RX210, RX21A, and RX220 Groups

Power Line Frequency (50/60 Hz) Discrimination

R01AN1202EJ0101
Rev.1.01
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Abstract

This application note describes how to discriminate a power line frequency (50/60 Hz) using the interrupt controller (ICUA) and compare match timer (CMT) in the RX210, RX21A, and RX220 Groups.

Products

RX210, RX21A, and RX220 Groups

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

Contents

1. Specifications

This sample program uses the CMT to count the time from one rising edge to the next on an input to the PD0/IRQ0 pin that consists of the commercial line waveform converted to a square wave.

The frequency is determined to be 50 Hz, 60 Hz, or an anomalous frequency by comparing the count value to threshold values. The sample code references the compare match timer counter to acquire the count value.

If the frequency discrimination result is the same (either 50 Hz or 60 Hz) for five consecutive measurements, the sample program recognizes the frequency to be 50 or 60 Hz, respectively. If an anomaly is recognized, the program repeats the frequency discrimination operation.

Table 1.1 lists the peripheral functions used and their applications and figure 1.1 presents an overview of this operation.

Table 1.1 Peripheral Functions Used and Their Applications

Peripheral Function	Application
CMT	Measures the time between rising edges on the power line frequency.
IRQ0	Detects rising edges on the power line frequency.

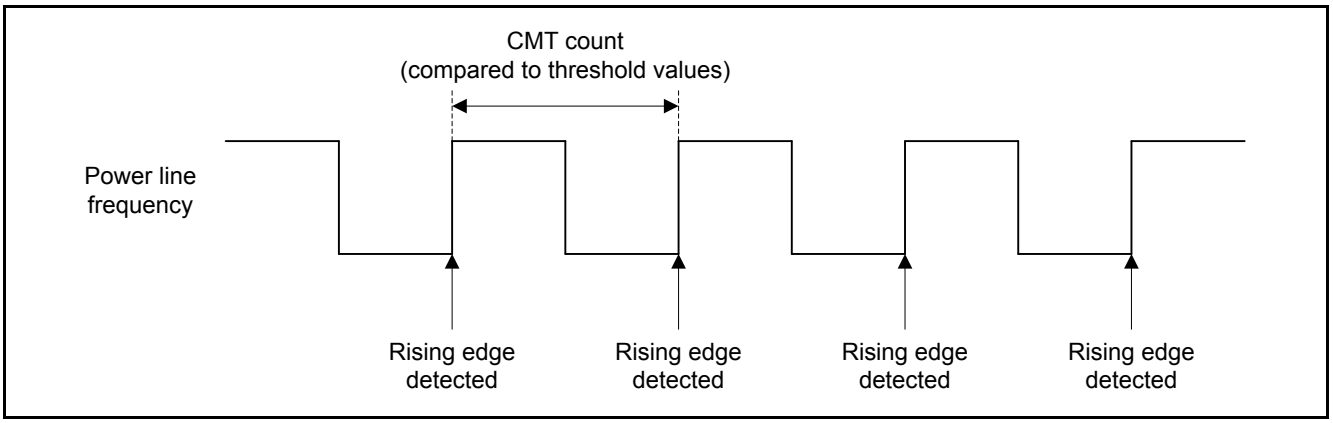

Figure 1.1 Operational Overview

2. Confirmed Operating Condition

Operation of the sample code in this application note has been verified under the following conditions.

Table 2.1 Confirmed Operating Condition

Item	Description
Microcontroller used	R5F52108ADFP (RX210 Group)
Operating frequency	Main clock: 20.0 MHz Sub clock: 32.768 kHz PLL: Main clock divided by 2 and multiplied by 10 System clock (ICLK): 50 MHz (PLL divided by 2) Peripheral module clock B (PCLKB): 25 MHz (PLL divided by 4)
Operating voltage	5.0 V is supplied from E1.
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.09.00.007
C compiler	RX Family C/C++ Compiler V.1.02
	-cpu=rx200 -output=obj="$(CONFIGDIR)\$(FILELEAF).obj" -debug –nologo (The integrated development environment default settings are used.)
iodefine.h version	Version 1.00
Endian order	Little endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.00
Board used	Renesas Starter Kit for RX210 (Product number: R0K505210C000BE)

3. Reference Application Notes

For additional information associated with this document, refer to the following application notes.

- RX210 Group Initial Setting Rev. 1.00 (R01AN1002EJ)
- RX21A Group Initial Setting Rev. 1.10 (R01AN1486EJ)
- RX220 Group Initial Setting Rev. 1.10 (R01AN1494EJ)

The initial setting functions in the reference application notes are used in the sample code in this application note. The revision numbers of the reference application notes are current as of when this application note was made. However the latest version is always recommended. Visit the Renesas Electronics Corporation website to check and download the latest version.

4. Hardware

4.1 Hardware Structure

Figure 4.1 shows the hardware connections used

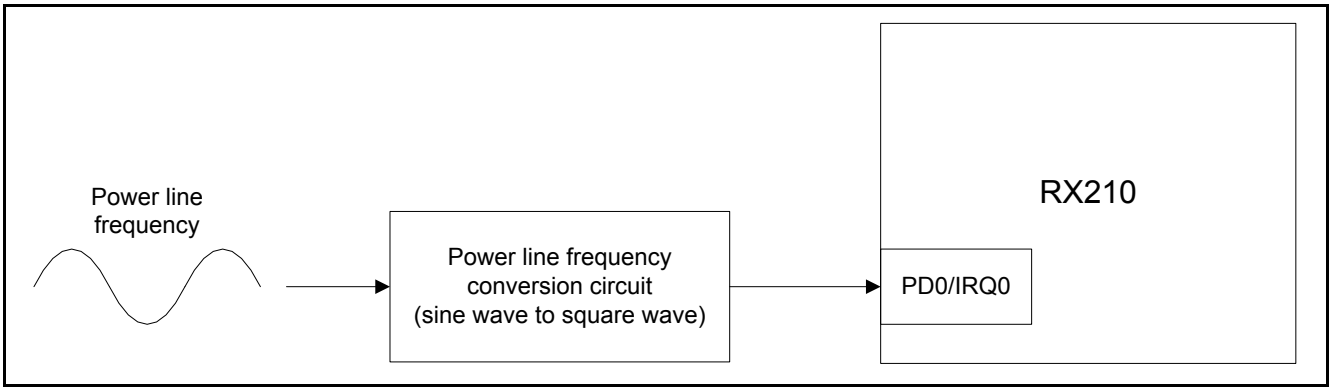

Figure 4.1 Hardware Connections

4.2 Pin Used

Table 4.1 lists the pin used and its function.

