LM7332

LM7332 Dual Rail-to-Rail Input/Output 30V, Wide Voltage Range, High Output Operational Amplifier

Literature Number: SNOSAV4

National Semiconductor

April 16, 2008

LM7332 Dual Rail-to-Rail Input/Output 30V, Wide Voltage Range, High Output Operational Amplifier

General Description

The LM7332 is a dual rail-to-rail input and output amplifier with a wide operating temperature range (−40°C to +125°C) which meets the needs of automotive, industrial and power supply applications. The LM7332 has the output current of 100 mA which is higher than that of most monolithic op amps. Circuit designs with high output current requirements often need to use discrete transistors because many op amps have low current output. The LM7332 has enough current output to drive many loads directly, saving the cost and space of the discrete transistors.

The exceptionally wide operating supply voltage range of 2.5V to 32V alleviates any concerns over functionality under extreme conditions and offers flexibility of use in a multitude of applications. Most of this device's parameters are insensitive to power supply variations; this design enhancement is another step in simplifying usage. Greater than rail-to-rail input common mode voltage range allows operation in many applications, including high side and low side sensing, without exceeding the input range.

The LM7332 can drive unlimited capacitive loads without oscillations.

The LM7332 is offered in the 8-pin MSOP and SOIC packages.

Features

(V_S = ±15V, T_A = 25°C, typical values unless specified.)

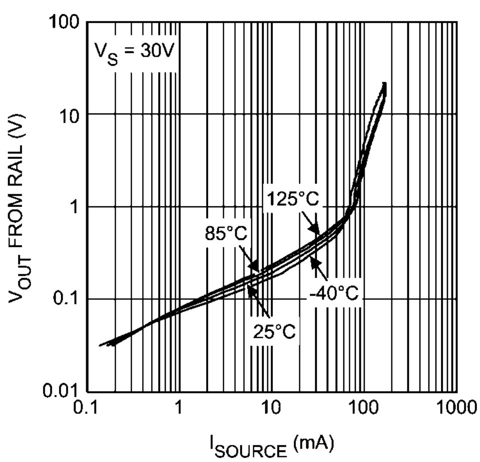
- Wide supply voltage range 2.5V to 32V
- Wide input common mode voltage 0.3V beyond rails
- Output short circuit current >100 mA
- High output current (1V from rails) ±70 mA
- GBWP 21 MHz
- Slew rate 15.2 V/μs
- Capacitive load tolerance Unlimited
- Total supply current 2.0 mA
- Temperature range −40°C to +125°C
- Tested at −40°C, +125°C, and 25°C at 5V, ±5V, ±15V

Applications

- MOSFET and power transistor driver
- Replaces discrete transistors in high current output circuits
- Instrumentation 4-20 mA current loops
- Analog data transmission
- Multiple voltage power supplies and battery chargers
- High and low side current sensing
- Bridge and sensor driving
- Digital to analog converter output

Key Graphs

Output Swing vs. Sourcing Current



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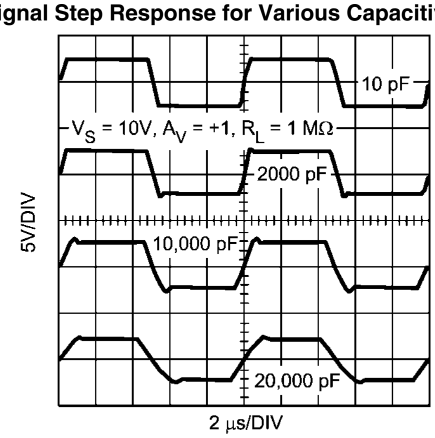
Large Signal Step Response for Various Capacitive Loads



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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

ESD Tolerance (Note 2)	
Human Body Model	2 kV
Machine Model	200V
V_{IN} Differential	±10V
Output Short Circuit Duration	(Notes 3, 9)
Supply Voltage (V_S = V+ - V−)	35V
Voltage at Input/Output pins	V+ +0.3V, V− −0.3V
Storage Temperature Range	−65°C to +150°C
Junction Temperature (Note 4)	+150°C
Soldering Information:	
Infrared or Convection (20 sec.)	235°C
Wave Soldering (10 sec.)	260°C

Operating Ratings

Supply Voltage (V_S = V+ - V−)	2.5V to 32V
Temperature Range(Note 4)	−40°C to +125°C
Package Thermal Resistance, θ_{JA}, (Note 4)	
8-Pin MSOP	235°C/W
8-Pin SOIC	165°C/W

5V Electrical Characteristics (Note 5)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V+ = 5V, V− = 0V, V_{CM} = 0.5V, V_O = 2.5V, and R_L > 1 MΩ to 2.5V. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Condition	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
V_{OS}	Input Offset Voltage	V_{CM} = 0.5V and V_{CM} = 4.5V	−4 **−5**	±1.6	+4 **+ 5**	mV
TC V_{OS}	Input Offset Voltage Temperature Drift	V_{CM} = 0.5V and V_{CM} = 4.5V (Note 10)		±2		μV/°C
I_B	Input Bias Current	(Note 11)	−2.0 **−2.5**	±1.0	+2.0 **+2.5**	μA
I_{OS}	Input Offset Current			20	250 **300**	nA
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 3V	67 **65**	80		dB
		0V ≤ V_{CM} ≤ 5V	62 **60**	70		
PSRR	Power Supply Rejection Ratio	5V ≤ V+ ≤ 30V	78 **74**	100		dB
CMVR	Input Common Mode Voltage Range	CMRR > 50 dB		−0.3	−0.1 **0.0**	V
			5.1 **5.0**	5.3		
A_{VOL}	Large Signal Voltage Gain	0.5V ≤ V_O ≤ 4.5V R_L = 10 kΩ to 2.5V	70 **65**	77		dB
V_O	Output Swing High	R_L = 10 kΩ to 2.5V V_{ID} = 100 mV		60	150 **200**	mV from either rail
		R_L = 2 kΩ to 2.5V V_{ID} = 100 mV		100	300 **350**	
	Output Swing Low	R_L = 10 kΩ to 2.5V V_{ID} = −100 mV		5	150 **200**	
		R_L = 2 kΩ to 2.5V V_{ID} = −100 mV		20	300 **350**	
I_{SC}	Output Short Circuit Current	Sourcing from V+, V_{ID} = 200 mV (Note 9)	60	90		mA
		Sinking to V−, V_{ID} = −200 mV (Note 9)	60	90		
I_{OUT}	Output Current	V_{ID} = ±200 mV, V_O = 1V from rails		±55		mA

Symbol	Parameter	Condition	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
I_S	Total Supply Current	No Load, V_{CM} = 0.5V		1.5	2.3 **2.6**	mA
SR	Slew Rate (Note 8)	A_V = +1, V_I = 5V Step, R_L = 1 MΩ, C_L = 10 pF		12		V/μs
f_u	Unity Gain Frequency	R_L = 10 MΩ, C_L = 20 pF		7.5		MHz
GBWP	Gain Bandwidth Product	f = 50 kHz		19.3		MHz
e_n	Input Referred Voltage Noise	f = 2 kHz		14.8		$nV/\sqrt{Hz}$
i_n	Input Referred Current Noise	f = 2 kHz		1.35		$pA/\sqrt{Hz}$
THD+N	Total Harmonic Distortion +Noise	A_V = +2, R_L = 100 kΩ, f = 1 kHz, V_O = 4 V_{PP}		−84		dB
CT Rej.	Crosstalk Rejection	f = 3 MHz, Driver R_L = 10 kΩ		68		dB

±5V Electrical Characteristics (Note 5)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = +5V, V^- = −5V, V_{CM} = 0V, V_O = 0V, and R_L > 1 MΩ to 0V. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Condition	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
V_{OS}	Input Offset Voltage	V_{CM} = −4.5V and V_{CM} = 4.5V	−4 **−5**	±1.6	+4 **+5**	mV
TC V_{OS}	Input Offset Voltage Temperature Drift	V_{CM} = −4.5V and V_{CM} = 4.5V (Note 10)		±2		μV/°C
I_B	Input Bias Current	(Note 11)	−2.0 **−2.5**	±1.0	+2.0 **+2.5**	μA
I_{OS}	Input Offset Current			20	250 **300**	nA
CMRR	Common Mode Rejection Ratio	−5V ≤ V_{CM} ≤ 3V	74 **75**	88		dB
		−5V ≤ V_{CM} ≤ 5V	70 **65**	74		
PSRR	Power Supply Rejection Ration	5V ≤ V^+ ≤ 30V, V_{CM} = −4.5V	78 **74**	100		dB
CMVR	Input Common Mode Voltage Range	CMRR > 50 dB		−5.3	−5.1 **−5**	V
			5.1 **5.0**	5.3		
A_{VOL}	Large Signal Voltage Gain	−4V ≤ V_O ≤ 4V R_L = 10 kΩ to 0V	72 **70**	80		dB
V_O	Output Swing High	R_L = 10 kΩ to 0V V_{ID} = 100 mV		75	250 **300**	mV from either rail
		R_L = 2 kΩ to 0V V_{ID} = 100 mV		125	350 **400**	
	Output Swing Low	R_L = 10 kΩ to 0V V_{ID} = −100 mV		10	250 **300**	
		R_L = 2 kΩ to 0V V_{ID} = −100 mV		30	350 **400**	
I_{SC}	Output Short Circuit Current	Sourcing from V^+, V_{ID} = 200 mV (Note 9)	90	120		mA
		Sinking to V^-, V_{ID} = −200 mV (Note 9)	90	100		

