

# **Field Service Report FM Combiner and Antenna System**

**Austin, TX.  
Broadcast Facility**

ERI Antenna: SHP-8AC6-SP  
ERI Constant Impedance Combiner 93.7 & 101.5 MHz.  
ERI Band Pass 103.5 MHz.  
Shively "T" Combiner 99.7 & 102.7 MHz.  
Feedline: Myat 4 1/16" Rigid 865 Feet

KLBJ-FM – 93.7 MHz. ~ K259AJ – 99.7 MHz.  
KROX – 101.5 MHz. ~ K274AX – 102.7 MHz.  
KBPA – 103.5 MHz.

ERI Project # 38094

October 25, 2020

## **Submitted By:**

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## INTRODUCTION

Listed below is a summary of the data and attached are the plots collected from the KLBJ-FM ~ K259AJ ~ KROX ~ K274AX ~ KBPA transmission site in Austin, TX. by Jeff Taylor October 25, 2020.

- The antenna is a SHP-10AC6-SP.
- The combiner is a 783-8 ~ 780-6 Constant Impedance Combiner, 783-4 Band Pass Low Power Shively "T" Combiner.
- Equipment used for testing combiner was a Copper Mountain S5048 VNA.
- Equipment used for filter to antenna testing was a Rohde & Schwarz ZVL3 VNA High RF setup.
- Equipment used for feedline and antenna testing was a Rohde & Schwarz ZVL3 VNA High RF setup.
- All output measurements of the combiner system were taken at the 6 1/8" output directional coupler unless noted otherwise.
- All input measurements of the ERI products were taken at the input directional couplers and the input Shively measurements were taken on the 7/8" input elbows of the band pass filters.
- All feedline and antenna measurements were taken on the 4 1/16" elbow on the gas block of the feedline in the transmitter room.

**Site Address:** 8300 Waymaker Way  
Austin, Texas 78746

**Attendees:** Jeff Taylor Electronics Research, Inc.  
Greg Shapiro, Jim Henkle, John Gifford Waterloo Media, L.C.

The reason for this Field Service Trip was install The ERI filter system, build the "T" network for the Shively band pass filters, and tie in the Shively "T" combiner to the ERI filter system, tune the antenna and conduct intermodulation measurements. The ERI constant impedance filter system is designed to operate with either the Shively "T" combiner or the ERI band pass filter system into the broad port of the constant impedance system via a 3 1/8" switch.

Please refer to the combiner layout drawing concerning the filter circuit.

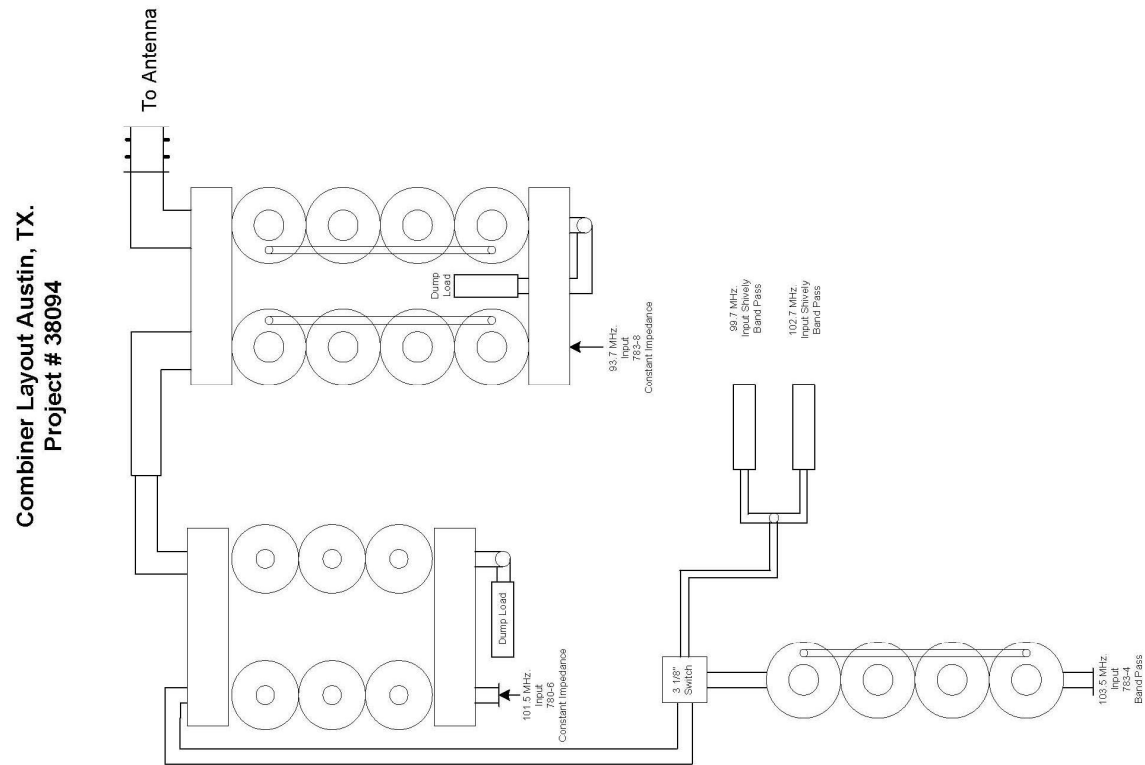
## SUMMARY and RECOMMENDATIONS

All measurements were taken by Jeff Taylor of Electronics Research Inc. October 2020.

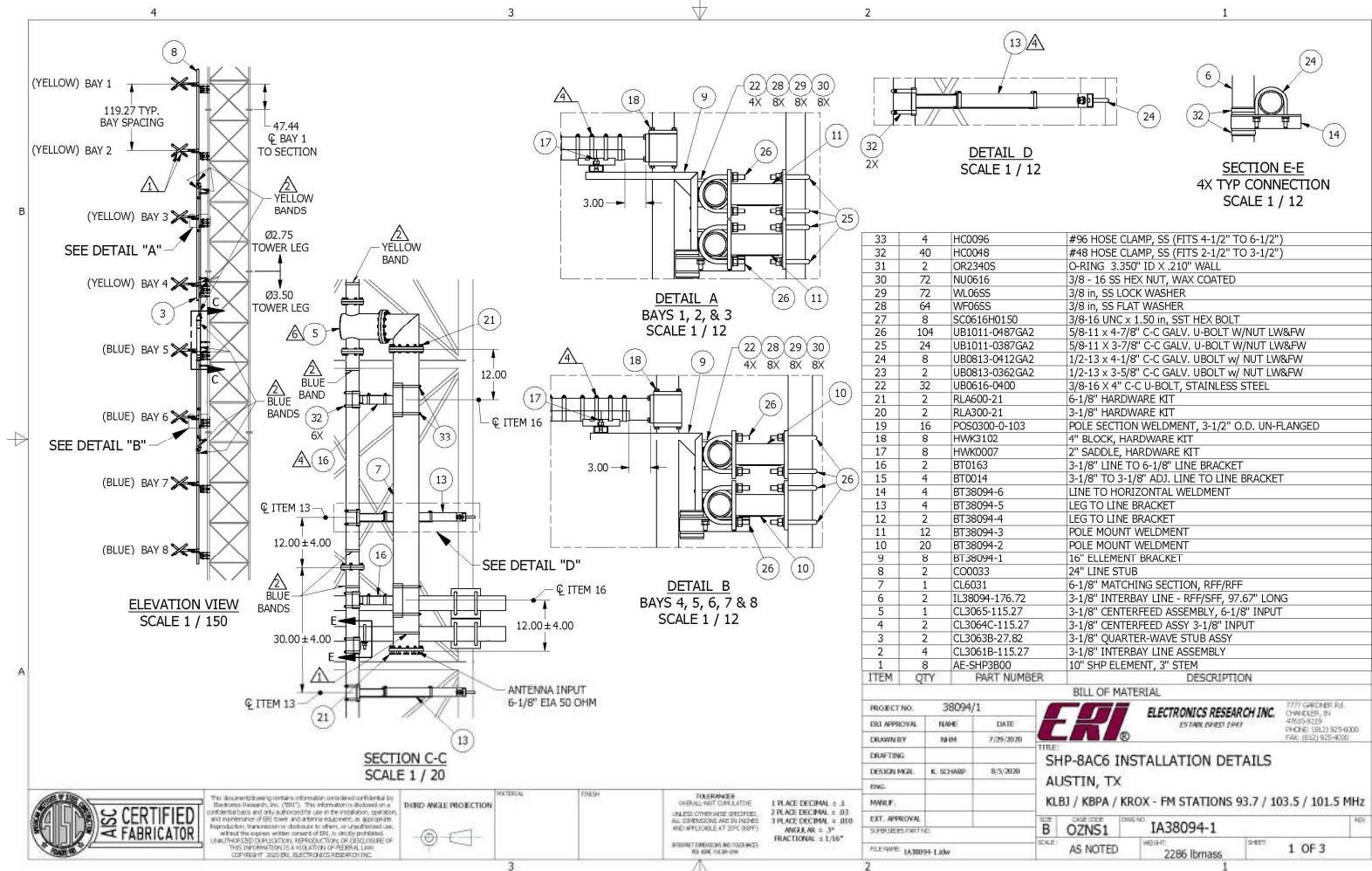
Sincerely Jeff Taylor

# DRAWINGS

## Drawing 1: Combiner Drawing.



## Drawing 2: Antenna Drawing.

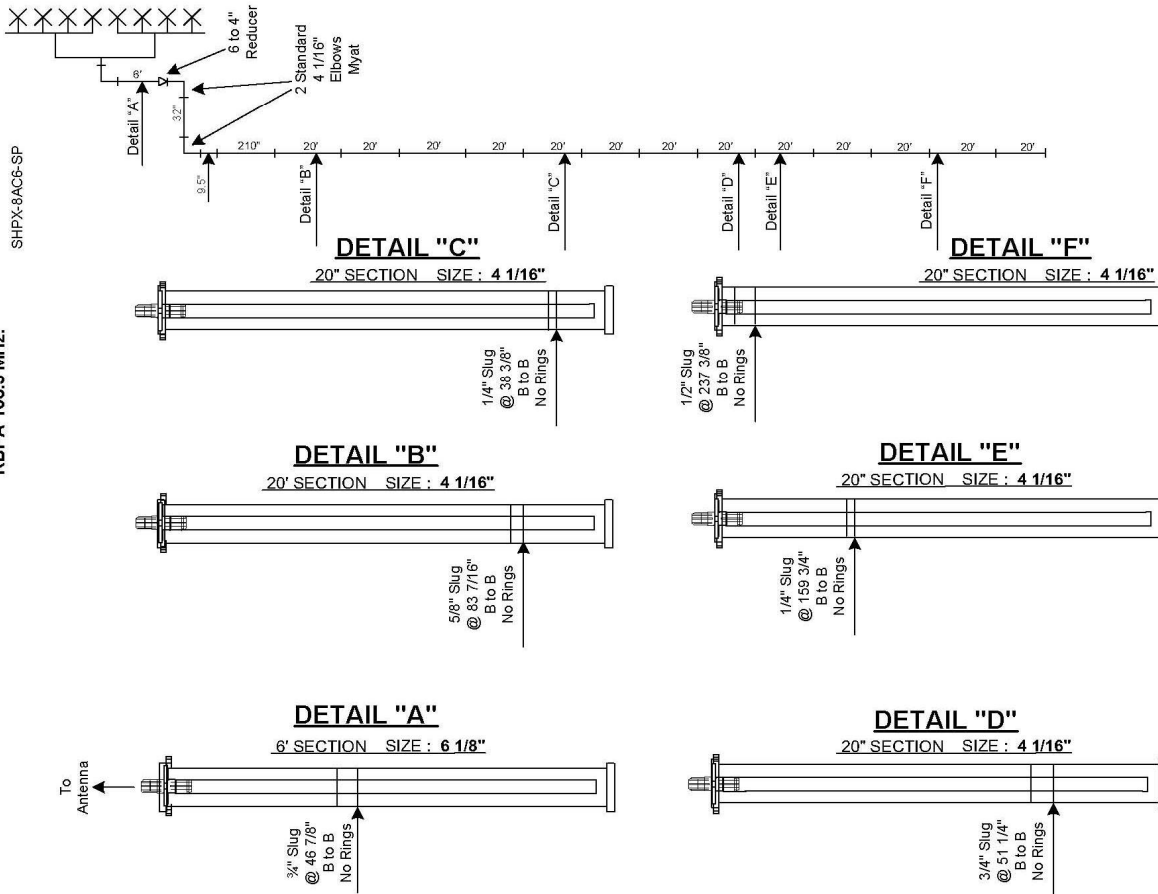


### Drawing 3: Tuning Slug Location.

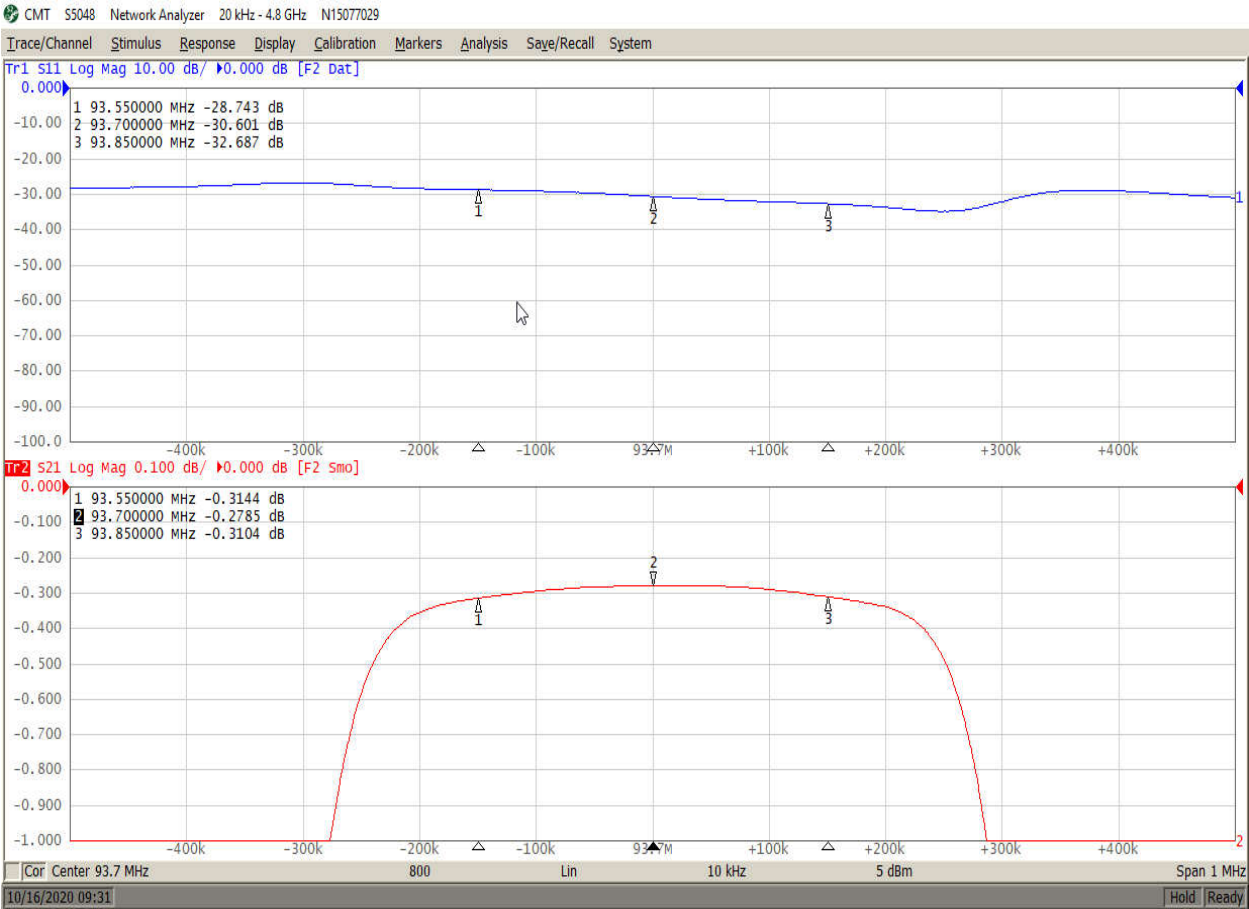
PROJECT # : 38094 DATE: 10-25-20 LINE SIZE: MYAT 4 1/16" Rigid 20' Sticks.

#### **Tuning Slug Location for Austin, TX.**

KLBJ-FM 93.7 MHz. ~ K259AJ 99.7 MHz.  
KKRX 101.5 MHz. ~ K274AX 102.7 MHz.  
KBPA 103.5 MHz.

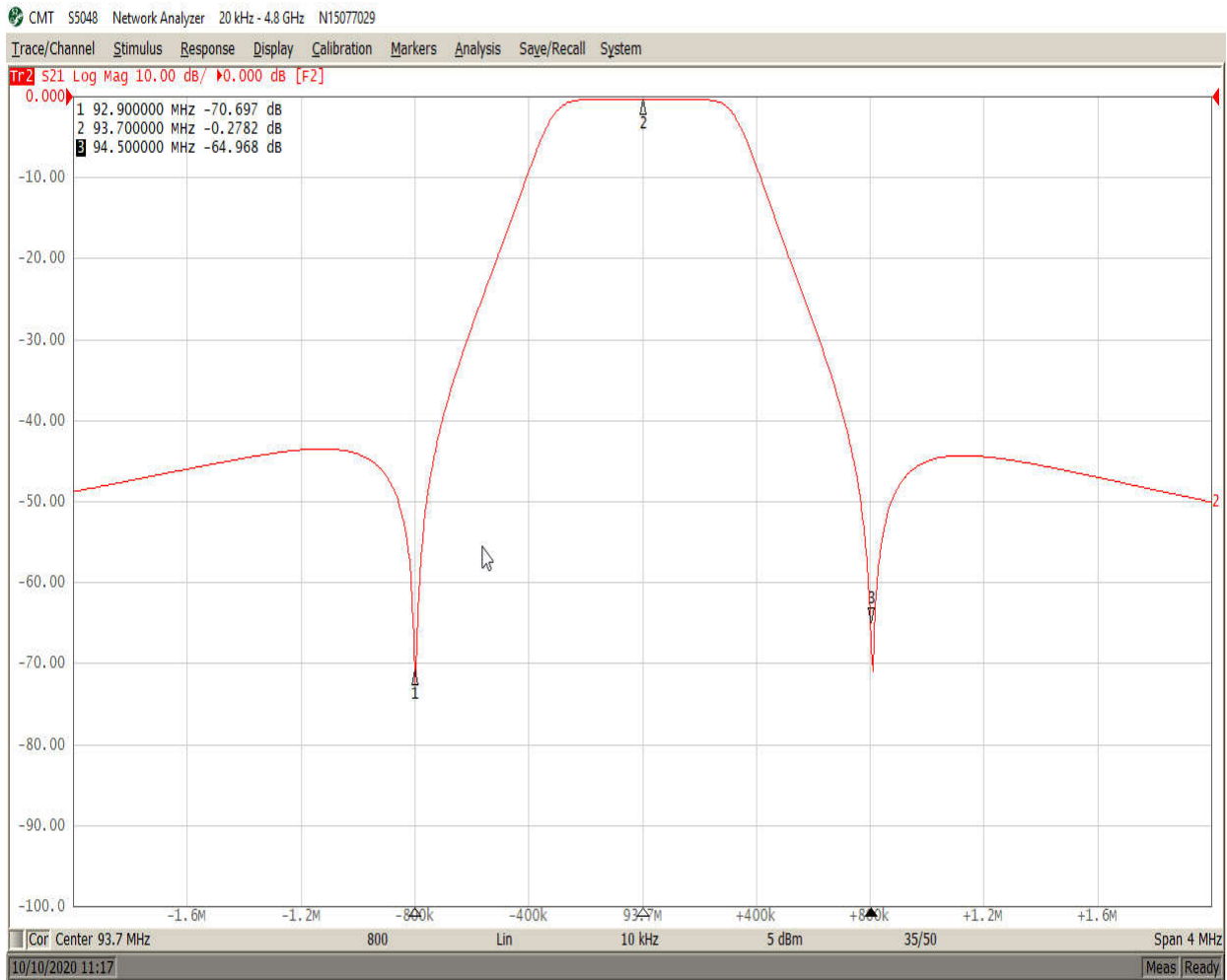


Measurement 1: Match and Insertion Loss of 93.7 MHz.

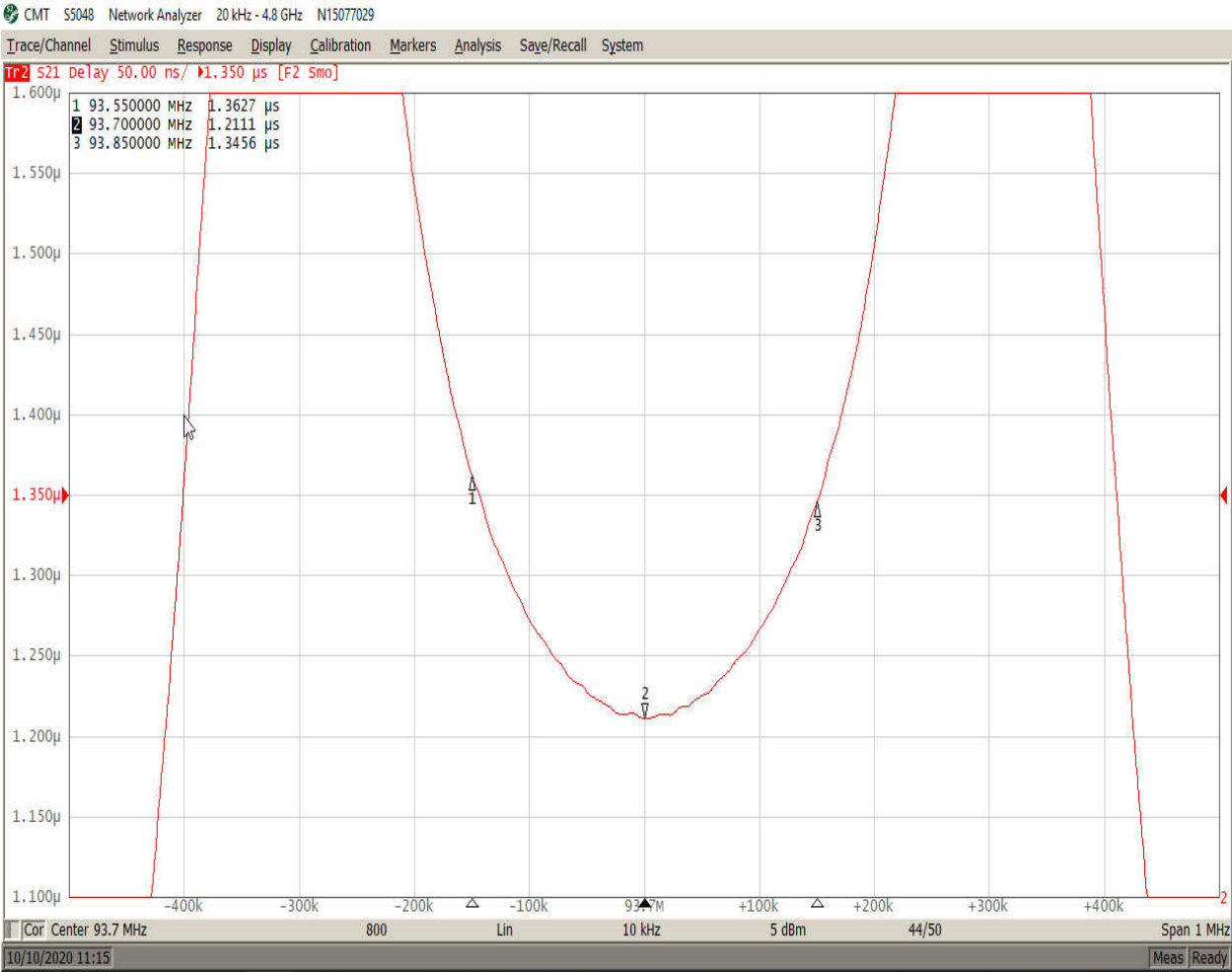




## Measurement 2: Isolation +/- 800 KHz. of 93.7 MHz.



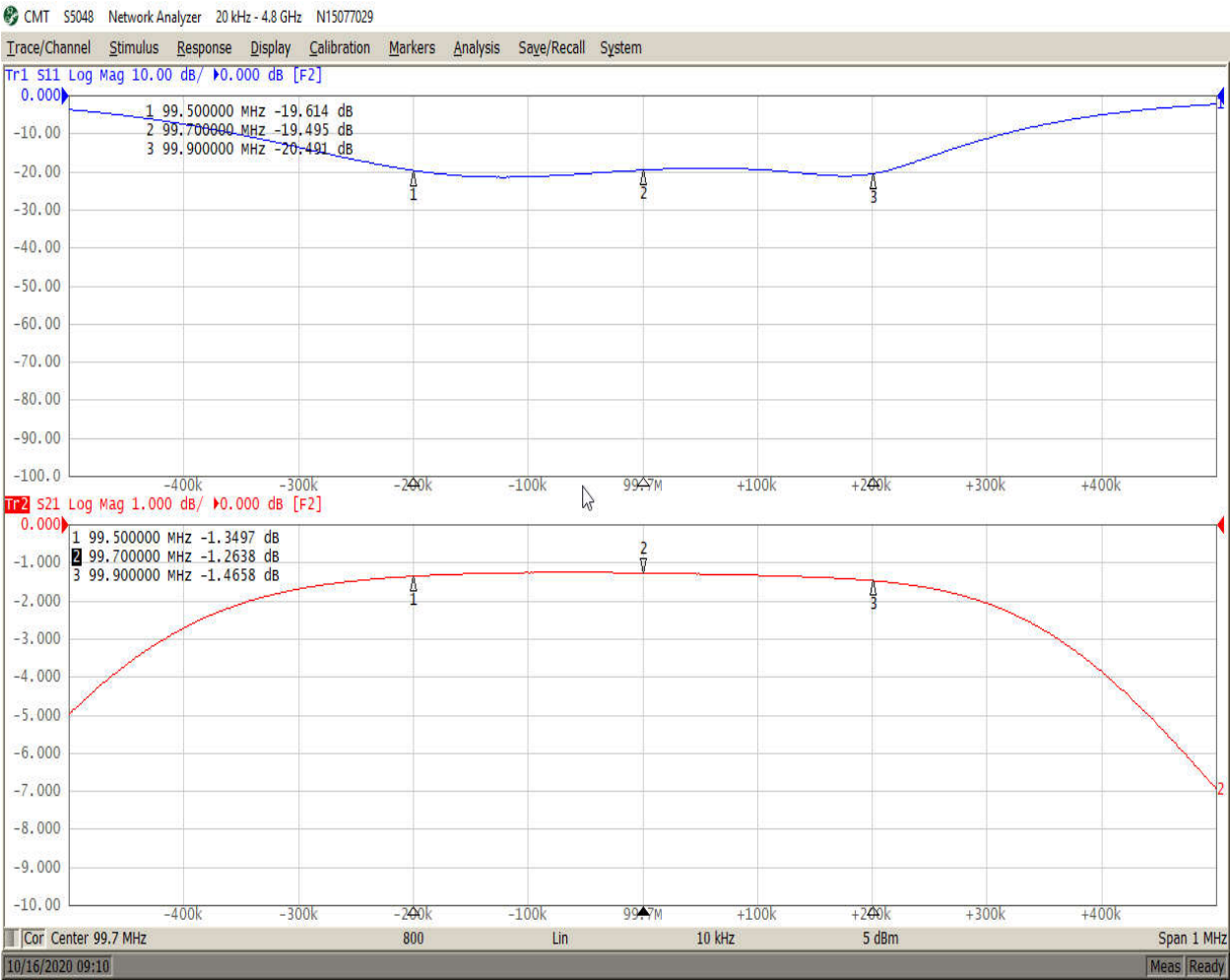
**Measurement 3: Group Delay of 93.7 MHz.**



