

LM4941 Boomer[®] Audio Power Amplifier Series 1.25 Watt Fully Differential Audio Power Amplifier With RF Suppression and Shutdown

Check for Samples: [LM4941](#), [LM4941SDBD](#), [LM4941TMBD](#)

FEATURES

- Improved RF Suppression, By Up to 20dB Over Previous Designs in Selected Applications
- Fully Differential Amplification
- Available in Space-Saving DSBGA Package
- Ultra Low Current Shutdown Mode
- Can Drive Capacitive Loads up to 100pF
- Improved Pop & Click Circuitry Eliminates Noises During Turn-On and Turn-Off Transitions
- 2.4 - 5.5V Operation
- No Output Coupling Capacitors, Snubber Networks or Bootstrap Capacitors Required

APPLICATIONS

- Mobile Phones
- PDAs
- Portable Electronic Devices

KEY SPECIFICATIONS

- Improved PSRR at 217Hz 95dB (typ)
- Power Output, $V_{DD} = 5.0V$, $R_L = 8\Omega$, 1% THD+N 1.25W (typ)
- Power Output, $V_{DD} = 3.0V$, $R_L = 8\Omega$, 1% THD+N 430mW (typ)
- Shutdown Current 0.1 μ A (typ)

DESCRIPTION

The LM4941 is a fully differential audio power amplifier primarily designed for demanding applications in mobile phones and other portable communication device applications. It is capable of delivering 1.25 watts of continuous average power to a 8 Ω load with less than 1% distortion (THD+N) from a 5V_{DC} power supply. The LM4941 does not require output coupling capacitors or bootstrap capacitors, and therefore is ideally suited for mobile phone and other small form factor applications where minimal PCB space is a primary requirement.

The LM4941 also features proprietary internal circuitry that suppresses the coupling of RF signals into the chip. This is important because certain types of RF signals (such as GSM) can couple into audio amplifiers in such a way that part of the signal is heard through the speaker. The RF suppression circuitry in the LM4941 makes it well-suited for portable applications in which strong RF signals generated by an antenna from or a cellular phone or other portable electronic device may couple audibly into the amplifier.

Other features include a low-power consumption shutdown mode, internal thermal shutdown protection, and advanced pop & click circuitry.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

Typical Application

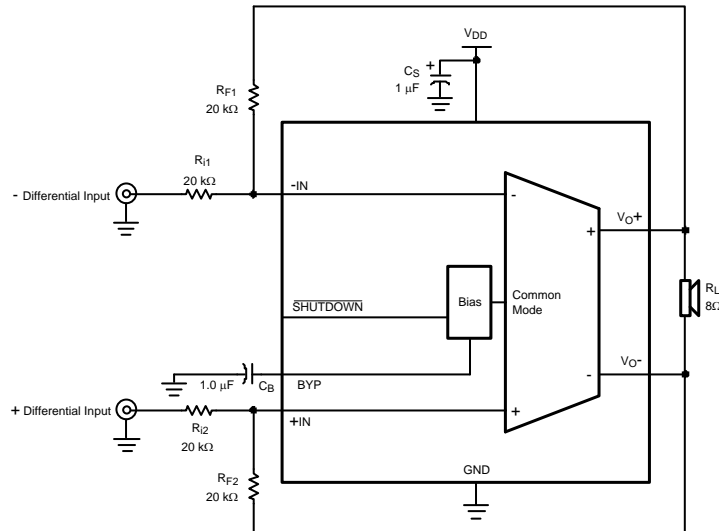


Figure 1. Typical Audio Amplifier Application Circuit

Connection Diagram

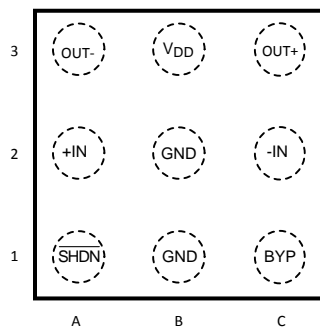


Figure 2. 9-Bump DSBGA - Top View
See YFQ0009 Package

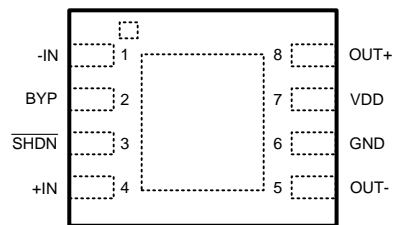


Figure 3. 8-Pin WSON - Top View
See NGS0008C Package



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings⁽¹⁾⁽²⁾⁽³⁾

Supply Voltage	6.0V	
Storage Temperature	–65°C to +150°C	
Input Voltage	–0.3V to V _{DD} + 0.3V	
Power Dissipation ⁽⁴⁾⁽⁵⁾	Internally Limited	
ESD Susceptibility ⁽⁶⁾	2000V	
ESD Susceptibility ⁽⁷⁾	200V	
Junction Temperature	150°C	
Thermal Resistance	θ_{JA} (TM)	100°C/W
	θ_{JA} (WSON)	71°C/W
Soldering Information	See AN-1187 (SNOA401)	

- (1) All voltages are measured with respect to the ground pin, unless otherwise specified.
- (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 ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the *Operating Ratings*. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
- (3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
- (4) 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 number given in Absolute Maximum Ratings, whichever is lower. For the LM4941, see [power derating](#) curve for additional information.
- (5) Maximum Power Dissipation (P_{DMAX}) in the device occurs at an output power level significantly below full output power. P_{DMAX} can be calculated using [Equation 3](#) shown in the [Application](#) section. It may also be obtained from the [Power Dissipation](#) graphs.
- (6) Human body model, 100pF discharged through a 1.5k Ω resistor.
- (7) Machine Model, 220pF – 240pF discharged through all pins.

Operating Ratings

Temperature Range T _{MIN} ≤ T _A ≤ T _{MAX}	–40°C ≤ T _A ≤ 85°C
Supply Voltage	2.4V ≤ V _{DD} ≤ 5.5V

Electrical Characteristics V_{DD} = 5V⁽¹⁾⁽²⁾

The following specifications apply for V_{DD} = 5V, A_V = 1V/V, and 8 Ω load unless otherwise specified. Limits apply for T_A = 25°C.

Symbol	Parameter	Conditions	LM4941		Units (Limits)
			Typical ⁽³⁾	Limit ⁽⁴⁾⁽⁵⁾	
I _{DD}	Quiescent Power Supply Current	V _{IN} = 0V, no load V _{IN} = 0V, R _L = 8 Ω	1.7 1.7	2.3	mA (max) mA
I _{SD}	Shutdown Current	V _{SHDN} = GND	0.1	0.8	μ A (max)
P _O	Output Power	THD+N = 1% (max); f = 1 kHz R _L = 8 Ω	1.25	1.15	W (min)
		THD+N = 10% (max); f = 1 kHz R _L = 8 Ω	1.54		W
THD+N	Total Harmonic Distortion + Noise	P _O = 0.7 W; f = 1kHz	0.04		%
PSRR	Power Supply Rejection Ratio	V _{RIPPLE} = 200mV _{P-P} Sine			
		f = 217Hz ⁽⁶⁾	95	80	dB (min)
		f = 1kHz ⁽⁶⁾	90		dB

- (1) All voltages are measured with respect to the ground pin, unless otherwise specified.
- (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 ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the *Operating Ratings*. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
- (3) Typicals are measured at 25°C and represent the parametric norm.
- (4) Limits are specified to TI's AOQL (Average Outgoing Quality Level).
- (5) Datasheet min/max specification limits are specified by design, test, or statistical analysis.
- (6) 10 Ω terminated input.

