Ka-Band LNA Simulation with X-Microwave Components
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18 May 2024

Simulation results reported in this paper were generated by cascading the S-parameters given for each X-Microwave building component from transmission line sections to microwave amplifiers to microwave coupler, etc. When S-parameters were not available for a particular building component from X-Microwave, S-parameters were generated from the component manufacturer provided S-parameters and modeling the effects of the microstrip transmission lines on the respective building component. Simulation results with all digital step attenuators set to maximum attenuation (30 dB) were prepared after the original document and have been included in Appendix A starting on page 11.

Figure 1 shows the LNA sequence of X-microwave components from the input 2.92 mm connector to the ADMV1014 microwave down converter RF input labeled as "output". The input 2.92 mm connector was modeled with a VSWR of 1.15:1 and insertion loss of 0.12 dB.

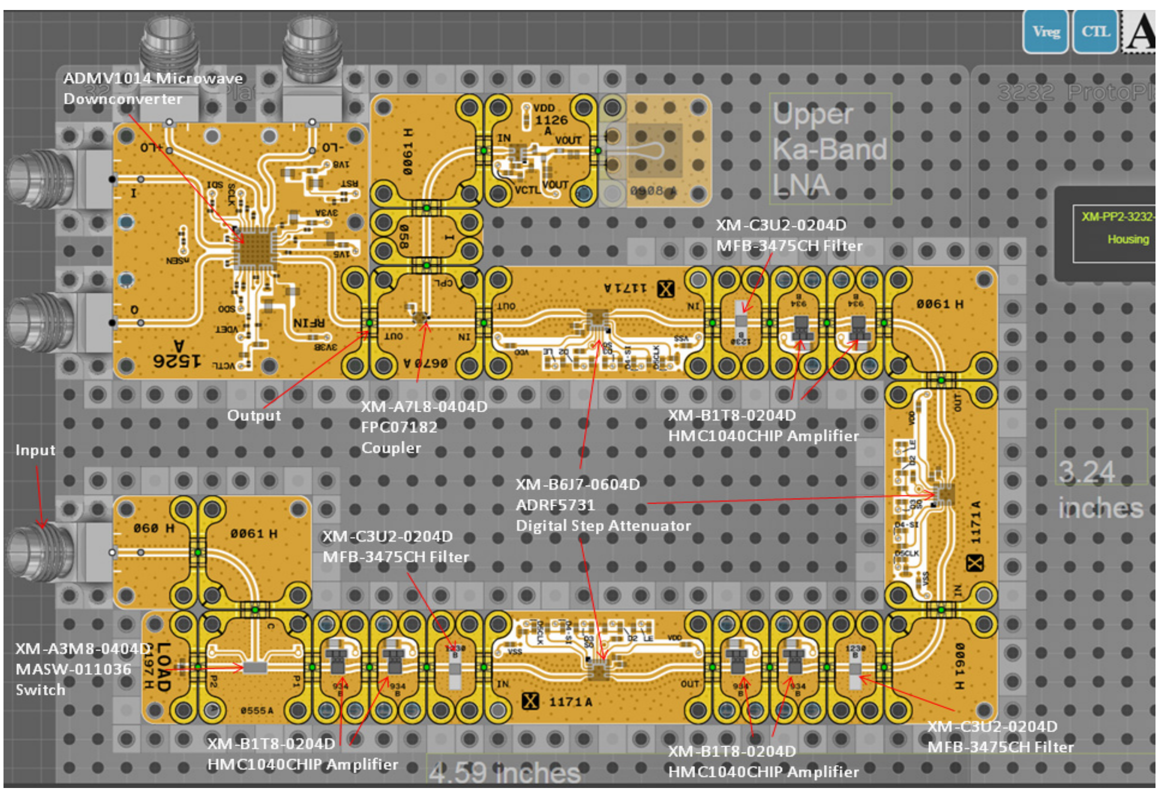

Figure 1. Ka-Band LNA based on X-Microwave Components

Figures 7 through 13 show the S-parameters for each X-Microwave building component. Figure 2 shows all S-parameters for the LNA from input connector to RF input of the ADMV1014 microwave down converter. S21 varies from 123.10 dB to 96.65 dB across Ka-band for a deviation of 26.45 dB. Figure 3 shows the LNA S-parameters less S12 to obtain a plot of better resolution. The S21 anomaly around 42.25 GHz is due to component reflections and mismatches within the LNA.

