

Network Evaluation for the PW A10 Schematic Review

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Parametric analysis of the L3 network was conducted in an effort to understand the electrical properties in the system over frequency. Use of a network analyzer to achieve this goal was utilized. As referenced from the PA A10 schematic diagram, evaluation of the network consists of a combination of inductance, capacitance and resistive system elements. The primary function of the network serves to provide a DC bias to the plate of V1 while passing RF energy into the user configurable tank for VSWR matching purposes.

Observation of the tank, and in particular element L3 reveal a structure typical of handling both low and high frequency elements. In particular, element L2 with the associated resistive elements is key to lowering the overall Q directly seen by the plate of V1 in an effort to ensure that VHF and/or UHF oscillation does not occur. L3 in conjunction with C25 shunt and C24 series makes up the primary mechanism for providing some form of impedance looking back into the +1500 VDC supply source for RF isolation. Evaluation of L4 was not considered as part of this analysis.

Observation of L3 reveals the impact of arcing in one section of the full inductor. In particular when addressing the section that impedes RF current flow closely associated with L2. Arcing stems from a number of factors, clearly of which excessive voltage buildup in conjunction with ample RF current leads to fusing of the wire assembly followed by “open” conditions rendering the amplifier useless.

The experimental setup consists of sweeping the frequency response as shown in the diagrams below. Primarily single port analysis was accomplished, but dual port was used as connecting to what the V1 plate would see and what L1 (port 2) would see in the system. In reality it is highly unlikely that the 50 ohm system presented by the network analyzer is characteristic of the actual environment, but it is sufficient enough to provide a fairly accurate reading of the element response. While emphasis should be on the HF response 300Kc to 30Mc, calibration and review up through the 2M band (150Mc) was equally conducted. This is useful to see how the network responds at these frequencies that can be necessary when evaluating response to harmonic energy in the system.

Section I Inductor L3 Evaluation

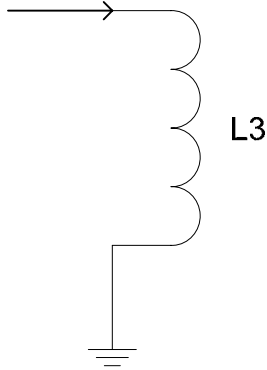


Figure 1 Schematic Configuration

Actual implementation of L3 is composed of two inductive sections where some mutual coupling must take place. My suspicion is that separating the winding into sections helps extend the frequency response. This analysis looks at L3 in the above configuration. With the help of a near duplicate L3 further analysis on one section breakout is accomplished. Due to arcing, etc., one section of L3 could not be electrically analyzed. However, this burnt section was unwound to ascertain number of turns and length.

S11 Parametric Measurement

1.8	157 uH
3.5	162 uH
4	166 uH
7	230 uH
7.3	195 uH
10	2 pF
14	2 pF
18.5	2.7 pF
21.2	2.2 pF
24.5	2.77 pF
30	3.1 pF

Table 1 Measured Inductance response over 160 to 10M HF band operation

The ability to report in reactance at frequency serves as one of the primary purposes of the network analyzer. Note that the inductor is designed to operate as an inductor from the 160M band up through the 40M band. Higher frequency input confirms the inductor simply behaves as a capacitor and would be ineffective in this function if other elements of the network were not present.

