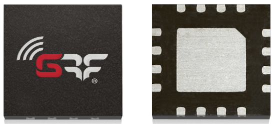
DATA SHEET



GRF5613

RELEASE Ø DATA SHEET

3.5 Watt Power Amplifier
1350 to 1627 MHz

FEATURES

- Flexible Biasing Provides Latitude for Linearity Optimization
- 185 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
- RoHS Compliant

Reference: 5 V / 185 mA I_{CCQ} / 1400 MHz

- Gain: 24.5 dB
- OP1dB: 35.4 dBm
- Evaluation Board Noise Figure: 3.5 dB

APPLICATIONS

- Customer Premise Equipment
- Military Radio
- Drones

ORDERING INFORMATION

Buy it Now

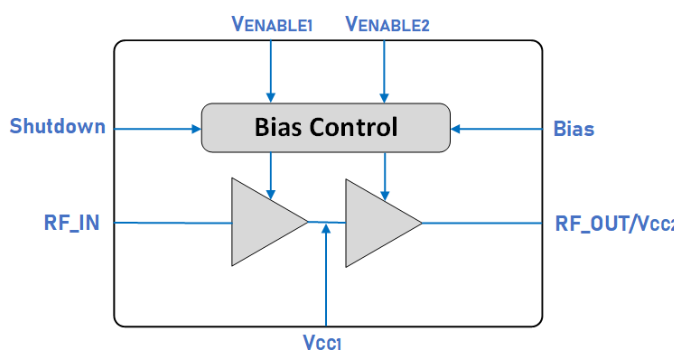
DESCRIPTION

The GRF5613 is a high gain, 2-stage InGaP HBT Power Amplifier designed to deliver 35.4 dBm output power at P1dB over the 1350 to 1627 MHz band.

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

Additional tunes can be found on the GRF5613 “Custom Tunes” product page: GRF5613 Custom Tunes

BLOCK DIAGRAM



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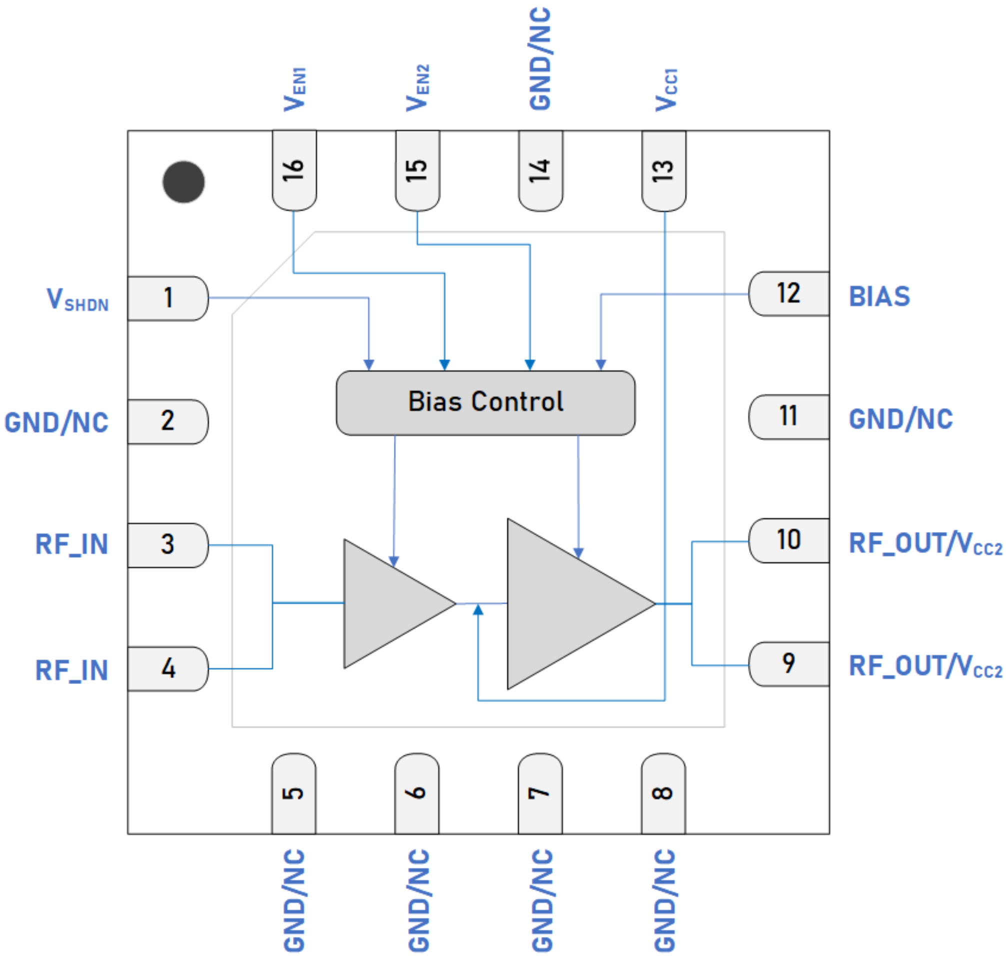


Pin Out (Top View)

Pin Assignments

Pin	Name	Description	Note
1	V_{SHDN}	Digital Shutdown	V_{SHDN} ≥ 1.8 V (Logic HIGH) disables device. V_{SHDN} ≤ 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 and 4 tied together on system board. An external DC blocking capacitor must be used.
9, 10	RF_OUT/V_{CC2}	PA Output/Bias Voltage	Pins 9 and 10 tied together on system board. V_{CC2} must be applied to this pin via an RF choke.
12	Bias	Bias Circuit Supply	Connect to V_{CC2} through external resistor.
13	V_{CC1}	Bias Voltage	Connect to V_{CC1} through external inductor or 0 Ω resistor.
15	V_{EN2}	Enable2 Voltage Input	V_{EN2} and series resistor set I_{CCQ} for the output stage. V_{EN2} ≤ 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} ≤ 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.

Absolute Ratings

Parameter	Symbol	Min.	Max.	Unit
Supply Voltage	V_{CC}	3	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
RF Input Power: 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		10	dBm
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	TSTG	-65	150	°C
Moisture Sensitivity Level	MSL		1	--

* M4 = 0 Ω. V_{SHDN} = 5.25 V yields I_{SHDN} = 540 µA. I_{SHDN} decreases linearity vs. V_{SHDN} (to 65 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} = 2.4 V/ 147 µA. Calculate M4 for V_{SHDN}/I_{SHDN} = 5 V/ 147 µA: 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 - Packaging and Manufacturing Information.

