LMH9226 Single-Ended to Differential 2.3-GHz to 2.9-GHz RF Amplifier With Balun

1 Features

- Single-channel, single-ended input to differential output RF gain block amplifier
- Supports 2.6-GHz center frequency with 400-MHz, 1-dB bandwidth
- 17-dB typical gain across the 1-dB bandwidth into Z_{LOAD} = 50 Ω
- Noise figure < 3 dB in 1-dB bandwidth
- 35-dBm OIP3 at 2-dBm two-tone output power into Z_{LOAD} = 50 Ω
- 17.5-dBm output P1dB into Z_{LOAD} = 50 Ω
- 275-mW power consumption on 3.3-V single supply
- Up to T_A = 105°C operating temperature

2 Applications

- 5G m-MIMO base stations
- Active antenna systems, m-MIMO (AAS)
- Small cell base stations
- TDD/FDD cellular base station
- Wireless infrastructure
- Low-cost radios
- Single-ended to differential conversion
- Balun alternatives
- RF gain blocks
- Differential driver for GSPS ADCs

3 Description

The LMH9226 is high-performance, single-channel, single-ended, 50-Ω input to differential 50-Ω or 100-Ω output RF gain block amplifier supporting a 2.3-GHz to 2.9-GHz frequency band. The device is well suited to meet requirements for 5G m-MIMO or small cell base station applications. The device integrates the functionality of a single-ended input and output RF gain block followed by a passive balun, where the device is mainly used in the final stage of a receiver signal chain to drive the full-scale voltage of an analog-to-differential converter (ADC) differential input.

The LMH9226 provides 17-dB typical gain with excellent linearity performance of 35-dBm output IP3 at 2.6 GHz, and maintains less than a 3-dB noise figure across the entire 1-dB bandwidth of 400 MHz. The device is internally matched for a 50-Ω impedance at the single-ended input. The differential output can easily interface to a 50-Ω impedance without any external matching circuitry. For 100-Ω impedance matching, an external matching circuitry is required that typically results in a 0.3-dB gain loss at 2.6 GHz.

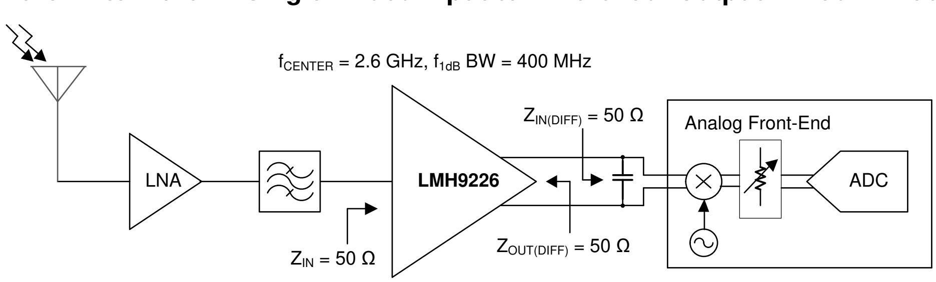
Operating on a single 3.3-V supply, the device consumes approximately 275 mW of stand-by power, making the device suitable for high-density, 5G, massive multiple-input and multiple-output (MIMO) applications. Also, the device is available in a space-saving, 2-mm × 2-mm, 12-pin WQFN package. The device is rated for an operating temperature of up to 105°C to provide a robust system design. A 1.8-V JEDEC compliant power-down pin is available for fast power-down and power-up of the device that is suitable for time division duplex (TDD) systems.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LMH9226	WQFN (12)	2.00 mm × 2.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

LMH9226: 2.3-GHz to 2.9-GHz Single-Ended Input to Differential Output RF Gain Block Amplifier



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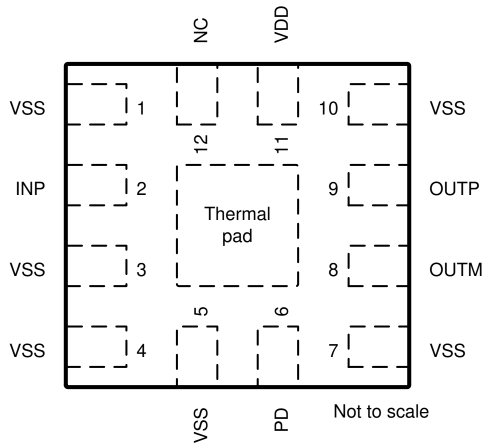
4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
December 2019	*	Initial release.

5 Pin Configuration and Functions

RRL Package
12-Pin WQFN
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	VSS	Power	Analog ground
2	INP	Input	RF single-ended input into amplifier
3	VSS	Power	Analog ground
4	VSS	Power	Analog ground
5	VSS	Power	Analog ground
6	PD	Input	Power-down connection. PD = 0 V, normal operation; PD = 1.8 V, power off mode.
7	VSS	Power	Analog ground
8	OUTM	Output	RF single-ended output negative
9	OUTP	Output	RF single-ended output positive
10	VSS	Power	Analog ground
11	VDD	Power	Positive supply voltage (3.3 V)
12	NC	—	Do not connect this pin
Thermal Pad		—	Connect the thermal pad to ground (VSS).

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
Supply voltage	VDD	–0.3	3.6	V
RF pins	INP, OUTP, OUTM	–0.3	VDD	V
Continuous wave (CW) input	f_{in} = 2.6 GHz at INP		25	dBm
Digital input pin	PD	–0.3	VDD	V
Junction temperature	T_J		150	°C
Storage temperature	T_{stg}	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, allpins(1)	±1000	V
		Charged device model (CDM), per JEDEC specificationJESD22-C101, all pins(2)	±500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
VDD	Supply voltage	3.15	3.3	3.45	V
T_A	Ambient temperature	–40		105	°C
T_J	Junction temperature	–40		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		LMH9226	UNIT
		RRL PKG	
		12-PIN WQFN	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	74.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	72.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	37.1	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	3.2	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	37.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	14.2	°C/W

