



OPA2541

## Dual High Power OPERATIONAL AMPLIFIER

### FEATURES

- OUTPUT CURRENTS TO 5A
- POWER SUPPLIES TO  $\pm 40V$
- FET INPUT
- ELECTRICALLY ISOLATED CASE

### APPLICATIONS

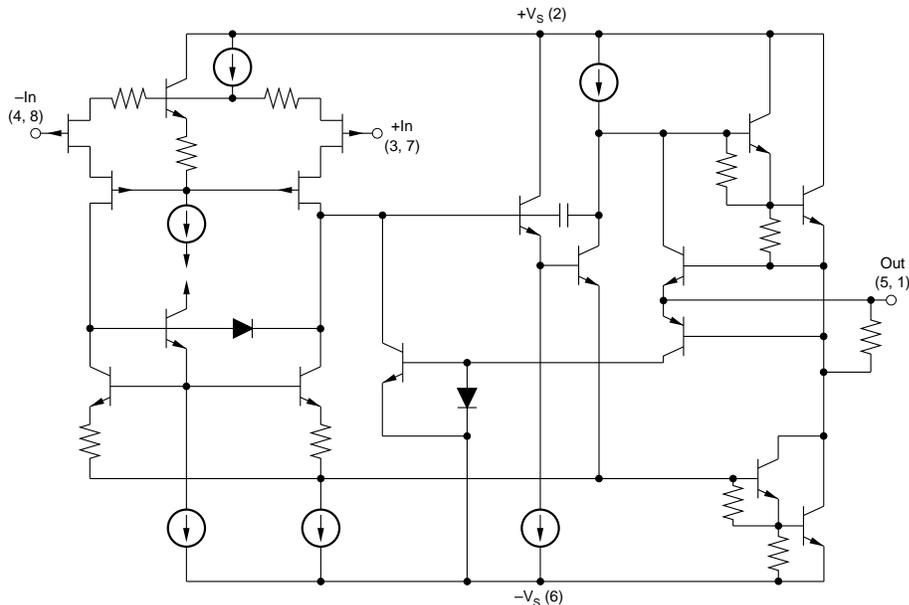
- MOTOR DRIVER
- SERVO AMPLIFIER
- SYNCRO/RESOLVER EXCITATION
- VOICE COIL DRIVER
- BRIDGE AMPLIFIER
- PROGRAMMABLE POWER SUPPLY
- AUDIO AMPLIFIER

### DESCRIPTION

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



International Airport Industrial Park • Mailing Address: PO Box 11400 • Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd. • Tucson, AZ 85706  
Tel: (520) 746-1111 • Twx: 910-952-1111 • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

# SPECIFICATIONS

## ELECTRICAL

At  $T_C = +25^\circ\text{C}$  and  $V_S = \pm 35\text{VDC}$ , unless otherwise noted.

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

\*Specification same as OPA2541AM.

NOTES: (1) Input bias and offset current approximately doubles for every  $10^\circ\text{C}$  increase in temperature. (2) Assumes equal dissipation in both amplifiers.

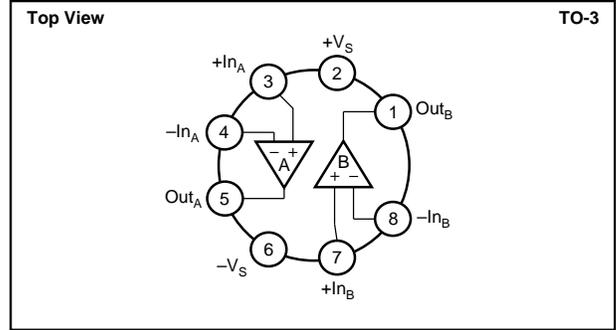
The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $+V_S$ to $-V_S$ .....	80V
Output Current .....	see SOA
Power Dissipation, Internal <sup>(1)</sup> .....	125W
Input Voltage: Differential .....	$\pm V_S$
Common-mode .....	$\pm V_S$
Temperature: Pin Solder, 10s .....	+300°C
Junction <sup>(1)</sup> .....	+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



## PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>
OPA2541AM	TO-3	030
OPA2541BM	TO-3	030
OPA2541SM	TO-3	030

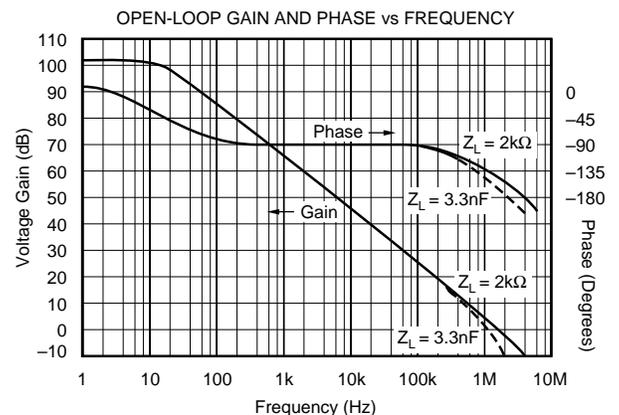
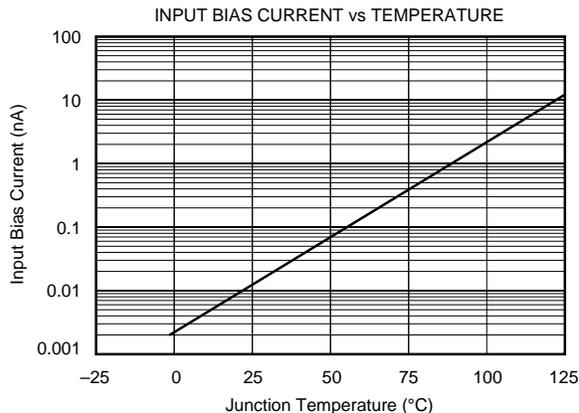
NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

