20V, 350mA, Rail-to-Rail Operational Amplifier

General Description
The RT9148/9 consists of a low power, high slew rate, single supply rail-to-rail input and output operational amplifier. The RT9148 contains a single amplifier and RT9149 contains two amplifiers in one package.

The RT9148/9 has a high slew rate (35V/μs), 350mA peak output current and offset voltage below 15mV. The RT9148/9 is ideal for Thin Film Transistor Liquid Crystal Displays (TFT-LCD).

The RT9148 is available in the WDFN-6L 2x2, TSOT-23-5 and UDFN-6L 2x2 packages. The RT9149 is available in the WDFN-8L 3x3 package. The RT9148/9 are specified for operation over the full temperature range from −40°C to 85°C.

Features
- Rail-to-Rail Output Swing
- Supply Voltage : 6V to 20V
- Peak Output Current : 350mA
- High Slew Rate : 35V/μs
- Unity Gain Stable
- RoHS Compliant and Halogen Free

Applications
- TFT LCD Panels
- Notebook Computers
- Monitors
- LCD TVs

Marking Information
RT9148ZQW
0E : Product Code
W : Date Code

RT9148GJ5
00=DNN
DNN : Date Code

RT9148GQU
2D : Product Code
W : Date Code

RT9149ZQW
86 YM
DNN : Date Code

Ordering Information
RT9148
QW : WDFN-6L 2x2 (W-Type)
Z : ECO (Ecological Element with Halogen Free and Pb free)

RT9148
JS : TSOT-23-5
QU : UDFN-6L 2x2 (U-Type)
G : Green (Halogen Free and Pb Free)

RT9149
QW : WDFN-8L 3x3 (W-Type)
Z : ECO (Ecological Element with Halogen Free and Pb free)

Note:
Richtek products are:
- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.
Pin Configurations

(TOP VIEW)

WDFN-6L 2x2 / UDFN-6L 2x2
RT9148

VS+ VIN- VOUT

VINA+ VINA- VOUTB

VINA+ VINA- VOUTB

VOUTA VOUTB

VS- VIN+

WDFN-8L 3x3
RT9149

Typical Application Circuit

Function Block Diagram
### Functional Pin Description

#### RT9148

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 7</td>
<td>VS−</td>
<td>Negative Supply Input.</td>
</tr>
<tr>
<td>2</td>
<td>NC</td>
<td>No Internal Connection.</td>
</tr>
<tr>
<td>3</td>
<td>VS+</td>
<td>Positive Supply Input.</td>
</tr>
<tr>
<td>4</td>
<td>VOUT</td>
<td>Output.</td>
</tr>
<tr>
<td>5</td>
<td>VIN−</td>
<td>Negative Input.</td>
</tr>
<tr>
<td>6</td>
<td>VIN+</td>
<td>Positive Input.</td>
</tr>
</tbody>
</table>

