具有集成平衡-非平衡变压器的 LMH9235 3.3GHz 至 4.2GHz 单端至差分放大器

1 特性

- 单通道、单端输入至差分输出射频增益块放大器
- 直接支持 3.3GHz – 3.8GHz 频带或通过外部匹配组件支持 3.7GHz – 4.2GHz 频带
- 在整个频带内具有 17.5dB 的典型增益
- 低于 3dB 噪声系数
- 34.5dBm OIP3
- 18dBm 输出 P1dB
- 3.3V 单电源供电，具有 270mW 功耗
- 工作温度高达 105°C T_C

2 应用

- 适用于高 GSPS ADC 的差分驱动器
- 单端到差分转换
- 平衡-非平衡变压器替代产品
- 射频增益块
- 小型蜂窝或 m-MIMO 基站
- 5G 有源天线系统 (AAS)
- 无线蜂窝基站
- 低成本无线电设备

3 说明

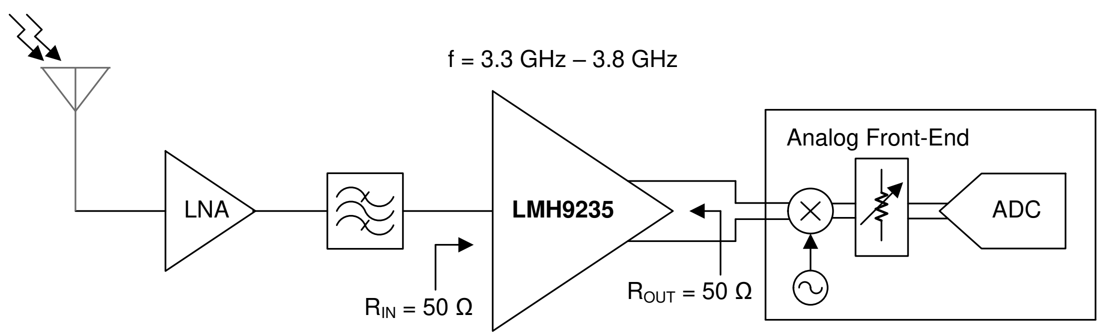
LMH9235 器件是一款高性能、单通道、单端输入至差分输出接收射频增益块放大器，支持 3.6GHz 中心频段。该器件非常适合支持下一代 5G AAS 或小型蜂窝应用的要求，其中 LNA 增益不足以驱动模拟前端 (AFE) 的满量程。该射频放大器可提供 17dB 的典型增益，并具有 34dBm 输出 IP3 的出色线性性能，同时在整个 1dB 带宽内保持大约 3dB 的噪声系数。该器件在单端输入以及差分输出端内部匹配 50Ω 阻抗，可轻松与射频采样或零中频模拟前端 (AFE) 相连。

该器件使用 3.3V 单电源供电，其有功功率约为 270mW，因此适用于高密度 5G 大规模 (MIMO) 应用。此外，该器件采用节省空间的 2mm x 2mm、12 引脚 QFN 封装。该器件的额定工作温度高达 105°C，可提供稳健的系统设计。该器件具有符合 JEDEC 标准的 1.8V 断电引脚，可为该器件快速断电和上电，适用于时分双工 (TDD) 系统。

器件信息(1)

器件型号	封装	封装尺寸（标称值）
LMH9235	WQFN (12)	2.00mm × 2.00mm

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。



LMH9235：单端至差分放大器

Table of Contents

4 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision B (June 2020) to Revision C (May 2021) **Page**

- 更新了整个文档中的表格、图和交叉参考的编号格式.......... 1

Changes from Revision A (May 2020) to Revision B (June 2020) **Page**

- 在“特性”部分添加了*具有外部匹配组件的 3.7GHz – 4.2GHz 频带*.......... 1
- Changed the P_{OUT}/TONE measurements of Figure 6, Figure 7 and Figure 8 From: *1-MHz tone spacing* To: *10-MHz tone spacing*.......... 6
- Added *Shifting the Operating Band* section.......... 12
- Added *Design Requirements and Procedure* section.......... 12

Changes from Revision * (May 2020) to Revision A (June 2020) **Page**

- 将状态从*产品预发布*更改为*量产数据*.......... 1

5 Pin Configuration and Functions

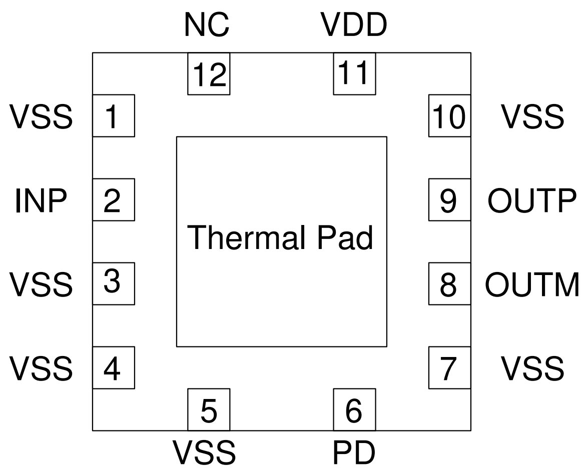


图 **5-1. RRL Package 12-Pin WQFN Top View**

表 **5-1. Pin Functions**

PIN		I/O	DESCRIPTION
NO.	**NAME**		
1	VSS	Power	Ground
2	INP	Input	RF single-ended input into amplifier
3	VSS	Power	Ground
4	VSS	Power	Ground
5	VSS	Power	Ground
6	PD	Input	Power down connection. PD = 0 V = normal operation; PD = 1.8 V = power off mode.
7	VSS	Power	Ground
8	OUTM	Output	RF differential output negative
9	OUTP	Output	RF differential output positive
10	VSS	Power	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

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} = 3.55 GHz at INP		25	dBm
Digital Input PIN	PD	–0.3	VDD	V
T_J	Junction temperature		150	°C
T_{stg}	Storage temperature	–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_C	Case (bottom) temperature	–40		105	°C
T_J	Junction temperature	–40		125	°C