Table 4.1 Pin Used and Its Function

Pin	I/O	Function
PD0/IRQ0	Input	Rising edge detection on the power line frequency

5. Software

5.1 Operational Overview

The sample program discriminates the frequency using the CMT count value counting between rising edges of the power line frequency input to the PD0/IRQ0 pin.

IRQ interrupt handling is performed on each rising edge of the power line frequency. In the IRQ interrupt handler, the CMT is temporarily stopped, the count value is read, and then the CMT is restarted to measure the time until the next edge.

The acquired count value is compared to threshold values to determine the line frequency. If the count is in the range corresponding to 45 to 55 Hz, a frequency of 50 Hz is recognized, and if it is in the range for 55 to 65 Hz, 60 Hz is recognized. An abnormality is determined if it is any other value. If the frequency discrimination result is either 50 Hz or 60 Hz for five consecutive measurements, the result is determined as the frequency.

The threshold values for 45 Hz, 55 Hz, and 65 Hz are calculated with the following procedure when the count cycle of the CMT is set to 128 μs.

1. The period for one cycle for each of the frequencies is determined
2. The CMT count period is determined
3. The period for one cycle for each of the frequencies is divided by the CMT count period and one is subtracted from the result.

The threshold values are calculated as follows using the above procedure.

45 Hz: 1 ÷ 45 (Hz) ÷ (1 ÷ 25000000 (Hz) × 32 (division)) – 1 = 17360.111... ≅ 17360

55 Hz: 1 ÷ 55 (Hz) ÷ (1 ÷ 25000000 (Hz) × 32 (division)) – 1 = 14203.545... ≅ 14204

65 Hz: 1 ÷ 65 (Hz) ÷ (1 ÷ 25000000 (Hz) × 32 (division)) – 1 = 12018.230... ≅ 12018

Figure 5.1 shows the timing chart for this function.

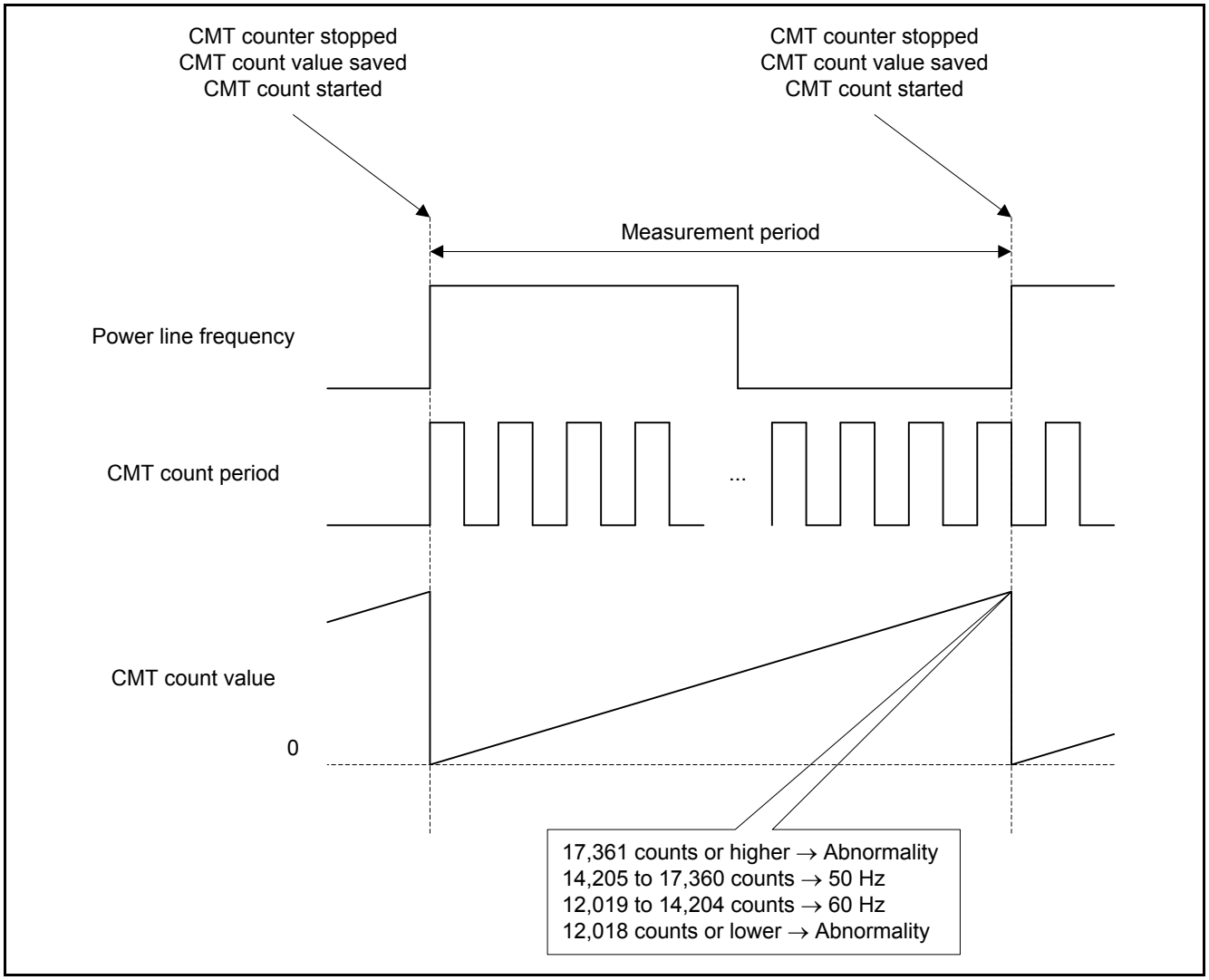

Figure 5.1 Timing Chart

5.2 File Composition

Table 5.1 lists the files used for the sample code. Note that the files generated automatically by the integrated development environment are not shown.

