DATA SHEET

GRF2176

LNA with Selectable Gain 0.5 to 6 GHz

RELEASE A DATA SHEET

FEATURES

- Selectable High Gain and Low Gain Modes
- Excellent Linearity Performance Over Wide Bandwidths
- 2.7 to 6 V Supply Voltage
- Flexible Biasing Provides Latitude for Linearity Optimization
- 64 mA Native Mode Quiescent Current Consumption
- 50 Ω Single-Ended Input and Output Impedances
- RoHS Compliant

Reference: High Gain Mode 5 V / 64 mA / 3.75 GHz

- Gain: 32.9 dB
- OP1dB: 19.6 dBm
- OIP3: 33.6 dBm
- Evaluation Board NF: 0.65 dB

Reference: Low Gain Mode 5 V / 28 mA / 3.75 GHz

- Gain: 16.3 dB
- OP1dB: 15.1 dBm
- OIP3: 28.8 dBm
- Evaluation Board NF: 0.68 dB

APPLICATIONS

- 5G Sub-6 GHz Massive MIMO Base Stations
- TDD Small Cells and Cellular Repeaters
- High-Performance RF Infrastructure

ORDERING INFORMATION

Buy it Now

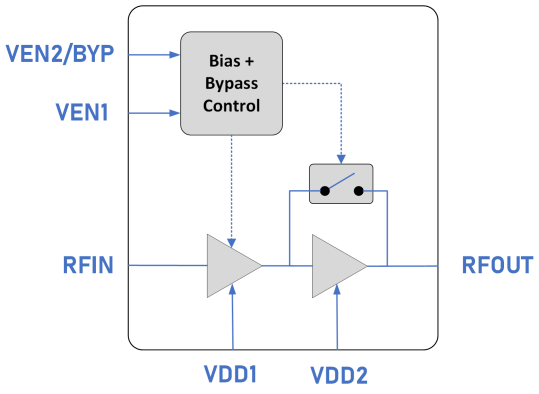
DESCRIPTION

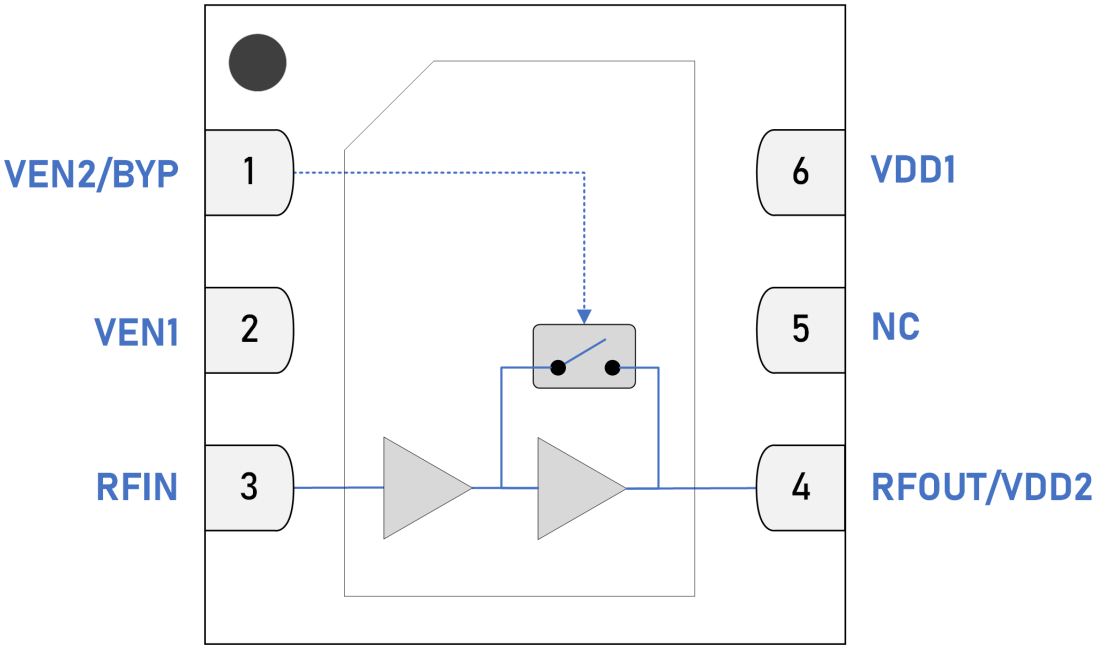
The GRF2176 is a two-stage GaAs pHEMT low noise amplifier targeting high-performance wireless infrastructure applications. The second stage can be bypassed with an independent control pin, thus allowing the device to support high and low gain modes of 32.9 and 16.3 dB, respectively.

For optimal efficiency and linearity, the amplifier was designed to operate with a single 5 V supply voltage while using only 64 mA of quiescent current. Supply voltages ranging from 2.7 to 6 V are also supported. Similarly, Quiescent Current can be increased beyond the native biasing point for enhanced linearity performance.

Additional tunes can be found on the GRF2176 "Custom Tunes" product page: GRF2176 Custom Tunes

BLOCK DIAGRAM





Pin Out (Top View)

Pin Assignments

Pin	Name	Description	Note
1	VEN2/BYP	2nd Stage Enable/Bypass	VEN2/BYP ≤ 0.2 V sets Bypass Mode. VEN2/BYP and external series resistor controls the second stage IDDQwhen VEN2/BYP is high.
2	VEN1	1st Stage Enable	VEN1 ≤ 0.2 V disables the first stage. VEN1 and external series resistor control the first stage IDDQ when VEN1 is high.
3	RFIN	RF Input	Internally matched 50 Ω. An external DC blocking cap must be used.
4	RFOUT/VDD2	RF Output/2nd Stage Bias	Internally matched 50 Ω. VDD must be applied through a choke to this pin.
5	NC	No Connect	No internal connection. This pin can be left unconnected, or be connected to the ground (recommended). Use a via as close to the pin as possible if grounded.
6	VDD1	1st Stage Bias	Pull up to VDD through the inductor and use bypass capacitors as close to the pin as possible. In addition to supplying the first stage of the device with a DC voltage, there is also an RF signal present.
PKG BASE	GND	Ground	Provides DC and RF ground for amplifiers, 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

Mode	Logic Levels		
	VDD	VEN1	VEN2/BYP
High Gain	HIGH	HIGH	HIGH
Low Gain (2nd Stage Bypass)	HIGH	HIGH	LOW
Standby	HIGH	LOW	LOW
High Isolation (Off State)	LOW	LOW	LOW

Absolute Ratings

Parameter	Symbol	Min.	Max.	Unit
Supply Voltage	VDD	0	6	V
RF Input Power - RX Mode: 50 Ω, VDD < 6.0 V, CW Max Pin	$P_{IN\ MAX}$		23	dBm
Operating Temperature (Package Heat Sink)	$T_{PKG\ BASE}$	-40	115	°C
Maximum Channel Temperature (MTTF > 10^6 Hours)	T_{MAX}		170	°C
Maximum Dissipated Power: Stage 1 (DC only, no RF applied).	$P_{DISS\ MAX}$		400	mW
Maximum Dissipated Power: Stage 2 (DC only, no RF applied).	$P_{DISS\ MAX}$		550	mW
Electrostatic Discharge				
Human Body Model	HBM	250		V
Storage				
Storage Temperature	T_{STG}	-65	150	°C
Moisture Sensitivity Level			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 - Packaging 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.		
Supply Voltage	VDD	4.75	5	5.25	V	
Operating Temperature Range	$T_{PKG\ BASE}$	-40		+115	°C	
RF Frequency Range	F_{RF}	3.3		4.2	GHz	3.75 GHz tuning set **(notes 1 & 2)**.
RF_IN Port Impedance	Z_{RFIN}		50		Ω	Single-ended with respective matching elements from each tuning set.
RF_OUT Port Impedance	Z_{RFOUT}		50		Ω	Single-ended with respective matching elements from each turning set.

