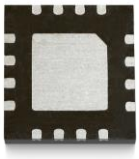
DATA SHEET

RELEASE Ø DATA SHEET



GRF5616

3.5 Watt Power Amplifier 1625 to 1675 MHz

FEATURES

- Flexible Biasing Provides Latitude for Linearity Optimization
- 285 mA Native Mode Quiescent Current Consumption
- 5 V Supply Voltage
- 50 Ω Single-ended Input and Output Impedances
- Digital Shutdown
- Rugged Design is Extremely Resilient to Mismatched Loads
- -40 to 85 °C Operating Temperature Range
- Compact 3 x 3 mm QFN-16 Package

Reference: 5 V / 285 mA I_{CCQ} / 1650 MHz

- Gain: 23.9 dB
- OP1dB: 35.6 dBm
- Evaluation Board Noise Figure: 3.6 dB

APPLICATIONS

- Military Radio
- Drones
- Customer Premise Equipment

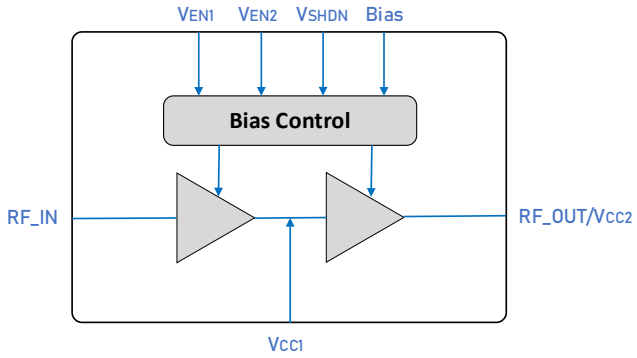
DESCRIPTION

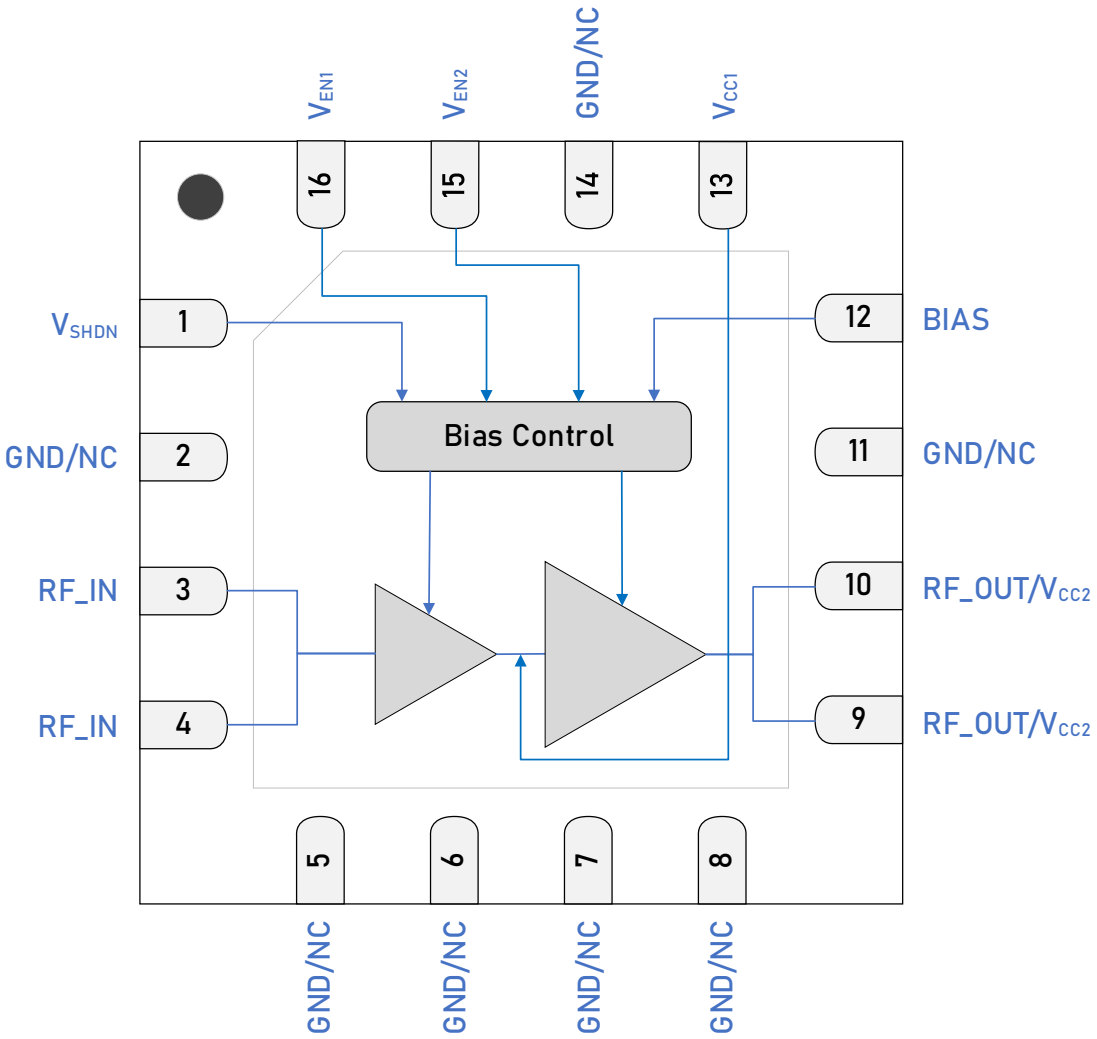
The GRF5616 is a high gain, two-stage InGaP HBT Power Amplifier designed to deliver high power over the 1625 to 1675 MHz band.

Please consult with the GRF applications engineering team for custom tuning/evaluation board data.

Additional tunes can be found on the GRF5616 "Custom Tunes" product page: GRF5616 Custom Tunes

BLOCK DIAGRAM





3 x 3 mm QFN-16 Pin Out (Top View)

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Pin Assignments

Pin	Name	Description	Note
1	V_{SHDN}	Digital Shutdown Pin	$V_{SHDN} \geq 1.8$ V (Logic HIGH) disables device. $V_{SHDN} \leq 0.8$ V (Logic LOW) enables device.
2, 5, 6, 7, 8, 11, 14	GND/NC	Ground or No Connect	No internal connection to die. These pins can be left unconnected, or be connected to ground (recommended). Use a via as close to the pin as possible if grounded.
3, 4	RF_IN	RF Input	Pins 3 & 4 tied together on system board. An external DC blocking cap must be used.
9, 10	RF_OUT/V_{CC2}	PA Output/Bias Voltage	Pins 9 & 10 tied together on system board. V_{CC2} must be applied to this pin via RF choke.
12	Bias	Bias Circuit Supply	Connect to V_{CC2} through external resistor.
13	V_{CC1}	Bias Voltage	Connect to V_{CC2} through ferrite or inductor for isolation. Capacitive tuning termination placed at device pin (see application schematic).
15	V_{EN2}	Enable2 Voltage Input	V_{EN2} and series resistor set I_{CCQ} for the output stage. $V_{EN2} \leq 0.2$ volts disables stage 2.
16	V_{EN1}	Enable1 Voltage Input	V_{EN1} and series resistor set I_{CCQ} for the input stage. $V_{EN1} \leq 0.2$ volts disables stage 1.
PKG BASE	GND	Ground	Provides DC and RF ground for the amplifier, as well as thermal heat sink. Recommend multiple 8 mil vias beneath the package for optimal RF and thermal performance. Refer to evaluation board top layer graphic on schematic page.

