AUDIOMAX DESIGN RESOURCE

AN-16

Microsemi
LINFINITY DIVISION

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INTRODUCING AUDIOMAX

The LX1710/1711 (Mono) and LX1721/1722 (Stereo) are high performance Class-D Controllers targeted for high efficiency audio requirements such as battery powered products, portable systems, or space constrained applications. Other ideal end products that can utilize Class-D switching technology include automotive amplifiers, multi-channel multimedia computers, and video game systems where maximum power density (output power per circuit area) is beneficial.

The LX1711/LX1722 are the high power mono/stereo versions (50Wrms/60Wrms x 2, 4Ω) with a supply voltage range of 7V-25V and the LX1710/LX1721 are the high fidelity mono/stereo versions (better SNR performance) with a supply voltage range of 7V-15V. The current rating of the external MOSFET's, the available supply voltage, and speaker load primarily determines the maximum output power.

The Class-D controllers are supported with complete audio amplifier evaluation modules. The amplifiers provide high fidelity performance and are designed to operate over the full 20Hz to 20kHz audio band. Signal distortion measurements yield THD+N levels of <0.06% (1kHz, 1Wrms). Efficiency is greater than 80%-85% typical, which eliminates the need for heatsinks in most applications. Reference designs are available to support a variety of requirements including multi channel systems, powered subwoofers, satellite/subwoofer combination products and various speaker loads (2Ω, 4Ω, 8Ω).

This design guide is intended to illustrate this versatile amplifier solution and demonstrate how to modify a design for frequency response, optimize for efficiency and performance, or design an amplifier to minimize PCB area and component count.

KEY FEATURES

- Integrated Switching Class-D Controllers
- Supports Full 20Hz-20kHz Audio Bandwidth
- High Fidelity (LX1710 Mono/LX1721 Stereo) Or High Power (LX1711/LX1722) Versions
- Single Supply Operation
- THD+N <0.06% Typical (1Wrms, 1kHz, 4Ω)
- Maximum Efficiency 80%-85%
- Output Power >60Wrms per Channel (LX1722, 4Ω, 1% THD+N)
- Reference Designs Available For >100W Applications
- PSRR –70dB Typical
- Differential Input To Minimize Noise Effects
- Synchronization to Support Multi-Channel Systems
- Complete Amplifier Evaluation Modules

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APPLICATIONS

- Multimedia Speakers
- Surround Sound Game Systems
- Automotive Amplifiers And Head Units
- Wireless Speakers
- Desktop Computers
- Battery Operated Equipment (Megaphone, Public Address System)
- Portable Audio (Boom Box)
- High Power Subwoofer
- Notebook Computers
- Home Theatre

AUDIOMAX CONTROLLERS

Part Number	Product	Description
LX1710CDB	AudioMAX High Fidelity Mono Controller IC	V_{DD} = 7V to 15V, Switching Class-D Mono Power Amplifier IC, 28-Pin SSOP Package.
LX1711CDB	AudioMAX High Power Mono Controller IC	V_{DD} = 7V to 25V, Switching Class-D Mono Power Amplifier IC, 28-Pin SSOP Package.
LX1721CDB	AudioMAX High Fidelity Stereo Controller IC	V_{DD} = 7V to 15V, Switching Class-D Stereo Power Amplifier IC, 44-Pin QSOP Package.
LX1722CDB	AudioMAX High Power Stereo Controller IC	V_{DD} = 7V to 25V, Switching Class-D Stereo Power Amplifier IC, 44-Pin QSOP Package.

TABLE 1 – AUDIOMAX CONTROLLERS

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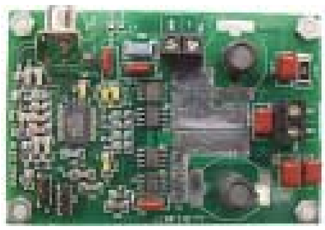
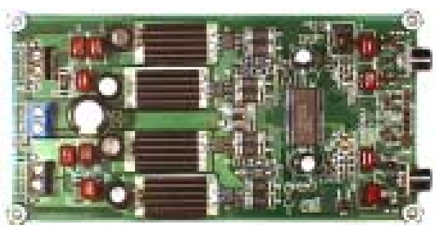
AUDIOMAX CONTROLLERS WITH EVALUATION BOARDS



LXE1710

LXE1711

LX1711-100 Buffer



LXE1721

LX1721-HV Driver

LXE1722

IC	EVALUATION BOARDS	TYPICAL OUTPUT POWER (4Ω, <1% THD+N)	TYPICAL OUTPUT POWER (2Ω, <1% THD+N)
LX1710	LXE1710	25W	~40W
LX1711	LXE1711 LXE1711-100 Buffer	50W 60W	~50W 120W
LX1721	LXE1721 LX1721-HV Driver	25W x 2 50W x 2, 250W x 1	~40W x 2 400W
LX1722	LXE1722	60W x 2	120W x 2

TABLE 2 – AUDIOMAX IC & EVAL BOARD INFO

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OUTPUT POWER CAPABILITY

Since the LX1710/1711/1721/1722 are Class-D controllers, the maximum output power is virtually unlimited and primarily a function of the current rating of the external MOSFET's, the available supply voltage, and the speaker load. The following output power values (derived from Audio Precision plots using evaluation boards) are shown for various loads and supply voltages at <1% THD+N, 1kHz. The plots are available in the controller datasheets.

VDD	LOAD (Ω)	OUTPUT POWER (TYPICAL WRMS)
15V	4Ω	25W
15V	2Ω	42W
25V	4Ω	63W
25V	2Ω	110W*

*Care must be exercised to provide adequate thermal conductivity.

Table 3 – Output Power & Load

Although power rating standards have been established such as FTC (Federal Trade Commission) or EIA (Electronic Industries Association), discussion involving power numbers does not always follow these guidelines. The "watts per channel" number could actually be "peak" power, "music" power, or "peak music power output" (PMPO) which are inflated numbers over their true W_{RMS} capability. Furthermore, conditions such as distortion level, input frequency band, and filter range should be specified. The output power numbers for the LX17xx Class-D amplifier series are specified as continuous W_{RMS} values. For the high power applications, care must be exercised to provide adequate thermal management for continuous operation at these levels.

Microsemi Class-D amplifiers support a wide range of maximum power levels from 25Wrms (<1%THD+N, 4Ω) to over 400Wrms (<1%THD+N, 2Ω). These configurations are available as evaluation boards and reference designs.

SCHEMATIC FOR LXE1710

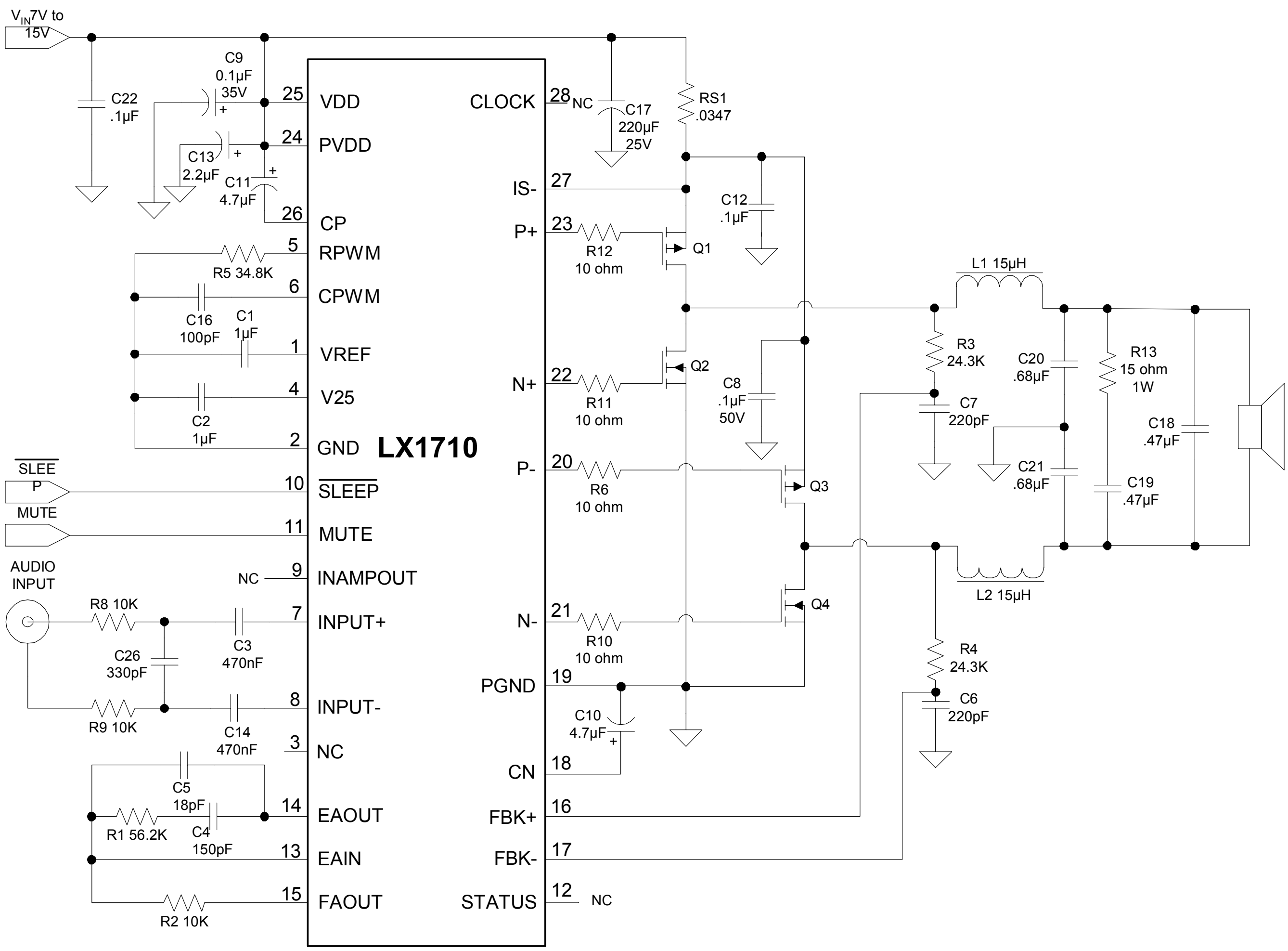


Figure 1 – LXE1710 Mono Evaluation Amplifier

SCHEMATIC FOR THE LXE1721

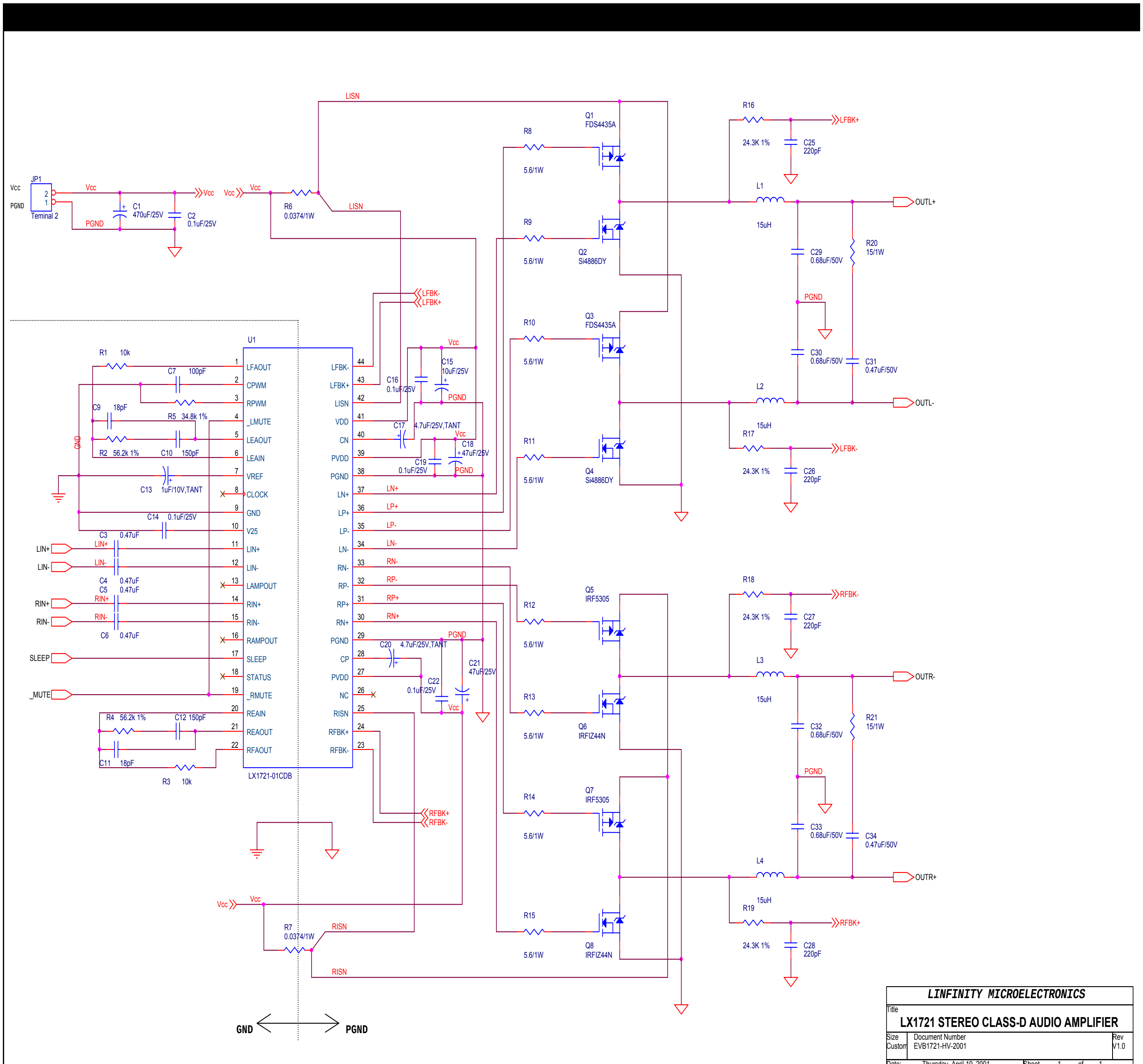


Figure 2 – LXE1721 Mono Evaluation Amplifier

CLASS-D CONTROLLER BLOCK DIAGRAM

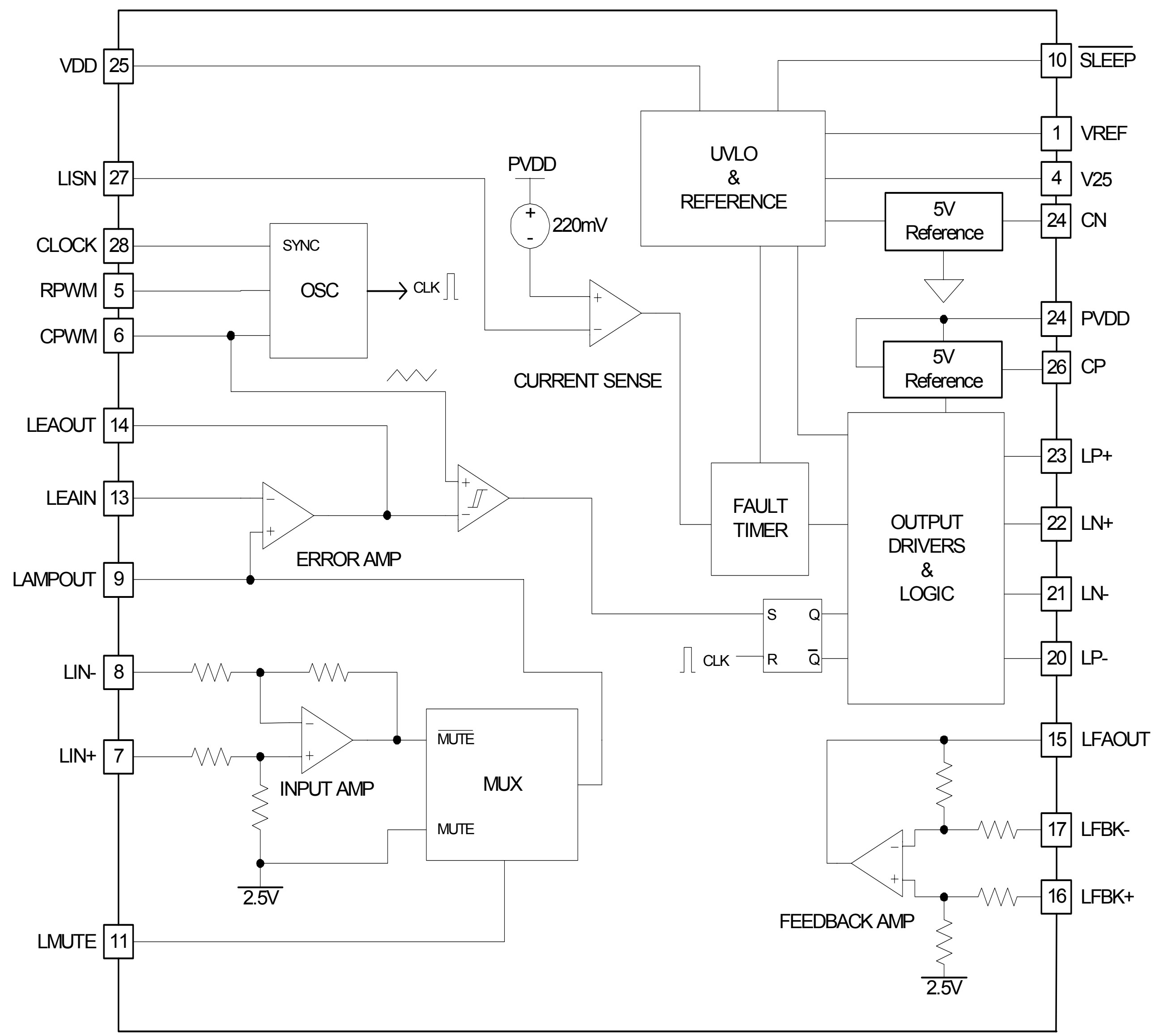


Figure 3 – Simplified Block Diagram (One Channel Shown)

CIRCUIT DESCRIPTION

The Microsemi Class-D Controllers require a minimal number of external components to create a complete amplifier solution. A Class-D Amplifier is a “switching” amplifier that converts a low-level, analog audio input signal into a high power, pulse-width modulated (PWM) output. Each channel consists of a control loop that adjusts the PWM output to “track” the audio input signal. The switching frequency (450kHz typical but can be adjusted) is much higher than the audio bandwidth (20Hz to 20kHz), and is easily filtered out with a simple LC filter. The support circuitry can be generally grouped into three areas (input circuit, output power stage, and output filter).

