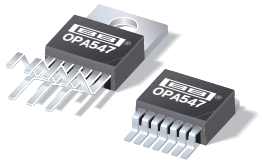
# OPA547



SBOS056A – JANUARY 2002

# High-Voltage, High-Current OPERATIONAL AMPLIFIER

## FEATURES

- **WIDE SUPPLY RANGE**
  **Single Supply: +8V to +60V**
  **Dual Supply: ±4V to ±30V**
- **HIGH OUTPUT CURRENT:**
  **500mA Continuous**
- **WIDE OUTPUT VOLTAGE SWING**
- **FULLY PROTECTED:**
  **Thermal Shutdown**
  **Adjustable Current Limit**
- **OUTPUT DISABLE CONTROL**
- **THERMAL SHUTDOWN INDICATOR**
- **HIGH SLEW RATE: 6V/μs**
- **LOW QUIESCENT CURRENT**
- **PACKAGES:**
  **7-Lead TO-220**
  **7-Lead DDPAK Surface-Mount**

## APPLICATIONS

- **VALVE, ACTUATOR DRIVER**
- **SYNCHRO, SERVO DRIVER**
- **POWER SUPPLIES**
- **TEST EQUIPMENT**
- **TRANSDUCER EXCITATION**
- **AUDIO AMPLIFIER**

## DESCRIPTION

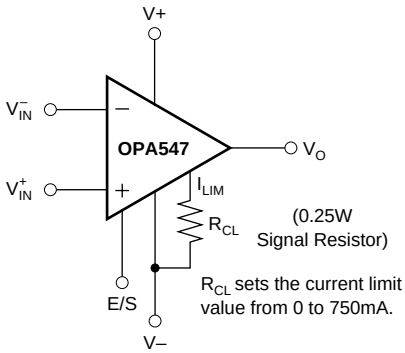
The OPA547 is a low cost, high-voltage/high-current operational amplifier ideal for driving a wide variety of loads. A laser-trimmed monolithic integrated circuit provides excellent low-level signal accuracy and high output voltage and current.

The OPA547 operates from either single or dual supplies for design flexibility. In single supply operation, the input common-mode range extends below ground.

The OPA547 is internally protected against over-temperature conditions and current overloads. In addition, the OPA547 was designed to provide an accurate, user-selected current limit. Unlike other designs which use a "power" resistor in series with the output current path, the OPA547 senses the load indirectly. This allows the current limit to be adjusted from 0 to 750mA with a 0 to 150μA control signal. This is easily done with a resistor/potentiometer or controlled digitally with a voltage-out or current-out DAC.

The Enable/Status (E/S) pin provides two functions. An input on the pin not only disables the output stage to effectively disconnect the load but also reduces the quiescent to conserve power. The E/S pin output can be monitored to determine if the OPA547 is in thermal shutdown.

The OPA547 is available in an industry-standard 7-lead staggered TO-220 package and a 7-lead DDPAK surface-mount plastic power package. The copper tab allows easy mounting to a heat sink or circuit board for excellent thermal performance. It is specified for operation over the extended industrial temperature range, –40°C to +85°C.




Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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## ABSOLUTE MAXIMUM RATINGS(1)

| | |
|---|---|
| Output Current | See SOA Curve |
| Supply Voltage, V+ to V– | 60V |
| Input Voltage | (V–)–0.5V to (V+)+0.5V |
| Input Shutdown Voltage | V+ |
| Operating Temperature | –40°C to +125°C |
| Storage Temperature | –55°C to +125°C |
| Junction Temperature | 150°C |
| Lead Temperature (soldering 10s)(2) | 300°C |

NOTE: (1) Stresses above these ratings may cause permanent damage. (2) Vapor-phase or IR reflow techniques are recommended for soldering the OPA547F surface mount package. Wave soldering is not recommended due to excessive thermal shock and "shadowing" of nearby devices.

## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

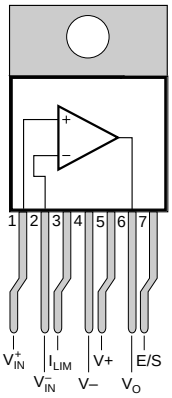
| PRODUCT | PACKAGE-LEAD | PACKAGE DESIGNATOR(1) | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER | TRANSPORT MEDIA, QUANTITY |
|---|---|---|---|---|---|---|
| OPA547T | TO-220-7 | KV | –40°C to +85°C | OPA547T | OPA547T | Tubes, 49 |
| OPA547F | DDPAK-7 | KTW | –40°C to +85°C | OPA547F | OPA547F | Tubes, 49 |
| " | " | " | " | OPA547F | OPA547F/500 | Tape and Reel, 500 |

NOTES: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

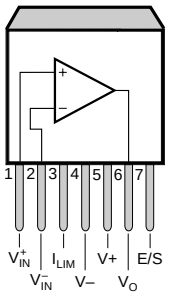
## PIN CONFIGURATIONS

**Top Front View**

**7-Lead Stagger-Formed TO-220**




**7-Lead DDPAK Surface-Mount**




NOTE: Tabs are electrically connected to V– supply.

# ELECTRICAL CHARACTERISTICS

At $T_{CASE}$ = +25°C, $V_S$ = ±30V and E/S pin open, unless otherwise noted.

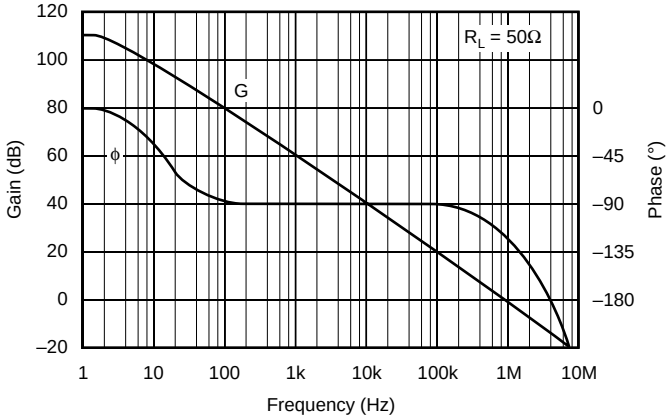
| PARAMETER | CONDITION | OPA547T, F MIN | OPA547T, F TYP | OPA547T, F MAX | UNITS |
|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | |
| Input Offset Voltage | $V_{CM}$ = 0, $I_O$ = 0 | | ±1 | ±5 | mV |
| vs Temperature | $T_A$ = –40°C to +85°C | | ±25 | | µV/°C |
| vs Power Supply | $V_S$ = ±4V to ±30V | | 10 | 100 | µV/V |
| **INPUT BIAS CURRENT**(1) | | | | | |
| Input Bias Current(2) | $V_{CM}$ = 0V | | –100 | –500 | nA |
| vs Temperature | | | ±0.5 | | nA/°C |
| Input Offset Current | $V_{CM}$ = 0V | | ±5 | ±50 | nA |
| **NOISE** | | | | | |
| Input Voltage Noise Density, f = 1kHz | | | 90 | | nV/√Hz |
| Current Noise Density, f = 1kHz | | | 200 | | fA/√Hz |
| **INPUT VOLTAGE RANGE** | | | | | |
| Common-Mode Voltage Range: Positive | Linear Operation | (V+) –3 | (V+) –2.3 | | V |
| Negative | Linear Operation | (V–) –0.1 | (V–) –0.2 | | V |
| Common-Mode Rejection | $V_{CM}$ = (V–) –0.1V to (V+) –3V | 80 | 95 | | dB |
| **INPUT IMPEDANCE** | | | | | |
| Differential | | | $10^7$ \|\| 6 | | Ω \|\| pF |
| Common-Mode | | | $10^9$ \|\| 4 | | Ω \|\| pF |
| **OPEN-LOOP GAIN** | | | | | |
| Open-Loop Voltage Gain, f = 10Hz | $V_O$ = ±25V, $R_L$ = 1kΩ | 100 | 115 | | dB |
| | $V_O$ = ±25V, $R_L$ = 50Ω | | 110 | | dB |
| **FREQUENCY RESPONSE** | | | | | |
| Gain-Bandwidth Product | $R_L$ = 50Ω | | 1 | | MHz |
| Slew Rate | G = 1, 50Vp-p, $R_L$ = 50Ω | | 6 | | V/µs |
| Full Power Bandwidth | | | See Typical Curve | | kHz |
| Settling Time: ±0.1% | G = –10, 50V Step | | 18 | | µs |
| Total Harmonic Distortion + Noise, f = 1kHz | $R_L$ = 50Ω, G = +3V, 1W Power | | 0.004(3) | | % |
| **OUTPUT** | | | | | |
| Voltage Output, Positive | $I_O$ = 0.5A | (V+) –2.2 | (V+) –1.9 | | V |
| Negative | $I_O$ = –0.5A | (V–) +1.6 | (V–) +1.3 | | V |
| Positive | $I_O$ = 0.1A | (V+) –1.8 | (V+) –1.5 | | V |
| Negative | $I_O$ = –0.1A | (V–) +1.2 | (V–) +0.8 | | V |
| Maximum Continuous Current Output: dc | | ±500 | | | mA |
| ac | | 500 | | | mArms |
| Leakage Current, Output Disabled, dc | | | See Typical Curve | | |
| Output Current Limit | | | | | |
| Current Limit Range | | | 0 to ±750 | | mA |
| Current Limit Equation | | | $I_{LIM}$ = (5000)(4.75)/(31600Ω + $R_{CL}$) | | A |
| Current Limit Tolerance(1) | $R_{CL}$ = 31.6kΩ ($I_{LIM}$ = ±375mA), $R_L$ = 50Ω | | ±10 | ±30 | mA |
| Capacitive Load Drive | | | See Typical Curve(4) | | |
| **OUTPUT ENABLE /STATUS (E/S) PIN** | | | | | |
| Shutdown Input Mode | | | | | |
| $V_{E/S}$ High (output enabled) | E/S Pin Open or Forced High | (V–) +2.4 | | | V |
| $V_{E/S}$ Low (output disabled) | E/S Pin Forced Low | | | (V–) +0.8 | V |
| $I_{E/S}$ High (output enabled) | E/S Pin High | | –60 | | µA |
| $I_{E/S}$ Low (output disabled) | E/S Pin Low | | –65 | | µA |
| Output Disable Time | | | 1 | | µs |
| Output Enable Time | | | 3 | | ms |
| Thermal Shutdown Status Output | | | | | |
| Normal Operation | Sourcing 20µA | (V–) +2.4 | (V–) +3.5 | | V |
| Thermally Shutdown | Sinking 5µA, $T_J$ > 160°C | | (V–) +0.35 | (V–) +0.8 | V |
| Junction Temperature, Shutdown | | | +160 | | °C |
| Reset from Shutdown | | | +140 | | °C |
| **POWER SUPPLY** | | | | | |
| Specified Voltage | | | ±30 | | V |
| Operating Voltage Range | | ±4 | | ±30 | V |
| Quiescent Current | $I_{LIM}$ Connected to V–, $I_O$ = 0 | | ±10 | ±15 | mA |
| Quiescent Current, Shutdown Mode | $I_{LIM}$ Connected to V– | | ±4 | | mA |
| **TEMPERATURE RANGE** | | | | | |
| Specified Range | | –40 | | +85 | °C |
| Operating Range | | –40 | | +125 | °C |
| Storage Range | | –55 | | +125 | °C |
| Thermal Resistance, $\theta_{JC}$ | | | | | |
| 7-Lead DDPAK, 7-Lead TO-220 | f > 50Hz | | 2 | | °C/W |
| 7-Lead DDPAK, 7-Lead TO-220 | dc | | 3 | | °C/W |
| Thermal Resistance, $\theta_{JA}$ | | | | | |
| 7-Lead DDPAK, 7-Lead TO-220 | No Heat Sink | | 65 | | °C/W |

