RZ/T1 Group

CRC Arithmetic Unit (CRC)

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Rev.1.40
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Introduction

This application note explains a sample program that generates and checks CRC data using CRC arithmetic unit (CRC) for use with data transmission on serial communication.

The major features of the sample program are listed below.

- CRC generator polynomial used is 16-CCITT ($X^{16} + X^{12} + X^5 + 1$).
- The sample program lights up LED0 when the CRC results of outgoing and incoming data match in serial communication.

Operation Checking Devices

RZ/T1 group

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

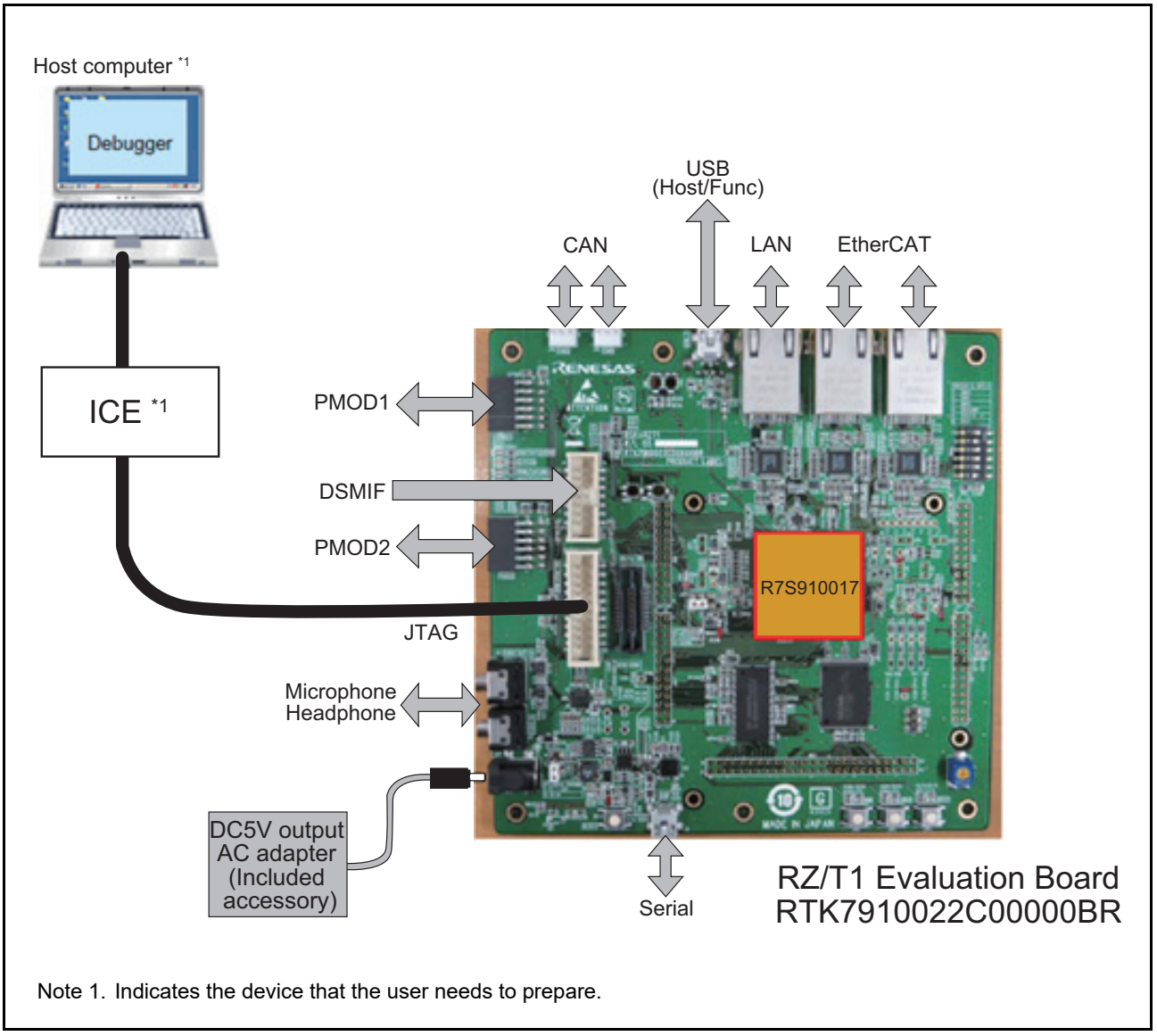
Table of Contents

1. Specifications

Table 1.1 lists the peripheral functions to be used and their applications and Figure 1.1 shows the operating environment.

Table 1.1 Peripheral Functions and Applications

Peripheral Function	Application
Clock generator (CPG)	Used as a CPU clock and low-speed on-chip oscillator.
Compare match timer (CMT)	Used for periodic counting operation
CRC arithmetic unit (CRC)	Used for calculating CRC data attached to outgoing data and incoming data in serial communication
Error control module (ECM)	Used to initialize ERROROUT# pin
General purpose I/O ports	Used to control a pin to turn an LED light on and off



Note 1. Indicates the device that the user needs to prepare.

Figure 1.1 Operating Environment

2. Operating Environment

The sample program covered in this application note is for the environment below.

Table 2.1 Operating Environment

Item	Description
Microcomputer	RZ/T1 group
Operating frequency	CPUCLK = 450 MHz
Operating voltage	3.3 V
Integrated development environment	Manufactured by IAR Systems Embedded Workbench® for Arm Version 8.20.2 Manufactured by Arm DS-5™ 5.26.2 Manufactured by RENESAS e2studio 6.1.0
Operating mode	SPI boot mode 16-bit bus boot mode
Board	RZ/T1 Evaluation Board (RTK7910022C00000BR)
Devices (functions to be used on the board)	• NOR flash memory (connected to CS0 or CS1 space) Manufacturer: Macronix International Co.,Ltd. Model: MX29GL512FLT2I-10Q • SDRAM (connected to CS2 or CS3 space) Manufacturer: Integrated Silicon Solution Inc. Model: IS42S16320D-7TL • Serial flash memory Manufacturer: Macronix International Co.,Ltd. Model: MX25L51245G

3. Related Application Note

An additional application note related to this application note is listed below for reference.

