E1 Emulator

Additional Document for User's Manual
(Notes on Connection for 78K0)

Supported Devices:
78K0 Family

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Chapter 1 Outline

1.1   Features

E1/E20 Emulator (hereinafter referred to as E1/E20) is an on-chip debug emulator with flash programming function, which is used for debugging and programming a program to be embedded in on-chip flash memory microcontrollers. This product can debug with the target microcontroller connected to the user system, and can write programs to the on-chip flash memory of microcontrollers.

1.2   Cautions on Using E20

The functions used for debugging of the 78K0 device by using the E20 are the same as in the E1. Large trace function, characteristic functions of the E20, cannot be used. The power supply function from the E20 is not supported.

1.3   Configuration of Manuals

Documentation for the E1/E20 emulator manual is in two parts: the E1/E20 Emulator User's Manual and the E1/E20 Emulator Additional Document for User's Manual (this manual). Be sure to read both of the manuals before using the E1/E20 emulator.

(1) E1/E20 Emulator User's Manual

The E1/E20 Emulator User's Manual has the following contents:

- Components of the emulators

- Emulator hardware specification

- Connection to the emulator and the host computer and user system

(2) E1/E20 Emulator Additional Document for User's Manual

The E1/E20 Emulator Additional Document for User's Manual has the following contents:

- For use in hardware design, an example of connection and the interface circuit required to connect the emulator.

- Notes on using the emulator

Chapter 2 Designing the User System

To connect the E1/E20 emulator, a connector for the user system interface cable must be mounted on the user system.

When designing the user system, read this section of this manual and the hardware manual for the MCUs.
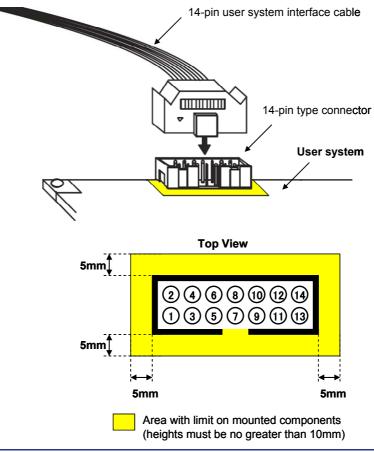
2.1 Connecting the Emulator with the User System

Table 2-1 shows the connector type numbers of the E1 emulators.

Table 2-1 Connector Type Numbers

	Type Number	Manufacturer	Specifications
14-pin Connector	7614-6002	Sumitomo 3M Limited	14-pin straight type (Japan)
	2514-6002	3M Limited	14-pin straight type (other countries)

Figure 2.1 shows examples of the connection between a user system interface cable of the 14-pin type. Do not mount other components with a height exceeding 10 mm within 5 mm of the connector on the user system. 38-pin of the E20 is not supported. To use the E20, use the 38-pin/14-pin conversion adapter [R0E000200CKA00] that comes with the E20 for connection.

Figure 2-1 Connecting the User System Interface Cable to the 14-pin Connector of the E1 Emulator

14-pin user system interface cable

14-pin type connector

User system

Top View

5mm

5mm

5mm

5mm

2 4 6 8 10 12 14
1 3 5 7 9 11 13

Area with limit on mounted components (heights must be no greater than 10mm)

2.2 Pin Assignment of the Connector on the User System

Table 2-2 shows the pin assignments of the 14-pin connectors.

Table 2-2   Pin assignments of the connector (14-pin)

Pin No.	Pin Name	Input/Output[Note 1]
1	R.F.U	–
2	GND[Note 2]	–
3	CLK	Output
4	FLMD0	Output
5	RxD	Input
6	RESET_IN	Input
7	TxD/DATA	Output/Input and Output
8	VDD	–
9	R.F.U	Output
10	RESET_OUT[Note 3]	Output
11	R.F.U	–
12	GND[Note 2]	–
13	RESET_OUT[Note 3]	Output
14	GND[Note 2]	–