Symbol	Parameter	Condition	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
I_{OUT}	Output Current	V_{ID} = ±200 mV, V_O = 1V from rails		±65		mA
I_S	Total Supply Current	No Load, V_{CM} = –4.5V		1.5	2.4 **2.6**	mA
SR	Slew Rate (Note 8)	A_V = +1, V_I = 8V Step, R_L = 1 MΩ, C_L = 10 pF		13.2		V/μs
R_{OUT}	Close Loop Output Resistance	A_V = +1, f = 100 kHz		3		Ω
f_u	Unity Gain Frequency	R_L = 10 MΩ, C_L = 20 pF		7.9		MHz
GBWP	Gain Bandwidth Product	f = 50 kHz		19.9		MHz
e_n	Input Referred Voltage Noise	f = 2 kHz		14.7		$nV/\sqrt{Hz}$
i_n	Input Referred Current Noise	f = 2 kHz		1.3		$pA/\sqrt{Hz}$
THD+N	Total Harmonic Distortion +Noise	A_V = +2, R_L = 100 kΩ, f = 1 kHz V_O = 8 V_{PP}		–87		dB
CT Rej.	Crosstalk Rejection	f = 3 MHz, Driver R_L = 10 kΩ		68		dB

±15V Electrical Characteristics (Note 5)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = +15V, V^- = –15V, V_{CM} = 0V, V_O = 0V, and R_L > 1 MΩ to 0V. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Condition	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
V_{OS}	Input Offset Voltage	V_{CM} = –14.5V and V_{CM} = 14.5V	–5 **–6**	±2	+5 **+6**	mV
TC V_{OS}	Input Offset Voltage Temperature Drift	V_{CM} = –14.5V and V_{CM} = 14.5V (Note 10)		±2		μV/°C
I_B	Input Bias Current	(Note 11)	–2.0 **–2.5**	±1.0	+2.0 **+2.5**	μA
I_{OS}	Input Offset Current			20	250 **300**	nA
CMRR	Common Mode Rejection Ratio	–15V ≤ V_{CM} ≤ 12V	74 **74**	88		dB
		–15V ≤ V_{CM} ≤ 15V	72 **72**	80		dB
PSRR	Power Supply Rejection Ratio	–10V ≤ V^+ ≤ 15V, V_{CM} = –14.5V	78 **74**	100		dB
CMVR	Input Common Mode Voltage Range	CMRR > 50 dB		–15.3	–15.1 **–15**	V
			15.1 **15**	15.3		V
A_{VOL}	Large Signal Voltage Gain	–14V ≤ V_O ≤ 14V R_L = 10 kΩ to 0V	72 **70**	80		dB
V_O	Output Swing High	R_L = 10 kΩ to 0V V_{ID} = 100 mV		100	350 **400**	mV from either rail
		R_L = 2 kΩ to 0V V_{ID} = 100 mV		200	550 **600**	mV from either rail
	Output Swing Low	R_L = 10 kΩ to 0V V_{ID} = –100 mV		20	450 **500**	mV from either rail
		R_L = 2 kΩ to 0V V_{ID} = –100 mV		25	550 **600**	mV from either rail

Symbol	Parameter	Condition	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
I_{SC}	Output Short Circuit Current	Sourcing from V^+, V_{ID} = 200 mV (Note 9)		140		mA
		Sinking to V^-, V_{ID} = −200 mV (Note 9)		140		
I_{OUT}	Output Current	V_{ID} = ±200 mV, V_O = 1V from rails		±70		mA
I_S	Total Supply Current	No Load, V_{CM} = −14.5V		2.0	2.5 **3.0**	mA
SR	Slew Rate (Note 8)	A_V = +1, V_I = 20V Step, R_L = 1 MΩ, C_L = 10 pF		15.2		V/μs
f_u	Unity Gain Frequency	R_L = 10 MΩ, C_L = 20 pF		9		MHz
GBWP	Gain Bandwidth Product	f = 50 kHz		21		MHz
e_n	Input Referred Voltage Noise	f = 2 kHz		15.5		$nV/\sqrt{Hz}$
i_n	Input Referred Current Noise	f = 2 kHz		1		$pA/\sqrt{Hz}$
THD+N	Total Harmonic Distortion +Noise	A_V = +2, R_L = 100 kΩ, f = 1 kHz V_O = 25 V_{PP}		−93		dB
CT Rej.	Crosstalk Rejection	f = 3 MHz, Driver R_L = 10 kΩ		68		dB

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Rating indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

Note 2: Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC) Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).

Note 3: Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C.

Note 4: The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA}. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/ \theta_{JA}$. All numbers apply for packages soldered directly onto a PC Board.

Note 5: Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$.

Note 6: Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

Note 7: All limits are guaranteed by testing or statistical analysis.

Note 8: Slew rate is the slower of the rising and falling slew rates. Connected as a Voltage Follower.

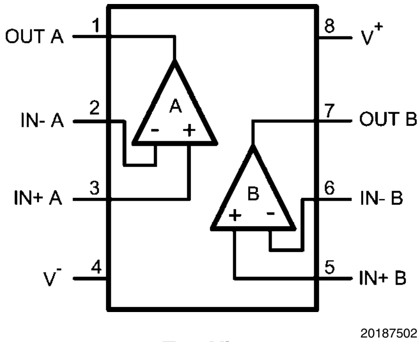
Note 9: Short circuit test is a momentary test. Output short circuit duration is infinite for $V_S \leq 6V$ at room temperature and below. For $V_S > 6V$, allowable short circuit duration is 1.5 ms.

Note 10: Offset voltage temperature drift determined by dividing the change in V_{OS} at temperature extremes into the total temperature change.

Note 11: Positive current corresponds to current flowing in the device.

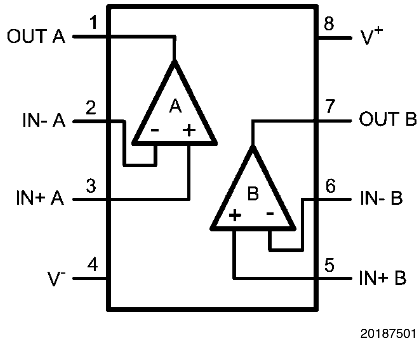
Connection Diagrams

8-Pin MSOP



Top View

8-Pin SOIC

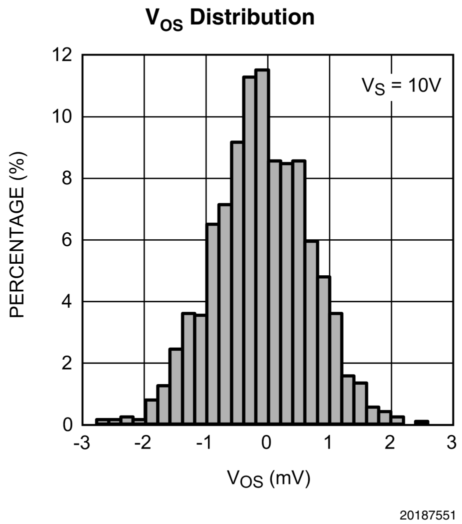


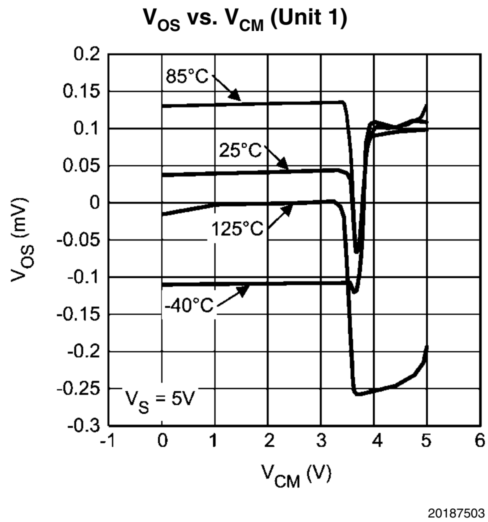
Top View

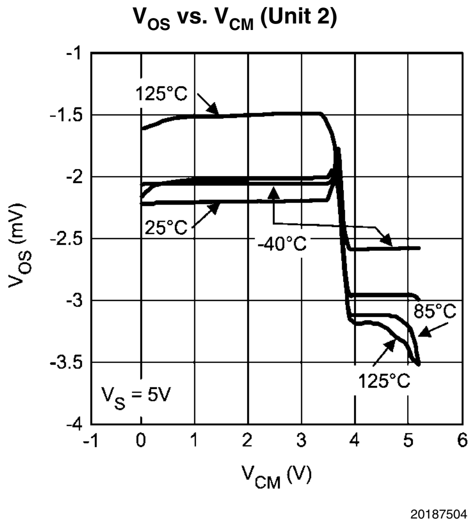
Ordering Information

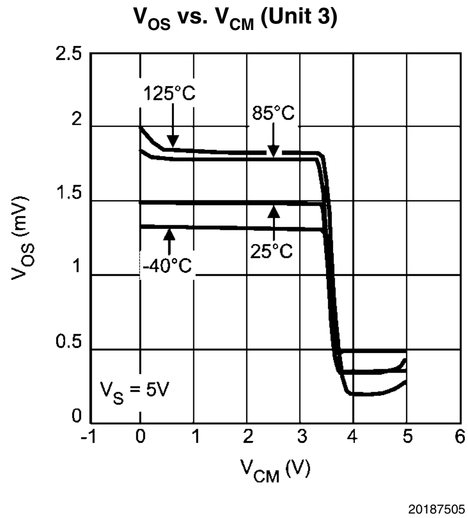
Package	Part Number	Package Marking	Transport Media	NSC Drawing
8-Pin MSOP	LM7332MM	AA5A	1k Unit Tape and Reel	MUA08A
	LM7332MME		250 Units Tape and Reel	
	LM7332MMX		3.5k Unit Tape and Reel	
8-Pin SOIC	LM7332MA	LM7332MA	95 Units/Rail	M08A
	LM7332MAX		2.5k Unit Tape and Reel	