- RZ/T1 Group Initial Settings

4. Peripheral Functions

See the RZ/T1 Group User's Manual: Hardware for basic descriptions for clock generator (CPG), error control module (ECM), CRC arithmetic unit (CRC) and general purpose I/O ports.

5. Hardware

5.1 Hardware Configuration Example

Figure 5.1 shows a hardware configuration example.

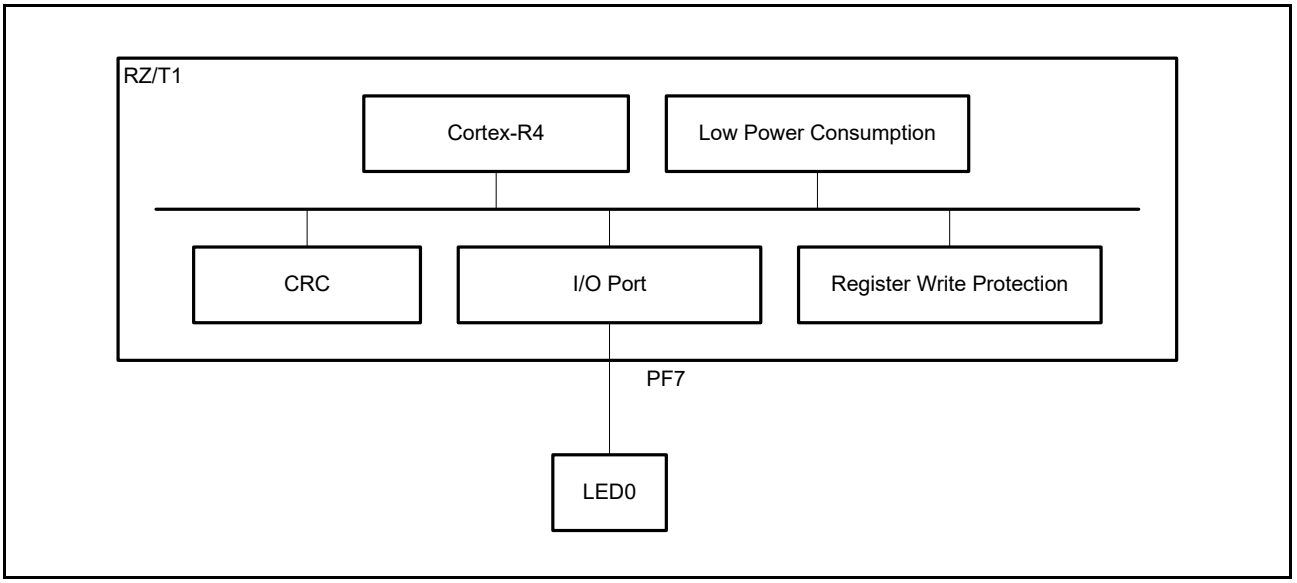


Figure 5.1 Hardware Configuration

5.2 Pins

Table 5.1 lists pins to be used and their functions.

Table 5.1 Pins and Functions

Pin Name	Input/Output	Function
MD0	Input	Boot mode selection: MD0="L", MD1="L", MD2="L" (SPI boot mode) MD0="L", MD1="H", MD2="L" (16-bit bus boot mode)
MD1	Input	
MD2	Input	
PF7	Output	Turns LED0 on and off

6. Software

6.1 Operation Overview

This sample program makes initial settings of the CRC arithmetic unit and generates outgoing data for serial communication that consists of the original data of 12345678H and a CRC calculation result attached to it.

Then, the program compares CRC data calculated from incoming data with the CRC data assumed to have been received in serial communication. If the data match, the program turns on LED0.

Table 6.1 Function Overview lists the sample program function overview. Figure 6.1 shows the operation image.

Table 6.1 Function Overview

Function	Overview
CRC calculation operand	8-bit
CRC generator polynomial	16-bit CCITT CRC (16-CCITT)

