

0.5MHz, Low Supply Voltage, Low Input Current BiMOS Operational Amplifiers

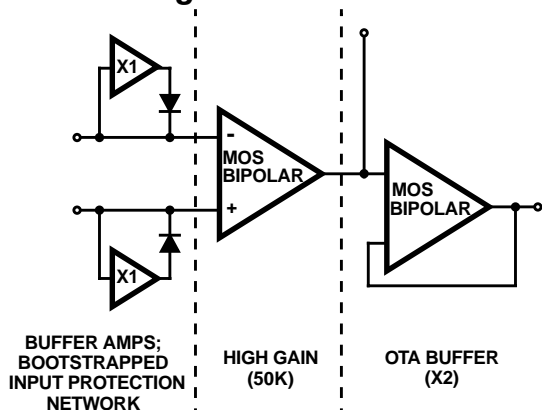
The CA5420A is an integrated circuit operational amplifier that combines PMOS transistors and bipolar transistors on a single monolithic chip. It is designed and guaranteed to operate in microprocessor logic systems that use $V+ = 5V$, $V- = GND$, since it can operate down to $\pm 1V$ supplies. It will also be suitable for 3.3V logic systems.

The CA5420A BiMOS operational amplifier features gate-protected PMOS transistors in the input circuit to provide very high input impedance, very low input currents (less than 1pA). The internal bootstrapping network features a unique guardbanding technique for reducing the doubling of leakage current for every $10^{\circ}C$ increase in temperature. The CA5420A operates at total supply voltages from 2V to 20V either single or dual supply. This operational amplifier is internally phase compensated to achieve stable operation in the unity gain follower configuration. Additionally, it has access terminals for a supplementary external capacitor if additional frequency roll-off is desired. Terminals are also provided for use in applications requiring input offset voltage nulling. The use of PMOS in the input stage results in common-mode input voltage capability down to 0.45V below the negative supply terminal, an important attribute for single supply application. The output stage uses a feedback OTA type amplifier that can swing essentially from rail-to-rail. The output driving current of 1.0mA (Min) is provided by using nonlinear current mirrors.

This device has guaranteed specifications for 5V operation over the full military temperature range of $-55^{\circ}C$ to $125^{\circ}C$.

The CA5420A has the same 8 lead pinout used for the industry standard 741.

Functional Diagram



Features

- CA5420A at 5V Supply Voltage with Full Military Temperature Range Guaranteed Specifications
- CA5420A Guaranteed to Operate from $\pm 1V$ to $\pm 10V$ Supplies
- 2V Supply at $300\mu A$ Supply Current
- 1pA (Typ) Input Current (Essentially Constant to $85^{\circ}C$)
- Rail-to-Rail Output Swing (Drive $\pm 2mA$ Into $1k\Omega$ Load)
- Pin Compatible with 741 Op Amp

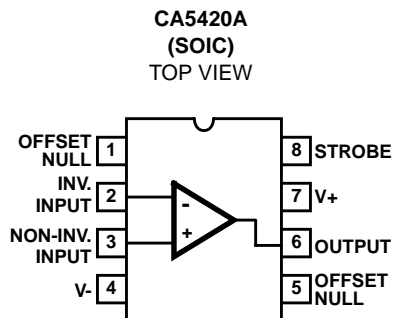
Applications

- pH Probe Amplifiers
- Picoammeters
- Electrometer (High Z) Instruments
- Portable Equipment
- Inaccessible Field Equipment
- Battery Dependent Equipment (Medical and Military)
- 5V Logic Systems
- Microprocessor Interface

Ordering Information

| PART NUMBER (BRAND) | TEMP. RANGE ($^{\circ}C$) | PACKAGE | PKG. NO. |
|---------------------|-----------------------------|-----------|----------|
| CA5420AM (5420A) | -55 to 125 | 8 Ld SOIC | M8.15 |

Pinout



NOTE: Pin is connected to Case.