Note 1: Operation outside of this range is supported by using different custom tunes. Examples of other optimized tunes can be found here: GRF2176 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

High Gain Mode: VEN1 = VEN2 = 3 V

Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Logic Input Low	V_{IL}	0		0.2	V	VEN1 and VEN2/BYP inputs.
Logic Input High	V_{IH}	1.5		V_{DD}	V	VEN1 and VEN2/BYP inputs.
Logic Current	I_{IH}		0.9		mA	VEN1 input.
Logic Current	I_{IH}		0.85		mA	VEN2/BYP input.
	I_{IL}		0			VEN2/BYP input.
VEN1 Switching Rise Time	$t_{VEN1-RISE}$		31		ns	Turn ON time (VEN1 Low to High, **note 2**).
VEN1 Switching Fall Time	$t_{VEN1-FALL}$		20		ns	Turn OFF time (VEN1 High to Low, **note 3**).
VEN2/BYP Switching Rise Time	$t_{GAIN-RISE}$		34		ns	Low to High gain mode switching (VEN2/BYP Low to High, **note 4**).
VEN2/BYP Switching Fall Time	$t_{GAIN-FALL}$		20		ns	High to Low gain mode switching (VEN2/BYP High to Low, **note 5**).

Disabled Mode

Standby Current	I_{STBY}		671		µA	VDD = 5 V, VEN1 = Low, VEN2/BYP = Low.

Thermal Data

Stage 1: Thermal Resistance (Infrared Scan). DC only, no RF applied.	θ_{JC}		69		°C/W	On standard evaluation board.
Stage 2: Thermal Resistance (Infrared Scan). DC only, no RF applied.	θ_{JC}		68		°C/W	On standard evaluation board.
Thermal Data: Stage 1 and 2 @ +115 °C.	T_J		129		°C	VDD = 5 V, IDDQ = 64 mA. On standard evaluation board **(note 6)**.

Note 2: Switching Rise Time: 50% of VEN1 to 90% of P_{OUT}.

Note 3: Switching Fall Time: 50% of VEN1 to 10% of P_{OUT}.

Note 4: Switching Rise Time: 50% of VEN2/BYP to 90% of P_{OUT}.

Note 5: Switching Fall Time: 50% of VEN2/BYP to 10% of P_{OUT}.

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

Nominal Operating Parameters - RF

3.3 to 4.2 GHz, 5 V Supply, High Gain Configuration

The following conditions apply unless noted otherwise: typical application schematic using the 3.3 to 4.2 GHz tuning set, VEN1 = 3 V, VEN2/BYP = 3 V (high gain mode), R_{BIAS1} = 2 kΩ, R_{BIAS2} = 2 kΩ (low bias mode), VDD = 5 V, P_{OUT} = 0 dBm, F_{TEST} = 3.75 GHz, 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 Quiescent Current	IDDQ		64		mA	R_{BIAS} = 2 kΩ, R_{BIAS2} = 2 kΩ
Supply Current with RF applied	IDD		64		mA	P_{OUT} = 0 dBm, R_{BIAS} = 2 kΩ, R_{BIAS2} = 2 kΩ
Gain	S21		32.9		dB	F_{RF} = 3.75 GHz
Gain Flatness	$S21_{FLAT}$		2		dB	F_{RF} = 3.3 to 4.2 GHz
Gain Variation Over Temp	$S21_{TEMP}$		1/-1.6		dB	$T_{PKG\ BASE}$ = -40 to 115 °C, Referenced to $T_{PKG\ BASE}$ = 25 °C
Standby Mode Gain	$S21_{STBY}$		-23		dB	VEN1 = VEN2/BYP = 0 V, P_{IN} = -7 dBm
Input Return Loss	S11		< -5		dB	F_{RF} = 3.3 to 4.2 GHz
Output Return Loss	S22		< -5.7		dB	F_{RF} = 3.3 to 4.2 GHz
Reverse Isolation	S12		> 44		dB	F_{RF} = 3.3 to 3.8 GHz
De-Embedded Noise Figure	NF		0.6		dB	F_{RF} = 3.75 GHz
Evaluation Board Noise Figure			0.65			F_{RF} = 3.75 GHz
Output 3rd Order Intercept Point	OIP3		33.6		dBm	IDDQ = 64 mA, 0 dBm P_{OUT} per tone at 2 MHz spacing
Output 1 dB Compression Power	OP1dB		19.6		dBm	IDDQ = 64 mA

Nominal Operating Parameters - RF

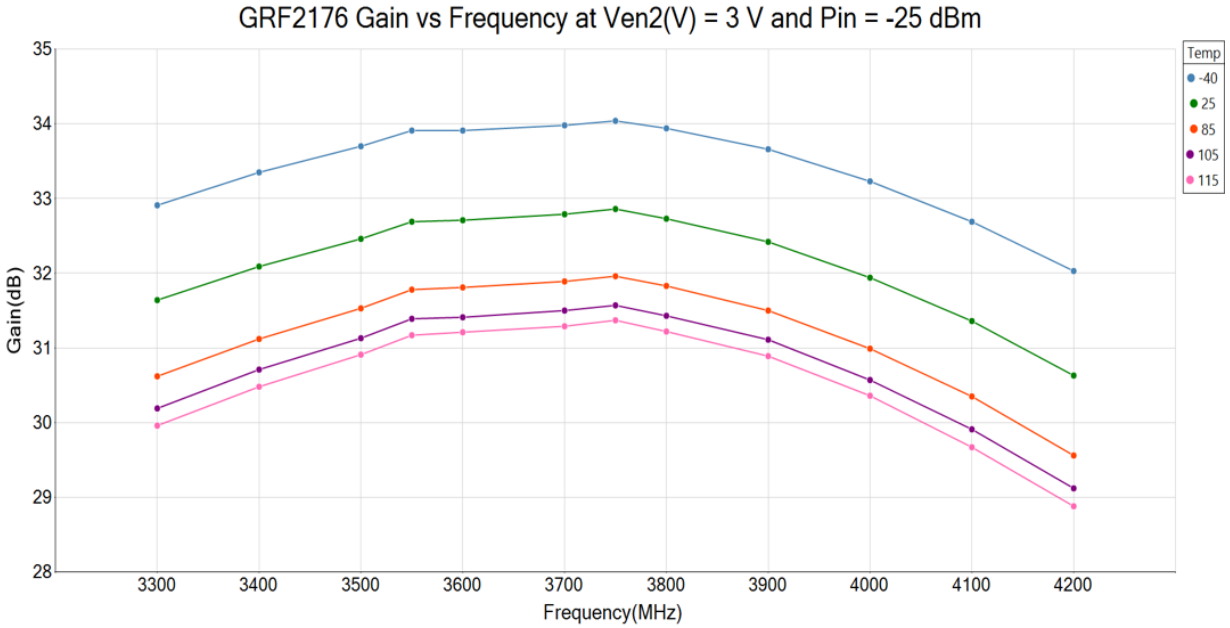
3.3 to 4.2 GHz, 5 V Supply, Low Gain Configuration