All Guerrilla RF products are provided in RoHS compliant lead (Pb)-free packaging. For additional information, please refer to the Certificate of RoHS Compliance.

Recommended Operating Conditions

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Voltage	V_{CC}	3	5	5.25	V	
Operating Temperature Range	$T_{PKG\ BASE}$	-40		85	°C	
RF Frequency Range	F_{RF}	1350	1400	1450	MHz	Typical application schematic using the 1350 to 1450 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: GRF5613 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

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Quiescent Current	I_{CCQ}		185		mA	I_{CCQ1} + I_{CCQ2}. No RF applied.
Enable Current 1	$I_{ENABLE1}$		0.2			$V_{CC}/V_{EN1}/V_{EN2}$ = 5 V. V_{SHDN} = 0 V.
Enable Current 2	$I_{ENABLE2}$		0.3			$V_{CC}/V_{EN1}/V_{EN2}$ = 5 V. V_{SHDN} = 0 V.
Operating Temperature Range	$T_{PKG\ BASE}$	-40		85		Measured on package base.
Logic Input Low	V_{IL}	0		0.8		Applies to V_{SHDN} Input.
Logic Input High	V_{IH}	1.8		V_{CC}		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}		65		µA	Applies to V_{SHDN} Input. V_{IH} = 1.8 V.
			285			Applies to V_{SHDN} Input. V_{IH} = 3.3 V.
Switching Rise Time	T_{RISE}		30		ns	Applies to V_{SHDN} Input.
Switching Fall Time	T_{FALL}		30		ns	Applied to V_{SHDN} Input.

Disabled Mode

Supply Quiescent Current	$I_{CCQ\ SHDN}$		10		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	$I_{ENABLE2\ SHDN}$		0.5		mA	V_{CC} = 5 V. $V_{SHDN}/V_{EN1}/V_{EN2}$ = High.

Thermal Data

Stage 1: Thermal Resistance (Infrared Scan). DC only, no RF applied.	Θ_{JC}		60		°C/W	On standard evaluation board.
Stage 2: Thermal Resistance (Infrared Scan). DC only, no RF applied.	Θ_{JC}		28		°C/W	On standard evaluation board.
Thermal Data Stage 1 and 2: see plot of junction temp vs. Output Power.	T_J				°C	V_{CC} = V_{EN1} = V_{EN2} = 5 V. On standard evaluation board **(note 3)**.

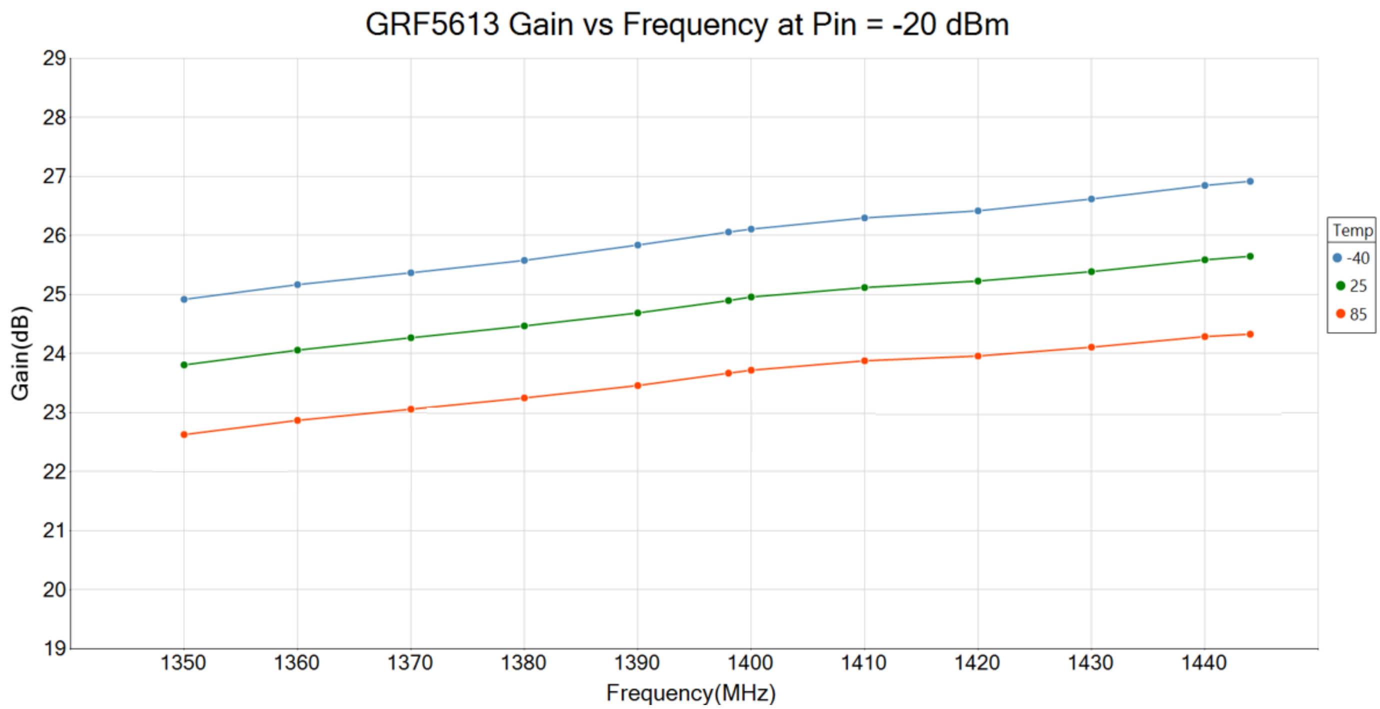
Note 3: MTTF > 10^6 hours for $T_j \leq 190$ °C

