

Field Service Report FM Combiner and Antenna System

Bemidji, MN.

Broadcast Facility

ERI Antenna: SHPX-10AC6-SP

ERI 783-4A "TEE" Combiner

Feedline: MacxLine 450 17.5' Sticks 200 Feet
and Andrew HJ11-50 Flex 275 Feet

KLLZ – 99.9 MHz.

KBHP – 101.9 MHz.

ERI Antenna: SHPX-10AC-SP

ERI 945-4 Notch Filters

Feedline: Andrew HJ8-50B Flex 361 Feet

KKZY – 95.5 MHz.

ERI Project # 32949C

February 15, 2015

Submitted By:

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TABLE OF CONTENTS

INTRODUCTION.....	3
SUMMARY and RECOMMENDATIONS	3
DRAWINGS	4
Figure 1: “T” Combiner Drawing for KLLZ and KBHP.....	4
Figure 2: Antenna Drawing for KLLZ and KBHP	5
Figure 3: Tuning Slug Location and Feedline Layout	6
Measurement 1: Match and Insertion Loss of 99.1 MHz.	7
Measurement 2: Isolation +/- 800 KHz. of 99.1 MHz.....	8
Measurement 3: Group Delay of 99.1 MHz.	9
Measurement 4: Match and Insertion Loss of 101.1 MHz.	10
Measurement 5: Isolation +/- 800 KHz. of 101.1 MHz.....	11
Measurement 6: Group Delay of 101.1 MHz.	12
Measurement 7: Port to Port Isolation 99.1 to 101.1 MHz.....	13
Measurement 8: Narrow Sweep of Feedline with 50 ohm Load.	14
Measurement 9: 88 to 108 MHz. Sweep of Feedline with 50 ohm Load.	15
Measurement 10: 50 to 400 MHz. Sweep of Feedline with 50 ohm Load TDR.	16
Measurement 11: Narrow Sweep of Final Antenna 99.1 & 101.1 MHz.	17
Measurement 12: Narrow Sweep of Final Antenna 99.1 & 101.1 MHz.	18
Measurement 13: Filter to Antenna 99.1 MHz. Return Loss Measurement.....	19
Measurement 14: Filter to Antenna 99.1 MHz. VSWR Measurement.	20
Measurement 15: Filter to Antenna of 101.1 MHz. Return Loss Measurement.....	21
Measurement 16: Filter to Antenna of 101.1 MHz. VSWR Measurement.	22
Figure 4: Vertical Plane relative Field Plot of 99.1 MHz.	23
Figure 5: Vertical Plane Relative Field Plot of 101.1 MHz.	24
Table 1: Loss Budget 99.1 MHz.	25
Table 2: Loss Budget Table 101.1 MHz.	26
Figure 6: Drawing of Notch System for 95.5 MHz.	27
Measurement 17: Match & Insertion Loss of Notch Filters 95.5 MHz.....	28
Measurement 18: Notch of 99.1 MHz. & 101.1 MHz. Filters.	29
Measurement 19: Narrow sweep of Feedline & Antenna 95.5 MHz.....	30

Measurement 20: 88 to 108 MHz sweep of Feedline & Antenna.	31
Measurement 21: 50 to 400 MHz. Sweep of Feedline & Antenna TDR.....	32
Measurement 22: Filter to Antenna Return Loss 95.5 MHz.....	33

INTRODUCTION

Listed below is a summary of the data and attached are the plots collected from the KLLZ ~ KBHP and KKZY transmission site in Bemidji, MN. By Jeff Taylor February 15, 2015.

- The antenna for KLLZ and KBHP is a SHPX-10AC6-SP.
- The combiner for KLLZ and KBHP is a 783-4A "TEE" Combiner with Forced Air Cooling.
- The antenna for KKZY is a SHPX-10AC-SP.
- The combiner for KKZY is a 945-4 Notch Filter System.
- Equipment used for both systems was a Rohde & Schwarz ZVL Network Analyzer.
- Equipment used for filter to antenna and antenna testing was a Rohde & Schwarz ZVL Network Analyzer High RF setup.
- All measurements of the "T" combiner for KLLZ and KBHP were taken at the input of each directional coupler and at the output directional coupler.
- All feedline and antenna measurements for KLLZ and KBHP were taken at the 6 1/8" elbow flex connector above the "T" combiner.
- All measurements of the Notch filters were taken were at the 3 1/8" input and output of the Notch filters.
- All feedline and antenna measurements for KKZY were taken at the 3 1/8" elbow on the flex connector.

Site Address: 49228 229th Ave.
Bemidji, MN.

Attendees: Sky Tower Works Aaron Adams
ERI: Jeff Taylor Field Technician

The reason for this Field Service Trip was to sweep the feedline, tune antenna, fine adjust "T" combiner, and proof the system for the combined system KLLZ and KBHP.

KKZY scope of work was to retune two notch filters to pass 95.5 MHz. and reject 99.1 MHz., then attach the retuned notches to the existing notches in the system. Feedline and antenna measurements were also taken for future use.

Final tuning of the KLLZ and KBHP antenna was completed with VSWR's no worse than 1.01:1 @ carrier and 1.02:1 +/- 100 KHz. of carrier.

Filter to antenna performance for KLLZ and KBHP VSWR's @ carriers was no worse than 1.03:1 and 1.06:1 +/- 100 KHz. of carrier.

Pages 4 thru 26 of this report are for the combined system of KLLZ & KBHP.

Pages 27 thru 33 of this report are for the notch system of KKZY.

SUMMARY and RECOMMENDATIONS

The antenna for KKZY antenna has been in service for 14 years with no operating issues to my knowledge. ERI recommends that the antenna is due for a rebuild which requires replacement of the up and down bullets and o-rings of the antenna array. This is not a requirement, but a good engineering practice to follow. Once that work has been completed, a field tune would improve the match to reduce the standing wave.

All measurements were taken by Jeff Taylor of Electronics Research Inc. February, 2015.

