Introduction
This application note describes how to use the VBAT pin (battery backup power) of RL78/G23. While power is supplied from VDD, clock time is displayed on the LCD using fixed-cycle interrupts of the realtime clock. If power is not supplied from VDD and is supplied from the VBAT pin, clock time is not displayed on the LCD though the realtime clock continues operating.

The voltage detector (LVD0) can determine whether power is supplied from VDD.

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. Specification

1.1 Overview of Specification

While power is supplied from VDD, clock time is displayed on the LCD using fixed-cycle interrupts of the realtime clock. If power is not supplied from VDD and is supplied from the VBAT pin, clock time is not displayed on the LCD though the realtime clock continues operating.

The voltage detection circuit (LVD0) can determine whether power is supplied from VDD.

Table 1-1 lists peripheral functions to be used and Figure 1-1 Overview of VBAT Operations shows the overview of VBAT operation.

<table>
<thead>
<tr>
<th>Peripheral Function</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realtime clock</td>
<td>Used to generate realtime clock (RTC) interrupts (INTRTC).</td>
</tr>
<tr>
<td>Serial interface IICA0</td>
<td>IIC communication with the LCD module Clock time is displayed in the fixed-cycle interrupt processing. Clock time is not displayed while power is supplied from the VBAT pin.</td>
</tr>
<tr>
<td>Voltage detector LVD0</td>
<td>Supply voltage (VDD) monitoring. An interrupt is generated when the power supply source changes to the VBAT pin.</td>
</tr>
</tbody>
</table>

Figure 1-1 Overview of VBAT Operation
1.1.1 Overview of the VBAT Pin

The main purpose of the VBAT pin is to maintain continuous operation of the real-time clock (RTC). If a backup battery is connected to the VBAT pin and power supply to the VDD pin is lost, power can be supplied from the VBAT pin.

The VBAT pin supplies power to the VDD pin via an internal diode. The internal diode of the VBAT pin is always connected to the VDD pin. To prevent backflow to a power circuit or another circuit that is connected to the VDD pin via a diode from the VBAT pin, connect external backflow-preventing diodes to the VDD, EVDD0, and EVDD1 pins.

The valid range of input voltage to the VBAT pin is 2.7 to 5.5 V. While power is being supplied from the VBAT pin, if the input voltage to the VBAT pin becomes less than 2.7 V, a POR reset might occur due to voltage drop of the diode.

The maximum current that the VBAT pin can supply is 150 µA. Therefore, while power is being supplied from the VBAT pin, the main system clock and peripheral functions (other than the RTC) must not operate. Make sure that no current flows to ports. Also, make sure that a reset does not occur while power is being supplied from the VBAT pin. This is because the current exceeds the maximum (150 µA) when the main system clock starts operating when reset is canceled.
1.2 Outline of Operation

While power is supplied from VDD, clock time is displayed on the LCD using fixed-cycle interrupts of the realtime clock. If power is not supplied from VDD and is supplied from the VBAT pin, clock time is not displayed on the LCD though the realtime clock continues operating.

The voltage detector (LVD0) is used to determine whether power is supplied from VDD. Monitoring the clock time on the LCD makes it possible to confirm that the realtime clock is continuously operating even during the VDD power-off period.

In this application note, the interrupt processing is performed as follows:
- Clock time is displayed on the LCD in the fixed-cycle interrupt processing.
- Fixed-cycle interrupts are enabled or disabled in the voltage detection interrupt processing.

Table 1-2 shows LCD display layout (Y: year, M: month, D: day, h: hour, m: minute, s: second). Slash (/) and colon (:) are output as they are. Blank space represents blank (white space).

<table>
<thead>
<tr>
<th>Top</th>
<th>Y</th>
<th>Y</th>
<th>/</th>
<th>M</th>
<th>M</th>
<th>/</th>
<th>D</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>h</td>
<td>h</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>s</td>
</tr>
</tbody>
</table>

The following describes main settings for peripheral functions.

(1) Initial settings for VBAT
- Set the OSCSEL bit in the CMC register to 1 to enable X1 oscillation mode. Clear the MSTOP bit in the CSC register to 0 to activate the X1 oscillation circuit. These settings prevent penetration current from flowing through the VBAT pin.

