Application Note
Integration of a Low Noise Amplifier and a USRP Device
Ettus Research
Universal Software Radio Peripheral

Introduction

Some applications require receivers to maintain extraordinarily low noise figure (NF). In these cases, it is possible to use an external low-noise amplifier (LNA) to improve the cascaded NF of the USRP™ (Universal Software Radio Peripheral). This application note provides directions on how to install and power an external LNA with a Ettus Research USRP hardware and/or Bias-Ts.

Why Use an LNA?

An LNA is typically used to provide low noise gain as close as possible to the antenna. Sometimes, especially in GPS receiver applications, the LNA is integrated into an active antenna. The ultimate effect is a reduction in receiver's noise figure achieved by amplifying the desired signal before it is attenuated by other, passive components in the receiver chain.

NF Performance of the USRP and Daughterboards

The NF of a USRP hardware-based receiver ranges from 5-13 dB and depends on the daughterboard selected. This parameter may vary from unit to unit, and is specified with maximum receiver gain settings.

LNA Integration with the USRP Devices

Generally, a wireless system designed with a USRP radio will utilize connectorized LNAs. Mini-Circuits® is a common source for these LNAs. In some cases, the LNA may be a component within the antenna. Example part numbers for a variety of LNAs and active antennas are shown in Table 1 and Table 2. The discussions about power distribution are applicable to both external LNAs and active antennas.

	Min Freq (MHz)	Max Freq (MHz)	Gain (dB)	P1DB (dB)	NF (dB)	IIP3 (dBm)	Currrent (mA)	Voltage (V)
ZFL-1000N+	0.1	1000	20	3	2.9	14	60	15
ZX60-33LN+	50	3000	13	16.5	1.1	32	88	5
ZEL-0812LN	800	1200	20	8	1.5	18	70	15
ZX60-542LN+	4400	5400	24	10	1.9	23	80	12
LNA-1575-349	1555	1595	8	20	1.9	24	100	5.5-18

Table 1- LNAs from Mini-Circuits

	Min Freq (MHz)	Max Freq (MHz)	Ant. Gain (dB)	LNA Gain (dB)	LNA NF (dB)	LNA IIP3 (dBm)	Currrent (mA)	Voltage (V)
UC-4364-513	435	438	18	No Spec	1	14	50	5-15
UL-1501-B384	100	3000	15	12	1.8	33	125	5-15
UC-1574-341	1565	1585	17	No Spec	1.9	24	100	5.5-18

Table 2- Active Antennas

Powering an External LNA or Active Antenna

There are two general methods used to provide power to an external LNA; coaxially or with an independent power connection. The method required will depend on the selected LNA, daughterboard and power requirements.

Many LNAs and active antennas require power to be applied to the conductor of the coaxial cable, which also acts as the path for the RF signal. This requires some method to isolate the receiver input from the DC component, which usually requires AC coupling via a capacitor, or a Bias-T. The functional model for a Bias-T is shown in Figure 1.

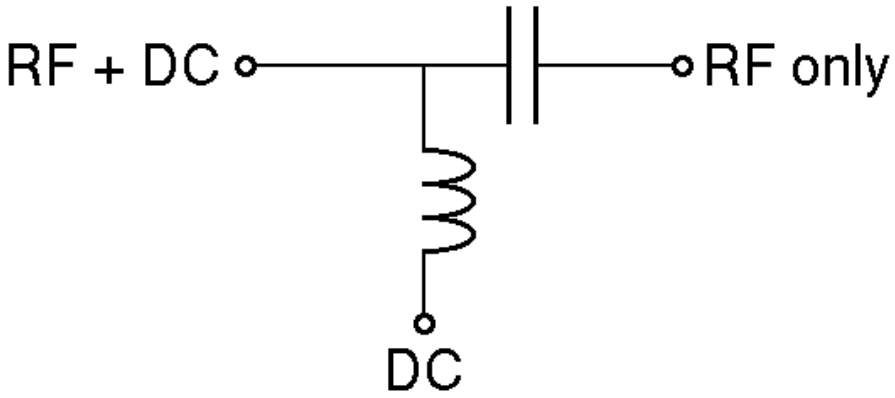

Figure 1-Schematic Representation of Bias-T

Powering an External LNA with a DBSRX2 Daughterboard

In order to provide easy access to DC power for common applications such as GPS reception, the DBSRX2 daughterboard includes an on-board Bias-T, which is enabled by populating and shorting jumper J101 on the board. This configuration provides a 3.3V power supply to the conductor of the RF connector via a 27 nH inductor. The purpose of the inductor is to filter any potential noise sources that may interfere with the RF reception of the DBSRX2.

Note the current sourced by this Bias-T should be limited to 100 mA. Any additional current will damage the in-line inductor, and could change the impedance of the circuit. This will reduce the receive performance of the DBSRX2, and could potentially lead to damage of other components within the system.

The schematic of the DBSRX2 daughterboard, and a photo of the jumper configuration, can be seen in figures Figure 2 and Figure 3, respectively.

