Introduction
This application note explains how to use UART communication through the serial interface (UARTA). ASCII characters transmitted from the device on the opposite side are analyzed to make responses.

Target Device
RL78/G23

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

1.1 Specification Outline

In this application note, UART communication is performed through the serial interface UARTA. ASCII characters transmitted from the device on the opposite side are analyzed to make responses.

Table 1.1 shows the peripheral function to be used and its use. Figure 1.1 and Figure 1.2 illustrate UART communication operation.

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>UARTA0</td>
<td>Perform UART communication using the TxD0 pin (transmission) and the RxD0 pin (reception).</td>
</tr>
</tbody>
</table>

Figure 1.1 UART Reception Timing Chart

- UTAEN: Permit supply of input clock to UARTA
- UARTAEN0: Permit start of UARTA0 communication
- RXEA0: Permit UARTA0 reception
- RXBA0: Receive data
- RxDA0 pin: ST, Receive data, P, SP
- Shift register: Reception & shift operation
- INTUR0: Reception completed

ST: Start bit
P: Parity bit
SP: Stop bit
Figure 1.2 UART Transmission Timing Chart

- Permit input clock supply to UARTA
- Permit start of UARTA0 communication
- Permit UARTA0 transmission
- TXEA0
- TXBA0
- Transmit data
- TxD0 pin: ST/ Transmit data P SP
- Shift register
- Shift operation
- INTUT0
- Transfer completed

ST: Start bit
P: Parity bit
SP: Stop bit
1.2 Operation Outline

This sample code transmits, to the device on the opposite side, the data corresponding to that received from the device. If an error occurs, it transmits to the device the data corresponding to the error. Table 1.2 and Table 1.3 show the correspondence between transmit data and receive data.

Table 1.2 Correspondence between Receive Data and Transmit Data

<table>
<thead>
<tr>
<th>Receive Data</th>
<th>Response (Transmit) Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>T (54H)</td>
<td>O (4FH), K (4BH), CR* (0DH), LF* (0AH)</td>
</tr>
<tr>
<td>t (74H)</td>
<td>o (6FH), k (6BH), CR* (0DH), LF* (0AH)</td>
</tr>
<tr>
<td>Other than above</td>
<td>U (55H), C (43H), CR* (0DH), LF* (0AH)</td>
</tr>
</tbody>
</table>

Table 1.3 Correspondence between Error and Transmit Data

<table>
<thead>
<tr>
<th>Error</th>
<th>Response (Transmit) Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parity error</td>
<td>P (50H), E (45H), CR* (0DH), LF* (0AH)</td>
</tr>
<tr>
<td>Framing error</td>
<td>F (46H), E (45H), CR* (0DH), LF* (0AH)</td>
</tr>
<tr>
<td>Overrun error</td>
<td>O (4FH), E (45H), CR* (0DH), LF* (0AH)</td>
</tr>
</tbody>
</table>

(1) Perform initial setting of UART.

UART Setting Conditions:

- Use UARTA channels 0.
- Use the P72/TxDA0 pin and the P71/RxDA0 pin for data output and data input, respectively.
- The data length is 8 bits.
- Set the data transfer direction to LSB first.
- Use even parity as the parity setting.
- Set the receive data level to standard.
- Set the transfer rate to 9600 bps.
- Use reception end interrupt (INTUR0), transmission end interrupt (INTUT0), and error interrupt (INTURE0).
- Set the interrupt priority orders of INTUR0, INTUT0, and INTURE0 to low priority.

(2) After the system is made to enter a UART communication wait state by using the serial channel start register, a HALT instruction is executed. Processing is performed in response to reception end interrupt (INTUR0) and error interrupt (INTURE0).

- When an INTUR0 occurs, the received data is taken in and the data corresponding to the received data is transmitted. When an INTURE0 occurs, error handling is performed to transmit the data corresponding to the error.
- After data transmission, a HALT instruction is executed again to wait for reception end interrupt (INTUR0) and error interrupt (INTURE0).
2. Operation Check Conditions

The sample code contained in this application note has been checked under the conditions listed in the table below.

