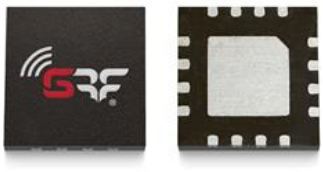
DATA SHEET

RELEASE A DATA SHEET



GRF5509

HIGH EFFICIENCY, 4-WATT PA
689 to 1090 MHz

FEATURES

- Flexible Bias Voltage and Current
- 125 mA Native Mode Quiescent Current Consumption
- 5 V Supply Voltage
- -40 to 85 °C Operating Temperature Range
- Compact 3 x 3 mm QFN-16 Package
- Process: InGaP HBT

Reference: 5 V / 125 mA I_{CCQ} / 915 MHz

- Gain: 33.4 dB
- I_{CCQ}: 125 mA
- P_{SAT}: 36.4 dBm
- OP1dB: 35.5 dBm
- PAE: 55% @P_{SAT}
- Evaluation Board Noise Figure: 3.7 dB

APPLICATIONS

- 900 MHz ISM
- Automatic Meter Reader
- RFID

DESCRIPTION

The GRF5509 is a high efficiency PA that delivers P_{sat} of 4 Watts with V_{CC} at 5 Volts and an I_{CCQ} of 125 mA. PAE at P_{sat} is roughly 55%.

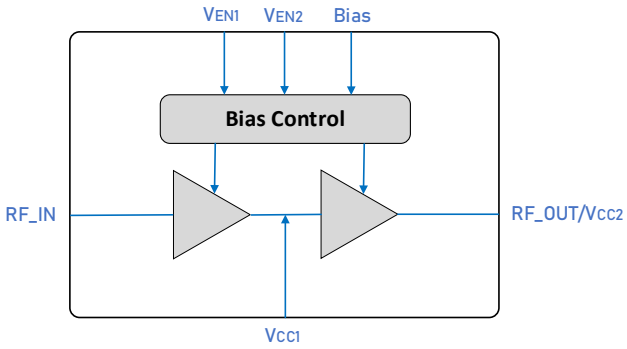
The device can be tuned over a range of frequencies from around 689 MHz to 1090 MHz with typical fractional bandwidths of 3 to 5%.

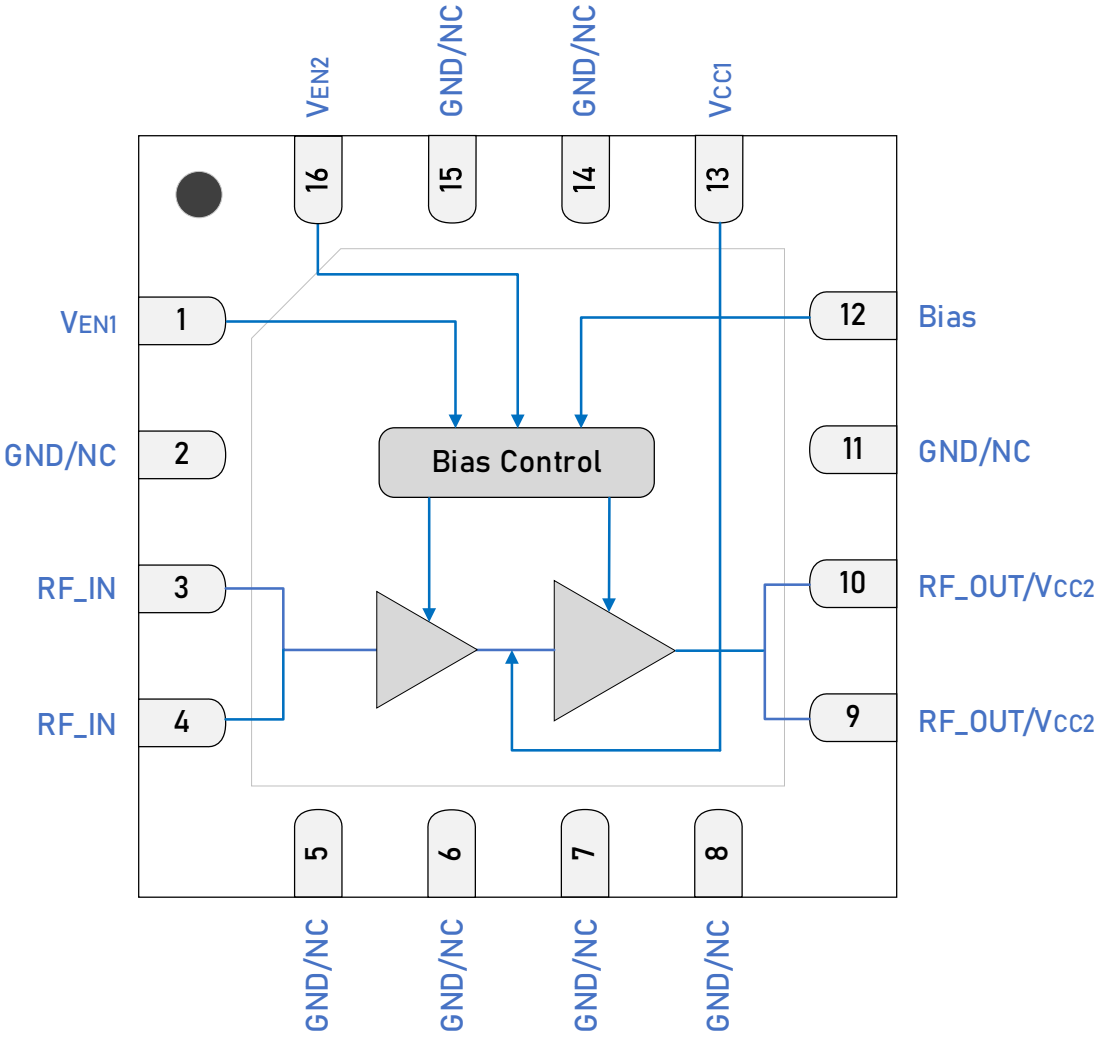
For frequencies in the 400-500 MHz range, GRF5504 offers high output power and slightly higher efficiency with the same package and pinout.

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

Additional tunes can be found on the GRF5509 "Custom Tunes" product page: GRF5509 Custom Tunes

BLOCK DIAGRAM





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

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Pin Assignments

Pin	Name	Description	Note
1	V_{EN1}	Enable1 Voltage Input	V_{EN1} and series resistor set I_{CCQ1} for the input stage. $V_{EN1} \leq 0.2$ volts disables device.
2, 5, 6, 7, 8, 11, 14, 15	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 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.
16	V_{EN2}	Enable2 Voltage Input	V_{EN2} and series resistor set I_{CCQ2} for the output stage. $V_{EN2} \leq 0.2$ volts disables device.
PKG BASE	GND	Ground	Provides DC and RF ground for PA, 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_{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
Transient Average RF Input Power: Load VSWR < 2:1, Duration: <1 hour	P_{IN} Max		13	dBm
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)	$P_{DISS\ MAX}$		400	mW
Maximum Dissipated Power (Stage 2)	$P_{DISS\ MAX}$		3800	mW
Ruggedness: V_{CC} = 5 V at Psat (all phase angles)	VSWR	8:1		--

Electrostatic Discharge

Human Body Model	HBM	250		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*

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Recommended Operating Conditions

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Voltage	V_{CC}	3	5	5.5	V	
Operating Temperature (package base)	$T_{PKG\ BASE}$	-40		85	°C	
RF Frequency Range	F_{RF}	689		1090	MHz	Typical application schematic using the 0.7 to 1 GHz 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 2-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: GRF5509 Custom Tunes

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

Nominal Operating Parameters – General

The following conditions apply unless noted otherwise: typical application schematic using the 0.902 to 0.928 GHz tuning set. V_{CC} = 4.75 to 5.25 V, I_{CCQ} = 125 mA. F_{TEST} = 0.915 GHz, M1 = 3.3 kΩ, M3 = 6.8 kΩ. 50 Ω system impedance. Typical values are V_{CC} = 5 V, I_{CCQ} = 125 mA. $T_{PKG\ BASE}$ = 25 °C. Evaluation board losses are included within the specifications.

