

LMV1089 Noise Suppression Microphone Amplifier Demo Board User's Guide

National Semiconductor
Application Note 1832
Nisha Patel
June 16, 2009



Contents

The LMV1089 evaluation kits contain the following:

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

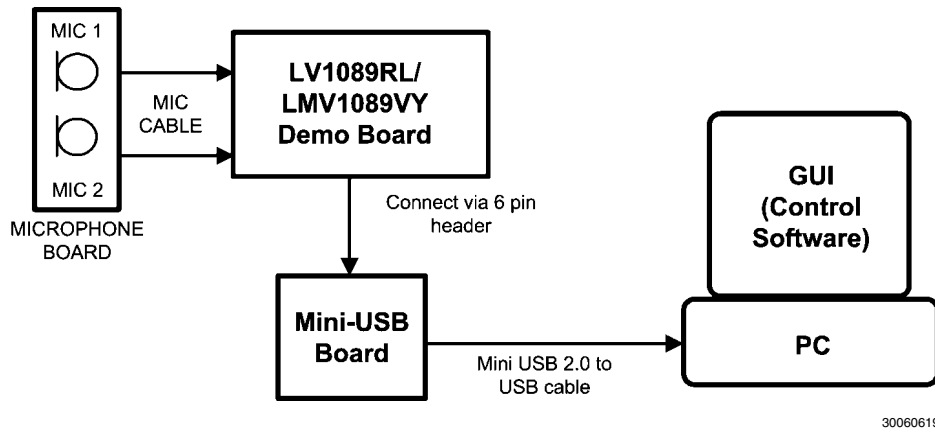
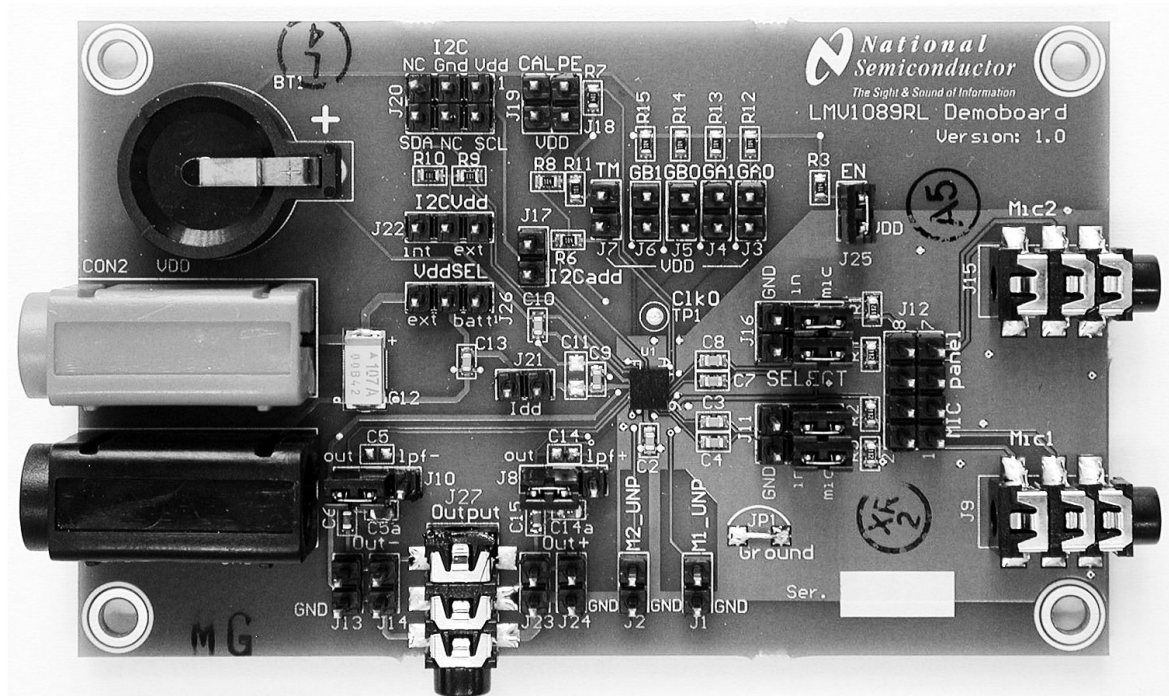


FIGURE 1. Basic Evaluation System

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 I²C interface for controlling the settings of the LMV1089. The automatic calibration mechanism integrated in the LMV1089 can be operated by I²C control or by control of the CAL pin.



30060601

FIGURE 2. The LMV1089RL Demo Board

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 I²C 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 ± 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.

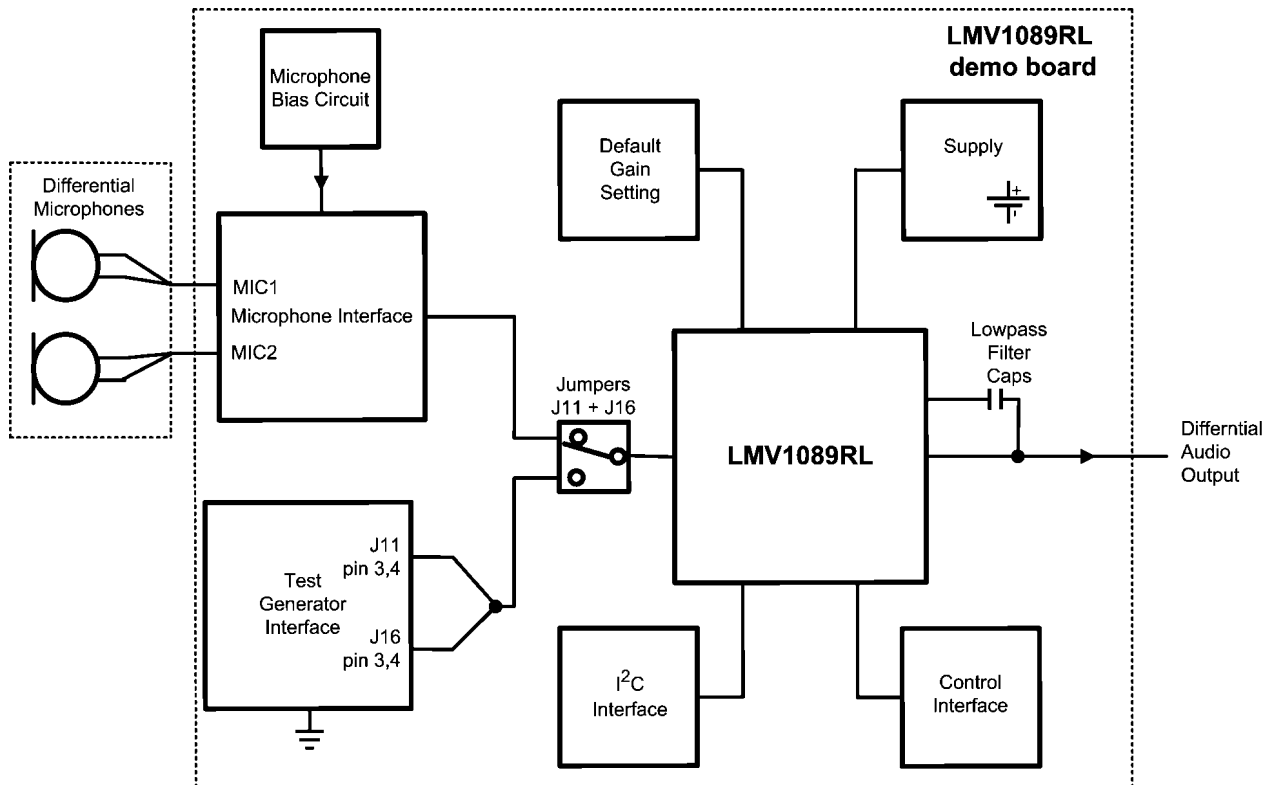
Operating Conditions

- Temperature Range $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$
- Power Supply Voltage $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$
- I²C supply voltage $1.7\text{V} \leq I^2C V_{DD} \leq 5.5\text{V}$

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 I²C 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.



30060602

FIGURE 3. The LMV1089RL Demo Board Block Diagram

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.

Power Supply of the LMV1089RL Demoboard

The LMV1089RL demoboard 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.

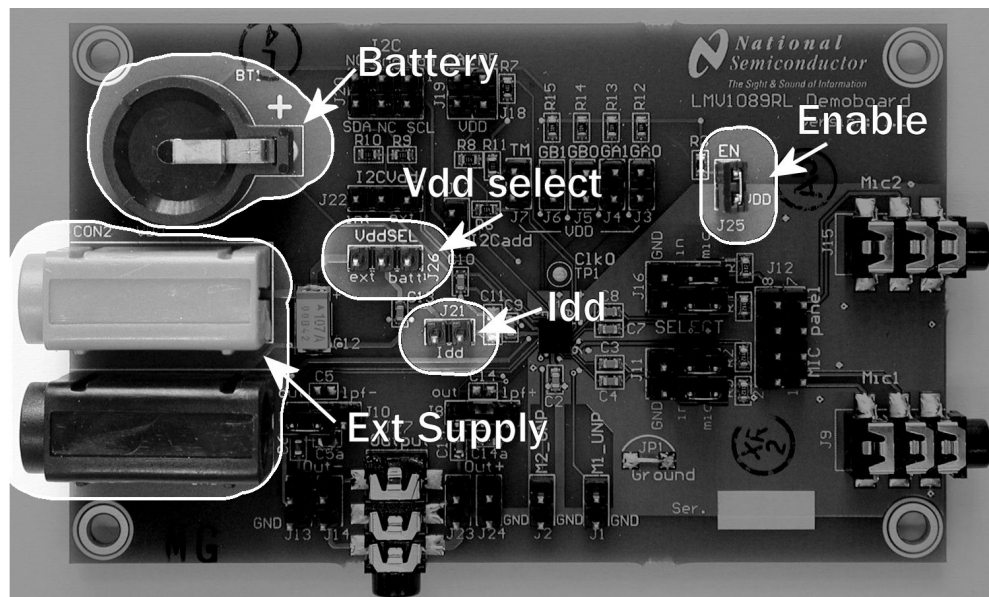
When using an external supply, the LMV1089 demoboard will receive its power supply via the banana connectors CON2 and CON3. In this mode, the jumper on J26 (see Figure 4) is placed between pin 2 and pin 3.