NOTES: (1) High-speed test at $T_J$ = +25°C. (2) Positive conventional current flows into the input terminals. (3) See "Total Harmonic Distortion+Noise" in the Typical Characteristics section for additional power levels. (4) See "Small-Signal Overshoot vs Load Capacitance" in the Typical Characteristics section.

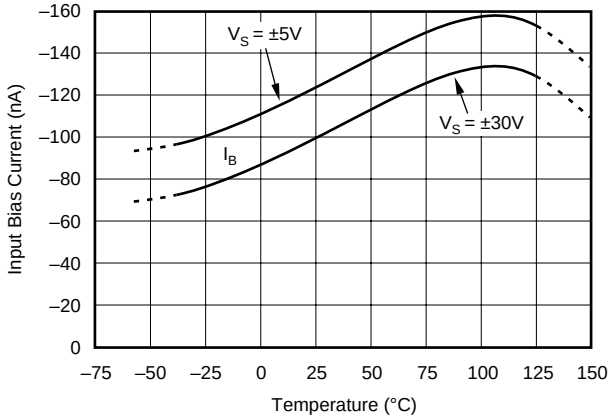
# TYPICAL CHARACTERISTICS

At $T_{CASE}$ = +25°C, $V_S$ = ±30V and E/S pin open, unless otherwise noted.

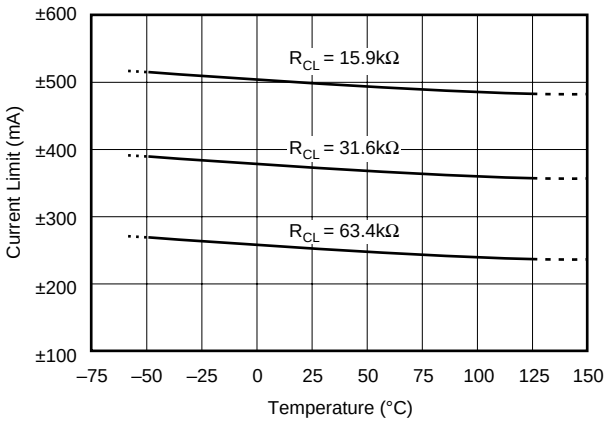
OPEN-LOOP GAIN AND PHASE vs FREQUENCY



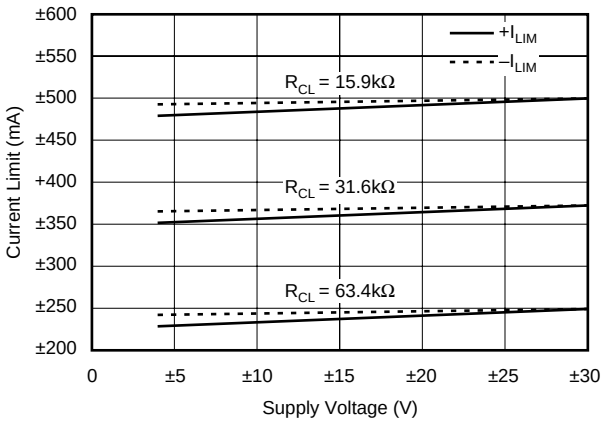

INPUT BIAS CURRENT vs TEMPERATURE



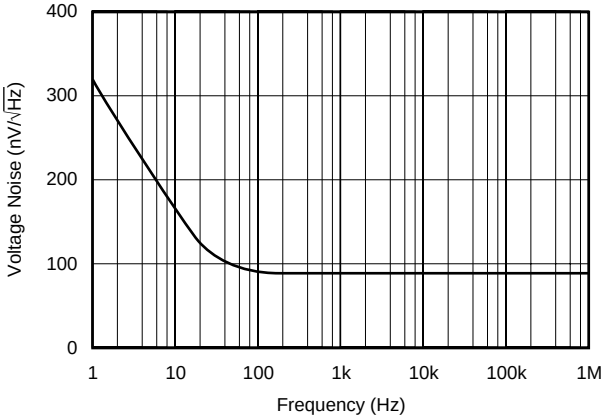

CURRENT LIMIT vs TEMPERATURE



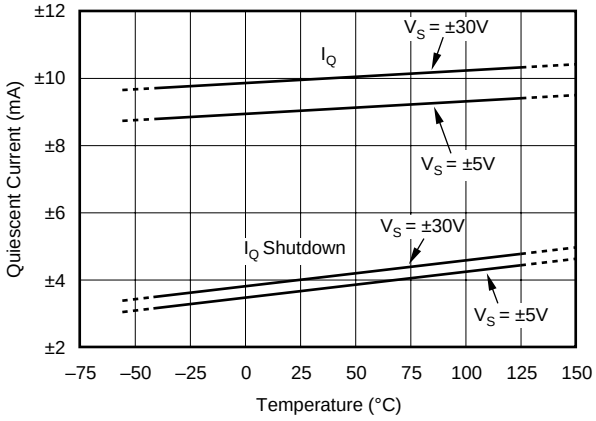

CURRENT LIMIT vs SUPPLY VOLTAGE




VOLTAGE NOISE DENSITY vs FREQUENCY



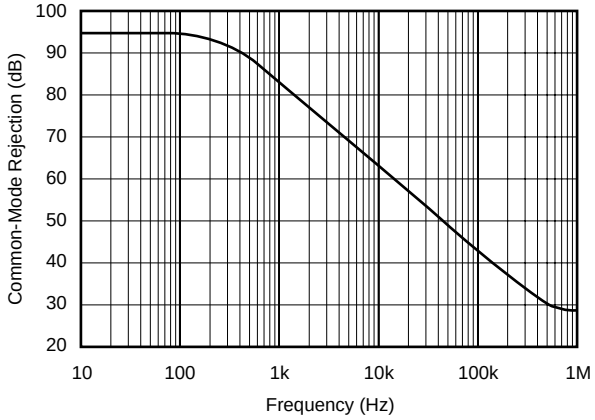

QUIESCENT CURRENT vs TEMPERATURE



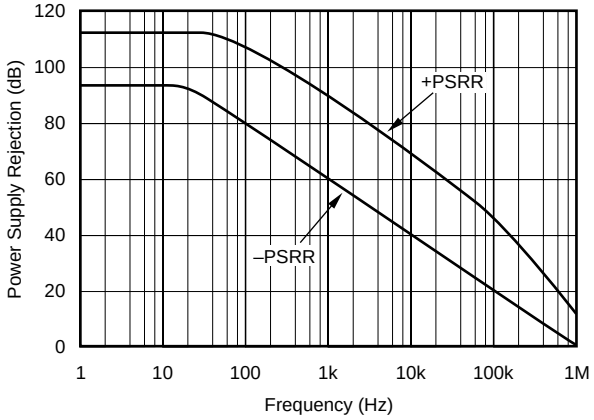
# TYPICAL CHARACTERISTICS (Cont.)

At $T_{CASE}$ = +25°C, $V_S$ = ±30V and E/S pin open, unless otherwise noted.