## 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

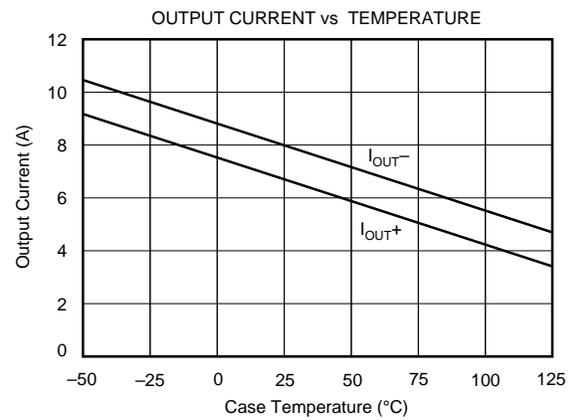
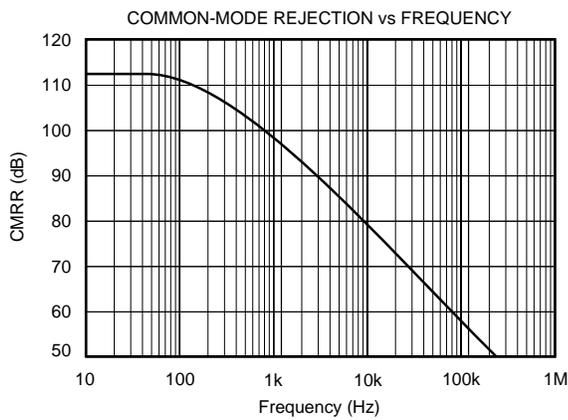
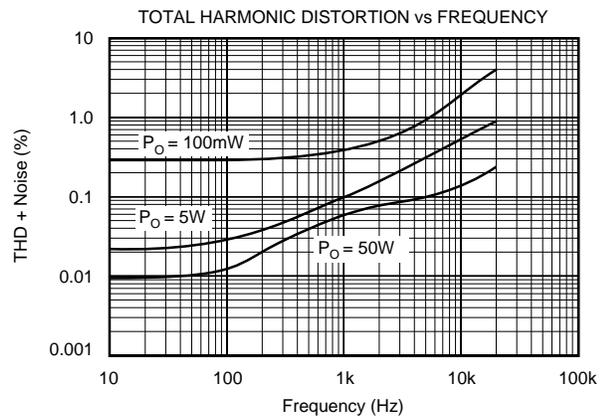
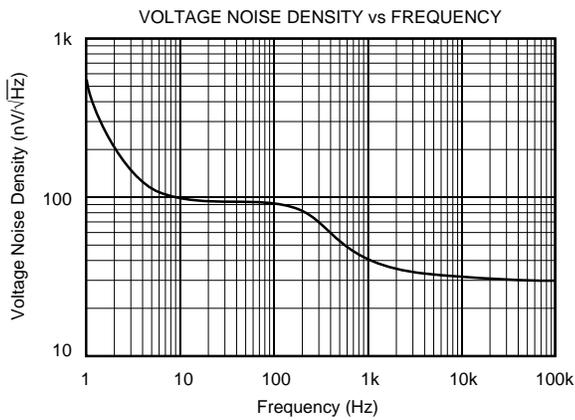
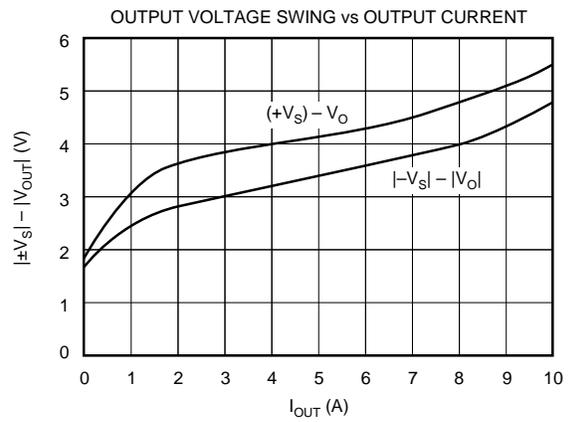
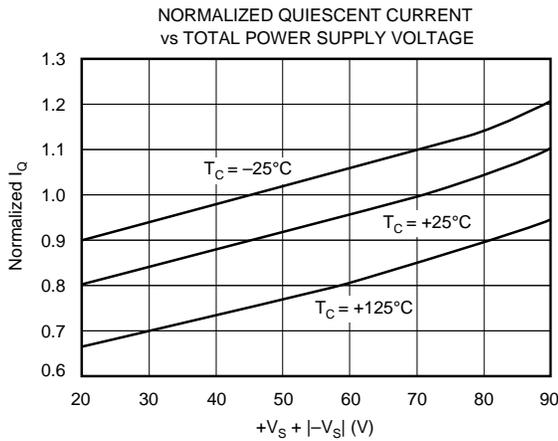
## TYPICAL PERFORMANCE CURVES

$T_A = +25^\circ\text{C}$  and  $V_S = \pm 35\text{VDC}$ , unless otherwise noted.



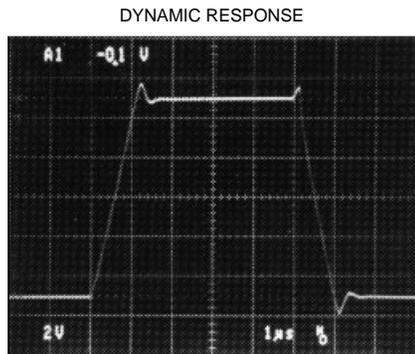
# TYPICAL PERFORMANCE CURVES (CONT)

$T_A = +25^\circ\text{C}$  and  $V_S = \pm 35\text{VDC}$ , unless otherwise noted.

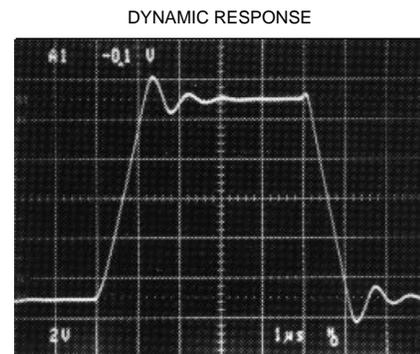


## TYPICAL PERFORMANCE CURVES (CONT)

$T_A = +25^\circ\text{C}$  and  $V_S = \pm 35\text{VDC}$ , unless otherwise noted.



