RL78/G23

How to control HDMI-CEC with a General-Purpose Timer

Introduction

This application note describes an application that uses the RL78/G23-64p Fast Prototyping Board (FPB) to control HDMI.

There are three modes in the sample codes: Monitor mode, Audio mode, and Player mode.

Monitor mode:

The CEC Viewer attached to the sample codes is used to monitor CEC/DDC signals on your PC monitor connected to the FPB via USB.

Audio mode:

The FPB is used as a Sound Bar in Audio mode. You can control the LEDs on the FPB through operations (Volume Up / Volume Down / Mute) on a TV remote control.

Player mode:

The FPB is used as a BD Player in Player mode. You can control the LEDs on the FPB through operations (Play, Fast Forward, Fast Reverse, Pause) on a TV remote control.

Target Device

RL78/G23

When applying this application note to other microcontrollers, please change them according to the specifications of the microcontroller and evaluate them thoroughly.

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1. Overview

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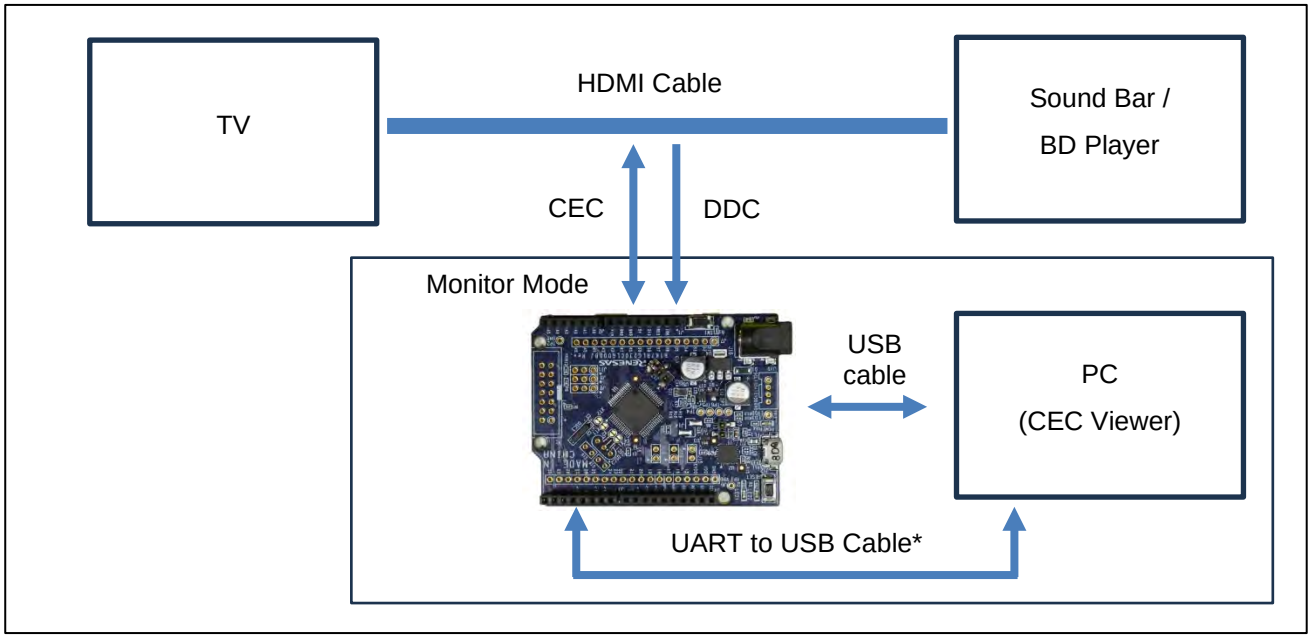
Audio mode:

The FPB is used as a Sound Bar in Audio mode. You can control the LEDs on the FPB through operations (Volume Up / Volume Down / Mute) on a TV remote control.

Player mode:

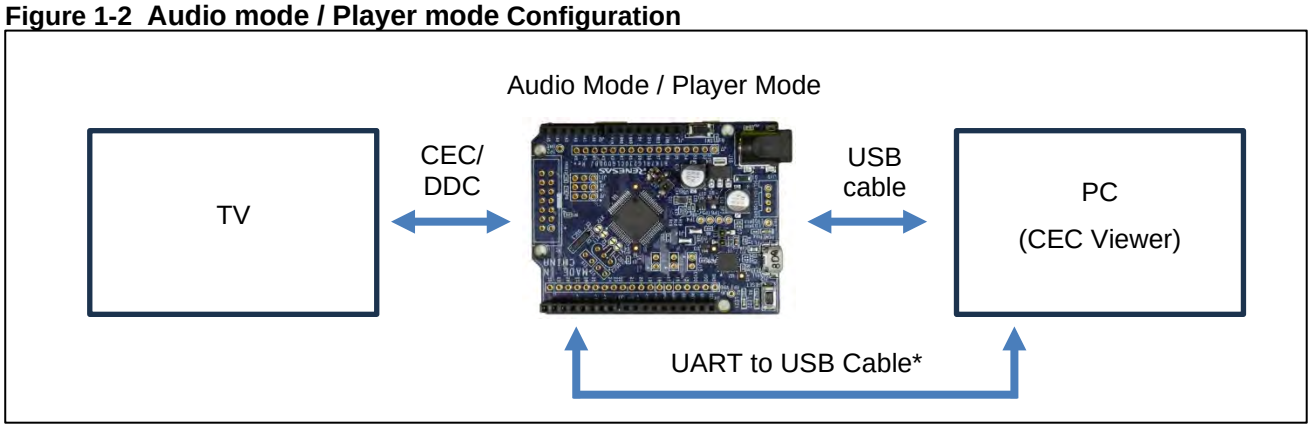
The FPB is used as a BD Player in Player mode. You can control the LEDs on the FPB through operations (Play, Fast Forward, Fast Reverse, Pause) on a TV remote control.

Figure 1-1 Monitor Mode Configuration



Note: It is not used in the demo project. It is only used in development projects.

Figure 1-2 Audio mode / Player mode Configuration



Note: It is not used in the demo project. It is only used in development projects.

Table 1-1 Peripheral Functions and Applications to be Used

Peripheral Functions	Usage	
IICA	IICA0*	Used to receive DDC signals.
INTC	INTP0	Used to detect the key (SW1) input when selecting a mode.
	INTP1	Used to detect CEC signals.
PORT	P51	Used as a receiving terminal for CEC signals.
	P52	Used for LED2 control.
	P53	Used for LED1 control.
	P42	Used as a transmitter terminal for CEC signals.
TAU0	Channel 0	Used for LED flashing control.
	Channel 1	Used for CEC communication.
	Channel 3	Used for SW1 press and hold determination and CEC line monitor.
SAU	UART0	Used for UART communication with a PC. (Demo project)
	UART1	Used for UART communication with a PC. (Development project)

Note: Since the all address match function is enabled, INTIICA0 interrupts are generated for all slave addresses.

2. Operation check conditions

The sample codes in this application note have been tested under the following conditions.

Table 2-1 Operation Confirming Conditions

Item	Contents
Microcontroller	RL78/G23 (R7F100GLGxFB)
Board	RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)
Operating Frequency	● High-speed on-chip oscillator clock (f_{IH}): 16 MHz* ● CPU/peripheral hardware clock: 16 MHz* Note: Changeable between 4 - 32 MHz.
Operating Voltage	3.3V
Integrated Development Environment (CS+)	Renesas Electronics CS+ V8.10.00
C Compiler (CS+)	Renesas Electronics CC-RL V1.12.01
Integrated Development Environment (e^2 studio)	Renesas Electronics e^2 studio V2023-10 (23.10.0)
C Compiler (e^2 studio)	Renesas Electronics CC-RL V1.12.01
Integrated Development Environment (IAR)	IAR Systems IAR Embedded Workbench for Renesas RL78 V5.10.3
C Compiler (IAR)	IAR Systems IAR C/C++ Compiler for Renesas RL78 V5.10.3.2716
Smart Configurator	CS+ V1.8.0, e2studio 23.10.0.v20230925-1024, IAR V1.8.0
Board Support Packages （r_bsp）	V1.61
Operating System	Windows 10/11

Table 2-2 Operation Confirming Devices

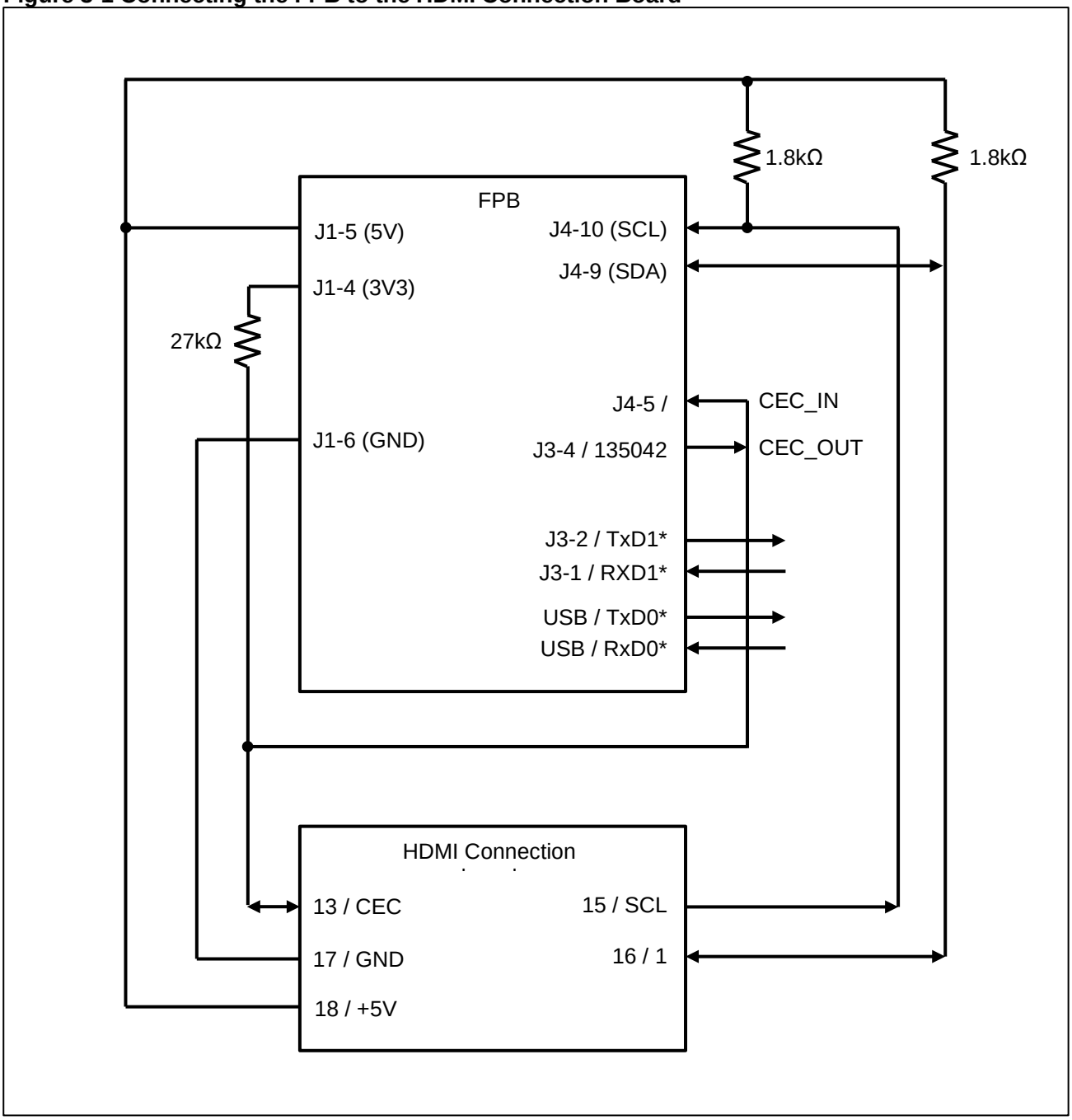
Item	Contents
TV	32LX7000PJB, 32S518K
BD Player	BP350Q, SGP200W
Sound Bar	SN7CY, YAS-109

3. Hardware

3.1 Example of Connecting FPB and HDMI Connection Board

The following is an example of the connection between the FPB and the HDMI connection board used in this application note.

Figure 3-1 Connecting the FPB to the HDMI Connection Board



Note: A USB cable is used in the demo project. To use the CEC Viewer, connect it to a PC via the USB connector on the FPB with a USB cable.
A UART-to-USB cable and a USB cable are used in development projects. To use the IDE, connect it to a PC with a USB cable via the USB connector on the FPB. In addition, to use the CEC Viewer, connect a USB-to-serial conversion cable to the J3-1 / J3-2 of the FPB and connect it to the PC.

3.2 Pins to be Used

The pins to be used are listed in Table 3-1.

Table 3-1 List of Pins to be Used on FPB

Pin Name in the FPB Circuit Diagram	Pin Name on RL78/G23	I/O	Contents
D1-5 (5V)	-	Output	HDMI connection board +5V supply and SCL/SDA pull-up
D1-4 (3V3)	VDD	Output	CEC pull-up
J1-6 (GND)	GND	-	Connection to GND on the HDMI connection board
J4-10 (SCL)	P60 / SCLA0	Input	SCL (Clock) Connection (DDC)
J4-9 (SDA)	P61 / SDAA0	I/O	SDA (Data) Connectivity (DDC)
J4-5	P50	Input	CEC Line Input (CEC_IN)
J3-4	P42	Output	Output to CEC line (CEC_OUT)
J3-2*	P02 / TxD1	Output	UART transmission to PC
J3-1*	P03 / RxD1	Input	UART reception from PC
USB	P12 / TxD0	Output	UART transmission to PC
	P11 / RxD0	Input	UART reception from PC

Note: It is not used in the demo project. It is only used in development projects.

Table 3-2 List of Pins to be Used on the HDMI Connection Board

Pin Name	I/O	Contents
13 / CEC	I/O	FPB CEC_IN/CEC_OUT and connection
15 / SCL	Output	Connection to SCL on the FPB
16 / 1	I/O	Connection to SDA on the FPB
17 / GND	-	Connection to GND on the FPB
18 / +5V	Input	Connection to 5V on the FPB

3.3 Required Devices

Required devices are listed in Table 3-3.

Table 3-3 List of Required Devices

Device Name	Quantity	Usage
RL78/G23-64p Fast Prototyping Board	1	Used as a Demo machine
HDMI connection board	1	HDMI wire connection
ARC-compatible HDMI cable*	2	Used to connect a TV to an HDMI connection board, or an HDMI connection board to an HDMI device
HDMI Relay Adapter	1	HDMI (male to male) cable connection
USB Cable (micro USB Type-B)	1	Used to connect the FPB to the PC
27 kΩ resistor	1	CEC Line pull-up resistor
1.8 kΩ resistor	2	Pull-up resistors for SCL/SDA lines
USB to serial cable	1	Used to use the CEC Viewer when using development projects.

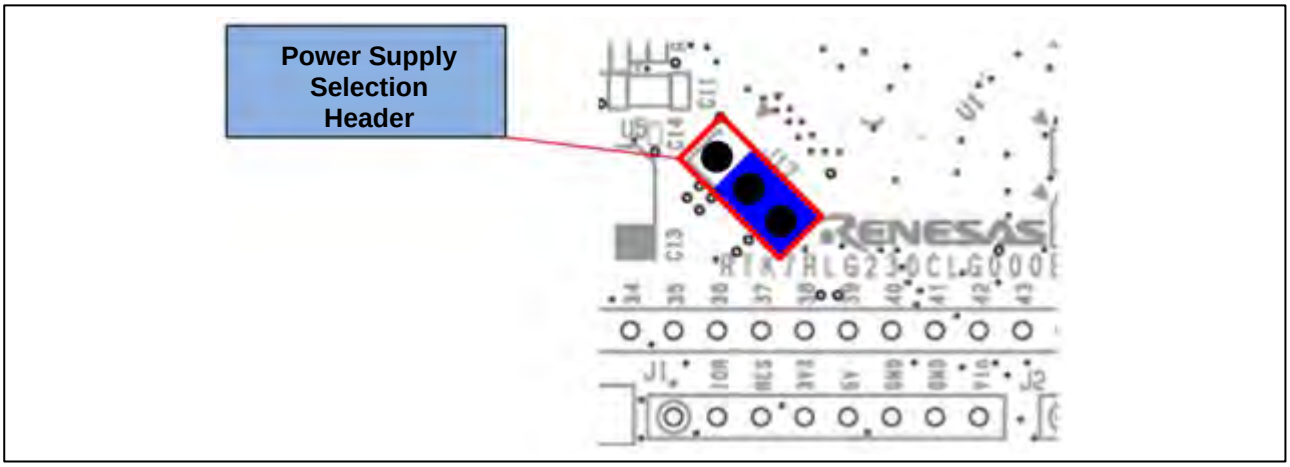
Note: An ARC-compatible cable is required only when using Audio mode or monitoring the Sound Bar.

3.4 Power Supply Selection Header

The FPB power supply selection header (J17) is used to select 3.3V as the MCU's operating power supply (VDD). Changing the jumper setting of the J17 should be done with the power supply OFF.

- When setting Jumper J17 to pins 2-3, 3.3V Power Supply is selected.

Figure 3-2 Header Setting when Using 3.3V (Component Side)



4. Project

There are projects for demo and development. For the demo project, connect the micro USB Type-B terminal of the FPB to the PC. For the development project, connect the FPB J3-1 / J3-2 to the PC via a USB to serial cable.

4.1 List of Projects

Table 4-1 shows the list of projects and Table 4-2 shows the list of ROM/RAM usage.

Table 4-1 Project List (for Windows)

Demo / Development	Mode	IDE	Project Folder Name
Demo project	Monitor mode, Audio mode*1, Player mode*1	CS+, e2 studio, IAR	RL78G23-HDMI-CEC-Demo
development project	Monitor mode, Audio mode*1, Player mode*1	CS+, e2 studio, IAR	rl78g23-hdmi-cec-dev
	Audio mode*1,2,3	CS+, e2 studio, IAR	rl78g23-hdmi-cec-dev-audio
	Player mode*1,2,4	CS+, e2 studio, IAR	rl78g23-hdmi-cec-dev-player

Note 1: Operation has been confirmed only with the 32LX7000PJB.

Note 2: It is a sample project designed for product development and does not include the Monitor function.

Note 3: The HDMI connector number is set to 2.

Note 4: The HDMI connector number is set to 1.

Table 4-2 List of ROM/RAM Usage

Demo / Development	Mode	IDE	Compiler	ROM	RAM
Demo project	Monitor mode Audio mode Player mode	CS+	CC-RL	20,941 bytes	4,250 bytes
		E2 Studio	CC-RL	20,941 bytes	4,250 bytes
		AGAIN	AGAIN	15,091 bytes	4,740 bytes
Development project	Monitor mode Audio mode Player mode	CS+	CC-RL	21,679 bytes	4,250 bytes
		E2 Studio	CC-RL	21,742 bytes	4,250 bytes
		AGAIN	AGAIN	15,292 bytes	4,740 bytes
	Audio mode	CS+	CC-RL	15,861 bytes	492 bytes
		E2 Studio	CC-RL	15,889 bytes	492 bytes
		AGAIN	AGAIN	11,053 bytes	1,004 bytes
	Player mode	CS+	CC-RL	16,135 bytes	490 bytes
		E2 Studio	CC-RL	16,163 bytes	490 bytes
		AGAIN	AGAIN	11,274 bytes	1,004 bytes

5. Modes

There are three modes: Monitor mode, Audio mode, and Player mode. In Monitor mode, it monitors communication between the devices connected with HDMI. In Audio mode and Player mode, it is used as an HDMI-connected device to demonstrate operation.