Sincerely Jeff Taylor

DRAWINGS

Figure 1: "T" Combiner Drawing for KLLZ and KBHP

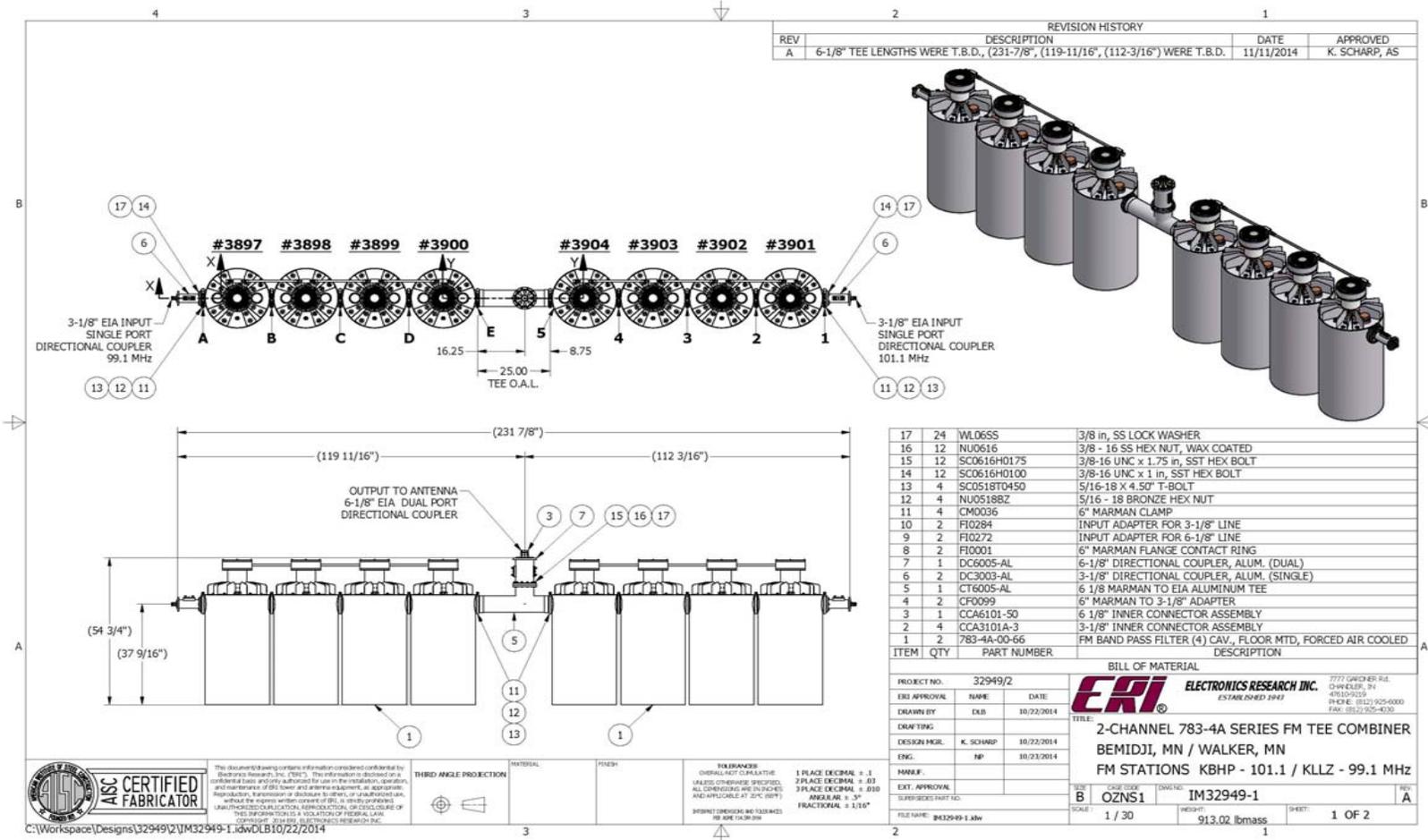


Figure 2: Antenna Drawing for KLLZ and KBHP

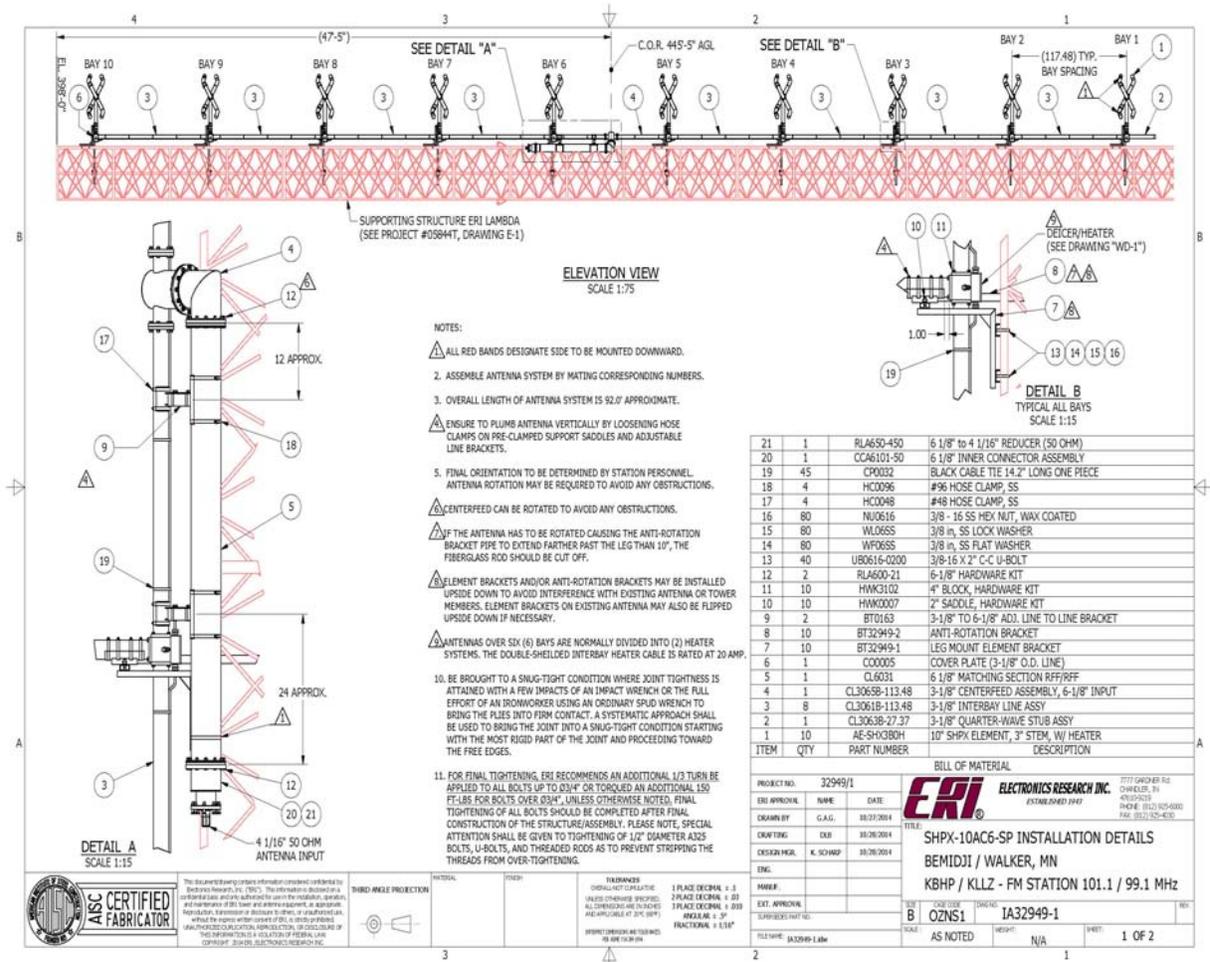
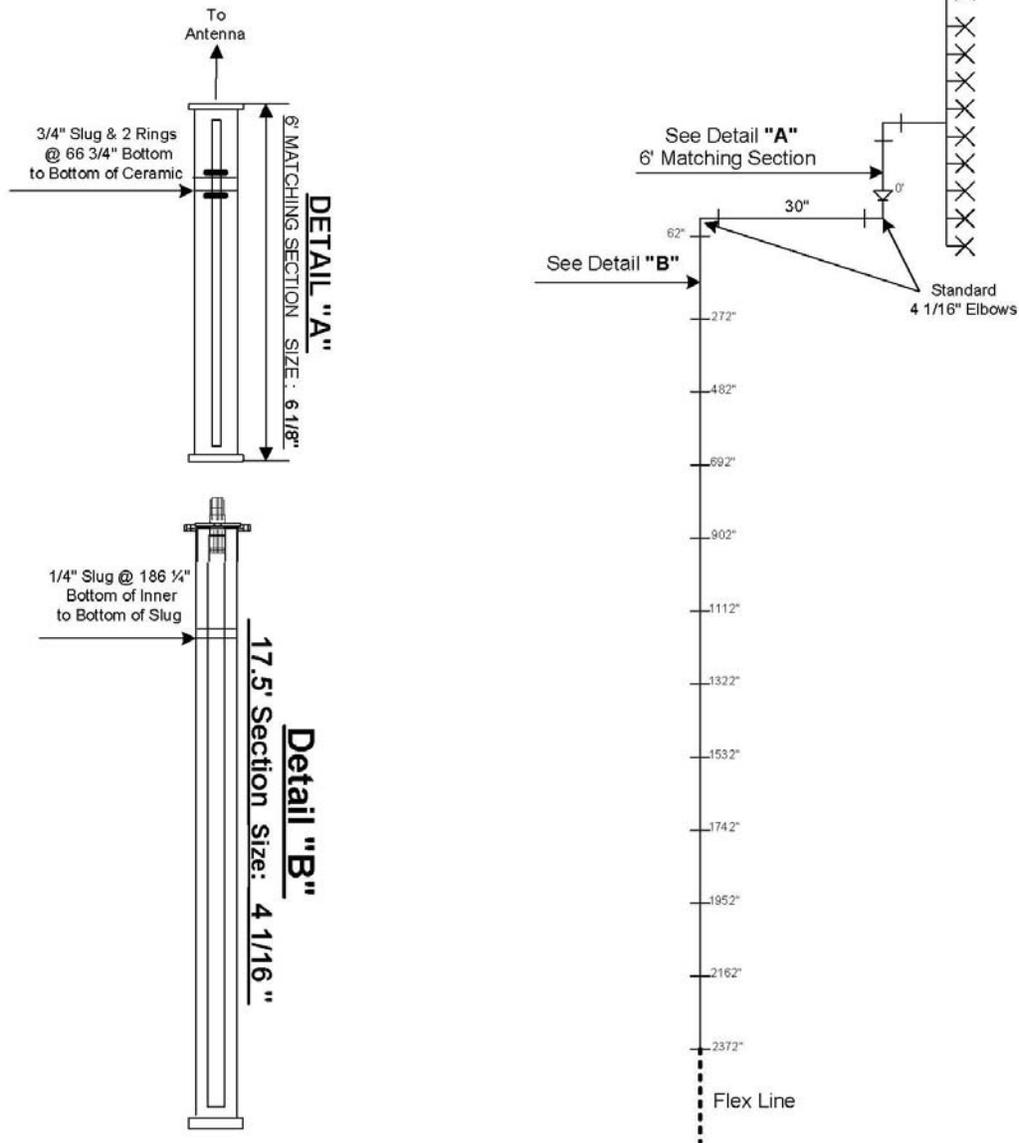


Figure 3: Tuning Slug Location and Feedline Layout

Tuning Slug Location for Bemidji, MN.

KLLZ - 99.1 MHz / KBHP - 101.1 MHz.

SHP-10AC6-SP



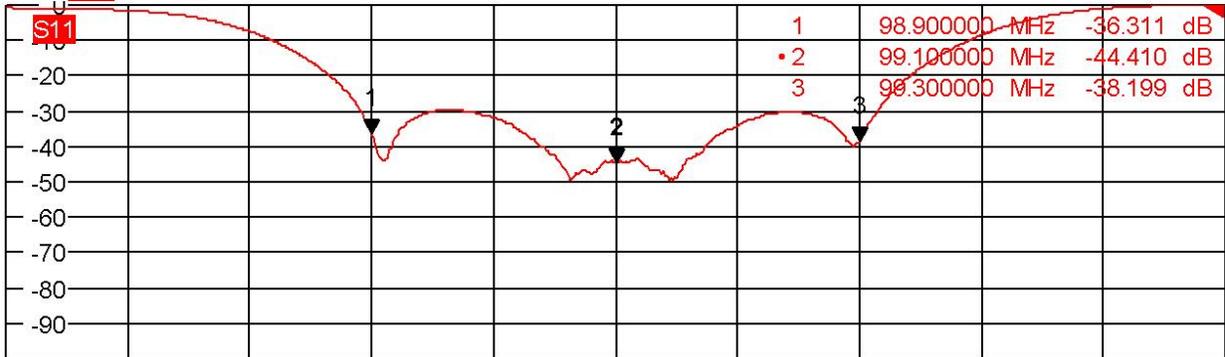
PROJECT #: 32949C DATE: 2-9-15 LINE SIZE: 4 1/16" ERI MacxLine Rigid SECTION LENGTHS: 17.5' & Andrew H11-50

Measurement 1: Match and Insertion Loss of 99.1 MHz.



Trc1 S11 dB Mag 10 dB / Ref 0 dB Cal Smo

1



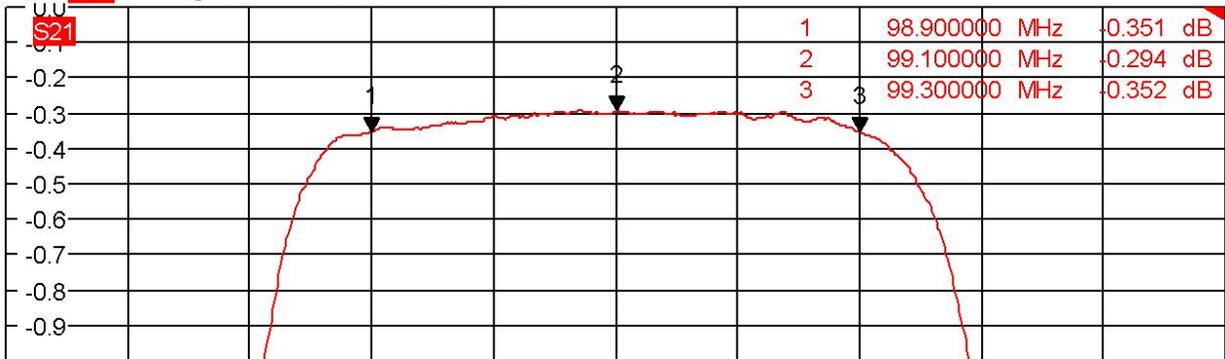
Ch1 Center 99.1 MHz

Pwr 10 dBm

Span 1 MHz

Trc2 S21 dB Mag 0.1 dB / Ref 0 dB Cal Smo

2



Ch1 Center 99.1 MHz

Pwr 10 dBm

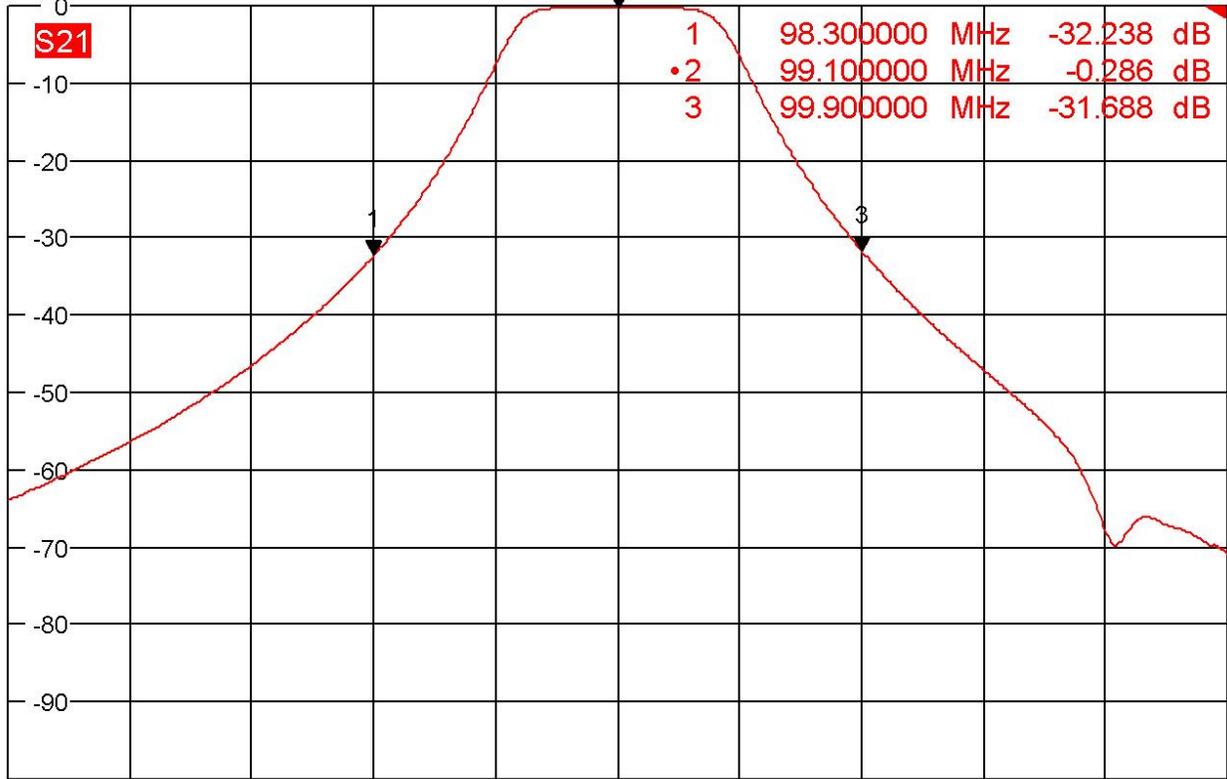
Span 1 MHz

Date: 10.FEB.2015 14:11:42

Measurement 2: Isolation +/- 800 KHz. of 99.1 MHz.



