19-1743; Rev 0; 7/00

MAXIM

Ultra-High PSRR Stereo Drivers + Microphone Amp + 100mA Linear Regulators

General Description

The MAX4298 and MAX4299 are audio system ICs designed for single +5V applications. The MAX4299 features a stereo headphone driver, a microphone amplifier, and a +3.3V linear regulator; the MAX4298 features a stereo headphone driver. The MAX4298/MAX4299 are designed specifically for harsh digital environments where board space is at a premium and the digital power supply is noisy. The design uses innovative design techniques to achieve ultra-high power-supply rejection across the audio signal band while, at the same time, delivering a high-current Rail-to-Rail® output drive capability. The chip is designed to drive highly capacitive loads that may be encountered when driving long cables to a remote load such as desktop/notebook headphones or speakers. These devices are fully compliant with PC99 standards.

The amplifiers exhibit 115dB of DC power-supply rejection and 80dB at 100kHz. The output amplifiers are capable of driving a 1.5V_{RMS} signal into a 10kΩ load with 0.0008% THD+N. They can also drive 32Ω headphones to 1.2V_{RMS} with 0.02% distortion. At +3.3V, the linear regulator can output 100mA of current. The MAX4298 is available in a tiny 10-pin µMAX while the MAX4299 is available in the space-saving 16-pin TSSOP package.

Applications

Notebook and Desktop Audio Systems
Hands-Free Headsets
USB Audio Peripherals
IP Telephones
Wireless Internet Devices
MP3 Players/Recorders

Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.

Features

- **Audio System IC (MAX4299)**
  Ultra-High PSRR Stereo Headphone Driver
  Ultra-High PSRR Microphone Amp
  100mA, 3.3V Linear Regulator
- **93dB typ PSRR at 20kHz Operates Directly from Noisy Digital Supplies**
- **Clickless/Popless Power Up, Power Down, Mute and Unmute**
- **PC99 Compliant Output Drivers:**
  Better than 1V_{RMS} Output into 16Ω Load and 1.5V_{RMS} and 0.0008% THD+N into 10kΩ Load
- **PC99-Compliant Microphone Amplifier:**
  0.01% THD+N into 10kΩ Load
- **22nF Capacitive Load Drive Capability**
- **4.5V to 5.5V Single-Supply Operation**
- **Internally Generated Bias Voltage**
- **All Gains Externally Adjustable**
- **Available in Space-Saving Packages**
  10-Pin µMAX (MAX4298)
  16-Pin TSSOP (MAX4299)

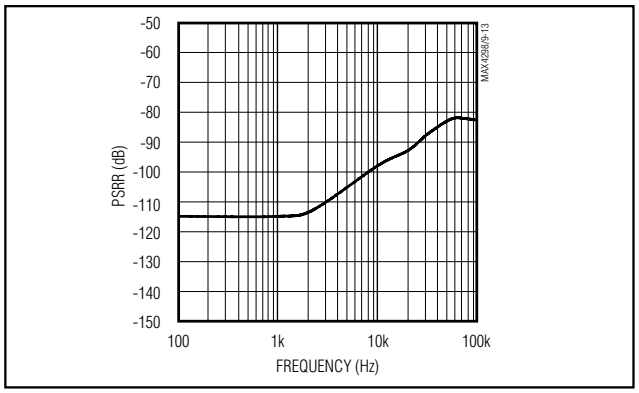
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4298EUB	-40°C to +85°C	10 µMAX
MAX4298ESD	-40°C to +85°C	14 SO
MAX4299ESE*	-40°C to +85°C	16 SO
MAX4299EUE*	-40°C to +85°C	16 TSSOP

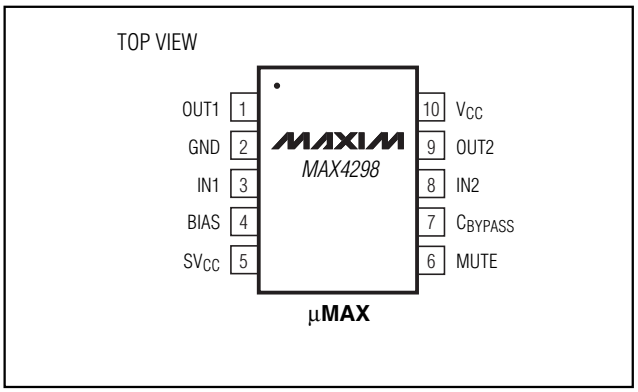
**Future product, available September 2000*

Typical Operating Circuit appears at end of data sheet.

PSRR vs. Frequency



Pin Configuration



Ultra-High PSRR Stereo Drivers + Microphone Amp + 100mA Linear Regulators

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC}) to GND .....+6V
Standby Supply Voltage (SV_{CC}) to GND.....+6V
REG, FB, REGON to GND.....-0.3V to (V_{CC} + 0.3V)
BIAS, C_{BYPASS}, MUTE, IN_, MICIN to GND
(0.3V to the larger of V_{CC} + 0.3V) and (SV_{CC} + 0.3V)
OUT_, MICOUT to GND to the smaller of.....-0.3V to +5.5V, -0.3V to (V_{CC} + 0.3V)
Duration of Output Short-Circuit to GND or V_{CC} 10min

Continuous Power Dissipation
10-Pin µMAX (derate 5.6 mW/°C above +70°C).....444 mW
14-Pin SO (derate 8.3 mW/°C above +70°C).....667 mW
16-Pin SO (derate 8.7 mW/°C above +70°C).....696 mW
16-Pin TSSOP (derate 9.4 mW/°C above +70°C).....755 mW
Operating Temperature Range .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

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.

