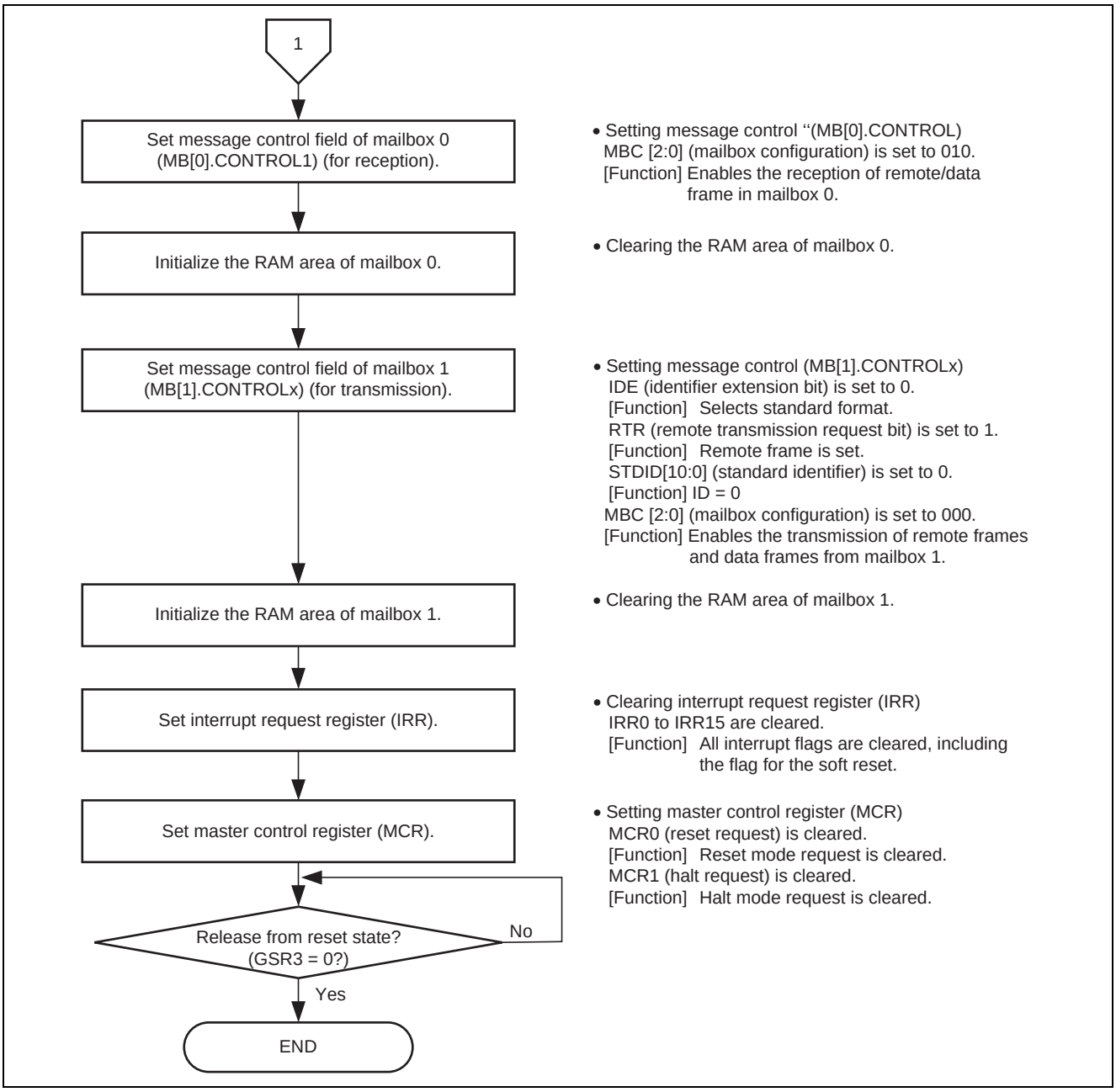


Figure 3 Example of Initialization Flow for the RCAN-TL1 Module (2)

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 = Tq, PRSEG = 3Tq, PHSEG1 = 4Tq, and PHSEG2 = 4Tq.