Trc2 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo 2 of 2 (Max)



Ch1 Center 99.1 MHz

Pwr 10 dBm

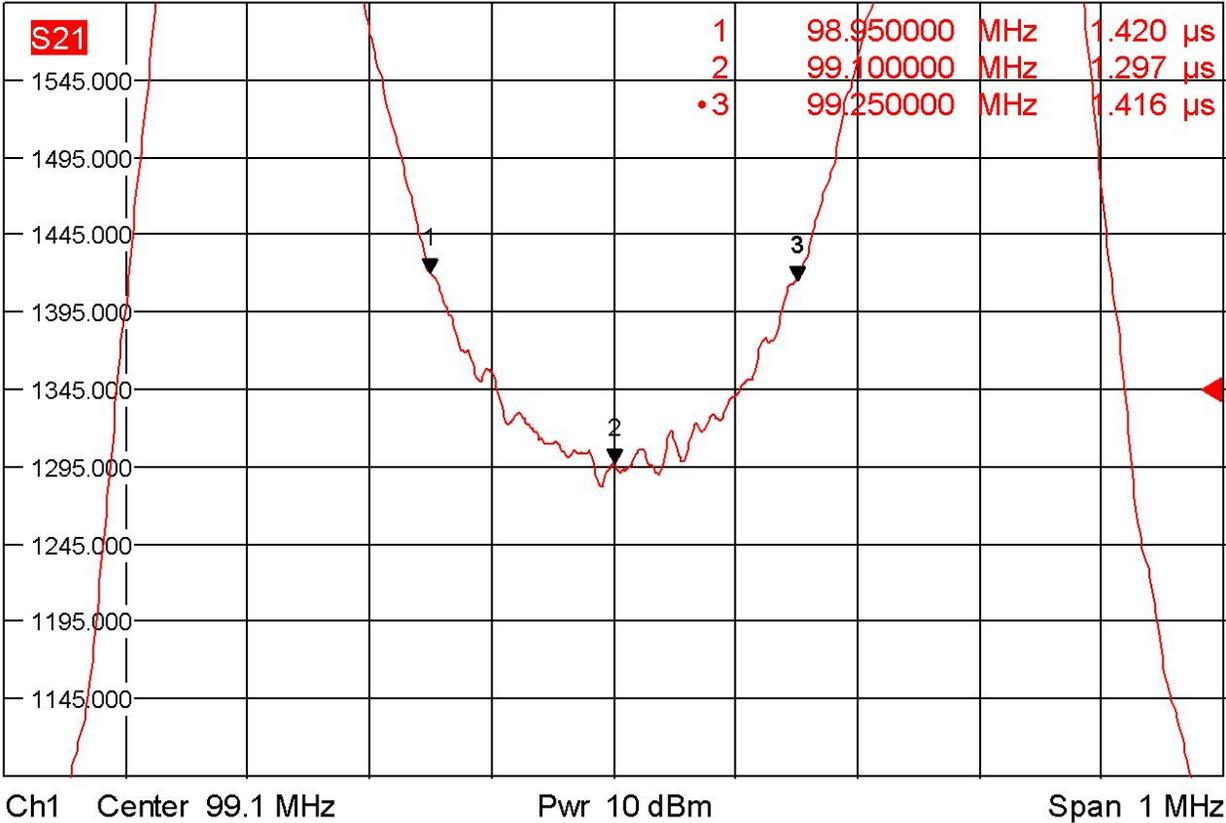
Span 4 MHz

Date: 10.FEB.2015 14:15:09

Measurement 3: Group Delay of 99.1 MHz.



Trc2 **S21** Delay 50 ns/ Ref 1.345 μ s Cal Smo 2 of 2 (Max)



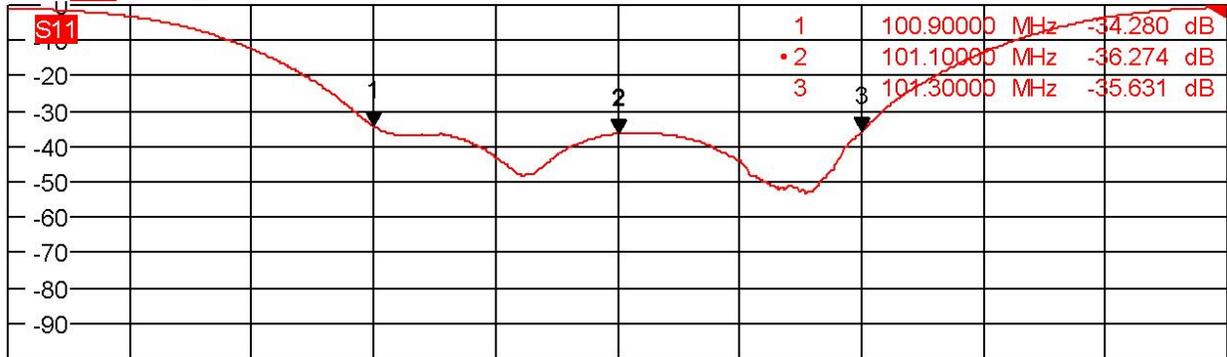
Date: 10.FEB.2015 14:16:13

Measurement 4: Match and Insertion Loss of 101.1 MHz.



Trc1 S11 dB Mag 10 dB / Ref 0 dB Cal Smo

1



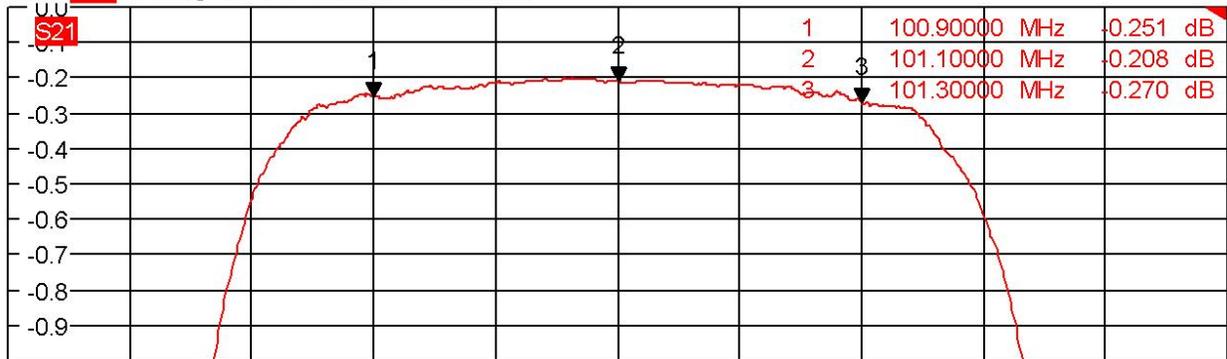
Ch1 Center 101.1 MHz

Pwr 10 dBm

Span 1 MHz

Trc2 S21 dB Mag 0.1 dB / Ref 0 dB Cal Smo

2



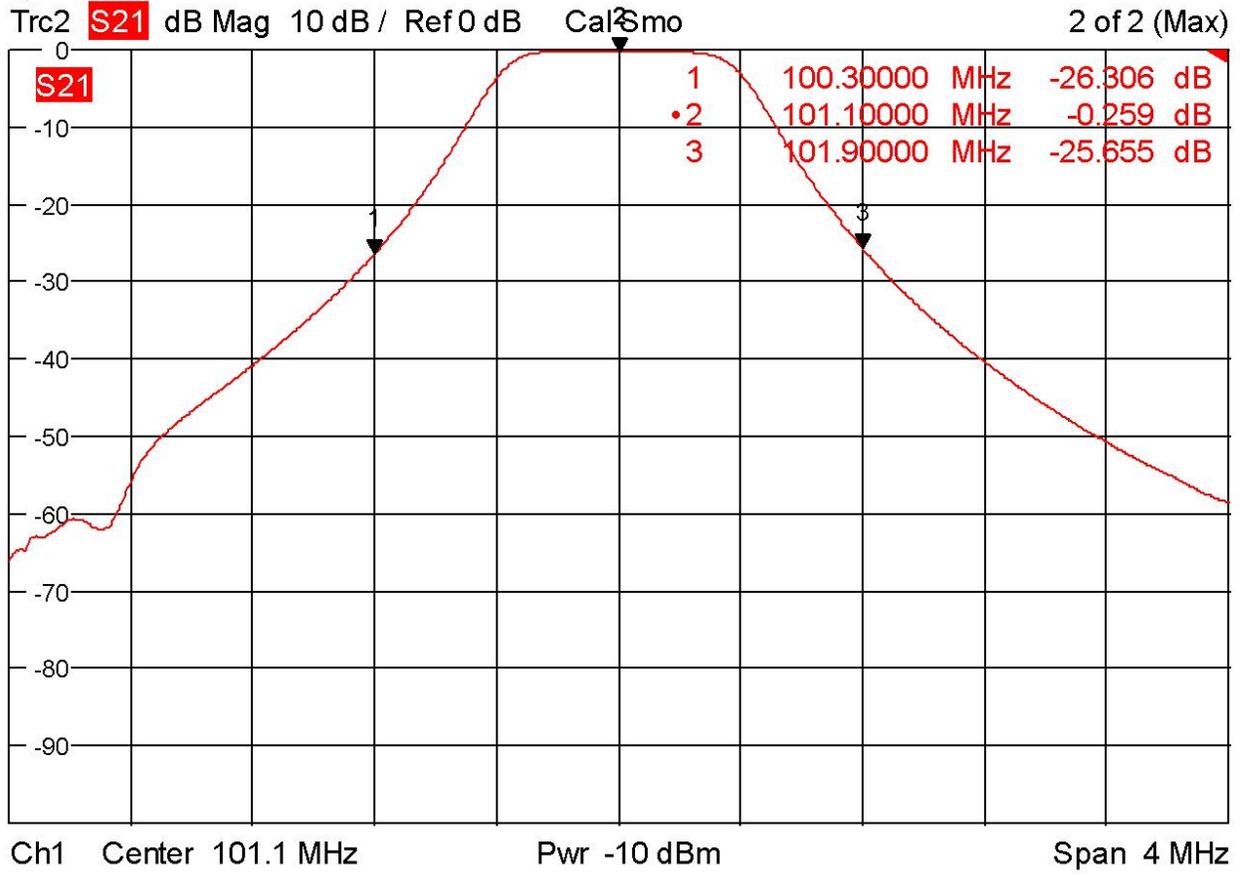
Ch1 Center 101.1 MHz

Pwr 10 dBm

Span 1 MHz

Date: 10.FEB.2015 14:21:49

Measurement 5: Isolation +/- 800 KHz. of 101.1 MHz.



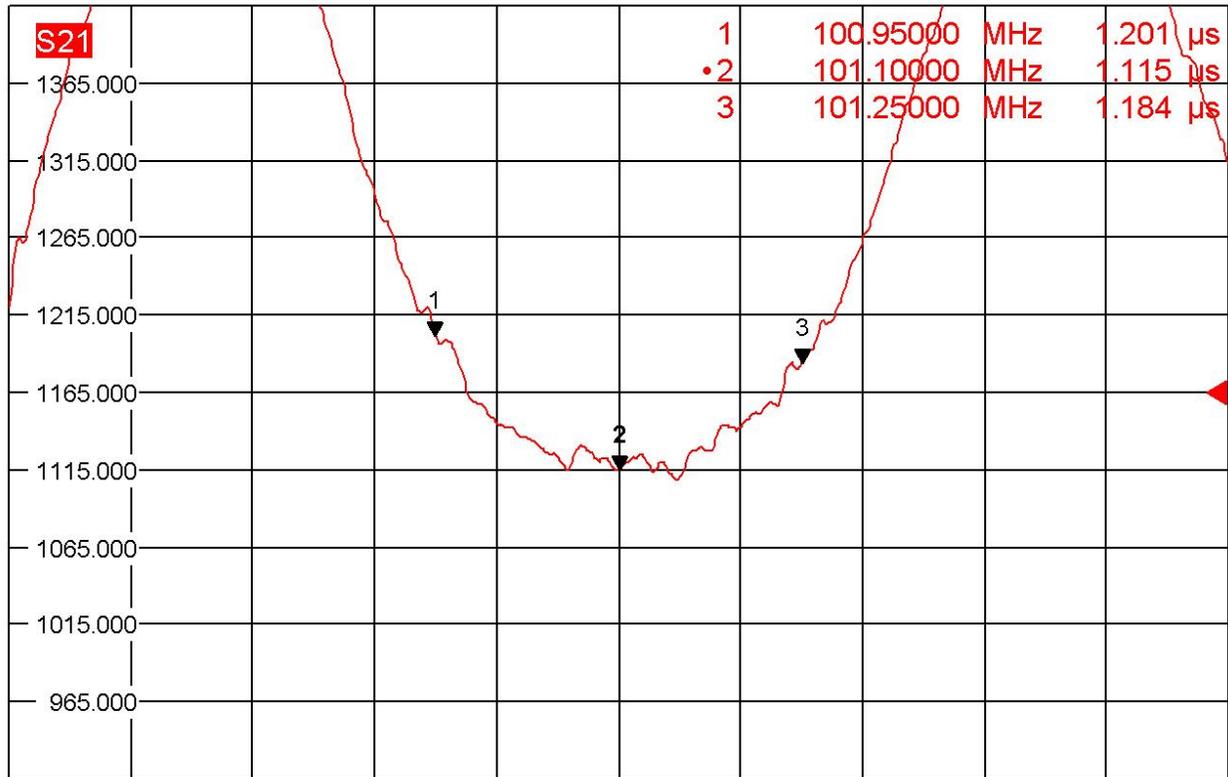
Date: 10.FEB.2015 14:22:57

Measurement 6: Group Delay of 101.1 MHz.