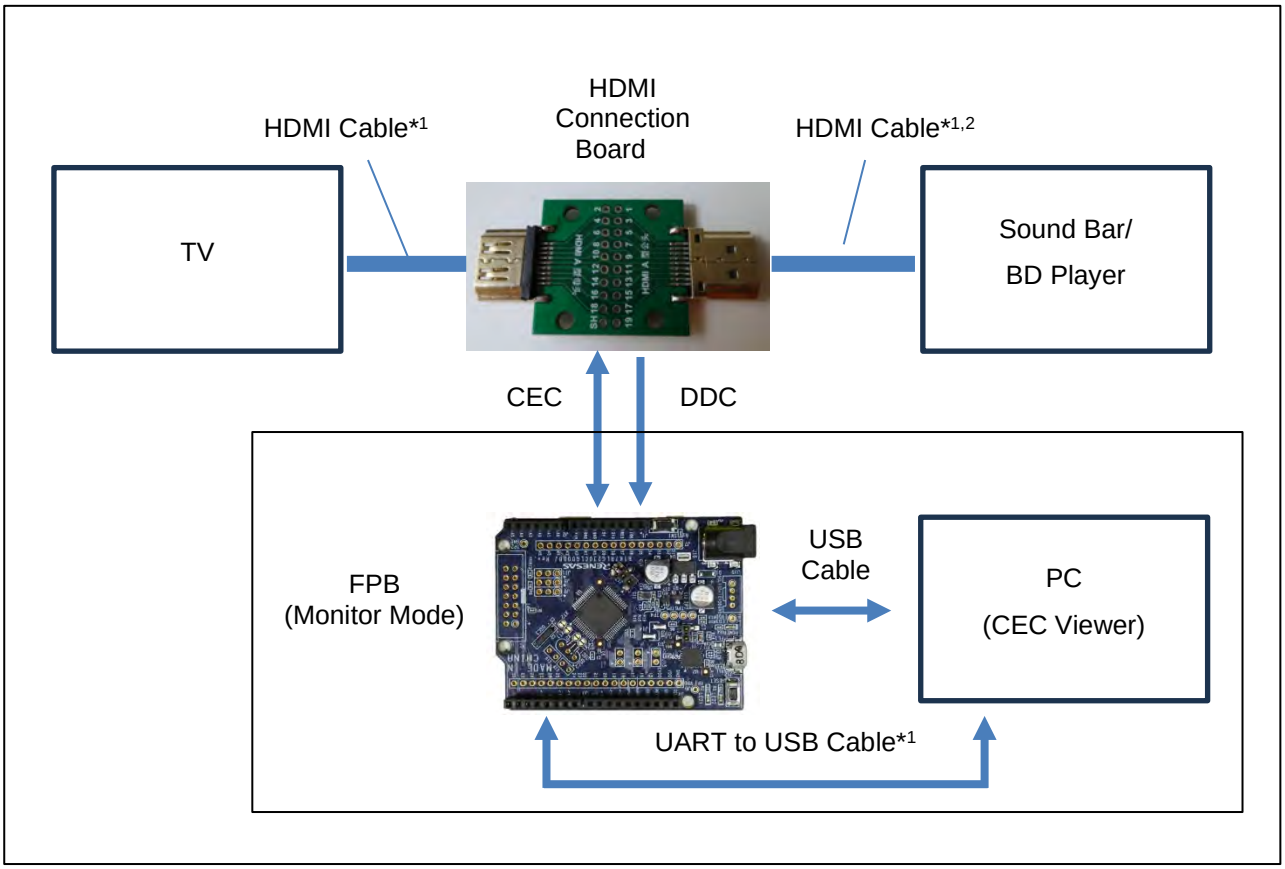
5.1 Monitor Mode

Monitor mode allows for the monitoring of CEC/DDC communication by the FPB connected via an HDMI cable. The attached CEC Viewer can be used to view the communication status on a PC.

5.1.1 Connection Configuration

Figure 5-1 shows the connection configuration in Monitor mode.

Figure 5-1 Connection Configuration in Monitor Mode



Note 1: When connecting the Sound Bar, use an ARC-compatible HDMI cable, and connect the TV to an ARC-compatible HDMI connector.
Note 2: Connect the HDMI cable to the HDMI connection board via the HDMI relay adapter.
Note 3: It is not used in the demo project. It is only used in development projects.

5.1.2 Setting Procedure

The following procedure describes how to set Monitor Mode.

1) Connect the FPB to the PC with a USB cable.
   Start CEC Viewer (PC software). “Renesas Electronics” is displayed in the CEC Viewer message window.
2) If using a development project, load the project in the IDE and start debugging. (When using the demo project, there is no need to load the project in the IDE.)
   The name of the currently selected mode is blinking in the CEC Viewer message window. If it is not blinking, check the Serial Config settings.
3) Switch modes with SW1. Each time SW1 is pressed, it switches between Audio mode, Player mode, and Monitor mode (repeatedly).
   The LED lighting status of FPB during mode selection is as follows.

Mode	LED1	LED2
Monitor Mode	ON	ON
Audio Mode	OFF	ON
Player Mode	ON	OFF

4) While "Monitor Mode" is blinking in the message window of CEC Viewer, press SW1 for more than 3 seconds to confirm the mode. "Monitor Mode" displayed in the message window of the CEC Viewer changes to always on. When the mode is switched, the logs currently displayed in the CEC Viewer will be deleted.
5) Connect an ARC-compatible HDMI cable to the ARC-compatible HDMI connector on the TV.

Note 1. For details on how to install and launch CEC Viewer on a PC, see “6.3 Installation and Startup” for more information.
Note 2. To change the mode again after the mode is confirmed, press RESET (SW2).

5.1.3 Monitor Starting

Press the Start button on the CEC Viewer to start Monitor mode. The communication data is displayed in the CEC/DDC Communication Data area.

5.2 Audio Mode

FPB is operated as a Sound Bar. The FPB LED lighting is controlled through the TV remote control operation (Volume Up/Down and Mute).

5.2.1 Reproducible Functions

When the audio output is switched to the Sound Bar using the keys on the TV remote control or the buttons on the TV, LEDs 1 and LED2 on the FPB simultaneously light up for 2 seconds from the off state, and then go off again.

The following is a list of features that can be reproduced in Audio mode.

Table 5-1 List of Reproducible Function

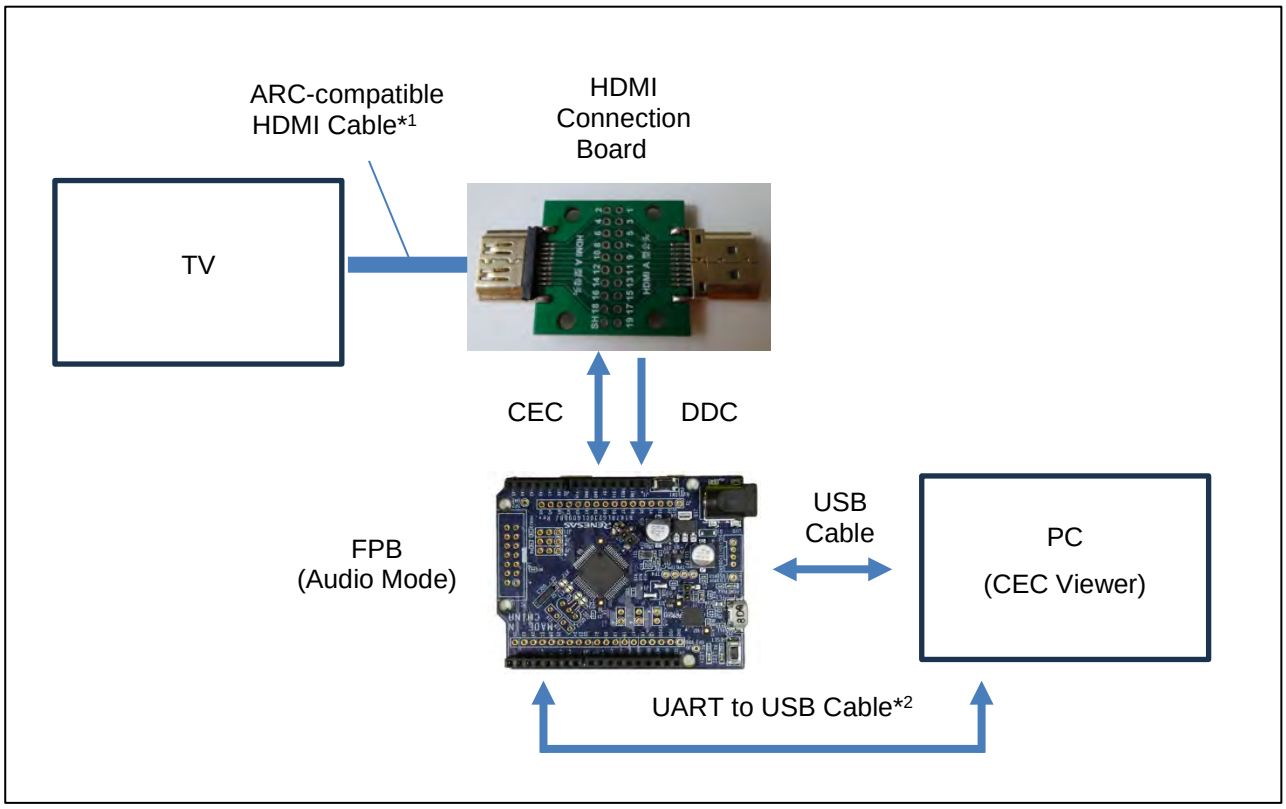
Function	Operating Method*	FPB Operation
Volume Up	Volume + (plus) button	• LED2 blinks once if the button is pressed once. • LED2 blinks shortly and repeatedly while the button is held down. • When the volume reaches the upper limit, LED2 blinks once for a long duration.
Volume Down	Volume - (minus) button	• LED1 blinks once if the button is pressed once. • LED1 blinks shortly and repeatedly while the button is held down. • When the volume reaches the lower limit, LED1 blinks once for a long duration.
Mute	Mute button	• The device is muted and LED1 and LED2 blink at the same time.
Unmute	Mute button Volume + (plus) button Volume - (minus) button	• Mute is canceled, LED1 and LED2 stop blinking and go out. • When volume + button is pressed, it will be unmuted after volume +1. • When volume - button is pressed, it will be unmuted after volume -1.

Note. Use the keys on the TV remote control or the buttons on the TV.

5.2.2 Connection configuration

Figure 5-2 shows the connection configuration in Audio mode.

Figure 5-2 Connection Configuration in Audio Mode



Note 1. For the TV, connect the ARC-compatible HDMI to the HDMI connector.

Note 2. It is not used in the demo project. It is only used in development projects.

5.2.3 Start Method

The following procedure describes how to set Audio mode.

1) Connect the FPB to the PC with a USB cable.
   Start CEC Viewer (PC software). “Renesas Electronics” is displayed in the CEC Viewer message window.

2) If using a development project, load the project in the IDE and start debugging. (When using the demo project, there is no need to load the project in the IDE.)
   The name of the currently selected mode is blinking in the CEC Viewer message window. If it is not blinking, check the Serial Config settings.

3) Switch modes with SW1. Each time SW1 is short-pressed, it switches between Audio mode, Player mode, and Monitor mode (repeatedly).
   The LED lighting status of FPB during mode selection is as follows.

Mode	LED1	LED2
Monitor Mode	ON	ON
Audio Mode	OFF	ON
Player Mode	ON	OFF

4) While "Audio Mode" is blinking in the message window of CEC Viewer, press SW1 for at least 3 seconds to confirm the mode. "Audio mode" displayed in the message window of the CEC Viewer changes to always on. When the mode is switched, the logs currently displayed in the CEC Viewer will be deleted.

5) Next, it switches to the HDMI connector number selection. Select the number of the HDMI connector on the TV to which the HDMI cable is to be connected. Each time SW1 is short-pressed, it switches between HDMI 2, HDMI 3, HDMI 4, HDMI 1 (repeatedly). The FPB LED lighting status during HDMI connector number selection is as follows.

HDMI Connector Number	LED1	LED2
HDMI 1	OFF	ON
HDMI 2	ON	OFF
HDMI 3	ON	ON
HDMI 4	OFF	OFF

And the currently selected HDMI connector number is displayed blinking in the message window of the CEC Viewer.

6) While the HDMI connector number is blinking in the message window of the CEC Viewer, press SW1 for at least 3 seconds to confirm the HDMI connector number. The HDMI connector number displayed in the message window of the CEC Viewer changes to always on.

7) “Audio Mode” is displayed in the message window of the CEC Viewer.

8) Connect an ARC-compatible HDMI cable to the ARC-compatible HDMI connector on the TV.

Note 1. For details on how to install and launch CEC Viewer on a PC, see “6.3 Installation and Startup” for more information.
Note 2. To change the mode again after the mode is confirmed, press RESET (SW2).
Note 3. To acquire communication data in Audio mode, press the Start button on the CEC Viewer.

5.3 Player mode

FPB is operated as a BD Player. The FPB LED lighting is controlled through the TV remote control operation (Play, Fast forward, Fast Reverse, Pause).

5.3.1 Reproducible Functions

When the input is switched to BD Player using the key on the TV remote control or the button on the TV itself, LEDs 1 and LED2 on the FPB simultaneously light up for 2 seconds from the off state, and then go off again.

The following is a list of functions that can be reproduced in Audio mode.

Table 5-2 List of Reproducible Functions

Function	Operating Method *1	FPB Operation
Playback	Play button *2	LED1 and LED2 light up simultaneously.
Stop	Stop button	LED1 and LED2 go off simultaneously.
Pause	Pause button	LED1 and LED2 blink simultaneously.
Fast forward	Fast-forward button *2	① LED1 goes off and LED2 lights up when the Fast Forward button is pressed. ② After ① is executed, LED2 blinks when the Fast Forward button is pressed. ③ After ② is executed, it returns to ① when the Fast Forward button is pressed. *3 To cancel fast forwarding during fast forwarding, press the Playback button.
Fast Reverse	Fast Reverse button *2	① LED1 lights up and LED2 goes off when the Fast Reverse button is pressed. ② After ① is executed, LED1 blinks when the Fast-Reverse button is pressed. ④ After ② is executed, it returns to ① when the Fast Reverse button is pressed. *3 To cancel fast reverse during fast reverse, press the Playback button.
Forward (By chapter)	Next button	LED2 blinks once and then enters playback.
Back (By chapter)	Previous button	LED1 blinks once and then enters playback.
Eject	*4	LED1 and LED2 go off simultaneously.

Note1. Use the keys on the TV remote control or the buttons on the TV itself.

Note2. It does not stop at the end of the seek.

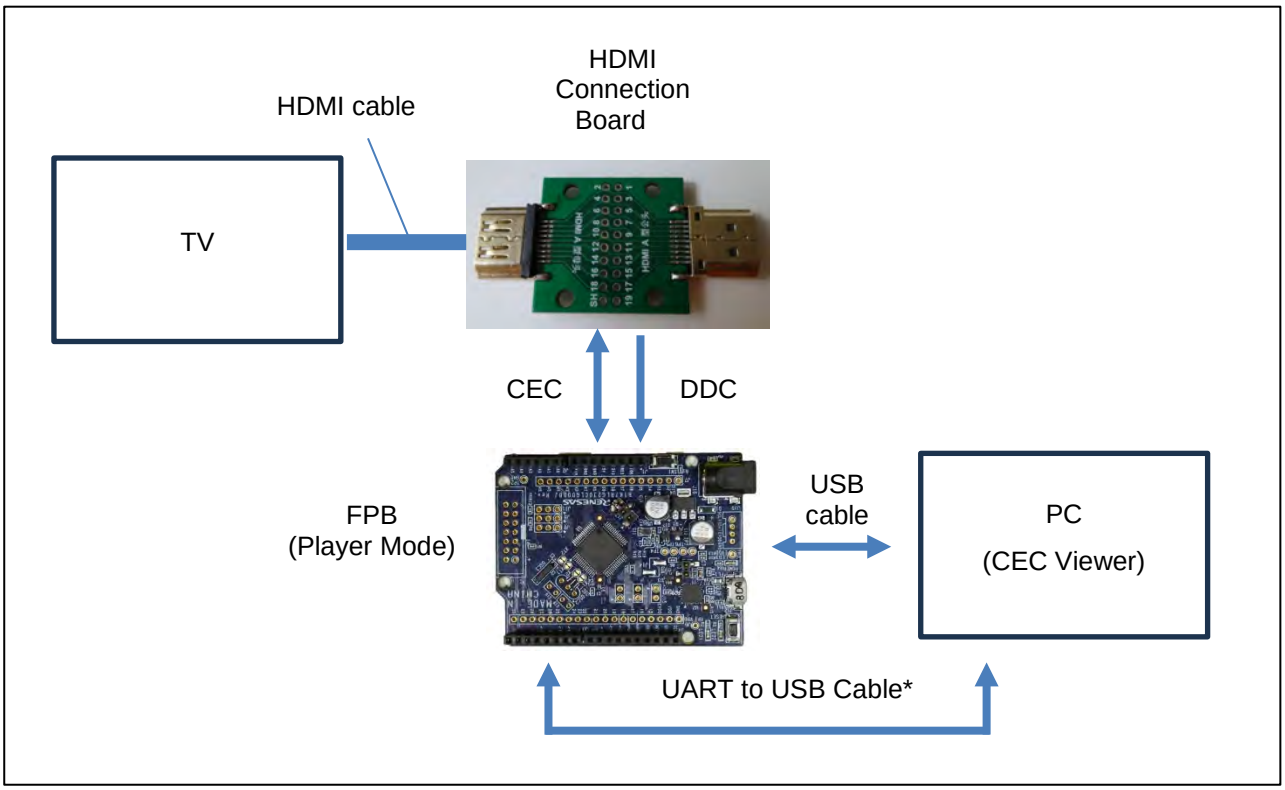
Note3. The fast forward/rewind speed has two levels (Low speed, High speed).

Note4. It can be operated if the TV remote control has an ejection function.

5.3.2 Connection Configuration

Figure 5-3 shows the connection configuration in Player mode.

Figure 5-3 Connection Configuration in Player Mode



Note: It is not used in the demo project. It is only used in development projects.

5.3.3 Start Method

The following procedure describes how to set Player mode.

1) Connect the FPB to the PC with a USB cable.
   Start CEC Viewer (PC software). “Renesas Electronics” is displayed in the CEC Viewer message window.
2) If using a development project, load the project in the IDE and start debugging. (When using the demo project, there is no need to load the project in the IDE.) The name of the currently selected mode is blinking in the CEC Viewer message window. If it is not blinking, check the Serial Config settings.
3) Switch modes with SW1. Each time SW1 is short-pressed, it switches between Audio mode, Player mode, and Monitor mode (repeatedly).