Table 2-3   Pin Functions

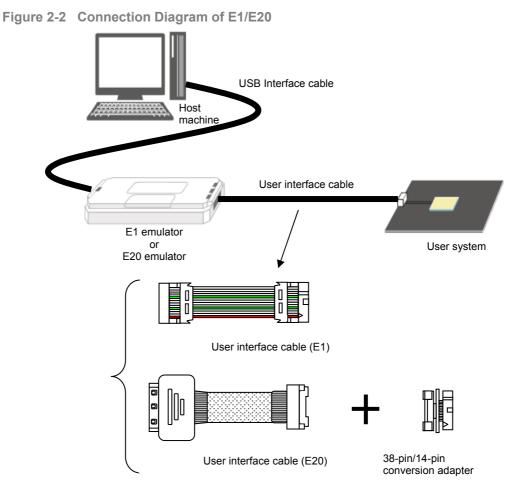| Pin Name	Input/Output[Note 1]	Description
RESET_IN	Input	Pin used to input reset signal from the user system
RESET_OUT	Output	Pin used to output reset signal to the target device
FLMD0	Output	Pin used to set the target device to debug mode or programming mode.
TOOL0	Output/Input	Pin used to transmit command/data to the target device
TOOL1	Input	Pin used to input clock signal to the target device
R.F.U.	–	This pin is reserved. For the connection of the reserved pins, see each circuit related to the pins.

Note 1   As seen from E1/E20
Note 2   Securely connect pins 2, 12, and 14 of the connector to GND of the user system. These pins are used for electrical grounding as well as for monitoring of connection with the user system by the E1/E20.
Note 3   Securely connect both pin 10 and pin 13. These pins are also used to monitor the user system.

2.3 System Configuration

Figure 2-2 shows the system configuration used for the E1/E20. For cautions on connection, refer to the E1/E20 User's Manual.

Figure 2-2   Connection Diagram of E1/E20

USB Interface cable

Host machine

User interface cable

E1 emulator or E20 emulator

User system

User interface cable (E1)

User interface cable (E20)

38-pin/14-pin conversion adapter

Remark   To use it with the E20, connect the 38-pin/14-pin conversion adapter to the user interface cable (E20). 38-pin is not supported.

2.4 Examples of Recommended Connection Circuits Between Emulator Connection Connector and MCU Recommend Circuit Connection

2.4.1 Cautions on creating recommended circuits and examples of circuit connection

The following are common cautions on creating recommended circuits.

- The circuits and resistance values listed are recommended but not guaranteed. Determine the circuit design and resistance values by taking into account the specifications of the target device and noise. For flash programming for mass production, perform sufficient evaluation about whether the specifications of the target device are satisfied.
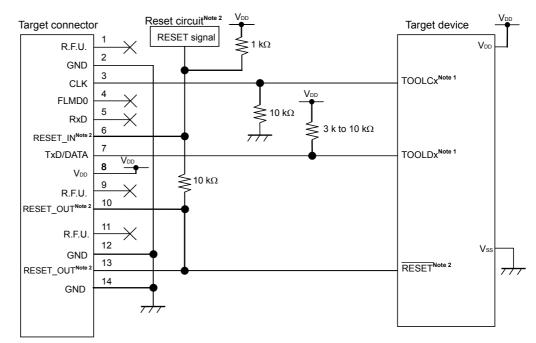
- For processing of pins not used by the E1/E20, refer to the user's manual of the device.

- Connect the TxD (transmission side) of the target device to the RxD (reception side) of the target connector. Connect the TxD (transmission side) of the target connector to the RxD (reception side) of the target device.

- Securely connect pins 2, 12, and 14 of the connection to GND of the user system. These pins are used for electrical grounding as well as for monitoring of connection with the user system by the E1/E20.

- Securely connect both pin 10 and pin 13. These pins are also used to monitor the user system.

- Pins for on-chip debugging and programming vary depending on the device. Refer to Table 2-4.

- In a circuit using the external oscillator, debugging with the debug pin connected to the external oscillator cannot be done.

