AMPLIFIER FOR HIGH-GAIN TWO-WIRE MICROPHONES

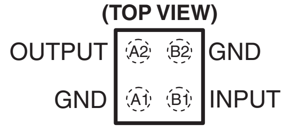
FEATURES

- **Supply Voltage: 2 V to 5 V**
- **Supply Current: <180 μA**
- **Signal-to-Noise Ratio (A-Weighted): 60 dB**
- **Output Voltage Noise (A-Weighted): −89 dBV**
- **Total Harmonic Distortion: 0.013%**
- **Voltage Gain: 15.6 dB**

APPLICATIONS

- **Cellular Phones**
- **Headsets**
- **Mobile Communications**
- **Automotive Accessories**
- **PDAs**
- **Accessory Microphone Products**

YDC PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

The TLV1012 is an audio amplifier series for small-form-factor electret microphones. This two-wire amplifier is designed to replace JFET amplifiers currently in use. The TLV1012 is ideally suited for applications that require high signal integrity in the presence of ambient or RF noise, such as in cellular communications. The TLV1012 audio amplifier is specified for operation over a 2.2-V to 5-V supply voltage range with a fixed gain of 15.6 dB. The device offers excellent THD, gain accuracy, and temperature stability compared to JFET microphones.

The TLV1012 enables a two-pin electret microphone solution, which provides direct pin-to-pin compatibility with the existing JFET market.

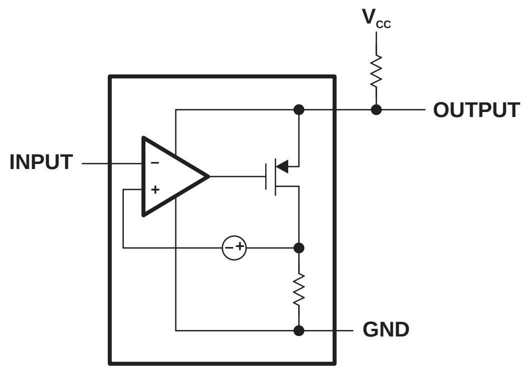
The TLV1012 is offered in a space-saving four-terminal ultra-thin lead-free package (YDC) and is ideally suited for the form factor of miniature electret microphone packages. The TLV1012 is characterized for operation over a free-air temperature range of –40°C to 85°C.

ORDERING INFORMATION[1]

T_A	A_V[2]	PACKAGE[3]		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	15.6 dB	NanoStar™ WCSP (DSBGA) – YDC	Reel of 3000	TLV1012-15YDCR	Y38

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Typical value measured at V_{DD} = 2.2 V, V_{IN} = 18 mV, R_L = 2.2 kΩ, C_L = 2.2 μF
(3) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

FUNCTIONAL BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS(1)

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

V_{CC}	Supply voltage	–0.3 V to 5.5 V
V_{IN}	Input voltage	–0.3 V to 0.3 V
θ_{JA}	Thermal impedance, junction to free air(2)	230.47°C/W
T_A	Operating free-air temperature range	–40°C to 85°C
T_{stg}	Storage temperature range	–65°C to 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) Package thermal impedance is calculated according to JESD 51-5.

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_{CC}	Supply voltage	2	5	V
T_A	Operating free-air temperature	–40	85	°C

