AN32258A

INTEGRATED WIRELESS POWER SUPPLY RECEIVER,
Qi (WIRELESS POWER CONSORTIUM) COMPLIANT
— AN32258A —

FEATURES

● Integrated Wireless Power Receiver Solution
● WPC Ver. 1.1 Compliant
● Synchronous Full Bridge Rectifier Control
● Input Voltage Range : VRECT = 4.4 V to 19 V
● Output Voltage: 5 V
● Temperature Detecting Circuit
● Full Charge Detection with Adjustable Current Level
● Switching Control of External Power Supply
● Supports Under Voltage Lockout, Thermal Shutdown, Over Voltage Detection, and Over Current Detection.
● LED Indicator
● 3.16 mm X 3.16 mm WLCSP
  48 Pins with 0.4mm pitch

DESCRIPTION

AN32258A is a wireless power system controller IC which is compliant with Qi version 1.1 of the System Description Wireless Power Transfer, Volume 1 for Low Power defined by Wireless Power Consortium. AN32258A is a controller IC of a power receiver (Rx) which can be used with any Qi-compliant wireless chargers.

APPLICATIONS

• WPC Compliant Receivers
• Cell Phones, Smartphones
• Headsets
• Digital Cameras
• Tablet Devices
• Portable Media Players etc.

IMPORTANT

AN32258A is designed to be used based on the circuits and external components described in this document and Application Note. Therefore, Panasonic cannot support any inquiries of modified solution.
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### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>$V_{RECT}$</td>
<td>20</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{EXT}$</td>
<td>6.9</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td>Output current</td>
<td>$I_{RECT}$</td>
<td>—</td>
<td>A</td>
<td>*1</td>
</tr>
<tr>
<td>Operating ambient temperature</td>
<td>$T_{opr}$</td>
<td>−30 to +85</td>
<td>°C</td>
<td>*2</td>
</tr>
<tr>
<td>Operating junction temperature</td>
<td>$T_J$</td>
<td>−40 to +125</td>
<td>°C</td>
<td>*2</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td>−50 to +125</td>
<td>°C</td>
<td>*2</td>
</tr>
<tr>
<td>Input voltage range</td>
<td>$V_{TD2}$, $V_{TD1}$, $V_{SC2}$, $V_{SC1}$, $V_{ISENSE1}$</td>
<td>−0.3 to 20</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{OUT}$, $V_{LED}$</td>
<td>−0.3 to 12</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{VTH}$, $V_{FCCNT}$, $V_{FODG}$, $V_{FULLCH}$, $V_{FOD}$, $V_{FODL}$</td>
<td>−0.3 to $(V_{VREG34V} + 0.3)$</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td>Output voltage range</td>
<td>$V_{VPGATE}$</td>
<td>−0.3 to $(V_{RECT} + 0.3)$</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{DT1H}$</td>
<td>−0.3 to $(V_{SC1} + V_{VREG47V} + 0.3)$</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{DT2H}$</td>
<td>−0.3 to $(V_{SC2} + V_{VREG47V} + 0.3)$</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{DT2L}$, $V_{DT1L}$</td>
<td>−0.3 to $(V_{VREG47V} + 0.3)$</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{EXTCNT}$</td>
<td>−0.3 to $(V_{EXT} + 0.3)$</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td></td>
<td>$V_{MEMBAT}$</td>
<td>−0.3 to $(V_{VREG34V} + 0.3)$</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td>ESD</td>
<td>TD2</td>
<td>1.0</td>
<td>kV</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>HBM (Human Body Model)</td>
<td>1.5</td>
<td>kV</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>ISENSE1, ISENSE2, ISENSE1-S, ISENSE1-S1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>HBM (Human Body Model)</td>
<td>2</td>
<td>kV</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Except for pins above</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Note) This product may sustain permanent damage if the actual condition is higher than the absolute maximum rating stated above. This rating is the maximum stress, and device will not be guaranteed to operate in case it is higher than our stated range. When exposed to the absolute maximum rating for a long time, the reliability of the product may be affected.

*1: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

*2: Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for $T_a = 25\, ^{\circ}\text{C}$. 

