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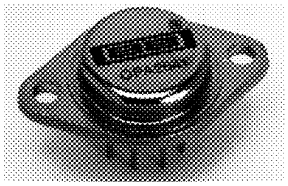


# OPA2541

# Dual High Power OPERATIONAL AMPLIFIER

## FEATURES

- OUTPUT CURRENTS TO 5A
- POWER SUPPLIES TO ±40V
- FET INPUT
- ELECTRICALLY ISOLATED CASE

## APPLICATIONS

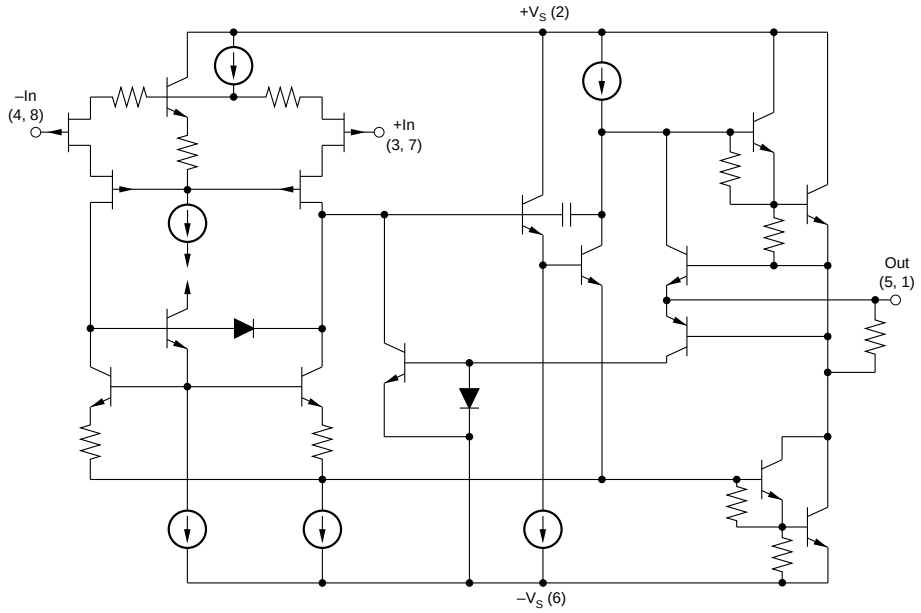
- MOTOR DRIVER
- SERVO AMPLIFIER
- SYNCRO/RESOLVER EXCITATION
- VOICE COIL DRIVER
- BRIDGE AMPLIFIER
- PROGRAMMABLE POWER SUPPLY
- AUDIO AMPLIFIER

## DESCRIPTION

The OPA2541 is a dual power operational amplifier capable of operation from power supplies up to ±40V and output currents of 5A continuous. With two monolithic power amplifiers in a single package it provides unequaled functional density.

The industry-standard 8-pin TO-3 package is isolated from all internal circuitry allowing it to be mounted directly to a heat sink without insulators which degrade thermal performance. Internal circuitry limits output current to approximately 6A.

The OPA2541 is available in both industrial and military temperature range versions.

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SBOS157

# SPECIFICATIONS

## ELECTRICAL

At $T_C$ = +25°C and $V_S$ = ±35VDC, unless otherwise noted.

