MINGDA
MICROELECTRONICS

MD1131/2/4
8kHz, 450nA, Rail-to-Rail I/O CMOS Operational Amplifiers

FEATURES

- Low Cost
- Rail-to-Rail Input and Output
  1mV Typical V_{OS}
- Unity Gain Stable
- Gain-Bandwidth Product: 8kHz
- Very Low Input Bias Current: 10pA
- Supply Voltage Range: 1.8V to 5.5V
- Input Voltage Range:
  -0.1V to +5.6V with $(V_{DD} - V_{SS}) = 5.5V$
- Low Supply Current: 450nA/Amplifier
- Small Packaging
  MD1131 Available in SOT-23-5
  MD1132 Available in SOP8
  MD1134 Available in SOP14

APPLICATIONS

- Current Sensing
- Threshold Detectors/Discriminators
- Low Power Filters
- Handsets and Mobile Accessories
- Wireless Remote Sensors, Active RFID Readers
- Gas/Oxygen/Environment Sensors
- Battery or Solar Powered Devices
- Sensor Network Powered by Energy Scavenging

PRODUCT DESCRIPTION

The MD1131 (single), MD1132 (dual) and MD1134 (quad) are low cost, rail-to-rail input and output voltage feedback amplifiers. They have a wide input common mode voltage range and output voltage swing, and take the minimum operating supply voltage down to 1.8V. The maximum recommended supply voltage is 5.5V. It is specified over the extended -40℃ to +85℃ temperature range.

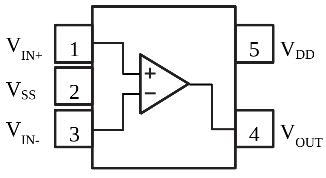
The MD1131/2/4 provides 8kHz bandwidth at a low current consumption of 450nA per amplifier. Very low input bias currents of 10pA enable MD1131/2/4 to be used for integrators, photodiode amplifiers, and piezoelectric sensors. Rail-to-rail input and output are useful to designers for buffering ASIC in single-supply systems.

Applications for this series of amplifiers include safety monitoring, portable equipment, battery and power supply control, and signal conditioning and interfacing for transducers in very low power systems.

The MD1131 is available in the Green SOT-23-5 Package. The MD1132 comes in the Green SOP8 package. The MD1134 comes in the Green SOP14 package.

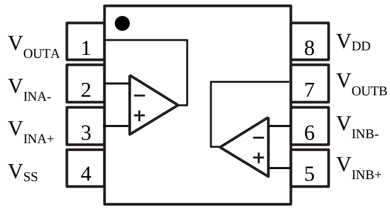
PIN CONFIGURATIONS (TOP VIEW)

MD1131



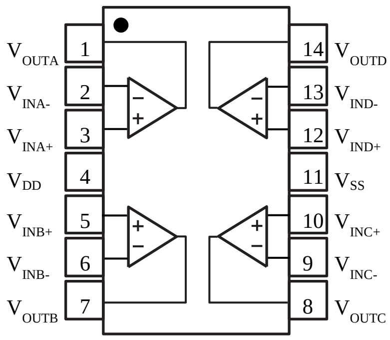
SOT-23-5

MD1132



SOP8

MD1134



SOP14

REV. A. 1.0

ORDER INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
MD1131	--	SOT23-5	Tape and Reel, 3000	--
MD1132	--	SOP8	Tape and Reel, 4000	--
MD1134	--	SOP14	Tape and Reel, 4000	--

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{DD} to V_{SS}..6V
Common Mode Input Voltage…...................V_{SS} - 0.3V to V_{DD} + 0.3V
Storage Temperature Range......................................-65℃ to +150℃
Junction Temperature..150℃
Operating Temperature Range.....................................-40℃ to +85℃

Package Thermal Resistance @ T_A = +25℃
SOP8, θJA...125℃/W
Lead Temperature (Soldering 10sec)................................260℃

NOTE:

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD		1	kV

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are At T_A=25℃, V_{DD} = +5V, V_{SS} = GND, R_L = 1MΩ, C_L = 60pF connected to $V_{DD}/2$, and V_{OUT} = $V_{DD}/2$.

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS							
Input Offset Voltage	V_{OS}	$V_{CM} = V_{DD}/2$			1	5	mV
		$V_{CM} = V_{DD}/2$	●			6.6	mV
Input Bias Current	I_B				10		pA
Input Offset Current	I_{OS}				10		pA
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta_T$				3		µV/℃
Input Common Mode Voltage Range	V_{CM}	V_{DD} = 5.5V			-0.1-5.6		V
Common Mode Rejection Ratio	CMRR	V_{DD} = 5.5V, V_{CM} = -0.1V to 4V			98		dB
Open-Loop Voltage Gain	A_{OL}	R_L = 1MΩ, V_{OUT} = 2.5V			96		dB
		R_L = 1MΩ, V_{OUT} = +0.2V to +4.8V			96		dB
OUTPUT CHARACTERISTICS							
Output Voltage Swing from Rail	V_{OH}	R_L = 1MΩ		4.980	4.995		V
	V_{OL}	R_L = 1MΩ		25	5		mV
	V_{OH}	R_L = 100kΩ		4.970	4.994		V
	V_{OL}	R_L = 100kΩ		35	6		mV
Output Current	I_{SOURCE}	R_L = 10Ω to $V_{DD}/2$			95		mA
	I_{SINK}				100		
POWER SUPPLY							
Operating Voltage Range				1.6		5.5	V
			●	1.8		5.5	V
Power Supply Rejection Ratio	PSRR	V_{DD} = +1.8V to +5.5V, V_{CM} = +0.5V			82		dB
Quiescent Current/Amplifier	I_Q				450		nA
			●	300		900	
DYNAMIC PERFORMANCE (C_L = 60pF)							
Gain-Bandwidth Product	GBP	R_L = 1MΩ			8		kHz
		R_L = 100kΩ			4		
Phase Margin	PM	R_L = 1MΩ, C_L = 60pF			90		°
Harmonic Distortion	HD2	f = 100Hz, G = +1, V_{OUT} = $2V_{PP}$			73		dBc
	HD3	f = 100Hz, G = +1, V_{OUT} = $2V_{PP}$			80		
Full Power Bandwidth	FPBW				200		Hz
Slew Rate	SR	G = +1, 2V Output Step			3		V/ms
Settling Time to 0.1%	t_S	G = +1, 2V Output Step，0.1%			0.5		ms
Overload Recovery Time		$V_{IN} \cdot G = V_{DD}$			1.6		ms
NOISE PERFORMANCE							
Voltage Noise Density	e_n	f = 100Hz			300		nV/$\sqrt{Hz}$
		f = 1kHz			300		nV/$\sqrt{Hz}$

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 1MΩ connected to V_{DD}/2, unless otherwise specified.