The following conditions apply unless noted otherwise: typical application schematic using the 3.3 to 4.2 GHz tuning set, VEN1 = 3 V, VEN2/BYP = 0 V (low gain mode), R_{BIAS1} = 2 kΩ, R_{BIAS2} = 2 kΩ (low bias mode), 50 Ω system impedance, VDD = 5 V, P_{OUT} = 0 dBm, F_{TEST} = 3.75 GHz, $T_{PKG\ BASE}$ = 25 °C. MIN/MAX values in *italics* are guaranteed by test; all other parameters are guaranteed by design and characterization. Evaluation board losses are included within the specifications.

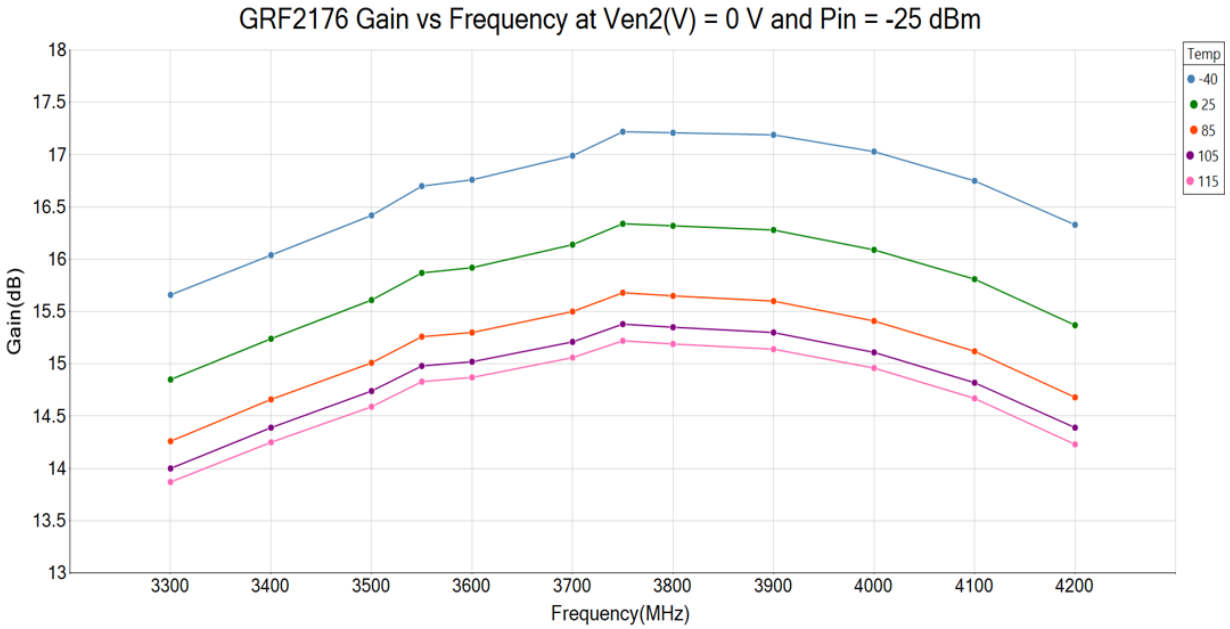
Parameter	Symbol	Specification			Unit	Condition
		Min.	Typ.	Max.		
Supply Quiescent Current	IDDQ		27		mA	R_{BIAS} = 2 kΩ, R_{BIAS2} = 2 kΩ
Supply Current with RF applied	IDD		28		mA	P_{OUT} = 0 dBm, R_{BIAS} = 2 kΩ, R_{BIAS2} = 2 kΩ
Gain	S21		16.3		dB	F_{RF} = 3.75 GHz
Gain Flatness	$S21_{FLAT}$		1.4		dB	F_{RF} = 3.3 to 4.2 GHz
Gain Variation Over Temp	$S21_{TEMP}$		0.6/-1.2		dB	$T_{PKG\ BASE}$ = -40 to 115 °C, Referenced to $T_{PKG\ BASE}$ = 25 °C
Standby Mode Gain	$S21_{STBY}$		-23		dB	VEN1 = VEN2/BYP = 0 V, P_{IN} = -7 dBm
Input Return Loss	S11		< -5.8		dB	F_{RF} = 3.3 to 4.2 GHz
Output Return Loss	S22		< -7		dB	F_{RF} = 3.3 to 4.2 GHz
Reverse Isolation	S12		> 45		dB	F_{RF} = 3.3 to 4.2 GHz
De-Embedded Noise Figure	NF		0.62		dB	F_{RF} = 3.75 GHz
Evaluation Board Noise Figure			0.68			F_{RF} = 3.75 GHz
Output 3rd Order Intercept Point	OIP3		28.8		dBm	IDDQ = 27 mA, 0 dBm P_{OUT} per tone at 2 MHz spacing
Output 1 dB Compression Power	OP1dB		15.1		dBm	IDDQ = 27 mA

