RL78/G10

Smart Power Strip

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Introduction

This document describes a Renesas microcontroller RL78/G10 application for a smart power strip.

Target Device

RL78/G10

When applying the sample program covered in this document to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

Contents

1. Description

1.1 Abstract

Smart power strip (master-slave outlets intelligent control) is a very popular kind of household appliance. It is widely used in the intelligent linkage control and power saving of the connecting devices, such as mainframe computer with peripheral equipment, television with set-top box and router, etc. This application note provides a smart power strip application based on the low power consumption and small package MCU of Renesas' RL78/G10. Its main product characteristic is when the device connected to the master outlet turns on or turns off, MCU turns on or turns off the power supply of the device connected to the slave outlet automatically. The intelligent linkage and power saving are realized by this way.

1.2 Specifications and Main Technical Parameters

Technical Parameters

- Voltage rating: 220 VAC
- Current rating: 10 A
- Power rating: < 2000 W
- Master outlet power detection threshold: > 30 W
- Slave outlet power supply ON-OFF delay setting: 100 ms
- Slave outlet power supply ON-OFF control method: Relay method

Specifications

- Intelligent linkage control and power saving: If the device connected to the master outlet turns on or turns off, the power supply of the slave outlet will be turned on or turned off with a delay of 100 ms automatically.
- Operating temperature: -10 °C ~ 40 °C
- Operating humidity: 30% RH ~ 95% RH

2. RL78/G10 Microcontroller

2.1 RL78/G10 Block Diagram

Figure 2.1 shows the block diagram of RL78/G10 (10-pin products).

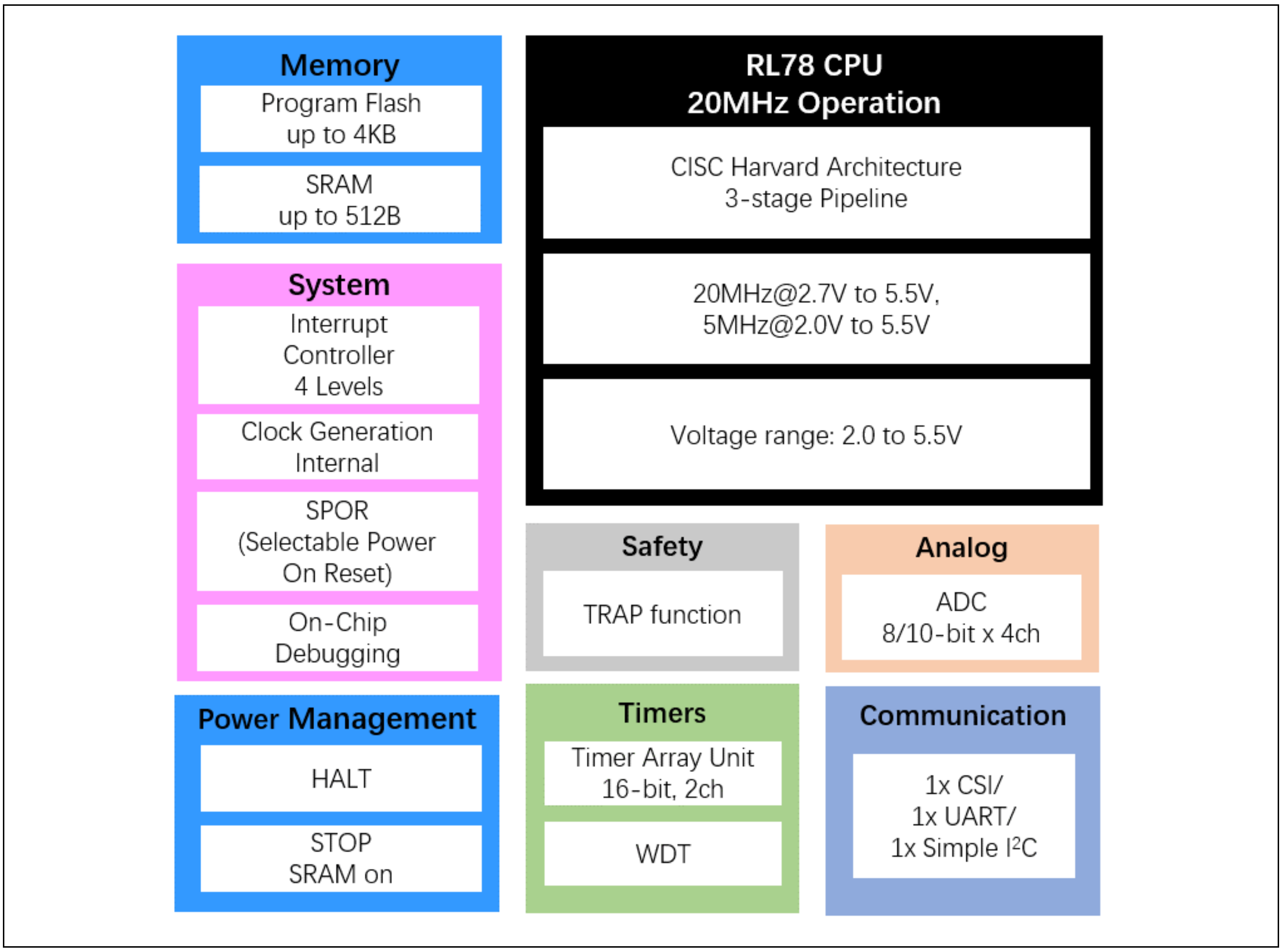

Figure 2.1 RL78/G10 (10-pin products) Block Diagram

2.2 Key Features

- Minimum instruction execution time: Can be changed from high speed (0.05 µs @ 20 MHz operation with high-speed on-chip oscillator) to low speed (1.0 µs @ 1 MHz operation)
- General-purpose registers: 8-bit register × 8
- ROM: 1 to 4 KB, RAM: 128 to 512 bytes
- Selectable high-speed on-chip oscillator clock: 20/10/5/2.5/1.25 MHz (TYP.)
- On-chip single power supply flash memory
- On-chip debug function
- On-chip selectable power-on-reset (SPOR) circuit
- On-chip watchdog timer (operable with the dedicated low-speed on-chip oscillator)
- On-chip key interrupt function: 6 key interrupt input pins
- On-chip clock output/buzzer output controller
- On-chip BCD (binary-coded decimal) correction circuit
- I/O port: 8
- Timer
  8/16-bit timer: 2 channels
- Serial interface
  CSI: 1 channel
  UART: 1 channel
  Simplified I²C communication: 1 channel
- 8/10-bit resolution A/D converter: 4 channels
- Standby function: HALT or STOP mode
- Power supply voltage: V_{DD} = 2.0 to 5.5 V
- Operating ambient temperature: T_A = -40 to +85 °C

RL78/G10 is widely used in small consumer electronics for industry, office, home appliance, healthcare, security and city application.