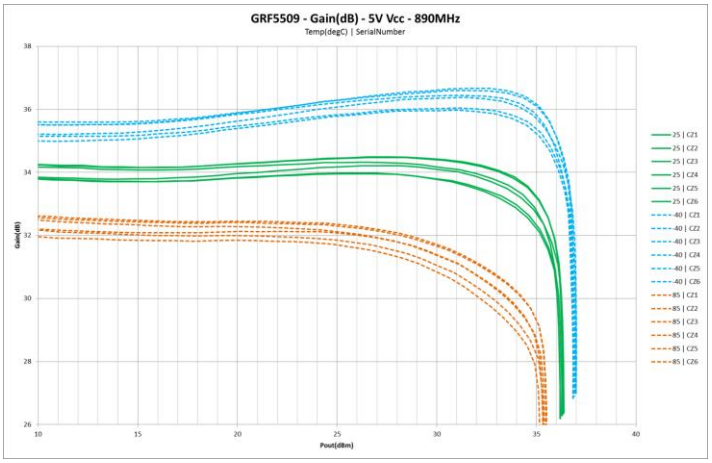
Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Quiescent Current	I_{CCQ}	90	125	160	mA	V_{CC} = V_{EN1} = V_{EN2} = 5 V.
Enable Current = I_{EN1} + I_{EN2}	I_{EN}		2	6	mA	V_{CC} = V_{EN1} = V_{EN2} = 5 V.
Operating Temperature Range	$T_{PKG\ BASE}$	-40		85	°C	Measured on package base.
Disabled Mode						
Supply Quiescent Current (Leakage)	I_{CC}		1	10	µA	V_{CC} = 5 V. V_{EN1} = V_{EN2} = 0 V.
Thermal Data						
Thermal Resistance (Infrared Scan)	Θ_{JC}		28		°C/W	On Standard Evaluation Board.

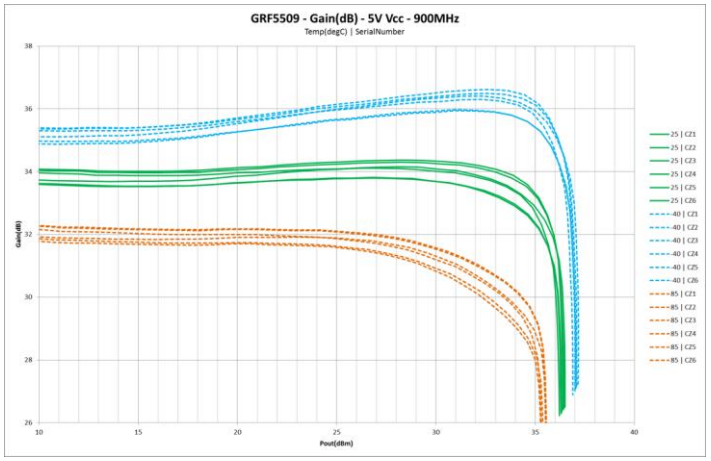
Nominal Operating Parameters – RF: 0.902 to 0.928 GHz

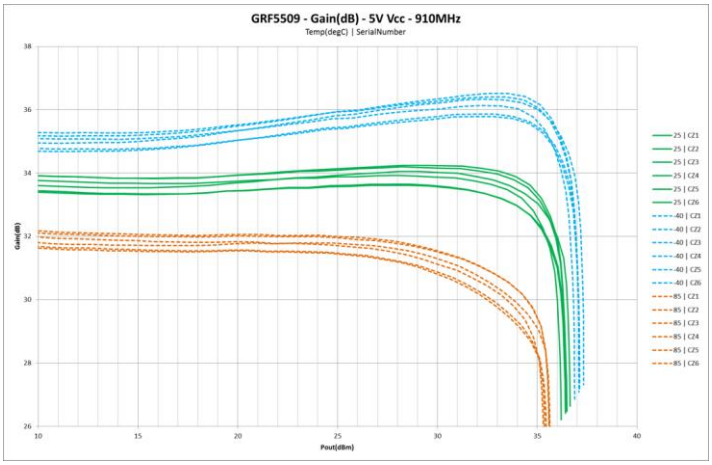
The following conditions apply unless noted otherwise: typical application schematic using the 0.902 to 0.928 GHz tuning set. V_{CC} = 4.75 to 5.25 V, I_{CCQ} = 125 mA, F_{TEST} = 0.915 GHz, M1 = 3.3 kΩ, M3 = 6.8 kΩ. 50 Ω system impedance. Typical values are V_{CC} = 5 V, I_{CCQ} = 125 mA. $T_{PKG\ BASE}$ = 25 °C. Evaluation board losses are included within the specifications.

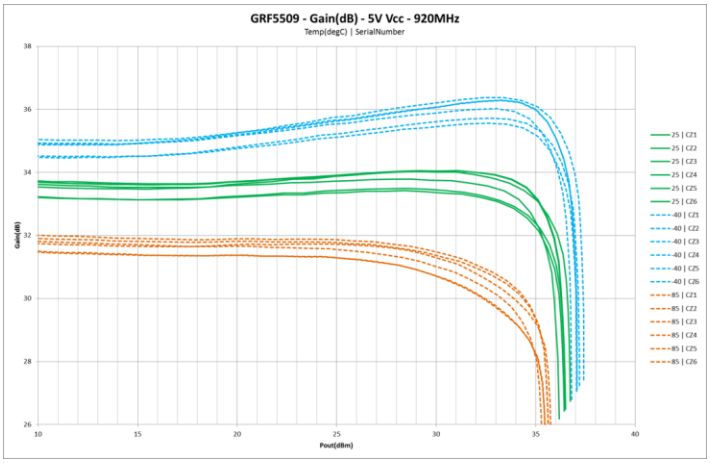
Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Small Signal Gain	S21	31.4	33.4		dB	F_{TEST} = 0.915 GHz. V_{CC} = 5 V. P_{IN} = -25 dBm.
Input Return Loss	S11		< -10		dB	F_{RF} = 0.902 to 0.928 GHz.
Output Return Loss	S22		< -7		dB	F_{RF} = 0.902 to 0.928 GHz.
Reverse Isolation	S12		< -42		dB	F_{RF} = 0.902 to 0.928 GHz.
Noise Figure	NF		3.7		dB	On standard evaluation board.
Saturated Output Power	P_{SAT}	35.7	36.4		dBm	RF input power = 8 dBm.
Power Added Efficiency (at P_{SAT})	PAE		55		%	
Output 1 dB Compression Power	OP1dB		35.5		dBm	CW input. V_{CC} = 5 V. $T_{PKG\ BASE}$ = 25 °C.

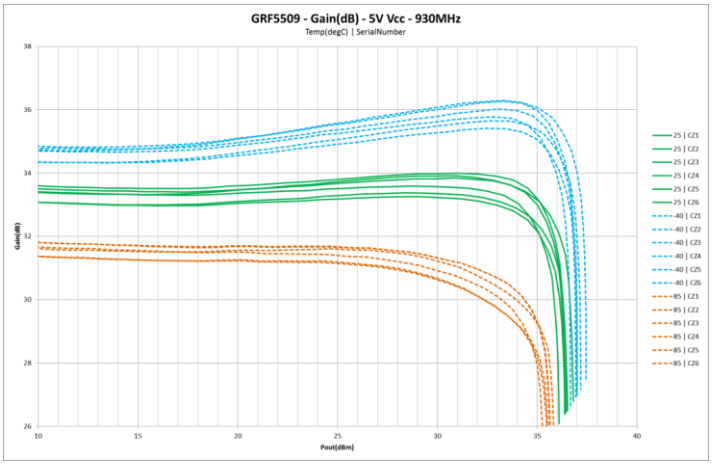
GRF5509 Typical Operating Curves: *Gain vs. P_{OUT} (5 V)*