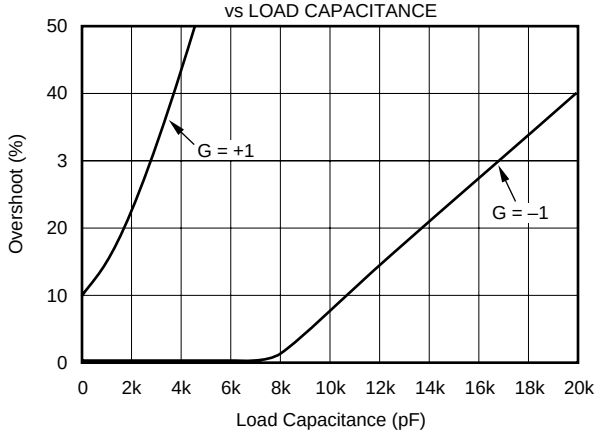
COMMON-MODE REJECTION vs FREQUENCY



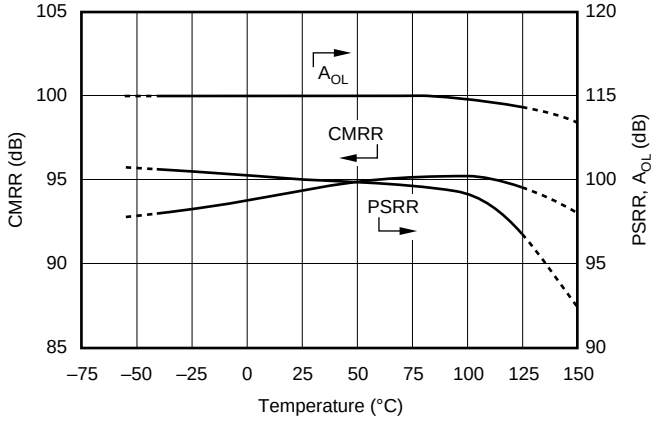

POWER SUPPLY REJECTION vs FREQUENCY



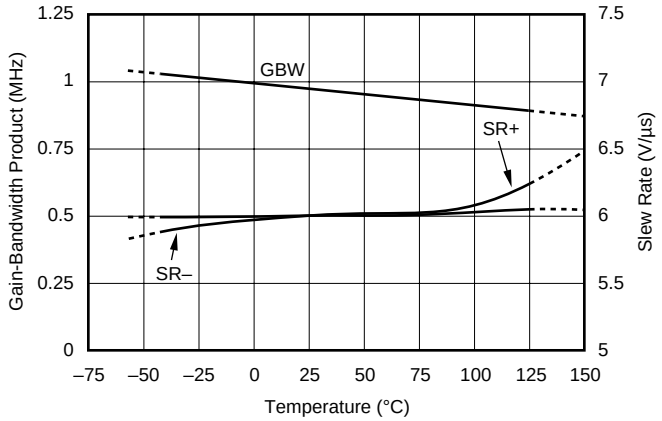

SMALL-SIGNAL OVERSHOOT vs LOAD CAPACITANCE



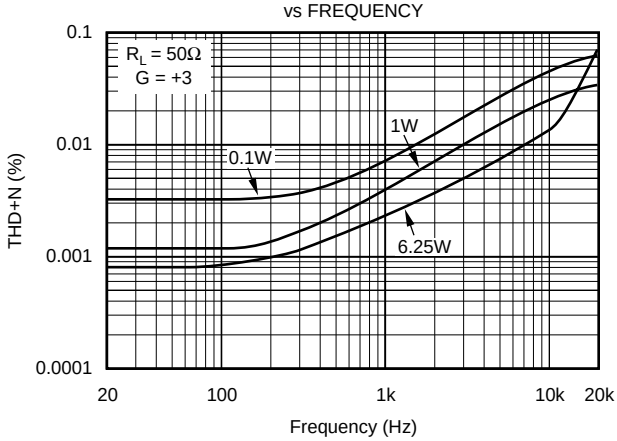

OPEN-LOOP GAIN, COMMON-MODE REJECTION, AND POWER SUPPLY REJECTION vs TEMPERATURE




GAIN-BANDWIDTH PRODUCT AND SLEW RATE vs TEMPERATURE



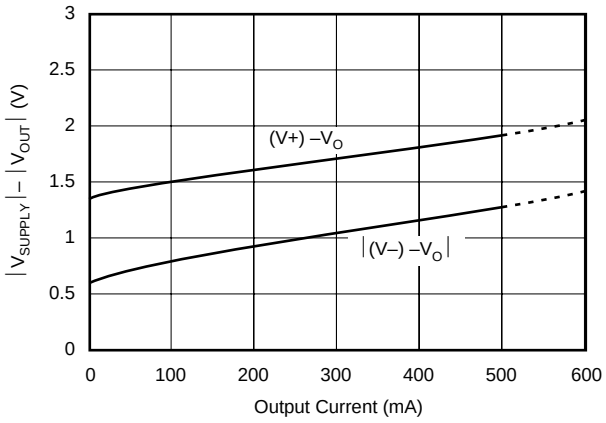

TOTAL HARMONIC DISTORTION+NOISE vs FREQUENCY



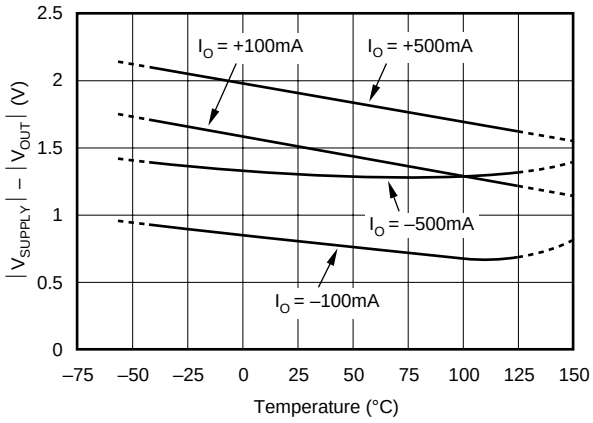
# TYPICAL CHARACTERISTICS (Cont.)

At $T_{CASE}$ = +25°C, $V_S$ = ±30V and E/S pin open, unless otherwise noted.

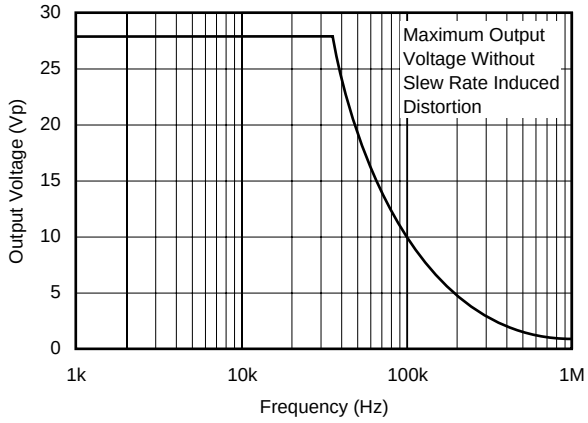
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



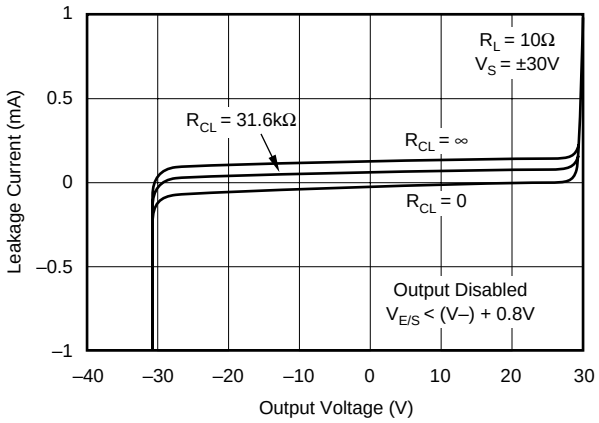

OUTPUT VOLTAGE SWING vs TEMPERATURE



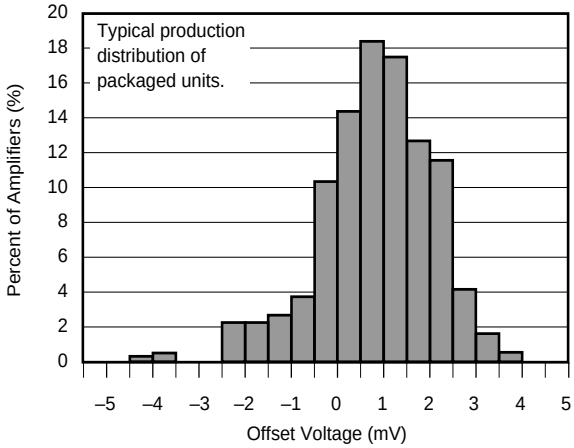

MAXIMUM OUTPUT VOLTAGE SWING vs FREQUENCY



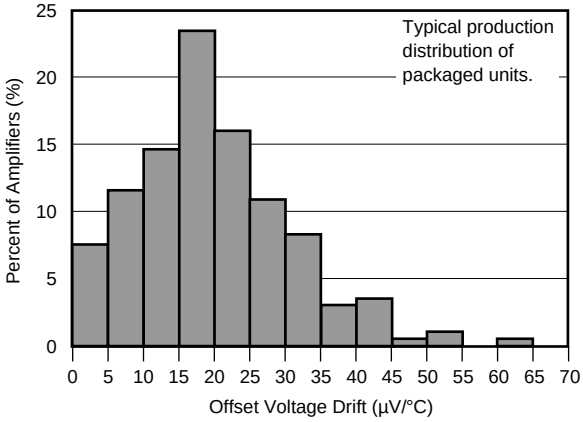

OUTPUT LEAKAGE CURRENT vs APPLIED OUTPUT VOLTAGE




OFFSET VOLTAGE PRODUCTION DISTRIBUTION



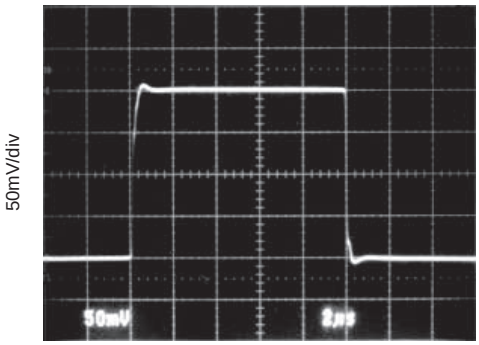

OFFSET VOLTAGE DRIFT PRODUCTION DISTRIBUTION



# TYPICAL CHARACTERISTICS (Cont.)

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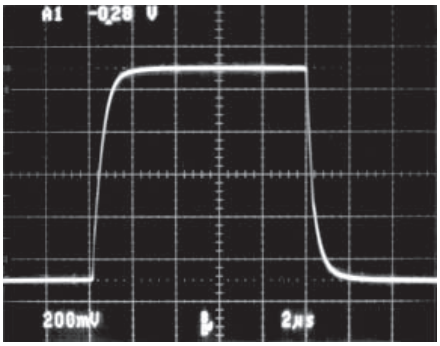
SMALL SIGNAL STEP RESPONSE
G = 1, $C_L$ = 1000pF