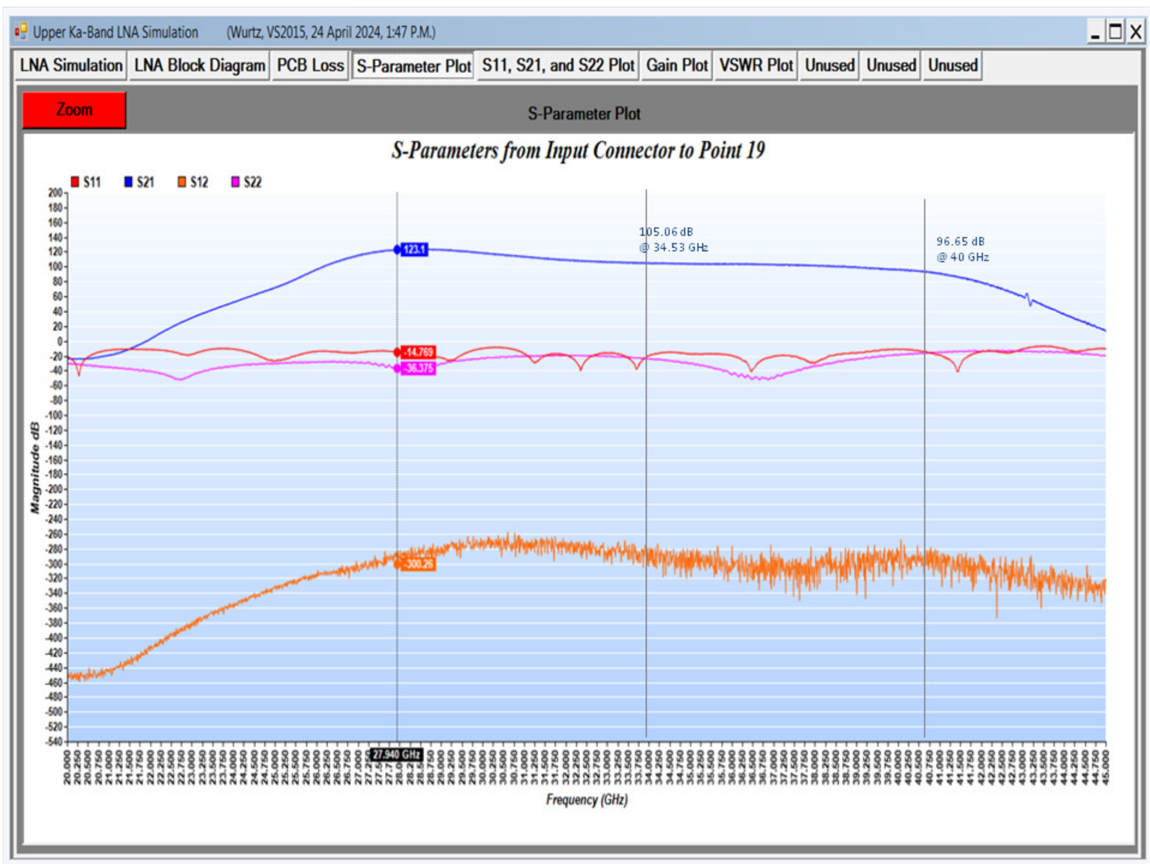

Figure 2. Full LNA S-parameters

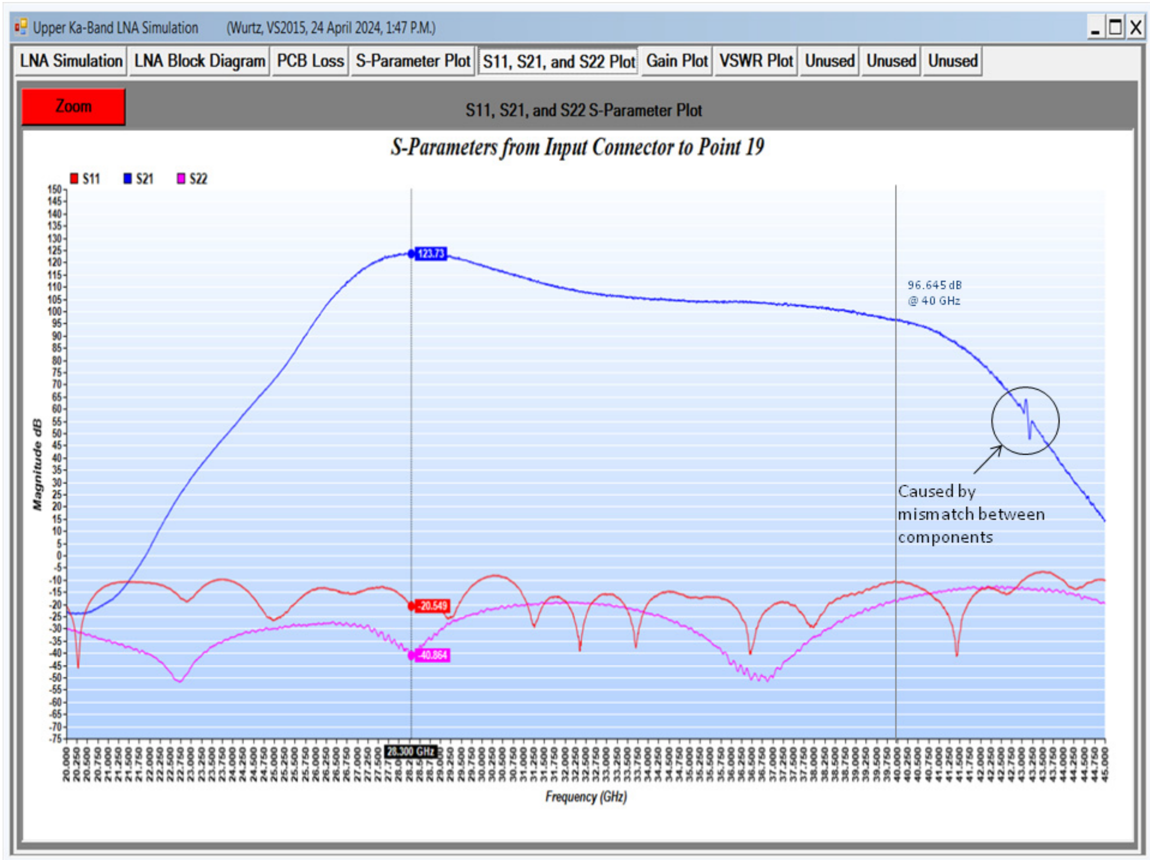

Figure 3. LNA S11, S22, and S21 S-parameters with Better Resolution

Figure 4 reports the LNA transducer gain. S-parameters report performance with the LNA input and output ports matched to 50 ohms. In a real system, the input and output ports most likely will be connected to components with less than a perfect match. In this case, the LNA input will be connected to a Millimeter Wave Products Ka-band axial feed 9" dish antenna (product 202A/599) with VSWR = 1.3:1. The LNA output will be connected to the RF input of an ADMV1014 microwave down converter with return loss versus frequency reported in the table shown in figure 4. With the mismatched input and output connections, the transducer gain ranges from ~123.5 dB to ~96.5 dB for a deviation of ~27 dB.

Figure 5 shows the LNA input and output VSWR. As a rule of thumb, it's always good to keep the input and output VSWR below 2.0:1. The input VSWR reaches 2.38:1 at 30.3 GHz. The input VSWR reaches ~2.8:1 at 42.25 GHz resulting in the S21 anomaly shown in figure 3. This will not be an issue in that the bandwidth of operation of the LNA is from 26.5 GHz to 40 GHz.