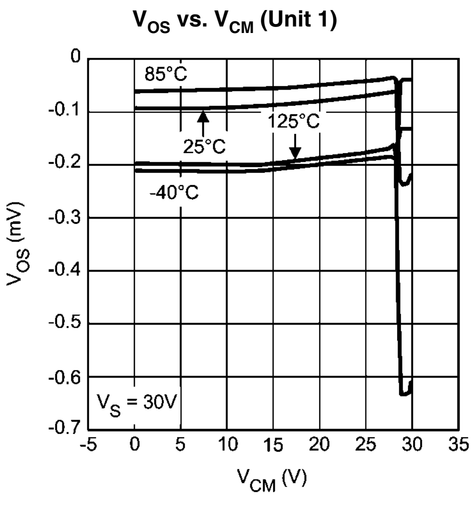
Typical Performance Characteristics Unless otherwise specified, T_A = 25°C.

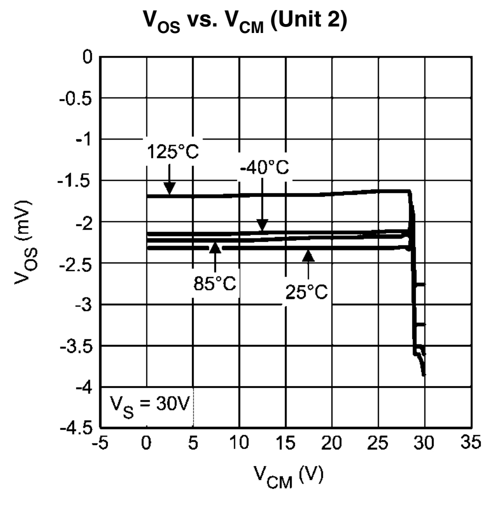




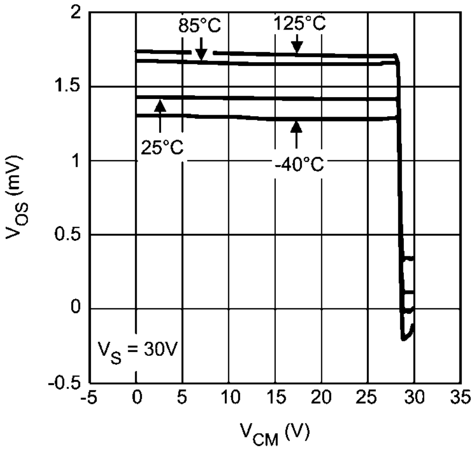








V_{OS} vs. V_{CM} (Unit 3)



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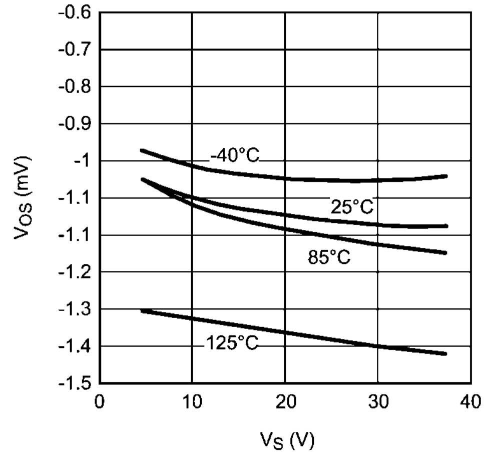
V_{OS} vs. V_S (Unit 1)



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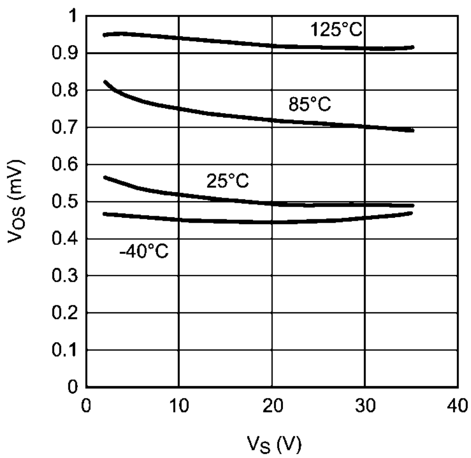
V_{OS} vs. V_S (Unit 2)



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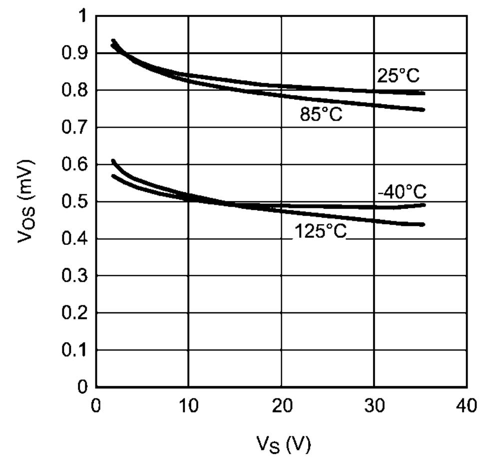
V_{OS} vs. V_S (Unit 3)



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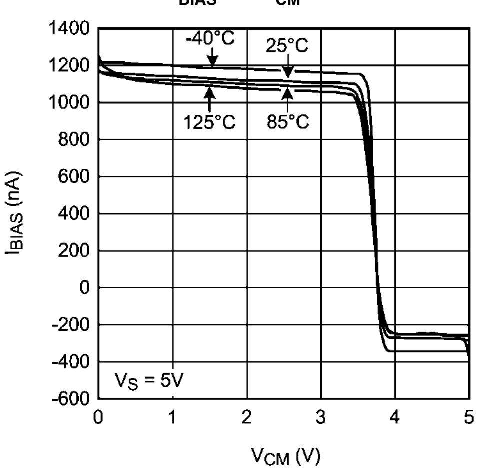
I_{BIAS} vs. V_{CM}



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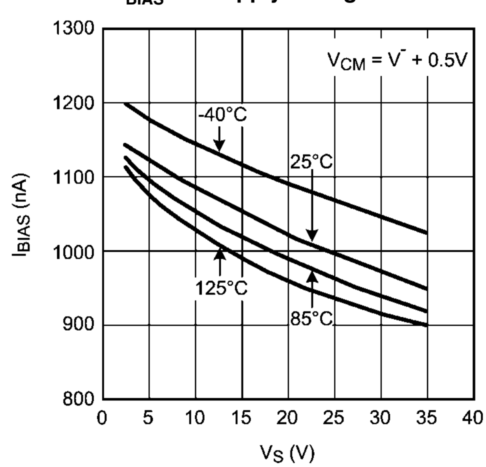
I_{BIAS} vs. Supply Voltage



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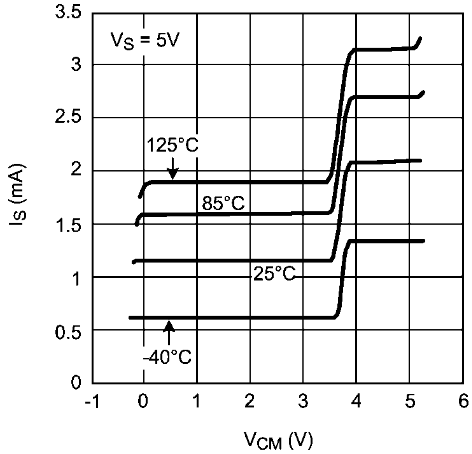
I_S vs. V_{CM}



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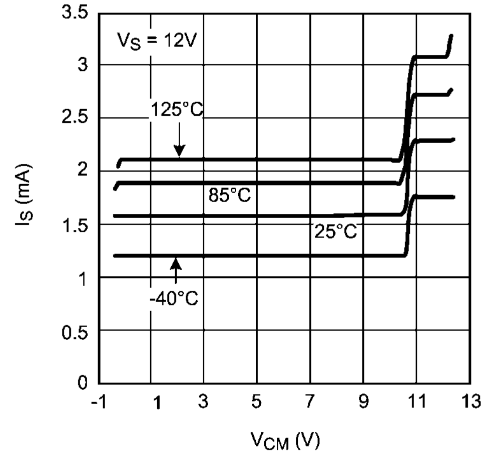
I_S vs. V_{CM}