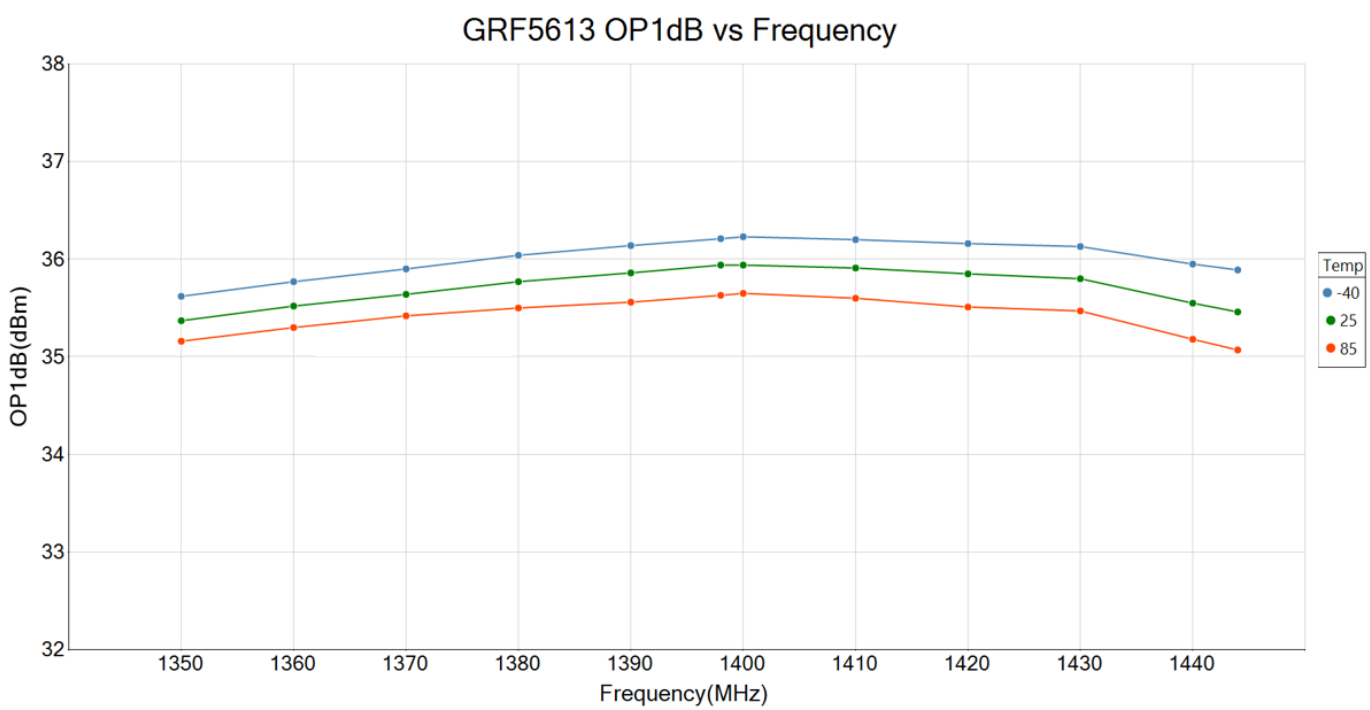
Nominal Operating Parameters - RF

The following conditions apply unless noted otherwise; typical application schematic, V_{CC} = 5 V, V_{SHDN} = Low, I_{CCQ} = 185 mA, F_{RF} = 1350 - 1450 MHz, M5 = 15 kΩ, M9 = 10.2 kΩ, F_{TEST} = 1400 MHz, 50 Ω system impedance, $T_{PKG\ BASE}$ = 25 °C. Evaluation board losses are included within the specifications.

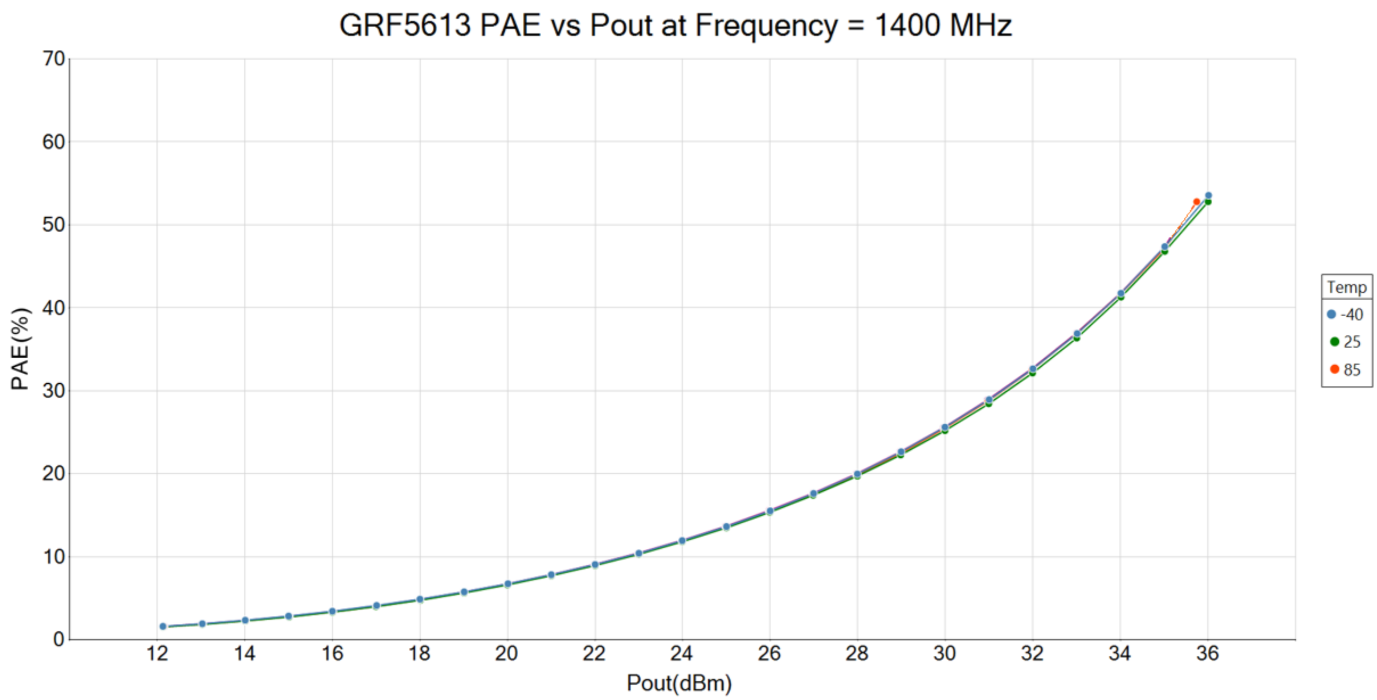
Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Small Signal Gain	S21		24.5		dB	F_{TEST} = 1400 MHz, V_{CC} = 5 V, Pin = -25 dBm.
Standby Mode Gain	$S21_{STBY}$		-29		dB	Disabled Mode: V_{SHDN}/V_{EN1}/V_{EN2} = High, Pin = 0 dBm.
Input Return Loss	S11		> 9		dB	F_{RF} = 1350 to 1450 MHz.
Output Return Loss	S22		> 6		dB	F_{RF} = 1350 to 1450 MHz.
Reverse Isolation	S12		> 46		dB	F_{RF} = 1350 to 1450 MHz.
Noise Figure	NF		3.5		dB	On standard evaluation board.
Output 1 dB Compression Power	OP1dB		35.4		dBm	Sinewave Input. V_{CC} = 5 V.

