

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
- Process: InGaP HBT

Reference: 5 V / 115 mA I_{CCQ} / 2.14 GHz

- Gain: 31 dB
- OIP3: 45 dBm at +23 dBm P_{OUT} / Tone
- OP1dB: 33 dBm
- Evaluation Board Noise Figure: 3.1 dB

APPLICATIONS

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

DESCRIPTION

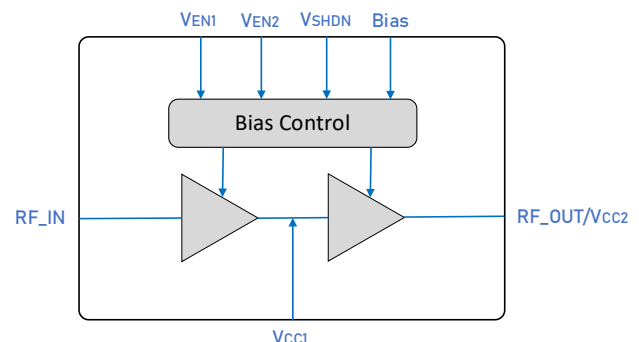
The GRF5521 is a high gain, two-stage InGaP HBT power amplifier designed to deliver excellent P1dB, ACLR and IM3 performance over the 2110 to 2170 MHz band. Its exceptional native linearity makes it an ideal choice for transmitter applications that typically do not employ digital predistortion correction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

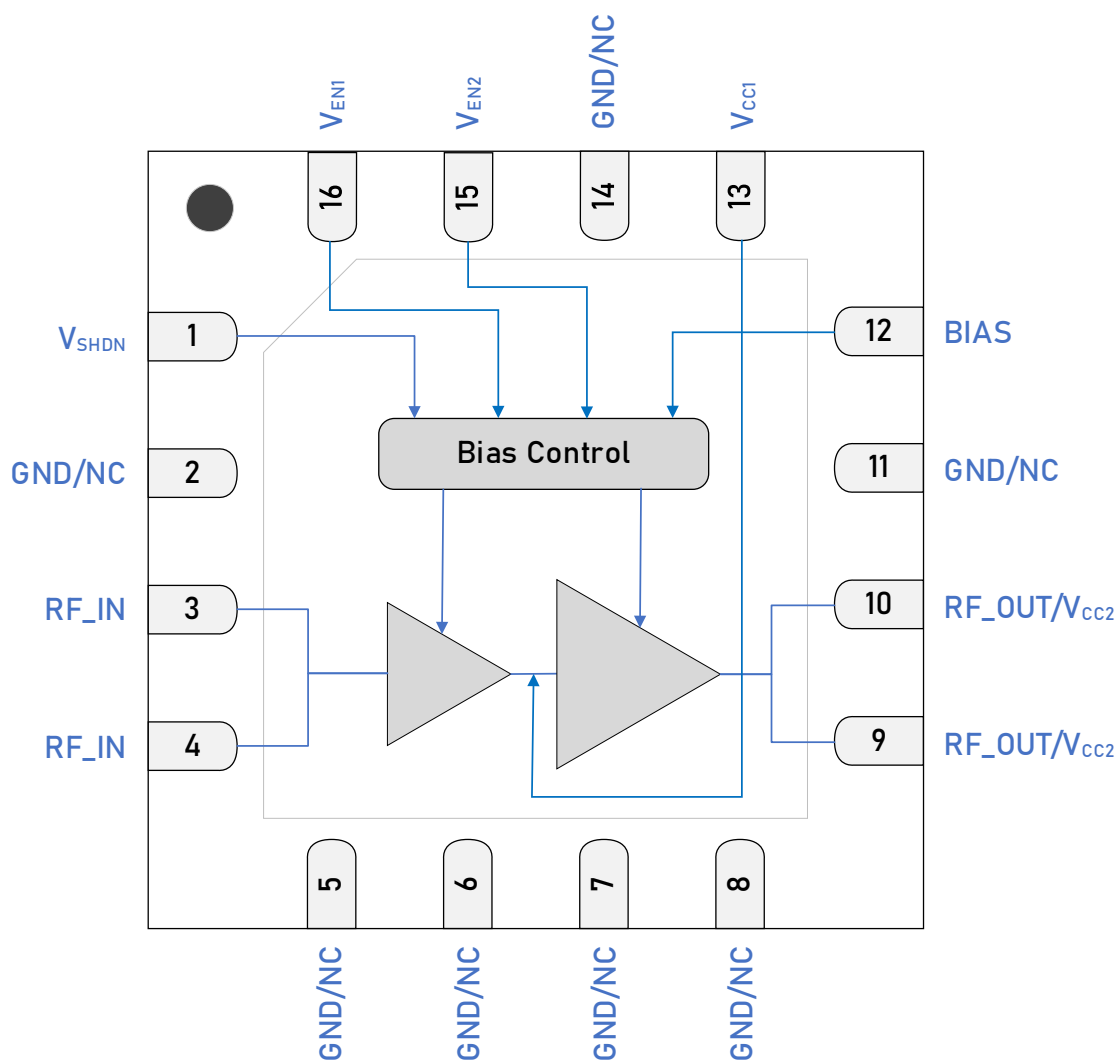
This device is part of a complete family of externally matched linear amplifiers that cover the following frequency ranges:

GRF5506: 0.66 - 0.72 GHz	GRF5518: 1.8 - 2.0 GHz
GRF5507: 0.7 - 0.91 GHz	GRF5519: 1.92 - 2.2 GHz
GRF5508: 0.777 - 0.96 GHz	GRF5521: 2.11 - 2.17 GHz
GRF5510: 0.88 - 0.96 GHz	GRF5526: 2.2 - 2.7 GHz
GRF5517: 1.6 - 1.92 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 3 mm 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	Pins 3 & 4 tied together on system board. Internally matched to 50 Ω. An external DC blocking capacitor 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 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 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 ground is required for optimal NF performance.
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}		5.5	V
RF Input Power	50 Ω , V_{CC} = 5 V, CW Tone, 100% DC, $T_{PKG\ BASE}$ = 25 °C.	$P_{IN\ MAX - 1:1}$		23	dBm
	Load VSWR < 8:1, all phase angles, V_{CC} = 5 V, CW Tone, 100% DC, $T_{PKG\ BASE}$ = -40 to 85 °C.	$P_{IN\ MAX - 8:1}$		20	
Operating Temperature (package base)		$T_{PKG\ BASE}$	-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](#).



Recommended Operating Conditions

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Voltage	V_{CC}	3	5	5.5	V	
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).
Operating Temperature (package base)	$T_{PKG\ BASE}$	-40		85	°C	
RF_IN Port Impedance	Z_{RF_IN}		50		Ω	Single-ended with 2-element Match.
RF_OUT Port Impedance	Z_{RF_OUT}		50		Ω	Single-ended with 3-element Match.

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 *Band 1* 2.11 to 2.17 GHz tuning set. $V_{CC} = 4.75$ to 5.25 V, $V_{SHDN} = \text{LOW}$, $I_{CCQ} = 115$ mA, $M5 = 6650 \Omega$, $M9 = 4750 \Omega$, $P_{OUT} = 23$ dBm, $F_{TEST} = 2.14$ GHz, 50Ω system impedance. $T_{PKG \text{ BASE}} = 25^\circ\text{C}$. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Current (Quiescent)	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, $P_{OUT} = 23$ dBm.
Enable Current 1	$I_{ENABLE1}$		2.5		mA	$V_{CC} = 5$ V. $T_{PKG \text{ BASE}} = 25^\circ\text{C}$.
Enable Current 2	$I_{ENABLE2}$		1.5		mA	$V_{CC} = 5$ V. $T_{PKG \text{ BASE}} = 25^\circ\text{C}$.
Operating Temperature Range	$T_{PKG \text{ BASE}}$	-40		85	$^\circ\text{C}$	Measured on package base.
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 Current (Quiescent)	$I_{CCQ-SHDN}$		1		μA	$V_{CC} = 5$ V, $V_{SHDN} = \text{HIGH}$.
Enable Current 1	$I_{ENABLE1-SHDN}$		3		mA	$V_{CC} = 5$ V, $V_{SHDN} = \text{HIGH}$.
Enable Current 2	$I_{ENABLE2-SHDN}$		1.3		mA	$V_{CC} = 5$ V, $V_{SHDN} = \text{HIGH}$.

Thermal Data

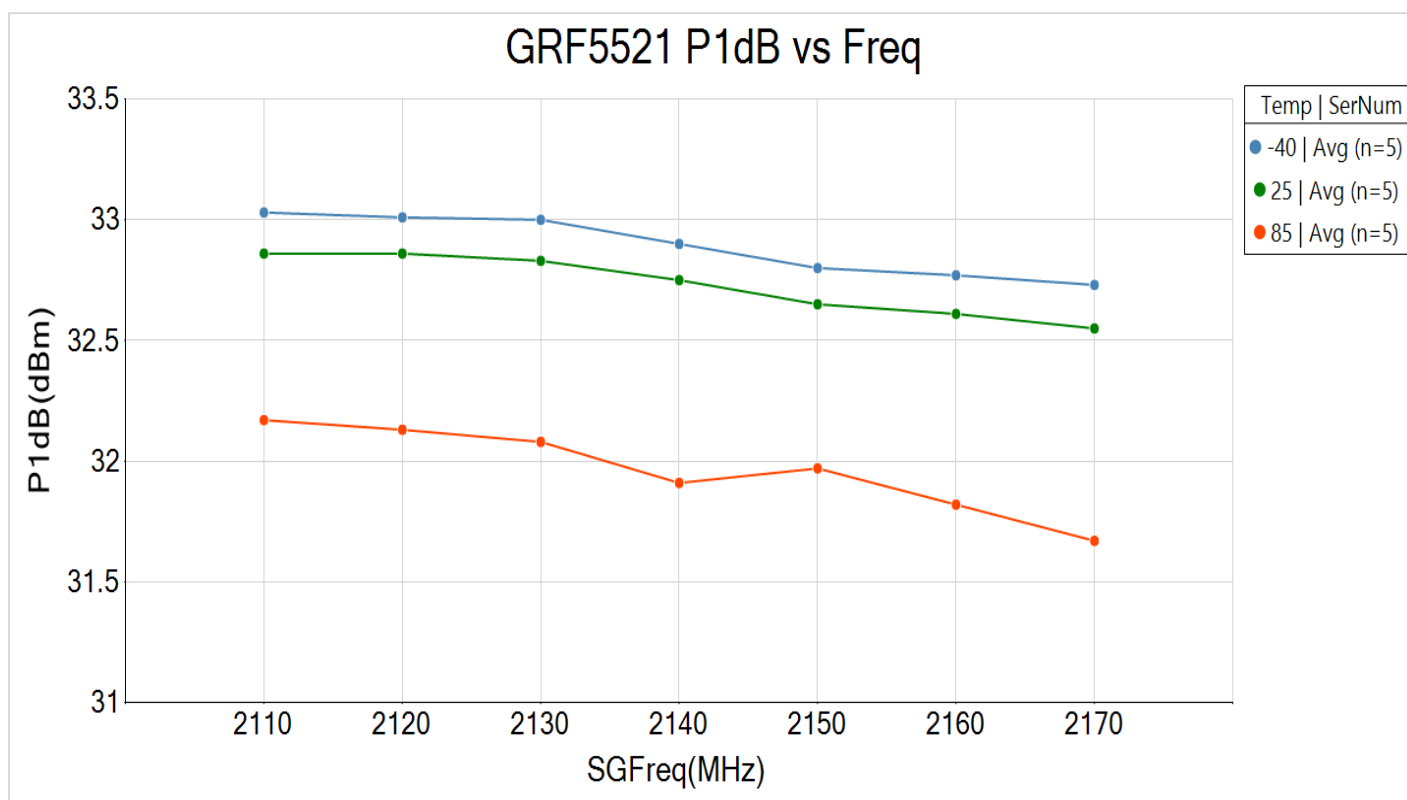
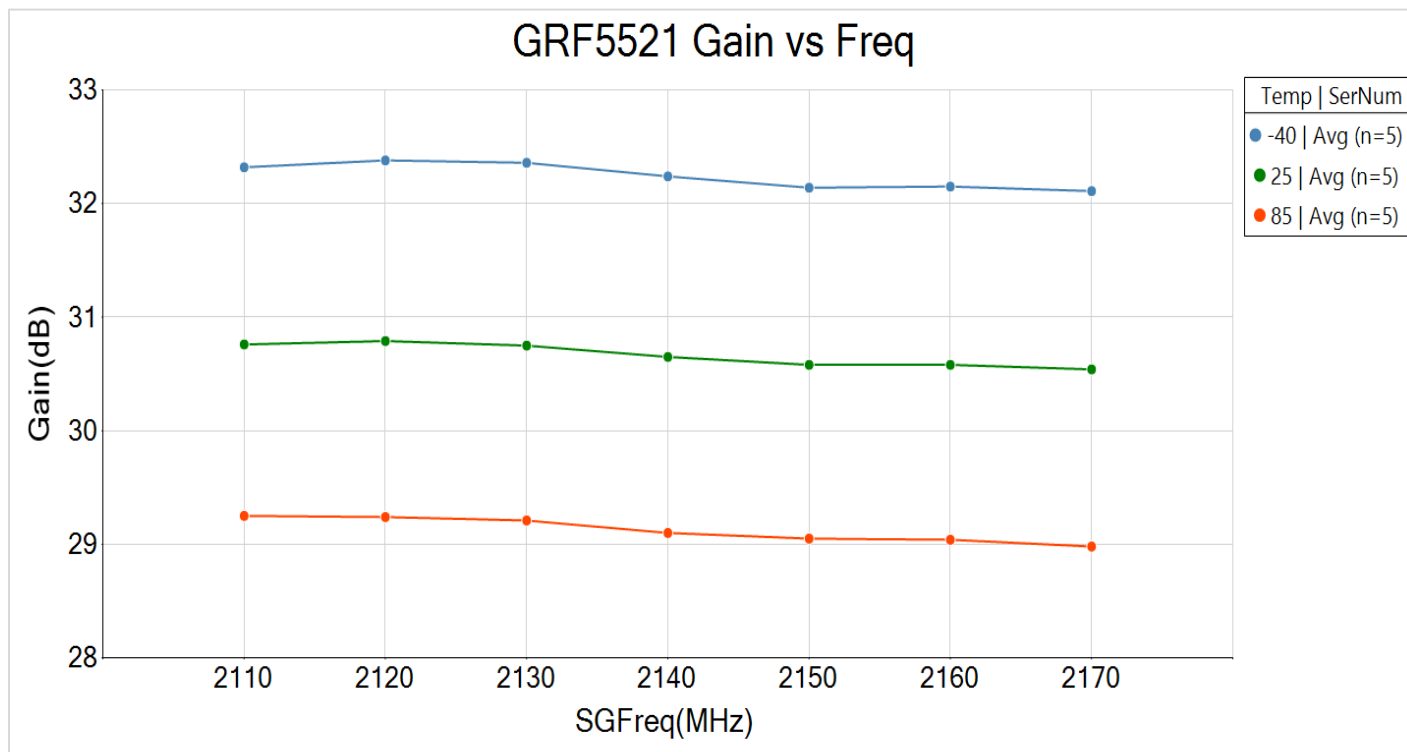
Thermal Resistance (Infrared Scan)	Θ_{JC}		38		$^\circ\text{C/W}$	On standard evaluation board.
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**Nominal Operating Parameters – RF (RF Band 1, 2.11 to 2.17 GHz, 5 V Operation)**