---

### DELIVERY INFORMATION

<table>
<thead>
<tr>
<th>Order Number</th>
<th>Package</th>
<th>Output Supply</th>
<th>Minimum Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN32258A-PR</td>
<td>48 pin WLCSP (3.2 × 3.2 mm) Embossed Taping</td>
<td>5000 pcs</td>
<td></td>
</tr>
</tbody>
</table>
POWER DISSIPATION RATING

<table>
<thead>
<tr>
<th>PACKAGE</th>
<th>$\theta_{ja}$</th>
<th>$\theta_{jc}$</th>
<th>PD (Ta = 25 °C)</th>
<th>PD (Ta = 85 °C)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer Level Chip Size Package (WLCSP type)</td>
<td>631.4 °C / W</td>
<td>7.2 °C / W</td>
<td>0.158 W</td>
<td>0.0632 W</td>
<td>*1</td>
</tr>
</tbody>
</table>

Note) *1: For the actual usage, please refer to the PD-Ta characteristics diagram in the package specification, and follow the power supply voltage, load and ambient temperature conditions to ensure that there is enough margin and the thermal design does not exceed the allowable value.

CAUTION
Although this device has limited built-in ESD protection circuit, permanent damage may occur on it. Therefore, proper ESD precautions are recommended to avoid electrostatic damage to the MOS gates.

RECOMMENDED OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pin Name</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage range</td>
<td>$V_{RECT}$</td>
<td>4.4</td>
<td>8</td>
<td>19</td>
<td>V</td>
<td>*2</td>
</tr>
<tr>
<td></td>
<td>$V_{EXT}$</td>
<td>4.4</td>
<td>5</td>
<td>6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{SENSE1}$</td>
<td>4.4</td>
<td>8</td>
<td>19</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{TD2}$</td>
<td>-0.3</td>
<td>—</td>
<td>20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{TD1}$</td>
<td>-0.3</td>
<td>—</td>
<td>20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{SC2}$</td>
<td>-0.3</td>
<td>—</td>
<td>20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{SC1}$</td>
<td>-0.3</td>
<td>—</td>
<td>20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{OUT}$</td>
<td>-0.3</td>
<td>—</td>
<td>7</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{LED}$</td>
<td>-0.3</td>
<td>—</td>
<td>7</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{VTH}$</td>
<td>-0.3</td>
<td>—</td>
<td>$V_{VREG34V}$ + 0.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{FCCNT}$</td>
<td>-0.3</td>
<td>—</td>
<td>$V_{VREG34V}$ + 0.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{FODG}$</td>
<td>-0.3</td>
<td>—</td>
<td>$V_{VREG34V}$ + 0.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{FULLCH}$</td>
<td>-0.3</td>
<td>—</td>
<td>$V_{VREG34V}$ + 0.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{FOD}$</td>
<td>-0.3</td>
<td>—</td>
<td>$V_{VREG34V}$ + 0.3</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

Note) Do not apply external currents or voltages to any pin not specifically mentioned.

*2: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.
### ELECRRTRICAL CHARACTERISTICS

Co = 10 µF, V\(_{RECT}\) = 8 V, T\(_a\) = 25 °C ± 2 °C unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Consumption</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiescent current</td>
<td>(I_{STBY})</td>
<td></td>
<td>10 12 14 mA</td>
<td></td>
</tr>
<tr>
<td><strong>Under-voltage lock-out (UVLO)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under-voltage lock-out</td>
<td>(V_{UVLO})</td>
<td>(V_{RECT}: 0V \rightarrow 5V)</td>
<td>3.29 3.5 3.71 V</td>
<td></td>
</tr>
<tr>
<td>Hysteresis on UVLO</td>
<td>(V_{UVLOHY})</td>
<td>(V_{RECT}: 5V \rightarrow 3V)</td>
<td>- 0.7 - V</td>
<td>*1</td>
</tr>
<tr>
<td><strong>Over-voltage protection (OVP)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input overvoltage threshold</td>
<td>(V_{OVP})</td>
<td>(V_{RECT}: 5V \rightarrow 19V)</td>
<td>17 18 19 V</td>
<td></td>
</tr>
<tr>
<td>Hysteresis on OVP</td>
<td>(V_{OVPHY})</td>
<td>(V_{RECT}: 19V \rightarrow 5V)</td>
<td>- 4 - V</td>
<td>*1</td>
</tr>
<tr>
<td><strong>V(_{RECT}) (5W, LDO 5V mode)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_{RECT}) Threshold1</td>
<td>(V_{RECTTH1})</td>
<td>In increasing (I_{OUT} &lt; 125mA)</td>
<td>- 8 - V</td>
<td>*1</td>
</tr>
<tr>
<td>(V_{RECT}) Threshold2</td>
<td>(V_{RECTTH2})</td>
<td>In increasing (125mA &lt; I_{OUT} &lt; 420mA)</td>
<td>- 5.4 - V</td>
<td>*1</td>
</tr>
<tr>
<td>(V_{RECT}) Threshold3</td>
<td>(V_{RECTTH3})</td>
<td>In increasing (I_{OUT} &gt; 420mA)</td>
<td>- 5.1 - V</td>
<td>*1</td>
</tr>
</tbody>
</table>