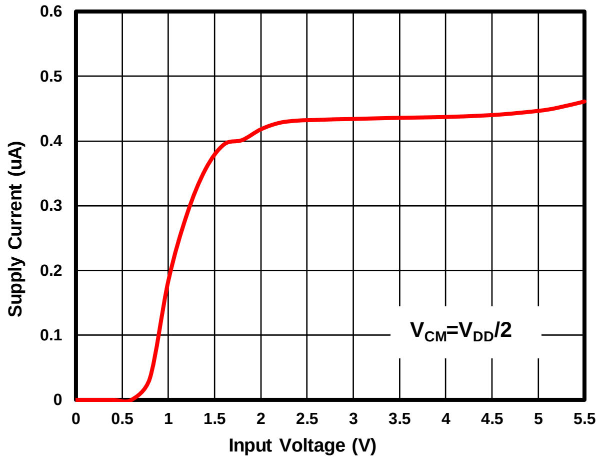


Figure 1. Supply Current vs. Supply Voltage

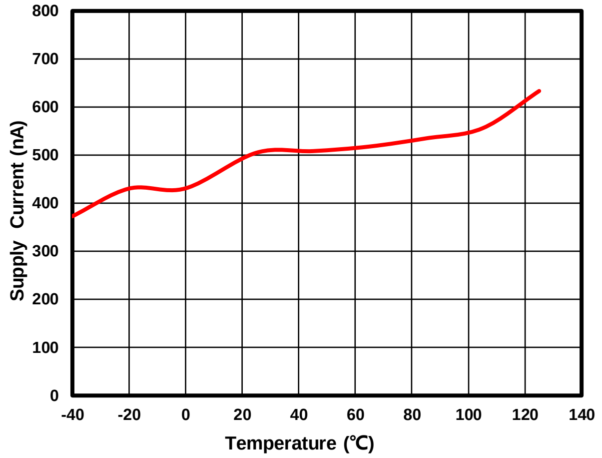


Figure 2. Supply Current vs. Temperature

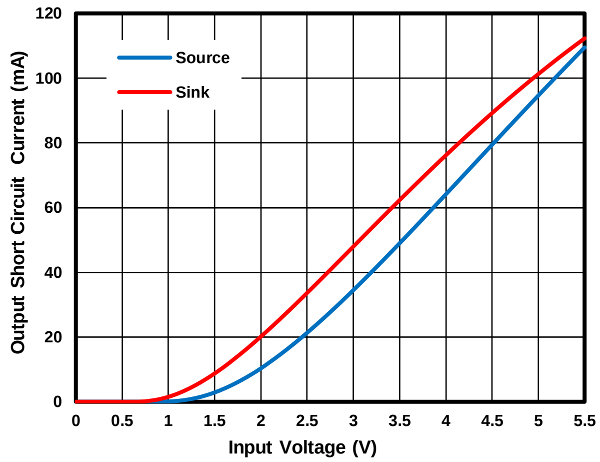


Figure 3. Output Short Circuit Current vs. Supply Voltage

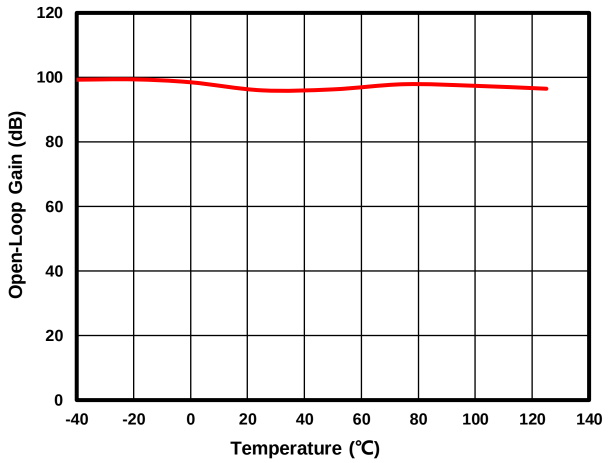


Figure 4. Open-Loop Gain vs. Temperature

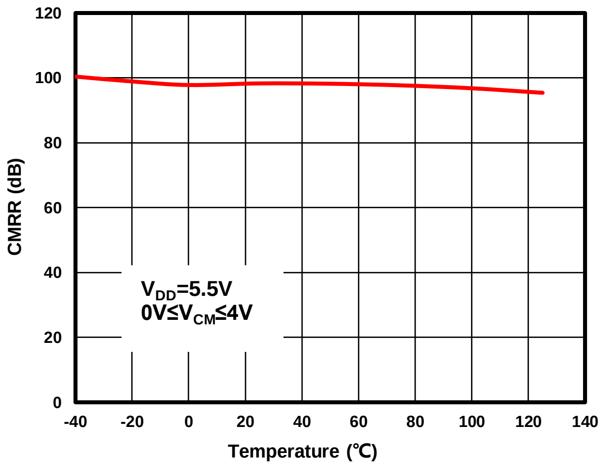


Figure 5. CMRR vs. Temperature

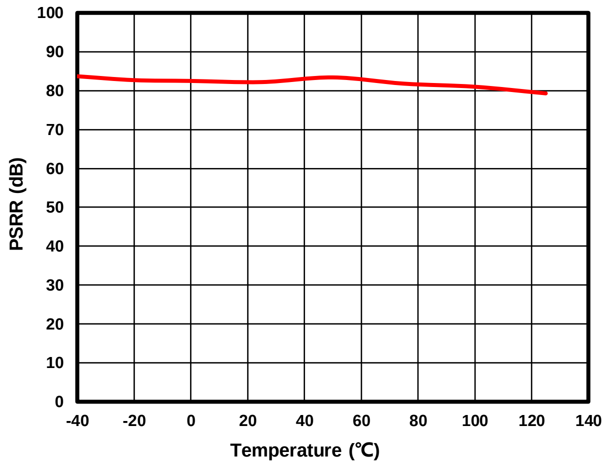


Figure 6. PSRR vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 1MΩ connected to V_{DD}/2, unless otherwise specified.

