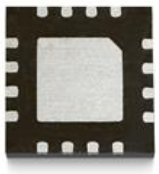
DATA SHEET

RELEASE Ø DATA SHEET



GRF5521

HIGH LINEARITY POWER AMPLIFIER 2.11 to 2.17 GHz

FEATURES

- Excellent OP1dB, OIP3, ACLR, and IM3 Performance
- Native Linearity Provides up to +23 dBm P_{OUT} with > 45 dBc ACLR – Without the Need for Digital Predistortion Correction
- +22.5 dBm Linear Output Power Maintained at 85 °C
- Flexible Biasing Provides Latitude for Linearity Optimization
- 115 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 / 2.14 GHz / 115 mA I_{CCQ}

- Gain: 31 dB
- OIP3: 45 dBm @ +23 dBm P_{OUT}/tone
- OP1dB: 33 dBm
- Noise Figure: 3.1 dB

APPLICATIONS

- Cellular Boosters/Repeaters
- Automotive Compensators
- Picocells/Femtocells
- Cellular DAS
- Customer Premise Equipment
- Wireless Infrastructure

DESCRIPTION

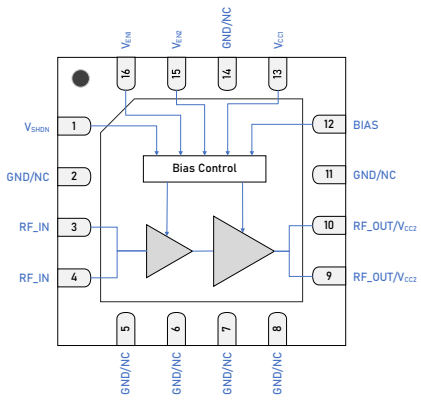
The GRF5521 is a high gain, two-stage InGaP HBT power amplifier designed to deliver excellent P1dB, ACLR, and IM3 performance over 2110 to 2170 MHz band. Its exceptional native linearity makes it an ideal choice for transmitter applications that typically do not employ digital pre-distortion correction schemes.

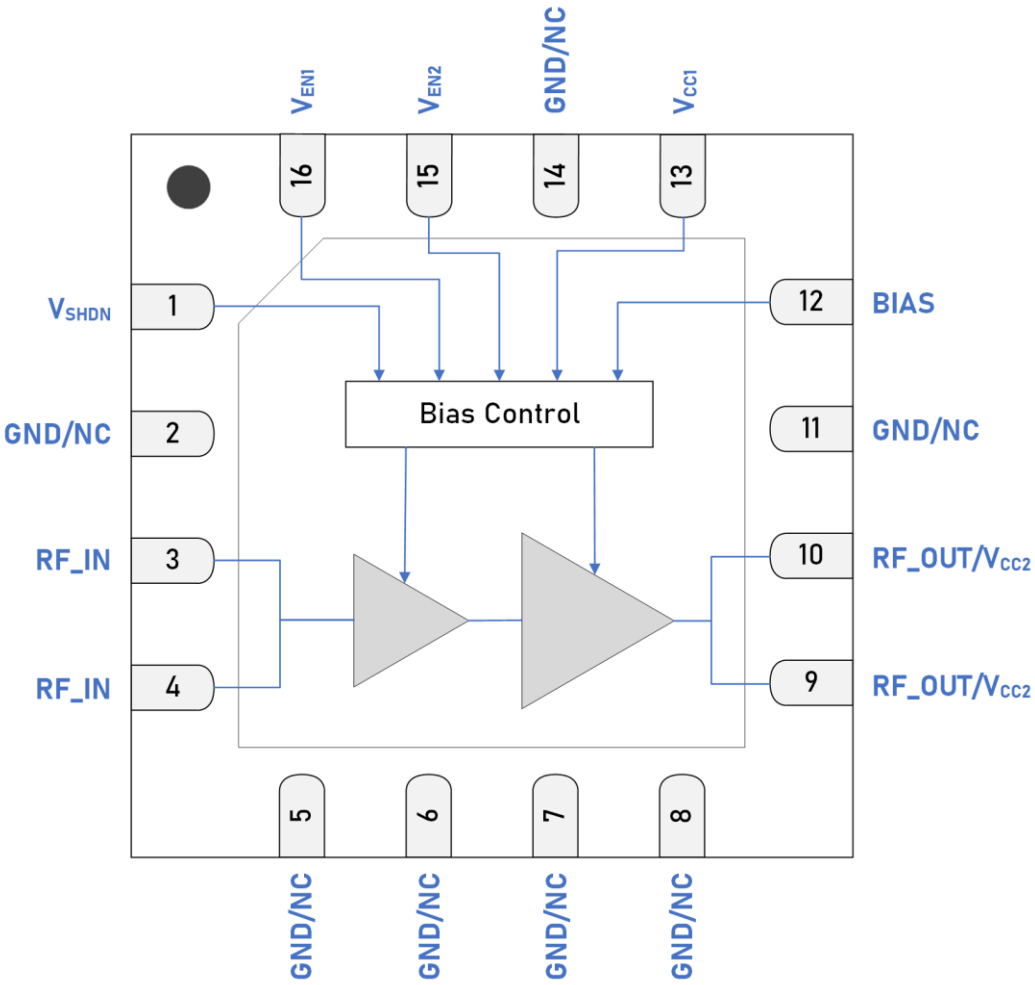
This device is part of a complete family of externally matched linear amplifiers that cover the following frequency ranges:

GRF5506: 0.66 - 0.72 GHz
GRF5507: 0.7 - 0.8 GHz
GRF5508: 0.8 - 0.9 GHz
GRF5510: 0.88 - 0.96 GHz
GRF5517: 1.7 - 1.8 GHz
GRF5518: 1.8 - 1.91 GHz
GRF5519: 1.92 - 2.0 GHz
GRF5521: 2.11 - 2.17 GHz
GRF5526: 2.5 - 2.7 GHz
GRF5536: 3.3 – 4.2 GHz

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

BLOCK DIAGRAM





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

Pin Assignments

Pin	Name	Description	Note
1	V_{SHDN}	Digital Shutdown Pin	V_{SHDN} ≥ 1.7 V (Logic HIGH) disables device. V_{SHDN} ≤ 0.9 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	Internally matched 50 Ω. An external DC blocking cap must be used. Pins 3 & 4 tied together on system board.
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 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 an external resistor.
15	V_{EN2}	Enable2 Voltage Input	V_{EN2} and series resistor set I_{CCQ} for the output stage. V_{EN2} ≤ 0.2 V 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 V disables stage 1. Connecting an external decoupling capacitor to the ground is required for optimal NF performance.
PKG BASE	GND	Ground	Provides DC and RF ground for the amplifier, as well as a thermal heat sink. Recommend multiple 8 mil vias beneath the package for optimal RF and thermal performance. Refer the to evaluation board top layer graphic on schematic page.

Absolute Ratings

Parameter		Symbol	Min.	Max.	Unit
Supply Voltage		V_{CC}		5.5	V
RF Input Power	50 Ω, V_{CC} = 5 V, CW Tone, 100% DC, $T_{PKG\ HEAT\ SINK}$ = 25°C	$P_{IN\ MAX-1:1}$		23	dBm
	Load VSWR ≤ 8:1, all phase angles, V_{CC} = 5 V, CW Tone, 100% DC, $T_{PKG\ HEAT\ SINK}$ = -40 to 85 °C	$P_{IN\ MAX-8:1}$		20	
Operating Temperature (Package Heat Sink)		$T_{PKG\ HEAT\ SINK}$	-40	85	°C
Maximum Junction Temperature (MTTF > 10^6 Hours)		$T_{J\ MAX}$		170	°C
Maximum Dissipated Power (Stage 1)		$P_{DISS\ MAX}$		500	mW
Maximum Dissipated Power (Stage 2)		$P_{DISS\ MAX}$		1400	mW
Shutdown Voltage		V_{SHDN}		4	V
Electrostatic Discharge					
Charged Device Model		CDM	1000		V
Human Body Model		HBM	1000		V
Storage					
Storage Temperature		T_{STG}	-65	150	°C
Moisture Sensitivity Level		MSL		1	

Caution! ESD Sensitive Device

Exceeding Absolute Maximum Rating conditions may cause permanent damage to the device.

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.*

www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409

Recommended Operating Conditions

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Voltage	V_{CC}	3	5	5.5	V	
Operating Temperature (Package Heat Sink)	$T_{PKG\ HEAT\ SINK}$	-40		85	°C	
RF Frequency Range	F_{RF}	2.11		2.17	GHz	Typical Application Schematic Using the 2.11 to 2.17 GHz Tuning Set (**note 2**).
RF_IN Port Impedance	Z_{RFIN}		50		Ω	Single Ended with 2-element Match.
RF_OUT Port Impedance	Z_{RFOUT}		50		Ω	Single Ended with 3-element Match.

Note 2: Operation outside this range is possible, but with degraded performance of some parameters.

Nominal Operating Parameters – General

The following conditions apply unless noted otherwise: Typical Application Schematic using the band 1 2.11 to 2.17 GHz tuning set. M5 = 6650 Ω, M9 = 4750 Ω. V_{SHDN} = LOW, V_{CC} = 4.75 to 5.25 V, I_{CCQ} = 115 mA. 50 Ω system impedance. P_{OUT} = +23 dBm, F_{TEST} = 2.14 GHz. $T_{PKG\ HEAT\ SINK}$ = 25 °C. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Quiescent Current	I_{CCQ}		115		mA	I_{CCQ1} + I_{CCQ2}. No RF Applied
Supply Current with RF Applied	I_{CC}		235		mA	I_{CC1} + I_{CC2}. RF Applied with P_{OUT} = 23 dBm
Enable Current 1	$I_{ENABLE1}$		2.5		mA	V_{CC} = 5 V. $T_{PKG\ HEAT\ SINK}$ = 25 °C
Enable Current 2	$I_{ENABLE2}$		1.5		mA	V_{CC} = 5 V. $T_{PKG\ HEAT\ SINK}$ = 25 °C
Operating Temperature Range	$T_{PKG\ HEAT\ SINK}$	-40		85	°C	Measured on Package Heat Sink
Logic Input Low	V_{IL}	0		0.9	V	Applies to V_{SHDN} Input
Logic Input High	V_{IH}	1.7		V_{CC}	V	Applies to V_{SHDN} Input
Logic Current Low	I_{IL}		3		nA	Applies to V_{SHDN} Input. V_{IL} = 0.9 V
Logic Current High	I_{IH}		60		µA	Applies to V_{SHDN} Input. V_{IH} = 1.8 V
			280			Applies to V_{SHDN} Input. V_{IH} = 3.3 V
Switching Rise Time	T_{RISE}		500		ns	Applies to V_{SHDN} Input
Switching Fall Time	T_{FALL}		2800		ns	Applies to V_{SHDN} Input
Disabled Mode						
Supply Quiescent Current	$I_{CCQ-SHDN}$		1		µA	V_{CC} = 5 V. V_{SHDN} = HIGH
Enable Current 1	$I_{ENABLE1-SHDN}$		3		mA	V_{CC} = 5 V. V_{SHDN} = HIGH
Enable Current 2	$I_{ENABLE2-SHDN}$		1.3		mA	V_{CC} = 5 V. V_{SHDN} = HIGH
Thermal Data						
Thermal Resistance (Infrared Scan)	Θ_{JC}		38		°C/W	On Standard Evaluation Board.

www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409

Nominal Operating Parameters – RF (Band 1, 2.11 to 2.17 GHz, 5 V Operation)

The following conditions apply unless noted otherwise: Typical Application Schematic using the band 1 2.11 to 2.17 GHz tuning set. M5 = 6650 Ω, M9 = 4750 Ω. V_{SHDN} = LOW, V_{CC} = 4.75 to 5.25 V, I_{CCQ} = 115 mA. 50 Ω system impedance. P_{OUT} = +23 dBm, F_{TEST} = 2.14 GHz. $T_{PKG\ HEAT\ SINK}$ = 25 °C. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Small Signal Gain	S21	*29 (Note 3)*	31		dB	LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8 dB PAR, F_{TEST} = 2.14 GHz, $T_{PKG\ HEAT\ SINK}$ = 25 °C, V_{CC} = 5 V, P_{IN} = -25 dBm.
Standby Mode Gain	$S21_{STBY}$		-45		dB	Disabled Mode, LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8dB PAR, V_{SHDN} = HIGH, P_{IN} = 0 dBm.
Input Return Loss	S11		> 10		dB	F_{RF} = 2.11 to 2.17 GHz
Output Return Loss	S22		> 5		dB	F_{RF} = 2.11 to 2.17 GHz
Reverse Isolation	S12		> 40		dB	F_{RF} = 2.11 to 2.17 GHz
Evaluation Board Noise Figure	NF		3.1		dB	
Output 3rd Order Intercept	OIP3		45		dBm	+23 dBm P_{OUT} per Tone at 600 kHz Spacing.
Output 1 dB Compression Power	OP1dB	*31.5 (Note 3)*	33		dBm	Sine wave input, V_{CC} = 5 V, $T_{PKG\ HEAT\ SINK}$ = 25 °C.
Adjacent Channel Leakage Ratio	ACLR			*-45*	dBc	P_{OUT} = +23 dBm, LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8dB PAR, F_{TEST} = 2.14 GHz, $T_{PKG\ HEAT\ SINK}$ = 25 °C, V_{CC} = 5 V **(note 3).**

Note 3: MIN/MAX limits are defined using *modeled 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.