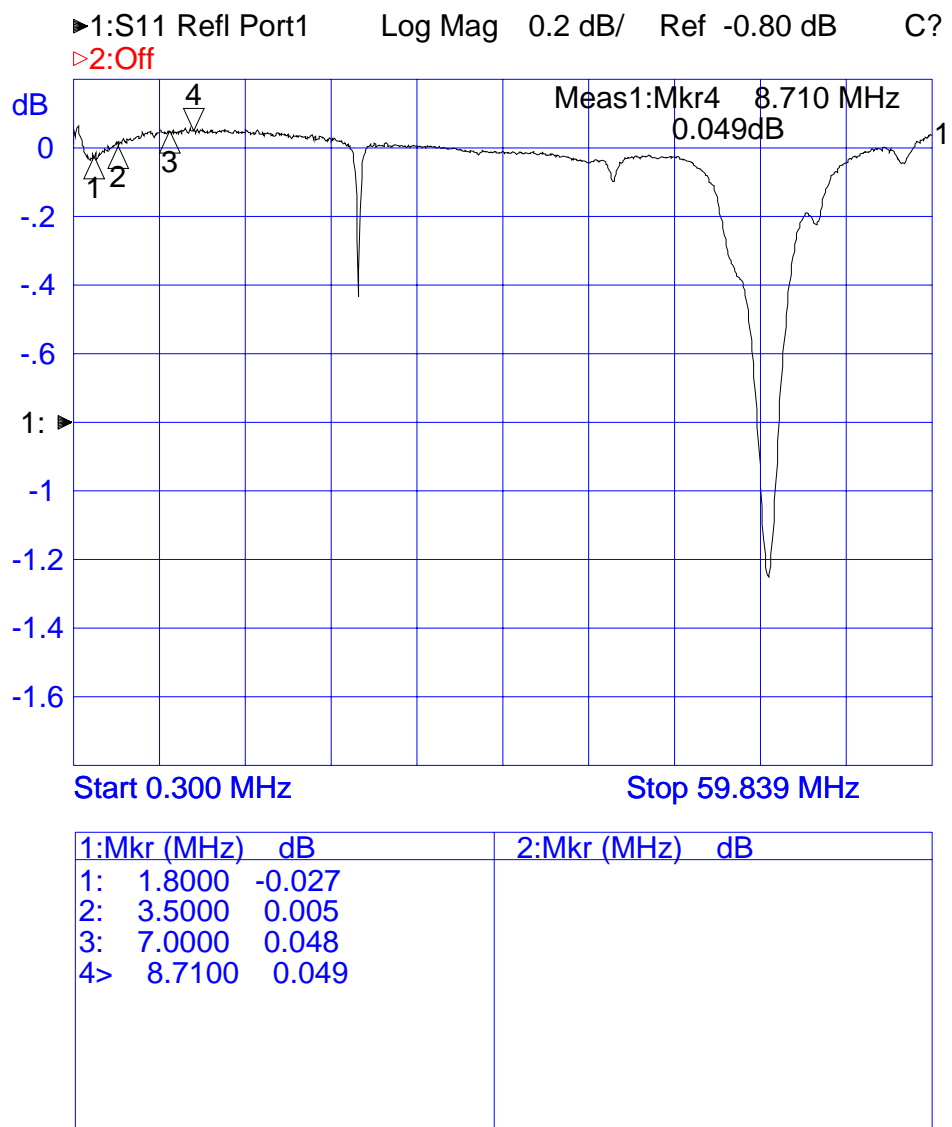


Figure 2 Log Mag Response

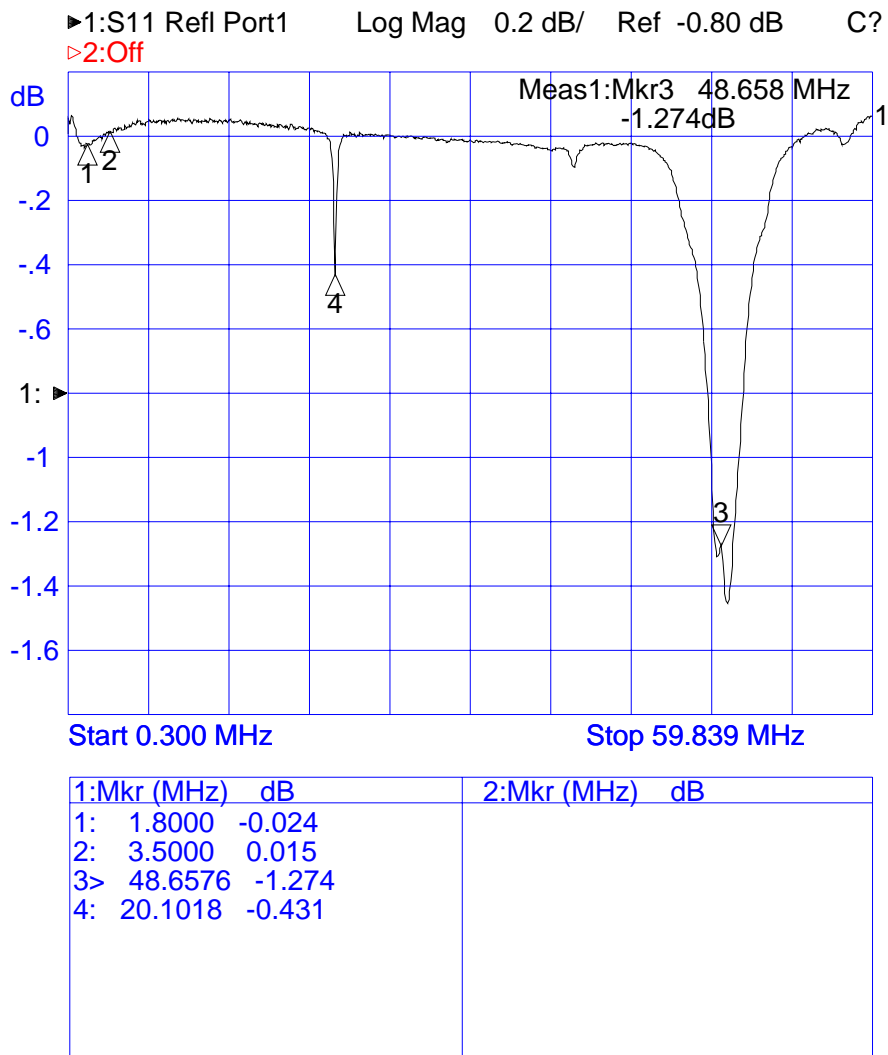


Figure 3 Log Mag

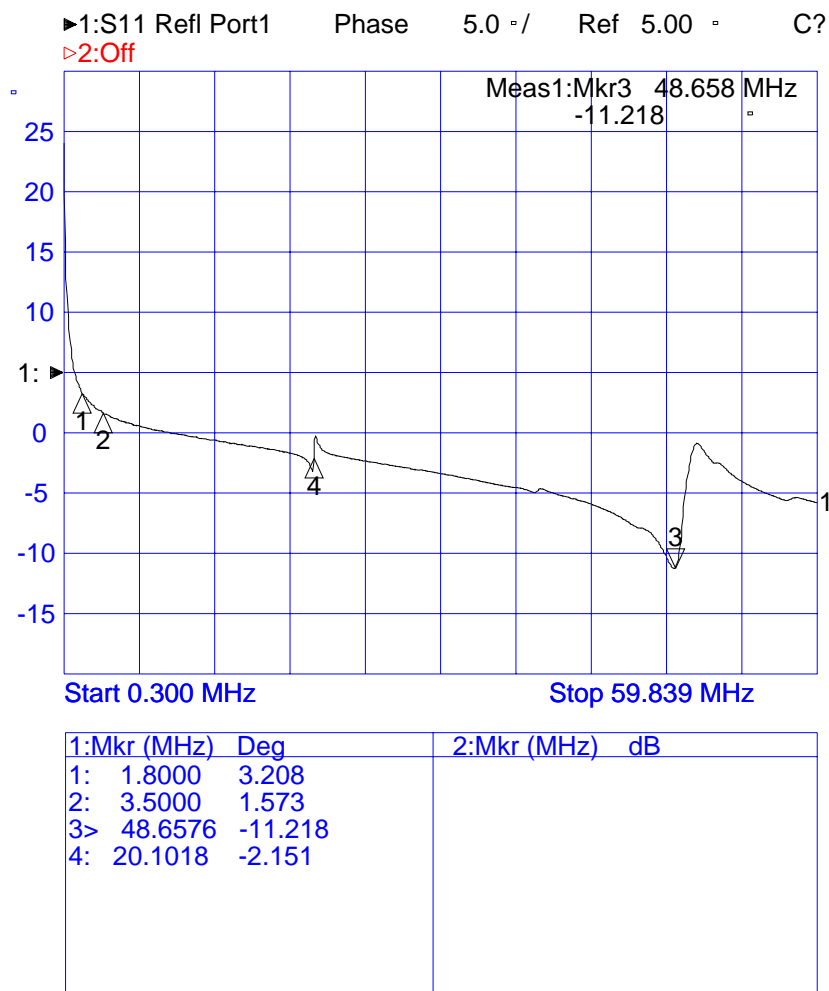


Figure 4 Phase response

Note that a resonant condition exhibits itself through the zero phase crossing at 8.6Mc.

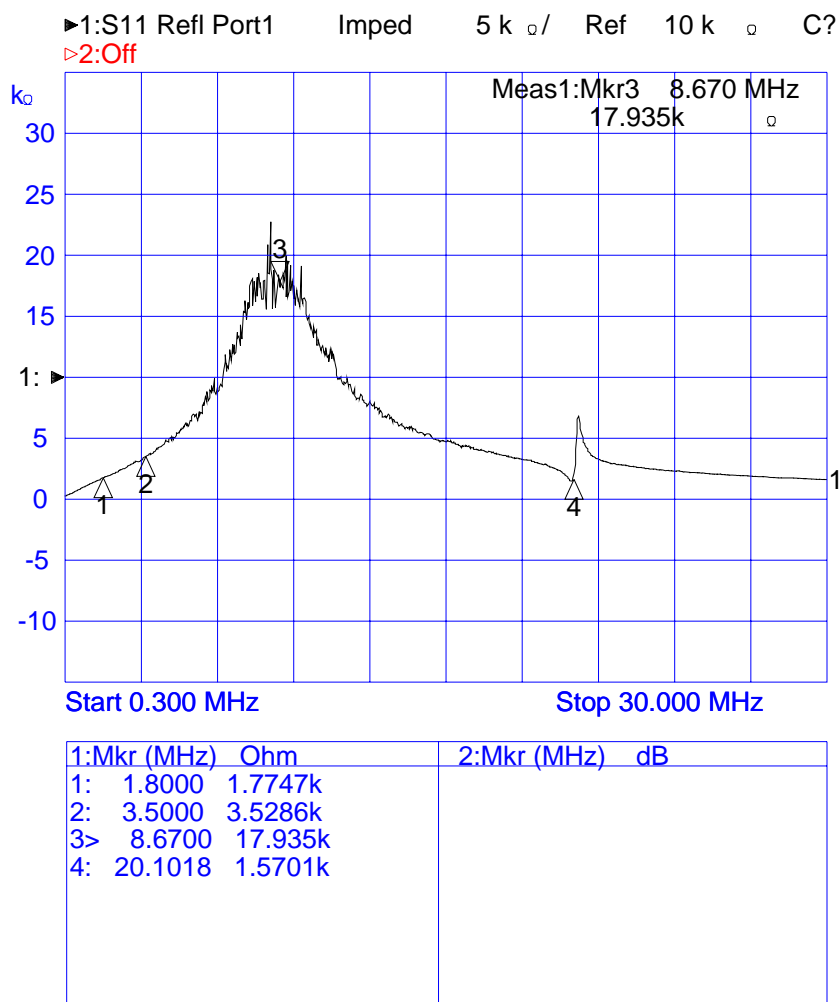


Figure 5 Impedance Response

Note that the resonant condition is further characterized by the rapid increase in impedance shown at 8.6Mc. This parallel resonate condition should NOT exist for any operational mode of HF band operation. As such, the coils are wound to ensure positioning of this between the 40M and 30M ham band. I don't know how stable the amplifier works on the 30M band due to increase choke impedance at this frequency.

Detailed Evaluation of individual L3 Elements

Inductor L3 is composed of two separate inductive windings on a ceramic rod. For the purposes of this evaluation, two L3 inductors are used. For the majority of measurements in this report the known good inductor is used for evaluation. L3, being composed of two inductors respectively named L3A and L3B are called to conduct the following analysis. Note that mutual coupling exists between the two inductors and the results of this analysis is shown above as the L3 response.

Inductor L3 section L3A attaches directly to the L2 inductive network and also sees capacitor C24. The other port of L3A connects to L3B.

Inductor L3 section L3B connects to L3A on one side and connects to capacitor C25 and inductor L4 by referencing the schematic.

Observation on the second L3 inductor indicates burns on L3A. There is no apparent burns or shorting on L3B. This leads me to believe that L3A sees the RF hot side and in cases of excessive reflection in combination with RF power output results in arcing of the inductor.

L3A is determined to be open and therefore measurements to obtain the actual inductive response of this section cannot be determined. However, an attempt to unwind and count turns will be attempted.

Number of Counted Turns on L3

L3A	74 Turns	10 feet wire length
L3B		

Table 2 Number of Turns Count for L3

Due to the destructive nature of these tests, L3B has not been unwound while L3A was unwound because the element was technically destroyed by arcing.

Analysis of section L3B

S11 Parametric Measurement

1.8	76 uH
3.5	83 uH
4	86 uH
7	118 uH
7.3	129 uH
10	366 uH
14	1 pF
18.5	1.7 pF
21.2	2 pF
24.5	2.6 pF
30	1.7 pF

