National Semiconductor

March 2005

LM4804 Boomer® Audio Power Amplifier Series
Low Voltage High Power Audio Power Amplifier

General Description

The LM4804 integrates a Boost Converter with an Audio Power Amplifier to drive voice coil speakers in portable applications. When powered by a 3V supply, it is capable of creating 1.8W power dissipation in an 8Ω bridge-tied-load (BTL) with less than 1% THD+N.

Boomer audio power amplifiers were designed specifically to provide high quality output power with a minimal amount of external components. The LM4804 does not require bootstrap capacitors, or snubber circuits. Therefore it is ideally suited for portable applications requiring high output voltage and minimal size.

The LM4804 features a micro-power shutdown mode. Additionally, the LM4804 features an internal thermal shutdown protection mechanism.

The LM4804 contains advanced pop & click circuitry that eliminates output transients which would otherwise occur during power or shutdown cycles.

The LM4804 is unity-gain stable. Its closed-loop gain is determined by the value of external, user selected resistors.

Key Specifications

■ Quiescent Power Supply Current
  (V_{DD} = 4.2V, R_L = 8Ω)   11mA (typ)
■ BTL Output Power
  (R_L = 8Ω, 2% THD+N, V_{DD} = 3V)   1.8W (typ)
■ Shutdown Current   2μA (max)

Features

■ Pop & click circuitry eliminates noise during turn-on and turn-off transitions
■ Low, 2μA (max) shutdown current
■ Low, 11mA (typ) quiescent current (V_{DD} = 4.2V, R_L = 8Ω)
■ 1.8W mono BTL output, R_L = 8Ω, V_{DD} = 3V
■ Short circuit protection
■ Unity-gain stable
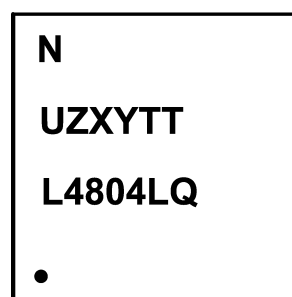■ External gain configuration capability

Applications

■ Cellphone
■ PDA

Connection Diagrams

LM4804LQ (5x5)
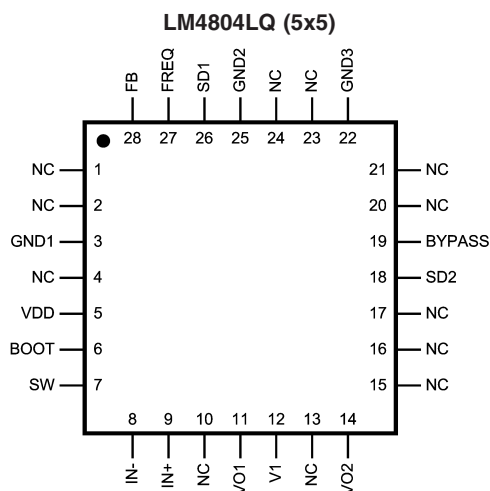
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Top View
Order Number LM4804LQ
See NS Package Number LQA28A

LQ Marking

N
UZXYTT
L4804LQ

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Top View
U = Wafer Fab Code
Z = Assembly Plant Code
XY = Date Code
TT = Die Run Code

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Typical Application
"LM4804LQ"
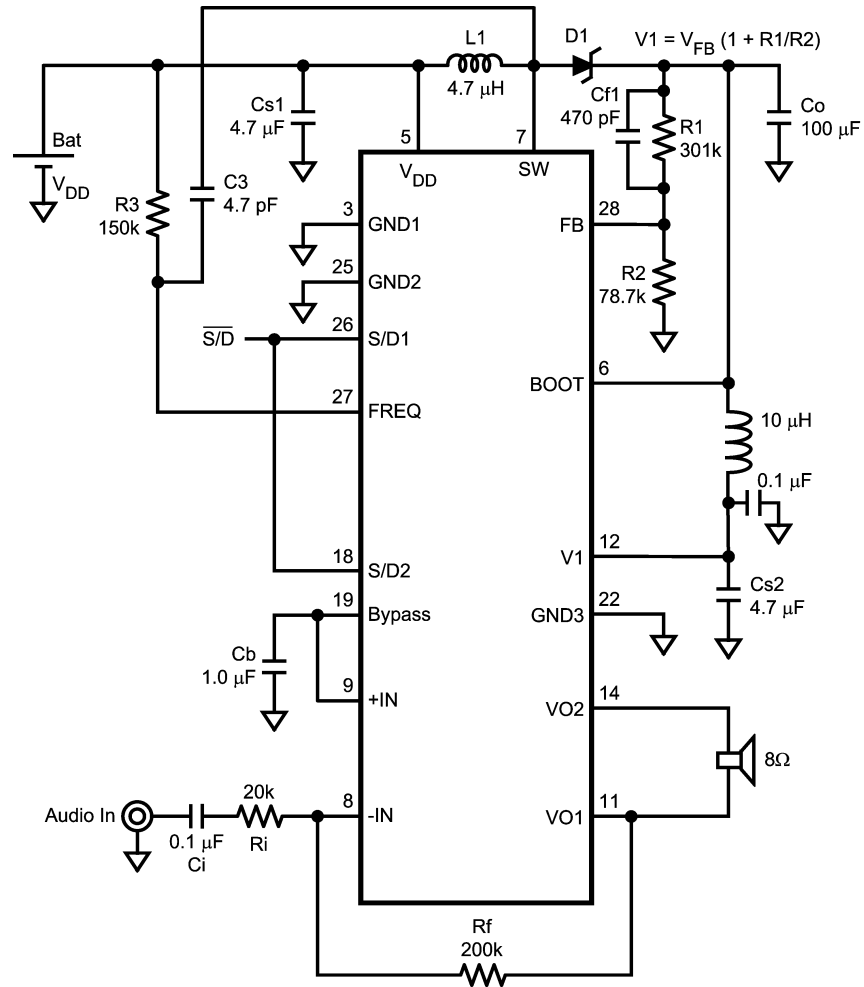
FIGURE 1. Typical LM4804 Audio Amplifier Application Circuit

Absolute Maximum Ratings (Notes 1, 2)

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

Supply Voltage (V_{DD})	6.5V
Supply Voltage (V_1)	6.5V
Storage Temperature	−65°C to +150°C
Input Voltage	−0.3V to V_{DD} + 0.3V
Power Dissipation (Note 3)	Internally limited
ESD Susceptibility (Note 4)	2000V
ESD Susceptibility (Note 5)	200V

Junction Temperature	125°C
Thermal Resistance	
θ_{JA} (LLP)	59°C/W

See AN-1187 'Leadless Leadframe Packaging (LLP).'

