LMV1015 Analog Series: Built-in Gain IC's for High Sensitivity 2-Wire Microphones

Check for Samples: LMV1015

FEATURES

- **(Typical LMV1015-15, 2.2V supply, R_L = 2.2 kΩ, C = 2.2 µF, V_{IN} = 18 mV_{PP}, unless otherwise specified)**
- **Supply Voltage: 2V - 5V**
- **Supply Current: <180 µA**
- **Signal to Noise Ratio (A-Weighted): 60 dB**
- **Output Voltage Noise (A-Weighted): −89 dBV**
- **Total Harmonic Distortion 0.09%**
- **Voltage Gain**
  - **LMV1015-15: 15.6 dB**
  - **LMV1015-25: 23.8 dB**
- **Temperature Range: −40°C to 85°C**
- **Large Dome 4-Bump DSBGA Package with Improved Adhesion Technology.**

APPLICATIONS

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

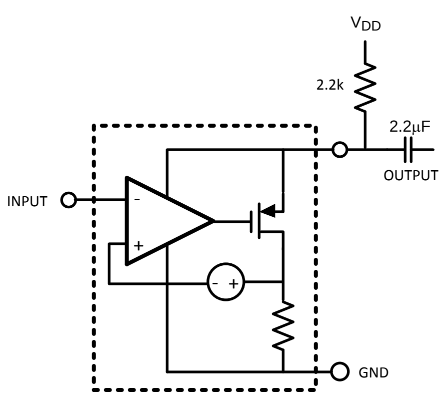
DESCRIPTION

The LMV1015 is an audio amplifier series for small form factor electret microphones. This 2-wire portfolio is designed to replace the JFET amplifier. The LMV1015 series is ideally suited for applications requiring high signal integrity in the presence of ambient or RF noise, such as in cellular communications. The LMV1015 audio amplifiers are ensured to operate over a 2.2V to 5.0V supply voltage range with fixed gains of 15.6 dB and 23.8 dB. The devices offer excellent THD, gain accuracy and temperature stability as compared to a JFET microphone.

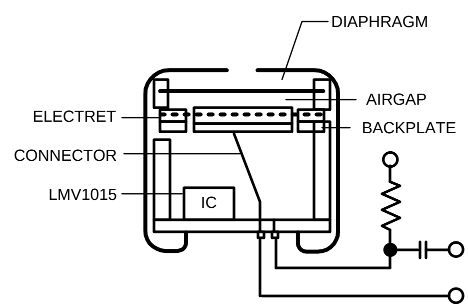
The LMV1015 series enables a two-pin electret microphone solution, which provides direct pin-to-pin compatibility with the existing older JFET market.

Texas Instruments' built-in gain families are offered in extremely thin space saving 4-bump DSBGA packages (0.3 mm maximum). The LMV1015XR is designed for 1.0 mm ECM canisters and thicker. These extremely miniature packages have the Large Dome Bump (LDB) technology. This DSBGA technology is designed for microphone PCBs requiring 1 kg adhesion criteria.

Schematic Diagram



Built-In Gain Electret Microphone



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]

ESD Tolerance[2]	Human Body Model	2500V
	Machine Model	250V
Supply Voltage	V_{DD} - GND	5.5V
Storage Temperature Range		−65°C to 150°C
Junction Temperature[3]		150°C max
Mounting Temperature	Infrared or Convection (20 sec.)	235°C

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.
(2) Human Body Model (HBM) is 1.5 kΩ in series with 100 pF.
(3) The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA} and T_A. 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 into a PC board.

Operating Ratings[1]

Supply Voltage	2V to 5V
Operating Temperature Range	−40°C to 85°C
Thermal Resistance (θ_{JA})	368°C/W

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

2.2V Electrical Characteristics[1]