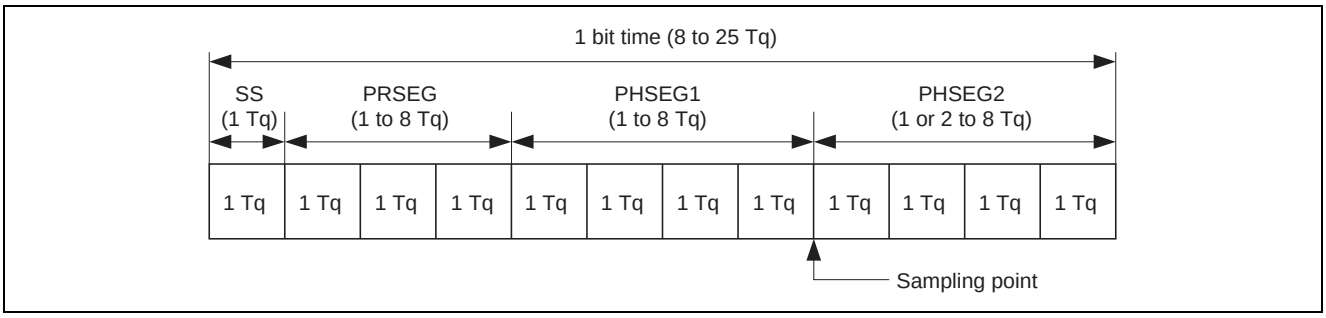


Figure 4 Configuration of One-Bit Time

In the RCAN-TL1, 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 *SH7203 Group Hardware Manual*.

By definition, Tq for the RCAN-TL1 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.

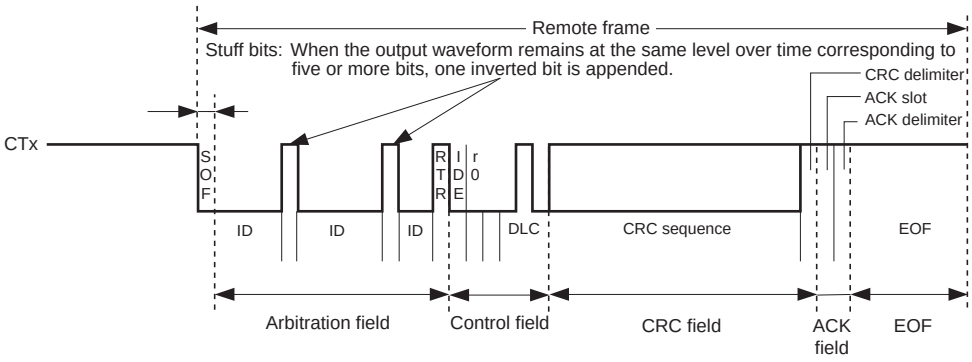
8 ≤ TSEG1 + TSEG2 + 1 ≤ 25 time quanta
TSEG2 ≥ 2

Since the settings in this sample program are as follows: peripheral bus clock = 24 MHz, BRP[7:0] = 1, TSG1[3:0] = 6, TSG2[2:0] = 3, the transfer rate is calculated with the following formula.

Transfer rate (bps) = 24 M (2 × (1+1) × ((6 + 1) + (3 + 1) + 1) = 500 k

2.4 Operation of the Sample Program

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



SOF (Start of frame)	: Indicates start of data frame and remote frame.
ID (Identifier)	: Indicates priority of data.
RTR (Request for remote transmission)	: Indicates distinction between data frame and remote frame.
IDE (Identifier extension)	: Indicates distinction between standard format and extended format.
r0	: Reserved bit
DLC (Data length code)	: Indicates the number of bytes in the data field. Setting range: 0 to 8 bytes
CRC sequence	: This value is used to check frames.
CRC delimiter	: This bit is used to delimit the CRC field and ACK field.
ACK slot	: The receiving unit is dominant, and overwrites this when no errors are detected in a transmitted message.
ACK delimiter	: This bit is used to delimit the ACK field and EOF.
EOF (End of frame):	: Indicates the end of the frame.