Trc2 **S21** Delay 50 ns/ Ref 1.165 μ s Cal Smo

2 of 2 (Max)



Ch1 Center 101.1 MHz

Pwr 10 dBm

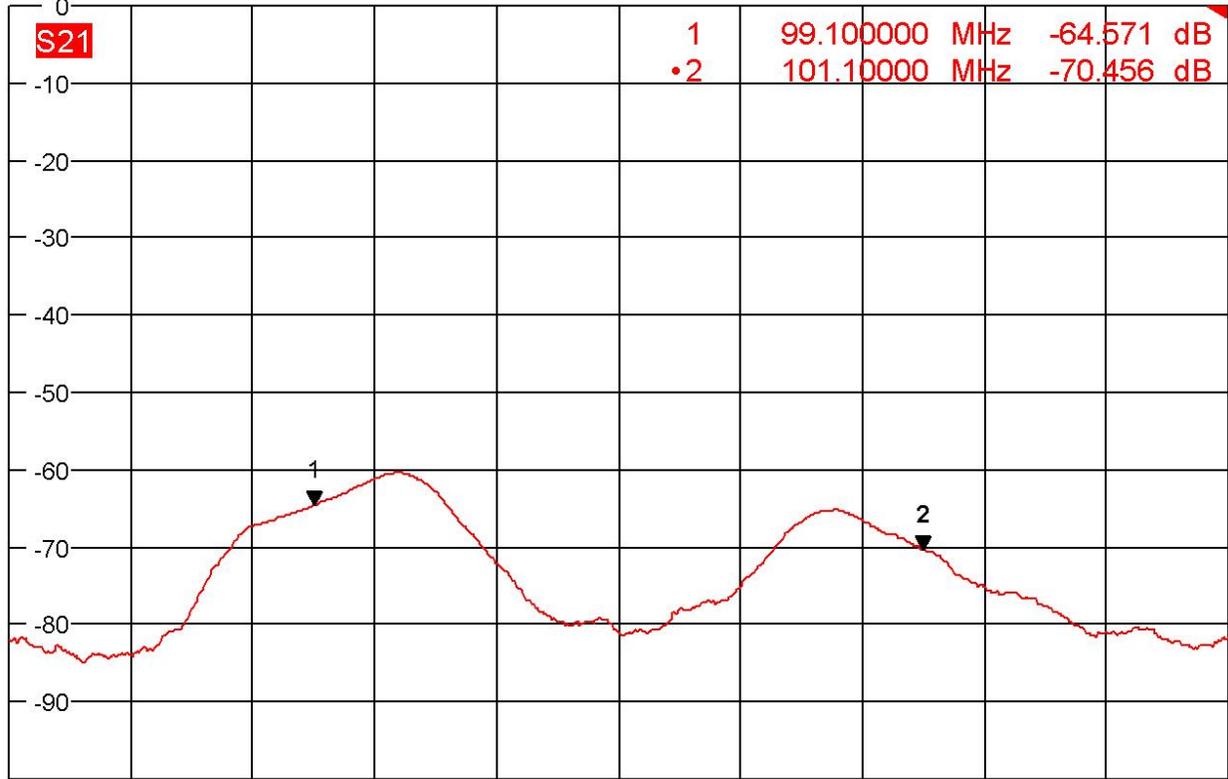
Span 1 MHz

Date: 10.FEB.2015 14:24:14

Measurement 7: Port to Port Isolation 99.1 to 101.1 MHz.



Trc2 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo 2 of 2 (Max)



Ch1 Start 98.1 MHz Pwr -10 dBm Stop 102.1 MHz

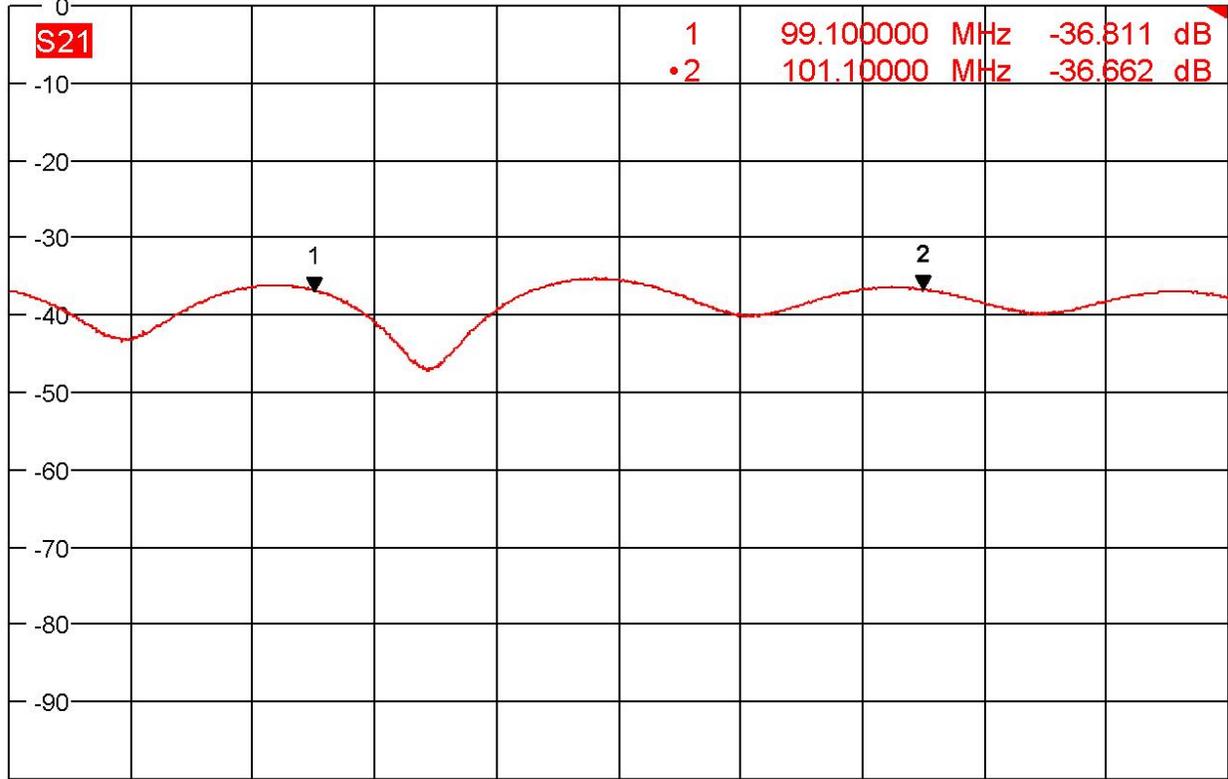
Date: 10.FEB.2015 14:18:32

Measurement 8: Narrow Sweep of Feedline with 50 ohm Load.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal

1



Ch1 Start 98.1 MHz

Pwr -10 dBm

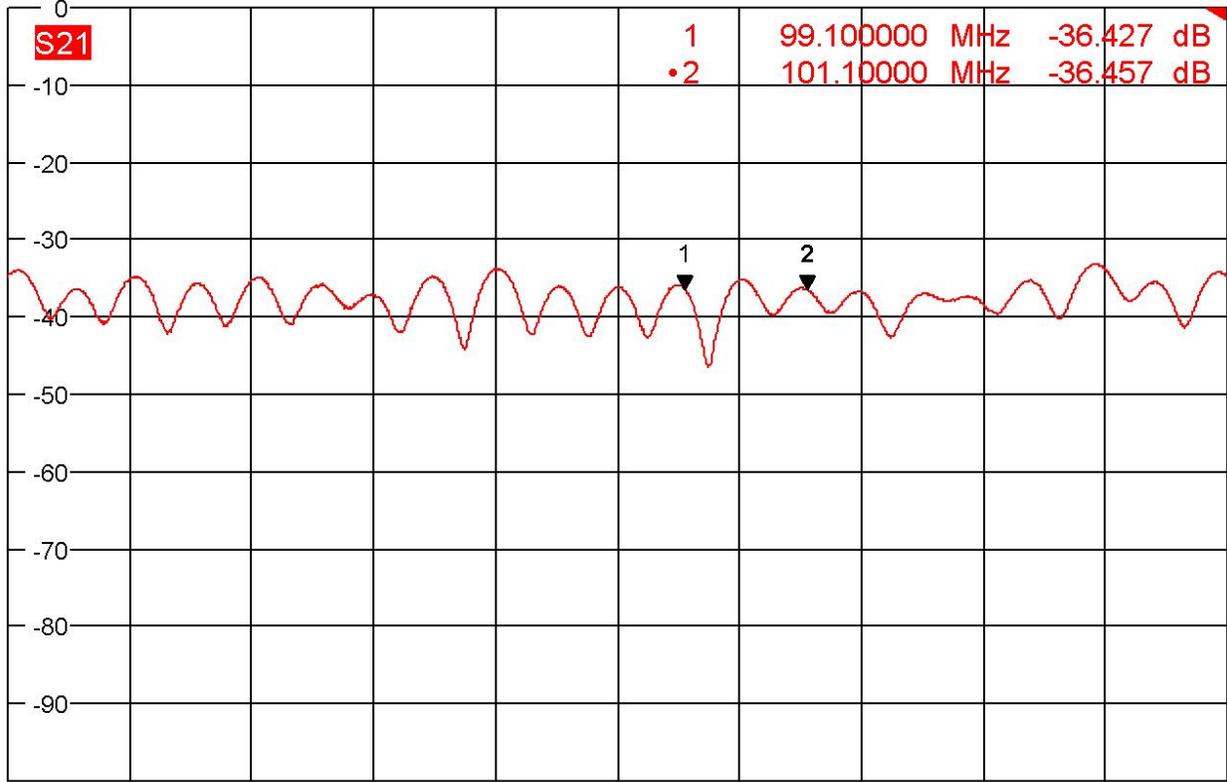
Stop 102.1 MHz

Date: 9.FEB.2015 17:55:46

Measurement 9: 88 to 108 MHz. Sweep of Feedline with 50 ohm Load.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal 1



Ch1 Center 98 MHz Pwr -10 dBm Span 20 MHz

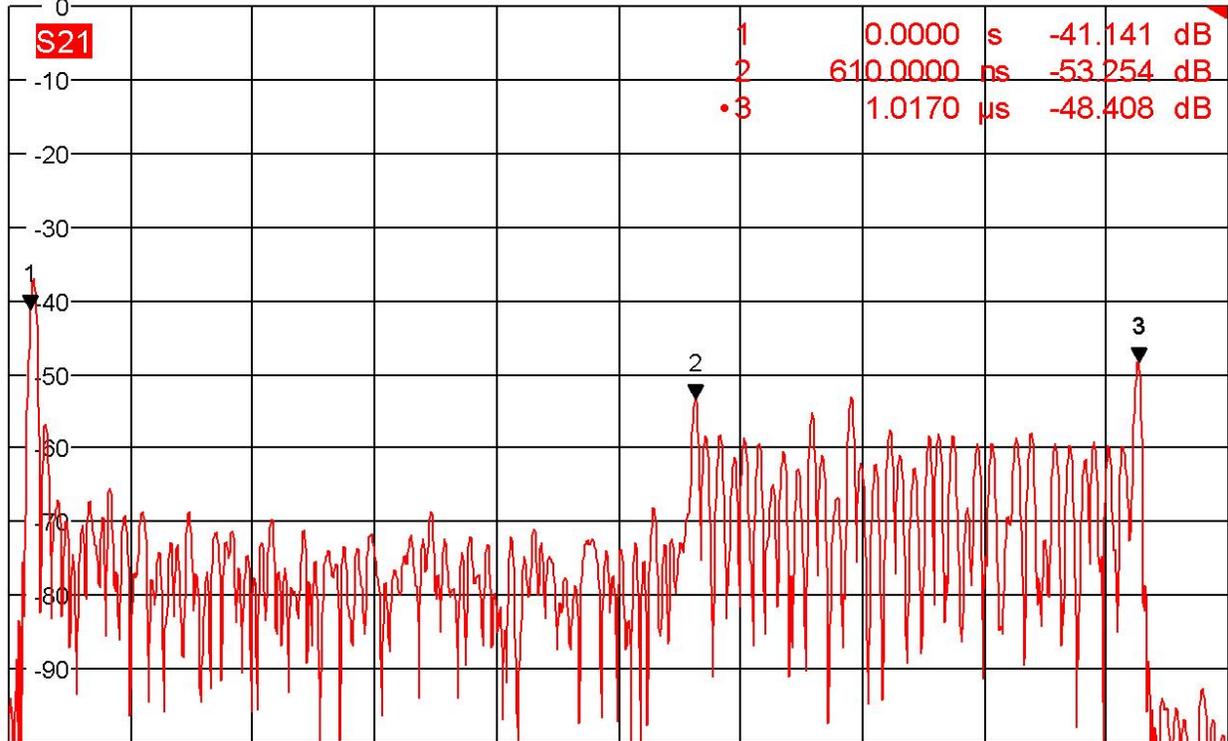
Date: 9.FEB.2015 17:57:32

Measurement 10: 50 to 400 MHz. Sweep of Feedline with 50 ohm Load TDR.

