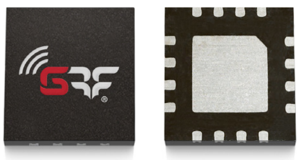
GUERRILLA RF

Data Sheet

RELEASE Ø



GRF5517

HIGH LINEARITY POWER AMPLIFIER 1.7 to 1.8 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
- +23 dBm Linear Output Power Maintained at 85 °C
- Flexible Biasing Provides Latitude for Linearity Optimization
- 225 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: 5.0V/1747MHz/225mA I_{CCQ}

- Gain: 27.5 dB
- OIP3: 48.0 dBm @ 23 dBm P_{OUT}/tone
- OP1dB: 32.0 dBm
- Noise Figure: 5.4 dB

APPLICATIONS

- Cellular Boosters
- Automotive Compensators
- Picocells/Femtocells
- Customer Premise Equipment

DESCRIPTION

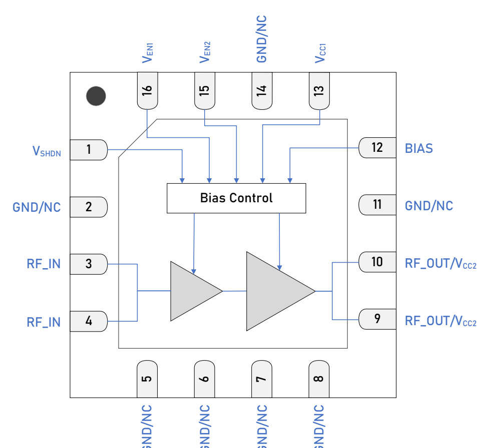
The GRF5517 is a high gain, two-stage InGaP HBT power amplifier designed to deliver excellent P1dB, ACLR and IM3 performance over the 1700 to 1800 MHz band. Its exceptional native linearity makes it an ideal choice for transmitter applications that typically do not employ digital predistortion correction 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 - 1.91 GHz
GRF5507: 0.7 - 0.8 GHz	GRF5519: 1.92 - 2.0 GHz
GRF5508: 0.8 - 0.9 GHz	GRF5521: 2.11 - 2.17 GHz
GRF5510: 0.88 - 0.96 GHz	GRF5526: 2.5 - 2.7 GHz
GRF5517: 1.7 - 1.8 GHz	GRF5536: 3.4 – 3.8 GHz

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

BLOCK DIAGRAM



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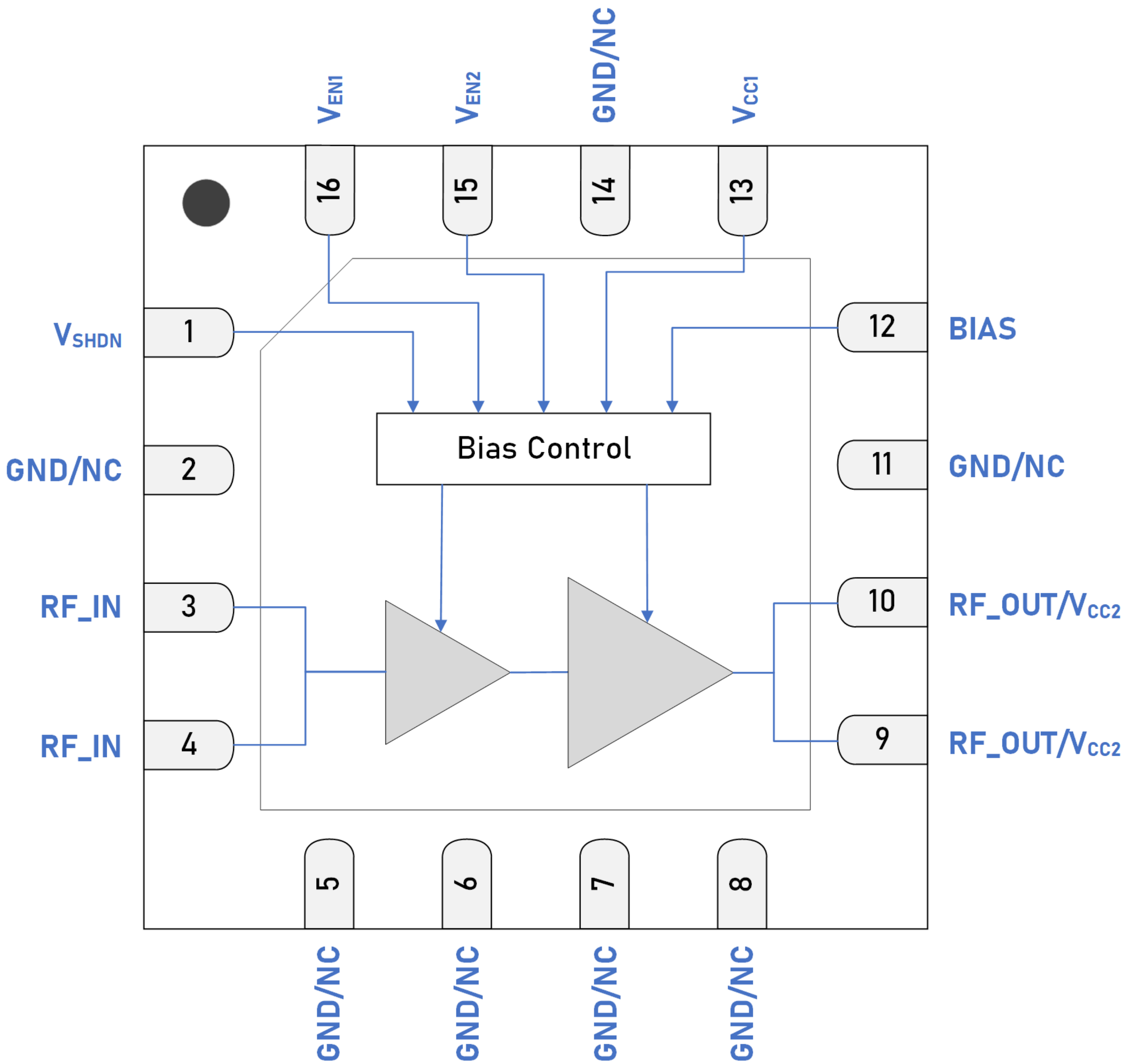


3 x 3mm QFN-16 Pin Out (Top View)

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, 5-8, 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 external 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. Connecting an external de-coupling 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.

Absolute Ratings

Parameter	Symbol	Min.	Max.	Unit
Supply Voltage	V_{CC}		5.5	V
RF Input Power (50 Ω, V_{CC} = 5.0 V, CW Tone, 100% Duty Cycle, $T_{PKG\ HEAT\ SINK}$ = 25°C)	$P_{IN\ MAX-1:1}$		23	dBm
RF Input Power (Load VSWR ≤ 8:1, all phase angles, V_{CC} = 5.0 V, CW Tone, 100% Duty Cycle, $T_{PKG\ HEAT\ SINK}$ = -40 to 85°C)	$P_{IN\ MAX-8:1}$		11	dBm
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.

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. For additional information, please refer to the *Certificate of RoHS Compliance.*

Recommended Operating Conditions

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Power 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}	1.7		1.8	GHz	Typical Application Schematic Using the 1.7 to 1.8 GHz Tuning Set (Note 1)
RFIN Port Impedance	Z_{RFIN}		50		Ω	Single Ended, with 2-element Match
RFOUT Port Impedance	Z_{RFOUT}		50		Ω	Single Ended, with 3-element Match

Note 1: 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 1.7 to 1.8 GHz tuning set, M5 = 2.26k Ω, M9 = 2.94k Ω, V_{SHDN} = LOW, V_{CC} = +4.75 to +5.25 V, I_{CCQ} = 225 mA, 50 Ω system impedance, P_{OUT} = +23 dBm, F_{TEST} = 1.7 to 1.8 GHz, $T_{PKG\ HEAT\ SINK}$ = -40 to +85 °C. Typical values are at V_{CC} = +5.0 V, I_{CCQ} = 225 mA, P_{OUT} = +23 dBm, F_{TEST} = 1.747 GHz, $T_{PKG\ HEAT\ SINK}$ = 25 °C. MIN/MAX specifications listed in italics are guaranteed via production test screening. All other parameters are guaranteed by design and characterization. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Quiescent Current	I_{CCQ}		225		mA	I_{CCQ1} + I_{CCQ2} . No RF Applied.
Supply Current with RF Applied	I_{CC}		305		mA	I_{CC1} + I_{CC2} . RF Applied with P_{OUT} = 23dBm.
Enable Current 1	$I_{ENABLE1}$		3.0		mA	V_{CC} = 5V, $T_{PKG\ HEAT\ SINK}$ = 25 °C
Enable Current 2	$I_{ENABLE2}$		1.0		mA	V_{CC} = 5V, $T_{PKG\ HEAT\ SINK}$ = 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} = 0.9V.
Logic Current High	I_{IH}		60		µA	Applies to V_{SHDN} Input, V_{IH} = 1.8V.
			280			Applies to V_{SHDN} Input, V_{IH} = 3.3V.
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}: 5.0 V; $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH
Enable Current 1	$I_{ENABLE1-SHDN}$		3		mA	V_{CC}: 5.0 V; $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH
Enable Current 2	$I_{ENABLE2-SHDN}$		1.3		mA	V_{CC}: 5.0 V; $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH
Thermal Data (Stage 1 and Stage 2)						
See plot of Die Temp vs. Output Power						On Standard Evaluation Board.

Nominal Operating Parameters – RF (1.7 to 1.8 GHz, 5V Operation)

The following conditions apply unless noted otherwise: Typical Application Schematic using the 1.7 to 1.8 GHz tuning set, M5 = 2.26k Ω, M9 = 2.94k Ω, V_{SHDN} = LOW, V_{CC} = +4.75 to +5.25 V, I_{CCQ} = 225 mA, 50 Ω system impedance, P_{OUT} = +23 dBm, F_{TEST} = 1.7 to 1.8 GHz, $T_{PKG\ HEAT\ SINK}$ = -40 to +85 °C. Typical values are at V_{CC} = +5.0 V, I_{CCQ} = 225 mA, P_{OUT} = +23 dBm, F_{TEST} = 1.747 GHz, $T_{PKG\ HEAT\ SINK}$ = 25 °C. MIN/MAX specifications listed in italics are guaranteed via production test screening. All other parameters are guaranteed by design and characterization. Evaluation board losses are included within the specifications.

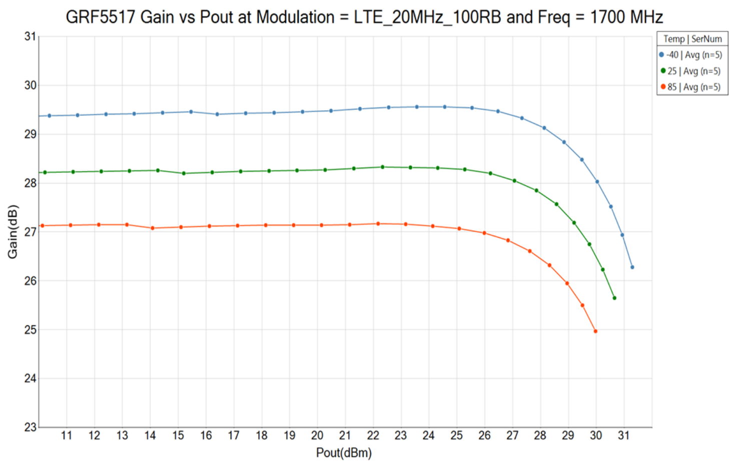
Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Small Signal Gain	S21		27.5		dB	LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8dB PAR, F_{TEST} = 1.747 GHz, $T_{PKG\ HEAT\ SINK}$ = 25 °C, V_{CC} = 5 V, P_{IN} = -25 dBm.
Standby Mode Gain	$S21_{STBY}$		-22		dB	Disabled Mode, LTE 20MHz 100RB TM1.1 Downlink Waveform with 9.8dB PAR, $V_{SHDN}/V_{EN1}/V_{EN2}$ = HIGH, P_{IN} = 0 dBm.
Input Return Loss	S11		>7		dB	F_{RF} = 1.7 to 1.8 GHz
Output Return Loss	S22		>10		dB	F_{RF} = 1.7 to 1.8 GHz
Reverse Isolation	S12		>50		dB	F_{RF} = 1.7 to 1.8 GHz
Evaluation Board Noise Figure	NF		5.4		dB	
Output 3rd Order Intercept	OIP3		48.0		dBm	23 dBm P_{OUT} per Tone at 600 kHz Spacing
Output 1 dB Compression Power	OP1dB		32.0		dBm	Sine wave input, V_{CC} = 5V, $T_{PKG\ HEAT\ SINK}$ = 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} = 1.747 GHz, $T_{PKG\ HEAT\ SINK}$ = 25 °C, V_{CC} = 5 V.