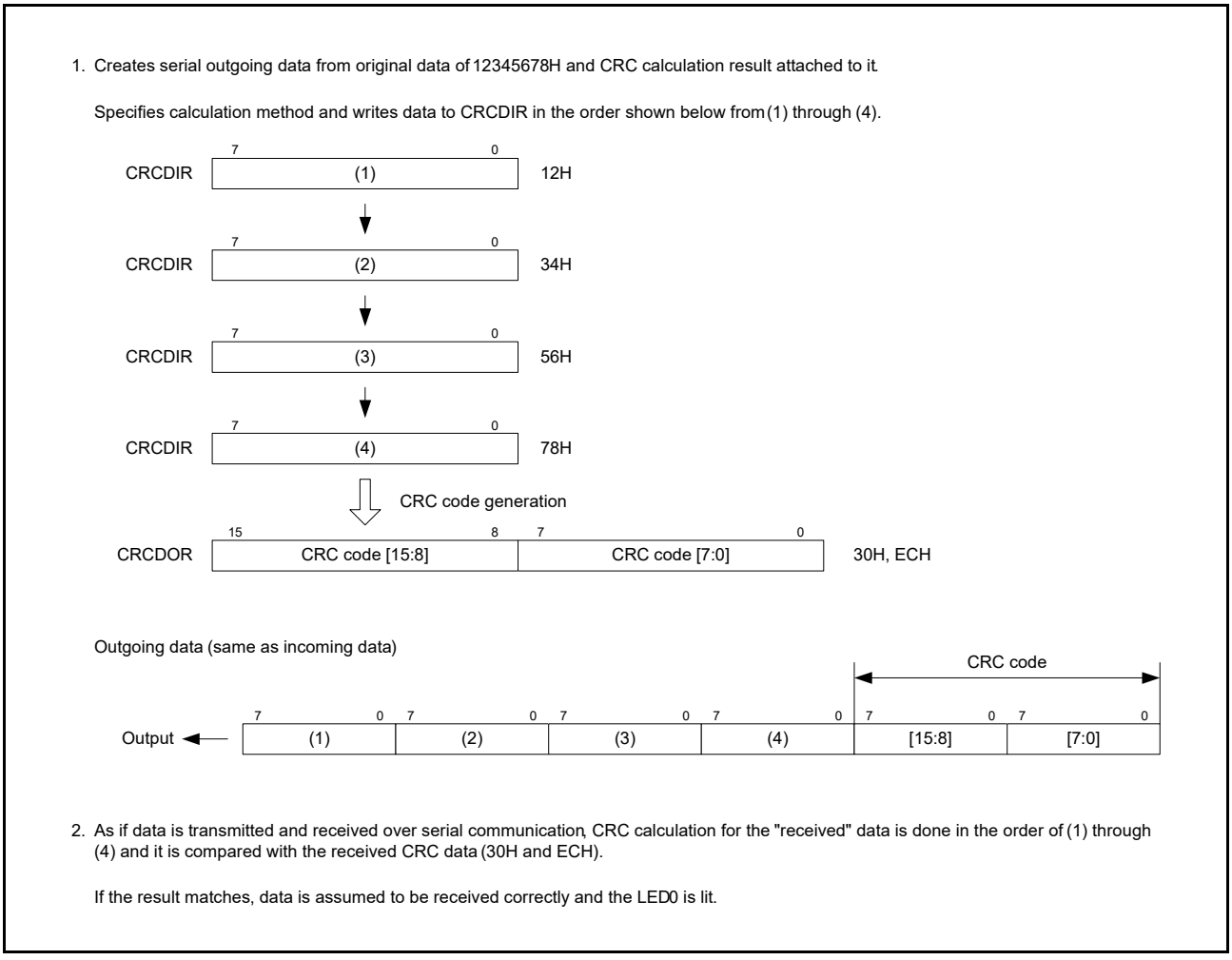


Figure 6.1 Operation Flow

6.1.1 Project Setting

See the Application Note: RZ/T1 Group Initial Settings about project setting used on the EWARM development environment.

6.2 Memory Mapping

See the Application Note: RZ/T1 Group Initial Settings about address spaces of the RZ/T1 group and memory mapping on the RZ/T1 evaluation board.

6.2.1 Section Placement in Sample Program

See the Application Note: RZ/T1 Group Initial Settings about the sections to be used in this sample program, initial setting of section placement (load view) of this sample program and section placement (execution view) after a scatter loading function is used.

6.2.2 MPU Settings

See the Application Note: RZ/T1 Group Initial Settings about the MPU settings.

6.2.3 Exception Processing Vector Table

See the Application Note: RZ/T1 Group Initial Settings about the exception processing vector table.

6.3 Fixed-Width Integer Types

Table 6.2 shows fixed-width integer types used in this sample program.

Table 6.2 Fixed-Width Integer Types

Symbol	Description
int8_t	8-bit signed integer (defined in the standard library)
int16_t	16-bit signed integer (defined in the standard library)
int32_t	32-bit signed integer (defined in the standard library)
int64_t	64-bit signed integer (defined in the standard library)
uint8_t	8-bit unsigned integer (defined in the standard library)
uint16_t	16-bit unsigned integer (defined in the standard library)
uint32_t	32-bit unsigned integer (defined in the standard library)
uint64_t	64-bit unsigned integer (defined in the standard library)

6.4 Constants/Error Codes

Table 6.3 lists constants to be used in the sample program.

Table 6.3 Constants to be Used in the Sample Program

Constant Name	Setting Value	Description
CRC_1ST_32_ETHERNET	(0xFFFFFFFF)	Constant to initialize the CRC output register (CRCDOR) when CRC generator polynomial is 32-Ethernet
CRC_1ST_16_CCITT	(0x0000FFFF)	Constant to initialize the CRC output register (CRCDOR) when CRC generator polynomial is 16-CCITT
CRC_1ST_8_SAE_J1850	(0x000000FF)	Constant to initialize the CRC output register (CRCDOR) when CRC generator polynomial is 8-SAE-J1850
CRC_1ST_8_0x2F	(0x000000FF)	Constant to initialize the CRC output register (CRCDOR) when CRC generator polynomial is 8-0x2F
CRC_MASK_16_CCITT	(0x0000FFFF)	Constant used to mask the value read from the CRC output register (CRCDOR) when CRC generator polynomial is 16-CCITT
CRC_MASK_8_SAE_J1850	(0x000000FF)	Constant used to mask the value read from the CRC output register (CRCDOR) when CRC generator polynomial is 8-SAE-J1850
CRC_MASK_8_0x2F	(0x000000FF)	Constant used to mask the value read from the CRC output register (CRCDOR) when CRC generator polynomial is 8-0x2F
CRC_CFG_PARAM_CHECKING_ENABLE	(1)	Constant to allow the CRC API function to check (1) or not to check (0) parameters
CRC_SERIAL_DATA_NUM	(4)	Constant to give a number to outgoing and incoming data in serial communication

6.5 Structures/Unions/Enumerated Types

Figure 6.2 shows structures/unions/enumerated types to be used in the sample program.

```
/* API ERROR RETURN CODES */
typedef enum e_crc_err              // CRC API error codes
{
      CRC_SUCCESS=0,
      CRC_ERR_OPEN_IGNORED,         // The module has already been Open()ed
      CRC_ERR_INVALID_ARG,          // Argument is not valid for parameter
      CRC_ERR_NULL_PTR,             // Received null pointer or missing required argument
      CRC_ERR_NOT_OPENED            // Open function has not yet been called
} crc_err_t;

/* Open() and GetData() DEFINITIONS */
typedef enum e_crc_mode                     // CRC generation mode
{
      CRC_32_ETHERNET  = 0x00u,             // 32-Ethernet
      CRC_16_CCITT     = 0x01u,             // 16-CCITT
      CRC_8_SAE_J1850  = 0x02u,             // 8-SAE J1850
      CRC_8_0x2F       = 0x03u,             // 8-0x2F
      CRC_PROHIBITED
} crc_mode_t;

typedef enum e_crc_width                    // CRC input bit width
{
      CRC_32_BIT          = 0x00u,          // 32 bits
      CRC_16_BIT          = 0x10u,          // 16 bits
      CRC_8_BIT           = 0x20u           // 8 bits
} crc_width_t;

typedef struct st_crc_config                // CRC configuration options used in Open function
{
      crc_mode_t                mode;       // CRC generation mode
      crc_width_t               width;      // CRC input bit width
 } crc_config_t;
```

Figure 6.2 Structures/Unions/Enumerated Types

6.6 Global Variables

Table 6.4 lists global variables.