Electrical Characteristics $V_{DD} = 5V^{(1)(2)}$ (continued)

The following specifications apply for $V_{DD} = 5V$, $A_V = 1V/V$, and 8Ω load unless otherwise specified. Limits apply for $T_A = 25^\circ C$.

Symbol	Parameter	Conditions	LM4941		Units (Limits)
			Typical ⁽³⁾	Limit ⁽⁴⁾⁽⁵⁾	
CMRR	Common-Mode Rejection Ratio	$f = 217\text{Hz}$, $V_{CM} = 200\text{mV}_{P-P}$ Sine	70		dB
		$f = 20\text{Hz} - 20\text{kHz}$, $V_{CM} = 200\text{mV}_{PP}$	70		dB
V_{OS}	Output Offset Voltage	$V_{IN} = 0V$	2	6	mV (max)
V_{SDIH}	Shutdown Voltage Input High			1.4	V (min)
V_{SDIL}	Shutdown Voltage Input Low			0.4	V (max)
SNR	Signal-to-Noise Ratio	$P_O = 1W$, $f = 1\text{kHz}$	108		dB
T_{WU}	Wake-up Time from Shutdown	$C_{BYPASS} = 1\mu F$	12		ms

Electrical Characteristics $V_{DD} = 3V^{(1)(2)}$

The following specifications apply for $V_{DD} = 3V$, $A_V = 1V/V$, and 8Ω load unless otherwise specified. Limits apply for $T_A = 25^\circ C$.

Symbol	Parameter	Conditions	LM4941		Units (Limits)
			Typical ⁽³⁾	Limit ⁽⁴⁾⁽⁵⁾	
I_{DD}	Quiescent Power Supply Current	$V_{IN} = 0V$, no load	1.6	2.2	mA (max)
		$V_{IN} = 0V$, $R_L = 8\Omega$	1.6		mA
I_{SD}	Shutdown Current	$V_{SHDN} = GND$	0.1	0.8	μA (max)
P_O	Output Power	THD+N = 1% (max); $f = 1\text{kHz}$ $R_L = 8\Omega$	0.43		W
		THD+N = 10% (max); $f = 1\text{kHz}$ $R_L = 8\Omega$	0.54		W
THD+N	Total Harmonic Distortion + Noise	$P_O = 0.25W$; $f = 1\text{kHz}$	0.05		%
PSRR	Power Supply Rejection Ratio	$V_{RIPPLE} = 200\text{mV}_{PP}$ Sine			
		$f = 217\text{Hz}^{(6)}$	95		dB
		$f = 1\text{kHz}^{(6)}$	90		dB
CMRR	Common-Mode Rejection Ratio	$f = 217\text{Hz}$, $V_{CM} = 200\text{mV}_{PP}$ Sine	70		dB
V_{OS}	Output Offset Voltage	$V_{IN} = 0V$	2	6	mV (max)
V_{SDIH}	Shutdown Voltage Input High			1.4	V (min)
V_{SDIL}	Shutdown Voltage Input Low			0.4	V (max)
T_{WU}	Wake-up Time from Shutdown	$C_{BYPASS} = 1\mu F$	8		ms

- (1) All voltages are measured with respect to the ground pin, unless otherwise specified.
- (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 ensure specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which ensure specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
- (3) Typicals are measured at $25^\circ C$ and represent the parametric norm.
- (4) Limits are specified to TI's AOQL (Average Outgoing Quality Level).
- (5) Datasheet min/max specification limits are specified by design, test, or statistical analysis.
- (6) 10Ω terminated input.

External Components Description

(Figure 1)

Components		Functional Description
1.	C_S	Supply bypass capacitor which provides power supply filtering. Refer to the Power Supply Bypassing section for information concerning proper placement and selection of the supply bypass capacitor.
2.	C_B	Bypass pin capacitor which provides half-supply filtering. Refer to the section, Proper Selection of External Components , for information concerning proper placement and selection of C_B .
3.	R_i	Inverting input resistance which sets the closed-loop gain in conjunction with R_F .
4.	R_F	External feedback resistance which sets the closed-loop gain in conjunction with R_i .

Typical Performance Characteristics

Data taken with Bandwidth = 80kHz, $A_v = 1V/V$ and inputs are AC-coupled except where specified.

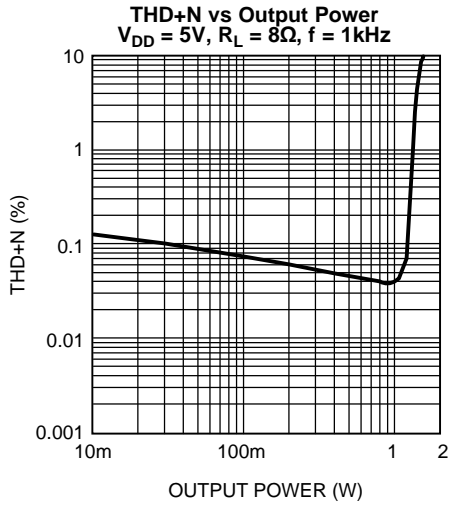


Figure 4.

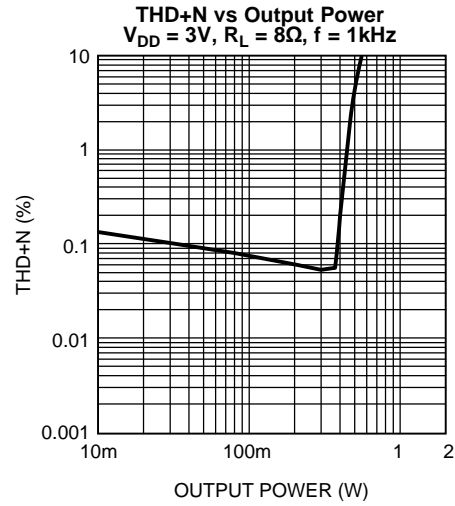


Figure 5.

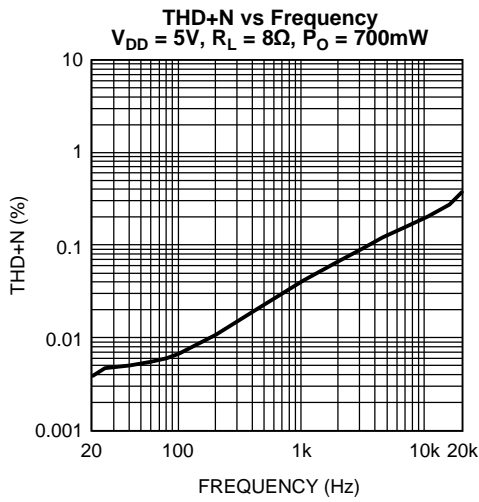


Figure 6.