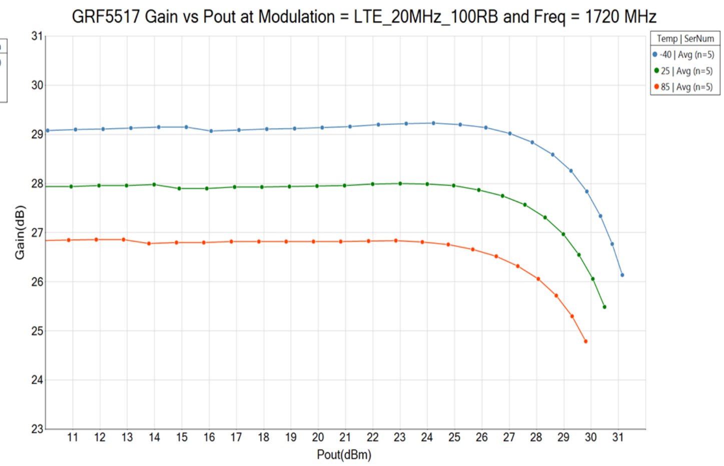
Note 2: MIN/MAX limits defined using *modelled estimates* that account for part-to-part variations and expected process spreads. As additional production lots are fabricated, accumulated test data will be used to refine the MIN/MAX limits.

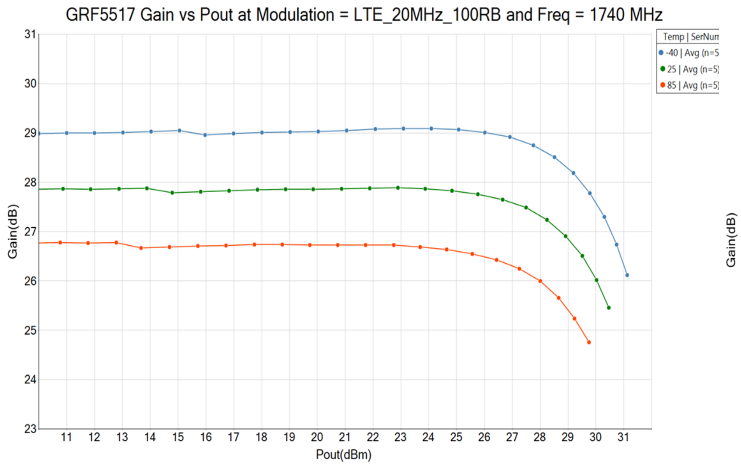
Typical Operating Curve Conditions

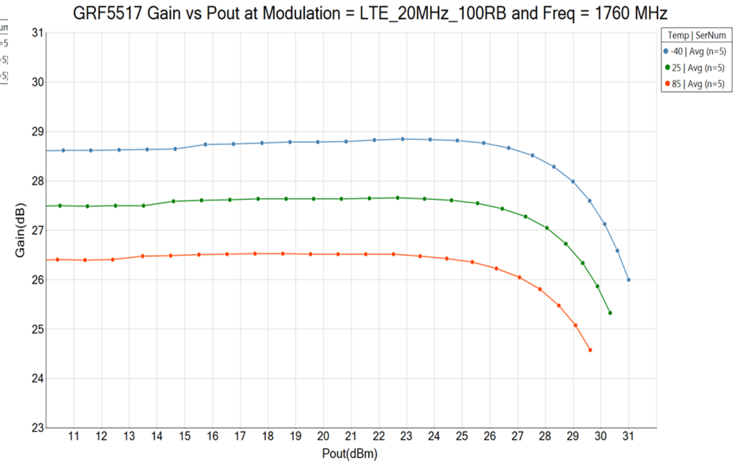
The following conditions apply unless noted otherwise: Typical Application Schematic using the 1.7 to 1.8 GHz tuning set, M5 = 2.26k Ω, M9 = 2.94k Ω, V_{SHDN} = LOW, V_{CC} = 5 V, I_{CCQ} = 225 mA, 50 Ω system impedance, F_{TEST} = 1.7 to 1.8 GHz, $T_{PKG\ HEAT\ SINK}$ = 25 °C. Evaluation board losses are included within the plots.

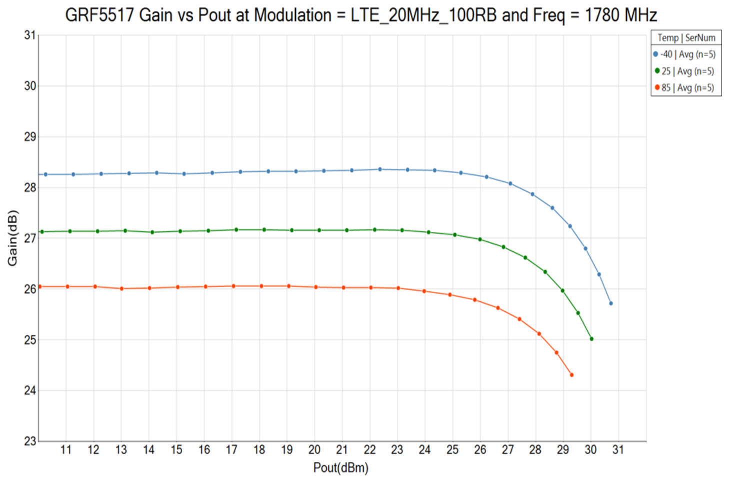
GRF5517 Typical Operating Curves: *Gain vs. P_{OUT} (9.8 dB PAR)*

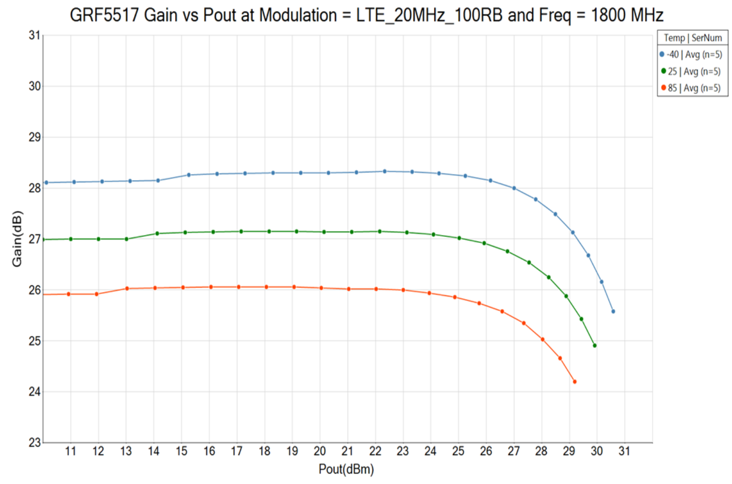












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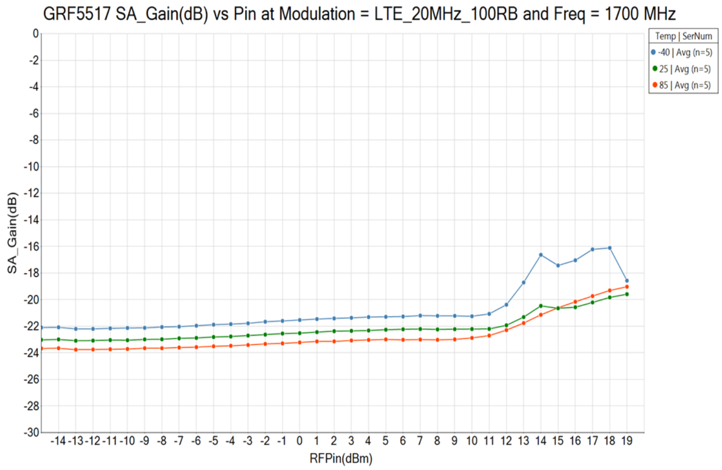
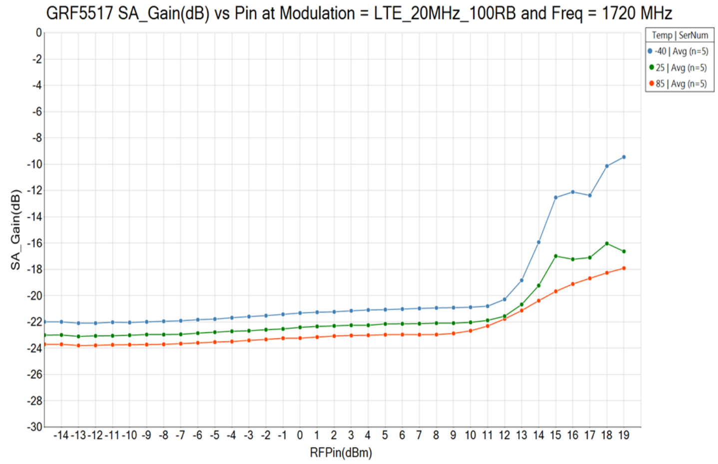
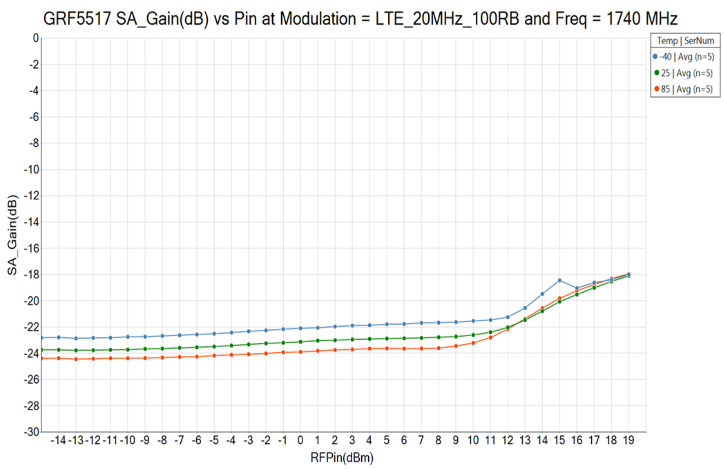
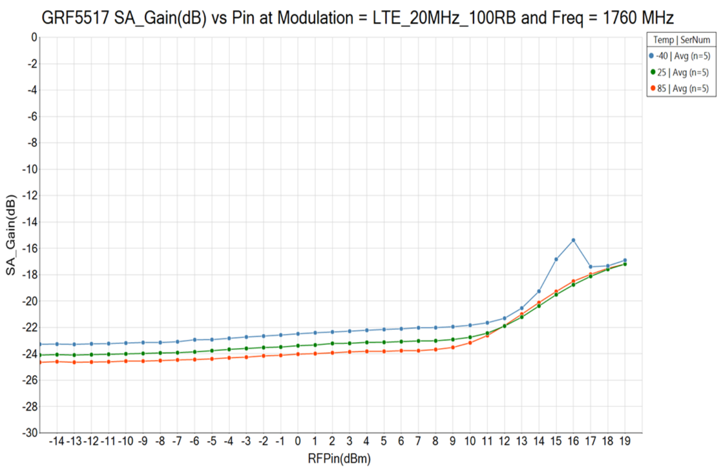
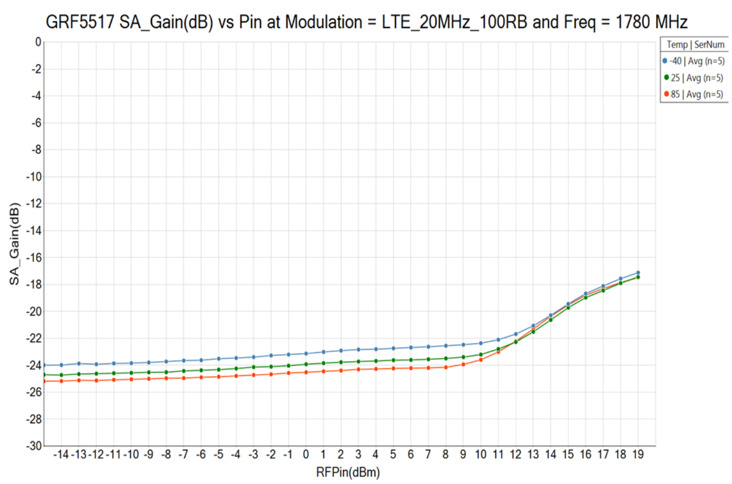
GRF5517 Typical Operating Curves: *Gain vs. P_{IN} (Shutdown Mode, V_{SHDN} = 3.3V, 9.8 dB PAR)*