| PARAMETER | CONDITIONS | OPA2541AM | | | OPA2541BM, SM | | | UNITS |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP | MAX | MIN | TYP | MAX | |
| **INPUT OFFSET VOLTAGE** | | | | | | | | |
| $V_{OS}$ | | | ±2 | ±10 | | ±0.25 | ±1 | mV |
| vs Temperature | Specified Temperature Range | | ±20 | ±40 | | ±15 | ±30 | µV/°C |
| vs Supply Voltage | $V_S$ = ±10V to ±$V_{MAX}$ | | ±2.5 | ±10 | | * | * | µV/V |
| vs Power | | | ±20 | ±60 | | * | * | µV/W |
| **INPUT BIAS CURRENT** | | | | | | | | |
| $I_B$ | | | 15 | 50 | | * | * | pA |
| | Specified Temperature Range | | Note 1 | | | * | | |
| **INPUT OFFSET CURRENT** | | | | | | | | |
| $I_{OS}$ | | | ±5 | ±30 | | * | * | pA |
| | Specified Temperature Range | | Note 1 | | | * | | |
| **INPUT CHARACTERISTICS** | | | | | | | | |
| Common-Mode Voltage Range | Specified Temperature Range | ±($\|V_S\|$ –6) | ±($\|V_S\|$ –3) | | * | * | | V |
| Common-Mode Rejection | $V_{CM}$ = ($\|±V_S\|$ –6V) | 95 | 106 | | * | * | | dB |
| Input Capacitance | | | 5 | | | * | | pF |
| Input Impedance, DC | | | 1 | | | * | | $10^{12}\Omega$ |
| **GAIN CHARACTERISTICS** | | | | | | | | |
| Open Loop Gain at 10Hz | $R_L$ = 6Ω | 90 | 96 | | * | * | | dB |
| Gain-Bandwidth Product | | | 1.6 | | | * | | MHz |
| **OUTPUT** | | | | | | | | |
| Voltage Swing | $I_O$ = 5A | ±($\|V_S\|$ –5.5) | ±($\|V_S\|$ –4.5) | | * | * | | V |
| | $I_O$ = 2A | ±($\|V_S\|$ –4.5) | ±($\|V_S\|$ –3.6) | | * | * | | V |
| | $I_O$ = 0.5A | ±($\|V_S\|$ –4) | ±($\|V_S\|$ –3.2) | | * | * | | V |
| Current, Continuous | +25°C | 5 | 7.0 | | * | * | | A |
| | +85°C | 4 | 5.0 | | * | | | A |
| | +125°C (SM grade only) | | | | 3 | 3.5 | | A |
| **AC PERFORMANCE** | | | | | | | | |
| Slew Rate | | 6 | 8 | | * | * | | V/µs |
| Power Bandwidth | $R_L$ = 8Ω, $V_O$ = 20Vrms | 45 | 55 | | * | * | | kHz |
| Settling Time to 0.1% | 2V Step | | 2 | | | * | | µs |
| Capacitive Load | Specified Temperature Range, G = 1 | | | 3.3 | | | * | nF |
| | Specified Temperature Range, G >10 | | | SOA | | | * | |
| Phase Margin | Specified Temperature Range, $R_L$ = 8Ω | | 40 | | | * | | Degrees |
| Channel Separation | 1kHz, $R_L$ = 6Ω | | 80 | | | * | | dB |
| **POWER SUPPLY** | | | | | | | | |
| Power Supply Voltage, ±$V_S$ | Specified Temperature Range | ±10 | ±30 | ±35 | * | ±35 | ±40 | V |
| Current, Quiescent | Total—Both Amplifiers | | 40 | 50 | | * | * | mA |
| **THERMAL RESISTANCE** | | | | | | | | |
| $\theta_{JC}$, (Junction-to-Case) | Both Amplifiers(2), AC Output f > 60Hz | | 0.8 | 1.0 | | * | * | °C/W |
| $\theta_{JC}$ | Both Amplifiers(2), DC Output | | 0.9 | 1.2 | | * | * | °C/W |
| $\theta_{JC}$ | One Amplifier, AC Output f > 60Hz | | 1.25 | 1.5 | | * | * | °C/W |
| $\theta_{JC}$ | One Amplifier, DC Output | | 1.4 | 1.9 | | * | * | °C/W |
| $\theta_{JA}$, (Junction-to-Ambient) | No Heat Sink | | 30 | | | * | | °C/W |
| **TEMPERATURE RANGE** | | | | | | | | |
| Case | AM, BM | –25 | | +85 | * | | * | °C |
| | SM | | | | –55 | | +125 | °C |

*Specification same as OPA2541AM.

NOTES: (1) Input bias and offset current approximately doubles for every 10°C increase in temperature. (2) Assumes equal dissipation in both amplifiers.

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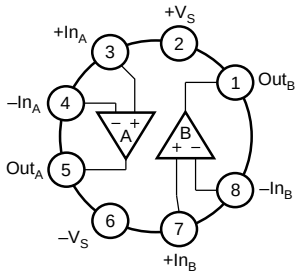
## ABSOLUTE MAXIMUM RATINGS

| | |
|---|---|
| Supply Voltage, $+V_S$ to $-V_S$ | 80V |
| Output Current | see SOA |
| Power Dissipation, Internal(1) | 125W |
| Input Voltage: Differential | $\pm V_S$ |
| Common-mode | $\pm V_S$ |
| Temperature: Pin Solder, 10s | +300°C |
| Junction(1) | +150°C |
| Temperature Range: | |
| Storage | –65°C to +150°C |
| Operating (Case) | –55°C to +125°C |

NOTE: (1) Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.

## CONNECTION DIAGRAM

**Top View** **TO-3**




## PACKAGE INFORMATION

| MODEL | PACKAGE | PACKAGE DRAWING NUMBER(1) |
|---|---|---|
| OPA2541AM | TO-3 | 030 |
| OPA2541BM | TO-3 | 030 |
| OPA2541SM | TO-3 | 030 |

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

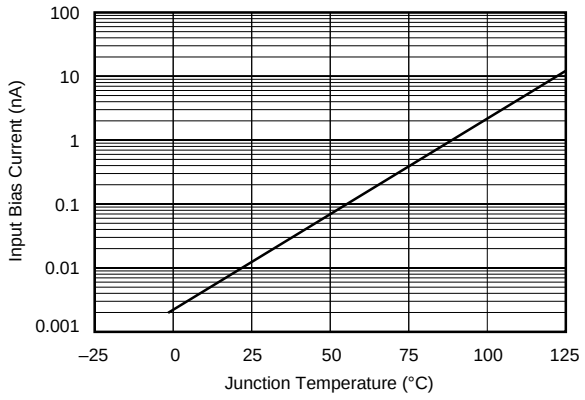
## ORDERING INFORMATION

| MODEL | PACKAGE | TEMPERATURE RANGE |
|---|---|---|
| OPA2541AM | TO-3 | –25°C to +85°C |
| OPA2541BM | TO-3 | –25°C to +85°C |
| OPA2541SM | TO-3 | –55°C to +125°C |

