

Matching Network Diagnostics Using a Nykar Phase IV Match Network Tester



Procedure 405.1
Revision 1 – August 2019

Preface

Frontier Technical Services – Carl Almgren
User Manual – Joe Cenedella

© 2019 Frontier Technical Services. All rights reserved.

Frontier Technical Services
2100 W Drake Rd, Suite #4
Fort Collins, CO 80526 USA
Tel: +1 970 217 6535

<http://www.ftsplasma.com>

Table of Contents

Preface	2
Table of Contents	3
Purpose of this Document	3
Network Analyzer Calibration	4
Verify TE3001 Network Analyzer Calibration	4
TE3001 Calibration Procedure	4
Select Com Port	7
Map Calibration Loads	8
Setup Instructions	9
Required Tools	9
Hardware Setup	9
Mapping Procedure	10
Testing a Match	10
Voltage Pulse Parameters	13
Find Map Corners	15
Point Correction	16
Match Timing Calculations	18
Interpreting Results	18
Troubleshooting	22

Purpose of this Document

This procedure outlines how to use a Nykar Phase IV Match Network Tester to perform matching network diagnostics in conjunction with a network analyzer. The data from these results can be used to detect and resolve issues that may be affecting the efficiency or reliability of your matching network.

These instructions detail how to measure the impedance range of a matching network and evaluate it against a known good matching network map. With this comparison, the user can perform an expert evaluation of a match at the site of the tool and avoid replacing good matching networks.

Network Analyzer Calibration

Before performing the testing procedure, ensure the network analyzer is properly calibrated and the correct COM port is selected. If the network analyzer has recently been calibrated and connected, you can move directly to the next section.

Verify TE3001 Network Analyzer Calibration

1. Turn on the network analyzer.
2. Connect the 50 ohm precision test cable to the network analyzer output port.
3. Install the 50R load at the end of the precision cable.
4. Press the “**Z**” button to set the network analyzer to impedance mode.
5. Set to rectangular impedance by pressing the “**Format**” button until screen shows “Rect Impedance”.
6. Verify that the 50R load reads $50 \pm j0.1$ Ohm at 13.56 MHz.

→ **If load does not read as above, perform following calibration procedure.**

TE3001 Calibration Procedure

1. Press “**System Z_o**” to enter the System Parameters menu.
2. Use the red arrows to scroll down to “**Calibration...**”
3. Press the **Enter** button to bring up the Calibration menu.
4. With the selection arrow pointing to “Cal Type”, pressing **Enter** will alternate between Standard and Custom calibration. Select “**Custom**”.
5. Press the down arrow to set the following parameters:
 - **Cal Kit: N-female**
 - **Cal Start: 0.03 MHz**
 - **Cal Stop: 300 MHz**
6. Press **Enter** when you have gotten to “Perform Cal” to start the process.

7. Arrow down and follow the on-screen prompts, which will take you through the calibration process.
8. Install the 50R load at the end of the test cable when prompted, followed by the “short” load and finally the “open” load.
9. When the calibration process is complete, scroll to “Done” and press **Enter**.

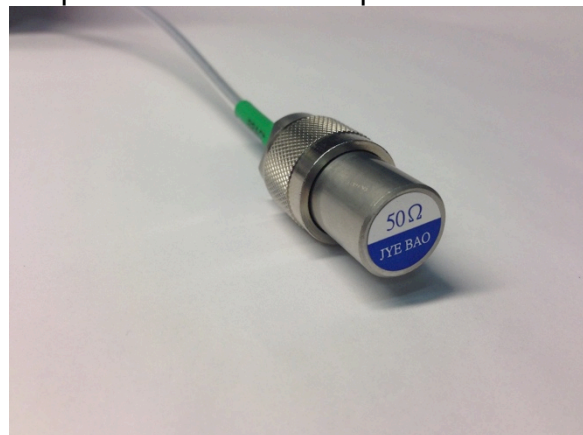
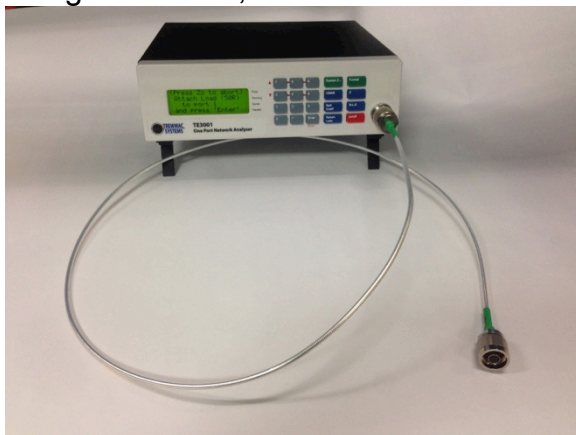
Custom S-O-L Calibration Loads

The N - type calibration kit comes standard with the TE3001

50R Load	"Short" Load	"Open" Load
<p>(Press Zo to abort) Attach Load (50R) to port 1 and press 'Enter'</p> <p>EWMAC SYSTEMS TE3001 One Port Network Analyser</p>	<p>(Press Zo to abort) Attach Short to port 1 and press 'Enter'</p> <p>EWMAC SYSTEMS TE3001 One Port Network Analyser</p>	<p>(Press Zo to abort) Attach Open to port 1 and press 'Enter'</p> <p>EWMAC SYSTEMS TE3001 One Port Network Analyser</p>
<p>50Ω JYE BAO</p>		

