DATA SHEET

RELEASE B DATA SHEET

GRF2093

Ultra-Low Noise Amplifier 1 to 6 GHz

FEATURES

- Low Noise Figure
- Flexible Bias Voltage and Current
- Process: GaAs pHEMT
- Compact 1.5 x 1.5 mm DFN-6 Package

Reference: 5 V / 55 mA / 2332.5 MHz

- Gain: 21 dB
- OP1dB: 19 dBm
- OIP3: 35.5 dBm
- Evaluation Board NF: 0.37 dB

APPLICATIONS

- Satellite Radio
- CBRS
- Small Cells and Cellular Repeaters
- Distributed Antenna Systems
- GPS

DESCRIPTION

The GRF2093 offers industry leading noise figure (NF) and gain performance. It can be tuned over a wide range of frequencies from roughly 1 to 6 GHz.

With application-specific biasing, GRF2093 is part of Guerrilla RF's highest performance satellite radio solution where it functions as the first-stage LNA over 2320 to 2345 MHz.

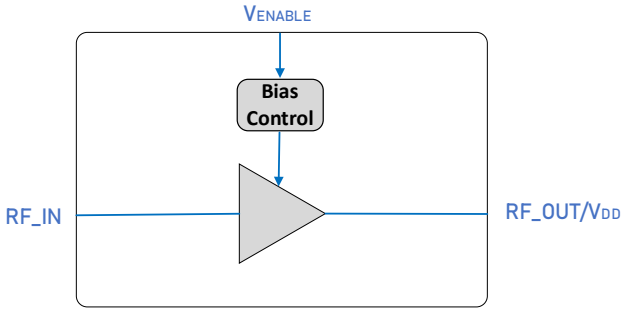
The device can be biased over a range of V_{DD} from 2.7 to 5 volts and I_{DDQ} values from 30 to 100 mA.

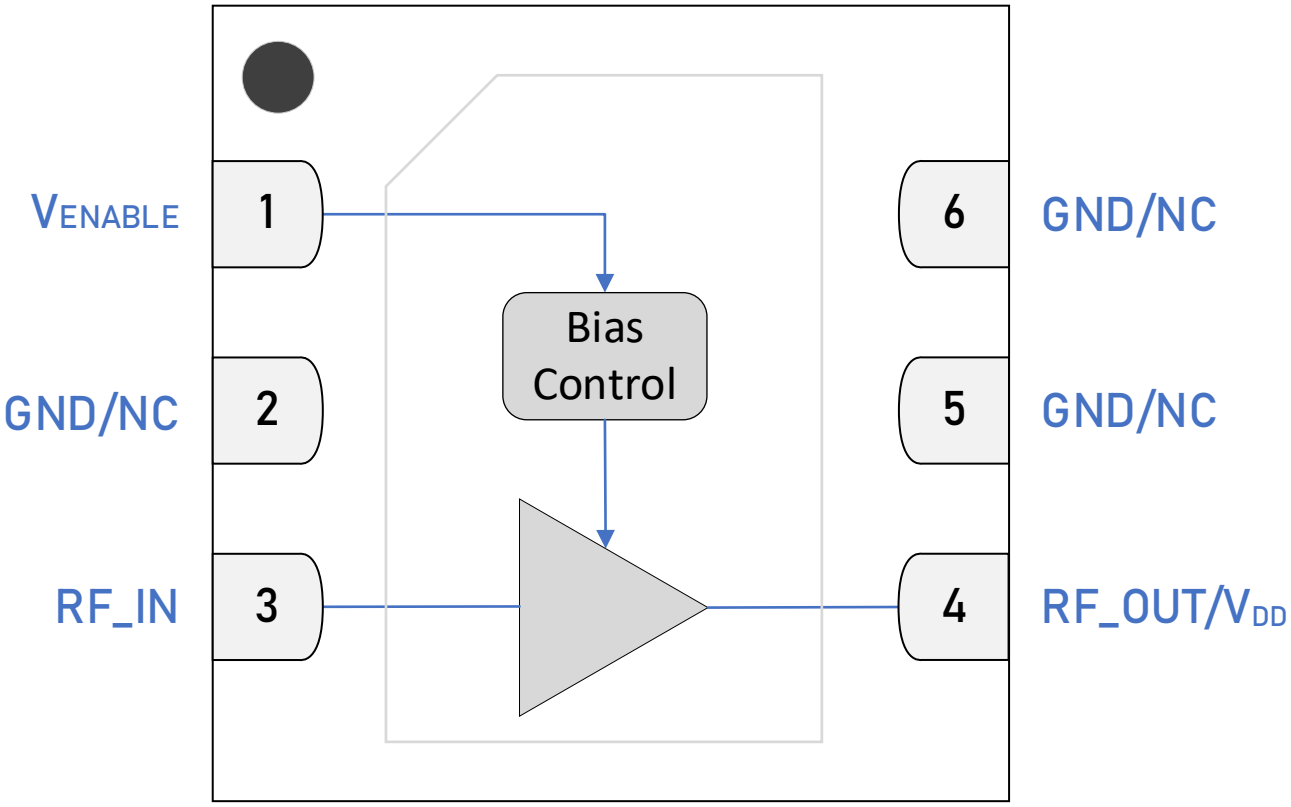
The device uses the standard Guerrilla RF 1.5 mm DFN-6 package and pinout. It joins more than 20 other LNAs and linear drivers which can use the same evaluation board.

Please consult with the GRF applications engineering team for custom tuning/evaluation board data and device S-parameters.

Additional tunes can be found on the GRF2093 "Custom Tunes" product page: GRF2093 Custom Tunes

BLOCK DIAGRAM





1.5 x 1.5 mm DFN-6 Pin Out (Top View)

www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 2000 Pisgah Church Road. Greensboro, NC 27455

Pin Assignments

Pin	Name	Description	Note
1	V_{ENABLE}	Enable Voltage Input	V_{ENABLE} and series resistor sets I_{DDQ}. $V_{ENABLE} \leq 0.2$ volts disables device. On-die pull-down resistor will turn the device off if this node is allowed to float.
2, 5, 6	GND/NC	Ground or No Connect	No internal connection to die. We recommend connecting these pins to ground.
3	RF_IN	RF Input	An external DC blocking capacitor must be used.
4	RF_OUT/V_{DD}	RF Output	V_{DD} must be applied through a RF choke to this pin.
PKG BASE	GND	Ground	Provides DC and RF ground for LNA, 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_{DD}	0	6	V
RF Input Power: Load VSWR < 2:1, V_{DD} = 5 V	$P_{IN\ MAX}$		23	dBm
Operating Temperature (Package Base)	$T_{PKG\ BASE}$	-40	105	°C
Maximum Channel Temperature (MTTF >10^6 Hours)	T_{MAX}		170	°C
Maximum Dissipated Power	$P_{DISS\ MAX}$		1	W