- When using the pins used for debugging or serial programming in your circuit, use a jumper for isolation to avoid conflict of signals. For details, refer to **2.4.3 Cautions on connecting the user circuit to the RxD pin of the target device.**

Table 2-4   Supported Device and Interfaces

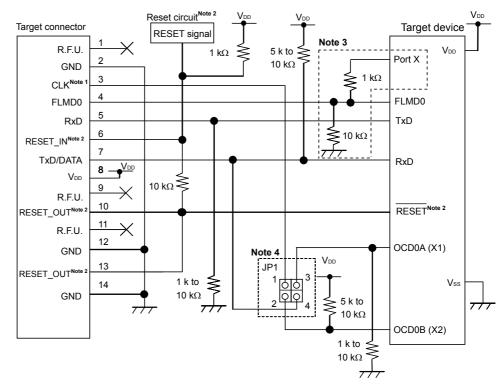| Supported Device	Programming Interface	Debug Interface	Circuit diagram
78K0/Kx2-L	TOOLCx, TOOLDx (x = 0, 1)		Figure 2-3
78K0/Ix2			
78K0/Fx2-L			
78K0/Kx2	TxD/RxD (UART)[Note 1]	OCDxA, OCDxB (x = 0, 1)	Figure 2-4 Figure 2-5 Figure 2-6 Figure 2-7
μPD78F8039 (μPD78F8017 to μPD78F8020, μPD78F8026 to μPD78F8039)			
78K0/Kx2-A			
78K0/Kx2-C			
78K0/Lx2			
78K0/Lx3			
78K0/Lx3-M			
78K0/Dx2			
78K0/Fx2			
μPD78F0730			

[Note 1]   Check the available channels in the user's manual of the target device (chapter on flash memory).

Figure 2-3   Using One Connector for Both Debugging and Programming (TOOLCx/TOOLDx Communication x = 0, 1)

Notes

1.   When the external clock is used, use the TOOLC1 and TOOLD1 pins for debugging.

2.   This connection is designed assuming that the RESET signal is output from the N-ch open-drain buffer (output resistance: 100 Ω or less). For details, refer to **2.4.2   Connection of reset pin**.

Figure 2-4   Using One Connector for Both Debugging and Programming (OCD0A, OCD0B Communication)

Notes

1. During on-chip debugging, the X1 oscillation circuit cannot be used as the operation clock of the target device.

2. This connection is designed assuming that the RESET signal is output from the N-ch open-drain buffer (output resistance: 100 Ω or less). For details, refer to **2.4.2 Connection of reset pin**.

3. The circuit enclosed by a dashed line is designed for flash self programming, which controls the FLMD0 pin via ports. (This circuit is used to control the port during flash programming.)

   Connect any port that can output data to FLMD0 via a resistor.

   When not using flash self programming, process the pins according to the device specifications.

4. Table 2-5 shows the JP1 setting.

Table 2-5 JP1 Setting

	JP1 Setting
On-chip debugging (1-3 short, 2-4 short)	1 ■■ 3 2 ■■ 4
Flash programming (1-2 short, 3-4 open)	1 ■○ 3 2 ■○ 4
E1/E20 not connected (all open)	1 ○○ 3 2 ○○ 4

2.4.2 Connection of reset pin

This section describes the connection of the reset pin, for which special attention must be paid, in circuit connection examples shown in the previous section.

During on-chip debugging, a reset signal from the target system is input to E1/E20, masked, and then output to the target device. Therefore, the reset signal connection varies depending on whether E1/E20 is connected.

For flash programming, the circuit must be designed so that the reset signals of the user system and E1/E20 do not conflict.

Select one of the following methods and connect the reset signal in the circuit. The details of each method are described on the following pages.
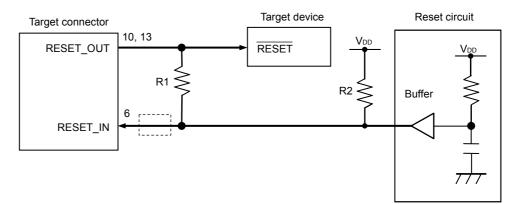
(1) Automatically switching the reset signal via series resistor (recommended; described in recommended circuit connection in the previous section)

(2) Manually switching the reset signal with jumper

(3) Resetting the target device by power-on reset (POC) only

(1) Automatically switching the reset signal via series resistor

Figure 2-4 illustrates the reset pin connection described in 2.5.1 Recommend Circuit Connection.