TE3001 Calibration Setup

During calibration, the loads are connected to the precision test cable tip



Select Com Port

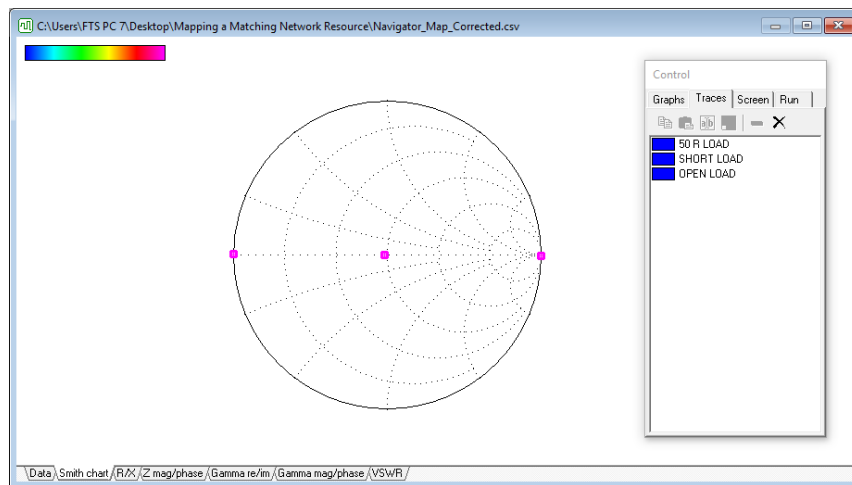
Ensure the Com port selected corresponds to the Com port on the computer that the network analyzer is plugged into. Selecting the incorrect port will result in a connection error.

1. Navigate to Windows > Device Manager > Ports (COM and LPT) > USB Serial Port (COM#). This number is the Com port you will be using.
2. In the Z'Analyze software, click the **Edit Settings** button.
3. Under the Serial tab, select the corresponding COM port from step 1. COM ports higher than COM8 can be manually entered by typing in the configured COM port number, ex. COM17.
4. Select the button "**Check connection...**"
5. If successfully connected, a popup window will display "Connected to: TE3001 F/W V12.0".

Map Calibration Loads

Test the short, 50R, and open loads to verify they display properly on the Smith Chart:

1. Connect network analyzer to a USB port on your PC and open Z'Analyze software.
2. In Z'Analyze Software, under the "Run" tab of the Control Panel, set values to:
 - **1 freq. selected**
 - **1 Samples**
 - **32 Average**
 - **13.56 f (MHz)**
3. Install the open load on the network analyzer precision test cable tip. In Z'Analyze software, press "Run" to obtain a data point on the Smith chart.
4. Repeat these steps for the 50R and short load. This should result in 3 data points across the center Smith Chart:



Mapped Calibration Loads (Short, 50R, Open)

5. If the three horizontal points do not display as above, ensure the network analyzer is properly set up and calibrated according to the previous sections.

When this process is completed, connect the network analyzer to the matching network output adaptor.

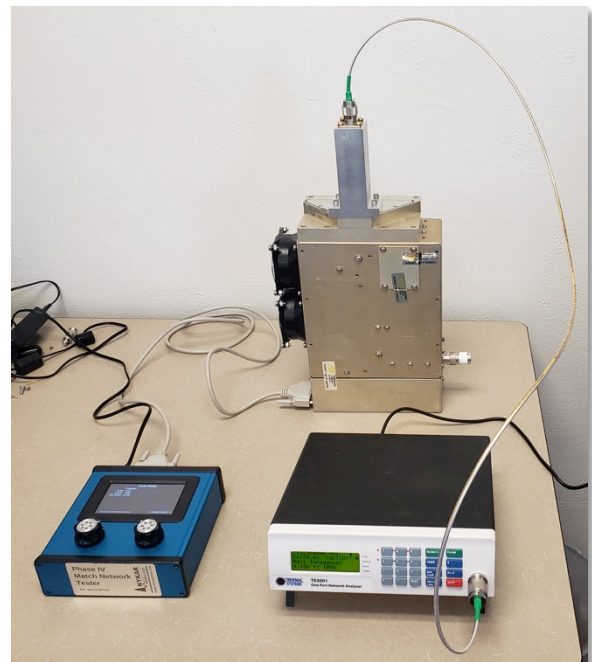
Setup Instructions

Required Tools

- Nykar Phase IV Match Network Tester
- Matching Network to be tested
- TE3001 Network Analyzer
- Windows PC with Z'Analyze Software Installed
- Golden Match (or known good test values) for comparison