Typical Operating Curves: 3.3 to 4.2 GHz

High Gain Mode

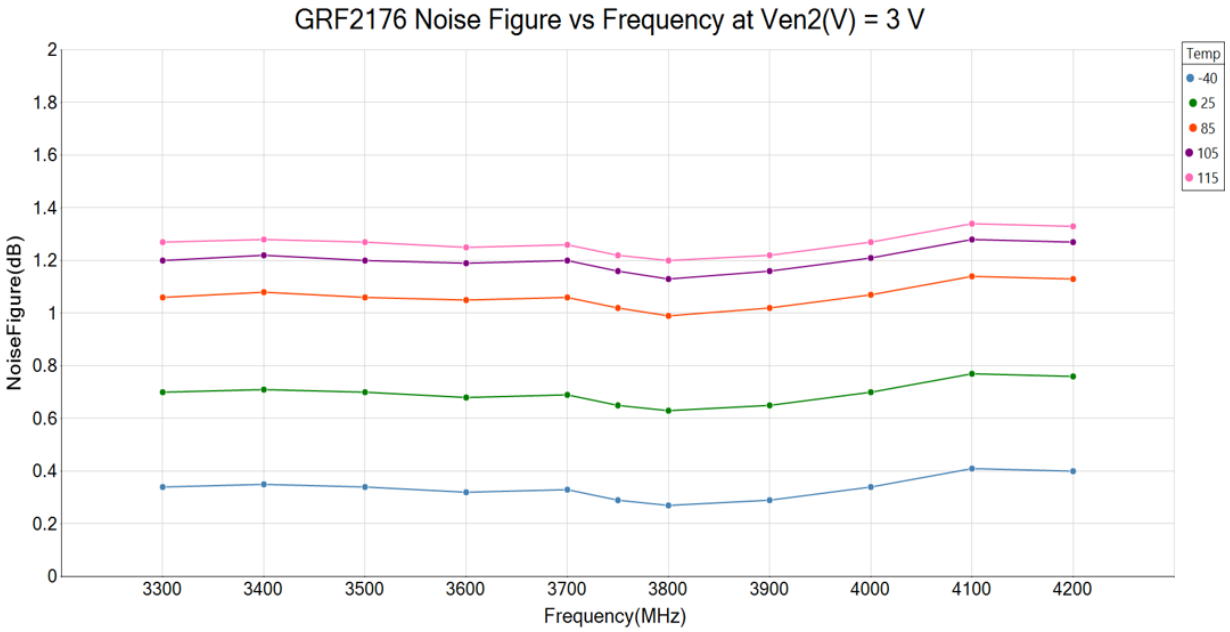


Low Gain Mode

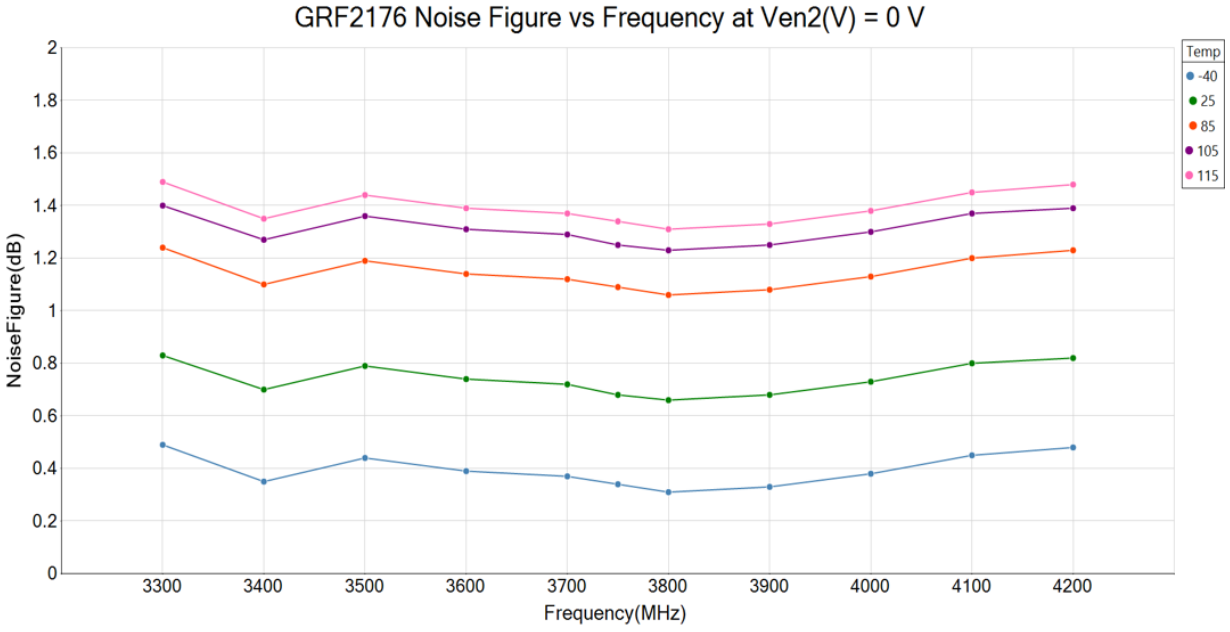


Typical Operating Curves: 3.3 to 4.2 GHz

High Gain Mode

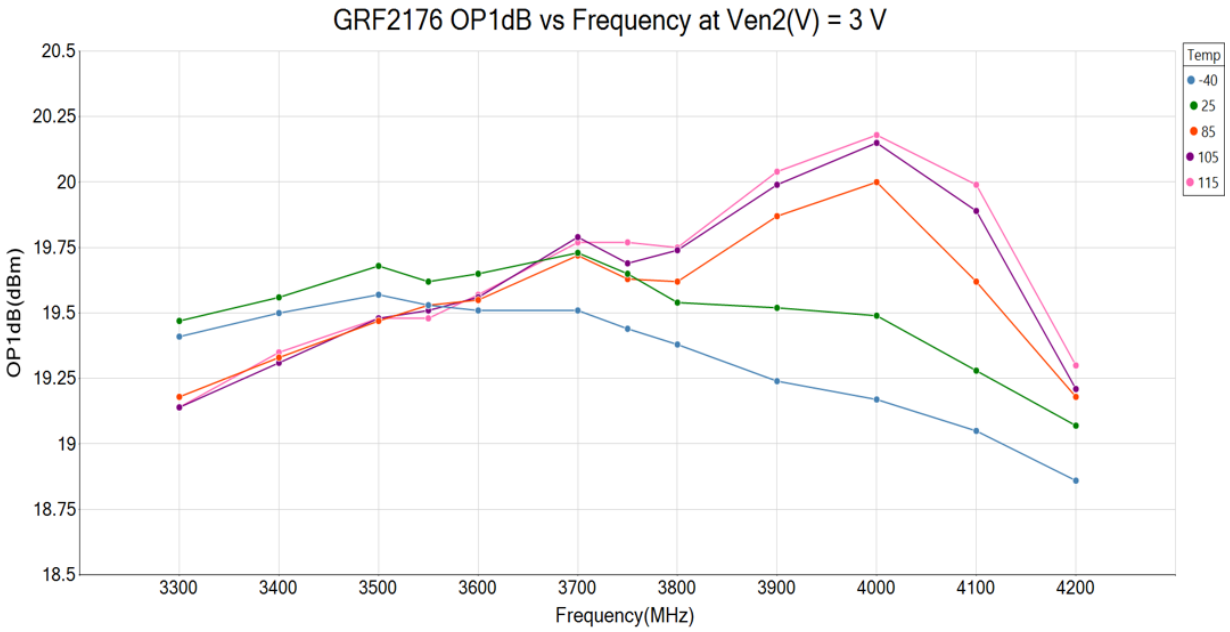


Low Gain Mode

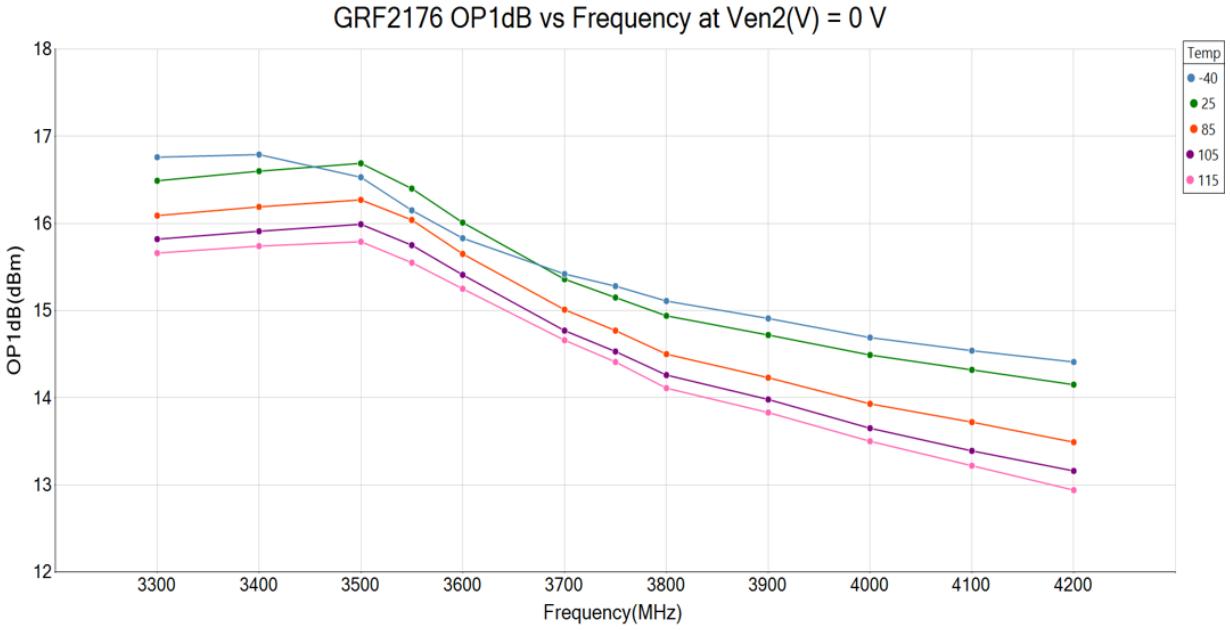


Typical Operating Curves: 3.3 to 4.2 GHz