Figure 5 Waveform for Remote Frame Transmission by the RCAN-TL1

2.5 Processing Procedure by the Sample Program

Tables 1 and 2 give an example of the settings for the controller area network (RCAN-TL1). Figures 6 and 7 show an example of the flow of processing by this sample program.

Table 1 Register Settings for Controller Area Network (RCAN-TL1) (1)

Register Name	Address	Setting Value	Description
Standby control register (STBCR5)	H'FFFE 0410	H'FB	• MSTP52 = 0: RCAN1 runs
Master control register_1 (MCR_1)	H'FFFF 0800	H'0001	• MCR0 = 1: Reset mode transition request
		H'8001	• MCR15 = 1: RCAN-TL1 is not the same as HCAN2
		H'8000	• MCR0 = 0: Release from reset mode
Interrupt mask register_1 (IMR_1)	H'FFFF 080A	H'FFFF	• Disables all interrupts of RCAN1
Bit configuration register 1_1 (BCR1_1)	H'FFFF 0804	H'6300	• TSG1[3:0] = 0110: PRSEG + PHSEG1 = 6 Tq • TSG2[2:0] = 011: PHSEG2 = 4 Tq • SJW = 0: SJW = 2 Tq • BSP = 0: Bit sampling at one point
Bit configuration register 0_1 (BCR0_1)	H'FFFF 0806	H'0001	• BRP[7:0] = 1: 1 Tq = 4 × Pϕ
Message control field (MB[0].CONTROL1_1)	H'FFFF 0910	H'0200	MBC[2:0] = 010: Enables reception of data frames and remote frames

Table 2 Register Settings for Controller Area Network (RCAN-TL1) (2)

Register Name	Address	Setting Value	Description
Message control field (MB[1].CONTROL1_1)	H'FFFF 0942	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].CONTROL0_1)	H'FFFF 0932	H'4000 0000	• IDE = 0: Standard format • RTR = 0: Remote frame • STDID[10:0] = 0: Standard ID = 0
Local acceptance filter mask_1 (MB[1].LAFM_1)	H'FFFF 0904	H'0000 0000	• Clear: MASK is not set
Transmit pending register_1 (TXPR_1)	H'FFFF 0820	H'0000 0002	• TXPR[31:0] = H'0000 0002: Generates a transmission request in mailbox 1
Transmit acknowledge register 0_1 (TXACK0)	H'FFFF 0832	H'0002	• Clears the transmit acknowledge flag
Data frame receive pending register 0_1 (RXPR0)	H'FFFF 0842	H'0001	• Clears the data frame reception-completed flag

