LMV1091

LMV1091 Dual Input, Far Field Noise Suppression Microphone Amplifier

National Semiconductor

LMV1091

January 13, 2011

Dual Input, Far Field Noise Suppression Microphone Amplifier

General Description

The LMV1091 is a fully analog dual differential input, differential output, microphone array amplifier designed to reduce background acoustic noise, while delivering superb speech clarity in voice communication applications.

The LMV1091 preserves near-field voice signals within 4cm of the microphones while rejecting far-field acoustic noise greater than 50cm from the microphones. Up to 20dB of far-field rejection is possible in a properly configured and using ±0.5dB matched micropohones.

Part of the Powerwise™ family of energy efficient solutions, the LMV1091 consumes only 600µA of supply current providing superior performance over DSP solutions consuming greater than ten times the power.

The dual microphone inputs and the processed signal output are differential to provide excellent noise immunity. The microphones are biased with an internal low-noise bias supply.

Key Specifications

- Far Field Noise Suppression Electrical *   34dB (typ)
- $SNRI_E$ 26dB (typ)
- Supply voltage   2.7V to 5.5V
- Supply current   600µA (typ)
- Standby current   0.1µA (typ)
- Signal-to-Noise Ratio (Voice band)   65dB (typ)
- Total Harmonic Distortion + Noise   0.1% (typ)
- PSRR (217Hz)   99dB (typ)

  *$FFNS_E$ at f = 1kHz

Features

- No loss of voice intelligibility
- Low power consumption
- Shutdown function
- No added processing delay
- Differential outputs
- Adjustable 12 - 54dB gain
- Excellent RF immunity
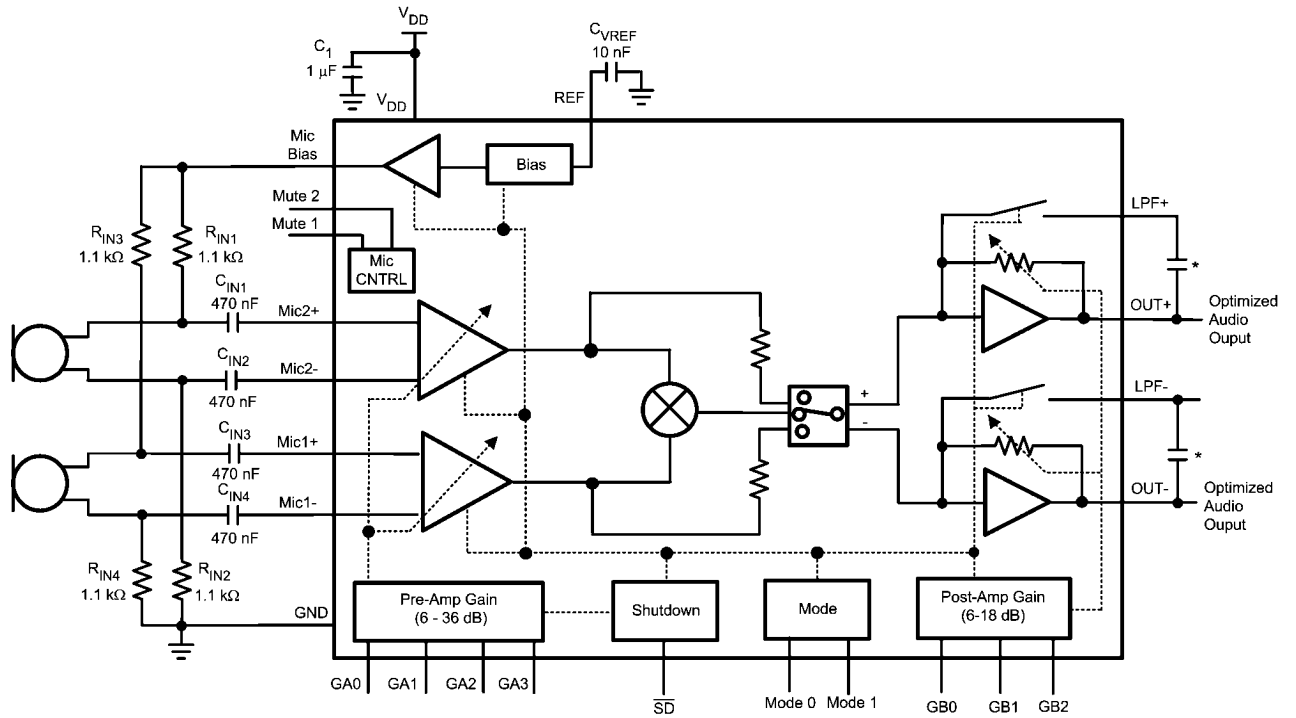- Available in a 25–bump micro SMD package

Applications

- Mobile headset
- Mobile and handheld two-way radios
- Bluetooth and other powered headsets
- Hand-held voice microphones

System Diagram
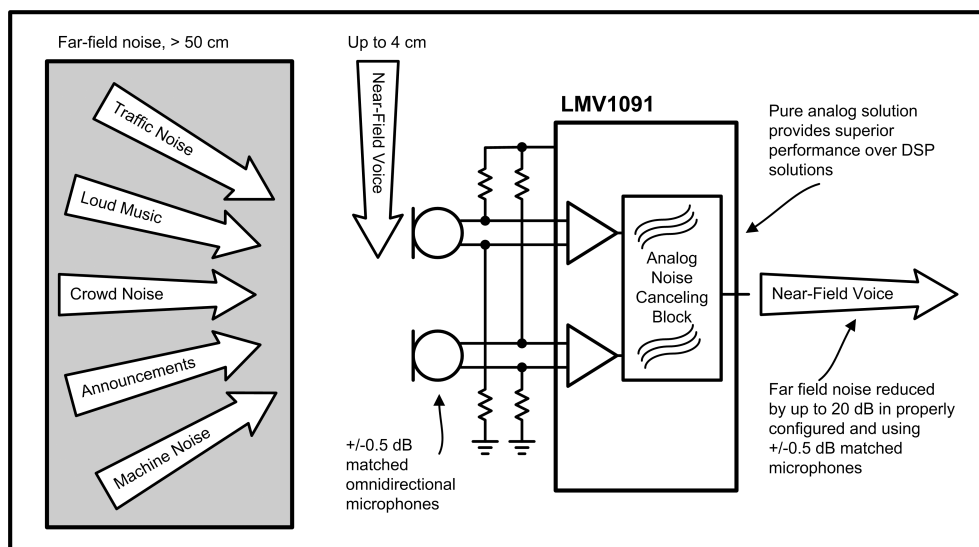
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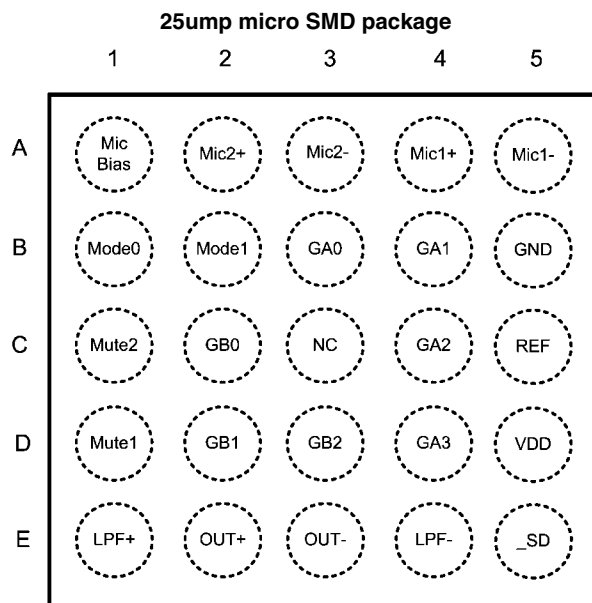
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Typical Application