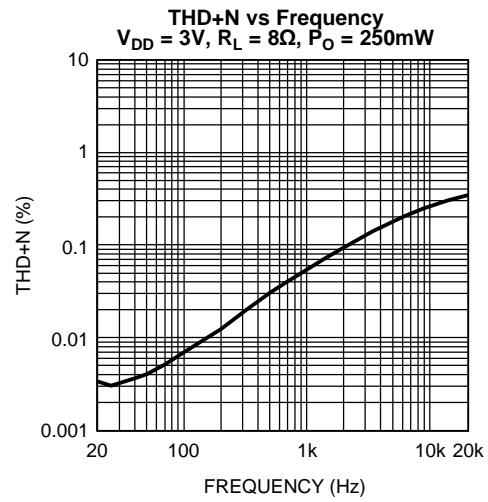


Figure 7.

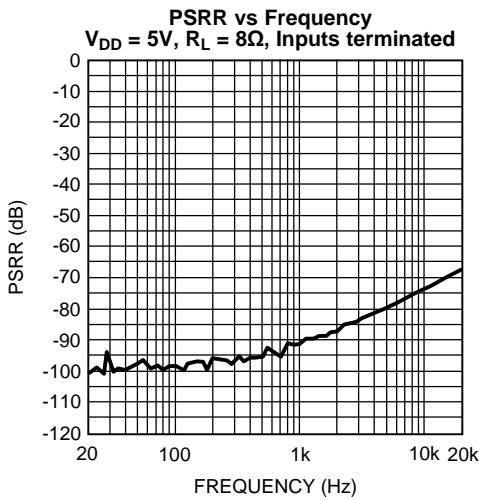


Figure 8.

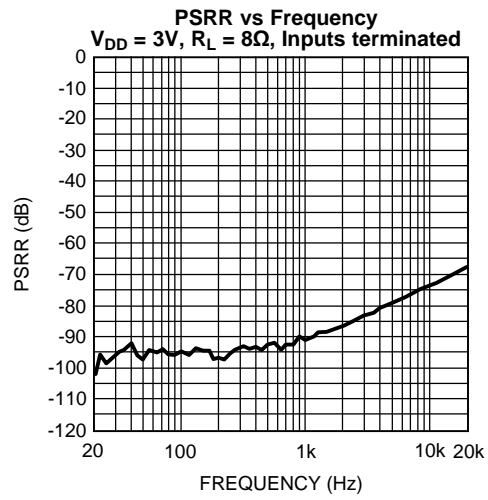


Figure 9.

Typical Performance Characteristics (continued)

Data taken with Bandwidth = 80kHz, $A_v = 1V/V$ and inputs are AC-coupled except where specified.

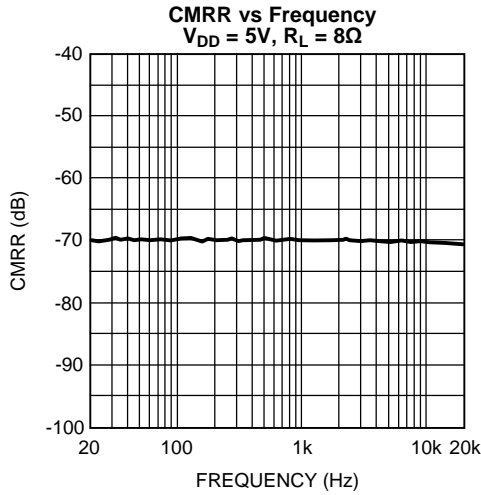


Figure 10.

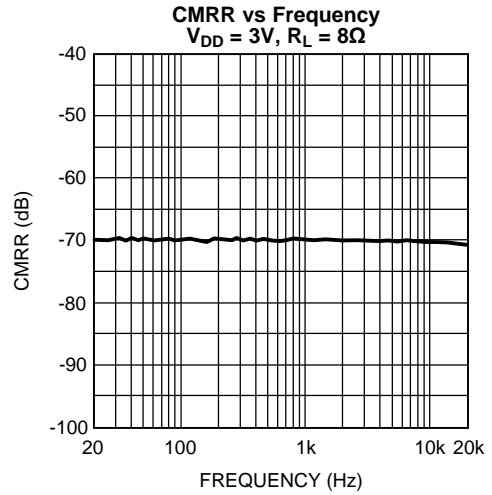


Figure 11.

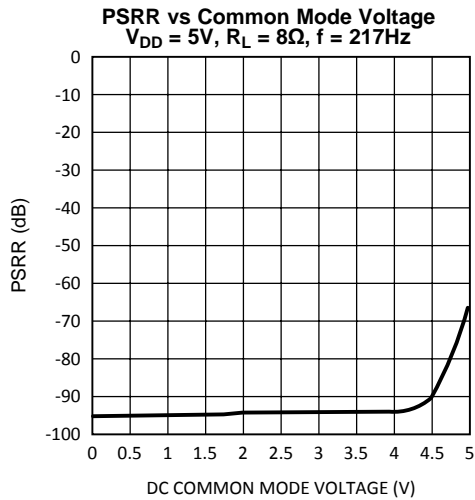


Figure 12.

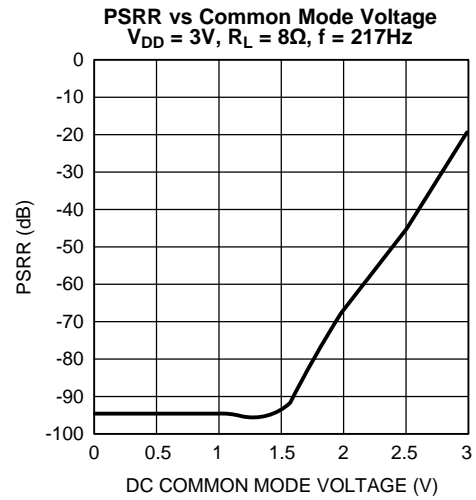


Figure 13.

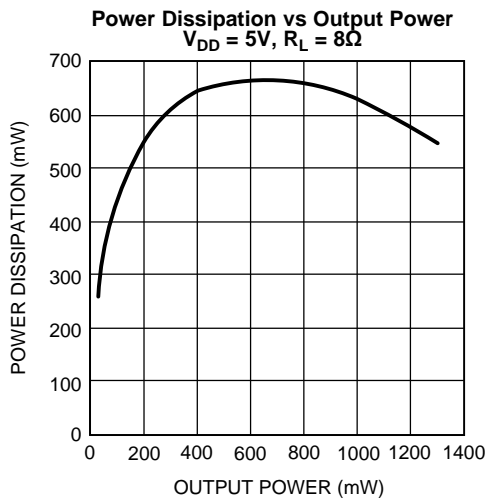


Figure 14.

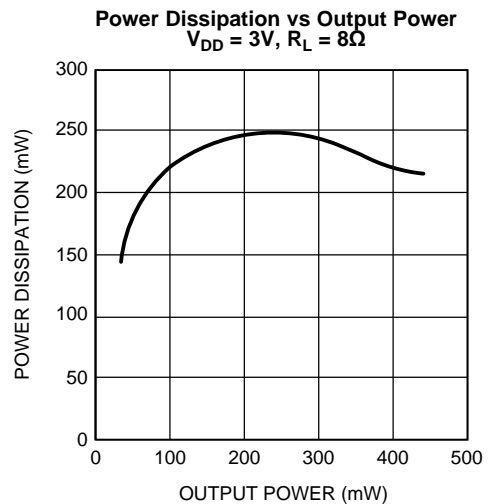


Figure 15.

Typical Performance Characteristics (continued)

Data taken with Bandwidth = 80kHz, $A_v = 1V/V$ and inputs are AC-coupled except where specified.