$Z_{\text{LOAD}} = \infty$ ,  $V_S = \pm 35\text{V}$ ,  $A_V = +1$



$Z_{\text{LOAD}} = 4700\text{pF}$ ,  $V_S = \pm 35\text{V}$ ,  $A_V = +1$

## INSTALLATION INSTRUCTIONS

### POWER SUPPLIES

The OPA2541 is specified for operation from power supplies up to  $\pm 40\text{V}$ . It can also be operated from an unbalanced or a single power supply so long as the total power supply voltage does not exceed  $80\text{V}$  ( $70\text{V}$  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  $150^\circ\text{C}$  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,  $\theta_{\text{JC}}$ , 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 dissi-

pation (total of both amplifiers) times the appropriate thermal resistance—

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

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:

$$\theta_{\text{HS}} = (150^\circ\text{C} - \Delta T_{\text{JC}} - T_A) / P_{\text{D}}.$$

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  $0.7^\circ\text{C}/\text{W}$  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  $V_s = \pm 35V$ , 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.

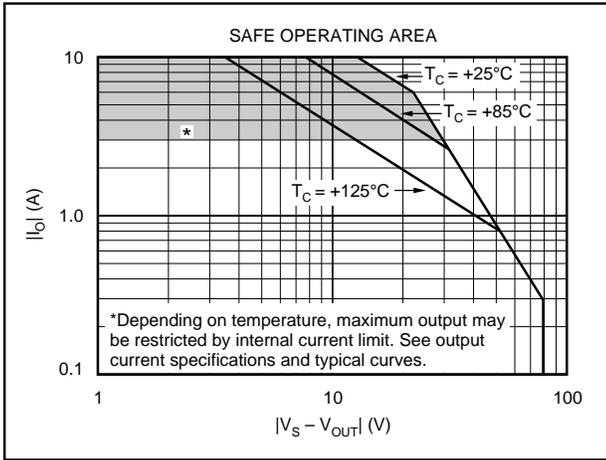


FIGURE 1. Safe Operating Area.

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

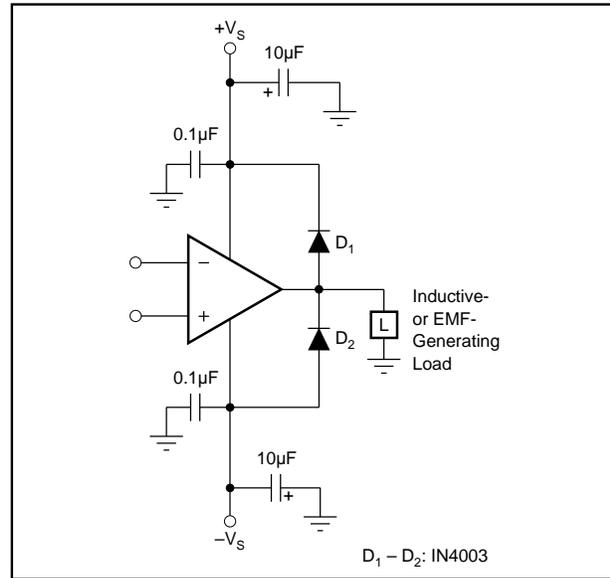


FIGURE 2. Clamping Output for EMF-Generating Loads.

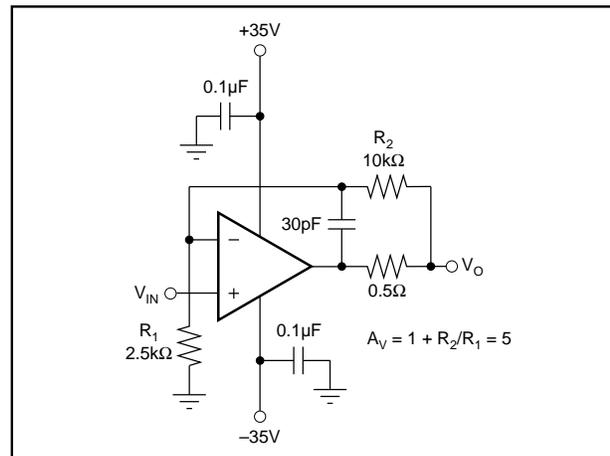


FIGURE 3. Isolating Capacitive Loads.