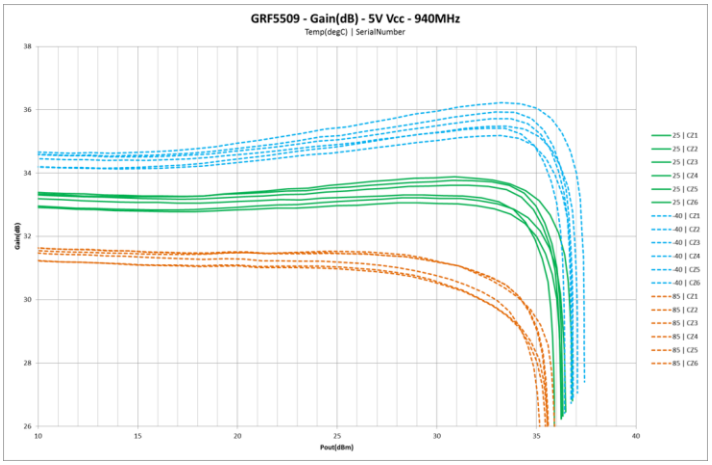




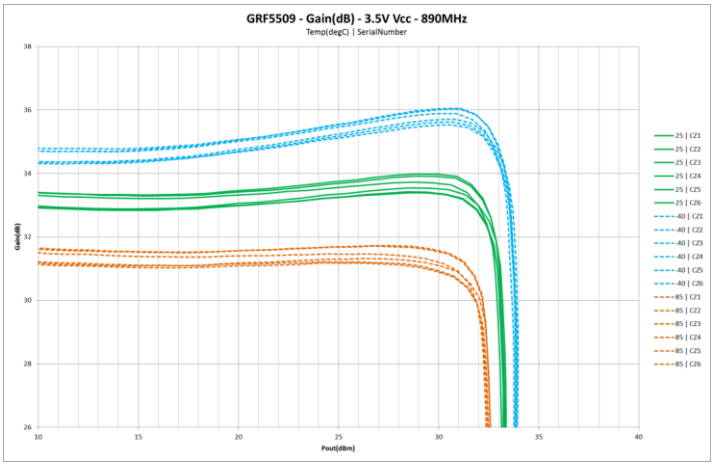


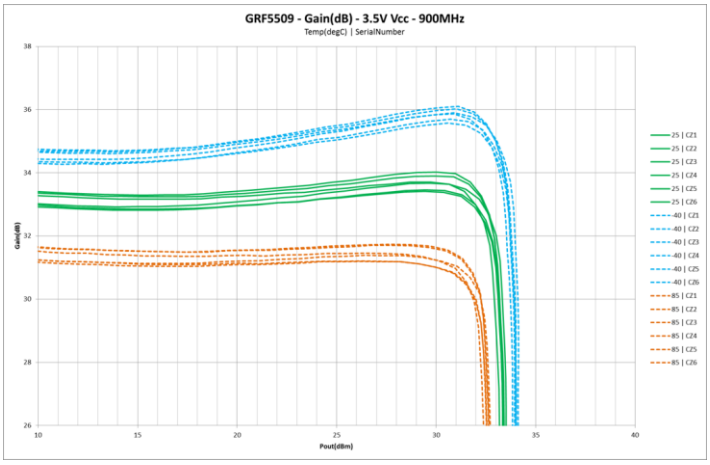


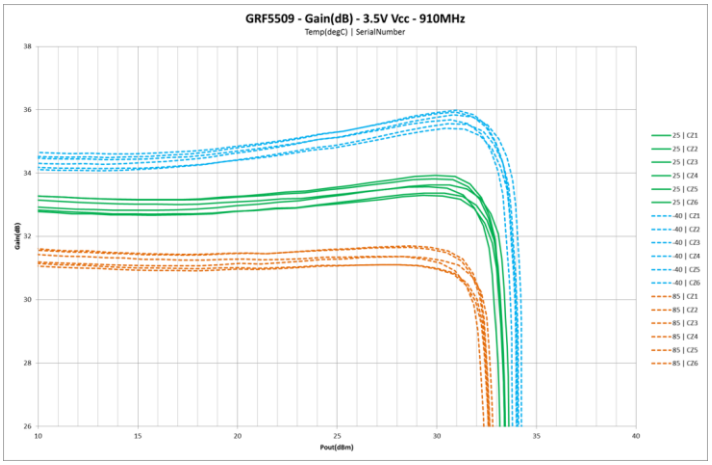


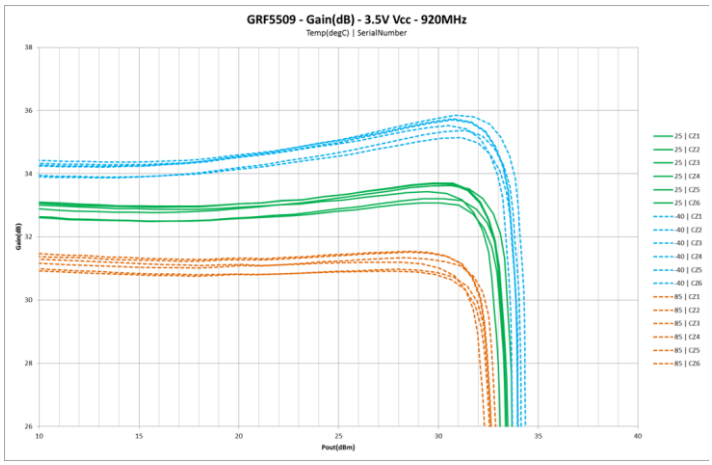


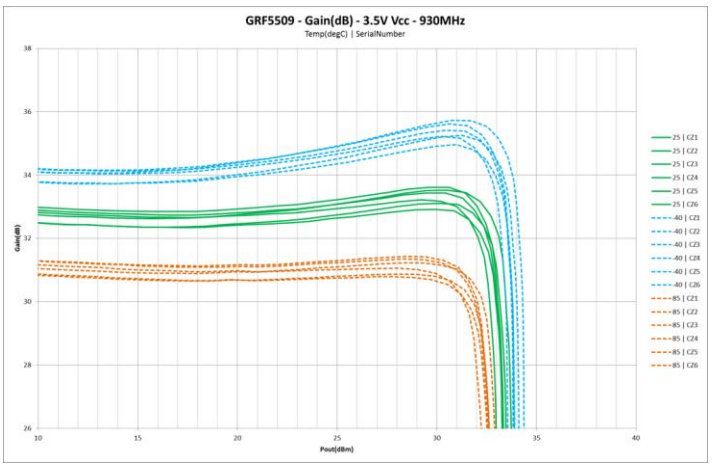
GRF5509 Typical Operating Curves: *Gain vs. P_{OUT} (3.5 V)*

