CA3094, CA3094A, CA3094B

30MHz, High Output Current Operational Transconductance Amplifier (OTA)

The CA3094 is a differential input power control switch/amplifier with auxiliary circuit features for ease of programmability. For example, an error or unbalance signal can be amplified by the CA3094 to provide an on-off signal or proportional control output signal up to 100mA. This signal is sufficient to directly drive high current thyristors, relays, DC loads, or power transistors. The CA3094 has the generic characteristics of the CA3080 operational amplifier directly coupled to an integral Darlington power transistor capable of sinking or driving currents up to 100mA.

The gain of the differential input stage is proportional to the amplifier bias current ($I_{ABC}$), permitting programmable variation of the integrated circuit sensitivity with either digital and/or analog programming signals. For example, at an $I_{ABC}$ of 100µA, a 1mV change at the input will change the output from 0 to 100µA (typical).

The CA3094 is intended for operation up to 24V and is especially useful for timing circuits, in automotive equipment, and in other applications where operation up to 24V is a primary design requirement (see Figures 28, 29 and 30 in Typical Applications text). The CA3094A and CA3094B are like the CA3094 but are intended for operation up to 36V and 44V, respectively (single or dual supply).

Ordering Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>TEMP. RANGE (°C)</th>
<th>PACKAGE</th>
<th>PKG. NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA3094AT, BT</td>
<td>-55 to 125</td>
<td>8 Pin Metal Can</td>
<td>T8.C</td>
</tr>
<tr>
<td>CA3094E, AE</td>
<td>-55 to 125</td>
<td>8 Ld PDIP</td>
<td>E8.3</td>
</tr>
<tr>
<td>CA3094M, BM</td>
<td>-55 to 125</td>
<td>8 Ld SOIC</td>
<td>M8.15</td>
</tr>
</tbody>
</table>

Features

- CA3094E, M for Operation Up to 24V
- CA3094AT, E, M for Operation Up to 36V
- CA3094BT, M for Operation Up to 44V
- Designed for Single or Dual Power Supply
- Programmable: Strobing, Gating, Squelching, AGC Capabilities
- Can Deliver 3W (Average) or 10W (Peak) to External Load (in Switching Mode)
- High Power, Single Ended Class A Amplifier will Deliver Power Output of 0.6W (1.6W Device Dissipation)
- Total Harmonic Distortion (THD) at 0.6W in Class A Operation 1.4% (Typ)

Applications

- Error Signal Detector: Temperature Control with Thermistor Sensor; Speed Control for Shunt Wound DC Motor
- Over Current, Over Voltage, Over Temperature Protectors
- Dual Tracking Power Supply with CA3085
- Wide Frequency Range Oscillator
- Analog Timer
- Level Detector
- Alarm Systems
- Voltage Follower
- Ramp Voltage Generator
- High Power Comparator
- Ground Fault Interrupter (GFI) Circuits

Pinouts

**CA3094 (PDIP, SOIC)**

- EXT. FREQUENCY COMPENSATION OR INHIBIT INPUT
- DIFFERENTIAL VOLTAGE INPUTS
- GND (V- IN DUAL SUPPLY OPERATION)
- SINK OUTPUT (COLLECTOR)
- V+
- DRIVE OUTPUT (EMITTER)
- $I_{ABC}$ CURRENT
- PROGRAMMABLE INPUT (STROBE OR AGC)

**CA3094 (METAL CAN)**

- EXT. FREQUENCY COMPENSATION OR INHIBIT INPUT
- DIFFERENTIAL VOLTAGE INPUTS
- GND (V- IN DUAL SUPPLY OPERATION)
- SINK OUTPUT (COLLECTOR)
- V+
- DRIVE OUTPUT (EMITTER)
- $I_{ABC}$ CURRENT
- PROGRAMMABLE INPUT (STROBE OR AGC)

NOTE: Pin 4 is connected to case.
Absolute Maximum Ratings

Supply Voltage (Between V+ and V- Terminals)
- CA3094: 24V
- CA3094A: 36V
- CA3094B: 44V