ELECTRICAL CHARACTERISTICS

(V_{CC} = SV_{CC} = +5V, R_L = ∞ on all outputs, C_{BYPASS} = 1µF, C_{BIAS} = 1µF, C_{REG} = 10µF (MAX4299), T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Load resistors (R_L) are terminated in 2.25V. Typical values are at +25°C. Specifications apply to both MAX4298 and MAX4299, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}	Inferred from PSRR test	4.5		5.5	V
Quiescent Current	I_{CC}	MAX4298		9	17.5	mA
		MAX4299		9.7	18.0	
Mute Quiescent Current		MAX4298		9	17.5	mA
		MAX4299		9.7	18.0	
SV_{CC} Current (Note 2)	I_{SVCC}	V_{BIAS} = 1.125V, V_{CC} = 0		300	450	µA
		V_{BIAS} = 2.25V, V_{CC} = 5.0V		7		
DRIVER AMPLIFIERS						
Input Offset Voltage	V_{OS}			±3	±10	mV
Input Bias Current	I_{BIAS}			0.2		nA
Power-Supply Rejection Ratio	PSRR	DC, V_{CC} = 4.5V to 5.5V		115		dB
		f = 20kHz		93		
		f = 100kHz		80		
Output Drive	V_{OUT}	R_L = 10kΩ	1.45	1.59		V_{RMS}
		R_L = 32Ω	1.2	1.53		
		R_L = 16Ω	1.0	1.48		
THD + Noise		A_V = -1V/V, f = 1kHz, R_L = 10kΩ, V_{OUT} = 1.5V_{RMS}		0.0008		%
		A_V = -1V/V, f = 1kHz, R_L = 32Ω, V_{OUT} = 1.2V_{RMS}, (Note 3)		0.02	0.1	
		A_V = -1V/V, f = 1kHz, R_L = 16Ω, V_{OUT} = 1.0V_{RMS}		0.04		
Full-Scale Signal-to-Noise Ratio	(SNR)	R_L = 10kΩ, 20Hz to 20kHz, V_{OUT} = 1.06V_{RMS}, A_V = 1V/V		105		dB
Capacitive Drive				22		nF
Open-Loop Voltage Gain		R_L = 32Ω, 0.55V ≤ V_{OUT} ≤ V_{CC} - 0.55V	76	87		dB
Unity-Gain Bandwidth				1.3		MHz

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = SV_{CC} = +5V, R_L = ∞ on all outputs, C_{BYPASS} = 1µF, C_{BIAS} = 1µF, C_{REG} = 10µF (MAX4299), T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Load resistors (R_L) are terminated in 2.25V. Typical values are at +25°C. Specifications apply to both MAX4298 and MAX4299, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
BIAS VOLTAGE OUTPUT							
DC BIAS Voltage	V_{BIAS}	I_L = 0		2.13	2.25	2.37	V
Line Regulation					120		dB
Load Regulation		I_L = 0 to 1µA			50		mV
DIGITAL INPUTS (MUTE for MAX4298/4299, and REG_{ON} for MAX4299)							
Input Voltage High	V_{INH}			2.4			V
Input Voltage Low	V_{INL}					0.8	V
Input Leakage Current	I_{IN}	V_{IN} = 0 or V_{CC}				±1	µA
MICROPHONE AMPLIFIER (MAX4299 only)							
Input Offset Voltage	V_{OS}				±3	±10	mV
Input Bias Current	IBIAS				0.2		nA
Power-Supply Rejection Ratio	PSRR	DC, V_{CC} = 4.5V to 5.5V			115		dB
		f = 20kHz			93		
		f = 100kHz			80		
Voltage Gain	A_{VOL}	R_L = 10kΩ, 0.13V ≤ V_{MICOUT} ≤ V_{CC} - 0.13V		70	86		dB
Output Drive	V_{OUT}	R_L = 10kΩ		1.4	1.57		V_{RMS}
THD + Noise		f = 1kHz, R_L = 10kΩ	A_V = -1V/V		0.01		%
		V_{MICOUT} = 1.5V_{RMS}	A_V = -10V/V		0.05		
Full-Scale Signal-to-Noise Ratio	SNR	R_L = 10kΩ, 20Hz to 20kHz, V_{MICOUT} = 1.06V_{RMS}, A_V = -10V/V			80		dB
All-Hostile Crosstalk		f = 10kHz			80		dB
Unity Gain Bandwidth					1		MHz
REGULATOR (MAX4299 only)							
Regulator Output Voltage	V_{REG}	V_{CC} = 4.5V to 5.5V. I_L from 1mA to 100mA, using internal feedback		3.15	3.3	3.45	V
Line Regulation		V_{CC} = 4.5V to 5.5V, I_L = 50mA			0.1		mV
Load Regulation		I_L = 10mA to 100mA			20		mV
		I_L = 0 to 100mA			40		mV
FB Voltage	V_{FB}	Reference for regulator adjustment			1.233		mV

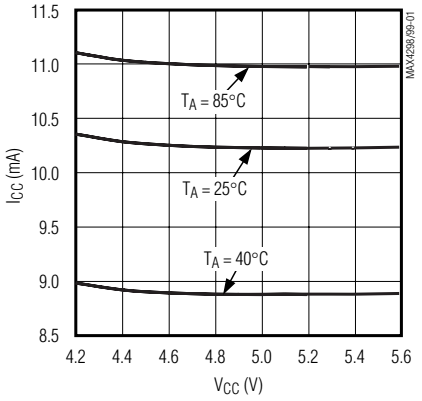
Note 1: All devices are 100% production tested at +25°C. All temperature limits are guaranteed by design.
Note 2: Current drawn from SV_{CC} when V_{CC} < 4V.
Note 3: Guaranteed by design.

Ultra-High PSRR Stereo Drivers + Microphone Amp + 100mA Linear Regulators

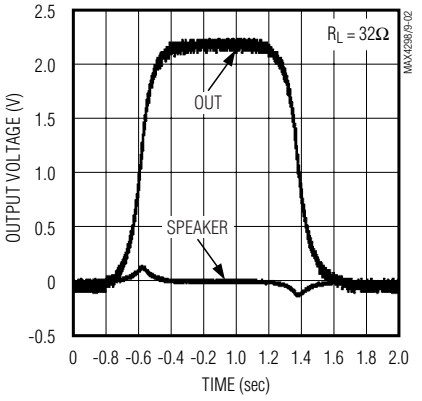
Typical Operating Characteristics

(V_{CC} = SV_{CC} = +5V, typical operating circuit, T_A = +25°C, unless otherwise noted.)