* The value of the low-pass filter capacitor is application dependent, see the application section for additional information.

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FIGURE 1. Typical Dual Microphone Far Field noise Cancelling Application
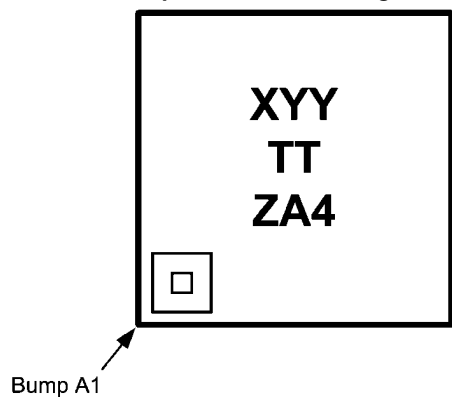
Connection Diagrams

25ump micro SMD package

30092214

Top View
Order Number LMV1091TM
See NS Package Number TMD25AAA

25–Bump micro SMD Marking

Bump A1

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Top View
X = Plant Code
YY = Date Code
TT = Die Traceability
ZA4 = LMV1091TM

micro SMD Package View
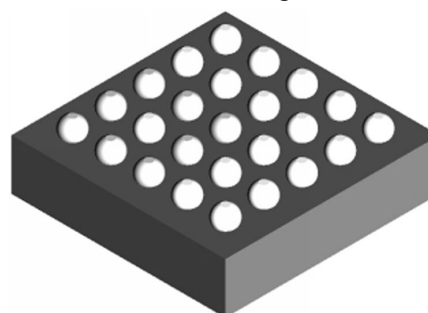
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Bottom View

Ordering Information

Order Number	Package	Package Drawing Number	Device Marking	Transport Media
LMV1091TM	25 Bump µSMD	TMD25AAA	ZA4	250 units on tape and reel
LMV1091TMX	25 Bump µSMD	TMD25AAA	ZA4	3000 units on tape and reel

TABLE 1. Pin Name and Function

Bump Number	Pin Name	Pin Function	Pin Type
A1	MIC BIAS	Microphone Bias	Analog Output
A2	MIC2+	Microphone 2 positive input	Analog Input
A3	MIC2−	Microphone 2 negative input	Analog Input
A4	MIC1+	Microphone 1 positive input	Analog Input
A5	MIC1−	Microphone 1 negative input	Analog Input
B1	MODE0	Mic mode select pin	Digital Input
B2	MODE1	Mic mode select pin	Digital Input
B3	GA0	Pre-Amplifier Gain select pin	Digital Input
B4	GA1	Pre-Amplifier Gain select pin	Digital Input
B5	GND	Ground	Ground
C1	MUTE2	Mute select pin	Digital Input
C2	GB0	Post-Amplifier Gain select pin	Digital Input
C3	NC	No Connect	
C4	GA2	Pre-Amplifier Gain select pin	Digital Input
C5	REF	Reference voltage de-coupling	Analog Ref
D1	MUTE1	Mute select pin	Digital Input
D2	GB1	Post-Amp Gain select pin	Digital Input
D3	GB2	Post-Amp Gain select pin	Digital Input
D4	GA3	Pre-Amp Gain select pin	Digital Input
D5	VDD	Power Supply	Supply
E1	LPF+	Low pass Filter for positive output	Analog Input
E2	OUT+	Positive optimized audio output	Analog Output
E3	OUT-	Negative optimized audio output	Analog Output
E4	LPF-	Low pass Filter for negative output	Analog Input
E5	$\overline{\text{SD}}$	Chip enable	Digital Input

Absolute Maximum Ratings (*Note 1*)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	6.0V
Storage Temperature	-85°C to +150°C
Power Dissipation (*Note 3*)	Internally Limited
ESD Rating (*Note 4*)	2000V
ESD Rating (*Note 5*)	200V
CDM	500V
Junction Temperature (T_{JMAX})	150°C

Mounting Temperature	
Infrared or Convection (20 sec.)	235°C
Thermal Resistance	
θ_{JA} (microSMD)	70°C/W

Soldering Information See AN-1112 "microSMD Wafer Level Chip Scale Package."

Operating Ratings (*Note 1*)

Supply Voltage	$2.7V \leq V_{DD} \leq 5.5V$
$T_{MIN} \leq T_A \leq T_{MAX}$	$-40°C \leq T_A \leq +85°C$

Electrical Characteristics 3.3V (*Note 1*, *Note 2*)

Unless otherwise specified, all limits guaranteed for T_A = 25°C, V_{DD} = 3.3V, V_{IN} = 18mV$_{P-P}$, f = 1kHz, $\overline{SD}$ = V_{DD}, Pre Amp gain = 20dB, Post Amp gain = 6dB, R_L = 100kΩ, and C_L = 4.7pF, f = 1kHz pass through mode.