   The status of the FPB LEDs during mode selection is as follows.

Mode	LED1	LED2
Monitor mode	ON	ON
Audio mode	OFF	ON
Player mode	ON	OFF

4) While “Player Mode” is blinking in the message window of the CEC Viewer, press SW1 for more than 3 seconds to confirm the Mode. The Player Mode displayed in the CEC Viewer message window changes to always on. When the mode is switched, the log displayed in the CEC Viewer is deleted.

5) Next, it switches to the HDMI connector number selection. Select the number of the HDMI connector on the TV to which the HDMI cable is to be connected. Each time SW1 is short-pressed, it switches between HDMI 2, HDMI 3, HDMI 4, HDMI 1 (repeatedly). The FPB LED lighting status during HDMI connector number selection is as follows.

HDMI Connector Number	LED1	LED2
HDMI 1	OFF	ON
HDMI 2	ON	OFF
HDMI 3	ON	ON
HDMI 4	OFF	OFF

And the currently selected HDMI connector number is displayed blinking in the message window of the CEC Viewer.

6) While the HDMI connector number is blinking in the message window of the CEC Viewer, press SW1 for at least 3 seconds to confirm the HDMI connector number. The HDMI connector number displayed in the message window of the CEC Viewer changes to always on.

7) “Player mode” is displayed in the message window of the CEC Viewer.

8) Connect the HDMI cable to the HDMI connector on the TV.

Note 1. For details on how to install and launch CEC Viewer on a PC, see “6.3 Installation and Startup” for more information.
Note 2. To change the mode again after the mode is confirmed, press RESET (SW2).
Note 3. To acquire communication data in Player mode, press the Start button on the CEC Viewer.

6. CEC Viewer

This chapter describes the GUI (CEC Viewer), enabling monitoring of CEC/DDC signals and CEC control on a PC monitor connected to the FPB via USB.

6.1 Function

The functions of CEC Viewer are as follows:

- Monitoring CEC/DDC signals
- Recording and sending CEC commands with Preset Keys (20 keys)
- Saving and reading the log stored in the CSV file

6.2 Installation Modules

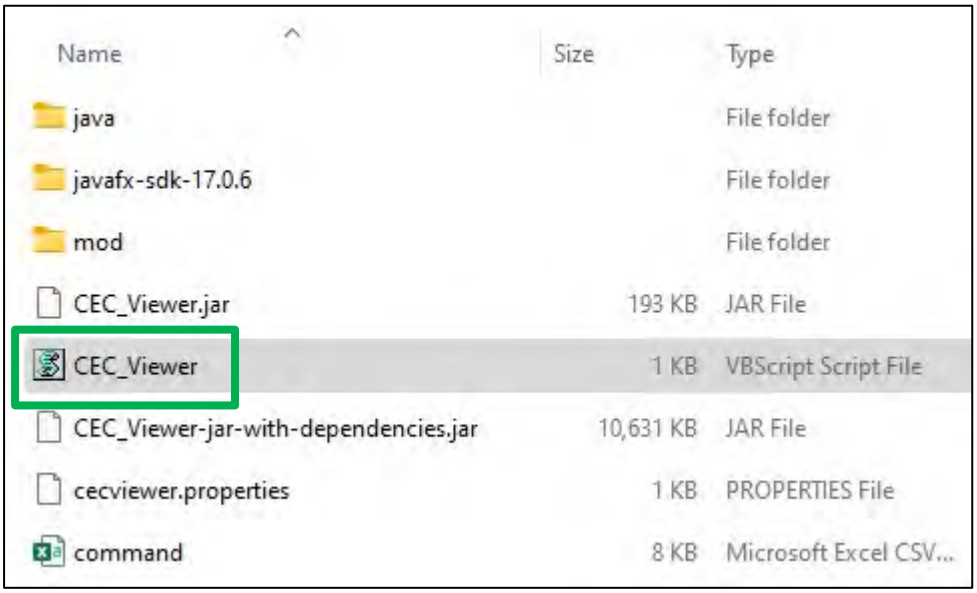
Table 6-1 List of Installation Modules

File Name	Contents
CEC_Viewer_windows.zip	Installation module for Windows

6.3 Installation and Startup

1) Unzip the installation module file in a folder of your choice.
2) Double-click CEC_Viewer.vbs to launch the CEC Viewer.

Figure 6-1 Startup Files



6.4 File List

Table 6-2 Operating Environment

File/Folder	Contents
CEC_Viewer.vbs	CEC Viewer can be used by running this file.
command.csv	This is a list data file of CEC commands (Op Code). By editing this file, a new Op code can be added.
cecviewer.properties	This is to save the settings of CEC Viewer and Preset Key Config contents.
CEC_Viewer-jar-with-dependencies.jar	CEC Viewer dependency files
CEC_Viewer.jar	CEC Viewer
java/	java17 folder
javafx-sdk-17.0.6/	javafx sdk folder
mod/	Startup module folder

6.5 Command.csv

Command.csv is a file that contains CEC command information. You can add a new Op code by editing it in the editor.

Table 6-3 shows the CSV file formats for CEC Viewer.

Table 6-3 CSV File Formats

Item	Contents
Character encoding	UTF-8
Newline code	LF (0x0A)
Field Format	A string enclosed in double quotes (cannot contain double quotes and commas)
Delimiter	Comma (spaces and tabs before and after the comma are ignored)

The command.csv file consists of 4 fields which are shown in Table 6-4.

Table 6-4 Command.csv Configuration

Field	Field Name	Example
1	Class Number (2 digits, Decimal)	"00"
2	Class Name	"One Touch Play / Routing Control"
3	By Code ((2 digits, Hexadecimal)	"82"
4	By Code Name	"<Active Source> [Physical Address]"

Figure 6-2 Commnad.csv (Extract)

```
"00", "One Touch Play / Routing Control" , "82",  "<Active Source> [Physical Address]"
"00", "One Touch Play"                   , "04",  "<Image View On> [None]"
"00", "One Touch Play"                   , "0D",  "<Text View On> [None]"
"01", "Routing Control"                  , "9D",  "<Inactive Source> [Physical Address]"
"01", "Routing Control"                  , "85",  "<Request Active Source> [None]"
"01", "Routing Control"                  , "80",  "<Routing Change> [Original Address][New Address]"
"01", "Routing Control"                  , "81",  "<Routing Information> [[Physical Address]"
"01", "Routing Control"                  , "86",  "<Set Stream Path> [Physical Address]"
"02", "Standby"                          , "36",  "<Standby> [None]"
"03", "One Touch Record"                 , "0B",  "<Record Off> [None]"
"03", "One Touch Record"                 , "09",  "<Record On> [Record Source]"
"03", "One Touch Record"                 , "0A",  "<Record Status> [Record Status Info]"
"03", "One Touch Record"                 , "0F",  "<Record TV Screen> [None]"
"04", "Timer Programming"                , "33",  "<Clear Analogue Timer> [Set AnalogueTimer]"
"04", "Timer Programming"                , "99",  "<Clear Digital Timer> [Set Digaital Timer]"
```

Note. When editing, make sure that the Class number is in ascending order and that the Op Code is not duplicated in the file.

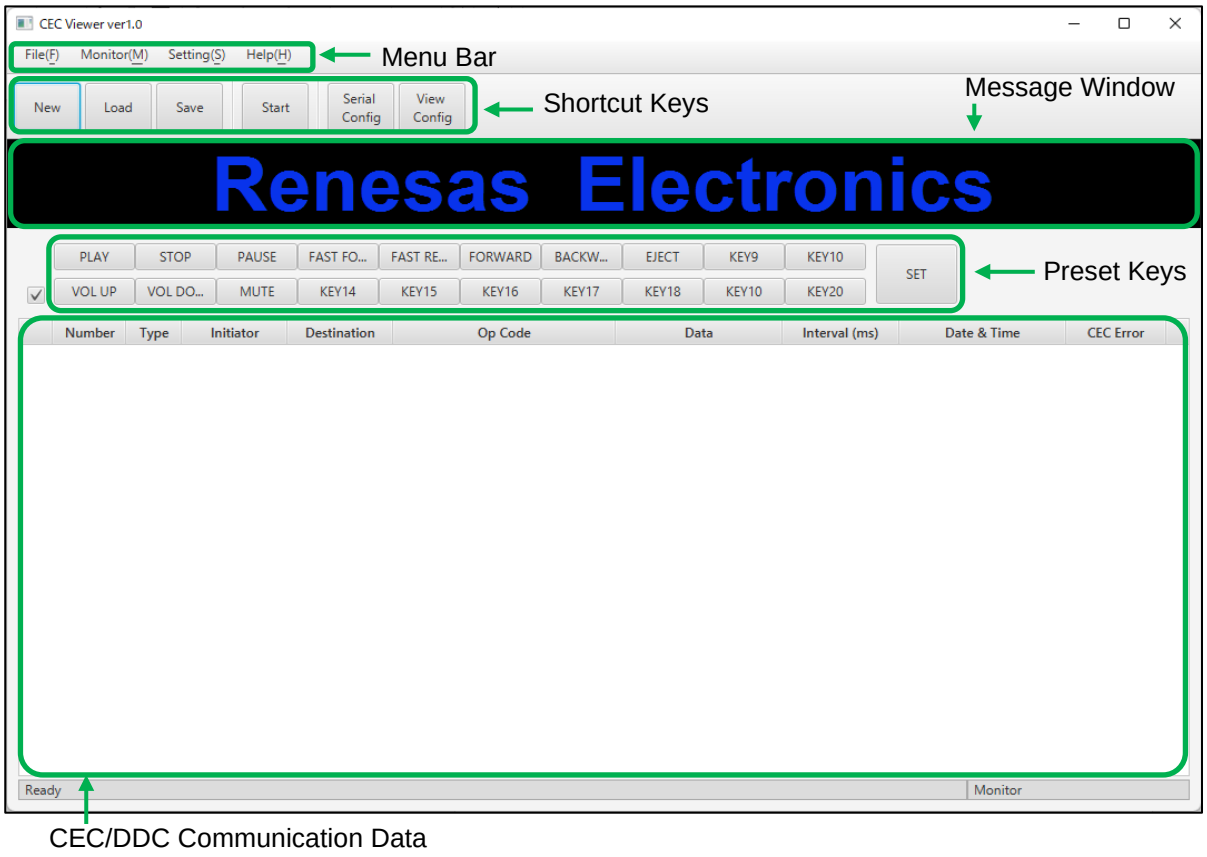
The CEC Viewer can use the following Op code names except for the command.csv:

By Code Name	Contents
<Logical Address Allocation>	This is displayed when the Initiator and Destination are the same.
<Polling Message>	This is displayed when the CEC data is only in the Header Block.

6.6 Main Window

The main window is shown below.

Figure 6-3 Main Window



[CEC / DDC Communication Data] *1, 2

Number：	Displays the order of the communication results. If you clear the log display, it will be numbered starting with Number 1.
Type：	Displays the type of CEC or DDC communication.
Initiator：	Displays the name of the Initiator Address.
Destination：	Displays the name of the Destination Address.
Op Code:	Displays the name of the operation code and the operand configuration of the operation code.
Data:	Displays the communication result of the frame. Data is displayed in odd-numbered bytes, and End of Message (EOM) and Acknowledge (ACK) are displayed in even-numbered bytes. The "e" is displayed if there is an EOM, and the "-" is displayed if there is no EOM. The "a" is displayed if there is an ACK, and the "n" is displayed if there is no ACK.
Interval (ms)：	Displays the interval time between CEC communications or DDC communications.
Data & Time：	Displays the date and time when the frame data was acquired.
CEC Error：	Displays CEC Error.

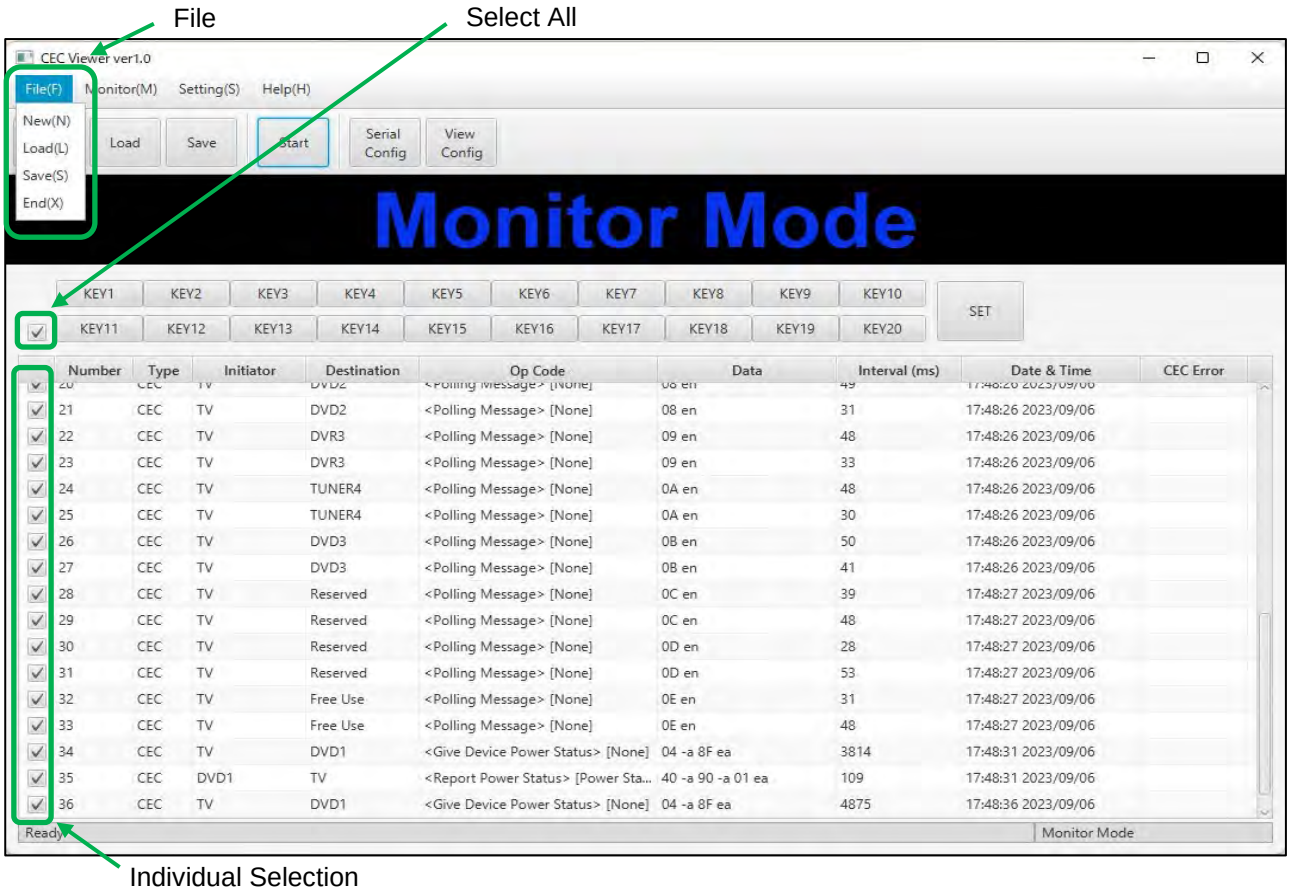
Note. The maximum number of lines in the log that can be displayed is 300.

Only communications that have an ACK response to the Header Block will be displayed in the CEC/DDC Communication Data.

6.7 File Menu

This section describes the File menu.

Table 6-4 File



[New] It can clear the log display while it is being displayed. And a confirmation screen will appear. The function is the same as the "New" of the Shortcut Key.

[Load]* It allows you to read the log data stored in a CSV file. The function is the same as the "Load" of the Shortcut Key.

[Save] It allows you to save the current log data to a CSV file. The function is the same as the "Save" of the Shortcut Key. Outputs the rows selected by the individual selection checkbox to the left of the number in the Number column to a CSV file. You can select the checkbox at the top of the Number column to select all of them.

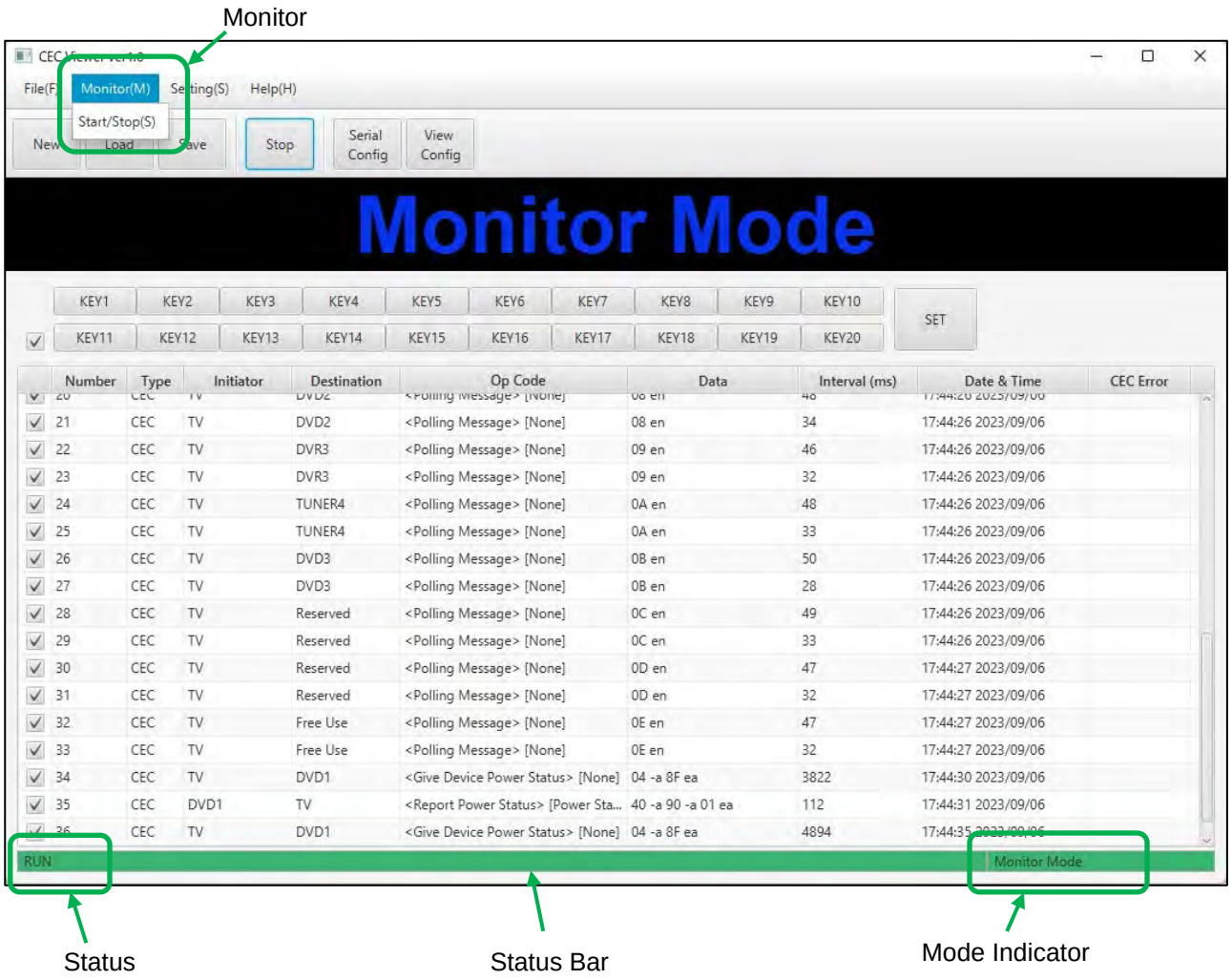
[End] This is to exit the CEC Viewer. A confirmation screen will pop up after.

