LM48901EVAL User Guide

Texas Instruments

Spatial Audio Speaker Array Evaluation System

spatial audio
TECHNOLOGY FROM TEXAS INSTRUMENTS

www.ti.com/spatialaudio

2Q 2012

Overview

This revised document describes the installation, setup, and operation of the LM48901 Spatial Array evaluation system. The LM48901 is a quad Class D amplifier that utilizes Texas Instrument's proprietary spatial sound processor to create an enhanced sound- stage for portable and small-stage multimedia devices.

The LM48901 evaluation board (shown in ***Figure 1***) accepts three audio input formats—stereo differential analog, SPDIF, or I²S. Multiple boards are easily cascaded, increasing the number of channels. The LM48901 can also be configured as a 2.1 amplifier for stereo + subwoofer applications.

The board is controlled though a Windows- and Mac OSX-compatible graphic user interface (GUI). The GUI configures the device, loads spatial coefficients, and provides a graphic equalizer. The board connects to a computer through a USB interface device (included).

System Components

Evaluation system hardware

- LM48901 Evaluation Board
- USB2ANY I²C Interface
- 10-pin adaptor board
- Ribbon cable

Evaluation System Software

All software and drivers associated with the LM48901 evaluation board are available for download from the device product folder. The system software consists of onboard and web application as follows:

- *LM48901_Control_SW_xxxx-setup.exe* – LM48901 control software
- *MCRInstaller.exe* – Graphic Equalizer tool add on for the LM48901 control software
- *Spatial Coefficient Generator* – A web application that generates the spatial coefficients

LM48901 Features:

- Spatial sound processing
- I2S digital Input
- Differential-input stereo ADC
- Edge rate control reduces EMI while preserving audio quality and efficiency
- Short-circuit and thermal overload protection
- Minimum external components
- Click and pop suppression
- Micro-power shutdown
- Available in space-saving microSMD and LLP packages

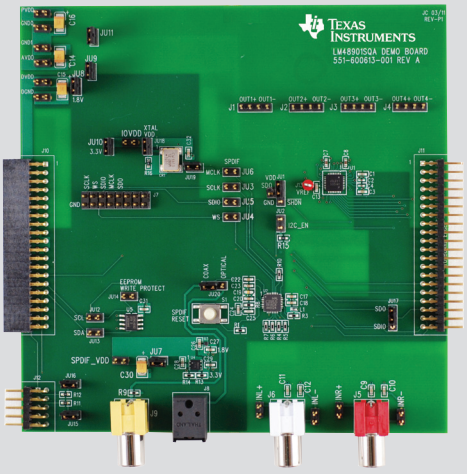


Figure 1. LM48901 Evaluation Board

Setup

Installing Software

Install LM48901 Evaluation Board Control Software

- To install the Welcome panel – choose Next.
- To install the Choose Install Location panel – choose Next.
- To install the Choose Start Menu Folder – choose Install.
- To install the Installing panel – after files load, choose Next.
- To install the Completing the Install panel – choose Finish.

Connecting Hardware

Connecting the LM48901 Demo Board

- Single 5V Supply Operation, Single Device/Master device, Analog Input, No MCLKSource
- Do not place shunts across JU2-6, JU12-14, or JU20.
- Place shunt on JU11 to connect PVDD and AVDD.
- Place shunt on JU8 to connect DVDD to 1.8V supply.
- Place shunt on JU9 to connect GND to DGND.
- Place shunt on JU10 to connect IOVDD to 3.3V supply.
- Place shunt on JU18 (XTAL VDD) to connect crystal to 3.3V.
- Place shunt on JU19 to connect crystal output to MCLK input of LM48901.
- Place shunts on JU15 and JU16 to connect I^2C pull up resistors to 3.3V.
- Place shunt on JU7 to connect PVDD to SPDIF_VDD to power SPDIF converter and 3.3V and1.8V regulators.
- Place shunt to VDD position on JU1 (SHDN).
- Place shunt across 2-3 on JU17 to connect SDIO to daisy chain connector.
- Connect 5V supply to PVDD header.
- Connect ground to GND header.
- Connect analog audio source to J5 and J6 RCA jacks or to INR+/- and INL+/- headers.
- Connect speakers across J1, J2, J3, and J4.
- Connect USB board to J12.

Single 5V Supply Operation, Single Device/Master Device, SPDIF Source

- Do not place shunts across: JU2-6, JU12-14, or JU18-19
- Place shunt on JU11 to connect PVDD and AVDD.
- Place shunt on JU8 to connect DVDD to 1.8V supply.
- Place shunt on JU9 to connect GND to DGND.
- Place shunt on JU10 to connect IOVDD to 3.3V supply.
- Place shunts on JU3-JU6 to connect I2S output of SPDIF converter to LM48901.
- Place shunts on JU15 and JU16 to connect I^2C pull up resistors to 3.3V.
- Place shunt on JU7 to connect PVDD to SPDIF_VDD to power SPDIF converter and 3.3V and 1.8V regulators.
- Place shunt across 1-2 (Optical) or 2-3 (Coax) on JU20 to select SPDIF input.
- Place shunt to VDD position on JU1 (SHDN).
- Place shunt across 2-3 on JU17 to connect SDIO to daisy chain connector.
- Connect 5V supply to PVDD header.
- Connect ground to GND header.
- Connect SPDIF source to either J8 (optical) or J9 (coax).
- Connect speakers across J1, J2, J3, and J4.
- Connect USB board to J12.

Multiple Supply Operation, Single Device/Master Device, Analog Input, No MCLK Source

- Do not place shunts across JU2-14 or JU20.
- Place shunt on JU18 (XTAL VDD) to connect crystal to 3.3V.
- Place shunt on JU19 to connect crystal output to MCLK input of LM48901.
- Place shunts on JU15 and JU16 to connect I^2C pull up resistors to 3.3V.
- Place shunt to VDD position on JU1 (SHDN).
- Place shunt across 2-3 on JU17 to connect SDIO to daisy chain connector.
- Connect 5V supply to PVDD, AVDD and SPDIF headers.
- Connect 3.3V supply to IOVDD.
- Connect 1.8V supply to DVDD.
- Connect GND to GND and DGND headers.
- Connect analog audio source to J5 and J6 RCA jacks or to INR+/- and INL+/- headers.
- Connect speakers across J1, J2, J3, and J4.
- Connect USB board to J12.

Multiple Supply Operation, Single Device/Master Device, SPDIF Source

- Do not place shunts across JU2-6, JU8-14, or JU18-19.
- Place shunts on JU3-JU6 to connect I2S output of SPDIF converter to LM48901.
- Place shunts on JU15 and JU16 to connect I^2C pull up resistors to 3.3V.
- Place shunt on JU7 to connect PVDD to SPDIF_VDD to power SPDIF converter and 3.3V and 1.8V regulators.
- Place shunt across 1-2 (Optical) or 2-3 (Coax) on JU20 to select SPDIF input.
- Place shunt to VDD position on JU1 (SHDN).
- Place shunt across 2-3 on JU17 to connect SDIO to daisy chain connector.
- Connect 5V supply to PVDD, AVDD, and SPDIF headers.
- Connect 3.3V supply to IOVDD.
- Connect 1.8V supply to DVDD.
- Connect GND to GND and DGND headers.
- Connect SPDIF source to either J8 (optical) or J9 (coax).
- Connect speakers across J1, J2, J3, and J4.
- Connect USB board to J12.

Slave Device

- Connect slave board J10 to master board J11. The daisy chain connection provides all supplies, grounds, I^2C and I2S signals.
- Do not place shunts across JU2-16, or JU18-20.
- Place shunt to VDD position on JU1 (SHDN).
- Place shunt across 2-3 on JU17 to connect SDIO to daisy chain connector.

Setup

Jumper Connections

JUx	Single 5V Supply, Single Device/Master Device Analog Input, No MCLK Source	Single 5V Supply, Single Device 2.1 Output Analog Input, No MCLK Source	Multiple Supply, Single Device/ Master Device Analog Input, No MCLK Source	Single 5V Supply, Single Device/Master Device SPDIF Source	Multiple Supply, Single Device/Master Device SPDIF Source	Slave Device
JU1	Short to VDD	Short to VDD	Short to VDD	Short to VDD	Short to VDD	Short to VDD
JU2	Open	Open	Open	Open	Open	Open
JU3	Open	Open	Open	Short	Short	Open
JU4	Open	Open	Open	Short	Short	Open
JU5	Open	Open	Open	Short	Short	Open
JU6	Open	Open	Open	Short	Short	Open
JU7	Short	Short	Open	Short	Short	Open
JU8	Short	Short	Open	Short	Open	Open
JU9	Short to 3.3V	Short to 3.3V	Open	Short to 3.3V	Open	Open
JU10	Short	Short	Open	Short	Open	Open
JU11	Short	Short	Open	Short	Open	Open
JU12	Open	Open	Open	Open	Open	Open
JU13	Open	Open	Open	Open	Open	Open
JU14	Open	Open	Open	Open	Open	Open
JU15	Short	Short	Short	Short	Short	Open
JU16	Short	Short	Short	Short	Short	Open
JU17	Short to SDIO	Short to SDIO	Short to SDIO	Short to SDIO	Short to SDIO	Short to SDIO
JU18	Short	Short	Short	Open	Open	Open
JU19	Short	Short	Short	Open	Open	Open
JU20	Open	Open	Open	Short to desired SPDIF input	Short to desired SPDIF input	Open
J1	Speaker	Speaker	Speaker	Speaker	Speaker	Speaker
J2	Speaker	Speaker	Speaker	Speaker	Speaker	Speaker
J3	Speaker	Short to J2	Speaker	Speaker	Speaker	Speaker
J4	Speaker	Speaker	Speaker	Speaker	Speaker	Speaker
J5	Right channel audio input	Right channel audio input	Right channel audio input	Open	Open	Open
J6	Left channel audio input	Left channel audio input	Left channel audio input	Open	Open	Open
J7	Open	Open	Open	Open	Open	Open
J8	Open	Open	Open	Connect optical SPDIF source	Connect optical SPDIF source	Open
J9	Open	Open	Open	Connect Coax SPDIF Source	Connect Coax SPDIF Source	Open
J10	Open	Open	Open	Open	Open	Connect to J11 of master board
J11	Connected to J10 of slave board in master configuration	Connected to J10 of slave board in master configuration	Connected to J10 of slave board in master configuration	Connected to J10 of slave board in master configuration	Connected to J10 of slave board in master configuration	Open
J12	Connect I2C controller	Connect I2C controller	Connect I2C controller	Connect I2C controller	Connect I2C controller	Open