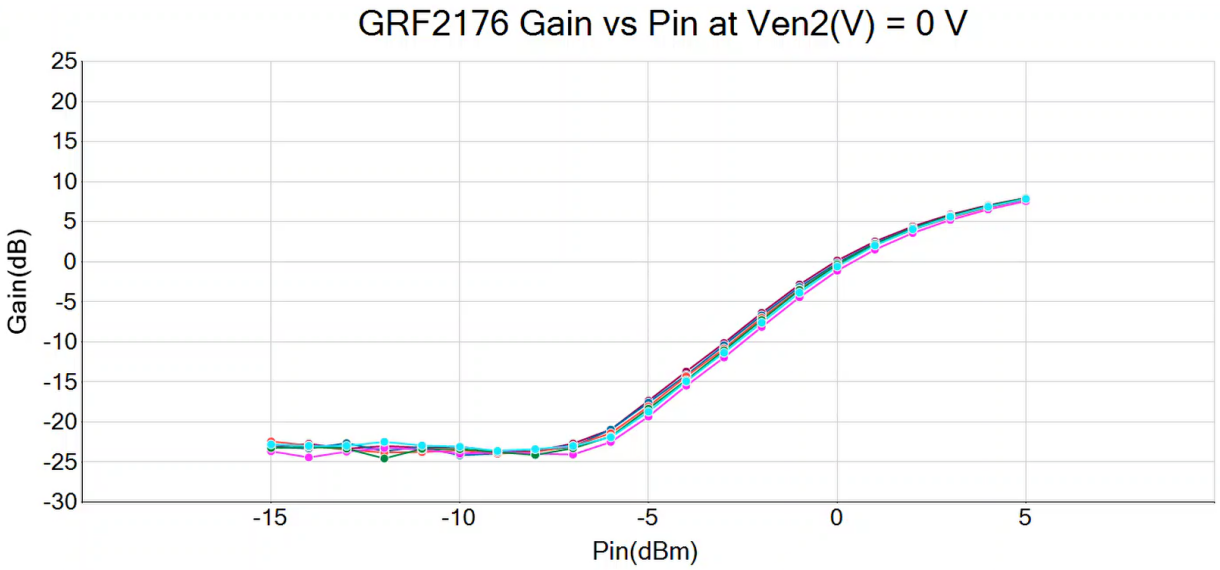
High Gain Mode



Low Gain Mode



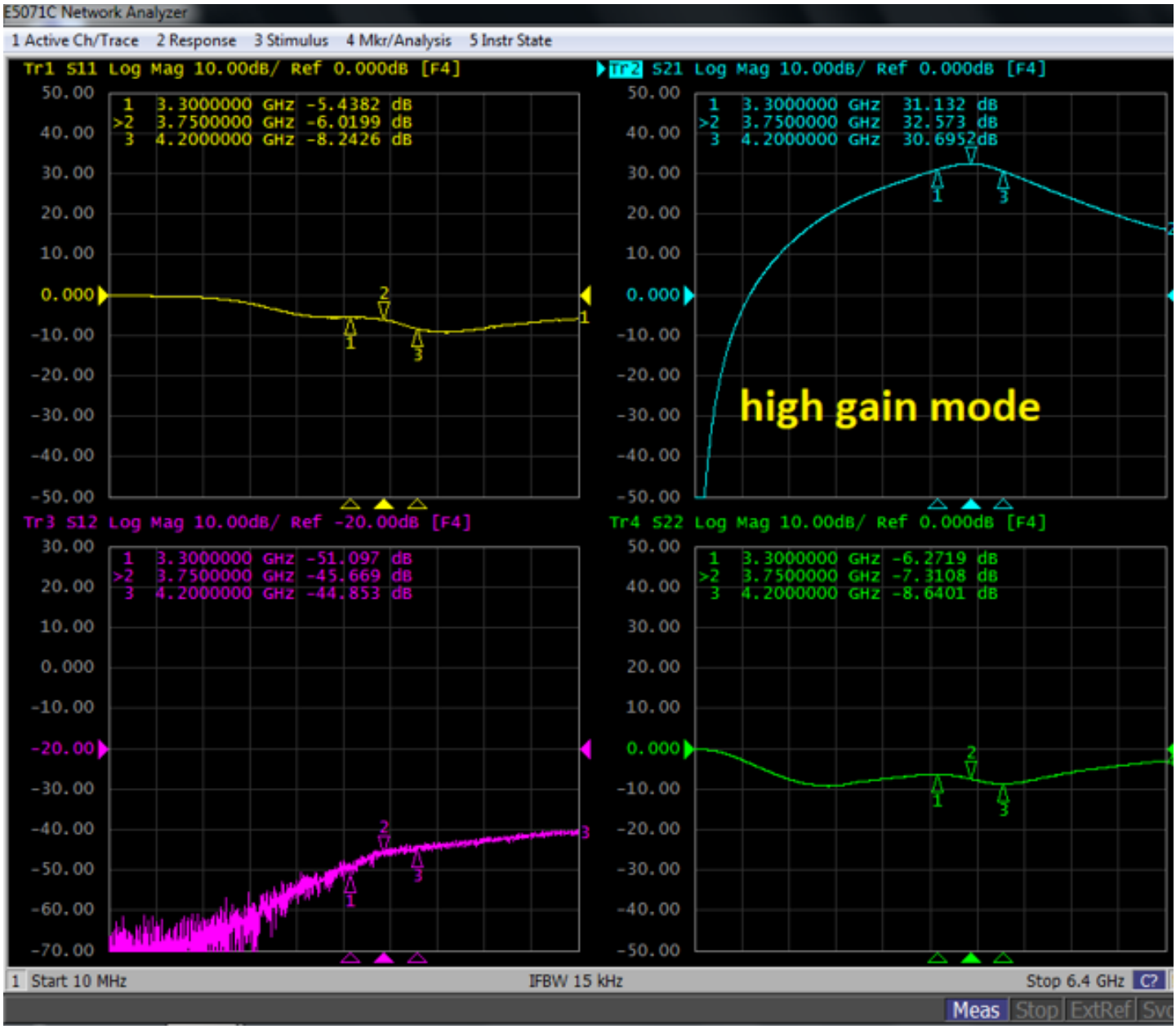
Typical Operating Curves: 3.3 to 4.2 GHz (VDD = HIGH, VEN1 = VEN2 = LOW)



NOTE: Pin < -7 dBm is recommended to prevent self-biasing in Off Mode using VEN1 & VEN2 only. Recommend VDD = VEN1 = VEN2 = 0 V for High Isolation Off State.