Differential Input Voltage (Terminals 2 and 3, Note 1): 5V

DC Input Voltage: V+ to V- ±1mA

Amplifier Bias Current (Terminal 5): 2mA

Average Output Current: 100mA

Peak Output Current: 300mA

Thermal Information

<table>
<thead>
<tr>
<th>Package Type</th>
<th>θJA (°C/W)</th>
<th>θJC (°C/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDIP Package</td>
<td>130</td>
<td>N/A</td>
</tr>
<tr>
<td>SOIC Package</td>
<td>170</td>
<td>N/A</td>
</tr>
<tr>
<td>Metal Can Package</td>
<td>175</td>
<td>100</td>
</tr>
</tbody>
</table>

Maximum Junction Temperature (Metal Can Package): 175°C

Maximum Junction Temperature (Plastic Package): 150°C

Maximum Storage Temperature Range: -65°C to 150°C

Maximum Lead Temperature (Soldering 10s): 300°C (SOIC - Lead Tips Only)

Operating Conditions

Temperature Range: -55°C to 125°C

CAUTION: Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:
1. Exceeding this voltage rating will not damage the device unless the peak input signal current (1mA) is also exceeded.
2. θJA is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications

T_A = 25°C for Equipment Design. Single Supply V+ = 30V, Dual Supply V_SUPPLY = ±15V, I_ABC = 100μA 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>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT PARAMETERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>VIO</td>
<td>T_A = 25°C</td>
<td>-</td>
<td>0.4</td>
<td>5.0</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_A = 0°C to 70°C</td>
<td>-</td>
<td>-</td>
<td>7.0</td>
<td>mV</td>
</tr>
<tr>
<td>Input Offset Voltage Change</td>
<td>AVIO</td>
<td>Change in VIO between I_ABC = 100μA and I_ABC = 5μA</td>
<td>-</td>
<td>1</td>
<td>8.0</td>
<td>mV</td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>IO</td>
<td>T_A = 25°C</td>
<td>-</td>
<td>0.02</td>
<td>0.2</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_A = 0°C to 70°C</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
<td>μA</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>Ii</td>
<td>T_A = 25°C</td>
<td>-</td>
<td>0.2</td>
<td>0.50</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_A = 0°C to 70°C</td>
<td>-</td>
<td>-</td>
<td>0.70</td>
<td>μA</td>
</tr>
<tr>
<td>Device Dissipation</td>
<td>PD</td>
<td>IOUT = 0mA</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>mW</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio</td>
<td>CMRR</td>
<td></td>
<td>70</td>
<td>110</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Common Mode Input Voltage Range</td>
<td>VICR</td>
<td>V+ = 30V (High)</td>
<td>27</td>
<td>28.8</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V- = 0V (Low)</td>
<td>1.0</td>
<td>0.5</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V+ = 15V</td>
<td>12</td>
<td>13.8</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V- = -15V</td>
<td>-14</td>
<td>-14.5</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Unity Gain Bandwidth</td>
<td>fT</td>
<td>I_C = 7.5mA, V_CE = 15V, I_ABC = 500μA</td>
<td>-</td>
<td>30</td>
<td>-</td>
<td>MHz</td>
</tr>
<tr>
<td>Open Loop Bandwidth at -3dB Point</td>
<td>BWOL</td>
<td>I_C = 7.5mA, V_CE = 15V, I_ABC = 500μA</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>kHz</td>
</tr>
<tr>
<td>Total Harmonic Distortion (Class A Operation)</td>
<td>THD</td>
<td>PD = 220mW</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PD = 600mW</td>
<td>-</td>
<td>1.4</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Amplifier Bias Voltage (Terminal 5 to Terminal 4)</td>
<td>VABC</td>
<td></td>
<td>-</td>
<td>0.68</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Input Offset Voltage Temperature Coefficient</td>
<td>ΔVIO/ΔT</td>
<td></td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>μV/°C</td>
</tr>
<tr>
<td>Power Supply Rejection</td>
<td>ΔVIO/ΔV</td>
<td></td>
<td>-</td>
<td>15</td>
<td>150</td>
<td>μV/V</td>
</tr>
<tr>
<td>1/F Noise Voltage</td>
<td>EN</td>
<td>f = 10Hz, I_ABC = 50μA</td>
<td>-</td>
<td>18</td>
<td>-</td>
<td>nV/√Hz</td>
</tr>
<tr>
<td>1/F Noise Current</td>
<td>IN</td>
<td>f = 10Hz, I_ABC = 50μA</td>
<td>-</td>
<td>1.8</td>
<td>-</td>
<td>pA/√Hz</td>
</tr>
<tr>
<td>Differential Input Resistance</td>
<td>Ri</td>
<td>I_ABC = 20μA</td>
<td>0.50</td>
<td>1.0</td>
<td>-</td>
<td>MΩ</td>
</tr>
<tr>
<td>Differential Input Capacitance</td>
<td>Ci</td>
<td>f = 1MHz, V+ = 30V</td>
<td>-</td>
<td>2.6</td>
<td>-</td>
<td>pF</td>
</tr>
</tbody>
</table>
**Electrical Specifications**