Table 3 Parametric Results of L3B Over frequency

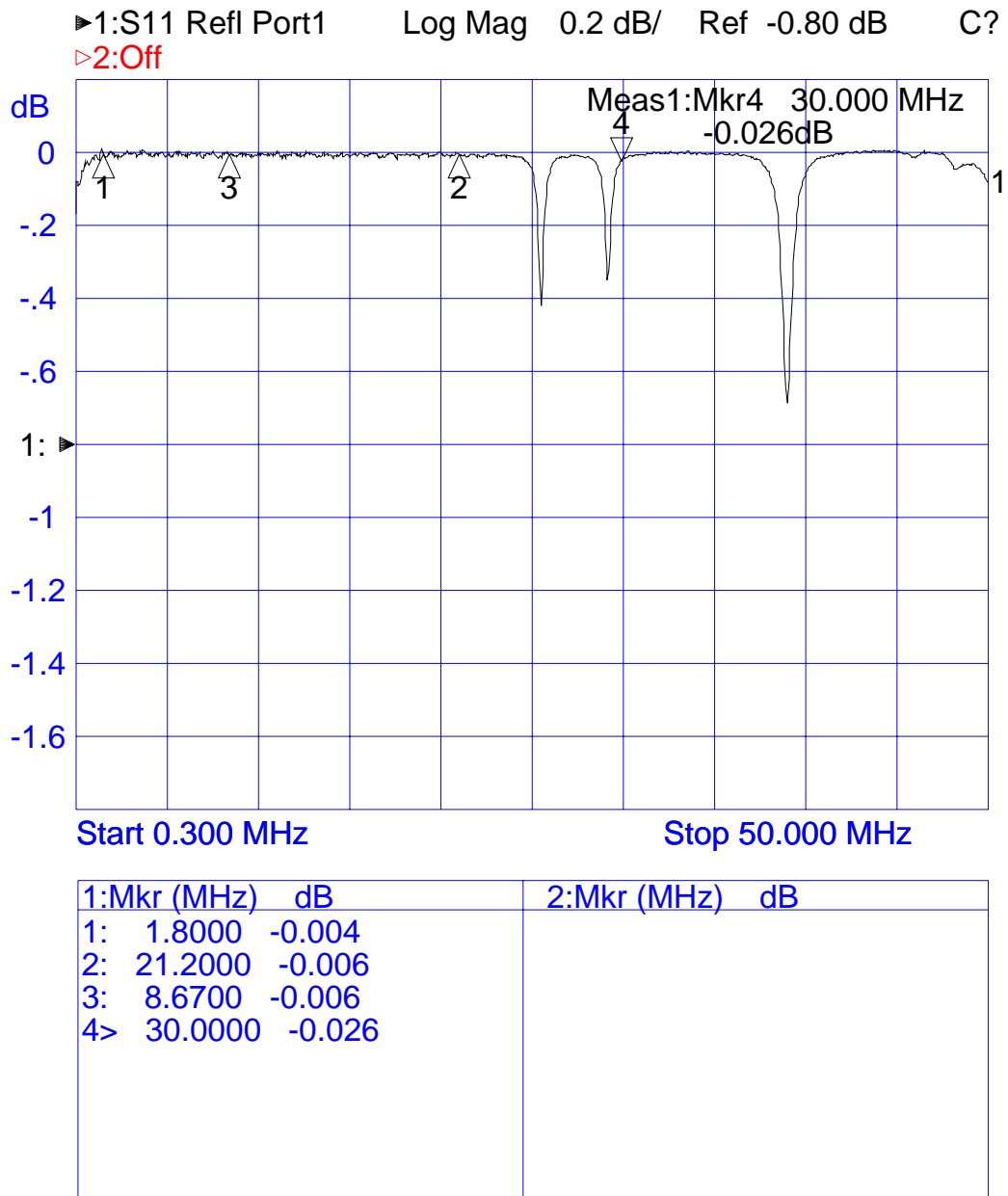


Figure 6 L3B S11 Log Mag

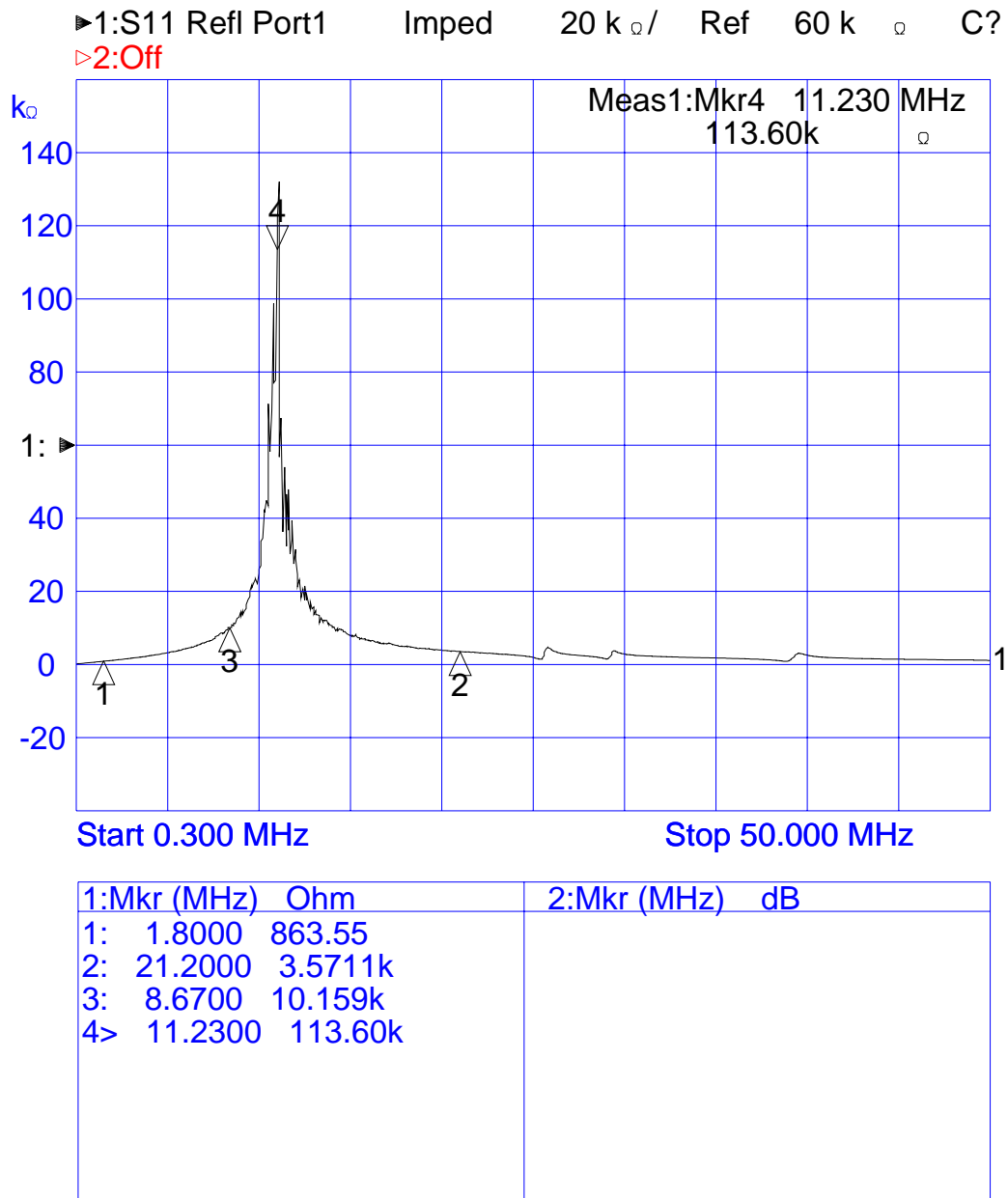


Figure 8 L3B Impedance Response

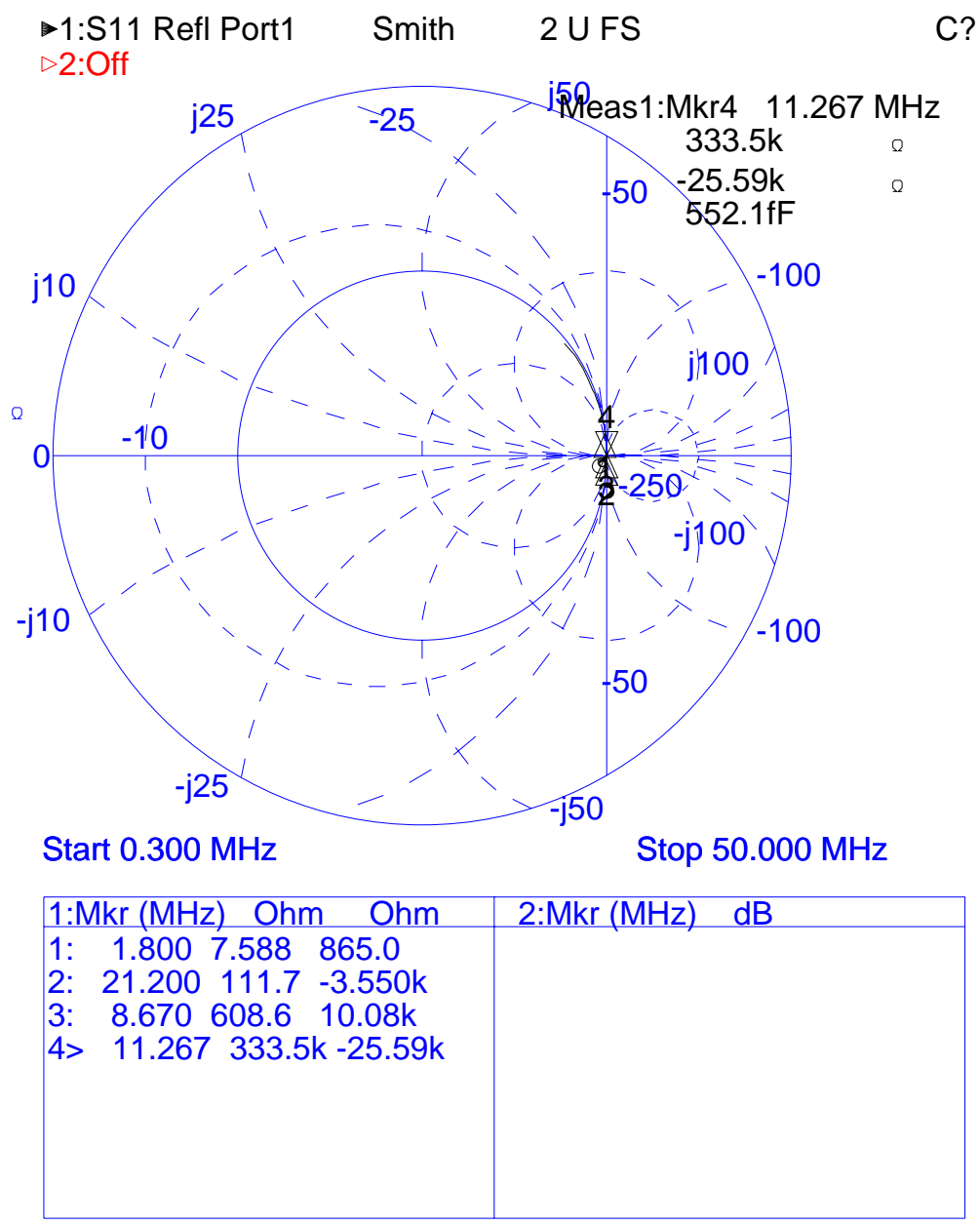
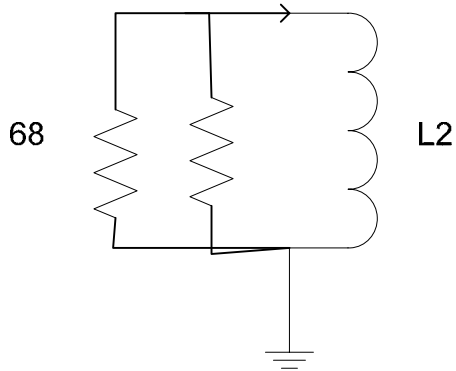


Figure 9 L3B S11 Smith analysis

Section II Inductor L2 Evaluation

The purpose of this inductor is to serve the high frequency portion of the HF band from 40M through 10M.



Note that Port 1 of the network analyzer is hooked to the top of the tank.

S11 Parametric Measurement

1.8	158 nH
3.5	144 nH
4	142 nH
7	135 nH
7.3	134 nH
10	131 nH
14	129 nH
18.5	127 nH
21.2	126 nH
24.5	125 nH
30	123 nH

Table 4 L2 Network Inductive Response

Note that this inductor looks and behaves like an inductor through the full HF range. No suck-outs or peaking occurs. This is used to complement the L3 response especially as the frequency increases above the natural resonant point of L3 and serves to provide inductive isolation to V1 at high frequencies.

