# ANALOG DEVICES

# Low-Noise, Precision Operational Amplifier

# OP27

## FEATURES

- **Low Noise: 80 nV p-p (0.1 Hz to 10 Hz), 3 nV/$\sqrt{Hz}$**
- **Low Drift: 0.2 μV/°C**
- **High Speed: 2.8 V/μs Slew Rate, 8 MHz Gain Bandwidth**
- **Low $V_{OS}$: 10 μV**
- **Excellent CMRR: 126 dB at $V_{CM}$ of ±11 V**
- **High Open-Loop Gain: 1.8 Million**
- **Fits 725, OP07, 5534A Sockets**
- **Available in Die Form**

## GENERAL DESCRIPTION

The OP27 precision operational amplifier combines the low offset and drift of the OP07 with both high speed and low noise. Offsets down to 25 μV and maximum drift of 0.6 μV/°C, makes the OP27 ideal for precision instrumentation applications. Exceptionally low noise, $e_n$ = 3.5 nV/$\sqrt{Hz}$, at 10 Hz, a low 1/f noise corner frequency of 2.7 Hz, and high gain (1.8 million), allow accurate high-gain amplification of low-level signals. A gain-bandwidth product of 8 MHz and a 2.8 V/μsec slew rate provides excellent dynamic accuracy in high-speed, data-acquisition systems.

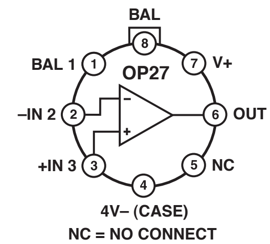
A low input bias current of ±10 nA is achieved by use of a bias-current-cancellation circuit. Over the military temperature range, this circuit typically holds $I_B$ and $I_{OS}$ to ±20 nA and 15 nA, respectively.

The output stage has good load driving capability. A guaranteed swing of ±10 V into 600 Ω and low output distortion make the OP27 an excellent choice for professional audio applications.

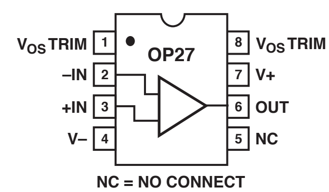
(Continued on page 7)

## PIN CONNECTIONS

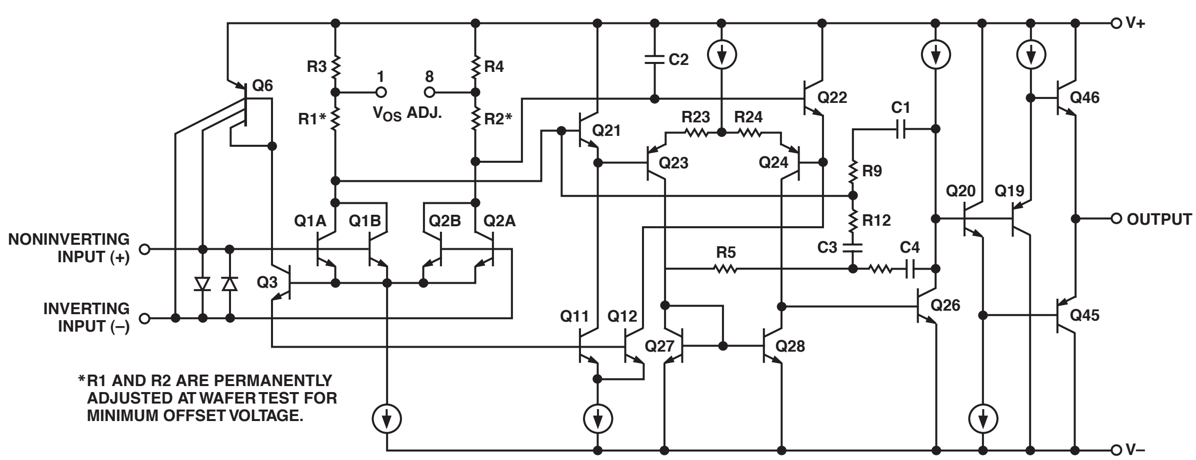
**TO-99 (J-Suffix)**




**8-Pin Hermetic DIP (Z-Suffix)**
**Epoxy Mini-DIP (P-Suffix)**
**8-Pin SO (S-Suffix)**




## SIMPLIFIED SCHEMATIC




REV. C



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# OP27–SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS (@ $V_S$ = ±15 V, $T_A$ = 25°C, unless otherwise noted.)

