MC33078-EP
DUAL HIGH-SPEED LOW-NOISE OPERATIONAL AMPLIFIER

SLOS495–OCTOBER 2006

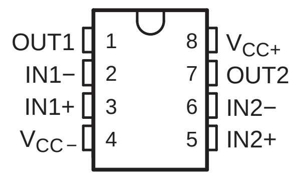
FEATURES

- **Controlled Baseline**
  - **One Assembly/Test Site, One Fabrication Site**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree** (1)
- **Dual-Supply Operation . . . ±5 V to ±18 V**
- **Low Noise Voltage . . . 4.5 nV/√Hz**

(1) Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

- **Low Input Offset Voltage . . . 0.15 mV**
- **Low Total Harmonic Distortion . . . 0.002%**
- **High Slew Rate . . . 7 V/μs**
- **High-Gain Bandwidth Product . . . 16 MHz**
- **High Open-Loop AC Gain . . . 800 at 20 kHz**
- **Large Output-Voltage Swing . . . 14.1 V to –14.6 V**
- **Excellent Gain and Phase Margins**

D PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

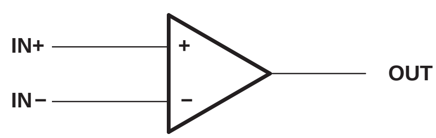
The MC33078-EP is a bipolar dual operational amplifier with high-performance specifications for use in quality audio and data-signal applications. This device operates over a wide range of single- and dual-supply voltages and offers low noise, high-gain bandwidth, and high slew rate. Additional features include low total harmonic distortion, excellent phase and gain margins, large output voltage swing with no deadband crossover distortion, and symmetrical sink/source performance.

ORDERING INFORMATION

T_A	PACKAGE (1)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–55°C to 125°C	SOIC – D	Reel of 2500	MC33078MDREP	33078M

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

SYMBOL (EACH AMPLIFIER)



Absolute Maximum Ratings(1)

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{CC+}	Supply voltage(2)		18	V
V_{CC-}	Supply voltage(2)		–18	V
V_{CC-} to V_{CC+}	Supply voltage		36	V
	Input voltage, either input(2)(3)		V_{CC-} or V_{CC+}	V
	Input current(4)		±10	mA
	Duration of output short circuit(5)		Unlimited	
θ_{JA}	Package thermal impedance(6)(7)		97	°C/W
T_J	Operating virtual junction temperature		150	°C
T_{stg}	Storage temperature range(8)	–65	150	°C

(1) 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 under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values, except differential voltages, are with respect to the midpoint between V_{CC+} and V_{CC-}.
(3) The magnitude of the input voltage must never exceed the magnitude of the supply voltage.
(4) Excessive input current will flow if a differential input voltage in excess of approximately 0.6 V is applied between the inputs, unless some limiting resistance is used.
(5) The output may be shorted to ground or either power supply. Temperature and/or supply voltages must be limited to ensure the maximum dissipation rating is not exceeded.
(6) Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(7) The package thermal impedance is calculated in accordance with JESD 51-7.
(8) Long-term high-temperature storage and/or extended use at maximum recommended operating conditions may result in a reduction of overall device life. See http://www.ti.com/ep_quality for additional information on enhanced plastic packaging.

Recommended Operating Conditions

		MIN	MAX	UNIT
V_{CC-}	Supply voltage	–5	–18	V
V_{CC+}	Supply voltage	5	18	V
T_A	Operating free-air temperature	–55	125	°C

Electrical Characteristics

V_{CC-} = –15 V, V_{CC+} = 15 V, T_A = 25°C (unless otherwise noted)

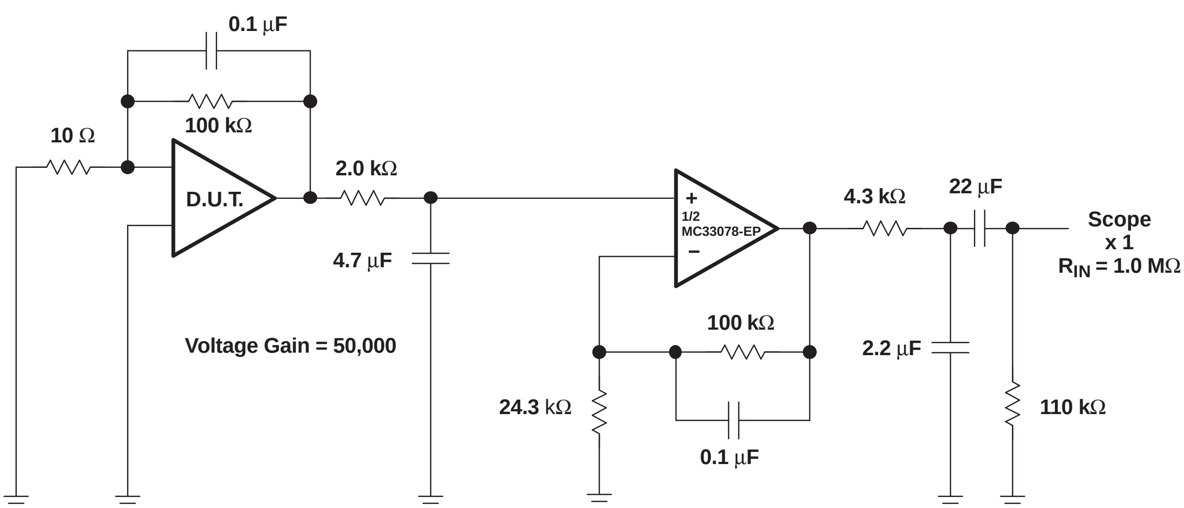
PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_O = 0, R_S = 10 Ω, V_{CM} = 0		T_A = 25°C		0.15	2	mV
				T_A = –55°C to 125°C			3	
αV_{IO}	Input offset voltage temperature coefficient	V_O = 0, R_S = 10 Ω, V_{CM} = 0		T_A = –55°C to 125°C		2		µV/°C
I_{IB}	Input bias current	V_O = 0,	V_{CM} = 0	T_A = 25°C		300	750	nA
				T_A = –55°C to 125°C			800	
I_{IO}	Input offset current	V_O = 0,	V_{CM} = 0	T_A = 25°C		25	150	nA
				T_A = –55°C to 125°C			175	
V_{ICR}	Common-mode input voltage range	ΔV_{IO} = 5 mV,	V_O = 0		±13	±14		V
A_{VD}	Large-signal differential voltage amplification	R_L ≥ 2 kΩ, V_O = ±10 V		T_A = 25°C	90	110		dB
				T_A = –55°C to 125°C	80			
V_{OM}	Maximum output voltage swing	V_{ID} = ±1 V	R_L = 600 Ω	V_{OM+}		10.7		V
				V_{OM-}		–11.9		
			R_L = 2k Ω	V_{OM+}	13.2	13.8		
				V_{OM-}	–13.2	–13.7		
			R_L = 10k Ω	V_{OM+}	13.5	14.1		
				V_{OM-}	–14	–14.6		
CMMR	Common-mode rejection ratio	V_{IN} = ±13 V			80	100		dB
k_{SVR}(1)	Supply-voltage rejection ratio	V_{CC+} = 5 V to 15 V, V_{CC-} = –5 V to –15 V			80	105		dB
I_{OS}	Output short-circuit current	$\|V_{ID}\|$ = 1 V, Output to GND		Source current	15	29		mA
				Sink current	–20	–37		
I_{CC}	Supply current (per channel)	V_O = 0		T_A = 25°C		2.05	2.5	mA
				T_A = –55°C to 125°C			3.5	