JUx	Single 5V Supply, Single Device/Master Device Analog Input, No MCLK Source	Single 5V Supply, Single Device 2.1 Output Analog Input, No MCLK Source	Multiple Supply, Single Device/Master Device Analog Input, No MCLK Source	Single 5V Supply, Single Device/Master Device SPDIF Source	Multiple Supply, Single Device/Master Device SPDIF Source	Slave Device
J12	Connect I2C controller	Connect I2C controller	Connect I2C controller	Connect I2C controller	Connect I2C controller	Open
PVDD	5V	5V	5V	5V	5V	Open
PGND	Gnd	Gnd	Gnd	Gnd	Gnd	Open
AVDD	Open	Open	5V	Open	5V	Open
AGND	Gnd	Gnd	Gnd	Gnd	Gnd	Open
DVDD	Open	Open	1.8V	Open	1.8V	Open
DGND	Gnd	Gnd	Gnd	Gnd	Gnd	Open
PLLVDD	Open	Open	3.3V	Open	3.3V	Open
IOVDD	Open	Open	3.3V	Open	3.3V	Open
IOGND	Gnd	Gnd	Gnd	Gnd	Gnd	Open
SPDIF_ VDD	5V	5V	Open	5V	5V	Open
INR+	Right channel non-inverting audio input (if J5 is not used)	Right channel non-inverting audio input (if J5 is not used)	Right channel non-inverting audio input (if J5 is not used)	Open	Open	Open
INR-	Right channel inverting audio input (if J5 is not used	Right channel inverting audio input (if J5 is not used	Right channel inverting audio input (if J5 is not used	Open	Open	Open
INL+	Left channel non-inverting audio input (if J6 is not used)	Left channel non-inverting audio input (if J6 is not used)	Left channel non-inverting audio input (if J6 is not used)	Open	Open	Open
INL-	Left channel inverting audio input (if J6 is not used)	Left channel inverting audio input (if J6 is not used)	Left channel inverting audio input (if J6 is not used)	Open	Open	Open

Setup

Connecting the USB Interface Module to the LM48901 Evaluation Board

Connect the USB2ANY (1) to the PC USB port.

Connect the USB2ANY 10-pin adaptor (2) to the USB2ANY I²C interface, as shown in ***Figure 3***.

Connect the ribbon cable to (3) the 10-pin adaptor. Line up the arrow on the male connector to the Pin 1 indicator dot on the 10-pin adaptor, as shown in ***Figure 3***.

Connect the ribbon cable to J12 on the LM48901 Evaluation Board, as shown in ***Figure 2***.

Run the LM48901 Evaluation Board Control Software.

Start/Programs/Run/lm48901_control_sw

NOTE: If the application fails to run, it is likely that you do not have the latest version of the *micro.net* framework software installed.

Figure 2 USB to LM48901 Evaluation Board Connection

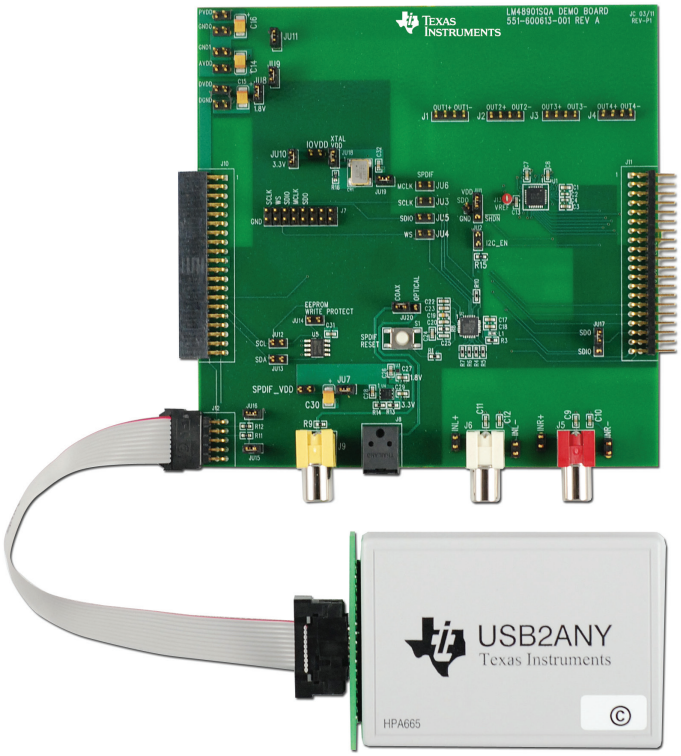
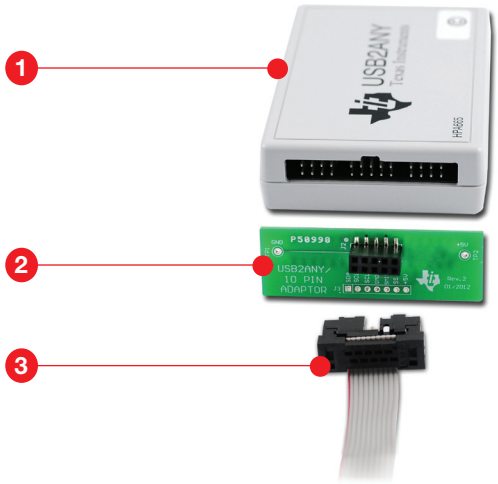


Figure 3 USB2ANY Assembly



Software Operation

LM48901 Spatial Evaluation Board Software System Controls and Operation

Start Up

The GUI start up screen is shown in ***Figure 4***.

– Gateway Connection – Select the proper USB interface (USB2ANY - USI3)

– Select *Connect*

– The GUI will ask to scan for devices – Select *YES*

– Select *Scan Devices*

– Once the device scan is complete – Select *OK*

– Close all dialog boxes

If the USB interface is disconnected, or the LM48901 EVM is disconnected or powered down any time after the GUI has completed the gateway and device scans, reconnect the interface/EVM and do the following:

– To rescan for Gateways, click on the  icon in the upper left corner

– To rescan for devices, click on the  icon in the upper left corner

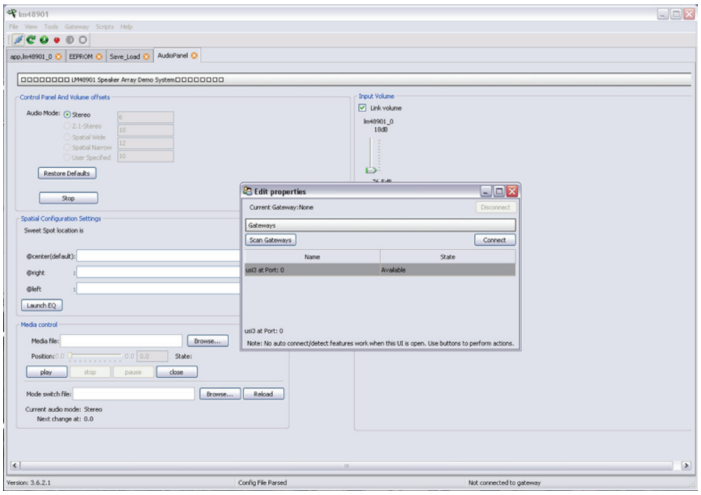


Figure 4 Control Software Startup Screen

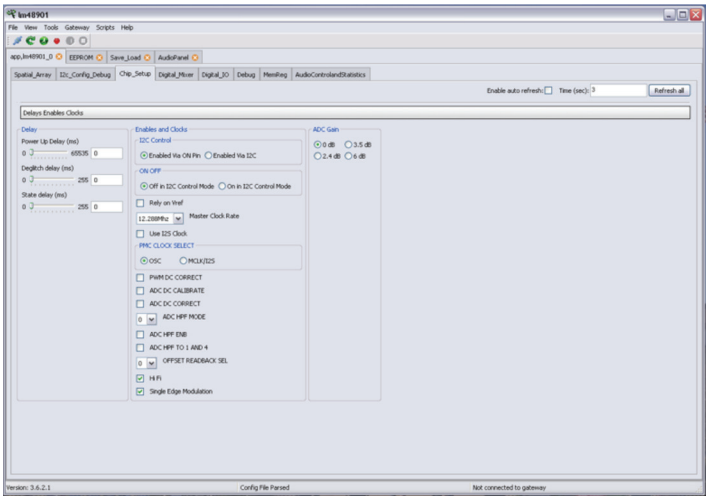


Figure 5 Chip Setup Tab

Basic Device Configuration

NOTE: When spatial coefficients are loaded, the GUI determines the required device settings and automatically configures the device. No extra configuration is required, unless custom settings are desired.

In the Device tab, select the *Chip_Setup* tab, shown in ***Figure 5***.

I²C Control selects device shutdown control and is enabled via the ON pin or I²C interface. SHDN enables/disables the device. If enabled via I²C interface, SHDN serves as an additional I²S serial data output.

Set Master Clock Rate to appropriate clock frequency. Onboard crystal is 12.288MHz.

PMC CLOCK SELECT selects which clock source drives the power management circuitry at start up.

Select OSC to run the PMC runs from the internal oscillator. The internal oscillator increases quiescent current in shutdown, but does not require an external clock to be present during start up. Select MCLK/I2S to run the PMC from an external clock. Quiescent current is low at shutdown, but the external clock must be enabled prior to device start up.

Set ADC Gain to desired gain setting.