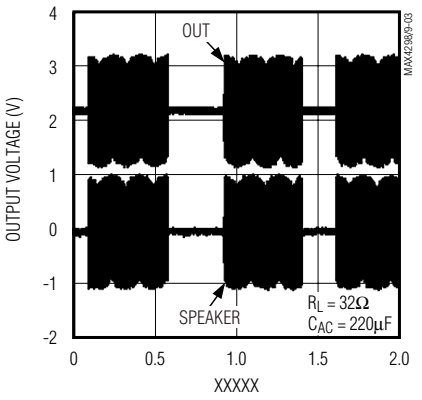
SUPPLY CURRENT vs. SUPPLY VOLTAGE



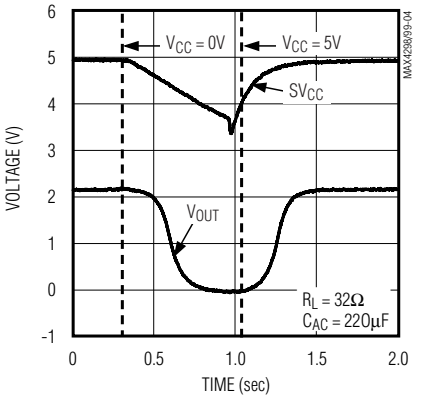
POWER-UP/POWER-DOWN



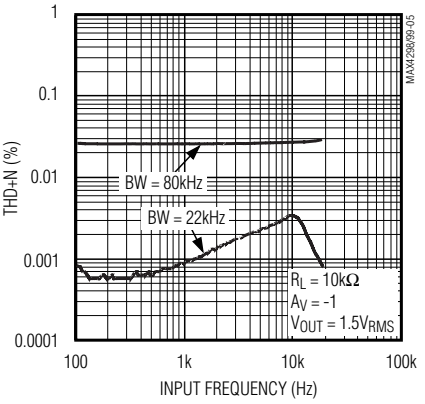
MUTE PERFORMANCE



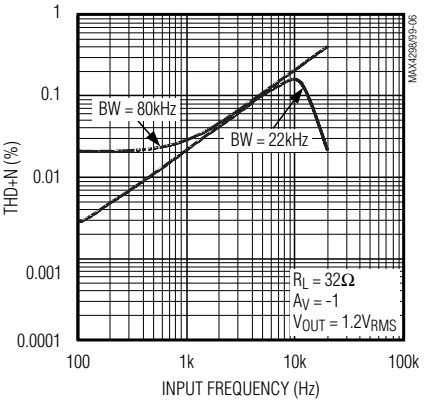
POWER-DOWN/POWER-UP with SCHOTTKY DIODE AND RESERVOIR CAPACITOR



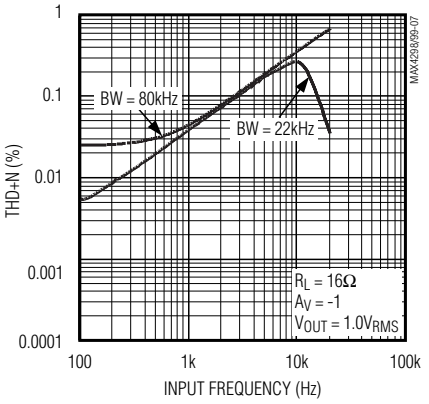
THD+N vs. FREQUENCY



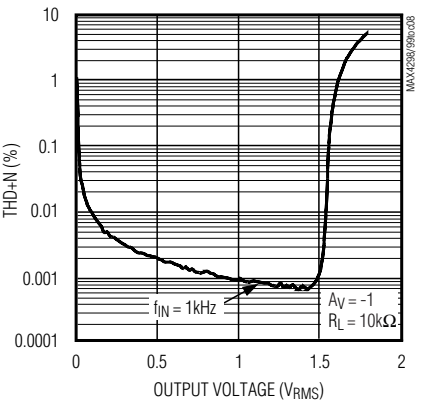
THD+N vs. FREQUENCY



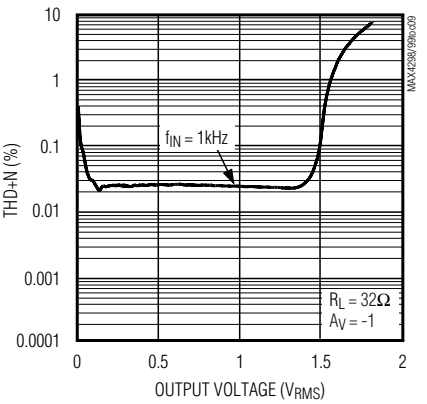
THD+N vs. FREQUENCY



THD+N vs. AMPLITUDE



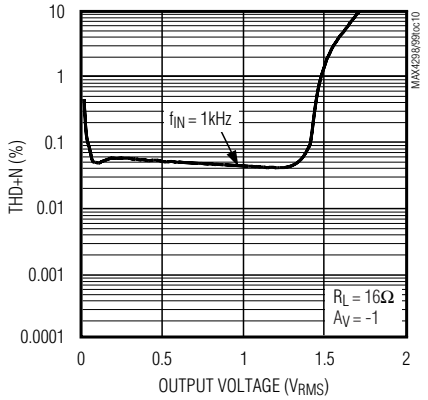
THD+N vs. AMPLITUDE



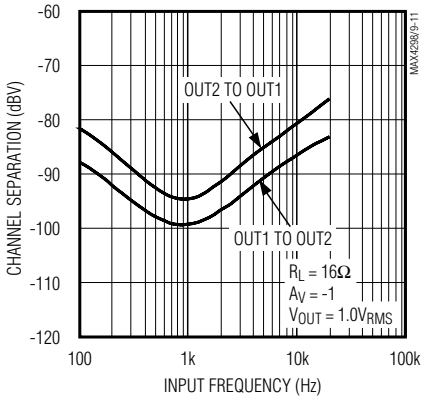
Typical Operating Characteristics (continued)

(V_{CC} = SV_{CC} = +5V, typical operating circuit, T_A = +25°C, unless otherwise noted.)

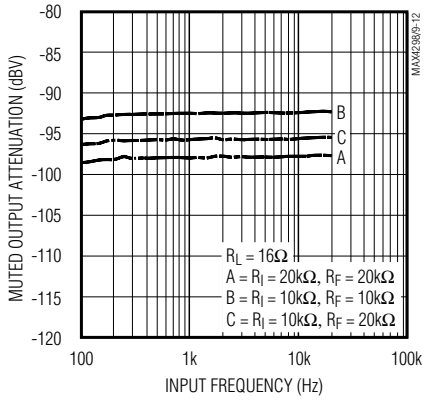
THD+N vs. AMPLITUDE



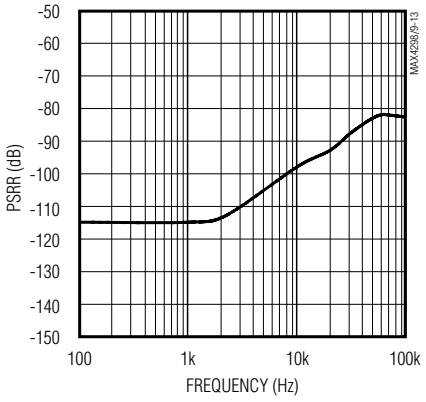
CHANNEL SEPARATION vs. INPUT FREQUENCY



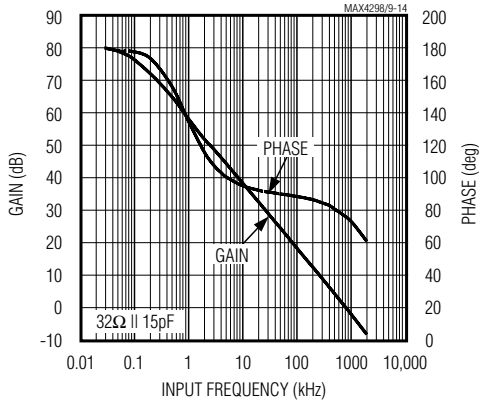
MUTED OUTPUT ATTENUATION vs. INPUT FREQUENCY