Electrostatic Discharge

Human Body Model	HBM	500		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 *Package Manufacturing Information | Guerrilla RF (guerrilla-rf.com)*

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 • 2000 Pisgah Church Road. Greensboro, NC 27455

Recommended Operating Conditions

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Voltage	V_{DD}	2.7	5	6	V	
Operating Temperature (Package Base)	$T_{PKG\ BASE}$	-40		105	°C	
RF Frequency Range	F_{TEST}	1000	2332.5	6000	MHz	Typical application schematic with external matching components **(notes 1 & 2)**.
RF_IN Port Impedance	Z_{RFIN}		50		Ω	Single-ended.
RF_OUT Port Impedance	Z_{RFOUT}		50		Ω	Single-ended.

Note 1: Operation outside of this range is supported by using different custom tunes. Examples of other optimized tunes can be found here: GRF2093 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 Measurement Schematic using the 2.3 to 2.7 GHz tuning set, V_{DD} = 5 V, V_{ENABLE} = 5 V, I_{DD} = 55 mA, M5 = 3 kΩ, F_{TEST} = 2332.5 MHz, 50 Ω system impedance, $T_{PKG\ BASE}$ = 25 °C. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Current	I_{DD}	40	55	70	mA	V_{DD} = 5 V, V_{ENABLE} = 5 V.
Enable Current	I_{ENABLE}		1.3	2	mA	V_{DD} = 5 V, V_{ENABLE} = 5 V.
Switching Rise Time	T_{RISE}		400		ns	Disabled Mode to Gain Mode **(note 3).**
Switching Fall Time	T_{FALL}		100		ns	Gain Mode to Disabled Mode **(note 4).**
Disabled Mode						
Leakage Current	$I_{LEAKAGE}$		180	500	µA	V_{DD} = 5 V, V_{ENABLE} = 0 V.
Thermal Data						
Thermal Resistance (Infrared Scan)	Θ_{JC}		43		°C/W	On standard evaluation board **(note 5).**

Note 3: Switching Time: 50% of V_{ENABLE} to 90% of Pout.

Note 4: Switching Time: 50% of V_{ENABLE} to 10% of Pout.

Note 5: MTTF >10^6 hours for $T_{CHANNEL}$ <170 °C.

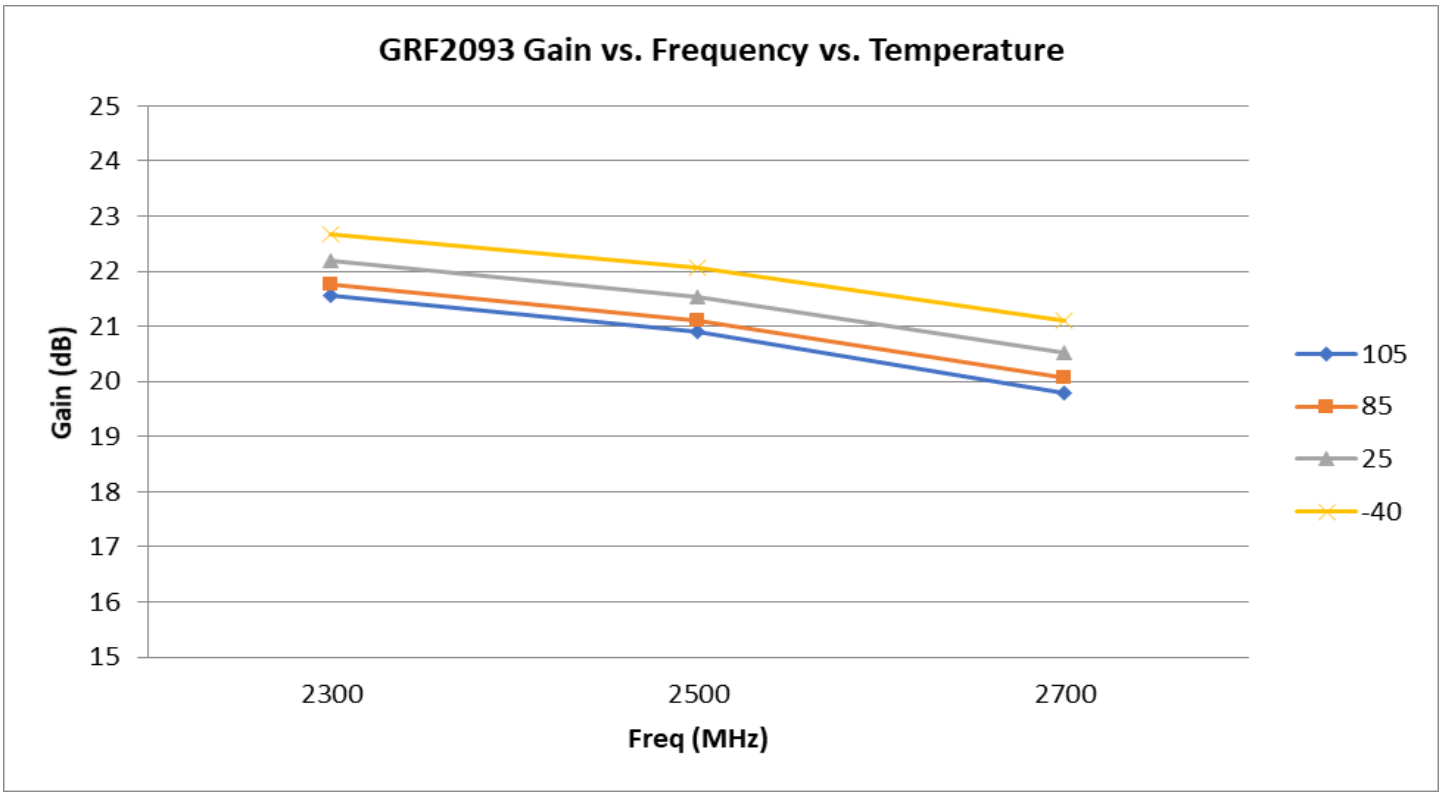
www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 2000 Pisgah Church Road. Greensboro, NC 27455

