CMOS LDO Regulators for Automotive

1ch 200mA
CMOS LDO Regulators
BUxxJA2DG-C series

General Description
BUxxJA2DG-C series are high-performance CMOS LDO regulators with output current ability of up to 200mA. The SSOP5 package can contribute to the downsizing of the set. These devices have excellent noise and load response characteristics despite of its low circuit current consumption of 33µA. They are most appropriate for various applications such as power supplies for radar modules and camera modules.

Features
- AEC-Q100 qualified(Note 1)
- High Output Voltage Accuracy: ±2.0%
  (In all recommended conditions)
- High Ripple Rejection: 68 dB (Typ, 1kHz)
- Compatible with small ceramic capacitor
  (Cin=Cout=0.47µF)
- Low Current Consumption: 33µA
- Output Voltage ON/OFF control
- Output Discharge
- Built-in Over Current Protection Circuit (OCP)
- Built-in Thermal Shutdown Circuit (TSD)
- Package SSOP5 is similar to SOT23-5(JEDEC)
  (Note1:Grade1)

Applications
- Automotive (Radar modules, Camera modules, etc.)

Typical Application Circuit

![Typical Application Circuit](image)

Key Specifications
- Input Power Supply Voltage Range: 1.7V to 6.0V
- Output Current Range: 0 to 200mA
- Operating Temperature Range: -40°C to +125°C
- Output Voltage Lineup: 1.0V to 3.3V
- Output Voltage Accuracy: ±2.0%
- Circuit Current: 33µA(Typ)
- Standby Current: 0µA (Typ)

Package
SSOP5
W(Typ) x D(Typ) x H(Max)
2.90mm x 2.80mm x 1.25mm

Figure 1. Typical Application Circuit
### Ordering Information

<table>
<thead>
<tr>
<th>BUXXJA2DG-C Series</th>
<th>CTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Number</td>
<td>Output Voltage</td>
</tr>
<tr>
<td>10 : 1.0V</td>
<td>Maximum Output Current : 200mA</td>
</tr>
<tr>
<td>12 : 1.2V</td>
<td>G : SSOP5</td>
</tr>
<tr>
<td>1C : 1.25V</td>
<td>Maximum Power Supply Voltage Range : 6.5V</td>
</tr>
<tr>
<td>15 : 1.5V</td>
<td></td>
</tr>
<tr>
<td>18 : 1.8V</td>
<td></td>
</tr>
<tr>
<td>25 : 2.5V</td>
<td></td>
</tr>
<tr>
<td>28 : 2.8V</td>
<td></td>
</tr>
<tr>
<td>2J : 2.85V</td>
<td></td>
</tr>
<tr>
<td>30 : 3.0V</td>
<td></td>
</tr>
<tr>
<td>33 : 3.3V</td>
<td></td>
</tr>
</tbody>
</table>

### Pin Descriptions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VIN</td>
<td>Input Pin</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>GND Pin</td>
</tr>
<tr>
<td>3</td>
<td>STBY</td>
<td>Output Control Pin (High:ON, Low:OFF)</td>
</tr>
<tr>
<td>4</td>
<td>N.C.</td>
<td>No Connect</td>
</tr>
<tr>
<td>5</td>
<td>VOUT</td>
<td>Output Pin</td>
</tr>
</tbody>
</table>

### Pin Configurations

SSOP5 (Top view)

- VOUT 5
- N.C. 4
- 1 VIN
- 2 GND
- 3 STBY

### Block Diagram

![Block Diagram](image)

Figure 2. Block diagram
Description of Blocks

<table>
<thead>
<tr>
<th>Block</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STBY</td>
<td>Control Standby mode</td>
<td>STBY controls internal block active and standby state</td>
</tr>
<tr>
<td>VREF</td>
<td>Internal Reference Voltage</td>
<td>VREF generates reference voltage.</td>
</tr>
<tr>
<td>AMP</td>
<td>Error AMP</td>
<td>AMP amplifies electric signal and drives output power transistor.</td>
</tr>
<tr>
<td>OCP</td>
<td>Over Current Protection</td>
<td>When output current exceeds current ability, OCP restricts Output Current.</td>
</tr>
<tr>
<td>TSD</td>
<td>Thermal Shutdown</td>
<td>When Junction temperature rise and exceed Maximum junction temperature, TSD turns off Output power transistor.</td>
</tr>
</tbody>
</table>

