AMPLIFIER FOR THREE-WIRE ANALOG ELECTRET MICROPHONES

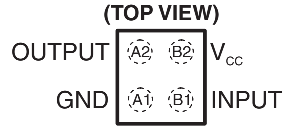
FEATURES

- **Output Voltage Noise (A Weighted): –89 dBV (Typ)**
- **Low Supply Current: 70 μA (Typ)**
- **Wide Supply Voltage Range: 1.7 V to 5 V**
- **PSRR: 70 dB (Typ)**
- **Signal-to-Noise Ratio: 61 dB (Typ)**
- **Input Capacitance: 2 pF (Typ)**
- **Input Impedance: >100 MΩ (Typ)**
- **Output Impedance: <100 Ω (Typ)**
- **Maximum Input Signal: 170 mV_{PP} (Typ)**

APPLICATIONS

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

YDC PACKAGE (TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

The TLV1018 is an audio amplifier for small-form-factor electret microphones and is designed to replace the currently implemented JFET preamplifiers. The TLV1018 is ideal for extended battery-life applications, such as a Bluetooth™ communication link. The addition of a third pin to an electret microphone that incorporates a TLV1018 allows for a dramatic reduction in supply current compared to a JFET-equipped electret microphone. Microphone supply current is reduced to 70 μA, assuring longer battery life.

The TLV1018 is specified for supply voltages from 1.7 V to 5 V and has fixed voltage gains of 15 dB and 25 dB. It offers low output impedance over the voice bandwidth, excellent power supply rejection (PSRR), and stability over temperature.

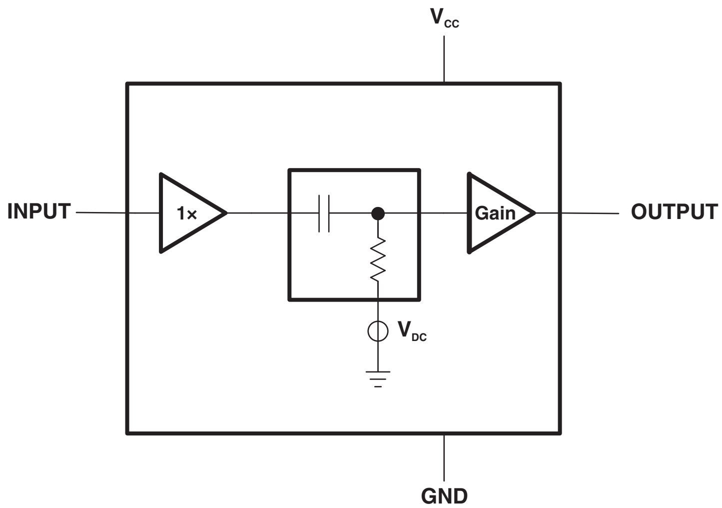
The TLV1018 is offered in a space-saving four-terminal ultra-thin lead-free package (YDC) and is ideally suited for the form factor of miniature electret microphone packages. The TLV1018 is characterized for operation over a free-air temperature range of –40°C to 85°C.

ORDERING INFORMATION(1)

T_A	A_V	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	15 dB	NanoStar™ WCSP (DSBGA) – YDC	Reel of 3000	TLV1018-15YDCR	Y28
	25 dB			TLV1018-25YDCR	YW8

(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) 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 51-7.

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_{CC}	Supply voltage	1.7	5	V
T_A	Operating free-air temperature	–40	85	°C