6.4 Thermal Information

THERMAL METRIC[(1)]		LMH9235 RRL PKG 12-PIN WQFN	UNIT
$R_{\theta JA}$	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 = 3.3V, frequency = 3.55 GHz, single-ended input impedance (R_{IN}) = 50 Ω, differential output load (R_{LOAD}) = 50 Ω unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
RF PERFORMANCE - LMH9235						
F_{RF}	RF frequency range		3300		3800	MHz
BW_{1dB}	1-dB Bandwidth			700		MHz
S_{21}	Gain			17.5		dB
NF	Noise Figure	R_S = 50 Ω		3		dB
OP1dB	Output P1dB	R_{LOAD} = 50 Ω differential		18		dBm
OIP3	Output IP3	f_{in} = 3.55 GHz ± 5 MHz spacing, P_{OUT}/TONE = 2 dBm		34.5		dBm
	Differential output gain Imbalance			±0.5		dB
	Differential output phase Imbalance			±3		degree
S_{11}	Input return loss (1)	f = 3.3 - 3.8 GHz		–9		dB
S_{22}	Output return loss (1)	f = 3.3 - 3.8 GHz		–10		dB
S_{12}	Reverse isolation	f = 3.3 - 3.8 GHz		–40		dB
CMRR	Common Mode Rejection Ratio (2)			30		dB
Switching and Digital input characteristics						
t_{ON}	Turn-ON time	50% V_{PD} to 90% RF		0.5		µs
t_{OFF}	Turn-OFF time	50% V_{PD} to 10% RF		0.2		µs
V_{IH}	High-Level Input Voltage	PD pin	1.4			V
V_{IL}	Low-Level Input Voltage	PD pin			0.5	V
DC current and Power Consumption						
I_{VDD_ON}	Supply Current - active	V_{PD} = 0 V		80		mA
I_{VDD_PD}	Supply Current - power down	V_{PD} = 1.8 V		10		mA
P_{dis}	Power Dissipation - active			270		mW

(1) Reference impedance: Input = 50 Ω single-ended, Output = 50 Ω differential
(2) CMRR is calculated using $(S_{21}-S_{31})/(S_{21}+S_{31})$ for Receive (1 is input port, 2 & 3 are differential output ports)

6.6 Typical Characteristics

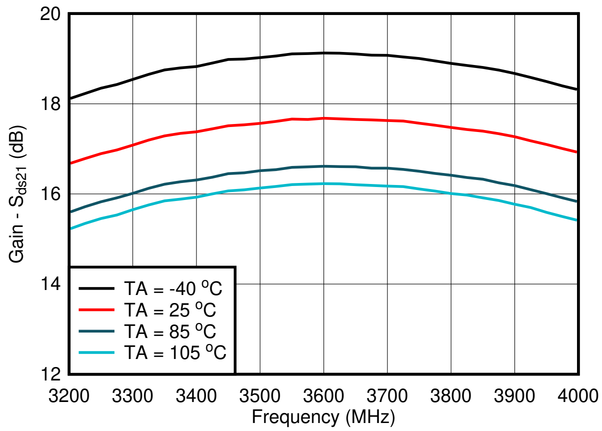


图 6-1. Gain vs Frequency and Temperature

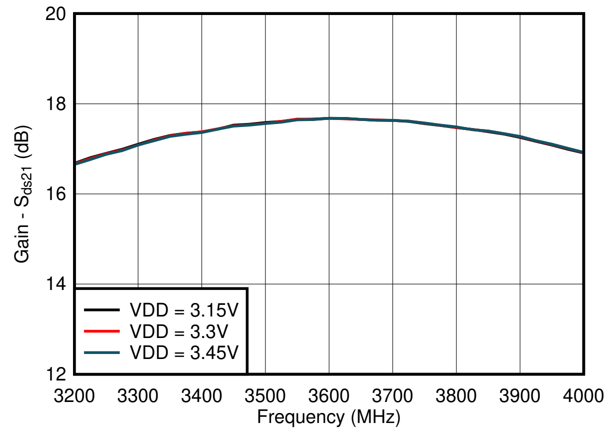


图 6-2. Gain vs Frequency and Supply Voltage

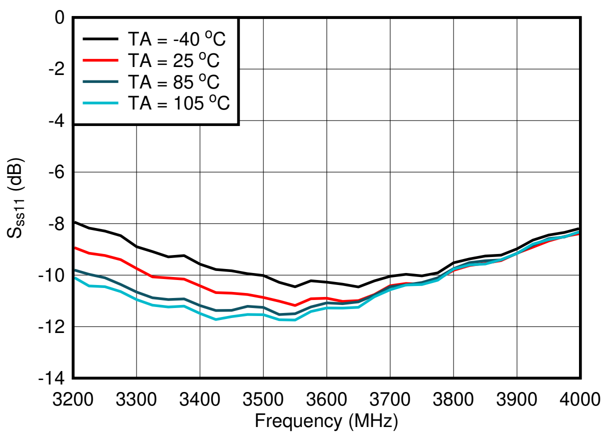


图 6-3. Input Return Loss vs Frequency

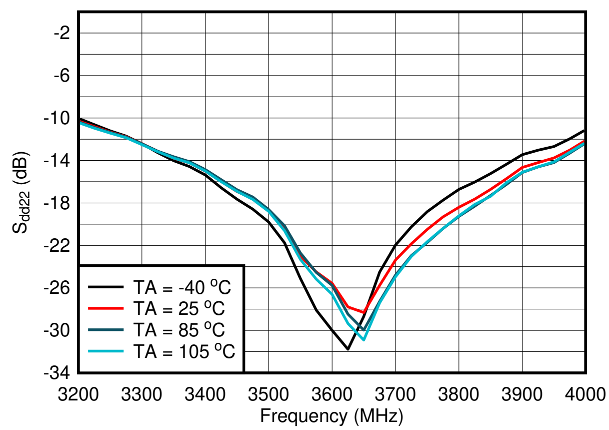


图 6-4. Output Return Loss vs Frequency

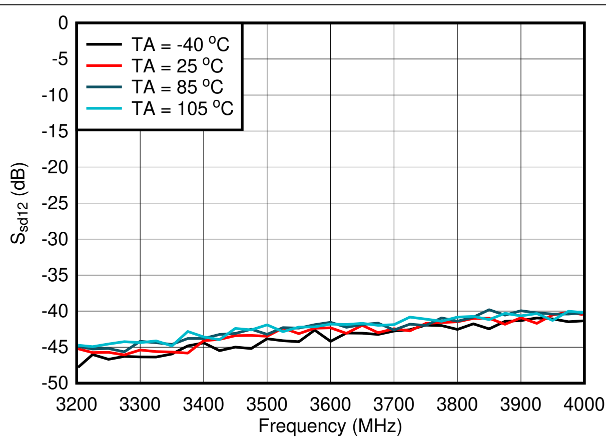
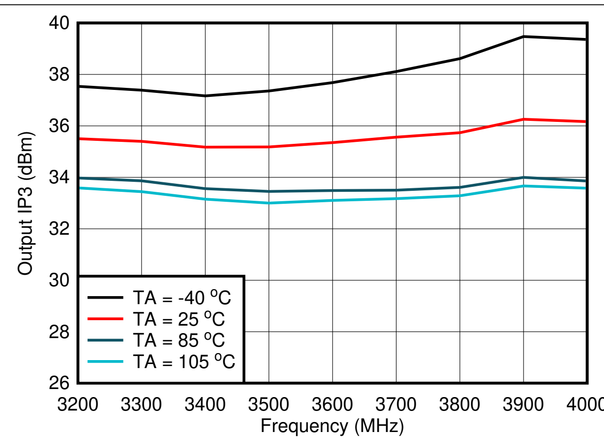