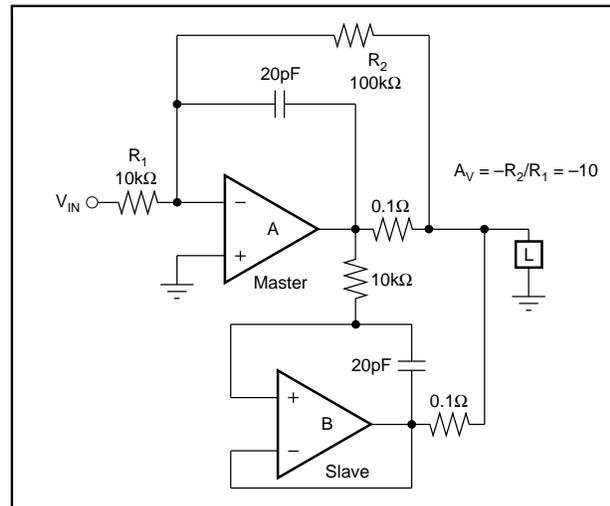


FIGURE 4. Paralleled Operation, Extended SOA.

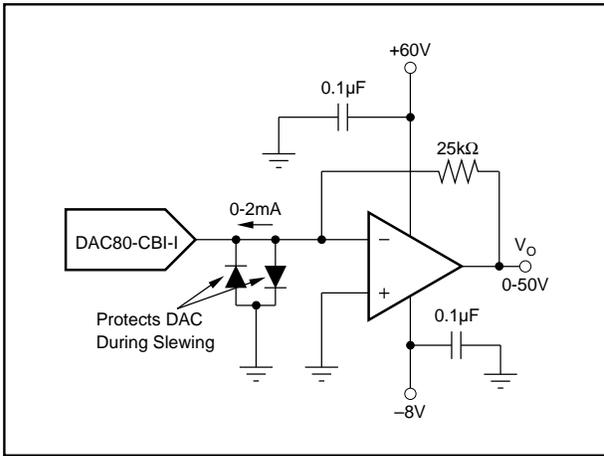


FIGURE 5. Programmable Voltage Source.