**OUTPUT**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{OUT}) (5W, LDO 5V mode)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_{OUT1})</td>
<td>(V_{RECT}=8V), (I_{OUT}=10mA)</td>
<td></td>
<td>4.76 5 5.24 V</td>
<td></td>
</tr>
<tr>
<td>(V_{OUT2})</td>
<td>(V_{RECT}=5.1V) , (I_{OUT}=1000mA)</td>
<td></td>
<td>4.76 — — V</td>
<td></td>
</tr>
</tbody>
</table>

Note) *1 : Designed typical values
### ELECTRICAL CHARACTERISTICS (Continued)

Co = 10 µF, \( V_{\text{RECT}} = 8 \) V, \( T_a = 25 \pm 2 \) °C unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature Detection [Thermistor : ERTJ0EV104F]</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over-temperature Detection Voltage</td>
<td>( V_{\text{TH}} )</td>
<td>60 ±( \Delta )C detection VTHR:47 kohm (±1%)</td>
<td>0.887 0.975 1.069</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>Over-current protection (OCP)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over-current threshold voltage 1</td>
<td>( V_{\text{OCPL}} )</td>
<td>—</td>
<td>1.25 1.5 1.75</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal protection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shutdown temperature</td>
<td>( T_j )</td>
<td>—</td>
<td>— 150</td>
<td>°C</td>
<td>*1</td>
</tr>
<tr>
<td>Thermal shutdown hysteresis</td>
<td>( T_{\text{hys}} )</td>
<td>—</td>
<td>— 20</td>
<td>°C</td>
<td>*1</td>
</tr>
<tr>
<td><strong>External voltage detection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{\text{EXT}} ) Rising threshold voltage</td>
<td>( V_{\text{EXTTH}} )</td>
<td>—</td>
<td>3.99 4.2 4.41</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{EXT}} ) hysteresis</td>
<td>( V_{\text{EXTHY}} )</td>
<td>—</td>
<td>— 0.4</td>
<td>V</td>
<td>*1</td>
</tr>
<tr>
<td><strong>Terminal voltage (FULLCH)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High input threshold (Termination)</td>
<td>( V_{\text{IH1}} )</td>
<td>—</td>
<td>1.6</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Low input threshold</td>
<td>( V_{\text{IL1}} )</td>
<td>—</td>
<td>-0.2</td>
<td>—</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Terminal voltage (FODL)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High input threshold (Termination)</td>
<td>( V_{\text{IH1}} )</td>
<td>—</td>
<td>1.6</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Low input threshold</td>
<td>( V_{\text{IL1}} )</td>
<td>—</td>
<td>-0.2</td>
<td>—</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Notes**  
*1: Designed typical values
ELECTRICAL CHARACTERISTICS (Continued)

Co = 10 µF, V_{RECT} = 8 V, T_a = 25 °C ± 2 °C unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Limits</th>
<th>Unit</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED Saturation voltage</td>
<td>LED_{SAT}</td>
<td>I_{LED} = 20mA</td>
<td>—</td>
<td>—</td>
<td>0.5 V</td>
</tr>
<tr>
<td>LED Leak current</td>
<td>LED_{LEAK}</td>
<td>LED = 7.5V</td>
<td>—</td>
<td>—</td>
<td>10 μA</td>
</tr>
</tbody>
</table>
Pin Layout

Top View

A TEST2 GND PGA TE OUT TD2 TD1 DT2L
B GND EXT CNT EXT SCL SDA DET IN DT1L
C ISEN SE2 VTH VREG 34V_S EXT CLK FCC NT FODG SC2
D ISEN SE_S MEM BAT TEST1 SC2_S VREG 47V_S VIO SC1
E ISEN SE_S1 SEL VER GND FULL CH FOD DT2H
F ISEN SE1 OUT HP SEL HP SEL OSR FODL EN I2C DT1H
G VRE CT SEL HV VREG 34V LED VREG 47V BT1 BT2