(2) Initial settings for the serial interface IICA
- Use IICA0 (P60 set to SCLA0 and P61 set to SDAA0).
- Select fCLK/2 at the IICA0 operation clock.
- Set the local address to 0x10.
- Set the standard mode as the operation mode.
- Set the transfer clock to 80000 bps.
- Enable INTIICA0 interrupt.
(4) Initial settings for the LCD module
- Set to 8 bits bus mode, 2-line display, and font type 5x8 dots.
- Make settings to enable display indication, disable cursor display, and disable cursor blinking.
- Set the cursor shift direction to right.

(5) Initial settings for the real-time clock (RTC)
- Select the frTC128HZ at the RTC operation clock.
- Present the time in 24-hour system.
- Disable the RTC1HZ pin output.
- Initialize the current date and time to 2000/1/1 (Fri) 00:00:00
- Enable fixed-cycle interrupt and set their cycle time to 1.0 second.
- Enable INTRTC interrupts.
- Set INTRTC interrupts priority level 2.
2. Operation Confirmation Conditions

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

Table 2-1 Operation Confirmation Conditions

<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/G23-64p Fast Prototyping Board (RTK7RLG230CLG000BJ)</td>
</tr>
<tr>
<td>Operating frequency</td>
<td>• High-speed on-chip oscillator clock (f_{hi}): 32 MHz</td>
</tr>
<tr>
<td></td>
<td>• Subsystem clock (XT1clock (f_{XT})): 32.768 kHz</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>During VDD operation: 5.0V</td>
</tr>
<tr>
<td></td>
<td>During VBAT operation: 3.0 V</td>
</tr>
<tr>
<td></td>
<td>LVD0 detection voltage: Interrupt mode</td>
</tr>
<tr>
<td></td>
<td>At rising edge TYP. 3.96 V (3.84 V to 4.08 V)</td>
</tr>
<tr>
<td></td>
<td>At falling edge TYP. 3.88 V (3.76 V to 4.00 V)</td>
</tr>
<tr>
<td>Integrated development environment</td>
<td>CS+ for CC V8.07.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>(CS+)</td>
<td></td>
</tr>
<tr>
<td>C compiler (CS+)</td>
<td>CC-RL V1.11.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Integrated development environment</td>
<td>e2studio V2022-04 (22.4.0) from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>(e2studio)</td>
<td></td>
</tr>
<tr>
<td>C compiler (e2studio)</td>
<td>CC-RL V1.11.00 from Renesas Electronics Corp.</td>
</tr>
<tr>
<td>Integrated development environment</td>
<td>IAR Embedded Workbench for Renesas RL78 V4.21.2 from IAR Systems Corp.</td>
</tr>
<tr>
<td>(IAR)</td>
<td></td>
</tr>
<tr>
<td>C compiler (IAR)</td>
<td>IAR C/C++ Compiler for Renesas RL78 V4.21.2.2420 from IAR Systems Corp.</td>
</tr>
<tr>
<td>LCD module</td>
<td>ACM1602NI-FLW-FBW-M01</td>
</tr>
</tbody>
</table>
3. Hardware Descriptions

3.1 Example of Hardware Configuration

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

![Figure 3-1 Hardware Configuration](image)

Note 1. This schematic circuit diagram is simplified to show the outline of connections. When creating circuits, design them so that they meet electrical characteristics by properly performing pin processing. (Connect input-only ports to VDD or VSS individually through a resistor.)

Note 2. Connect pins (with a name beginning with EVSS), if any, to VSS, and connect pins (with a name beginning with EVDD), if any, to VDD.

Note 3. Supply a voltage not less than 2.7 V to the power source for battery backup.

3.2 List of Pins to be Used

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

<table>
<thead>
<tr>
<th>Pin name</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P121 / X1 / VBAT</td>
<td>—</td>
<td>Power supply pin for battery backup</td>
</tr>
<tr>
<td>P60 / SCLA0, P61 / SDAA0</td>
<td>Input / Output</td>
<td>IIC communication with LCD module</td>
</tr>
</tbody>
</table>

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

4.1 Changing the Settings of the Custom Board Support Package (BSP)

In the sample program, the P121, X1, VBAT, and EI121 pins are set in X1 oscillation mode. To specify this setting, add an instruction to the mcu_clocks.c file (the instruction indicated in red in the following section):

```
Line 646: /* Clock operation mode control register(CMC) setting */
Line 647:    cmc_tmp |= 0x40U;
Line 648:    CMC = cmc_tmp;
```

4.2 Setting of Option Byte

Table 4-1 shows the option byte settings.