Operating Ratings

Temperature Range	
$T_{MIN} \leq T_A \leq T_{MAX}$	−40°C $\leq T_A \leq$ +85°C
Supply Voltage (V_{DD})	3V $\leq V_{DD} \leq$ 5V
Supply Voltage (V_1)	2.7V $\leq V_1 \leq$ 6.1V

Electrical Characteristics V_{DD} = 4.2V (Notes 1, 2)

The following specifications apply for V_{DD} = 4.2V, V_1 = 6.0V, A_{V-BTL} = 20dB, R_L = 8Ω, f_{IN} = 1kHz, C_B = 1.0µF, R_1 = 301kΩ, R_2 = 78.7kΩ unless otherwise specified. Limits apply for T_A = 25°C. See Figure 1.

Symbol	Parameter	Conditions	LM4804 Typical (Note 6)	LM4804 Limit (Notes 7, 8)	Units (Limits)
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0, R_{LOAD} = ∞	11	22	mA (max)
I_{SD}	Shutdown Current	$V_{SHUTDOWN}$ = GND (Notes 9, 10)	0.1	2	µA (max)
V_{SDIH}	Shutdown Voltage Input High	SD1 SD2		$0.7V_{DD}$ 1.4	V (min)
V_{SDIL}	Shutdown Voltage Input Low	SD1 SD2		$0.15V_{DD}$ 0.4	V (max)
T_{WU}	Wake-up Time	C_B = 1.0µF	70		msec (max)
V_{OS}	Output Offset Voltage		4	40	mV (max)
TSD	Thermal Shutdown Temperature			125	°C (min)
P_{OUT}	Output Power	THD = 2% (max)	1.9	1.7	W (min)
THD+N	Total Harmomic Distortion + Noise	P_{OUT} = 1.5W	0.13	0.5	%
ϵ_{OS}	Output Noise	A-Weighted Filter, V_{IN} = 0V, Input Referred	22		µV
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200mV_{p-p} f = 217Hz f = 1kHz	72 67		dB (min)
V_{FB}	Feedback Pin Reference Voltage		1.24	1.2772 1.2028	V (max) V (min)

Electrical Characteristics V_{DD} = 3.0V (Notes 1, 2)

The following specifications apply for V_{DD} = 3.0V, V_1 = 6.0V, A_{V-BTL} = 20dB, R_L = 8Ω, f_{IN} = 1kHz, C_B = 1.0µF, R_1 = 301kΩ, R_2 = 78.7kΩ unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4804 Typical (Note 6)	LM4804 Limit (Notes 7, 8)	Units (Limits)
I_{DD}	Quiescent Power Supply Current	V_{DD} = 3.2V, V_{IN} = 0, R_{LOAD} = ∞	19	33	mA (max)
I_{SD}	Shutdown Current	$V_{SHUTDOWN}$ = GND (Notes 9, 10)	0.1	2	µA (max)
V_{SDIH}	Shutdown Voltage Input High	SD1 SD2		$0.7V_{DD}$ 1.4	V (min)
V_{SDIL}	Shutdown Voltage Input Low	SD1 SD2		$0.15V_{DD}$ 0.4	V (max)
T_{WU}	Wake-up Time	C_B = 1.0µF	70		msec (max)
V_{OS}	Output Offset Voltage		3	40	mV (max)

Electrical Characteristics V$_{DD}$ = 3.0V (Notes 1, 2) (Continued)

specifications apply for V$_{DD}$ = 3.0V, V$_1$ = 6.0V, A$_{V-BTL}$ = 20dB, R$_L$ = 8Ω, f$_{IN}$ = 1kHz, C$_B$ = 1.0µF, R$_1$ = 301kΩ, R$_2$ = 78.7kΩ unless otherwise specified. Limits apply for T$_A$ = 25˚C.

Symbol	Parameter	Conditions	LM4804		Units
			Typical	**Limit**	**(Limits)**
			(Note 6)	(Notes 7, 8)	
TSD	Thermal Shutdown Temperature			125	˚C (min))
P$_{OUT}$	Output Power	THD = 2% (max)	1.8	1.65	W (min)
THD+N	Total Harmomic Distortion + Noise	P$_{OUT}$ = 1.5W	0.15	0.5	%
ε$_{OS}$	Output Noise	A-Weighted Filter, V$_{IN}$ = 0V, Input Referred	30		µV
PSRR	Power Supply Rejection Ratio	V$_{RIPPLE}$ = 200mV$_{p-p}$ f = 217Hz f = 1kHz	73 66		dB (min)
V$_{FB}$	Feedback Pin Reference Voltage	(Note 11)	1.24	1.2772 1.2028	V (max) V (min)

Note 1: All voltages are measured with respect to the GND pin, unless otherwise specified.

Note 2: *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not guarantee specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 3: The maximum power dissipation must be derated at elevated temperatures and is dictated by T$_{JMAX}$, θ$_{JA}$, and the ambient temperature, T$_A$. The maximum allowable power dissipation is P$_{DMAX}$ = (T$_{JMAX}$ − T$_A$) / θ$_{JA}$ or the given in Absolute Maximum Ratings, whichever is lower.

Note 4: Human body model, 100pF discharged through a 1.5kΩ resistor.

Note 5: Machine Model, 220pF – 240pF discharged through all pins.

Note 6: Typicals are measured at 25˚C and represent the parametric norm.

Note 7: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 8: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.
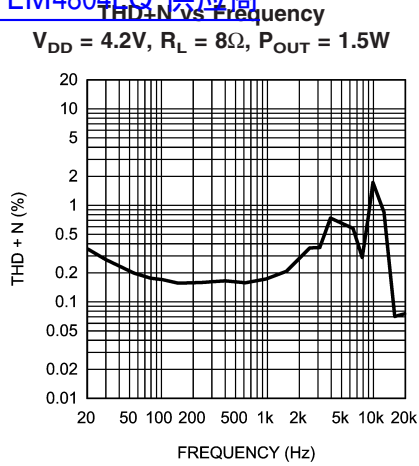
Note 9: Shutdown current is measured in a normal room environment. The Shutdown pin should be driven as close as possible to V$_{in}$ for minimum shutdown current.

