GRF2093
Ultra-Low Noise Amplifier
Tuning Range: 1.0 to 6.0 GHz

Product Description

GRF2093 offers industry leading NF and gain performance and can be tuned over a wide range of frequencies from roughly 1.0 to 6.0 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.

It can be biased over a range of Vdd from 2.7 to 5.0 volts and Iddq values from 30 mA to 100 mA.

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

Consult with the GRF applications engineering team for custom tuning/evaluation board data and device s-parameters.

Features

Reference: 5V/55mA/2332.5 MHz
• EVB NF: 0.37dB
• Gain: 21.0 dB
• OP1dB: 19.0 dBm
• OIP3: 35.5 dBm
• Flexible Bias Voltage and Current
• Process: GaAs pHEMT

Applications

• Satellite Radio
• CBRS
• Small Cells and Cellular Repeaters
• Distributed Antenna Systems
• GPS
## Absolute Ratings:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>$V_{DD}$</td>
<td>0</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>RF Input Power CW : (Load VSWR &lt; 2:1; $V_D$: 5.0 volts)</td>
<td>$P_{IN\text{ MAX}}$</td>
<td>23</td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>Operating Temperature (Package Heat Sink)</td>
<td>$T_{AMB}$</td>
<td>-40</td>
<td>105</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Channel Temperature (MTTF &gt; 10^6 Hours)</td>
<td>$T_{MAX}$</td>
<td>170</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Dissipated Power</td>
<td>$P_{Diss\text{ MAX}}$</td>
<td>1000</td>
<td>1000</td>
<td>mW</td>
</tr>
</tbody>
</table>

### Electrostatic Discharge:
- **Charged Device Model:** CDM (TBD)
- **Human Body Model:** HBM (TBD)

### Storage:
- **Storage Temperature:** $T_{STG}$
- **Moisture Sensitivity Level:** MSL

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**Caution! ESD Sensitive Device**

Exceeding Absolute Maximum Rating conditions may cause permanent damage to the device.

**Note:** For manufacturing information, see the Guerrilla-RF.com website for the following document located on the GRF2093 landing page: Manufacturing Note—MN-001 Product Tape and Reel, Solderability and Package Outline Specification.

[Link to manufacturing note](#)
Pin Out (Top View)

Pin Assignments:

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Description</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V_ENABLE</td>
<td>Enable Voltage Input</td>
<td>$V_{\text{ENABLE}}$ and series resistor set $I_{\text{DDQ}}$. $V_{\text{ENABLE}} &lt; 0.2$ volts disables device. On -die pull-down resistor will turn the part off if this node is allowed to float.</td>
</tr>
<tr>
<td>2</td>
<td>NC</td>
<td>No Connect or Ground</td>
<td>No internal connection to die</td>
</tr>
<tr>
<td>3</td>
<td>RF_In</td>
<td>LNA RF input</td>
<td>An external DC blocking cap must be used.</td>
</tr>
<tr>
<td>4</td>
<td>RF_Out</td>
<td>LNA RF output</td>
<td>$V_{\text{DD}}$ must be applied through a choke to this pin.</td>
</tr>
<tr>
<td>5</td>
<td>NC</td>
<td>No Connect or Ground</td>
<td>No internal connection to die</td>
</tr>
<tr>
<td>6</td>
<td>NC</td>
<td>No Connect or Ground</td>
<td>No internal connection to die</td>
</tr>
<tr>
<td>PKG BASE</td>
<td>GND</td>
<td>Ground</td>
<td>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.</td>
</tr>
</tbody>
</table>
Nominal Operating Parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Specification</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Frequency</td>
<td>F_{TEST}</td>
<td>2332.5</td>
<td>MHz</td>
<td>V_{DD} = 5.0 V, T_{A} = 25°C</td>
</tr>
<tr>
<td>Gain</td>
<td>S21</td>
<td>20.2</td>
<td>22.0</td>
<td>23.2 dB</td>
</tr>
<tr>
<td>Evaluation Board Noise Figure</td>
<td>NF</td>
<td>0.37</td>
<td>0.57</td>
<td>dB Incudes Board Losses</td>
</tr>
<tr>
<td>Output 1dB Compression Power</td>
<td>OP1dB</td>
<td>17.2</td>
<td>19.0</td>
<td>dBm</td>
</tr>
<tr>
<td>Output 3rd Order Intercept</td>
<td>OIP3</td>
<td>35.5</td>
<td>dBm</td>
<td>4.0 dBm P_{OUT} per tone at 2 MHz Spacing (2331.5 and 2333.5 MHz)</td>
</tr>
<tr>
<td>Switching Rise Time</td>
<td>T_{RISE}</td>
<td>400</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Switching Fall Time</td>
<td>T_{FALL}</td>
<td>100</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>I_{DD}</td>
<td>40</td>
<td>55</td>
<td>70 mA</td>
</tr>
<tr>
<td>Enable Current</td>
<td>I_{ENABLE}</td>
<td>1.8</td>
<td>mA</td>
<td>V_{DD}=V_{ENABLE}=5.0V; R_{BIAS}=3.3k Ohm</td>
</tr>
<tr>
<td>Leakage Current</td>
<td>I_{LEAKAGE}</td>
<td>180</td>
<td>uA</td>
<td>V_{DD}: 5.0V; V_{ENABLE}: 0.0V</td>
</tr>
<tr>
<td>Thermal Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance: (Infra-Red Scan)</td>
<td>\theta_{jc}</td>
<td>43</td>
<td>\degree C/W</td>
<td>On standard Evaluation Board</td>
</tr>
<tr>
<td>Channel Temperature @ +85 C Reference (Package heat sink)</td>
<td>T_{CHANNEL}</td>
<td>100</td>
<td>\degree C</td>
<td>V_{DD}: 5.0 V; I_{DDQ}: 70 mA; No RF; P_{Diss}: 350 mW</td>
</tr>
</tbody>
</table>