(1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

6.5 Electrical Characteristics

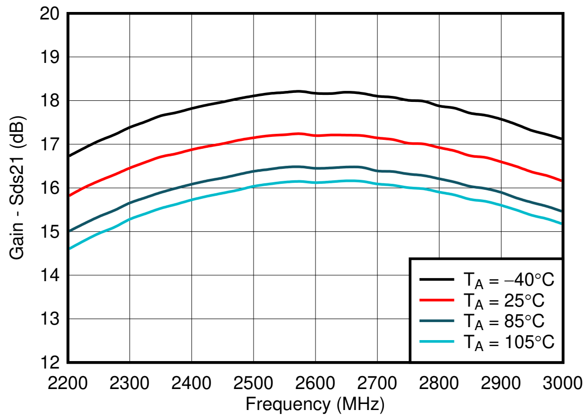
T_A = +25°C, VDD = 3.3 V, center frequency (f_{in}) = 2.6 GHz, single-ended input impedance (Z_{IN}) = 50 Ω, differential output impedance (Z_{LOAD}) = 50 Ω, $P_{OUT(TOTAL)}$ = 8 dBm into Z_{LOAD} = 50 Ω (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RF PERFORMANCE						
f_{RF}	RF frequency range		2300		2900	MHz
BW_{1dB}	1-dB bandwidth	Center Frequency (f_{in}) = 2.6 GHz		400		MHz
S21	Gain	f_{in} = 2.6 GHz		17		dB
NF	Noise figure	f_{in} = 2.6 GHz, R_S = 50 Ω		3		dB
OIP1	Output P1dB	f_{in} = 2.6 GHz, R_{LOAD} = 50 Ω		17.5		dBm
OIP3	Output IP3	f_{in} = 2.6 GHz ± 10 MHz spacing, $P_{OUT/TONE}$ = 2 dBm		35		dBm
	Differential output gain imbalance (1)			0.5		dB
	Differential output phase imbalance (1)			4		degree
S11	Input return loss	f_{in} = 2.6 GHz, BW = 400 MHz		–11		dB
Z_{IN}	Single ended input reference impedance			50		Ω
S22	Differential output return loss	f_{in} = 2.6 GHz, BW = 400 MHz		–12		dB
Z_{LOAD}	Differential ouput reference impedance			50		Ω
S12	Reverse isolation	f_{in} = 2.6 GHz		–35		dB
CMRR	Common-mode rejection ratio (2)			27		dB
SWITCHING AND DIGITAL INPUT CHARACTERISTICS						
t_{ON}	Turn-on time	PD pin = 1.8 V to 0 V, f_{in} = 2.6 GHz		0.5		µs
t_{OFF}	Turn-off time	PD pin = 0 V to 1.8 V, f_{in} = 2.6 GHz		0.2		µs
V_{IH}	High-level input voltage (3)	At the PD pin	1.4			V
V_{IL}	Low-level input voltage (3)	At the PD pin			0.5	V
I_{IH}	High-level input current (3)	At the PD pin		28	60	µA
I_{IL}	Low-level input current (3)	At the PD pin		10	30	µA
DC CURRENT AND POWER CONSUMPTION						
I_{VDD_ON}	Supply current (3)	PD pin = 0 V		84	100	mA
I_{VDD_PD}	Power-down current (3)	PD pin = 1.8 V			10	mA
P_{dis}	Power dissipation	VDD = 3.3 V		275		mW

(1) Measured at f_{in} = 2.6GHz, over the BW_{1dB}
(2) CMRR is calculated using (S21-S31)/(S21+S31) for receive (1 is input port, 2 and 3 are differential output ports)
(3) 100% tested at T_A = 25℃

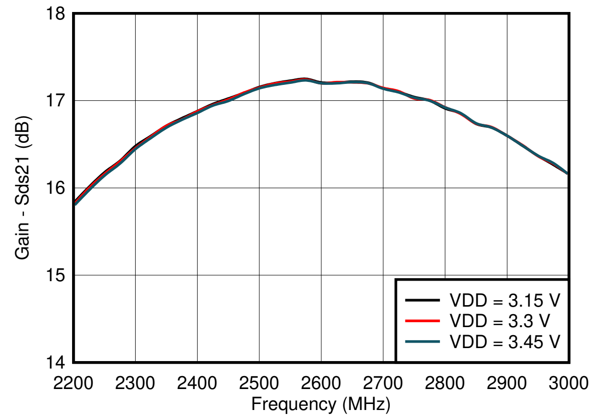
6.6 Typical Characteristics

at T_A = 25°C, VDD = 3.3 V, center frequency (f_{IN}) = 2.6 GHz, single-ended input impedance (Z_{IN}) = 50 Ω, differential output impedance (Z_{LOAD}) = 50 Ω, and $P_{OUT(TOTAL)}$ = 8 dBm into Z_{LOAD} = 50 Ω (unless otherwise noted)



P_{OUT} = 2 dBm

Figure 1. Gain vs Frequency and Temperature



P_{OUT} = 2 dBm

Figure 2. Gain vs Frequency and Supply Voltage

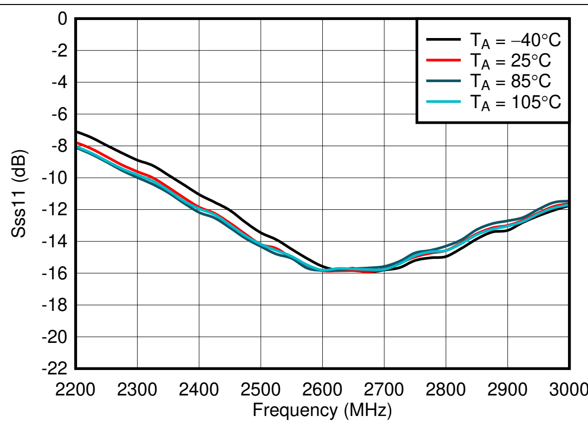


Figure 3. Input Return Loss vs Frequency

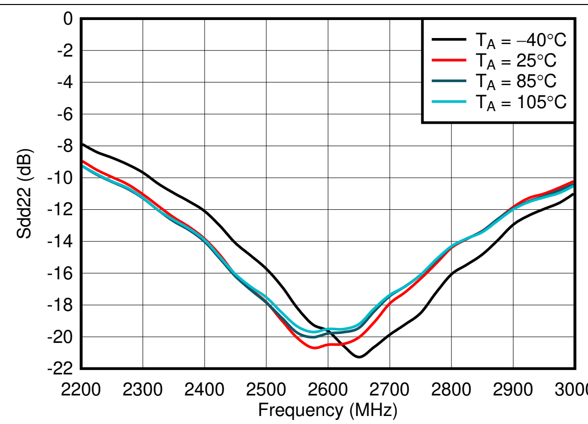


Figure 4. Output Return Loss vs Frequency

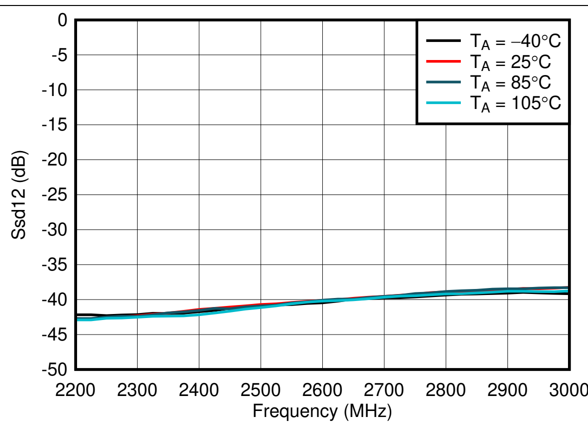
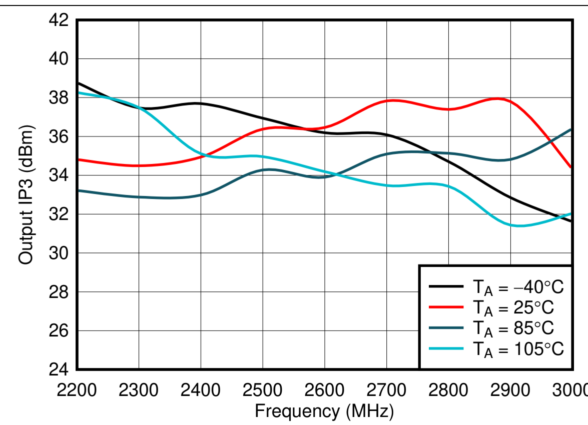