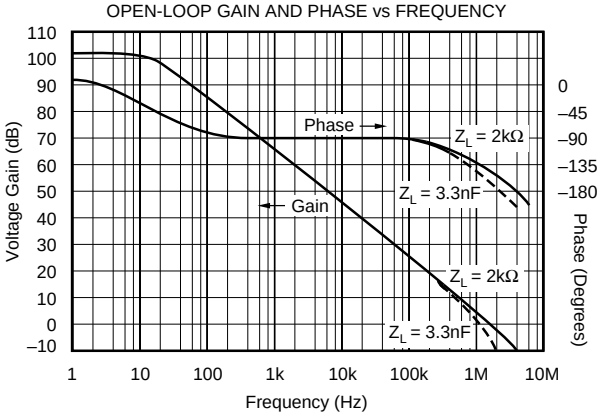
# TYPICAL PERFORMANCE CURVES

$T_A$ = +25°C and $V_S$ = ±35VDC, unless otherwise noted.

INPUT BIAS CURRENT vs TEMPERATURE



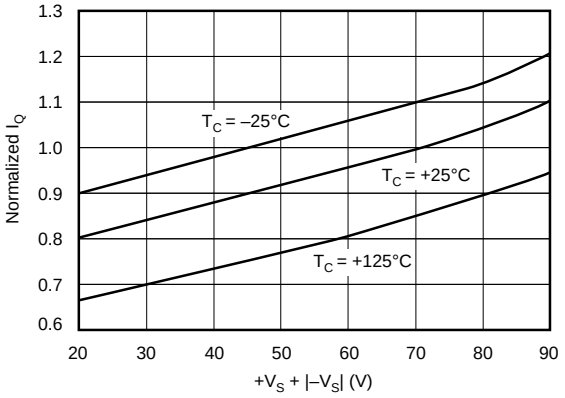

OPEN-LOOP GAIN AND PHASE vs FREQUENCY



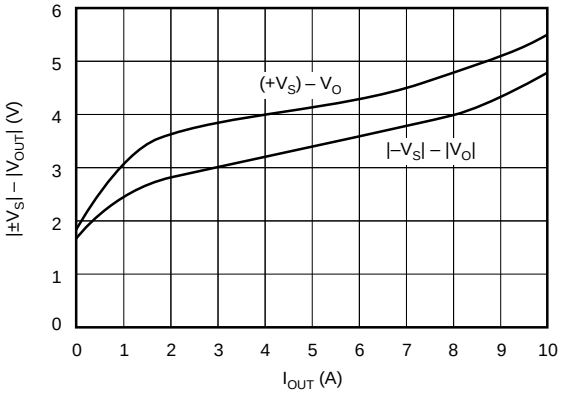
# TYPICAL PERFORMANCE CURVES (CONT)

$T_A$ = +25°C and $V_S$ = ±35VDC, unless otherwise noted.

