



## GRF2093W

### 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

#### Tested to AEC-Q100 Grade 2

- 100% Device Reflow at Assembly
- 100% Optical Die Inspection

#### 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 GRF2093W 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, GRF2093W is part of Guerrilla RF's highest performance satellite radio solution where it functions as the first-stage LNA over 2320 to 2345 MHz.

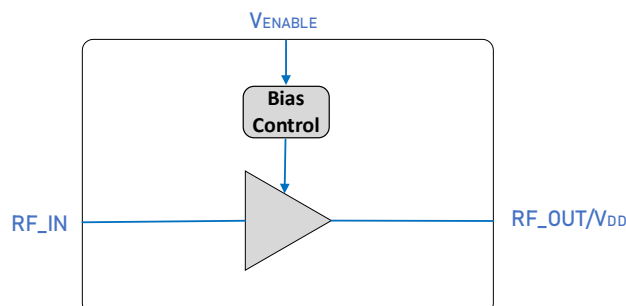
The device can be biased over a range of  $V_{DD}$  from 2.7 to 5 volts and  $I_{DDQ}$  values from 30 to 100 mA.

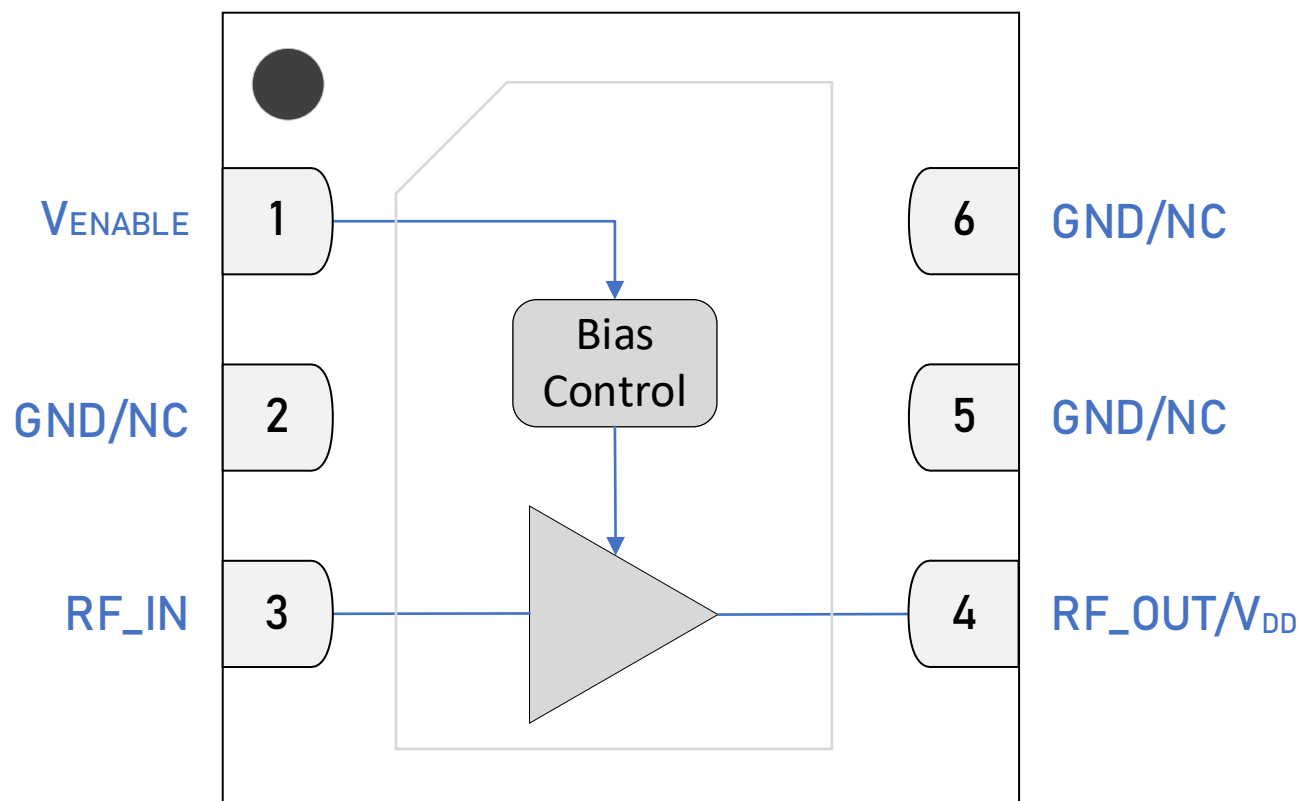
The device uses the standard Guerrilla RF 1.5 mm DFN-6 package and pinout. It joins more than 20 other LNAs and linear drivers which can use the same evaluation board.

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 GRF2093W "Custom Tunes" product page: [GRF2093W Custom Tunes](#)

#### BLOCK DIAGRAM





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

## Pin Assignments

| Pin      | Name                   | Description          | Note                                                                                                                                                                                                                      |
|----------|------------------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | V <sub>ENABLE</sub>    | Enable Voltage Input | V <sub>ENABLE</sub> and series resistor sets I <sub>DDQ</sub> . V <sub>ENABLE</sub> ≤ 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 <sub>DD</sub> | RF Output            | V <sub>DD</sub> 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 <sup>6</sup> 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](#).