Select Hi Fi for low-noise mode.

Select Single Edge Modulation for improved THD performance.

Software Operation

Controls and Operation

Basic Device Configuration (con't)

Select the *Digital_Mixer* tab, as shown in ***Figure 6***.

DSP Input Select will select which audio input is directed to the Spatial Engine. Both ADC and I²S inputs may be selected, in which case both inputs are mixed in the Spatial Engine.

- Set the ADC and I²S levels either through the slider bars or drop down menu selection options.
- Use Inputs to select which digital audio source is directed to the I²S transmitters.
  - None: No audio data sent to I²S transmitter
  - ADC: ADC output sent to I²S transmitter
  - DSP1/2: DSP channels 1 and 2 sent to I²S transmitter
  - DSP3/4: DSP channels 3 and 4 sent to I²S transmitter
- To ON PAD selects which I²S data output of the LM48901 appears on SHDN. I2SA Tx data can be output on both SDID and SHDN. I2SB Tx data is only on SHDN. If both I2SA and I2SB are selected, I2SB takes precendence.

Outputs selects the audio source for the corresponding output. The Spatial Engine can be bypassed by selecting either the I²S or ADC source even with the spatial effect enabled.

  - OFF: Output disabled
  - I2SL: I²S left audio data
  - I2SR: I²S right audio data
  - ADCL: Left channel analog input
  - ADCR: Right channel analog input
  - DSP: Spatial Engine audio data. DSP must be selected for spatial or EQ effects.
- Amps 2 & 3 in Parallel
  DO NOT select
- QSA Settings
  - PRE BYPASS: Bypasses the pre-array filter
  - ARRAY BYPASS: Bypasses the Spatial Engine
  - PRE ENABLE: Enables the pre-array filter
  - ARRAY ENABLE: Enables the Spatial Engine

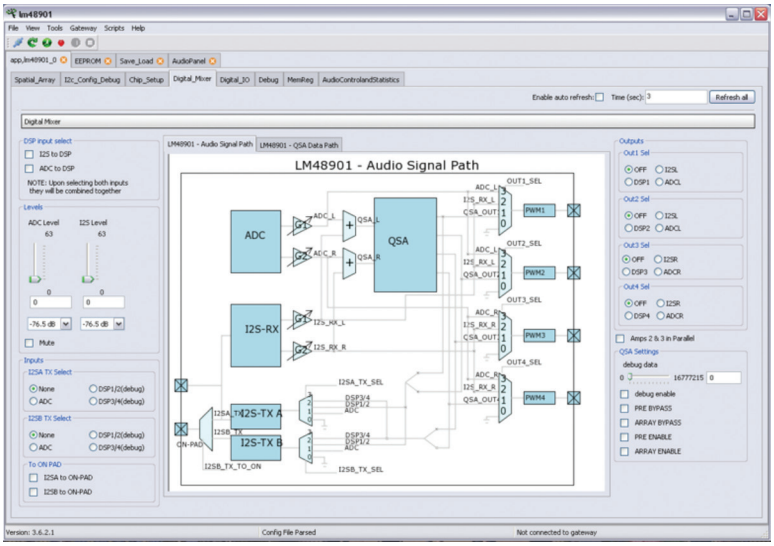


Figure 6 Digital Mixer Tab

Basic Device Configuration (con't)

Select the *Digital_IO Tab*, shown in ***Figure 7***.

48ksps I2S Master Configuration

- Stereo Settings select STEREO
- Stereo Sync Mode select appropriate L/R data configuration
- Clock Generation in Master Mode set Half Cycle Divider to 7
- Communication select Transmission Enable. Reception Enable allows the master device to use the internal I2S data bus. This mode eliminates any time delay issues when daisy chaining multiple devices.
- Clock Settings
  - Select Clock Master (LM48901 drives SCLK)
  - Select Sync Master (LM48901 drives WS)
- Sync Generation in Master Mode
  - No. of bits/word in Mono/Stereo Select appropriate number of bits
  - Sync Width in Mono Select 7
- AudioPort Reception/Transmission select appropriate number of bits/channel
- MSB Offset Control
  - Set both TX and RX MSB Position to 1

I2S Slave Configuration

- Stereo Settings select STEREO
- Stereo Sync Mode select appropriate L/R data configuration
- Communication select Reception Enable
- Clock Settings leave unselected
- Sync Generation in Master Mode leave unselected
- AudioPort Reception/Transmission Select appropriate number of bits/channel
- MSB Offset Control
  - Set both TX and RX MSB Position to 1

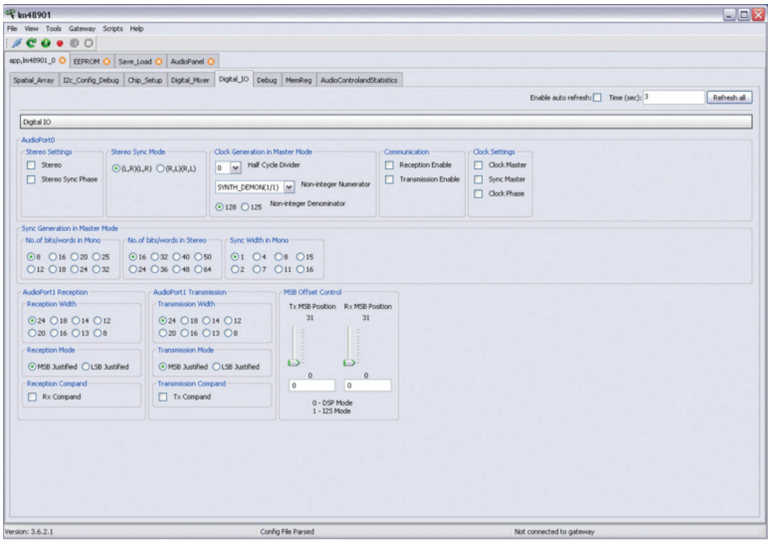


Figure 7 Digital IO Tab

Sample Board Configurations

Sample Single Board Configuration

Device settings apply to Single or Multiple Supply, Single Device Analog Input jumper configuration.

- Select Device tab (*app,lm48901_0*)
- Select Chip_Setup tab
  - Set Master Clock Rate to appropriate clock frequency
  - Set ADC Gain to desired gain setting
- Select Digital_Mixer tab
  - DSP Input Select Select ADC
  - Levels Set desired ADC and I2S levels
  - Outputs Select DSP
  - QSA Settings
    - Select PRE ENABLE
    - Select ARRAY ENABLE

Sample Single Board 2.1 Output Channel Configuration

Device settings apply to Single Supply, Single Device 2.1 Output Analog Input jumper configuration.

- Select Device tab (*app,lm48901_0*)
- Select Chip_Setup tab
  - Set Master Clock Rate to appropriate clock frequency
  - Set ADC Gain to desired gain setting
  - Select Amps 2 & 3 in Parallel

NOTE: in this mode, OUT2 and OUT3 operate in parallel and are controlled by the same modulator. Connect OUT2+ to OUT3 + and connect OUT2- to OUT3-.

WARNING! Ensure Amps 2 & 3 in Parallel is selected before enabling either OUT2 or OUT3 when both outputs are connected to each other. The device may be damaged if OUT2 and OUT3 are connected, Amps 2 & 3 in Parallel is not selected, and OUT2 and OUT3 are enabled.

On the Digital Mixer tab, Out2 Select controls both OUT2 and OUT3. Out3 Select is ignored.

Audio Panel

- Spatial Configuration Settings load coefficient file into the @center(default) Sweet Spot Location.
  - The GUI will only allow Stereo and 2.1-Stereo mode to be selected.

NOTE: The GUI will automatically configure the device for 2.1 Mode.

- Select Digital_Mixer tab
  - DSP Input Select Select ADC
  - Levels Set desired ADC and I2S levels
  - Outputs
    - Out1 Select DSP
    - Out2 Select DSP
    - Out3 Select OFF
    - Out4 Select DSP
  - QSA Settings
    - Select PRE BYPASS
    - Select ARRAY ENABLE

Sample Two–Board Master/Slave Configuration with Spatial Effect

Master Device settings apply to Single or Multiple Supply, Master Device Analog Input jumper configuration.

- Select Master Device tab (*app,lm48901_0*)
- Select Chip_Setup tab
  - Set Master Clock Rate to appropriate clock frequency
  - Set ADC Gain to desired gain setting
- Select Digital_Mixer tab
  - DSP Input Select Select ADC
  - Levels Set desired ADC and I2S levels
  - Inputs/I2SA TX Select Select ADC
  - To ON PAD Leave unselected
  - Outputs Select DSP
  - QSA Settings
    - Select PRE ENABLE
    - Select ARRAY ENABLE
- Select Digital_IO tab

48ksps I2S Master Configuration

- Stereo Settings Select STEREO
- Stereo Sync Mode Select appropriate L/R data configuration
- Clock Generation in Master Mode Set Half Cycle Divider to 7
- Communication
  - Select Transmission Enable
  - Select Reception Enable
- Clock Settings
  - Select Clock Master (LM48901 drives SCLK)
  - Select Sync Master (LM48901 drives WS)
- Sync Generation in Master Mode
  - Select 64 bits/word in Stereo Mode
  - Sync Width in Mono: select 7
- AudioPort Reception/Transmission select 24
- MSB Offset Control set both TX and RX MSB Position to 1
- Select Slave Device tab (*app,lm488901_1*)
- Select Chip_Setup tab
  - Set Master Clock Rate to appropriate clock frequency
- Select Digital_Mixer tab
  - DSP Input Select Select I2S
  - Levels Set desired I2S level
  - Inputs/I2SA TX Select Select None
  - To ON PAD Leave unselected
  - Outputs Select DSP
  - QSA Settings
    - Select PRE ENABLE
    - Select ARRAY ENABLE
- Select Digital_IO tab

I^2S Slave Configuration

- Stereo Settings Select STEREO
- Stereo Sync Mode Select appropriate L/R data configuration
- Communication select Reception Enable
- Clock Settings Leave unselected
- Sync Generation in Master Mode leave unselected
- AudioPort Reception/Transmission select appropriate number of bits/channel
- MSB Offset Control
  - Set both TX and RX MSB Position to 1

Loading Coefficients

Audio Panel Tab

Coefficients are loaded through the Audio Panel tab, shown in ***Figure 8***. When spatial coefficients are loaded, the GUI determines the required device settings and automatically configures the device. No additional configuration is required, unless custom settings are desired.