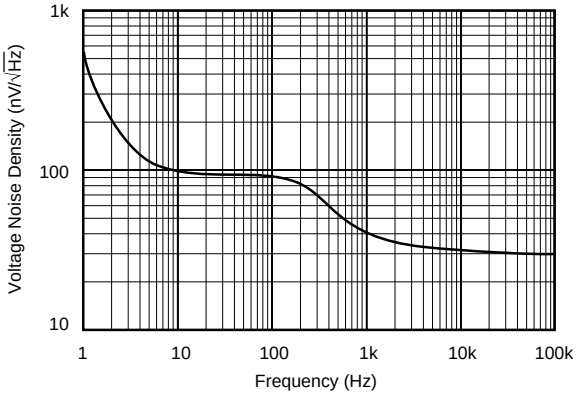
NORMALIZED QUIESCENT CURRENT vs TOTAL POWER SUPPLY VOLTAGE



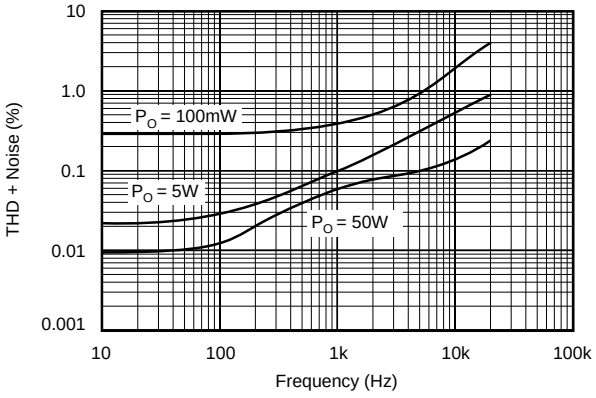

OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



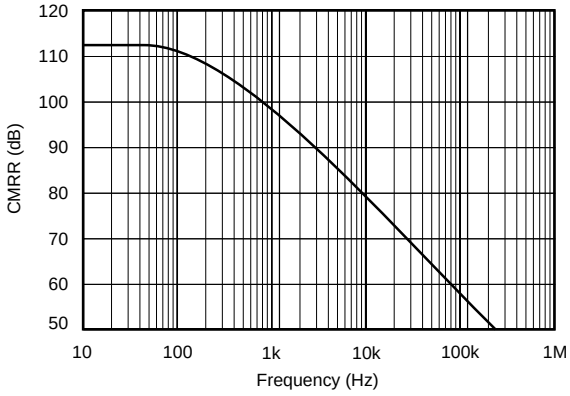

VOLTAGE NOISE DENSITY vs FREQUENCY



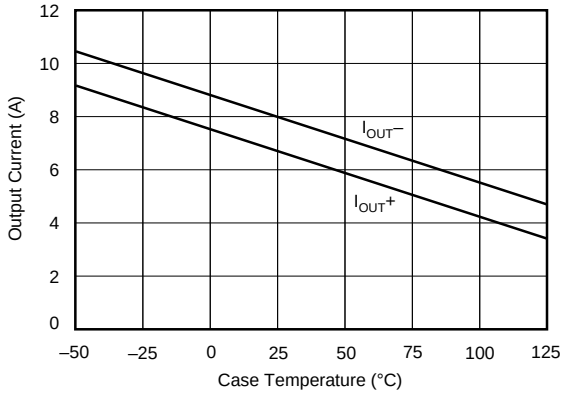

TOTAL HARMONIC DISTORTION vs FREQUENCY




COMMON-MODE REJECTION vs FREQUENCY



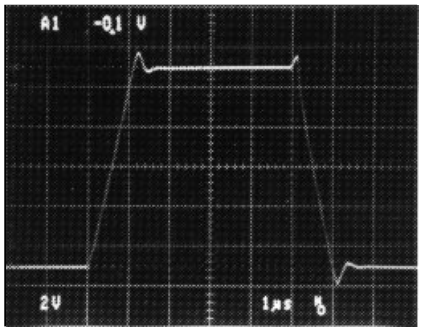

OUTPUT CURRENT vs TEMPERATURE



# TYPICAL PERFORMANCE CURVES (CONT)

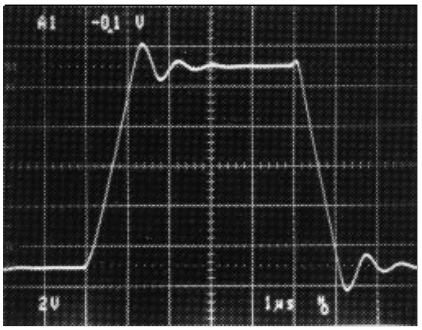
$T_A$ = +25°C and $V_S$ = ±35VDC, unless otherwise noted.

DYNAMIC RESPONSE




$Z_{LOAD}$ = ∞, $V_S$ = ±35V, $A_V$ = +1

DYNAMIC RESPONSE




$Z_{LOAD}$ = 4700pF, $V_S$ = ±35V, $A_V$ = +1

# INSTALLATION INSTRUCTIONS

## POWER SUPPLIES

The OPA2541 is specified for operation from power supplies up to ±40V. It can also be operated from an unbalanced or a single power supply so long as the total power supply voltage does not exceed 80V (70V for "AM" grade). The power supplies should be bypassed with low series impedance capacitors such as ceramic or tantalum. These should be located as near as practical to the amplifier's power supply pins. Good power amplifier circuit layout is, in general, like good high-frequency layout. Consider the path of large power supply and output currents. Avoid routing these connections near low-level input circuitry to avoid waveform distortion and instability.

Signal dependent load current can modulate the power supply voltage with inadequate power supply bypassing. This can affect both amplifiers' outputs. Since the second amplifier's signal may not be related to the first, this will degrade the inherent channel separation of the OPA2541.

## HEAT SINKING

Most applications will require a heat sink to prevent junction temperatures from exceeding the 150°C maximum rating. The type of heat sink required will depend on the output signals, power dissipation of each amplifier, and ambient temperature. The thermal resistance from junction-to-case, $\theta_{JC}$, depends on how the power dissipation is distributed on the amplifier die.

DC output concentrates the power dissipation in one output transistor. AC output distributes the power dissipation equally between the two output transistors and therefore has lower thermal resistance. Similarly, the power dissipation may be all in one amplifier (worst case) or equally distributed between the two amplifiers (best case). Thermal resistances are provided for each of these possibilities. The case-to-junction temperature rise is the product of the power dissipation (total of both amplifiers) times the appropriate thermal resistance—

$$\Delta T_{JC} = (P_D \text{ total}) (\theta_{JC}).$$

Sufficient heat sinking must be provided to keep the case temperature within safe limits for the maximum ambient temperature and power dissipation. The thermal resistance of the heat sink required may be calculated by:

$$\theta_{HS} = (150°C - \Delta T_{JC} - T_A)/P_D.$$

Commercially available heat sinks usually specify thermal resistance. These ratings are often suspect, however, since they depend greatly on the mounting environment and air flow conditions. Actual thermal performance should be verified by measurement of case temperature under the required load and environmental conditions.

No insulating hardware is required when using the OPA2541. Since mica and other similar insulators typically add 0.7°C/W thermal resistance, this is a significant advantage. See Burr-Brown Application Note AN-83 for further details on heat sinking.

## SAFE OPERATING AREA

The Safe Operating Area (SOA) curve provides comprehensive information on the power handling abilities of the OPA2541. It shows the allowable output current as a function of the voltage across the conducting output transistor (see Figure 1). This voltage is equal to the power supply voltage minus the output voltage. For example, as the amplifier output swings near the positive power supply voltage, the voltage across the output transistor decreases and the device can safely provide large output currents demanded by the load.