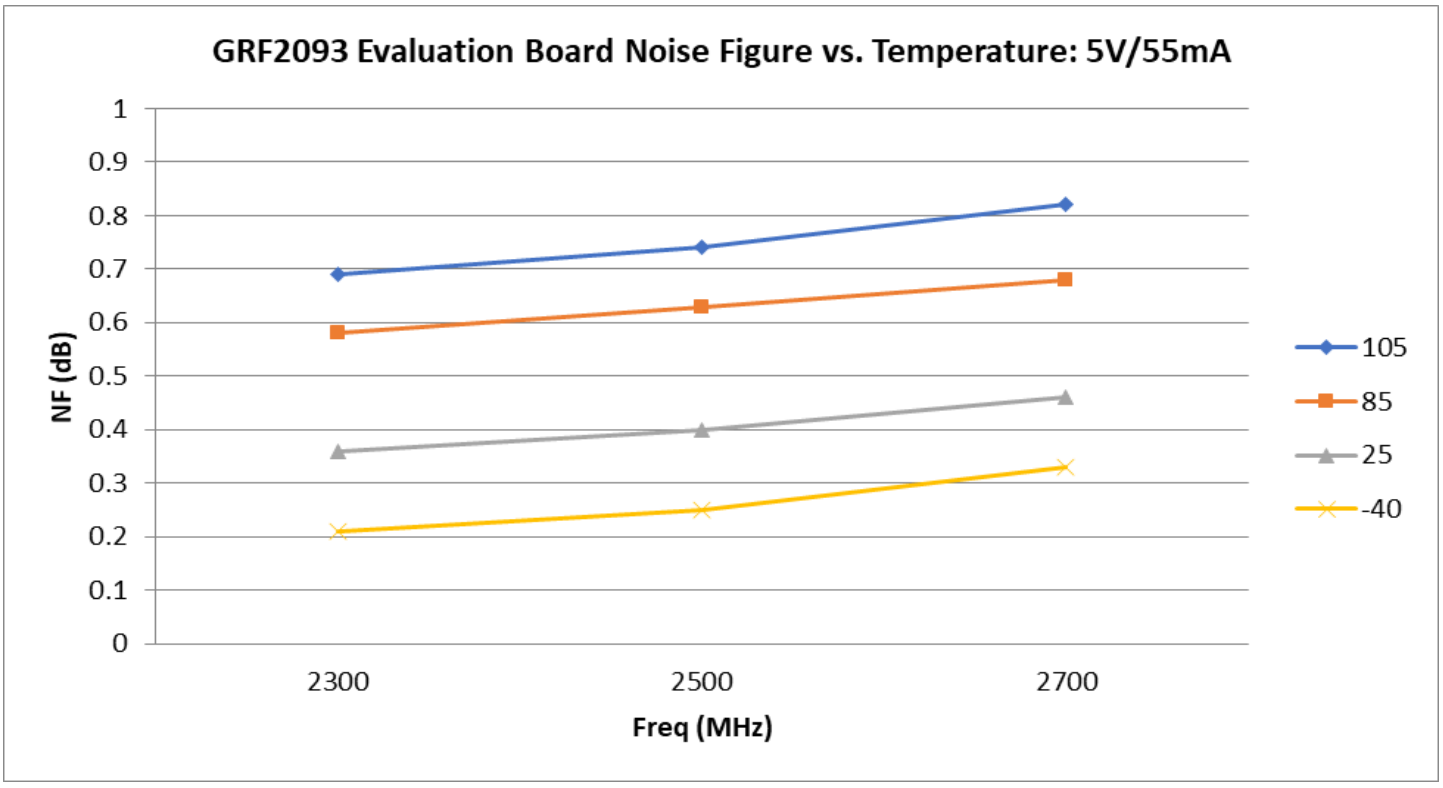
Nominal Operating Parameters – RF

The following conditions apply unless noted otherwise: Typical Measurement Schematic using the 2.3 to 2.7 GHz tuning set, V_{DD} = 5 V, V_{ENABLE} = 5 V, I_{DD} = 55 mA, M5 = 3 kΩ, F_{TEST} = 2332.5 MHz, 50 Ω system impedance, $T_{PKG\ BASE}$ = 25 °C. Evaluation board losses are included within the specifications.

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Gain	S21	20.8	22	23.2	dB	V_{DD} = 5 V, V_{ENABLE} = 5 V.
Noise Figure	NF		0.37	0.57	dB	On standard evaluation board.
Output 3rd Order Intercept Point	OIP3		35.5		dBm	4 dBm P_{OUT} per tone at 2 MHz spacing (2331.5 and 2333.5 MHz).
Output 1 dB Compression Power	OP1dB	17.2	19		dBm	

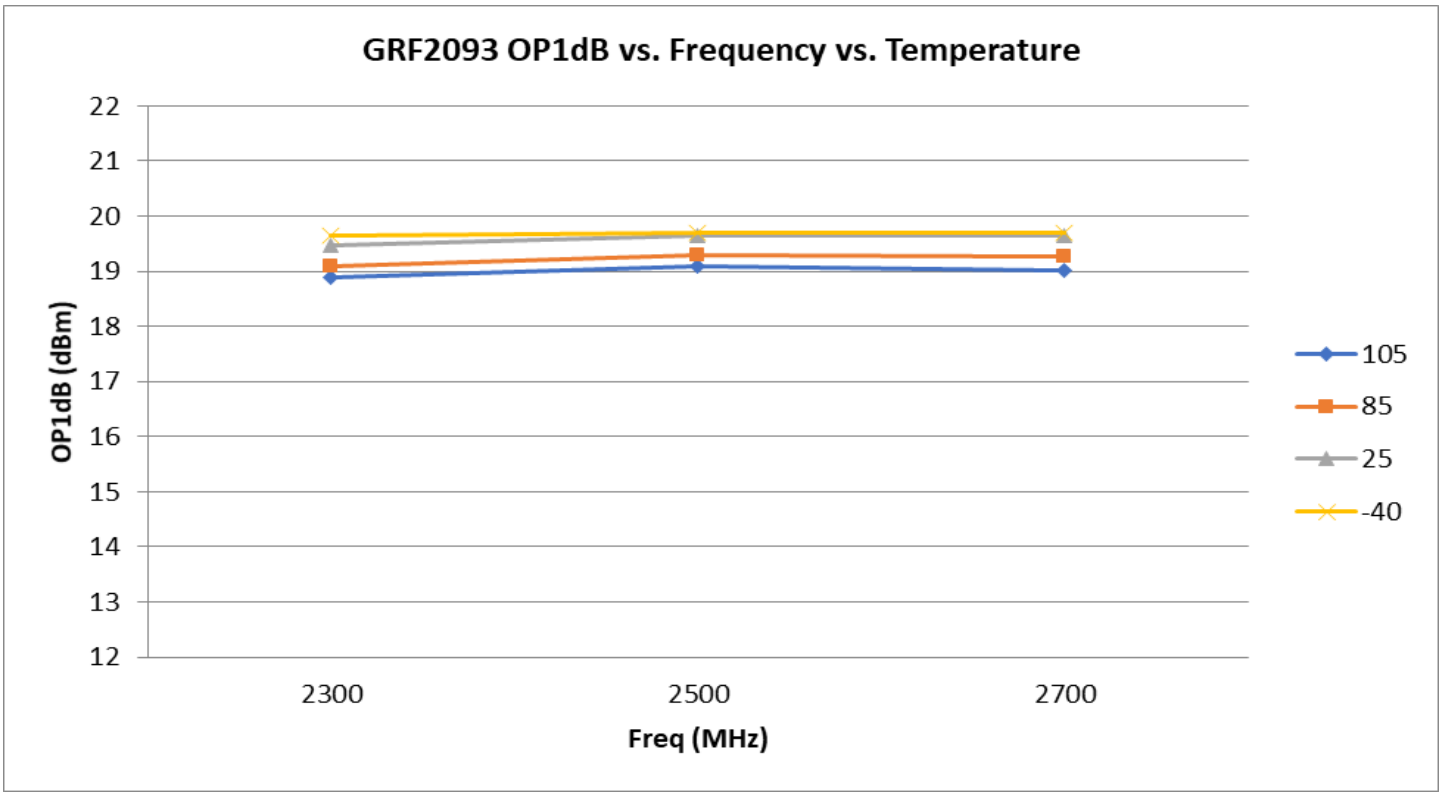
GRF2093 Typical Operating Curves: 5 V, 55 mA (2.3 to 2.7 GHz Tune)