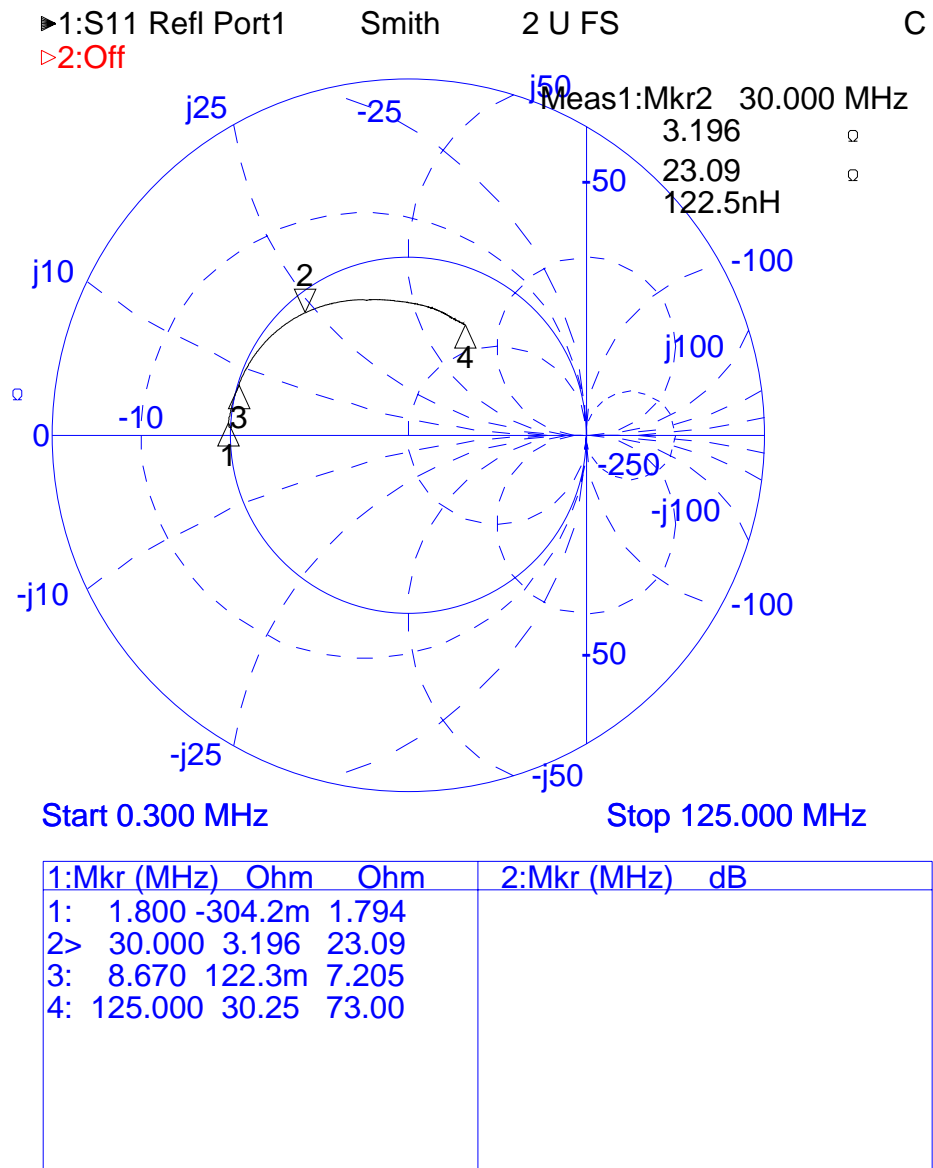
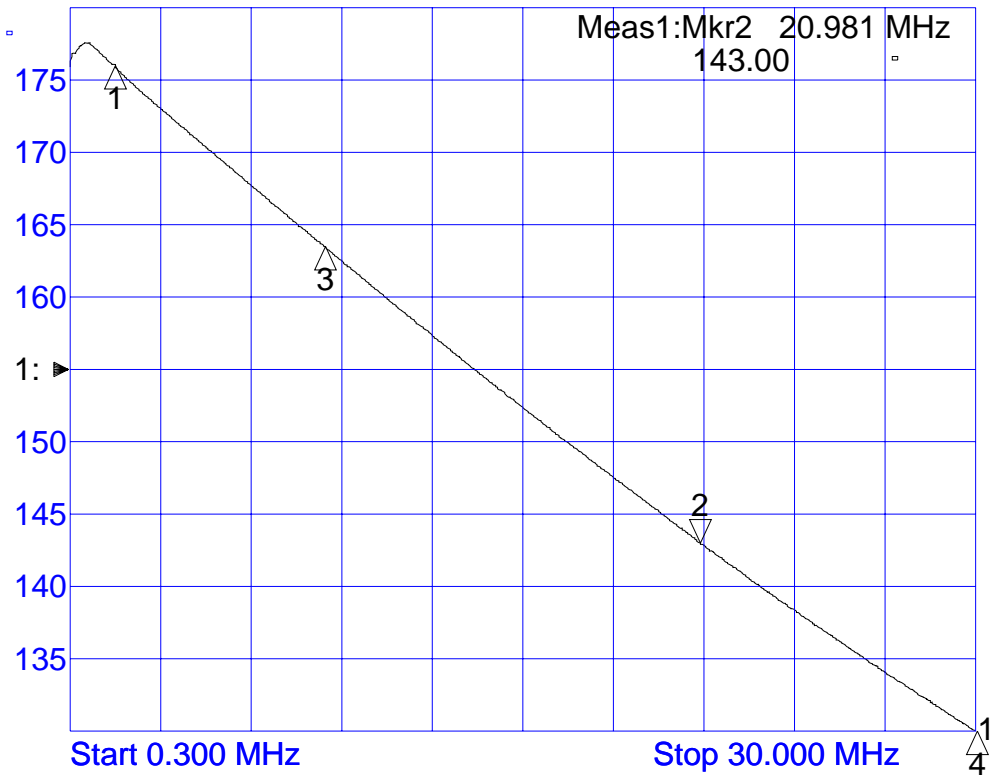


Figure 10 Smith response of L2 Network

►1:S11 Refl Port1 Phase 5.0 °/ Ref 155.00° C?
 ►2:Off



1:Mkr (MHz)	Deg	2:Mkr (MHz)	dB
1: 1.8000	175.99		
2> 20.9811	143.00		
3: 8.6700	163.49		
4: 30.0000	130.03		

Figure 12 Phase Response

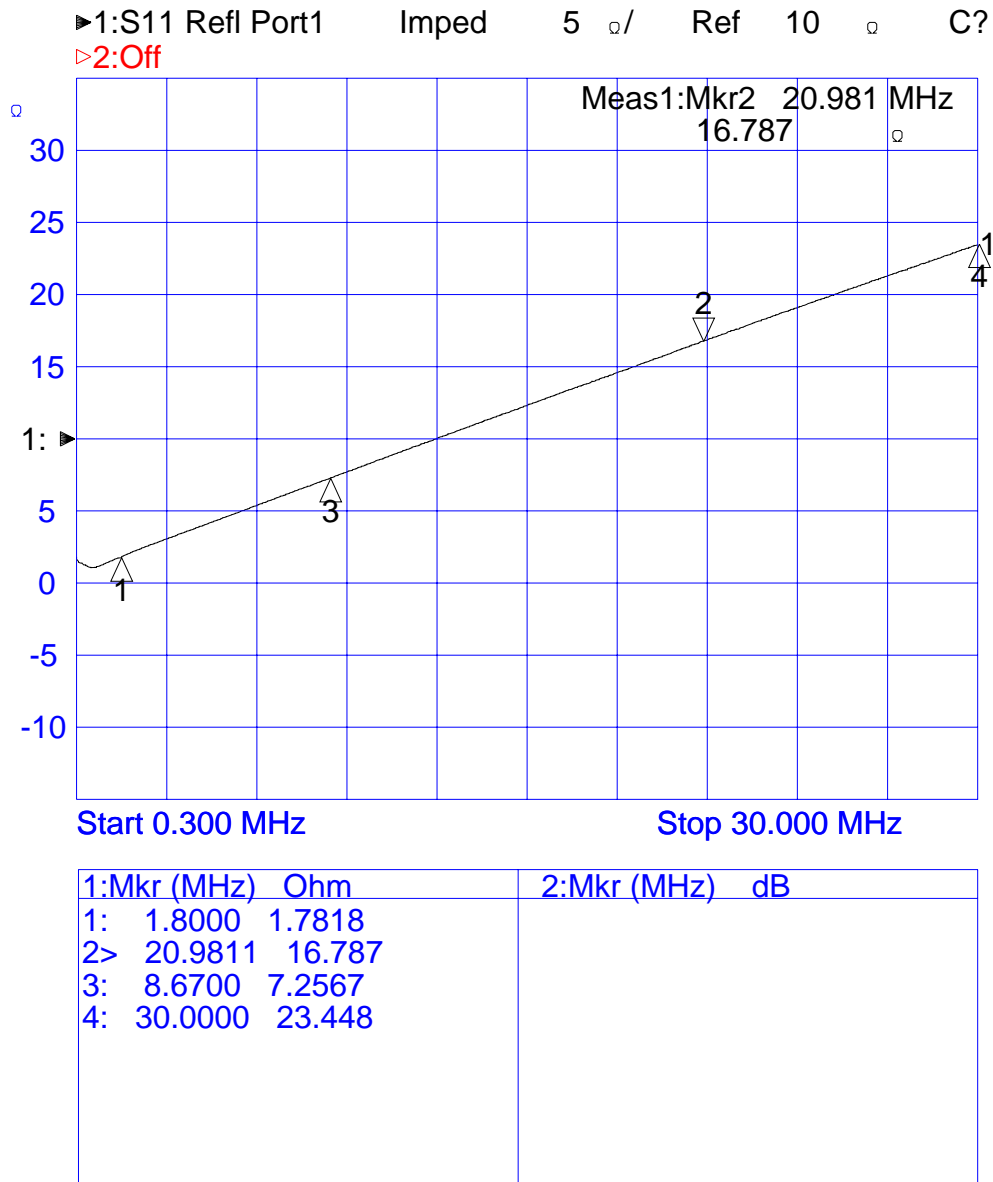


Figure 13 L2 Network Impedance Response

Section III Inductor L3 & L2 Evaluation

This section reviews the combination of L2 and L3 network elements. In order to minimize inductive coupling, the inductors are set perpendicular to one another. No further attempts to change coupling ratios due to non-orthogonal configurations is attempted.

Capacitor C25 was hooked to ground and the same test rerun. It is determined that the inclusion of C25 does not change the overall network response as was predicted from

general observation of the circuit. C25 is considered “fat” (low impedance) when it comes to frequency evaluation.