Symbol	Parameter	Conditions	LMV1091 Typical (*Note 6*)	LMV1091 Limits (*Note 7*)	Units (Limits)
SNR	Signal-to-Noise Ratio	V_{IN} = 18mV$_{P-P}$, A-weighted, Audio band	63		dB
		V_{OUT} = 18V$_{P-P}$, voice band (300–3400Hz)	65		dB
e_N	Input Referred Noise level	A-Weighted	5		µV$_{RMS}$
V_{IN}	Maximum Input Signal	THD+N < 1%, Pre Amp Gain = 6dB	880	820	mV$_{P-P}$ (min)
V_{OUT}	Maximum AC Output Voltage	Differential Out+, Out- THD+N < 1%	1.2	1.1	V$_{RMS}$ (min)
	DC Level at Outputs	Out+, Out-	820		mV
THD+N	Total Harmonic Distortion + Noise	Differential Out+ and Out-	0.1	0.2	% (max)
Z_{IN}	Input Impedance		142		kΩ
Z_{OUT}	Output Impedance		220		Ω
Z_{LOAD}	Load Impedance (Out+, Out-) (*Note 9*)	R_{LOAD} C_{LOAD}		10 100	kΩ (min) pF (max)
A_M	Microphone Preamplifier Gain Range	Minimum Maximum	6 36		dB dB
A_{MR}	Microphone Preamplifier Gain Adjustment Resolution		2	1.7 2.3	dB (min) dB (max)
A_P	Post Amplifier Gain Range	Minimum Maximum	6 18		dB dB
A_{PR}	Post Amplifier Gain Resolution		3	2.6 3.4	dB (min) dB (max)
$FFNS_E$	Far Field Noise Suppression Electrical	f = 1kHz (See Test Method) f = 300Hz (See Test Method)	34 42	26	dB
$SNRI_E$	Signal-to-Noise Ratio Improvement Electrical	f = 1kHz (See Test Method) f = 300Hz (See Test Method)	26 33	18	dB
PSRR	Power Supply Rejection Ratio	Input Referred, Input AC grounded			
		f_{RIPPLE} = 217Hz (V_{RIPPLE} = 100mV$_{P-P}$)	99	85	dB (min)
		f_{RIPPLE} = 1kHz (V_{RIPPLE} = 100mV$_{P-P}$)	95	80	dB (min)
CMRR	Common Mode Rejection Ratio	Input referred	60		dB
V_{BM}	Microphone Bias Supply Voltage	I_{BIAS} = 1.2mA	2.0	1.85 2.15	V (min) V (max)
e_{VBM}	Mic bias noise voltage on V_{REF} pin	A-Weighted, C_B = 10nF	7		µV$_{RMS}$
I_{DDQ}	Supply Quiescent Current	V_{IN} = 0V	0.60	0.8	mA (max)
I_{DD}	Supply Current	V_{IN} = 25mV$_{P-P}$ both inputs Noise cancelling mode	0.60		mA

I_{SD}	Shut Down Current	$\overline{SD}$ pin = GND		0.1	0.7	μA (max)
T_{ON}	Turn-On Time (*Note 9*)				40	ms (max)
T_{OFF}	Turn-Off Time (*Note 9*)				60	ms (max)
V_{IH}	Logic High Input Threshold	GA0, GA1, GA2, GA3, GB0, GB1, GB2, Mute1, Mute2, Mode 0, Mode 1, $\overline{SD}$			1.4	V (min)
V_{IL}	Logic Low Input Threshold	GA0, GA1, GA2, GA3, GB0, GB1, GB2, Mute1, Mute2, Mode 0, Mode 1, $\overline{SD}$			0.4	V (max)

Electrical Characteristics 5.0V (*Note 1*)

Unless otherwise specified, all limits guaranteed for T_A = 25°C, V_{DD} = 5V, V_{IN} = 18mV$_{P-P}$, $\overline{SD}$ = V_{DD}, Pre Amp gain = 20dB, Post Amp gain = 6dB, R_L = 100kΩ, and C_L = 4.7pF, f = 1kHz pass through mode.

Symbol	Parameter	Conditions	LMV1091		Units (Limits)
			Typical	Limit	
			(*Note 6*)	(*Note 7*)	
SNR	Signal-to-Noise Ratio	V_{IN} = 18mV$_{P-P}$, A-weighted, Audio band	63		dB
		V_{OUT} = 18mV$_{P-P}$, voice band (300–3400Hz)	65		dB
e_N	Input Referred Noise level	A-Weighted	5		μV$_{RMS}$
V_{IN}	Maximum Input Signal	THD+N < 1%	880	820	mV$_{P-P}$ (min)
V_{OUT}	Maximum AC Output Voltage	f = 1kHz, THD+N < 1% between differential output	1.2	1.1	V$_{RMS}$ (min)
	DC Output Voltage		820		mV
THD+N	Total Harmonic Distortion + Noise	Differential Out+ and Out-	0.1	0.2	% (max)
Z_{IN}	Input Impedance		142		kΩ
Z_{OUT}	Output Impedance		220		Ω
A_M	Microphone Preamplifier Gain Range	Minimum Maximum	6 36		dB dB
A_{MR}	Microphone Preamplifier Gain Adjustment Resolution		2	1.7 2.3	dB (min) dB (max)
A_P	Post Amplifier Gain Range	Minimum Maximum	6 18		dB dB
A_{PR}	Post Amplifier Gain Adjustment Resolution		3	2.6 3.4	dB (min) dB (max)
FFNS$_E$	Far Field Noise Suppression Electrical	f = 1kHz (See Test Method) f = 300Hz (See Test Method)	34 42	26	dB
SNRI$_E$	Signal-to-Noise Ratio Improvement Electrical	f = 1kHz (See Test Method) f = 300Hz (See Test Method)	26 33	18	dB
PSRR	Power Supply Rejection Ratio	Input Referred, Input AC grounded			
		f_{RIPPLE} = 217Hz (V_{RIPPLE} = 100mV$_{P-P}$)	99	85	dB (min)
		f_{RIPPLE} = 1kHz (V_{RIPPLE} = 100mV$_{P-P}$)	95	80	dB (min)
CMRR	Common Mode Rejection Ratio	Input referred	60		dB
V_{BM}	Microphone Bias Supply Voltage	I_{BIAS} = 1.2mA	2.0	1.85 2.15	V (min) V (max)
e_{VBM}	Microphone bias noise voltage on V_{REF} pin	A-Weighted, C_B = 10nF	7		μV$_{RMS}$
I_{DDQ}	Supply Quiescent Current	V_{IN} = 0V	0.60	0.8	mA (max)
I_{DD}	Supply Current	V_{IN} = 25mV$_{P-P}$ both inputs Noise cancelling mode	0.60		mA
I_{SD}	Shut Down Current	$\overline{SD}$ pin = GND	0.1		μA
T_{ON}	Turn On Time			40	ms (max)
T_{OFF}	Turn Off Time			60	ms (max)

| Symbol | Parameter | Conditions | LMV1091 | | Units |
			Typical	Limit	(Limits)
V_{IH}	Logic High Input Threshold	GA0, GA1, GA2, GA3, GB0, GB1, GB2, Mute1, Mute2, Mode 0, Mode 1, $\overline{SD}$		1.4	V (min)
V_{IL}	Logic Low Input Threshold	GA0, GA1, GA2, GA3, GB0, GB1, GB2, Mute1, Mute2, Mode 0, Mode 1, $\overline{SD}$		0.4	V (max)

Note 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.

Note 2: *The Electrical Characteristics* tables list guaranteed 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 guaranteed.

