

Features

- Single-Supply Operation from +1.8V ~ +6V
 - Rail-to-Rail Input / Output
 - Gain-Bandwidth Product: 1MHz (Typ)
 - Low Input Bias Current: 1pA (Typ)
 - Low Offset Voltage: 3.5mV (Max)
 - Quiescent Current: 75µA per Amplifier (Typ)
 - Embedded RF Anti-EMI Filter
 - Operating Temperature: -40°C ~ +125°C
 - Small Package:
- GS6001 Available in SOT23-5 and SC70-5 Packages**
GS6002 Available in SOP-8 and MSOP-8 Packages
GS6004 Available in SOP-14 and TSSOP-14 Packages

General Description

The GS600X family have a high gain-bandwidth product of 1MHz, a slew rate of 0.8V/µs, and a quiescent current of 75µA/amplifier at 5V. The GS600X family is designed to provide optimal performance in low voltage and low noise systems. They provide rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 3.5mV for GS600X family. They are specified over the extended industrial temperature range (-40°C to +125°C). The operating range is from 1.8V to 6V. The GS6001 single is available in Green SC70-5 and SOT23-5 packages. The GS6002 dual is available in Green SOP-8 and MSOP-8 packages. The GS6004 Quad is available in Green SOP-14 and TSSOP-14 packages.

Applications

- ASIC Input or Output Amplifier
- Sensor Interface
- Medical Communication
- Smoke Detectors
- Audio Output
- Piezoelectric Transducer Amplifier
- Medical Instrumentation
- Portable Systems

Pin Configuration

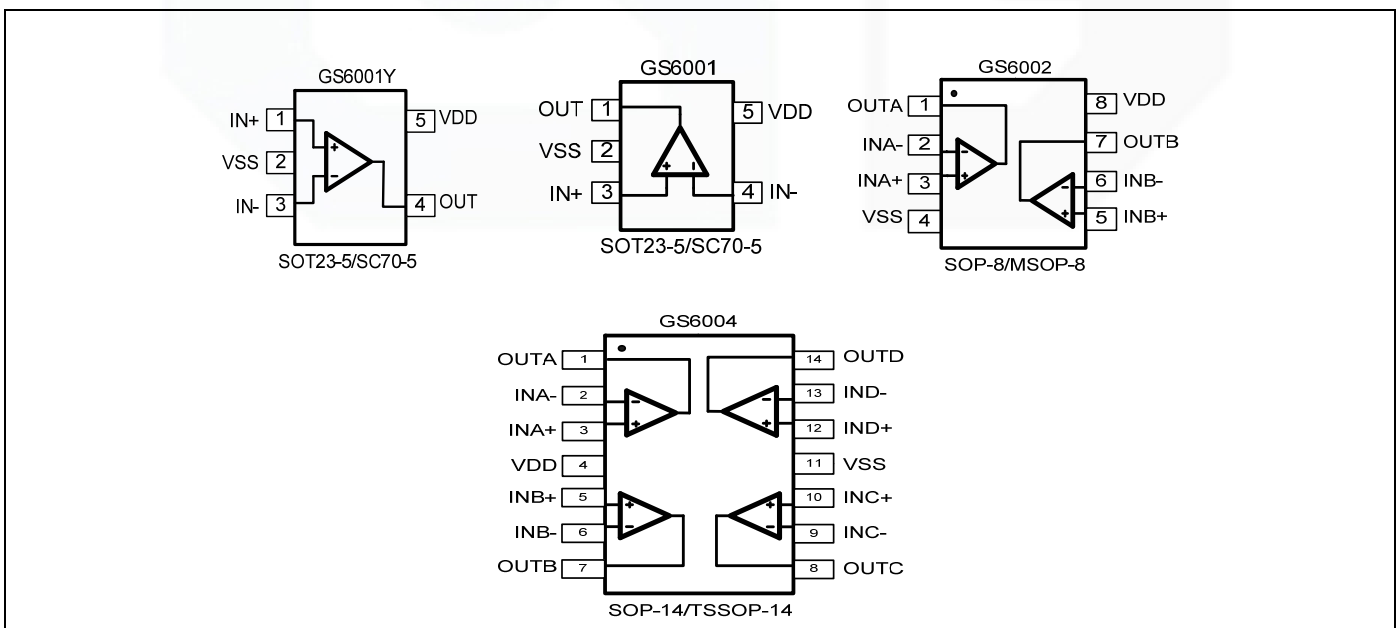


Figure 1. Pin Assignment Diagram

Absolute Maximum Ratings

| Condition | Min | Max |
|--|-----------------------|-----------------------|
| Power Supply Voltage (V _{DD} to V _{SS}) | -0.5V | +7.5V |
| Analog Input Voltage (IN+ or IN-) | V _{SS} -0.5V | V _{DD} +0.5V |
| PDB Input Voltage | V _{SS} -0.5V | +7V |
| Operating Temperature Range | -40°C | +125°C |
| Junction Temperature | +160°C | |
| Storage Temperature Range | -55°C | +150°C |
| Lead Temperature (soldering, 10sec) | +260°C | |
| Package Thermal Resistance (T_A=+25°C) | | |
| SOP-8, θ _{JA} | 125°C/W | |
| MSOP-8, θ _{JA} | 216°C/W | |
| SOT23-5, θ _{JA} | 190°C/W | |
| SC70-5, θ _{JA} | 333°C/W | |
| ESD Susceptibility | | |
| HBM | 6KV | |
| MM | 400V | |

Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Package/Ordering Information

| MODEL | CHANNEL | ORDER NUMBER | PACKAGE DESCRIPTION | PACKAGE OPTION | MARKING INFORMATION |
|--------|---------|--------------|---------------------|--------------------|---------------------|
| GS6001 | Single | GS6001-CR | SC70-5 | Tape and Reel,3000 | 6001 |
| | | GS6001-TR | SOT23-5 | Tape and Reel,3000 | 6001 |
| | | GS6001Y-CR | SC70-5 | Tape and Reel,3000 | 6001Y/321 |
| | | GS6001Y-TR | SOT23-5 | Tape and Reel,3000 | 6001Y/321 |
| GS6002 | Dual | GS6002-SR | SOP-8 | Tape and Reel,4000 | GS6002 |
| | | GS6002-MR | MSOP-8 | Tape and Reel,3000 | GS6002 |
| GS6004 | Quad | GS6004-TR | TSSOP-14 | Tape and Reel,3000 | GS6004 |
| | | GS6004-SR | SOP-14 | Tape and Reel,2500 | GS6004 |

Electrical Characteristics

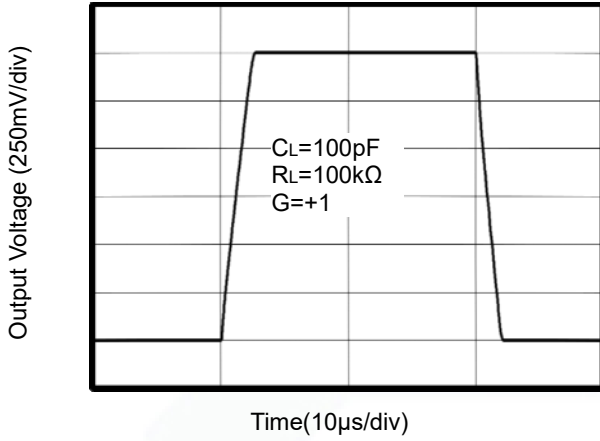
 (At $V_S = +5V$, $R_L = 100k\Omega$ connected to $V_S/2$, and $V_{OUT} = V_S/2$, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | GS6001/2/4 | | | | |
|---|--------------------------|---|--------------|--------------------------|----------------|------------------|---------|
| | | | TYP | MIN/MAX OVER TEMPERATURE | | | |
| | | | +25°C | +25°C | -40°C to +85°C | UNITS | MIN/MAX |
| INPUT CHARACTERISTICS | | | | | | | |
| Input Offset Voltage | V_{OS} | $V_{CM} = V_S/2$ | 0.8 | 3.5 | 5.6 | mV | MAX |
| Input Bias Current | I_B | | 1 | | | pA | TYP |
| Input Offset Current | I_{OS} | | 1 | | | pA | TYP |
| Common-Mode Voltage Range | V_{CM} | $V_S = 5.5V$ | -0.1 to +5.6 | | | V | TYP |
| Common-Mode Rejection Ratio | CMRR | $V_S = 5.5V, V_{CM} = -0.1V$ to 4V | 70 | 62 | 62 | dB | MIN |
| | | $V_S = 5.5V, V_{CM} = -0.1V$ to 5.6V | 68 | 56 | 55 | | |
| Open-Loop Voltage Gain | A_{OL} | $R_L = 5k\Omega, V_O = +0.1V$ to +4.9V | 80 | 70 | 70 | dB | MIN |
| | | $R_L = 10k\Omega, V_O = +0.1V$ to +4.9V | 100 | 94 | 85 | | |
| Input Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | 2.7 | | | $\mu V/^\circ C$ | TYP |
| OUTPUT CHARACTERISTICS | | | | | | | |
| Output Voltage Swing from Rail | V_{OH} | $R_L = 100k\Omega$ | 4.997 | 4.980 | 4.970 | V | MIN |
| | V_{OL} | $R_L = 100k\Omega$ | 5 | 20 | 30 | mV | MAX |
| | V_{OH} | $R_L = 10k\Omega$ | 4.992 | 4.970 | 4.960 | V | MIN |
| | V_{OL} | $R_L = 10k\Omega$ | 8 | 30 | 40 | mV | MAX |
| Output Current | I_{SOURCE} | $R_L = 10\Omega$ to $V_S/2$ | 84 | 60 | 45 | mA | MIN |
| | I_{SINK} | | 75 | 60 | 45 | | |
| POWER SUPPLY | | | | | | | |
| Operating Voltage Range | | | | 1.8 | 1.8 | V | MIN |
| | | | | 6 | 6 | V | MAX |
| Power Supply Rejection Ratio | PSRR | $V_S = +2.5V$ to +6V, $V_{CM} = +0.5V$ | 82 | 60 | 58 | dB | MIN |
| Quiescent Current / Amplifier | I_Q | | 75 | 110 | 125 | μA | MAX |
| DYNAMIC PERFORMANCE (CL = 100pF) | | | | | | | |
| Gain-Bandwidth Product | GBP | | 1 | | | MHz | TYP |
| Slew Rate | SR | $G = +1, 2V$ Output Step | 0.8 | | | $V/\mu s$ | TYP |
| Settling Time to 0.1% | t_s | $G = +1, 2V$ Output Step | 5.3 | | | μs | TYP |
| Overload Recovery Time | | $V_{IN} \cdot Gain = V_S$ | 2.6 | | | μs | TYP |
| NOISE PERFORMANCE | | | | | | | |
| Voltage Noise Density | e_n | f = 1kHz | 27 | | | nV/\sqrt{Hz} | TYP |
| | | f = 10kHz | 20 | | | nV/\sqrt{Hz} | TYP |

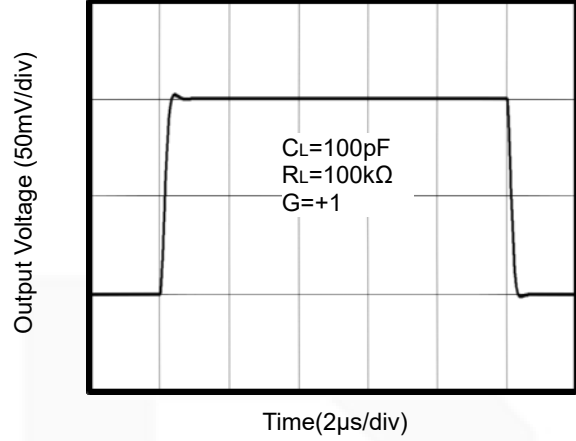
Typical Performance characteristics

At $T_A=+25^{\circ}\text{C}$, $V_s=5\text{V}$, $R_L=100\text{k}\Omega$ connected to $V_S/2$ and $V_{OUT}=V_S/2$, unless otherwise noted.

