LME49713 High Performance, High Fidelity Current Feedback Audio Operational Amplifier

Check for Samples: LME49713

FEATURES

- **Easily Drives 150Ω Loads**
- **Optimized for Superior Audio Signal Fidelity**
- **Output Short Circuit Protection**
- **100dB (Typ) PSRR and 88dB (Typ) CMRR**
- **SOIC High-Performance and TO-99 Packages**

APPLICATIONS

- **Ultra High Quality Audio Amplification**
- **High-Fidelity Preamplifiers**
- **High-Fidelity Multimedia**
- **State-of-the-Art Phono Pre Amps**
- **High-Performance Professional Audio**
- **High-Fidelity Equalization and Crossover Networks**
- **High-Performance Line Drivers**
- **High-Performance Line Receivers**
- **High-Fidelity Active Filters**

KEY SPECIFICATIONS

- **Power Supply Voltage Range: ±5V to ±18V**
- **THD+N, f = 1kHz (A_V = 1, R_L = 100Ω, V_{OUT} = 3V_{RMS}): 0.0006% (typ)**
- **THD+N, f = 1kHz (A_V = 1, R_L = 600Ω, V_{OUT} = 1.4V_{RMS}): 0.00036% (typ)**
- **Input Noise Density: 1.9nV/$\sqrt{Hz}$ (typ)**
- **Slew Rate: ±1900V/μs (typ)**
- **Bandwidth (A_V = –1, R_L= 2kΩ, R_F = 1.2kΩ): 132 MHz (typ)**
- **Input Bias Current: 1.8μA (typ)**
- **Input Offset Voltage: 0.05mV (typ)**

DESCRIPTION

The LME49713 is an ultra-low distortion, low noise, ultra high slew rate current feedback operational amplifier optimized and fully specified for high performance, high fidelity applications. Combining advanced leading-edge process technology with state-of-the-art circuit design, the LME49713 current feedback operational amplifier delivers superior signal amplification for outstanding performance. Operating on a wide supply range of ±5V to ±18V, the LME49713 combines extremely low voltage noise density (1.9nV/$\sqrt{Hz}$) with very low THD+N (0.00036%) to easily satisfy the most demanding applications. To ensure that the most challenging loads are driven without compromise, the LME49713 has a high slew rate of ±1900V/μs and an output current capability of ±100mA. Further, dynamic range is maximized by an output stage that drives 150Ω loads to within 2.9V of either power supply voltage.

The LME49713's outstanding CMRR (88dB), PSRR (100dB), and V_{OS} (0.05mV) give the amplifier excellent operational amplifier DC performance.

The LME49713 is available in an 8-lead narrow body SOIC and an 8-lead TO-99. Demonstration boards are available.

CONNECTION DIAGRAMS

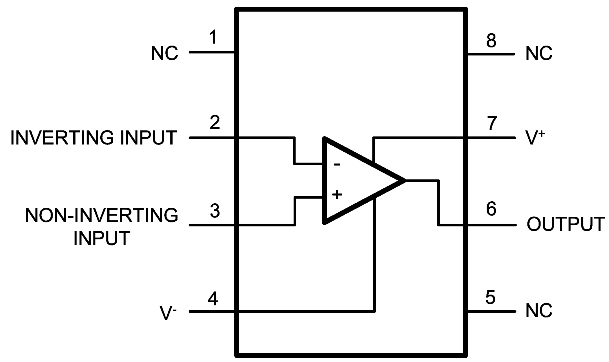

Figure 1. 8-Lead SOIC (D Package)

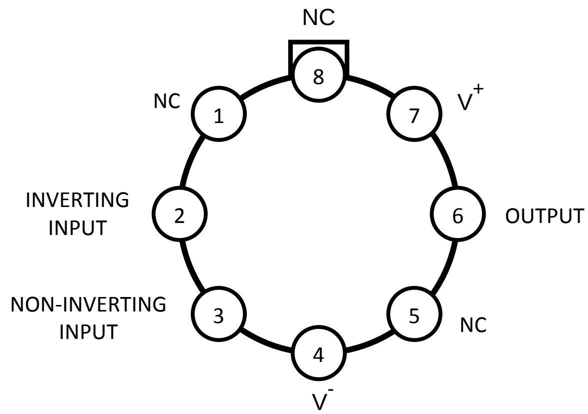

Figure 2. 8-Lead TO-99 (LMC Package)

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS[1][2][3]

Power Supply Voltage ($V_S = V^+ - V^-$)	38V
Storage Temperature	−65°C to 150°C
Input Voltage	(V-) - 0.7V to (V+) + 0.7V
Output Short Circuit[4]	Continuous
Power Dissipation	Internally Limited
ESD Rating[5]	2000V
ESD Rating[6]	200V
Junction Temperature	150°C
Thermal Resistance	
θ_{JA} (MA)	145°C/W
Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	–40°C ≤ T_J ≤ 70°C
Supply Voltage Range	±5.0V ≤ V_S ≤ ± 18V

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the *Absolute Maximum Ratings* or other conditions beyond those indicated in the *Recommended Operating Conditions* is not implied. The *Recommended Operating Conditions* indicate conditions at which the device is functional and the device should not be operated beyond such conditions. All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) The *Electrical Characteristics* tables list ensured specifications under the listed *Recommended Operating Conditions* except as otherwise modified or specified by the *Electrical Characteristics Conditions* and/or Notes. Typical specifications are estimations only and are not ensured.
(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(4) Amplifier output connected to GND, any number of amplifiers within a package.
(5) Human body model, applicable std. JESD22-A114C.
(6) Machine model, applicable std. JESD22-A115-A.

ELECTRICAL CHARACTERISTICS[1][2]

The following specifications apply for the V_S = ±15V, R_L = 2kΩ, R_{SOURCE} = 10Ω, f_{IN} = 1kHz, and T_J = 25°C, unless otherwise specified.

