



# RF LDMOS Integrated Power Amplifier

This 12.5 W CW RF power integrated circuit is designed for RF energy applications operating in the 2450 MHz ISM band.

**Typical Performance:**  $V_{DD} = 28$  Vdc,  $P_{in} = 11$  dBm,  $I_{DQ1} = 15$  mA,  $I_{DQ2} = 75$  mA

Frequency (MHz)	Signal Type	$G_{ps}$ (dB)	PAE (%)	$P_{out}$ (W)
2400	CW	30.1	51.3	13.0
2450		30.0	51.4	12.7
2500		29.7	50.5	11.7

## Features

- High gain simplifies layout and reduced PCB area compared to a discrete design
- Qualified up to a maximum of 32  $V_{DD}$  operation
- On-chip input and interstage matching (50 ohm input)
- Integrated quiescent current temperature compensation with enable/disable function (1)
- Integrated ESD protection
- 150°C case and junction temperature rating
- Ideal as a driver for high power RF energy applications

## Typical Applications

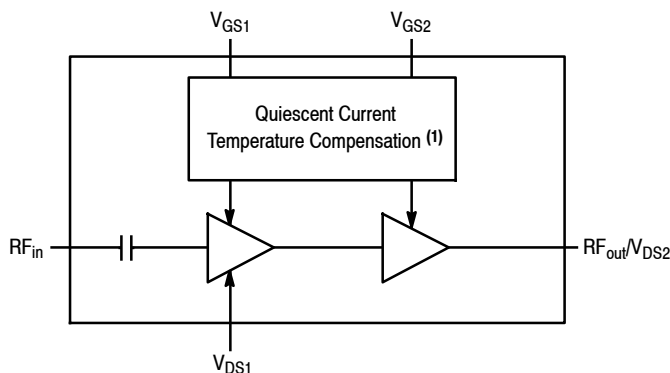
- Driver for consumer and commercial cooking applications
- Driver for industrial heating applications, such as sterilization, pasteurization, drying, moisture-leveling process, curing and welding
- Driver for medical applications, such as microwave ablation, renal denervation and diathermy
- Final stage for portable heating devices and portable medical systems

**MHT2012N**

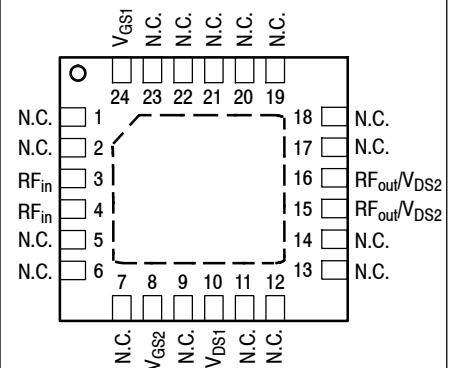
**2400–2500 MHz, 12.5 W CW, 28 V  
 RF LDMOS INTEGRATED  
 POWER AMPLIFIER**



**PQFN 8 × 8  
 PLASTIC**



**Figure 1. Functional Block Diagram**



Note: Exposed backside of the package is the source terminal for the transistor.

**Figure 2. Pin Connections**

1. Refer to AN1977, *Quiescent Current Thermal Tracking Circuit in the RF Integrated Circuit Family*, and to AN1987, *Quiescent Current Control for the RF Integrated Circuit Device Family*. Go to <http://www.nxp.com/RF> and search for AN1977 or AN1987.



**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +10	Vdc
Operating Voltage	$V_{DD}$	32, +0	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Case Operating Temperature Range	$T_C$	-40 to +150	°C
Operating Junction Temperature Range (1,2)	$T_J$	-40 to +150	°C
Input Power	$P_{in}$	20	dBm

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 81°C, 12.5 W, 2450 MHz Stage 1, 28 Vdc, $I_{DQ1} = 12$ mA Stage 2, 28 Vdc, $I_{DQ2} = 72$ mA	$R_{\theta JC}$	14 4.3	°C/W

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JS-001-2017)	1B, passes 500 V
Charge Device Model (per JS-002-2014)	C3, passes 1000 V