Hardware Setup

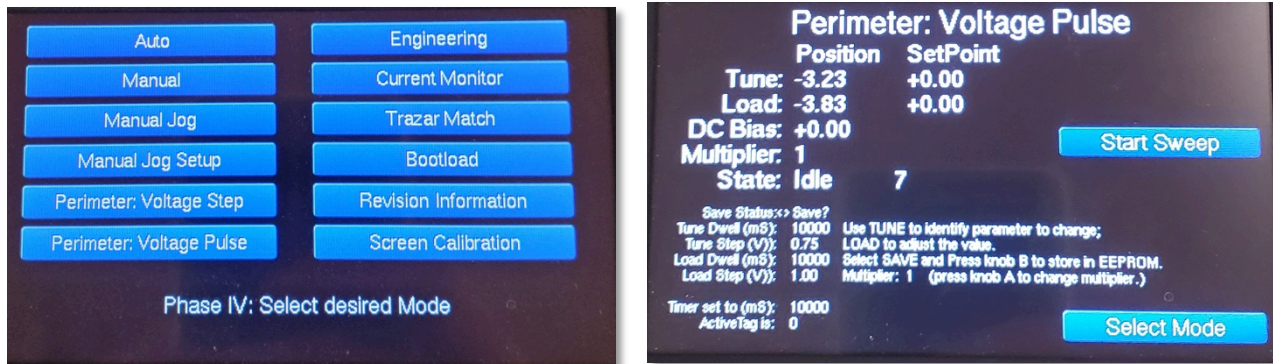
1. Plug the TE3001 Network Analyzer and Nykar Match Network Tester into a power source.
2. Terminate the matching network input connector with a 50 ohm load.
3. Connect network analyzer precision test cable to the matching network output adaptor.
4. Using a DB25 connector cable, connect the Nykar Match Network Tester to the matching network.
5. Using a USB cable, connect the network analyzer to a PC with *Frontier Technical Services Z'Analyze* Software installed.



Mapping Procedure

Testing a Match

1. Turn on the Phase IV Match Network Tester by flipping the switch located on the back of the device to the “On” position. After an automatic calibration, the match network tester will start in auto mode.
2. Using the rubber-tip stylus included in the kit, press “**Select Mode**” in the lower right-hand corner of the touchscreen to open the menu.
3. Select “**Perimeter: Voltage Pulse**” in the left-hand column using the touch screen and stylus.



Nykar Match Network Tester Interface

4. In the bottom of the Perimeter Voltage Pulse screen, ensure the testing parameters are set to the optimal values for your match. The B dial on the Nykar Match Network Tester changes selection, marked with the “ < > ” symbol. Rotating the A dial changes value of the selected parameter. (See Voltage Pulse Parameters on page 12)

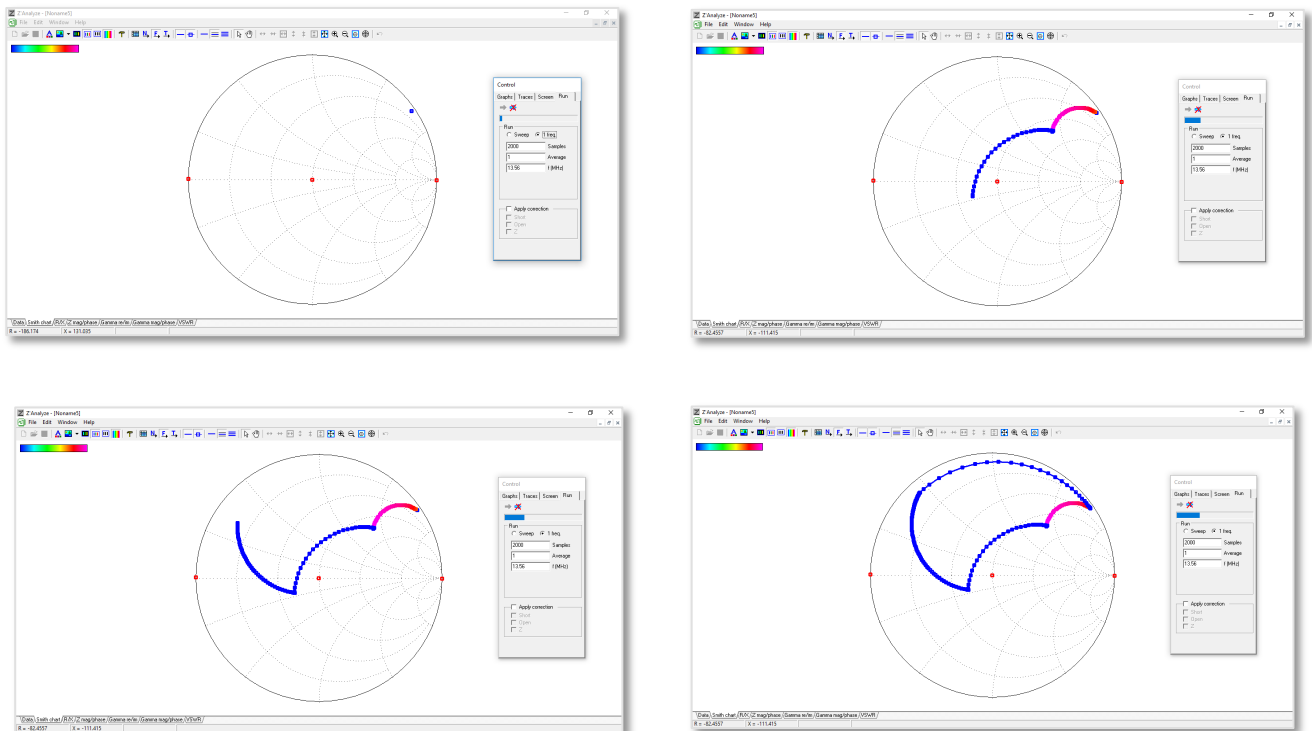
Starting Voltage Pulse Parameters:

Tune Dwell (mS):	10000
Tune Step (V):	0.75
Load Dwell (mS):	10000
Load Step (V):	1.00
Timer set to (mS):	10000
ActiveTag is:	0

5. Scroll up to “**Save Status**” with the B dial and press down on the dial to save changes. Ensure the text “**SAVED**” is displayed.