Table 4-1 Option Byte Settings

<table>
<thead>
<tr>
<th>Address</th>
<th>Setting Value</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>000C0H / 040C0H</td>
<td>11101111B</td>
<td>Disables the watchdog timer. (Counting stopped after reset)</td>
</tr>
<tr>
<td>000C1H / 040C1H</td>
<td>10111010B</td>
<td>LVD0 detection voltage: Interrupt mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At rising edge TYP. 3.96 V (3.84 V to 4.08 V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At falling edge TYP. 3.88 V (3.76 V to 4.00 V)</td>
</tr>
<tr>
<td>000C2H / 040C2H</td>
<td>11101000B</td>
<td>HS mode, High-speed on-chip oscillator clock (f_in): 32 MHz</td>
</tr>
<tr>
<td>000C3H / 040C3H</td>
<td>10000100B</td>
<td>Enables on-chip debugging</td>
</tr>
</tbody>
</table>
### 4.3 List of Constants

Table 4-2 Constants (1/2) and Table 4-3 Constants (2/2) lists the constants that are used in the sample code.

#### Table 4-2 Constants (1/2)

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>_0xA0_LCM_SLAVE_ADDR</td>
<td>0xA0</td>
<td>Slave address for LCM commands</td>
</tr>
<tr>
<td>_0x00_LCM_SLAVE_ADDR_RW_LOW</td>
<td>0x00</td>
<td>Data write flag</td>
</tr>
<tr>
<td>_0x00_LCM_CONTROL_BYTE</td>
<td>0x00</td>
<td>Control byte for LCM commands</td>
</tr>
<tr>
<td>_0x80_LCM_CONTROL_BYTE_RS_HIGH</td>
<td>0x80</td>
<td>Control byte: Data transfer</td>
</tr>
<tr>
<td>_0x00_LCM_CONTROL_BYTE_RS_LOW</td>
<td>0x00</td>
<td>Control byte: Command transfer</td>
</tr>
<tr>
<td>_0x00_LCM_COMMAND_CLEAR_DISPLAY</td>
<td>0x00</td>
<td>Command: Clear Display</td>
</tr>
<tr>
<td>_0x04_LCM_COMMAND_ENTRY_MODE_SET</td>
<td>0x04</td>
<td>Command: Entry Mode Set</td>
</tr>
<tr>
<td>_0x02_LCM_COMMAND_ENTRY_MODE_SET_ID_HIGH</td>
<td>0x02</td>
<td>Entry Mode Set: Address increment</td>
</tr>
<tr>
<td>_0x00_LCM_COMMAND_ENTRY_MODE_SET_S_LOW</td>
<td>0x00</td>
<td>Entry Mode Set: Display shift OFF</td>
</tr>
<tr>
<td>_0x08_LCM_COMMAND_DISPLAY_ONOFF</td>
<td>0x08</td>
<td>Command: Display ON/OFF Control</td>
</tr>
<tr>
<td>_0x04_LCM_COMMAND_DISPLAY_ONOFF_D_HIGH</td>
<td>0x04</td>
<td>Display ON/OFF control: Display ON</td>
</tr>
<tr>
<td>_0x00_LCM_COMMAND_DISPLAY_ONOFF_C_LOW</td>
<td>0x00</td>
<td>Display ON/OFF control: Cursor display OFF</td>
</tr>
<tr>
<td>_0x00_LCM_COMMAND_DISPLAY_ONOFF_B_LOW</td>
<td>0x00</td>
<td>Display ON/OFF control: Cursor blinking OFF</td>
</tr>
<tr>
<td>_0x20_LCM_COMMAND_FUNCTION_SET</td>
<td>0x20</td>
<td>Command: Function Set</td>
</tr>
<tr>
<td>_0x10_LCM_COMMAND_FUNCTION_SET_DL_HIGH</td>
<td>0x10</td>
<td>Function Set: Mpu 8-bit bus mode</td>
</tr>
<tr>
<td>_0x08_LCM_COMMAND_FUNCTION_SET_N_HIGH</td>
<td>0x08</td>
<td>Function Set: 2-line display</td>
</tr>
<tr>
<td>_0x00_LCM_COMMAND_FUNCTION_SET_F_LOW</td>
<td>0x00</td>
<td>Function Set: 5x8-dot font</td>
</tr>
<tr>
<td>_0x80_LCM_COMMAND_SET_DDRAM_ADDR_ESS</td>
<td>0x80</td>
<td>Command: Set DDRAM Address</td>
</tr>
</tbody>
</table>
Table 4-3 Constants (2/2)