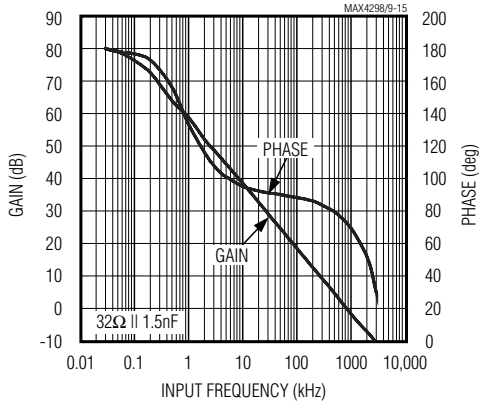
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



OPEN-LOOP FREQUENCY RESPONSE



OPEN-LOOP FREQUENCY RESPONSE

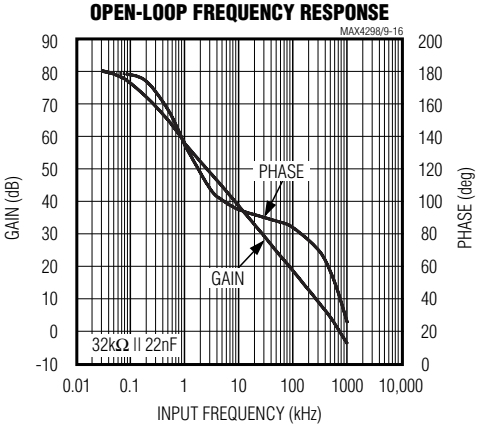


Ultra-High PSRR Stereo Drivers + Microphone Amp + 100mA Linear Regulators

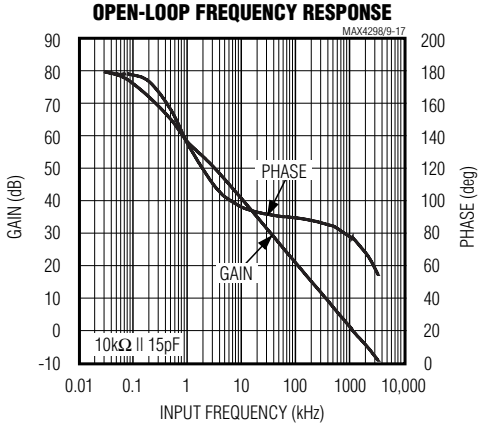
Typical Operating Characteristics (continued)

(V_{CC} = SV_{CC} = +5V, typical operating circuit, T_A = +25°C, unless otherwise noted.)

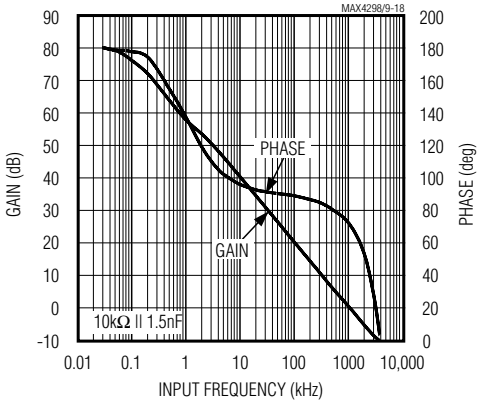
OPEN-LOOP FREQUENCY RESPONSE



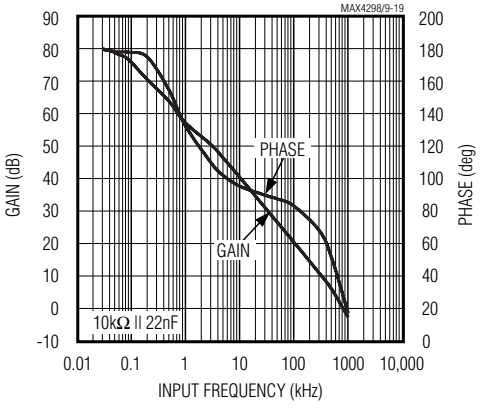
OPEN-LOOP FREQUENCY RESPONSE



OPEN-LOOP FREQUENCY RESPONSE



OPEN-LOOP FREQUENCY RESPONSE



Pin Description

PIN	NAME			FUNCTION
	MAX4298	MAX4298	MAX4299	
	10-PIN µMAX	14-PIN SO	16-PIN TSSOP/SO	
REG	—	—	1	Regulator Output. Bypass REG to GND with a 10µF capacitor.
FB	—	—	2	Regulator Feedback. Internal resistors from this point to REG and GND define the regulator output value. Adjustments can be made to the output value by adding resistors in the same place externally.
OUT1	1	2	3	Driver Amplifier Output
GND	2	3	4	Ground
IN1	3	4	5	Inverting input for driver amplifiers
BIAS	4	5	6	Bias point for amplifiers. Bypass BIAS to GND with a 1µF capacitor.
SV_{CC}	5	6	7	Standby Power Supply. Connect to a standby +5V supply that is always on, or bypass with 220µF and connect a Schottky diode from V_{CC} to SV_{CC}. Short to V_{CC} if clickless power-down is not essential.
MICOUT	—	—	8	Microphone Amplifier Output
MICIN	—	—	9	Inverting input for Microphone Amplifier
MUTE	6	9	10	Mute Digital Input. Connect to GND for normal operation. When MUTE is connected to V_{CC}, OUT1 and OUT2 are muted, REG stays on, and MICOUT stays on.
C_{BYPASS}	7	10	11	Bypass to GND with a 1µF capacitor.
IN2	8	11	12	Inverting input for driver amplifier
OUT2	9	12	13	Driver Amplifier Output
V_{CC}	10	13	14	Power Supply. Connect to +5V.
N.C.	—	1, 7, 8, 14	15	No Internal Connection.
REGON	—	—	16	Regulator Control. Connect to V_{CC} for normal operation. Connect to GND to shut off the regulator.