Symbol	Parameter	Conditions	LME49713		Units (Limits)
			Typical[3]	Limit[4]	
THD+N	Total Harmonic Distortion + Noise	A_V = 1, V_{OUT} = $3V_{RMS}$, R_F = 1.2kΩ R_L = 100Ω, V_{OUT} = $3V_{RMS}$ R_L = 600Ω, V_{OUT} = $1.4V_{RMS}$	0.0006 0.00036	0.00071 0.00045	% (max) % (max)
IMD	Intermodulation Distortion	A_V = 1, V_{IN} = $3V_{RMS}$ Two-tone, 60Hz & 7kHz 4:1	0.00009		%
BW	Bandwidth	A_V = –1, R_F = 1.2kΩ	132		MHz
SR	Slew Rate	V_O = $20V_{P-P}$, A_V = –1	±1900		V/μs
FPBW	Full Power Bandwidth	V_{OUT} = $20V_{P-P}$, A_V = –1	30		MHz
t_s	Settling time	A_V = –1, 10V step, 0.1% error range	50		ns
e_n	Equivalent Input Noise Voltage	f_{BW} = 20Hz to 20kHz	0.26	0.6	$μV_{RMS}$ (max)
	Equivalent Input Noise Density	f = 1kHz f = 10Hz	1.9 11.5	4.0	nV/√Hz (max)
i_n	Current Noise Density	f = 1kHz f = 10Hz	16 160		pA/√Hz
V_{OS}	Input Offset Voltage		±0.05	±1.0	mV (max)
$ΔV_{OS}/Δ$Temp	Average Input Offset Voltage Drift vs Temperature	–40°C ≤ T_A ≤ 85°C	0.29		μV/°C
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	V_{SUPPLY} = ±5V to ±15V [5]	100	95	dB (min)
I_B	Input Bias Current	V_{CM} = 0V	1.8	6	μA (max)
$ΔI_{OS}/Δ$Temp	Input Bias Current Drift vs Temperature	–40°C ≤ T_A ≤ 85°C Inverting input Non-inverting input	4.5 4.7		nA/°C nA/°C
I_{OS}	Input Offset Current	V_{CM} = 0V	1.3	5	μA (max)
V_{IN-CM}	Common-Mode Input Voltage Range		±13.5	(V+) – 2.0 (V-) + 2.0	V (min) V (min)
CMRR	Common-Mode Rejection	–10V<Vcm<10V	88	86	dB (min)
Z_{IN}	Non-inverting-input Input Impedance	–10V<Vcm<10V	1.2		MΩ
	Inverting-input Input Impedance	–10V<Vcm<10V	58		Ω
Z_T	Transimpedance	V_{OUT} = ±10V R_L = 200Ω R_L = ∞	4.2 4.7	2.0 2.65	MΩ (min) MΩ (min)
V_{OUTMAX}	Maximum Output Voltage Swing	R_L = 150Ω	±11.1	±10.3	V (min)
		R_L = 600Ω	±11.6	±11.4	V (min)
I_{OUT}	Output Current	R_L = 150Ω, V_S = ±18V	±100	±91	mA (min)
I_{OUT-CC}	Instantaneous Short Circuit Current		±140		mA
R_{OUT}	Output Resistance	f_{IN} = 5MHz, Open-Loop	10		Ω
I_S	Total Quiescent Current	I_{OUT} = 0mA	8.5	10	mA (max)

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the *Absolute Maximum Ratings* or other conditions beyond those indicated in the *Recommended Operating Conditions* is not implied. The *Recommended Operating Conditions* indicate conditions at which the device is functional and the device should not be operated beyond such conditions. All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) The *Electrical Characteristics* tables list ensured specifications under the listed *Recommended Operating Conditions* except as otherwise modified or specified by the *Electrical Characteristics Conditions* and/or Notes. Typical specifications are estimations only and are not ensured.
(3) Typical values represent most likely parametric norms at T_A = +25ºC, and at the *Recommended Operation Conditions* at the time of product characterization and are not ensured.
(4) Datasheet min/max specification limits are specified by test or statistical analysis.
(5) PSRR is measured as follows: V_{OS} is measured at two supply voltages, ±5V and ±15V. PSRR = | $20\log(ΔV_{OS}/ΔV_S)$ |.

TYPICAL PERFORMANCE CHARACTERISTICS

THD FFT vs Frequency
V_O = 3V_{RMS}, R_L = 1kΩ, V_S = ±15V, A_V = 1

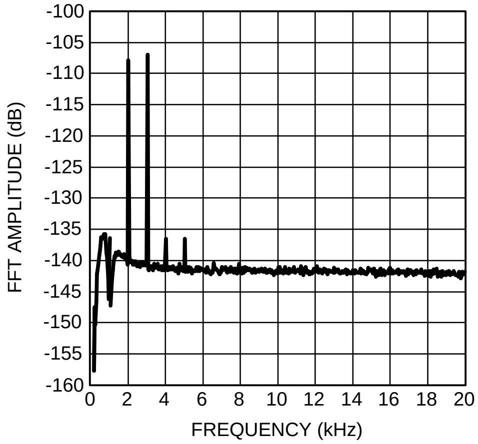

Figure 3.

THD FFT vs Frequency
V_O = 3V_{RMS}, R_L = 100Ω, V_S = ±15V, A_V = 1

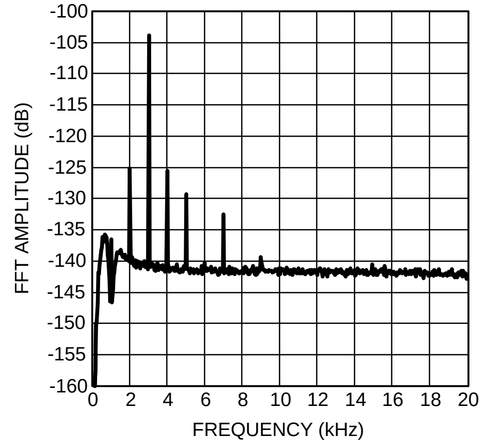

Figure 4.

