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M16C/28, 29 Group

Remote Control Reception

1. Abstract

This documents describes how to receive a remote control signal using the time measurement function of timer S.

2. Introduction

The application example described in this document is applied to the following MCU and parameter(s):
MCU: M16C/28, 29 Group

This program can be used with other M16C Family MCUs which have the same special function registers (SFRs) as the M16C/28 and M16C/29 Groups. Check the manual for any additions and modifications to functions. Careful evaluation is recommended before using this application note.

3. Remote Control Reception Overview

An infrared signal transmitted from the remote control is transmitted to the receiver at a certain frequency (carrier frequency). As the infrared signal is weakened through diffusion at the receiver, the output of the infrared receiving element must be amplified using a preamplifier. Also, passing though a bandpass filter (BPF) allows an accurate remote control signal to be obtained by extracting only the carrier waveform element and detecting and rectifying the waveform. In this case, the carrier frequency is set to 38 kHz.
Figure 3.1 shows the Block Diagram of Remote Control Reception Overview, Figure 3.2 shows the Internal Block Diagram of Infrared Remote Control Receive Module, and Figure 3.3 shows the Carrier Waveform.

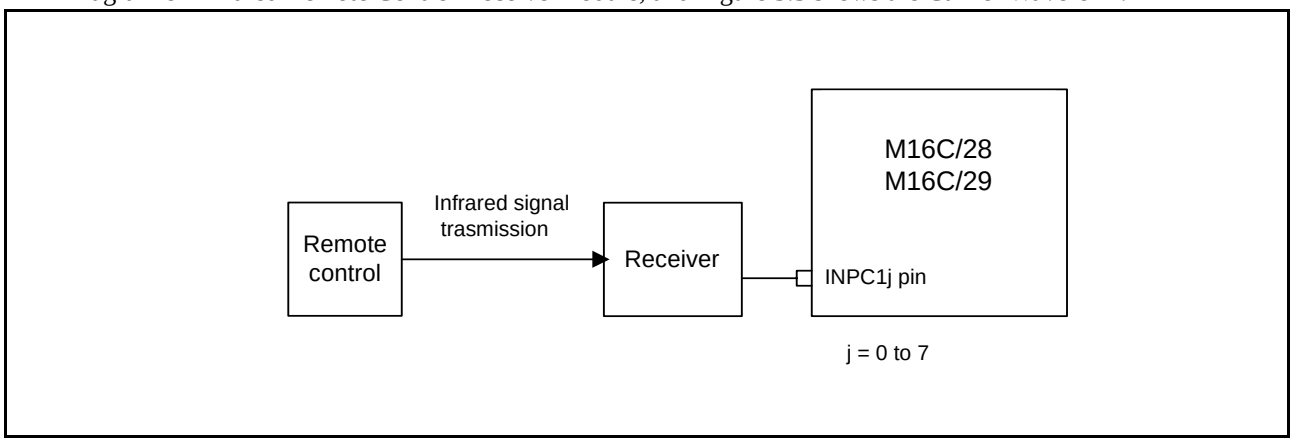


Figure 3.1 Block Diagram of Remote Control Reception Overview

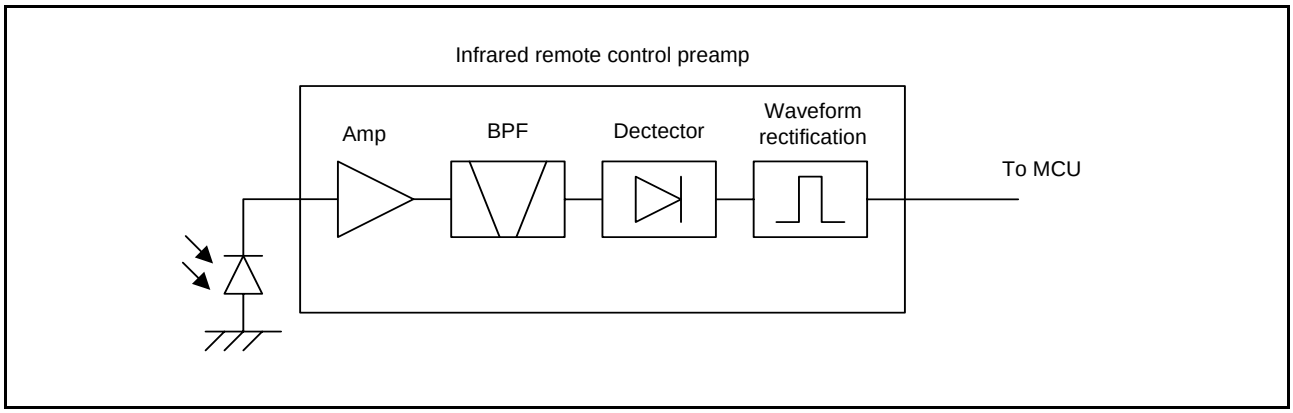
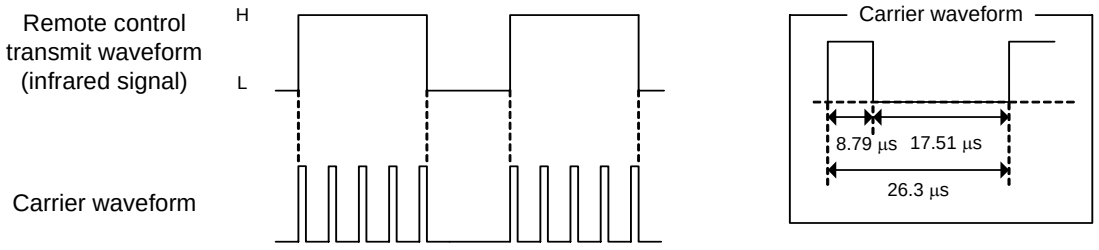


Figure 3.2 Internal Block Diagram of Infrared Remote Control Receive Module

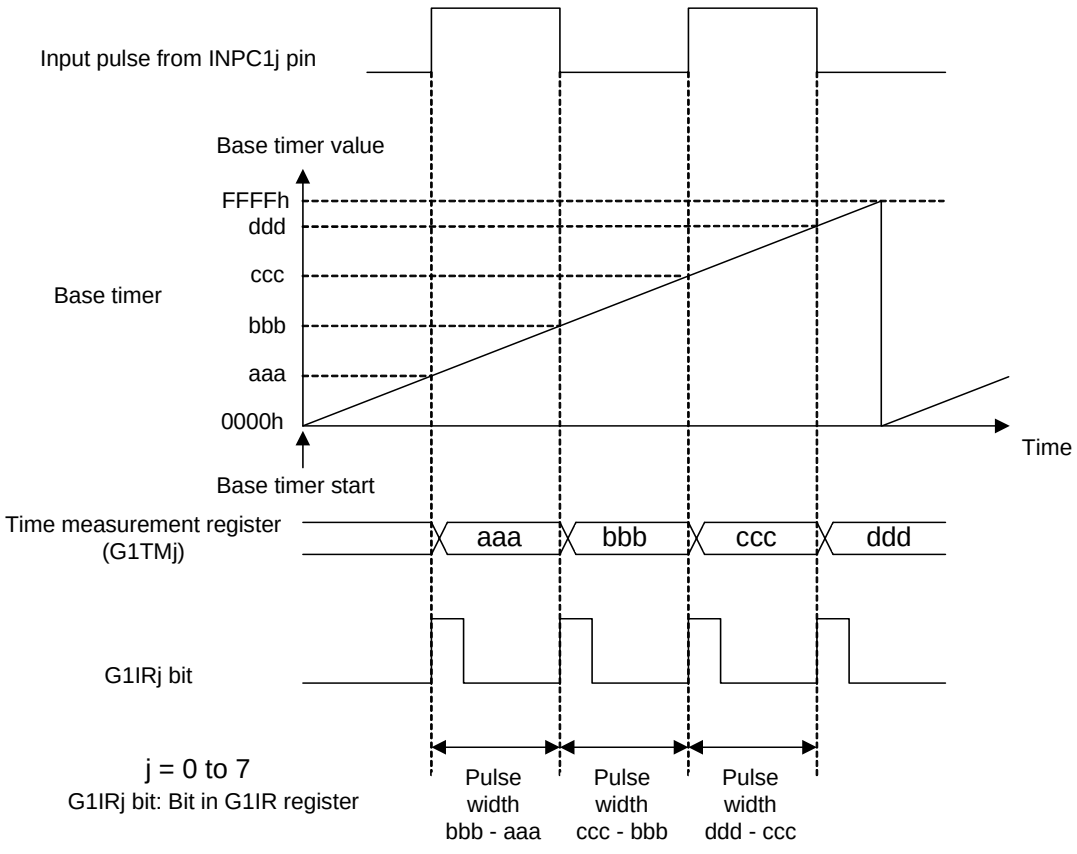


An infrared signal is not continuously transmitted throughout the entire “H” interval of the remote control transmit waveform. The interval of infrared transmission/no transmission is repeated at a certain frequency (carrier frequency).

Figure 3.3 Carrier Waveform

4. Time Measurement Function

The time measurement function of timer S synchronizes with the external trigger input and stores the base timer value to the G1TMj register (j = 0 to 7). Figure 4.1 shows the Operational Timing of Time Measurement Function.



This applies under the following conditions:
- Time measurement trigger: Both edges
- No timer reset at the match between the G1PO0 register and the base timer
- Base timer value: Up count mode

Figure 4.1 Operational Timing of Time Measurement Function

5. Operational Description

In this sample program, the count source f1 is set to 20 MHz and the count source division is set to divide-by-40 for timer S.
Waveform data can be measured using either positive or negative logic.

Table 5.1 lists the Resource List

Table 5.1 Resource List

Resource	Channel	Period	Application
Timer S	Time measurement 0 channel	2 μs	Remote control transmit waveform time measurement
Timer A	Timer A0	1 ms	One frame timer measurement (for timer A1 event count)
	Time A1	140 ms	One frame timer measurement

5.1

- Timer S -

1. Set the base timer to divide-by-40 and the count source f1.
2. Set the timer measurement trigger for the base timer to both edges.
3. Setting the base timer start bit to 1 increments the base timer value.
4. Timer S time measurement function 0 interrupt request bit is set to 1 at the rising or falling edge of the INPC10 pin. At the same time, the base timer value (G1TM0) is stored.
5. The stored base timer value is converted to a pulse value and compared with the remote control data.

5.2

- Timer A -

1. Use timer A to measure one frame from the leader code.
2. Set timer A0 to timer mode and timer A1 to event counter mode (timer A0 underflow counted).
3. Set the timer A0 register (TA0) to (4E1F)h in order to set the timer A0 period to a 1 ms interval.
4. Set the timer A1 register (TA1) to (008B)h in order to set the timer A1 period to a 140 ms interval (one frame ±30% error).
5. Set the timer A0 and timer A1 count start flags to 1 upon detecting the rising or falling edge of the INPC10 pin and start the timer.
6. Stop timer A0 and timer A1 at the timer A1 underflow. If the stop bit is not received at this time, the frame is invalid.