Mkr#1 is Test Transition @ 0 Feet.
Mkr#2 is the End of the Flex run @ Approx 275 Feet.
Mkr#3 is the 50 ohm Load @ Approx 475 Feet.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal 1



Ch1 Start 50 MHz Pwr -10 dBm Stop 400 MHz
Trc1 Start -20 ns — Time Domain Stop 1.1 μs

Date: 9.FEB.2015 18:01:06

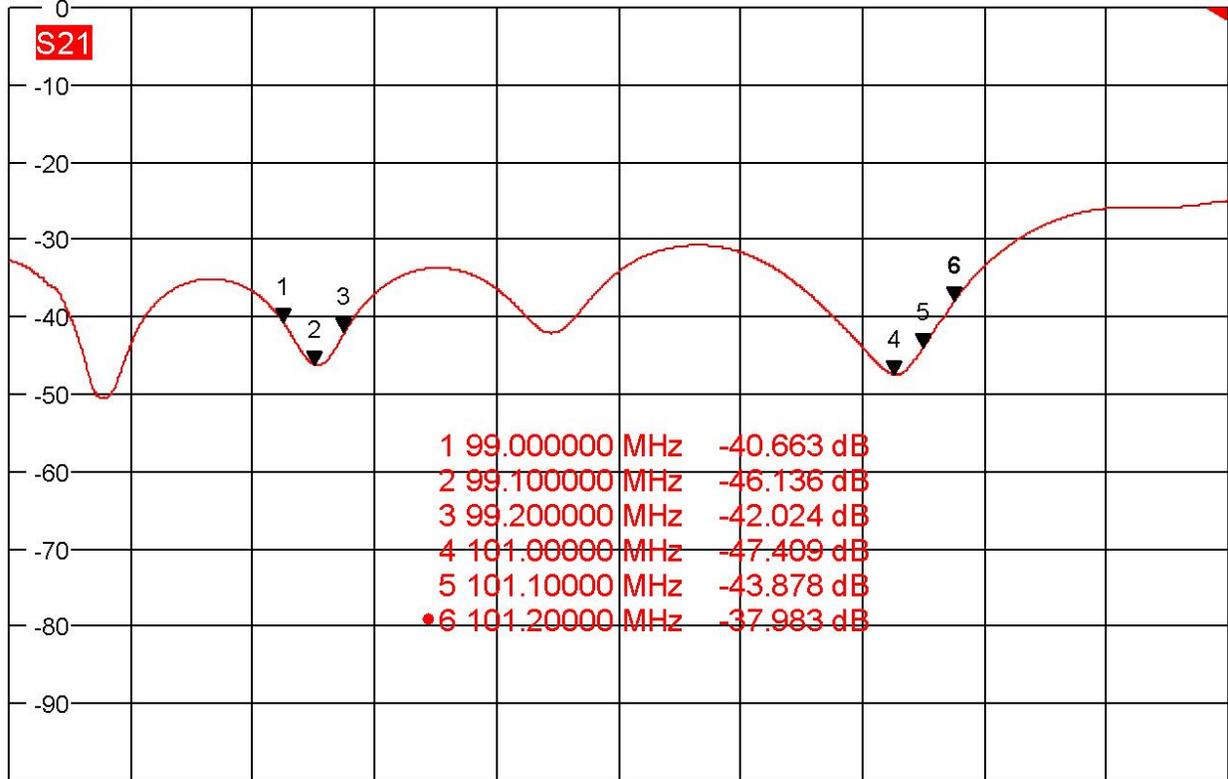
Measurement 11: Narrow Sweep of Final Antenna 99.1 & 101.1 MHz.

Return Loss Measurement.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo

1



Ch1 Start 98.1 MHz

Pwr -10 dBm

Stop 102.1 MHz

Date: 9.FEB.2015 23:19:01

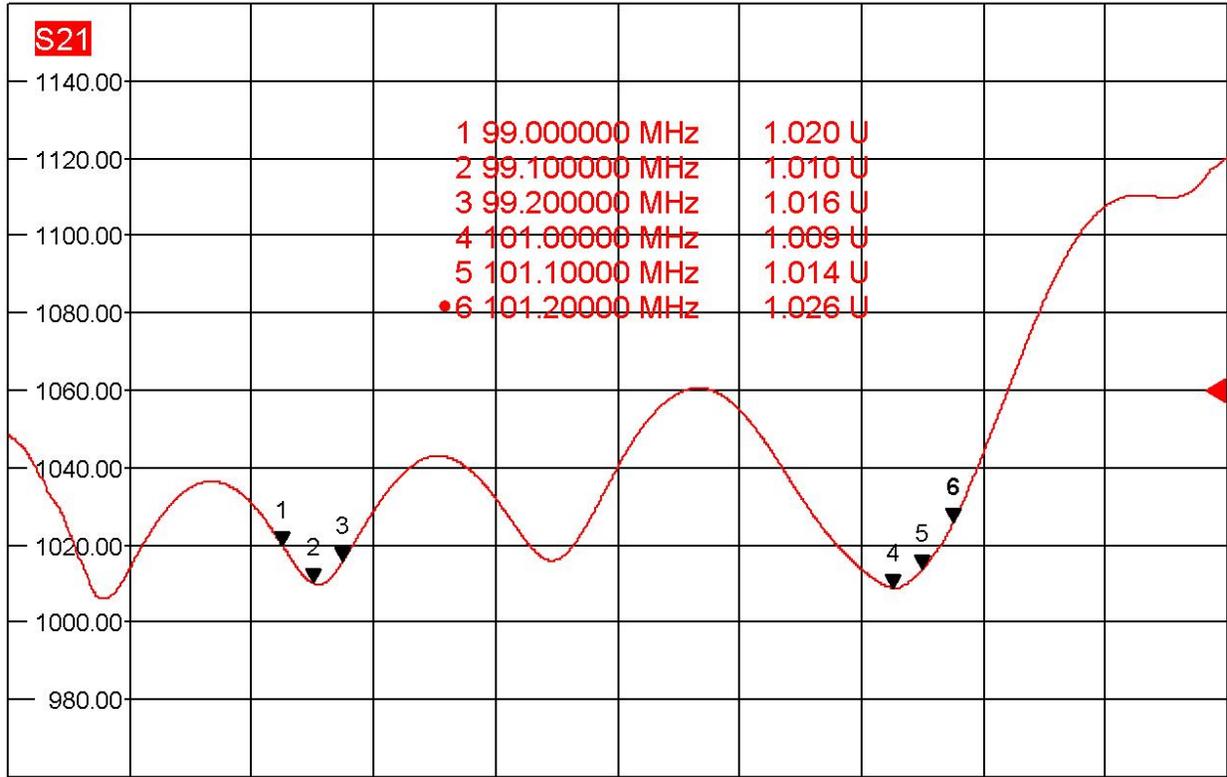
Measurement 12: Narrow Sweep of Final Antenna 99.1 & 101.1 MHz.

VSWR Measurement.



Trc1 **S21** SWR 20 mU/ Ref 1.06 U Cal Smo

1



Ch1 Start 98.1 MHz

Pwr -10 dBm

Stop 102.1 MHz

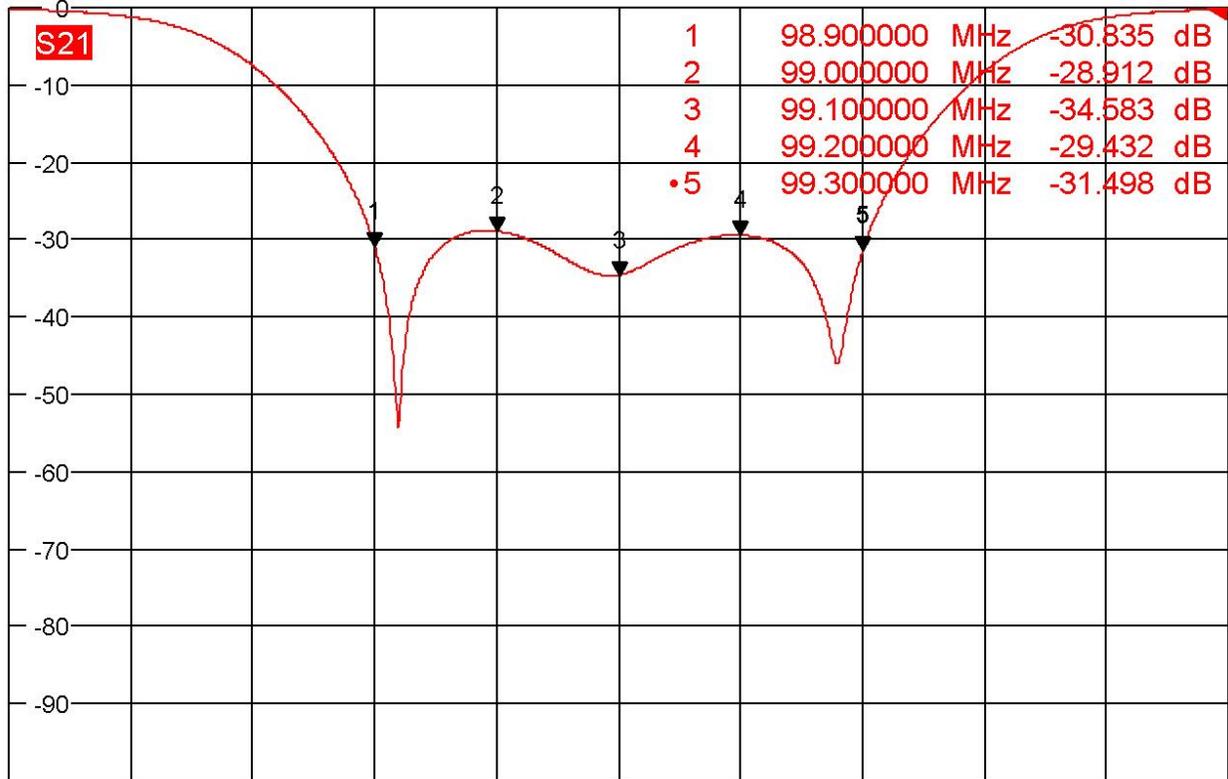
Date: 9.FEB.2015 23:19:26

Measurement 13: Filter to Antenna 99.1 MHz. Return Loss Measurement.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal

1



Ch1 Center 99.1 MHz

Pwr -10 dBm

Span 1 MHz

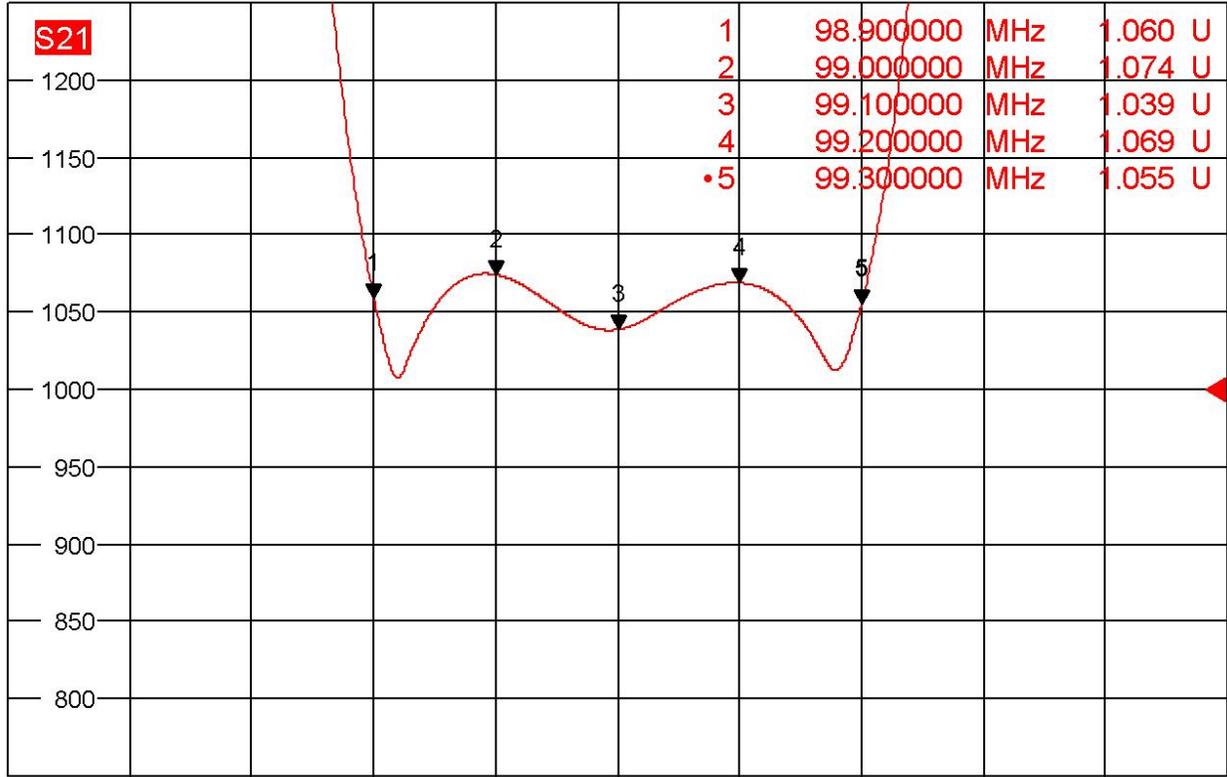
Date: 11.FEB.2015 15:23:55

Measurement 14: Filter to Antenna 99.1 MHz. VSWR Measurement.



