GALI-74+ Amplifier Performance Measurements
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This document discusses measurements of the Mini-Circuits (MCL) GALI-74+ amplifier at various supply voltages and may be used as an aid in deciding to use the existing LWA power supplies or replace them. All measurements described here use the MCL TB-409-74+ Evaluation Board with the GALI-74+ amplifier. All measurements were made at room temperature (20 °C), and no attempt was made to determine the device characteristics at other temperatures.

The GALI-74+ amplifiers in the Rev. G ARX use a 7 Vdc supply voltage derived from the 8 Vdc bus. 7 Vdc is the minimum supply voltage (Vcc) listed in the device datasheet. The same amplifiers are used in the Rev. I ARX, and it was thought that increasing the supply voltage may improve device (and receiver) performance. The measurements discussed below indicate that, at least under the conditions tested, there are no practical differences across the MCL recommended voltage range.

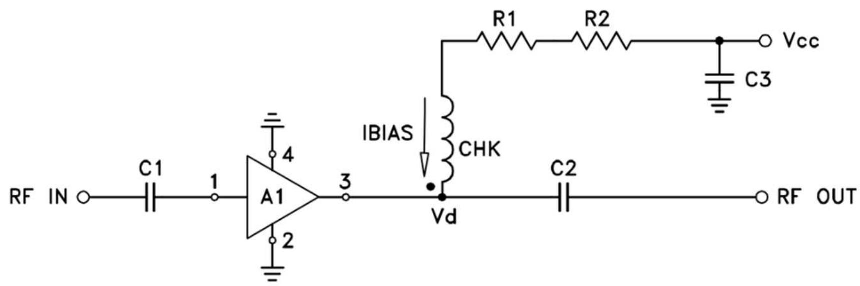
The existing 8 Vdc bus power supplies can be adjusted for 8.8 Vdc operation without replacing the power supplies or associated systems. Voltages higher than 8.8 Vdc require costly power supply replacements and other changes, all of which are not yet known.

It is noted that the 7 Vdc bus voltage regulator (LM1084) on each PCB in the Rev. G ARX has no margin in its dropout voltage. Specifically, the dropout voltage given in figure 1 of the LM1084 datasheet shows a dropout of 1.0 V at the estimated load of 2 A (the entire PCB) at 25 °C. This is a typical value that varies with temperature and device manufacturing; there is no specified maximum dropout voltage given in the datasheet. It may be possible to find a voltage regulator for the Rev. I ARX that has a lower dropout voltage. In any case, it is recommended that the new PCBs be operated with the 8 V power supplies adjusted to 8.8 Vdc to ensure adequate dropout margin.

The measurements discussed here are:

- S-parameter measurements including S11, S21, S12 and S22, 5 to 200 MHz
- Noise figure measurements (10 to 200 MHz)
- 1 dB compression measurements (40 MHz)

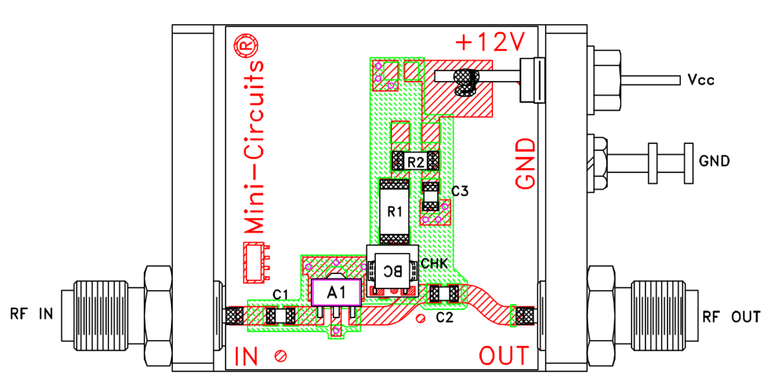
<u>Evaluation Board modifications</u>: The measurements require modification of the TB-409-74+ Evaluation Board for lower frequencies and different supply voltages. The RF choke CHK, MCL p/n TCCH-80+, is replaced with a Coilcraft p/n 1008CS-472 (4.7 µH) inductor, and the 2400 pF input and output coupling capacitors C1 and C2 are replaced with 0.1 µF MLCC. The board is further modified for each set of supply voltage measurements by replacing the R1 and R2 bias resistors as shown in the schematic and table below.