**Table 4. Moisture Sensitivity Level**

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD22-A113, IPC/JEDEC J-STD-020	3	260	°C

**Table 5. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Stage 1 - Off Characteristics</b>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65$ Vdc, $V_{GS} = 0$ Vdc)	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 32$ Vdc, $V_{GS} = 0$ Vdc)	$I_{DSS}$	—	—	500	nAdc
Gate-Source Leakage Current ( $V_{GS} = 0.9$ Vdc, $V_{DS} = 0$ Vdc)	$I_{GSS}$	—	—	200	nAdc
<b>Stage 1 - On Characteristics</b>					
Gate Threshold Voltage ( $V_{DS} = 10$ Vdc, $I_D = 3$ $\mu\text{Adc}$ )	$V_{GS(th)}$	0.8	1.2	1.6	Vdc
Fixture Gate Quiescent Voltage (4) ( $V_{DS} = 28$ Vdc, $I_{DQ1} = 12$ mAdc)	$V_{GG(Q)}$	—	4.9	—	Vdc

1. Continuous use at maximum temperature will affect MTF.
2. MTF calculator available at <http://www.nxp.com/RF/calculators>.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.nxp.com/RF> and search for AN1955.
4. Data measured in NXP test fixture with 4.7 k $\Omega$  resistor in series with  $V_{GS1}$  and  $V_{GS2}$  pins.

(continued)

**Table 5. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Stage 2 - Off Characteristics</b>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{A dc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 32\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	500	$\text{nA dc}$
Gate-Source Leakage Current ( $V_{GS} = 0.9\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	200	$\text{nA dc}$
<b>Stage 2 - On Characteristics</b>					
Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 14\ \mu\text{A dc}$ )	$V_{GS(th)}$	0.8	1.2	1.6	Vdc
Fixture Gate Quiescent Voltage (1) ( $V_{DS} = 28\text{ Vdc}$ , $I_{DQ2} = 72\text{ mA dc}$ )	$V_{GG(Q)}$	—	4.8	—	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 140\text{ mA dc}$ )	$V_{DS(on)}$	0.05	0.14	0.20	Vdc

**Table 6. Typical Performance**

In NXP Reference Circuit, 50 ohm system,  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ1} = 15\text{ mA}$ ,  $I_{DQ2} = 75\text{ mA}$ , 2400–2500 MHz Bandwidth

Power Gain	$G_{ps}$	—	29.7	—	dB
Power Added Efficiency	PAE	—	50.5	—	%
$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	11.7	—	W
$P_{out}$ @ 3 dB Compression Point, CW	P3dB	—	14	—	W
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.036	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.004	—	dB/ $^\circ\text{C}$

**Table 7. Load Mismatch/Ruggedness**

In NXP Reference Circuit, 50 ohm system,  $I_{DQ1} = 12\text{ mA}$ ,  $I_{DQ2} = 72\text{ mA}$

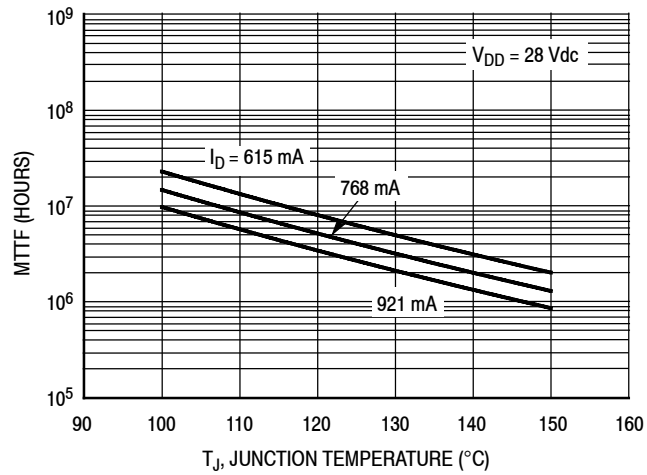
Frequency (MHz)	Signal Type	VSWR	$P_{in}$ (dBm)	Test Voltage, $V_{DD}$	Result
2450	CW	10:1 at all Phase Angles	14 (3 dB Overdrive)	32	No Device Degradation