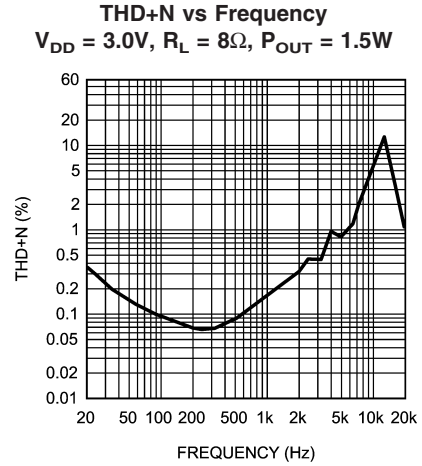**Note 10:** Shutdown current is measured with components R1 and R2 removed.

Note 11: Feedback pin reference voltage is measured with the Audio Amplifier disconnected from the Boost converter (the Boost converter is unloaded).
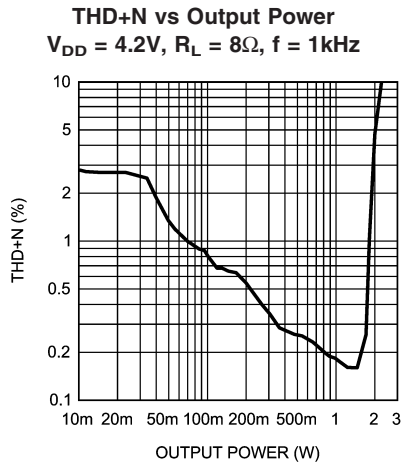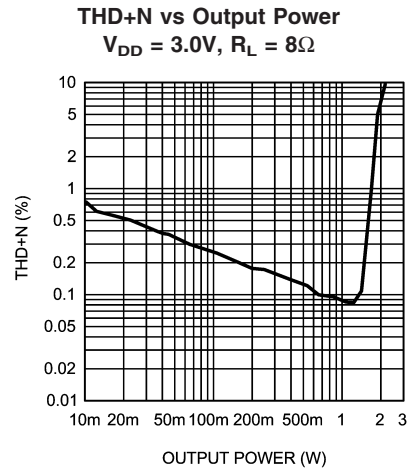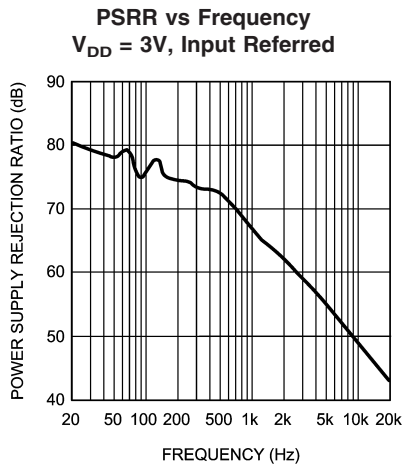
Typical Performance Characteristics

THD+N vs Frequency

V_{DD} = 4.2V, R_L = 8Ω, P_{OUT} = 1.5W

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THD+N vs Frequency

V_{DD} = 3.0V, R_L = 8Ω, P_{OUT} = 1.5W

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THD+N vs Output Power

V_{DD} = 4.2V, R_L = 8Ω, f = 1kHz

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THD+N vs Output Power

V_{DD} = 3.0V, R_L = 8Ω

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PSRR vs Frequency

V_{DD} = 3V, Input Referred

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PSRR vs Frequency

V_{DD} = 4.2V, Input Referred
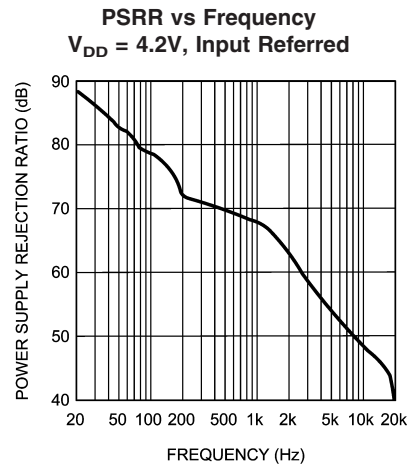
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Typical Performance Characteristics (Continued)

"LM4804LQ"

**Power Supply Current
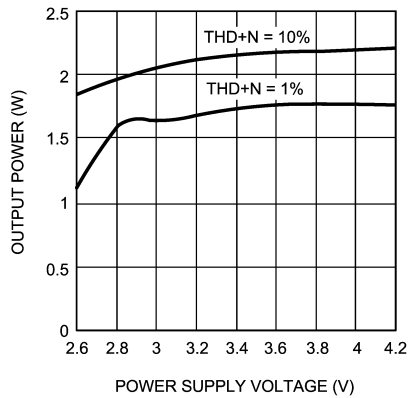vs Power Supply Voltage
$R_L = 8\Omega$**
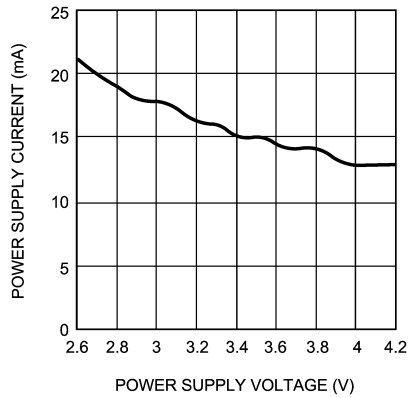
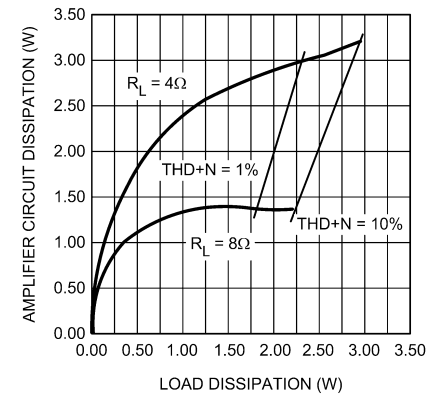20116727