2.2-V ELECTRICAL CHARACTERISTICS

V_{CC} = 2.2 V, V_{IN} = 18 mV, R_L = 2.2 kΩ and C_L = 2.2 µF (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_J	MIN	TYP	MAX	UNIT
I_{CC}	Supply current	V_{IN} = GND	25°C		150	240	µA
			Full range			280	
SNR	Signal-to-noise ratio	f = 1 kHz, V_{IN} = 18 mV_{PP}, A-weighted	25°C		60		dB
V_{IN}	Maximum input signal	f = 1 kHz, THD+N < 1%	25°C		100		mV_{PP}
V_{OUT}	Output voltage	V_{IN} = GND	25°C	1.70	1.87	1.94	V
			Full range	1.63		2.00	
f_{LOW}	Lower –3-dB roll-off frequency	R_{SOURCE} = 50 Ω	25°C		65		Hz
f_{HIGH}	Upper –3-dB roll-off frequency	R_{SOURCE} = 50 Ω	25°C		95		kHz
V_N	Output noise	A-weighted	25°C		–89		dBV
THD	Total harmonic distortion	f = 1 kHz, V_{IN} = 18 mV_{PP}	25°C		0.013		%
C_{IN}	Input capacitance		25°C		2		pF
Z_{IN}	Input impedance		25°C		>1000		GΩ
A_V	Gain	f = 1 kHz, R_{SOURCE} = 50 Ω	25°C	14.0	15.6	16.9	dB
			Full range	13.1		17.5	

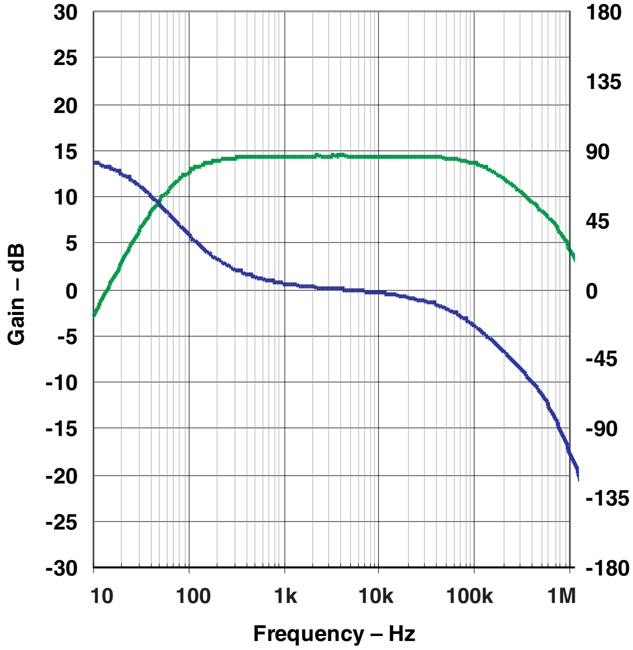
5-V ELECTRICAL CHARACTERISTICS

V_{CC} = 5 V, V_{IN} = 18 mV, R_L = 2.2 kΩ and C_L = 2.2 µF (unless otherwise noted)

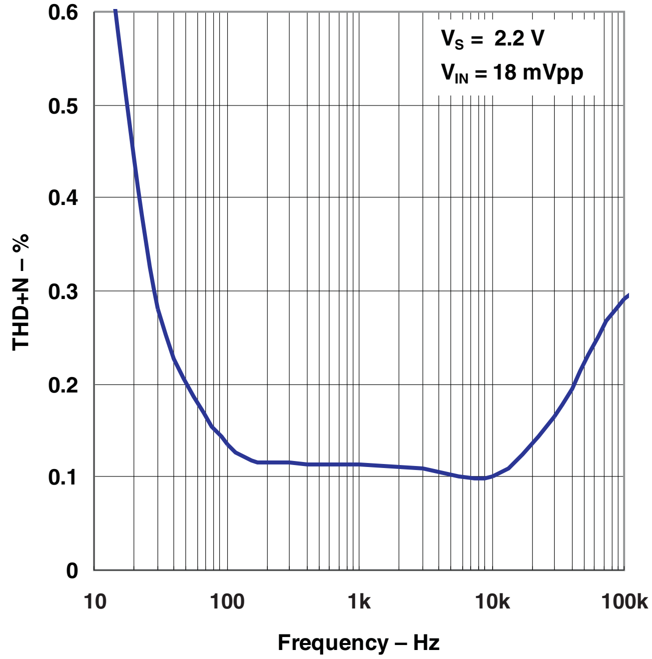
PARAMETER		TEST CONDITIONS	T_J	MIN	TYP	MAX	UNIT
I_{CC}	Supply current	V_{IN} = GND	25°C		160	300	µA
			Full range			325	
SNR	Signal-to-noise ratio	f = 1 kHz, V_{IN} = 18 mV_{PP}, A-weighted	25°C		60		dB
V_{IN}	Maximum input signal	f = 1 kHz, THD+N < 1%	25°C		100		mV_{PP}
V_{OUT}	Output voltage	V_{IN} = GND	25°C	4.34	4.56	4.74	V
			Full range	4.28		4.80	
f_{LOW}	Lower –3-dB roll-off frequency	R_{SOURCE} = 50 Ω	25°C		67		Hz
f_{HIGH}	Upper –3-dB roll-off frequency	R_{SOURCE} = 50 Ω	25°C		150		kHz
V_N	Output noise	A-weighted	25°C		–89		dBV
THD	Total harmonic distortion	f = 1 kHz, V_{IN} = 18 mV_{PP}	25°C		0.013		%
C_{IN}	Input capacitance		25°C		2		pF
Z_{IN}	Input impedance		25°C		>1000		GΩ
A_V	Gain	f = 1 kHz, R_{SOURCE} = 50 Ω	25°C	14.0	15.6	16.9	dB
			Full range	13.1		17.5	