Table 2.1 Operation Check Conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU used</td>
<td>RL78/G23 (R7F100GLG)</td>
</tr>
<tr>
<td>Board used</td>
<td>RL78/G23 Fast Prototyping Board (RTK7RLG230CLG000BJ)</td>
</tr>
<tr>
<td>Operating frequency</td>
<td>High-speed on-chip oscillator clock: 32 MHz</td>
</tr>
<tr>
<td></td>
<td>CPU/peripheral hardware clock: 32 MHz</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>3.3 V (can be operated at 1.8 V to 5.5 V)</td>
</tr>
<tr>
<td></td>
<td>LVD0 detection voltage: Reset mode</td>
</tr>
<tr>
<td></td>
<td>At rising edge TYP. 1.90 V (1.84 V to 1.95 V)</td>
</tr>
<tr>
<td></td>
<td>At falling edge TYP. 1.86 V (1.80 V to 1.91 V)</td>
</tr>
<tr>
<td>Integrated development environment (CS+)</td>
<td>CS+ V8.05.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>C compiler (CS+)</td>
<td>CC-RL V1.10.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Integrated development environment (e2studio)</td>
<td>e2 studio V2021-04 (21.4.0) from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>C compiler (e2studio)</td>
<td>CC-RL V1.10.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Integrated development environment (IAR)</td>
<td>IAR Embedded Workbench for Renesas RL78 V4.21.1 from IAR Systems Corp.</td>
</tr>
<tr>
<td>C compiler (IAR)</td>
<td>IAR C/C++ Compiler for Renesas RL78 V4.21.1 from IAR Systems Corp.</td>
</tr>
<tr>
<td>Smart configurator (SC)</td>
<td>V1.0.1 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Board support package (BSP)</td>
<td>V1.00 from Renesas Electronics Corp.</td>
</tr>
</tbody>
</table>
3. Hardware

3.1 Hardware Configuration Example

Figure 3.1 shows an example of hardware configuration that is used for this application note.

Figure 3.1 Hardware Configuration

Caution: 1. The purpose of this circuit is only to provide the connection outline and the circuit is simplified accordingly. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met (connect the input-only ports separately to \( V_{DD} \) or \( V_{SS} \) via a resistor).
2. Connect any pins whose name begins with \( EV_{SS} \) to \( V_{SS} \) and any pins whose name begins with \( EV_{DD} \) to \( V_{DD} \), respectively.
3. \( V_{DD} \) must be held at not lower than the reset release voltage \( (V_{LVD}) \) that is specified as LVD.

3.2 List of Pins to be Used

Table 3.1 lists the pins to be used and their function.

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P72/TS04/KR2/SQ21/TxDA0</td>
<td>Output</td>
<td>Data transmission pin</td>
</tr>
<tr>
<td>P71/TS03/KR1/SQ21/SDA21/RxDA0</td>
<td>Input</td>
<td>Data reception pin</td>
</tr>
</tbody>
</table>

Caution: In this application note, only the used pin is properly connected. When designing and implementing an actual circuit, provide proper pin treatment and make sure that the hardware's electrical specifications are met.
4. Software

4.1 List of Option Byte Settings
Table 4.1 summarizes the settings of the option bytes.

Table 4.1 Option Byte Settings

<table>
<thead>
<tr>
<th>Address</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>000C0H / 010C0H</td>
<td>01101110B</td>
<td>Disables the watchdog timer. (Stops counting after the release from the reset state.)</td>
</tr>
</tbody>
</table>
| 000C1H / 010C1H | 11111110B | LVD operation (VLVD): Reset mode  
At rising edge TYP. 1.90 V (1.84 V to 1.95 V)  
At falling edge TYP. 1.86 V (1.80 V to 1.91 V) |
| 000C2H / 010C2H | 11101000B | HS mode,  
High-speed on-chip oscillator (HOCO) clock: 32 MHz |
| 000C3H / 010C3H | 10000100B | Enables the on-chip debugger. |

4.2 List of Constants
Table 4.2 lists the constants that are used in this sample program.

Table 4.2 Constants for the Sample Program

<table>
<thead>
<tr>
<th>Constant</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>g_messageOK[4]</td>
<td>&quot;OK\r\n&quot;</td>
<td>Response message to reception of &quot;T&quot;.</td>
</tr>
<tr>
<td>g_messageok[4]</td>
<td>&quot;ok\r\n&quot;</td>
<td>Response message to reception of &quot;t&quot;.</td>
</tr>
<tr>
<td>g_messageUC[4]</td>
<td>&quot;UC\r\n&quot;</td>
<td>Response message to reception of characters other than &quot;T&quot; or &quot;t&quot;.</td>
</tr>
<tr>
<td>g_messageFE[4]</td>
<td>&quot;FE\r\n&quot;</td>
<td>Response message to a framing error.</td>
</tr>
<tr>
<td>g_messagePE[4]</td>
<td>&quot;PE\r\n&quot;</td>
<td>Response message to a parity error.</td>
</tr>
<tr>
<td>g_messageOE[4]</td>
<td>&quot;OE\r\n&quot;</td>
<td>Response message to an overrun error.</td>
</tr>
</tbody>
</table>
### 4.3 List of Variables

Table 4.3 lists the global variable that is used by this sample program.