THD FFT vs Frequency
V_O = 3V_{RMS}, R_L = 600Ω, V_S = ±15V, A_V = 1

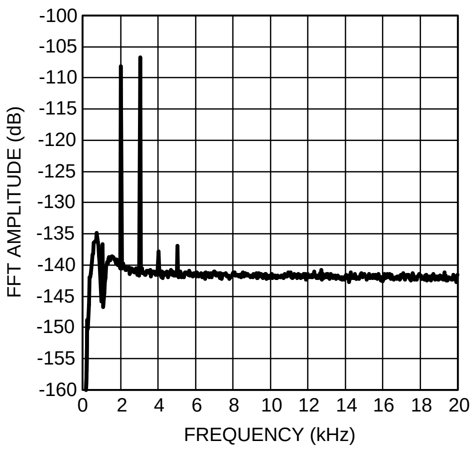

Figure 5.

THD FFT vs Frequency
V_{O1} = 1.4V_{RMS}, R_L = 1kΩ, V_S = ±15V, A_V = 1

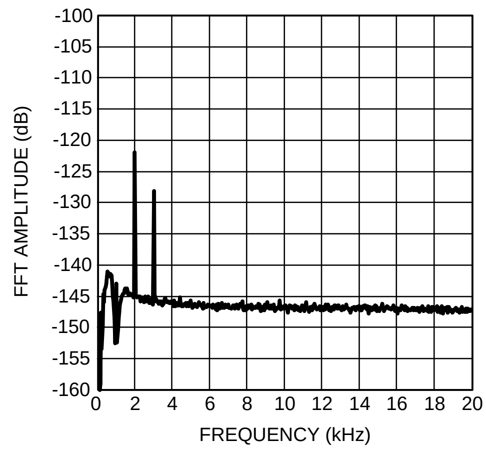

Figure 6.

THD FFT vs Frequency
V_{O1} = 1.4V_{RMS}, R_L = 100Ω, V_S = ±15V, A_V = 1

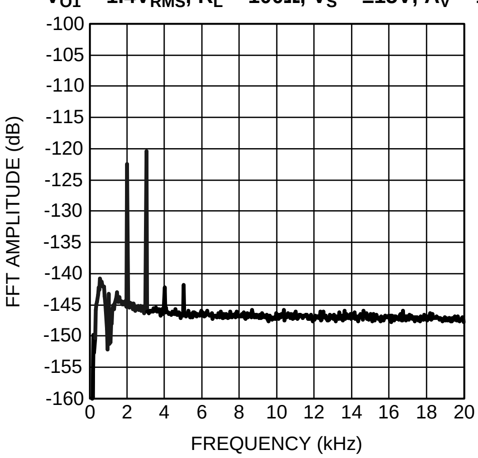

Figure 7.

THD FFT vs Frequency
A_V =1. 4V_{RMS}, R_L = 600Ω, V_S = ±15V, A_V = 1

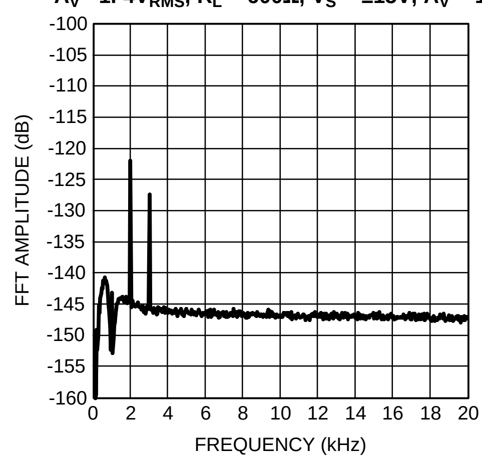

Figure 8.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

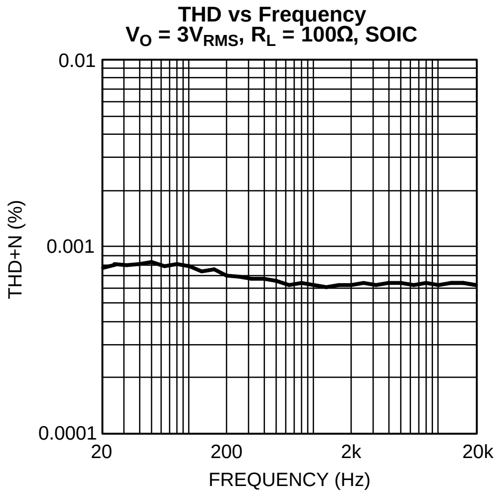

Figure 9.

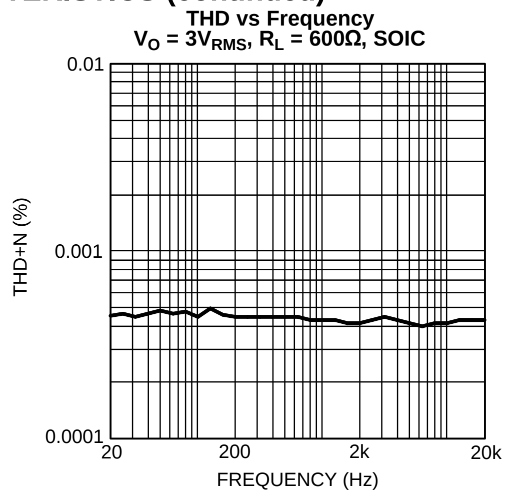

Figure 10.

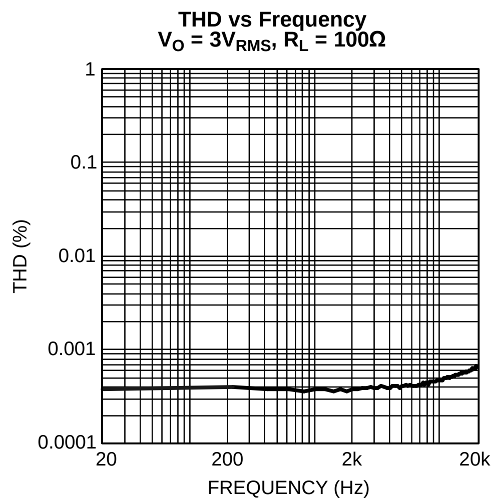

Figure 11.

