Passive RF Lab Report
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Pre-Lab Questions

1. (4 Points) Before beginning, please read this short article on calibrating a VNA using a SOLT standard: After reading the article, please explain the following:
    a. Why do we need to calibrate the VNA? Give specific examples.

        We need to shift the reference plane of the VNA to the connections of the device under test (DUT). We are essentially removing the effects of connectors and connection lines from the measurements of our DUT.

    b. Please explain how the use of SOLT calibration can help us solve the 12 term error model.

        Because we know the desired response when we connect a short, open, a known load, or thru to a two-port system we can calculate the modifications required to mathematically augment the reference plane of the VNA to the locations of the short, known load, and open.

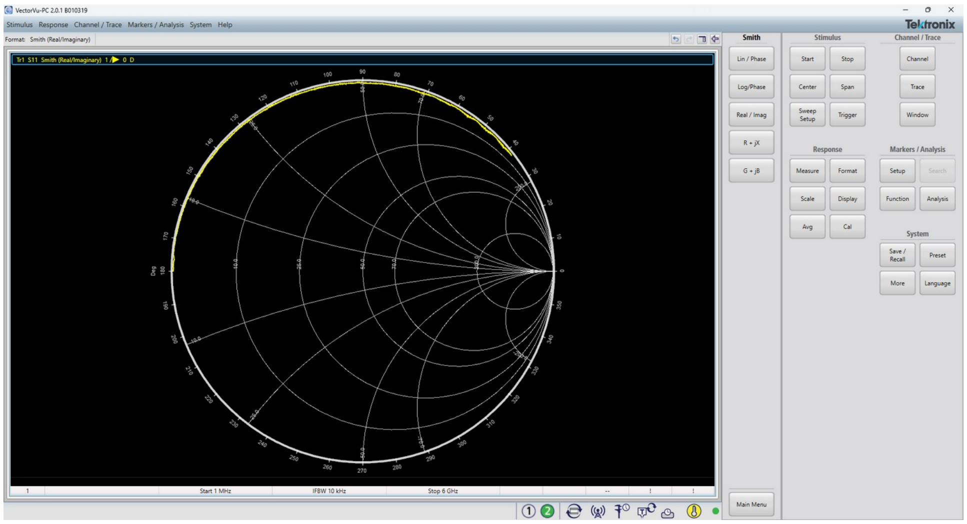
    c. Can you think of another way to calibrate a VNA?

        Another way to calibrate a VNA is to perform a Thru, Reflect, and Load (TRL) calibration which has the capability to move the reference plane of the VNA to a location in the middle of the substrate and is not confined to the edges.

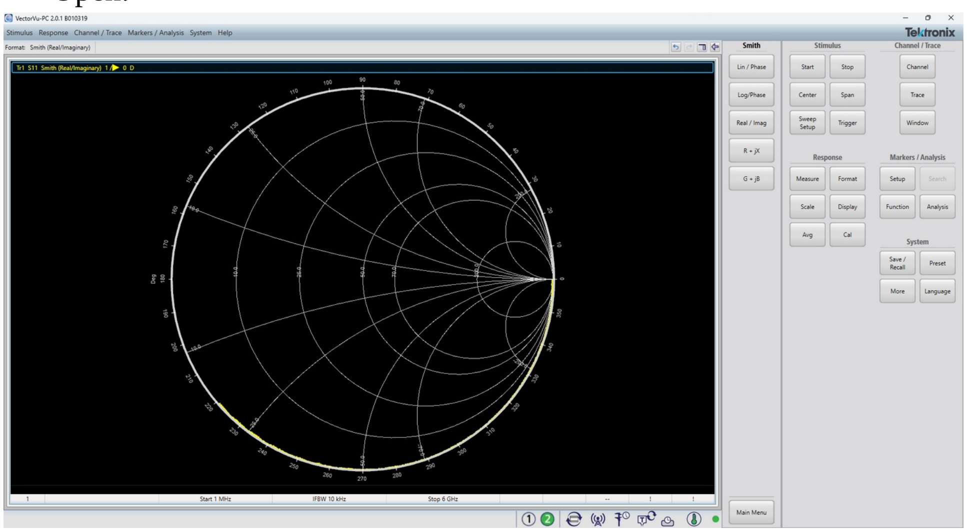
Lab Questions

1. Plot S_{11} of the short, open, and load on a smith chart. Why are they not at a single point? Are there losses, how do you know?