Typical Operating Curve Conditions

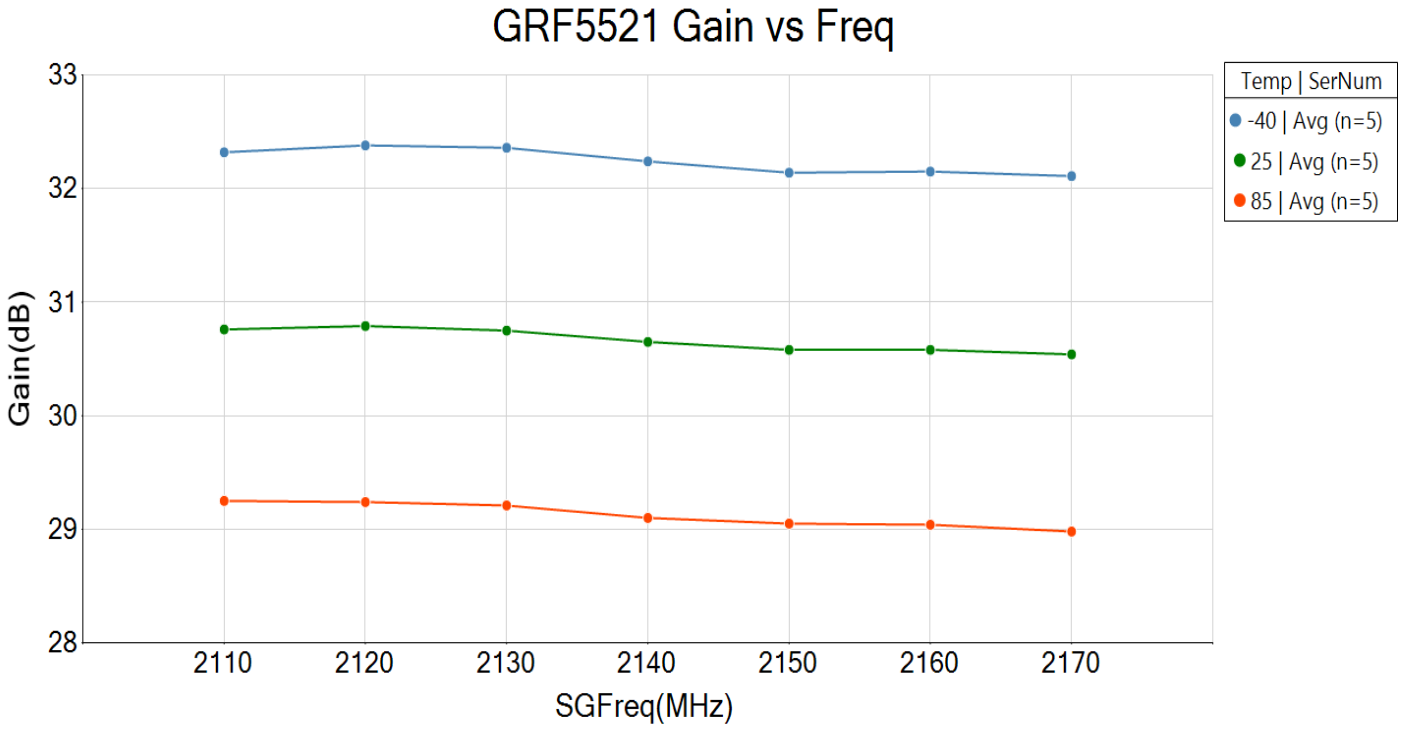
The following conditions apply unless noted otherwise: Typical Application Schematic using the band 1 2.11 to 2.17 GHz tuning set. M5 = 6650 Ω, M9 = 4750 Ω. V_{SHDN} = LOW, V_{CC} = 5 V, I_{CCQ} = 115 mA. 50 Ω system impedance. F_{TEST} = 2.14 GHz. $T_{PKG\ HEAT\ SINK}$ = 25 °C. Evaluation board losses are included within the plots.

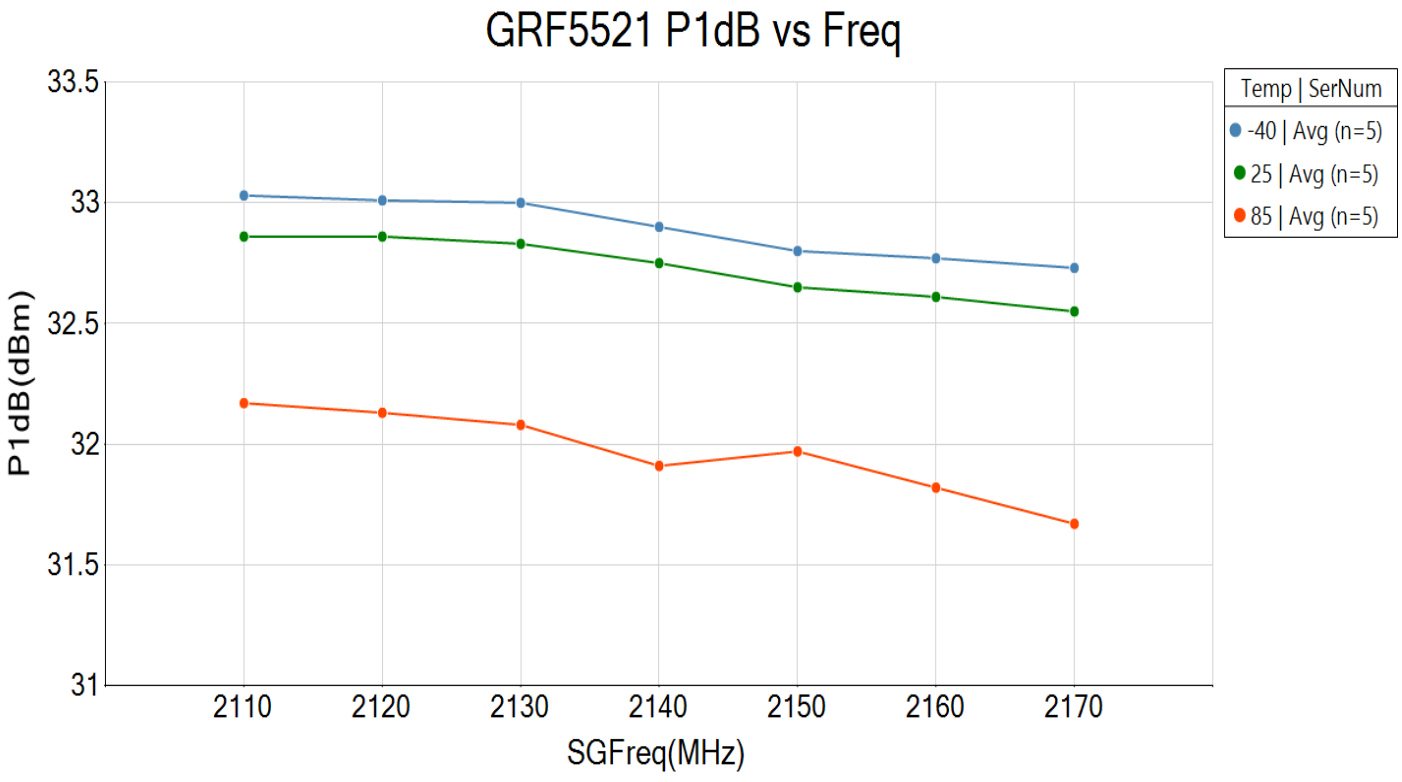
Truth Table

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

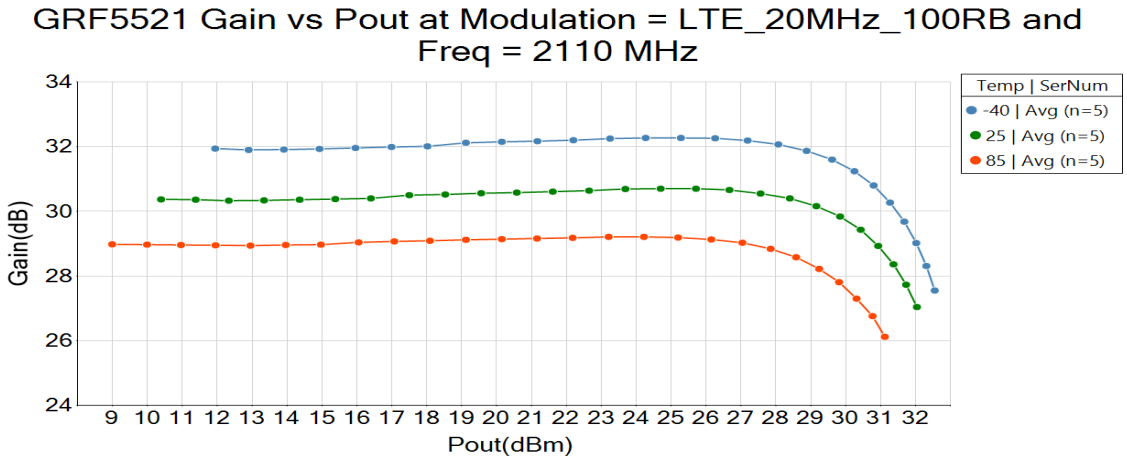
www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409

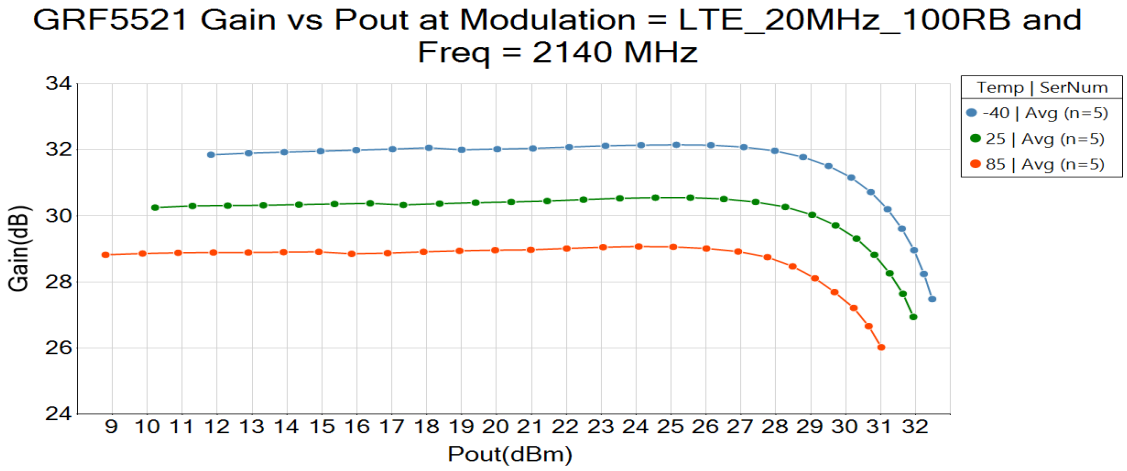
GRF5521 Typical Operating Curves: *2.11 - 2.17 GHz Tune*