(1) Measured with $V_{CC\pm}$ differentially varied at the same time

Operating Characteristics

V_{CC-} = –15 V, V_{CC+} = 15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	A_{VD} = 1, V_{IN} = –10 V to 10 V, R_L = 2 kΩ, C_L = 100 pF		5	7		V/µs
GBW	Gain bandwidth product	f = 100 kHz			16		MHz
B_1	Unity gain frequency	Open loop			9		MHz
	Gain margin	R_L = 2 kΩ	C_L = 0 pF		–11		dB
			C_L = 100 pF		–6		
ϕ_m	Phase margin	R_L = 2 kΩ	C_L = 0 pF		55		deg
			C_L = 100 pF		40		
	Amplifier-to-amplifier isolation	f = 20 Hz to 20 kHz			–120		dB
	Power bandwidth	V_O = 27 $V_{(PP)}$, R_L = 2 kΩ, THD ≤ 1%			120		kHz
THD	Total harmonic distortion	V_O = 3 V_{rms}, A_{VD} = 1, R_L = 2 kΩ, f = 20 Hz to 20 kHz			0.002		%
z_o	Open-loop output impedance	V_O = 0,	f = 9 MHz		37		Ω
r_{id}	Differential input resistance	V_{CM} = 0			175		kΩ
C_{id}	Differential input capacitance	V_{CM} = 0			12		pF
V_n	Equivalent input noise voltage	f = 1 kHz,	R_S = 100 Ω		4.5		nV/√Hz
I_n	Equivalent input noise current	f = 1 kHz			0.5		pA/√Hz

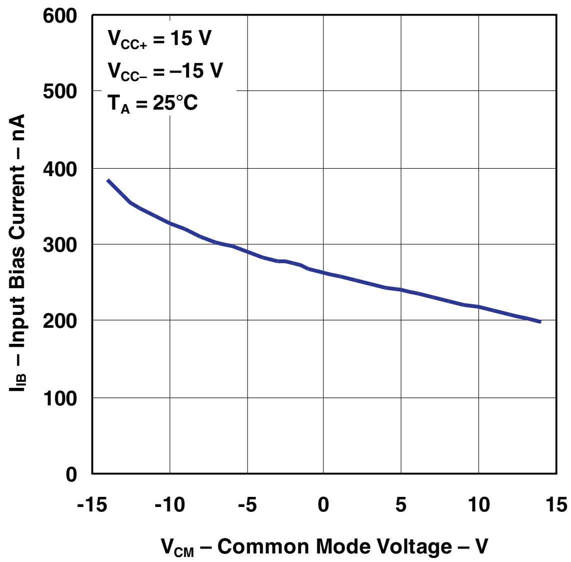


NOTE: All capacitors are nonpolarized.

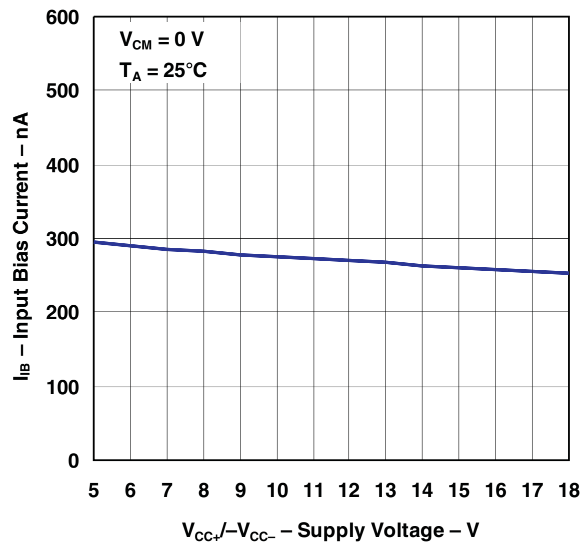
Figure 1. Voltage Noise Test Circuit (0.1 Hz to 10 Hz_{p-p})

TYPICAL CHARACTERISTICS

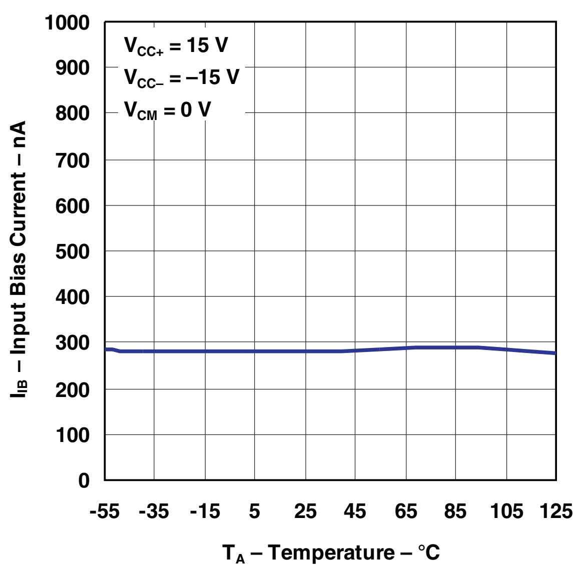
INPUT BIAS CURRENT
vs
COMMON-MODE VOLTAGE



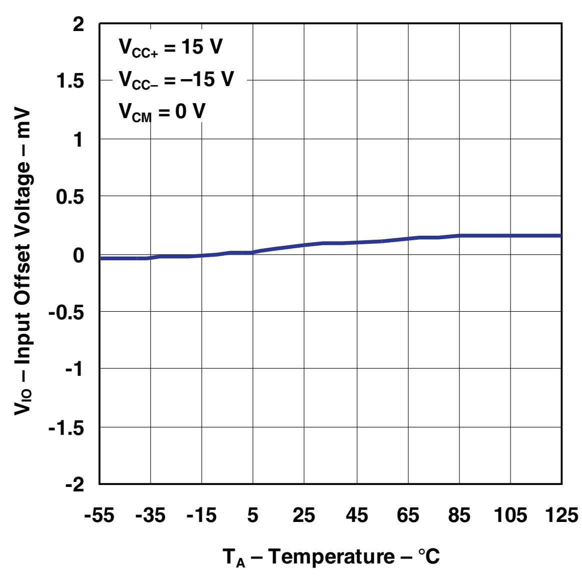
INPUT BIAS CURRENT
vs
SUPPLY VOLTAGE



INPUT BIAS CURRENT
vs
TEMPERATURE



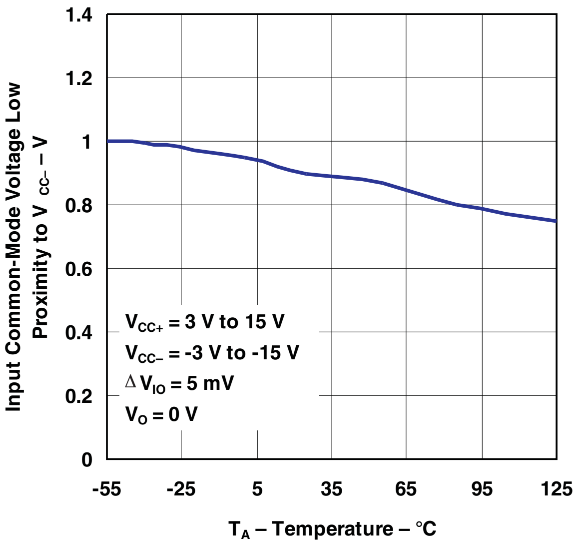
INPUT OFFSET VOLTAGE
vs
TEMPERATURE



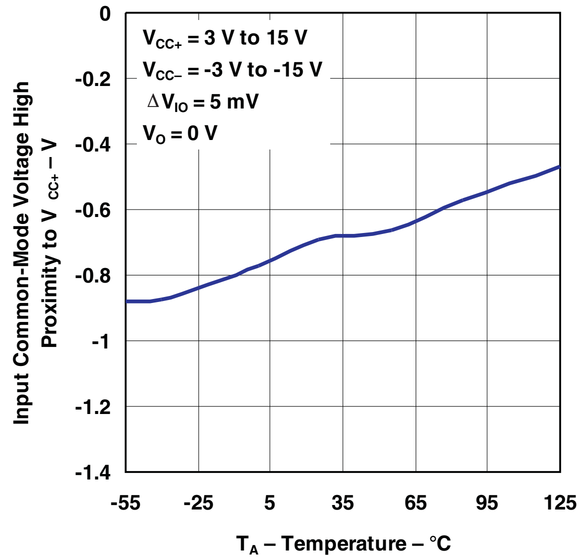
Texas Instruments
www.ti.com

TYPICAL CHARACTERISTICS (continued)