TYPICAL CHARACTERISTICS

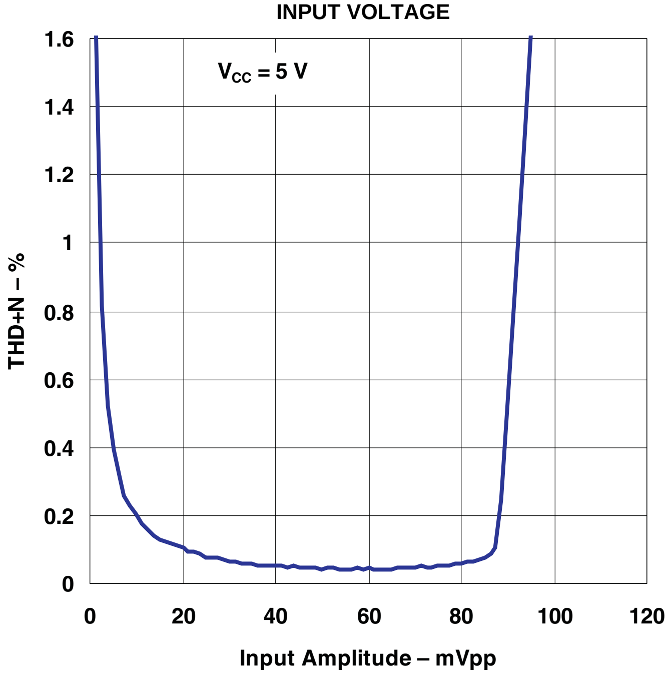
CLOSED LOOP GAIN AND PHASE
vs
FREQUENCY



TOTAL HARMONIC DISTORTION + NOISE
vs
FREQUENCY



TOTAL HARMONIC DISTORTION + NOISE
vs
INPUT VOLTAGE



TOTAL HARMONIC DISTORTION + NOISE
vs
INPUT VOLTAGE

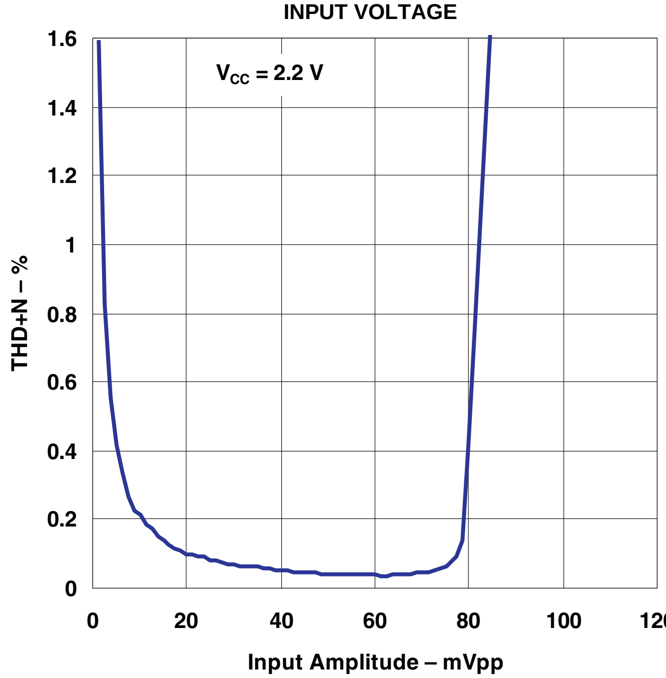
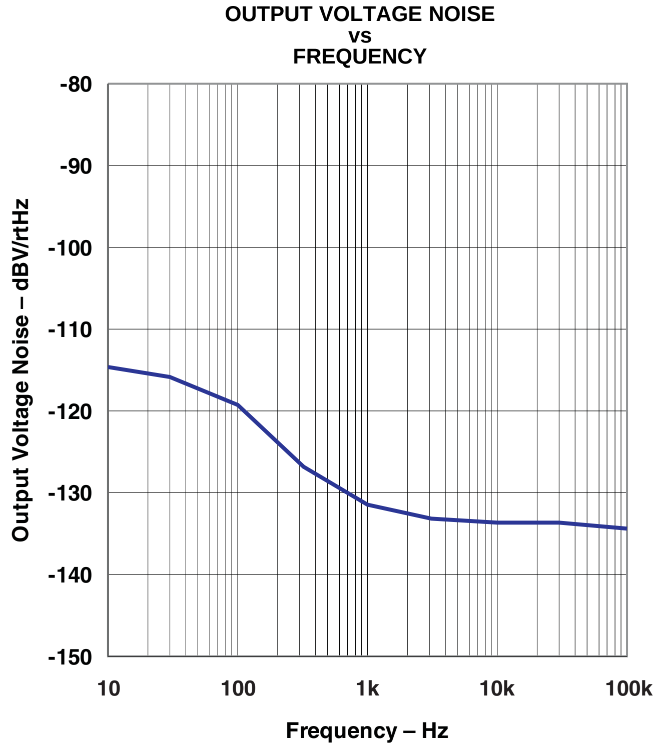


Figure 1.

TYPICAL CHARACTERISTICS (continued)



APPLICATION INFORMATION

High Gain

The TLV1012 provides outstanding gain compared to JFET amplifiers and still maintains the same ease of implementation, with improved gain, linearity, and temperature stability. A high gain eliminates the need for extra external components.

Built-In Gain