Truth Table

Pin	Logic	Condition
V_{SHDN}	LOW	Full Operation
	HIGH	All Amplifiers Off
V_{EN1}	LOW	Stage 1 Amplifier Off
	HIGH	Stage 1 Amplifier On
V_{EN2}	LOW	Stage 2 Amplifier Off
	HIGH	Stage 2 Amplifier On

Absolute Ratings

Parameter		Symbol	Min.	Max.	Unit
Supply Voltage		V_{CC}	3.0	5.25	V
RF Input Power	50 Ω, V_{CC} = 5 V, CW Tone, 100% Duty Cycle, $T_{PKG\ BASE}$ = 25 °C.	$P_{IN\ MAX-1:1}$		20	dBm
	Load VSWR ≤ 8:1, all phase angles, V_{CC} = 5 V, CW Tone, 100% Duty Cycle, $T_{PKG\ BASE}$ = -40 to 85 °C.	$P_{IN\ MAX-8:1}$		13	
Operating Temperature (package base).		$T_{PKG\ BASE}$	-40	85	°C
Maximum Junction Temperature (MTTF >10^6 Hours).		$T_{J\ MAX}$		190	°C
Maximum Dissipated Power: Stage 1. DC only (no RF applied).		$P_{DISS\ MAX}$		750	mW
Maximum Dissipated Power: Stage 2. DC only (no RF applied).		$P_{DISS\ MAX}$		1350	mW
Shutdown Voltage		V_{SHDN}		* 5.25	V

Electrostatic Discharge

Human Body Model		HBM	750		V

Storage

Storage Temperature		T_{STG}	-65	150	°C
Moisture Sensitivity Level		MSL		1	--

* M4 = 0 Ω. V_{SHDN} = 5.25 V yields I_{SHDN} = 540 µA. I_{SHDN} decreases linearly vs V_{SHDN} (to 68 µA with V_{SHDN} = 1.8 V).
Said linear relationship can be used to scale M4 for higher V_{SHDN} voltage: use the pin condition V_{SHDN}_pin/I_{SHDN} = 2.4V/147µA. Calculate M4 for V_{SHDN}/I_{SHDN} = 5V/147µA: M4 = (5–2.4)/(0.000147) = 17.7 kΩ.

Caution! ESD Sensitive Device.
Exceeding Absolute Maximum Rating conditions may cause permanent damage.

Note: For additional information, please refer to *Manufacturing Note MN-001 — Package and Manufacturing Information.*

All Guerrilla RF products are provided in RoHS compliant lead (Pb)-free packaging requiring no exemptions . Additional information for this topic can be found at this link - *Environmental and Restricted Substance Statement Library*

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Recommended Operating Conditions

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Voltage	V_{CC}	3.0	5	5.25	V	
Operating Temperature (package base)	$T_{PKG\ BASE}$	-40		85	°C	
RF Frequency Range	F_{RF}	1625		1675	MHz	Typical application schematic using the 1625 to 1675 MHz tuning set (**notes 1 & 2**).
RF_IN Port Impedance	Z_{RFIN}		50		Ω	Single-ended with 3-element match.
RF_OUT Port Impedance	Z_{RFOUT}		50		Ω	Single-ended with 3-element match.

Note 1: Operation outside of this range is supported by using different custom tunes. Examples of other optimized tunes can be found here: GRF5616 Custom Tunes

Note 2: Contact the Guerrilla RF applications team for guidance on optimizing the tuning of the device for alternative bands.

Nominal Operating Parameters – General

The following conditions apply unless noted otherwise: typical application schematic using the 1625 to 1675 MHz tuning set. $V_{CC}/V_{EN1}/V_{EN2}$/ = 5 V, V_{SHDN} = LOW, I_{CCQ} = 285 mA, F_{TEST} = 1650 MHz, M5 = 15 kΩ, M9 = 6.34 kΩ, 50 Ω system impedance, $T_{PKG\ BASE}$ = 25 °C. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Quiescent Current	I_{CCQ}		285		mA	I_{CCQ1} + I_{CCQ2}. No RF Applied.
Enable Current 1	$I_{ENABLE1}$		0.17		mA	$V_{CC}/V_{EN1}/V_{EN2}$ = 5 V, V_{SHDN} = 0 V.
Enable Current 2	$I_{ENABLE2}$		0.39		mA	$V_{CC}/V_{EN1}/V_{EN2}$ = 5 V, V_{SHDN} = 0 V.
Operating Temperature Range	$T_{PKG\ BASE}$	-40		+85	°C	Measured on package base.
Logic Input Low	V_{IL}	0		0.8	V	Applies to V_{SHDN} input.
Logic Input High	V_{IH}	1.8		V_{CC}	V	Applies to V_{SHDN} input.
Logic Current Low	I_{IL}		1.3		nA	Applies to V_{SHDN} input, V_{IL} = 0.8 V.
Logic Current High	I_{IH}		68		µA	Applies to V_{SHDN} input, V_{IH} = 1.8 V.
			260			Applies to V_{SHDN} input, V_{IH} = 3.3 V.
Switching Rise Time	T_{RISE}		50		ns	Applies to V_{SHDN} input.
Switching Fall Time	T_{FALL}		50		ns	Applies to V_{SHDN} input.

Disabled Mode

Supply Quiescent Current	$I_{CCQ-SHDN}$		8		µA	V_{CC} = 5 V, $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH.
Enable Current 1	$I_{ENABLE1-SHDN}$		0.3		mA	V_{CC} = 5 V, $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH.
Enable Current 2	$I_{ENABLE2-SHDN}$		0.7		mA	V_{CC} = 5 V, $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH.

Thermal Data (Stage 1 and Stage 2)

Stage 1: Thermal Resistance (Infrared Scan). DC only (no RF applied).	Θ_{JC}		115		°C/W	
Stage 2: Thermal Resistance (Infrared Scan). DC only (no RF applied).	Θ_{JC}		30		°C/W	
See plot of Die Temp vs. Output Power.	T_J				°C	On standard evaluation board **(note 3)**.

Note 3: MTTF >10^6 hours for T_J ≤190 °C.

