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April 1st, 2010
Renesas Electronics Corporation

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1. **Abstract**

This document describes a program for key matrix and determination.

2. **Introduction**

The application example described in this document applies to the following MCU and parameter(s):

- MCU: R8C/25 Group

This program can be used with other R8C/Tiny Series MCUs which have the same special function registers (SFRs) as the R8C/25 Group. Check the manual for any additions and modifications to functions. Careful evaluation is recommended before using this application note.
3. Application Example Description

The key input and determination specifications are as follows:

1. The keys are set to “L” active (“L”: pressed; “H”: not pressed). If the key codes match three times, it is determined that they are fixed.

2. If multiple keys are pressed simultaneously (multiple pressing), it is determined as an error.

3. The key matrix uses eight ports in total - four ports for scan output and four ports for key input.
   - Scan output: “L” active, P0_4 to P0_7
   - Key input: “L” active, P2_0 to P2_3

4. The scan output is set to serial active output every 5 ms and controlled by the variable scan. Timer RA is used to measure 5 ms.

5. The key input is fixed after each scan output cycle.

6. Key input data is set into the variable key_data and a key code is generated based on this data. The key code is set into the variable now_keycode.

Table 3.1 Keys and Key Codes

<table>
<thead>
<tr>
<th>KEY</th>
<th>Key code</th>
<th>KEY</th>
<th>Key code</th>
<th>KEY</th>
<th>Key code</th>
<th>KEY</th>
<th>Key code</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEY1</td>
<td>01h</td>
<td>KEY2</td>
<td>05h</td>
<td>KEY3</td>
<td>09h</td>
<td>KEY4</td>
<td>0Dh</td>
</tr>
<tr>
<td>KEY5</td>
<td>02h</td>
<td>KEY6</td>
<td>06h</td>
<td>KEY7</td>
<td>0Ah</td>
<td>KEY8</td>
<td>0Eh</td>
</tr>
<tr>
<td>KEY9</td>
<td>03h</td>
<td>KEY10</td>
<td>07h</td>
<td>KEY11</td>
<td>0Bh</td>
<td>KEY12</td>
<td>0Fh</td>
</tr>
<tr>
<td>KEY13</td>
<td>04h</td>
<td>KEY14</td>
<td>08h</td>
<td>KEY15</td>
<td>0Ch</td>
<td>KEY16</td>
<td>10h</td>
</tr>
</tbody>
</table>

The key code for no key being pressing is 00h, and the key code for multiple pressing is FFh.

7. The key code fixed two times previously and the key code fixed one time previously are set into the variables last_keycode[1] and last_keycode[0], respectively. If the key codes set in last_keycode[1], last_keycode[0], and now_keycode match, it is considered the same key code is identified three times and set into the variable fix_keycode.

This sample program may include operations of unused bit functions for the SFR bit layout. Set these values according to the operating conditions of the user system.
### 3.1 Pin Usage

#### Table 3.2 Pin Usage and Functions

<table>
<thead>
<tr>
<th>Pin</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0_4</td>
<td>Output</td>
<td>Scan output 0</td>
</tr>
<tr>
<td>P0_5</td>
<td>Output</td>
<td>Scan output 1</td>
</tr>
<tr>
<td>P0_6</td>
<td>Output</td>
<td>Scan output 2</td>
</tr>
<tr>
<td>P0_7</td>
<td>Output</td>
<td>Scan output 3</td>
</tr>
<tr>
<td>P2_0</td>
<td>Input</td>
<td>Key input 0</td>
</tr>
<tr>
<td>P2_1</td>
<td>Input</td>
<td>Key input 1</td>
</tr>
<tr>
<td>P2_2</td>
<td>Input</td>
<td>Key input 2</td>
</tr>
<tr>
<td>P2_3</td>
<td>Input</td>
<td>Key input 3</td>
</tr>
</tbody>
</table>

**Figure 3.1 Key Matrix Configuration**
3.2 Memory Usage

Table 3.3 Memory Usage

<table>
<thead>
<tr>
<th>Memory Usage</th>
<th>Size</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM</td>
<td>351 bytes</td>
<td>In main.c module</td>
</tr>
<tr>
<td>RAM</td>
<td>9 bytes</td>
<td>In main.c module</td>
</tr>
<tr>
<td>Maximum user stack usage</td>
<td>14 bytes</td>
<td>main function: 3 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sfr_init function: 3 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>key_mat function: 3 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>key_scan function: 3 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>key_decode function: 8 bytes</td>
</tr>
<tr>
<td>Maximum interrupt stack usage</td>
<td>0 bytes</td>
<td>Unused</td>
</tr>
</tbody>
</table>

Memory usage varies depending on the C compiler version and the compile option.
The above applies under the following conditions:
- C compiler: M16C/60, 30, 20, 10, Tiny, R8C/Tiny Series Compiler V.5.40 Release 00
- Compile option: -c -finfo; NOTE: -dir “$(CONFIGDIR)” -R8C
NOTE: Unavailable in the R8C/Tiny-exclusive free version.