Note 3: The maximum power dissipation must be de-rated at elevated temperatures and is dictated by T_{JMAX}, θ_{JC}, and the ambient temperature T_A. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$ or the number given in the *Absolute Maximum Ratings*, whichever is lower. For the LMV1091, $T_{JMAX} = 150°C$ and the typical θJA for this microSMD package is 70°C/W and for the LLP package θ_{JA} is 64°C/W. Refer to the *Thermal Considerations* section for more information.

Note 4: Human body model, applicable std. JESD22-A114C.

Note 5: Machine model, applicable std. JESD22-A115-A.

Note 6: Typical values represent most likely parametric norms at T_A = +25°C, and at the *Recommended Operation Conditions* at the time of product characterization and are not guaranteed.

Note 7: Datasheet min/max specification limits are guaranteed by test, or statistical analysis.

Note 8: Default value used for performance measurements.

Note 9: Guaranteed by design.

Test Methods
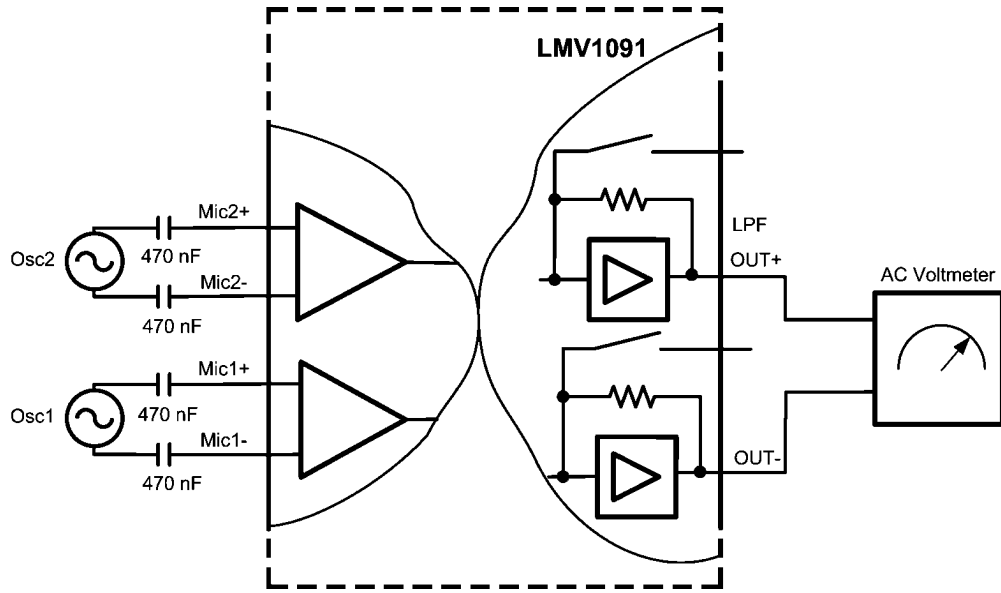
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FIGURE 2. FFNS$_E$, NFSL$_E$, SNRI$_E$ Test Circuit

FAR FIELD NOISE SUPPRESSION (FFNS$_E$)

For optimum noise suppression the far field noise should be in a broadside array configuration from the two microphones (see Figure 8). Which means the far field sound source is equidistance from the two microphones. This configuration allows the amplitude of the far field signal to be equal at the two microphone inputs, however a slight phase difference may still exist. To simulate a real world application a slight phase delay was added to the FFNS$_E$ test. The block diagram from Figure 3 is used with the following procedure to measure the FFNS$_E$.

1. A sine wave with equal frequency and amplitude (25mV$_{P-P}$) is applied to Mic1 and Mic2. Using a signal generator, the phase of Mic 2 is delayed by 1.1° when compared with Mic1.
2. Measure the output level in dBV (X)
3. Mute the signal from Mic2
4. Measure the output level in dBV (Y)
5. FFNS$_E$ = Y - X dB

NEAR FIELD SPEECH LOSS (NFSL$_E$)

For optimum near field speech preservation, the sound source should be in an endfire array configuration from the two microphones (see Figure 9). In this configuration the speech signal at the microphone closest to the sound source will have greater amplitude than the microphone further away. Additionally the signal at microphone further away will experience a phase lag when compared with the closer microphone. To simulate this, phase delay as well as amplitude shift was added to the NFSL$_E$ test. The schematic from Figure 3 is used with the following procedure to measure the NFSL$_E$.

1. A 25mV$_{P-P}$ and 17.25mV$_{P-P}$ (0.69*25mV$_{P-P}$) sine wave is applied to Mic1 and Mic2 respectively. Once again, a signal generator is used to delay the phase of Mic2 by 15.9° when compared with Mic1.
2. Measure the output level in dBV (X)
3. Mute the signal from Mic2
4. Measure the output level in dBV (Y)
5. NFSL$_E$ = Y - X dB

SIGNAL TO NOISE RATIO IMPROVEMENT ELECTRICAL (SNRI$_E$)

The SNRI$_E$ is the ratio of FFNS$_E$ to NFSL$_E$ and is defined as:

SNRI$_E$ = FFNS$_E$ - NFSL$_E$

Measuring Noise and SNR

The overall noise of the LMV1091 is measured within the frequency band from 10Hz to 22kHz using an A-weighted filter.

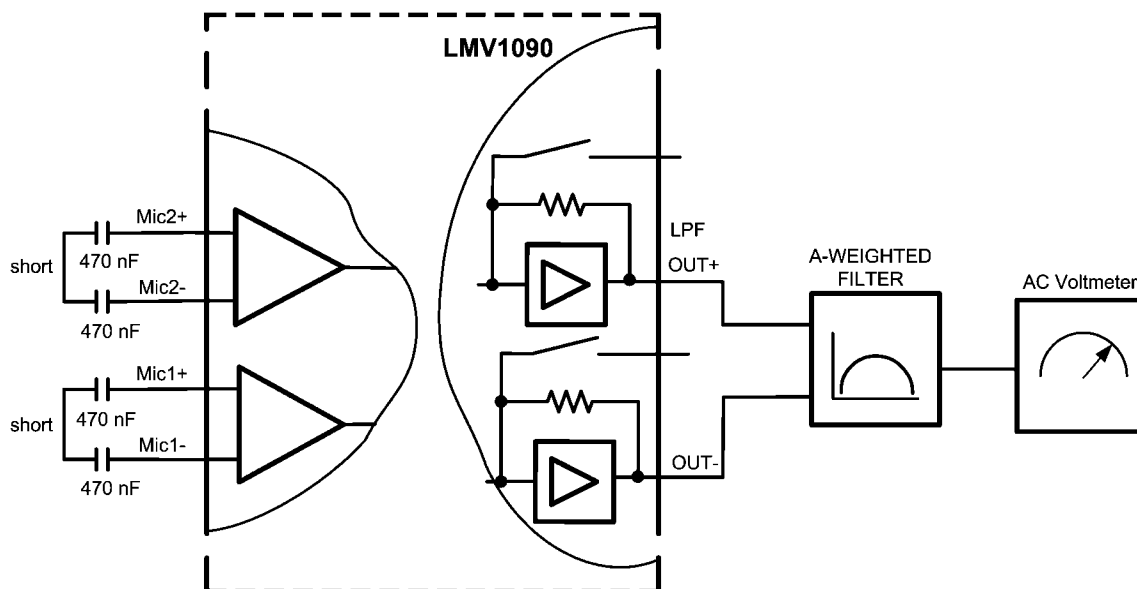The Mic+ and Mic- inputs of the LMV1091 are AC shorted between the input capacitors, see Figure 11.

