

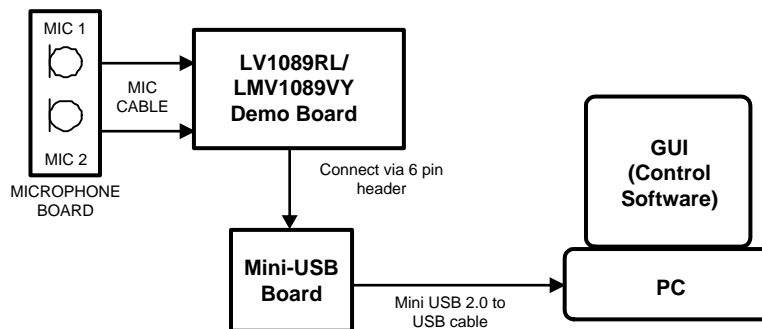
# **AN-1832 LMV1089 Noise Suppression Microphone Amplifier Demo Board User's Guide**

The LMV1089 evaluation kits contain the following:

## **1 Contents**

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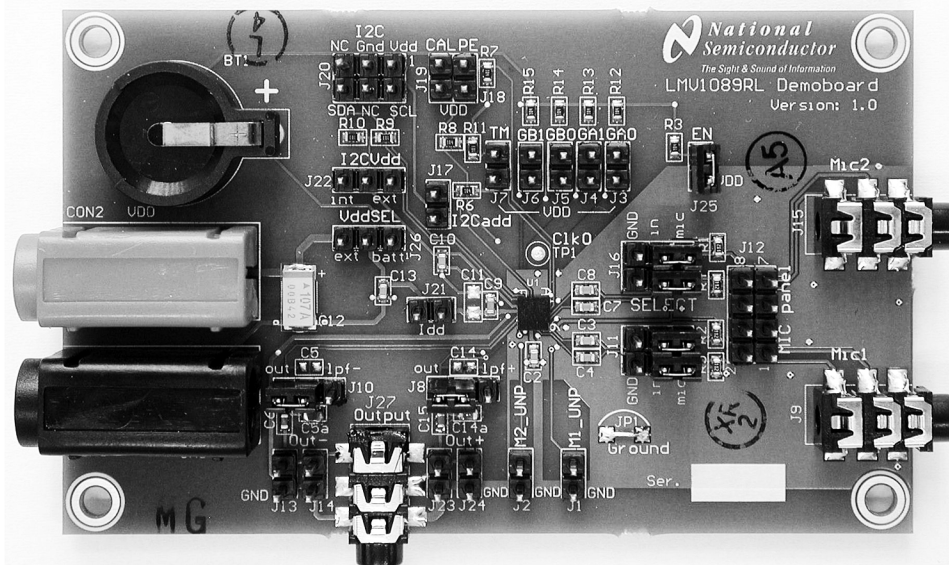
- LMV1089RL/LMV1089VY Demonstration Board
- Mini USB Board
- Control Software GUI
- Microphone board
- Microphone cable
- Mini USB 2.0 to USB cable



**Figure 1. Basic Evaluation System**

## **2 Introduction**

The LMV1089 demo board offers the means for easy evaluation of the LMV1089 Dual input, Far Field Noise Suppression (FFNS) Microphone Amplifier with Automatic gain Ability and Differential Outputs. This board has the LMV1089 mounted on the PCB together with surrounding components ready for evaluation. This board offers interfaces for connecting two microphones and an I<sup>2</sup>C interface for controlling the settings of the LMV1089. The automatic calibration mechanism integrated in the LMV1089 can be operated by I<sup>2</sup>C control or by control of the CAL pin.



**Figure 2. The LMV1089RL Demo Board**

### 3 General Description

The LMV1089 is a fully analog dual input, differential output, microphone array amplifier designed to reduce background acoustic noise, while delivering superb speech clarity in voice communications applications. The LMV1089 incorporates calibration circuitry which may be initiated by either an I<sup>2</sup>C command or by a logic level control on a separate input pin. The calibration sequence compensates for gain and frequency response variations of the microphones used with the LMV1089, eliminating the need to use expensive matched microphone sets. The calibration data is stored in the internal EEPROM memory. The LMV1089 has two differential input microphone amplifier channels plus far field noise suppression (FFNS) processing circuitry. The amplifiers and FFNS circuitry are adjustable for gain differences in the MIC channels of 6dB. The frequency response variations of the microphones over the voice band frequency range can also be adjusted for differences of  $\pm 3$ dB. The compensation or calibration function is achieved via memory stored coefficients. These are determined when the FFNS calibration function is activated. The purpose of the calibration sequence is to choose the optimized coefficients for the FFNS circuitry for the given microphones, spacing, and acoustical environment.

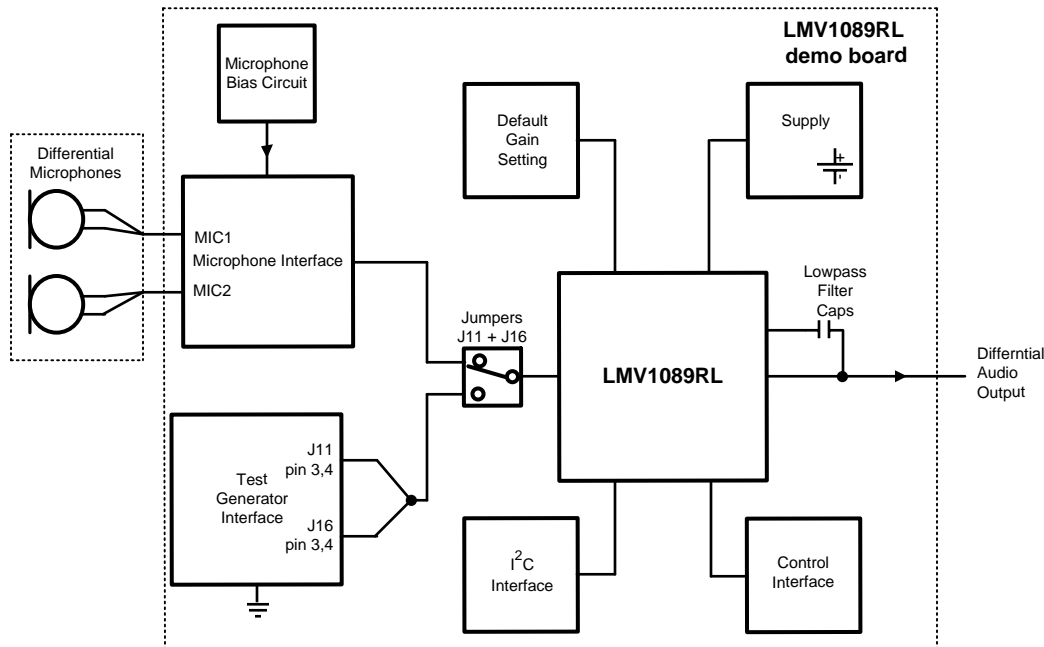
### 4 Operating Conditions

- Temperature Range  $-40^{\circ}\text{C} \leq \text{TA} \leq 85^{\circ}\text{C}$
- Power Supply Voltage  $2.7\text{V} \leq \text{VDD} \leq 5.5\text{V}$
- I<sup>2</sup>C supply voltage  $1.7\text{V} \leq \text{I}^2\text{CV}_{\text{DD}} \leq 5.5\text{V}$

### 5 LMV1089 Demo Board Features

With the LMV1089 demo board, evaluation of the noise suppression function of the LMV1089 is very convenient. This board makes it easier to measure most of the characteristics of the LMV1089 that can be found in the LMV1089 data sheet. To facilitate this there are various connections to apply test signals and measure output signals and supply currents. These connections are described later in this document. The LMV1089 demo board can also be hooked up in a test application to evaluate the operation of the FFNS system. There are connectors for microphone inputs and processed outputs. The LMV1089 demo board is equipped with a generic 6-pin header for I<sup>2</sup>C interfacing to the part.

The physical effect of the operation of the noise suppressions function will result in a first order high-pass behavior with a corner frequency at about 2 kHz. (The corner frequency is application and construction dependent). In most application containing the LMV1089 there will be a low pass filter required that will correct for this high-pass effect. This low-pass filter can be configured at the differential output stages of the LMV1089. The LMV1089 demo board provides the means to easily change the cutoff frequency of that filter by connecting the frequency determining capacitors to headers on the PCB.



**Figure 3. The LMV1089RL Demo Board Block Diagram**

## 6 Power Supply of the LMV1089VY Demo Board

The LMV1089VY demo board provides three (3) possible sources for the power supply. The first one is using the external supply via header J12 for  $V_{DD}$  and GND. The  $I^2C V_{DD}$  pin can get its supply from the  $V_{DD}$  pin by shorting pin 1 of J21 to pin 1 of J22 using a jumper.

The second source of power supply is a small battery placed in the battery holder mounted on the PCB. For a limited time, the demo board can be operated from the board battery (CR1220 placed in the battery holder BT1). To operate the board using a battery the jumper on J26 should be placed between pin 2 and pin 3, and pin 1 of J21 should be shorted to pin 1 of J22 using a jumper.

The third source of power is via the  $I^2C$  interface header J20. This is the default configuration of the LMV1090VY demonstration board. Using this configuration and a mini USB board eliminates the need for a separate power supply for evaluation. Supplying the demo board is possible by connecting jumpers on headers J21 and J22.

## 7 Power Supply of the LMV1089RL Demo Board

The LMV1089RL demo board provides three possible sources for the power supply. One is the external supply via the banana connectors CON2 and CON3 (see [Figure 4](#)), another is a small battery placed in the battery holder mounted on the PCB (see [Figure 4](#)), the third is via the  $I^2C$  interface.

When using an external supply, the LMV1089 demo board will receive its power supply via the banana connectors CON2 and CON3. In this mode, the jumper on J26 (see [Figure 4](#)) is placed between pin 2 and pin 3.

For a limited time, the demo board can also be operated from an on board battery (CR1220 placed in the battery holder BT1). To operate the board on the on board battery supply, the jumper on J26 must be removed from pin 2 and pin 3 and it must be placed between pin 1 and pin 2.

It is possible to supply the LMV1089 via the I<sup>2</sup>C interface header J20 (see Figure 6). Using this configuration and a USB – I<sup>2</sup>C converter board eliminates the need for a separate power supply for evaluation. Supplying the demo board this way is possible by connecting pins 1 and 3 of the I<sup>2</sup>CV<sub>DD</sub> supply selection header J22 (see Figure 6). This is the default configuration for the LMV1089RL demo board.

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**NOTE:** Never have the on board battery and the normal power supply enabled at the same time.