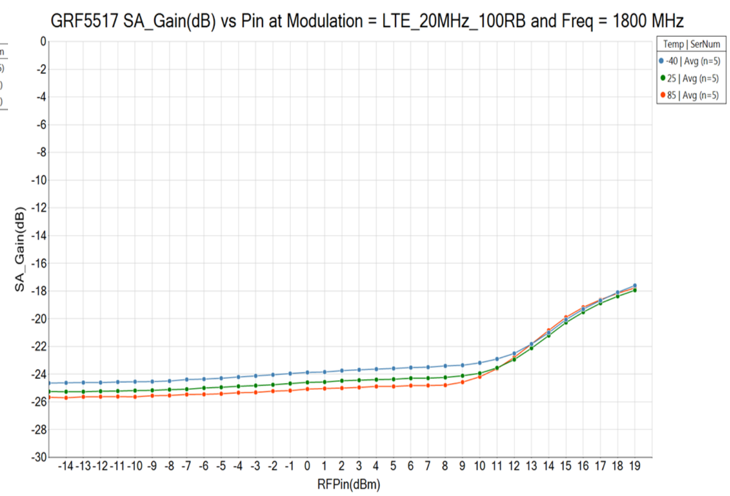




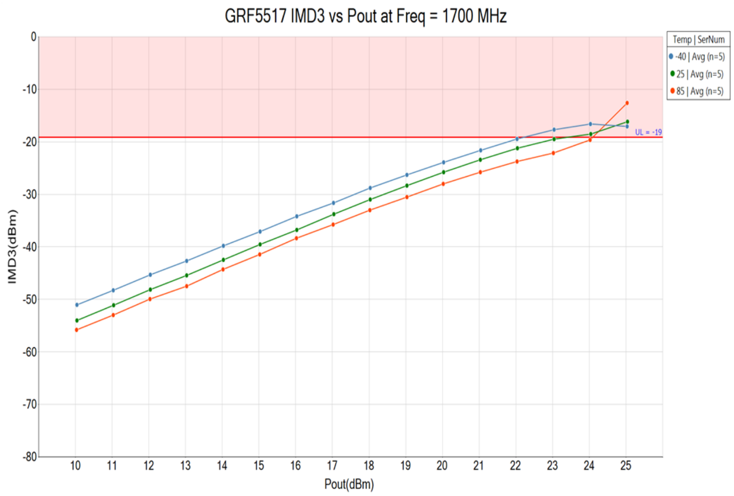


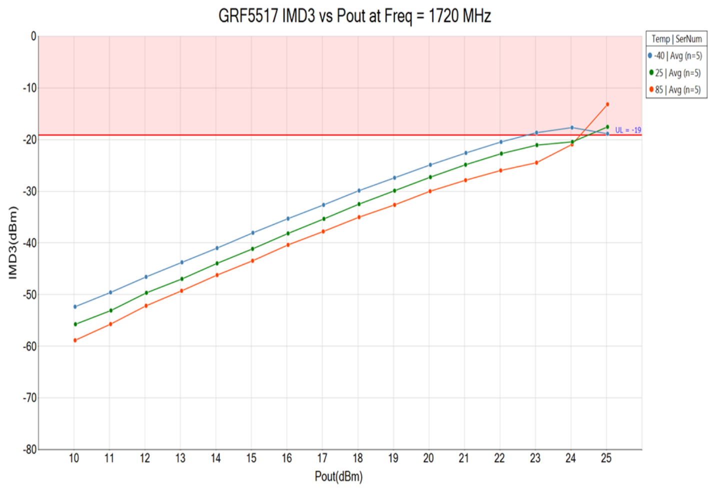


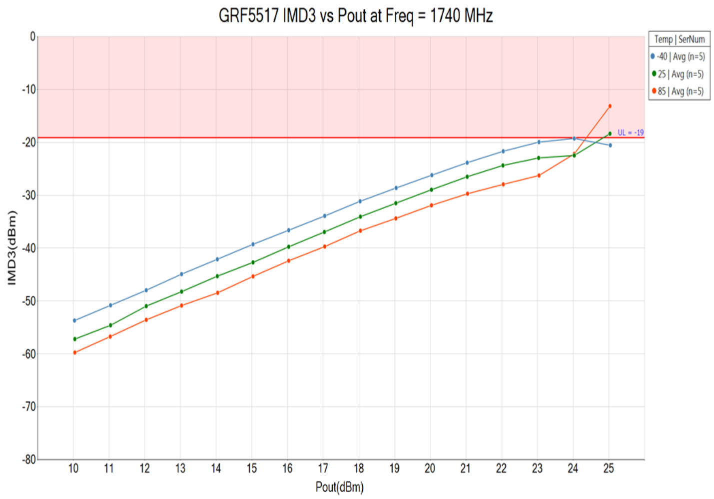


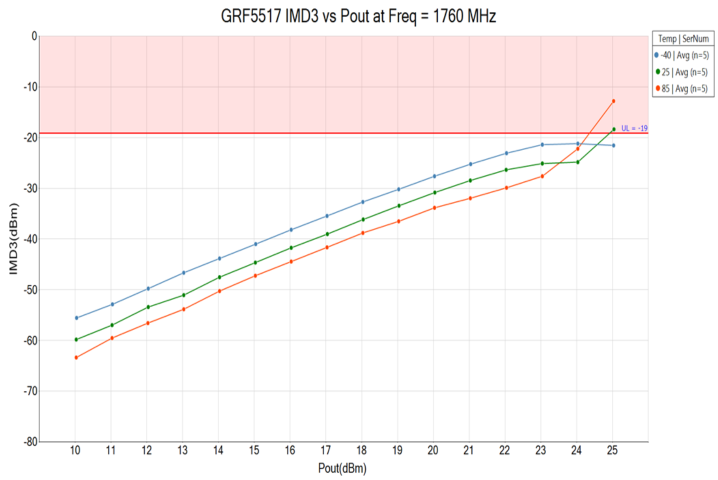


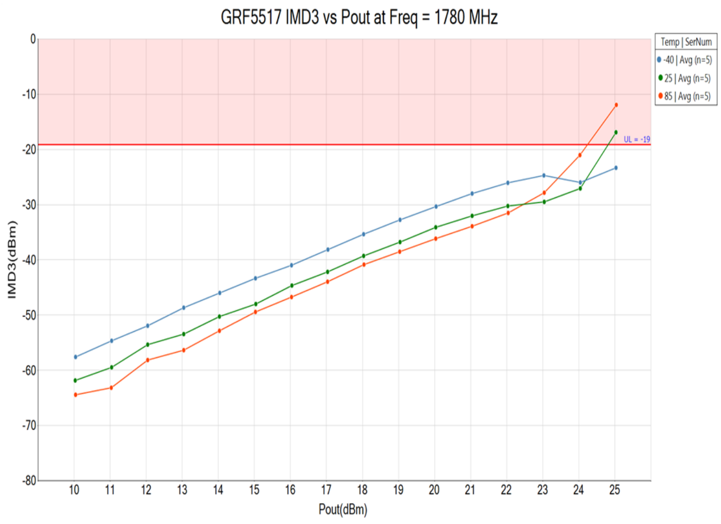
GRF5517 Typical Operating Curves: *IMD3 vs. P_{OUT} (Per Tone with 600kHz Tone Spacing)*

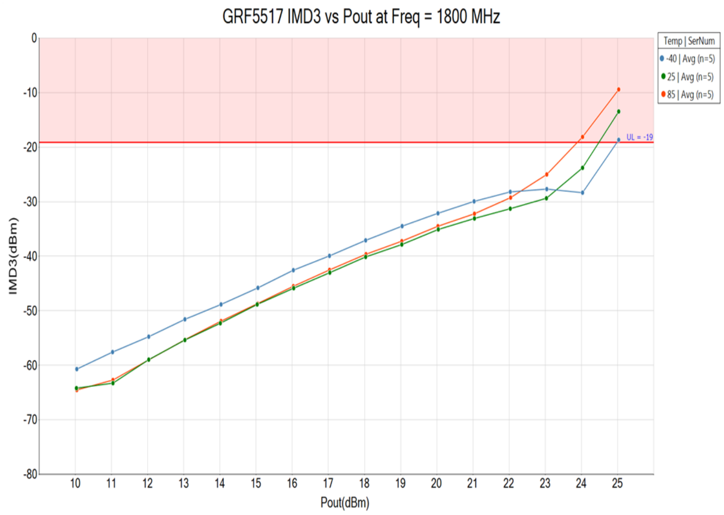












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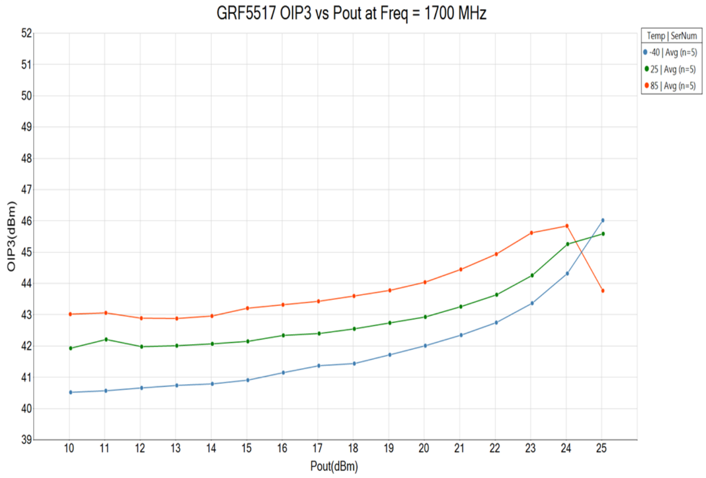
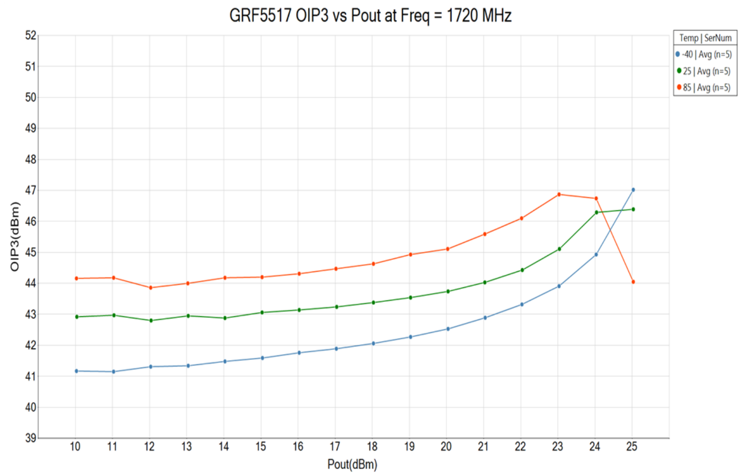
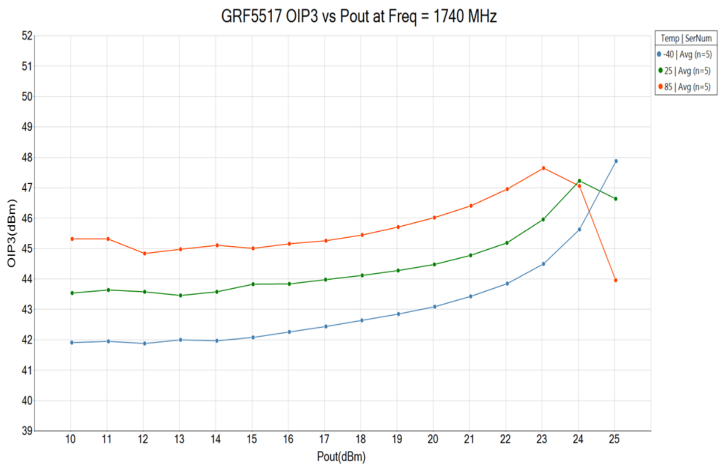
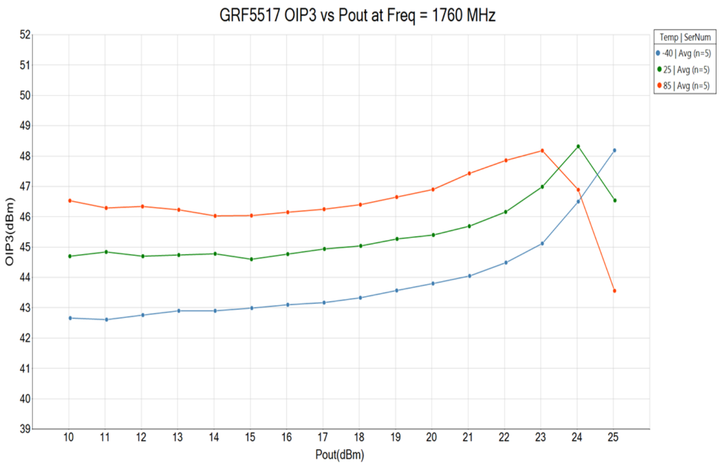
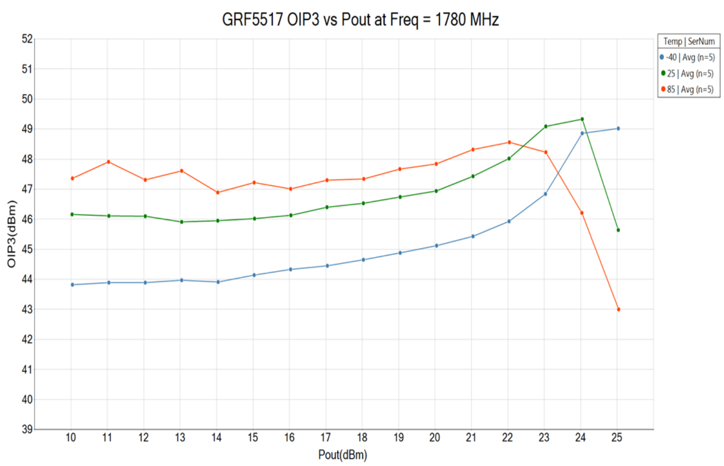
GRF5517 Typical Operating Curves: *OIP3 vs. P_{OUT} (Per Tone with 600kHz Tone Spacing)*