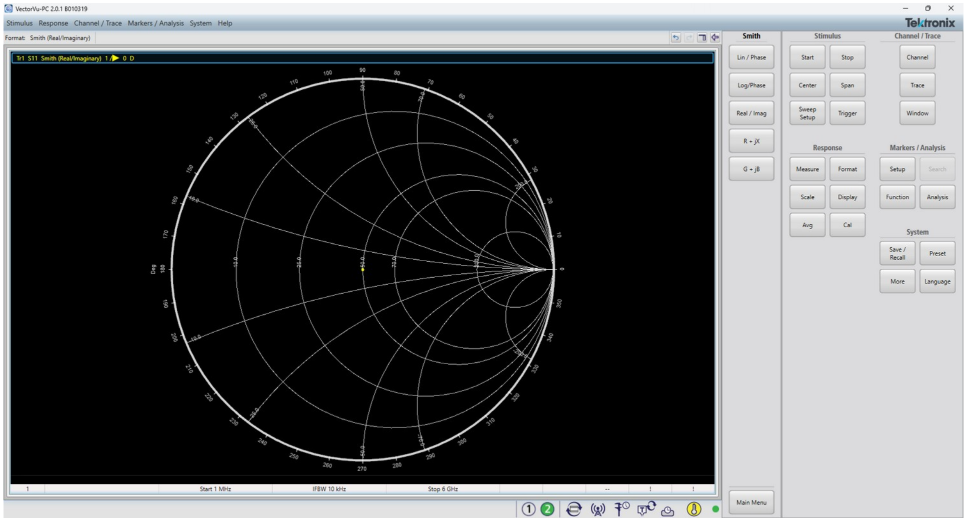
Short:



Open:

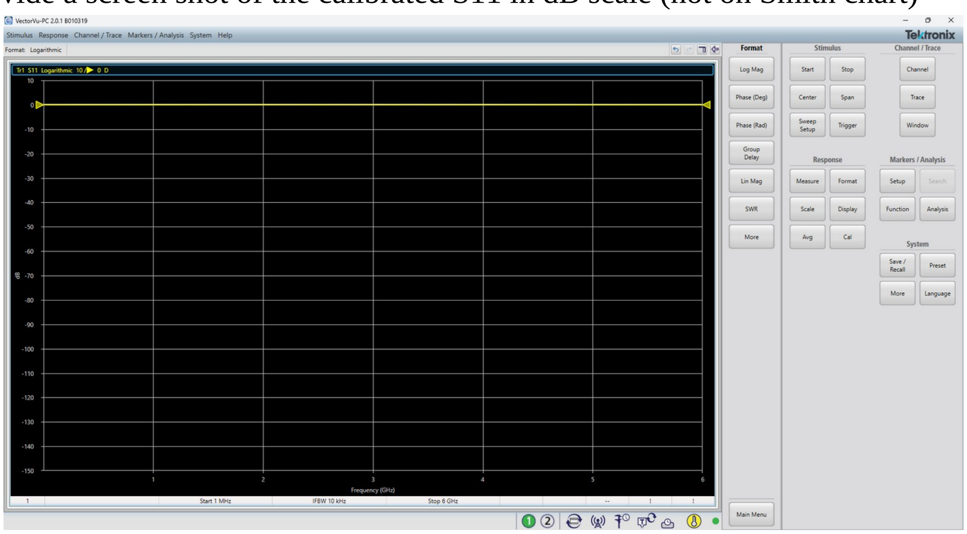


Load:

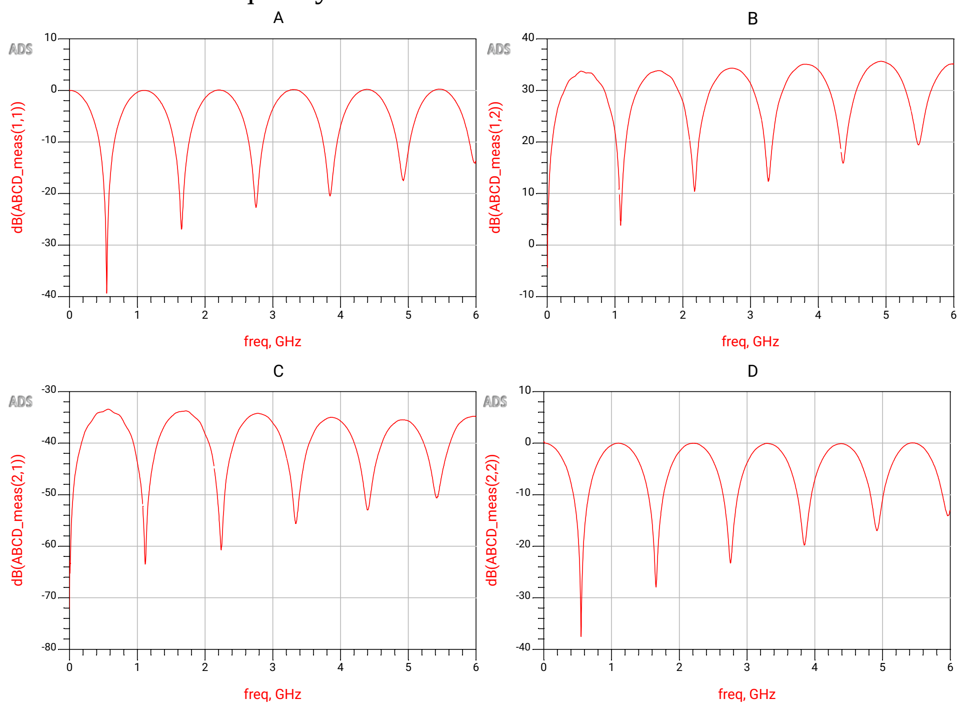


The first image is the short, the second is the open, and the third image is of the load. The load shows almost a single point at the origin of the smith chart because there is no reflection from a matched termination. This means we see a perfect 50 ohms. Any wiggle in this graph is attributed to slight imperfections in the match or slight movements in cables as the test was occurring or when the measurements were being taken. We know there are losses in the short and open graphs because the trace is inside the smith chart opposed to being perfectly on the edges of the smith chart.

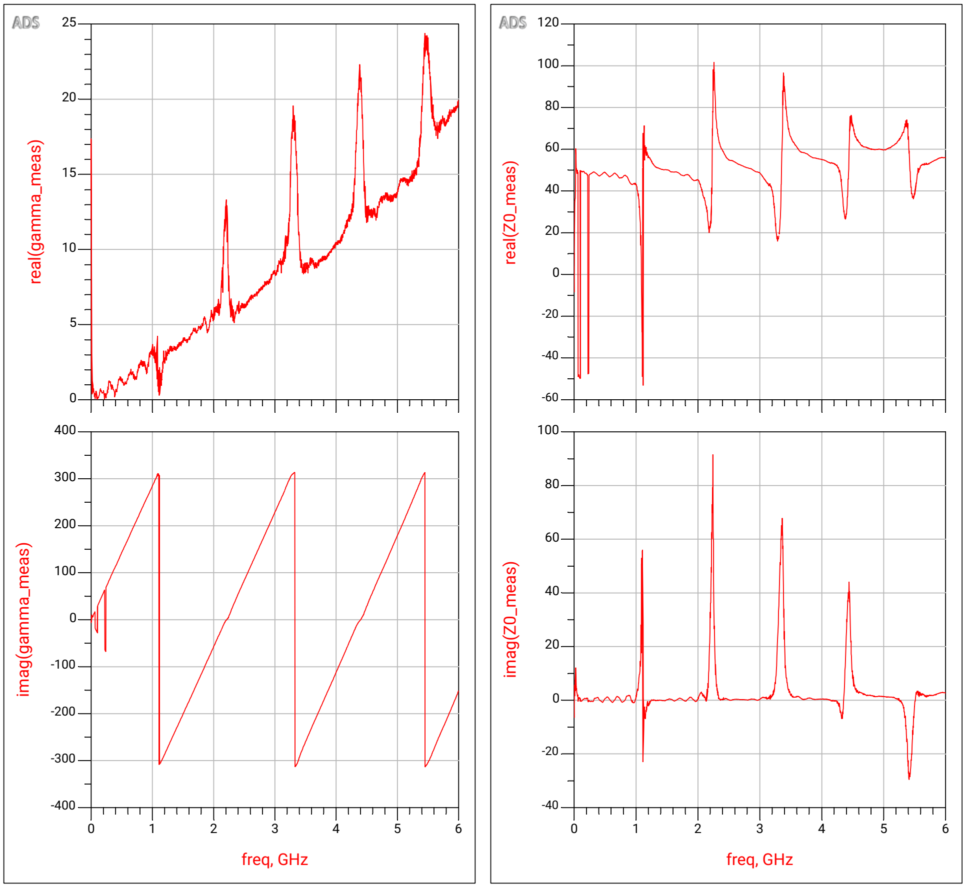
2. Provide a screen shot of the calibrated S11 in dB scale (not on Smith chart)