Detailed Description

The MAX4298/MAX4299 are audio system ICs designed for single +5V applications. The MAX4299 has a stereo headphone driver, a microphone amplifier, and a 100mA +3.3V linear regulator; the MAX4298 has the stereo headphone driver only. The MAX4298/MAX4299 are designed specifically for harsh digital environments where board space is at a premium and the digital power supply is noisy. The design uses innovative design techniques to achieve ultra-high power-supply rejection across the audio signal band while, at the same time, delivering a high current rail-to-rail output drive capability. These devices are designed to drive highly capacitive loads that may be encountered when driving long cables to a remote load such as desktop/notebook headphones or speakers. They are fully compliant to PC99 standards. Figure 1 is the MAX4298 block diagram and Figure 2 is the MAX4299 block diagram.

The amplifiers exhibit better than 115dB of DC power-supply rejection and 93dB at 20kHz. The output amplifiers are capable of driving a $1.5V_{RMS}$ signal into 10kΩ load with 0.0008% distortion. They can also drive 32Ω headphones to $1.2V_{RMS}$ with 0.02% distortion. At +3.3V, the linear regulator can output 100mA of current. The MAX4298 is available in a 10-pin µMAX package; the MAX4299 is available in a 16-pin TSSOP package.

Ultra-High PSRR Stereo Drivers + Microphone Amp + 100mA Linear Regulators

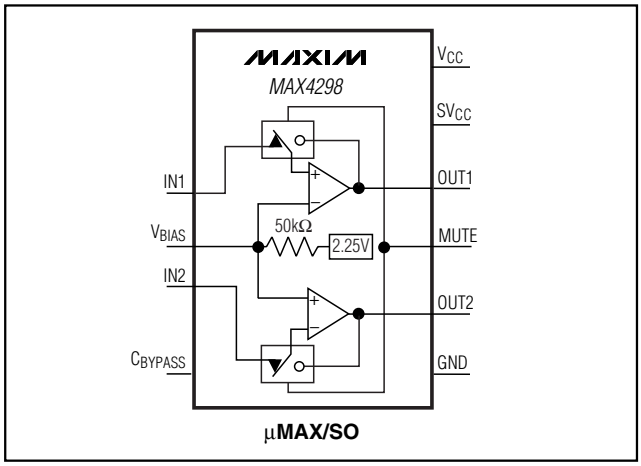


Figure 1. MAX4298 Block Diagram

BIAS

The common-mode bias point for the amplifiers is set to 2.25V by internal circuitry that has two functions. It provides a clickless/popless power-up/power-down waveform for the amplifiers. Also, it generates a ground-referenced bias voltage with ultra-high power-supply rejection ratio (PSRR). BIAS should be bypassed with 1µF to GND.The output impedance of the BIAS pin is 50kΩ.

Clickless/Popless Function

The MAX4298/MAX4299 are designed for high-fidelity audio performance into AC-coupled loads. Patented design techniques achieve a clickless/popless power-up sequence, and the use of a low-current standby supply (SV_{CC}) or external Schottky diode/reservoir capacitor combination allows clickless/popless power-down. A clickless/popless mute function is also provided to maintain a low impedance output when the input signal is switched off.

Mute Function

The MAX4298/MAX4299 have a MUTE pin that allows the user to mute the outputs of the device. This feature disconnects the input signal from the power amplifiers when a logic high is present at the MUTE pin. To ensure proper functionality, the MUTE pin should always be tied to either V_{CC} or GND. MUTE only affects the headphone driver outputs. REG, BIAS, and MICOUT are unaffected. OUT1 and OUT2 are muted, but remain in a low impedance state to ensure clickless/popless operation.

SVcc

The MAX4298/MAX4299 provide a fully clickless power-down sequence. SV_{CC} can either be connected to a low-current +5V power source or alternatively can be connected with a reservoir capacitor to ground and a Schottky diode to V_{CC}. A reservoir capacitor of 220µF or higher provides enough charge for the clickless power-down sequence when C_{BIAS} = 1µF. For larger values of C_{BIAS}, increase the reservoir capacitor accordingly. Short to V_{CC} if clickless power-down is not needed.

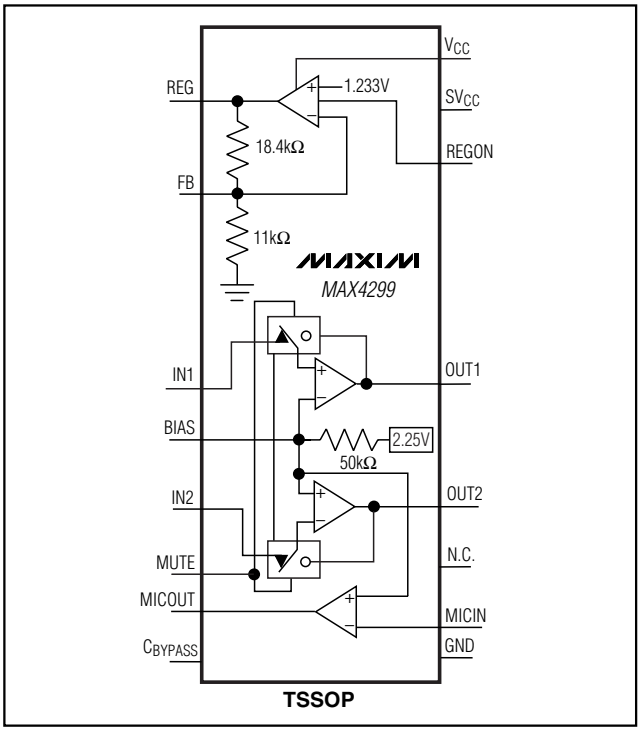


Figure 2. MAX4299 Block Diagram

Driver Amplifier

The headphone driver amplifier is a class AB amplifier designed to drive 16Ω loads. The amplifiers have innovative architectures for both the input and output stages to achieve ultra-high PSRR while maintaining rail-to-rail output drive capability. The output stage can drive high capacitive loads encountered when driving long cables used for desktop speakers or headphones.

Microphone Preamplifier (MAX4299)

The MAX4299 provides a microphone preamplifier that is a low-power version of the audio amplifier. It is intended to be used for low-level signal amplification. This microphone preamplifier provides rail-to-rail output with very high PSRR.