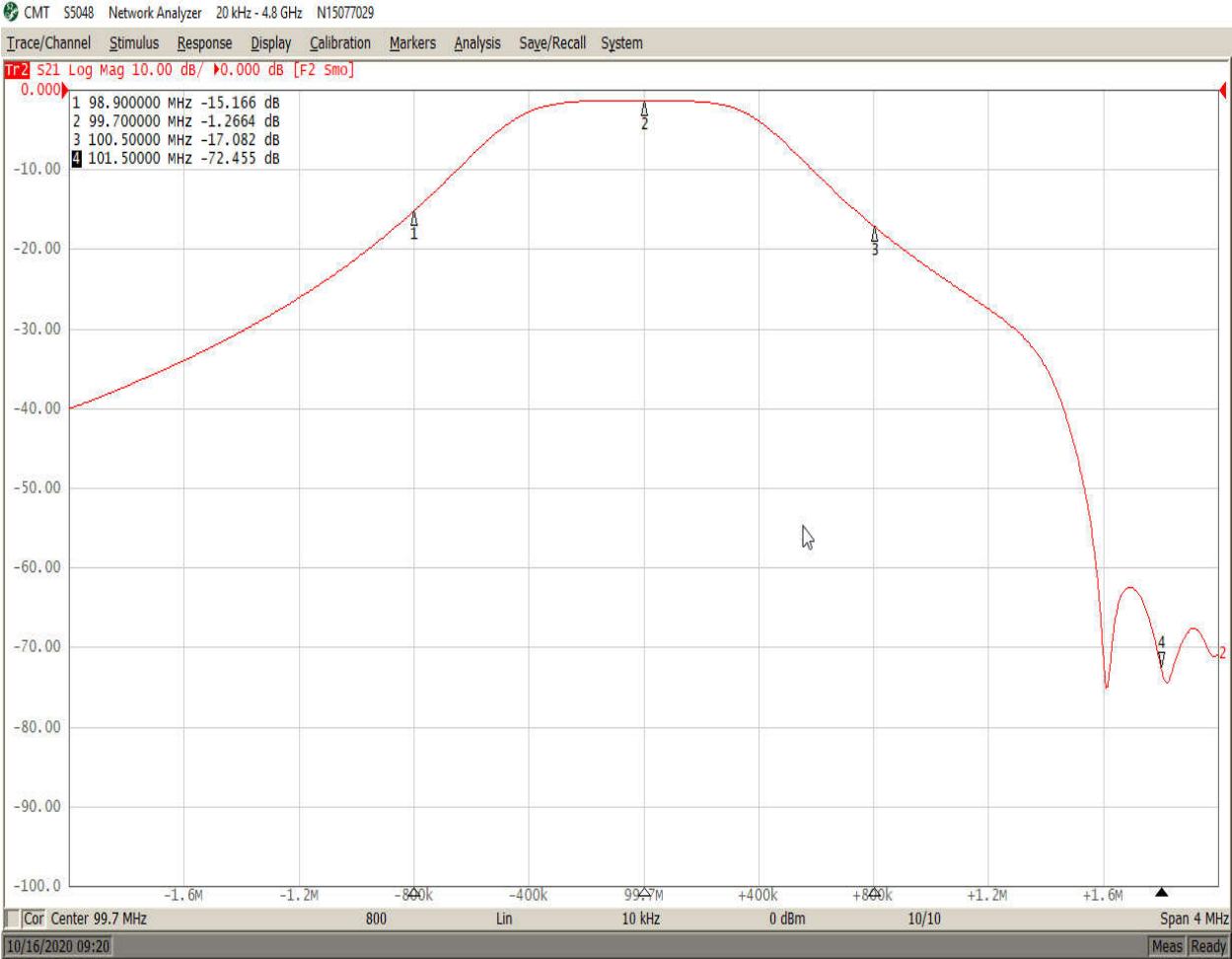
### Measurement 4: Broad Port Isolation for 93.7 MHz.



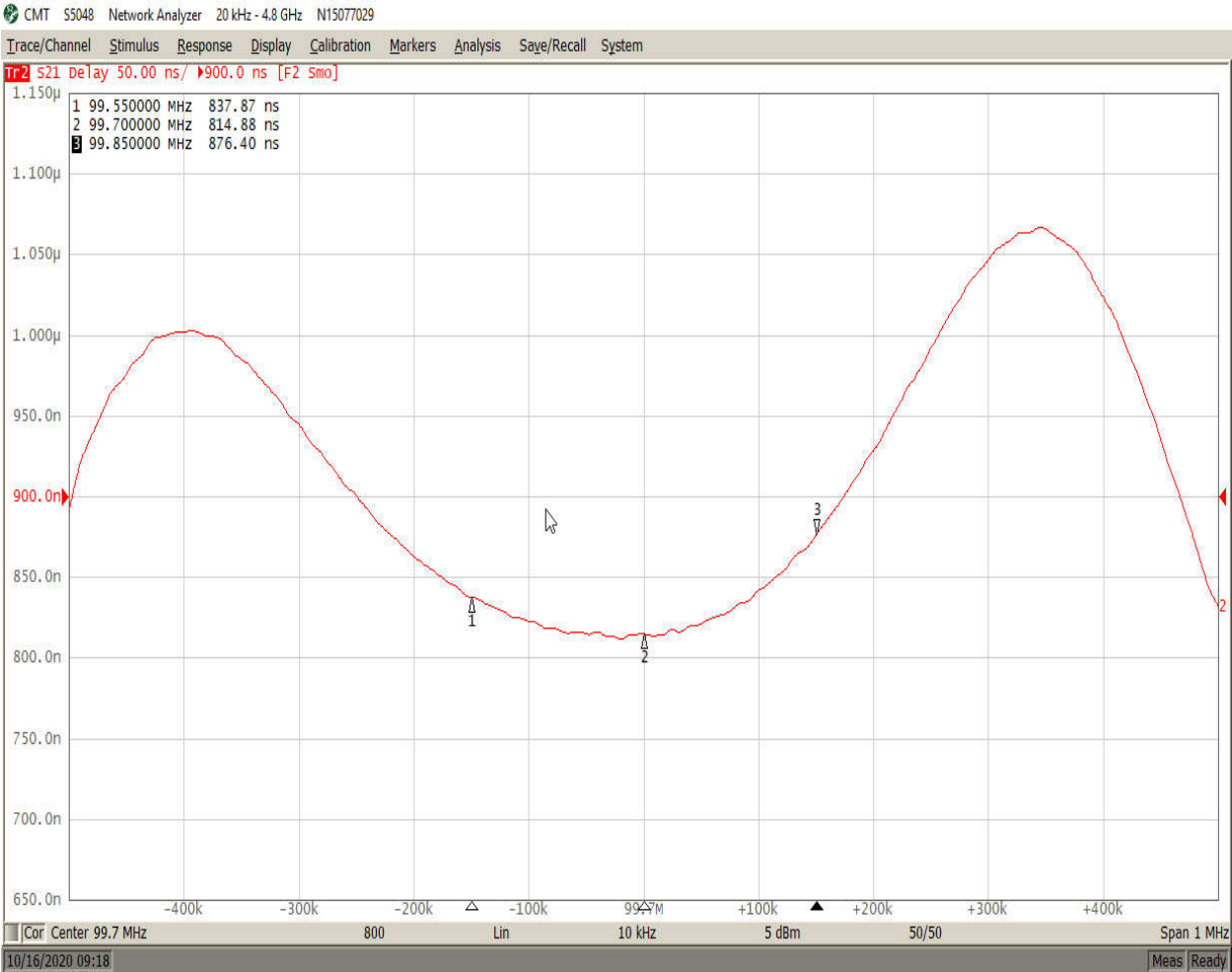
Measurement 5: Match and Insertion Loss of 99.7 MHz.



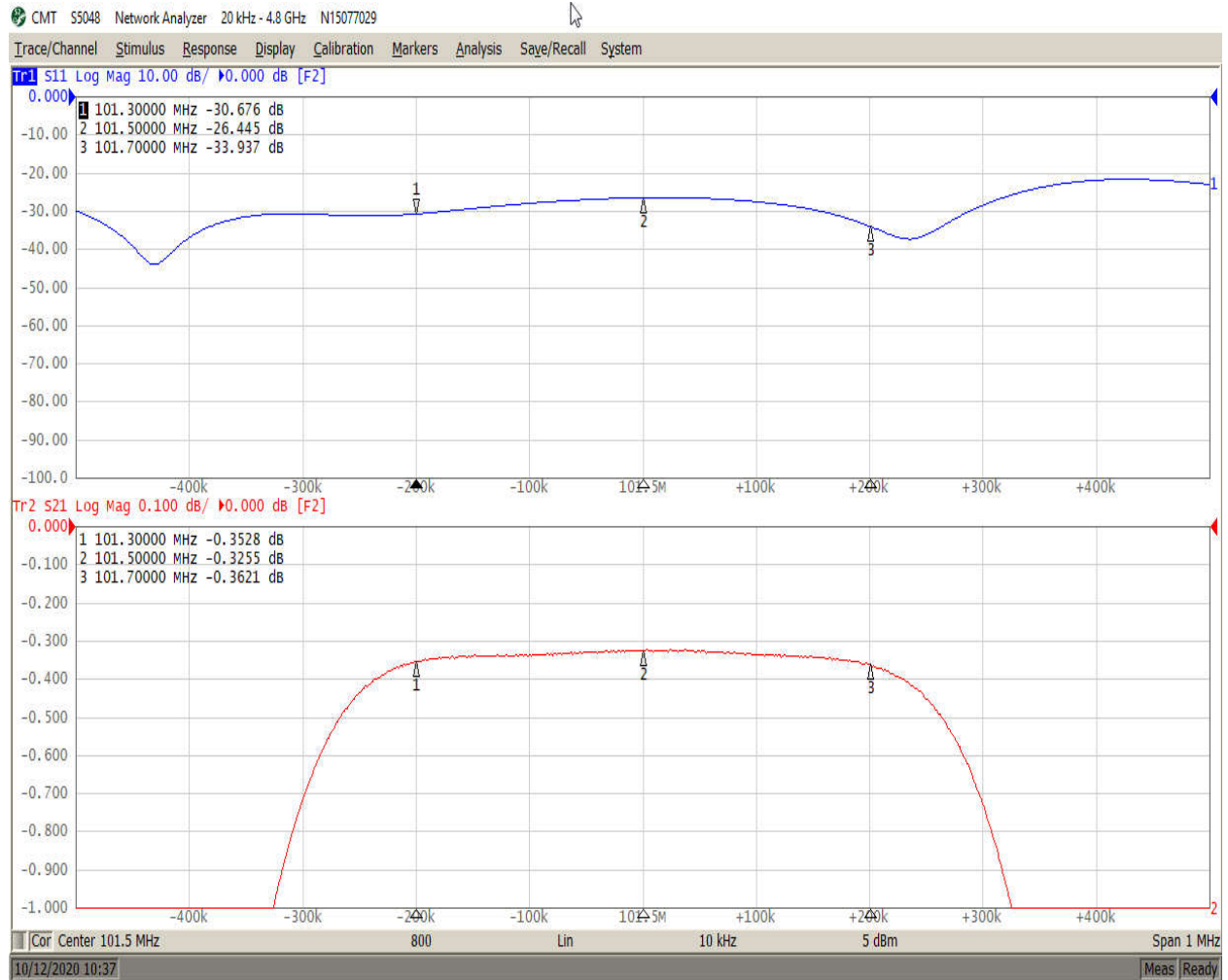
**Measurement 6: Isolation +/- 800 KHz. of 99.7 MHz.**



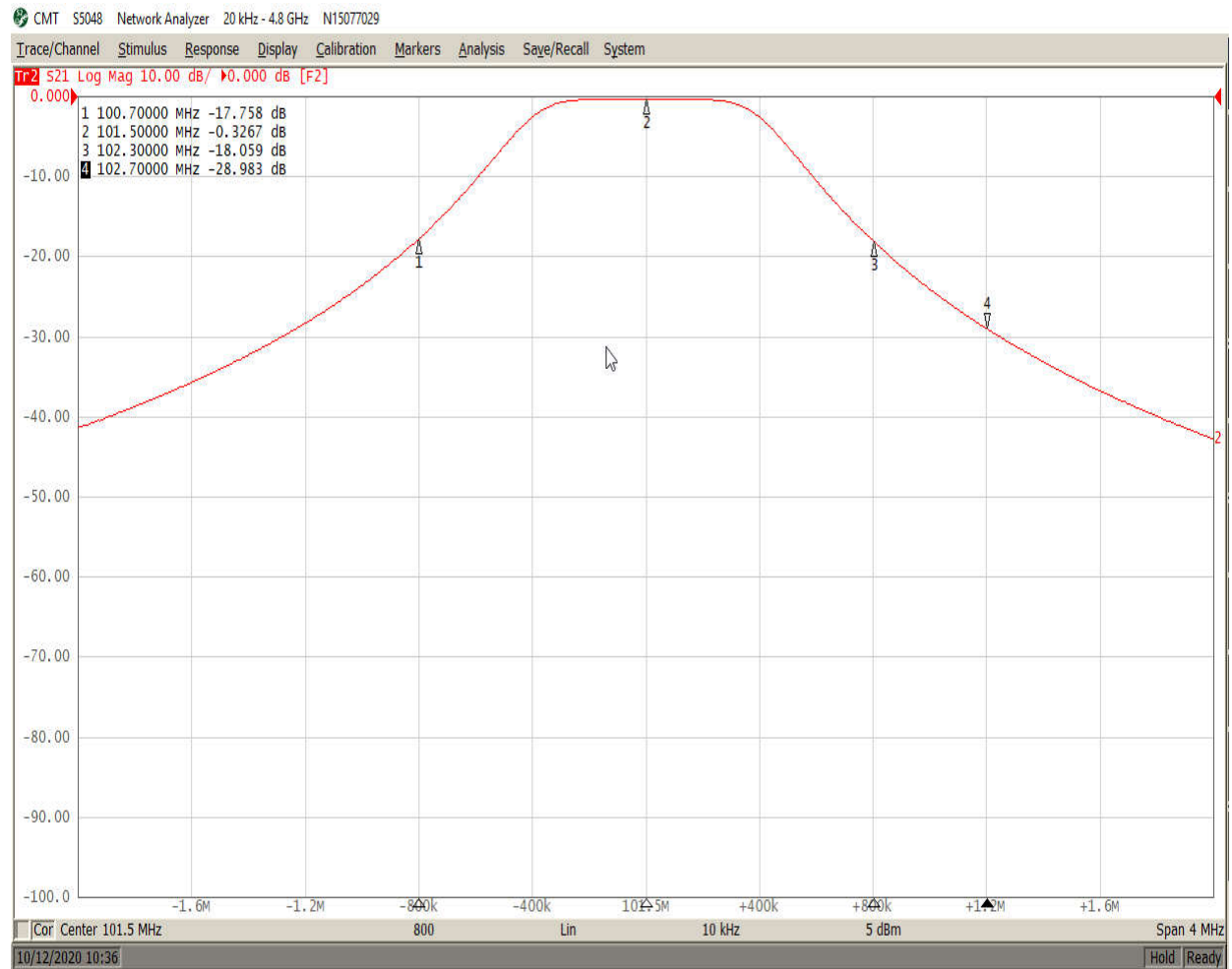
**Measurement 7: Group Delay of 99.7 MHz.**



## Measurement 8: Match & Insertion Loss of 101.5 MHz.



## Measurement 9: Isolation +/- 800 KHz. of 101.5 MHz.



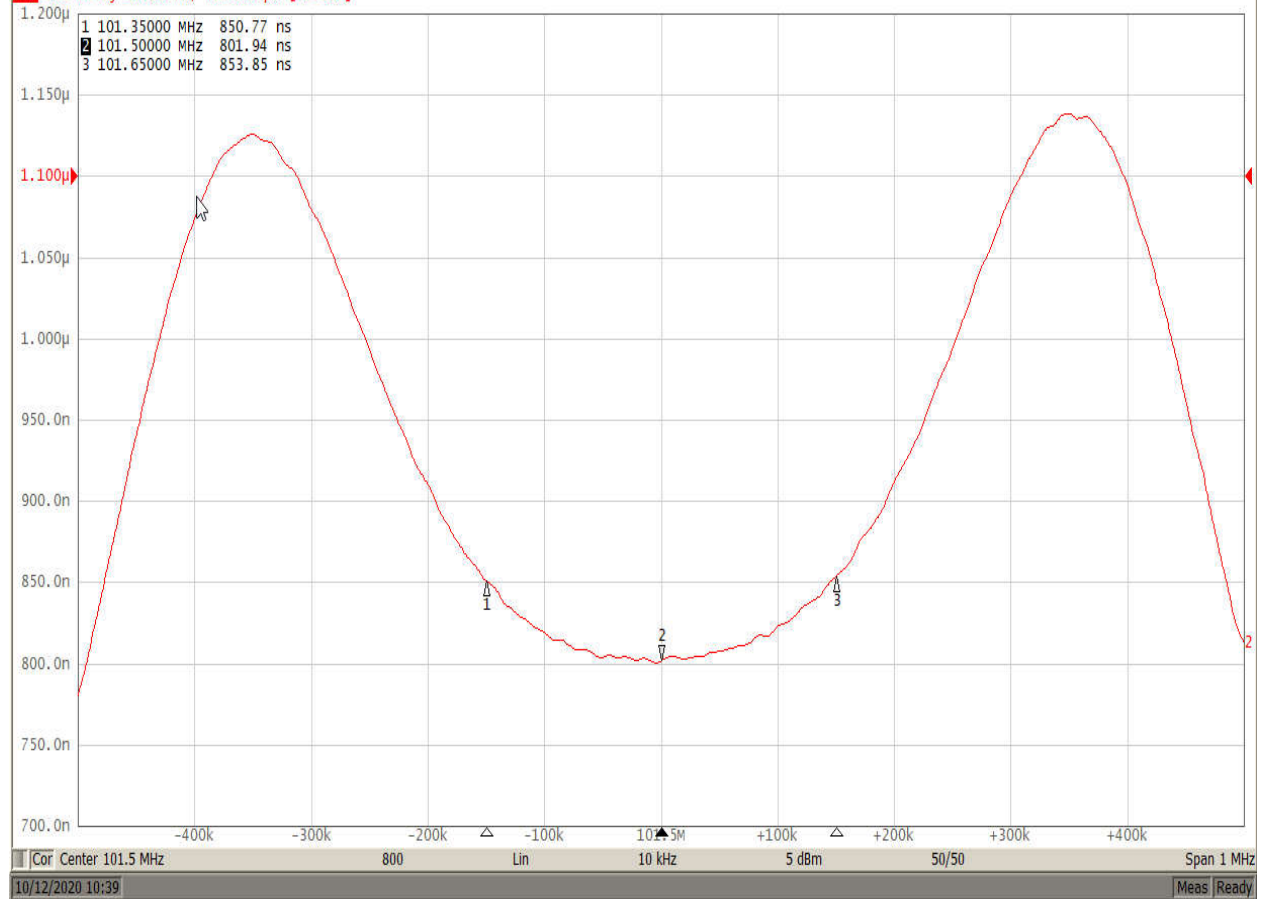


## Measurement 10: Group Delay of 101.5 MHz.

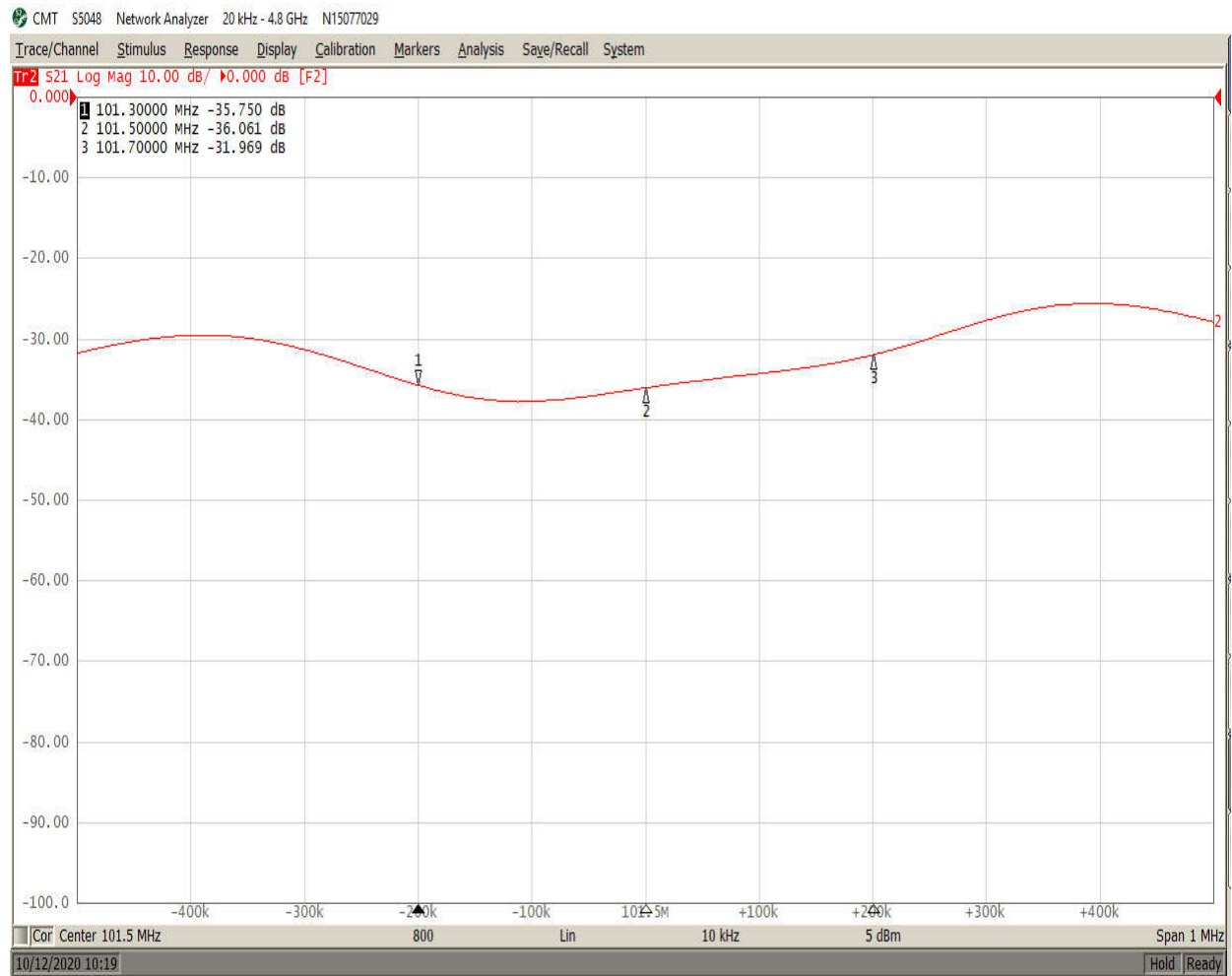
CMT S5048 Network Analyzer 20 kHz - 4.8 GHz N15077029