CA5420A

Absolute Maximum Ratings

| | |
|--|-------------------------|
| Supply Voltage (Between V+ and V- Terminals) | 22V |
| Differential Input Voltage | 15V |
| Input Voltage | (V+ + 8V) to (V- -0.5V) |
| Input Current | 1mA |
| Output Short Circuit Duration (Note 1) | Indefinite |

Thermal Information

| | | |
|--|-------------------------------|----------------------|
| Thermal Resistance (Typical, Note 2) | θ_{JA} (°C/W) | θ_{JC} (°C/W) |
| SOIC Package | 157 | N/A |
| Maximum Junction Temperature (Plastic Package) | 150°C | |
| Maximum Storage Temperature Range (All Types) | -65°C to 150°C | |
| Maximum Lead Temperature (Soldering 10s) | 300°C (SOIC - Lead Tips Only) | |

Operating Conditions

| | |
|-------------------|----------------|
| Temperature Range | -55°C to 125°C |
|-------------------|----------------|

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

- Short circuit may be applied to ground or to either supply.
- θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications

Typical Values Intended Only for Design Guidance. V+ = +5V; V- = GND, T_A = 25°C

| PARAMETER | | SYMBOL | TEST CONDITIONS | | CA5420A | UNITS |
|--|-----------|------------------|--|-------------------------|---------|--------|
| Input Resistance | | R _I | | | 150 | TΩ |
| Input Capacitance | | C _I | | | 4.9 | pF |
| Output Resistance | | R _O | | | 300 | Ω |
| Equivalent Input Noise Voltage | | e _N | f = 1kHz | R _S = 100Ω | 62 | nV/√Hz |
| | | | f = 10kHz | | 38 | nV/√Hz |
| Short-Circuit Current To Opposite Supply | Source | I _{OM+} | | | 2.6 | mA |
| | Sink | I _{OM-} | | | 2.4 | mA |
| Gain Bandwidth Product | | f _T | | | 0.5 | MHz |
| Slew Rate | | SR | | | 0.5 | V/μs |
| Transient Response | Rise Time | t _r | R _L = 2kΩ, C _L = 100pF | | 0.7 | μs |
| | Overshoot | OS | | | 15 | % |
| Current from Terminal 8 To V- | | I _{g+} | | | 20 | μA |
| Current from Terminal 8 To V+ | | I _{g-} | | | 2 | mA |
| Settling Time | | 0.01% | A _V = 1 | 2V _{P-P} Input | 8 | μs |
| | | 0.10% | A _V = 1 | 2V _{P-P} Input | 4.5 | μs |

Electrical Specifications

T_A = 25°C, V+ = 5V, V- = 0, Unless Otherwise Specified

| PARAMETER | SYMBOL | TEST CONDITIONS | CA5420A | | | UNITS |
|---------------------------------|-------------------|--|---------|------|-----|-------|
| | | | MIN | TYP | MAX | |
| Input Offset Voltage | V _{IO} | V _O = 2.5V | - | 1 | 5 | mV |
| Input Offset Current | I _{IO} | V _O = 2.5V | - | 0.02 | 0.5 | pA |
| Input Current | I _I | V _O = 2.5V | - | 0.02 | 1 | pA |
| Common Mode Rejection Ratio | CMRR | V _{CM} = 0 to 3.7V, V _O = 2.5V | 75 | 83 | - | dB |
| Common Mode Input Voltage Range | V _{ICR+} | V _O = 2.5V | 3.7 | 4 | - | V |
| | V _{ICR-} | | - | -0.3 | 0 | V |
| Power Supply Rejection Ratio | PSRR | ΔV+ = 1V; ΔV- = 1V | 75 | 83 | - | dB |
| Large Signal Voltage Gain | A _{OL} | R _L = ∞ | 85 | 87 | - | dB |
| | | R _L = 10kΩ | 85 | 87 | - | dB |
| | | R _L = 2kΩ | 80 | 85 | - | dB |

