

RL78/G23

Remote Control Signal Reception (AEHA Format, STOP Mode)

Introduction

This application note describes how to receive remote control signals using a remote control signal receiver (REMC) and STOP mode.

The applicable remote control format is AEHA (including header and 48-bit data).

Target Device

RL78/G23

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.

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1. Specification

1.1 Overview of Specification

In this application note, a remote control signal receiver (REMC) is used. LEDs are turned on according to the remote control code received by the remote control signal receiver (REMC). When no remote control signal input is detected for 10 seconds, the MCU shifts to STOP mode. When a remote control signal input is detected in STOP mode, the application performs the remote control signal reception processing using the low-speed peripheral clock (f_{SXP}).

Also, at startup, frequency correction processing is performed for the low-speed on-chip oscillator clock used for the low-speed peripheral clocks. For details on frequency compensation processing, see the application note "Low-speed On-chip Oscillator (LOCO) Clock Frequency Correction".

Table 1-1 lists peripheral functions and their use. Figure 1-1 shows an overview of sample code operation. Table 1-2 shows the relation between remote control signal input and LED ON/OFF state.

Table 1-1 Peripheral Function and Use

Peripheral Function	Use
Remote control signal receiver (REMC)	Remote control signal reception
Channels 1 of time array unit 0 (TAU0)	STOP mode transition decision timer
32-bit interval timer channel 0, 1	Used for calibration of LOCO.
P03, P02, P43, P42, P77, P41, P31, P76	Output pins to LED1-LED8

Figure 1-1 Overview of Operation

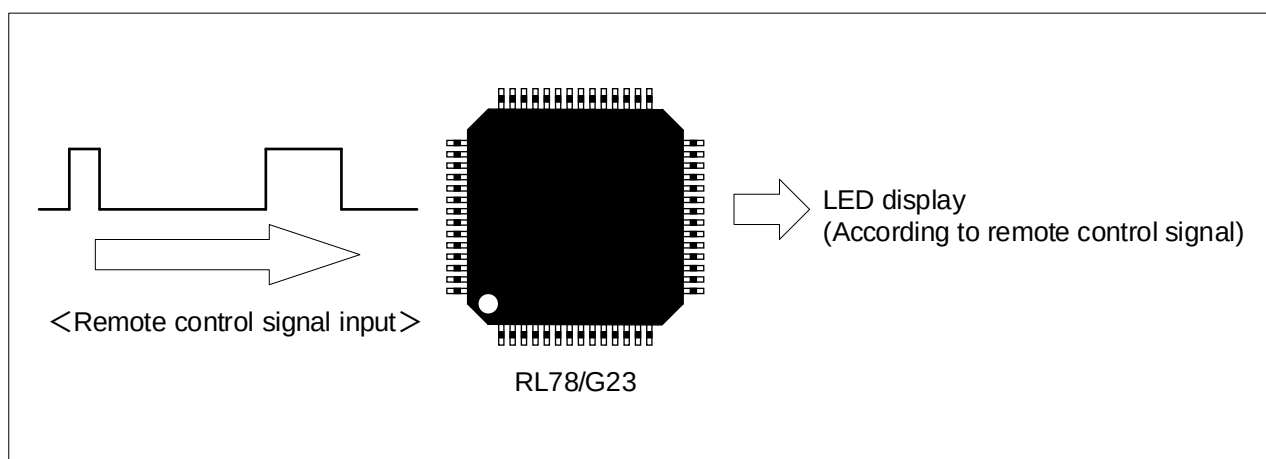


Table 1-2 Relation between Remote Control Signal Input and LED ON/OFF State

Remote Control Signal Input	LED1 to LED8 ON/OFF State
No input	All LEDs OFF
Channel 1 select	LED1 ON
Channel 2 select	LED2 ON
Channel 3 select	LED3 ON
Channel 4 select	LED4 ON
Channel 5 select	LED5 ON
Channel 6 select	LED6 ON
Channel 7 select	LED7 ON
Channel 8 select	LED8 ON
Other signal inputs	All LEDs OFF
No input (STOP mode)	All LEDs OFF

1.2 Details of Operation

This application note shows an example of use of the remote control signal receiver (REMC). The REMC receives AEHA-format remote control signals (including header and 48-bit data). When the application recognizes that the relevant channel button was pressed, it turns on the corresponding LED. Figure 1-2 shows the remote control signal (AEHA format including header and 48-bit data) reception timing.