| Parameter | Symbol | Conditions | OP27A/E Min | OP27A/E Typ | OP27A/E Max | OP27F Min | OP27F Typ | OP27F Max | OP27C/G Min | OP27C/G Typ | OP27C/G Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INPUT OFFSET VOLTAGE[1] | $V_{OS}$ | | | 10 | 25 | | 20 | 60 | | 30 | 100 | μV |
| LONG-TERM $V_{OS}$ STABILITY[2, 3] | $V_{OS}$/Time | | | 0.2 | 1.0 | | 0.3 | 1.5 | | 0.4 | 2.0 | μV/$M_O$ |
| INPUT OFFSET CURRENT | $I_{OS}$ | | | 7 | 35 | | 9 | 50 | | 12 | 75 | nA |
| INPUT BIAS CURRENT | $I_B$ | | | ±10 | ±40 | | ±12 | ±55 | | ±15 | ±80 | nA |
| INPUT NOISE VOLTAGE[3, 4] | $e_{n\ p\text{-}p}$ | 0.1 Hz to 10 Hz | | 0.08 | 0.18 | | 0.08 | 0.18 | | 0.09 | 0.25 | μV p-p |
| INPUT NOISE Voltage Density[3] | $e_n$ | $f_O$ = 10 Hz | | 3.5 | 5.5 | | 3.5 | 5.5 | | 3.8 | 8.0 | nV/√Hz |
| | | $f_O$ = 30 Hz | | 3.1 | 4.5 | | 3.1 | 4.5 | | 3.3 | 5.6 | nV/√Hz |
| | | $f_O$ = 1000 Hz | | 3.0 | 3.8 | | 3.0 | 3.8 | | 3.2 | 4.5 | nV/√Hz |
| INPUT NOISE Current Density[3, 5] | $i_n$ | $f_O$ = 10 Hz | | 1.7 | 4.0 | | 1.7 | 4.0 | | 1.7 | | pA/√Hz |
| | | $f_O$ = 30 Hz | | 1.0 | 2.3 | | 1.0 | 2.3 | | 1.0 | | pA/√Hz |
| | | $f_O$ = 1000 Hz | | 0.4 | 0.6 | | 0.4 | 0.6 | | 0.4 | 0.6 | pA/√Hz |
| INPUT RESISTANCE Differential-Mode[6] | $R_{IN}$ | | 1.3 | 6 | | 0.94 | 5 | | 0.7 | 4 | | MΩ |
| Common-Mode | $R_{INCM}$ | | | 3 | | | 2.5 | | | 2 | | GΩ |
| INPUT VOLTAGE RANGE | IVR | | ±11.0 | ±12.3 | | ±11.0 | ±12.3 | | ±11.0 | ±12.3 | | V |
| COMMON-MODE REJECTION RATIO | CMRR | $V_{CM}$ = ±11 V | 114 | 126 | | 106 | 123 | | 100 | 120 | | dB |
| POWER SUPPLY REJECTION RATIO | PSRR | $V_S$ = ±4 V to ±18 V | | 1 | 10 | | 1 | 10 | | 2 | 20 | μV/V |
| LARGE-SIGNAL VOLTAGE GAIN | $A_{VO}$ | $R_L$ ≥ 2 kΩ, $V_O$ = ±10 V | 1000 | 1800 | | 1000 | 1800 | | 700 | 1500 | | V/mV |
| | | $R_L$ ≥ 600 Ω, $V_O$ = ±10 V | 800 | 1500 | | 800 | 1500 | | 600 | 1500 | | V/mV |
| OUTPUT VOLTAGE SWING | $V_O$ | $R_L$ ≥ 2 kΩ | ±12.0 | ±13.8 | | ±12.0 | ±13.8 | | ±11.5 | ±13.5 | | V |
| | | $R_L$ ≥ 600 Ω | ±10.0 | ±11.5 | | ±10.0 | ±11.5 | | ±10.0 | ±11.5 | | V |
| SLEW RATE[7] | SR | $R_L$ ≥ 2 kΩ | 1.7 | 2.8 | | 1.7 | 2.8 | | 1.7 | 2.8 | | V/μs |
| GAIN BANDWIDTH PRODUCT[7] | GBW | | 5.0 | 8.0 | | 5.0 | 8.0 | | 5.0 | 8.0 | | MHz |
| OPEN-LOOP OUTPUT RESISTANCE | $R_O$ | $V_O$ = 0, $I_O$ = 0 | | 70 | | | 70 | | | 70 | | Ω |
| POWER CONSUMPTION | $P_d$ | $V_O$ | | 90 | 140 | | 90 | 140 | | 100 | 170 | mW |
| OFFSET ADJUSTMENT RANGE | | $R_P$ = 10 kΩ | | ±4.0 | | | ±4.0 | | | ±4.0 | | mV |