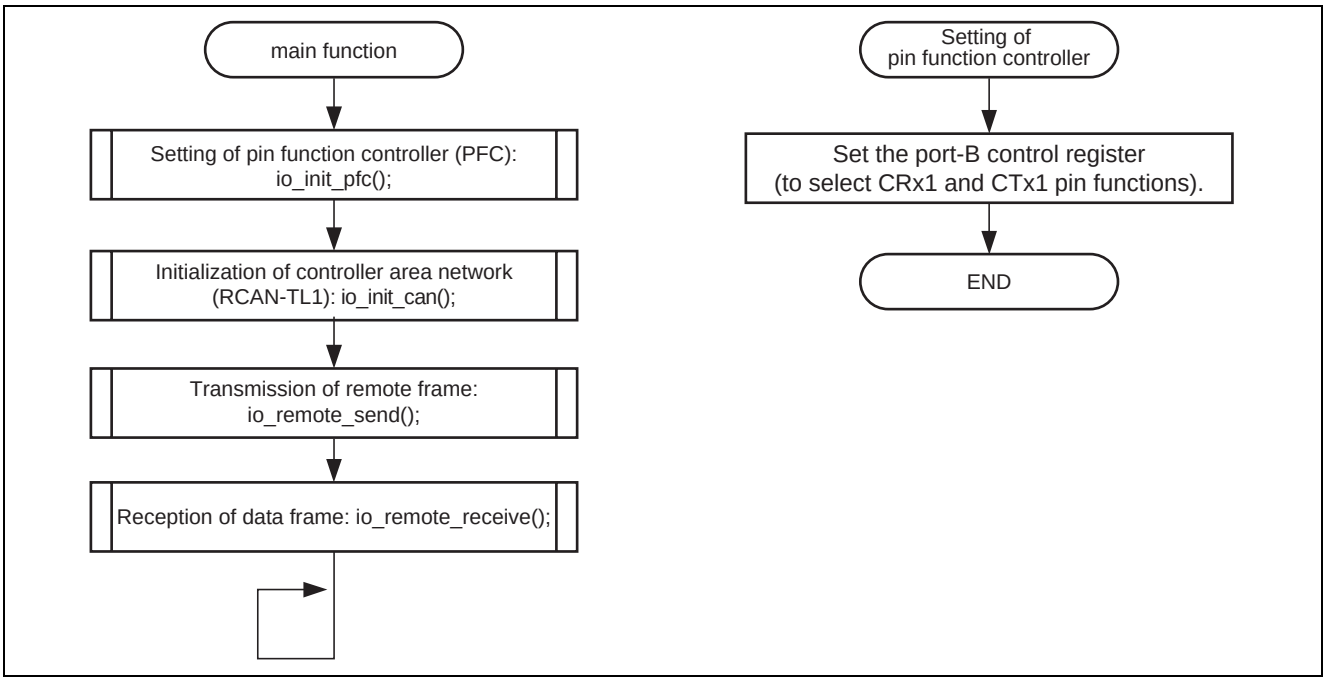


Figure 6 Example of Flow of Processing by the Sample Program (1)