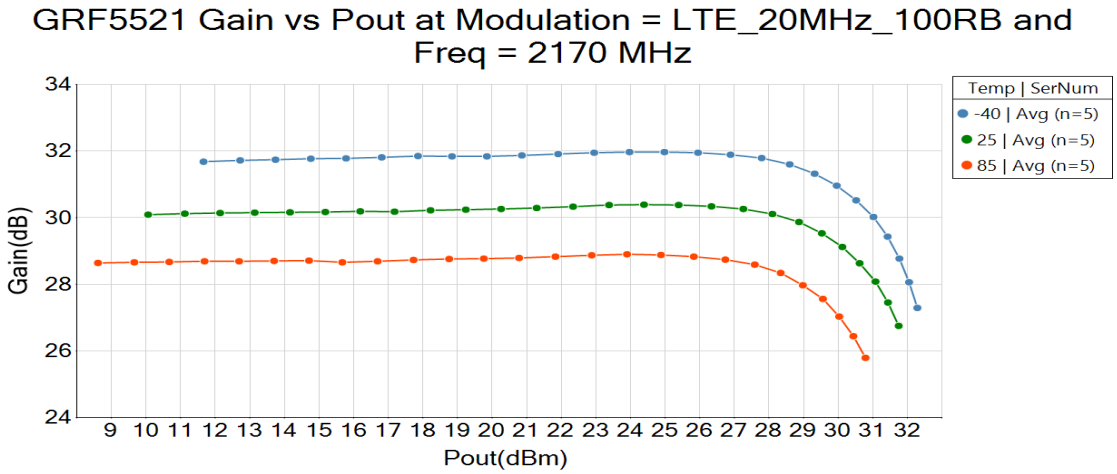




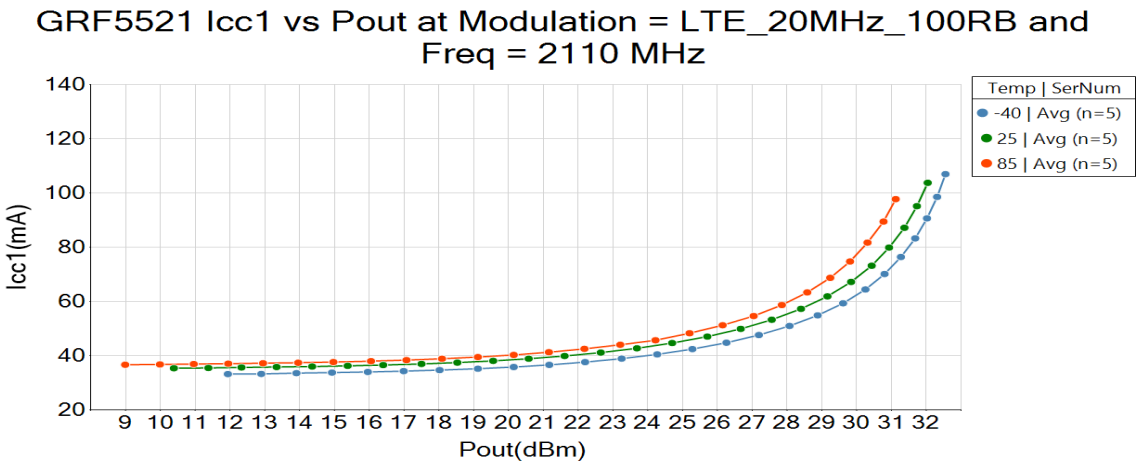
GRF5521 Typical Operating Curves: *Gain vs. P_{OUT} (9.8 dB PAR)*

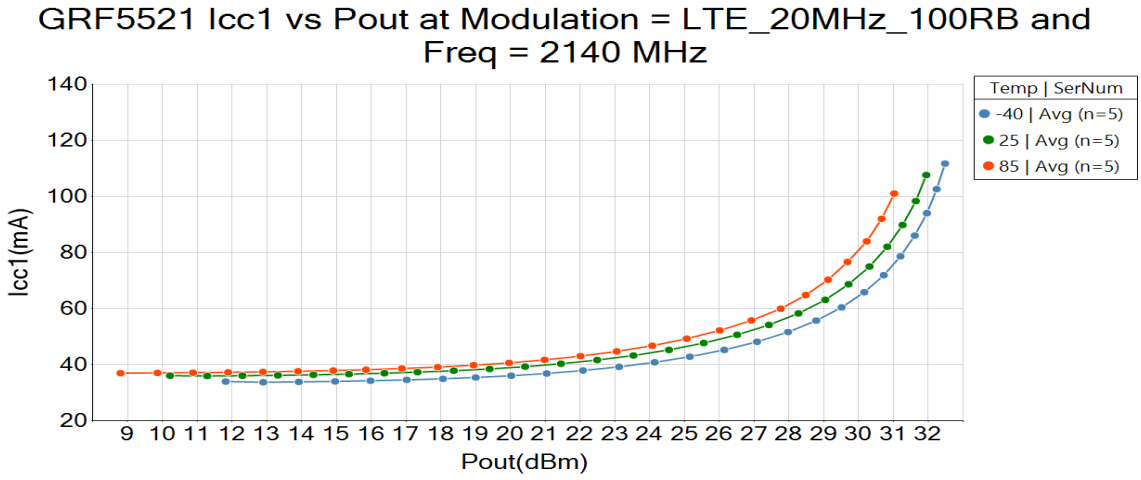


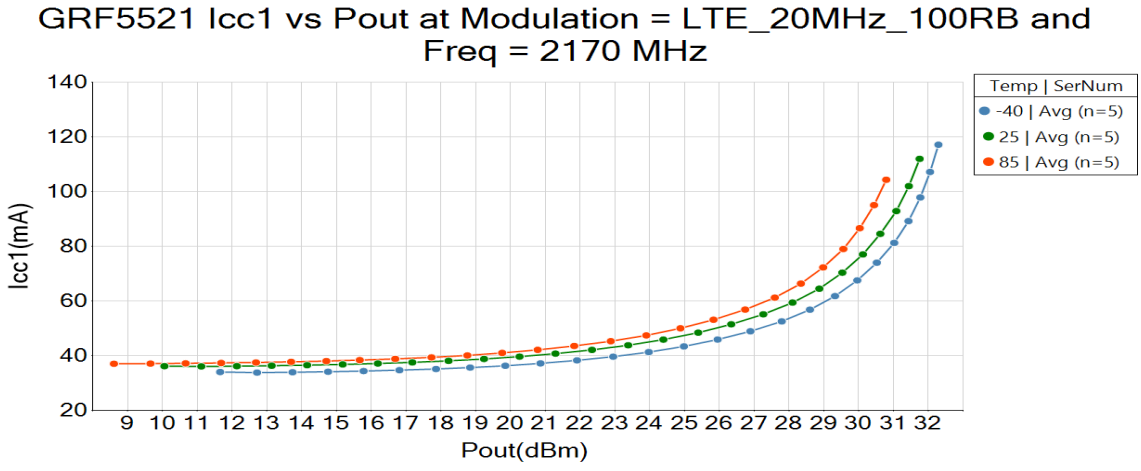




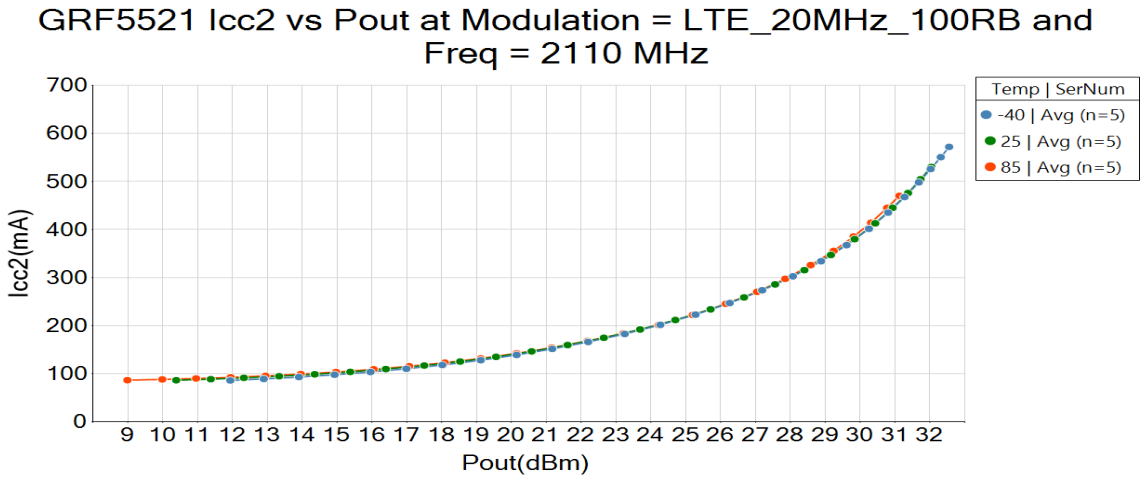
GRF5521 Typical Operating Curves: *Icc1 vs. P_{OUT} (9.8 dB PAR)*