Load coefficient file into the @center(default) Sweet Spot location, by navigating to the file or dragging and dropping the coefficient file into the text box. Once the desired file is has been selected, click Load.

The GUI will determine if the coefficient file is for a 2.1 or multi-speaker spatial configuration and a dialog box will appear to indicate which type of file has been loaded. Click OK.

Audio Mode allows for easy switching between modes.

Stereo Spatial engine is bypassed, device operates in stereo mode.

2.1-Stereo available only if a 2.1 coefficient file is loaded.

Spatial Wide optimizes virtual speaker placement for widest perceived sound stage. This mode is best for movies or video content.

Spatial Narrow optimizes virtual speaker placement for a narrower perceived sound stage. This mode maintains more center channel content volume level while still providing a wider sound stage than Stereo mode. Spatial Narrow mode is best for music tracks.

User Specified user–configured sound stage. Access the User Specified tool through the Launch EQ button. See Equalization and Spatial Effect Adjustment section (page 17) for more details.

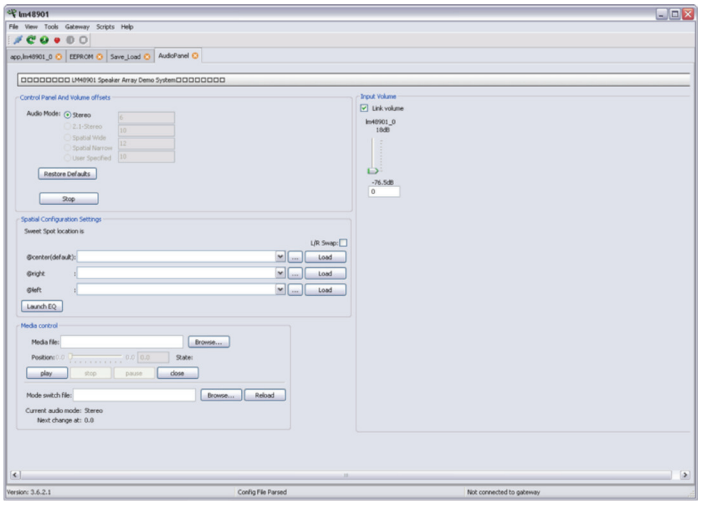


Figure 8 Audio Panel Tab

Spatial coefficients can be created using the TI Spatial Coefficient Generator tool found at **ti.com/spatialaudio**.

Save_Load Tab

Device configuration and coefficient settings are saved through the Save_Load tab, shown in ***Figure 9***.

- Configure the device
- Select the Save_Load tab
- Select the device(s) to be saved
- Select the memory regions
- Select Save
- A dialog box will appear – Select Browse
- Navigate to the desired folder
- Enter file *name.txt* (include the extension)
- Select OK

The GUI generates a text file with the selected register contents. The GUI can load device settings from saved configuration files.

- Select Load
- A dialog box will appear – Select Browse
- Navigate to the proper folder
- Enter the file name
- Select OK

A dialog window will appear once the GUI has successfully loaded the configuration file. Although the device will be configured, the GUI will not automatically reflect the updated device settings. Select the device tab, and click Refresh All to update the GUI.

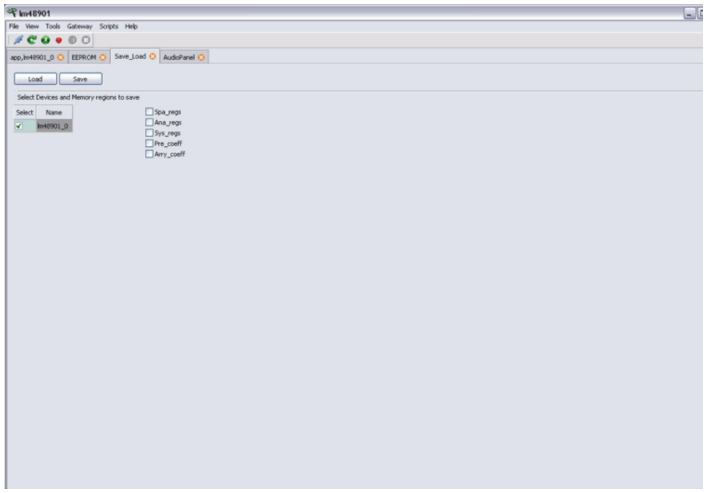


Figure 9 Save Load Tab

The MemReg tab ***Figure 10*** allows the register content to be viewed, and changed. There are two ways to change registers. Single click on a register cell to bring up a mini GUI window for the contents of that register. Double click on a register cell to manually enter register data in Hex.

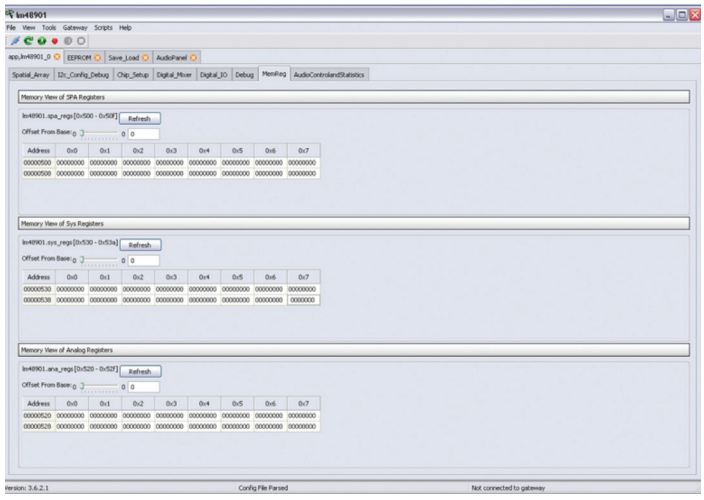


Figure 10 MemReg Tab

Debug Tab

The Debug tab, shown in ***Figure 11***, provides control for different debug modes—ADC coefficient setting, MBIST (Memory Built In Self Test), external EEPROM write control, output short, and thermal fault indicators.

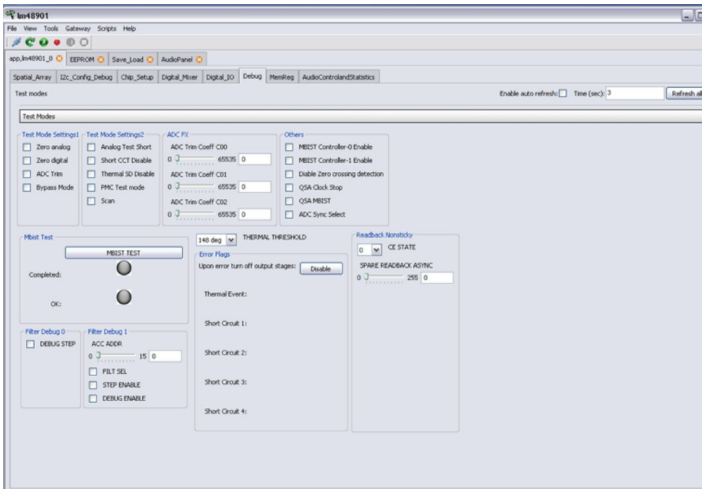


Figure 11 Debug Tab

Equalization, Spatial Effect Adjustment, and Volume Control

The LM48901 GUI includes a multiband graphic equalizer, parametric equalizer, volume control, and spatial effect adjustment tools, (shown in ***Figures 12-15)***. In the Audio Panel, click Launch EQ. The MCRInstaller must be installed in order for the tool to function. EQ, volume, and spatial effect adjustments are performed in the LM48901 DSP. The tool modifies existing spatial coefficient files with minimal impact to the spatial effect.

NOTE: The initial boot of the Spatial tool will open a DOS window and may take several minutes to boot, depending on system performance. DO NOT CLOSE the DOS window during this time.

Output Channel Configuration

1. SPA Coefficients – Input Coefficient File
   Select the source coefficient file to add equalization to by browsing to the file or dragging and dropping the file into the text box. The source file will be unaffected by the EQ tool.

2. SPA Coefficients – Output Coefficient File
   Specify the graphic EQ output coefficient file. If the output coefficient file of the graphic EQ tool is the same coefficient file loaded into the Audio Panel Spatial Configuration Settings, the GUI will automatically update the LM48901 when Generate Coefficients is selected, and the coefficient file is modified.

3. Graphic Equalizer
   The multiband graphic EQ tool features a selectable number of EQ bands (10, 20, or 30). Move the sliders to create the desired equalization. The graphic EQ tool allows for individual channel equalization. To set the same EQ across all channels, select All under Link Channels. To apply the same EQ across select channels, deselect All and select the desired channel check boxes.

   NOTE: Applying different equalization to individual channels may degrade the spatial effect.

4. EQ Presets
   The EQ tool starts up with a flat EQ at 0dB, regardless of whether the input coefficient file contains equalization information or not. EQ presets allow equalization profiles to be saved and recalled. Create a new EQ preset by clicking on the … button and specifying a file name and path. Select Add to add presets to the file menu.

5. Generate Coefficients based on current EQ
   Select Generate Coefficients based on Current EQ to create the new coefficient file.