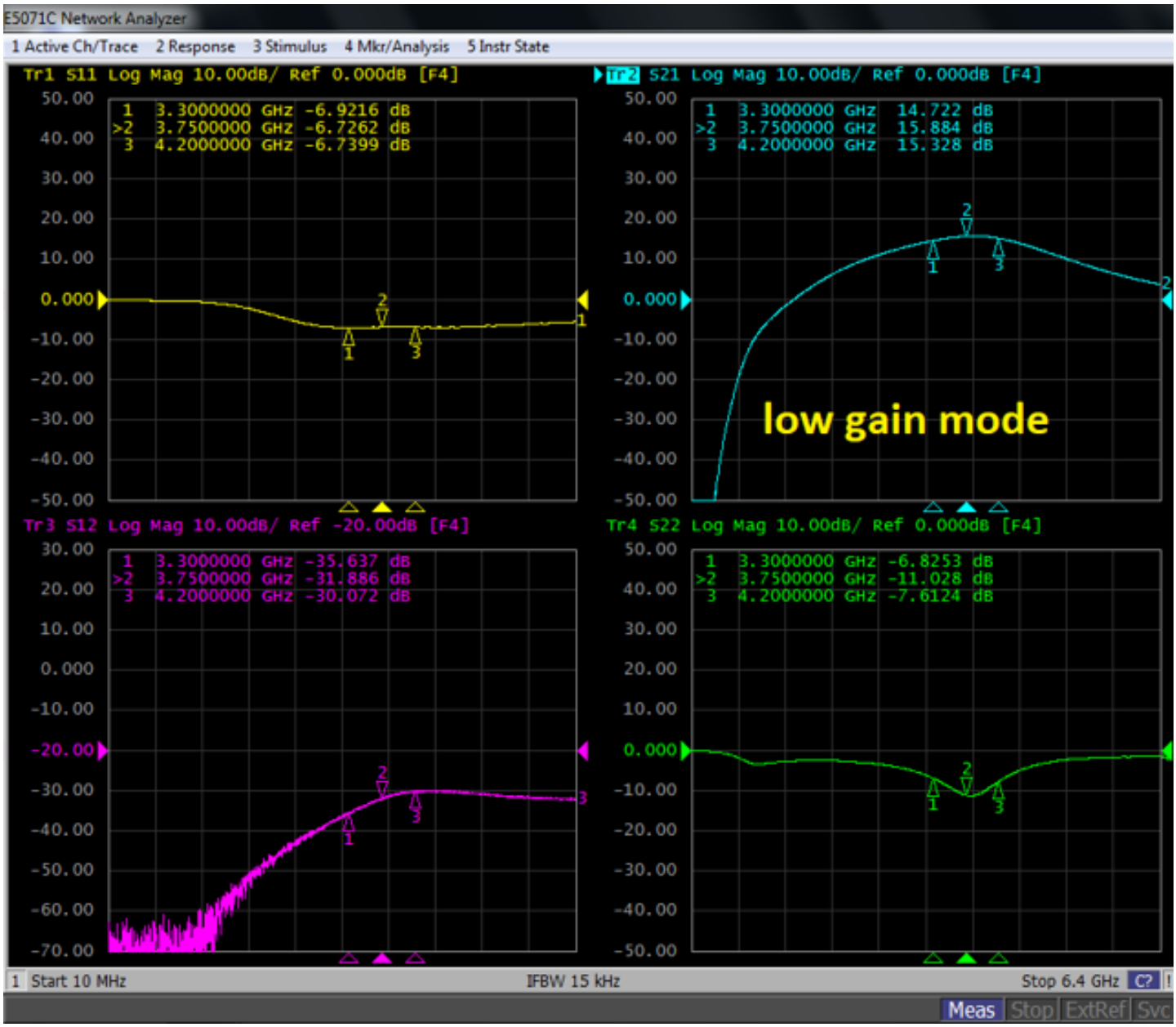
Typical Operating Curves: S-Parameters (3.3 to 4.2 GHz)