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Name</th>
<th>Contents</th>
<th>Function Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uint8_t</td>
<td>g_uarta0_rx_buffer</td>
<td>Receive data buffer</td>
<td>main()</td>
</tr>
<tr>
<td>Uint8_t</td>
<td>gp_uarta0_tx_address</td>
<td>Transmit data pointer</td>
<td>R_Config_UARTA0_Send(), r_Config_UARTA0_interrupt_send()</td>
</tr>
<tr>
<td>Uint16_t</td>
<td>g_uarta0_tx_count</td>
<td>Transmit data number counter</td>
<td>R_Config_UARTA0_Send(), r_Config_UARTA0_interrupt_send()</td>
</tr>
<tr>
<td>Uint8_t</td>
<td>gp_uarta0_rx_address</td>
<td>Receive data pointer</td>
<td>R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()</td>
</tr>
<tr>
<td>Uint16_t</td>
<td>g_uarta0_rx_num</td>
<td>Receive data number counter</td>
<td>R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()</td>
</tr>
<tr>
<td>Uint16_t</td>
<td>g_uarta0_rx_total_num</td>
<td>Receive data number</td>
<td>R_Config_UARTA0_Receive(), r_Config_UARTA0_interrupt_receive()</td>
</tr>
<tr>
<td>MD_STATUS</td>
<td>g_uarta0_tx_end</td>
<td>Transmit status</td>
<td>main(), r_Config_UARTA0_callback_sendend()</td>
</tr>
<tr>
<td>uint8_t</td>
<td>g_uarta0_rx_error</td>
<td>Receive error status</td>
<td>main(), r_Config_UARTA0_callback_receiveend(), r_Config_UARTA0_callback_error()</td>
</tr>
</tbody>
</table>

### 4.4 List of Functions

Table 4.4 lists the functions that are used in this sample program.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_Config_UARTA0_Start()</td>
<td>UARTA0 operation start</td>
</tr>
<tr>
<td>R_Config_UARTA0_Receive()</td>
<td>UARTA0 reception status initialization function</td>
</tr>
<tr>
<td>R_Config_UARTA0_Send()</td>
<td>UARTA0 data transmission function</td>
</tr>
<tr>
<td>r_Config_UARTA0_interrupt_receive()</td>
<td>UARTA0 reception end interrupt handling</td>
</tr>
<tr>
<td>r_Config_UARTA0_callback_receiveend()</td>
<td>UARTA0 receive data classification function</td>
</tr>
<tr>
<td>r_Config_UARTA0_interrupt_error()</td>
<td>UARTA0 error interrupt handling</td>
</tr>
<tr>
<td>r_Config_UARTA0_callback_error()</td>
<td>UARTA0 reception error classification function</td>
</tr>
<tr>
<td>r_Config_UARTA0_interrupt_send()</td>
<td>UARTA0 transmission end interrupt handling</td>
</tr>
<tr>
<td>r_Config_UARTA0_callback_sendend()</td>
<td>UARTA0 transmission end processing function</td>
</tr>
</tbody>
</table>
4.5 Function Specifications

This section describes the specifications for the functions that are used in this sample program.

**[Function Name] R_UARTA0_Start()**

**Synopsis**
UARTA0 operation start

**Header**
r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h

**Declaration**
void R_Config_UARTA0_Start(void)

**Explanation**
Starts operation of channel 0 of serial array interface UARTA0 to make the system enter a communication wait state.

**Arguments**
- None

**Return value**
- None

**[Function Name] R_Config_UARTA0_Recieve()**

**Synopsis**
UARTA0 reception status initialization function

**Header**
r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h

**Declaration**
MD_STATUS R_Config_UARTA0_Receive (uint8_t * const rx_buf, uint16_t rx_num)

**Explanation**
Makes initial setting for UARTA0 reception.

**Arguments**
- uint8_t * const rx_buf: [Receive data buffer address]
- uint16_t rx_num: [Receive data buffer size]

**Return value**
- [MD_OK]: Reception setting is completed
- [MD_ARGERROR]: Reception setting failed

**[Function Name] R_Config_UARTA0_Send()**

**Synopsis**
UARTA0 data transmission function

**Header**
r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h

**Declaration**
MD_STATUS R_Config_UARTA0_Send (uint8_t * const tx_buf, uint16_t tx_num)

**Explanation**
Makes initial setting for UARTA0 transmission, and starts data transmission.

**Arguments**
- uint8_t * const tx_buf: [Transmit data buffer address]
- uint16_t tx_num: [Transmit data buffer size]

**Return value**
- [MD_OK]: Transmission setting is completed
- [MD_ARGERROR]: Transmission setting failed

**[Function Name] r_Config_UARTA0_interrupt_receive()**

**Synopsis**
UART0 reception end interrupt function

**Header**
r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h

**Declaration**
static void __near r_Config_UARTA0_interrupt_receive (void)

**Explanation**
Makes a response (data transmission) corresponding to received data.

**Arguments**
- None

**Return value**
- None
[Function Name] r_Config_UARTA0_callback_receiveend()

Synopsis | UART A0 reception error flag clear function
Header | r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h
Declaration | static void r_Config_UARTA0_callback_receiveend (void)
Explanation | Clear UART A0 reception error flag.
Arguments | • None
Return value | • None