6. Status
   This area displays short messages to indicate the results of various operations.

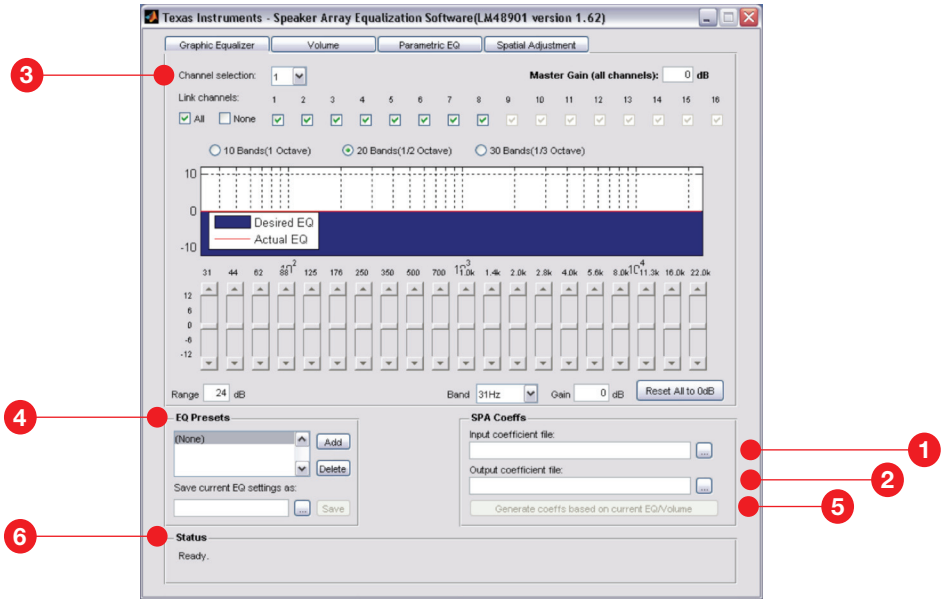


Figure 12 Graphic Equalizer Tool

Equalization, Spatial Effect Adjustment and Volume Control

Parametric Equalizer

1. SPA Coefficients – Input Coefficient File
   Select the source coefficient file to add equalization to by browsing to the file or dragging and dropping the file into the text box. The source file will be unaffected by the EQ tool.

2. SPA Coefficients – Output Coefficient File
   Specify the parametric EQ output coefficient file. If the output coefficient file of the parametric EQ tool is the same coefficient file loaded into the Audio Panel Spatial Configuration Settings, the GUI will automatically update the LM48901 when Generate Coefficients is selected, and the coefficient file is modified.

3. Parametric Equalizer
   The 10-band Parametric EQ tool features user selectable Filter types, Frequency, gain and Q. Select the desired filter band in the Current Band drop down menu. To set the same EQ across all channels, select All under Link Channels. To apply the same EQ across select channels, deselect All and select the desired channel check boxes.

   NOTE: Applying different equalization to individual channels may degrade the spatial effect.

4. EQ Presets
   The EQ tool starts up with a flat EQ at 0dB, regardless of whether the input coefficient file contains equalization information or not. EQ presets allow equalization profiles to be saved and recalled. Create a new EQ preset by clicking on the … button and specifying a file name and path. Select Add to add presets to the file menu.

5. Generate Coefficients based on current EQ
   Select Generate Coefficients based on Current EQ to create the new coefficient file.

6. Status
   This area displays short messages to indicate the results of various operations.

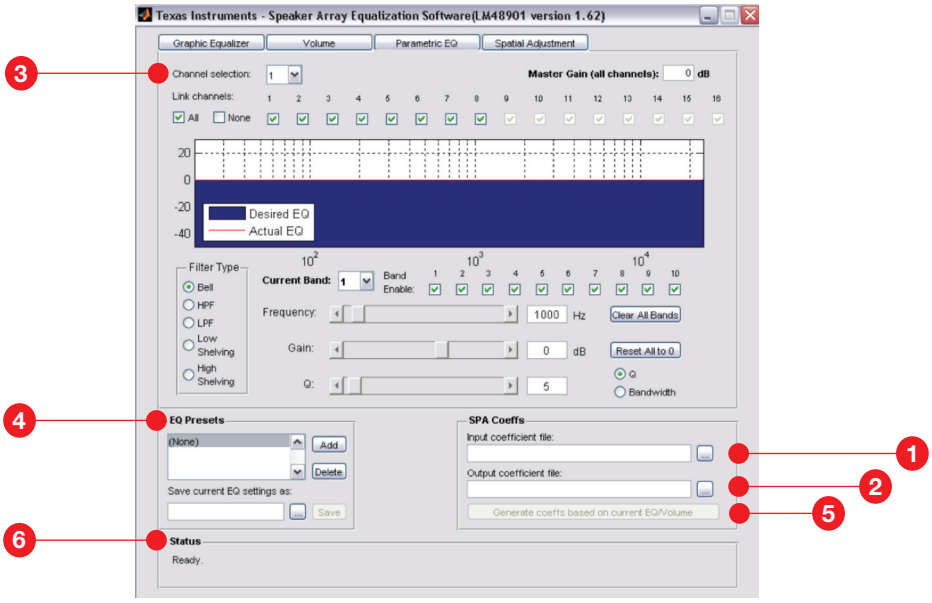


Figure 13 Parametric Equalizer Tool

Equalization, Spatial Effect Adjustment, and Volume Control

Volume Control

1. SPA Coeffs – Input Coefficient File
   Select the source coefficient file to add volume control to by browsing to the file or dragging and dropping the file into the text box. The source file will be unaffected by the volume control.

2. SPA Coefficients – Output Coefficient File
   Specify the volume control output coefficient file. If the output coefficient file of the volume control tool is the same coefficient file loaded into the Audio Panel Spatial Configuration Settings, the GUI will automatically update the LM48901 when Generate Coefficients is selected, and the coefficient file is modified.

3. Volume Control
   The volume control tool allows the channel volume to be set independently, or linked together. To set the same volume level across all channels, select All under Link Channels. To apply the same volume across select channels, deselect All and select the desired channel check boxes.

   Note: Applying different volume levels to individual channels may degrade the spatial effect.

4. EQ Presets
   The volume tool starts up with all channels set to 0dB, regardless of whether the input coefficient file contains equalization information or not. EQ presets allow volume control profiles to be saved and recalled. Create a new preset by clicking on the … button and specifying a file name and path. Select Add to add presets to the file menu.

5. Generate Coefficients based on current EQ
   Select Generate Coefficients based on Current EQ to create the new coefficient file.

6. Status
   This area displays short messages to indicate the results of various operations.

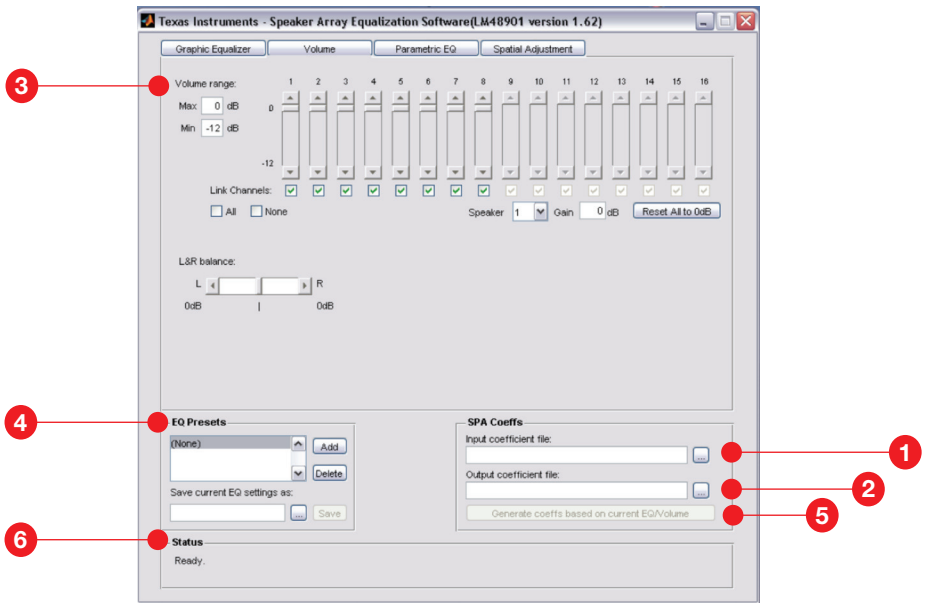


Figure 14 Channel Volume Control Tool

Equalization, Spatial Effect Adjustment, and Volume Control

Virtual Speaker Separation

1. SPA Coeffs – Input Coefficient File
   Select the source coefficient file to add spatial adjustment to browsing to the file or dragging and dropping the file into the text box. The source file will be unaffected by the spatial adjustment tool.

2. SPA Coefficients – Output Coefficient File
   Specify the spatial effect adjustment coefficient file. If the output coefficient file of the effect adjustment tool is the same coefficient file loaded into the Audio Panel Spatial Configuration Settings, the GUI will automatically update the LM48901 when Generate Coefficients is selected, and the coefficient file is modified.

3. Virtual Speaker Separation
   The speaker separation tool changes the perceived speaker separation width. Change the speaker separation by moving the slider between wide and narrow. The graphic below the slider reflects the angle of separation between the two virtual speakers.

4. EQ Presets
   The spatial effect adjustment tool starts up with the speaker separation set to 2x45°, regardless of whether the input coefficient file contains effect adjustment information or not. EQ presets allow effect adjustment profiles to be saved and recalled. Create a new preset by clicking on the … button and specifying a file name and path. Select Add to add presets to the file menu.

5. Generate Coefficients based on current EQ
   Select Generate Coefficients based on Current EQ to create the new coefficient file.