The TLV1012 is offered in the space-saving YDC package, which fits perfectly into the metal can of a microphone. This allows the TLV1012 to be placed on the PCB inside the microphone.

The bottom side of the PCB usually shows a bull's-eye pattern, where the outer ring, which is shorted to the metal can, should be connected to the ground. The center dot on the PCB is connected to the V_{CC} through a resistor. This phantom biasing allows both supply voltage and output signal on one connection.

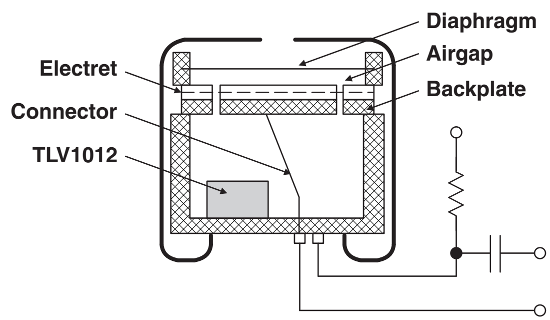


Figure 2. Built-In Gain

A-Weighted Filter

The human ear has a frequency range from 20 Hz to about 20 kHz. Within this range the sensitivity of the human ear is not equal for each frequency. To approach the hearing response, weighting filters are introduced. One of those filters is the A-weighted filter.