6. Remote Control Detection Performance

- For the first data, reception is determinded as complete if the following are received within 108 ms: the leader code, custom code (8 bits), inverted custom code (8 bits), data code (8 bits), inverted data code (8 bits), stop bit (1 bit), and one frame (interval including from the leader code to the frame space) of the frame space (interval of no infrared transmission).
- For the second or subsequent data, reception is determind as complete if the following are received within 108 ms: the leader code, stop bit (1 bit), and one frame of the frame space.
- For each code, code recognition is determinded as complete if the error is within ±30% of the format value. The same applies to one frame if the error is within 108 ms +30 %.
- When the leader code is detected, detection takes place in the order of custom code, data code, stop bit, and frame space.
- If a receive error occurs on each code, the next rising or falling egde is determinded as the leader code (first data) and reception starts.
- When one frame (including the +30% error) or more has elasped after the leader code, if the frame space is being recognized in the received data, reception is determinded as complete.
- When the leader code after the frame space is detected within one frame (including the +30% error), the detected received data is recognized as the second or sebsequent data. (The first leader code may be received within one frame after the frame space as the +30% error is included.)
- Figure 6.1 shows the Remote Control Format Diagram.

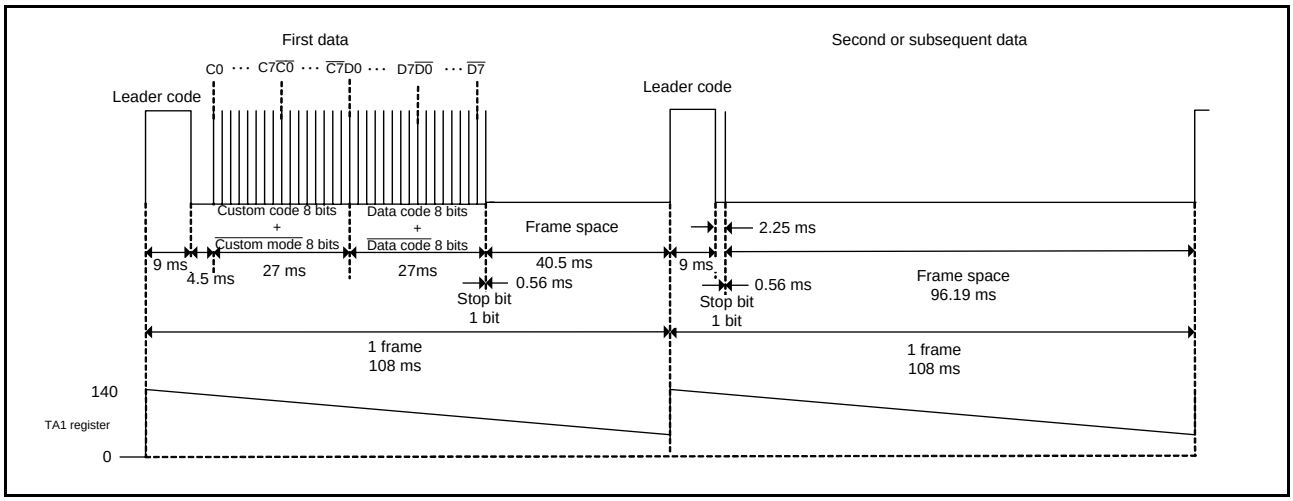


Figure 6.1 Remote Control Format Diagram

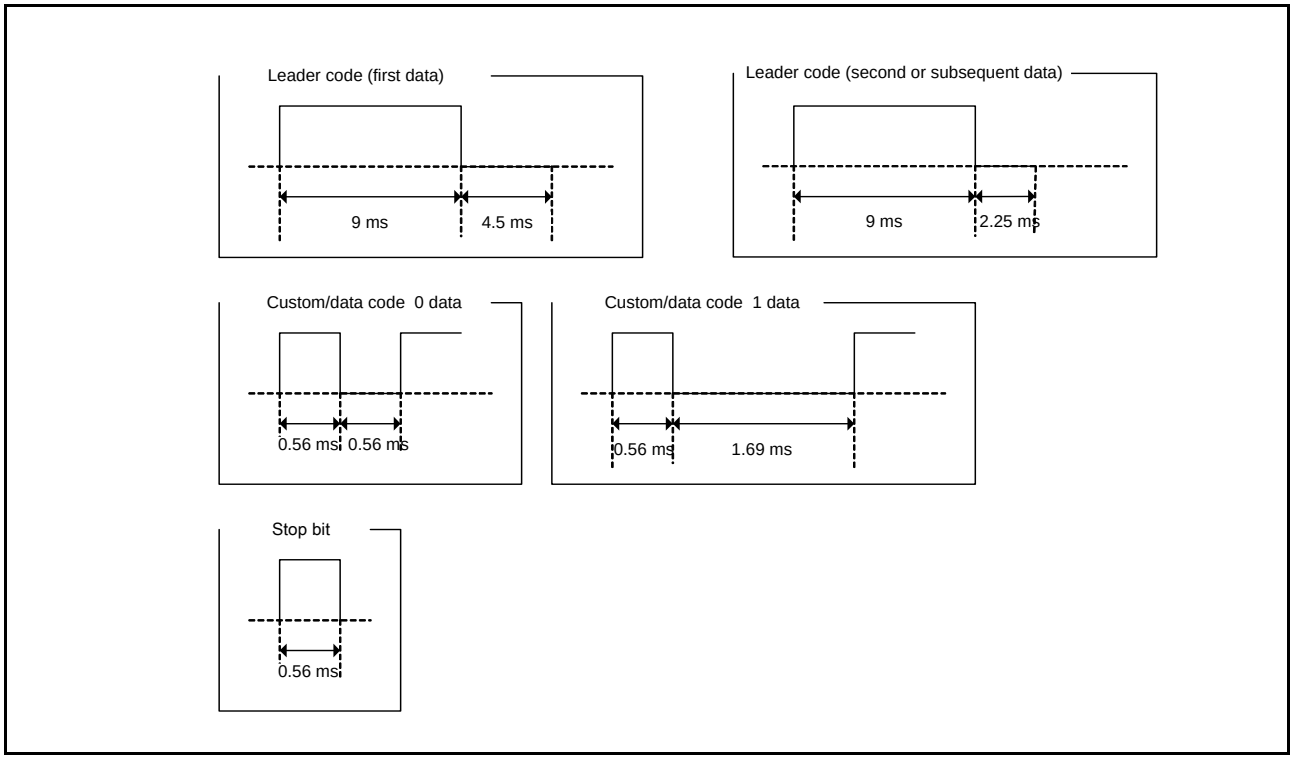


Figure 6.2 Expanded Codes

Table 6.1 Recognition Range Value by Code

Code Name	Code Recognition Range Value
Leader code “H”	6.30 ms to 11.70 ms
Leader code “L”	3.15 ms to 5.85 ms
Custom code “H”	0.39 ms to 0.73 ms
Custom code (0 data) “L”	0.39 ms to 0.73 ms
Custom code (1 data) “L”	1.18 ms to 2.20 ms
Data code “H”	0.39 ms to 0.73 ms
Data code (0 data) “L”	0.39 ms to 0.73 ms
Data code (1 data) “L”	1.18 ms to 2.20 ms
Stop bit	0.39 ms to 0.73 ms
Frame space	28.35 ms to 52.65 ms
Leader code “H” (repeat)	6.30 ms to 11.70 ms
Leader code “L” (repeat)	1.58 ms to 2.92 ms
Stop bit (repeat)	0.39 ms to 0.73 ms
Frame space (repeat)	67.33 ms to 125.05 ms

7. Software Description

7.1 Function Description

Table 7.1 lists the Function Description.

Table 7.1 Function Description

Function Name	Label Name	Feature
Main processing	main	Used register setting, used RAM initialization, interrupt enable, received data decision, timer decision
Received data setting processing	rcv_data	Received data setting process upon received data interrupt detection
Time over setting processing	time_over	Setup processing after one-frame time elapsed upon leader code detection
Pulse value setting processing	set_pulse_value	Pulse value setting
Received data decision processing	check_code	Received data decision/setting
Received data range check processing	cop_pulse	Received data range decision
Inverted data code decision processing	judge_reversing_code	Inverted data code decision
Inverted data code buffer setting processing	set_reversubg_code	Inverted data code buffer setting
Inverted data code comparison processing	cop_reversing_code	Inverted data code comparison

7.2 Register Description

Table 7.2 lists the Register Description.

Table 7.2 Register Description

Register Name		Address	Setting Value	Feature
G1BCR0	Base timer control register 0	0322h	00h 03h	• Clock stop • Bit 15 overflow, f1
G1DV	Count source divide register	032Ah	27h	• Divide-by-40
G1BCR1	Base timer control register 1	0323h	00h 10h	• Up count mode • Base timer reset/count start • No base timer reset at the “L” level input to the INT1 pin • No base timer reset at the match between the G1PO0 register and the base timer
G1TMCR0	Time measurement control register 0	0318h	03h	• No digital filter • The time measurement trigger is selected as both edges.
G1FS	Function select register	0327h	01h	Time measurement function for channel 0
G1FE	Function enable register	0326h	01h	Functional operation for channel 0
G1TM0	Time measurement register 0	0300h	-	A base timer value is stored at every time measurement timing.
G1IR	Interrupt request register	0330h	00h	Timer S Channel 0 interrupt request clear
TABSR	Count start flag	0380h	00h 03h	Timer A0, A1 count stop/start
TA0MR	Timer A0 mode register	0396h	00h	• Count source f1 • No gate function • Timer mode
TA0	Timer A0 register	0386h	4E1Fh	Set to 1 ms.
TA1MR	Timer A1 mode register	0397h	01h	• Reload type • Event counter mode
TA1	Timer A1 register	0388h	008Bh	Set to 140 ms (108 ms +30%).
TRGSR	Trigger select register	0383h	02h	The timer A1 event trigger selected as the timer TA0 underflow.
TA0IC	Interrupt control register	0055h	00h	Priority level 0
TA1IC	Interrupt control register	0056h	00h	Priority level 0

7.3 RAM Description

Table 7.3 lists the RAM Description.