For a limited time, the demoboard 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^2C interface header J20 (see Figure 6). Using this configuration and a USB – I^2C converter board eliminates the need for a separate power supply for evaluation. Supplying the demoboard this way is possible by connecting pins 1 and 3 of the $I^2C V_{DD}$ supply selection header J22 (see Figure 6). This is the default configuration for the LMV1089RL demoboard.

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

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



30060604

FIGURE 4. Power Supply Connectors and Headers

Measuring the LMV1089 Supply Current (I_{DD})

The supply current (I_{DD}) of the LMV1089 mounted on the demoboard 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 $I^2C V_{DD}$ 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).

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

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).

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 (Note 2). In most applications the gain will be set via the I²C interface.

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 I²C 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 I²C interface will remain valid until the part is powered down.

TABLE 1. Default pre amplifier gain

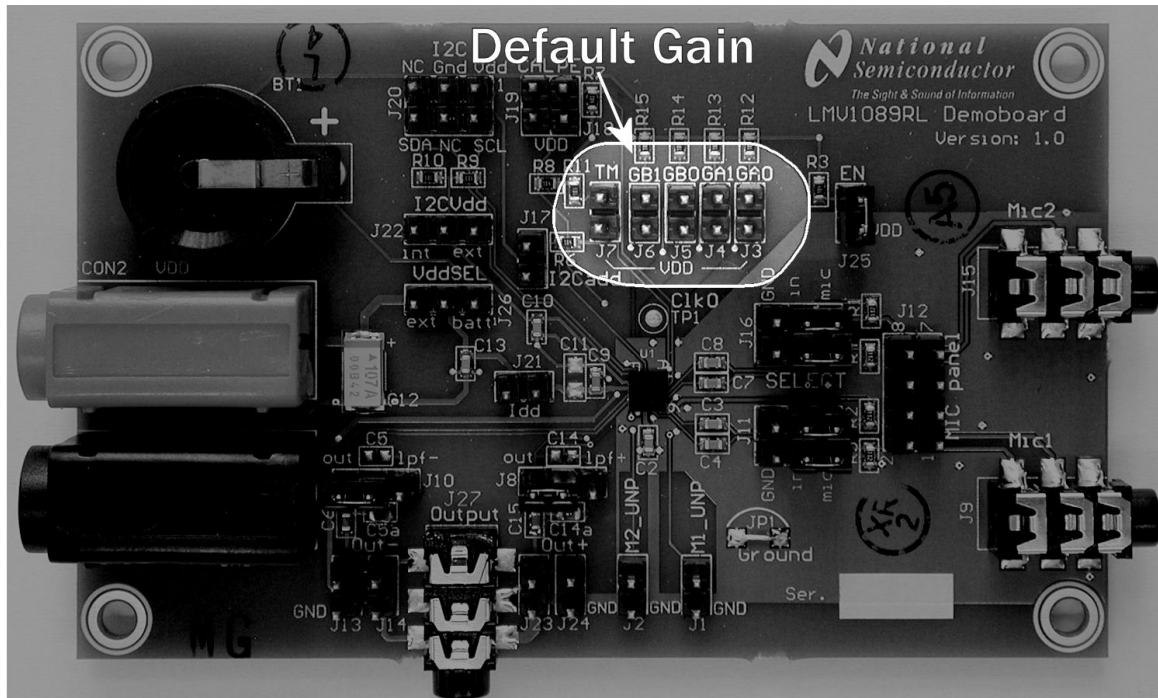
GA1	GA0	Gain
0	0	12dB
0	1	20dB (Note 1)
1	0	28dB
1	1	36dB

TABLE 2. Default post amplifier gain

GB1	GB0	Gain
0	0	6dB (Note 1)
0	1	9dB
1	0	12dB
1	1	15dB

Note 1: Default value used for performance measurements.

Note 2: See the application section of LMV1089 data sheet for a more detailed explanation of the gain budget.



30060603

FIGURE 5. Headers for Default Gain

The On Board I²C Compatible Interface

The I²C Compatible Interface that is available on the LMV1089 demoboard 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. I²C connector

PIN	Function
1	I ² CV _{DD}
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 I²CV_{DD} mounted on the PCB.

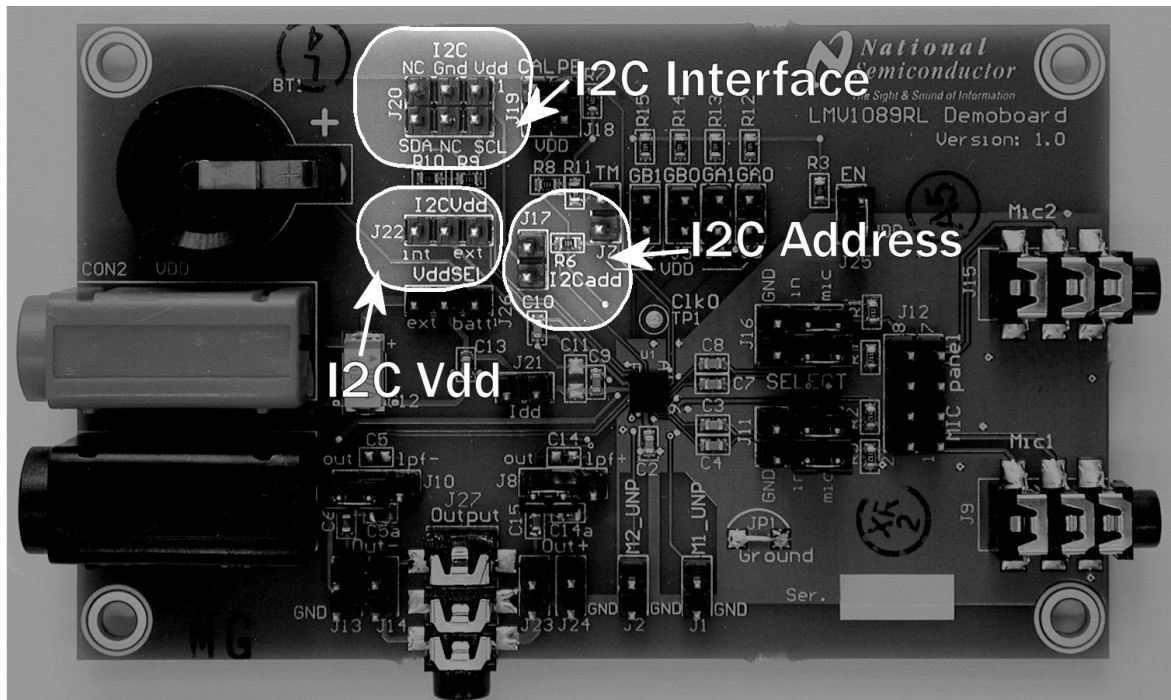
Controlling I²CV_{DD}

The supply voltage for the I²C 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 I²C interface levels will be related to supply voltage of the LMV1089.

With the jumper between pin 1 and pin 2 the I²C interface levels will be related to the voltage supplied via pin 1 at the I²C interface connector J20.

Note: To avoid possible damage to the LMV1089 part, the I²CV_{DD} voltage should not exceed the V_{DD} voltage.



30060615

FIGURE 6. I²C Compatible Interface

The I²C 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. I²C Address

J17	D7	D6	D5	D4	D3	D4	D1	D0
open	1	1	0	0	1	1	0	W/R
short	1	1	0	0	1	1	1	W/R

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 I²C Interface. This software is operated via the graphical user interface as shown in *Figure 7*. This software provides two groups of functions.

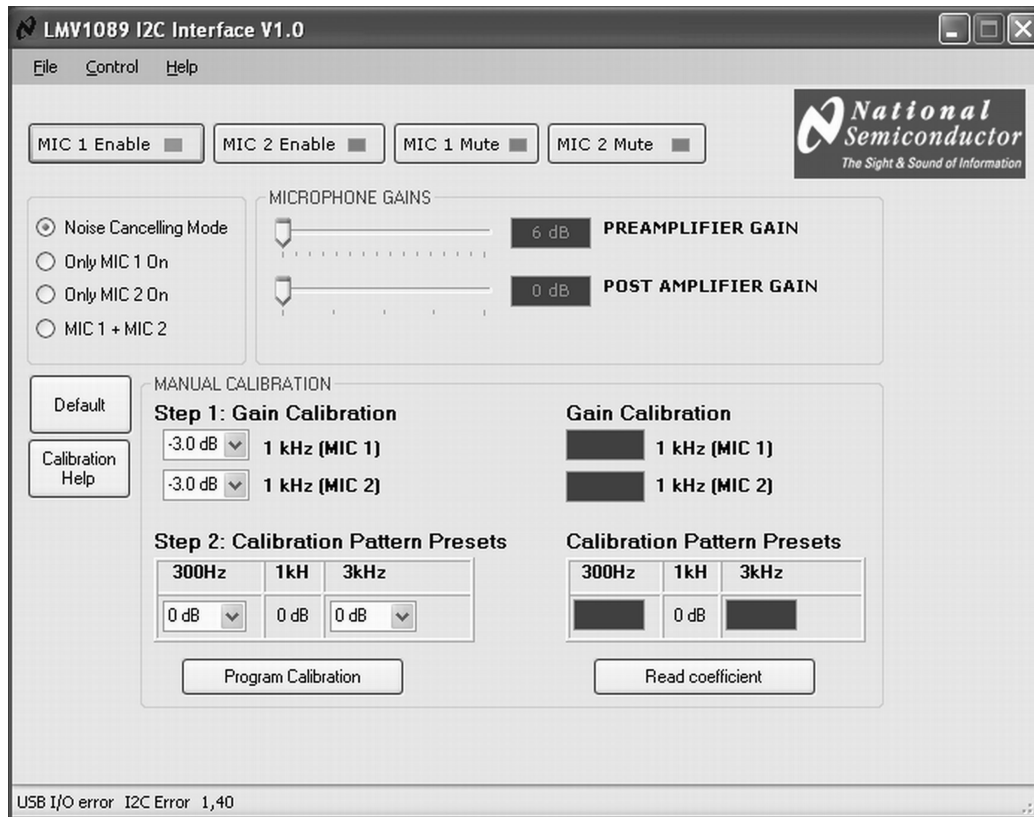
In the top half of the screen there are functions like:

- 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 (Note 3):

- Gain difference compensation (Gain Calibration)
- Frequency response difference compensation (Calibration Pattern Presets)
- Button to write the manual calibration date (Program Calibration)
- Button to read the calibration date (Read coefficients)

Note 3: Using Manual Calibration is described in more detail in the application section of the LMV1089 data sheet.