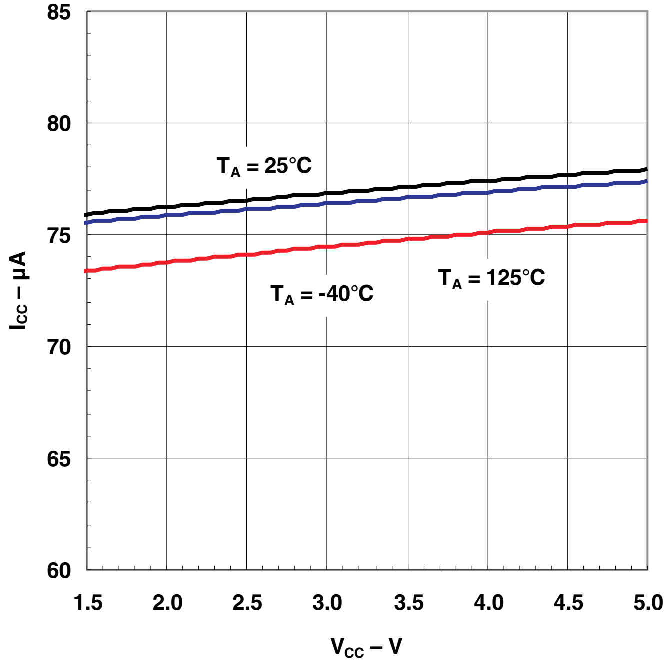
ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

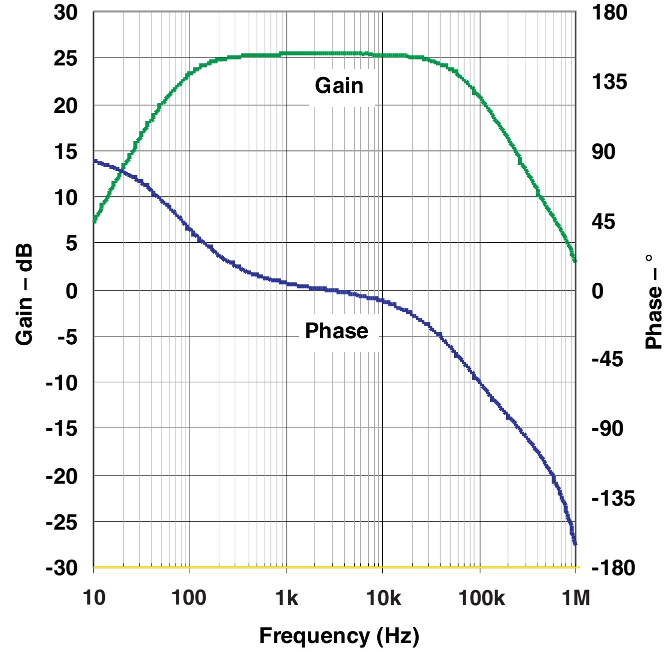
PARAMETER		TEST CONDITIONS		T_J	MIN	TYP	MAX	UNIT
I_{CC}	Supply current	V_{IN} = GND		25°C		70	90	µA
				Full range			100	
SNR	Signal-to-noise ratio	V_{CC} = 1.7 V, V_{IN} = 18 mV_{PP}, f = 1 kHz	TLV1018-15	25°C		61		dB
			TLV1018-25	25°C		61		
		V_{CC} = 5 V, V_{IN} = 18 mV_{PP}, f = 1 kHz	TLV1018-15	25°C		61		
			TLV1018-25	25°C		62		
PSRR	Power-supply rejection ratio	V_{CC} = 1.7 V to 5 V	TLV1018-15	25°C	55	70		dB
				Full range	50			
			TLV1018-25	25°C	55	65		
				Full range	50			
V_{IN}	Input voltage	f = 1 kHz, THD+N < 1%	TLV1018-15	25°C		170		mV_{PP}
			TLV1018-25	25°C		60		
f_{LOW}	Lower –3-dB roll-off frequency	R_{SOURCE} = 50 Ω, V_{IN} = 18 mV_{PP}		25°C		70		Hz
f_{HIGH}	Upper –3-dB roll-off frequency	R_{SOURCE} = 50 Ω, V_{IN} = 18 mV_{PP}	TLV1018-15	25°C		75		kHz
			TLV1018-25	25°C		75		
e_n	Output noise	A-weighted	TLV1018-15	25°C		–89		dBV
			TLV1018-25	25°C		–80		
V_{OUT}	Output voltage	V_{IN} = GND	TLV1018-15	25°C		500		mV
				Full range	250		750	
			TLV1018-25	25°C		600		
				Full range	400		800	
Z_{OUT}	Output impedance	f = 1 kHz		25°C		<100		Ω
I_{OUT}	Output current	V_{CC} = 1.7 V, V_{OUT} = 1.7 V, Sinking		25°C	0.9	2.3		mA
				Full range	0.5			
		V_{CC} = 1.7 V, V_{OUT} = 0 V, Sourcing		25°C	0.3	1.5		
				Full range	0.2			
		V_{CC} = 5 V, V_{OUT} = 1.7 V, Sinking		25°C	0.9	2.9		
				Full range	0.5			
		V_{CC} = 5 V, V_{OUT} = 0 V, Sourcing		25°C	0.4	2.6		
				Full range	0.1			
THD	Total harmonic distortion	f = 1 kHz, V_{IN} = 18 mV_{PP}	TLV1018-15	25°C		0.13		%
			TLV1018-25	25°C		0.2		
C_{IN}	Input capacitance					2		pF
Z_{IN}	Input impedance					>100		MΩ
A_V	Gain	f = 1 kHz, V_{IN} = 18 mV_{PP}	TLV1018-15	25°C	14.8	15.4	16	dB
				Full range	14		17	
			TLV1018-25	25°C	24.8	25.5	26.2	
				Full range	24		27	