2.3 Pin Configuration

Figure 2.2 shows the pin configuration of RL78/G10 (10-pin products).

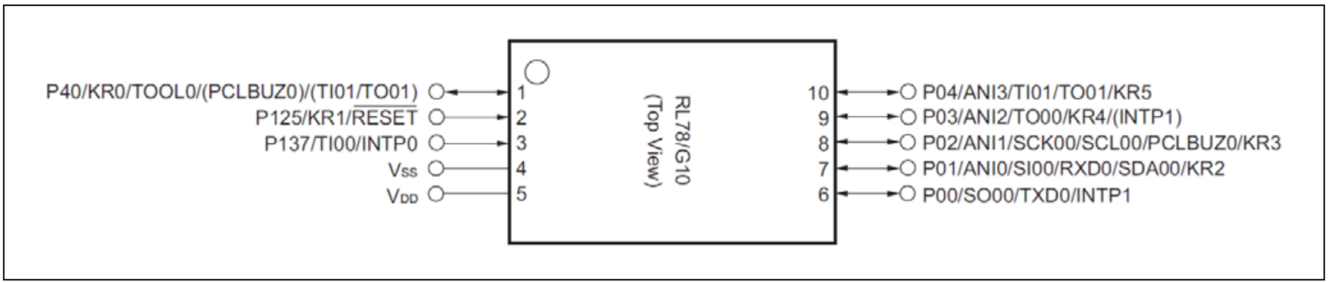

Figure 2.2 RL78/G10 (10-pin products) Pin Configuration

3. System Outline

3.1 Principle Introduction

After system initialization is completed, MCU detects whether a device is connected to the master outlet or not through a low cost single-phase active energy metering chip in real-time. To improve the anti-interference capability, the default threshold is set to 30 W. Meanwhile, the MCU also detects the power of the device connected to the master outlet with filtering method by using software trimmed mean in real-time. When the power of the device connected to the master outlet is larger than the default threshold, the MCU uses a relay to turn on the power supply of the slave outlet. When the power of device connected to the master outlet is less than the default threshold, MCU uses relay to turn off the power supply of the slave outlet. By this way, the intelligent linkage control between master and slave outlets and the power saving can be realized.

Figure 3.1 shows the system block diagram.

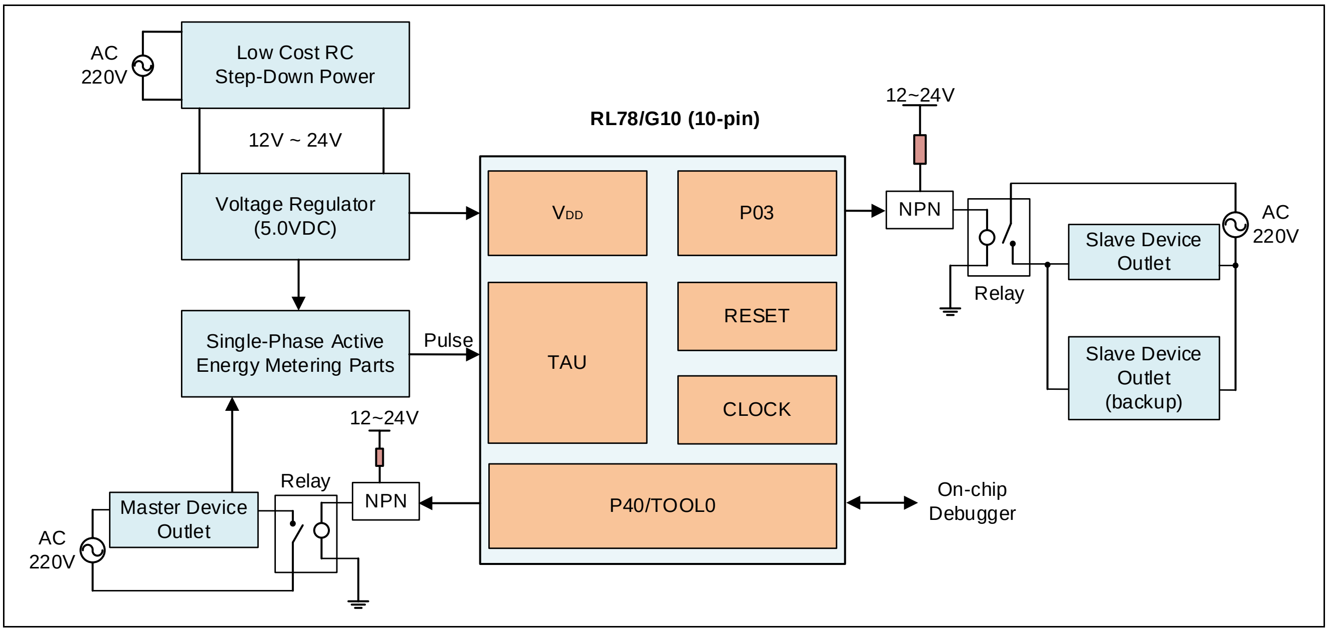

Figure 3.1 System Block Diagram

3.2 Peripheral Functions to be Used

Table 3.1 lists the peripheral functions to be used and their usage.

Table 3.1 Peripheral Functions to be Used

Peripheral Function	Usage
Channel 0 of TAU0	Measure pulse from energy metering IC to check whether an electric appliance (> 30 W) is turned on in master outlet.
Channel 1 of TAU0	Operated as a 20 ms counter. When count to 200 ms continuously, that indicates there is no load in master outlet.

3.3 Pins to be Used

Table 3.2 lists the pins to be used and their function.

Table 3.2 Pins to be Used

Pin Name	Description
P40/TOOL0[Note]	On-chip debug / Relay control signal for master outlet
P125/RESET	Hardware reset
P137/TI00	Power measurement frequency signal input
V_{SS}	Ground
V_{DD}	Power supply voltage
P00/TxD0	UART transfer (reserved)
P01/RxD0	UART receive (reserved)
P03	Relay control signal for slave outlet

Note: When JP1 setting is pin1-2 shorted, P40 is connected to E1 debugger interface as the TOOL0 function.
When JP1 setting is pin2-3 shorted, P40 is connected to the relay for the master outlet as control signal.