Table 7.3 RAM Description

RAM Name	Feature	Data Length	Function Used
rcv_mode	Receive mode	1 byte	main, rcv_data, time_over, check_code
rcv_bit_cnt	Number of received custom/data code bit	1 byte	main, rcv_data, check_code
rcv_data_cnt	Number of received data	1 byte	main, rcv_data, time_over, check_code
pulse[100]	Received data buffer Storage in hexdecimal	200 bytes	time_over, set_pulse_value, check_code
pulse_cnt	Received data buffer position	1 byte	main, rcv_data, time_over, set_pulse_value, check_code
code_low_cnt	Received data code “L” counter	1 byte	main, rcv_data, judge_reversing_code,
rev_cnt	Inverted data counter	1 byte	main, rcv_data, judge_reversing_code, set_reversing_code, cmp_reversing_code
rev_pulse[8]	Inverted data code confirmation buffer If the code is not inverted data, it is stored to the following: If 0 data: 0xF1 If 1 data: 0xF0	8 bytes	set_reversing_code, cmp_reversing_code
old_tr	Timer measurement capture value for next comparison	2 bytes	set_pulse_value

7.4 ROM Description

Table 7.4 lists the ROM Description.

Table 7.4 ROM Description

ROM Name	Feature	Data Length	Function Used
cmp_tbl[14][2]	Received code compare table • [*][0]: Format value for each interval, [*][1]: Format value ±30% • [*][0]-[*][1] to [*][0]+[*][1]: Code recognition range value • If an error has ±30% of a format value, recognition is OK. [0][*]: Leader code “H” interval (6.30 ms to 11.70 ms) [1][*]: Leader code “L” interval (3.15 ms to 5.85 ms) [2][*]: Custom code “H” interval (0.39 ms to 0.73 ms) [3][*]: Custom code (0 data) “L” interval (0.39 ms to 0.73 ms) [4][*]: Custom code (1 data) “L” interval (1.18 ms to 2.20 ms) [5][*]: Data code “H” interval (0.39 ms to 0.73 ms) [6][*]: Data code (0 data) “L” interval (0.39 ms to 0.73 ms) [7][*]: Data code (1 data) “L” interval (1.18 ms to 2.20 ms) [8][*]: Stop bit interval (0.39 ms to 0.73 ms) [9][*]: Frame space interval (28.35 ms to 52.65 ms) [10][*]: Leader code “H” interval (repeat) (6.30 ms to 11.70 ms) [11][*]: Leader code “L” interval (repeat) (1.58 ms to 2.92 ms) [12][*]: Stop bit interval (repeat) (0.39 ms to 0.74 ms) [13][*]: Frame space interval (repeat) (67.33 ms to 125.05 ms)	56 bytes	check_code

8. Setup Procedure

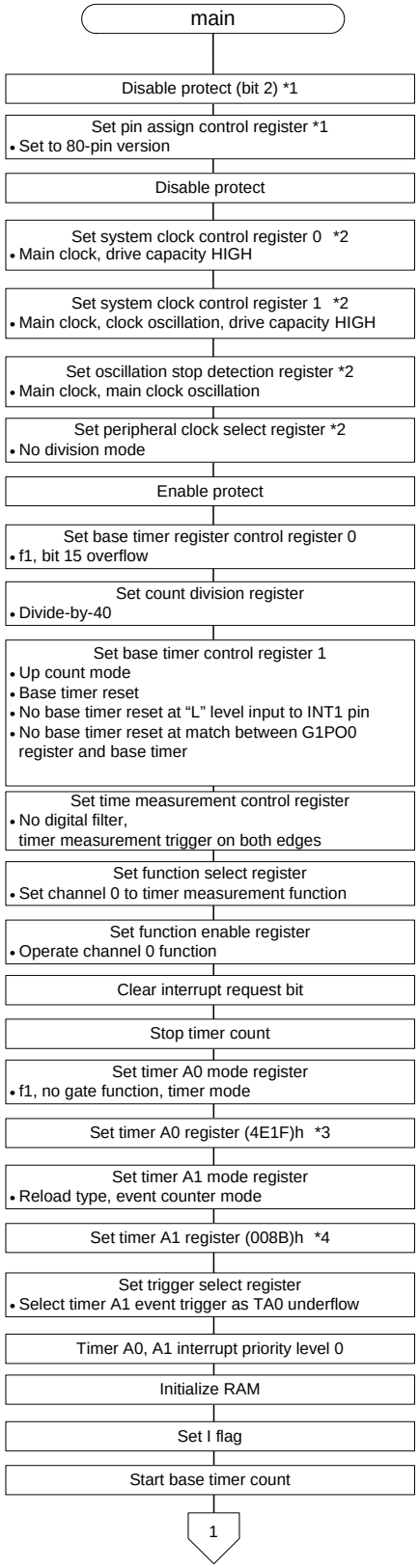


Figure 8.1 Flowchart (main)

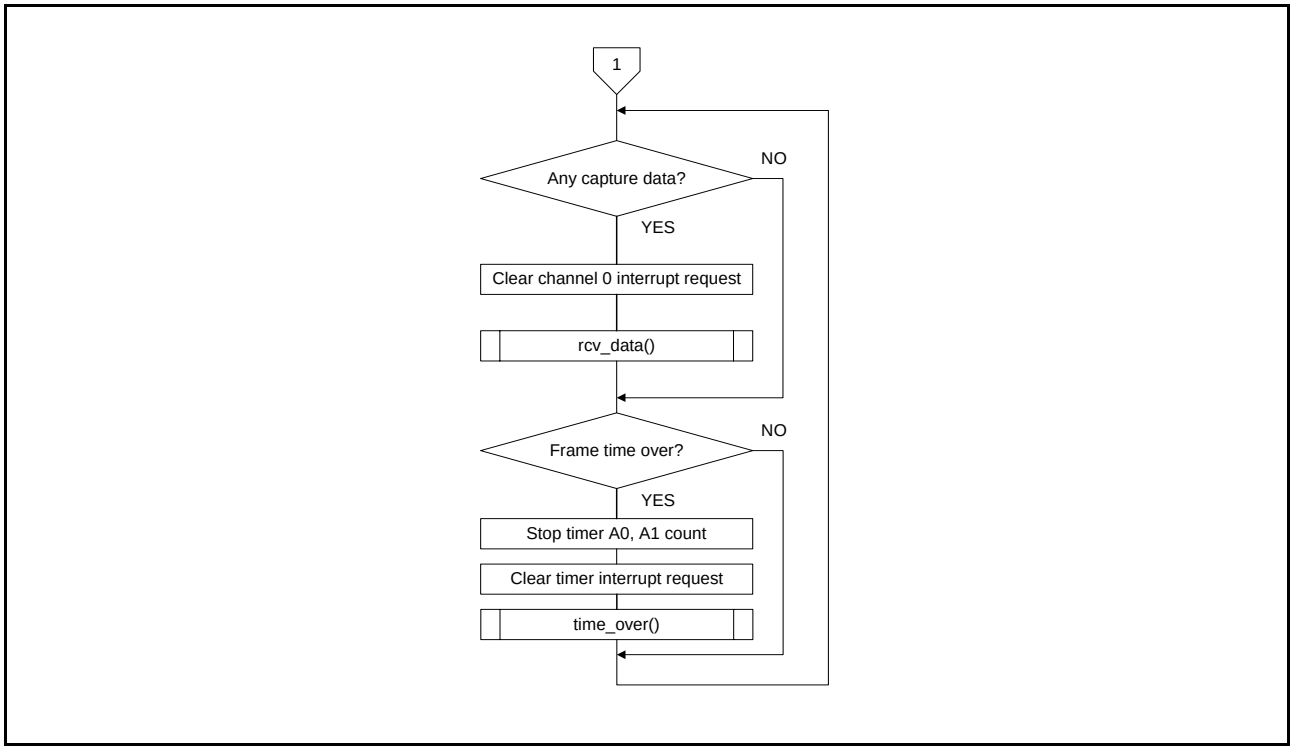


Figure 8.2 Flowchart (main)

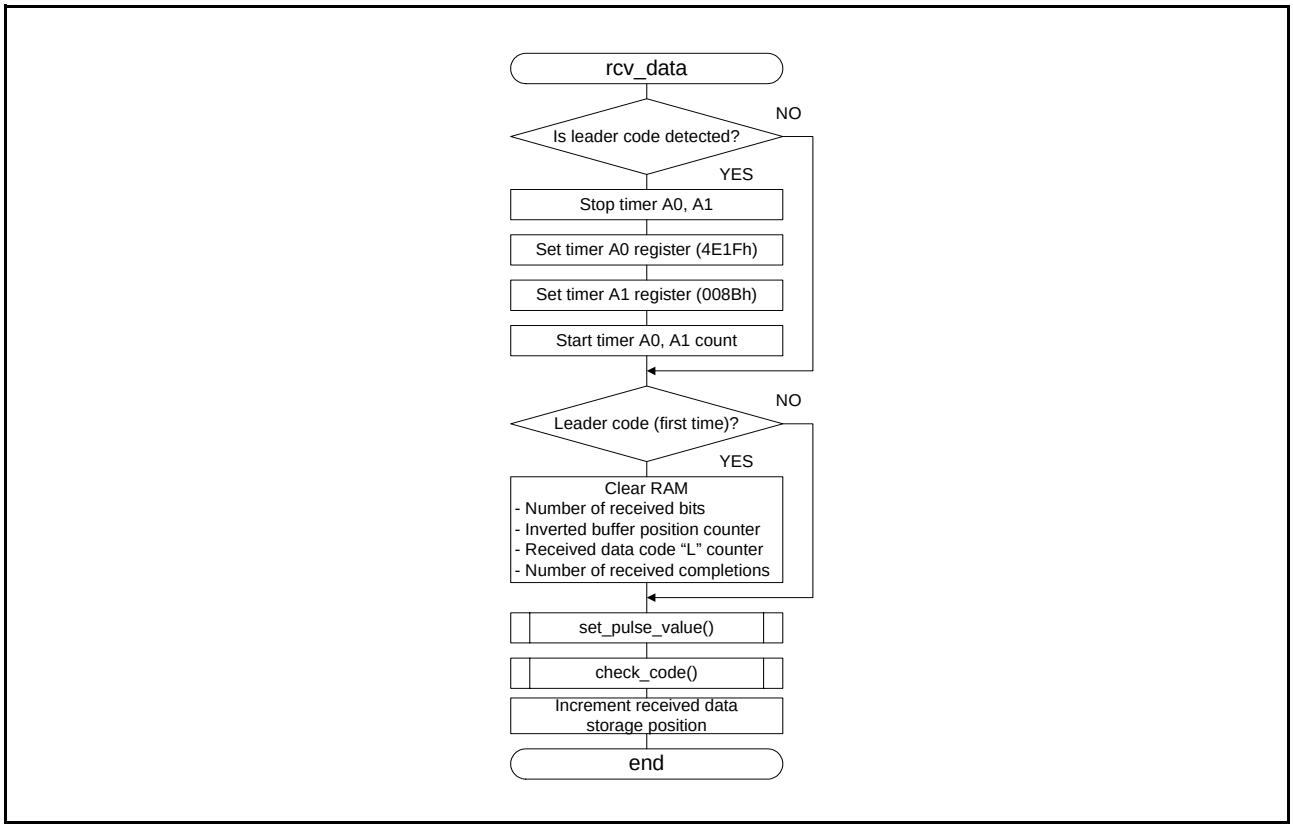


Figure 8.3 Flowchart (rcv_data)