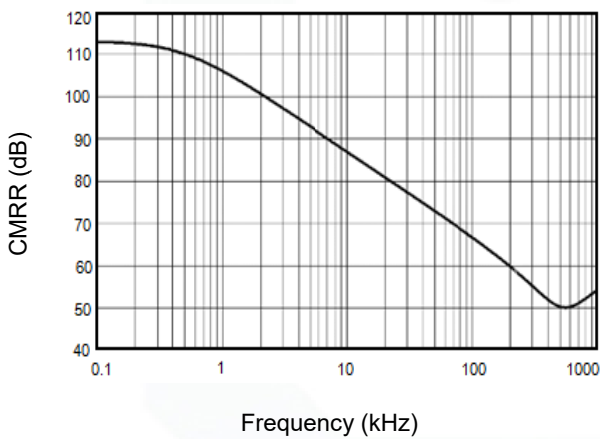
Large Signal Transient Response



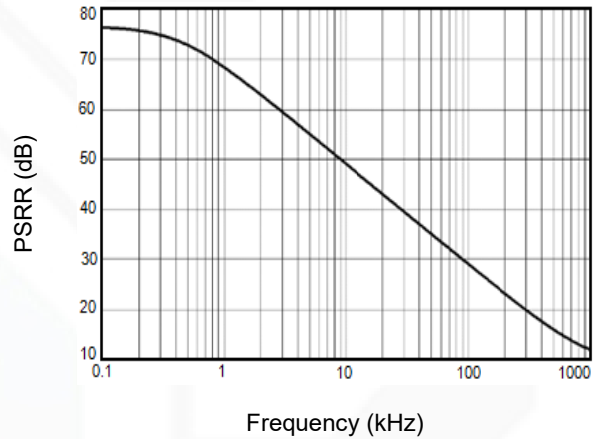
Small Signal Transient Response



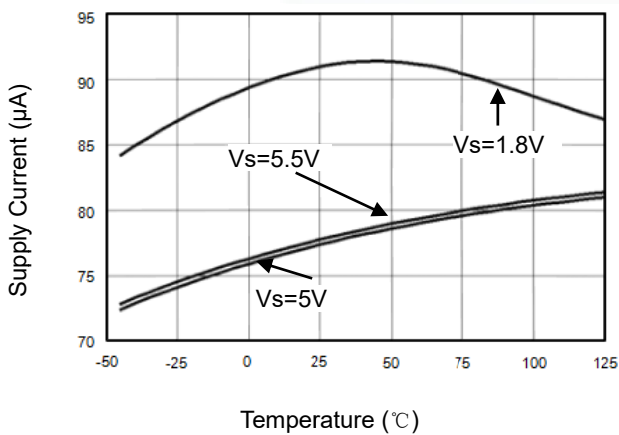
CMRR vs. Frequency



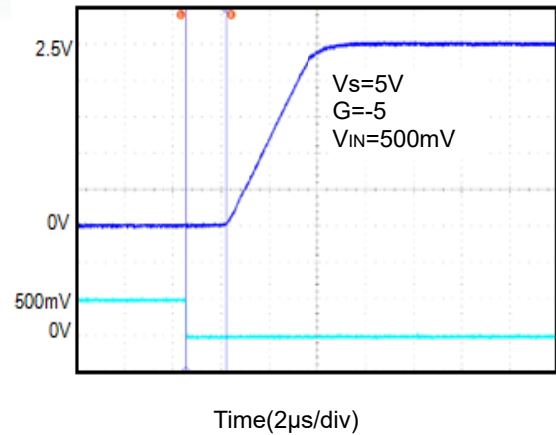
PSRR vs. Frequency



Supply Current vs. Temperature



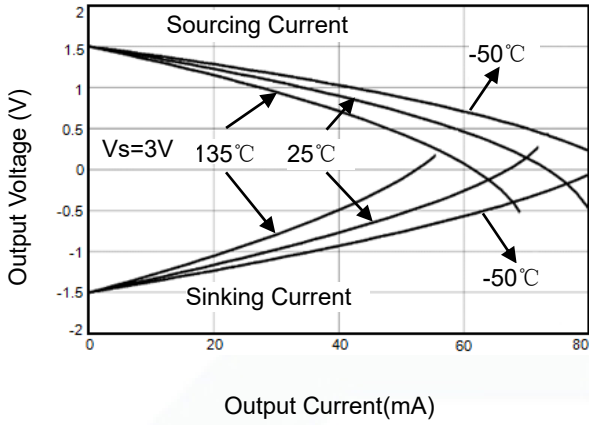
Overload Recovery Time



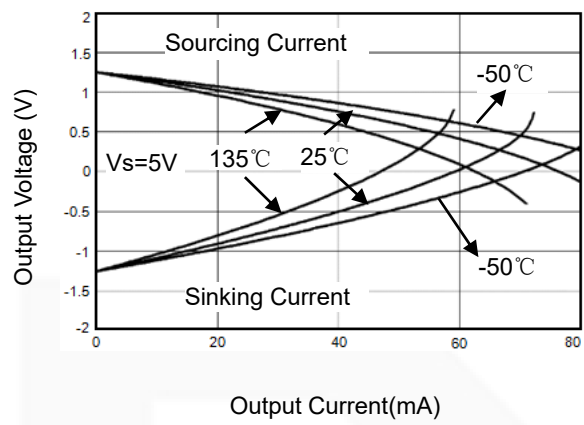
Typical Performance characteristics

At $T_A=+25^\circ\text{C}$, $R_L=100\text{K}\Omega$ connected to $V_S/2$ and $V_{OUT}=V_S/2$, unless otherwise noted.