3.4 Operating Instructions

(1) After system initialization is completed, the master outlet is connected to the power supply.

(2) If an electric appliance (> 30 W) is turned on in the master outlet, the slave outlets will be connected to the power supply. If there is no appliance or there is an appliance which is turned off or an electric appliance (< 30 W) is turned on in master outlet, the slave outlets will be cut off from the power supply.

4. Hardware

There is a low cost RC step-down circuit to transform 220 VAC voltage to 24 VDC voltage then supplies it to the relay. And further, TL431A buck circuit reduces 24 VDC voltage to 5 VDC voltage then supplies it to the MCU and the low cost single phase active energy metering chip. And there are two Omron single relays. One is to control master outlet power supply, the other is to control all slave outlets power supply. Energy metering chip detects the active power of the device in master outlet, and sends the energy signal to the MCU via a pulse. The MCU receives the pulse and calculates the value of the power to control the relays.

Figure 4.1 shows the board picture.

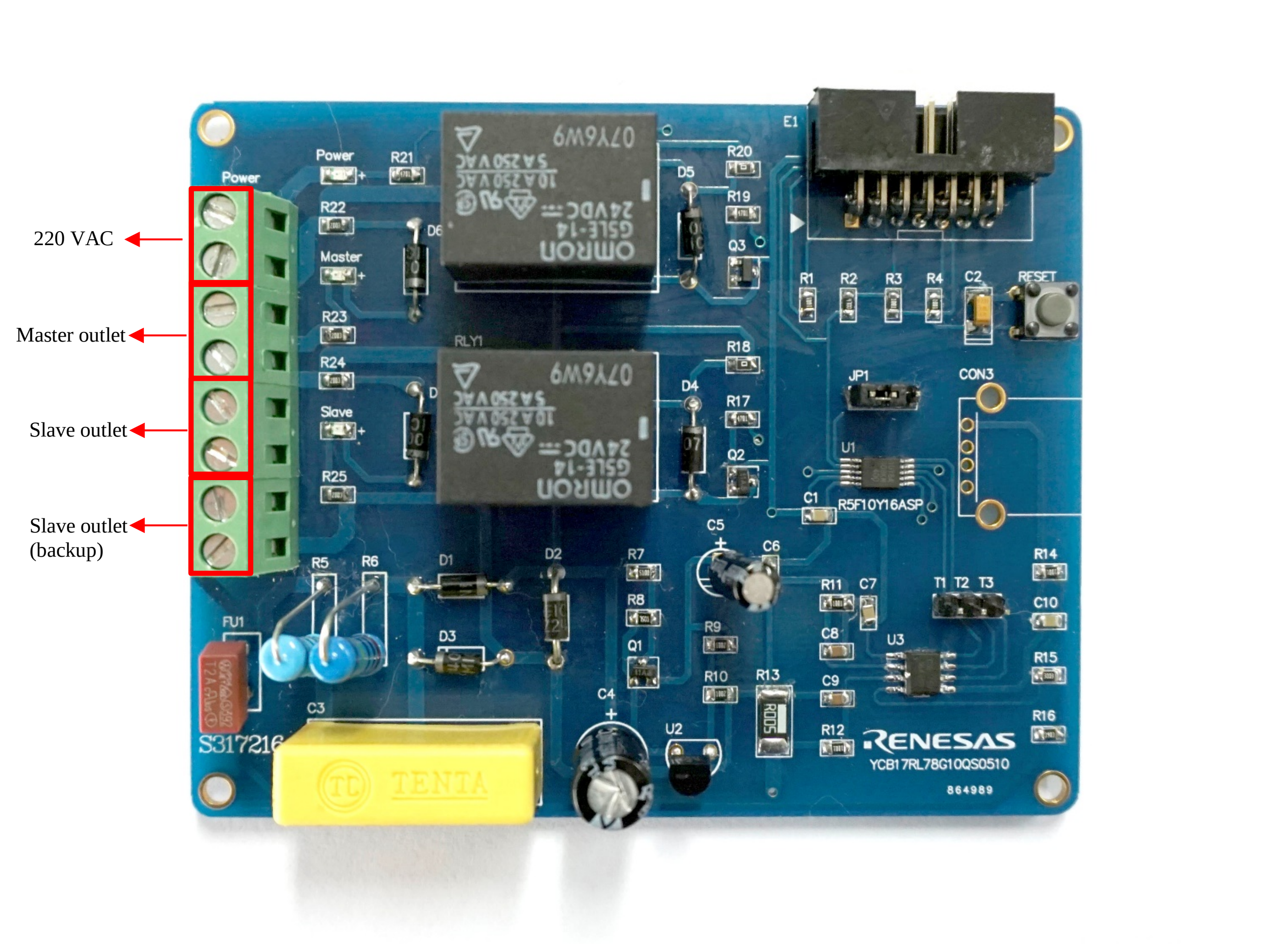

Figure 4.1 Board Picture

4.1 Power Supply Circuit

Figure 4.2 shows the schematics of the power supply circuit.