**Table 8. Ordering Information**

Device	Tape and Reel Information	Package
MHT2012NT1	T1 Suffix = 1000 Units, 16 mm Tape Width, 13-inch Reel	PQFN 8 × 8

1. Data measured in NXP test fixture with 4.7 k $\Omega$  resistor in series with  $V_{GS1}$  and  $V_{GS2}$  pins.

## TYPICAL CHARACTERISTICS



**Note:** MTTF value represents the total cumulative operating time under indicated test conditions.

MTTF calculator available at <http://www.nxp.com/RF/calculators>.

**Figure 3. MTTF versus Junction Temperature – CW**

**Table 9. Load Pull Performance — Maximum Power Tuning**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ1} = 12 \text{ mA}$ ,  $I_{DQ2} = 73 \text{ mA}$ , Pulsed CW, 10  $\mu\text{sec(ON)}$ , 10% Duty Cycle

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Output Power					
			P1dB					
			$Z_{\text{load}}^{(1)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	PAE (%)
2400	40.9 + j23.6	48.3 – j23.1	7.22 – j4.32	30.0	42.2	17	49.8	49.7
2450	38.1 + j30.8	47.3 – j30.9	7.06 – j3.92	29.9	42.3	17	51.9	51.8
2500	32.9 + j30.7	40.4 – j32.8	6.76 – j3.83	30.0	42.4	18	52.6	52.5

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Output Power					
			P3dB					
			$Z_{\text{load}}^{(2)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	PAE (%)
2400	40.9 + j23.6	42.8 – j26.8	7.50 – j4.46	27.9	42.8	19	49.4	49.3
2450	38.1 + j30.8	40.4 – j32.0	7.20 – j4.35	27.8	43.0	20	50.8	50.7
2500	32.9 + j30.7	33.9 – j32.4	7.05 – j4.26	27.9	43.0	20	51.2	51.1

(1) Load impedance for optimum P1dB power.

(2) Load impedance for optimum P3dB power.

$Z_{\text{source}}$  = Measured impedance presented to the input of the device at the package reference plane.

$Z_{\text{in}}$  = Impedance as measured from gate contact to ground.

$Z_{\text{load}}$  = Measured impedance presented to the output of the device at the package reference plane.

**Note: Measurement made on a per side basis.**

**Table 10. Load Pull Performance — Maximum Efficiency Tuning**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ1} = 12 \text{ mA}$ ,  $I_{DQ2} = 73 \text{ mA}$ , Pulsed CW, 10  $\mu\text{sec(ON)}$ , 10% Duty Cycle

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Efficiency					
			P1dB					
			$Z_{\text{load}}^{(1)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	PAE (%)
2400	40.9 + j23.6	58.6 – j22.8	4.19 – j1.25	30.5	40.9	12	56.2	56.1
2450	38.1 + j30.8	56.8 – j34.4	4.01 – j1.06	30.2	41.0	13	56.8	56.7
2500	32.9 + j30.7	48.5 – j37.7	3.63 – j1.34	30.4	41.1	13	59.5	59.4

f (MHz)	$Z_{\text{source}} (\Omega)$	$Z_{\text{in}} (\Omega)$	Max Efficiency					
			P3dB					
			$Z_{\text{load}}^{(2)} (\Omega)$	Gain (dB)	(dBm)	(W)	$\eta_D$ (%)	PAE (%)
2400	40.9 + j23.6	51.9 – j26.8	4.28 – j1.45	28.5	41.6	15	54.3	54.2
2450	38.1 + j30.8	48.5 – j35.0	4.19 – j1.50	28.2	41.9	15	55.2	55.1
2500	32.9 + j30.7	40.4 – j36.5	3.94 – j1.74	28.4	42.0	16	57.0	56.9

(1) Load impedance for optimum P1dB efficiency.