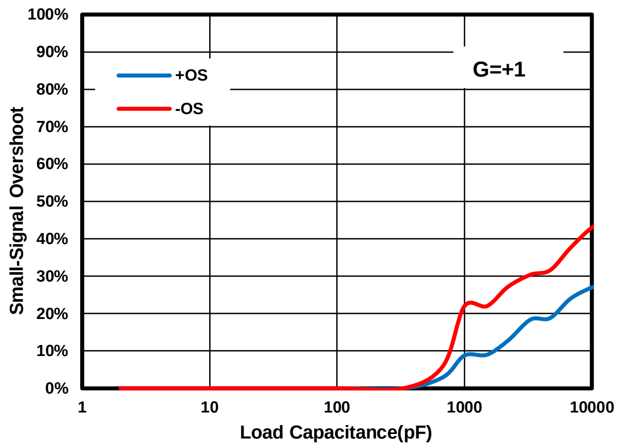


Figure 7. Small-Signal Overshoot vs. Load Capacitance

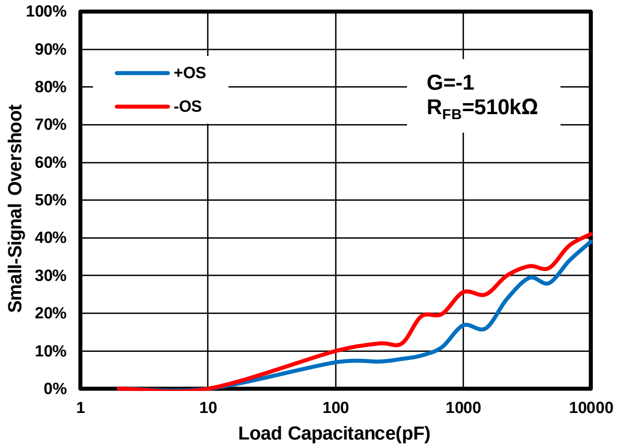


Figure 8. Small-Signal Overshoot vs. Load Capacitance

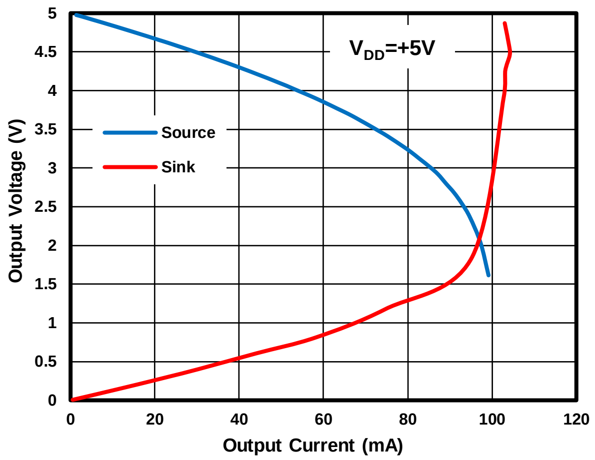


Figure 9. Output Voltage vs. Output Current

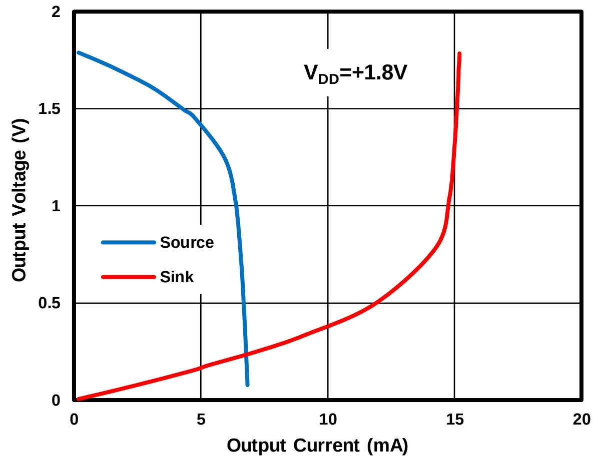


Figure 10. Output Voltage vs. Output Current

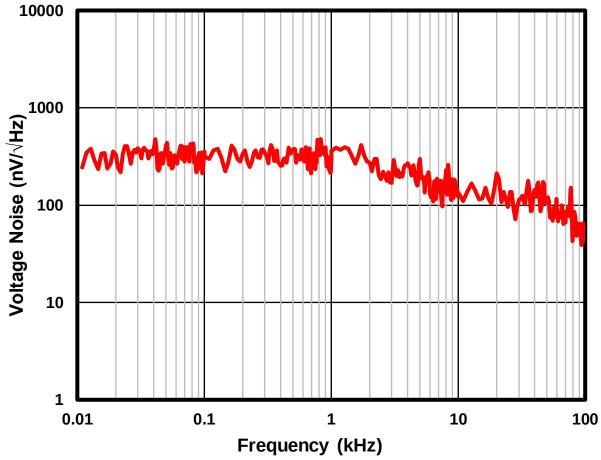


Figure 11. Input Voltage Noise Spectral Density vs. Frequency

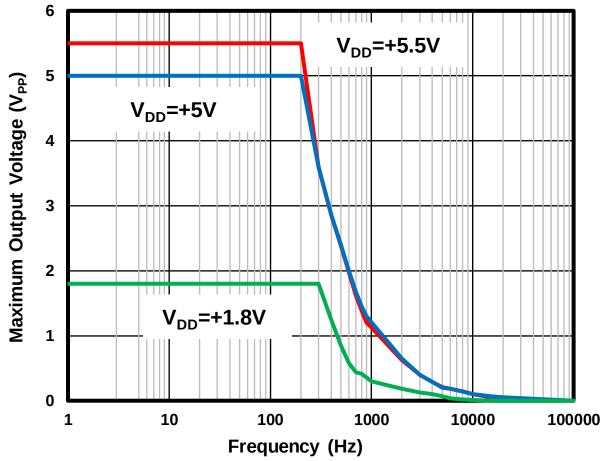


Figure 12. Maximum Output Voltage vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 1MΩ connected to $V_{DD}/2$, unless otherwise specified