30060612

FIGURE 7. Control Demo Software GUI

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 I²C interface by operating the **Default** setting button (see Figure 7) in the graphical user interface of the program that is available from National.

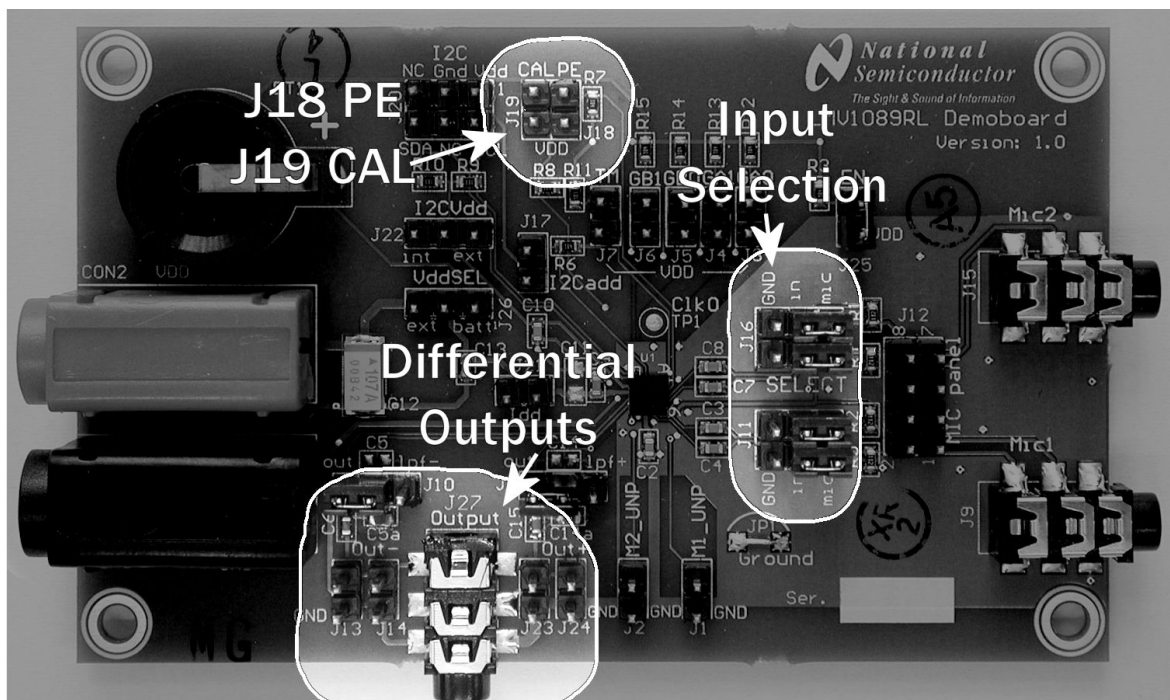
Connecting to an Audio Tester

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).



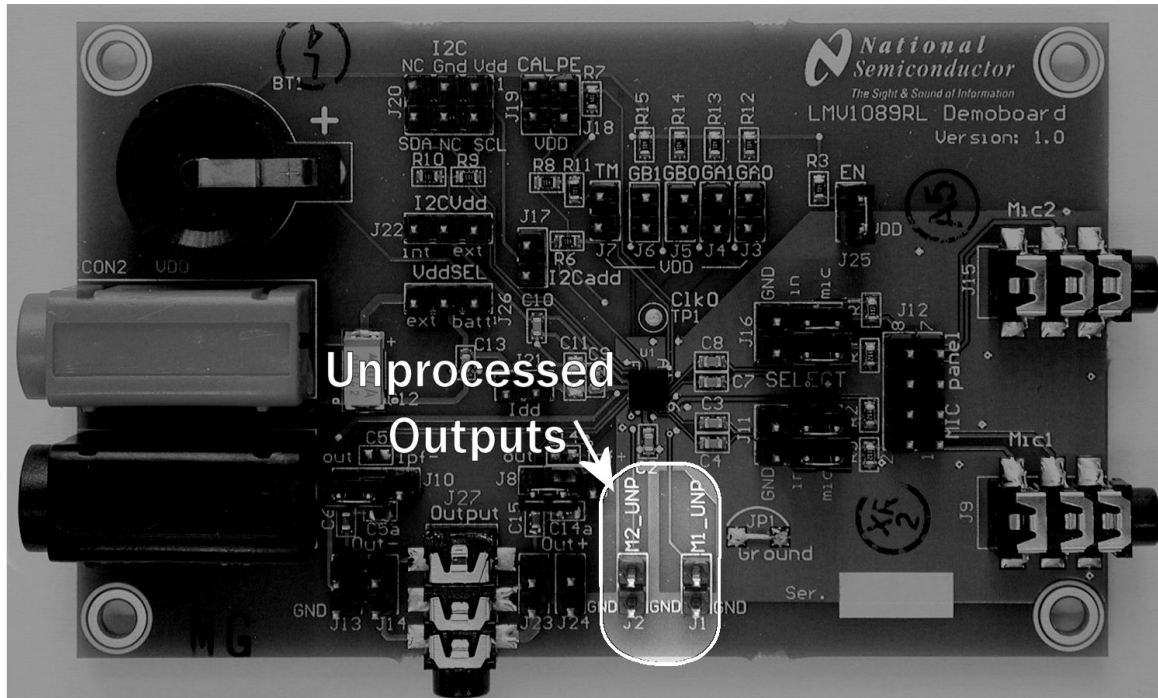
30060606

FIGURE 8. Audio tester connections

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*).



30060607

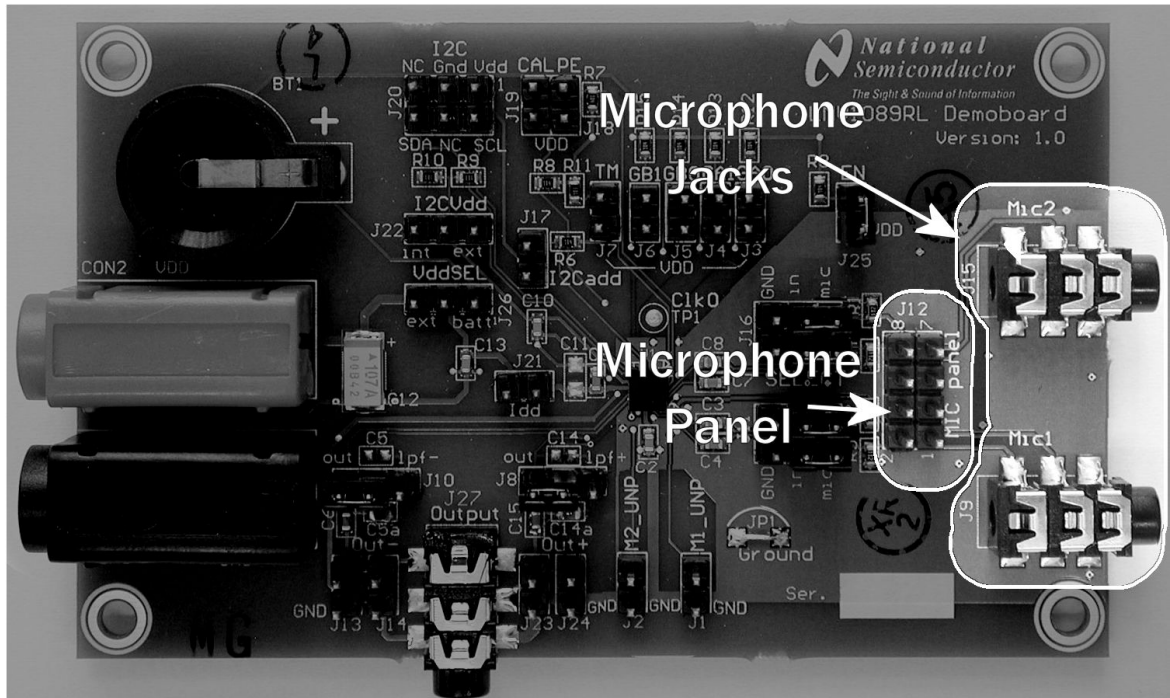
FIGURE 9. Unprocessed Audio Outputs

Connecting Microphones to the LMV1089 Demoboard

The demoboard 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 demoboard 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 $2V_{DC}$ power supply via resistors R1, R2, R4 and R5 mounted on the LMV1089 demoboard.