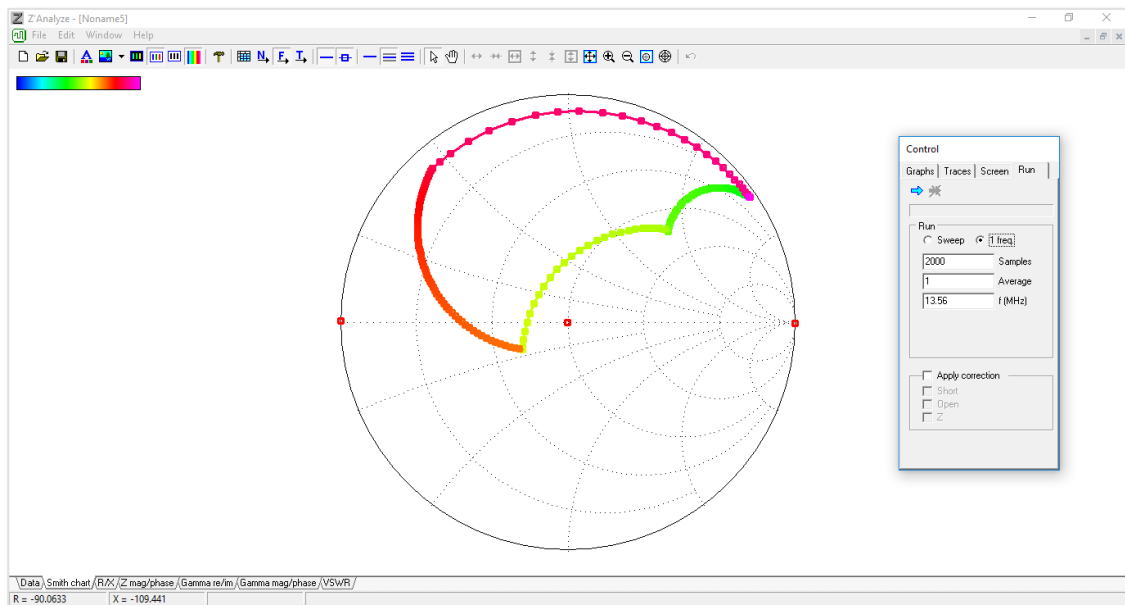
6. Press the “**Start Sweep**” button on the touch screen of the match network tester and let the device run through a full sweep. This will reset the match.
7. Open the Z’Analyze software with mapped calibration loads.
8. Set view to “**Smith Chart**” using the tab at the bottom of the main display window.
9. In the control panel under the run tab, change the settings to:
 - **1 freq. selected**
 - **2000 samples**
 - **1 Average**
 - **13.56 f (MHz)**
10. Press the blue “**Run**” arrow in the Z’Analyze Software control panel.
11. Then, press the “**Start Sweep**” button on the touch screen of the Nykar Match Network Tester.
12. After a 10 second delay, the sweep will start.

The data points on the smith chart will move along a set of curves as the sweep runs:



13. Press the “**Stop**” button in Z’Analyze software once the data points on the smith chart return to the start position. This will also end the sweep on the match network tester.

The test should result in a completed impedance curve similar to the following. If the curve is incomplete, compressed, or choppy, see the next section to change the voltage pulse parameters in order to obtain a complete test.



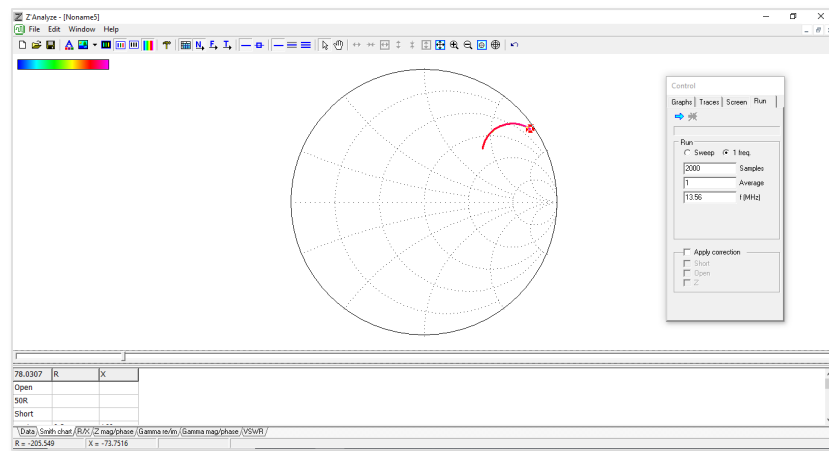
Completed Impedance Map

Voltage Pulse Parameters

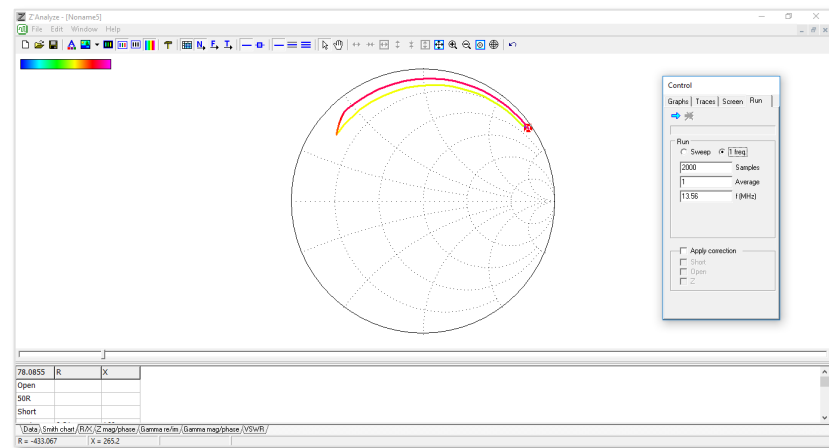
- If a completed impedance map was obtained in the previous step, you can move to the next section.