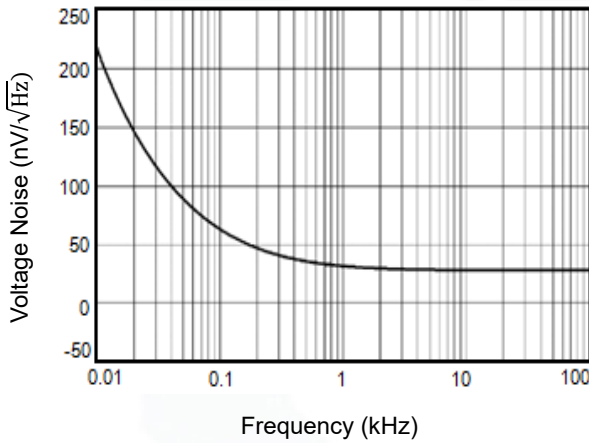
Output Voltage Swing vs. Output Current



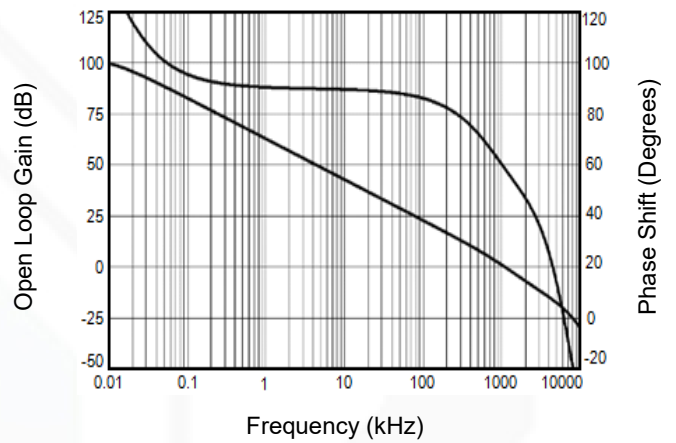
Output Voltage Swing vs. Output Current



Input Voltage Noise Spectral Density vs. Frequency



Open Loop Gain, Phase Shift vs. Frequency



Application Note

Size

GS600X family series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the GS600X family packages save space on printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

GS600X family series operates from a single 1.8V to 6V supply or dual $\pm 0.9V$ to $\pm 3V$ supplies. For best performance, a $0.1\mu F$ ceramic capacitor should be placed close to the V_{DD} pin in single supply operation. For dual supply operation, both V_{DD} and V_{SS} supplies should be bypassed to ground with separate $0.1\mu F$ ceramic capacitors.

Low Supply Current

The low supply current (typical $75\mu A$ per channel) of GS600X family will help to maximize battery life. They are ideal for battery powered systems.

Operating Voltage

GS600X family operates under wide input supply voltage (1.8V to 6V). In addition, all temperature specifications apply from $-40^\circ C$ to $+125^\circ C$. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime.

Rail-to-Rail Input

The input common-mode range of GS600X family extends $100mV$ beyond the supply rails ($V_{SS}-0.1V$ to $V_{DD}+0.1V$). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of GS600X family can typically swing to less than $10mV$ from supply rail in light resistive loads ($>100k\Omega$), and $60mV$ of supply rail in moderate resistive loads ($10k\Omega$).

Capacitive Load Tolerance

The GS600X family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole in the amplifier's feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the amplifier's output and the load capacitance and (2) reducing the bandwidth of the amplifier's feedback loop by increasing the overall noise gain. Figure 2 shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

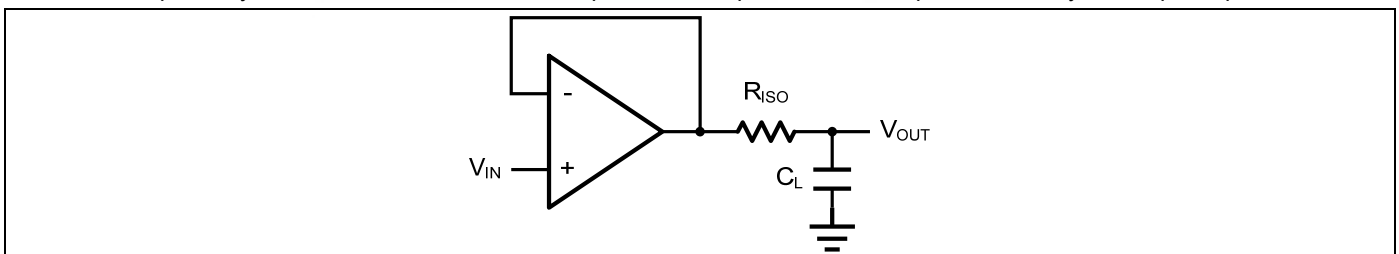


Figure 2 Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the R_{ISO} resistor value, the more stable V_{OUT} will be. However, if there is a resistive load R_L in parallel with the capacitive load, a voltage divider (proportional to R_{ISO}/R_L) is formed, this will result in a gain error.

The circuit in Figure 3 is an improvement to the one in Figure 2. R_F provides the DC accuracy by feed-forward the V_{IN} to R_L . C_F and R_{ISO} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of C_F . This in turn will slow down the pulse response.