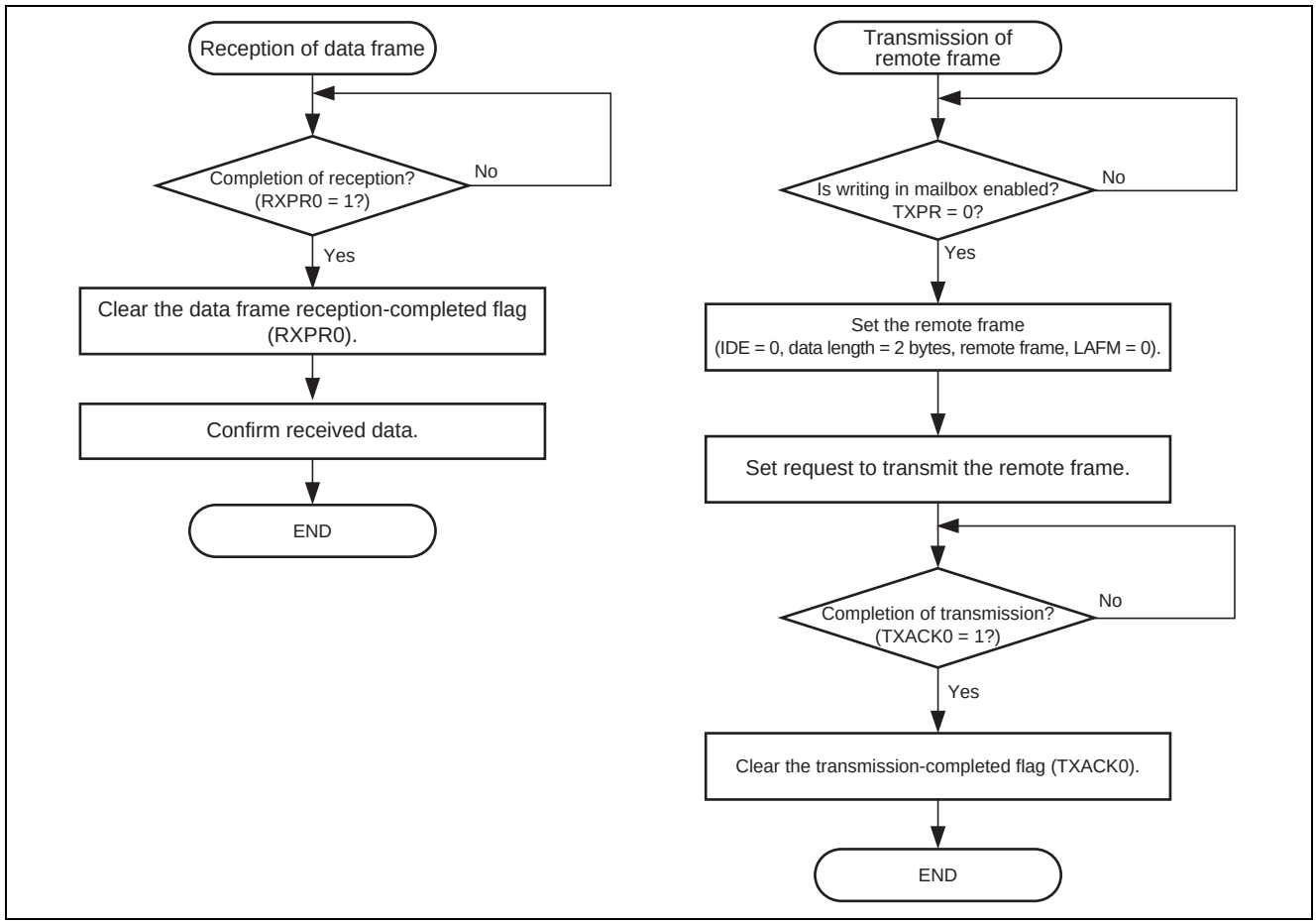


Figure 7 Example of Flow of Processing by the Sample Program (2)

3. Sample Program

```
/*""FILE COMMENT""*****************************************************************
*
*       System Name : SH7203 Sample Program
*       File Name   : main.c
*       Contents    : Application of CAN Module (Data Frame Transmission)
*       Version     : 1.00.00
*       Model       : M3A-HS30
*       CPU         : SH7203
*       Compiler    : SHC9.0.3.0
*       note        : The module transmits a remote frame (DLC: 2) in standard format
*                     (IDE: 0) from mailbox 1 of CAN at a 500-kbps transfer rate over the
*                     CAN bus once. After transmission, it receives a data frame from
*                     mailbox 0 of CAN1 and writes the received frame to RAM.
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*
*       history   : 2007.06.26 ver.1.00.00
*""FILE COMMENT END""*************************************************************/
#include <machine.h>
#include "iodefine.h"       /* SH7203 iodefine  */

/* ---- prototype declaration ---- */
void main(void);
void io_init_pfc(void);
void io_init_can(void);
void io_remote_send(void);
void io_data_receive(void);

/* ---- symbol definition ---- */
#define CAN_GSR3 0x0008
#define CAN_MB0  0x0001
#define CAN_MB1  0x0002

/* ---- RAM allocation variable declaration ---- */
unsigned char   nIDE = 0;           /* ide */
unsigned char   nRTR = 0;           /* rtr */
unsigned char   nDLC = 0;           /* dlc */
unsigned int    nSID = 0;           /* sid */
unsigned int    nEID = 0;           /* eid */
unsigned char   gRcv_data[8];       /* data of message */
```