TYPICAL CHARACTERISTICS

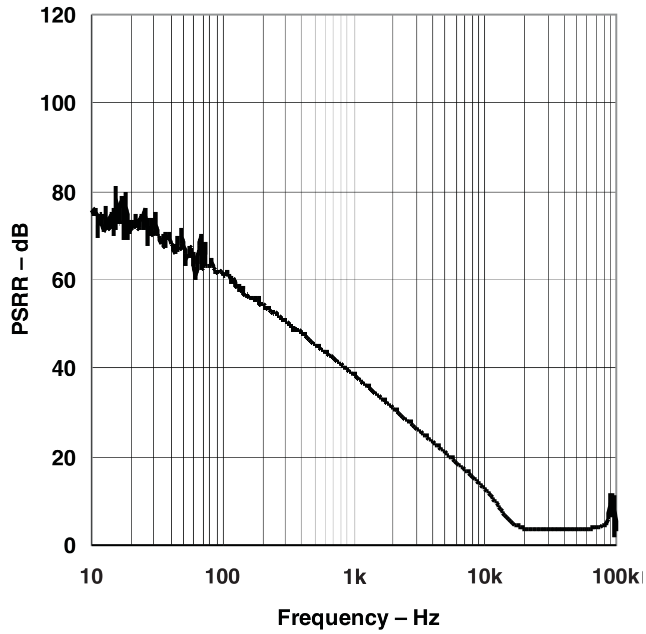
SUPPLY CURRENT
vs
SUPPLY VOLTAGE



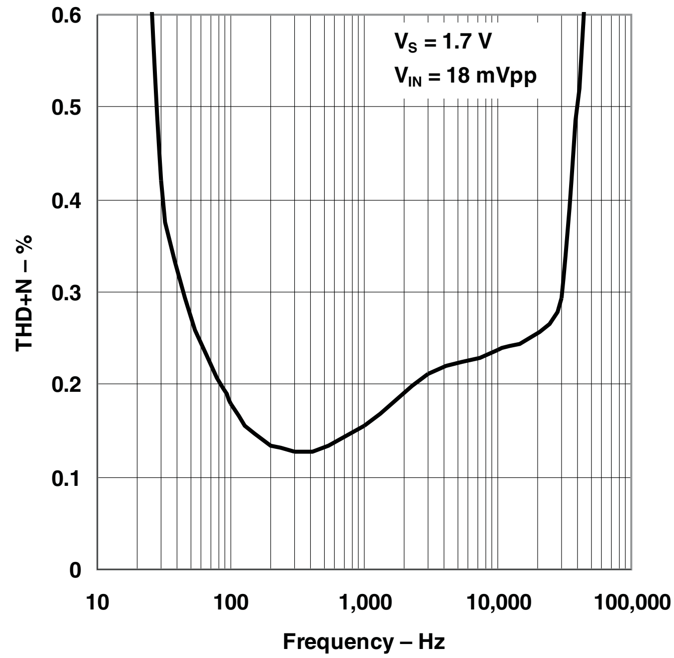
CLOSED LOOP GAIN AND PHASE
vs
FREQUENCY



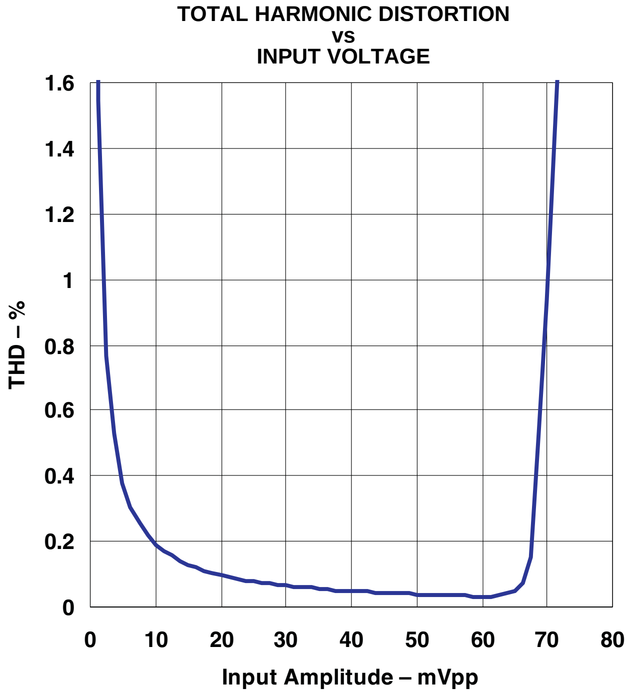
POWER SUPPLY REJECTION RATIO
vs
FREQUENCY

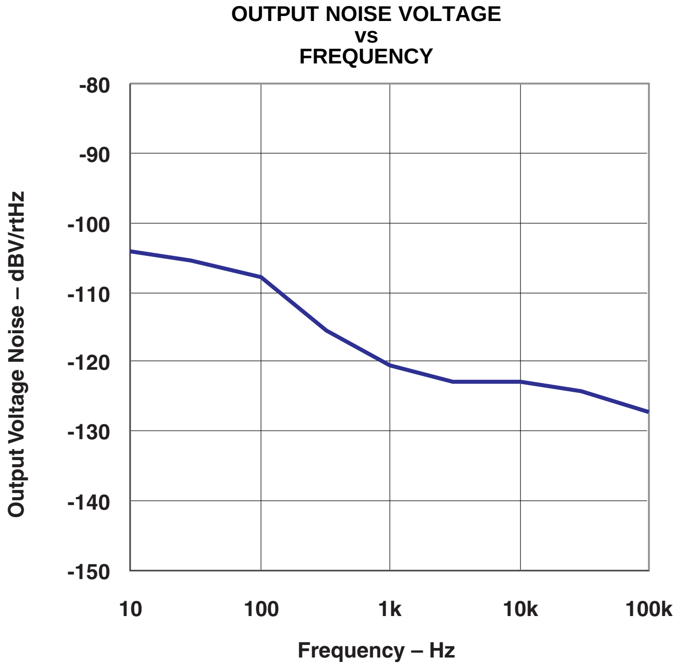


TOTAL HARMONIC DISTORTION + NOISE
vs
FREQUENCY



TYPICAL CHARACTERISTICS (continued)





APPLICATION INFORMATION

Low Current

The TLV1018 has a low supply current, which allows for a longer battery life. The low supply current of 70 µA makes this amplifier optimal for microphone applications that need to be always on.

Built-In Gain

The TLV1018 is offered in the space-saving YDC package, which fits perfectly into the metal can of a microphone. This allows the TLV1018 to be placed on the PCB inside the microphone.

The bottom side of the PCB has pins that connect the supply voltage to the amplifier and make the output available. The input of the amplifier is connected to the microphone via the PCB.