1 2 3 4 5 6 7
## PIN FUNCTIONS

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>I/O</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>TEST2</td>
<td>I</td>
<td>Test pin</td>
<td>Connect to GND. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>A2, B1, E4</td>
<td>GND</td>
<td>GND</td>
<td>Ground</td>
<td>—</td>
</tr>
<tr>
<td>A3</td>
<td>PGATE</td>
<td>O</td>
<td>LDO control</td>
<td>Controls the PMOS gate of the LDO</td>
</tr>
<tr>
<td>A4</td>
<td>OUT</td>
<td>I</td>
<td>LDO feedback</td>
<td>Connects to the PMOS drain of the LDO</td>
</tr>
<tr>
<td>A5</td>
<td>TD2</td>
<td>O</td>
<td>Drive load to transmit 2</td>
<td>Controls capacitive load modulation for Qi data</td>
</tr>
<tr>
<td>A6</td>
<td>TD1</td>
<td>O</td>
<td>Drive load to transmit 1</td>
<td>Controls capacitive load modulation for Qi data</td>
</tr>
<tr>
<td>A7</td>
<td>DT2L</td>
<td>O</td>
<td>Rectification low side switch gate control 2</td>
<td>Controls the switching gate of the low side of the rectifier</td>
</tr>
<tr>
<td>B2</td>
<td>EXTCNT</td>
<td>O</td>
<td>External PMOS control</td>
<td>Controls the switch to an external power supply. This pin is internally connected to the drain of NMOS to use under 2mA. When EXT is larger than 4.2V, EXTCNT will become low and the external MOSFET will turn on.</td>
</tr>
<tr>
<td>B3</td>
<td>EXT</td>
<td>Power Supply</td>
<td>External power detection</td>
<td>Supplies power externally in direct. When EXT becomes larger than 4.2V, EXTCNT will become low and the wireless power transmission will stop. The external power supply will then directly output, and the Tx will be stopped. (Refer to the circuit diagram followed by Pin Functions.)</td>
</tr>
<tr>
<td>B4</td>
<td>SCL</td>
<td>I</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>B5</td>
<td>SDA</td>
<td>I/O</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>B6</td>
<td>DETIN</td>
<td>I</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
</tbody>
</table>
## PIN FUNCTIONS (Continued)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>I/O</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B7</td>
<td>DT1L</td>
<td>O</td>
<td>Rectification Low side Switch Gate Control 1</td>
<td>Controls the switching gate of the low side of the rectifier</td>
</tr>
<tr>
<td>C1</td>
<td>ISENSE2</td>
<td>I</td>
<td>Current sensor 2</td>
<td>Detects the output current from LDO. Connect this pin to ISENSE1-S1(E2).</td>
</tr>
<tr>
<td>C2</td>
<td>VTH</td>
<td>I</td>
<td>Thermistor voltage</td>
<td>Connect to a thermistor placed where temperature needs to be measured to prevent over heat. Connect to VREG34V (G3) if thermistors are not in use.</td>
</tr>
<tr>
<td>C3</td>
<td>VREG34V_S</td>
<td>O</td>
<td>Internal regulator sense output</td>
<td>This pin is shorted internally to VREG34V(G3).</td>
</tr>
<tr>
<td>C4</td>
<td>EXTCLK</td>
<td>I</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>C5</td>
<td>FCCNT</td>
<td>I</td>
<td>Full charge control</td>
<td>Connect a pull-down resistor to set an automatic full-charge detecting current. For example, when a resistor of 100kohm is used, decreasing output current to less than 80mA will shutdown the LDO, and also data is sent to Tx to stop power transmission. The current detection starts 5 seconds after power transmission starts. Using this pin can also replace the full-charge control from FULLCH(E5).</td>
</tr>
</tbody>
</table>
### PIN FUNCTIONS (Continued)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>I/O</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6</td>
<td>FODG</td>
<td>I</td>
<td>FOD gain control</td>
<td>Connect a pull-down resistor to adjust the gain level of Received Power Packet defined in WPC specification. The resistance can be varied from 10k ohms to 180k ohms.</td>
</tr>
<tr>
<td>C7</td>
<td>SC2</td>
<td>I</td>
<td>Synchronous rectifier control 2</td>
<td>Connect to the rectifier to detect its voltage level.</td>
</tr>
<tr>
<td>D1</td>
<td>ISENSE1_S</td>
<td>I</td>
<td>Sense pin for ISENSE1</td>
<td>Connect to the source of the LDO’s MOSFET to detect the output current. A sense resistor of 50mohms is connected to ISENSE1(F1) inside the IC.</td>
</tr>
<tr>
<td>D2</td>
<td>MEMBAT</td>
<td>O</td>
<td>Random number memory adjustment</td>
<td>Connect a capacitor of 1uF to fix a memory time.</td>
</tr>
<tr>
<td>D3</td>
<td>TEST1</td>
