Description
The P9235A-RB-EVK Mass-Market Evaluation Board demonstrates the features of the P9235A-RB 5W Wireless Power Transmitter (TX). It is intended to evaluate the functionality and performance of the P9235A-RB when combined with a power receiver in a wireless charging system. The P9235A-RB-EVK offers the flexibility to select parameters, such as the over-current limit threshold, LED pattern, and external temperature sensing function. The printed circuit board (PCB) has four layers.

The P9235A-RB Evaluation Board is designed to function with the P9225-R Receiver Evaluation Board, which is ordered separately (see www.idt.com/p9225-r-evk for details). It can also be used with the user’s WPC-1.2.4 compliant receiver.

The high-efficiency, turnkey reference design is supported by comprehensive online digital resources to significantly expedite the design-in effort and enable rapid prototyping. The total active area is optimized to 21mm x 21mm.

Kit Contents
- P9235A-RB-EVK Mass-Market Evaluation Board

Features
- P9235A-RB Evaluation Board provides support for WPC-1.2.4
- Power capability: 5W for 5V input
- Adjustable over-current protection (OCP) threshold
- Adjustable temperature shutdown
- Two programmable LED status indicators
- Supports 5V input voltage
- Secured authentication (16-bit private key and 16-bit random number)
- Fully assembled with test points and coil fixture

P9235A-RB EVK Mass-Market Evaluation Board

P9235A-RB Transmitter Board Connected to P9225-R-EVK

P9235A-RB Transmitter Evaluation Board
Transmitter Coil
P9225-R-EVK Receiver Board

Green LEDs illuminate when connection has been established

VOUT and GND Test Points
Important Notes

Disclaimer
Integrated Device Technology, Inc. and its affiliated companies (herein referred to as “IDT”) shall not be liable for any damages arising out of defects resulting from
(i) delivered hardware or software
(ii) non-observance of instructions contained in this manual and in any other documentation provided to user, or
(iii) misuse, abuse, use under abnormal conditions, or alteration by anyone other than IDT.

TO THE EXTENT PERMITTED BY LAW, IDT HEREBY EXPRESSLY DISCLAIMS AND USER EXPRESSLY WAIVES ANY AND ALL WARRANTIES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING, WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE, STATUTORY WARRANTY OF NON-INFRINGEMENT, AND ANY OTHER WARRANTY THAT MAY ARISE BY REASON OF USAGE OF TRADE, CUSTOM, OR COURSE OF DEALING.

Restrictions in Use
IDT’s P9235A-RB-EVK Mass-Market Evaluation Board and the P92xx 5-15W Wireless Power Pro software are designed for evaluation purposes only. The P9235A-RB-EVK Mass-Market Evaluation Board and software must not be used for module production or production test setups.

Contents
1. Setup .................................................................................................................................................4
   1.1 Required or Recommended User Equipment ..................................................................................4
   1.2 User Computer Requirements and Software Installation ..............................................................4
      1.2.1 Computer Requirements ...........................................................................................................4
      1.2.2 Software Installation ................................................................................................................4
   1.3 Kit Hardware Connections ...........................................................................................................5
2. Usage Guide ......................................................................................................................................5
   2.1 Overview of the P9235A-RB-EVK ...............................................................................................5
   2.2 LED Pattern ..............................................................................................................................7
   2.3 OCP and FOD Tuning ..................................................................................................................9
   2.4 External Temperature Sensing – TS ..........................................................................................10
   2.5 Programming Interface .............................................................................................................11
   2.6 Transmitter Coil ........................................................................................................................11
3. P9235A-RB Evaluation Board V1P1 Schematic ...............................................................................12
4. Bill of Materials (BOM) ..................................................................................................................13
5. Board Layout ....................................................................................................................................15
6. Ordering Information .......................................................................................................................18
7. Revision History ..............................................................................................................................18
List of Figures

Figure 1. Connecting the Dongle .............................................................................................................. 4
Figure 2. P9235A-RB V1P1 Evaluation Board Features .................................................................................. 5
Figure 3. P9235A-RB Evaluation Board Details ........................................................................................... 6
Figure 4. R61 and R62 Schematic Location ................................................................................................. 8
Figure 5. R61 and R62 PCB Location ........................................................................................................... 8
Figure 6. R58 and R59 Schematic Location ................................................................................................. 9
Figure 7. R58 and R59 PCB Location ........................................................................................................... 9
Figure 8. RTH1 and R60 Schematic Location .............................................................................................. 10
Figure 9. RTH1 and R60 PCB Location ...................................................................................................... 10
Figure 10. Silkscreen – Top of Board ......................................................................................................... 15
Figure 11. Copper – Top Layer .................................................................................................................... 15
Figure 12. Copper L1 Layer ......................................................................................................................... 16
Figure 13. Copper L2 Layer ......................................................................................................................... 16
Figure 14. Copper Bottom .......................................................................................................................... 17