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.

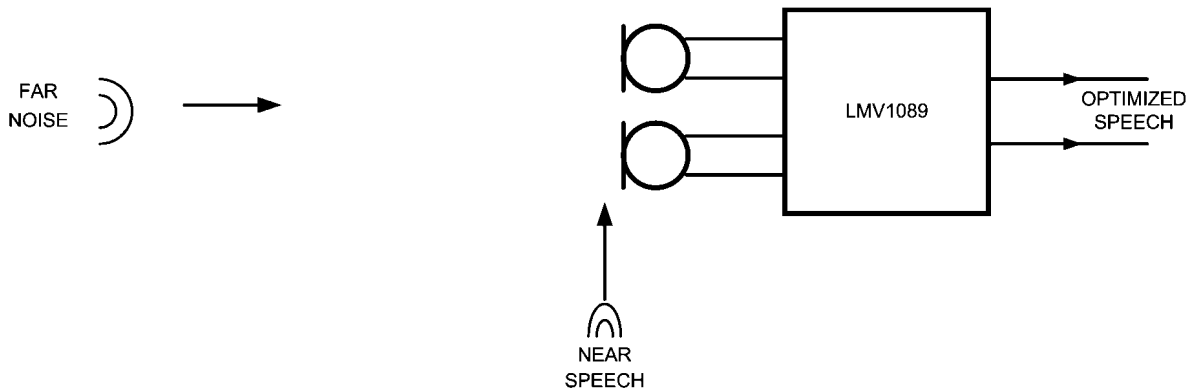


30060608

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*.



30060609

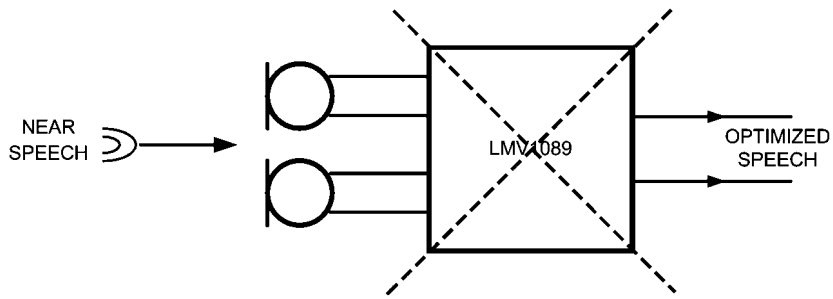
FIGURE 11. Orientation of Microphones and Sound Sources

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

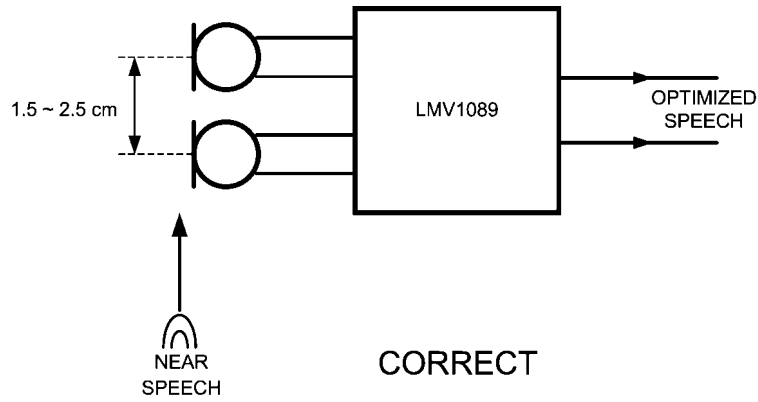
large, the far field noise reduction performance will be degraded. The optimum spacing between Mic 1 and Mic 2 is 1.5-2.5cm. This range provides a balance of minimal near field speech loss and maximum far field noise reduction. The microphones should be in line with the desired sound source 'near speech' 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.



WRONG

30060610

FIGURE 12. Broadside Array (WRONG)



CORRECT

30060611

FIGURE 13. End fire Array (CORRECT)

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.

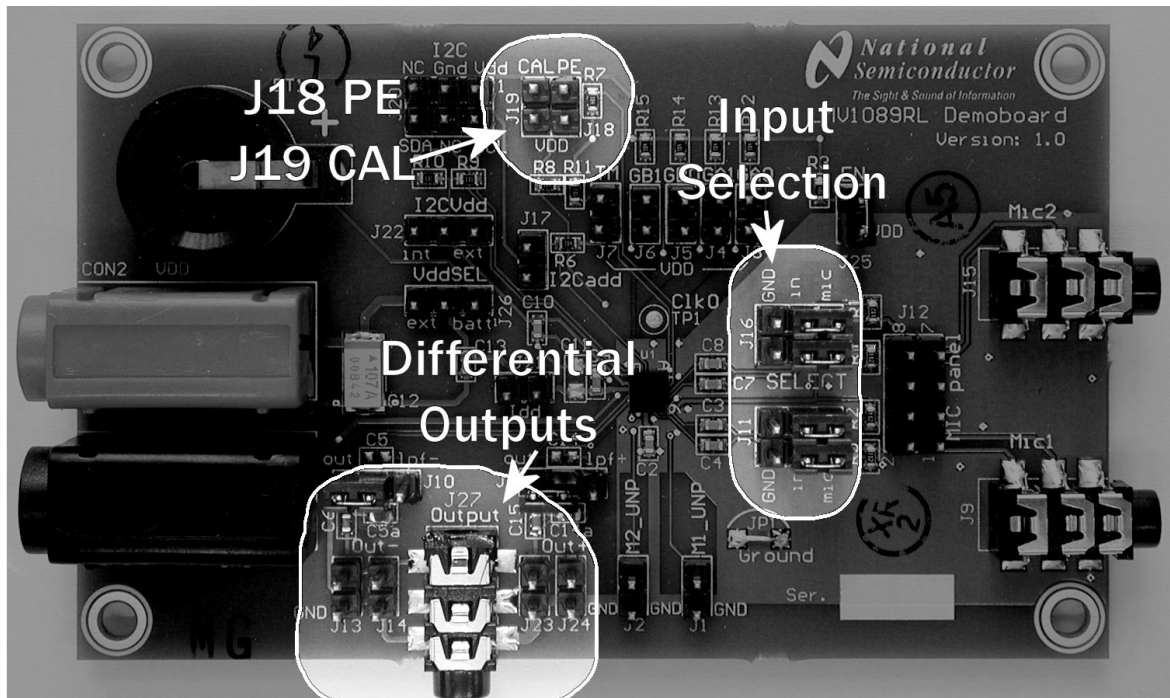
The compensation or calibration technology is achieved via memory stored coefficients when the Far Field Noise Suppression (FFNS) circuitry activates the calibration sequence. The purpose of the calibration sequence is to choose the optimized coefficients for the FFNS circuitry for the given micro-

phones, spacing, and acoustical environment of the product containing the LMV1089

A basic calibration can be performed with a single 1kHz tone (see section *Performing a One Tone Calibration*), however to take full advantage of this calibration feature a three tone calibration (see the section *Performing a Three Tone Calibration*) is preferred.

The automatic calibration process can be initiated from either a digital interface CALIBRATE pin (CAL / J19 see *Figure 14*) or via the I²C 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.



30060606

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 applying a valid logical level to these pins ('Low' < $0.4 \cdot I^2C V_{DD}$ or 'High' > $0.6 \cdot I^2C V_{DD}$).

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

Automatic Calibration Setup

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 *Performing a One Tone Calibration* and *Performing a Three Tone Calibration*)
- 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.

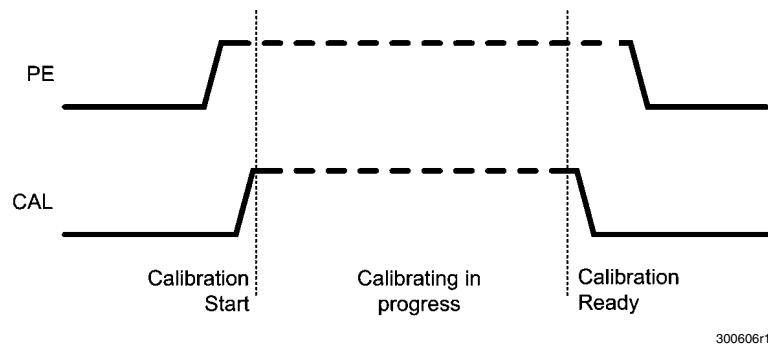


FIGURE 15. Automatic Calibration via CAL pin

Note: When the I²C 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 oper-

ation. 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.

AUTOMATIC CALIBRATION VIA I²C COMMAND

To initiate the automatic calibration via the I²C 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 I²C register 'R' (address 0x12) bit 0 to start calibration
- Apply Audio stimulus (single tone 1kHz or three tone sequence as described in *Performing a One Tone Calibration* and *Performing a Three Tone Calibration*)

- Wait at least 790ms
- Remove Audio stimulus
- Write '0' into I²C 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 I²C calibration bit. Signals applied to the microphone inputs before rising of PE or setting the I²C calibration bit are ignored by the calibration system.

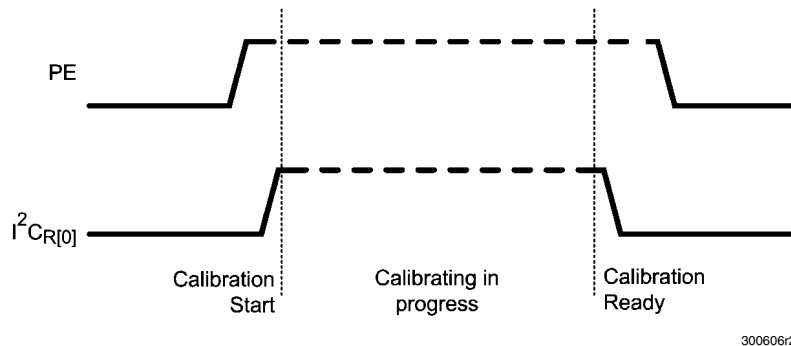


FIGURE 16.