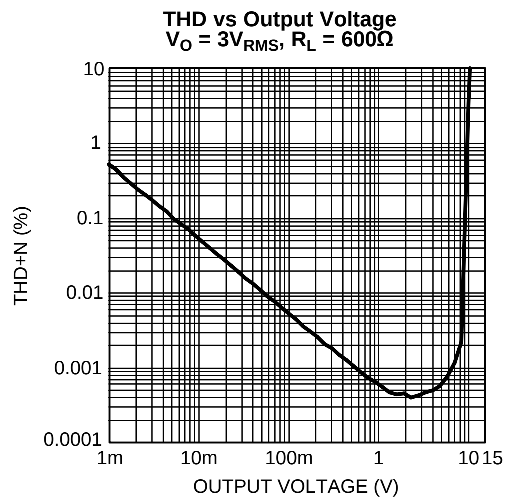

Figure 12.

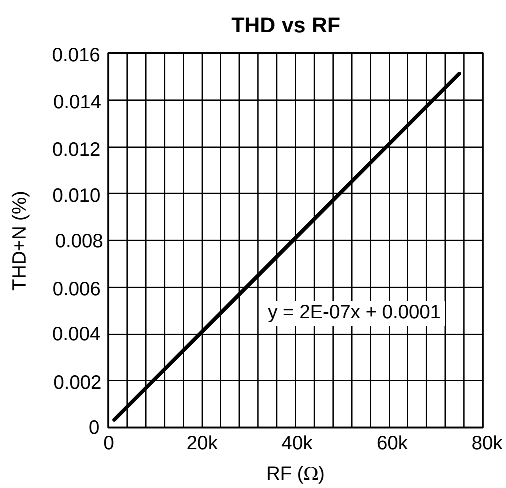

Figure 13.

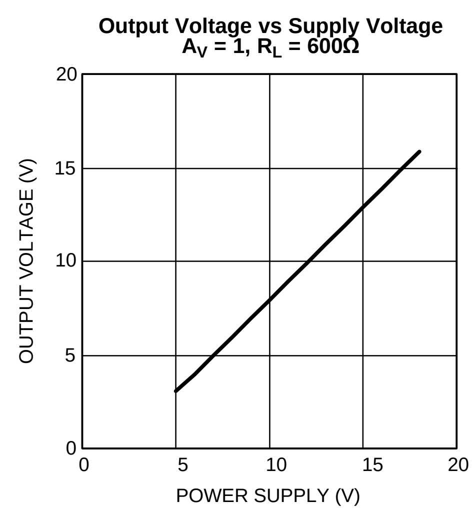

Figure 14.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Output Voltage vs Supply Voltage
A_V = 1, R_L = open

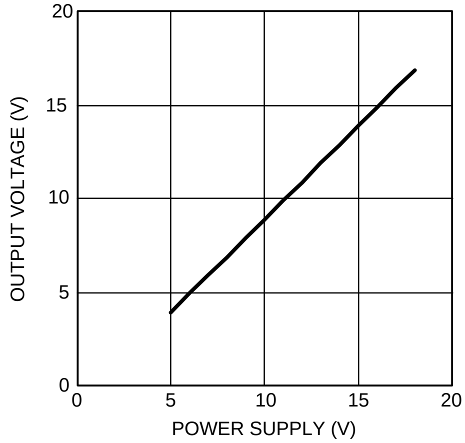

Figure 15.

Supply Current (I_{CC}) vs Power Supply
R_L = open

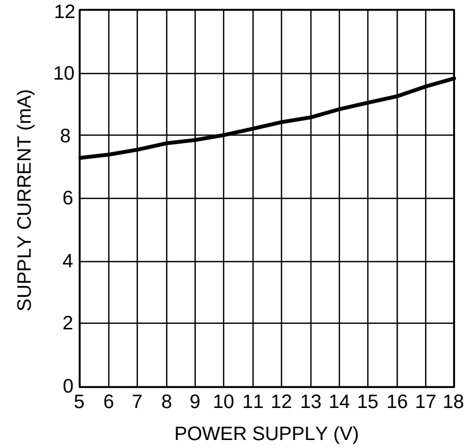

Figure 16.

Supply Current (I_{EE}) vs Power Supply
R_L = open

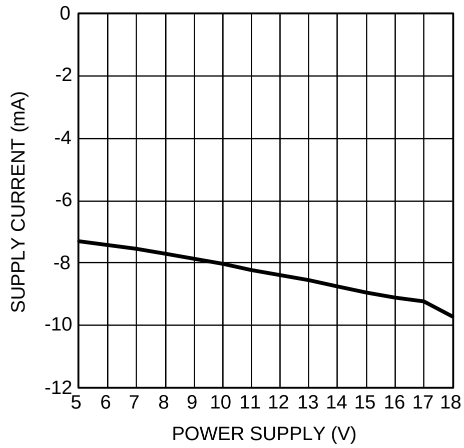

Figure 17.

Gain vs Frequency
V_S = ±15V, G = –1

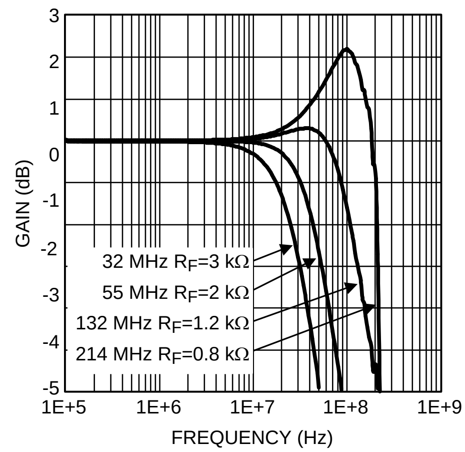

Figure 18.