$T_A = 25^\circ C$ for Equipment Design. Single Supply $V_+ = 30V$, Dual Supply $V_{SUPPLY} = \pm 15V$, $I_{ABC} = 100\mu A$ Unless Otherwise Specified

### OUTPUT PARAMETERS (Differential Input Voltage = 1V)

<table>
<thead>
<tr>
<th>PARAMETER/CONDITION</th>
<th>SYMBOL</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Output Voltage (Terminal 6)</td>
<td>$V_{OM+}$</td>
<td>$V_+ = 30V$, $R_L = 2k\Omega$ to GND</td>
<td>26</td>
<td>27</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$V_{OM-}$</td>
<td></td>
<td>-</td>
<td>0.01</td>
<td>0.05</td>
<td>V</td>
</tr>
<tr>
<td>Peak Output Voltage (Terminal 6)</td>
<td>Positive $V_{OM+}$</td>
<td>$V_+ = 15V$, $V_- = -15V$, $R_L = 2k\Omega$ to -15V</td>
<td>11</td>
<td>12</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Negative $V_{OM-}$</td>
<td></td>
<td>-</td>
<td>-14.99</td>
<td>-14.95</td>
<td>V</td>
</tr>
<tr>
<td>Peak Output Voltage (Terminal 8)</td>
<td>With $Q_{13}$ “OFF” $V_{OM+}$</td>
<td>$V_+ = 30V$, $R_L = 2k\Omega$ to 30V</td>
<td>29.95</td>
<td>29.99</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$V_{OM-}$</td>
<td></td>
<td>-</td>
<td>0.040</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Peak Output Voltage (Terminal 8)</td>
<td>Positive $V_{OM+}$</td>
<td>$V_+ = 15V$, $V_- = -15V$, $R_L = 2k\Omega$ to 15V</td>
<td>14.95</td>
<td>14.99</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Negative $V_{OM-}$</td>
<td></td>
<td>-</td>
<td>-14.96</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Collector-to-Emitter Saturation Voltage (Terminal 8)</td>
<td>$V_{CE(SAT)}$</td>
<td>$V_+ = 30V$, $I_C = 50mA$, Terminal 6 Grounded</td>
<td>-</td>
<td>0.17</td>
<td>0.80</td>
<td>V</td>
</tr>
<tr>
<td>Output Leakage Current (Terminal 6 to Terminal 4)</td>
<td></td>
<td>$V_+ = 30V$</td>
<td>-</td>
<td>2</td>
<td>10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Composite Small Signal Current Transfer Ratio (Beta) ($Q_{12}$ and $Q_{13}$)</td>
<td>$h_{FE}$</td>
<td>$V_+ = 30V$, $V_{CE} = 5V$, $I_C = 50mA$</td>
<td>16,000</td>
<td>100,000</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>Terminal 6 $C_O$</td>
<td>$f = 1MHz$, All Remaining Terminals Tied to Terminal 4</td>
<td>-</td>
<td>5.5</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td></td>
<td>Terminal 8 $C_O$</td>
<td></td>
<td>-</td>
<td>17</td>
<td>-</td>
<td>pF</td>
</tr>
</tbody>
</table>