<td>O</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>D4</td>
<td>SC2_S</td>
<td>I</td>
<td>Synchronous rectifier sense pin</td>
<td>Leave this pin open. Panasonic uses this pin to sense SC2(C7) for test purposes only.</td>
</tr>
<tr>
<td>D5</td>
<td>VREG47V_S</td>
<td>O</td>
<td>Internal regulator sense output</td>
<td>This pin in shorted internally to VREG47V(G5).</td>
</tr>
<tr>
<td>D6</td>
<td>VIO</td>
<td>I</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>D7</td>
<td>SC1</td>
<td>I</td>
<td>Synchronous rectifier control 1</td>
<td>Connect to the rectifier to detect its voltage level.</td>
</tr>
<tr>
<td>E2</td>
<td>ISENSE1_S1</td>
<td>I</td>
<td>Sense pin 1 for ISENSE1</td>
<td>Connect to ISENSE2(C1) to detect the output current. Refer to the circuit diagram followed by Pin Functions.</td>
</tr>
<tr>
<td>E3</td>
<td>SELVER</td>
<td>I</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
</tbody>
</table>
### PIN FUNCTIONS (Continued)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>I/O</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E5</td>
<td>FULLCH</td>
<td>I</td>
<td>Full charge detection</td>
<td>This input controls the full charge detection externally such as from an MCU. When a high voltage level (over 1.6V) is inputted for over 50us, AN32258A will recognize it as full-charge and send packets to Tx to stop the power transmission. Right after the input becomes low, the power transmission can restart.</td>
</tr>
<tr>
<td>E6</td>
<td>FOD</td>
<td>O</td>
<td>Foreign object detection offset</td>
<td>Connect a pull-down resistor to adjust the offset level of received power of WPC specification. For example, a pull-down resistor of 100kohm will set the offset to be zero. Refer to No.3 of the Functions section.</td>
</tr>
<tr>
<td>E7</td>
<td>DT2H</td>
<td>O</td>
<td>Rectification high side switch gate control 2</td>
<td>Controls the switching gate of the high side of the rectifier</td>
</tr>
<tr>
<td>F1</td>
<td>ISENSE1</td>
<td>I</td>
<td>Current sensor 1</td>
<td>Connect to VRECT(G1) to detect the output current. A sense resistor of 50mohms is connected to ISENSE1-S(D1) inside the IC.</td>
</tr>
<tr>
<td>F2</td>
<td>OUTHP</td>
<td>O</td>
<td>TEST pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>F3</td>
<td>SELHP</td>
<td>I</td>
<td>TEST pin</td>
<td>Connect to GND. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>F4</td>
<td>SELOSR</td>
<td>I</td>
<td>TEST pin</td>
<td>Connect to GND. Panasonic uses this pin for test purposes only.</td>
</tr>
</tbody>
</table>
### PIN FUNCTIONS (Continued)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>I/O</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F5</td>
<td>FODL</td>
<td>I</td>
<td>Foreign object detection offset for low</td>
<td>Inputting a logical high level (over 1.6V) will introduce an offset to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>current</td>
<td>Received Power Packet when IOUT is small. When GND is inputted, no offset</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>will be added.</td>
</tr>
<tr>
<td>F6</td>
<td>ENI2C</td>
<td>O</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>F7</td>
<td>DT1H</td>
<td>O</td>
<td>Rectification high side switch gate control 1</td>
<td>Controls the switching gate of high side of the rectifier</td>
</tr>
<tr>
<td>G1</td>
<td>VRECT</td>
<td>Power Supply</td>
<td>Voltage of rectifier</td>
<td>Voltage of the rectifier output becomes the power supply of AN32258A.</td>
</tr>
<tr>
<td>G2</td>
<td>SELHV</td>
<td>I</td>
<td>Test pin</td>
<td>Leave this pin open. Panasonic uses this pin for test purposes only.</td>
</tr>
<tr>
<td>G3</td>
<td>VREG34V</td>
<td>O</td>
<td>Internal regulator output</td>
<td>Outputs a voltage level of 3.4V.</td>
</tr>
<tr>
<td>G4</td>
<td>LED</td>
<td>O</td>
<td>LED control</td>
<td>This pin is internally connected to the drain of NMOS which turns on when</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>the LDO outputs a voltage.</td>
</tr>
<tr>
<td>G5</td>
<td>VREG47V</td>
<td>O</td>
<td>Internal regulator output</td>
<td>Outputs a voltage level of 4.7V.</td>
</tr>
<tr>
<td>G6</td>
<td>BT1</td>
<td>O</td>
<td>Boot strap 1</td>
<td>Connect to the rectifier</td>
</tr>
<tr>
<td>G7</td>
<td>BT2</td>
<td>O</td>
<td>Boot strap 2</td>
<td>Connect to the rectifier</td>
</tr>
</tbody>
</table>
FUNCTIONS