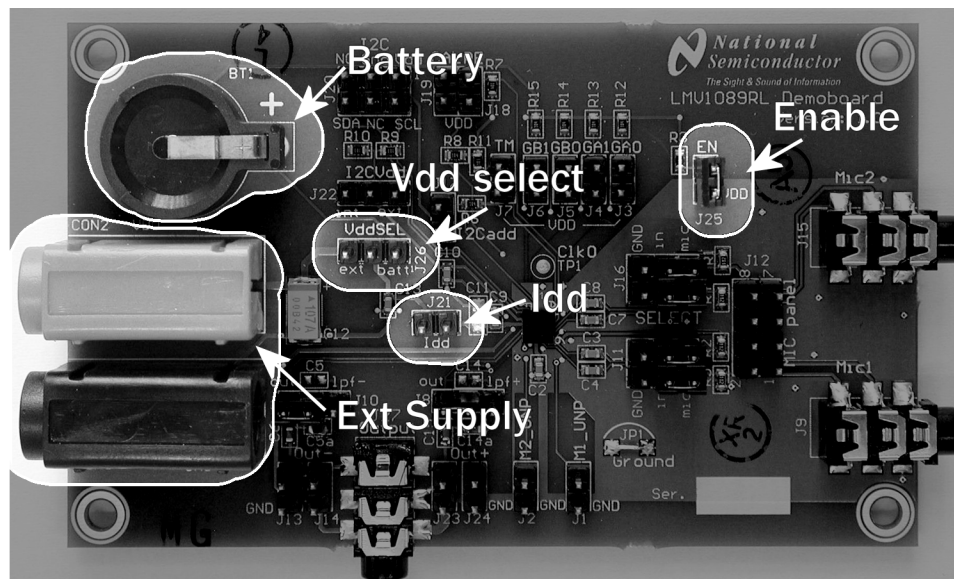
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**NOTE:** Never connect all three pins (pin 1, pin 2 and pin 3) of J26 together.

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**Figure 4. Power Supply Connectors and Headers**

### 7.1 Measuring the LMV1089 Supply Current ( $I_{DD}$ )

The supply current ( $I_{DD}$ ) of the LMV1089 mounted on the demo board should not be measured by measuring the current flowing into CON2 as this includes not only the supply current ( $I_{DD}$ ) of the part but also will include pull-up and pull-down currents and I<sup>2</sup>CV<sub>DD</sub> current. To measure the true  $I_{DD}$  of the LMV1089, the jumper on J21 (see Figure 4) should be removed and a DMM in a proper current range should be mounted instead. In normal operation the supply current of the LMV1089 will be 1.1mA (typ).

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**NOTE:** The LMV1089 can for a short time (<200ms) draw up to 50mA supply current during the programming of the EEPROM.

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### 7.2 Enable Pin

The enable pin must be logic high for operating the on board LMV1089. This is done by placing a jumper on header J25 (see Figure 4).

## 8 Adjustable Gain

The LMV1089 has two gain stages where the gain can be adjusted to meet the requirements for the application. There is a pre amplifier and a post amplifier gain that can be varied independent of each other <sup>(1)</sup>. In most applications the gain will be set via the I<sup>2</sup>C interface.

<sup>(1)</sup> See the application section of LMV1089 data sheet for a more detailed explanation of the gain budget.

### 8.1 Setting the Default Gain

The LMV1089 provides 4 pins GA0, GA1, GB0 and GB1(see Figure 5) to set the default gain settings at power-up of the device. This is convenient for applications without a micro controller . The default gain of the preamplifier is controlled by the GA0 and GA1 pins and can be set by wiring those pins to either  $V_{DD}$  or GND. In this way, one of the four possible values in the 12dB to 36dB range is selected. The default post amplifier gain is set in the same way by connection the GB0 and GB1 to either  $V_{DD}$  or GND to select a gain between 6dB and 15dB. Setting the gain of the preamplifier and post amplifier via the I<sup>2</sup>C interface will override this default gain.

The default gain is only read and set during power up of the device. Toggling the logic level of the enable pin (EN) will not change the current gain setting of the part. Any gain setting done via the I<sup>2</sup>C interface will remain valid until the part is powered down.

**Table 1. Default pre amplifier gain**

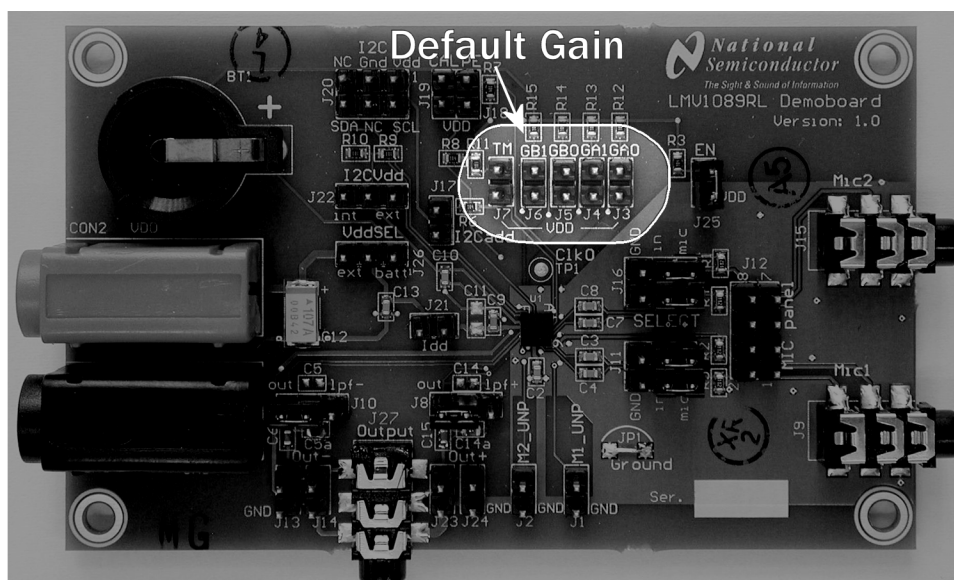
GA1	GA0	Gain
0	0	12dB
0	1	20dB <sup>(1)</sup>
1	0	28dB
1	1	36dB

<sup>(1)</sup> Default value used for performance measurements.

**Table 2. Default post amplifier gain**

GB1	GB0	Gain
0	0	6dB <sup>(1)</sup>
0	1	9dB
1	0	12dB
1	1	15dB

<sup>(1)</sup> Default value used for performance measurements.



**Figure 5. Headers for Default Gain**

## 9 The On Board I<sup>2</sup>C Compatible Interface

The I<sup>2</sup>C Compatible Interface that is available on the LMV1089 demo board is located at the header J20 with an indication 'I2C' printed on the PCB (see Figure 6). The signals on this header are described in Table 3.

Table 3. I<sup>2</sup>C connector

PIN	Function
1	I <sup>2</sup> CV <sub>DD</sub>
2	SCL
3	GND
4	NC
5	NC
6	SDA

The SCL pin and the SDA pin both have a 10kΩ pull-up resistor to I<sup>2</sup>CV<sub>DD</sub> mounted on the PCB.

### 9.1 Controlling I<sup>2</sup>CV<sub>DD</sub>

The supply voltage for the I<sup>2</sup>C interface of the LMV1089 can be selected with the jumper on J22 (see Figure 6).

With the jumper between pin 2 and pin 3 the I<sup>2</sup>C interface levels will be related to supply voltage of the LMV1089.

With the jumper between pin 1 and pin 2 the I<sup>2</sup>C interface levels will be related to the voltage supplied via pin 1 at the I<sup>2</sup>C interface connector J20.

**NOTE:** To avoid possible damage to the LMV1089 part, the I<sup>2</sup>CV<sub>DD</sub> voltage should not exceed the V<sub>DD</sub> voltage.

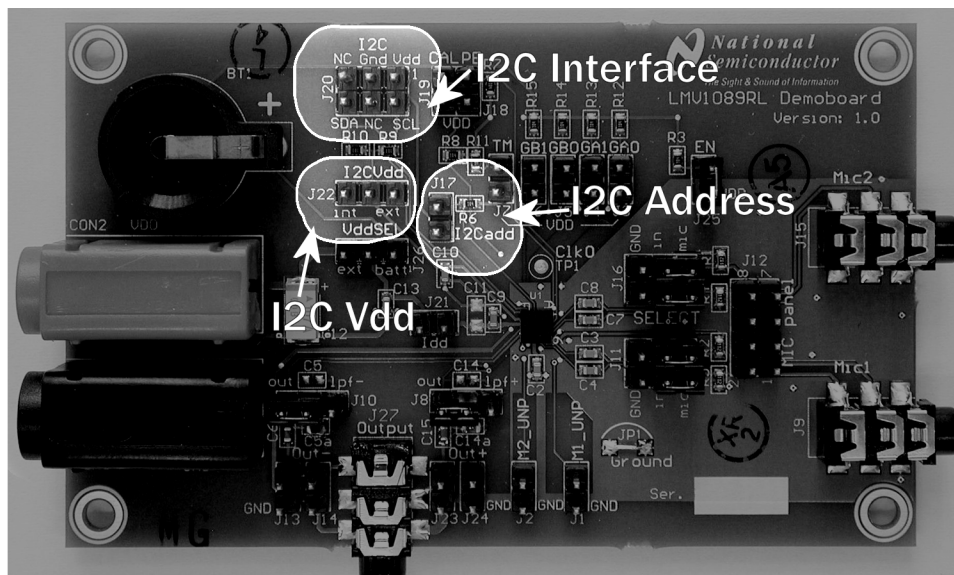


Figure 6. I<sup>2</sup>C Compatible Interface

The I<sup>2</sup>C address on which the registers of the on board LMV1089 can be accessed is selected with the jumper on header J17 (see Figure 6).

Table 4. I<sup>2</sup>C Address

J17	D7	D6	D5	D4	D3	D4	D1	D0
open	1	1	0	0	1	1	0	$\bar{W}/R$
short	1	1	0	0	1	1	1	$\bar{W}/R$

## 10 LMV1089 Control Demo Software

Together with the LMV1089 demo board, there is a software package available that can assist in evaluation, programming, and testing of the LMV1089 chip via the I<sup>2</sup>C Interface. This software is operated via the graphical user interface as shown in Figure 7. This software provides two groups of functions.