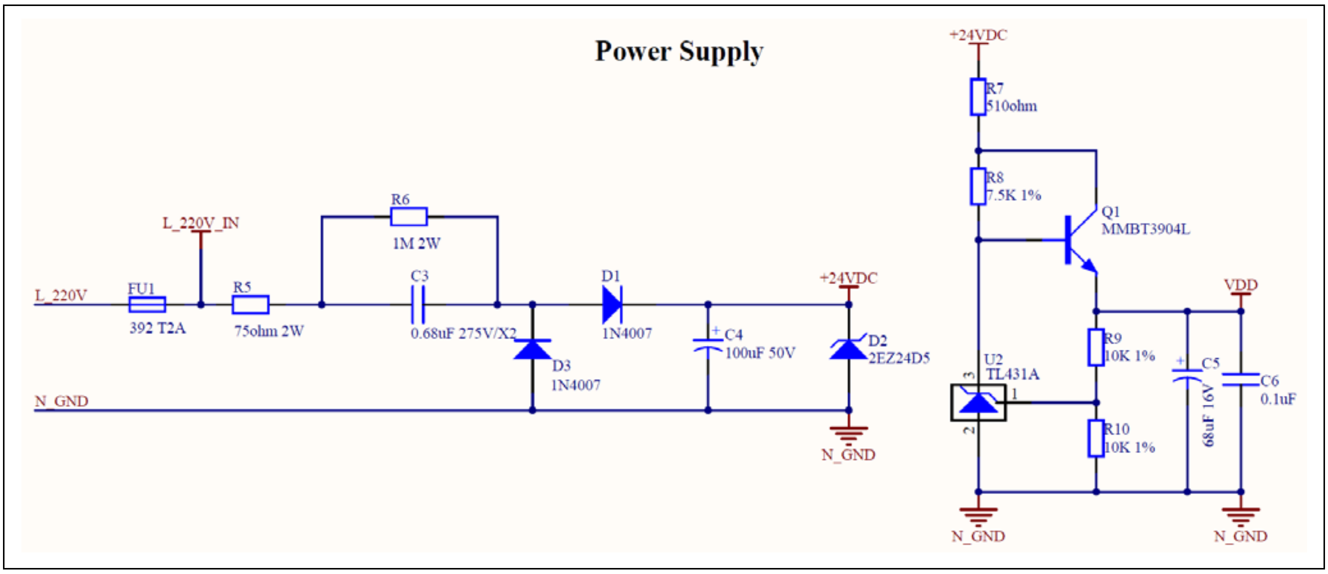

Figure 4.2 Power Supply Circuit

Low cost RC step-down circuit transforms 220 VAC voltage to 24 VDC voltage then supplies it to the relay. And further, TL431A buck circuit reduces 24 VDC voltage to 5 VDC voltage then supplies it to the MCU and the low cost single phase active energy metering chip.

4.2 Energy Metering Circuit

Figure 4.3 shows the schematics of the energy metering circuit.

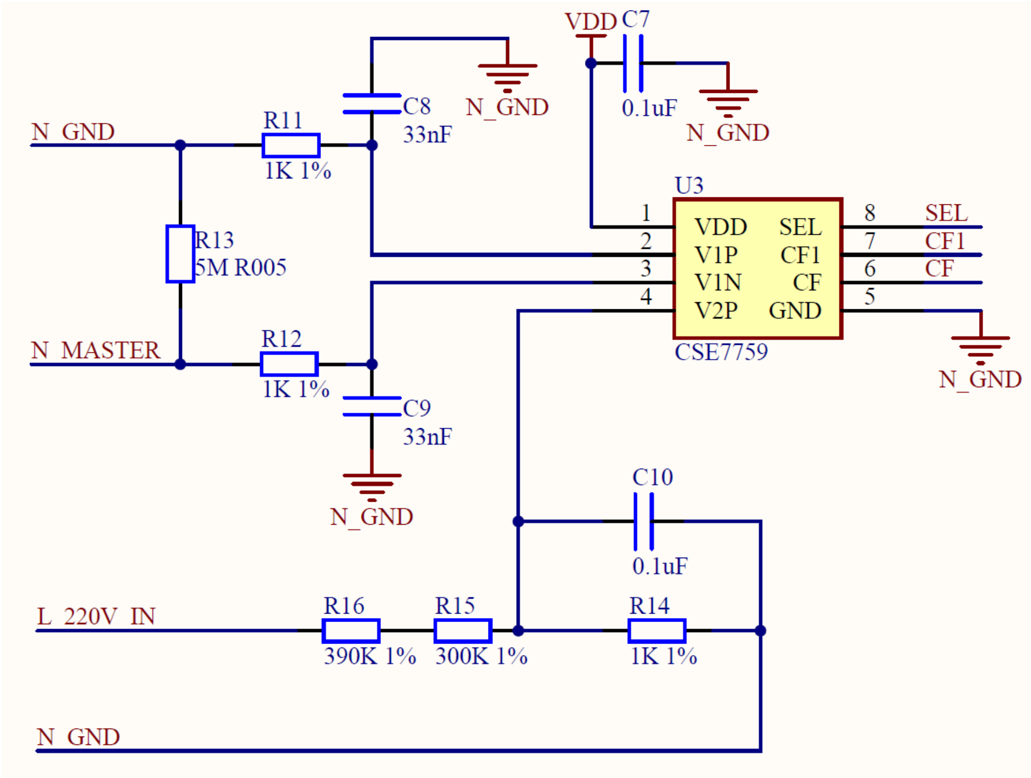

Figure 4.3 Energy Metering Circuit

Energy metering circuit detects the energy of the device connected to the master outlet through a low cost single-phase energy metering chip in real-time. The input values are the current and voltage of the master outlet load, the output value is square wave of which frequency is proportional to load power. In actual use, it is needed to determine the sampling resistance (R13) according to the actual situation.

4.3 Slave Power Control Circuit

Figure 4.4 shows the schematics of the slave power control circuit.

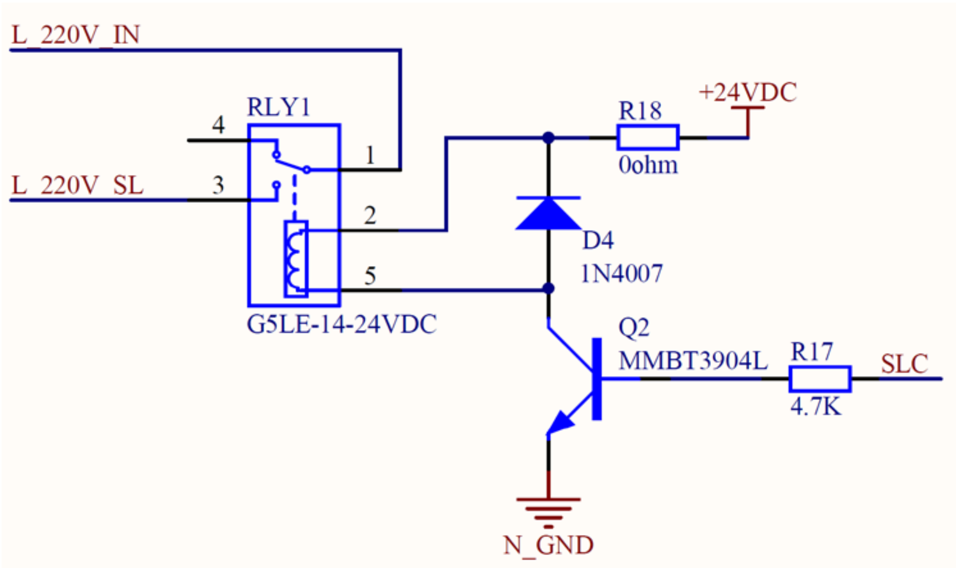

Figure 4.4 Slave Power Control Circuit

Slave power control circuit consists of NPN triode and an Omron single relay. The slave outlet power supply can be enabled or disabled through the control signal of SLC from the MCU.