Unless otherwise specified, all limits ensured for T_J = 25°C, V_{DD} = 2.2V, V_{IN} = 18 mV_{PP}, R_L = 2.2 kΩ and C = 2.2 µF. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions		Min[2]	Typ[3]	Max[2]	Units
I_{DD}	Supply Current	V_{IN} = GND	LMV1015-15		180	300 **325**	µA
			LMV1015-25		141	250 **300**	
SNR	Signal to Noise Ratio	f = 1 kHz, V_{IN} = 18 mV_{PP}, A-Weighted	LMV1015-15		60		dB
			LMV1015-25		61		
V_{IN}	Max Input Signal	f = 1 kHz and THD+N < 1%	LMV1015-15		100		mV_{PP}
			LMV1015-25		28		
V_{OUT}	Output Voltage	V_{IN} = GND	LMV1015-15	1.54 **1.48**	1.81	1.94 **2.00**	V
			LMV1015-25	1.65 **1.49**	1.90	2.02 **2.18**	
f_{LOW}	Lower −3dB Roll Off Frequency	R_{SOURCE} = 50Ω			65		Hz
f_{HIGH}	Upper −3dB Roll Off Frequency	R_{SOURCE} = 50Ω			95		kHz
e_n	Output Noise	A-Weighted	LMV1015-15		−89		dBV
			LMV1015-25		−82		
THD	Total Harmonic Distortion	f = 1 kHz, V_{IN} = 18 mV_{PP}	LMV1015-15		0.09		%
			LMV1015-25		0.15		
C_{IN}	Input Capacitance				2		pF
Z_{IN}	Input Impedance				>1000		GΩ
A_V	Gain	f = 1 kHz, R_{SOURCE} = 50Ω	LMV1015-15	14.0 **13.1**	15.6	16.9 **17.5**	dB
			LMV1015-25	22.5 **21.4**	23.8	25.0 **25.7**	

(1) 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 specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$.
(2) All limits are specified by design or statistical analysis.
(3) Typical values represent the most likely parametric norm.

5V Electrical Characteristics[1]

Unless otherwise specified, all limits ensured for T_J = 25°C, V_{DD} = 5V, V_{IN} = 18 mV_{PP}, R_L = 2.2 kΩ and C = 2.2 μF. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions		Min[2]	Typ[3]	Max[2]	Units
I_{DD}	Supply Current	V_{IN} = GND	LMV1015-15		200	300 **325**	μA
			LMV1015-25		160	250 **300**	
SNR	Signal to Noise Ratio	f = 1 kHz, V_{IN} = 18 mV_{PP}, A-Weighted	LMV1015-15		60		dB
			LMV1015-25		61		
V_{IN}	Max Input Signal	f = 1 kHz and THD+N < 1%	LMV1015-15		100		mV_{PP}
			LMV1015-25		28		
V_{OUT}	Output Voltage	V_{IN} = GND	LMV1015-15	4.34 **4.28**	4.56	4.74 **4.80**	V
			LMV1015-25	4.45 **4.39**	4.65	4.83 **4.86**	
f_{LOW}	Lower −3dB Roll Off Frequency	R_{SOURCE} = 50Ω			67		Hz
f_{HIGH}	Upper −3dB Roll Off Frequency	R_{SOURCE} = 50Ω			150		kHz
e_n	Output Noise	A-Weighted	LMV1015-15		−89		dBV
			LMV1015-25		−82		
THD	Total Harmonic Distortion	f = 1 kHz, V_{IN} = 18 mV_{PP}	LMV1015-15		0.13		%
			LMV1015-25		0.21		
C_{IN}	Input Capacitance				2		pF
Z_{IN}	Input Impedance				>1000		GΩ
A_V	Gain	f = 1 kHz, R_{SOURCE} = 50Ω	LMV1015-15	14.0 **13.1**	15.6	16.9 **17.5**	dB
			LMV1015-25	22.5 **21.2**	23.9	25.1 **25.9**	

(1) 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 specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where T_J > T_A.
(2) All limits are specified by design or statistical analysis.
(3) Typical values represent the most likely parametric norm.

Connection Diagram

Top View

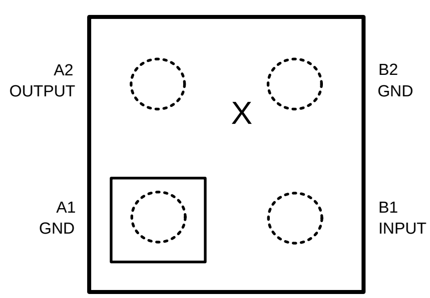


Figure 1. Large Dome 4-Bump DSBGA Package

NOTE:

- Pin numbers are referenced to package marking text orientation.
- The actual physical placement of the package marking will vary slightly from part to part. The package will designate the date code and will vary considerably. Package marking does not correlate to device type in any way.