#### RT9149

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VOUTA</td>
<td>Output of Amplifier A.</td>
</tr>
<tr>
<td>2</td>
<td>VINA−</td>
<td>Negative Input of Amplifier A.</td>
</tr>
<tr>
<td>3</td>
<td>VINA+</td>
<td>Positive Input of Amplifier A.</td>
</tr>
<tr>
<td>4, 9</td>
<td>VS−</td>
<td>Negative Supply Input.</td>
</tr>
<tr>
<td>5</td>
<td>VINB+</td>
<td>Positive Input of Amplifier B.</td>
</tr>
<tr>
<td>6</td>
<td>VIN−</td>
<td>Negative Input of Amplifier B.</td>
</tr>
<tr>
<td>7</td>
<td>VOUTB</td>
<td>Output of Amplifier B.</td>
</tr>
<tr>
<td>8</td>
<td>VS+</td>
<td>Positive Supply Input.</td>
</tr>
</tbody>
</table>
Absolute Maximum Ratings  (Note 1)
- Supply Voltage, (VS+ to VS−)  24V
- VINx+, VINx− to VS−  0.3V to 24V
- VINx+ to VINx−  ±5V
- Power Dissipation, P_D @ T_A = 25°C
  WDFN-6L 2x2  2.1W
  TSOT-23-5  0.43W
  UDFN-6L 2x2  2.09W
  WDFN-8L 3x3  3.22W
- Package Thermal Resistance  (Note 2)
  WDFN-6L 2x2, θ_JA  47.5°C/W
  TSOT-23-5, θ_JA  230.6°C/W
  UDFN-6L 2x2, θ_JA  47.7°C/W
  WDFN-8L 3x3, θ_JA  31°C/W
  WDFN-8L 3x3, θ_JC  8°C/W
- Lead Temperature (Soldering, 10 sec.)  260°C
- Junction Temperature  150°C
- Storage Temperature Range  −65°C to 150°C
- ESD Susceptibility  (Note 3)
  HBM (Human Body Model)  2kV
  MM (Machine Model)  200V

Recommended Operating Conditions  (Note 4)
- Supply Voltage, VS− = 0V, VS+  6V to 20V
- Junction Temperature Range  −40°C to 125°C
- Ambient Temperature Range  −40°C to 85°C

Electrical Characteristics
(VS+ = 16V, VS− = 0V, VINx+ = VOUTx = VS+ / 2, RL = 10kΩ and CL = 10pF, T_A = 25°C, unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>V_OS</td>
<td>V CM = V S+ / 2</td>
<td>--</td>
<td>2</td>
<td>15</td>
<td>mV</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>I_B</td>
<td>V CM = V S+ / 2</td>
<td>--</td>
<td>2</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>ΔV_LOAD</td>
<td>I_L = 0 to −80mA</td>
<td>--</td>
<td>0.1</td>
<td>--</td>
<td>mV/mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I_L = 0 to 80mA</td>
<td>--</td>
<td>0.1</td>
<td>--</td>
<td>mV/mA</td>
</tr>
<tr>
<td>Common Mode Input Range</td>
<td>CMIR</td>
<td></td>
<td>0.5</td>
<td>--</td>
<td>V_S+−0.5</td>
<td>V</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio</td>
<td>CMRR</td>
<td>0.5V ≤ VOUTx ≤ V S+−0.5V</td>
<td>--</td>
<td>95</td>
<td>--</td>
<td>dB</td>
</tr>
<tr>
<td>Open Loop Gain</td>
<td>AVOL</td>
<td>0.5V ≤ VOUTx ≤ V S+−0.5V</td>
<td>--</td>
<td>118</td>
<td>--</td>
<td>dB</td>
</tr>
<tr>
<td>Parameter</td>
<td>Symbol</td>
<td>Test Conditions</td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Unit</td>
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<tr>
<td>-----------</td>
<td>--------</td>
<td>-----------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
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<tr>
<td><strong>Output Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Swing Low</td>
<td>( V_{OL} )</td>
<td>( I_L = -50\text{mA} )</td>
<td>–</td>
<td>0.6</td>
<td>1.5</td>
<td>V</td>
</tr>
<tr>
<td>Output Swing High</td>
<td>( V_{OH} )</td>
<td>( I_L = 50\text{mA} )</td>
<td>( V_{S+} -1.5 )</td>
<td>( V_{S+} -0.3 )</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>Transient Peak Output Current</td>
<td>( I_{PK} )</td>
<td></td>
<td>300</td>
<td>350</td>
<td>400</td>
<td>mA</td>
</tr>
<tr>
<td><strong>Power Supply</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>PSRR</td>
<td>( V_{S+} = 6\text{V to 20\text{V}}, V_{CM} = V_{OUTx} = \frac{V_{S+}}{2} )</td>
<td>–</td>
<td>96</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>( I_{DD} )</td>
<td>No Load</td>
<td>–</td>
<td>4</td>
<td>–</td>
<td>mA</td>
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<tr>
<td><strong>Dynamic Performance</strong></td>
<td></td>
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<tr>
<td>Slew Rate</td>
<td>SR</td>
<td>4V step, 20% to 80%, ( A_V = 1 )</td>
<td>–</td>
<td>35</td>
<td>–</td>
<td>V/( \mu \text{s} )</td>
</tr>
<tr>
<td>Setting to ( \pm 0.1% ) (( A_V = 1 ))</td>
<td>( t_S )</td>
<td>( A_V = 1, V_{OUTx} = 2\text{V step} ) ( R_L = 10\text{k}\Omega, C_L = 10\text{pF} )</td>
<td>–</td>
<td>270</td>
<td>–</td>
<td>ns</td>
</tr>
<tr>
<td>–3dB Bandwidth</td>
<td>BW</td>
<td>( R_L = 10\text{k}\Omega, C_L = 10\text{pF} )</td>
<td>–</td>
<td>16</td>
<td>–</td>
<td>MHz</td>
</tr>
<tr>
<td>Gain-Bandwidth Product</td>
<td>GBWP</td>
<td>( R_L = 10\text{k}\Omega, C_L = 10\text{pF} )</td>
<td>–</td>
<td>12</td>
<td>–</td>
<td>MHz</td>
</tr>
<tr>
<td>Phase Margin</td>
<td>PM</td>
<td>( R_L = 10\text{k}\Omega, C_L = 10\text{pF} )</td>
<td>–</td>
<td>50°</td>
<td>–</td>
<td>--</td>
</tr>
</tbody>
</table>