This connection is designed assuming that the reset circuit on the target system contains an N-ch open-drain buffer (output resistance: 100Ω or less). The V_{DD} or GND level may be unstable when the logic of RESET_IN/OUT of E1/E20 is inverted, so observe the conditions described below in **Remark**.
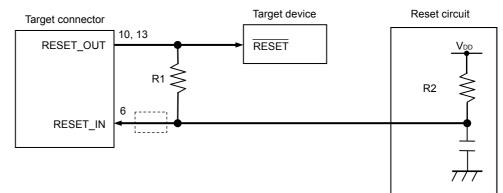
Figure 2-4   Circuit Connection with Reset Circuit That Contains Buffer

Remark   Make the resistance of R1 at least ten times that of R2, R1 being 10 kΩ or more. Pull-up resistor R2 is not required if the buffer of the reset circuit consists of CMOS output. The circuit enclosed by a dashed line is not required when only flash programming is performed.

Figure 2-5 illustrates the circuit connection for the case where the reset circuit on the target system contains no buffers and the reset signal is only generated via resistors or capacitors. Design the circuit, observing the conditions described below in **Remark**.
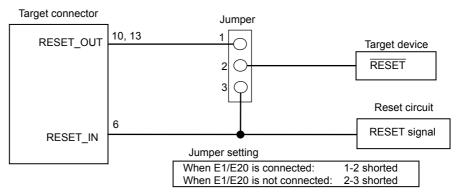
Figure 2-5　Circuit Connection with Reset Circuit That Contains No Buffers

Remark　Make the resistance of R1 at least ten times that of R2, R1 being 10 kΩ or more. The circuit enclosed by a dashed line is not required when only flash programming is performed.

(2)　Manually switching the reset signal with jumper

Figure 2-6 illustrates the circuit connection for the case where the reset signal is switched using the jumper, with or without E1/E20 connected. This connection is simple, but the jumper must be set manually.
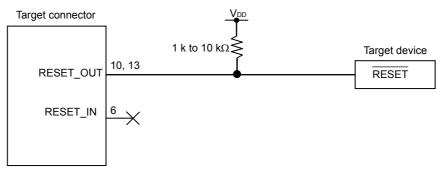
Figure 2-5　Circuit in connection for Switching Reset Signal with Jumper

Jumper setting	
When E1/E20 is connected:	1-2 shorted
When E1/E20 is not connected:	2-3 shorted

(3)　Resetting the target device by power-on reset (POR) only

Figure 2-7 illustrates the circuit connection for the case where the target device is only reset via POC without using the reset pin. RESET_OUT becomes active when power is applied to E1/E20. Even if power supply to the target system is turned off during debugging, pseudo POC function emulation is available because RESET_OUT becomes active.

Figure 2-6　Circuit Connection for the Case Where Target Device Is Only Reset via POC

Chapter 3 Specification

Specifications are shown in Table 3-1 below.

Table 3-1 E1/E20 Specification List

Large	Middle Item	Small Item	Specification	
			E1	E20
Hardware Common	Target host machine		Computer equipped with a USB port OS depends on the software.	←
	User system interface		14-pin connector	←
	Host machine interface		USB2.0 (Full speed/High speed)	←
	Connection to the user system		Connection by the provided user-system interface cable	←
	Power supply function		3.3 V or 5.0 V, set in software tool, can be supplied to the user system (with current up to 200 mA)	Cannot supply power.
	Power supply for the emulator		No need (the host computer supplies power through the USB)	←
Related debugging	Break	Software break	2000 points	←
		Hardware break	1 point (commonly used by execution and access)	←
		Forced break	Available	←
	Event	Number of events	1 point (commonly used by execution and access)	←
		Available function	Hardware break only	←
	Trace		Unavailable	←
	Performance measurement	Measurement item	From run to break	←
		Performance	Resolution 100 μs, Max. measurement time 100 hours	←
	Pseudo realtime RAM monitor (RRM)		Available (CPU is used when monitoring)	←
	Dynamic memory modification (DMM)		Available (CPU is used when changing)	←
	Hot plug-in		Unavailable	←
	Security		10-byte ID code authentication	←
Related programming	Clock supply		Clock mounted on the user system can be used	←
	Security flag setting		Available	←
	Standalone operation		Unavailable (must be connected to host machine)	←

Chapter 4 Notes on Usage

This section describes cautions on use of the E1/E20 emulator. To use the E1/E20 properly, read the cautions thoroughly.