### TRANSFER PARAMETERS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Gain</td>
<td>$A$</td>
<td>$V_+ = 30V$, $I_{ABC} = 100\mu A$, $\Delta V_{OUT} = 20V$, $R_L = 2k\Omega$</td>
<td>20,000</td>
<td>100,000</td>
<td>-</td>
<td>V/V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_+ = 30V$</td>
<td>86</td>
<td>100</td>
<td>-</td>
<td>dB</td>
</tr>
<tr>
<td>Forward Transconductance to Terminal 1</td>
<td>$g_M$</td>
<td>$I_{ABC} = 100\mu A$, $R_L = 2k\Omega$</td>
<td>1650</td>
<td>2200</td>
<td>2750</td>
<td>$\mu S$</td>
</tr>
<tr>
<td>Slew Rate (Open Loop)</td>
<td>Positive Slope $SR$</td>
<td>$I_{ABC} = 500\mu A$, $R_L = 2k\Omega$</td>
<td>-</td>
<td>500</td>
<td>-</td>
<td>V/$\mu s$</td>
</tr>
<tr>
<td></td>
<td>Negative Slope $SR$</td>
<td></td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>V/$\mu s$</td>
</tr>
<tr>
<td>Unity Gain (Non-Inverting Compensated)</td>
<td>$I_{ABC} = 500\mu A$, $R_L = 2k\Omega$</td>
<td></td>
<td>-</td>
<td>0.70</td>
<td>-</td>
<td>V/$\mu s$</td>
</tr>
</tbody>
</table>

### Schematic Diagram

![Schematic Diagram](image)

**EXTERNAL FREQUENCY COMPENSATION OR INHIBIT INPUT**

**DIFFERENTIAL VOLTAGE INPUT**

**DIFFERENTIAL VOLTAGE INPUT**

**AMPLIFIER BIAS INPUT $I_{ABC}$**

**OUTPUT MODE**

<table>
<thead>
<tr>
<th>INPUTTERMS</th>
<th>INV</th>
<th>NON-INV</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Source”</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>“Sink”</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
Operating Considerations

The “Sink” Output (Terminal 8) and the “Drive” Output (Terminal 6) of the CA3094 are not inherently current (or power) limited. Therefore, if a load is connected between Terminal 6 and Terminal 4 (V- or Ground), it is important to connect a current limiting resistor between Terminal 8 and Terminal 7 (V+) to protect transistor Q13 under shorted load conditions. Similarly, if a load is connected between Terminal 8 and Terminal 7 (V+), the current limiting resistor should be connected between Terminal 6 and Terminal 4 or ground. In circuit applications where the emitter of the output transistor is not connected to the most negative potential in the system, it is recommended that a 100Ω current limiting resistor be inserted between Terminal 7 and the V+ supply.

1/f Noise Measurement Circuit

When using the CA3094, A, or B audio amplifier circuits, it is frequently necessary to consider the noise performance of the device. Noise measurements are made in the circuit shown in Figure 20. This circuit is a 30dB, non-inverting amplifier with emitter follower output and phase compensation from Terminal 2 to ground. Source resistors (Rs) are set to 0Ω or 1MΩ for E noise and I noise measurements, respectively. These measurements are made at frequencies of 10Hz, 100Hz and 1kHz with a 1Hz measurement bandwidth. Typical values for 1/f noise at 10Hz and 50µA IABC are:

\[ E_N = 18\text{nV}/\sqrt{\text{Hz}} \quad \text{and} \quad I_N = 1.8\text{pA}/\sqrt{\text{Hz}}. \]

Test Circuits

**FIGURE 1. INPUT OFFSET VOLTAGE AND POWER SUPPLY REJECTION TEST CIRCUIT**

![Input Offset Voltage and Power Supply Rejection Test Circuit](image1)

**NOTES:**
3. Input Offset Voltage: \[ V_{IO} = \frac{E_{OUT}}{100} \]
4. For Power Supply Rejection Test: (1) vary V+ by -2V; then (2) vary V- by +2V.
5. Equations:
   1. \[ V^+ \text{ Rejection} = \frac{E_{0\text{OUT}} - E_{1\text{OUT}}}{200} \]
   2. \[ V^- \text{ Rejection} = \frac{E_{0\text{OUT}} - E_{2\text{OUT}}}{200} \]
6. Power Supply Rejection: (dB) = 20\log \left( \frac{1}{\text{REJECTION}^\dagger} \right).
   \(\dagger\) Maximum Reading of Step 1 or Step 2

