

GRF2176

LNA with Selectable Gain 2.3 to 6 GHz

PRELIMINARY DATA SHEET

FEATURES

- Two Selectable Gain Modes: 32.4 & 15.8 dB
- Excellent Linearity Performance Over Wide Bandwidths
- 2.7 to 6 V Supply Voltage
- Flexible Biasing Provides Latitude for Linearity Optimization
- 66 mA Native Mode Quiescent Current Consumption
- 50 Ω Single-Ended Input and Output Impedances
- RoHS Compliant

Reference: High Gain Mode 5 V / 66 mA / 3.75 GHz

- Gain: 32.4 dB
- OP1dB: 20.9 dBm
- OIP3: 32 dBm
- Evaluation Board NF: 0.68 dB

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

- Gain: 15.8 dB
- OP1dB: 13.9 dBm
- OIP3: 24.9 dBm
- Evaluation Board NF: 0.65 dB

APPLICATIONS

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



ORDERING INFORMATION

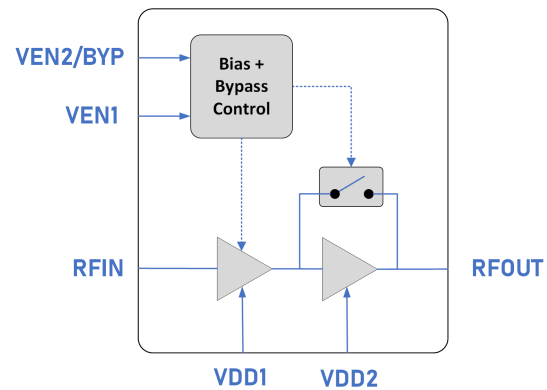
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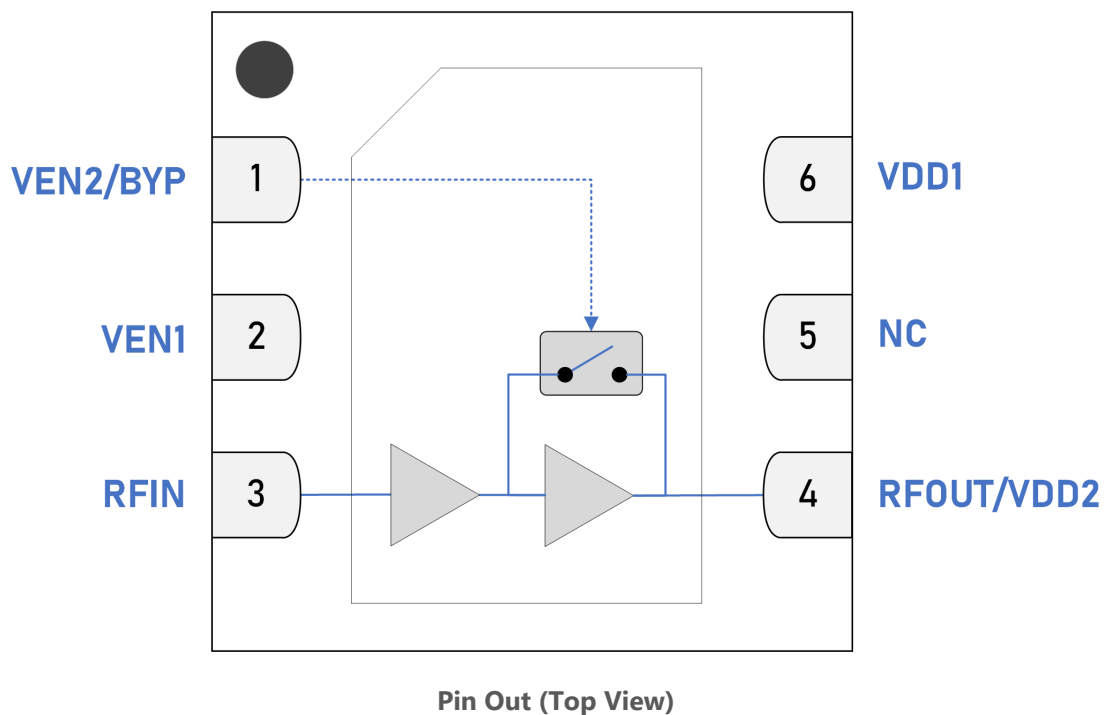
DESCRIPTION

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 32.4 and 15.8 dB, respectively.

For optimal efficiency and linearity, the amplifier was designed to operate with a single 5 V supply voltage while using only 66 mA of quiescent current. Supply voltages ranging from 2.7 to 6 V are also supported. Similarly, I_{DDQ} can be increased beyond the native biasing point for enhanced linearity performance.

BLOCK DIAGRAM





Pin Assignments

Pin	Name	Description	Note
1	VEN2/BYP	2nd Stage Enable/Bypass	VEN2/BYP ≤ 0.2 volts sets Bypass Mode. VEN2/BYP and external series resistor controls the second stage I_{DDQ} when VEN2/BYP is high.
2	VEN1	1st Stage Enable	VEN1 ≤ 0.2 disables the first stage. VEN1 and external series resistor control the first stage I_{DDQ} 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 . V_{DD} 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 V_{DD} 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.