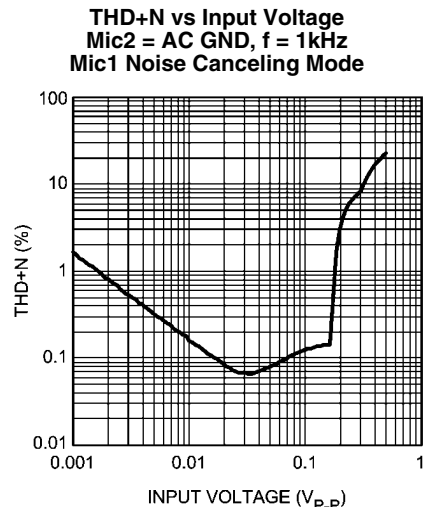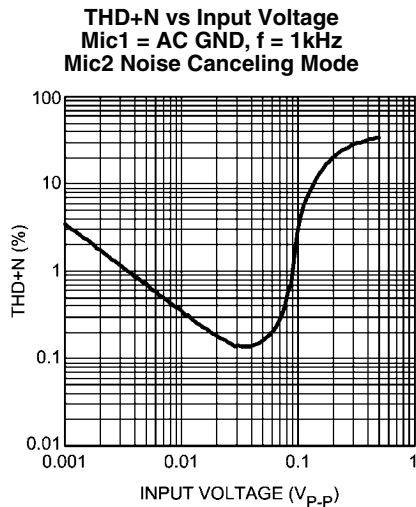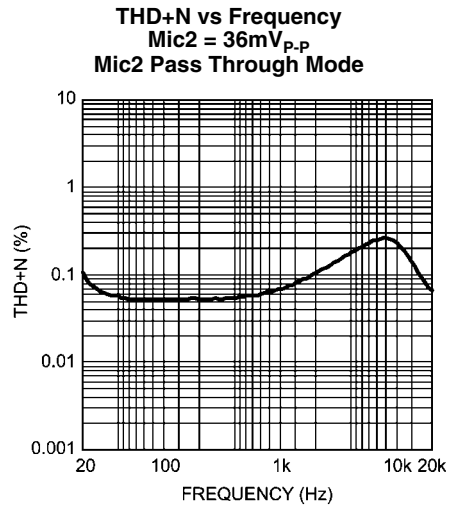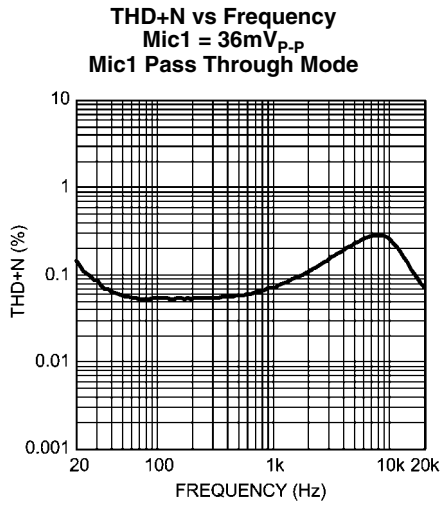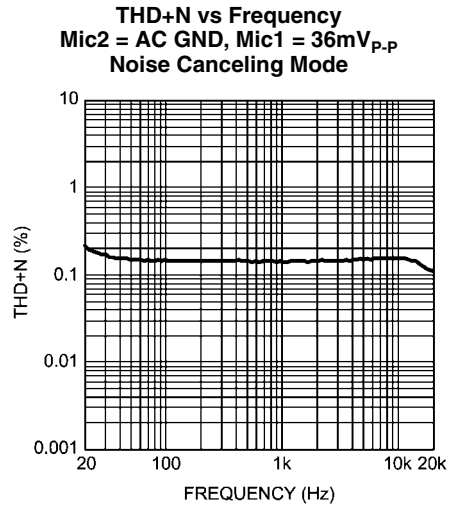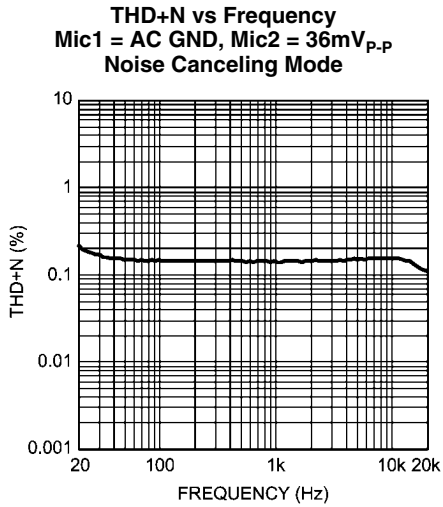**FIGURE 11: Noise Measurement Setup**

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For the signal to noise ratio (SNR) the signal level at the output is measured with a 1kHz input signal of $18mV_{P-P}$ using an A-weighted filter. This voltage represents the output voltage of a typical electret condenser microphone at a sound pressure level of 94dB SPL, which is the standard level for these measurements. The LMV1091 is programmed for 26dB of total gain (20dB preamplifier and 6dB postamplifier) with only Mic1 or Mic2 used.

The input signal is applied differentially between the Mic+ and Mic-. Because the part is in Pass Through mode the low-pass filter at the output of the LMV1091 is disabled.

Typical Performance Characteristics
Unless otherwise specified, T_J = 25°C, V_{DD} = 3.3V, Input Voltage = 18mV$_{P-P}$, f = 1kHz, pass through mode, Pre Amp gain = 20dB, Post Amp gain = 6dB, R_L = 100kΩ, and C_L = 4.7pF.