Typical Performance Characteristics

Unless otherwise specified, V_S = 2.2V, R_L = 2.2 kΩ, C = 2.2 µF, single supply, T_A = 25°C

Supply Current vs. Supply Voltage (LMV1015-15)

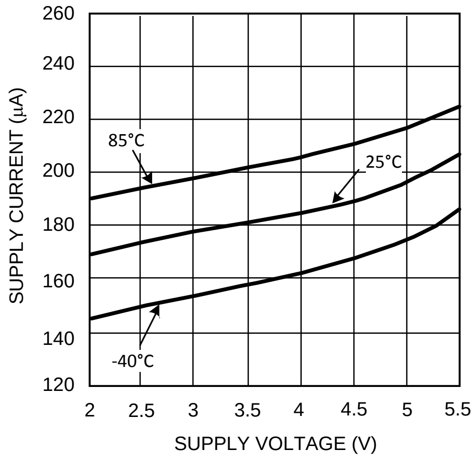


Figure 2.

Supply Current vs. Supply Voltage (LMV1015-25)

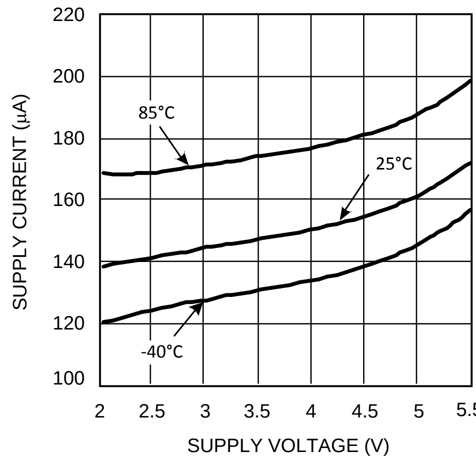


Figure 3.

Gain and Phase vs. Frequency (LMV1015-15)

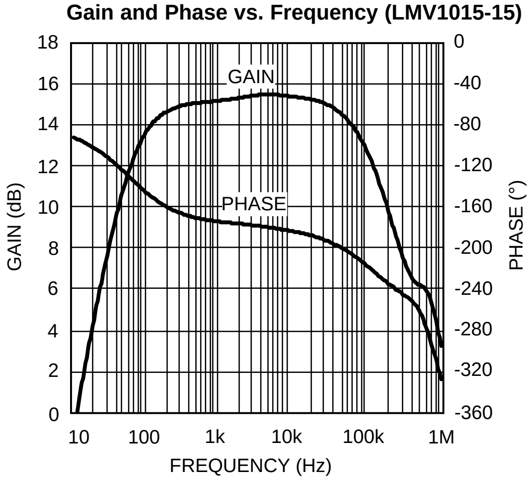


Figure 4.

Gain and Phase vs. Frequency (LMV1015-25)

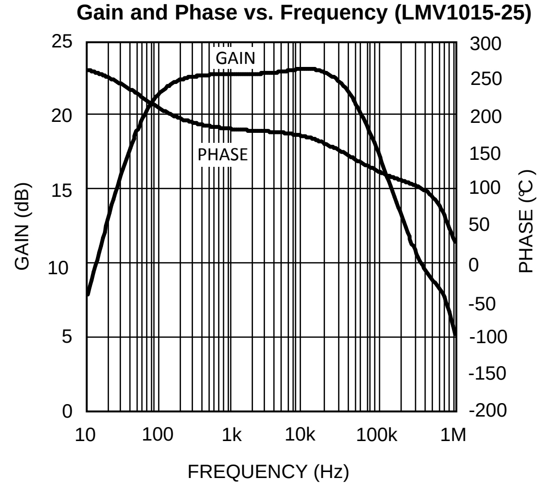


Figure 5.

Total Harmonic Distortion vs. Frequency (LMV1015-15)

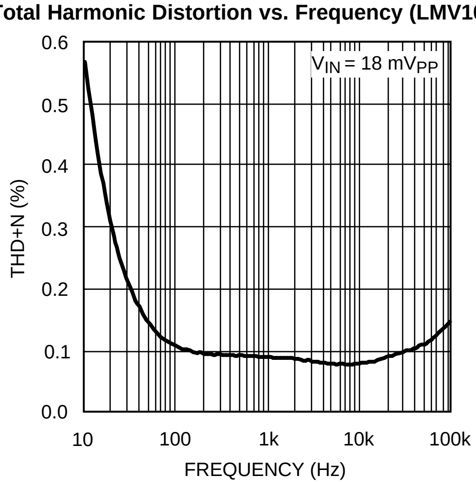


Figure 6.