The parameters for Voltage Pulse will depend on the matching network and intended application. If the recommended values do not result in a completed impedance map similar to the example on page 11, the Tune or Step values may need to be changed.

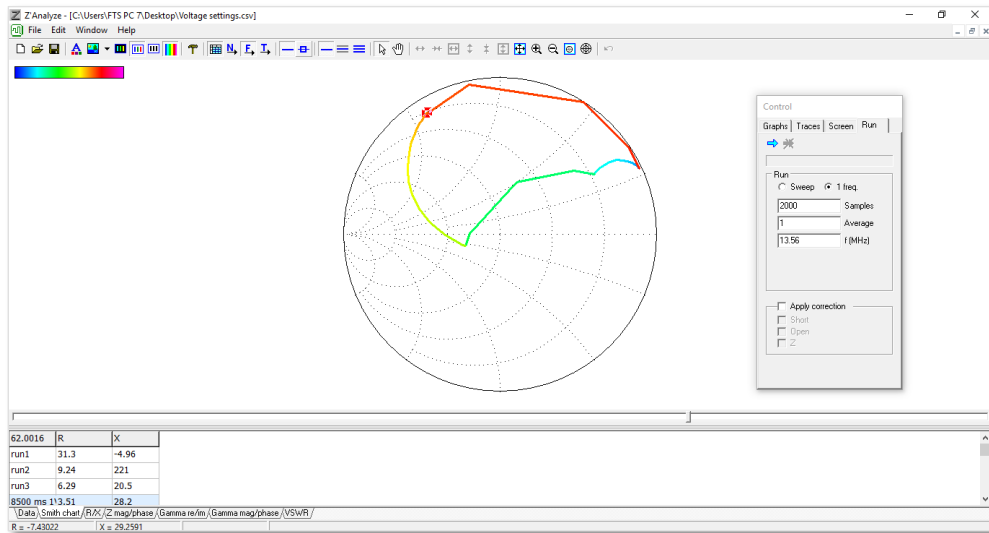
If the **Tune Step Voltage value is too low**, the sweep will not be able to move through the full curve. Perform the sweep again with a higher tune value:



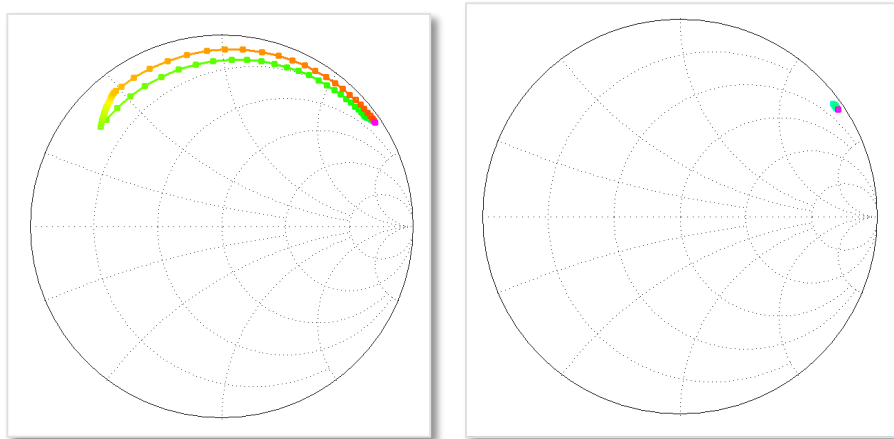
If the **Load Step Voltage value is too low**, the sweep will be compressed and missing curves. Perform the sweep again with a higher step value. (This map may also be caused by a Tune Dwell Time that is too low—see next page.)



If the RF elements are moving too quickly, the Tune values may need to be decreased.
If the **Tune value is too high**, the curve will be choppy or jagged.



If the **Tune Dwell Time** is too low, the sweep will end before it has fully moved its component. If a test results in an incomplete map (pictured below), increasing the Tune Dwell value on the match network tester may solve this problem.

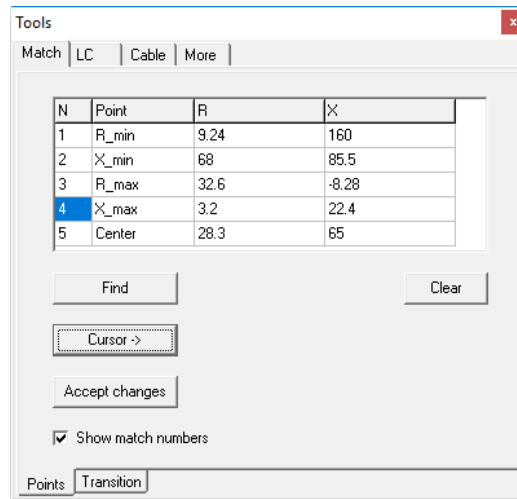


Find Map Corners

1. In Z'Analyze software, press the “**Show Table**” icon.



2. Next, press the “**Tools**” icon. Under “**Match**”, with the “**Points**” sub tab selected, press the “**Find**” Button.