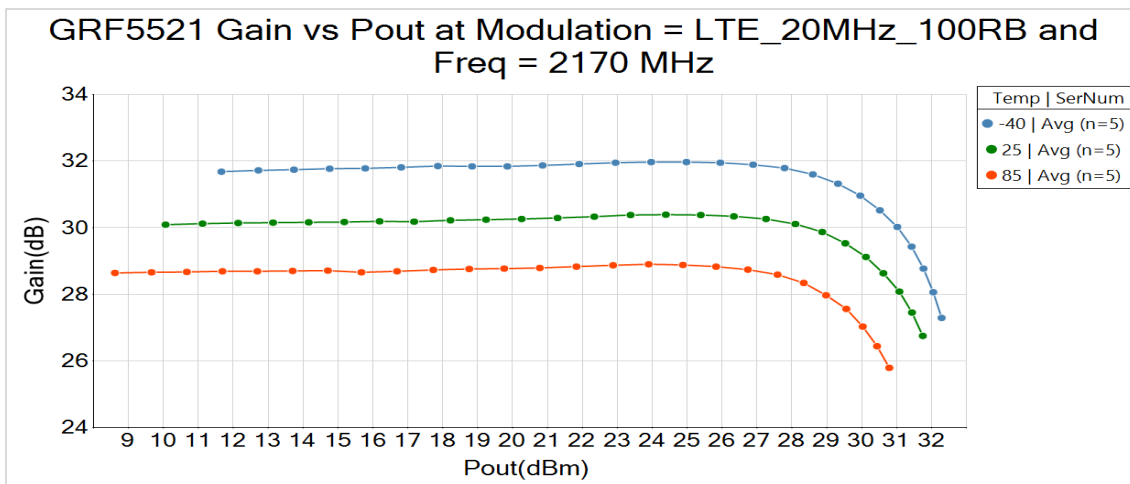
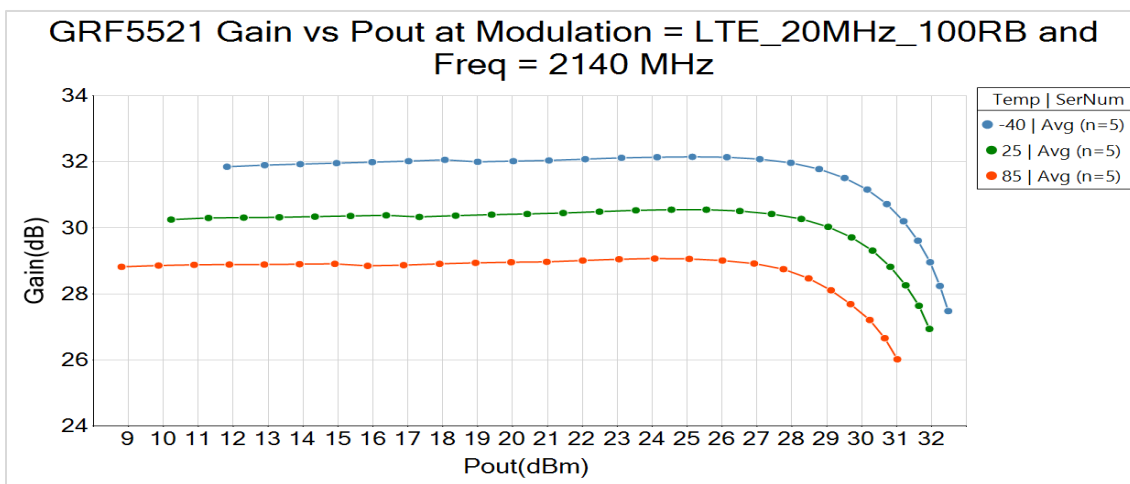
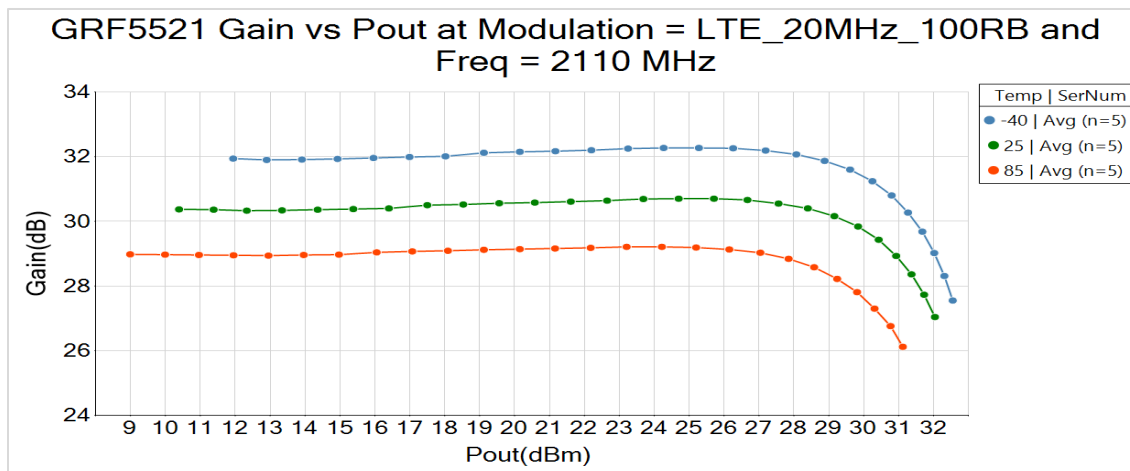
The following conditions apply unless noted otherwise: typical application schematic using the *Band 1* 2.11 to 2.17 GHz tuning set. $V_{CC} = 4.75$ to 5.25 V, $V_{SHDN} = \text{LOW}$, $I_{CCQ} = 115$ mA, $M5 = 6650 \Omega$, $M9 = 4750 \Omega$, $P_{OUT} = 23$ dBm, $F_{TEST} = 2.14$ GHz, 50Ω system impedance. $T_{PKG \text{ BASE}} = 25^\circ\text{C}$. Evaluation board losses are included within the specifications.