Total Harmonic Distortion vs. Frequency (LMV1015-25)

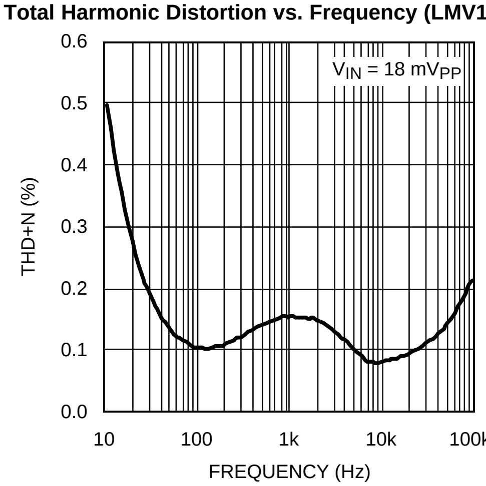


Figure 7.

Typical Performance Characteristics (continued)

Unless otherwise specified, V_S = 2.2V, R_L = 2.2 kΩ, C = 2.2 μF, single supply, T_A = 25°C

Total Harmonic Distortion vs. Input Voltage (LMV1015-15)

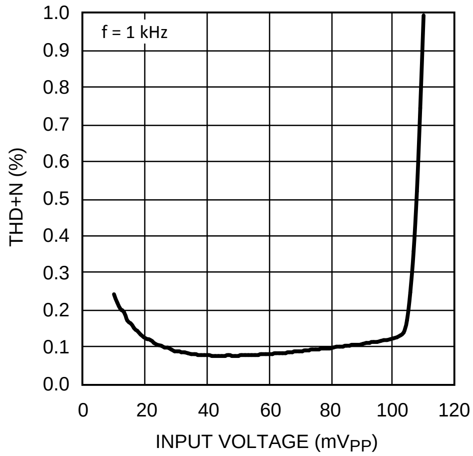


Figure 8.

Total Harmonic Distortion vs. Input Voltage (LMV1015-25)

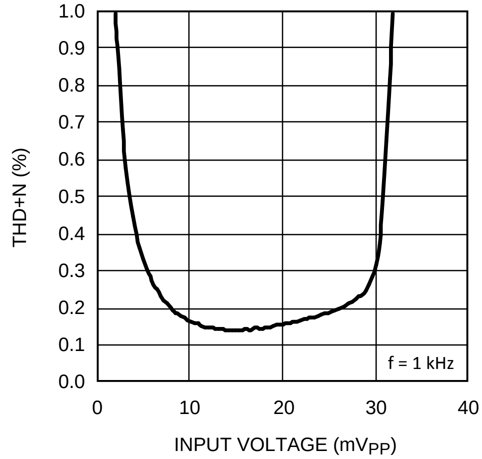


Figure 9.

Output Noise vs. Frequency (LMV1015-15)

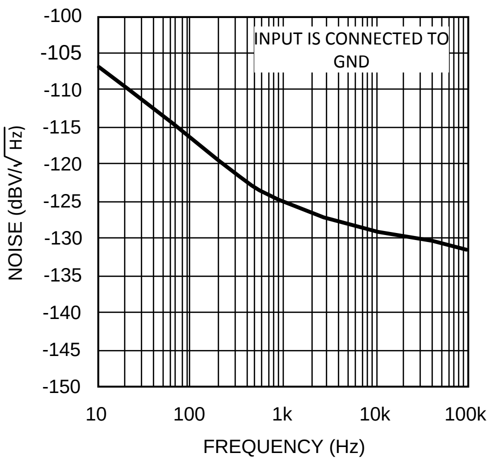


Figure 10.

Output Noise vs. Frequency (LMV1015-25)

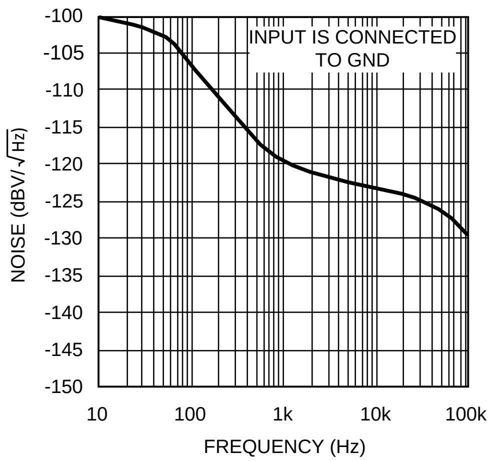


Figure 11.