The internal current limit will not provide short-circuit protection in most applications. When the amplifier output is shorted to ground, the full power supply voltage is impressed across the conducting output transistor. For instance, with $V_S$ = ±35V, a short circuit to ground would impress 35V across the conducting power transistor. The maximum safe output current at this voltage is 1.8A, so the internal current limit would not protect the amplifier. The unit-to-unit variation and temperature dependence of the internal current limit suggest that it be used to handle abnormal conditions and not activated in commonly encountered circuit operation.

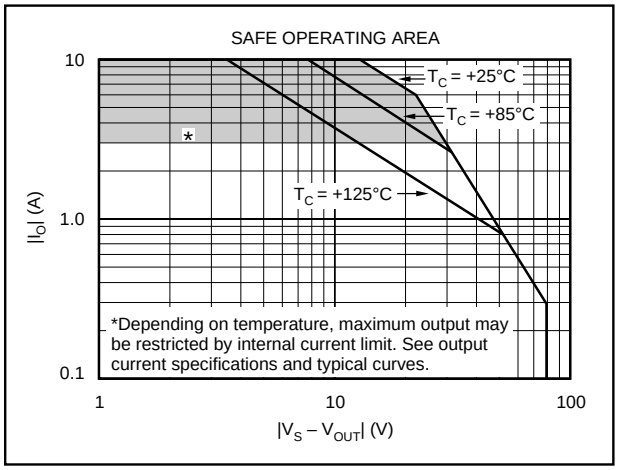



FIGURE 1. Safe Operating Area.

Reactive, or EMF generating loads such as DC motors can present demanding SOA requirements. With a purely reactive load, output voltage current occurs when the output voltage is zero and the voltage across the conducting transistor is equal to the full power supply voltage. See Burr-Brown Application Note AN-123 for further information on evaluating SOA.

Applications with inductive or EMF-generating loads which can produce “kick back” voltage surges to the amplifiers should include clamp diodes from the output terminals to the power supplies. These diodes should be chosen to limit the peak amplifier output voltage surges to less than 2V beyond the power supply rail voltage. Common 1A rated rectifier diodes will suffice in most applications.

# APPLICATIONS CIRCUITS

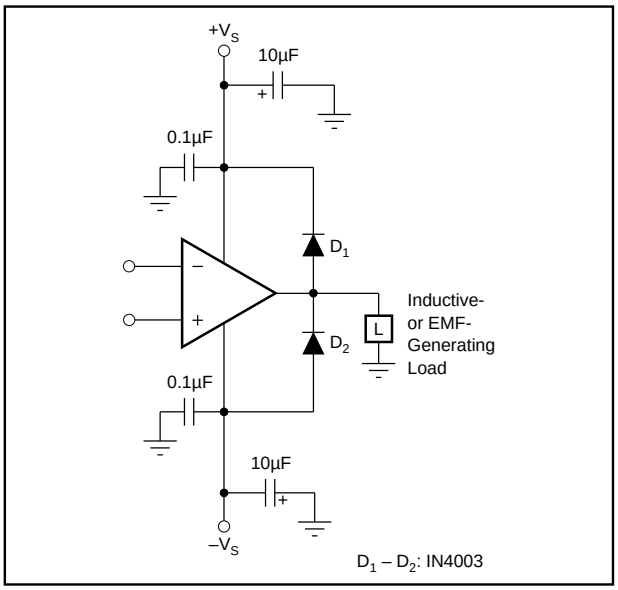



FIGURE 2. Clamping Output for EMF-Generating Loads.

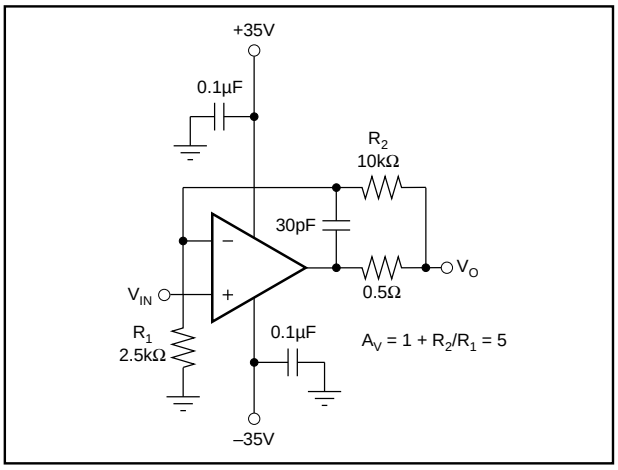



FIGURE 3. Isolating Capacitive Loads.