Figure 1-2 Remote Control Signal Reception Timing

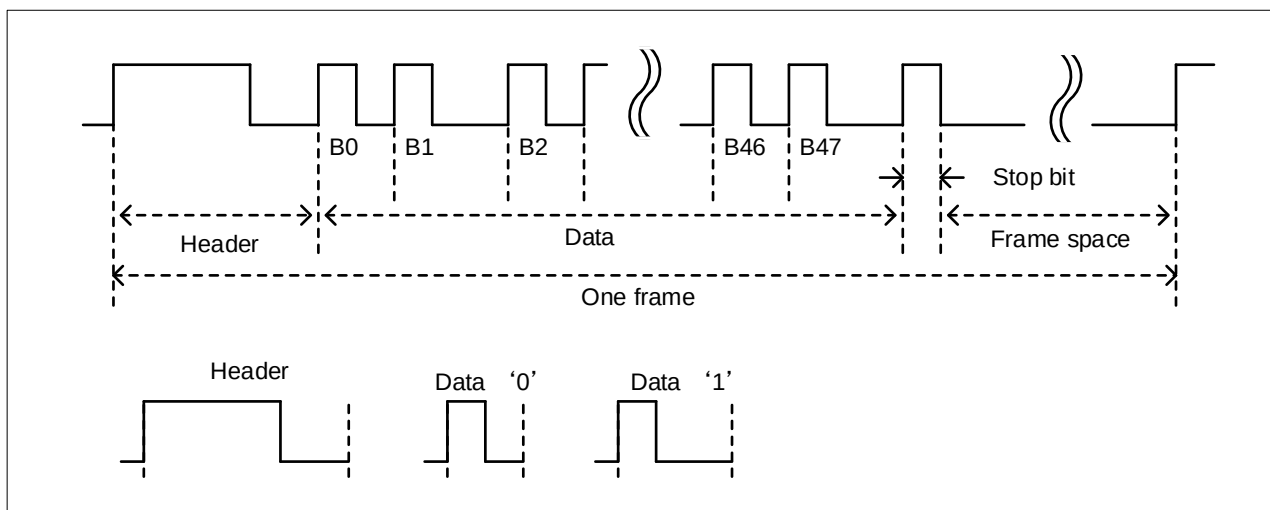


Table 1-3 shows the correspondence between remote control input signals and remote control signal data. When the fifth byte (B32 to B39 in Figure 1-2) of the received remote control signal data matches the signal data in Table 1-3, the application recognizes that the relevant channel button was pressed.

Table 1-3 Correspondence between Remote Control Input Signals and Signal Data

Remote Control Input Signal	Signal Data
Channel 1	0x10
Channel 2	0x11
Channel 3	0x12
Channel 4	0x13
Channel 5	0x14
Channel 6	0x15
Channel 7	0x16
Channel 8	0x17

When no remote control signal input is detected for 10 seconds, the application shifts to STOP mode. When a remote control signal is detected in STOP mode, the application performs the remote control signal reception processing using the low-speed peripheral clock (f_{SXP}). Upon receiving the REMC interrupt request signal, the application transitions from SNOOZE mode to normal operation mode.

Figure 1-3 shows the transition (to STOP mode) timing. Figure 1-4 shows the state transition diagram.

Figure 1-3 Transition (to STOP Mode) Timing

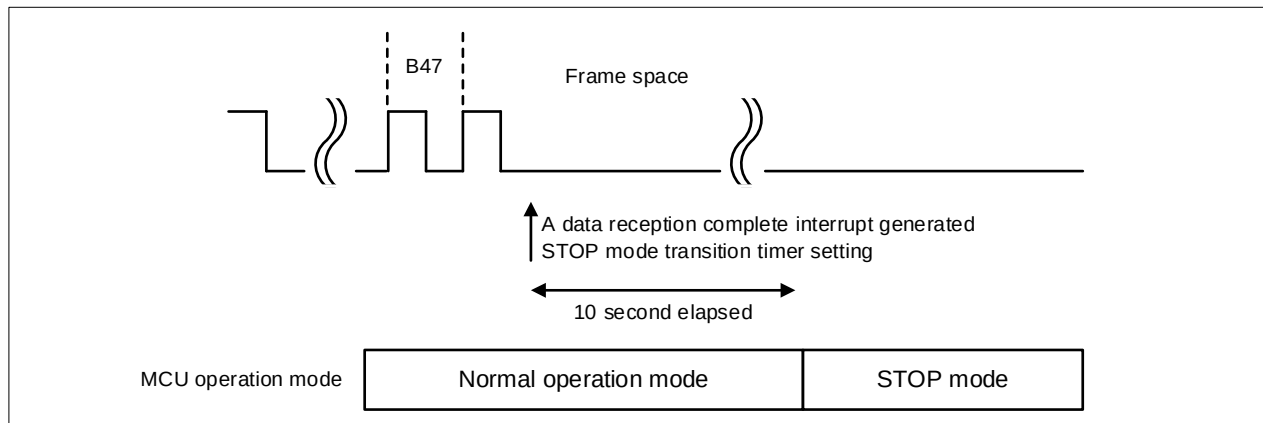
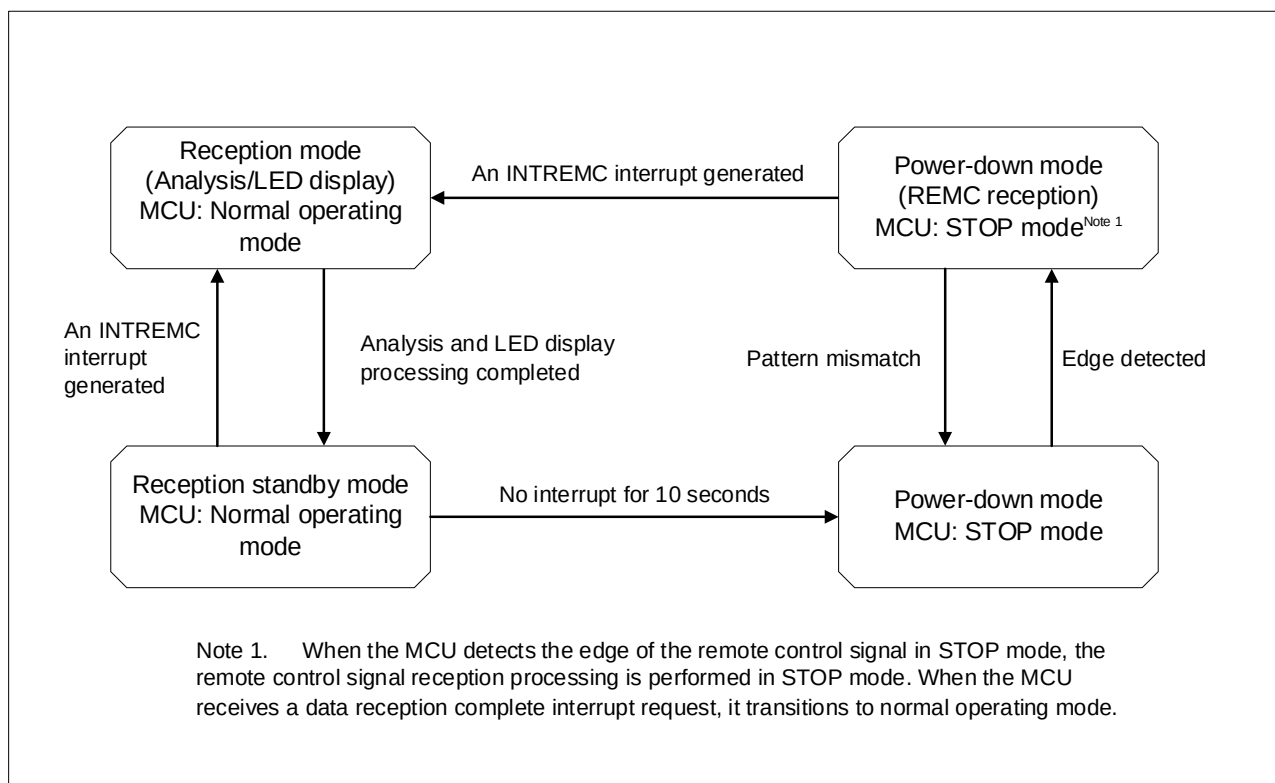