Table 3.4 RAM Usage and Definition

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Type</th>
<th>Size</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>scan</td>
<td>unsigned char</td>
<td>1 byte</td>
<td>Scan output counter</td>
</tr>
<tr>
<td>key_data[4]</td>
<td>unsigned char</td>
<td>4 bytes</td>
<td>Input key data</td>
</tr>
<tr>
<td>now_keycode</td>
<td>unsigned char</td>
<td>1 byte</td>
<td>Key data fixed this time</td>
</tr>
<tr>
<td>last_keycode[2]</td>
<td>unsigned char</td>
<td>2 bytes</td>
<td>[0]: Key code fixed one time previously</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>[1]: Key code fixed two times previously</td>
</tr>
<tr>
<td>fix_keycode</td>
<td>unsigned char</td>
<td>1 byte</td>
<td>Key code fixed by three matches</td>
</tr>
</tbody>
</table>
4. Flowchart

4.1 Main Function

```
main()
asm("FCLR I")
prc0 ← 1
cm14 ← 0
fra2 ← 0x00
fra00 ← 1

Repeat
(i <= 255)
i++;

fra01 ← 1
cm16 ← 0
cm17 ← 0
cm06 ← 0
prc0 ← 0

SFR initial setting processing
sfr_init()
asm("FSET I")

No
ir_traic = 1?
Yes

traic ← traic & 0xF7

Key matrix input processing
key_mat()
```

- Disable interrupt
- Disable system control register protect
- Start low-speed on-chip oscillator oscillation
- High-speed on-chip oscillator clock divided-by-2 mode
- Start high-speed on-chip oscillator oscillation
- Wait until oscillation becomes stable
- Select high-speed on-chip oscillator
- No main clock division
- Enable CM16, CM17
- System control register protect
- SFR initial setting processing (port initial setting/timer RA setting)
- Enable interrupt
- Timer RA Wait for request (5 ms)
- Timer RA Clear interrupt request flag
- Key matrix input processing
4.2 SFR Initial Setting Processing

4.2.1 SFR Initial Setting Processing 1

sfr_init()

\[ p0 \leftarrow p0 | 0xF0 \]

Port P0_4 to P0_7 initial setting

\[ \text{prc2} \leftarrow 1 \]

Disable oort P0 direction register protect

\[ \text{pd0} \leftarrow \text{pd0} | 0xF0 \]

Port P0_4 to P0_7: Set to output ports

\[ \text{pd2} \leftarrow \text{pd2} & 0xF0 \]

Port P2_0 to P2_3: Set to input ports

\[ \text{tstart\_tracr} \leftarrow 0 \]

Stop timer RA operation

\[ \text{tcstf\_tracr} = 0? \]

Yes

\[ \text{traic} \leftarrow 0x00 \]

Disable timer RA interrupt

\[ \text{tstop\_tracr} \leftarrow 1 \]

Initialize registers TRAPRE and TRA, and bits TSTART and TCSTF in TRACR register

\[ \text{trapre} \leftarrow 125 - 1 \]

Underflow period: Set to 5 ms (40 MHz \( \times \) \( f_2 \) \( \times \) \( f_8 \) \( \times \) \( 125 \) \( \times \) \( 100 \) = 5 ms)

\[ \text{tra} \leftarrow 100 - 1 \]

Set to 0 in timer mode.

\[ \text{tedgsel\_traioc} \leftarrow 0 \]

Set to 0 in timer mode.

\[ \text{topcr\_traioc} \leftarrow 0 \]

Set to 0 in timer mode.

\[ \text{toena\_traioc} \leftarrow 0 \]

Set to 0 in timer mode.

\[ \text{tipf0\_traioc} \leftarrow 0 \]

Set to 0 in timer mode.

\[ \text{tipf1\_traioc} \leftarrow 0 \]

Set to 0 in timer mode.

\[ \text{tmod0\_tramr} \leftarrow 0 \]

Set to 000 in timer mode.

\[ \text{tmod1\_tramr} \leftarrow 0 \]

\[ \text{tmod2\_tramr} \leftarrow 0 \]
4.2.2 SFR Initial Setting Processing 2

1.

\[ tck0_{tramr} \leftarrow 1 \]

\[ tck1_{tramr} \leftarrow 0 \]

\[ tck2_{tramr} \leftarrow 0 \]

\[ tckcut_{tramr} \leftarrow 0 \]

\[ tstart_{tracr} \leftarrow 1 \]

If \( tcsf_{tracr} = 1 \)

- Yes: return
- No: Timer RA count source: f8
  - Supply count source
  - Start timer RA operation
4.3 Key Matrix Input Processing

4.3.1 Key Matrix Input Processing

key_mat()

Key read processing
key_scan()

Key fix processing
key_decode()

return

4.3.2 Key Read Processing

key_scan()

\[
p_0 \leftarrow p_0 \mid 0xF0
\]

scan++

scan = 4?

\[\text{No}\]

\[\text{Yes}\]

\[
\text{scan} \leftarrow 0
\]

\[
p_0 \leftarrow p_0 \& \text{MAT_OUT}\_\text{data}\[\text{scan}\]
\]

key_data\[\text{scan}\] \leftarrow p_2 \& 0x0F

return
### 4.3.3 Key Fix Processing

```plaintext
key_decode()

key_work ← 0

scan = 3

Yes

last_keycode[1] ← last_keycode[0]

last_keycode[0] ← now_keycode

now_keycode ← 0

Repeat
i = 0; i < 4; i ++

Repeat
j = 0; j < 4; j ++

key_work++

(Key_data[i] & tblkeydecode[j]) = 0?

Yes

now_keycode = 0?

Yes

now_keycode ← keywork

Store key code

Key code error

No

Clear key code generation counter

Check scan output

Update key code

Clear key code

Increment key code generation counter

Check key pressing

Check multiple key pressing

Determine three matches

Fix key code

Fix key code

Fix key code

return
```
5. **Sample Programming Code**

A sample program can be downloaded from the Renesas Technology website.
To download, click “Application Notes” in the left-hand side menu of the R8C/Tiny Series page.

6. **Reference Documents**

Hardware Manual
R8C/25 Group Hardware Manual
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