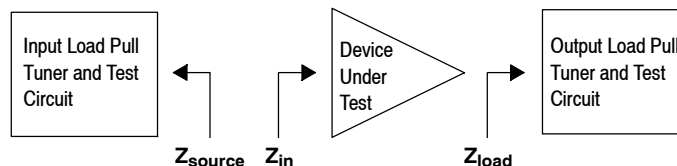
(2) Load impedance for optimum P3dB efficiency.

$Z_{\text{source}}$  = Measured impedance presented to the input of the device at the package reference plane.

$Z_{\text{in}}$  = Impedance as measured from gate contact to ground.

$Z_{\text{load}}$  = Measured impedance presented to the output of the device at the package reference plane.

**Note: Measurement made on a per side basis.**



## P3dB – TYPICAL LOAD PULL CONTOURS — 2450 MHz

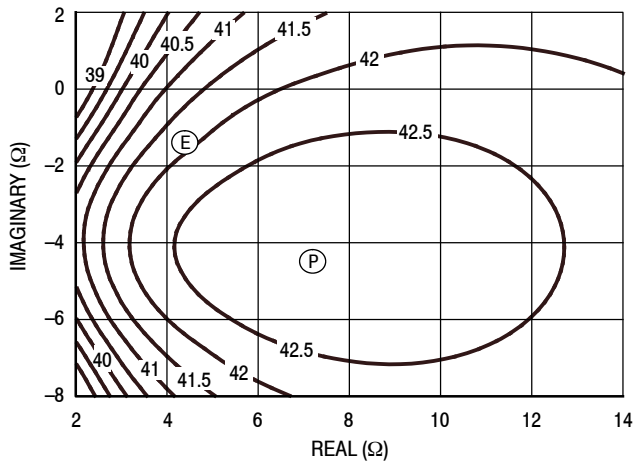


Figure 4. P3dB Load Pull Output Power Contours (dBm)

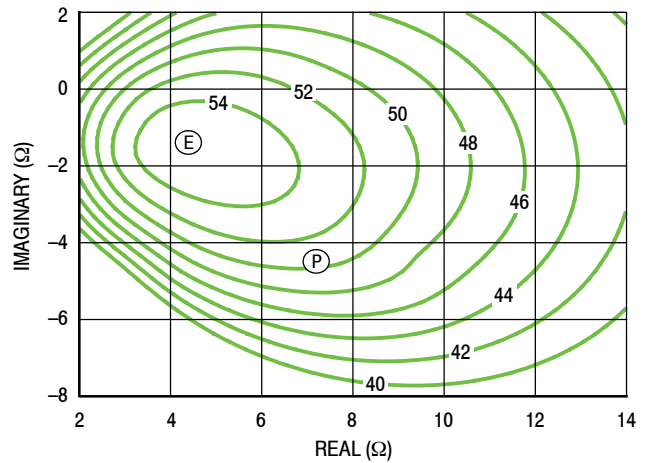


Figure 5. P3dB Load Pull Efficiency Contours (%)