Note. If log data exists in CEC / DDC Communication Data and you select Load, the log data saved in the CSV file will be added after the displayed log data.

6.8 Monitor

This section describes the Monitor menu.

Figure 6-5 Monitor



[Start / Stop]

When Start/Stop is selected, the Status Bar at the bottom of the window will change to green, and the CEC/DDC reception starts. The Status changes from Ready to RUN.

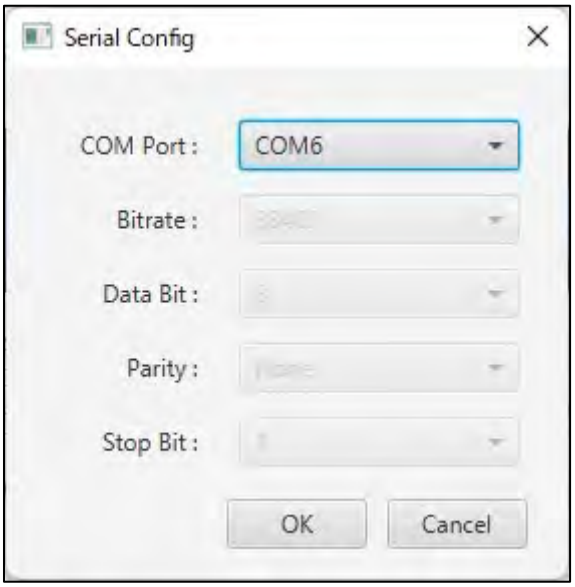
When monitoring CEC/DDC signals, select Start/Stop to enter the RUN state. If stop, select Start / Stop again.

This is the same as "Start" or "Stop" of the Shortcut Key. When you click "Start" of the Shortcut Key, it changes to "Stop", and when you click "Stop", it changes to "Start".

6.9 Settings

Figure 6-6 Settings

Figure 6-7 Serial Config

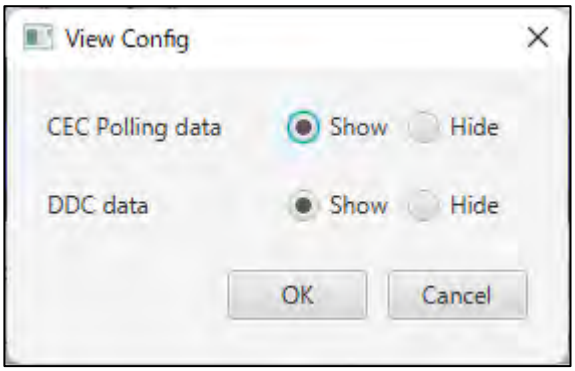


[Serial Config]

It is used to configure the settings for serial communication.

COM Port:	Select the COM Port to be used. Be sure to restart CEC Viewer after changing the COM Port.
Bitrate:	Fixed at 38400.
Data Bit:	Fixed at 8-bit.
Parity:	Fixed to None.
Stop Bit:	Fixed at 1-bit.

Figure 6-8 View Config



[View Config]

It is used to configure the settings for log display.

CEC Polling data:	Select whether to show or hide the data.
DDC data:	Select whether to show or hide the data.

6.10 Preset Key

You can set the Preset Key for CEC commands sending.

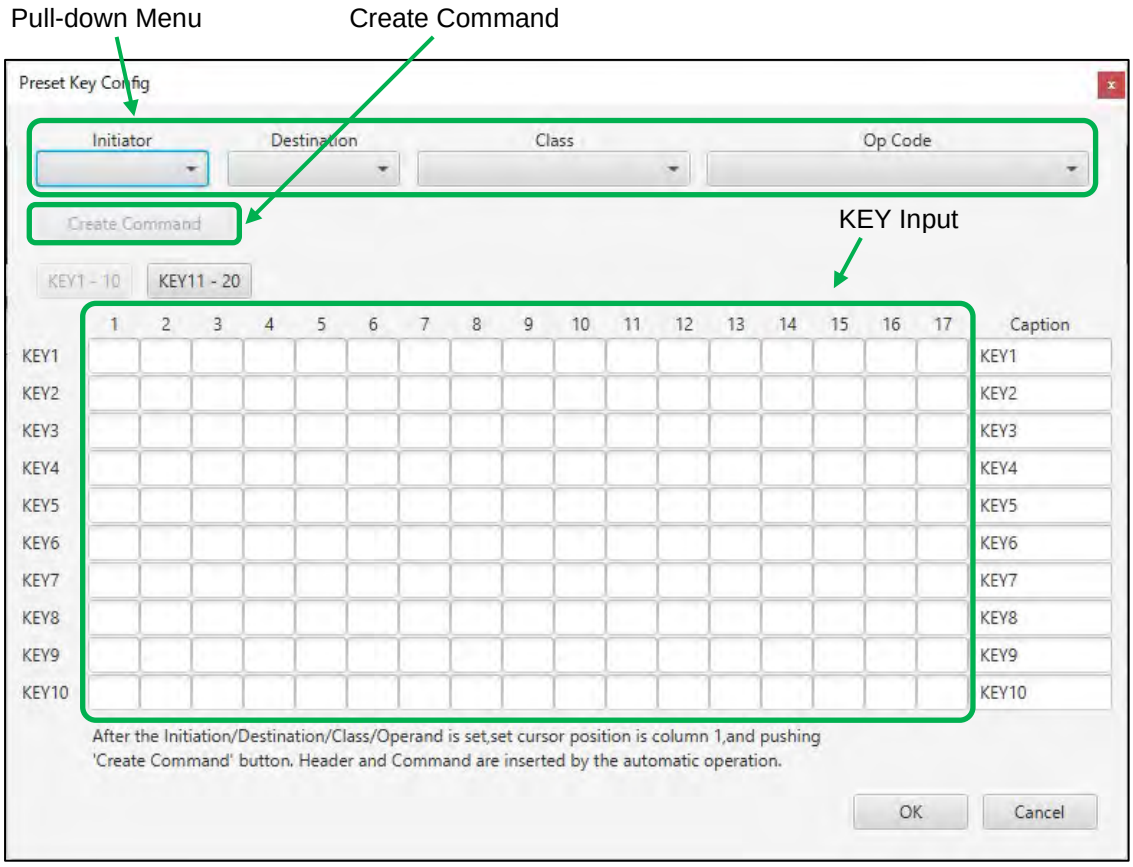
6.10.1 Setting Method

1) Press the SET key.

Figure 6-9 Preset Key

2) The Preset Key Config screen appears. You can set the KEY in the following way.

Figure 6-10 Preset Key Config



KEY Settings：

Select the Initiator, Destination, and Op Code of the CEC data to be sent in the pull-down menu above. It is also possible to directly input in the KEY Input area.

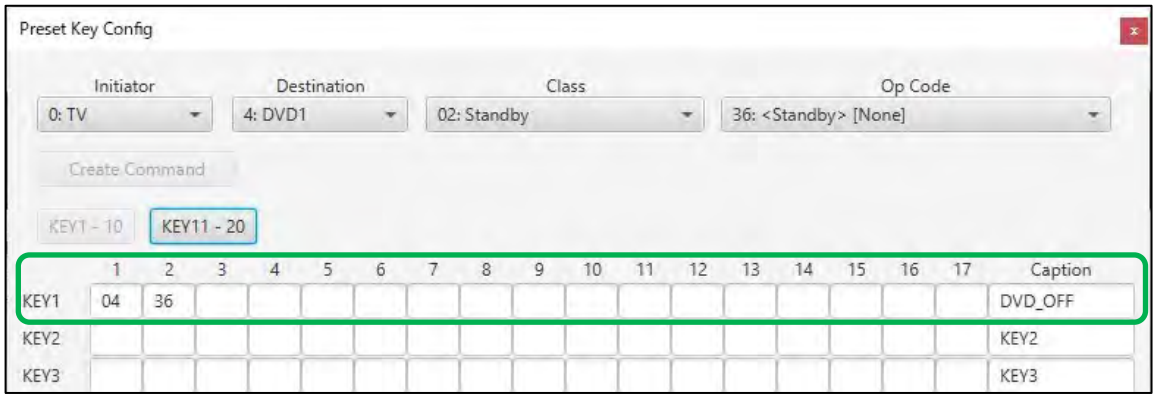
① Select Initiator Address of the transmission source under “Initiator”.
② Select Destination Address of the transmission destination under “Destination”.
③ Select the type of Op Code to be sent under “Class”.
④ Select Op Code to be sent under “Op Code”.
⑤ Place the cursor on the first byte of the KEY to be preset, then press Create Command. This will input Initiator, Destination, and Op Code.
⑥ If the command to be sent requires an operand, enter it directly in the KEY Input area.

3) Now set the Caption of the KEY.

Example of changing the caption

① Set the Caption of KEY1 to [DVD_OFF] and set data to [04] [36].

Figure 6-11 Preset Key Config



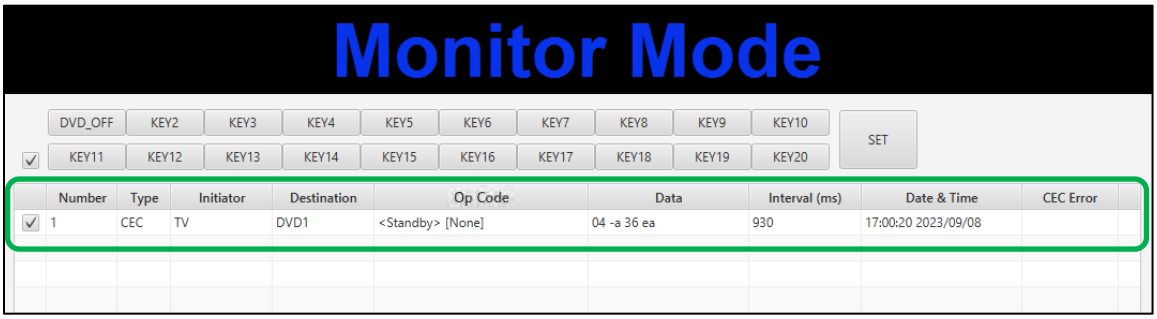
② Press OK and the display of KEY1 changes to [DVD_OFF].

Figure 6-12 Caption Display Change

6.10.2 Usage

1) Press the Start of the Shortcut Key to enter the RUN state.
2) Press the [DVD_OFF] key, the output command is displayed in the CEC / DDC Communication Data area.

Figure 6-13 Communication Status Display



6.10.3 Operation Conditions of the Preset Keys

The following operating conditions apply when using Preset Keys.

- A device (Sound Bar, BD Player) corresponding to the command set as a preset key is connected to the TV via HDMI.

6.10.4 Preset Keys Configured

Some Preset Keys have been configured as typical commands in advance.

Figure 6-14 Preset Keys Configured

Note. If the word length set for CAPTION exceeds the display area, the CAPTION will be shown in abbreviation.

Table 6-5 List of Preset Keys Configured

KEY NUMBER	CAPTION	Setting	Summary
1	PLAY	04 44 44	Playback in Player
2	STOP	04 44 45	To stop the Player
3	PAUSE	04 44 46	To pause the Player
4	FAST FORWARD	04 44 49	Fast forward in Player
5	FAST REVERSE	04 44 48	Fast reverse in Player
6	FORWARD	04 44 4B	Player forward (By chapter)
7	BACKWARD	04 44 4C	Player backward (By chapter)
8	EJECT	04 42 04	EJECT in Player
11	FLIGHT UP	05 44 41	Sound Bar Volume Up
12	VOL DOWN	05 44 42	Sound Bar Volume Down
13	MUTE	05 44 43	Mute Sound Bar

6.11 Message Window

The Message Window displays information about the FPB mode and received keystrokes.

Figure 6-15 An Example in Monitor Mode

The following is a list of messages displayed in the Message Window.

Table 6-6 Display in the Message Window

Selection Function	Message Window Display	Status
-	Renesas Electronics	CEC Viewer Startup
HDMI Connector Number	HDMI 1	- Blinking during selection - Change to always-on display when selected
	HDMI 2	Same as above
	HDMI 3	Same as above
	HDMI 4	Same as above
Monitor mode	Monitor mode	- Blinking during Mode selection - Change to always-on display when selected
Audio mode	Audio mode	- Blinking during Mode selection - Change to always-on display when selected
	VOLUME UP	Volume Up
	VOLUME DOWN	Volume Down
	MUTE	Mute / Unmute
Player mode	Player mode	- Blinking during Mode selection - Change to always-on display when selected
	PLAY	Playback
	STOP	Stop
	PAUSE	Pause
	FAST FORWARD	Fast forward
	FAST REVERSE	Fast reverse
	FORWARD	Forward (By chapter)
	BACKWARD	Backward (By chapter)
	EJECT	Eject

7. Software Configurations

This chapter describes software configurations of the sample codes.

7.1 Folder Structure

Table 7-1 Folder Structure

Folder, File name	Description
/rl78g23-hdmi-cec-(Omitted)	Folder for the sample program
cec_control.c	CEC control layer program
cec_control.h	CEC control layer header file
cec_define.h	CEC definition header
cec_driver.c	CEC communication processing program
cec_driver.h	CEC communication processing header file
cec_if_driver.c	User I/F processing program
cec_if_driver.h	User I/F processing header file
ddc_monitor.c*1	DDC Monitor program
ddc_monitor.h *1	DDC Monitor header file
device.h	For hardware macro definition INCLUDE
host_com.c *1	Programs for PC communication
host_com.h *1	Header file for PC communication
main.c	Main program
R7F100GL.h	Hardware macro definition for RL78/G23
std_define.h	Standard definition header file
/demo_mode	Folder for the Demo Mode
bd_player.c *2	Programs for Player Mode
bd_player.h*2	Header file for Player Mode
sound_bar.c *3	Programs for Audio Mode
sound_bar.h *3	Header file for Audio Mode
/src	
/smc_gen	Smart Configurator generation folder
/Config_IICA0 *1	
/Config_INTC	
/Config_PORT	
/Config_TAU0_0	
/Config_TAU0_1	
/Config_TAU0_3	
/Config_UART0 Note 1*4	
/Config_UART1 Note 1*5	
/general	
/r_bsp	
/r_config	
/r_pincfg	

Note 1. It exists only in projects that support DDC communication and communication with a PC. (rl78g23-hdmi-cec-demo, rl78g23-hdmi-cec-dev)

Note 2. It exists only in projects that support Player mode. (rl78g23-hdmi-cec-demo, rl78g23-hdmi-cec-dev, rl78g23-hdmi-cec-dev-player)

Note 3. It exists only in projects that support Audio mode. (rl78g23-hdmi-cec-demo, rl78g23-hdmi-cec-dev, rl78g23-hdmi-cec-dev-audio)

Note 4. It exists only in the demo project. (rl78g23-hdmi-cec-demo)

Note 5. It exists only in development projects. (rl78g23-hdmi-cec-dev)

7.2 Drivers

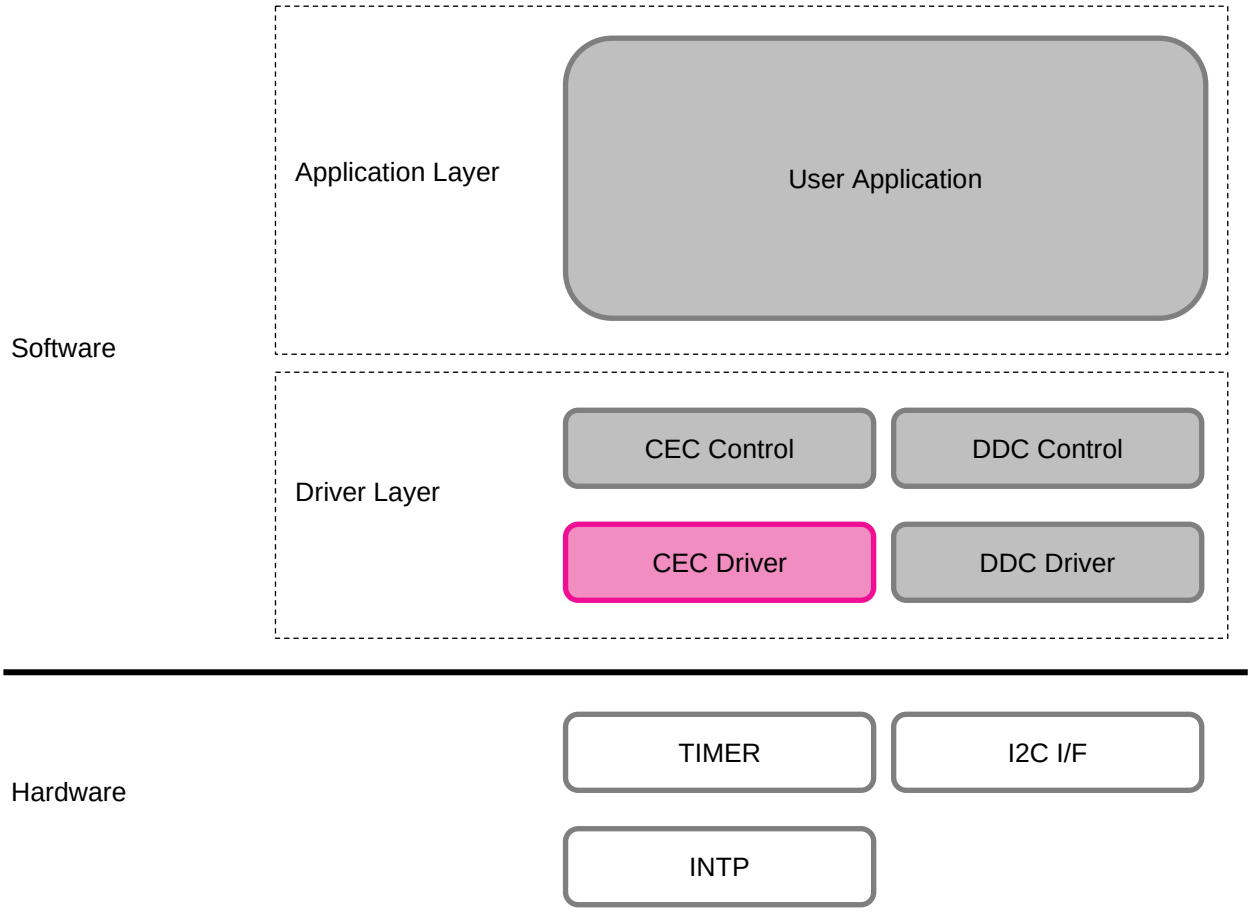
7.2.1 Summary

This driver software allows users to control the transmission and reception of arbitrary data using the CEC line. By importing this driver software into the user program, it is possible to easily transmit and receive data despite of the CEC line control.

7.2.2 Software Hierarchy

To implement the link function using CEC, the driver software (driver layer) shown in Figure 7-1 is required. The functions (hierarchy) provided by this driver software are shown in Figure 7-1.