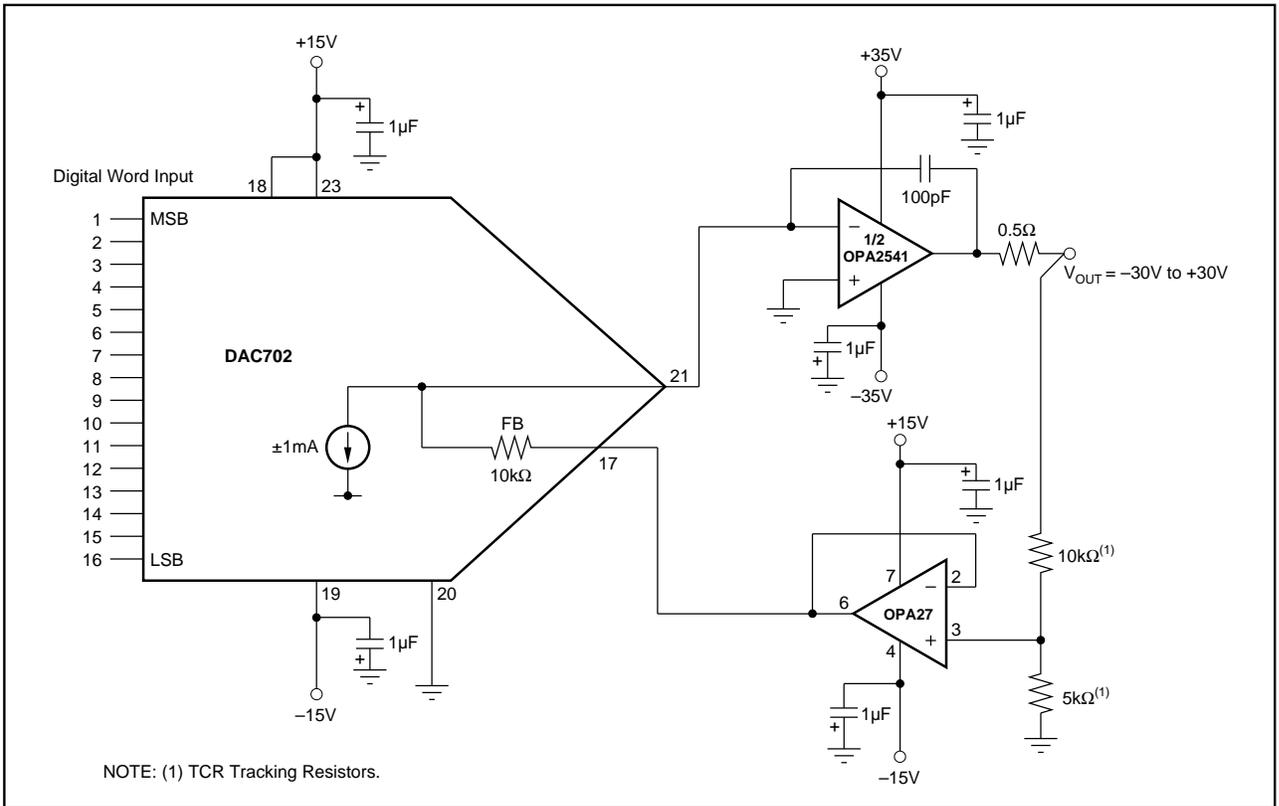


FIGURE 6. 16-Bit Programmable Voltage Source.

