ALPHA SEMICONDUCTOR
Excellence in Analog Power Products

# AS OP-27

## Ultra Low Noise Precision Operational Amplifier

### FEATURES

- Low offset Vos. ..... 10μV Max.
- Low drift vs. temperature..... 0.2μV/°C
- High CMMR.....126dB @ $V_{CM}$ of ±11V
- Low noise..... 3nV/√Hz @ 1kHz
  .....80 nVpp(0.1Hz to 10Hz)
- High open loop gain .....1.8 Million
- Slew rate .....2.8V/μS
- Gain bandwidth.....8 MHz

### APPLICATIONS

- Precision Instrumentation
- Data Acquisition
- Test Equipment
- Professional Audio Equipment
- Transducer Amplifier

### PRODUCT DESCRIPTION

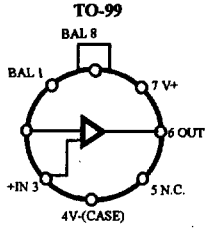
The ALPHA Semiconductor AS OP-27 is a precision operational amplifier with low noise combined with low offset and high speed operation. OP-27 is ideal for precision instrumentation application through offering low offset down to 25 μV and drift of 0.6 μV/°C maximum. A gain bandwidth product of 8MHz and a 2.8 V/μSec slew rate provides excellent dynamic accuracy in high-speed data-acquisition. Input bias current of ±10nA is achieved with the use of a bias-current-cancellation circuit. Over the military temperature range, this circuitry typically holds $I_B$ and $I_{OS}$ to ±20nA and 15nA respectively.

The output stage has good load driving capability. A guaranteed swing of ±10V into 600Ωand low output distortion make the OP-27 an excellent choice for professional audio applications. PSRR and CMRR exceed 120dB. These characteristics coupled with long-term drift of 0.2μV/month, allow the circuit designer to achieve performance levels previously attained only by discrete designs.

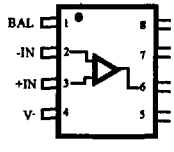
### ORDERING INFORMATION

| TA=25°C $V_{os}$ Max (mv) | TO-99 8-PIN | PLASTIC DIP 8-PIN | PLASTIC SOIC 8-PIN | OPER. TEMP. RANGE |
|---|---|---|---|---|
| 25 | OP-27AJ | | | MIL. |
| 25 | OP-27EJ | OP-27EP | OP-27ES | IND/COM |
| 60 | OP-27BJ | | | MIL. |
| 60 | OP-27FJ | OP-27FP | OP-27FS | IND/COM |
| 100 | OP-27CJ | | | MIL. |
| 100 | OP-27GJ | OP-27GP | OP-27GS | IND/COM |

### PIN CONNECTIONS



Bottom View



Top View

## ABSOLUTE MAXIMUM RATINGS

Input Voltage ..... ±22V
Internal Power Dissipation ( Note 1 ) ..... 500mW
Input Voltage (Note 3) ..... ±22V
Output Short-Circuit Duration ..... Indefinite
Differential Input Voltage (Note 2) ..... ±0.7V
Differential Input Current (Note 2) ..... ±25mA
Storage Temperature Range ..... -65 to +150°
Operating Temperature Range
OP-27A, OP-27B, OP-27C (J) ..... -55 to +125°C
OP-27E, OP-27F, OP-27G (J) ..... -25 to +85°C
OP-27E, OP-27F, OP-27G(P,S) ..... 0 to +70°C
Dice Junction Temperature(Tj) ..... -65 to +150°C
Lead Temperature (Soldering, 60 Sec.) ..... 300°C

**NOTES:**
1. See Table for maximum ambient temperature rating and derating factor.
2. The OP-27'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 ±0.7V the input current should be limited to 25mA.
3. For supply voltage less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

| PACKAGE TYPE | MAXIMUM AMBIENT TEMPERATURE FOR RATING | DERATE ABOVE MAXIMUM AMBIENT TEMPERATURE |
|---|---|---|
| TO-99(J) | 80°C | 7.1 mW/°C |
| 8-Pin Plastic SOIC (S) | 62°C | 5.6mW/°C |
| 9-Pin Plastic DIP (P) | 62°C | 5.7mW/°C |