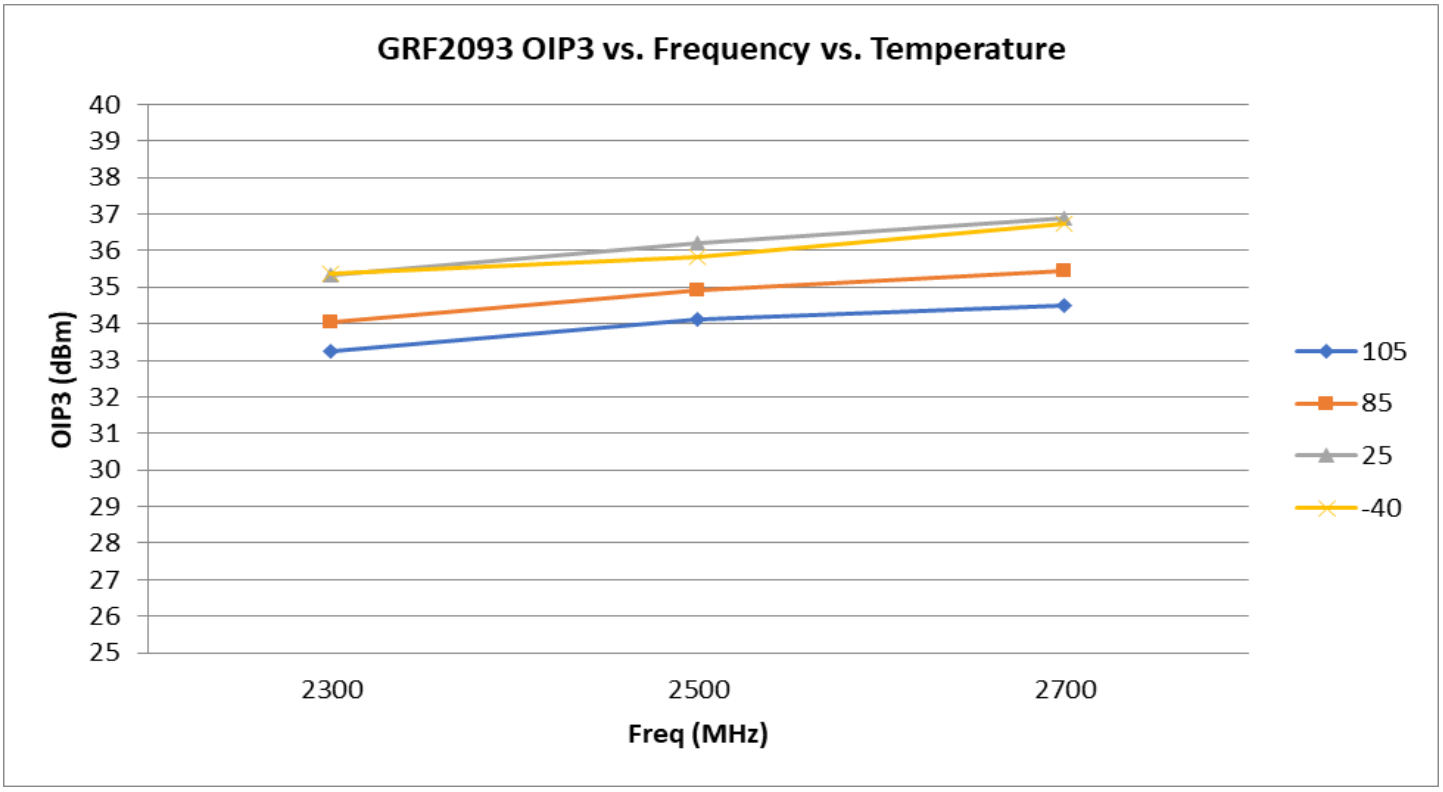




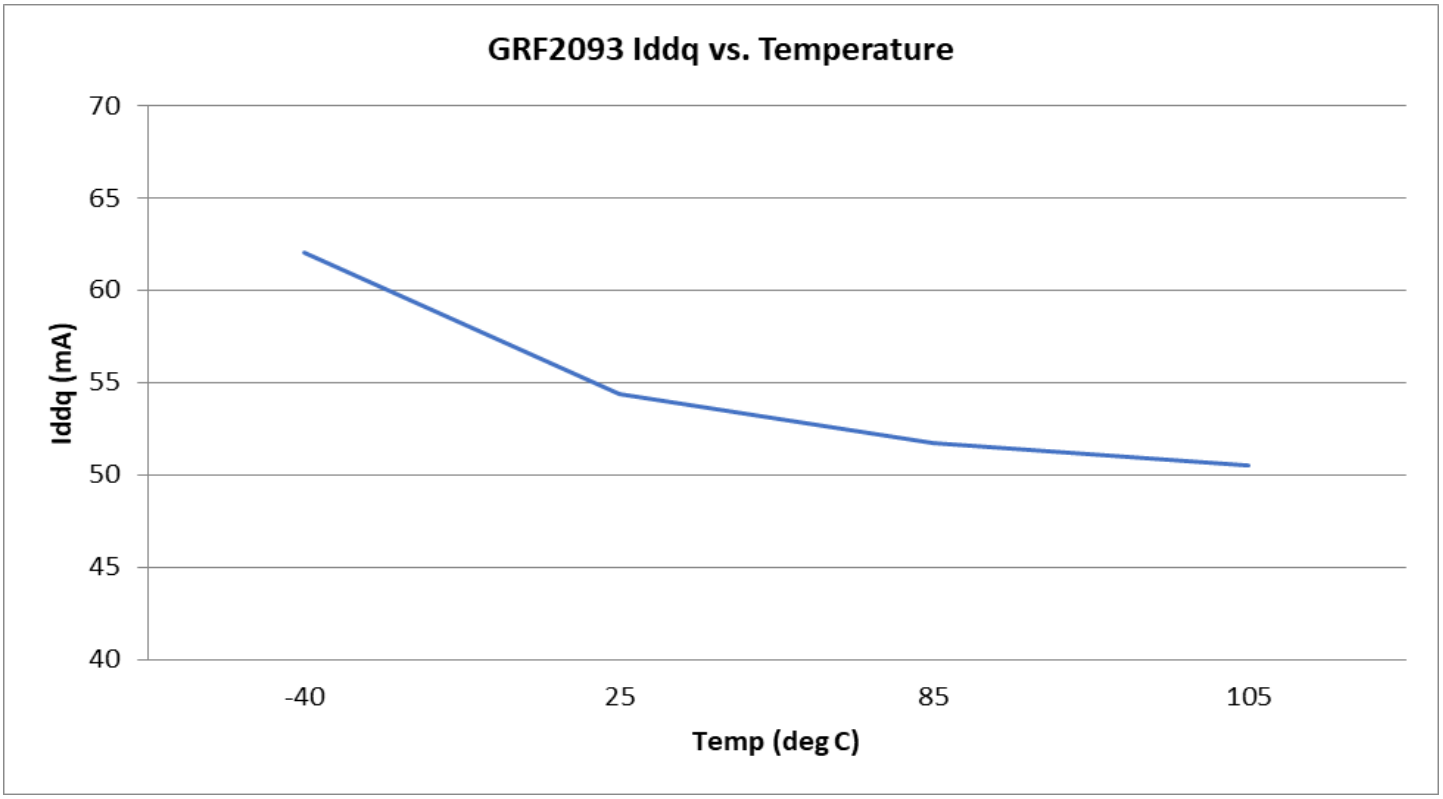
www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 2000 Pisgah Church Road. Greensboro, NC 27455