6. Status
   This area displays short messages to indicate the results of various operations.

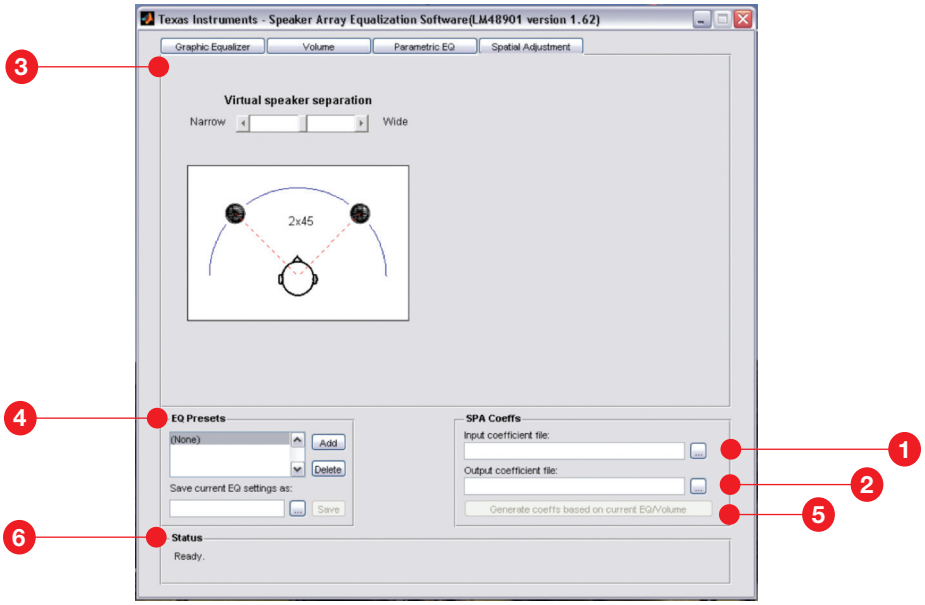


Figure 15 Spatial Effect Adjustment Tool

Appendix

Board Schematics

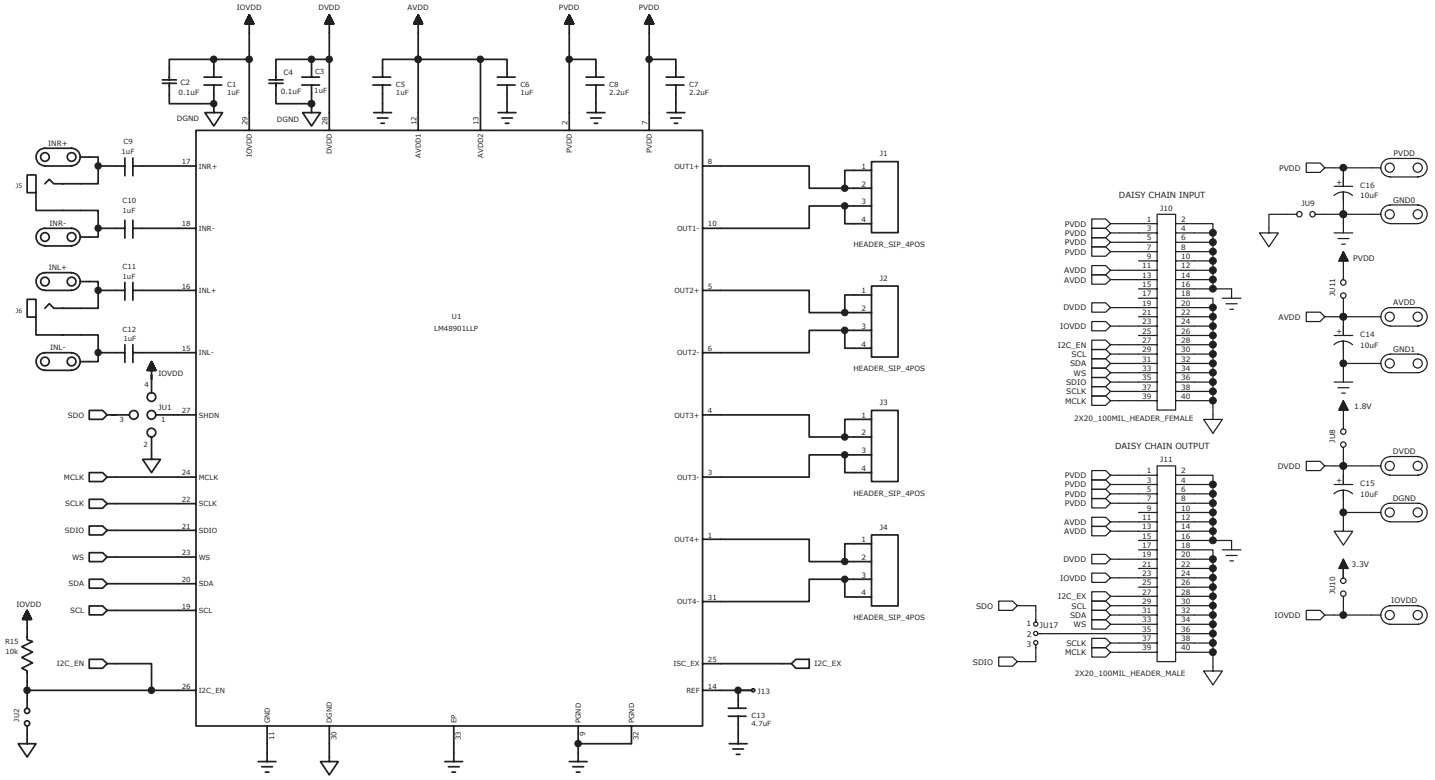


Figure 16 LM48901 Board Schematic Sheet 1

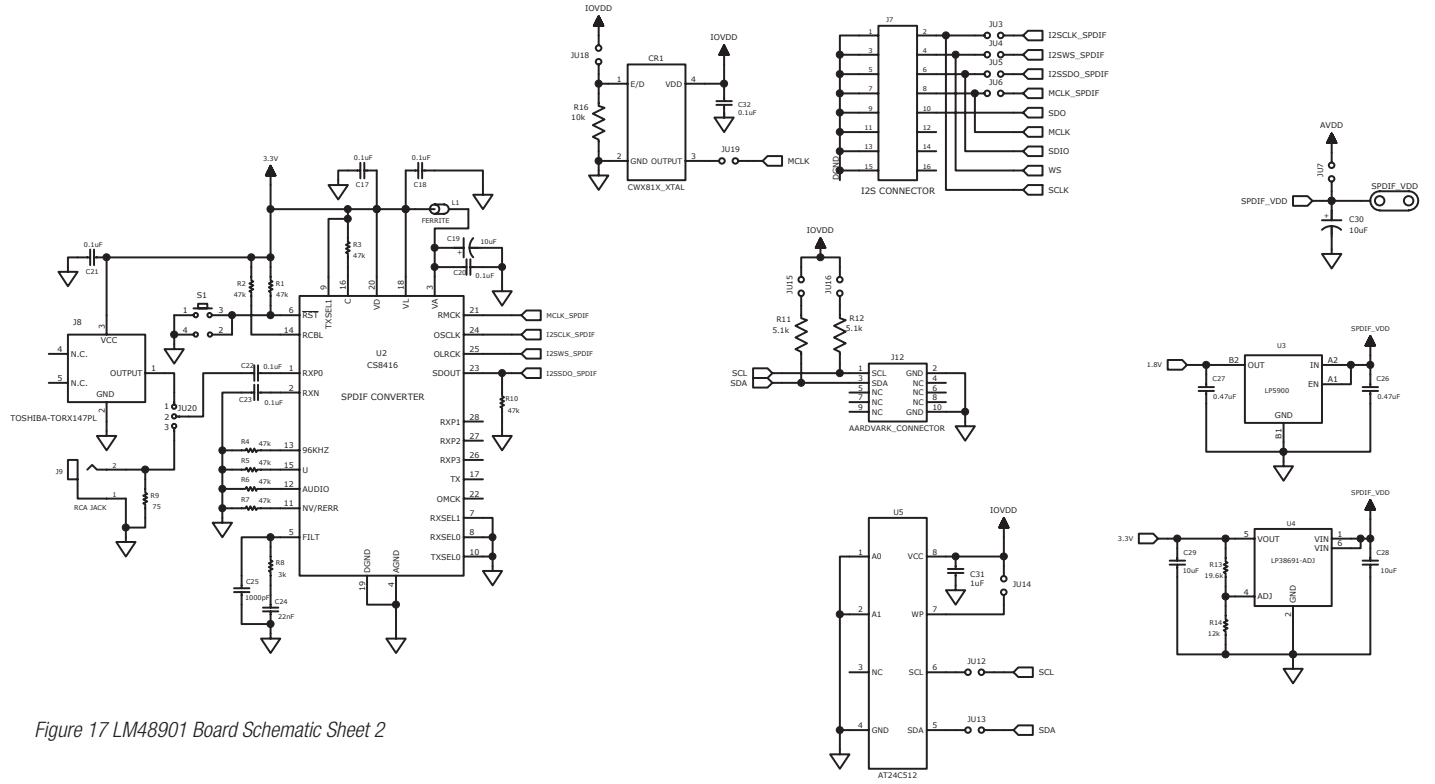


Figure 17 LM48901 Board Schematic Sheet 2

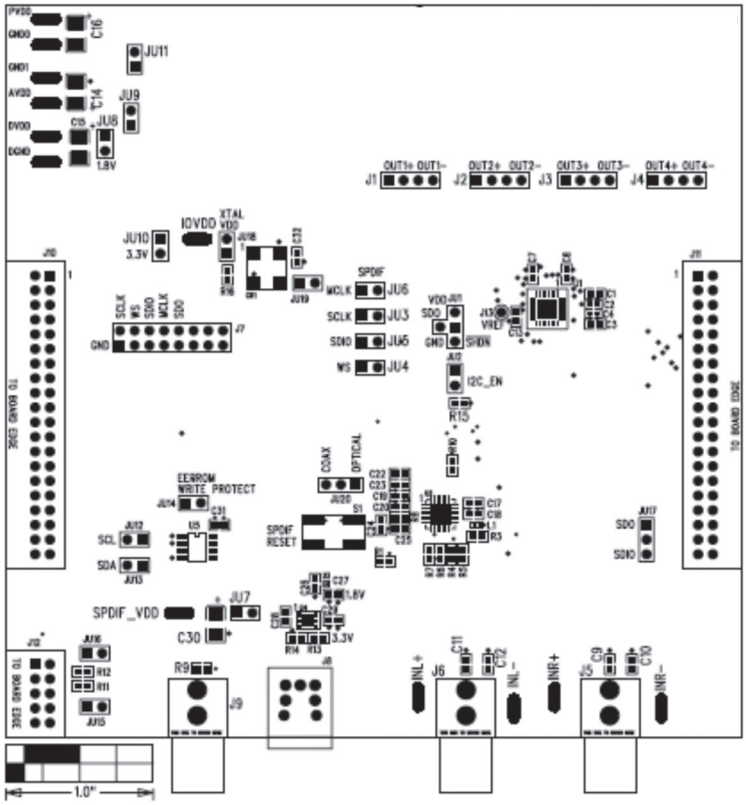


Figure 18 LM48901 Board Top Silkscreen

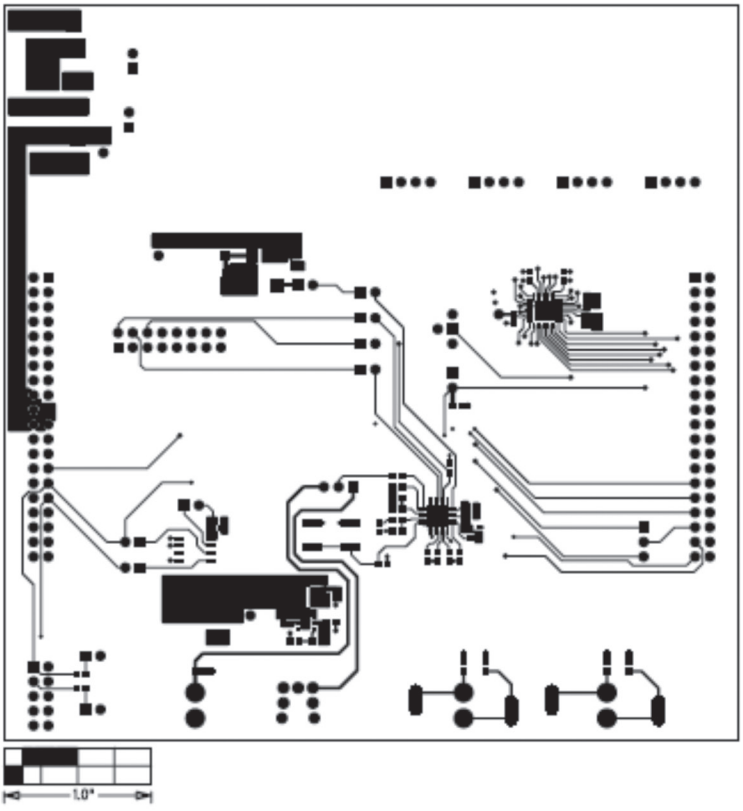


Figure 19 LM48901 Board Top Layer

Appendix

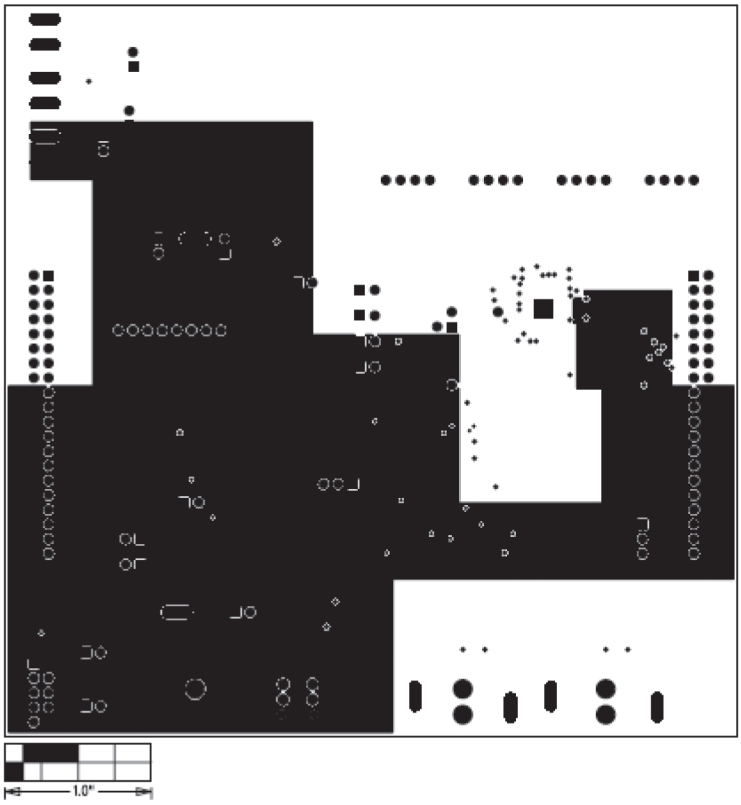


Figure 20 LM48901 Board Layer 2

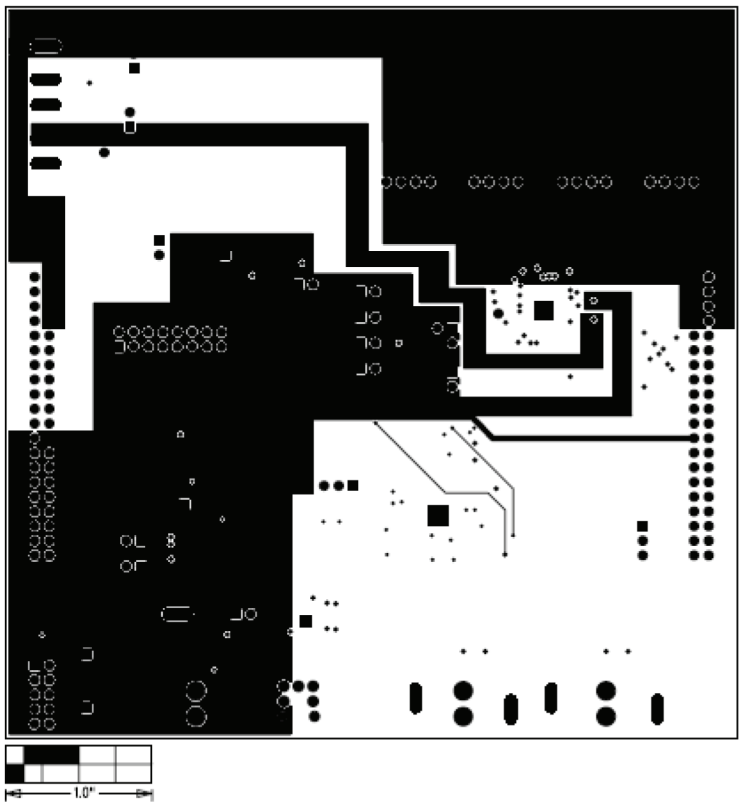


Figure 21 LM48901 Board Layer 3

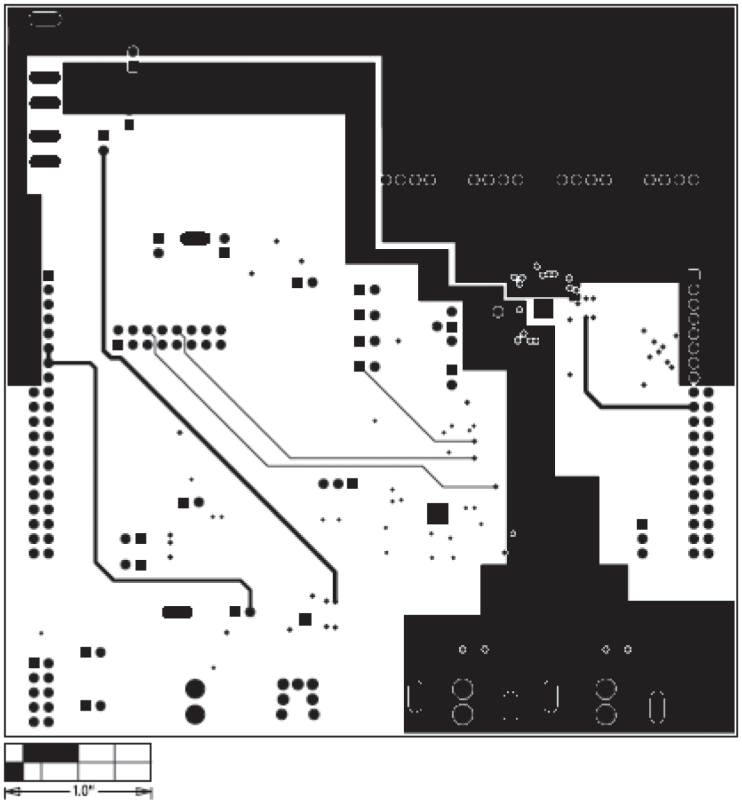


Figure 22 LM48901 Board Layer 4

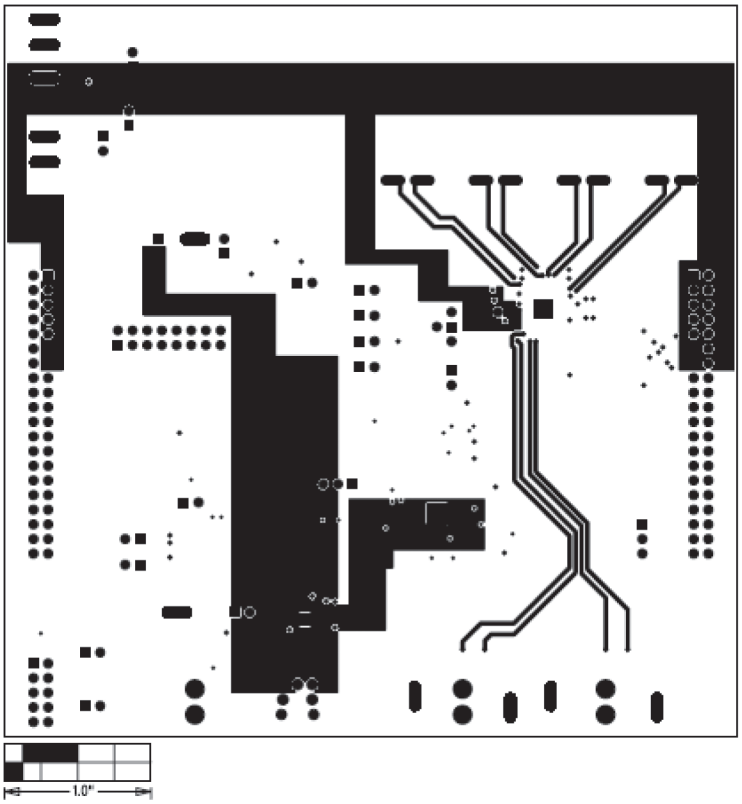


Figure 23 LM48901 Board Layer 5

Appendix

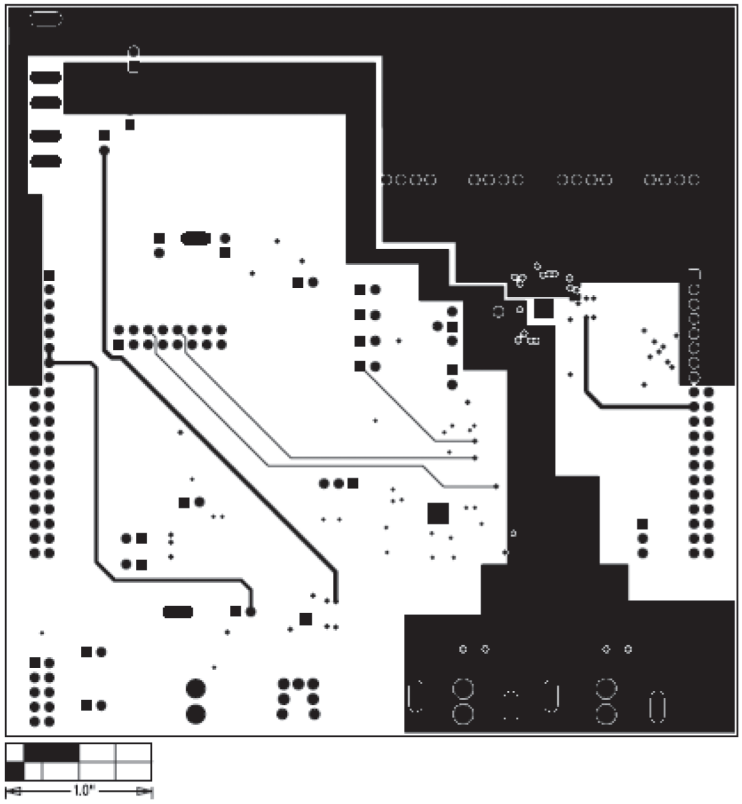


Figure 24 LM48901 Board Bottom Layer

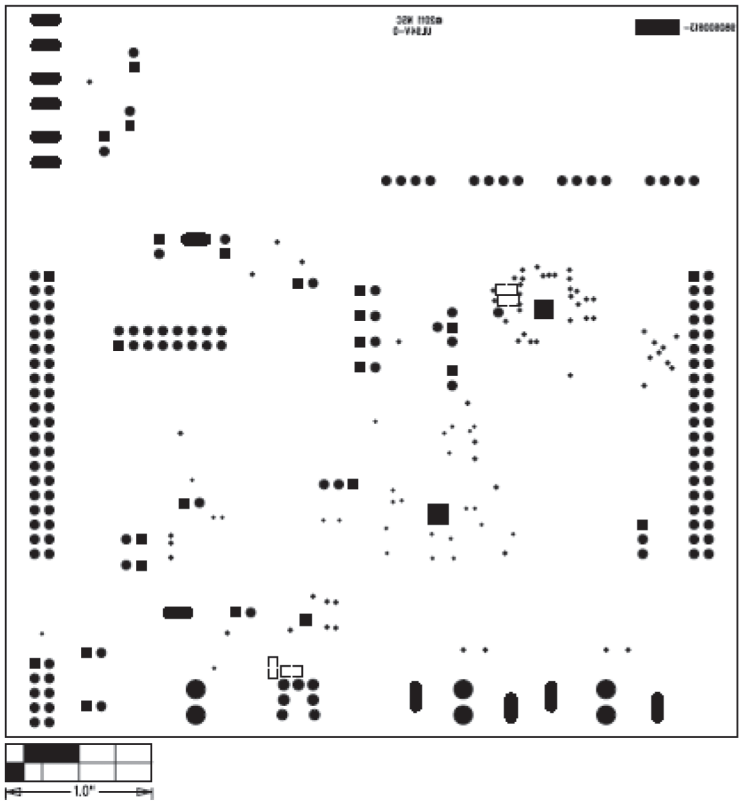


Figure 25 LM48901 Board Bottom Silkscreen

Appendix

Bill of Materials

RefDes	Part Description	Manufacturer #1	Manufacturer Part Number
C1, C3, C5, C6, C9-12	603 Ceramic Capacitor	Murata	GRM188R61C105KA93D
C13	603 Ceramic Capacitor	Murata	GRM188R60J475KE19D
C14-16, C30	B Case Tantalum	AVX	TPSB106K016R0800
C17, C18, C20-23, C32	603 Ceramic Capacitor	Murata	GRM188R71C104KA01D
C19	603 Tantalum Capacitor	AVX	TACL106M010XTA
C2, C4	402 Ceramic Capacitor	TDK	C1005X7R1C104K
C24	603 Ceramic Capacitor	Panasonic	ECJ-1VB1C223K
C25	603 Ceramic Capacitor	Panasonic	ECJ-1VC1H102J
C26, C27	603 Ceramic Capacitor	Murata	GRM188R71C474KA88D