Regulator (MAX4299)

The MAX4299 also has an additional 100mA low-dropout (LDO) regulator to provide clean analog power for other sensitive analog circuitry on the PC board, such as a typical PC99 audio codec or microphone

biasing. It is designed to provide good AC line regulation. The nominal output voltage of REG is 3.3V, and is adjustable between 1.2V and 4.5V by connecting a resistor-divider from REG to GND. Connect FB to the junction of the resistor-divider. The input impedance at FB is typically 10kΩ, which should be considered in output voltage calculations. REG should be bypassed to GND with at least 10µF.

Applications Information

Capacitor Selection and Regulator Stability

Normally, use a 10µF capacitor on REG (MAX4299 only) and a 1µF capacitor on C_{BYPASS}. Larger capacitor values and lower ESRs provide better supply-noise rejection and line-transient response. Reduce noise and improve load-transient response, stability, and power-supply rejection by using larger capacitors. For stable operation over the full temperature range and load currents up to 100mA, a minimum of 10µF (REG) and 1µF (C_{BYPASS}) is recommended.

Use a 1µF bypass capacitor on BIAS to ensure a fully clickless/popless power-up sequence. Smaller capacitor values may be used here to decrease the power-up time, but may cause the power-up transient to become audible. Larger bypass capacitors are not necessary to reduce noise and/or improve AC power-supply rejection.

SV_{CC} is the standby power supply. If using an external diode for charging, a 220µF reservoir capacitor on SV_{CC} provides standby power for the clickless power-down sequence. Smaller capacitors here may cause an audible output transient on power-down; 220µF or higher provides enough energy when C_{BIAS} = 1µF. For larger values of C_{BIAS}, increase the reservoir capacitor accordingly.

Mic Biasing (MAX4299)

Common microphone elements require resistive biasing to power their internal circuitry. A 2kΩ resistor is typically used, and the microphone is AC-coupled to the microphone amplifier. If the microphone element allows low-voltage operation, biasing to the REG output provides excellent power-supply rejection.

Power Supply and Bypassing

The excellent PSRR of the MAX4298/MAX4299 allows them to operate from noisy power supplies. In most applications, a 0.1µF capacitor from V_{CC} to GND is sufficient. This bypass capacitor should be placed close to the V_{CC} pin.

Layout

Good layout improves performance by decreasing the amount of stray capacitance and noise at the power amplifier's inputs and output. To decrease stray capacitance, minimize PC board trace lengths and resistor leads, and place external components as close to the pins as possible.

Power Dissipation

The first equation below indicates the maximum power dissipation point for a package that has two power amplifiers operating at identical known supply voltages and loads with sine wave inputs:

$$P_{IC(DISS)} = (V_{CC})^2 / (\pi^2 R_L) \quad [W]$$

For example, with a 5V power supply and a load of 16Ω, the maximum power dissipation of the amplifiers alone is 317mW.

The additional power dissipation due to the 100mA regulator operating at maximum current is nominally 170mW, but will increase if the output is reduced externally from its nominal 3.3V. The regulator power consumption is given by:

$$P_{REG} = (V_{CC} - V_{REG}) \times 100mA \quad [W]$$

To avoid thermal shutdown the sum of the regulator and amplifier power dissipation must not exceed the absolute maximum power-dissipation rating of the package.

Short-Circuit Protection and Thermal Shutdown

The MAX4298/MAX4299 have short-circuit current protection on all outputs. They also have a thermal shutdown function designed to protect the chip from junction temperatures in excess of +150°C that may arise from temporary short circuits or operation beyond the power dissipation limit of the package. The driver amplifier outputs limit at around ±220mA, the regulator at 150mA, and the microphone amplifier at +1.5mA/-12mA.