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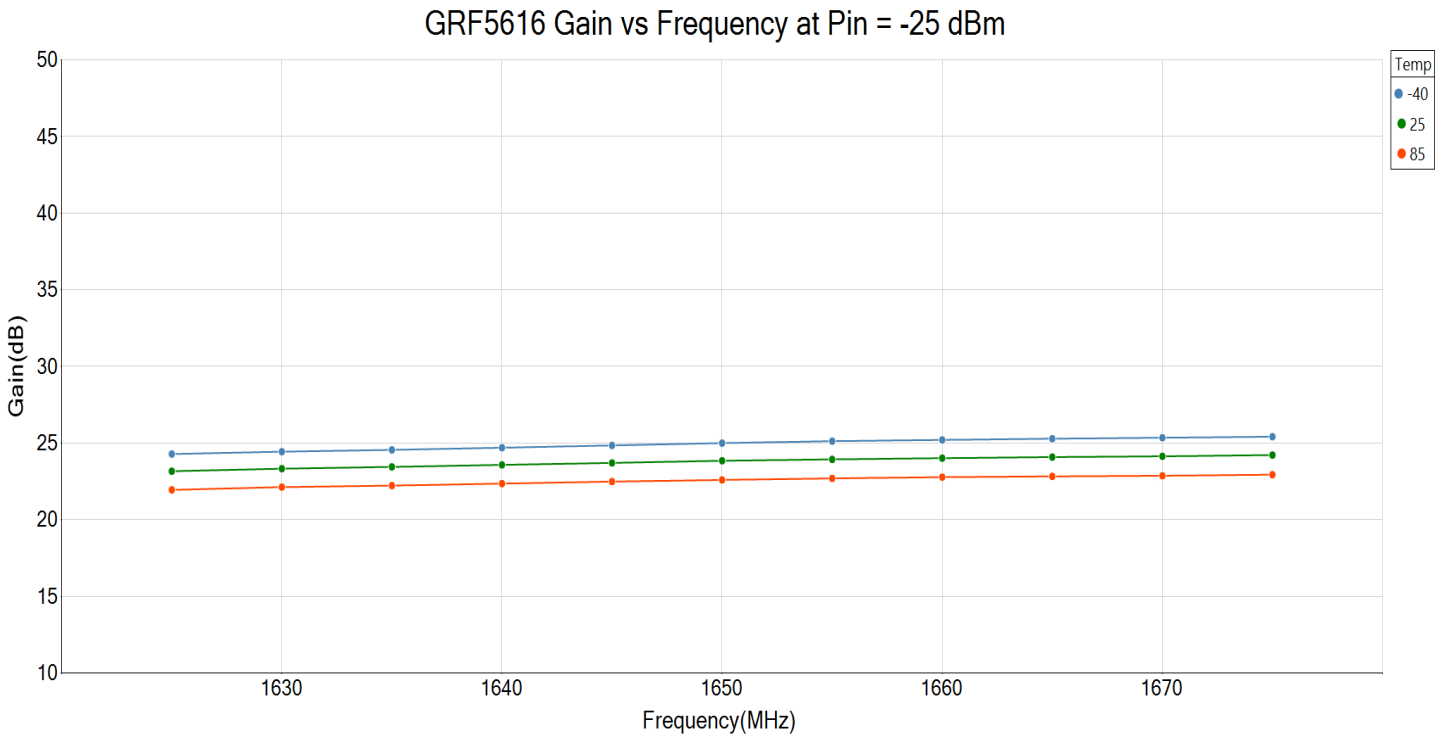
Nominal Operating Parameters – RF: 1625 to 1675 MHz

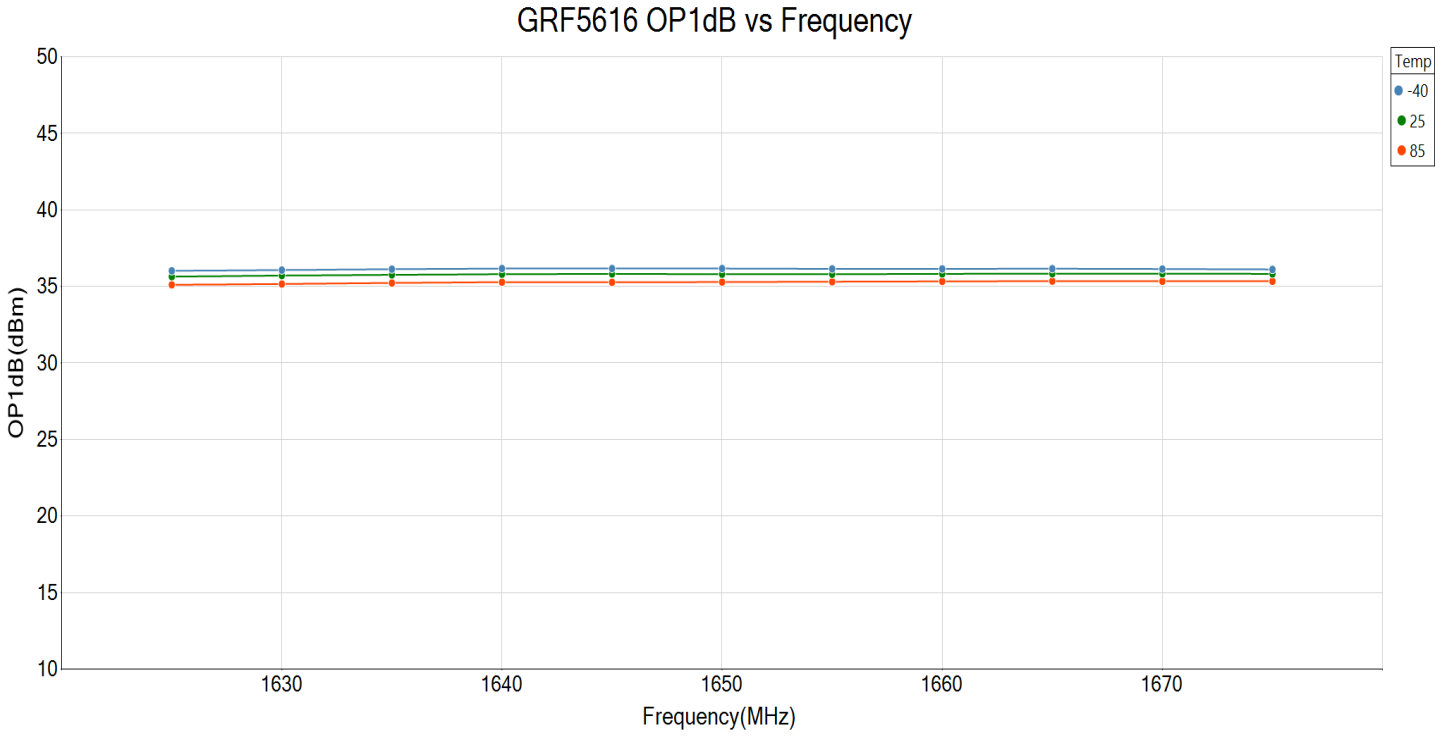
The following conditions apply unless noted otherwise: typical application schematic using the 1625 to 1675 MHz tuning set. $V_{CC}/V_{EN1}/V_{EN2}/$ = 5 V, V_{SHDN} = LOW, I_{CCQ} = 285 mA, F_{TEST} = 1650 MHz, M5 = 15 kΩ, M9 = 6.34 kΩ, 50 Ω system impedance, $T_{PKG\ BASE}$ = 25 °C. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Small Signal Gain	S21		23.9		dB	V_{CC} = 5 V, P_{IN} = -25 dBm, F_{TEST} = 1650 MHz.
Standby Mode Gain	$S21_{STBY}$		-24		dB	Disabled mode, $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH, P_{IN} = 0 dBm.
Input Return Loss	S11		< -9.5		dB	F_{RF} = 1625 to 1675 MHz.
Output Return Loss	S22		< -7.5		dB	F_{RF} = 1625 to 1675 MHz.
Reverse Isolation	S12		< -45		dB	F_{RF} = 1625 to 1675 MHz.
Noise Figure	NF		3.6		dB	On standard evaluation board.
Output 1 dB Compression Power	OP1dB		35.6		dBm	V_{CC} = 5 V, Sinewave input.