Gain vs Frequency
V_S = ±15V, G = –2

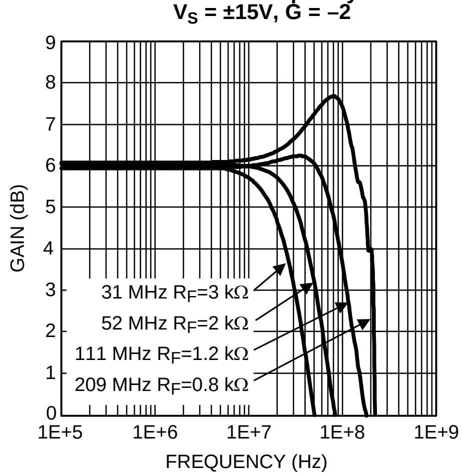

Figure 19.

Gain vs Frequency
V_S = ±15V, G = –5

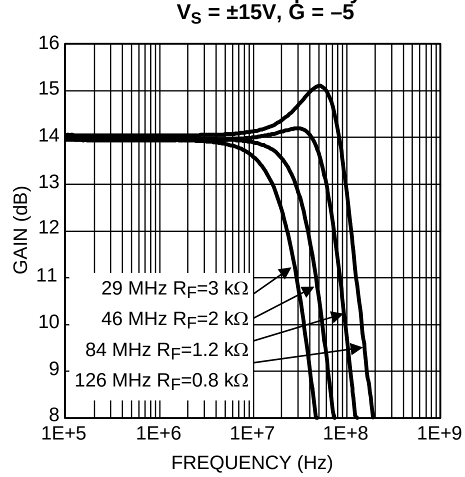

Figure 20.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

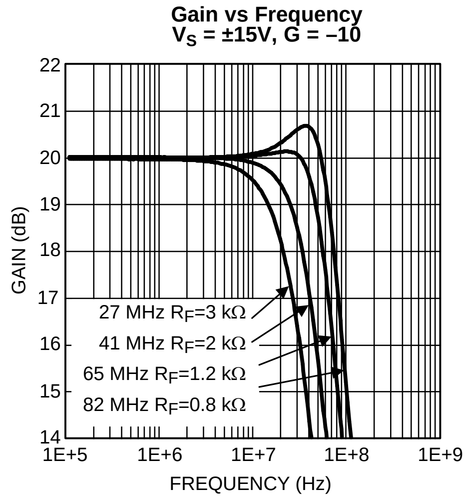

Figure 21.

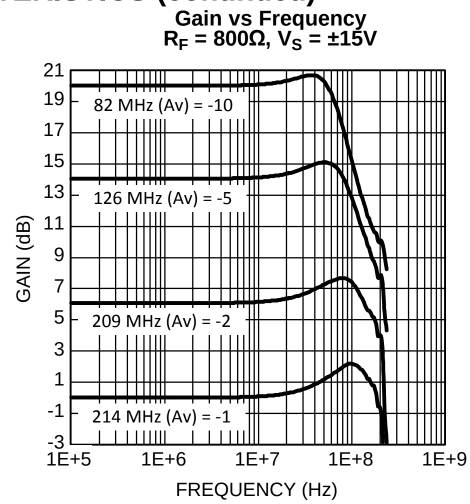

Figure 22.

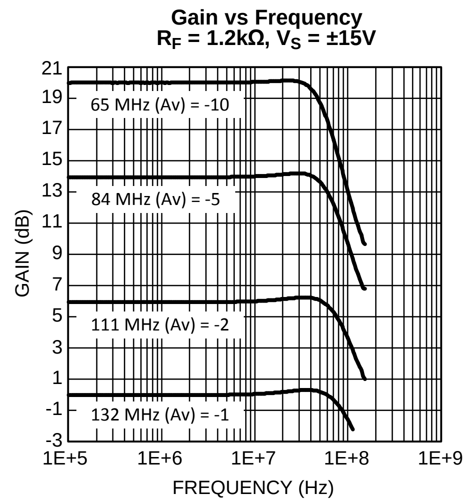

Figure 23.

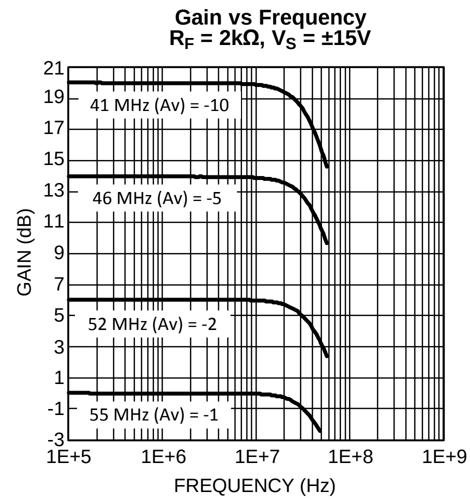

Figure 24.

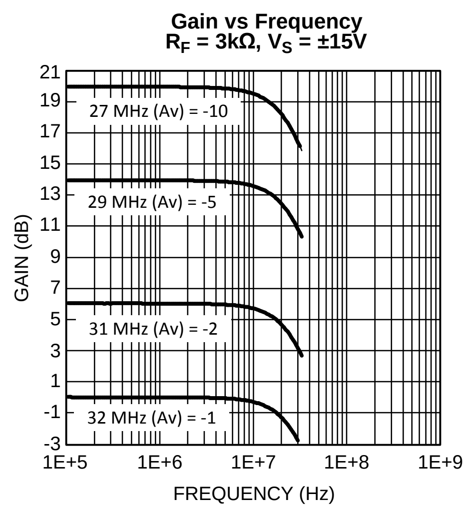

Figure 25.