C28, C29	603 Ceramic Capacitor	Panasonic	ECJ-1VB0J106M
C31	603 Ceramic Capacitor	Murata	GRM188R61C105KA93D
C7, C8	603 Ceramic Capacitor	Panasonic	ECJ-1VB1A225K
CR1	Crystal Oscillator	Connor-Winfield	CWX813-012.288M
DGND, DVDD, GND0, GND1, INL+INL-, INR+, INR-, IOVDD, AVDD, PVDD, SPDIF_VDD	2-pin Header	Tyco Electronics	87220-2
J10	40-pin Header, Right Angle	Samtec	SSW-120-02-G-D-RA
J11	40-pin Header, Right Angle	Samtec	TSW-120-08-G-D-RA
J12	10-pin Right Angle	Samtec	TSW-105-08-G-D-RA
J1-4	4-pin Header	Tyco Electronics	87224-4
J5	Mono RCA Jack, Right Angle	CUI	RCJ-042
J6	Mono RCA Jack, Right Angle	CUI	RCJ-043
J7	16-pin Header	Samtec	TSW-108-14-G-D
J8	Fiber Optic Receiver Module	Toshiba	TORX147PL(F,T)
J9	Mono RCA Jack, Right Angle	CUI	RCJ-044
JU1, JU17, JU20	3-pin Header	Tyco Electronics	87220-3
JU2-19	2-pin Header	Tyco Electronics	87220-2
L1	Ferrite Chip	Murata	BLM15PD300SN1D
R11, R12	603 Thick Film Resistor	Vishay	CRCW06035K10JNEA
R13	603 Thick Film Resistor	Panasonic	ERJ-3EKF1962V
R14	603 Thick Film Resistor	Panasonic	ERJ-3EKF1202V
R15, R16	603 Thick Film Resistor	Panasonic	ERJ-3GEYJ103V
R1-7, R10	603 Thick Film Resistor	Panasonic	ERJ-3EKF4702V
R8	603 Thick Film Resistor	Panasonic	ERJ-3EKF3001V
R9	603 Thick Film Resistor	Panasonic	ERJ-3EKF75R0V
S1	Momentary Push Button	Panasonic	EVQ-Q2K03W
U1	Spatial Audio Quad Array IC	Texas Instruments	LM489901SQ
U2	SPDIF Converter	Cirrus Logic	CS8416-CNZ
U3	LP5900TL-1.8	NSC	LP5900TL-1.8
U4	LP38691SD-ADJ	NSC	LP38691SD-ADJ
U5	I²C EEPROM	Atmel	AT24C512BN-SH25-T

TI Worldwide Technical Support

Internet