NOTES

[1]Input offset voltage measurements are performed ~ 0.5 seconds after application of power. A/E grades guaranteed fully warmed up.

[2]Long-term input offset voltage stability refers to the average trend line of $V_{OS}$ versus. Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in $V_{OS}$ during the first 30 days are typically 2.5 μV. Refer to typical performance curve.

[3]Sample tested.

[4]See test circuit and frequency response curve for 0.1 Hz to 10 Hz tester.

[5]See test circuit for current noise measurement.

[6]Guaranteed by input bias current.

[7]Guaranteed by design.

# ELECTRICAL CHARACTERISTICS (@ $V_S$ = ±15 V, –55°C ≤ $T_A$ ≤ 125°C, unless otherwise noted.)

| Parameter | Symbol | Conditions | OP27A Min | OP27A Typ | OP27A Max | OP27C Min | OP27C Typ | OP27C Max | Unit |
|---|---|---|---|---|---|---|---|---|---|
| INPUT OFFSET VOLTAGE[1] | $V_{OS}$ | | | 30 | 60 | | 70 | 300 | µV |
| AVERAGE INPUT OFFSET DRIFT | $TCV_{OS}$[2] $TCV_{OSn}$[3] | | | 0.2 | 0.6 | | 4 | 1.8 | µV/°C |
| INPUT OFFSET CURRENT | $I_{OS}$ | | | 15 | 50 | | 30 | 135 | nA |
| INPUT BIAS CURRENT | $I_B$ | | | ±20 | ±60 | | ±35 | ±150 | nA |
| INPUT VOLTAGE RANGE | IVR | | ±10.3 | ±11.5 | | ±10.2 | ±11.5 | | V |
| COMMON-MODE REJECTION RATIO | CMRR | $V_{CM}$ = ±10 V | 108 | 122 | | 94 | 118 | | dB |
| POWER SUPPLY REJECTION RATIO | PSRR | $V_S$ = ±4.5 V to ±18 V | | 2 | 16 | | 4 | 51 | µV/V |
| LARGE-SIGNAL VOLTAGE GAIN | $A_{VO}$ | $R_L$ ≥ 2 kΩ, $V_O$ = ±10 V | 600 | 1200 | | 300 | 800 | | V/mV |
| OUTPUT VOLTAGE SWING | $V_O$ | $R_L$ ≥ 2 kΩ | ±11.5 | ±13.5 | | ±10.5 | ±13.0 | | V |

NOTES

[1]Input offset voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power. A/E grades guaranteed fully warmed up.

[2]The $TCV_{OS}$ performance is within the specifications unnulled or when nulled with $R_P$ = 8 kΩ to 20 kΩ. $TCV_{OS}$ is 100% tested for A/E grades, sample tested for C/F/G grades.

[3]Guaranteed by design.

## ELECTRICAL CHARACTERISTICS (@ $V_S$ = ±15 V, –25°C ≤ $T_A$ ≤ 85°C for OP27J, OP27Z, 0°C ≤ $T_A$ ≤ 70°C for OP27EP, OP27FP, and –40°C ≤ $T_A$ ≤ 85°C for OP27GP, OP27GS, unless otherwise noted.)