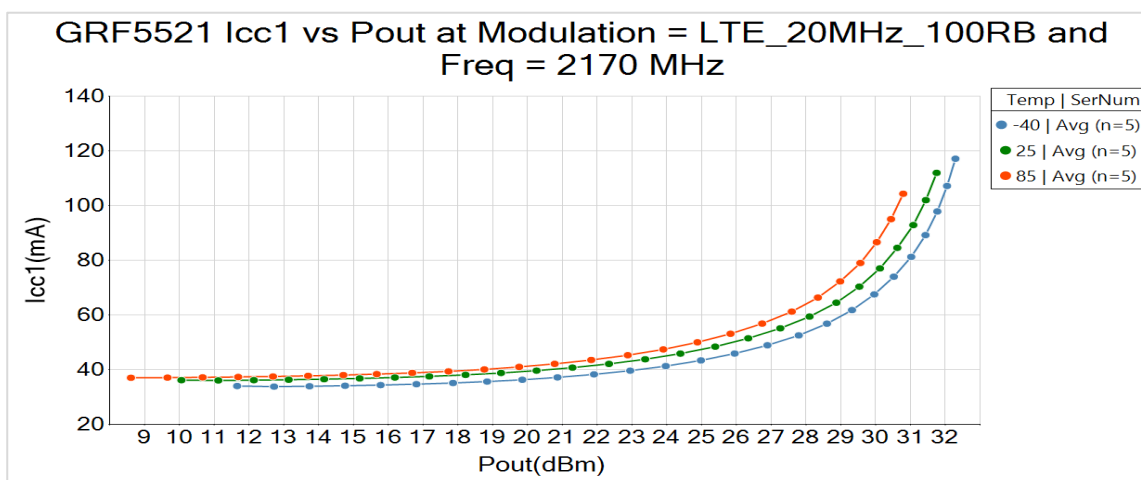
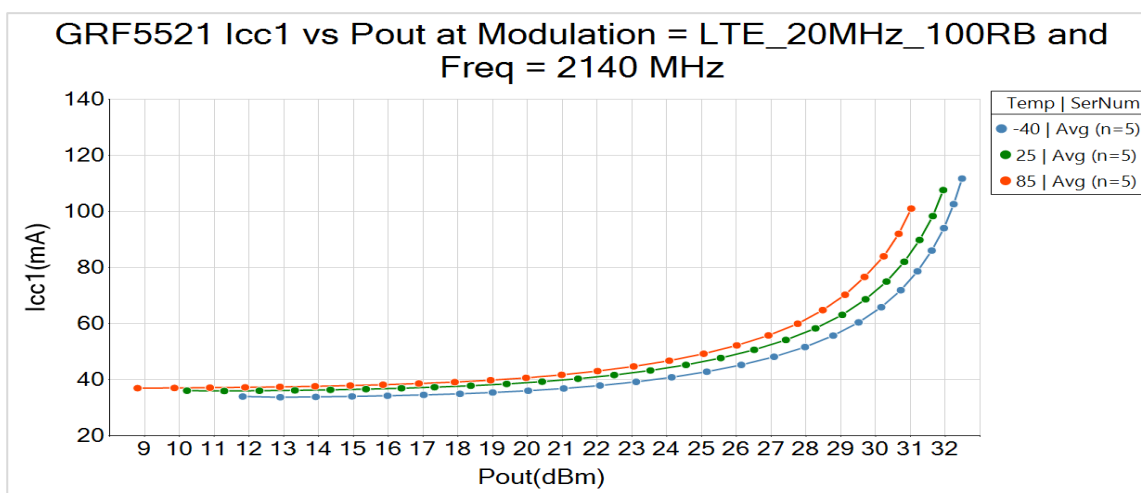
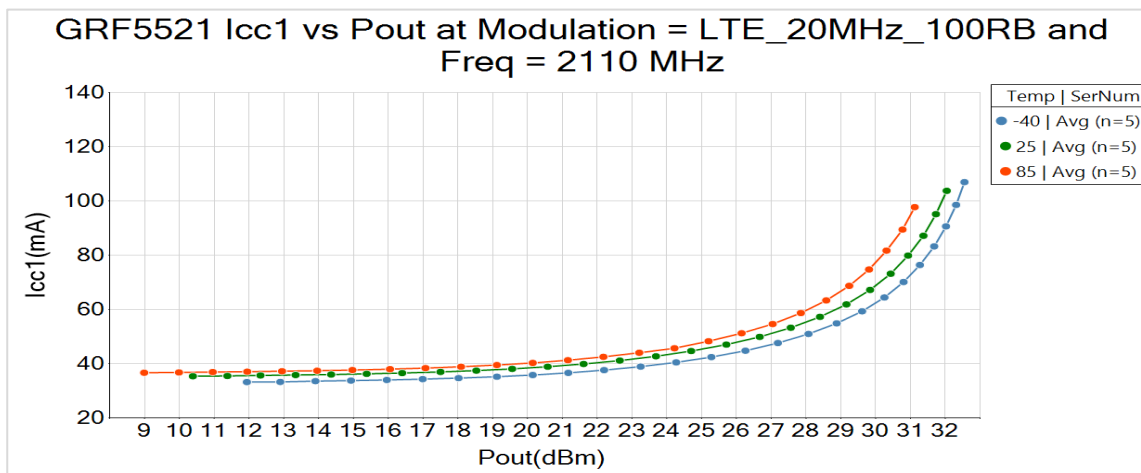
Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Small Signal Gain	S21	29	31		dB	$V_{CC} = 5$ V, $P_{IN} = -25$ dBm, $F_{TEST} = 2.14$ GHz, LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8 dB PAR, $T_{PKG \text{ BASE}} = 25^\circ\text{C}$. Note 3.
Standby Mode Gain	S21 _{STBY}		-45		dB	Disabled mode: $P_{IN} = 0$ dBm, $V_{SHDN} = \text{HIGH}$, LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8 dB PAR.
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.
Noise Figure	NF		3.1		dB	On standard evaluation board.
Output 3rd Order Intercept Point	OIP3		45		dBm	$P_{OUT} = 23$ dBm per tone at 600 kHz spacing.
Output 1 dB Compression Power	OP1dB	31.5	33		dBm	$V_{CC} = 5$ V, sine wave input, $T_{PKG \text{ BASE}} = 25^\circ\text{C}$. Note 3.
Adjacent Channel Leakage Ratio	ACLR			-45	dBc	$V_{CC} = 5$ V, $F_{TEST} = 2.14$ GHz, $P_{OUT} = 23$ dBm, LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8 dB PAR, $T_{PKG \text{ BASE}} = 25^\circ\text{C}$. Note 3.

Note 3: 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.

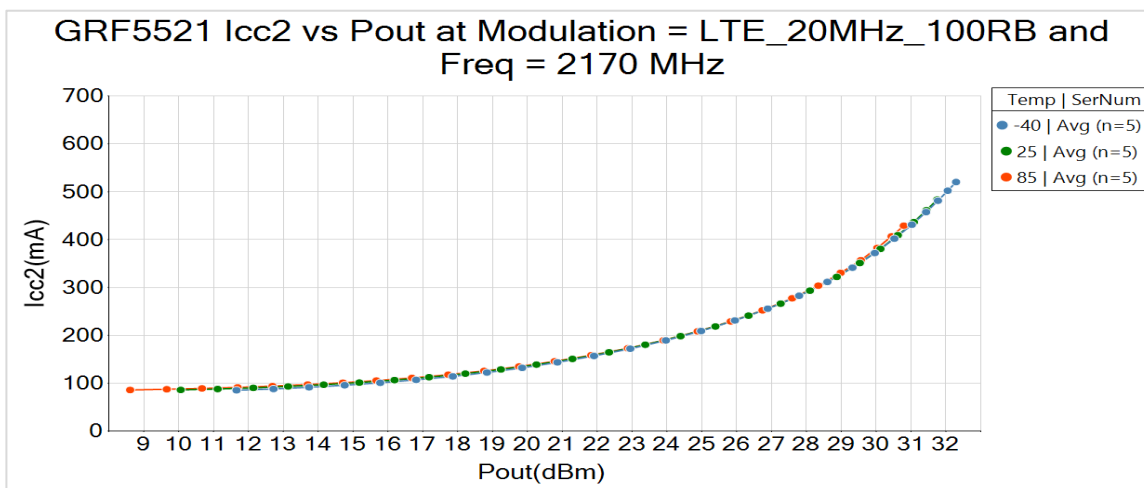
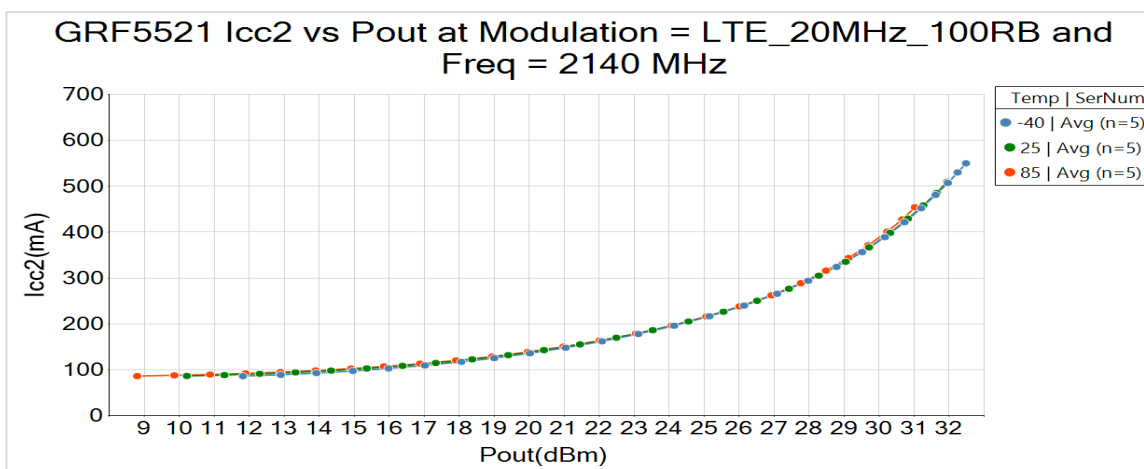
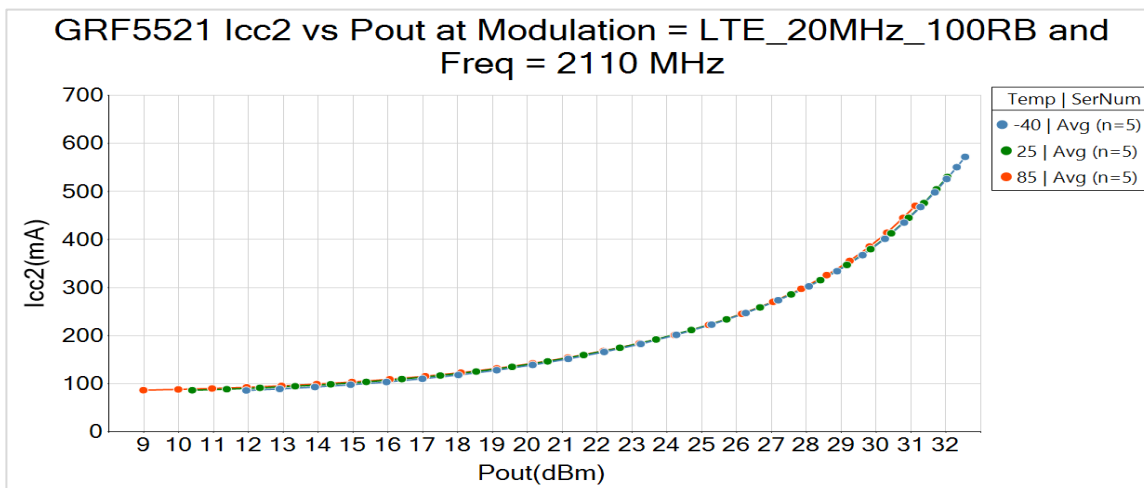
GRF5521 Typical Operating Curves: 2.11 to 2.17 GHz Tune


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

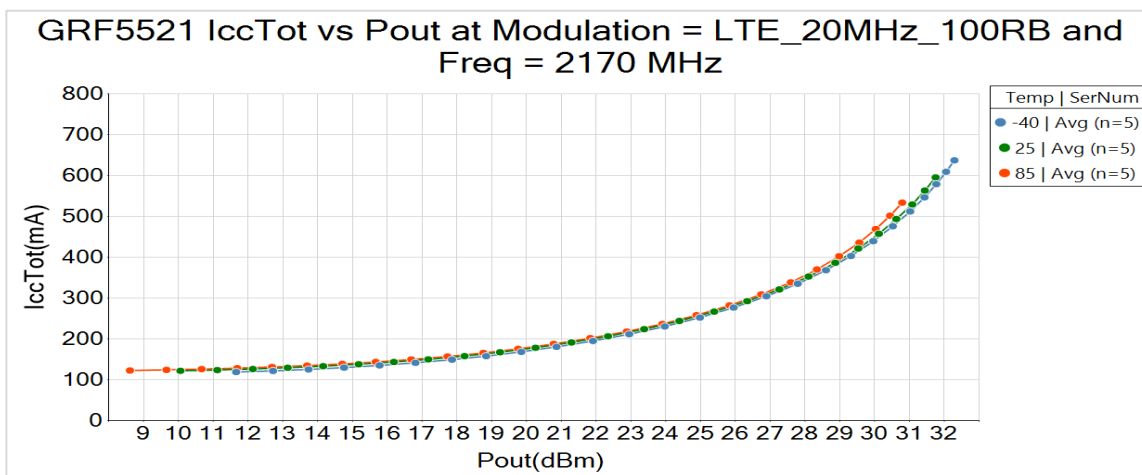
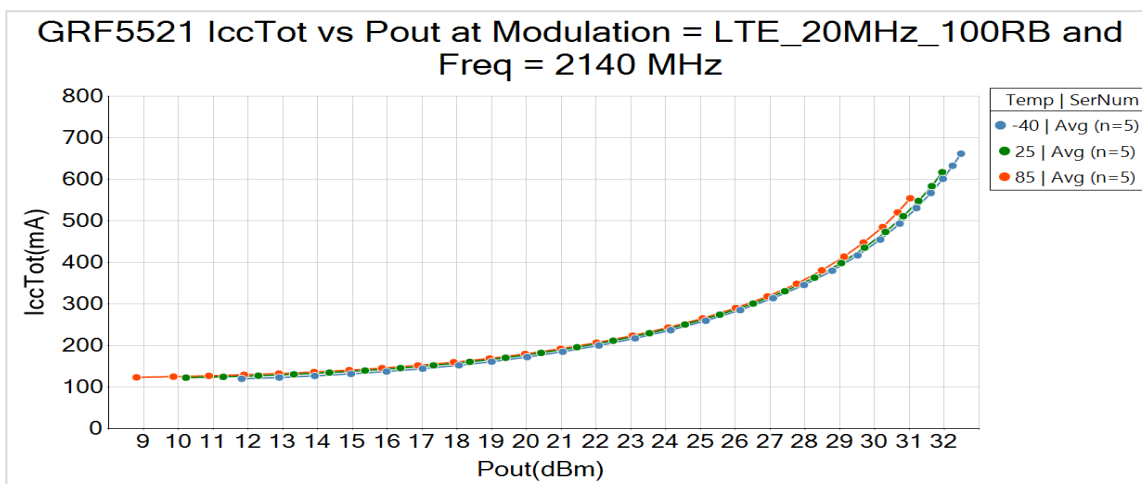
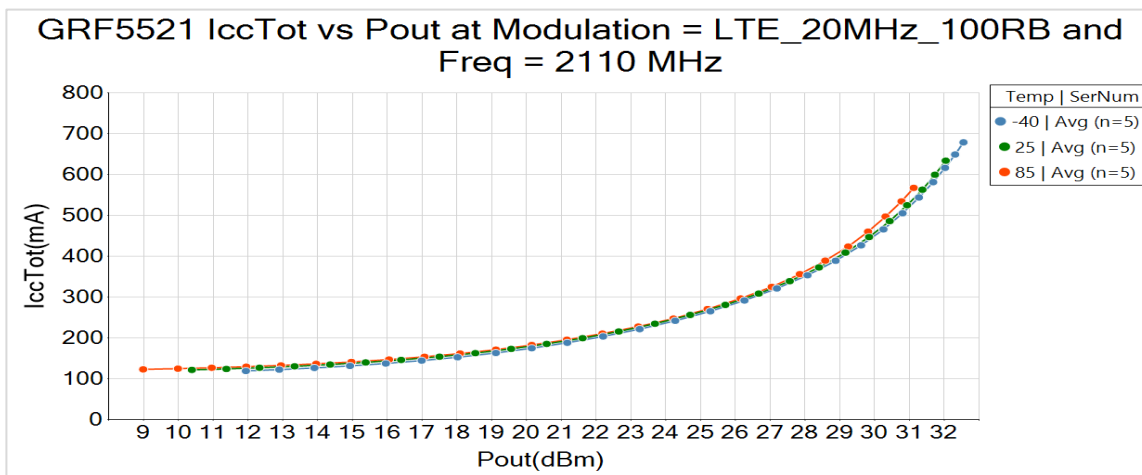