**Power Supply Current
vs Output Power**
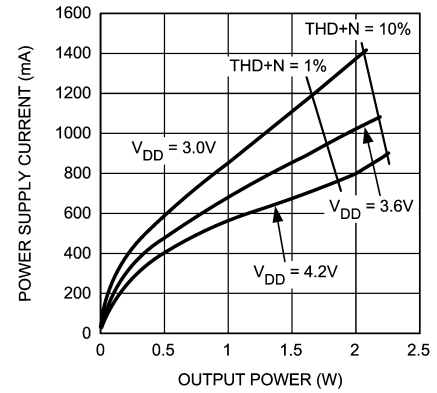
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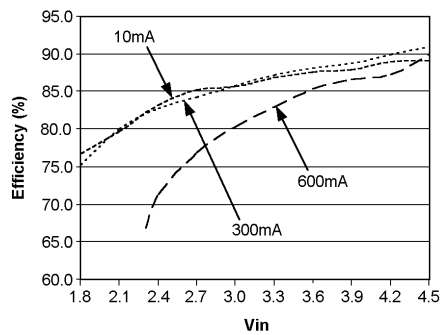**Output Power
vs Power Supply Voltage
$R_L = 8\Omega$**

20116729
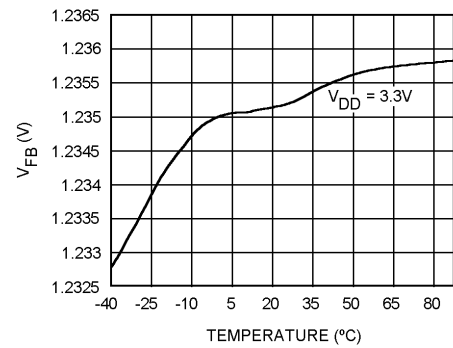
**Amplifier Circuit Dissipation
vs Load Dissipation**

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**Efficiency vs V_{IN}
$V_{OUT} = 5.0V$**

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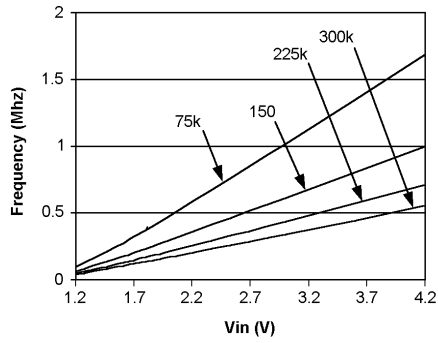**V_{FB} vs Temperature**

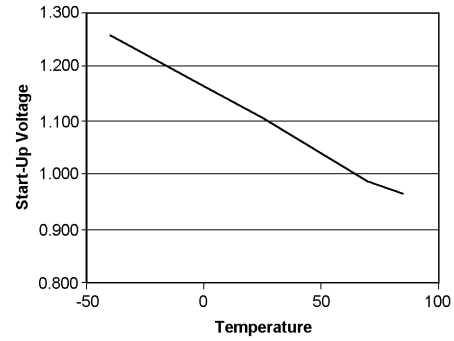20116732

Typical Performance Characteristics (Continued)

"LM4804LQ"

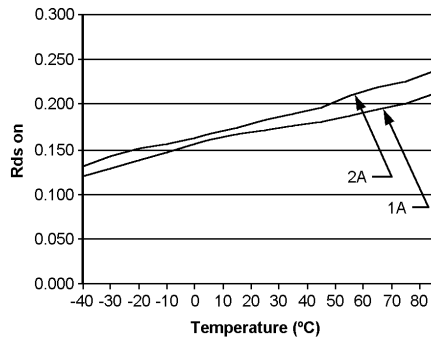**Frequency vs V_IN**
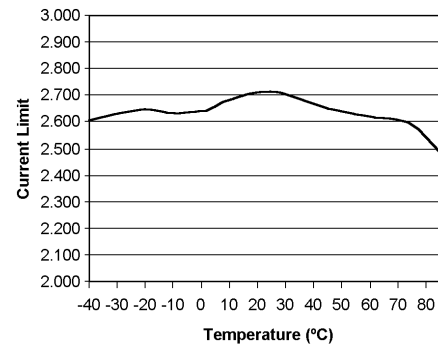

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**Maximum Start Up Voltage
vs Temperature**

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**Typical R_DS(ON)
vs Temperature**

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**Typical Current Limit
vs Temperature**

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Application Information

BRIDGE CONFIGURATION EXPLANATION

Audio Amplifier portion of the LM4804 has two operational amplifiers internally, allowing for a few different amplifier configurations. The first amplifier's gain is externally configurable, while the second amplifier is internally fixed in a unity-gain, inverting configuration. The closed-loop gain of the first amplifier is set by selecting the ratio of Rf to Ri while the second amplifier's gain is fixed by the two internal 20kΩ resistors. Figure 1 shows that the output of amplifier one serves as the input to amplifier two which results in both amplifiers producing signals identical in magnitude, but out of phase by 180˚. Consequently, the differential gain for the IC is

$$A_{VD} = 2*(Rf/Ri)$$

By driving the load differentially through outputs Vo1 and Vo2, an amplifier configuration commonly referred to as "bridged mode" is established. Bridged mode operation is different from the classical single-ended amplifier configuration where one side of the load is connected to ground.

A bridge amplifier design has a few distinct advantages over the single-ended configuration, as it provides differential drive to the load, thus doubling output swing for a specified supply voltage. Four times the output power is possible as compared to a single-ended amplifier under the same conditions. This increase in attainable output power assumes that the amplifier is not current limited or clipped. In order to choose an amplifier's closed-loop gain without causing excessive clipping, please refer to the **Audio Power Amplifier Design** section.

A bridge configuration also creates a second advantage over single-ended amplifiers. Since the differential outputs, Vo1 and Vo2, are biased at half-supply, no net DC voltage exists across the load. This eliminates the need for an output coupling capacitor which is required in a single supply, single-ended amplifier configuration. Without an output coupling capacitor, the half-supply bias across the load would result in both increased internal IC power dissipation and also possible loudspeaker damage.

AMPLIFIER POWER DISSIPATION

Power dissipation is a major concern when designing a successful amplifier, whether the amplifier is bridged or single-ended. A direct consequence of the increased power delivered to the load by a bridge amplifier is an increase in internal power dissipation. Since the amplifier portion of the LM4804 has two operational amplifiers, the maximum internal power dissipation is 4 times that of a single-ended amplifier. The maximum power dissipation for a given BTL application can be derived from Equation 1.

$$P_{DMAX(AMP)} = 4(V_{DD})^2 / (2\pi^2 R_L) \qquad (1)$$

BOOST CONVERTER POWER DISSIPATION

At higher duty cycles, the increased ON time of the FET means the maximum output current will be determined by power dissipation within the LM2731 FET switch. The switch power dissipation from ON-state conduction is calculated by Equation 2.

$$P_{DMAX(SWITCH)} = DC \times I_{IND}(AVE)^2 \times R_{DS}(ON) \qquad (2)$$

There will be some switching losses as well, so some derating needs to be applied when calculating IC power dissipation.