4.1 List

Table 4-1 List of notes on usage

No.	Item
1	Handling the device used for debugging
2	Rewriting of the flash memory during debugging
3	Software brake
4	Self-programming
5	Boot swapping during self-programming
6	Emulation in the self-programming mode
7	Stack pointer initialization fail-safe function
8	Downloading a HEX file
9	Cautions on using step-in (step execution)
10	Cautions on using the pseudo real-time RAM monitor function
11	Emulation of the POC function
12	Devices with/without the on-chip debug function
13	Cautions on reading locations with a break or reserved areas
14	Operation after a reset

4.2 Details

No. 1 Handling of device that was used for debugging

Do not mount a device that was used for debugging on a mass-produced product. (Because the flash memory was rewritten during debugging and the number of rewrites of the flash memory cannot be guaranteed.) Do not embed the monitor program for debugging in a mass-produced product.

No. 2 Overwriting flash memory during on-chip debugging

If the following debugger operations <1> to <8> are performed on-chip, the flash memory in the device is overwritten.

If any of the following debugger operations <1> to <8>, which involve flash memory rewriting, is performed while flash memory cannot be rewritten, the debugger automatically changes the register setting so as to enable flash memory rewriting, and restores the register setting after the operation is completed. If any of the following operations <1> to <8> is performed while flash memory rewriting is disabled or operation is performed at a voltage at which flash memory cannot be rewritten, however, the debugger outputs an error and the operation is ignored.

<1>   Writing to internal flash memory

<2>   Program execution after specifying or canceling software breakpoints

<3>   Setop-over execution, Return Out execution

<4>   Come Here

<5> If Permit is selected in the Target Power off area in the Configuration dialog box, the following operations can not be performed

a) Specifying, changing, or canceling hardware breakpoints

b) (Un-)Masking internal resets

c) Switching peripheral breakpoints

d) Program execution

e) Software reset (a reset performed by the debugger)

<6> Adding, changing, or deleting the monitor address when using the pseudo real-time RAM monitor function

<7> Performing operations without using breakpoints when software breakpoints are specified

<8> When the debugger is started or terminated

It takes a while from the completion of flash memory programming until control is passed to the GUI.

No. 3 Software break

During program running, do not rewrite the data at the address where a software break is set. This includes self programming and rewriting to RAM. If performed, the instruction placed at the address may be invalid.

No. 4 Self Programming

If the space where the monitor program for debugging is rewritten by flash self programming, the debugger does not operate correctly. This also holds true when boot swapping is executed.

No. 5 Boot swapping during self programming

The boot swapping function cannot be emulated. This is because boot swapping moves the memory spaces used for debugging, and thus the debug communication can no longer be performed.

No. 6 Emulation in self programming mode

For self programming, the mode is switched from normal mode to self programming mode.

```
MOV PFCMD, #0A5H

MOV FLPMC, #1H        ← (1)

MOV FLPMC, #0FEH

MOV FLPMC, #1H

--------------------------------------------- From this position

CALL !08100H          ← (2)            ↑

MOV PFCMD, #0A5H

MOV FLPMC, #0H                     Mode A1

MOV FLPMC, #0FEH

MOV FLPMC, #0H                        ↓

--------------------------------------------- To this position
```

The section between (2) and (3) is in self programming mode A1. Step execution or debug operations, such as stopping program execution, cannot be performed in this section. In addition, do not set a software break in the section between (1) and (3); otherwise the execution continues without a break but emulation is not performed normally.

No. 7 Break function for stack pointer initialization failure

This function executes a break when an interrupt occurs or a PUSH instruction is executed while the initial setting has not been made for the stack pointer.

If the manipulation or instruction shown below is executed immediately after a reset operation, the break function for stack pointer initialization failure becomes invalied

- Setting a software break

- Write to the stack pointer from the Register window

- Write to the memory window, etc

If a software break occurs while the initial setting has not been made for stack pointer, the message "Uninitialized Stack Pointer" is displayed on the status bar.

The subsequent operations are not performed normally, so make sure to set the SP value in the user program.

No. 8 Caution on downloading a HEX file

When downloading a HEX file, do not set a filling value other than 0xFF for the option (-U) of the Renesas object converter.

No. 9 Cautions when stepping into code

The value of some SFRs (special function registers) might remain unchanged while stepping into code. If the value of the SFRs does not change while stepping into code, operate the microcontroller by continuously executing the instructions instead of executing them in steps.