50mV/div

2µs/div

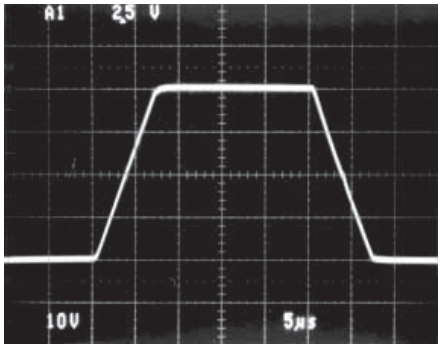
SMALL SIGNAL STEP RESPONSE
G = 3, $C_L$ = 1000pF




50mV/div

2µs/div

LARGE SIGNAL STEP RESPONSE
G = 3, $C_L$ = 100pF, $R_L$ = 50Ω



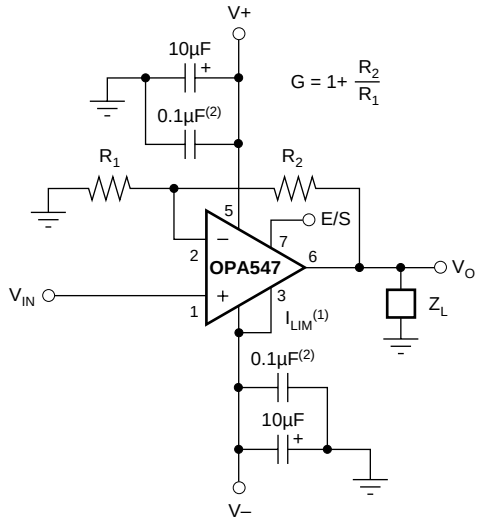

10V/div

5µs/div

# APPLICATIONS INFORMATION

Figure 1 shows the OPA547 connected as a basic non-inverting amplifier. The OPA547 can be used in virtually any op amp configuration.

Power supply terminals should be bypassed with low series impedance capacitors. The technique shown, using a ceramic and tantalum type in parallel is recommended. Power supply wiring should have low series impedance.




NOTE: (1) $I_{LIM}$ connected to V– gives the maximum current limit, 750mA (peak). (2) Connect 0.1µF capacitors directly to package power supply pins.

FIGURE 1. Basic Circuit Connections.

## POWER SUPPLIES

The OPA547 operates from single (+8V to +60V) or dual (±4V to ±30V) supplies with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the typical characteristics curves.

Some applications do not require equal positive and negative output voltage swing. Power supply voltages do not need to be equal. The OPA547 can operate with as little as 8V between the supplies and with up to 60V between the supplies. For example, the positive supply could be set to 55V with the negative supply at –5V, or vice-versa.

## ADJUSTABLE CURRENT LIMIT

The OPA547 features an accurate, user-selected current limit. Current limit is set from 0 to 750mA by controlling the input to the $I_{LIM}$ pin. Unlike other designs which use a power resistor in series with the output current path, the OPA547 senses the load indirectly. This allows the current limit to be set with a 0 to 150µA control signal. In contrast, other designs require a limiting resistor to handle the full output current (750mA in this case).

With the OPA547, the simplest method for adjusting the current limit uses a resistor or potentiometer connected between the $I_{LIM}$ pin and V– according to the equation:

$$R_{CL} = \frac{(5000)(4.75)}{I_{LIM}} - 31.6k\Omega$$

The low level control signal (0 to 150µA) also allows the current limit to be digitally controlled with a current-out or voltage-out DAC reference to V– according to the equations given in Figure 3.

Figure 3 shows a simplified schematic of the internal circuitry used to set the current limit. Leaving the $I_{LIM}$ pin open programs the output current to zero, while connecting $I_{LIM}$ directly to V– programs the maximum output current limit, typically 750mA.

## SAFE OPERATING AREA

Stress on the output transistors is determined both by the output current and by the output voltage across the conducting output transistor, $V_S - V_O$. The power dissipated by the output transistor is equal to the product of the output current and the voltage across the conducting transistor, $V_S - V_O$. The Safe Operating Area (SOA curve, Figure 2) shows the permissible range of voltage and current.

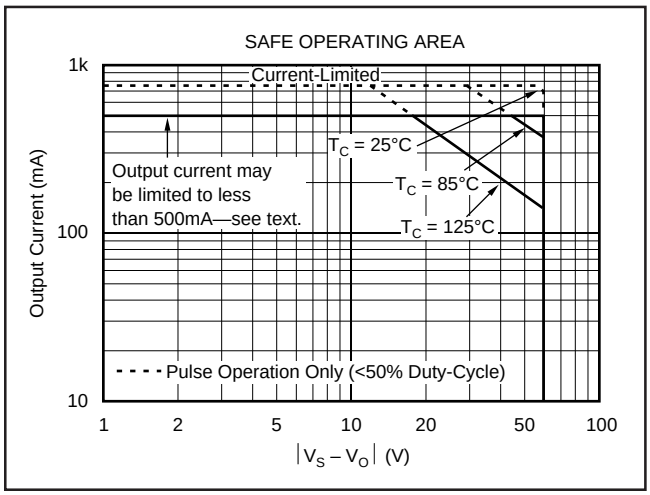



FIGURE 2. Safe Operating Area.

The safe output current decreases as $V_S - V_O$ increases. Output short-circuits are a very demanding case for SOA. A short-circuit to ground forces the full power supply voltage (V+ or V–) across the conducting transistor. With $T_C = 25°C$ the maximum output current of 500mA can be achieved under most conditions. Increasing the case temperature reduces the safe output current that can be tolerated without activating the thermal shutdown circuit of the OPA547. For further insight on SOA, consult Application Bulletin AB-039.

## POWER DISSIPATION

Power dissipation depends on power supply, signal and load conditions. For dc signals, power dissipation is equal to the product of output current times the voltage across the con-

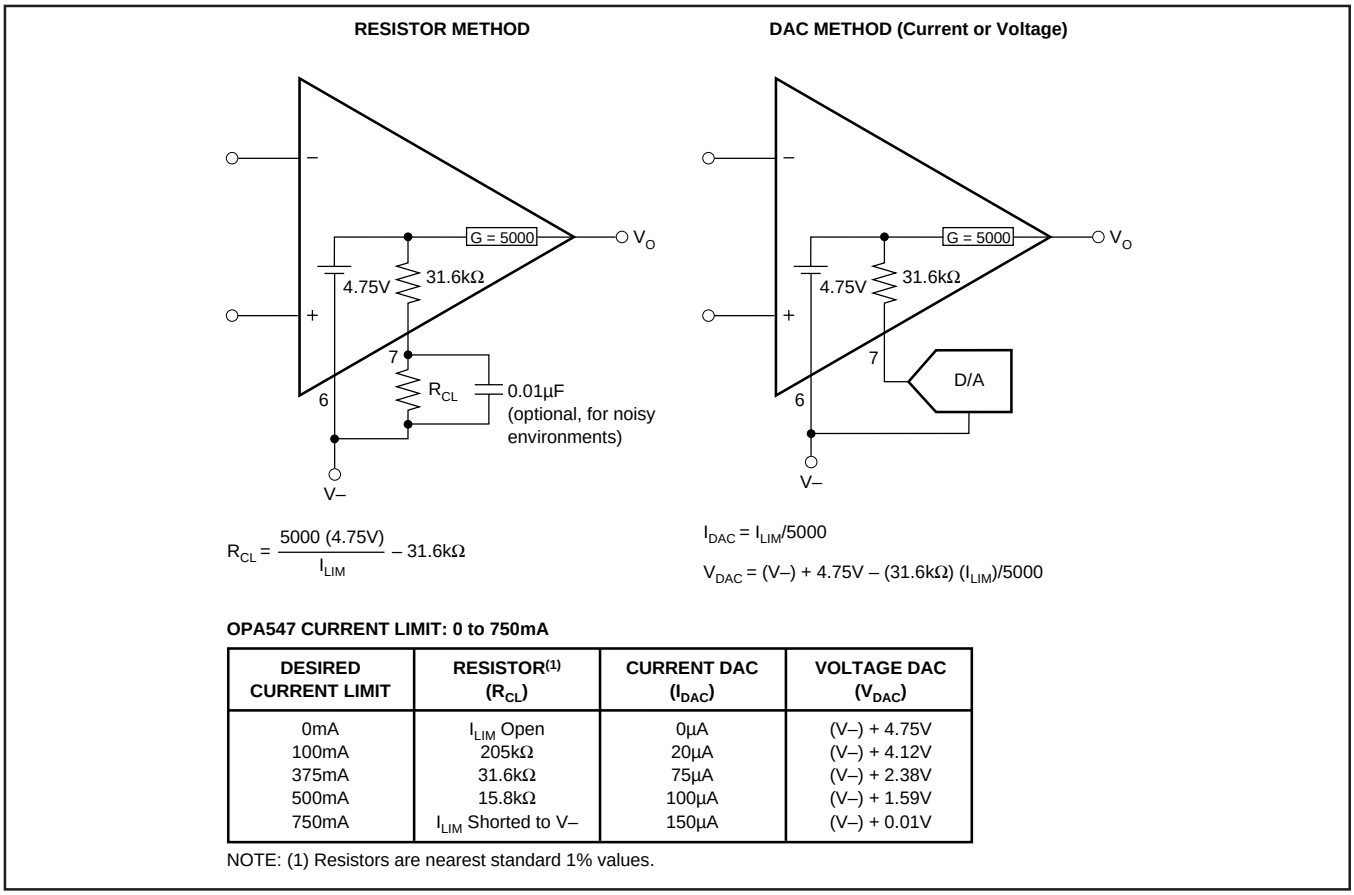
ducting output transistor. Power dissipation can be minimized by using the lowest possible power supply voltage necessary to assure the required output voltage swing.