Note 4: MIN/MAX limits defined using *modelled estimates* that account for part-to-part variations and expected process spreads. As additional production lots are fabricated, accumulated test data will be used to refine the MIN/MAX limits.

GRF5616 Typical Operating Curves: 1625 to 1675 MHz Tune





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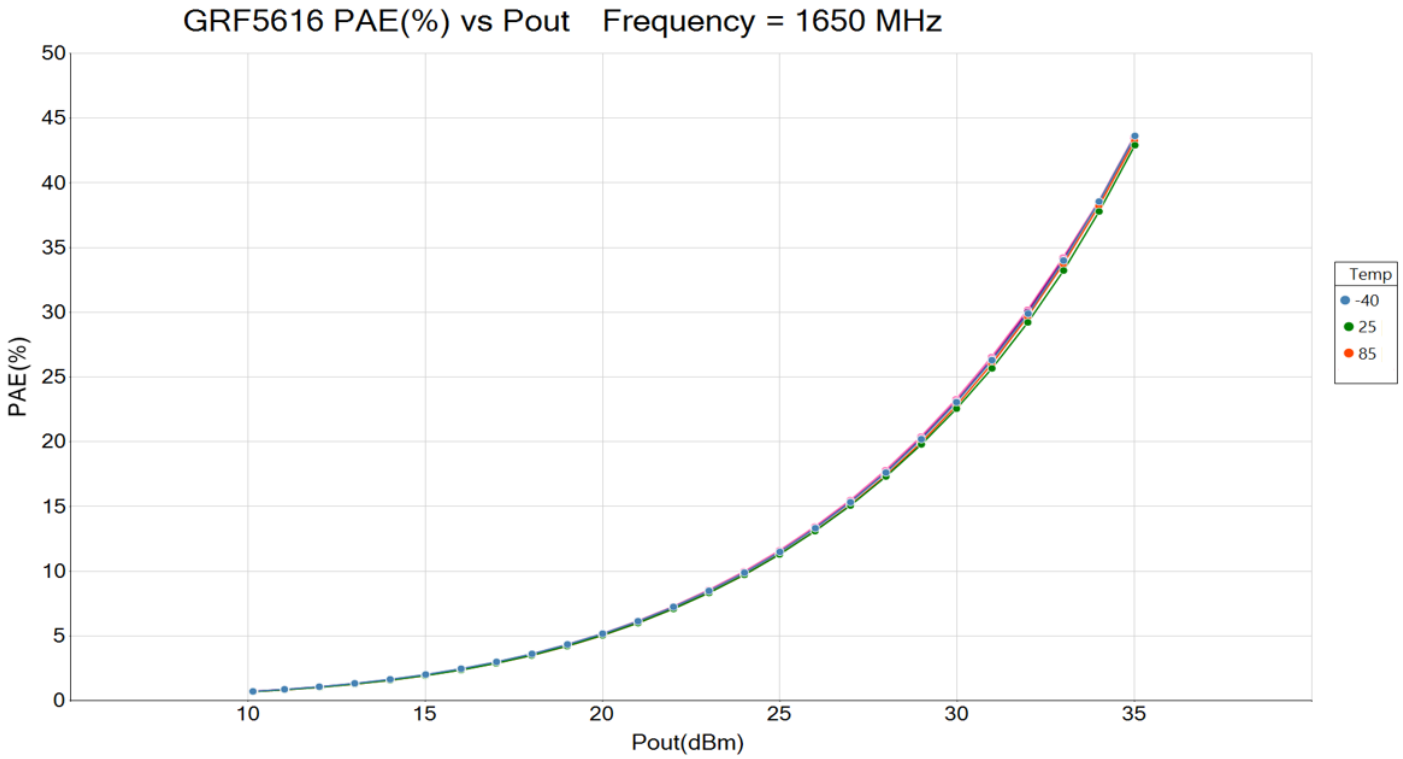
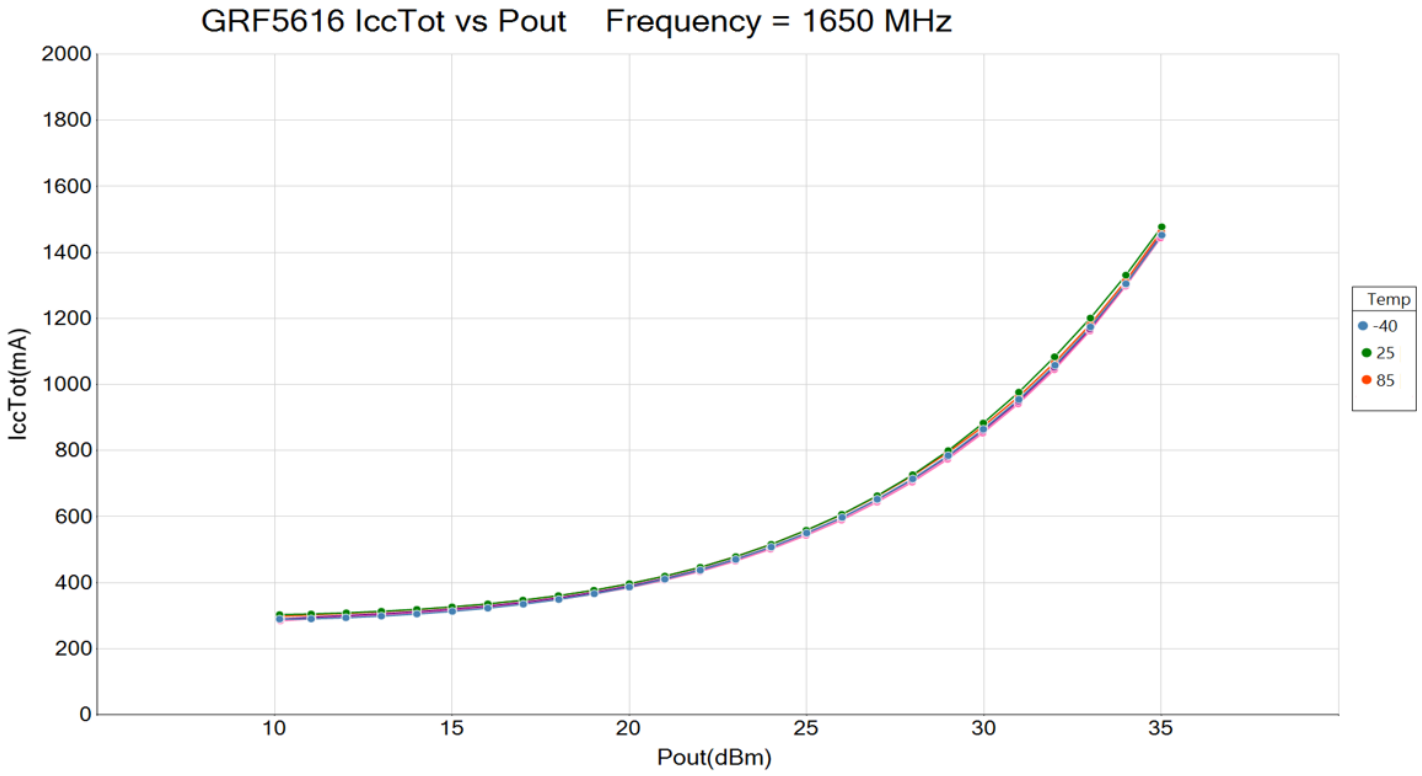
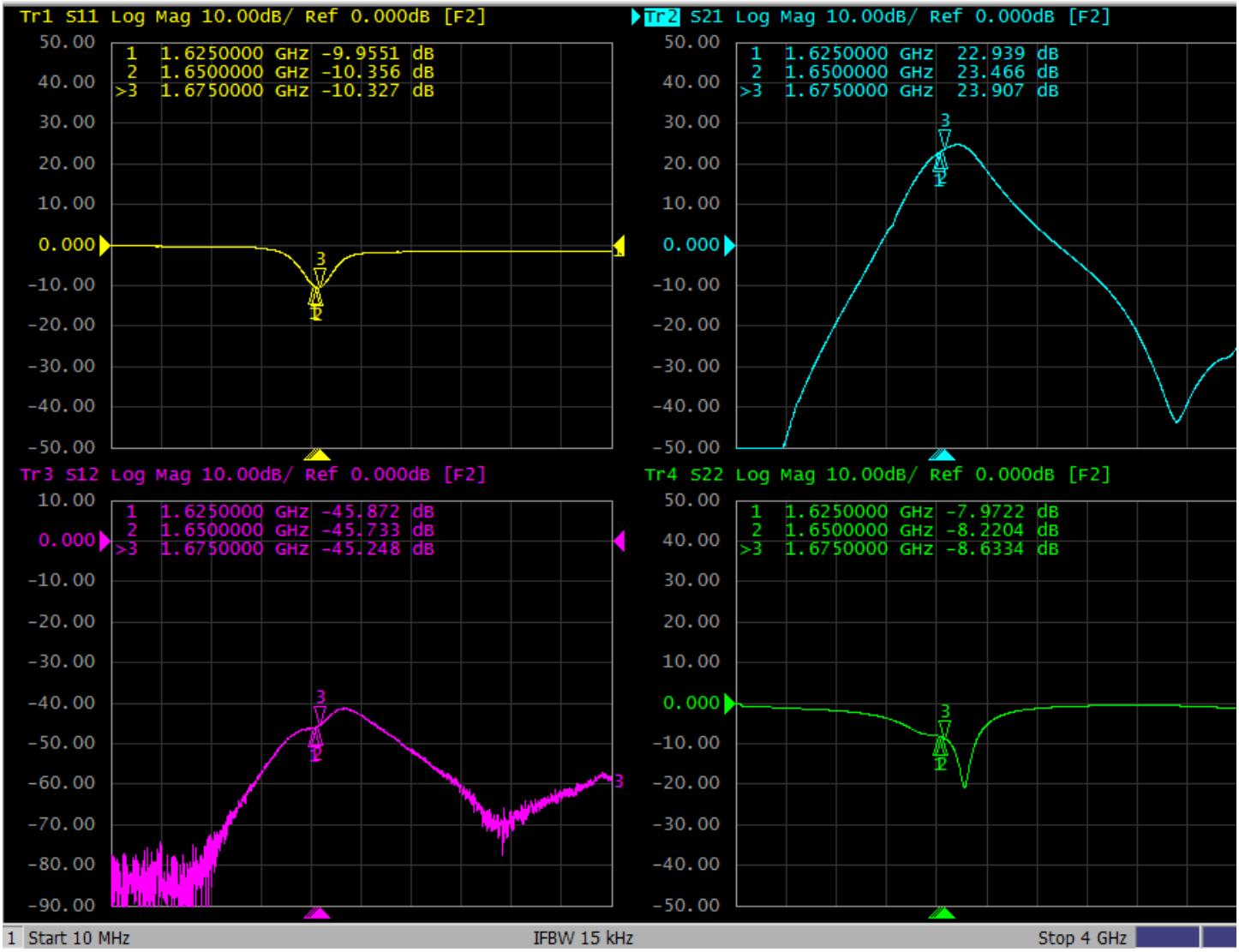
GRF5616 Typical Operating Curves: 1625 to 1675 MHz Tune





GRF5616 Typical Operating Curves: S-Parameters (1625 to 1675 MHz Tune)