Vcc	Bias resistor R1 (ohms)	Bias resistor R2 (ohms)	Bias resistor R1+R2 (ohms)	Datasheet (ohms)	Remarks
7	27.4	1.2	28.6	28.7	
7.5	33.0	2.0	35.0	N/A	Estimated bias resistors
8	41.2	0	41.2	41.2	
9	53.6	0	53.6	53.6	
10	66.5	0	66.5	66.5	
11	78.7	0	78.7	78.7	
12	68.1	22.6	90.7	90.9	

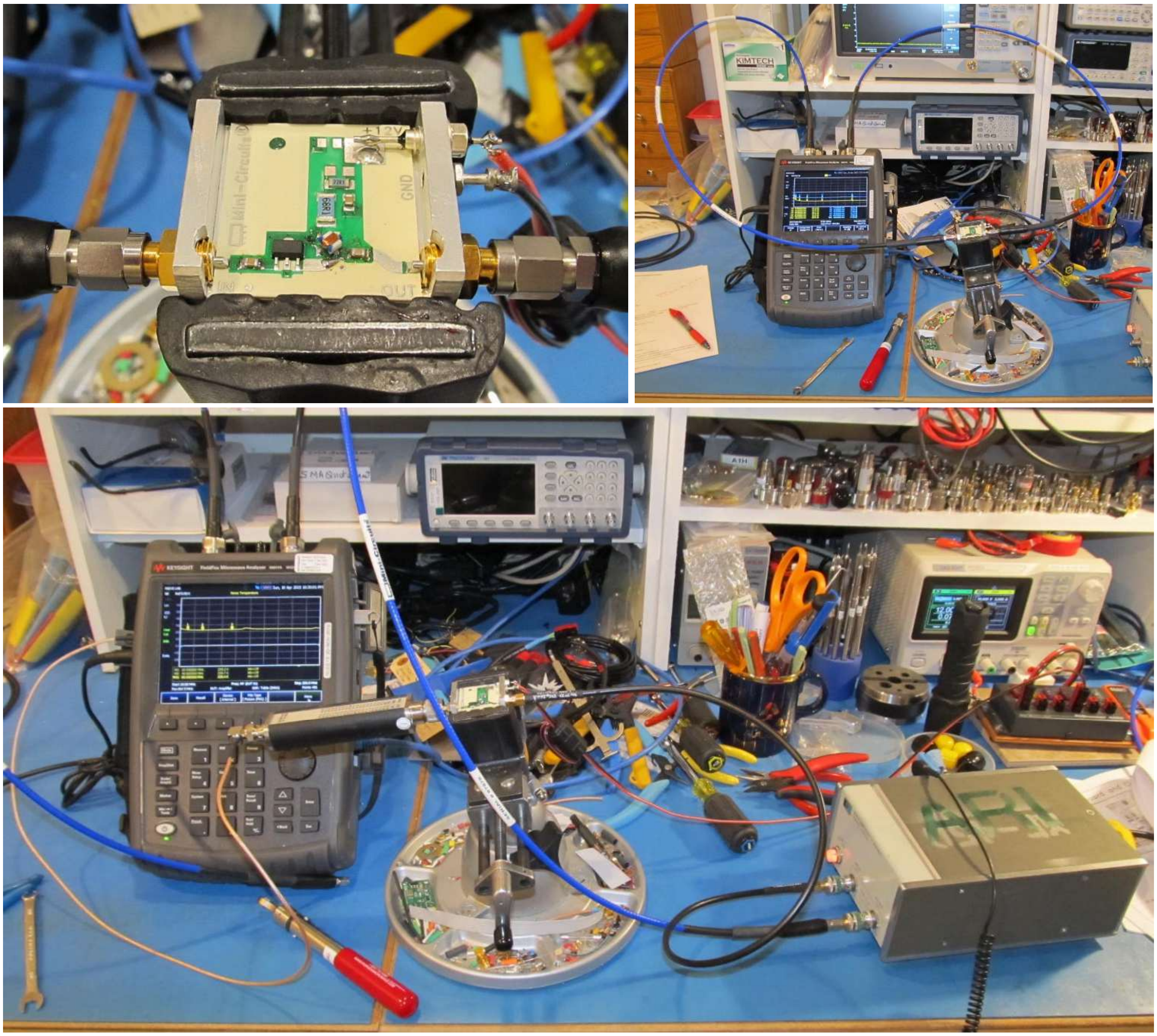
The above resistor values are from the GALI-74+ datasheet (except 7.5 V) and do not take into account the resistance of the bias-tee inductor. The original bias-tee inductor (RF choke) on the evaluation board has a typical dc resistance of 0.1 ohms, which is relatively small compared to the specified total bias resistance. However, the replacement inductor has a dc resistance up to 4 ohms. This increased resistance inadvertently was not taken into account when purchasing the resistors for the evaluation. Since this resistance is significant at the lower supply voltages, the supply voltage Vcc at each increment was increased slightly to provide a device bias current of 78 mA. See table below, which includes the measured device voltage at each supply voltage. According to the datasheet the optimum bias current is 80 mA but actually was set slightly lower.