Trace/Channel Stimulus Response Display Calibration Markers Analysis Save/Recall System

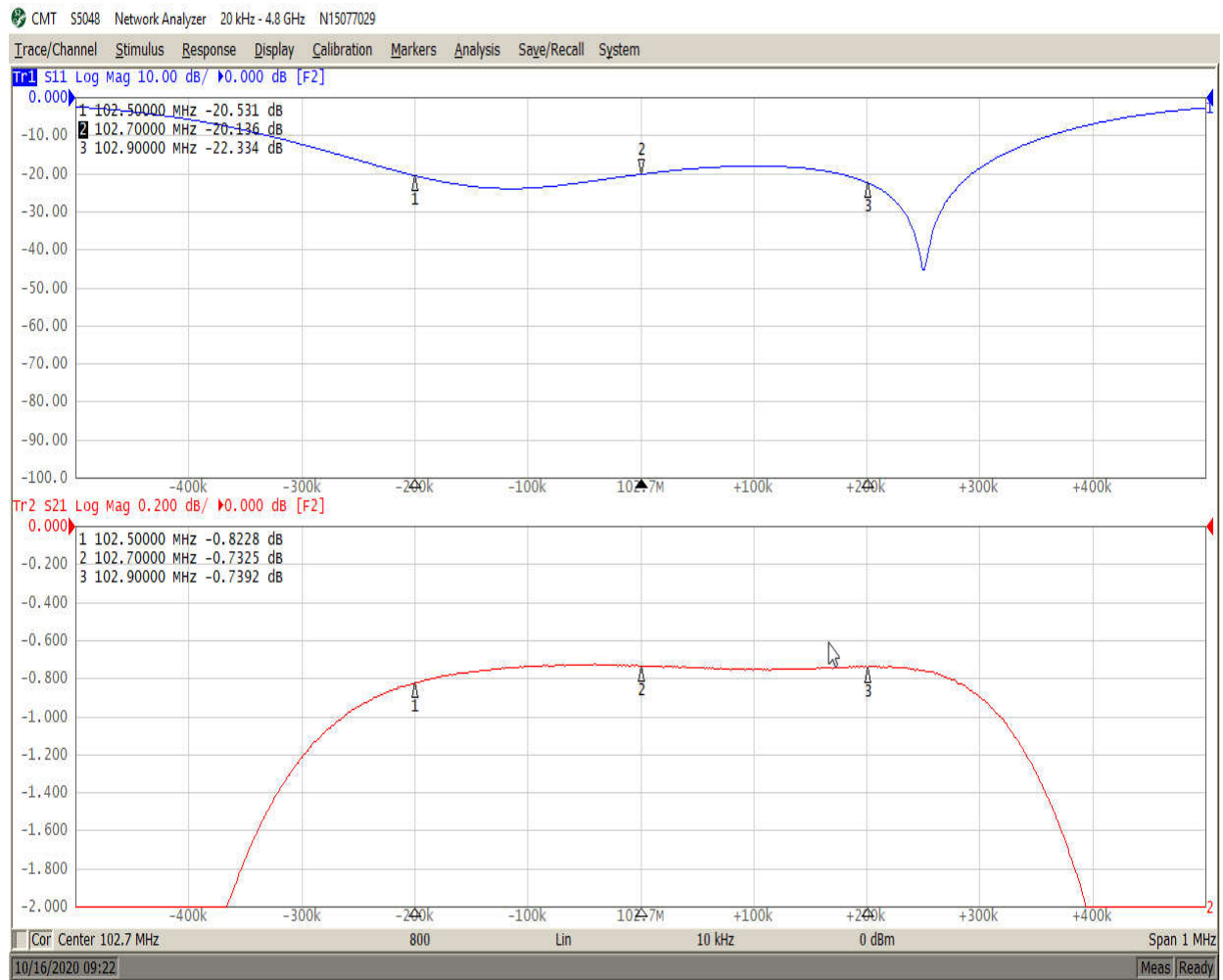
Tr2 S21 Delay 50.00 ns/ 1.100  $\mu$ s [F2 Smo]



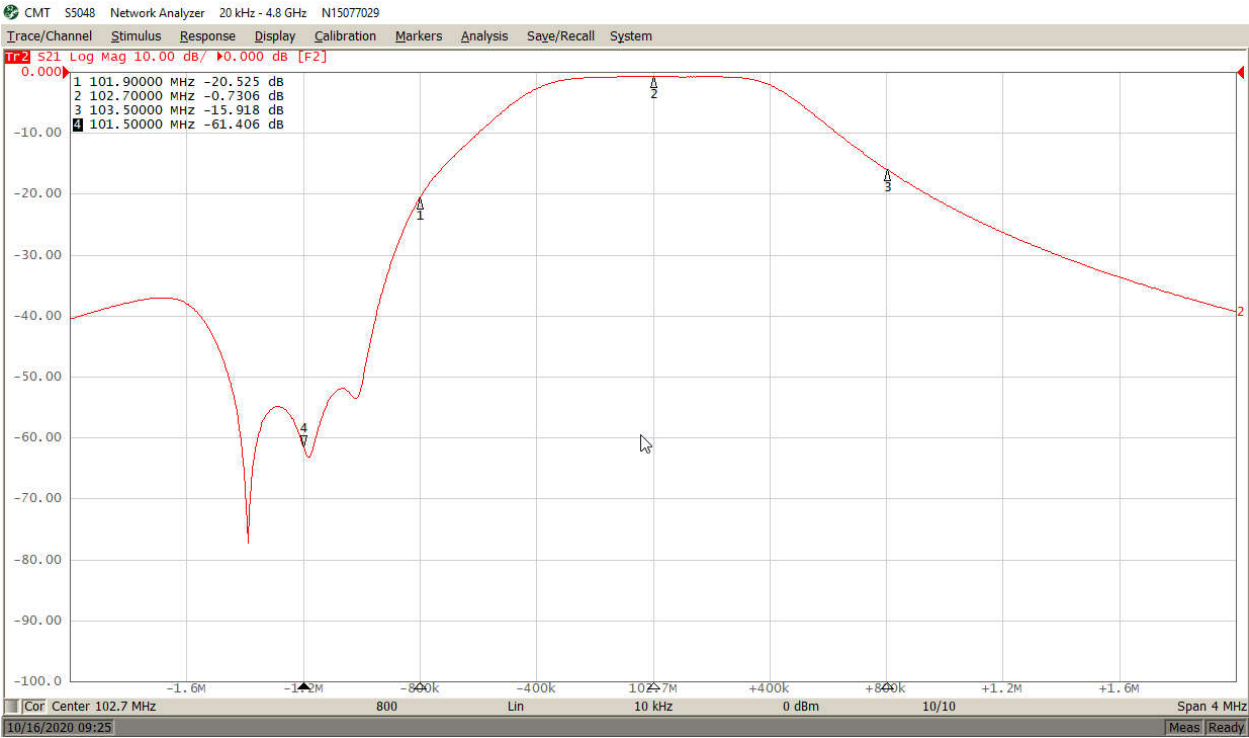
## Measurement 11: Isolation to Broad Port of 101.5 MHz.



## Measurement 12: Match and Insertion Loss of 102.7 MHz.



# Measurement 13: Isolation +/- 800 KHz. of 102.7 MHz.

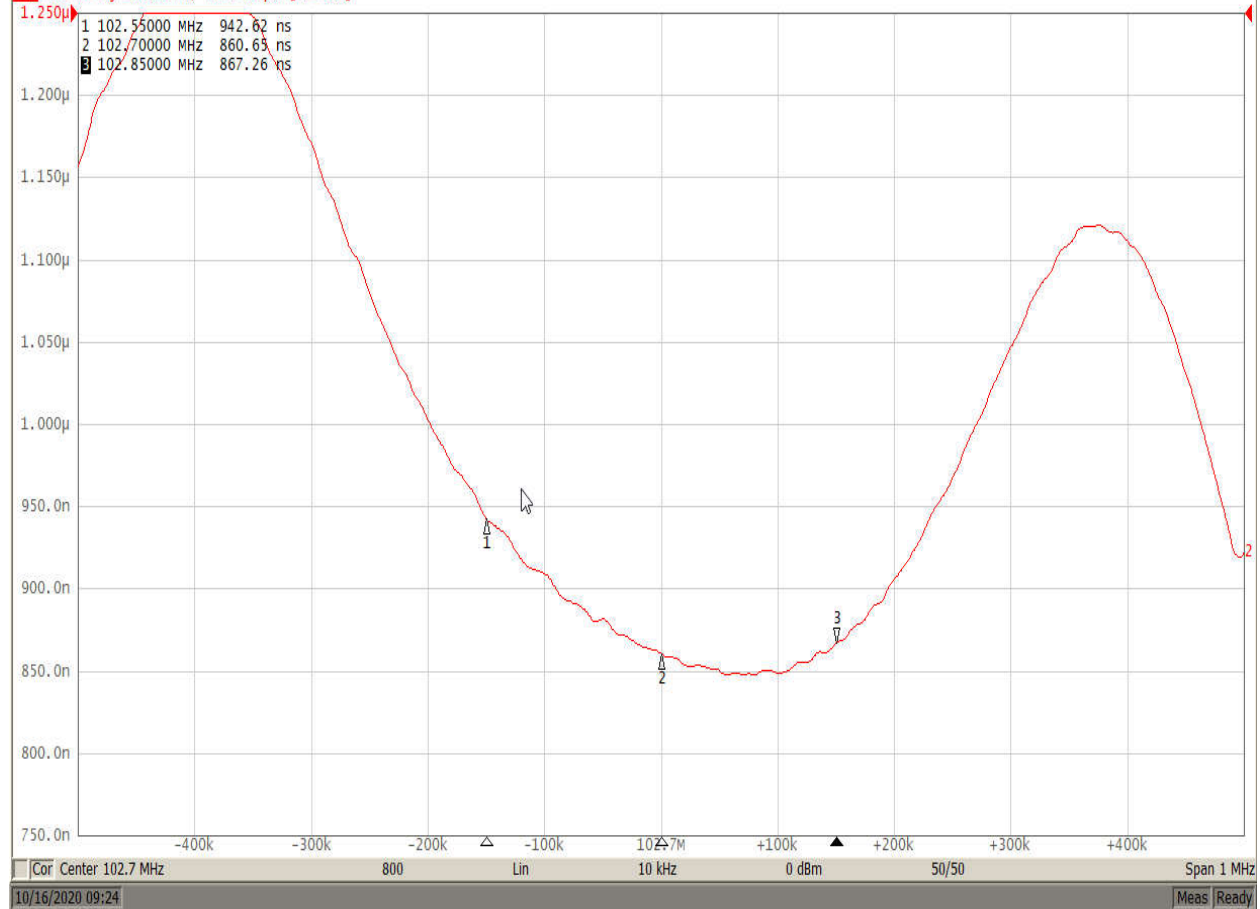


## Measurement 14: Group Delay of 102.7 MHz.

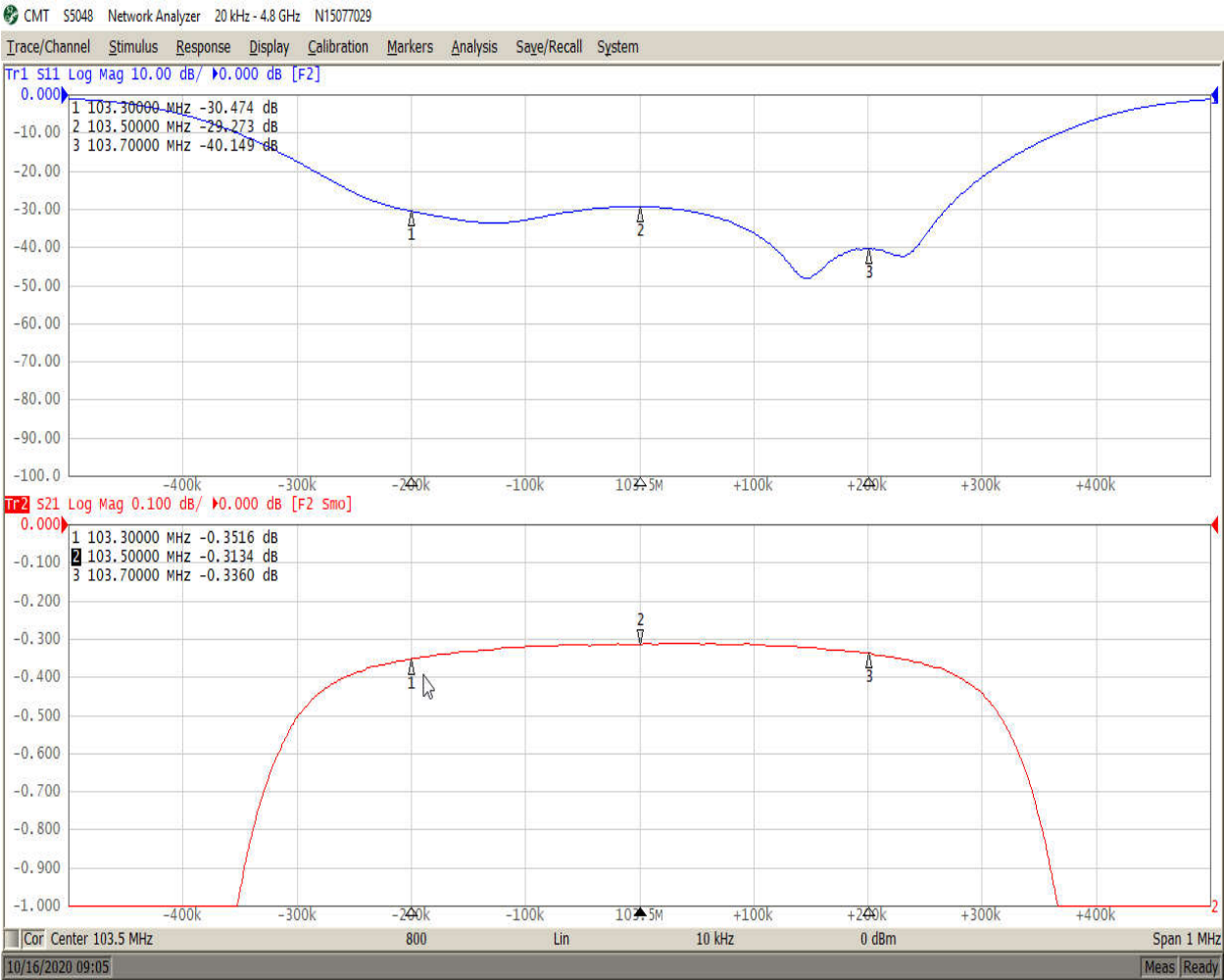
CMT S5048 Network Analyzer 20 kHz - 4.8 GHz N15077029

Trace/Channel Stimulus Response Display Calibration Markers Analysis Save/Recall System

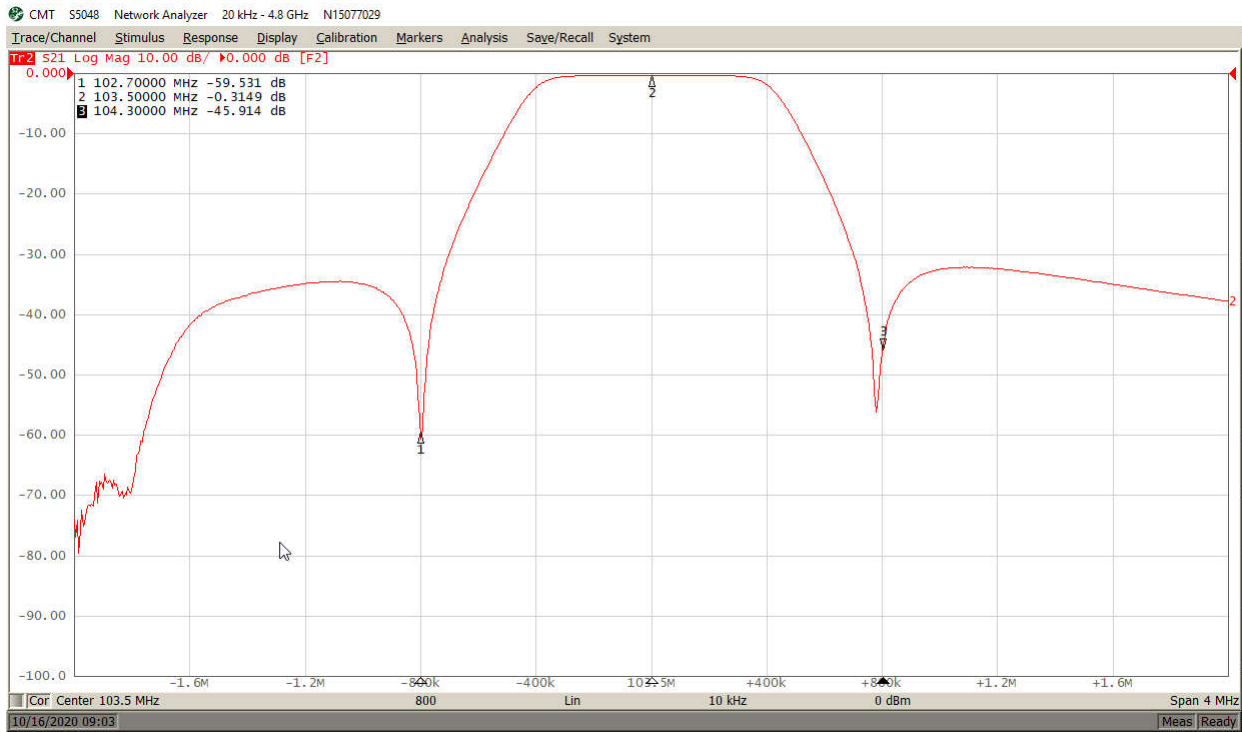
Tr2 S21 Delay 50.00 ns/ 1.250  $\mu$ s [F2 Smo]



Measurement 15: Match & Insertion Loss of 103.5 MHz.



**Measurement 16: Isolation +/- 800 KHz. of 103.5 MHz.**

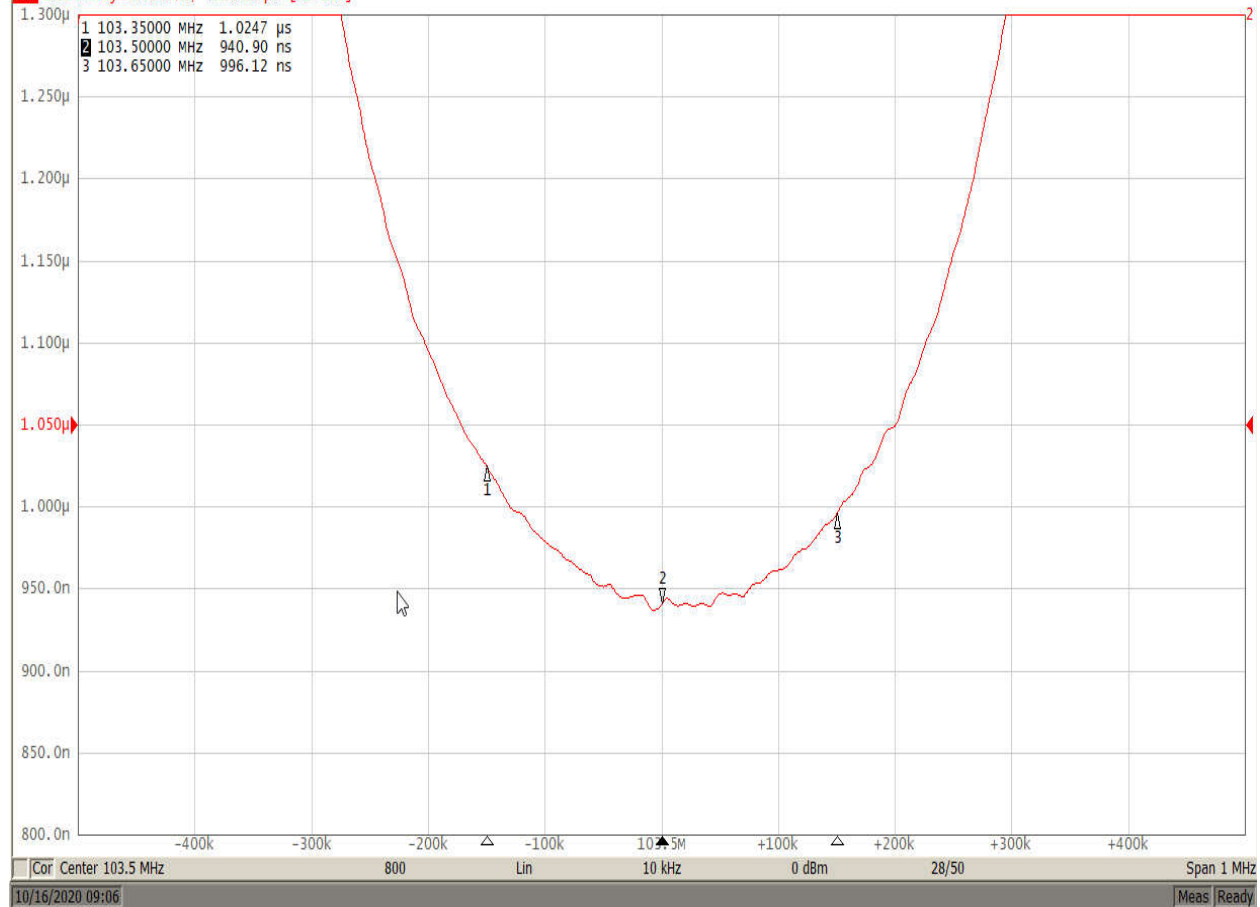


## Measurement 17: Group Delay of 103.5 MHz.

CMT S5048 Network Analyzer 20 kHz - 4.8 GHz N15077029

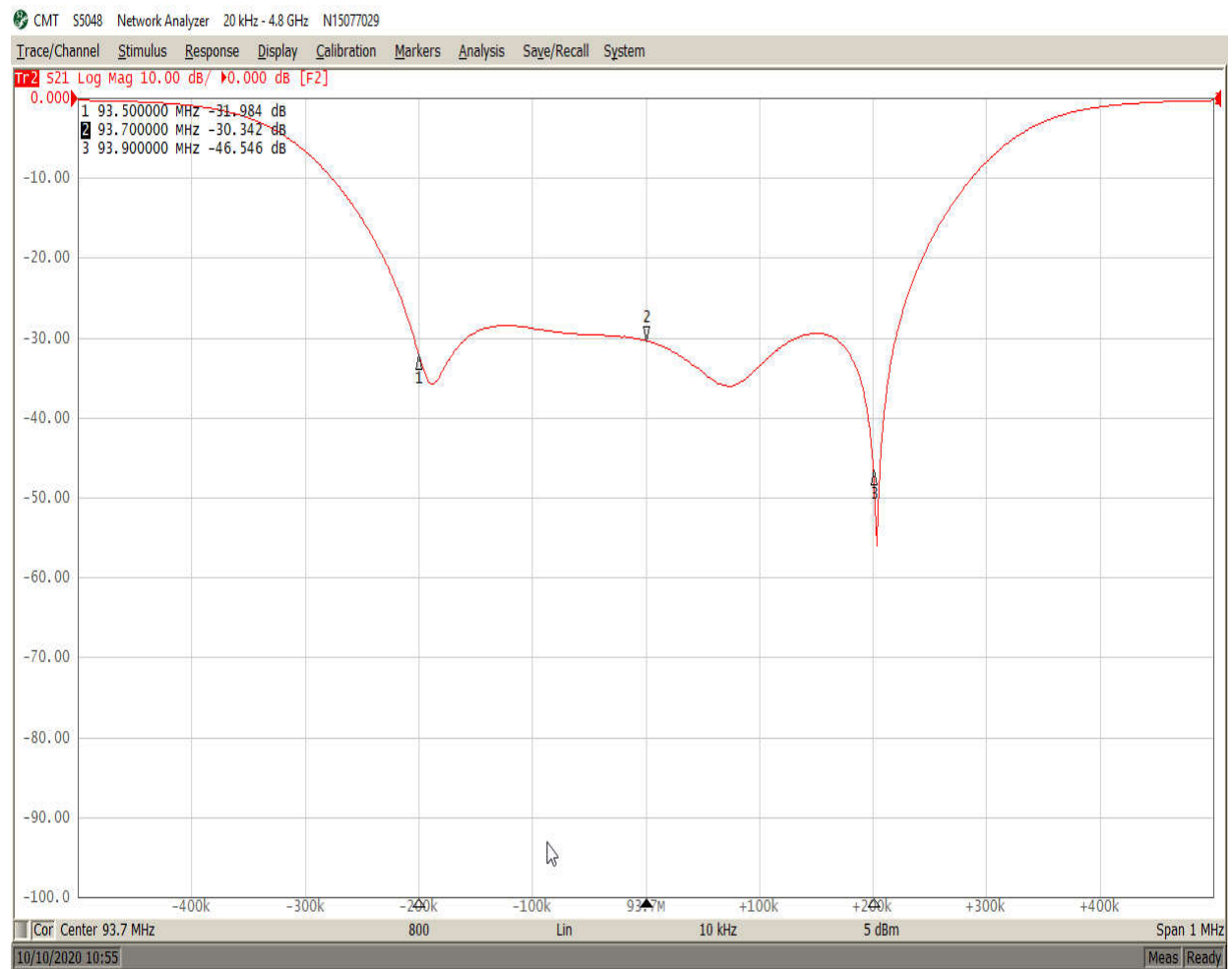
Trace/Channel Stimulus Response Display Calibration Markers Analysis Save/Recall System