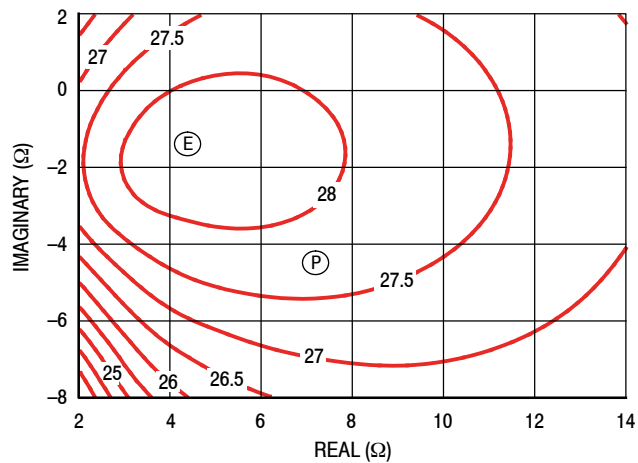
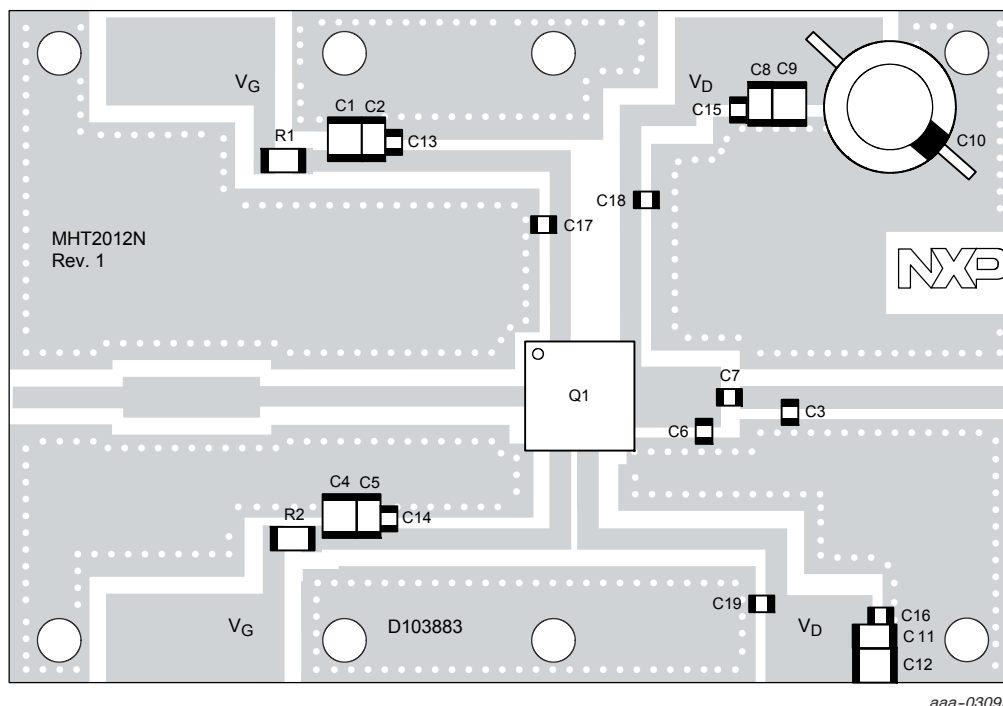


Figure 6. P3dB Load Pull Gain Contours (dB)