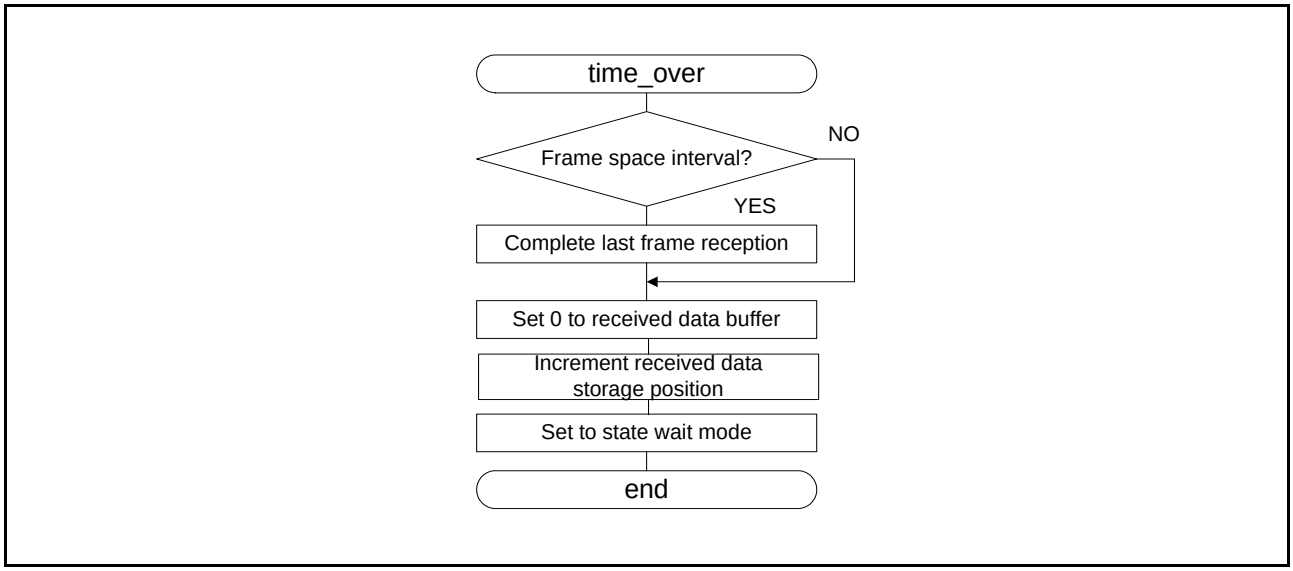


Figure 8.4 Flowchart (time_over)

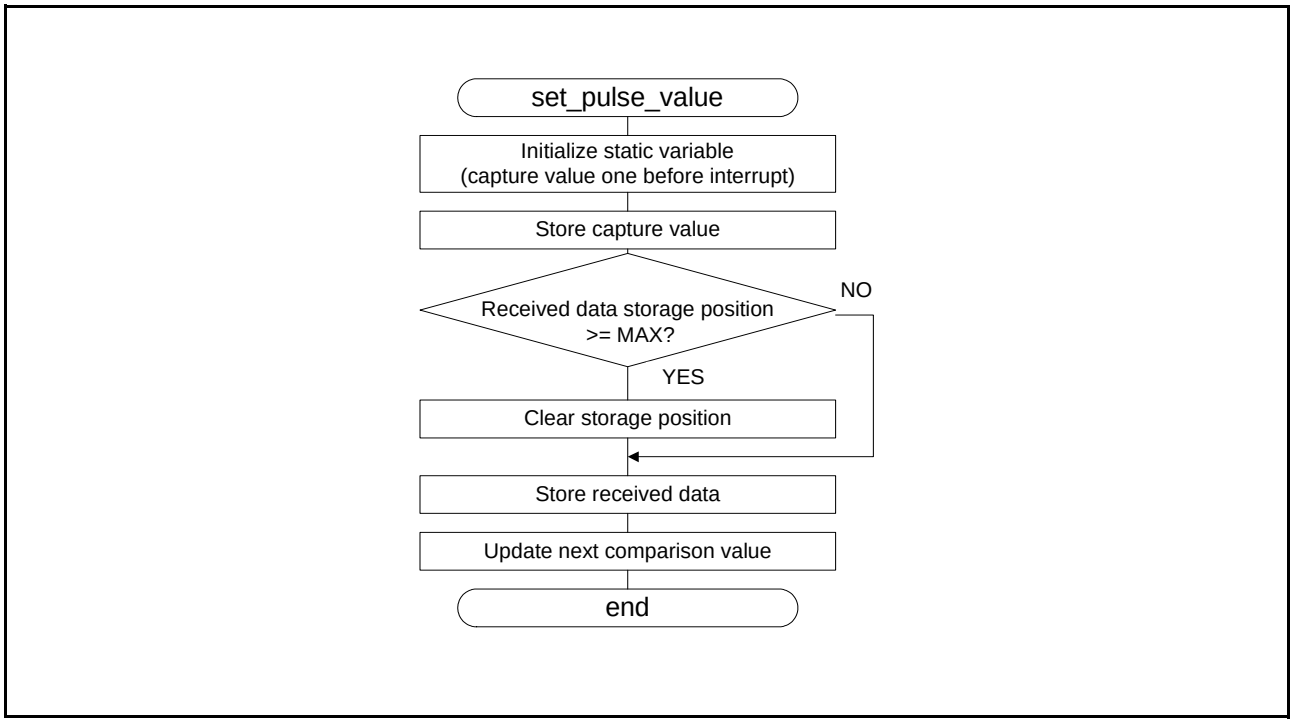


Figure 8.5 Flowchart (set_pulse_value)

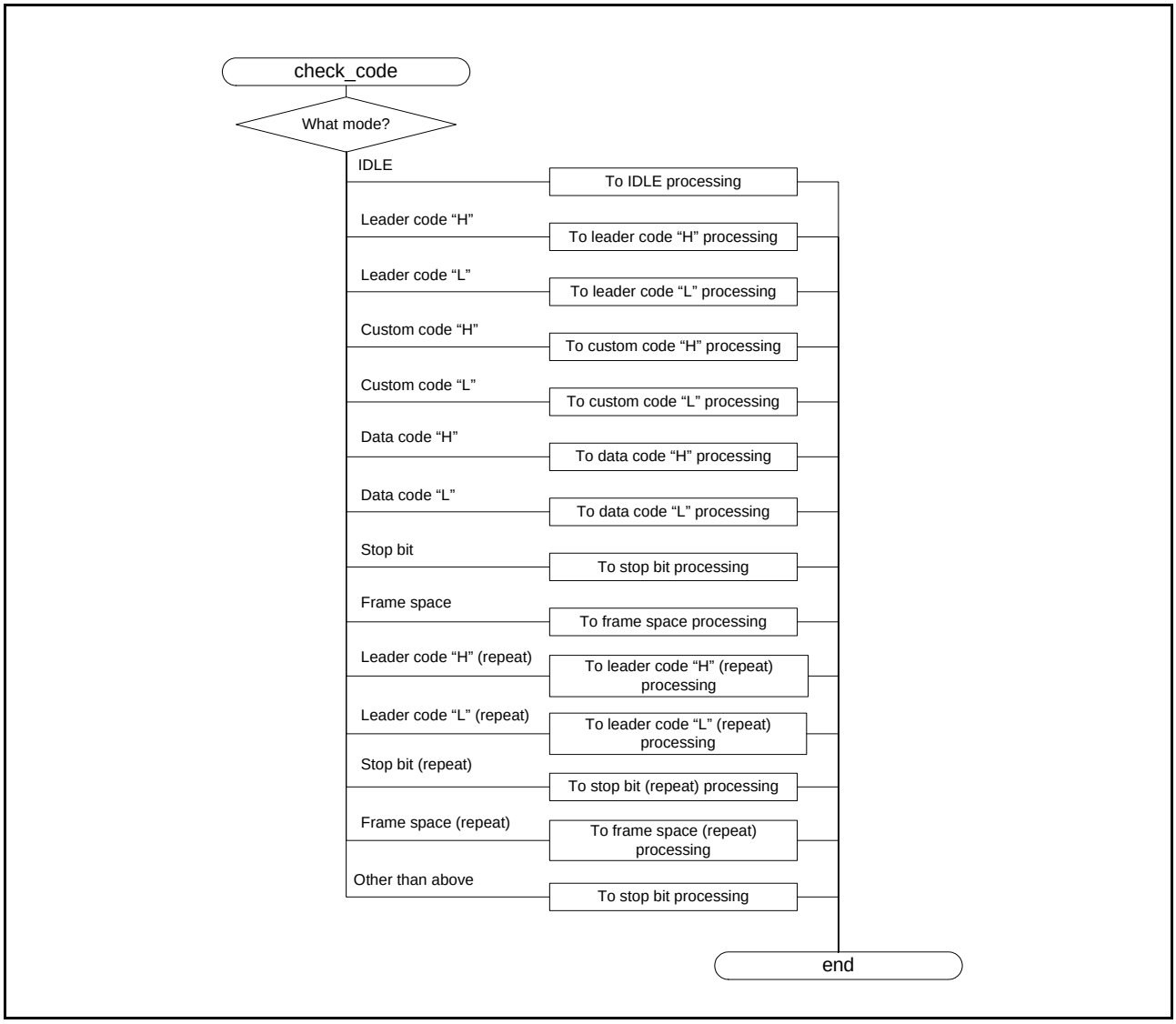


Figure 8.6 Flowchart (check_code)

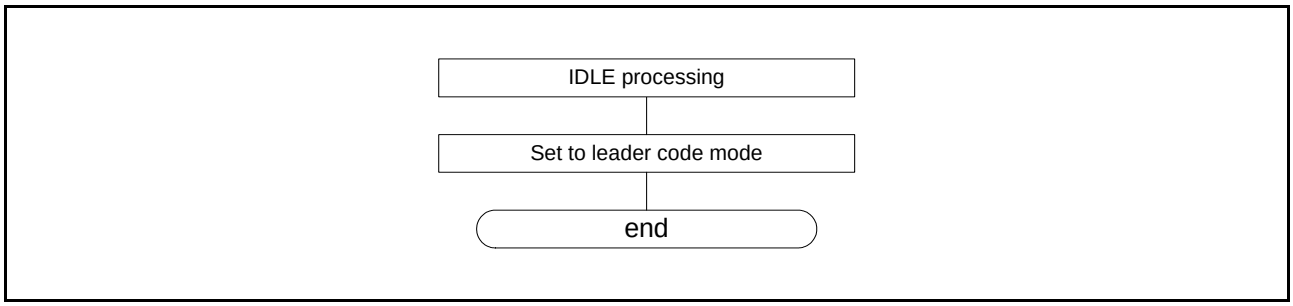


Figure 8.7 Flowchart (check_code/IDLE)