## 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 ( <b>notes 1 &amp; 2</b> ). |
| RF_IN Port Impedance                 | $Z_{RFIN}$      |               | 50     |      | $\Omega$ | Single-ended.                                                                               |
| RF_OUT Port Impedance                | $Z_{RFOUT}$     |               | 50     |      | $\Omega$ | 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: [GRF2093W 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,  $V_{DD} = 5\text{ V}$ ,  $V_{ENABLE} = 5\text{ V}$ ,  $I_{DD} = 55\text{ mA}$ ,  $M5 = 3\text{ k}\Omega$ ,  $F_{TEST} = 2332.5\text{ MHz}$ ,  $50\text{ }\Omega$  system impedance,  $T_{PKG\text{ BASE}} = 25\text{ }^{\circ}\text{C}$ . Evaluation board losses are included within the specifications.

| Parameter           | Symbol       | Specification |      |      | Unit | Condition                                           |
|---------------------|--------------|---------------|------|------|------|-----------------------------------------------------|
|                     |              | Min.          | Typ. | Max. |      |                                                     |
| Supply Current      | $I_{DD}$     | 40            | 55   | 70   | mA   | $V_{DD} = 5\text{ V}$ , $V_{ENABLE} = 5\text{ V}$ . |
| Enable Current      | $I_{ENABLE}$ |               | 1.3  | 2    | mA   | $V_{DD} = 5\text{ V}$ , $V_{ENABLE} = 5\text{ V}$ . |
| Switching Rise Time | $T_{RISE}$   |               | 400  |      | ns   | Disabled Mode to Gain Mode ( <b>note 3</b> ).       |