[Function Name] r_Config_UARTA0_interrupt_error

Synopsis | UART error interrupt function
Header | r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h
Declaration | static void __near r_Config_UARTA0_interrupt_error (void)
Explanation | Save the received error content as err_type.
Arguments | • None
Return value | • None

[Function Name] r_uart0_callback_error()

Synopsis | UART A0 reception error classification function
Header | r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h
Declaration | static void r_Config_UARTA0_callback_error (uint32_t err_type)
Explanation | Save the determined error in g_uart0_rx_error.
Arguments | uint32_t err_type: Error type
Return value | • None
Remarks | Called from r_Config_UARTA0_interrupt_error function

[Function Name] r_Config_UARTA0_interrupt_send()

Synopsis | UART A0 transmission end interrupt function
Header | r_cg_macrodriver.h, Config_UARTA0.h, r_cg_userdefine.h
Declaration | static void __near r_Config_UARTA0_interrupt_send (void)
Explanation | Transmits a specified number of pieces of data.
Arguments | • None
Return value | • None

[Function Name] r_Config_UARTA0_callback_sendend()

Synopsis | UART A0 transmission end processing function
Header | r_cg_macrodriver.h, r_cg_serial.h, r_cg_userdefine.h
Declaration | static void r_uart0_callback_sendend(void)
Explanation | Set the transmission completion flag.
Arguments | • None
Return value | • None
4.6 Flowcharts

4.6.1 Main Function

Figure 4.1, Figure 4.2 and Figure 4.3 show the flowchart for the main function.

Figure 4.1 Main Function (1/3)

```
main()

main initializes settings
R_MAIN_UserInit()

UARTA0 operation start function
R_Config_UARTA0_Start()

Move to HALT mode

IE ← 0
Specify the UARTA0 receive
buffer and the number of
pieces of data (1)

UARTA0 reception status
initialization function
R_Config_UARTA0_Receive()

Reception error detected?

NO

YES

Framing error?

NO

YES

UARTA0 data transmission
function
R_Config_UARTA0_Send()

Transmission completed?

NO

YES

URMK0 bit ← 1
UREMK0 bit ← 1
```

3

4
Figure 4.2 Main Function (2/3)

3

Parity error?

YES

UARTA0 data transmission function
R_Config_UARTA0_Send()

NO

Transmission completed?

YES

Over run error?

NO

YES

UARTA0 data transmission function
R_Config_UARTA0_Send()

Transmission completed?

NO

YES
Figure 4.3 Main Function (3/3)

What is the receive data?

- UARTA0 data transmission function
  \texttt{R\_Config\_UARTA0\_Send()}
  Argument: “OK”

- UARTA0 data transmission function
  \texttt{R\_Config\_UARTA0\_Send()}
  Argument: “ok”

- UARTA0 data transmission function
  \texttt{R\_Config\_UARTA0\_Send()}
  Argument: “UC”

Transmission completed?

NO

- Enable reception interrupt
- \texttt{URMK0 \leftarrow 0}
- \texttt{UREMK0\_bit \leftarrow 0}

YES

- UARTA0 reception status initialization function
  \texttt{R\_Config\_UARTA0\_Receive()}

Other than “T” and “t”

5. Sample Code
Sample code can be downloaded from the Renesas Electronics website.

6. Reference Documents
   RL78/G23 User's Manual: Hardware (R01UH0896)
   RL78 family User's Manual: Software (R01US0015)
   (The latest version can be downloaded from the Renesas Electronics website.)

Technical Update/Technical News
   (The latest version can be downloaded from the Renesas Electronics website.)

Website and Support
Renesas Electronics Website
   http://www.renesas.com/
Inquiries
   http://www.renesas.com/contact/
## Revision History

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
<th>Page</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Apr.13.21</td>
<td>—</td>
<td>—</td>
<td>First Edition</td>
</tr>
<tr>
<td>1.01</td>
<td>May.19.21</td>
<td>—</td>
<td>—</td>
<td>IDE. Revision Update</td>
</tr>
<tr>
<td>1.02</td>
<td>June.2.21</td>
<td>—</td>
<td>—</td>
<td>Correction of transmission end process</td>
</tr>
</tbody>
</table>
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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