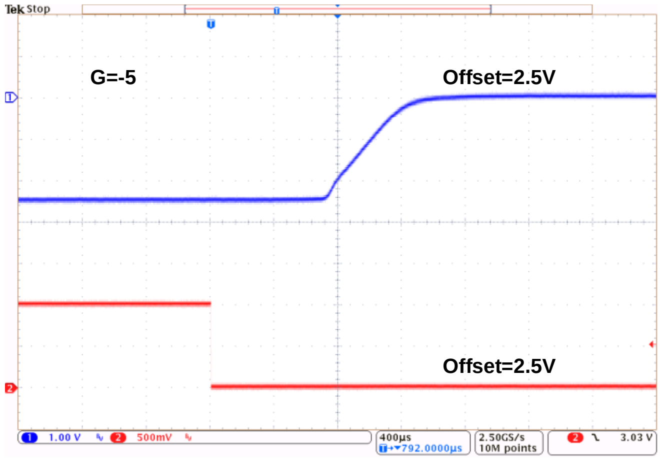


Figure 13. Positive Overload Recovery Time

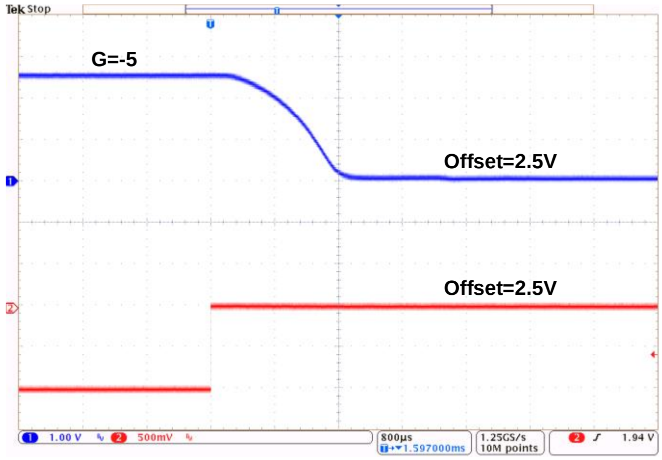


Figure 14. Negative Overload Recovery Time

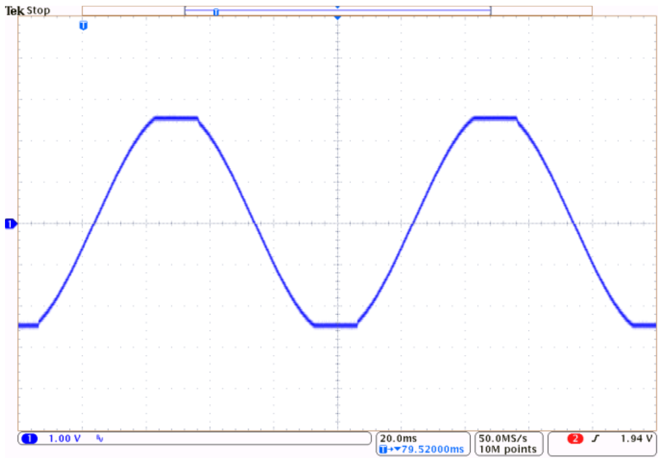


Figure 15. Phase Reversal

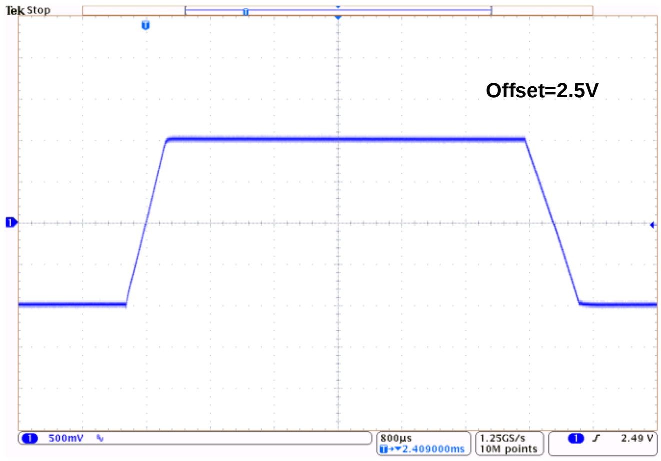


Figure 16. Large-Signal Step Response

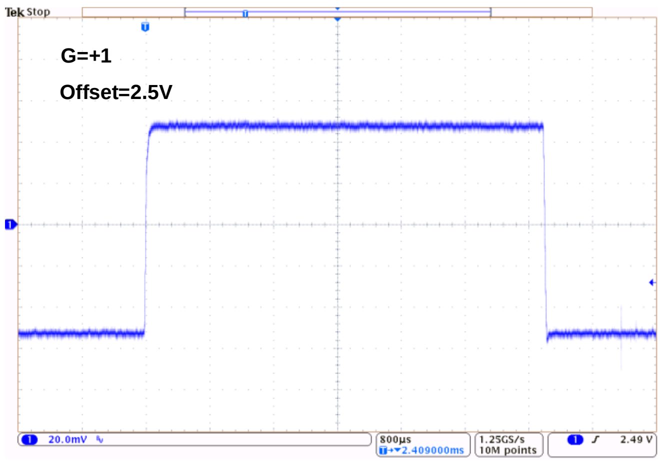


Figure 17. Small-Signal Step Response

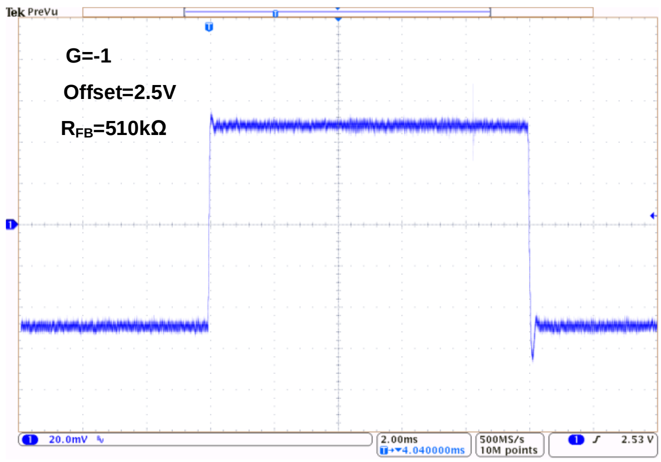


Figure 18. Small-Signal Step Response

TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_{DD} = +5V, V_{SS} = GND, and R_L = 1MΩ connected to $V_{DD}/2$, unless otherwise specified.