CA5420A

Electrical Specifications $T_A = 25^\circ\text{C}$, $V_+ = 5\text{V}$, $V_- = 0$, Unless Otherwise Specified (Continued)

| PARAMETER | SYMBOL | TEST CONDITIONS | CA5420A | | | UNITS |
|----------------|---------------------|--------------------------|---------|------|------|---------------|
| | | | MIN | TYP | MAX | |
| Source Current | I_{SOURCE} | $V_O = 0\text{V}$ | 1.2 | 2.7 | - | mA |
| Sink Current | I_{SINK} | $V_O = 5\text{V}$ | 1.2 | 2.1 | - | mA |
| Output Voltage | $V_{\text{OM}+}$ | $R_L = \infty$ | 4.9 | 4.94 | - | V |
| | $V_{\text{OM}-}$ | | - | 0.13 | 0.15 | V |
| | $V_{\text{OM}+}$ | $R_L = 10\text{k}\Omega$ | 4.7 | 4.9 | - | V |
| | $V_{\text{OM}-}$ | | - | 0.12 | 0.15 | V |
| | $V_{\text{OM}+}$ | $R_L = 2\text{k}\Omega$ | 3.5 | 4.6 | - | V |
| | $V_{\text{OM}-}$ | | - | 0.1 | 0.15 | V |
| Supply Current | I_{SUPPLY} | $V_O = 0\text{V}$ | - | 400 | 500 | μA |
| | | $V_O = 2.5\text{V}$ | - | 430 | 550 | μA |

Electrical Specifications $T_A = -55^\circ\text{C}$ to 125°C , $V_+ = 5\text{V}$, $V_- = 0$, Unless Otherwise Specified

| PARAMETER | SYMBOL | TEST CONDITIONS | CA5420A | | | UNITS |
|--|---------------------|---|---------|------|-----|---------------|
| | | | MIN | TYP | MAX | |
| Input Offset Voltage | V_{IO} | $V_O = 2.5\text{V}$ | - | 2 | 10 | mV |
| Input Offset Current Up to $T_A = 85^\circ\text{C}$ | I_{IO} | $V_O = 2.5\text{V}$ | - | 1.5 | 3 | nA |
| | | | - | 2 | 10 | pA |
| Input Current Up to $T_A = 85^\circ\text{C}$ | $ I_{\text{I}} $ | $V_O = 2.5\text{V}$ | - | 2 | 5 | nA |
| | | | - | 10 | 15 | pA |
| Common Mode Rejection Ratio | CMRR | $V_{\text{CM}} = 0$ to 3.7V , $V_O = 2.5\text{V}$ | 70 | 80 | - | dB |
| Common Mode Input Voltage Range | $V_{\text{ICR}+}$ | $V_O = 2.5\text{V}$ | 3.7 | 4 | - | V |
| | $V_{\text{ICR}-}$ | | - | -0.3 | 0 | V |
| Power Supply Rejection Ratio | PSRR | $\Delta V_+ = 1\text{V}$; $\Delta V_- = 1\text{V}$ | 70 | 83 | - | dB |
| Large Signal Voltage Gain | A_{OL} | $R_L = \infty$ | 85 | 87 | - | dB |
| | | $R_L = 10\text{k}\Omega$ | 80 | 87 | - | dB |
| | | $R_L = 2\text{k}\Omega$ | 75 | 80 | - | dB |
| Source Current | I_{SOURCE} | $V_O = 0\text{V}$ | 1 | 2.7 | - | mA |
| Sink Current | I_{SINK} | $V_O = 5\text{V}$ | 1 | 2.1 | - | mA |
| Output Voltage | $V_{\text{OM}+}$ | $R_L = \infty$ | 4.8 | 4.9 | - | V |
| | $V_{\text{OM}-}$ | | - | 0.16 | 0.2 | V |
| | $V_{\text{OM}+}$ | $R_L = 10\text{k}\Omega$ | 4.7 | 4.9 | - | V |
| | $V_{\text{OM}-}$ | | - | 0.15 | 0.2 | V |
| | $V_{\text{OM}+}$ | $R_L = 2\text{k}\Omega$ | 3 | 4 | - | V |
| | $V_{\text{OM}-}$ | | - | 0.14 | 0.2 | V |
| Supply Current | I_{SUPPLY} | $V_O = 0\text{V}$ | - | 430 | 550 | μA |
| | | $V_O = 2.5\text{V}$ | - | 480 | 600 | μA |