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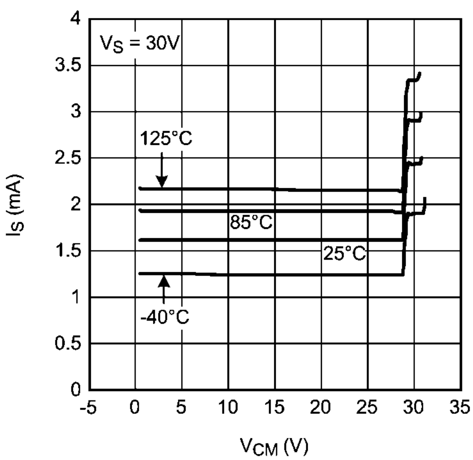
I_S vs. V_{CM}



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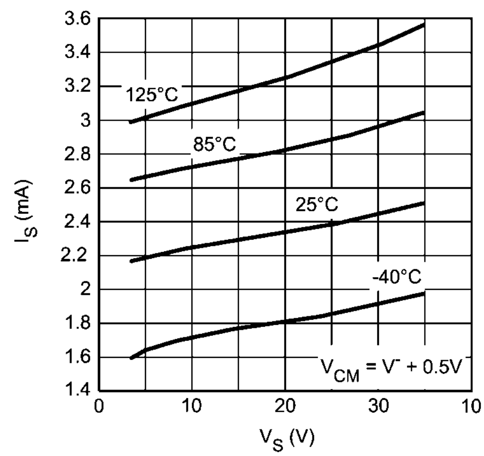
I_S vs. Supply Voltage



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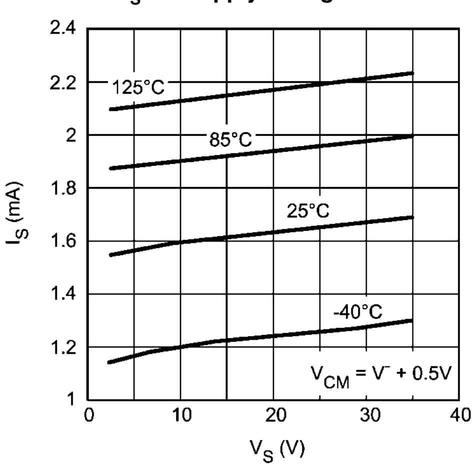
I_S vs. Supply Voltage



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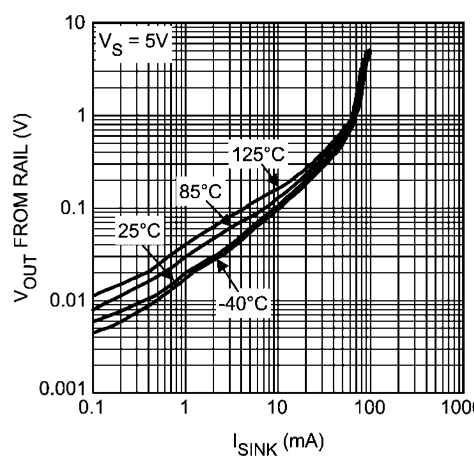
Output Swing vs. Sinking Current



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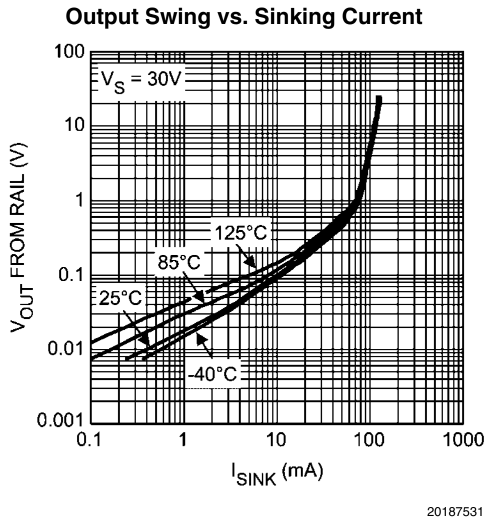
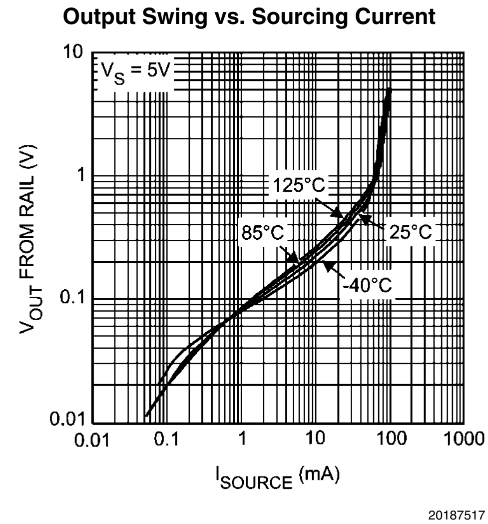
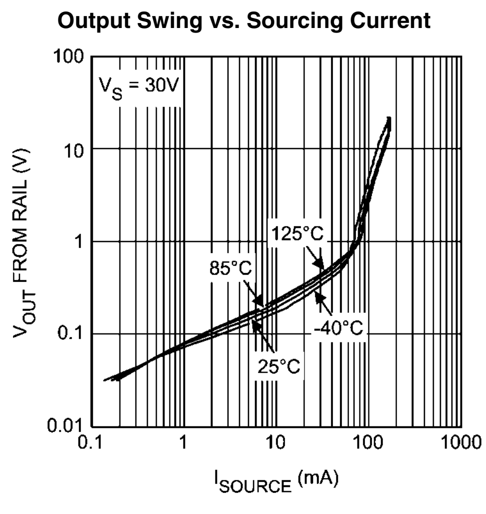

Output Swing vs. Sinking Current
V_S = 30V
125°C
85°C
25°C
-40°C
V_OUT FROM RAIL (V)
I_SINK (mA)
20187531


Output Swing vs. Sourcing Current
V_S = 5V
125°C
85°C
25°C
-40°C
V_OUT FROM RAIL (V)
I_SOURCE (mA)
20187517


Output Swing vs. Sourcing Current
V_S = 30V
125°C
85°C
-40°C
25°C
V_OUT FROM RAIL (V)
I_SOURCE (mA)
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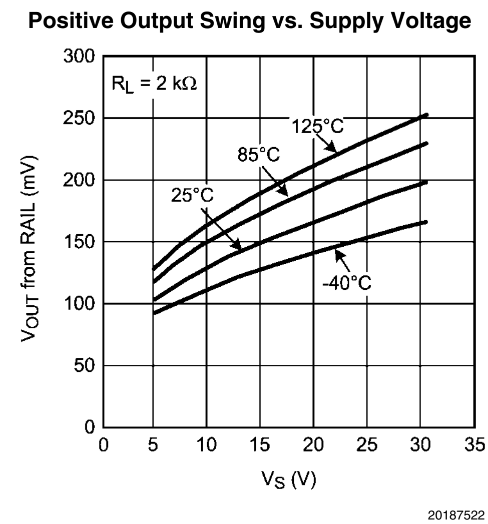
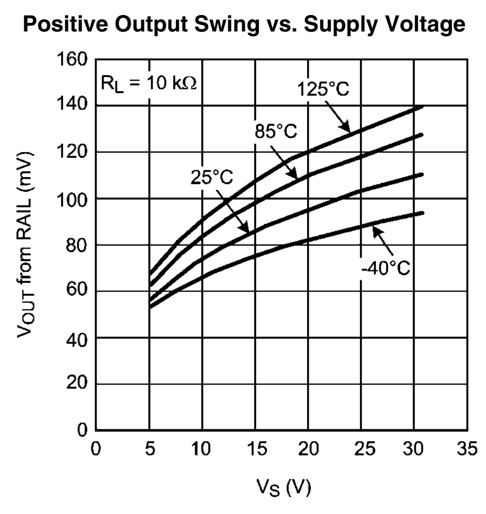
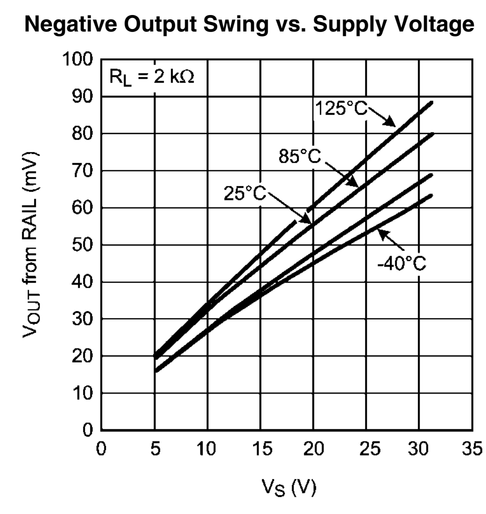
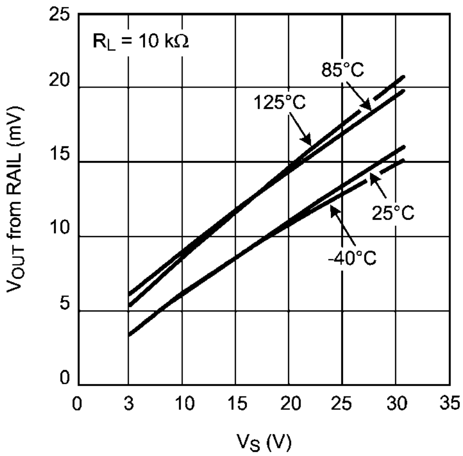