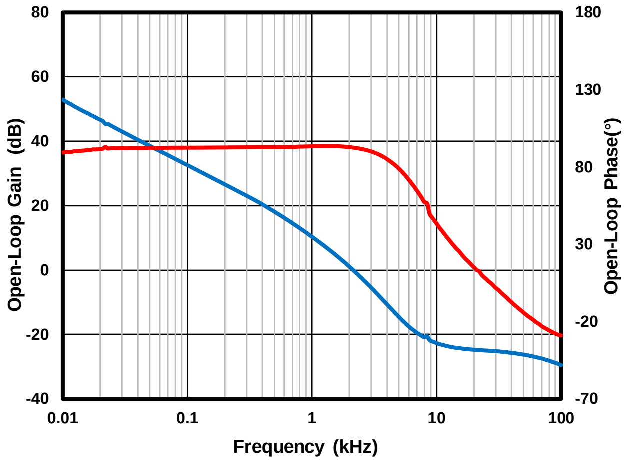


Figure 19. Gain and Phase vs. Frequency

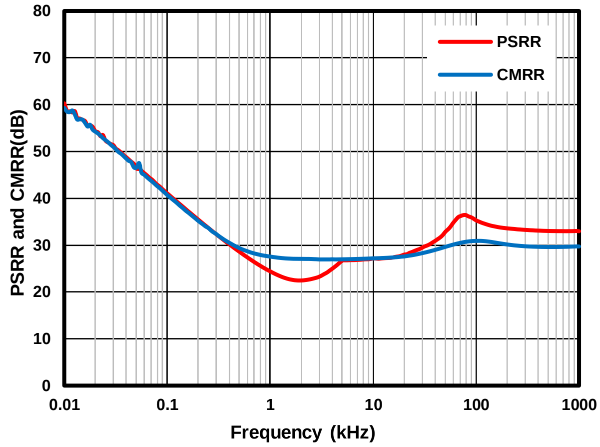


Figure 20. CMRR and PSRR vs. Frequency

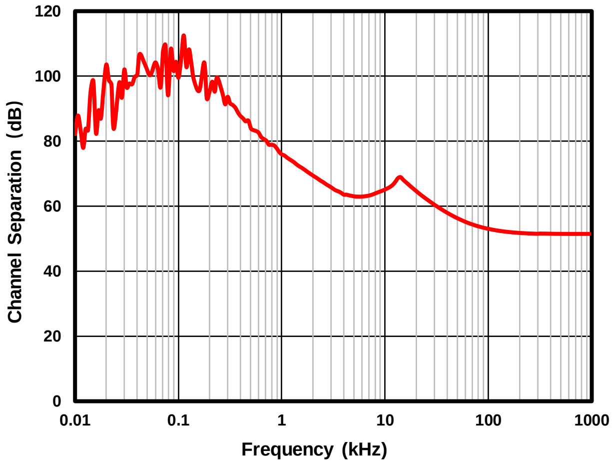


Figure 21. Channel Separation vs. Frequency

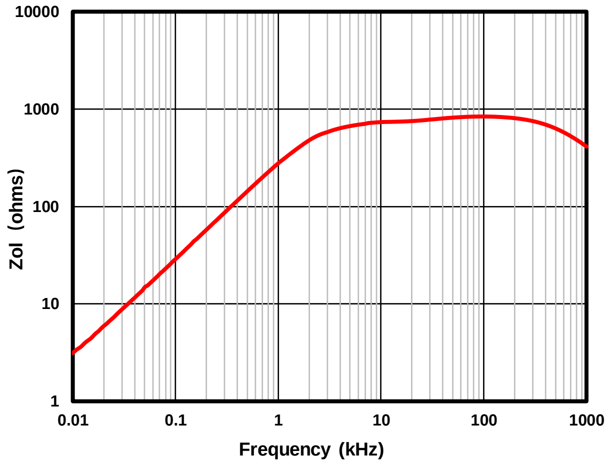


Figure 22. Zol vs. Frequency

APPLICATION INFORMATION

MD1131/2/4 are CMOS, rail-to-rail input and output voltage feedback amplifiers designed for general purpose applications.

Operating Voltage

The MD1131/2/4 are specified over a power-supply range of +1.8V to +5.5V (±0.9V to ±2.75V), Supply voltages higher than 6V (absolute maximum) can permanently damage the amplifier. Parameters that vary over supply voltage or temperature are shown in the typical characteristics section of this datasheet.

Rail-to-Rail Input

The input stage of the amplifiers is a true rail-to-rail architecture, allowing the input common-mode voltage range of the op amp to extend to both positive and negative supply rails. This maximizes the usable voltage range of the amplifier, an important feature for single-supply and low voltage applications. This rail-to-rail input range is achieved with a complementary input stage—an NMOS input differential pair in parallel with a PMOS differential pair. The NMOS pair is active at the upper end of the common-mode voltage range, typically V_{DD} – 1.2V to 100mV above the positive supply, while the PMOS pair is active for inputs from 100mV below the negative supply to approximately V_{DD} – 1.2V.

Rail-to-Rail Output

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. The maximum output voltage swing is proportional to the output current, and larger currents will limit how close the output voltage can get to the proximity of the output voltage to the supply rail. This is a characteristic of all rail-to-rail output amplifiers. See the typical performance characteristic Figure 9, Output Voltage Swing vs. Output Current.

Capacitive Loads

The MD1131/2/4 op amps can directly drive large capacitive loads. As the load capacitance increases, the feedback loop's phase margin decreases and the closed-loop's bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response. While a op amp in unity gain configuration (G = +1 V/V) is most susceptible to the effects of capacitive loading.