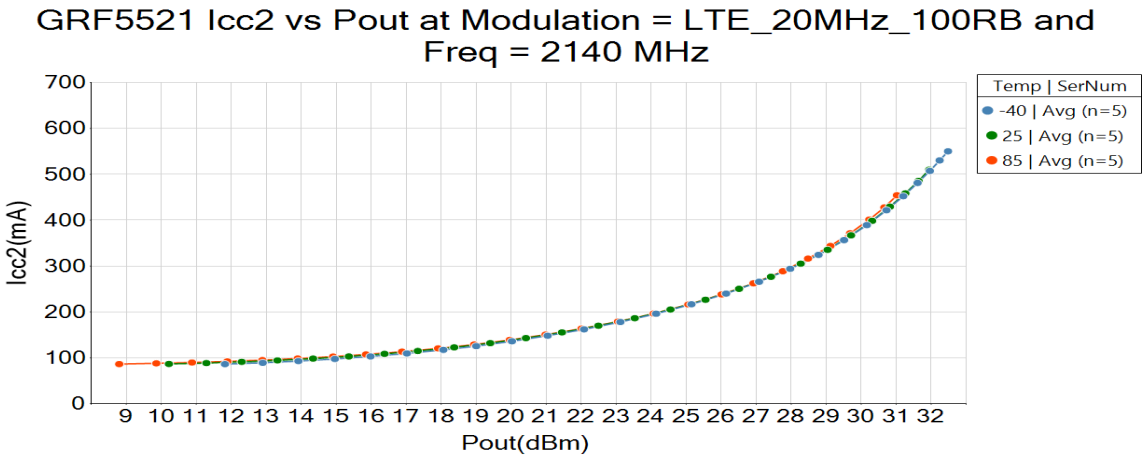


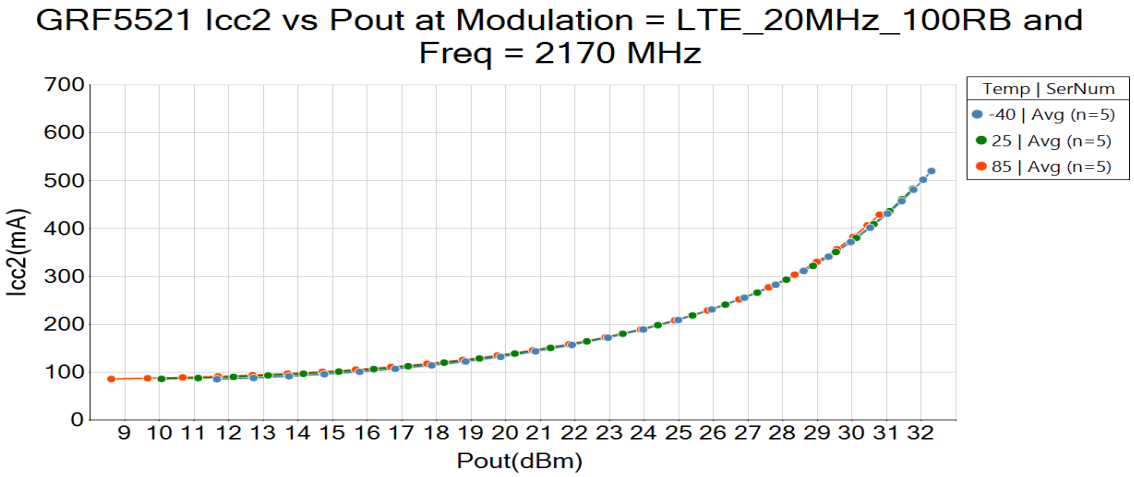




GRF5521 Typical Operating Curves: *Icc2 vs. POUT (9.8 dB PAR)*

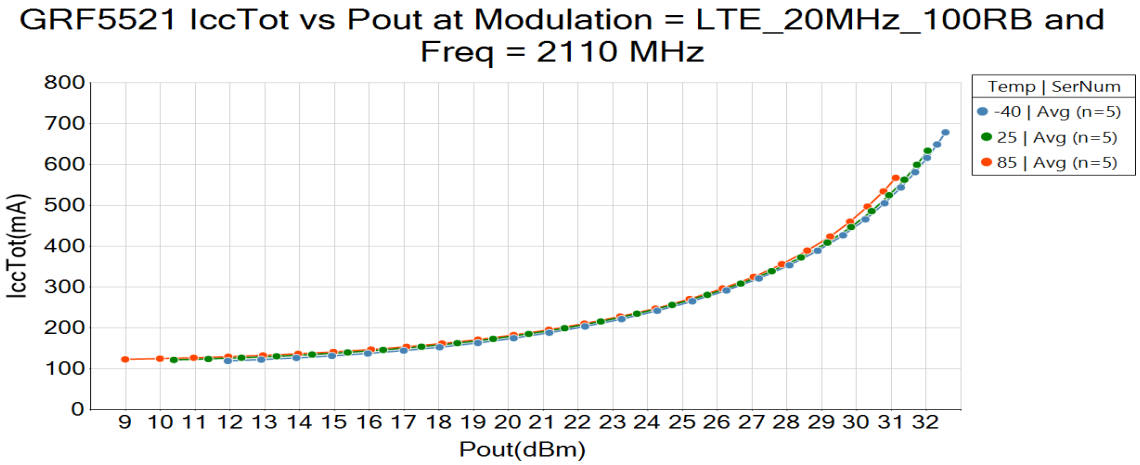


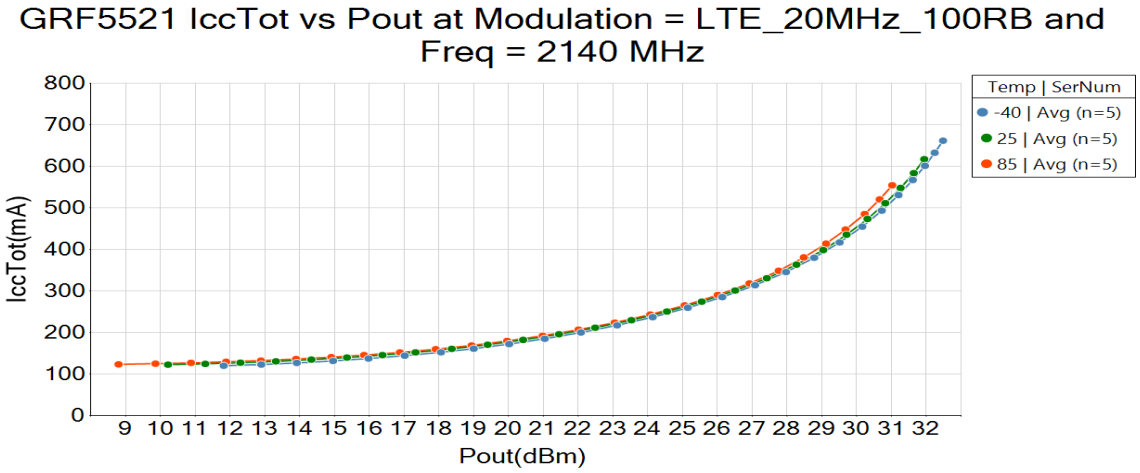


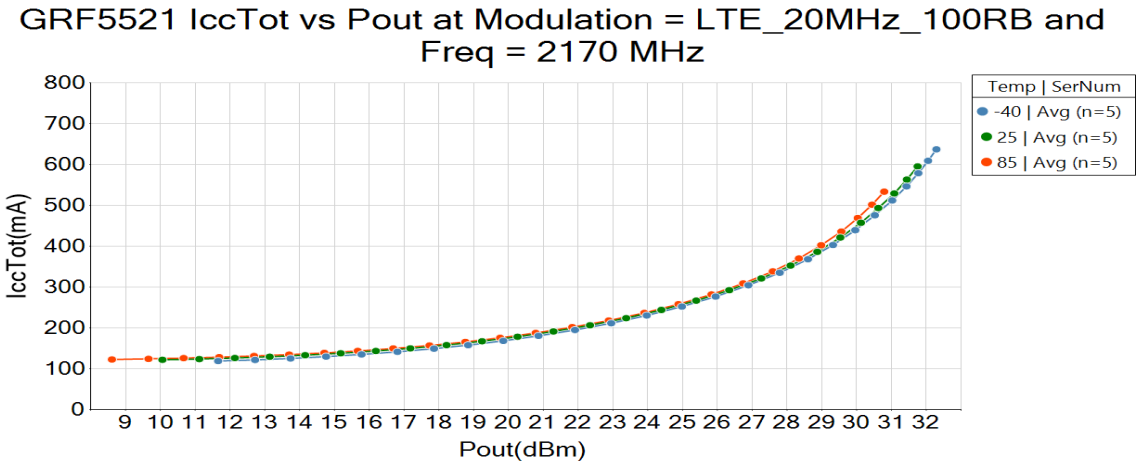


www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409

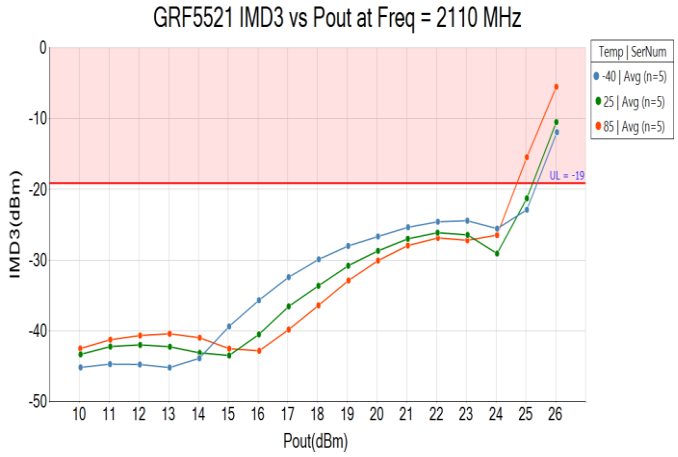
GRF5521 Typical Operating Curves: *IccTotal vs. P_{OUT} (9.8 dB PAR)*

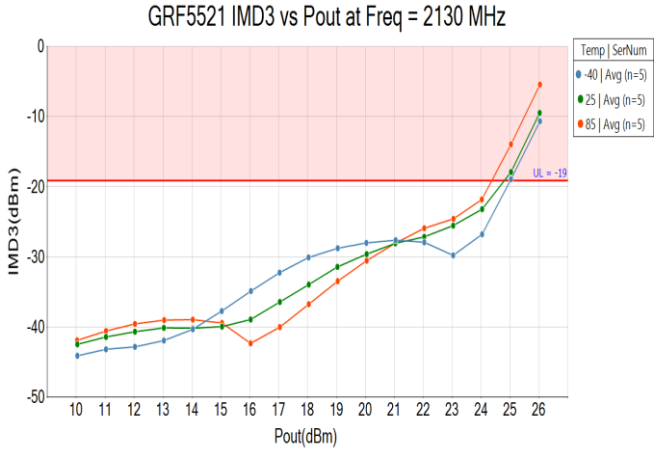


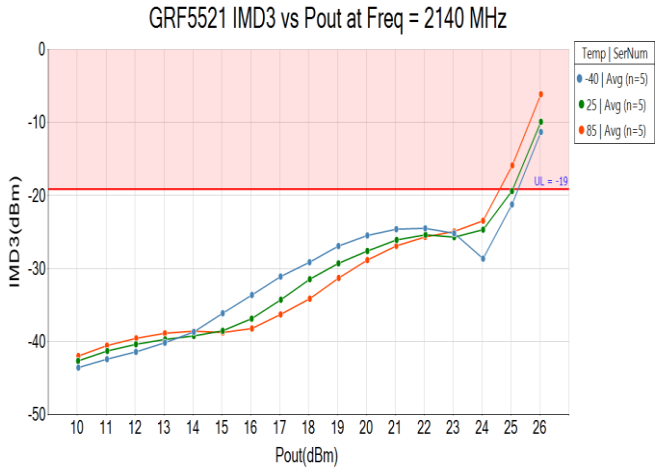


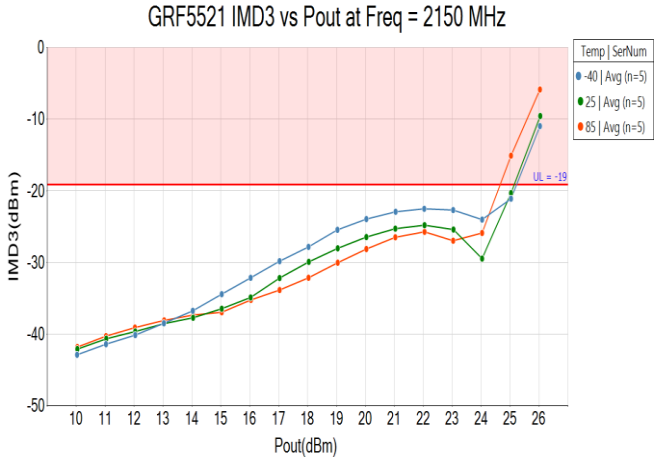


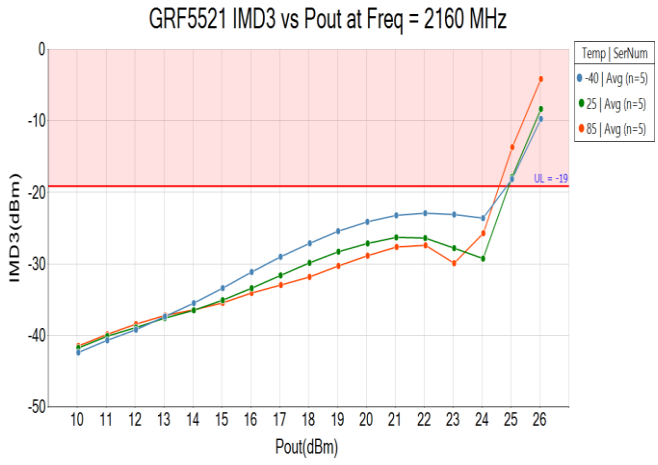
GRF5521 Typical Operating Curves: *IMD3 vs. P_{OUT} (Per Tone with 600kHz Tone Spacing)*