AN32258A has the following functions.

<table>
<thead>
<tr>
<th>No.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Full charge control</td>
</tr>
<tr>
<td>2</td>
<td>Over current control</td>
</tr>
<tr>
<td>3</td>
<td>Foreign object detection</td>
</tr>
<tr>
<td>4</td>
<td>Over temperature detection</td>
</tr>
<tr>
<td>5</td>
<td>Rectifier voltage control</td>
</tr>
<tr>
<td>6</td>
<td>LED display</td>
</tr>
<tr>
<td>7</td>
<td>External voltage supply switch</td>
</tr>
</tbody>
</table>

1. Full Charge Control

AN32258A has two ways to detect full-charge.

1-1. Switch ON/OFF externally : FULLCH (Pin E5)

AN32258A recognizes an input of high level to FULLCH as full-charge detected and an input of low level as full-charge not detected. When full-charge is detected, a Qi protocol of End Power Transfer Packet will be sent to Tx. The Tx will then stop the power transmission, and the output of AN32258A will shutdown. Keep the high level to FULLCH for longer than 50μs for full-charge detection. Change it to low level to restart charging. When this function with FULLCH is not needed, connect the pin to GND.

*Time to resume power transmission depends on the Tx. When NN32251A is used, it will take 15 minutes to restart power transmission after full-charge is detected. Notice that the charge may start and stop repeatedly, if the Tx does not have sufficient time to resume power transmission.

![Diagram of Full Charge Detection by FULLCH](image-url)
FUNCTIONS (Continued)

1-2. Control by output current: FCCNT (Pin C5)
When charging current becomes less than the value set at FCCNT (Pin C5), the power transmission
stops as full charge. The threshold is determined by a pull-down resistor connected at this pin.
For example, when a resistor of 100kohm is used, decreasing output current to less than 80mA will shutdown
the LDO, and also data is sent to Tx to stop power transmission. The data to transmit is defined in Qi and
called End Power Transfer packet. The current detection starts 5 seconds after power transmission starts.

Connect this pin to VREG34V, when this full-charge detection is not needed. When FULLCH pin is
connected to high level to be activated, FCCNT will not control the full-charge detection. This function does
not work for FCCNT voltage of over 3V. Also, note that the minimum threshold is 40mA.

*Time to resume power transmission depends on the Tx. When NN32251A is used, it will take 15 minutes to restart
power transmission after full-charge is detected. Notice that the charge may start and stop repeatedly, if the Tx
does not have sufficient time to resume power transmission.

![Diagram of Communication Signal (Figure A-2. Full Charge Detection by FCCNT)](image)

![Graph of Full Charge Detection (Figure A-3.)](image)

\[
\text{Full-charge Current [mA]} = \frac{2000}{3.4} \times 0.00000136 \times R[\Omega]
\]
FUNCTIONS (Continued)

2. Current Limit Control
When the output current exceeds the threshold value, AN32258A will shutdown the output.
When this over-current is detected, data is sent to Tx to stop power transmission. The data to transmit to Tx is End Power Transfer packet defined in Qi, and right after the Tx receives the data, it stops its power transmission. The threshold value is about 1.5A.

![Timing characteristics for current limit control](image)

3. Foreign Object Detection
AN32258A has a foreign object detection complying with the WPC 1.1 specification. The specification defines a foreign object when the difference between transmitted power and received power is large. The Tx measures the power difference and stops power transmission when the difference is large. The value of Received Power (address 04h) can be adjusted by the following three pins.

3-1. Offset Control: FOD (Pin E6)
Connect a pull-down resistor at FOD pin to adjust the offset level of received power sent to the Tx. For example, a pull-down resistor of 100kohm will set the offset to be zero. This function does not work for FOD voltage of over 3V. If this function is not needed, connect the FOD pin to VREG34V.

![FOD offset is controlled by a resistor connected to FOD pin](image)
Functions (Continued)

3. Foreign Object Detection (Continued)

3-2. Offset Control for low current: FOD (Pin F5)
An offset can be introduced to the received power for low current at IOUT.
Set the FODL pin to either logical high or low.

- Low (GND) : No offset
- High (over 1.6V) : Offset added (IOUT < ~125mA)

3-3. Gain control: FODG (Pin C6)
The gain of received power can be adjusted by a pull-down resistor connected at this pin. The resistance can be varied from 10k ohms to 180k ohms as the following figure shows.

![Figure A-5-1. The relationship between received power gain and pull-down resistance at FODG](image)

4. Over Temperature Detection: VTH (Pin C2)
A thermistor, ERTJ0EV104F recommended, can be connected to VTH pin. Connecting a resistor from VTH to VREG34V will fix the threshold temperature. For example, a 47kΩ resistor yields a threshold of 60 °C.
Refer to TYPICAL CHARACTERISTICS section for more detail.
Connect to VREEG34V (G3) if thermistors are not in use.
5. Rectifier Voltage Control

AN32258A controls the rectifier output (VRECT) depending on the current value (IOUT). The following figure shows the change of VRECT due to IOUT. Note that the changed timing in increasing IOUT is different from that in decreasing IOUT.