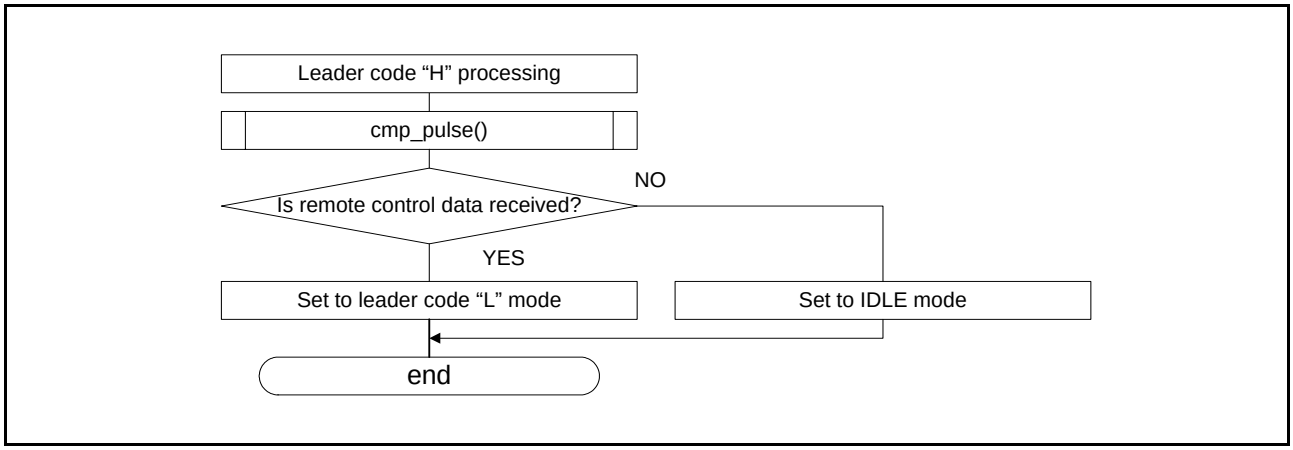


Figure 8.8 Flowchart (check_code/leader code “H”)

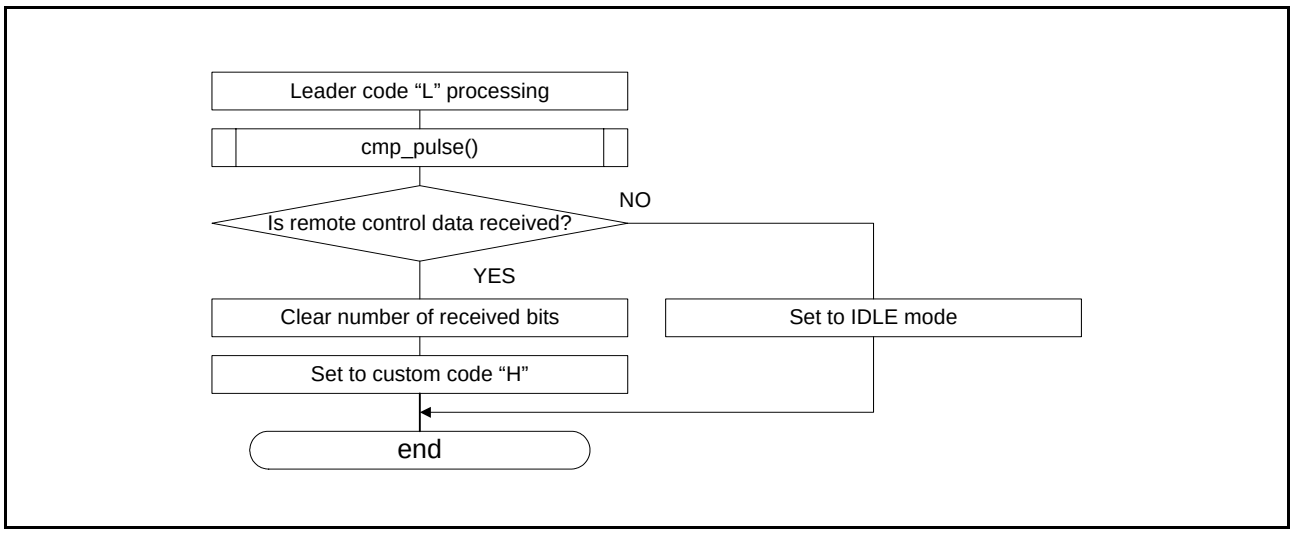


Figure 8.9 Flowchart (check_code/leader code “L”)

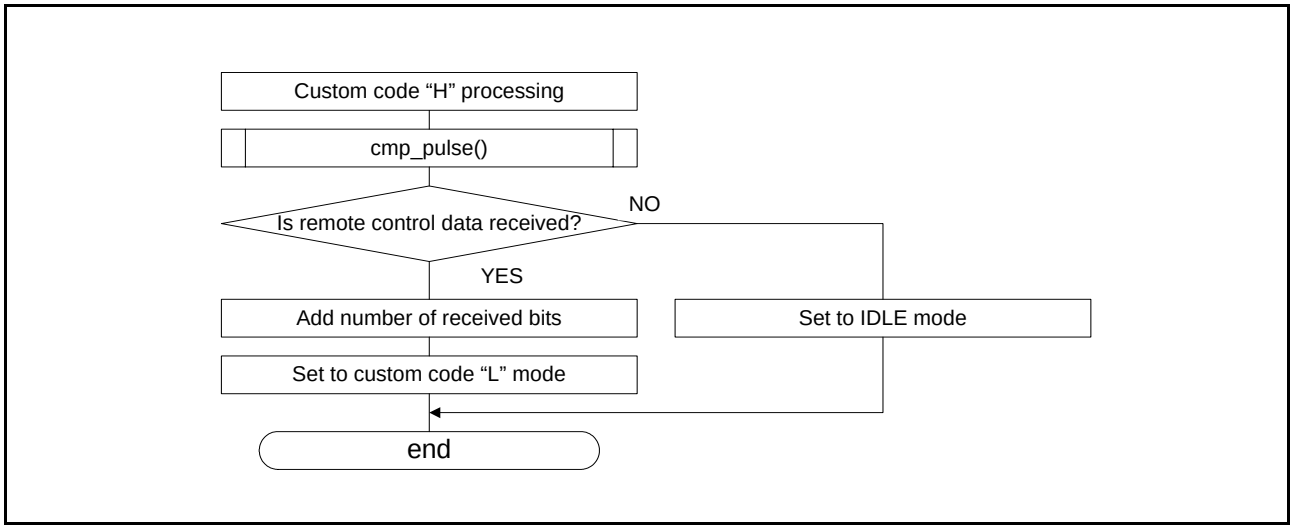


Figure 8.10 Flowchart (check_code/custom code “H”)

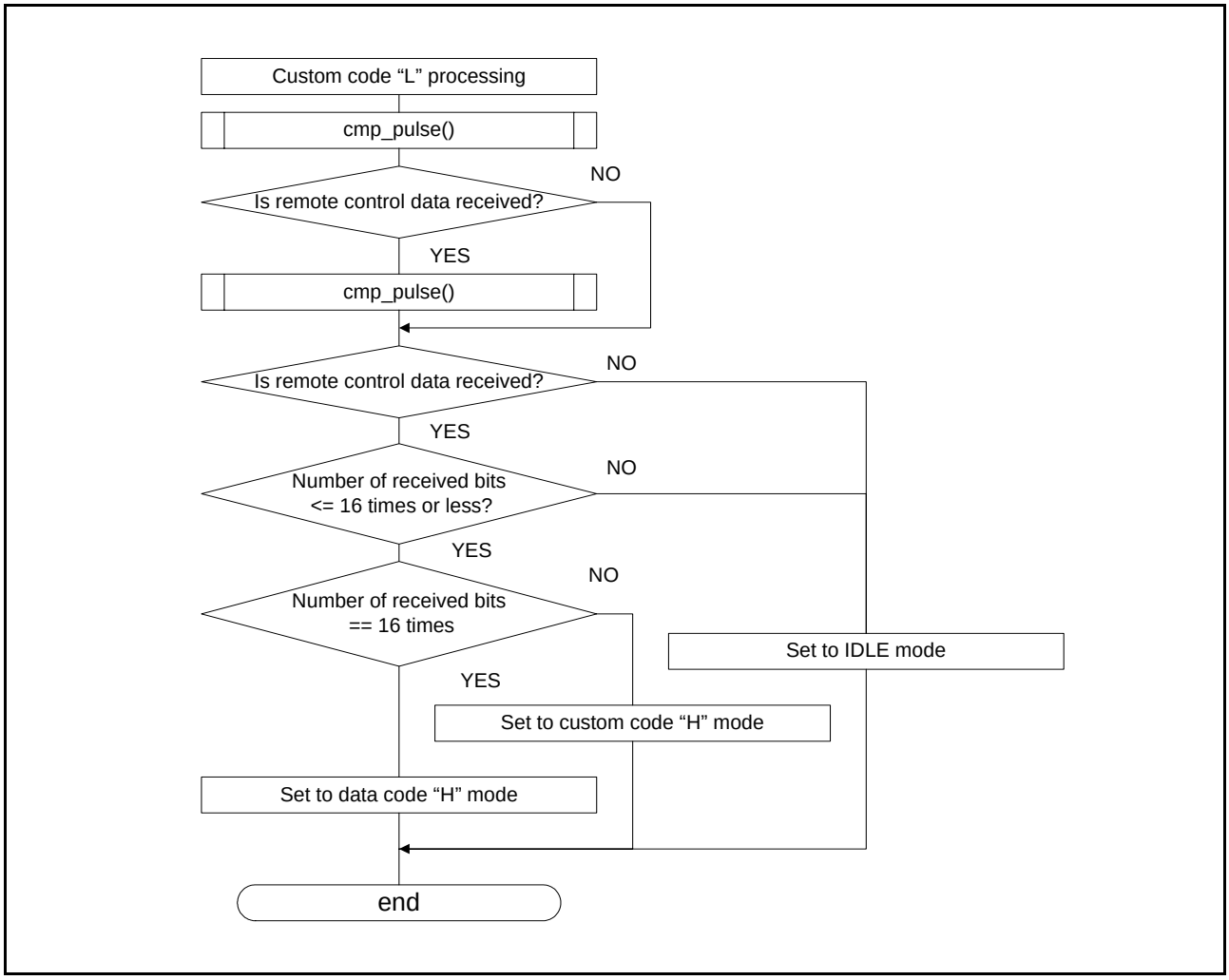


Figure 8.11 Flowchart (check_code/custom code “L”)

