



# GRF AN002

## GRF4002 Broadband Performance Optimization

---

GRF4002 has been developed with the RF system designer in mind. The device offers simple configuration handles which, when adjusted, suit a wide range of applications. A single baseline application schematic covers frequency range 100 – 4000 MHz, with two simple external resistor values provided for adjusting bias point and enabling trade-offs between the following specifications:

1. Compression Point (IP1dB/OP1dB)
2. Third Order Intercept Point (IIP3/OIP3)
3. EVM (Error Vector Magnitude), which comes as a direct result of 1 and 2 above.
4. Current, and therefore power, dissipated

Bias Point would be defined by supply voltage, drain voltage and drain current.

1. supply voltage, Vdd: system supply, or battery.
2. drain voltage, Vd: that seen at supply pin of device
3. drain current, Idd: current to the device via supply voltage

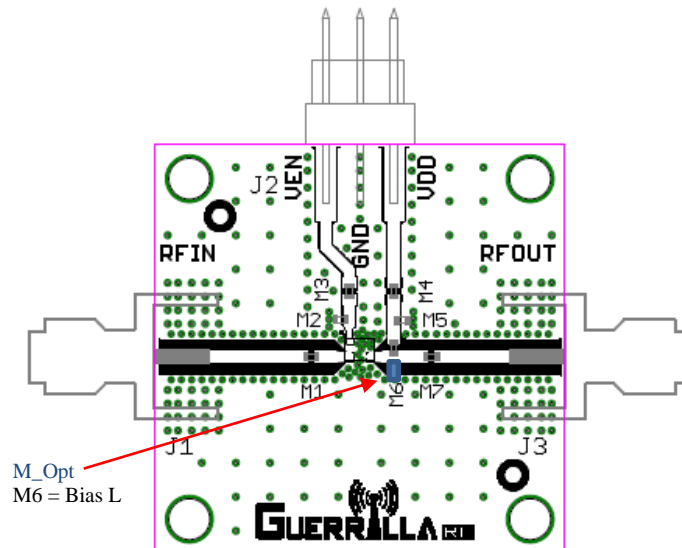
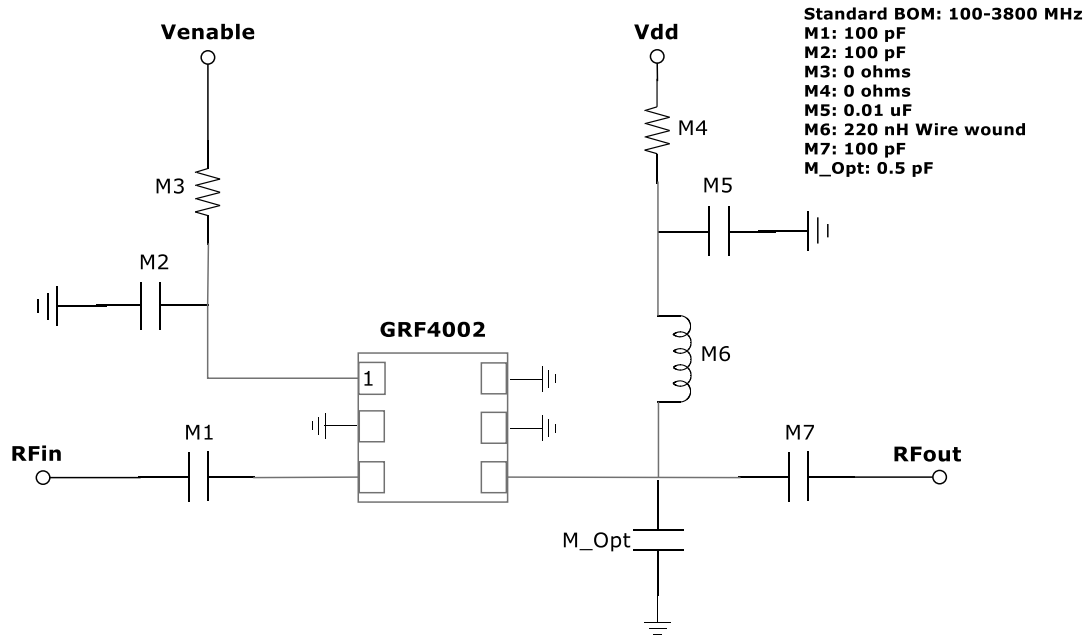
Desired trade-offs are implemented while maintaining excellent broadband return losses, unconditional stability and sub 1 dB noise figure.