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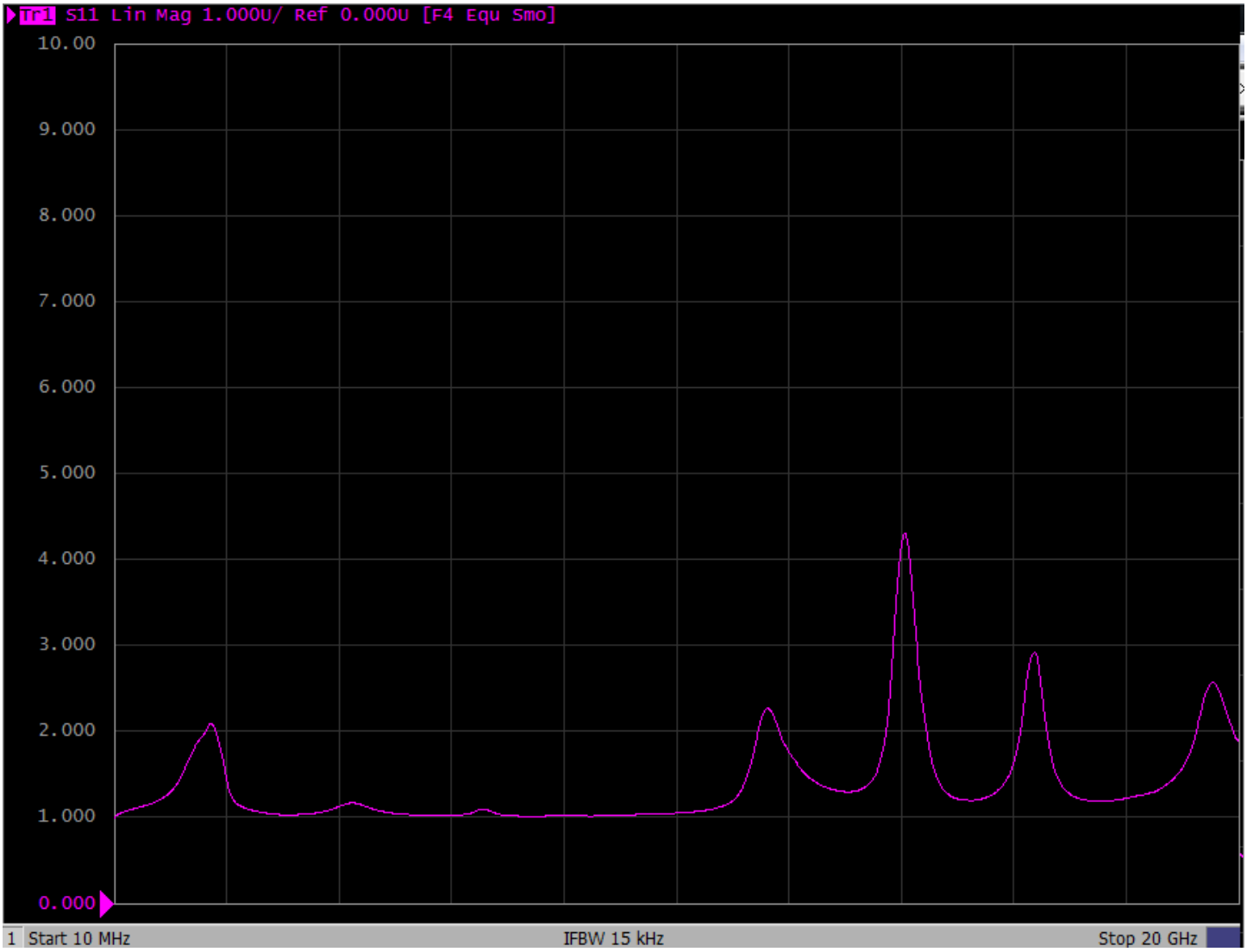
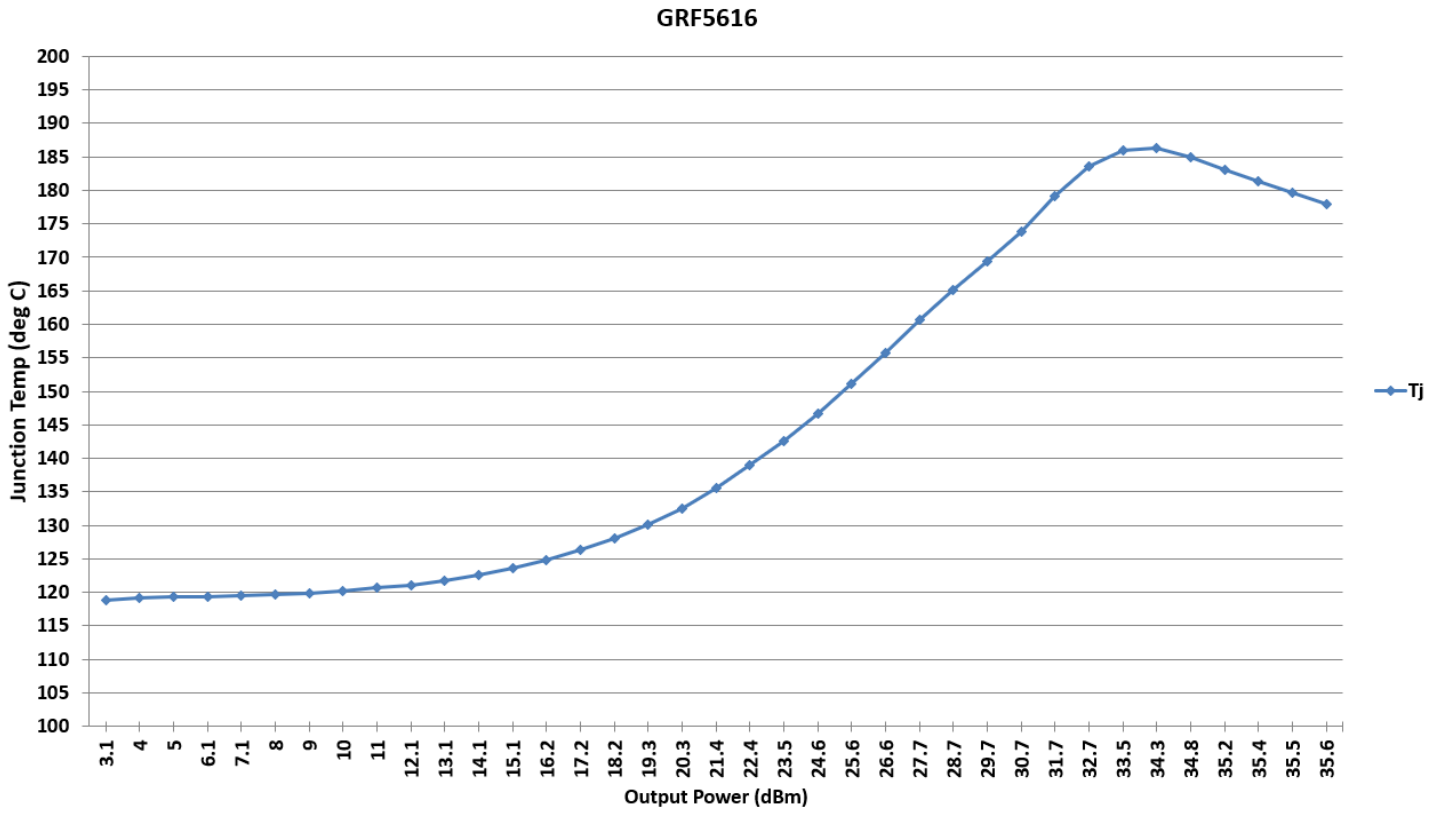
GRF5616 Typical Operating Curves: Stability Mu (10 MHz to 20 GHz)



Note: Mu factor ≥ 1.0 implies unconditional stability (small signal).