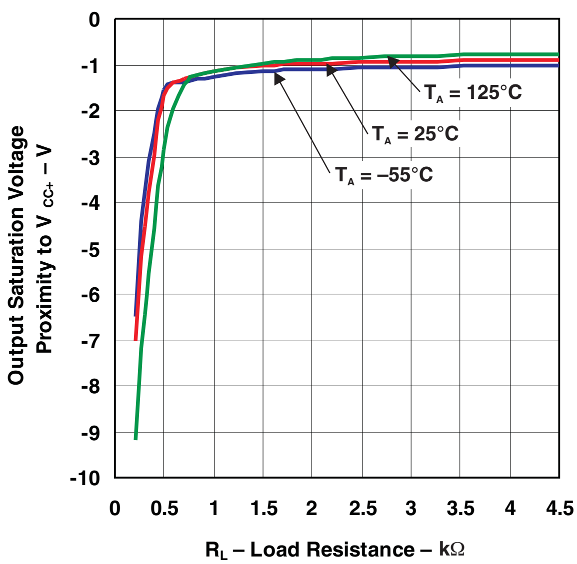
INPUT COMMON-MODE VOLTAGE LOW PROXIMITY TO V_{CC-} vs TEMPERATURE



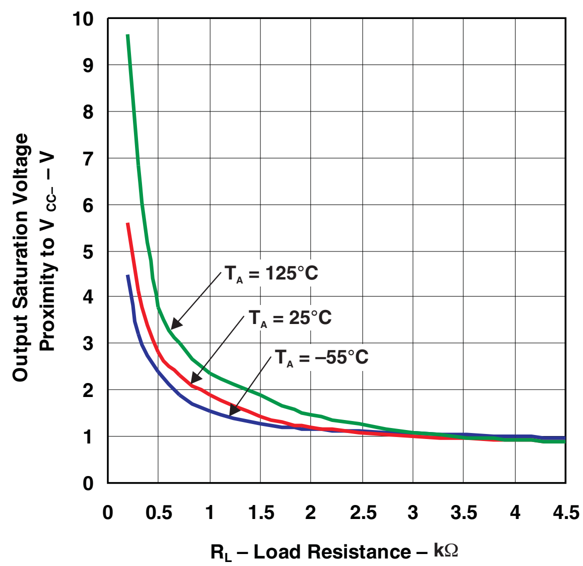
INPUT COMMON-MODE VOLTAGE HIGH PROXIMITY TO V_{CC+} vs TEMPERATURE



OUTPUT SATURATION VOLTAGE PROXIMITY TO V_{CC+} vs LOAD RESISTANCE

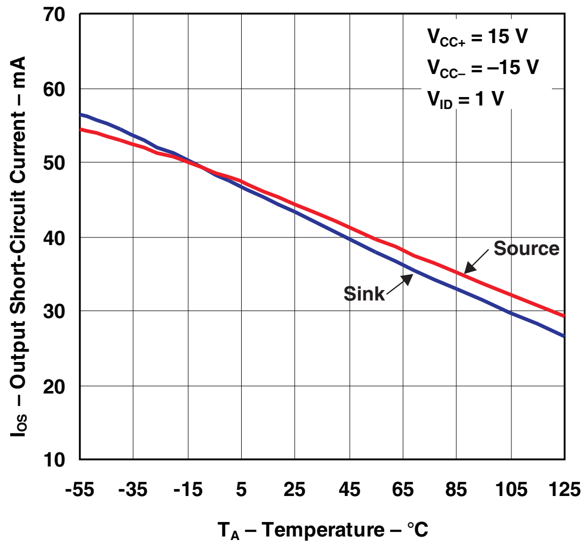


OUTPUT SATURATION VOLTAGE PROXIMITY TO V_{CC-} vs LOAD RESISTANCE

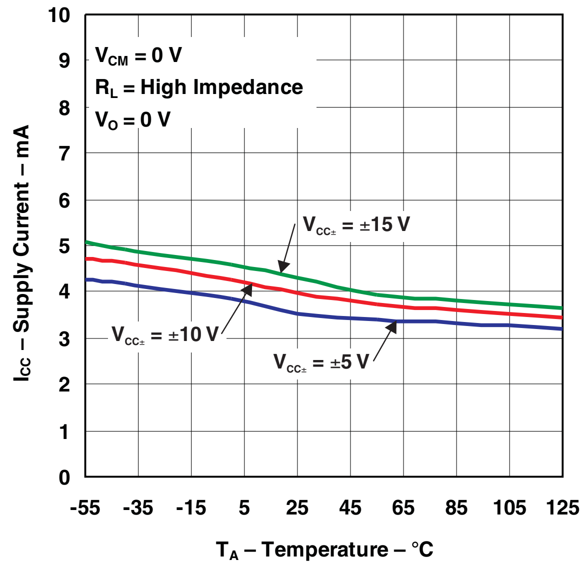


TYPICAL CHARACTERISTICS (continued)

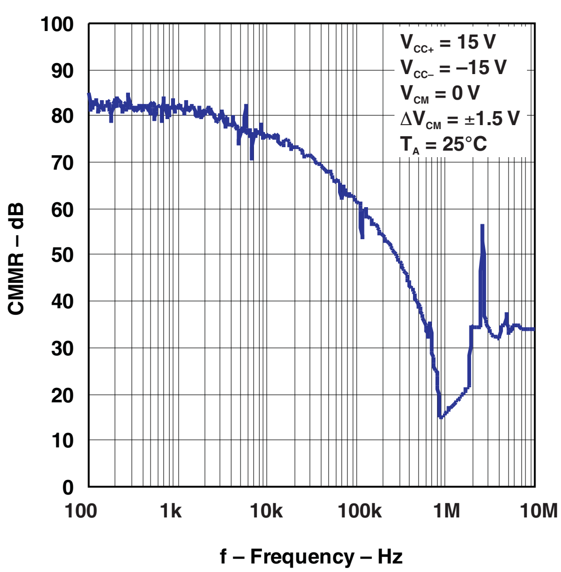
OUTPUT SHORT-CIRCUIT CURRENT
vs
TEMPERATURE



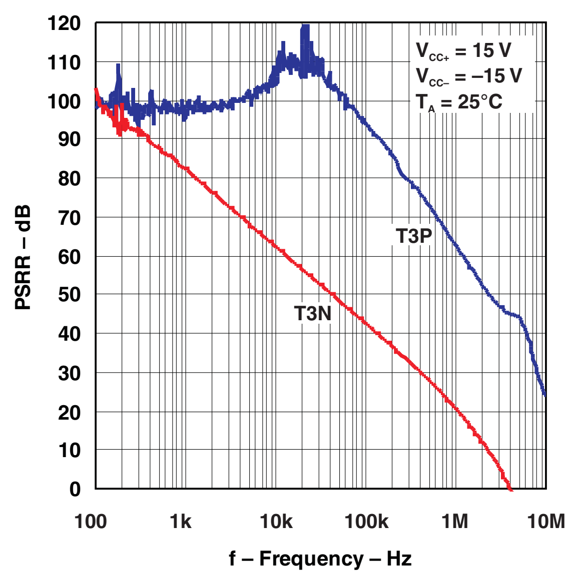
SUPPLY CURRENT
vs
TEMPERATURE



CMRR
vs
FREQUENCY

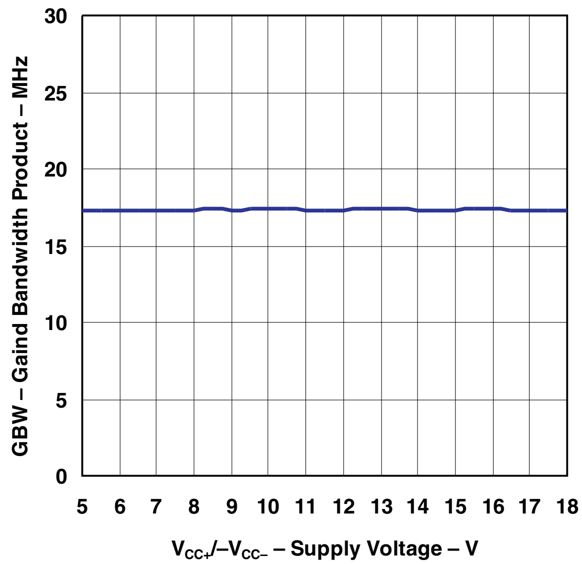


PSSR
vs
FREQUENCY

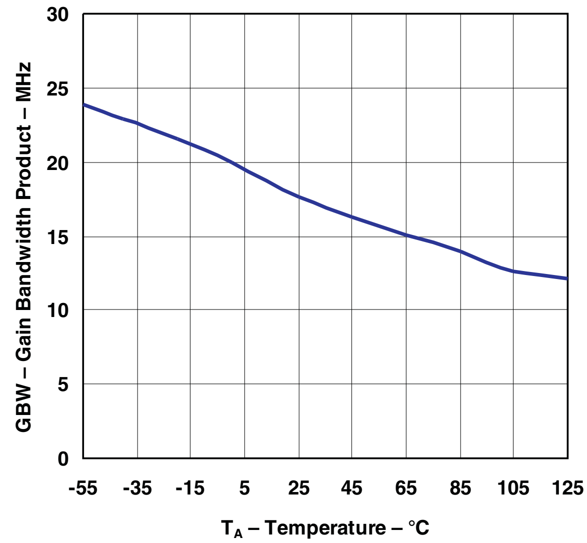


TYPICAL CHARACTERISTICS (continued)