**FIGURE 2. INPUT OFFSET CURRENT TEST CIRCUIT**

![Input Offset Current Test Circuit](image2)

**NOTES:**
7. \[ P_{Dissipation} = (V^+)(I) \]
8. \[ I_{OS} = \frac{E_{OUT}}{10^6 \text{ VOLTS AMPS}} \]

**FIGURE 3. INPUT BIAS CURRENT TEST CIRCUIT**

![Input Bias Current Test Circuit](image3)

**NOTE:** \[ I_I = \frac{I}{2} \]
**Test Circuits** (Continued)

**FIGURE 4. COMMON MODE RANGE AND REJECTION RATIO TEST CIRCUIT**

$$\text{CMRR (dB)} = 20 \log \left( \frac{100 \times 26V}{E_{2\text{OUT}} - E_{1\text{OUT}}} \right)$$

NOTES:
9. \( \text{CMRR} = \left| \frac{100 \times 26V}{E_{2\text{OUT}} - E_{1\text{OUT}}} \right| \).
10. Input Voltage Range for CMRR = 1V to 27V.
11. \( \text{CMRR} \) (dB) = \( 20 \log \left( \frac{100 \times 26V}{E_{2\text{OUT}} - E_{1\text{OUT}}} \right) \).

**FIGURE 5. 1/F NOISE TEST CIRCUIT**

**FIGURE 6. OPEN LOOP GAIN vs FREQUENCY TEST CIRCUIT**

**FIGURE 7. OPEN LOOP SLEW RATE vs \( I_{ABC} \) TEST CIRCUIT**

**FIGURE 8. SLEW RATE vs NON-INVERTING UNITY GAIN TEST CIRCUIT**

<table>
<thead>
<tr>
<th>( I_{ABC} ) (( \mu )A)</th>
<th>( C_{COMP} ) (pF)</th>
<th>( R_S ) (( \Omega ))</th>
<th>( I_{ABC} ) (( \mu )A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>56K</td>
<td>500</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>560K</td>
<td>50</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
<td>56M</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( R_S ) (( \Omega ))</th>
<th>( I_{ABC} ) (( \mu )A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>3.6k</td>
<td>3.6k</td>
</tr>
<tr>
<td>10k</td>
<td>10k</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1k</td>
<td>1k</td>
</tr>
<tr>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>10000</td>
<td>10000</td>
</tr>
<tr>
<td>100000</td>
<td>100000</td>
</tr>
<tr>
<td>1000000</td>
<td>1000000</td>
</tr>
<tr>
<td>10000000</td>
<td>10000000</td>
</tr>
<tr>
<td>100000000</td>
<td>100000000</td>
</tr>
<tr>
<td>1000000000</td>
<td>1000000000</td>
</tr>
<tr>
<td>10000000000</td>
<td>10000000000</td>
</tr>
<tr>
<td>100000000000</td>
<td>100000000000</td>
</tr>
<tr>
<td>1000000000000</td>
<td>1000000000000</td>
</tr>
<tr>
<td>10000000000000</td>
<td>10000000000000</td>
</tr>
<tr>
<td>100000000000000</td>
<td>100000000000000</td>
</tr>
</tbody>
</table>

**CA3094, CA3094A, CA3094B**
Application Information

For additional application information, refer to Application Note AN6048, "Some Applications of a Programmable Power/Switch Amplifier IC" and AN6077 "An IC Operational Transconductance Amplifier (OTA) with Power Capability".

Design Considerations

The selection of the optimum amplifier bias current (I_{ABC}) depends on:

1. The Desired Sensitivity - The higher the I_{ABC}, the higher the sensitivity, i.e., a greater drive current capability at the output for a specific voltage change at the input.
2. Required Input Resistance - The lower the I_{ABC}, the higher the input resistance.

If the desired sensitivity and required input resistance are not known and are to be experimentally determined, or the anticipated equipment design is sufficiently flexible to tolerate a wide range of these parameters, it is recommended that the equipment designer begin his calculations with an I_{ABC} of 100\mu A, since the CA3094 is characterized at this value of amplifier bias current.