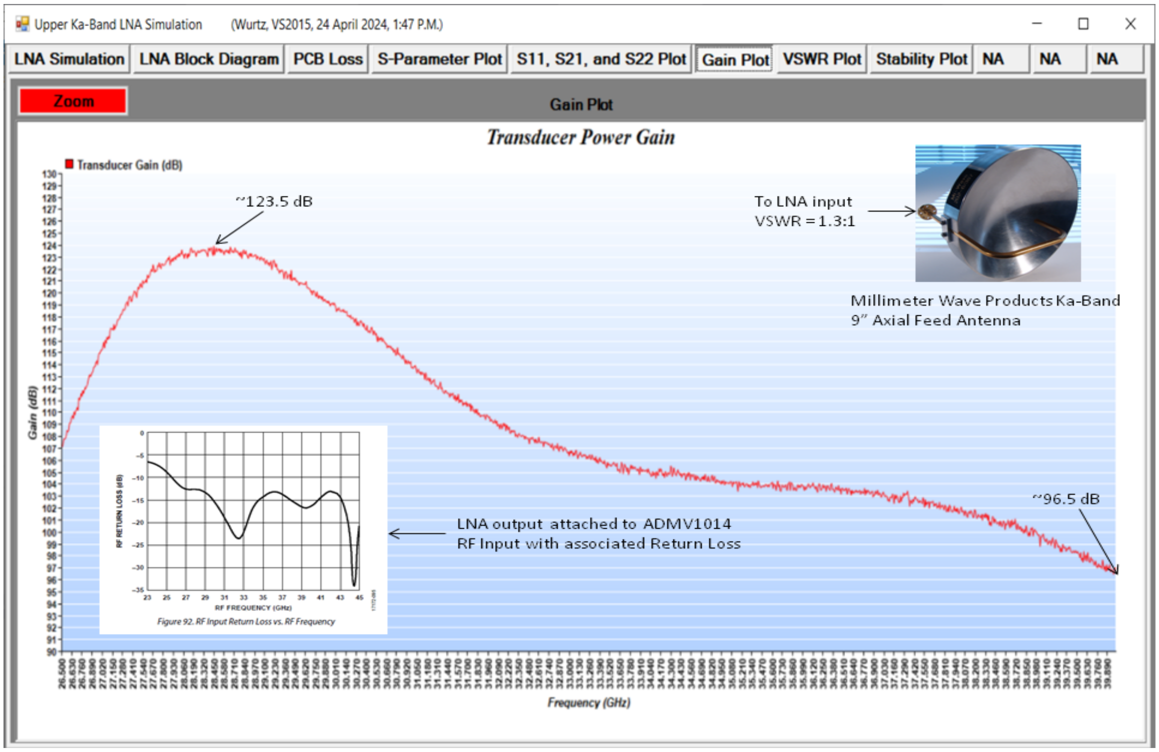

Figure 4. LNA Transducer Power Gain Plot

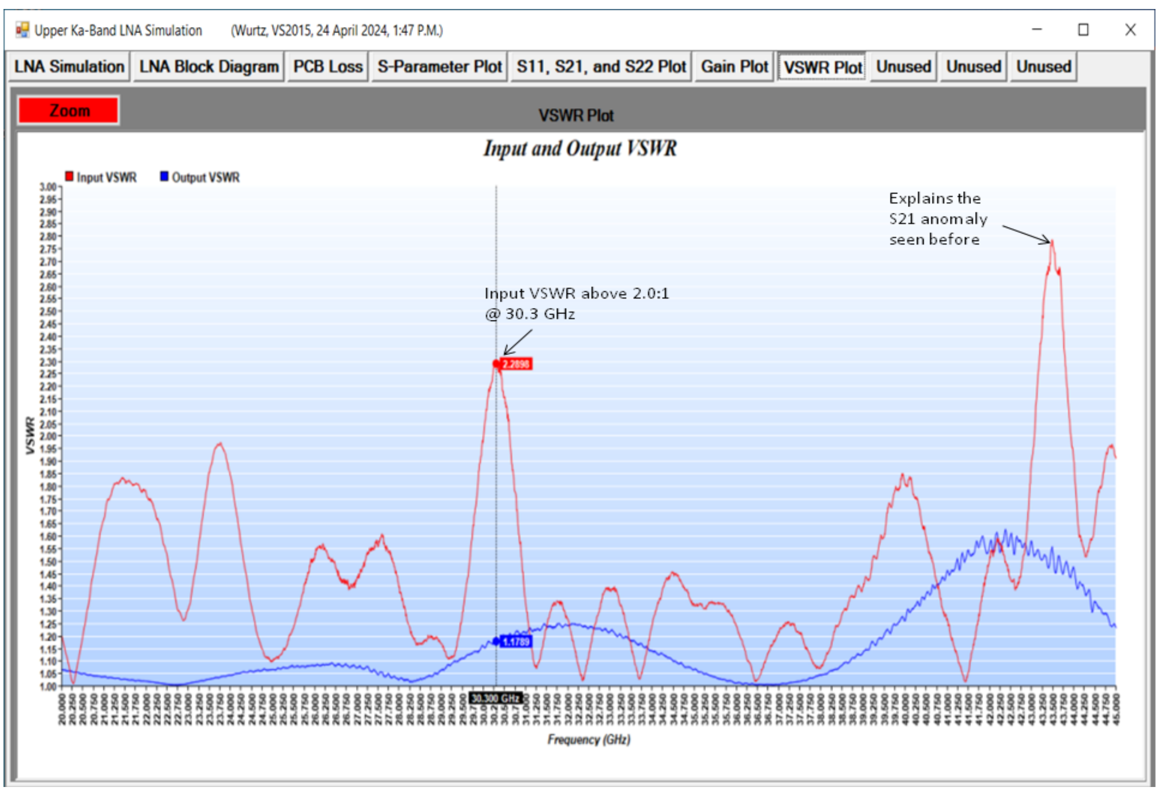

Figure 5. LNA Input and Output VSWR

The S21 anomaly does raise a question of stability. Accordingly, the stability (K factor) plot was generated and shown in figure 6. As a general rule, a K factor above 1 is considered unconditionally stable. Then from figure 6, the simulated LNA is always stable. It's important to mention that due to the high gain of the LNA and nature of the layout where the circuit loops from input on the left and back to output on the left, care must be given to ensure that feedback does not occur from the output port back to input. Improper isolation between these two ports could result in an oscillator rather than LNA.

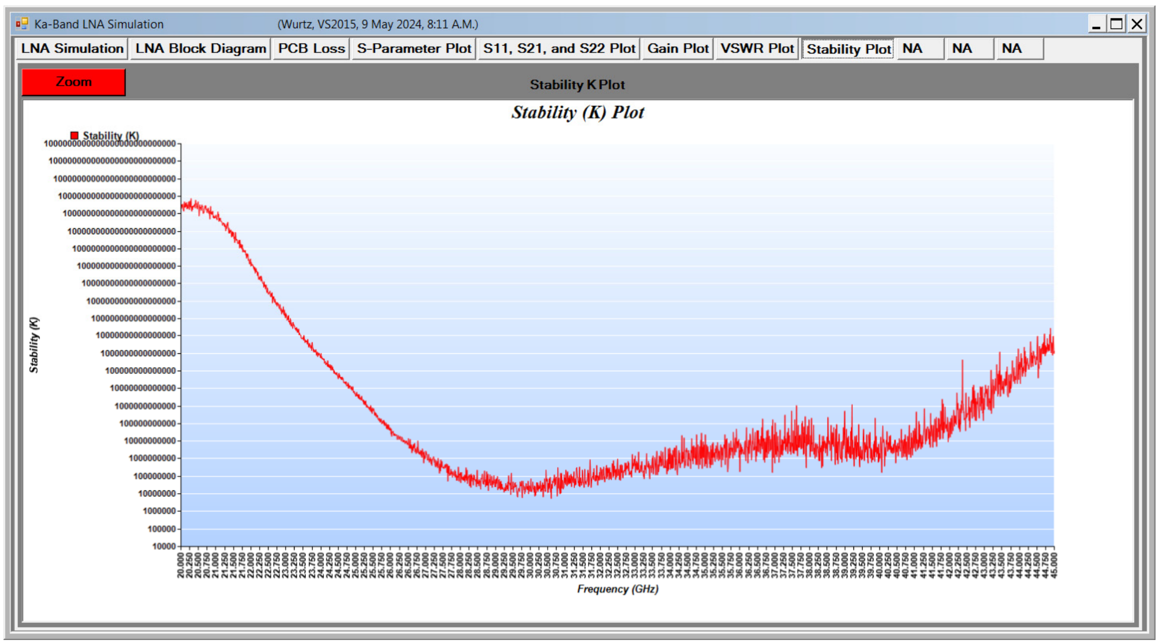

Figure 6. LNA Stability (K Factor) Plot

The LNA build of materials is listed in Table 1. Bias circuits needed for the X-Microwave building components are included in the BOM.