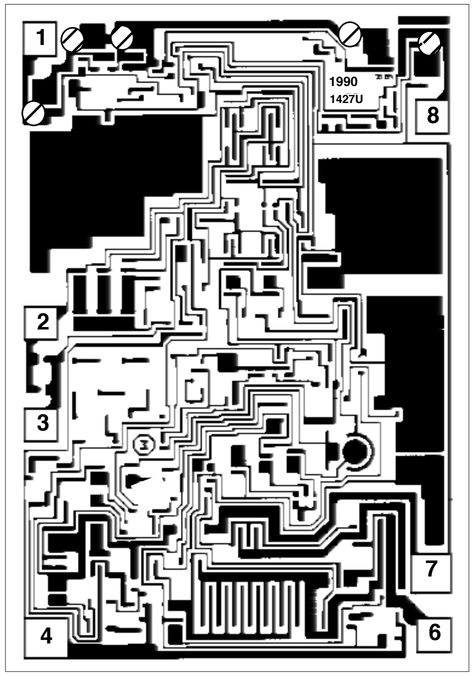
| Parameter | Symbol | Conditions | OP27E Min | OP27E Typ | OP27E Max | OP27F Min | OP27F Typ | OP27F Max | OP27G Min | OP27G Typ | OP27G Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INPUT ONSET VOLTAGE | $V_{OS}$ | | | 20 | 50 | | 40 | 140 | | 55 | 220 | µV |
| AVERAGE INPUT OFFSET DRIFT | $TCV_{OS}$[1] | | | 0.2 | 0.6 | | 0.3 | 1.3 | | 0 4 | 1.8 | µV/°C |
| | $TCV_{OSn}$[2] | | | 0.2 | 0.6 | | 0.3 | 1.3 | | 0 4 | 1.8 | µV/°C |
| INPUT OFFSET CURRENT | $I_{OS}$ | | | 10 | 50 | | 14 | 85 | | 20 | 135 | nA |
| INPUT BIAS CURRENT | $I_B$ | | | ±14 | ±60 | | ±18 | ±95 | | ±25 | ±150 | nA |
| INPUT VOLTAGE RANGE | IVR | | ±10.5 | ±11.8 | | ±10.5 | ±11.8 | | ±10.5 | ±11.8 | | V |
| COMMON-MODE REJECTION RATIO | CMRR | $V_{CM}$ = ±10 V | 110 | 124 | | 102 | 121 | | 96 | 118 | | dB |
| POWER SUPPLY REJECTION RATIO | PSRR | $V_S$ = ±4.5 V to ±18 V | | 2 | 15 | | 2 | 16 | | 2 | 32 | µV/V |
| LARGE-SIGNAL VOLTAGE GAIN | $A_{VO}$ | $R_L$ ≥ 2 kΩ, $V_O$ = ±10 V | 750 | 1500 | | 700 | 1300 | | 450 | 1000 | | V/mV |
| OUTPUT VOLTAGE SWING | $V_O$ | $R_L$ ≥ 2 kΩ | ±11.7 | ±13.6 | | ±11.4 | ±13.5 | | ±11.0 | ±13.3 | | V |

NOTES

[1]The $TCV_{OS}$ performance is within the specifications unnulled or when nulled with $R_P$ = 8 kΩ to 20 kΩ. $TCV_{OS}$ is 100% tested for A/E grades, sample tested for C/F/G grades.

[2]Guaranteed by design.

## DIE CHARACTERISTICS




1. NULL
2. (–) INPUT
3. (+) INPUT
4. V–
6. OUTPUT
7. V+
8. NULL

## WAFER TEST LIMITS (@ $V_S$ = ±15 V, $T_A$ = 25°C unless otherwise noted.)

| Parameter | Symbol | Conditions | OP27N Limit | OP27G Limit | OP27GR Limit | Unit |
|---|---|---|---|---|---|---|
| INPUT OFFSET VOLTAGE* | $V_{OS}$ | | 35 | 60 | 100 | μV Max |
| INPUT OFFSET CURRENT | $I_{OS}$ | | 35 | 50 | 75 | nA Max |
| INPUT BIAS CURRENT | IB | | ±40 | ±55 | ±80 | nA Max |
| INPUT VOLTAGE RANGE | IVR | | ±11 | ±11 | ±11 | V Min |
| COMMON-MODE REJECTION RATIO | CMRR | $V_{CM}$ = IVR | 114 | 106 | 100 | dB Min |
| POWER SUPPLY | PSRR | $V_S$ = ±4 V to ±18 V | 10 | 10 | 20 | μV/V Max |
| LARGE-SIGNAL VOLTAGE GAIN | $A_{VO}$<br>$A_{VO}$ | $R_L$ ≥ 2 kΩ, $V_O$ = ±10 V<br>$R_L$ ≥ 600 Ω, $V_O$ = ±10 V | 1000<br>800 | 1000<br>800 | 700<br>600 | V/mV Min<br>V/mV Min |
| OUTPUT VOLTAGE SWING | $V_O$<br>$V_O$ | $R_L$ ≥ 2 kΩ<br>RL2600n | ±12.0<br>±10.0 | ±12.0<br>±10.0 | +11.5<br>±10.0 | V Min<br>V Min |
| POWER CONSUMPTION | $P_d$ | $V_O$ = 0 | 140 | 140 | 170 | mW Max |