GRF5521 Typical Operating Curves: I_{CC1} vs. P_{OUT} (9.8 dB PAR)


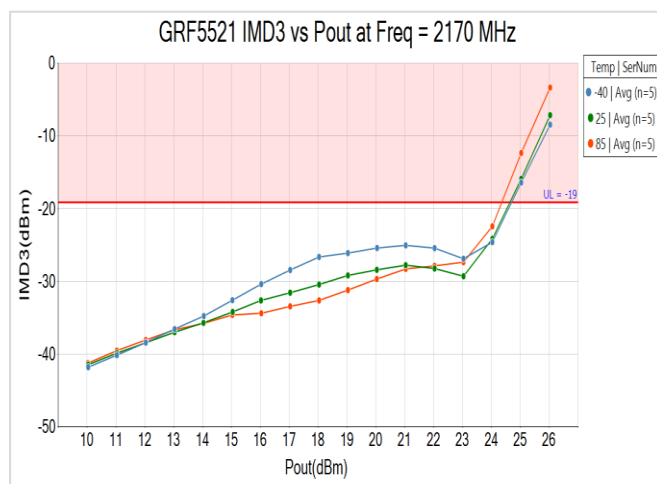
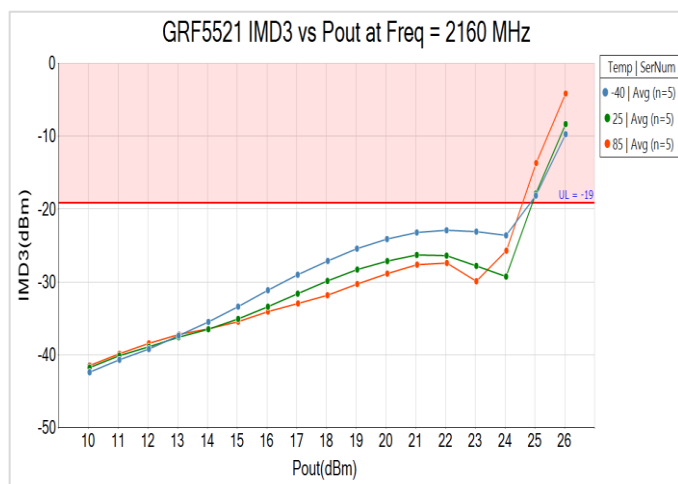
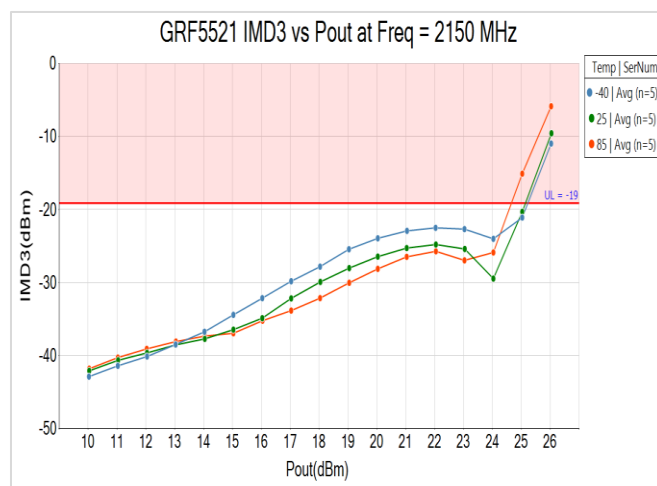
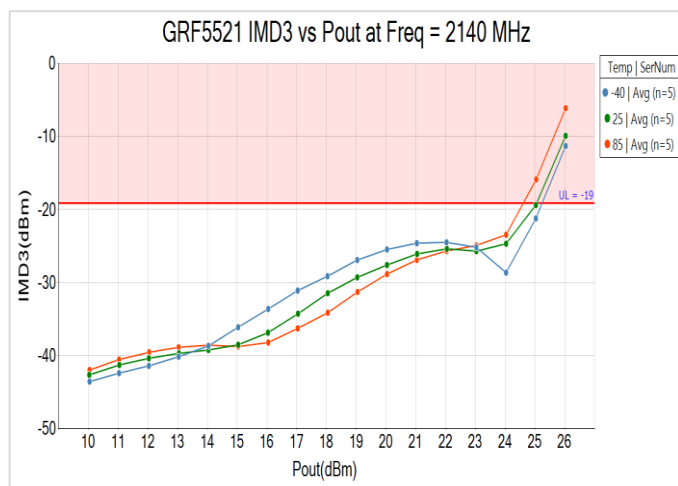
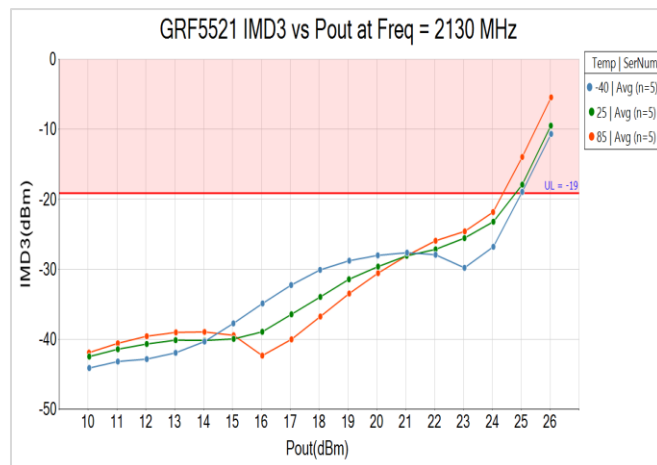
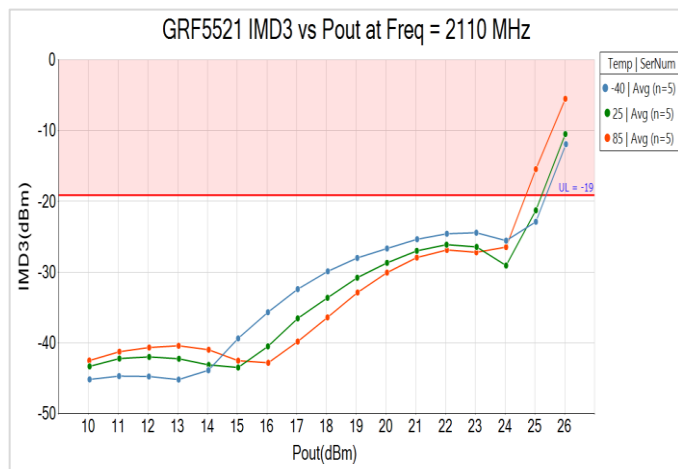
GRF5521 Typical Operating Curves: I_{CC2} vs. P_{OUT} (9.8 dB PAR)