**NOTE:** (P) = Maximum Output Power  
 (E) = Maximum Drain Efficiency

- Gain
- Drain Efficiency
- Linearity
- Output Power

## 2400–2500 MHz REFERENCE CIRCUIT — 2" × 3" (5.1 cm × 7.6 cm)

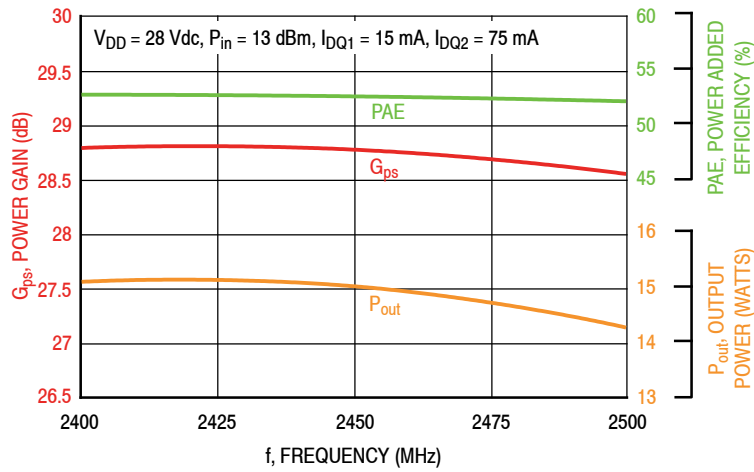


**Figure 7. MHT2012N Reference Circuit Component Layout — 2400–2500 MHz**

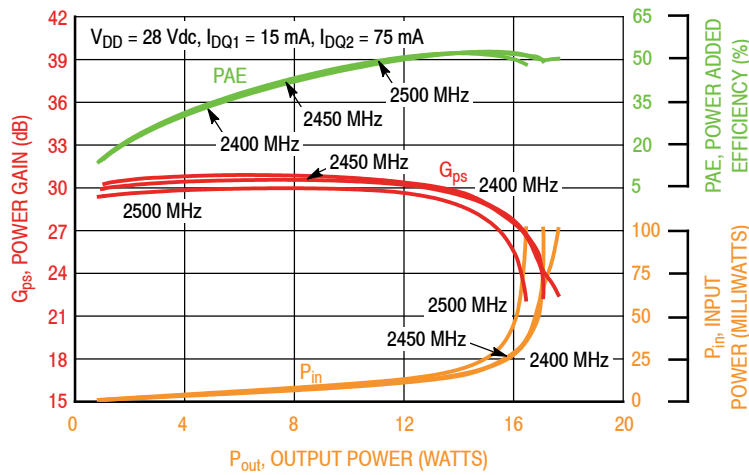
**Table 11. MHT2012N Reference Circuit Component Designations and Values — 2400–2500 MHz**

Part	Description	Part Number	Manufacturer
C1, C4, C9, C12	10 $\mu$ F Chip Capacitor	GRM32ER61H106KA12L	Murata
C2, C5, C8, C11	0.1 $\mu$ F Chip Capacitor	GRM32NR72A104KA01B	Murata
C3	0.5 pF Chip Capacitor	ATC600F0R5BT250XT	ATC
C6	1.6 pF Chip Capacitor	ATC600F1R6BT250XT	ATC
C7	4.7 pF Chip Capacitor	ATC600F4R7BT250XT	ATC
C10	220 $\mu$ F, 50 V Electrolytic Capacitor	227CKS050M	Illinois Capacitor
C13, C14, C15, C16, C17, C18, C19	5.6 pF Chip Capacitor	ATC600F5R6BT250XT	ATC
Q1	RF Power LDMOS Transistor	MHT2012N	NXP
R1, R2	4.7 k $\Omega$ , 1/4 W Chip Resistor	CRCW12064K70FKEA	Vishay
PCB	Rogers RT6035HTC, 0.030", $\epsilon_r = 3.5$	D103883	MTL