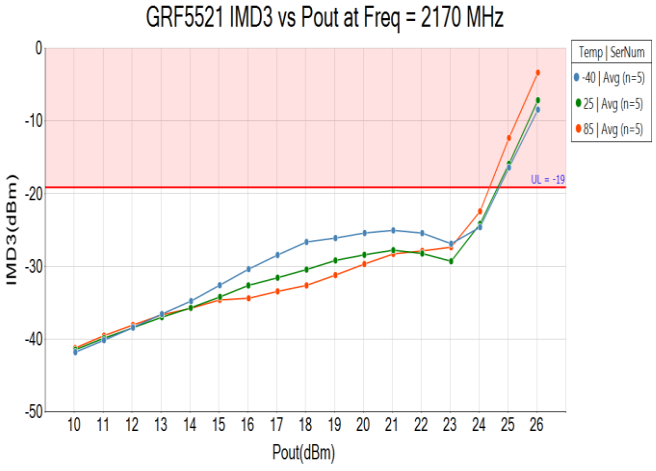




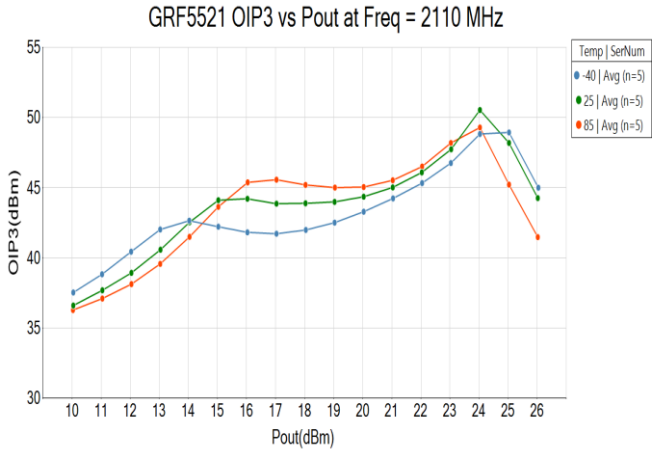


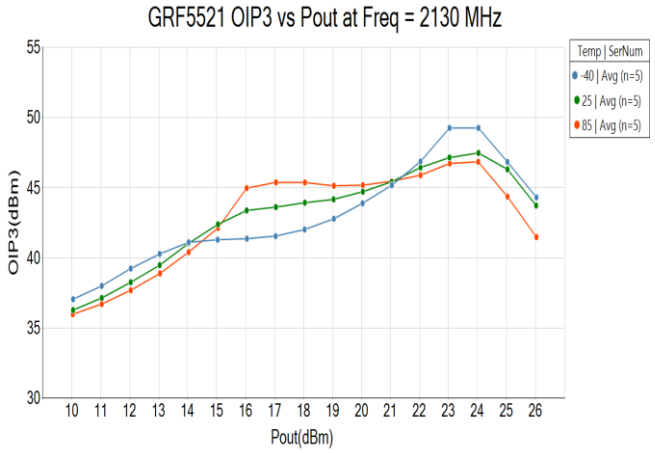


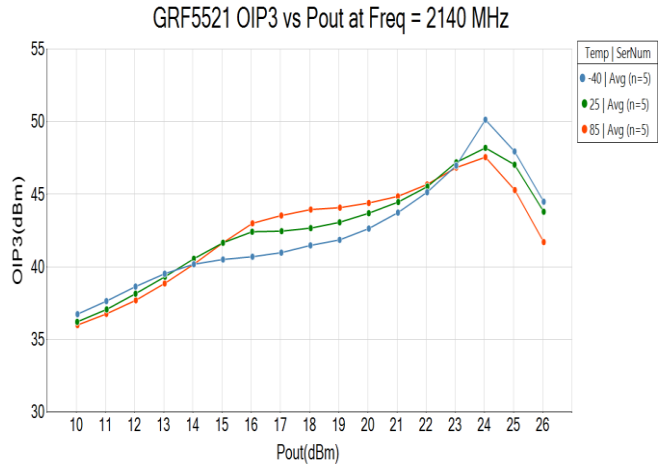


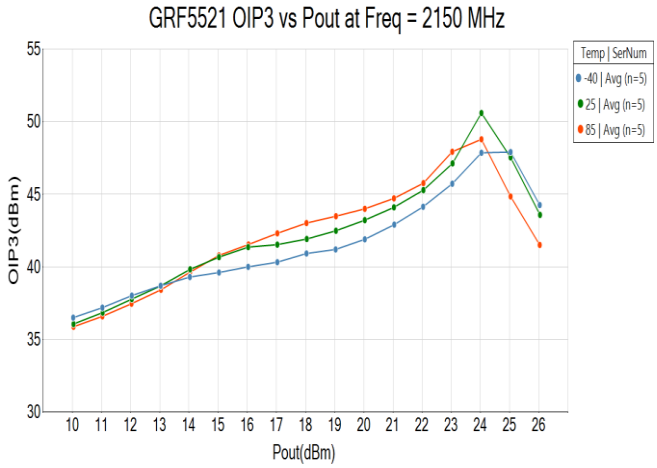


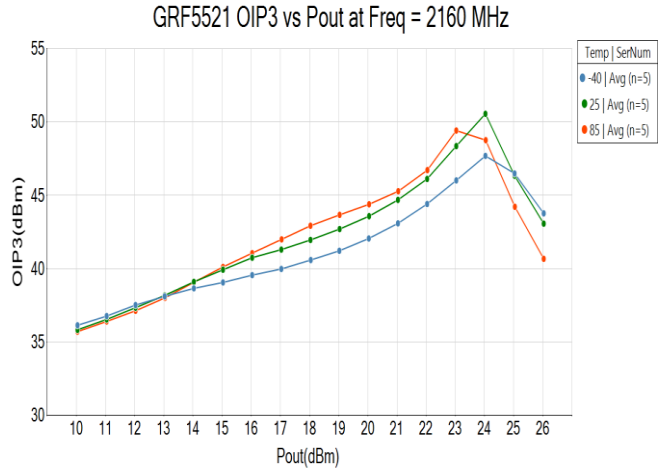
GRF5521 Typical Operating Curves: *OIP3 vs. P_{OUT} (Per Tone with 600kHz Tone Spacing)*