TOTAL POWER DISSIPATION

The total power dissipation for the LM4804 can be calculated by adding Equation 1 and Equation 2 together to establish Equation 3:

$$P_{DMAX(TOTAL)} = [4*(V_{DD})^2/2\pi^2 R_L]+[DC \times I_{IND}(AVE)^2 \times R_{DS}(ON)] \qquad (3)$$

The result from Equation 3 must not be greater than the power dissipation that results from Equation 4:

$$P_{DMAX} = (T_{JMAX} - T_A) / \theta JA \qquad (4)$$

For package LQA28A, θ_{JA} = 59˚C/W. T_{JMAX} = 125˚C for the LM4804. Depending on the ambient temperature, T_A, of the system surroundings, Equation 4 can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation 3 is greater than that of Equation 4, then either the supply voltage must be increased, the load impedance increased or T_A reduced. For the typical application of a 3V power supply, with V1 set to 6.0V and 8Ω load, the maximum ambient temperature possible without violating the maximum junction temperature is approximately TBD˚C provided that device operation is around the maximum power dissipation point. Thus, for typical applications, power dissipation is not an issue. Power dissipation is a function of output power and thus, if typical operation is not around the maximum power dissipation point, the ambient temperature may be increased accordingly. Refer to the Typical Performance Characteristics curves for power dissipation information for lower output levels.

EXPOSED-DAP PACKAGE PCB MOUNTING CONSIDERATIONS

The LM4804's exposed-DAP (die attach paddle) package (LD) provides a low thermal resistance between the die and the PCB to which the part is mounted and soldered. This allows rapid heat transfer from the die to the surrounding PCB copper traces, ground plane, and surrounding air. The LD package should have its DAP soldered to a copper pad on the PCB. The DAP's PCB copper pad may be connected to a large plane of continuous unbroken copper. This plane forms a thermal mass, heat sink, and radiation area. Further detailed and specific information concerning PCB layout, fabrication, and mounting an LD (LLP) package is available from National Semiconductor's Package Engineering Group under application note AN1187.

SHUTDOWN FUNCTION

In many applications, a microcontroller or microprocessor output is used to control the shutdown circuitry to provide a quick, smooth transition into shutdown. Another solution is to use a single-pole, single-throw switch, in conjunction with an external pull-up resistor to drive both shutdown pins simultaneously. When the switch is closed, the shutdown pin is connected to ground which disables the amplifier. If the switch is open, then the external pull-up resistor to V_{DD} will enable the LM4804. This scheme guarantees that the shutdown pins will not float thus preventing unwanted state changes.

Application Information (Continued)

EXTERNAL COMPONENT SELECTION

Proper selection of external components in applications using integrated power amplifiers, and switching DC-DC converters, is critical to optimize device and system performance. Consideration to component values must be used to maximize overall system quality.

The best capacitors for use with the switching converter portion of the LM4804 are multi-layer ceramic capacitors. They have the lowest ESR (equivalent series resistance) and highest resonance frequency which makes them optimum for use with high frequency switching converters.

When selecting a ceramic capacitor, only X5R and X7R dielectric types should be used. Other types such as Z5U and Y5F have such severe loss of capacitance due to effects of temperature variation and applied voltage, they may provide as little as 20% of rated capacitance in many typical applications. Always consult capacitor manufacturer's data curves before selecting a capacitor. High-quality ceramic capacitors can be obtained from Taiyo-Yuden, AVX, and Murata.

POWER SUPPLY BYPASSING

As with any amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. The capacitor location on both the bypass and power supply pins should be as close to the device as possible.

SELECTING THE AUDIO AMPLIFIER'S INPUT CAPACITOR

One of the major considerations is the closedloop bandwidth of the amplifier. To a large extent, the bandwidth is dictated by the choice of external components shown in Figure 1. The input coupling capacitor, C_i, forms a first order high pass filter which limits low frequency response. This value should be chosen based on needed frequency response for a few distinct reasons.

Large input capacitors are both expensive and space hungry for portable designs. Clearly, a certain sized capacitor is needed to couple in low frequencies without severe attenuation. But ceramic speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 100Hz to 150Hz. Thus, using a large input capacitor may not increase actual system performance.

In addition to system cost and size, click and pop performance is effected by the size of the input coupling capacitor, C_i. A larger input coupling capacitor requires more charge to reach its quiescent DC voltage (nominally 1/2 V_{DD}). This charge comes from the output via the feedback and is apt to create pops upon device enable. Thus, by minimizing the capacitor size based on necessary low frequency response, turn-on pops can be minimized.

SELECTING THE AUDIO AMPLIFIER'S BYPASS CAPACITOR

Besides minimizing the input capacitor size, careful consideration should be paid to the bypass capacitor value. Bypass capacitor, C_B, is the most critical component to minimize turn-on pops since it determines how fast the amplifier turns on. The slower the amplifier's outputs ramp to their quiescent DC voltage (nominally 1/2 V_{DD}), the smaller the turn-on pop. Choosing C_B equal to 1.0μF along with a small value of C_i (in the range of 0.039μF to 0.39μF), should produce a virtually clickless and popless shutdown function. While the device will function properly, (no oscillations or motorboating), with C_B equal to 0.1μF, the device will be much more susceptible to turn-on clicks and pops. Thus, a value of C_B equal to 1.0μF is recommended in all but the most cost sensitive designs.

OPERATING PRINCIPLE

The LM4804 includes step-up DC-DC voltage regulation for battery-powered and low-input voltage systems. It combines a step-up switching regulator, N-channel power MOSFET, built-in current limit, thermal limit, and voltage reference. The switching DC-DC regulator boosts an input voltage between .8V and 14V to a regulated output voltage between 1.24V and 14V. The LM4804 starts from a low 1.1V input and remains operational down to below .8V.

This device is optimized for use in cellular phones and other applications requiring a small size, low profile, as well as low quiescent current for maximum battery life during stand-by and shutdown.

Additional features include a built-in peak switch current limit, a high-efficiency gated-oscillator topology that offers an output of up to 2A at low output voltages, and thermal protection circuitry.