CA5420A

Electrical Specifications For Equipment Design at $V_{SUPPLY} = \pm 1V$, $T_A = 25^\circ C$, Unless Otherwise Specified

| PARAMETER | SYMBOL | TEST CONDITIONS | CA5420A | | | UNITS |
|----------------------------------|--------------------------|-------------------|---------|-------|------------|------------------|
| | | | MIN | TYP | MAX | |
| Input Offset Voltage | V_{IO} | | - | 2 | 5 | mV |
| Input Offset Current | $ I_{IO} $ | | - | 0.01 | 4 (Note 3) | pA |
| Input Current | $ I_I $ | | - | 0.02 | 5 (Note 3) | pA |
| Large Signal Voltage Gain | A_{OL} | $R_L = 10k\Omega$ | 20 | 100 | - | kV/V |
| | | | 86 | 100 | - | dB |
| Common Mode Rejection Ratio | CMRR | | - | 560 | 1000 | $\mu V/V$ |
| | | | 60 | 65 | - | dB |
| Common Mode Input Voltage Range | V_{ICR+} | | 0.2 | 0.5 | - | V |
| | V_{ICR-} | | -1 | -1.3 | - | V |
| Power Supply Rejection Ratio | PSRR | | - | 32 | 320 | $\mu V/V$ |
| | | | 70 | 90 | - | dB |
| Maximum Output Voltage | V_{OM+} | $R_L = \infty$ | 0.9 | 0.95 | - | V |
| | V_{OM-} | | -0.85 | -0.91 | - | V |
| Supply Current | I_{SUPPLY} | | - | 350 | 650 | μA |
| Device Dissipation | P_D | | - | 0.7 | 1.1 | mW |
| Input Offset Voltage Temp. Drift | $\Delta V_{IO}/\Delta T$ | | - | 4 | - | $\mu V/^\circ C$ |

Electrical Specifications For Equipment Design at $V_{SUPPLY} = \pm 10V$, $T_A = 25^\circ C$, Unless Otherwise Specified

| PARAMETER | SYMBOL | TEST CONDITIONS | CA5420A | | | UNITS |
|--|--------------------------|-------------------|---------|-------|------------|------------------|
| | | | MIN | TYP | MAX | |
| Input Offset Voltage | V_{IO} | | - | 2 | 5 | mV |
| Input Offset Current | $ I_{IO} $ | | - | 0.03 | 4 (Note 3) | pA |
| Input Current | $ I_I $ | | - | 0.05 | 5 (Note 3) | pA |
| Large Signal Voltage Gain | A_{OL} | $R_L = 10k\Omega$ | 20 | 100 | - | kV/V |
| | | | 86 | 100 | - | dB |
| Common Mode Rejection Ratio | CMRR | | - | 100 | 320 | $\mu V/V$ |
| | | | 70 | 80 | - | dB |
| Common Mode Input Voltage Range | V_{ICR+} | | 9 | 9.3 | - | V |
| | V_{ICR-} | | -10 | -10.3 | - | V |
| Power Supply Rejection Ratio | PSRR | | - | 32 | 320 | $\mu V/V$ |
| | | | 70 | 90 | - | dB |
| Maximum Output Voltage | V_{OM+} | $R_L = \infty$ | 9.7 | 9.9 | - | V |
| | V_{OM-} | | -9.7 | -9.85 | - | V |
| Supply Current | I_{SUPPLY} | | - | 450 | 1000 | μA |
| Device Dissipation | P_D | | - | 9 | 14 | mW |
| Input Offset Voltage Temperature Drift | $\Delta V_{IO}/\Delta T$ | | - | 4 | - | $\mu V/^\circ C$ |

NOTE:

- The maximum limit represents the levels obtainable on high-speed automatic test equipment. Typical values are obtained under laboratory conditions.

Typical Applications

Picoammeter Circuit

The exceptionally low input current (typically 0.2pA) makes the CA5420A highly suited for use in a picoammeter circuit. With only a single 10GΩ resistor, this circuit covers the range from ±1.5pA. Higher current ranges are possible with suitable switching techniques and current scaling resistors. Input transient protection is provided by the 1MΩ resistor in series with the input. Higher current ranges require that this resistor be reduced. The 10MΩ resistor connected to pin 2 of the CA5420A decouples the potentially high input capacitance often associated with lower current circuits and reduces the tendency for the circuit to oscillate under these conditions.