ID	Part Number	QTY	Each	Total
1	XM-PB1-292F	5	$278.00	$1390.00
2	XM-PP2-3232-01	2	$347.00	$694.00
3	XM-WT1-0301	7	$20.00	$140.00
4	XM-WT1-0501	6	$20.00	$120.00
5	XM-A2M8-0404D	4	$48.00	$192.00
6	XM-ANCHOR2-A(R)	6	$12.00	$72.00
7	XM-ANCHOR2	32	$12.00	$384.00
8	XM-B5M1-0404D	1	$204.00	$204.00
9	XM-B5M2-0404D	1	$0.00	$0.00
10	XM-PB4-SMA	1	$58.00	$58.00
11	XM-B916-0809D	1	$0.00	$0.00
12	XM-B9U7-0909D	1	$547.00	$547.00
13	XM-GSGJ	23	$5.00	$115.00
14	XM-ANCHOR2-A(L)	6	$12.00	$72.00
15	XM-A2M5-0204D	1	$43.00	$43.00
16	XM-WT1-0601	13	$20.00	$260.00
17	XM-A7L8-0404D	1	$95.00	$95.00
18	XM-ANCHOR2-AA	2	$12.00	$24.00
19	XM-C378-0804D	3	$350.00	$1050.00
20	XM-C379-0804D	3	$0.00	$0.00
21	XM-C3U2-0204D	3	$348.00	$1044.00
22	XM-B1T8-0204D	6	$433.00	$2598.00
23	XM-B1T9-0204D	6	$0.00	$0.00
24	XM-WT1-0401	4	$20.00	$80.00
25	XM-A2M6-0304D	1	$48.00	$48.00
26	XM-A354-0204D	1	$56.00	$56.00
27	XM-A3M8-0404D	1	$0.00	$0.00
28	XM-A3M9-0404D	1	$0.00	$0.00
29	Housing 1616	1	$0.00	$0.00
	Export CSV		**Estimated (USD)**	**$9286.00**