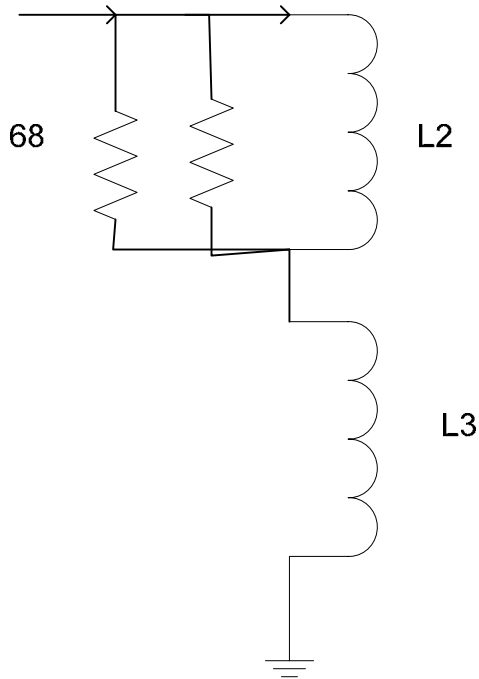


Figure 14 L2 and L3 Network Measurement Configuration

S11 Parametric Measurement

1.8	158 uH
3.5	168 uH
4	176 uH
7	242 uH
7.3	221 uH
10	1.55 pF
14	2.4 pF
18.5	3.1 pF
21.2	2.4 pF
24.5	3 pF
30	3.4 pF

Table 5 Parametric Results

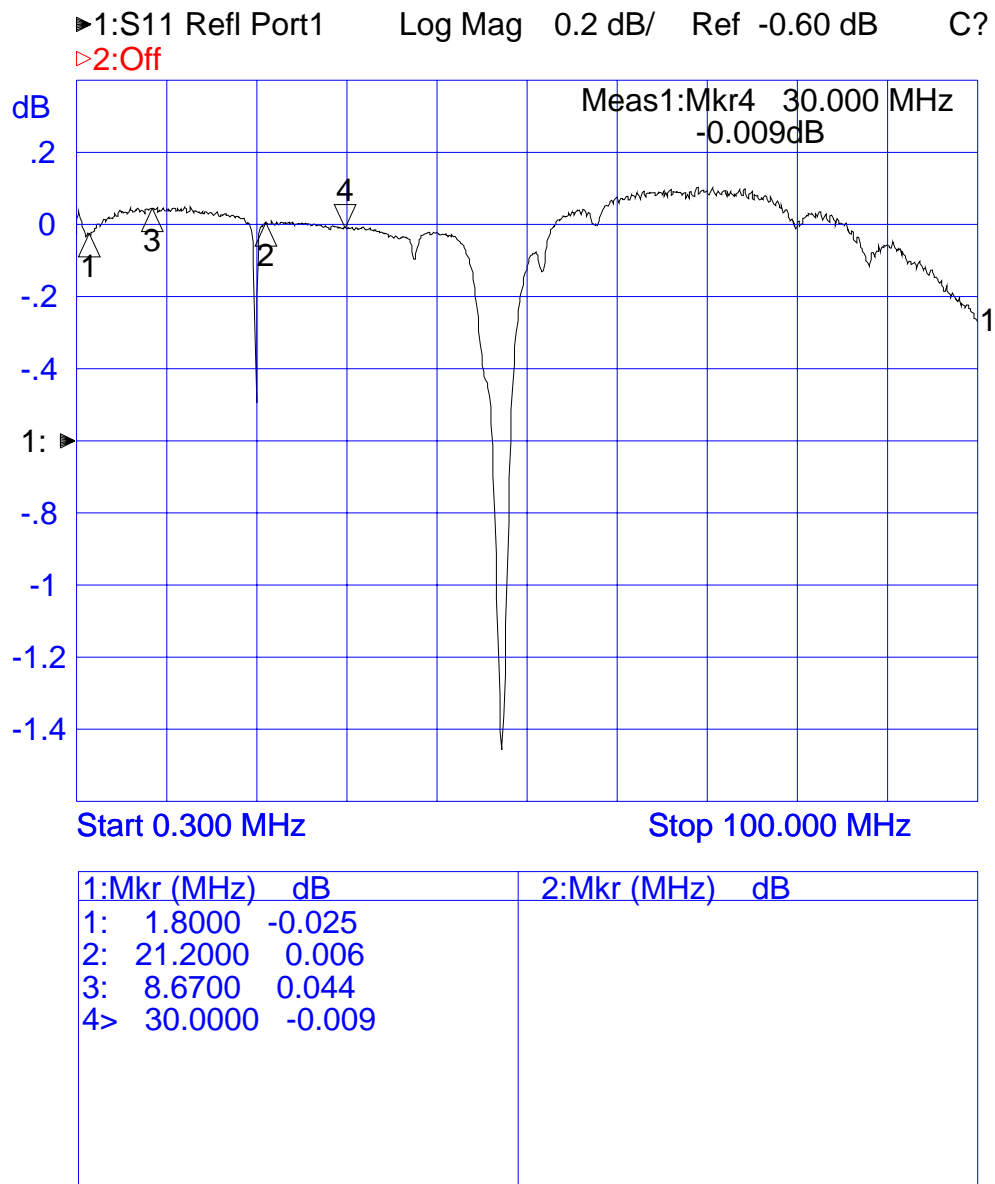


Figure 15 Log Mag Response

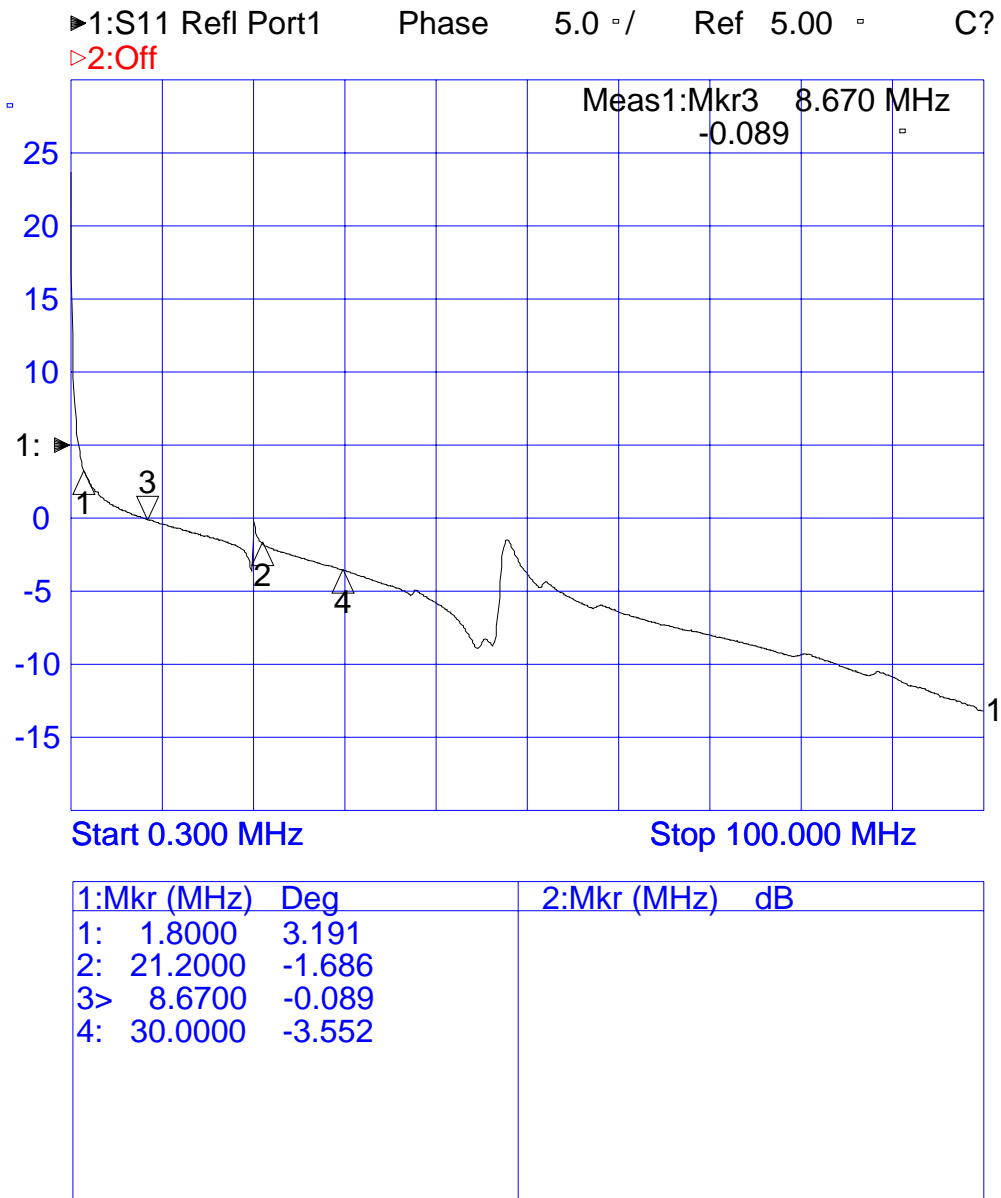
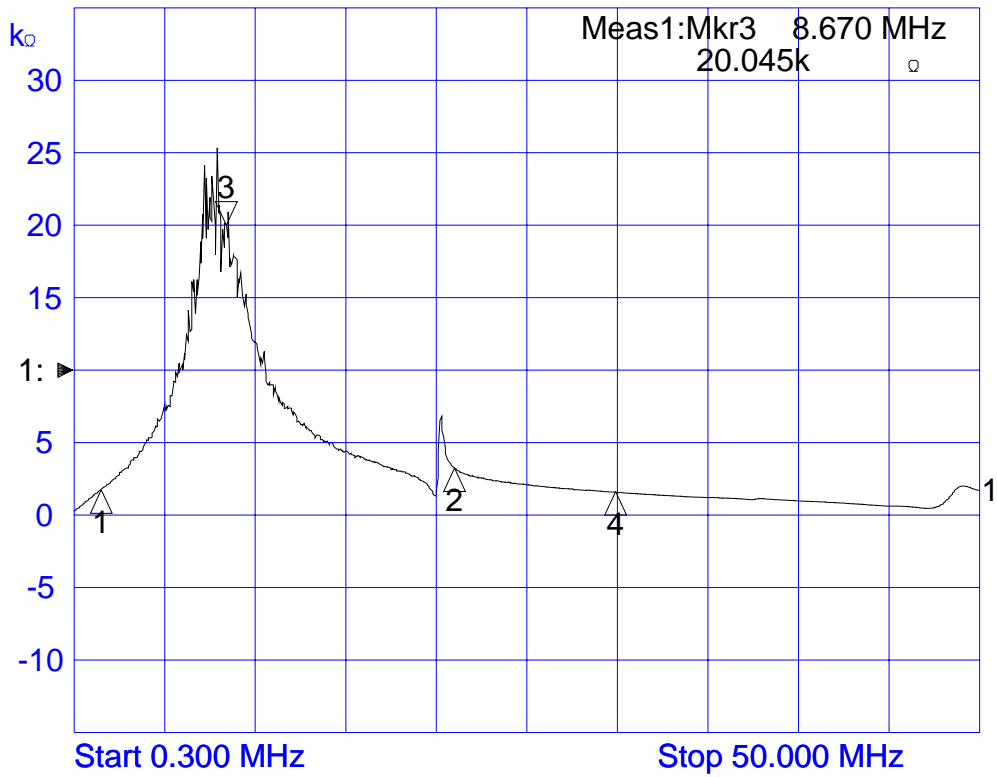