Tr2 S21 Delay 50.00 ns/ 1.050  $\mu$ s [F2 Smo]

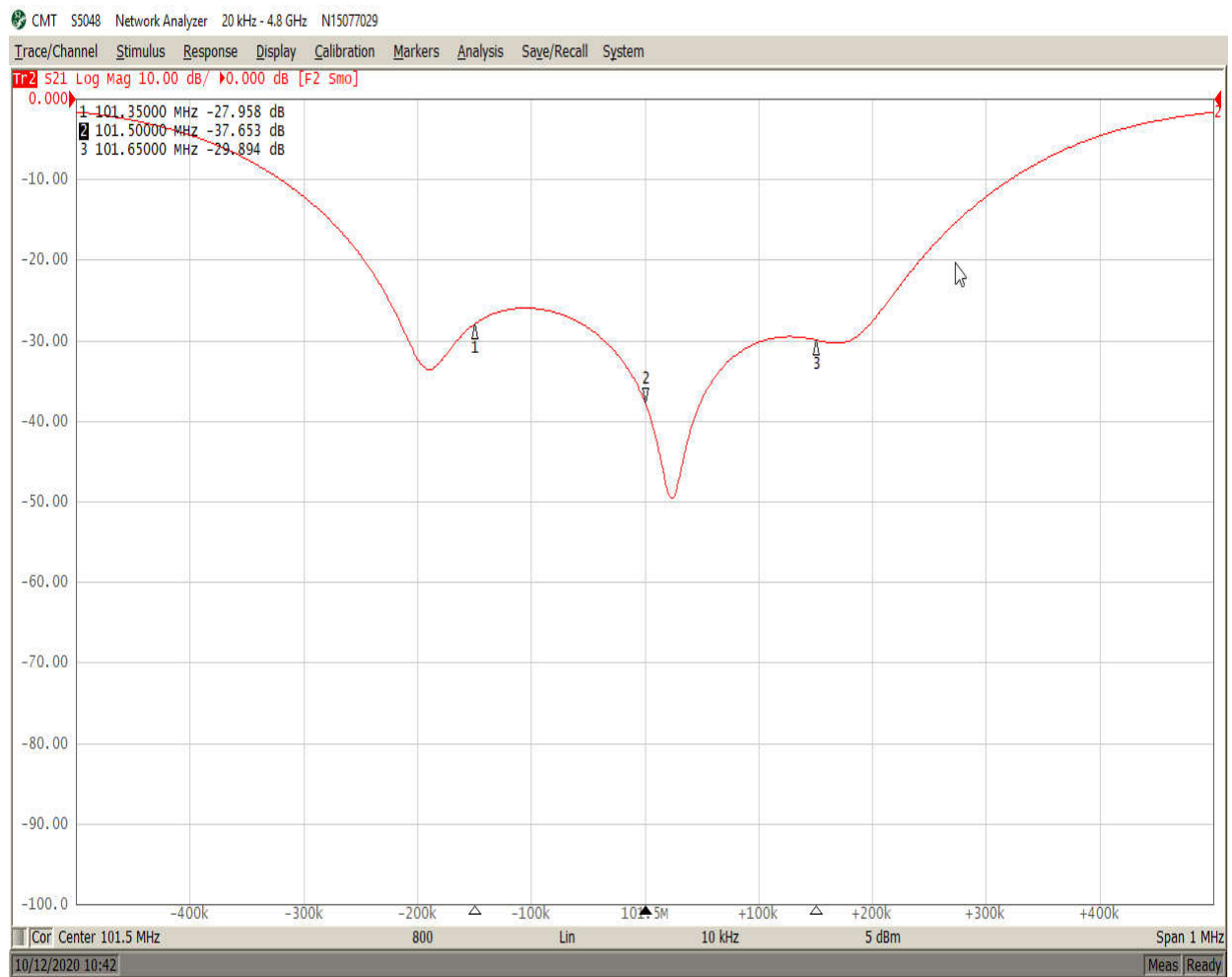




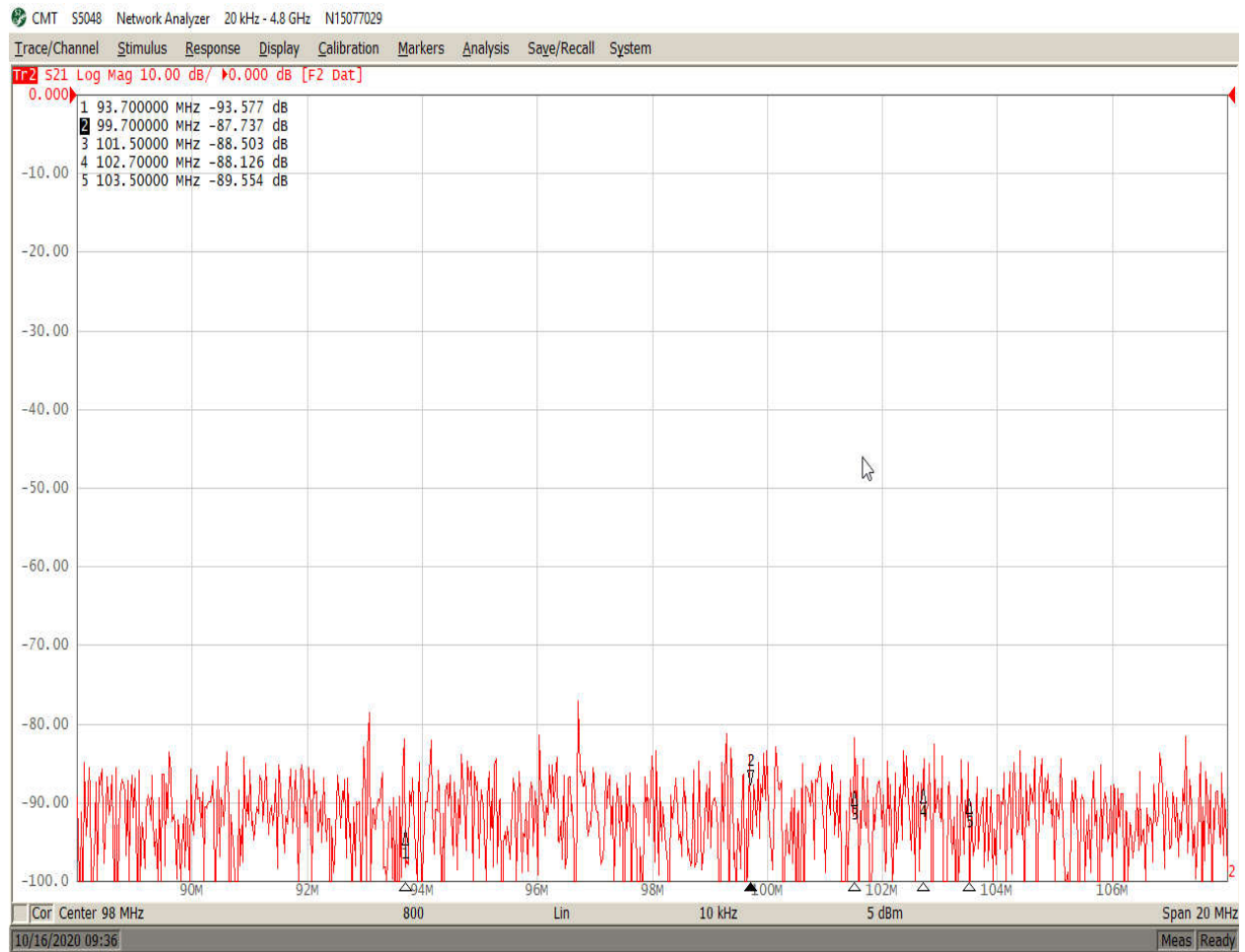
## Measurement 18: Isolation to Dump Load 93.7 MHz.



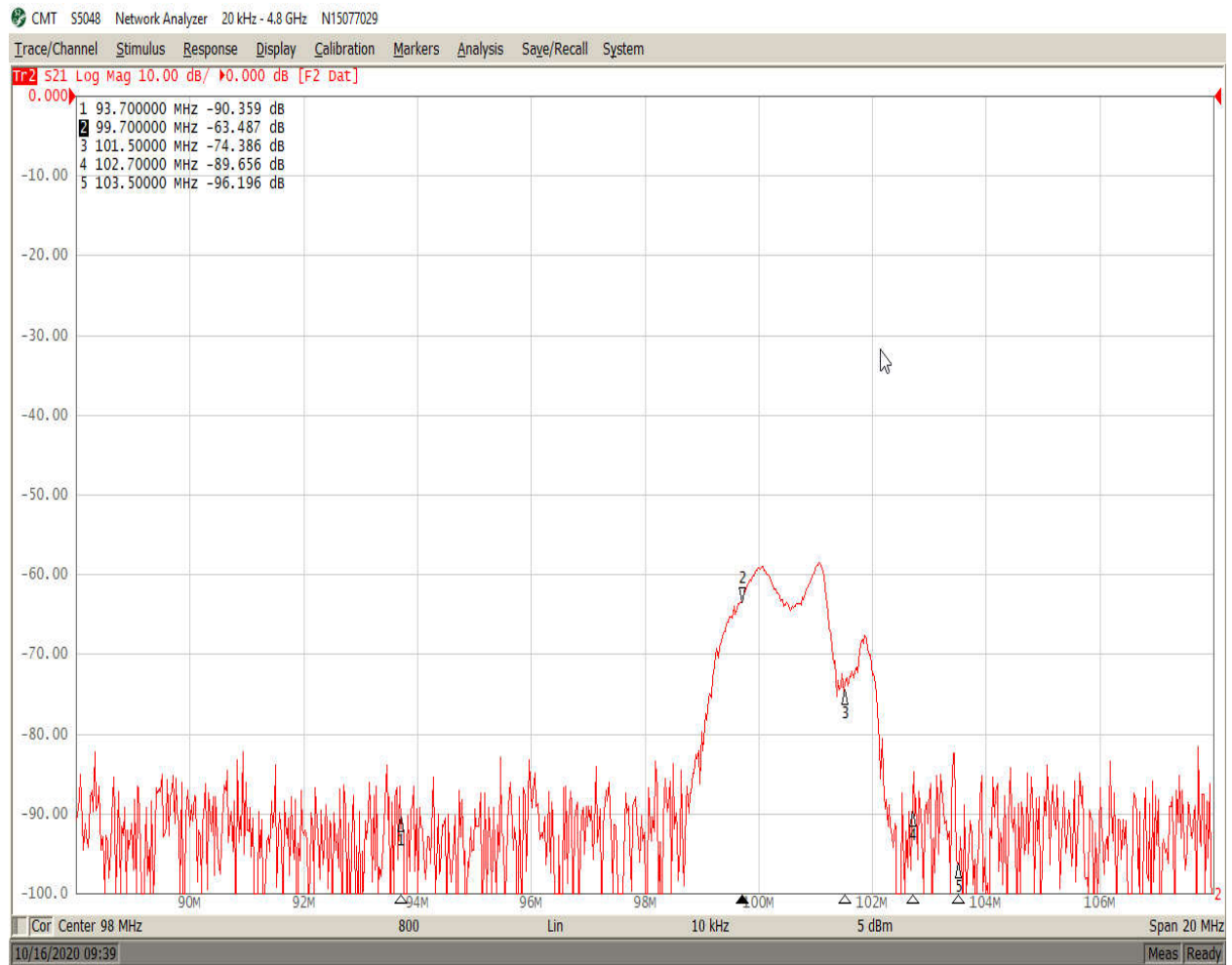
## Measurement 19: Isolation to Dump Load 101.5 MHz.



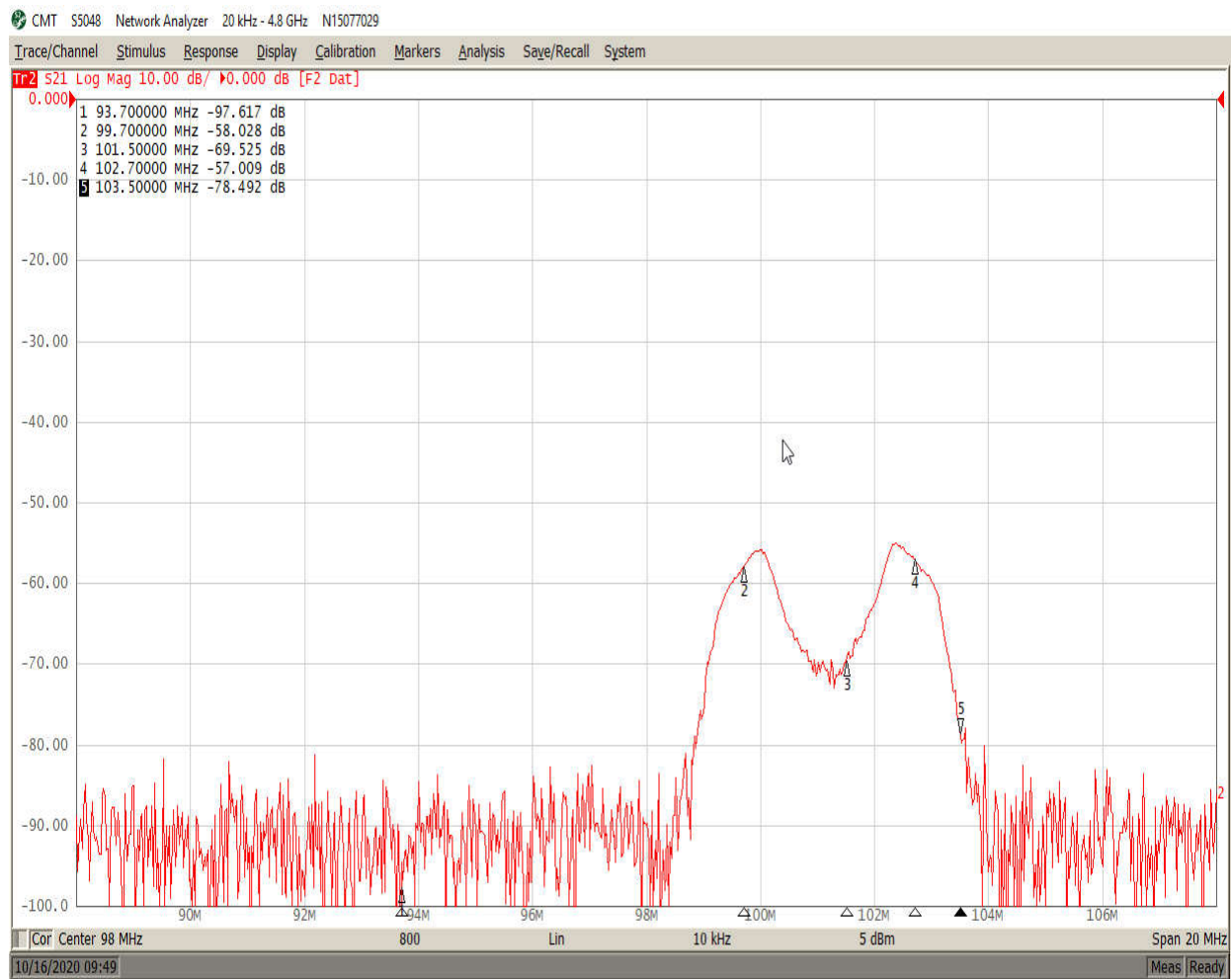
## Measurement 20: Port to Port Isolation 93.7 to 99.7 MHz.



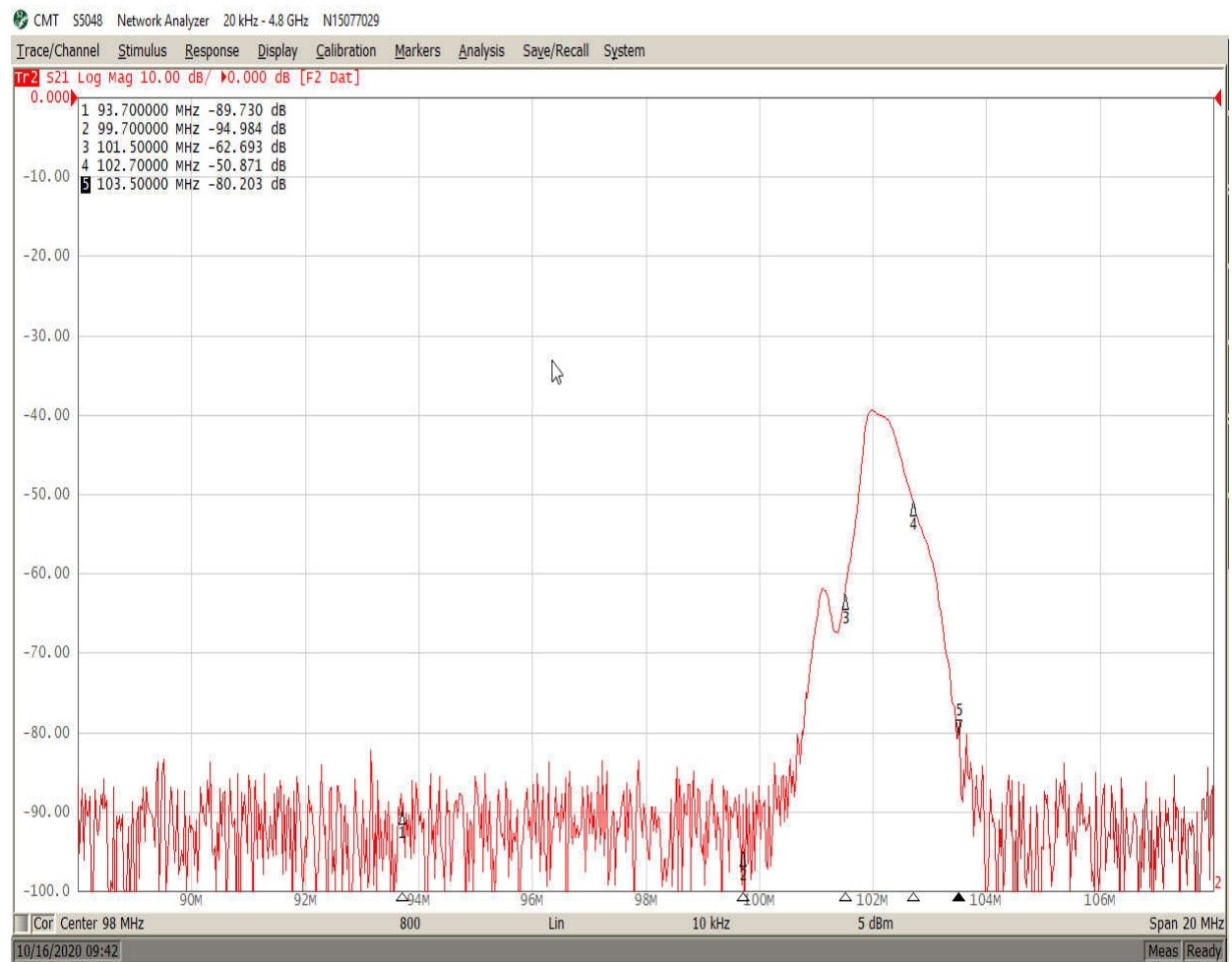
## Measurement 21: Port to Port Isolation 99.7 to 101.5 MHz.



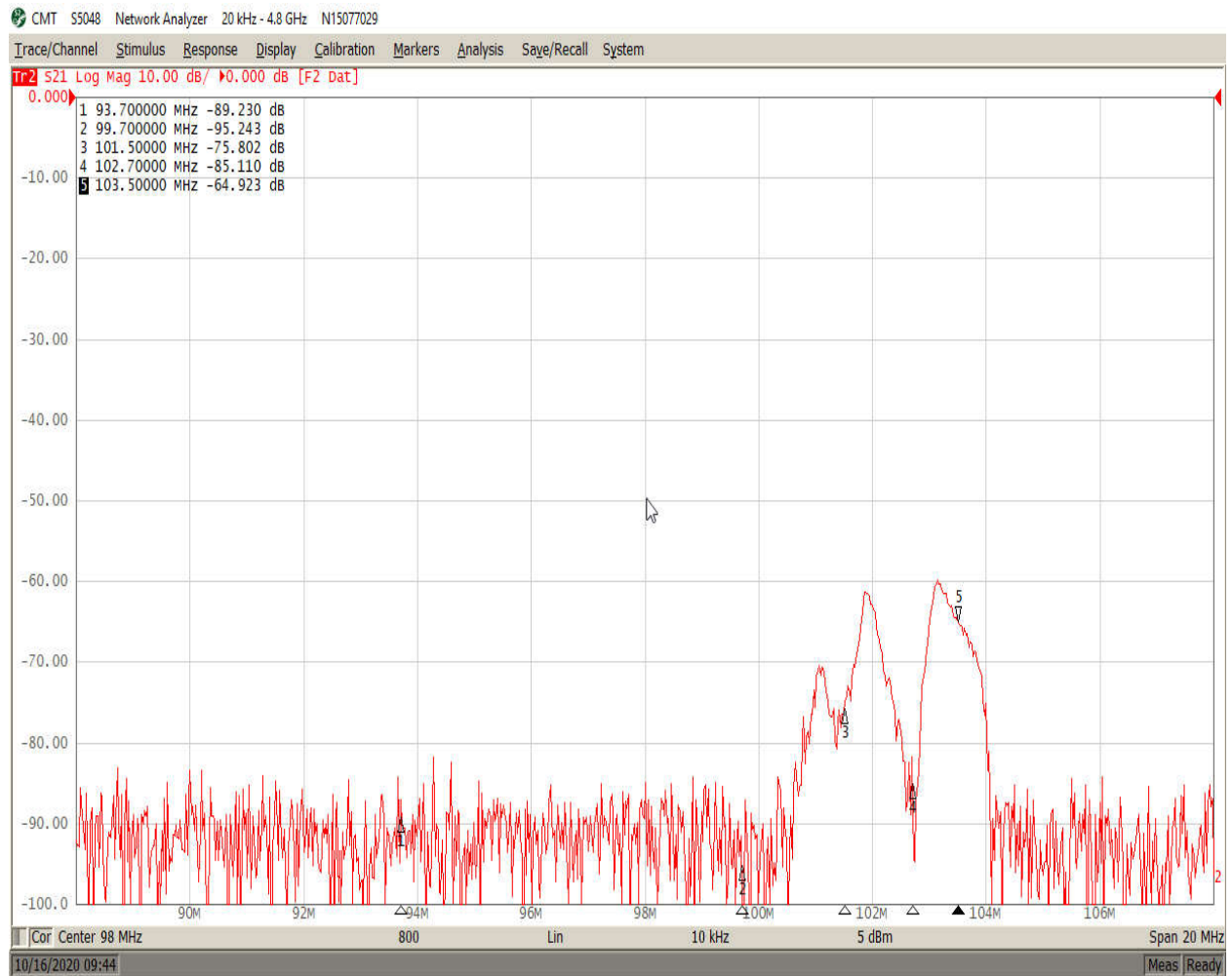
**Measurement 22: Port to Port Isolation 99.7 to 102.7 MHz.**