Table 6.4 Global Variables

Type	Variable Name	Description	Function
uint8_t	g_serial_data [CRC_SERIAL_DATA_NUM + 2]	Outgoing and incoming data over serial communication	set_send_data check_receive_data

6.7 Functions

Table 6.5 shows list of functions.

Table 6.5 Functions

Function Name	Page Number
main	12
crc_init	12
set_send_data	13
check_receive_data	13
R_CRC_Open	14
R_CRC_Set1stValue	15
R_CRC_GetData	15

6.8 Specification of Functions

6.8.1 main

main	
Synopsis	Main processing
Declaration	int main(void)
Description	Makes initial settings of the ports, ECM and CRC. Then, the program generates data and calculates and compares CRC for the data as if it has been transmitted and then received over serial communication.
Arguments	None
Return values	None
Remarks	None

6.8.2 crc_init

crc_init	
Synopsis	CRC initialization processing
Declaration	void crc_init(void)
Description	Initializes CRC by calling a function to open CRC processing and another function to initialize and set a starting value to CRC data output register.
Arguments	None
Return values	None
Remarks	None

6.8.3 set_send_data

set_send_data	
Synopsis	Serial outgoing data setting processing
Declaration	void set_send_data(void)
Description	Calculates CRC to attach to outgoing data over serial communication.
Arguments	None
Return values	None
Remarks	None

6.8.4 check_receive_data

check_receive_data	
Synopsis	Serial incoming data check processing
Declaration	void check_receive_data(void)
Description	Initializes CRC data output register, calculates CRC for incoming serial data, and compares it with CRC attached to the data. If the CRC of both data match, LED0 is turned on.
Arguments	None
Return values	None
Remarks	None

6.8.5 R_CRC_Open

R_CRC_Open	
Synopsis	CRC open function
Header	r_crc_if.h
Declaration	crc_err_t R_CRC_Open (void * const p_cfg)
Description	Initializes CRC related registers.
Arguments	void * const p_cfg Pointer to data for storing in CRC control registers CRC generation method selection CRC_32_ETHERNET CRC_16_CCITT CRC_8_SAE_J1850 CRC_8_0x2F CRC input bit width selection CRC_32_BIT CRC_16_BIT CRC_8_BIT
Return values	Returns open function execution result. CRC_SUCCESS : CRC has been initialized. CRC_ERR_OPEN_IGNORED : Module is already open. CRC_ERR_INVALID_ARG : Invalid value is included in the p_cfg structure element. CRC_ERR_NULL_PTR : p_cfg pointer is null.
Remarks	Return value parameter checking is enabled by setting CRC_CFG_PARAM_CHECKING_ENABLE to 1 defined by r_crc_config.h.

6.8.6 R_CRC_Set1stValue

R_CRC_Set1stValue		
Synopsis	Function to specify the first data value for CRC data generation register	
Header	r_crc_if.h	
Declaration	crc_err_t R_CRC_Set1stValue(crc_mode_t const mode)	
Description	Specifies the starting value for CRC data generation register.	
Arguments	crc_mode_t const mode	Specify CRC generation method. CRC_32_ETHERNET CRC_16_CCITT CRC_8_SAE_J1850 CRC_8_0x2F
Return values	Returns a result of execution of this function.(CRC data generation register starting value setting function). CRC_SUCCESS : Terminated normally. CRC_ERR_INVALID_ARG : Argument value is invalid. CRC_ERR_NOT_OPENED : Open is not read out.	
Remarks	Argument parameter checking is enabled by setting CRC_CFG_PARAM_CHECKING_ENABLE to 1 defined by r_crc_config.h.	

6.8.7 R_CRC_GetData

R_CRC_GetData		
Synopsis	CRC data retrieving function	
Header	r_crc_if.h	
Declaration	crc_err_t R_CRC_GetData(crc_mode_t const mode, uint32_t * p_result)	
Description	Retrieves CRC calculation result.	
Arguments	crc_mode_t const mode	Specify CRC generation method. CRC_32_ETHERNET CRC_16_CCITT CRC_8_SAE_J1850 CRC_8_0x2F
	uint32_t * p_result	Pointer to a position to store CRC calculation result
Return values	Returns CRC data retrieving function execution result. CRC_SUCCESS : Terminated normally. CRC_ERR_INVALID_ARG : Argument value is invalid. CRC_ERR_NULL_PTR : p_result pointer is null. CRC_ERR_NOT_OPENED : Open has not been read out yet.	
Remarks	Argument parameter checking is enabled by setting CRC_CFG_PARAM_CHECKING_ENABLE to 1 defined by r_crc_config.h.	

6.9 Flowchart

6.9.1 Main Processing

Figure 6.3 shows the flowchart of main processing.