APPLICATION SECTION

HIGH GAIN

The LMV1015 series provides outstanding gain versus the JFET 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 LMV1015 is offered in 0.3 mm height space saving small 4-pin DSBGA packages in order to fit inside the different size ECM canisters of a microphone. The LMV1015 is placed on the PCB inside the microphone using Large Dome Bump technology (LDB).

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_{DD} through a resistor. This phantom biasing allows both supply voltage and output signal on one connection.

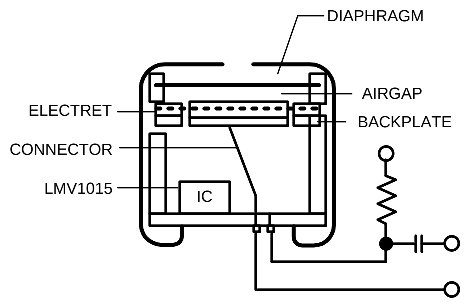


Figure 12. Built in Gain

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. This filter improves the correlation of the measured data to the signal to noise ratio perceived by the human ear.

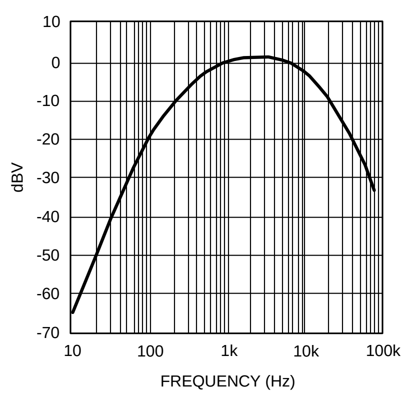


Figure 13. A-Weighted Filter

MEASURING NOISE AND SNR

The overall noise of the LMV1015 is measured within the frequency band from 10 Hz to 22 kHz using an A-weighted filter. The input of the LMV1015 is connected to ground with a 5 pF capacitor, as in Figure 14. Special precautions in the internal structure of the LMV1015 have been taken to reduce the noise on the output.

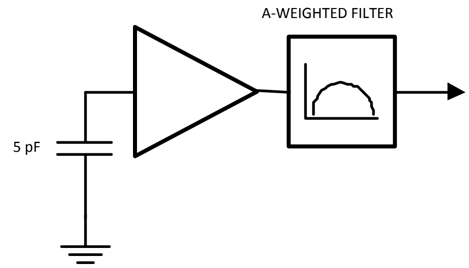


Figure 14. Noise Measurement Setup

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 dB SPL. No input capacitor is connected for the measurement.

SOUND PRESSURE LEVEL

The volume of sound applied to a microphone is usually stated as a pressure level referred 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

P_O is the threshold of hearing (20 μPa)

In order to be able to calculate the resulting output voltage of the microphone for a given SPL, the sound pressure in dB SPL needs to be converted to the absolute sound pressure in dBPa. This is the sound pressure level in decibels referred to 1 Pascal (Pa).

The conversion is given by:

dBPa = dB SPL + 20*log 20 μPa

dBPa = dB SPL - 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.

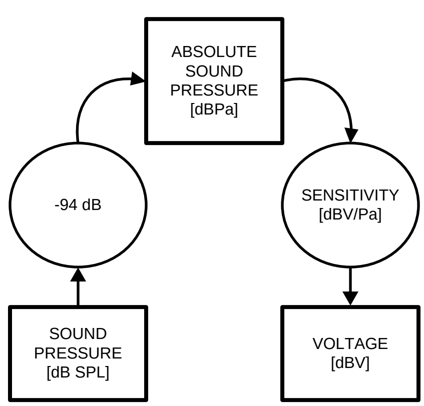


Figure 15. dB SPL to dBV Conversion

Example: Busy traffic is 70 dB SPL.

V_{OUT} = 70 −94 −44 = −68 dBV. This is equivalent to 1.13 mV_{PP}

Since the LMV1015-15 has a gain of 6 (15.6 dB) over the JFET, the output voltage of the microphone is 6.78 mV_{PP}. By implementing the LMV1015-15, 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 frequency cut off filter has been implemented. This filter reduces the effect of wind and handling noise.