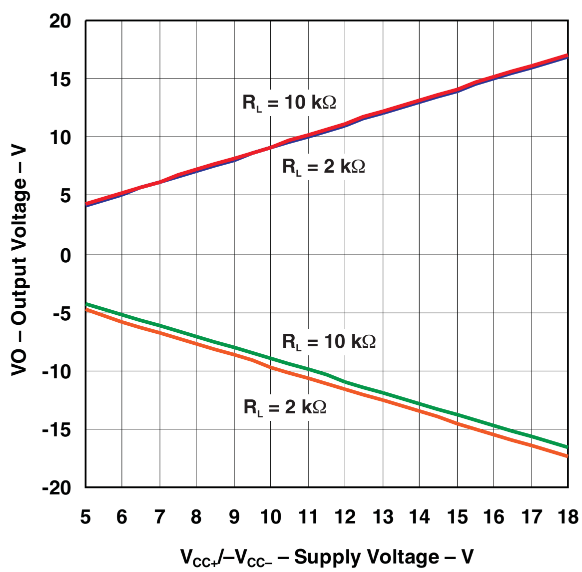
GAIN BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE



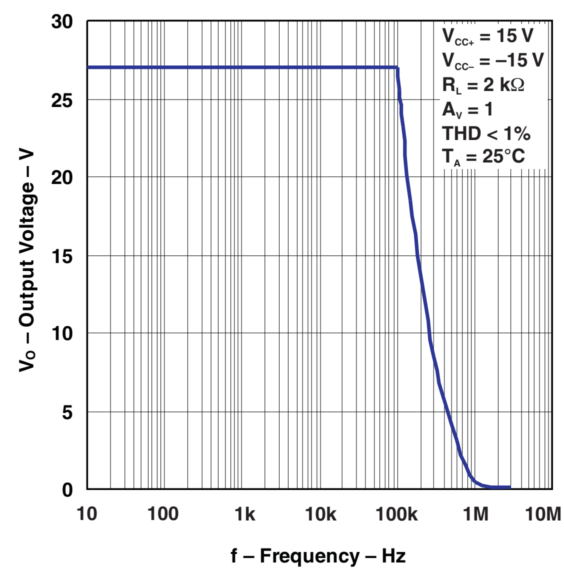
GAIN BANDWIDTH PRODUCT
vs
TEMPERATURE



OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE

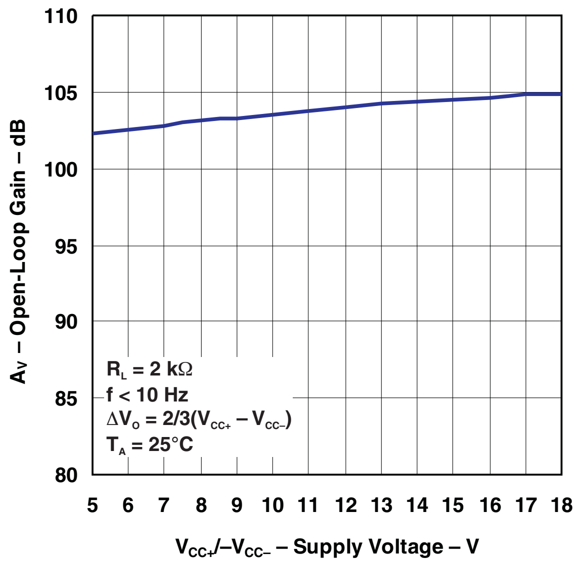


OUTPUT VOLTAGE
vs
FREQUENCY

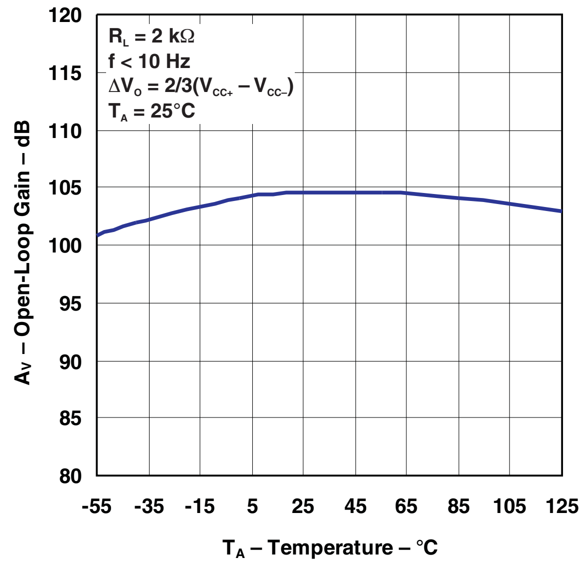


TYPICAL CHARACTERISTICS (continued)