This will add impedance points to the corners of the smith chart labeled 1 through 4.

Point Correction

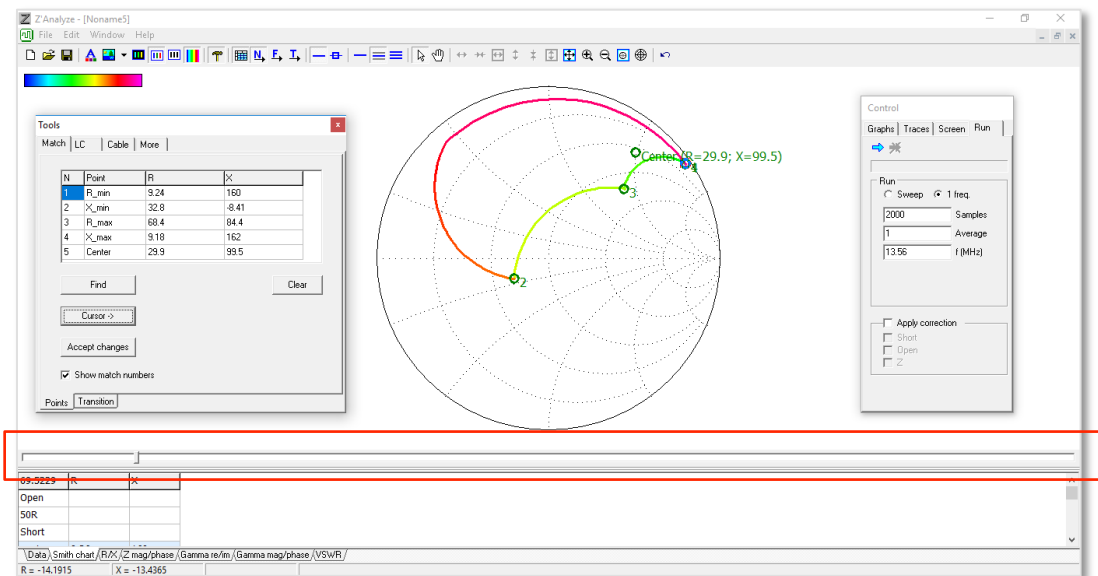
The Z'Analyze automatic algorithm is not always perfect, and these points may need to be corrected.

1. In the Tools window, select the first point under the “N” column by clicking the number 1.
2. In the main display window, press the Sample Number button. This will display a blue circle on the smith chart, highlighting a selected point.

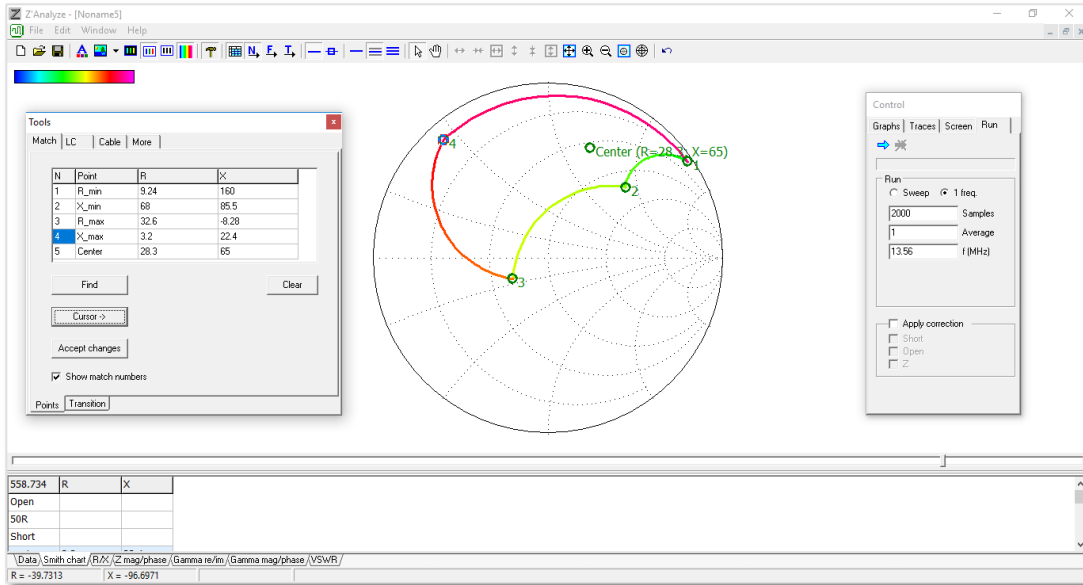


Sample Number

3. Point 1 should already be highlighted at the start of the impedance curve. Press the “**Cursor ->**” button in the Tools window to accept changes and mark this point as N1.
4. Change selection to ‘2’ in the N column.
5. Drag the slider located directly below the smith chart to move the selected point to the second corner. Press the “**Cursor ->**” button in the Tools window to accept these changes for N2.