The A-weighted filter is usually used in signal-to-noise ratio measurements, where sound is compared to device noise. It improves the correlation of the measured data to the signal-to-noise ratio perceived by the human ear.

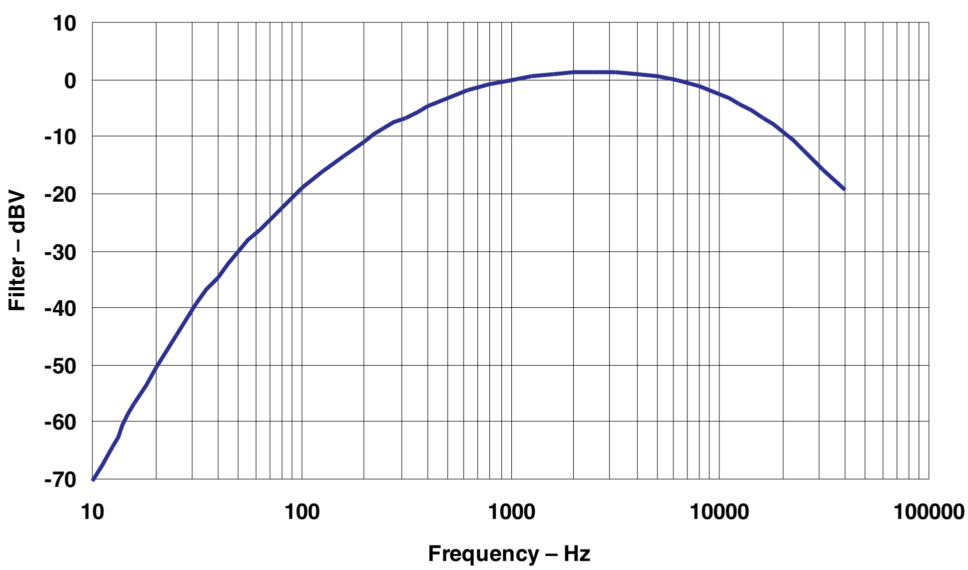


Figure 3. A-Weighted Filter

Measuring Noise and SNR

The overall noise of the TLV1012 is measured within the frequency band from 10 Hz to 22 kHz using an A-weighted filter. The input of the TLV1012 is connected to ground with a 5-pF capacitor.

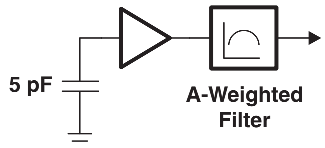


Figure 4. Noise Measurement

The signal-to-noise ratio (SNR) is measured with a 1 kHz input signal of 18 mV_{PP} using an A-weighted filter. This represents a sound pressure level of 94 dBSPL. No input capacitor is connected.

Sound Pressure Level

The volume of sound applied to a microphone is usually stated as the pressure level with respect to the threshold of hearing of the human ear. The sound pressure level in decibels is defined by:

Sound pressure level (dB) = 20 log P_m/P_O

Where P_m is the measured sound pressure, and P_O is the threshold of hearing (20 μPa).

To calculate the resulting output voltage of the microphone for a given sound pressure level, the sound pressure in dBSPL needs to be converted to the absolute sound pressure in dBPa. This is the sound pressure level in decibels, which is referred to as 1 Pascal (Pa).

The conversion is given by:

dBPa = dBSPL + 20 log 20 μPa

dBPa = dBSPL – 94 dB

Translation from absolute sound pressure level to a voltage is specified by the sensitivity of the microphone. A conventional microphone has a sensitivity of –44 dBV/Pa.