It's 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.

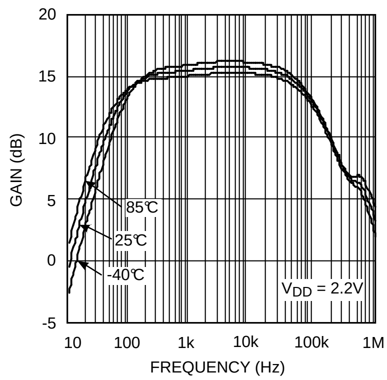


Figure 16. LMV1015-15 Gain vs. Frequency Over Temperature

The LMV1015 is optimized to be used in audio band applications. By using the LMV1015, the gain response is flat within the audio band and has linearity and temperature stability Figure 16.

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 amongst other 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 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 17. One capacitor reduces the noise caused by the 900 MHz carrier and the other reduces the noise caused by 1800/1900 MHz.

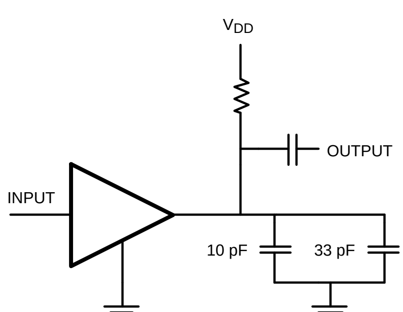


Figure 17. RF Noise Reduction

REVISION HISTORY

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)	Device Marking (4/5)	Samples
LMV1015UR-25/NOPB	ACTIVE	DSBGA	YPD	4	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM			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] There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

[5] Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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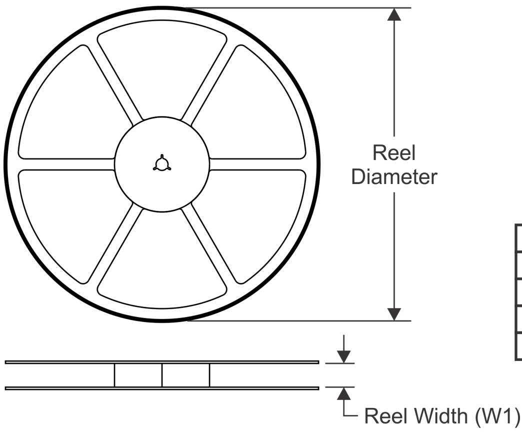
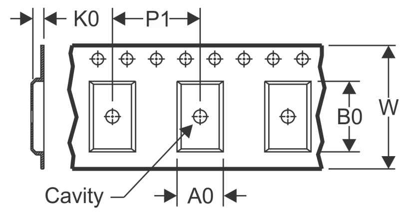
TAPE AND REEL INFORMATION