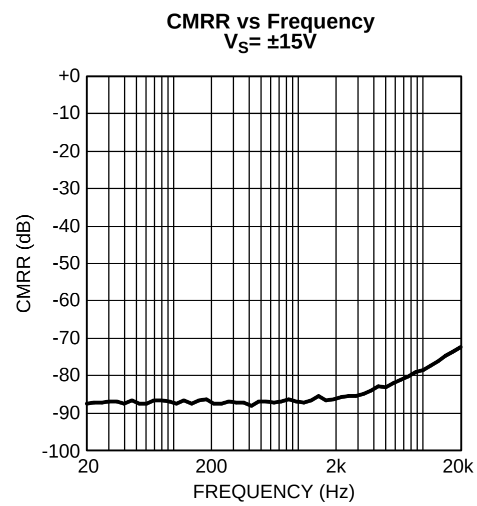

Figure 26.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

PSRR vs Frequency
V_S= ±15V, V_{RIPPLE} = 200mV$_{P-P}$

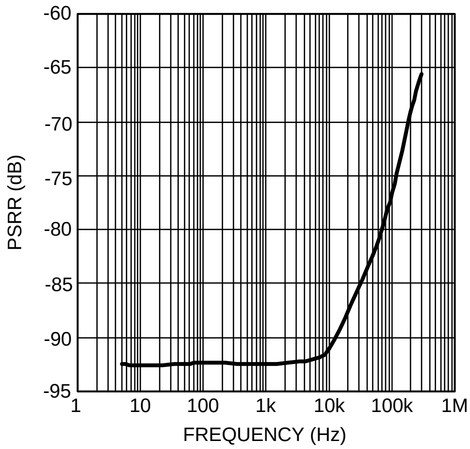

Figure 27.

Current Noise vs Frequency
V_S= ±15V

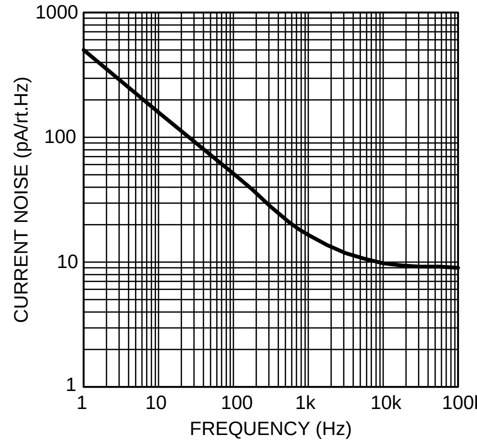

Figure 28.

Equivalent Voltage Noise vs Frequency
V_S= ±15V

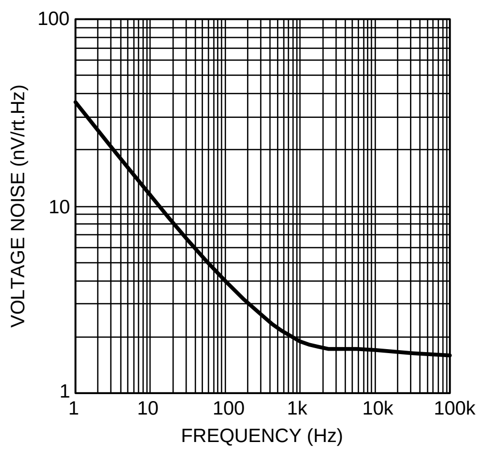

Figure 29.

Slew Rate vs Output Voltage
V_S= ±15V

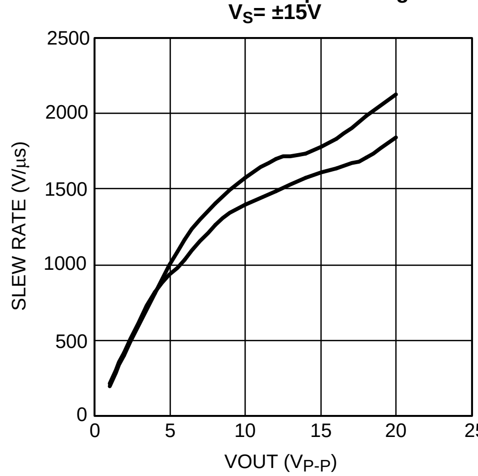

Figure 30.

APPLICATION INFORMATION

GENERAL AMPLIFIER FUNCTION

Voltage feedback amplifiers have a small-signal bandwidth that is a function of the closed-loop gain. Conversely, the LME49713 current feedback amplifier features a small-signal bandwidth that is relatively independent of the closed-loop gain. This is shown in Figure 31 where the LME49713's gain is –1, –2, –5, and –10. Like all current feedback amplifiers, the LME49713's closed-loop bandwidth is a function of the feedback resistance value. Therefore, R_S must be varied to select the desired closed-loop gain.

POWER SUPPLY BYPASSING AND LAYOUT CONSIDERATIONS

Properly placed and correctly valued supply bypassing is essential for optimized high-speed amplifier operation. The supply bypassing must maintain a wideband, low-impedance capacitive connection between the amplifier's supply pin and ground. This helps preserve high speed signal and fast transient fidelity. The bypassing is easily accomplished using a parallel combination of a 10μF tantalum and a 0.1μF ceramic capacitors for each power supply pin. The bypass capacitors should be placed as close to the amplifier power supply pins as possible.

FEEDBACK RESISTOR SELECTION (R_f)

The value of the R_f, is also a dominant factor in compensating the LME49713. For general applications, the LME49713 will maintain specified performance with an 1.2kΩ feedback resistor. Although this value will provide good results for most applications, it may be advantageous to adjust this value slightly for best pulse response optimized for the desired bandwidth. In addition to reducing bandwidth, increasing the feedback resistor value also reduces overshoot in the time domain response.

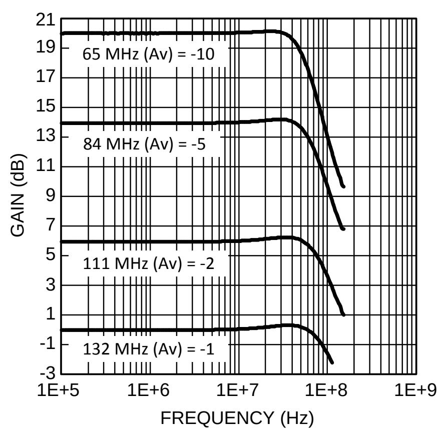

Figure 31. Bandwidth as a Function of Gain

SLEW RATE CONSIDERATIONS

A current feedback amplifier's slew rate characteristics are different than that of voltage feedback amplifiers. A voltage feedback amplifier's slew rate limiting or non-linear amplifier behavior is dominated by the finite availability of the first stage tail current charging the second stage voltage amplifier's compensation capacitor. Conversely, a current feedback amplifier's slew rate is not constant. Transient current at the inverting input determines slew rate for both inverting and non-inverting gains. The non-inverting configuration slew rate is also determined by input stage limitations. Accordingly, variations of slew rates occur for different circuit topologies.