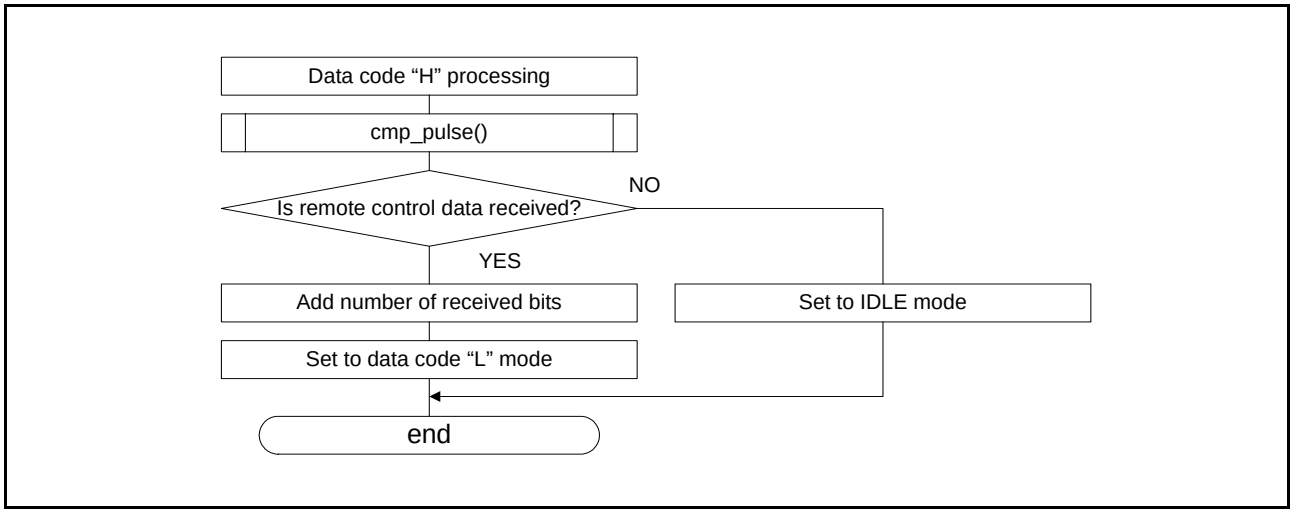


Figure 8.12 Flowchart (check_code/data code “H”)

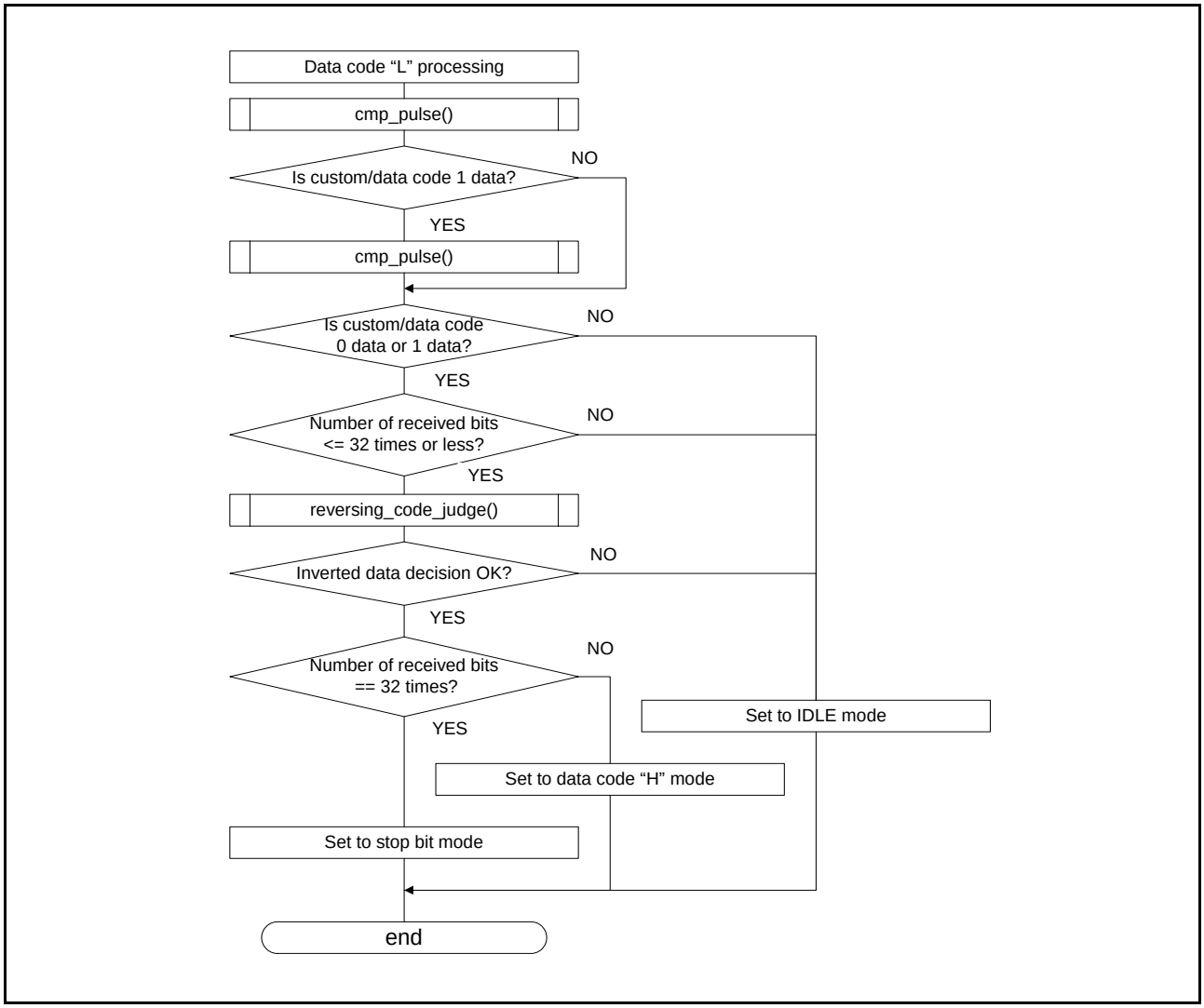


Figure 8.13 Flowchart (check_code/data code “L”)

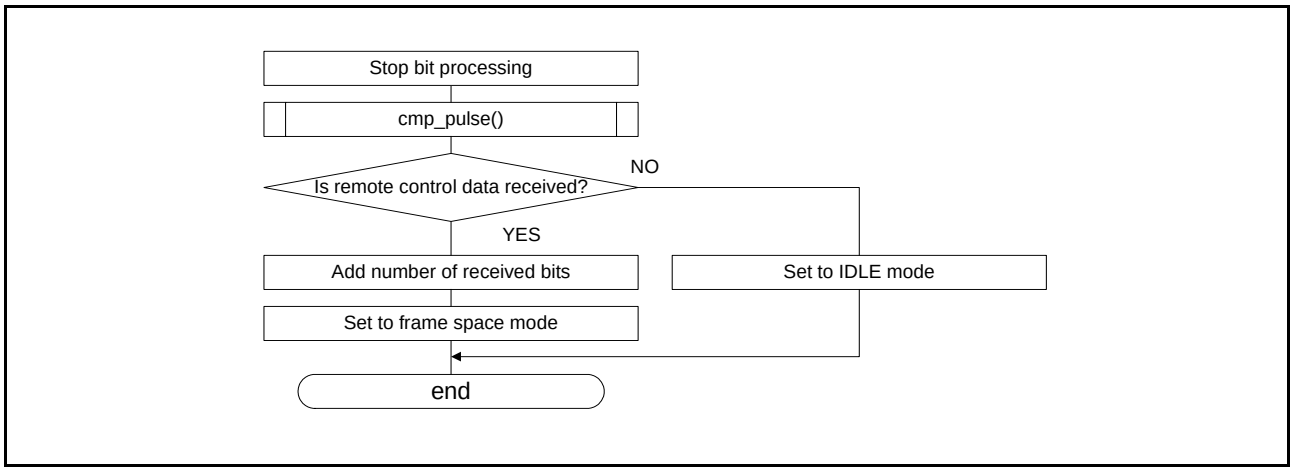


Figure 8.14 Flowchart (check_code/stop bit)

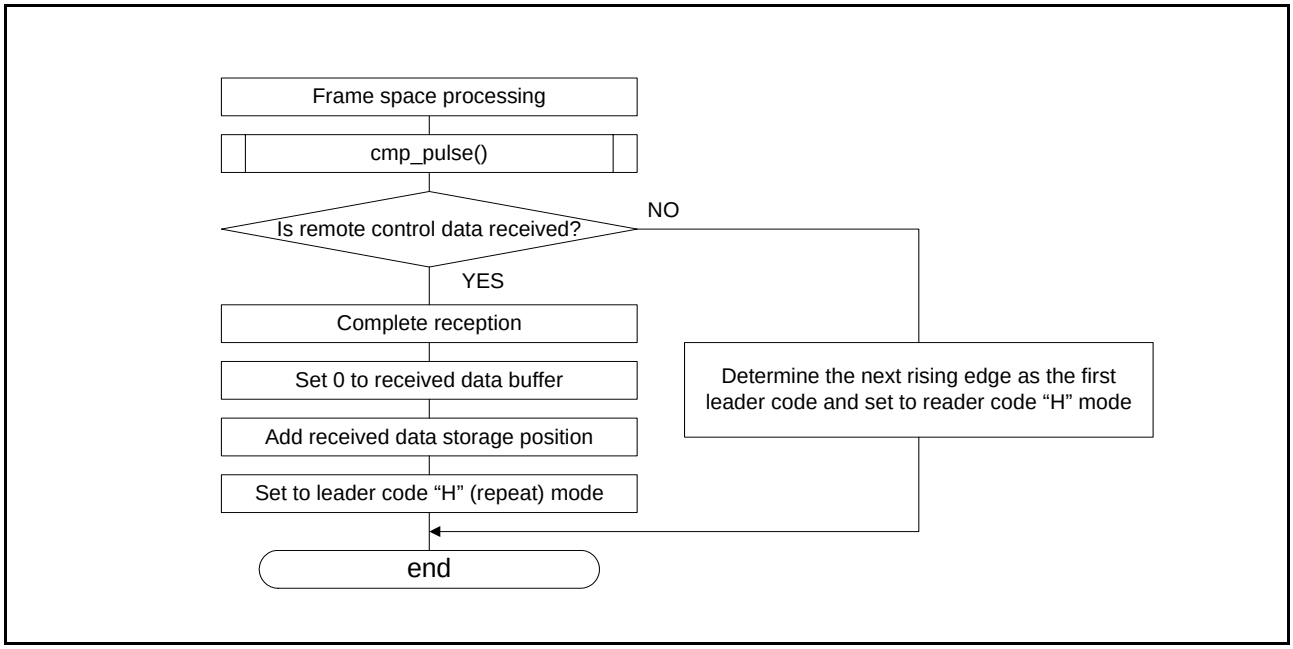


Figure 8.15 Flowchart (check_code/frame space)