Vcc (V)	Actual Vcc (V)	Bias current (mA)	Device voltage Vd (V)	Remarks
7	7.00	70	4.7550	Initial setting, no measurements
7	7.30	78	4.7820	Final setting
7.5	7.80	78	4.7793	Vcc not listed in datasheet
8	8.25	78	4.7738	
9	9.20	78	4.7766	
10	10.23	78	4.7852	
11	11.10	78	4.7656	
12	12.00	77	4.7677	



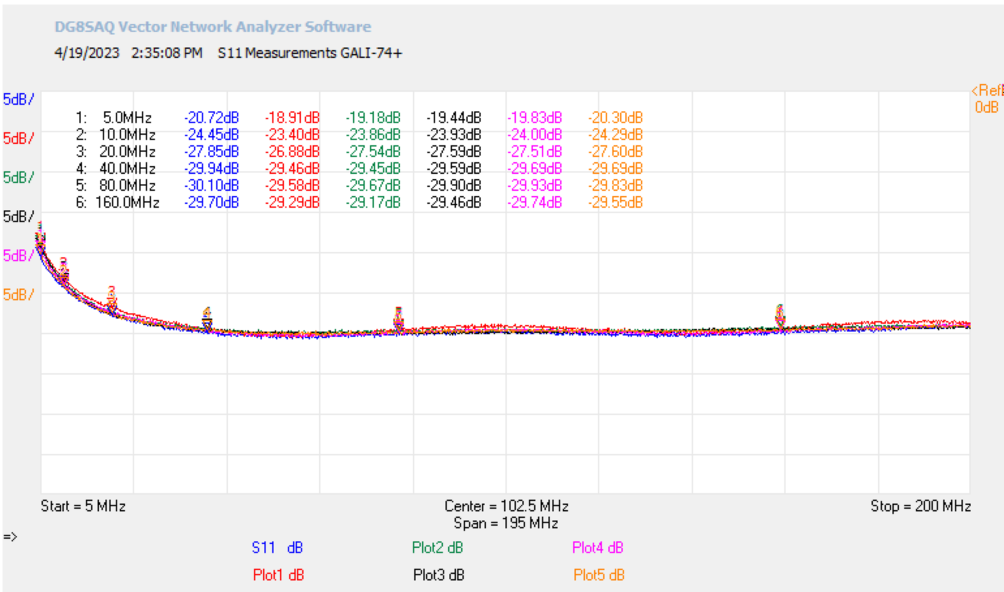
Mini-Circuits TB-409-74+ Evaluation Board. Bias resistor R1 is size 2010 rated 3/4 W and R2 is size 0805 rated 1/10 W. The RF choke CHK is not a standard size and was replaced with a 4.7 µH Coilcraft part (p/n 1008CS-472XGRC, 2%) installed at an angle to reach to two pads. Also, C1 and C2 were replaced with 0.1 µF 0805 parts to improve the evaluation board low frequency response. See Appendix for before and after images of the evaluation board.

Test equipment: The S-parameters were measured with a FieldFox N9917A in Network Analyzer mode and calibrated with a Mini-Circuits KSOLT-63+ calibration kit. The noise figure was measured with the N9917A in Noise Figure mode and an HP 346A noise source with 6 dB excess noise ratio (ENR). An HP 8447A amplifier was used with the N9917A to lower N9917A receiver noise figure for the measurements; the N9917A is calibrated for noise figure measurements with the external amplifier. A Rohde & Schwarz SMC100A RF signal generator and Siglent SSA 3032X spectrum analyzer were used for the 1 dB compression measurements. The 1 dB compression point is a difference measurement, so calibration is not critical. The evaluation board was powered by a Siglent SPC3303X 3-channel variable output power supply. All test cables were MCL CBL-1M-SMNM+.



Test setups: Upper-left: Modified evaluation board. The replacement bias-tee inductor near the lower-middle had to be mounted at an angle to reach the two pads. Upper-right: S-parameter measurements; Lower: Noise figure measurements. The evaluation board is mounted in a bench vise near the middle-left, and it is connected to the noise source. The noise source is powered by the N9917A internal Voltage Variable Source (VVS). The external amplifier is seen in the lower-right of the image and the power supply for the evaluation board is seen near the upper-right.