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.

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 17*.

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 17*. 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 17* and *Table 5* are ignored by the calibration system.

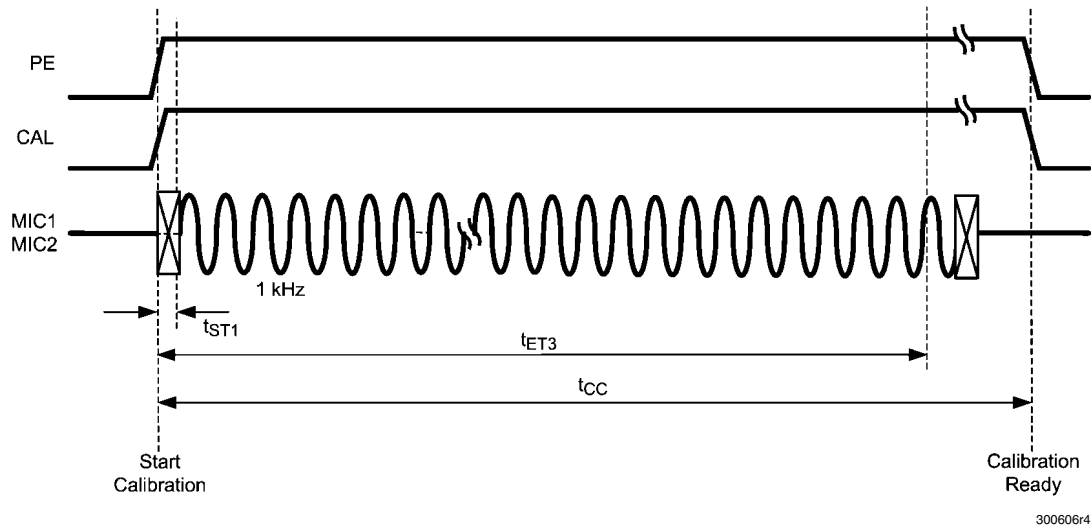


FIGURE 17. One Tone Calibration Timing

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 1 kHz

- 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 18* 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.

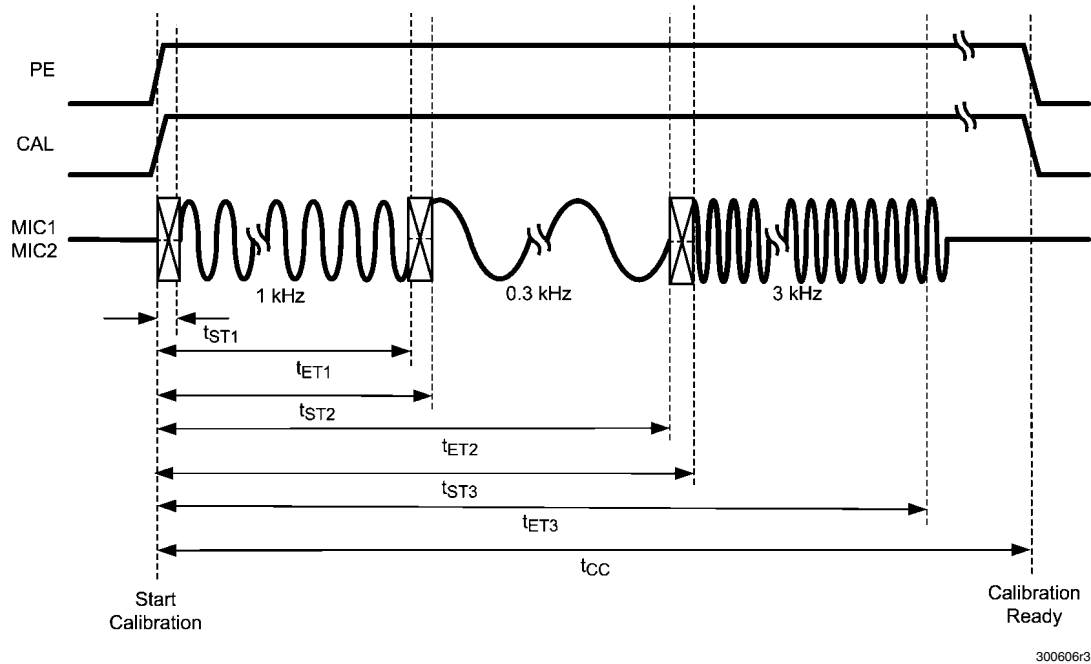


FIGURE 18. Calibration Timing

TABLE 5. Automatic Calibration Timing Parameters

Symbol	Parameter	Limits		Unitis
		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

NOTE: Data guaranteed by design

Creating the Three Tone Sequence with an AWG

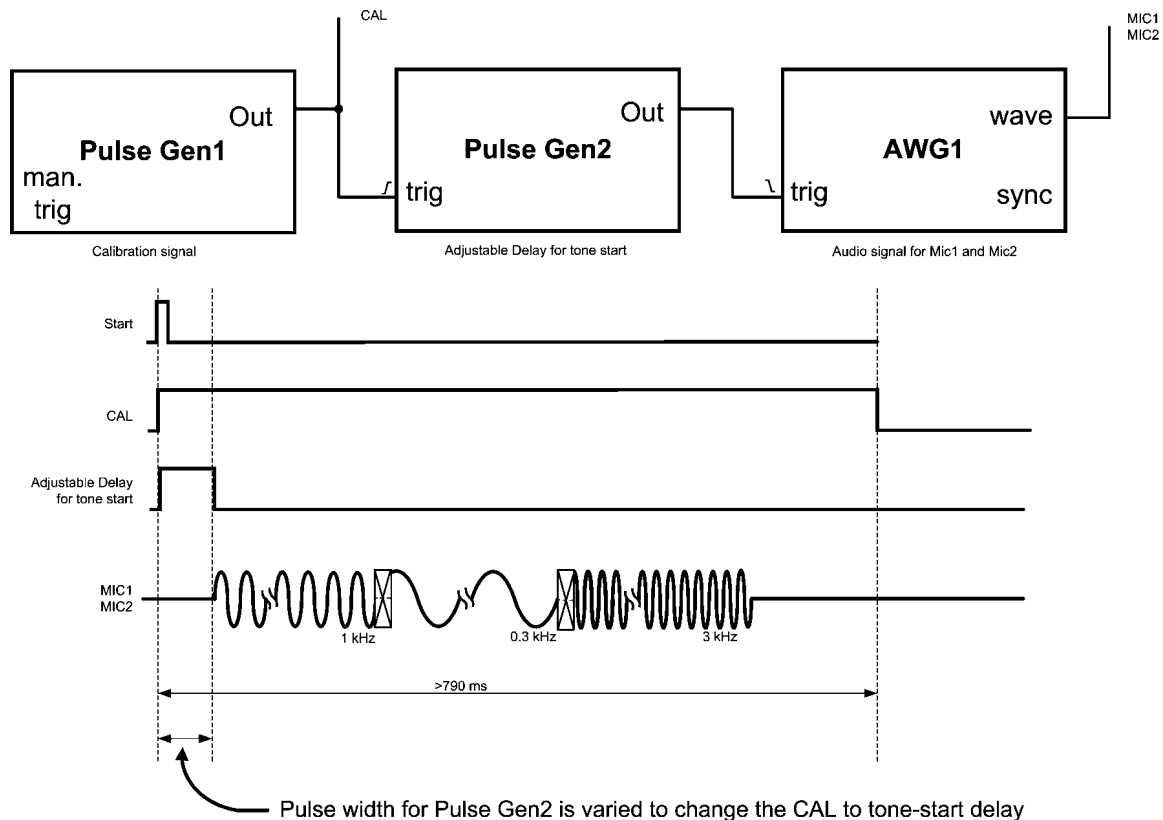
It is possible to create the three tone test sequence as described in *Performing a Three Tone Calibration* with an Arbitrary Waveform Generator (AWG). For this the sequence should be programmed in the memory of the AWG. The sequence should consist of:

- 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 19*.



300606r6

FIGURE 19. Example of Three Tone Signal Generation

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 *Creating the Three Tone Sequence with an AWG*). The test setup is shown in Figure 20. 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 $100\text{mV}_{\text{pp}} \pm 6\text{dB}$.