The CA3094 is extremely versatile and can be used in a wide variety of applications.
Typical Applications

\[
\frac{E_{\text{OUT}}}{E_{\text{IN}}} = \left(\frac{Z_2}{Z_1}\right)
\]

depends on the characteristics of \(Z_1\) and \(Z_2\)

NOTE: In single-ended output operation, the CA3094 may require a pull up or pull down resistor.

FIGURE 11A. INVERTING OP AMP

FIGURE 11B. NON-INVERTING MODE, AS A FOLLOWER

FIGURE 11. APPLICATION OF THE CA3094

Problem: To calculate the maximum value of \(R\) required to switch a 100mA output current comparator

Given:
\[I_{\text{ABC}} = 5\,\mu A, \quad R_{\text{ABC}} = 3.6\Omega = \frac{18\,V}{5\,\mu A}\]

\[I_I = 500\,nA \text{ at } I_{\text{ABC}} = 100\mu A \text{ (from Figure 3)}\]

Then: \[I_I = 33\,nA \text{ at } I_{\text{ABC}} = 5\mu A\]

\[R_{\text{MAX}} = \frac{18\,V - 12\,V}{33\,nA} = 180\,\Omega \text{ at } T_A = 25^\circ C\]

\[R_{\text{MAX}} = 180\,\Omega \times \frac{2}{3} \approx 120\,\Omega \text{ at } T_A = -55^\circ C\]

\(R_{\text{LOAD}}\) will return to the “off” state and the output will be pulled low by \(R_{\text{LOAD}}\). This condition will be independent of the interval when input (A) returns to a high level.

FIGURE 12. RC TIMER

On a negative going transient at input (A), a negative pulse at C will turn “on” the CA3094, and the output (E) will go from a low to a high level.

At the end of the time constant determined by \(C_1, R_1, R_2, R_3\), the CA3094 will return to the “off” state and the output will be pulled low by \(R_{\text{LOAD}}\). This condition will be independent of the interval when input (A) returns to a high level.

FIGURE 13. RC TIMER TRIGGERED BY EXTERNAL NEGATIVE PULSE
**Typical Applications** (Continued)

**FIGURE 14. FREE RUNNING PULSE GENERATOR**

**FIGURE 15. CURRENT OR VOLTAGE CONTROLLED OSCILLATOR**

**FIGURE 16. SINGLE SUPPLY ASTABLE MULTIVIBRATOR**

**FIGURE 17. DUAL SUPPLY ASTABLE MULTIVIBRATOR**

NOTES:
14. \( R = 1 \text{M} \Omega, \ C = 1 \mu \text{F} \).
15. Time Constant: \( t = RC \times 120 \).
16. Pulse Width: \( \omega = K(C_1/C) \).

NOTE: \( f_{\text{OUT}} = \frac{1}{(2RC) \ln \left( \frac{2R_1}{R_2 + 1} \right)} \)

If: \( R_2 = 3.08R_1 \), \( f_{\text{OUT}} = \frac{1}{RC} \)
Typical Applications (Continued)

**FIGURE 18A. DUAL SUPPLY**

**FIGURE 18B. SINGLE SUPPLY**

**FIGURE 18. COMPARATORS (THRESHOLD DETECTORS) DUAL AND SINGLE SUPPLY TYPES**

NOTES:

17. \( R = \frac{R_1 R_2}{R_1 + R_2} \).

18. \( \pm \text{Threshold} = [\pm \text{Supply}] \left[ \frac{R_1}{R_1 + R_2} \right] \).

19. Upper Threshold = \( [V+] \left[ \frac{R_B}{R_1 + R_A + R_B} \right] \).

20. Lower Threshold = \( [V+] \left[ \frac{R_1 R_B}{R_1 + R_B + R_A} \right] \).

**FIGURE 19. TEMPERATURE CONTROLLER**

NOTE: All Resistors are 1/2W.
Typical Applications (Continued)

**FIGURE 20. DUAL VOLTAGE TRACKING REGULATOR**

**FIGURE 21. GROUND FAULT INTERRUPTER (GFI) AND WAVEFORMS PERTINENT TO GROUND FAULT DETECTOR**

**NOTES:**
23. Max $I_{OUT} = \pm 100mA$.
24. Regulation:

\[
\text{Max Line} = \frac{\Delta V_{OUT}}{V_{OUT(Initial)} \Delta V_{IN}} \times 100 = 0.075\% / V
\]

\[
\text{Max Load} = \frac{\Delta V_{OUT}}{V_{OUT(Initial)} \times 100} = 0.075\% V_{OUT}
\]