NOTE
*Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

## TYPICAL ELECTRICAL CHARACTERISTICS (@ $V_S = \pm 15$ V, $T_A = 25°C$ unless otherwise noted.)

| Parameter | Symbol | Conditions | OP27N Typical | OP27G Typical | OP27GR Typical | Unit |
|---|---|---|---|---|---|---|
| AVERAGE INPUT OFFSET VOLTAGE DRIFT* | $TCV_{OS}$ or $TCV_{OSn}$ | Nulled or Unnulled $R_P$ = 8 kΩ to 20 kΩ | 0.2 | 0.3 | 0.4 | µV/°C |
| AVERAGE INPUT OFFSET CURRENT DRIFT | $TCI_{OS}$ | | 80 | 130 | 180 | pA/°C |
| AVERAGE INPUT BIAS CURRENT DRIFT | $TCI_B$ | | 100 | 160 | 200 | pA/°C |
| INPUT NOISE VOLTAGE DENSITY | $e_n$ | $f_O$ = 10 Hz | 3.5 | 3.5 | 3.8 | nV/√Hz |
| | $e_n$ | $f_O$ = 30 Hz | 3.1 | 3.1 | 3.3 | nV/√Hz |
| | $e_n$ | $f_O$ = 1000 Hz | 3.0 | 3.0 | 3.2 | nV/√Hz |
| INPUT NOISE CURRENT DENSITY | $i_n$ | $f_O$ = 10 Hz | 1.7 | 1.7 | 1.7 | pA/√Hz |
| | $i_n$ | $f_O$ = 30 Hz | 1.0 | 1.0 | 1.0 | pA/√Hz |
| | $i_n$ | $f_O$ = 1000 Hz | 0.4 | 0.4 | 0.4 | pA/√Hz |
| INPUT NOISE VOLTAGE | $e_{np-p}$ | 0.1 Hz to 10 Hz | 0.08 | 0.08 | 0.09 | µV p-p |
| SLEW RATE | SR | $R_L \geq 2$ kΩ | 2.8 | 2.8 | 2.8 | V/µs |
| GAIN BANDWIDTH PRODUCT | GBW | | 8 | 8 | 8 | MHz |

NOTE
*Input offset voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power.

(Continued from page 1)

PSRR and CMRR exceed 120 dB. These characteristics, coupled with long-term drift of 0.2 µV/month, allow the circuit designer to achieve performance levels previously attained only by discrete designs.

Low-cost, high-volume production of OP27 is achieved by using an on-chip Zener zap-trimming network. This reliable and stable offset trimming scheme has proved its effectiveness over many years of production history.

The OP27 provides excellent performance in low-noise, high-accuracy amplification of low-level signals. Applications include stable integrators, precision summing amplifiers, precision voltage-threshold detectors, comparators, and professional audio circuits such as tape-head and microphone preamplifiers.

The OP27 is a direct replacement for 725, OP06, OP07, and OP45 amplifiers; 741 types may be directly replaced by removing the 741's nulling potentiometer.

## ABSOLUTE MAXIMUM RATINGS[4]

Supply Voltage . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . ±22 V
Input Voltage[1] . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . ±22 V
Output Short-Circuit Duration . . . . . . . . . . . . . . . . Indefinite
Differential Input Voltage[2] . . . . . . . . . . . . . . . . . . . . . . ±0.7 V
Differential Input Current[2] . . . . . . . . . . . . . . . . . . . . ±25 mA
Storage Temperature Range . . . . . . . . . . . . –65°C to +150°C
Operating Temperature Range
  OP27A, OP27C (J, Z) . . . . . . . . . . . . . . . . –55°C to +125°C
  OP27E, OP27F (J, Z) . . . . . . . . . . . . . . . . . –25°C to +85°C
  OP27E, OP27F (P) . . . . . . . . . . . . . . . . . . . . . 0°C to 70°C
  OP27G (P, S, J, Z) . . . . . . . . . . . . . . . . . –40°C to +85°C
Lead Temperature Range (Soldering, 60 sec) . . . . . . . 300°C
Junction Temperature . . . . . . . . . . . . . . . . . –65°C to +150°C