Herein we will demonstrate the broadband application covering frequency range 100 to 3800 MHz, with the intent of obtaining maximum third order output intercept point (OIP3) over frequency. This, combined with sufficient compression point and low noise figure, enable GRF4002 use at multiple points within a radio architecture and across platforms:

1. Linear driver amplifier
2. Final power amplifier (PA) in “small cell” or “picocell” designs requiring 15 – 20 dBm at antenna
3. Low noise amplifier: 1<sup>st</sup>, 2<sup>nd</sup> or 3<sup>rd</sup> stage
4. IF amplifier where up/down conversion between RF and IF is implemented

Thus, GRF4002 offers the convenience of re-use with common board layout and component values.

GRF4002 data sheet evaluation board schematic and assembly diagram:





# GRF AN002

## GRF4002 Broadband Performance Optimization

---

The following bias point will be used:

1.  $V_{dd} = 3.0\text{ V}$ . Reasoning here explained via discussion of GRF4002 flexibility, which allows for operation over  $V_{dd}/V_d$  ranging from 1.8 to 5.0 V (refer to GRF4002 data sheet). With maximum IP3 performance desired over the full frequency range under consideration,  $V_{dd}/V_d = 3.0\text{ V}$  is near optimal. “ $V_{dd}/V_d$ ” used here, as supply and device pin voltage are nearly the same. Viewing the schematic, they are only separated by 3 ohm resistance of the 220 nH choke inductor. In the case where equivalent performance is desired using larger  $V_{dd}$  (5.0 V for instance), resistor R2 can be adjusted to reduce device voltage  $V_d$  to 3.0 V ; and of course, outside the scope of this application note, compression point can be increased by operating with higher  $V_{dd}/V_d$  (using lower value at R2).
2.  $V_{en} = 1.6\text{ V}$ . This in the presence of  $R1 = 0\text{ ohm}$ . Likewise,  $V_{en}$  can be scaled for a larger supply voltage using the appropriate R1 value.
3.  $I_{ddq} = 63\text{ mA}$ , resulting from bias voltages above. This current is sufficient in maintaining best linearity (IP3) over frequency and temperature (refer to GRF4002 data sheet for data vs. temperature).