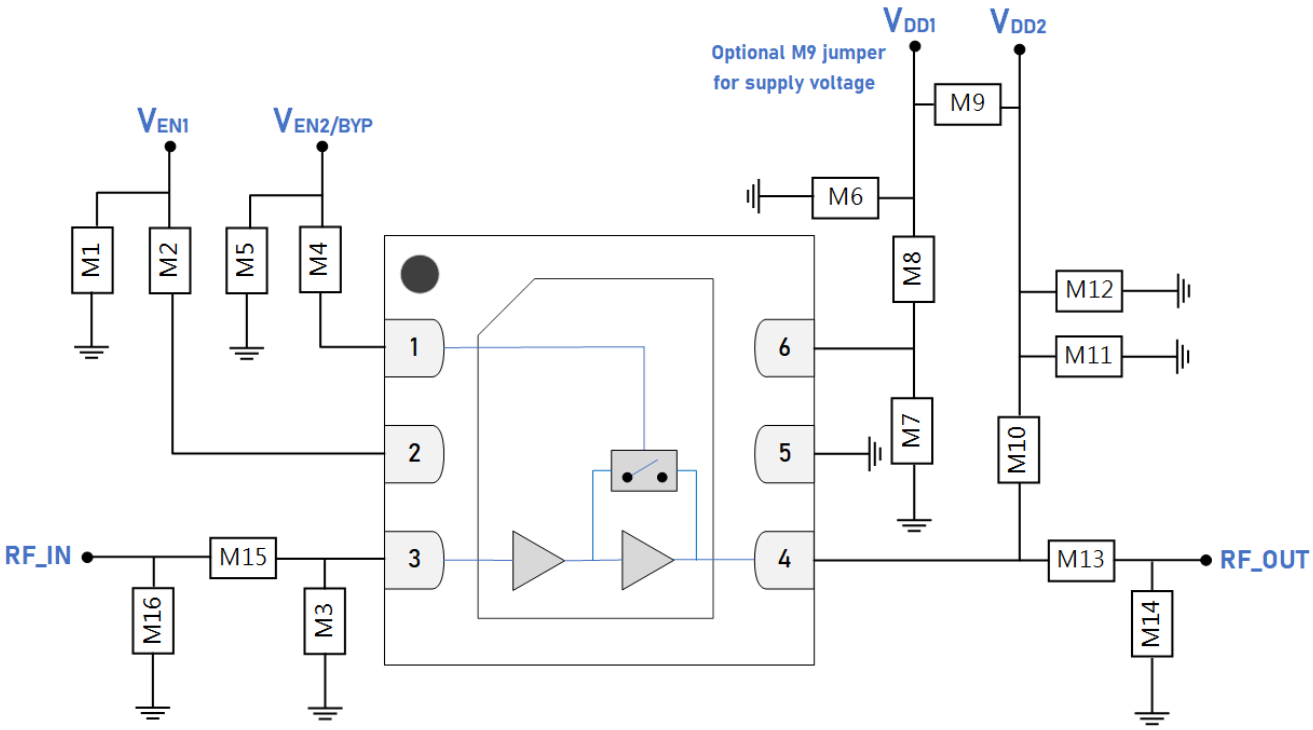
High Gain Mode



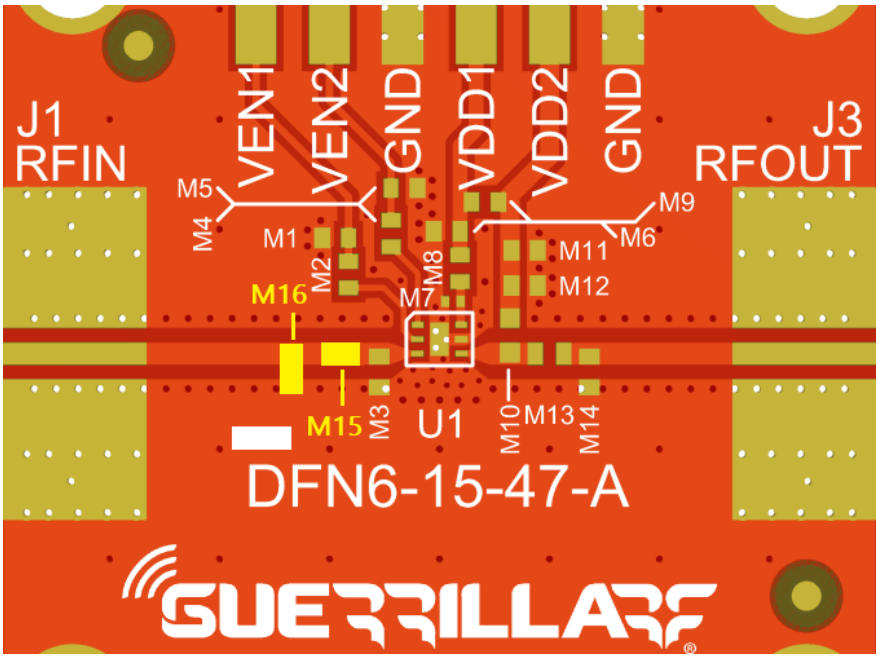
Typical Operating Curves: S-Parameters (3.3 to 4.2 GHz)

