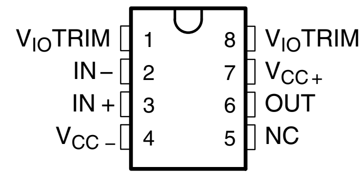
- **Replacements for ADI, PMI and LTC OP27 Series**

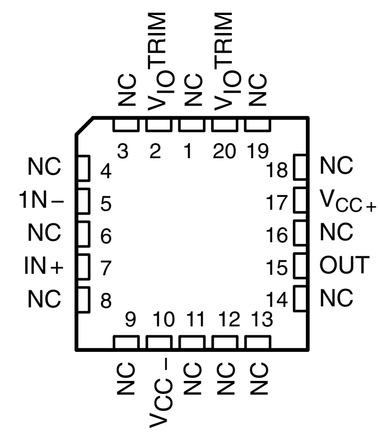
Features of OP27A and OP27C:

- **Maximum Equivalent Input Noise Voltage:**
  3.8 nV/√Hz at 1 kHz
  5.5 nV/√Hz at 10 kHz
- **Very Low Peak-to-Peak Noise Voltage at 0.1 Hz to 10 Hz . . . 80 nV Typ**
- **Low Input Offset Voltage**
  OP27A . . . 25 μV Max
  OP27C . . . 100 μV Max
- **High Voltage Amplification**
  OP27A . . . 1 V/μV Min
  OP27C . . . 0.7 V/μV Min

JG PACKAGE
(TOP VIEW)



FK PACKAGE
(TOP VIEW)



NC − No internal connection

description

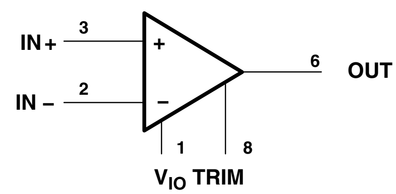
The OP27 operational amplifiers combine outstanding noise performance with excellent precision and high-speed specifications. The wideband noise is only 3 nV/√Hz and with the 1/f noise corner at 2.7 Hz, low noise is maintained for all low-frequency applications.

The outstanding characteristics of the OP27 make these devices excellent choices for low-noise amplifier applications requiring precision performance and reliability.

The OP27 series is compensated for unity gain.

The OP27A and OP27C are characterized for operation over the full military temperature range of −55°C to 125°C.

symbol

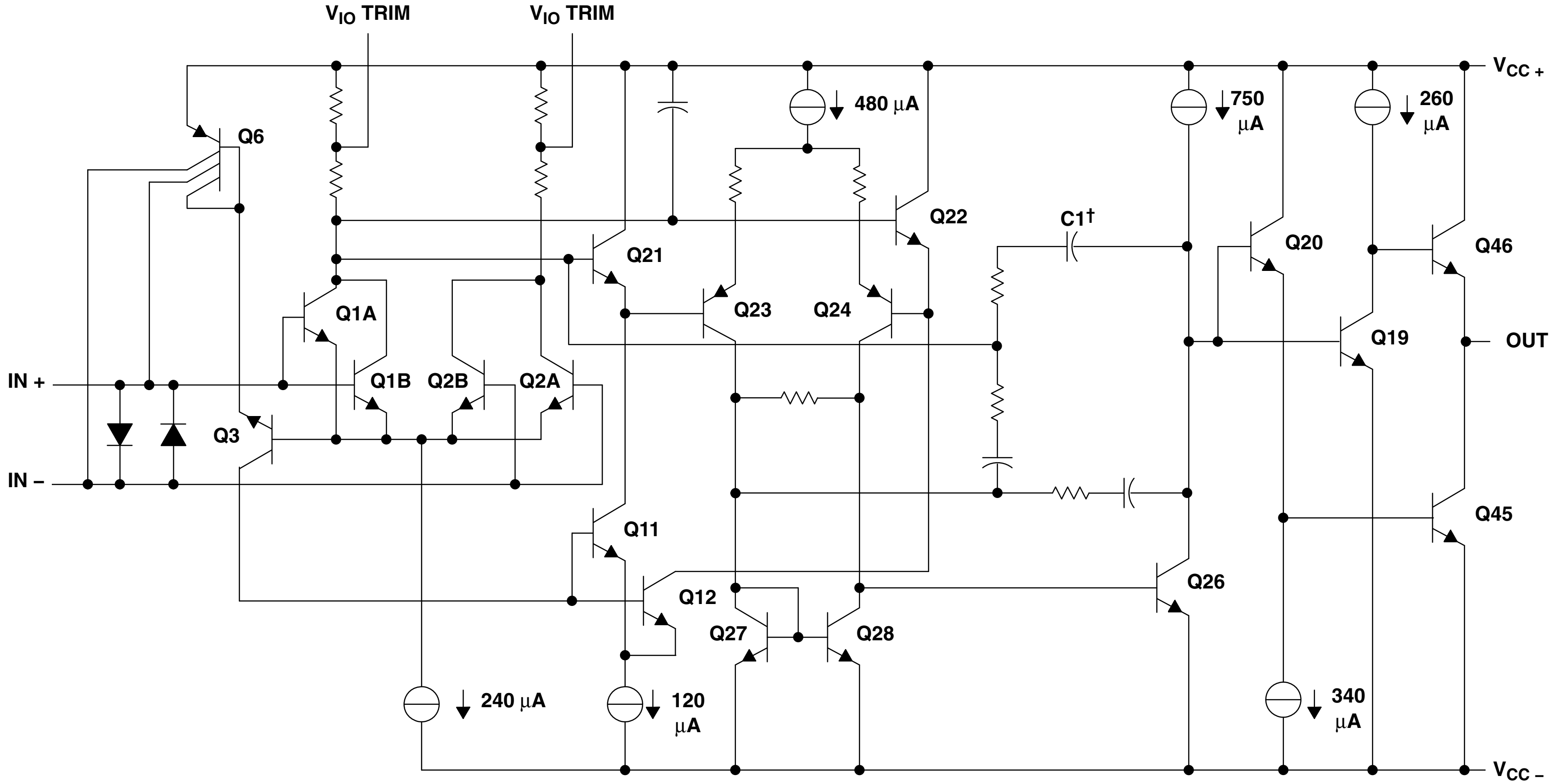


Pin numbers are for the JG packages.

AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	STABLE GAIN	PACKAGE CERAMIC DIP (JG)	PACKAGE CHIP CARRIER (FK)
−55°C to 125°C	25 μV	1	OP27AJG	OP27AFK
	100 μV	1	OP27CJG	—

schematic



† C1 = 120 pF for OP27

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC+} (see Note 1) . . . . 22 V
Supply voltage, V_{CC-} (see Note 1) . . . . 22 V
Input voltage, V_I . . . . $V_{CC\pm}$
Duration of output short circuit . . . . unlimited
Differential input current (see Note 2) . . . . ±25 mA
Continuous power dissipation . . . . See Dissipation Rating Table
Operating free-air temperature range: OP27A, OP27C . . . . –55°C to 125°C
Storage temperature range . . . . –65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG or FK package . . . . 300°C

NOTES: 1. All voltage values are with respect to the midpoint between V_{CC+} and V_{CC-} unless otherwise noted.
2. The inputs are protected by back-to-back diodes. Current-limiting resistors are not used in order to achieve low noise. Excessive input current will flow if a differential input voltage in excess of approximately ±0.7 V is applied between the inputs unless some limiting resistance is used.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
JG	1050 mW	8.4 mW/°C	546 mW	210 mW
FK	1375 mW	11.0 mW/°C	715 mW	275 mW

recommended operating conditions

		OP27A MIN	OP27A NOM	OP27A MAX	OP27C MIN	OP27C NOM	OP27C MAX	UNIT
Supply voltage, V_{CC+}		4	15	22	4	15	22	V
Supply voltage, V_{CC-}		−4	−15	−22	−4	−15	−22	V
Common-mode input voltage, V_{IC}	$V_{CC\pm} = \pm 15$ V, $T_A = 25°C$	± 11			±11			V
	$V_{CC\pm} = \pm 15$ V, $T_A = -55°C$ to 125°C	±10.3			±10.2			
Operating free-air temperature, T_A		−55		125	−55		125	°C