| Switching Fall Time | $T_{FALL}$   |               | 100  |      | ns   | Gain Mode to Disabled Mode ( <b>note 4</b> ).       |

### Disabled Mode

|                 |               |  |     |     |               |                                                     |
|-----------------|---------------|--|-----|-----|---------------|-----------------------------------------------------|
| Leakage Current | $I_{LEAKAGE}$ |  | 180 | 500 | $\mu\text{A}$ | $V_{DD} = 5\text{ V}$ , $V_{ENABLE} = 0\text{ V}$ . |
|-----------------|---------------|--|-----|-----|---------------|-----------------------------------------------------|

### Thermal Data

|                                    |               |  |    |  |                             |                                                 |
|------------------------------------|---------------|--|----|--|-----------------------------|-------------------------------------------------|
| Thermal Resistance (Infrared Scan) | $\Theta_{JC}$ |  | 43 |  | $^{\circ}\text{C}/\text{W}$ | On standard evaluation board ( <b>note 5</b> ). |
|------------------------------------|---------------|--|----|--|-----------------------------|-------------------------------------------------|

**Note 3:** Switching Time: 50% of  $V_{ENABLE}$  to 90% of  $P_{out}$ .

**Note 4:** Switching Time: 50% of  $V_{ENABLE}$  to 10% of  $P_{out}$ .

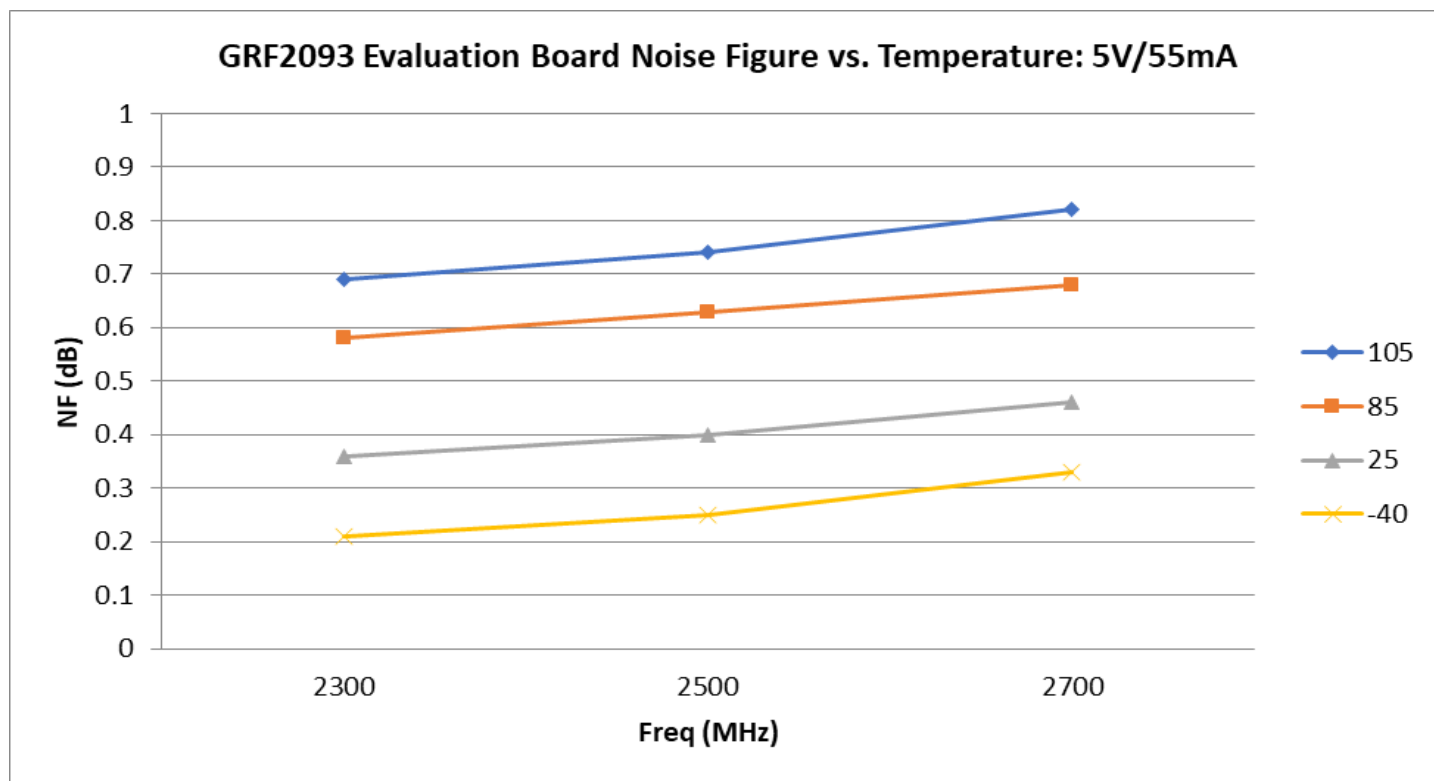
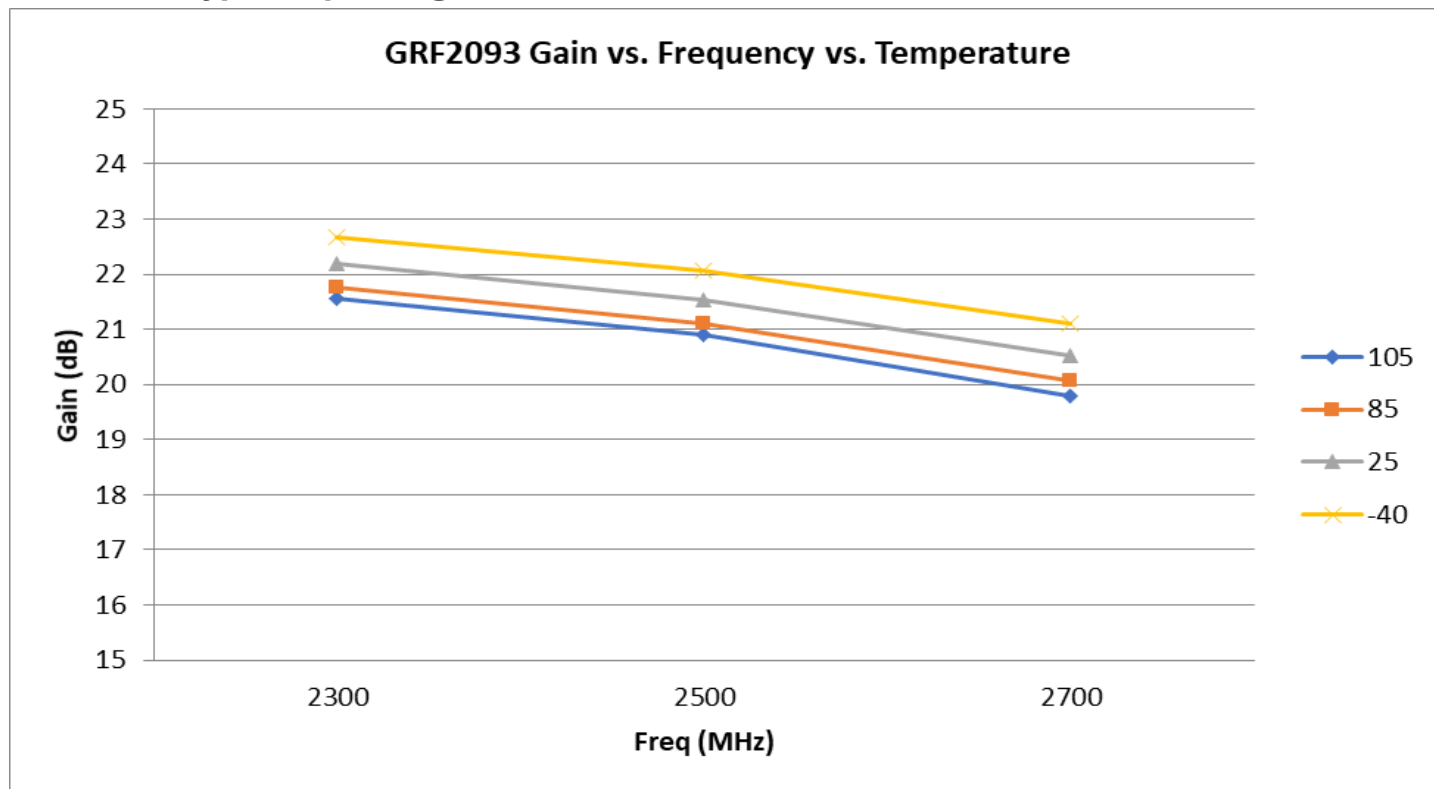
**Note 5:** MTTF >  $10^6$  hours for  $T_{CHANNEL} < 170\text{ }^{\circ}\text{C}$ .