Table 5.1 File Composition

File	Overview	Remarks
main.c	Main processing	
non_existent_port_init.c	Nonexistent port initialization	
non_existent_port_init.h	External reference include header for nonexistent port initialization	
clock_init.c	Clock initialization	
clock_init.h	External reference include header for clock initialization	
intprg.c	Interrupt handling	

5.3 Option Settings Memory

Table 5.2 lists the states of the option settings memory used by the sample code. Set these locations to appropriate values for your user system as required.

Table 5.2 Option Settings Memory Set by the Sample Code

Symbol	Address	Set value	Description
OFS0	FFFF FF8Fh – FFFF FF8Ch	FFFF FFFFh	Stops IWDT after a reset Stops WDT after a reset
OFS1	FFFF FF8Bh – FFFF FF88h	FFFF FFFFh	Disables voltage monitoring resets after a reset Disables HOCOC oscillation after a reset
MDES	FFFF FF83h – FFFF FF80h	FFFF FFFFh	Little endian (in single-chip mode)

5.4 Constants

Table 5.3 lists the constants used in the sample code.

Table 5.3 Constants Used in the Sample Code

Constant	Set Value	Description
CNT_45HZ	17360	CMT period count for 45 Hz (22.2 ms)
CNT_55HZ	14204	CMT period count for 55 Hz (18.2 ms)
CNT_65HZ	12018	CMT period count for 65 Hz (15.4 ms)
FREQ_ERROR	0	Discrimination error
FREQ_50HZ	1	Discrimination result is 50 Hz
FREQ_60HZ	2	Discrimination result is 60 Hz

5.5 Variables

Table 5.4 lists the global variables.

Table 5.4 Global Variables

Type	Name	Description	Function
unsigned char	f_edge	Rising edge information	freq_judge IRQ_INT
unsigned short	cnt_buf	CMT count value storage	freq_judge IRQ_INT
unsigned char	freq_fix	Frequency discrimination result	freq_judge

5.6 Functions

Table 5.5 lists the functions.

Table 5.5 Functions

Function	Description
main	Main processing
port_init	Port initialization
non_existent_port_init	Nonexistent port initialization
clock_init	Clock initialization
peripheral_init	Peripheral function initialization
cmt_init	CMT initialization
irq_init	IRQ initialization
freq_judge	Frequency discrimination
IRQ_INT	IRQ0 interrupt handler

5.7 Function Specifications

This section lists the specifications of the functions in the sample code.

main	
Overview	Main processing
Header	None
Declaration	void main(void)
Description	Initializes the ports, clocks, and peripheral functions used. Performs frequency discrimination processing.
Arguments	None
Return values	None

port_init	
Overview	Port initialization
Header	None
Declaration	void port_init(void)
Description	Initializes the ports.
Arguments	None
Return values	None

non_existent_port_init	
Overview	Nonexistent port initialization
Header	non_existent_port_init.h
Declaration	void non_existent_port_init(void)
Description	Initializes the nonexistent ports.
Arguments	None
Return values	None
Remarks	For details on this function, refer to the Initial Setting application note for the product used. There are cases where ports that do not exist must be initialized due to the number of pins in the particular microcontroller product used. This processing is not required for products that include the RSK used by this system.

clock_init	
Overview	Clock initialization
Header	clock_init.h
Declaration	void clock_init(void)
Description	Initializes the clocks.
Arguments	None
Return values	None
Remarks	For details on this function, refer to the Initial Setting application note for the product used.

peripheral_init	
Overview	Peripheral function initialization
Header	None
Declaration	void peripheral_init(void)
Description	Initializes the used peripheral functions.
Arguments	None
Return values	None

cmt_init	
Overview	CMT initialization
Header	None
Declaration	void cmt_init(void)
Description	Initializes CMT. • Counts with PCLK/32.
Arguments	None
Return values	None

irq_init	
Overview	IRQ initialization
Header	None
Declaration	void mtu_init(void)
Description	Initializes IRQ0. • An interrupt is generated on a rising edge.
Arguments	None
Return values	None

freq_judge	
Overview	Frequency discrimination
Header	None
Declaration	void freq_judge(void)
Description	Determines the frequency of the power line frequency. • Recognizes the frequency as 50 Hz for frequencies in the range 45 to 55 Hz. • Recognizes the frequency as 60 Hz for frequencies in the range 55 to 65 Hz.
Arguments	None
Return values	None

IRQ_INT	
Overview	IRQ0 interrupt handler
Header	None
Declaration	void IRQ_INT(void)
Description	Stops the CMT count, acquires the count value, and restarts the CMT count.
Arguments	None
Return values	None

5.8 Flowcharts

5.8.1 Main Processing

Figure 5.2 shows the flowchart for the main processing.