## TYPICAL CHARACTERISTICS — 2400–2500 MHz REFERENCE CIRCUIT



**Figure 8. Power Gain, Power Added Efficiency and CW Output Power versus Frequency at a Constant Input Power**



**Figure 9. Power Gain, Power Added Efficiency and Input Power versus CW Output Power and Frequency**



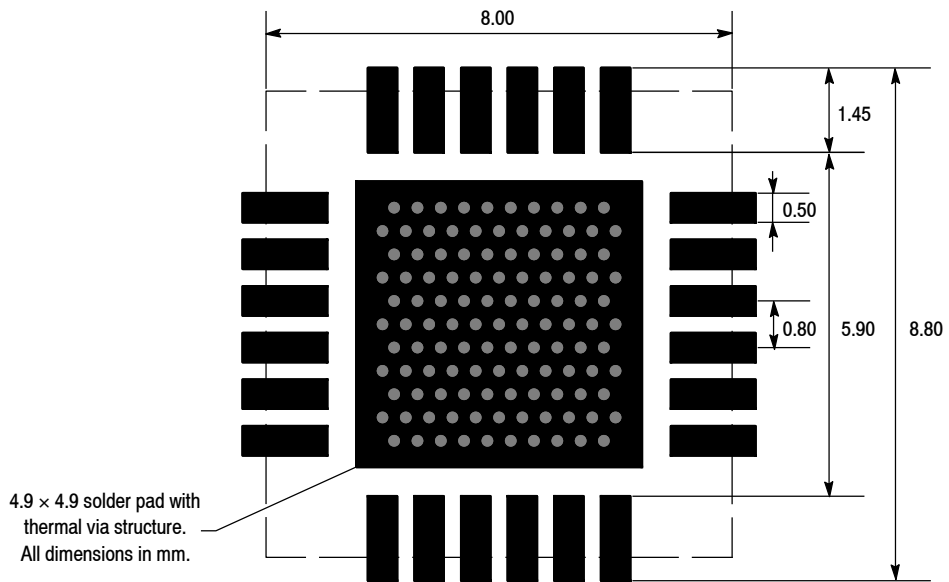
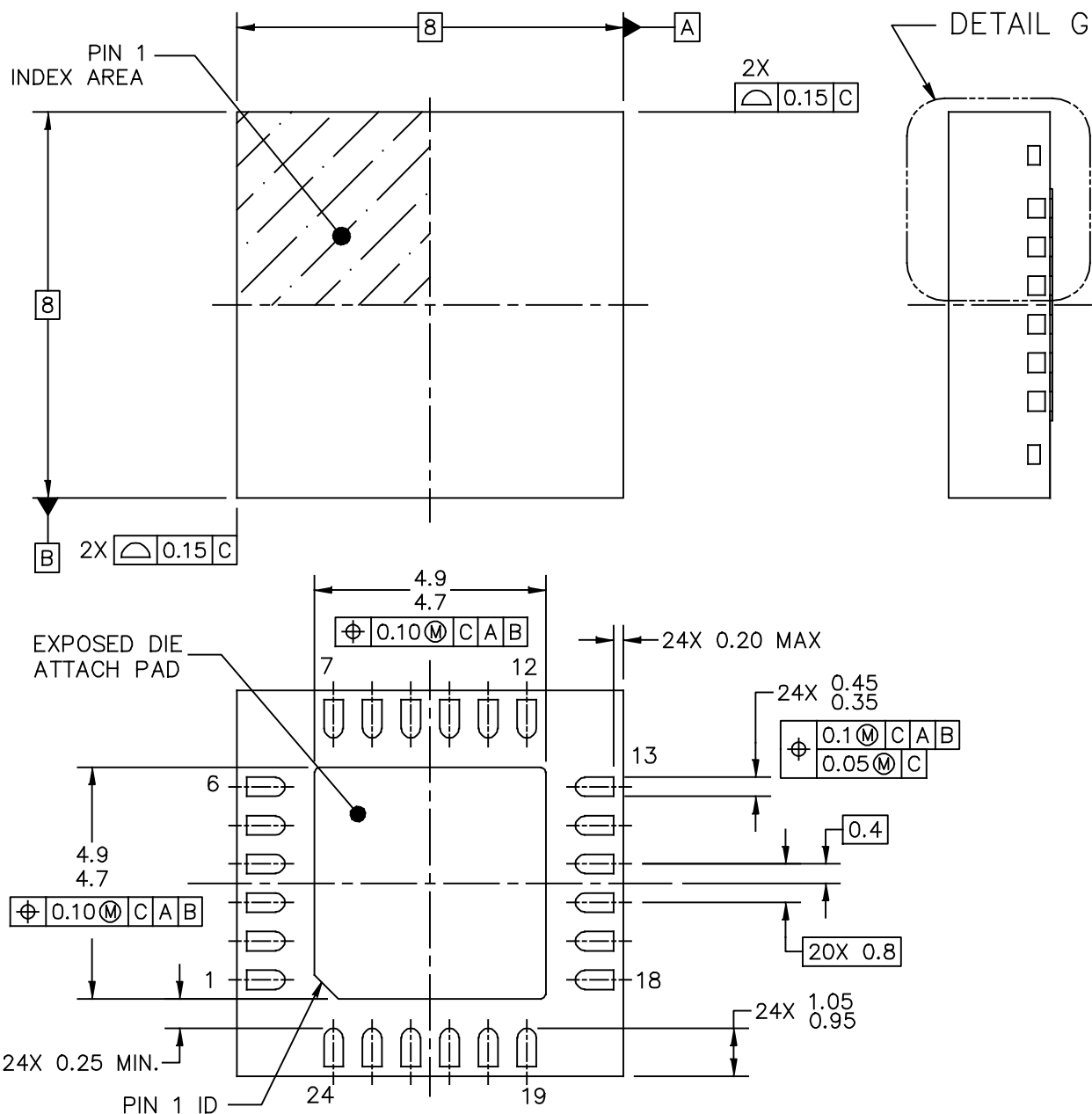