## Nominal Operating Parameters – RF

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

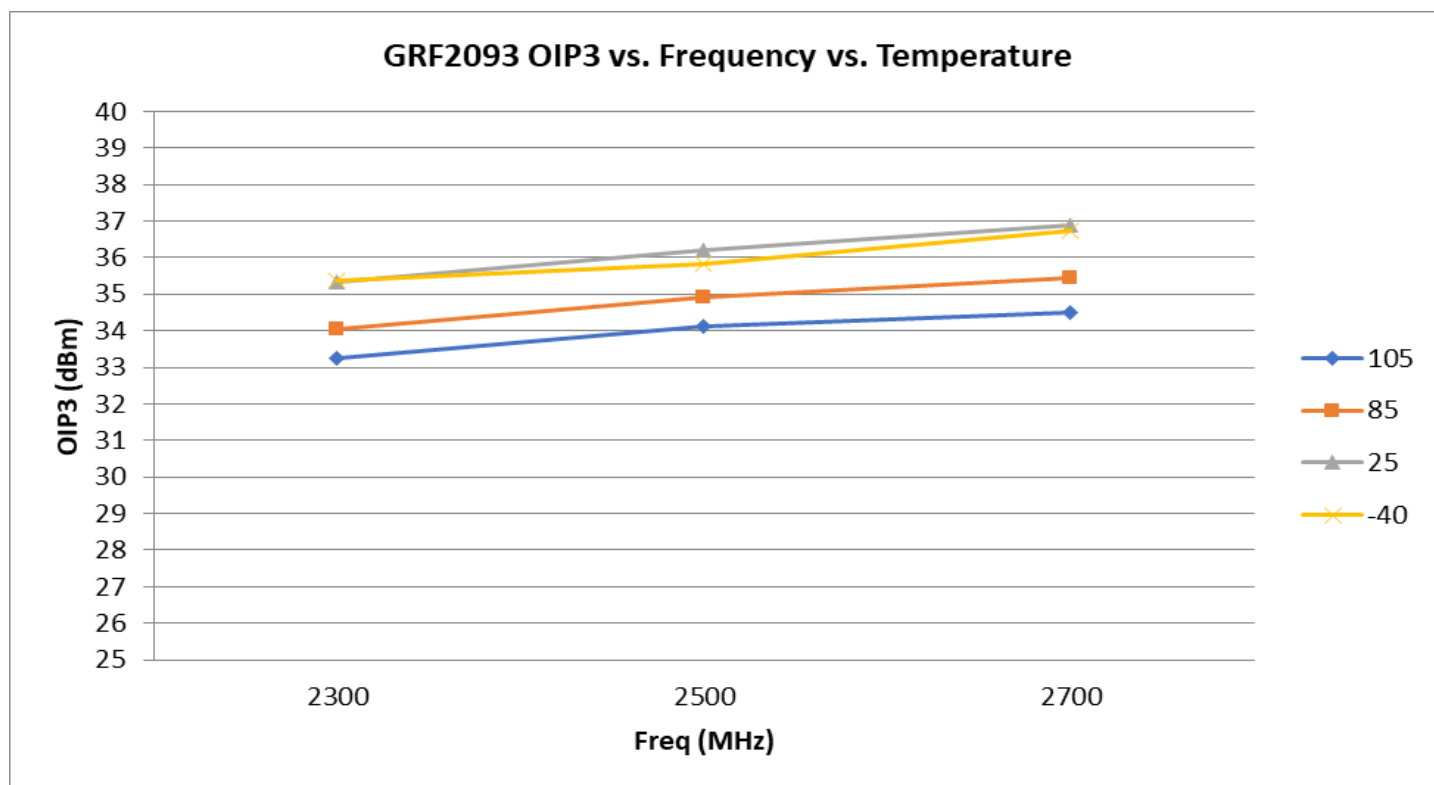
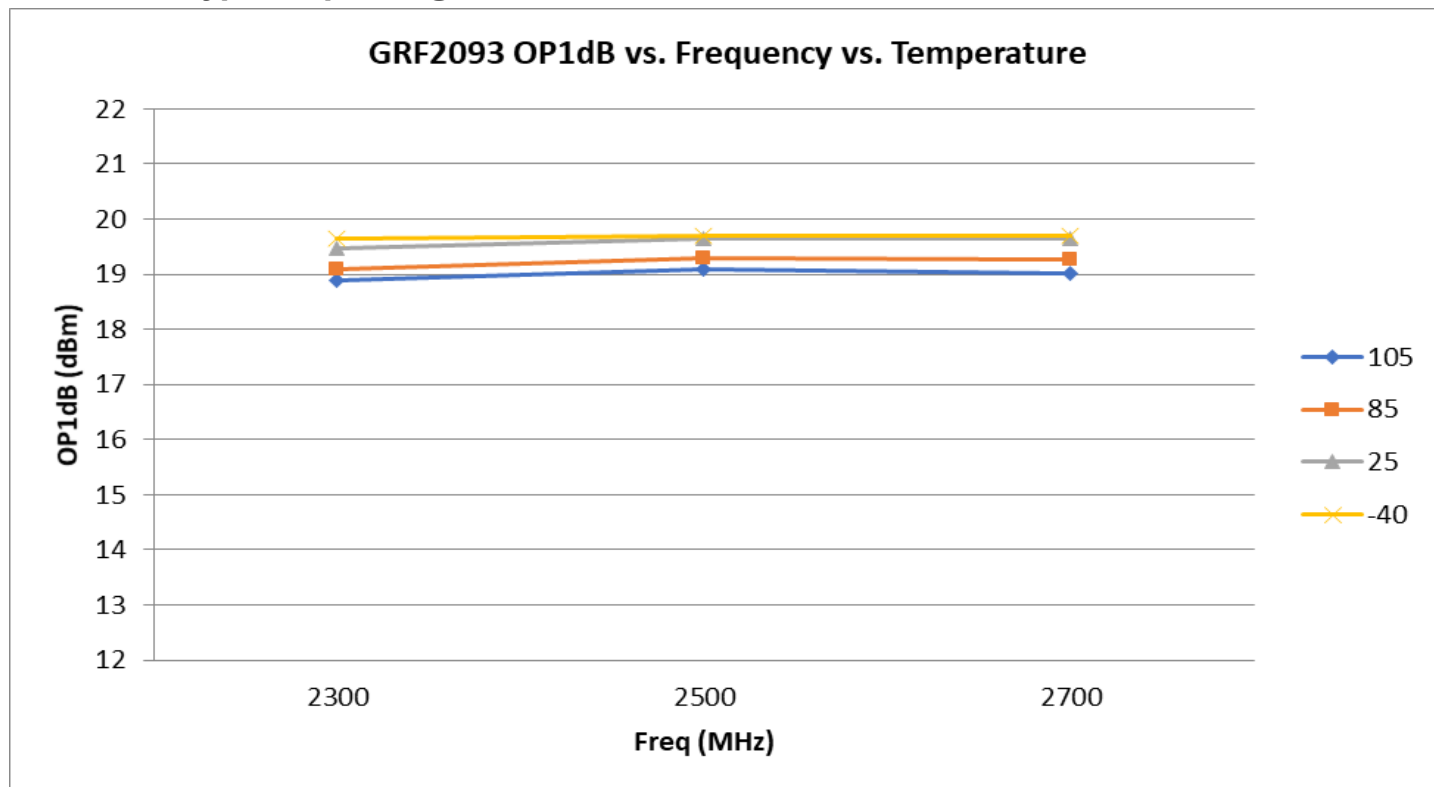
| Parameter                        | Symbol | Specification |      |      | Unit | Condition                                                          |
|----------------------------------|--------|---------------|------|------|------|--------------------------------------------------------------------|
|                                  |        | Min.          | Typ. | Max. |      |                                                                    |
| Gain                             | S21    | 20.8          | 22   | 23.2 | dB   | $V_{DD} = 5\text{ V}$ , $V_{ENABLE} = 5\text{ V}$ .                |
| 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  |                                                                    |