For resistive loads, the maximum power dissipation occurs at a dc output voltage of one-half the power supply voltage. Dissipation with ac signals is lower. Application Bulletin AB-039 explains how to calculate or measure power dissipation with unusual signals and loads.

## HEAT SINKING

Most applications require a heat sink to assure that the maximum junction temperature (150°C) is not exceeded. The heat sink required depends on the power dissipated and on ambient conditions. Consult Application Bulletin AB-038 for information on determining heat sink requirements. The internal protection circuitry was designed to protect against overload conditions. It does not activate until the junction temperature reaches approximately 160°C and was not intended to replace proper heat sinking. Continuously running the OPA547 into thermal shutdown will degrade reliability.

The tab of the DDPAK surface-mount version should be soldered to a circuit board copper area for good heat dissipation. Figure 4 shows typical thermal resistance from junction to ambient as a function of the copper area.




**OPA547 CURRENT LIMIT: 0 to 750mA**

| DESIRED CURRENT LIMIT | RESISTOR(1) ($R_{CL}$) | CURRENT DAC ($I_{DAC}$) | VOLTAGE DAC ($V_{DAC}$) |
|---|---|---|---|
| 0mA | $I_{LIM}$ Open | 0µA | (V–) + 4.75V |
| 100mA | 205kΩ | 20µA | (V–) + 4.12V |
| 375mA | 31.6kΩ | 75µA | (V–) + 2.38V |
| 500mA | 15.8kΩ | 100µA | (V–) + 1.59V |
| 750mA | $I_{LIM}$ Shorted to V– | 150µA | (V–) + 0.01V |

NOTE: (1) Resistors are nearest standard 1% values.

FIGURE 3. Adjustable Current Limit.

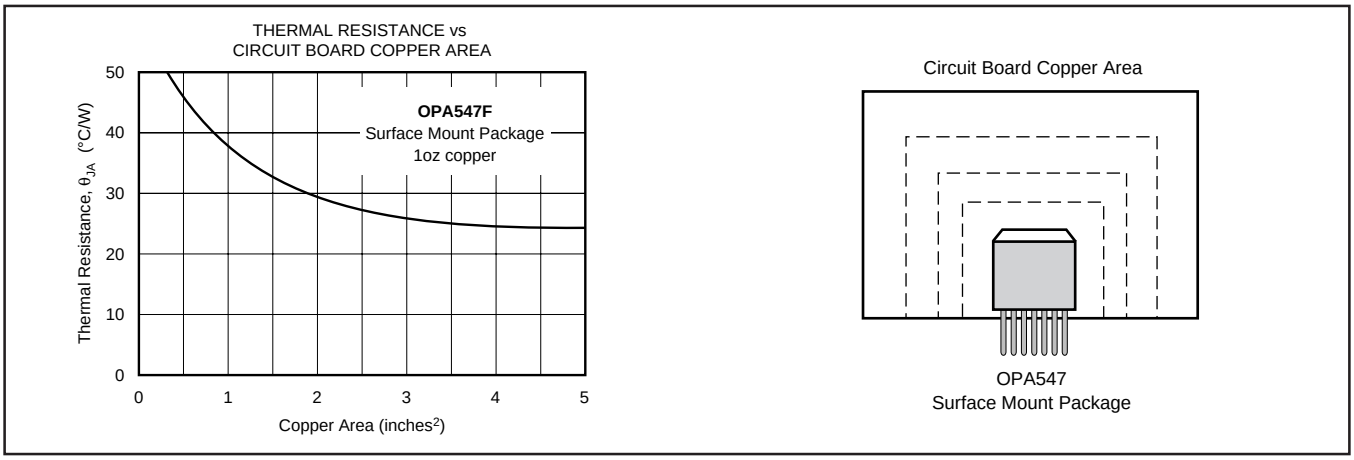



FIGURE 4. Thermal Resistance vs. Circuit Board Copper Area.

## THERMAL PROTECTION

The OPA547 has thermal shutdown that protects the amplifier from damage. Activation of the thermal shutdown circuit during normal operation is an indication of excessive power dissipation or an inadequate heat sink. Depending on load and signal conditions, the thermal protection circuit may cycle on and off. This limits the dissipation of the amplifier but may have an undesirable effect on the load.

The thermal protection activates at a junction temperature of approximately 160°C. However, for reliable operation junction temperature should be limited to 150°C. To estimate the margin of safety in a complete design (including heat sink), increase the ambient temperature until the thermal protection is activated. Use worst-case load and signal conditions. For good reliability, the thermal protection should trigger more than 35°C above the maximum expected ambient condition of your application. This produces a junction temperature of 125°C at the maximum expected ambient condition.

## ENABLE/STATUS (E/S) PIN

The Enable/Status Pin provides two functions: forcing this pin low disables the output stage, or, E/S can be monitored to determine if the OPA547 is in thermal shutdown. One or both of these functions can be utilized on the same device using single or dual supplies. For normal operation (output enabled), the E/S pin can be left open or pulled high (at least +2.4V above the negative rail).

### Output Disable

A unique feature of the OPA547 is its output disable capability. This function not only conserves power during idle periods (quiescent current drops to approximately 4mA) but also allows multiplexing in low frequency (f<10kHz), multichannel applications. Signals that are greater than 10kHz may cause leakage current to increase in devices that are shutdown. Figure 15 shows the two OPA547s in a switched amplifier configuration. The on/off state of the two amplifiers is controlled by the voltage on the E/S pin.

To disable the output, the E/S pin is pulled low, no greater than 0.8V above the negative rail. Typically the output is shutdown in 1µs. Figure 5 provides an example of how to implement this function using a single supply. Figure 6 gives a circuit for dual supply applications. To return the output to an enabled state, the E/S pin should be disconnected (open) or pulled to at least (V–) + 2.4V. It should be noted that pulling the E/S pin high (output enabled) does not disable internal thermal shutdown.

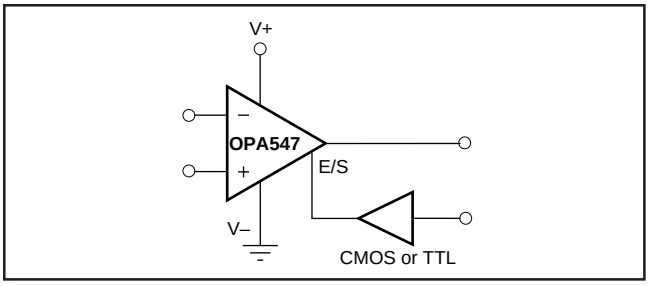



FIGURE 5. Output Disable with a Single Supply.

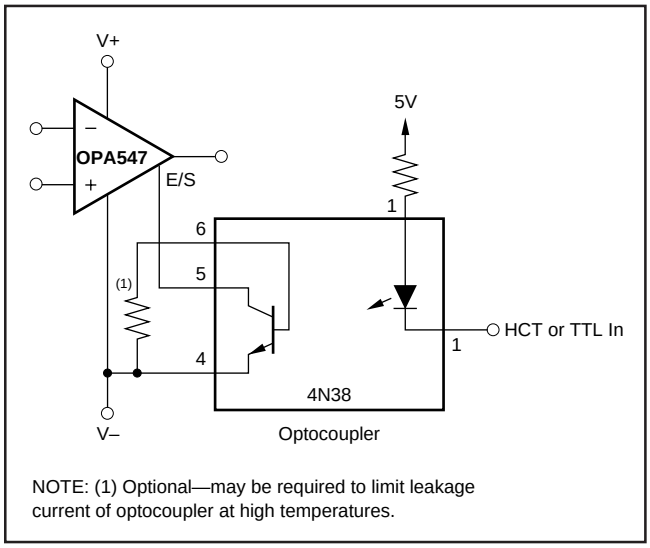



FIGURE 6. Output Disable with Dual Supplies.

### Thermal Shutdown Status

Internal thermal shutdown circuitry shuts down the output when the die temperature reaches approximately 160°C, resetting when the die has cooled to 140°C. The E/S pin can be monitored to determine if shutdown has occurred. During normal operation the voltage on the E/S pin is typically 3.5V above the negative rail. Once shutdown has occurred this voltage drops to approximately 350mV above the negative rail.

Figure 7 gives an example of monitoring shutdown in a single supply application. Figure 8 provides a circuit for dual supplies. External logic circuitry or an LED could be used to indicate if the output has been thermally shutdown, see Figure 13.

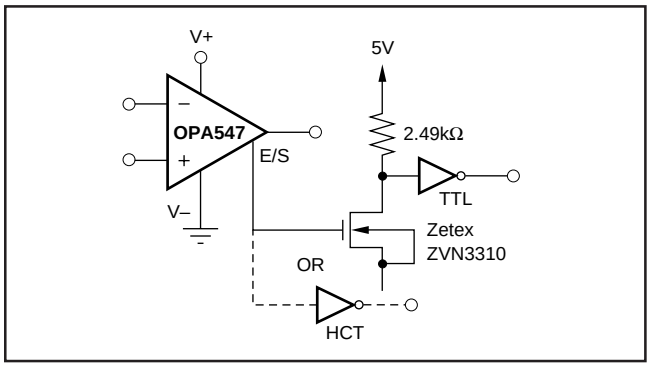



FIGURE 7. Thermal Shutdown Status with a Single Supply.