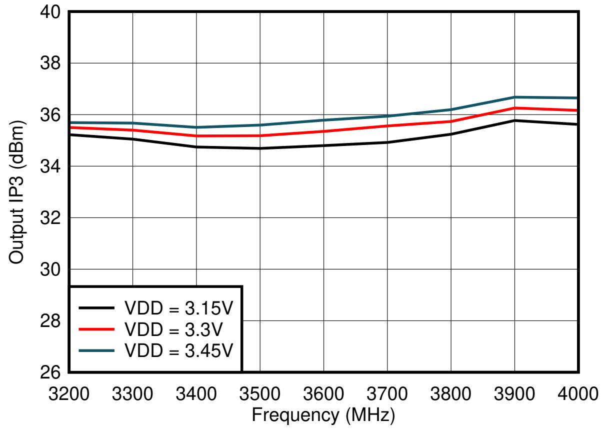
图 6-5. Reverse Isolation vs Frequency



P_{OUT}/TONE = 2 dBm, 10-MHz tone spacing

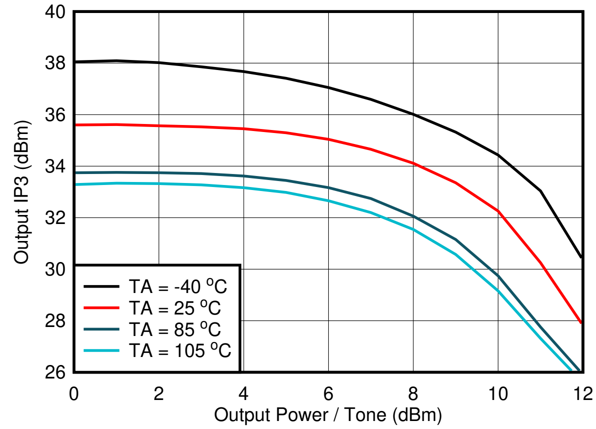
图 6-6. Output IP3 vs Frequency and Temperature

6.6 Typical Characteristics (continued)



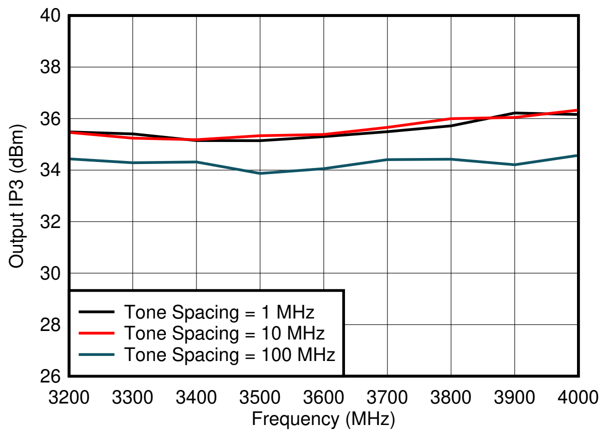
P_{OUT}/TONE = 2 dBm, 10-MHz tone spacing

图 6-7. Output IP3 vs Frequency and Supply Voltage



f = 3550 MHz, 10-MHz tone spacing

图 6-8. Output IP3 vs Output Power per Tone



P_{OUT}/TONE = 2 dBm

图 6-9. Output IP3 vs Frequency and Tone Spacing

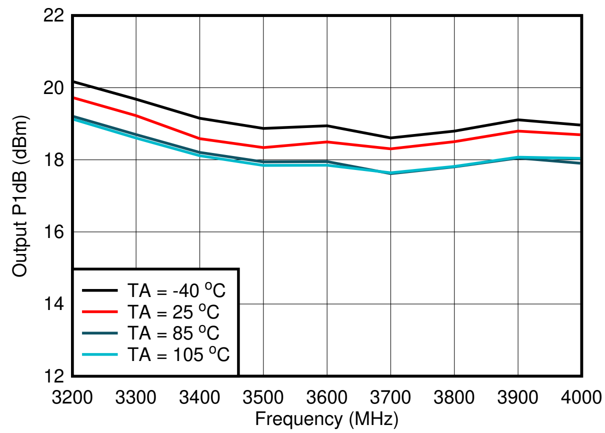


图 6-10. Output P1dB vs Frequency and Temperature

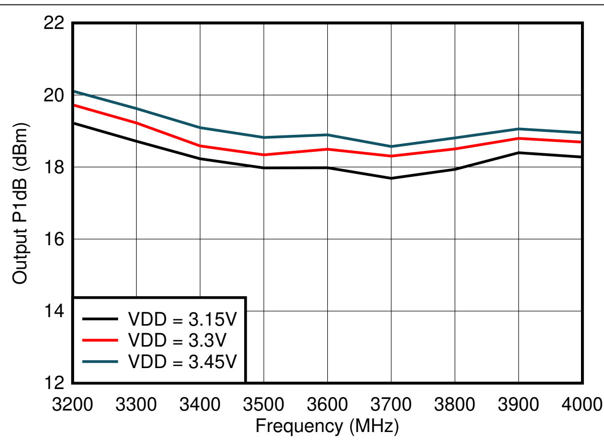
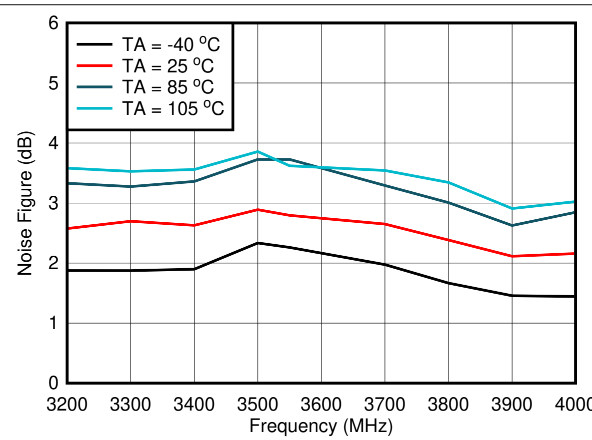