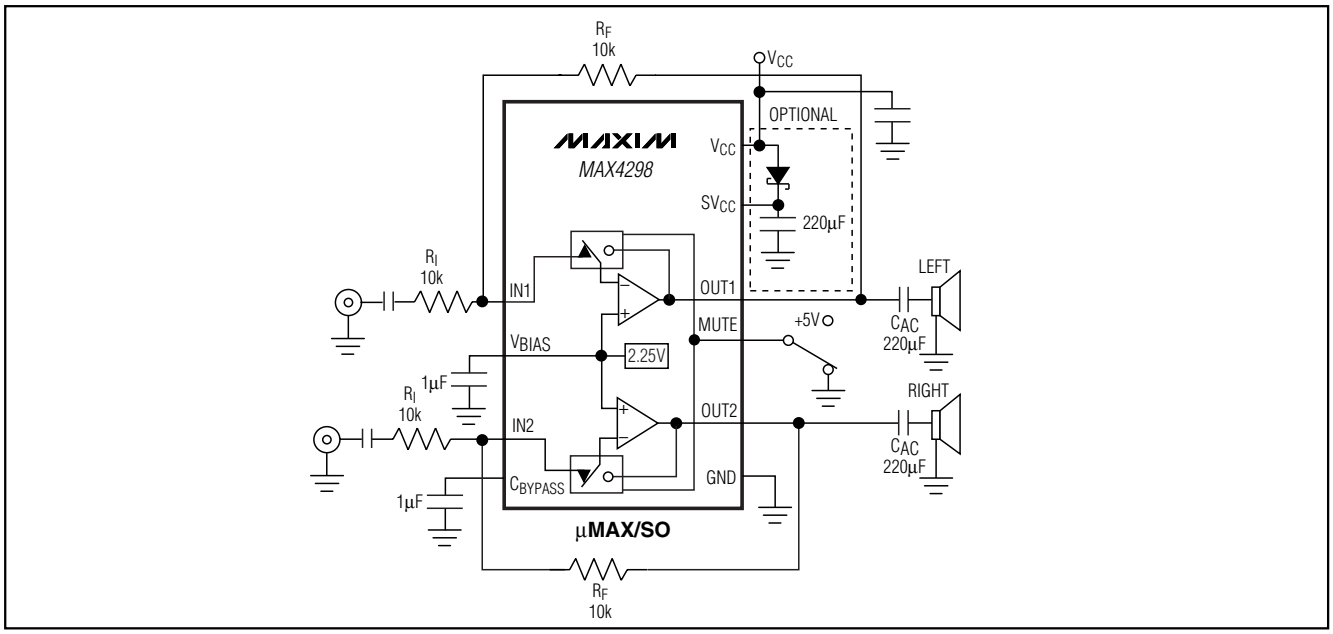
USB Applications

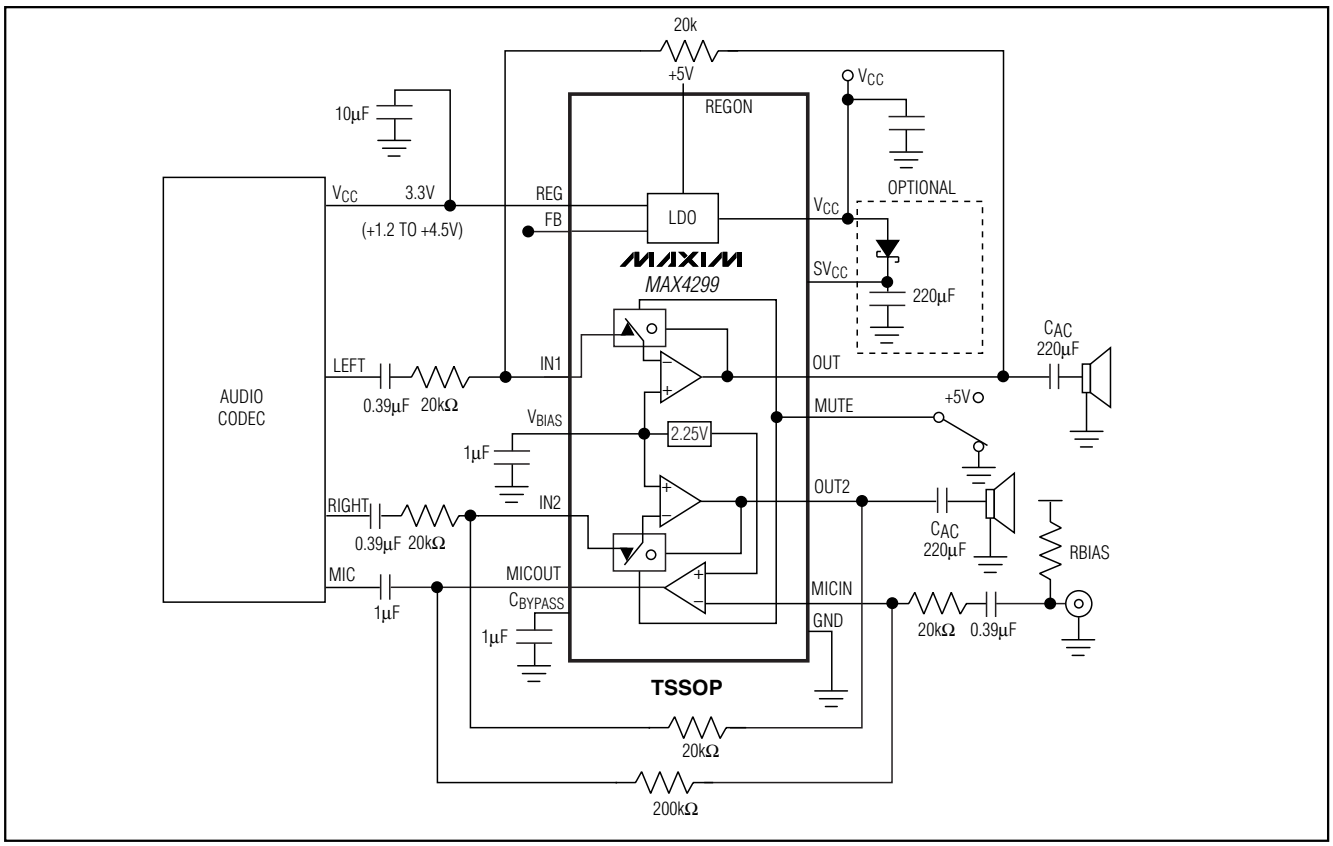
Universal serial bus (USB) interfaces are an increasingly popular method of interfacing medium-speed (up to 12Mbps) PC peripherals. One of the great benefits of the USB interface is the inclusion of a +5V supply. While this supply works well for a mouse or keyboard, its susceptibility tor noise pickup can be unsuitable for high-fidelity audio applications. The MAX4298/ MAX4299s' excellent PSRR make them ideal candidates for USB applications due to their insensitivity to the supply noise.

Of particular interest is an Internet-Protocol (IP) phone. This PC peripheral uses the local internet service provider as a free long-distance phone. The MAX4299, with its integral microphone amp, headphone driver,

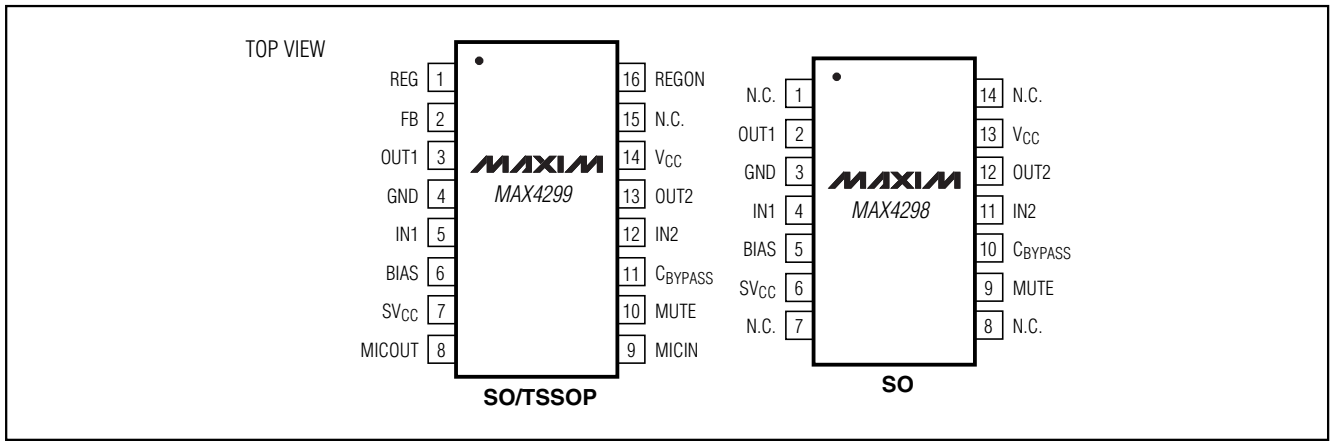
Ultra-High PSRR Stereo Drivers + Microphone Amp + 100mA Linear Regulators

Typical Operating Circuits





Pin Configurations (continued)