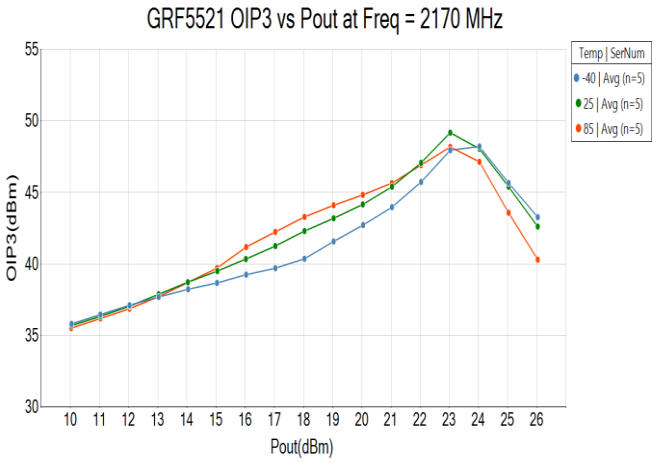




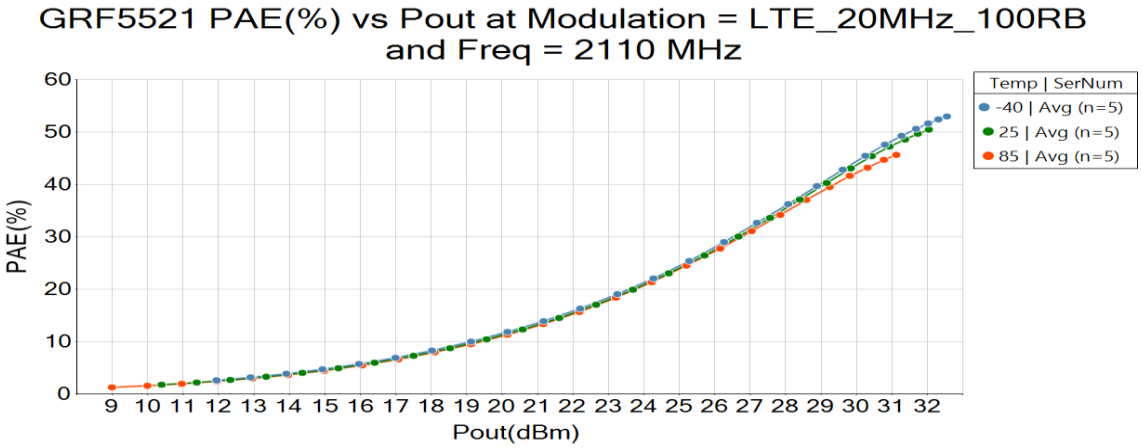


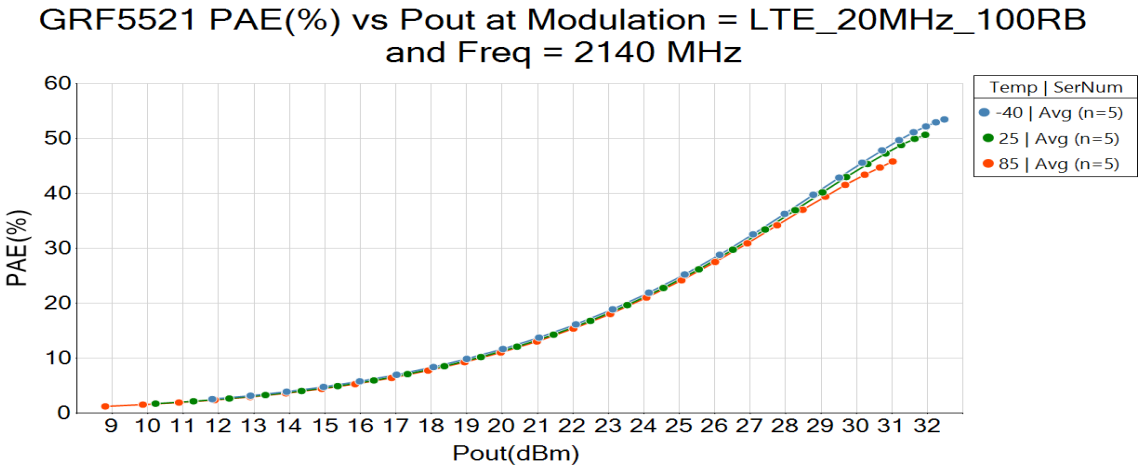


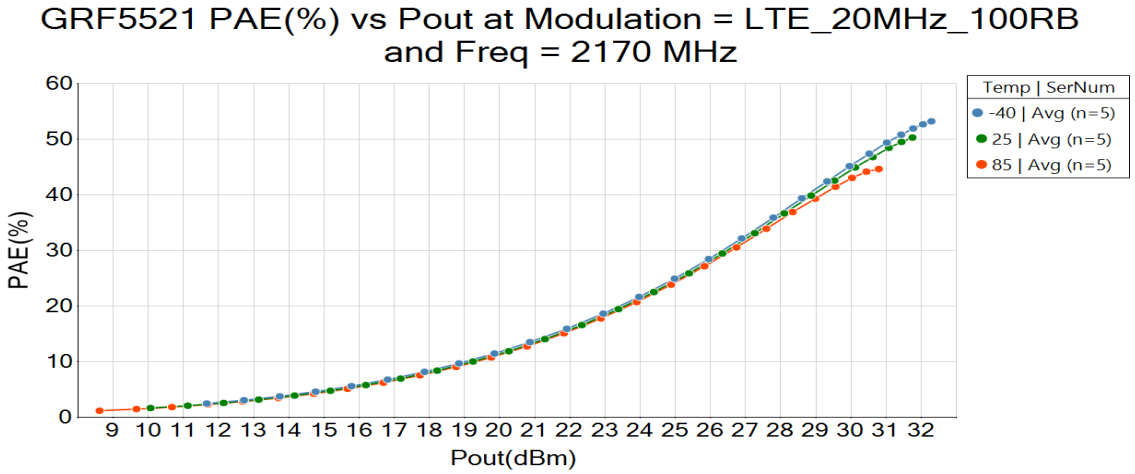




GRF5521 Typical Operating Curves: *PAE vs. P_{OUT} (9.8 dB PAR)*

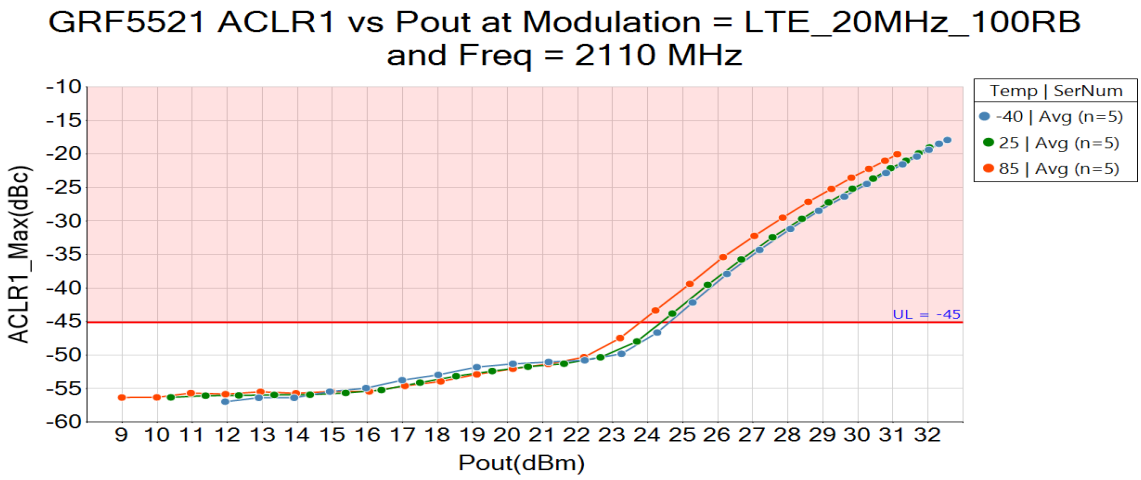


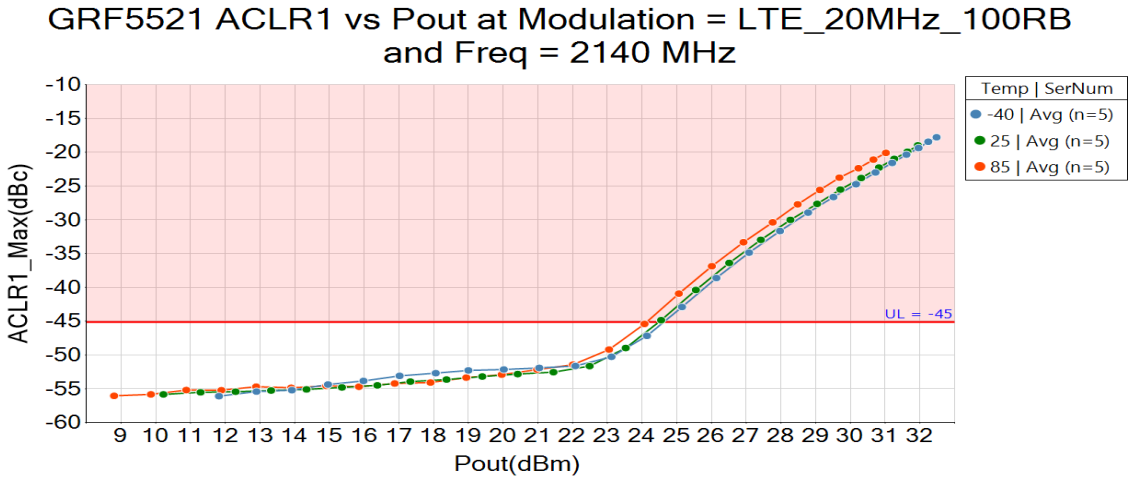


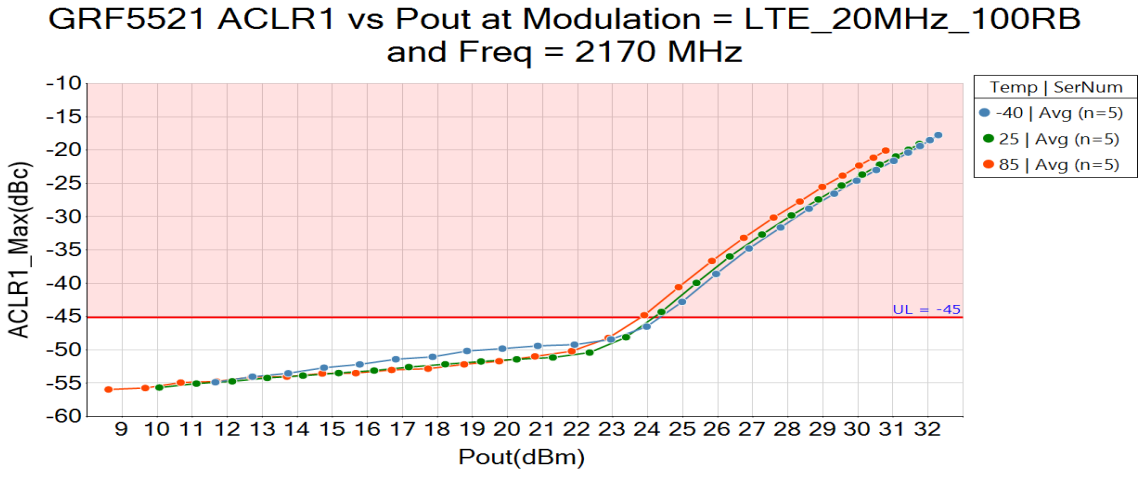


www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409

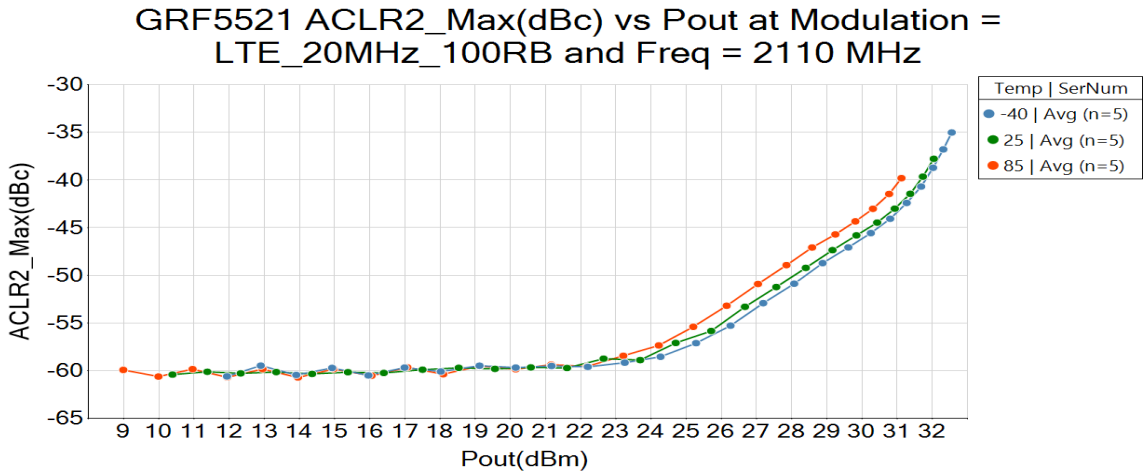
GRF5521 Typical Operating Curves: *ACLR1 vs. P_{OUT} (9.8 dB PAR)*