| Package Type | $\theta_{JA}$[3] | $\theta_{JC}$ | Unit |
|---|---|---|---|
| TO 99 (J) | 150 | 18 | °C/W |
| 8-Lead Hermetic DIP (Z) | 148 | 16 | °C/W |
| 8-Lead Plastic DIP (P) | 103 | 43 | °C/W |
| 20-Contact LCC (RC) | 98 | 38 | °C/W |
| 8-Lead SO (S) | 158 | 43 | °C/W |

NOTES
[1]For supply voltages less than ±22 V, the absolute maximum input voltage is equal to the supply voltage.
[2]The OP27's inputs are protected by back-to-back diodes. Current limiting resistors are not used in order to achieve low noise. If differential input voltage exceeds ±0.7 V, the input current should be limited to 25 mA.
[3]$\theta_{JA}$ is specified for worst-case mounting conditions, i.e., $\theta_{JA}$ is specified for device in socket for TO, CERDIP, and P-DIP packages; $\theta_{JA}$ is specified for device soldered to printed circuit board for SO package.
[4]Absolute Maximum Ratings apply to both DICE and packaged parts, unless otherwise noted.

## ORDERING INFORMATION[1]

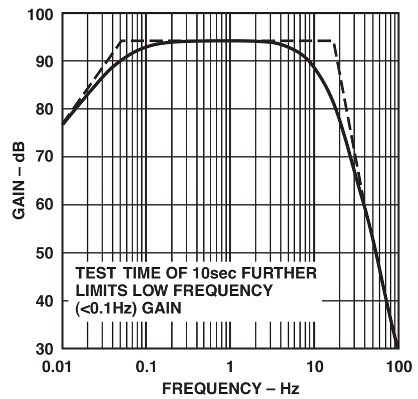
| $T_A$ = 25°C $V_{OS}$ Max (µV) | Package: TO-99 | Package: CERDIP 8-Lead | Package: Plastic 8-Lead | Operating Temperature Range |
|---|---|---|---|---|
| 25 | OP27AJ[2, 3] | OP27AZ[2] | | MIL |
| 25 | OP27EJ[2, 3] | OP27EZ | OP27EP | IND/COM |
| 60 | | | OP27FP[3] | IND/COM |
| 100 | | OP27CZ[3] | | MIL |
| 100 | OP27GJ | OP27GZ | OP27GP | XIND |
| 100 | | | OP27GS[4] | XIND |

NOTES
[1]Burn-in is available on commercial and industrial temperature range parts in CERDIP, plastic DIP, and TO-can packages.
[2]For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.
[3]Not for new design; obsolete April 2002.
[4]For availability and burn-in information on SO and PLCC packages, contact your local sales office.

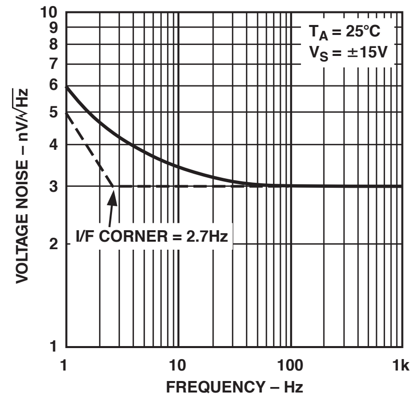
## CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the OP27 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high-energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

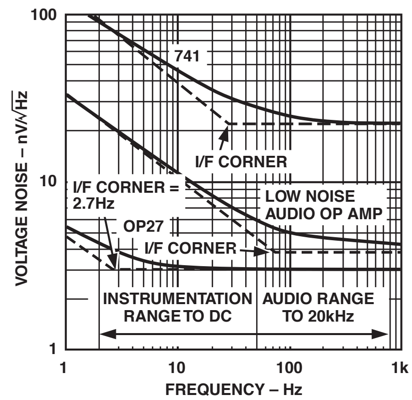
# OP27–Typical Performance Characteristics