Figure 5. Reverse Isolation vs Frequency

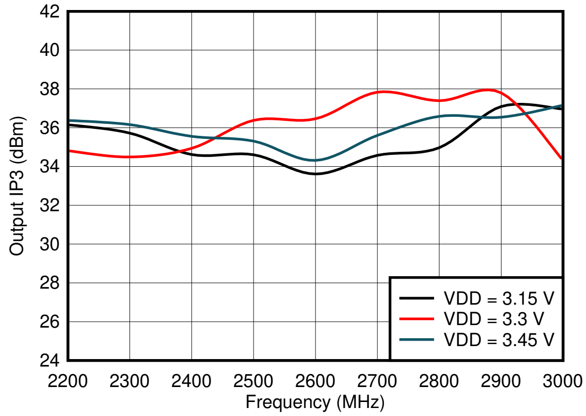


$P_{OUT/TONE}$ = 2 dBm, ±1-MHz tone spacing

Figure 6. Output IP3 vs Frequency and Temperature

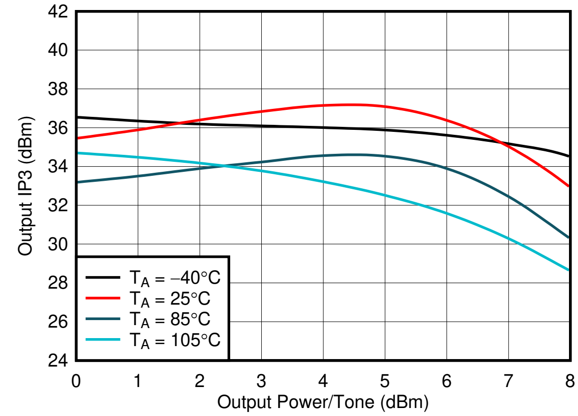
Typical Characteristics (continued)

at T_A = 25°C, VDD = 3.3 V, center frequency (f_{IN}) = 2.6 GHz, single-ended input impedance (Z_{IN}) = 50 Ω, differential output impedance (Z_{LOAD}) = 50 Ω, and $P_{OUT(TOTAL)}$ = 8 dBm into Z_{LOAD} = 50 Ω (unless otherwise noted)



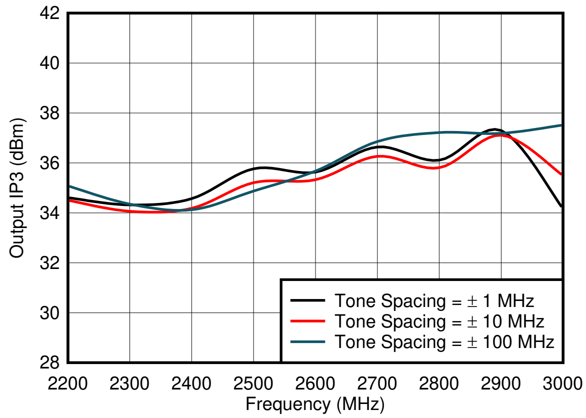
$P_{OUT/TONE}$ = 2 dBm, ±1-MHz tone spacing

Figure 7. Output IP3 vs Frequency and Supply Voltage



f = 2.6 GHz, ±1-MHz tone spacing

Figure 8. Output IP3 vs Output Power per Tone



$P_{OUT/TONE}$ = 2 dBm

Figure 9. Output IP3 vs Frequency and Tone Spacing

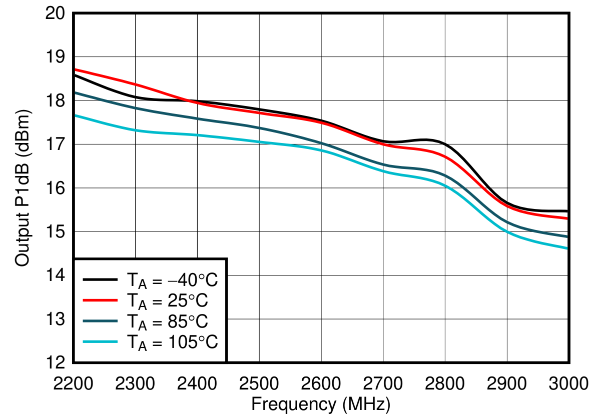


Figure 10. Output P1dB vs Frequency and Temperature

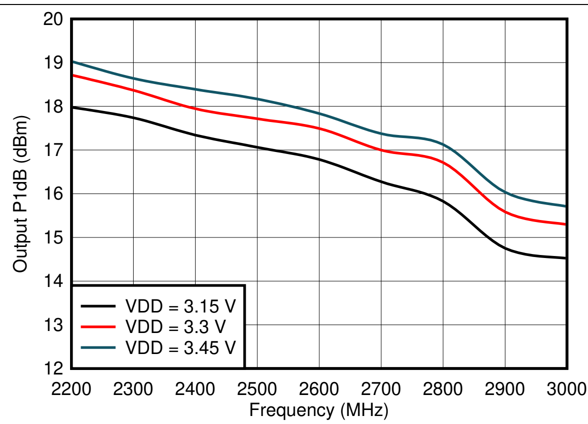
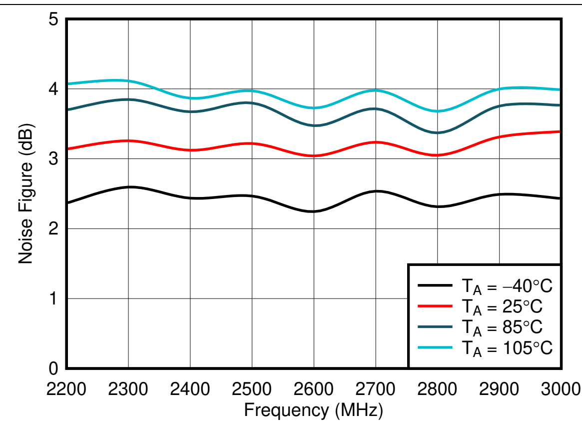


Figure 11. Output P1dB vs Frequency and Supply Voltage

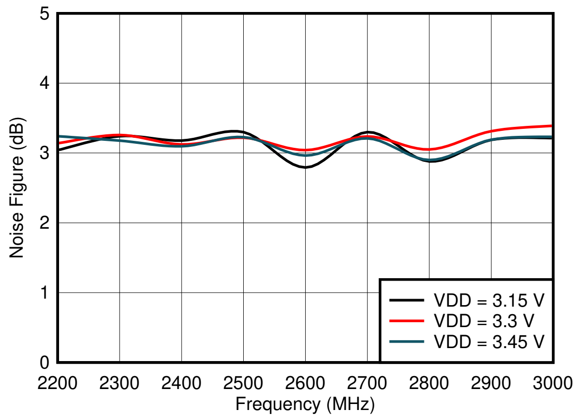


Z_{SOURCE} = 50 Ω

Figure 12. Noise Figure vs Frequency and Temperature

Typical Characteristics (continued)

at T_A = 25°C, VDD = 3.3 V, center frequency (f_{IN}) = 2.6 GHz, single-ended input impedance (Z_{IN}) = 50 Ω, differential output impedance (Z_{LOAD}) = 50 Ω, and $P_{OUT(TOTAL)}$ = 8 dBm into Z_{LOAD} = 50 Ω (unless otherwise noted)