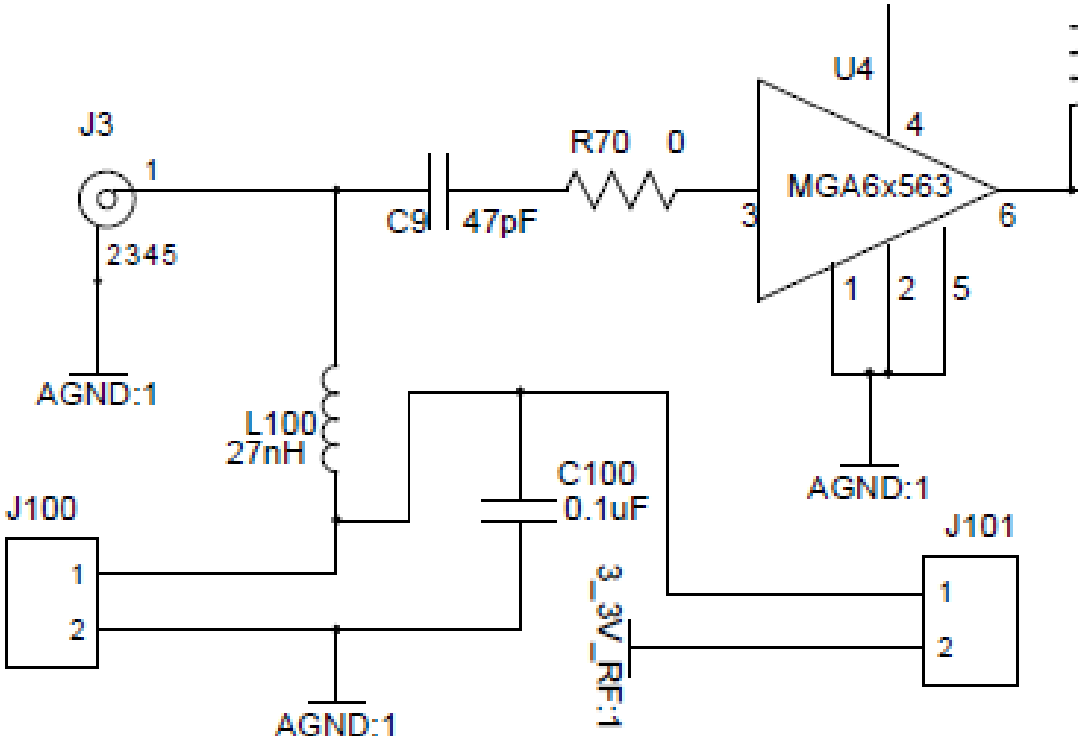

Figure 2- DBSRX2 Daughterboard Bias-T Schematic

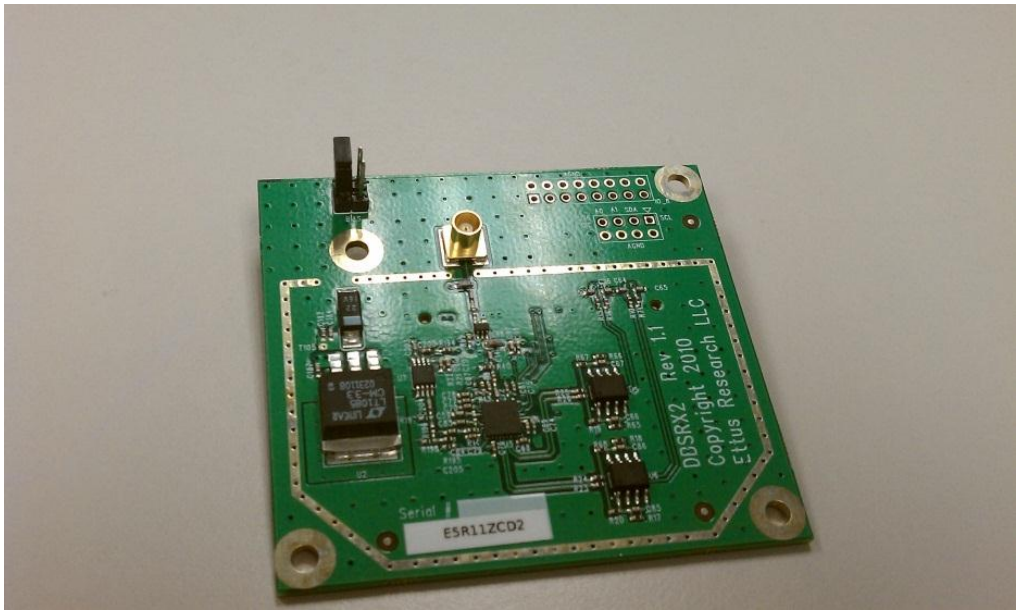

Figure 3- DBSRX-2 Daughterboard with Bias-T Jumper Enabled

Power an External LNA with All Other Daughterboards **(not DBSRX2)**

The DBSRX2 is the only daughterboard available from Ettus Research that provides an on-board Bias-T. All other daughterboards require an external Bias-T if DC power provided via coaxial connection. As mentioned, Mini-Circuits is a common supplier of coaxial Bias-T's, and generally provide wide bandwidth capability and relative low insertion loss. One example is the ZFBT-6G+, which is approximately $80 in per unit (as of Feb 2012). This provides coverage from 10 MHz to 6 GHz. The ZFBT-4R2GW+ is more ideal for applications utilizing the BasicRX daughterboard.

Other LNAs with similar properties and a variety of packaging options are available at:

http://www.minicircuits.com/products/bias_tees_coax.html

Conclusion

This application note examined some sources for LNAs and active antennas and methods to integrate the LNA into a receiver system based on the Ettus Research USRP hardware. If you have any questions on this application note, please send them to support@ettus.com.

References

Mini-Circuits. (n.d.). *Mini-Circuits* . Retrieved February 15, 2012, from http://www.minicircuits.com/products/amplifiers_coax_low_noise.shtml

Myers Engineering International, Inc. (n.d.). Retrieved February 15, 2012, from Antenna Store: http://www.antennas.us/