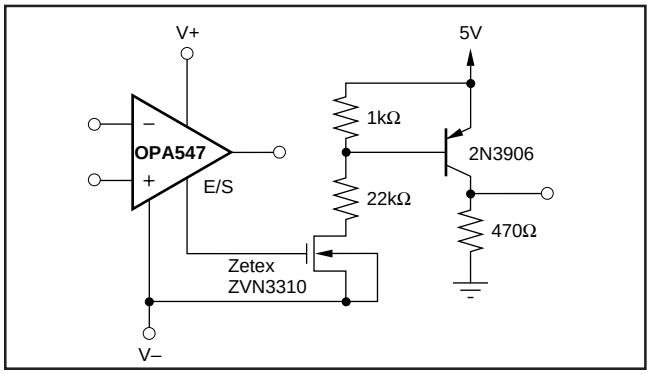



FIGURE 8. Thermal Shutdown Status with Dual Supplies.

### Output Disable and Thermal Shutdown Status

As mentioned earlier, the OPA547's output can be disabled and the disable status can be monitored simultaneously. Figures 9 and 10 provide examples using a single supply and dual supplies, respectively.

## OUTPUT STAGE COMPENSATION

The complex load impedances common in power op amp applications can cause output stage instability. For normal operation output compensation circuitry is not typically required. However, if the OPA547 is intended to be driven into current limit, a R/C network may be required. Figure 11 shows an output series R/C compensation (snubber) network (3Ω in series with 0.01µF) which generally provides excellent stability. Some variations in circuit values may be required with certain loads.

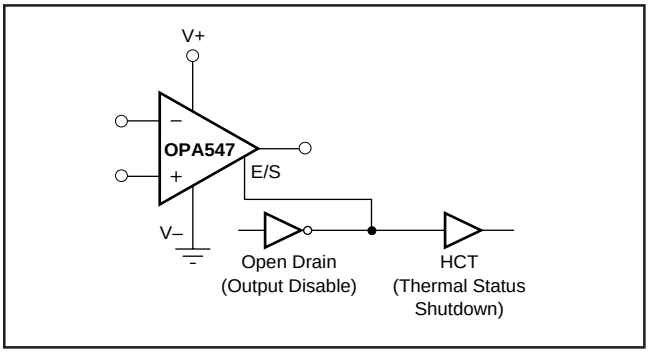



FIGURE 9. Output Disable and Thermal Shutdown Status with a Single Supply.

## OUTPUT PROTECTION

Reactive and EMF-generating loads can return load current to the amplifier, causing the output voltage to exceed the power supply voltage. This damaging condition can be avoided with clamp diodes from the output terminal to the power supplies as shown in Figure 11. Schottkey rectifier diodes with a 1A or greater continuous rating are recommended.

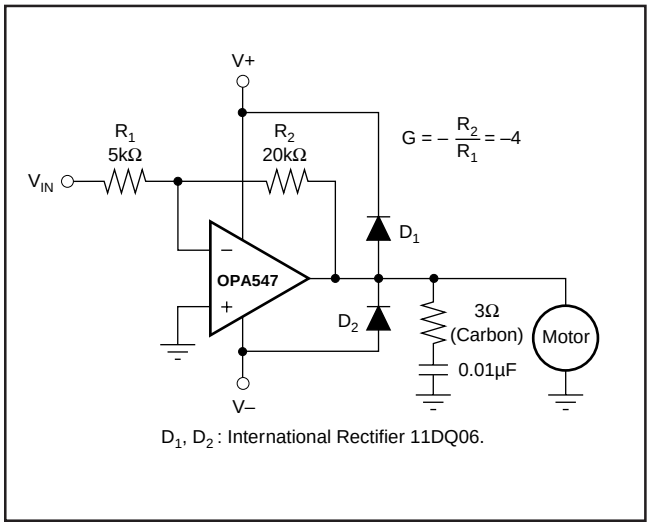



FIGURE 11. Motor Drive Circuit.

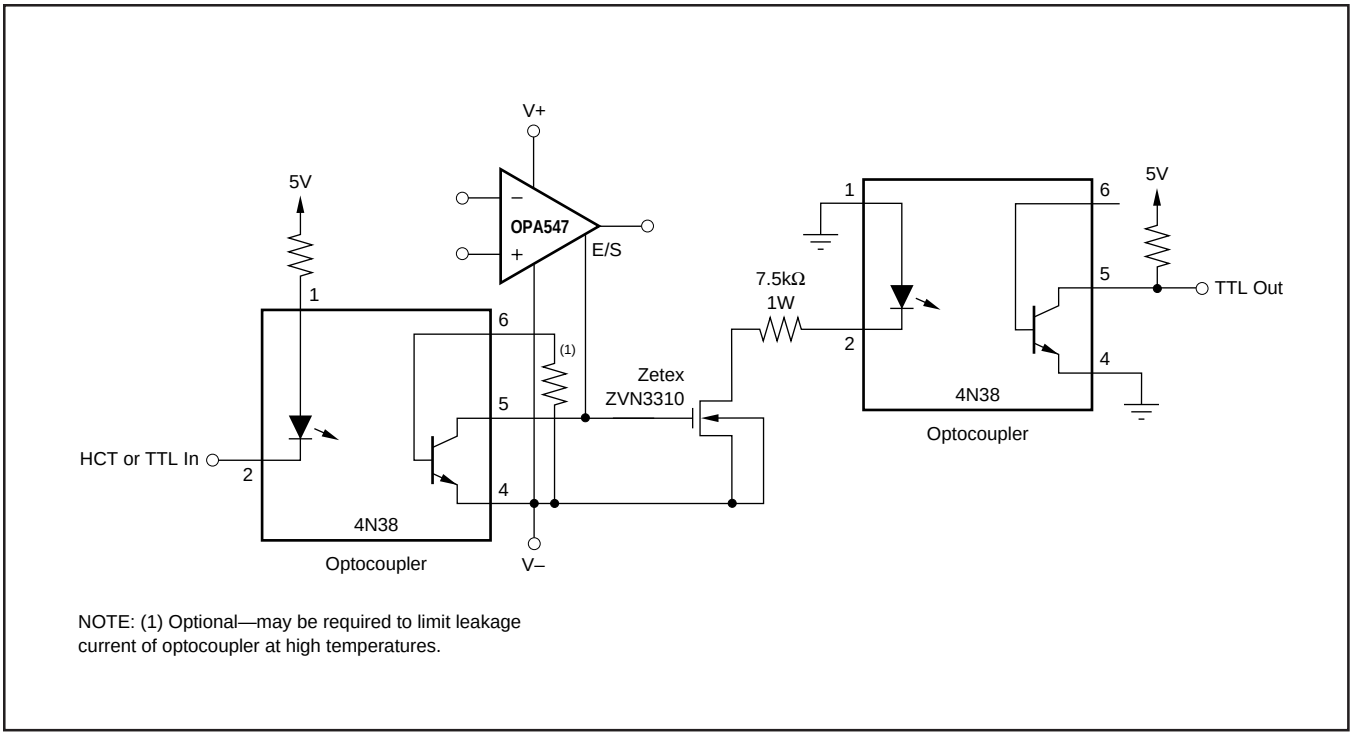



FIGURE 10. Output Disable and Thermal Shutdown Status with Dual Supplies.

## VOLTAGE SOURCE APPLICATION

Figure 12 illustrates how to use the OPA547 to provide an accurate voltage source with only three external resistors. First, the current limit resistor, $R_{CL}$, is chosen according to the desired output current. The resulting voltage at the $I_{LIM}$ pin is constant and stable over temperature. This voltage, $V_{CL}$, is connected to the noninverting input of the op amp and used as a voltage reference, thus eliminating the need for an external reference. The feedback resistors are selected to gain $V_{CL}$ to the desired output voltage level.

## PROGRAMMABLE POWER SUPPLY

A programmable power supply can easily be built using the OPA547. Both the output voltage and output current are user-controlled. Figure 13 shows a circuit using potentiometers to adjust the output voltage and current while Figure 14 uses digital-to-analog converters. An LED tied to the E/S pin through a logic gate indicates if the OPA547 is in thermal shutdown.

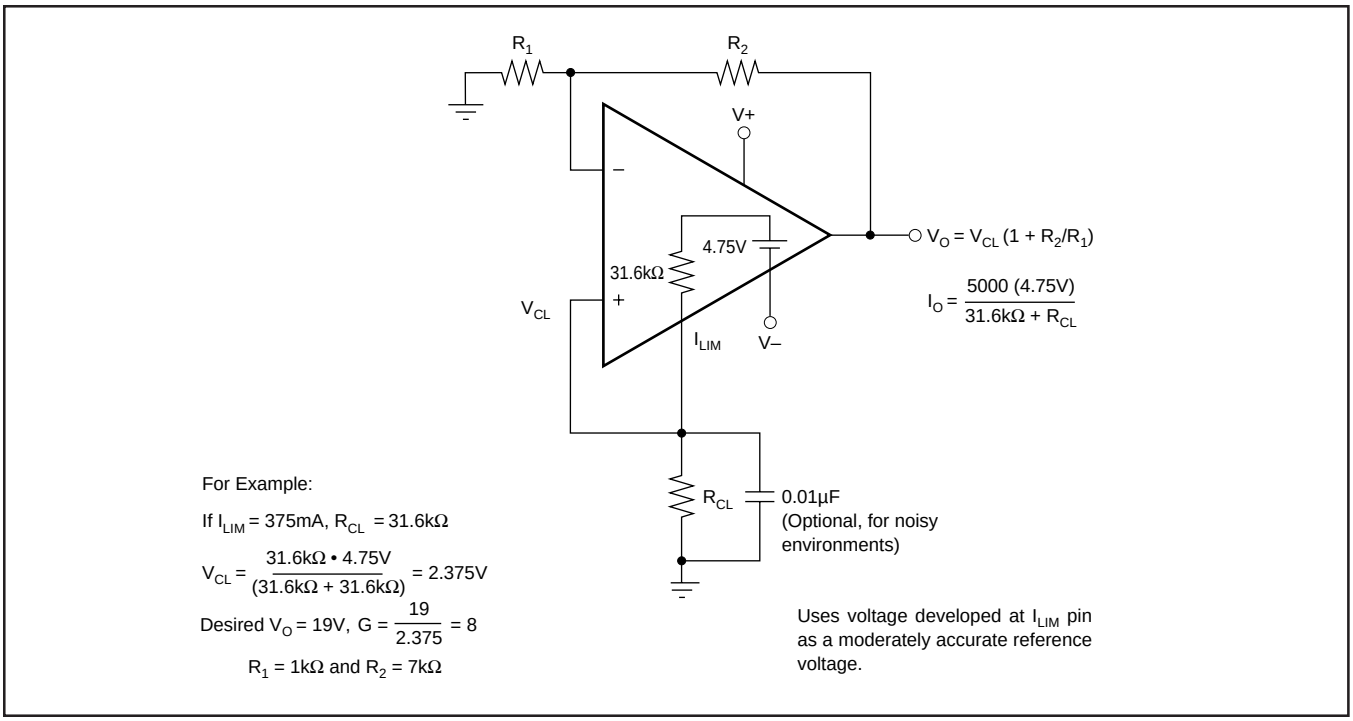



FIGURE 12. Voltage Source.