Figure 1-4 Remote Control Signal Reception State Transition Diagram



The following describes the main settings for peripheral functions.

- (1) Timer array unit 0 (TAU0) channel 1 (for deciding transition to STOP mode)
 - Set the timer operation mode to interval timer mode.
 - Operating clock: CK00, clock source: $f_{CLK}/2^{13}$
 - Interval period: 10,000 ms (10 seconds)
 - Disable interrupts at count start.
 - Enable INTTM01 interrupts (interrupt priority level 3).
- (2) 32-bit interval timer
 - Set to 16-bit capture mode.
 - Select fIHP as the operating clock.
 - Select fSXP (low-speed on-chip oscillator) as the capture trigger operating clock.
- (3) I/O ports
 - P03, P02, P43, P42, P77, P41, P31 and P76 pins: Set as output ports.

(3) Remote control signal receiver (REMC)

- Operating clock: f_{SXP}
- Enable digital filters (three-time match). Digital filter sampling clock: f_{SXP}
- Disable transitions from STOP mode to SNOOZE mode.
- Reception mode: Format A pattern. Enable input/output signal inversion.
- Pattern settings: Shown below (Special data and patterns are not used.)

Table 1-4 Pattern Settings

Item		Setting value ^{Note}
Pattern end width		230
Header pattern	Maximum width	197
	Minimum width	138
Data 0 pattern	Maximum width	33
	Minimum width	23
Data 1 pattern	Maximum width	66
	Minimum width	46

Note. In RL78/G23, an error of f_{IL} is within $\pm 15\%$. When using f_{IL} as f_{SXP} , you may need to correct f_{IL} . For the correction method of f_{IL} , refer to the Application Note for RL78/G23 Low-speed On-chip Oscillator (LOCO) Clock Frequency Correction (R01AN5557).

- Number of compare bits: 16, compare value: 0x2002
- No data capture at the time of a receive error
- Enable compare match interrupts, data reception complete interrupts, and header pattern match interrupts.
- Set interrupts mode to sequential interrupt mode (interrupt priority level 3)

2. Operation Confirmation Conditions

The operation of the sample code provided with this application note has been tested under the following conditions.