When driving large capacitive loads with the MD1131/2/4 amplifiers (e.g., > 60pF when G = +1 V/V), a small series resistor at the output (R_{ISO} in Figure 21) improves the feedback loop's phase margin (stability) by making the output load resistive at higher frequencies.

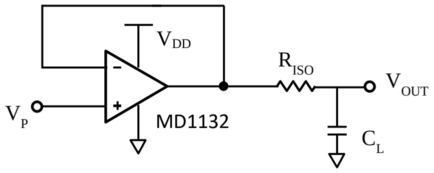


Figure 21. Driving Large Capacitive Loads

PCB Surface Leakage

In Applications where low input bias current is critical, PC board surface leakage effects need to be considered. Surface leakage is caused by humidity, dust or other contamination on the board. Under low humidity conditions, a typical resistance between nearby traces is $10^{12}\Omega$. A 5V difference would cause 5pA of current to flow; which is similar to the MD1131/2/4 op amps' bias current at +25℃ (±10pA, typical).

The best way to reduce surface leakage is to use a guard ring around sensitive pins (or traces). The guard ring is biased at the same voltage as the sensitive pin. An example of this type of layout is shown in Figure 22.

1. Non-inverting Gain and Unity-Gain Buffer:
   a) Connect the non-inverting pin (V_{IN+}) to the input with a wire that does not touch the PCB surface.
   b) Connect the guard ring to the inverting input pin (V_{IN-}). This biases the guard ring to the Common Mode input voltage.
2. Inverting Gain and Transimpedance Gain Amplifiers (convert current to voltage, such as photo detectors):
   a) Connect the guard ring to the non-inverting input pin (V_{IN+}). This biases the guard ring to the same reference voltage as the op amp (e.g., $V_{DD}/2$ or ground).
   b) Connect the inverting pin (V_{IN-}) to the input with a wire that does not touch the PCB surface.

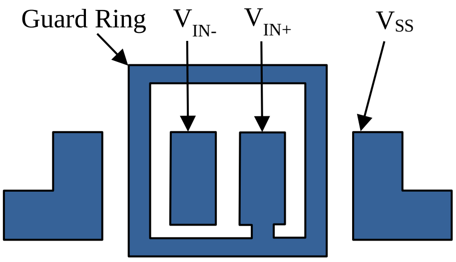


Figure 22. Example Guard Ring Layout for Inverting Gain

TYPICAL APPLICATION

Differential Amplifier

The circuit shown in Figure 23 performs the difference function. If the resistor ratios are equal to (R_4 / R_3 = R_2 / R_1), then V_{OUT} = (V_P - V_N) × R_2 / R_1 + V_{REF}.

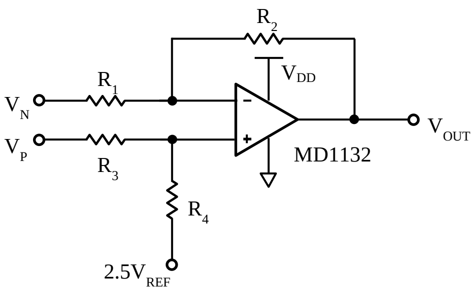


Figure 23. Differential Amplifier

Photodiode Application

The MD1131/2/4 have very high impedance with an input bias current typically around 100 pA. This characteristic allows the MD1131/2/4 op amp to be used in photodiode applications and other applications that require high input impedance. Note that the MD1131/2/4 have significant voltage offset that can be removed by capacitive coupling or software calibration.

Figure 24 illustrates a photodiode or current measurement application. The feedback resistor is limited to 10 MΩ to avoid excessive output offset. In addition, a resistor is not needed on the noninverting input to cancel bias current offset because the bias current-related output offset is not significant when compared to the voltage offset contribution. For best performance, follow the standard high impedance layout techniques, which include the following:

- Shielding the circuit.
- Cleaning the circuit board.
- Putting a trace connected to the noninverting input around the inverting input.
- Using separate analog and digital power supplies.

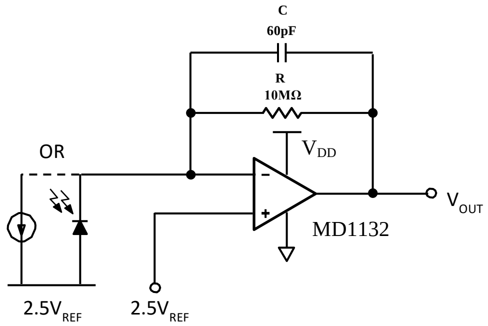


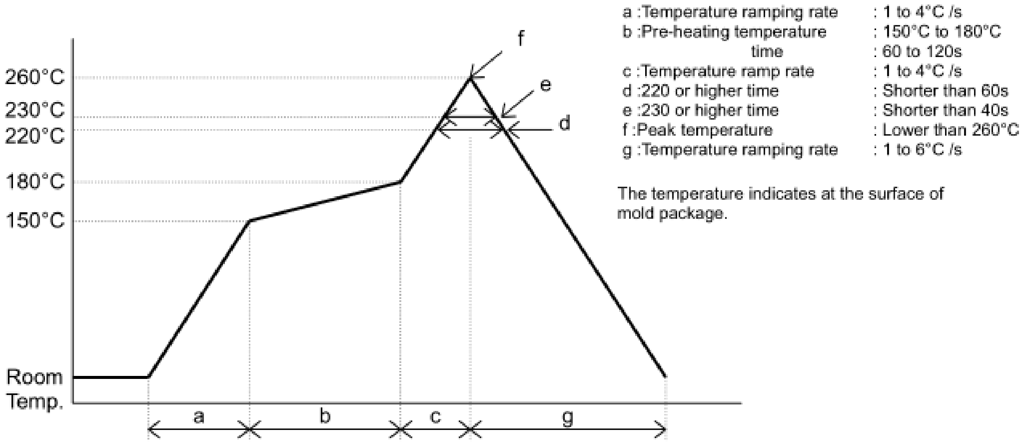
Figure 24. High Input Impedance Application—Photodiode Amplifier

RECOMMENDED MOUNTING METHOD

Soldering Methods, Recommended Soldering Method for Moisture-Proof Packing and Flux Cleaning are in the following Mounting was evaluated with the following profiles in our company, so there was no problem. However, confirm mounting by the condition of your company beforehand.