3. (20 Points) Now, measure the S-parameters of line 2. Store the measurements in an S2P file. Use MATLAB to help answer the following questions. (System → Save / Recall → Save SnP → S2P)
    a. Convert the S-parameters into ABCD parameters. Plot the magnitude as a function of frequency.

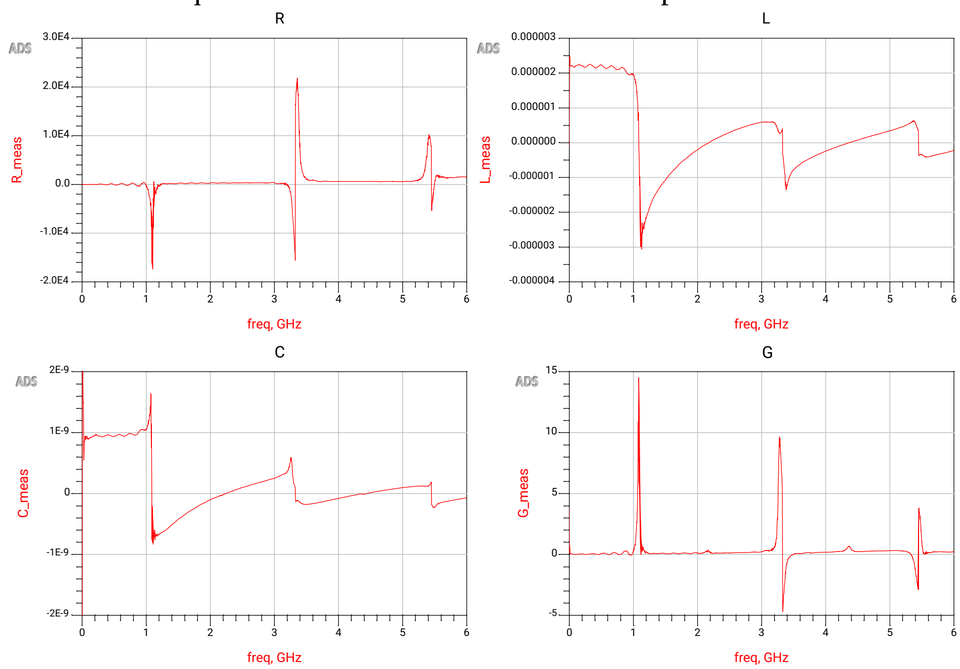


b. Calculate the propagation constant and characteristic impedance. Plot the real and imaginary parts as function of frequency.



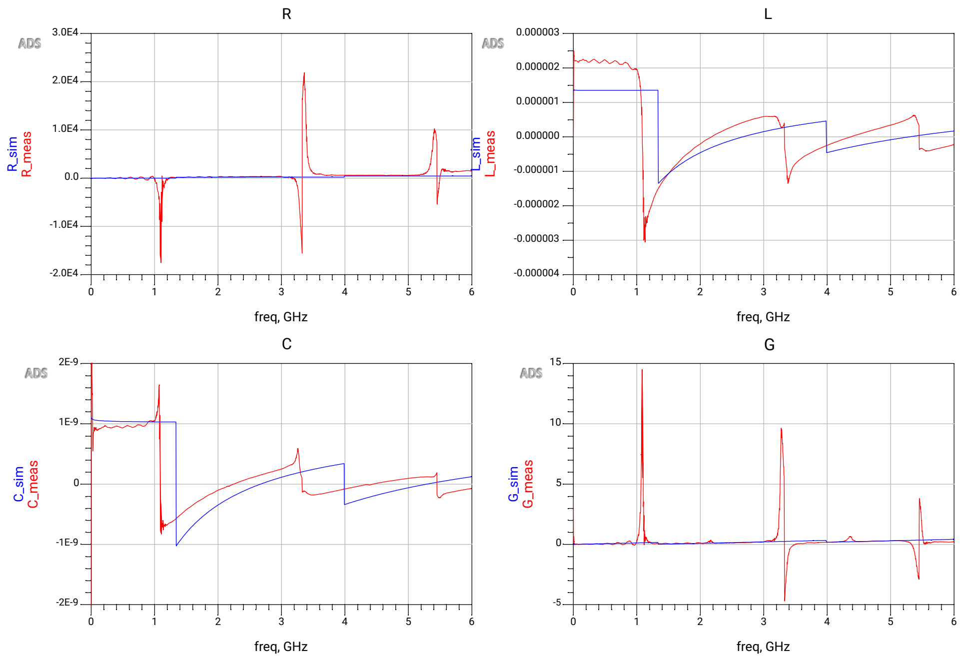
c. Find and calculate the RLCG parameters of the line. Plot them as a function of frequency. Explain how the parameters change as a function of frequency.