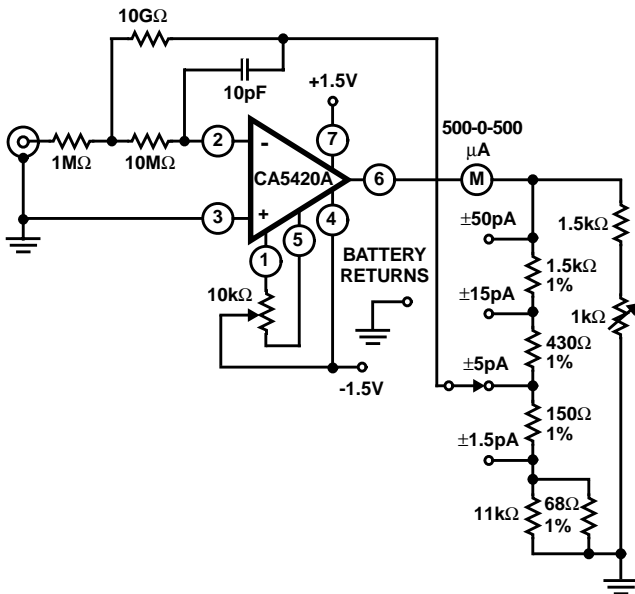


FIGURE 1. PICOAMMETER CIRCUIT

High Input Resistance Voltmeter

Advantage is taken of the high input impedance of the CA5420A in a high input resistance DC voltmeter. Only two 1.5V “AA” type penlite batteries power this exceedingly high-input resistance (>1,000,000MΩ) DC voltmeter. Full-scale deflection is ±500mV, ±150mV, and ±15mV. Higher voltage ranges are easily added with external input voltage attenuator networks.

The meter is placed in series with the gain network, thus eliminating the meter temperature coefficient error term.

Supply current in the standby position with the meter undeflected is 300μA. At full-scale deflection this current rises to 800μA. Carbon-zinc battery life should be in excess of 1,000 hours.