GRF5616 Typical Operating Curves: Junction Temperature (per application schematic @ 85 °C)

GRF5616, being a 2-stage device, sees one of the stages governing junction temperature over power sweep. Stage 2 governs TJ (Q2 TJ is higher). Setting bias resistors M5/M9 per application schematic yields thermal performance shown in the plot.



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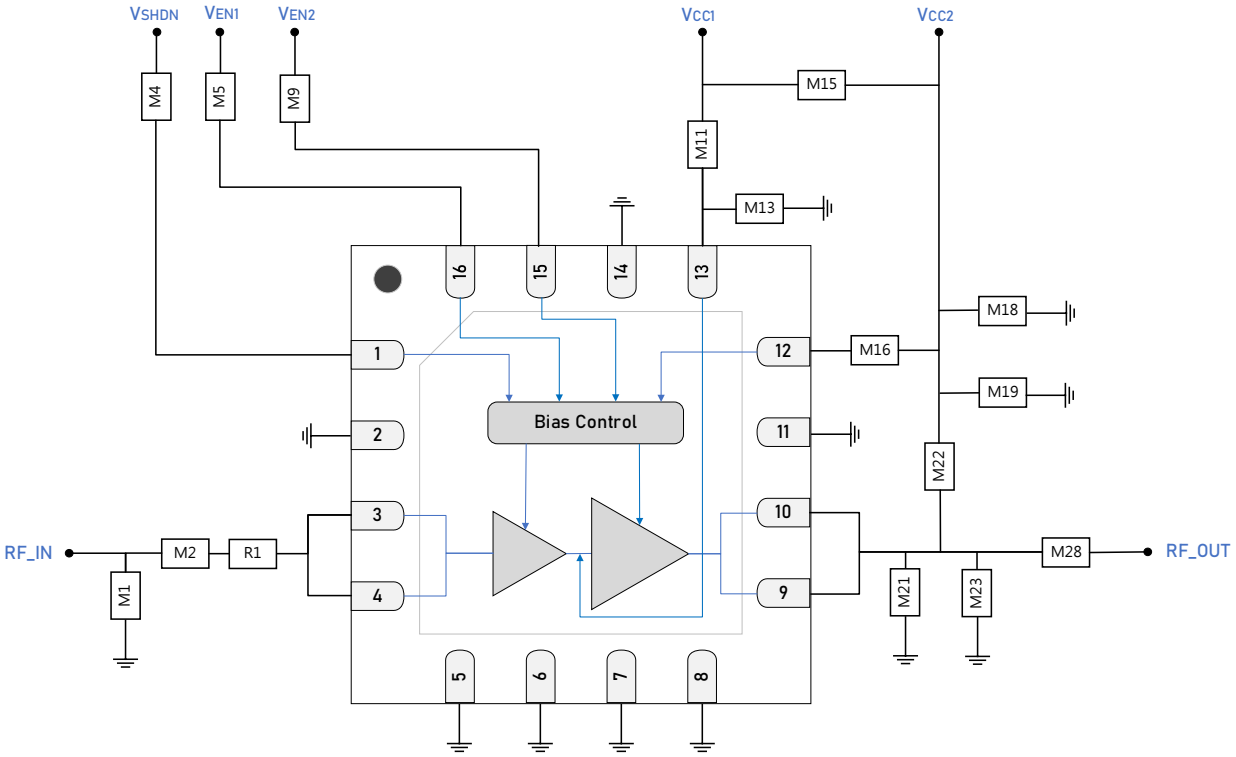
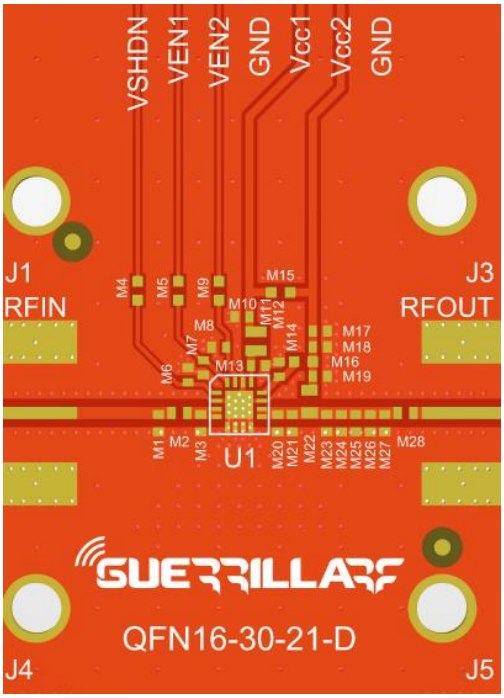


GRF5616 Standard Evaluation Board Schematic



GRF5616 Evaluation Board Assembly Diagram

GRF5616 Evaluation Board Assembly Diagram Reference

Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1	Inductor	Murata	LQG	2.0 nH	0402	ok
M2	Capacitor	Murata	GJM	2.7 pF	0402	ok
MX	Resistor	Various	1%	2 Ω	0402	ok
M4	Resistor	Various	--	0 Ω	0402	ok
M5	Resistor	Various	1%	15 kΩ	0402	ok
M9	Resistor	Various	1%	6.34 kΩ	0402	ok
M11	Resistor	Various	--	0 Ω	0402	ok
M13	Capacitor	Murata	GRM	0.1 µF	0402	ok
M15	Resistor (jumper)	Various	--	0 Ω	0402	ok
M16	Resistor	Various	--	0 Ω	0402	ok
M18	Capacitor	Murata	**GRM	10 µF	0402	ok
M19	Capacitor	Murata	GRM	100 pF	0402	ok
M21	Capacitor	Murata	GJM	5.1 pF	0404	ok
M22	Inductor	Coilcraft	0807SQ	14 nH	0807	ok
M23	Capacitor	Murata	GJM	1.5 pF	0404	ok
M28	Capacitor	Murata	GJM	22 pF	0402	ok
Evaluation Board	QFN16-30-21-D					

Note: Standard evaluation board bias: V_{CC} = 5 V, V_{ENABLE} = 5 V.

** 10 µF must be rated for > 5 V at maximum ambient temperature. Manufacturer Part Number in this case = GRM155C80J106ME11D.