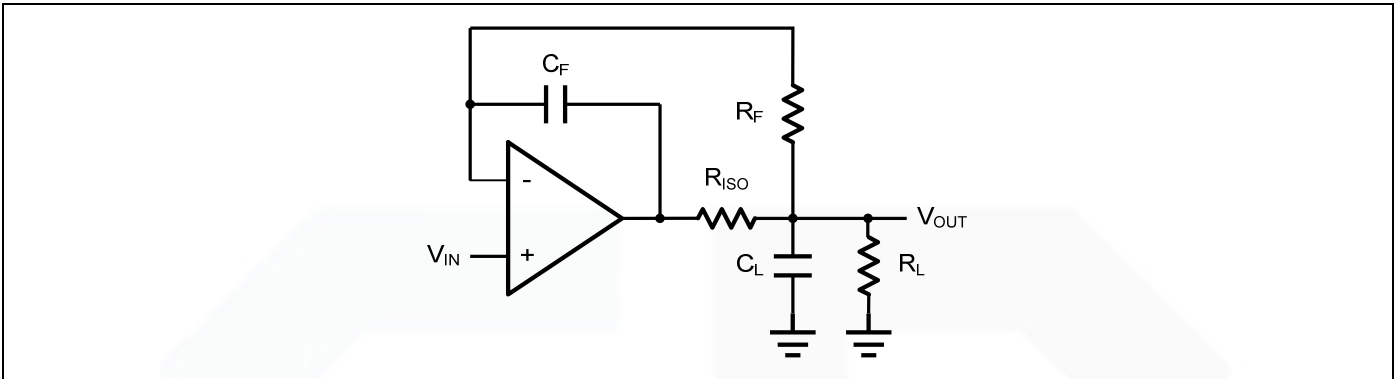


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

Typical Application Circuits

Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common to the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 4. shows the differential amplifier using GS600X family.

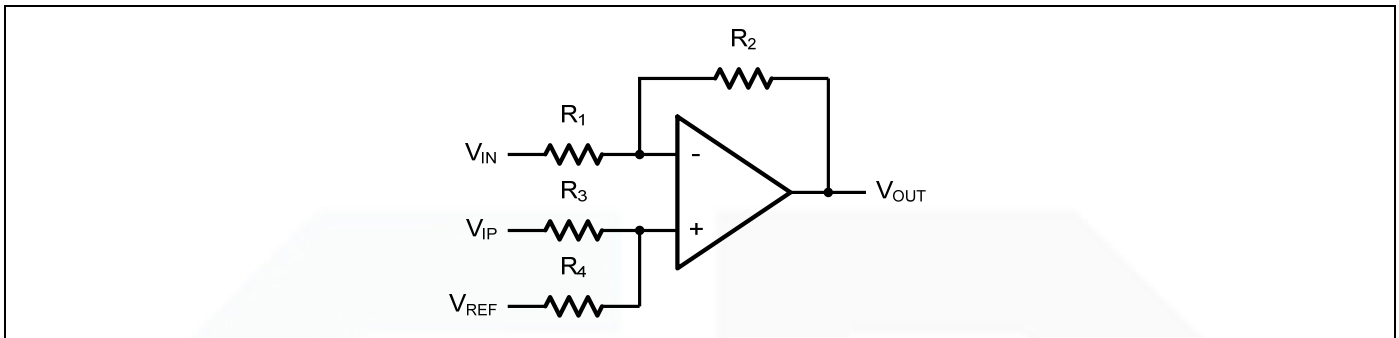


Figure 4. Differential Amplifier

$$V_{OUT} = \left(\frac{R_1+R_2}{R_3+R_4}\right) \frac{R_4}{R_1} V_{IN} - \frac{R_2}{R_1} V_{IP} + \left(\frac{R_1+R_2}{R_3+R_4}\right) \frac{R_3}{R_1} V_{REF}$$

If the resistor ratios are equal (i.e. $R_1=R_3$ and $R_2=R_4$), then

$$V_{OUT} = \frac{R_2}{R_1} (V_{IP} - V_{IN}) + V_{REF}$$

Low Pass Active Filter

The low pass active filter is shown in Figure 5. The DC gain is defined by $-R_2/R_1$. The filter has a -20dB/decade roll-off after its corner frequency $f_c=1/(2\pi R_3 C_1)$.

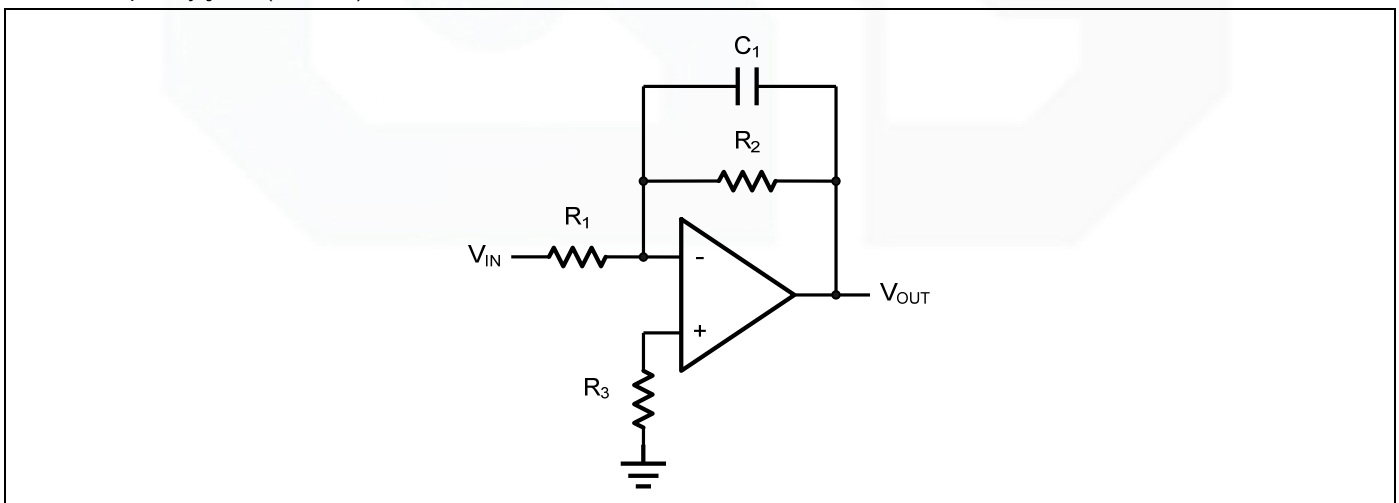


Figure 5. Low Pass Active Filter

Instrumentation Amplifier

The triple GS600X family can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6. The amplifier in Figure 6 is a high input impedance differential amplifier with gain of R_2/R_1 . The two differential voltage followers assure the high input impedance of the amplifier.