Figure 7-1 CEC Driver Software Hierarchy



7.2.3 Hardware Resources

This driver software uses the following hardware resources.

Table 7-2 Peripheral Functions and Usages

Peripheral Function	Usage
Interrupt Function (INTP1)	CEC Reception
Channel 1 of Timer Array Unit 0 (TAU0)	Pulse control of CEC transmission and reception
Channel 3 of Timer Array Unit 0 (TAU0)	CEC line monitor
Serial Interface IICA	DDC Reception
P42	CEC Transmission
P51	CEC Reception

7.2.4 CEC Specification

This section describes the availability of this driver software to the CEC Communication Specification (Version 1.4b).

Table 7-3 CEC Specification Availability Table

Specification No.	Contents	Availability
CEC5	Signaling and Bit Timing	Available
CEC6.1.1	EOM (End of Message)	Available
CEC6.1.2	ACK (Acknowledge)	Available
CEC7.1	Frame Re-transmissions	Not Available
CEC7.2	Flow Control	Not Available
CEC7.3	Frame Validation	Available
CEC7.4	CEC Line Error Handling	Available
CEC8	Protocol Extensions	Not Available
CEC9	CEC Arbitration	Available
CEC9.1	Signal Free Time	Available
CEC9.2	Message Time Constrain	Not Available
CEC10.2.1	Logical Address Allocation	Available
CEC11	Switch Requirements	Not Available
CEC12	High Level Protocol	Not Available
CEC13	CEC Feature Description	Not Available
CEC14	Device Status	Not Available

Note. The “Not Available” items above are not available in this driver software, because they require high-level control according to the judgement by Op codes.

7.2.5 Functional Overview

7.2.5.1 Data Transfer Format

- Header / Data Block 10 bits (Data 8 bits, EOM 1 bit, ACK 1 bit)
- Maximum Data Length 16×10 bits (Header / Data Block)

7.2.5.2 Transfer Support

- CEC Transmission and Reception
- Arbitration Detection

7.2.5.3 Standard Functions

This section describes the standard functions of this driver software.

1) Arbitration Recovery Function
If the timing when one device transmits data on the CEC line overlaps with the communication start timing of the other device, an arbitration occurs. Then one of the two devices is determined to have lost in the arbitration, and the losing one must open the CEC line to the other one or shift to the data reception. By using this function, the next time the CEC line is opened, the data that could not be sent the last time due to arbitration loss can be sent again.

Note 1. Monitoring is performed on the start bit and the initiator address section of the header.
Note 2. If arbitration loss occurs in a device other than the Initiator address of the Header Block, it is determined to be a transmission error, and transmission is stopped at that point and retransmission is processed.

2) The CEC specification specifies a waiting time which is between the time when the self-device/the other device has transmitted data and the time when the next transmission can be executed on the CEC line, or between the time when the self-device has received data and the time when its next transmission can be executed. This is called the "Signal Free Time".
This function manages this specified time so that data can be transmitted and received in accordance with the specified time.
< Signal Free Time>
- Period of 3 bits or more: When the same Initiator retransmits previously failed data.
- Period of 5 bits or more: When a new Initiator transmits (after reception completion).
- Period of 7 bits or more: When the same Initiator transmits continuously.

3) CEC Line Error Handling Function
The receiver (Destination) detects noise on the CEC line and notifies the transmitter (Initiator) that an error occurs in the current communication. This function is called "Error Handling" and is defined in the CEC specification. When a noise pulse is detected, the receiver outputs a low level to the initiator at a rate of 1.4 to 1.6 times the normal bit duration (3.6 ms in the driver software).
In this driver software, "Error Handling" is defined as follows.
- The Start bit section is not applicable, data after header (address) section is applicable.
- The criterion for noise pulses is a pulse of less than 2.05 ms, which is the minimum time for a valid bit.
- The receiver (Destination) performs "Error Handling" regardless of whether or not it is logically addressed (even if it is a third device that does not participate in the communication).

When the transmitter (Initiator) detects a low level due to the "Error Handling" of the receiver (Destination), it stops retransmitting and retransmits the data.

7.2.5.4 Option Functions

This section describes the option functions of this driver software. These functions are extensions that are not included in the CEC specifications.

1) CEC Line Monitor Function
The CEC bus status can be monitored by periodically calling the CEC bus lock detection function "monitor_cec_line()" from the user program. Factors that may cause a CEC bus lock to be detected are as follows:

- The CEC line is broken, or it adheres to a low level

If a CEC line lock is detected, the driver software stops CEC communication and returns an error status to the user program. For more information, see “monitor_cec_line” in 7.2.12 Function Specifications.

7.2.6 File Structure

The file structure of this driver software is shown in Table 7-4.

Table 7-4 List of C Source Files

File Name	Type	Contents
cec_define.h	header	CEC Definition Header
cec_driver.c	C Source	CEC Communication Processing
cec_driver.h	header	CEC Communication Macro Definitions
cec_driver.c	C Source	User I/F Processing
cec_driver.h	header	User I/F Macro Definitions
device.h	header	Device Macro Definitions (for User Include)
R7F100GL.h	header	Hardware Macro Definition for RL78/G23
std_define.h	header	Standard Value Definition Header File

7.2.7 How to Import the Driver Software

Follow the steps below to import the driver software into your program.

① Change the definition value of the CEC definition header "cec_define.h" to a value of your choice (e.g., the capacity of the CEC receive ring buffer).
② Include "device.h", "cec_driver.h", "cec_if_driver.h", and "std_define.h" in the user program.

main.c

```
19 /************************************************************************
20  Includes
21  ************************************************************************
22 #include <stdint.h>
23 #include <string.h>
24 #include "device.h"
25 #include "cec_driver.h"
26 #include "cec_if_driver.h"
27 #include "cec_control.h"
28 #include "ddc_monitor.h"
29 #include "host_com.h"
30 #include "std_define.h"
31
```

③ Add "cec_if_driver.c", "cec_if_driver.h", "cec_driver.c", "cec_driver.h", "cec_define.h", "device.h", "R7F100GL.h", and "std_define.h" to your project and then compile the codes.

7.2.8 Defining Types in the Driver Software

cec_define.h

Structure	Description
/*--- CEC Transfer Data Structure ---*/ typedef struct { uint8_t c_len; uint8_t c_data[CEC_TXDAT_SIZE]; } s_cec_tx_buf_t;	CEC Transmission Data Structure Data Length Transmission data
/*--- CEC Receive Data Structure ---*/ typedef struct { uint8_t c_len; uint8_t c_data[CEC_RXDAT_SIZE]; } s_cec_rx_buf_t;	CEC Receive data Structure Data Length Reception data
/*--- CEC Error Data Structure ---*/ typedef struct { uint8_t c_len; uint8_t c_data[CEC_ERROR_SIZE]; } s_cec_error_buf_t;	CEC Error Data Structure Data Length Error Data
/*--- CEC Status ---*/ typedef union { uint8_t c_all; struct { uint8_t cec_tx_busy :1; /* now CEC transmitting */ uint8_t cec_rx_busy :1; /* now CEC receiving */ uint8_t cec_log_adr_alc :1; /* now CEC logical allocation */ } flag; } e_cec_status_t;	CEC Status Union Bit Allocation Structure Bits being transmitted Bits being received Logical Allocation Bits

7.2.9 User-Modifiable Definitions

cec_define.h

Definition Name	Default Value	Contents
CEC_RXBUF_SIZE	5	Number of buffers when CEC reception (Setting range: 1 - 255)
CEC_TX_RETRY	3	Maximum number of retries for ACK errors when sending CEC. (Setting range: 1 - 5)
CEC_LINE_LOCK	200	Number of CEC line lock detections. (Setting range: Max. 255) Set the Min. to be longer than the Low width of the CEC communication.

7.2.10 List of User Variables

The following variables can be used for CEC communication by users.

cec_if_driver.c

Type / Variable Name	Contents
uint8_t g_cec_tx_req_no	CEC Transmission Requirements Set "2" for normal transmission on the user side and "1" for logical address allocation. The driver clears "0" after transmission is completed.
s_cec_tx_buf_t g_cec_tx_buffer	CEC Transmission Data Buffer Set transmission data length and transmission data.

cec_driver.c

Type / Variable Name	Contents
uint8_t g_cec_error_status	CEC Error Status The driver side is cleared only at initial setup. After that, it should be cleared by the user.
uint8_t g_cec_dev_type	CEC Device Type The driver will set values according to modes. Set “5” (Audio System) in Audio mode, Set “4” (Playback Device) in Player mode.

7.2.11 User I/F Functions

Users may use the following functions CEC communication.

cec_if_driver.c

Function Name	Overview
init_cec_driver()	CEC Driver Initialization Processing
cec_driver_main()	CEC Transmission Startup Monitoring Processing
monitor_cec_line()	CEC Bus Clock Detection Processing
trans_cec_rx_buffer()	I/F Processing for CEC Receive data
send_cec_commond()	CEC Command Transmission Processing
stop_cec_driver()	CEC Communication Termination Processing

7.2.12 Function Specifications

Specifications of the functions used by users are shown as follows.

Function Name	void init_cec_driver(void)
Function	To initialize the CEC Driver
Description	To call CEC's SFR Initialization Functions and RAM Initialization Functions
Example	Call it when the user is performing the initial setting or when CEC communication starts.

Function Name	void cec_driver_main(void)
Function	CEC Transmission Startup Monitoring Processing
Description	The conditions for starting up CEC transmission are as follows. ・ Not during signal free time. (Not in the state of waiting for transmission after the end of transmission/reception) ・ Not during CEC transmission/reception. ・ There is a transmission request from the user. (General transmission, logical address allocation) In order to prevent other interrupt processing after the transmit activation monitoring causes a delay in the transmission and prevents the user from sending itself after others have already send, the transmit activation monitoring process prohibits all interrupt processing.
Example	When CEC communication status is available, call it in the main function.

Function name	void monitor_cec_line(void)
Function	CEC line abnormality detection
Description	To detect the CEC Line level. If it is a low level, the counter is incremented. When the set count value is reached, it jumps to CEC initialization.
Example	Call at any time of the user's choice (However, the setting value must be set to a count value that is equal to or greater than the time that the CEC communication reaches the low level.))

Function name	uint8_t trans_cec_rx_buffer(s_cec_rx_buf_t * ptr)
function	I/F processing for CEC receive data
argument	The head address of the destination where the user's received data is stored
Return Values	"1" with receive data, "0" with no receive data
Description	Transfers the number of bytes received and data to the area specified by the argument.
Example	Call at the user's discretion

Function name	void send_cec_commond(uint8_t init_addr, uint8_t dest_addr, uint8_t opcode, uint8_t * operand, uint8_t length)
Function	Processing of sending CEC commands
Argument	init_addr Initiator Logical Address dest_addr Destination Logical address Opcode CEC opcode to be sent operand Head address of the operand storage location to be sent. length Length from Initiator to the last operand (in bytes)
Explanation	To send the CEC command. The operand argument must be the address of the area where the operands (up to 16 bytes) are stored. If the operand does not exist, specify NULL.
Example	Call at the user's discretion

Function name	void stop_cec_driver(void)
Function	Termination of CEC communication
Explanation	Terminate CEC communication If you need to communicate again after this function call, call init_cec_driver.
Example	Call at the user's discretion

7.2.13 Error Status

The contents of the error status in CEC communication are as follows.

cec_if_driver.h

Defination Name	Value	Contents
CEC_NO_ERR	0	No Errors
CEC_TX_NACK_ERR	1	ACK error on transmission (Normally, there is no ACK, but there is an ACK when broadcast communication)
CEC_TX_RETRYOUT_ERR	2	The specified number exceeds the retry transmissions
CEC_TX_ALOST_ERR	3	Arbitration loss on transmission
CEC_TX_HANDLING_ERR	4	Low level detected during high-level output when transmitting (Detects low-level output of error handling on the follower side)
CEC_TX_DBIT_ERR	5	Bit error in transmission (The data you are trying to send has not been sent)
CEC_RX_STBIT_TM_ERR	6	Timing error in the start bit when receiving
CEC_RX_DBIT_TM_ERR	7	Timing errors in receiving data (except error handling)
CEC_RX_HANDLING_ERR	8	During the low-level output period of error handling at the time of reception, the frame width of the data is shorter than the specified minimum time.
CEC_RX_DT_OVER_ERR	9	Received data exceeds the specified byte limit

7.2.14 Operation Description

7.2.14.1 CEC Transmission Operation

When there is a CEC transmission request from the user program (g_cec_tx_req_no is set to CEC_LOGALC_TXREQ (= 2) or CEC_NORMAL_TXREQ (= 1)), the Signal Free Time Management function adjusts the timing and starts the CEC transmission operation.

If the transmission is successful, the g_cec_tx_req_no is cleared and the user is notified that the transmission is complete.

If this flag is cleared, the user can make the next transmission request.

If the transmission is not completed normally, the transmission operation (retry operation) is performed again up to the specified number of times.

Figure 7-2 Signal Free Time after Transmission is Completed (When its own Logical Address is 0x01)

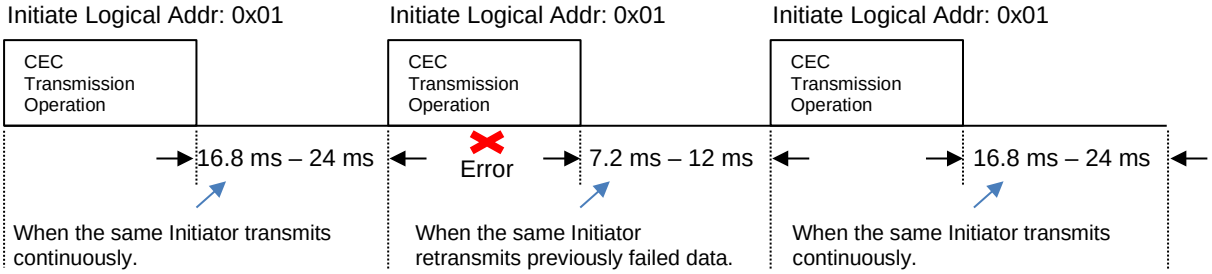
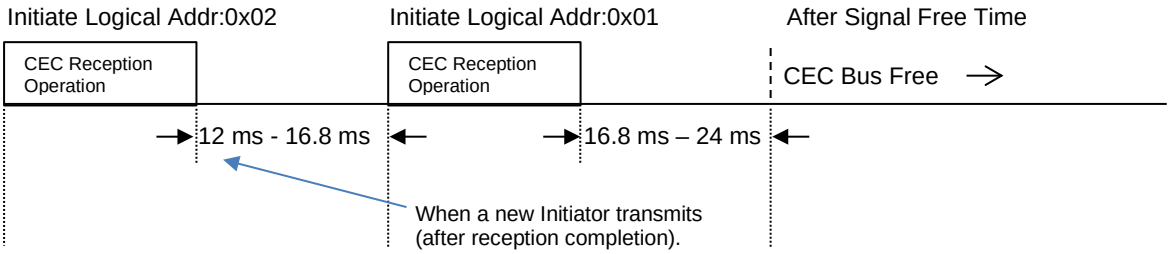


Figure 7-3 Signal Free Time after Reception is Completed (When its own Logical Address is 0x01)

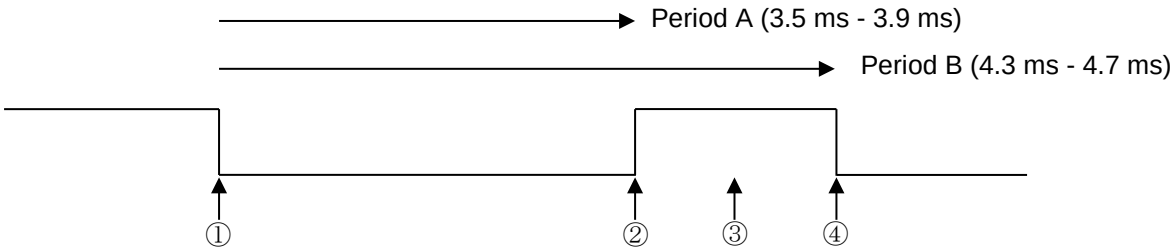


7.2.14.2 Interrupt Timing Processing during CEC Transmission

The timer time set in the software is set by subtracting the delay time for interrupt processing.

1) Start bit (Transmission)

<Initiator Output Waveform>



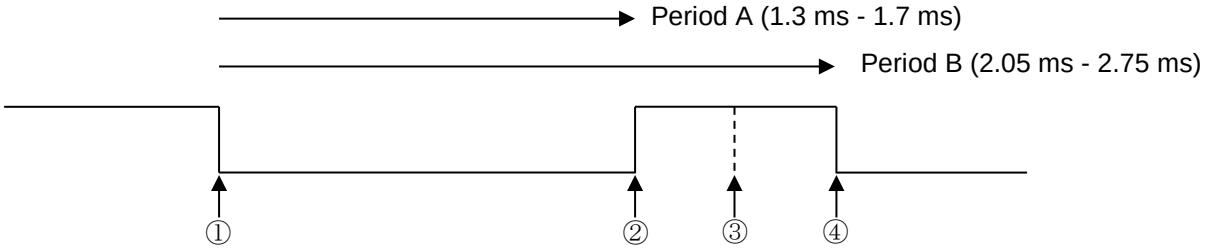
	Interrupt Sources	Handling
①	Timer Interrupt (Signal Free Time only)	●Low-level output ●Set the timer to 3.7 ms (for generating the timing of ②)
②	Timer Interrupt	●High-level output ●Set the timer to 0.4 ms[*1] (for generating the timing of ③)
③	Timer Interrupt	●Level Detection of CEC-IN Port ✓ If the level is High, it is determined to be a normal start bit, and data transmission continues. Set the timer to 0.4 ms[*2] (for generating the timing of ④) ✓ If the level is Low, it is determined to be lost in arbitration, and the error status is set to CEC_TX_ALOST_ERR, switching to reception mode. Set the timer to 1.9 ms[*3.]

Note1. The maximum A period (3.9 ms) - Period A (3.7 ms) + Check time (0.2 ms)
Note2. Start bit high-level time (0.8 ms) - Time set in ② (0.4 ms)
Note3. Start bit error detection time at reception (6.0 ms) - Start bit low-level time (3.7 ms) - Time set in ② (0.4 ms)

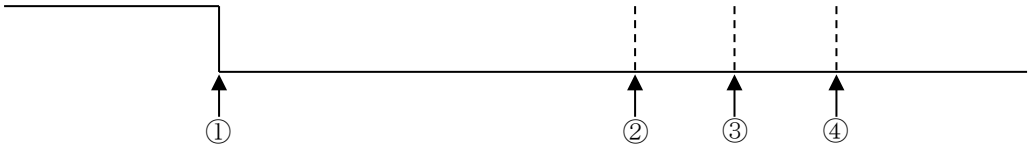
Caution. The Error Handling is not performed during the start bit period.