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	OP27A MIN	OP27A TYP	OP27A MAX	OP27C MIN	OP27C TYP	OP27C MAX	UNIT
V_{IO}	Input offset voltage	$V_O = 0$, $V_{IC} = 0$ $R_S = 50\ \Omega$, See Note 3	25°C		10	25		30	100	μV
			Full range			60			300	
α_{VIO}	Average temperature coefficient of input offset voltage		Full range		0.2	0.6		0.4	1.8	μV/°C
	Long-term drift of input offset voltage	See Note 4			0.2	1		0.4	2	μV/mo
I_{IO}	Input offset current	$V_O = 0$, $V_{IC} = 0$	25°C		7	35		12	75	nA
			Full range			50			135	
I_{IB}	Input bias current	$V_O = 0$, $V_{IC} = 0$	25°C		±10	±40		±15	±80	nA
			Full range			±60			±150	
V_{ICR}	Common-mode input voltage range		25°C	11 to −11			11 to −11			V
			Full range	10.3 to −10.3			10.5 to −10.5			
V_{OM}	Peak output voltage swing	$R_L \geq 2\ k\Omega$		±12	±13.8		±11.5	±13.5		V
		$R_L \geq 0.6\ k\Omega$		±10	±11.5		±10	±11.5		
		$R_L \geq 2\ k\Omega$	Full range	±11.5			10.5			
A_{VD}	Large-signal differential voltage amplification	$R_L \geq 2\ k\Omega$, $V_O = \pm 10$ V		1000	1800		700	1500		V/mV
		$R_L \geq 1\ k\Omega$, $V_O = \pm 10$ V		800	1500			1500		
		$R_L \geq 0.6\ k\Omega$, $V_O = \pm 1$ V, $V_{CC\pm} = \pm 4$ V		250	700		200	500		
		$R_L \geq 2\ k\Omega$, $V_O = \pm 10$ V	Full range	600			300			
$r_{i(CM)}$	Common-mode input resistance				3			2		GΩ
r_o	Output resistance	$V_O = 0$, $I_O = 0$	25°C		70			70		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = \pm 11$ V	25°C	114	126		100	120		dB
		$V_{IC} = \pm 10$ V	Full range	110			94			
k_{SVR}	Supply voltage rejection ratio	$V_{CC\pm} = \pm 4$ V to ±18 V	25°C	100	120		94	118		dB
		$V_{CC\pm} = \pm 4.5$ V to ±18 V	Full range	96			86			

† Full range is – 55°C to 125°C.

NOTES: 3. Input offset voltage measurements are performed by automatic test equipment approximately 0.5 seconds after applying power.

4. Long-term drift of input offset voltage refers to the average trend line of offset voltage versus time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in V_{IO} during the first 30 days are typically 2.5 μV (see Figure 3).

OP27 operating characteristics, $V_{CC\pm} = \pm 15$ V, $T_A = 25°C$

PARAMETER		TEST CONDITIONS		OP27A			OP27C			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate	$A_{VD} \geq 1$,	$R_L \geq 2$ kΩ	1.7	2.8		1.7	2.8		V/μs
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz, See Figure 26	R_S = 20 Ω,		0.225	0.375		0.225	0.375	μV
V_n	Equivalent input noise voltage	f = 10 Hz,	R_S = 20 Ω		3.5	8		3.8	8	nV/√Hz
		f = 1 kHz,	R_S = 20 Ω		3	4		3.2	4	
I_n	Equivalent input noise current	f = 10 Hz,	See Figure 27		5	25		5	25	pA/√Hz
		f = 1 kHz,	See Figure 27		0.7	2.5		0.7	2.5	
	Gain-bandwidth product	f = 100 kHz		5	8		5	8		MHz

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
V_{IO}	Input offset voltage	vs Temperature	1
ΔV_{IO}	Change in input offset voltage	vs Time after power on vs Time (long-term drift)	2 3
I_{IO}	Input offset current	vs Temperature	4
I_{IB}	Input bias current	vs Temperature	5
V_{ICR}	Common-mode input voltage range	vs Supply voltage	6
V_{OM}	Maximum peak output voltage	vs Load resistance	7
$V_{O(PP)}$	Maximum peak-to-peak output voltage	vs Frequency	8
A_{VD}	Differential voltage amplification	vs Supply voltage vs Load resistance vs Frequency	9 10 11, 12
CMRR	Common-mode rejection ratio	vs Frequency	13
k_{SVR}	Supply voltage rejection ratio	vs Frequency	14
SR	Slew rate	vs Temperature	15
ϕ_m	Phase margin	vs Temperature	16
ϕ	Phase shift	vs Frequency	11
V_n	Equivalent input noise voltage	vs Bandwidth vs Source resistance vs Supply voltage vs Temperature vs Frequency	17 18 19 20 21
	Gain-bandwidth product	vs Temperature	16
I_{OS}	Short-circuit output current	vs Time	22
I_{CC}	Supply current	vs Supply voltage	23
	Pulse response	Small signal Large signal	24 25