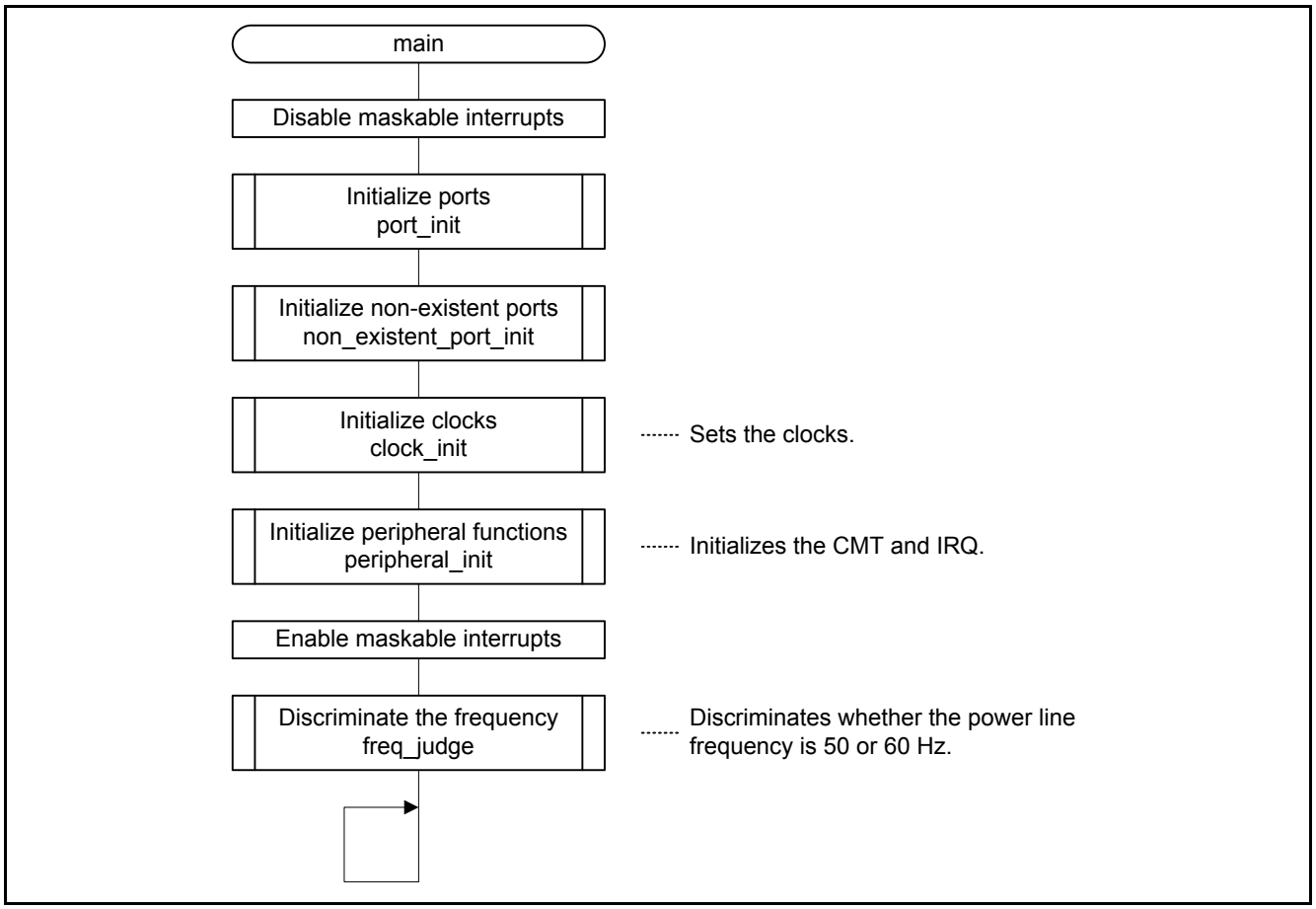

Figure 5.2 Main Processing

5.8.2 Port Initialization

Figure 5.3 shows the flowchart for port initialization.

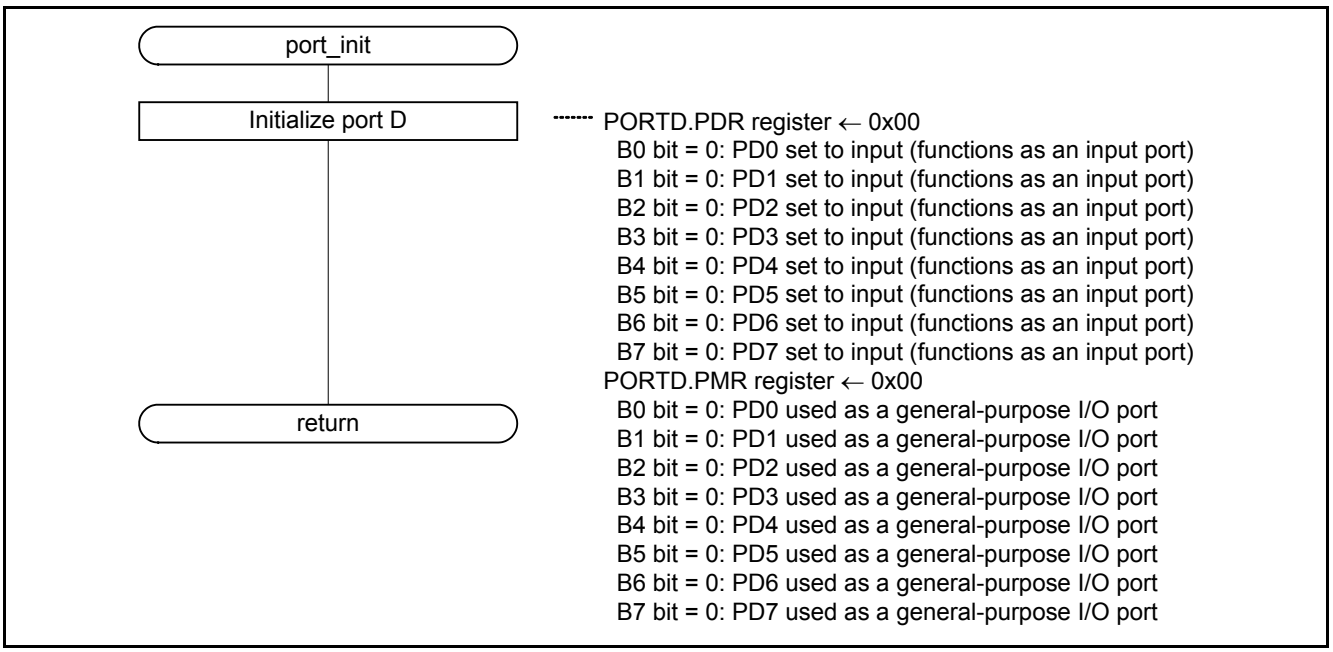

Figure 5.3 Port Initialization

5.8.3 Peripheral Function Initialization

Figure 5.4 shows the flowchart for peripheral function initialization.