Z_{SOURCE} = 50 Ω

Figure 13. Noise Figure vs Frequency and Supply Voltage

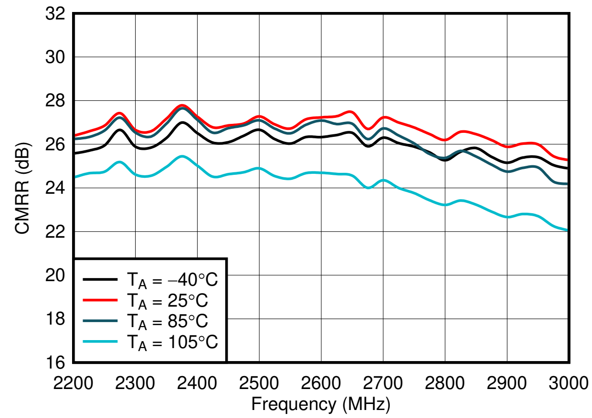


Figure 14. CMRR vs Frequency

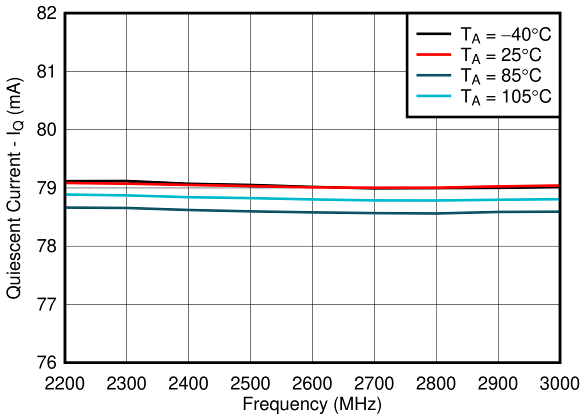


Figure 15. Quiescent Current vs Frequency and Temperature

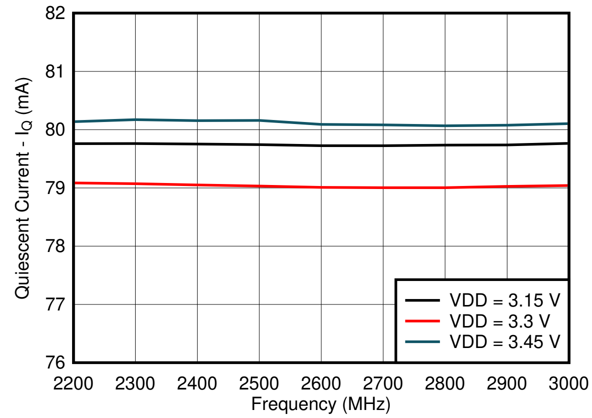


Figure 16. Quiescent Current vs Frequency and Supply Voltage

7 Detailed Description

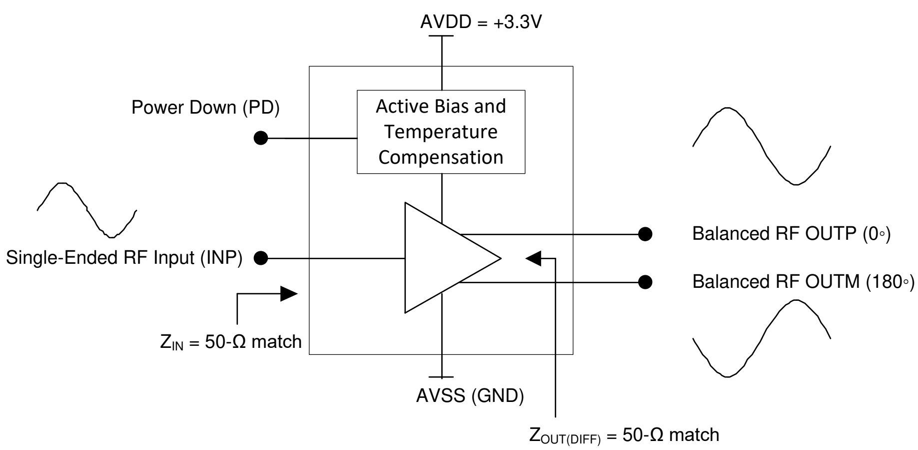
7.1 Overview

The LMH9226 is single-ended, 50-Ω input to differential 50-Ω or 100-Ω output RF gain block amplifier used in 2.3-GHz to 2.9-GHz, frequency-band, 5G, m-MIMO TDD receiver applications. The device provides a 17-dB fixed power gain with excellent linearity and noise performance across 400 MHz of the 1-dB bandwidth at the 2.6-GHz center frequency. The device is internally matched for a 50-Ω input impedance at 2.6 GHz. The device differential output can be matched to the 50-Ω impedance without external matching circuitry, or to the 100-Ω impedance with external matching circuitry (see the *Application and Implementation* section for details). The device is typically used in the final stage of a receive signal chain to drive the differential input of an analog-to-differential converter (ADC), while providing additional gain to a low-noise amplifier (LNA) to increase dynamic range and the required single-ended to differential conversion.

The LMH9226 has an on-chip active bias circuitry to maintain device performance over a wide temperature and supply voltage range. The included power-down function allows the amplifier to shut down and save power when the amplifier is not needed. Fast shut-down and start-up enable the amplifier to be used in a host of time division duplex (TDD) applications.

Operating on a single 3.3-V supply and consuming 84 mA of typical supply current, the device is available in a 2-mm × 2-mm, 12-pin WQFN package.

7.2 Functional Block Diagram



7.3 Feature Description

As shown in Figure 17, the LMH9226 integrates the functionality of a single-ended RF amplifier and passive balun in a traditional receive application, achieving a small form factor with good linearity and noise performance. The active balun implementation, along with a higher operating temperature of 105°C, allows for a more robust receiver system implementation compared to a passive balun that is prone to reliability failures at high temperatures. The high-temperature operation is achieved by the on-chip, active bias circuitry that maintains device performance over a wide temperature and supply voltage range.

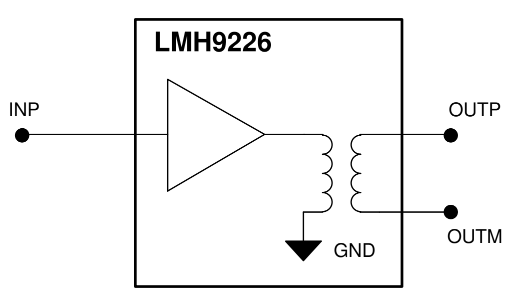


Figure 17. Single-Ended Input to Differential Output, Active Balun Implementation

7.4 Device Functional Modes

The LMH9226 features a PD pin that must be connected to GND for normal operation. For power-down mode, connect the PD pin to a logic high voltage of 1.8 V.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LMH9226 is a single-ended, 50-Ω input to differential 50-Ω or 100-Ω output RF gain block amplifier, used in the receive path of a 2.6-GHz center frequency, 5G, TDD m-MIMO or small cell base station. The device replaces the traditional single-ended RF amplifier and passive balun offering a smaller footprint solution to the customer. TI recommends following good RF layout and grounding techniques to maximize the device performance.