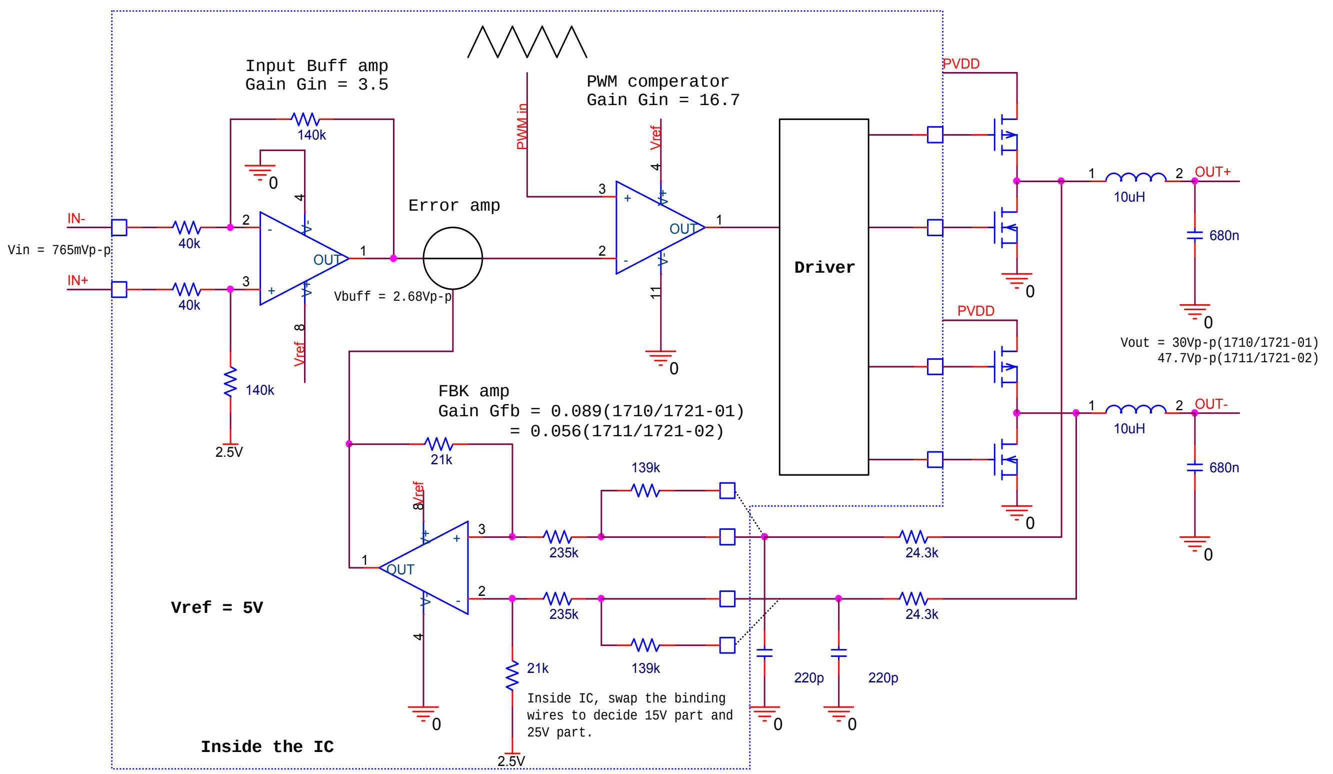
INPUT SECTION AND COMPENSATION

The first group is the input section, compensation network and control setting components. These resistors and capacitors set up the controller operating frequency, response characteristics, and comparator ramp fundamental to Class-D operation. The controllers have differential signal inputs, LIN+ (RIN+) and LIN- (RIN-) to reduce input noise. The input amplifier has a gain 3.5V/V (+10.9dB), and 42kΩ input impedance. Adding serial external resistors with IN+ and IN- can reduce the input amplifier gain. For example, if 100kΩ resistors are added to the input, the gain will be reduced to 1V/V (0dB), also increasing the input impedance to 140kΩ. The differential audio input is AC coupled into the LXE1721 via an external pair of capacitors C3/C4 and C5/C6 (C3/C14 for the LXE1710/1711). The internal op-amp level shifts the input signal to 2.5 volts as seen in the System Gain Diagram.

Error Amplifier: The input amplifier’s output is fed to the error amplifier. The output of the feedback amplifier is also fed to the error amplifier. The error amplifier integrates the “error signal” (integrates the difference between the audio input and the feedback signal). The output of the error amplifier represents the desired audio output signal.

PWM Generator: The output of the error amplifier (LEAOUT and REAOUT for the LX1721) and a voltage ramp waveform are connected to a comparator. The voltage ramp repeats at the switching frequency which is much greater than the audio band. At the beginning of the ramp, the comparator output is reset high. When the ramp voltage exceeds L/REAOUT, the comparator output switches low. Thus, the pulse-width or duty-cycle of the comparator output is proportional to the voltage at L/REAOUT. The comparator output is latched into a flip-flop which drives the external MOSFETs to complete the control loop. The action of the control loop causes the PWM output to accurately track the audio input signal.