Absolute Ratings

Parameter	Symbol	Min.	Max.	Unit
Supply Voltage	V_{DD}	0	6	V
RF Input Power - RX Mode: 50 Ω , $V_{DD} < 6.0$ V average power rating, LTE 20 MHz waveform with 8 dB PAR, 100% DC, 115 °C	$P_{IN\ MAX}$		TBD	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	$P_{DISS\ MAX}$		TBD	W
Electrostatic Discharge				
Charged Device Model	CDM	TBD		kV
Human Body Model	HBM	TBD		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	V_{CC}	4.75	5	5.25	V	
Operating Temperature Range	T_{PKG} BASE	-40		+115	°C	
RF Frequency Range (note 1)	F_{RF}	2.3		2.7	GHz	2.5 GHz tuning set.
		3.3		4.2		3.75 GHz tuning set.
		4.4		5.0		4.7 GHz tuning set.
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 tuning set.

Note1: Operation outside of this range is possible but with the degraded performance of some parameters.

Nominal Operating Parameters - General

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_{IL}, I_{IH}		TBD		μA	VEN1 and VEN2/BYP inputs.
VEN1 Switching Rise Time	$t_{VEN1-RISE}$		200		ns	Turn ON time (VEN1 Low to High, note 2).
VEN1 Switching Fall Time	$t_{VEN1-FALL}$		50		ns	Turn OFF time (VEN1 High to Low, note 3).
VEN2/BYP Switching Rise Time	$t_{GAIN-RISE}$		200		ns	Low to High gain mode switching (VEN2/BYP Low to High, note 4).
VEN2/BYP Switching Fall Time	$t_{GAIN-FALL}$		50		ns	High to Low gain mode switching (VEN2/BYP High to Low, note 5).

Disabled Mode

Standby Current	I_{STBY}		TBD		μA	$V_{DD} = 5 V$, VEN1 = Low, VEN2/BYP = Low.
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Thermal Data

Thermal Resistance (Infrared Scan)	θ_{JC}		TBD		$^{\circ}C/W$	On Standard Evaluation Board
Channel Temp @ +115 $^{\circ}C$ (Reference Package Heat Sink)	T_{CHAN}		TBD		$^{\circ}C$	$V_{DD} = 5 V$, $I_{DDQ} = 66 mA$, $P_{DISS} = TBD$. No RF applied (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 $T_{CHAN} < 170^{\circ}C$.

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), $R_{BIAS1} = 2 \text{ k}\Omega$, $R_{BIAS2} = 2 \text{ k}\Omega$ (low bias mode), $50 \text{ }\Omega$ system impedance, $V_{DD} = 5 \text{ V}$, $P_{OUT} = 0 \text{ dBm}$, $F_{TEST} = 3.75 \text{ GHz}$, $T_{PKG \text{ BASE}} = 25 \text{ }^{\circ}\text{C}$. 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 (High Bias Mode)	$I_{DDQ-HIGH}$		TBD		mA	$R_{BIAS} = \text{TBD}$, $R_{BIAS2} = \text{TBD}$
Supply Quiescent Current (Low Bias Mode)	I_{DD-LOW}		66			$R_{BIAS} = 2 \text{ k}\Omega$, $R_{BIAS2} = 2 \text{ k}\Omega$
Supply Current with RF applied (High Bias Mode)	$I_{DD-HIGH}$		TBD		mA	$P_{OUT} = 0 \text{ dBm}$, $R_{BIAS} = \text{TBD}$, $R_{BIAS2} = \text{TBD}$
Supply Current with RF applied (Low Bias Mode)	I_{DD-LOW}		TBD			$P_{OUT} = 0 \text{ dBm}$, $R_{BIAS} = 2 \text{ k}\Omega$, $R_{BIAS2} = 2 \text{ k}\Omega$
Gain	S_{21}		32.4		dB	$F_{RF} = 3.75 \text{ GHz}$
Gain Flatness	$S_{21_{FLAT}}$		1.9		dB	$F_{RF} = 3.3 \text{ to } 4.2 \text{ GHz}$
Gain Variation Over Temp	$S_{21_{TEMP}}$		1/-1.25		dB	$T_{PKG \text{ BASE}} = -40 \text{ to } 115 \text{ }^{\circ}\text{C}$, Referenced to $T_{PKG \text{ BASE}} = 25 \text{ }^{\circ}\text{C}$
Standby Mode Gain	$S_{21_{STBY}}$		TBD		dB	VEN1 = VEN2/BYP = 0 V
Input Return Loss	S_{11}		> 5.5		dB	$F_{RF} = 3.3 \text{ to } 4.2 \text{ GHz}$
Output Return Loss	S_{22}		> 6.2		dB	$F_{RF} = 3.3 \text{ to } 4.2 \text{ GHz}$
Reverse Isolation	S_{12}		> 44		dB	$F_{RF} = 3.3 \text{ to } 3.8 \text{ GHz}$
De-Embedded Noise Figure	NF		TBD		dB	$F_{RF} = 3.75 \text{ GHz}$
Evaluation Board Noise Figure			0.68			$F_{RF} = 3.75 \text{ GHz}$
Output 3rd Order Intercept Point	OIP3 _{HI BIAS}		TBD		dBm	$I_{DDQ} = \text{TBD}$, 0 dBm P_{OUT} per tone at 2 MHz spacing
	OIP3 _{LO BIAS}		32			$I_{DDQ} = 66 \text{ mA}$, 0 dBm P_{OUT} per tone at 2 MHz spacing
Output 1 dB Compression Power	OP1dB _{HI BIAS}		TBD		dB	$I_{DDQ} = \text{TBD}$
	OP1dB _{LO BIAS}		22			$I_{DDQ} = 66 \text{ mA}$