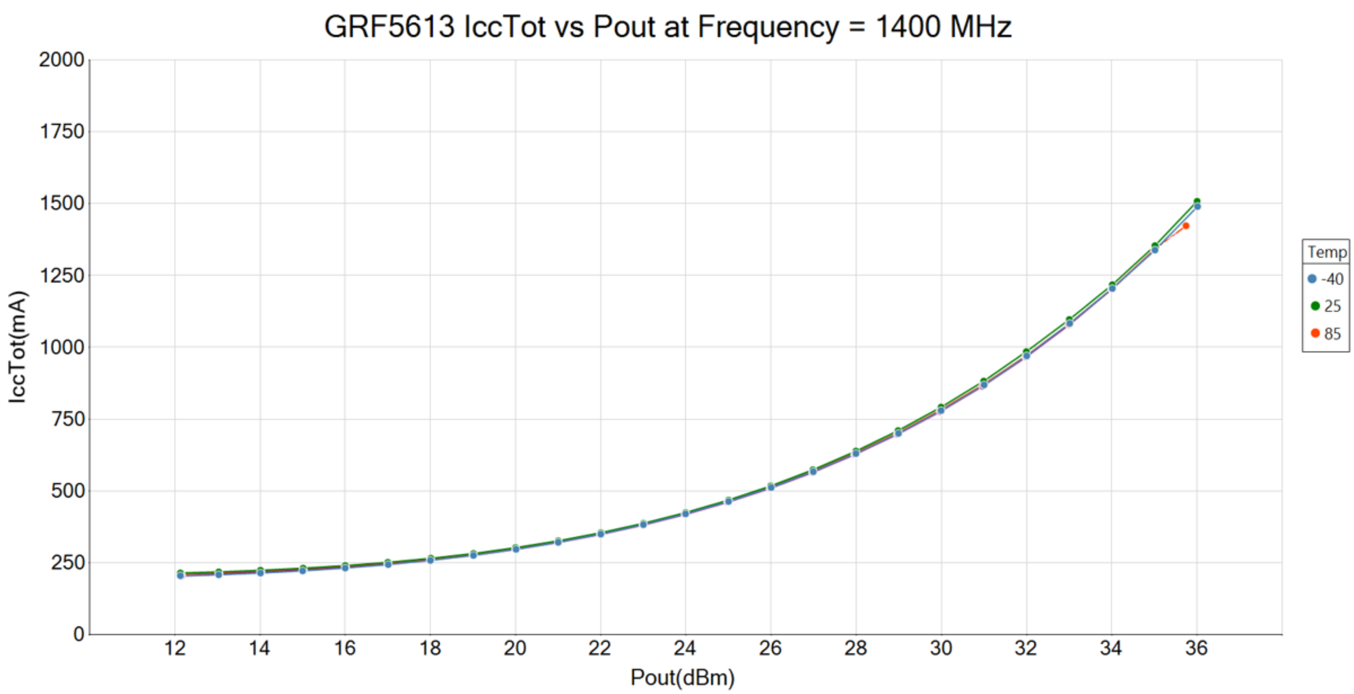
GRF5613 Typical Operating Curves: 1350 to 1450 MHz Tune