**Note 1.** Stresses beyond those listed “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

**Note 2.** \( \theta_{JA} \) is measured at \( T_A = 25^\circ\text{C} \) on a high effective thermal conductivity four-layer test board per JEDEC 51-7. \( \theta_{JC} \) is measured at the exposed pad of the package.

**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

**Note 4.** The device is not guaranteed to function outside its operating conditions.
Typical Operating Characteristics

Supply Current / Amplifier vs. Supply Voltage

Supply Current (mA)

Unity Gain, One OP, VINA+ = VS+ / 2, VS+ = 6V to 20V, VS− = 0V

Supply Voltage (V)

Supply Current / Amplifier vs. Temperature

Supply Current (mA)

Unity Gain, One OP, VINA+ = 8V, VS+ = 16V, VS− = 0V

Temperature (°C)

Input Offset Voltage vs. Supply Voltage

Input Offset Voltage (mV)

Unity Gain, VINA+ = VS+ / 2, VS+ = 6V to 20V, VS− = 0V

Supply Voltage (V)

Input Offset Voltage vs. Temperature

Input Offset Voltage (mV)

Unity Gain, VINA+ = 8V, VS+ = 16V, VS− = 0V

Temperature (°C)

Output Voltage Swing vs. Supply Voltage

Output Voltage Swing (V)

Swing Low, VINA+ = 0V, VINA− = 3V, ILOAD = −50mA

Supply Voltage (V)

Swing High, VINA+ = 3V, VINA− = 0V, ILOAD = 50mA

Rail to Rail

Unity Gain, f = 10kHz

Vin+, VIN− (2.8V/Div), VOUT+ (2.8V/Div)

Time (25μs/Div)

Supply Voltage (V)

Vin+, 0.5V to 15.5V, VS+ = 16V, VS− = 0V

VOUT+ 6V to 20V, VS− = 0V
Small Signal Response

Unity Gain, VinA+ = 7.9V to 8.1V, 
Vs+ = 16V, Vs− = 0V, f = 100kHz

Time (2.5μs/Div)

Large Signal Response

Unity Gain, VinA+ = 6V to 10V, 
Vs+ = 16V, Vs− = 0V, f = 100kHz

Time (2.5μs/Div)