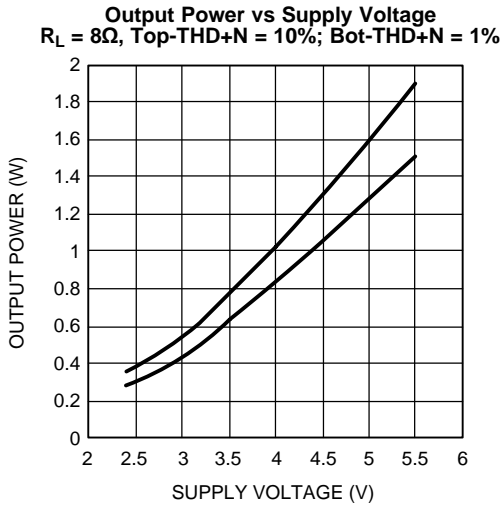


Figure 16.

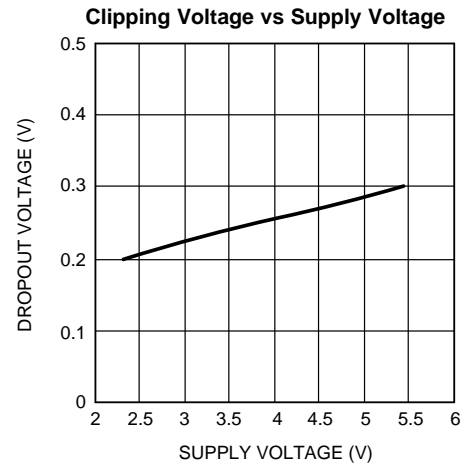


Figure 17.

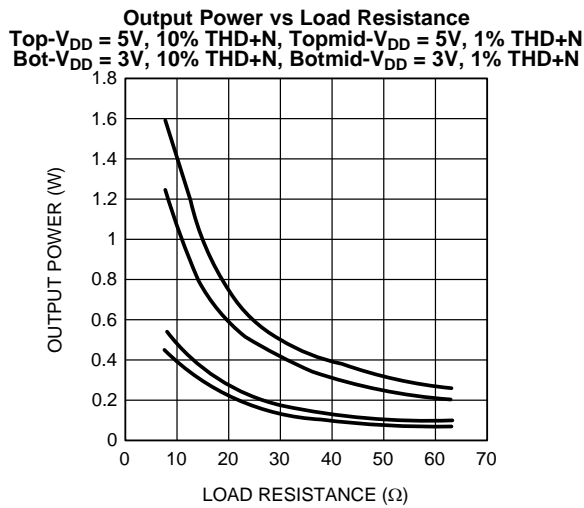


Figure 18.

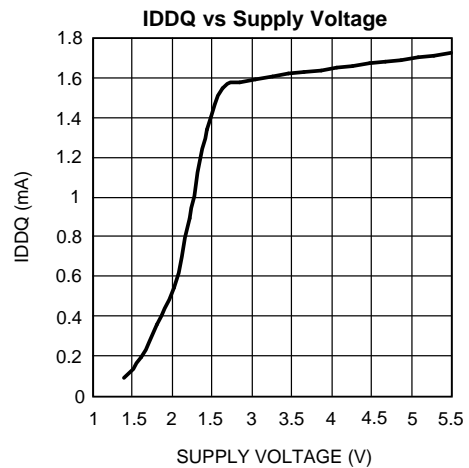


Figure 19.

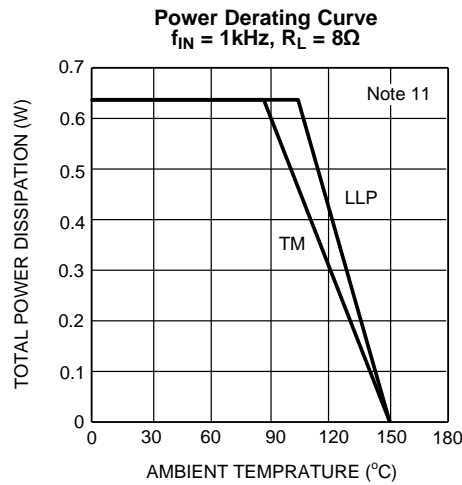


Figure 20.

APPLICATION INFORMATION

OPTIMIZING RF IMMUNITY

The internal circuitry of the LM4941 suppresses the amount of RF signal that is coupled into the chip. However, certain external factors, such as output trace length, output trace orientation, distance between the chip and the antenna, antenna strength, speaker type, and type of RF signal, may affect the RF immunity of the LM4941. In general, the RF immunity of the LM4941 is application specific. Nevertheless, optimal RF immunity can be achieved by using short output traces and increasing the distance between the LM4941 and the antenna.

DIFFERENTIAL AMPLIFIER EXPLANATION

The LM4941 is a fully differential audio amplifier that features differential input and output stages. Internally this is accomplished by two circuits: a differential amplifier and a common mode feedback amplifier that adjusts the output voltages so that the average value remains $V_{DD} / 2$. When setting the differential gain, the amplifier can be considered to have "halves". Each half uses an input and feedback resistor (R_i and R_f) to set its respective closed-loop gain (see [Figure 1](#)). With $R_{i1} = R_{i2}$ and $R_{f1} = R_{f2}$, the gain is set at $-R_f / R_i$ for each half. This results in a differential gain of

$$A_{VD} = -R_f/R_i \quad (1)$$

It is extremely important to match the input resistors to each other, as well as the feedback resistors to each other for best amplifier performance. See the [Proper Selection of External Components](#) section for more information. A differential amplifier works in a manner where the difference between the two input signals is amplified. In most applications, input signals will be 180° out of phase with each other. The LM4941 can be used, however, as a single-ended input amplifier while still retaining its fully differential benefits because it simply amplifies the difference between the inputs.

All of these applications provide what is known as a "bridged mode" output (bridge-tied-load, BTL). This results in output signals that are 180° out of phase with respect to each other. Bridged mode operation is different from the single-ended amplifier configuration that connects the load between the amplifier output and ground. A bridged amplifier design has distinct advantages over the single-ended configuration: it provides differential drive to the load, thus doubling maximum possible output swing for a specific supply voltage. Four times the output power is possible compared with a single-ended amplifier under the same conditions. This increase in attainable output power assumes that the amplifier is not current limited or clipped. Choose an amplifier's closed-loop gain without causing excess clipping.

A bridged configuration, such as the one used in the LM4941, also creates a second advantage over single-ended amplifiers. Since the differential outputs are biased at half-supply, no net DC voltage exists across the load. This assumes that the input resistor pair and the feedback resistor pair are properly matched (see [Proper Selection of External Components](#)). BTL configuration eliminates the output coupling capacitor required in single-supply, single-ended amplifier configurations. If an output coupling capacitor is not used in a single-ended output configuration, the half-supply bias across the load would result in both increased internal IC power dissipation as well as permanent loudspeaker damage. Further advantages of bridged mode operation specific to fully differential amplifiers like the LM4941 include increased power supply rejection ratio, common-mode noise reduction, and click and pop reduction.