<table>
<thead>
<tr>
<th>Constant Name</th>
<th>Setting Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCM_COMMAND_EXEC_WAIT</td>
<td>26600</td>
<td>LCD module command execution wait time 5 ms (32 MHz operation)</td>
</tr>
<tr>
<td>LCM_CONFIG_FUNCTION_SET_PARAMS</td>
<td>0x18</td>
<td>Parameters for function set _0x10_LCM_COMMAND_FUNCTION_SET_DL_HIGH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>_0x08_LCM_COMMAND_FUNCTION_SET_N_HIGH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>_0x00_LCM_COMMAND_FUNCTION_SET_F_LOW</td>
</tr>
<tr>
<td>LCM_CONFIG_ENTRY_MODE_SET_PARAMS</td>
<td>0x20</td>
<td>Parameters for entry mode set _0x02_LCM_COMMAND_ENTRY_MODE_S_ET_ID_HIGH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>_0x00_LCM_COMMAND_ENTRY_MODE_S_ET_S_LOW</td>
</tr>
<tr>
<td>LCM_CONFIG_DISPLAY_ONOFF_PARAMS</td>
<td>0x40</td>
<td>Display ON/OFF control command parameters _0x04_LCM_COMMAND_DISPLAY_ONOFF_D_HIGH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>_0x00_LCM_COMMAND_DISPLAY_ONOFF_C_LOW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>_0x00_LCM_COMMAND_DISPLAY_ONOFF_B_LOW</td>
</tr>
<tr>
<td>LCM_CONFIG_MAX_CHAR_PER_LINE</td>
<td>16</td>
<td>Maximum number of characters per line</td>
</tr>
<tr>
<td>LCM_CONFIG_WAIT_COUNT</td>
<td>13</td>
<td>IIIA0 wait count</td>
</tr>
<tr>
<td>LCM_POSITION_TOP</td>
<td>0x00</td>
<td>LCD module display line (top)</td>
</tr>
<tr>
<td>LCM_POSITION_BOTTOM</td>
<td>0x40</td>
<td>LCD module display line (bottom)</td>
</tr>
<tr>
<td>_01_VDD_DOWN</td>
<td>1</td>
<td>LVD0 (falling) generation flag value</td>
</tr>
<tr>
<td>_00_VDD_NOT_DOWN</td>
<td>0</td>
<td>LVD0 (falling) generation flag value not generated</td>
</tr>
</tbody>
</table>

4.4 List of Variables

Table 4-4 lists global variables.

Table 4-4 Global Variables

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable Name</th>
<th>Description</th>
<th>Function Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>int</td>
<td>g_vdd_down</td>
<td>LVD0 (falling) generation flag</td>
<td>r_set_vdd_down_flag</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r_is_vdd_down_flag</td>
</tr>
<tr>
<td>uint8_t</td>
<td>g_LCM_is_sendend</td>
<td>I2C communication (with LCD module) end flag</td>
<td>r_LCM_init</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r_LCM_turn_sendend_on</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r_LCM_wait_sendend</td>
</tr>
</tbody>
</table>
4.5 List of Functions