图 6-11. Output P1dB vs Frequency and Supply Voltage



Z_{SOURCE} = 50 Ω

图 6-12. Noise Figure vs Frequency and Temperature

6.6 Typical Characteristics (continued)

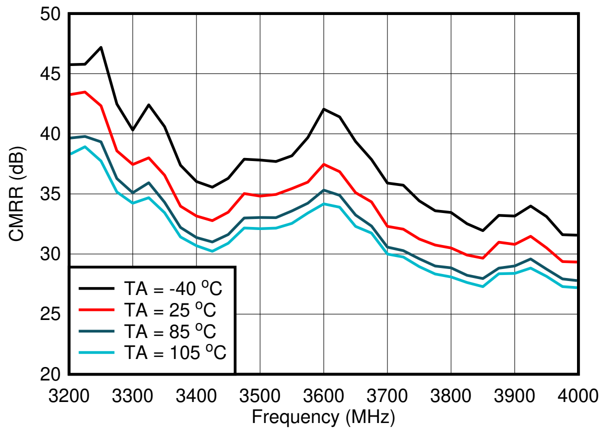


图 6-13. CMRR vs Frequency

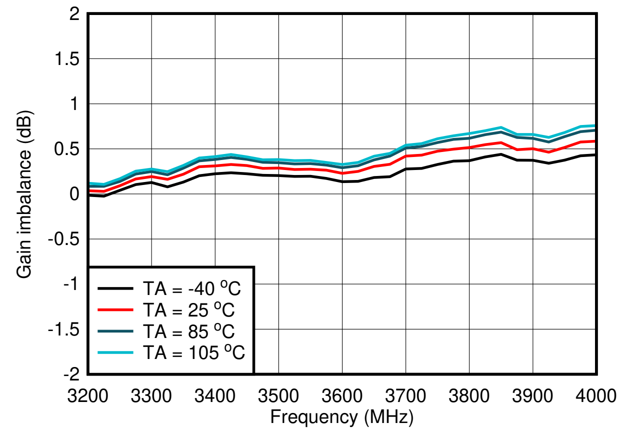


图 6-14. Gain Imbalance vs Frequency and Temperature

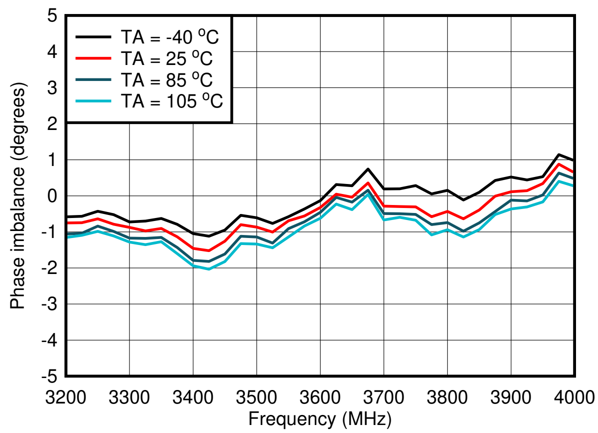


图 6-15. Phase Imbalance vs Frequency and Temperature

7 Detailed Description

7.1 Overview

The LMH9235 device is a single-ended input to differential output narrow-band RF amplifier that is used in receiver applications. The LMH9235 provides ≈ 17 dB fixed power gain with excellent linearity and noise performance across 1 dB bandwidth of the 3.55 GHz center frequency. The device is internally matched for 50 Ω impedance at both the single-ended input as well as the differential output, as shown in 节 8.

The LMH9235 has 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 saving power when the amplifier is not needed. Fast shut down and start up enable the amplifier to be used in a host of TDD applications.

Operating on a single 3.3 V supply and consuming ≈ 80 mA of typical supply current, the device is available in a 2 mm x 2 mm 12-pin QFN package.

7.2 Functional Block Diagram

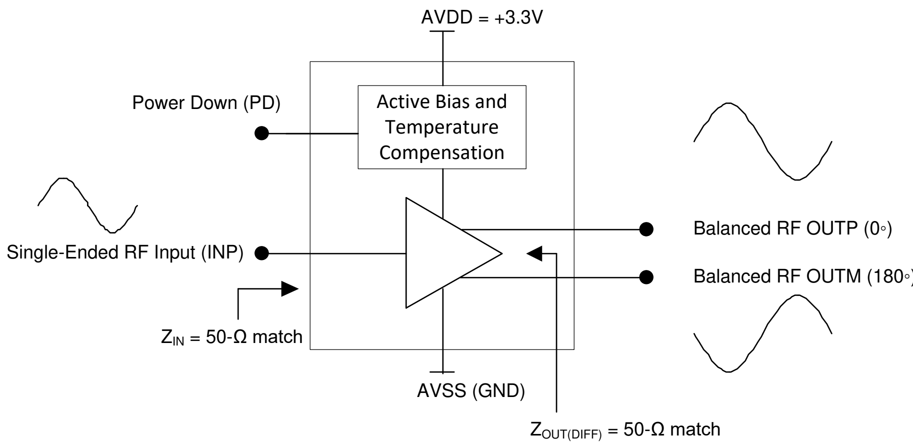


图 7-1. Functional Block Diagram

7.3 Feature Description

The LMH9235 device is single-ended to differential RF amplifier for narrow band active balun implementation. The device integrates the functionality of a single-ended RF amplifier and passive balun in traditional receive applications achieving small form factor with comparable linearity and noise performance, as shown in 图 7-2.

The active balun implementation coupled with higher operating temperature of 105°C allows for more robust receiver system implementation compared to passive balun that is prone to reliability failures at high temperatures. The high temperature operation is achieved by the on-chip active bias circuitry which maintains device performance over a wide temperature and supply voltage range.

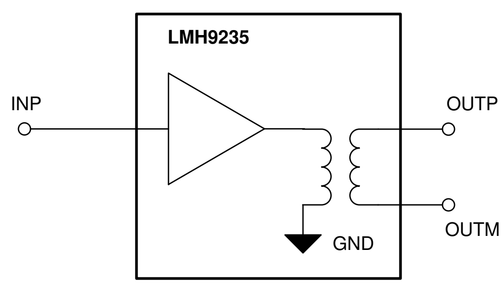


图 7-2. Single-Ended Input to Differential Output, Active Balun Implementation

7.4 Device Functional Modes

The LMH9235 features a PD pin which should be connected to GND for normal operation. To power down the device, connect the PD pin to a logic high voltage of 1.8 V.

8 Application and Implementation

备注

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客 户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

8.1 Application Information

The LMH9235 device is a single-ended, 50 Ω input to differential 50 Ω output RF gain block amplifier, used in the receive path of a 3.55 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

8.2.1 Matching to a 100 Ω AFE

A typical application of the LMH9235 device driving an AFE is shown in 图 8-1.