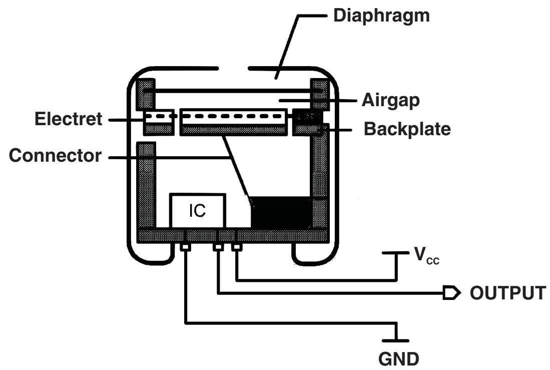


Figure 1. Built-In Gain

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.

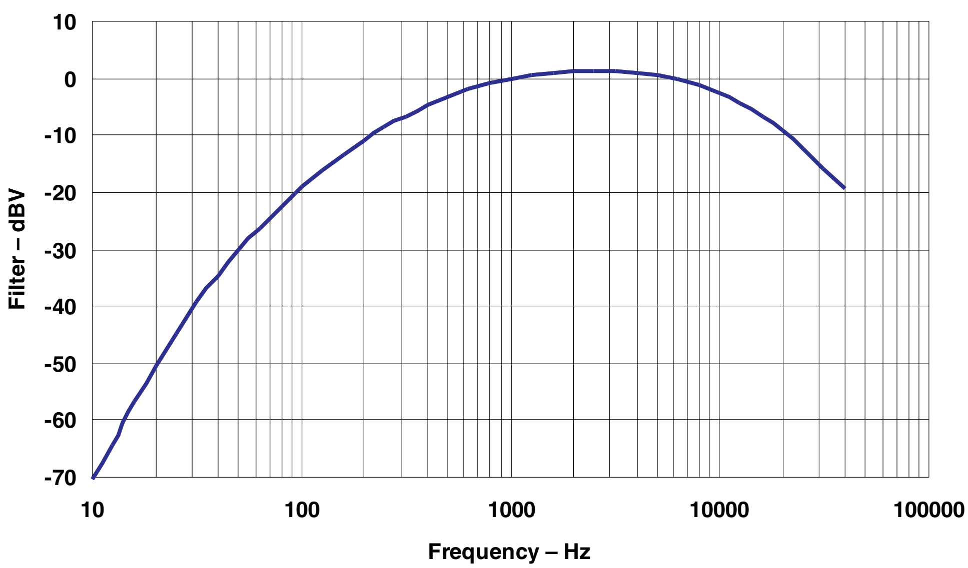


Figure 2. A-Weighted Filter

Measuring Noise and SNR

The overall noise of the TLV1018 is measured within the frequency band from 10 Hz to 22 kHz using an A-weighted filter. The input of the TLV1018 is connected to ground with a 5-pF capacitor.

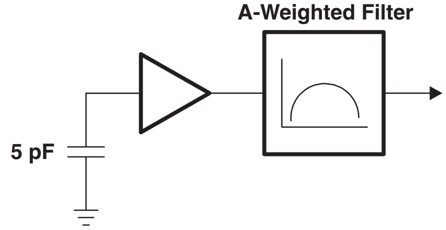


Figure 3. Noise Measurement

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 (SPL) 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 (SPL) 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 SPL, 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.

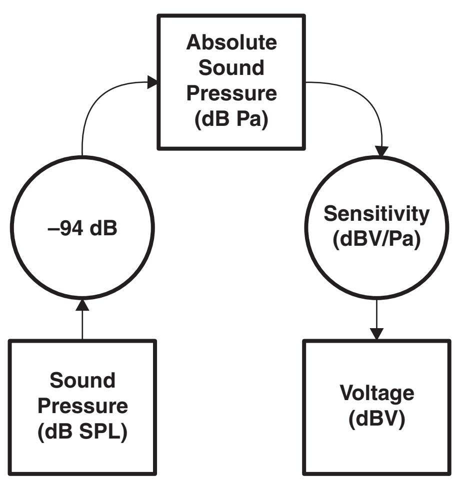


Figure 4. dBSPL to dBV Conversion

Example: Busy traffic is 70 dBSPL

V_{OUT} = 70 – 94 – 44 = –68 dBV

This is equivalent to 1.13 mV_{PP}.