THD+N vs Frequency
Mic1 = AC GND, Mic2 = 36mV$_{P-P}$
Noise Canceling Mode

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THD+N vs Frequency
Mic2 = AC GND, Mic1 = 36mV$_{P-P}$
Noise Canceling Mode

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THD+N vs Frequency
Mic1 = 36mV$_{P-P}$
Mic1 Pass Through Mode

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THD+N vs Frequency
Mic2 = 36mV$_{P-P}$
Mic2 Pass Through Mode

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THD+N vs Input Voltage
Mic1 = AC GND, f = 1kHz
Mic2 Noise Canceling Mode

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THD+N vs Input Voltage
Mic2 = AC GND, f = 1kHz
Mic1 Noise Canceling Mode

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THD+N vs Input Voltage
f = 1kHz
Mic1 Pass Through Mode
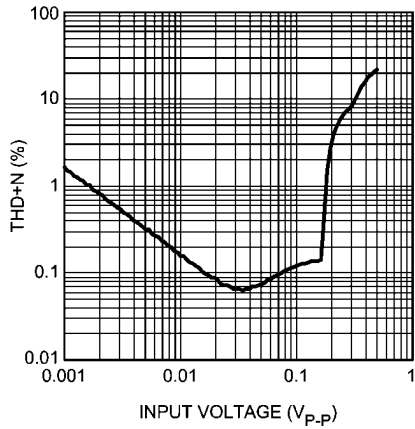
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THD+N vs Input Voltage
f = 1kHz
Mic2 Pass Through Mode
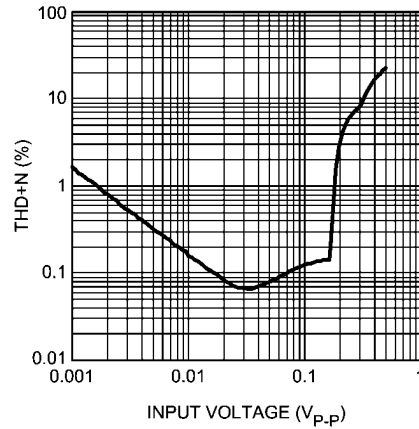
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PSRR vs Frequency
Pre Amp Gain = 20dB, Post Amp Gain = 6dB
V_{RIPPLE} = 100mV$_{P-P}$, Mic1 = Mic2 = AC GND
Mic1 Pass Through Mode
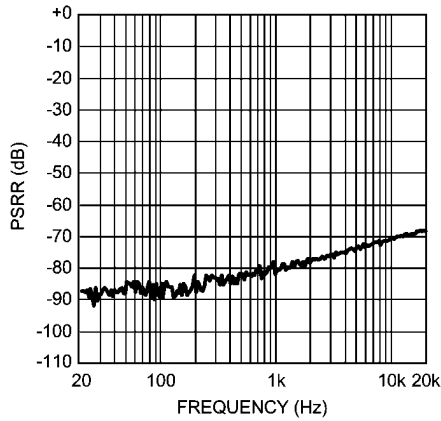
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PSRR vs Frequency
Pre Amp Gain = 20dB, Post Amp Gain = 6dB
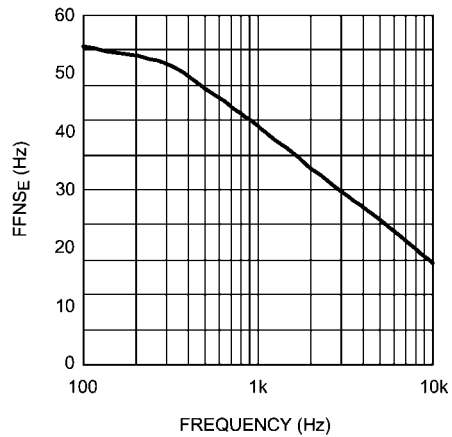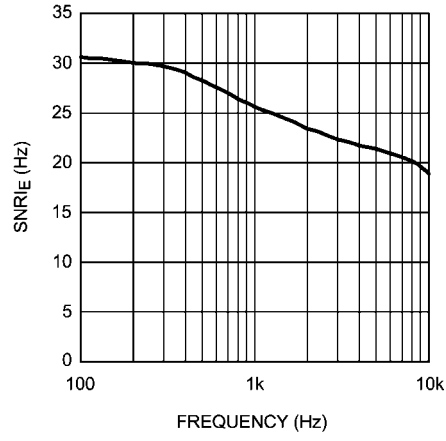V_{RIPPLE} = 100mV$_{P-P}$, Mic1 = Mic2 = AC GND
Mic2 Pass Through Mode
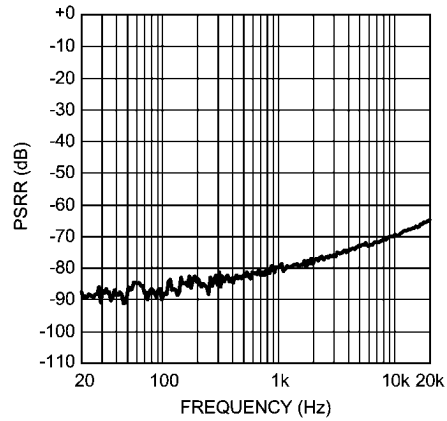
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PSRR vs Frequency
Pre Amp Gain = 20dB, Post Amp Gain = 6dB
V_{RIPPLE} = 100mV$_{P-P}$, Mic1 = Mic2 = AC GND
Noise Canceling Mode
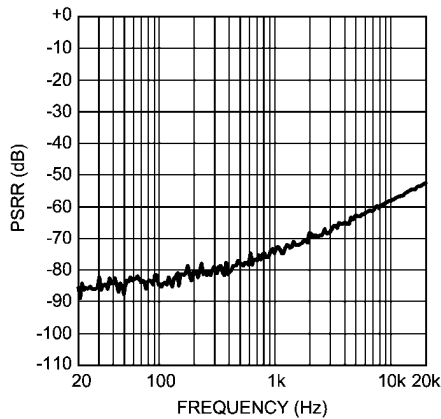
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Far Field Noise Suppression Electrical vs Frequency

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Signal-to-Noise Ratio Electrical vs Frequency

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Application Data

INTRODUCTION

The LMV1091 is a fully analog single chip solution to reduce the far field noise picked up by microphones in a communi-

FIGURE 3. Simplified Block Diagram of the LMV1091

The output signal of the microphones is amplified by a pre-amplifier with adjustable gain between 6dB and 36dB. After the signals are matched the analog noise cancelling suppresses the far field noise signal. The output of the analog noise cancelling processor is amplified in the post amplifier with adjustable gain between 6dB and 18dB. For optimum noise and EMI immunity, the microphones have a differential connection to the LMV1091 and the output of the LMV1091 is also differential. The adjustable gain functions can be controlled via GA0–GA3 and GB0–GB2 pins.

Power Supply Circuits

A low drop-out (LDO) voltage regulator in the LMV1091 allows the device to be independent of supply voltage variations.

The Power On Reset (POR) circuitry in the LMV1091 requires the supply voltage to rise from 0V to V_{DD} in less than 100ms.