## ELECTRICAL CHARACTERISTICS at $V_s$=±15V, Ta=25°C, unless otherwise noted.

| PARAMETER | SYMBOL | CONDITIONS | OP-27A/E | | | OP-27B/F | | | OP-27C/G | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Input Offset Voltage | $V_{os}$ | (Note 1) | | 10 | 25 | | 20 | 60 | | 30 | 100 | mV |
| Long Term Input offset Vos Stability | $V_{OS}$/Time | (Note 2,3) | | 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 | $e_{npp}$ | 0.1Hz to10Hz(Note 3,5) | | 0.08 | 0.18 | | 0.08 | 0.18 | | 0.09 | 0.25 | µV$_{p-p}$ |
| Input Noise Voltage Density | $e_n$ | $f_o$=10Hz(Note 3) | | 3.5 | 5.5 | | 3.5 | 5.5 | | 3.8 | 8.0 | nV/√Hz |
| Input Noise Voltage Density | $e_n$ | $f_o$=30Hz (Note 3) | | 3.1 | 4.5 | | 3.1 | 4.5 | | 3.3 | 5.6 | nV/√Hz |
| Input Noise Voltage Density | $e_n$ | $f_o$=1000Hz(Note 3) | | 3.0 | 3.8 | | 3.0 | 3.8 | | 2.0 | 4.5 | nV/√Hz |
| Input Noise Current Density | $i_n$ | $f_o$=10Hz(Note 3,6) | | 1.7 | 4.0 | | 1.7 | 4.0 | | 1.7 | | pV/√Hz |
| Input Noise Current Density | $i_n$ | $f_o$=30Hz(Note 3,6) | | 1.0 | 2.3 | | 1.0 | 2.3 | | 1.0 | | pV/√Hz |
| Input Noise Current Density | $i_n$ | $f_o$=1000Hz(Note 3,6) | | 0.4 | 0.6 | | 0.4 | 0.6 | | 0.4 | 0.6 | pV/√Hz |
| Input Resistance-Differential-Mode | $R_{in}$ | (Note 3) | 1.3 | 6 | | 0.94 | 5 | | 0.7 | 4 | | MΩ |
| Input Resistance-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 | $V_{CM}$=±11.0 | 114 | 126 | | 106 | 123 | | 100 | 120 | | dB |
| Power Supply Rejection Ratio | PSRR | $V_S$=±4 to ±18 | | 1 | 10 | | 1 | 10 | | 2 | 20 | µV/V |
| Large Signal Voltage Gain | AV$_O$ | $R_l$ ≥2kΩ $V_o$=±10V | 1000 | 1800 | | 1000 | 1800 | | 700 | 1500 | | V/mV |
| Large Signal Voltage Gain | AV$_O$ | $R_l$ ≥600kΩ$V_o$=±10V | 800 | 1500 | | 800 | 1500 | | 600 | 1500 | | V/mV |
| Output Voltage Swing | $V_o$ | Rl ≥ 2kΩ | ±12.0 | ±13.8 | | ±12.0 | ±13.8 | | ±11.5 | ±13.5 | | V |
| Output Voltage Swing | $V_o$ | Rl ≥600kΩ | ±10.0 | ±11.5 | | ±10.0 | ±11.5 | | ±10.0 | ±11.5 | | V |
| Slew Rate | SR | Rl ≥2kΩ (Note 4) | 1.7 | 2.8 | | 1.7 | 2.8 | | 1.7 | 2.8 | | V/µs |
| Gain Bandwidth Prod. | GBW | (Note 4) | 5.0 | 8.0 | | 5.0 | 8.0 | | 5.0 | 8.0 | | MHz |
| Open Loop Output Resistance | $R_o$ | $V_o$=0, Io=0 | | 70 | | | 70 | | | 70 | | Ω |
| Power Consumption | $P_d$ | $V_o$ | | 90 | 140 | | 90 | 140 | | 100 | 170 | mW |
| Offset Adjustment Range | | $R_p$=21kΩ | | ±4.0 | | | ±4.0 | | | ±4.0 | | mV |