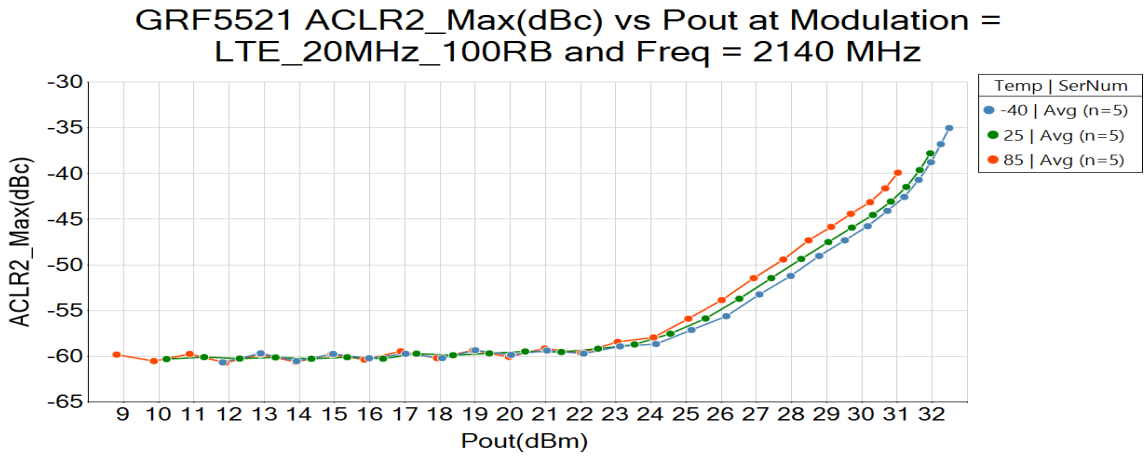


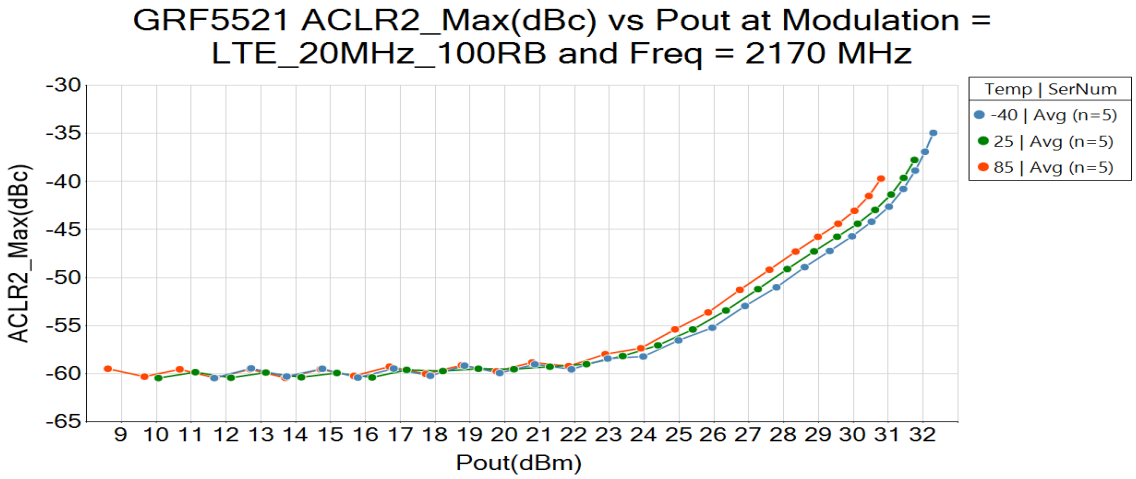




GRF5521 Typical Operating Curves: *ACLR2_Max vs. POUT (9.8 dB PAR)*

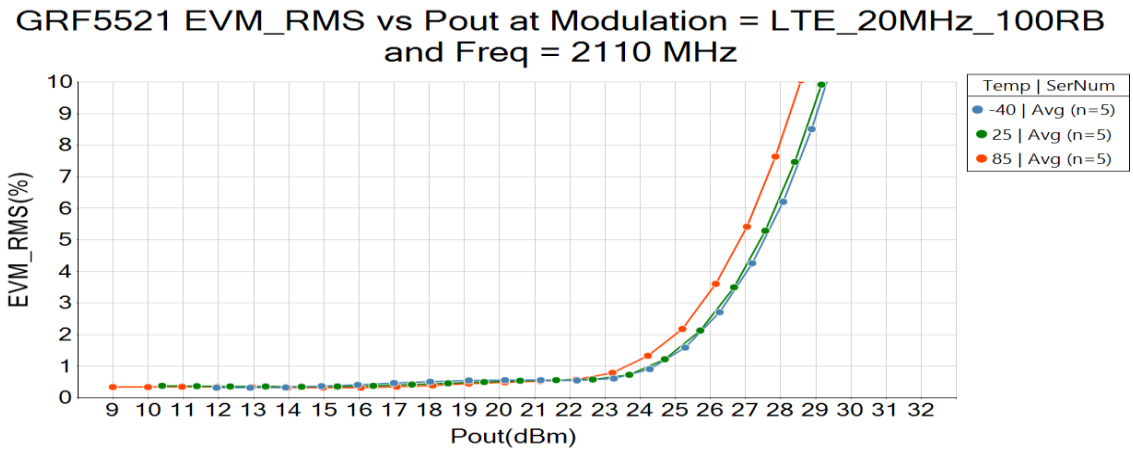


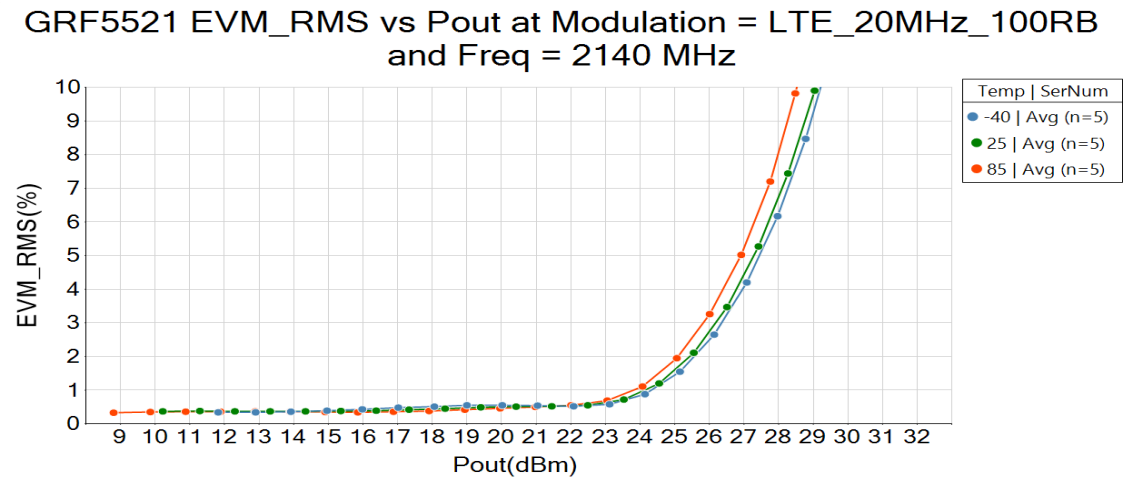


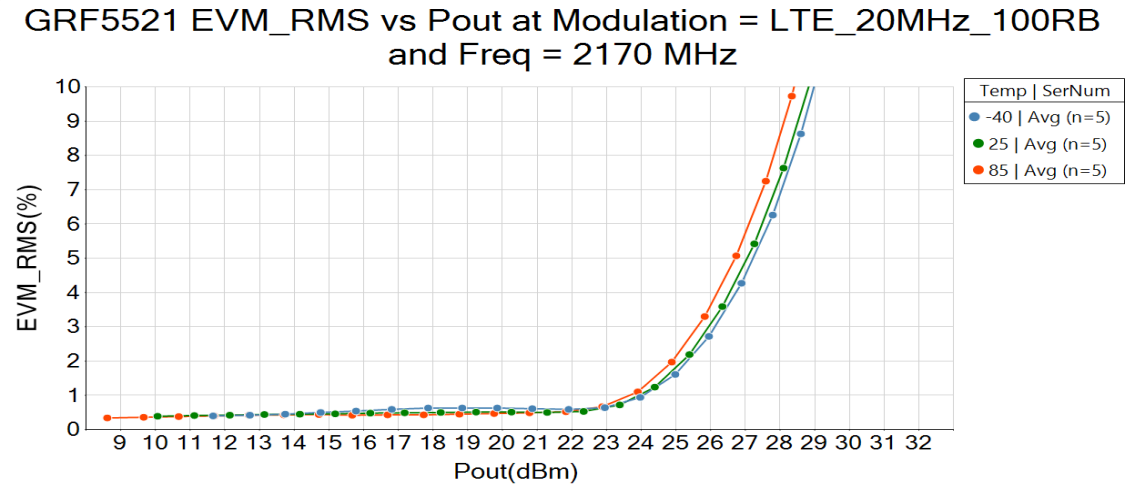


www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409

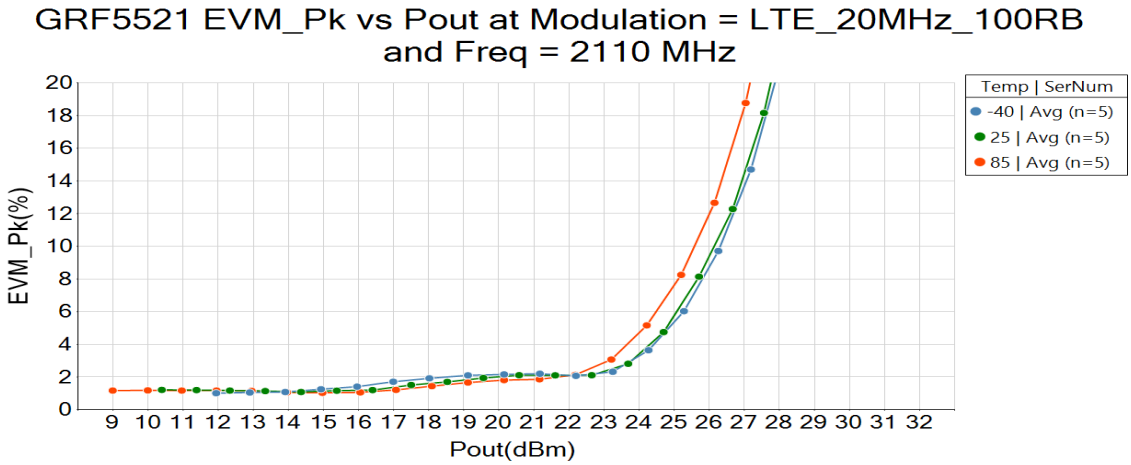
GRF5521 Typical Operating Curves: *EVM_RMS vs. P_{OUT} (9.8 dB PAR)*

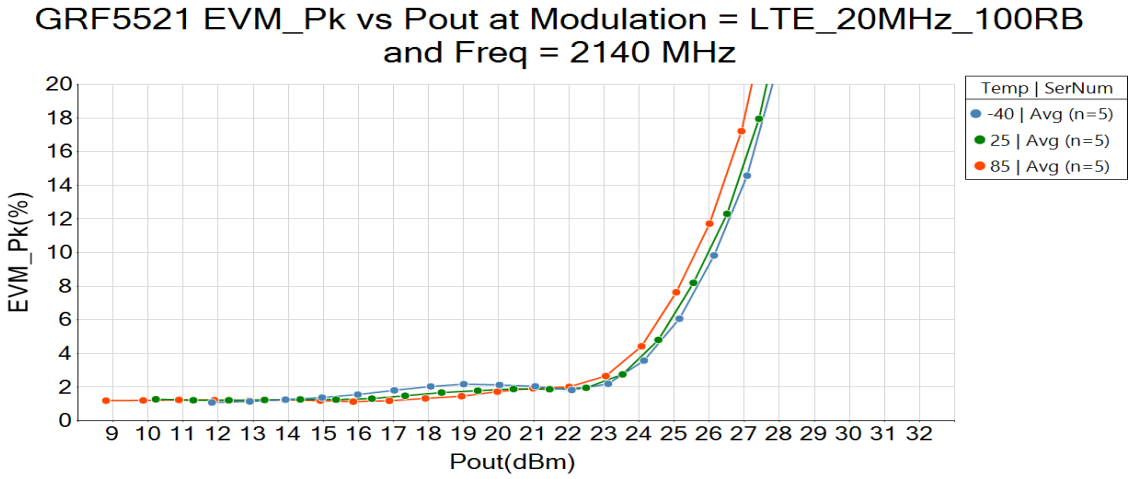


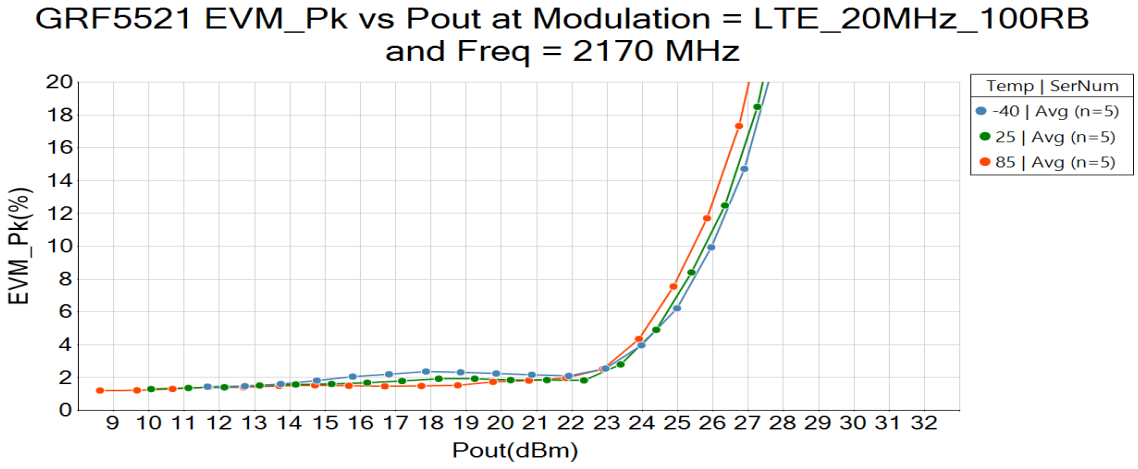




GRF5521 Typical Operating Curves: *EVM_Pk vs. POUT (9.8 dB PAR)*

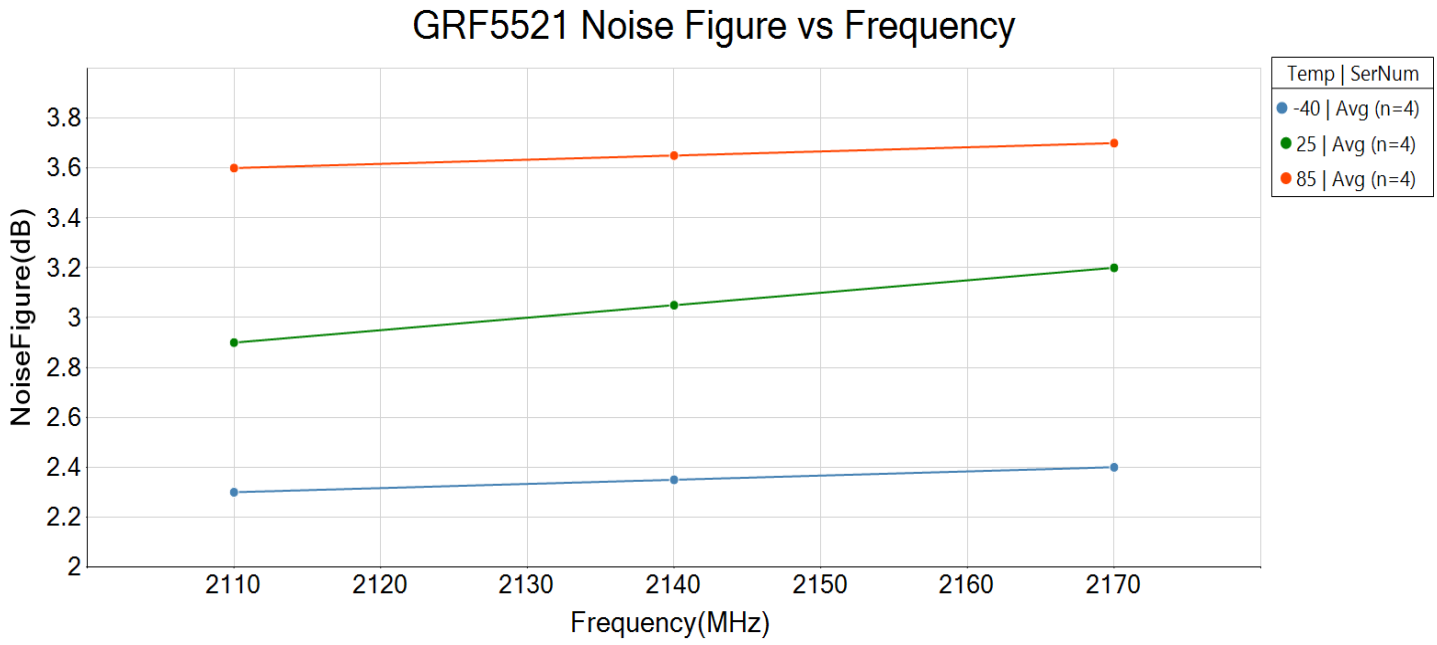




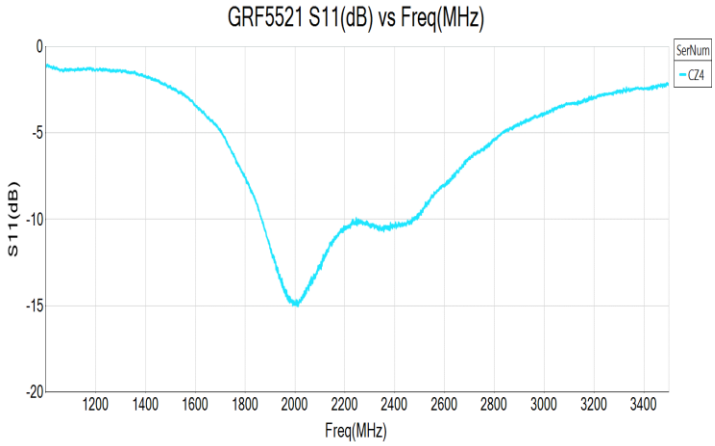


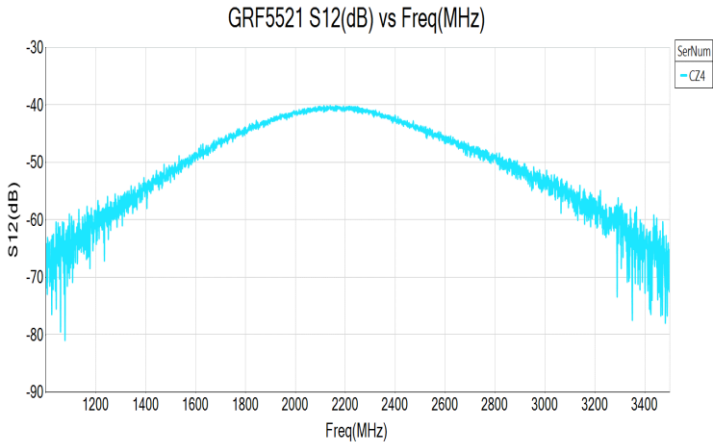
www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409

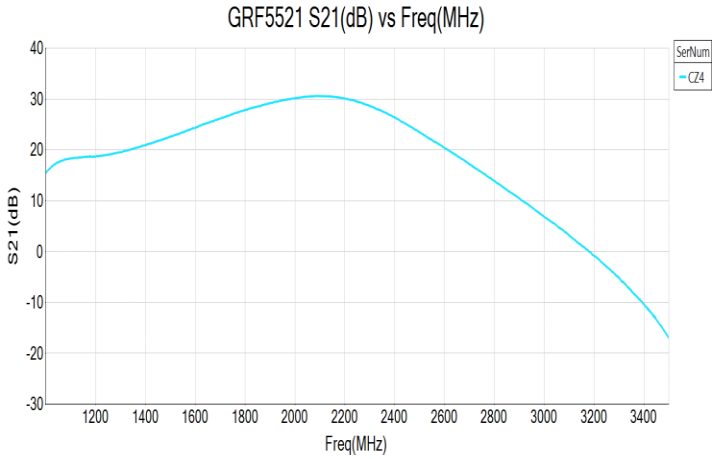
GRF5521 Typical Operating Curves: *Noise Figure (2.11 – 2.17 GHz Tune)*