Trc1 **S21** SWR 50 mU/ Ref 1 U Cal Smo

1



Ch1 Center 99.1 MHz

Pwr -10 dBm

Span 1 MHz

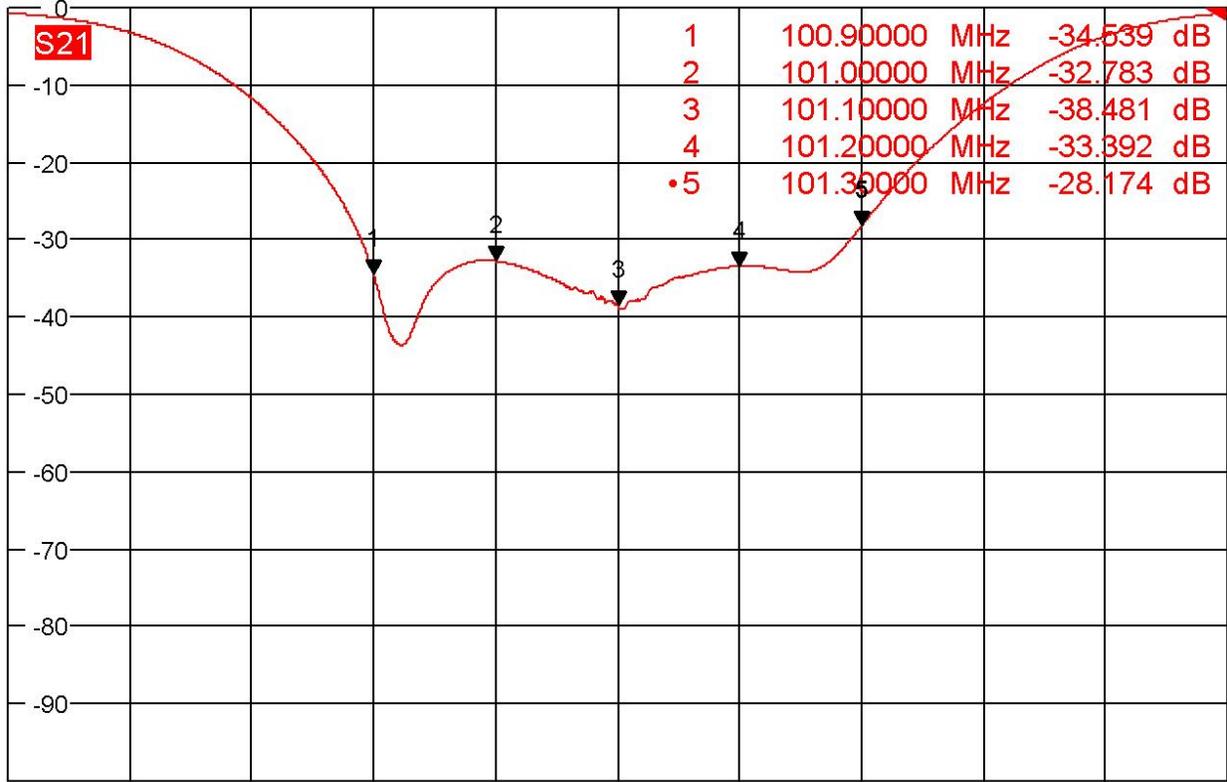
Date: 11.FEB.2015 15:25:24

Measurement 15: Filter to Antenna of 101.1 MHz. Return Loss Measurement.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo

1



Ch1 Center 101.1 MHz

Pwr -10 dBm

Span 1 MHz

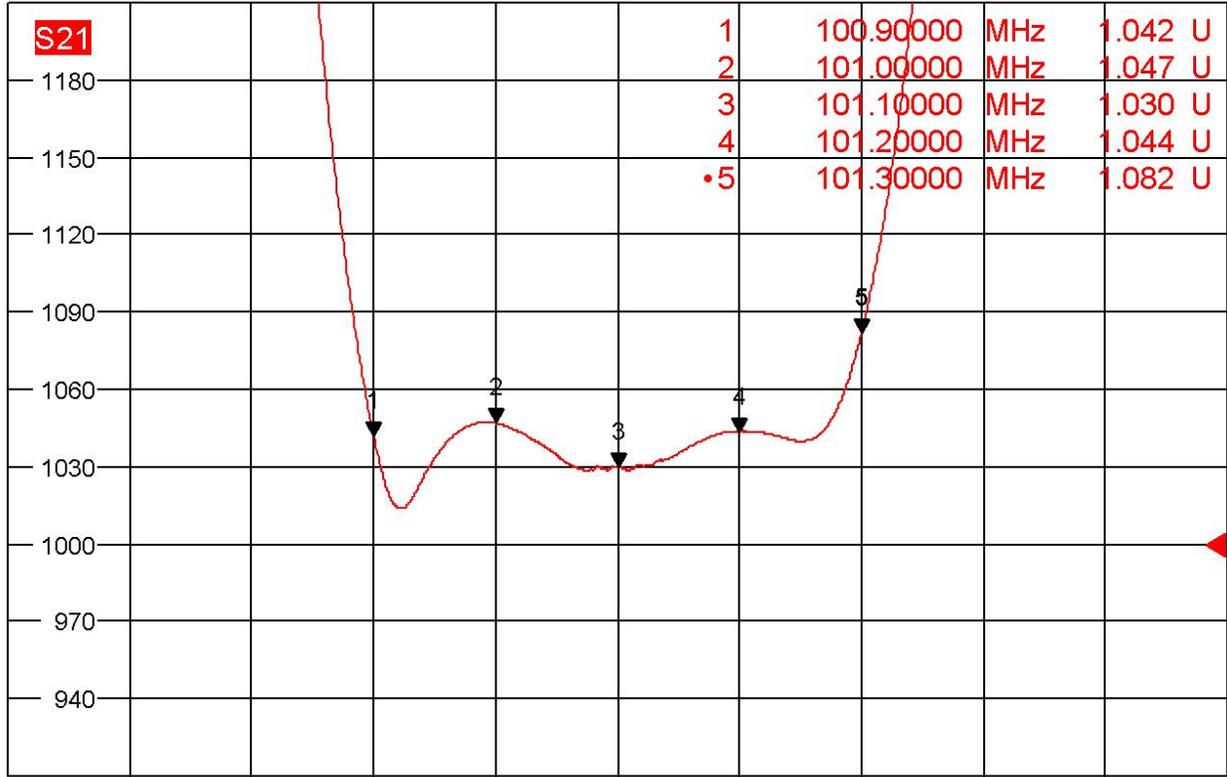
Date: 11.FEB.2015 15:28:15

Measurement 16: Filter to Antenna of 101.1 MHz. VSWR Measurement.



Trc1 **S21** SWR 30 mU/ Ref 1 U Cal Smo

1



Ch1 Center 101.1 MHz Pwr -10 dBm Span 1 MHz

Date: 11.FEB.2015 15:29:09

Figure 4: Vertical Plane relative Field Plot of 99.1 MHz.

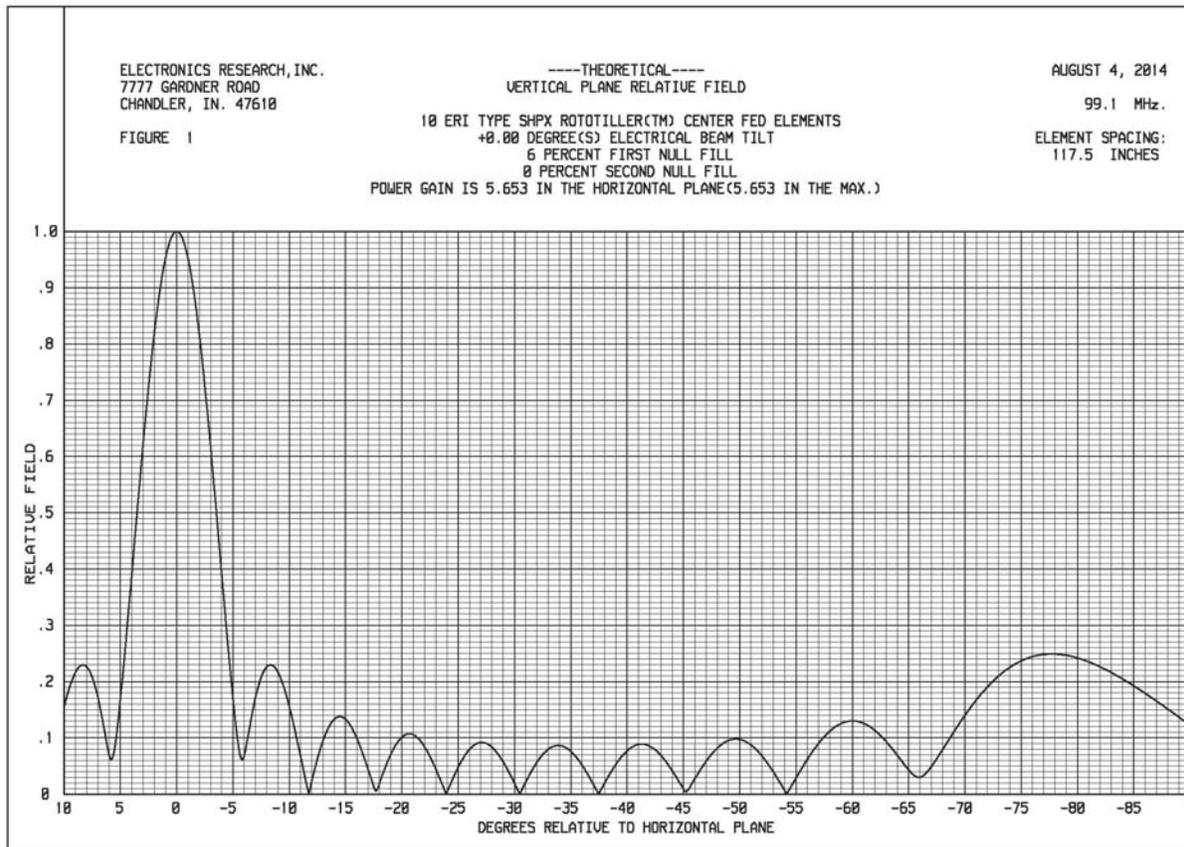


Figure 5: Vertical Plane Relative Field Plot of 101.1 MHz.