Note: MTTF >10^6 hours for T_{CHANNEL} <=170 degrees C.
GRF2093 Evaluation Board Data:

**GRF2093 Gain vs. Frequency vs. Temperature**

- **Gain (dB)**
  - 25
  - 24
  - 23
  - 22
  - 21
  - 20
  - 19
  - 18
  - 17
  - 16
  - 15

- **Freq (MHz)**
  - 2300
  - 2500
  - 2700
  - 2800

- **Temperature**
  - 105°C
  - 85°C
  - 25°C
  - -40°C

**GRF2093 Evaluation Board Noise Figure vs. Temperature: 5V/55mA**

- **Noise Figure (dB)**
  - 1.0
  - 0.9
  - 0.8
  - 0.7
  - 0.6
  - 0.5
  - 0.4
  - 0.3
  - 0.2
  - 0.1
  - 0.0

- **Freq (MHz)**
  - 2300
  - 2500
  - 2700
  - 2900

- **Temperature**
  - 105°C
  - 85°C
  - 25°C
  - -40°C
GRF2093 Evaluation Board Data:

**GRF2093 OP1dB vs. Frequency vs. Temperature**

- **OP1dB (dBm)**
  - 22
  - 21
  - 20
  - 19
  - 18
  - 17
  - 16
  - 15
  - 14
  - 13
  - 12
  - **Freq (MHz)**
    - 2300
    - 2500
    - 2700

- **Temperature**
  - 105
  - 85
  - 25
  - -40

**GRF2093 OIP3 vs. Frequency vs. Temperature**

- **OIP3 (dBm)**
  - 40
  - 39
  - 38
  - 37
  - 36
  - 35
  - 34
  - 33
  - 32
  - 31
  - 30
  - 29
  - 28
  - 27
  - 26
  - 25
  - **Freq (MHz)**
    - 2300
    - 2500
    - 2700

- **Temperature**
  - 105
  - 85
  - 25
  - -40
GRF2093 Evaluation Board Data:

![Graph of GRF2093 Iddq vs. Temperature]

- **Tuning Range:** 1.0 to 6.0 GHz
- **Iddq (mA)**
  - 70
  - 65
  - 60
  - 55
  - 50
  - 45
  - 40
- **Temp (deg C)**
  - -40
  - 25
  - 85
  - 105

Please contact Guerrilla RF at (+1) 336-510-7840 or sales@guerrilla-rf.com
GRF2093 Evaluation Board S-Pars and Stability Mu Factor: (2.3 to 2.7 GHz Match)

Note: Mu >= 1.0 implies unconditional stability.
GRF2093
Ultra-Low Noise Amplifier
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GRF2093 Application Schematic

GRF2093 Evaluation Board Assembly Diagram
### Preliminary

**GRF2093**

Ultra-Low Noise Amplifier

Tuning Range: 1.0 to 6.0 GHz

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GRF2093 Standard Evaluation Board BOM: (2.3 to 2.7 GHz Tune)