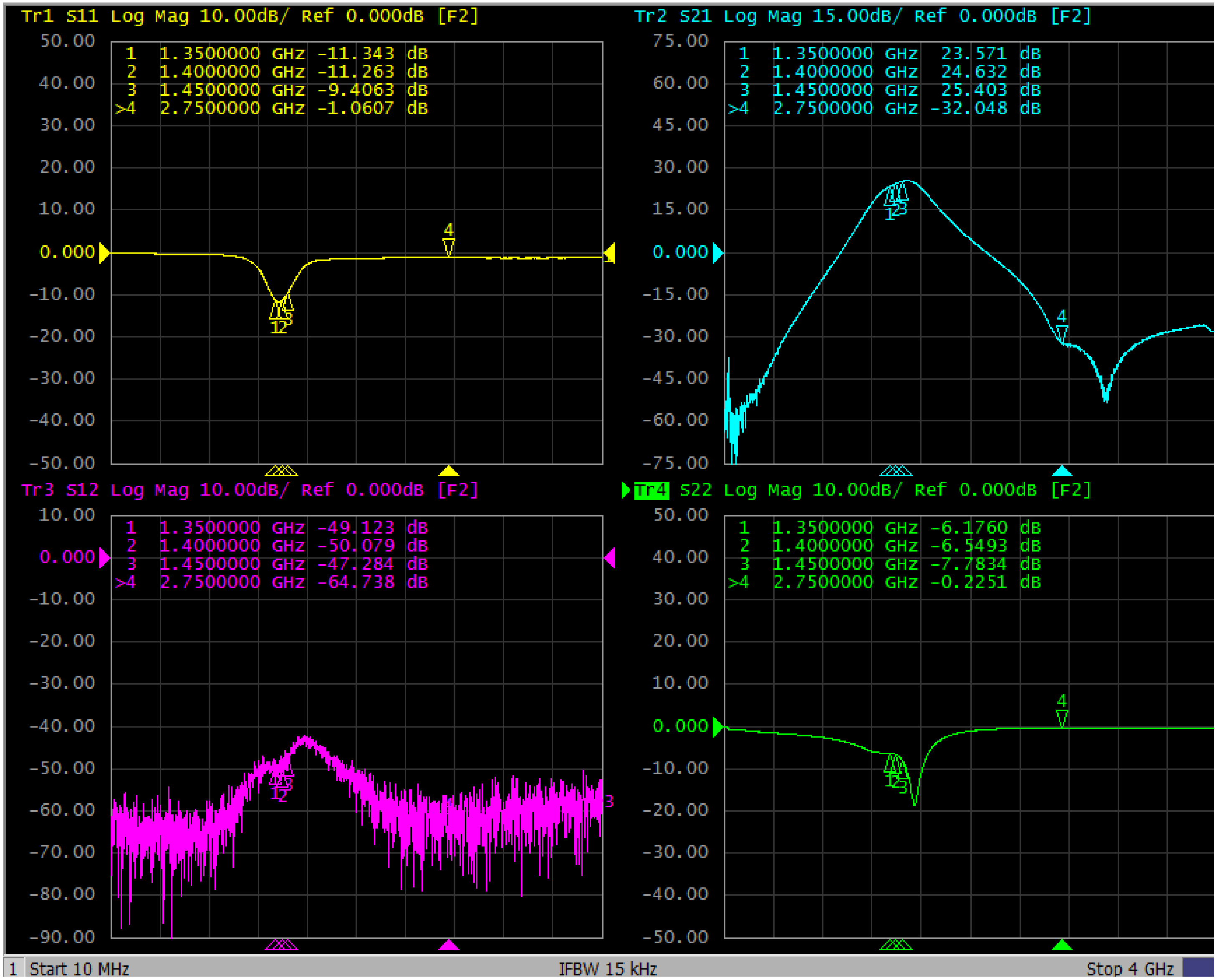


GRF5613 Typical Operating Curves: 1350 to 1450 MHz Tune

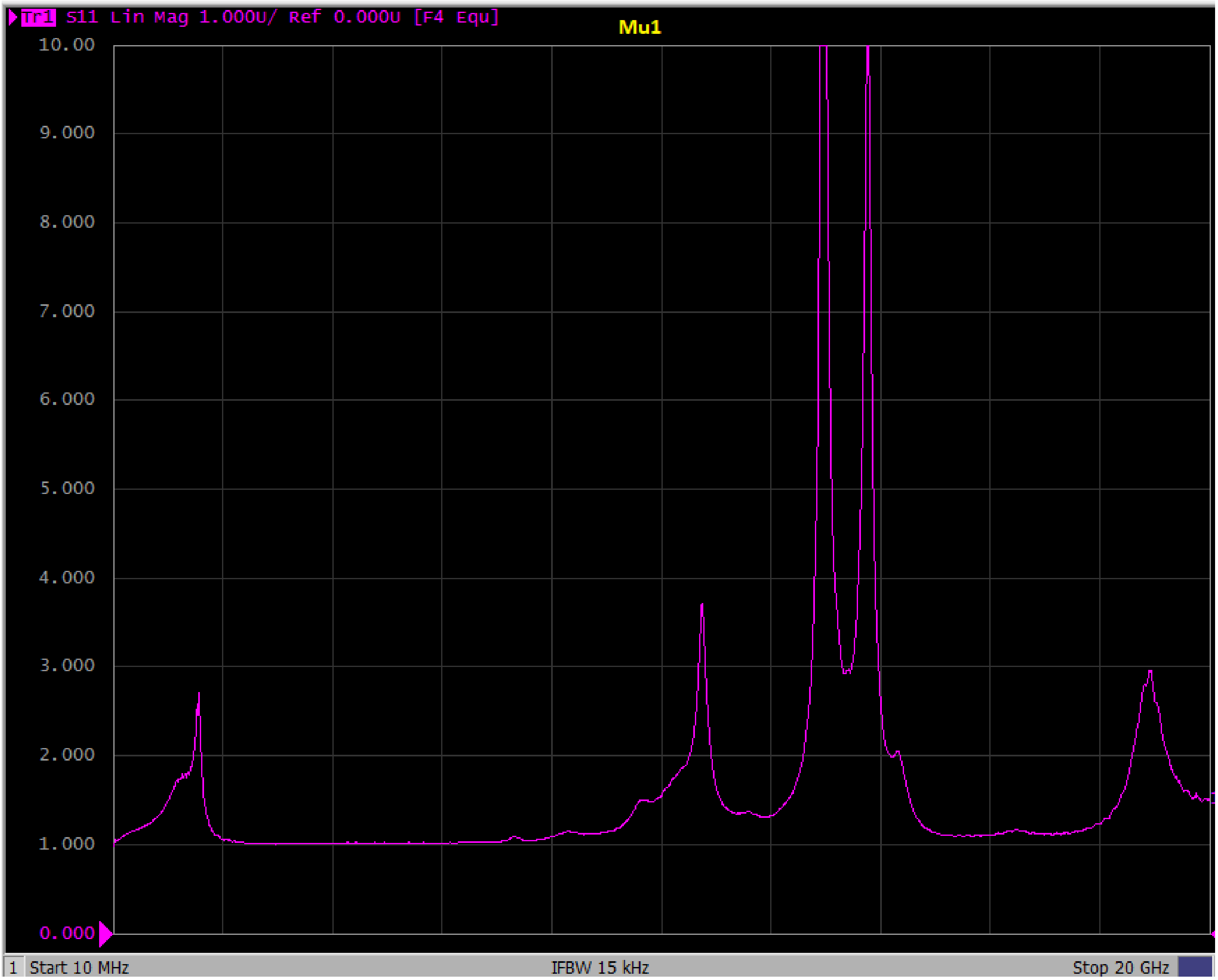




GRF5613 Typical Operating Curves: S-Parameters (1350 to 1450 MHz Tune)



GRF5613 Typical Operating Curves: Stability Mu (10 MHz to 20 GHz)