$I_L$ from 1mA to 50mA

25. Differential current sensor provides 60mV signal $\approx 5mA$ of unbalance (Trip) current.
26. All Resistors are 1/2 Watt, $\pm 10\%$.
27. RC selected for 3dB point at 200Hz.
28. $C_2 = AC$ bypass.
29. Offset adj. included in $R_{TRIP}$.
30. Input impedance from 2 to 3 = 800kΩ.
31. With no input signal Terminal 8 (output) at 36V.
**Typical Applications**

**TYPICAL PERFORMANCE DATA FOR 12W AUDIO AMPLIFIER CIRCUIT**

- **Power Output (8Ω load, Tone Control Set at “Flat”)**
  - Music (at 5% THD, Regulated Supply)................. 15W
  - Continuous (at 0.2% IMD, 60Hz and 2kHz Mixed in a 4:1 Ratio, Unregulated Supply)
    - See Figure 8 in AN6048.......................... 12W

- **Total Harmonic Distortion**
  - At 1W, Unregulated Supply.......................... 0.05%
  - At 12W, Unregulated Supply......................... 0.57%

- **Voltage Gain** ............................................. 40dB

- **Hum and Noise (Below Continuous Power Output)**........... 83dB

**Input Resistance** ................................................... 250kΩ

**Tone Control Range** .............................................. See Figure 9 in AN6048

**NOTES:**
- 32. For standard input: Short R1; C1 = 0.047µF; remove R2.
- 33. For ceramic cartridge input: C1 = 0.0047µF, R1 = 2.5MΩ, remove jumper from C2; leave R2.

**FIGURE 22. 12W AUDIO AMPLIFIER CIRCUIT FEATURING TRUE COMPLEMENTARY SYMMETRY OUTPUT STAGE WITH CA3094 IN DRIVER STAGE**
Typical Performance Curves

**FIGURE 23.** INPUT OFFSET VOLTAGE vs AMPLIFIER BIAS CURRENT ($I_{ABC}$, TERMINAL 5)

**FIGURE 24.** INPUT OFFSET CURRENT vs AMPLIFIER BIAS CURRENT ($I_{ABC}$, TERMINAL 5)

**FIGURE 25.** INPUT BIAS CURRENT vs AMPLIFIER BIAS CURRENT ($I_{ABC}$, TERMINAL 5)

**FIGURE 26.** DEVICE DISSIPATION vs AMPLIFIER BIAS CURRENT ($I_{ABC}$, TERMINAL 5)

**FIGURE 27.** AMPLIFIER SUPPLY CURRENT vs AMPLIFIER BIAS CURRENT ($I_{ABC}$, TERMINAL 5)

**FIGURE 28.** COMMON MODE INPUT VOLTAGE vs AMPLIFIER BIAS CURRENT ($I_{ABC}$, TERMINAL 5)
Typical Performance Curves (Continued)

**FIGURE 29. 1/F NOISE VOLTAGE vs FREQUENCY**

**FIGURE 30. 1/F NOISE CURRENT vs FREQUENCY**

**FIGURE 31. COLLECTOR-TO-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT OF OUTPUT TRANSISTOR (Q13)**

**FIGURE 32. COMPOSITE DC BETA vs COLLECTOR CURRENT OF DARLINGTON CONNECTED OUTPUT TRANSISTORS (Q12, Q13)**

**FIGURE 33. OPEN LOOP VOLTAGE GAIN vs FREQUENCY**

**FIGURE 34. FORWARD TRANSCONDUCTANCE vs AMPLIFIER BIAS CURRENT**
Typical Performance Curves (Continued)

**FIGURE 35. SLEW RATE vs AMPLIFIER BIAS CURRENT**

**FIGURE 36. SLEW RATE vs CLOSED LOOP VOLTAGE GAIN**

**FIGURE 37. PHASE COMPENSATION CAPACITANCE AND RESISTANCE vs CLOSED LOOP VOLTAGE GAIN**