### Measurement 23: Port to Port Isolation 102.7 to 101.5 MHz.



## Measurement 24: Port to Port Isolation 103.5 to 101.5 MHz.

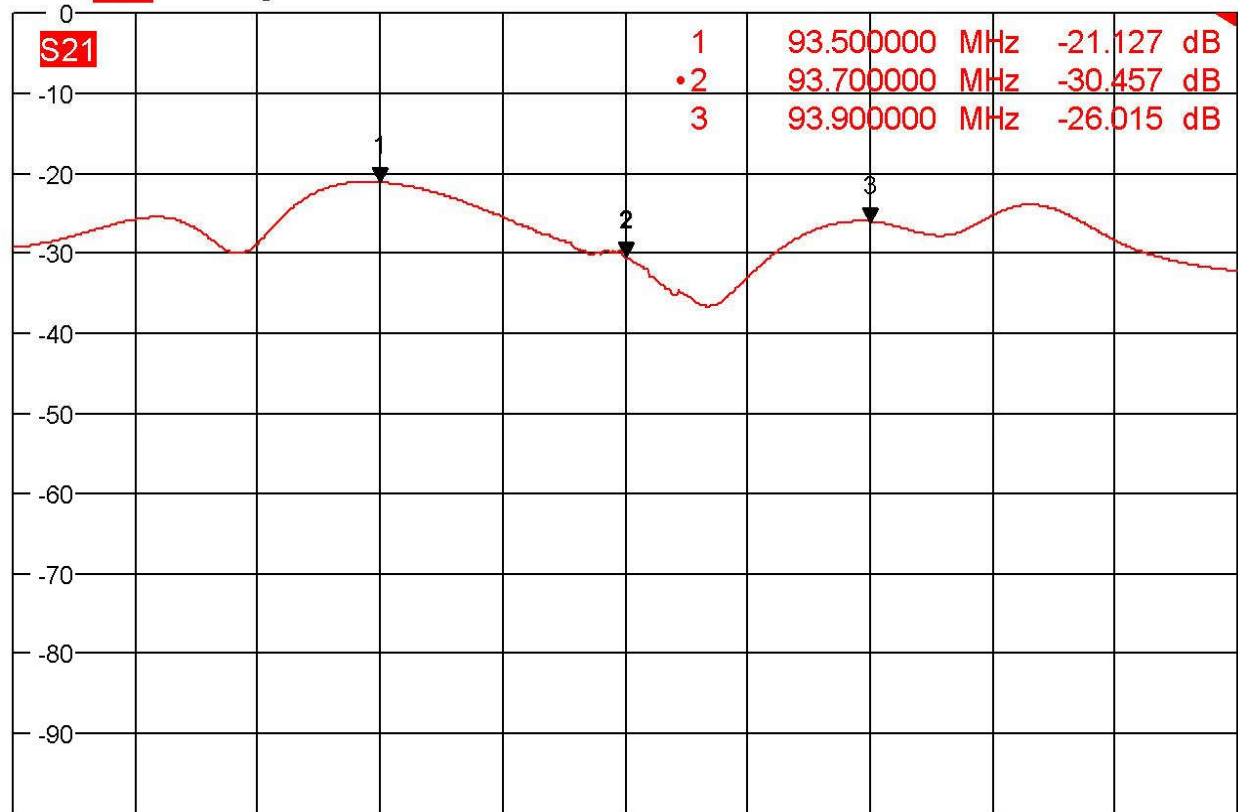


### Measurement 25: Filter to Antenna Match 93.7 MHz.



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

1



Ch1 Center 93.7 MHz

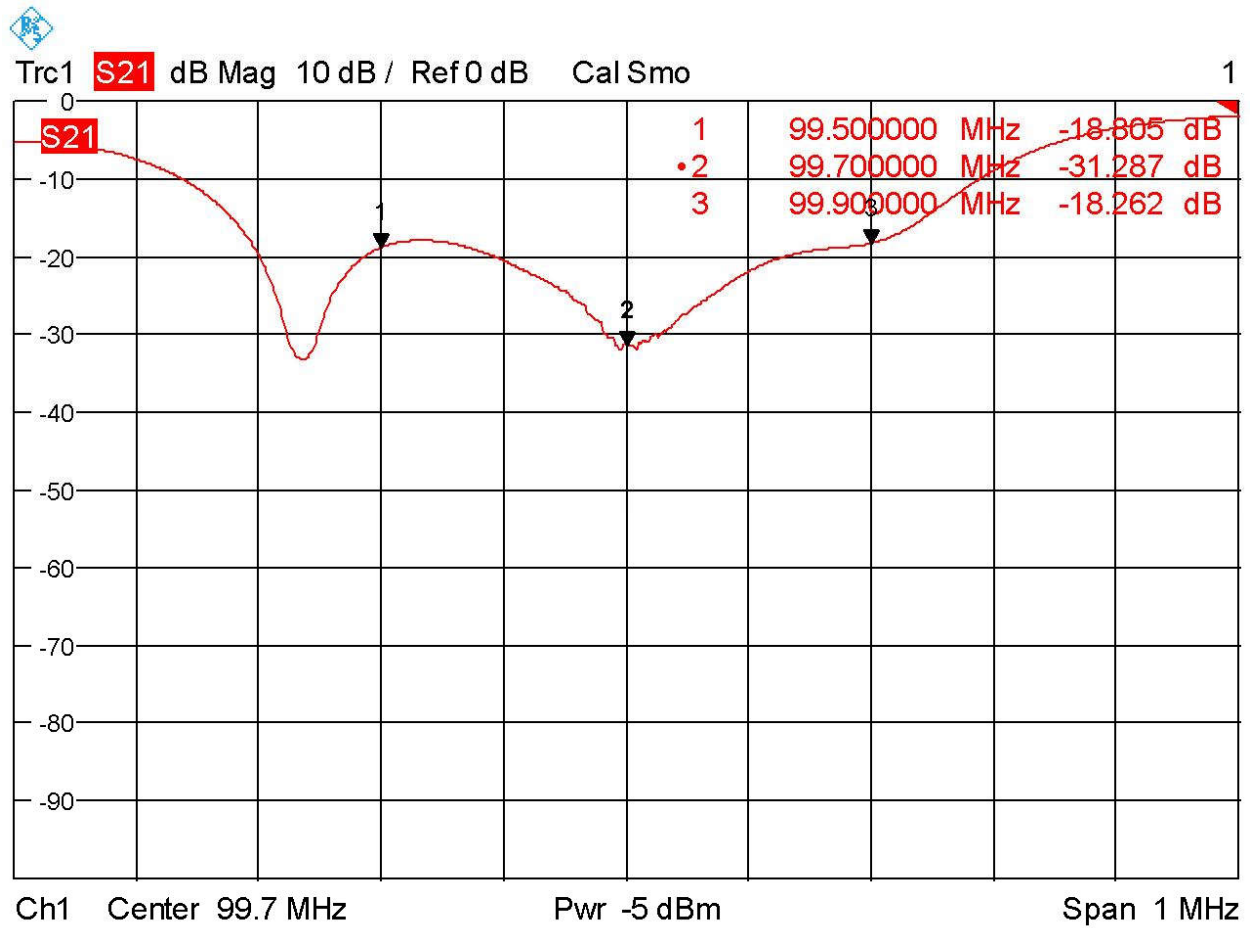
Pwr -5 dBm

Span 1 MHz

Date: 10-24-20



### Measurement 26: Filter to Antenna Match 99.7 MHz.



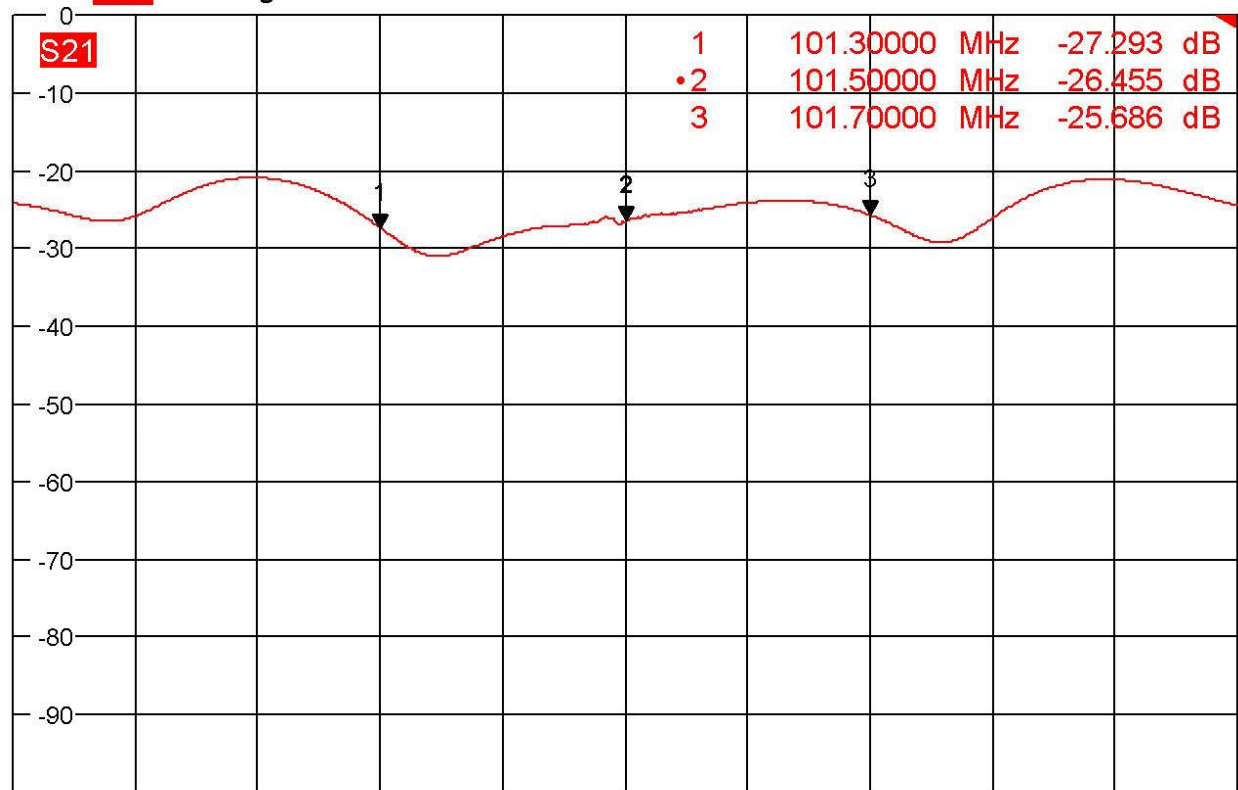
Date: 10-24-20

### Measurement 27: Filter to Antenna Match 101.5 MHz.



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

1



Ch1 Center 101.5 MHz

Pwr -5 dBm

Span 1 MHz

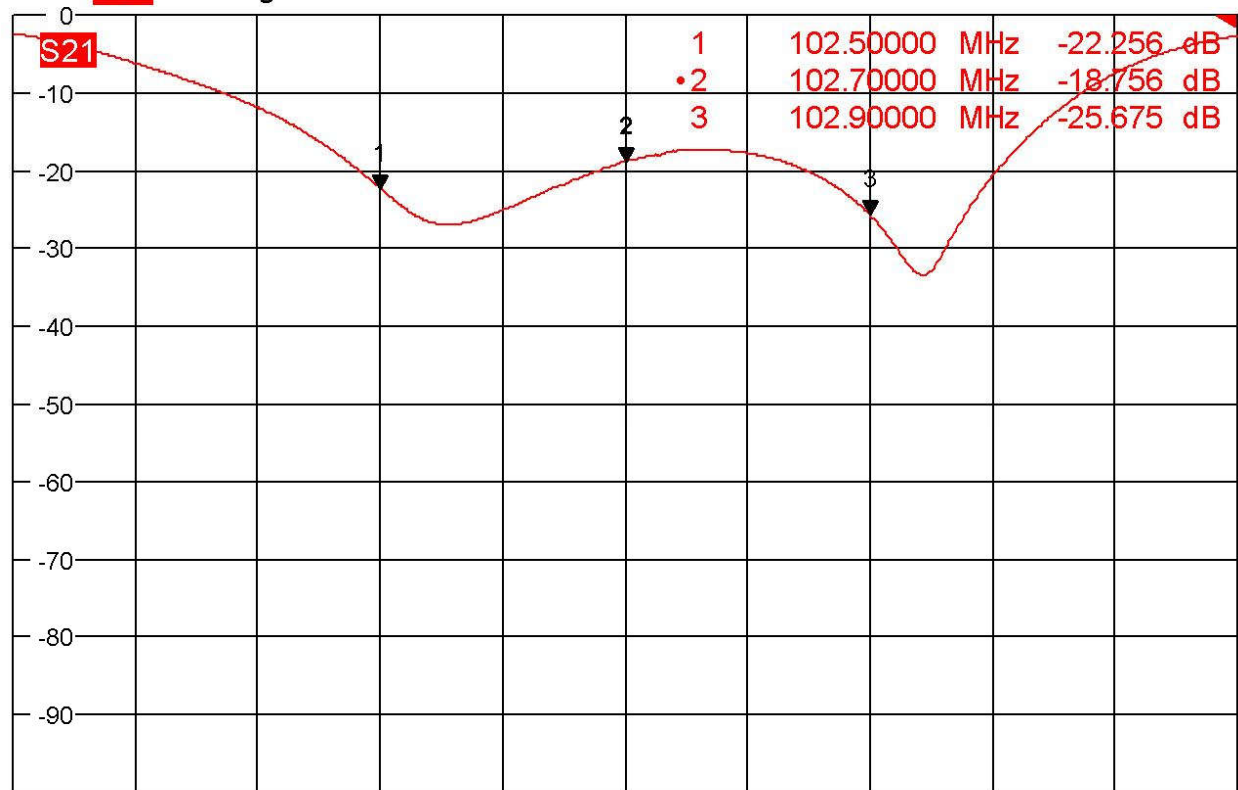
Date: 10-24-20

### Measurement 28: Filter to Antenna Match 102.7 MHz.



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

1



Ch1 Center 102.7 MHz

Pwr -5 dBm

Span 1 MHz

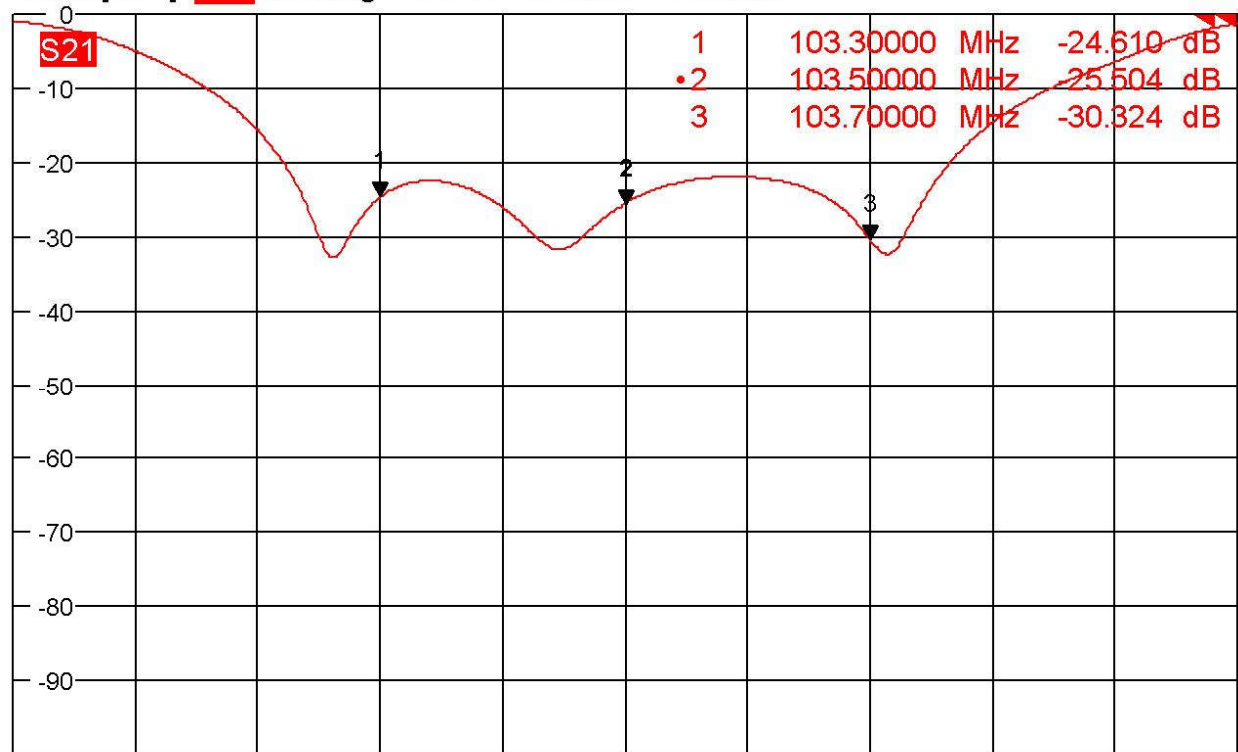
Date: 10-24-20

### Measurement 29: Filter to Antenna Match 103.5 MHz.



Trc1 S21 dB Mag 10 dB / Ref 0 dB Cal Smo  
Mem2[Trc1] S21 dB Mag 10 dB / Ref 0 dB Invisible

1



Ch1 Center 103.5 MHz

Pwr -5 dBm

Span 1 MHz

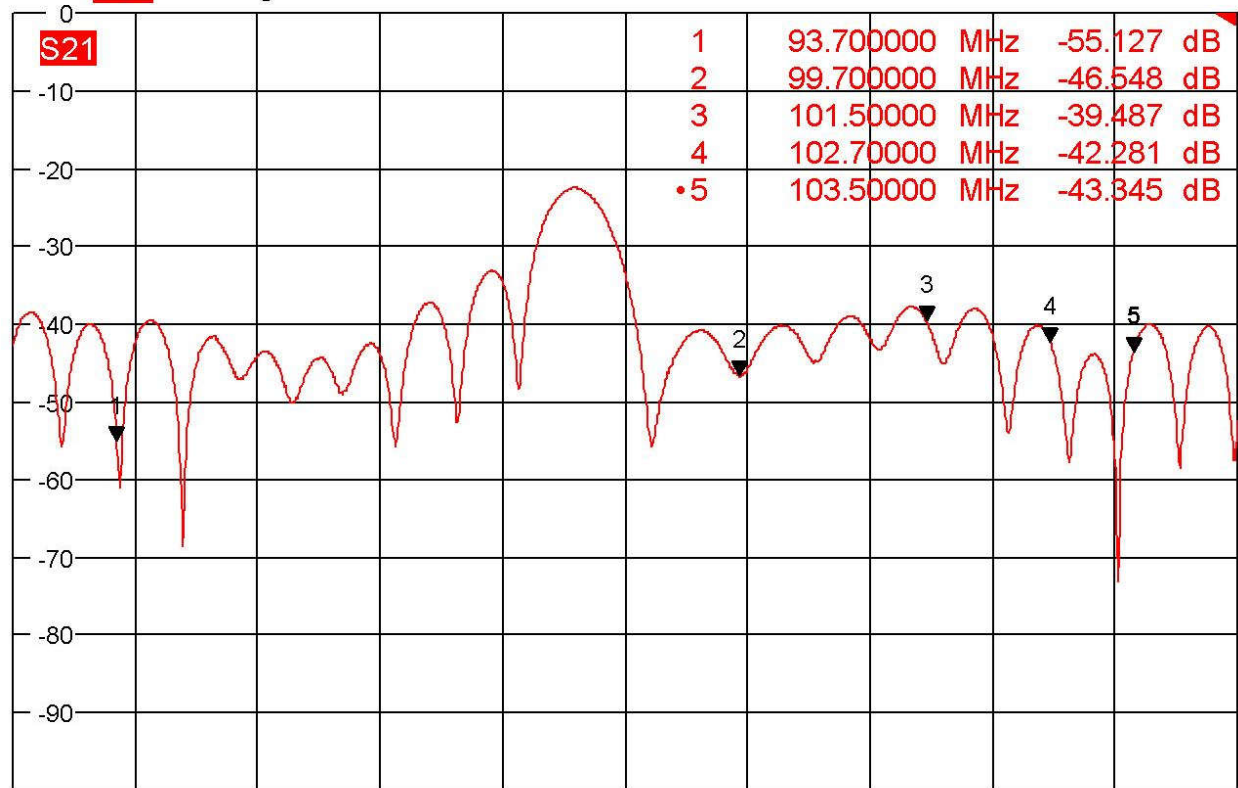
Date: 10-24-20

**Measurement 30: 92.7 to 104.5 MHz. Sweep of Feedline with 50-ohm Load.**



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

1



Ch1 Start 92.7 MHz

Pwr -10 dBm

Stop 104.5 MHz

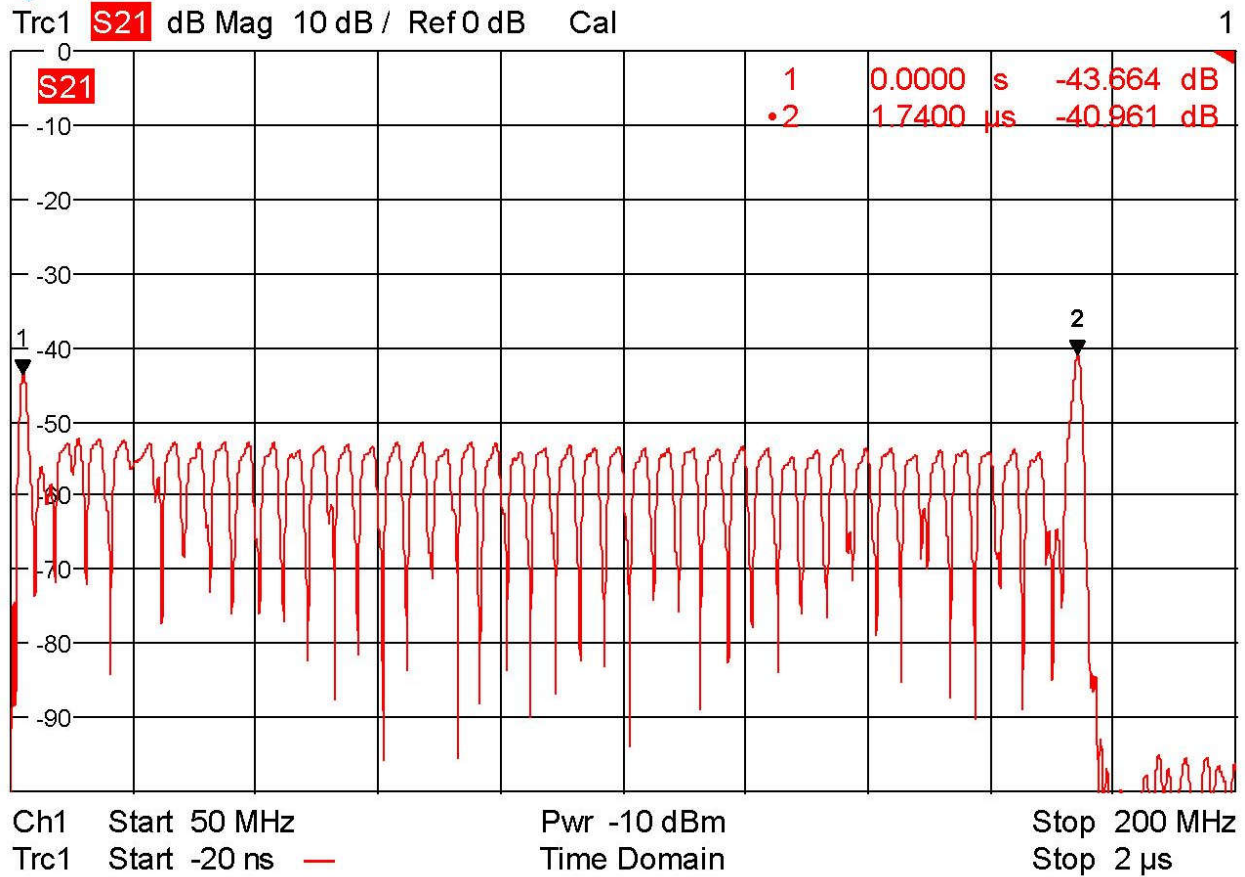
Date: 10-22-20

### Measurement 31: 50 to 200 MHz. sweep of Feedline with 50-ohm Load.

#### TDR Return Loss Measurement.

Mkr#1 is the Test Measurement Location @ Zero Feet.

Mkr#2 is the 50-ohm Load @ Approx. 865 Feet.