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Power Supply Voltage Range</td>
<td>V_IN</td>
<td>-0.3 to +6.5(Note1)</td>
<td>V</td>
</tr>
<tr>
<td>STBY Voltage</td>
<td>V_STBY</td>
<td>-0.3 to +6.5</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>Tj_max</td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Tp</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>Tstg</td>
<td>-55 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(Note1) Not to exceed Tjmax

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Recommended Operating Ratings(Ta=-40°C to +125°C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limit</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power Supply Voltage Range</td>
<td>V_IN</td>
<td>1.7 to 6.0</td>
<td>V</td>
</tr>
<tr>
<td>STBY voltage</td>
<td>V_STBY</td>
<td>1.7 to 6.0</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Output Current</td>
<td>I_OMAX</td>
<td>0 to 200</td>
<td>mA</td>
</tr>
</tbody>
</table>

Recommended Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating (Min, Typ, Max)</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input capacitor</td>
<td>C_in</td>
<td>0.47(Note1) 1.0 100</td>
<td>µF</td>
<td>A ceramic capacitor is recommended.</td>
</tr>
<tr>
<td>Output capacitor</td>
<td>C_out</td>
<td>0.47(Note1) 1.0 100</td>
<td>µF</td>
<td>A ceramic capacitor is recommended.</td>
</tr>
</tbody>
</table>

(Note1) Set the value of the capacitor so that it does not fall below the minimum value. Take into consideration the temperature characteristics, DC device characteristics and degradation with time.
### Thermal Resistance (Note 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Thermal Resistance (Typ)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction to Ambient</td>
<td>$\theta_{JA}$</td>
<td>376.5</td>
<td>185.4</td>
</tr>
<tr>
<td>Junction to Top Characterization Parameter (Note 2)</td>
<td>$\Psi_{JT}$</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

(Note 1) Based on JESD51-2A (Still-Air).
(Note 2) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

#### Layer Number of Measurement Board

<table>
<thead>
<tr>
<th>Material</th>
<th>Board Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>FR-4 114.3mm x 76.2mm x 1.57mm</td>
</tr>
</tbody>
</table>

#### Top

- Copper Pattern Thickness
- Footprints and Traces 70μm

(Note 4) Using a PCB board based on JESD51-7.

<table>
<thead>
<tr>
<th>Layer Number of Measurement Board</th>
<th>Material</th>
<th>Board Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Layers</td>
<td>FR-4</td>
<td>114.3mm x 76.2mm x 1.6mm</td>
</tr>
</tbody>
</table>

#### Bottom

<table>
<thead>
<tr>
<th>Copper Pattern Thickness</th>
<th>Copper Pattern Thickness</th>
<th>Copper Pattern Thickness</th>
<th>Copper Pattern Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>70μm</td>
<td>74.2mm x 74.2mm</td>
<td>35μm</td>
<td>74.2mm x 74.2mm</td>
</tr>
</tbody>
</table>
## Electrical Characteristics

(Unless otherwise noted, $T_a=40$ to $125^\circ C$, $V_{IN}=V_{OUT}+1.0V$\(^{(Note 1)}\), $V_{STBY}=1.5V$, $C_{IN}=1\mu F$, $C_{OUT}=1\mu F$.