TYPICAL CHARACTERISTICS

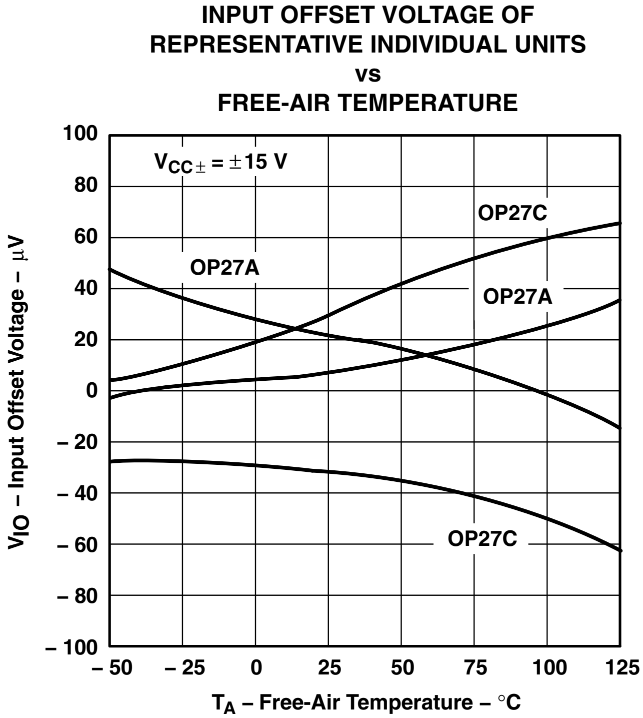


Figure 1

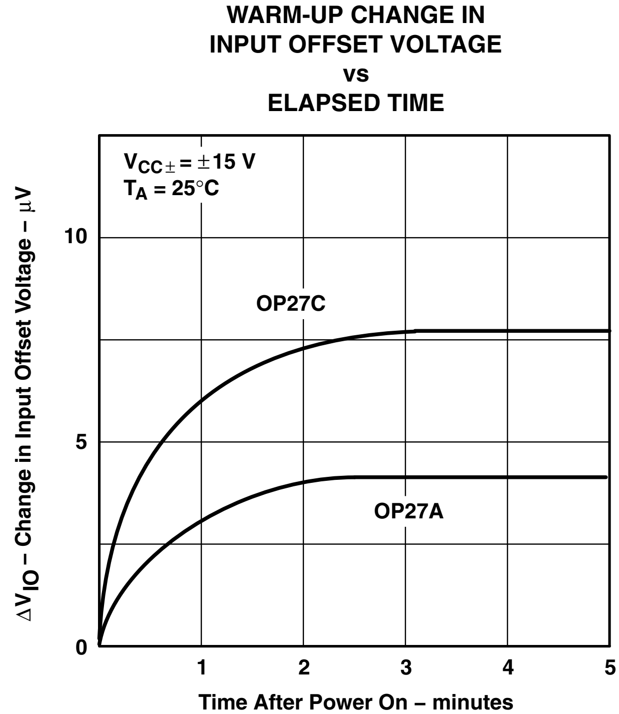


Figure 2

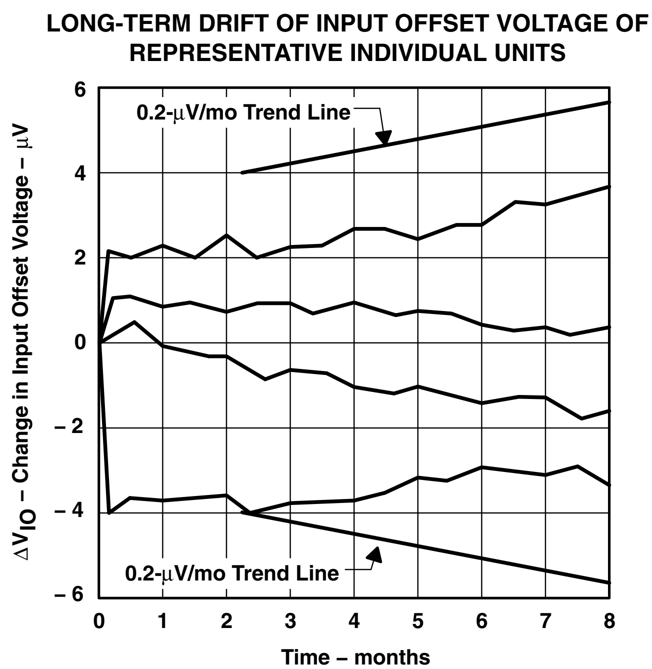


Figure 3

TYPICAL CHARACTERISTICS

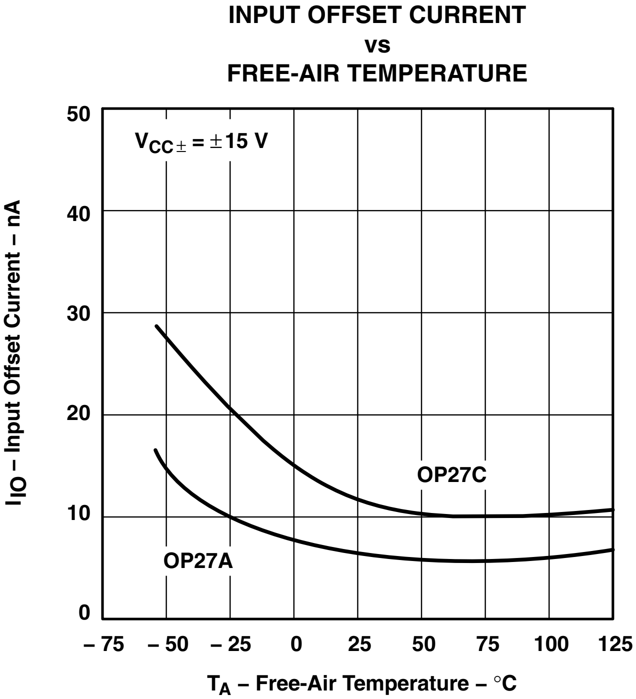


Figure 4

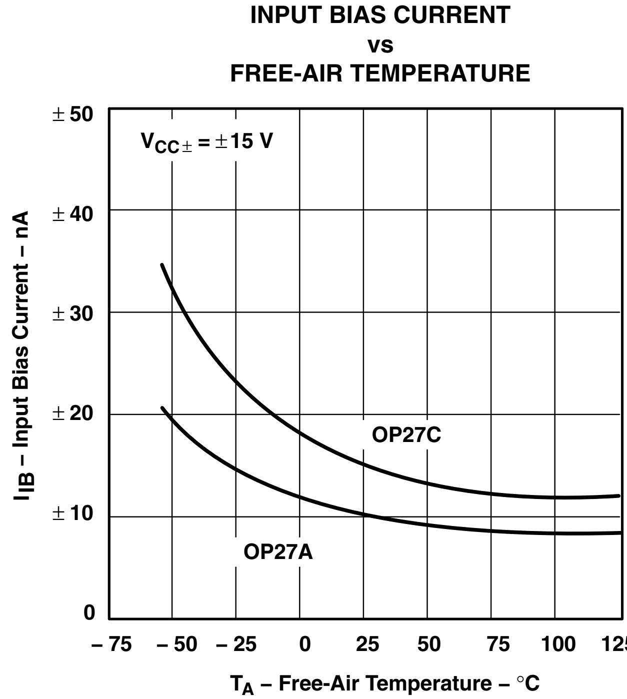


Figure 5

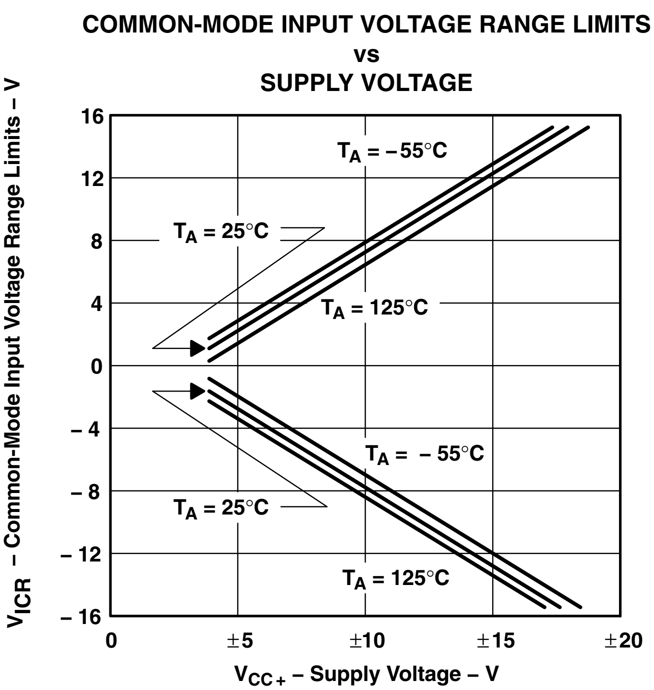


Figure 6

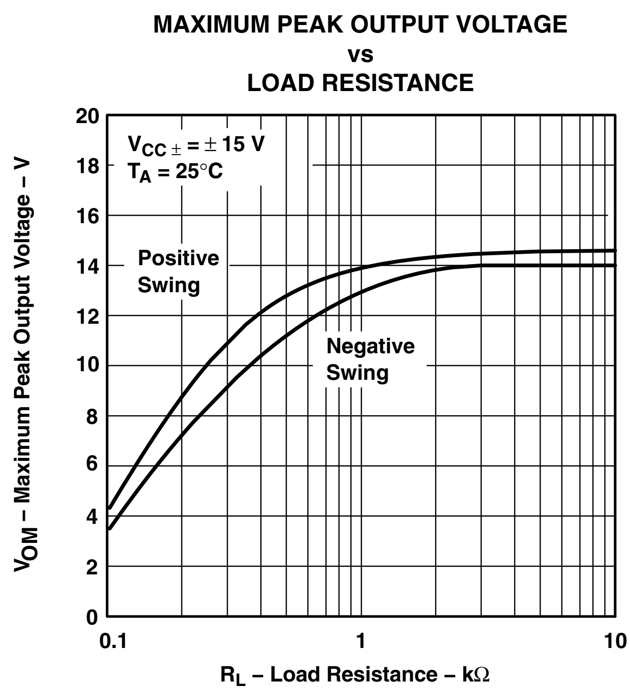


Figure 7

TYPICAL CHARACTERISTICS

OP27
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE vs FREQUENCY

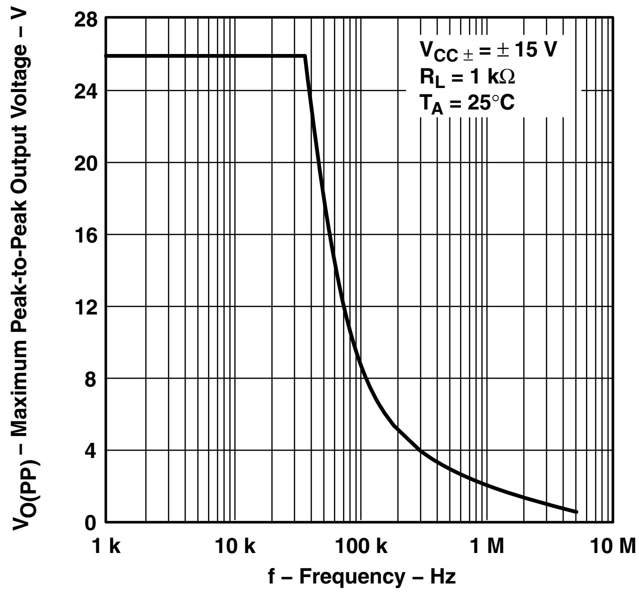


Figure 8.

OP27A
LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs TOTAL SUPPLY VOLTAGE

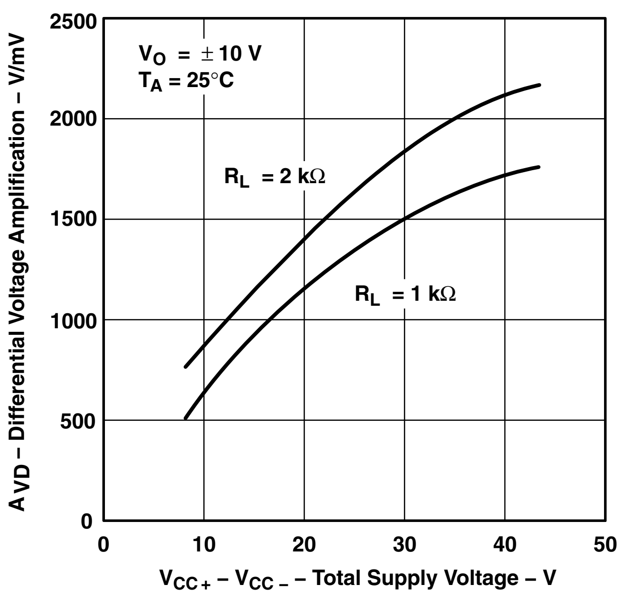


Figure 9

OP27A
LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE

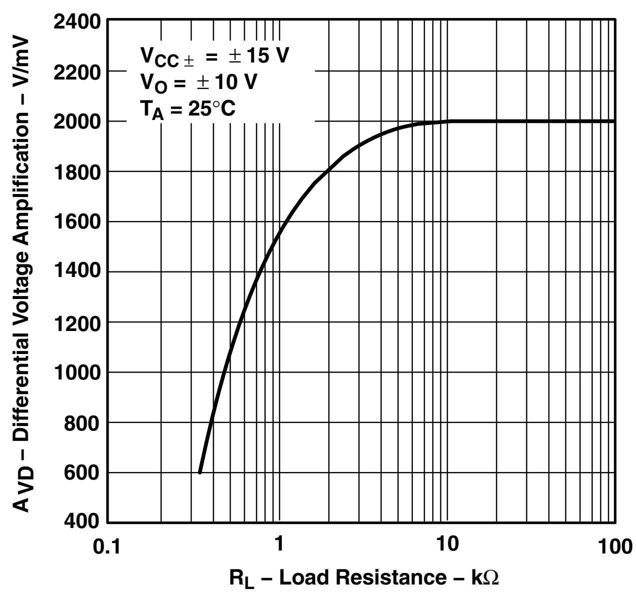


Figure 10

TYPICAL CHARACTERISTICS

OP27
LARGE-SIGNAL DIFFERENTIAL
VOLTAGE AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY

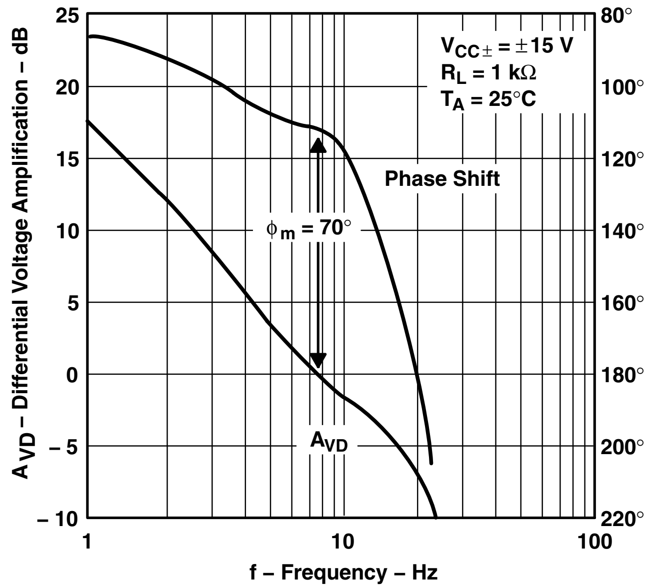


Figure 11.