Positive Output Swing vs. Supply Voltage
R_L = 2 kΩ
125°C
85°C
25°C
-40°C
V_OUT from RAIL (mV)
V_S (V)
20187522


Positive Output Swing vs. Supply Voltage
R_L = 10 kΩ
125°C
85°C
25°C
-40°C
V_OUT from RAIL (mV)
V_S (V)
20187519

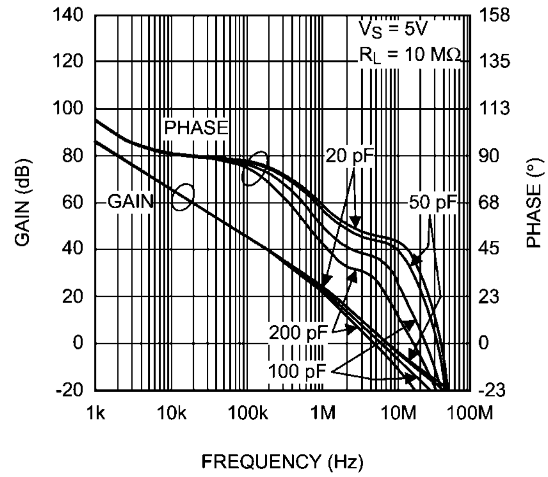

Negative Output Swing vs. Supply Voltage
R_L = 2 kΩ
125°C
85°C
25°C
-40°C
V_OUT from RAIL (mV)
V_S (V)
20187520