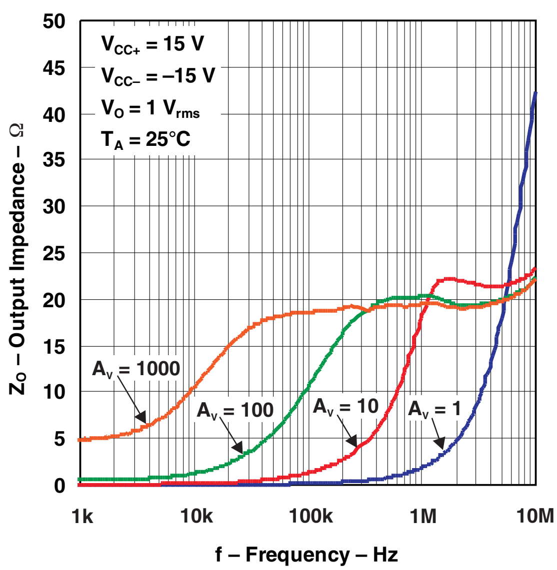
OPEN-LOOP GAIN
vs
SUPPLY VOLTAGE



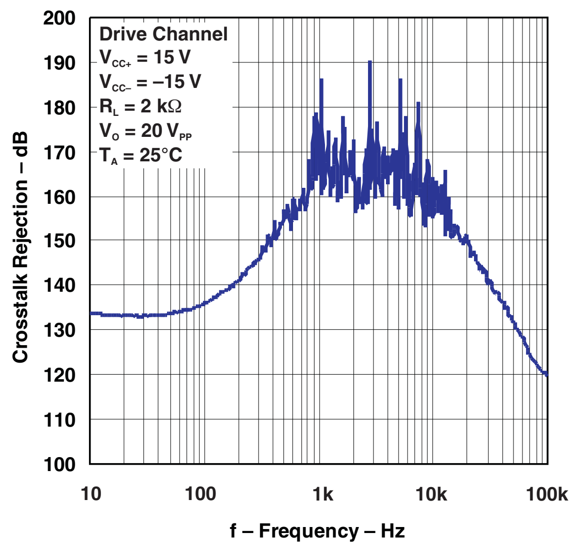
OPEN-LOOP GAIN
vs
TEMPERATURE



OUTPUT IMPEDANCE
vs
FREQUENCY

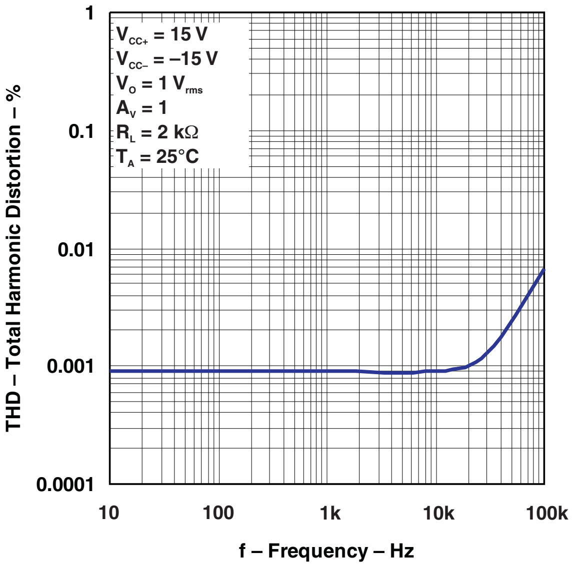


CROSSTALK REJECTION
vs
FREQUENCY

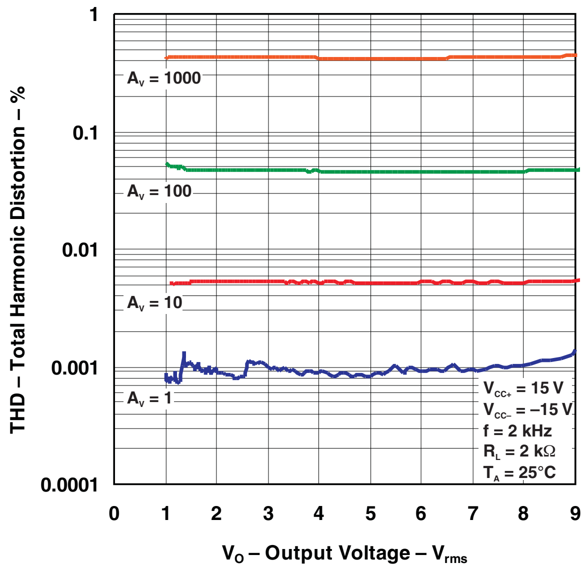


TYPICAL CHARACTERISTICS (continued)

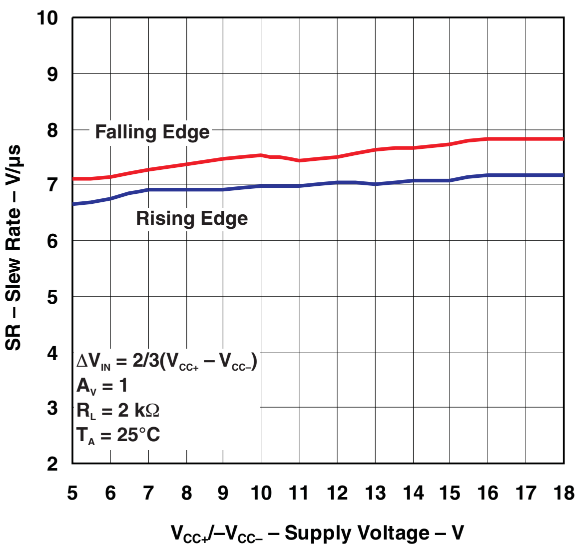
TOTAL HARMONIC DISTORTION
vs
FREQUENCY



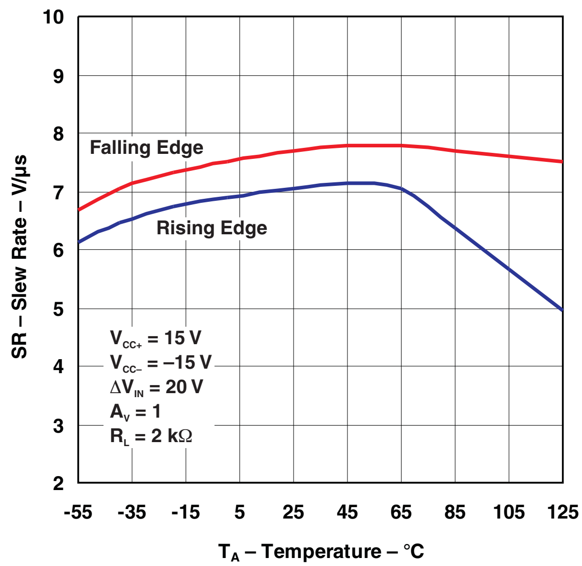
TOTAL HARMONIC DISTORTION
vs
OUTPUT VOLTAGE



SLEW RATE
vs
SUPPLY VOLTAGE

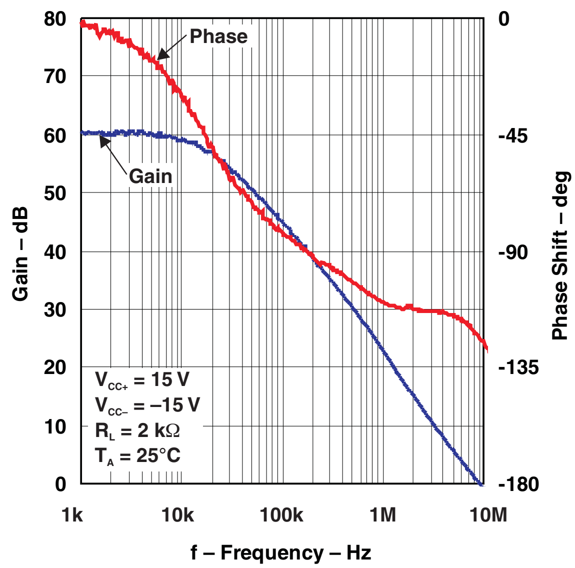


SLEW RATE
vs
TEMPERATURE

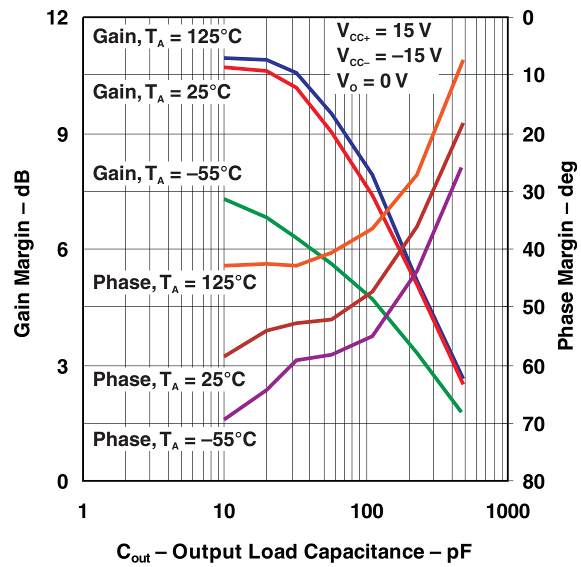


TYPICAL CHARACTERISTICS (continued)

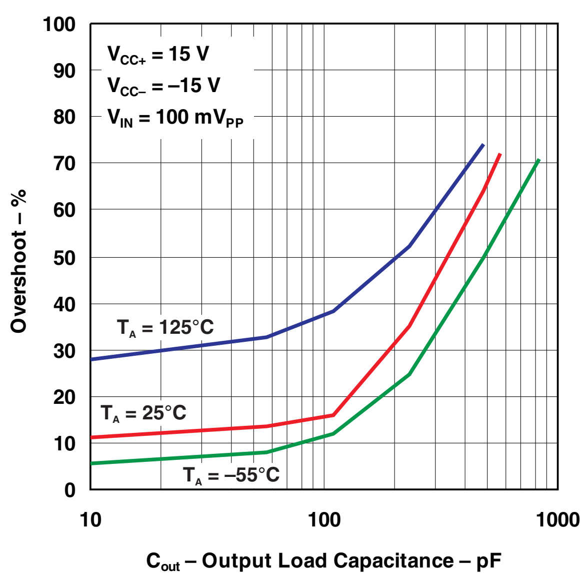
GAIN AND PHASE
vs
FREQUENCY



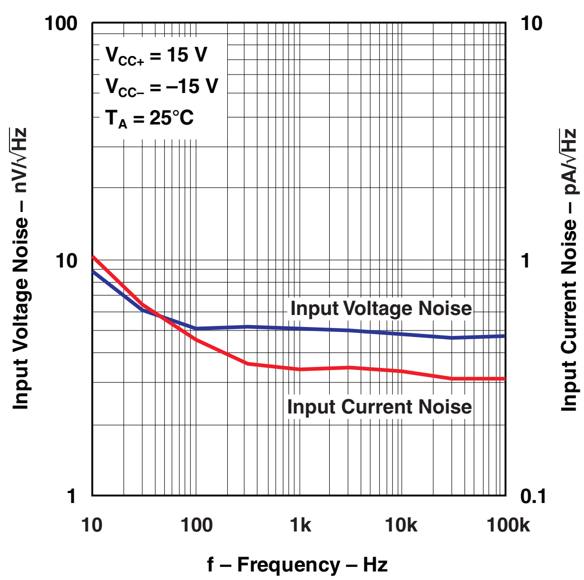
GAIN AND PHASE MARGIN
vs
OUTPUT LOAD CAPACITANCE