<table>
<thead>
<tr>
<th>Component</th>
<th>Type</th>
<th>Manufacturer</th>
<th>Family</th>
<th>Value</th>
<th>Package Size</th>
<th>Substitution</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Inductor</td>
<td>Coilcraft</td>
<td>HP</td>
<td>3.3 nH</td>
<td>0402</td>
<td>ok</td>
</tr>
<tr>
<td>M2</td>
<td>Capacitor</td>
<td>Murata</td>
<td>GJM</td>
<td>2.7 pF</td>
<td>0402</td>
<td>ok</td>
</tr>
<tr>
<td>M5 (See curves)</td>
<td>Resistor: 5%</td>
<td>Various</td>
<td>—</td>
<td>—</td>
<td>0402</td>
<td>ok</td>
</tr>
<tr>
<td>C1</td>
<td>Capacitor</td>
<td>Murata</td>
<td>GRM</td>
<td>0.1 uF</td>
<td>0402</td>
<td>ok</td>
</tr>
<tr>
<td>M10</td>
<td>Inductor</td>
<td>Murata</td>
<td>LQG</td>
<td>1.8 nH</td>
<td>0402</td>
<td>ok</td>
</tr>
<tr>
<td>M12</td>
<td>Capacitor</td>
<td>Murata</td>
<td>GJM</td>
<td>2.7 pF</td>
<td>0402</td>
<td>ok</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation Board</th>
<th>component</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRF400X_RevC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**GRF2093 w/Vdd = 5.0V: Required Bias R @ Venable vs. Iddq**

![Graph showing the required bias R at Venable vs. Iddq for different voltage levels (Ven = 5V, 4V, 3V, 2V).](image)

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Revision Date: 09/09/19

Please contact Guerrilla RF at (+1) 336-510-7840 or sales@guerrilla-rf.com
1.5 mm DFN-6 Suggested PCB Footprint (Top View)

Dimensions in millimeters

1.5 mm DFN-6 Package Dimensions

<table>
<thead>
<tr>
<th>Dimensions (mm)</th>
</tr>
</thead>
</table>
| A               | 1.5 +/- 0.050  
| B               | 1.5 +/- 0.050  
| C               | 6 +/- 0.050    
| D               | 1.1 +/- 0.050  
| E               | 5 BSO         
| F               | 0.2 +/- 0.050  
| G               | 0.2 +/- 0.050  
| H               | 0.45 +/- 0.050 
| J               | .12 Ref.     

Revision Date: 09/09/19

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Tape and Reel Information:

Guerrilla RF’s Tape and Reel specification complies with the Electronics Industries Association (EIA) standards for “Embossed Carrier Tape of Surface Mount Components for Automatic Handling”. Reference EIA-481. See the table on the following page for Tape and Reel specifications along with units per reel.

Devices are loaded with pins down into the carrier pocket with protective cover tape, wound into a plastic reel. Each reel will be packaged in a cardboard box. There will be product labels on the reel, the protective ESD bag and the outside surface of the box.
## Tape and Reel Specification and Device Package Information Table

<table>
<thead>
<tr>
<th>Type</th>
<th>Dimensions (mm)</th>
<th>Leads</th>
<th>Weight (mg)</th>
<th>Width (W) (mm)</th>
<th>Pocket Pitch (P) (mm)</th>
<th>Pin 1 Quadrant</th>
<th>Diameter (D) (inches)</th>
<th>Units per Reel</th>
</tr>
</thead>
<tbody>
<tr>
<td>QFN</td>
<td>2.0 x 2.0 x 0.50</td>
<td>12</td>
<td>7</td>
<td>8</td>
<td>4</td>
<td>Q1</td>
<td>7</td>
<td>2500</td>
</tr>
<tr>
<td>QFN</td>
<td>3.0 x 3.0 x 0.85</td>
<td>16</td>
<td>24</td>
<td>12</td>
<td>8</td>
<td>Q1</td>
<td>7</td>
<td>1500</td>
</tr>
<tr>
<td>DFN</td>
<td>1.5 x 1.5 x 0.45</td>
<td>6</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>Q1</td>
<td>7</td>
<td>2500</td>
</tr>
<tr>
<td>DFN</td>
<td>2.0 x 2.0 x 0.75</td>
<td>8</td>
<td>12</td>
<td>8</td>
<td>4</td>
<td>Q1</td>
<td>7</td>
<td>2500</td>
</tr>
<tr>
<td>LFM</td>
<td>3.5 x 3.5 x 0.75</td>
<td>See TBD</td>
<td>12</td>
<td>8</td>
<td>Q2</td>
<td>7</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>LFM</td>
<td>4.0 x 4.0 x 0.75</td>
<td>See note TBD</td>
<td>12</td>
<td>8</td>
<td>Q2</td>
<td>7</td>
<td>1500</td>
<td></td>
</tr>
</tbody>
</table>

Note: Lead count may vary. Reference applicable product data sheet.
<table>
<thead>
<tr>
<th>Data Sheet Release Status</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advance</td>
<td>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.</td>
</tr>
<tr>
<td>Preliminary</td>
<td>All data based on evaluation board measurements in the Guerrilla RF Applications Lab.</td>
</tr>
<tr>
<td>Released</td>
<td>All data based on device qualification data. Typically, this data is nearly identical to the data found in the preliminary version. Max and min values for key RF parameters are included.</td>
</tr>
</tbody>
</table>

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