DRIVING CAPACITIVE LOADS

The LME49713 can drive significantly higher capacitive loads than many current feedback amplifiers. Although the LME49713 can directly drive as much as 100pF without oscillating, the resulting response will be a function of the feedback resistor value.

CAPACITIVE FEEDBACK

It is quite common to place a small lead-compensation capacitor in parallel with a voltage feedback amplifier's feedback resistance, R_f. This compensation reduces the amplifier's peaking in the frequency domain and damps the transient response. Whereas this yields the expected results when used with voltage feedback amplifiers, this technique must not be used with current feedback amplifiers. The dynamic impedance of capacitors in the feedback loop reduces the amplifier's stability. Instead, reduced peaking in the frequency response and bandwidth limiting can be accomplished by adding an RC circuit to the amplifier's input.

REVISION HISTORY

Rev	Date	Description
1.0	09/26/07	Initial release.
1.1	09/28/07	Added the Typical Performance curves.
1.2	10/03/07	Input Limit values.
1.3	10/29/07	Edited the Specification table, typical performance curve, and text edits.
1.4	01/29/08	Added more curves in the Typical Performance section.
1.5	07/24/08	Added the Metal Can package.
1.6	08/20/08	Text edits (updated some of the curves' titles).
1.7	08/22/08	Text edits.
1.8	02/08/10	Input changes on typical and limits in the EC table.
1.9	04/23/10	Input Typical and Limit edits on THD+N and I_{OUT} in the EC table.
2.0	06/02/10	Input text edits on the first page.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LME49713HA/NOPB	ACTIVE	TO-99	LMC	8	20	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	-40 to 85		Samples
LME49713MA/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	L49713 MA	Samples
LME49713MAX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	L49713 MA	Samples

(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.

(4) Only one of markings shown within the brackets will appear on the physical device.

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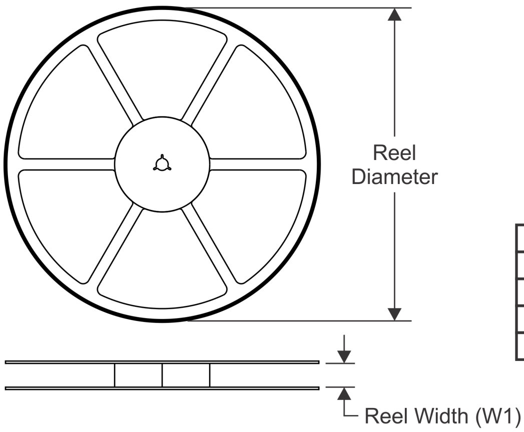
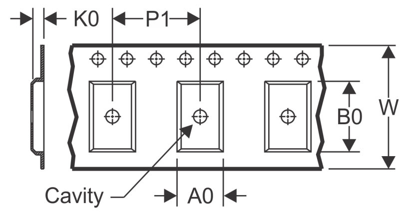
TAPE AND REEL INFORMATION

REEL DIMENSIONS

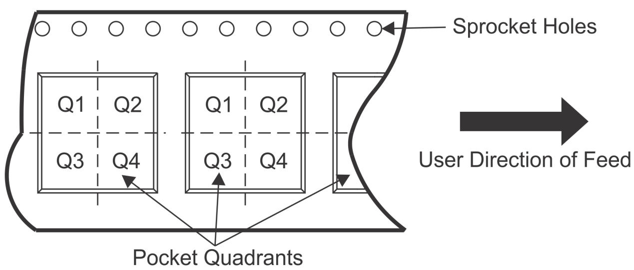


TAPE DIMENSIONS



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

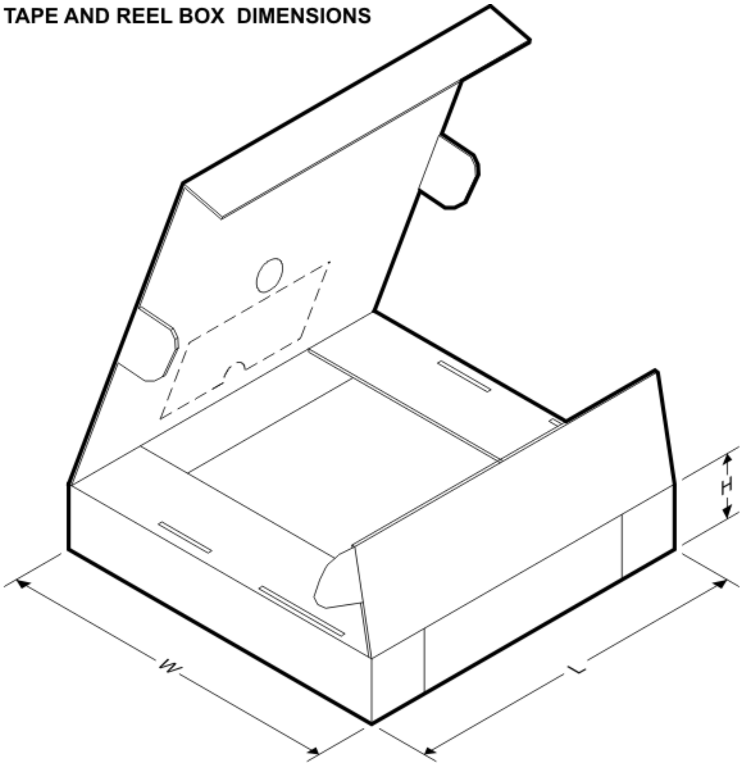
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LME49713MAX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1