Negative Output Swing vs. Supply Voltage



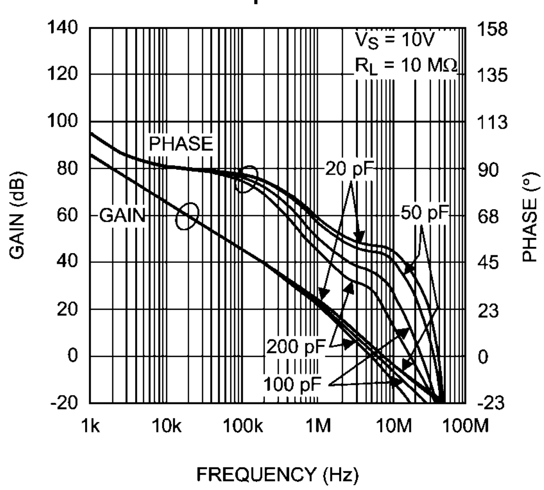
20187521

Open Loop Frequency Response with Various Capacitive Loads



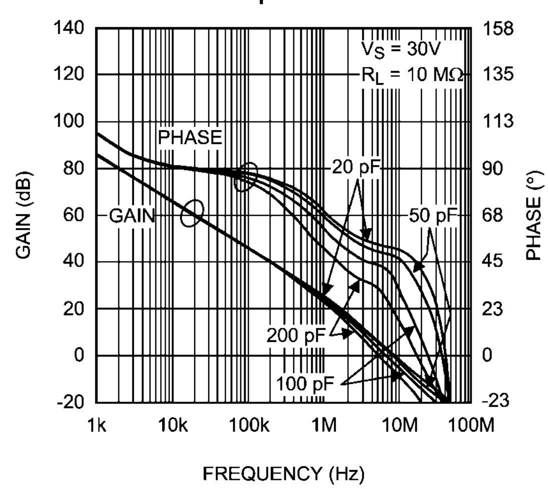
20187540

Open Loop Frequency Response with Various Capacitive Loads



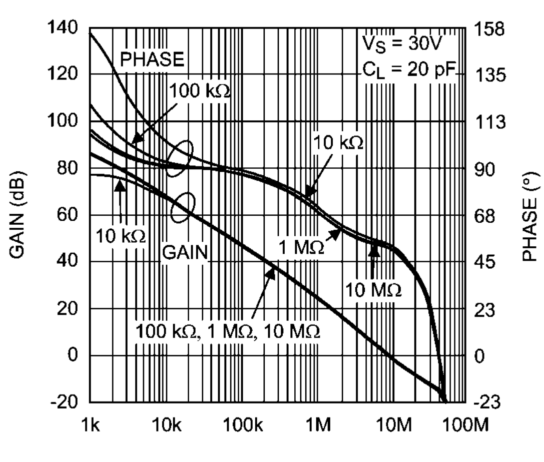
20187541

Open Loop Frequency Response with Various Capacitive Loads



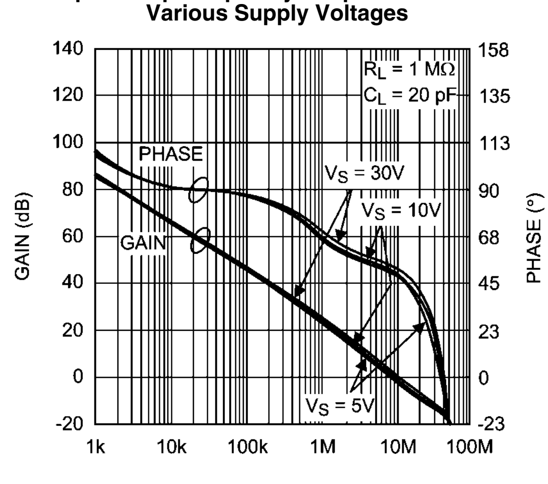
20187542

Open Loop Frequency Response vs. with Various Resistive Loads



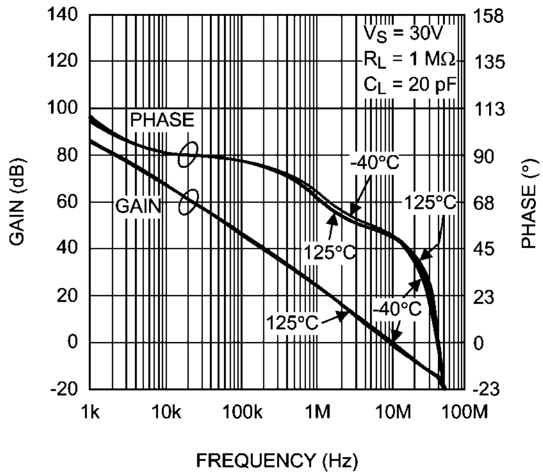
20187539

Open Loop Frequency Response vs. with Various Supply Voltages



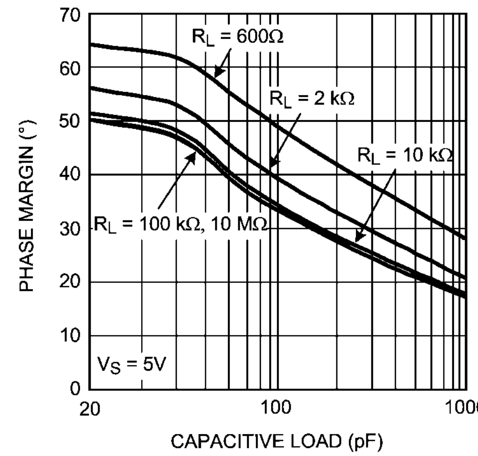
20187537

Open Loop Frequency Response at Various Temperatures



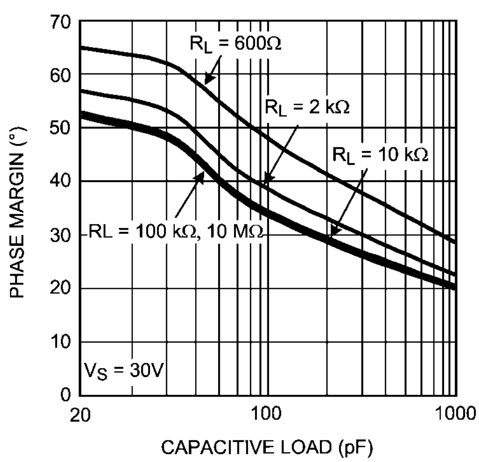
20187538

Phase Margin vs. Capacitive Load



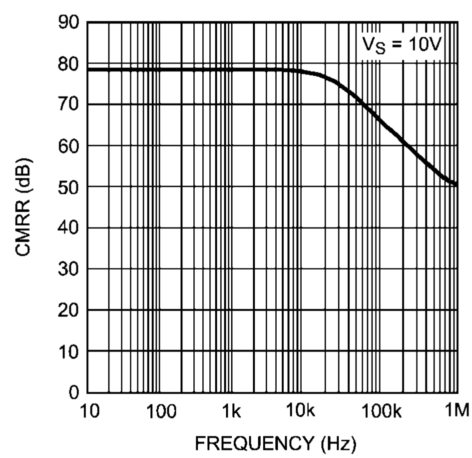
20187543

Phase Margin vs. Capacitive Load



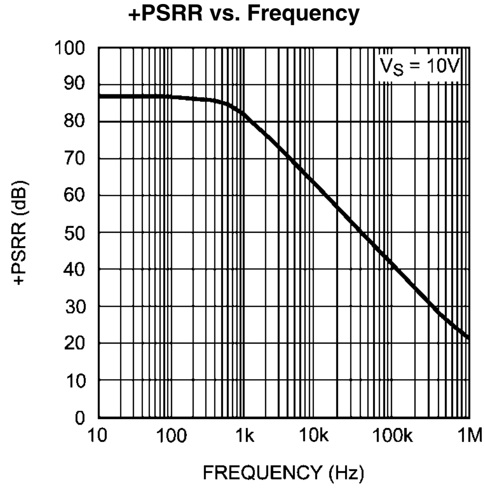
20187544

CMRR vs. Frequency



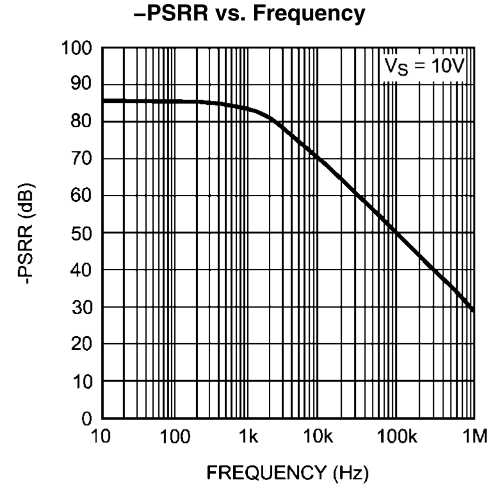
20187545

+PSRR vs. Frequency



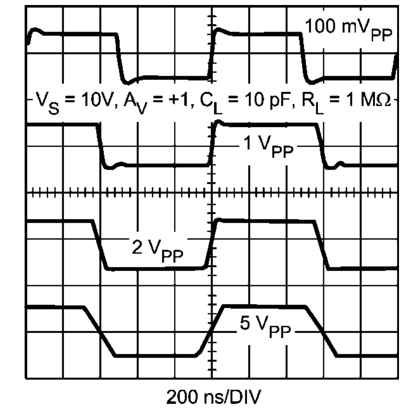
20187546

–PSRR vs. Frequency



20187547

Step Response for Various Amplitudes



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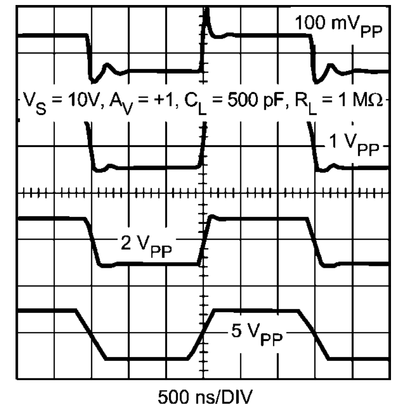
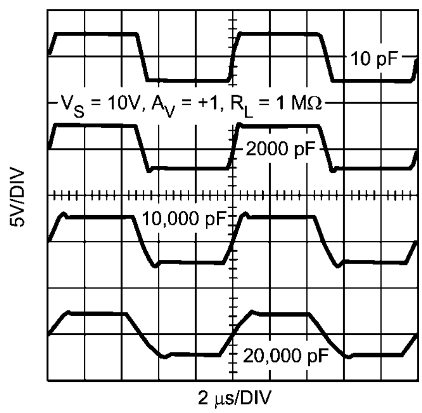
Step Response for Various Amplitudes



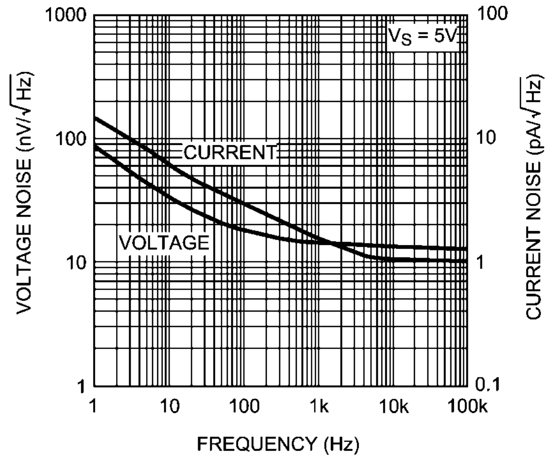
20187532

Large Signal Step Response for Various Capacitive Loads



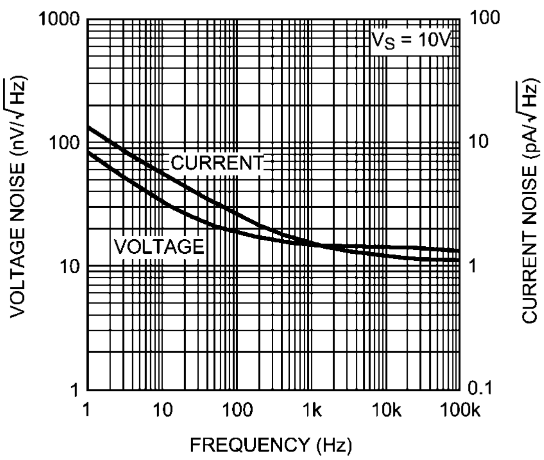
20187534

Input Referred Noise Density vs. Frequency



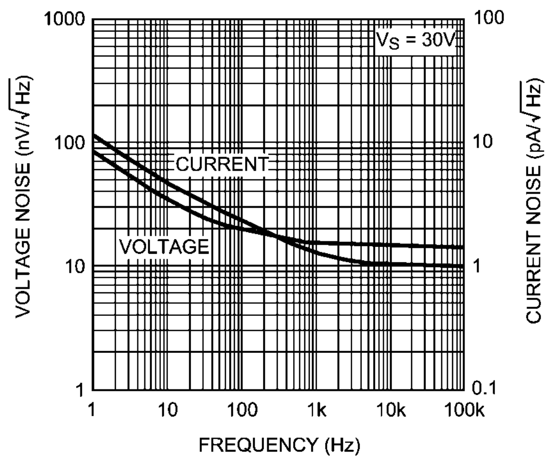
20187548

Input Referred Noise Density vs. Frequency



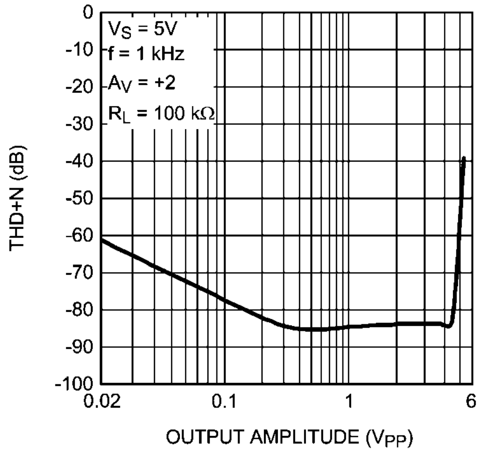
20187549

Input Referred Noise Density vs. Frequency



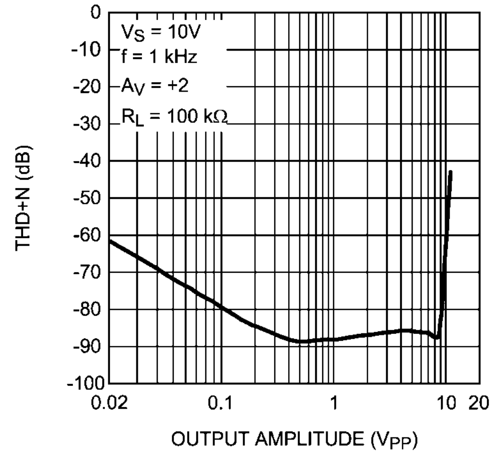
20187550

THD+N vs. Output Amplitude (V_{PP})



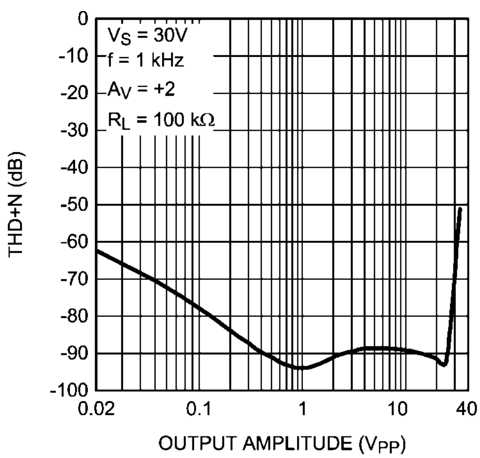
20187552

THD+N vs. Output Amplitude (V_{PP})



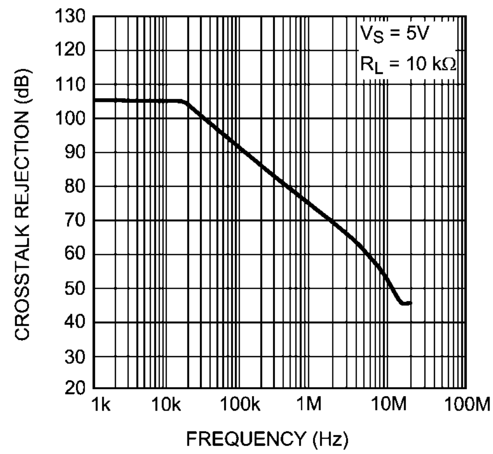
20187553

THD+N vs. Output Amplitude (V_{PP})



20187554

Crosstalk vs. Frequency



20187536

Application Information

ADVANTAGES OF THE LM7332

Wide Operating Voltage Range

The LM7332 has an operating voltage from 2.5V to 32V which makes it suitable for industrial and automotive applications.