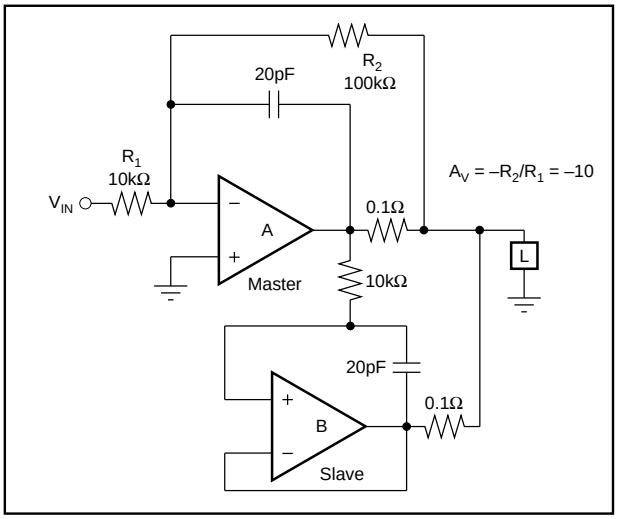



FIGURE 4. Paralleled Operation, Extended SOA.

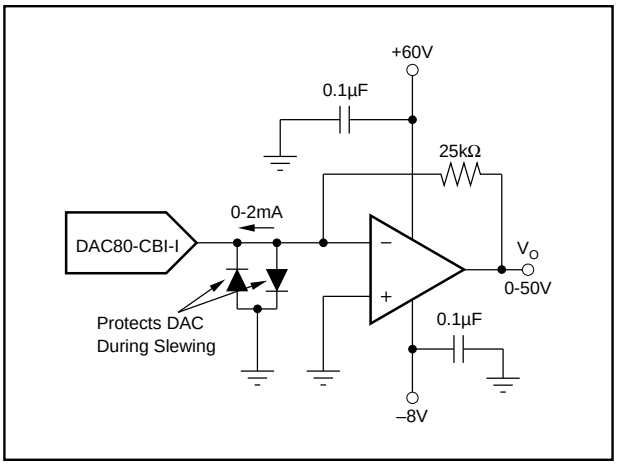



FIGURE 5. Programmable Voltage Source.

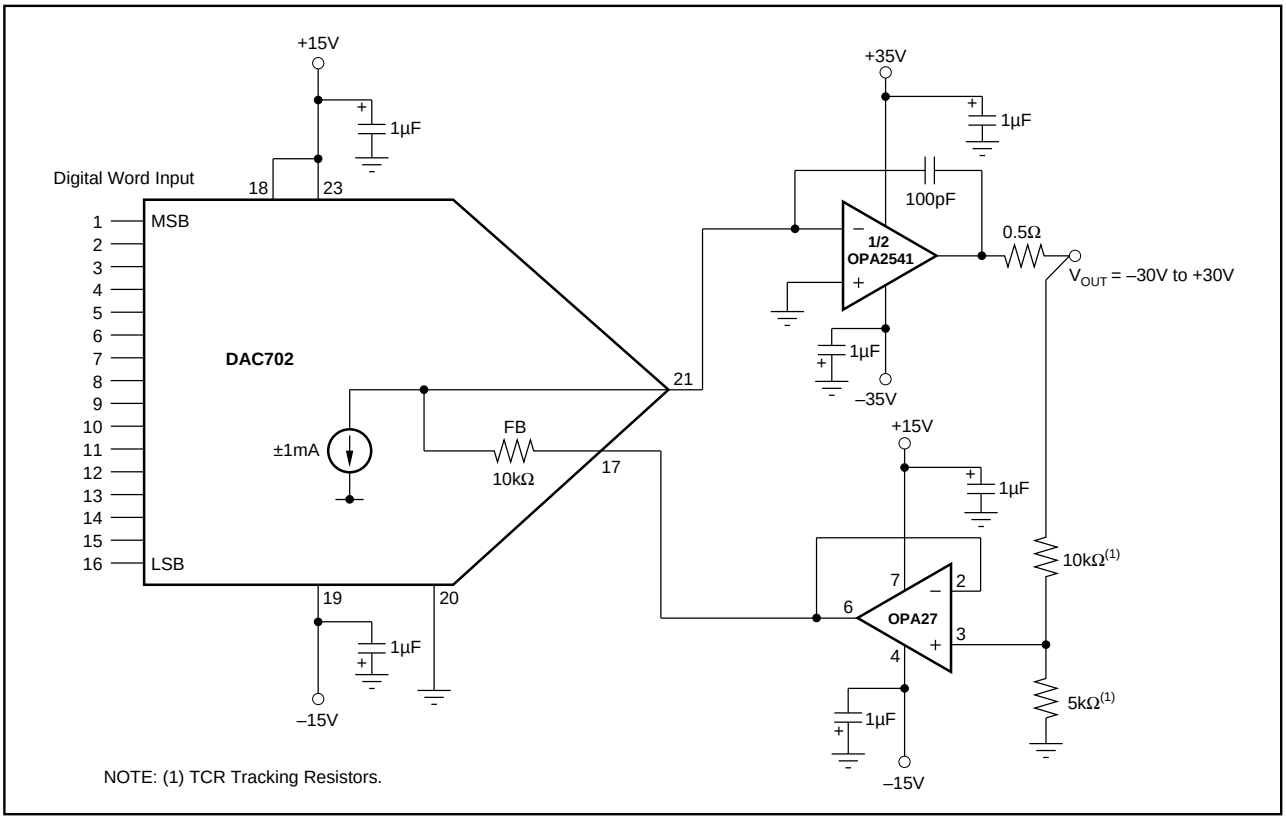



FIGURE 6. 16-Bit Programmable Voltage Source.