Table 2-1 Operation Confirmation Conditions

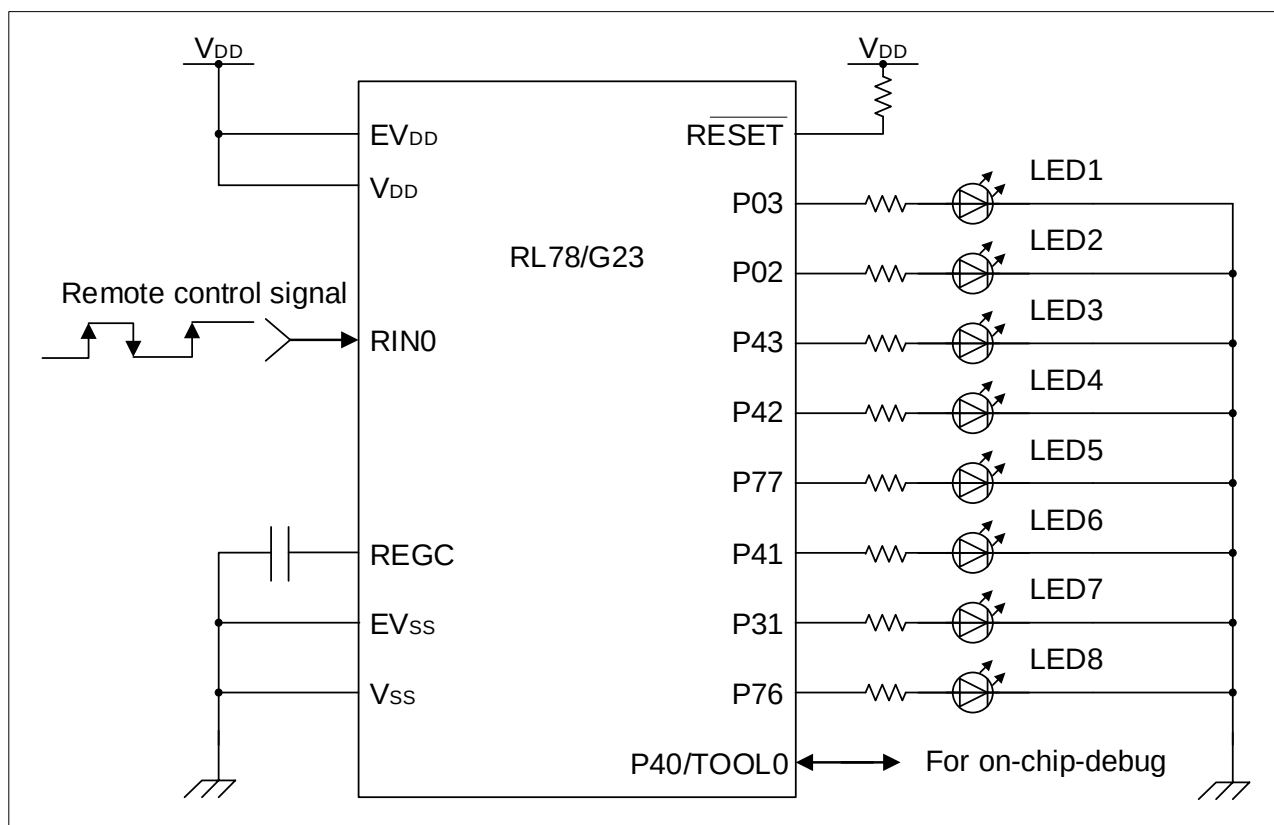
Item	Description
MCU used	RL78/G23 (R7F100GLG)
Board used	RL78/G23-64p Fast Prototyping Board (RTK7RLG230CLG000BJ)
Operating frequency	- High-speed on-chip oscillator clock (f_{IH}): 32 MHz - Low-speed on-chip oscillator clock (f_{IL}): 32.768 kHz
Operating voltage	5.0V (can be operated at 2.0 V to 5.5 V) LVD0 operations (V_{LVD0}): Reset mode At rising edge TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86 V (1.80 V to 1.91 V)
Integrated development environment (CS+)	CS+ for CC V8.11.00 from Renesas Electronics Corp.
C compiler (CS+)	CC-RL V1.13.00 from Renesas Electronics Corp.
Integrated development environment (e2studio)	e2studio V2024-01 (24.1.0) from Renesas Electronics Corp.
C compiler (e2studio)	CC-RL V1.13.00 from Renesas Electronics Corp.
Integrated development environment (IAR)	IAR Embedded Workbench for Renesas RL78 V4.21.2 from IAR Systems Corp.
C compiler (IAR)	IAR C/C++ Compiler for Renesas RL78 V4.21.2.2420 from IAR Systems Corp.
Smart Configurator	V1.9.0 from Renesas Electronics Corp.
Board support package (BSP)	V1.40 from Renesas Electronics Corp.
Remote controller used	ATV-102 supplied by Asahi Electrochemical Co., Ltd. (Panasonic TV ⑩①⑨)

3. Hardware Descriptions

3.1 Example of Hardware Configuration

Figure 3-1 shows an example of the hardware configuration used in the application note.

Figure 3-1 Hardware Configuration



- Note 1. This schematic circuit diagram is simplified to show the outline of connections. When creating actual circuits, design them using appropriate pin processing so that the circuits meet electrical characteristics. (Connect input-only ports to V_{DD} or V_{SS} individually through a resistor.)
- Note 2. Connect pins (with a name beginning with EV_{SS}), if any, to V_{SS} , and connect pins (with a name beginning with EV_{DD}), if any, to V_{DD} .
- Note 3. Set V_{DD} to a voltage not less than the reset release voltage (V_{LVD0}) set by the LVD0.

3.2 List of Pins to be Used

Table 3-1 lists the pins to be used and their functions.

Table 3-1 Pins to be Used and Their Functions

Pin name	I/O	Functions
RIN0/P70	Input	Remote control signal input
P03	Output	LED (LED1) control port
P02	Output	LED (LED2) control port
P43	Output	LED (LED3) control port
P42	Output	LED (LED4) control port
P77	Output	LED (LED5) control port
P41	Output	LED (LED6) control port
P31	Output	LED (LED7) control port
P76	Output	LED (LED8) control port

Caution In this application note, only the used pins are processed. When actually designing your circuit, make sure the design includes sufficient pin processing and meets electrical characteristic requirements.

4. Software Explanation

4.1 Setting of Option Byte

Table 4-1 shows the option byte settings.

Table 4-1 Option Byte Settings

Address	Setting Value	Contents
000C0H / 040C0H	11101111B	Disables the watchdog timer. (Counting stopped after reset)
000C1H / 040C1H	11111110B	LVD0 detection voltage: reset mode At rising edge TYP. 1.90 V (1.84 V to 1.95 V) At falling edge TYP. 1.86 V (1.80 V to 1.91 V)
000C2H / 040C2H	11101000B	HS mode, High-speed on-chip oscillator clock (f_{IH}): 32 MHz
000C3H / 040C3H	10000101B	Enables on-chip debugging

4.2 List of Constants

Table 4-2 lists the constants that are used in the sample code.

Table 4-2 Constant

Constant Name	Setting Value	Description
R_REMC_BUFF_SIZE	32	REMC receive buffer size
R_AEHA_DATA_LEN	6	Remote control data length (AEHA format)
R_AEHA_DATA_CODE_POS	4	Data storage location (AEHA format)
R_AEHA_DATA_CODE_01	0x10	Channel 1 data (AEHA format)
R_AEHA_DATA_CODE_02	0x11	Channel 2 data (AEHA format)
R_AEHA_DATA_CODE_03	0x12	Channel 3 data (AEHA format)
R_AEHA_DATA_CODE_04	0x13	Channel 4 data (AEHA format)
R_AEHA_DATA_CODE_05	0x14	Channel 5 data (AEHA format)
R_AEHA_DATA_CODE_06	0x15	Channel 6 data (AEHA format)
R_AEHA_DATA_CODE_07	0x16	Channel 7 data (AEHA format)
R_AEHA_DATA_CODE_08	0x17	Channel 8 data (AEHA format)
R_LED_ALL_OFF	0	Data for turning off all LEDs
R_INTR_STATE_NONE	0x00	No interrupt detected
R_INTR_STATE_RECV_END	0x01	REMC reception complete interrupt generated
R_INTR_STATE_TIME_OUT	0x02	Timeout occurred
LIOTRM_MAX	11111111B	Maximum value of the LIOTRM register
LIOTRM_MIN	00000000B	Minimum value of the LIOTRM register
CCNT_MAX	7860	Upper threshold of clock count
CCNT_MIN	7765	Lower threshold of clock count

4.3 List of Variables

Table 4-3 lists global variables.