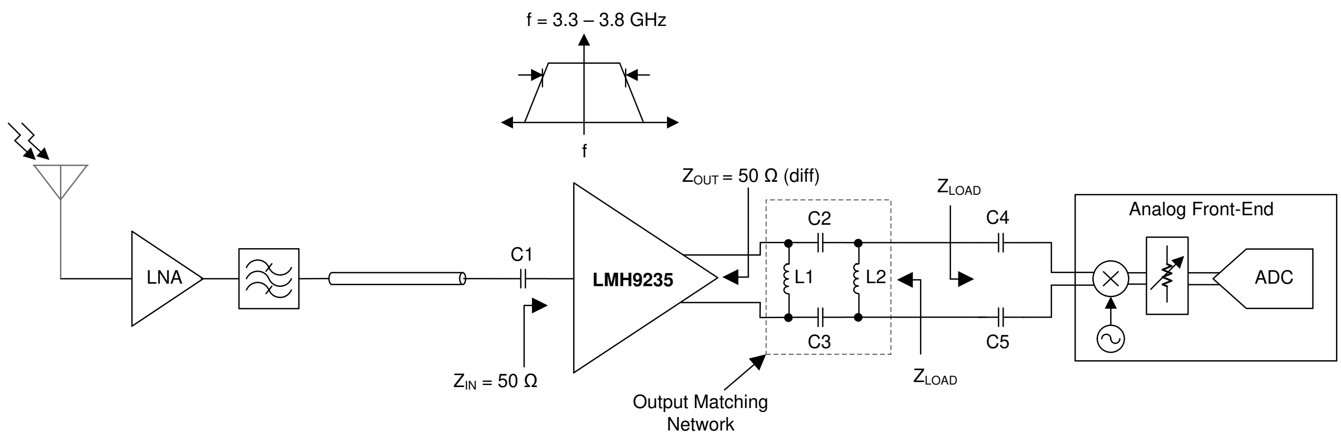


图 8-1. LMH9235 in Receive Chain Driving an Analog Front-End

8.2.1.1 Design Requirements

Z_{LOAD} represents the impedance of the AFE. With a matching network comprising of L1, L2, C2, and C3 as shown, the LMH9235 is matched to the impedance of AFE. The capacitors C1, C4, and C5 are for dc-blocking purpose.

8.2.1.2 Detailed Design Procedure

The table shows the matching network components for 50 Ω (differential) and 100 Ω (differential) AFE impedances.

表 8-1. Matching Network Component Values

Component	Value for $Z_{LOA\ D}$ = 50 Ω (differential)	Value for Z_{LOAD} = 100 Ω (differential)
C1	22 pF	22 pF
C2, C3	SHORT	1.5 pF
L1	OPEN	OPEN
L2	OPEN	4.3 nH
C4, C5	22 pF	22 pF

8.2.1.3 Application Curves

The graphs given below show the gain, input return loss and output return loss of the design with different AFE terminations.

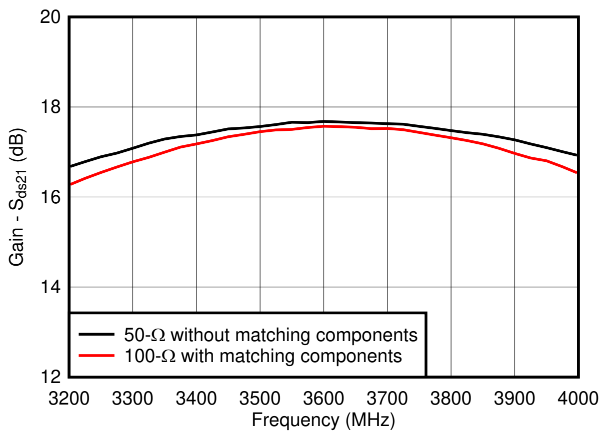


图 8-2. Gain vs Frequency for Different Terminations

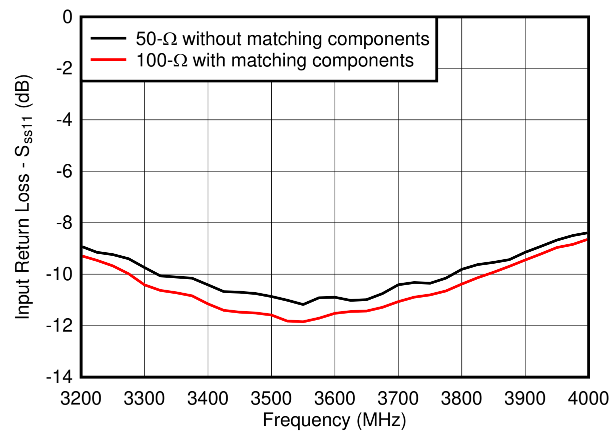


图 8-3. Input Return Loss vs Frequency for Different Terminations

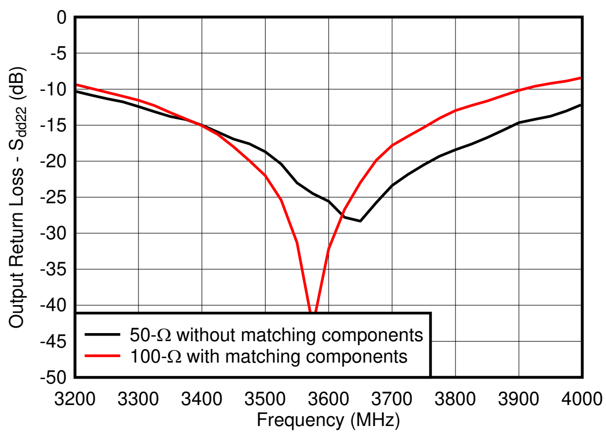


图 8-4. Output Return Loss vs Frequency for Different Terminations

8.2.2 Shifting the Operating Band

It is possible to tune the frequency band of operation of this chip by a simple external network at the input as shown in 图 8-1. In this example, with the help of 2 components at the input, the frequency band is shifted to 3.7 - 4.2 GHz.

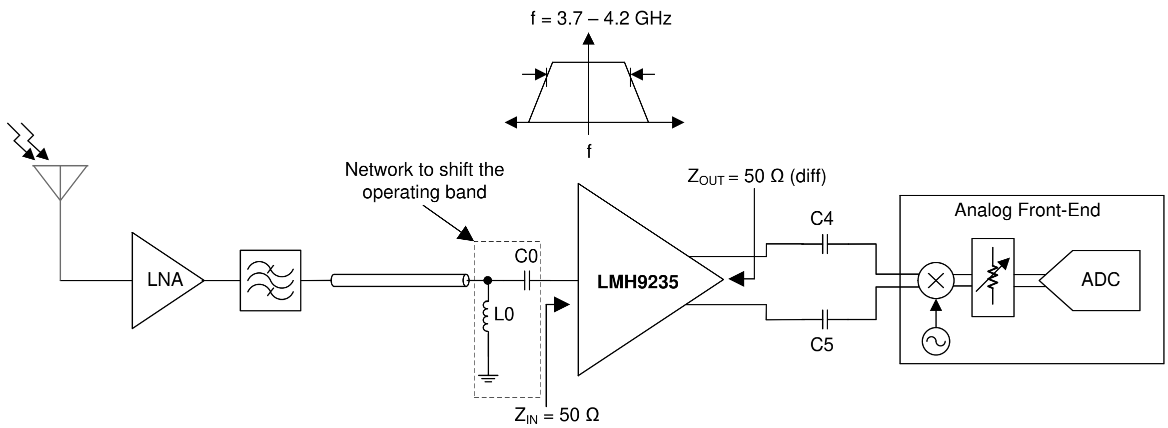


图 8-5. Shifting the Operating Band

8.2.2.1 Design Requirements and Procedure

The components C0 and L0 are meant to shift the operating band from 3.3 - 3.8 GHz to 3.7 - 4.2 GHz. The capacitors C4, and C5 are for dc-blocking purpose. The values of these components are given in the table below.