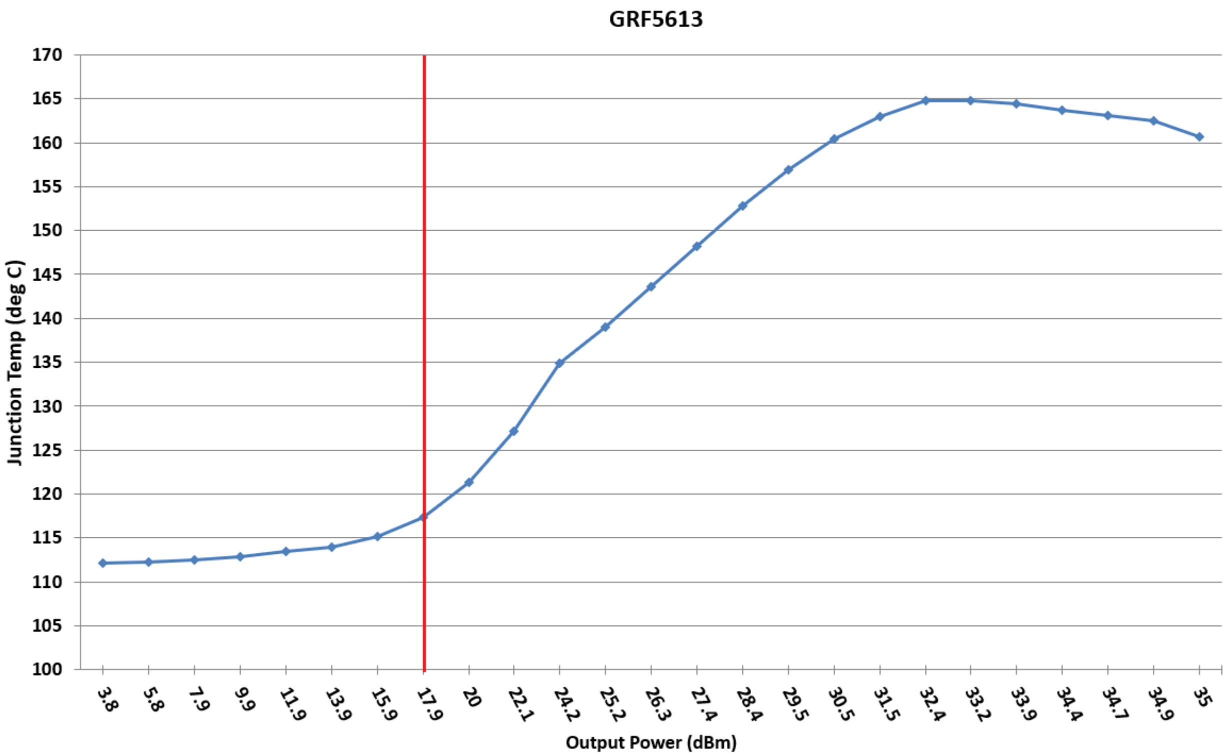


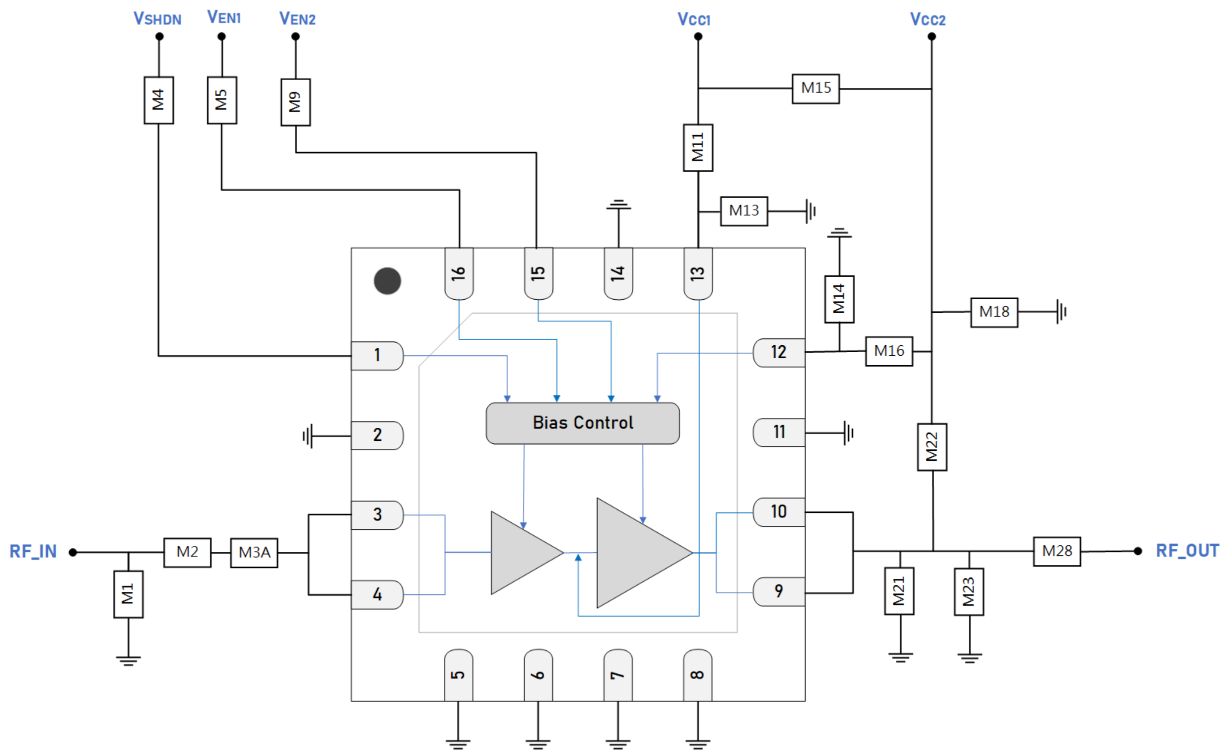
Note: Mu factor ≥ 1.0 implies unconditional stability.

GRF5613 Typical Operating Curves:

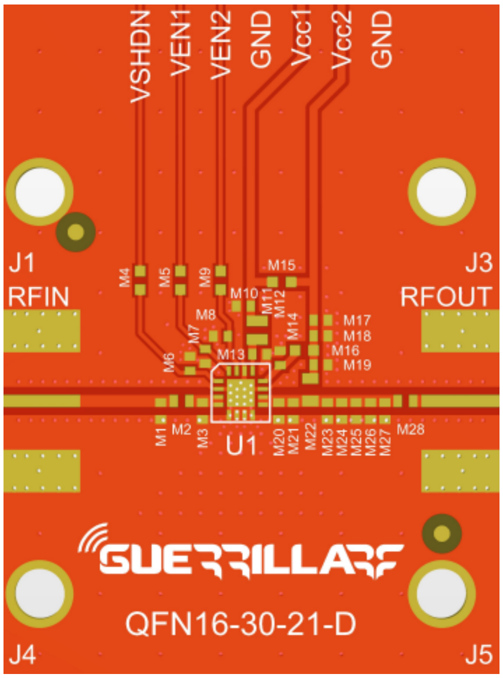
Junction Temperature per application schematic at 85 °C.