1. Input Offset voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power. A F grades guaranteed fully warmed up.
2. Long term input offset voltage stability refers to the average trend line of Vos vs. Time over extended periods after the first 30 days of operation, changes in Vos during the first 30 days are typically 2.5µV.
3. Sample tested
4. Guaranteed by Design
5. See test circuit and frequency response curve for 0.1 Hz tester
6. See test circuit for current noise measurement
7. Guaranteed by input bias current.

## ELECTRICAL CHARACTERISTICS at $V_s$=±15V, Ta=25°C, unless otherwise noted.

| PARAMETER | SYMBOL | CONDITIONS | OP-27N/NT Typical | OP-27G/GT Typical | OP-27GR Typical | UNITS |
|---|---|---|---|---|---|---|
| Average Input Offset Voltage Drift | $TCV_{OS}$ | Nulled or Unnulled | 0.2 | 0.3 | 0.4 | μV/°C |
| Average Input Offset Voltage Drift | $TCV_{OS}$ | Rp =8kW to 20kW | 0.2 | 0.3 | 0.4180 | μV/°C |
| Average Input Offset Current Drift | $TCI_{OS}$ | | 80 | 130 | 200 | pA/°C |
| Average Input Offset Current Drift | $TCI_B$ | | 100 | 160 | 3.8 | pA/°C |
| Input Noise Voltage Density | $e_n$ | $f_o$=10Hz | 3.5 | 3.5 | 3.3 | nV√Hz |
| Input Noise Voltage Density | $e_n$ | $f_o$=30Hz | 3.1 | 3.1 | 0.4 | nV√Hz |
| Input Noise Voltage Density | $e_n$ | $f_o$=1000Hz | 3.0 | 3.0 | 3.2 | nV√Hz |
| Input Noise Current Density | $i_n$ | $f_o$=10Hz | 1.7 | 1.7 | 1.0 | pV√Hz |
| Input Noise Current Density | $i_n$ | $f_o$=30Hz | 1.0 | 1.0 | 0.4 | pV√Hz |
| Input Noise Current Density | $i_n$ | $f_o$=1000Hz | 0.4 | 0.4 | 0.09 | pV√Hz |
| Input Noise Voltage | $e_{np}$ | 0.1Hz to10Hz | 0.08 | 0.08 | 2.8 | μVpp |
| Slew Rate | SR | R≥2kΩ | 2.8 | 2.8 | 8 | V/μs |
| Gain Bandwidth Product | GBW | | 8 | 8 | | MHz |

Note:
1. Input offset voltage measurements are performed by automated test equipment approximately 0.5 second after application of power

## ELECTRICAL CHARACTERISTICS at $V_s$=±15V, -55°C≤Ta≤+125°C, unless otherwise noted.

| | | | OP-27A | | | OP-27B | | | OP-27C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | SYMBOL | CONDITIONS | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | UNITS |
| Input Offset Voltage | $V_{os}$ | (Note 1) | | 30 | 60 | | 50 | 200 | | 70 | 300 | μV |
| Average Input Offset Drift | $TCV_{os}$ | (Note 2) | | 0.2 | 0.6 | | 0.3 | 1.3 | | 0.4 | 1.8 | μV/°C |
| Average Input Offset Drift | $TCV_{os}$ | (Note 3) | | 0.2 | 0.6 | | 0.3 | 1.3 | | 0.4 | 1.8 | μV/°C |
| Input Offset Current | $I_{os}$ | | | 15 | 50 | | 22 | 85 | | 30 | 135 | nA |
| Input Bias Current | $I_{os}$ | | | ±20 | ±60 | | ±28 | ±95 | | ±35 | ±150 | nA |
| Input Voltage Range | IVR | | ±10.3 | ±11.5 | | ±10.3 | ±11.5 | | ±10 | ±11.5 | | V |
| Common Mode Rejection Ratio | CMRR | VCM=±10V | 108 | 122 | | 100 | 119 | | 94 | 116 | | dB |
| Power Supply Rejection Ratio | PSSR | $V_s$ ±4.5V to ±18V | | 2 | 16 | | 2 | 20 | | 4 | 51 | μV/V |
| Large Signal Voltage Gain | $A_{vo}$ | Rl ≥2kΩ,$V_o$=±10V | 600 | 1200 | | 500 | 1000 | | 300 | 800 | | V/mV |
| Output Voltage Swing | $V_o$ | Rl ≥2kΩ | ±11.5 | ±13.5 | | ±11.0 | ±13.2 | | ±10 | ±13.0 | | V |