S-parameters: Although all four S-parameters were measured and recorded, only S11 (equivalent to input return loss) and S21 (equivalent to forward gain) are shown in the plots below. There are no discernible differences in either parameter across the voltage range 7.3 to 11.1 V. The traces for Vcc = 12.0 V are not shown due to limitation in the software used to plot the data but they are identical to the others.



GALI-74+ S11 Key:

Plot1 (red) 7.3 V;

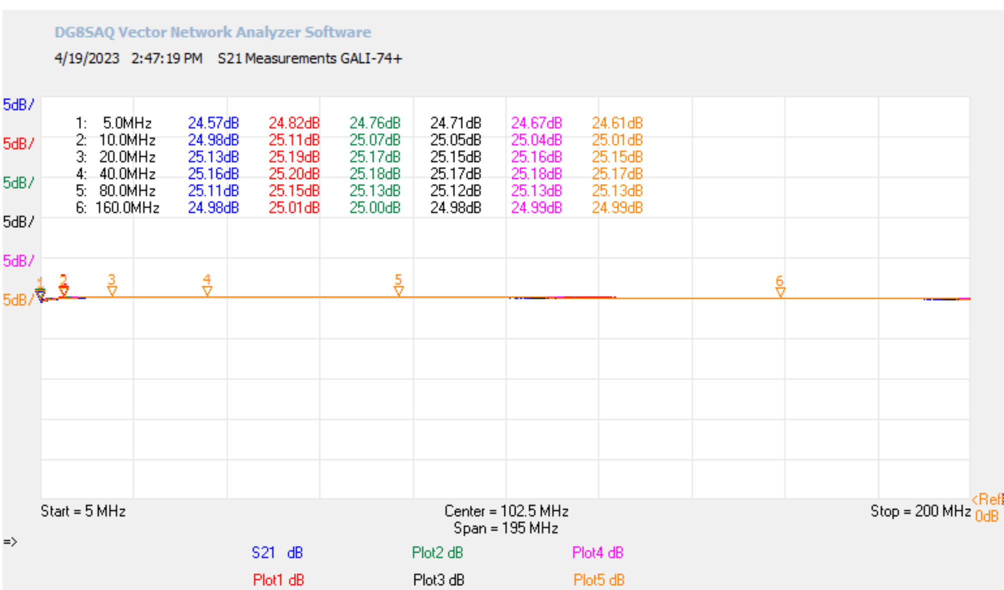
Plot2 (green) 7.8 V;

Plot3 (black) 8.25 V;

Plot4 (magenta) 9.20 V;

Plot5 (orange) 10.23 V;

S11 (blue) 11.10 V



GALI-74+ S21 Key:

Plot1 (red) 7.3 V;

Plot2 (green) 7.8 V;

Plot3 (black) 8.25 V;

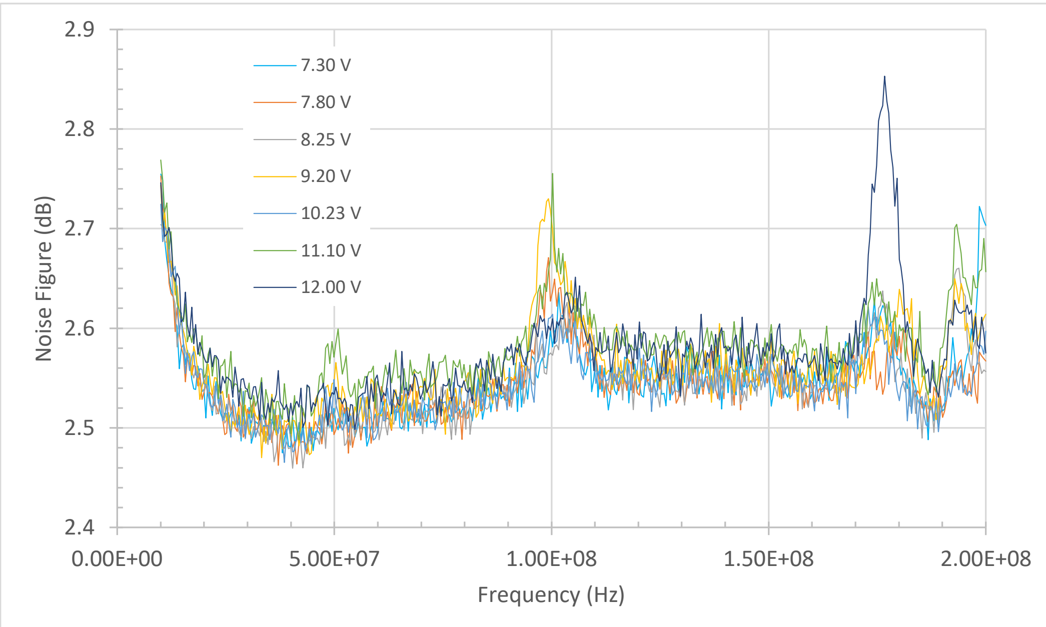
Plot4 (magenta) 9.20 V;