List of Tables

Table 1. Selecting the LED Pattern ............................................................................................................. 7
Table 2. Recommend Coil Manufacturer ..................................................................................................... 11
Table 3. P9235A-RB-EVK BOM ............................................................................................................... 13
1. Setup

1.1 Required or Recommended User Equipment

The following additional lab equipment is required for using the kit:

- P9225-R-EVK Receiver Evaluation Board or any WPC-1.2.4 compliant receiver
- 5V power supply or 5V/2A AC adaptor USB adaptor provided by the user
- IDT Dongle (sold separately)

1.2 User Computer Requirements and Software Installation

1.2.1 Computer Requirements

A Windows®-based computer is required for interfacing with the kit and configuring the part. The user must have administrative rights on the computer to download and install the software for the P9235A-RB-EVK.

The computer must meet the following requirements:

- Windows® 7 or higher version
- Internet access

1.2.2 Software Installation

Follow these procedures for the P9225-R/P9235A-RB software installation:

Step 1: Obtain the P92xx 5-15W Wireless Power Pro graphical user interface (GUI) software from IDT (see contact information on the last page) or the distributor, and install the software according to the P92xx 5-15W Wireless Power Pro GUI User Manual, which is available upon request from IDT.

Step 2: Use the dongle to connect the P9235A-RB-EVK with the user’s computer as shown in Figure 1.

**Figure 1. Connecting the Dongle**

Connect the Dongle to J4 on the P9235A-RB-EVK
1.3 Kit Hardware Connections

Follow these procedures to set up the kit as shown on page 1.

1. Set up the P9235A-RB Evaluation Board by plugging the 5V adapter or the user’s power supply into J11 (Micro-USB connector). Refer to Figure 2.

2. If using the P9225-R-EVK Evaluation Board as the receiver, connect wires to the VOUT and GND test points on the P9225-R-EVK receiver to allow measuring the output voltage and applying a load.

3. Place the P9225-R-EVK or the user’s receiver on the transmitter (TX) pad with the components facing up as shown on page 1.

4. Verify that the two green LEDs identified in Figure 2 are illuminated indicating that coupling has been established.

2. Usage Guide

2.1 Overview of the P9235A-RB-EVK

Figure 2. P9235A-RB V1P1 Evaluation Board Features

- P9235A-RB IC
- Micro-USB J11
- LED1 and LED2 Pattern Indicators
- IDT Programming Connector J4
- TX Coil
Figure 3. P9235A-RB Evaluation Board Details

- Coil Current Communication Demodulation
- Vin Decoupling Capacitors
- Cout for LDO33
- L4
- Cout for VCC5V
- VCC5V
- In Sense Resistor
- Tx Coil Driver External Power FETs: Q5
- LC Tank Capacitors (4 x 100nF)
- Coil Voltage Communication Demodulation
- Tx Coil Driver External Power FETs: Q7
- Thermistor TH_COIL1 for Detecting External Temperature
- R62 and R61 for LED_PAT
- Resistors R59 and R58 for ILIMIT and FOD_ADJ
2.2 LED Pattern

The P9235A-RB-EVK uses two LEDs (LED1 and LED2 as shown in Figure 2 to indicate the power transfer status, faults, and operating modes. The LEDs are connected to the LED1 and LED2 pins as shown on the P9235A-RB-EVK schematics (see section 3). The LED patterns can be selected by setting the voltage on the LED_PAT pin via the resistor divider R61 and R62; see Table 1 for the options. On the P9235A-RB-EVK, the LED_PAT pin is pulled up to 3.3V through R61. R62 is unpopulated; therefore, option 7 is the default option.