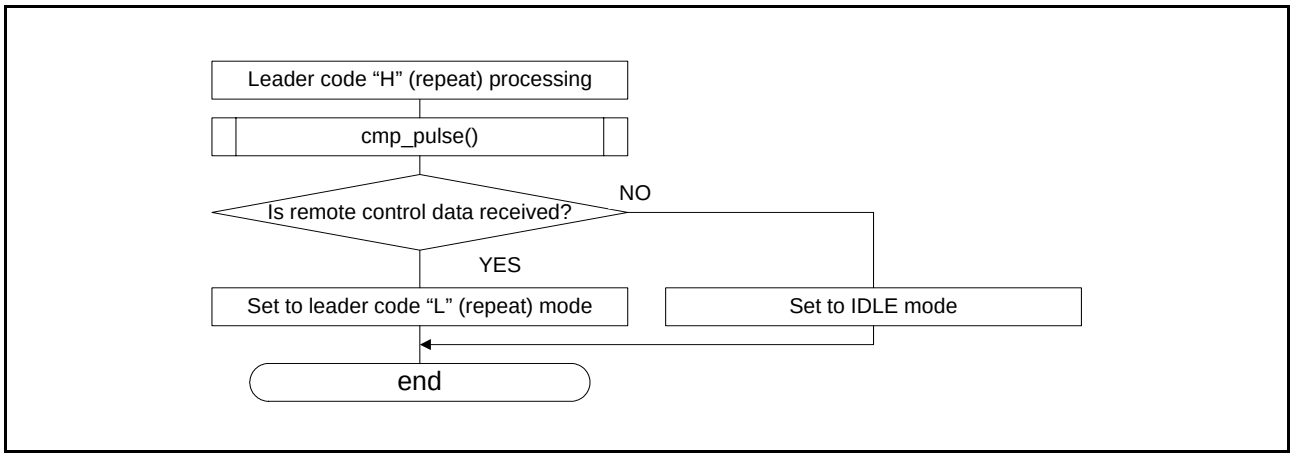


Figure 8.16 Flowchart (check_code/leader code “H” (repeat))

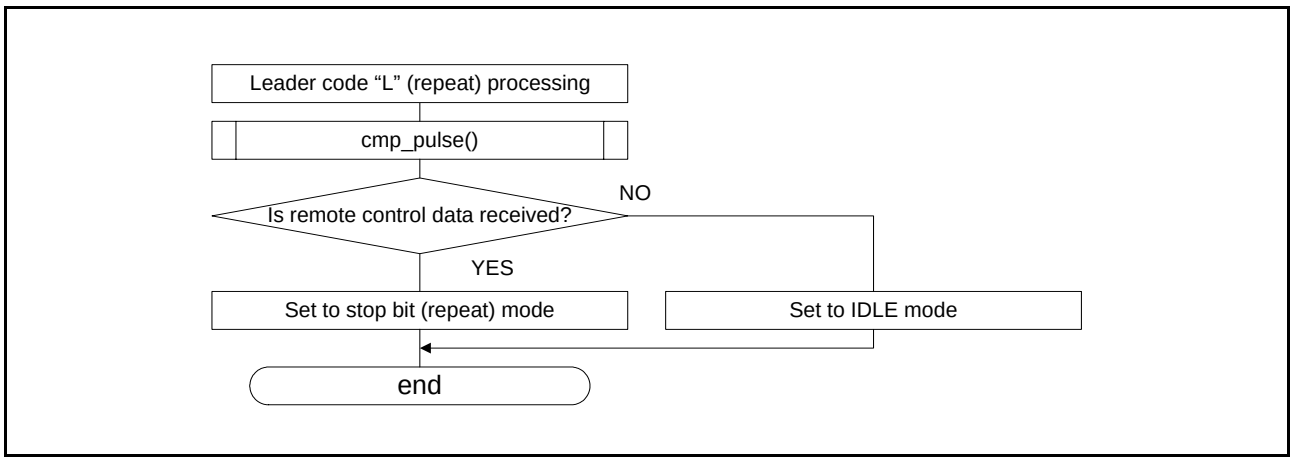


Figure 8.17 Flowchart (check_code/leader code “L” (repeat))

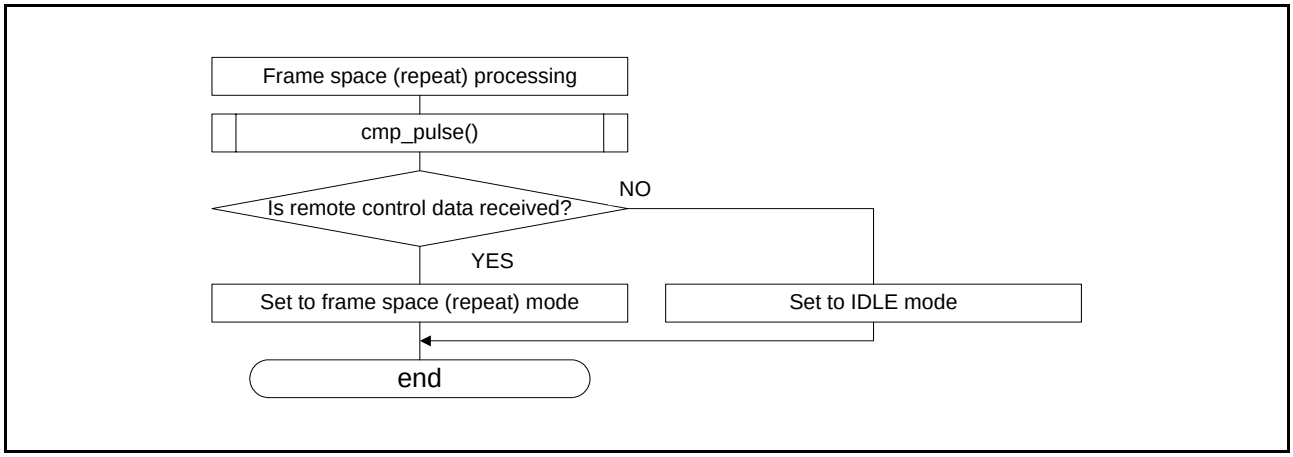


Figure 8.18 Flowchart (check_code/stop bit (repeat))

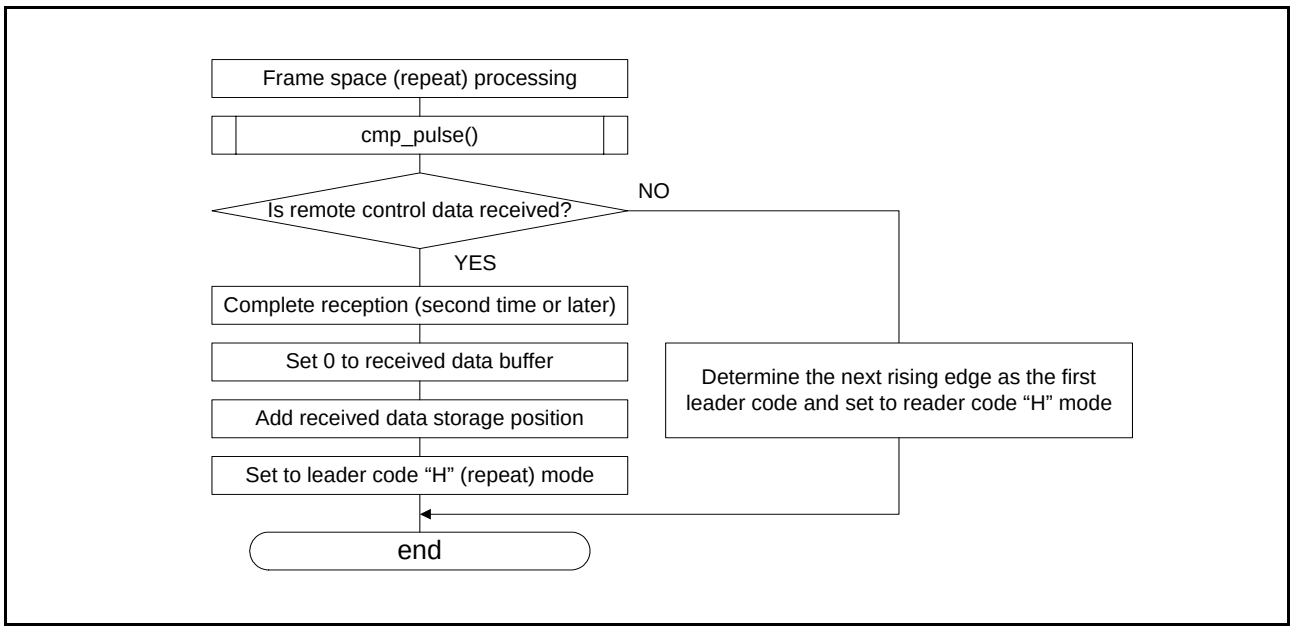


Figure 8.19 Flowchart (check_code/frame space (repeat))

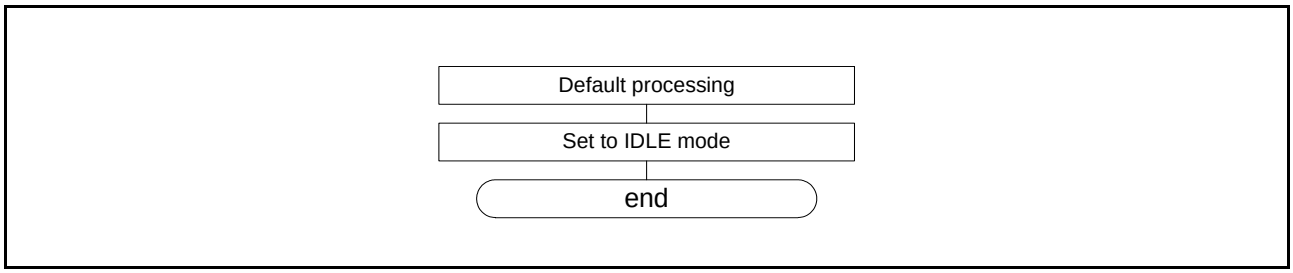


Figure 8.20 Flowchart (check_code/default)