Low Gain Mode





GRF2176 Standard Evaluation Board Schematic

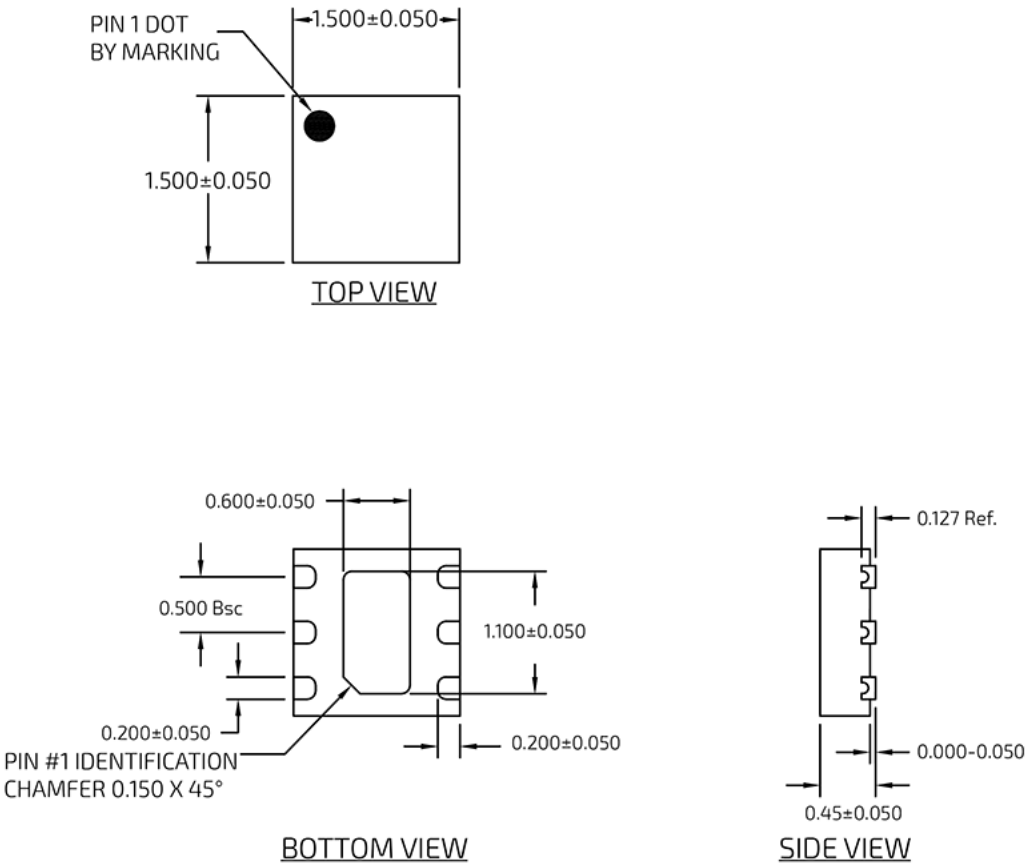


GRF2176 Evaluation Board Assembly Drawing

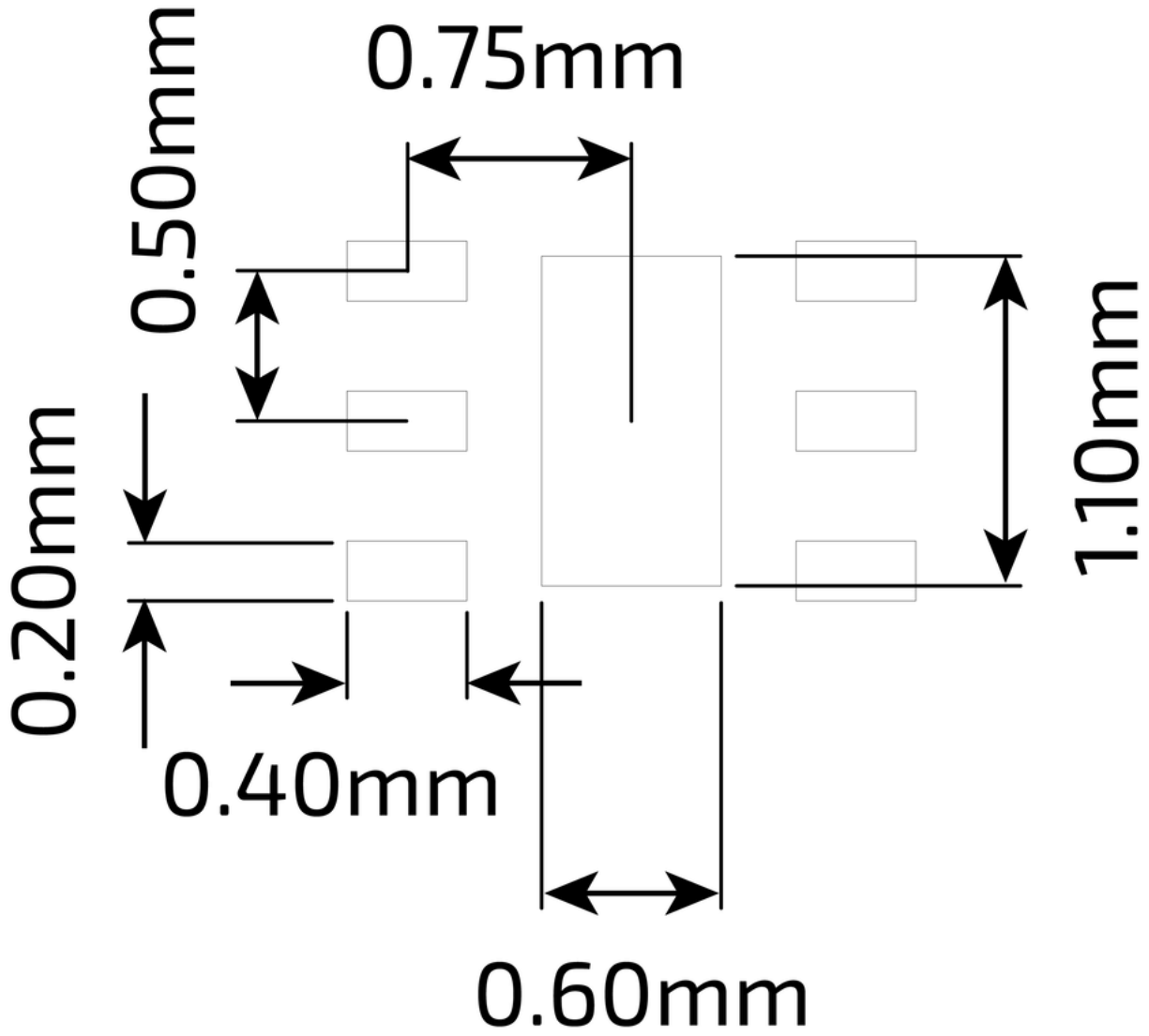
GRF2176 Evaluation Board Assembly Diagram Reference

Component	Type	Manufacturer	Family	Value	Package Size	Substitution
M1, M3, M5, M6 M11, M14	DNP	--	--	--	--	--
M2	Resistor	Various	5%	2 kΩ	0402	Ok
M4	Resistor	Various	5%	2 kΩ	0402	Ok
M7	Capacitor	Murata	GJM	0.1 µF	0402	Ok
M8	Inductor	Murata	LQG	15 nH	0201	Ok
M9	Inductor	Murata	LQGWH	18 nH	0402	Ok
M10	Inductor	Murata	LQG	6.8 nH	0402	Ok
M12	Capacitor	Murata	GJM	0.1 µF	0402	Ok
M13	Capacitor	Murata	GJM	10 pF	0402	Ok
M15	Capacitor	Murata	GJM	1.8 pF	0402	Ok
M16	Inductor	Murata	LQG	3.3 nH	0402	Ok
Evaluation Board	DFN6-15-47-A					

Note: Standard evaluation board bias: V_{DD} = 5 V.



DFN 6 1.5x1.5mm Package Dimensions



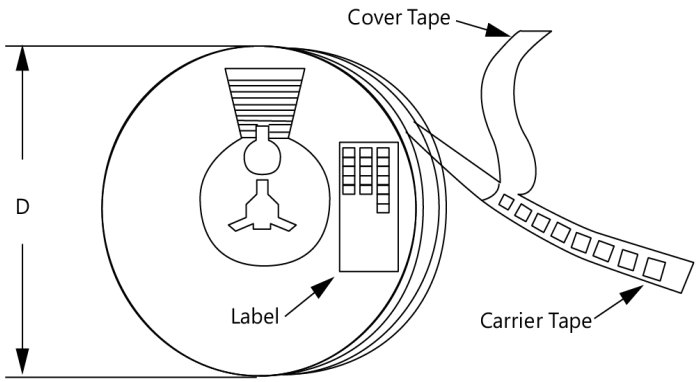
DFN 6 1.5x1.5mm Suggested PCB Footprint (Top View)

Package Marking Diagram

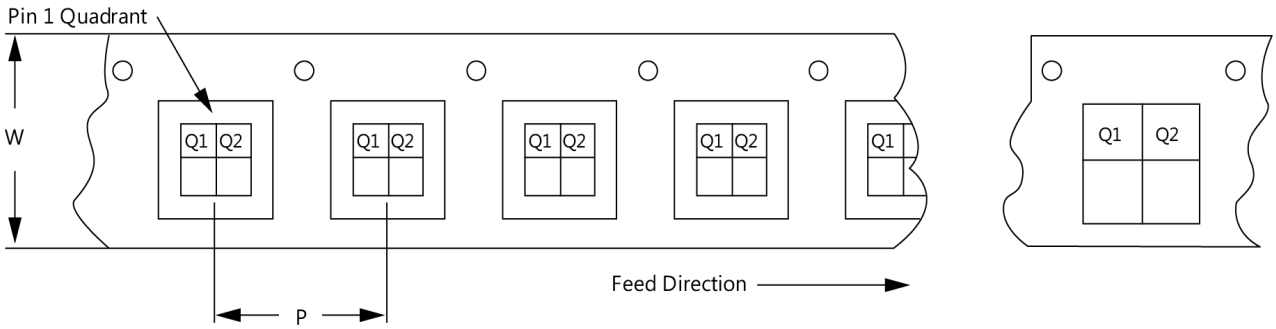
Line 1: "Y" = YEAR (single digit). "WW" = WORK WEEK the Device was assembled.
Line 2: "XXXX" = Device Part Number.

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). 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 latest reel specifications and package information (including units/reel), please visit 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
November 24, 2020	Advance Data Sheet - Initial Release.
February 13, 2023	Preliminary Data Sheet - Initial Release.
July 31, 2023	Upgraded Data Sheet to new format. Removed M1 and M5 from EVB BOM and added Capacitors C1 and C2.
October 6, 2023	Added "RoHS Compliant" to Features list on Page-1.
February 7. 2024	Lowered the low end of the Frequency Range from 2.3 to 1.9 GHz.
June 10, 2024	Lowered the low end of the Frequency Range from 1.9 to 1.7 GHz. Added new characterization plots. Updated specifications, evaluation board, schematic and BOM. Added link to "GRF2176 Custom Tunes".
September 9, 2024	Release Ø Data Sheet. Updated Maximum Dissipated Power specifications (Stage1 & 2). Updated Thermal Data specifications (Stage 1 & 2).
December 5, 2024	Release A Data Sheet. Lowered low end of frequency range from 1.7 GHz to 500 MHz.

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.

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