8.2 Typical Application

The LMH9226 is typically used in a four transmit and four receive (4T/4R) array of active antenna system for 5G, TDD, wireless base station applications. Such a system is shown in Figure 18, where the LMH9226 is used in the receive path as the final stage differential driver to an ADC input. TI typically recommends reducing the trace distance between the LMH9226 output and the ADC input to minimize amplitude and phase imbalance during the single-to-differential conversion.

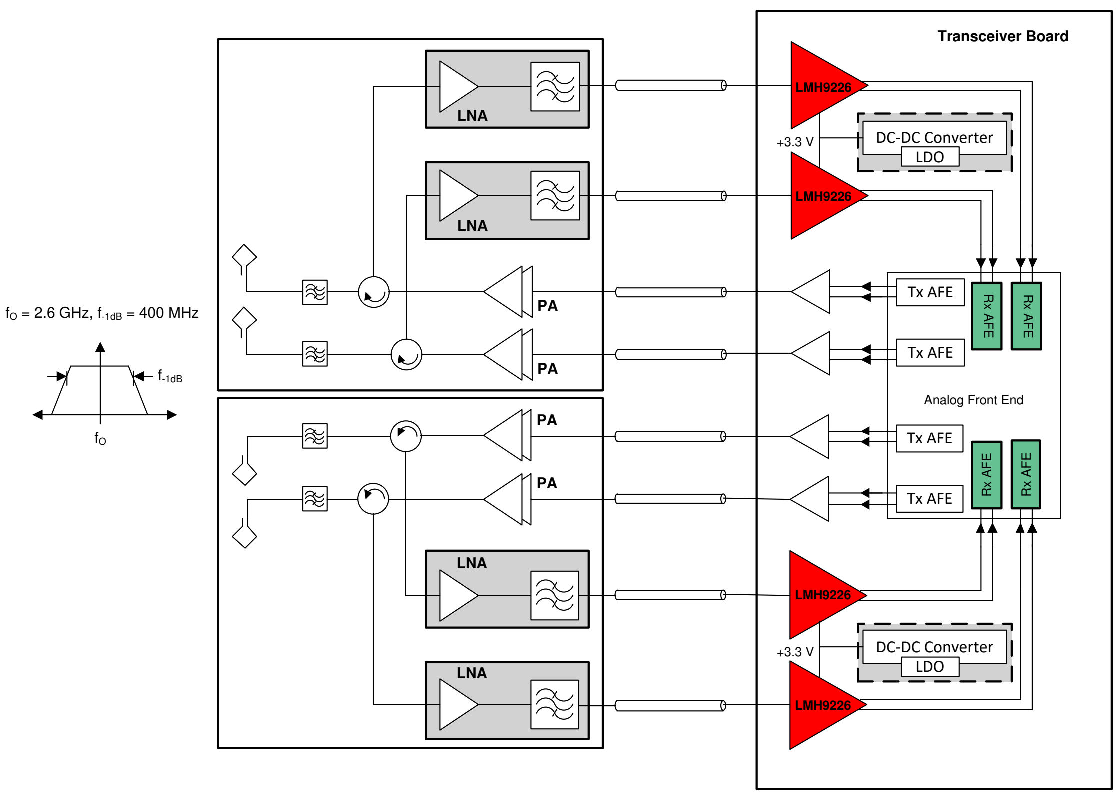


Figure 18. LMH9226 in a 4T/4R 5G Active Antenna System

Typical Application (continued)

The 4T/4R system is easily scaled to 16T/16R, 64T/64R, or higher antenna arrays that result in proportional scaling of the overall system power dissipation. As a result of the proportional scaling factor for multiple channels in a system, the individual device power consumption must be reduced to dissipate less overall heat in the system. Operating on a single 3.3-V supply, the LMH9226 consumes only 275 mW and therefore provides power saving to the customer. Multiple LMH9226 devices can be powered from a single DC/DC converter or a low-dropout regulator (LDO) operating on a 3.3-V supply. A DC/DC converter provides the most power efficient way of generating the 3.3-V supply. However, care must be taken when using the DC/DC converter to minimize the switching noise using inductor chokes and adequate isolation must be provided between the analog and digital supplies.

8.2.1 Design Requirements

Table 1 shows example design requirements for an RF amplifier in a typical 5G, active antenna TDD system. The LMH9226 meets these requirements.

Table 1. Design Parameters

DESIGN PARAMETERS	EXAMPLE VALUE
Frequency range and 1-dB BW	2300 MHz to 2900 MHz with 400 MHz of 1-dB BW
Configuration	Single-ended 50-Ω input to differential 50-Ω output
Power gain	> 15 dB
Output IP3 at $P_{OUT/TONE}$ = 2 dBm	> 32 dBm
Noise figure at Zin = 50 Ω	< 4 dB
Output P1dB	< 17 dBm
Power consumption	< 350 mW
Turn-on time	< 1 µs
Package size	2 mm × 2 mm^2

8.2.2 Detailed Design Procedure

The LMH9226 is a single-to-differential RF gain block amplifier for a 2.6-GHz center frequency application with 400 MHz of the 1-dB bandwidth. Figure 19 shows a single receive channel consisting of a low-noise amplifier (LNA) that sits close to the antenna and drives the signal into a single-ended, 50-Ω coaxial cable that then connects to a transceiver board. The LMH9226 that sits at the transceiver board input converts this single-ended signal received from the coax cable into a differential signal, thereby offering low noise and distortion performance while interfacing with the receiver analog front-end (AFE). The LMH9226 input impedance must be matched to 50 Ω to prevent any signal reflections resulting from the coax cable. The device differential output interfaces directly with the differential input of an AFE. The output matching is optimized for a 50-Ω output at the 2.6-GHz center frequency with 400 MHz of the 1-dB bandwidth. The AFE input impedance must be matched to 50 Ω at 2.6 GHz as well to prevent any ripple in the frequency response.

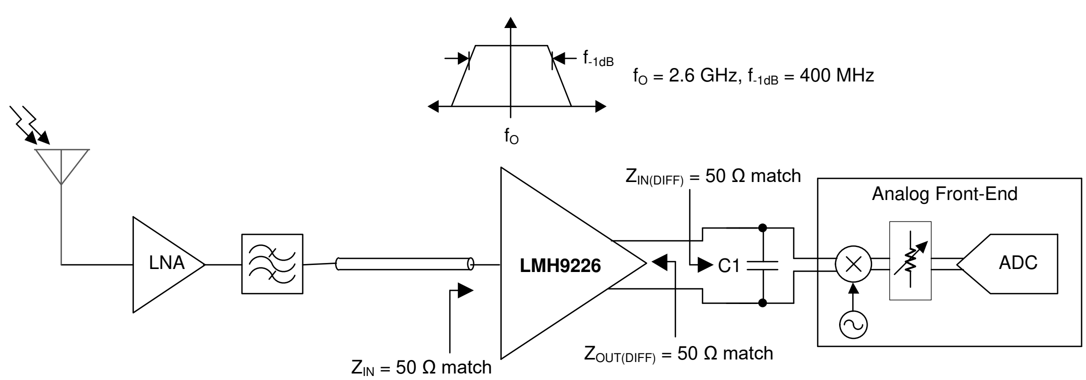


Figure 19. LMH9226 in a Receive Application Driving an AFE ($Z_{OUT(DIFF)}$ = 50 Ω)