SYSTEM GAIN DIAGRAM

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Gain caculation:
At error amp, the signal level should be same, we have
Vin x Gin = Vout x Gfb
So, the whole system Gain = Vout/Vin = Gin/Gfb ;
At LX1710/LX1721-01 :Gain=3.5/0.089=39.2 V/V(31.9dB);
At LX1711/LX1721-02 :Gain=3.5/0.056=62.3 V/V(35.9dB);
```

Figure 4 – System Gain

OUTPUT STAGE AND FEEDBACK AMPLIFIER

The next section is the output stage. The controller IC generates a PWM output by controlling external FETs connected in a full bridge configuration. The full bridge configuration is connected between the single supply voltage (PVDD) and ground (PGND) with the output of the bridge driving the LC filter stage which removes the switching frequency component of the PWM output prior to driving the speaker. Because the FETs are either fully "on" or fully "off", Class-D topology is extremely efficient (up to 85% typical), circuit power dissipation is minimal, and maximum power is delivered to the speaker.

Feedback Control: Each bridge output also drives an RC low pass filter (R16-R19/C25-C28 for LXE1721, R3-R4/C6-C7 for LXE1710/1711) which provides the feedback for the control loop through the FBK+ and FBK- inputs. Internal to the controllers, these two differential feedback inputs are converted to a single-ended signal by the feedback amplifier. The feedback amplifier also attenuates the feedback signals and level shifts its output to 2.5 volts. The "High Fidelity" LX1721 and "High Power" LX1722 have different feedback loop gain. The LX1721 stage gain is approximately 91mV/V (-21dB) and the LX1722 approximately 57mV/V (-25dB). Feedback resistors internal to the IC as seen in the System Gain Diagram control this feedback gain.

FILTER STAGE

The single stage, second order LC filter is used to remove the switching frequency and reconstruct the amplified audio signal. The frequency response and corner frequency can be easily adjusted for optimization of various loads. The LC evaluation board component values have been chosen for a 4Ω load. See section on LC filter design for component selection.

APPLICATION INFORMATION

THD + N vs. Output Power (4Ω, 1kHz)
LX1710 Filter Implementation, 1-stage vs. 2- stage

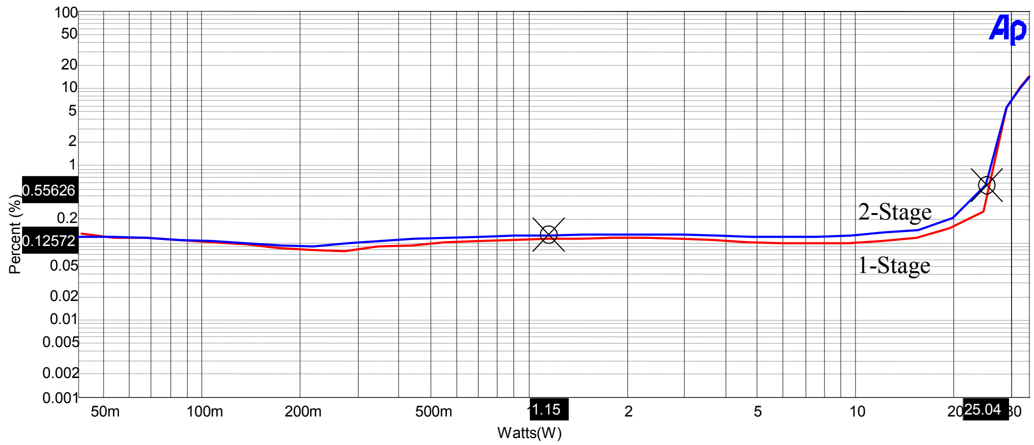

Figure 5

FILTER DESIGN TRADEOFFS (1-STAGE VS. 2-STAGE)

A 1-stage or 2-stage filter may be used depending on your application and performance targets. The main tradeoff in this selection is price (number of components, component costs, PCB area) vs. performance. The primary advantage of the single stage filter is lower cost whereas the main benefit to a 2-stage filter is that it will provide steeper attenuation. This allows the corner frequency to be selected further outside of the audio band (to minimize the effects of impedance variations in the passband) and still provide adequate RF attenuation. Normally, the single stage design is adequate to filter out the switching frequency. However, in some applications such as long speaker wire systems, a two stage approach may offer other advantages.

Single Stage Filter Advantages

- Low Cost: The 1-stage LC filter uses one half the number of inductors/capacitors resulting in a substantial cost savings over a 2-stage design. Key parameters such as THD+N, frequency response, and nose performance do not change significantly.
- Power Loss: Since current will flow in two inductors and not four, the inductor power loss will be less in the single stage design. The overall amplifier will have a wider dynamic range and improved efficiency.
- Filter Design: This easy-to-design filter can limit audio signal changes within +/- 3dB across the audio band with impedance

variance from 2Ω to approximately 8Ω. Due to a steeper rolloff with the 2-stage filter, impedance changes could result in a +/- 6dB change.

- THD: There are minimal differences between the 1-stage and 2-stage implementations with other parameters such as THD+N as seen in the above graph.

Single Stage Filter Disadvantages

- EMI and Switching Frequency: For the 1-stage, the switching frequency must be higher than 400kHz to ensure the corner frequency will provide adequate amplifier performance in the high end of the audio frequency range. If f_S < 400kHz, then $f_C < f_S$ /10 = 40kHz which is too close to the desired audio band. A higher oscillation frequency could translate into greater MOSFET switching losses, slightly lower efficiency, and increased EMI effects. With a 2-stage 4th order filter, the switching frequency f_S can be reduced to 120kHz. If f_S = 120kHz, then f_C = f_S /3 = 40kHz. The lower oscillation frequency could help minimize EMI issues.

LC FILTER DESIGN

The output filter helps to reconstruct the amplified audio signal and filter out the switching frequency. The design of the filter depends on the type of attenuation and frequency response desired at the output. The output filter designed into the LXE1710/1711 and LXE1721 evaluation boards are a second order, LC type filter as shown below. Tradeoffs between performance and component cost must be considered when determining the complexity or type of filter selected.

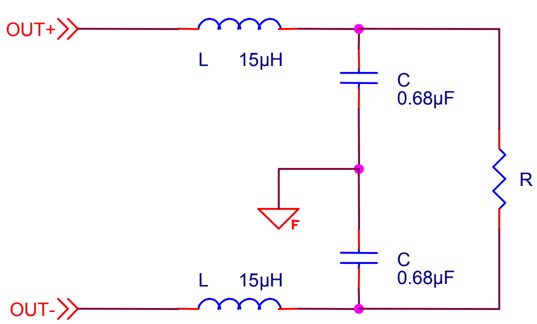

Figure 6

Its Laplace Transform function is:

$$H(S) = \frac{\frac{S}{C}}{S^2 + \frac{1}{RC}S + \frac{1}{LC}} = \frac{\frac{S}{C}}{S^2 + \frac{\omega}{Q}S + \omega^2}$$

Where $\omega = \frac{1}{\sqrt{LC}}$

$$Q = RC\omega$$

The Class-D amplifier evaluation board design has a pass-band of 20Hz to 20kHz to support the audio frequency range and is configured to utilize a switching or oscillator frequency f_s = 500kHz. Depending on the application, this oscillator frequency may be adjusted (see section on Oscillator Configuration) to optimize amplifier performance or modified for other considerations such as EMI effects. Further requirements of the filter are that the pass band attenuation of switching frequency f_s should be lower than 40dB and the corner frequency of the LC filter should be set higher than 20kHz to avoid attenuating audio signals in the desired audio band by more than 1dB. A speaker DC impedance of 4Ω with an f_C = 50kHz corner frequency are defined for the evaluation board.

The Q (selectivity factor or ratio of the center frequency divided by the bandwidth) of the filter must also be considered when designing a filter. Too high a Q will result in a boost of the audio signal across the audio band whereas a low Q will cause too much attenuation of the signal. A Q value of 0.707 provides the required audio response and is used in the calculation below.

$$C = \frac{Q}{R\omega} = \frac{Q}{R(2\pi f_C)} = \frac{0.707}{4(2\pi)(50000)} = 0.56\mu F$$

$C = 0.68\mu F$ is used in the Evaluation Board

To Compute the Inductor Value:

$$L = \frac{1}{\omega^2 C} = \frac{1}{(2\pi f_C)^2 C} = \frac{1}{[(2\pi)(50000)]^2(.68\mu)} = 14.9\mu H$$