Nominal Operating Parameters - RF

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

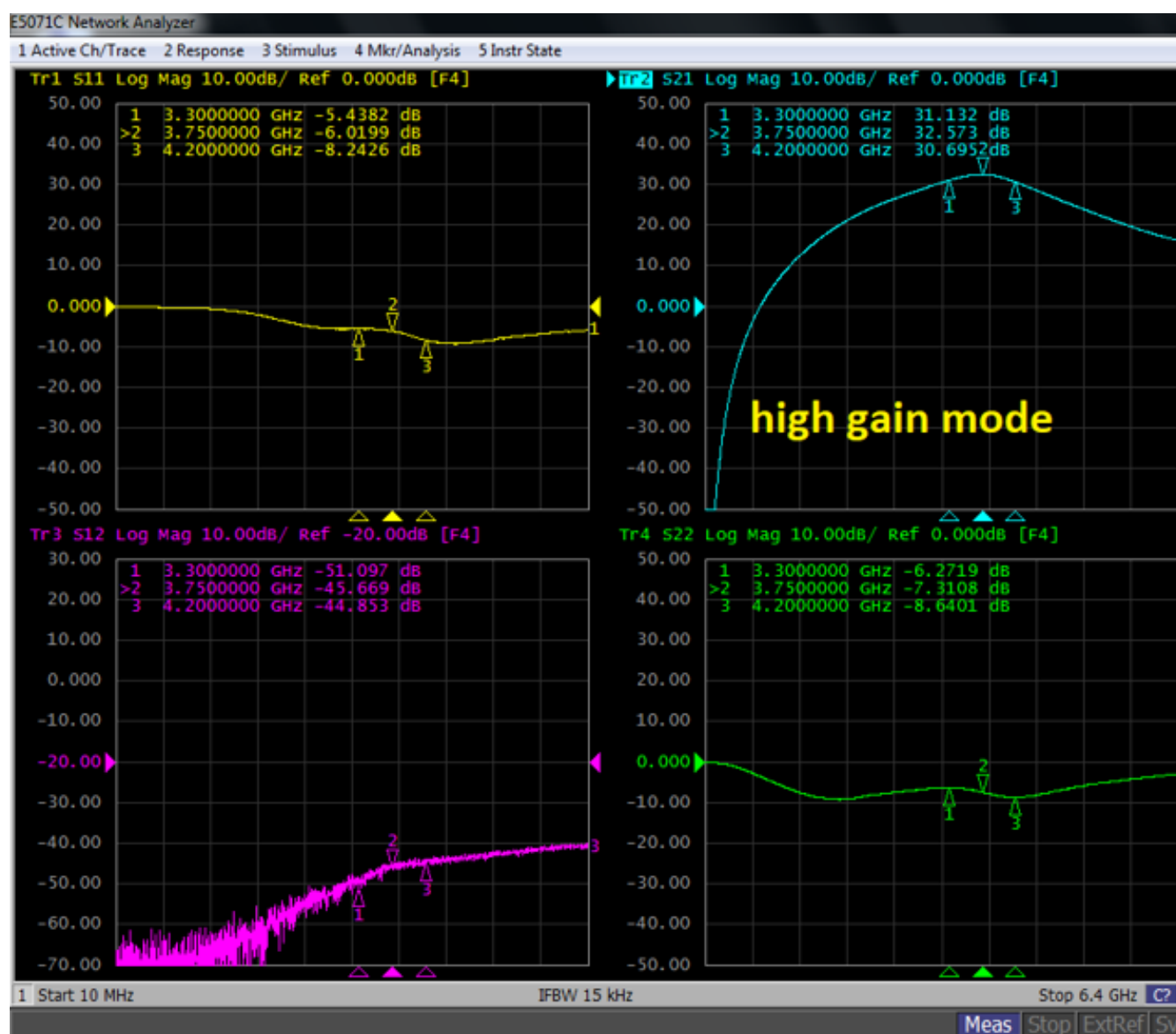
The following conditions apply unless noted otherwise: typical application schematic using the 3.3 to 4.2 GHz tuning set, VEN1 = 3 V, VEN2/BYP = 0 V (low gain mode), $R_{BIAS1} = 2 \text{ k}\Omega$, $R_{BIAS2} = 2 \text{ k}\Omega$ (low bias mode), $50 \text{ }\Omega$ system impedance, $V_{DD} = 5 \text{ V}$, $P_{OUT} = 0 \text{ dBm}$, $F_{TEST} = 3.75 \text{ GHz}$, $T_{PKG \text{ BASE}} = 25 \text{ }^{\circ}\text{C}$. 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 (High Bias Mode)	$I_{DDQ-HIGH}$		TBD		mA	$R_{BIAS} = \text{TBD}$, $R_{BIAS2} = \text{TBD}$
Supply Quiescent Current (Low Bias Mode)	I_{DD-LOW}		28			$R_{BIAS} = 2 \text{ k}\Omega$, $R_{BIAS2} = 2 \text{ k}\Omega$
Supply Current with RF applied (High Bias Mode)	$I_{DD-HIGH}$		TBD		mA	$P_{OUT} = 0 \text{ dBm}$, $R_{BIAS} = \text{TBD}$, $R_{BIAS2} = \text{TBD}$
Supply Current with RF applied (Low Bias Mode)	I_{DD-LOW}		TBD			$P_{OUT} = 0 \text{ dBm}$, $R_{BIAS} = 2 \text{ k}\Omega$, $R_{BIAS2} = 2 \text{ k}\Omega$
Gain	S_{21}		15.8		dB	$F_{RF} = 3.75 \text{ GHz}$
Gain Flatness	$S_{21_{FLAT}}$		1.4		dB	$F_{RF} = 3.3 \text{ to } 4.2 \text{ GHz}$
Gain Variation Over Temp	$S_{21_{TEMP}}$		0.6/-1.2		dB	$T_{PKG \text{ BASE}} = -40 \text{ to } 115 \text{ }^{\circ}\text{C}$, Referenced to $T_{PKG \text{ BASE}} = 25 \text{ }^{\circ}\text{C}$
Standby Mode Gain	$S_{21_{STBY}}$		TBD		dB	VEN1 = VEN2/BYP = 0 V
Input Return Loss	S_{11}		> 6.7		dB	$F_{RF} = 3.3 \text{ to } 4.2 \text{ GHz}$
Output Return Loss	S_{22}		> 6.8		dB	$F_{RF} = 3.3 \text{ to } 4.2 \text{ GHz}$
Reverse Isolation	S_{12}		> 30		dB	$F_{RF} = 3.3 \text{ to } 3.8 \text{ GHz}$
De-Embedded Noise Figure	NF		TBD		dB	$F_{RF} = 3.75 \text{ GHz}$
Evaluation Board Noise Figure			0.65			$F_{RF} = 3.75 \text{ GHz}$
Output 3rd Order Intercept Point	OIP3 _{HI BIAS}		TBD		dBm	$I_{DDQ} = \text{TBD}$, 0 dBm P_{OUT} per tone at 2 MHz spacing
	OIP3 _{LO BIAS}		24.9			$I_{DDQ} = 66 \text{ mA}$, 0 dBm P_{OUT} per tone at 2 MHz spacing
Output 1 dB Compression Power	OP1dB _{HI BIAS}		TBD		dB	$I_{DDQ} = \text{TBD}$
	OP1dB _{LO BIAS}		13.9			$I_{DDQ} = 66 \text{ mA}$