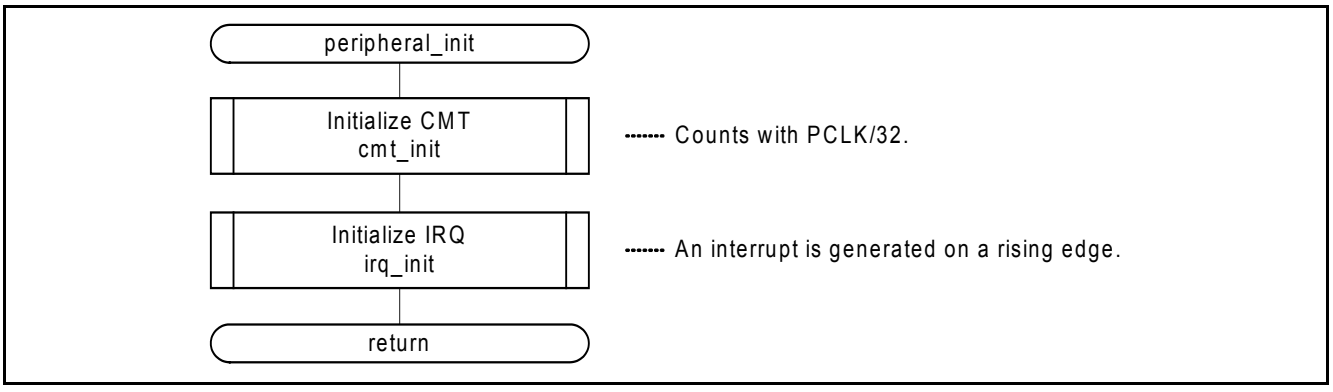

Figure 5.4 Peripheral Function Initialization

5.8.4 CMT Initialization

Figure 5.5 shows the flowchart for CMT initialization.

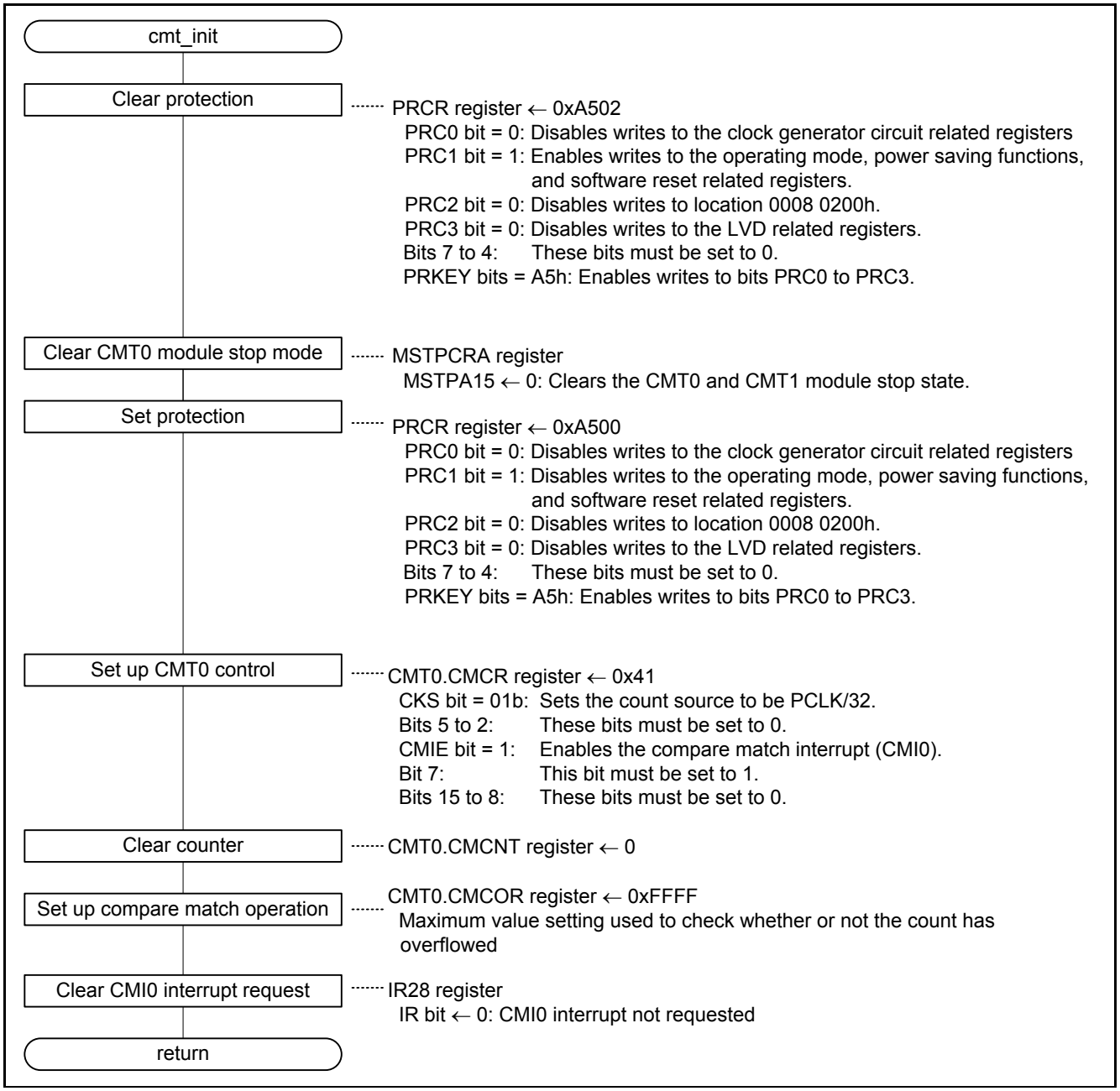

Figure 5.5 CMT Initialization

5.8.5 IRQ Initialization

Figure 5.6 shows the flowchart for IRQ initialization.