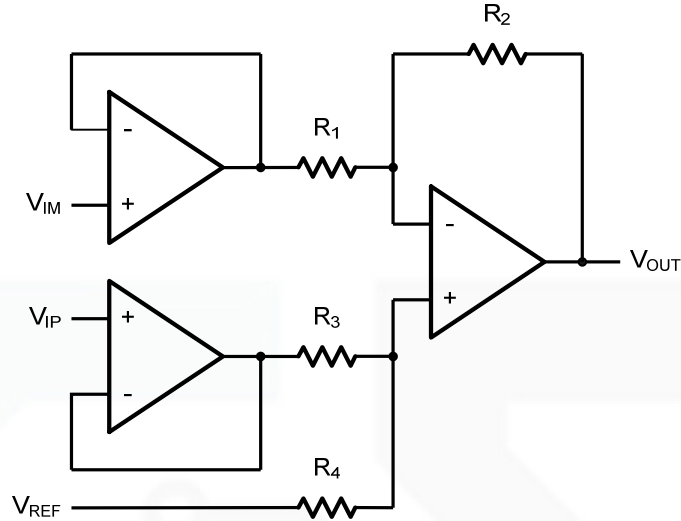
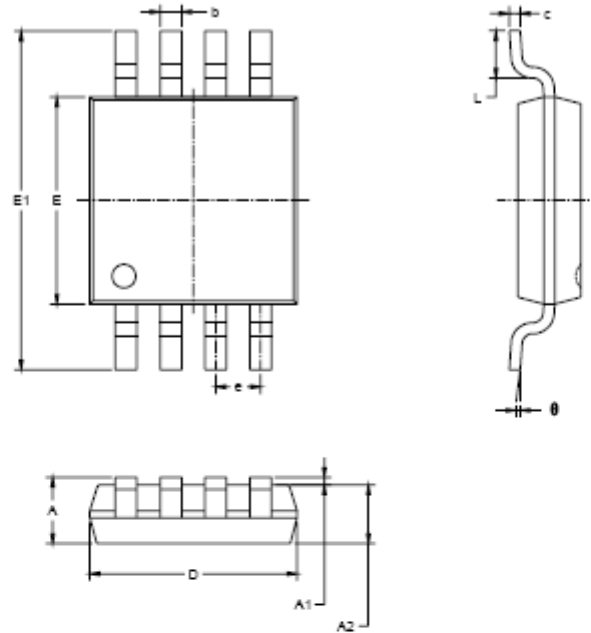


Figure 6. Instrument Amplifier

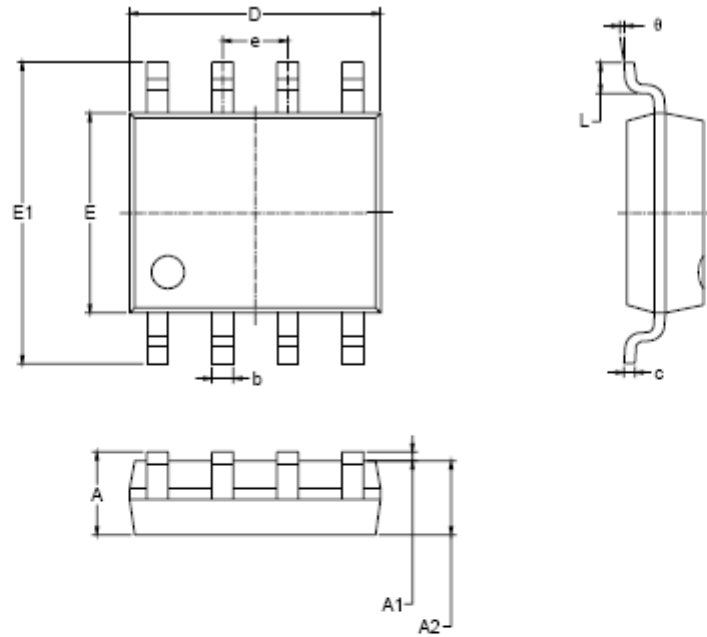
Package Information

MSOP-8



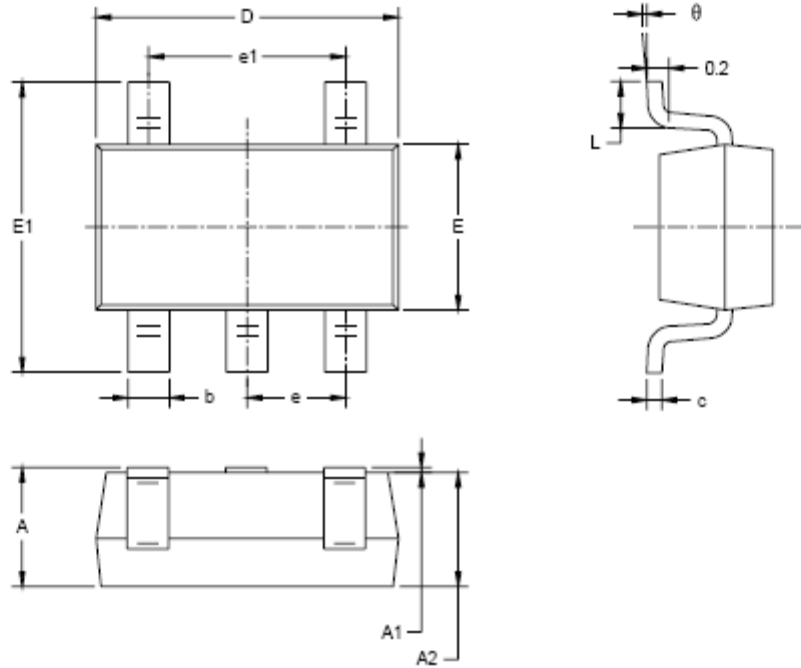
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|----------|------------------------------|-------|-------------------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.008 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| D | 2.900 | 3.100 | 0.114 | 0.122 |
| E | 2.900 | 3.100 | 0.114 | 0.122 |
| E1 | 4.750 | 5.050 | 0.187 | 0.199 |
| e | 0.650 BSC | | 0.026 BSC | |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0° | 8° | 0° | 8° |