$L = 15\mu H$ is used in the Evaluation Board

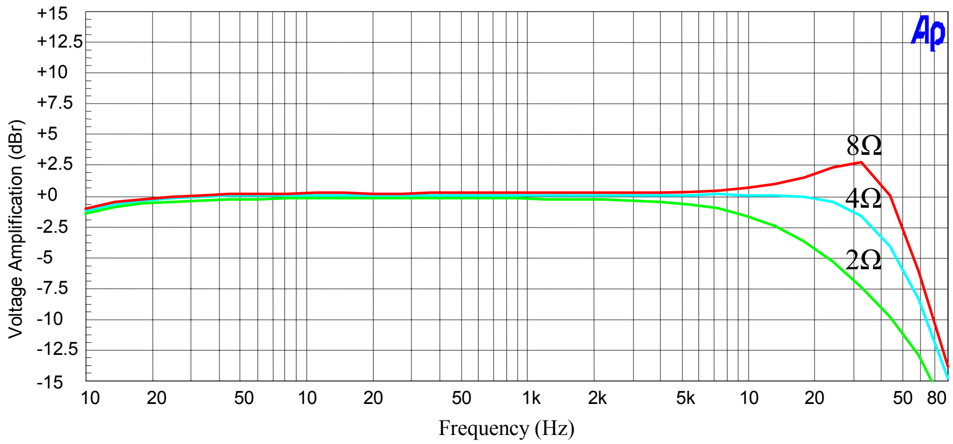

Figure 7 – LXE1710 Evaluation Board, Frequency Response

Frequency response of the audio amplifier was measured using various speaker load impedances 2Ω, 4Ω, and 8Ω. The graphs verify that the filter calculations were based on a 4Ω speaker. The 8Ω and 2Ω curves display a 2dB boost and a –4dB attenuation respectively. Therefore, to improve frequency response performance for other loads, the value of Q must be increased/decreased by changing the capacitor. Since a different value C will affect the corner frequency, values for L and C must be recalculated. Below are recommended inductor and capacitor values for 2Ω, 4Ω, and 8Ω loads for this single stage LC filter design.

	CAPACITOR C (µF)	INDUCTOR L (µH)
2Ω	1.0	10
4Ω	0.68	15
8Ω	0.47	22

Table 4 – Filter Component Values

Please note: These recommended values are guidelines for speaker loads. Actual speakers have varying impedances, which may require revised filter calculations and optimization. Furthermore, your application may have different design goals than those chosen for the AudioMAX evaluation boards.

MOSFET SELECTION

As seen in previous sections, the user can design the output filter of the amplifier to meet performance or costs targets. In addition, the amplifier's power stage (selection of MOSFETs) can be selected depending on these tradeoffs. The efficiency of the amplifier circuit can be approximated by the following equation.

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{I^2 R_L}{I^2[2(R_{NDS} + R_{PDS} + R_{IND}) + R_L] + P_{CROSS} + P_{IC} + P_{SEN}}$$

Where

R_L	=	DC Resistance of Speaker
R_{NDS}	=	n-channel MOSFET on-resistance
R_{PDS}	=	p-channel MOSFET on-resistance
R_{IND}	=	DC Resistance of Inductor
P_{CROSS}	=	MOSFET Switching Loss
P_{IC}	=	IC Power Consumption
P_{SEN}	=	Sense Resistor Loss

The overall efficiency is a function of primarily the MOSFETs and output filter inductors. The "Inductor" section's contribution will be considered later. The MOSFET Power loss is a function of the on-resistance and gate charge.

On-Resistance, R_{DS}:

$$\text{MOSFET Power Loss} = P_{DS} = I^2[2(R_{NDS} + R_{PDS})]$$

$$\text{If} \qquad P_O = 25W \text{ at } 4\Omega$$

$$\text{Then} \qquad I = \sqrt{\frac{P}{R}} = \sqrt{\frac{25}{4}} = 2.5A$$

The LX1710 Evaluation Board is designed using FDS4953 p-channel and FDS6612A n-channel MOSFETS.

$$R_{NDS} = 0.03\Omega, \quad R_{PDS} = 0.095\Omega$$

$$P_{DS} = (2.5)^2[2(0.03 + 0.095)] = 1.56W$$

MOSFET power loss is proportional to on-resistance.

Total Gate Charge, Q_g:

$$\text{MOSFET Switching Loss} = P_{CROSS} = CV^2 f_s n$$

Where

C = Input Capacitance

V = Supply Voltage
f_S = Switching Frequency
n = Number of MOSFETS

Assume C = 1000pF
V = 15VDC
f_S = 500kHz

$$P_{CROSS} = (1\times10^{-9})(15^2)(500\times10^3)(4) = 0.45W$$

MOSFET switching loss is proportional to total gate charge, supply voltage, and switching frequency.

There are a few other important parameters to consider when selecting the output power components besides the on-resistance and gate charge of the MOSFETs. The drain-source voltage must provide ample margin for circuit noise and high speed switching transients. Since the amplifier configuration requires output bridge operation at the supply voltage, the MOSFETs should have a drain-source voltage of at least 25% - 50% greater than the supply voltage. The power dissipation of the MOSFETs should also be able to dissipate the heat generated by the internal losses and be greater than the sum of P_{DS} and P_{CROSS}. MOSFETs with R_{DS} < 0.10Ω are recommended.

The Class-D controller's gate drive capability determine MOSFET selection related to key parameters of total gate charge (Qg) and gate capacitance (Ciss). Although the controllers can drive a wide range of FETs, too high a drive current can result in increased temperature and power dissipation. The LX1721 driving Ciss = 3300pF with a switching frequency of 450kHz at room temperature 28°C could approach a case temperature greater than 100°C. Therefore, Qg < 25nC and Ciss < 2200pF are recommended for the LX1721 and Qg < 15nC and Ciss < 1500pF for the LX1710/1711. If higher value gate charge MOSFETs are used, reducing the switching frequency may be helpful.

Other important considerations are Turn-ON delay (Tdon), Turn-OFF delay (Tdoff), Rise time (Tr) and Fall time (Tf). The LX1721 has 35ns typical dead time control. If the rise/fall times Tdon/Tdoff are too long, MOSFET shoot-through, higher switching losses, or pulse skipping when the output signal level is close to PVDD level could occur resulting negatively on THD (0.1% to 0.5%).

MOSFET Selection Guide Summary

- Vds > Power Supply Voltage by a minimum of 25% ~ 50% greater
- Use Logic level MOSFET (4.5V-5V gate voltage)
- R_{DS}(on) < 0.10Ω is typical, but lower values are better.
- Ids > Irms through the MOSFET
- Total gate charge Qg < 25nC (LX1721), 15nC (LX1710/1711)
- Ciss gate capacitance < 2200pF (LX1721), 1500pF (LX1710/1711)

The table below provides several MOSFET options.

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P/N	Channel	Vds	Rds(on) @10.0V	Rds(on) @4.5V	Id(A) max	Qg(nC) typ.	Package	Source
Si4886DY	Single N	30	0.01	0.013	13	14.5	SO8	Vishay
Si4884DY	Single N	30	0.01	0.016	12	15.3	SO8	Vishay
Si4882DY	Single N	30	0.01	0.02	11	13.5	SO8	Vishay
Si4416DY	Single N	30	0.018	0.028	9	13	SO8	Vishay
Si4800DY	Single N	30	0.018	0.033	9	8.7	SO8	Vishay
FDS4410	Single N	30	0.0135	0.02	10	13	SO8	Fairchild
FDS6614A	Single N	30	0.018	0.025	9.3	12	SO8	Fairchild
FDS6612A	Single N	30	0.022	0.03	8.4	9	SO8	Fairchild
Si4431ADY	Single P	-30	0.03	0.055	-7	15	SO8	Vishay
Si4953DY	Dual P	-30	0.053	0.095	-4.9	16	SO8	Vishay
Si4953ADY	Dual P	-30	0.053	0.09	-4.9	15	SO8	Vishay
FDS6975	Single P	-30	0.032	0.045	-6	14.5	SO8	Fairchild
FDS4435	Single P	-30	0.02	0.035	-8.8	17	SO8	Fairchild
Si4539ADY	N P	30 -30	0.036 0.053	0.053 0.09	5.9 -4.9	13 15	SO8	Vishay
Si4539DY	N P	30 -30	0.037 0.053	0.055 0.095	5.8 -4.9	16 16	SO8	Vishay
Si4558DY	N P	30 -30	0.04 0.04	0.06 0.07	6 -6.0	17 22	SO8	Vishay
Si4532ADY	N P	30 -30	0.053 0.08	0.075 0.135	4.9 -3.9	8 10	SO8	Vishay
Si4532DY	N P	30 -30	0.065 0.085	0.095 0.19	3.9 -3.5	9.8 8.7	SO8	Vishay
FDS8958A	N P	30 -30	0.028 0.052	0.04 0.08	7.0 -5.0	16 14	SO8	Fairchild
IRF7309	N P	30 -30	0.05 0.1	0.08 0.16	4.0 -3.0	25 25	SO8	IR
IRF7379	N P	30 -30	0.055 0.13	0.075 0.18	5.8 -4.3	25 25	SO8	IR

*Please refer to Manufacturer's Datasheets for latest specifications

Table 5 – Mosfet Selection Guide

INDUCTOR SELECTION