Figure 8 Sample Program Listing: "main.c" (1)

```
47    /*""FUNC COMMENT""*****************************************************
48     * Outline     : Sample Program main
49     *-------------------------------------------------------------------
50     * Include     : none
51     *-------------------------------------------------------------------
52     * Declaration : void main(void);
53     *-------------------------------------------------------------------
54     * Function    : Sample Program main
55     *-------------------------------------------------------------------
56     * Argument    : none
57     *-------------------------------------------------------------------
58     * Return Value: none
59     *-------------------------------------------------------------------
60     * Notice      : none
61     *""FUNC COMMENT END""*************************************************/
62    void main(void)
63    {
64
65        /* ==== Setting of PFC ==== */
66        io_init_pfc();
67
68        /* ==== Initializing CAN module ==== */
69        io_init_can();
70
71        /* ==== CAN remote frame transmission ==== */
72        io_remote_send();
73
74        /* ==== CAN data frame reception ==== */
75        io_data_receive();
76
77        while(1){
78            /* loop */
79        }
80
81    }
82
83    /*""FUNC COMMENT""*****************************************************
84     * Outline     : Setting of PFC
85     *-------------------------------------------------------------------
86     * Include     : #include "iodefine.h"
87     *-------------------------------------------------------------------
88     * Declaration : void io_init_pfc(void);
89     *-------------------------------------------------------------------
90     * Function    : Setting of Pin Function Controller (PFC)
91     *-------------------------------------------------------------------
92     * Argument    : none
93     *-------------------------------------------------------------------
94     * Return Value: none
95     *-------------------------------------------------------------------
96     * Notice      : none
97     *""FUNC COMMENT END""*************************************************/
98    void io_init_pfc(void)
99    {
100       /* ==== Setting of PFC ==== */
101       /* ---- Port B control register L3 ---- */
102       PORT.PBCRL3.BIT.PB10MD = 0x1;   /* Set CRx1 */
103       PORT.PBCRL3.BIT.PB11MD = 0x1;   /* Set CTx1 */
104
105   }
```

Figure 9 Sample Program Listing: "main.c" (2)

```
106    /*""FUNC COMMENT""*****************************************************
107     * Outline     : Setting of RCAN
108     *-------------------------------------------------------------------------
109     * Include     : #include "iodefine.h"
110     *-------------------------------------------------------------------------
111     * Declaration : void io_init_can(void);
112     *-------------------------------------------------------------------------
113     * Function    : Setting of Controller Area Network (RCAN)
114     *-------------------------------------------------------------------------
115     * Argument    : none
116     *-------------------------------------------------------------------------
117     * Return Value: none
118     *-------------------------------------------------------------------------
119     * Notice      : none
120     *""FUNC COMMENT END""*************************************************/
121    void io_init_can(void)
122    {
123        int i;
124
125        /* ==== Setting of power down mode(RCAN1) ==== */
126        CPG.STBCR5.BIT.MSTP52 = 0;
127
128        /* ==== Initializing CAN module ==== */
129        RCAN1.MCR.WORD |= 0x0001;       /* CAN Interface reset mode */
130        while((RCAN1.GSR.WORD & CAN_GSR3) != CAN_GSR3){
131            /* Reset state waiting */
132        }
133
134        /* ---- RCAN mode selection ---- */
135        RCAN1.MCR.WORD |= 0x8000;       /* RCAN-TL1 is not same as HCAN2 */
136
137        /* ---- Disable all can interrupt ---- */
138        RCAN1.IMR.WORD  = 0xFFFF;
139
140        /* ---- Config baudrate ---- */
141        RCAN1.BCR1.WORD = 0x6300;       /* tsg1=6(7bit),tsg2=3(4bit),sjw=0(1bit),bsp=0 */
142        RCAN1.BCR0.WORD = 0x0001;       /* 500K bps */
143    //  RCAN1.BCR0.WORD = 0x0003;       /* 250K bps */
144    //  RCAN1.BCR0.WORD = 0x0007;       /* 125K bps */
145
146        /* ---- Config mailbox0 as reception slot ---- */
147        RCAN1.MB[0].CONTROL1.WORD = 0x0200;     /* can receive data and remote frame */
148        RCAN1.MB[0].CONTROL0.LONG = 0x00000000; /* Initialize the Message Control Field */
149        RCAN1.MB[0].LAFM.LONG = 0x00000000;
150        for(i = 0; i < 8; i++){                 /* data clear */
151            RCAN1.MB[0].MSG_DATA[i] =  0x00;
152        }
153        /* ---- Config mailbox1 as transmission slot ---- */
154        RCAN1.MB[1].CONTROL1.WORD = 0x0002;     /* Can send data or remote frame, dlc=2 */
155        RCAN1.MB[1].CONTROL0.LONG = 0x40000000; /* standard remote frame, id=0x000 */
156        RCAN1.MB[1].LAFM.LONG = 0x00000000;
157        for(i = 0; i < 8; i++){                 /* data clear */
158            RCAN1.MB[1].MSG_DATA[i] =  0x00;
159        }
160
161        /* ---- Clear interrupt flags ---- */
162        RCAN1.IRR.WORD = 0xffff;
163
164        /* ---- Clear reset and halt ---- */
165        RCAN1.MCR.WORD &= 0xfffc;
166        while( (RCAN1.GSR.WORD & CAN_GSR3) != 0x0000 ){
167            /* reset state is end */
168        }
169
170    }
```