## ELECTRICAL CHARACTERISTICS at $V_s$=±15V, -25°C≤Ta≤+85°C, for OP-27J and OP-27Z, 0°C≤Ta≤+70°C for OP-27P and OP-27S unless otherwise noted.

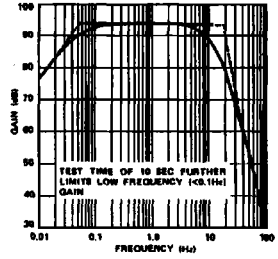
| | | | OP-27E | | | OP-27F | | | OP-27G | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{os}$ | (Note 1) | | 20 | 50 | | 40 | 140 | | 55 | 220 | µV |
| Average Input Offset Drift | $TCV_{os}$ | (Note 2) | | 0.2 | 0.6 | | 0.3 | 1.3 | | 0.4 | 1.8 | µV/°C |
| Average Input Offset Drift | $TCV_{os}$ | (Note 3) | | 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 | $I_{os}$ | | | ±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 | VCM=±10V | 110 | 124 | | 102 | 121 | | 96 | 118 | | dB |
| Power Supply Rejection Ratio | PSSR | $V_s$ ±4.5V to ±18V | | 2 | 15 | | 2 | 16 | | 2 | 32 | µV/V |
| Large Signal Voltage Gain | $A_{VO}$ | Rl≥2kΩ, $V_o$=±10V | 750 | 1500 | | 700 | 1300 | | 450 | 1000 | | V/mV |
| Output Voltage Swing | $V_o$ | Rl ≥2kΩ | ±11.7 | ±13.6 | | ±11.4 | ±13.5 | | ±11.0 | ±13.3 | | V |

**Notes:**

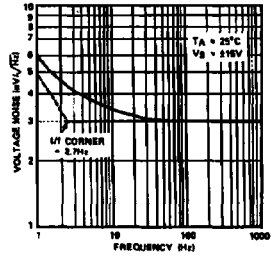
1. Input offset voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power A F Grades guaranteed fully warmed up.
2. The TCVos performance is within the specifications unnulled or when nulled with Rp=8kΩ. TCVos is 100% tested for A/E grades. Sample tested for B C F G grades
3. Guaranteed by Design.

## TYPICAL CHARACTERISTICS

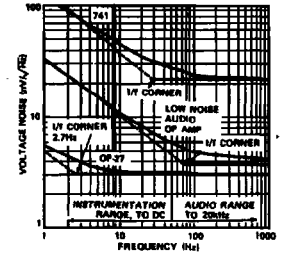
**0.1Hz TO 10Hz$_{p-p}$ NOISE TESTER FREQUENCY RESPONSE**