Table 4-5 shows a list of functions.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>r_main_user_init()</td>
<td>Main initial settings</td>
</tr>
<tr>
<td>BCD_to_str()</td>
<td>BCD value-to-character string conversion processing</td>
</tr>
<tr>
<td>r_is_vdd_over()</td>
<td>LVD0F flag judgment processing</td>
</tr>
<tr>
<td>r_set_vdd_down_flag()</td>
<td>LVD0 (falling) generation flag setting</td>
</tr>
<tr>
<td>r_is_vdd_down()</td>
<td>LVD0 (falling) generation judgment processing</td>
</tr>
<tr>
<td>r_RTC_wait()</td>
<td>HALT/STOP mode transition wait processing at the beginning of RTC operation</td>
</tr>
<tr>
<td>r_LCM_init()</td>
<td>LCD module Initialization.</td>
</tr>
<tr>
<td>r_LCM_clear()</td>
<td>LCD module display clear processing</td>
</tr>
<tr>
<td>r_LCM_send_string()</td>
<td>LCD module character string transmission processing</td>
</tr>
<tr>
<td>r_LCM_send_command()</td>
<td>LCD module command transmission processing</td>
</tr>
<tr>
<td>r_LCM_send_data()</td>
<td>LCD module data transmission processing</td>
</tr>
<tr>
<td>r_LCM_turn_sendend_on()</td>
<td>LCD module communication end flag setting</td>
</tr>
<tr>
<td>r_lvd_interrupt()</td>
<td>LVD0 interrupt processing</td>
</tr>
<tr>
<td>r_Config_IICA0_callback_master_sendend()</td>
<td>IICA0 send end callback processing.</td>
</tr>
<tr>
<td>r_Config_IICA0_callback_master_error()</td>
<td>IICA0 error callback processing.</td>
</tr>
</tbody>
</table>

4.6 Specification of Functions

The function specifications of the sample code are shown below.

---

**r_main_user_init()**

**Outline**  
Main initial settings

**Header**  
r_cg_macrodriver.h, Config_LVD0.h, Config_RTC.h, LCM_driver.h

**Declaration**  
static void r_main_user_init(void)

**Description**  
Make initial settings for peripheral functions and peripheral devices used for applications.

**Argument**  
None

**Return Value**  
None

**BCD_to_str()**

**Outline**  
BCD value-to-character string conversion processing

**Header**  
r_cg_macrodriver.h

**Declaration**  
void BCD_to_str(uint8_t BCD, uint8_t *str)

**Description**  
Convert a 2-digit BCD value to a 2-digit character string.

**Argument**  
uint8_t BCD: BCD value to be converted
uint8_t *str: An area of at least two characters is required as a conversion destination

**Return Value**  
None
### r_is_vdd_over()

<table>
<thead>
<tr>
<th>Outline</th>
<th>LVD0F flag judgment processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>r_cg_macrodriver.h, r_cg_userdefine.h</td>
</tr>
<tr>
<td>Declaration</td>
<td>int r_is_vdd_over(void)</td>
</tr>
<tr>
<td>Description</td>
<td>Reference the LVD0F value and return the current VDD state.</td>
</tr>
<tr>
<td>Argument</td>
<td>None</td>
</tr>
</tbody>
</table>
| Return Value    | 1: VDD is LVD0 detection voltage (rising) or higher.  
0: VDD is lower than the LVD0 detection voltage (falling). |

### r_set_vdd_down_flag()

<table>
<thead>
<tr>
<th>Outline</th>
<th>LVD0 (falling) generation flag setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>r_cg_macrodriver.h, r_cg_userdefine.h</td>
</tr>
<tr>
<td>Declaration</td>
<td>void r_set_vdd_down_flag(void)</td>
</tr>
<tr>
<td>Description</td>
<td>Set _01_VDD_DOWN for g_vdd_down.</td>
</tr>
<tr>
<td>Argument</td>
<td>None</td>
</tr>
<tr>
<td>Return Value</td>
<td>None</td>
</tr>
</tbody>
</table>

### r_is_vdd_down()

<table>
<thead>
<tr>
<th>Outline</th>
<th>LVD0 (falling) generation judgment processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>r_cg_macrodriver.h, r_cg_userdefine.h</td>
</tr>
<tr>
<td>Declaration</td>
<td>int r_is_vdd_down(void)</td>
</tr>
</tbody>
</table>
| Description     | Reference g_vdd_down and return the LVD0 (falling) interrupt state.  
g_vdd_down is cleared by _00_VDD_NOT_DOWN. |
| Argument        | None                                         |
| Return Value    | 1: An LVD0 (falling) interrupt was generated.  
0: An LVD0 (falling) interrupt is not generated. |