GRF5613 being a 2-stage device, sees one of the stages governing junction temperature over power sweep. Red line = 18 dBm shows where T_J is equivalent in both stages. At left of red line, stage-1 governs T_J (Q1 T_J is higher). To the right of red line, stage-2 governs T_J (Q2 T_J is higher).





GRFR5613 Standard Evaluation Board Schematic



GRF5613 Evaluation Board Assembly Diagram

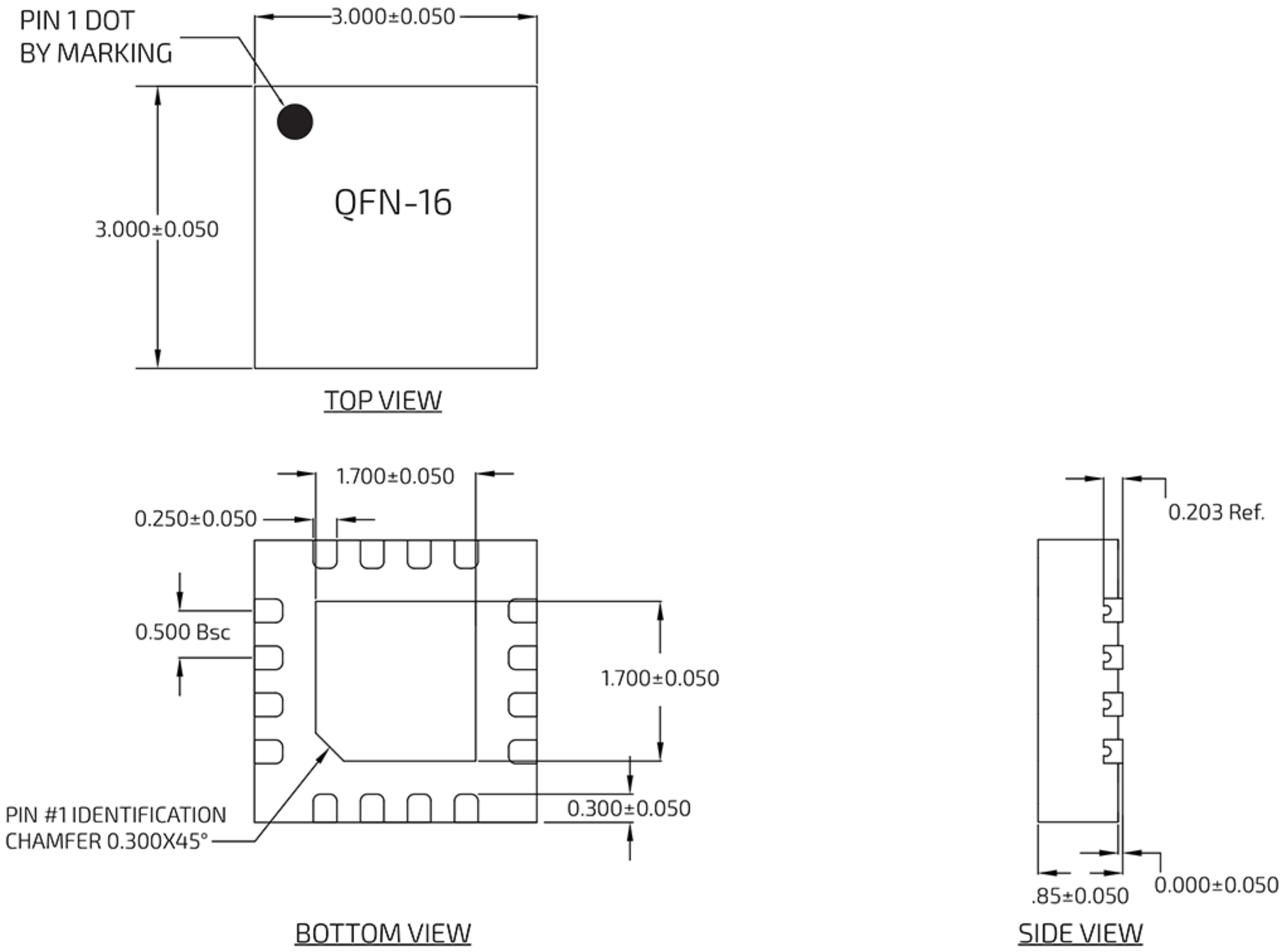
GRF5613 Evaluation Board Assembly Diagram Reference

Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1	Inductor	Murata	LQG	2.4 nH	0402	ok
M2	Capacitor	Murata	GJM	4.3 pF	0402	ok
M3A	Resistor	Various	1%	2 Ω	0402	ok
M4	Resistor	Various	1%	0 Ω	0402	ok
M5	Resistor	Various	1%	15 kΩ	0402	ok
M9	Resistor	Various	1%	10.2 kΩ	0402	ok
M11	Inductor	Coilcraft	0402HP	22 nH	0402	ok
M13	Capacitor	Murata	GRM	0.1 µF	0402	ok
M14	Capacitor	Murata	GRM	1.0 µF	0402	ok
M15	Resistor (jumper)	Various	5%	0 Ω	0402	ok
M16	Resistor	Various	1%	0 Ω	0402	ok
M18	Capacitor	Murata	** GRM	10 µF	0402	ok
M21	Capacitor	Murata	GJM	1.8 pF	0402	ok
M22	Inductor	Coilcraft	0908SQ	23 nH	0908	ok
M23	Capacitor	Murata	GJM	5.1 pF	0402	ok
M28	Capacitor	Murata	GJM	22 pF	0402	ok
Evaluation Board	QFN16-30-21-D					