Slew Rate

Unity Gain, VinA+ = 4V to 8V, 
Vs+ = 16V, Vs− = 0V, f = 10kHz

Time (50ns/Div)

Slew Rate

Unity Gain, VinA+ = 8V to 4V, 
Vs+ = 16V, Vs− = 0V, f = 10kHz

Time (50ns/Div)

3dB Bandwidth

Unity Gain, VinA+ = 8V, Vs+ = 16V, 
Vs− = 0V, RL = 10kΩ, CL = 10pF

Gain Bandwidth Product

Unity Gain, VinA+ = 8V, Vs+ = 16V, 
Vs− = 0V, RL = 10kΩ, CL = 10pF
Applications Information

The RT9148/9 is a high performance operational amplifier capable of driving large loads for different applications. A high slew rates, rail-to-rail input and output capability, and low power consumption are the features which make the RT9148/9 ideal for LCD applications. The RT9148/9 also has wide bandwidth and phase margin to drive a load with 10kΩ resistance and 10pF capacitance.

Operating Voltage

The RT9148/9 total supply voltage range is guaranteed from 6V to 20V. The specifications are stable over both the full supply range and operating temperatures from −40°C to 85°C. The output swing of the RT9148/9 typically extends to within 1.5V of positive/negative supply rails with 50mA load current source/sink. Decreasing the load current will obtain an output swing even closer to the supply rails.

Short Circuit Condition

An internal short circuit protection is implemented to protect the device from output short circuit. The RT9148/9 limits the short circuit current to ±350mA if the output is directly shorted to positive/negative supply rails.

LCD Panel Applications

The RT9148/9 is mainly designed for LCD V-com buffer. The operational amplifier has 350mA instantaneous source/sink peak current.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula:

\[ P_{D(MAX)} = \frac{(T_{J(MAX)} - T_A)}{\theta_{JA}} \]

where \( T_{J(MAX)} \) is the maximum junction temperature, \( T_A \) is the ambient temperature, and \( \theta_{JA} \) is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, \( \theta_{JA} \), is layout dependent. For WDFN-6L 2x2 packages, the thermal resistance, \( \theta_{JA} \), is 47.5°C/W on a standard JEDEC 51-7 four-layer thermal test board. For TSOT-23-5 packages, the thermal resistance, \( \theta_{JA} \), is 230.6°C/W on a standard JEDEC 51-7 four-layer thermal test board. For UDFN-6L 2x2 packages, the thermal resistance, \( \theta_{JA} \), is 31°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at \( T_A = 25°C \) can be calculated by the following formula:

\[ P_{D(MAX)} = \frac{(125°C - 25°C)}{47.5°C/W} = 2.1W \text{ for WDFN-6L 2x2 package} \]

\[ P_{D(MAX)} = \frac{(125°C - 25°C)}{230.6°C/W} = 0.43W \text{ for TSOT-23-5 package} \]

\[ P_{D(MAX)} = \frac{(125°C - 25°C)}{47.7°C/W} = 2.09W \text{ for WDFN-6L 2x2 package} \]

\[ P_{D(MAX)} = \frac{(125°C - 25°C)}{31°C/W} = 3.22W \text{ for WDFN-8L 3x3 package} \]

The maximum power dissipation depends on the operating ambient temperature for fixed \( T_{J(MAX)} \) and thermal resistance, \( \theta_{JA} \). The derating curve in Figure 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.
Layout Consideration

PCB layout is very important for designing power converter circuits. The following layout guidelines should be strictly followed for best performance of the RT9148/9.