Plot5 (orange) 10.23 V;

S11 (blue) 11.10 V

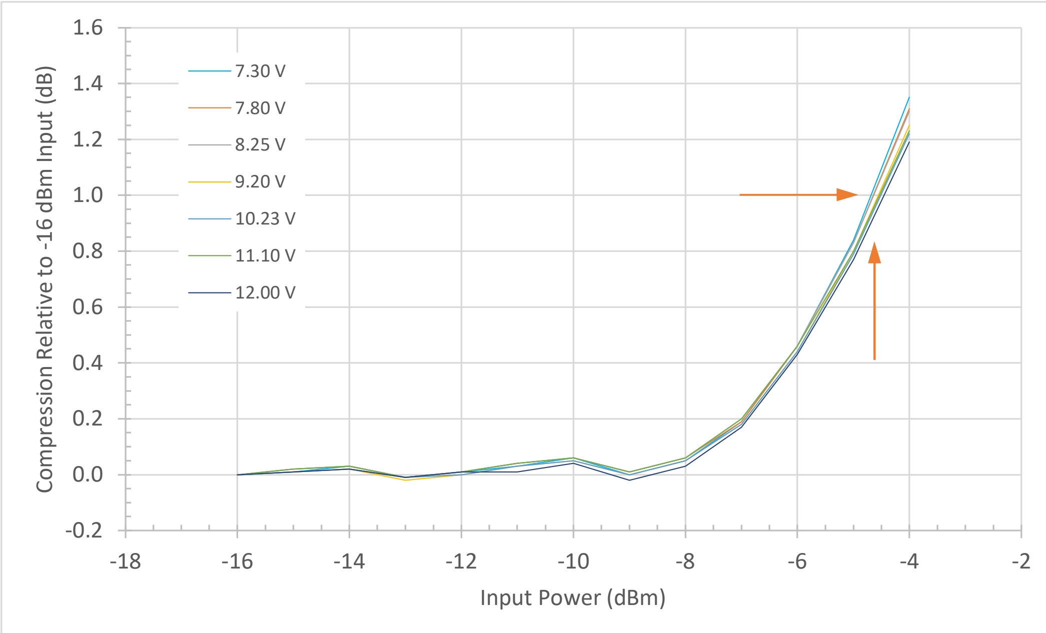
Noise figure: The GALI-74+ noise figure was measured with a calibrated 6 dB ENR noise source and the Fieldfox instrument in Noise Figure mode. In addition to the FieldFox, an external low noise amplifier was used in the measurements to lower the system noise figure. The external amplifier was calibrated as part of the system for these measurements. Because the FieldFox is limited to a low frequency of 10 MHz when in the Noise Figure mode, the frequency range of the measurements covered 10 to 200 MHz.

The plots appear to show a slightly higher noise figure at the higher voltages whereas the noise figure plots at the lower voltages overlay very closely. However, the variations fall within the inherent uncertainty with these types of measurements. The peak near 100 MHz likely is from FM broadcast station interference and the peak near 175 MHz likely is from TV broadcast station interference. Both peaks varied slightly with each sweep of the instrument and are exaggerated in the plots because of the scale.