The output filter inductors are key elements in the performance of a Class-D audio power amplifier. Inductor selection criteria also involves tradeoffs between performance (efficiency) and component costs. The critical specifications for the inductor are the DC resistance (lower value equates to less power loss), DC current, and peak current ratings. The rated current specification must be greater than the current through the inductors. Inductance vs. current data should also be reviewed for inductance loss at rated DC current (<15% is recommended). The inductors should be able to handle the amplifier's power as well as operate within its linear region. Saturating the inductors could decrease performance (increase THD) and even produce a short, which can damage either the circuit or the speaker.

Certain variables when selecting an inductor depend on the switching frequency of the designed amplifier. A higher switching frequency implies that the corner frequency of the LC filter can be higher. With a higher f_C, the inductor value is smaller (and case size reduction). Other characteristics such as SRF (self resonant frequency) must be considered. The SRF should be at least greater than the 7th harmonic of the switching frequency.

The amplifier's application and design constraints will help determine whether the inductors are selected for size, power, or performance. Various inductors such as those that are shielded may also have different EMI effects and distortion performance. The overall efficiency (η) of the amplifier circuit is given in the previous MOSFET section. The inductor's power loss contribution is a function of the inductor's DC resistance, R_{IND}.

Inductor DC Resistance, R_{IND}:

$$\text{Inductor Power Loss} = P_{IND} = (I^2)(2)(R_{IND})$$

The LXE1710 and LXE1721 Evaluation boards utilize 15µH radial leaded R.F. inductors from Inductor Supply, Inc. (ISI). When evaluating component options, inductors such as from Coilcraft can be used for other performance / price tradeoffs. See inductor table below.

$$P_{IND} = (2.5^2)(2)(.056) = 0.7W$$

The efficiency approximation can now be completed.

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{I^2 R_L}{I^2[2(R_{NDS} + R_{PDS} + R_{IND}) + R_L] + P_{CROSS}}$$

$$\eta = \frac{I^2 R_L}{P_{DS} + P_{IND} + P_{CROSS} + I^2 R_L}$$

$$\eta = \frac{25}{1.56 + .7 + .45 + 25} = 90.2\%$$

The efficiency is a function of the power and switching loss in the MOSFETs and inductors.

Manufacturer	Part Number	Inductance (µH)	Q min	Test Frequency	DC Resistance max (mΩ)	DC Current max (A_{RMS})	Self Resonant Frequency min (MHz)
ISI	RL622-150K	15.0	50	2.520MHz	56	2.50	12.0
Coilcraft	DO5022P-153HC	15.0		100kHz	32	4.4	20

Table 6 – Inductor Component Options

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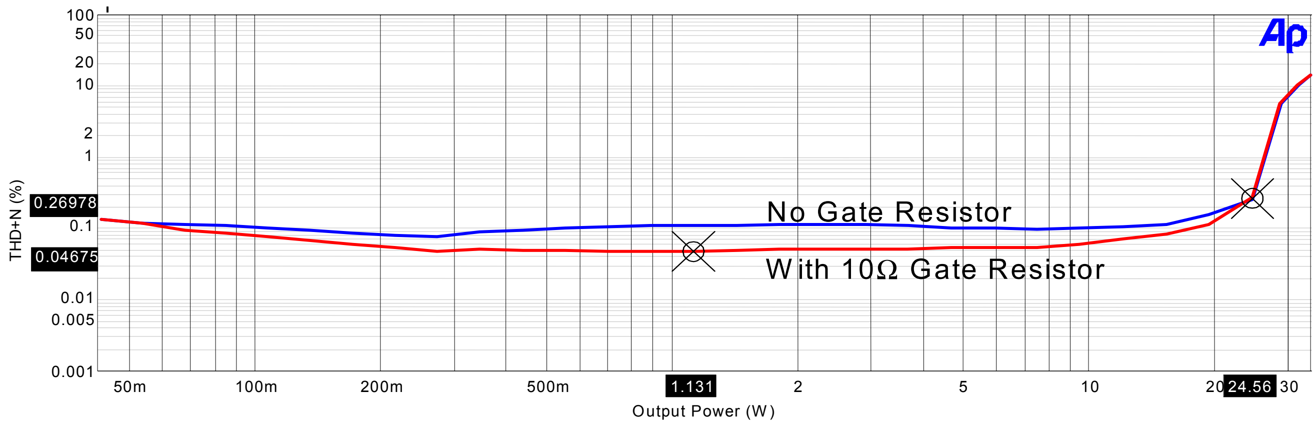
CAPACITOR SELECTION

The LC filter design section discusses filter options and the calculation of component values. However, the specification of capacitor type depends on the application in the circuit. The table provides descriptions and guidelines for capacitors in the LX1710 AudioMAX amplifier boards.

Reference Designator	Capacitor	Comments
C10, C11	FET gate drive	These 4.7µF tantalum capacitors are charge transfer capacitors for the FET gate drive.
C3 C14	Audio input path	These decoupling capacitors are used for the audio input +/- signals.
C18, C19, C20, C21	Output filter	The output filter metal film capacitors (low ESR, 5% tolerance) work well to set an accurate corner frequency at a low cost.
C8, C12	FET bypass	These metal film capacitors are used for the power supply bypass for the FETs. Place adjacent to the FETs or consider lower value ESR solutions depending on the PCB component placement.
C22	LX1710 bypass	The metal film capacitor is a high frequency bypass for the LX1710 IC.
C9, C13	VDD, PVDD bypass	These tantalum capacitors provide the bypass for the IC supply voltage and output driver supply voltage utilizing a minimal footprint area.
C17	Output power stage	The electrolytic filter capacitor smoothes out ripple current and should be placed close to the output FETs.
C16	Oscillator frequency	The timing capacitor (5% tolerance) sets the oscillator frequency.
C6, C7	Feedback filter	These (5%) capacitors are used in the RC filter to provide feedback for the control loop.
C4, C5	Error amplifier	These (5%) capacitors create the compensation network. Make sure the appropriate “temperature grade” is used to ensure stability.
C1, C2	Voltage references	The filter capacitors provide the bypass for the 5V and 2.5V references.
C26	Audio input filter	The RC filter minimizes high frequency noise to the amplifier.

Table 7 – Capacitor Description



V_{IN} = 15V f_{IN} = 1kHz R_L =4Ω

Figure 8 – Gate Resistor

GATE RESISTOR

Series resistors (R6, R10, R11, R12) can be added to the gate of MOSFETs (Q1 to Q4) to control the switching transition times. This reduces signal distortion as seen in the THD+N vs. Output Power graph below. The slower switching speeds will however, increase power dissipation and therefore slightly decrease the overall efficiency of the amplifier.

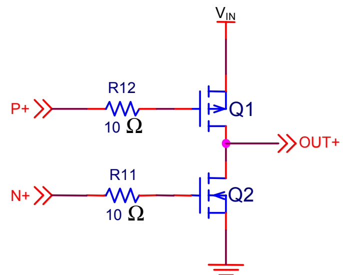


Figure 9

The LXE1710 evaluation board utilizes 10Ω (5Ω on LXE1721) gate resistors, which improves (decreases) the THD+N from 0.1% to 0.05% with a slight impact on efficiency of approximately 2%. The recommended gate resistor is from 0 to 15Ω.

OSCILLATOR CONFIGURATION

The oscillator is programmed by the external timing components RPWM and CPWM. RPWM and CPWM values of 34.8kΩ and 100pF produce a nominal frequency of 429kHz (with the LX1710/1711) and a nominal frequency of 449kHz (with the LX1721/1722). Note that in order to keep the slope of the PWM ramp voltage proportional to the supply voltage, both the ramp peak and valley voltages, and the charge and discharge currents are proportional to the supply voltage. This keeps the frequency relatively constant while keeping the slope of the PWM ramp proportional to the voltage on the VDD pin. For operating frequencies other than those specified above, the frequency can be approximated by the following equations:

For the LX1710/1711

$$\text{Frequency} = \frac{1}{(0.577)(R_{PWM})(C_{PWM}) + 320ns}$$

For the LX1721/1722

$$\text{Frequency} = \frac{1}{(0.525)(R_{PWM})(C_{PWM}) + 400ns}$$

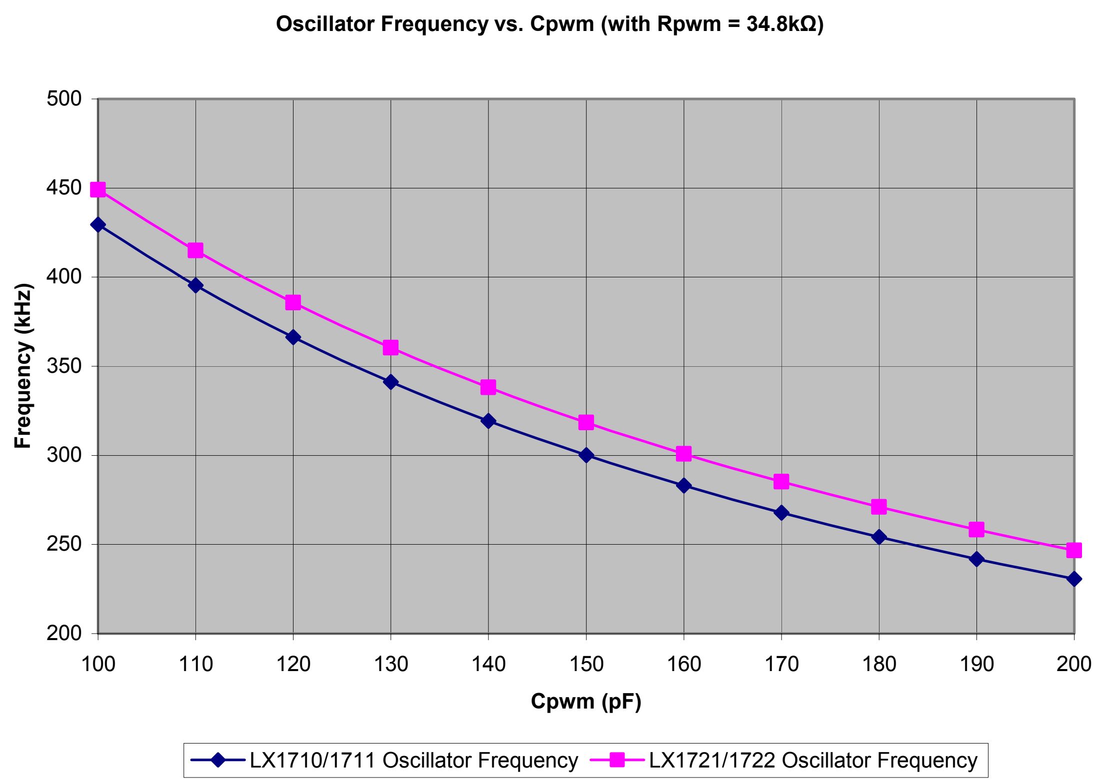


Figure 10

MULTI CHANNEL REQUIREMENTS AND FREQUENCY SYNCHRONIZATION

For applications that require more than a single channel (such as a 5.1 surround sound application), the oscillators of multiple LX1710/1711 or LX1721/1722 controllers can be configured for synchronous operation and eliminate possible beat frequency noise. Although individual controllers will run at very similar frequencies, the additional tolerance associated with other external components (resistors, capacitors) and even different propagation times and voltage levels internal to the IC could affect the controller's run frequency. The delta frequency difference between two controllers of 2kHz for example, falls within the audio range and will not be filtered out. This unwanted tone can be heard and measured at the speaker but is easily eliminated with synchronization.

