OUTLINE

The R1500x series are CMOS-based positive voltage regulator (VR) ICs. The R1500xxxxB has features of high input voltage operating, 500mA output current drive, and low supply current.

A DMOS transistor is used for the driver, high voltage operating and low on resistance (0.6Ω at VOUT=10V) device is realized. A standard regulator circuit with a current limit circuit and a thermal shutdown circuit are built in the R1500x series.

As the operating temperature range is from -40°C to 105°C and maximum input voltage is up to 24V, the R1500x series are suitable for the constant voltage source for car accessories.

The regulator output voltage is fixed in the R1500x. Output voltage accuracy is ±2.0% and output voltage range is from 3.0V to 12.0V with a step of 0.1V. The chip enable pin realizes ultra low supply current standby mode.

Since the packages for these ICs are the SOT-89-5 for high density mounting of the ICs on boards, and the TO-252-5-P2.

* The DMOS (Double Diffused MOS) transistor adopted by R1500x is characterized by a double diffusion structure which comprises a low density n-type (channel) diffused layer and a high density p-type (sources) diffused layer from the edge of the gate electrode. The R1500x series possess outstanding properties of high operating voltage and low on-resistance, which have been achieved by the channel length scaled down to submicron dimensions and decreased thickness of the gate oxide film.

FEATURES

- Input Voltage Range ....................................................4.0V to 24.0V
- Supply Current .............................................................Typ. 70µA
- Standby Current ..........................................................Typ. 0.1µA
- Ripple Rejection .........................................................Typ. 60dB (VOUT=5.0V)
- Temperature-Drift Coefficient of Output Voltage .......Typ. ±100ppm/°C
- Output Current.............................................................Min. 500mA (VIN=VOUT+1V)
- Line Regulation ............................................................Typ. 0.05%/V
- Output Voltage Accuracy ..............................................±2%
- Output Voltage............................................................3.0V to 12.0V (0.1V steps)
  (For other voltages, please refer to MARK INFORMATIONS.)
- Packages...........................................................................SOT-89-5, TO-252-5-P2
- Built-in Current Limit Circuit
- Built-in Fold-Back Circuit
- Built-in Thermal Shutdown Circuit
- Operating Temperature range .........................................−40°C to 105°C

APPLICATIONS

- Power source for home appliances such as refrigerators, rice cookers, electric water warmers, etc.
- Power source for car audio equipment, car navigation system, ETC system, etc.
- Power source for notebook PCs, digital TVs, cordless phones, and private LAN system, etc.
- Power source for office equipment machines such as copiers, printers, facsimiles, scanners, projectors, etc.
**BLOCK DIAGRAMS**

[Diagram of R1500xxxxB IC]

**SELECTION GUIDE**

The output voltage, package for the ICs can be selected at the user's request.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Package</th>
<th>Quantity per Reel</th>
<th>Pb Free</th>
<th>Halogen Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1500HxxxxB-T1-FE</td>
<td>SOT-89-5</td>
<td>1,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>R1500JxxxxB-T1-FE</td>
<td>TO-252-5-P2</td>
<td>3,000 pcs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

xxx : The output voltage can be designated in the range from 3.0V(030) to 12.0V(120) in 0.1V steps. (For other voltages, please refer to MARK INFORMATIONS.)

* R1500J (TO-252-5-P2) is the limited product. As of March in 2014.
PIN CONFIGURATIONS

- SOT-89-5

- TO-252-5-P2

PIN DESCRIPTIONS

- SOT-89-5

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>Input Pin</td>
</tr>
<tr>
<td>2</td>
<td>GND*</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>3</td>
<td>GND*</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>4</td>
<td>CE</td>
<td>Chip Enable Pin (&quot;H&quot; Active)</td>
</tr>
<tr>
<td>5</td>
<td>V&lt;sub&gt;OUT&lt;/sub&gt;</td>
<td>Output Pin</td>
</tr>
</tbody>
</table>

*) The GND pin must be wired together when it is mounted on board.