表 8-2. Matching Network Component Values

Component	Value
C0	2 pF
L0	2 nH
C4	22 pF
LC5	22 pF

8.2.2.2 Application Curves

The graphs given below show the gain, input and output return loss and OIP3 of the design shown in 图 8-1.

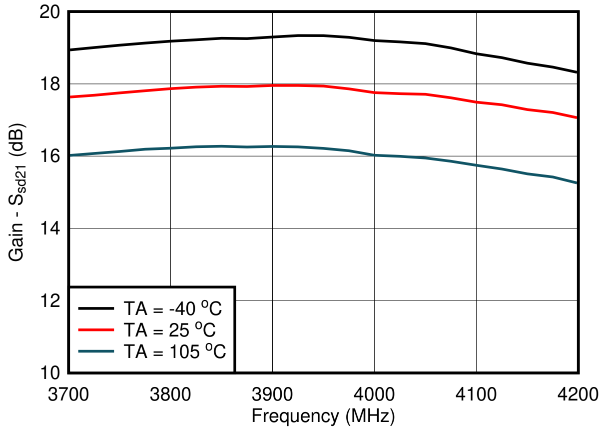


图 8-6. Gain vs Frequency

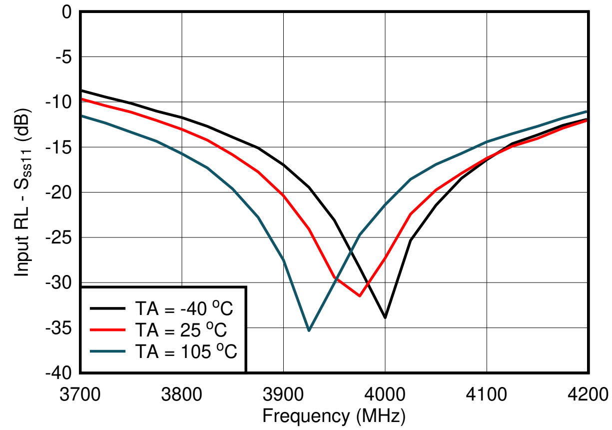


图 8-7. Input Return Loss vs Frequency

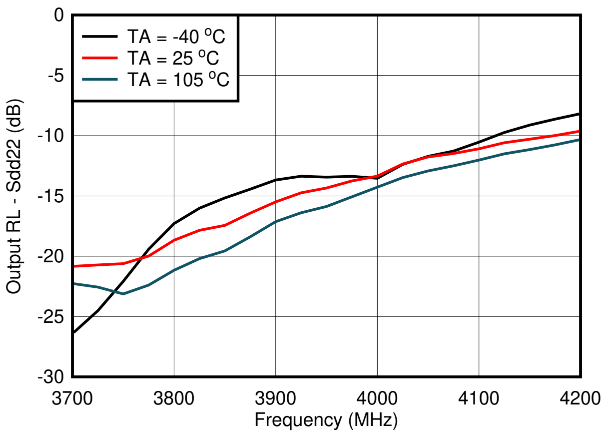


图 8-8. Output Return Loss vs Frequency

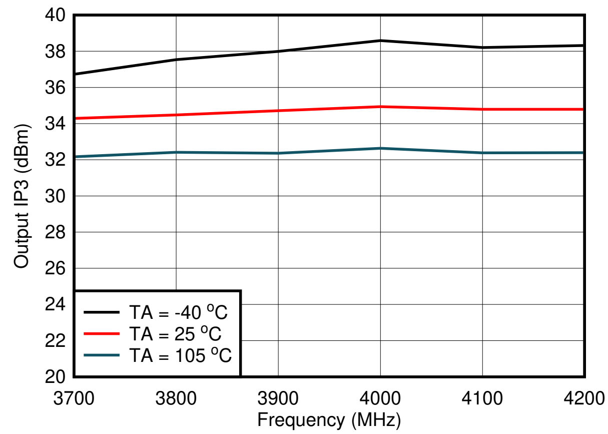


图 8-9. Output IP3 vs Frequency and Temperature

9 Power Supply Recommendations

The LMH9235 device operates on a common nominal 3.3-V supply voltage. It is recommended to isolate the supply voltage through decoupling capacitors placed close to the device. Select capacitors with self-resonant frequency above 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.

10 Layout

10.1 Layout Guidelines

When designing with an RF amplifier operating in the frequency range 3.3 GHz to 3.8 GHz with relatively high gain, certain board layout precautions must be taken to ensure stability and optimum performance. TI recommends that the LMH9235 board be multi-layered to improve thermal performance, grounding, and power-supply decoupling. 图 10-1 shows a good layout example. In this figure, only the top signal layer is 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.
- Ensure that ground planes on the top and any internal layers are well stitched with vias.
- Design the input and output RF traces for appropriate impedance. TI recommends grounded coplanar waveguide (GCPW) type transmission lines for the RF traces. Use a PCB trace width calculator tool to design the transmission lines.
- Avoid routing clocks and digital control lines near RF signal lines.
- Do not route RF or DC signal lines over noisy power planes.
- Place supply decoupling caps close to the device.
- The differential output traces must be symmetrical in order to achieve the best differential balance and linearity performance.

See the *LMH9235 Evaluation Module* user's guide for more details on board layout and design.