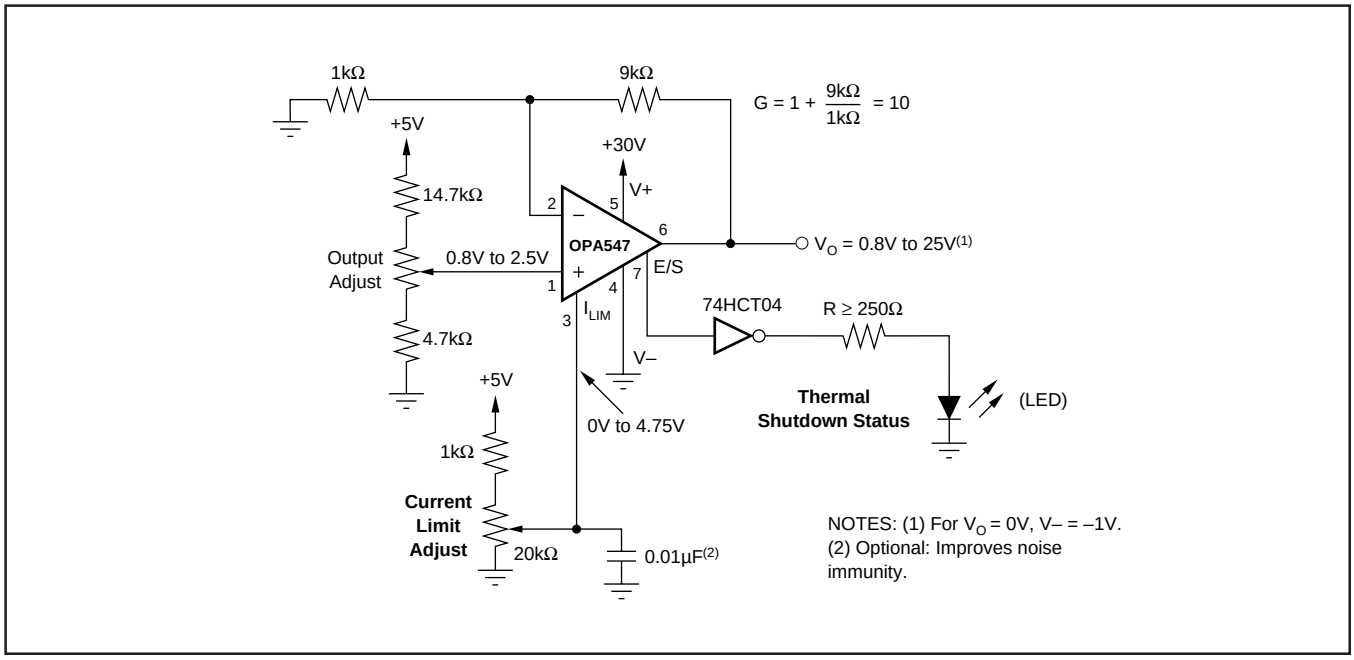
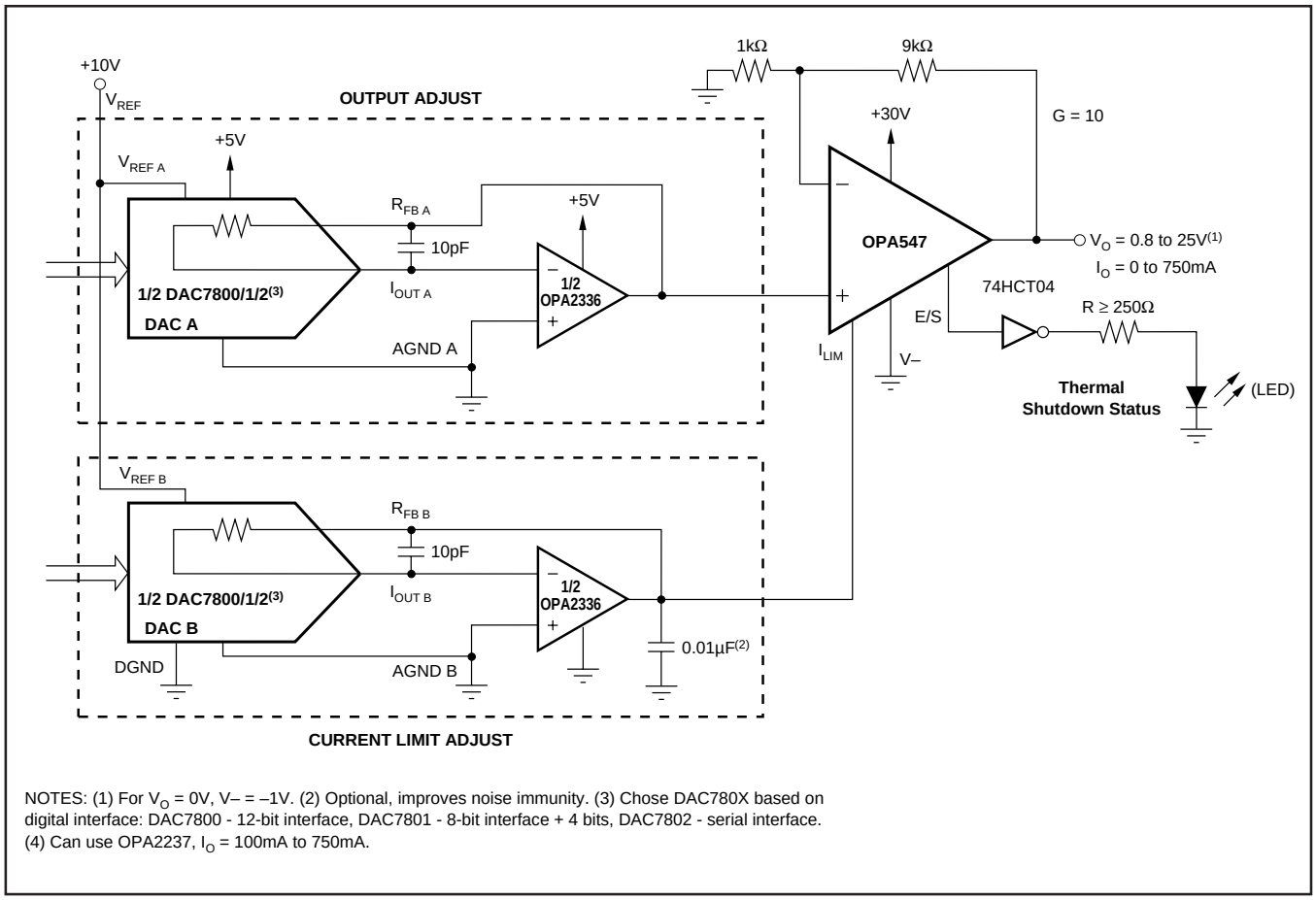



FIGURE 13. Resistor-Controlled Programmable Power Supply.




NOTES: (1) For $V_O$ = 0V, V– = –1V. (2) Optional, improves noise immunity. (3) Chose DAC780X based on digital interface: DAC7800 - 12-bit interface, DAC7801 - 8-bit interface + 4 bits, DAC7802 - serial interface. (4) Can use OPA2237, $I_O$ = 100mA to 750mA.

FIGURE 14. Digitally-Controlled Programmable Power Supply.

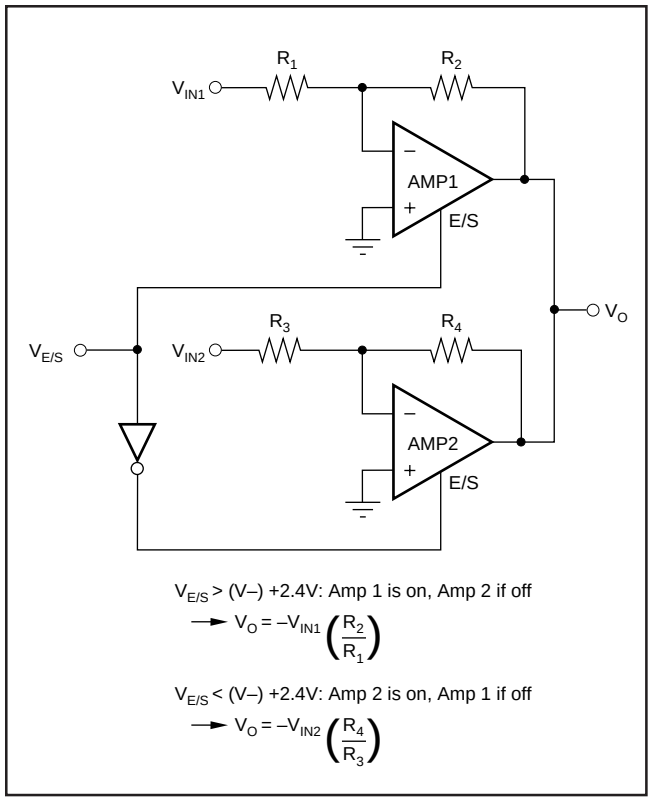



FIGURE 15. Swap Amplifier.