Figure A-8. VRECT changes by the value of output current.
(Values shown are for reference.)
6. LED Display : LED (Pin G4)
AN32258A has LED driver. Connect an LED and a resistor in series from OUT to LED pins.
The LED turns on and off as the following figure shows.

Table A-1. LED Display

<table>
<thead>
<tr>
<th>Status</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standby</td>
<td>OFF</td>
</tr>
<tr>
<td>Charging</td>
<td>ON</td>
</tr>
<tr>
<td>Full-charge detected</td>
<td>OFF</td>
</tr>
<tr>
<td>External power supply detected</td>
<td>OFF</td>
</tr>
<tr>
<td>Over-current detected</td>
<td>OFF</td>
</tr>
<tr>
<td>Over-temperature detected</td>
<td>OFF</td>
</tr>
</tbody>
</table>

7. External Voltage Supply Switch : EXT (Pin B3), EXTCNT (Pin B2)
The voltage supply to a charger can be switched from AN32258A to some external voltage supply, such as USB.
For this function to work, introduce an external voltage to EXT pin. When EXT becomes larger than 4.2V,
the external MOSFET switch will turn on to output the external voltage in direct. Also, End Power Transfer
Packet is sent to Tx to stop power transmission at the same time.
If the external voltage supply becomes lower than 3.8V, the external MOSFET switch will turn off. Then, Tx will
resume power transmission, and AN32258A will start to output at the LDO. Refer to the circuit diagram before
FUNCTIONS section for the configuration at EXT pin.
EVALUATION RESULTS

Evaluation Circuit Diagram

Conditions:

EXT (B3): 5V input
FCCNT (C5): Pulled down with a 100kΩ resistor for section 3, and connected to REG34V for other evaluations.
FULLCH (E5): Voltage swept for section 3, and connected to GND for other evaluations.

Coil (L1): 13.94μH (TDK: WR464650-12K5-P2)
Charger: NN32251AA_EVM(A11) (except section 12)

Figure B-1. AN32258A Evaluation Circuit
TYPICAL CHARACTERISTICS (Continued)

1. Output Voltage Characteristics

![Figure B-2 Output Voltage vs Output Current](image)

2. $V_{\text{RECT}}$ Voltage Characteristics

![Figure B-3 $V_{\text{RECT}}$ Voltage vs Output Current](image)

3. Full-Charge Characteristics

![Figure B-4 Full-Charge Detecting Current vs FCCNT Voltage with a 100kΩ Resistor Connected](image)

![Figure B-5 Output Voltage vs FULLCH Level](image)

![Figure B-6 Received Signal Characteristics after a Full-Charge Detection](image)

*After the output voltage becomes zero, an End Power Transfer Packet is sent.*
4. Over Current Protection Characteristics

![Figure B-7 VOUT vs IOUT](image)

**Figure B-7 VOUT vs IOUT**

5. Temperature Detection Characteristics

![Figure B-8 Output Voltage vs VTH](image)

**Figure B-8 Output Voltage vs VTH**

![Figure B-9 Received Signal Characteristics after a Temperature Detection](image)

**Figure B-9 Received Signal Characteristics after a Temperature Detection**

*Conditions: IOUT = 500mA*

The power transmission from Tx stops due to temperature detection (VTH).
TYPICAL CHARACTERISTICS (Continued)

6. Over Voltage Protection Characteristics

![Figure B-10 VOUT vs VRECT by OVP](image1)

![Figure B-11 Output Voltage Response by OVP](image2)

7. Foreign Object Detection Characteristics

![Figure B-12 Received Power vs FOD Voltage](image3)

*Received Power = (RPWR[7:0] / 128) × (Maximum Power / 2) × 10Power Class W
TYPICAL CHARACTERISTICS (Continued)

8. External Power Supply Switch Characteristics

Figure B-13 Voltage when an External Power is Inputted during Normal Wireless Power Transmission
*Condition : IOUT=500mA

9. Start-up Characteristics

Figure B-15 Characteristics of Starting Wireless Power Transmission
*Condition : IOUT=1000mA

10. Communication Packet Configuration

Figure B-16 Rx Communication Packet Structure
TYPICAL CHARACTERISTICS (Continued)

11. LED Display Characteristics

Figure B-17 LED Characteristics 1
*Condition: LED is pulled up to VREG34V first

Figure B-18 LED Characteristics 2
*LED lights up when the output starts.