**GRF2093W Typical Operating Curves: 5 V, 55 mA (2.3 to 2.7 GHz Tune)**

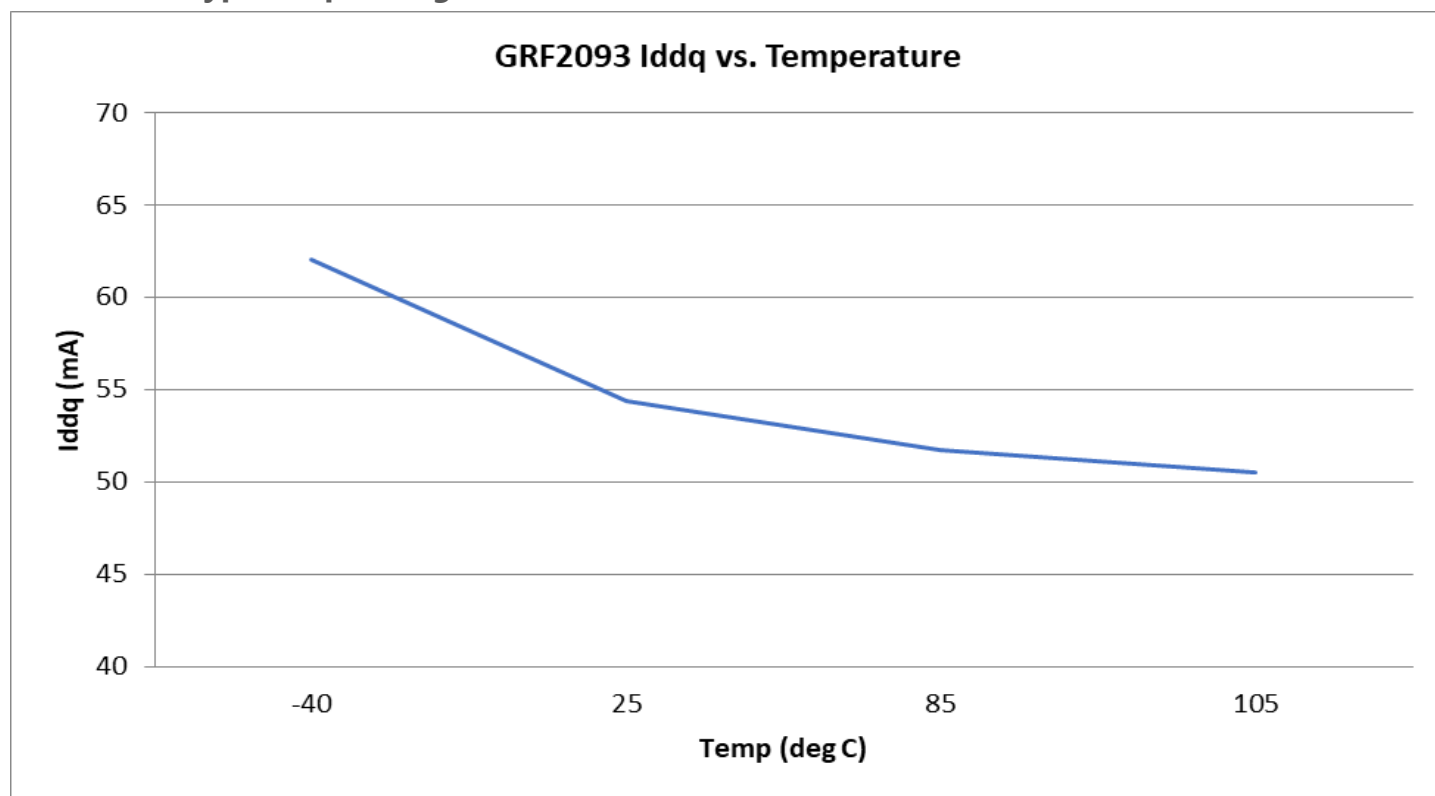




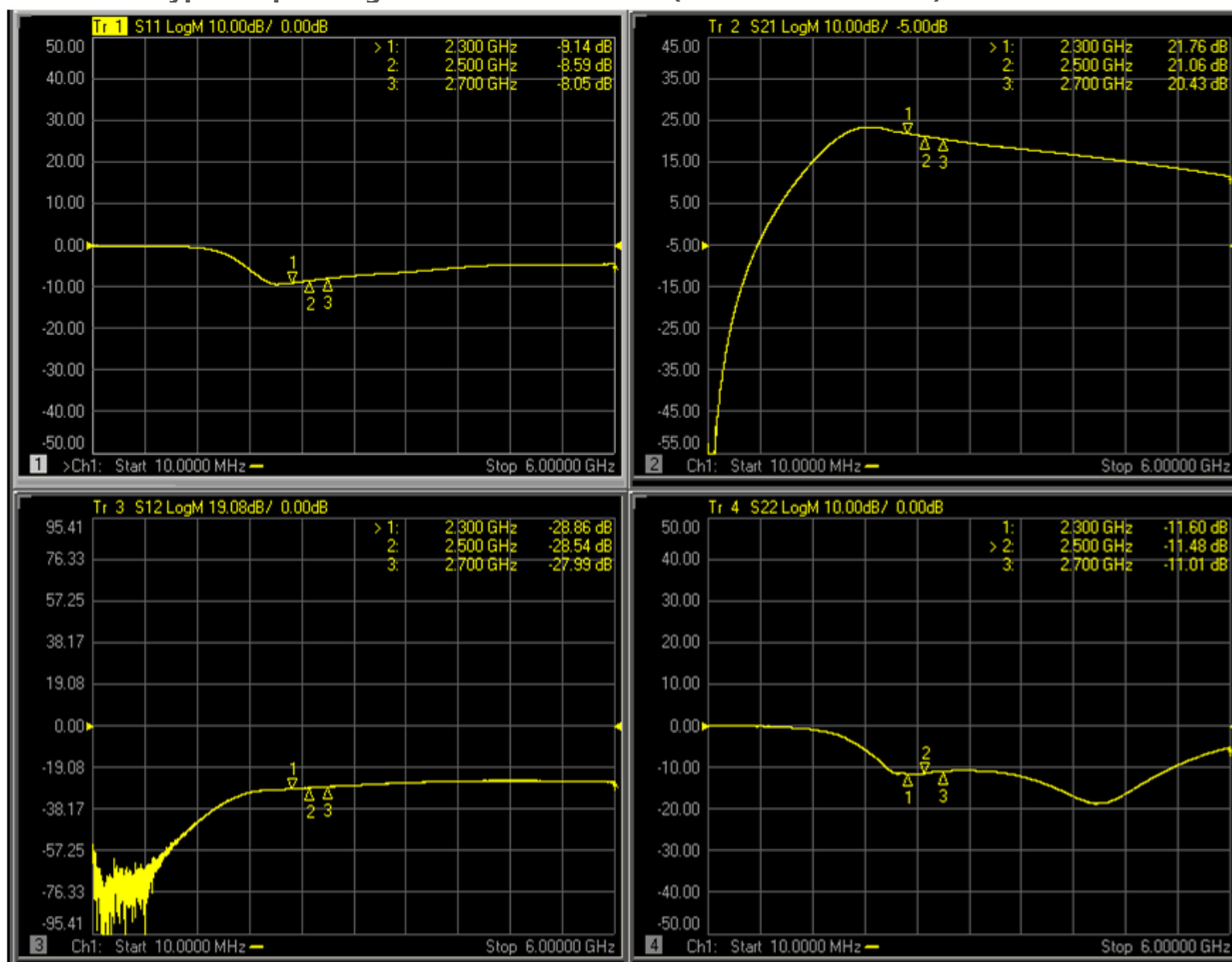
**GRF2093W Typical Operating Curves: 5 V, 55 mA (2.3 to 2.7 GHz Tune)**