OVERSHOOT
vs
OUTPUT LOAD CAPACITANCE

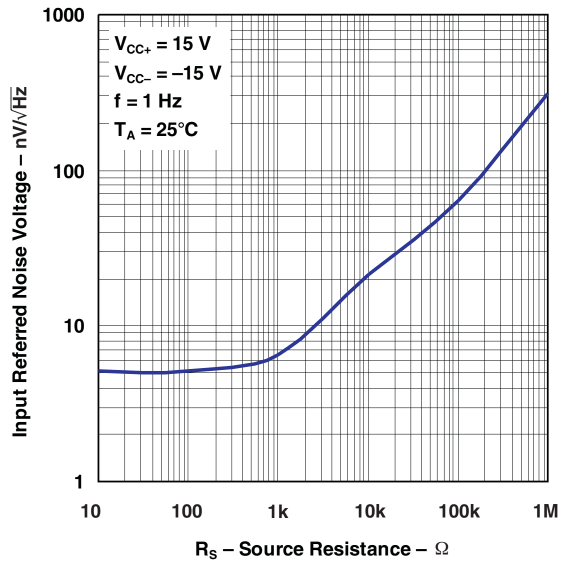


INPUT VOLTAGE AND CURRENT NOISE
vs
FREQUENCY

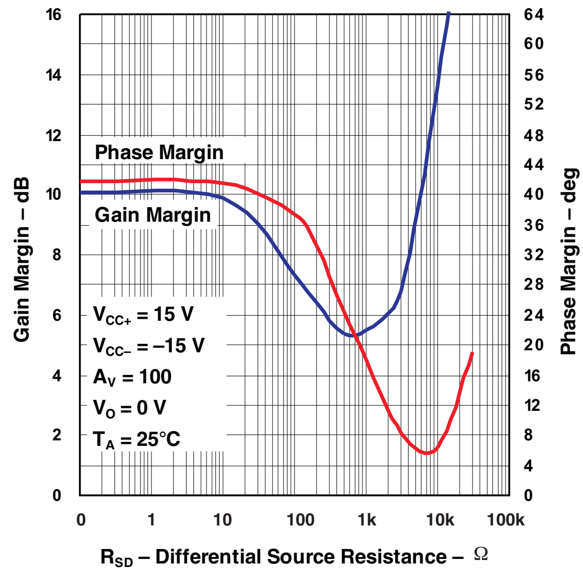


TYPICAL CHARACTERISTICS (continued)

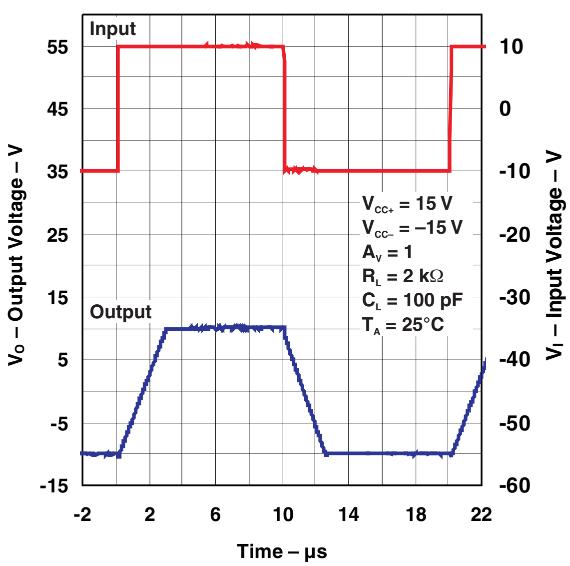
INPUT REFERRED NOISE VOLTAGE
vs
SOURCE RESISTANCE



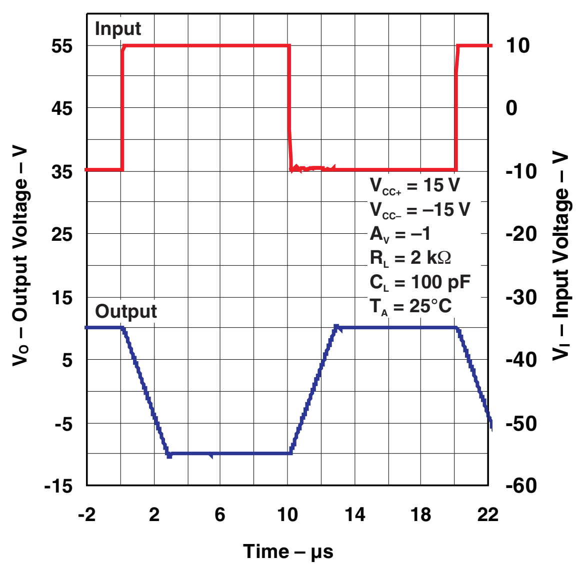
GAIN AND PHASE MARGIN
vs
DIFFERENTIAL SOURCE RESISTANCE



LARGE SIGNAL TRANSIENT RESPONSE
($A_V = 1$)

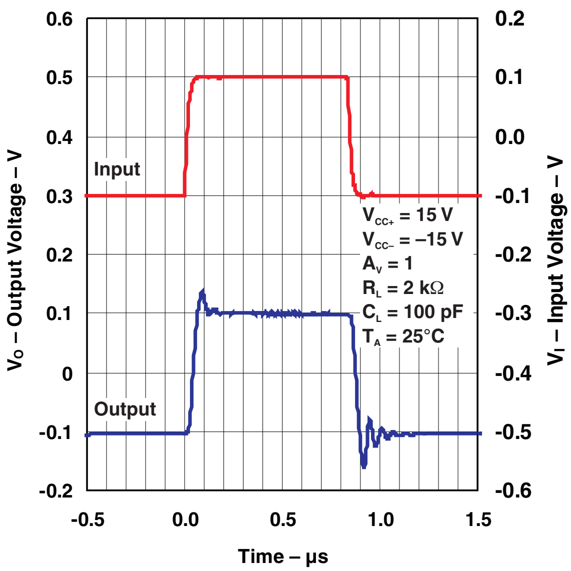


LARGE SIGNAL TRANSIENT RESPONSE
($A_V = –1$)

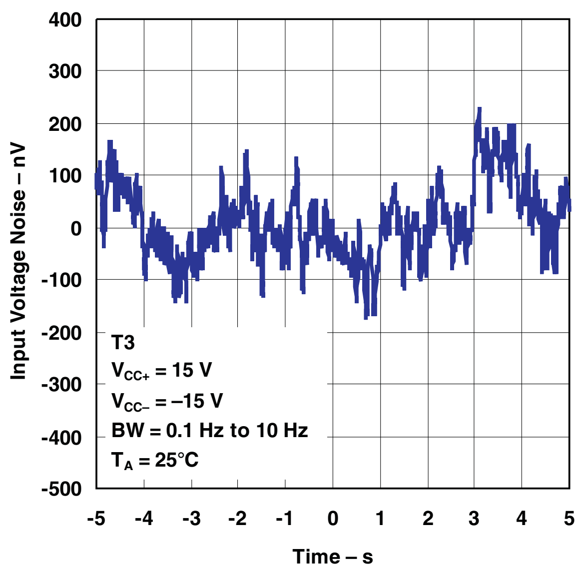


TYPICAL CHARACTERISTICS (continued)

SMALL SIGNAL TRANSIENT RESPONSE



LOW_FREQUENCY NOISE



APPLICATION INFORMATION

Output Characteristics

All operating characteristics are specified with 100-pF load capacitance. The MC33078 can drive higher capacitance loads. However, as the load capacitance increases, the resulting response pole occurs at lower frequencies, causing ringing, peaking, or oscillation. The value of the load capacitance at which oscillation occurs varies from lot to lot. If an application appears to be sensitive to oscillation due to load capacitance, adding a small resistance in series with the load should alleviate the problem (see Figure 2).