POWER DISSIPATION

Power dissipation is a major concern when designing a successful amplifier, whether the amplifier is bridged or single-ended. [Equation 2](#) states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified output load.

$$P_{DMAX} = (V_{DD})^2 / (2\pi^2R_L) \text{ Single-Ended} \quad (2)$$

However, a direct consequence of the increased power delivered to the load by a bridge amplifier is an increase in internal power dissipation versus a single-ended amplifier operating at the same conditions.

$$P_{DMAX} = 4 * (V_{DD})^2 / (2\pi^2R_L) \text{ Bridge Mode} \quad (3)$$

Since the LM4941 has bridged outputs, the maximum internal power dissipation is four times that of a single-ended amplifier. Even with this substantial increase in power dissipation, the LM4941 does not require additional heatsinking under most operating conditions and output loading. From [Equation 3](#), assuming a 5V power supply and an 8Ω load, the maximum power dissipation point is 625mW. The maximum power dissipation point obtained from [Equation 3](#) must not be greater than the power dissipation results from [Equation 4](#):

$$P_{\text{DMAX}} = (T_{\text{JMAX}} - T_{\text{A}}) / \theta_{\text{JA}} \quad (4)$$

The LM4941's θ_{JA} in a DSBGA package is 100°C/W. 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 decreased, the load impedance increased, the ambient temperature reduced, or the θ_{JA} reduced with heatsinking. In many cases, larger traces near the output, V_{DD} , and GND pins can be used to lower the θ_{JA} . The larger areas of copper provide a form of heatsinking allowing higher power dissipation. For the typical application of a 5V power supply, with an 8Ω load, the maximum ambient temperature possible without violating the maximum junction temperature is approximately 87.5°C provided that device operation is around the maximum power dissipation point. Recall that internal power dissipation is a function of output power. If typical operation is not around the maximum power dissipation point, the LM4941 can operate at higher ambient temperatures. Refer to the [Typical Performance Characteristics](#) curves for power dissipation information.

POWER SUPPLY BYPASSING

As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection ratio (PSRR). The capacitor location on both the bypass and power supply pins should be as close to the device as possible. Typical applications employ a 5V regulator with 10μF and 0.1μF bypass capacitors that increase supply stability. This, however, does not eliminate the need for bypassing the supply nodes of the LM4941. The LM4941 will operate without the bypass capacitor C_{B} , although the PSRR may decrease. A 1μF capacitor is recommended for C_{B} . This value maximizes PSRR performance. Lesser values may be used, but PSRR decreases at frequencies below 1kHz. The issue of C_{B} selection is thus dependant upon desired PSRR and click and pop performance as explained in the section [Proper Selection of External Components](#).

SHUTDOWN FUNCTION

In order to reduce power consumption while not in use, the LM4941 contains shutdown circuitry that is used to turn off the amplifier's bias circuitry. The device may then be placed into shutdown mode by toggling the SHDN pin to logic low. It is best to switch between ground and supply for maximum performance. While the device may be disabled with shutdown voltages in between ground and supply, the idle current may be greater than the typical value of 0.1μA. In either case, the SHDN pin should be tied to a definite voltage to avoid unwanted state changes.

In many applications, a microcontroller or microprocessor output is used to control the shutdown circuitry, which provides a quick, smooth transition to shutdown. Another solution is to use a single-throw switch in conjunction with an external pull-up resistor. This scheme ensures that the shutdown pin will not float, thus preventing unwanted state changes.

PROPER SELECTION OF EXTERNAL COMPONENTS

Proper selection of external components in applications using integrated power amplifiers is critical when optimizing device and system performance. Although the LM4941 is tolerant to a variety of external component combinations, consideration of component values must be made when maximizing overall system quality.

The LM4941 is unity-gain stable, giving the designer maximum system flexibility. The LM4941 should be used in low closed-loop gain configurations to minimize THD+N values and maximize signal to noise ratio. Low gain configurations require large input signals to obtain a given output power. Input signals equal to or greater than $1V_{\text{RMS}}$ are available from sources such as audio codecs. When used in its typical application as a fully differential power amplifier the LM4941 does not require input coupling capacitors for input sources with DC common-mode voltages of less than V_{DD} . Exact allowable input common-mode voltage levels are actually a function of V_{DD} , R_{i} , and R_{F} and may be determined by [Equation 5](#):

$$V_{\text{CMi}} < (V_{\text{DD}} - 1.2)(R_{\text{i}} + R_{\text{F}}) / R_{\text{F}} - V_{\text{DD}} / 2(R_{\text{i}} / R_{\text{F}}) \quad (5)$$

$$-R_{\text{F}} / R_{\text{i}} = A_{\text{VD}} \quad (6)$$

When using DC coupled inputs, special care must be taken to match the values of the input resistors (R_{i1} and R_{i2}) to each other. Because of the balanced nature of differential amplifiers, resistor matching differences can result in net DC currents across the load. This DC current can increase power consumption, internal IC power dissipation, reduce PSRR, and possibly damaging the loudspeaker. The chart below demonstrates this problem by showing the effects of differing values between the feedback resistors while assuming that the input resistors are perfectly matched. The results below apply to the application circuit shown in Figure 1, and assumes that $V_{DD} = 5V$, $R_L = 8\Omega$, and the system has DC coupled inputs tied to ground.

Tolerance	R_{i1}	R_{i2}	$V_{01}-V_{02}$	I_{LOAD}
20%	0.8R	1.2R	-0.500V	62.5mA
10%	0.9R	1.1R	-0.250V	31.25mA
5%	0.95R	1.05R	-0.125V	15.63mA
1%	0.99R	1.01R	-0.025V	3.125mA
0%	R	R	0	0

Since the same variations can have a significant effect on PSRR and CMRR performance, it is highly recommended that the input resistors be matched to 1% tolerance or better for best performance.