Because the TLV1018-15 has a gain of 5.6 (15 dB) over the JFET, the output voltage of the microphone is 6.35 mV_{PP}. By replacing the JFET with the TLV1018-15, the sensitivity of the microphone is –29 dBV/Pa (–44 + 15).

Low-Frequency Cut-Off Filter

To reduce noise on the output of the microphone, a low-cut filter is implemented in the TLV1018. 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.

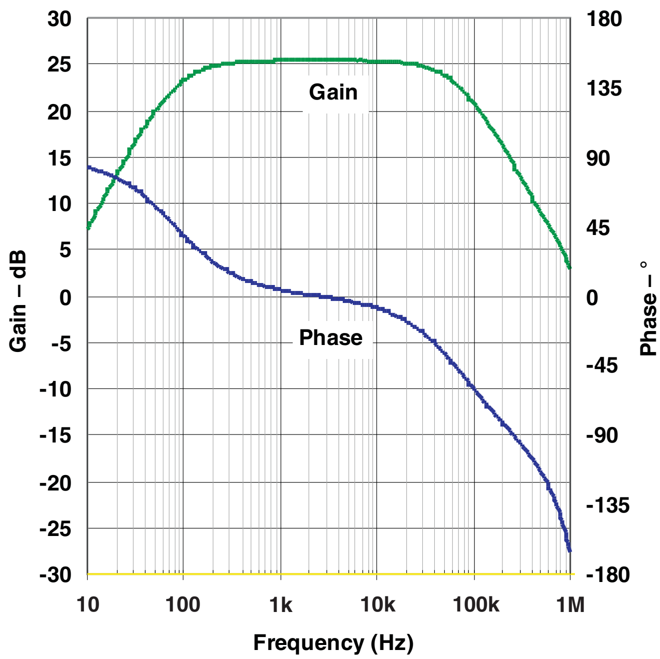


Figure 5. Gain vs. Frequency

The TLV1018 is optimized to be used in audio-band applications. The TLV1018 provides a flat gain response within the audio band and offers linearity and excellent temperature stability.

Advantage of Three Pins

The TLV1018 ECM solution has three pins, instead of the two pins provided in the case of a JFET solution. The third pin provides the advantage of a low supply current, high PSRR, and eliminates the need for additional components.

Noise pick-up by a microphone in a cell phone is a well known problem. A conventional JFET circuit is sensitive for noise pick-up because of its high output impedance. The output impedance is usually around 2.2 kΩ. By providing separate output and supply pins a much lower output impedance is achieved and therefore is less sensitive to noise pick-up.

RF noise is one of the noises caused by non-linear behavior. The non-linear 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 type of noise is called bumblebee noise.

External Pre-Amplifier Application

The TLV1018 can also be used outside of an ECM as a space saving external preamplifier. In this application, the TLV1018 follows a phantom biased JFET microphone in the circuit. This is shown in Figure 6. The input of the TLV1018 is connected to the microphone via the 2.2-µF capacitor. The advantage of this circuit over one with only a JFET microphone are the additional gain and the high-pass filter supplied by the TLV1018. The high-pass filter makes the output signal more robust and less sensitive to low frequency disturbances. In this configuration, the TLV1018 should be placed as close as possible to the microphone.