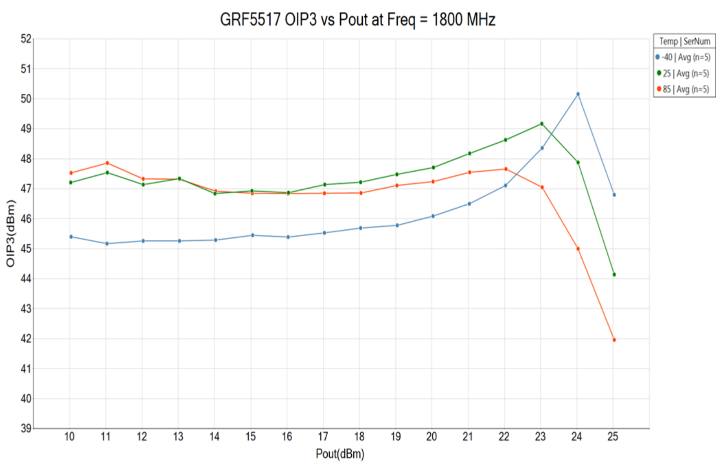




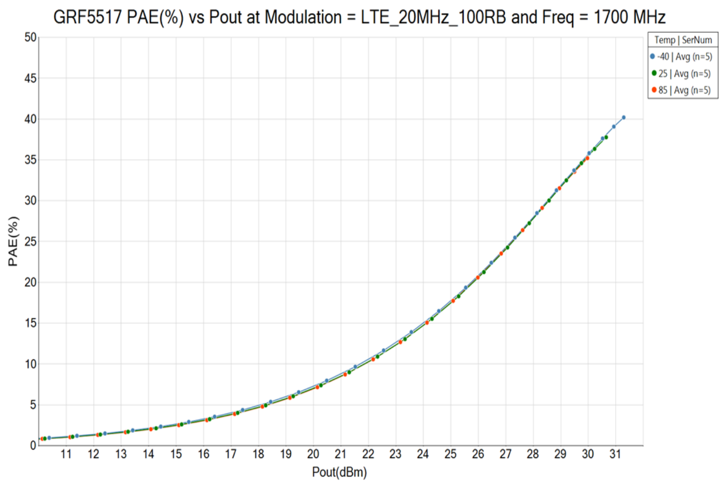


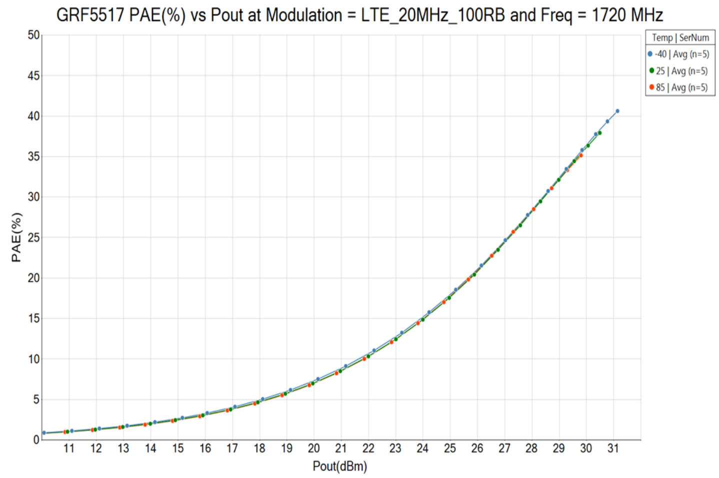


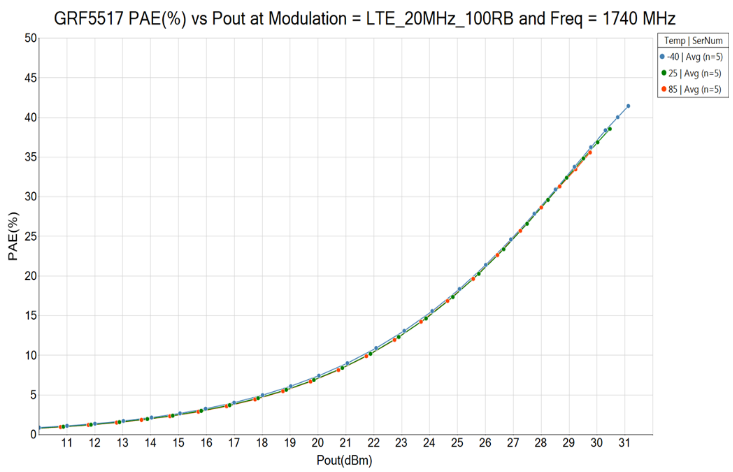


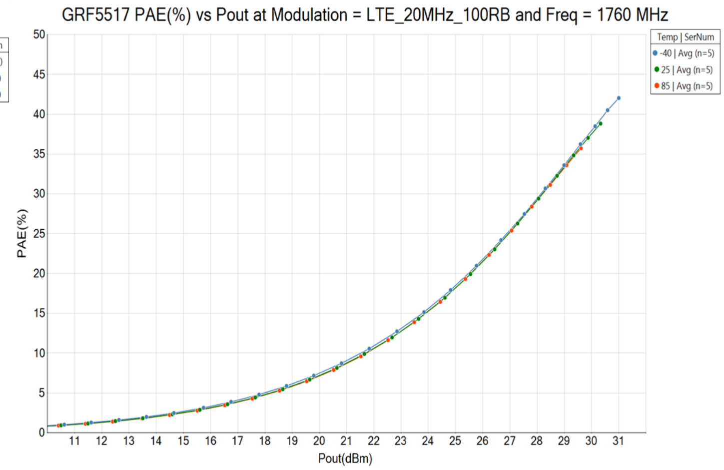


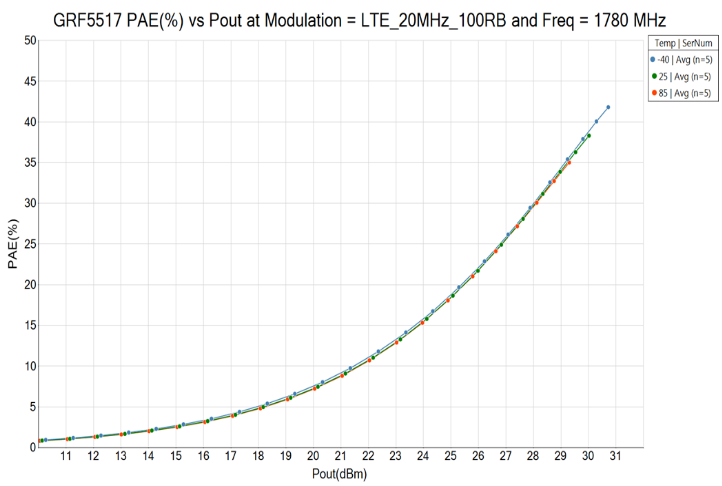
GRF5517 Typical Operating Curves: *PAE vs. P_{OUT} (9.8 dB PAR)*