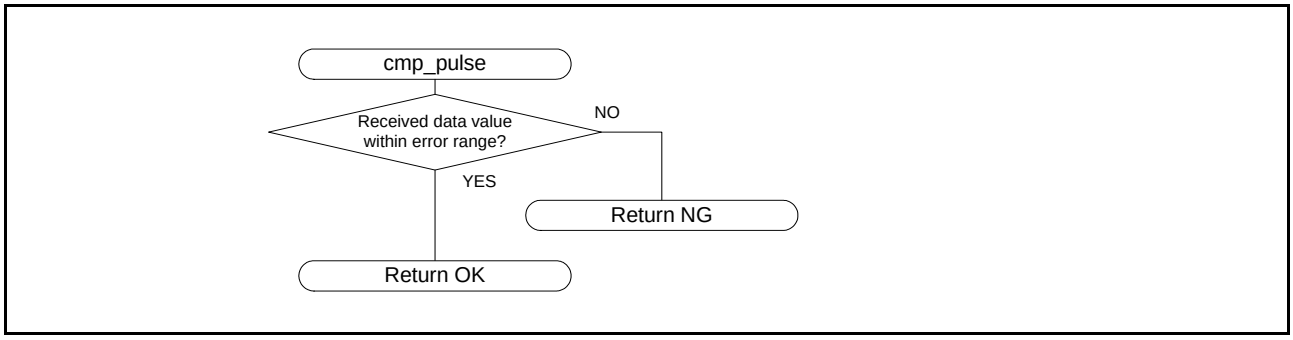


Figure 8.21 Flowchart (cmp_pulse)

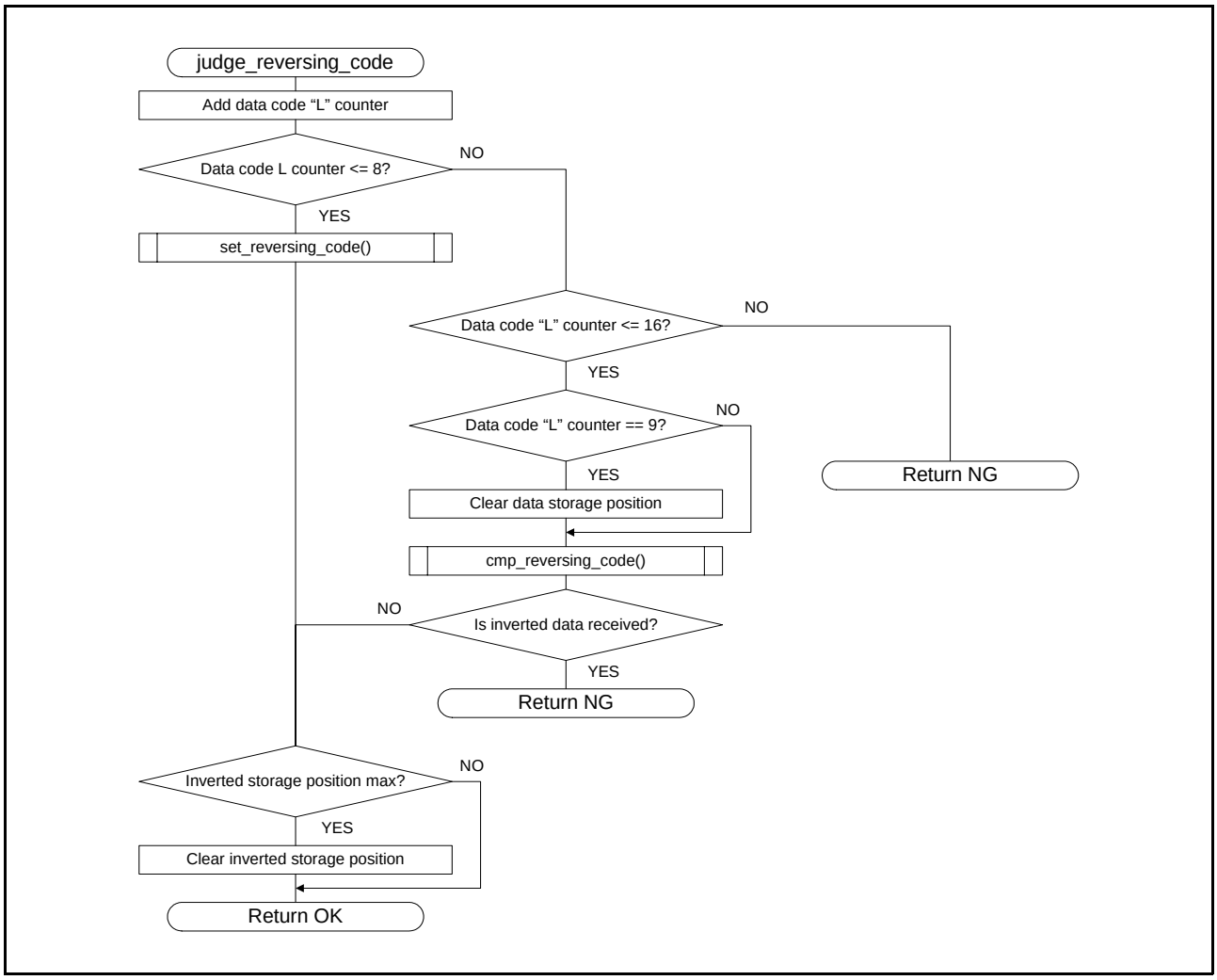


Figure 8.22 Flowchart (judge_reversing_code)

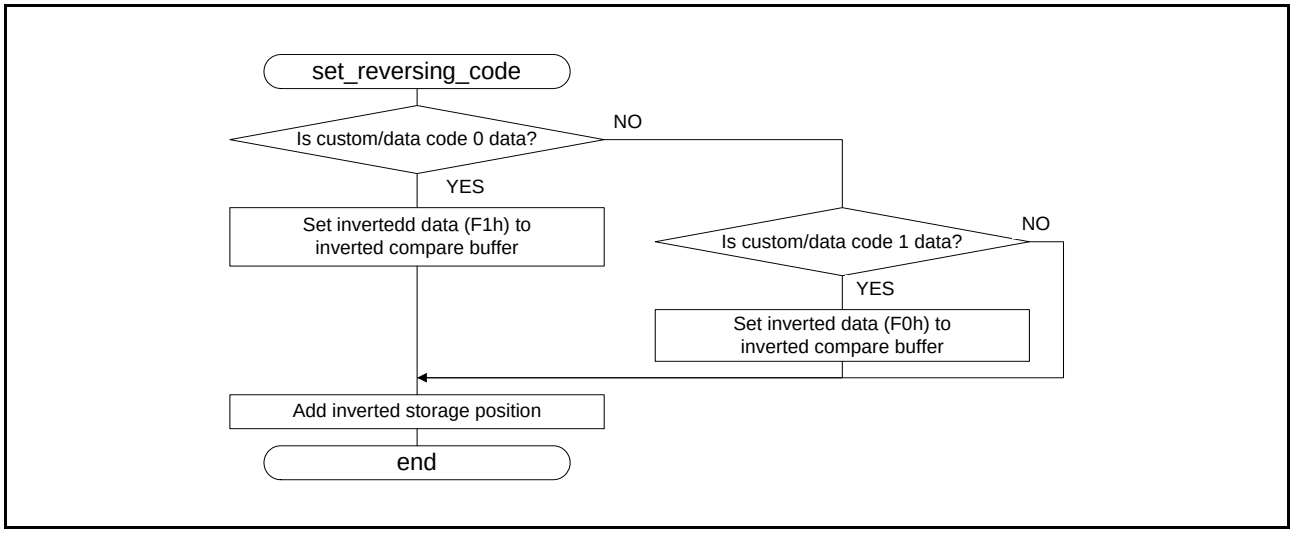


Figure 8.23 Flowchart (set_reversing_code)

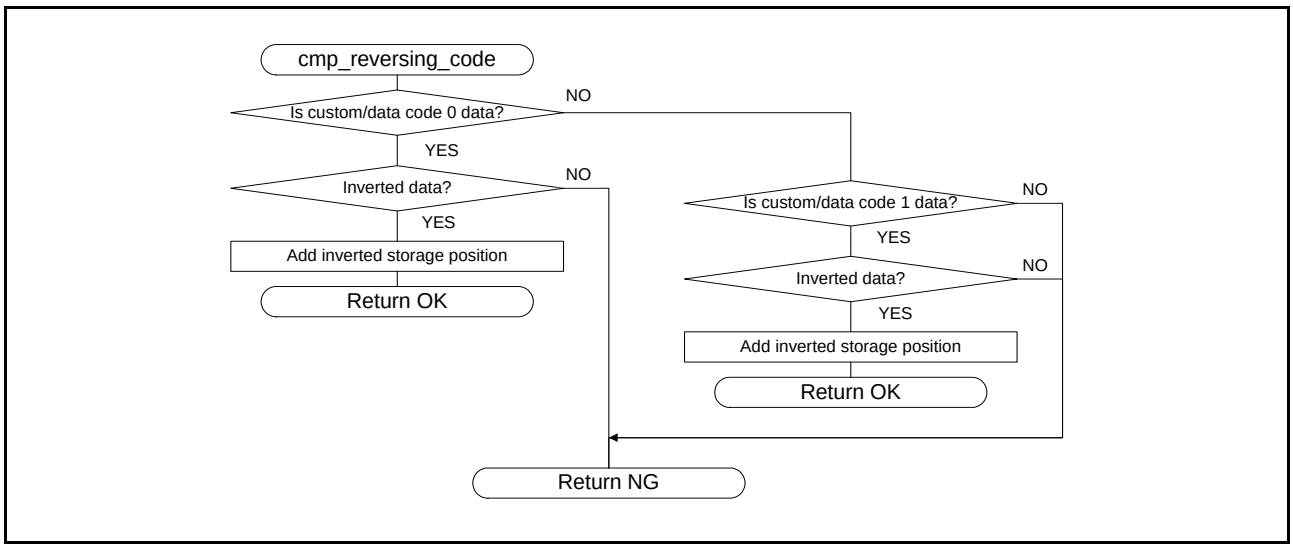


Figure 8.24 Flowchart (cmp_reversing_code)

9. Reference Documents

Hardware Manuals
M16C/28 Group Hardware Manual Rev. 1.11
M16C/29 Group Hardware Manual Rev. 1.10
The latest versions can be downloaded from the Renesas Technology website.

Technical Update/Technical News
The latest information can be downloaded from the Renesas Technology website.

Website and Support

Renesas Technology website
http://www.renesas.com/

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http://www.renesas.com/inquiry
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