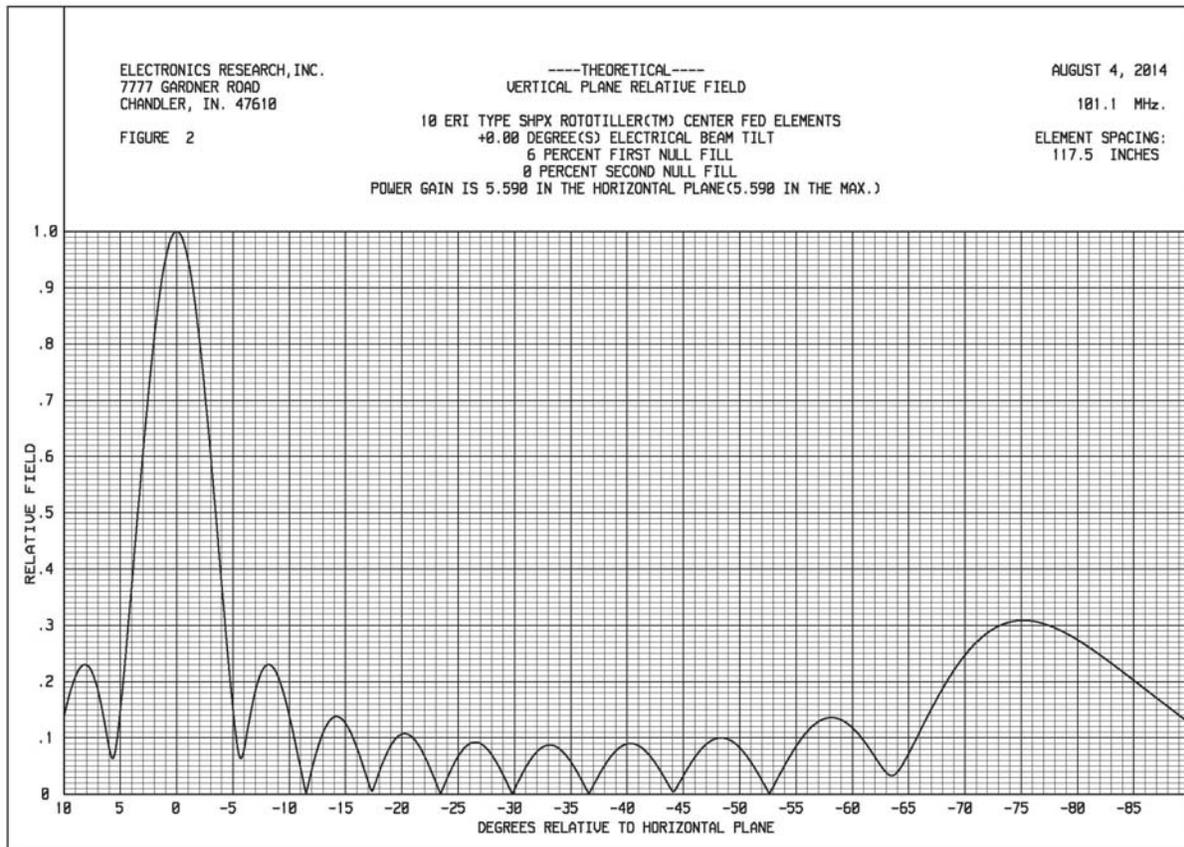


Table 1: Loss Budget 99.1 MHz.

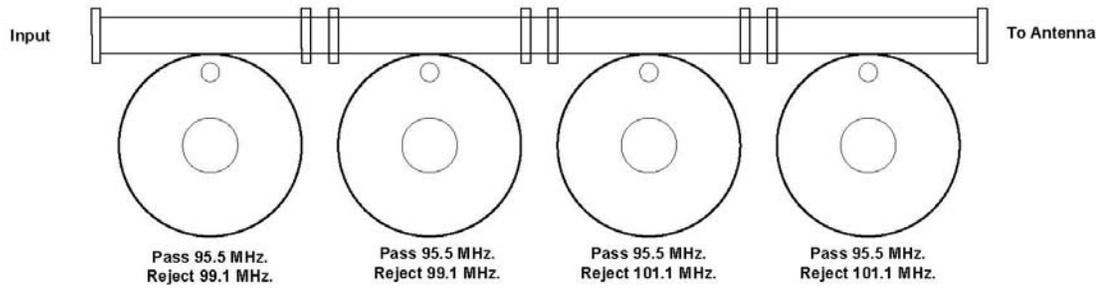
Power Analysis 2-10-15		
	<i>Analog</i>	
Call Letters:	KLLZ (FM)	
Frequency:	99.1 MHz	
ERP:	100.000 kW	20.000 dBk
Polarization:	Circular	
Antenna Gain:	5.653 Numeric	7.523 dB
Antenna Input Power:	17.690 kW	12.477 dBk
Peak Voltage:	1,330 volts	
Transmission Line Type - Tower Vertical Run:	Andrew HJ11-50	
Tower Vertical Run Length:	275 feet	83.8 meters
Tower Vertical Run Attenuation:	0.114 dB/100-feet	
Transmission Line Type - Vertical Run:	ERI MacxLine 4 1/16" Rigid	
Vertical Run Length:	200 feet	61.0 meters
Vertical Run Attenuation:	0.074 dB/100-feet	
Line Loss:	-1.983 kW	0.462 dB
Line Efficiency:	89.919%	
Power Output from Combiner:	19.673 kW	12.939 dBk
Peak Voltage:	1,403 volts	
Combiner Losses:	-1.378 kW	0.294 dB
Transmitter Power Output:	21.051 kW	13.233 dBk

Table 2: Loss Budget Table 101.1 MHz.

Call Letters:	KBPH (FM)	
Frequency:	101.1 MHz	
ERP:	100.000 kW	20.000 dBk
Polarization:	Circular	
Antenna Gain:	5.590 Numeric	7.474 dB
Antenna Input Power:	17.889 kW	12.526 dBk
Peak Voltage:	1,338 volts	
Transmission Line Type - Tower Vertical Run:	Andrew HJ11-50	
Tower Vertical Run Length:	275 feet	83.8 meters
Tower Vertical Run Attenuation:	0.115 dB/100-feet	
Transmission Line Type - Vertical Run:	ERI MacxLine 4 1/16" Rigid	
Vertical Run Length:	200 feet	61.0 meters
Vertical Run Attenuation:	0.075 dB/100-feet	
Line Loss:	-2.027 kW	0.466 dB
Line Efficiency:	89.820%	
Power Output from Combiner:	19.917 kW	12.992 dBk
Peak Voltage:	1,411 volts	
Combiner Losses:	-0.977 kW	0.208 dB
Transmitter Power Output:	20.894 kW	13.200 dBk

Figure 6: Drawing of Notch System for 95.5 MHz.

Notch Filter System for 95.5 MHz. Bemidji, MN. Project 32949C

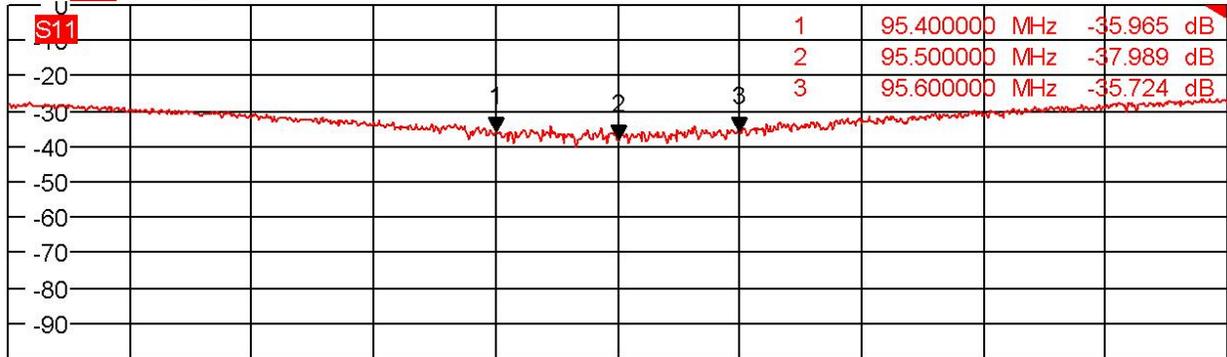


Measurement 17: Match & Insertion Loss of Notch Filters 95.5 MHz.



Trc1 S11 dB Mag 10 dB / Ref 0 dB Cal

1



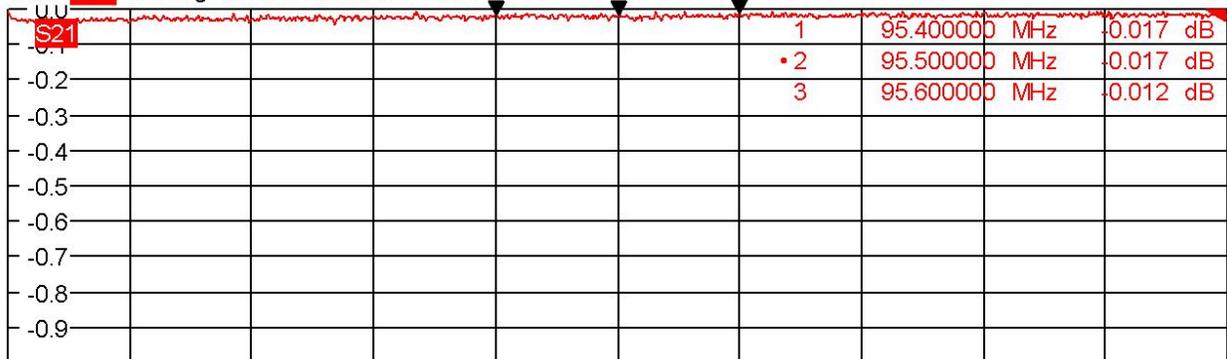
Ch1 Center 95.5 MHz

Pwr 10 dBm

Span 1 MHz

Trc2 S21 dB Mag 0.1 dB / Ref 0 dB Cal

2



Ch1 Center 95.5 MHz

Pwr 10 dBm

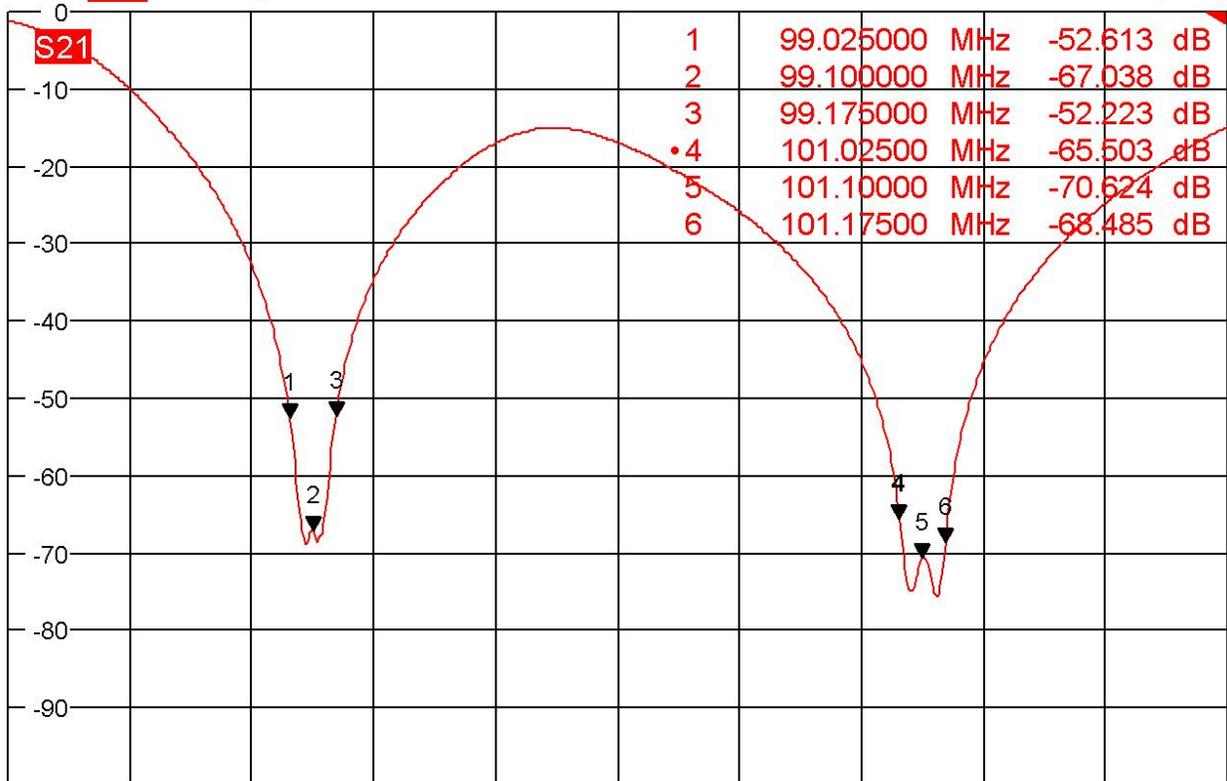
Span 1 MHz

Date: 12.FEB.2015 16:22:14

Measurement 18: Notch of 99.1 MHz. & 101.1 MHz. Filters.