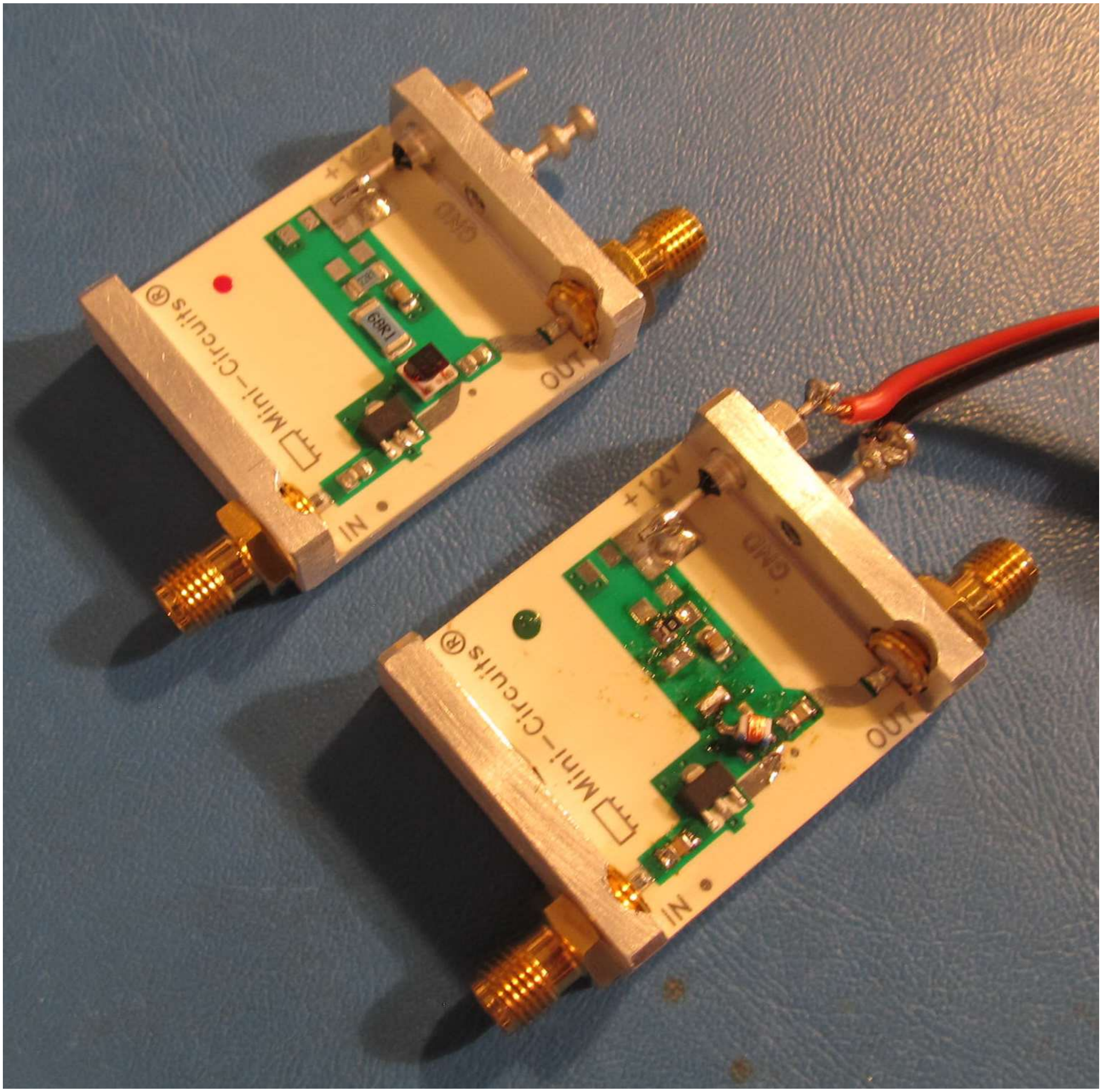
GALI-74+ Noise Figure for each supply voltage. Note exaggerated vertical scale.

<u>1 dB compression</u>: The GALI-74+ datasheet specifies a minimum output power of +18 dBm for 1 dB compression. Assuming 25 dB amplifier gain, the input would be –6 dBm minimum. In all cases, the 1 dB compression point was reached with a higher input level of about –4.7 to –4.5 dB. The compression measurements were made at a single frequency of 40 MHz, approximately mid-band for the LWA. Measurements were made at the input levels of –50, –30, –20 and –16 dBm and above –16 dBm in 1 dB increments up to –4 dBm. The measurements showed linear amplifier operation (within a couple hundredths of a dB) at all supply voltages and device input powers up to of approximately –8 dBm at which point the output started to compress slightly. With an input power of –4 dBm, the output compression level decreased 0.16 dB from 1.35 dB at 7.3 V supply voltage to 1.19 dB at 12.0 V supply voltage. See plot below.



GALI-74+ 1 dB Compression for each supply voltage. The orange arrows point to the 1 dB compression points.

Appendix ~ Mini-Circuits TB-409-74+ Evaluation Board Before (upper) & After (lower) Bias-Tee Modification



Document Information

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