Figure 16 Phase Response

▶1:S11 Refl Port1 Imped 5 k Ω / Ref 10 k Ω C?
 ▷2:Off



1:Mkr (MHz)	Ohm	2:Mkr (MHz)	dB
1: 1.8000	1.7855k		
2: 21.2000	3.2473k		
3> 8.6700	20.045k		
4: 30.0000	1.5848k		

Figure 17 Impedance Response

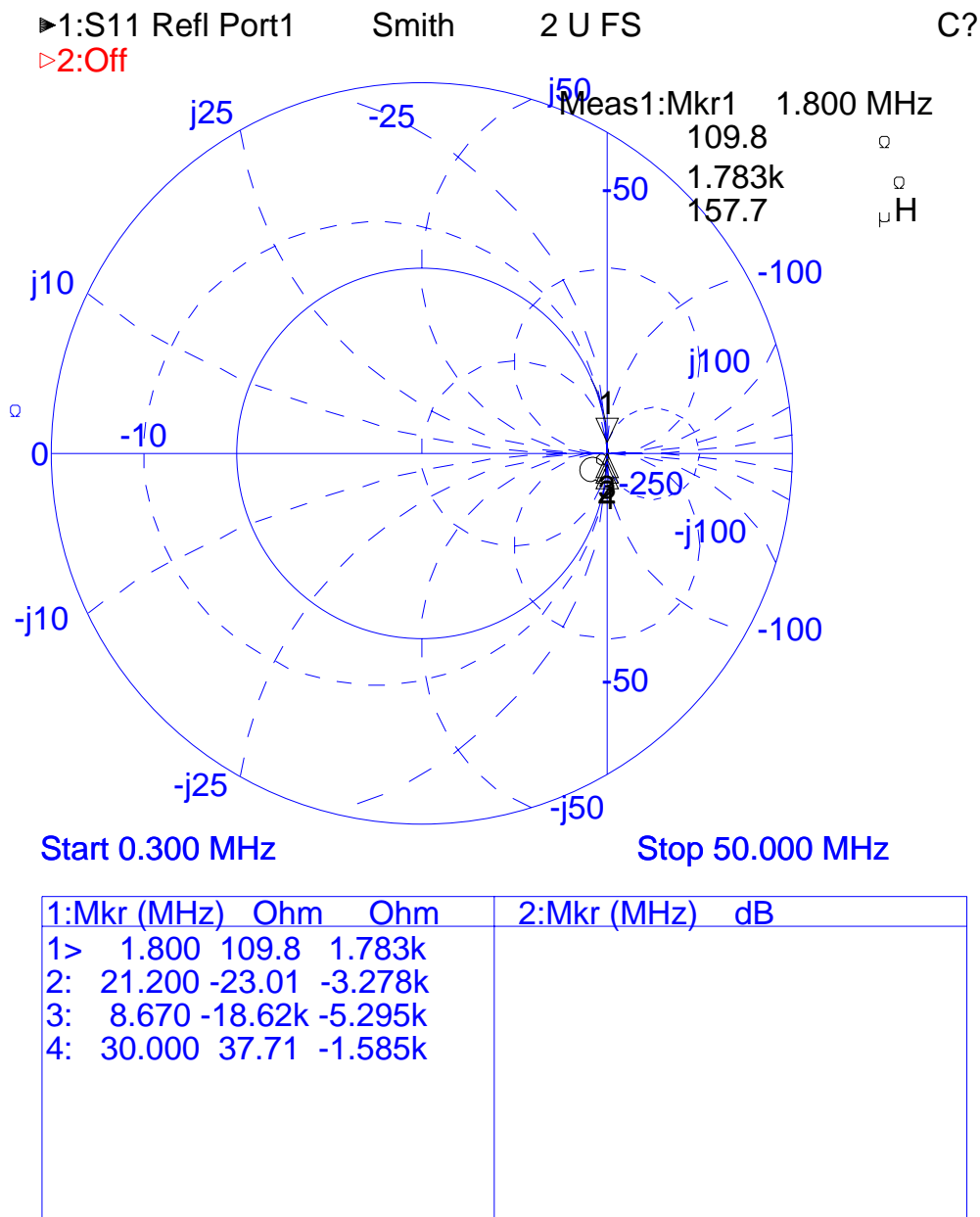


Figure 18 Smith Response

Section IV Full Two Port Response

This section looks at the full network in a 50-ohm source and loading. Understand that the actual parameters of the circuit most likely has differing source and load impedance, but the story in the results is nevertheless valuable. Further, the coupling capacitor that feeds Port 2 in figure 15 will see radical range of input impedance due to the loading C/L network loading.

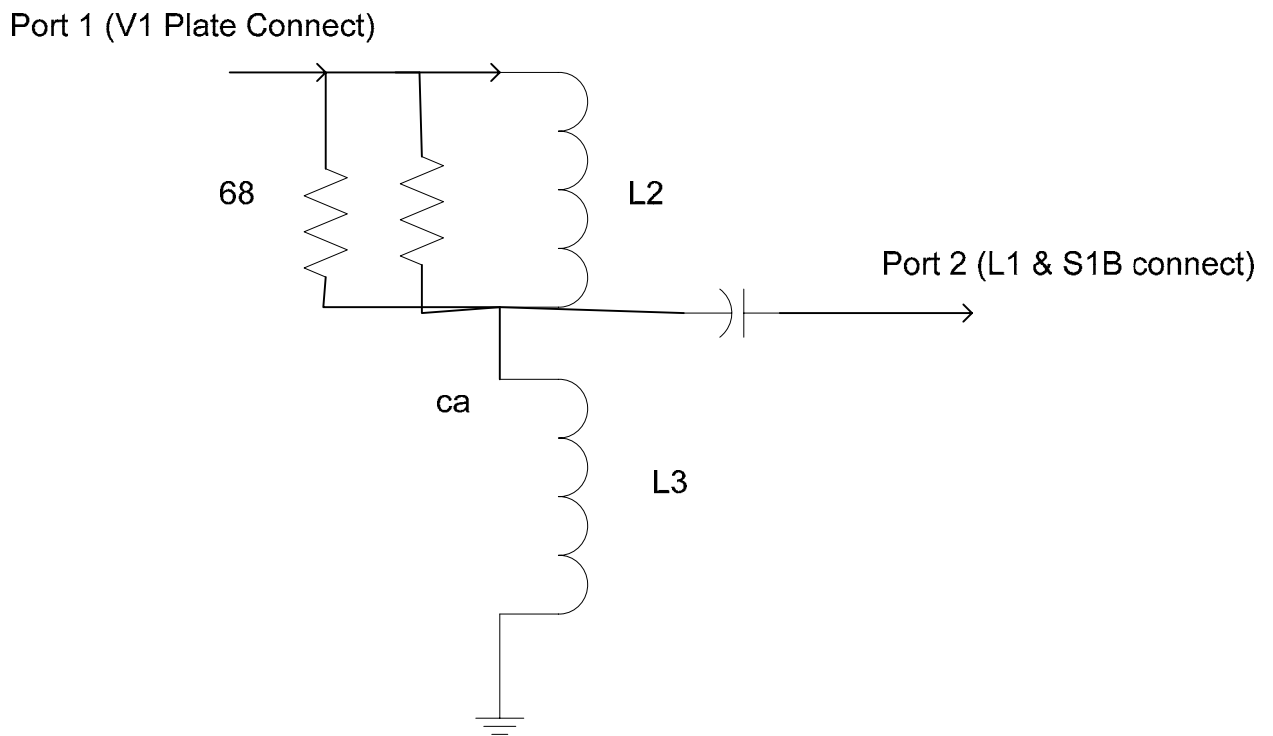
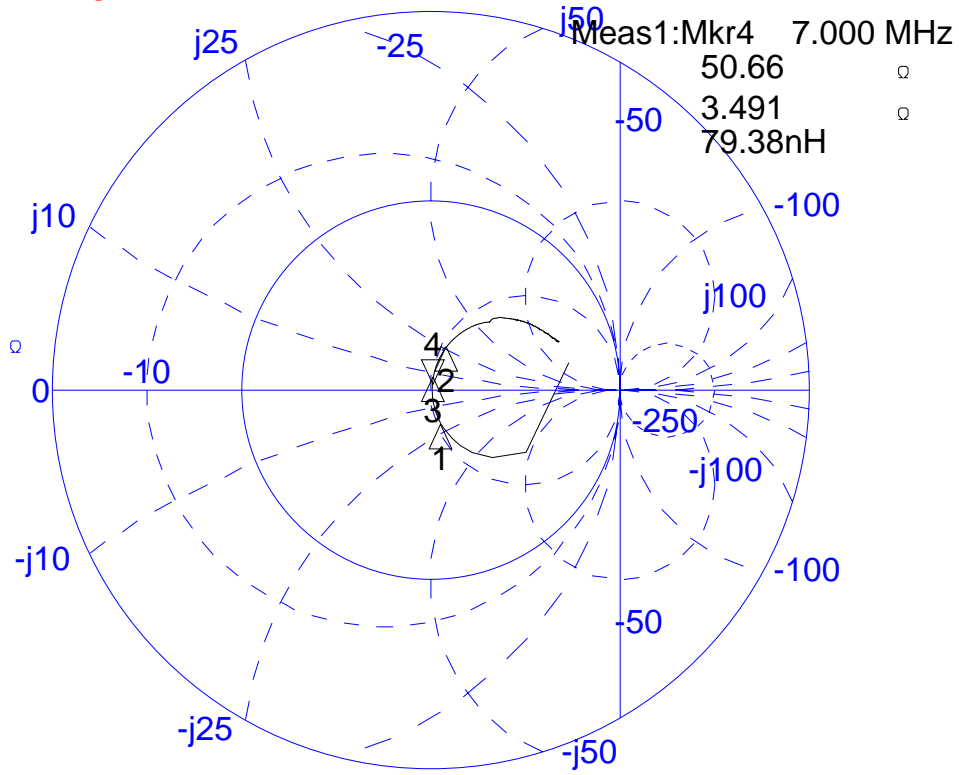


Figure 19 2-Port Configurations

In this configuration, Port 1 serves to connect where the plate of V1 8072 connects. Port 2 serves as the output that coupled into L1 and S1B for the overall schematic of the L/C tank. Port 1 and 2 are configured as 50 ohm source and load.