The Mic Bias output is provided as a low noise supply source for the electret microphones. The noise voltage on the Mic Bias microphone supply output pin depends on the noise voltage on the internal the reference node. The de-coupling capacitor on the V_{REF} pin determines the noise voltage on this internal reference. This capacitor should be larger than 1nF; having a larger capacitor value will result in a lower noise voltage on the Mic Bias output.

Gain Balance and Gain Budget

In systems where input signals have a high dynamic range, critical noise levels or where the dynamic range of the output voltage is also limited, careful gain balancing is essential for the best performance. Too low of a gain setting in the preamplifier can result in higher noise levels while too high of a gain setting in the preamplifier will result in clipping and saturation in the noise cancelling processor and output stages.

The gain ranges and maximum signal levels for the different functional blocks are shown in *Figure 4*. Two examples are given as a guideline on how to select proper gain settings.
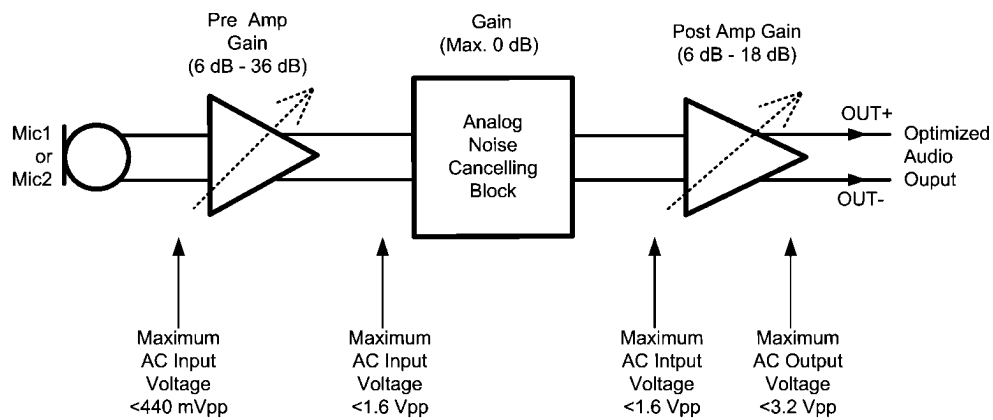
FIGURE 4. Maximum Signal Levels

Example 1

An application using microphones with 50mV$_{P-P}$ maximum output voltage, and a baseband chip after the LMV1091 with 1.5V$_{P-P}$ maximum input voltage.

For optimum noise performance, the gain of the input stage should be set to the maximum.

1. 50mV$_{P-P}$ +36dB = 3.1V$_{P-P}$.

2. 3.1V$_{P-P}$ is higher than the maximum 1.5V$_{P-P}$ allowed for the Noise Cancelling Block (NCB). This means a gain lower than 29.5dB should be selected.

3. Select the nearest lower gain from the gain settings shown in Table 2,28dB is selected. This will prevent the NCB from being overloaded by the microphone. With this setting, the resulting output level of the Pre Amplifier will be 1.26V$_{P-P}$.

4. The NCB has a gain of 0dB which will result in 1.26V$_{P-P}$ at the output of the LMV1091. This level is less than maximum level that is allowed at the input of the post amp of the LMV1091.

5. The baseband chip limits the maximum output voltage to 1.5V$_{P-P}$ with the minimum of 6dB post amp gain, this results in requiring a lower level at the input of the post amp of 0.75V$_{P-P}$. Now calculating this for a maximum preamp gain, the output of the preamp must be no more than 0.75mV$_{P-P}$.

6. Calculating the new gain for the preamp will result in <23.5dB gain.

7. The nearest lower gain will be 22dB.

So using preamp gain = 22dB and postamp gain = 6dB is the optimum for this application.

Example 2

An application using microphones with 10mV$_{P-P}$ maximum output voltage, and a baseband chip after the LMV1091 with 3.3V$_{P-P}$ maximum input voltage.

For optimum noise performance we would like to have the maximum gain at the input stage.

1. 10mV$_{P-P}$ + 36dB = 631mV$_{P-P}$.

2. This is lower than the maximum 1.5V$_{P-P}$, so this is OK.

3. The NCB has a gain of 0dB which will result in 1.5V$_{P-P}$ at the output of the LMV1091. This level is lower than the maximum level that is allowed at the input of the Post Amp of the LMV1091.

4. With a Post Amp gain setting of 6dB the output of the Post Amp will be 3V$_{P-P}$ which is OK for the baseband.

5. The nearest lower Post Amp gain will be 6dB.

So using preamp gain = 36dB and postamp gain = 6dB is optimum for this application.

Pre-Amp/Post-Amp Gains

The Pre-amplifier gain of the LMV1091TM can be controlled using the GA0-GA3 pins. See table 2 below for Pre-amplifier

gain control. The Post-Amp gain can be controlled using the GB0-GB2 pins. See table 3 below for Post-amplifier control.

TABLE 2. Mic Pre-Amp Gain Settings

GA3	GA2	GA1	GA0	Pre-Amplifier Gain
0	0	0	0	6dB
0	0	0	1	8dB
0	0	1	0	10dB
0	0	1	1	12dB
0	1	0	0	14dB
0	1	0	1	16dB
0	1	1	0	18dB
0	1	1	1	20dB
1	0	0	0	22dB
1	0	0	1	24dB
1	0	1	0	26dB
1	0	1	1	28dB
1	1	0	0	30dB
1	1	0	1	32dB
1	1	1	0	34dB
1	1	1	1	36dB

TABLE 3. Post-Amp Gain Settings

GB2	GB1	GB0	Post-Amplifier Gain
0	0	0	6dB
0	0	1	9dB
0	1	0	12dB
0	1	1	15dB
1	0	0	18dB
1	0	1	18dB
1	1	0	18dB
1	1	1	18dB

Noise Reduction Mode Settings

The LMV1091TM has four mode settings. It can be placed in noise cancellation mode, mic 1 on with mic 2 off, mic 1 off with mic 2 on, and mic1 and mic2. See table 4 for control settings.

TABLE 4. Noise Reduction Mode Settings

Mode 1	Mode 0	Noise Reduction Mode Selection
0	0	Noise cancelling mode
0	1	Only Mic 1 On
1	0	Only Mic 2 On
1	1	Mic 1 + Mic 2

Mute Section

Mic 1 and Mic 2 can be muted independently, using the Mute 1 and Mute 2 pins. See Table 5 for control settings.