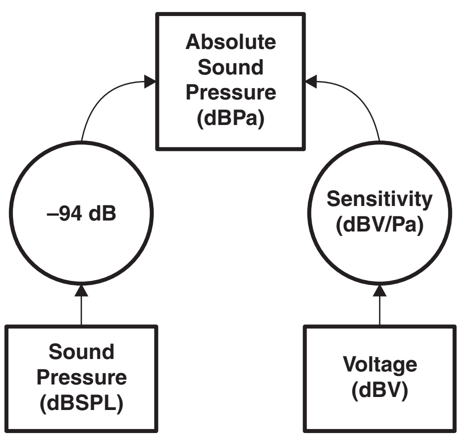


Figure 5. dB SPL to dBV Conversion

For example, busy traffic is 70 dBSPL:

V_{OUT} = 70 – 94 – 44 = –68 dBV

This is equivalent to 1.13 mV_{PP}.

Because the TLV1012-15 has a gain of 6 (15.6 dB) over the JFET, the output voltage of the microphone is 6.78 mV_{PP}. By replacing the JFET with the TLV1012-15, the sensitivity of the microphone is –28.4 dBV/Pa (–44 + 15.6).

Low-Frequency Cut-Off Filter

To reduce noise on the output of the microphone, a low-cut filter is implemented in the TLV1012. This filter reduces the effect of wind and handling noise.

It is also helpful to reduce the proximity effect in directional microphones. This effect occurs when the sound source is very close to the microphone. The lower frequencies are amplified, which gives a bass sound. This amplification can cause an overload, which results in a distortion of the signal.

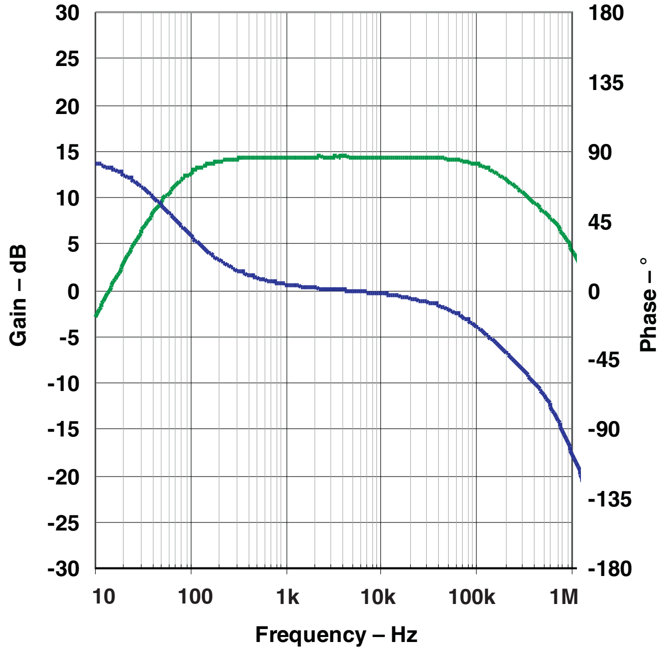


Figure 6. Gain and Phase vs Frequency

The TLV1012 is optimized to be used in audio-band applications. The TLV1012 provides a flat gain response within the audio band and offers linearity and excellent temperature stability.

Noise

Noise pick-up by a microphone in cell phones is a well known problem. A conventional JFET circuit is sensitive for noise pick-up because of its high output impedance, which is usually around 2.2 kΩ.

RF noise is among other noises caused by nonlinear behavior. The nonlinear behavior of the amplifier at high frequencies, well above the usable bandwidth of the device, causes AM demodulation of high-frequency signals. The AM modulation contained in such signals folds back into the audio band, thereby disturbing the intended microphone signal. The GSM signal of a cell phone is such an AM-modulated signal. The modulation frequency of 216 Hz and its harmonics can be observed in the audio band. This kind of noise is called bumblebee noise.

RF noise caused by a GSM signal can be reduced by connecting two external capacitors to ground (see Figure 7). One capacitor reduces the noise caused by the 900-MHz carrier, and the other reduces the noise caused by 1800/1900 MHz.