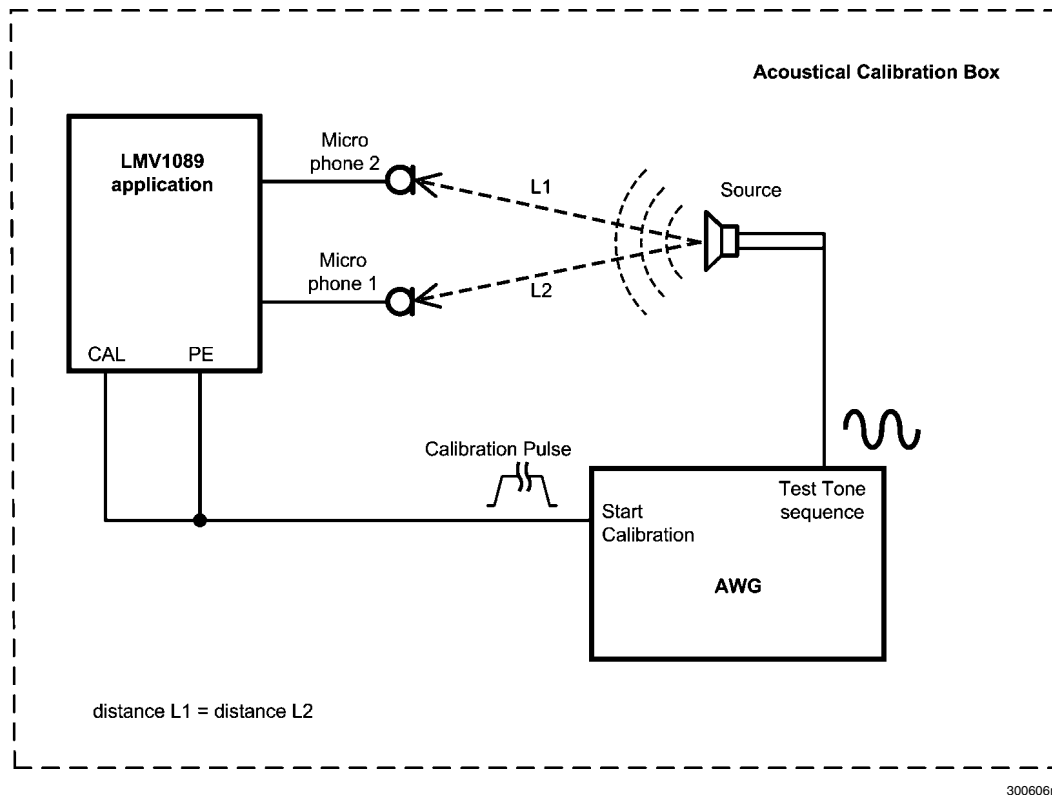


FIGURE 20. Automatic Calibration Setup

Performing a Manual Calibration

The LMV1089 provides the option to program the calibration parameters directly into the LMV1089 registers via the I²C 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.

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.

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.

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_{DD} pin (F3) and ground (D3). Avoid that the current for the de-coupling capacitors flow through the ground from pin B4.

Description of Headers and Connectors of the LMV1089 Demoboard

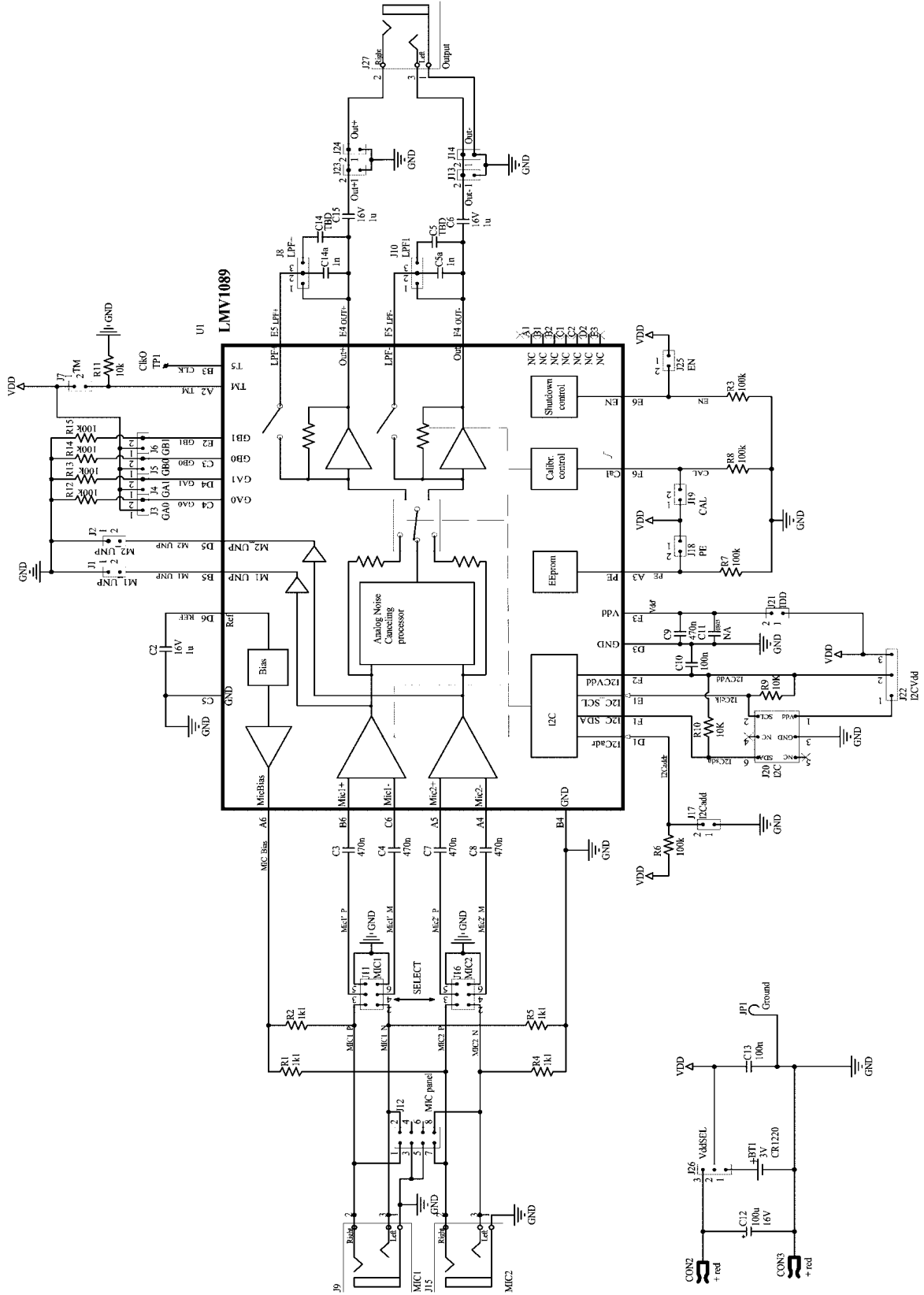
The LMV1089 demoboard provides many headers and connectors for connecting test equipment and controlling the settings of the part. The function that is controlled by the

jumpers on the LMV1089 demo board is also indicated on the PCB in silk screen.

Connector and Header Functions for the LMV1089RL Demoboard

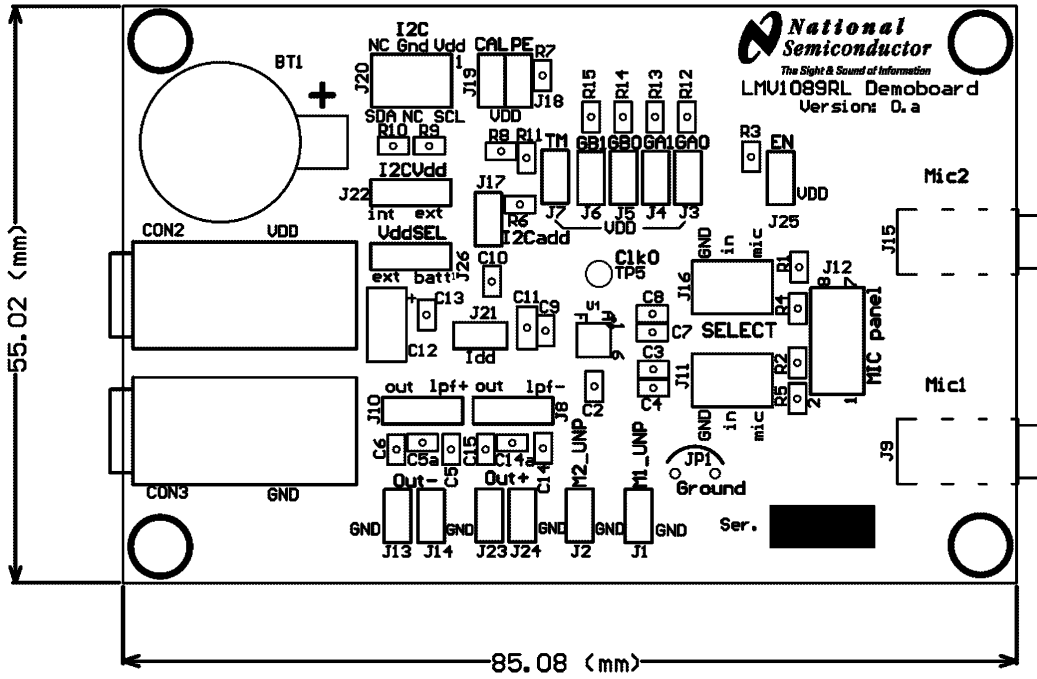
Designator	Function or Use	Comments
J1	(M1_UNP) Microphone 1 Unprocessed signal output	
J2	(M2_UNP) Microphone 2 Unprocessed signal output	
J3, J4	(GA0, GA1) Pre-Amplifier default gain setting	See <i>Table 1</i>
J6, J6	(GB0, GB1) Post-Amplifier default gain setting	See <i>Table 2</i>
J7	(TM) Auxiliary 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 ² 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) I ² C interface connector	
J21	(I _{DD}) Supply current measurement	Normally shorted by jumper, replace jumper by DMM for supply current measurement
J22	(I ² CV _{DD}) Selection of I ² CV _{DD}	
J23, J24	(OUT+) Output signal of the processed audio	Differential output (+)
		1 = GND 2 = OUT
J25	(EN) Enable Chip	Closed = Chip Enable
J26	(V _{DD} SEL)	Selection of V _{DD} source
		2-3 = Ext V _{DD} 1-2 = Battery
CON2	(V _{DD}) Ext V _{DD} Plus	Power supply connection
CON3	(GND) Ext V _{DD} Minus	
JP1	Ground connection for probes	
TP1	(TP5) Test signal	Not for Customer Use
BT1	3 V Lithium battery holder	CR1220 size