OP27A
LARGE-SIGNAL
DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
FREQUENCY

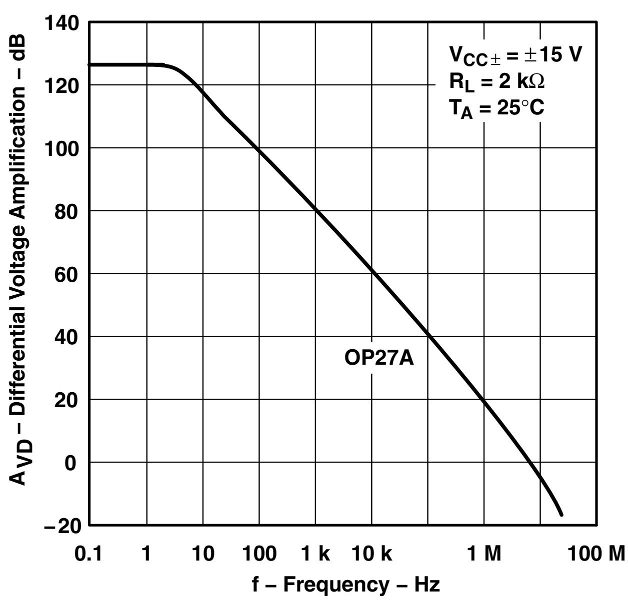


Figure 12

OP27A
COMMON-MODE REJECTION RATIO
vs
FREQUENCY

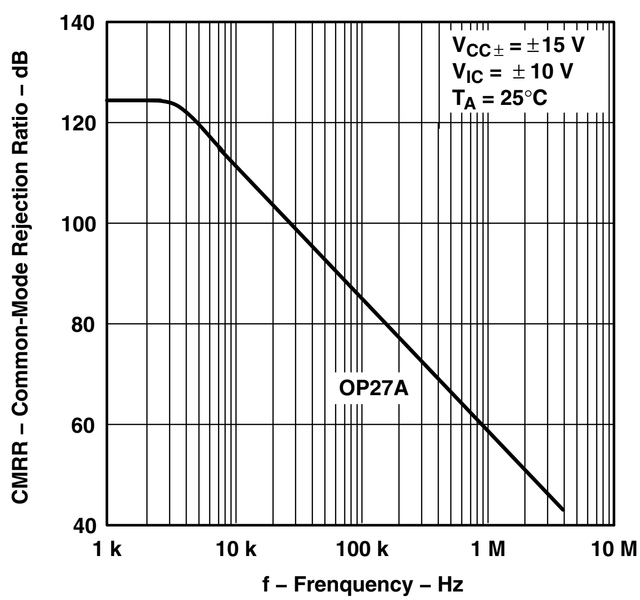


Figure 13

TYPICAL CHARACTERISTICS

SUPPLY VOLTAGE REJECTION RATIO vs FREQUENCY

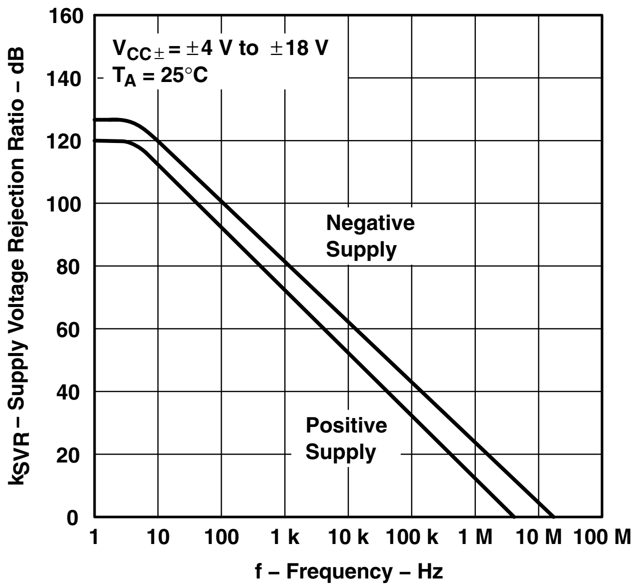


Figure 14

SLEW RATE vs FREE-AIR TEMPERATURE

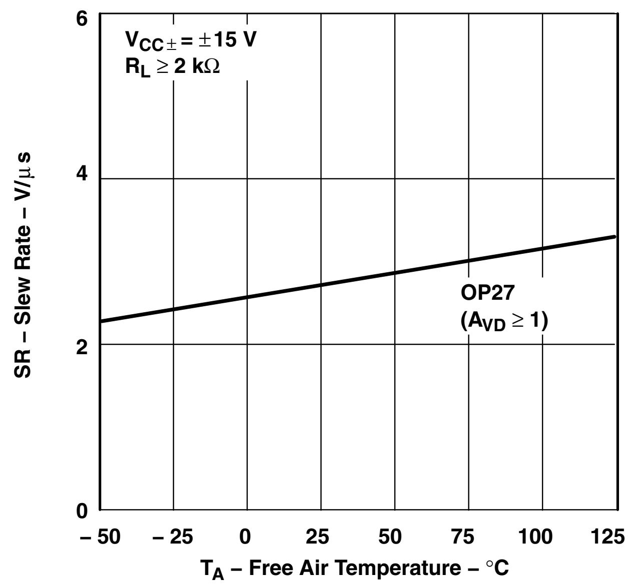


Figure 15

OP27 PHASE MARGIN AND GAIN-BANDWIDTH PRODUCT vs FREE-AIR TEMPERATURE

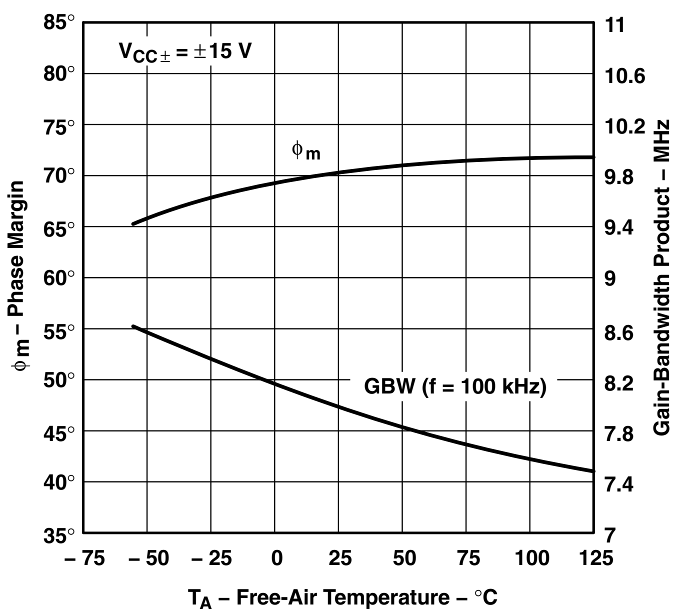


Figure 16.