- TO-252-5-P2

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>Input Pin</td>
</tr>
<tr>
<td>2</td>
<td>GND*</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>3</td>
<td>GND*</td>
<td>Ground Pin</td>
</tr>
<tr>
<td>4</td>
<td>CE</td>
<td>Chip Enable Pin (&quot;H&quot; Active)</td>
</tr>
<tr>
<td>5</td>
<td>V&lt;sub&gt;OUT&lt;/sub&gt;</td>
<td>Output Pin</td>
</tr>
</tbody>
</table>

*) The GND pin must be wired together when it is mounted on board.

*R1500J (TO-252-5-P2) is the limited product. As of March in 2014.
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>Input Voltage</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CE}$</td>
<td>Input Voltage (CE Pin)</td>
<td>-0.3 to $V_{IN} \leq 36$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>Output Voltage</td>
<td>-0.3 to $V_{IN} \leq 36$</td>
<td>V</td>
</tr>
<tr>
<td>$P_D$</td>
<td>Power Dissipation (SOT-89-5)*</td>
<td>900</td>
<td>mW</td>
</tr>
<tr>
<td>$P_D$</td>
<td>Power Dissipation (TO-252-5-P2)*</td>
<td>1900</td>
<td>mW</td>
</tr>
<tr>
<td>$T_{opt}$</td>
<td>Operating Temperature Range</td>
<td>-40 to 105</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature Range</td>
<td>-55 to 125</td>
<td>°C</td>
</tr>
</tbody>
</table>

*) For Power Dissipation, please refer to PACKAGE INFORMATION.

Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the life time and safety for both device and system using the device in the field.

The functional operation at or over these absolute maximum ratings is not assured.
ELECTRICAL CHARACTERISTICS

• R1500xxxxB

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Item</th>
<th>Conditions</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_IN</td>
<td>Input Voltage</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>I_SS</td>
<td>Supply Current</td>
<td>V_IN=V_OUT+1.0V, V_IN=V_CE</td>
<td>70</td>
</tr>
<tr>
<td>I_standby</td>
<td>Standby Current</td>
<td>V_IN=24V</td>
<td>0.1</td>
</tr>
<tr>
<td>V_OUT</td>
<td>Output Voltage</td>
<td>V_IN=V_OUT+1.0V, I_OUT=100mA</td>
<td>×0.98</td>
</tr>
<tr>
<td>ΔV_OUT/ΔI_OUT</td>
<td>Load Regulation</td>
<td>V_IN=V_OUT+2.0V, 0.1mA ≤ I_OUT ≤ 200mA</td>
<td>25</td>
</tr>
<tr>
<td>ΔV_OUT/ΔV_IN</td>
<td>Line Regulation</td>
<td>V_OUT+1V ≥ V_IN ≥ 24V, I_OUT=10mA</td>
<td>0.05</td>
</tr>
<tr>
<td>V_DIFF</td>
<td>Dropout Voltage</td>
<td>I_OUT=200mA</td>
<td>3.0V ≤ V_OUT &lt; 5.0V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.0V ≤ V_OUT &lt; 9.0V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.0V ≤ V_OUT ≤ 12.0V</td>
</tr>
<tr>
<td>ΔV_OUT/ΔT_TOPT</td>
<td>Output Voltage Temperature Coefficient</td>
<td>V_IN=V_OUT+2.0V, I_OUT=100μA, -40°C ≤ T_TOPT ≤ 105°C</td>
<td>±100</td>
</tr>
<tr>
<td>I_LIM</td>
<td>Output Current</td>
<td>V_IN=V_OUT+1.0V</td>
<td>500</td>
</tr>
<tr>
<td>I_SC</td>
<td>Short Current Limit</td>
<td>V_OUT=0V</td>
<td>65</td>
</tr>
<tr>
<td>RR</td>
<td>Ripple Rejection</td>
<td>f=1kHz, Ripple 0.5Vp-p, I_OUT=100mA, V_IN=V_OUT+2V</td>
<td>V_OUT ≤ 6.0V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V_OUT &gt; 6.0V</td>
</tr>
<tr>
<td>V_CE_H</td>
<td>CE Input Voltage &quot;H&quot;</td>
<td>2.0</td>
<td>V_IN</td>
</tr>
<tr>
<td>V_CE_L</td>
<td>CE Input Voltage &quot;L&quot;</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>T_TSD</td>
<td>Thermal Shutdown Temperature</td>
<td>Junction Temperature</td>
<td>150</td>
</tr>
<tr>
<td>T_TSR</td>
<td>Thermal Shutdown Released Temperature</td>
<td>Junction Temperature</td>
<td>145</td>
</tr>
</tbody>
</table>