One unit, the master, is programmed for the desired frequency with the RPWM and CPWM as usual. Additional units will be slave units, and their oscillators will be disabled by leaving the RPWM pin disconnected. The CLOCK pin and the CPWM pin of the slave units should be tied to the CLOCK pin and the CPWM pin of the master unit respectively. In this configuration, the CLOCK pins of the slave units begin receiving instead of transmitting clock pulses. Also, the CPWM pins quit driving the PWM capacitor in the slave units. Note that for optimum performance, all slave units should be located within a few inches of the master unit. If two controllers are located far apart or on separate PCB, synchronization may not be necessary since the traces or wires of the PCB could sink the beat frequency noise.

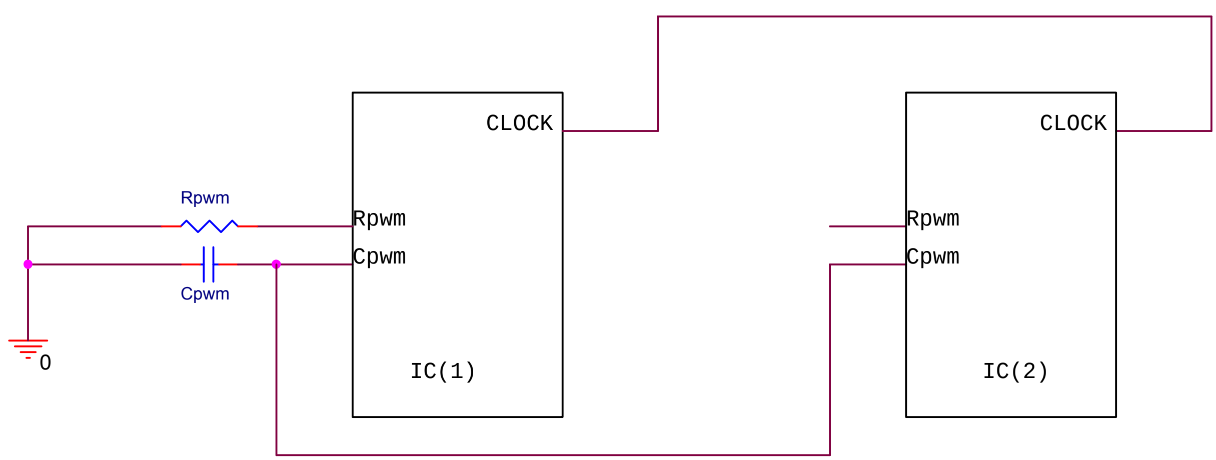


Figure 11 – Frequency Synchronization

SYSTEM GAIN

Some applications such as very high output power designs utilizing a gate driver may require modifying the feedback gain circuit. The system gain can be calculated. At the error amplifier,

$$(Vin)(3.5) = (Vout)(G_{FB})$$

$$G = (Vout)/(Vin) = (3.5)/(G_{FB})$$

For the LX1721, G_{FB} = 0.091 V/V, so G = 39V/V = 32dB;

For the LX1722, G_{FB} = 0.057 V/V, so G = 61.4V/V = 36dB.

AudioMAX controllers can be used with high voltage gate drivers for very high power amplifier solutions. For these high power output applications, the feedback gain must be reduced to provide a higher system gain. With the LXE1722 evaluation board, increasing the value of the feedback resistors R16-R19 increases the overall system gain

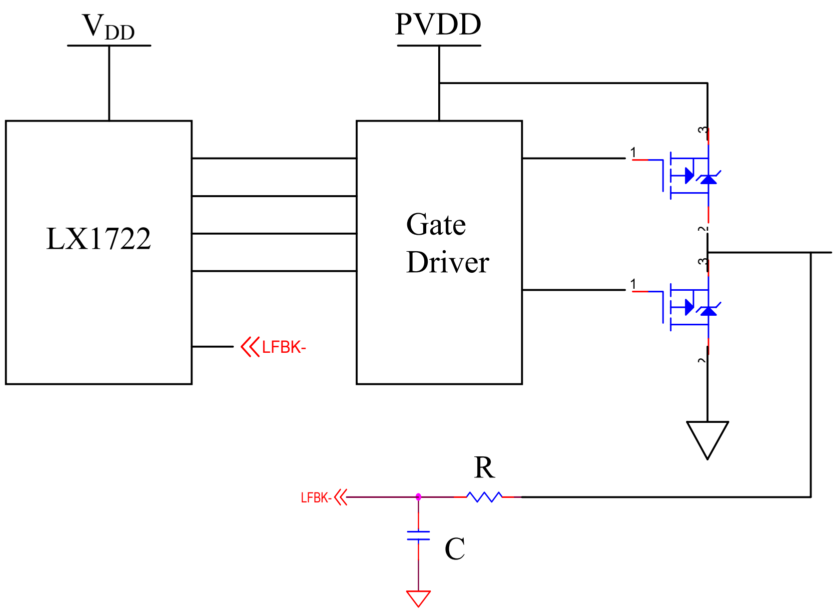


Figure 12 – High System Gain Diagram

To calculate feedback gain G_{FB},

$$G_{FB} = (21k) / (135k+239k+R)$$

Increasing R results in the desired higher system gain. However, the capacitor value (C) must also be adjusted to make sure the characteristics of the low pass filter do not change.

f = 1/(2 π RC) should be greater than 20kHz to minimize audio band interference.

THERMAL CONSIDERATION

Thermal resistance calculations and analysis must be performed especially with the high power designs. Assume the absolute maximum conditions.

VDD = 25VDC
Die temperature Td = 125°C
f = 450kHz (Cpwm =100pF)
Ambient temperature Ta = 40°C

From LX1721/22 thermal characteristics,

Junction-to-Case θjc = 17.8°C/W
Junction-to-Ambient θja = 50°C/W

MOSFETs FDS4435 (Ciss = 1600pF) and FDS6612A (830pF) have been used and averaged to a gate capacitance of 1200pF. From the Dynamic Current vs. CPWM (PWM Capacitor) vs. Gate Capacitance Load Graph, the dynamic current and power dissipation is determined.

Id = 40mA
Pd = (Id)(VDD) = (0.04)(25) = 1W

So, the case temperature Tc = 40°C + (50°C/W)(1W) = 90°C

Since the Die temperature Td = 90°C + (17.8°C/W)(1W) = 107.8°C < 125°C

No extra heatsink is required for this LX1721 example.

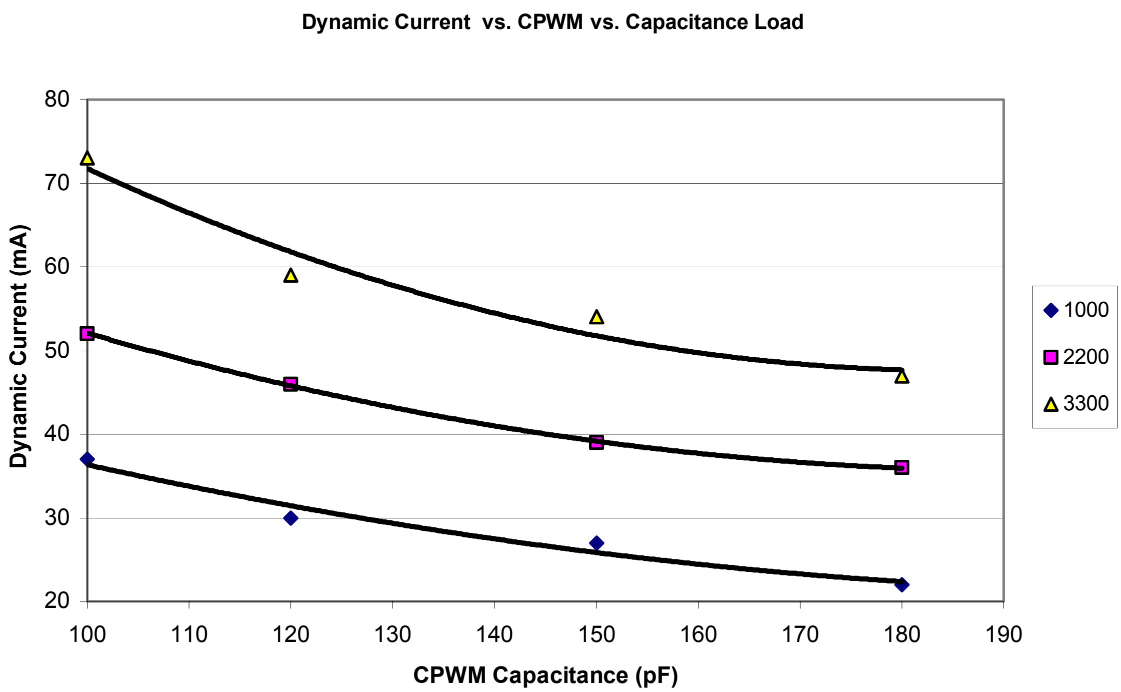


Figure 13

The graph illustrates case temperature test results using different loads at different switching frequencies with the following conditions.

VDD = 25VDC, open air Ta = 25°C

If MOSFETs with Ciss > 3000pF are used in the design, the case temperature is raised and thermal methods like heatsinks are recommended for cooling to keep the Die temperature below 125°C.

If MOSFETs with Ciss < 2000pF are used at 40°C or lower operating temperature, heatsinks are typically not required.

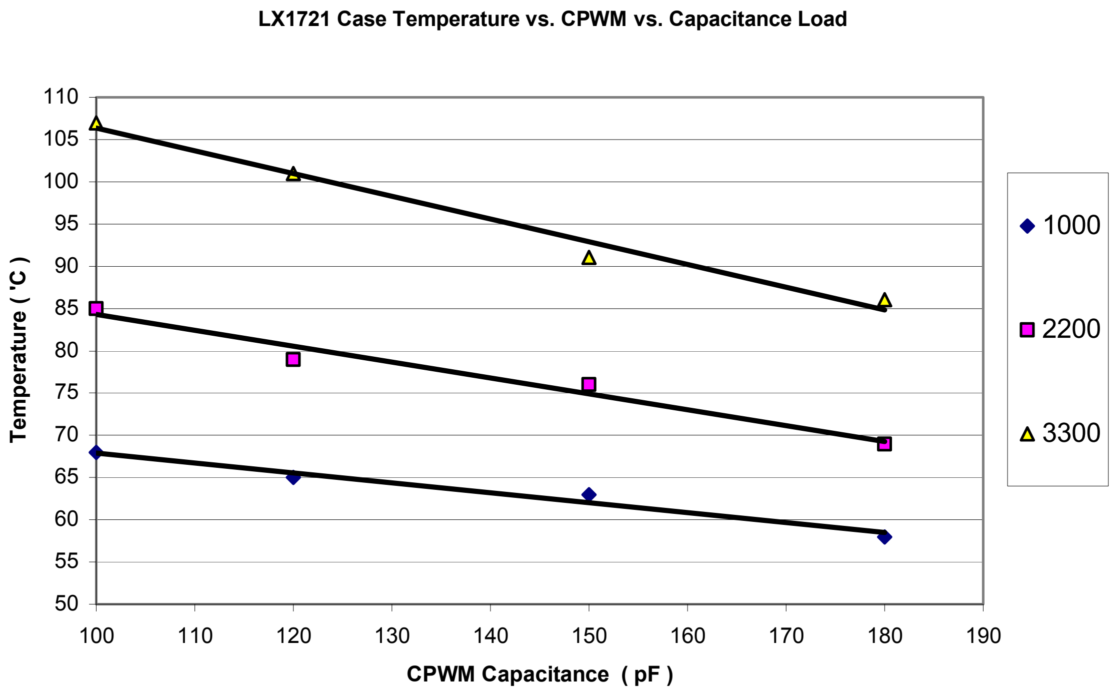


Figure 14

PCB LAYOUT RECOMMENDATIONS

Like most analog circuits, component placement, signal routing, and power/ground isolation can affect the overall performance of the design. The layout should utilize individual ground traces/planes for the audio amplifier whenever possible. The audio input and controller ground, FET ground, and output filter ground are routed using a "star" connection in the LXE1710 evaluation board. See PCB layer views. The power to the controller IC should be routed using separate traces that do not carry high current pulses from the switching circuit. In general, minimizing the high frequency, high power currents from flowing through the same copper as the audio signal references are recommended. Signal traces that could be sensitive to noise should be node to node connections (no "shared" traces). Stray capacitance at the controller pins RPWM, EAOUT, EAIN, and FAOUT can affect the circuit performance and components associated with these pins should be placed as close to the controller IC as possible.

LXE1710/1711 PRINTED CIRCUIT BOARD LAYOUT

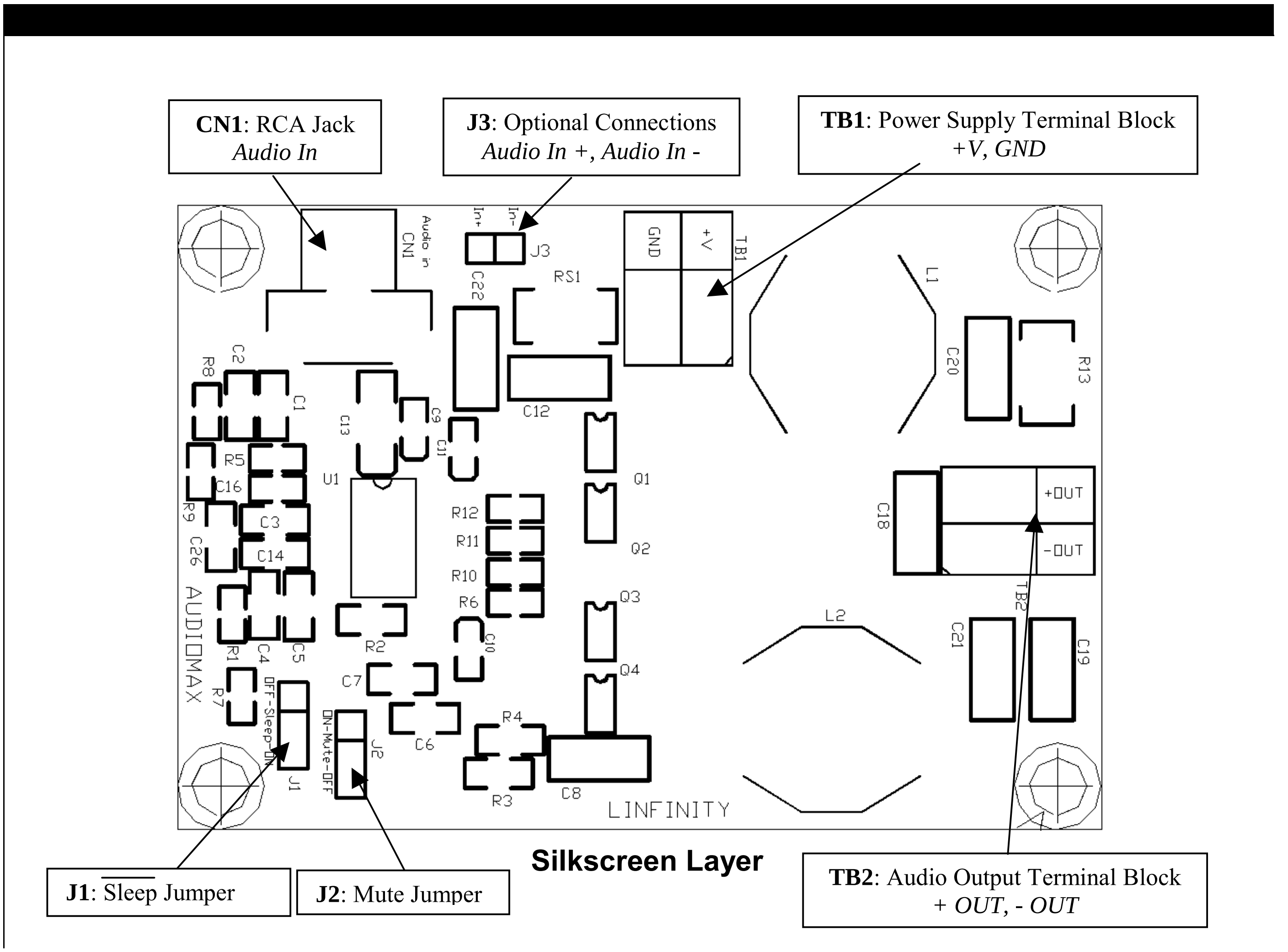


Figure 15

PRINTED CIRCUIT BOARD FOR THE LXE1710

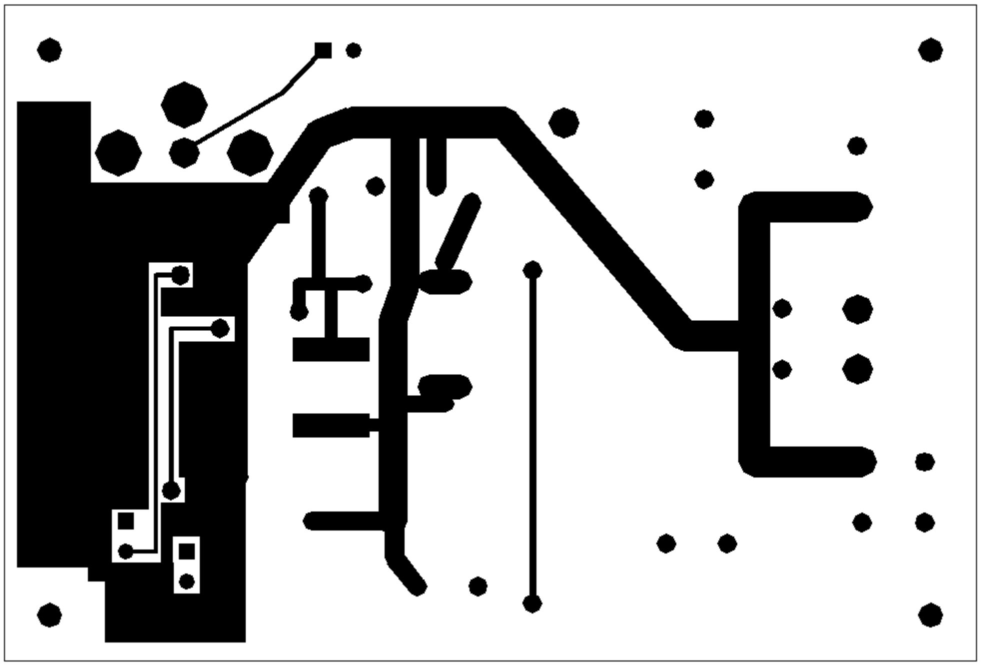


Figure 16 – Bottom Layer

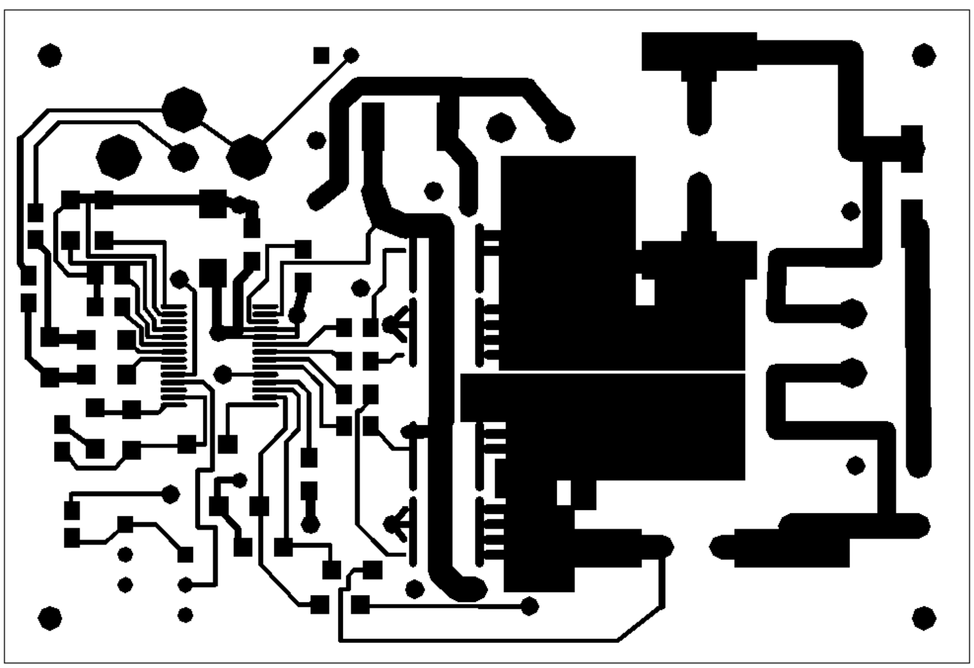


Figure 17 – Top Layer

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LXE1721 APPLICATION

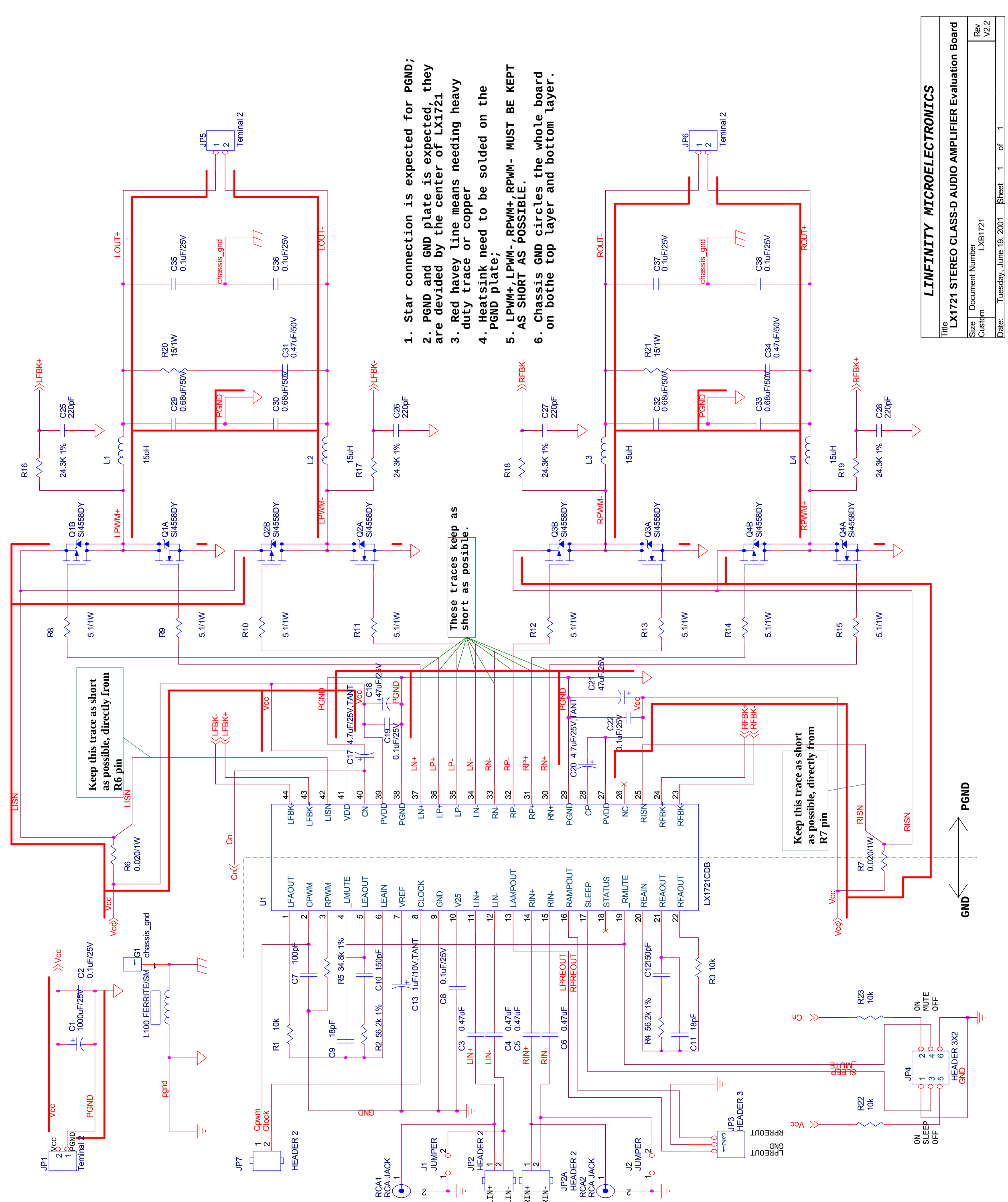

Figure 18 – LXE1721 Schematic and Layout Recommendations

LXE1721 PRINTED CIRCUIT BOARD LAYOUT

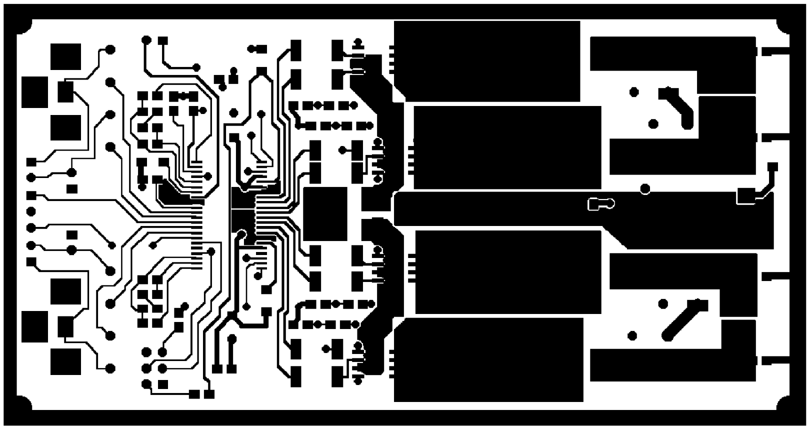

Figure 19 – Top Layer

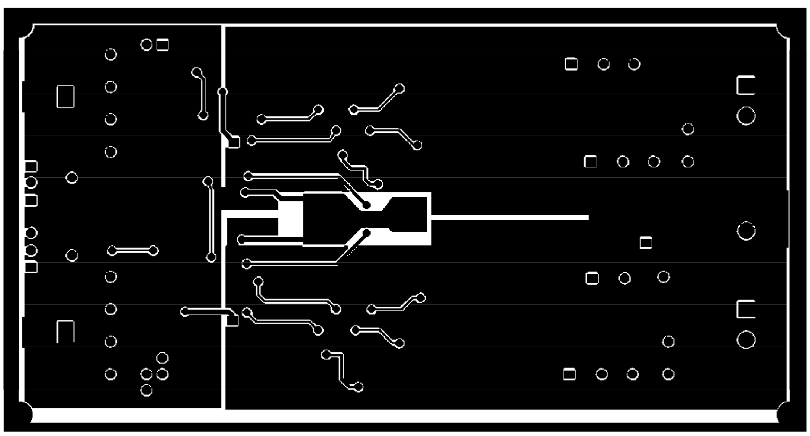

Figure 20 – Bottom Layer

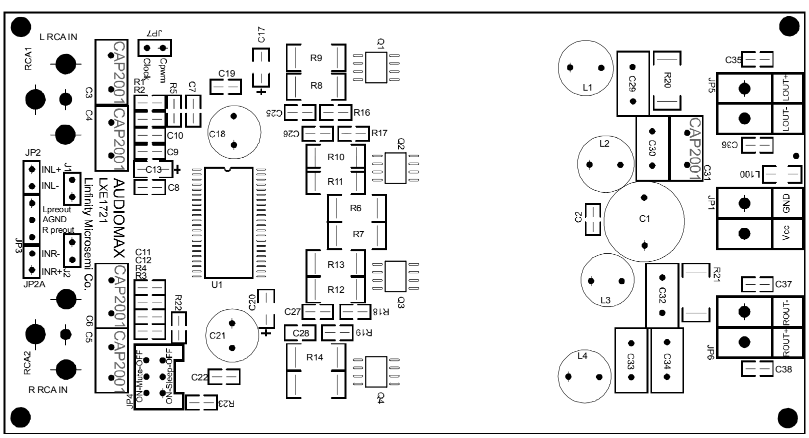

Figure 21 – Component Location

LXE1710/1711 BILL OF MATERIALS

MISCELLANEOUS COMPONENTS

Line Item	Part Description	Manufacturer & Part #	Case	Reference Designators	Qty
1	Controller	**LINFINITY** LX1710 / LX1711	SSOP 28	U1	1
2	N-Channel MOSFET	**FAIRCHILD** FDS6612A	SO-8	Q2, Q4	2
3	P-Channel MOSFET	**FAIRCHILD** FDS4953	SO-8	Q1, Q3	2
4	Printed Circuit Board	**LINFINITY** SGE2758		REV.X	1
5	Inductor, 15uH	**ISI** RL622-150K (LXE1710) **COILCRAFT** DO5022-153HC (LXE1711)	TH SMT	L1, L2	2
6	Phono Jacks, 90° Nickel Plated, Wht	**MOUSER** 161-4214	TH	CN1	1
7	Strip Line Plugs, Straight, Single Row .100"	**CA** CA-S36-24B-44	TH	J1, J2	2
8	Shorting Jumpers, Open Top, Black	**MOUSER** 151-8030	TH	J1	1
9	Terminal Block 2 pos 5mm	**BLOCK MASTER** 301-021-1000	TH	TB1, TB2	2

CAPACITORS

Line Item	Part Description	Part Description	Case	Reference Designators	Qty
1	Capacitor, COG, 18pF, 50V, 5%	**NOVACAP** 1206N180J500NT **AVX** 12065C180JAT2A	1206	C5	1
2	Capacitor, COG, 150pF, 50V, 5%	**NOVACAP** 1206N151J500NT **AVX** 12065C151JAT2A	1206	C4	1
3	Capacitor, COG, 220pF, 50V, 5%	**AVX** 12065C221JAT2A	1206	C6, C7	2
4	Capacitor, X7R, 330pF, 50V, 10%	**PANASONIC** ECU-V1H331KBM	1206	C26	1
5	Capacitor, X7R, .47uF, 16V, 20%	**NOVACAP** 1206B474M160NT **AVX** 1206YC474MAT2A	1206	C3, C14	2
6	Capacitor, X7R, 1uF, 50V, 10%	**NOVACAP** 1206B105K500NT **AVX** 12065C105KAT2A	1206	C1, C2	2
7	Capacitor, COG, 100pF, 50V, 5%	**NOVACAP** 0805N101J500NT **AVX** 08055C101JAT2A	0805	C16	1
8	Capacitor Tant 0.1uF 35V 20%	**AVX** TAJA104M035R	3216	C9	1
9	Capacitor Tant 2.2uF 25V 20%	**KEMET** T491A225M025AS	3216	C13	1