### r_RTC_wait()

<table>
<thead>
<tr>
<th>Outline</th>
<th>HALT/STOP mode transition wait processing at the beginning of RTC operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>r_cg_macrodriver.h, Config_RTC.h</td>
</tr>
<tr>
<td>Declaration</td>
<td>void r_RTC_wait(void)</td>
</tr>
</tbody>
</table>
| Description     | Perform the processing for transition to HALT/STOP mode immediately after RTC  
operation starts.                                                            |
| Argument        | None                                                                       |
| Return Value    | None                                                                       |

### r_LCM_init()

<table>
<thead>
<tr>
<th>Outline</th>
<th>LCD module Initialization.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>LCM_driver.h, Config_IICA0.h</td>
</tr>
<tr>
<td>Declaration</td>
<td>void r_LCM_init(void)</td>
</tr>
<tr>
<td>Description</td>
<td>Initializes the LCD module.</td>
</tr>
<tr>
<td>Argument</td>
<td>None</td>
</tr>
<tr>
<td>Return Value</td>
<td>None</td>
</tr>
</tbody>
</table>
r_LCM_clear()

Outline  LCD module display clear processing
Header   LCM_driver.h, Config_IICA0.h
Declaration  void r_LCM_clear(void)
Description  Send the clear display command to the LCD module to clear display.
Argument  None
Return Value  None

r_LCM_send_string()

Outline  LCD module character string transmission processing
Header   LCM_driver.h, Config_IICA0.h
Declaration  void r_LCM_send_string(uint8_t * const str, lcm_position_t pos)
Description  Display the character string transferred with str on the LCD module.
Argument  uint8_t * const str: Character string to be displayed
lcm_position_t pos: LCM_POSITION_TOP: Displayed at the top
LCM_POSITION_BOTTOM: Displayed at the bottom
Return Value  None

r_LCM_send_command()

Outline  LCD module command transmission processing
Header   LCM_driver.h, Config_IICA0.h
Declaration  void r_LCM_send_command(uint8_t command)
Description  Send the command transferred with the command to the LCD module.
Argument  uint8_t command: Command to be sent to the LCD module
Return Value  None

r_LCM_send_data()

Outline  LCD module data transmission processing
Header   LCM_driver.h, Config_IICA0.h
Declaration  void r_LCM_send_data(uint8_t data);
Description  Send the data transferred with the data to the LCD module.
Argument  uint8_t data: Data to be sent to the LCD module
Return Value  None

r_LCM_turn_sendend_on()

Outline  LCD module communication end flag setting
Header   LCM_driver.h, Config_IICA0.h
Declaration  void r_LCM_turn_sendend_on(void)
Description  Set the I2C communication (with the LCD module) end flag for
LCM_is_sendend.
Argument  None
Return Value  None
### r_LCM_wait_sendend()

**Outline**
LCD module communication end wait processing

**Header**
LCM_driver.h, Config_IICA0.h

**Declaration**
static void r_LCM_wait_sendend(void)

**Description**
Wait until the I2C communication (with the LCD module) ends, and then perform
wait processing during the command execution wait time period (5 ms).

**Argument**
None

**Return Value**
None

### r_lvd_interrupt()

**Outline**
LVD0 interrupt processing.

**Header**
r_cg_macrodriver.h, Config_LVD0.h, Config_RTC.h

**Declaration**
static void r_lvd_interrupt(void)

**Description**
Judge the VDD state and set/reset the INTRTC interrupt mask.
If VDD is lower than LVD0 (falling), set the voltage detection interrupt flag.

**Argument**
None

**Return Value**
None

### r_Config_IICA0_callback_master_sendend()

**Outline**
IICA0 send end callback processing.

**Header**
r_cg_macrodriver.h, Config_IICA0.h, LCM_driver.h

**Declaration**
static void r_Config_IICA0_callback_master_sendend(void)

**Description**
This callback function is called upon completion of IICA0 transmission
Generate stop conditions, and then call the LCD module communication end flag
setting function.

**Argument**
None

**Return Value**
None

### r_Config_IICA0_callback_master_error()

**Outline**
IICA0 error callback processing.

**Header**
r_cg_macrodriver.h, Config_IICA0.h, LCM_driver.h

**Declaration**
static void r_Config_IICA0_callback_master_error(MD_STATUS flag)

**Description**
This callback function is called when an IICA0 error occurs.
Call the LCD module communication end flag setting function.