GRF2093 Typical Operating Curves: 5 V, 55 mA (2.3 to 2.7 GHz Tune)



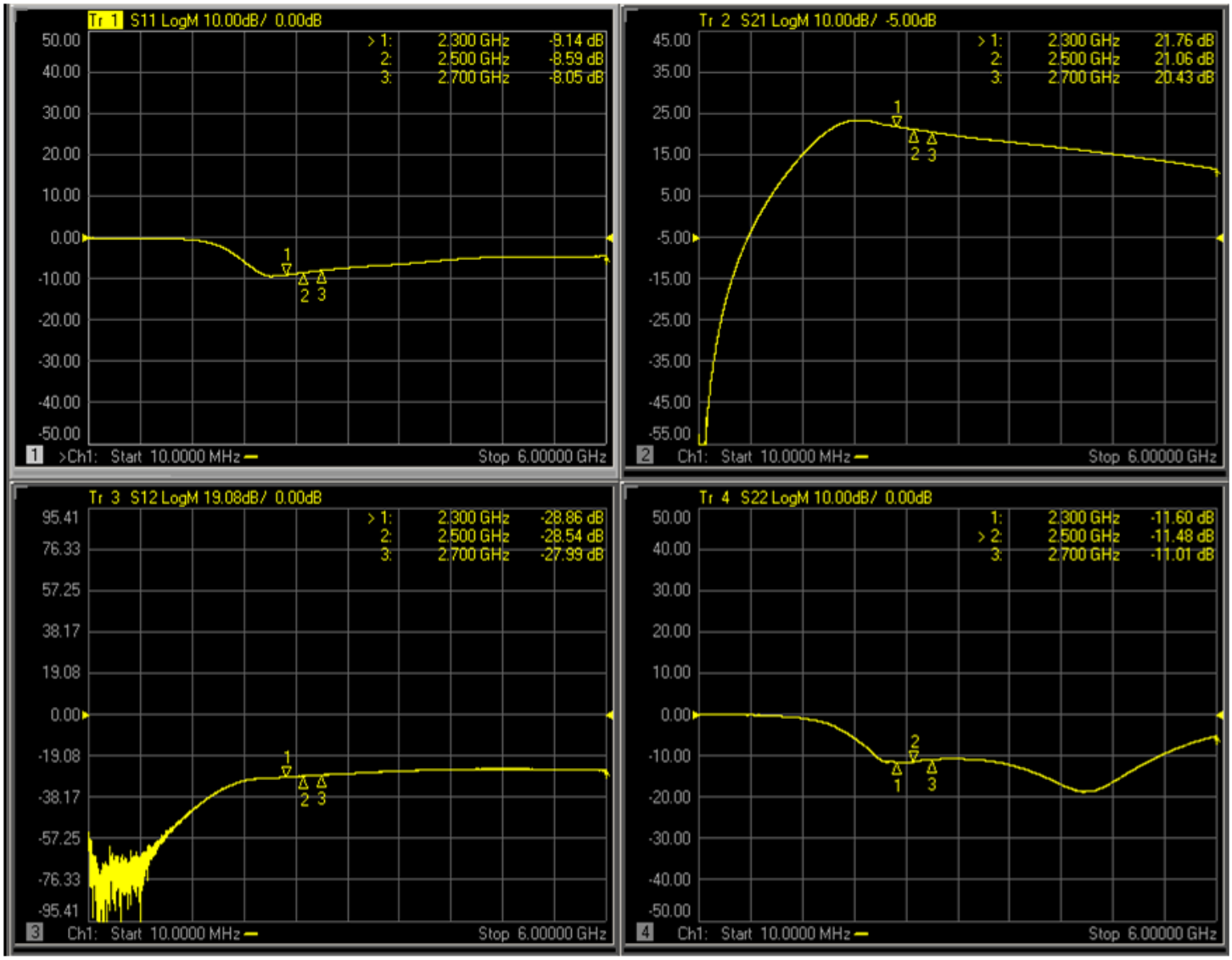


GRF2093 Typical Operating Curves: 5 V, 55 mA (2.3 to 2.7 GHz Tune)