Figure B-19 LED Turned off by a Full Charge
*FULLCH detects a full-charge, and LED turns off when the output goes down.

Figure B-20 LED Turned off by an over temperature
*VTH detects an over temperature, and LED turns off when the output goes down.

Figure B-21 LED Turned off by an over current
After an over current is detected, LED turns off when the output goes down.


TYPICAL CHARACTERISTICS (Continued)

12. Power Efficiency

![Figure B-22. Power Efficiency](image)

13. Transient Characteristics

![Figure B-23. Load current changed](image)

VRECT minimum: 4.25V

![Figure B-24. Load Current Changed](image)

VRECT minimum: 4.47V

![Figure B-25. Load current changed](image)

VRECT minimum: 4.65V

![Figure B-26. Load current changed](image)

VRECT minimum: 4.74V

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Documentation:

- **Doc No.**: TA4-EA-06273
- **Revision**: 1
- **Established**: 2014-10-22
- **Revised**: 2014-10-22

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*AN32258A Ver.2.00*
TYPICAL CHARACTERISTICS (Continued)

13. Transient Characteristics (Continued)

Figure B-27. Load Current Changed (400mA → 1000mA)

Figure B-28. Load Current Changed (400mA → 800mA)

Figure B-29. Load Current Changed (400mA → 600mA)

14. VOUT Ripple Voltage

Figure B-30. VOUT Ripple Characteristics
Package Information

**Package Code:** XBGA048-W-3232AML

Unit: mm

---

**Established:** 2014-10-22

**Revised:** ####-##-##
IMPORTANT NOTICE

1. When using the IC for new models, verify the safety including the long-term reliability for each product.
2. When the application system is designed by using this IC, please confirm the notes in this book.
   Please read the notes to descriptions and the usage notes in the book.
3. This IC is intended to be used for general electronic equipment.
   Consult our sales staff in advance for information on the following applications: Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this IC may directly jeopardize life or harm the human body.
   Any applications other than the standard applications intended.
   (1) Space appliance (such as artificial satellite, and rocket)
   (2) Traffic control equipment (such as for automotive, airplane, train, and ship)
   (3) Medical equipment for life support
   (4) Submarine transponder
   (5) Control equipment for power plant
   (6) Disaster prevention and security device
   (7) Weapon
   (8) Others : Applications of which reliability equivalent to (1) to (7) is required
   Our company shall not be held responsible for any damage incurred as a result of or in connection with the IC being used for any special application, unless our company agrees to the use of such special application.
   However, for the IC which we designate as products for automotive use, it is possible to be used for automotive.
4. This IC is neither designed nor intended for use in automotive applications or environments unless the IC is designated by our company to be used in automotive applications.
   Our company shall not be held responsible for any damage incurred by customers or any third party as a result of or in connection with the IC being used in automotive application, unless our company agrees to such application in this book.
5. Please use this IC in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Our company shall not be held responsible for any damage incurred as a result of our IC being used by our customers, not complying with the applicable laws and regulations.
6. Pay attention to the direction of the IC. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might be damaged.
7. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins.
   In addition, refer to the Pin Description for the pin configuration.
8. Perform visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as solder-bridge between the pins of the IC. Also, perform full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the IC during transportation.
9. Take notice in the use of this IC that it might be damaged when an abnormal state occurs such as output pin-VCC short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short). Safety measures such as installation of fuses are recommended because the extent of the above-mentioned damage will depend on the current capability of the power supply.
10. The protection circuit is for maintaining safety against abnormal operation. Therefore, the protection circuit should not work during normal operation.
    Especially for the thermal protection circuit, if the area of safe operation or the absolute maximum rating is momentarily exceeded due to output pin to VCC short (Power supply fault), or output pin to GND short (Ground fault), the IC might be damaged before the thermal protection circuit could operate.
11. Unless specified in the product specifications, make sure that negative voltage or excessive voltage are not applied to the pins because the IC might be damaged, which could happen due to negative voltage or excessive voltage generated during the ON and OFF timing when the inductive load of a motor coil or actuator coils of optical pick-up is being driven.
12. Verify the risks which might be caused by the malfunctions of external components.
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(4) The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date Product Standards in advance to make sure that the latest specifications satisfy your requirements.

(5) When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment. Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.

(6) Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. We do not guarantee quality for disassembled products or the product re-mounted after removing from the mounting board. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.

(7) When reselling products described in this book to other companies without our permission and receiving any claim of request from the resale destination, please understand that customers will bear the burden.

(8) This book may be not reprinted or reproduced whether wholly or partially, without the prior written permission of our company.