REEL DIMENSIONS

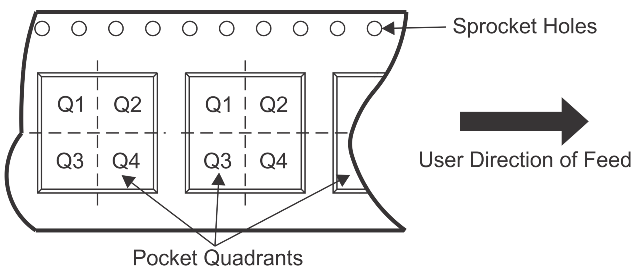


TAPE DIMENSIONS



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

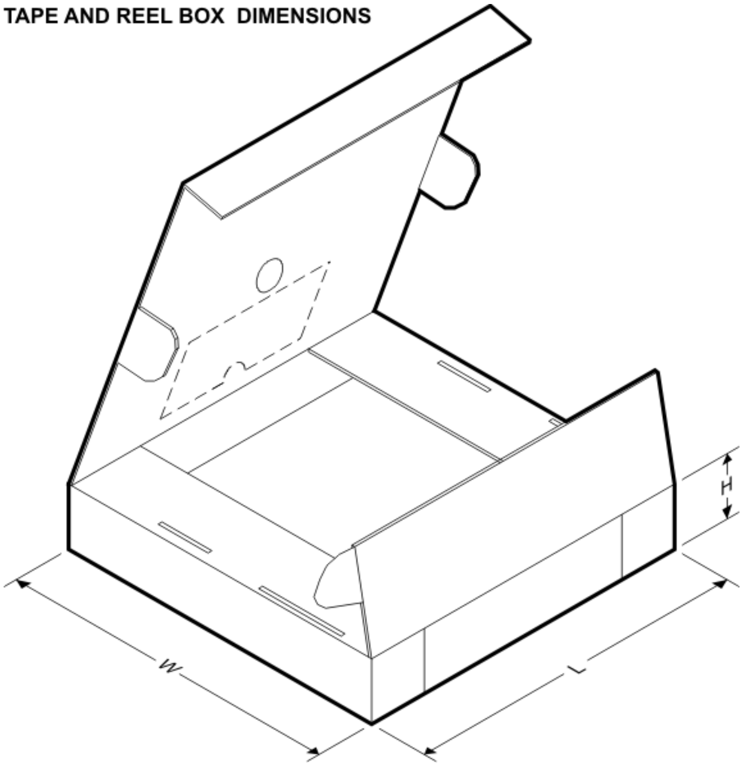
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LMV1015UR-25/NOPB	DSBGA	YPD	4	250	178.0	8.4	1.02	1.09	0.56	4.0	8.0	Q1

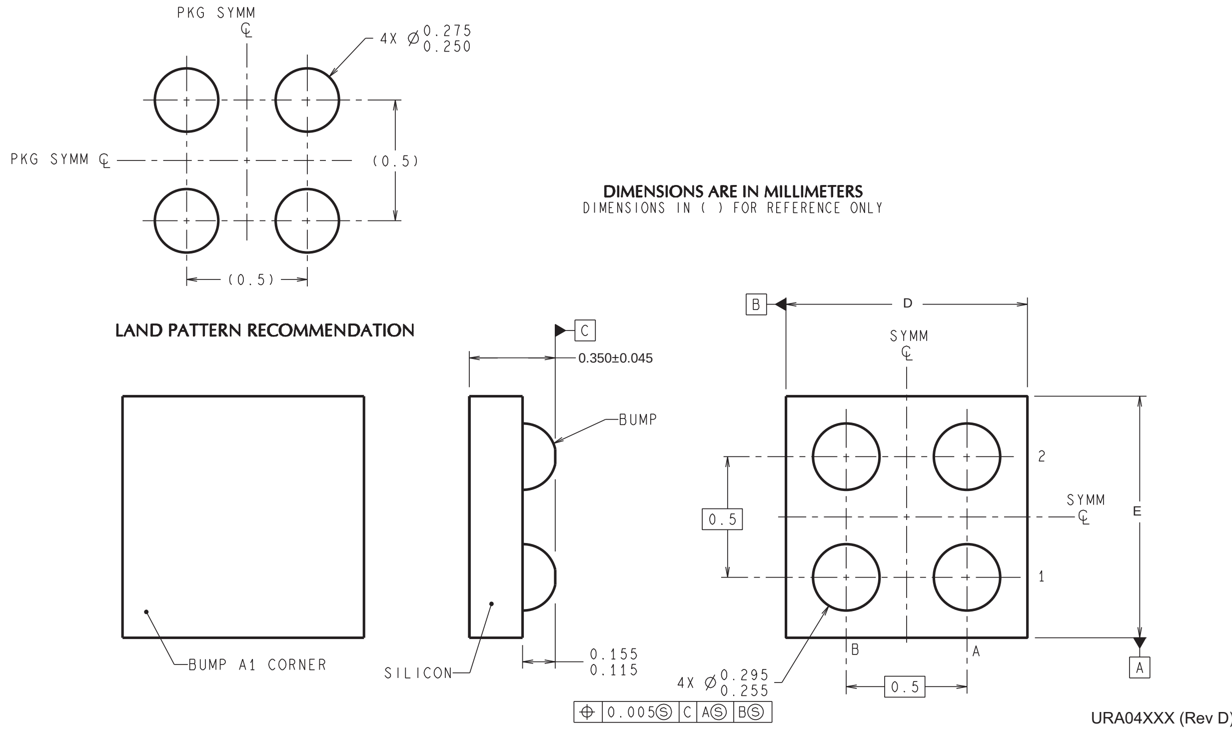
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMV1015UR-25/NOPB	DSBGA	YPD	4	250	210.0	185.0	35.0

YPD0004



D: Max = 1.057 mm, Min =0.996 mm

E: Max = 0.981 mm, Min = 0.92 mm

4215141/A 12/12

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.

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