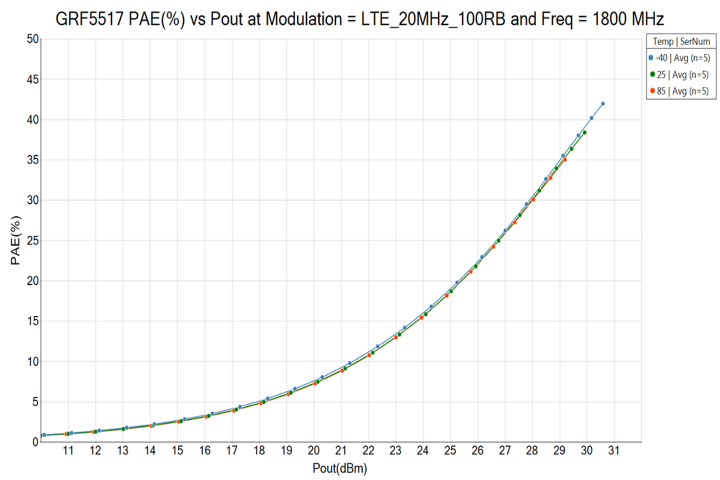












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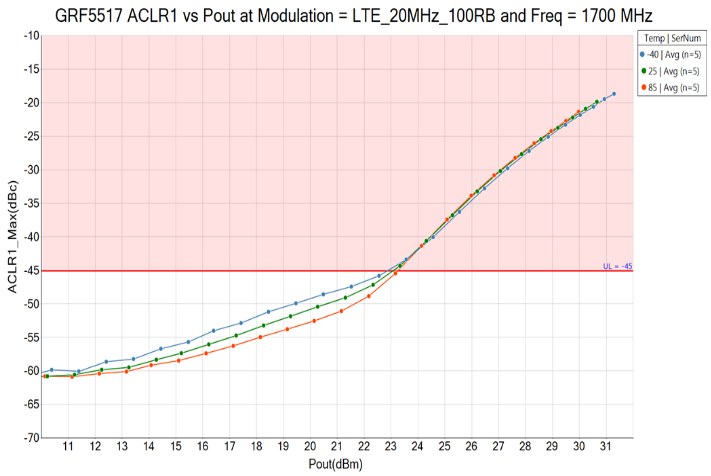
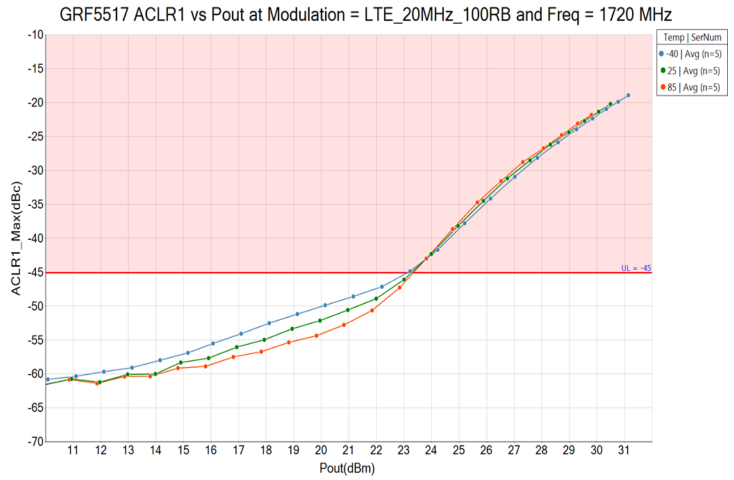
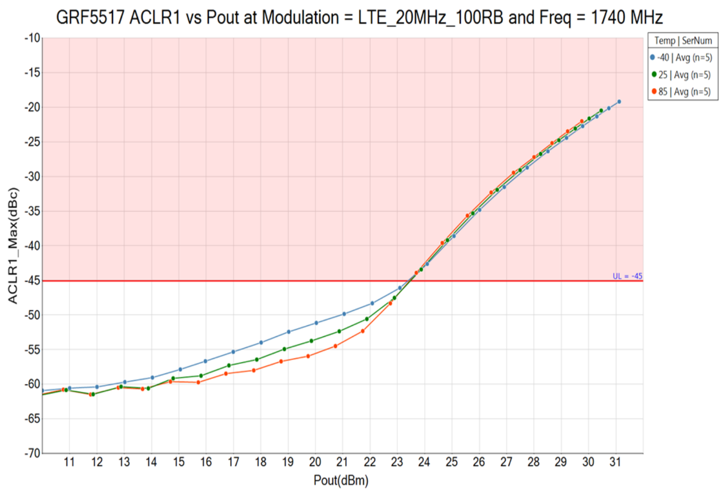
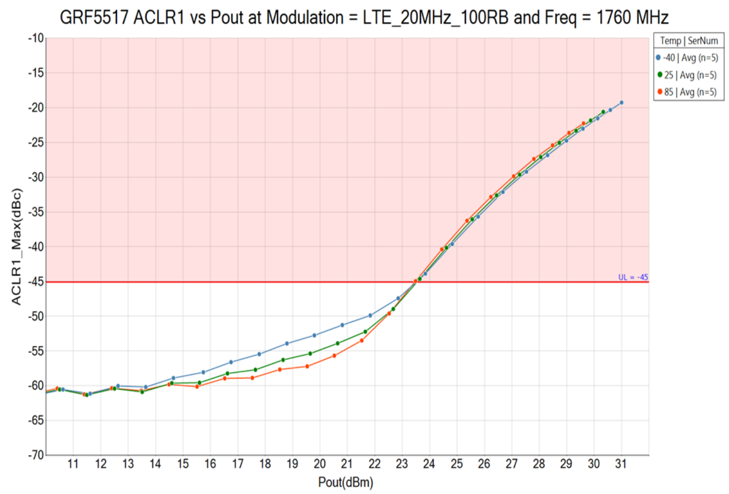
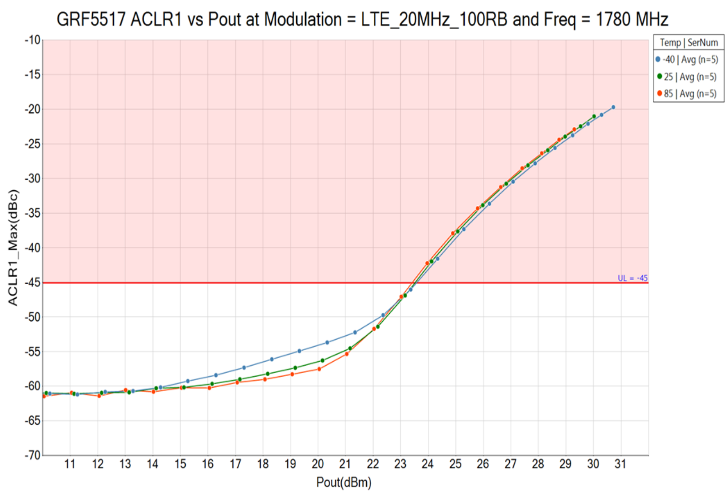
GRF5517 Typical Operating Curves: *ACLR vs. P_{OUT} (9.8 dB PAR)*

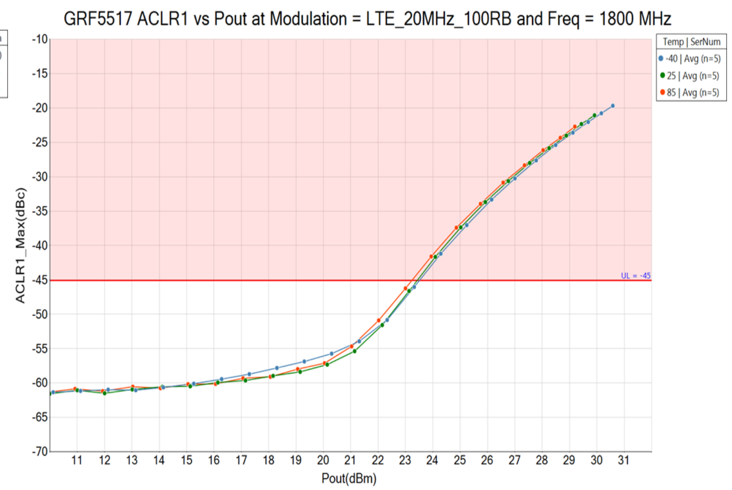




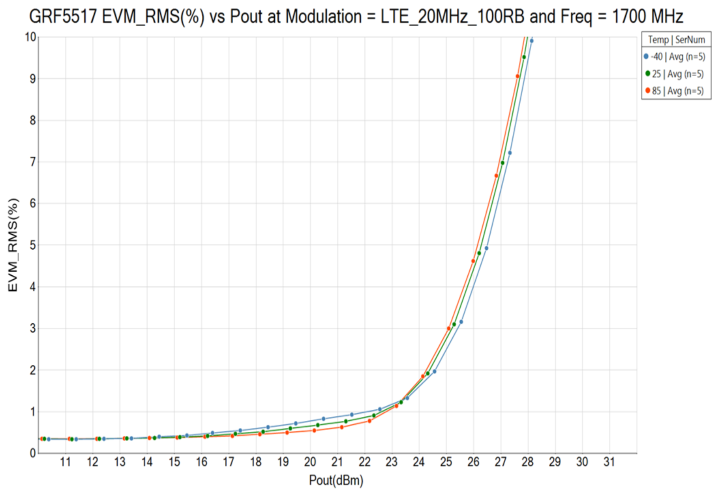


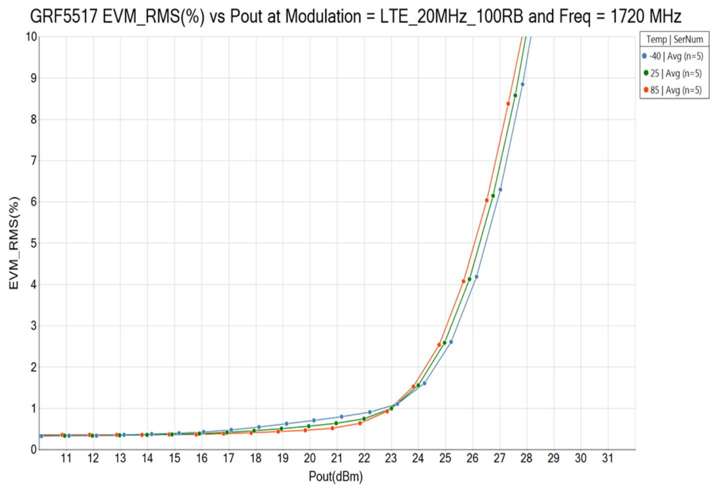


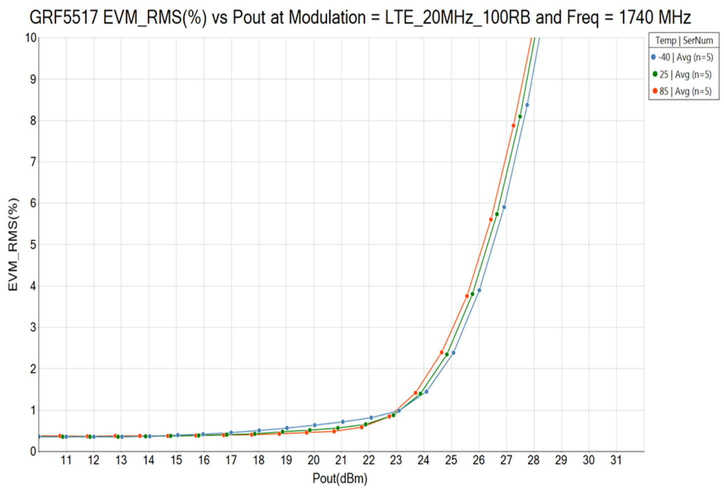


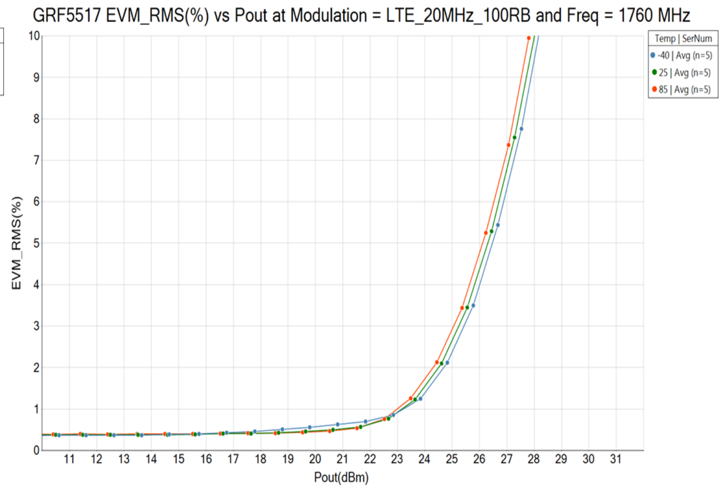


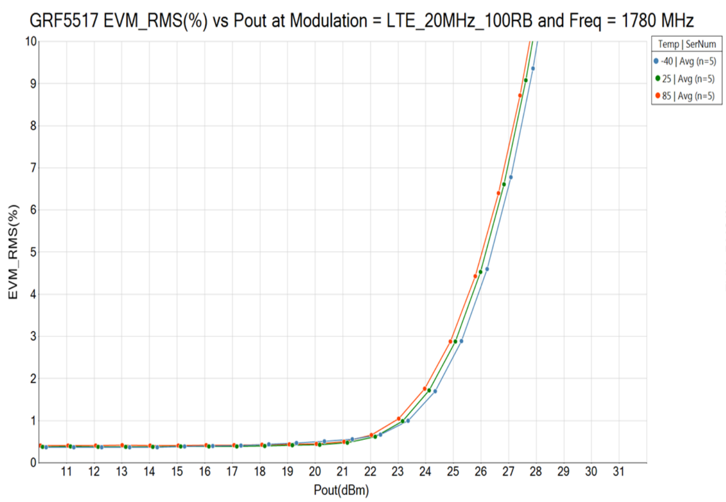
GRF5517 Typical Operating Curves: *EVM vs. P_{OUT} (9.8 dB PAR)*