The Typical value is defined at $T_a=25^\circ C$)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limit</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage</td>
<td>$V_{OUT}$</td>
<td>$V_{OUT} \times 0.98$</td>
<td>$V_{OUT} \times 1.02$</td>
<td>$V$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{OUT}&gt;2.5V$, $V_{IN}=V_{OUT}+0.5$ to $6.0V$</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>$V_{DLI}$</td>
<td>-</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{OUT}\geq2.5V$, $V_{IN}=3.0$ to $6.0V$</td>
</tr>
<tr>
<td>Load Regulation1</td>
<td>$V_{DLO1}$</td>
<td>-</td>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>Load Regulation2</td>
<td>$V_{DLO2}$</td>
<td>-</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>$V_{DROP}$</td>
<td>-</td>
<td>160</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{OUT}=2.5V$, $I_{OUT}=100mA$</td>
</tr>
<tr>
<td>Maximum Output Current</td>
<td>$I_{OMAX}$</td>
<td>200</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Limit Current</td>
<td>$I_{LMAX}$</td>
<td>250</td>
<td>400</td>
<td>-</td>
</tr>
<tr>
<td>Short Current</td>
<td>$I_{SHORT}$</td>
<td>-</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Circuit Current</td>
<td>$I_{GND}$</td>
<td>-</td>
<td>33</td>
<td>80</td>
</tr>
<tr>
<td>Circuit Current (STBY)</td>
<td>$I_{CCST}$</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
</tr>
<tr>
<td>Ripple Rejection Ratio</td>
<td>R.R.</td>
<td>-</td>
<td>68</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$I_{OUT}=10mA$, $T_a=25^\circ C$</td>
</tr>
<tr>
<td>Load Transient Response</td>
<td>$V_{LOT}$</td>
<td>-</td>
<td>$\pm 65$</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{IN}=V_{OUT}+1.0V$, $T_a=25^\circ C$</td>
</tr>
<tr>
<td>Line Transient Response</td>
<td>$V_{LIT}$</td>
<td>-</td>
<td>$\pm 5$</td>
<td>-</td>
</tr>
<tr>
<td>Output Noise Voltage</td>
<td>$V_{NOSIS}$</td>
<td>-</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Startup Time(^{(Note 2)})</td>
<td>$T_{ST}$</td>
<td>-</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Discharge Resistor</td>
<td>$R_{DISC}$</td>
<td>20</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>STBY Control Voltage</td>
<td>$V_{STBH}$</td>
<td>1.1</td>
<td>-</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>$V_{STBL}$</td>
<td>0</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>STBY Pin Current</td>
<td>$I_{STBY}$</td>
<td>-</td>
<td>-</td>
<td>4.0</td>
</tr>
</tbody>
</table>

\(^{(Note 1)}V_{IN}=3.0V$ for $V_{OUT}<2.5V$.\n
\(^{(Note 2)}$Startup time=time from EN assertion to $V_{OUT} \times 0.98$.\n
Reference data BU18JA2DG-C (Unless otherwise specified, Ta=25°C)

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**Figure 3. Output Voltage vs. Input Voltage**

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**Figure 4. Line Regulation**

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**Figure 5. Circuit Current vs. Input Voltage**

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**Figure 6. Load Regulation**
Reference data BU18JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 7. Circuit Current vs. Output Current

Figure 8. OCP Threshold

Figure 9. Output Voltage vs. Temperature

Figure 10. Circuit Current vs. Temperature
Reference data BU18JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 11. STBY Threshold

Figure 12. Circuit Current (STBY) vs. Temperature

Figure 13. STBY Pin Current vs. STBY Pin Voltage

Figure 14. Dropout Voltage vs. Output Current
Reference data BU18JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 15. Ripple Rejection Ratio vs. Frequency
Reference data BU18JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 16. Load Response (1mA to 100mA)

Figure 17. Load Response (1mA to 150mA)

Figure 18. Line Transient Response (3.0 to 3.5V)

Figure 19. Line Transient Response (3.0V to 6.0V)
Reference data BU18JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 20. Startup Time
(Rout=open)

Figure 21. Startup Time
(Rout=9Ω)

Figure 22. Discharge Time
(Rout=open)

Figure 23. Discharge Time
(Rout=9Ω)
Reference data BU28JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 24. Output Voltage vs. Input Voltage

Figure 25. Line Regulation

Figure 26. Circuit Current vs. Input Voltage

Figure 27. Load Regulation
Reference data BU28JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 28. Circuit Current vs. Output Current

Figure 29. OCP Threshold

Figure 30. Output Voltage vs. Temperature

Figure 31. Circuit Current vs. Temperature
Reference data BU28JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 32. STBY Threshold

Figure 33. Circuit Current (STBY) vs. Temperature

Figure 34. STBY Pin Current vs. STBY Pin Voltage

Figure 35. Dropout Voltage vs. Output Current
Reference data BU28JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 36. Ripple Rejection Ratio vs. Frequency

Ripple Rejection Ratio R.R. (dB) vs. Frequency (Hz)