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

* R1500J (TO-252-5-P2) is the limited product. As of March in 2014.
**TYPICAL APPLICATION**

![Circuit Diagram]

(External Components)
- C1: Ceramic 0.47\(\mu\)F
- C2: Ceramic 10\(\mu\)F  MURATA: GRM32DB31E106K (size: 3225)

**TECHNICAL NOTES**

When using these ICs, consider the following points:

**Phase Compensation**
- In these ICs, phase compensation is made for securing stable operation even if the load current is varied. For this purpose, use a capacitor C2 with good frequency characteristics and ESR (Equivalent Series Resistance).
- If you use a tantalum type capacitor and ESR value of the capacitor is large, output might be unstable. Evaluate your circuit with considering frequency characteristics.
- Depending on the capacitor size, manufacturer, and part number, the bias characteristics and temperature characteristics are different. Evaluate the circuit with actual using capacitors.

**PCB Layout**
- Make V\(\text{DD}\) and GND lines sufficient. If their impedance is high, noise pickup or unstable operation may result.
- Connect a capacitor C1 with a capacitance value as much as 0.47\(\mu\)F or more between V\(\text{DD}\) and GND pin, and as close as possible to the pins.
- Set external components, especially the output capacitor C2, as close as possible to the ICs, and make wiring as short as possible.
- No.2 pin and No.3 pin of SOT-89-5 and TO-252-5-P2 package must be wired to the GND plane when it is mounted on board.

**Thermal Shutdown**
- There is the built-in thermal-shutdown function in R1500x series. It discontinues operation of the IC when the junction temperature becomes over 170°C (Typ.) and IC re-operates when the junction temperature under 145°C. If the temperature increasing keeps the IC repeats ON and OFF operating. The output becomes the pulse condition.
TYPICAL APPLICATION FOR PREVENTING IC DESTRUCTION

C1: 0.47μF or more (preventing for unstable operation)
C2: 10μF or more (preventing for unstable operation)

D1: If V_{OUT} pin could be higher than V_{IN} pin, D1 is necessary.
D2: If V_{OUT} pin could be lower than GND pin, SBD is necessary.

Note: Do not force the voltage to V_{OUT} pin.
TEST CIRCUITS

Basic Test Circuit

Test Circuit for Supply Current

Test Circuit for Ripple Rejection, Input Transient Response

C1=Ceramic 0.47μF
C2=Ceramic 10μF

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**Test Circuit for Load Transient Response**

**Test Circuit for Turn On Speed with CE pin**
TYPICAL CHARACTERISTICS

1) Output Voltage vs. Output Current (C1=Ceramic 0.47μF, C2=Ceramic 10μF, Topt=25°C)

2) Output Voltage vs. Input Voltage (C1=Ceramic 0.47μF, C2=Ceramic 10μF, Topt=25°C)
3) Supply Current vs. Input Voltage (C1=Ceramic 0.47\(\mu\)F, C2=Ceramic 10\(\mu\)F, Topt=25°C)
4) Output Voltage vs. Temperature (C1=Ceramic 0.47\(\mu\)F, C2=Ceramic 10\(\mu\)F, \(I_{\text{OUT}}=100\)mA)

5) Supply Current vs. Temperature (C1=Ceramic 0.47\(\mu\)F, C2=Ceramic 10\(\mu\)F, \(I_{\text{OUT}}=0\)mA)

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6) Dropout Voltage vs. Output Current (C1=Ceramic 0.47μF, C2=Ceramic 10μF)
7) Dropout Voltage vs. Set Output Voltage (C1\(=\)Ceramic 0.47\(\mu\)F, C2\(=\)Ceramic 10\(\mu\)F, Topt\(=\)25\(^\circ\)C)

![Graph showing Dropout Voltage vs. Set Output Voltage]