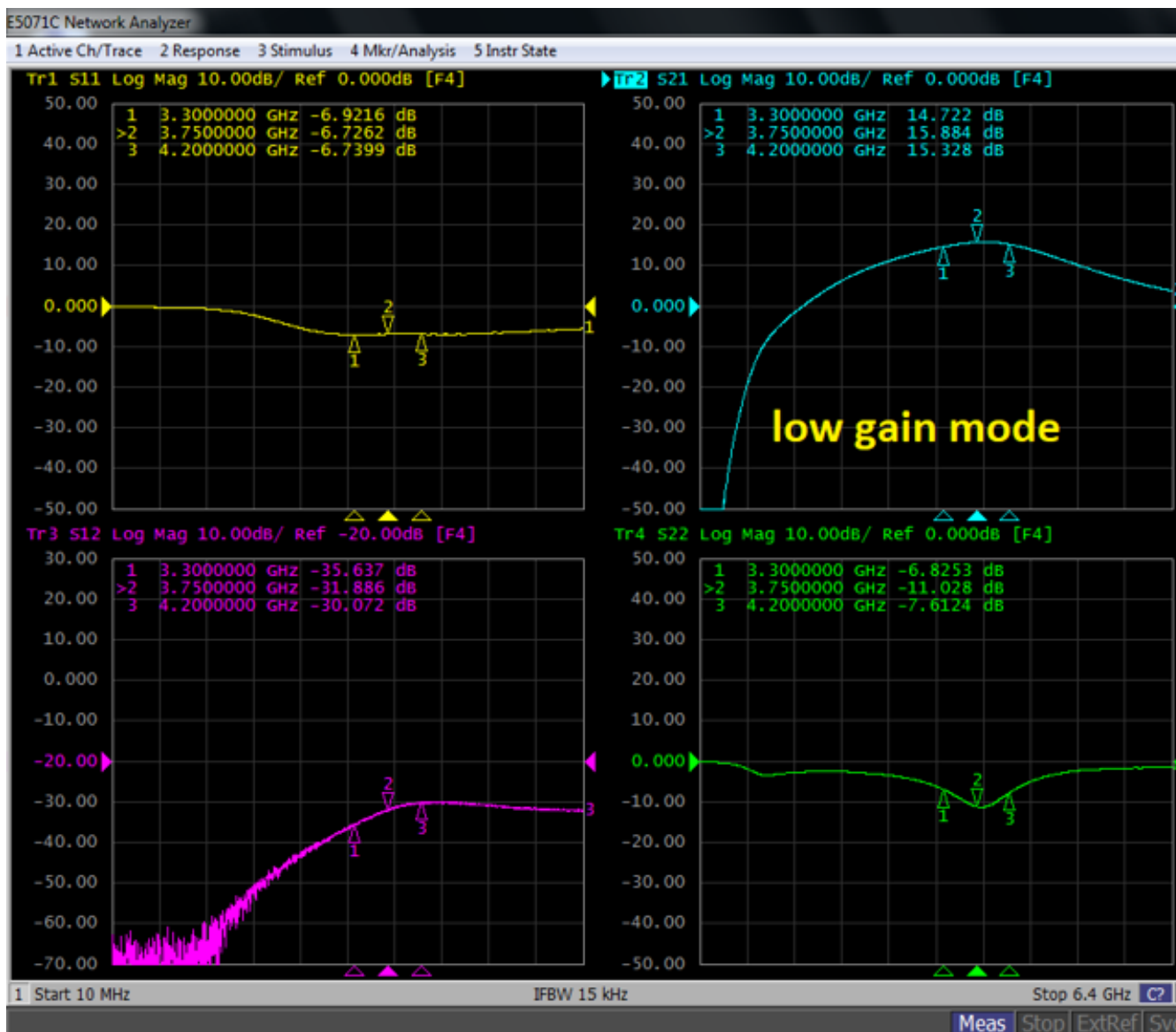
TRUTH TABLE

Mode	Pin Logic	
	VEN1	VEN2/BYP
High Gain	HIGH	HIGH
Low Gain (2nd Stage Bypass)	HIGH	LOW
Standby	LOW	LOW