- Ta=25°C
- VIN=3.8V
- VRR=-20dBv
- VSTBY=1.5V
- IOUT=10mA
- Cin=Cout=1μF
Reference data BU28JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 37. Load Response (1mA to 100mA)

Figure 38. Load Response (1mA to 150mA)

Figure 39. Line Transient Response (3.3V to 3.8V)

Figure 40. Line Transient Response (3.3V to 6.0V)
Reference data BU28JA2DG-C (Unless otherwise specified, Ta=25°C)

Figure 41. Startup Time (Rout=open)

Figure 42. Startup Time (Rout=14Ω)

Figure 43. Discharge Time (Rout=open)

Figure 44. Discharge Time (Rout=14Ω)
Input/Output Capacitor

It is recommended that a capacitor is placed close to pin between input pin and GND as well as output pin and GND. The input capacitor becomes more necessary when the power supply impedance is high or when the PCB trace has significant length. Moreover, the higher the capacitance of the output capacitor the more stable the output will be, even with load and line voltage variations. However, please check the actual functionality by mounting on a board for the actual application. Also, ceramic capacitors usually have different thermal and equivalent series resistance characteristics and may degrade gradually over continued use.

For additional details, please check with the manufacturer and select the best ceramic capacitor for your application.

Figure 46. Stability area characteristics (Cin=0.47μF, Cout=0.47μF VIN=1.7V to 6.0V)

Equivalent Series Resistance (ESR) of a Ceramic Capacitor

To prevent oscillation, please attach a capacitor between VOUT and GND. Generally, capacitors have ESR (Equivalent Series Resistance) and is different for each type- ceramic, tantalum, electrolytic type etc. Please use the stable operating region graph on the right as reference then confirm capacitor’s ESR to ensure that the actual application evaluation is within the stable operating range.

Figure 45. Ceramic Capacitor Capacitance Value vs. DC Bias Characteristics (Characteristics Example)
Power Dissipation

IC mounted on ROHM standard board based on JEDEC.

① : 1-layer PCB
(Copper foil area on the reverse side of PCB: 0 mm × 0 mm)
Board material: FR4
Board size: 114.3 mm × 76.2 mm × 1.57 mmt
Mount condition: PCB and exposed pad are soldered.
Top copper foil: ROHM recommended footprint + wiring to measure, 2 oz. copper.

② : 4-layer PCB
(2 inner layers copper foil area of PCB, copper foil area on the reverse side of PCB: 74.2 mm × 74.2 mm)
Board material: FR4
Board size: 114.3 mm × 76.2 mm × 1.6 mmt
Mount condition: PCB and exposed pad are soldered.
Top copper foil: ROHM recommended footprint + wiring to measure, 2 oz. copper.
2 inner layers copper foil area of PCB: 74.2 mm × 74.2 mm, 1 oz. copper.
Copper foil area on the reverse side of PCB: 74.2 mm × 74.2 mm, 2 oz. copper.

Condition①: θJA = 376.5 °C/W, ΨJT (top center) = 40 °C/W
Condition②: θJA = 185.4 °C/W, ΨJT (top center) = 30 °C/W

Figure 47. Power Dissipation (Reference Data)
Thermal Design

Within this IC, the power consumption is decided by the dropout voltage condition, the load current and the circuit current. Refer to power dissipation curves illustrated in Figure 47 when using the IC in an environment of Ta ≥ 25 °C. Even if the ambient temperature Ta is at 25 °C, depending on the input voltage and the load current, chip junction temperature can be very high. Consider the design to be Tj ≤ Tjmax = 150 °C in all possible operating temperature range.

Should by any condition the maximum junction temperature Tjmax = 150 °C rating be exceeded by the temperature increase of the chip, it may result in deterioration of the properties of the chip. The thermal impedance in this specification is based on recommended PCB and measurement condition by JEDEC standard. Verify the application and allow sufficient margins in the thermal design by the following method is used to calculate the junction temperature Tj.

Tj can be calculated by either of the two following methods.