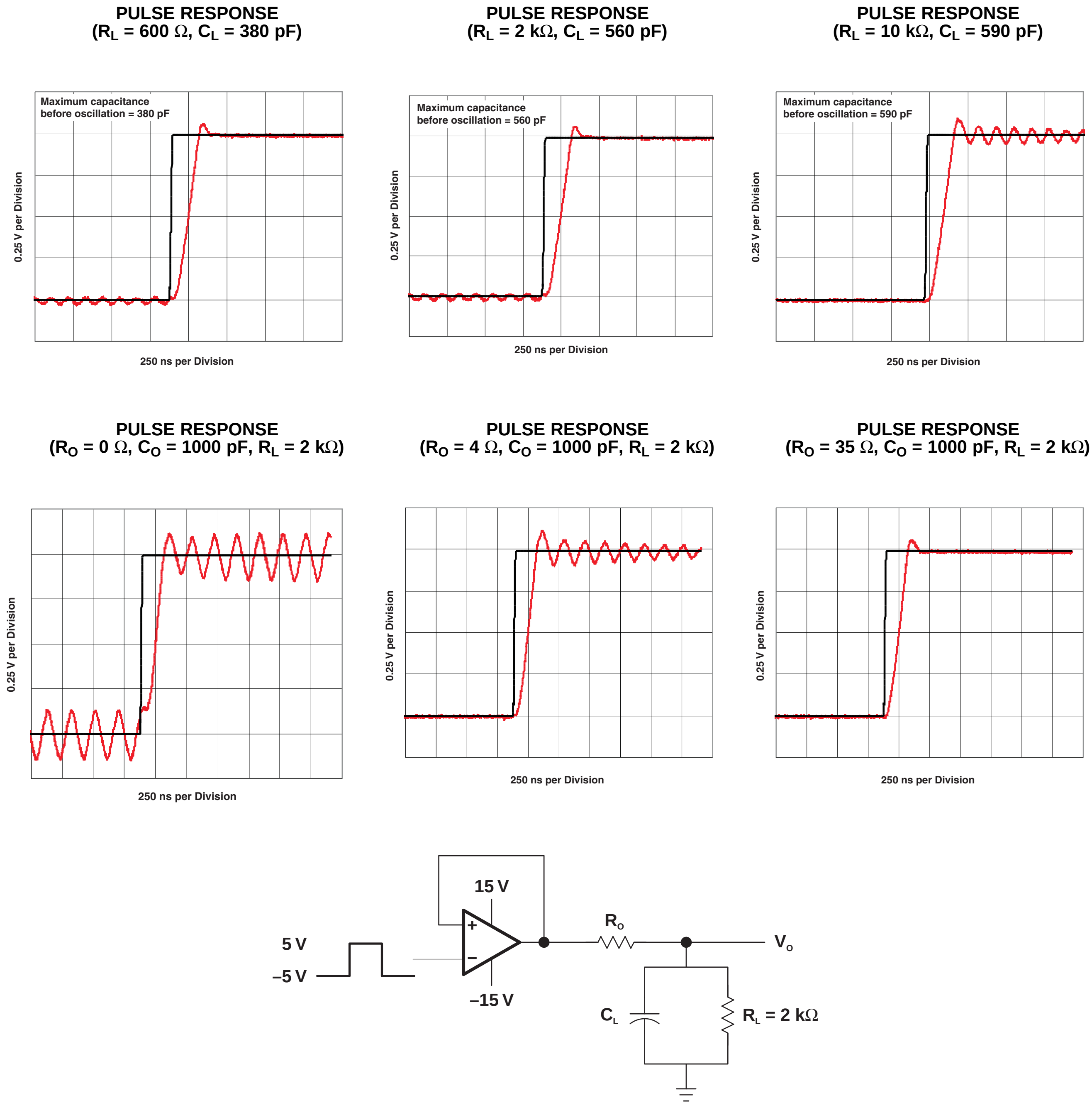


Figure 2. Output Characteristics

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
MC33078MDREP	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MC33078MDREPG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
V62/07606-01XE	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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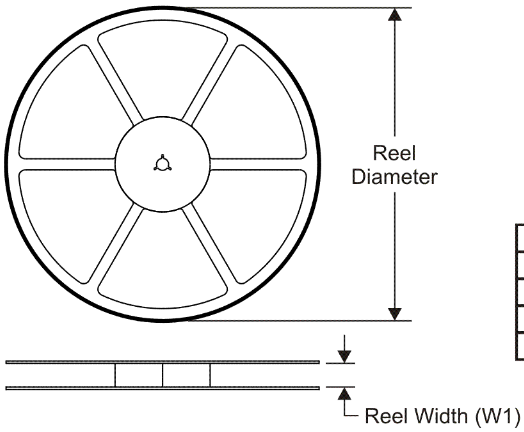
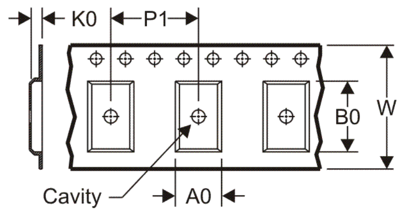
OTHER QUALIFIED VERSIONS OF MC33078-EP :
- Catalog: MC33078

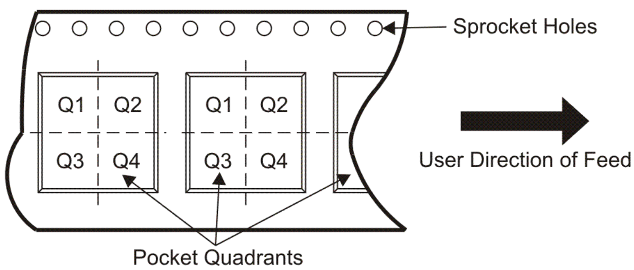
NOTE: Qualified Version Definitions:
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION





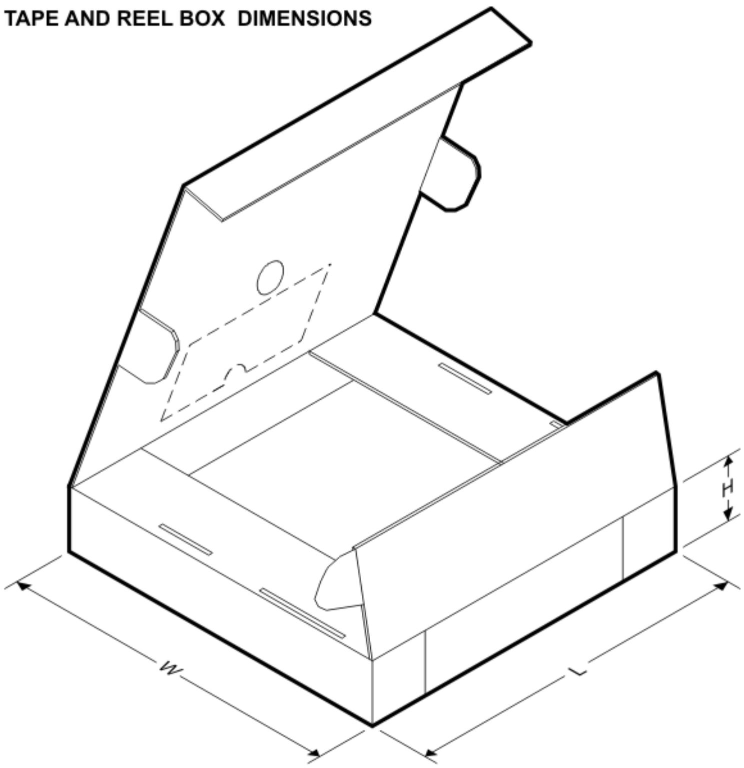
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
MC33078MDREP	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