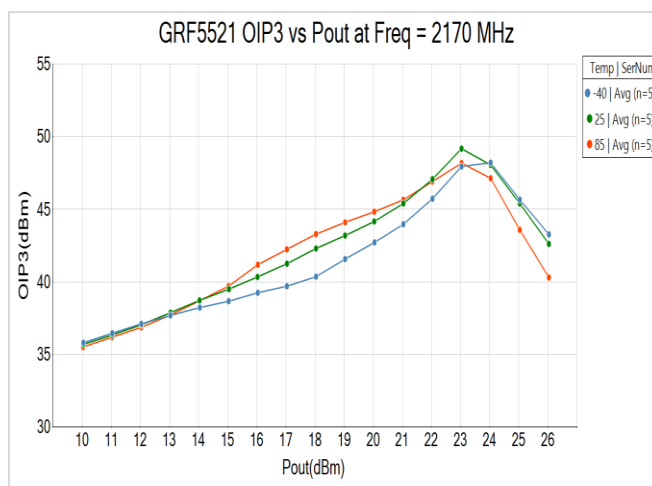
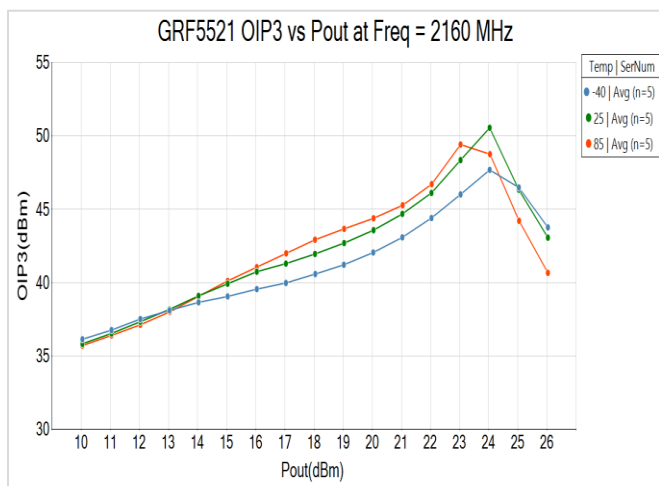
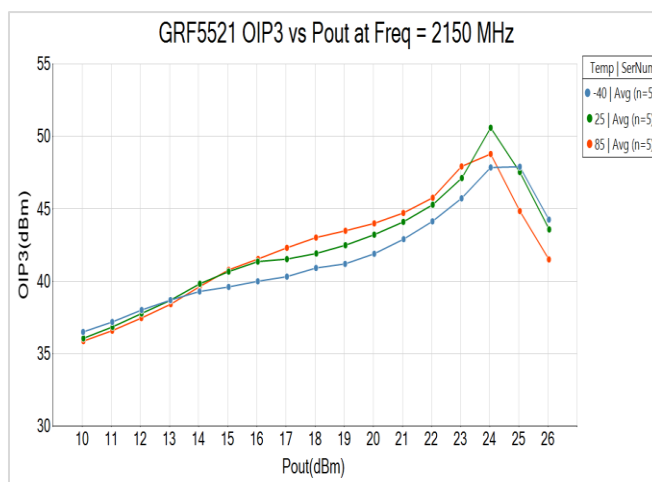
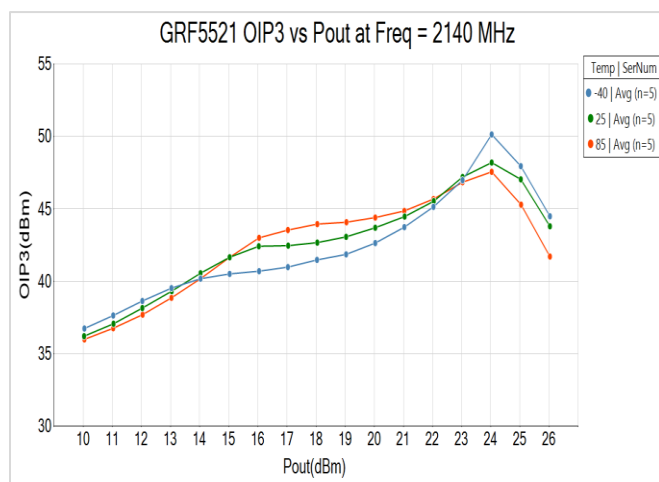
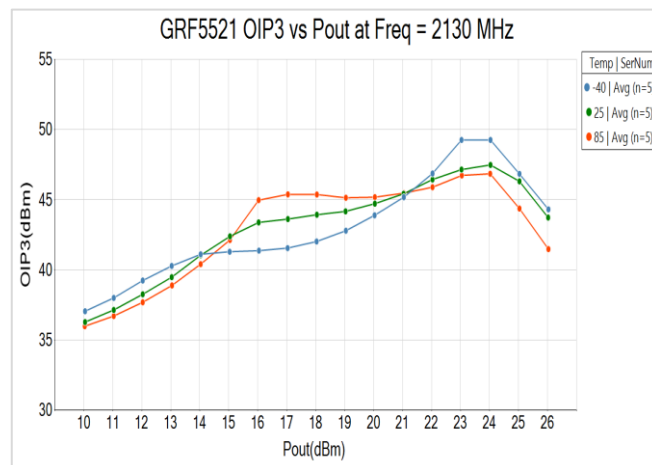
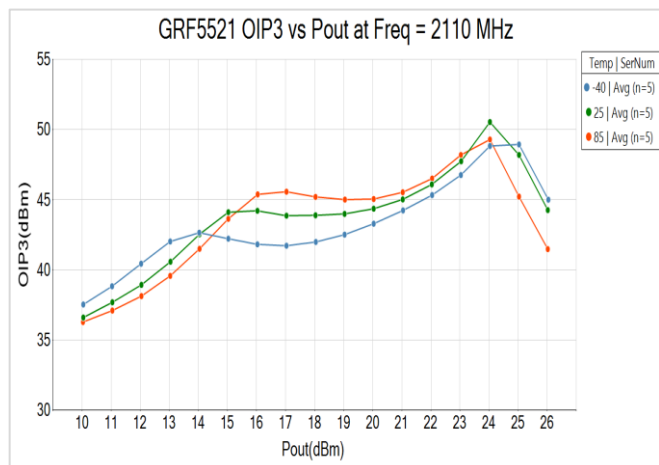
GRF5521 Typical Operating Curves: $I_{CC-TOTAL}$ vs. P_{OUT} (9.8 dB PAR)

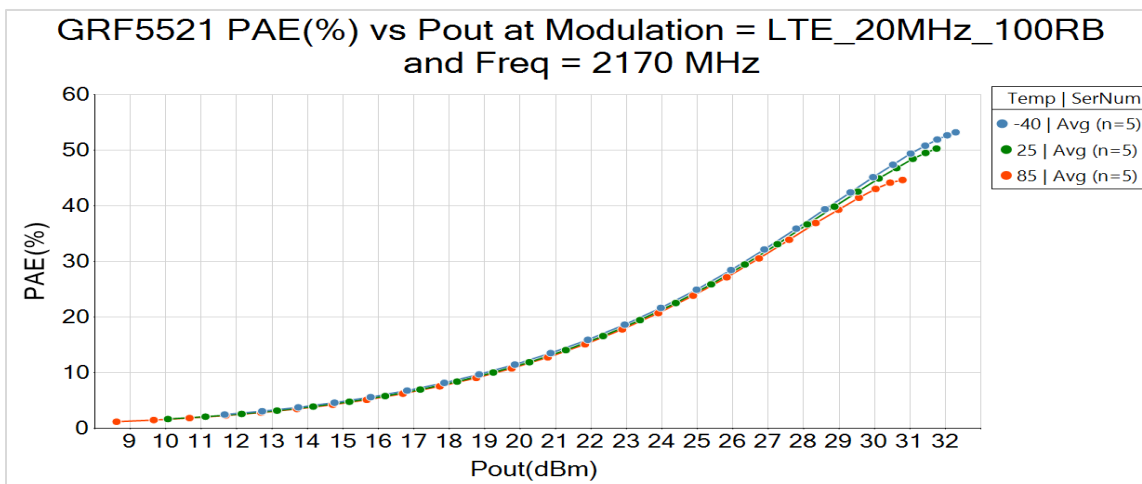
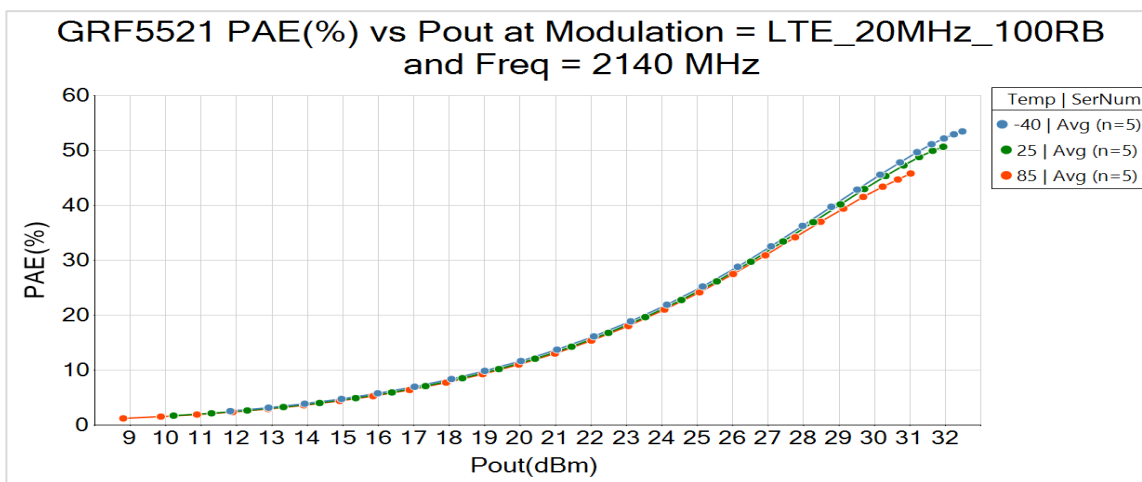
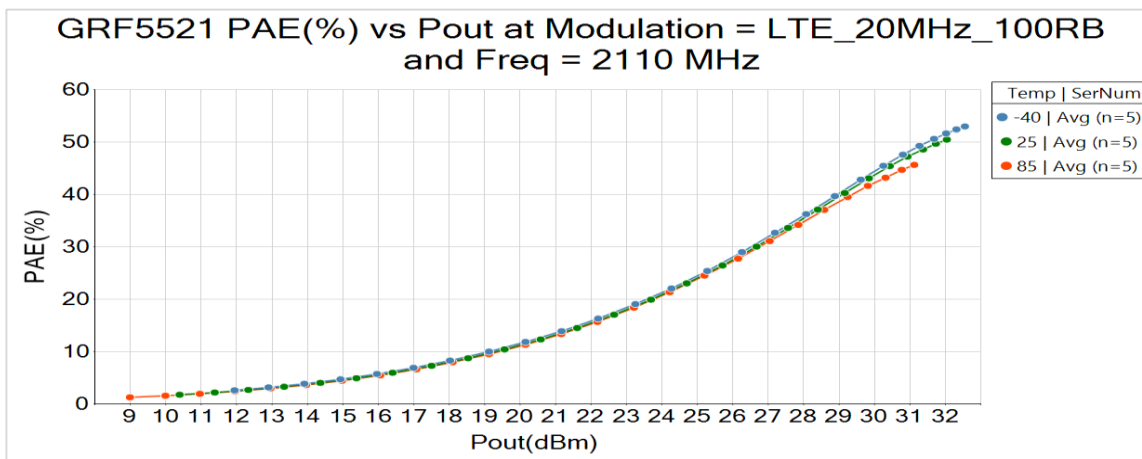


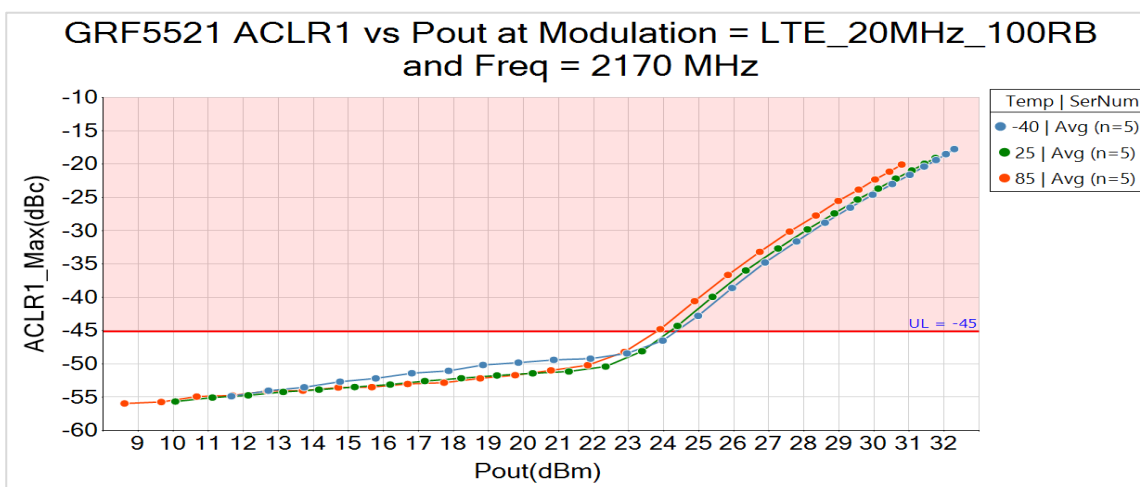
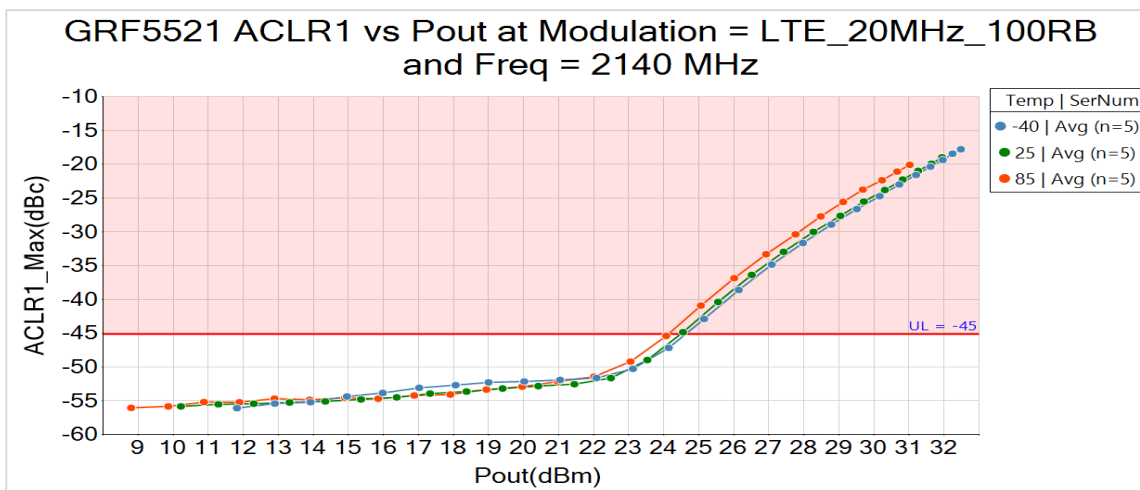
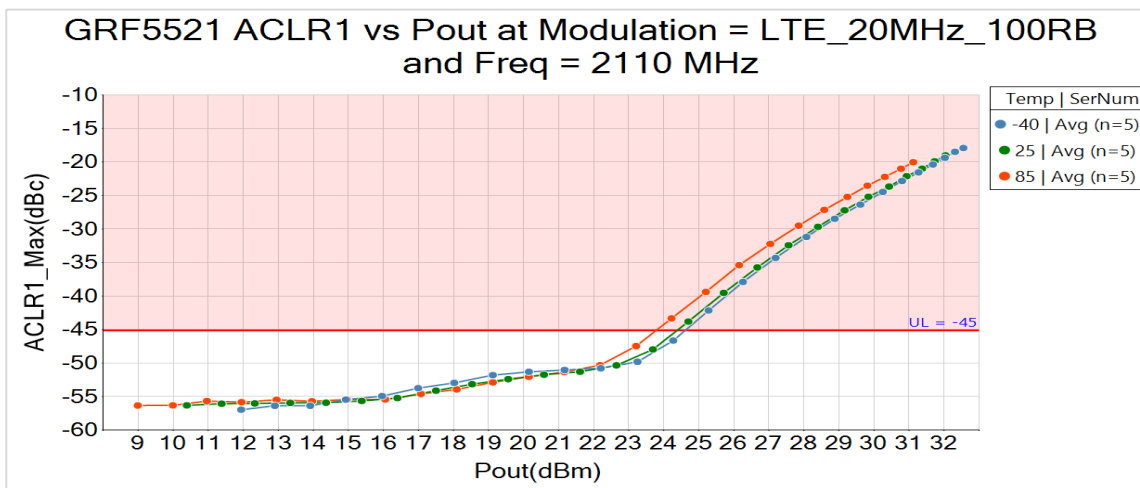
GRF5521 Typical Operating Curves: IMD3 vs. P_{OUT} (Per Tone at 600 kHz Spacing)