1. The following method is used to calculate the junction temperature Tj.

\[ Tj = Ta + PC \times \thetaJA \]

Where:
- \( Tj \): Junction Temperature
- \( Ta \): Ambient Temperature
- \( PC \): Power Consumption
- \( \thetaJA \): Thermal Impedance
  (Junction to Ambient)

2. The following method is also used to calculate the junction temperature Tj.

\[ Tj = TT + PC \times \PsiJT \]

Where:
- \( Tj \): Junction Temperature
- \( TT \): Top Center of Case’s (mold) Temperature
- \( PC \): Power consumption
- \( \PsiJT \): Thermal Impedance
  (Junction to Top Center of Case)

The following method is used to calculate the power consumption \( PC \) (W).

\[ PC = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND} \]

Where:
- \( PC \): Power Consumption
- \( V_{IN} \): Input Voltage
- \( V_{OUT} \): Output Voltage
- \( I_{OUT} \): Load Current
- \( I_{GND} \): Circuit Current
• Calculation Example (SSOP5)

If $V_{IN} = 3.0 \, \text{V}$, $V_{OUT} = 1.8 \, \text{V}$, $I_{OUT} = 50 \, \text{mA}$, $I_{GND} = 33 \, \mu\text{A}$, the power consumption $P_c$ can be calculated as follows:

$$P_c = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND}$$
$$= (3.0 \, \text{V} - 1.8 \, \text{V}) \times 50 \, \text{mA} + 3.0 \, \text{V} \times 33 \, \mu\text{A}$$
$$= 0.06 \, \text{W}$$

At the ambient temperature $T_{\text{max}} = 125^\circ\text{C}$, the thermal impedance (Junction to Ambient)$\theta_{JA} = 185.4 \, ^\circ\text{C} / \text{W}$ (4-layer PCB),

$$T_j = T_{\text{max}} + P_c \times \theta_{JA}$$
$$= 125^\circ\text{C} + 0.06 \, \text{W} \times 185.4 \, ^\circ\text{C} / \text{W}$$
$$= 136.1^\circ\text{C}$$

When operating the IC, the top center of case’s (mold) temperature $T_T = 100 \, ^\circ\text{C}$, $\Psi_{JT} = 40 \, ^\circ\text{C} / \text{W}$ (1-layer PCB),

$$T_j = T_T + P_c \times \Psi_{JT}$$
$$= 100 \, ^\circ\text{C} + 0.06 \, \text{W} \times 40 \, ^\circ\text{C} / \text{W}$$
$$= 102.4^\circ\text{C}$$

For optimum thermal performance, it is recommended to expand the copper foil area of the board, increasing the layer and thermal via between thermal land pad.

I/O Equivalence Circuits

<table>
<thead>
<tr>
<th>1pin (VIN)</th>
<th>3pin (STBY)</th>
<th>5pin (VOUT)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="VIN" alt="IC" /></td>
<td><img src="IC" alt="STBY" /></td>
<td><img src="IC" alt="VOUT" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>xx</th>
<th>Output Voltage [V] (Typ)</th>
<th>R1 [kΩ] (Typ)</th>
<th>R2 [kΩ] (Typ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.0</td>
<td>173</td>
<td>185</td>
</tr>
<tr>
<td>12</td>
<td>1.2</td>
<td>241</td>
<td>185</td>
</tr>
<tr>
<td>1C</td>
<td>1.25</td>
<td>260</td>
<td>185</td>
</tr>
<tr>
<td>15</td>
<td>1.5</td>
<td>352</td>
<td>185</td>
</tr>
<tr>
<td>18</td>
<td>1.8</td>
<td>463</td>
<td>185</td>
</tr>
<tr>
<td>25</td>
<td>2.5</td>
<td>710</td>
<td>185</td>
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<tr>
<td>33</td>
<td>3.3</td>
<td>1001</td>
<td>185</td>
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</table>

Figure 48. Input / Output equivalent circuit
Linear Regulators Surge Voltage Protection
The following provides instructions on surge voltage over absolute maximum ratings polarity protection for ICs.

1. Applying positive surge to the input
   If the possibility exists that surges higher than absolute maximum ratings 6.5 V will be applied to the input, a Zener Diode should be placed to protect the device in between the \( V_{IN} \) and the GND as shown in the figure 49.

   ![Figure 49. Surges Higher than 6.5 V will be Applied to the Input](image)

2. Applying negative surge to the input
   If the possibility exists that surges lower than absolute maximum ratings -0.3 V will be applied to the input, a Schottky Diode should be placed to protect the device in between the \( V_{IN} \) and the GND as shown in the figure 50.