Table 4-3 Global Variables

Type	Variable Name	Description	Function Used
uint8_t	g_remc_buf [R_REMC_BUF_SIZE]	REMC receive buffer	main
r_intr_state_t	g_intr_state	Interrupt flag	main, r_Config_REMC_callback_ receiveend, r_Config_TAU0_1_interrupt
uint8_t	calibration_count	Calibration count value	R_Main_Calibrate_LOCO()
uint8_t	calibrate_history	Calibration history	R_Main_Calibrate_LOCO()
uint16_t	count_value	Count value (Used as an argument of R_Trimming_OCO)	R_Trimming_OCO()
uint16_t	max	Upper threshold of count	R_Main_Calibrate_LOCO()
uint16_t	min	Lower threshold of count	R_Trimming_OCO()

4.4 List of Functions

Table 4-4 shows a list of functions.

Table 4-4 Functions

Function Name	Outline
r_calibration_main	Frequency correction processing
r_Config_REMC_callback_receiveend	REMC reception complete interrupts
r_port_set_LED	LED lighting control
r_Config_TAU0_1_interrupt	STOP mode transition timer interrupts

4.5 Specification of Functions

The function specifications of the sample code are shown below.

r_calibration_main	
Outline	Frequency correction processing
Header	None
Declaration	void r_calibration_main(void)
Description	Execute the R_Main_Calibrate_LOCO and R_Trimming_OCO functions to correct the frequency of the low-speed on-chip oscillator clock. Refer to the application note "RL78/G23 Low-speed On-chip Oscillator (LOCO) Clock Frequency Correction (R01AN5557)" for details.
Argument	None
Return Value	None
r_Config_REMC_callback_receiveend	
Outline	REMC reception complete interrupts
Header	Config_REMC.h
Declaration	static void r_Config_REMC_callback_receiveend(void)
Description	Sets R_INTR_STATE_RECV_END for the interrupt flag g_intr_state.
Argument	None
Return Value	None
r_port_set_LED	
Outline	LED lighting control
Header	Config_PORT.h
Declaration	void r_port_set_LED(uint8_t num)
Description	Turns on the LED specified by argument "num". When R_LED_ALL_OFF is specified, all LEDs are turned off.
Argument	uint8_t num: Number of LED (1 to 8) to be turned on
Return Value	None
r_Config_TAU0_1_interrupt	
Outline	STOP mode transition timer interrupts
Header	Config_TAU0_1.h
Declaration	static void __near r_Config_TAU0_1_interrupt(void)
Description	Sets R_INTR_STATE_TIME_OUT for the interrupt flag g_intr_state.
Argument	None
Return Value	None

4.6 Flowcharts

4.6.1 Main Processing

Figure 4-1 and Figure 4-2 show the flowchart of the main processing.

Figure 4-1 Main Processing (1/2)