4.4 Master Power Control Circuit

Figure 4.5 shows the schematics of the master power control circuit.

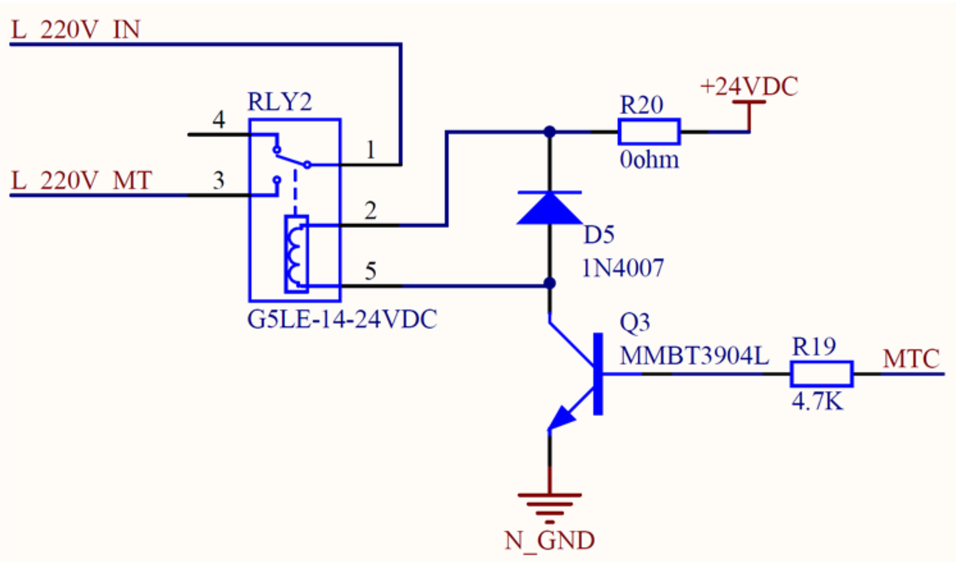

Figure 4.5 Master Power Control Circuit

Master power control circuit consists of NPN triode and an Omron single relay. The master outlet power supply can be enabled or disabled through the control signal of MTC from the MCU.

5. Software

5.1 Integrated Development Environment

The sample code described in this chapter has been checked under the conditions listed in the table below.

Table 5.1 Operation Check Conditions

Item	Description
Microcontroller used	RL78/G10 (R5F10Y16)
Operating frequency	High-speed on-chip oscillator (HOCO) clock: 20 MHz CPU/peripheral hardware clock: 20 MHz
Operating voltage	5V (can run on a voltage range of 2.7 V to 5.5 V.) SPOR detection voltage When power supply falls: TYP. 2.84V (2.70 V to 2.96 V) When power supply rises: TYP. 2.90V (2.76 V to 3.02 V)
Integrated development environment (CS+)	CS+ V6.00.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.05.00 from Renesas Electronics Corp.
Integrated development environment (e2 studio)	e2 studio V6.0.0 from Renesas Electronics Corp.
C compiler (e2 studio)	CC-RL V1.05.00 from Renesas Electronics Corp.

5.2 Option Byte

Table 5.2 summarizes the settings of the option bytes.

Table 5.2 Option Byte Settings

Address	Value	Description
000C0H/010C0H	11101111B	Watchdog timer counter operation enabled (counting started after reset)
000C1H/010C1H	11110111B	SPOR detection voltage When power supply falls: TYP. 2.84V (2.70 V to 2.96 V) When power supply rises: TYP. 2.90V (2.76V to 3.02 V)
000C2H/010C2H	11111001B	Operating frequency: 20 MHz (2.7 V ~ 5.5 V)
000C3H/010C3H	00000101B	Disables on-chip debugging

5.3 Operation Outline

The tasks of the whole system are listed as below: reset/initialization task, idle task, measuring timeout task, metrical data processing task, slave controlling task, exception handler task.

Figure 5.1 shows the block diagram for the tasks transition.

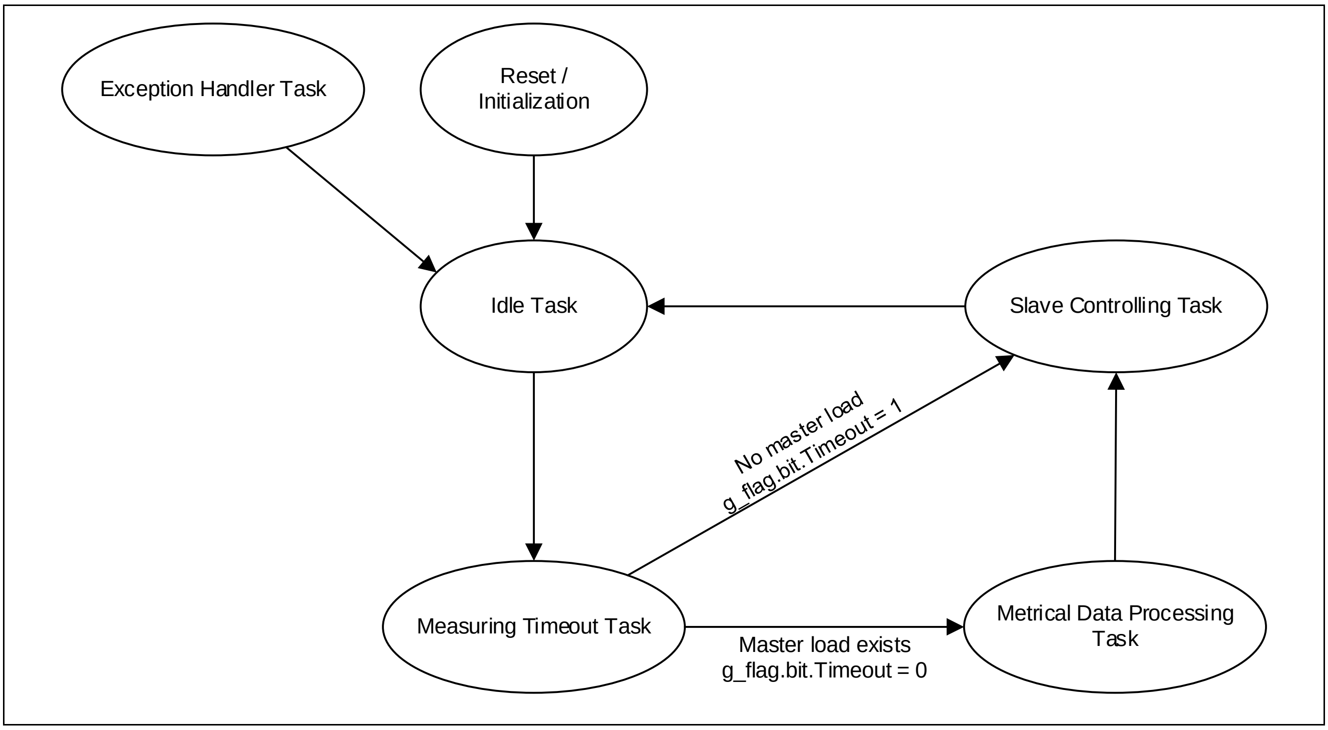

Figure 5.1 Tasks Transition Block Diagram

(1) Reset / Initialization

After power-on the system executes reset/initialization operation. System status and related global variables used by users are initialized. After the initialization is completed, system will execute idle task.