Application Information (Continued)

FIGURE 2. Functional Diagram of the LM4804's Regulator

GATED OSCILLATOR CONTROL SCHEME

The on/off regulation mode of the LM4804, along with its ultra-low quiescent current, results in good efficiency over a very wide load range. The internal oscillator frequency can be programmed using an external resistor to be constant or vary with the battery voltage. Adding a capacitor to program the frequency allows the designer to adjust the duty cycle and optimize it for the application. Adding a resistor in addition to the capacitor allows the duty cycle to dynamically compensate for changes to the input/output voltage ratio. We call this a Ratio Adaptive Gated Oscillator circuit. Using the correct RC components to adjust the oscillator allows the part to run with low ripple and high efficiency over a wide range of loads and input/output voltages.

FIGURE 3. Typical Step-Up Regulator Waveforms

Application Information (Continued)

PULSE FREQUENCY MODULATION (PFM)

Pulse Frequency Modulation is typically accomplished by switching continuously until the voltage limit is reached and skipping cycles after that to just maintain it. This results in a somewhat hysteretic mode of operation. The coil stores more energy each cycle as the current ramps up to high levels. When the voltage limit is reached, the system usually overshoots to a higher voltage than required, due to the stored energy in the coil (see Figure 3). The system will also undershoot somewhat when it starts switching again because it has depleted all the stored energy in the coil and needs to store more energy to reach equilibrium with the load. Larger output capacitors and smaller inductors reduce the ripple in these situations. The frequency being filtered, however, is not the basic switching frequency. It is a lower frequency determined by the load, the input/output voltage and the circuit parameters. This mode of operation is useful in situations where the load variation is significant. Power managed computer systems, for instance, may vary from zero to full load while the system is on and this is usually the preferred regulation mode for such systems.

CYCLE TO CYCLE PFM

When the load doesn't vary over a wide range (like zero to full load), ratio adaptive circuit techniques can be used to achieve cycle to cycle PFM regulation and lower ripple (or smaller output capacitors). The key to success here is matching the duty cycle of the circuit closely to what is required by the input to output voltage ratio. This ratio then needs to be dynamically adjusted for input voltage changes (usually caused by batteries running down). The chosen ratio should allow most of the energy in each switching cycle to be delivered to the load and only a small amount to be stored. When the regulation limit is reached, the overshoot will be small and the system will settle at an equilibrium point where it adjusts the off time in each switching cycle to meet the current requirements of the load. The off time adjustment is done by exceeding the regulation limit during each switching cycle and waiting until the voltage drops below the limit again to start the next switching cycle. The current in the coil never goes to zero like it frequently does in the hysteretic operating mode of circuits with wide load variations or duty cycles that aren't matched to the input/output voltage ratio. Optimizing the duty cycle for a given set of input/output voltages conditions can be done by using the circuit values in the Application Notes.

LOW VOLTAGE START-UP

The LM4804 can start-up from voltages as low as 1.1 volts. On start-up, the control circuitry switches the N-channel MOSFET continuously until the output reaches 3 volts. After this output voltage is reached, the normal step-up regulator feedback and gated oscillator control scheme take over. Once the device is in regulation, it can operate down to below .8V input, since the internal power for the IC can be boot-strapped from the output using the Vdd pin.

SHUT DOWN

The LM4804 features a shutdown mode that reduces the quiescent current to less than a guaranteed 2.5uA over temperature. This extends the life of the battery in battery powered applications. During shutdown, all feedback and control circuitry is turned off. The regulator's output voltage drops to one diode drop below the input voltage. Entry into the shutdown mode is controlled by the active-low logic input pin EN (pin- 2). When the logic input to this pin is pulled below $0.15V_{DD}$, the device goes into shutdown mode. The logic input to this pin should be above $0.7V_{DD}$ for the device to work in normal step-up mode.

SELECTING OUTPUT CAPACITOR (C_O) FOR BOOST CONVERTER

A single ceramic capacitor of value 4.7µF to 10µF will provide sufficient output capacitance for most applications. If larger amounts of capacitance are desired for improved line support and transient response, tantalum capacitors can be used. Aluminum electrolytics with ultra low ESR such as Sanyo Oscon can be used, but are usually prohibitively expensive. Typical Al electrolytic capacitors are not suitable for switching frequencies above 500 kHz due to significant ringing and temperature rise due to self-heating from ripple current. An output capacitor with excessive ESR can also reduce phase margin and cause instability.

In general, if electrolytics are used, it is recommended that they be paralleled with ceramic capacitors to reduce ringing, switching losses, and output voltage ripple.

INTERNAL CURRENT LIMIT AND THERMAL PROTECTION

An internal cycle-by-cycle current limit serves as a protection feature. This is set high enough (2.85A typical, approximately 4A maximum) so as not to come into effect during normal operating conditions. An internal thermal protection circuit disables the MOSFET power switch when the junction temperature (T_J) exceeds about 160°C. The switch is re-enabled when T_J drops below approximately 135°C.

NON-LINEAR EFFECT

The LM4804 takes advantage of a non-linear effect that allows for the duty cycle to be programmable. The C3 capacitor is used to dump charge on the FREQ pin in order to manipulate the duty cycle of the internal oscillator. The part is being tricked to behave in a certain manner, in the effort to make this Pulse Frequency Modulated (PFM) boost switching regulator behave as a Pulse Width Modulated (PWM) boost switching regulator.

CHOOSING THE CORRECT C3 CAPACITOR

The C3 capacitor allows for the duty cycle of the internal oscillator to be programmable. Choosing the correct C3 capacitor to get the appropriate duty cycle for a particular application circuit is a trial and error process. The non-linear effect that C3 produces is dependent on the input voltage and output voltage values. The correct C3 capacitor for particular input and output voltage values cannot be calculated. Choosing the correct C3 capacitance is best done by trial and error, in conjunction with the checking of the inductor peak current to make sure your not too close to the current limit of the device. As the C3 capacitor value increases, so does the duty cycle. And conversely as the C3 capacitor value decreases, the duty cycle decreases. An incorrect choice of the C3 capacitor can result in the part prematurely tripping the current limit and/or double pulsing, which could lead to the output voltage not being stable.

SETTING THE OUTPUT VOLTAGE

The output voltage of the step-up regulator can be set by connecting a feedback resistive divider made of R_{F1} and R_{F2}. The resistor values are selected as follows:

$$R_1 = R_2[(V_{OUT}/1.24) - 1]$$

Application Information (Continued)

"LM4804LQ"

A value of 50k to 100k is suggested for R_2. Then, R_1 can be selected using the above equation.