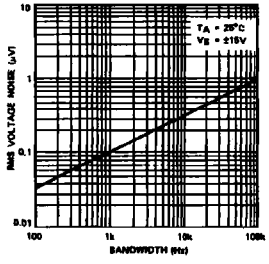

**VOLTAGE NOISE DENSITY vs FREQUENCY**



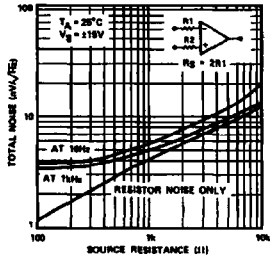

**A COMPARISON OF OP AMP VOLTAGE NOISE SPECTRA**



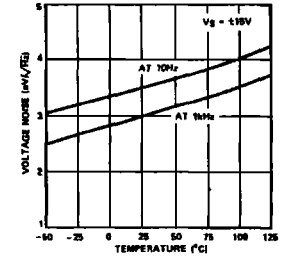

**INPUT WIDEBAND VOLTAGE NOISE vs BANDWIDTH (0.1Hz TO FREQUENCY INDICATED)**




**TOTAL NOISE vs SOURCE RESISTANCE**

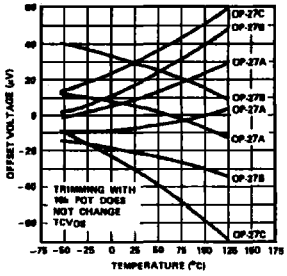



**VOLTAGE NOISE DENSITY vs TEMPERATURE**

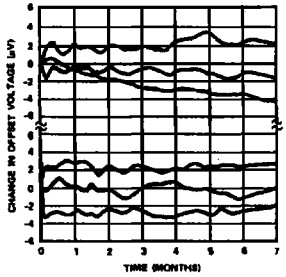


## TYPICAL CHARACTERISTICS (continued)

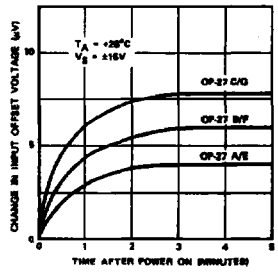
**OFFSET VOLTAGE DRIFT OF EIGHT REPRESENTATIVE UNITS vs TEMPERATURE**



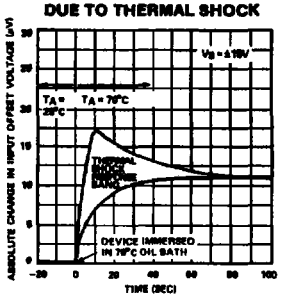

**LONG-TERM OFFSET VOLTAGE DRIFT OF SIX REPRESENTATIVE UNITS**



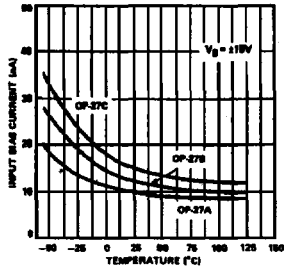

**WARM-UP OFFSET VOLTAGE DRIFT**



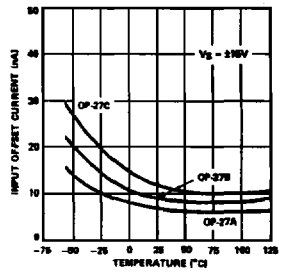

**OFFSET VOLTAGE CHANGE DUE TO THERMAL SHOCK**



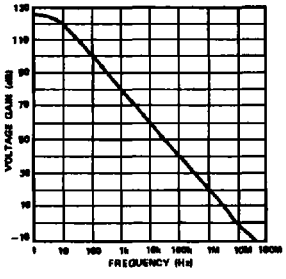

**INPUT BIAS CURRENT vs TEMPERATURE**



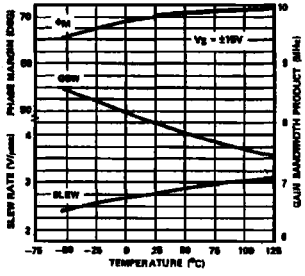

**INPUT OFFSET CURRENT vs TEMPERATURE**



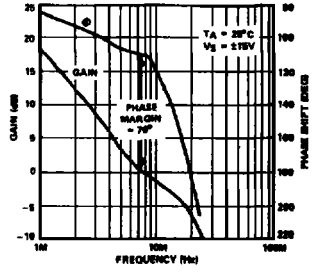

**OPEN-LOOP GAIN vs FREQUENCY**




**SLEW RATE, GAIN-BANDWIDTH PRODUCT, PHASE MARGIN vs TEMPERATURE**

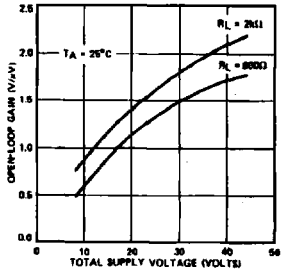



**GAIN, PHASE SHIFT vs FREQUENCY**

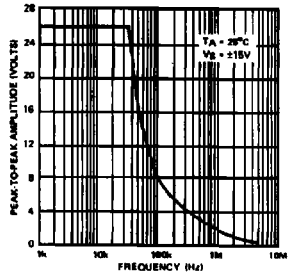


## TYPICAL CHARACTERISTICS (continued)

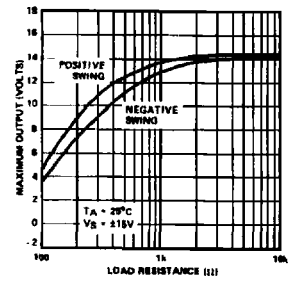
**OPEN-LOOP VOLTAGE GAIN vs SUPPLY VOLTAGE**