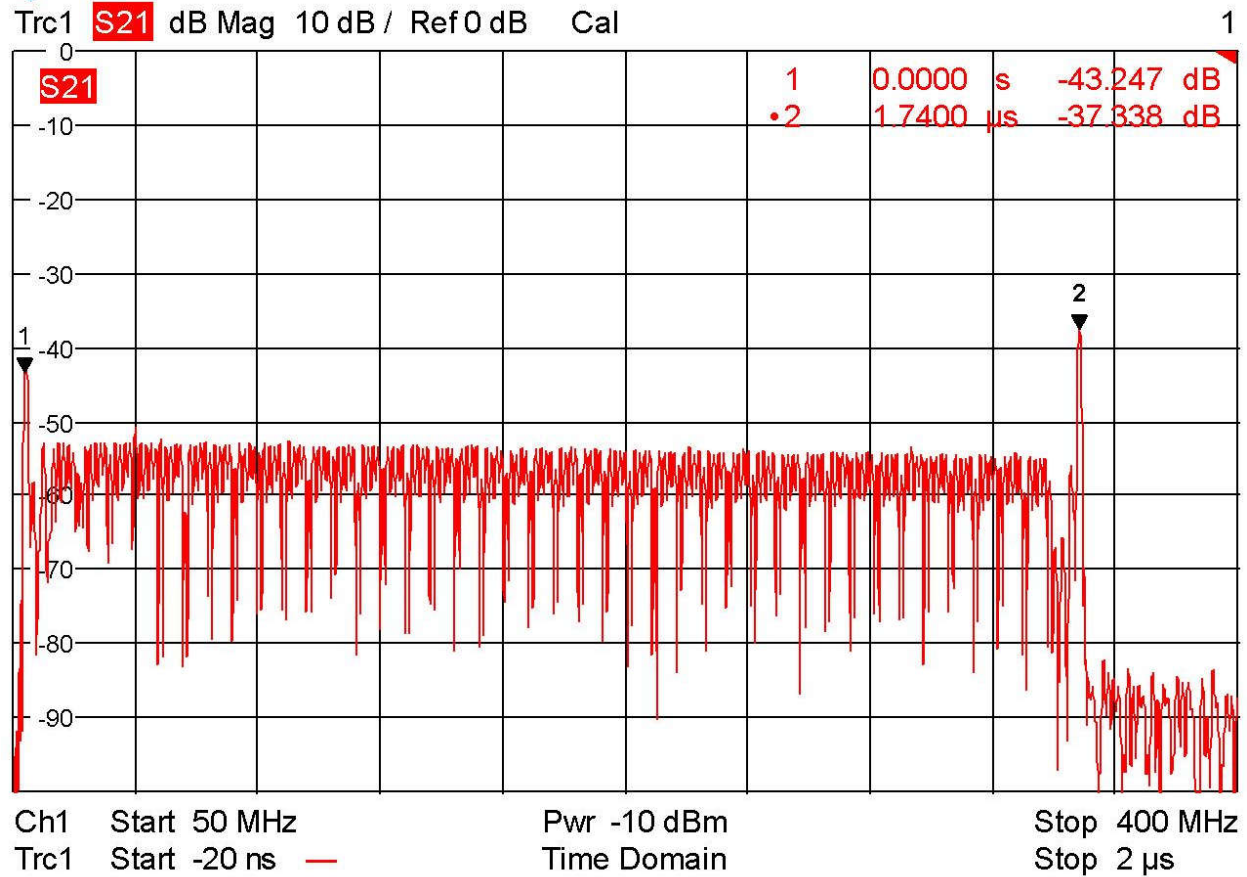
Date: 10-22-20

### Measurement 32: 50 to 400 MHz Sweep of Feedline with 50-ohm Load.

#### TDR Return Loss Measurement.

Mkr#1 is Test Measurement Location @ Zero Feet.

Mkr#2 is the 50-ohm Load @ Approx. 865 Feet.



Date: 10-22-20

### Measurement 33: 50 to 400 MHz Sweep of Feedline and Antenna After Tuning.

Mkr#1 is Test Measurement Location @ Zero Feet.

Mkr#2 is the Bottom Slug @ Approx. 609 Feet.

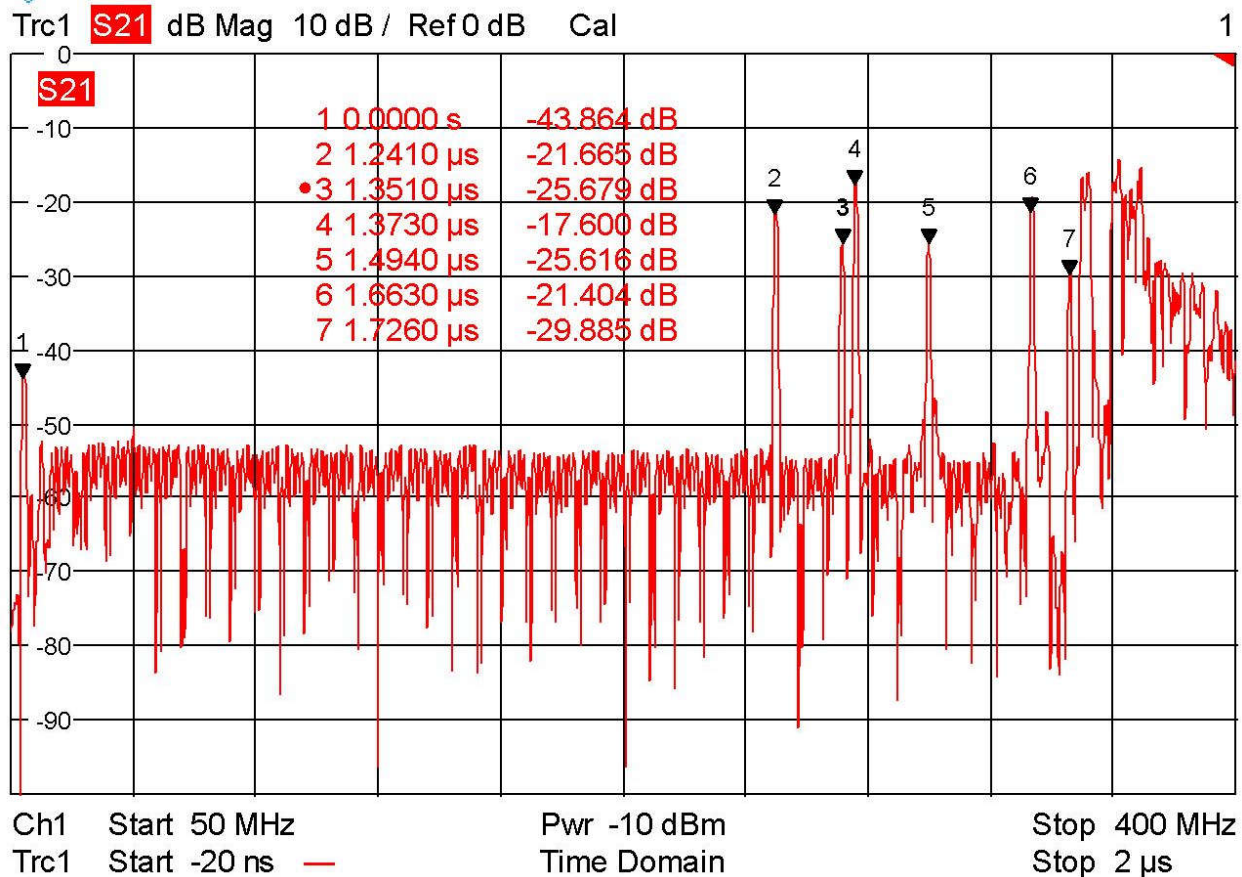
Mkr#3 is the Next Slug @ Approx. 664 Feet.

Mkr#4 is the Next Slug @ Approx. 675 Feet.

Mkr#5 is the Next Slug @ Approx. 734 Feet.

Mkr#6 is the Next Slug @ Approx. 817 Feet.

Mkr#7 is the Top Slug @ Approx. 848 Feet.

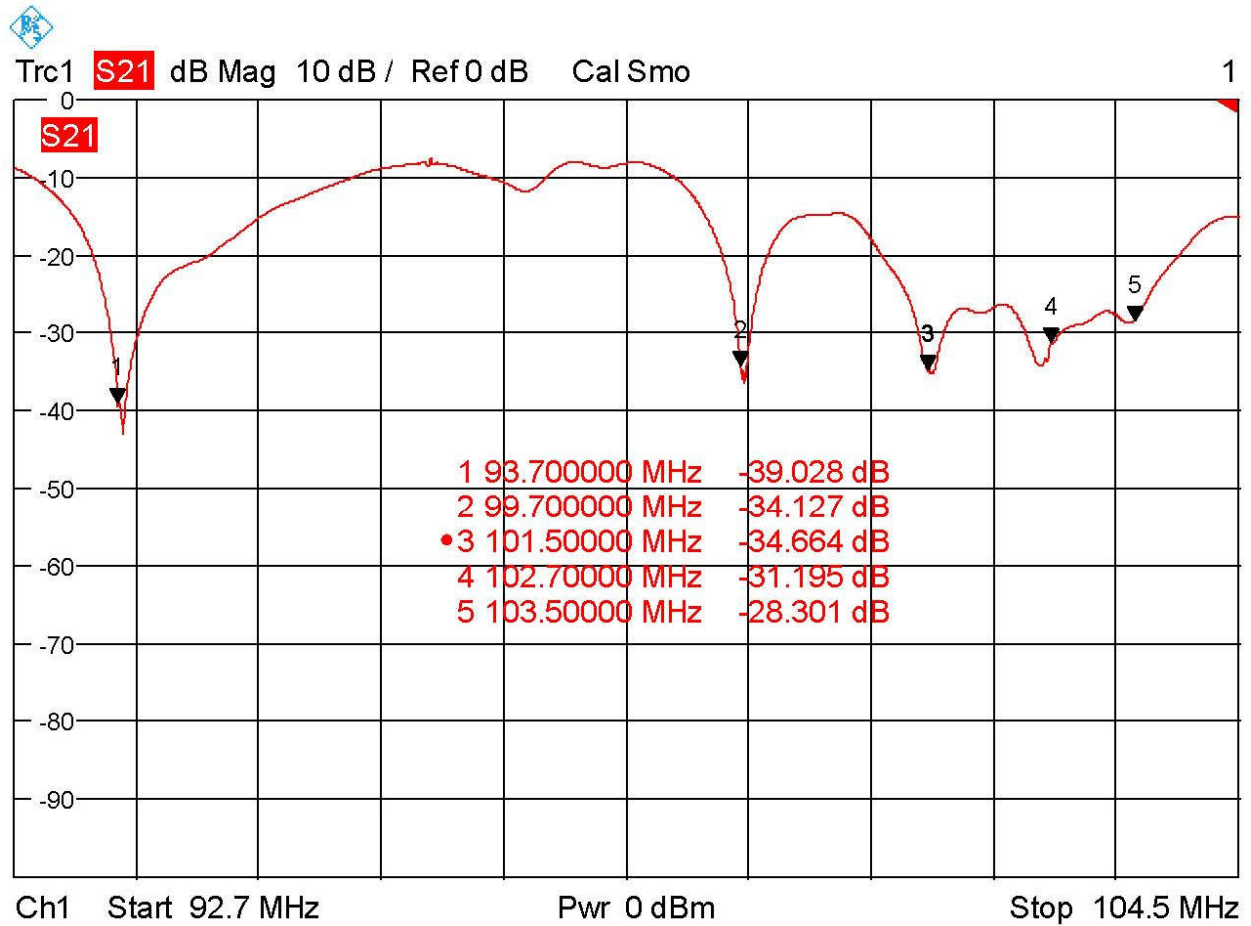


Date: 24.OCT.2020 13:16:56



### Measurement 34: Final Antenna Measurement After Tuning.

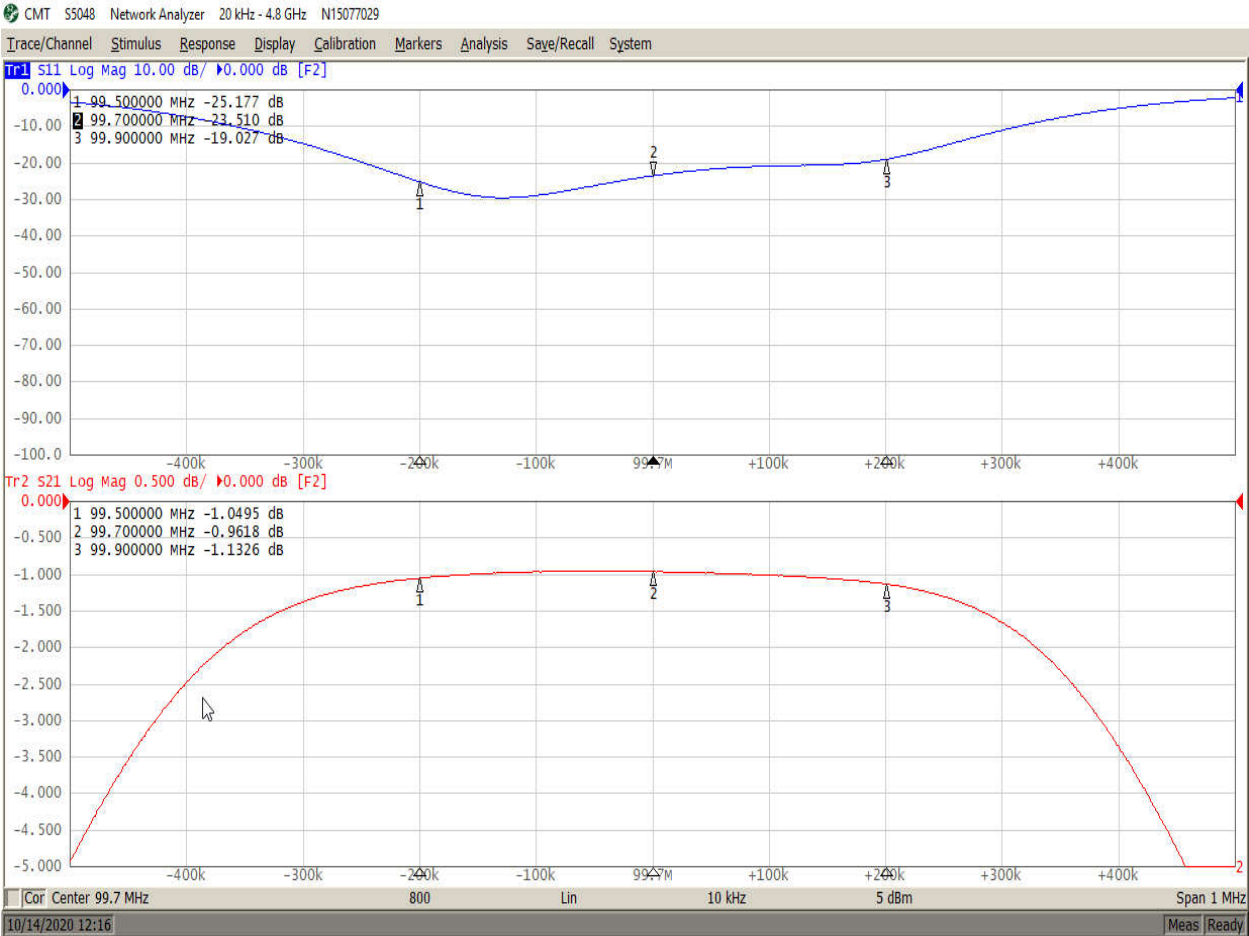
92.7 to 104.5 MHz. Sweep.



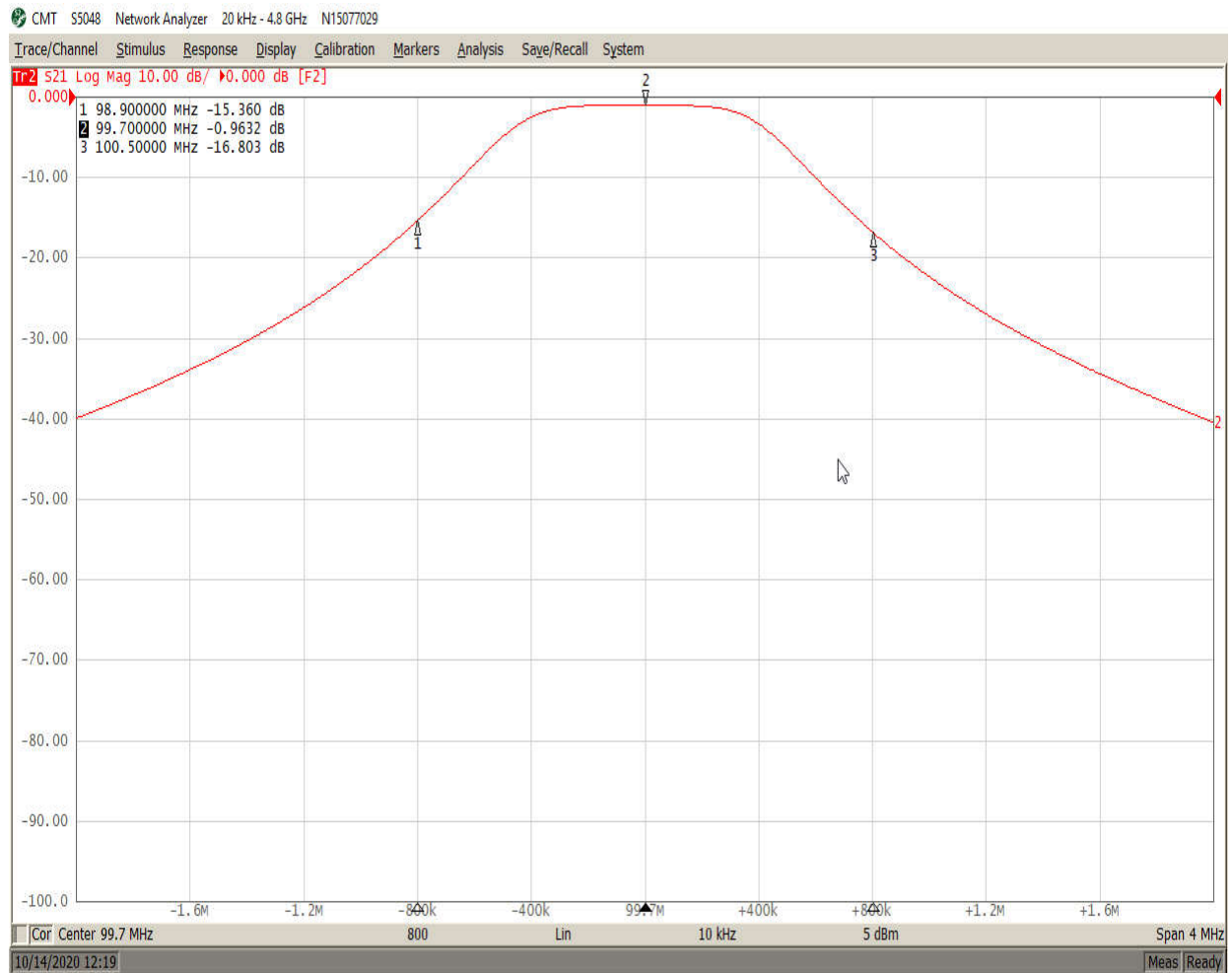
Date: 24.OCT.2020 13:12:09

**Stand Alone Shively “T” Combiner Data**

**Measurement 35: Match & Insertion Loss of 99.7 MHz.**



### Measurement 36: Isolation +/- 800 KHz. of 99.7 MHz.

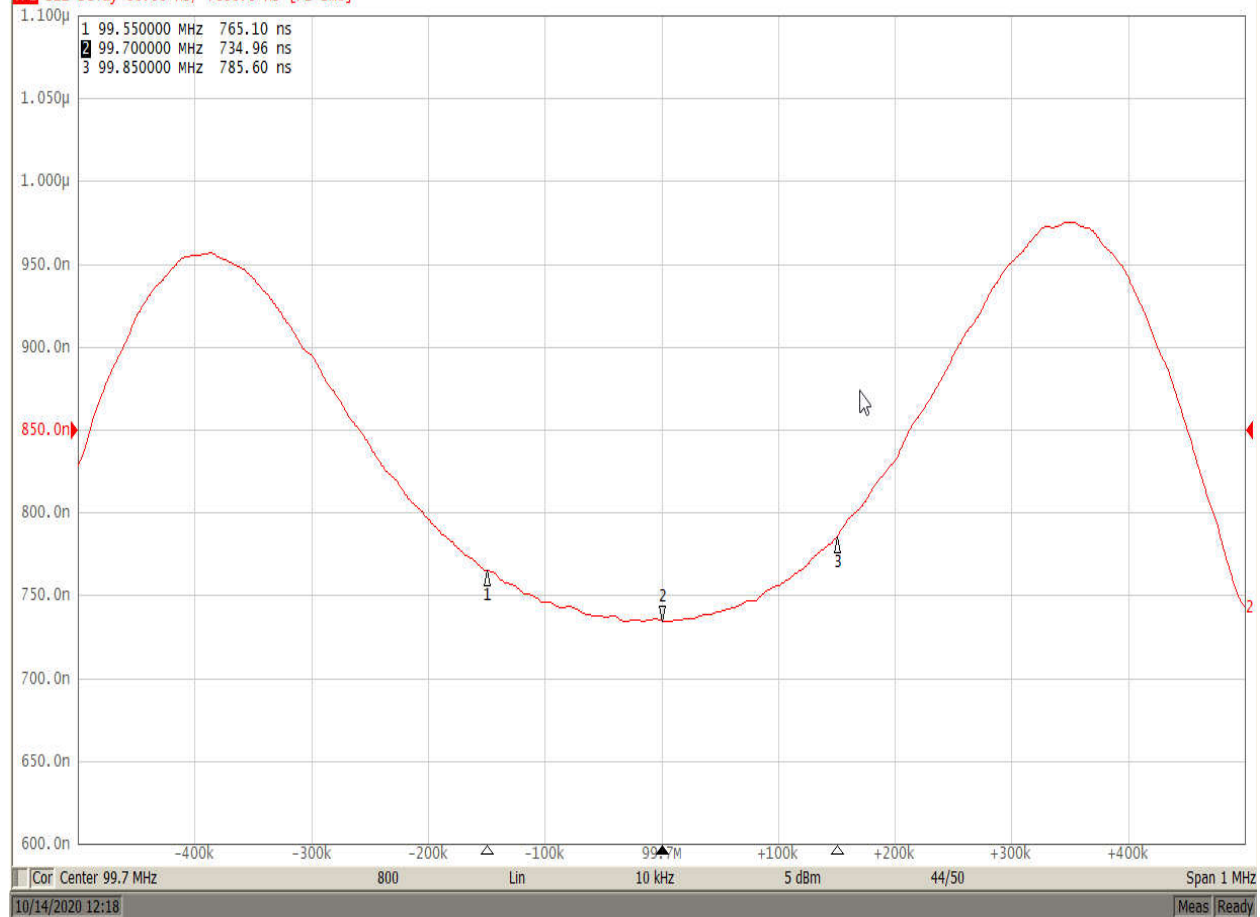


## Measurement 37: Group Delay of 99.7 MHz.

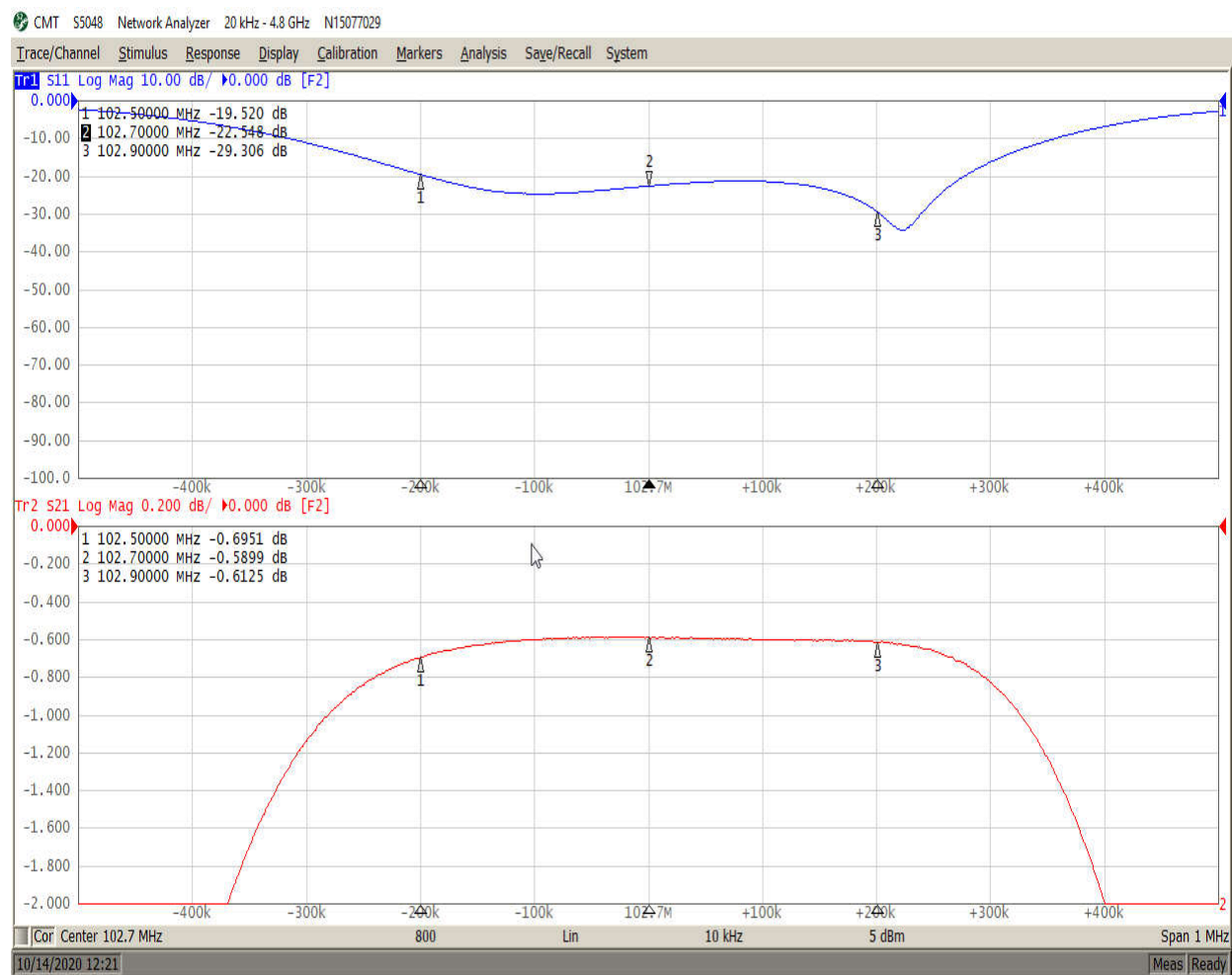
CMT S5048 Network Analyzer 20 kHz - 4.8 GHz N15077029