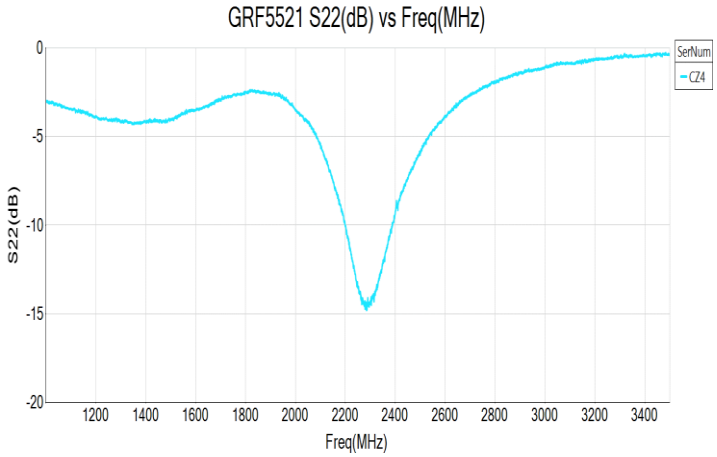


GRF5521 Typical Operating Curves: *S-Parameters (2.11 – 2.17 GHz Tune)*

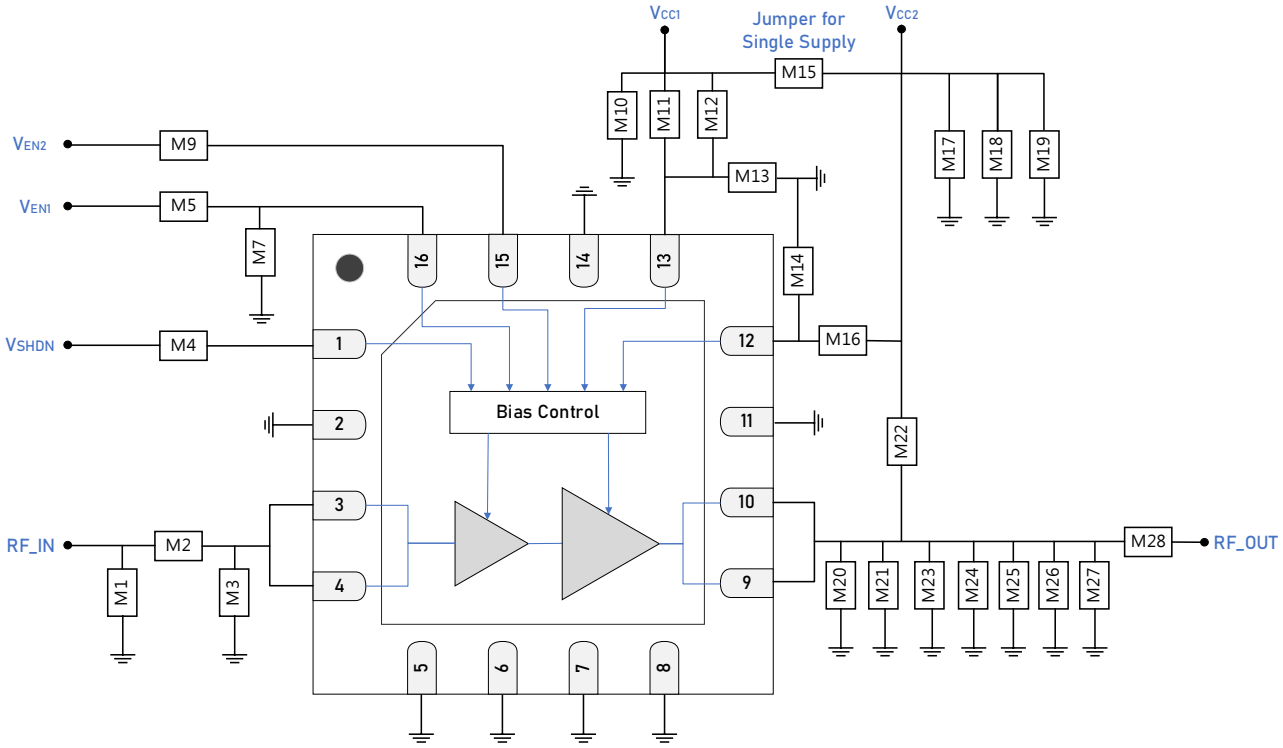




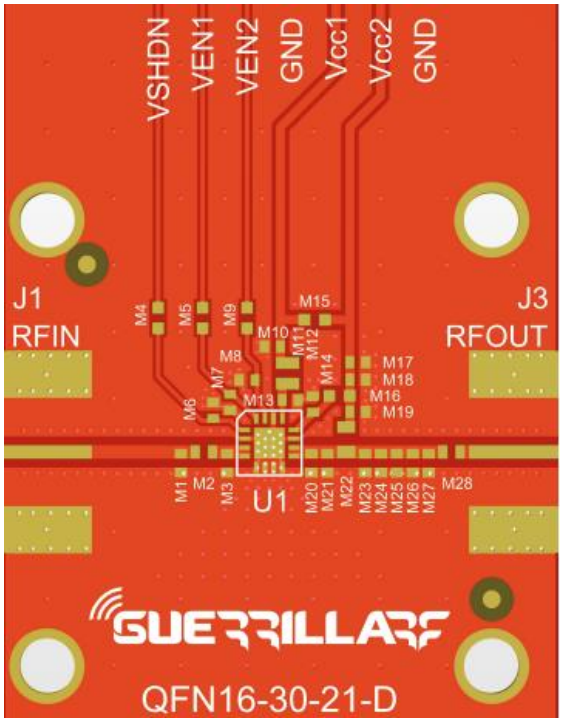




www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409



GRF5521 Standard Test Schematic



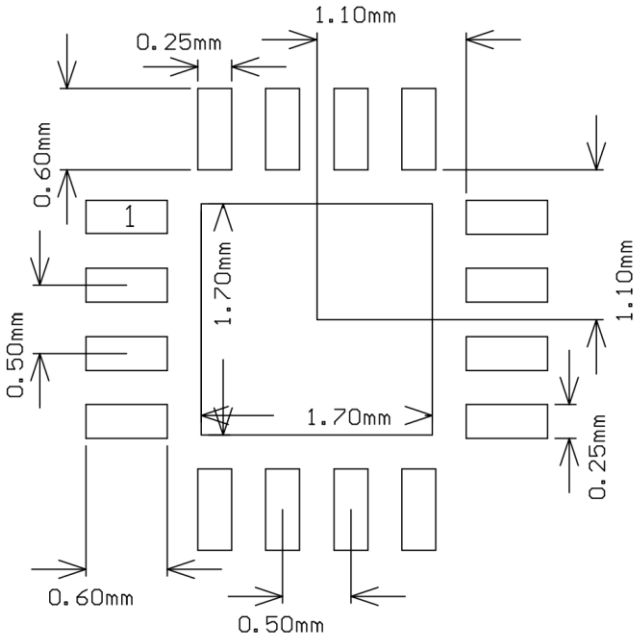
GRF5521 Evaluation Board Assembly Diagram

GRF5521 Evaluation Board Assembly Diagram Reference

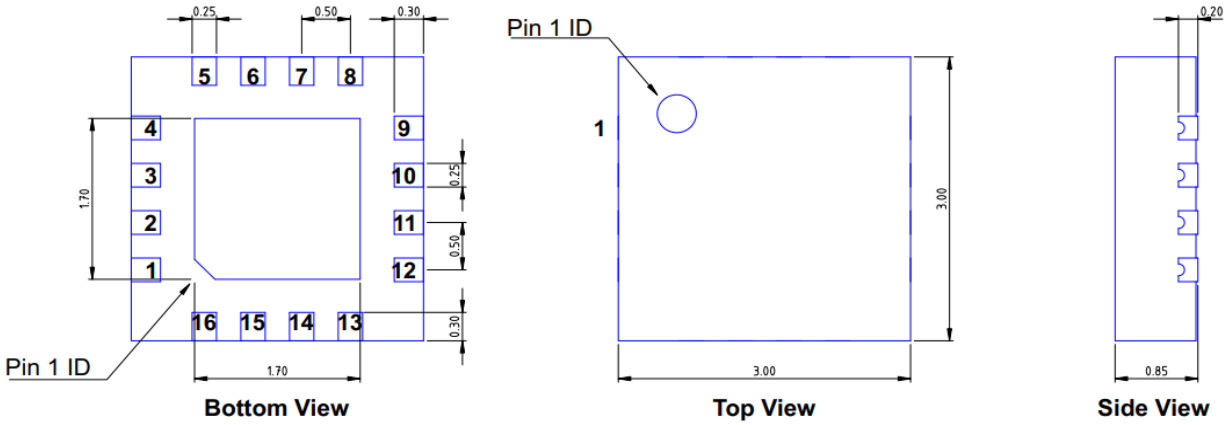
Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1	Inductor	Murata	LQG	2.7 nH	0402	ok
M2	Capacitor	Murata	GJM	2.2 pF	0402	ok
M4	Resistor	Various	5%	0 Ω	0402	ok
M5	Resistor	Various	5%	6650 Ω	0402	ok
M9	Resistor	Various	5%	4750 Ω	0402	ok
M11	Resistor	Murata	LQG	0 Ω	0402	ok
M13	Capacitor	Murata	GRM	0.1 µF	0402	ok
M14, M18	Capacitor	Murata	GRM155C80J06 ME11D	10 µF	0402	ok
M15	Resistor (jumper)	Various	5%	0 Ω	0402	ok
M16	Resistor	Various	5%	0 Ω	0402	ok
M19	Capacitor	Murata	GRM	100 pF	0402	ok
M21	Capacitor	Murata	GJM	3.6 pF	0402	ok
M22	Inductor: High Q	Murata	LQW18AN4N3B80	4.3 nH	0603	ok
M28	Capacitor	Murata	GJM	5.1pF	0402	ok
M3, M7, M10, M12, M17, M20, M23, M24, M25, M26, M27	DNP	--	--	--	--	--
Evaluation Board	QFN16-30-21-D	--	--	--	--	--

Note 4: Standard Evaluation Board Bias: V_{CC} = 5 V. V_{ENABLE} = 5 V.

www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 1196 Pleasant Ridge Road, Greensboro, NC 27409



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

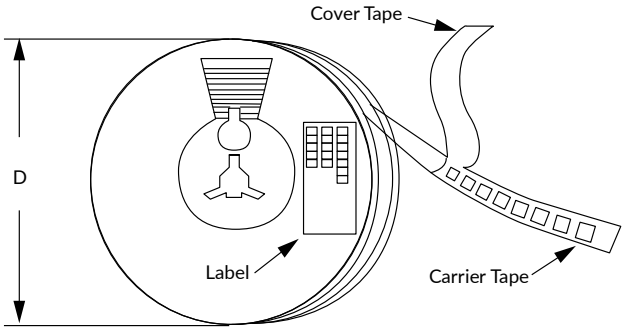
- Line 1: "YY" = YEAR. "WW" = WORK WEEK the Device was assembled.
- Line 2: "GRF" = Guerrilla RF.
- Line 3: "XXXX" = Device PART NUMBER.

Tape and Reel Information

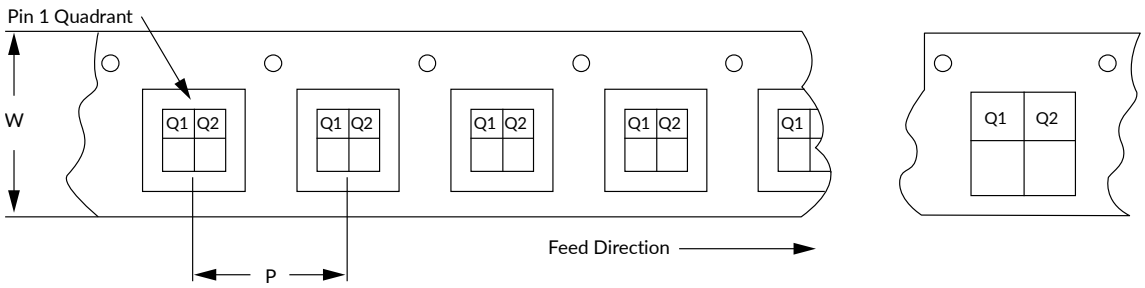
Guerrilla RF's tape and reel specification comply with Electronics Industries Association (EIA) standards for "Embossed Carrier Tape of Surface Mount Components for Automatic Handling" (reference EIA-481). See the following page for the Tape and Reel Specification and Device Package Information table, 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: *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

Revision History

Revision Date	Description of Change
July 19, 2021	Updated to new format.
May 11, 2022	Changed HBM minimum specification from TBD to 1000v.
July 21, 2022	Added new data plots. Updated EVB BOM and schematic.
October 20, 2022	Release 0 update. Replaced all TBDs in the Absolute Ratings table. Implemented changes to the datasheet formatting.

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.