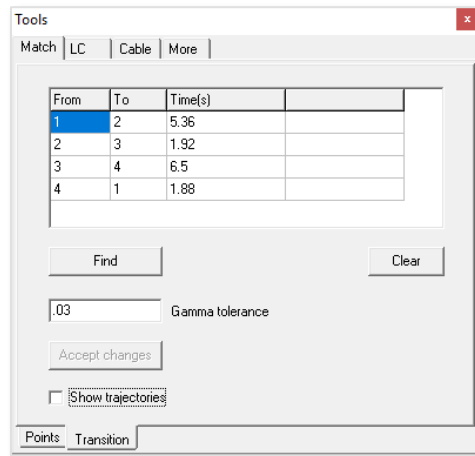


- Repeat this process for points 3 and 4. The result should look similar to the following, with the impedance points sequentially labeled from 1 to 4 and a corrected center point value:



Match Timing Calculations

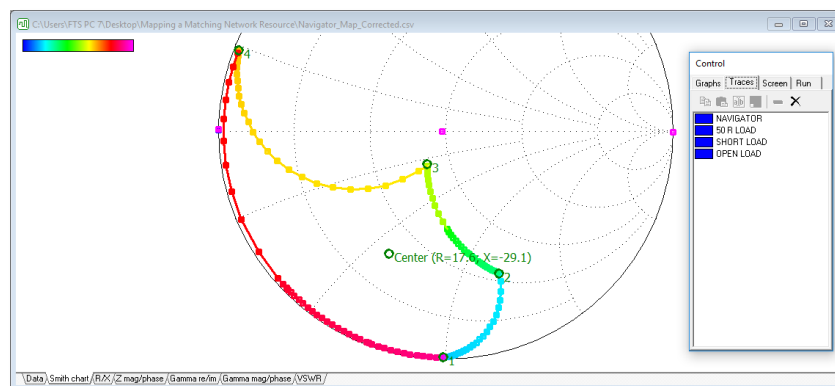
Open the tools window, under the Match tab with the “Transition” sub tab selected. In the Gamma tolerance box, enter **.03** and press “**Accept changes**”.



This will provide calculations for the transition time between each impedance curve. These timing metrics can be compared to a golden match. Deviation from these values may mean a motor or an RF element is deficient.

Interpreting Results

The corrected center point will consist of two values: resistance (R) and reactance (X). These data points can be numerically compared to a known good matching network map. More commonly, your matching network map can be visually compared to a good matching network to check for a similar curve, smooth transitions, and complete corners.

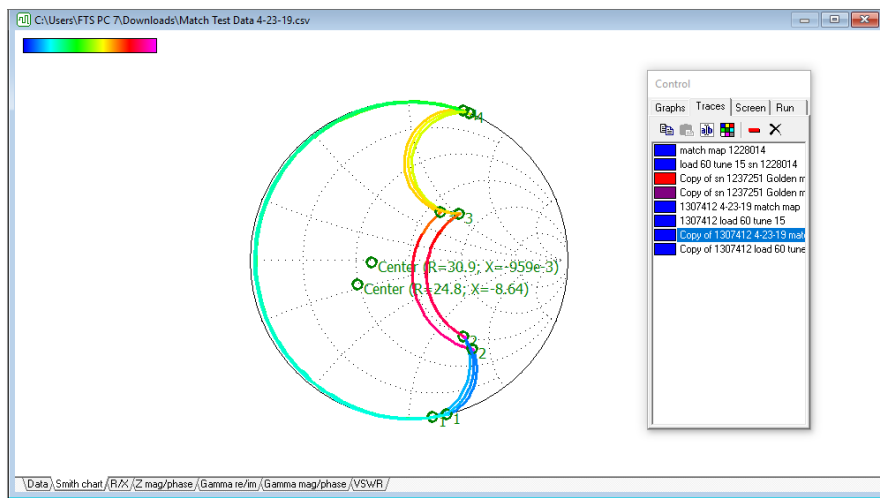


Healthy Matching Network Map

Matching network traces can be copied and pasted into a single file for direct comparison using FTS Z'Analyze software. See page 13 of the **Z'Analyze Software Manual**, which can be downloaded from:

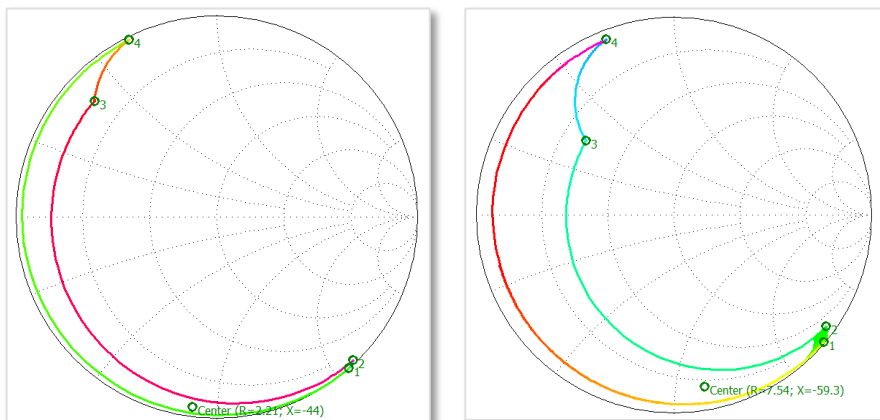
www.ftsplasma.com/manuals

Below is an example of acceptable variance between 3 matching network maps that all perform correctly. Acceptable variance will depend on the specific instrumentation being used and intended application.