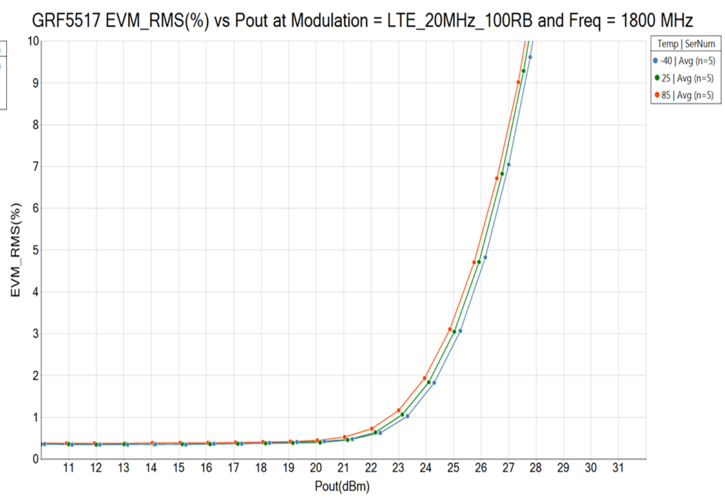












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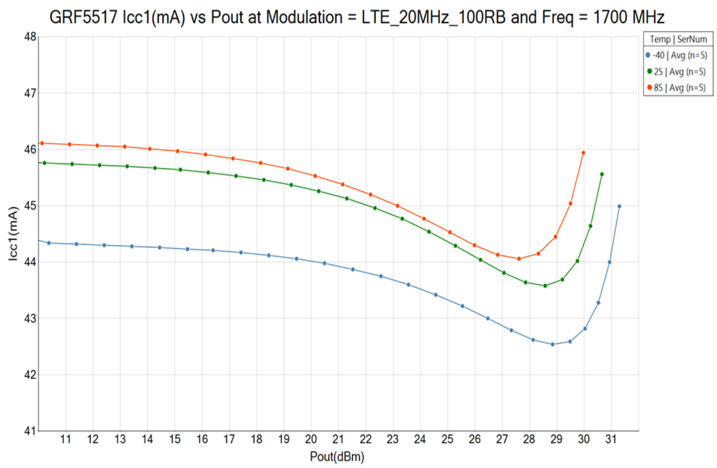
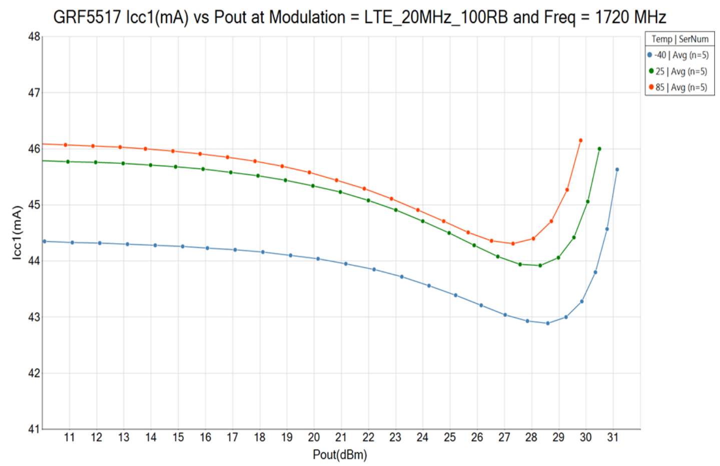
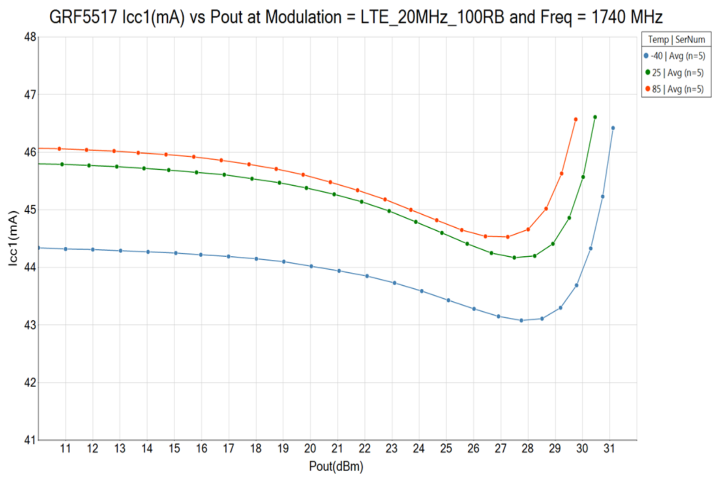
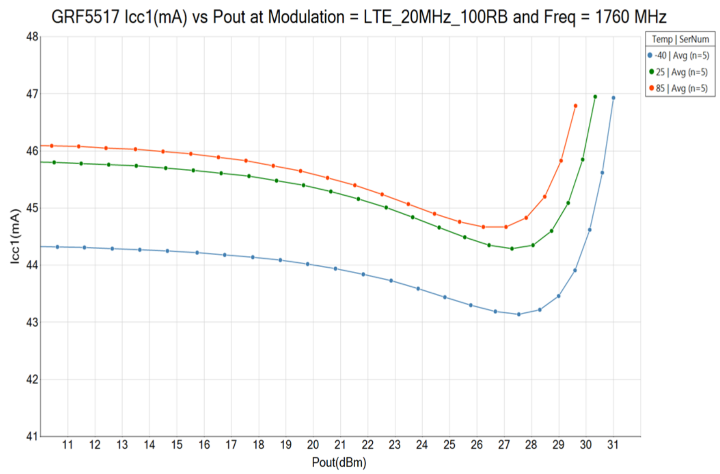
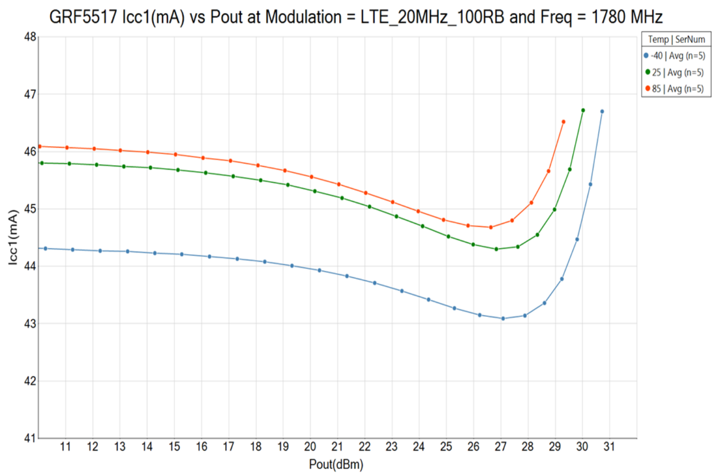
GRF5517 Typical Operating Curves: *Stage1 I_{CC} vs. Stage2 P_{OUT} (9.8 dB PAR)*

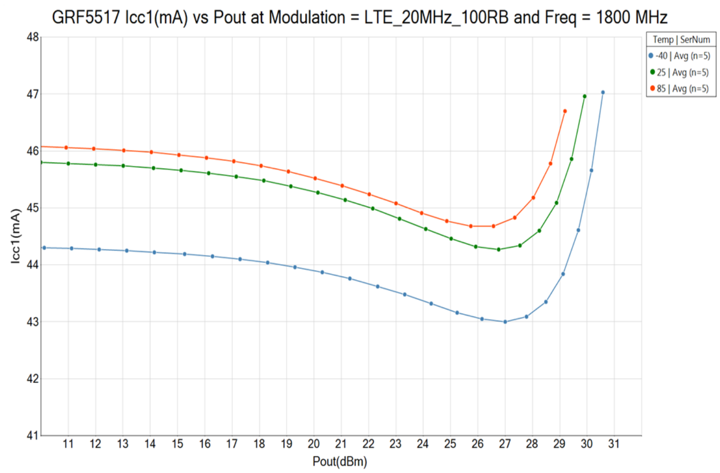




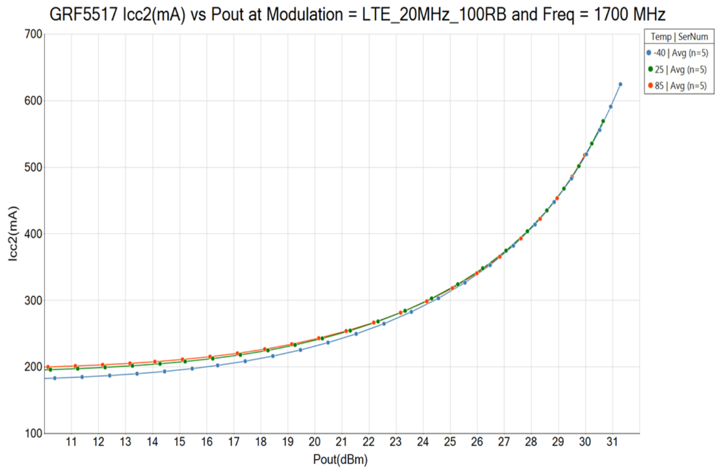


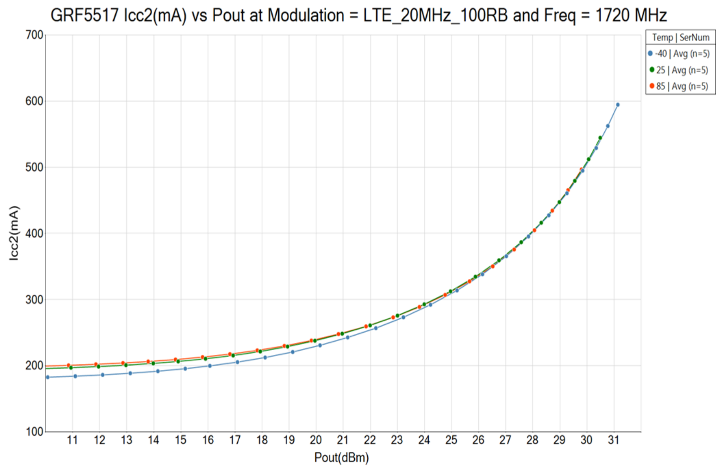


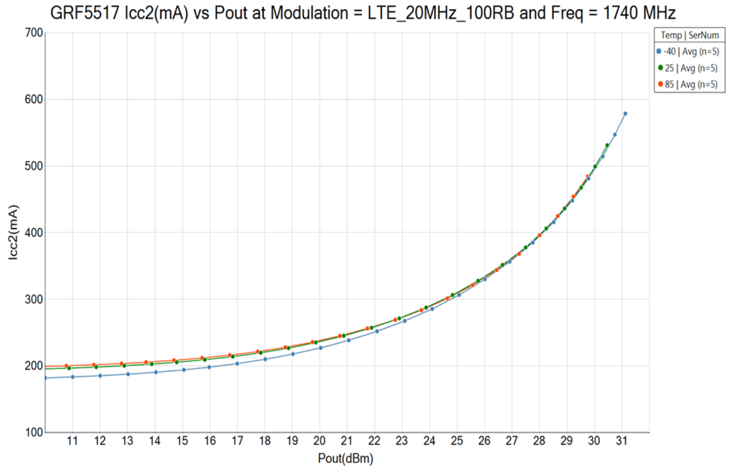


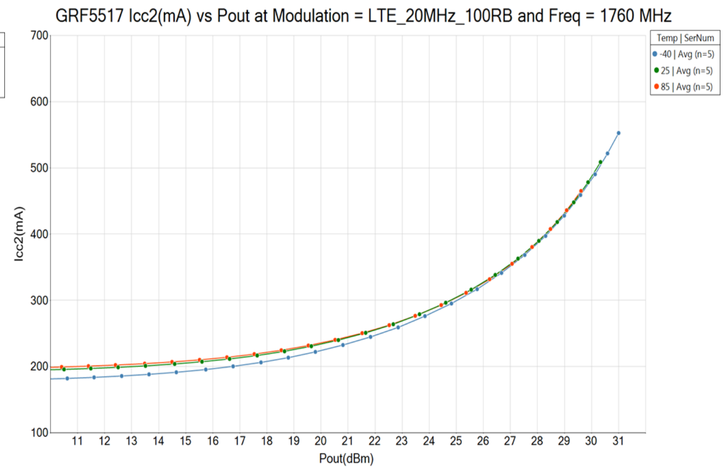


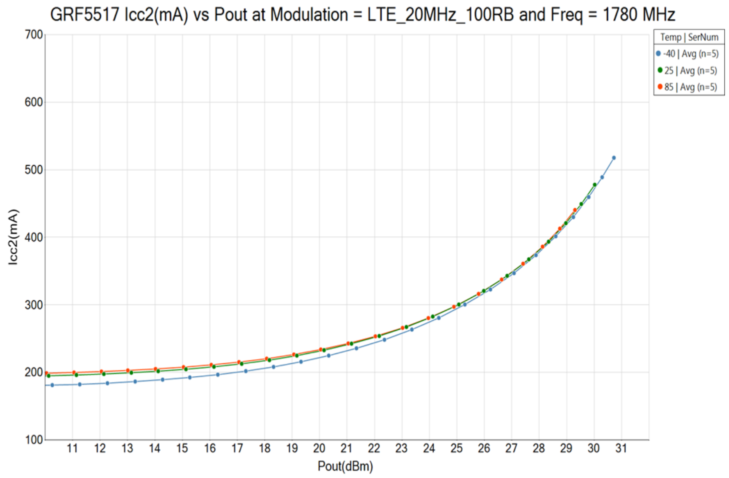
GRF5517 Typical Operating Curves: *Stage2 I_{CC} vs. Stage2 P_{OUT} (9.8 dB PAR)*