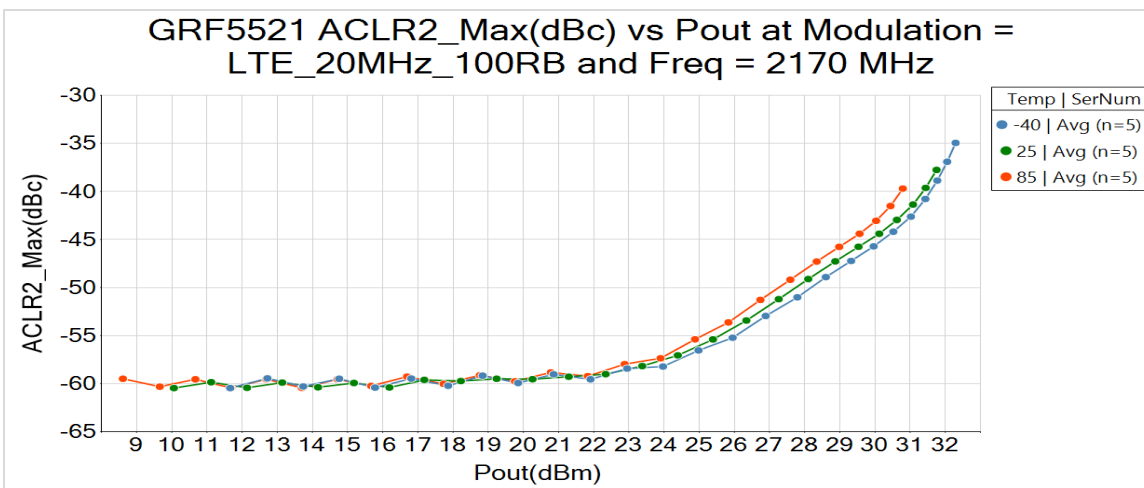
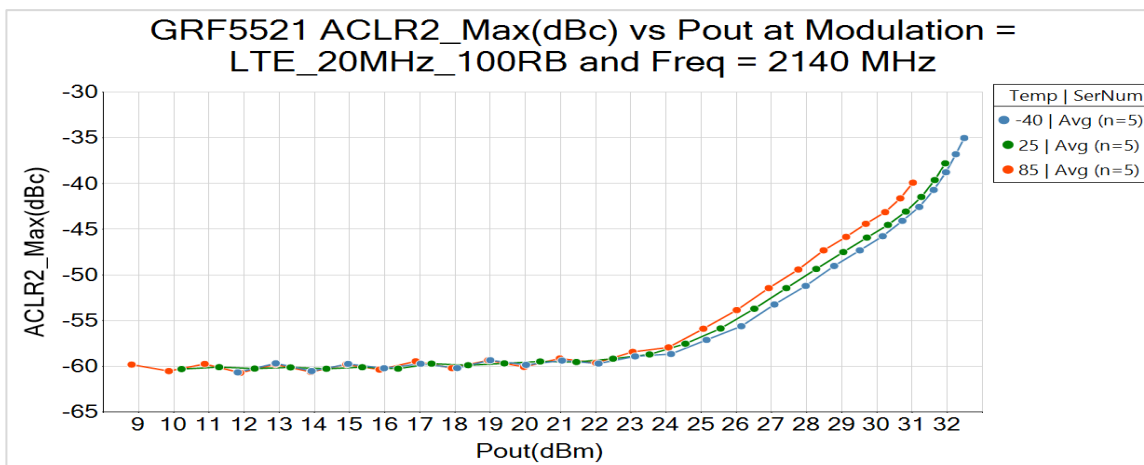
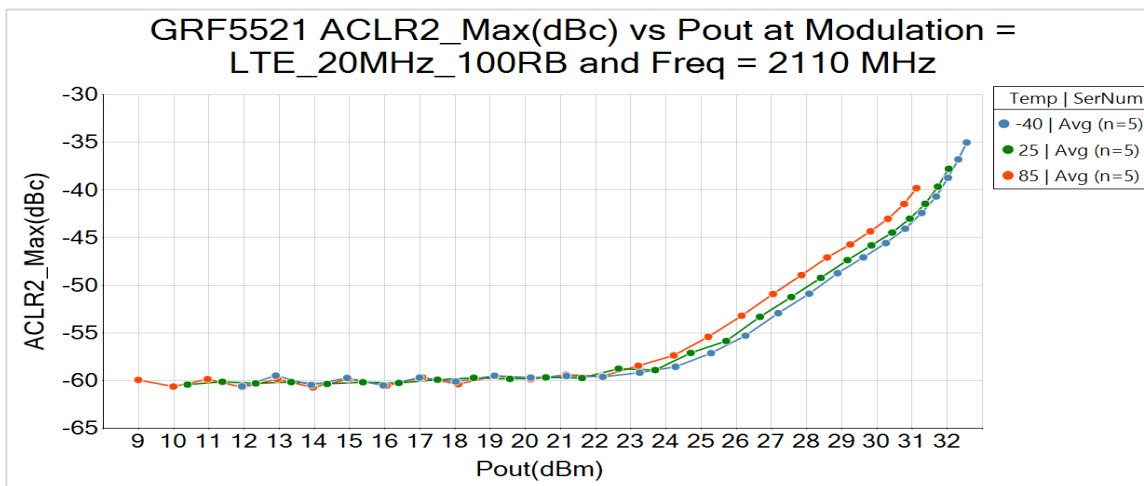


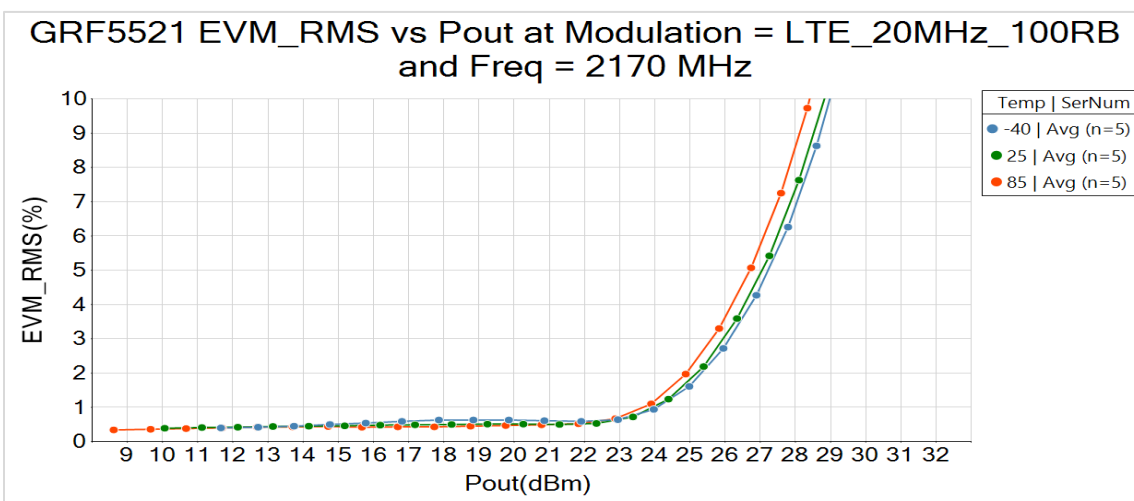
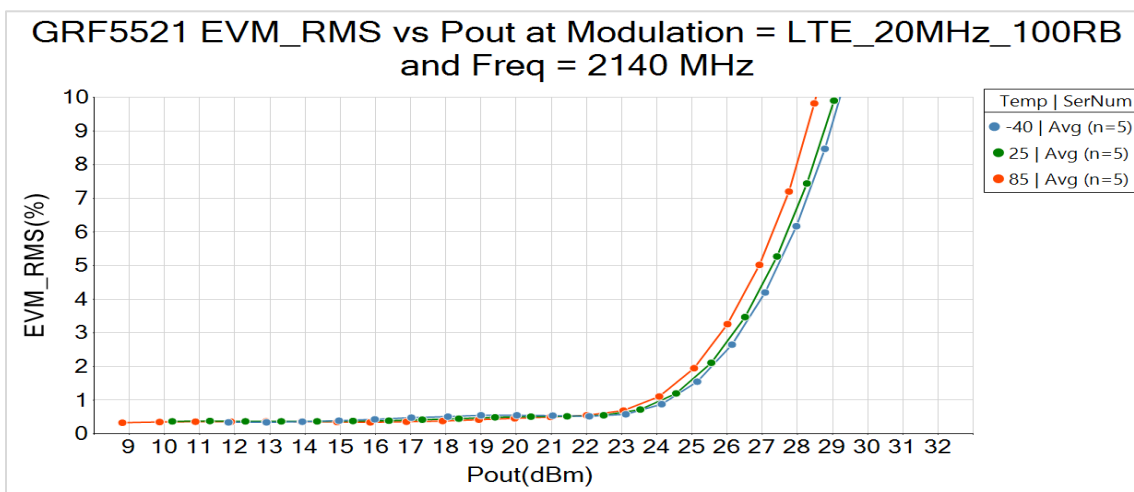
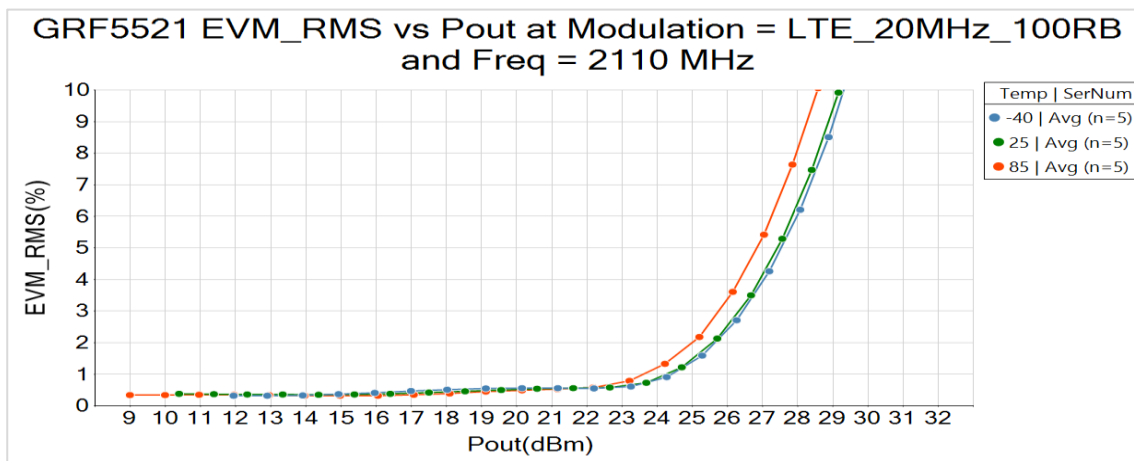
GRF5521 Typical Operating Curves: OIP3 vs. P_{OUT} (Per Tone at 600 kHz Spacing)