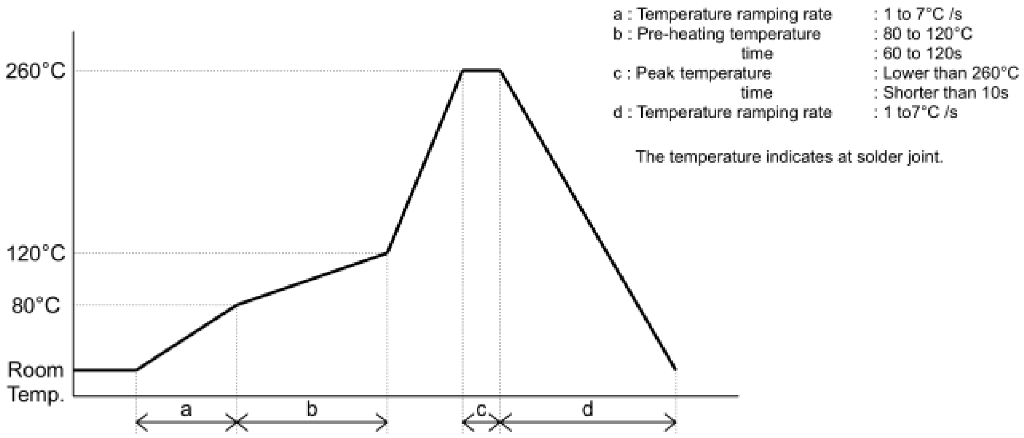
1. Soldering Temperature Profile of Reflow

   Recommended reflow soldering temperature profile is in the following



2. Soldering Temperature Profile of Flow

   Recommended flow soldering temperature profile is in the following.



3. Soldering Temperature Profile of Iron

   Recommended iron soldering temperature profile is in the following.

   At 1 lead Temperature: Lower than 350°C

   Time: within 3s

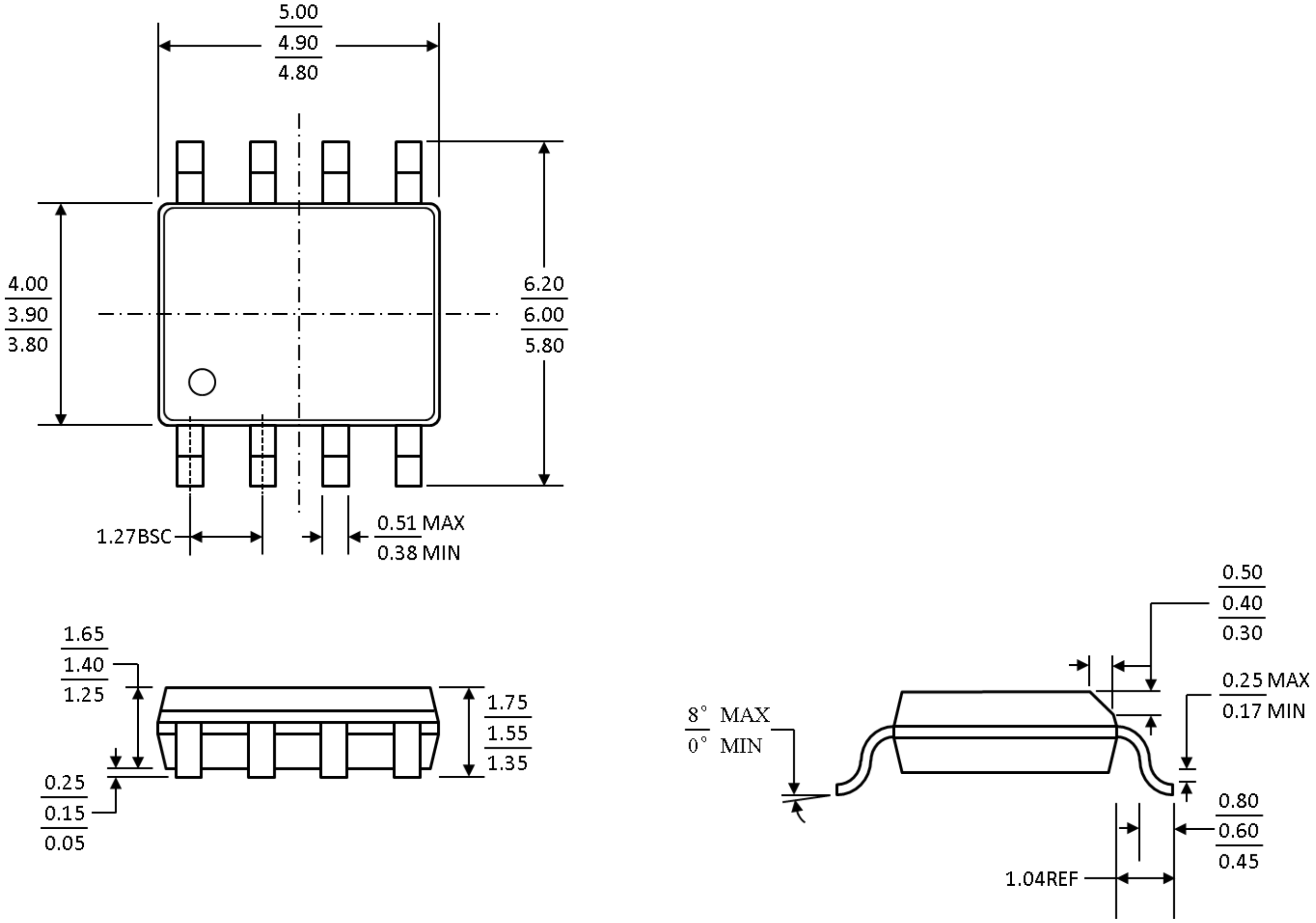
4. Note

It is not good for IC's reliability to keep IC high temperature for long time within limit of recommended ranges.

Please finish soldering as soon as possible within limit of recommended ranges.

See the next section, “IC storage Conditions and Duration” for Moisture-Proof Packing and Deaeration Packing.