In the top half of the screen there are functions like:

- Enable and disable the microphone amplifiers
- Muting the microphone input amplifiers
- Controlling the pre- and post-amplifier gain
- A 'DEFAULT' button for resetting the part to its un-calibrated state

The functions in the bottom half of the screen are mostly used for manual calibration :

- Gain difference compensation (gain calibration)
- Frequency response difference compensation (calibration pattern presets)
- Button to write the manual calibration data (program calibration)
- Button to read the calibration data (read coefficients)

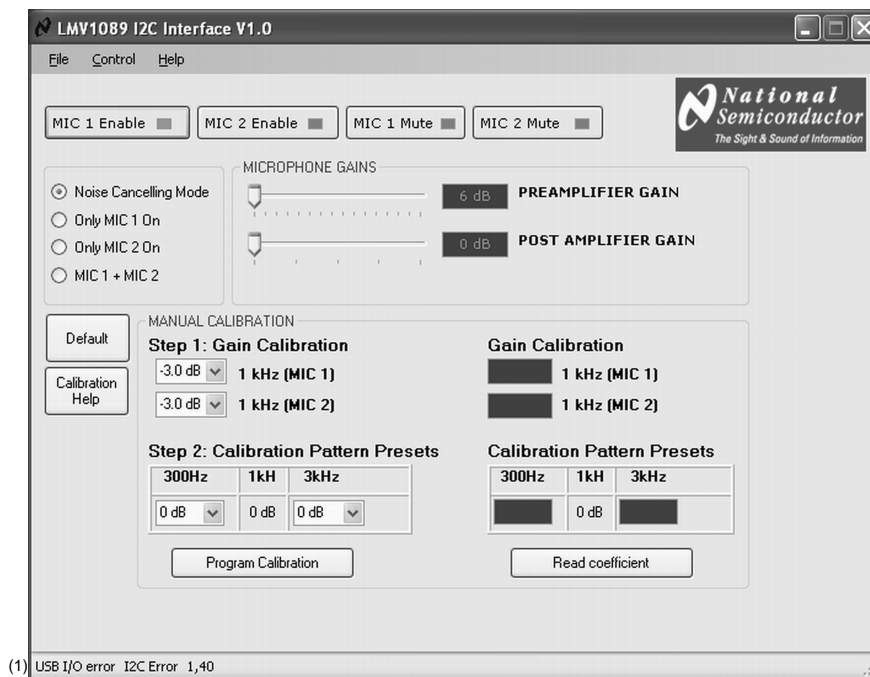


Figure 7. Control Demo Software GUI

(1) Using Manual Calibration is described in more detail in the application section of the LMV1089 data sheet.

## 11 Measuring Characteristics of the LMV1089

### Important:

Whenever the LMV1089 part calibration data is stored into the EEPROM, some parameters like Gain will differ from the measured data in the datasheet. This is due to the nature of the calibration system which equalizes the gain between the two microphone channels. To measure the characteristics of the part as described in the data sheet tables, the part should not be calibrated. The part can be set in 'un-calibrated state' via the I<sup>2</sup>C interface by operating the **Default** setting button (see [Figure 7](#)) in the graphical user interface of the program that is available from TI.

### 11.1 Connecting to an Audio Tester

For measuring the performance of the part as described in the data sheet tables, there will be no header placed on J11 and J16 (see [Figure 8](#)), while J21 and J25 (see [Figure 4](#)) must be shorted to supply and enable the part and the headers J18 and J19 (see [Figure 8](#)) that are used for automatic calibration are open.

The outputs of the generator are connected differentially to J11 and J16 where the (+) and (-) signals are applied to pin 3 and 4 and where pin 5 and 6 on J11 and J16 are ground connection for shielding.

In a similar way the differential outputs of the LMV1089 can be connected to the differential inputs of a tester via J14 and J24 (see [Figure 8](#)). Pin 2 of the header must be connected to the (+) and (-) inputs of the tester. Pin 1 of these headers are ground pins that can be used for shielding. Optionally the tester can also be connected via the 3.5mm jack at J27 (see [Figure 8](#)).

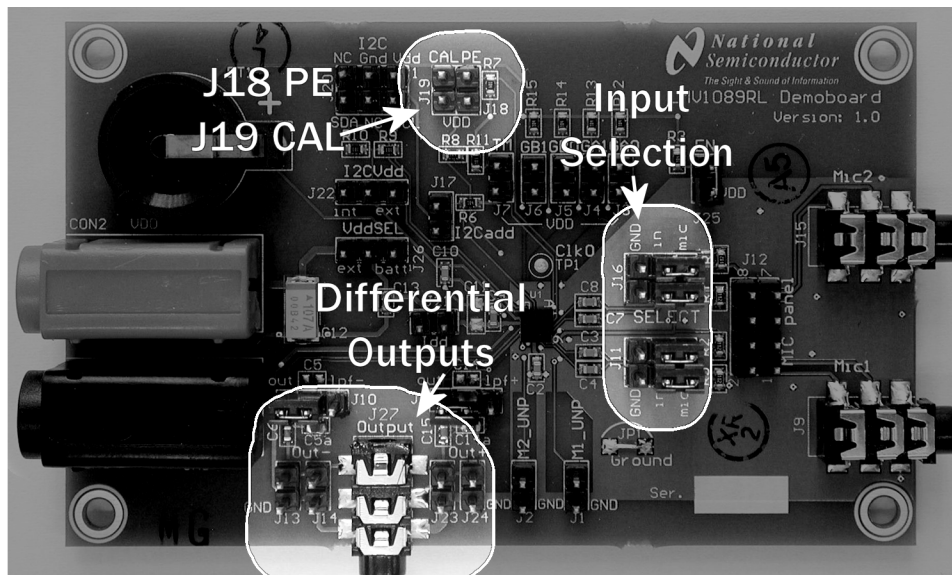


Figure 8. Audio Tester Connections

### 11.2 Unprocessed Output Pins

The individual stereo output signal of the two microphone channels MIC1 and MIC2 are available at the corresponding outputs of the LMV1089 M1\_UNP and M2\_UNP. These signals are available at the headers J1 and J2. (see [Figure 9](#)).



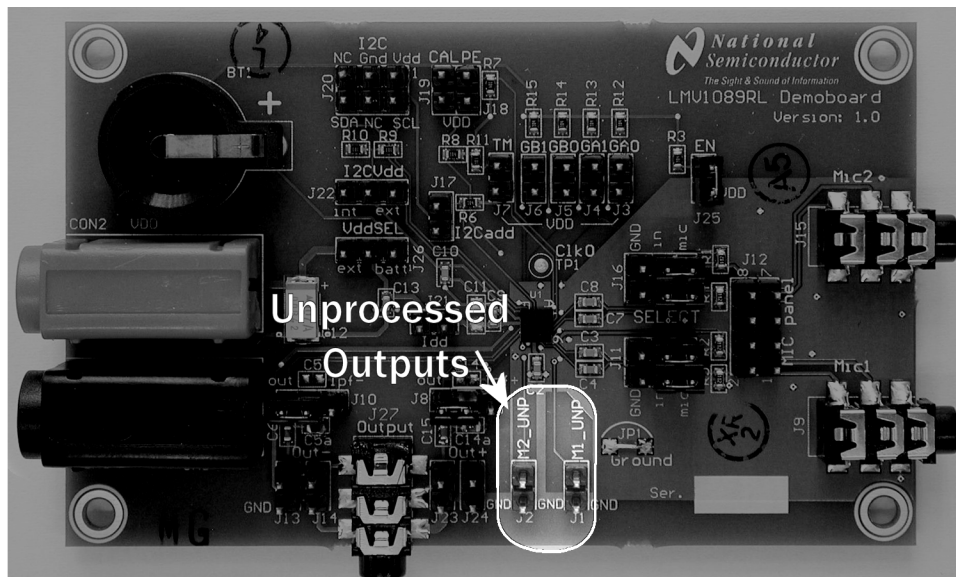


Figure 9. Unprocessed Audio Outputs

### 11.3 Connecting Microphones to the LMV1089 Demo Board

The demo board can be used to connect a set of two microphones to the LMV1089 to evaluate the performance of the LMV1089 in a customer application. To enable these microphone input connectors, the jumpers on header J11 and J16 (see Figure 10) must be placed between pin 3–5 and pin 4–6 of both headers. Microphones can also be connected to 3.5mm connectors J9 and J15 (see Figure 10). The LMV1089RL demo board has a provision to place a small PCB on J12 (see Figure 10) on which two microphones can be mounted.

Microphones that are connected to the PCB receive a low noise 2V<sub>DC</sub> power supply via resistors R1, R2, R4 and R5 mounted on the LMV1089 demo board.

For situations where microphones are used which do not allow for a DC voltage, these microphones should be connected in a similar way as connecting the audio tester to the inputs. The jumpers from J11 and J16 (see Figure 8) must be removed and one microphone is connected between pin 2 and pin 4 of J11 and the other microphone is connected between pin 2 and pin 4 of J16.

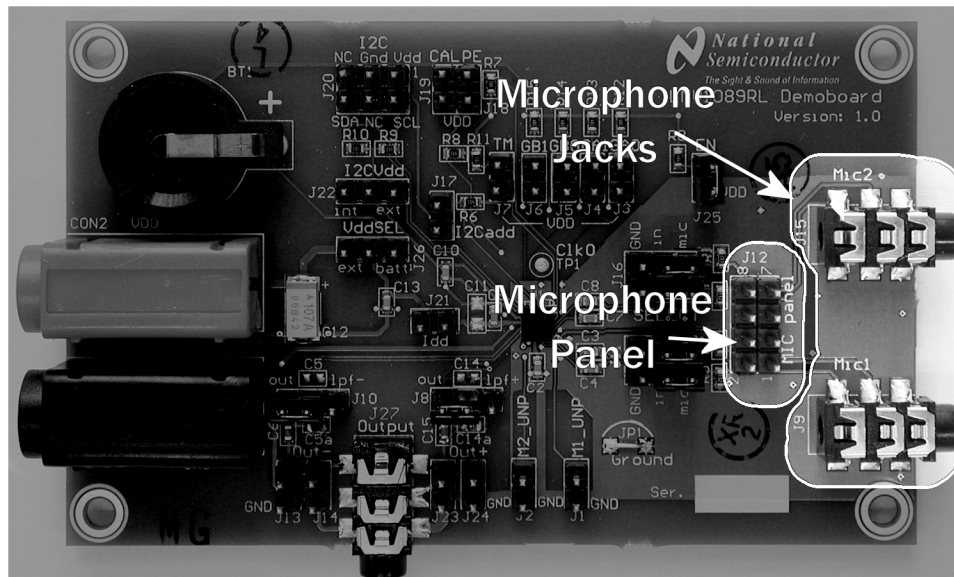


Figure 10. Connecting Microphones

For an optimal performance of the Far Field Noise Reduction system it is important to find the correct placement of the microphones. In many applications the microphones are placed next to each other with a distance of 1.5cm to 2.5cm between the microphones. The best noise cancelling performance will occur in systems where the far field signals comes from a source orthogonal to the plane of the microphones and where the desired signal is close to the microphones and is located in line with the microphones as shown in Figure 11.