TABLE 5. Noise Reduction Mode Settings

Mute 2	Mute 1	Mute Mode Selection
0	0	Mic 1 an Mic 2 on
0	1	Mic 1 mute
1	0	Mic 2 mute
1	1	Mic 1 and Mic 2 mute

Microphone Placement

Because the LMV1091 is a microphone array Far Field Noise Reduction solution, proper microphone placement is critical for optimum performance. Two things need to be considered: The spacing between the two microphones and the position of the two microphones relative to near field source

If the spacing between the two microphones is too small near field speech will be canceled along with the far field noise. Conversely, if the spacing between the two microphones is large, the far field noise reduction performance will be degraded. The optimum spacing between Mic 1 and Mic 2 is 1.5-2.5cm. This range provides a balance of minimal near field speech loss and maximum far field noise reduction. The microphones should be in line with the desired sound source 'near speech' and configured in an endfire array (see Figure 9) orientation from the sound source. If the 'near speech' (desired sound source) is equidistant to the source like a broadside array (see Figure 8) the result will be a great deal of near field speech loss.
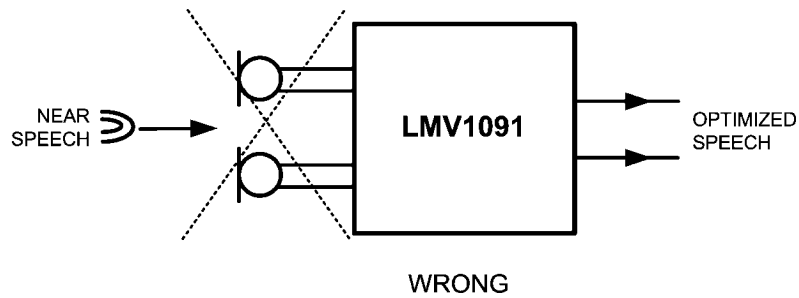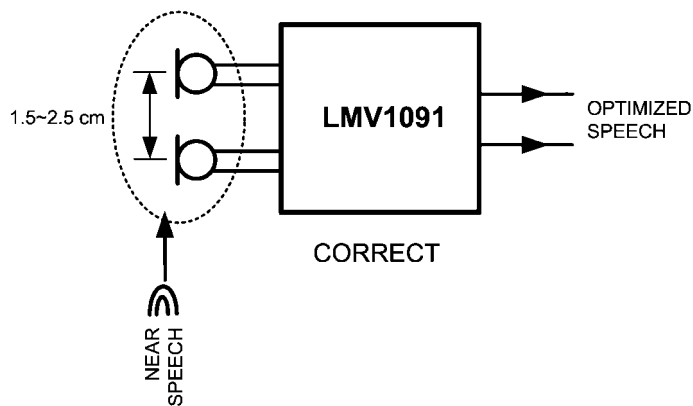

FIGURE 8: Broadside Array (WRONG)

FIGURE 9: Endfire Array (CORRECT)

Low-Pass Filter At The Output

At the output of the LMV1091 there is a provision to create a 1st order low-pass filter (only enabled in 'Noise Cancelling' mode). This low-pass filter can be used to compensate for the change in frequency response that results from the noise cancellation process. The change in frequency response resembles a first-order high-pass filter, and for many of the applications it can be compensated by a first-order low-pass filter with cutoff frequency between 1.5kHz and 2.5kHz.

The transfer function of the low-pass filter is derived as:

$$H(s) = \frac{\text{Post Amplifier gain}}{sR_fC_f+1}$$

This low-pass filter is created by connecting a capacitor between the LPF pin and the OUT pin of the LMV1091. The value of this capacitor also depends on the selected output gain. For different gains the feedback resistance in the low-pass filter network changes as shown in *Table 6*.

This will result in the following values for a cutoff frequency of 2000 Hz:

TABLE 6. Low-Pass Filter Capacitor For 2kHz

Post Amplifier Gain Setting (dB)	R_f (kΩ)	C_f (nF)
6	20	3.9
9	29	2.7
12	40	2.0
15	57	1.3
18	80	1.0

A-Weighted Filter

The human ear is sensitive for acoustic signals within a frequency range from about 20Hz to 20kHz. 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 used in signal to noise measurements, where the wanted audio signal is compared to device noise and distortion.

The use of this filter improves the correlation of the measured values to the way these ratios are perceived by the human ear.
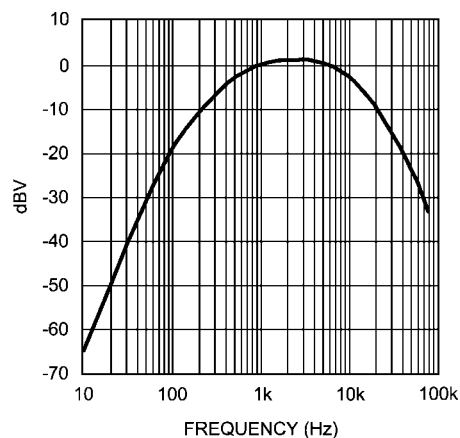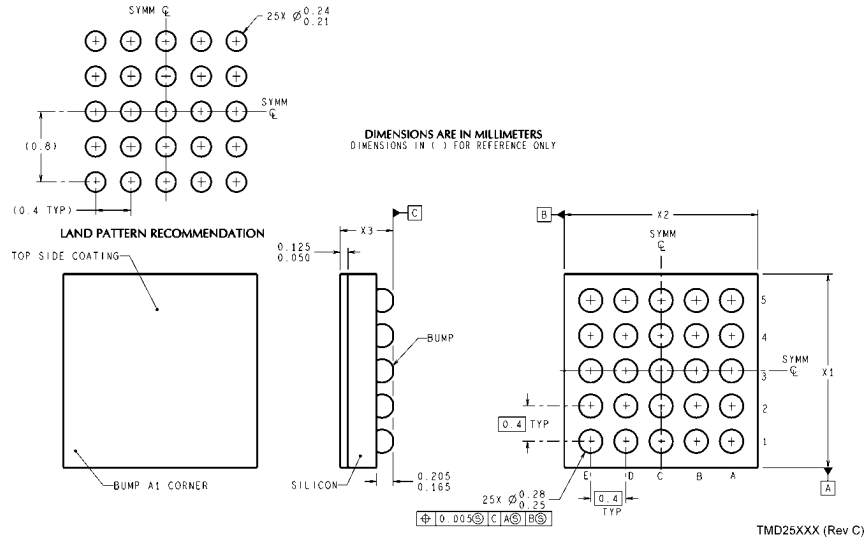

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FIGURE 10: A-Weighted Filter

Revision History

Rev	Date	Description
1.0	10/28/09	Initial released.
1.01	05/17/10	Changed the unit measure of the X1, X2, and X3 (under the Physical Dimension) from mm to µm.
1.02	01/13/11	Fixed typos on Figure 1 (Typical Application diagram).

Physical Dimensions inches (millimeters) unless otherwise noted

DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY

TMD25XXX (Rev C)

25 Bump micro SMD Technology
NS Package Number TMD25AAA
X_1 = 2015µm X_2 = 2015µm X_3 = 600µm

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Interface	www.national.com/interface	Eval Boards	www.national.com/evalboards
LVDS	www.national.com/lvds	Packaging	www.national.com/packaging
Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
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