10	Capacitor, Tant, 4.7uF, 16V, 20%	**KEMET** T491A475M016AS **AVX** TAJA475M016R	3216	C10, C11	2
11	Capacitor Stacked MF 0.1uF 50V 5%	**PANASONIC** ECQ-V1H104JL	TH	C8, C12, C22	3
12	Capacitor Stacked MF 0.47uF 50V 5%	**PANASONIC** ECQ-V1H474JL	TH	C18, C19	2
13	Capacitor Stacked MF 0.68uF 50V 5%	**PANASONIC** ECQ-V1H684JL	TH	C20, C21	2
14	Capacitor, Elect 220uF, 25V, 20%	**ELNA** RV-25V221MH10-R	NT	C17	1

RESISTORS

Line Item	Part Description	Part Description	Case	Reference Designators	Qty
1	Resistor, 10K, 5%, 1/4W	**ASJ** CR32J103T	1206	R2	1
2	Resistor, 24.3K, 1%, 1/4W	**ASJ** CR32F2432T	1206	R3, R4	2
3	Resistor, 10 Ohm, 5%, 1/8W	**ASJ** CR J100T	0805	R6, R10, R11, R12	4
4	Resistor, 10K, 5%, 1/8W	**ASJ** CR21J103T	0805	R8, R9	2
5	Resistor, 34.8K, 1%, 1/8W	**ASJ** CR21F3482T	0805	R5	1
6	Resistor,20K, 5%, 1/8W	**ASJ** CR J203T	0805	R7	1
7	Resistor, 56.2K, 1%, 1/8W	**ASJ** CR21F5622T	0805	R1	1
8	Resistor, 15 Ohm 5% 1W	**KOA** RM73B3A150J **ROHM** MCR100JZHJ150	2512	R13	1
9	Resistor, Low Value Flat .0374	**IRC** LR2010-01-R0374-F	2512	RS1	1

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LXE1721 BILL OF MATERIALS

MISCELLANEOUS COMPONENTS

Line Item	Part Description	Manufacturer & Part #	Case	Reference Designators	Qty
1	IC, Controller	**LINFINITY** LX1721CDB	QSOP 44	U1	1
2	IC, N & P – Channel MOSFET	**SILICONIX** Si4558DY	SO-8	Q1, Q2, Q3, Q4	4
3	Ferrite Bead, 1000 Ohm	**MURATA** BLM41P102SGPT	1206	L100	1
4	Printed Circuit Board	**LINFINITY** LXE1721 DC2601		Rev.	1
5	Inductor, 15uH	**ISI** # RL622-150K	TH	L1, L2, L3, L4	4
6	Phono Jack, 90° Nickel Plated, White	**MOUSER** 161-4214	TH	RCA1	1
7	Phono Jack, 90° Nickel Plated, Red	**MOUSER** 161-4215	TH	RCA2	1
8	Header, Str. .100" Center, 2Pos	**AMP** 87220-2	TH	J1, J2, JP2, JP2A, JP7	5
9	Header, Str. .100" Center, 3Pos	**AMP** 87220-3	TH	JP3	1
10	Header, Double Row .100" Center, 6Pos		TH	JP4	1
11	Shorting Jumpers, Open Top, Black	**3M** 929950-00 **AMP** 531220-7 **SULLINS** STC02SYAN	TH	J1, J2	2
12	Terminal Block 2Pos 5mm	**BLOCK MASTER** 301-021-1000	TH	JP1, JP5, JP6	3
13	Heat Sink Low-Cost for DIP	**WAKEFIELD** 651B	SMT		4
14	Epoxy, Thermal Conductive	**WAKEFIELD** 156K			

CAPACITORS

Line Item	Part Description	Manufacturer & Part #	Case	Reference Designators	Qty
1	Capacitor, COG, 18pF, 50V, 5%	**NOVACAP** 0805N180J500NT **AVX** 08055C180JAT2A	0805	C9, C11	2
2	Capacitor, COG, 100pF, 50V, 5%	**NOVACAP** 0805N101J500NT **AVX** 08055C101JAT2A	0805	C7	1
3	Capacitor, COG, 150pF, 50V, 5%	**NOVACAP** 0805N151J500NT **AVX** 08055C151JAT2A	0805	C10, C12	2
4	Capacitor, COG, 220pF, 100V, 5%	**AVX** 08055C221JAT2A	0805	C25, C26, C27, C28	4
5	Capacitor, X7R, 100nF, 50V, 20%	**AVX** 08055C104MAT2A **NOVACAP** 0805B104M500NT **SAMSUNG** CL21B104MBNC	0805	C2, C8, C16, C19, C22, C35, C36, C37, C38	9
6	Capacitor, Tant 1µF, 25V, 10%	**KEMET** T491A105K025AS	3216	C13	1
7	Capacitor, Tant 4.7µF, 16V, 20%	**KEMET** T491A475M016AS **AVX** TAJA475M016R	3216	C17, C20	2
8	Capacitor, Stacked MF 0.47µF, 50V, 5%	**PANASONIC** ECQ-V1H474JL	TH	C3, C4, C5, C6, C31, C34	6
9	Capacitor, Stacked MF 0.68µF, 50V, 5%	**PANASONIC** ECQ-V1H684JL	TH	C29, C30, C32, C33	4
10	Capacitor, Alum Elect. 47µF, 50V	**PANASONIC** ECA-1HM470I	TH	C18, C21	2
11	Capacitor, Alum Elect. 1000µF, 25V	**PANASONIC** EEU-FC1E102	TH	C1	1

RESISTORS

Line Item	Part Description	Manufacturer & Part #	Case	Reference Designators	Qty
1	Resistor, 10K, 5%, 1/8W	**ASJ** CR21J103T	0805	R1, R3, R22, R23	4
2	Resistor, 24.3K, 1%, 1/8W	**ASJ** CR21F2432T	0805	R16, R17, R18, R19	4
3	Resistor, 34.8K, 1%, 1/8W	**ASJ** CR21F3482T	0805	R5	1
4	Resistor, 56.2K, 1%, 1/8W	**ASJ** CR21F5622T	0805	R2, R4	2
5	Resistor, 5.1 Ohm, 5%, 1W	**KOA** RM73B3A5R1J **ROHM** MCR100JZHJ5R1	2512	R8, R9, R10, R11, R12, R13, R14, R15	8
6	Resistor 15 Ohm, 5%, 1W	**KOA** RM73B3A150J **ROHM** MCR100JZHJ150	2512	R20, R21	2
7	Resistor, Low Value Flat .020	**IRC** LR2010-01-R0200-F	2512	R6, R7	2

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EMI RECOMMENDATIONS AND TESTING

Due to the high speed switching topology of Class-D amplifiers, passing emissions and gaining the required certifications can be a challenge. Although EMI is a function of each individual design (including system mechanics and enclosure, component placement, PCB routing and layout), there are general options which may help to reduce EMI in most systems.

The major source of the EMI in Class-D topology is in the switches. The EMI is produced by fast switching edges that can couple into the circuit. These risetimes have frequency components that are orders of magnitude above the oscillator frequency. To minimize the switching EMI, the switching edges can be slowed down by controlling the risetime of the gate drive signal. The risetime limiting should be subtle as there is a tradeoff between EMI reduction and efficiency. To prevent conduction overlap of the FET switches, the switch turn off time should be as fast as possible, but the turn on edges can be slowed down with some series resistance to the gate capacitance.

Similar techniques can be applied to designs that utilize a Class-D controller with a gate driver. A typical gate driver will source and sink current so a resistor can be added to the source leg of the NMOS driver and the sink leg of the PMOS driver. If there is stray inductance and capacitance on the drains of the switching FETs, there may be ringing on the output. In some layouts this stray impedance is unavoidable due to the need to heatsink the switches and other layout constraints. The ringing can be eliminated with a snubber (a series resistor and capacitor). The snubber capacitor is sized to be greater than the stray capacitance and the snubber resistor is sized so the time constant of the snubber coincides with the frequency of the ringing. The tradeoff is the resistor will reduce efficiency of the amplifier. The resistor will dissipate a power equivalent to Fsw x Csnubber x V x V. A carefully optimized, tight layout may be enough to prevent ringing.

The following schematic contains a buffer circuit used in the LX1711-100 buffer board. R38 and C28 are the snubber circuit that can be added to reduce EMI. Scope photos illustrate the effects of the snubber circuit to reduce ringing noise at the MOSFET output.

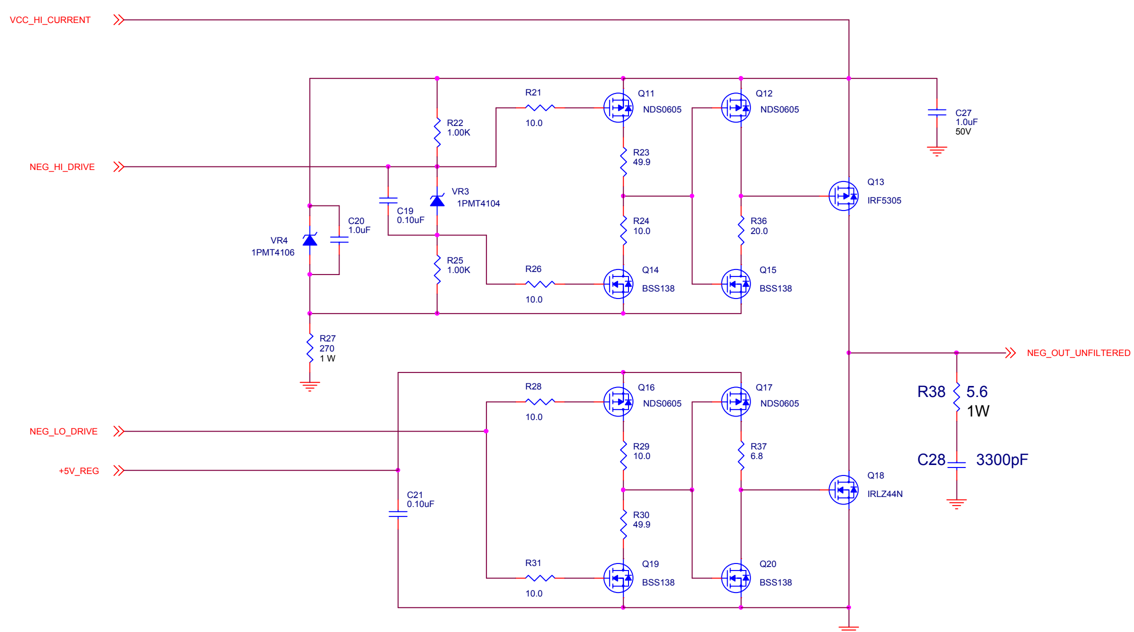


Figure 22

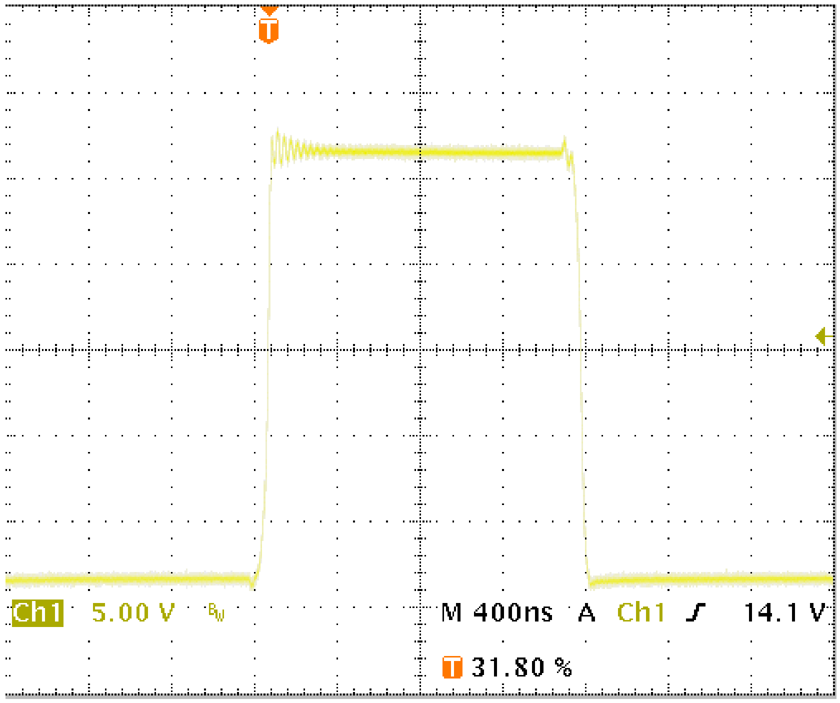


Figure 23 – MOSFET Output Without Snubber Circuit

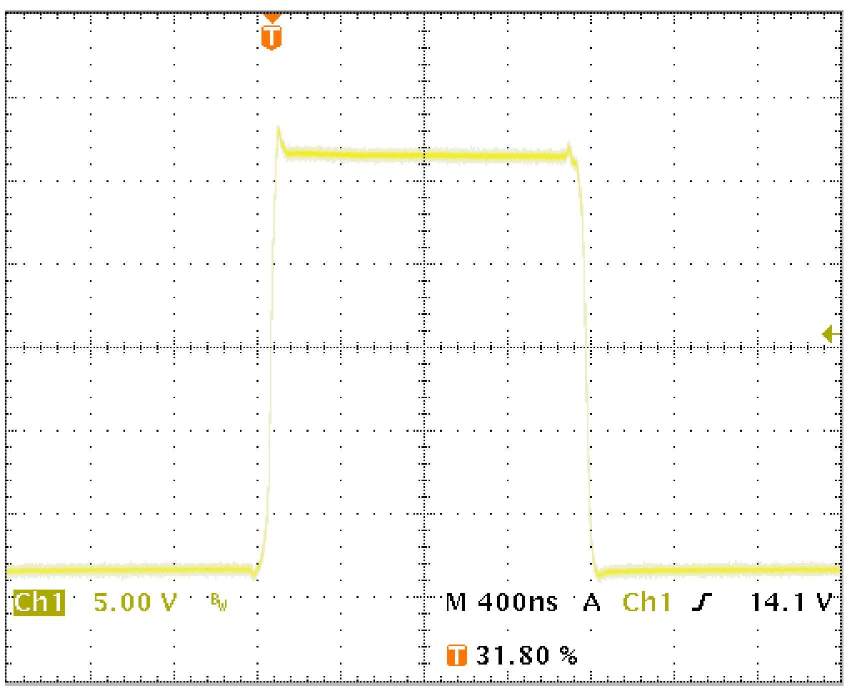


Figure 24 – MOSFET Output With Snubber Circuit

EMI REPORT

The following sweep was performed on a LXE1721 Stereo Evaluation Amplifier that utilized a second stage LC filter (2.2uH/0.1uF) as an EMI filter, a ground plane, chassis ground, and a small high-current loop. Results are from a pre-scan test at 3 meters in a chamber with a 120VAC/60Hz switching power supply. Desktop computer speakers with 3 feet of speaker wire and a portable CD player set at full volume were used. Maximum peak value is about 15dB lower than FCC CISPR 22 B limit at about 30MHz ~ 1GHz band.