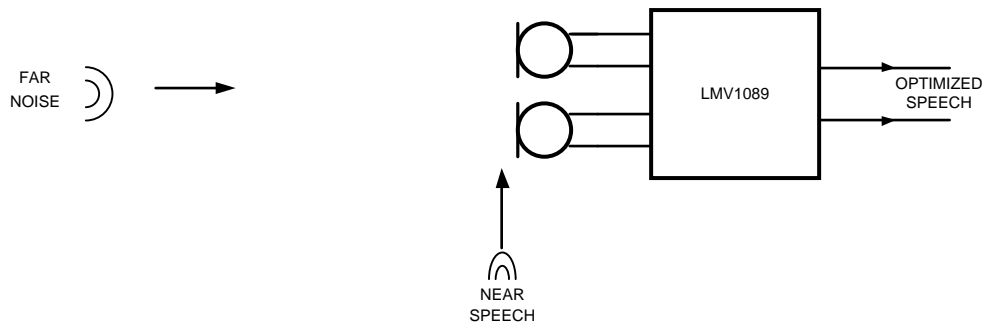
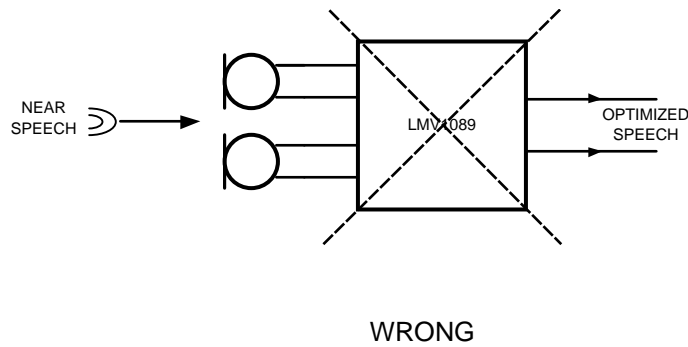


Figure 11. Orientation of Microphones and Sound Sources

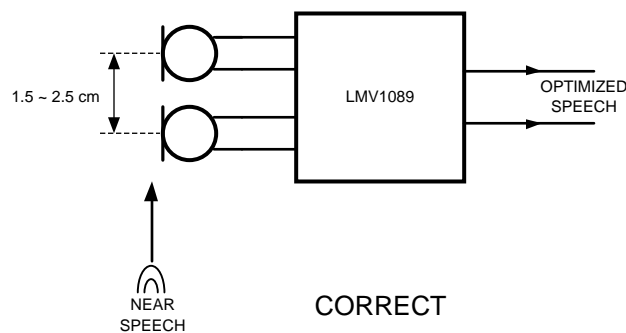
#### 11.4 Microphone Placement in the Application

Because the LMV1089 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 orientation from the sound source (see Figure 13). If the 'near speech' (desired sound source) is equidistant to the source like a broadside array (see Figure 12) the result will be a great deal of near field speech loss.



**Figure 12. Broadside Array (WRONG)**



**Figure 13. End fire Array (CORRECT)**

## 12 Automatic Calibrating of a System Containing the LMV1089

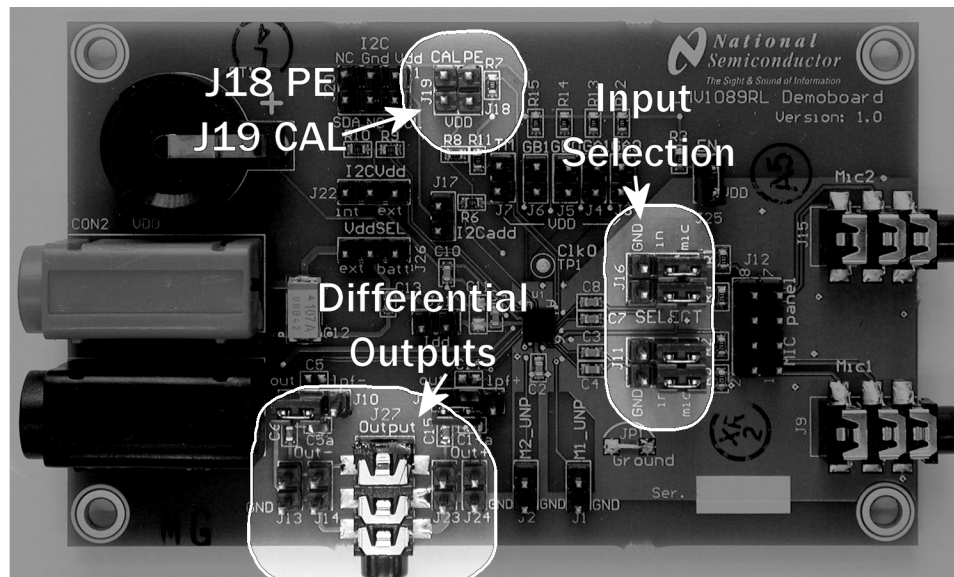
The full automatic calibration should only be required once, when the product containing the LMV1089 has completed manufacture, and prior to application packaging. The product containing the LMV1089 will be calibrated to the microphones, the microphone spacings, and the acoustical properties of the final manufactured product containing the LMV1089.

The compensation or calibration technology is achieved via memory stored coefficients when the Far Field Noise Suppression (FFNS) circuitry activates the calibration sequence. The purpose of the calibration sequence is to choose the optimized coefficients for the FFNS circuitry for the given microphones, spacing, and acoustical environment of the product containing the LMV1089.

A basic calibration can be performed with a single 1kHz tone (see section [Section 12.2](#)), however to take full advantage of this calibration feature a three tone calibration (see the section [Section 12.3](#)) is preferred.

The automatic calibration process can be initiated from either a digital interface CALIBRATE pin (CAL / J19 see [Figure 14](#)) or via the I<sup>2</sup>C interface.

The logic level at the PROGRAM ENABLE (PE) pin determines if the result of the calibration is volatile or permanent. To make the result of the calibration permanent (stored in the EEPROM) the PROGRAM ENABLE pin (PE / J18 see [Figure 14](#)) must be high during the automatic calibration process.



**Figure 14. Location of CAL pin and PE pin**

Both the CAL pin and the PE pin can be pulled up by connecting a jumper at the corresponding header J19 and J18. The Pin 2 of those header can be controlled by a applying a valid logical level to these pins ('Low' <  $0.4 \cdot I^2 CV_{DD}$  or 'High' >  $0.6 \cdot I^2 CV_{DD}$ ).

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**NOTE:** Pin 1 of the headers J18 and J19 are connected to  $V_{DD}$ .

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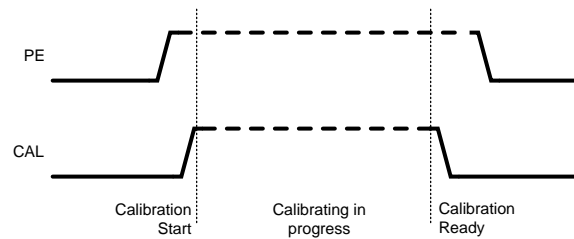
## 12.1 Automatic Calibration Setup

### 12.1.1 Automatic CALibration via CAL Pin

To initiate the automatic calibration via the CAL pin, the following procedure is required:

- From the initial condition where both PE and CAL are at 'low' level
- Bring PE to a 'high' level (enable EEprom write)
- Bring CAL to a 'high' level to start Calibration
- Apply Audio stimulus (single tone 1kHz or three tone sequence as described in [Section 12.2](#) and [Section 12.3](#))
- Hold CAL 'high' for at least 790ms
- Remove Audio stimulus
- Bring CAL to a 'low' level to stop Calibration
- Bring PE to a 'low' level (disable EEprom write)

A tone may be applied prior to the rising of CAL and PE. Signals applied to the microphone inputs before rising of CAL and PE are ignored by the calibration system.



**Figure 15. Automatic Calibration via CAL pin**

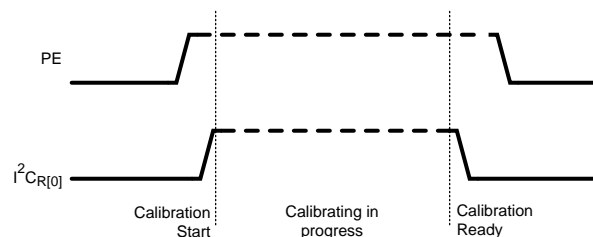
**NOTE:** When the I<sup>2</sup>C is operated, make sure that register 'R' (address 0x12) bit 0 is '0' before operating the CAL pin (default value for this bit). When this bit is set '1' the calibration engine of the LMV1089 is started and will remain active with a higher supply current than normal operation. The state of the calibration remains active until this bit is reset, '0'. With the bit set the 'low' to 'high' transfer of the CAL pin will be ignored.

### 12.1.2 Automatic Calibration via I<sup>2</sup>C Command

To initiate the automatic calibration via the I<sup>2</sup>C interface, the following procedure is required:

- From the initial condition where PE is 'low' level
- Bring PE to a 'high' level (enable EEPROM write)
- Write '1' into I<sup>2</sup>C register 'R' (address 0x12) bit 0 to start calibration
- Apply Audio stimulus (single tone 1kHz or three tone sequence as described in [Section 12.2](#) and [Section 12.3](#))
- Wait at least 790ms
- Remove Audio stimulus
- Write '0' into I<sup>2</sup>C to finish calibration
- Bring PE to a 'low' level (disable EEPROM write)

A tone may be applied prior to the rising of PE or setting the I<sup>2</sup>C calibration bit. Signals applied to the microphone inputs before rising of PE or setting the I<sup>2</sup>C calibration bit are ignored by the calibration system.



### 12.1.3 Performing the Automatic Calibration

Automatic calibration can be performed as 'one tone' or as 'three tone' calibration. Three tone calibration is preferred because the three tone calibration not only compensates for differences in the gain between the two microphones, but this function also corrects for a difference in frequency response between the two microphones and compensates for the acoustical effects of the enclosure.

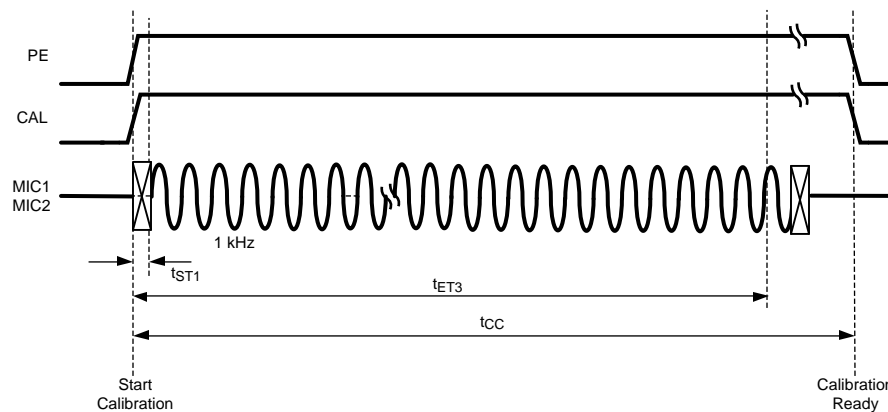
The one tone calibration only compensates for the gain difference between the two microphones at 1kHz and can lead to less far field noise reduction when compared to three tone calibration.

## 12.2 Performing a One -Tone Calibration

The easiest way to perform an automatic calibration with the LMV1089 uses one 1kHz tone. This tone can be a steady state tone or a 1kHz tone that is switched on and off using the timing from Figure 16.