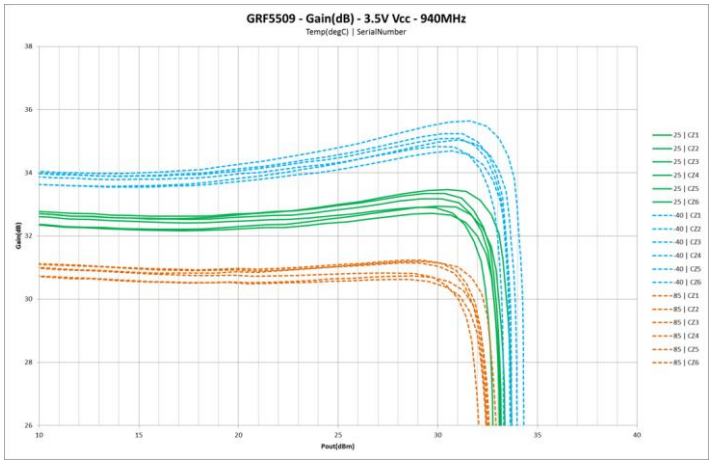




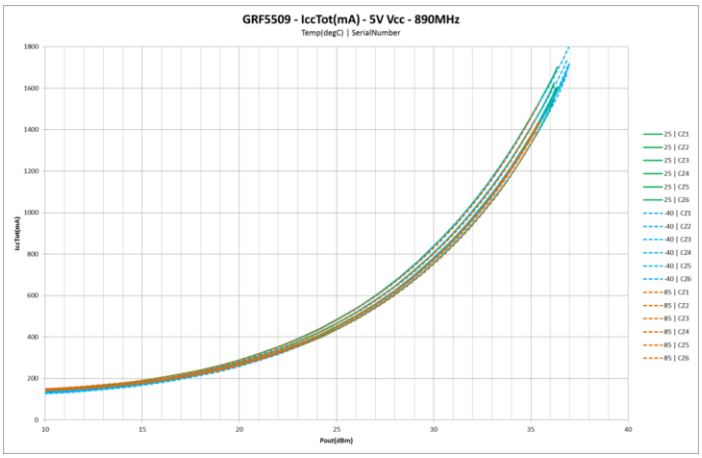


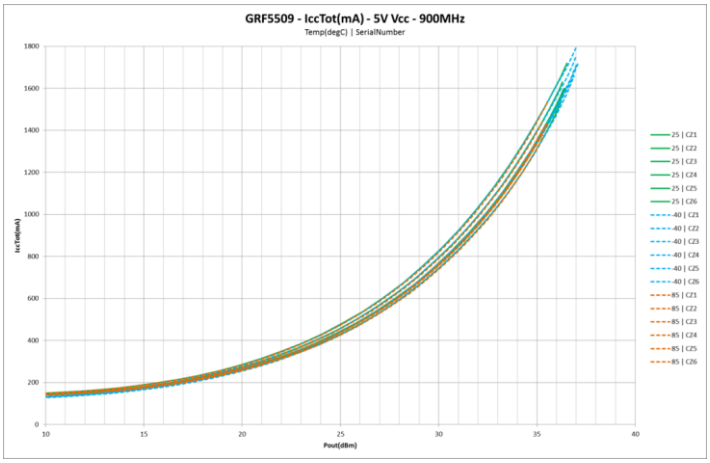


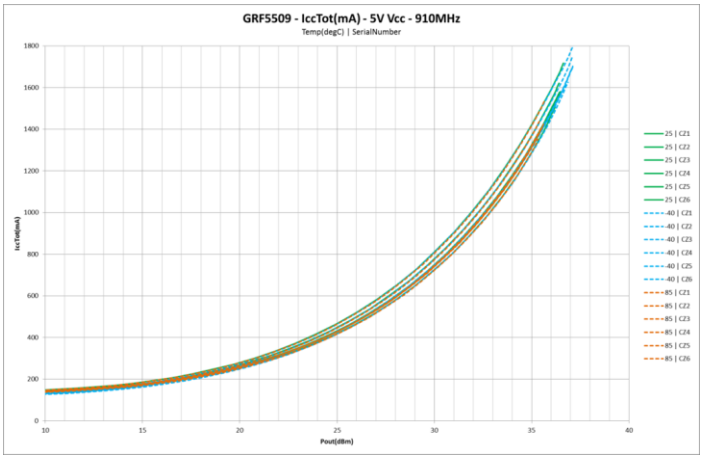


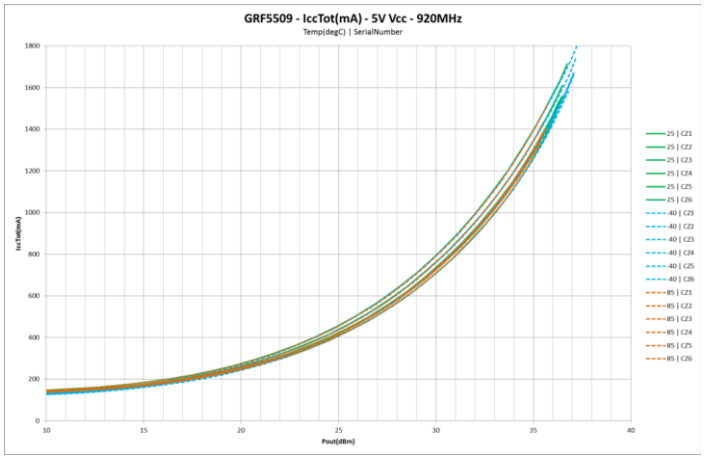


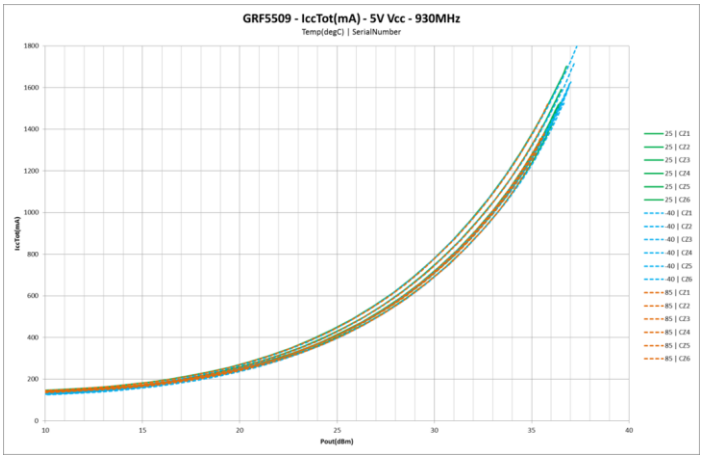
GRF5509 Typical Operating Curves: I_{CC} *Total vs.* P_{OUT} *(5 V)*

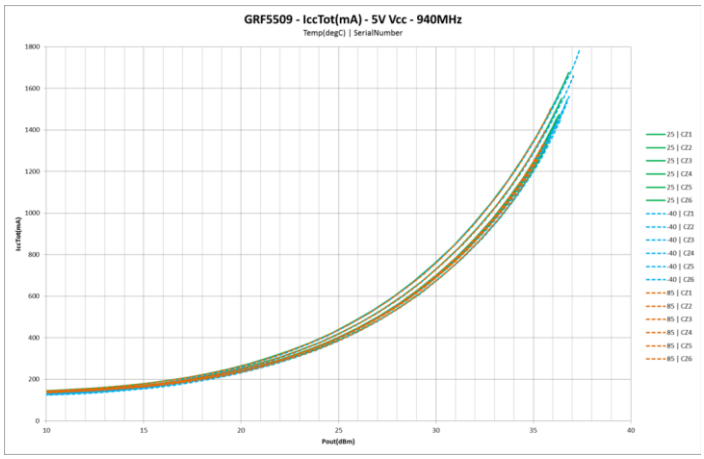




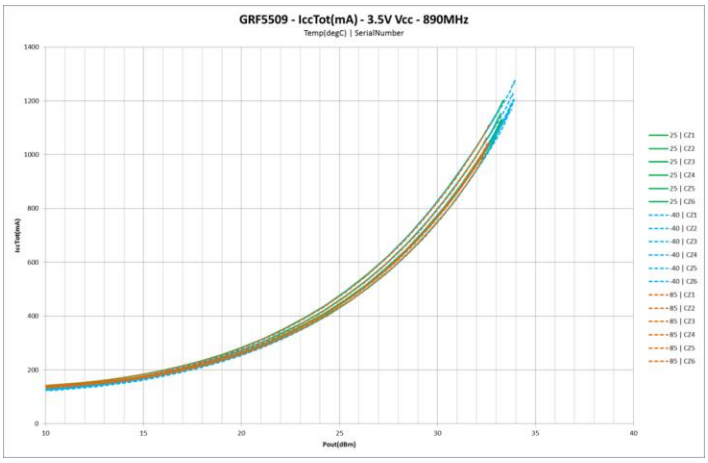


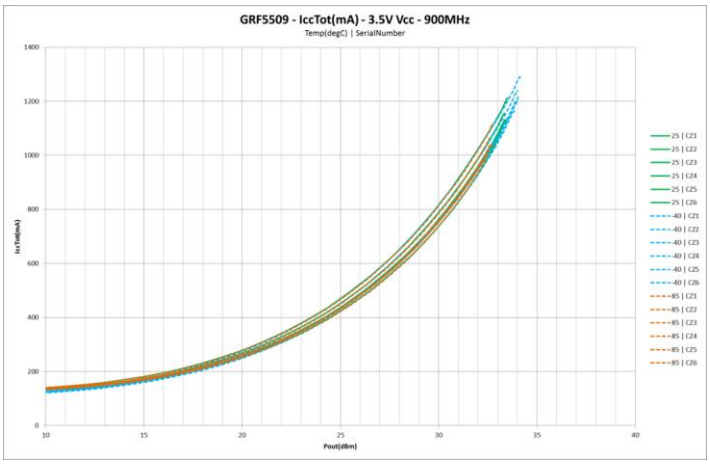


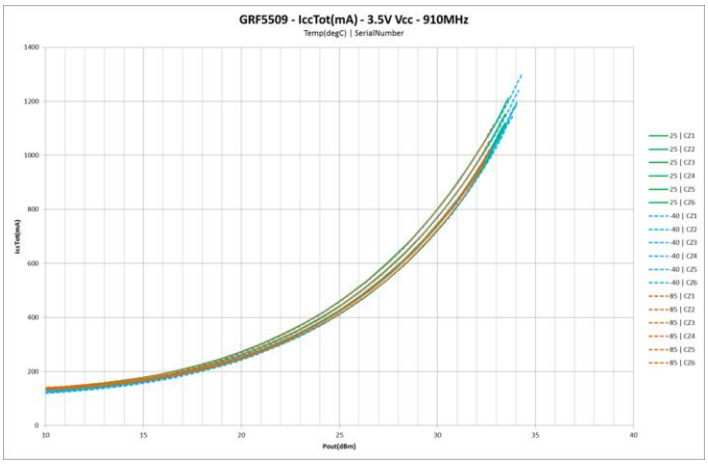


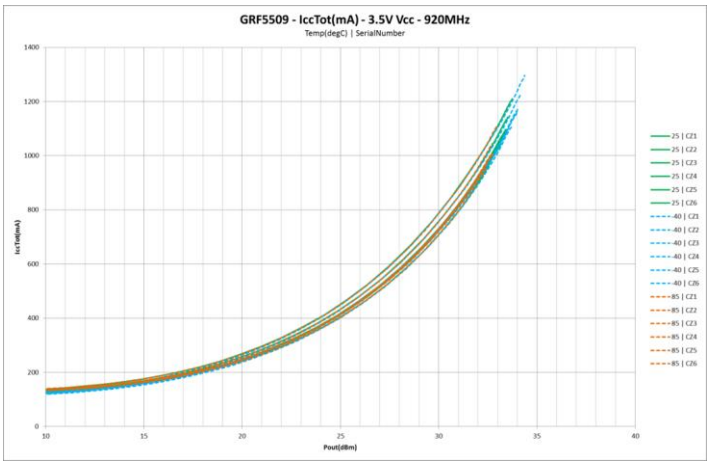


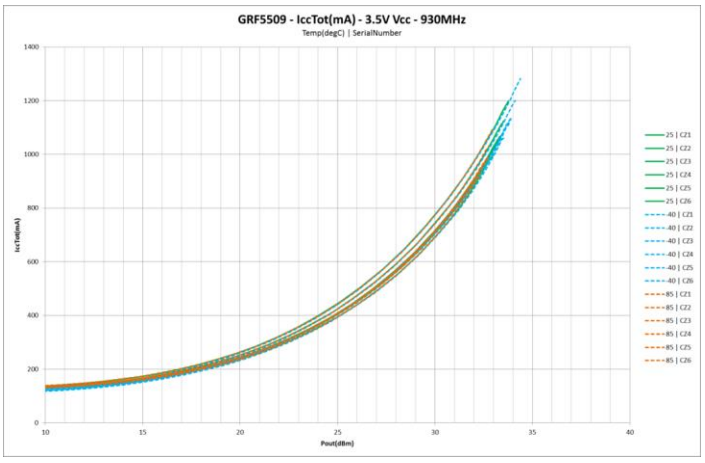
GRF5509 Typical Operating Curves: I_{CC} *Total vs.* P_{OUT} *(3.5 V)*