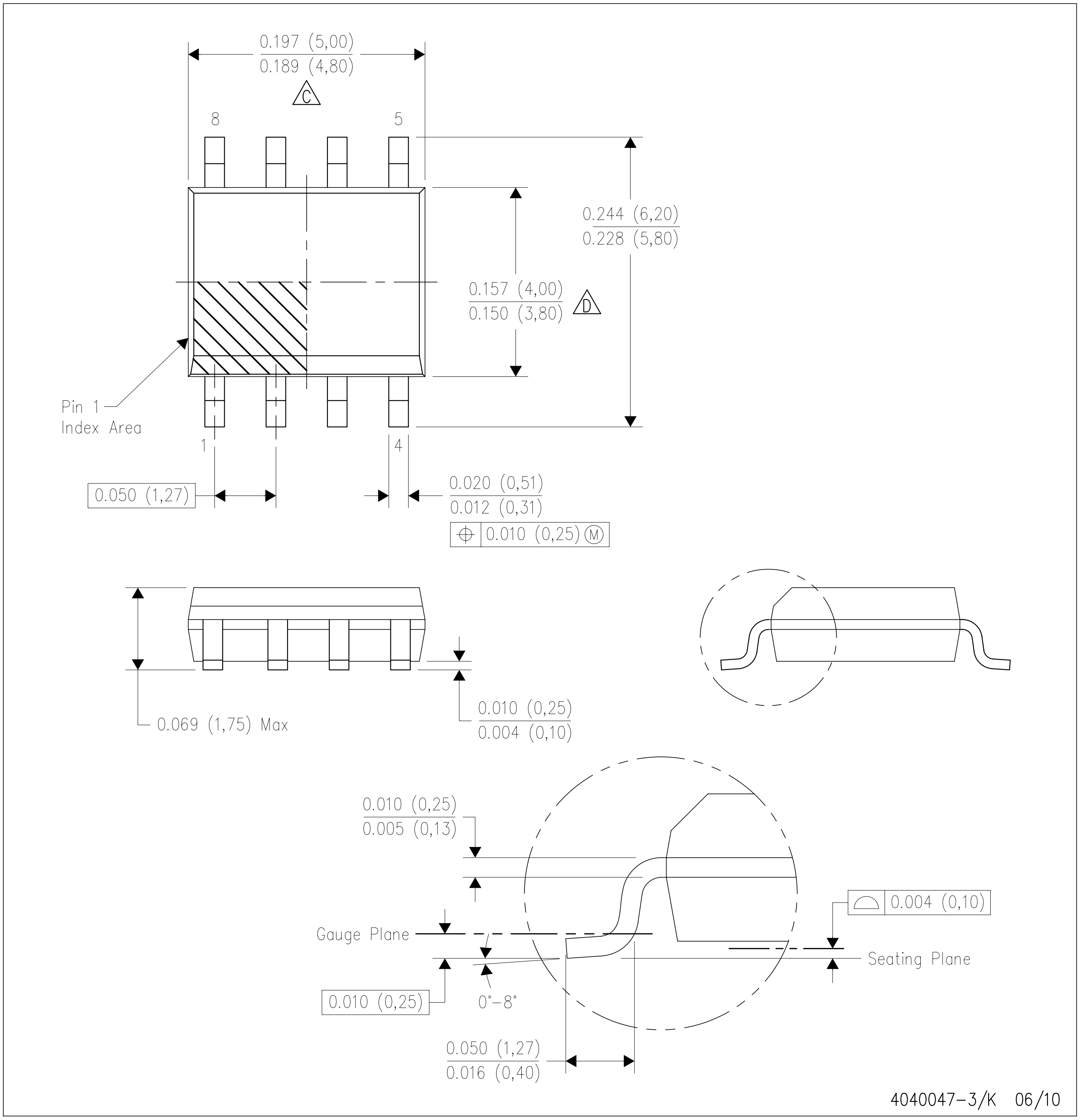
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

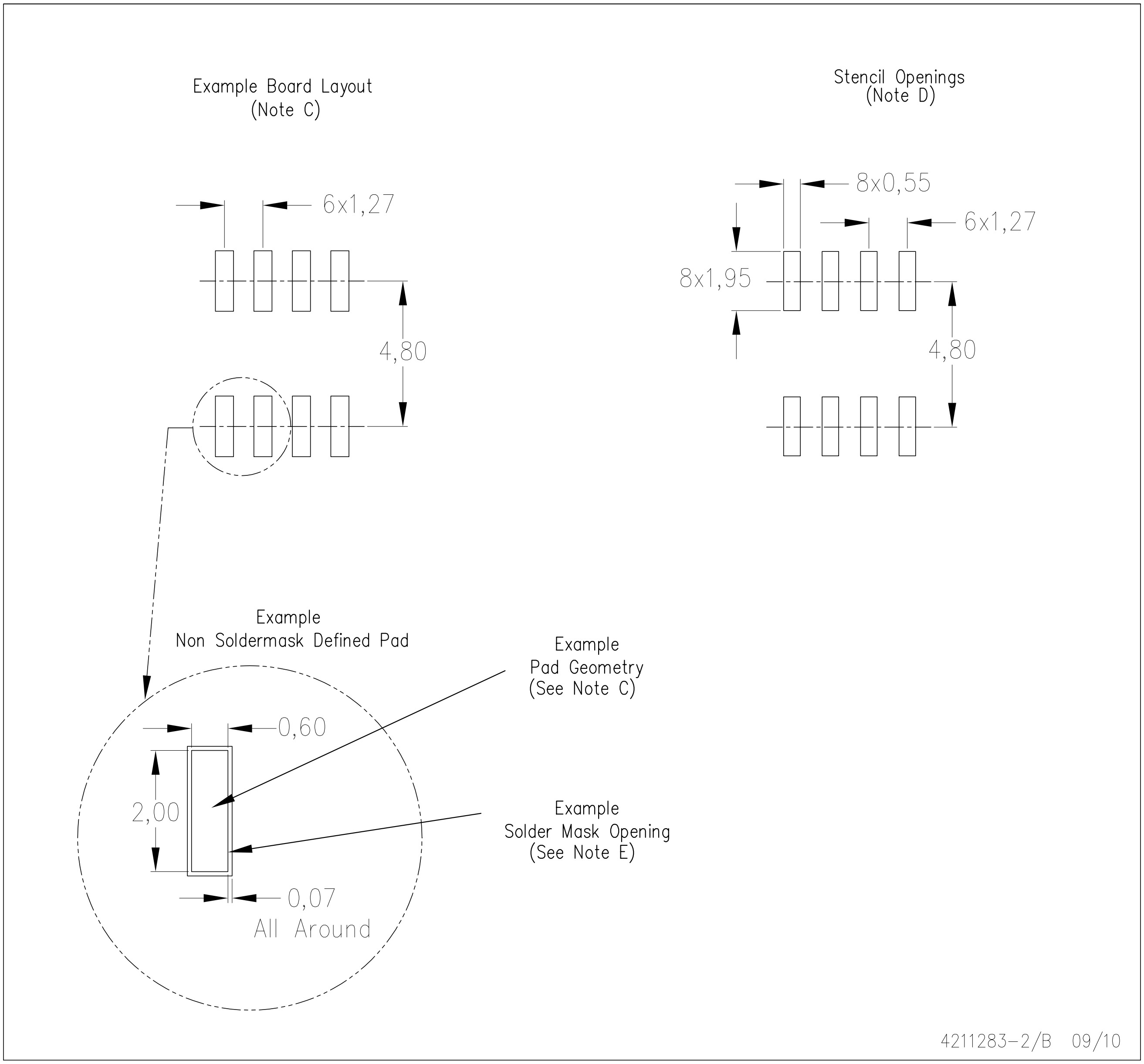
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
MC33078MDREP	SOIC	D	8	2500	346.0	346.0	29.0

D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS–012 variation AA.

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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