For interfacing with a 100-Ω differential input AFE, as shown in Figure 20, an external matching circuitry is needed close to the LMH9226 output. Table 2 lists example recommended component values when transforming the LMH9226 output impedance from 50 Ω to 100 Ω. The component values must be tweaked on the board, depending on the trace length between the matching circuitry and the AFE input to maintain 400 MHz of the 1-dB BW at the 2.6-GHz center frequency. LC component values must be selected with Q(min) > 30 that have a self resonant frequency (SRF) sufficiently higher than the desired frequency of operation. Figure 21 and Figure 22 provide a comparison of device performance when interfacing with a 50-Ω output matching as compared to a 100-Ω output matching. As depicted in Figure 21, the forward path gain (S_{DS21}) is slightly lower for the 100-Ω differential output impedance because of the extra loss in the external matching circuitry.

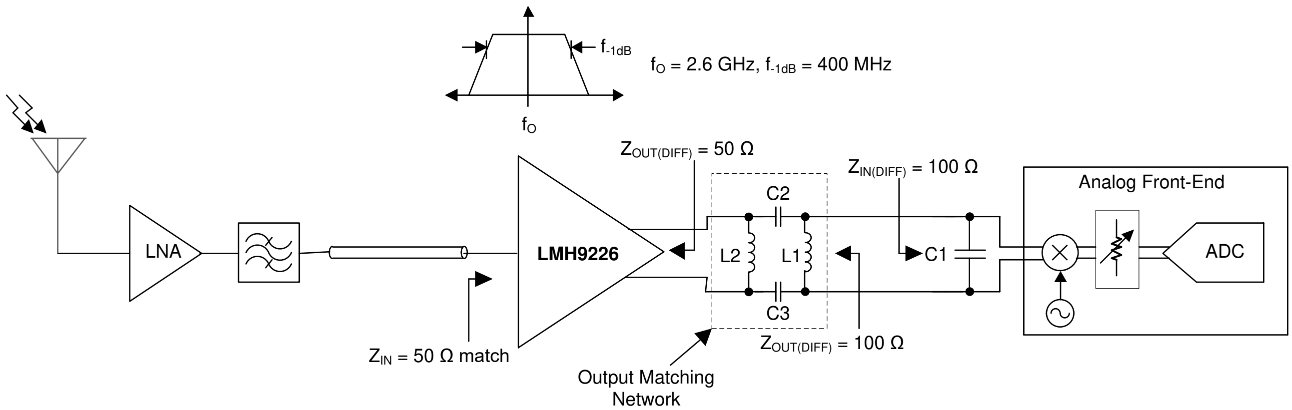


Figure 20. LMH9226 in a Receive Application Driving an AFE ($Z_{OUT(DIFF)}$ = 100 Ω)

Table 2. Output Matching Network Component Values

COMPONENT	VALUE
C2, C3	2.2 pF
L1	6.2 nH
L2	Do not install (DNI)

Following the recommended RF layout with good quality RF components and local DC bypass capacitors ensures optimal performance is achieved. TI provides various support materials including S-parameter and ADS models to allow the design to be optimized to the application-specific performance needs.

8.2.3 Application Curves

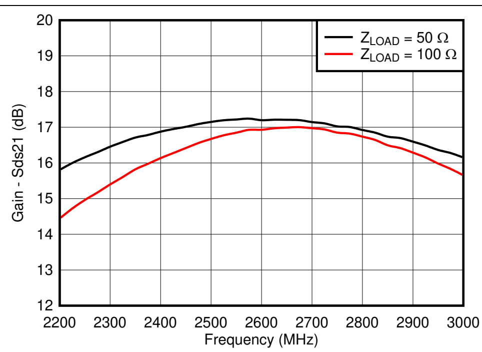


Figure 21. Power Gain vs Frequency and Z_{LOAD}

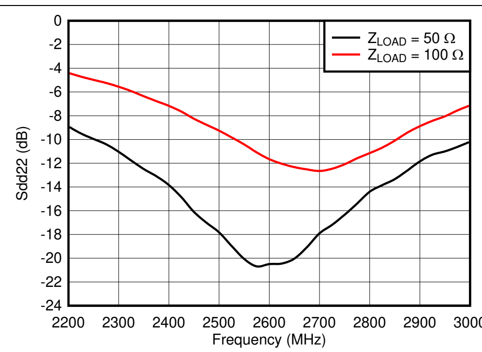


Figure 22. Output Return Loss vs Frequency and Z_{LOAD}

9 Power Supply Recommendations

The LMH9226 operates on a common nominal 3.3-V supply voltage. The supply voltage is recommended to be isolated through the decoupling capacitors placed close to the device. Select capacitors with a self-resonant frequency near the application frequency. When multiple capacitors are used in parallel to create a broadband decoupling network, place the capacitor with the higher self-resonant frequency closer to the device.

The LMH9226 can be powered from a DC/DC converter or an LDO operating on a 3.3-V supply. A DC/DC converter provides the most power efficient way of generating the 3.3-V supply. However, care must be taken when using the DC/DC converter to minimize the switching noise from inductor chokes and adequate isolation must be provided between the analog and digital supplies.

10 Layout

10.1 Layout Guidelines

When dealing with an RF amplifier with relatively high gain and a center frequency of 2.6 GHz, certain board layout precautions must be taken to ensure stability and optimum performance. TI recommends that the LMH9226 board be multi-layered to improve thermal performance, grounding, and power-supply decoupling. Figure 23 shows a good layout example. In Figure 23, only the top signal layer and its adjacent ground reference plane are shown.

- Excellent electrical connection from the thermal pad to the board ground is essential. Use the recommended footprint, solder the pad to the board, and do not include a solder mask under the pad.
- Connect the pad ground to the device terminal ground on the top board layer.
- Verify that the return DC and RF current path have a low impedance ground plane directly under the package and that the RF signal traces into and out of the amplifier.
- Ensure that ground planes on the top and any internal layers are well stitched with vias.
- Do not route RF signal lines over breaks in the reference ground plane.
- Avoid routing clocks and digital control lines near RF signal lines.
- Do not route RF or DC signal lines over noisy power planes. Ground is the best reference, although clean power planes can serve where necessary.
- Place supply decoupling close to the device.
- The differential output traces must be symmetrical in order to achieve the best linearity performance.

A board layout software package can simplify the trace thickness design to maintain impedances for controlled impedance signals. To isolate the affect of board parasitic on frequency response, TI recommends placing the external output matching resistors close to the amplifier output pins. See the *LMH9226 Evaluation Module* user guide for more details on board layout and design.