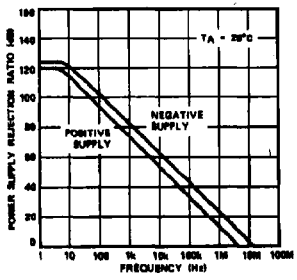

**MAXIMUM OUTPUT SWING vs FREQUENCY**



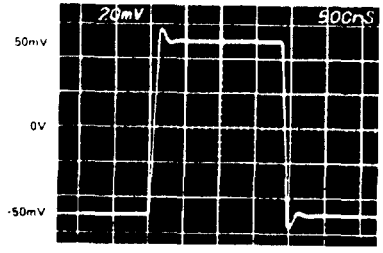

**MAXIMUM OUTPUT VOLTAGE vs LOAD RESISTANCE**




**PSRR vs FREQUENCY**

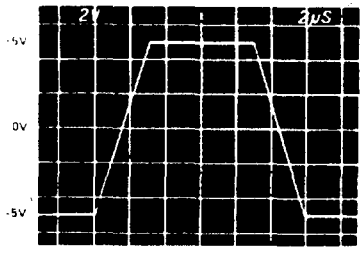



**SMALL-SIGNAL TRANSIENT RESPONSE**



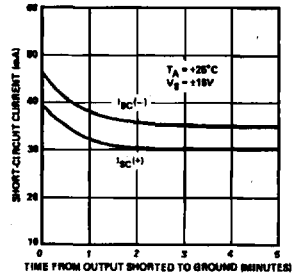

$A_{VCL}$ = +1, $C_L$ = 15pF
$V_S$ = ±15V
$T_A$ = 25°C

**LARGE-SIGNAL TRANSIENT RESPONSE**

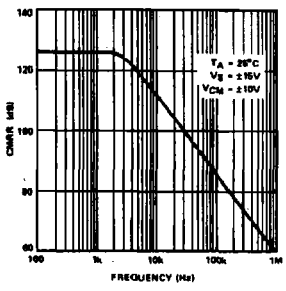



$A_{VCL}$ = +1
$V_S$ = ±15V
$T_A$ = 25°C

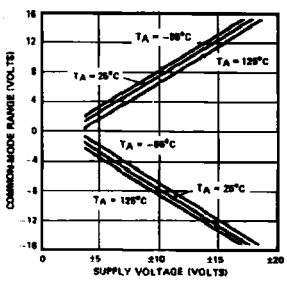
**SHORT-CIRCUIT CURRENT vs TIME**




**CMRR vs FREQUENCY**

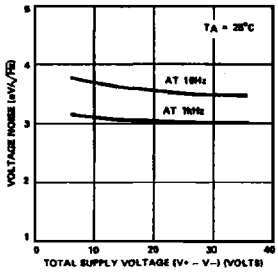



**COMMON-MODE INPUT RANGE vs SUPPLY VOLTAGE**

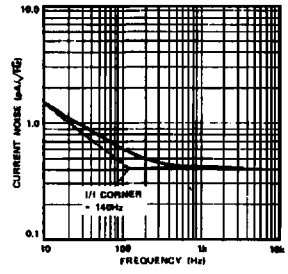


## TYPICAL CHARACTERISTICS (continued)

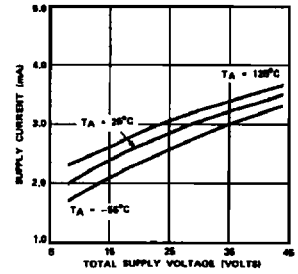
**VOLTAGE NOISE DENSITY vs SUPPLY VOLTAGE**




**CURRENT NOISE DENSITY vs FREQUENCY**




**SUPPLY CURRENT vs SUPPLY VOLTAGE**




## APPLICATION HINTS

OP-27 series devices can be fitted directly into 725 and OP-06, OP-07 & OP-05 Series sockets with or without removal of external compensation components. Additionally, the OP-27 may be fitted to unnulled 741 series. However, if conventional 741 nulling circuitry is in use, it should be modified or removed to enable proper OP-27 operation. The OP-27 provides stable operation with load capacitance of up to 500pF and ±10V swings; larger capacitances should be decoupled with a 50Ω resistor