Trace/Channel Stimulus Response Display Calibration Markers Analysis Save/Recall System

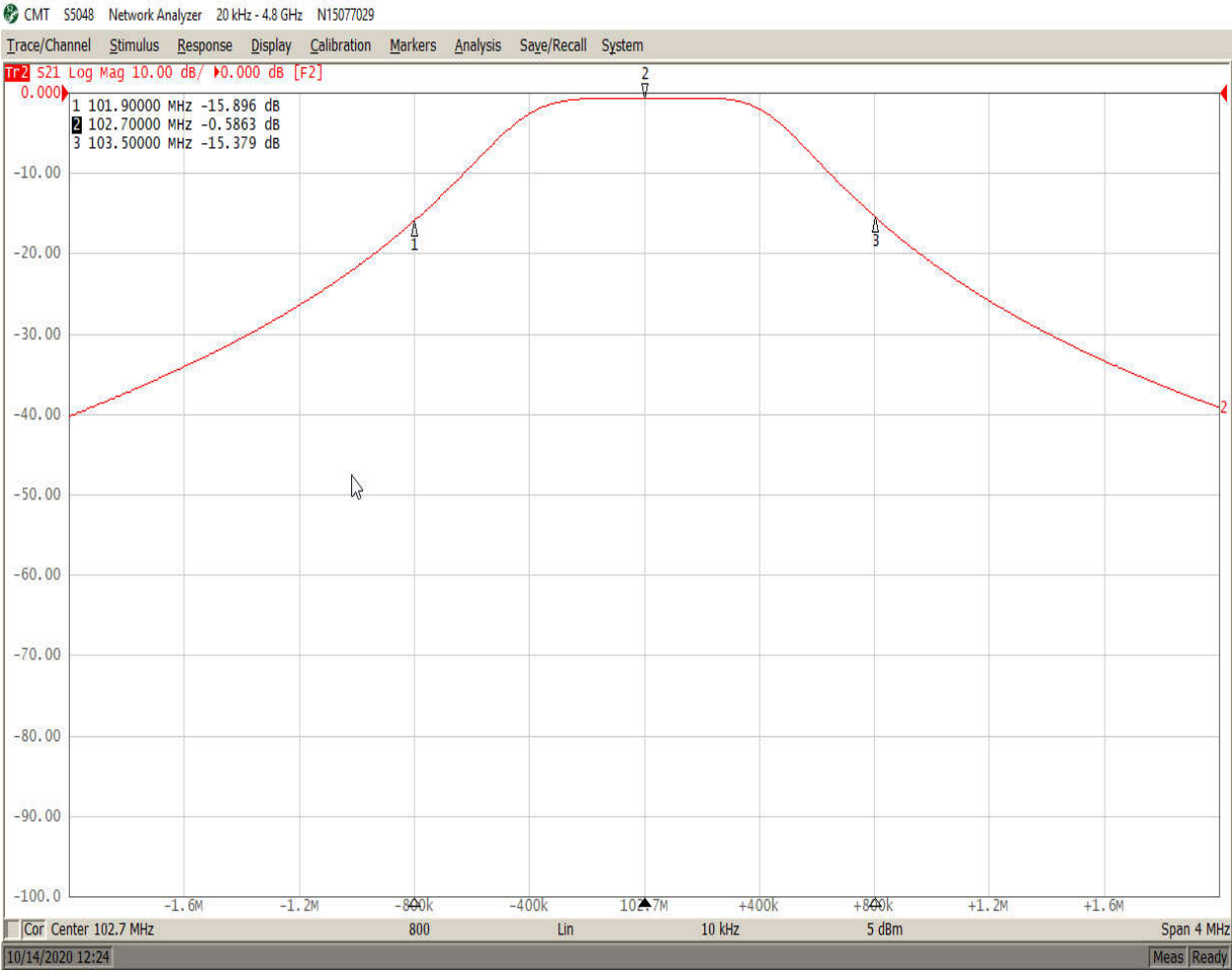
Tr2 S21 Delay 50.00 ns / 850.0 ns [F2 Smo]



Measurement 38: Match & Insertion Loss of 102.7 MHz.



**Measurement 39: Isolation +/- 800 KHz. of 102.7 MHz.**

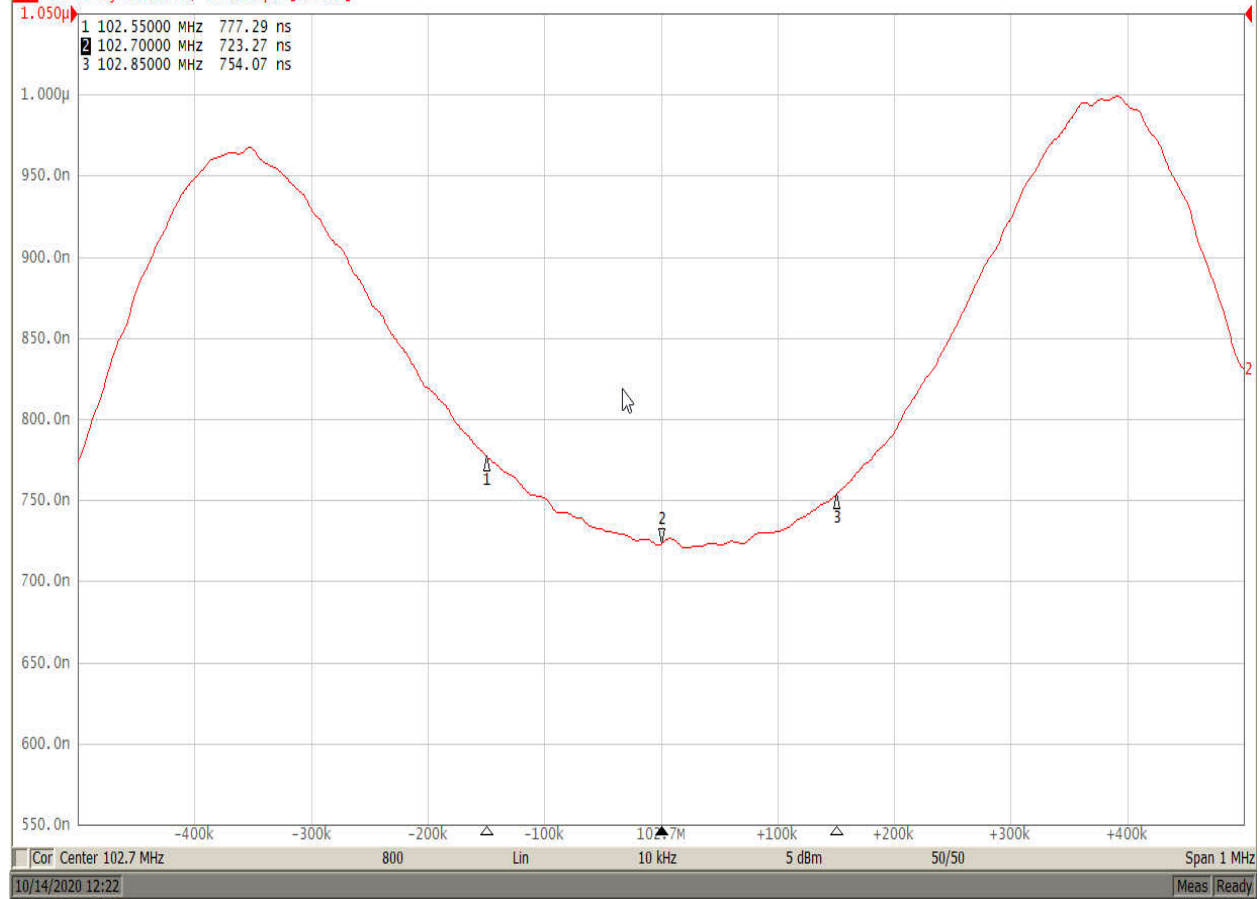


## Measurement 40: Group Delay of 102.7 MHz.

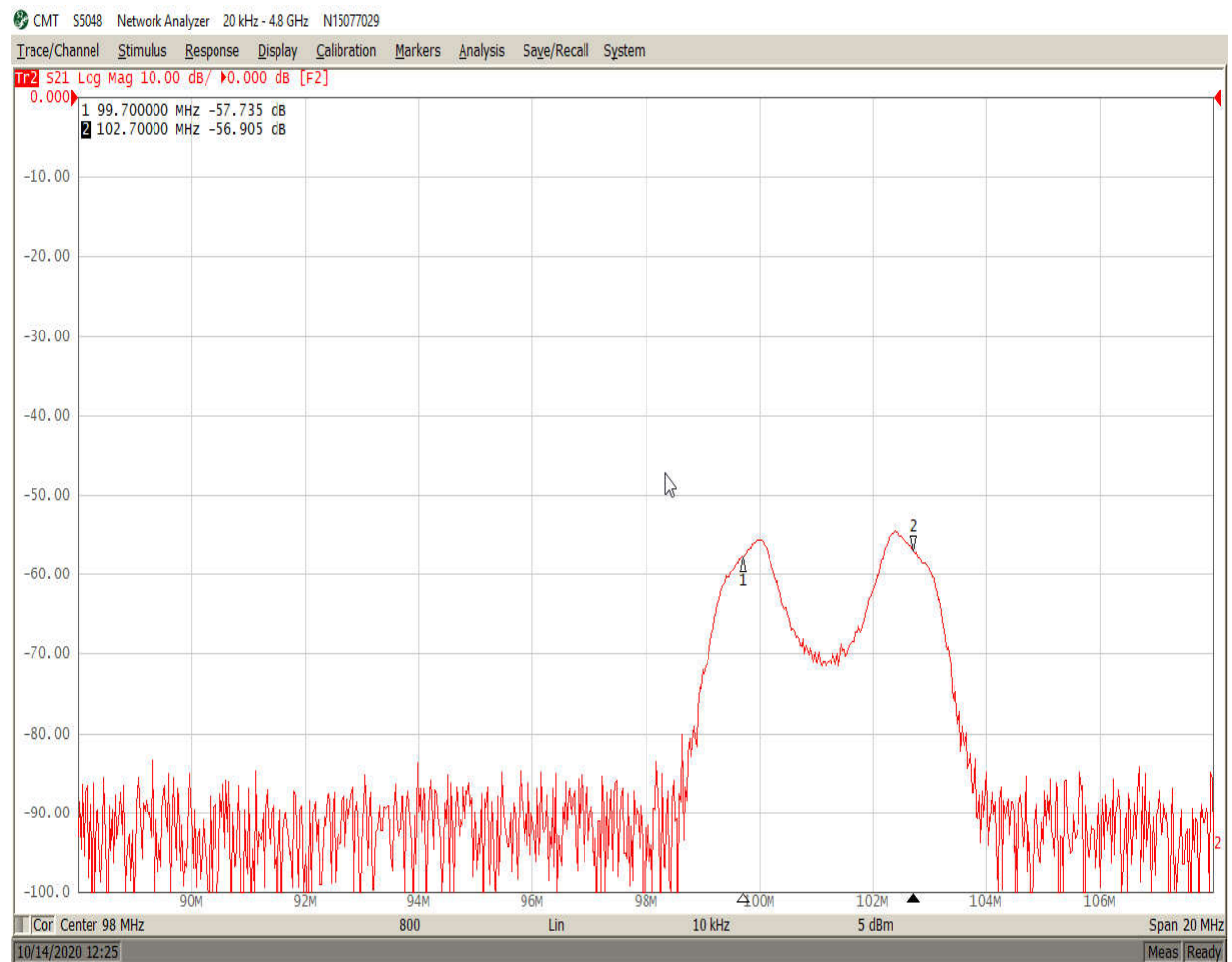
CMT S5048 Network Analyzer 20 kHz - 4.8 GHz N15077029

Trace/Channel Stimulus Response Display Calibration Markers Analysis Save/Recall System

Tr2 S21 Delay 50.00 ns/ 1.050  $\mu$ s [F2 Smo]



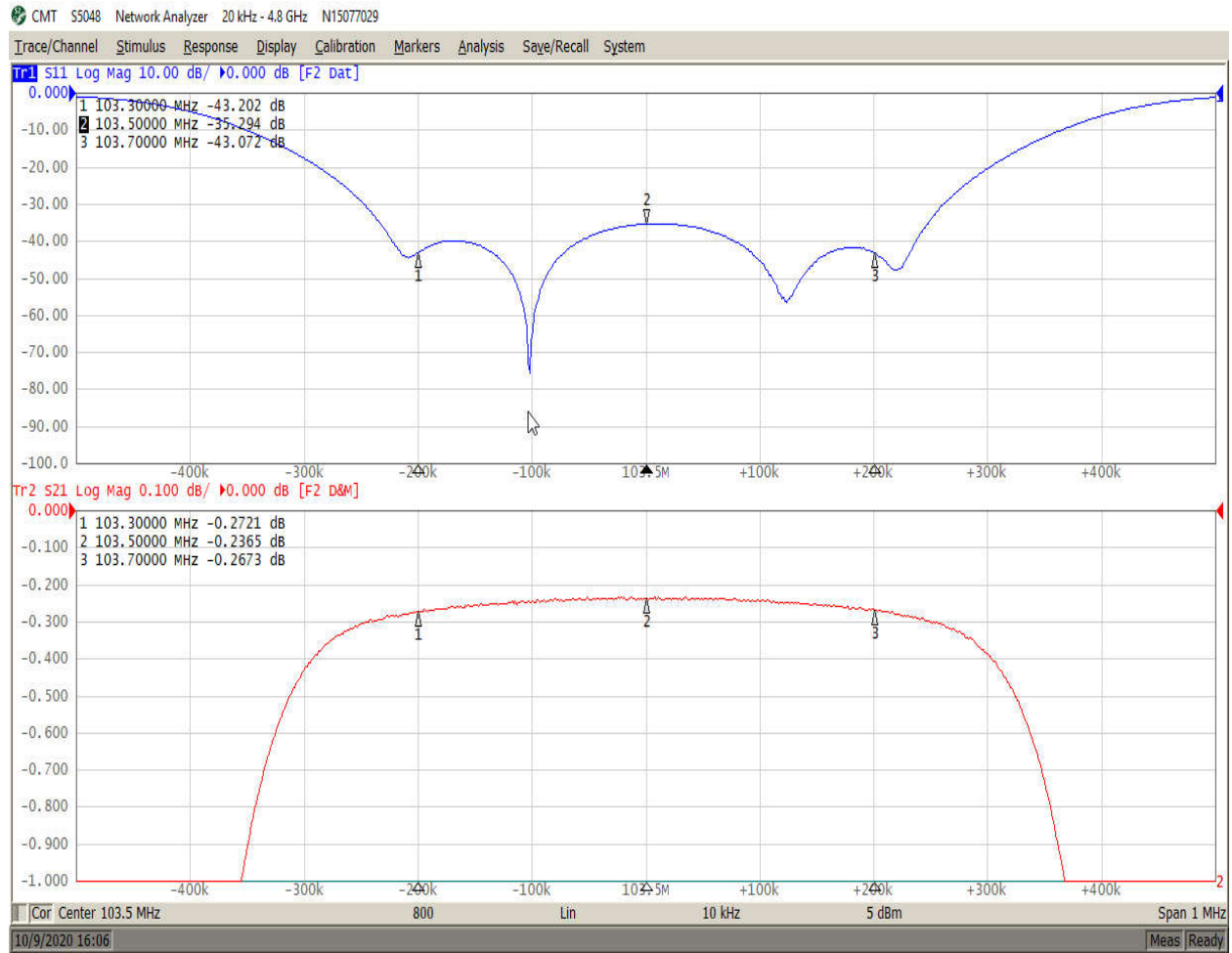
## Measurement 41: Port to Port Isolation 99.7 to 102.7 MHz.



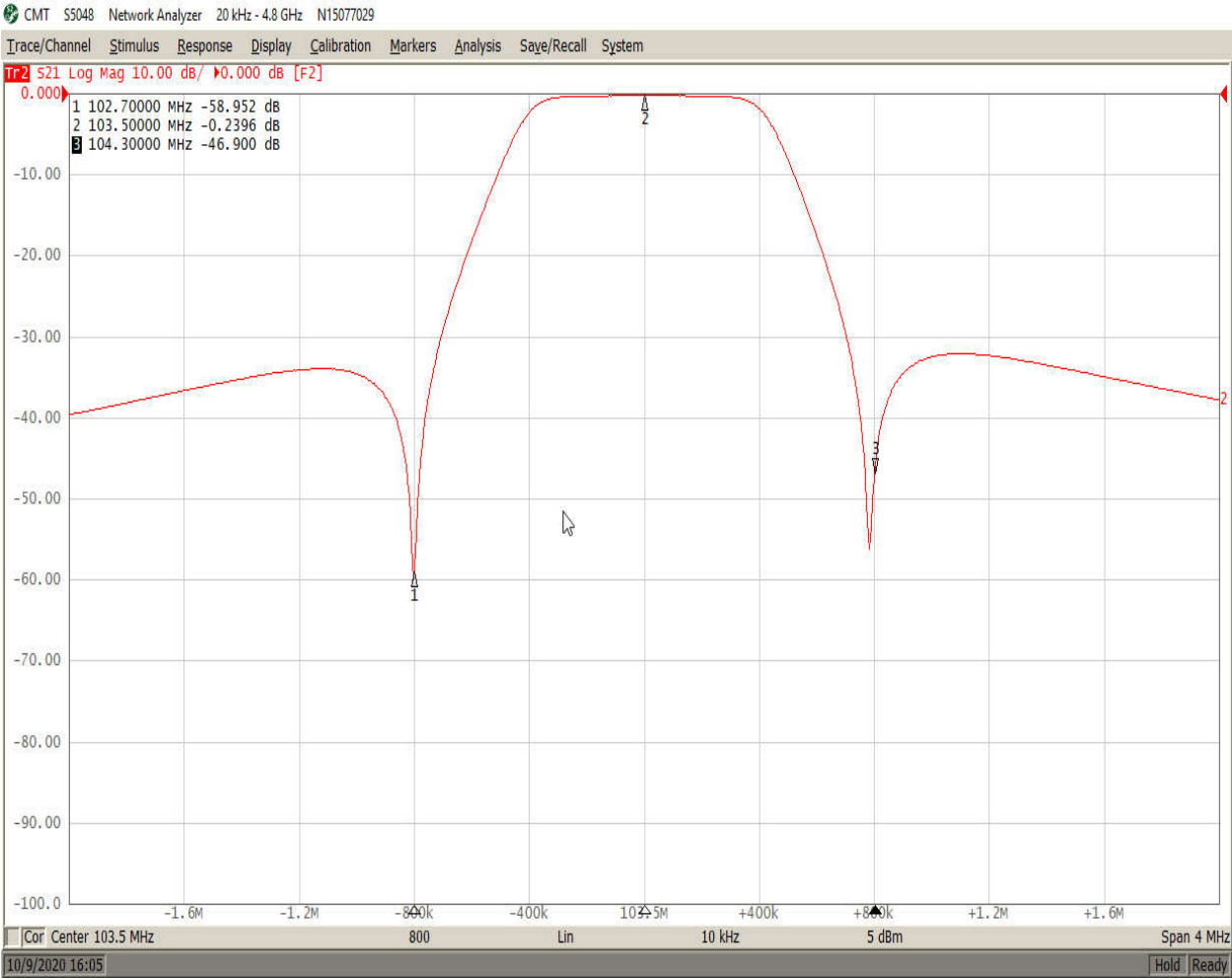


# Stand Alone ERI Band Pass Filter Data

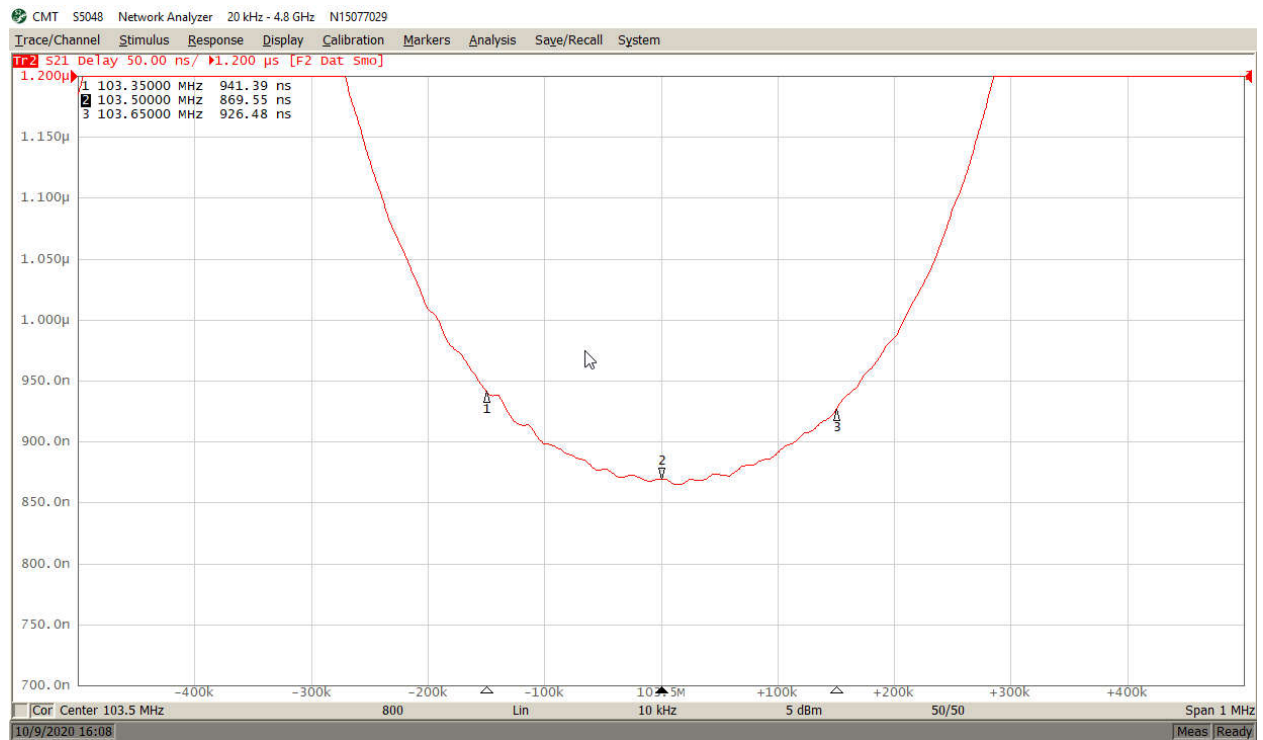
## Measurement 42: Match & Insertion Loss of 103.5 MHz.