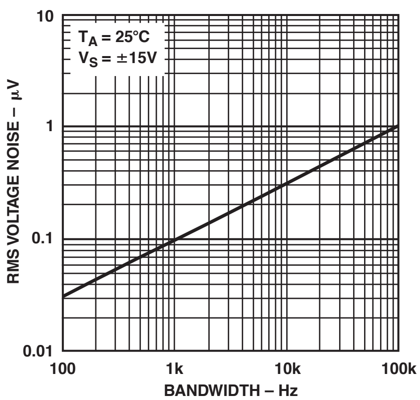

*TPC 1. 0.1 Hz to 10 $Hz_{p-p}$ Noise Tester Frequency Response*



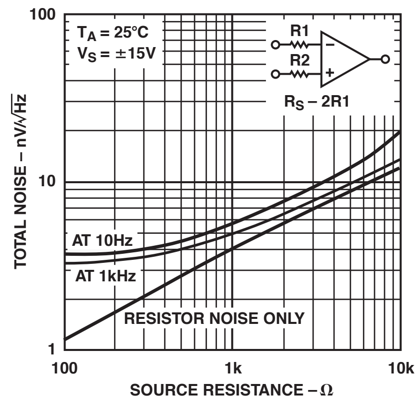

*TPC 2. Voltage Noise Density vs. Frequency*



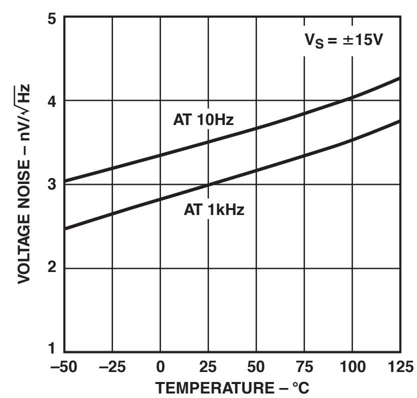

*TPC 3. A Comparison of Op Amp Voltage Noise Spectra*



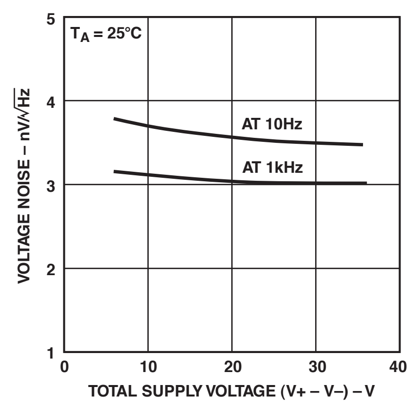

*TPC 4. Input Wideband Voltage Noise vs. Bandwidth (0.1 Hz to Frequency Indicated)*



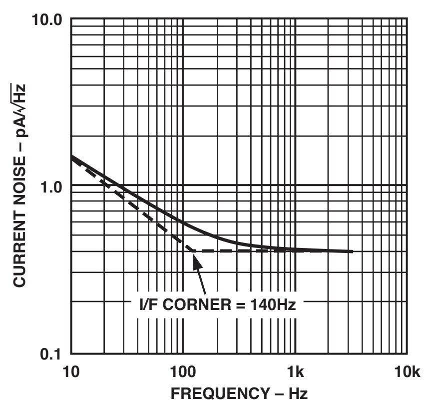

*TPC 5. Total Noise vs. Sourced Resistance*



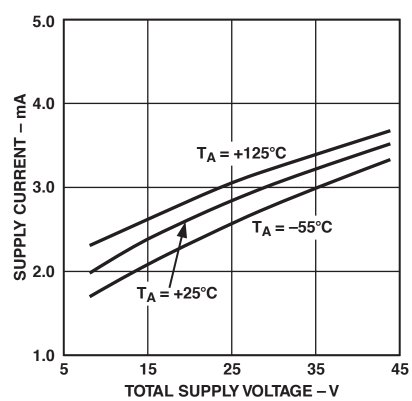

*TPC 6. Voltage Noise Density vs. Temperature*




*TPC 7. Voltage Noise Density vs. Supply Voltage*




*TPC 8. Current Noise Density vs. Frequency*




*TPC 9. Supply Current vs. Supply Voltage*

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