Schematic for the LMV1089RL



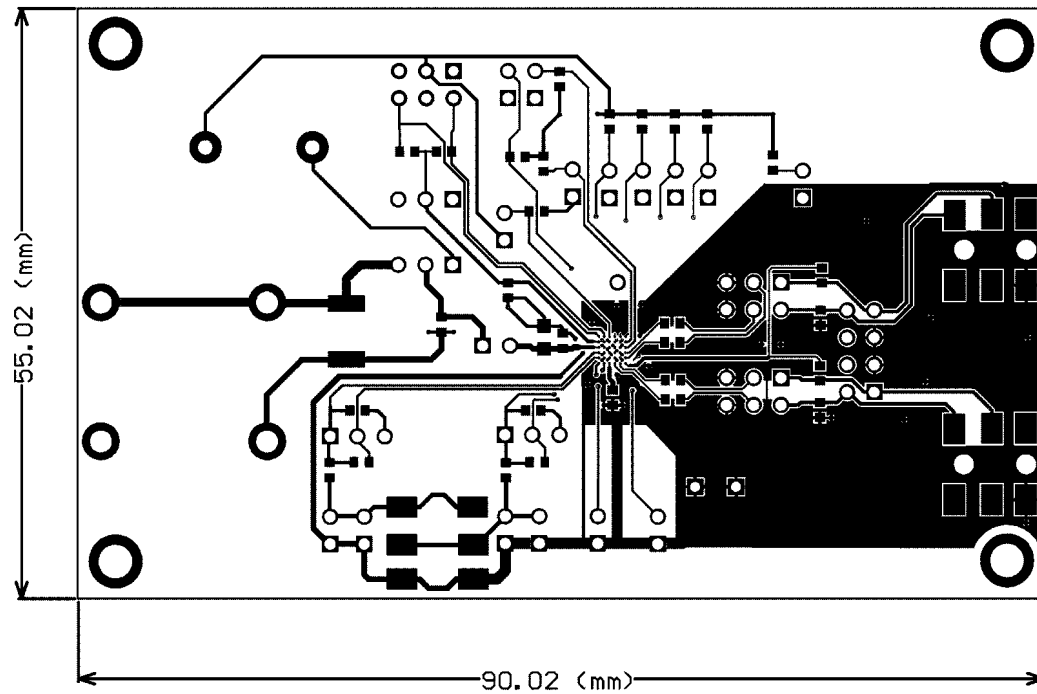
30060655

Demo Board Layout for the LMV1089RL



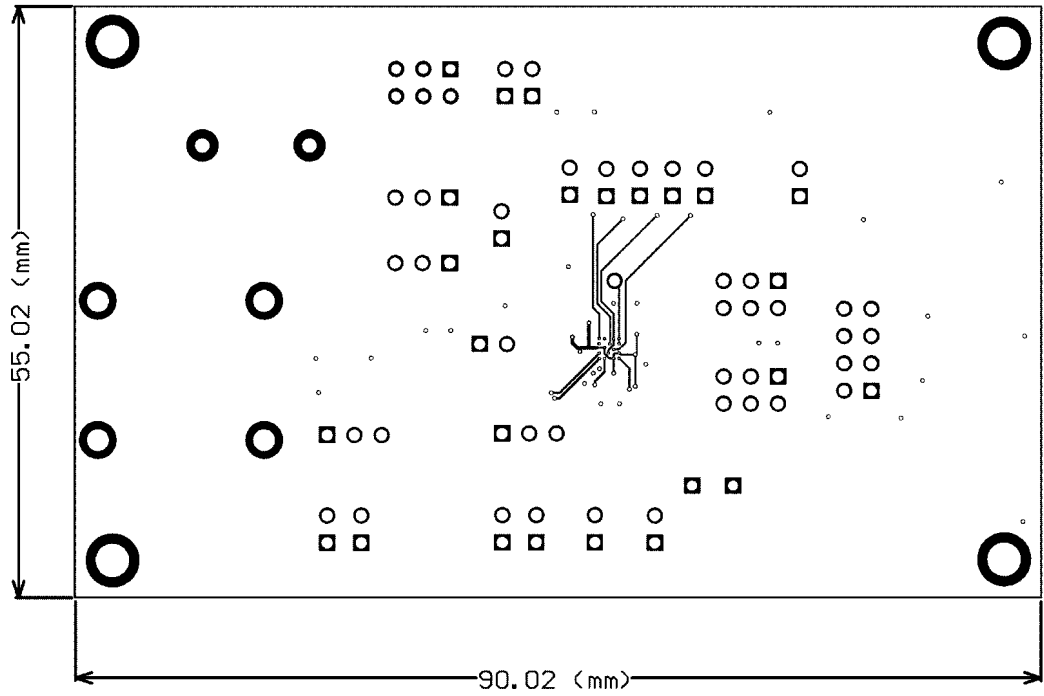
30060650

FIGURE 21. Silk Screen



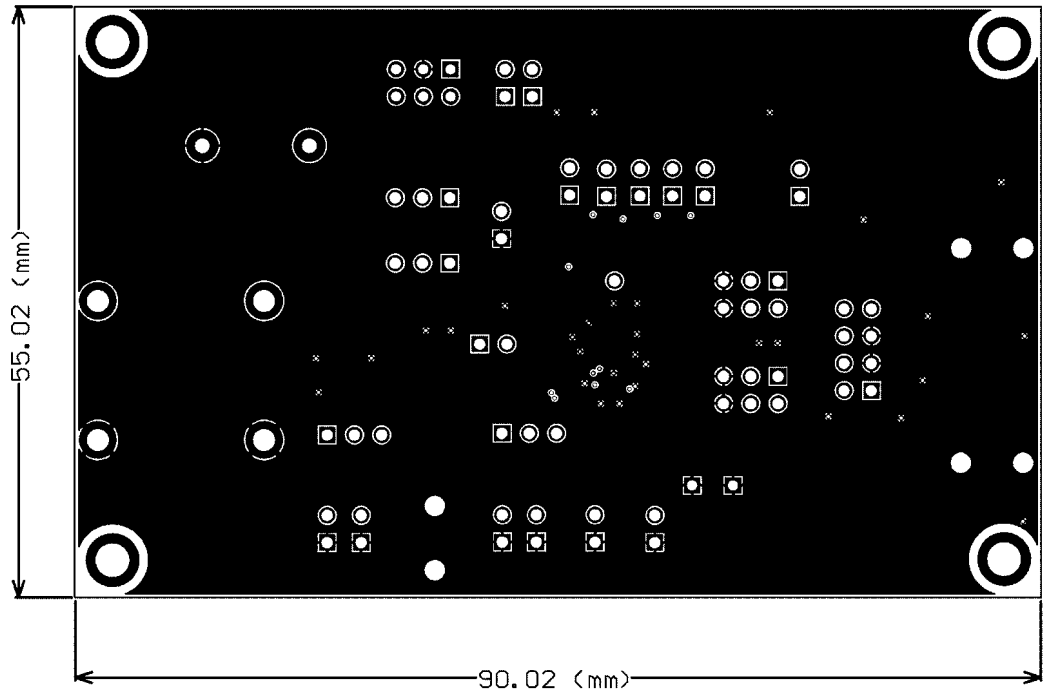
30060651

FIGURE 22. Top Layer



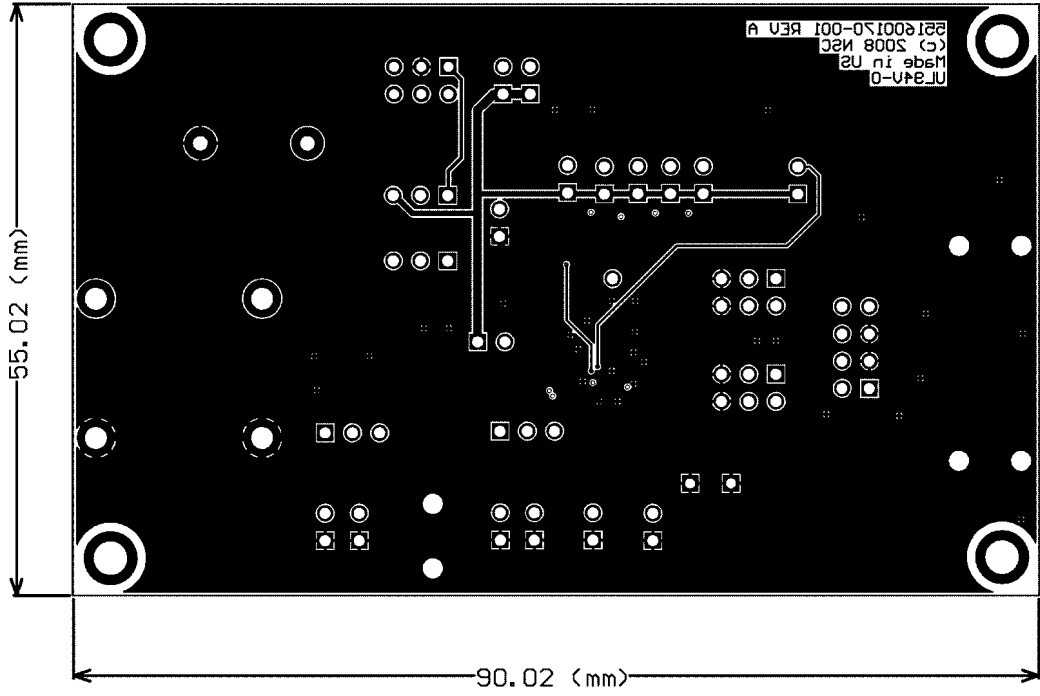
30060652

FIGURE 23. Top Inner Layer



30060653

FIGURE 24. Bottom Inner Layer



30060654

FIGURE 25. Bottom Layer

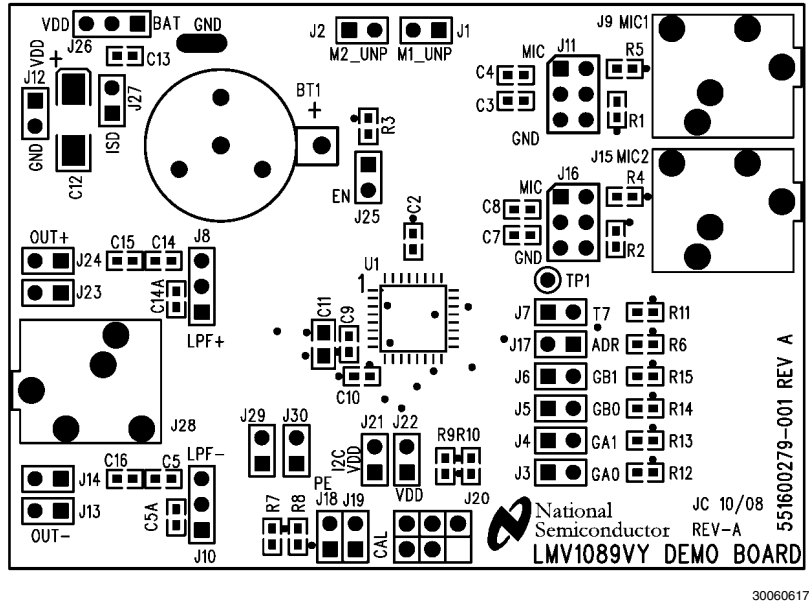
Bill of Materials for the LMV1089RL Demoboard

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	LMV1089RL				USMD RLA36TTA
JP1	Ground hook	jumper			5mm high

Connector and Header Functions for the LMV1089VY Demoboard

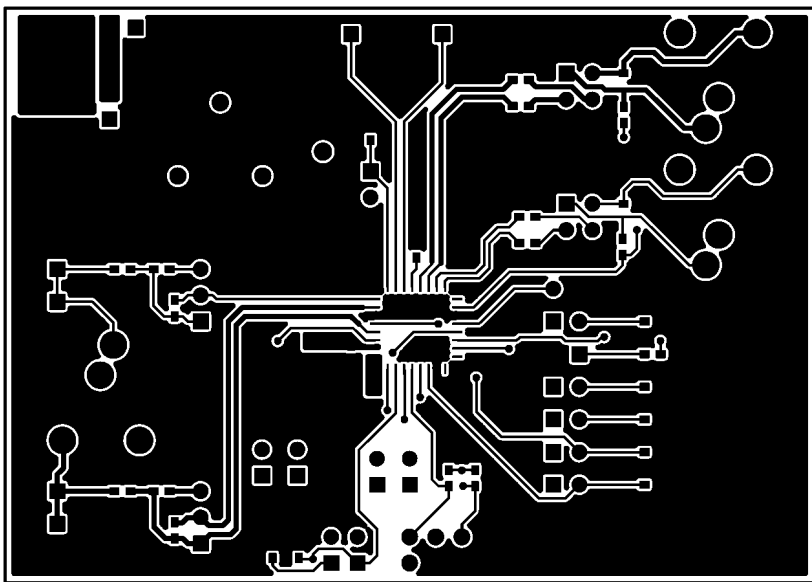
Header/ Connector	Indication/Function	Comments
J1	(M1_UNP) Unprocessed audio output for microphone channel 1	
J2	(M2_UNP) Unprocessed audio output for microphone channel 2	
J3	(GA0) Default input gain setting bit 0	See Table 2 Default Pre Amplifier gain
J4	(GA1) Default input gain setting bit 1	
J5	(GB0) 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 or	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 ² Cadd) I ² 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 ² C) I ² C interface connector	
J23+J24	(OUT+) Output signal of the processed audio	
J27	(I _{DD}) Supply current measurement	Normally shorted by jumper, replace jumper by DMM for supply current measurement
J21/J22	(I ² CV _{DD}) Selection of I ² CV _{DD}	Short J21 & J22 to power demo board from I ² C_USB board
J25	(EN)	Normally shorted to enable
J26	(V _{DD} 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	

Demo Board Layout for the LMV1089VY



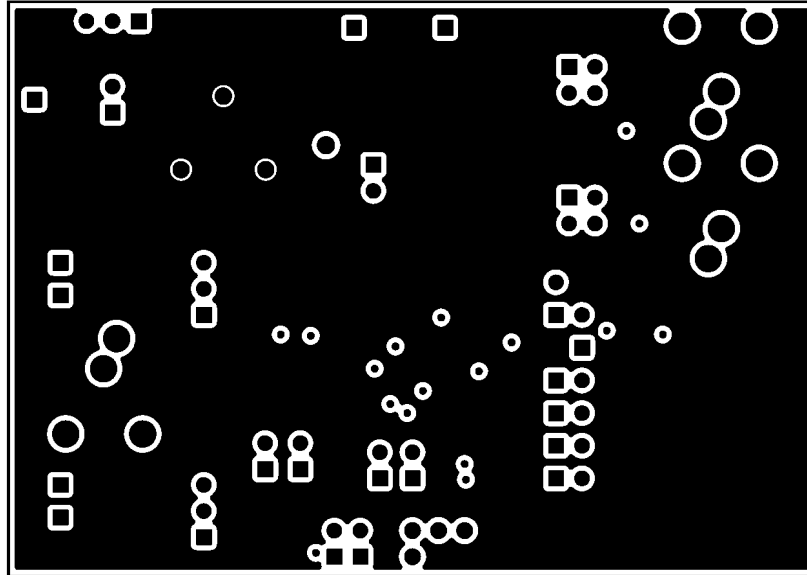
30060617