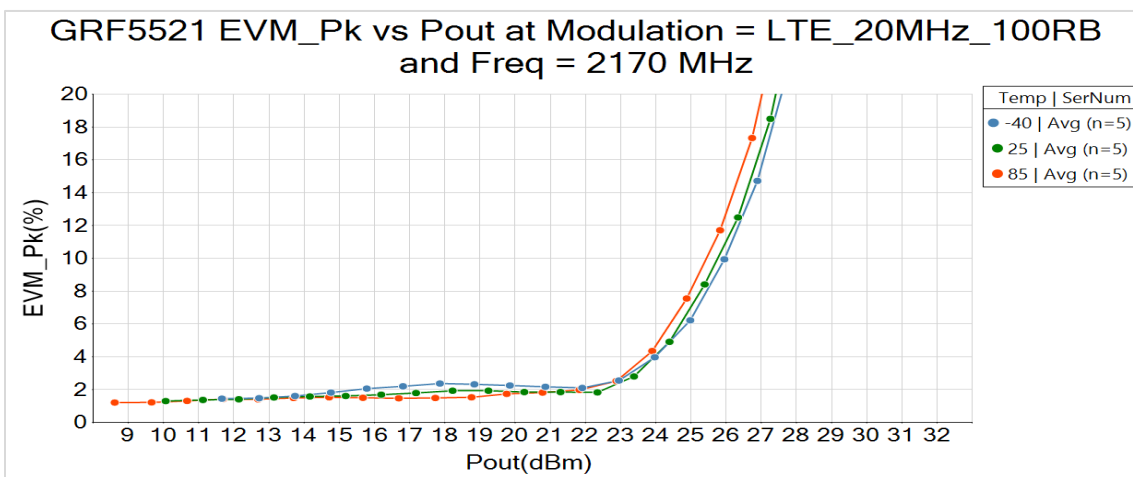
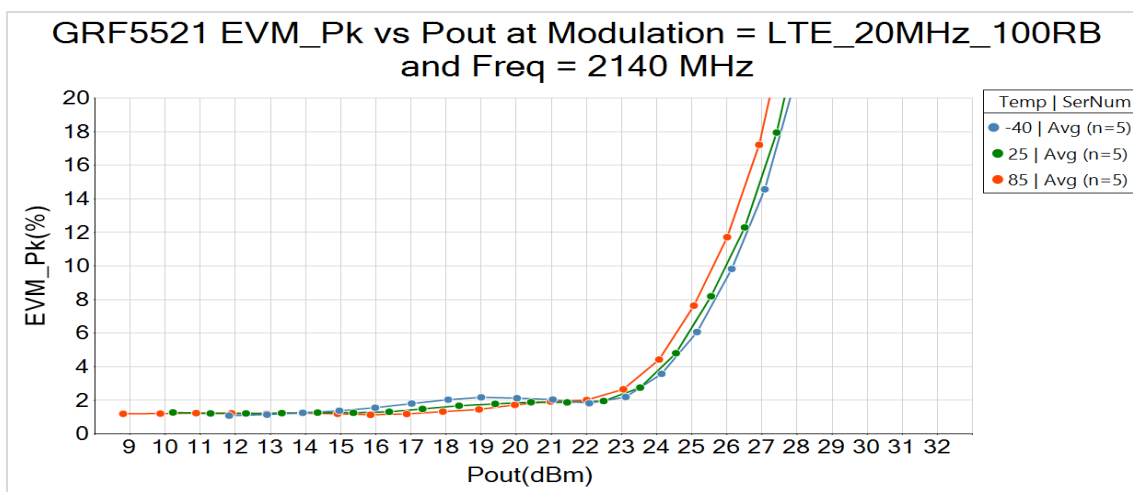
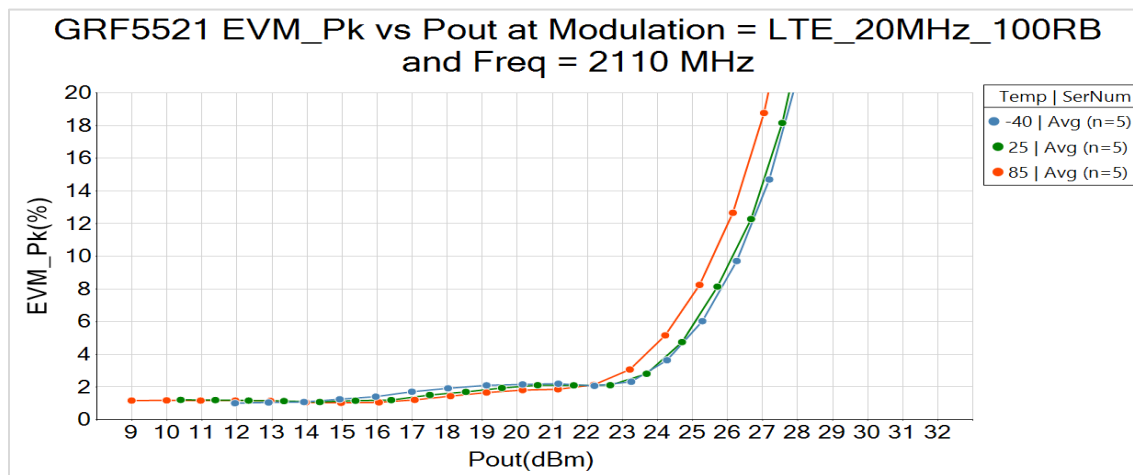


GRF5521 Typical Operating Curves: PAE vs. P_{OUT} (9.8 dB PAR)


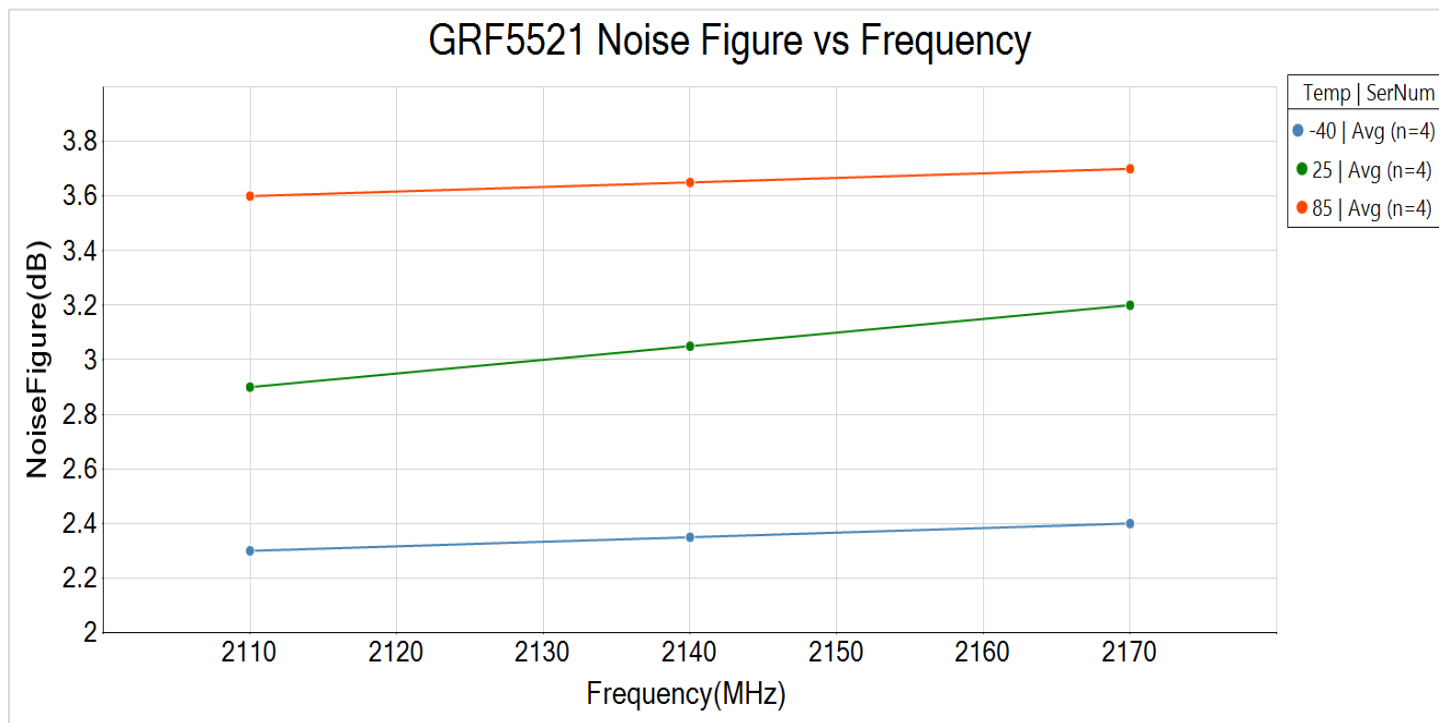
GRF5521 Typical Operating Curves: ACLR1 vs. P_{OUT} (9.8 dB PAR)


GRF5521 Typical Operating Curves: ACLR2_Max vs. P_{OUT} (9.8 dB PAR)


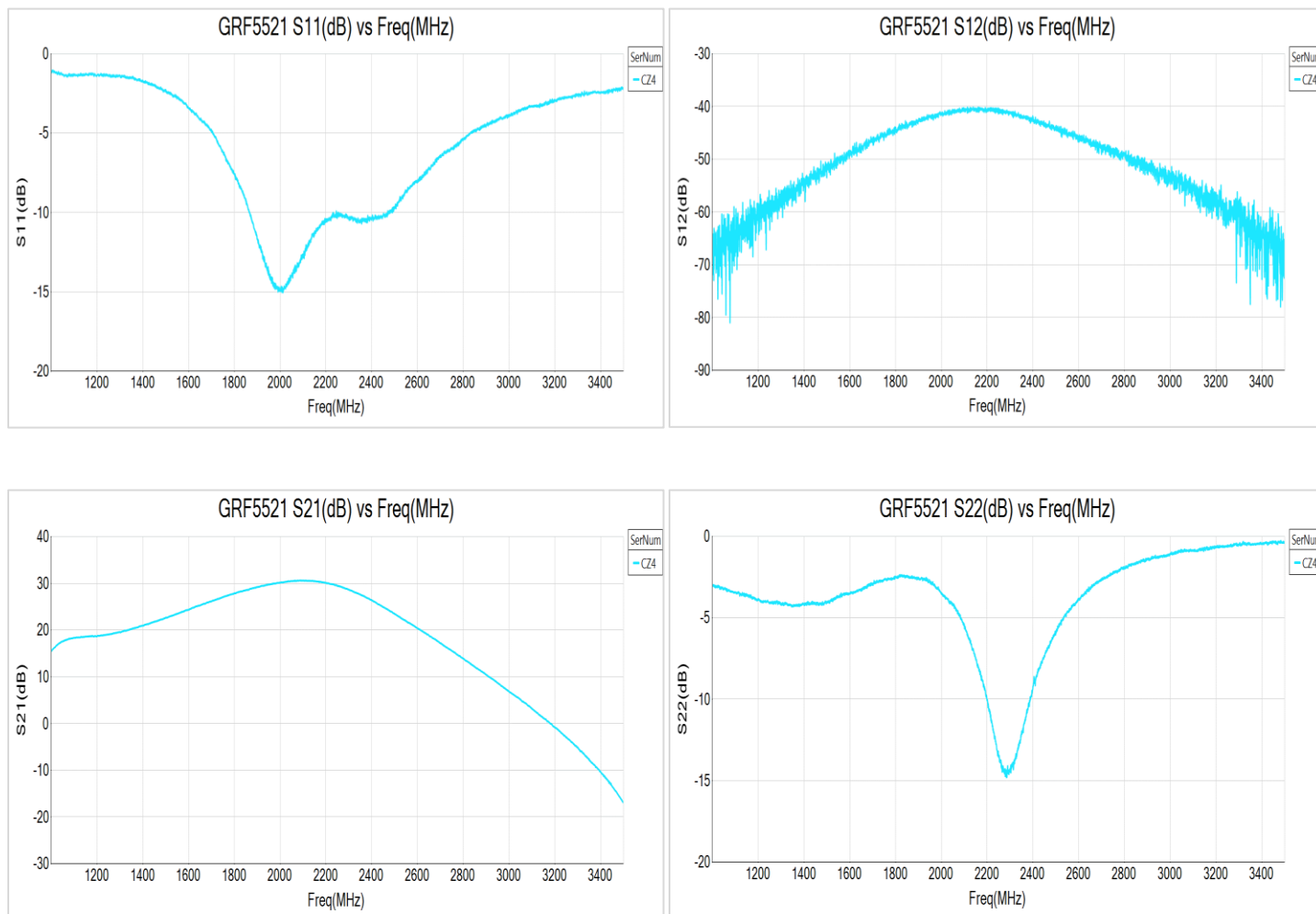
GRF5521 Typical Operating Curves: EVM_RMS vs. P_{OUT} (9.8 dB PAR)