Table 1. LNA BOM

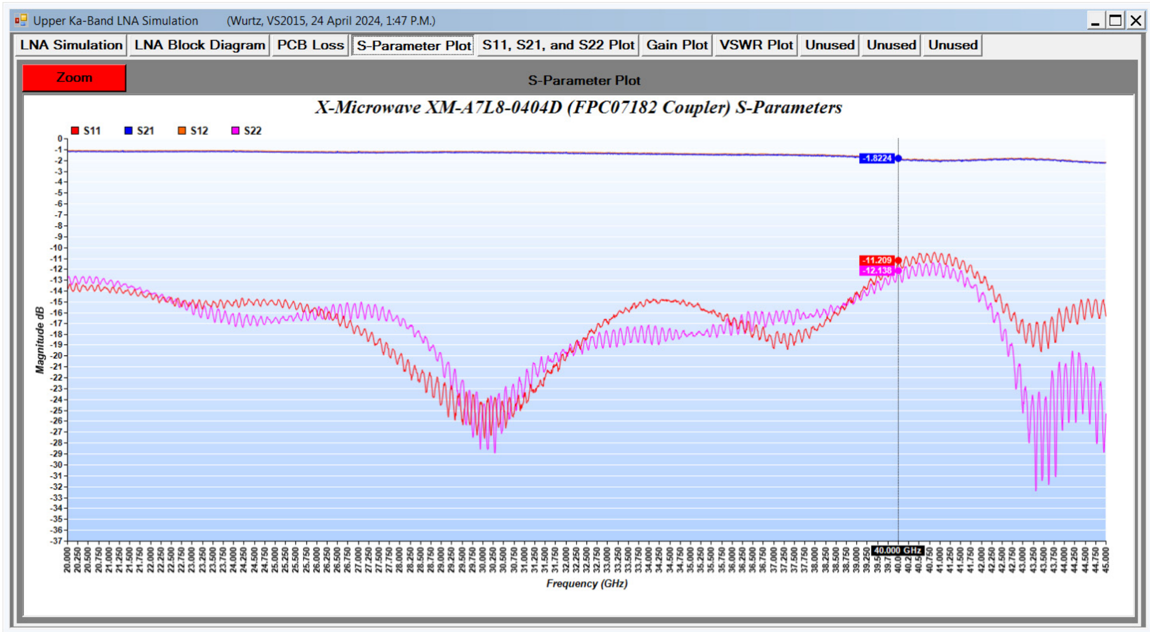

Figure 7. X-Microwave XM-A7L8-0404D (FPC07182) Coupler S-Parameters

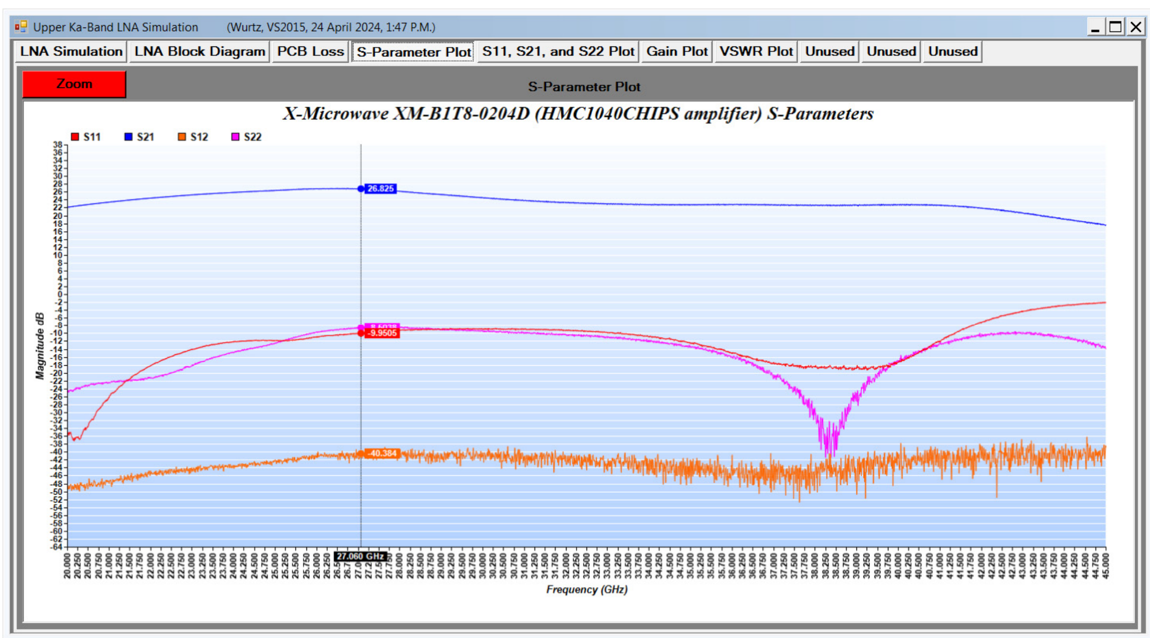

Figure 8. X-Microwave XM-B1T8-0204D (HMC1040 chip) Amplifier S-Parameters

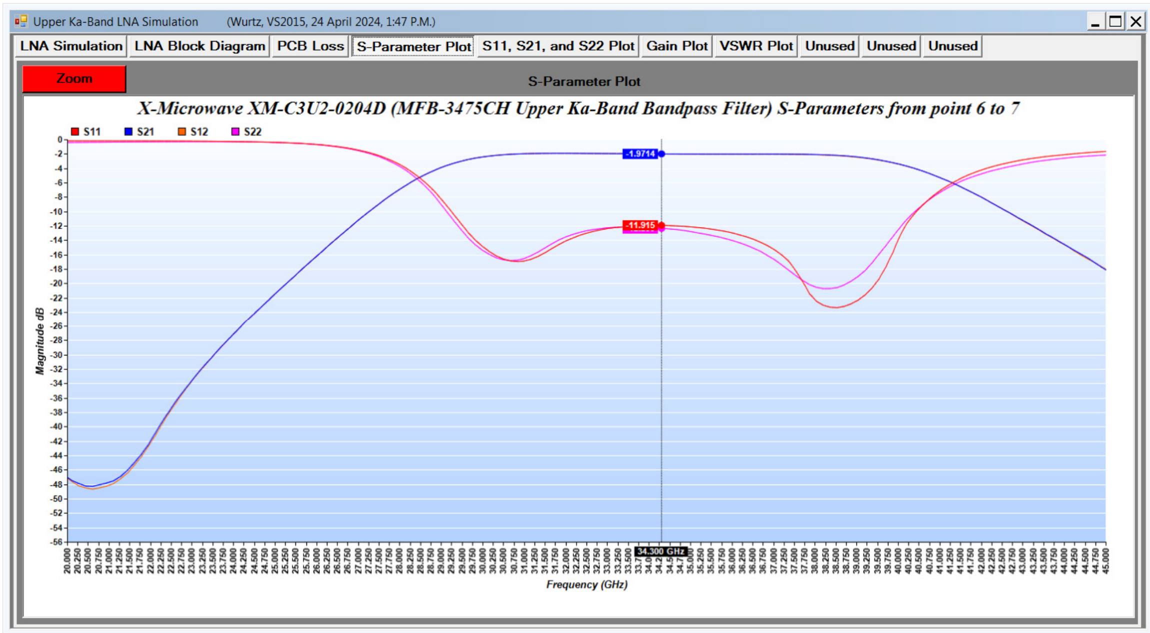

Figure 9. X-Microwave XM-C3U2-0204D (MFB-3475CH) Bandpass Filter S-Parameters

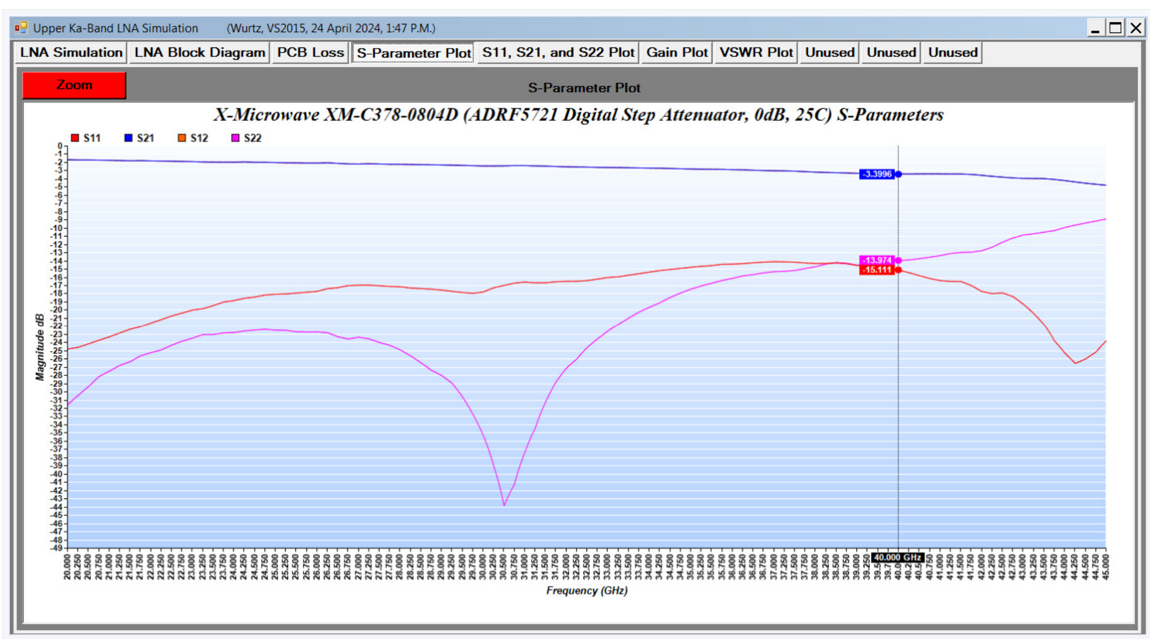

Figure 9. X-Microwave XM-C378-0804D (ADRF5731) Digital Step Attenuator S-Parameters