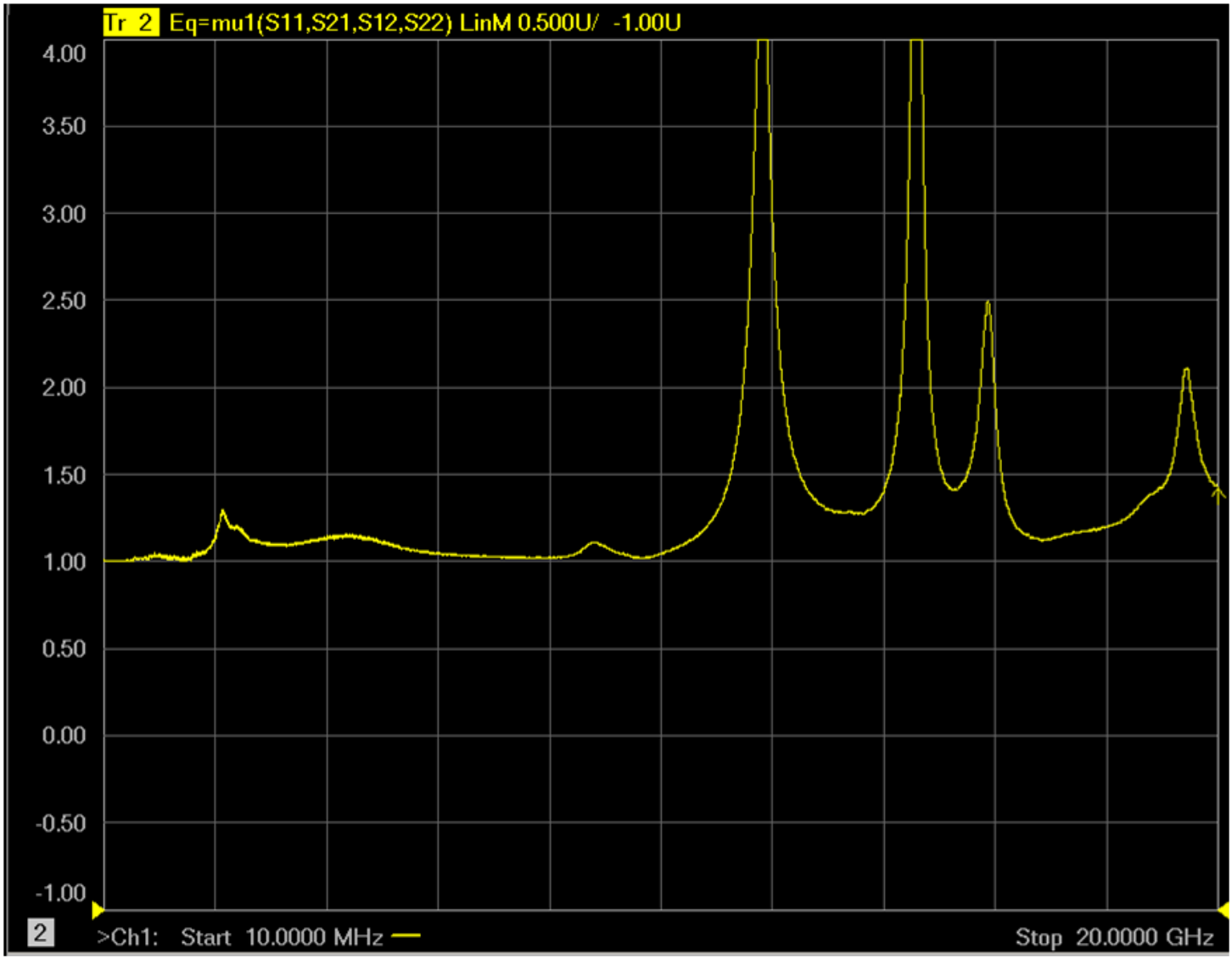


www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 2000 Pisgah Church Road. Greensboro, NC 27455

GRF2093 Typical Operating Curves: S-Parameters (2.3 to 2.7 GHz Tune)

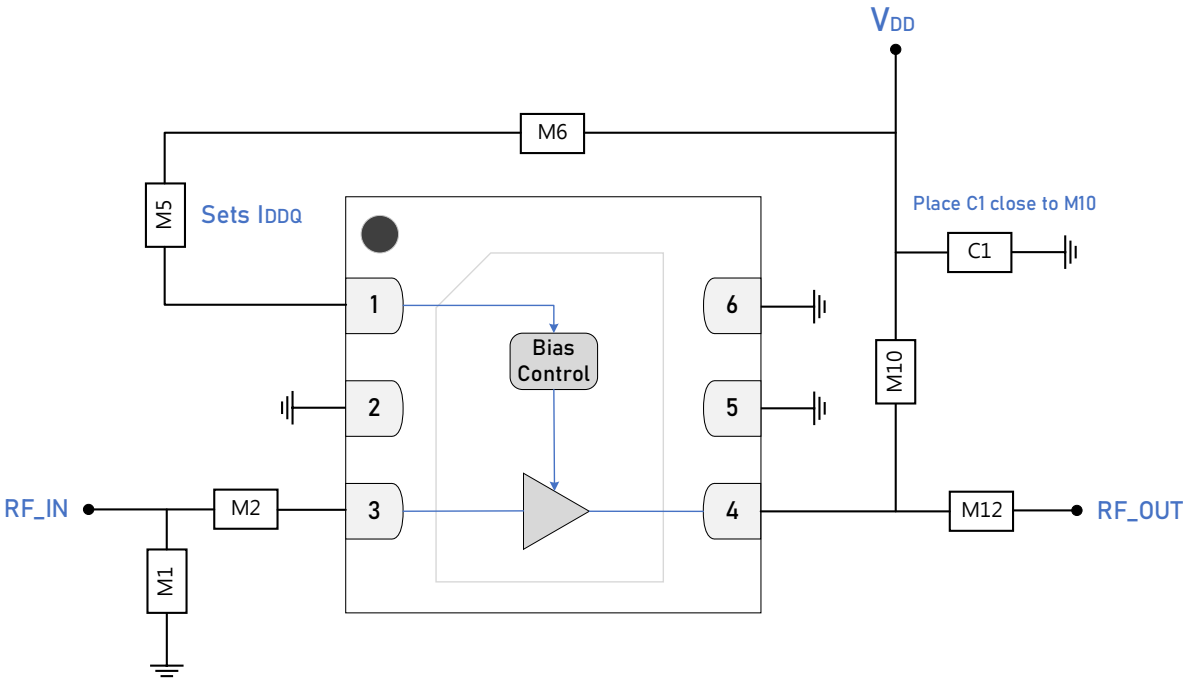


GRF2093 Typical Operating Curves: Stability Mu Factor (10 MHz to 20 GHz)