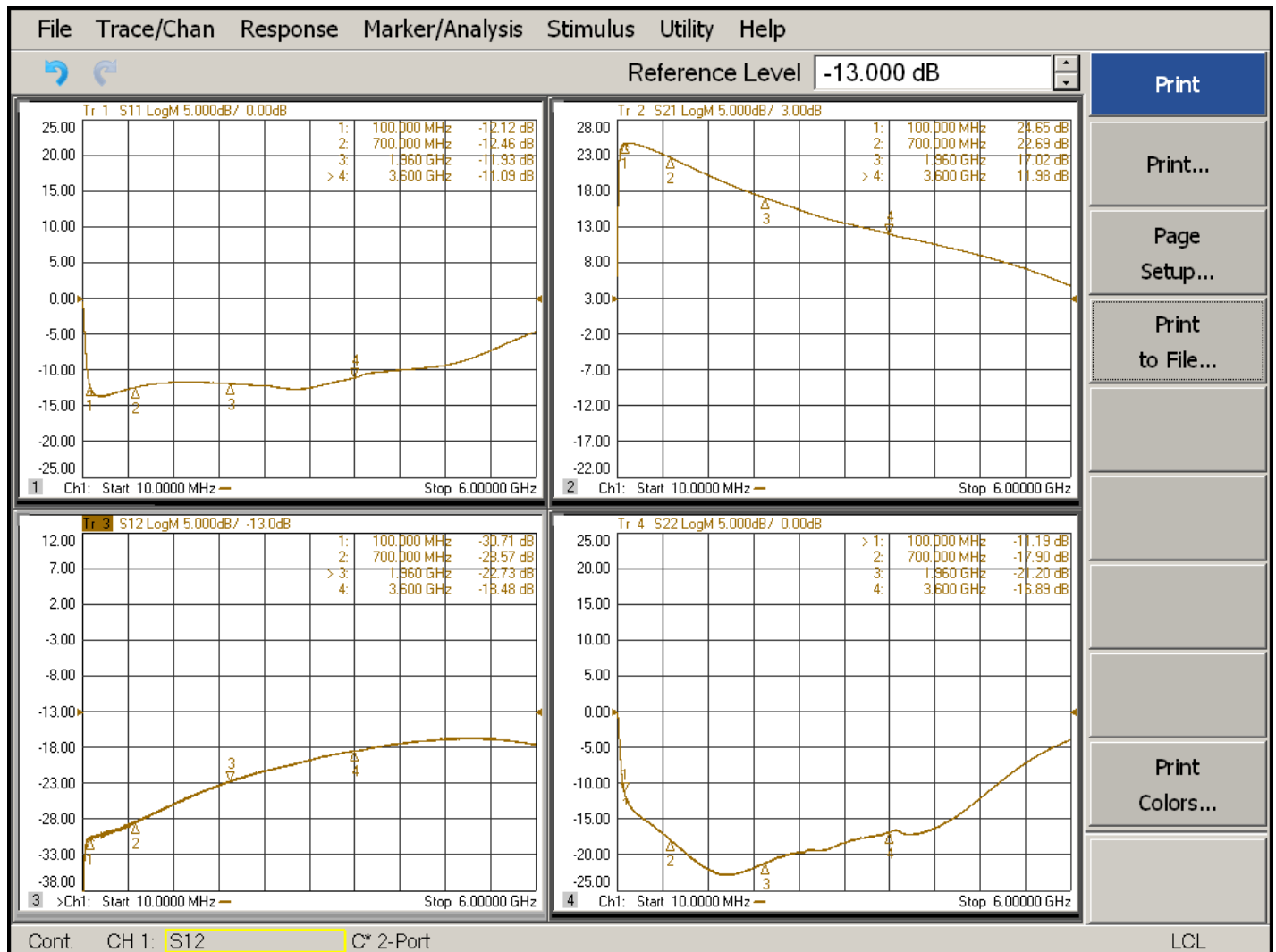


# GRF AN002

## GRF4002 Broadband Performance Optimization

Resultant data from our optimized broadband application circuit. All reported data taken at temperature = 25C.

Evaluation board s-parameters:

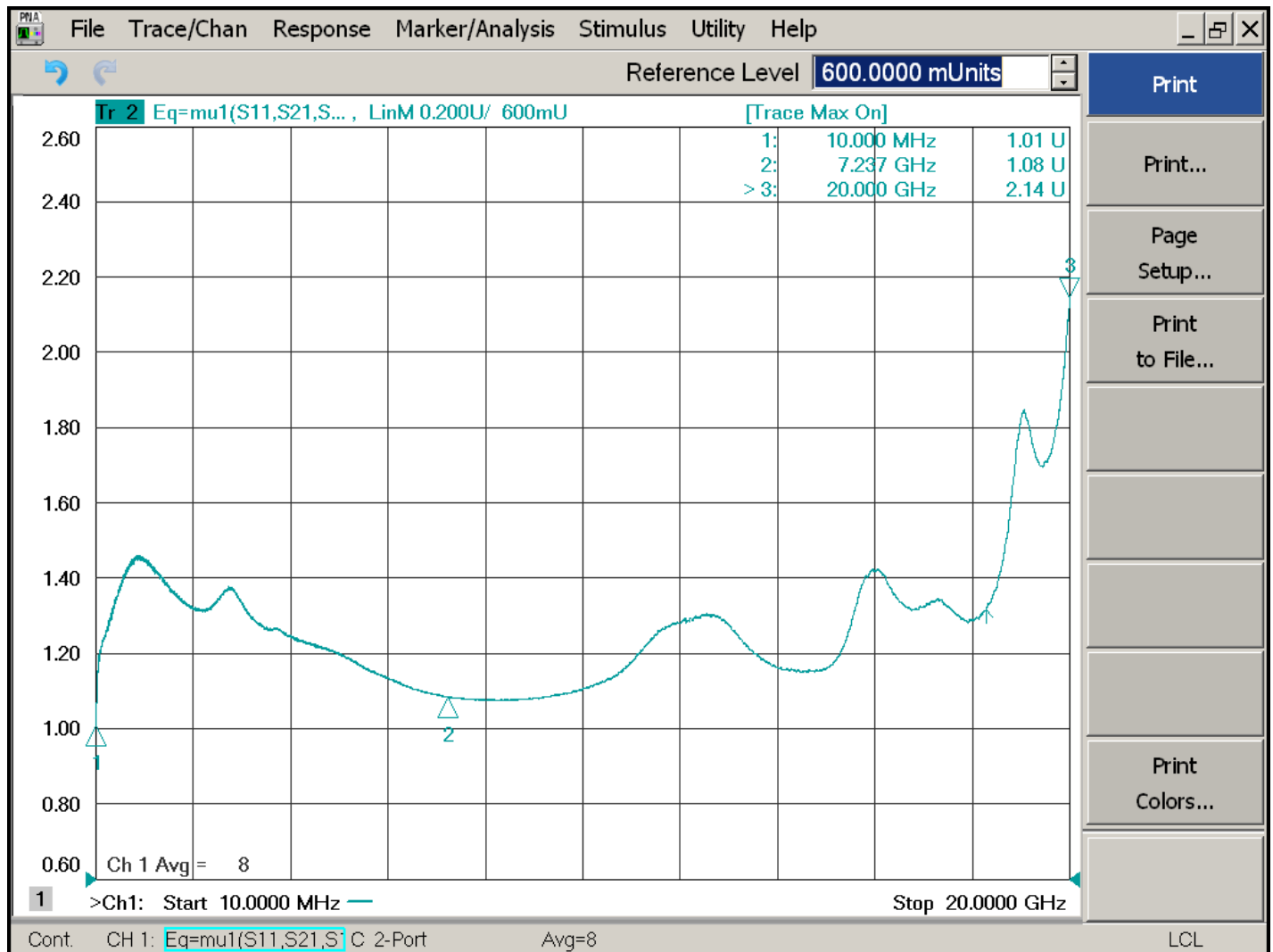




# GRF AN002

## GRF4002 Broadband Performance Optimization

Evaluation board stability Mu factor:

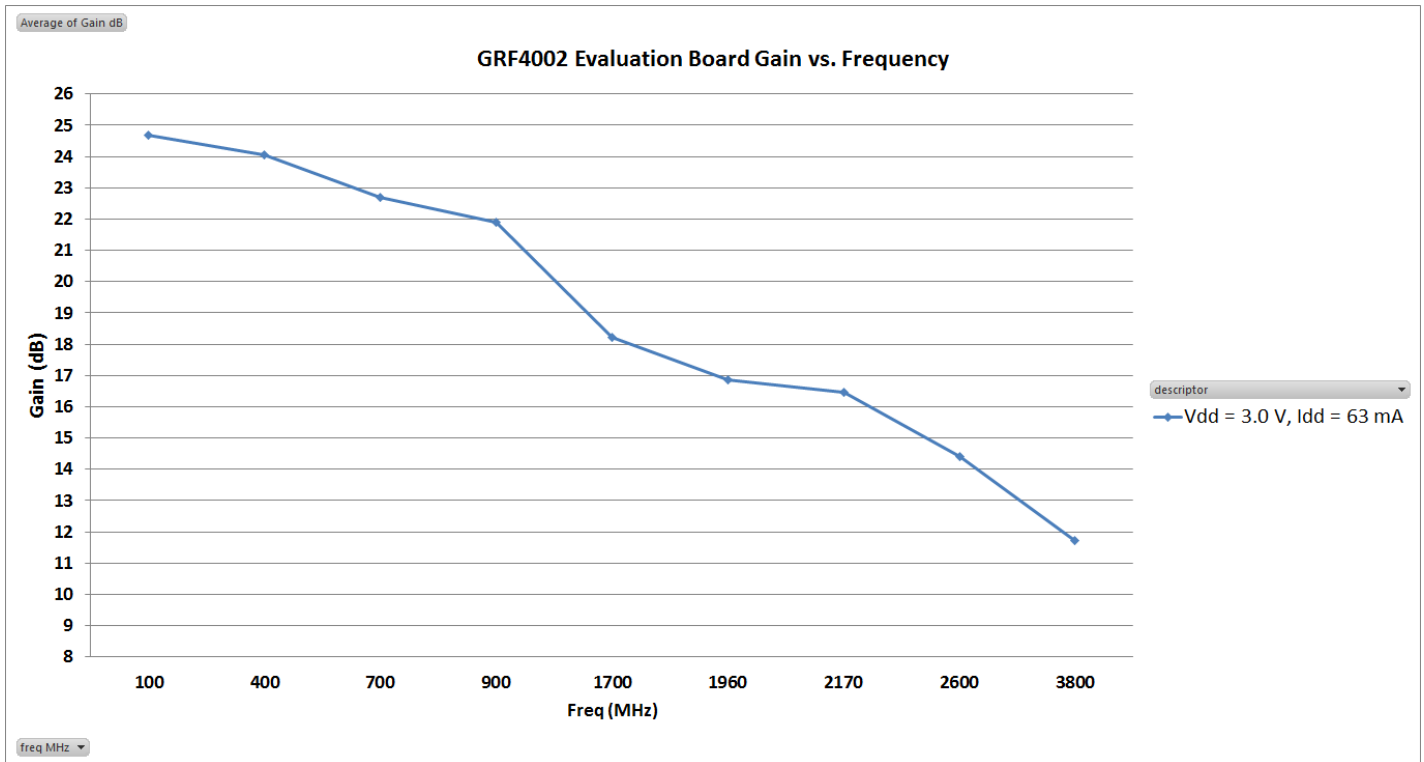




# GRF AN002

## GRF4002 Broadband Performance Optimization

Gain:

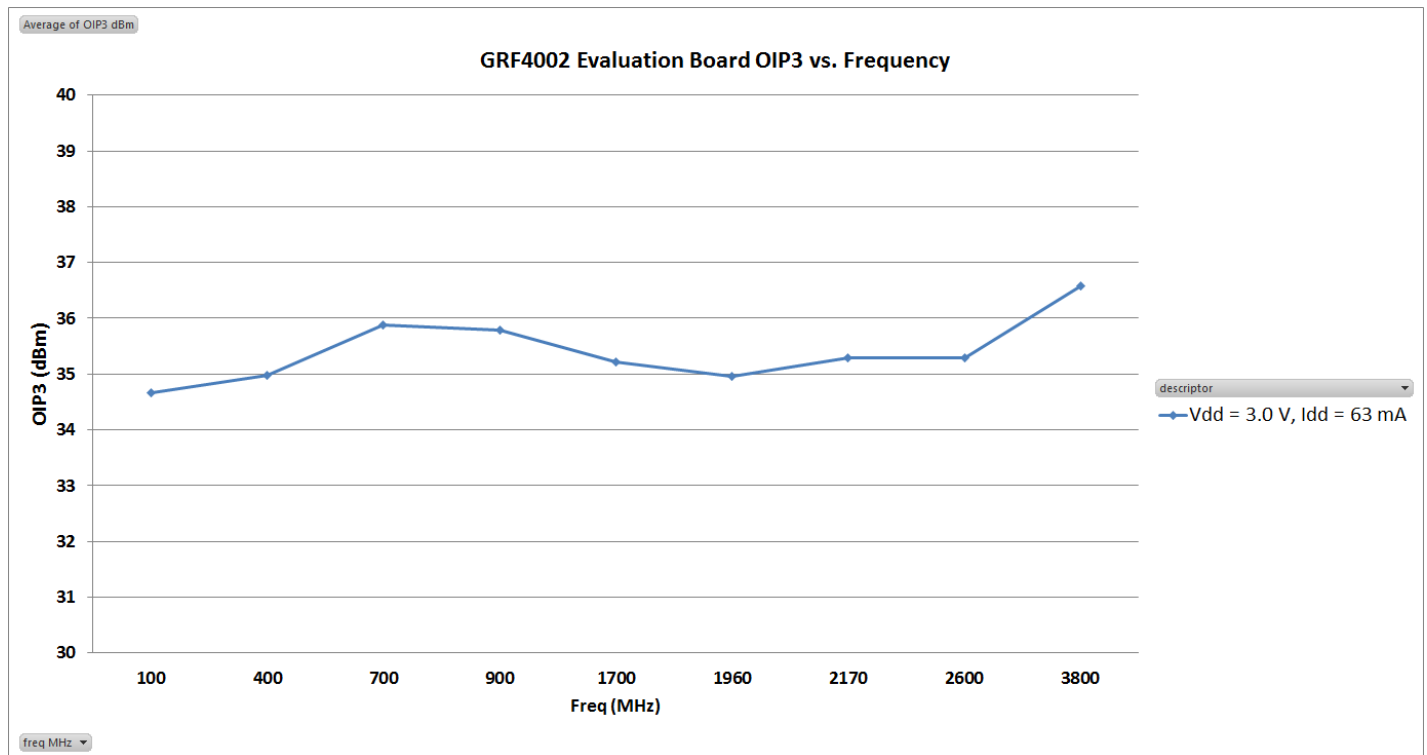




# GRF AN002

## GRF4002 Broadband Performance Optimization

OIP3:

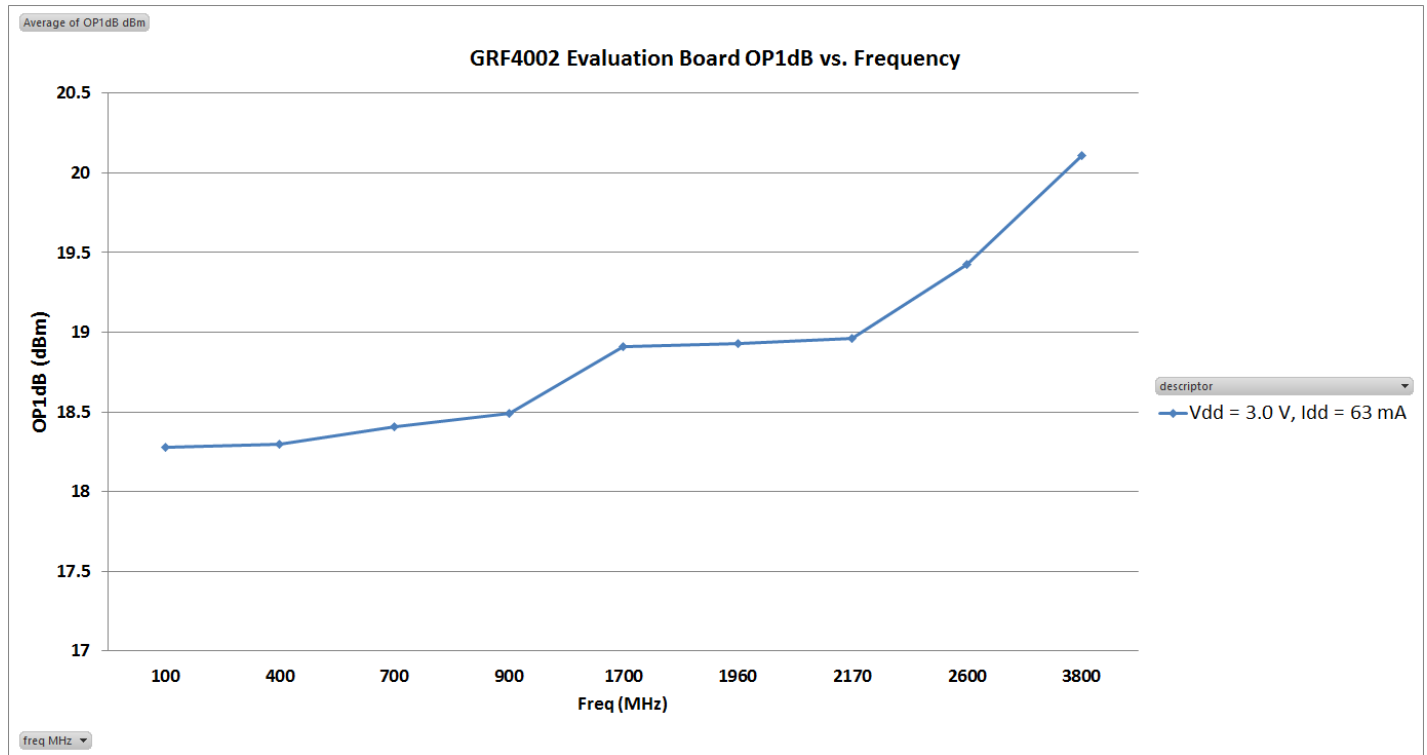




# GRF AN002

## GRF4002 Broadband Performance Optimization

OP1dB:



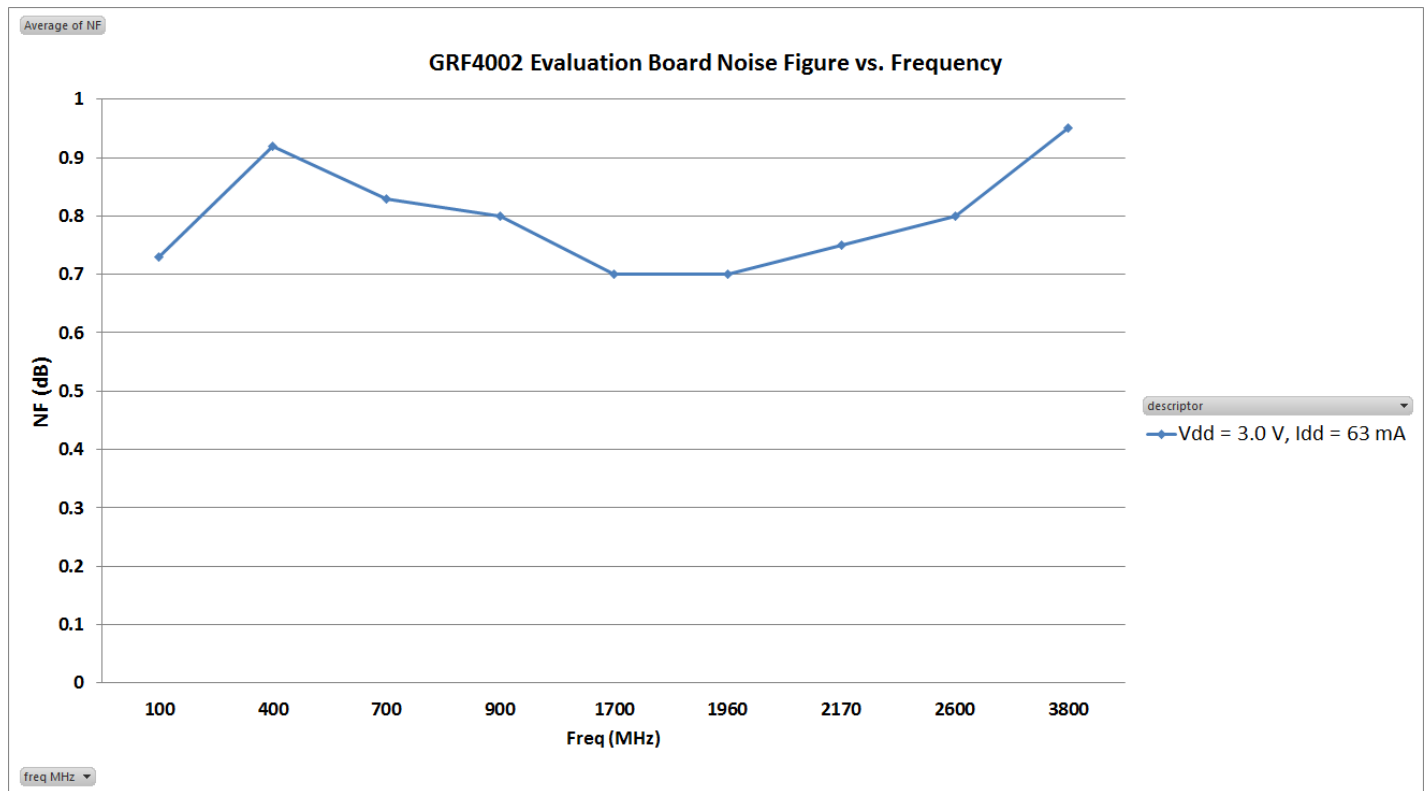




# GRF AN002

## GRF4002 Broadband Performance Optimization

Noise Figure:





# GRF AN002

## GRF4002 Broadband Performance Optimization

Tabular data summary:

| Freq MHz | Gain dB | OIP3 dBm | OP1dB dBm | Noise Figure dB |
|----------|---------|----------|-----------|-----------------|
| 100      | 24.7    | 34.7     | 18.3      | 0.73            |
| 400      | 24.1    | 35.0     | 18.3      | 0.92            |
| 700      | 22.7    | 35.9     | 18.4      | 0.83            |
| 900      | 21.9    | 35.8     | 18.5      | 0.8             |
| 1700     | 18.2    | 35.2     | 18.9      | 0.7             |
| 1960     | 16.9    | 35.0     | 18.9      | 0.7             |
| 2170     | 16.4    | 35.3     | 19.0      | 0.75            |
| 2600     | 14.4    | 35.3     | 19.4      | 0.8             |
| 3800     | 11.7    | 36.6     | 20.1      | 0.95            |

GRF4002 design and associated evaluation board configurations provide the system/radio designer convenient options in extracting performance to accommodate specific applications, one of which outlined herein. The flexibility to do so makes it an excellent candidate across different designs, as well as that within multiple slots on the same platform.

Information in this datasheet is specific to the Guerrilla RF, LLC ("Guerrilla RF") product identified.

This datasheet, including the information contained in it, is provided by Guerrilla RF as a service to its customers and may be used for informational purposes only by the customer. Guerrilla RF assumes no responsibility for errors or omissions on this datasheet or the information contained herein. Information provided is believed to be accurate and reliable, however, no responsibility is assumed by Guerrilla RF for its use, nor for any infringement of patents, or other rights of third parties, resulting from its use. Guerrilla RF assumes no liability for any datasheet, datasheet information, materials, products, product information, or other information provided hereunder, including the sale, distribution, reproduction or use of Guerrilla RF products, information or materials.

No license, whether express, implied, by estoppel, by implication or otherwise is granted by this datasheet for any intellectual property of Guerrilla RF, or any third party, including without limitation, patents, patent rights, copyrights, trademarks and trade secrets. All rights are reserved by Guerrilla RF.

All information herein, products, product information, datasheets, and datasheet information are subject to change and availability without notice. Guerrilla RF reserves the right to change component circuitry, recommended application circuitry and specifications at any time without prior notice. Guerrilla RF may further change its datasheet, product information, documentation, products, services, specifications or product descriptions at any time, without notice. Guerrilla RF makes no commitment to update any materials or information and shall have no responsibility whatsoever for conflicts, incompatibilities, or other difficulties arising from any future changes.

GUERRILLA RF INFORMATION, PRODUCTS, PRODUCT INFORMATION, DATASHEETS AND DATASHEET INFORMATION ARE PROVIDED "AS IS" AND WITHOUT WARRANTY OF ANY KIND, WHETHER EXPRESS, IMPLIED, STATUTORY, OR OTHERWISE, INCLUDING FITNESS FOR A PARTICULAR PURPOSE OR USE, MERCHANTABILITY, PERFORMANCE, QUALITY OR NON-INFRINGEMENT OF ANY INTELLECTUAL PROPERTY RIGHT; ALL SUCH WARRANTIES ARE HEREBY EXPRESSLY DISCLAIMED. GUERRILLA RF DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. GUERRILLA RF SHALL NOT BE LIABLE FOR ANY DAMAGES, INCLUDING BUT NOT LIMITED TO ANY SPECIAL, INDIRECT, INCIDENTAL, STATUTORY, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS THAT MAY RESULT FROM THE USE OF THE MATERIALS OR INFORMATION, WHETHER OR NOT THE RECIPIENT OF MATERIALS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Customers are solely responsible for their use of Guerrilla RF products in the Customer's products and applications or in ways which deviate from Guerrilla RF's published specifications, either intentionally or as a result of design defects, errors, or operation of products outside of published parameters or design specifications. Customers should include design and operating safeguards to minimize these and other risks. Guerrilla RF assumes no liability or responsibility for applications assistance, customer product design, or damage to any equipment resulting from the use of Guerrilla RF products outside of stated published specifications or parameters.

Guerrilla RF Proprietary Information. Guerrilla RF™ and the composite logo of Guerrilla RF™ are trademarks of Guerrilla RF, LLC. ©2014 Guerrilla RF, LLC. All rights reserved.

Revision Date: 08/15/2014

Please contact Guerrilla RF at (+1) 336-510-7840 or [sales@guerrilla-rf.com](mailto:sales@guerrilla-rf.com)

10 of 10