(2) Idle Task

When the system is in idle task, it means system has completed all the tasks. In idle task, the only operation is transferring the system to measuring timeout task.

(3) Measuring Timeout Task

In this task the system judges whether the routing inspection of the power signal hits timeout. If the routing inspection times out that means there is no load in master outlet, the timeout flag is set and then the system is transferred to slave controlling task. If the routing inspection is not out of time, the timeout flag is cleared and then the system is transferred to metrical data processing task.

(4) Metrical Data Processing Task

In this task, system measures the pulse signal from the single-phase active energy metering chip with TAU0 channel 0 input pulse interval measurement function. It filters data with trimmed mean filtering method, then gets the final measurement result. The system the compares the final measurement result with the default threshold, and then sets the related flag bit of slave outlet control. After the task is completed, the system is transferred to slave controlling task.

(5) Slave Controlling Task

In this task, in order to realize the intelligent linkage control and power saving, the system turns on or turns off the power supply of the device connected to the slave outlet according to the related flag bit of the slave outlet control and the timeout flag. After the task is completed, the system is transferred to idle task.

(6) Exception Handler Task

If an exception occurred in the system task transition (system is not in status between (2) ~ (5)), the system will be transferred to exception handler task. In this task, system initializes all the related peripheral functions and the related global variables used by users. After the exception handler task is completed, the system is transferred to idle task. Exception handler task is used to improve the anti-interference capability of the software.

5.4 Flow Chart

5.4.1 Main Processing

Figure 5.2 and Figure 5.3 show the flowchart for main processing routine.

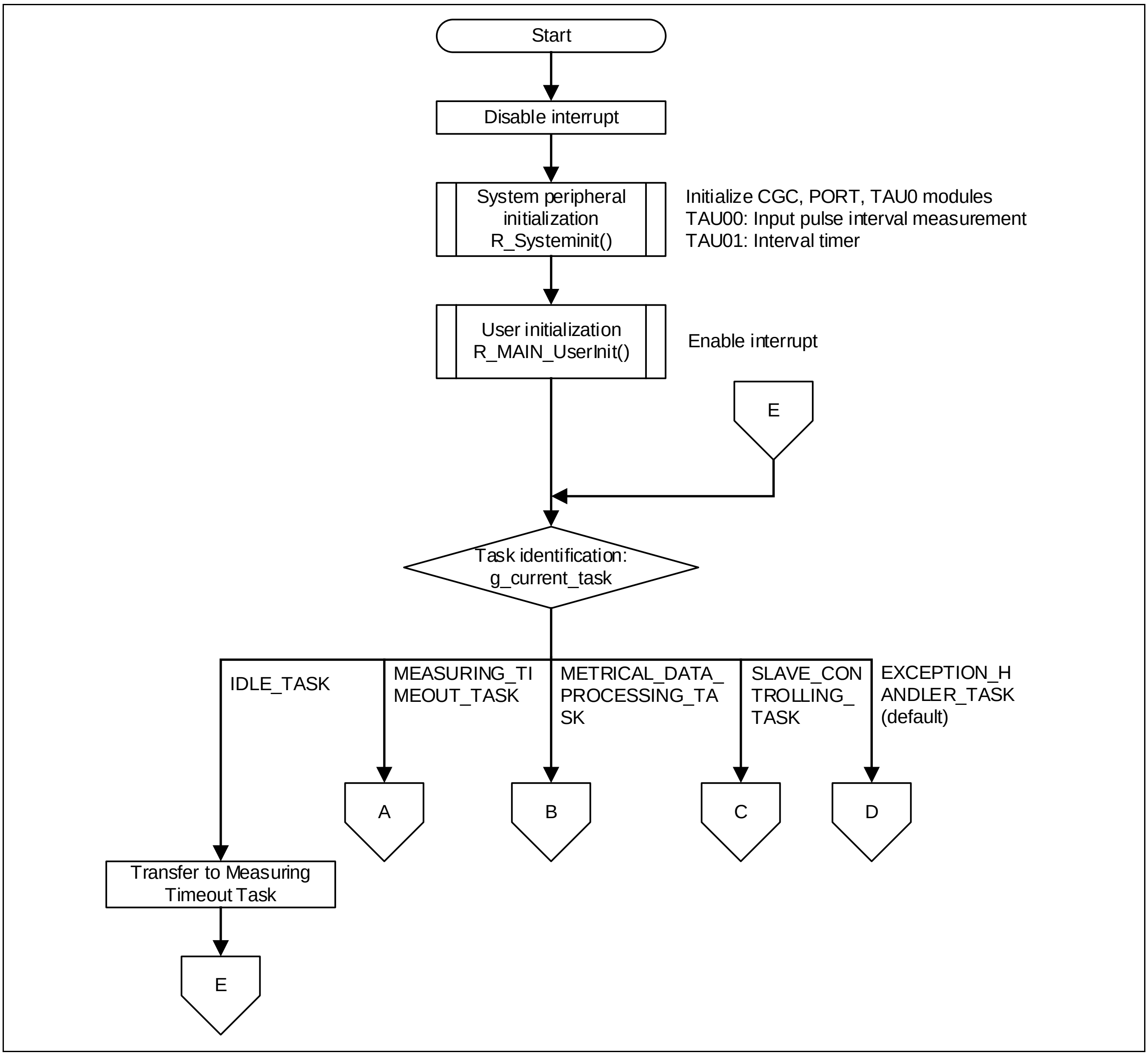

Figure 5.2 Main Processing (1/2)