### Table 1. Selecting the LED Pattern

<table>
<thead>
<tr>
<th>Option #</th>
<th>R61 [KΩ]</th>
<th>R62 [KΩ]</th>
<th>Description</th>
<th>LED #/Color</th>
<th>Operational Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Standby</td>
</tr>
<tr>
<td>1</td>
<td>Open</td>
<td>10</td>
<td>Dual-LED, Standby on, Blink</td>
<td>LED1 – RED</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.232</td>
<td></td>
<td>LED2 – GREEN</td>
<td>Off</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>0.732</td>
<td>Dual-LED, Standby on, No Blink</td>
<td>LED1 – RED</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LED2 – GREEN</td>
<td>Off</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>1.27</td>
<td>Single-LED, Standby on No Blink</td>
<td>LED1 – RED</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LED2 – GREEN</td>
<td>Off</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>1.87</td>
<td>Single-LED, Standby on, No Blink</td>
<td>LED1 – RED</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LED2 – GREEN</td>
<td>Off</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>2.55</td>
<td>Dual-LED, Standby-Off, No Blink</td>
<td>LED1 – RED</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LED2 – GREEN</td>
<td>Off</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>3.32</td>
<td>Dual-LED, Standby-Off, No Blink</td>
<td>LED1 – RED</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LED2 – GREEN</td>
<td>Off</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>4.22</td>
<td>Reserved</td>
<td>LED1 – RED</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Open</td>
<td></td>
<td>LED2 – GREEN</td>
<td>Off</td>
</tr>
</tbody>
</table>

Note: The tolerance of R61 and R62 as shown in Table 1 is ±1%.
Figure 4. R61 and R62 Schematic Location

Figure 5. R61 and R62 PCB Location
2.3 OCP and FOD Tuning

The over-current protection (OCP) is designed to protect the transmitter from operating conditions that could potentially cause damage or unexpected behavior from the system. The input current is continuously monitored during the power transfer stage. If the input current goes above the OCP threshold of the programmed current limit, the P9235A-RB will shut down the TX and restart again. ILIM/FOD_ADJ (pin 15) is used to turn on/off the FOD function. When ILIM/FOD_ADJ voltage is greater than 2.4V, FOD is enabled, and vice versa. The OCP threshold is always set to 2400mA. On the P9235A-RB-EVK, the ILIM/FOD_ADJ pin is pulled up to 3.3V through R58. R59 is unpopulated, so the FOD function is enabled.

Figure 6. R58 and R59 Schematic Location

Figure 7. R58 and R59 PCB Location
2.4 External Temperature Sensing – TS

The P9235A-RB includes an optional temperature sense input pin, TS, used to monitor a remote temperature, such as for a coil or a battery charger.

The TS pin voltage can be calculated by Equation 1.

\[ V_{TS} = V_{LDO33} \times \frac{NTC}{(NTC + R_{60})} \]  

Equation 1

Where

- \( NTC \) Thermistor’s resistance (TH_COIL1)
- \( R_{60} \) Pull-up resistor connected to the 3.3V supply voltage on the P9235A-RB Evaluation Board

The over-temperature shutdown is triggered if the voltage on the TS pin is lower than 0.65V. The RTH1 is not populated on the P9235A-RB Evaluation Board.

Figure 8. RTH1 and R60 Schematic Location

Figure 9. RTH1 and R60 PCB Location
2.5 Programming Interface

The initial state of the P9235A-RB is blank. It cannot function without firmware. There are two types of firmware: one-time programmable memory (OTP) and flash memory. The OTP file is burned into the P9235A-RB memory. For the flash file, the bootloader (part of the flash file) is burned into the P9235A-RB memory; the other part of the flash file is programmed into the flash chip (U7) on the P9235A-RB-EVK. The P92xx 5-15W Wireless Power Pro GUI can be used for programming the OTP or the flash file. For programming details and instructions, refer to the P92xx 5-15W Wireless Power Pro GUI User Manual.

2.6 Transmitter Coil

The following coil is recommended with the P9235A-RB transmitter for 5W applications for optimum performance. The recommended vendor has been tested and verified.