To perform a one tone calibration, a 1kHz test tone is required right after the PE and CAL inputs are brought to a logic high level and that tone should be stable during the time as indicated in Figure 16. At the end of this sequence the calibration data is automatically stored in the internal EEPROM.

A tone may be applied prior to the rising of CAL start signal and PE. Signals applied to the microphone outside the limits shown in Figure 16 and Table 5 are ignored by the calibration system.



**Figure 16. One Tone Calibration Timing**

## 12.3 Performing a Three-Tone Calibration

In a system with two microphones in an enclosure there will always be a difference in the transfer function in both gain and frequency response. The LMV1089 has the capability to perform an automatic calibration function to minimize these differences. To perform this calibration, a test sequence of three tones is required right after the PE and CAL inputs are brought to a logic high level. At the end of this sequence the calibration data is automatically stored in the internal EEPROM.

The three tones have to be applied as follows:

- A first tone with a frequency of 1kHz
- A second tone with a frequency of 300Hz
- A third tone with a frequency of 3kHz

A tone may be applied prior to the rising of CAL start signal and PE. Signals applied to the microphone outside the limits shown in Figure 17 and Table 5 are ignored by the calibration system.

Between each tone pair there is a small time, indicated by a cross, to change the frequency. During that time the input tone is ignored by the calibration system.

The total calibration sequence requires less than 790ms.

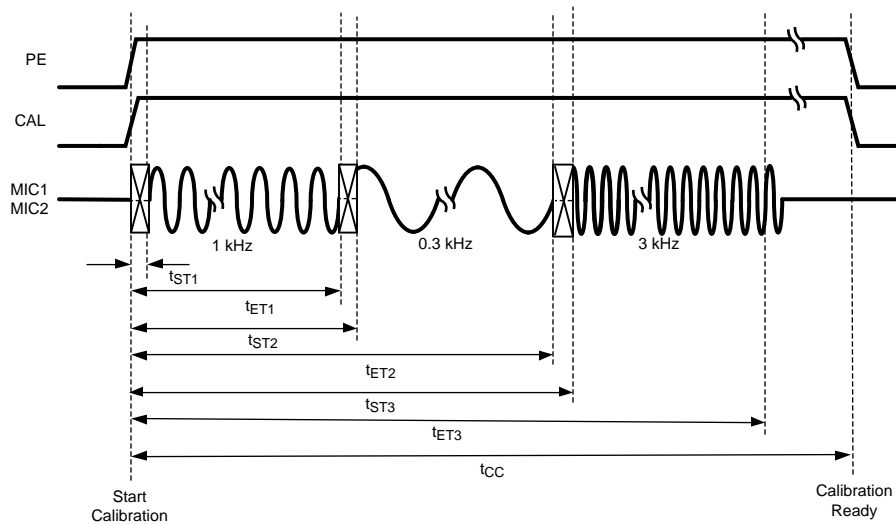


Figure 17. Calibration Timing

Table 5. Automatic Calibration Timing Parameters<sup>(1)</sup>

Symbol	Parameter	Limits		Units
		Min	Max	
$t_{ST1}$	Calibration Start Tone 1		10	ms
$t_{ET1}$	Calibration End Tone 1	200		ms
$t_{ST2}$	Calibration Start Tone 2		210	ms
$t_{ET2}$	Calibration End Tone 2	400		ms
$t_{ST3}$	Calibration Start Tone 3		410	ms
$t_{ET3}$	Calibration End Tone 3	600		ms
$t_{CC}$	Calibration Complete	790		ms

<sup>(1)</sup> Data guaranteed by design

## 12.4 Creating the Three-Tone Sequence with an AWG

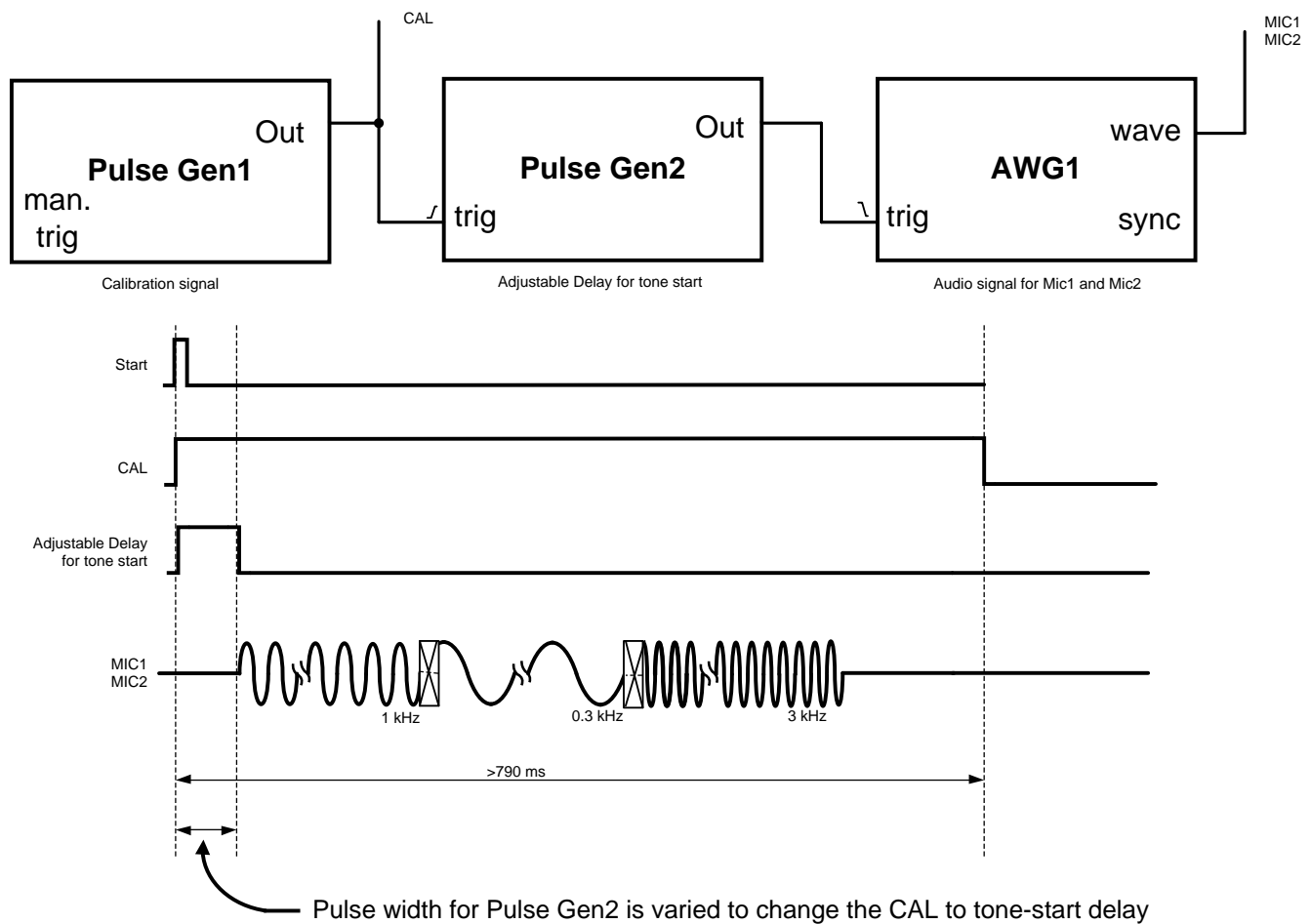
It is possible to create the three tone test sequence as described in Section 12.3 with an Arbitrary Waveform Generator (AWG). For this the sequence should be programmed in the memory of the AWG. The sequence should consist of:

- 201 cycles 1 kHz sine wave (duration 201 ms)
- 67 cycles 300 kHz sine wave (duration 201 ms)
- 603 cycles 3 kHz sine wave (duration 201 ms)
- A few milliseconds silence (optional)

The level of these tones must all be equal and excite the output of the generator sufficient (50 — 100% relative amplitude) so the noise of the DAC in the generator will not have a negative contribution to the calibration process. The period time for this sequence will be 603ms + the length of the additional programmed 'few milliseconds silence'.

A signal applied to the microphones before the CAL signal goes 'high' is ignored by the automatic calibration system.

A possible setup for generation of the three tone test signal is shown in the drawing Figure 18.



**Figure 18. Example of Three Tone Signal Generation**

## 12.5 Automatic Calibration Setup

A calibration test setup consists of a test room (acoustical box) with a loudspeaker (acoustical source) driven with the test tone (e.g. the sequence from Section 12.4). The test setup is shown in Figure 19. The distances between the source and microphone 1 and microphone 2 must be equal and the sound must travel without any obstacle from source to both microphones. The sound will travel with the limited speed of 300m/s from the loudspeaker source to the microphones. When creating the calibration signals this time should not be ignored, 30cm distance will cause 1ms delay.

For an optimum automatic calibration the output level of the microphones and Pre-Amp gain must be set so that the resulting signal at the output of the Pre-Amp is  $100\text{mV}_{pp} \pm 6\text{dB}$ .



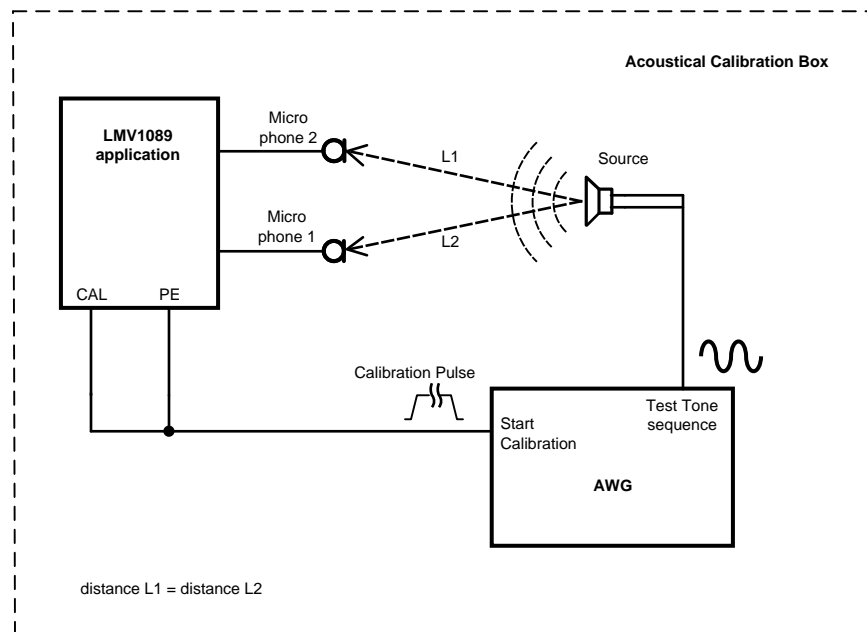


Figure 19. Automatic Calibration Setup

### 13 Performing a Manual Calibration

The LMV1089 provides the option to program the calibration parameters directly into the LMV1089 registers via the I<sup>2</sup>C interface, instead of performing the above described Automatic Calibration on each apparatus. This is very convenient for applications where the microphones have good matching and where the compensation for acoustical effect on the frequency and gain of the application are known. This manual calibration is performed by writing the appropriate data to the calibration registers of the LMV1089 as described in the application section of the LMV1089 data sheet. This can be much more time efficient in an application production environment.