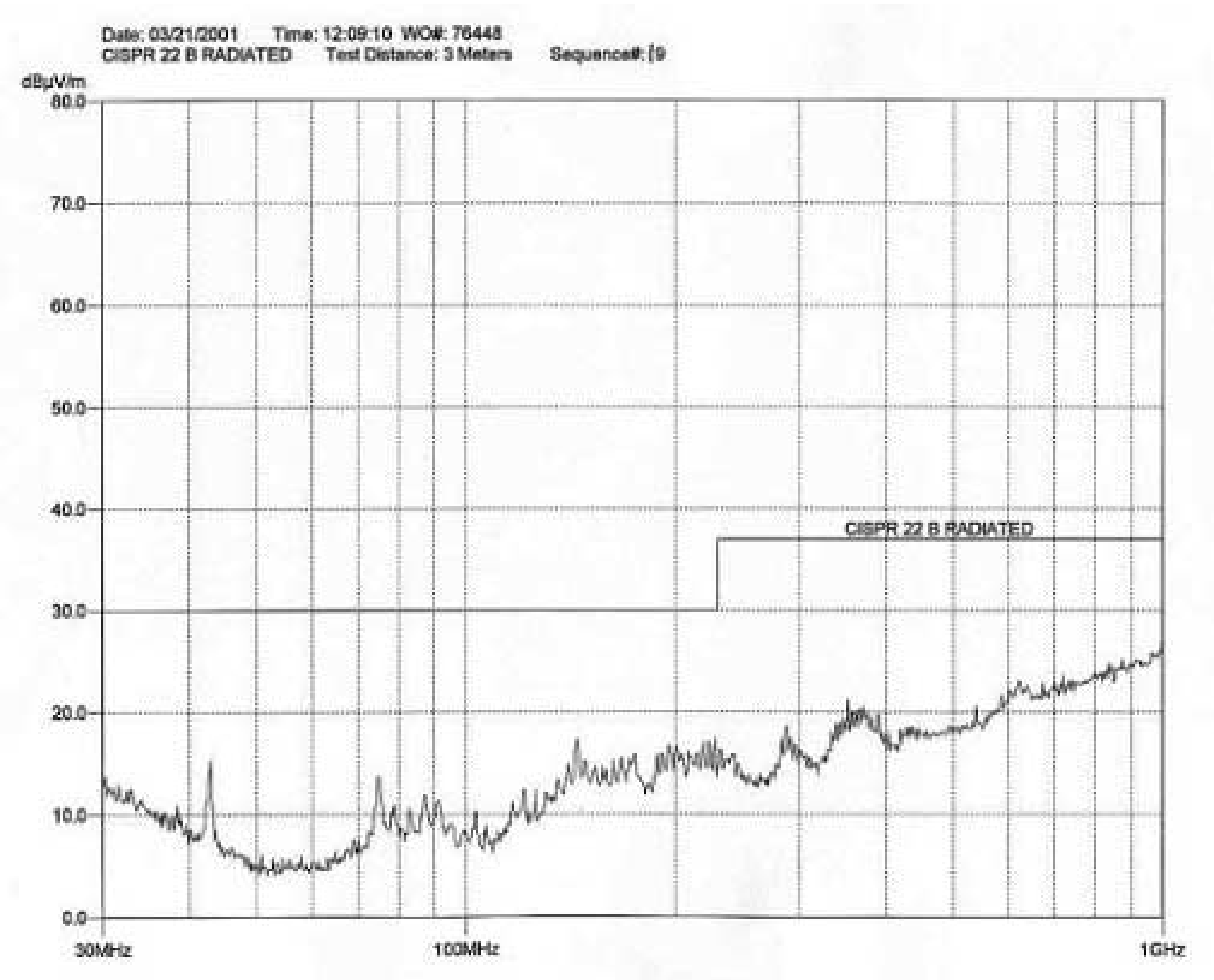


Figure 25

REFERENCE DESIGNS AND EVALUATION BOARDS

LX1711-100 Buffer High Power Amplifier Board

The LX1711 Mono Class-D Controller is used with a discrete drive circuit that shifts the LX1711 logic gate drive level to 12V to increase its drive capability. Greater than 120Wrms (2Ω) or 60Wrms (4Ω) output power levels are supported.

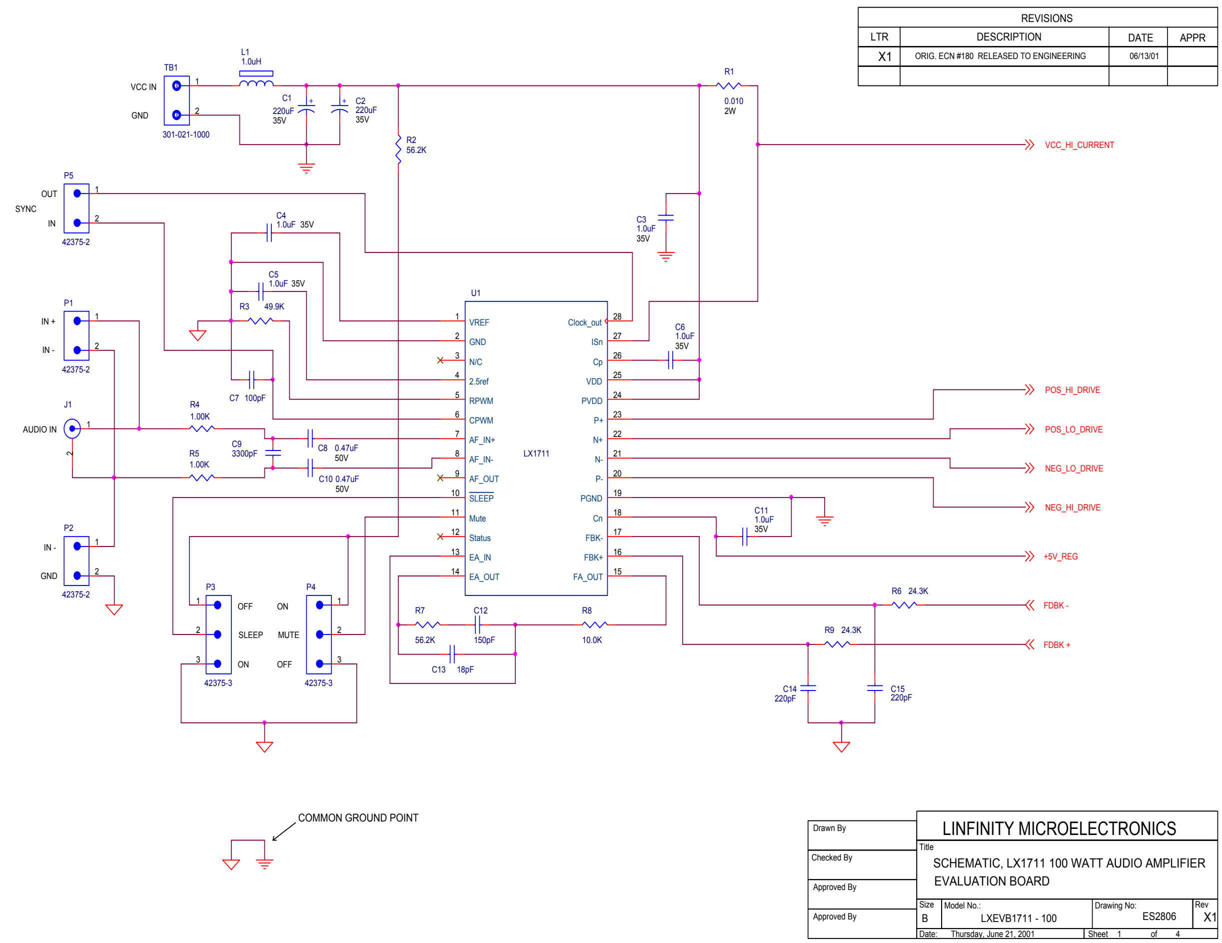


Figure 26 – LX1711-100 Buffer Schematic, Sheet 1

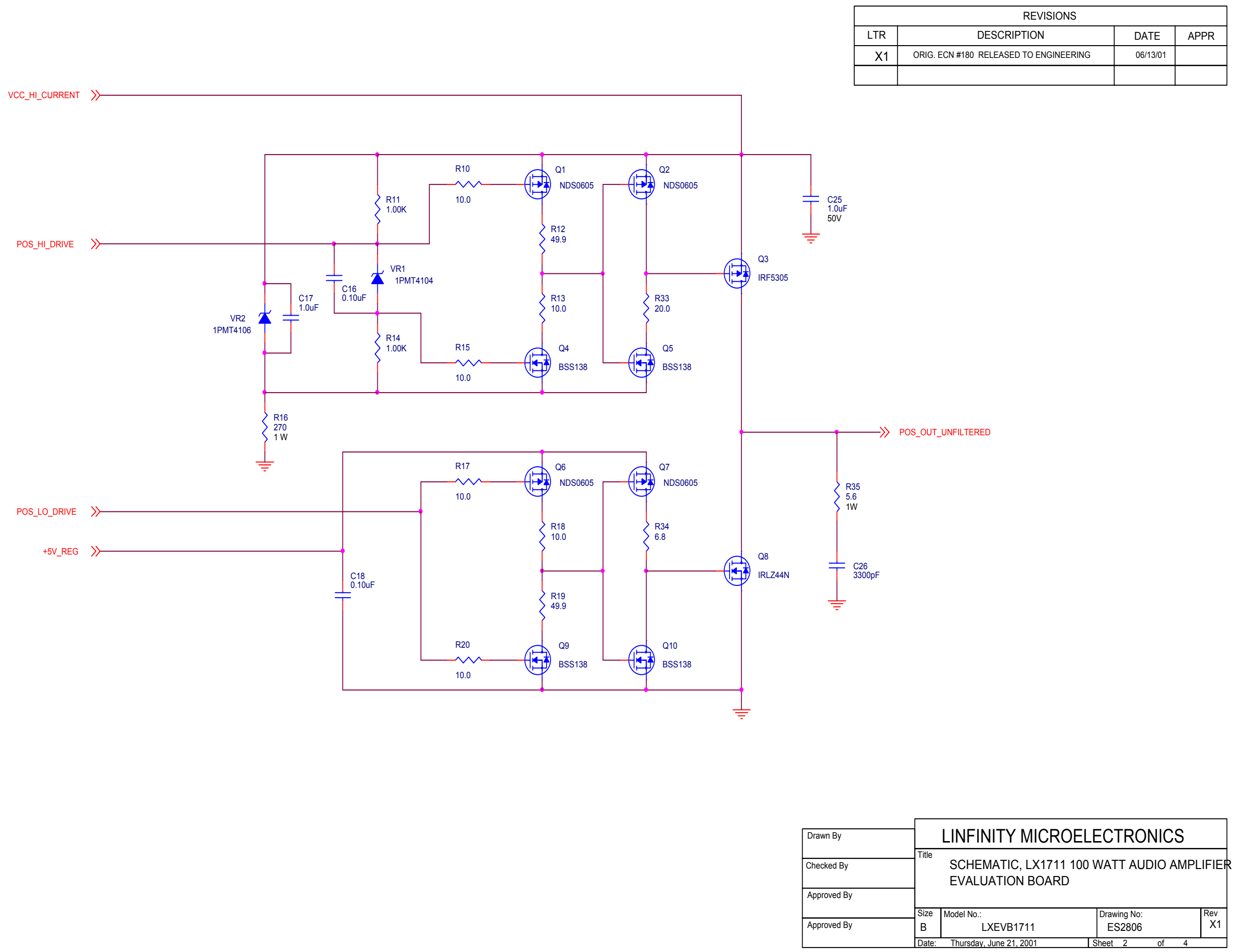


Figure 27 – LX1711-100 Buffer Schematic, Sheet 2

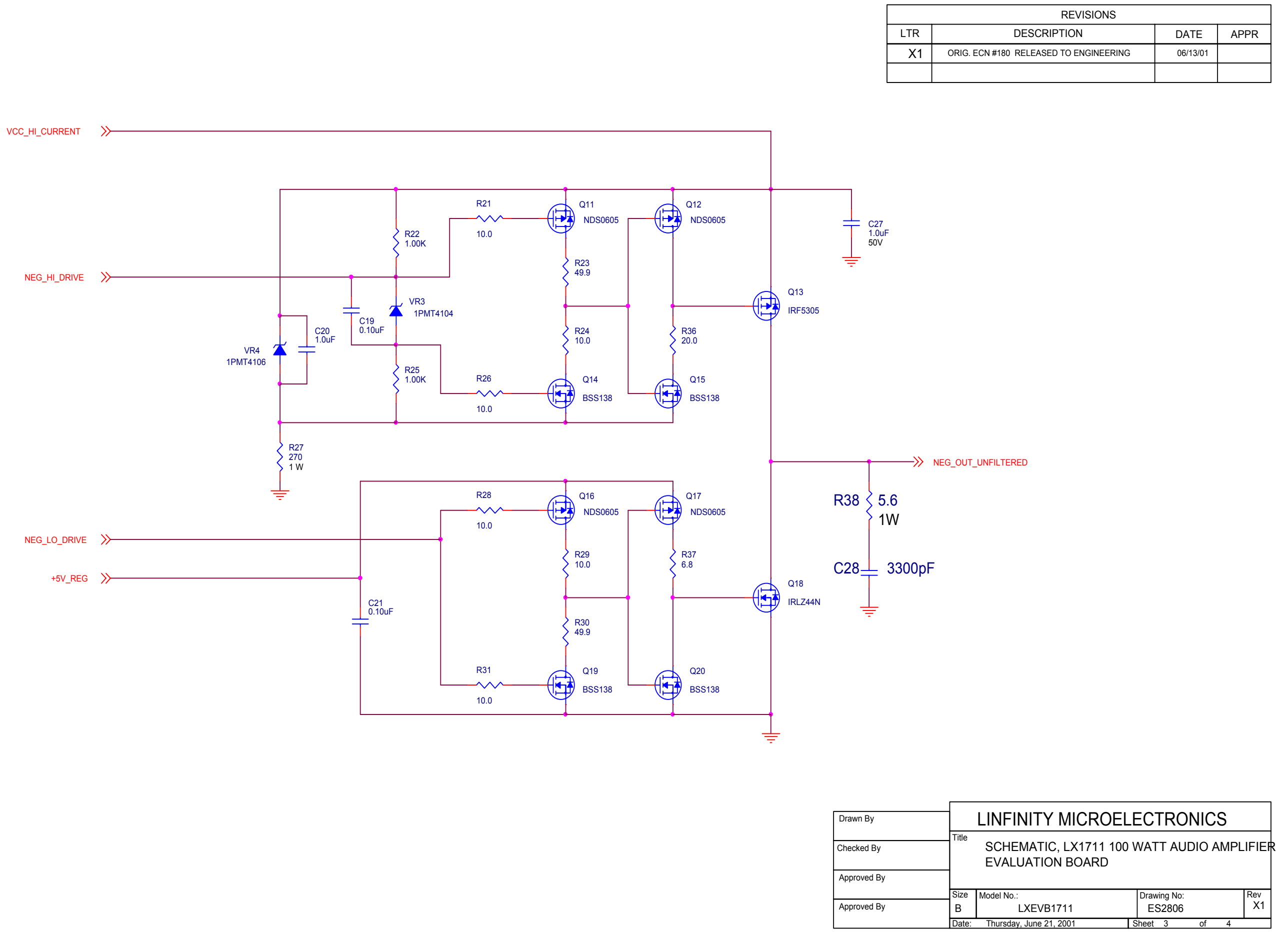
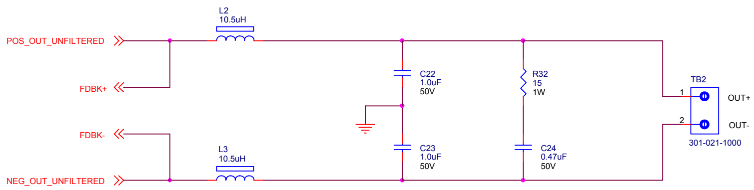


Figure 28 – LX1711-100 Buffer Schematic, Sheet 3

REVISIONS			
LTR	DESCRIPTION	DATE	APPR
X1	ORIG. ECN #180 RELEASED TO ENGINEERING	06/13/01	



Drawn By	LINFINITY MICROELECTRONICS		
Checked By	Title: SCHEMATIC, LX1711 100 WATT AUDIO AMPLIFIER EVALUATION BOARD		
Approved By	Size: B	Model No.: LXEVB1711	Drawing No: ES2806 / Rev: X1
Approved By	Date: Thursday, June 21, 2001	Sheet 4 of 4	

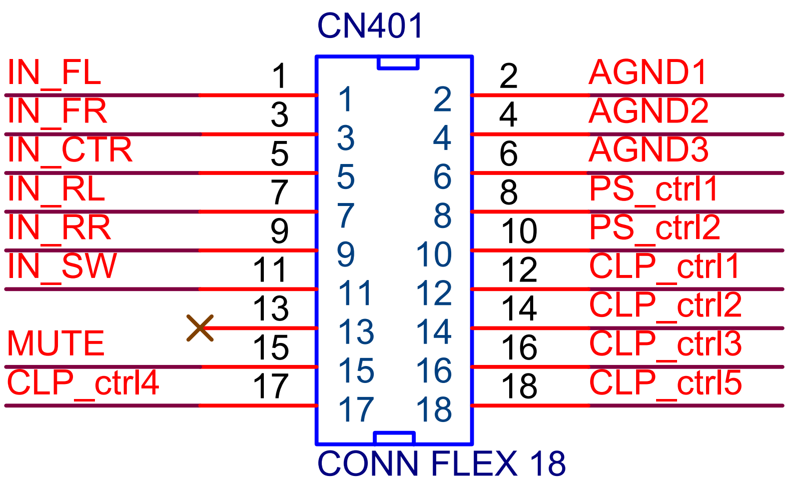
Figure 30 – LX1711-100 Buffer Schematic, Sheet 4

REFERENCE DESIGNS AND EVALUATION BOARDS

5.1 Channel LX1710/ LX1711 Evaluation Board (Mono x 6 channels) and User Guide

This 5.1 Channel amplifier has been designed to support applications such as the combo DVD type systems with output power of 25Wx6 @4ohm, 1%THD, single supply 15V or 50Wx6 @4ohm, 1%THD, single supply 25V.

Input Connector CN401



Pin1 ---- Front Left (FL) Input;
Pin2 ---- Signal Ground for FL and RL Input;
Pin3 ---- Front Right (FR) Input;
Pin4 ---- Signal Ground for CTR and SW Input;
Pin5 ---- Center Channel (CTR) Input;
Pin6 ---- Signal Ground for FR and RR Input;
Pin7 ---- Rear Left (RL) Input;
Pin8 ---- Power Supply PWM Control pin1;
Pin9 ---- Rear Right (RR) Input;
Pin10 ---- Power Supply PWM Control pin2;
Pin11 ---- SubWoofer (SW) Channel Input;
Pin12 ---- Clipping Detection Control Pin1;
Pin13 ---- No Connection;
Pin14 ---- Clipping Detection Control Pin2;
Pin15 ---- MUTE Control;
Pin16 ---- Clipping Detection Control Pin3;
Pin17 ---- Clipping Detection Control Pin4;
Pin18 ---- Clipping Detection Control Pin5;

- If all the channels input are single wire/no ground, then AGND1, AGND2, AGND3 must be tied to the power supply GND.
- MUTE = ON if pin15 is high, if no mute is to be connected, then pin15 must be connected to the power GND for system operation.
- Pin8, pin10 are power supply PWM control pins from a microcontroller. If power supply control is not available, leave these two pins open.

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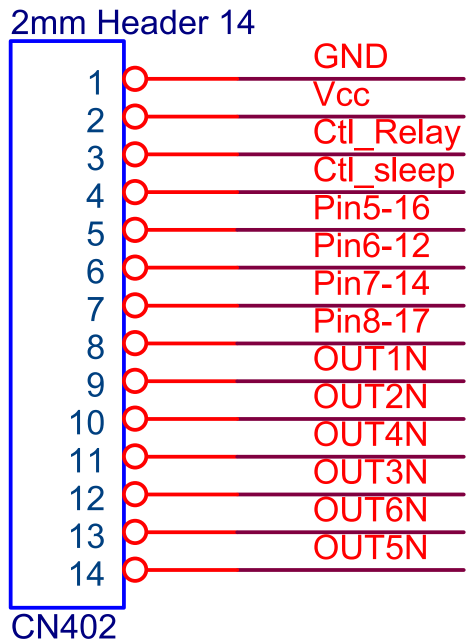
11861 Western Avenue, Garden Grove, CA. 92841, 714-898-8121, Fax: 714-893-2570

- Pin12, pin14, pin16~18 are clipping detection control from/to microcontroller. If a microcontroller is not used, leave them open.

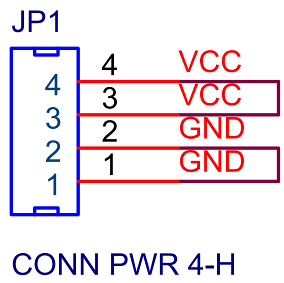
Clipping Detection Control Connector CN402



Pin1 ---- Ground for clipping board;
Pin2 ---- Power supply for clipping board, comes from main board Vcc;
Pin3 ---- Relay control pin;
Pin4 ---- Sleep control pin;
Pin5 ---- Clipping Detection Control Pin3;
Pin6 ---- Clipping Detection Control Pin1;
Pin7 ---- Clipping Detection Control Pin2;
Pin8 ---- Clipping Detection Control Pin4;
Pin9 ---- FL channel negative feedback;
Pin10 ---- RL channel negative feedback;
Pin11 ---- SW channel negative feedback;
Pin12 ---- CTR channel negative feedback;
Pin13 ---- RR channel negative feedback;
Pin14 ---- FR channel negative feedback;

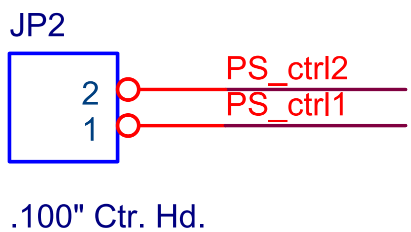
- If the clipping detection board is not plugged into the socket, pin4 must be connected to the power GND, and relay control pin3 must be connected to the Vcc or short the Relay pin3 to pin4, pin5 to pin6 and leave pin3 of CN402 open. All other pins are left open.

Power Supply Connector JP1



Pin1, 2 ---- Power Ground;
Pin3, 4 ---- Power Supply: 15VDC for LX1710 and 25VDC for LX1711;

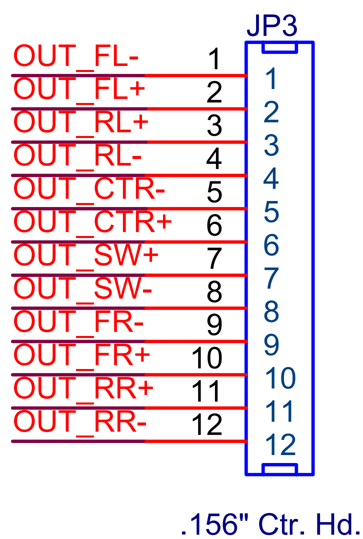
Power Supply PWM Control Connector



Pin1 ---- Power Supply PWM Control pin1;
Pin2 ---- Power Supply PWM Control pin2;

- These pins come from the microcontroller and connect to the power supply board. If power supply is not connected, leave them open.

Output Connector JP3



Pin1 ---- Front Left Negative Output;
Pin2 ---- Front Left Positive Output;
Pin3 ---- Rear Left Positive Output;
Pin4 ---- Rear Left Negative Output;
Pin5 ---- Center Negative Output;
Pin6 ---- Center Positive Output;
Pin7 ---- SubWoofer Positive Output;
Pin8 ---- SubWoofer Negative Output;
Pin9 ---- Front Right Negative Output;
Pin10 ---- Front Right Positive Output;
Pin11 ---- Rear Right Positive Output;
Pin12 ---- Front Right Negative Output;

Gain Control Potentiometers

- There are four Potentiometers POT1~4 to control the gain of each channel. POT1 controls FL/FR; POT2 controls CTR; POT3 controls SW; POT4 controls RL/RR. Each channel's gain can be adjusted for special effects.

System Configuration

- All channels use LX1710 with output power of 25Wx6 @4ohm, 1%THD output power under 15VDC power supply condition.
- All channels use LX1711, can get 50Wx6 @4ohm, 1% THD output power under 20~25VDC power supply condition. Care must be exercised for thermal performance and possible heatsink options.
- Different mono controllers can be uses. FL, FR, RL, RR channels use LX1710 and CTR, SW channels use LX1711 for a system of 25Wx4+35Wx1+50Wx1 @4ohm, 1% THD output power under 15~25VDC condition. Gain can be individually adjusted using POT1~4.
- Another option is to use the LX1711-100 high power buffer design. FL/FR/RL/RR/CTR use LX1711, SW channel uses LX1711 buffer solution to get 50Wx5 @4ohm + 130W @2ohm, 1%THD for a total output power of 380W. This solution requires a layout change to the SW channel on the evaluation board.

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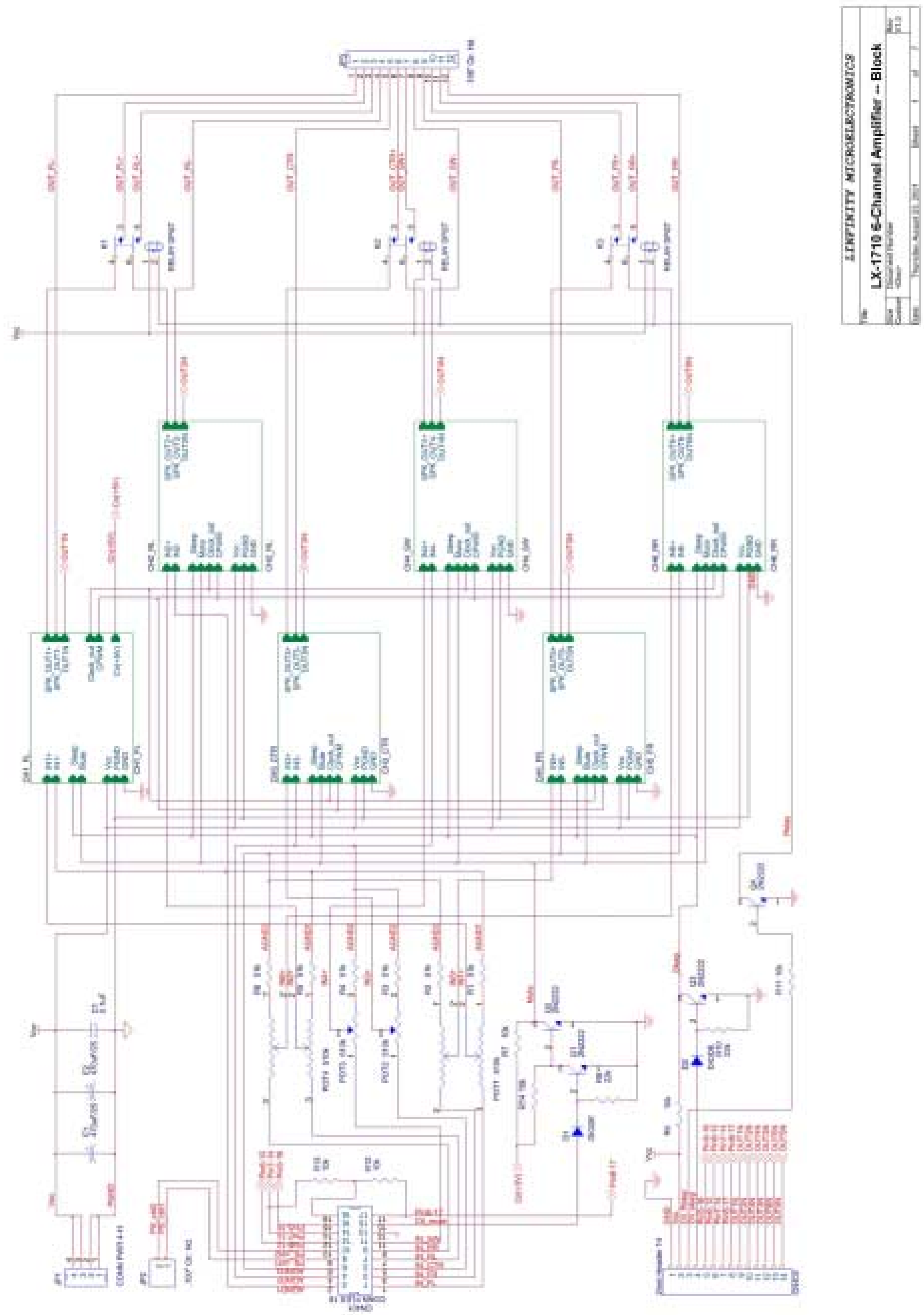
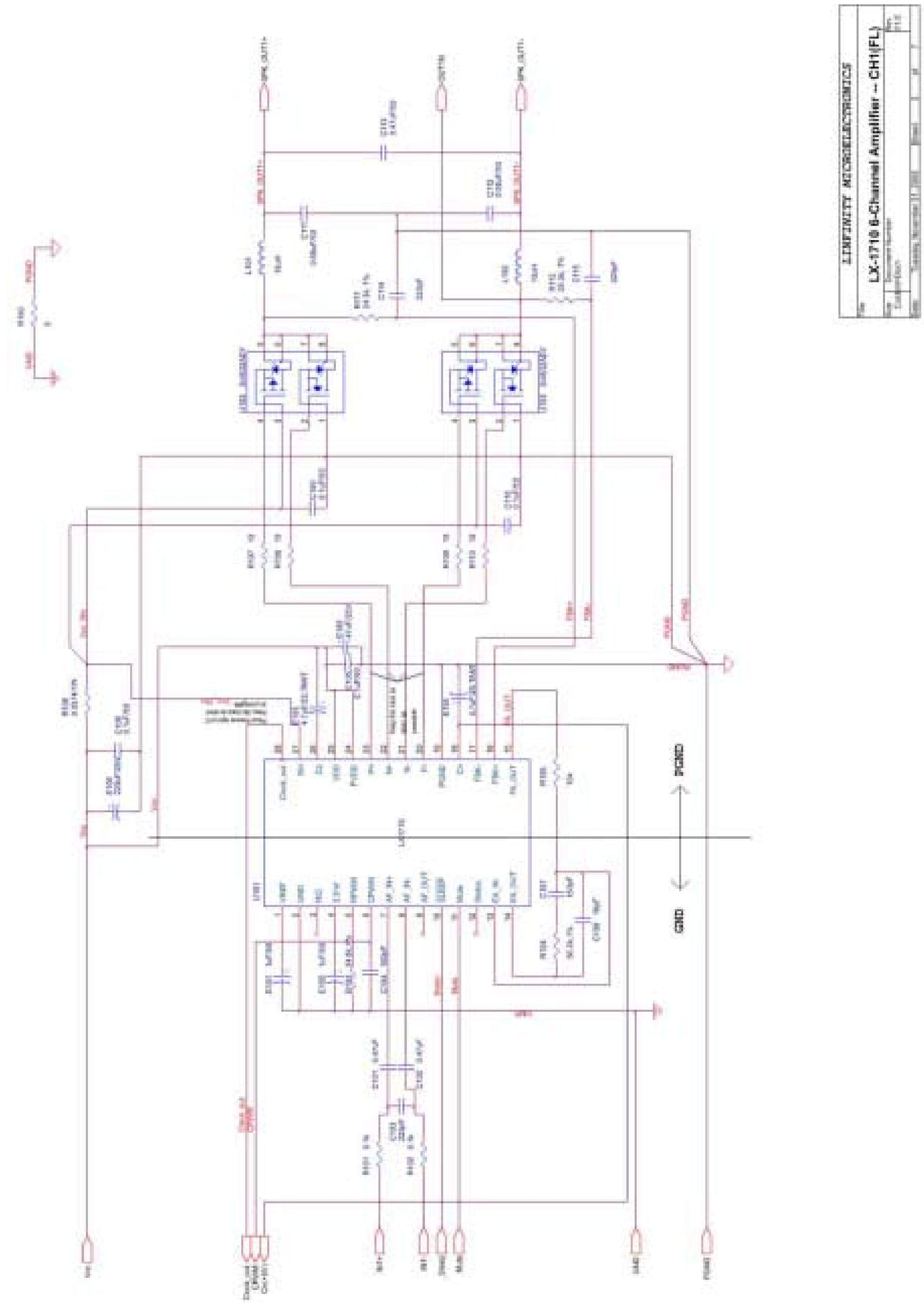
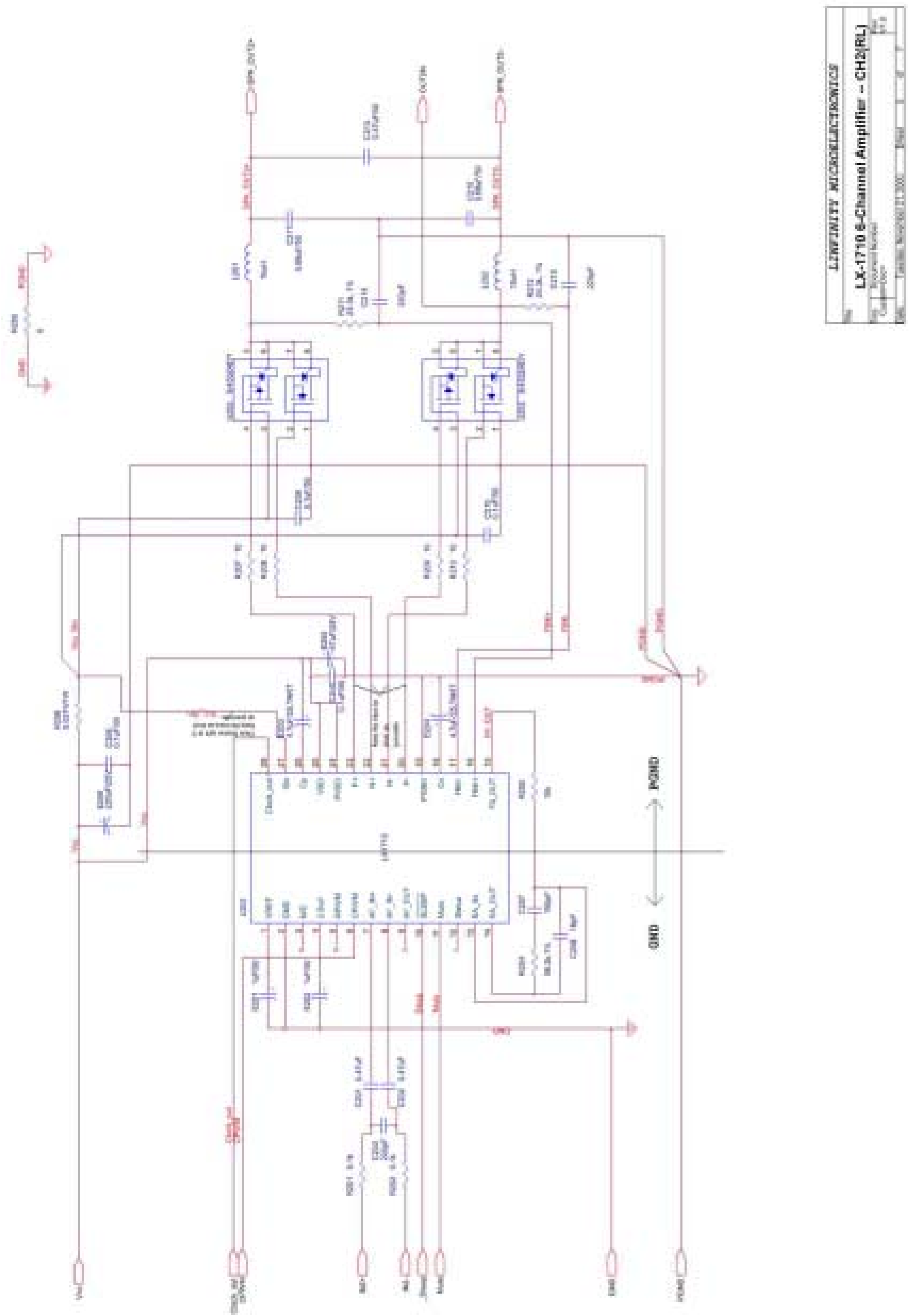
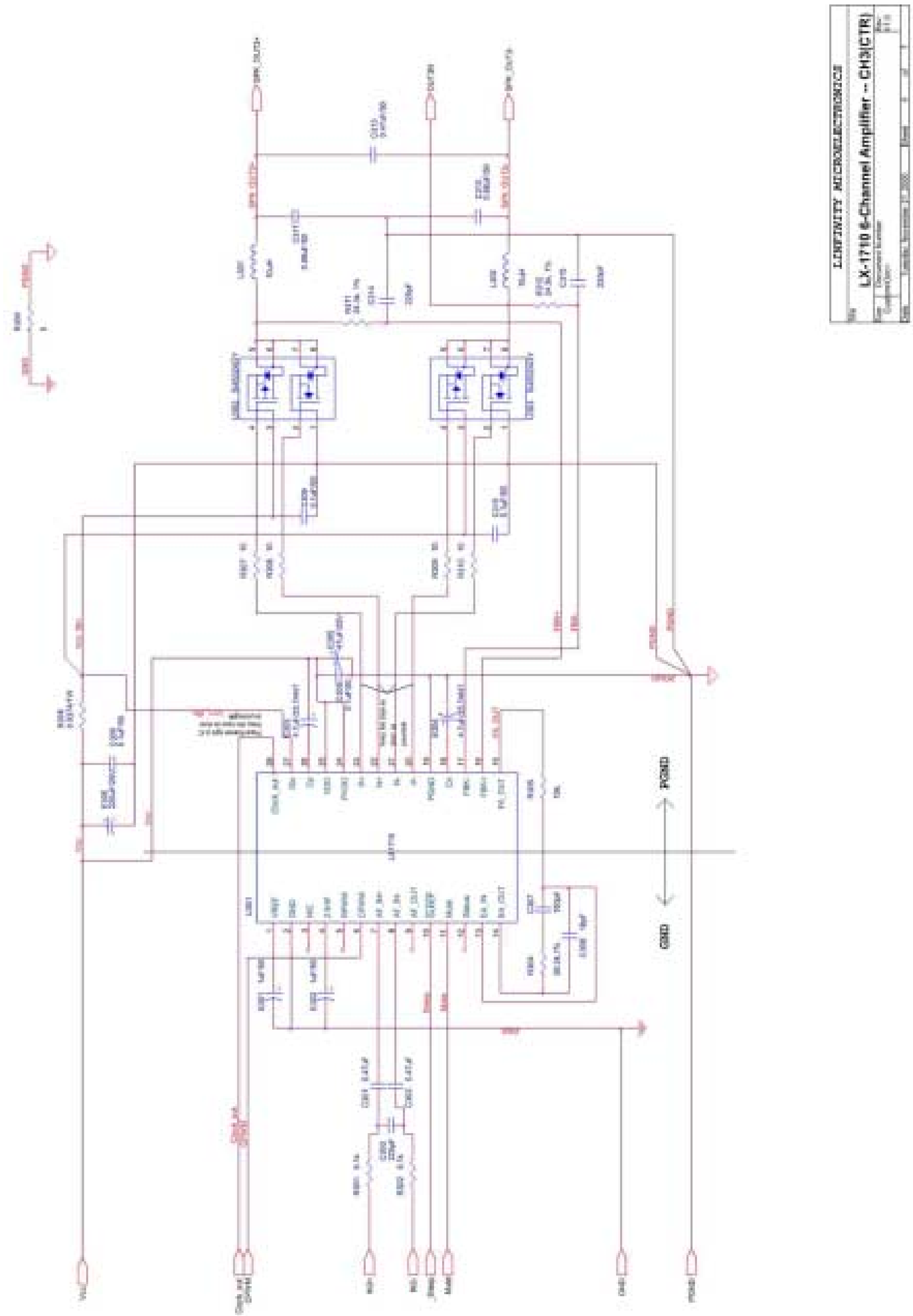
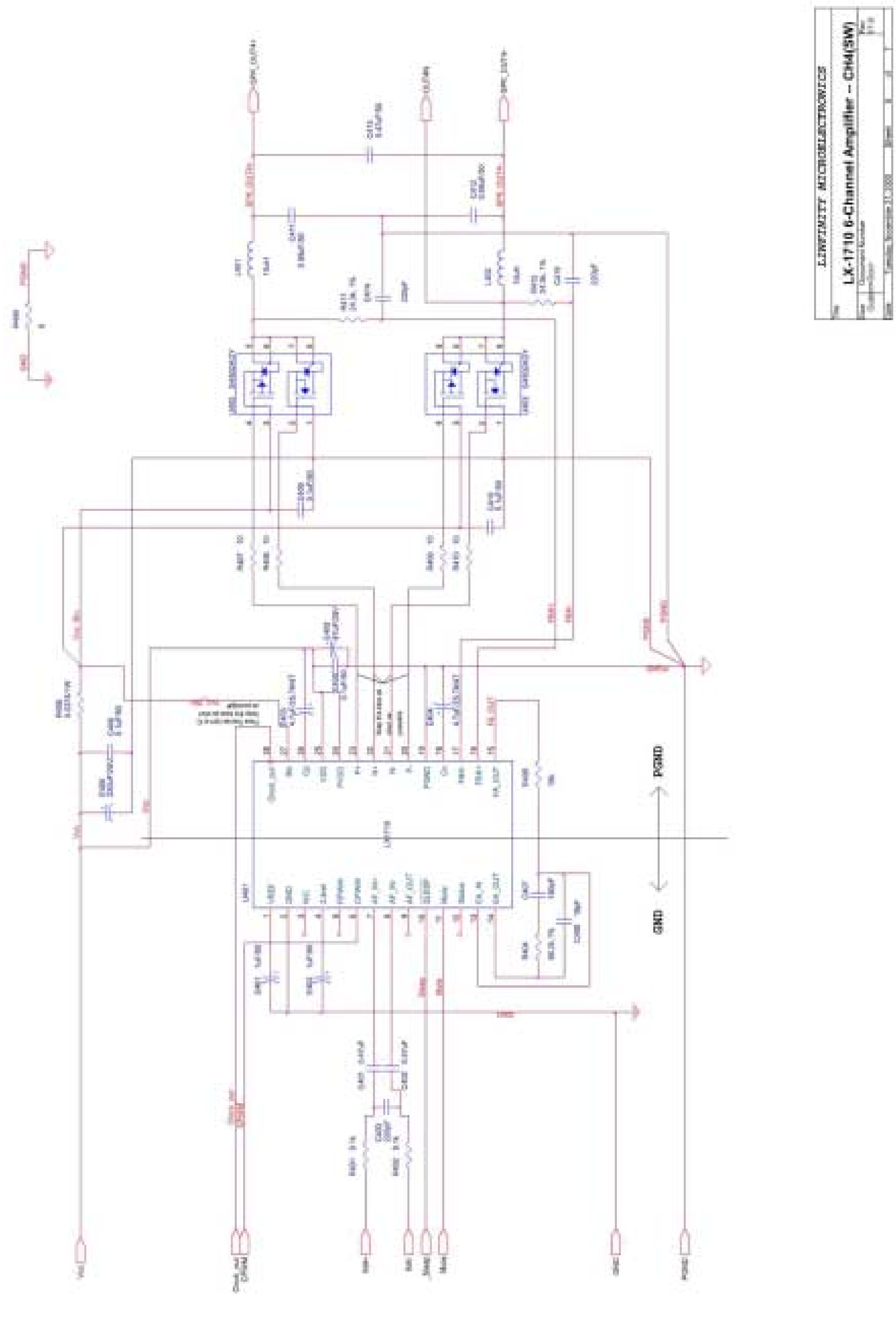
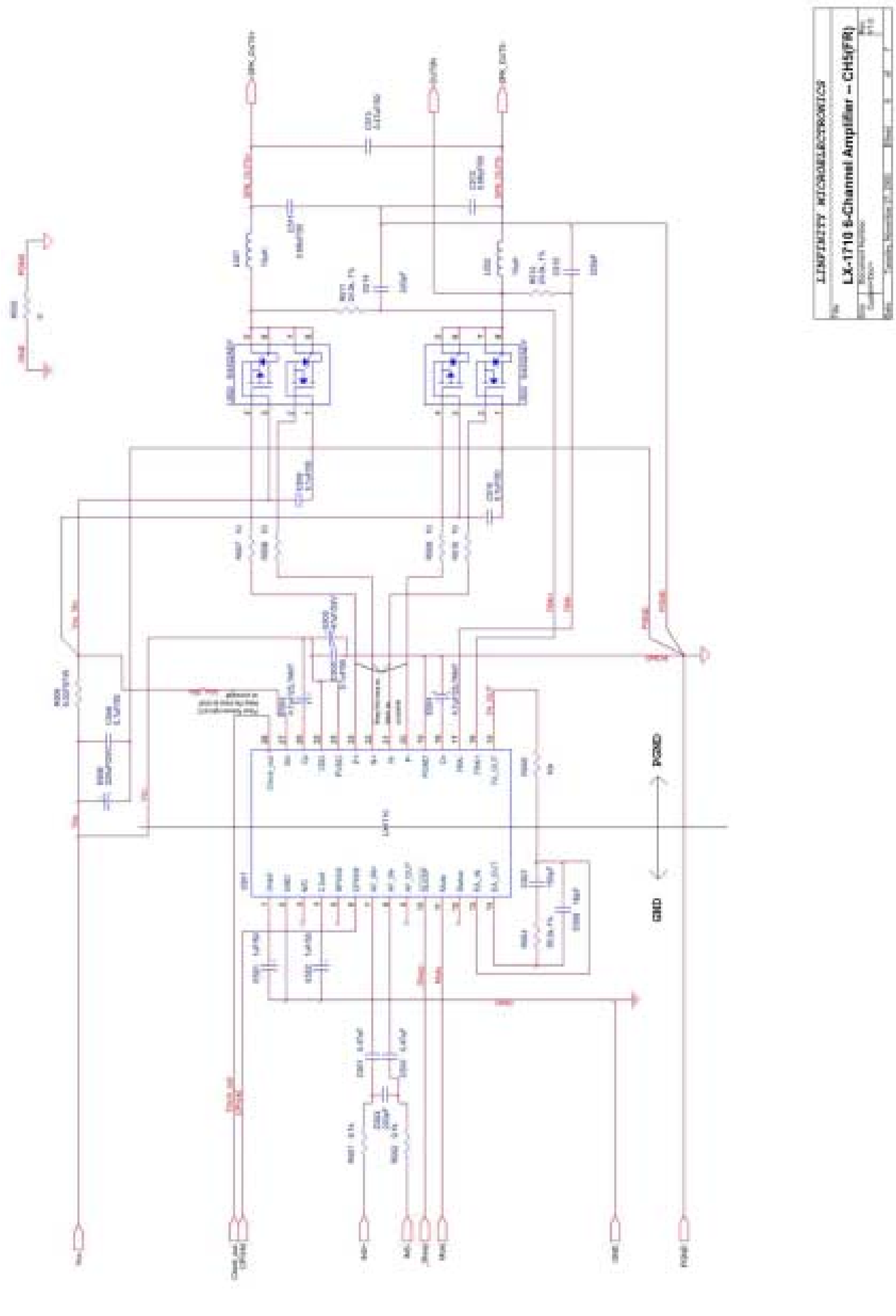

LINFINITY MICROELECTRONICS
LX-1710 6-Channel Amplifier -- Block

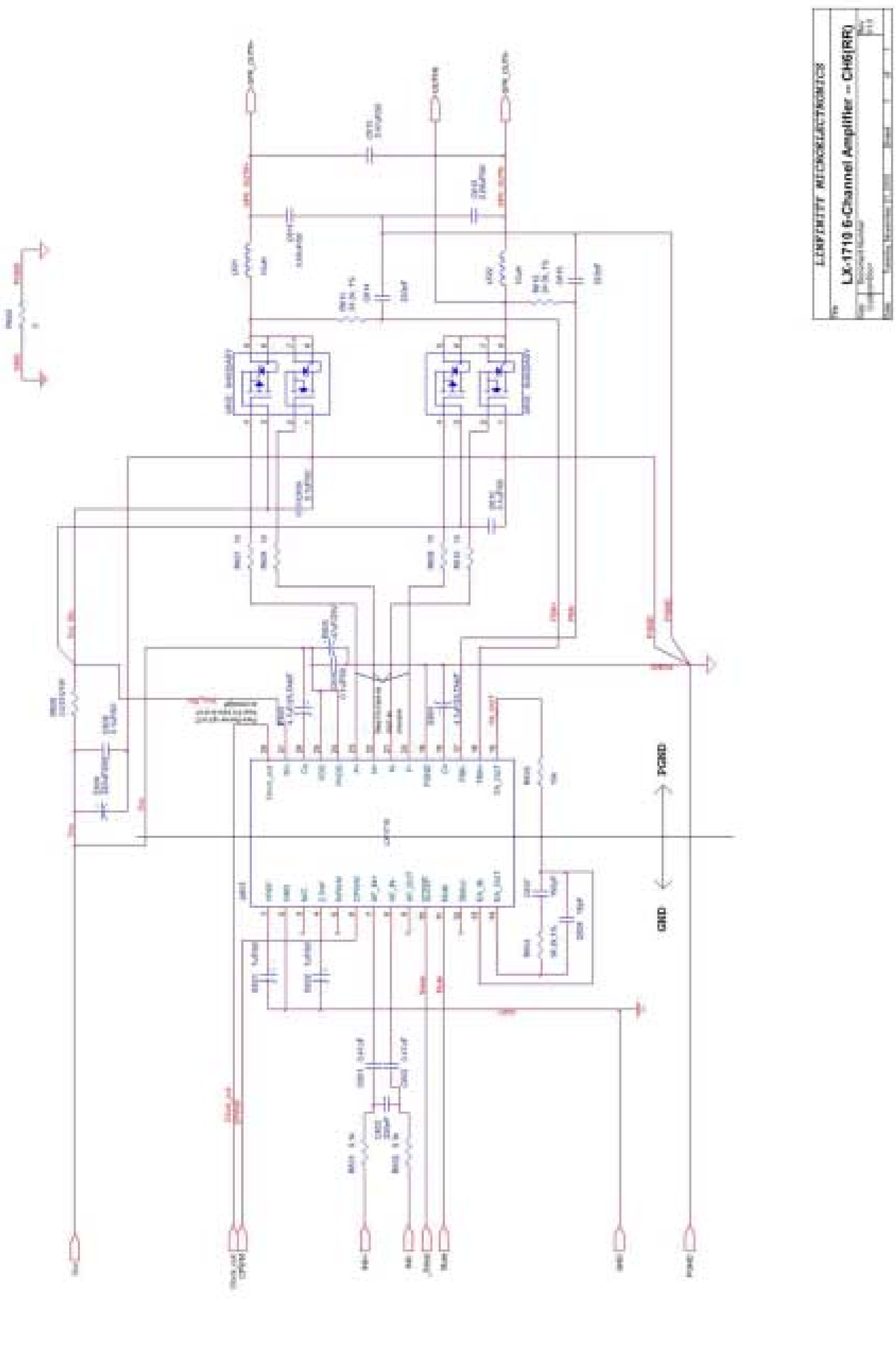

LINFINITY MICROELECTRONICS
LX-1710 6-Channel Amplifier -- CH1(FL)
PGND
GND


LINFINITY MICROELECTRONICS
LX-1710 6-Channel Amplifier -- CH2(RL)
PGND
GND


LINFINITY MICROELECTRONICS
LX-1710 6-Channel Amplifier -- CH3(CTR)


LINFINITY MICROELECTRONICS
LX-1710 6-Channel Amplifier -- CH4(SW)
PGND
GND


LINFINITY MICROELECTRONICS
LX-1710 6-Channel Amplifier – CH5(FR)
PGND
GND


LINFINITY MICROELECTRONICS
LX-1710 6-Channel Amplifier -- CH6(RR)