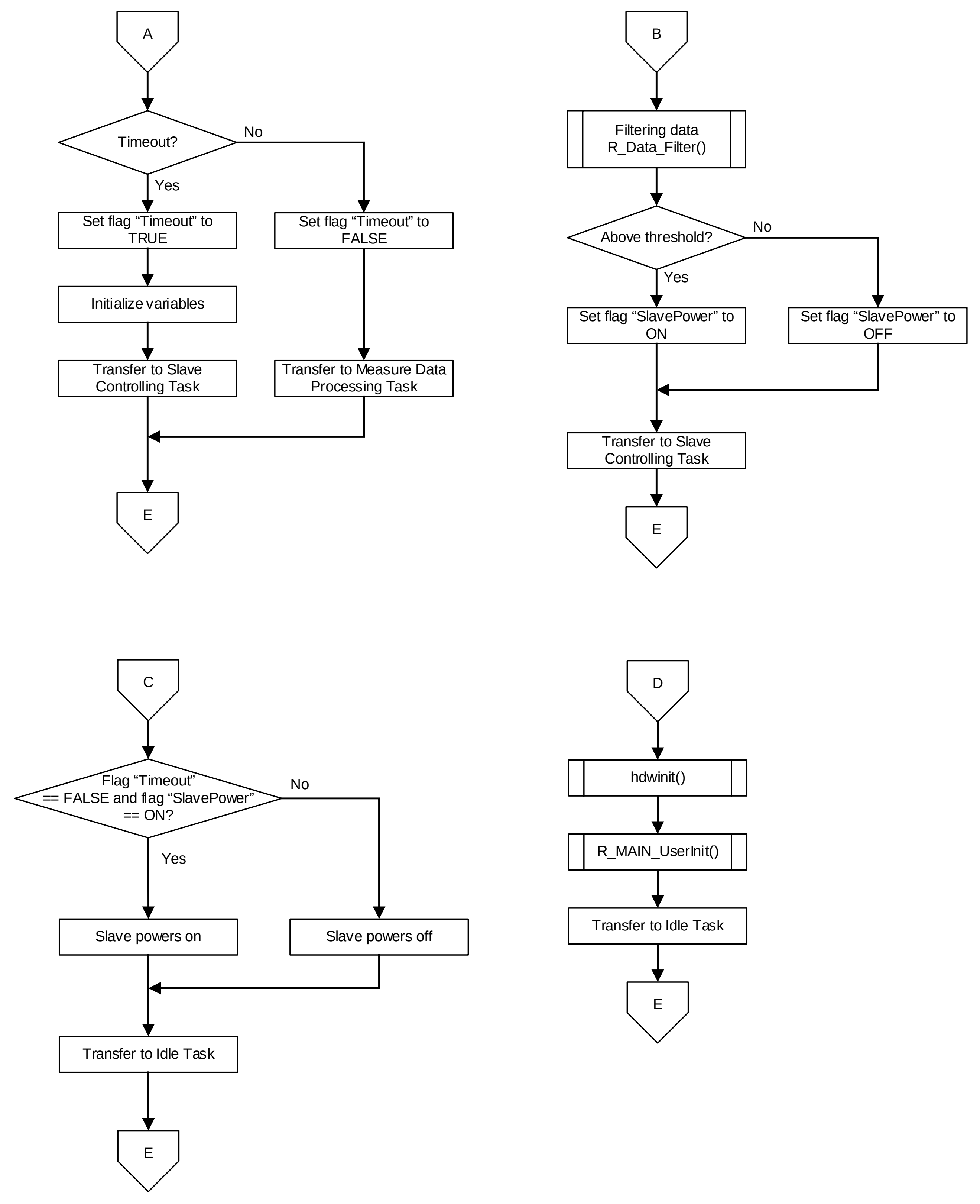

Figure 5.3 Main Processing (2/2)

5.4.2 User Initialization

Figure 5.4 shows the flowchart for user initialization.