10.2 Layout Example

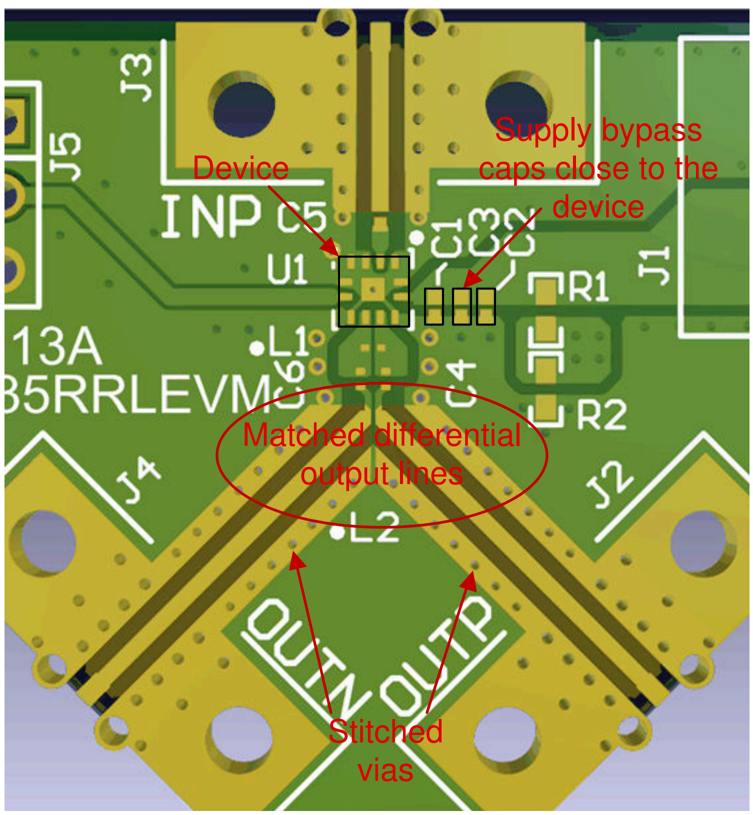


图 10-1. Layout Showing Matched Differential Traces and Supply Decoupling

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, LMH9235RRLEVM EU Declaration of Conformity (DoC).
- Texas Instruments, LMH9235 Evaluation Module User's Guide.

11.2 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击 *订阅更新* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

11.3 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

11.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
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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 术语表

TI 术语表　　本术语表列出并解释了术语、首字母缩略词和定义。

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 part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LMH9235IRRLR	Active	Production	WQFN (RRL) | 12	3000 | LARGE T&R	Yes	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 105	35BO
LMH9235IRRLR.B	Active	Production	WQFN (RRL) | 12	3000 | LARGE T&R	Yes	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 105	35BO

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

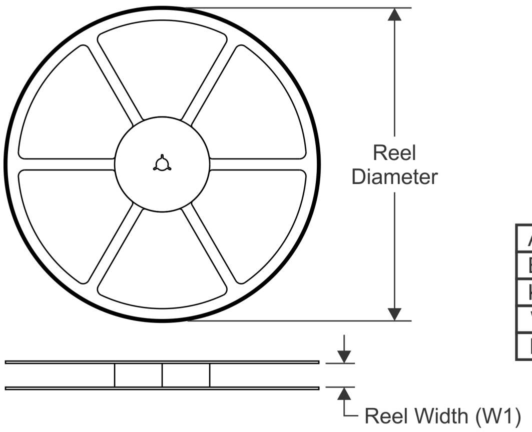
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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.

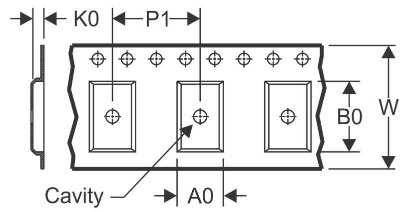
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

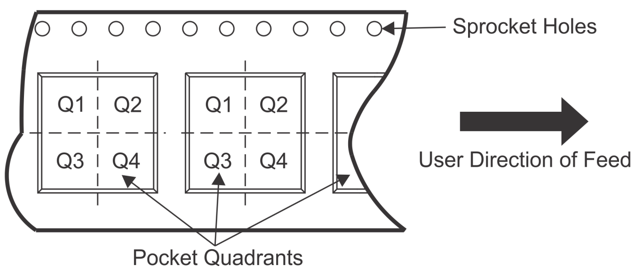


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

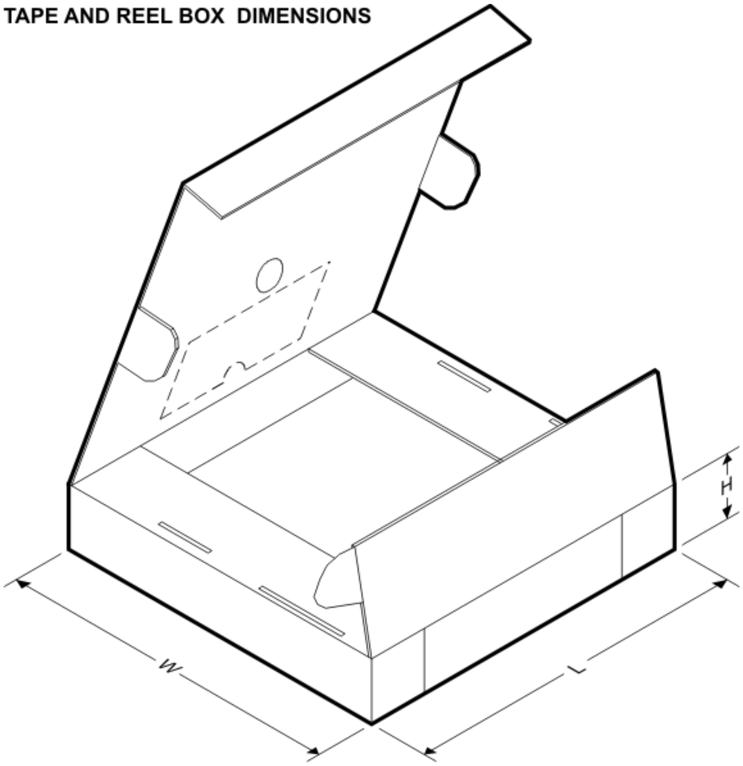
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