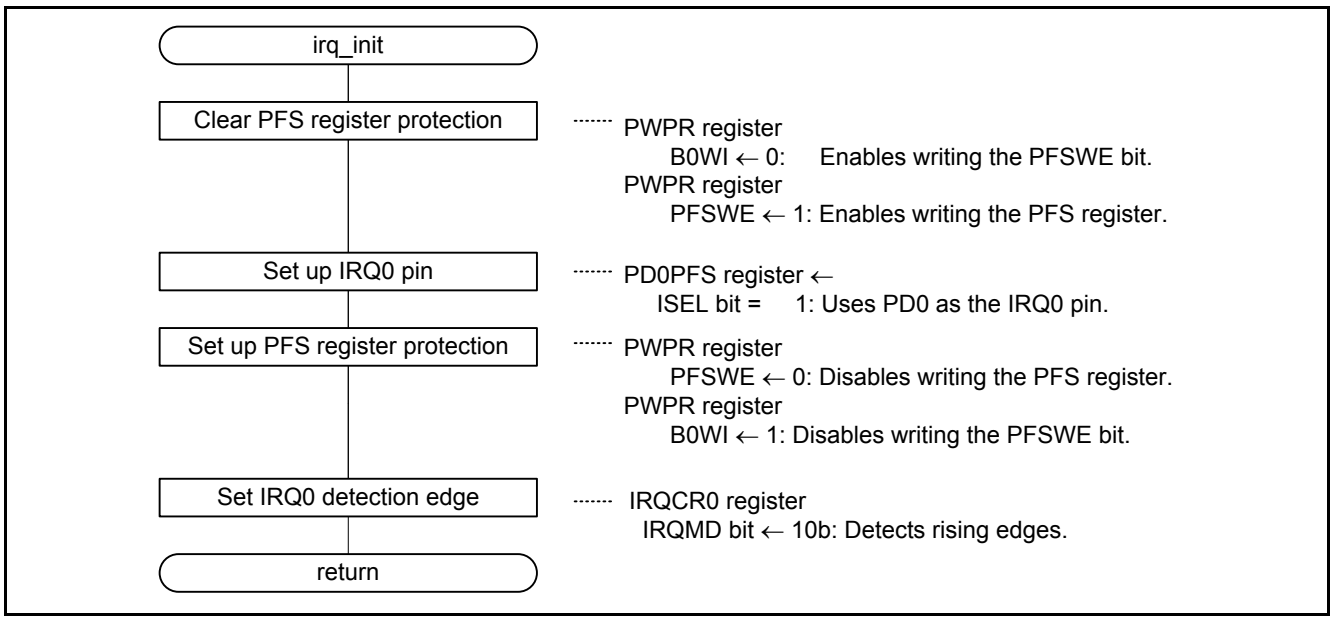

Figure 5.6 IRQ Initialization

5.8.6 Frequency Discrimination

Figures 5.7 and 5.8 show the flowchart for frequency discrimination.