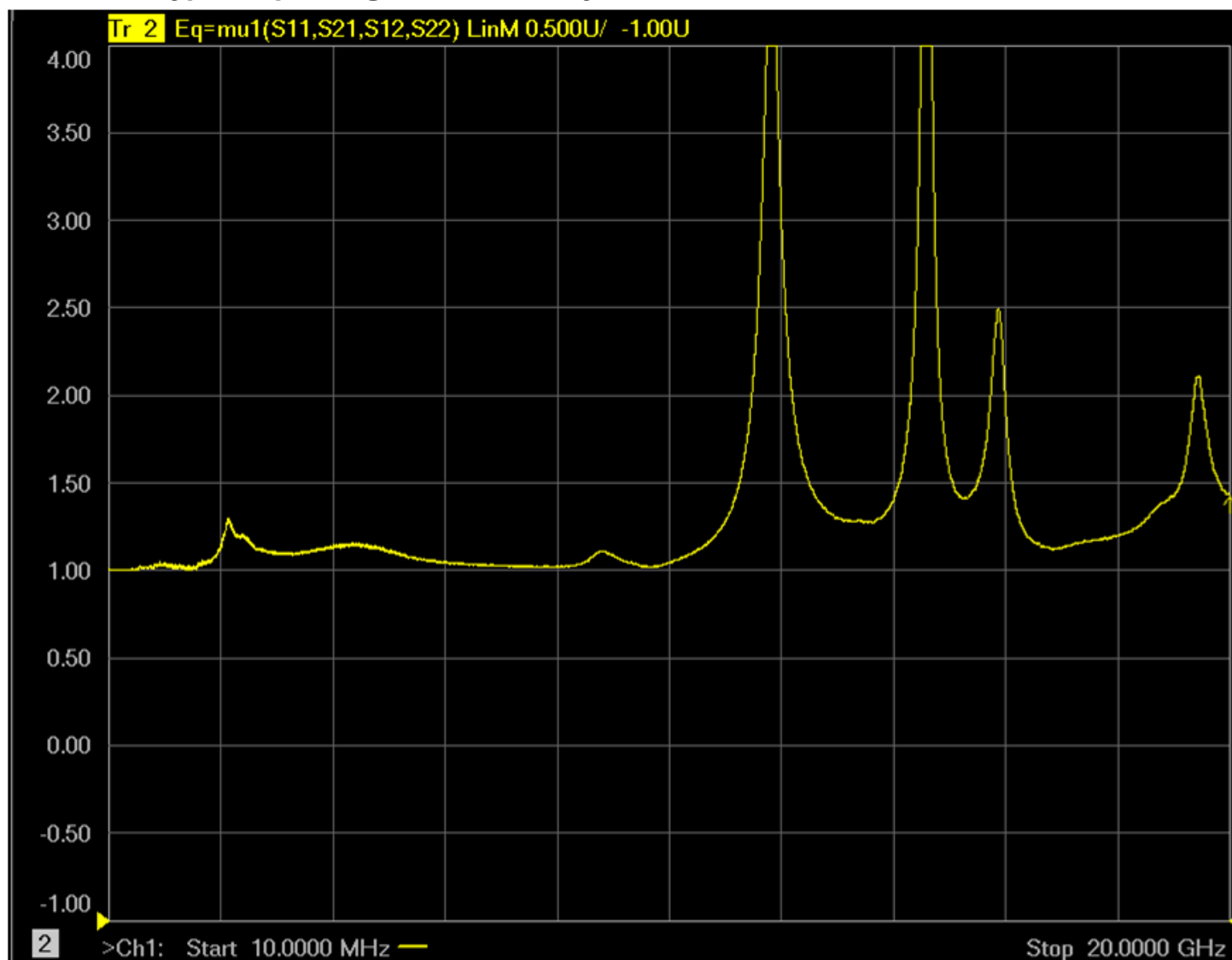
**GRF2093W Typical Operating Curves: 5 V, 55 mA (2.3 to 2.7 GHz Tune)**



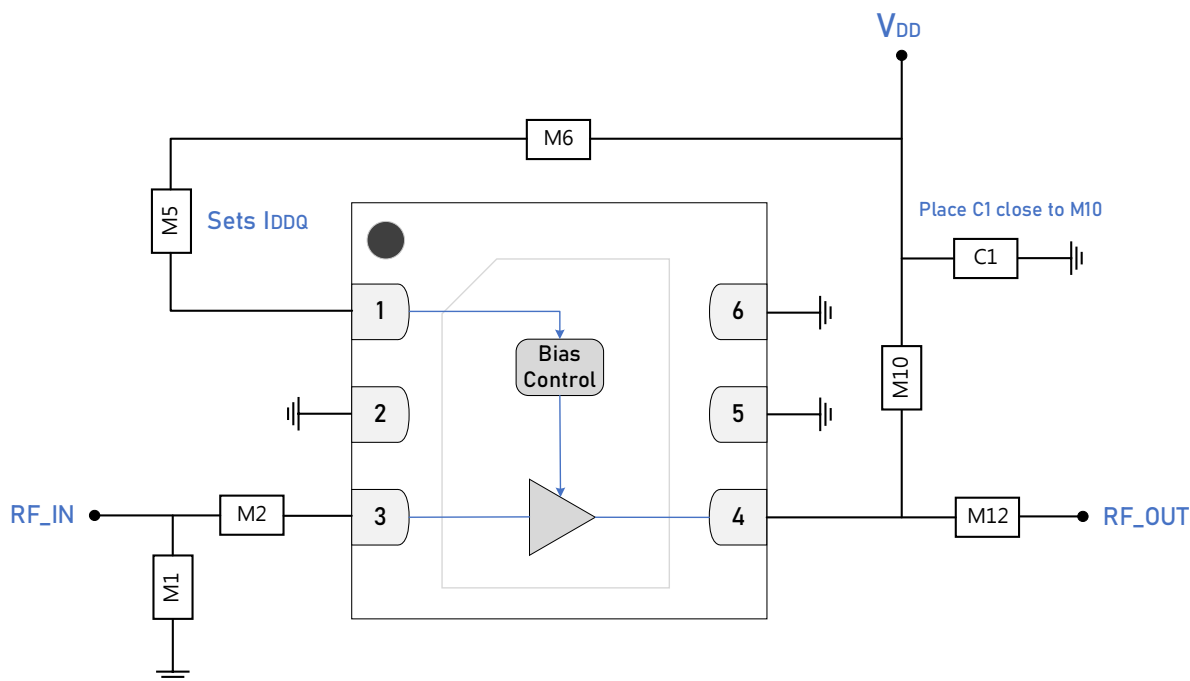
## GRF2093W Typical Operating Curves: S-Parameters (2.3 to 2.7 GHz Tune)