### 14 PCB Layout Guidelines

This section provides general practical guidelines for PCB layouts that use various power and ground traces. Designers should note that these are only "rule-of-thumb" recommendations and the actual results are predicated on the final layout.

#### 14.1 Differential Signals

Keep both signals coupled by routing them closely together and keeping them of equal length. Keep all impedances in both traces of the signal equal.

#### 14.2 Power and Ground

Connect all ground pins together under the part forming a star point. Keep the current for the de-coupling capacitor of the REF pin (D6) and the accompanying ground pin (C5) separated from the other currents. Keep the location of the supply de-coupling capacitor close to V<sub>DD</sub> pin (F3) and ground (D3). Avoid that the current for the de-coupling capacitors flow though the ground from pin B4.

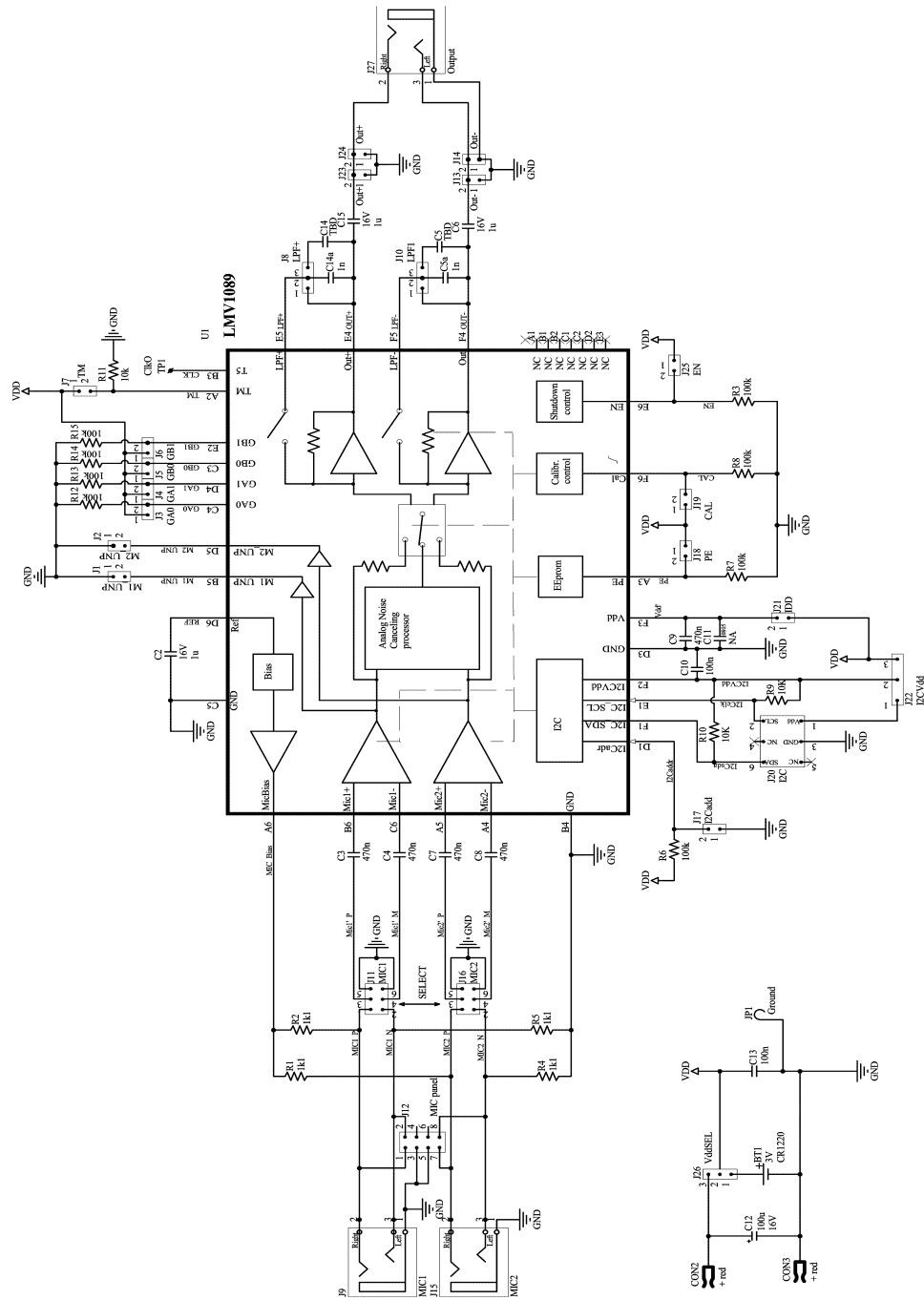
### 15 Description of Headers and Connectors of the LMV1089 Demo Board

The LMV1089 demo board provides many headers and connectors for connecting test equipment and controlling the settings of the part. The function that is controlled by the jumpers on the LMV1089 demo board is also indicated on the PCB in silk screen.

**Table 6. Connector and Header Functions for the LMV1089RL Demo Board**

Designator	Function or Use	Comments
J1	(M1_UNP) Microphone 1 Unprocessed signal output	
J2	(M2_UNP) Microphone 2 Unprocessed signal output	
J3, J4	(GA0, GA1) Pre-Amplifier default gain setting	See <a href="#">Table 1</a>
J6, J6	(GB0, GB1) Post-Amplifier default gain setting	See <a href="#">Table 2</a>
J7	(TM) Auxiliary control	
J8, J10	(LPF+, LPF-) Low pass filter selection	Pin 1+2 to connect an external LPF capacitor. Pin 2+3 select the on board LPF capacitor C5, C14 (a minimum of 1nF is always mounted on the board)
J9	(MIC1) Microphone input jack	Stereo 3.5 mm jack with ground connection. tip = Mic+ 1st ring = Mic-
J11	(SELECT) Connection for input of electrical test signals at pin 4 and 5	Pin 3+4 differential input with ground at Pin 5+6
	Activation of Microphone1 input connectors J12 / J9	Header between Pin 1+3 and 2+4
J12	MIC panel / For connecting a Microphone panel with 2 microphones	Mic1 between Pin 1+2 Mic2 between Pin 7+8 Ground is at Pin 3+5
J13, J14	(OUT-) Output signal of the processed audio	Differential output (-)
		1 = GND 2 = OUT
J15	(MIC2) Microphone input jack	Stereo 3.5 mm jack with ground connection. tip = Mic+ 1st ring = Mic-
J16	(SELECT) Connection for input of electrical test signals at pin 4 and 5	Pin 3+4 differential input with ground at Pin 5+6
	Activation of Microphone2 input connectors J12 / J9	Header between Pin 1+3 and 2+4
J17	(I2Cadd) I <sup>2</sup> C address selection	Open: (0CE Hex) Closed (0CC Hex)
J18	(PE) Enable Programming of the EEPROM	Closed = Program Enable
J19	(CAL) Start calibration of the two microphones	Closed = Program Enable
J20	(I2C) I2C interface connector	
J21	(I <sub>DD</sub> ) Supply current measurement	Normally shorted by jumper, replace jumper by DMM for supply current measurement
J22	(I <sup>2</sup> CV <sub>DD</sub> ) Selection of I <sup>2</sup> CV <sub>DD</sub>	
J23, J24	(OUT+) Output signal of the processed audio	Differential output (+)
		1 = GND 2 = OUT
J25	(EN) Enable Chip	Closed = Chip Enable
J26	(V <sub>DD</sub> SEL)	Selection of V <sub>DD</sub> source
		2-3 = Ext V <sub>DD</sub> 1-2 = Battery
CON2	(V <sub>DD</sub> ) Ext V <sub>DD</sub> Plus	Power supply connection
CON3	(GND) Ext V <sub>DD</sub> Minus	
JP1	Ground connection for probes	
TP1	(TP5) Test signal	Not for Customer Use
BT1	3 V Lithium battery holder	CR1220 size