The value of C and L oscillate around $0\,F$ and $0\,H$ respectively. This oscillation decays with frequency such that at higher frequencies the height of the peaks and dips are progressively lower. The value of G is approximately $0\,\mho$ for all frequencies except for some positive and negative spikes at $1.084\,GHz$, $3.285\,GHz$, and $5.454\,GHz$. The value of R is essentially flat except for positive and negative spikes at the same frequencies that are mentioned in the explanation for G.

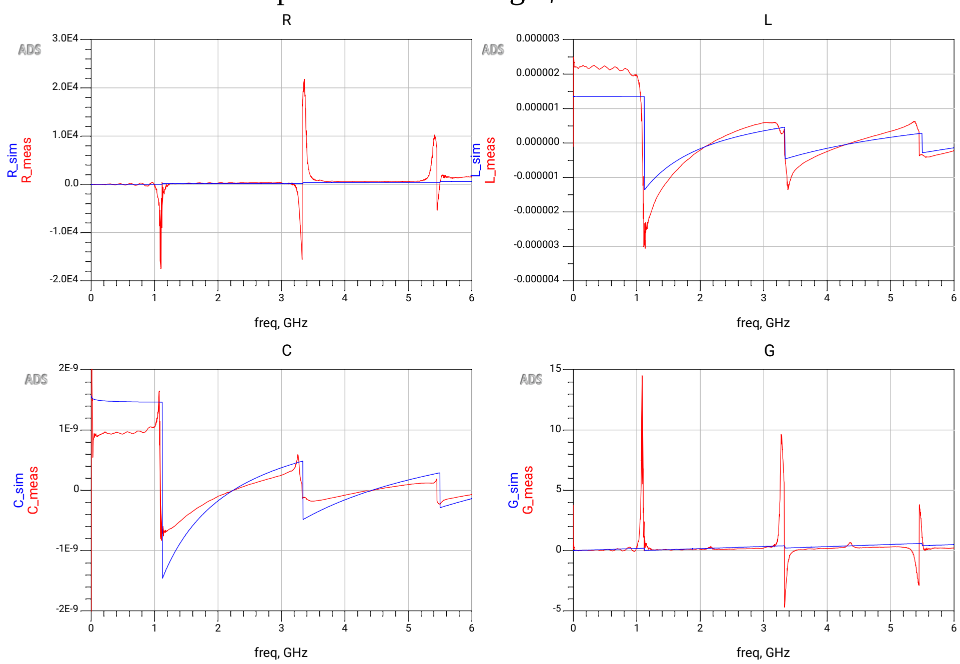


d. Compare the results to simulated model in ADS. We are using an FR4 substrate with a line length of 60 mm.

ADS comparison without tuning ϵ_r:



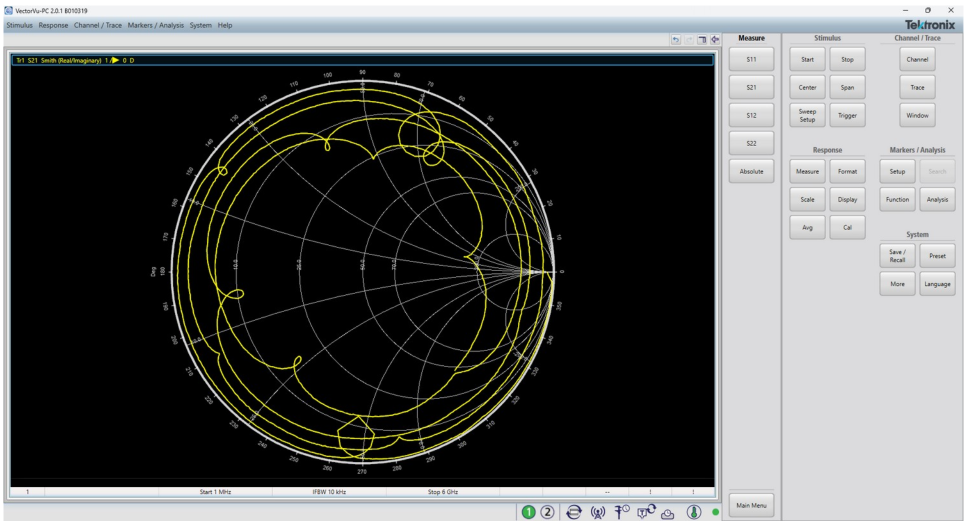
ADS comparison with tuning ϵ_r:

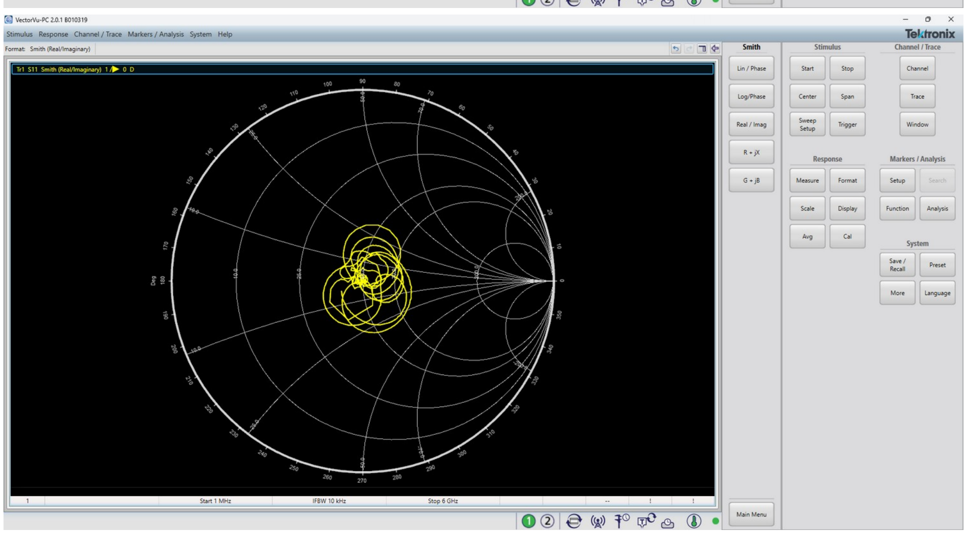


4. (20 Points)

   a. Measure the coupled line resonator. Show S_{11} and S_{21}. Explain the loops in the Smith Chart.

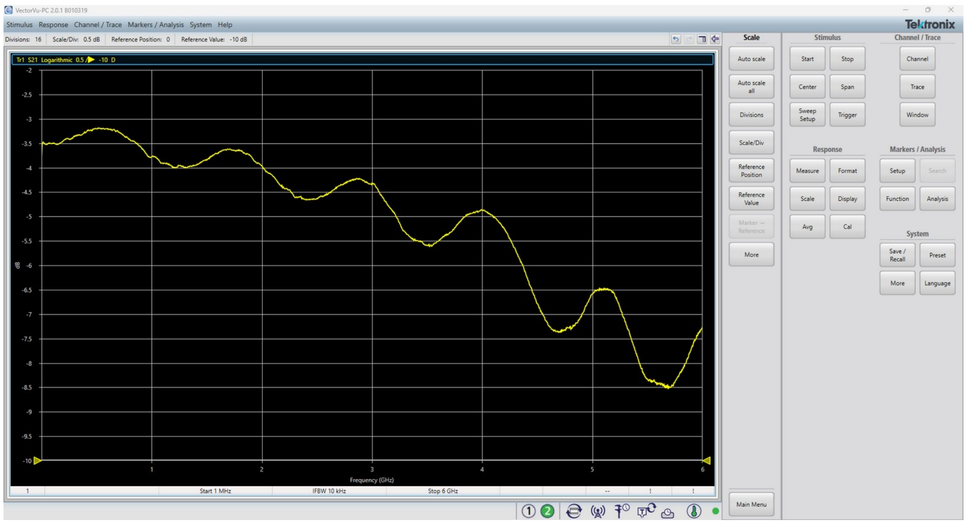
      Closed loops on the S_{21}Smith chart correspond to the resonances of the resonator. This essentially happens when the magnitude dips along with changes to the phases' slope at the same frequency.