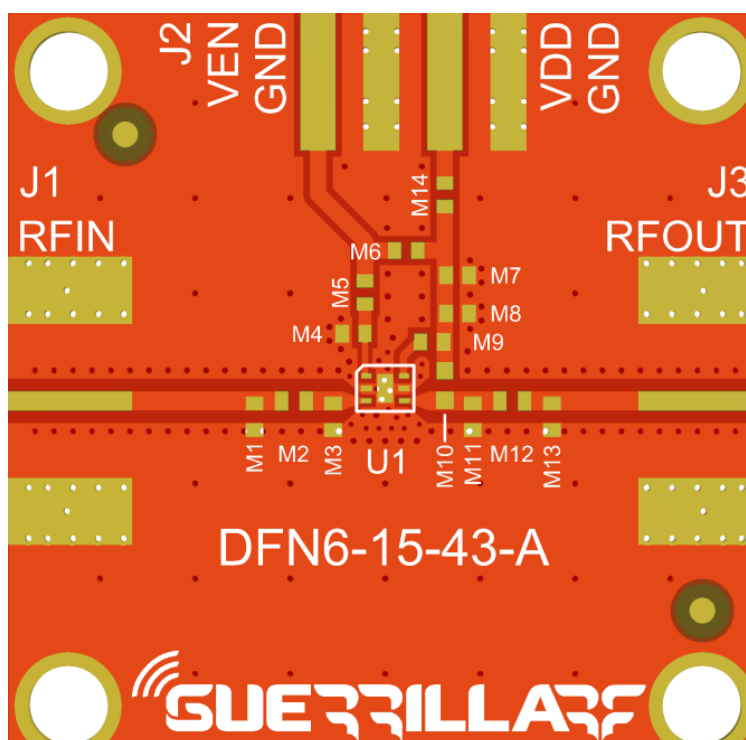
### GRF2093W Typical Operating Curves: Stability Mu Factor (10 MHz to 20 GHz)



Note:  $\mu \geq 1.0$  implies unconditional stability.



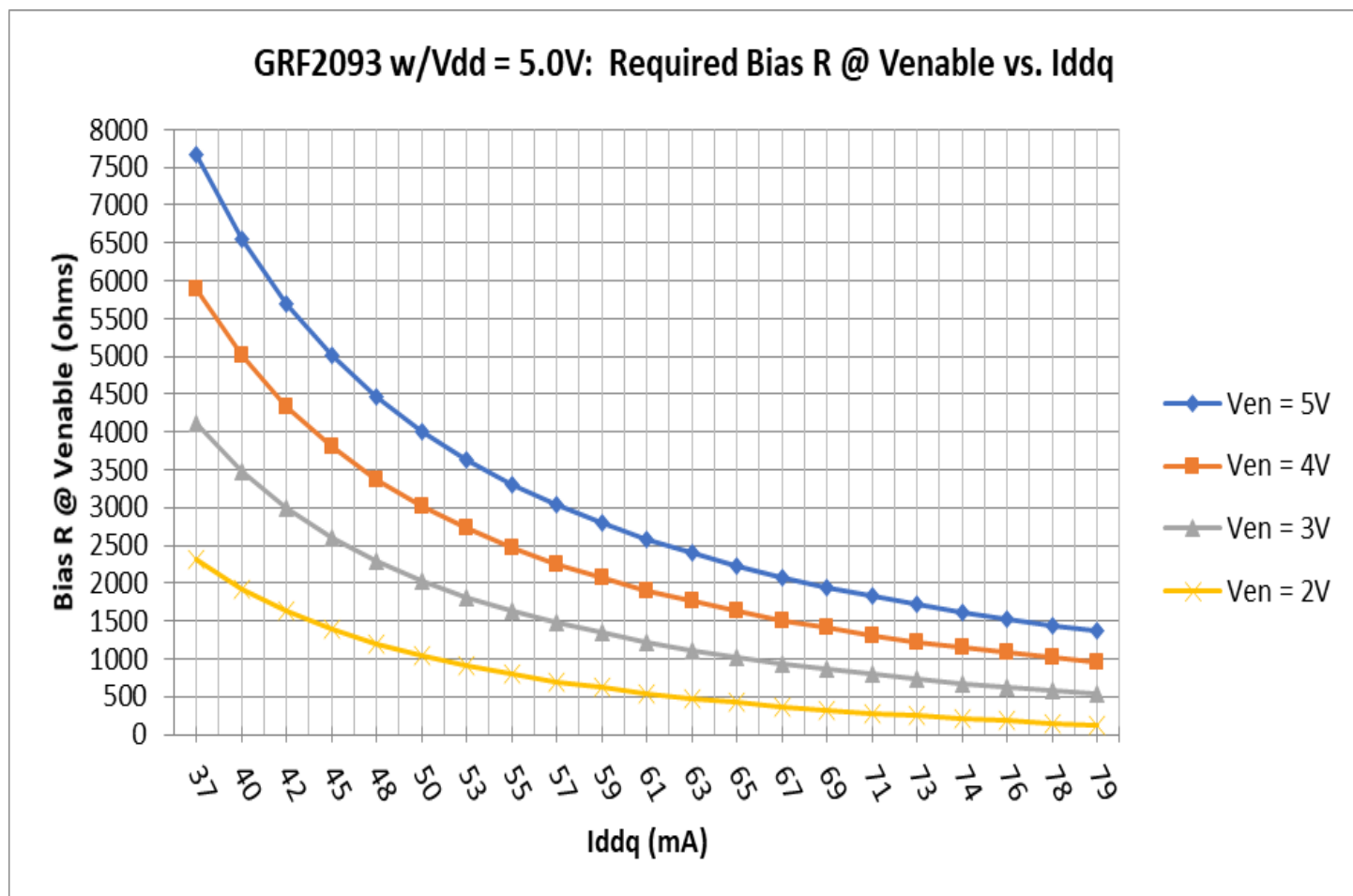
**GRF2093W Standard Evaluation Board Schematic**