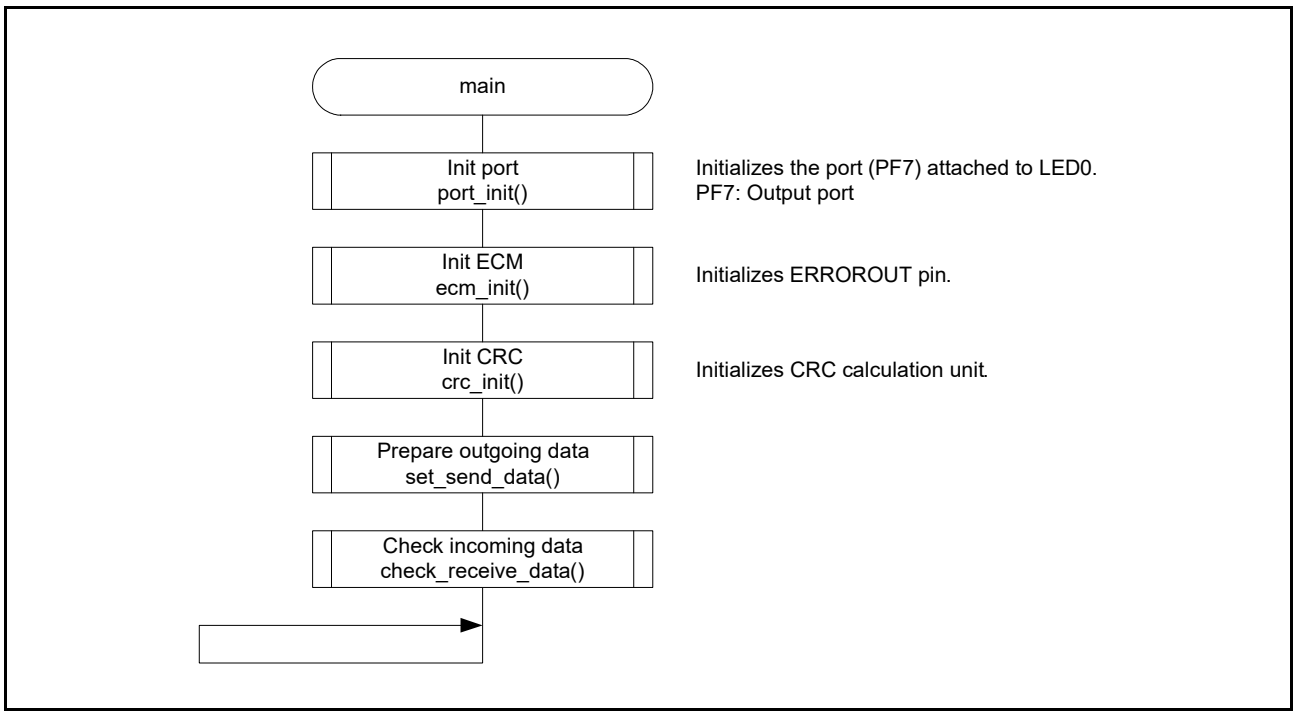


Figure 6.3 Main Processing

6.9.2 CRC Initialization Processing

Figure 6.4 shows the flowchart of CRC initialization processing.

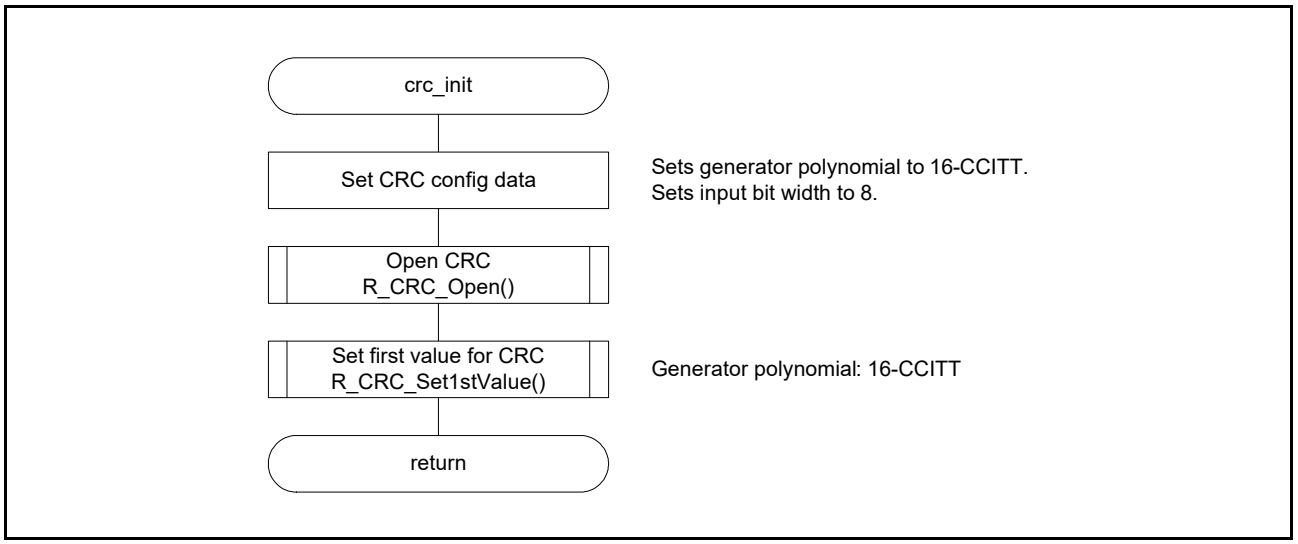


Figure 6.4 CRC Initialization Processing

6.9.3 Serial Outgoing Data Setting Processing

Figure 6.5 shows the flowchart of serial outgoing data setting processing.

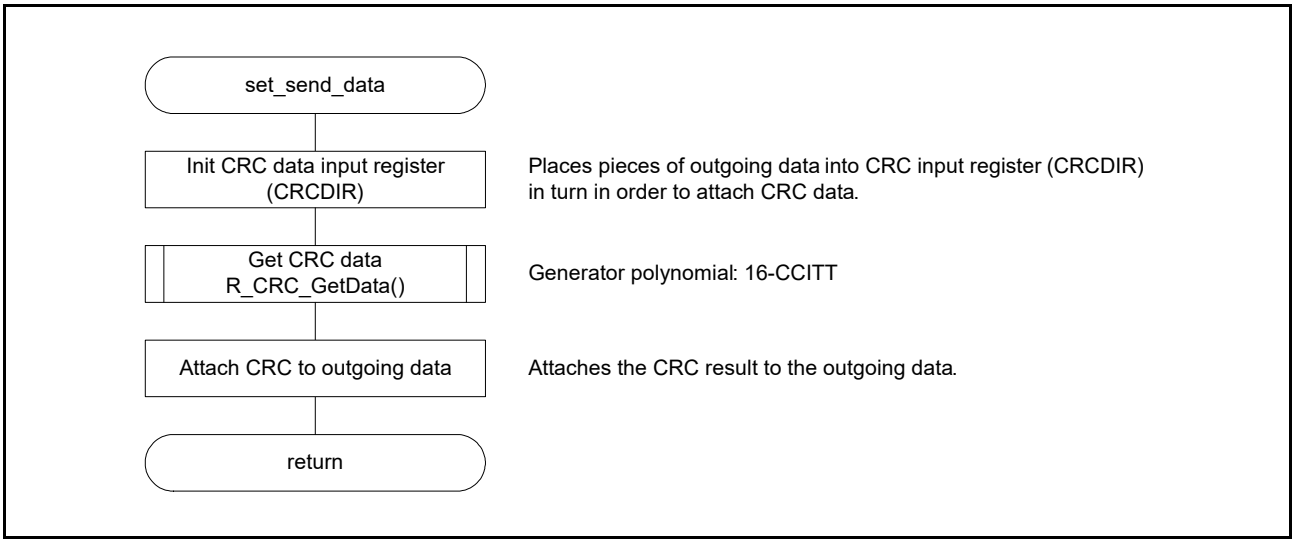


Figure 6.5 Serial Outgoing Data Setting Processing

6.9.4 Serial Incoming Data Setting Processing

Figure 6.6 shows the flowchart of serial incoming data setting processing.