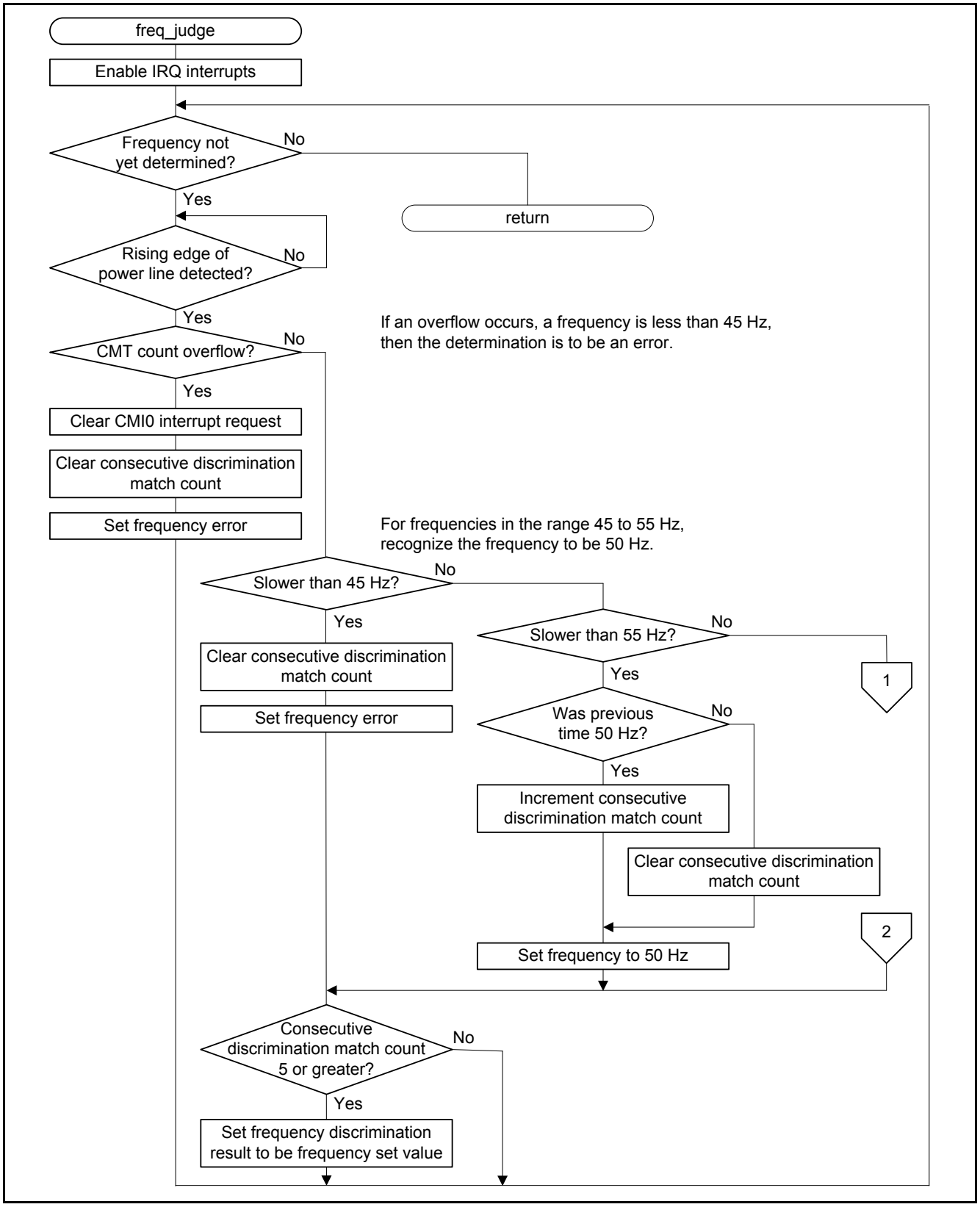

Figure 5.7 Frequency Discrimination (1/2)

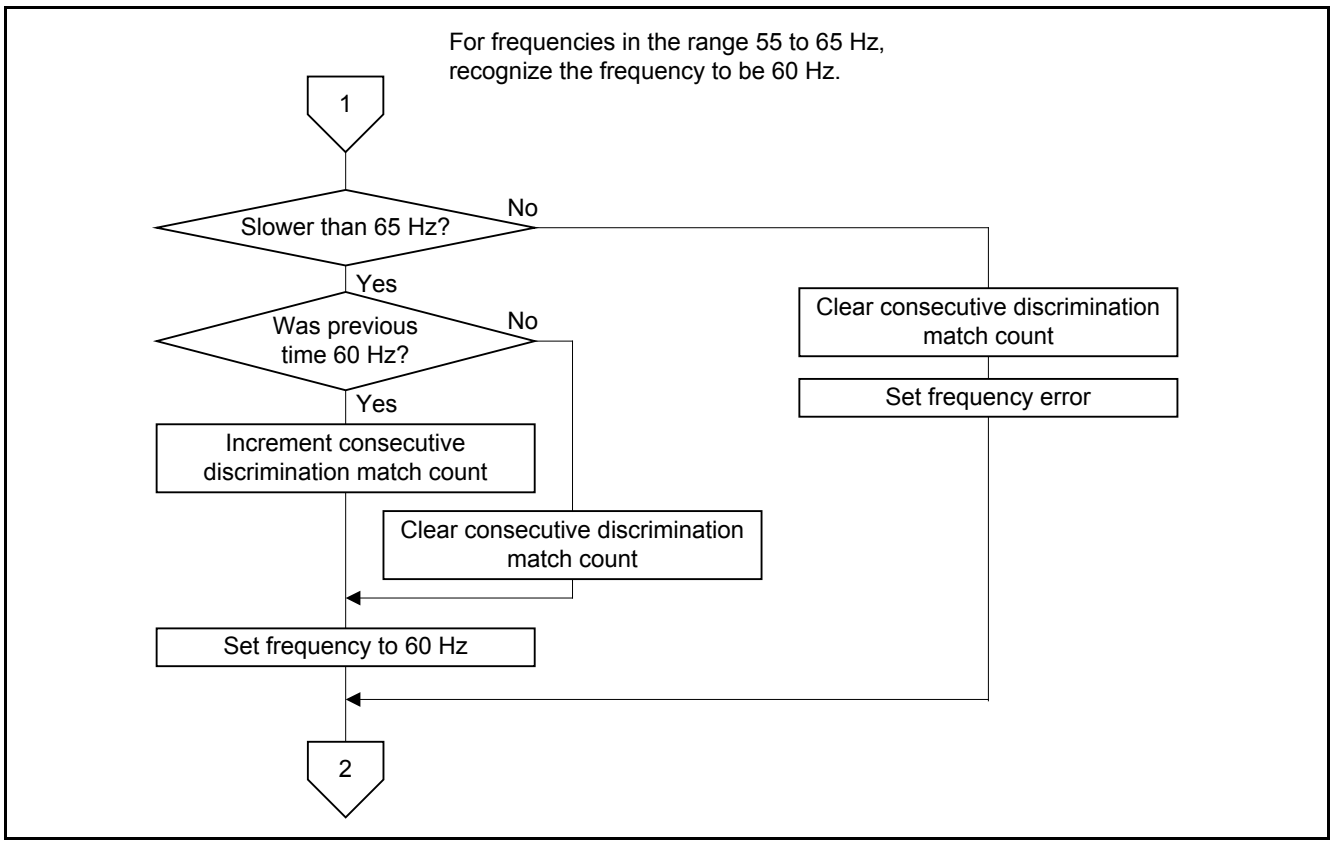

Figure 5.8 Frequency Discrimination (2/2)

5.8.7 IRQ Interrupt Handler

Figure 5.9 shows the flowchart for IRQ interrupt handling.