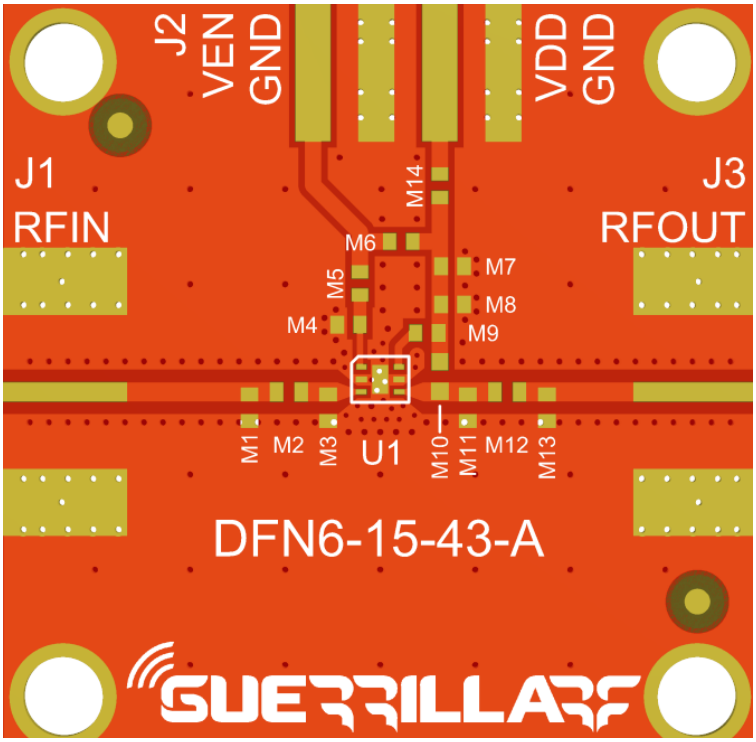


Note: Mu ≥ 1.0 implies unconditional stability.

www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 2000 Pisgah Church Road. Greensboro, NC 27455