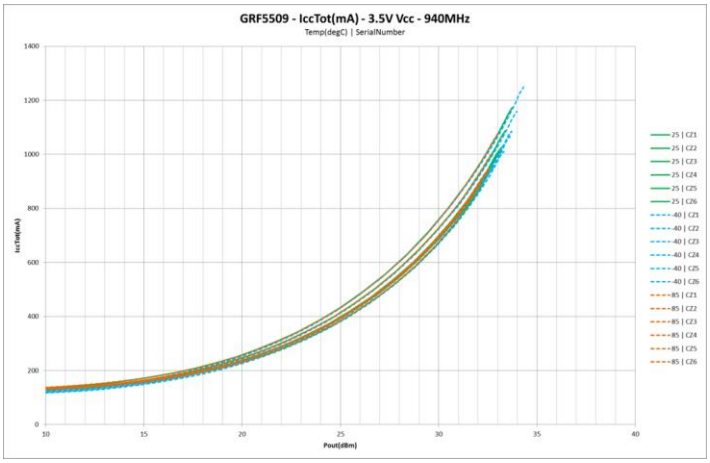




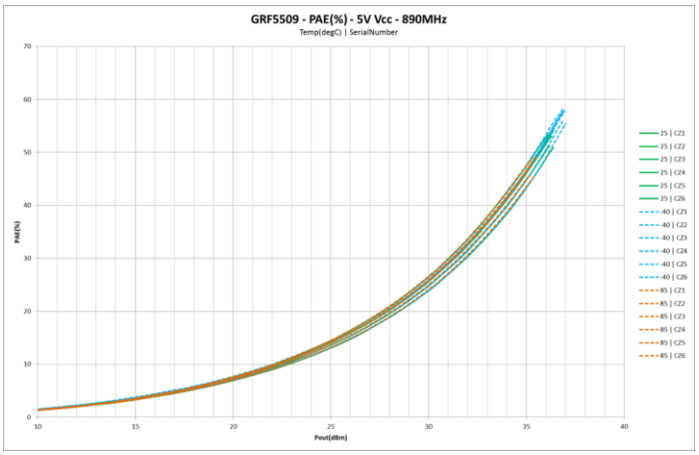


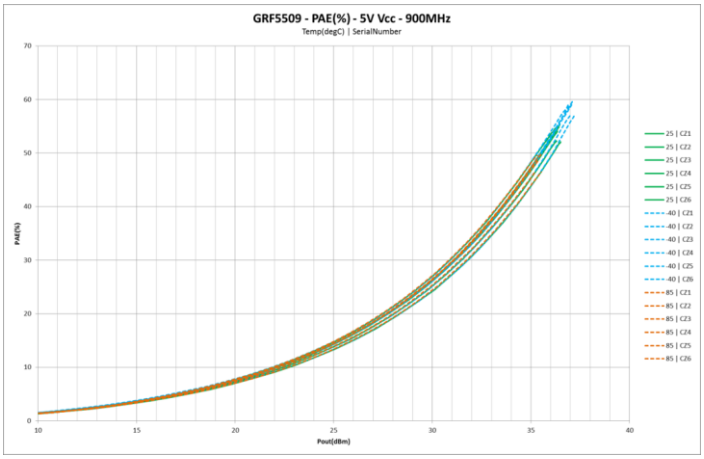


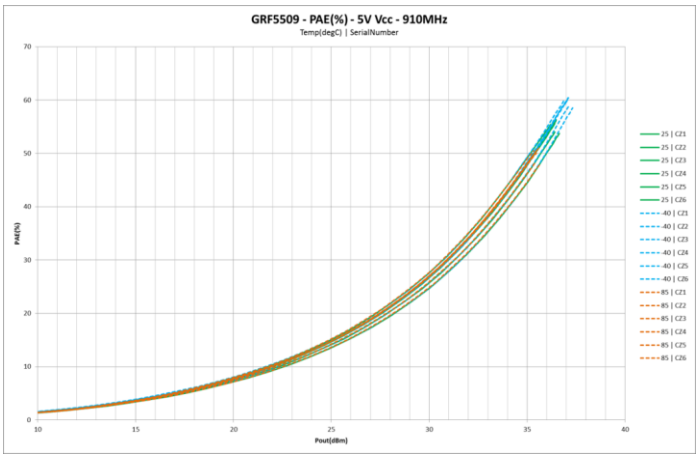


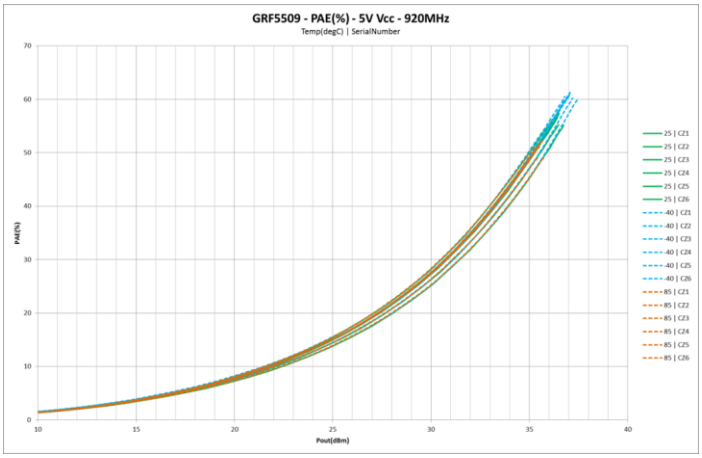


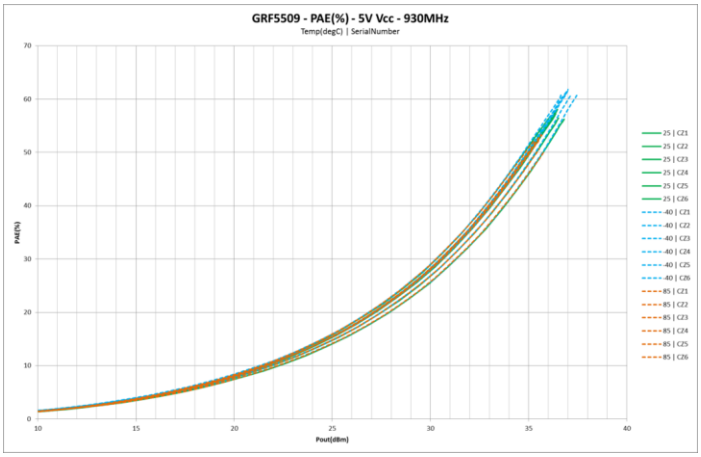
GRF5509 Typical Operating Curves: *PAE vs. P_{OUT} (5 V)*