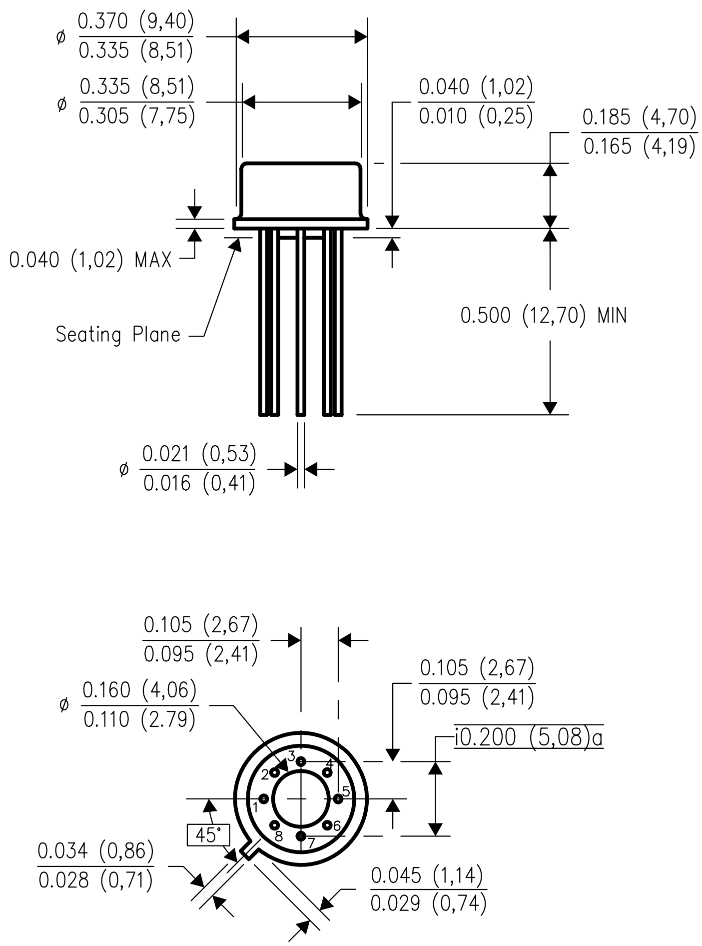
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

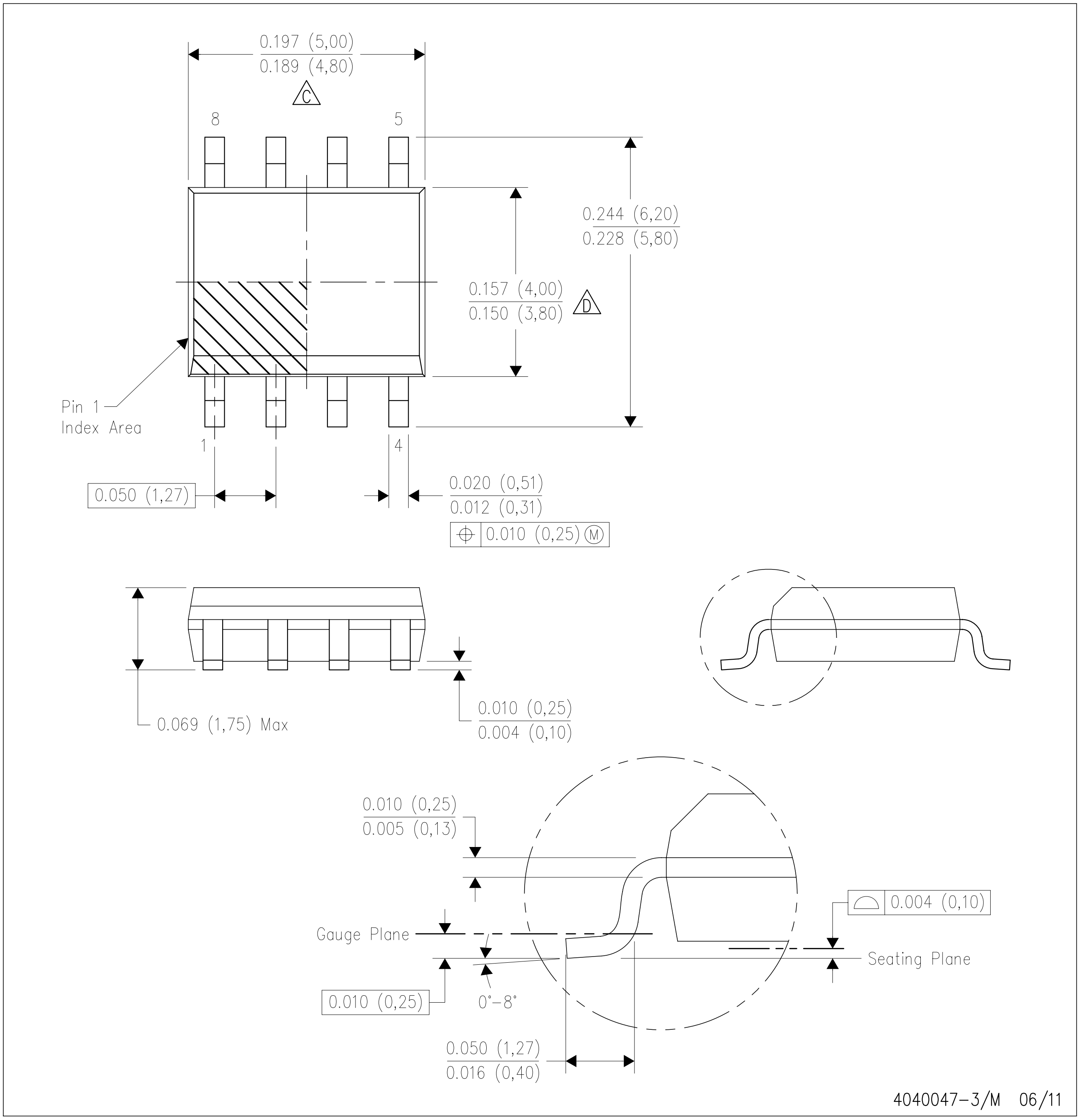
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LME49713MAX/NOPB	SOIC	D	8	2500	349.0	337.0	45.0

LMC (O-MBCY-W8) METAL CYLINDRICAL PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
D. Pin numbers shown for reference only. Numbers may not be marked on package.
E. Falls within JEDEC MO-002/TO-99.

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



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 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AA.

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