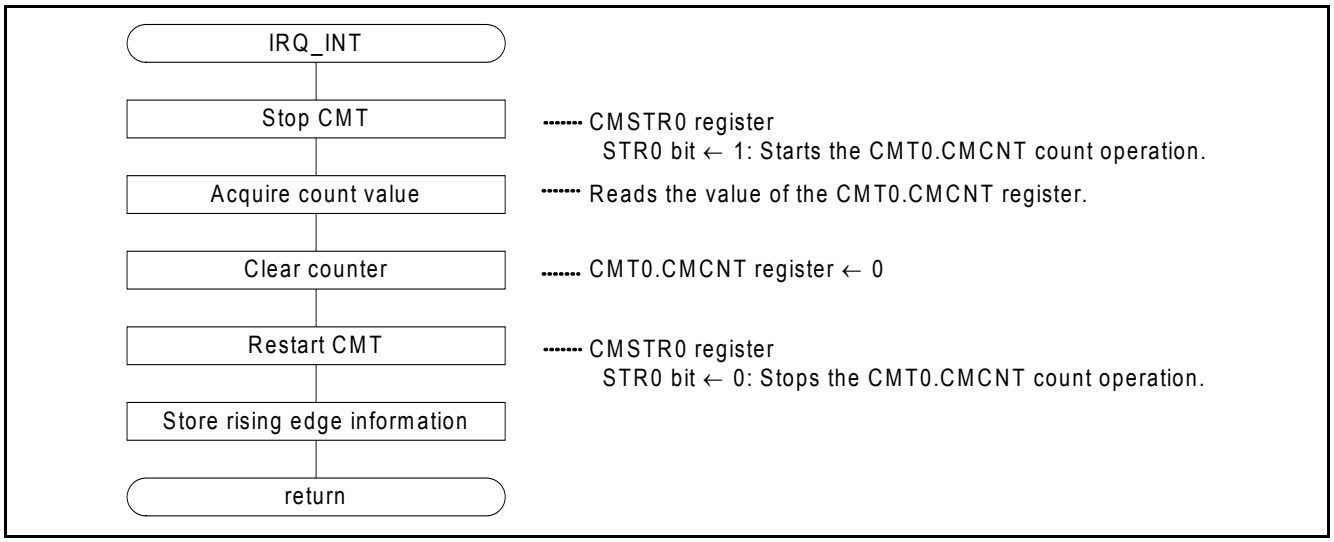

Figure 5.9 IRQ Interrupt Handler

6. Applying This Application Note to the RX21A or RX220 Group

The sample code accompanying this application note has been confirmed to operate with the RX210 Group. To make the sample code operate with the RX21A or RX220 Group, use this application note in conjunction with the Initial Setting application note for each group.

To use this application note with the RX21A and RX220 Group, modify the main.c file accompanying this application note as shown steps (1) to (5) below, and then refer to “5. Applying the RX210 Group Application Note to the RX21A Group” in the RX21A Group Initial Setting application note, and “4. Applying the RX210 Group Application Note to the RX220 Group” in the RX220 Group Initial Setting application note.

(1) Change the #include for “iodefine.h” to “../iodefine.h”.

(2) Add a #include for “r_init_stop_module.h”.

(3) Change the #includes for “clock_init.h” and “non_existent_port_init.h” to “r_init_clock.h” and “r_init_non_existent_port.h”, respectively.

```
39  ***********************************************************************************
40  * History : DD.MM.YYYY Version Description
41  *         : 14.05.2010 1.00    First Release
42  ***********************************************************************************/
43  #include    "../iodefine.h"
44  #include <machine.h>
45  #include "r_init_clock.h"
46  #include "r_init_stop_module.h"
47  #include "r_init_non_existent_port.h"
48
```

(4) Add a call for the R_INIT_StopModule() function in the main function.

(5) Change the calls for “non_existent_port_init()” and “clock_init()” in the main function to calls for “R_INIT_NonExistentPort()” and “R_INIT_Clock()”, respectively.

```
84  * Calling Functions    : sfr_init() : Sfr Setting
85  *""FUNC COMMENT END""*************************************************/
86  void main(void)
87  {
88      /* ---- Disable maskable interrupts ---- */
89      clrpsw_i();
90      /* ---- initialize prots ---- */
91      port_init();
92
93      R_INIT_StopModule();
94      /* ---- Initialize non-existent ports ---- */
95      R_INIT_NonExistentPort();
96      /* ---- Initialize the clock ---- */
97      R_INIT_Clock();
98      /* ---- Initialize peripheral functions ---- */
99      peripheral_init();
100     /* ---- enable maskable interrupts ---- */
101     setpsw_i();
102
103     freq_judge();
104
105     while(1);
106 }
```

7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

8. Reference Documents

User's Manual: Hardware

RX210 Group User's Manual: Hardware Rev.1.50 (R01UH0037EJ)
RX21A Group User's Manual: Hardware Rev.1.00 (R01UH0251EJ)
RX220 Group User's Manual: Hardware Rev.1.10 (R01UH0292EJ)
The latest versions can be downloaded from the Renesas Electronics website.

Technical updates and technical news

The latest technical information can be downloaded from the Renesas Electronics Corporation website.

C compiler manual

RX210 C Compiler Package, Version 1.02
C Compiler User's Manual, Revision 1.00
Download the latest version of this manual from the Renesas Electronics Corporation website.

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REVISION HISTORY	RX210, RX21A, and RX220 Groups Application Note Power Line Frequency (50/60 Hz) Discrimination

Rev.	Date	Description	
		Page	Summary
1.00	Sep. 25, 2012	—	First edition issued
1.01	July 1, 2014	1	Products: Added the RX21A and RX220 Groups.
		4	3. Reference Application Notes: Added the Initial Setting application notes for the RX21A and RX220 Groups.
		10	Modified the description of reference application note in the following functions: non_existent_port_init and clock_init.
		18	6. Applying This Application Note to the RX21A or RX220 Group: Added.
		19	8. Reference Documents: Added the User's Manual: Hardware for the RX21A and RX220 Groups.

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 document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Handling of Unused Pins

   Handle unused pins in accordance 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 a product with a different part number, confirm that the change will not lead to problems.

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