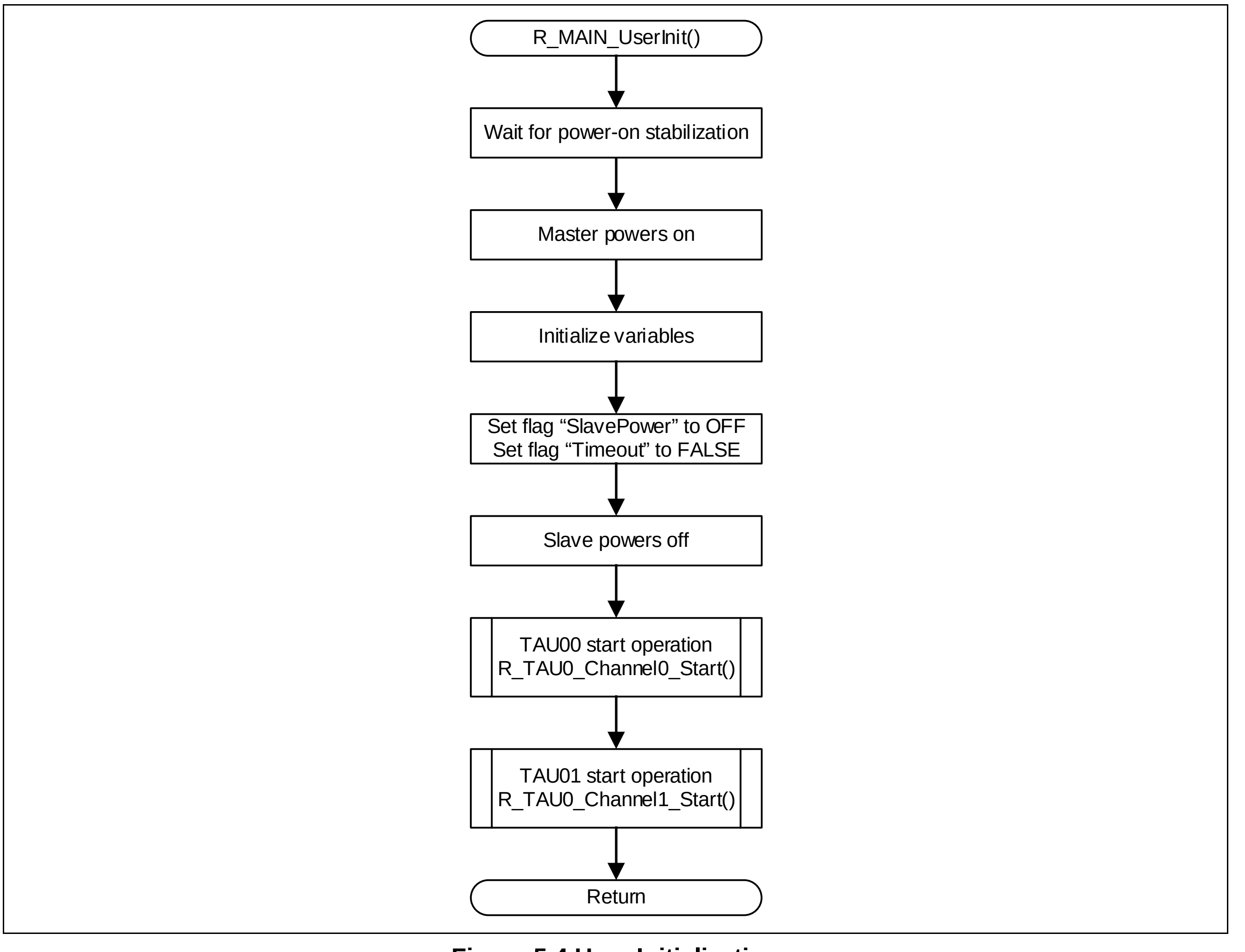

Figure 5.4 User Initialization

5.4.3 TAU0 Interrupt Processing

Figure 5.5 ~ Figure 5.6 show the flowchart for TAU0 channel 0 interrupt and TAU0 channel 1 interrupt.

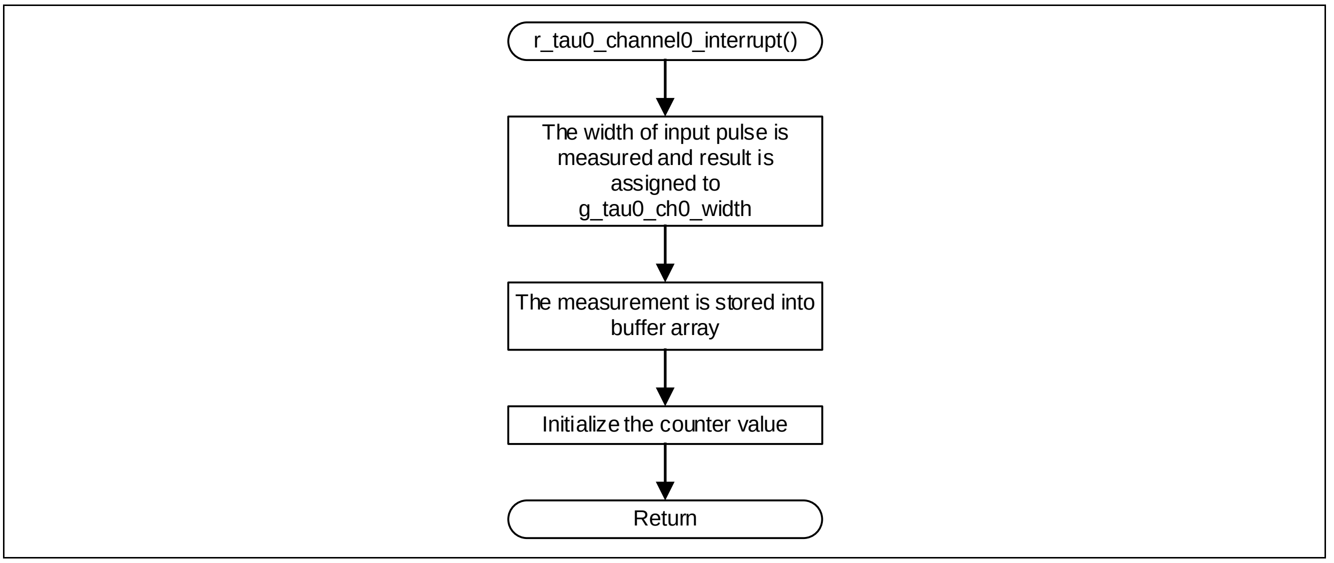

Figure 5.5 TAU0 Channel 0 Interrupt Processing

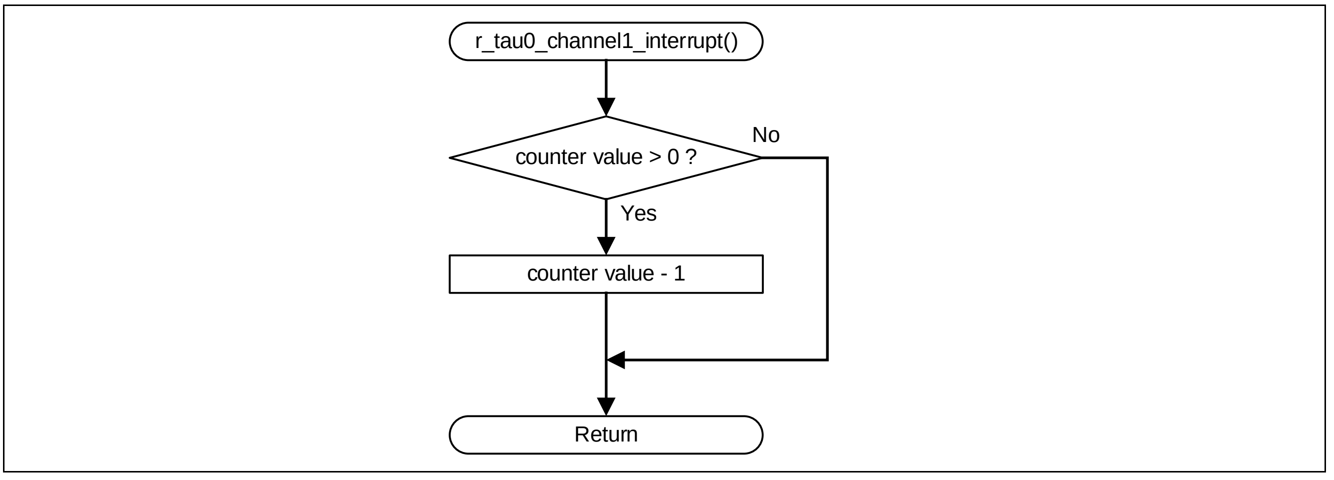

Figure 5.6 TAU0 Channel 1 Interrupt Processing

6. Sample Code

The sample code is available on the Renesas Electronics Website.

7. Reference Documents

RL78/G10 User's Manual: Hardware (R01UH0384)

RL78 Family User's Manual: Software (R01US0015)

(The latest versions of the documents are available on the Renesas Electronics Website.)

Technical Updates/Technical News

(The latest information can be downloaded from the Renesas Electronics Website.)

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Dec. 31, 2017	—	First edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit 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.

   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL II Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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