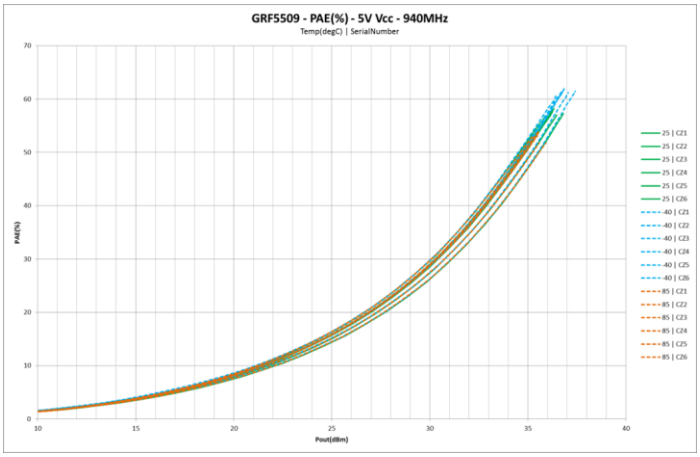












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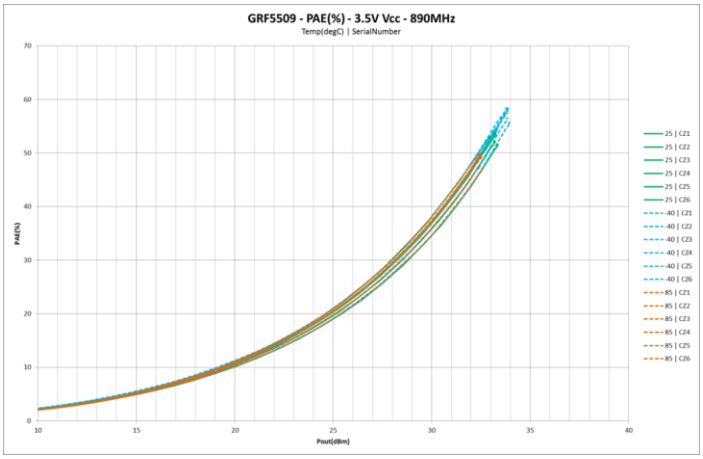
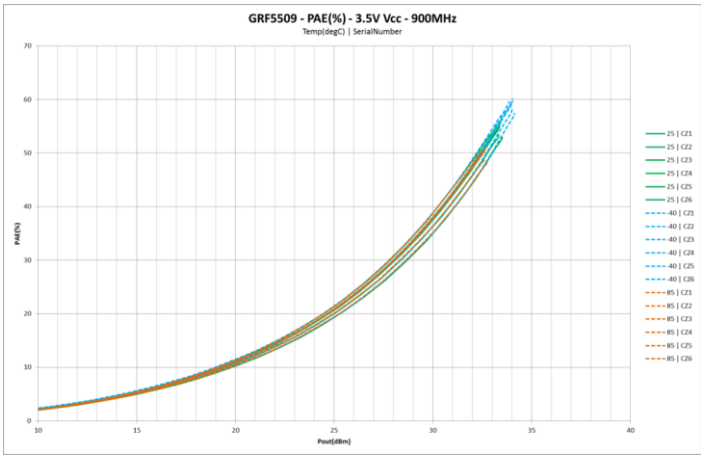
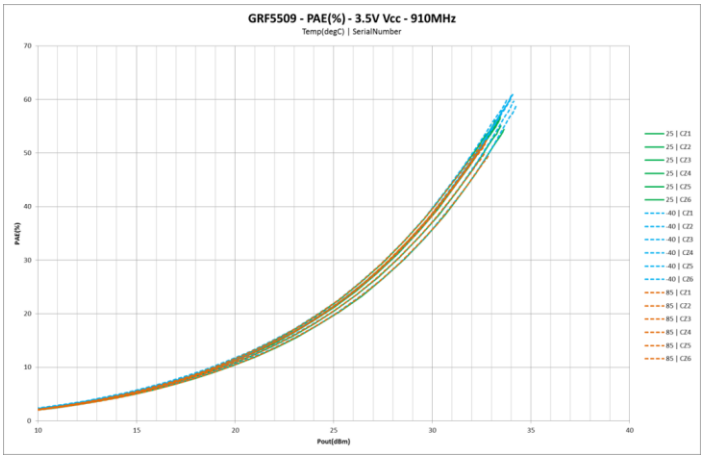
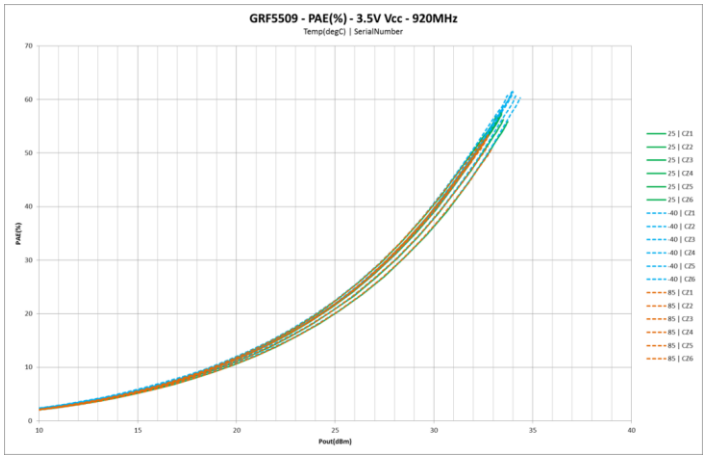
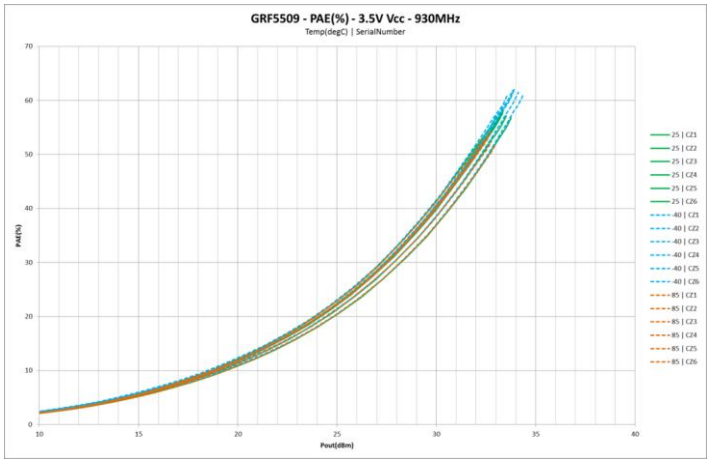
GRF5509 Typical Operating Curves: *PAE vs. P_{OUT} (3.5 V)*