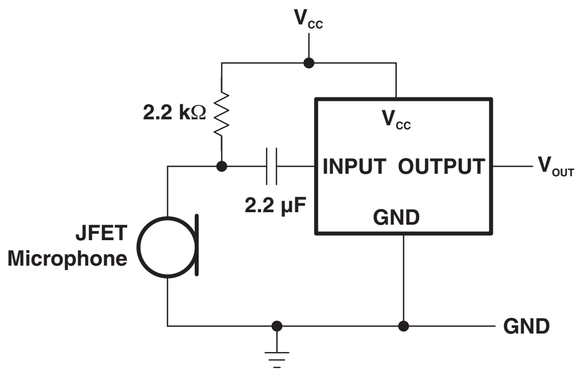


Figure 6. External Preamplifier

PACKAGING INFORMATION

Orderable Device	Status [(1)]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [(2)]	Lead/Ball Finish	MSL Peak Temp [(3)]
TLV1018-15YDCR	ACTIVE	DSBGA	YDC	4	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM
TLV1018-25YDCR	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.
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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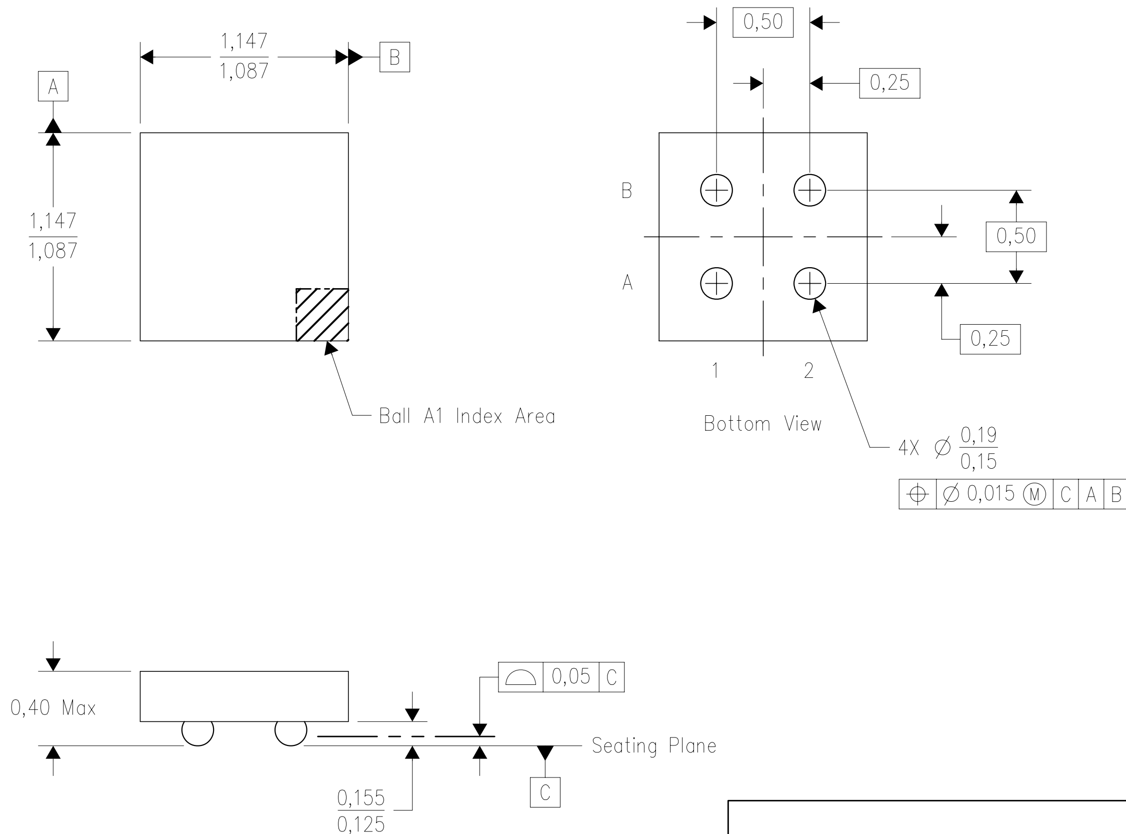
YDC (S–XBGA–N4) DIE–SIZE BALL GRID ARRAY



D: Max = 1.142 mm, Min =1.082 mm

E: Max = 1.142 mm, Min =1.082 mm

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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.

NanoFree is a trademark of Texas Instruments.