TYPICAL CHARACTERISTICS

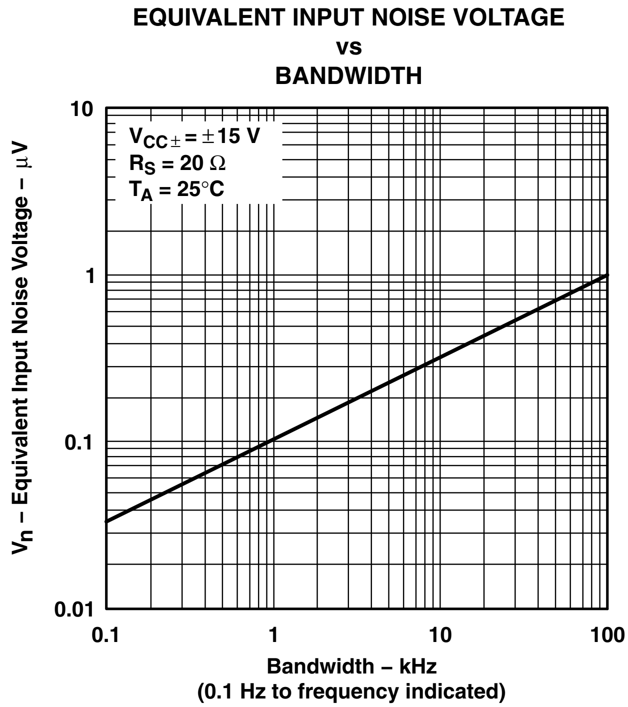


Figure 17

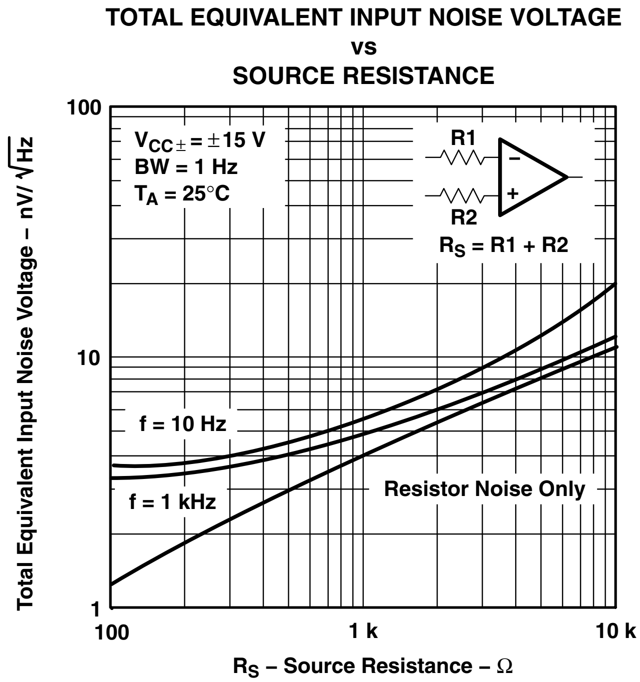


Figure 18

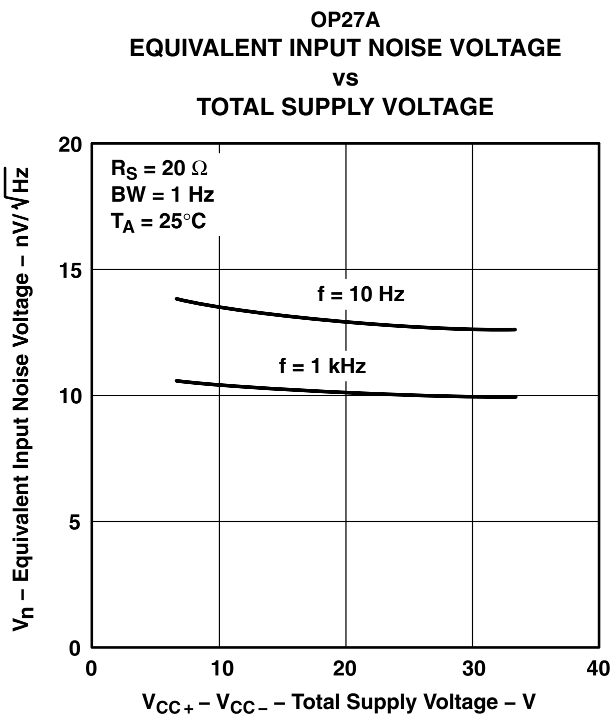


Figure 19

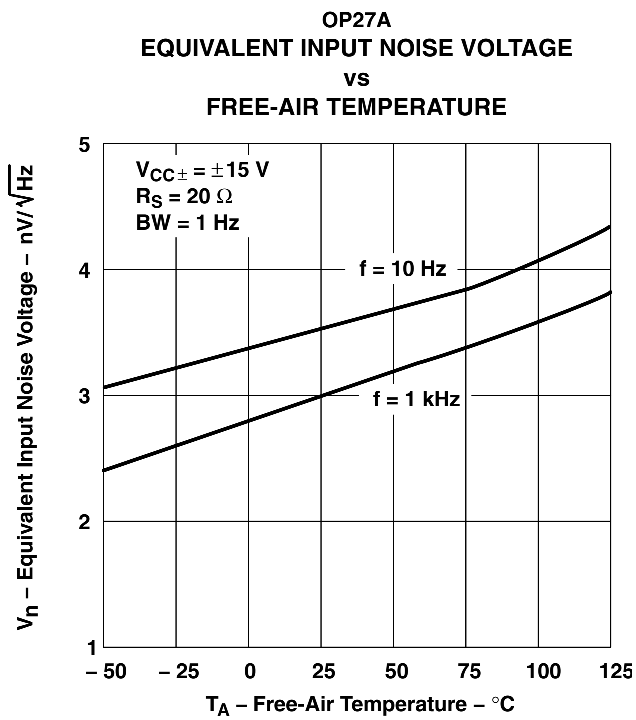


Figure 20

TYPICAL CHARACTERISTICS

OP27A
EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

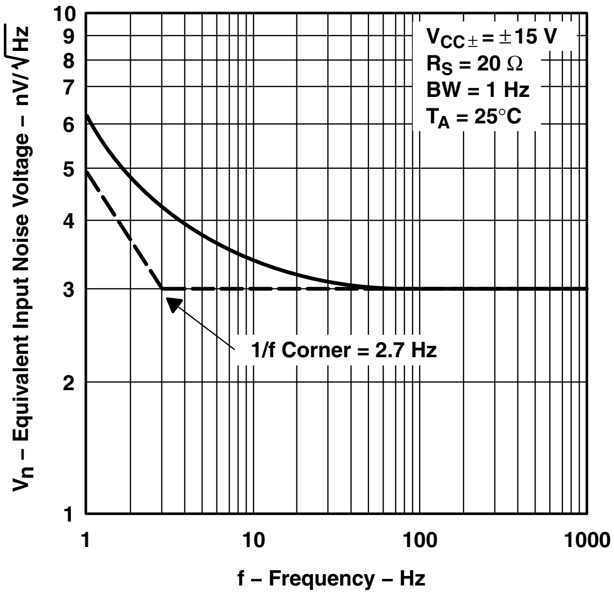


Figure 21

SHORT-CIRCUIT OUTPUT CURRENT
vs
ELAPSED TIME

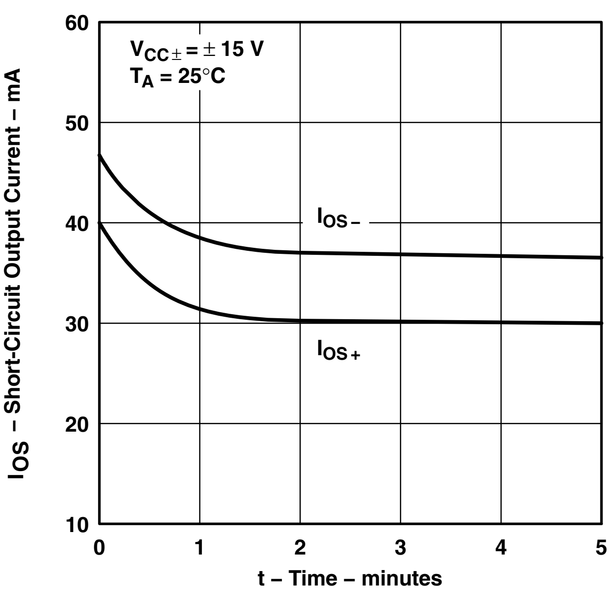


Figure 22

SUPPLY CURRENT
vs
TOTAL SUPPLY VOLTAGE

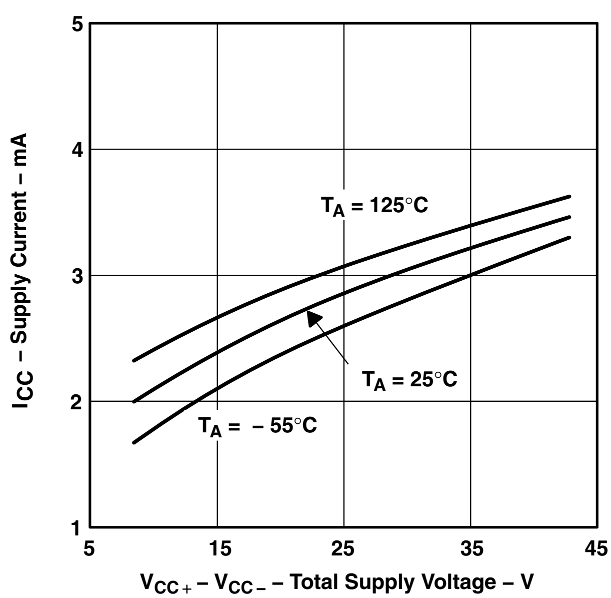


Figure 23

TYPICAL CHARACTERISTICS

OP27
VOLTAGE FOLLOWER
SMALL-SIGNAL
PULSE RESPONSE

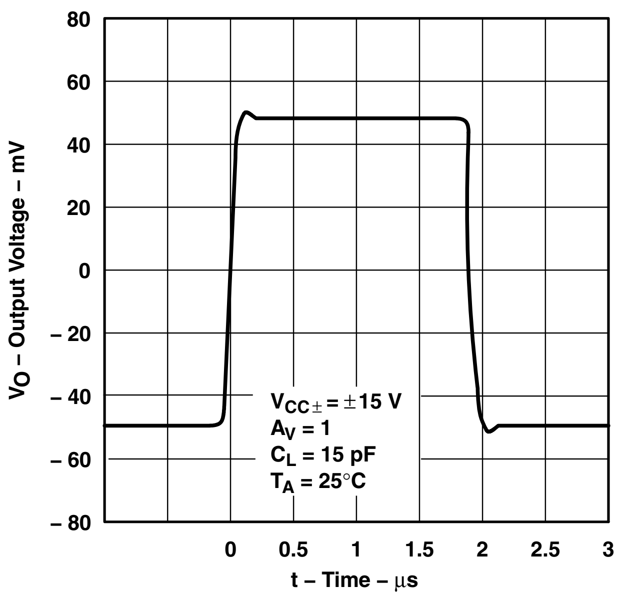


Figure 24

OP27
VOLTAGE FOLLOWER
LARGE-SIGNAL
PULSE RESPONSE

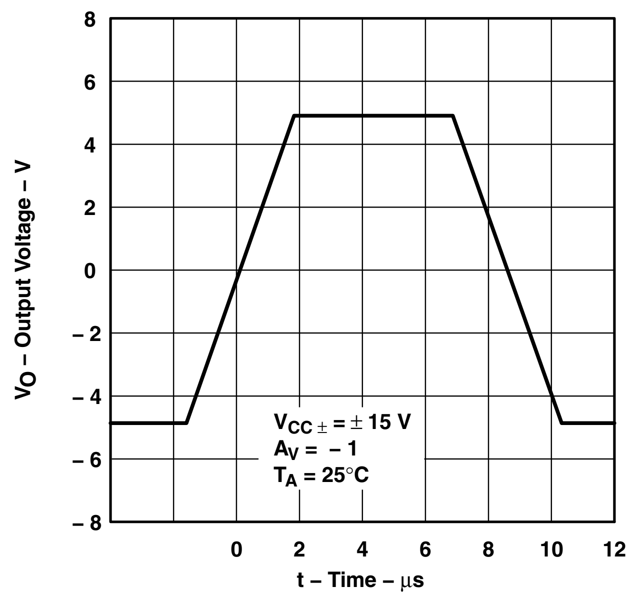


Figure 25

APPLICATION INFORMATION

general

The OP27 series devices can be inserted directly onto OP07, OP05, µA725, and SE5534 sockets with or without removing external compensation or nulling components. In addition, the OP27 can be fitted to µA741 sockets by removing or modifying external nulling components.

noise testing

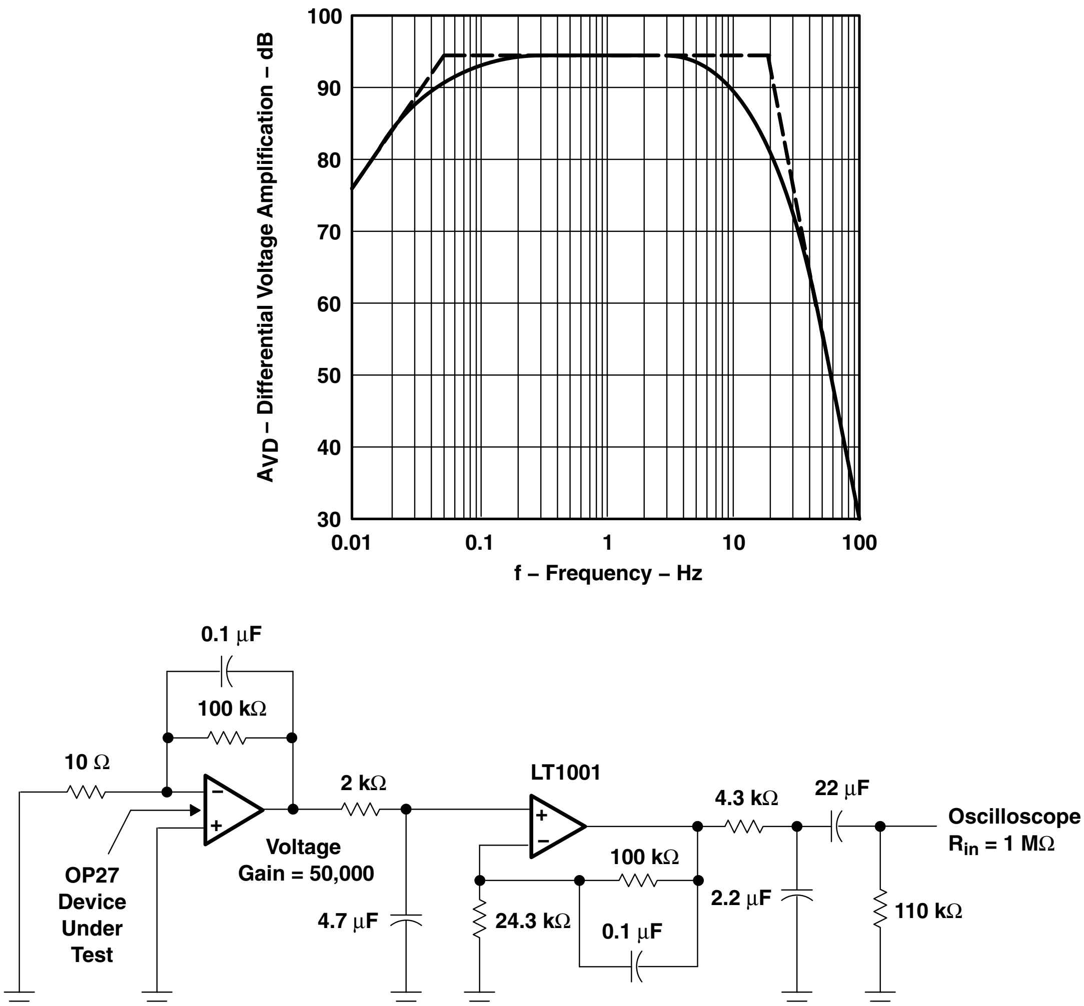
Figure 26 shows a test circuit for 0.1-Hz to 10-Hz peak-to-peak noise measurement of the OP27. The frequency response of this noise tester indicates that the 0.1-Hz corner is defined by only one zero. Because the time limit acts as an additional zero to eliminate noise contributions from the frequency band below 0.1 Hz, the test time to measure 0.1-Hz to 10-Hz noise should not exceed 10 seconds.

Measuring the typical 80-nV peak-to-peak noise performance of the OP27 requires the following special test precautions:

APPLICATION INFORMATION

noise testing (continued)

1. The device should be warmed up for at least five minutes. As the operational amplifier warms up, the offset voltage typically changes 4 μV due to the chip temperature increasing from 10°C to 20°C starting from the moment the power supplies are turned on. In the 10-s measurement interval, these temperature-induced effects can easily exceed tens of nanovolts.