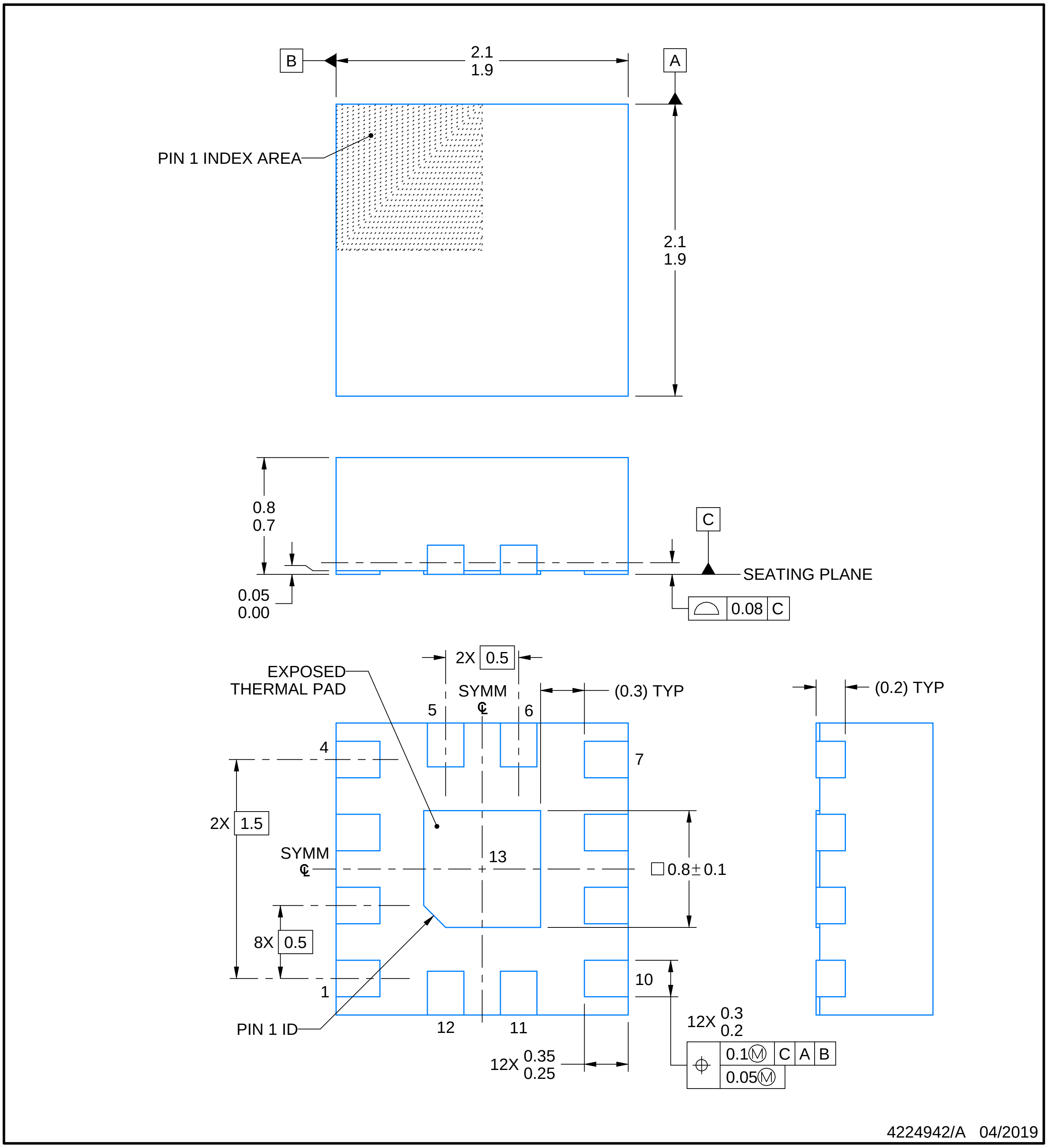
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMH9235IRRLR	WQFN	RRL	12	3000	180.0	8.4	2.2	2.2	1.2	4.0	8.0	Q2

TAPE AND REEL BOX DIMENSIONS



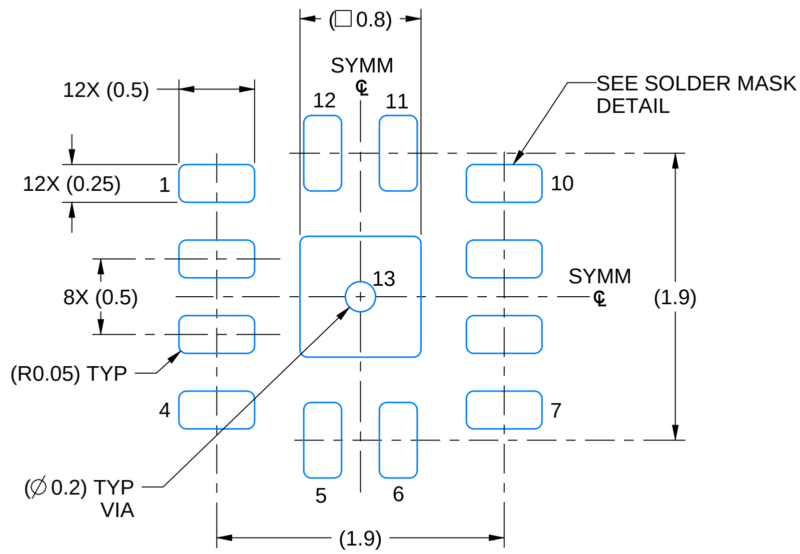
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMH9235IRRLR	WQFN	RRL	12	3000	213.0	191.0	35.0

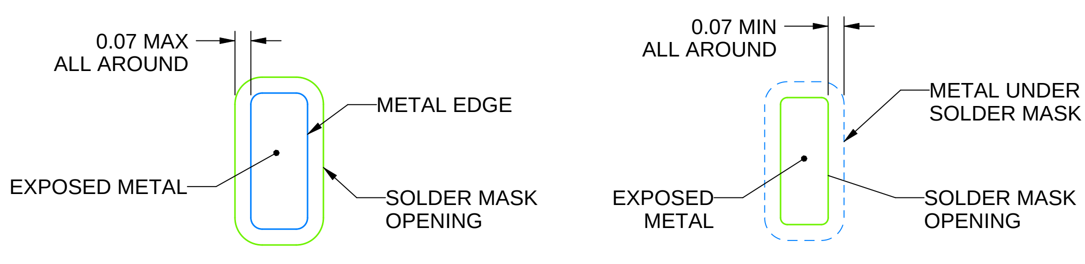


NOTES:

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



NON SOLDER MASK
DEFINED
(PREFERRED)

SOLDER MASK DEFINED

SOLDER MASK DETAILS

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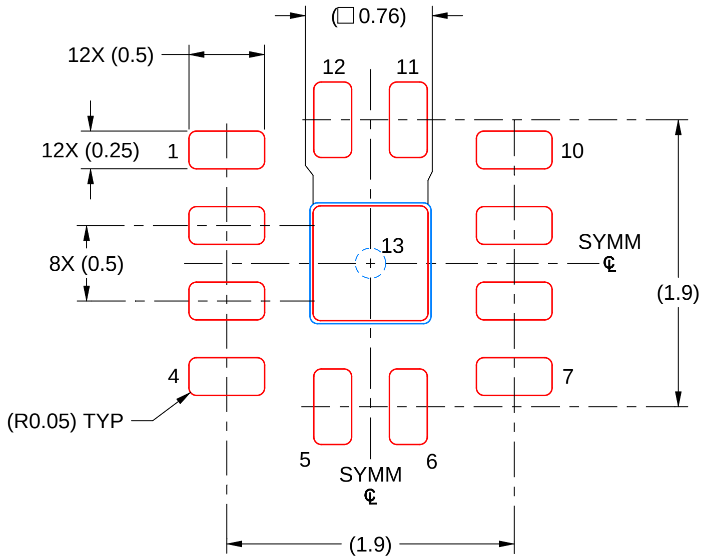
NOTES: (continued)

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

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NOTES: (continued)

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

重要通知和免责声明

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