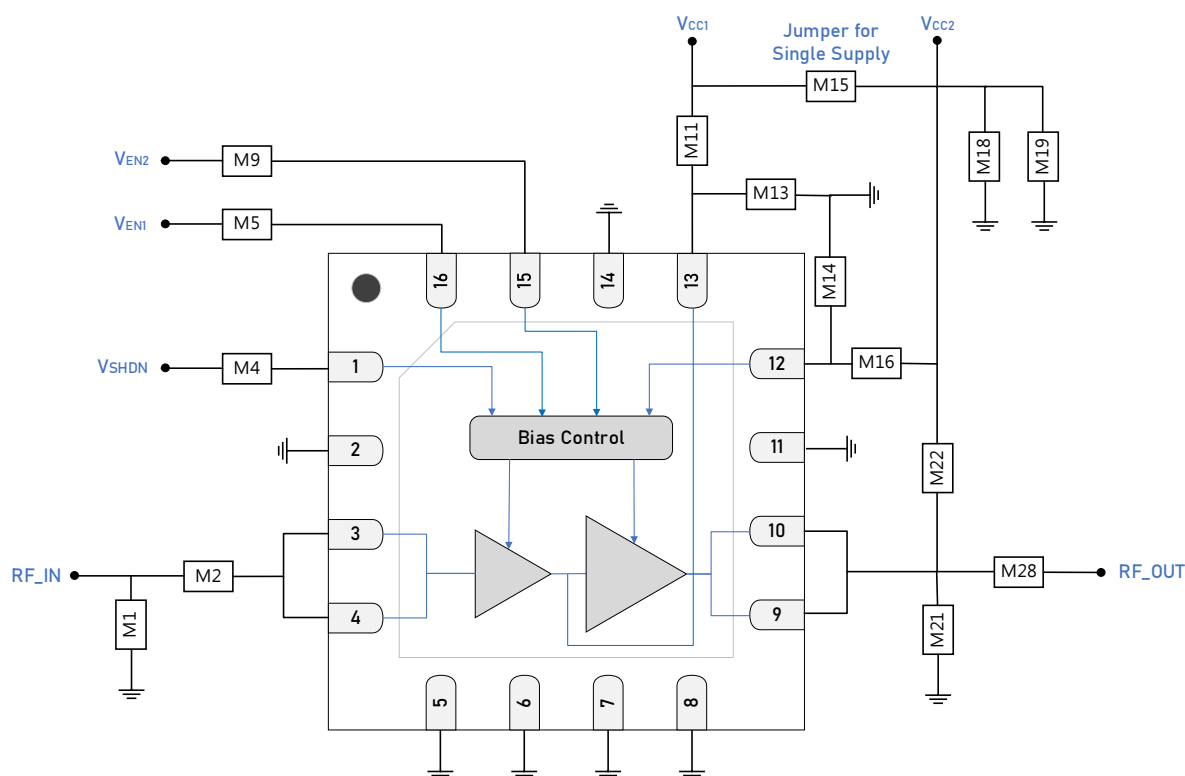
GRF5521 Typical Operating Curves: EVM_{Peak} vs. P_{OUT} (9.8 dB PAR)


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

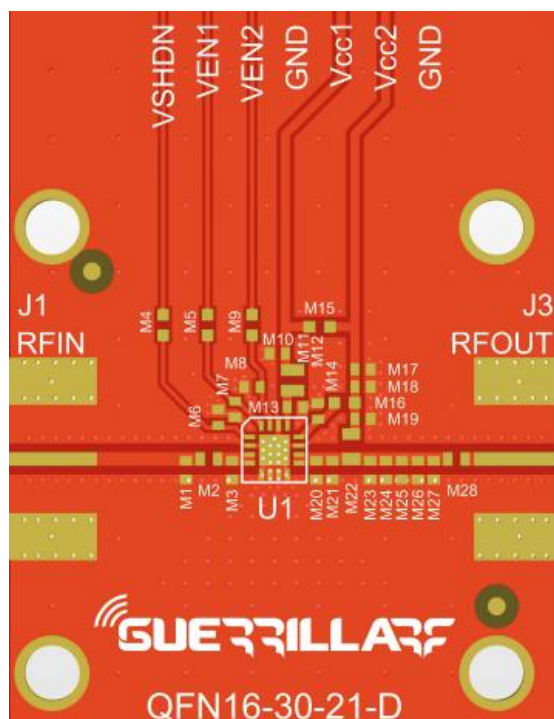


GRF5521 Typical Operating Curves: S-Parameters (2.11 to 2.17 GHz Tune)





GRF5521 Standard Evaluation Board Schematic



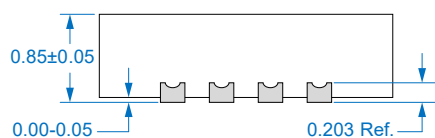
GRF5521 Evaluation Board Assembly Diagram

GRF5521 Evaluation Board Assembly Diagram Reference

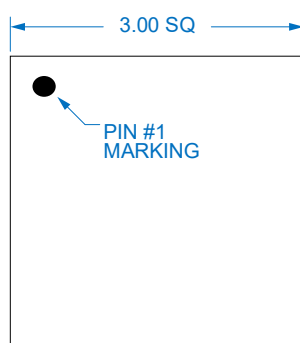
Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1	Inductor	Murata	LQG	2.7 nH	0402	ok
M2	Capacitor	Murata	GJM	2.2 pF	0402	ok
M4	Resistor	Various	5%	0 Ω	0402	ok
M5	Resistor	Various	5%	6650 Ω	0402	ok
M9	Resistor	Various	5%	4750 Ω	0402	ok
M11	Resistor	Murata	LQG	0 Ω	0402	ok
M13	Capacitor	Murata	GRM	0.1 μ F	0402	ok
M14, M18	Capacitor	Murata	GRM155C80J06ME11D	10 μ F	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	5.1 pF	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.

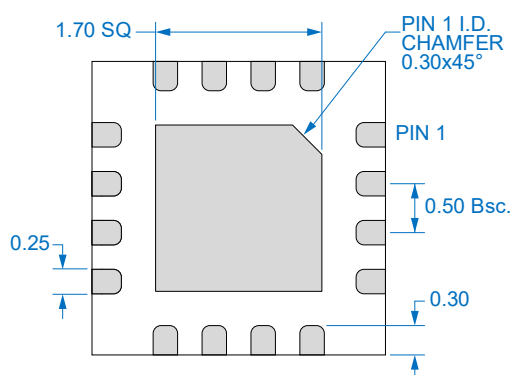
Package Outline Drawing



SIDE VIEW

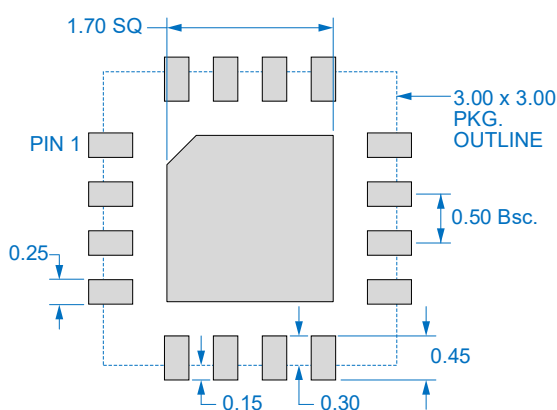


TOP VIEW



BOTTOM VIEW

Recommended PCB Footprint



TOP VIEW

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

Package Marking Diagram



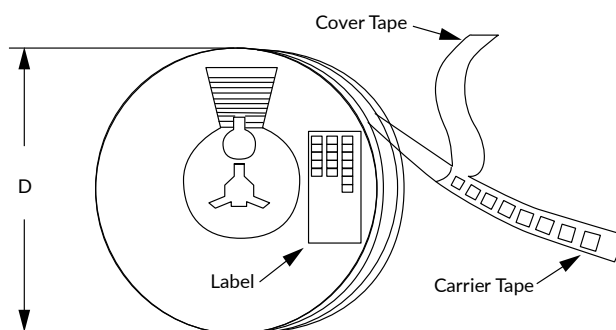
- Line 1: "YY" = YEAR. "WW" = WORK WEEK the device was assembled.
- Line 2: "GRF" = Guerrilla RF.
- Line 3: "XXXX" = Device PART NUMBER.

Tape and Reel Information

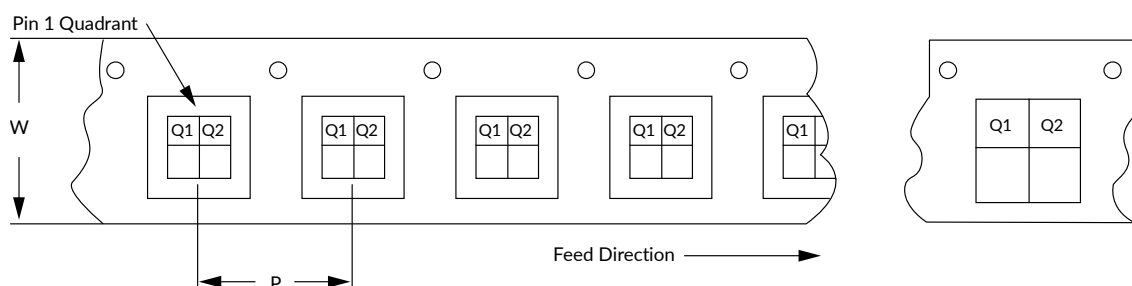
Guerrilla RF's tape and reel specification complies with Electronic Industries Alliance (EIA) standards for "Embossed Carrier Tape of Surface Mount Components for Automatic Handling" (reference EIA-481). See the following page for the Tape and Reel Specification and Device Package Information table, 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: [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 Data Sheet to new format. No change to device or device specifications.
May 11, 2022	Changed HBM from TBD to 1000 volts.
July 21, 2022	Release Ø Data Sheet. Added new data plots. Updated evaluation board BOM and schematic.
October 20, 2022	Updated Data Sheet to new format. Updated specifications in Absolute Ratings table.
May 21, 2025	Updated frequency of family of part numbers listed on page 1.
February 12, 2026	Updated Data Sheet to new format. 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 <i>production-released</i> material. TYP values are based on a combination of ATE and bench-level measurements, with MIN/MAX limits defined using <i>modelled estimates</i> 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 <i>derived from multiple lots which have been fabricated over an extended period of time</i> . MIN/MAX limits may be refined over previous releases as more statistically significant data is collected to account for process spreads.

Information in this data sheet is specific to the Guerrilla RF, Inc. ("Guerrilla RF") product identified.

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