2. For similar reasons, the device should be well shielded from air currents to eliminate the possibility of thermoelectric effects in excess of a few nanovolts, which would invalidate the measurements.
3. Sudden motion in the vicinity of the device should be avoided, as it produces a feedthrough effect that increases observed noise.



NOTE: All capacitor values are for nonpolarized capacitors only.

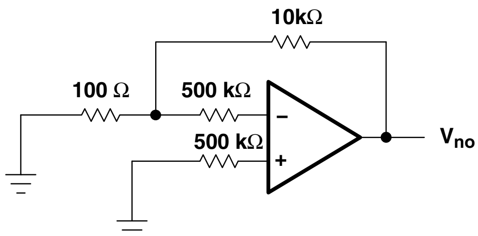
Figure 26. 0.1-Hz to 10-Hz Peak-to-Peak Noise Test Circuit and Frequency Response

APPLICATION INFORMATION

noise testing (continued)

When measuring noise on a large number of units, a noise-voltage density test is recommended. A 10-Hz noise-voltage density measurement correlates well with a 0.1-Hz to 10-Hz peak-to-peak noise reading since both results are determined by the white noise and the location of the 1/f corner frequency.

Figure 27 shows a circuit measuring current noise and the formula for calculating current noise.



$$I_n = \frac{[V_{no}^2 - (130\ \text{nV})^2]^{1/2}}{1\ \text{M}\Omega \times 100}$$

Figure 27. Current Noise Test Circuit and Formula

offset voltage adjustment

The input offset voltage and temperature coefficient of the OP27 are permanently trimmed to a low level at wafer testing. However, if further adjustment of V_{IO} is necessary, using a 10-kΩ nulling potentiometer as shown in Figure 28 does not degrade the temperature coefficient α_{VIO}. Trimming to a value other than zero creates an α_{VIO} of V_{IO}/300 μV/°C. For example, if V_{IO} is adjusted to 300 μV, the change in α_{VIO} is 1 μV/°C.

The adjustment range with a 10-kΩ potentiometer is approximately ±2.5 mV. If a smaller adjustment range is needed, the sensitivity and resolution of the nulling can be improved by using a smaller potentiometer in conjunction with fixed resistors. The example in Figure 29 has an approximate null range of ±200 μV.