V_{DD} SUPPLY

The Vdd supply must be between 3 to 5 volts for the LM4804. This voltage can be bootstrapped from a much lower input voltage by simply connecting the V_{DD} pin to V_{OUT}. In the event that the V_{DD} supply voltage is not a low ripple voltage source (less than 200 millivolts), it may be advisable to use an RC filter to clean it up. Excessive ripple on V_{DD} may reduce the efficiency.

SETTING THE SWITCHING FREQUENCY

The switching frequency of the oscillator is selected by choosing an external resistor (R3) connected between V_{IN} and the FREQ pin. See the graph titled "Frequency vs V_{IN}" in the Typical Performance Characteristics section of the data sheet for choosing the R3 value to achieve the desired switching frequency. A high switching frequency allows the use of very small surface mount inductors and capacitors and results in a very small solution size. A switching frequency between 300kHz and 2MHz is recommended.

OUTPUT DIODE SELECTION

A Schottky diode should be used for the output diode. The forward current rating of the diode should be higher than the peak input current, and the reverse voltage rating must be higher than the output voltage. Do not use ordinary rectifier diodes, since slow switching speeds and long recovery times cause the efficiency and the load regulation to suffer. Table 1 shows a list of the diode manufacturers.

LLP PACKAGE DEVICES

The LM4804 is offered in the 14 lead LLP surface mount package to allow for increased power dissipation compared to the MSOP-8. For details of the thermal performance as well as mounting and soldering specifications, refer to **Application Note AN-1187**.

RECOMMENDED PRINTED CIRCUIT BOARD LAYOUT

Figure 5 through Figure 10 show the recommended four-layer PC board layout that is optimized for the LQ-packaged, 3V 1.7W LM4804 mono-BTL audio amplifier and its associated external components. This circuit is designed for use with an external 3V to 4.2V supply and speakers with 4Ω or higher impedance (8Ω nominal).

The LM4804 circuit board is easy to use. Apply between 3V and 4.2V (equivalent to, respectfully, a discharged or a fully charged Li-ion or NMH battery) and ground to JP2's V_{DD} and GND pins, respectively. Connect a speaker with an impedance of 4Ω or greater (8Ω nominal) between the board's VO1 (-) and VO2 (+) pins. An audio signal is applied to JP1 between the V_{IN} (+) and GND (-) pins.
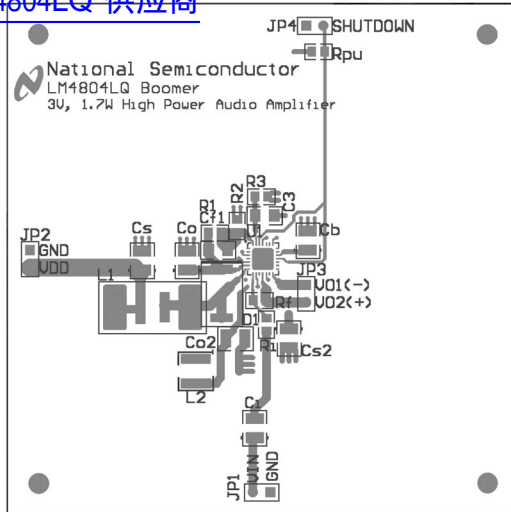
The circuit board is configured for a gain of 20 or 26dB (VO2 -VO1 with respect to VIN). An inverting gain of -10 at VO1 is set by Rf (200kΩ) versus Ri (20kΩ). The extra gain of 2 is a product of the BTL output (VO2 - VO1). Gain can be modified by changing Rf's value with respect to Ri.

TABLE 1. Suggested Manufacturers List

Inductors	Capacitors	Diodes
Coilcraft	**Sprague/ Vishay**	**Motorola**
Tel: (800) 322-2645	Tel: (207) 324-4140	Tel: (800) 521-6274
Fax: (708) 639-1469	Fax: (207) 324-7223	Fax: (602) 244-6609
Coiltronics	**Kemet**	**International Rectifier (IR)**
Tel: (407) 241-7876	Tel: (864) 963-6300	Tel: (310) 322-3331
Fax: (407) 241-9339	Fax: (864) 963-6521	Fax: (310) 322-3332
Pulse Engineering	**Nichicon**	**General Semiconductor**
Tel: (619) 674-8100	Tel: (847) 843-7500	Tel: (516) 847-3222
Fax: (619) 674-8262	Fax: (847) 843-2798	Fax: (516) 847-3150

Application Information (Continued)
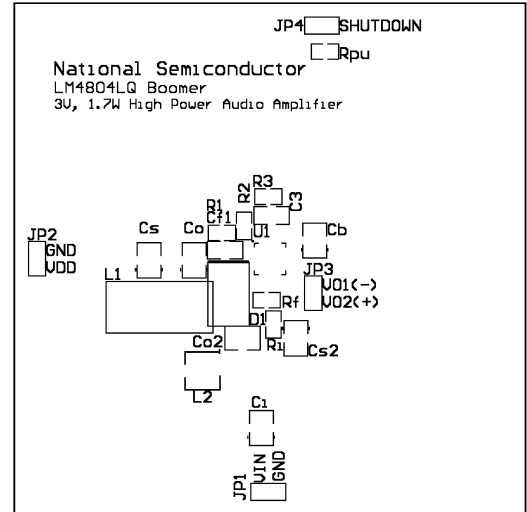
"LM4804LQ"

FIGURE 4. Demo Board Reference Schematic
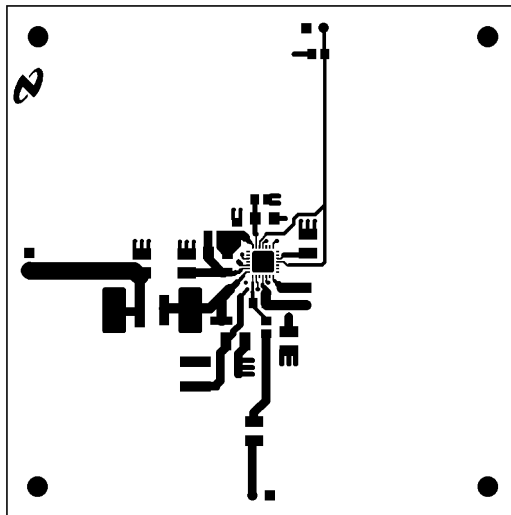
Demonstration Board Layout