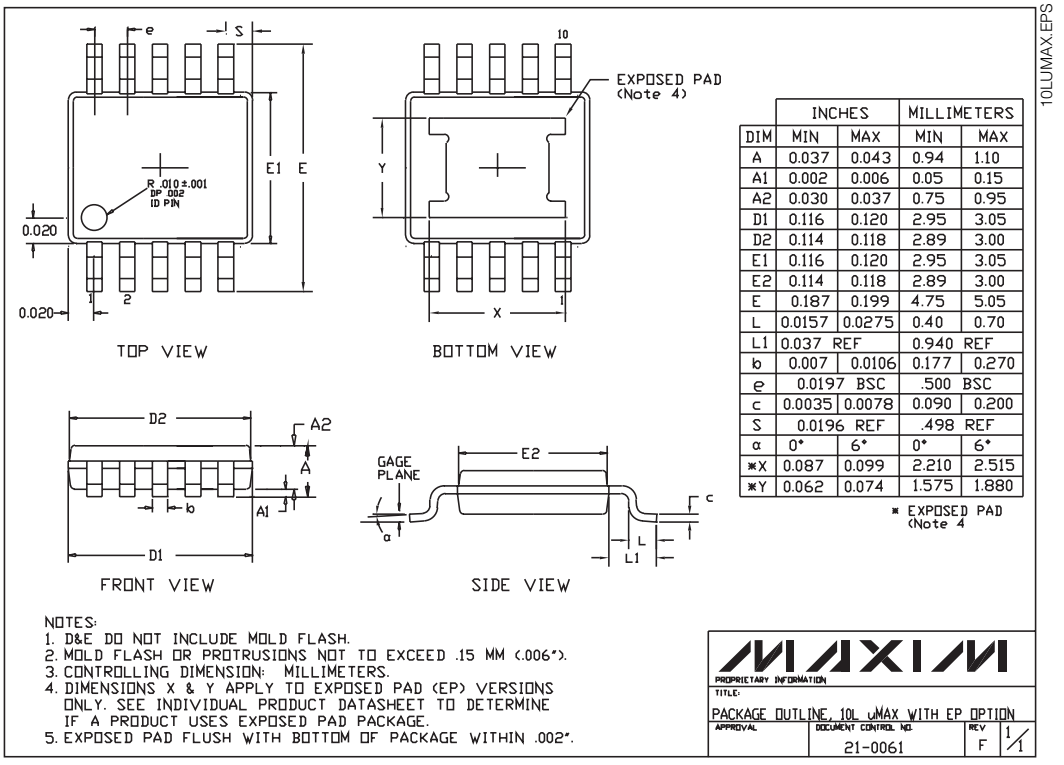
Chip Information

TRANSISTOR COUNT: MAX4298: 760

MAX4299: 905

PROCESS: BiCMOS

Package Information



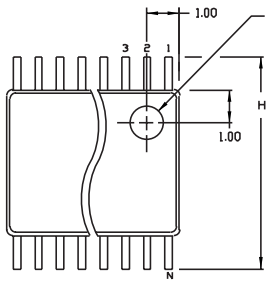
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.037	0.043	0.94	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
D1	0.116	0.120	2.95	3.05
D2	0.114	0.118	2.89	3.00
E1	0.116	0.120	2.95	3.05
E2	0.114	0.118	2.89	3.00
E	0.187	0.199	4.75	5.05
L	0.0157	0.0275	0.40	0.70
L1	0.037 REF		0.940 REF	
b	0.007	0.0106	0.177	0.270
e	0.0197 BSC		.500 BSC	
c	0.0035	0.0078	0.090	0.200
S	0.0196 REF		.498 REF	
α	0°	6°	0°	6°
*X	0.087	0.099	2.210	2.515
*Y	0.062	0.074	1.575	1.880

* EXPOSED PAD (Note 4

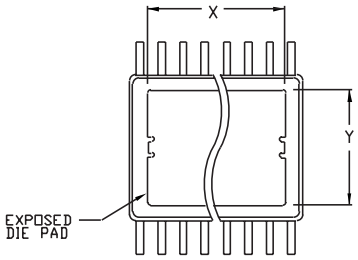
Ultra-High PSRR Stereo Drivers + Microphone Amp + 100mA Linear Regulators

Package Information

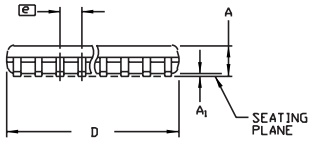
TSSOP.EPS



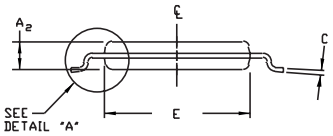
TOP VIEW



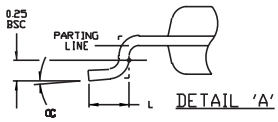
BOTTOM VIEW



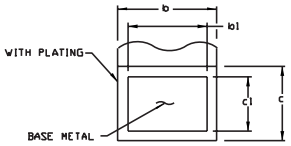
SIDE VIEW



END VIEW



DETAIL 'A'



LEAD TIP DETAIL

SYMBOL	COMMON DIMENSIONS			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	----	1.10		.043
A_1	0.05	0.15	.002	.006
A_2	0.85	0.95	.033	.037
b	0.19	0.30	.007	.012
b1	0.19	0.25	.007	.010
c	0.090	0.20	.0035	.008
c1	0.090	0.135	.0035	.0053
D	SEE VARIATIONS		SEE VARIATIONS	
E	4.30	4.50	.169	.177
e	0.65 BSC		.026 BSC	
H	6.25	6.50	.246	.256
L	0.50	0.70	.020	.028
N	SEE VARIATIONS		SEE VARIATIONS	
Y	2.85	3.15	.112	.124
α	0°	8°	0°	8°

JEDEC			VARIATIONS			
MO-153	N		MILLIMETERS		INCHES	
			MIN.	MAX.	MIN.	MAX.
AB	14	D	4.90	5.10	.193	.201
AC	16	D	4.90	5.10	.193	.201
AC-EP	16	D	4.90	5.10	.193	.201
		X	2.85	3.15	.112	.124
AD	20	D	6.40	6.60	.252	.260
AD-EP	20	D	6.40	6.60	.252	.260
		X	4.00	4.34	.157	.171
AE	24	D	7.70	7.90	.303	.311
AF	28	D	9.60	9.80	.378	.386
AF-EP		D	9.60	9.80	.378	.386
		X	5.35	5.65	.211	.222

NOTES:
1. DIMENSIONS D AND E DO NOT INCLUDE FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 mm PER SIDE.
3. CONTROLLING DIMENSION: MILLIMETER.
4. MEETS JEDEC OUTLINE MO-153 VARIATIONS AB, AC, AD, AE, AF.
5. DIMENSIONS X AND Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY.
6. EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

MAXIM
PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, TSSOP, 4.40mm BODY, 0.65mm PITCH

APPROVAL	DOCUMENT CONTROL NO.	REV	
	21-0066	C	1/1