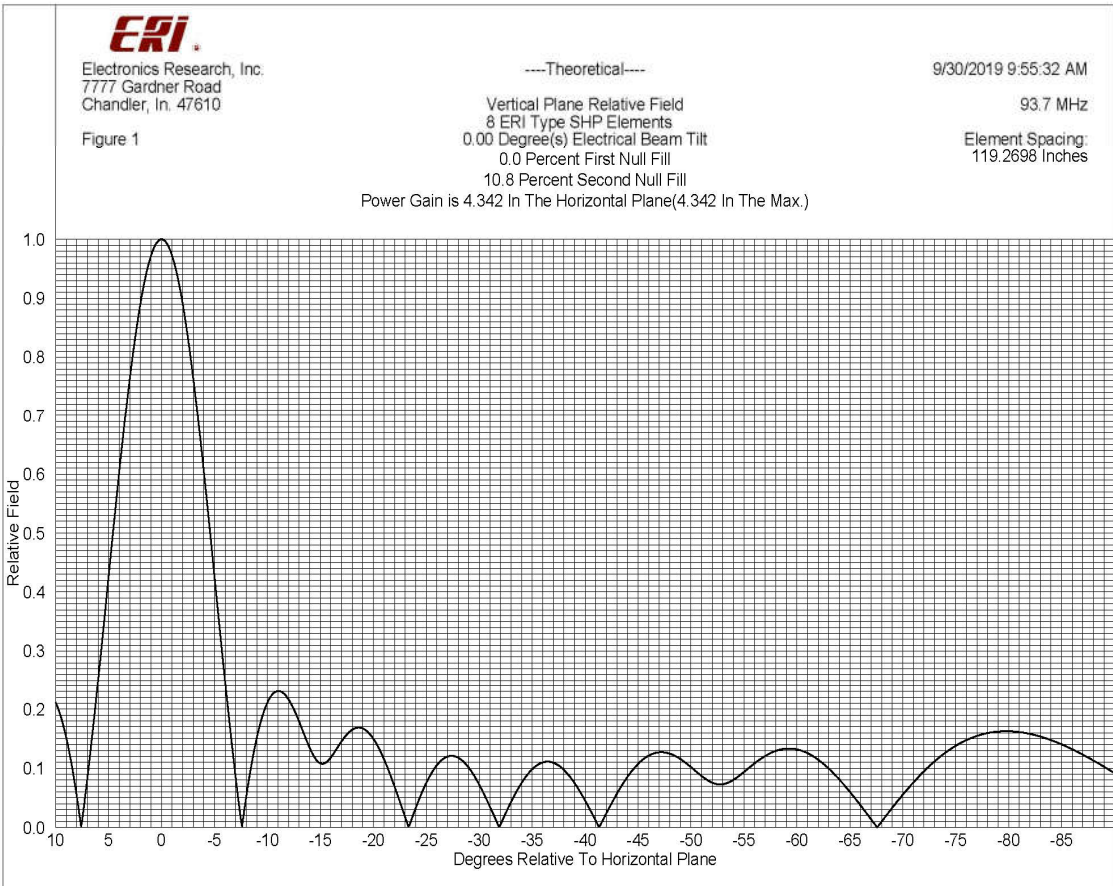
**Measurement 43: Isolation +/- 800 KHz. of 103.5 MHz.**



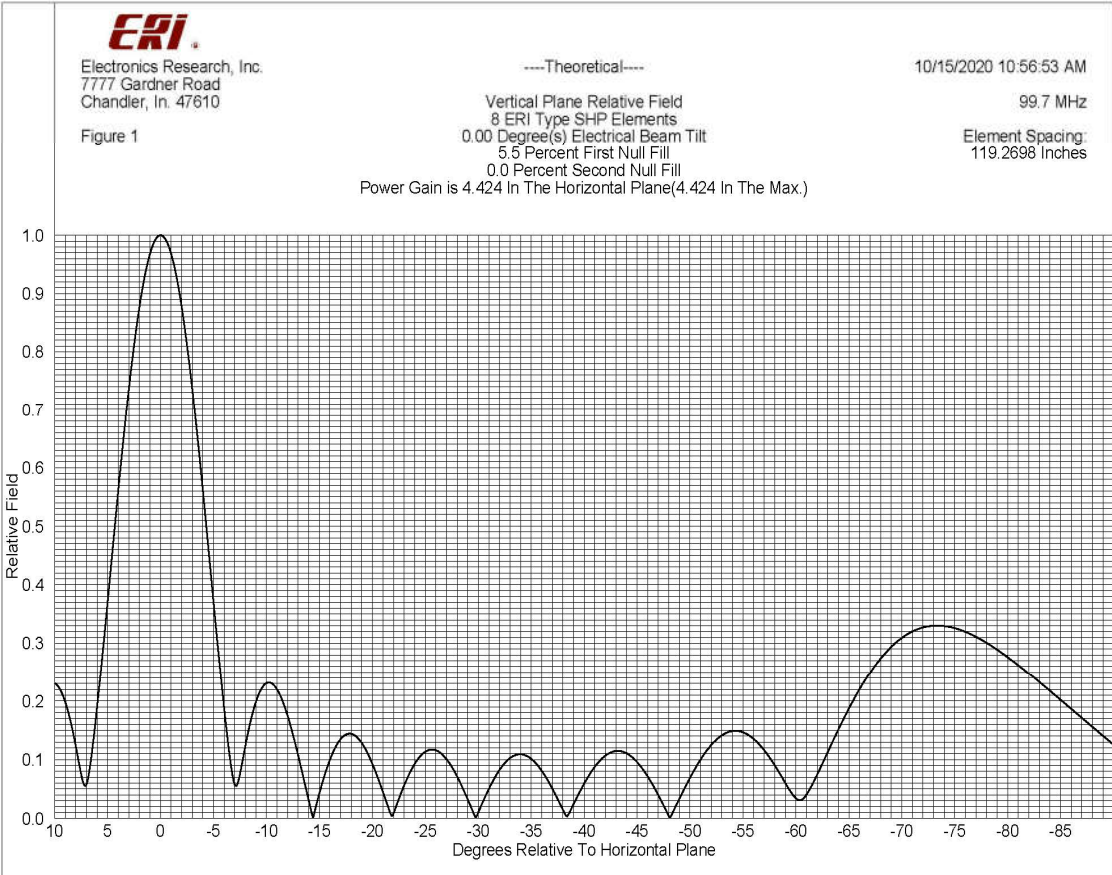
## Measurement 44: Group Delay of 103.5 MHz.



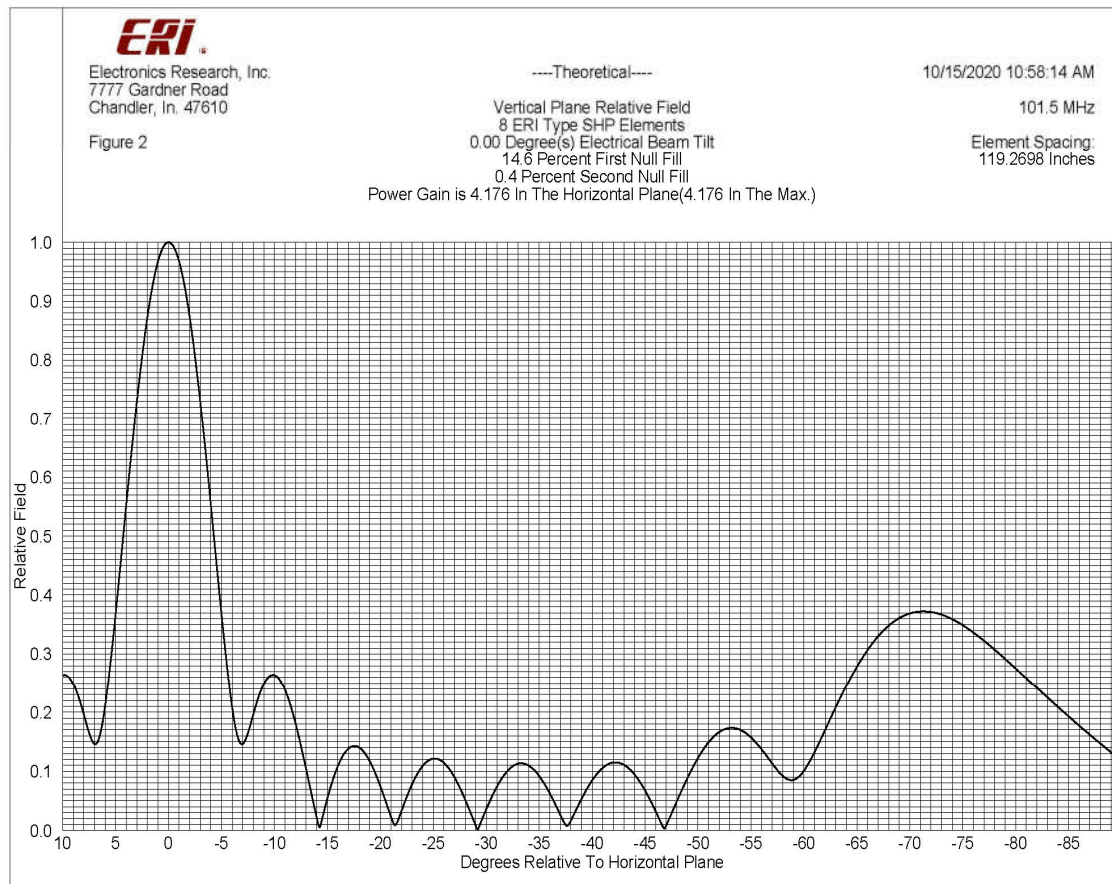
**Figure 1: Vertical Plane Relative Field Plot of 93.7 MHz.**



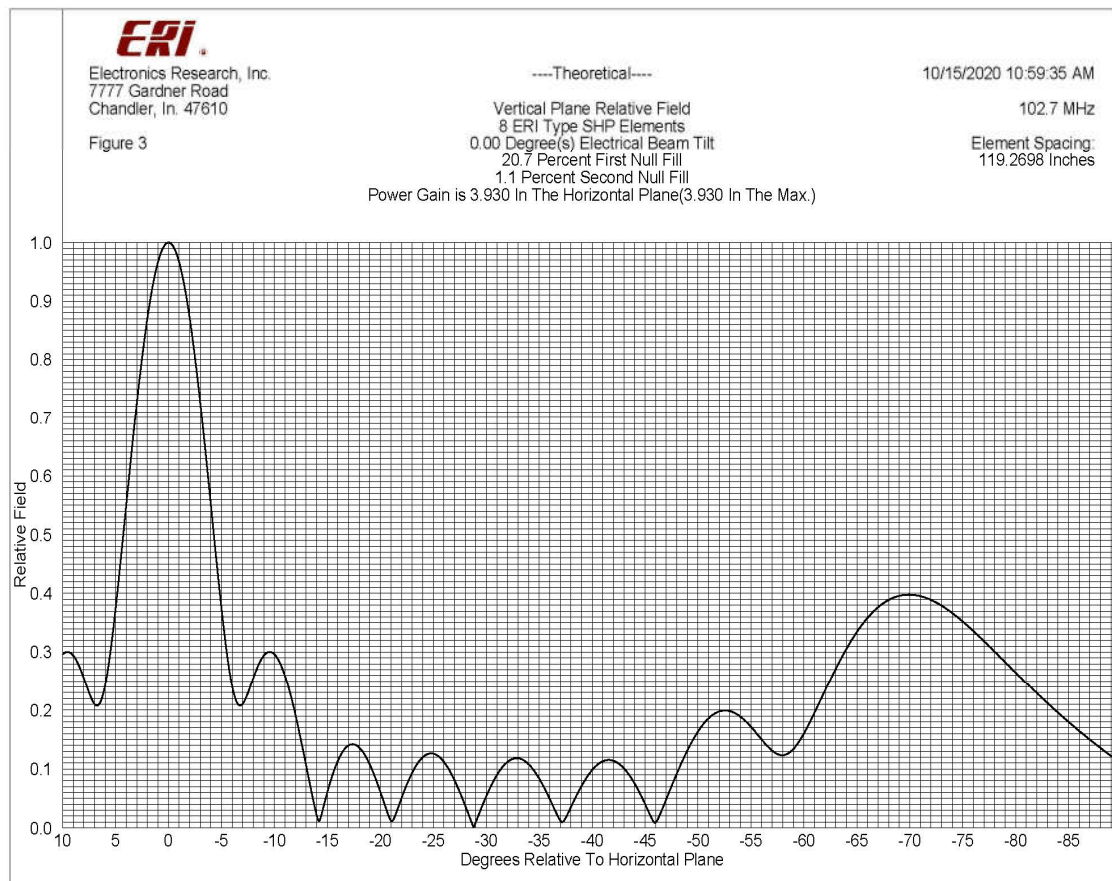
**Figure 2: Vertical Plane Relative Field Plot of 99.7 MHz.**



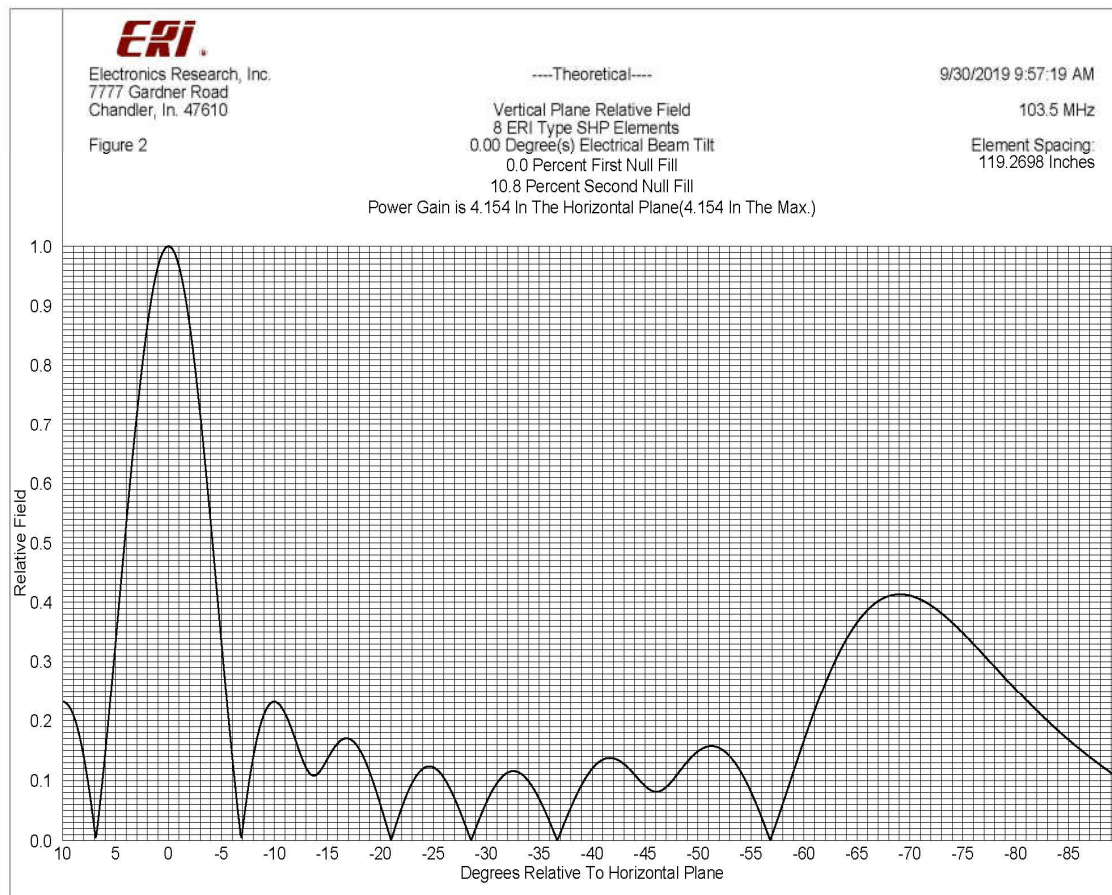
**Figure 3: Vertical Plane Relative Field Plot of 101.5 MHz.**



**Figure 4: Vertical Plane Relative Field Plot of 102.7 MHz.**



**Figure 5: Vertical Plane Relative Field Plot of 103.5 MHz.**





**Table 1: Power Analysis for 93.7 MHz.**

	<i>Analog</i>		<i>Digital (-14 dBc)</i>	
<b>Call Letters:</b>	KLBJ-FM, Austin, Texas			
<b>Frequency:</b>	93.7 MHz			
<b>ERP:</b>	100.000 kW	20.000 dBk	4.000 kW	6.021 dBk
<b>Polarization:</b>	Circular		Circular	
<b>Antenna RMS Gain:</b>	4.342 Numeric	6.377 dB	4.342 Numeric	6.377 dB
<b>Antenna Input Power:</b>	23.031 kW	13.623 dBk	0.921 kW	-0.356 dBk
<b>Peak Voltage:</b>	1,518 volts		607 volts	
<b>Transmission Line Type - Vertical Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Vertical Run Length:</b>	765 feet	233.2 meters	765 feet	233.2 meters
<b>Vertical Run Attenuation:</b>	0.072 dB/100-feet	0.236 dB/100-meters	0.072 dB/100-feet	0.236 dB/100-meters
<b>Transmission Line Type - Horizontal Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Horizontal Run Length:</b>	100 feet	30.5 meters	100 feet	30.5 meters
<b>Horizontal Run Attenuation:</b>	0.072 dB/100-feet	0.236 dB/100-meters	0.072 dB/100-feet	0.236 dB/100-meters
<b>Line Loss:</b>	-3.551 kW	0.623 dB	-0.142 kW	0.623 dB
<b>Line Efficiency:</b>	86.640%		86.640%	
<b>Power Output from Combiner:</b>	26.582 kW	14.246 dBk	1.063 kW	0.267 dBk
<b>Peak Voltage:</b>	1,630 volts		652 volts	
<b>Combiner Losses:</b>	-1.757 kW	0.278 dB	-0.070 kW	0.278 dB
<b>Transmitter Power Output:</b>	28.339 kW	14.524 dBk	1.134 kW	0.545 dBk

**Table 2: Power Analysis for 99.7 MHz.**

<b>Call Letters:</b>	K259AJ (FM), Austin, Texas			
<b>Frequency:</b>	99.7 MHz			
<b>ERP:</b>	0.250 kW	-6.021 dBk	0.010 kW	-20.000 dBk
<b>Polarization:</b>	Circular		Circular	
<b>Antenna RMS Gain:</b>	4.424 Numeric	6.458 dB	4.424 Numeric	6.458 dB
<b>Antenna Input Power:</b>	0.057 kW	-12.479 dBk	0.002 kW	-26.458 dBk
<b>Peak Voltage:</b>	75 volts		30 volts	
<b>Transmission Line Type - Vertical Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Vertical Run Length:</b>	865 feet	263.6 meters	865 feet	263.6 meters
<b>Vertical Run Attenuation:</b>	0.074 dB/100-feet	0.243 dB/100-meters	0.074 dB/100-feet	0.243 dB/100-meters
<b>Transmission Line Type - Horizontal Run:</b>	1/2" Foam LDF4-50		1/2" Foam LDF4-50	
<b>Horizontal Run Length:</b>	35 feet	10.7 meters	35 feet	10.7 meters
<b>Horizontal Run Attenuation:</b>	0.683 dB/100-feet	2.241 dB/100-meters	0.683 dB/100-feet	2.241 dB/100-meters
<b>Line Loss:</b>	-0.013 kW	0.879 dB	-0.001 kW	0.879 dB
<b>Line Efficiency:</b>	81.674%		81.674%	
<b>Power Output from Combiner:</b>	0.069 kW	-11.600 dBk	0.003 kW	-25.579 dBk
<b>Peak Voltage:</b>	83 volts		33 volts	
<b>Combiner Losses:</b>	-0.023 kW	1.263 dB	-0.001 kW	1.263 dB
<b>Transmitter Power Output:</b>	0.123 kW	-10.337 dBk	0.004 kW	-24.316 dBk

**Table 3: Power Analysis for 101.5 MHz.**

<b>Call Letters:</b>	KROX (FM), Buda, Texas			
<b>Frequency:</b>	101.5 MHz			
<b>ERP:</b>	12.500 kW	10.969 dBk	0.500 kW	-3.010 dBk
<b>Polarization:</b>	Circular		Circular	
<b>Antenna RMS Gain:</b>	4.176 Numeric	6.208 dB	4.176 Numeric	6.208 dB
<b>Antenna Input Power:</b>	2.993 kW	4.761 dBk	0.120 kW	-9.218 dBk
<b>Peak Voltage:</b>	547 volts		219 volts	
<b>Transmission Line Type - Vertical Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Vertical Run Length:</b>	765 feet	233.2 meters	765 feet	233.2 meters
<b>Vertical Run Attenuation:</b>	0.075 dB/100-feet	0.246 dB/100-meters	0.075 dB/100-feet	0.246 dB/100-meters
<b>Transmission Line Type - Horizontal Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Horizontal Run Length:</b>	100 feet	30.5 meters	100 feet	30.5 meters
<b>Horizontal Run Attenuation:</b>	0.075 dB/100-feet	0.246 dB/100-meters	0.075 dB/100-feet	0.246 dB/100-meters
<b>Line Loss:</b>	-0.482 kW	0.649 dB	-0.019 kW	0.649 dB
<b>Line Efficiency:</b>	86.124%		86.124%	
<b>Power Output from Combiner:</b>	3.476 kW	5.410 dBk	0.139 kW	-8.569 dBk
<b>Peak Voltage:</b>	590 volts		236 volts	
<b>Combiner Losses:</b>	-0.270 kW	0.325 dB	-0.011 kW	0.325 dB
<b>Transmitter Power Output:</b>	3.746 kW	5.735 dBk	0.150 kW	-8.244 dBk

**Table 4: Power Analysis for 102.7 MHz.**

<b>Call Letters:</b>	K274AX (FM), Austin, Texas			
<b>Frequency:</b>	102.7 MHz			
<b>ERP:</b>	0.250 kW	-6.021 dBk	0.010 kW	-20.000 dBk
<b>Polarization:</b>	Circular		Circular	
<b>Antenna RMS Gain:</b>	3.930 Numeric	5.944 dB	3.930 Numeric	5.944 dB
<b>Antenna Input Power:</b>	0.064 kW	-11.965 dBk	0.003 kW	-25.944 dBk
<b>Peak Voltage:</b>	80 volts		32 volts	
<b>Transmission Line Type - Vertical Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Vertical Run Length:</b>	865 feet	263.6 meters	865 feet	263.6 meters
<b>Vertical Run Attenuation:</b>	0.075 dB/100-feet	0.246 dB/100-meters	0.075 dB/100-feet	0.246 dB/100-meters
<b>Transmission Line Type - Horizontal Run:</b>	1/2" Foam LDF4-50		1/2" Foam LDF4-50	
<b>Horizontal Run Length:</b>	35 feet	10.7 meters	35 feet	10.7 meters
<b>Horizontal Run Attenuation:</b>	0.694 dB/100-feet	2.277 dB/100-meters	0.694 dB/100-feet	2.277 dB/100-meters
<b>Line Loss:</b>	-0.014 kW	0.892 dB	-0.001 kW	0.892 dB
<b>Line Efficiency:</b>	81.439%		81.439%	
<b>Power Output from Combiner:</b>	0.078 kW	-11.073 dBk	0.003 kW	-25.052 dBk
<b>Peak Voltage:</b>	88 volts		35 volts	
<b>Combiner Losses:</b>	-0.014 kW	0.732 dB	-0.001 kW	0.732 dB
<b>Transmitter Power Output:</b>	0.122 kW	-10.341 dBk	0.004 kW	-24.320 dBk

**Table 5: Power Analysis for 103.5 MHz.**

<b>Call Letters:</b>	KBPA (FM), Austin, Texas			
<b>Frequency:</b>	103.5 MHz			
<b>ERP:</b>	11.000 kW	10.414 dBk	0.440 kW	-3.565 dBk
<b>Polarization:</b>	Circular		Circular	
<b>Antenna RMS Gain:</b>	4.154 Numeric	6.185 dB	4.154 Numeric	6.185 dB
<b>Antenna Input Power:</b>	2.648 kW	4.229 dBk	0.106 kW	-9.750 dBk
<b>Peak Voltage:</b>	515 volts		206 volts	
<b>Transmission Line Type - Vertical Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Vertical Run Length:</b>	765 feet	233.2 meters	765 feet	233.2 meters
<b>Vertical Run Attenuation:</b>	0.076 dB/100-feet	0.249 dB/100-meters	0.076 dB/100-feet	0.249 dB/100-meters
<b>Transmission Line Type - Horizontal Run:</b>	4-1/16-inch, 50-ohm, rigid line		4-1/16-inch, 50-ohm, rigid line	
<b>Horizontal Run Length:</b>	100 feet	30.5 meters	100 feet	30.5 meters
<b>Horizontal Run Attenuation:</b>	0.076 dB/100-feet	0.249 dB/100-meters	0.076 dB/100-feet	0.249 dB/100-meters
<b>Line Loss:</b>	-0.433 kW	0.657 dB	-0.017 kW	0.657 dB
<b>Line Efficiency:</b>	85.953%		85.953%	
<b>Power Output from Combiner:</b>	3.081 kW	4.887 dBk	0.123 kW	-9.093 dBk
<b>Peak Voltage:</b>	555 volts		222 volts	
<b>Combiner Losses:</b>	-0.231 kW	0.313 dB	-0.009 kW	0.313 dB
<b>Transmitter Power Output:</b>	3.311 kW	5.200 dBk	0.132 kW	-8.779 dBk