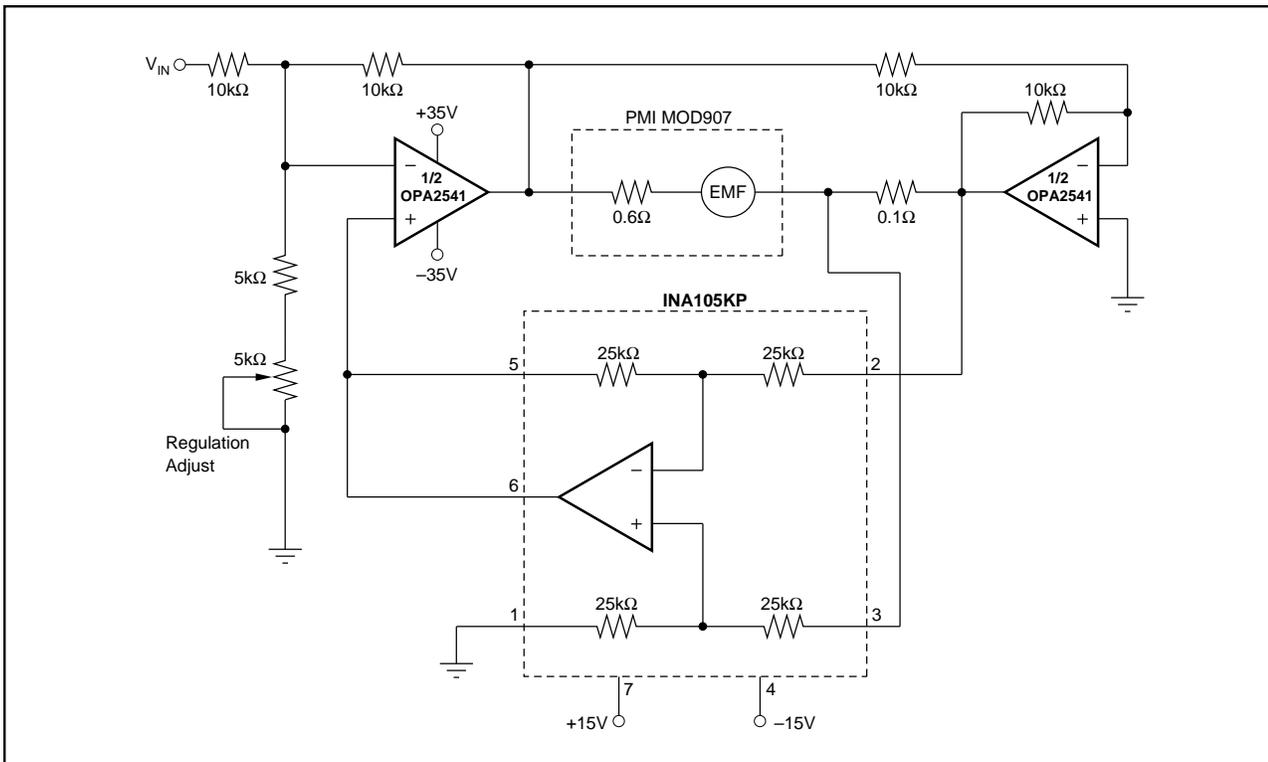


FIGURE 7. Bridge Amplifier Motor-Speed Controller.

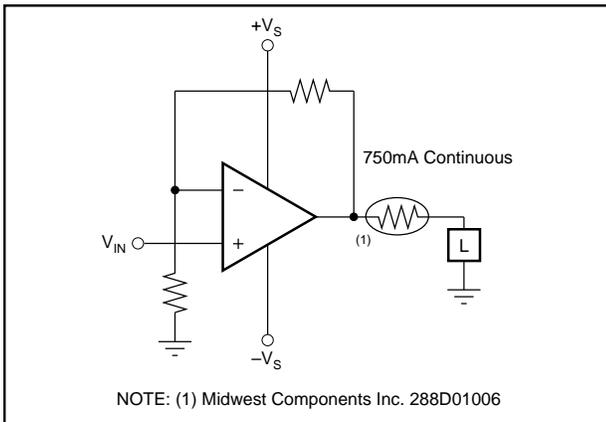


FIGURE 8. Limiting Output Current.

**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)
<a href="#">OPA2541AM</a>	Active	Production	TO-3 (LMF)   8	18   TUBE	-	Call TI	N/A for Pkg Type	-55 to 125	OPA2541AM
OPA2541AM.A	Active	Production	TO-3 (LMF)   8	18   TUBE	-	Call TI	N/A for Pkg Type	-55 to 125	OPA2541AM
OPA2541AM.B	Active	Production	TO-3 (LMF)   8	18   TUBE	-	Call TI	N/A for Pkg Type	-55 to 125	OPA2541AM
<a href="#">OPA2541BM</a>	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
OPA2541BM.B	Active	Production	TO-3 (LMF)   8	18   TUBE	No	NI	N/A for Pkg Type	-55 to 125	OPA2541BM
<a href="#">OPA2541SM</a>	Active	Production	TO-3 (LMF)   8	18   TUBE	-	Call TI	N/A for Pkg Type	-55 to 125	OPA2541SM
OPA2541SM.A	Active	Production	TO-3 (LMF)   8	18   TUBE	-	Call TI	N/A for Pkg Type	-55 to 125	OPA2541SM
OPA2541SM.B	Active	Production	TO-3 (LMF)   8	18   TUBE	-	Call TI	N/A for Pkg Type	-55 to 125	OPA2541SM
<a href="#">OPA2541SMQ</a>	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	-55 to 125	OPA2541 OPA2541SMQ
OPA2541SMQ.B	Active	Production	TO-3 (LMF)   8	18   TUBE	Yes	NI	N/A for Pkg Type	-55 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.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**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
OPA2541AM.B	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
OPA2541BM.B	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
OPA2541SM.B	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
OPA2541SMQ.B	LMF	TO-CAN	8	18	532.13	21.59	889	NA



## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2025, Texas Instruments Incorporated