   ![Figure 50. Surges Lower than -0.3 V will be Applied to the Input](image)

Linear Regulators Reverse Voltage Protection
A linear regulator integrated circuit (IC) requires that the input voltage is always higher than the regulated voltage. Output voltage, however, may become higher than the input voltage under specific situations or circuit configurations, and that reverse voltage and current may cause damage to the IC. A reverse polarity connection or certain inductor components can also cause a polarity reversal between the input and output pins. The following provides instructions on reversed voltage polarity protection for ICs.

1. about Input /Output Voltage Reversal
   In an MOS linear regulator, a parasitic element exists as a body diode in the drain-source junction portion of its power MOSFET. Reverse input/output voltage triggers the current flow from the output to the input through the body diode. The inverted current may damage or destroy the semiconductor elements of the regulator since the effect of the parasitic body diode is usually disregarded for the regulator behavior (Figure 51).

   ![Figure 51. Reverse Current Path in an MOS Linear Regulator](image)
An effective solution to this is an external bypass diode connected in-between the input and output to prevent the reverse current flow inside the IC (see Figure 52). Note that the bypass diode must be turned on before the internal circuit of the IC. Bypass diodes in the internal circuits of MOS linear regulators must have low forward voltage $V_F$. Some ICs are configured with current-limit thresholds to shut down high reverse current even when the output is off, allowing large leakage current from the diode to flow from the input to the output; therefore, it is necessary to choose one that has a small reverse current. Specifically, select a diode with a rated peak inverse voltage greater than the input to output voltage differential and rated forward current greater than the reverse current during use.

![Figure 52. Bypass Diode for Reverse Current Diversion](image)

The lower forward voltage ($V_F$) of Schottky barrier diodes cater to requirements of MOS linear regulators, however the main drawback is found in the level of their reverse current ($I_R$), which is relatively high. So, one with a low reverse current is recommended when choosing a Schottky diode. The $V_IN$-$I_R$ characteristics versus temperatures show increases at higher temperatures.

If $V_IN$ is open in a circuit as shown in the following Figure 53 with its input/output voltage being reversed, the only current that flows in the reverse current path is the bias current of the IC. Because the amperage is too low to damage or destroy the parasitic element, a reverse current bypass diode is not required for this type of circuit.

![Figure 53. Open V_IN](image)

2. Protection against Input Reverse Voltage

Accidental reverse polarity at the input connection flows a large current to the diode for electrostatic breakdown protection between the input pin of the IC and the GND pin, which may destroy the IC (see Figure 54).

A Schottky barrier diode or rectifier diode connected in series with the power supply as shown in Figure 55 is the simplest solution to prevent this from happening. The solution, however, is unsuitable for a circuit powered by batteries because there is a power loss calculated as $V_F \times I_{OUT}$ as the forward voltage $V_F$ of the diode drops in a correct connection. The lower $V_F$ of a Schottky barrier diode than that of a rectifier diode gives a slightly smaller power loss. Because diodes generate heat, care must be taken to select a diode that has enough allowance in power dissipation. A reverse connection allows a negligible reverse current to flow in the diode.

![Figure 54. Current Path in Reverse Input Connection](image)

![Figure 55. Protection against Reverse Polarity 1](image)
Figure 56 shows a circuit in which a P-channel MOSFET is connected in series with the power. The diode located in the drain-source junction portion of the MOSFET is a body diode (parasitic element). The voltage drop in a correct connection is calculated by multiplying the resistance of the MOSFET being turned on by the output current \( I_{OUT} \), therefore it is smaller than the voltage drop by the diode (see Figure 55) and results in less of a power loss. No current flows in a reverse connection where the MOSFET remains off.

If the voltage taking account of derating is greater than the voltage rating of MOSFET gate-source junction, lower the gate-source junction voltage by connecting voltage dividing resistors as shown in Figure 57.

![Figure 56. Protection against Reverse Polarity 2](image)

![Figure 57. Protection against Reverse Polarity 3](image)

3. Protection against Output Reverse Voltage when Output Connect to an Inductor

If the output load is inductive, electrical energy accumulated in the inductive load is released to the ground upon the output voltage turning off. In-between the IC output and ground pins is a diode for preventing electrostatic breakdown, in which a large current flows that could destroy the IC. To prevent this from happening, connect a Schottky barrier diode in parallel with the diode (see Figure 58).