Offset stability can be degraded by stray thermoelectric voltages arising from dissimilar metals at the contacts to the input terminals. Best operation will be obtained when both input contacts are maintained at the same temperature, preferably close to the temperature of the device's package

## OP-27 OFFSET VOLTAGE ADJUSTMENT

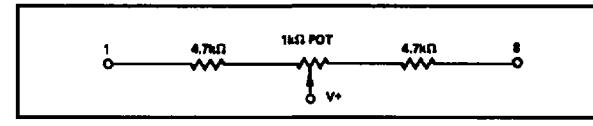
The OP-27 offset voltage is trimmed at wafer level. However if further adjustment of $V_{OS}$ is necessary, a 10kΩ trim potentiometer may be used. Other potentiometer values from 1kΩ to 1MΩ can be used with a slight degradation. Trimming to a value other than zero creates a drift of approx. $V_{OS}/300$ µV / °C.

## OP-27 UNITY-GAIN BUFFER APPLICATION

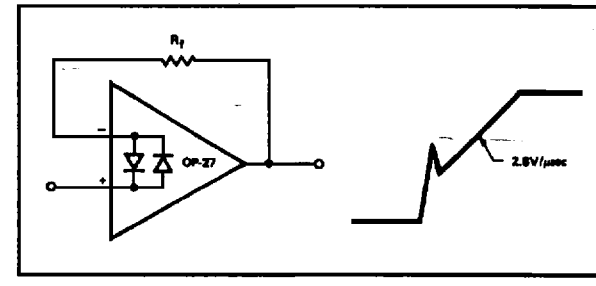
When $R_f \leq 100\ \Omega$ and the input is driven with a fast, large signal pulse (>1V), the output waveform will look like the following diagram:

## OP-27 COMPENSATION

The OP-27 is internally compensated for unity-gain. However, it may still require a small value capacitor in parallel with the feedback resistor. The capacitor can compensate for the pole generated by $R_f$ and input capacitance and eliminate oscillation.




PULSED OPERATION



## INPUT PROTECTION OF OP-27

For input protection of the OP-27, back to back diodes can be used. Over a few hundred mV differential input signals will make current flow and without external current limiting resistors at the input, it will be destroyed.

The amplifier can be damaged by any static discharge as well as high current input. The OP-27 can still be functional but for any precision amplifier such as OP-27 the input offset, drift, and noise can be permanently damaged.

## APPLICATION HINTS