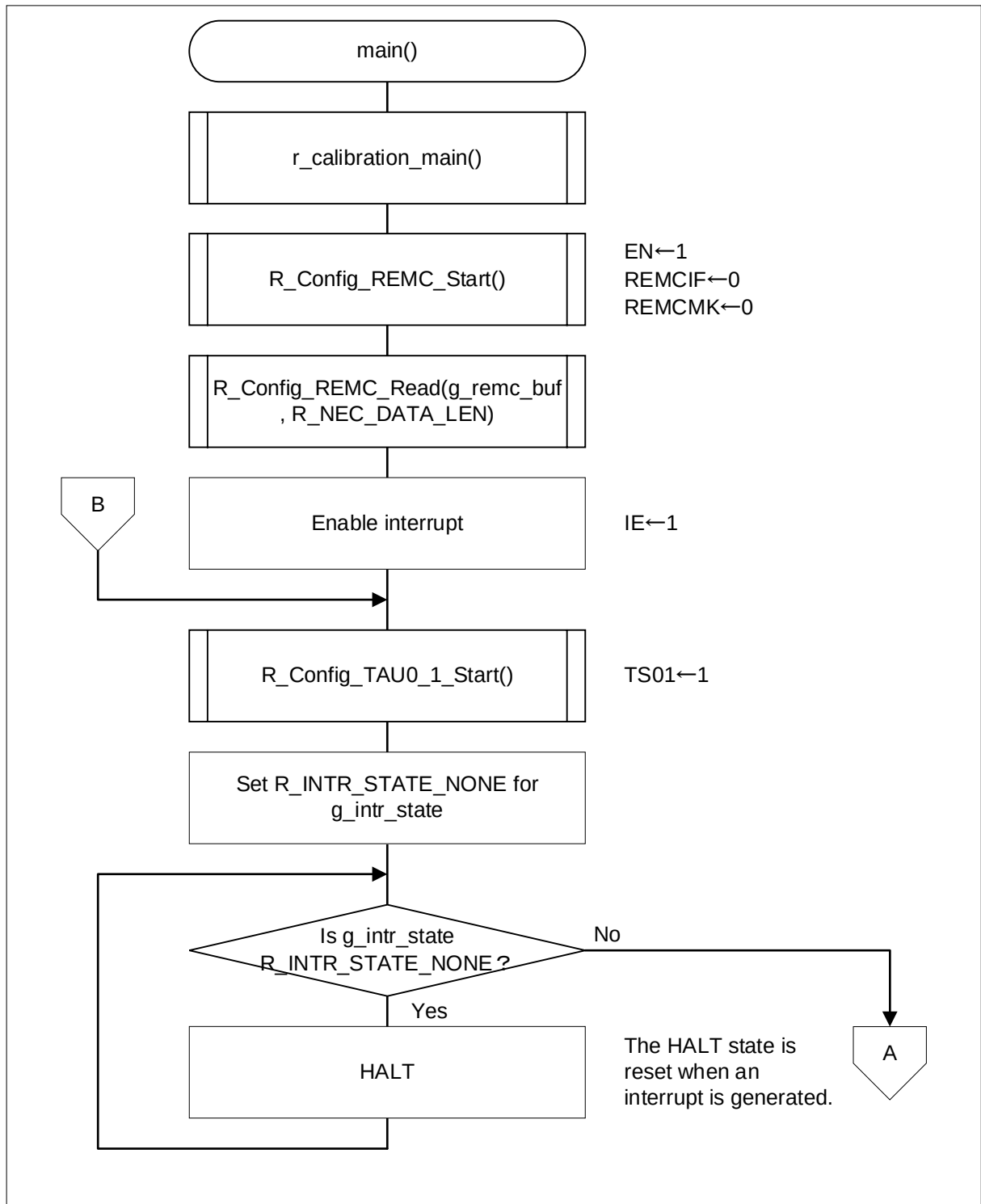
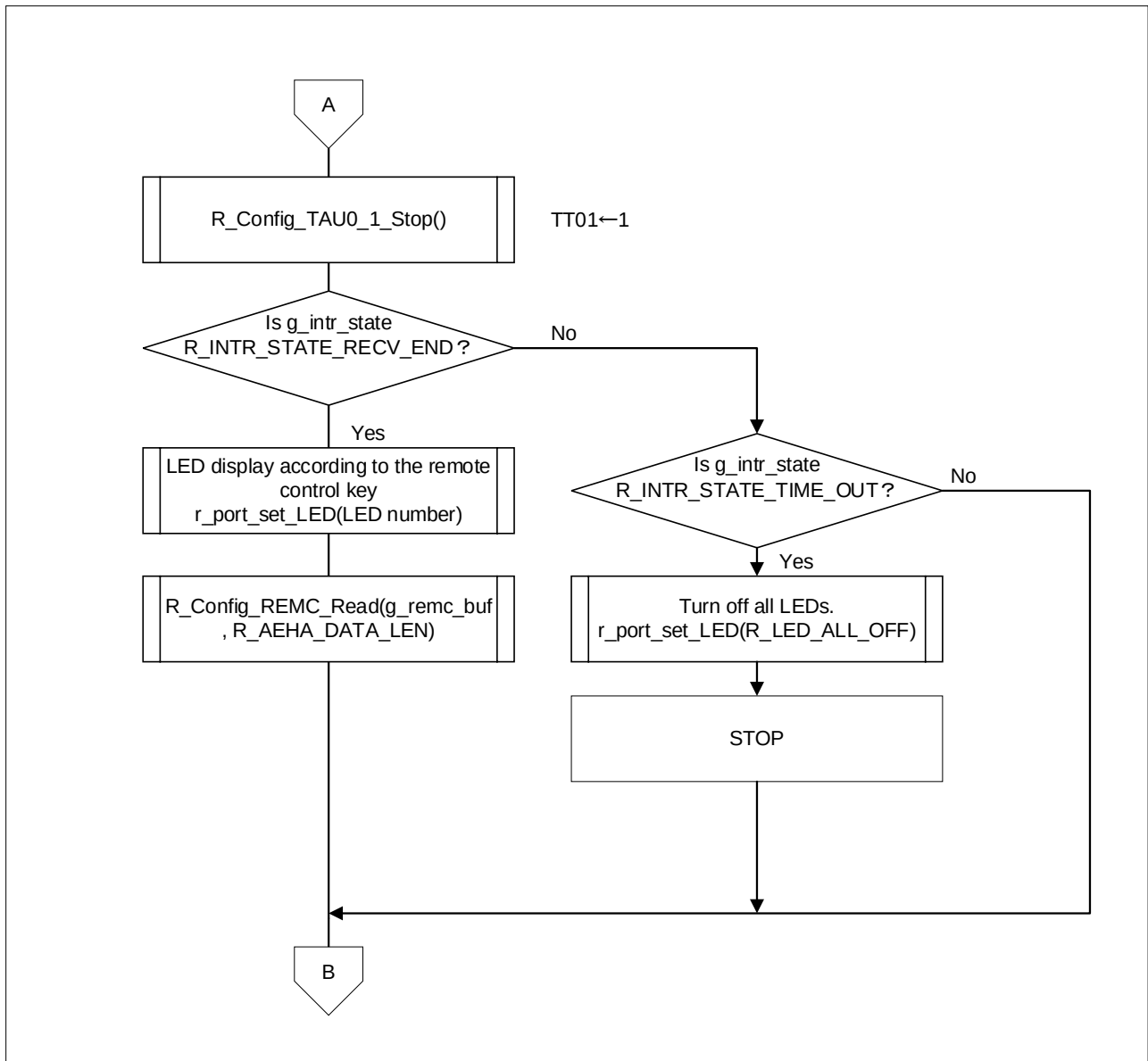