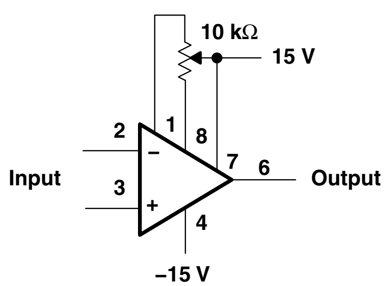


Figure 28. Standard Input Offset Voltage Adjustment

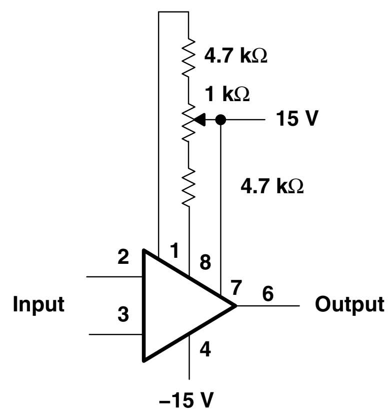


Figure 29. Input Offset Voltage Adjustment With Improved Sensitivity

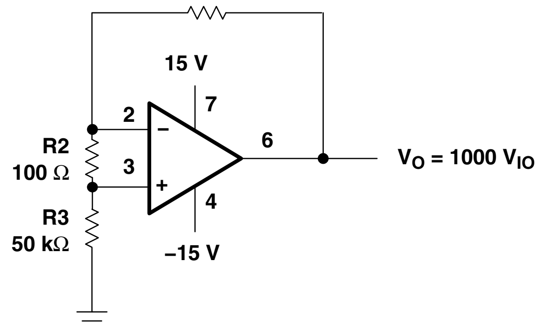
offset voltage and drift

Unless proper care is exercised, thermoelectric effects caused by temperature gradients across dissimilar metals at the contacts to the input terminals can exceed the inherent temperature coefficient $\propto V_{IO}$ of the amplifier. Air currents should be minimized, package leads should be short, and the two input leads should be close together and at the same temperature.

APPLICATION INFORMATION

offset voltage and drift (continued)

The circuit shown in Figure 30 measures offset voltage. This circuit can also be used as the burn-in configuration for the OP27 with the supply voltage increased to 20 V, R1 = R3 = 10 kΩ, R2 = 200 Ω, and A_{VD} = 100.



NOTE A: Resistors must have low thermoelectric potential.

Figure 30. Test Circuit for Offset Voltage and Offset Voltage Temperature Coefficient

unity gain buffer applications

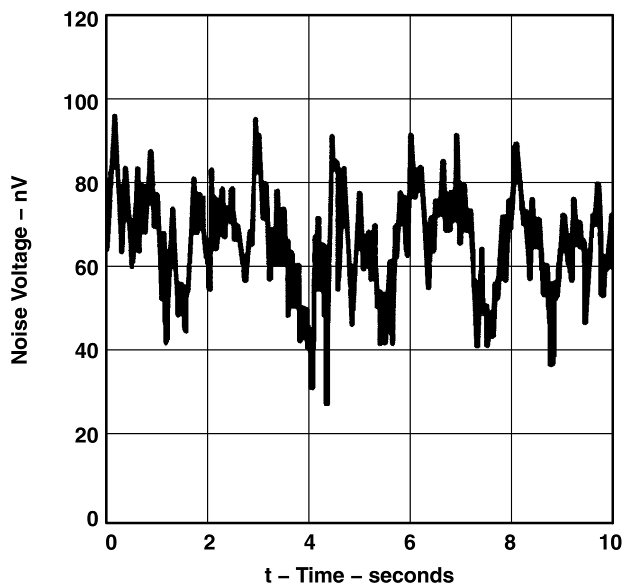
The resulting output waveform, when R_f ≤ 100 Ω and the input is driven with a fast large-signal pulse (>1 V), is shown in the pulsed-operation diagram in Figure 31.

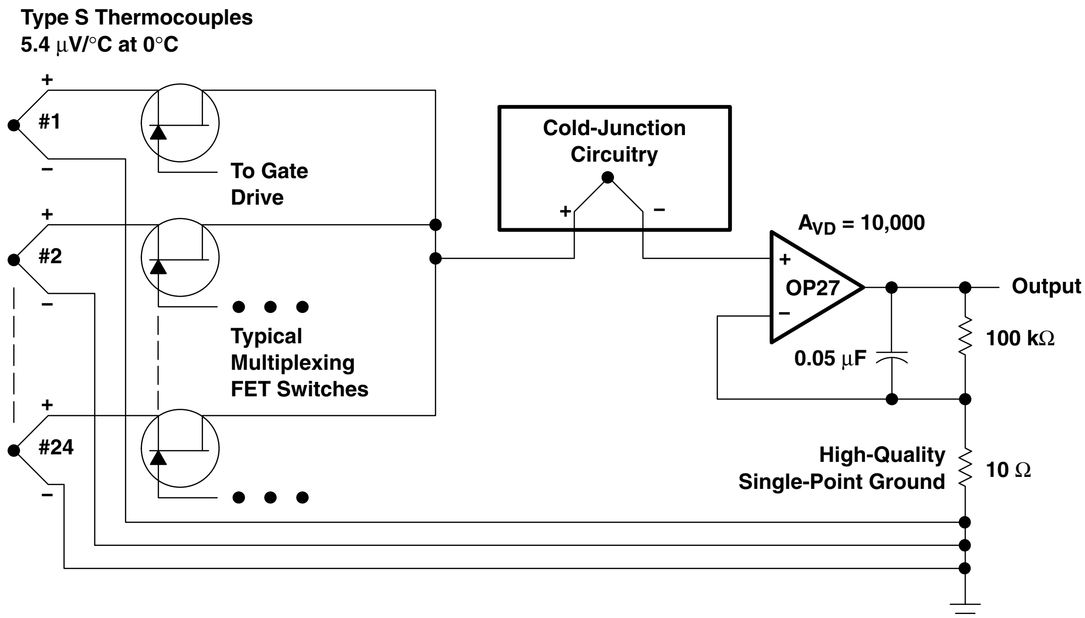
Figure 31. Pulsed Operation

During the initial (fast-feedthrough-like) portion of the output waveform, the input protection diodes effectively short the output to the input, and a current, limited only by the output short-circuit protection, is drawn by the signal generator. When R_f ≥ 500 Ω, the output is capable of handling the current requirements (load current ≤20 mA at 10 V), the amplifier stays in its active mode, and a smooth transition occurs. When R_f > 2 kΩ, a pole is created with R_f and the amplifier's input capacitance, creating additional phase shift and reducing the phase margin. A small capacitor (20 pF to 50 pF) in parallel with R_f eliminates this problem.

APPLICATION INFORMATION

unity gain buffer applications (continued)





NOTE A: If 24 channels are multiplexed per second and the output is required to settle to 0.1 % accuracy, the amplifier's bandwidth cannot be limited to less than 30 Hz. The peak-to-peak noise contribution of the OP27 will still be only 0.11 μV, which is equivalent to an error of only 0.02°C.

Figure 32. Low-Noise, Multiplexed Thermocouple Amplifier and 0.1-Hz to 10-Hz Peak-to-Peak Noise Voltage

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)
JM38510/13506BPA	Active	Production	CDIP (JG) | 8	50 | TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	JM38510 /13506BPA
JM38510/13506BPA.A	Active	Production	CDIP (JG) | 8	50 | TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	JM38510 /13506BPA
OP27AFKB	Active	Production	LCCC (FK) | 20	55 | TUBE	No	SNPB	N/A for Pkg Type	-	OP27AFKB
OP27AFKB.A	Active	Production	LCCC (FK) | 20	55 | TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	OP27AFKB
OP27AJGB	Active	Production	CDIP (JG) | 8	50 | TUBE	No	SNPB	N/A for Pkg Type	-	OP27AJGB
OP27AJGB.A	Active	Production	CDIP (JG) | 8	50 | TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	OP27AJGB
OP27CJGB	Active	Production	CDIP (JG) | 8	50 | TUBE	No	SNPB	N/A for Pkg Type	-	OP27CJGB
OP27CJGB.A	Active	Production	CDIP (JG) | 8	50 | TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	OP27CJGB