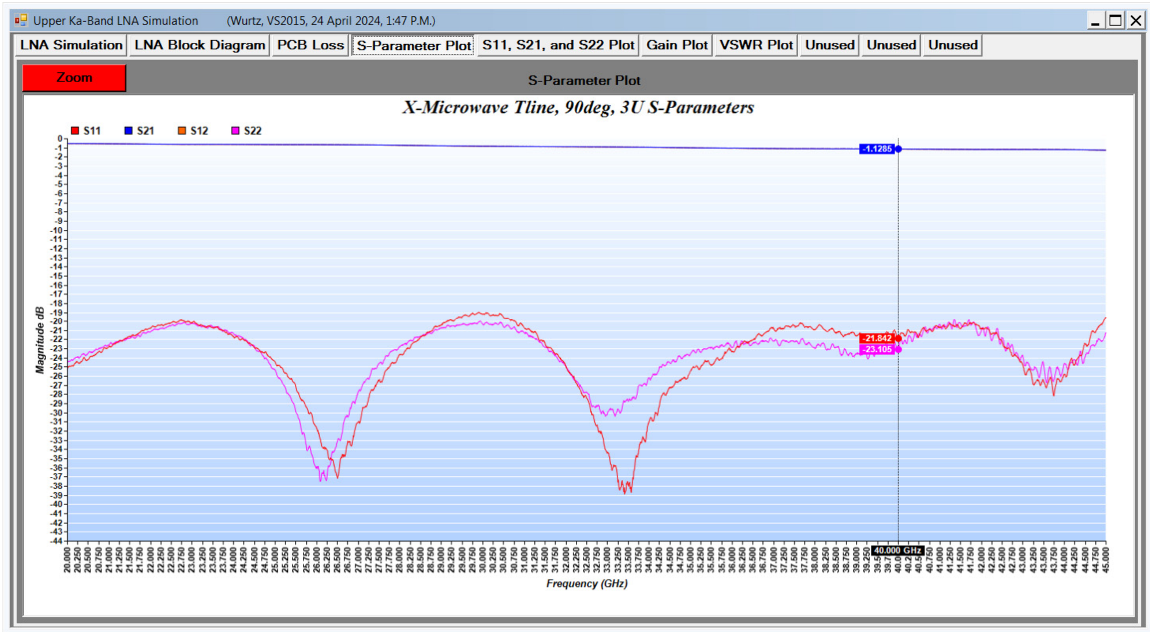

Figure 10. X-Microwave 90 deg, 3U, Transmission Line S-Parameters

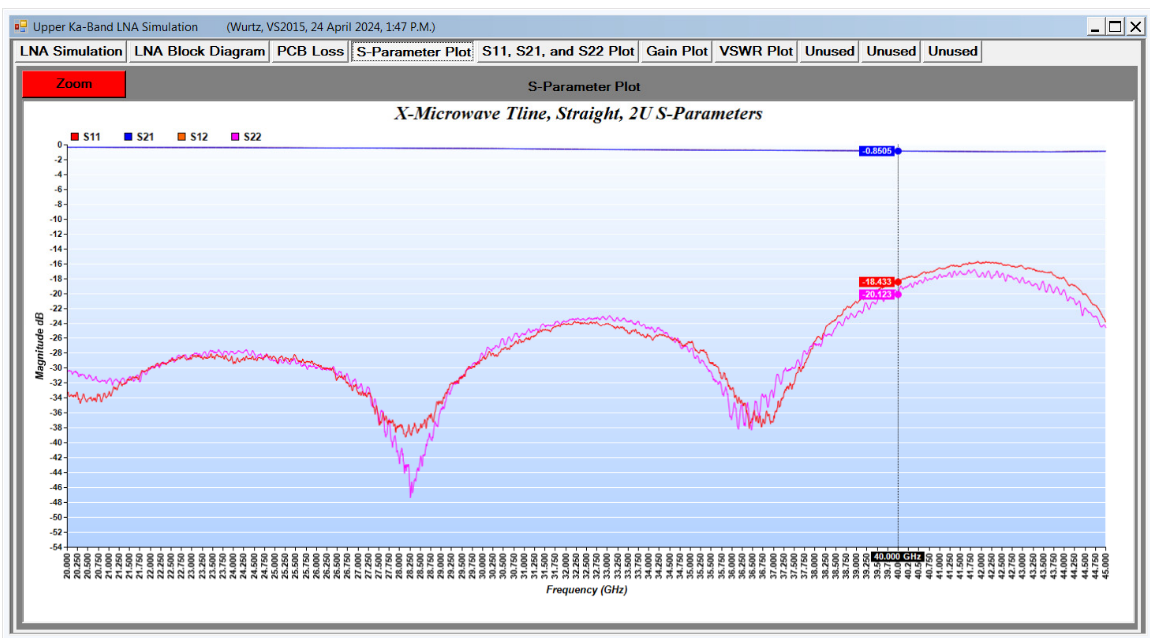

Figure 11. X-Microwave Straight, 2U, Transmission Line S-Parameters

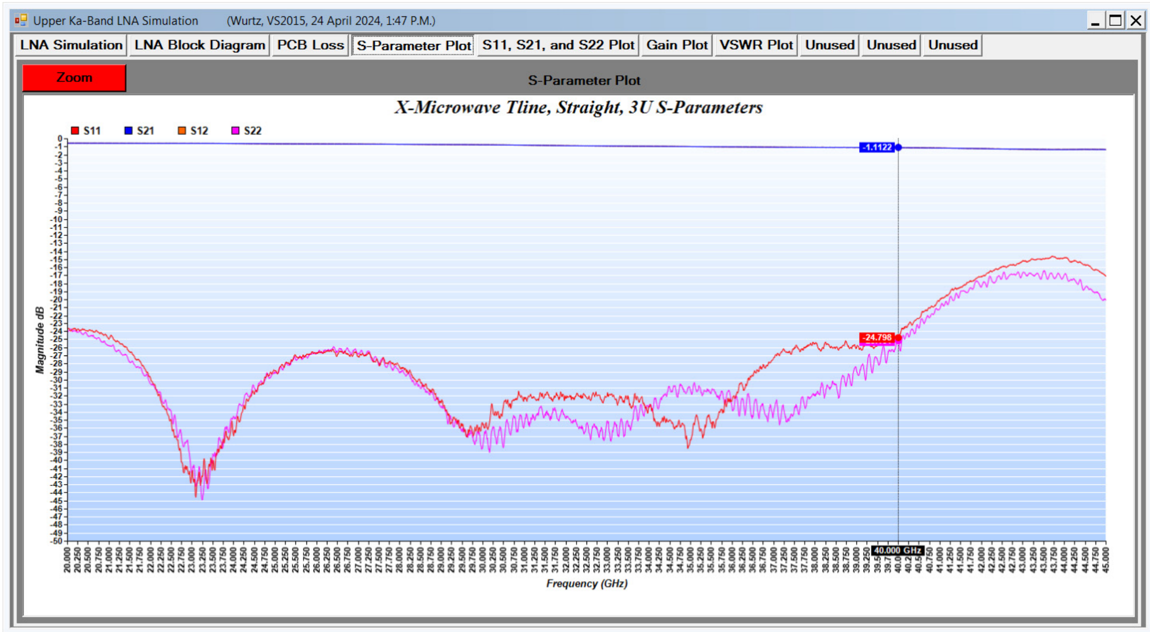

Figure 12. X-Microwave Straight, 3U, Transmission Line S-Parameters

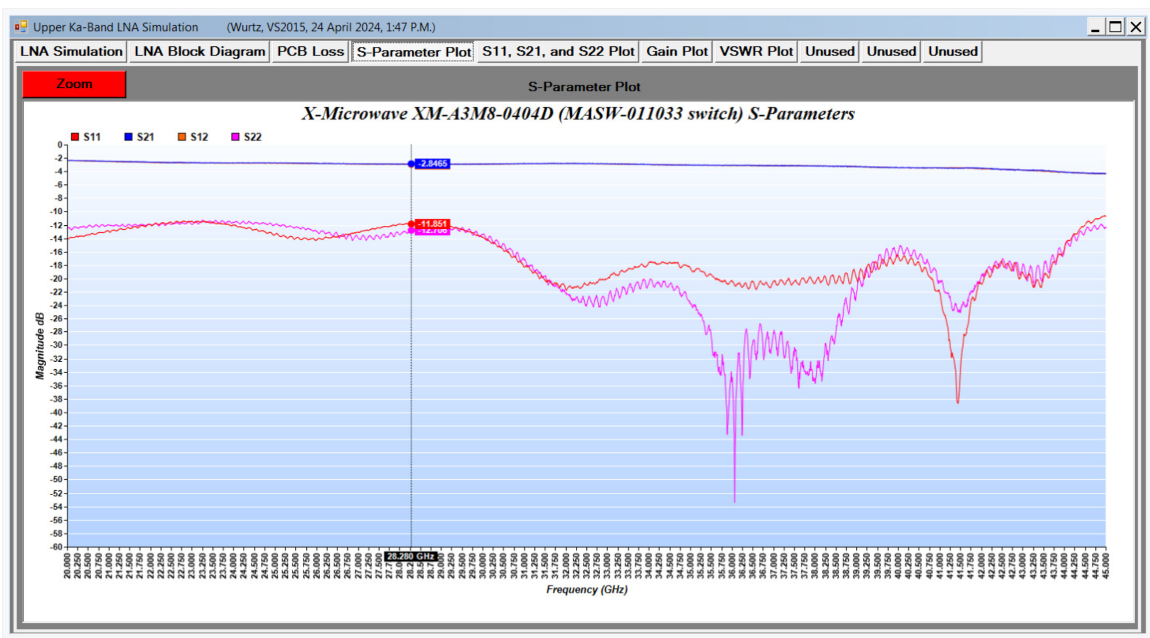

Figure 13. X-Microwave XM-A3M8-0404D (MASW-011036) Switch S-Parameters

Appendix A. LNA Simulation Results with all Digital Step Attenuators set to Maximum Attenuation (30 dB)

Figure 14 shows the S-parameters of the X-Microwave XM-C378-0804D digital step attenuator with full attenuation (30 dB) and at 25 Degs C. Figure 15 shows all S-Parameters of the LNA from input connector to RF input of the ADMV1014 downconverter will all attenuators set at maximum attenuation. S21 ranges from 34.142 dB at 27.970 GHz to 17.621 dB at 40.000 GHz. Figure 16 shows the LNA S-Parameters without S12 for greater resolution.