Table 2.  Recommend Coil Manufacturer

<table>
<thead>
<tr>
<th>Output Power</th>
<th>Vendor</th>
<th>Part Number</th>
<th>Inductance at 100kHz</th>
<th>DCR at 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5W</td>
<td>SUNLORD</td>
<td>MQQTC505030S6R3</td>
<td>6.3µH</td>
<td>38mΩ</td>
</tr>
</tbody>
</table>
3. P9235A-RB Evaluation Board V1P1 Schematic
### 4. Bill of Materials (BOM)

#### Table 3. P9235A-RB-EVK BOM

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference</th>
<th>Value</th>
<th>Description</th>
<th>Part Number</th>
<th>PCB Footprint</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C7, C31, C32, C35, C42, C45, C55, C56</td>
<td>10µF</td>
<td>CAP CER 10UF 10V X5R 0603</td>
<td>GRM188R61A106KE69D</td>
<td>0603</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>C8, C30, C33, C34, C38, C46, C57, C66, C67, C68</td>
<td>0.1µF</td>
<td>CAP CER 0.1UF 10V X7R 0402</td>
<td>GRM155R71A104KA01D</td>
<td>0402</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>C18</td>
<td>22nF</td>
<td>CAP CER 0.022UF 25V X5R 0402</td>
<td>GRM155R71E223KA55J</td>
<td>0402</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>C19, C70</td>
<td>5.6nF</td>
<td>CAP CER 5600PF 25V X7R 0603</td>
<td>GRM188R71E562KA01D</td>
<td>0603</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>C20, C29</td>
<td>680pF</td>
<td>CAP CER 680PF 10V X7R 0402</td>
<td>8.85012E+11</td>
<td>0402</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>C21, C69</td>
<td>22nF</td>
<td>CAP CER 0.022UF 16V X5R 0402</td>
<td>GRM155R61C223KA01D</td>
<td>0402</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>C28</td>
<td>56pF</td>
<td>CAP CER 56PF 50V C0G/NP0 0402</td>
<td>GRM1555C1H560FA01D</td>
<td>0402</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>C37, C43</td>
<td>1µF</td>
<td>CAP CER 1UF 10V X5R 0603</td>
<td>GRM188R61A105KA61D</td>
<td>0603</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>C39, C59</td>
<td>47nF</td>
<td>CAP CER 0.047UF 16V X7R 0603</td>
<td>GRM188R71C473KA01D</td>
<td>0603</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>C44, C47, C48, C49</td>
<td>100nF</td>
<td>CAP CER 0.1UF 50V C0G/NP0 1206</td>
<td>GRM31C5C1H104JA01L</td>
<td>1206</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>C50, C53</td>
<td>1µF</td>
<td>CAP CER 1UF 6.3V X5R 0603</td>
<td>GRM188R61A105KA61D</td>
<td>0603</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>D2</td>
<td>BAV21WS</td>
<td>DIODE GEN PURP 200V 200MA SOD323</td>
<td>BAV21WS-7-F</td>
<td>SOD-323</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>GND1, GND2, GND3, GND4, VIN_SEL, VIN, GND</td>
<td>TP</td>
<td>TEST POINT PC MINIATURE SMT</td>
<td>5015</td>
<td>test_pt_sm_13 5x70</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>J4</td>
<td>Prog Conn</td>
<td>BERGSTIK II .100&quot; SR STRAIGHT</td>
<td>68000-105HLF</td>
<td>sip5</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>J11</td>
<td>5P</td>
<td>CON 005 F RA OTH PC NLK SRW 80 MINIUSB</td>
<td>90080004</td>
<td>usb_micro_ab</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>LED1</td>
<td>LED</td>
<td>LED RED CLEAR 0603 SMD</td>
<td>150060RS75000</td>
<td>0603</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>LED2</td>
<td>LED</td>
<td>LED GREEN CLEAR 0603 SMD</td>
<td>150060GS75000</td>
<td>0603</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>L4</td>
<td>4.7µH</td>
<td>FIXED IND 4.7UH 620MA 550 MOHM</td>
<td>LQM18PN4R7MFRL</td>
<td>0603</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>Q5, Q7</td>
<td>AM7930N</td>
<td>Dual N-Channel 30-V (D-S) MOSFET</td>
<td>AM7930N</td>
<td>DFN-5X6-8Ld-N1</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>R2, R9</td>
<td>0Ω</td>
<td>RES SMD 0 OHM JUMPER 1/4W 1206</td>
<td>RC1206JR-070RL</td>
<td>1206</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>R20</td>