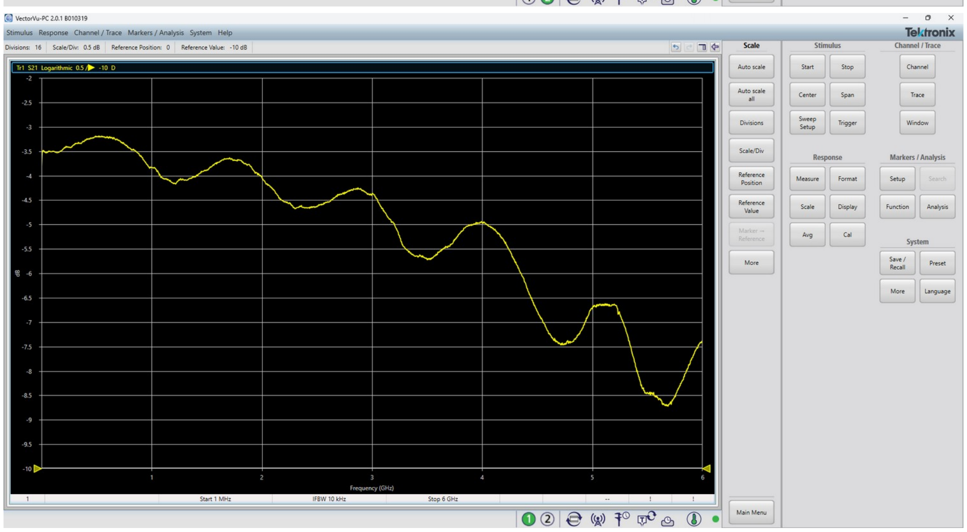


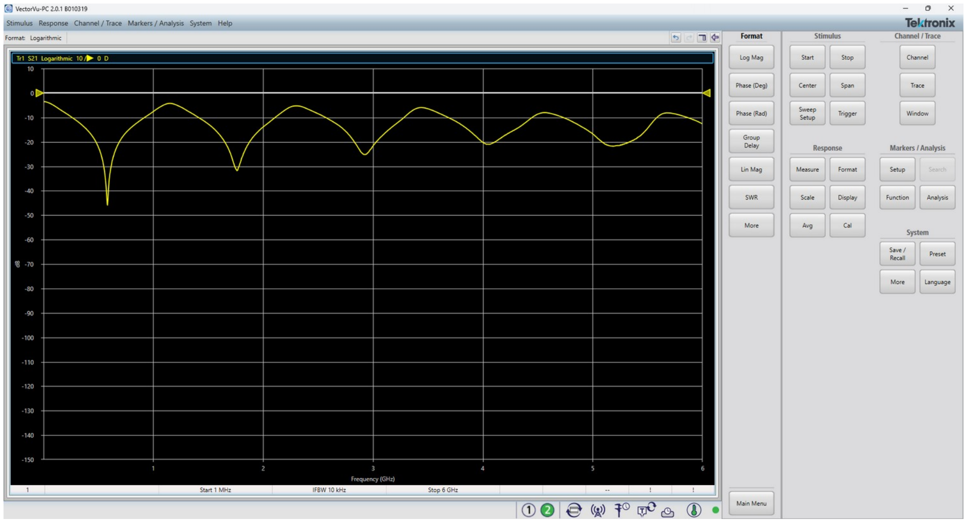


b. Measure the Wilkinson Power divider. Terminate the unused port in a 50Ω load. Report the isolation between the output ports. Report the power delivered from port 1 to the 2 output ports. Show all the relevant plots.

The first two images correspond to attenuation at the outputs and convey power delivered, as can be seen, the response is approximately $-3\,dB$ at the design frequency and degrades at higher harmonics. The third graph corresponds to the isolation of the outputs and shows good isolation at the design frequency and the harmonics.







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Stimulus Response Channel / Trace Markers / Analysis System Help
Tektronix
Format: Logarithmic
Tr1 S21 Logarithmic 10 / 0 D
Frequency (GHz)
Start 1 MHz
IFBW 10 kHz
Stop 6 GHz
Format
Log Mag
Phase (Deg)
Phase (Rad)
Group Delay
Lin Mag
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