Recommended TM Board Layout

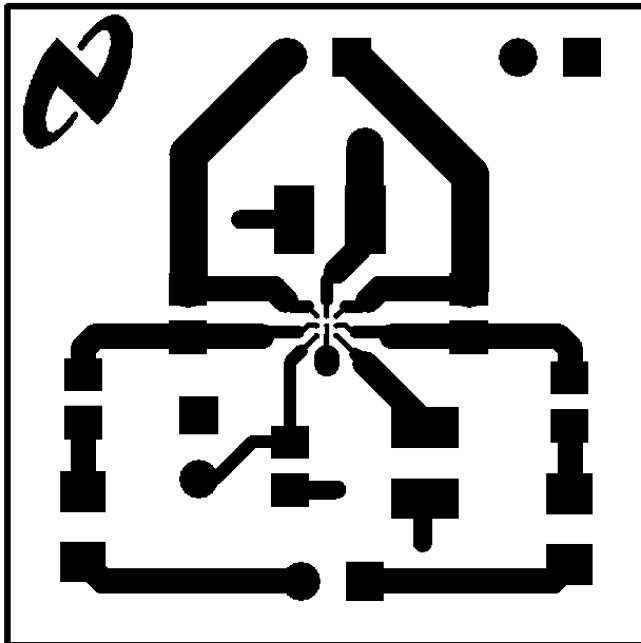


Figure 21. Recommended TM Board Layout: Top Layer

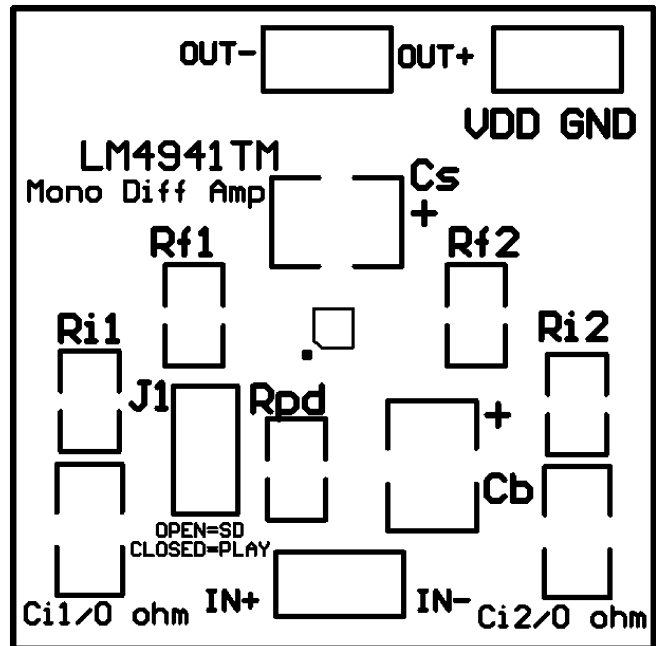


Figure 22. Recommended TM Board Layout: Top Overlay

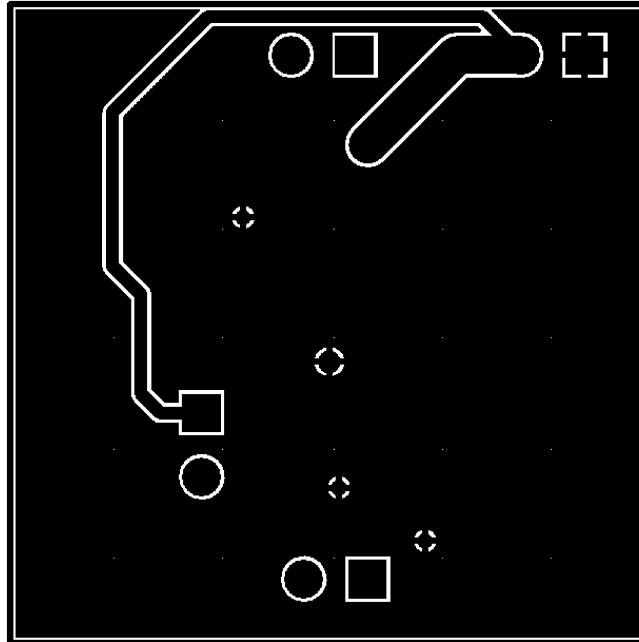


Figure 23. Recommended TM Board Layout: Bottom Layer

Recommended WSON Board Layout

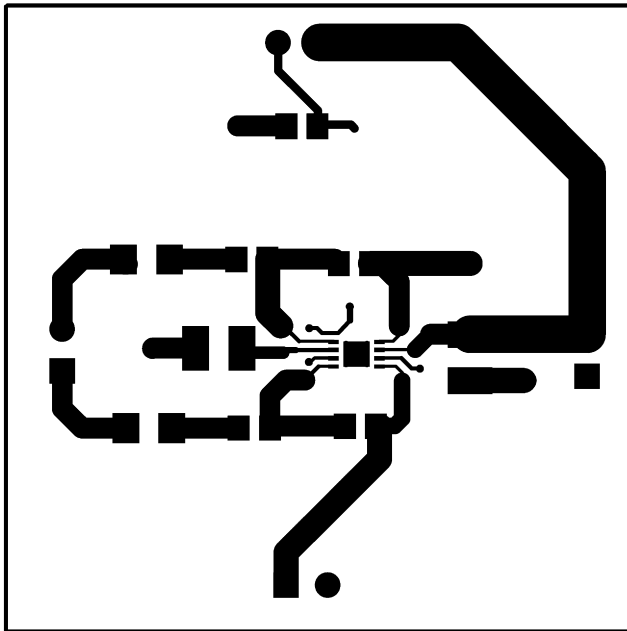


Figure 24. Recommended WSON Board Layout: Top Layer

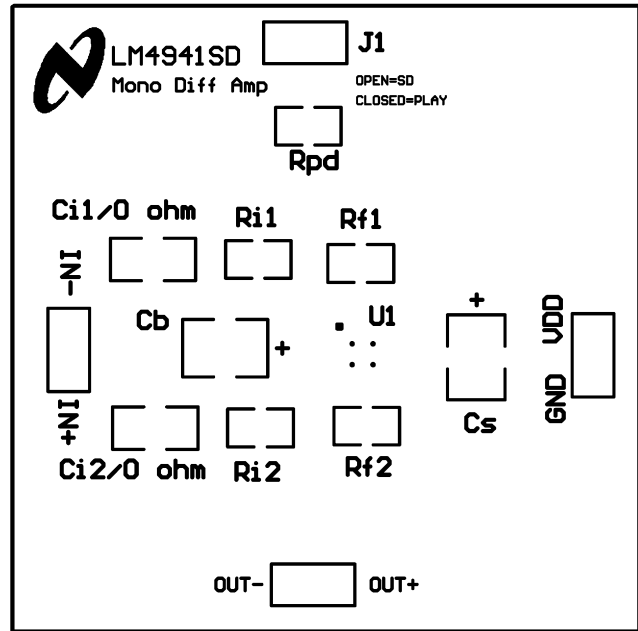


Figure 25. Recommended WSON Board Layout: Top Overlay

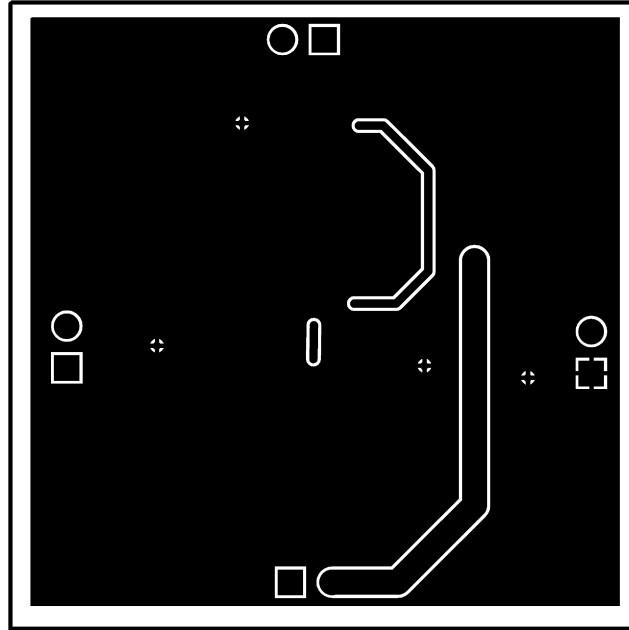


Figure 26. Recommended WSON Board Layout: Bottom Layer

LM4941 Reference Design Boards Bill Of Materials

Designator	Value	Tolerance	Part Description	Comments
Ri1, Ri2	20k Ω	0.10%	1/10W, 0.1% 0805 Resistor	
Rf1, Rf2	20k Ω	0.10%	1/10W, 0.1% 0805 Resistor	
Ci1, Ci2	0 Ω		1/10W, 0.1% 0805 Resistor	
Cb, Cs	1 μ F	10%	16V Tantalum 1210 Capacitor	
In, Out, VDD, J1			0.100" 1x2 header, Vertical mount	Input, Output, VDD/GND, Shutdown Control