2) Logical 0 (Transmission)

< Output Waveform>



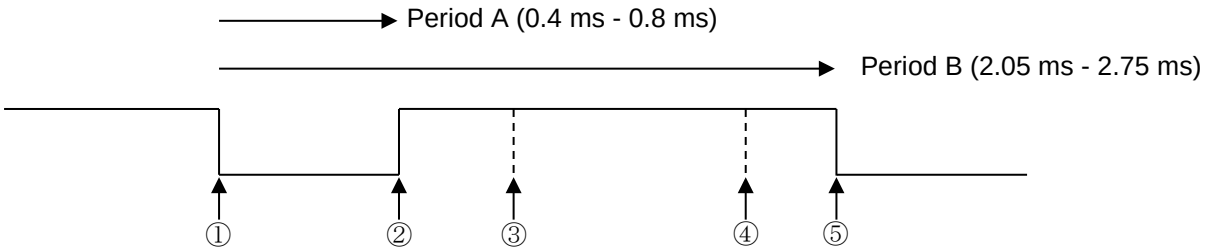
<Communication waveform during error handling by Follower>



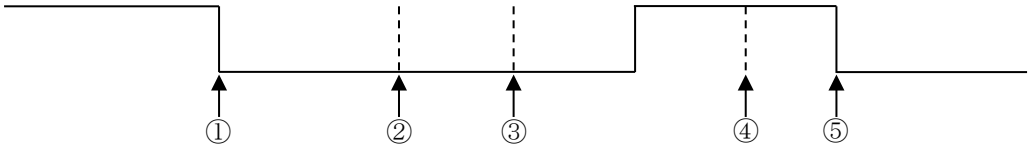
	Interrupt Sources	Handling
①	Timer Interrupt	●Low-level output ●Set the timer to 1.5 ms (timing generation of ②)
②	Timer Interrupt	●High-level output ●Set the timer to 0.45 ms (for generating the timing of ③)
③	Timer Interrupt	●Level Detection of CEC-IN Port If a low level is detected during high-level output, the follower determines that the error handling process is low-level output and sets the error status to CEC_TX_HNADLING_ERR. The data will be retransmitted after a period of 3 bits. ●Set the timer to 0.45 ms (for generating the timing of ④)

3) Logical 1 (Transmission)

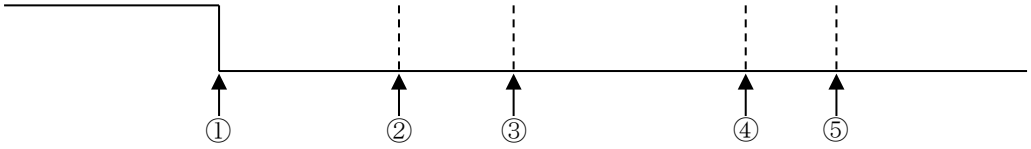
< Output Waveform>



<Communication waveform when arbitration loss>



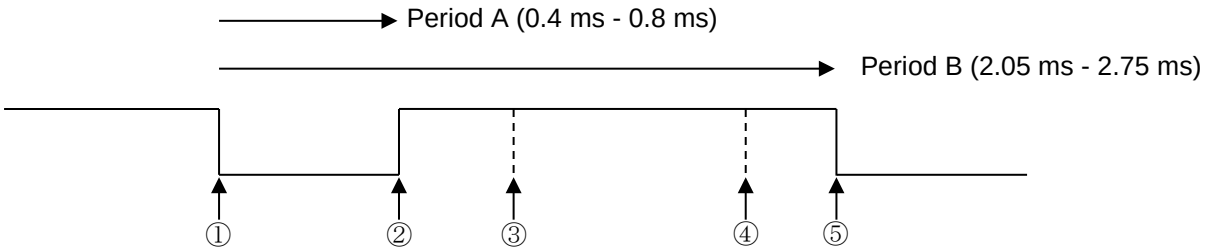
<Communication waveform during error handling by Follower>



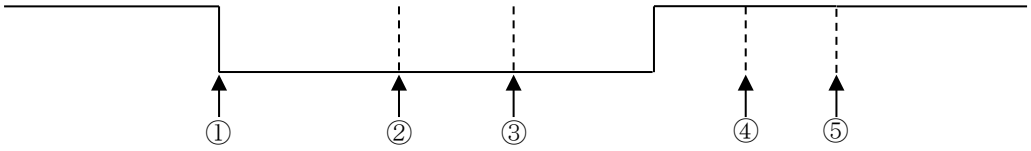
	Interrupt Sources	Handling
①	Timer Interrupt	●Low-level output ●Set the timer to 0.6 ms (for generating the timing of ②)
②	Timer Interrupt	●High-level output ●Set the timer to 0.45 ms (for generating the timing of ③)
③	Timer Interrupt	●Level Detection of CEC-IN Port ✓ If the level is High, it is determined to be a normal bit. Set the timer to 1.35 ms (for generating the timing of ⑤). ✓ If the level is Low, it is not possible to determine whether it is an arbitration loss or error handling by Follower, so recheck the port level in ④. Set the timer to 0.9 ms (for generating the timing of ④).
④	Timer Interrupt	●CEC-IN Port Ray Bell Detection ✓ If the level is High, it is determined as an arbitration loss. If arbitration loss occurs during the Initiator address period of the Header Block, CEC_TX_ALOST_ERR is set in the error status and the operation switches to receiving mode. If arbitration loss occurs outside the Initiator address period of the Header Block, it is considered a transmission error, and CEC_TX_DBIT_ERR is set in the error status. The data will be retransmitted after a period of 3 bits. ✓ If the level is Low, it is determined as error handling by the Follower, and CEC_TX_HNADLING_ERR is set in the error status. The data will be retransmitted after a period of 3 bits.

4) ACK Period

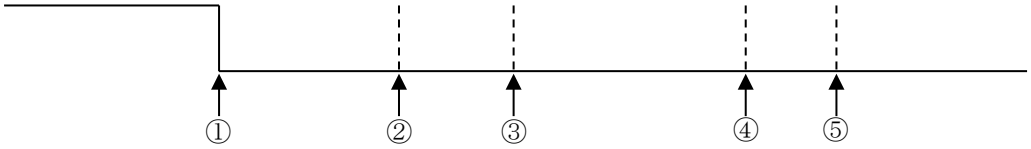
<Initiator Output Waveform>



<Follower ACK Output Waveform >



<Communication waveform during error handling by Follower>



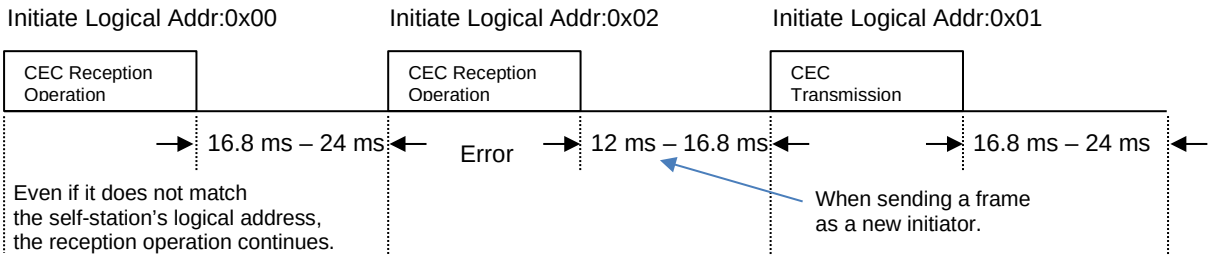
	Interrupt Sources	Handling
①	Timer Interrupt	●Low-level output ●Set the timer to 0.6 ms (for generating the timing of ②)
②	Timer Interrupt	●High-level output ●Set the timer to 0.45 ms (for generating the timing of ③)
③	Timer Interrupt	●CEC-IN Port Level Detection (for ACK detection) ✓ If the level is High, it is determined to be NACK. Set the timer to 1.35 ms (for generating the timing of ⑤). ✓ If the level is Low, it is not possible to determine whether it is ACK output or error handling, so recheck the port level in ④. Set the timer to 0.9 ms (for generating the timing of ④)
④	Timer Interrupt	●CEC-IN Port Level Detection ✓ If the level is High, it is determined to be ACK. ✓ If the level is Low, it is determined to be an error handling by the follower and set the error status to CEC_TX_HNADLING_ERR. The data will be retransmitted after a period of 3 bits. ●Set the timer to 0.45 ms (for generating the timing of ⑤)
⑤	Timer Interrupt	●Check ACK/NACK If the destination address is BroadCast (0xF) and ACK, or if it is NACK without BroadCast (0xF), the data will be retransmitted after a period of 3 bits. ●When continuing the frame, set the timer time for the leading bit of the next byte. ●At the end of the frame, set the timer for 7 bits of time.

7.2.14.3 Reception Operation

When data is received, it is sequentially stored in the ring buffer. Ring buffer control uses two pointers: a read pointer and a write pointer.

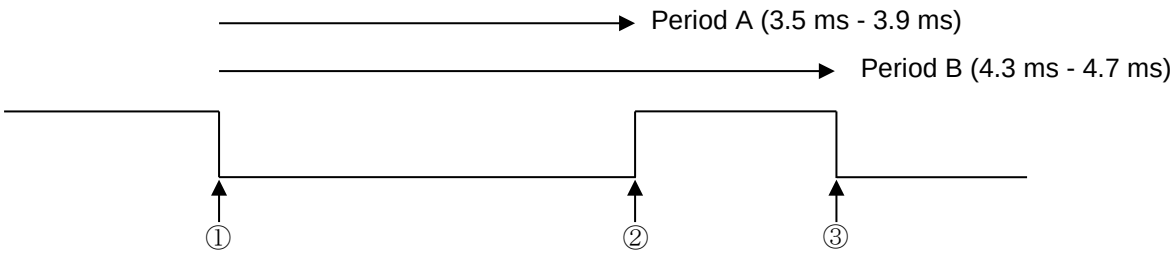
Even if the self-station's own logical address is not specified in the header address of the received data, all exchanges on the CEC line are received. Signal Free Time is managed, but ACK response is not executed.

Figure 7-4 Signal Free Time after Reception Ends (When the Self-station's Own Logical Address is 0x01)



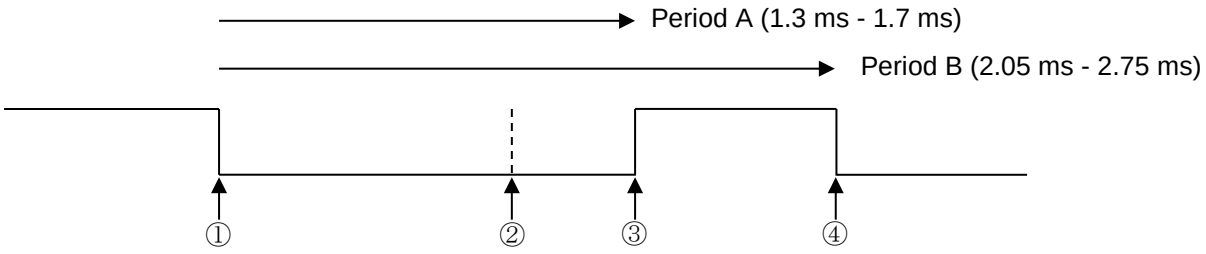
7.2.14.4 Interrupt Timing Handling when CEC Reception

1) Start bit (Reception)



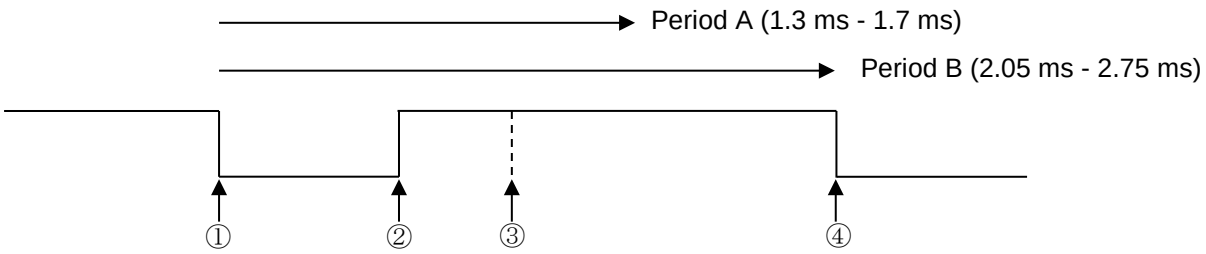
	Interrupt Sources	Handling
①	Edge Interrupts	●Set the timer to 6.0 ms, If no edge is detected within this time, error handling is performed.
②	Edge Interrupts	●Save the timer for Period A
③	Edge Interrupts	●Save the timer for Period B ●Timing determination of Period A and Period B If the case of timing errors in Period A or Period B, set the error status to CEC_RX_STBIT_TM_ERR.

2) Logical 0 (Reception)



	Interrupt Sources	Handling
①	Edge Interrupts	●Set the timer to 1.05 ms
②	Timer interrupt	●CEC-IN Port Level Detection (for Logical 0 and Logical 1 determination) Determines that the High level is Logical 1 and the Low level is Logical 0. ●Set the timer to 3.6 ms.
③	Edge Interrupts	●Save the timer duration for period A. ●Bit timing determination for Period A. If the case of timing errors in Period A, set the error status to CEC_RX_DBIT_TM_ERR.
④	Edge Interrupts	●Save the timer duration for period B ●Bit timing determination of Period B If Period B is shorter than the minimum time, set the error status to CEC_RX_HNADLING_ERR and perform the error handling processing (low-level output). In the case of a timing error in Period B, set the error status to CEC_RX_DBIT_TM_ERR.

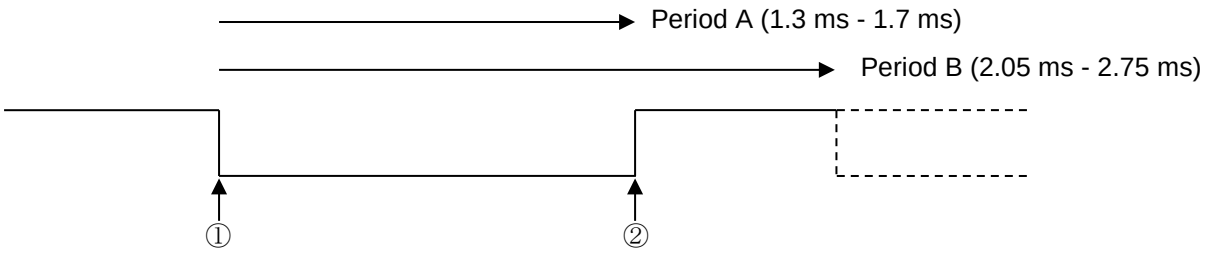
3) Logical 1 (Reception)



	Interrupt Sources	Handling
①	Edge Interrupts	●Set the timer to 1.05 ms
②	Edge Interrupts	●Save the timer duration for period A. ●Bit timing determination of Period A In case of a timing error in Period A, set the error status to CEC_RX_DBIT_TM_ERR.
③	Timer interrupt	●CEC-IN Port Level Detection (for Logical 0 and Logical 1 determination) Determines that the High level is Logical 1 and the Low level is Logical 0. ●Set the timer to 3.6 ms
④	Edge Interrupts	●Save the timer duration for period B ●Bit timing determination for Period B If Period B is shorter than the minimum time, set the error status to CEC_RX_HNADLING_ERR and perform the error handling processing (low-level output). If there is a timing error in Period B, set the error status to CEC_RX_DBIT_TM_ERR.

4) ACK Period

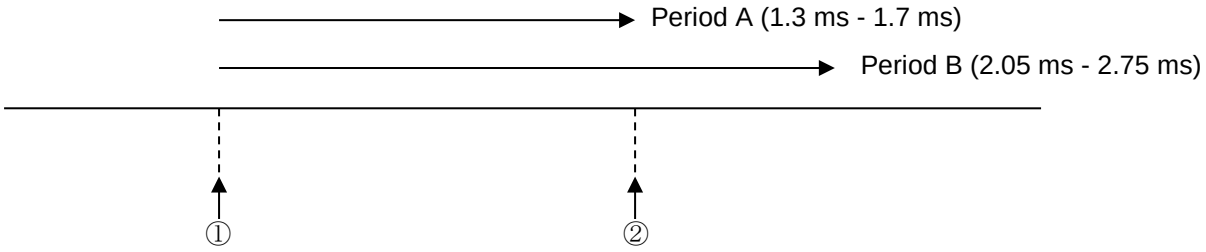
When ACK output is present.



	Interrupt Sources	Handling
①	Edge Interrupt	●Low-level output ●Set the timer to 1.05 ms
②	Timer Interrupt	●High-level output ●If the frame continues, set the timer to 1.5 ms. ●If the frame ends, set the timer based on the rules of Signal Free Time.

When ACK output is absent.

< Output Waveform>



<CEC Line Waveform (Initiator output waveform) >

	Interrupt Sources	Handling
①	Edge Interrupt	●Set the timer to 1.05 ms
②	Timer Interrupt	●If the frame continues, set the timer to 1.5 ms. ●If the frame ends, set the timer based on the rules of Signal Free Time.

7.3 Controllers

7.3.1 Overview

This chapter describes the control layer that performs CEC control using the driver software described in “7.2 Driver”.

The control software has the following modes:

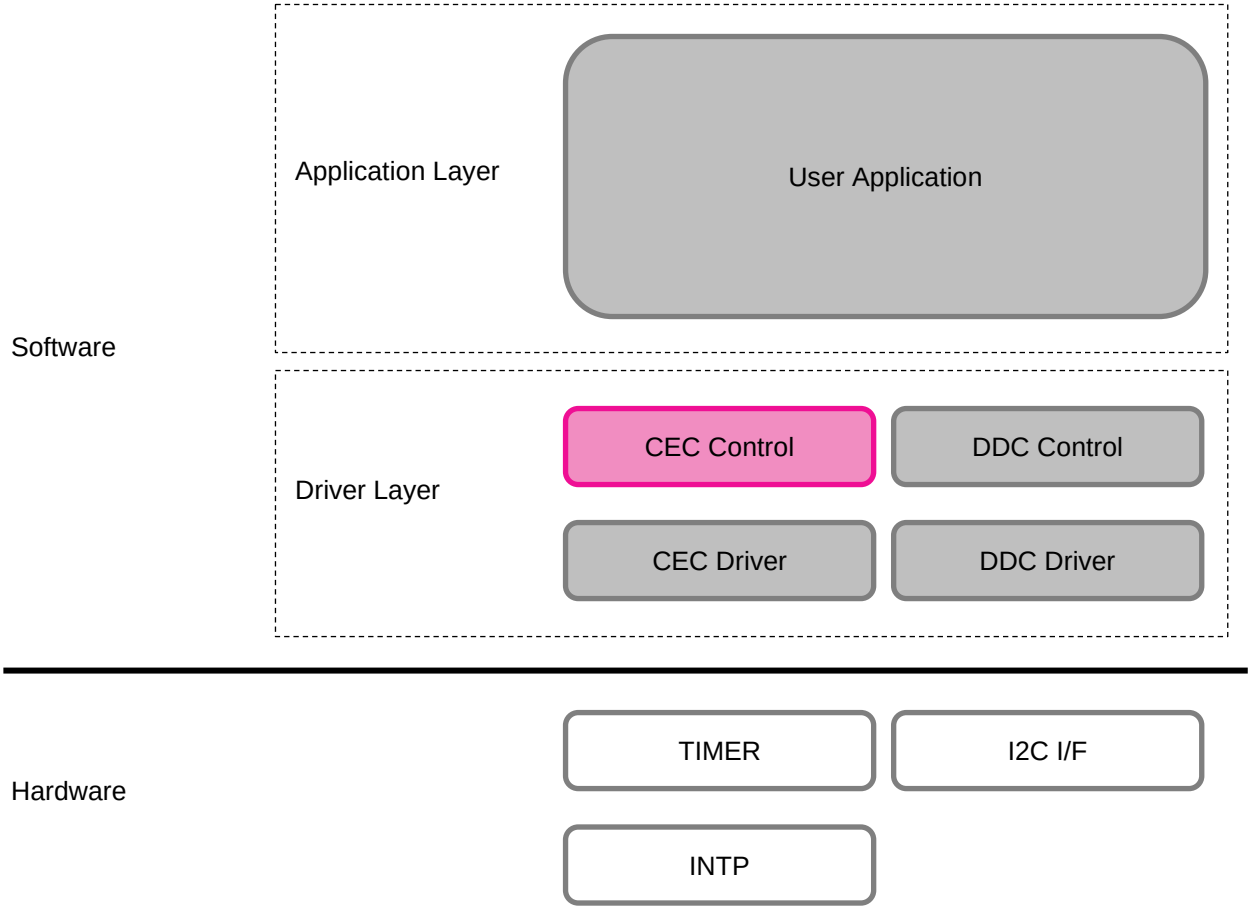
- Monitor mode
- Sound Bar mode
- Player mode

For more information, see the overviews in each section.