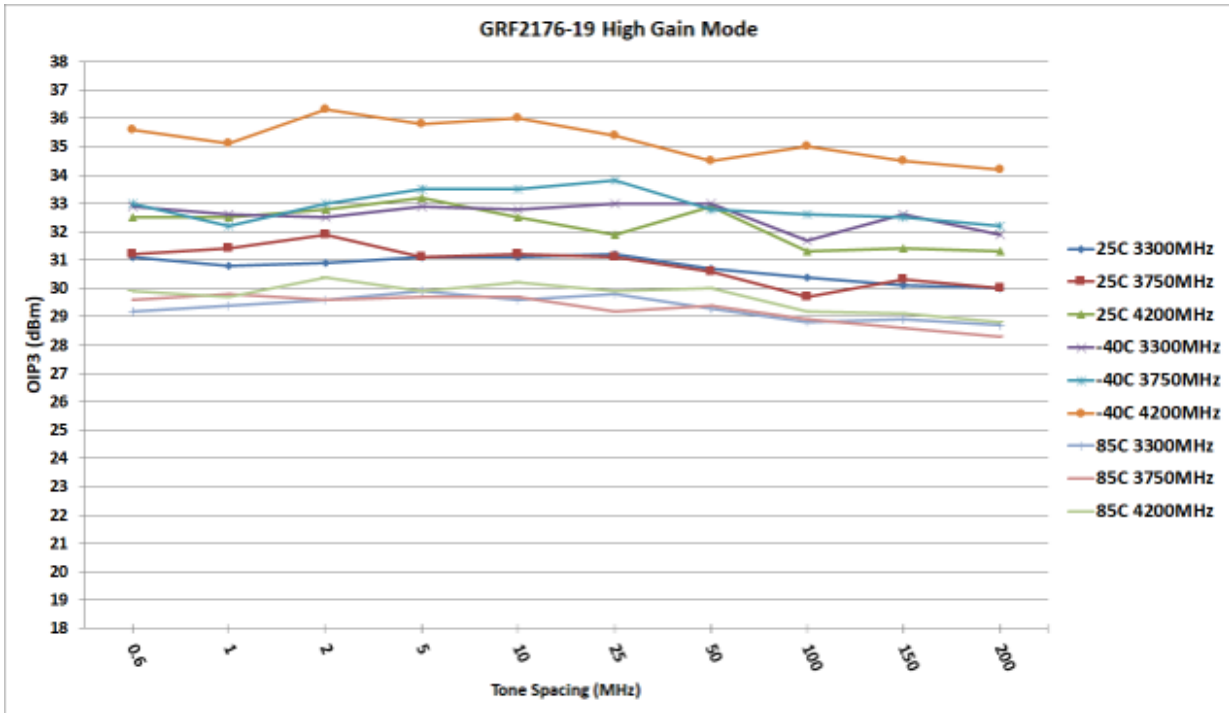
S-Parameters - HIGH GAIN MODE



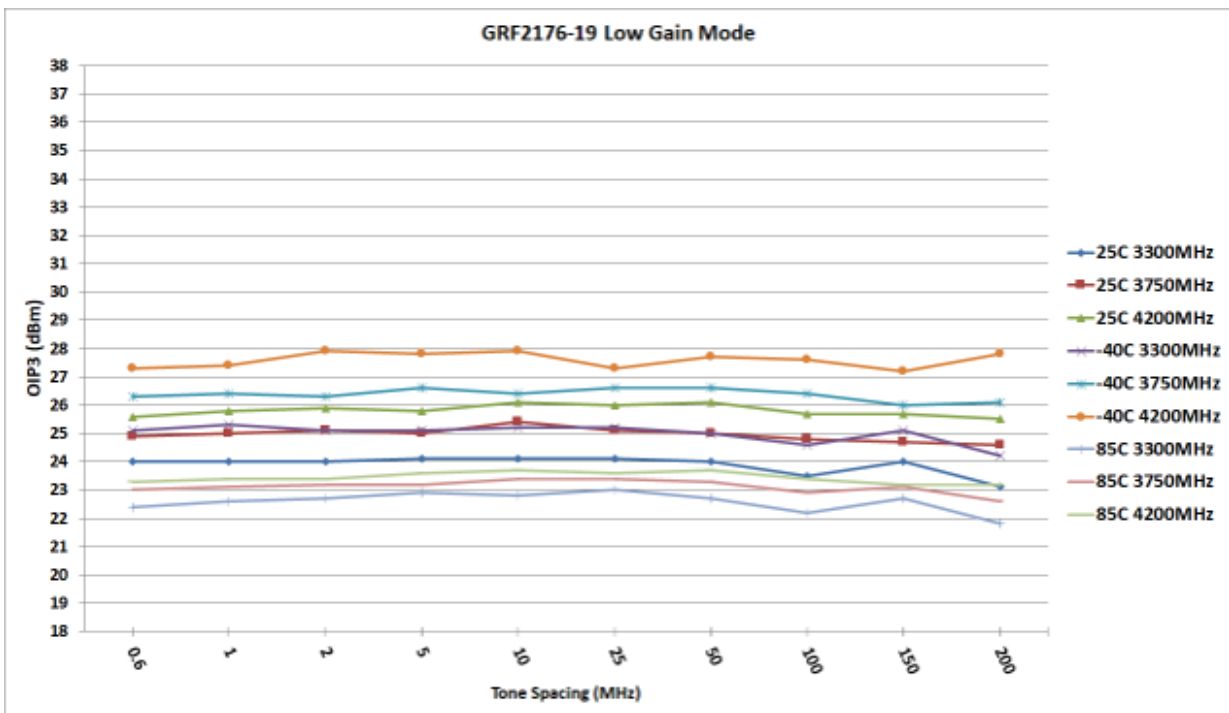
S-Parameters - LOW GAIN MODE