Further, if a long wire is in use for the connection between the output pin of the IC and the load, observe the waveform on an oscilloscope, since it is possible that the load becomes inductive. An additional diode is needed for a motor load that is affected by its counter electromotive force, as it produces an electrical current in a similar way.

![Figure 58. Current Path in Inductive Load (Output: Off)](image)
Operational Notes

1) Absolute maximum ratings
   This product is produced with strict quality control, however it may be destroyed if operated beyond its absolute maximum ratings. In addition, it is impossible to predict all destructive situations such as short-circuit modes, open circuit modes, etc. Therefore, it is important to consider circuit protection measures, like adding a fuse, in case the IC is operated in a special mode exceeding the absolute maximum ratings.

2) GND Potential
   GND potential must be the lowest potential of all pins of the IC at all operating conditions. Ensure that no pins are at a voltage below the ground pin at any time, even during transient condition.

3) Setting of Heat
   Carry out the heat design that have adequate margin considering Pd of actual working states.

4) Pin Short and Mistake Fitting
   When mounting the IC on the PCB, pay attention to the orientation of the IC. If there is mistake in the placement, the IC may be burned up.

5) Mutual Impedance
   Use short and wide wiring tracks for the power supply and ground to keep the mutual impedance as small as possible. Use a capacitor to keep ripple to a minimum.

6) STBY Pin Voltage
   To enable standby mode for all channels, set the STBY pin to 0.5 V or less, and for normal operation, to 1.1 V or more. Setting STBY to a voltage over 0.5v and under 1.1 V may cause malfunction and should be avoided. Keep transition time between high and low (or vice versa) to a minimum. Additionally, if STBY is shorted to VIN, the IC will switch to standby mode and disable the output discharge circuit, causing a temporary voltage to remain on the output pin. If the IC is switched on again while this voltage is present, overshoot may occur on the output. Therefore, in applications where these pins are shorted, the output should always be completely discharged before turning the IC on.

7) Over Current Protection Circuit
   Over current and short circuit protection is built-in at the output, and IC destruction is prevented at the time of load short circuit. These protection circuits are effective in the destructive prevention by sudden accidents, please avoid applications to where the over current protection circuit operates continuously.

8) Thermal Shutdown
   This IC has Thermal Shutdown Circuit (TSD Circuit). When the temperature of IC Chip is higher than 175°C(typ), the output is turned off by TSD Circuit. TSD Circuit is only designed for protecting IC from thermal over load. Therefore it is not recommended that you design application where TSD will work in normal condition.

9) Output capacitor
   To prevent oscillation at output, it is recommended that the IC be operated at the stable region shown in Figure 46. It operates at the capacitance of more than 0.47µF. As capacitance is larger, stability becomes more stable and characteristic of output load fluctuation is also improved.
## Marking Diagram

### SSOP5 (TOP VIEW)

- **Part Number Marking**
- **Lot Number**

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<tr>
<th>Part Number</th>
<th>Output Voltage [V]</th>
<th>Part Number Marking</th>
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<td>BU12JA2DG-C</td>
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<td>BU33JA2DG-C</td>
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## Physical Dimension and Packing Information

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**< Tape and Reel Information >**

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</thead>
<tbody>
<tr>
<td>Quantity</td>
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</tbody>
</table>

**Direction of feed:** TR  
The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand.

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TSZ22111 - 15 - 001

TSZ02201-0G5G1AN00020-1-2  
10.Nov.2017 Rev.003
## Revision History

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<td>New Release</td>
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<td>30.Mar.2017</td>
<td>002</td>
<td>p.21 The circuit of 5pin(VOUT) is modified in “I/O Equivalence Circuits”</td>
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<td>p.26 Marking of BU28JA2DG-C is revised.</td>
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<td>10.Nov.2017</td>
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<td>p.25 An expression method of “Marking Diagram” is changed.</td>
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(Note1) Medical Equipment Classification of the Specific Applications

<table>
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<th>CLASS II b</th>
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   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

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1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification
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   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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