7.3.2 Software Layers

The functions (Control Layer) provided by this control software are shown in the figure below.

Figure 7-5 CEC Control Software Hierarchy

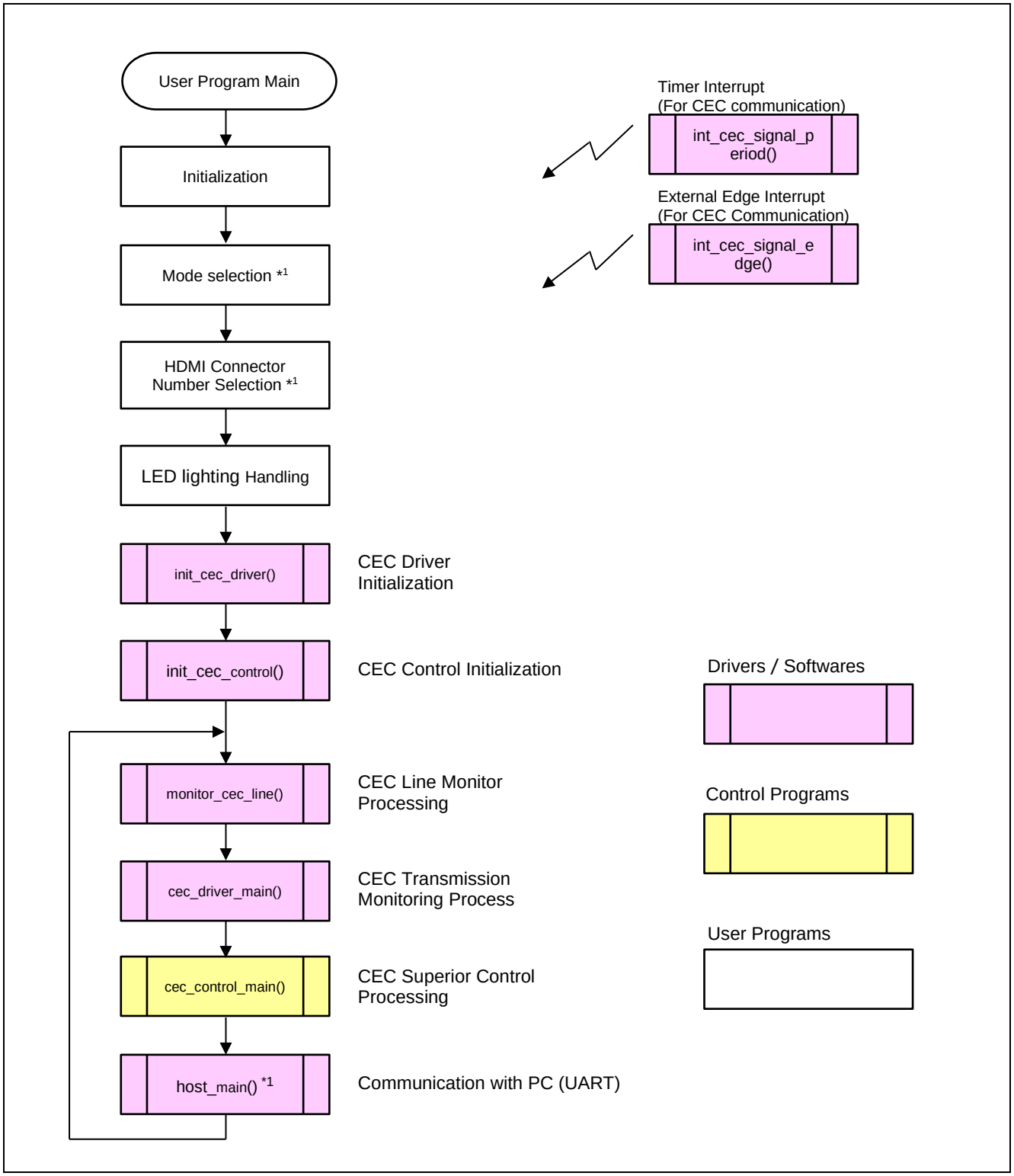


7.3.3 Flowchart

7.3.3.1 General Flow

The general flow when using this control software is as follows.

Figure 7-6 CEC Control Software General Flow

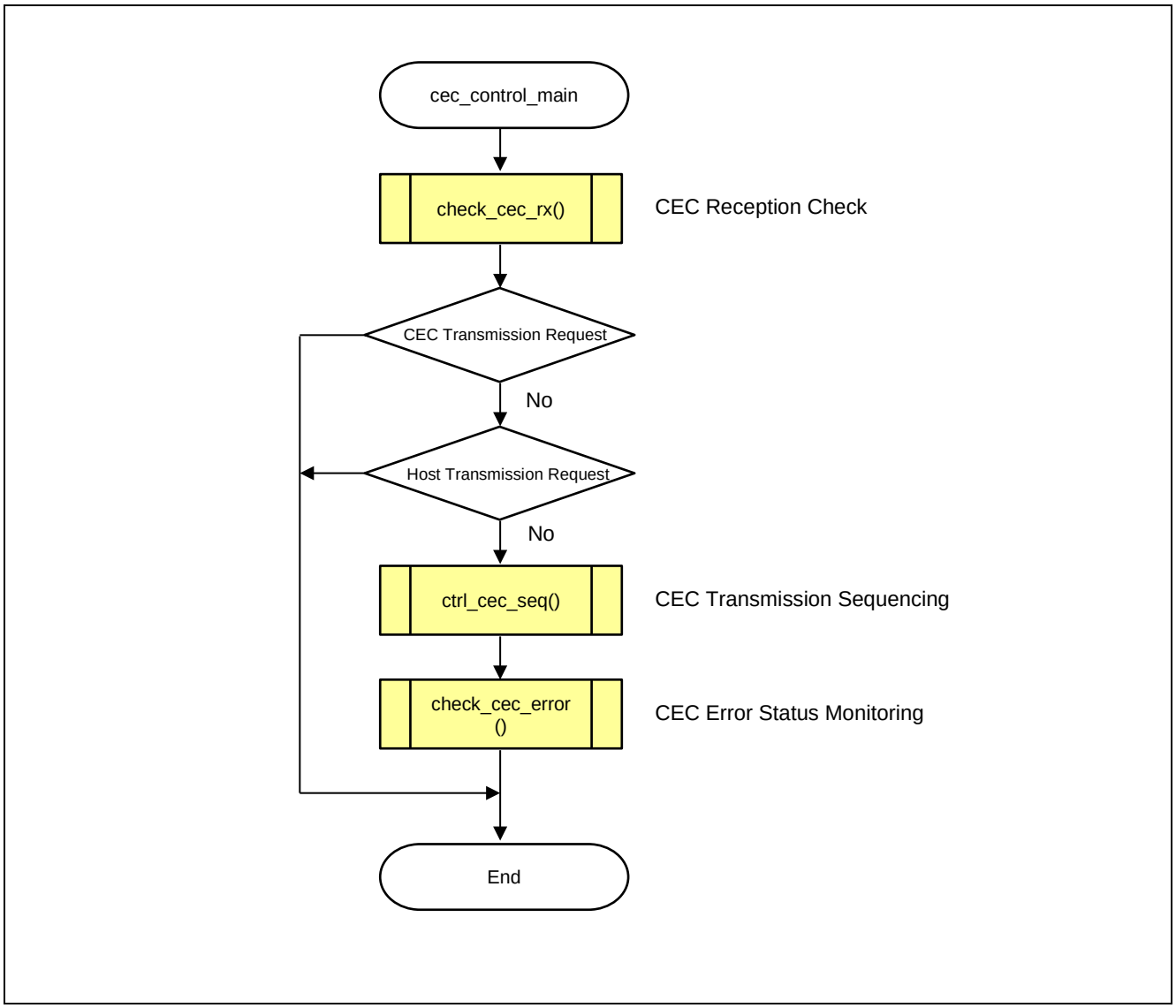


Note 1. It exists only in projects that support Mode selection, HDMI number selection, and communication with a PC. (rl78g23-hdmi-cec-demo, rl78g23-hdmi-cec-dev)

7.3.3.2 CEC Control Flow

The CEC control flow is as follows.

Figure 7-7 CEC Control Flow



7.3.4 Functions of Each Mode

To suit different applications, the control software offers three modes: Monitor mode, Audio mode, and Player mode. This section describes the CEC command communications for different operations in each mode. The operations are as follows.

Monitor Mode

The CEC Viewer attached to the sample codes is used to monitor the CEC / DDC signals on a PC monitor which is connected to the FPB via USB.

Audio Mode

The FPB operates as a Sound Bar, controlling the FPB LEDs in response to the TV remote control operations (Volume Up/Down, Mute).

Player Mode

The FPB operates as a BD Player, controlling the FPB LEDs in response to the TV remote control operations (Play, Fast-Forward, Fast-Reverse, Pause).

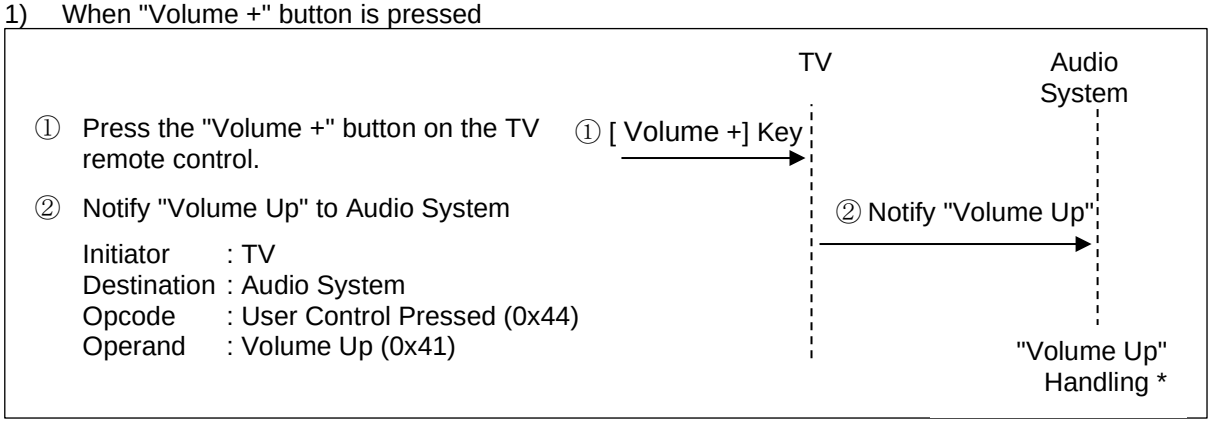
7.3.4.1 Monitor Mode

The CEC Viewer attached to the sample codes is used to monitor the CEC / DDC signals on a PC monitor which is connected to the FPB via USB.

7.3.4.2 Audio Mode

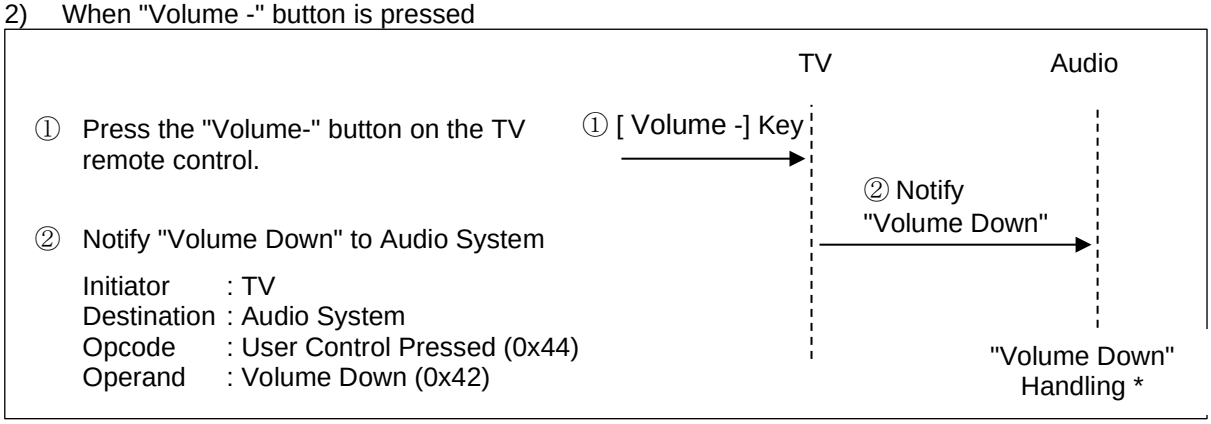
Audio mode allows communication with the TV as a simulated audio system.

1) When "Volume +" button is pressed



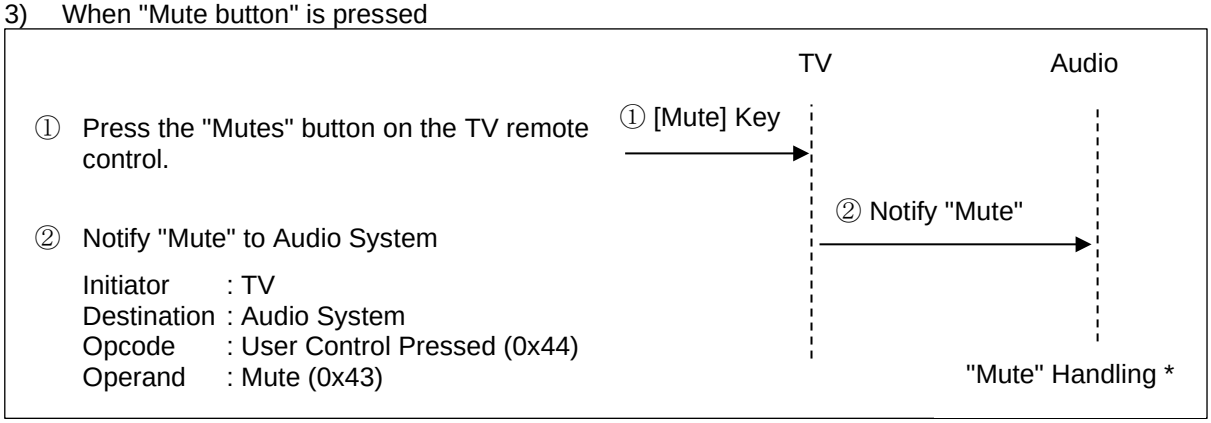
Note. If the volume reaches its upper limit, it remains at the maximum value (100).

2) When "Volume -" button is pressed



Note. If it reaches the lower limit, it stays at the minimum value (0).

3) When "Mute button" is pressed

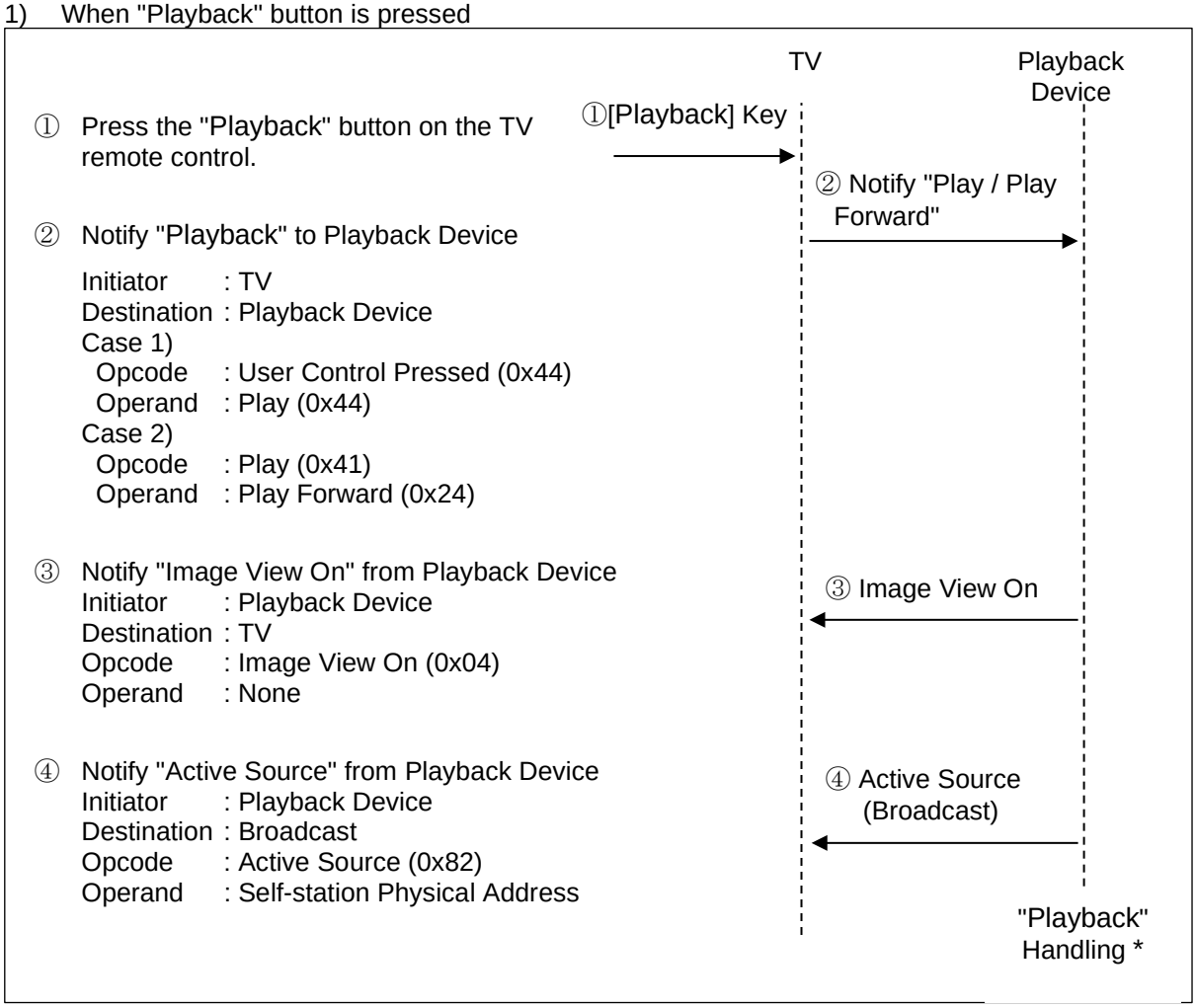


Note. If the Audio System is muted, the mute will be lifted.