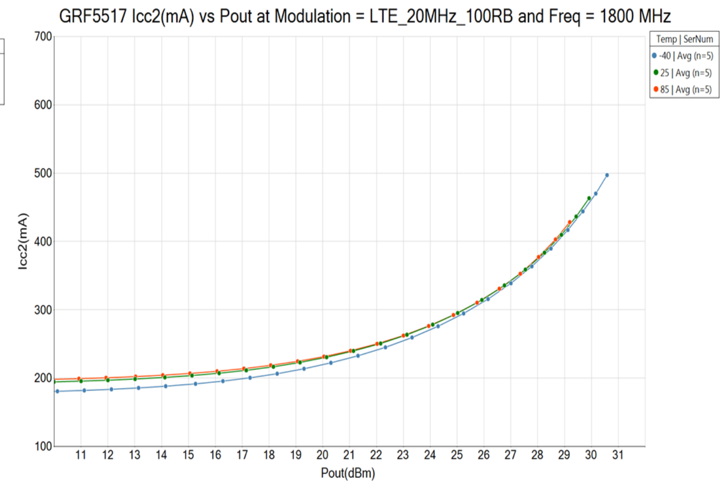












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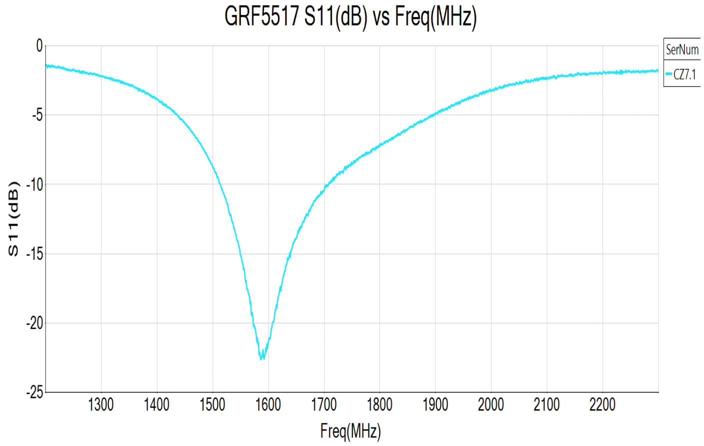
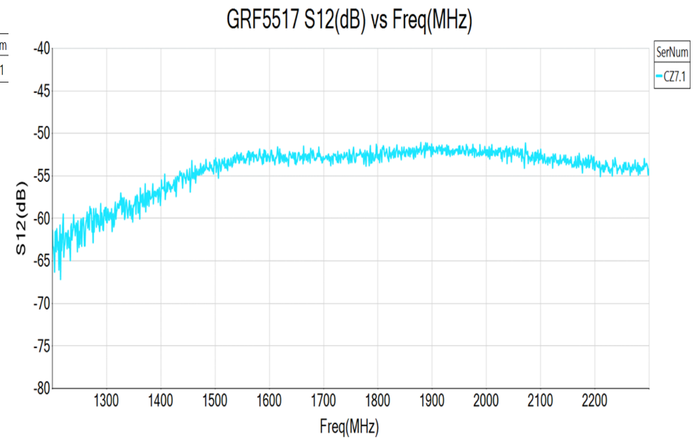
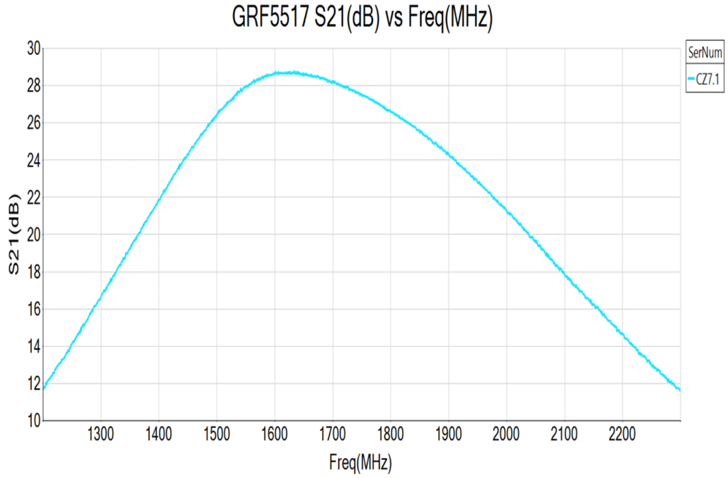
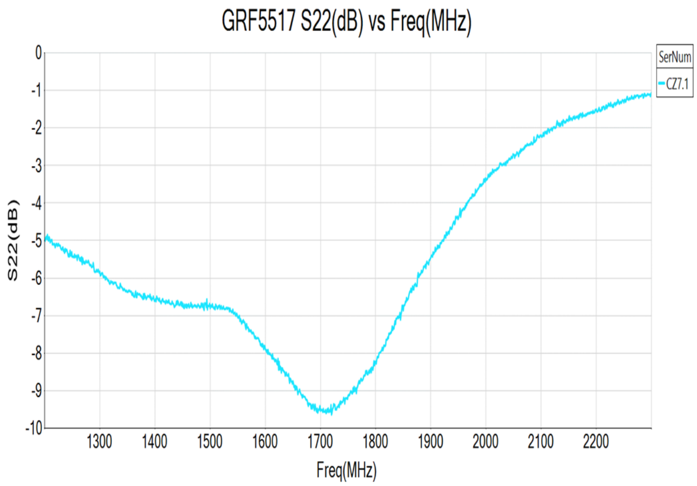
GRF5517 Typical Operating Curves: S-Parameters (1.7 to 1.8 GHz Tune)

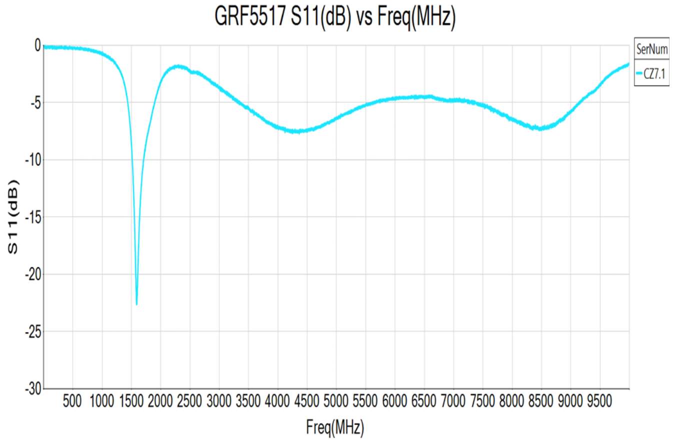


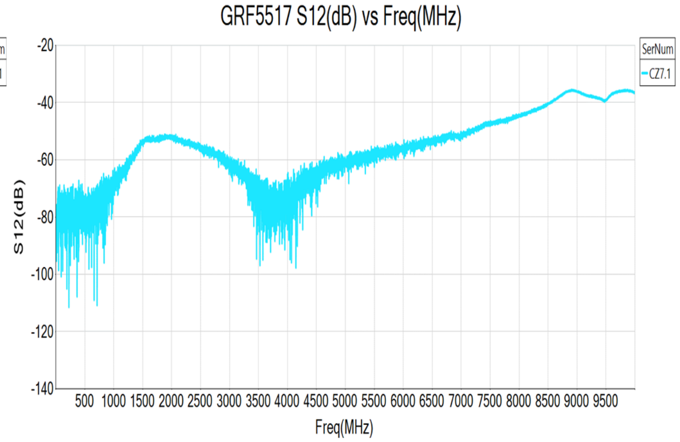


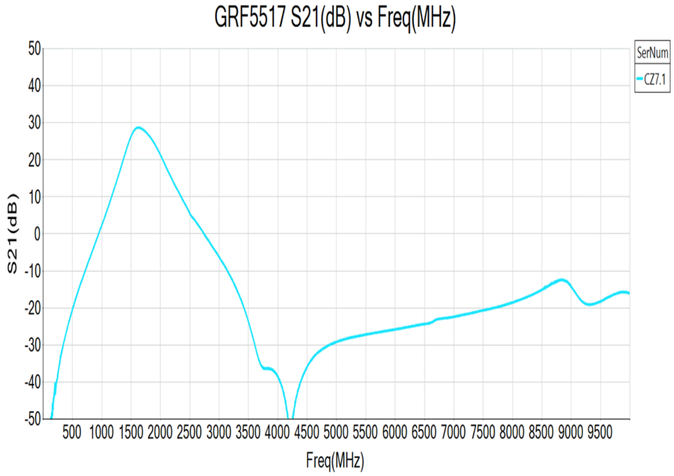


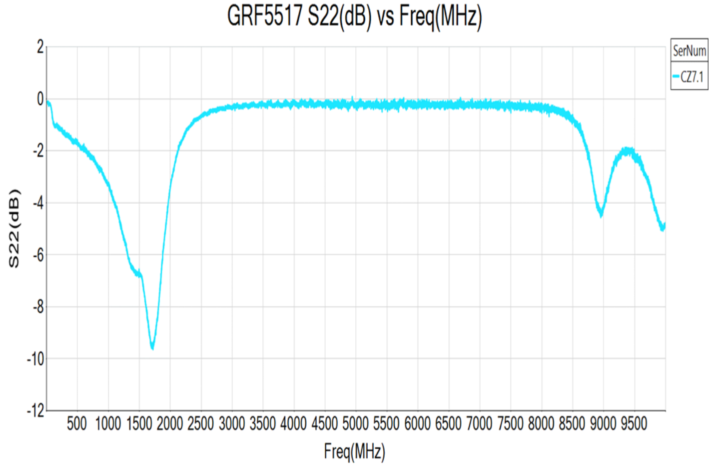


GRF5517 Typical Operating Curves: S-Parameters (1.7 to 1.8 GHz Tune)

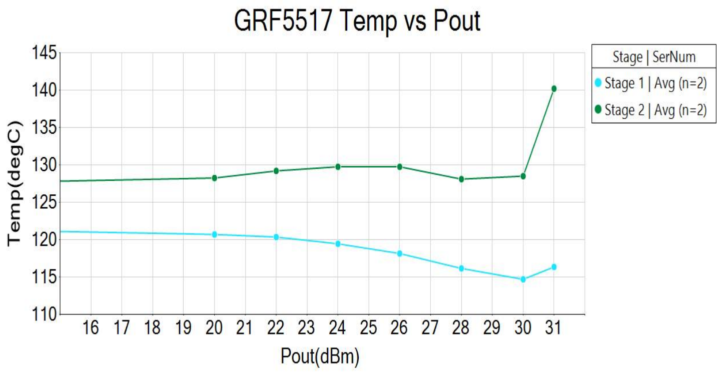








GRF5517 Typical Operating Curves: Maximum Die Temperatures vs. Pout *(85C Reference Temperature on Standard Evaluation Board; CW Tone Input)*