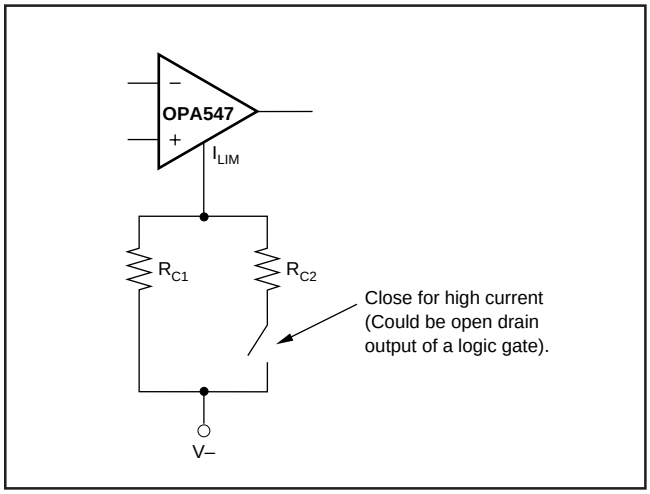
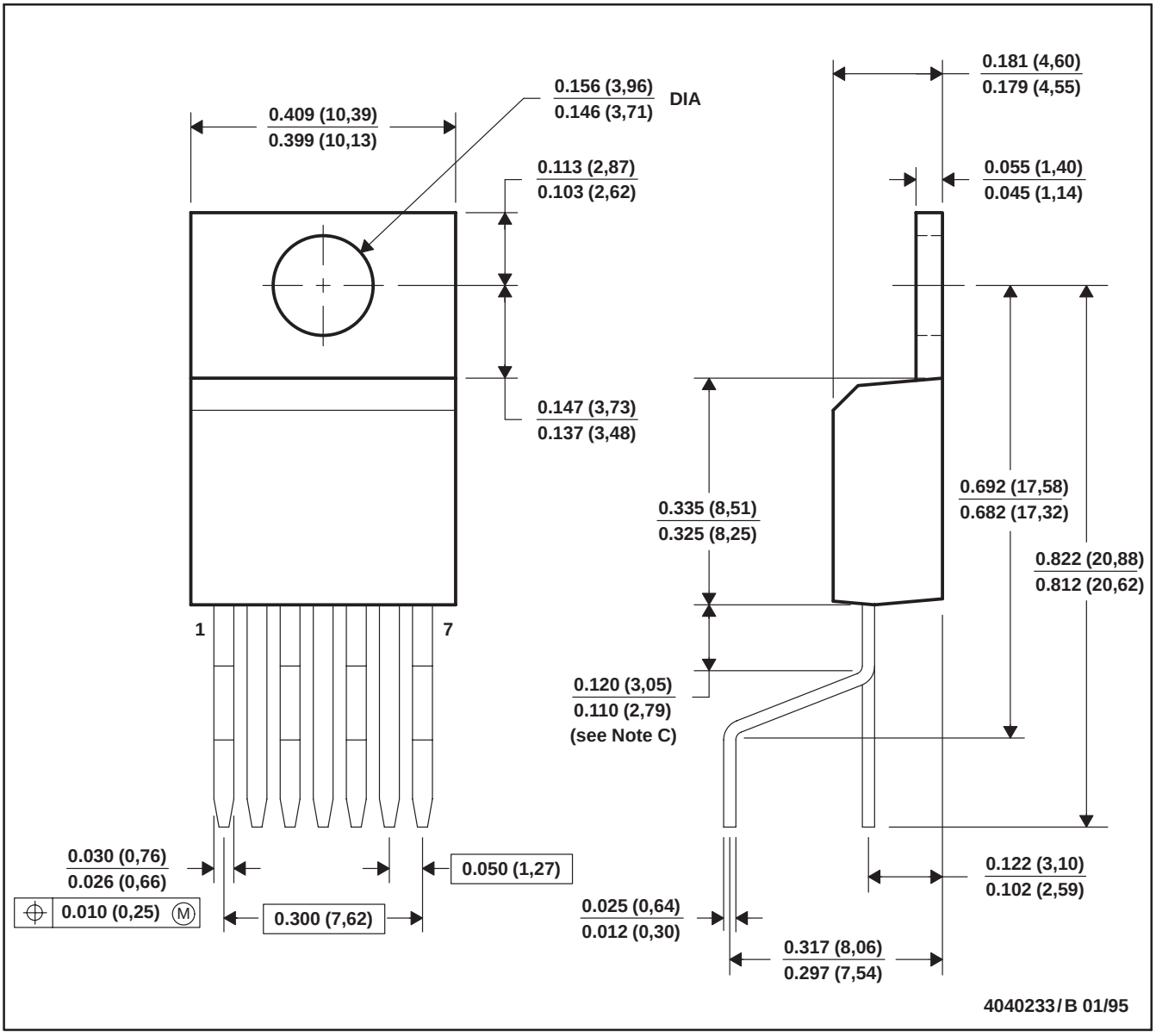


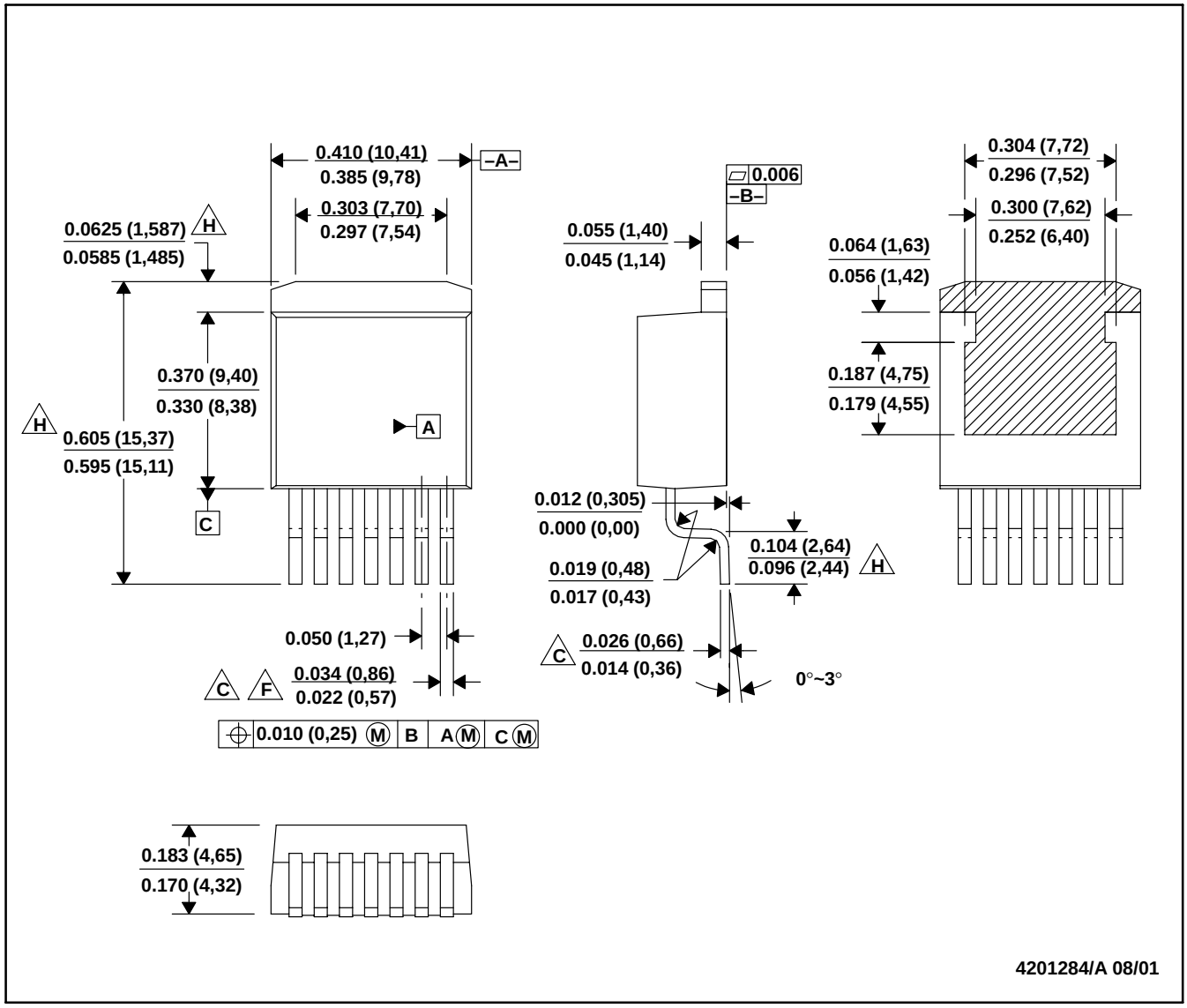

FIGURE 16. Multiple Current Limit Values.

## KV (R-PZFM-T7) PLASTIC FLANGE-MOUNT PACKAGE




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Lead dimensions are not controlled within this area.
D. All lead dimensions apply before solder dip.

**KTW (R-PSFM-G7)** **PLASTIC FLANGE-MOUNT**




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Lead width and height dimensions apply to the plated lead.
D. Leads are not allowed above the Datum B.
E. Stand–off height is measured from lead tip with reference to Datum B.
F. Lead width dimension does not include dambar protrusion. Allowable dambar protrusion shall not cause the lead width to exceed the maximum dimension by more than 0.003”.
G. Cross–hatch indicates exposed metal surface.
H. Falls within JEDEC MO–169 with the exception of the dimensions indicated.

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