GRF2093 Standard Evaluation Board Schematic

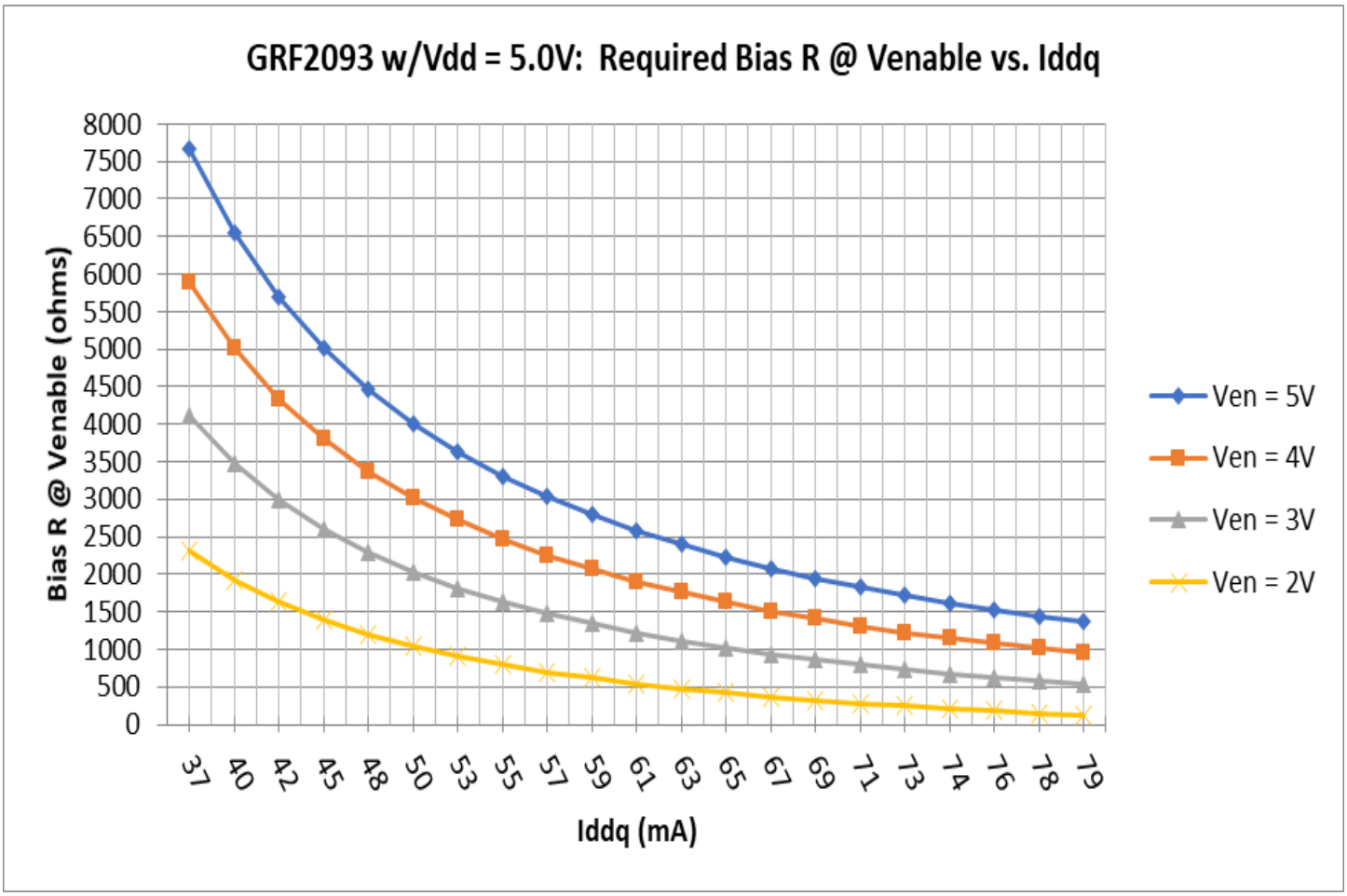


GRF2093 Evaluation Board Assembly Diagram

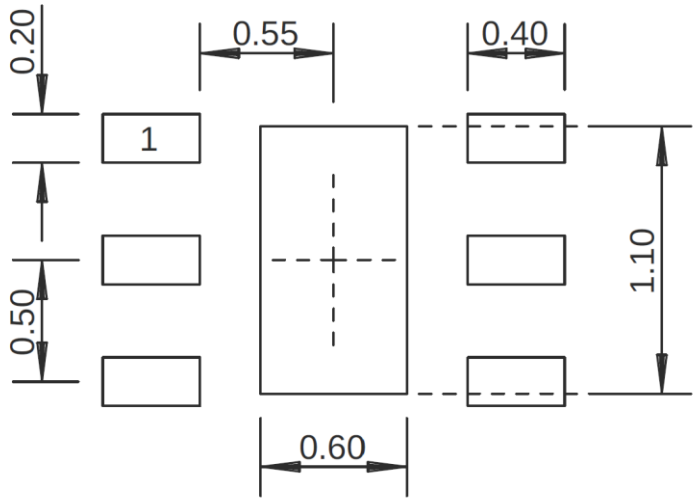
GRF2093 Evaluation Board Assembly Diagram Reference (2.3 to 2.7 GHz Tune)

Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1	Inductor	Coilcraft	HP	3.3 nH	0402	ok
M2	Capacitor	Murata	GJM	2.7 pF	0402	ok
M5 (sets I_{DDQ})	Resistor	Various	5%	See Curves	0402	ok
M6	Resistor (jumper)	Various	5 %	0 Ω	0402	ok
C1	Capacitor	Murata	GRM	0.1 µF	0402	ok
M10	Inductor	Murata	LQG	1.8 nH	0402	ok
M12	Capacitor	Murata	GJM	2.7 pF	0402	ok
Evaluation Board	DFN6-15-43-A					

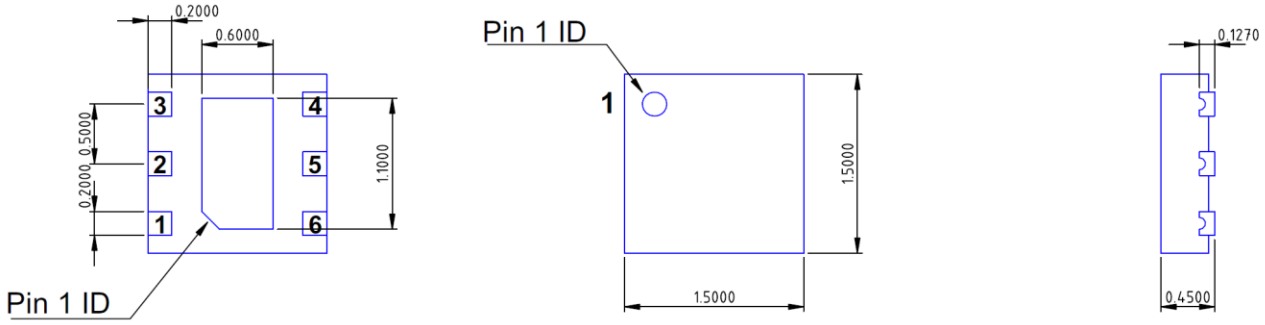
GRF2093 Bias Resistor Selection Curves



www.guerrilla-rf.com • (336) 510-7840 • sales@guerrilla-rf.com • 2000 Pisgah Church Road. Greensboro, NC 27455



1.5 x 1.5 mm DFN-6 Suggested PCB Footprint (Top View)



Bottom View **Top View** **Side View**

DFN6 1.5x1.5mm
Dimensions in millimeters

1.5 x 1.5 mm DFN-6 Package Dimensions

Package Marking Diagram

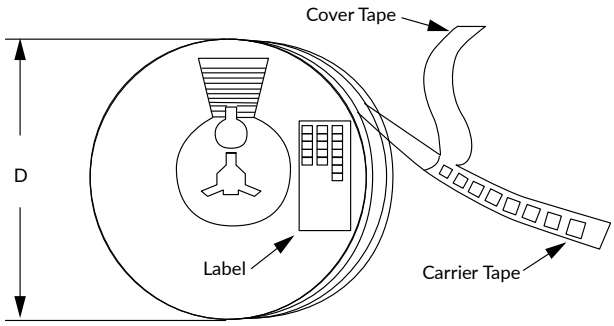
- Line 1: "Y" = YEAR (single digit). "WW" = WORK WEEK the Device was assembled.
- Line 2: "XXXX" = Device PART NUMBER.

Tape and Reel Information

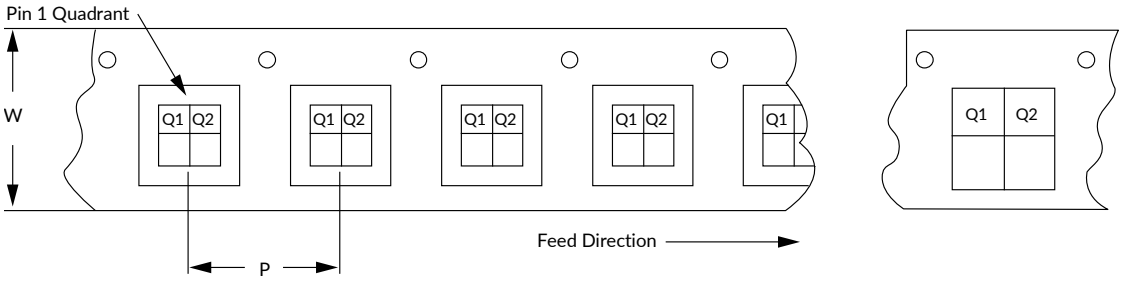
Guerrilla RF's tape and reel specification complies with Electronics Industries Association (EIA) standards for "Embossed Carrier Tape of Surface Mount Components for Automatic Handling" (reference EIA-481). See the following page for the Tape and Reel Specification and Device Package Information table, 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
September 9, 2019	Preliminary Data Sheet.
June 25, 2021	Release Ø Data Sheet.
May 16, 2023	Release A Data Sheet. Upgraded Data Sheet to new format.
May 25, 2023	Release B Data Sheet. Changed RF Input Power (Pin Max) V_{DD} to 5 V.

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.