REVISION HISTORY

Rev	Date	Description
1.0	06/28/06	Initial release.
1.1	07/10/06	Added the WSON pkg mktg outline (per Kashif J.)
1.2	08/04/06	Added the WSON package and marking diagrams.
1.3	10/12/06	Edited some of the Typical Performance curves' labels and some text edits.
1.4	10/25/06	Added the WSON boards.
1.5	11/07/06	Text edits.
1.6	11/15/06	Replaced curve 20170381 with 20170382 and input text edits.
1.7	03/09/07	Changed the Limit value from 70 to 80 on the PSRR in the EC 5V EC table.
C	05/03/13	Changed layout of National Data Sheet to TI format.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM4941SD/NOPB	ACTIVE	WSO	NGS	8	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM		4941	Samples
LM4941SDX/NOPB	ACTIVE	WSO	NGS	8	4500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM		4941	Samples
LM4941TM/NOPB	ACTIVE	DSBGA	YFQ	9	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	G H6	Samples
LM4941TMX/NOPB	ACTIVE	DSBGA	YFQ	9	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	G H6	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

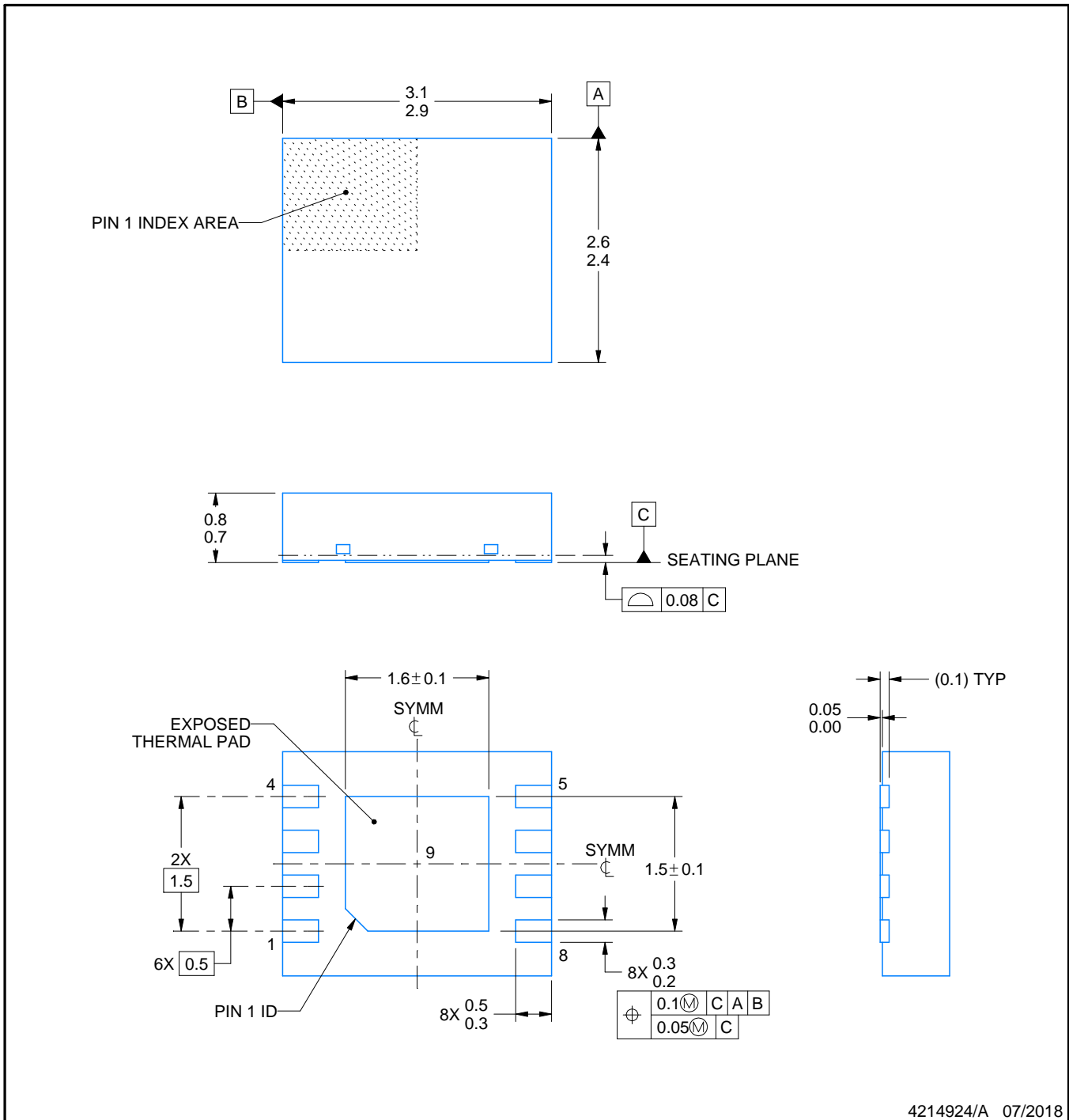
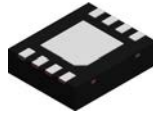

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM4941SD/NOPB	WSON	NGS	8	1000	178.0	12.4	3.3	2.8	1.0	8.0	12.0	Q1
LM4941SDX/NOPB	WSON	NGS	8	4500	330.0	12.4	3.3	2.8	1.0	8.0	12.0	Q1
LM4941TM/NOPB	DSBGA	YFQ	9	250	178.0	8.4	1.35	1.35	0.76	4.0	8.0	Q1
LM4941TMX/NOPB	DSBGA	YFQ	9	3000	178.0	8.4	1.35	1.35	0.76	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4941SD/NOPB	WSON	NGS	8	1000	210.0	185.0	35.0
LM4941SDX/NOPB	WSON	NGS	8	4500	367.0	367.0	35.0
LM4941TM/NOPB	DSBGA	YFQ	9	250	210.0	185.0	35.0
LM4941TMX/NOPB	DSBGA	YFQ	9	3000	210.0	185.0	35.0



NOTES:

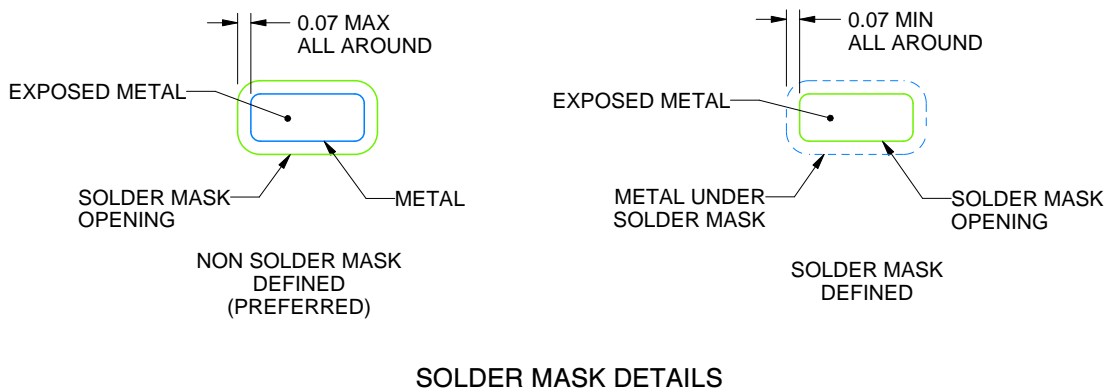
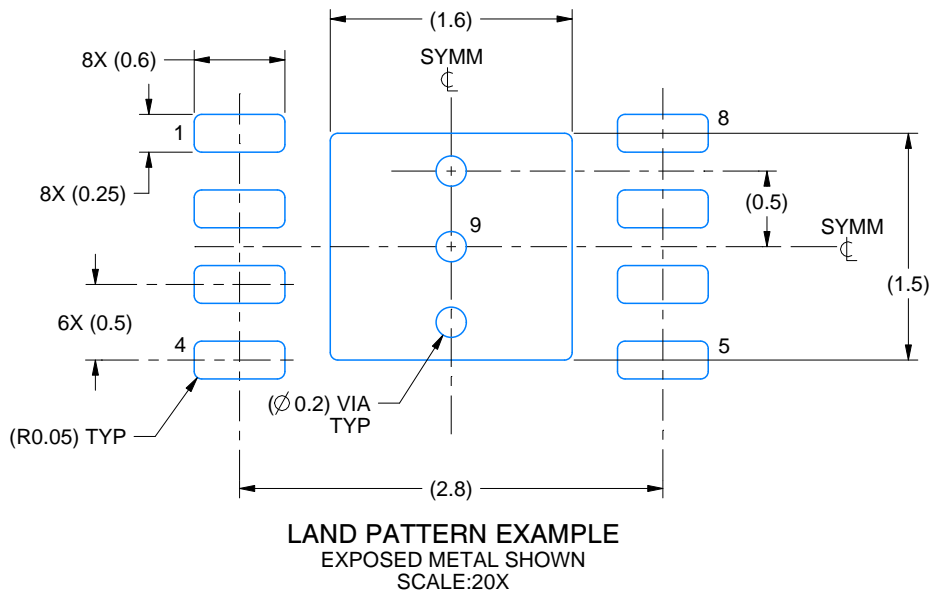
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

NGS0008C

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



4214924/A 07/2018

NOTES: (continued)

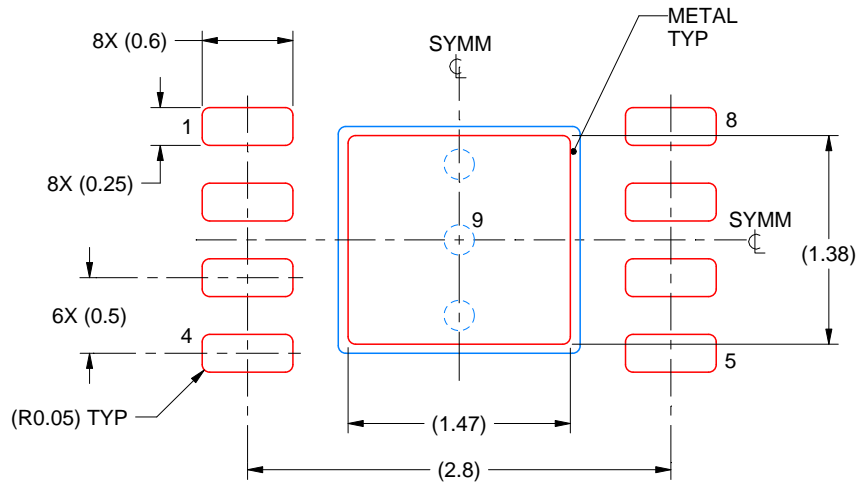
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

NGS0008C

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL

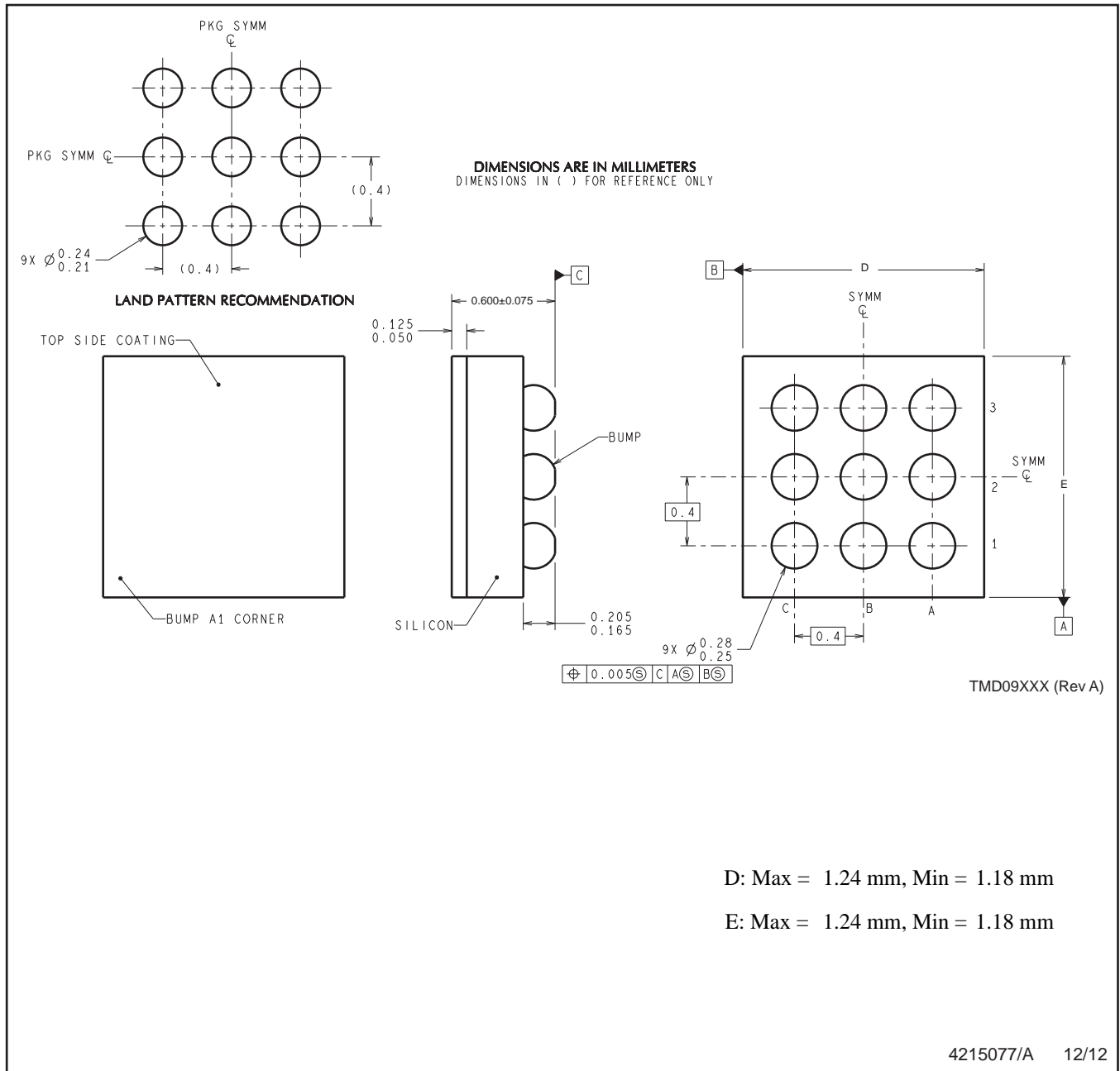
EXPOSED PAD 9:
82% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4214924/A 07/2018

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

YFQ0009



NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
B. This drawing is subject to change without notice.

IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

TI's published terms of sale for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such reproduced documentation. Information of third parties may be subject to additional restrictions. Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.