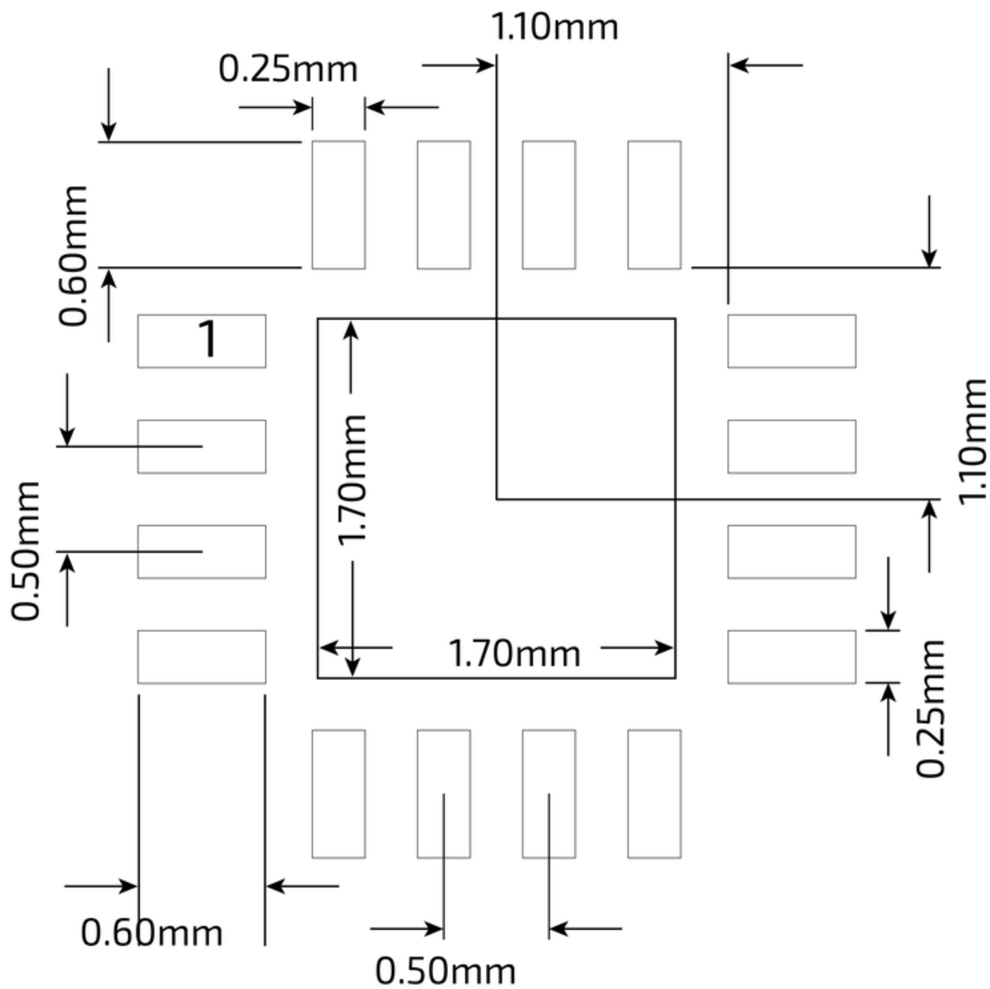
Notes:

Standard evaluation board bias: V_{CC} = 5 V, V_{EN1} = V_{EN2} = 5 V, V_{SHDN} = 0 V.

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



QFN 16 3x3mm Package Dimensions



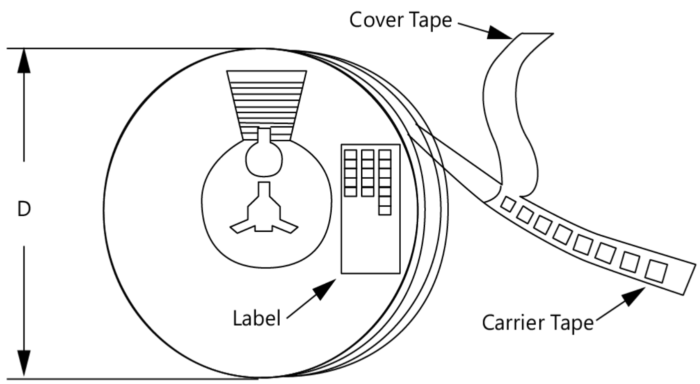
QFN 16 3x3mm Suggested PCB Footprint (Top View)

Package Marking Diagram

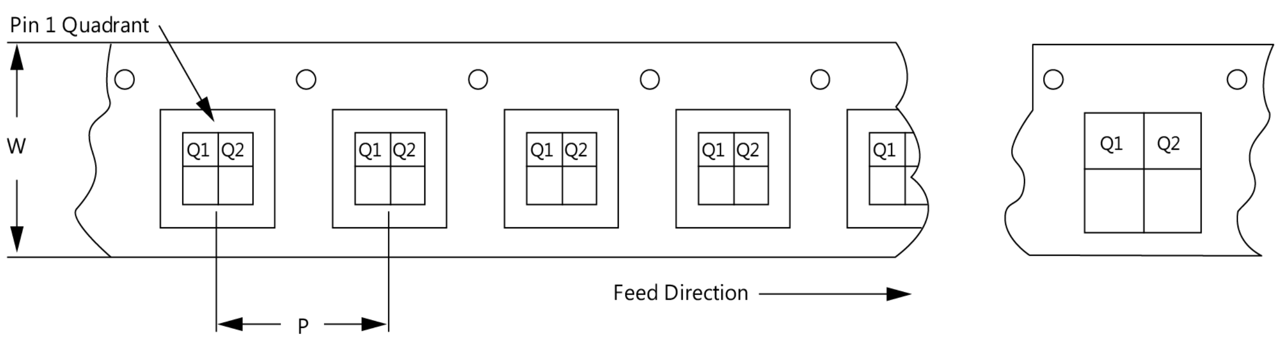
Line 1: "YY" = Year. "WW" = WORK WEEK the Device was assembled.
Line 2: "GRF" = Guerrilla RF
Line 3: "XXXX" = Device Part Number.

Tape and Reel Information

Guerrilla RF's tape and reel specification complies with Electronics Industries Association (EIA) standards for "Embossed Carrier Tape of Surface Mount Components for Automatic Handling" (reference EIA-481). 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 latest reel specifications and package information (including units/reel), please visit Package Manufacturing Information | Guerrilla RF (guerrilla-rf.com).



Tape and Reel Packaging with Reel Diameter Noted (D)



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

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Revision History

Revision Date	Description of Change
October 3, 2023	Preliminary Data Sheet.
December 5, 2024	Release Ø Data Sheet.
June 19, 2025	Extended upper frequency range from 1450 MHz to 1627 MHz.

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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 evaluation board measurements taken within the Guerrilla RF Applications Lab. Any MIN/MAX limits represented within the data sheet are based solely on *estimated* part-to-part variations and process spreads. 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.