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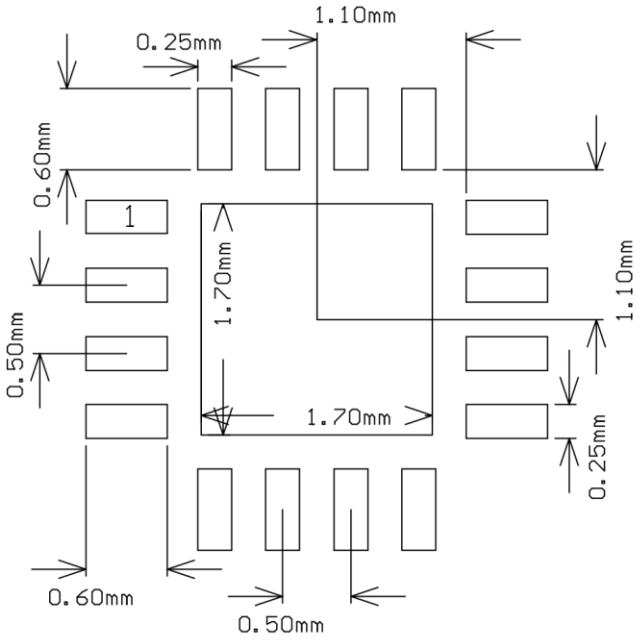
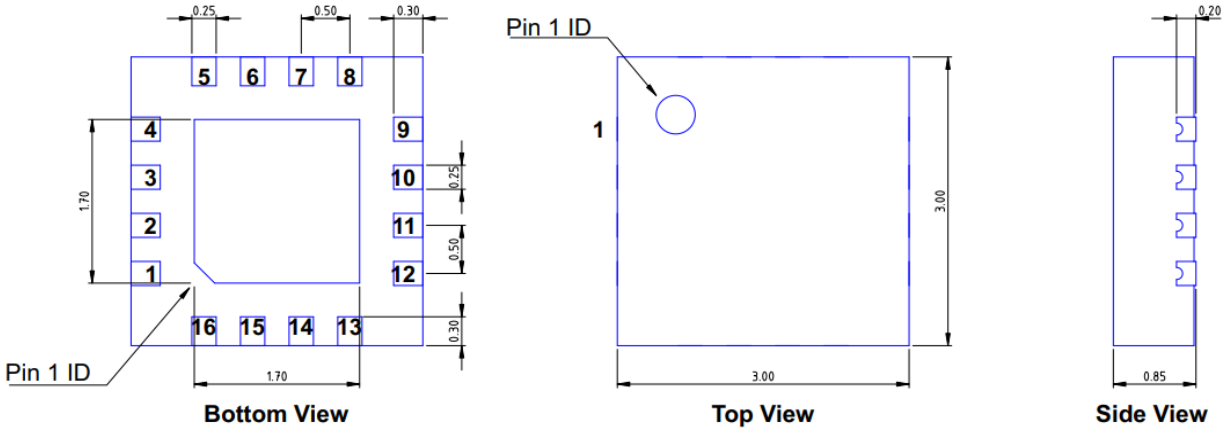


3 x 3 mm QFN-16 Suggested PCB Footprint (Top View)



QFN16 3x3mm

Dimensions in millimeters
Dimensional Tolerance: ±0.05

3 x 3 mm QFN-16 Package Dimensions

Package Marking Diagram

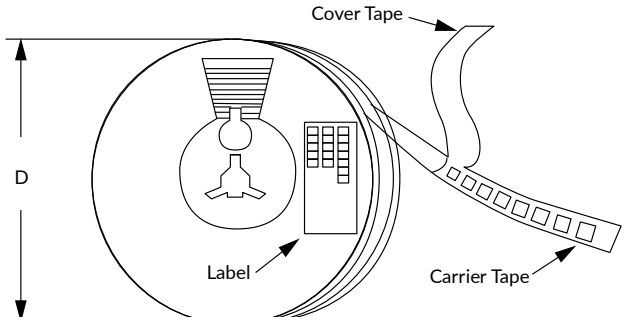
- Line 1: "YY" = YEAR. "WW" = WORK WEEK the device was assembled.
- Line 2: "GRF" = Guerrilla RF.
- Line 3: "XXXX" = Device PART NUMBER.

Tape and Reel Information

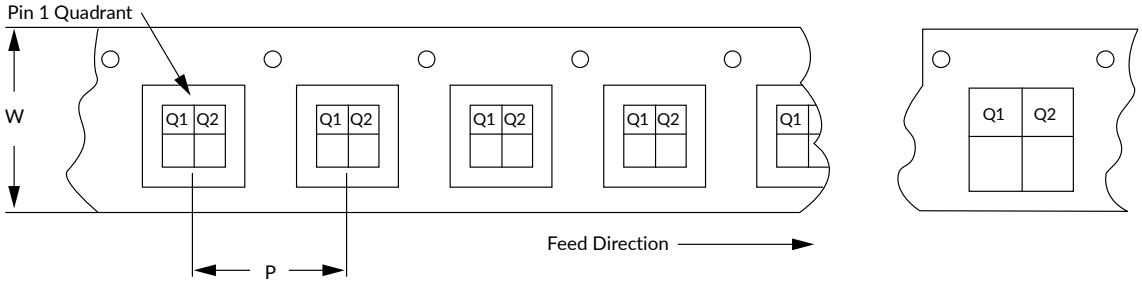
Guerrilla RF's tape and reel specification complies with Electronic Industries Alliance (EIA) standards for "Embossed Carrier Tape of Surface Mount Components for Automatic Handling" (reference EIA-481). See the following page for the Tape and Reel Specification and Device Package Information table, which includes units per reel.

Devices are loaded with pins down into the carrier pocket with protective cover tape and reeled onto a plastic reel. Each reel is packaged in a cardboard box. There are product labels on the reel, the protective ESD bag and the outside surface of the box.

For the Tape and Reel Reference Table, please refer to: *https://www.guerrilla-rf.com/prodFiles/Manufacturing/MN001.pdf*



Tape and Reel Packaging with Reel Diameter Noted (D)



Carrier Tape Width (W), Pitch (P), Feed Direction and Pin 1 Quadrant Information

Revision History

Revision Date	Description of Change
January 14, 2022	Preliminary Data Sheet.
April 11, 2022	Updated maximum junction temperature.
April 10, 2024	Updated specifications, plots and block diagram.
May 17, 2024	Release Ø Data Sheet.
February 6, 2025	Upgraded Data Sheet with minor cosmetic changes only. No change to device or device specifications.

Data Sheet Classifications

Data Sheet Status	Notes
Advance	S-parameter and NF data based on EM simulations for the fully packaged device using foundry-supplied transistor S-parameters. Linearity estimates based on device size, bias condition and experience with related devices.
Preliminary	All data based on limited evaluation board measurements taken within the Guerrilla RF Applications Lab. All parametric values are subject to change pending the collection of additional data.
Release Ø	All data based on measurements taken with *production-released* material. TYP values are based on a combination of ATE and bench-level measurements, with MIN/MAX limits defined using *modelled estimates* that account for part-to-part variations and expected process spreads. Although unlikely, future refinements to the TYP/MIN/MAX values may be in order as multiple lots are processed through the factory.
Release A-Z	All data based on measurements taken with production-released material *derived from multiple lots which have been fabricated over an extended period of time.* MIN/MAX limits may be refined over previous releases as more statistically significant data is collected to account for process spreads.