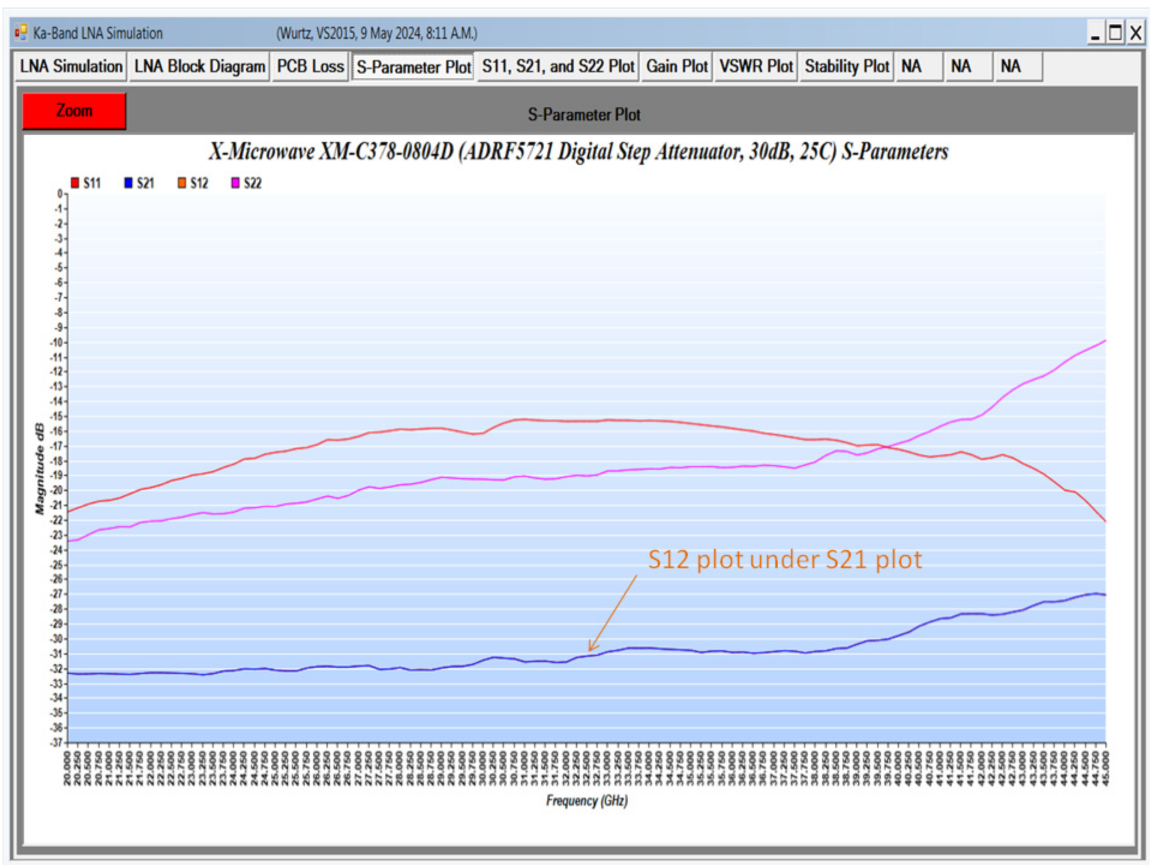

Figure 14. S-Parameters of X-Microwave Digital Step Attenuator at Full Attenuation

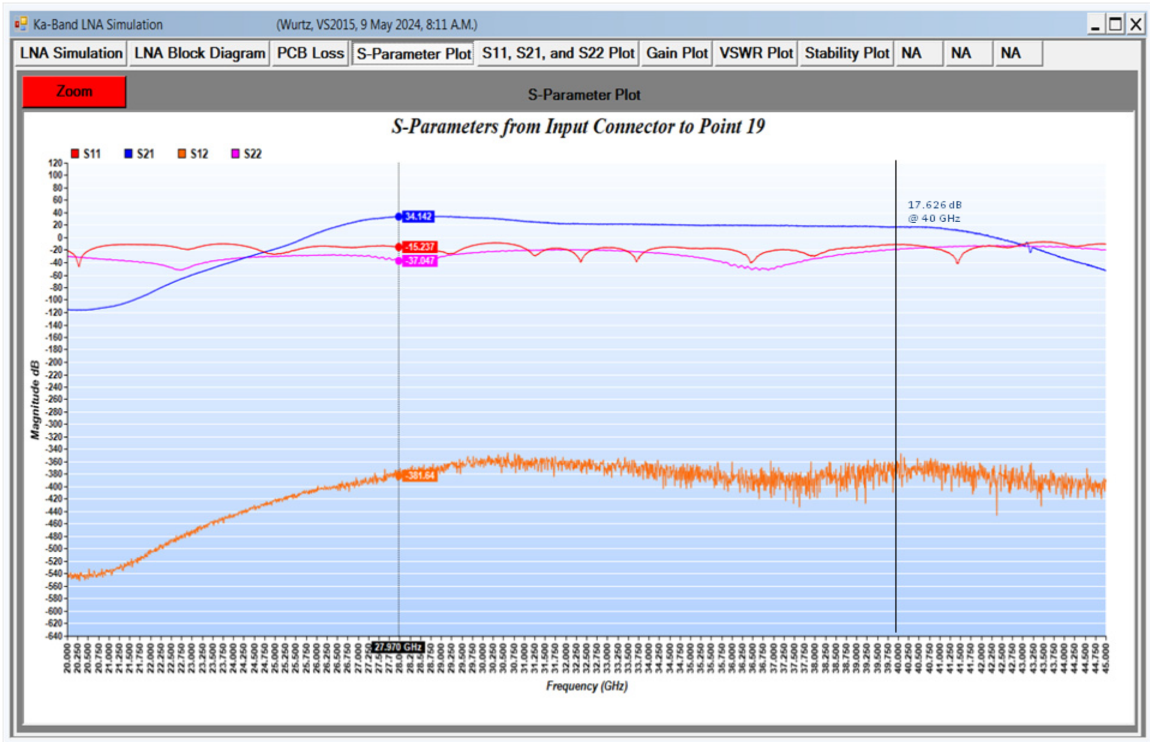

Figure 15. LNA S-Parameters from Input Connector to the ADMV1014 Downconverter RF Input

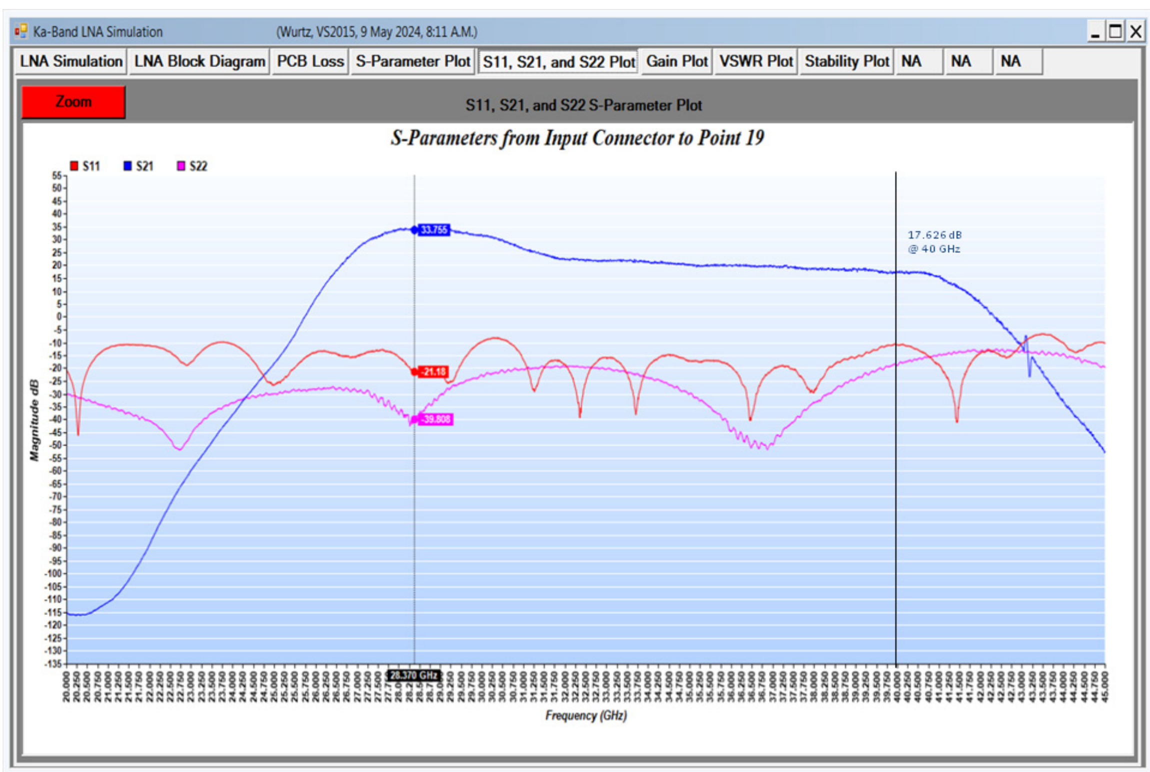

Figure 16. LNA S-Parameters without S12 for greater resolution

Figure 17 shows the LNA input and output VSWR across Ka-Band. Output VSWR is well behaved. However, the input VSWR reaches 2.29:1 at 30.280 GHz and is tolerable at all other in band frequencies. The LNA input is coupled to the antenna network of WR90 waveguides and rotary joints. Figure 18 reports the LNA transducer power gain which accounts for the impedance mismatch of coupling to a less that perfect antenna return loss on the input and ADMV1014 Downconverter return loss on the output. It appears the LNA input and output VSWRs are well tolerated without the need for isolators. Transducer power gain ranges from ~34.0 dB to ~17.5 dB with full attenuation.