▶1:S11 Refl Port1 Smith 2 UFS C
 ▷2:Off



Start 0.300 MHz Stop 150.000 MHz

1:Mkr (MHz)	Ohm	Ohm	2:Mkr (MHz)	dB
1:	1.800	51.98	-19.31	
2:	21.200	52.49	25.09	
3:	8.670	50.76	6.653	
4>	7.000	50.66	3.491	

Figure 20 Full range S11 view of network
 S11 sweep of the reflected impedance on the port.

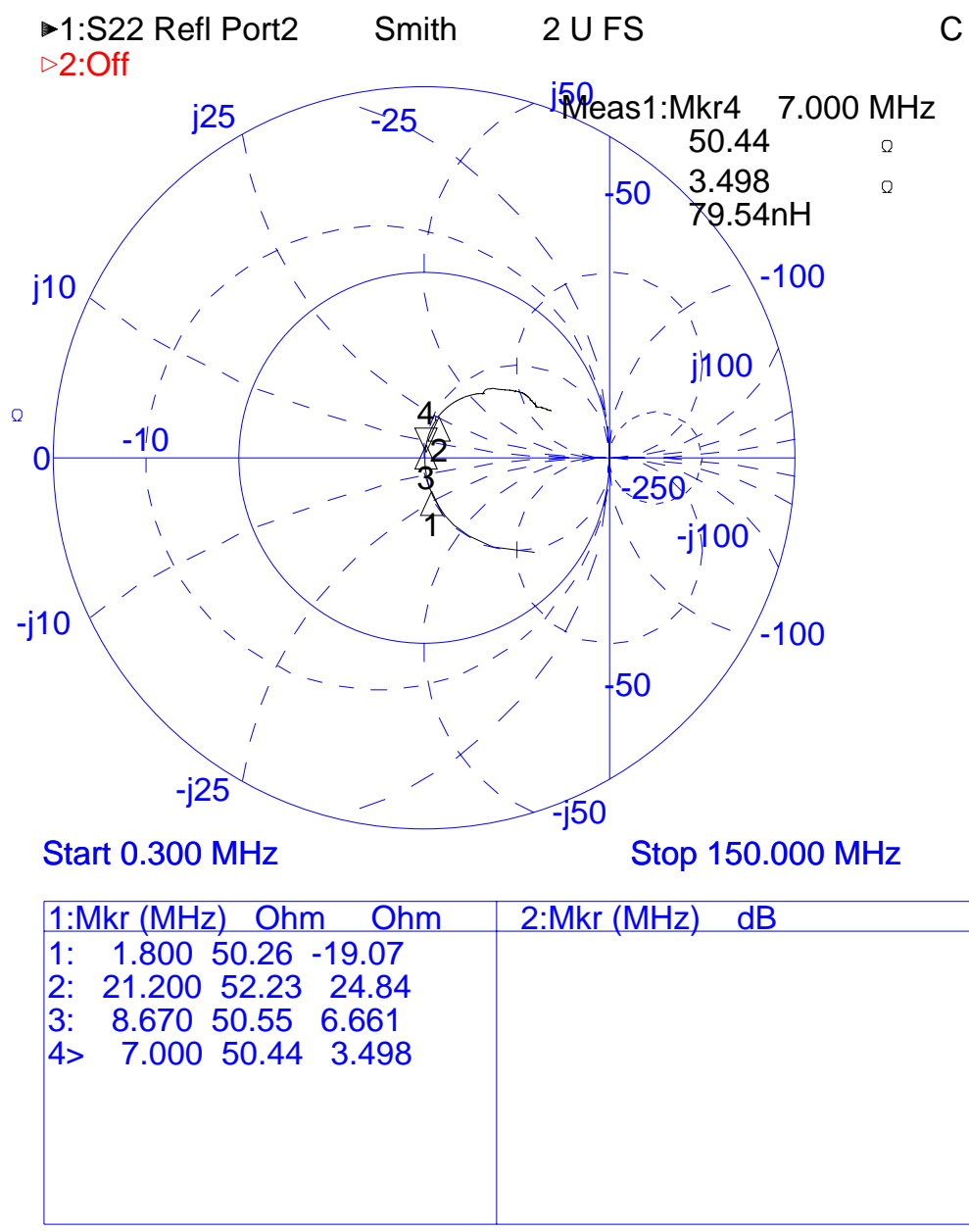
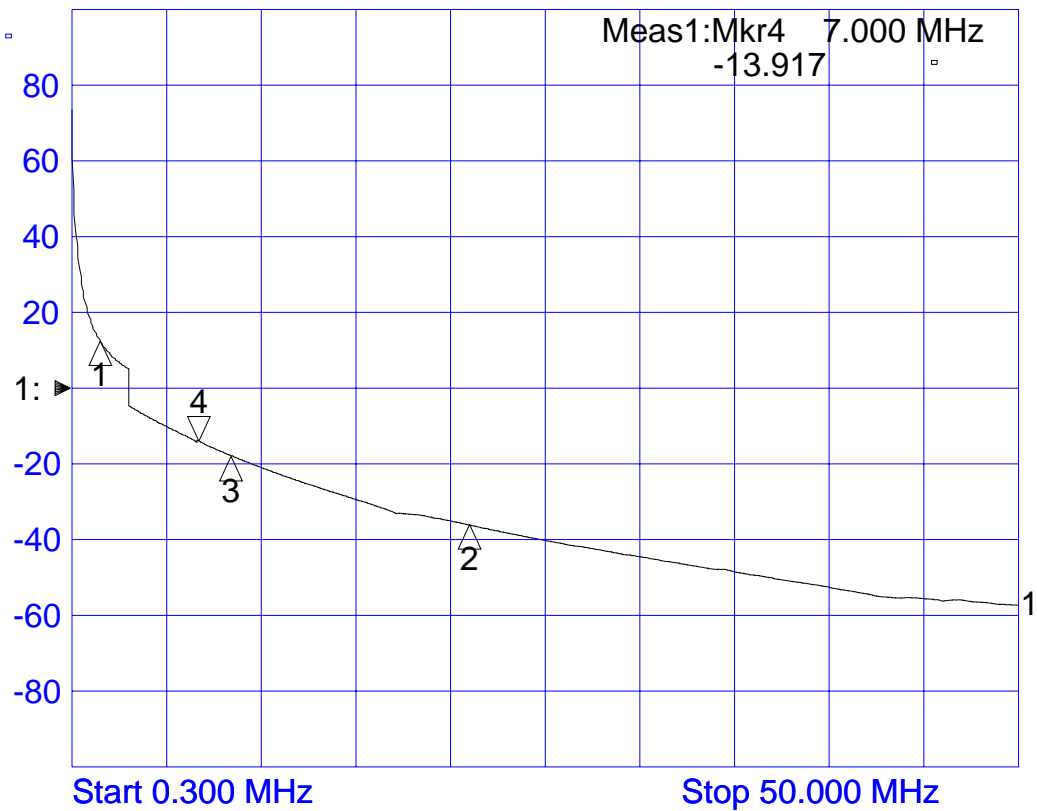


Figure 21 Full range sweep
S22 sweep of the impedance on Port 2 looking back into the network.

data ▶1:S21 Fwd Trans Phase 20.0°/ Ref 0.00 ° C?
 ▶2:Off



1:Mkr (MHz)	Deg	2:Mkr (MHz)	dB
1: 1.8000	12.561		
2: 21.2000	-36.094		
3: 8.6700	-17.778		
4> 7.0000	-13.917		