8) Ripple Rejection vs. Input Bias Voltage (C1\(=\)none, C2\(=\)Ceramic 10\(\mu\)F, Iout\(=\)100mA, Topt\(=\)25\(^\circ\)C)

**R1500x050B**

- **Ripple = 0.5Vp-p**
  - 120Hz
  - 1kHz
  - 10kHz

**R1500x050B**

- **Ripple = 0.2Vp-p**
  - 120Hz
  - 1kHz
  - 10kHz

9) Ripple Rejection vs. Frequency (C1\(=\)none, C2\(=\)Ceramic 10\(\mu\)F, Ripple = 0.5Vp-p)

**R1500x030B**

- **VIN = 4.0V**
  - 1mA
  - 100mA
  - 300mA

**R1500x050B**

- **VIN = 6.0V**
  - 1mA
  - 100mA
  - 300mA

---

*R1500J (TO-252-5-P2) is the limited product. As of March in 2014.*
10) Input Transient Response (C1=none, C2=Ceramic 10μF, I_{out}=100mA, t_{r}=t_{f}=10μs, Topt=25°C)

- R1500x030B
- R1500x050B
- R1500x090B
- R1500x120B

* R1500J (TO-252-5-P2) is the limited product. As of March in 2014.
11) Load Transient Response (C1=Ceramic 0.47 μF, C2=Ceramic 10 μF, tr=tf=0.5 μs, Topt=25°C)

<table>
<thead>
<tr>
<th>VIN=4.0V</th>
<th>VIN=6.0V</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="graph1.png" alt="Graph" /></td>
<td><img src="graph2.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VIN=2.2V</th>
<th>VIN=2.2V</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="graph3.png" alt="Graph" /></td>
<td><img src="graph4.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

12) Turn On Speed with CE pin (C1=Ceramic 0.47 μF, C2=Ceramic 10 μF, Topt=25°C)

<table>
<thead>
<tr>
<th>IOUT=100mA</th>
<th>IOUT=500mA</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="graph5.png" alt="Graph" /></td>
<td><img src="graph6.png" alt="Graph" /></td>
</tr>
</tbody>
</table>
R1500J (TO-252-5-P2) is the limited product. As of March in 2014.
13) Turn Off Speed with CE (C1=Ceramic 0.47μF, C2=Ceramic 10μF, I_{out}=500mA, T_{opt}=25°C)

*R1500J (TO-252-5-P2) is the limited product. As of March in 2014.*
ESR vs. Output Current

The relations between $I_{\text{OUT}}$ (Output Current) and ESR of an output capacitor are shown below. The conditions when the white noise level is under the specified certain level are marked as the hatched area in the graph.

**Measurement conditions**
- **Input Voltage**: $V_{\text{OUT}} + 1\text{V}$
- **Frequency Band**: 10Hz to 1MHz
- **Temperature**: $-40\degree \text{C}$ to $105\degree \text{C}$

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* R1500J (TO-252-5-P2) is the limited product. As of March in 2014.
R1500x090B
Noise level = 120μVRms

VIN = 10V
C1 = Ceramic 0.47μF, C2 = Ceramic 10μF

Output Current IOUT (mA)

ESR (Ω)

0.01 0.1 1 10 100 1000
0 50 100 150 200 250 300 350 400 450 500

R1500x120B
Noise level = 140μVRms

VIN = 13V
C1 = Ceramic 0.47μF, C2 = Ceramic 10μF

Output Current IOUT (mA)

ESR (Ω)

0.01 0.1 1 10 100 1000
0 50 100 150 200 250 300 350 400 450 500

R1500x090B
Noise level = 120μVRms

VIN = 10V to 24V
C1 = Ceramic 0.47μF, C2 = Ceramic 10μF

Output Current IOUT (mA)

ESR (Ω)

0.01 0.1 1 10 100 1000
0 5 10 15 20 25 30 35 40 45 50

R1500x120B
Noise level = 140μVRms

VIN = 13V to 24V
C1 = Ceramic 0.47μF, C2 = Ceramic 10μF

Output Current IOUT (mA)

ESR (Ω)

0.01 0.1 1 10 100 1000
0 5 10 15 20 25 30 35 40 45 50

* R1500J (TO-252-5-P2) is the limited product. As of March in 2014.
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