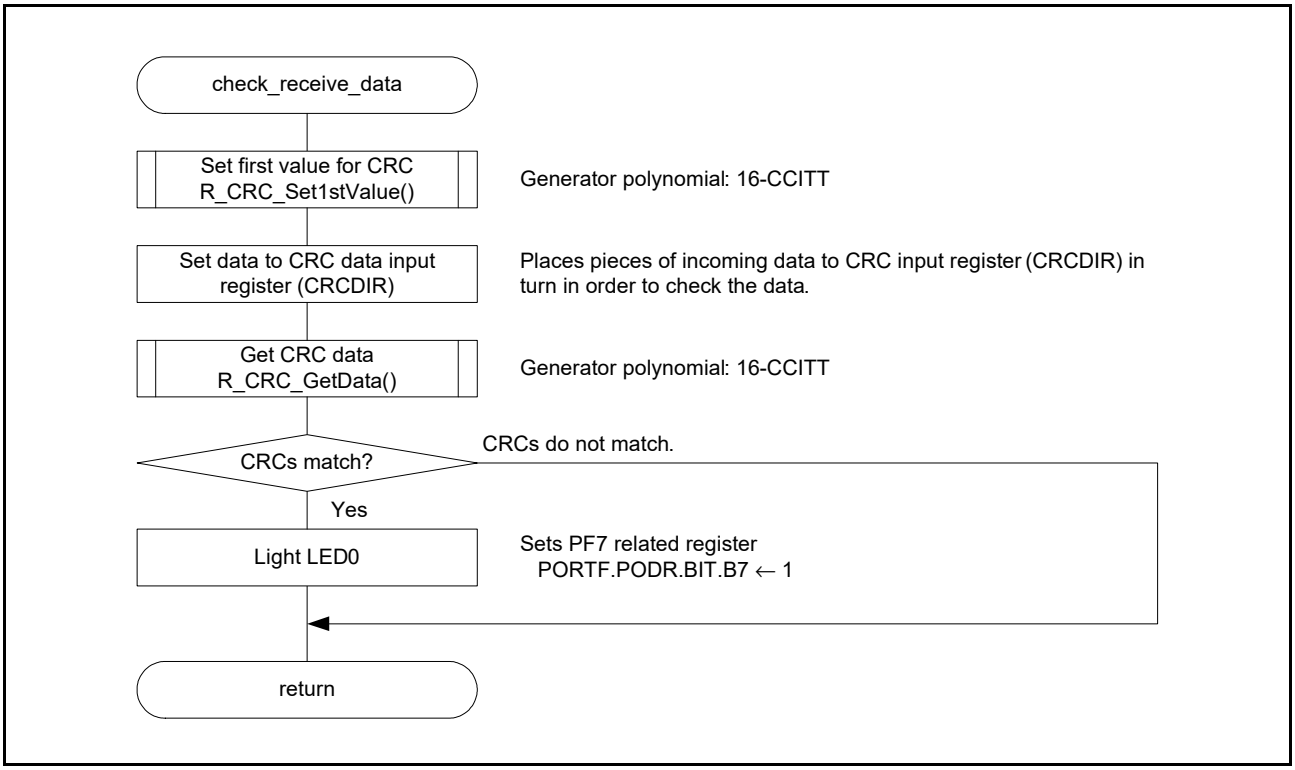
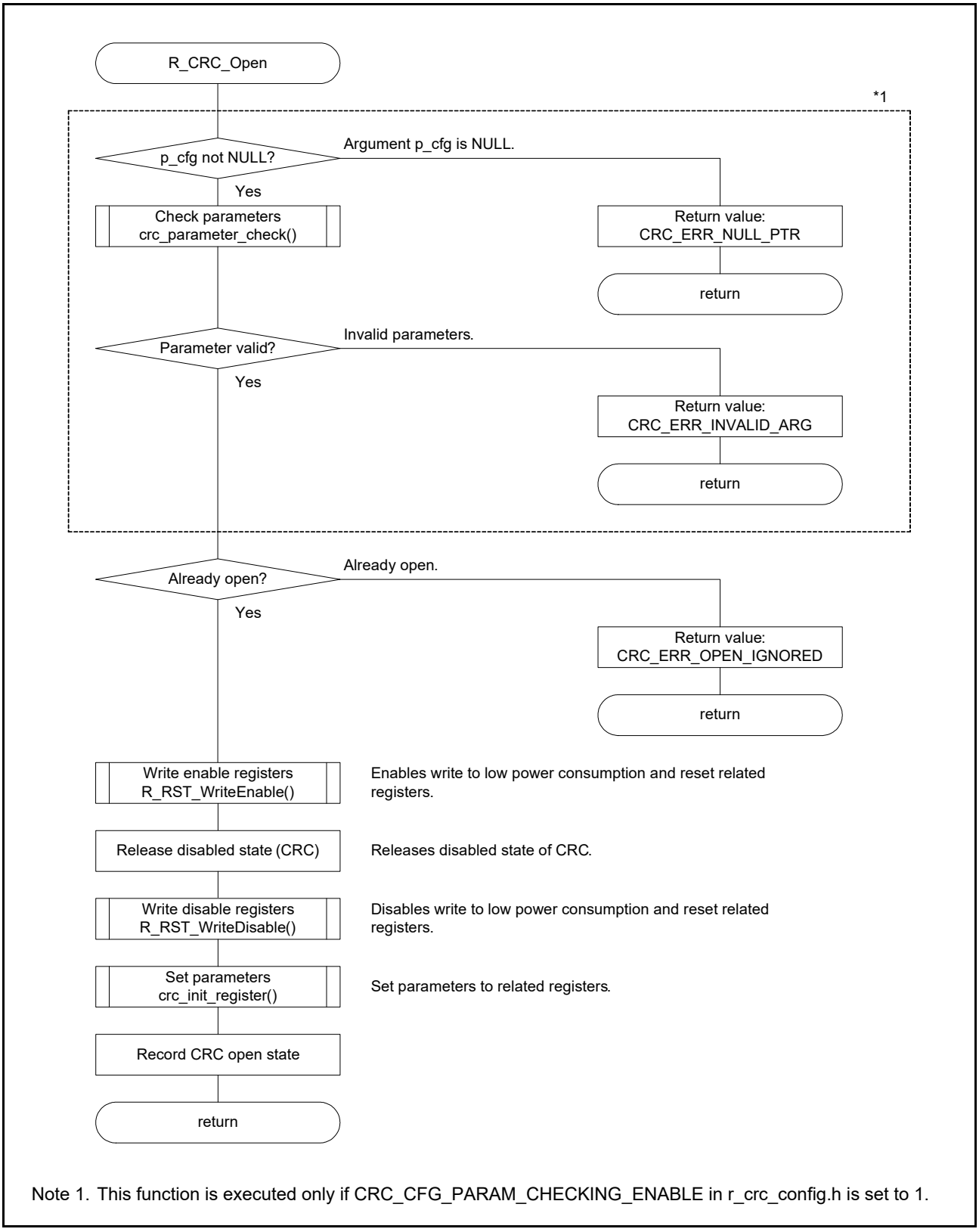