RRIO with 100 mA Output Current

The LM7332 takes advantages of National Semiconductor's VIP3 process which enables high current driving from the rails. Rail-to-rail output swing provides the maximum possible output dynamic range. The LM7332 eliminates the need to use extra transistors when driving large capacitive loads, therefore reducing the application cost and space.

-40°C to 125°C Operating Temperature Range

The LM7332 has an operating temperature ranging from -40°C to 125°C, which is Automotive Grade 1, and also meets most industrial requirements.

SOIC and MSOP Packages

The LM7332 are offered in both the standard SOIC package and the space saving MSOP package. Please refer to the Physical Dimensions on page 17 for details.

OUTPUT VOLTAGE SWING CLOSE TO V^-

The LM7332's output stage design allows voltage swings to within millivolts of either supply rail for maximum flexibility and improved useful range. Because of this design architecture, with output approaching either supply rail, the output transistor Collector-Base junction reverse bias will decrease. With output less than a V_{be} from either rail, the corresponding output transistor operates near saturation. In this mode of operation, the transistor will exhibit higher junction capacitance and lower f_t which will reduce phase margin. With the Noise Gain ($NG = 1 + R_F/R_G$, R_F and R_G are external gain setting resistors) of 2 or higher, there is sufficient phase margin that this reduction in phase margin is of no consequence. However, with lower Noise Gain (<2) and with less than 150 mV to the supply rail, if the output loading is light, the phase margin reduction could result in unwanted oscillations.

In the case of the LM7332, due to inherent architectural specifics, the oscillation occurs only with respect to the output transistor at V^- when output swings to within 150 mV of V^-. However, if this output transistor's collector current is larger than its idle value of a few microamps, the phase margin loss becomes insignificant. In this case, 300 µA is the required output transistor's collector current to remedy this situation. Therefore, when all the aforementioned critical conditions are present at the same time ($NG < 2$, $V_{OUT} < 150$ mV from supply rails, & output load is light) it is possible to ensure stability by adding a load resistor to the output to provide the output transistor the necessary minimum collector current (300 µA).

For 12V (or ±6V) operation, for example, add a 39 kΩ resistor from the output to V^+ to cause 300 µA output sinking current and ensure stability. This is equivalent to about 15% increase in total quiescent power dissipation.

DRIVING CAPACITIVE LOADS

The LM7332 is specifically designed to drive unlimited capacitive loads without oscillations. In addition, the output current handling capability of the device allows for good slewing characteristics even with large capacitive loads as shown in *Figure 1*. The combination of these features is ideal for applications such as TFT flat panel buffers, A/D converter input amplifiers and power transistor driver.

However, as in most op amps, addition of a series isolation resistor between the op amp and the capacitive load improves the settling and overshoot performance.

Output current drive is an important parameter when driving capacitive loads. This parameter will determine how fast the output voltage can change. Referring to *Figure 1*, two distinct regions can be identified. Below about 10,000 pF, the output Slew Rate is solely determined by the op amp's compensation capacitor value and available current into that capacitor. Beyond 10 nF, the Slew Rate is determined by the op amp's available output current. An estimate of positive and negative slew rates for loads larger than 100 nF can be made by dividing the short circuit current value by the capacitor.

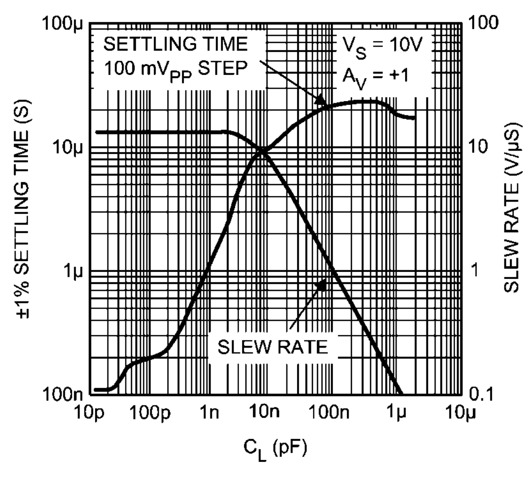


FIGURE 1. Settling Time and Slew Rate vs. Capacitive Load

ESTIMATING THE OUTPUT VOLTAGE SWING

It is important to keep in mind that the steady state output current will be less than the current available when there is an input overdrive present. For steady state conditions, *Figure 2* and *Figure 3* plots can be used to predict the output swing. These plots also show several load lines corresponding to loads tied between the output and ground. In each case, the intersection of the device plot at the appropriate temperature with the load line would be the typical output swing possible for that load. For example, a 600Ω load can accommodate an output swing to within 100 mV of V^- and to 250 mV of V^+ (V_S = ±5V) corresponding to a typical 9.65 V_{PP} unclipped swing.

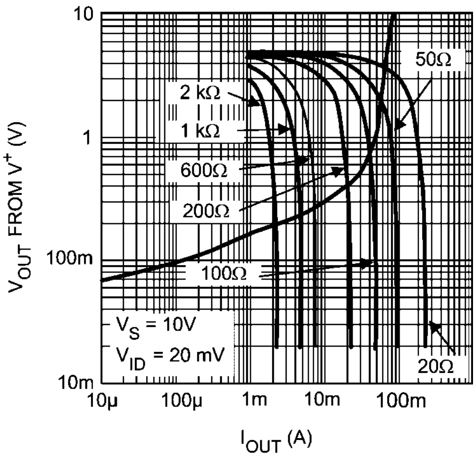


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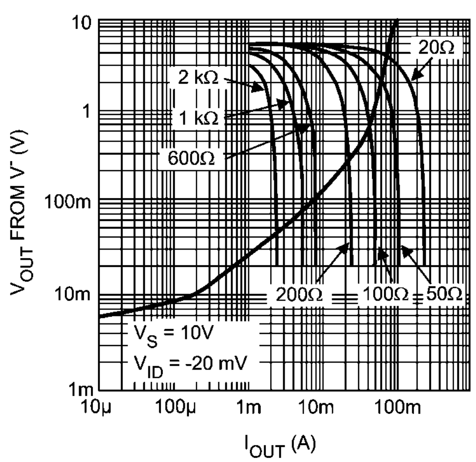
FIGURE 2. Steady State Output Sourcing Characteristics with Load Lines



20187591

FIGURE 3. Steady State Output Sinking Characteristics with Load Lines

OUTPUT SHORT CIRCUIT CURRENT AND DISSIPATION ISSUES

The LM7332 output stage is designed for maximum output current capability. Even though momentary output shorts to ground and either supply can be tolerated at all operating voltages, longer lasting short conditions can cause the junction temperature to rise beyond the absolute maximum rating of the device, especially at higher supply voltage conditions. Below supply voltage of 6V, the output short circuit condition can be tolerated indefinitely.

With the op amp tied to a load, the device power dissipation consists of the quiescent power due to the supply current flow into the device, in addition to power dissipation due to the load current. The load portion of the power itself could include an average value (due to a DC load current) and an AC component. DC load current would flow if there is an output voltage offset, or the output AC average current is non-zero, or if the op amp operates in a single supply application where the output is maintained somewhere in the range of linear operation. Therefore:

$P_{TOTAL} = P_Q + P_{DC} + P_{AC}$

$P_Q = I_S \cdot V_S$ Op Amp Quiescent Power Dissipation

$P_{DC} = I_O \cdot (V_r - V_o)$ DC Load Power

P_{AC} = See Table 1 below AC Load Power

where:

I_S: Supply Current

V_S: Total Supply Voltage ($V^+ - V^-$)

V_O: Average Output Voltage

V_r: V^+ for sourcing and V^- for sinking current

Table 1 below shows the maximum AC component of the load power dissipated by the op amp for standard Sinusoidal, Triangular, and Square Waveforms:

TABLE 1. Normalized AC Power Dissipated in the Output Stage for Standard Waveforms

P_{AC} (W.Ω/V²)		
Sinusoidal	Triangular	Square
50.7×10^{-3}	46.9×10^{-3}	62.5×10^{-3}

The table entries are normalized to V_S^2/R_L. To figure out the AC load current component of power dissipation, simply multiply the table entry corresponding to the output waveform by the factor V_S^2/R_L. For example, with ±12V supplies, a 600Ω load, and triangular waveform power dissipation in the output stage is calculated as:

$$P_{AC} = (46.9 \times 10^{-3}) \cdot [24^2/600] = 45.0 \text{ mW}$$

The maximum power dissipation allowed at a certain temperature is a function of maximum die junction temperature ($T_{J(MAX)}$) allowed, ambient temperature T_A, and package thermal resistance from junction to ambient, θ_{JA}.