Figure 10. PCB Pad Layout for 24-Lead PQFN 8 × 8

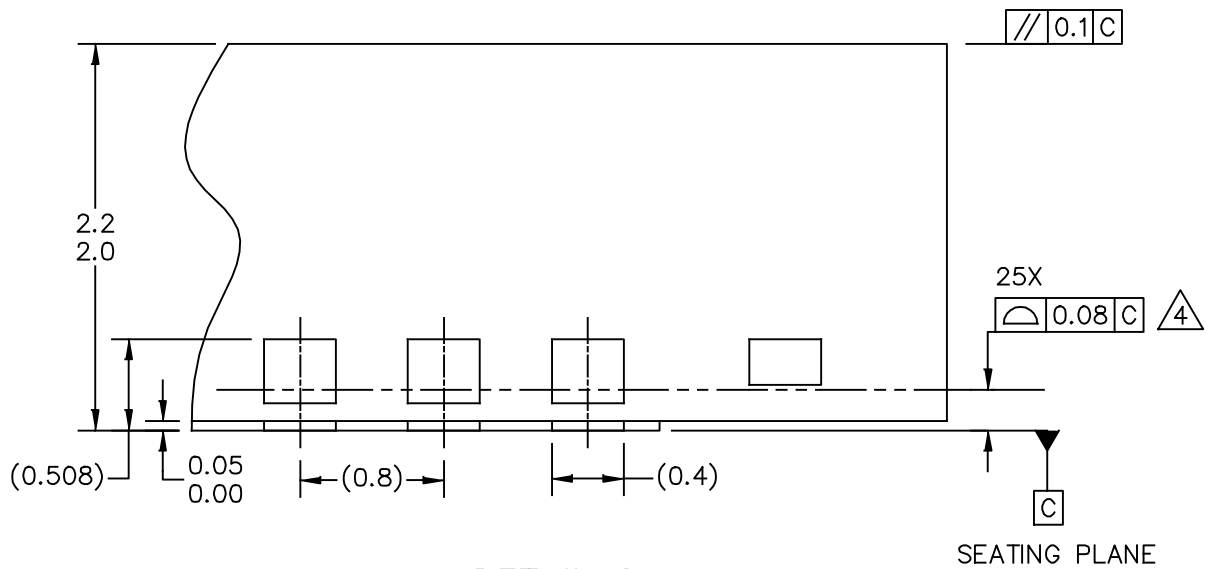


Figure 11. Product Marking

**PACKAGE DIMENSIONS**



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TITLE: PQFN (SAW), THERMALLY ENHANCED 8 X 8 X 2.1, 0.8 PITCH, 24 TERMINAL	DOCUMENT NO: 98ASA10760D	REV: B
	STANDARD: NON-JEDEC	
	SOT1664-1	11 MAR 2016



DETAIL G  
 VIEW ROTATED 90° CW

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	STANDARD: NON-JEDEC	
	SOT1664-1	11 MAR 2016

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. THE COMPLETE JEDEC DESIGNATOR FOR THIS PACKAGE IS: HF-PQFN.

4. COPLANARITY APPLIES TO LEADS AND DIE ATTACH PAD.

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		STANDARD: NON-JEDEC	
		SOT1664-1	11 MAR 2016

## PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

Refer to the resources to aid your design process.

### Application Notes

- AN1907: Solder Reflow Attach Method for High Power RF Devices in Over-Molded Plastic Packages
- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

### Software

- Electromigration MTTF Calculator
- RF High Power Model

### Development Tools

- Printed Circuit Boards

### To Download Resources Specific to a Given Part Number:

1. Go to <http://www.nxp.com/RF>
2. Search by part number
3. Click part number link
4. Choose the desired resource from the drop down menu

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	July 2018	<ul style="list-style-type: none"><li>• Initial release of data sheet</li></ul>