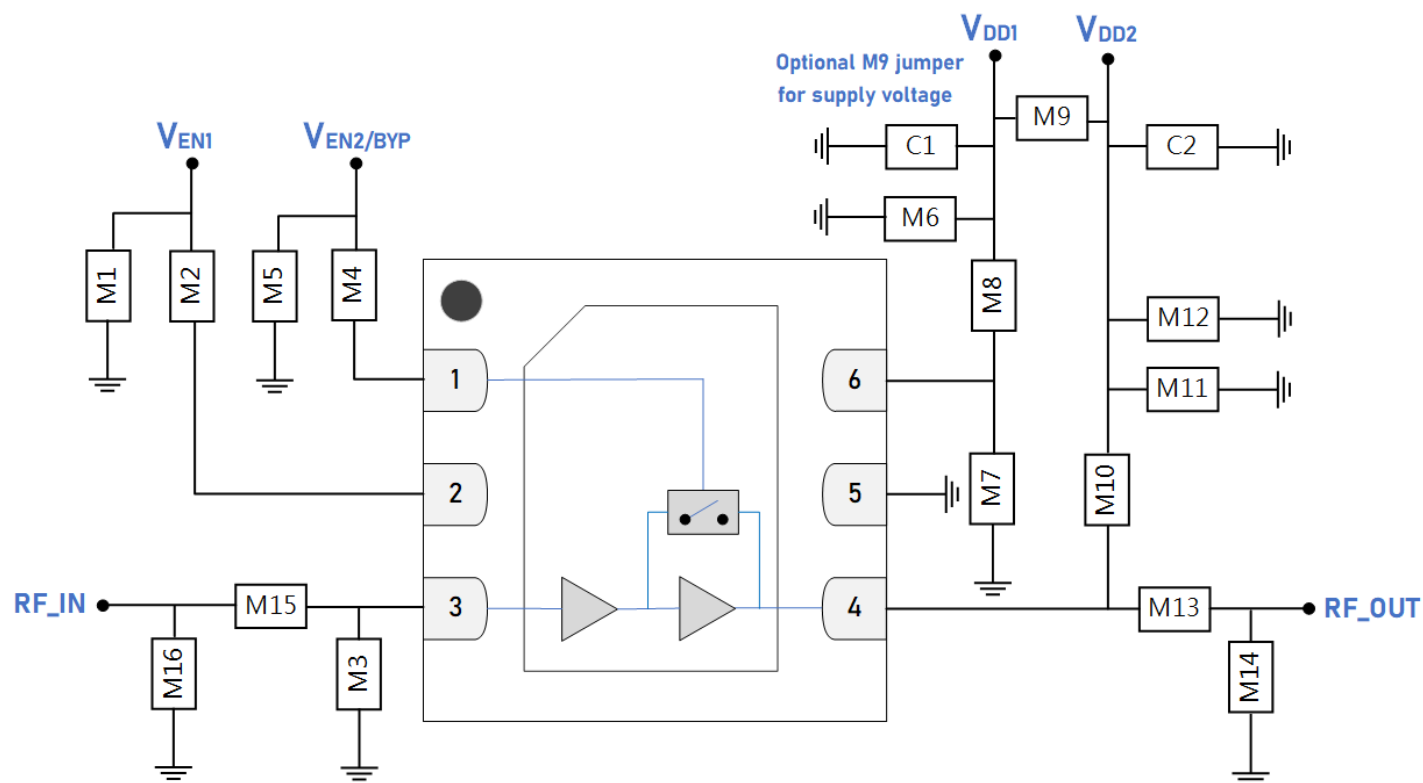


OIP3 - HIGH GAIN MODE

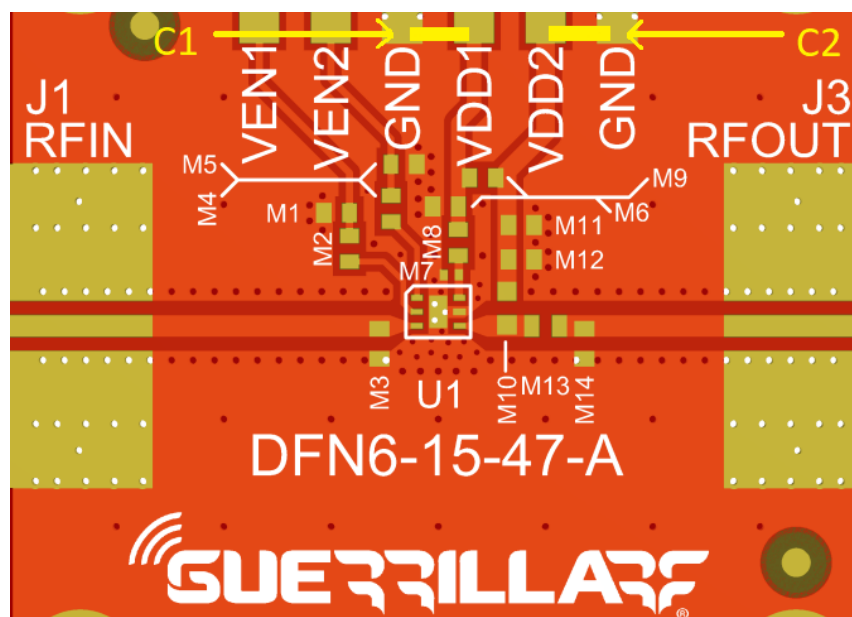


OIP3 - LOW GAIN MODE