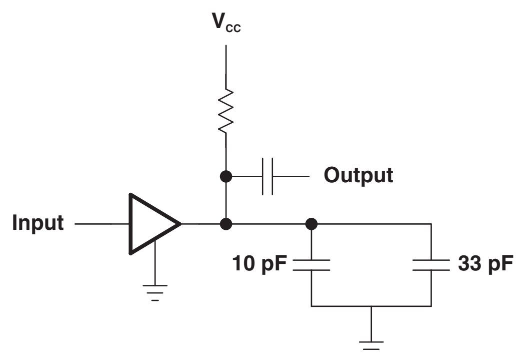


Figure 7. RF Noise Reduction

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
TLV1012-15YDCR	ACTIVE	DSBGA	YDC	4	3000	Green (RoHS & no Sb/Br)	SNAGCU	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.
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(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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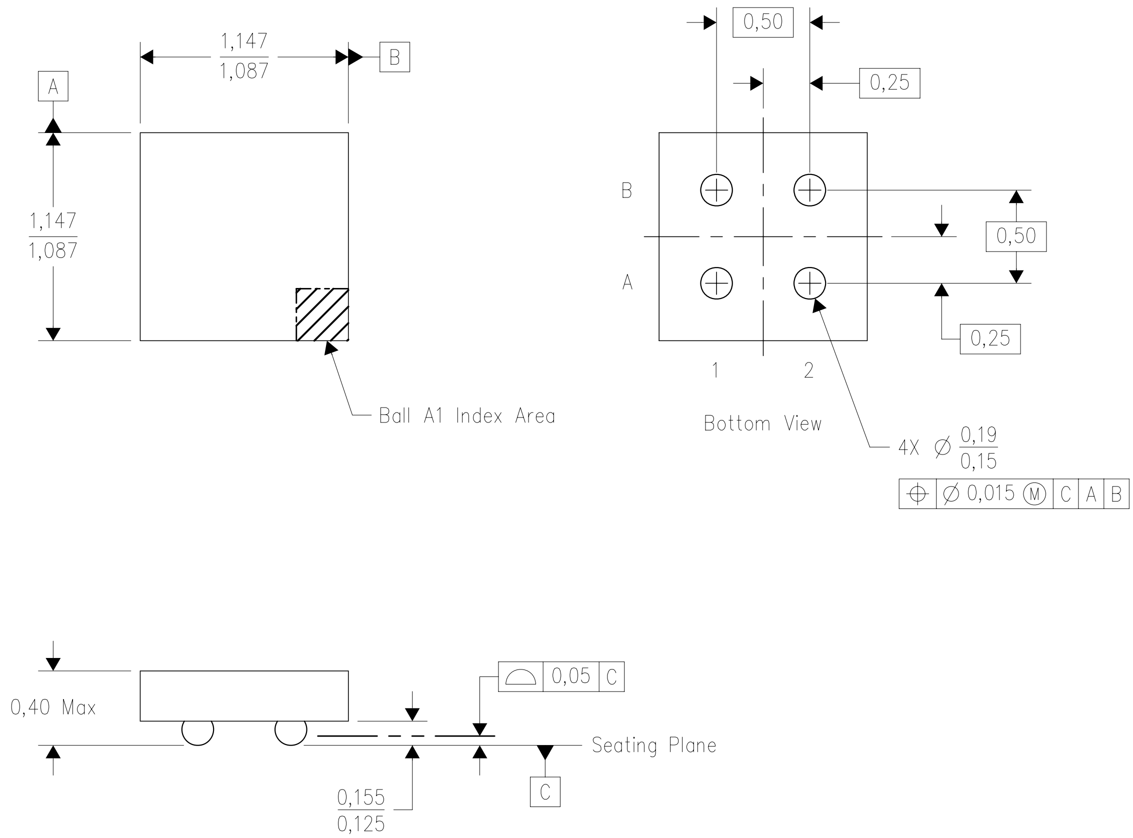
YDC (S–XBGA–N4) DIE–SIZE BALL GRID ARRAY



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NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. NanoFree™ package configuration.
D. This package contains lead–free solder balls.

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