Designing for Low Noise and Excellent Matching in Amplifier Applications

AN001

This App Note outlines a methodology for optimizing noise figure and return loss when designing in an amplifier.

One challenge with cascading ultra-low noise amplifiers with high Q filters is the impedance matching. To achieve optimal passband and out-of-band responses, these filters often need to be terminated with an impedance close to 50 ohms or, equivalently, with a return loss >15 dB.

Ultra-low noise LNAs are typically presented with standard matches in their data sheets that optimize NF at the expense of return loss. The architecture of these LNAs also dictates that changes to their input matches strongly affect their output matches, and vice-versa. Attempting to reactively match the output for better S(2,2) will tend to disturb the input match and may even make it worse. Fortunately, there is a simple way around this problem.

Resistive loading can be added to the output match. The resistance will improve the output return loss while allowing the input to be matched with a high Q reactive network for improved S(1,1) and optimal NF. The loading can take the form of either a shunt R, series R, or a resistive Pi or T pad.

Below is an example of an improved return loss schematic for our ultra-low noise GRF2071. The high Q shunt L on the input side improves S(1,1) while the 500 Ohm resistor in parallel with the bias inductor increases S(2,2).

![Figure 1. GRF2071 1.7 – 2.2GHz Applications Circuit](image)
Negatives of this approach are that the device gain and output linearity are reduced by the loss of the resistor. For a high gain LNA, this resistive loss will have negligible impact on the noise figure. It should be noted that since the resistive loss occurs on the output side of the transistor, the input referenced linearity is relatively unaffected. An additional benefit of the resistive loading is that the stability margin of the amplifier is improved.

How much noise figure do we give up with this approach? For today’s ultra-low noise pHEMT LNAs, matching for a high input return loss of perhaps 20 dB with high Q inductors and capacitors will typically result in a noise figure penalty of less than 0.2 dB.

Please take a look at some of our ultra-low noise amplifiers and contact our applications team at applications@guerrilla-rf.com with any questions!
Disclaimers

Information in this application note is specific to the Guerrilla RF, Inc. (“Guerrilla RF”) product identified.

This application note, including the information contained in it, is provided by Guerrilla RF as a service to its sales team, sales representatives and distributors and may be used for informational purposes only. Guerrilla RF assumes no responsibility for errors or omissions within this note 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, APPLICATION NOTES, 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 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.

Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Reason for Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Release</td>
<td>September 1, 2020</td>
<td></td>
</tr>
</tbody>
</table>