Trc2 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo 2 of 2 (Max)



Ch1 Start 98.1 MHz Pwr 10 dBm Stop 102.1 MHz

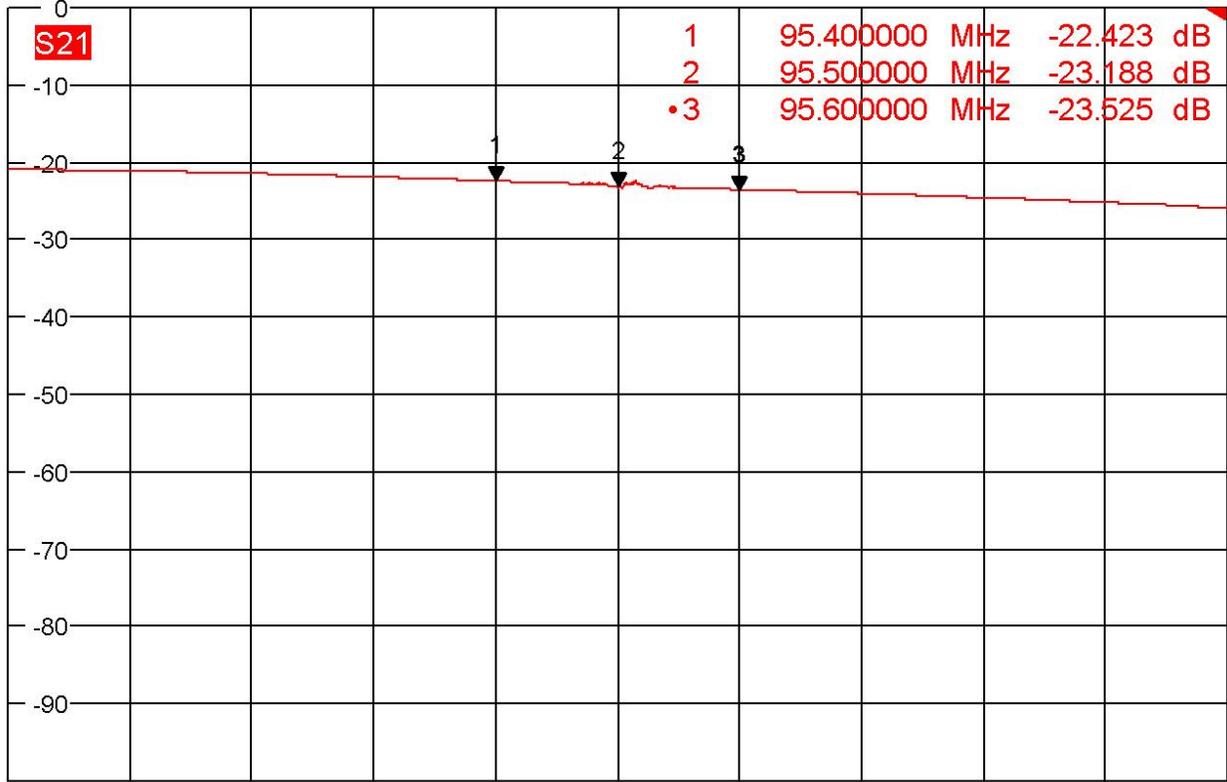
Date: 12.FEB.2015 16:21:11

Measurement 19: Narrow sweep of Feedline & Antenna 95.5 MHz.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo

1



Ch1 Center 95.5 MHz

Pwr -10 dBm

Span 1 MHz

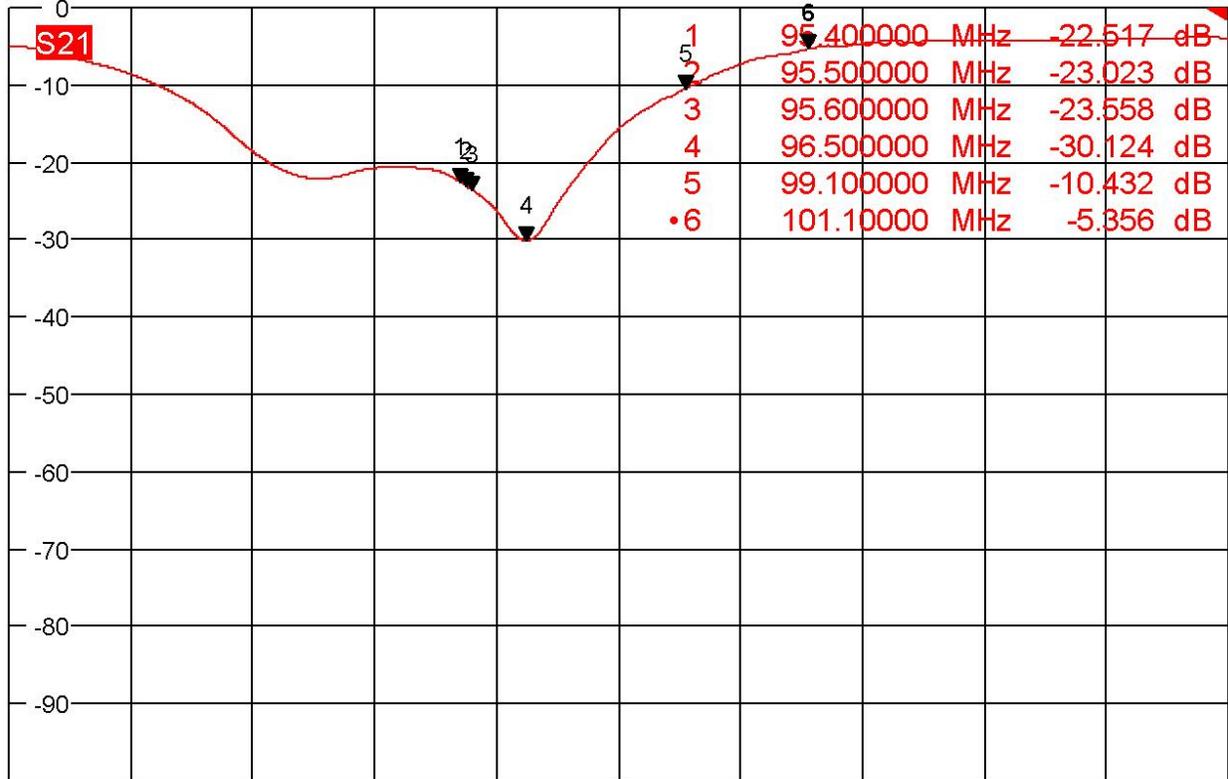
Date: 12.FEB.2015 16:33:39

Measurement 20: 88 to 108 MHz sweep of Feedline & Antenna.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo

1



Ch1 Center 98 MHz

Pwr -10 dBm

Span 20 MHz

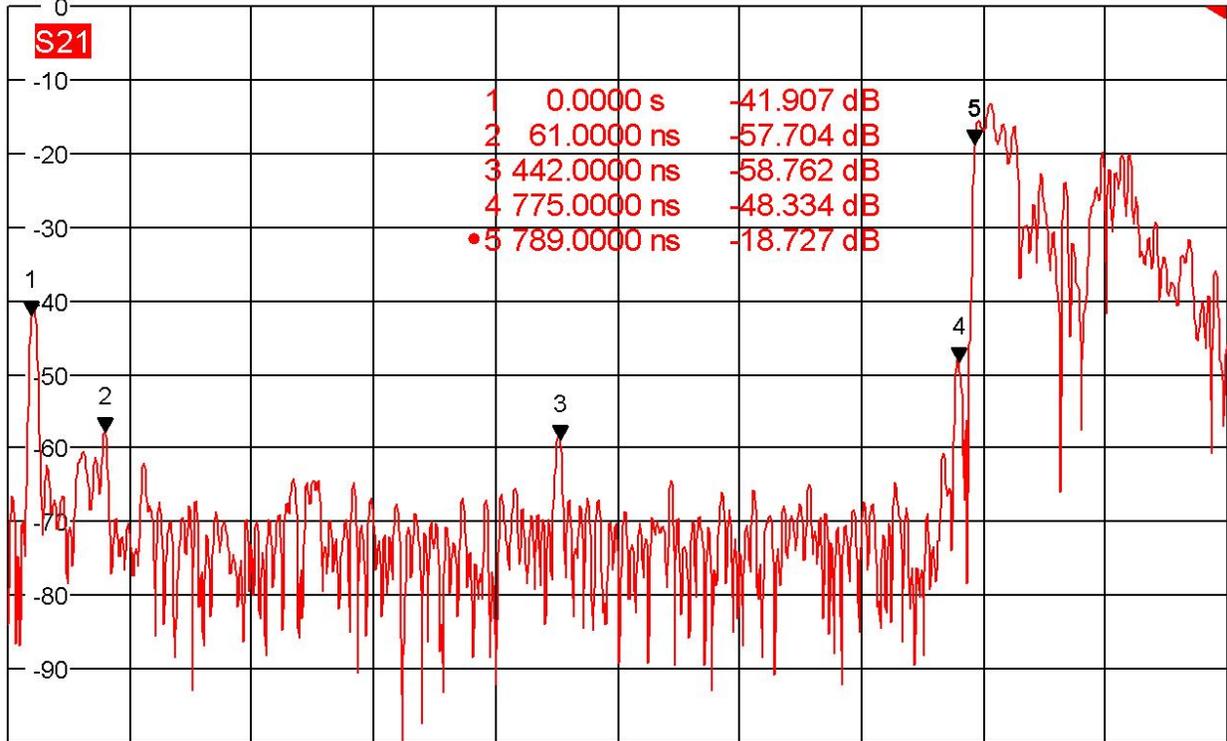
Date: 12.FEB.2015 16:37:41

Measurement 21: 50 to 400 MHz. Sweep of Feedline & Antenna TDR.

Mkr#1 Test Measurement Point @ Zero Feet.
Mkr#2,3,4 are Impedance Mismatches Throughout the Verticle Run.
Mkr#5 is the Antenna @ Approx 361 Feet.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo 1



Ch1 Start 50 MHz Pwr -10 dBm Stop 400 MHz
Trc1 Start -20 ns — Time Domain Stop 1 μ s

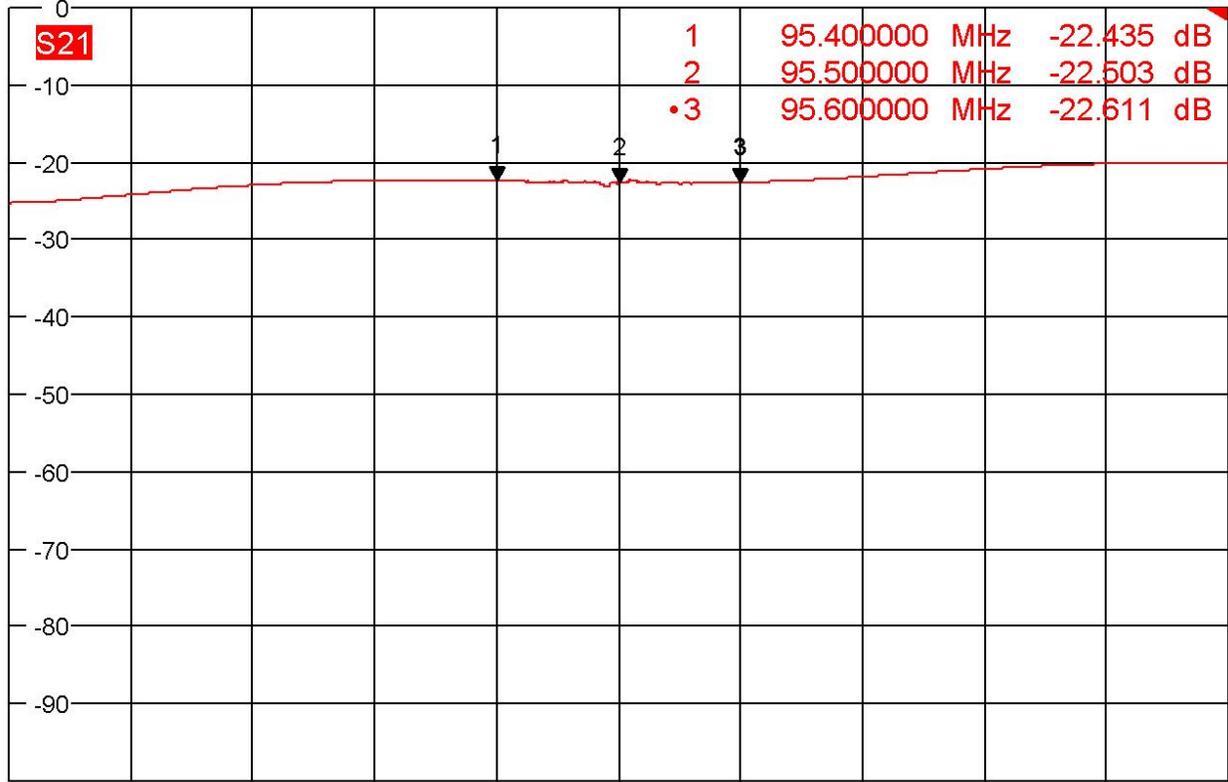
Date: 12.FEB.2015 16:40:58

Measurement 22: Filter to Antenna Return Loss 95.5 MHz.



Trc1 **S21** dB Mag 10 dB / Ref 0 dB Cal Smo

1



Ch1 Center 95.5 MHz

Pwr -10 dBm

Span 1 MHz

Date: 12.FEB.2015 16:51:12