PACKAGE OUTLINE DIMENSIONS

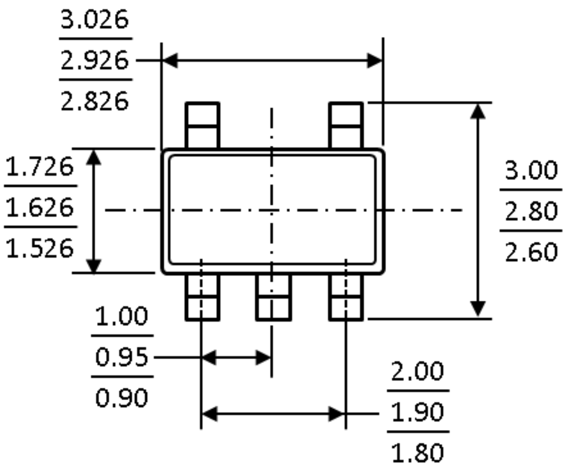


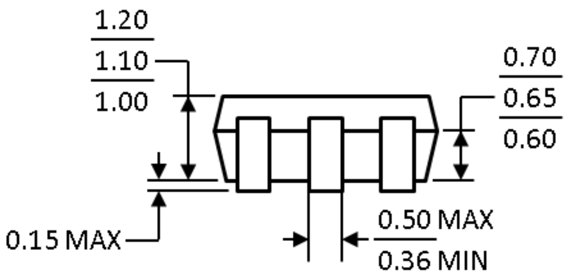
COMPLIANT TO JEDEC STANDARD MS-012-AA

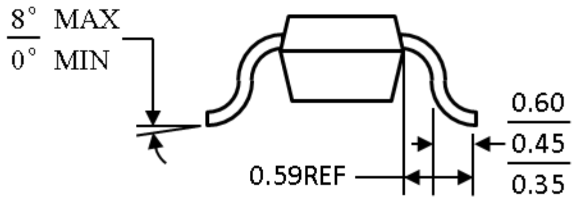
Figure 25 8-Lead Small Outline Package [SOP8]

Dimensions shown in millimeters

PACKAGE OUTLINE DIMENSIONS





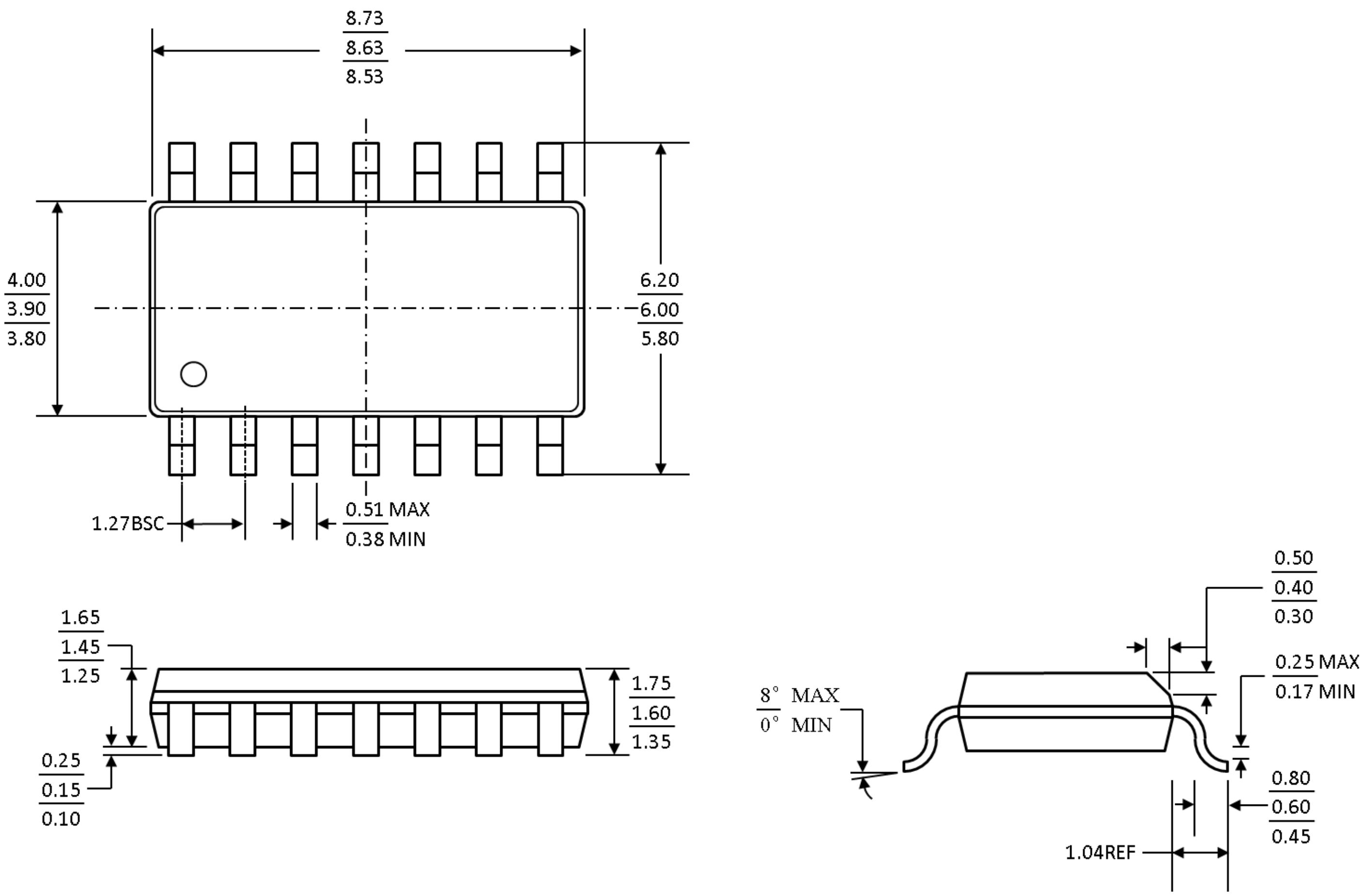


COMPLIANT TO JEDEC STANDARD MO-178-AA

Figure 26 5-Lead Small Outline Transistor Package [SOT-23]

Dimensions shown in millimeters

PACKAGE OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARD MS-012-AB

Figure 27 14-Lead Small Outline Package [SOP14]

Dimensions shown in millimeters