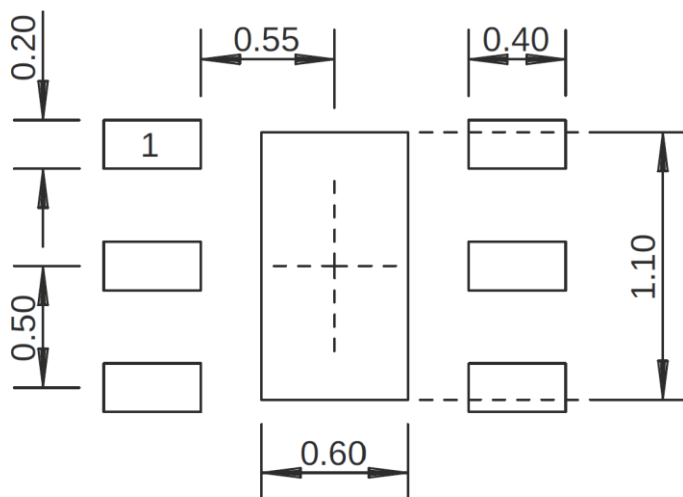


**GRF2093W Evaluation Board Assembly Diagram**

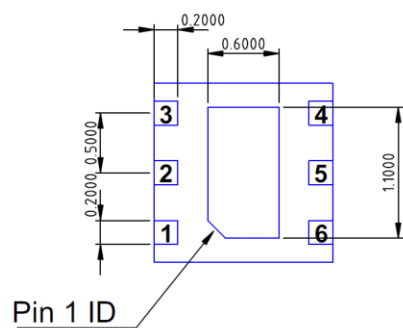
**GRF2093W Evaluation Board Assembly Diagram Reference (2.3 to 2.7 GHz Tune)**

| 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 $\Omega$  | 0402         | ok           |
| C1                   | Capacitor         | Murata       | GRM    | 0.1 $\mu$ F | 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      |              |        |             |              |              |

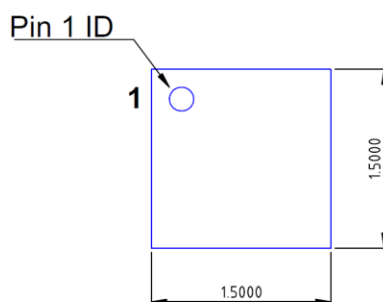
**GRF2093W Bias Resistor Selection Curves**




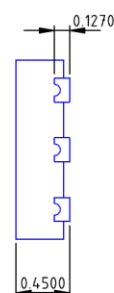
**1.5 x 1.5 mm DFN-6 Suggested PCB Footprint (Top View)**



**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



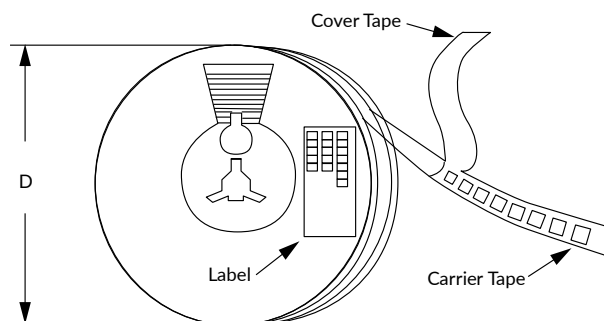
- Line 1: "Y" = YEAR (single digit). "WW" = WORK WEEK and "w" = W for automotive.
- Line 2: "XXXX" = Device PART NUMBER.

## Tape and Reel Information

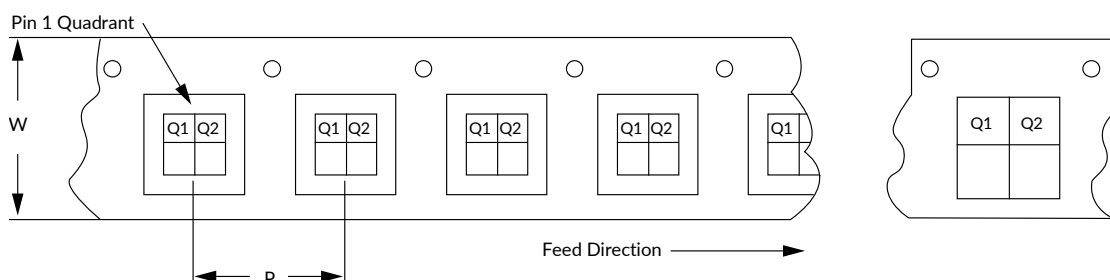
Guerrilla RF's tape and reel specification complies with Electronics Industries Association (EIA) standards for "Embossed Carrier Tape of Surface Mount Components for Automatic Handling" (reference EIA-481). See the following page for the Tape and Reel Specification and Device Package Information table, 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 17, 2019 | Preliminary Data sheet.                                                 |
| September 12, 2022 | Release Ø Data Sheet.                                                   |
| May 16, 2023       | Release A Data Sheet. Upgraded Data sheet to new format only.           |
| 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 <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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