- Place the power components as close to the IC as possible. The traces should be wide and short, especially for the high current loop.
- A series resistance may be needed at the output for some applications.
- Connect a 0.1μF capacitor from VINx+ to ground and place it as close to the IC as possible for better performance.
- The exposed pad of the chip should be connected to a large PCB plane for maximum thermal consideration.
Outline Dimension

Note: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Dimensions in Millimeters</th>
<th>Dimensions in Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.700 0.800</td>
<td>0.028 0.031</td>
</tr>
<tr>
<td>A1</td>
<td>0.000 0.050</td>
<td>0.000 0.002</td>
</tr>
<tr>
<td>A3</td>
<td>0.175 0.250</td>
<td>0.007 0.010</td>
</tr>
<tr>
<td>b</td>
<td>0.200 0.350</td>
<td>0.008 0.014</td>
</tr>
<tr>
<td>D</td>
<td>1.950 2.050</td>
<td>0.077 0.081</td>
</tr>
<tr>
<td>D2</td>
<td>1.000 1.450</td>
<td>0.039 0.057</td>
</tr>
<tr>
<td>E</td>
<td>1.950 2.050</td>
<td>0.077 0.081</td>
</tr>
<tr>
<td>E2</td>
<td>0.500 0.850</td>
<td>0.020 0.033</td>
</tr>
<tr>
<td>e</td>
<td>0.650</td>
<td>0.026</td>
</tr>
<tr>
<td>L</td>
<td>0.300 0.400</td>
<td>0.012 0.016</td>
</tr>
</tbody>
</table>

W-Type 6L DFN 2x2 Package
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Dimensions In Millimeters</th>
<th>Dimensions In Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>A</td>
<td>0.700</td>
<td>1.000</td>
</tr>
<tr>
<td>A1</td>
<td>0.000</td>
<td>0.100</td>
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<tr>
<td>B</td>
<td>1.397</td>
<td>1.803</td>
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<td>b</td>
<td>0.300</td>
<td>0.559</td>
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<tr>
<td>C</td>
<td>2.591</td>
<td>3.000</td>
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<tr>
<td>D</td>
<td>2.692</td>
<td>3.099</td>
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<tr>
<td>e</td>
<td>0.838</td>
<td>1.041</td>
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<tr>
<td>H</td>
<td>0.080</td>
<td>0.254</td>
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<tr>
<td>L</td>
<td>0.300</td>
<td>0.610</td>
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</tbody>
</table>

**TSOT-23-5 Surface Mount Package**
Note: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Dimensions In Millimeters</th>
<th>Dimensions In Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>A</td>
<td>0.500</td>
<td>0.600</td>
</tr>
<tr>
<td>A1</td>
<td>0.000</td>
<td>0.050</td>
</tr>
<tr>
<td>A3</td>
<td>0.100</td>
<td>0.175</td>
</tr>
<tr>
<td>b</td>
<td>0.200</td>
<td>0.300</td>
</tr>
<tr>
<td>D</td>
<td>1.900</td>
<td>2.100</td>
</tr>
<tr>
<td>D2</td>
<td>1.350</td>
<td>1.450</td>
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<tr>
<td>E</td>
<td>1.900</td>
<td>2.100</td>
</tr>
<tr>
<td>E2</td>
<td>0.750</td>
<td>0.850</td>
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<tr>
<td>e</td>
<td>0.650</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>0.300</td>
<td>0.400</td>
</tr>
</tbody>
</table>

U-Type 6L DFN 2x2 Package
Directions in Millimeters | Dimensions In Inches
---|---
A | 0.700 | 0.800 | 0.028 | 0.031
A1 | 0.000 | 0.050 | 0.000 | 0.002
A3 | 0.175 | 0.250 | 0.007 | 0.010
b | 0.200 | 0.300 | 0.008 | 0.012
D | 2.950 | 3.050 | 0.116 | 0.120
D2 | 2.100 | 2.350 | 0.083 | 0.093
E | 2.950 | 3.050 | 0.116 | 0.120
E2 | 1.350 | 1.600 | 0.053 | 0.063
e | 0.650 | 0.026
L | 0.425 | 0.525 | 0.017 | 0.021

W-Type 8L DFN 3x3 Package

Note: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

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Tel: (8863)5526789

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