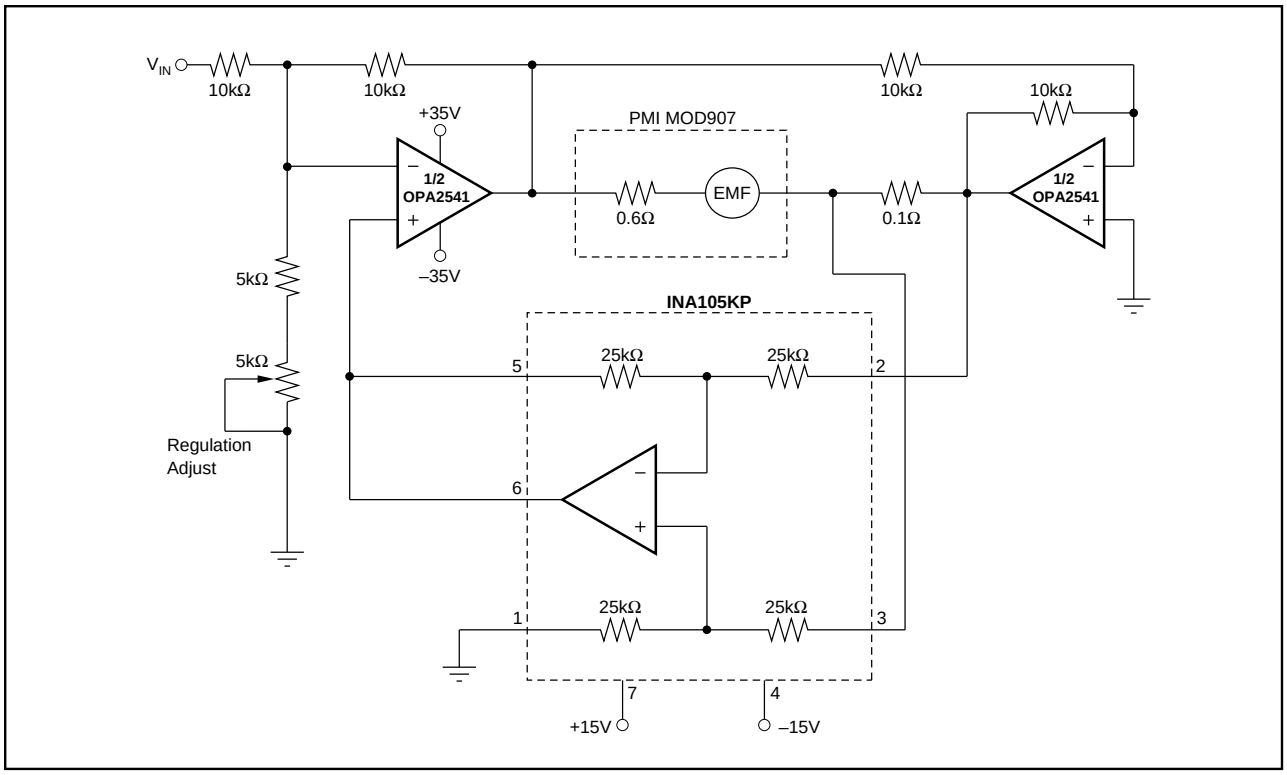



FIGURE 7. Bridge Amplifier Motor-Speed Controller.

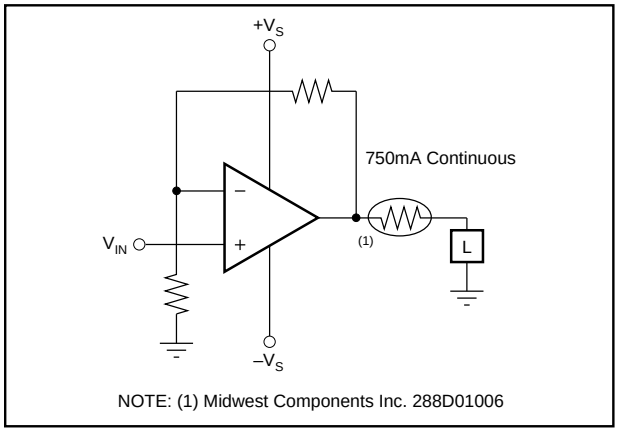



FIGURE 8. Limiting Output Current.

## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| OPA2541AM | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | Yes | Call TI | N/A for Pkg Type | -55 to 125 | OPA2541AM |
| OPA2541AM.A | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | Yes | Call TI | N/A for Pkg Type | -55 to 125 | OPA2541AM |
| OPA2541BM | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | No | NI | N/A for Pkg Type | -55 to 125 | OPA2541BM |
| OPA2541BM.A | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | No | NI | N/A for Pkg Type | -55 to 125 | OPA2541BM |
| OPA2541SM | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | Yes | Call TI | N/A for Pkg Type | -55 to 125 | OPA2541SM |
| OPA2541SM.A | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | Yes | Call TI | N/A for Pkg Type | -55 to 125 | OPA2541SM |
| OPA2541SMQ | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | Yes | NI | N/A for Pkg Type | -40 to 125 | OPA2541 OPA2541SMQ |
| OPA2541SMQ.A | Active | Production | TO-3 (LMF) \| 8 | 18 \| TUBE | Yes | NI | N/A for Pkg Type | -40 to 125 | OPA2541 OPA2541SMQ |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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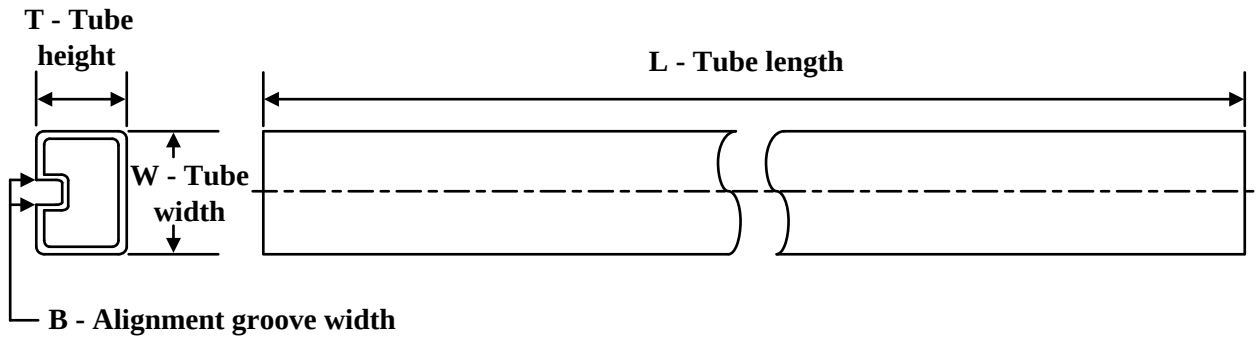
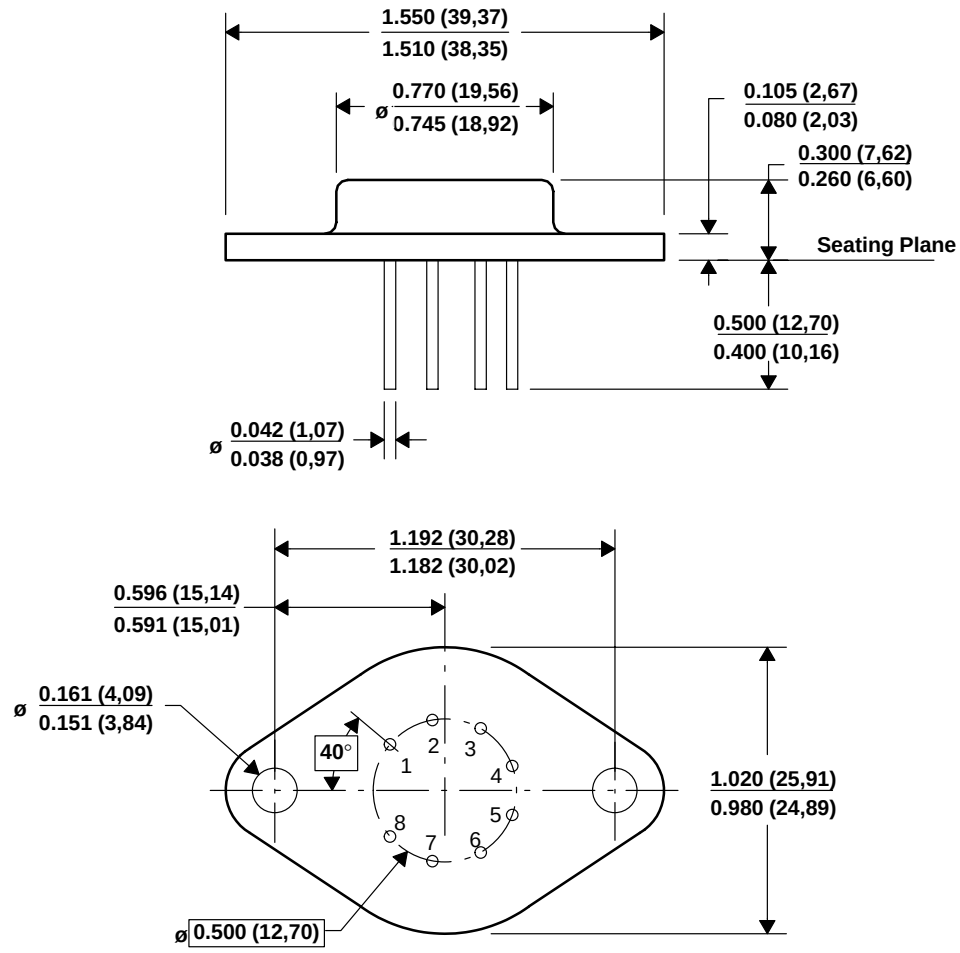
## TUBE




*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| OPA2541AM | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |
| OPA2541AM.A | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |
| OPA2541BM | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |
| OPA2541BM.A | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |
| OPA2541SM | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |
| OPA2541SM.A | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |
| OPA2541SMQ | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |
| OPA2541SMQ.A | LMF | TO-CAN | 8 | 18 | 532.13 | 21.59 | 889 | NA |

**LMF (O–MBCY–W8)** **METAL CYLINDRICAL PACKAGE**




4202491/A 03/01

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
D. Pin numbers shown for reference only. Numbers may not be marked on package.

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