Figure 10 Sample Program Listing: "main.c" (3)

```
171    /*""FUNC COMMENT""*****************************************************
172     * Outline     : Transmission of Remote Frame
173     *-----------------------------------------------------------------------
174     * Include     : #include "iodefine.h"
175     *-----------------------------------------------------------------------
176     * Declaration : void io_remote_send(void);
177     *-----------------------------------------------------------------------
178     * Function    : RCAN1 is used to transmit a remote frame.
179     *-----------------------------------------------------------------------
180     * Argument    : none
181     *-----------------------------------------------------------------------
182     * Return Value: none
183     *-----------------------------------------------------------------------
184     * Notice      : none
185     *""FUNC COMMENT END""*************************************************/
186    void io_remote_send(void)
187    {
188
189        /* ---- Transmission waiting ---- */
190        while((RCAN1.TXPR0.LONG & CAN_MB1) == CAN_MB1){
191        }
192
193        /* ---- transmission data set ---- */
194        RCAN1.MB[1].CONTROL1.WORD = 0x0002;     /* Can send data or remote frame, dlc=2 */
195        RCAN1.MB[1].CONTROL0.LONG = 0x40000000; /* standard remote frame, id=0x000 */
196
197        /* ---- tramsmit the data ---- */
198        RCAN1.TXPR0.LONG = CAN_MB1;
199
200        /* ---- Transmission completion waiting ---- */
201        while((RCAN1.TXACK0.WORD & CAN_MB1) != CAN_MB1){
202        }
203
204        /* ---- Transmission completion flag clear ---- */
205        RCAN1.TXACK0.WORD = CAN_MB1;
206
207    }
```

Figure 11 Sample Program Listing: "main.c" (4)

```
208    /*""FUNC COMMENT""************************************************
209     * Outline     : Reception of Data frame
210     *-----------------------------------------------------------------
211     * Include     : #include "iodefine.h"
212     *-----------------------------------------------------------------
213     * Declaration : void io_data_receive(void);
214     *-----------------------------------------------------------------
215     * Function    : RCAN1 is used to receive a data frame.
216     *-----------------------------------------------------------------
217     * Argument    : none
218     *-----------------------------------------------------------------
219     * Return Value: none
220     *-----------------------------------------------------------------
221     * Notice      : none
222     *""FUNC COMMENT END""*******************************************/
223    void io_data_receive(void)
224    {
225        int i;
226
227        /* ---- Reception completion waiting ---- */
228        while((RCAN1.RXPR0.WORD & CAN_MB0) != CAN_MB0){
229        }
230
231        /* ---- Receive data storage ---- */
232        nIDE = RCAN1.MB[0].CONTROL0.BIT.IDE;
233        nRTR = RCAN1.MB[0].CONTROL0.BIT.RTR;
234        nDLC = RCAN1.MB[0].CONTROL1.BIT.DLC;
235        nSID = RCAN1.MB[0].CONTROL0.BIT.STDID;
236        nEID = RCAN1.MB[0].CONTROL0.BIT.EXDID;
237        if(nDLC > 8){
238            nDLC = 8;
239        }
240        for(i = 0; i < nDLC; i++){
241            gRcv_data[i] = RCAN1.MB[0].MSG_DATA[i];
242        }
243
244        /* ---- Reception completion flag clear ---- */
245        RCAN1.RXPR0.WORD = CAN_MB0;
246
247    }
248
249    /* End of File */
```

Figure 12 Sample Program Listing: "main.c" (5)

4. Documents for Reference

- Software Manual
  SH-2A, SH2A-FPU Software Manual
  The most up-to-date version of this document is available on the Renesas Technology Website.
- Hardware Manual
  SH7263 Group Hardware Manual
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