FIGURE 5. Top Trace Layer Silkscreen

20116720

FIGURE 6. Top Layer Silkscreen

20116718

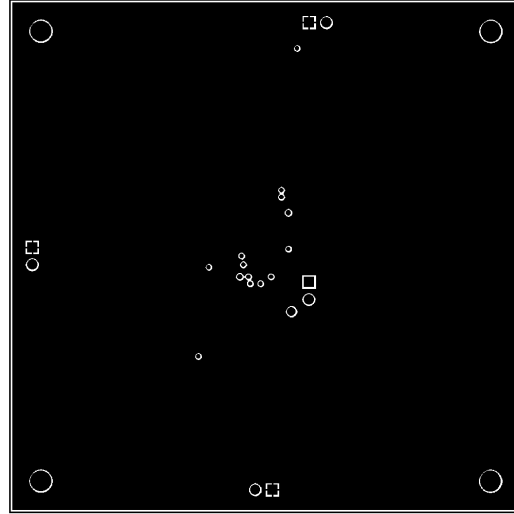**FIGURE 7. Top Trace Layer**
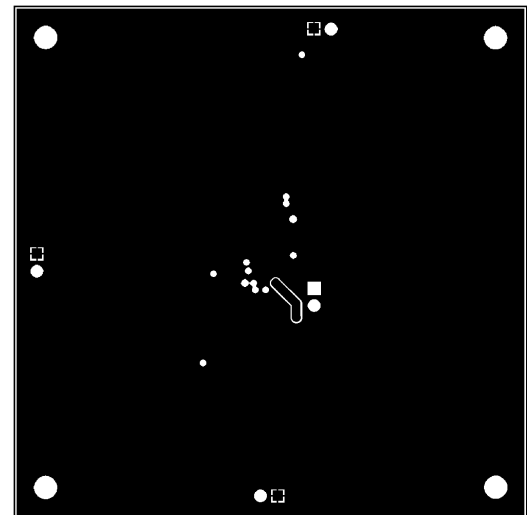
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FIGURE 8. Upper Internal GND Layer

20116716

14

Demonstration Board Layout (Continued)
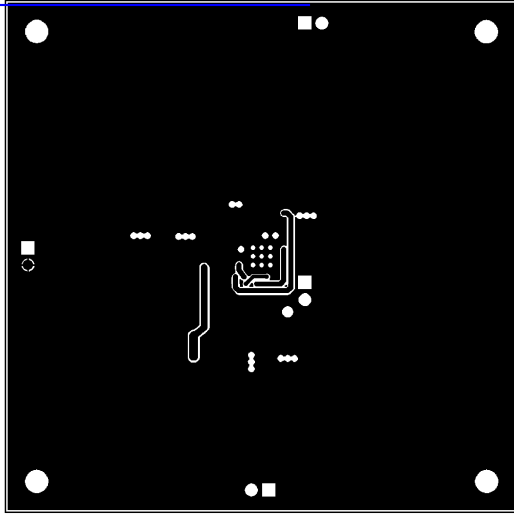
"LM4804LQ"
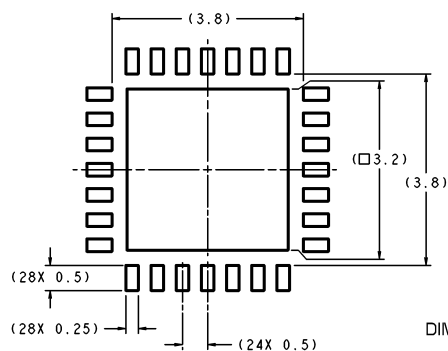

20116717

FIGURE 9. Lower Internal V$_{DD}$ Layer

20116715

FIGURE 10. Bottom Trace Layer with GND Plane

Physical Dimensions   inches (millimeters)
unless otherwise noted

(3.8)

(☐3.2)

(3.8)

(28X 0.5)

(28X 0.25)

(24X 0.5)

DIMENSIONS ARE IN MILLIMETERS

RECOMMENDED LAND PATTERN
1:1 RATION WITH PKG SOLDER PADS

(0.2)   0.23$^{+0.05}_{0}$

(0.25)

(0.25)

DETAIL A

PIN 1 INDEX AREA

5±0.1

5±0.1

B   A

C

0.8 MAX

(0.2)

SEE DETAIL A

PIN 1 ID

☐ 3.2±0.1

0.1 MAX
ALL LEADS

1   7

28   8

4X ☐3

22   14

21   15

28X 0.5±0.05

28X 0.25±0.05

24X ☐0.5

⊕ 0.1Ⓜ C AⓈ BⓈ
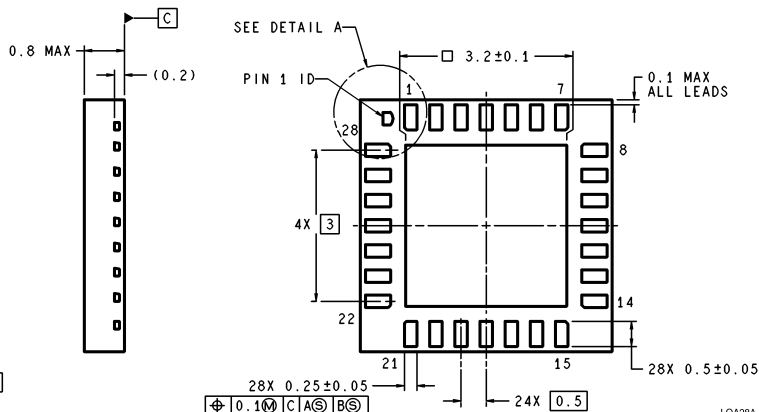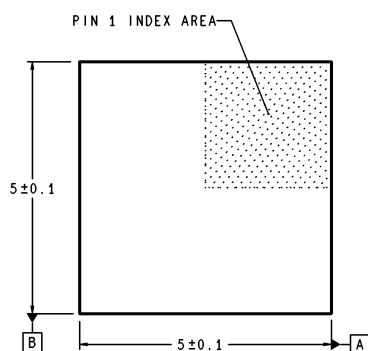
LQA28A (Rev B)

LQ Package
Order Number LM4804LQ
NS Package Number LQA28A

LIFE SUPPORT POLICY

BANNED SUBSTANCE COMPLIANCE