FIGURE 26. Top Silkscreen



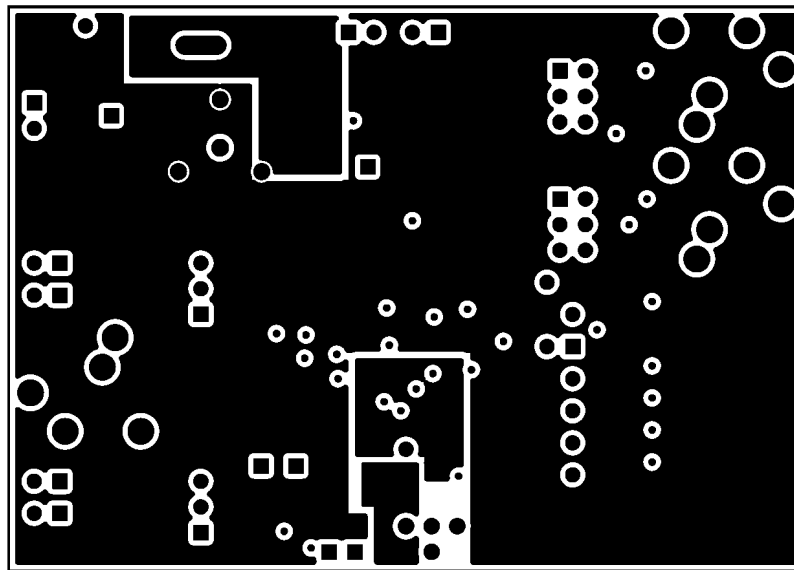
30060616

FIGURE 27. Top Layer



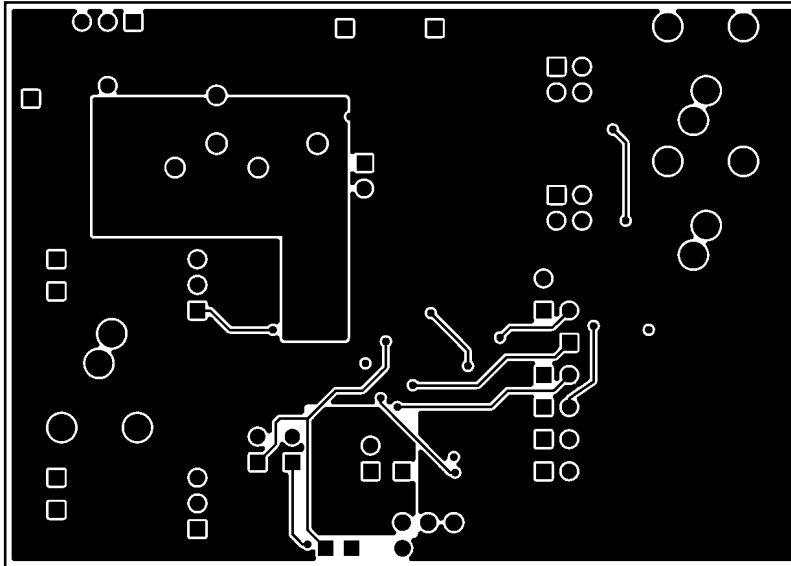
30060614

FIGURE 28. Layer 2



30060615

FIGURE 29. Layer 3



30060613

FIGURE 30. Bottom Layer

Bill of Materials for the LMV1089VY Demoboard

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	1μF
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	100μF
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	

Notes

AN-1832

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH® Tools	www.national.com/webench
Audio	www.national.com/audio	App Notes	www.national.com/appnotes
Clock and Timing	www.national.com/timing	Reference Designs	www.national.com/refdesigns
Data Converters	www.national.com/adc	Samples	www.national.com/samples
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/lido	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage Reference	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Solutions	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
Temperature Sensors	www.national.com/tempensors	SolarMagic™	www.national.com/solarmagic
Wireless (PLL/VCO)	www.national.com/wireless	PowerWise® Design University	www.national.com/training

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2009 National Semiconductor Corporation

For the most current product information visit us at www.national.com



National Semiconductor Americas Technical Support Center
Email: support@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Technical Support Center
Email: europe.support@nsc.com

National Semiconductor Asia Pacific Technical Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Technical Support Center
Email: jpn.feedback@nsc.com