GRF2176 Standard Test Schematic

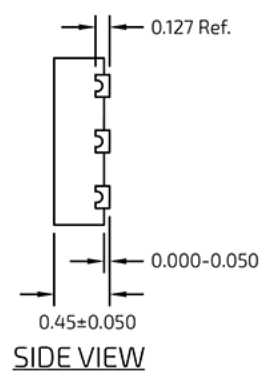
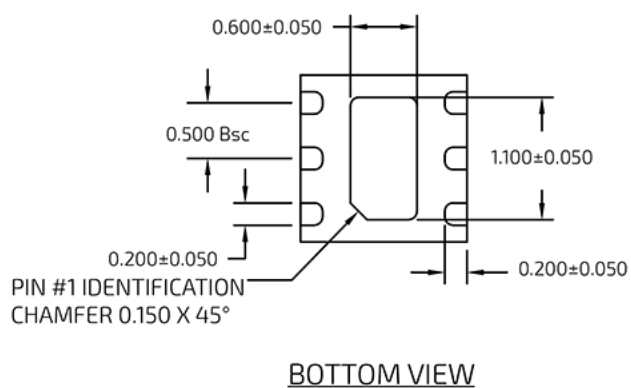
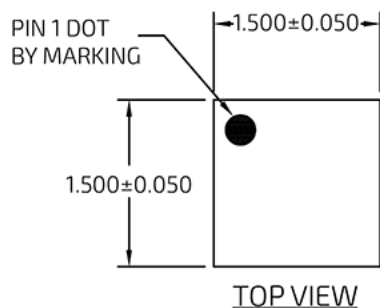