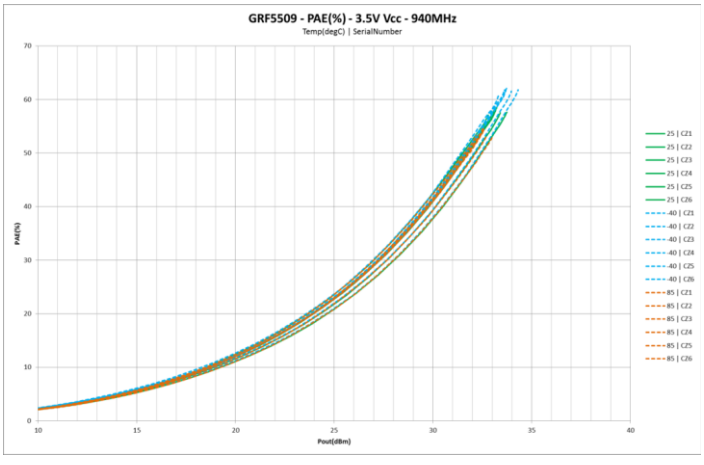




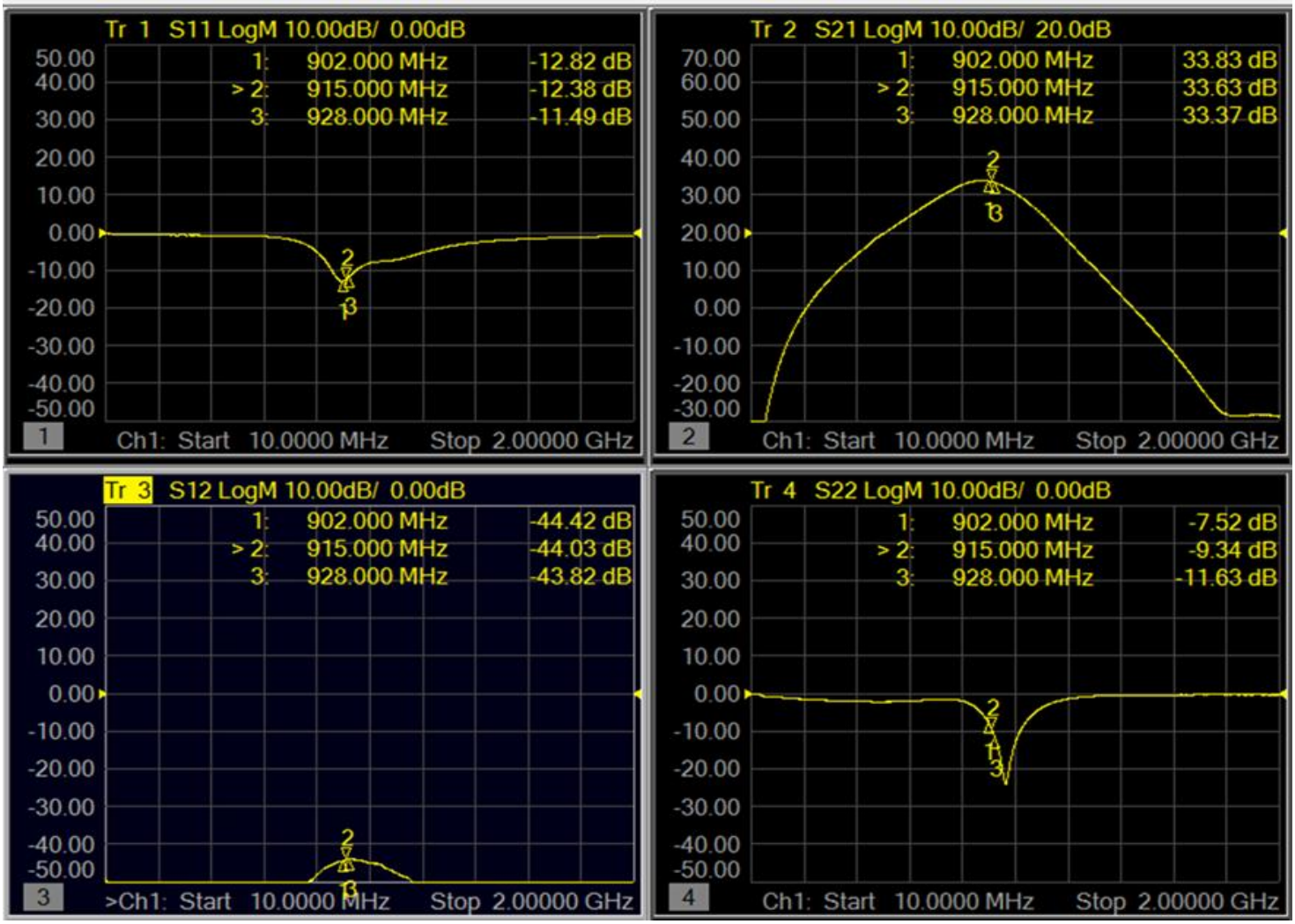




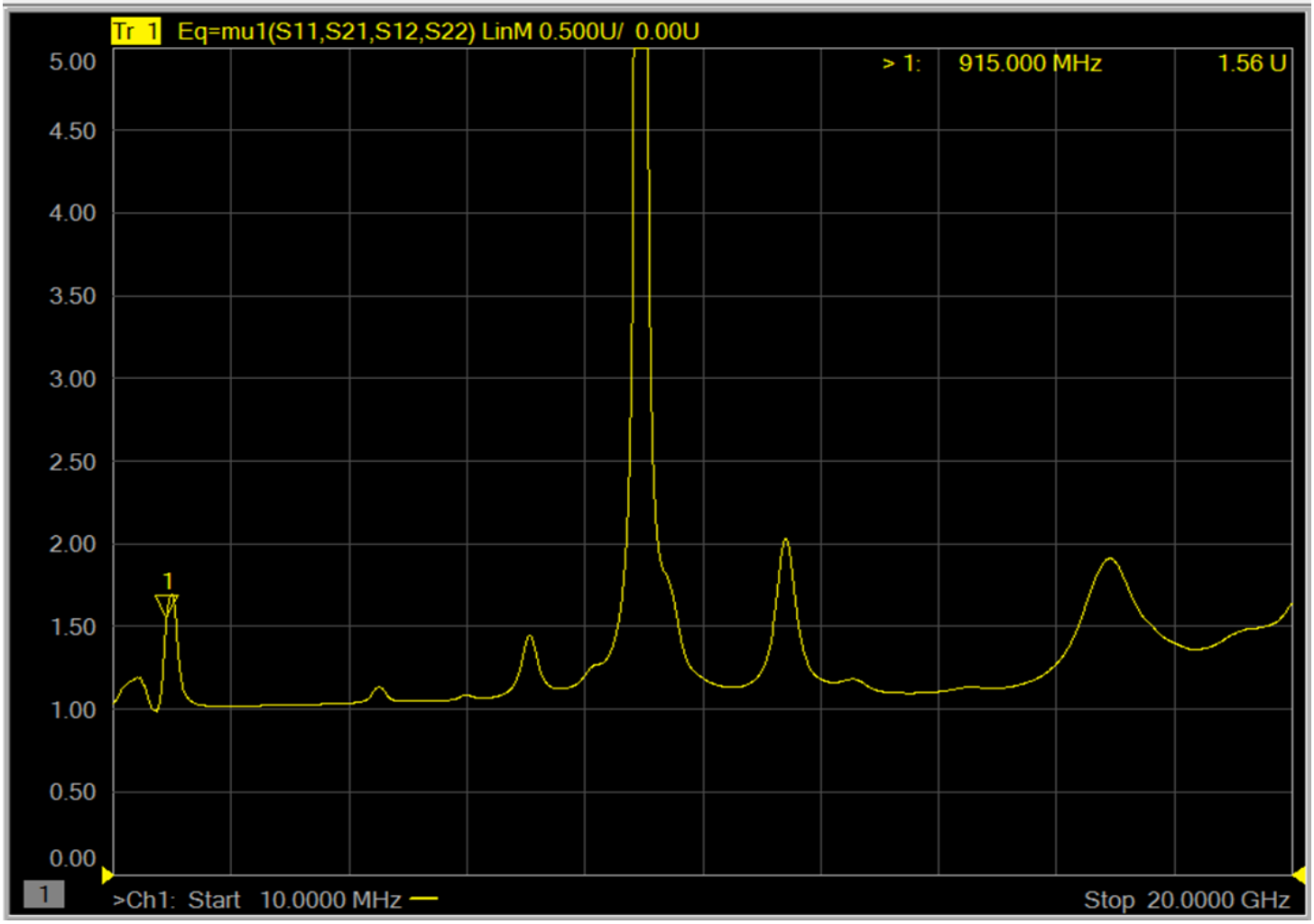




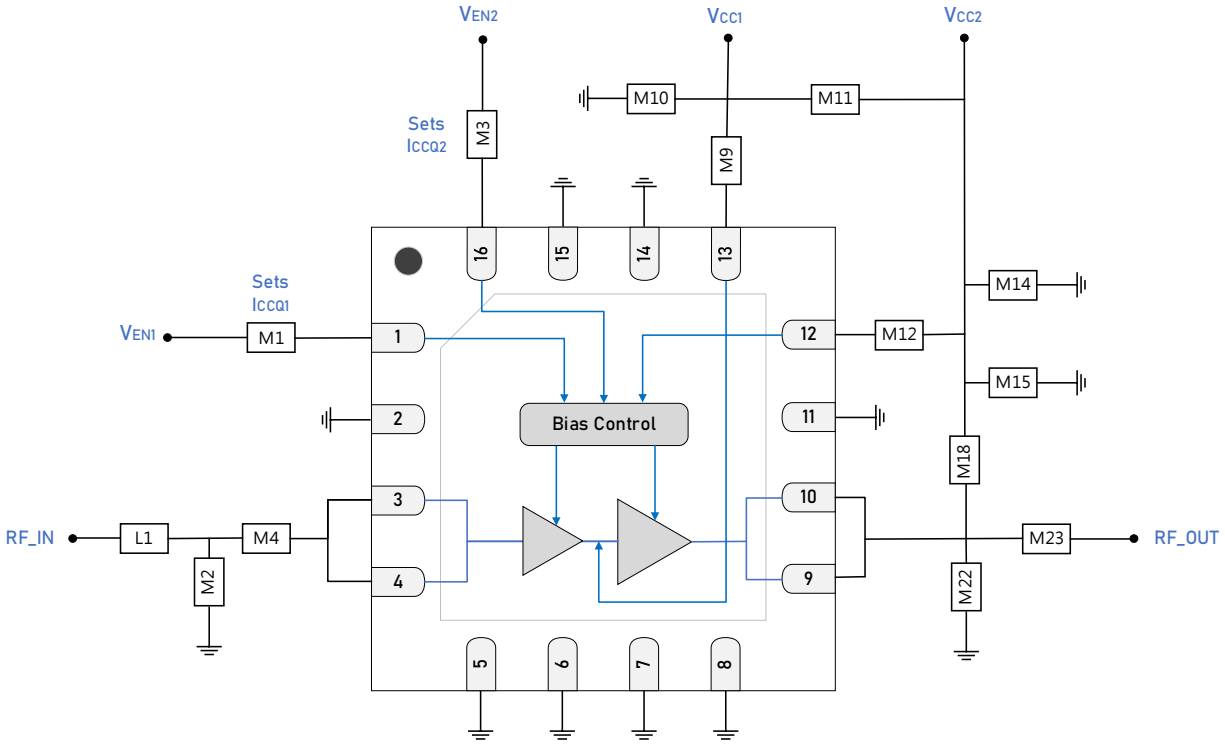
GRF5509 Small Signal S-Parameters: 902 to 928 MHz Tune



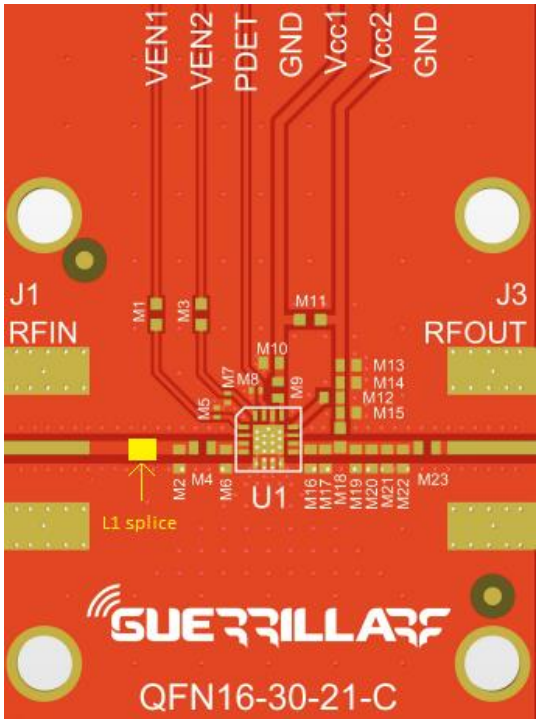
GRF5509 Stability Mu Factor: 10 MHz to 20 GHz