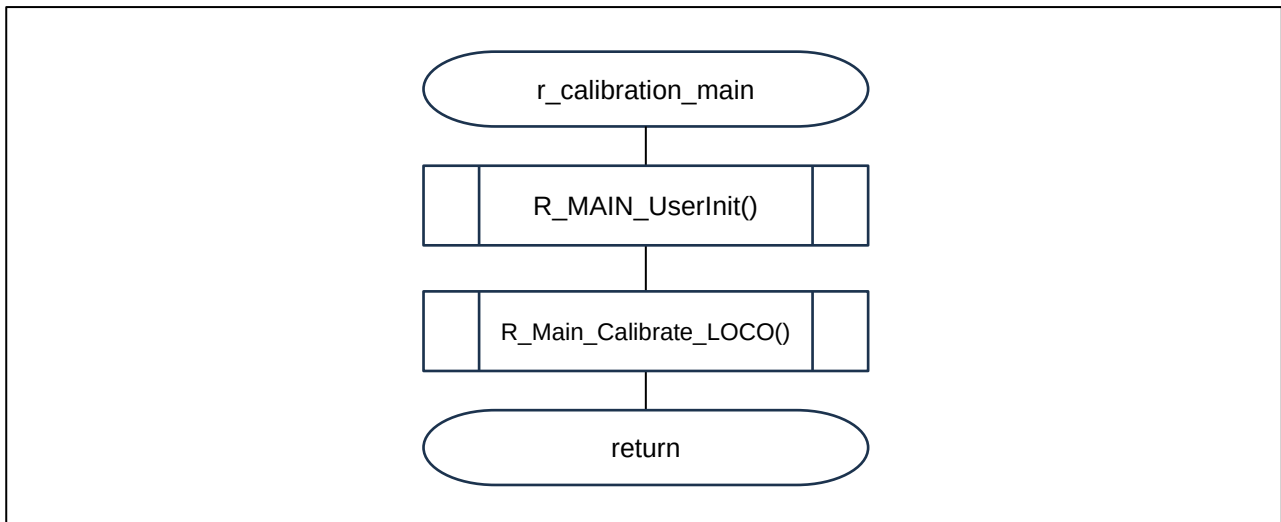
Figure 4-2 Main Processing (2/2)



4.6.2 Frequency Correction Processing

Figure 4-3 show the flowchart of the frequency correction processing.

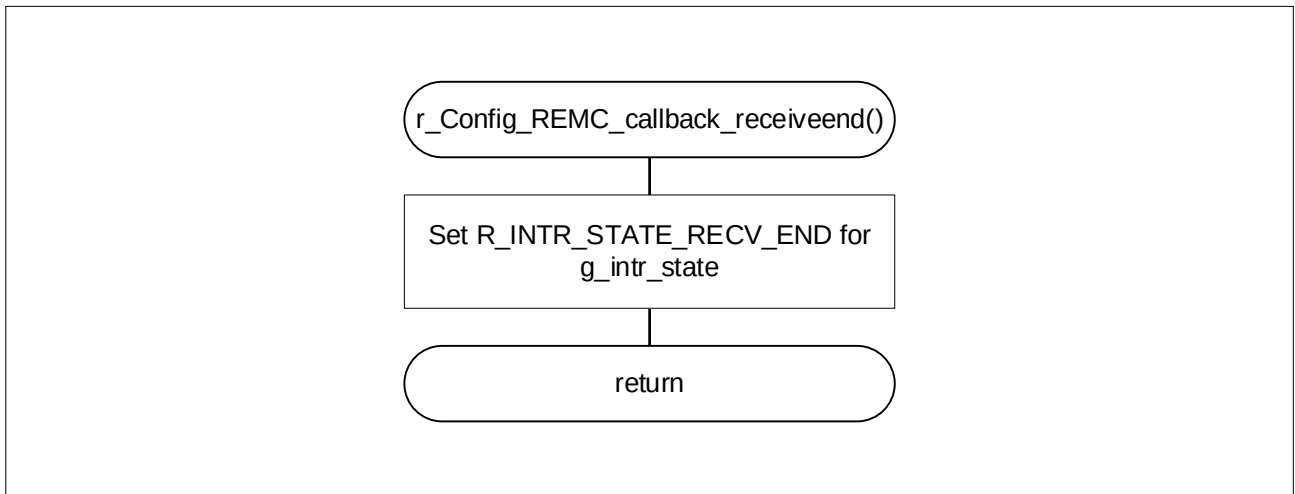
Figure 4-3 Frequency Correction Processing



4.6.3 REMC Reception Complete Interrupts

Figure 4-4 shows the flowchart of the REMC reception complete interrupts.