Figure 6.6 Serial Incoming Data Setting Processing

6.9.5 CRC Open Function

Figure 6.7 shows the flowchart of CRC Open Function.

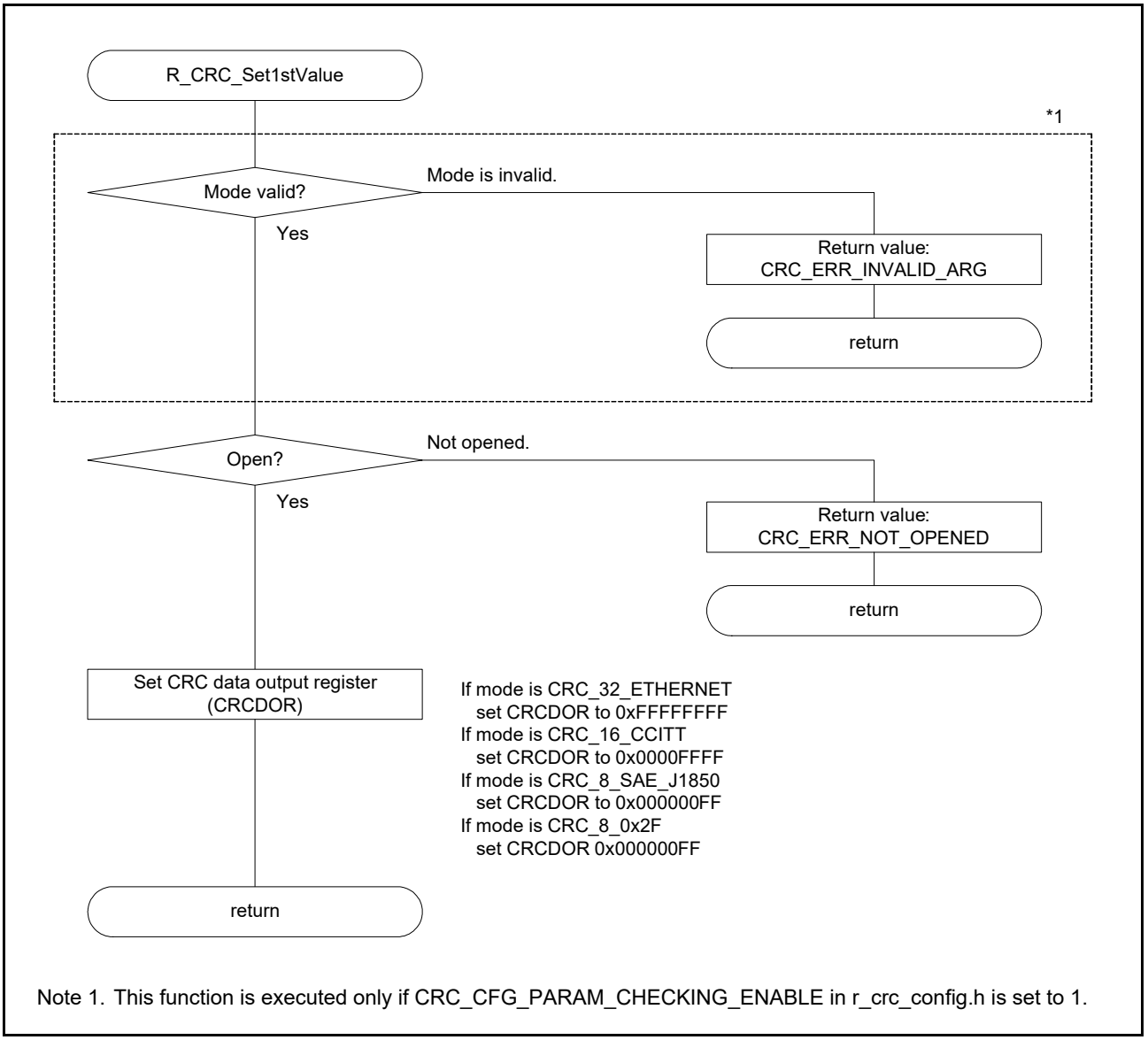


Note 1. This function is executed only if CRC_CFG_PARAM_CHECKING_ENABLE in r_crc_config.h is set to 1.

Figure 6.7 CRC Open Function

6.9.6 CRC Data Generation Register Starting Value Setting Function

Figure 6.8 shows the flowchart of CRC data generation register starting value setting function.