**Argument**
MD_STATUS flag : error type

**Return Value**
None
4.7 Flowcharts

4.7.1 Main Processing

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

Figure 4-1 Main Processing (1/2)
Figure 4-2 Main Processing (2/2)

A

Substitute ' ' for rtc_str[0][15] from rtc_str[0][8].
Substitute '0' for rtc_str[1][16].

Substitute ' ' for rtc_str[0][7] from rtc_str[1][0].

Convert the BCD value of hour to a character string.
BCD_to_str(rtc_now.hour, &rtc_str[1][8])

Substitute ' ' for rtc_str[1][10].

Convert the BCD value of minute to a character string.
BCD_to_str(rtc_now.min, &rtc_str[1][11])

Substitute ' ' for rtc_str[1][13].

Convert the BCD value of second to a character string.
BCD_to_str(rtc_now.sec, &rtc_str[1][14])

Substitute '0' for rtc_str[1][16].

r_LCM_send_string(rtc_str[0], LCM_POSITION_TOP)

B

r_LCM_send_string(rtc_str[1], LCM_POSITION_BOTTOM)

LVD0F = 1 and is g_vdd_down set?

YES

r_LCM_init()

NO

C

The top of the LCD module is displayed.

The bottom of the LCD module is displayed.
4.7.2 Main Initial Settings

Figure 4-3 shows the flowchart of the initial settings for main functions.

Figure 4-3 Main Initial Settings

1. r_main_user_init()
2. LCD module Initialization
   r_LCM_init()
3. Disable interrupt (IE ← 0)
4. Start the RTC.
   R_Config_RTC_Start()
5. Wait for the transition to HALT/STOP mode
   when the RTC starts.
   r_RTC_wait()
6. Disable interrupt (IE ← 1)
7. Return

Notes:
- RTCIF ← 0
- RTCMK ← 0
- RTCE ← 1
4.7.3 BCD Value-to-Character String Conversion Processing
Figure 4-4 shows the flowchart of the processing for converting a BCD value to a character string.

Figure 4-4 BCD Value-to-Character String Conversion Processing

4.7.4 LVD0F Flag Judgment Processing
Figure 4-5 shows the flowchart of the LVD0F flag judgment processing.

Figure 4-5 LVD0F Flag Judgment Processing
4.7.5 LVD0 (Falling) Generation Flag Setting
Figure 4-6 shows the flowchart for setting the LVD0 (falling) generation flag.

Figure 4-6 LVD0 (Falling) Generation Flag Setting

```
   r_set_vdd_down_flag()
       Set g_vdd_down flag
       Return
```

4.7.6 LVD0 (Falling) Generation Judgment Processing
Figure 4-7 shows the flowchart of the LVD0 (Falling) generation judgment processing.

Figure 4-7 LVD0 (Falling) Generation Judgment Processing

```
   r_is_vdd_down()
       Disable interrupt
       IE ← 0
       Save the gvdd_down flag in the local variable.
       Clear gvdd_down flag
       Enable interrupt
       IE ← 1
       Is the saved gvdd_down flag set?
           YES
           Return "1"
           Return
           NO
           Return "0"
```
4.7.7 HALT/STOP Mode Transition Wait Processing at the Beginning of RTC Operation

Figure 4-8 shows the flowchart of the HALT/STOP mode transition wait processing at the beginning of RTC operation.

Figure 4-8 HALT/STOP Mode Transition Wait Processing at the Beginning of RTC Operation

4.7.8 LCD Module Initialization

Figure 4-9 shows the flowchart of the LCD module initialization.

Figure 4-9 LCD Module Initialization
4.7.9 LCD Module Display Clear Processing

Figure 4-10 shows the flowchart of the display clear processing for the LCD module.

Figure 4-10 LCD Module Display Clear Processing

- **r_LCM_clear()**
- **r_LCM_send_command(_0x00_LCM_COMMAND_CLEAR_DISPLAY)**
- **Return**

Send the Clear Display command.
4.7.10 LCD Module Character String Transmission Processing
Figure 4-11 shows the flowchart of the character string transmission processing for the LCD module.