GRF2176 Evaluation Board Assembly Drawing

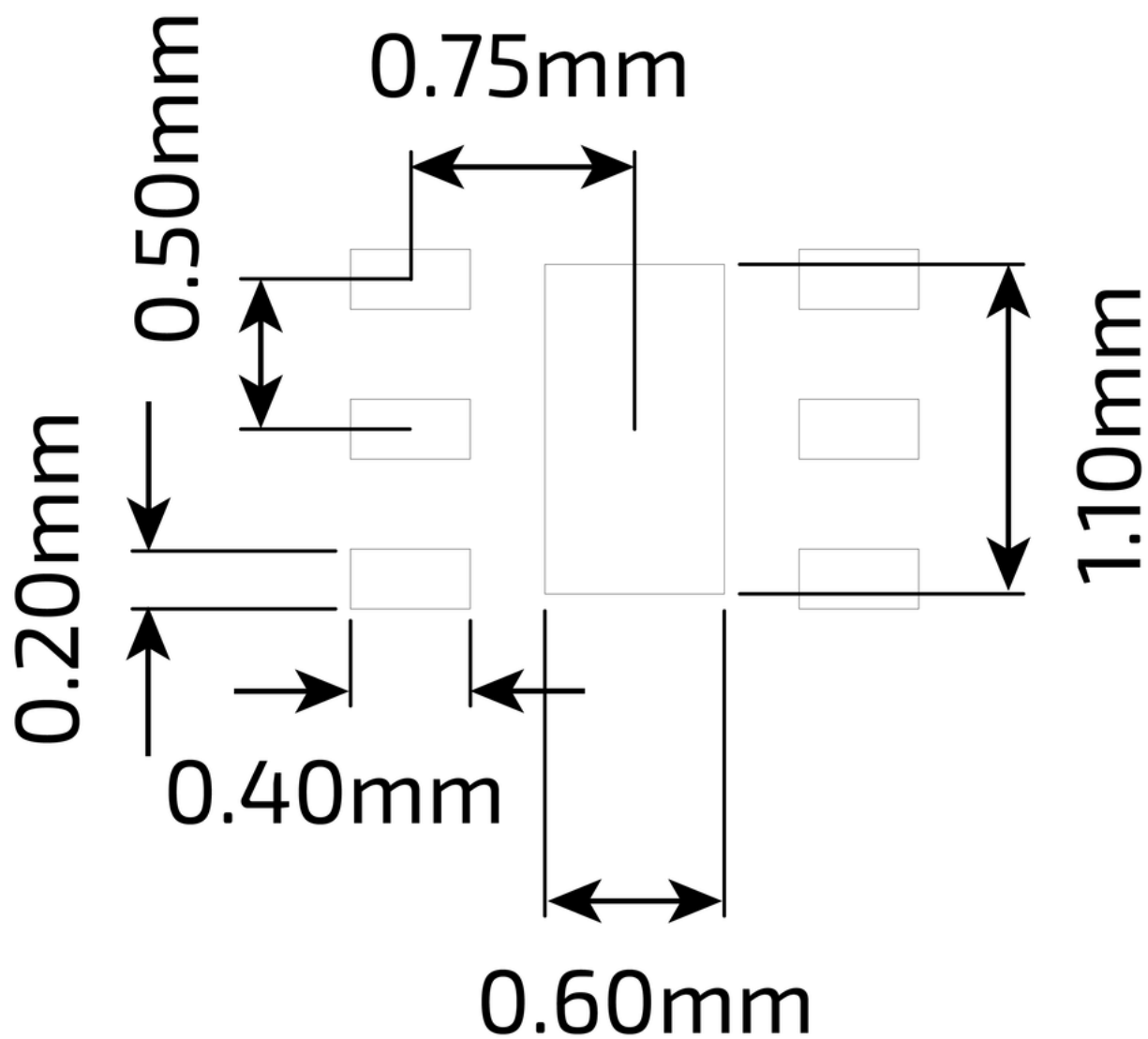
GRF2176 Evaluation Board Assembly Diagram Reference

Component	Type	Manufacturer	Family	Value	Package Size	Substitution
C1	Capacitor	Murata	GJM	100 pF	0402	Ok
C2	Capacitor	Murata	GJM	100 pF	0402	Ok
M1, M3, M5, M6 M11, M14	DNP	--	--	--	--	--
M2	Resistor	Various	5%	2 k Ω	0402	Ok
M4	Resistor	Various	5%	2 k Ω	0402	Ok
M7	Capacitor	Murata	GJM	0.1 μ F	0402	Ok
M8	Inductor	Murata	LQG	15 nH	0402	Ok
M9	Resistor	Various	5%	0 Ω	0402	Ok
M10	Inductor	Murata	LQG	6.8 nH	0402	Ok
M12	Capacitor	Murata	GJM	0.1 μ F	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)

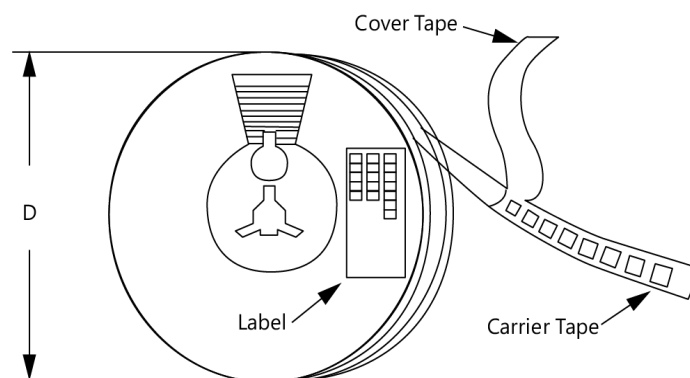
Package Marking Diagram



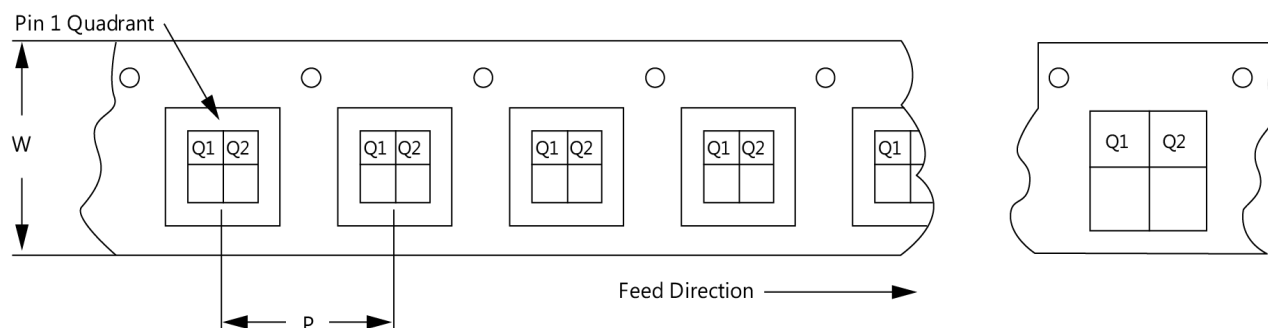
Line 1: "Y" = YEAR (single digit). "WW" = WORK WEEK the Device was assembled.
Line 2: "XXXX" = Device Part Number.

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 to new Data Sheet 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.



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 <i>estimated</i> 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 <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.

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