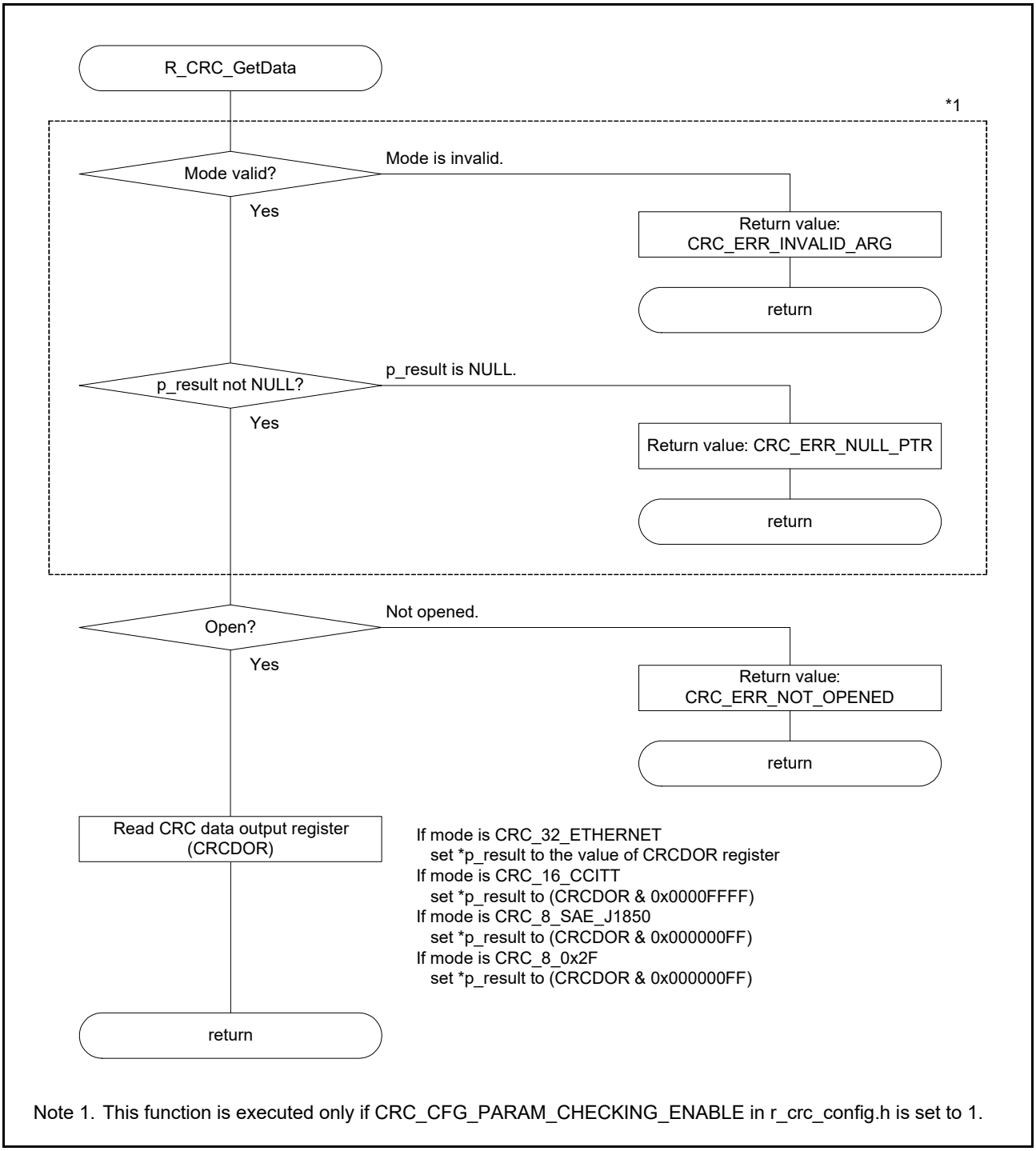


Note 1. This function is executed only if CRC_CFG_PARAM_CHECKING_ENABLE in r_crc_config.h is set to 1.

Figure 6.8 CRC Data Generation Register Starting Value Setting Function

6.9.7 CRC Data Retrieving Function

Figure 6.9 shows the flowchart of CRC data retrieving function.



Note 1. This function is executed only if CRC_CFG_PARAM_CHECKING_ENABLE in r_crc_config.h is set to 1.

Figure 6.9 CRC Data Retrieving Function

7. Sample Program

Download the sample program from the Renesas Electronics website.

8. Related Documents

- User's Manual: Hardware
  RZ/T1 Group User's Manual: Hardware
  (Download the latest version from the Renesas Electronics website.)

  RZ/T1 Evaluation Board RTK7910022C00000BR User's Manual
  (Download the latest version from the Renesas Electronics website.)

- Technical Update/Technical News
  (Download the latest information at the Renesas Electronics website.)

- User's Manual: Development Environment
  Documents of IAR Embedded Workbench® for Arm are available at the home page of IAR Systems.
  (Download the latest version from the IAR Systems website.)

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http://www.renesas.com/

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Revision History	Application Note: CRC Arithmetic Unit (CRC)

Rev.	Date	Description	
		Page	Summary
0.20	Mar. 25, 2015	—	First Edition issued
1.00	Apr. 10, 2015	—	Only the revision number was changed to be posted on a website.
1.10	Aug. 18, 2015	2. Operating Environment	
		4	Table 2.1 Operating Environment: Integrated Development Environment, partially amended and added
		6. Software	
		9	6.2.4 Required Memory Size: Description and reference added
		9	Table 6.2: Table title was partially amended
		10	Table 6.3 added
		10	Table 6.4 added
1.20	Dec. 04, 2015	2. Operating Environment	
		4	Table 2.1 Operating Environment: Integrated Development Environment, information partially amended
1.30	Apr. 05, 2017	2. Operating Environment	
		4	Table 2.1 Operating Environment: Integrated Development Environment, modified
		6. Software	
		—	6.2.4 Required Memory Size, deleted
1.40	Jun. 07, 2018	2. Operating Environment	
		4	Table 2.1 Operating Environment: The description on the integrated development environment, modified
		5. Hardware	
		7	Figure 5.1 Hardware configuration example: The name of module, modified
		8. Related Documents	
		22	The name of IAR Embedded Workbench, modified

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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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Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

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: +44-1628-651-700, Fax: +44-1628-651-804

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, 200333 P. R. China
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 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338

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