SOP-8



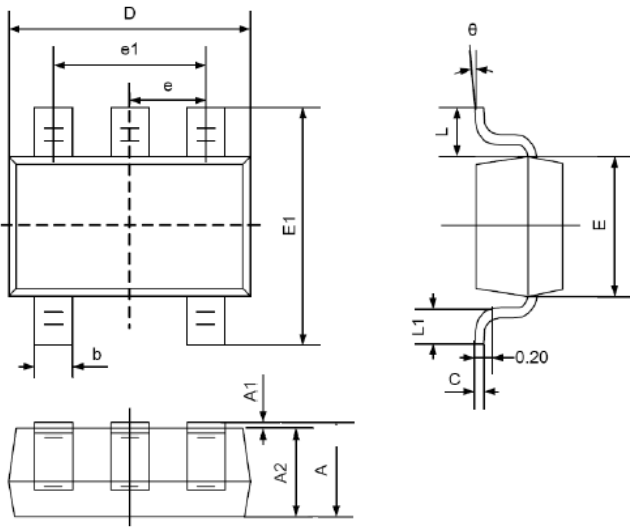
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|----------|------------------------------|-------|-------------------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.006 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.200 |
| E | 3.800 | 4.000 | 0.150 | 0.157 |
| E1 | 5.800 | 6.200 | 0.228 | 0.244 |
| e | 1.27 BSC | | 0.050 BSC | |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

SOT23-5

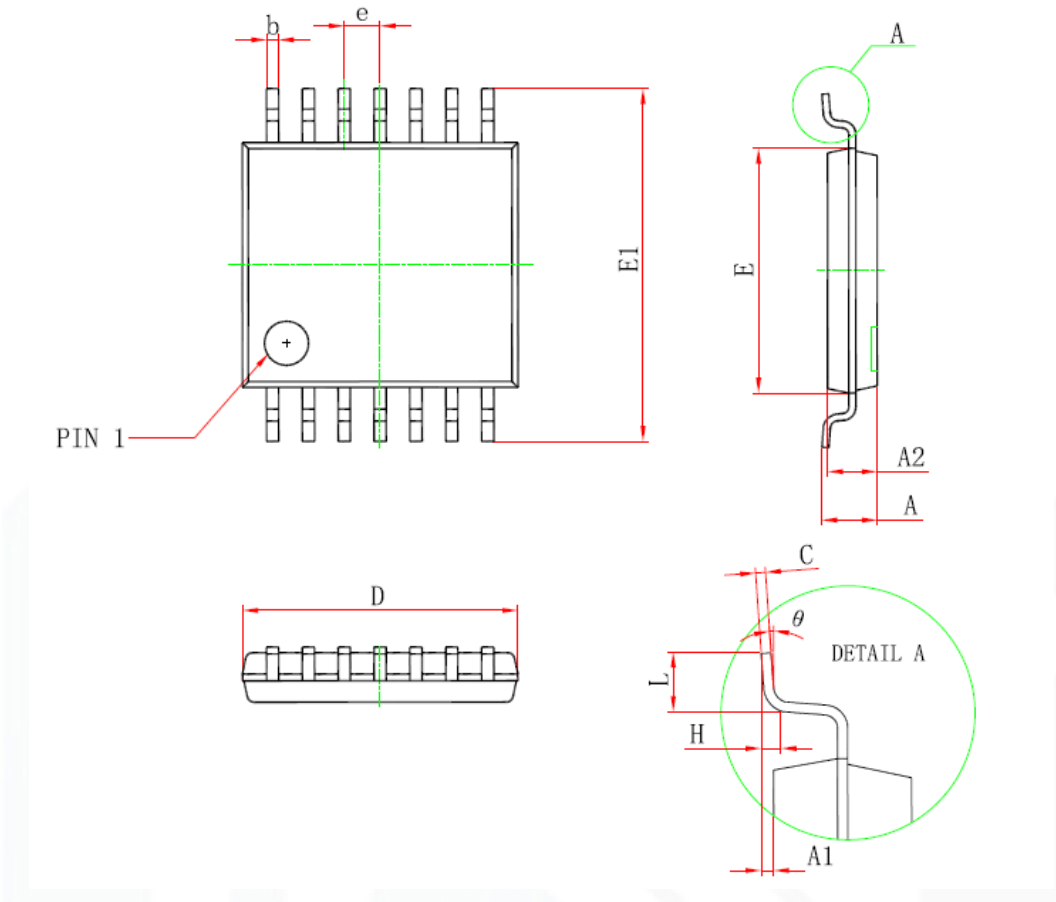


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|------------------------------|-------|-------------------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950 BSC | | 0.037 BSC | |
| e1 | 1.900 BSC | | 0.075 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