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

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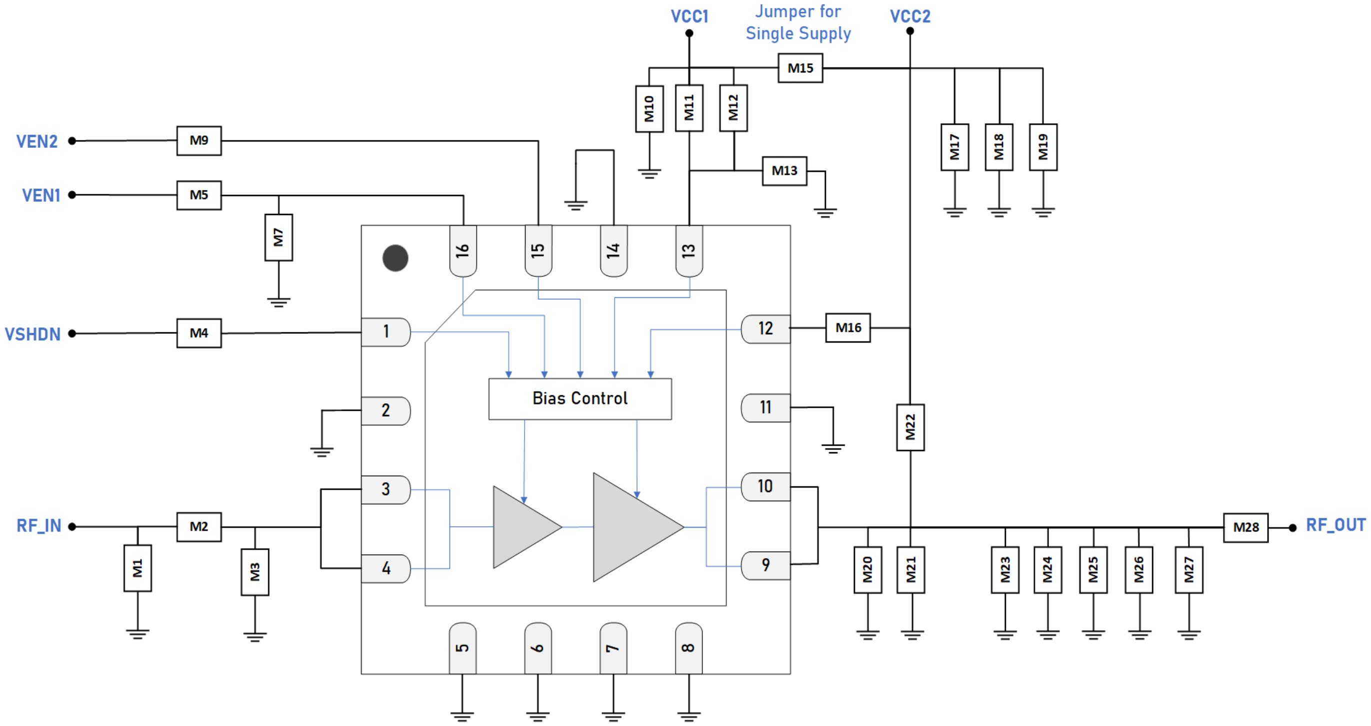
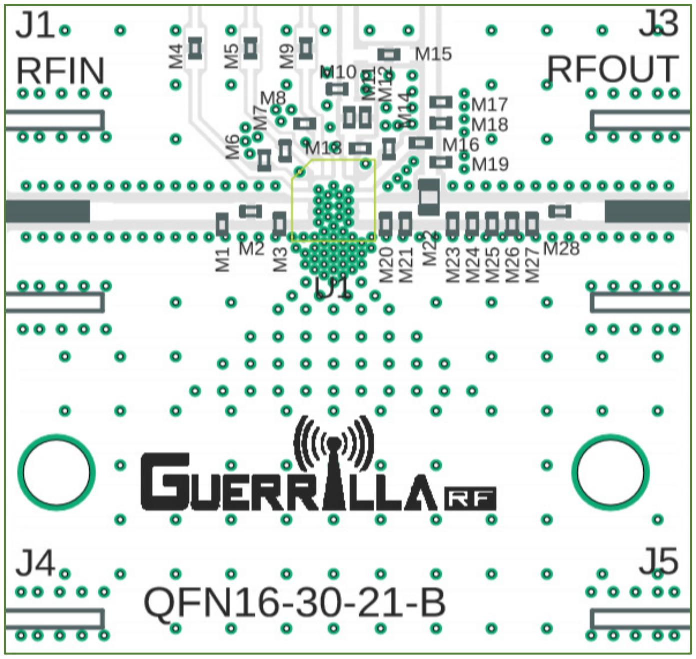


GRF5517 Application Schematic



GRF5517 Evaluation Board Assembly Diagram

GRF5517 Evaluation Board Assembly Diagram Reference

Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1	Inductor	Murata	LQG	1.8 nH	0402	ok
M2	Capacitor	Murata	LQG	4.7 pF	0402	ok
M3,M6,M7,M8,M10,M12, M14,M17,M19,M20,M21, M23,M24,M26,M27	DNP					
M4	Resistor	Various	--	0 Ohm	0402	ok
M5	Resistor	Various	1%	2260	0402	ok
M9	Resistor	Various	1%	2940	0402	ok
M11	Resistor	Various	--	0 Ohm	0402	ok
M13	Capacitor	Murata	GRM	0.1 uF	0402	ok
M15	Inductor	Murata	LQG	47 nH	0402	ok
M16	Resistor	Various	--	0 Ohm	0402	ok
M18	Capacitor	Murata	GJM	10 uF	0402	ok
M22	Inductor: High Q	Murata	LQW	10 nH	0402	ok
M25	Capacitor	Murata	GJM	3.6 pF	0402	ok
M28	Capacitor	Murata	GJM	15 pF	0402	ok
Evaluation Board	QFN16-30-21-B					

Note: Standard evaluation board bias: V_{CC}: 5.0 V; V_{ENABLE}: 5.0 V.

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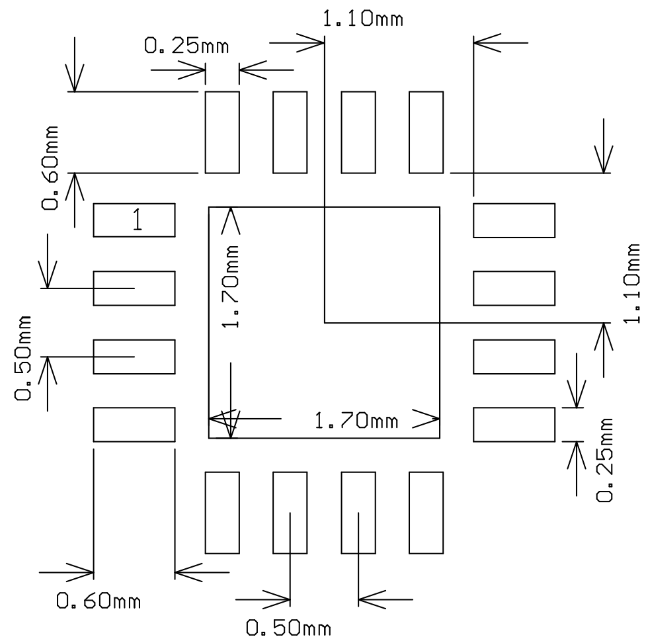
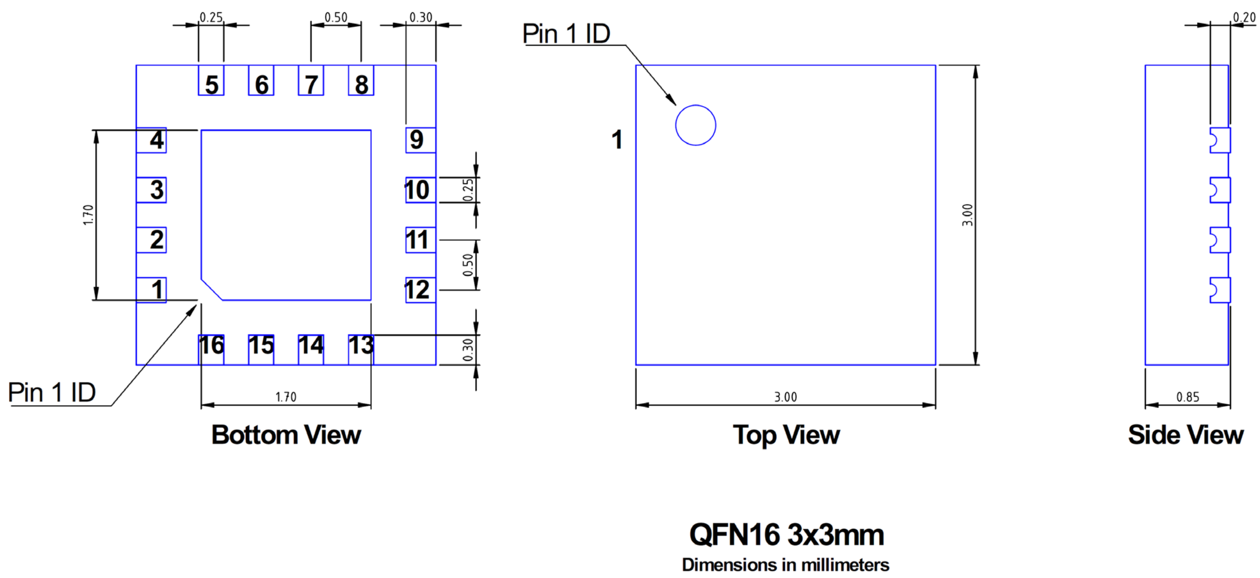
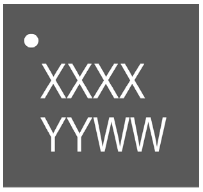


3 x 3 mm QFN-16 Suggested PCB Footprint (Top View)



3 x 3 mm QFN-16 Package Dimensions

Package Marking Diagram



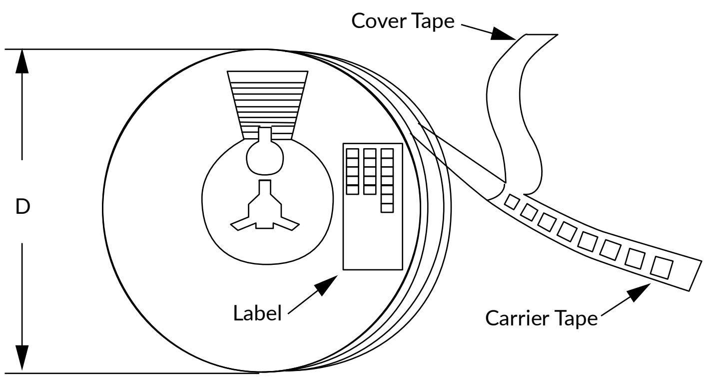
Line 1 *"XXXX" = PART NUMBER*

Line 2 *"YY" = YEAR and "WW" = WEEK* that the part was assembled.

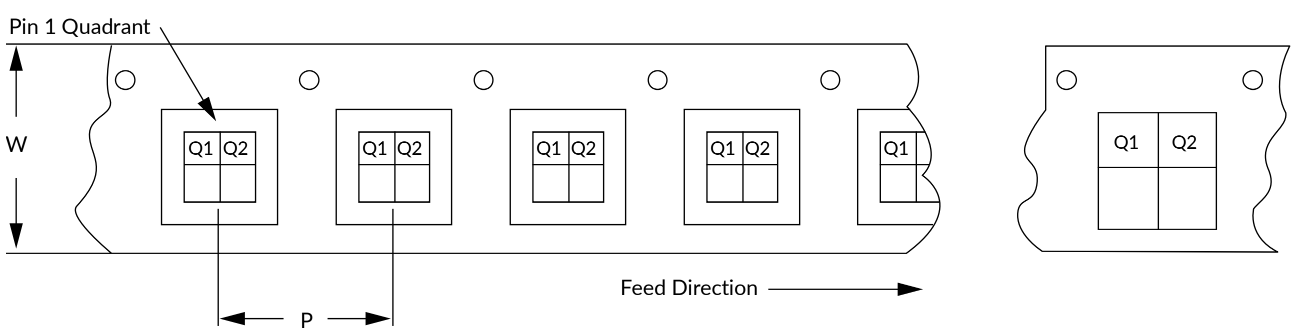
Tape and Reel Information

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). 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.



Tape and Reel Packaging with Reel Diameter Noted (D)



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

Tape and Reel Specification and Device Package Information

Package			Carrier Tape			Reel	
Type	Dimensions (mm)	Leads	Width (W) (mm)	Pocket Pitch (P) (mm)	Pin 1 Quadrant	Diameter (D) (Inches)	Units per Reel
QFN	2.0 x 2.0 x 0.50	12	8	4	Q1	7	2500
QFN	3.0 x 3.0 x 0.85	16	12	8	Q1	7	1500
DFN	1.5 x 1.5 x 0.45	6	8	4	Q1	7	2500
DFN	2.0 x 2.0 x 0.75	8	8	4	Q1	7	2500
LFM	3.5 x 3.5 x 0.85	See Note	12	8	Q1	7	1500
LFM	4.0 x 4.0 x 0.75	See Note	12	8	Q2	7	1500

Note: Lead count may vary. Reference applicable product data sheet.

Revision History

Revision Date	Description of Change
March 17, 2021	Release Ø update. Converted format to new template. Added typical operating curves.

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Datasheet 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 datasheet 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.