Figure 4-11 LCD Module Character String Transmission Processing

```
r_LCM_send_string(str, pos)

R_LCM_send_command(_0x80_LCM_COMMAND_SET_DDRAM_ADDRESS | pos)

i = 0

Is i less than the number of str characters?

YES

Is i less than the number of displayable characters?

YES

r_LCM_send_data(The i-th character of str)

Increment i.

Return

Send the Set DDRAM Address command and designate the position specified by pos as the drawing start position.
```
4.7.11 LCD Module Command Transmission Processing

Figure 4-12 shows the flowchart of the command transmission processing for the LCD module.

Figure 4-12 LCD Module Command Transmission Processing

```
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>r_LCM_send_command(command)</td>
<td>Send the command to the LCM.</td>
</tr>
<tr>
<td>R_Config_IICA0_Master_Send(</td>
<td>Prepare a temporary buffer and place</td>
</tr>
<tr>
<td>LCM slave address,</td>
<td>&quot;_0x00_LCM_CONTROL_BYTE_RS_LOW&quot; and</td>
</tr>
<tr>
<td>temporary buffer, temporary buffer size,</td>
<td>the command consecutively.</td>
</tr>
<tr>
<td>LCM_CONFIG_WAIT_COUNT)</td>
<td></td>
</tr>
<tr>
<td>r_LCM_wait_sendend()</td>
<td></td>
</tr>
</tbody>
</table>

LCD module specification:
The command is placed next to 0x00.
```
4.7.12 LCD Module Data Transmission Processing

Figure 4-13 shows the flowchart of the data transmission processing for the LCD module.

Figure 4-13 LCD Module Data Transmission Processing

```
4.7.12 LCD Module Data Transmission Processing

Figure 4-13 LCD Module Data Transmission Processing

r_LCM_send_data(data)

Prepare a temporary buffer and place "0x80_LCM_CONTROL_BYTE_RS_HIGH" and data consecutively.

Send the command to the LCM.
R_Config_IICA0_Master_Send(LCM slave address, temporary buffer, temporary buffer size, LCM_CONFIG_WAIT_COUNT)

r_LCM_wait_sendend()

Return

LCD module specification:
Data is placed next to 0x80.
```
4.7.13 LCD Module Communication End Flag Setting
Figure 4-14 shows the flowchart for setting the communication end flag for the LCD module.

Figure 4-14 LCD Module Communication End Flag Setting

```
  r_LCM_turn_sendend_on()

  g_LCM_is_sendend = 1

  Return
```

4.7.14 LCD Module Communication End Wait Processing
Figure 4-15 shows the flowchart of the communication end wait processing for the LCD module.

Figure 4-15 LCD Module Communication End Wait Processing

```
  r_LCM_wait_sendend(str, pos)

  NO

  YES

  g_LCM_is_sendend = 1?

  g_LCM_is_sendend = 0

  Wait processing

  LCD module specification:
  A wait time of at least 5 ms is required after transmission.

  Return
```
4.7.15 LVD0 Interrupt Processing
Figure 4-16 shows the flowchart of the LVD0 interrupt processing.

Figure 4-16 LVD0 Interrupt Processing

4.7.16 IICA0 Send End Callback Processing
Figure 4-17 shows the flowchart of the IICA0 send end callback processing.

Figure 4-17 IICA0 Send End Callback Processing
4.7.17 IICA0 Error Callback Processing

Figure 4-18 shows the flowchart of the IICA0 error callback processing.

Figure 4-18 IICA0 Error Callback Processing

r_Config_IICA0_callback_master_error(flag)

r_LCM_turn_sendend_on()

Return
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 versions can be downloaded from the Renesas Electronics website.

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

LCD module datasheet
(ACM1602NI-FLW-FBW-M01 (ZETTLER DISPLAYS) CHARACTER MODULE VER1.4)
## Revision History

<table>
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<tr>
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<th>Date</th>
<th>Page</th>
<th>Description</th>
<th>Summary</th>
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<tr>
<td>1.00</td>
<td>2021.04.13</td>
<td>-</td>
<td>First Edition</td>
<td></td>
</tr>
<tr>
<td>1.01</td>
<td>2021.07.12</td>
<td>6</td>
<td>Updated the Operation Confirmation Conditions</td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>2022.06.17</td>
<td>1, 3, 5, 11-13, 15, 19, 20, 27</td>
<td>Changed LVD1 to LVD0</td>
<td>Updated operation check conditions</td>
</tr>
</tbody>
</table>
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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.

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   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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