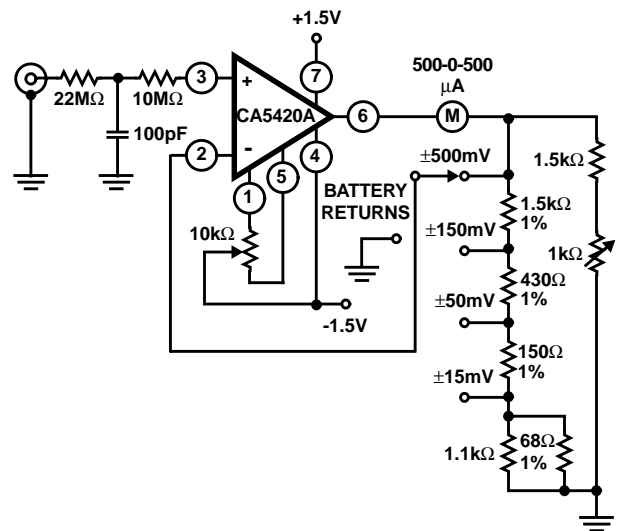


FIGURE 2. HIGH INPUT RESISTANCE VOLTMETER

Typical Performance Curves

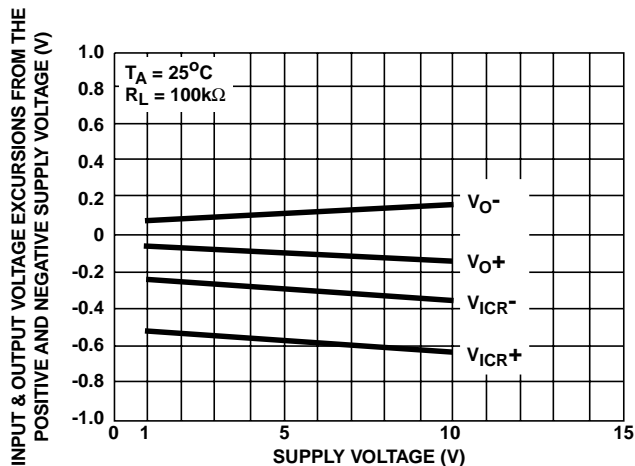


FIGURE 3. OUTPUT VOLTAGE SWING AND COMMON MODE INPUT VOLTAGE RANGE vs SUPPLY VOLTAGE

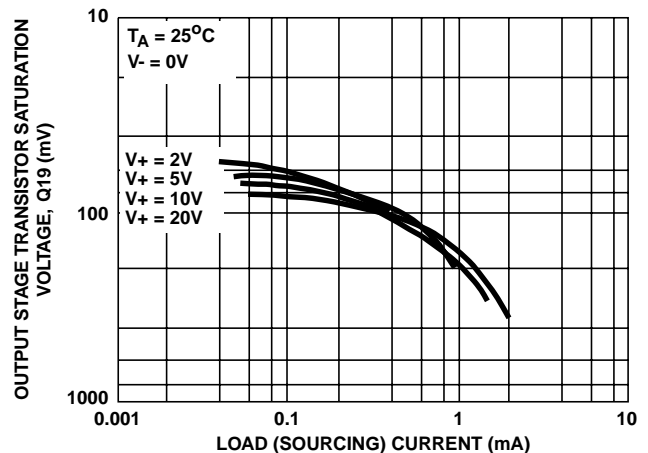


FIGURE 4. OUTPUT VOLTAGE vs LOAD SOURCING CURRENT

Typical Performance Curves (Continued)