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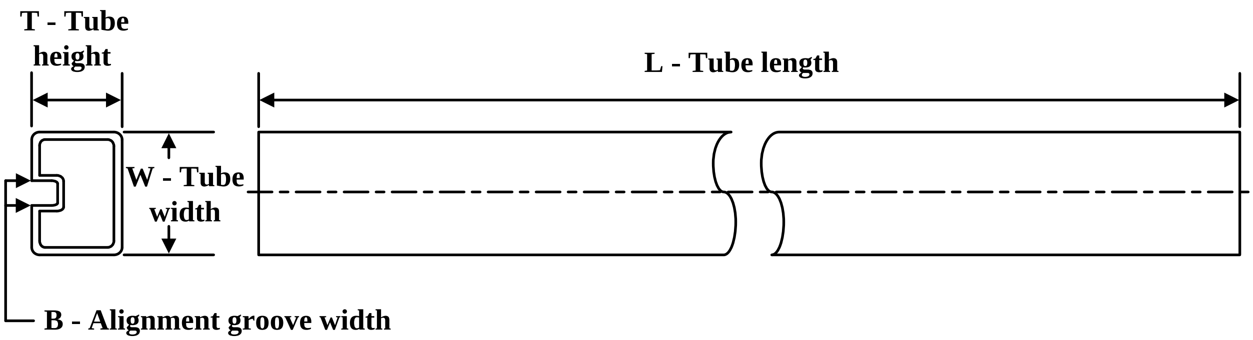
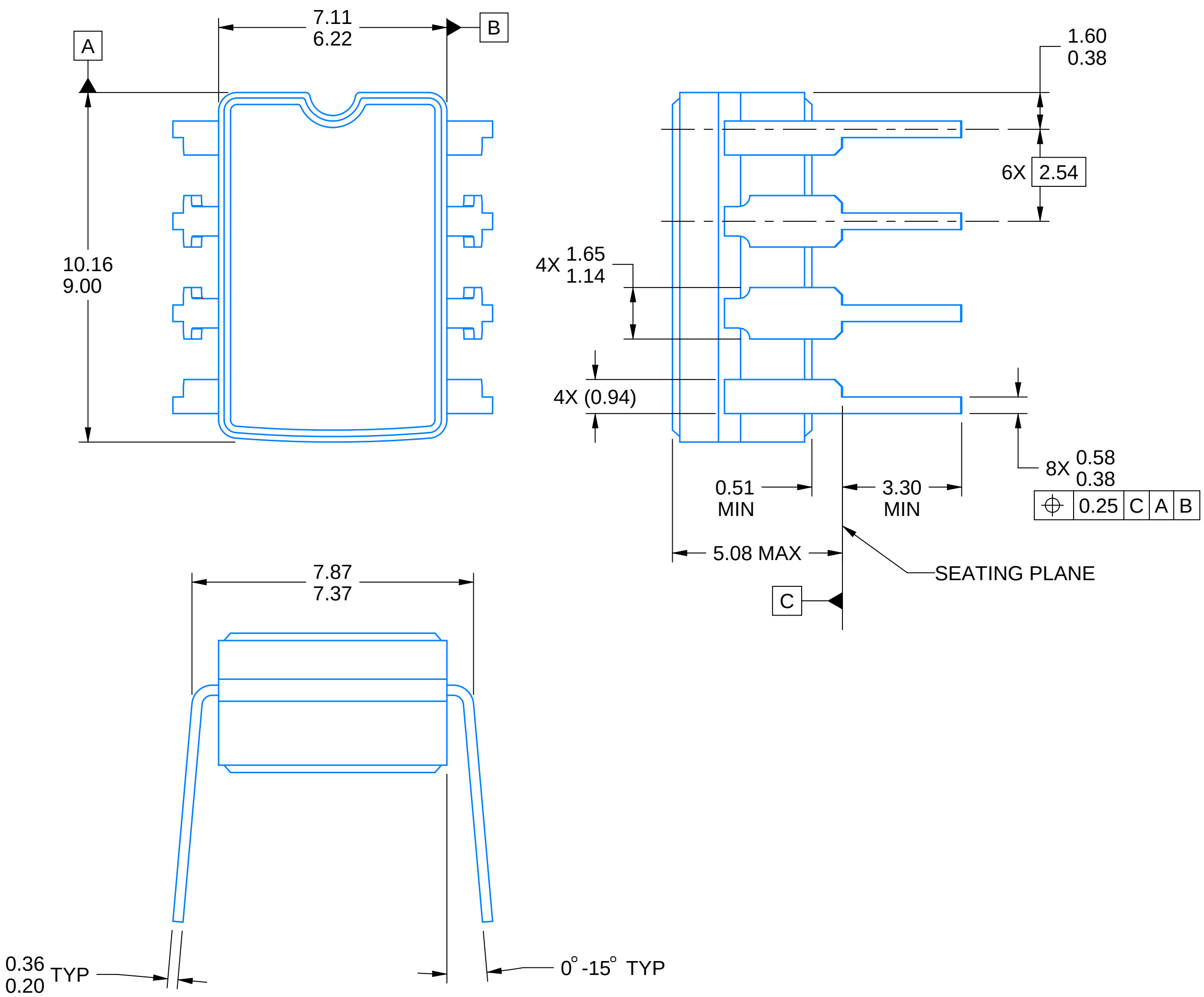
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TUBE



*All dimensions are nominal

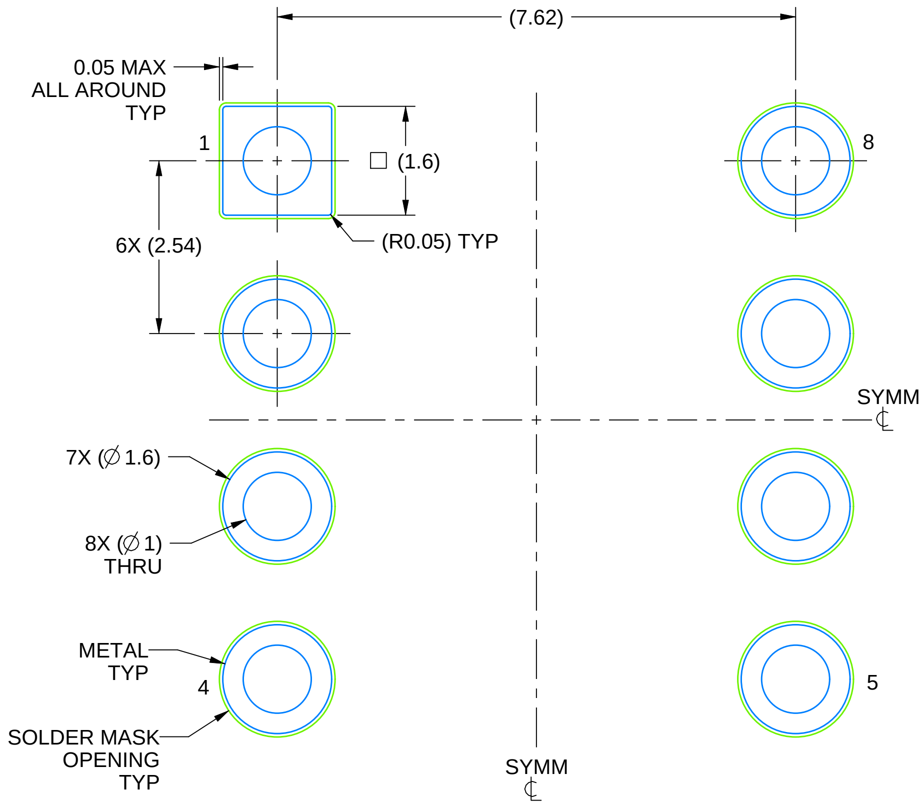
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
OP27AFKB	FK	LCCC	20	55	506.98	12.06	2030	NA
OP27AFKB.A	FK	LCCC	20	55	506.98	12.06	2030	NA



4230036/A 09/2023

NOTES:

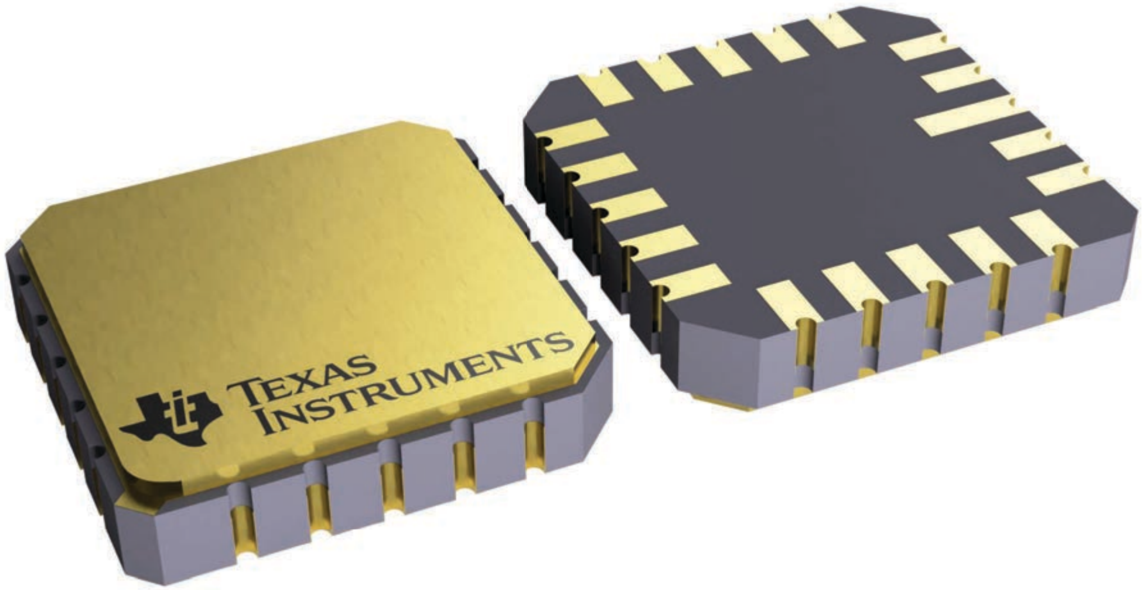
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package can be hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided on cap for terminal identification.
5. Falls within MIL STD 1835 GDIP1-T8



LAND PATTERN EXAMPLE
NON SOLDER MASK DEFINED
SCALE: 9X

4230036/A 09/2023

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



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