16 Schematic for the LMV1089RL



17 Demo Board Layout for the LMV1089RL

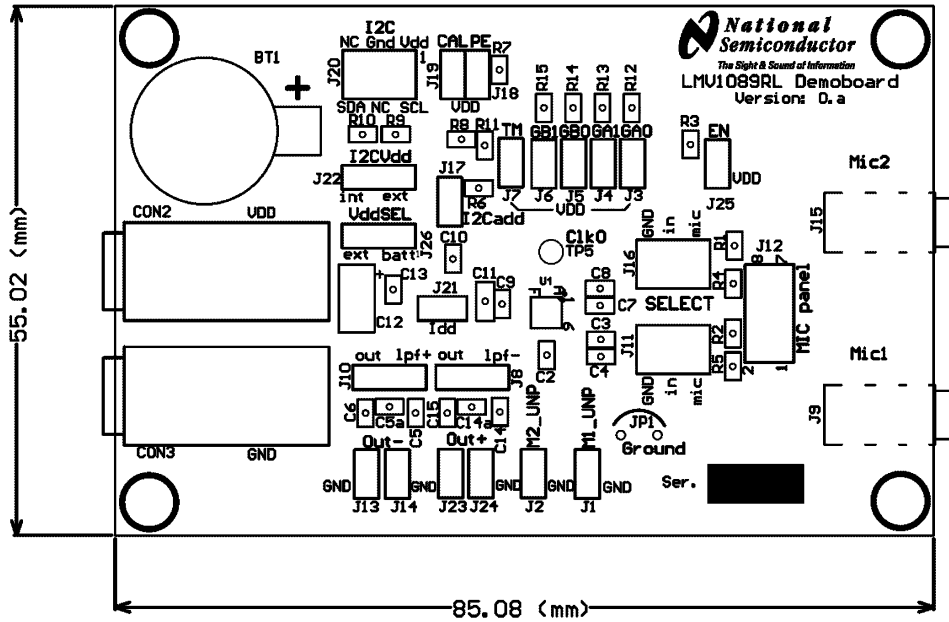


Figure 20. Silk Screen

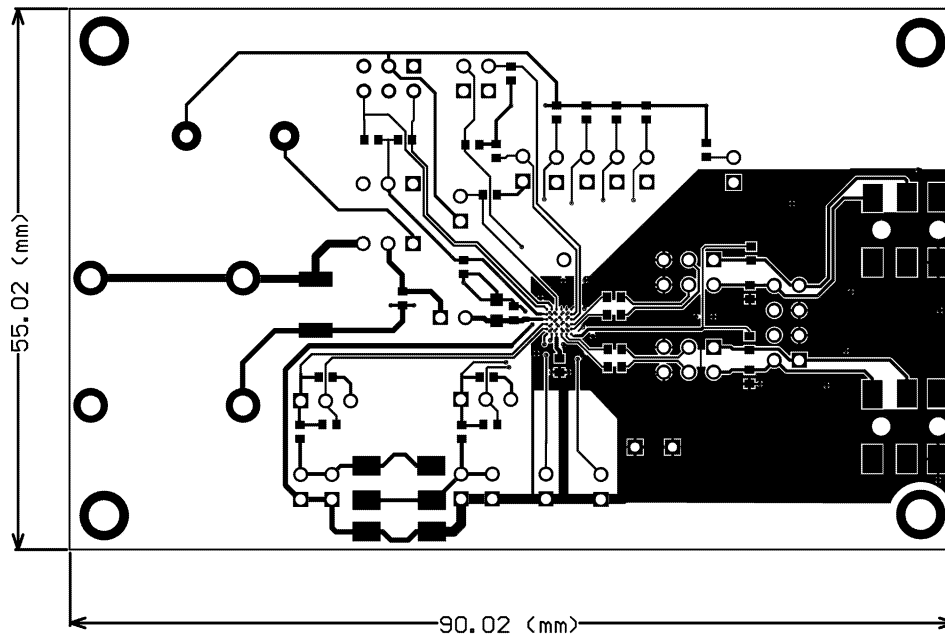
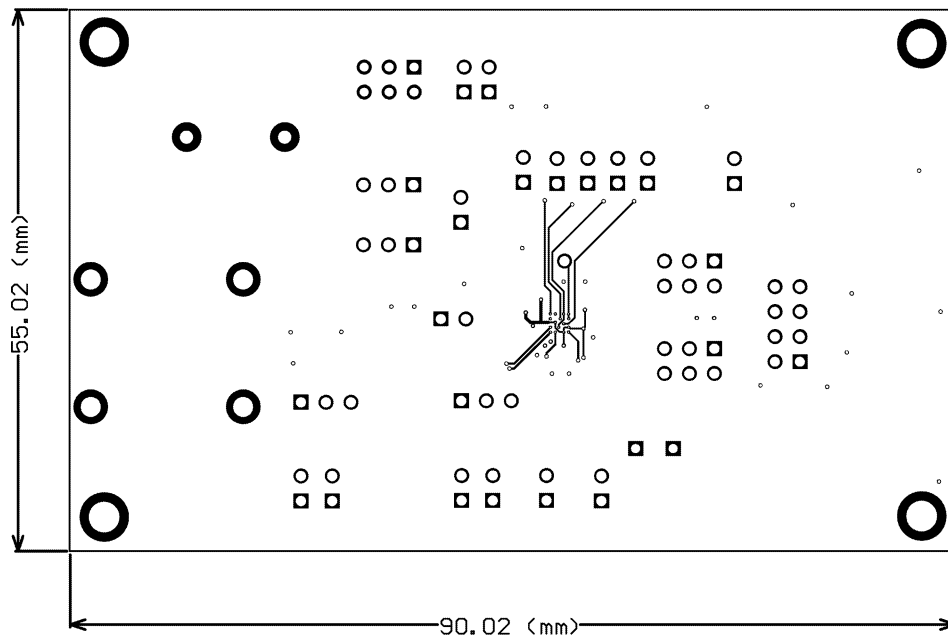
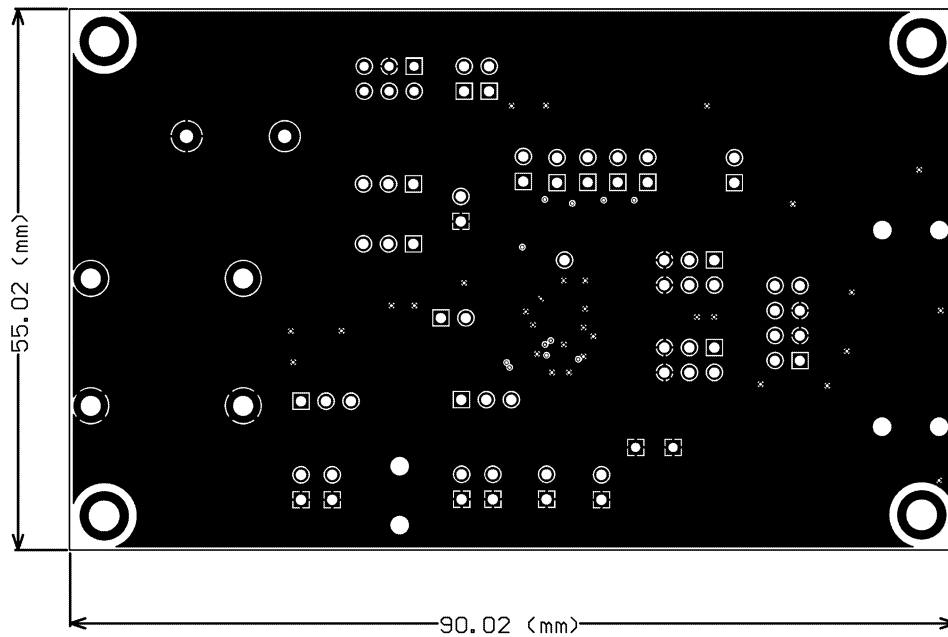


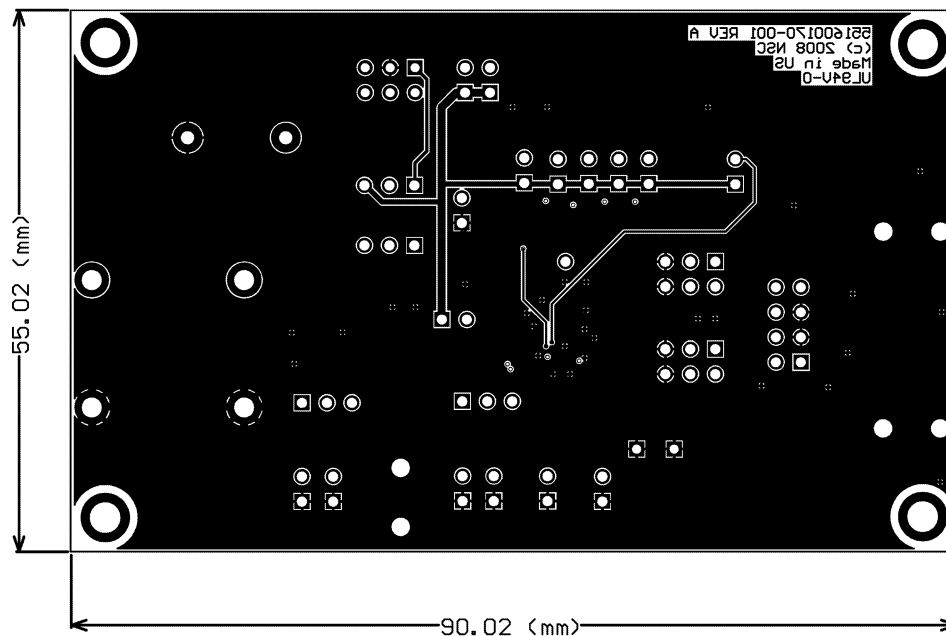
Figure 21. Top Layer



**Figure 22. Top Inner Layer**



**Figure 23. Bottom Inner Layer**


**Figure 24. Bottom Layer**

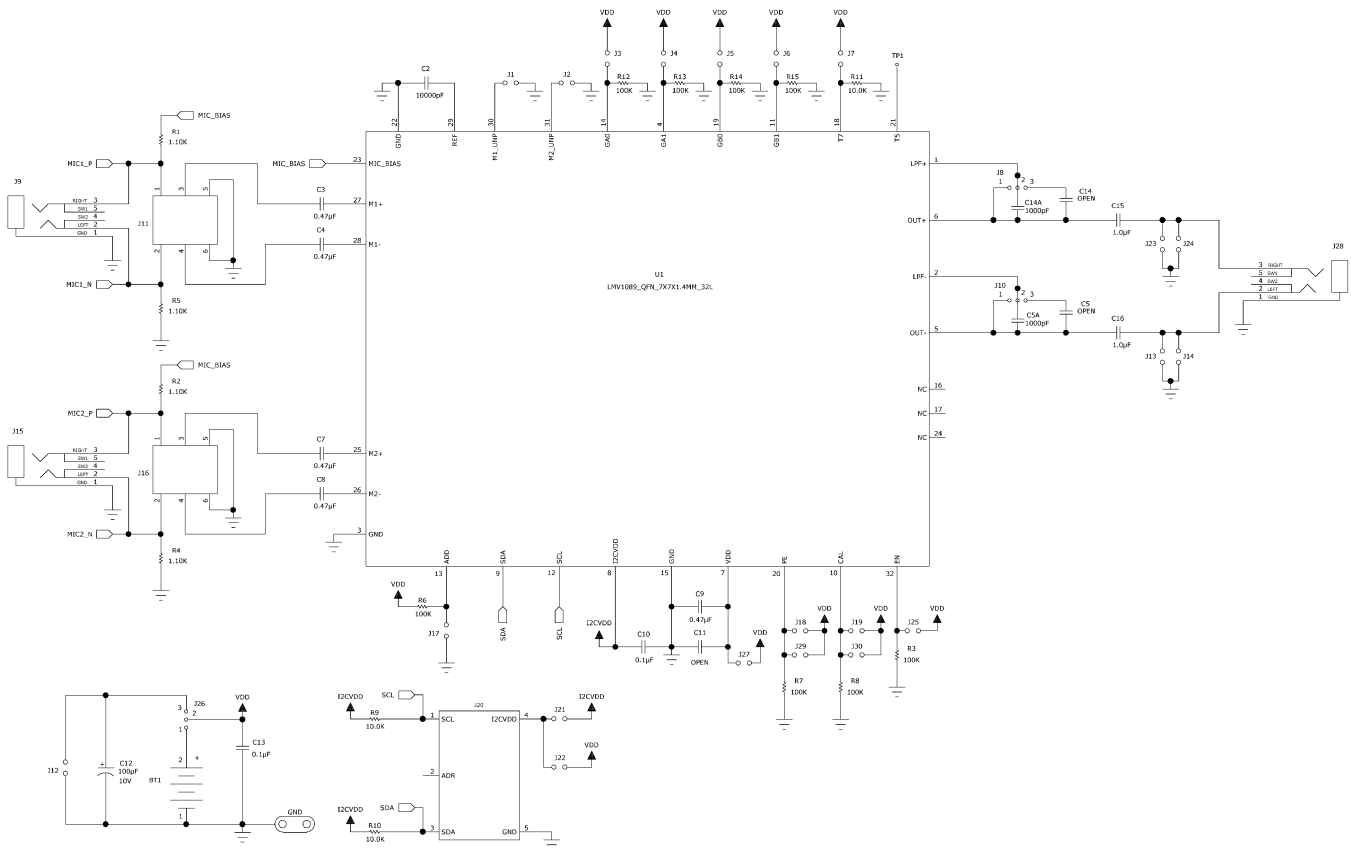
## 18 Bill of Materials for the LMV1089RL Demo Board