Figure 22 Network Phase Response

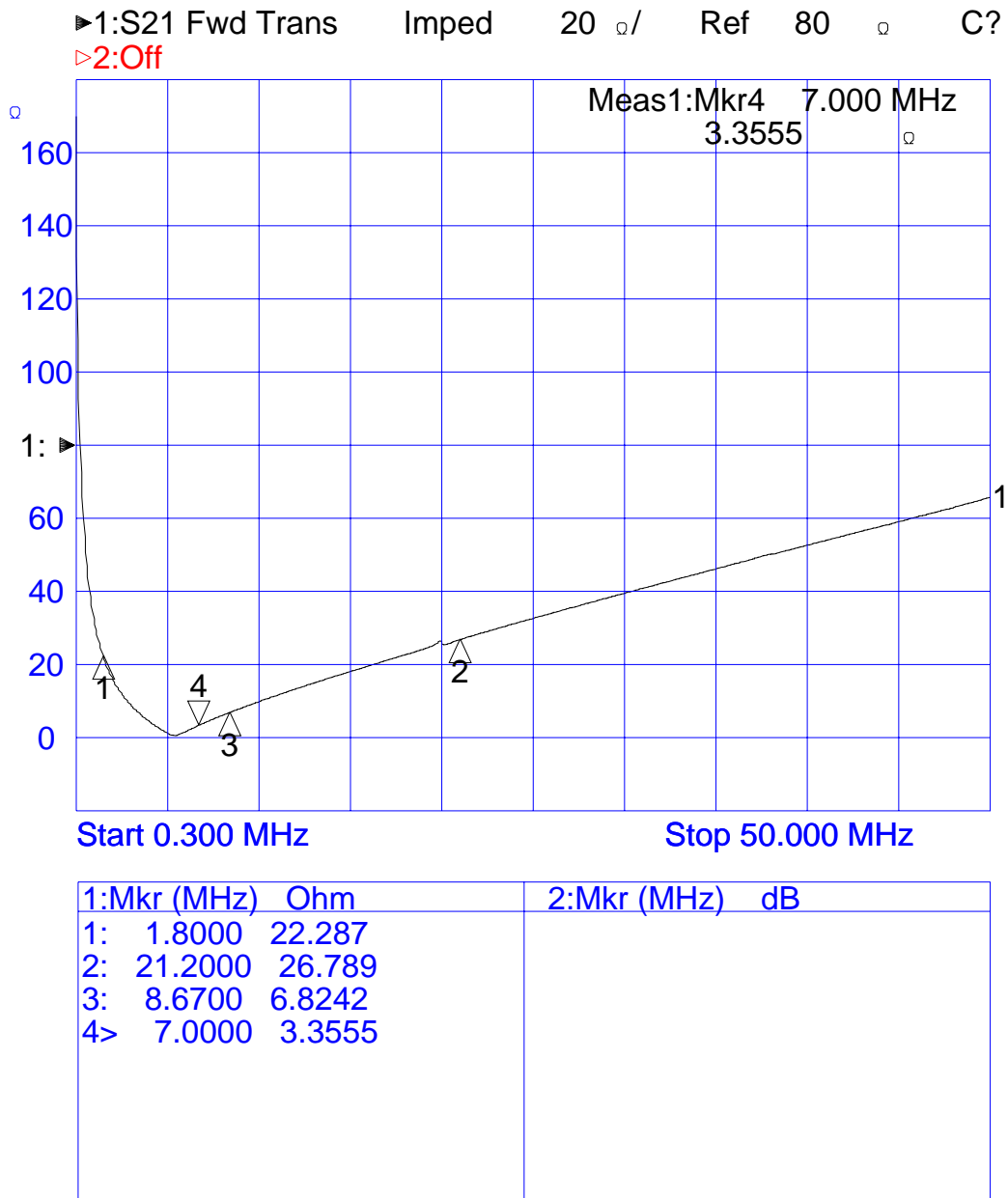


Figure 23 Impedance Response

Note the smooth response that on average runs around 12 ohms for the HF bands of operation.

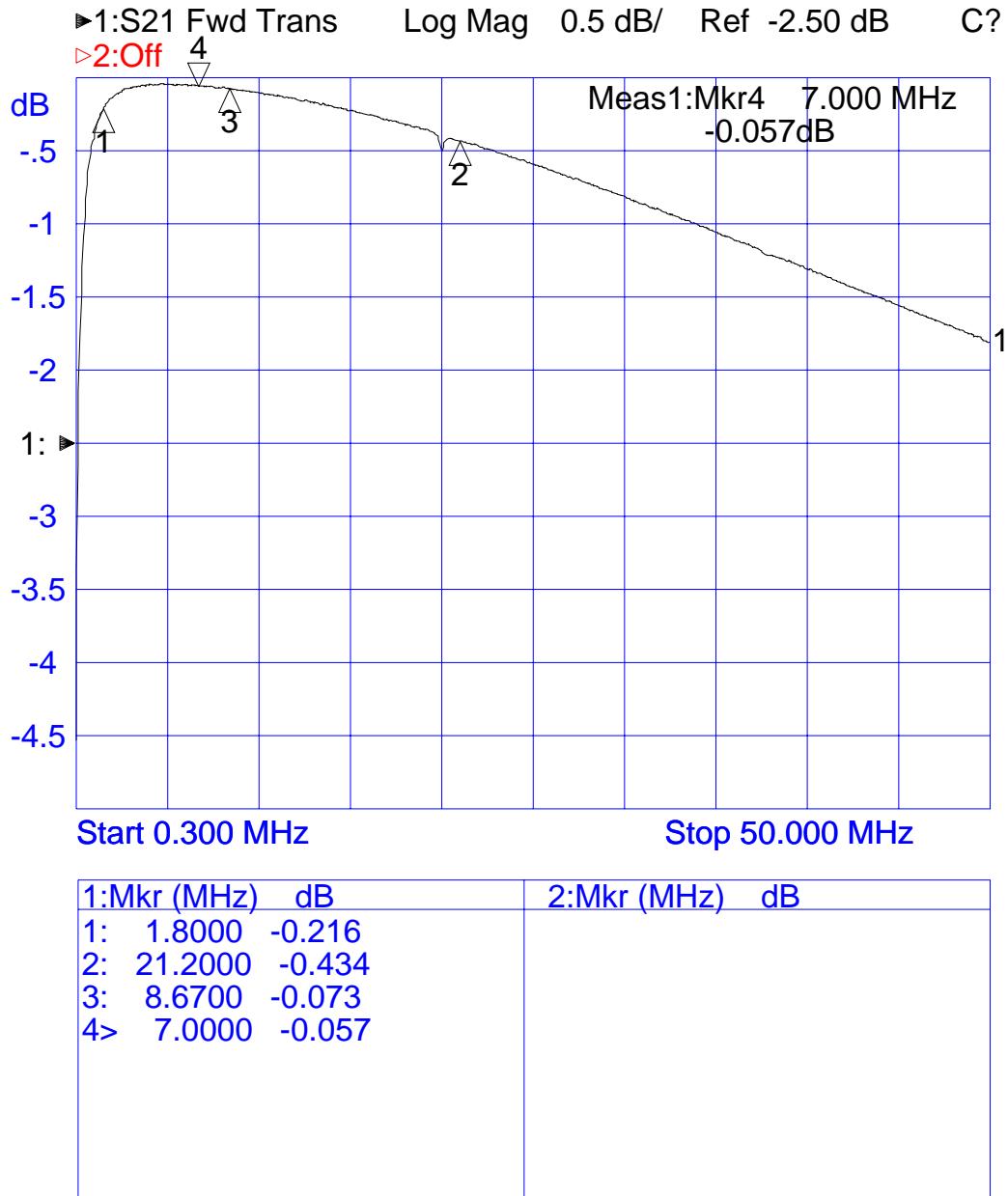
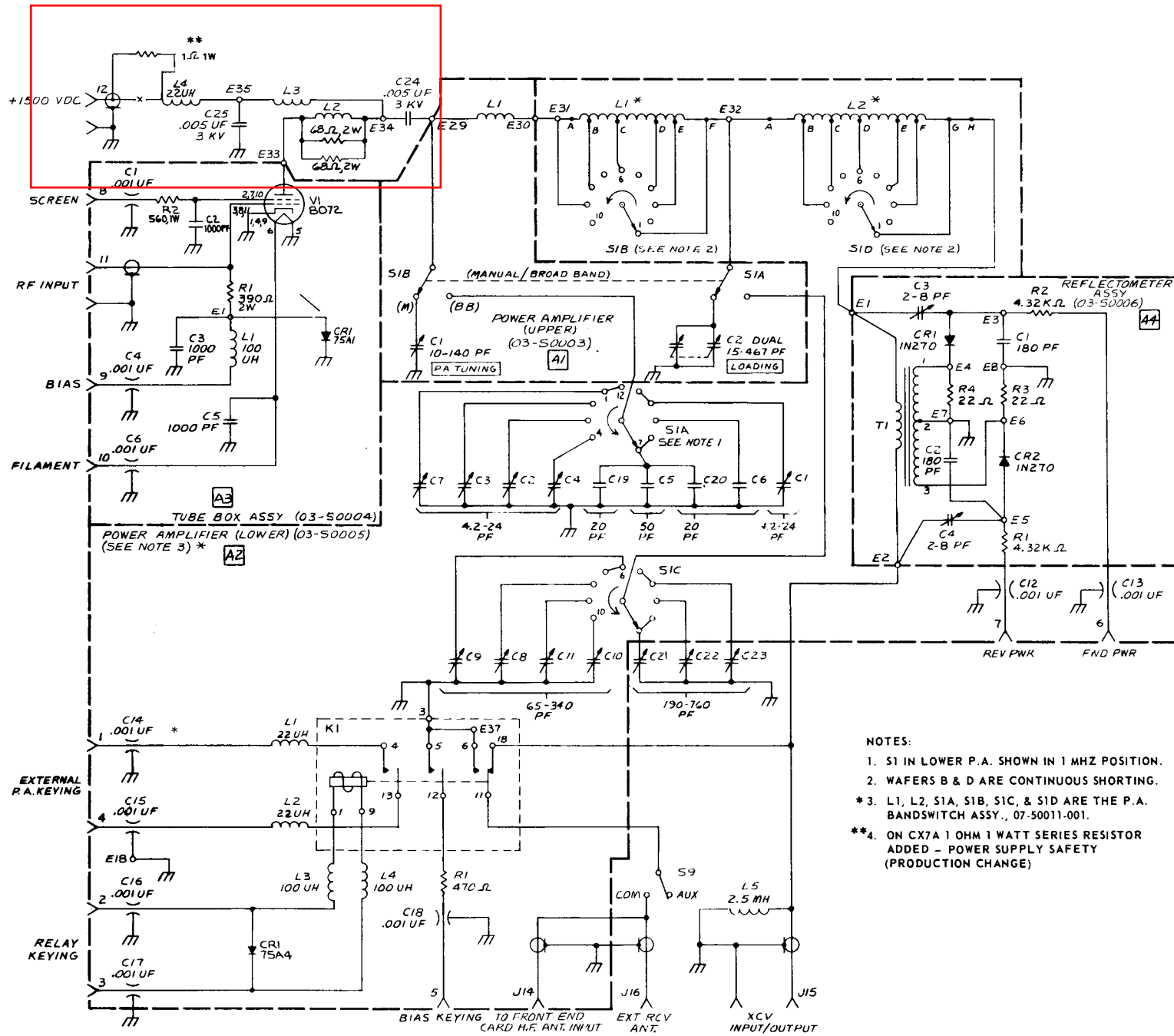


Figure 24 Log Mag response

This represents a smooth attenuation response. With the least impact on isolation in the network existing somewhere between the 80 and 40M band sections of operation.

Summary

Clearly operational response of the full network makes much better sense rather than looking at individual components of the network. Operation of the network is smooth and expected. Enough information is available in this analysis that winding and evaluation of the inductor, with a network analyzer can be accomplish should the network be duplicated.



- NOTES:
1. S1 IN LOWER P.A. SHOWN IN 1 MHZ POSITION.
 2. WAFERS B & D ARE CONTINUOUS SHORTING.
 3. L1, L2, S1A, S1B, S1C, & S1D ARE THE P.A. BANDSWITCH ASSY., 07-50011-001.
 - **4. ON CX7A 1 OHM 1 WATT SERIES RESISTOR ADDED - POWER SUPPLY SAFETY (PRODUCTION CHANGE)

Figure 6-11. Power Amplifier Assembly A10 Schematic Diagram