Referencing Figures 4 and 18, the LNA has an adjustable gain in the lower Ka-Band from ~123.5 dB to ~34.0 dB (delta ~89.5 dB) and ~96.5 dB to ~17.5 dB (delta ~79.0) in the upper Ka-band.

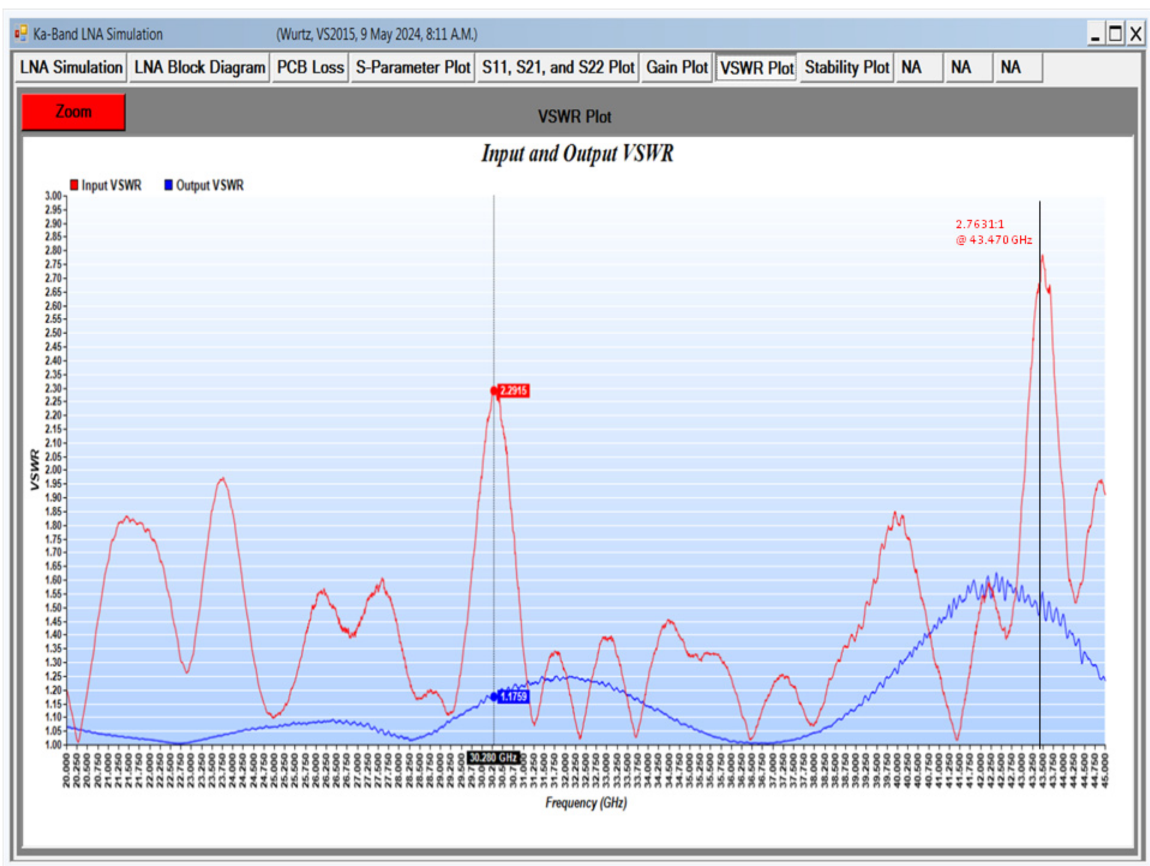

Figure 17. LNA Input and Output VSWR

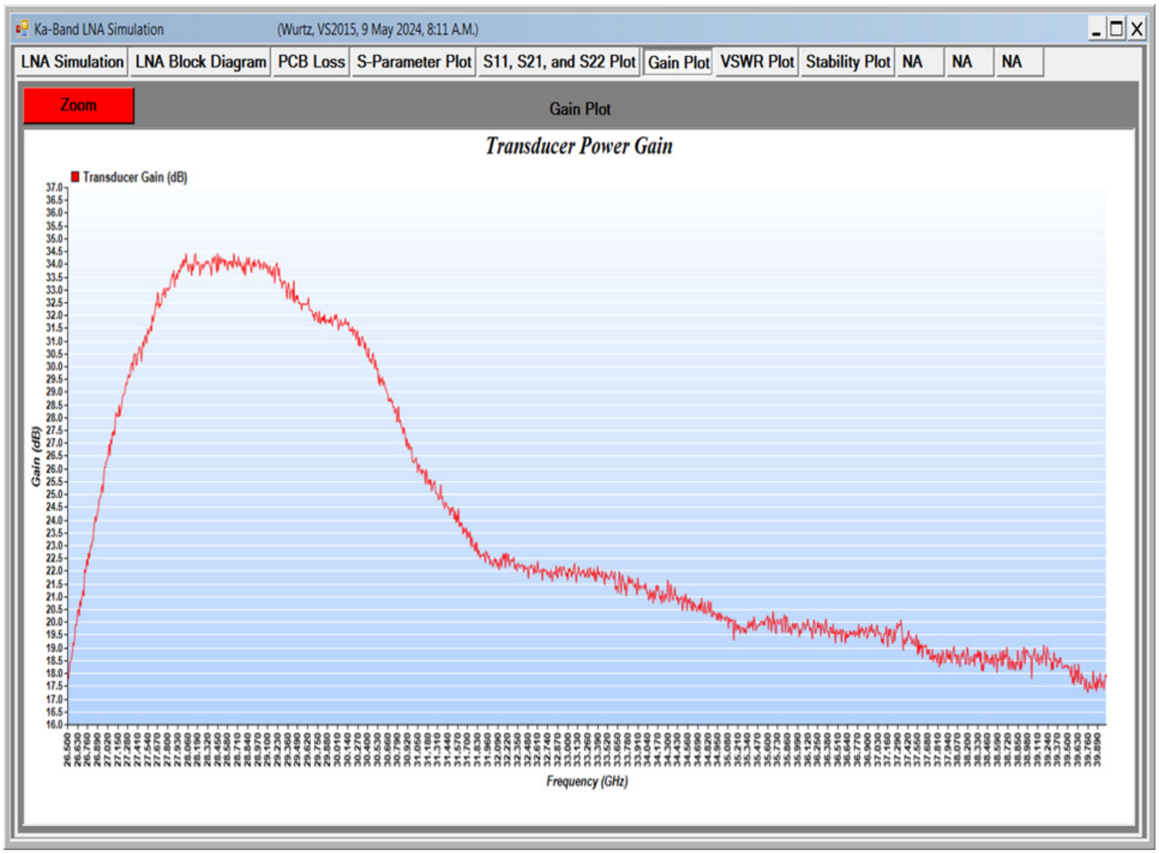

Figure 18. LNA Transducer Power Gain Plot