<td>2.4kΩ</td>
<td>RES SMD 2.4K OHM 1% 1/10W 0603</td>
<td>RC0603FR-027K4L</td>
<td>0603</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>R22, R25</td>
<td>10Ω</td>
<td>RES SMD 10 OHM 0.5% 1/16W 0402</td>
<td>RT0402GRE0710RL</td>
<td>0402</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>R23</td>
<td>200kΩ</td>
<td>RES SMD 200K OHM 1% 1/10W 0402</td>
<td>ERJ-2RKF2003X</td>
<td>0402</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>R26</td>
<td>0.02Ω</td>
<td>RES 0.02 OHM 1% 1/8W 0805</td>
<td>PF0805FRM7P0R02L</td>
<td>0805</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>R28, R58, R60, R61, R72, R76</td>
<td>10kΩ</td>
<td>RES SMD 10K OHM 1% 1/16W 0402</td>
<td>RC0402FR-0710KL</td>
<td>0402</td>
<td>6</td>
</tr>
<tr>
<td>26</td>
<td>R35, R40, R44, R47</td>
<td>22Ω</td>
<td>RES SMD 22 OHM 1% 1/10W 0402</td>
<td>RC0105FR220CS</td>
<td>0402</td>
<td>4</td>
</tr>
<tr>
<td>27</td>
<td>R36, R42, R45, R48, R57</td>
<td>100kΩ</td>
<td>RES SMD 100K OHM 1% 1/16W 0402</td>
<td>RC0402FR-07100KL</td>
<td>0402</td>
<td>5</td>
</tr>
<tr>
<td>Item</td>
<td>Reference</td>
<td>Value</td>
<td>Description</td>
<td>Part Number</td>
<td>PCB Footprint</td>
<td>Quantity</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>-------</td>
<td>----------------------------------</td>
<td>---------------</td>
<td>---------------</td>
<td>----------</td>
</tr>
<tr>
<td>28</td>
<td>R39, R49</td>
<td>0</td>
<td>RES SMD 0 OHM JUMPER 1/16W 0402</td>
<td>RC0402JR-070RP</td>
<td>0402</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>R41, R43</td>
<td>1kΩ</td>
<td>RES SMD 1K OHM 5% 1/16W 0402</td>
<td>RC0402JR-071KL</td>
<td>0402</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>R46</td>
<td>680Ω</td>
<td>RES SMD 680 OHM 5% 1/16W 0402</td>
<td>RC0402JR-07680RL</td>
<td>0402</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>R50, R52</td>
<td>5.1kΩ</td>
<td>RES SMD 5.1K OHM 5% 1/16W 0402</td>
<td>RC0402JR-075K1L</td>
<td>0402</td>
<td>2</td>
</tr>
<tr>
<td>32</td>
<td>R70</td>
<td>47kΩ</td>
<td>RES SMD 47K OHM 1% 1/16W 0402</td>
<td>RC0402FR-0747KL</td>
<td>0402</td>
<td>1</td>
</tr>
<tr>
<td>33</td>
<td>TH_Coil1</td>
<td>10kΩ</td>
<td>NTC THERMISTOR 10K OHM 1% 0603</td>
<td>ERT-J1VG103FA</td>
<td>0603</td>
<td>1</td>
</tr>
<tr>
<td>34</td>
<td>U3</td>
<td>P9235A-RB</td>
<td>Wireless power transmitter</td>
<td>P9235A-RB</td>
<td>qfn40_5x5_N</td>
<td>1</td>
</tr>
<tr>
<td>35</td>
<td>U7</td>
<td>W25X40CLUXIG</td>
<td>IC FLASH 4MBIT 104MHZ 8USON</td>
<td>W25X40CLUXIG TR</td>
<td>uson_2x3_8LD</td>
<td>1</td>
</tr>
</tbody>
</table>
5. Board Layout

Figure 10. Silkscreen – Top of Board

Figure 11. Copper – Top Layer
Figure 12. Copper L1 Layer

Figure 13. Copper L2 Layer
Figure 14. Copper Bottom
6. Ordering Information

<table>
<thead>
<tr>
<th>Orderable Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P9235A-RB-EVK</td>
<td>P9235A-RB-EVK Evaluation Board</td>
</tr>
</tbody>
</table>

7. Revision History

<table>
<thead>
<tr>
<th>Revision Date</th>
<th>Description of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 21, 2019</td>
<td>Initial release.</td>
</tr>
</tbody>
</table>
Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

5. Renesas Electronics products are classified according to the following two quality grades. "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implants; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any damages or losses occurring as a result of your noncompliance with specified ranges.

7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

Corporate Headquarters
TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information
For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/

Trademarks
Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

© 2019 Renesas Electronics Corporation. All rights reserved.