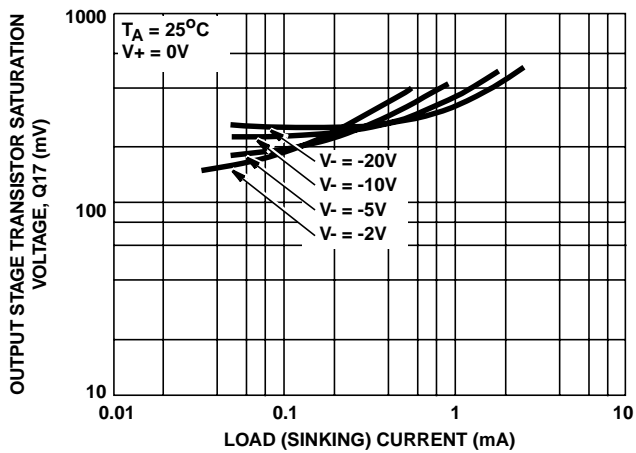


FIGURE 5. OUTPUT VOLTAGE vs LOAD SINKING CURRENT

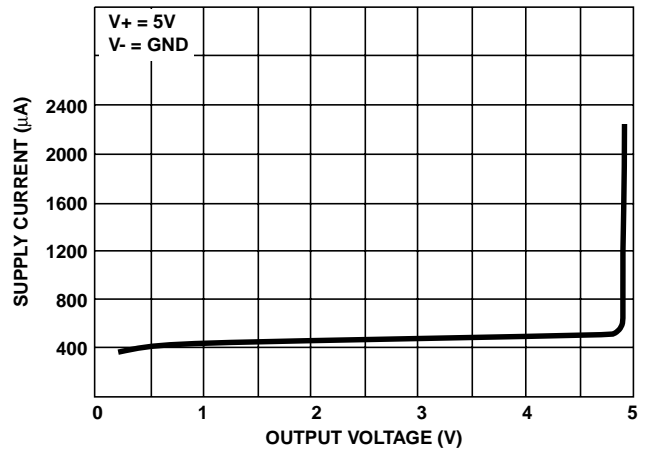


FIGURE 6. SUPPLY CURRENT vs OUTPUT VOLTAGE

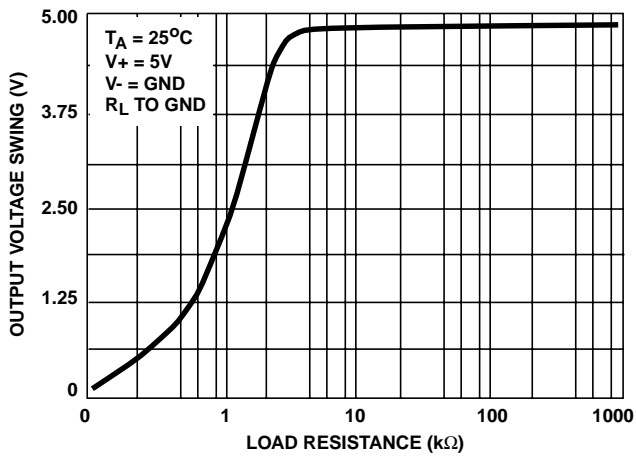


FIGURE 7. OUTPUT VOLTAGE SWING vs LOAD RESISTANCE

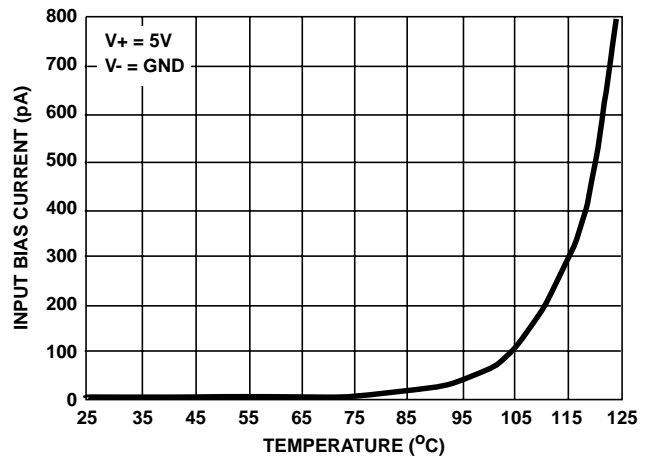


FIGURE 8. INPUT BIAS CURRENT DRIFT ($\Delta I_B/\Delta T$)

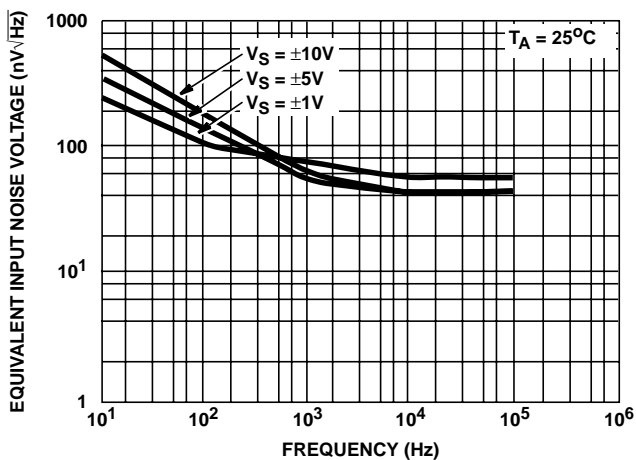


FIGURE 9. INPUT NOISE VOLTAGE vs FREQUENCY

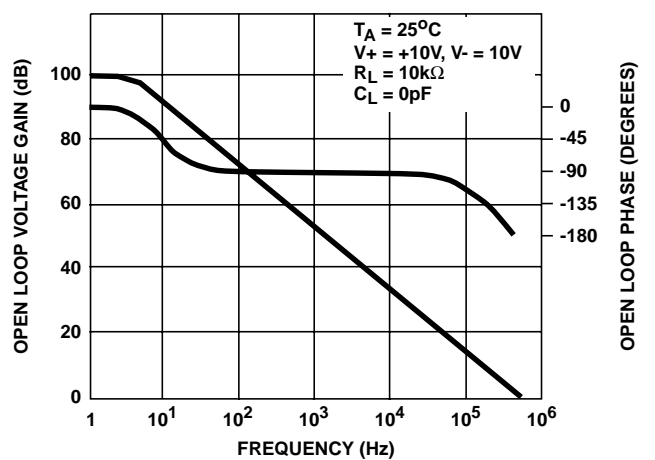


FIGURE 10. OPEN LOOP GAIN AND PHASE SHIFT RESPONSE

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Sales Office Headquarters

NORTH AMERICA

Intersil Corporation
P. O. Box 883, Mail Stop 53-204
Melbourne, FL 32902
TEL: (321) 724-7000
FAX: (321) 724-7240

EUROPE

Intersil SA
Mercure Center
100, Rue de la Fusee
1130 Brussels, Belgium
TEL: (32) 2.724.2111
FAX: (32) 2.724.22.05

ASIA

Intersil (Taiwan) Ltd.
7F-6, No. 101 Fu Hsing North Road
Taipei, Taiwan
Republic of China
TEL: (886) 2 2716 9310
FAX: (886) 2 2715 3029