10.2 Layout Example

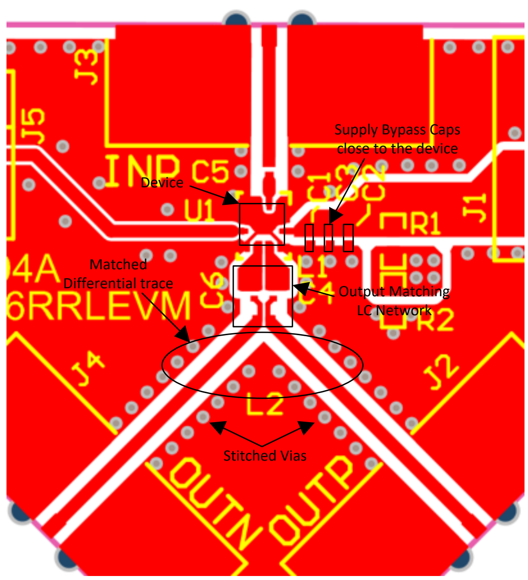


Figure 23. Supply Bypass and Output Matching

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following:

Texas Instruments, *LMH9226 Evaluation Module* user guide

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.3 Community Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

11.4 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LMH9226IRRLR	ACTIVE	WQFN	RRL	12	3000	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 105	22GO	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.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

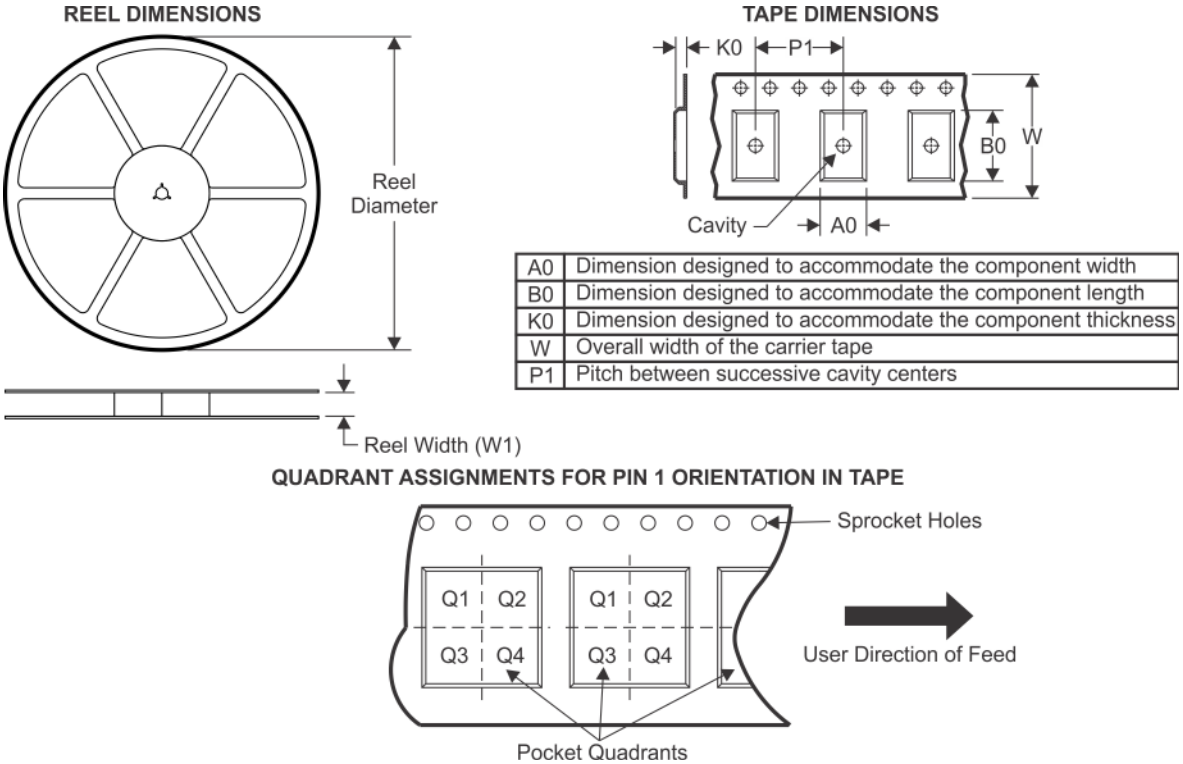
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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.