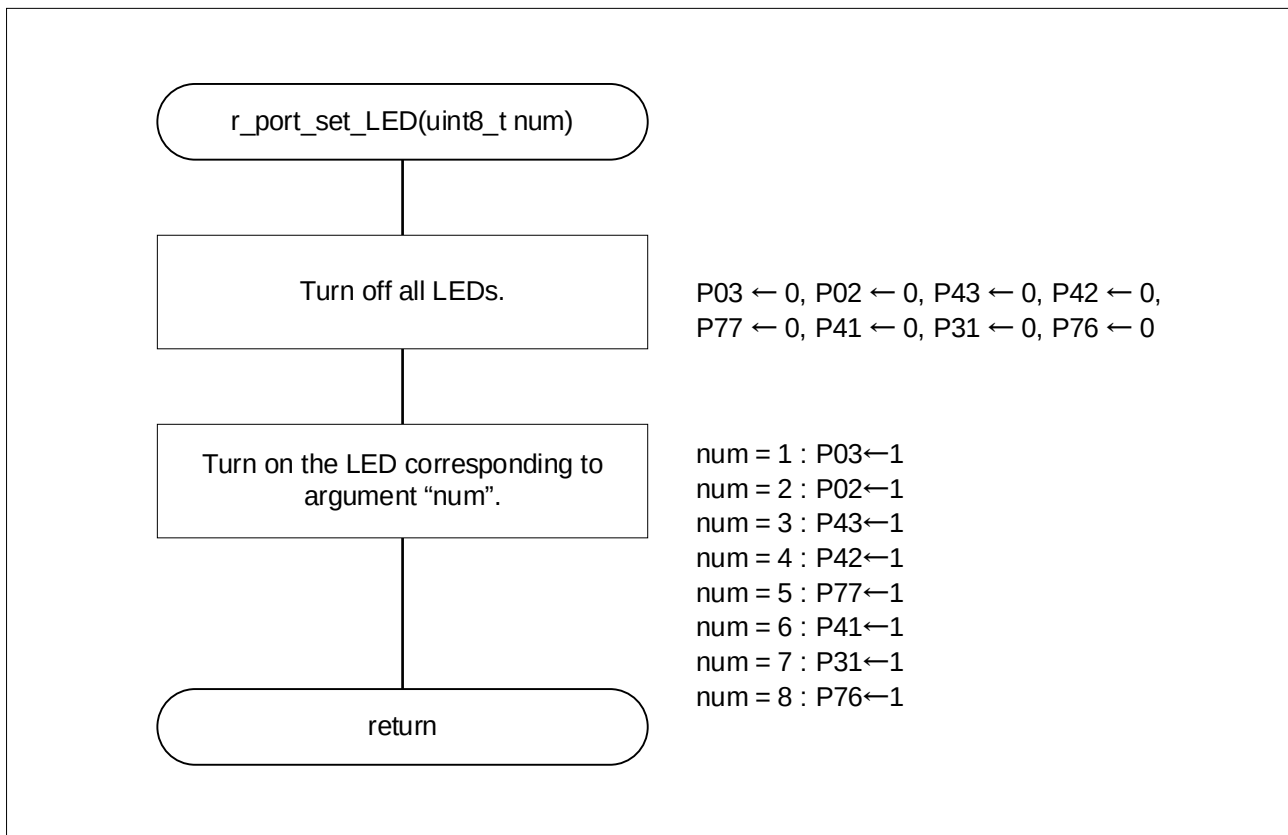
Figure 4-4 REMC Reception Complete Interrupts



4.6.4 LED Lighting Control

Figure 4-5 shows the flowchart for LED lighting control.

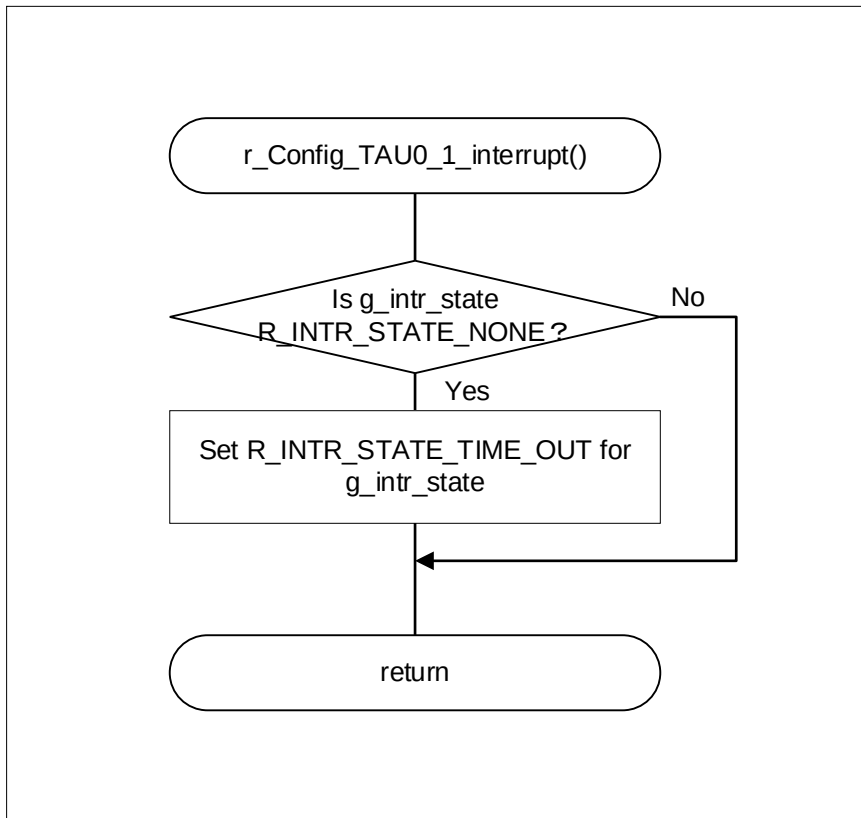
Figure 4-5 LED Lighting Control



4.6.5 STOP Mode Transition Timer Interrupts

Figure 4-6 shows the flowchart of the STOP mode transition timer interrupts.

Figure 4-6 STOP Mode Transition Timer Interrupts



5. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents

RL78/G23 User's Manual: Hardware (R01UH0896)

RL78 family user's manual software (R01US0015)

RL78/G23 Low-speed On-chip Oscillator (LOCO) Clock Frequency Correction (R01AN5557E)

The latest versions can be downloaded from the Renesas Electronics website.

Technical update

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Revision History

Rev.	Data	Description	
		Page	Point
1.00	2021.12.28	—	First Edition
1.10	2022.10.04	7	Modification of Pattern Settings in Table 1.4
2.00	2024.2.7	—	Added frequency correction processing

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1. Precaution against Electrostatic Discharge (ESD)

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The state of the product is undefined at the time 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 time 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 time 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 time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

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5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is 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. Additionally, 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.

6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

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