7.3.4.3 Player Mode

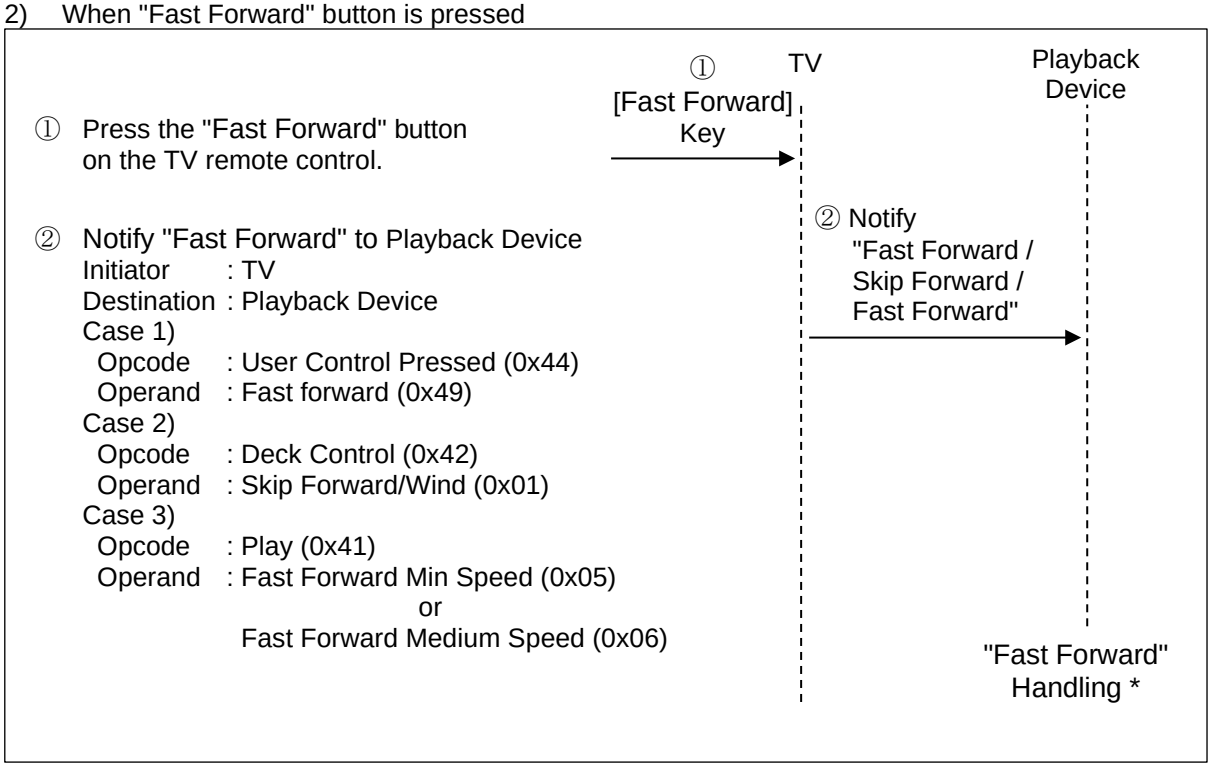
Player mode allows communication with the TV as a simulated Playback Device.

1) When "Playback" button is pressed



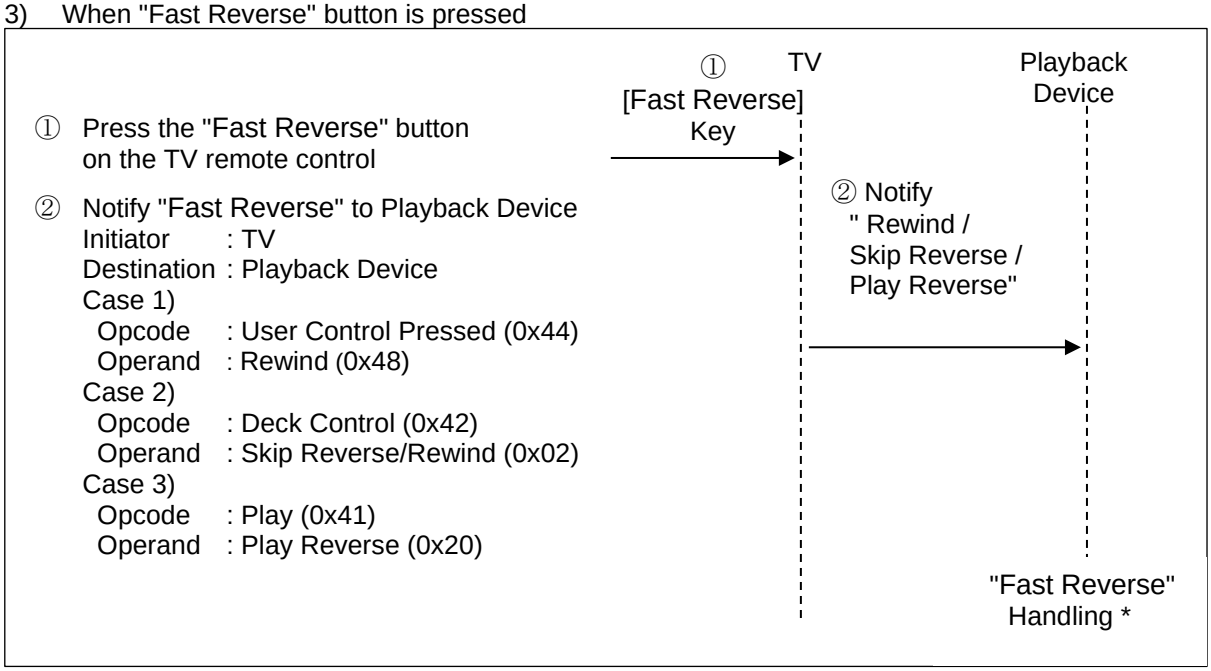
Note. If the Playback Device is currently playing, the procedures from ③ will not be executed.

2) When "Fast Forward" button is pressed



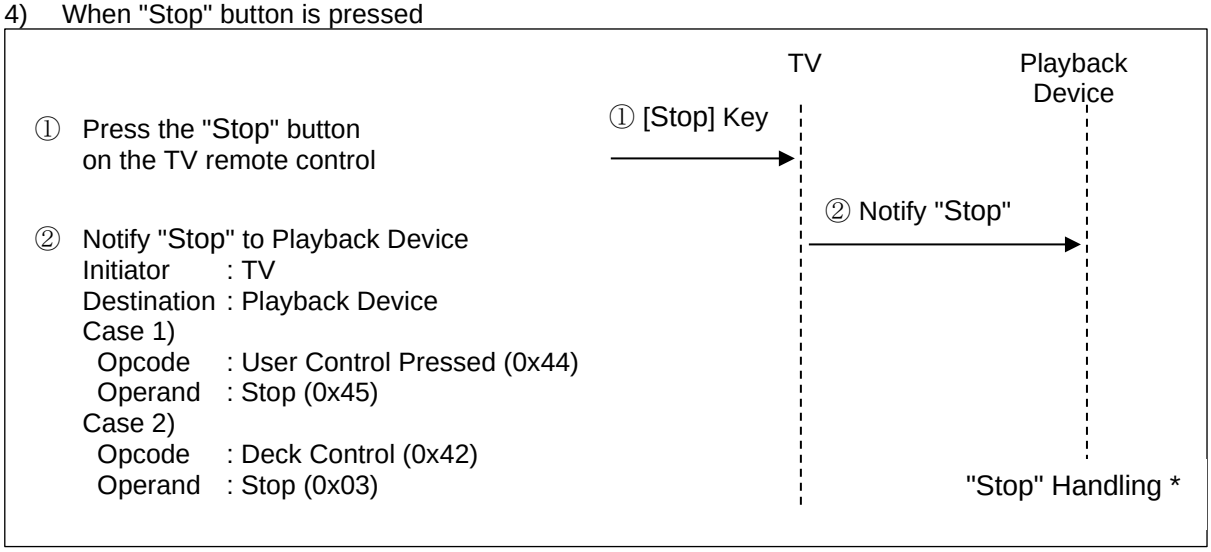
Note. If the Playback Device is currently in STOP status, "Fast Forward" will not be executed.

3) When "Fast Reverse" button is pressed



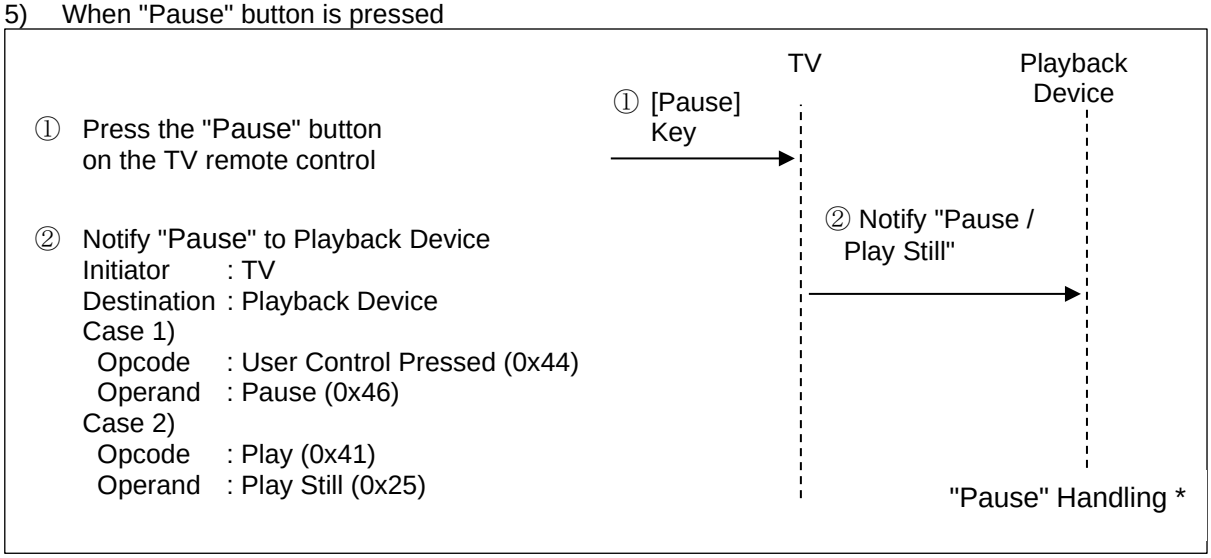
Note. If the Playback Device is currently in STOP status, "Fast Reverse" will not be executed.

4) When "Stop" button is pressed



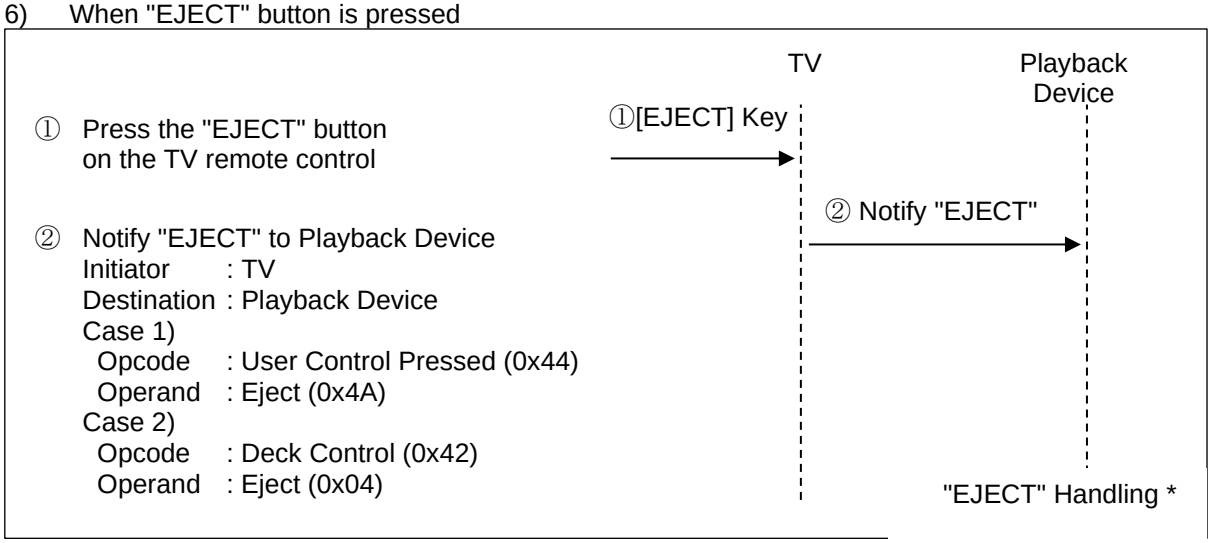
Note. If the Playback Device is currently in STOP status, "STOP" will not be executed.

5) When "Pause" button is pressed



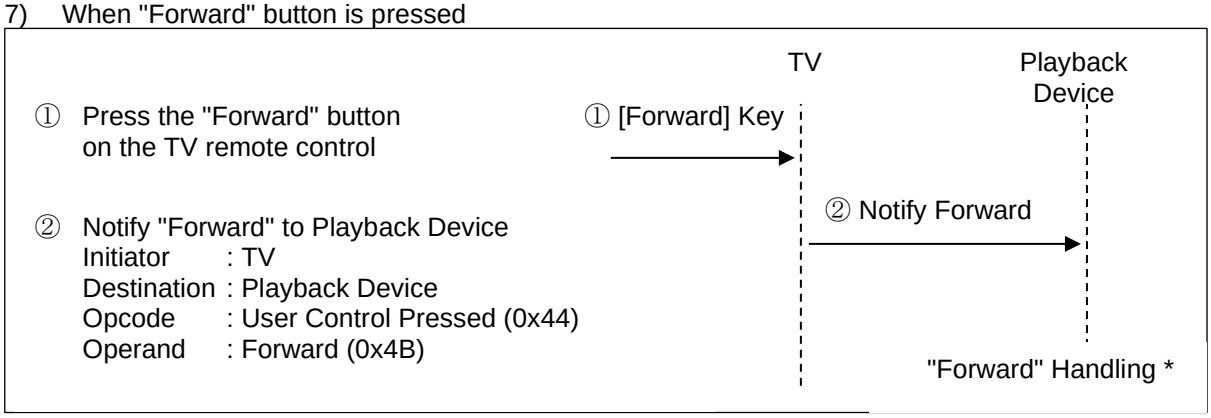
Note. If the Playback Device is currently in STOP status, "Pause" operation will not be executed.
If the Playback Device is currently in PAUSE status, "Pause" will be released.

6) When "EJECT" button is pressed



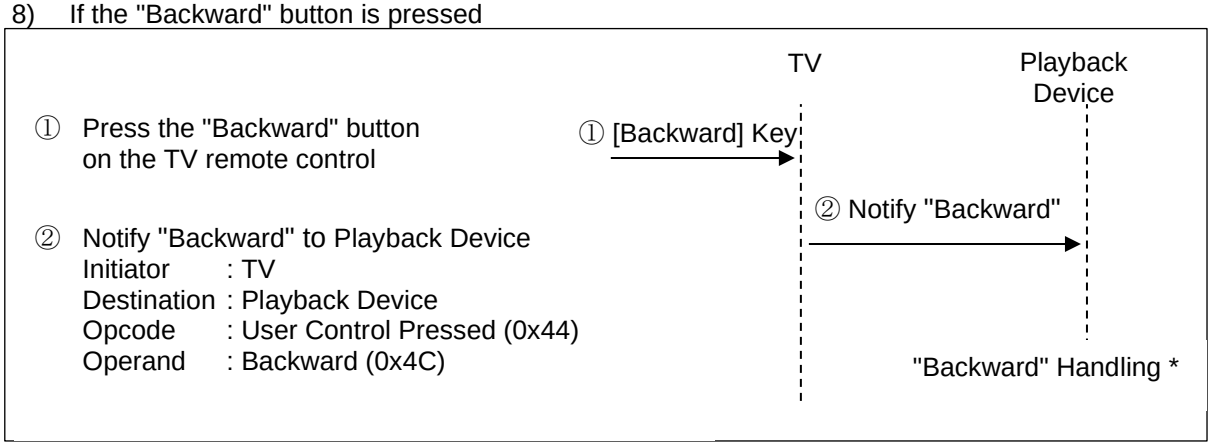
Note. If the Playback Device is currently in EJECT status, the tray storage process will be executed.

7) When "Forward" button is pressed



Note. If the Playback Device is currently in STOP status, "Forward" operation will not be executed.

8) If the "Backward" button is pressed



Note. If the Playback Device is currently in STOP status, "Backward" operation will not be executed.

7.3.5 Status Changing

7.3.5.1 Status Changing in Audio Mode

The following shows the state changing for each operation request in Audio Mode.

Table 7-5 State Changing in Audio Mode

Status	Volume+ Request	Volume- Request	Mute request
① During Audio Output	① → ① *1	① → ① *2	① → ②
② Muted state	② → ① *1	② → ① *2	② → ①

Note 1. Turn up the volume by one. (Upper limit: 100)
Note 2. Turn down the volume by one. (Lower limit: 0)

7.3.5.2 Status Changing in Player Mode

The following lists the status changing for each request in Player Mode.

Table 7-6 Status Changing in Player Mode

Status	Stop Request	Replay Request	Pause Request	Fast Forward Request	Fast Reverse Request	Forward Request	Backward Request	EJECT request
① Paused	-	① → ②	-	-	-	-	-	① → ⑥
② Playing	② → ①	-	② → ③	② → ④	② → ⑤	② → ② *1	② → ② *2	② → ⑥
③ Paused	-	③ → ②	③ → ②	③ → ④	③ → ⑤	③ → ② *1	③ → ② *2	③ → ⑥
④ Fast Forwarding	④ → ①	④ → ②	④ → ③	④ → ④ *3	④ → ⑤	④ → ② *1	④ → ② *2	④ → ⑥
⑤ Fast Reversing	⑤ → ①	⑤ → ②	⑤ → ③	⑤ → ④	⑤ → ⑤ *4	⑤ → ② *1	⑤ → ② *2	⑤ → ⑥
⑥ Ejecting	-	⑥ → ②	-	-	-	-	-	⑥ → ①

- : No change.
Note 1. Forward by chapter.
Note 2. Backward by chapter.
Note 3. This changes the fast forward speed. (Low speed → High speed, High speed → Low speed)
Note 4. This changes the fast reverse speed. (Low speed → High speed, High speed → Low speed)

8. Sample Codes

The samples codes can be downloaded from Renesas Electronics website.

9. References

- RL78/G23 User's Manual: Hardware Rev.1.21
- RL78/G23-64p Fast Prototyping Board User's Manuel Rev.1.10
- RL78/G23 I2C (Slave) for Multiple Slave Addresses Rev.1.01
- High-Definition Multimedia Interface Specification Version 1.4b

Homepage

- Renesas Electronics Homepage
  http://www.renesas.com/

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	2024.7.16	-	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. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   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.
4. 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 the 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.
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.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of 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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