Note: Mu factor ≥ 1.0 implies unconditional stability



GRF5509 Standard Evaluation Board Schematic



GRF5509 Evaluation Board Assembly Diagram

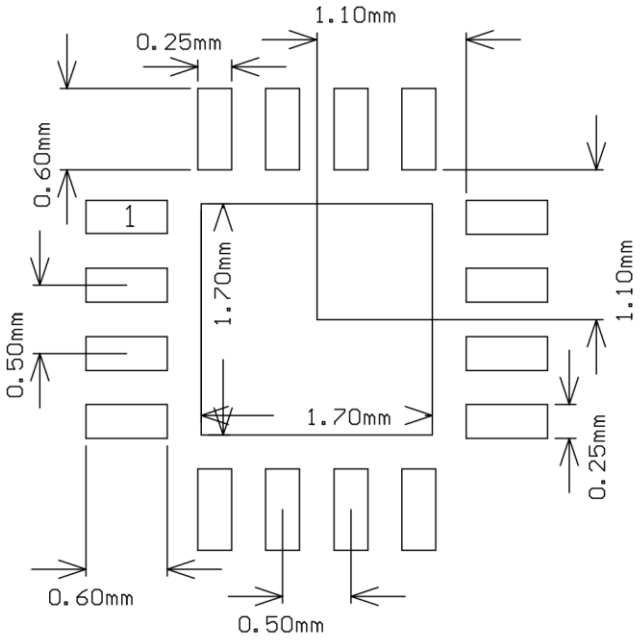
GRF5509 Evaluation Board Assembly Diagram Reference: 0.902 to 0.928 GHz

Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1	Resistor	Various	5%	3.3 kΩ	0402	ok
L1 (Adjacent to M2)	Inductor	Murata	LQG	6.8 nH	0402	ok
M2	Inductor	Murata	LQG	6.8 nH	0402	ok
M3	Resistor	Various	5%	6.8 kΩ	0402	ok
M4	Capacitor	Murata	GJM	5.6 pF	0402	ok
M9	Resistor (jumper)	Various	5%	0 Ω	0402	ok
M10	Capacitor	Murata	GRM	0.1 uF	0402	ok
M11	Resistor (jumper)	Various	5%	0 Ω	0402	ok
M12	Resistor (jumper)	Various	5%	0 Ω	0402	ok
M14	Capacitor	Murata	GRM	0.1 uF	0402	ok
M15	Capacitor	Murata	GRM	100 pF	0402	ok
M18	Inductor: High Q	Murata	LQW18AN	24 nH	0603	ok
M22	Capacitor	Murata	GJM	12 pF	0402	ok
M23	Capacitor	Murata	GJM	20 pF	0402	ok
Evaluation Board	QFN16-30-21-C					

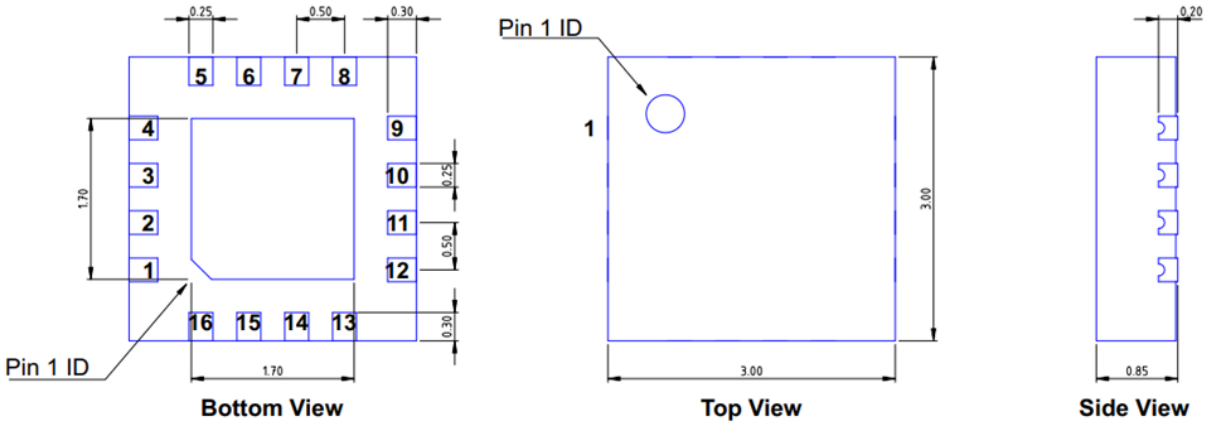
Note: Standard evaluation board bias: V_{CC} = 5 V, V_{EN1} = V_{EN2} = 5 V.

GRF5509 Bias Resistor Selection Table

V_{CC1} (V)	V_{CC2} (V)	V_{EN1}, V_{EN2} (V)	I_{CCQ1} (mA)	I_{CCQ2} (mA)	Bias R M1 (Ω)	Bias R M3 (Ω)
5	5	5	30	90	3.3 kΩ	6.8 kΩ
4.5	4.5	4.5	26	80	3.3 kΩ	5.9 kΩ
4	4	4	24	70	2.8 kΩ	4.9 kΩ
3.5	3.5	3.5	22	60	2.35 kΩ	3.7 kΩ
3	3	3	22	60	1.6 kΩ	1.6 kΩ



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



3 x 3 QFN-16 Package Dimensions

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Package Marking Diagram

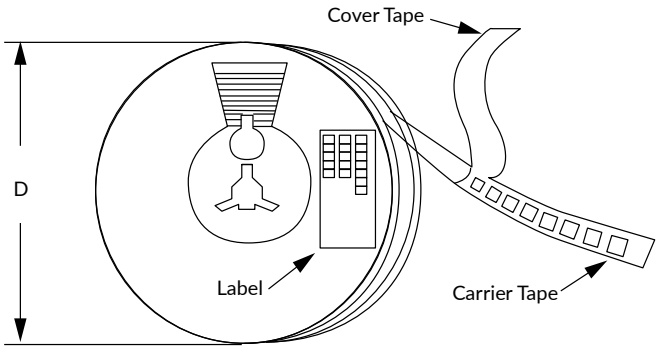
- Line 1: "YY" = YEAR. "WW" = WORK WEEK the device was assembled.
- Line 2: "XXXX" = Device PART NUMBER.

Tape and Reel Information

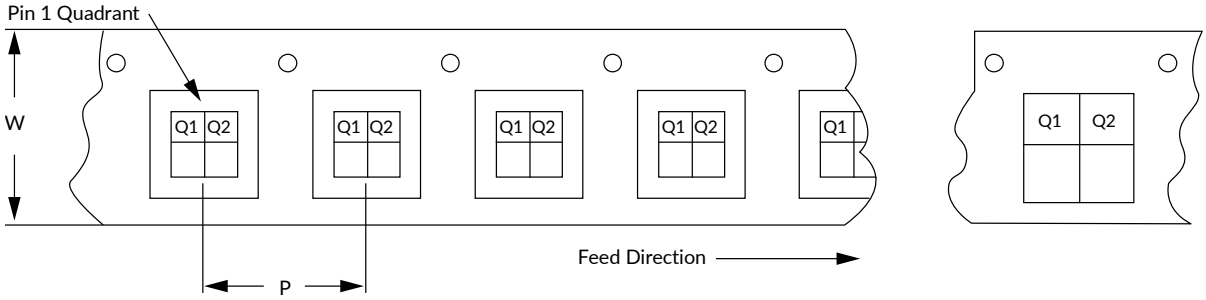
Guerrilla RF's tape and reel specification complies with Electronic Industries Alliance (EIA) standards for "Embossed Carrier Tape of Surface Mount Components for Automatic Handling" (reference EIA-481). See the following page for the Tape and Reel Specification and Device Package Information table,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

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

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



Tape and Reel Packaging with Reel Diameter Noted (D)



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

Revision History

Revision Date	Description of Change
December 19, 2019	Preliminary Data Sheet.
August 24, 2020	Converted Data Sheet to new format. Added typical operating curves.
October 15, 2020	Release Ø Data Sheet. Added components to assembly diagram table. Updated PCB footprint drawing.
December 15, 2021	Release A Data Sheet.
March 1, 2022	Updated Package Marking Diagram.
May 16, 2022	Updated Evaluation Board to new layout.
June 2, 2022	Updated evaluation board schematic and BOM.
June 20, 2022	Changed Thermal Resistance Θ_{JC} typical value from 19 to 21.6 °C/W.
September 29, 2022	Changed Thermal Resistance Θ_{JC} typical value from 21.6 to 28 °C/W and removed RF Input Level.
January 7, 2025	Updated Data Sheet with cosmetic changes only. No changes to device or device specifications.
May 14, 2025	Extended frequency range from 700 - 1000 MHz to 689 - 1090 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 limited evaluation board measurements taken within the Guerrilla RF Applications Lab. All parametric values are subject to change pending the collection of additional data.
Release Ø	All data based on measurements taken with *production-released* material. TYP values are based on a combination of ATE and bench-level measurements, with MIN/MAX limits defined using *modelled estimates* that account for part-to-part variations and expected process spreads. Although unlikely, future refinements to the TYP/MIN/MAX values may be in order as multiple lots are processed through the factory.
Release A-Z	All data based on measurements taken with production-released material *derived from multiple lots which have been fabricated over an extended period of time*. MIN/MAX limits may be refined over previous releases as more statistically significant data is collected to account for process spreads.