Designator	Component	Value	Tolerance	Rating	Package Type
BT1	Bat holder CR1220	3V			
C2, C6, C15	Capacitor Ceramic	1u	10%	16V	0603
C3, C4, C7, C8, C9	Capacitor Ceramic	470n	10%	16V	0603
C5, C14	Capacitor Ceramic	TBD		16V	0603
C5a, C14a	Capacitor Ceramic	1n	10%	50V	0603
C10, C13	Capacitor Ceramic	100n	10%	16V	0603
C11	Capacitor Ceramic	NA		16V	0603
C12	Capacitor Tantalum	100u		10V	Case C
R1, R2, R4, R5	Resistor	1k1	0.05		0603
R3, R6, R7, R8, R12, R13, R14, R15	Resistor	100k	0.05		0603
R9, R10, R11	Resistor	10K	0.05		0603
CON2, CON3	Banana plug				
J1, J2, J3, J4, J5, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, J16, J17, J18, J19, J20, J21, J22, J23, J24, J25	Header 0.1 Pitch	1x2 pin			
J10, J22, J26	Header 0.1 Pitch	1x3 pin			
J11, J16, J20	Header 0.1 Pitch	2x3 pin			
J12	Header 0.1 Pitch	2x4 pin			
J9, J15	Headphone jack 3.5mm				
U1	LMV1089				DSBGA / LQFP
JP1	Ground hook	jumper			5mm high

**Table 7. Connector and Header Functions for the LMV1089VY Demo Board**

Header/ Connector	Indication/Function	Comments
J1	(M1_UNP) Unprocessed audio output for microphone channel 1	
J2	(M2_UNP) Unprocessed audio output for microphone channel 2	
J3	(GA0) Default input gain setting bit 0	See Table 2 Default Pre Amplifier gain
J4	(GA1) Default input gain setting bit 1	
J5	(GB0) Default output gain setting bit 0	See Table 3 Default Post Amplifier gain
J6	(GB1) Default output gain setting bit 1	
J7	(TM) Test Mode	Close to enter Test Mode
J8, J10	(LPF) Low pass filter selection	Pin 1+2 to connect an external LPF capacitor. Pin 2+3 select the on board LPF capacitor C5, C14 (a minimum of 1nF is always mounted on the board)
J28	(MIC1) Microphone input jack	Stereo 3.5 mm jack with ground connection. tip = Mic+ 1st ring = Mic-
J11	(SELECT) Connection for input of electrical test signals at pin 4 and 5	Pin 3+4 differential input with ground at Pin 5+6
	Activation of Microphone input connector J9	Header between Pin 1+3 and 2+4
J12	Power supply Connection	Connect power supply here if not powering from USB. Be sure to remove shorts from J22 & J21.
J13+J14	(OUT-) Output signal of the processed audio	
J15	(MIC2) Microphone input jack	Stereo 3.5 mm jack with ground connection. tip =Mic+ 1st ring = Mic-
J16	(SELECT) Connection for input of electrical test signals at pin 4 and 5 or	Pin 3+4 differential input with ground at Pin 5+6
	activation of Microphone input connector J15	Header between Pin 1+3 and 2+4
J17	(I <sup>2</sup> Cadd) I <sup>2</sup> C address selection	Open: (0CE Hex) Closed (0CC Hex)
J18	(PE) Enable Programming of the EEPROM	Closed = Program Enable
J19	(CAL) Start calibration of the two microphones	Close = start Calibration
J20	(I <sup>2</sup> C) I <sup>2</sup> C interface connector	
J23+J24	(OUT+) Output signal of the processed audio	
J27	(I <sub>DD</sub> ) Supply current measurement	Normally shorted by jumper, replace jumper by DMM for supply current measurement
J21/J22	(I <sup>2</sup> CV <sub>DD</sub> ) Selection of I <sup>2</sup> CV <sub>DD</sub>	Short J21 & J22 to power demo board from I <sup>2</sup> C_USB board
J25	(EN)	Normally shorted to enable
J26	(V <sub>DD</sub> SEL) Selection of the supply source	Header Pin 1+2 = Battery enabled, Header Pin 2+3 =
J27	(Output) Processed output signal	
BT1	3V Lithium battery holder	

### 19 Schematic for the LMV1089VY



### 20 Demo Board Layout for the LMV1089VY

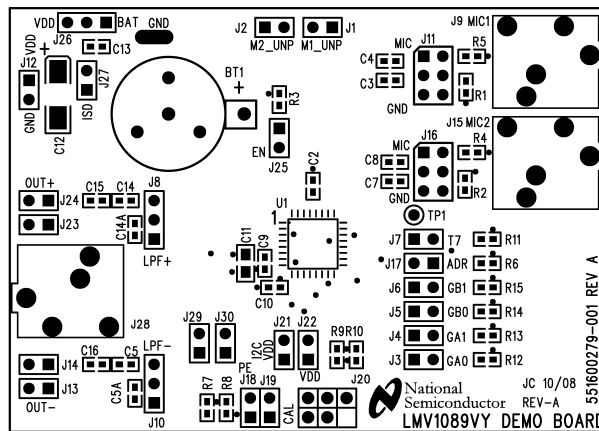


Figure 25. Top Silkscreen



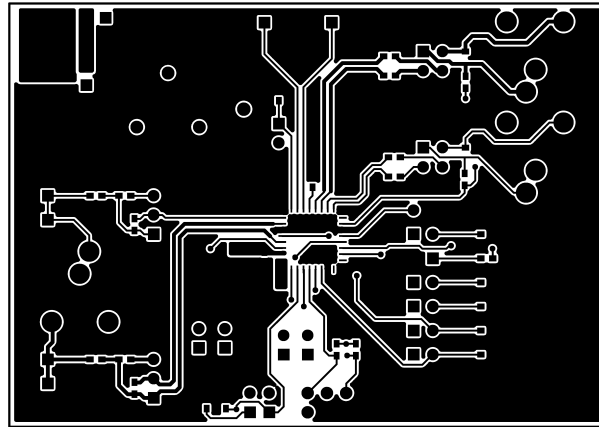


Figure 26. Top Layer

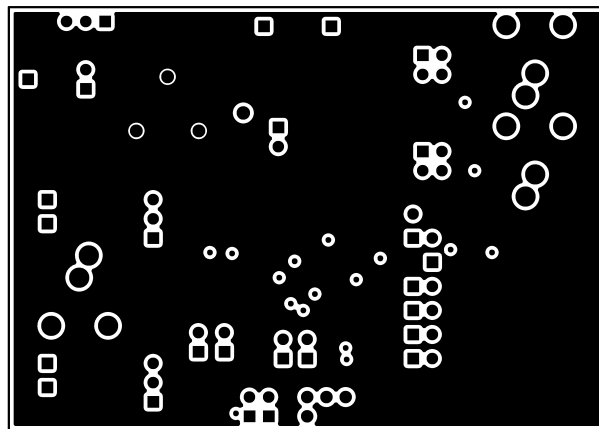


Figure 27. Layer 2

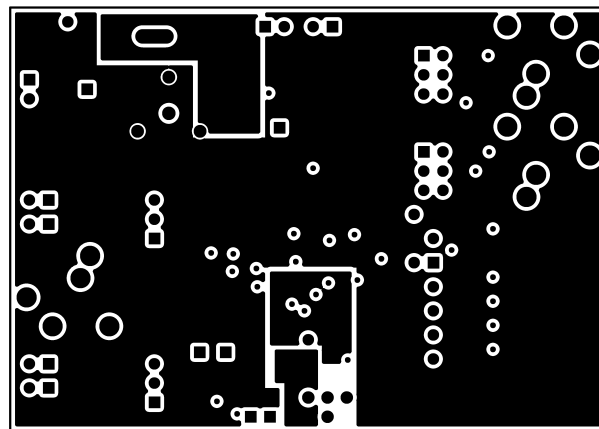
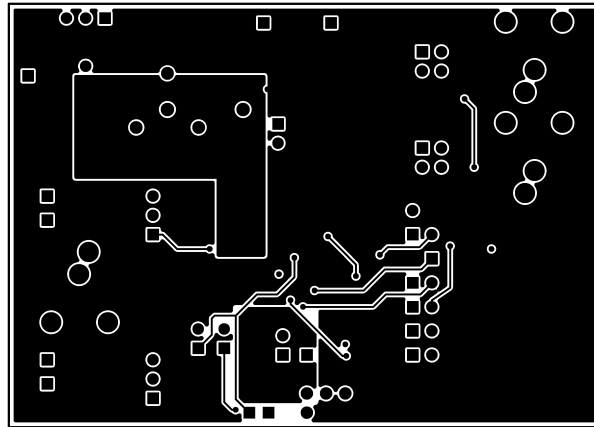


Figure 28. Layer 3


**Figure 29. Bottom Layer**
**21 Bill of Materials for the LMV1089VY Demo Board**

Designator	Part Number	Case Size	Comp Type	Value
	551600279-001		LMV1089VY Eval Board PCB, RevA	
U1	LMV1089VY			
C6, C15,16	C0603C105K4PAC	603	CAPACITOR, 1UF, 16V, X5R	1 $\mu$ F
C2	C0603C103K5RACTU	603	CAP 10000PF 50V CERAMIC X7R 0603	10nF
C3, C4, C7, C8, C9	C0603C474K4RAC	603	CAPACITOR, 0603, 470NF, 16V, X7R	470nF
C5, C14	No Load	603	Capacitor Ceramic	No Load
C5a, C14a	06031C102KAT2A	603	0603, 1NF, 100V, X7R	1nF
C10, C13	0603YC104KAT2A	603	CAPACITOR, 0603, 100000PF, 16V, X7R	100nF
C11	No Load	603	Capacitor Ceramic	No Load
C12	TAJC107K010R	Case C	CAPACITOR, CASE C, 100UF, 10V	100 $\mu$ F
R1, R2, R4, R5	ERJ-3EKF1101V	603	1.1K, 1%, 0.1W, 50V, 0603	1.1K
R3, R6, R7, R8, R12, R13, R14, R15	ERJ-3EKF1003V	603	100K, 5%, 0.1W, 50V, 0603, 200ppm	100K
R9, R10, R11	ERJ-3EKF1002V	603	10K, 5%, 0.1W, 50V, 0603, 200ppm	10K
J1, J2, J3, J4, J5, J6, J7, J12, J13, J14, J17, J18, J19, J21, J22, J23, J24, J25, J27, J29, J30	9-1469-146285-0-02285-0-02		1X2 Header 0.1 Pitch (90mil/2.29mm tail)	
J8, J10, J22, J26	9-146285-0-03		1X3 Header 0.1 Pitch (90mil/2.29mm tail)	
J11, J16, J20	9-146261-0-03		2X3 Header 0.1 Pitch	
TP1	No Load			
J9, J15, J28	35RAPC4BH3			
BT1	500		Bat holder CR1220, 1 cell, 12mm	

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Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
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