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$$

For the LM7332, the maximum junction temperature allowed is 150°C at which no power dissipation is allowed. The power capability at 25°C is given by the following calculations:

For MSOP package:

$$P_{D(MAX)} = \frac{150°C - 25°C}{235°C/W} = 0.53W$$

For SOIC package:

$$P_{D(MAX)} = \frac{150°C - 25°C}{165°C/W} = 0.76W$$

Similarly, the power capability at 125°C is given by:

For MSOP package:

$$P_{D(MAX)} = \frac{150°C - 125°C}{235°C/W} = 0.11W$$

For SOIC package:

$$P_{D(MAX)} = \frac{150°C - 125°C}{165°C/W} = 0.15W$$

Figure 4 shows the power capability vs. temperature for MSOP and SOIC packages. The area under the maximum thermal capability line is the operating area for the device. When the device works in the operating area where P_{TOTAL} is less than $P_{D(MAX)}$, the device junction temperature will remain below 150°C. If the intersection of ambient temperature and package power is above the maximum thermal capability line, the junction temperature will exceed 150°C and this should be strictly prohibited.

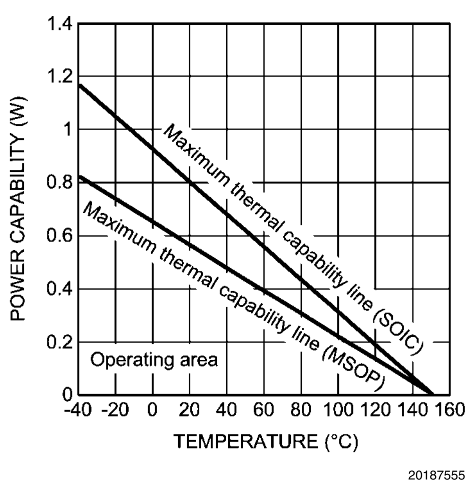


FIGURE 4. Power Capability vs. Temperature

When high power is required and ambient temperature can't be reduced, providing air flow is an effective approach to reduce thermal resistance therefore to improve power capability.

APPLICATION HINTS ON SUPPLY DECOUPLING

The use of supply decoupling is mandatory in most applications. As with most relatively high speed/high output current op amps, best results are achieved when each supply line is decoupled with two capacitors; a small value ceramic capacitor (~0.01 µF) placed very close to the supply lead in addition to a large value Tantalum or Aluminum capacitor (> 4.7 µF). The large capacitor can be shared by more than one device if necessary. The small ceramic capacitor maintains low supply impedance at high frequencies while the large capacitor will act as the charge “bucket” for fast load current spikes at the op amp output. The combination of these capacitors will provide supply decoupling and will help keep the op amp oscillation free under any load.

SIMILAR HIGH CURRENT OUTPUT DEVICES

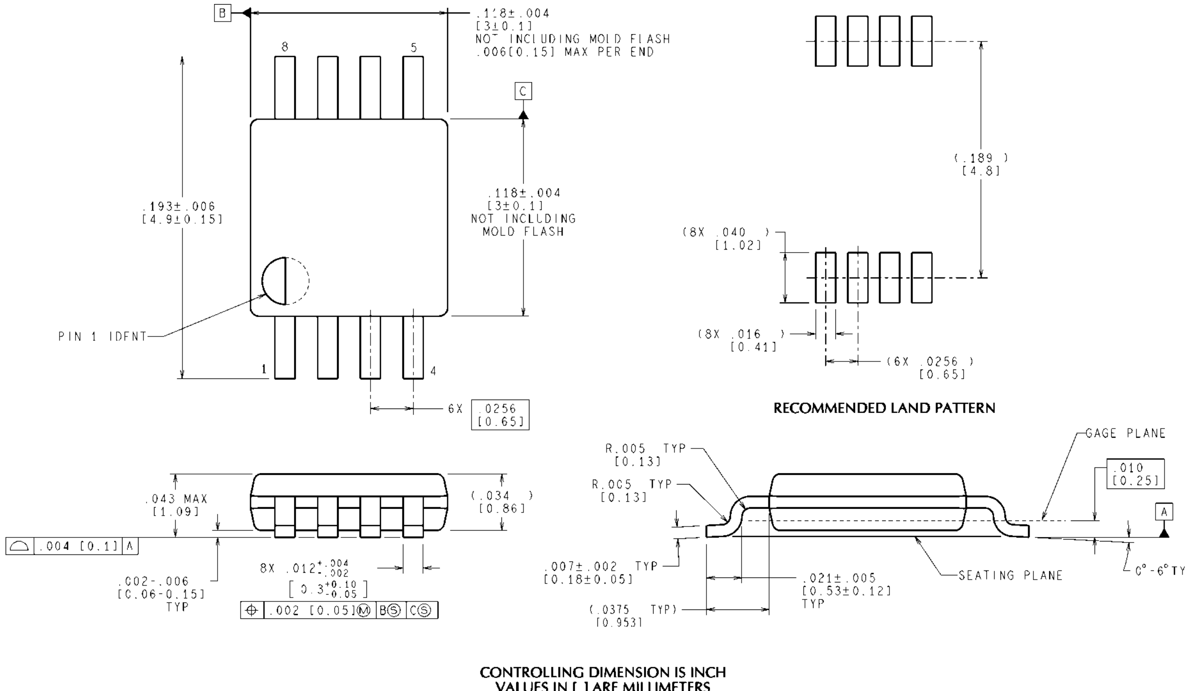
The LM6172 has a higher GBW of 100 MHz and over 80 mA of current output. There is also a single version, the LM6171. The LM7372 has 120 MHz of GBW and 150 mA of current output. The LM7372 is available in a small pin LLP package, an 8-pin PSOP, and 16-pin SOIC packages with higher power dissipation.

The LME49600 buffer has 250 mA of current out and a 110 MHz bandwidth. The LME49600 is available in a TO-263 package for higher power dissipation.

The LM7322 is a rail-to-rail input and output part with a slightly higher GBW of 20 MHz. It has current capability of 40 mA sourcing and 65 mA sinking, and can drive unlimited capacitive loads. The LM7322 is available in both MSOP and SOIC packages.

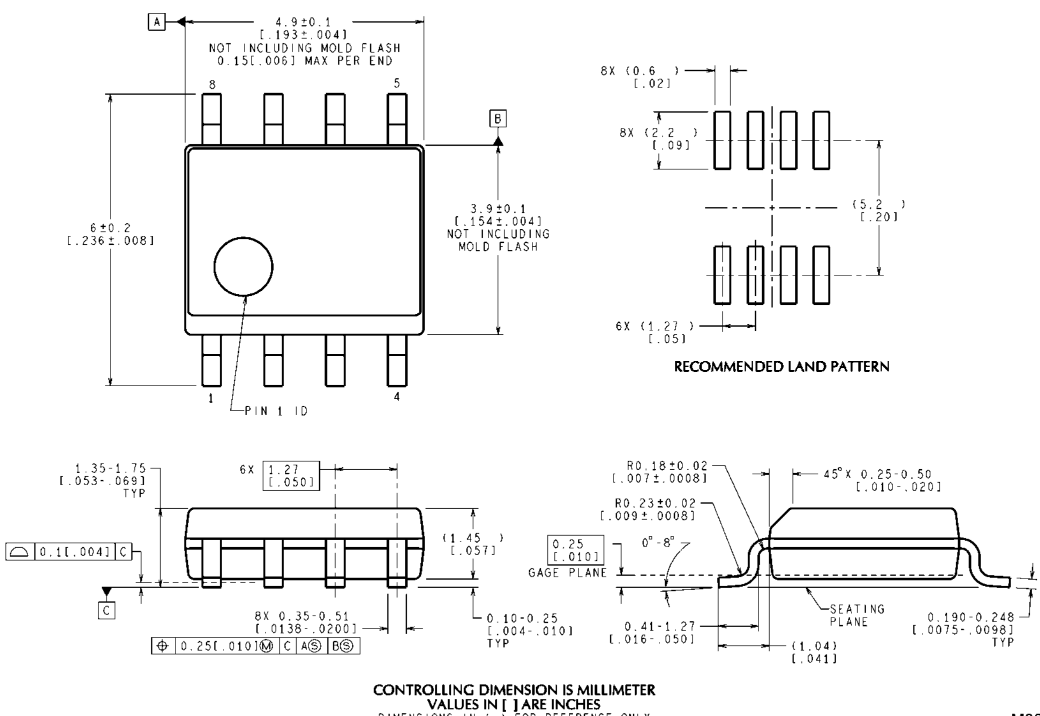
Detailed information on these parts can be found at www.national.com.

Physical Dimensions inches (millimeters) unless otherwise noted



MUA08A (Rev F)

8-Pin MSOP
NS Package Number MUA08A



M08A (Rev L)

8-Pin SOIC
NS Package Number M08A

Notes

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Ethernet	www.national.com/ethernet	Packaging	www.national.com/packaging
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