SC70-5

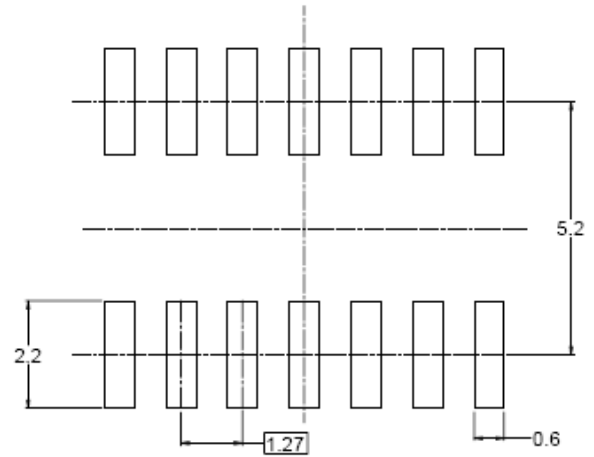
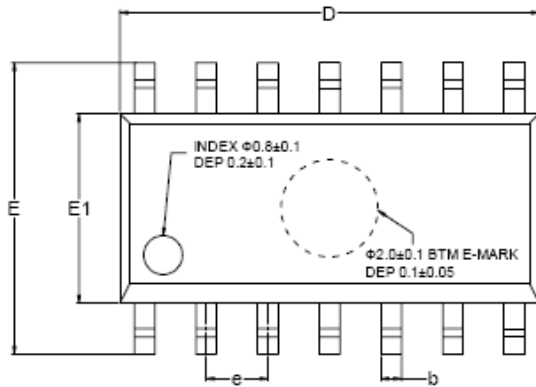


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|----------|------------------------------|-------|-------------------------|-------|
| | Min | Max | Min | Max |
| A | 0.900 | 1.100 | 0.035 | 0.043 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 0.900 | 1.000 | 0.035 | 0.039 |
| b | 0.150 | 0.350 | 0.006 | 0.014 |
| C | 0.080 | 0.150 | 0.003 | 0.006 |
| D | 2.000 | 2.200 | 0.079 | 0.087 |
| E | 1.150 | 1.350 | 0.045 | 0.053 |
| E1 | 2.150 | 2.450 | 0.085 | 0.096 |
| e | 0.650TYP | | 0.026TYP | |
| e1 | 1.200 | 1.400 | 0.047 | 0.055 |
| L | 0.525REF | | 0.021REF | |
| L1 | 0.260 | 0.460 | 0.010 | 0.018 |
| θ | 0° | 8° | 0° | 8° |

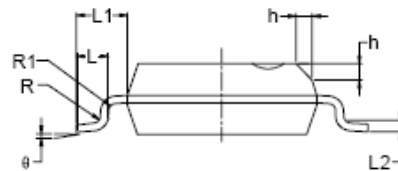
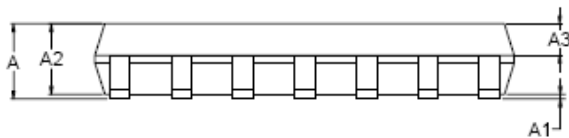


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|----------|---------------------------|-------|----------------------|-------|
| | Min | Max | Min | Max |
| D | 4.900 | 5.100 | 0.193 | 0.201 |
| E | 4.300 | 4.500 | 0.169 | 0.177 |
| b | 0.190 | 0.300 | 0.007 | 0.012 |
| c | 0.090 | 0.200 | 0.004 | 0.008 |
| E1 | 6.250 | 6.550 | 0.246 | 0.258 |
| A | | 1.200 | | 0.047 |
| A2 | 0.800 | 1.000 | 0.031 | 0.039 |
| A1 | 0.050 | 0.150 | 0.002 | 0.006 |
| e | 0.65 (BSC) | | 0.026 (BSC) | |
| L | 0.500 | 0.700 | 0.020 | 0.028 |
| H | 0.25(TYP) | | 0.01(TYP) | |
| θ | 1° | 7° | 1° | 7° |

SOP-14



RECOMMENDED LAND PATTERN (Unit: mm)



| Symbol | Dimensions In Millimeters | | | Dimensions In Inches | | |
|----------|---------------------------|-----|------|----------------------|-----|-------|
| | MIN | MOD | MAX | MIN | MOD | MAX |
| A | 1.35 | | 1.75 | 0.053 | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.25 | | 1.65 | 0.049 | | 0.065 |
| A3 | 0.55 | | 0.75 | 0.022 | | 0.030 |
| b | 0.36 | | 0.49 | 0.014 | | 0.019 |
| D | 8.53 | | 8.73 | 0.336 | | 0.344 |
| E | 5.80 | | 6.20 | 0.228 | | 0.244 |
| E1 | 3.80 | | 4.00 | 0.150 | | 0.157 |
| e | 1.27 BSC | | | 0.050 BSC | | |
| L | 0.45 | | 0.80 | 0.018 | | 0.032 |
| L1 | 1.04 REF | | | 0.040 REF | | |
| L2 | 0.25 BSC | | | 0.01 BSC | | |
| R | 0.07 | | | 0.003 | | |
| R1 | 0.07 | | | 0.003 | | |
| h | 0.30 | | 0.50 | 0.012 | | 0.020 |
| θ | 0° | | 8° | 0° | | 8° |

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[NCS5651MNTXG](#) [NCV33202DMR2G](#) [NJM324E](#) [NTE925](#) [5962-9080901MCA*](#) [AP4310AUMTR-AG1](#) [HA1630D02MMEL-E](#)
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[NTE924](#) [NTE937](#) [MCP6V16UT-E/OT](#) [MCP6V17T-E/MS](#) [MCP6V19T-E/ST](#) [SCY6358ADR2G](#) [LTC2065IUD#PBF](#) [NCS20282FCTTAG](#)
[LM4565FVT-GE2](#) [EL5420CRZ-T7A](#) [TSV791IYLT](#) [TSV772IQ2T](#) [TLV2772QPWR](#) [NJM2100M-TE1](#) [NJM4556AM-TE1](#) [MCP6487-E/SN](#)
[MCP6487-E/MS](#) [AS324MTR-E1](#) [AS358MMTR-G1](#) [MCP6232T-EMNY](#) [MCP662-E/MF](#) [TLC081AIP](#) [TLC082AIP](#) [TLE2074ACDW](#)
[TLV07IDR](#) [TLV2170IDGKT](#)