TI Semiconductor Product Information Center Home Page
support.ti.com

TI E2E™ Community Home Page
e2e.ti.com

Product Information Centers

Americas Phone +1(972) 644-5580

Brazil Phone 0800-891-2616

Mexico Phone 0800-670-7544

Fax +1(972) 927-6377
Internet/Email support.ti.com/sc/pic/americas.htm

Europe, Middle East, and Africa

Phone
European Free Call 00800-ASK-TEXAS (00800 275 83927)
International +49 (0) 8161 80 2121
Russian Support +7 (4) 95 98 10 701

Note: The European Free Call (Toll Free) number is not active in all countries. If you have technical difficulty calling the free call number, please use the international number above.

Fax +(49) (0) 8161 80 2045
Internet support.ti.com/sc/pic/euro.htm
Direct Email asktexas@ti.com

Japan

Phone	Domestic	0120-92-3326
Fax	International	+81-3-3344-5317
	Domestic	0120-81-0036
Internet/Email	International	support.ti.com/sc/pic/japan.htm
	Domestic	www.tij.co.jp/pic

Asia

Phone
International +91-80-41381665
Domestic Toll-Free Number

Note: Toll-free numbers do not support mobile and IP phones.

Australia 1-800-999-084
China 800-820-8682
Hong Kong 800-96-5941
India 1-800-425-7888
Indonesia 001-803-8861-1006
Korea 080-551-2804
Malaysia 1-800-80-3973
New Zealand 0800-446-934
Philippines 1-800-765-7404
Singapore 800-886-1028
Taiwan 0800-006800
Thailand 001-800-886-0010

Fax +8621-23073686
Email tiasia@ti.com or ti-china@ti.com
Internet support.ti.com/sc/pic/asia.htm

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46C and to discontinue any product or service per JESD48B. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265