Stepping into code: Instructions in the user-created program are executed one by one.

Continuous execution: The user-created program is executed from the current PC value.

No. 10 Operation at voltage with which flash memory cannot be written

<1> The user program is stopped while the pseudo real-time RAM monitor function processing is being performed

Example)

When 78K0/Kx2: $30 \times (n+1)$ [µs] per n bytes when operating at 20MHz

When 78K0/Kx2-L: $120 \times (n+1)$ [µs] per n bytes when operating at 20MHz

<2> If the pseudo real-time RAM monitor function is executed during a standby state, the standby state is released.

<3> If the clock signal switches to that generated by the internal low-speed oscillator or to the subsystem clock signal by the user-created program is stopped for about 200 clock cycles by pseudo real-time RAM monitoring.

<4> Pseudo real-time RAM monitoring updates RAM information in byte units. Therefore, even if information is displayed in word units in the debugger, there will be a difference of a few ms in updating the higher and lower byte data.

<5>   The pseudo real-time RAM monitor does not operate during execution of self-programming.

No. 11 Emulation of POC function

If power supply to the target system is turned off during debugging, the target device enters the reset state by the RESET_OUT pin of E1/E20. Consequently, the target device's POC function performs pseudo emulation. Note that there is an error of ±1 V between the POC detection voltage and the target system voltage. Note that the POC detection voltage might be 1 V higher than that of the target device.

No. 12 Device with/without on-chip debug function

Only the devices with the on-chip debug function can be debugged. See the user's manual of the target device for checking whether it is equipped with the on-chip debug function.

To debug a device without the on-chip debug function, perform debugging by using an upper-compatible product. The following shows an example when using the 78K0/KF2.

Target Device	On-Chip Debug Function	Device for Debugging
μPD78F0544	Not equipped	μPD78F0547D (Set the IMS and IXS registers to values according to the target device.)
μPD78F0545		
μPD78F0546		
μPD78F0547		

No. 13 Cautions when reading the location and the reserved area where SW/HW breaks are set

When the addresses where the software breaks are set are read, the data read from the addresses differ from the actual data. When the addresses where the hardware breaks are set are read, breaks occur.

When the addresses where are reserved for E1, the operations differ depending on the following usages by the software breaks.

- When software breaks are not used
  The data read from the addresses may differ from the actual data.

- When software breaks are used:
  The data read from the addresses may differ from the actual data, or breaks may occur.
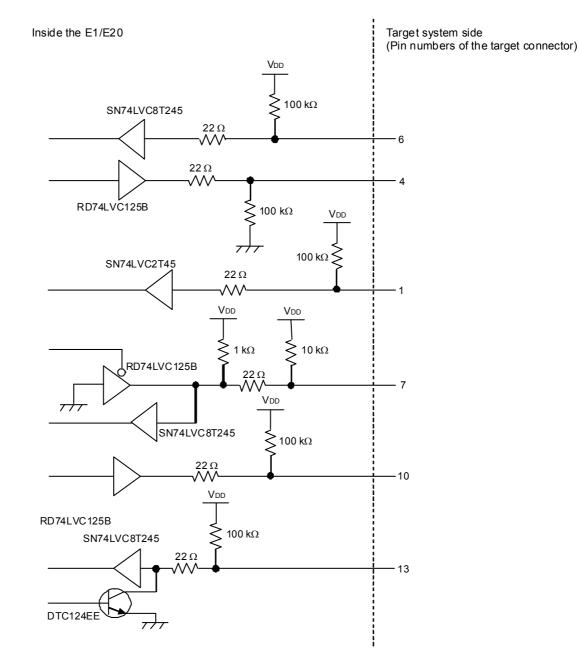
No. 14 Operation after a reset

After a reset of the external pin or an internal reset, the time from the occurrence of the reset to the execution of the user program is different from the actual device operation because the debugging monitor program performs initialization processing for debugging.

Appendix Equivalent Circuit for E1/E20-78K0R Connection

The internal equivalent circuit related to the communication interface between the E1/E20 and user system is shown below. An example of circuit connection for the user system is shown in this document. Please use it as a reference when determining parameters in board design.

Figure A-1 E1/E20 Equivalent Circuit

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E1 Emulator
Additional Document for User's Manual
(Notes on Connection for 78K0)

RENESAS

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