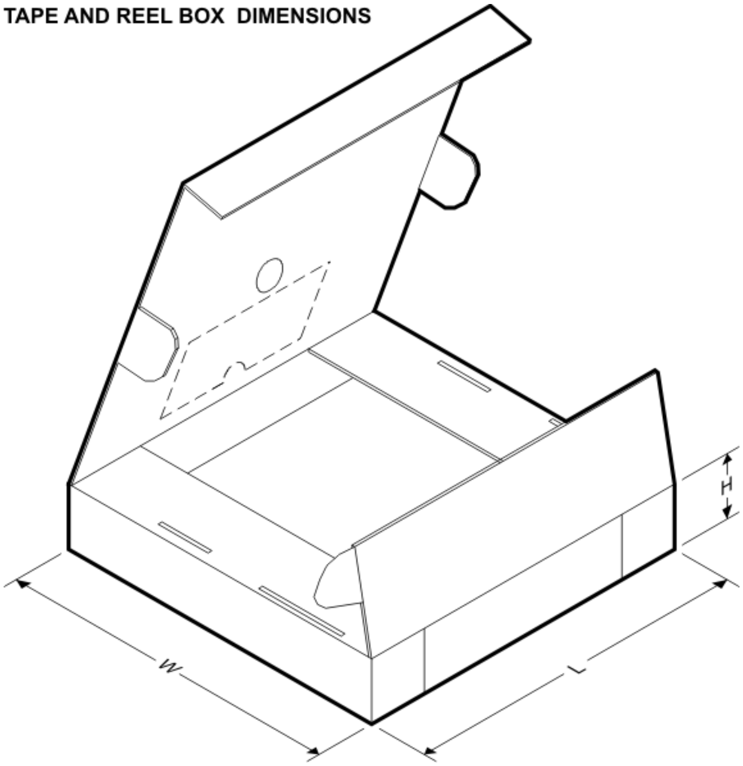
TAPE AND REEL INFORMATION



*All dimensions are nominal

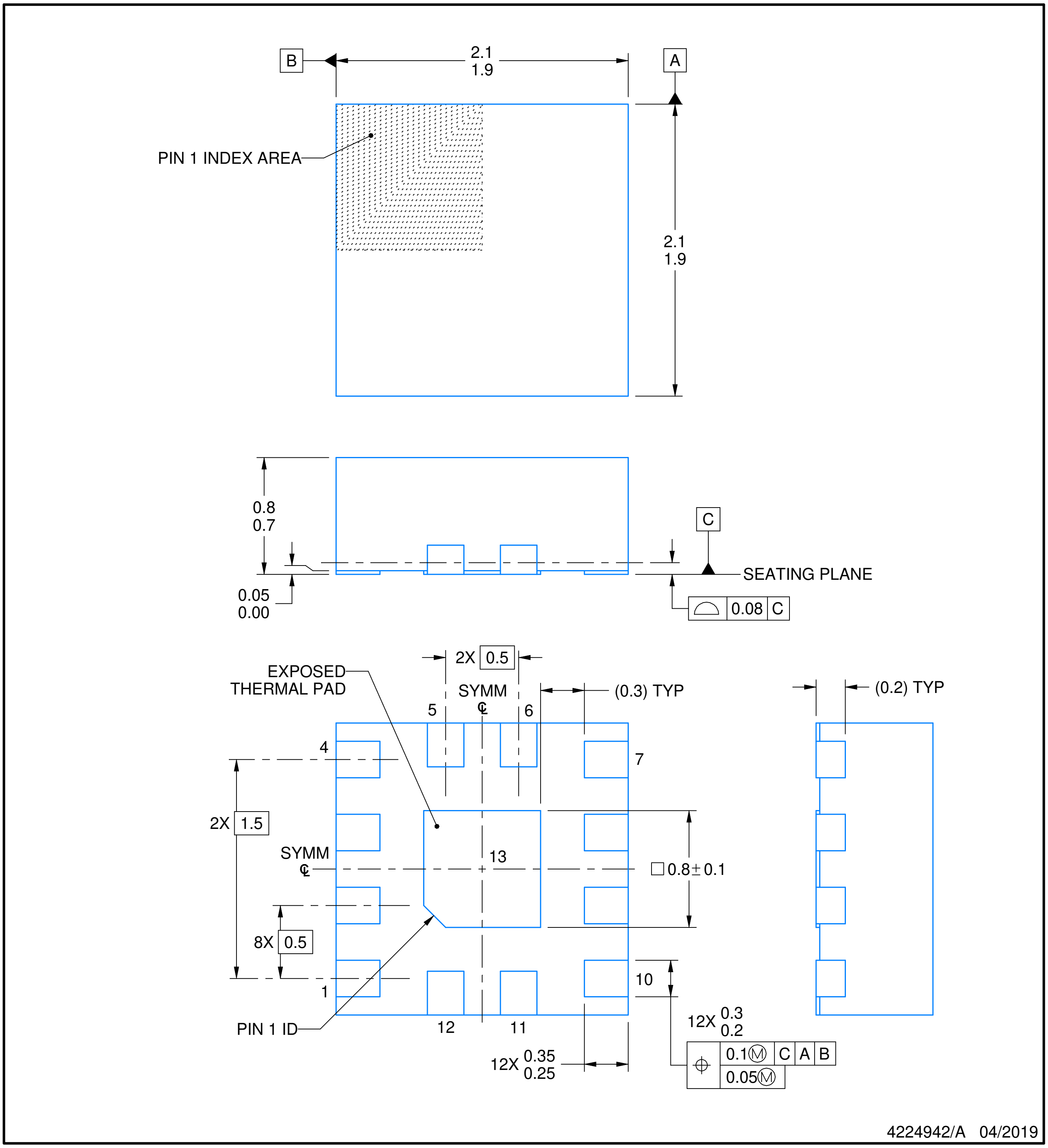
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMH9226IRRLR	WQFN	RRL	12	3000	180.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2

TAPE AND REEL BOX DIMENSIONS



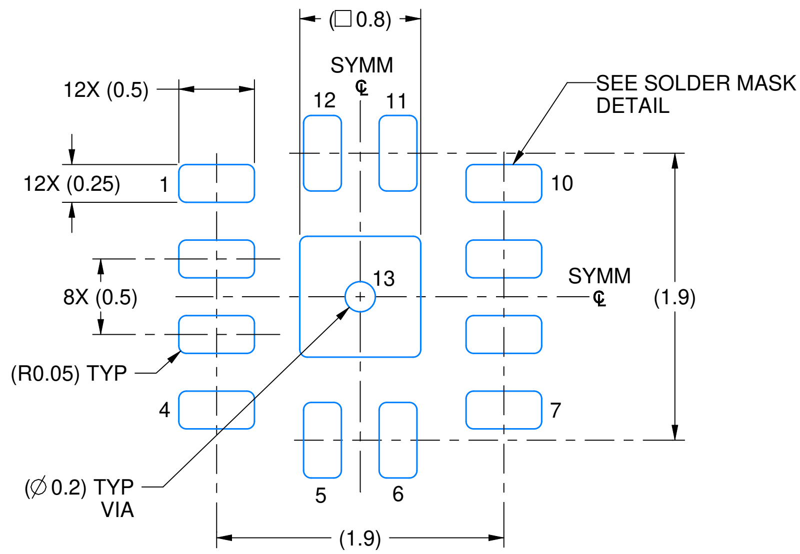
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMH9226IRRLR	WQFN	RRL	12	3000	213.0	191.0	35.0

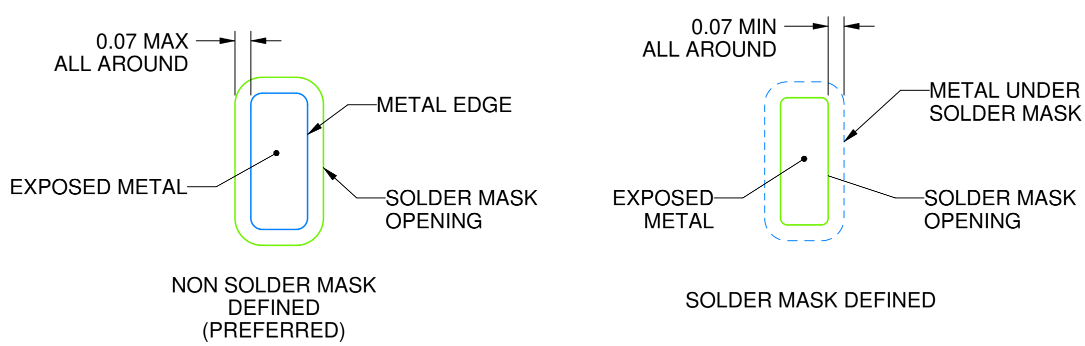


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X



SOLDER MASK DETAILS

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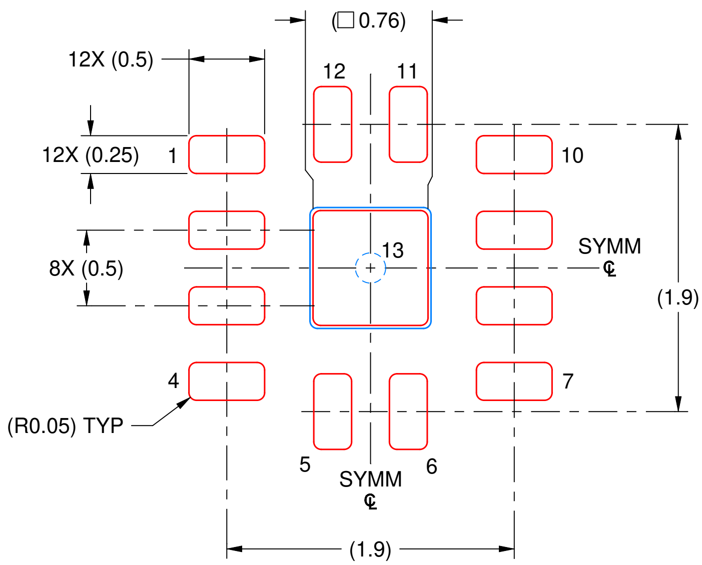
NOTES: (continued)

4. 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).
5. 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.



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 20X

EXPOSED PAD 13
90% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

4224942/A 04/2019

NOTES: (continued)

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

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