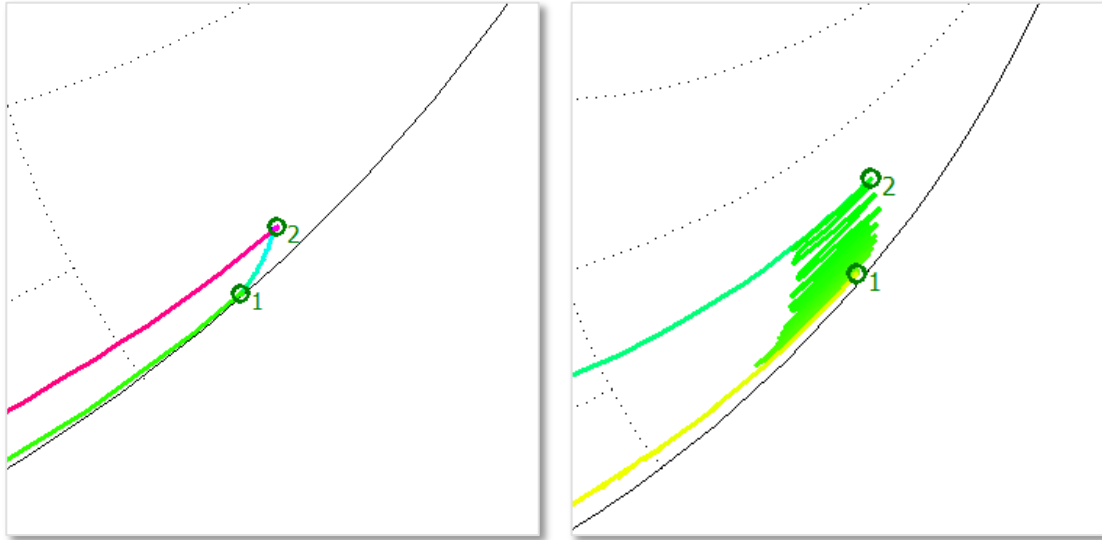
Acceptable Variance

Wide deviation from a golden match impedance range may indicate misadjusted or failing match components.



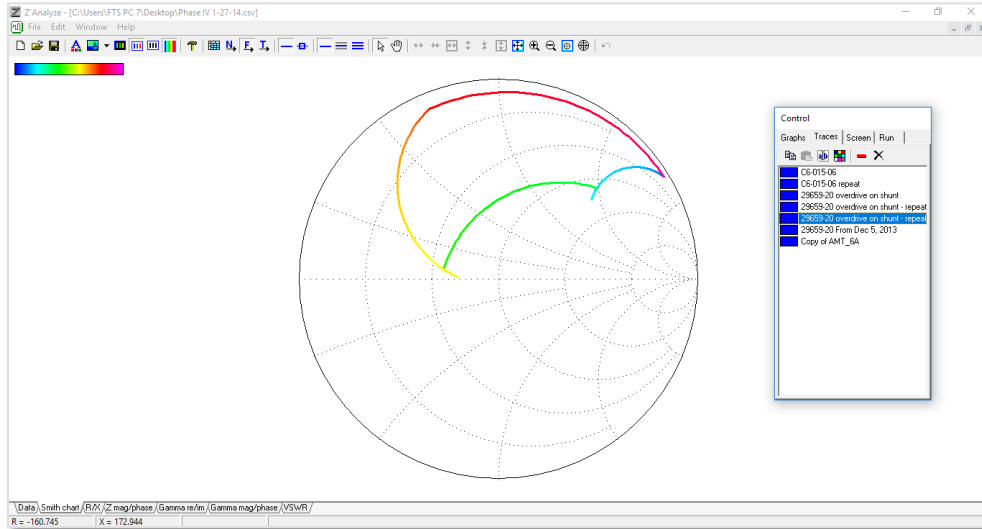
Golden Match (Left) vs. Unacceptable Impedance Range (Right)

Widely varied and choppy corners may indicate burned load capacitor contacts.



Healthy Load Capacitor Contacts (Left) vs. Burned Contacts (Right)

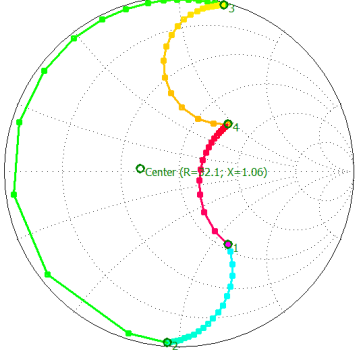
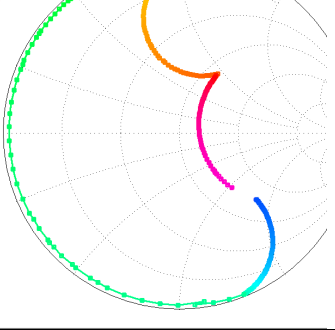
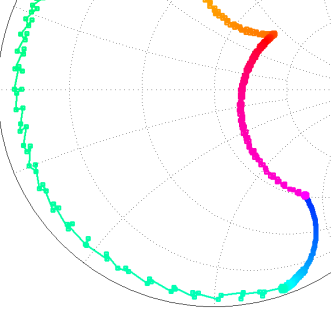
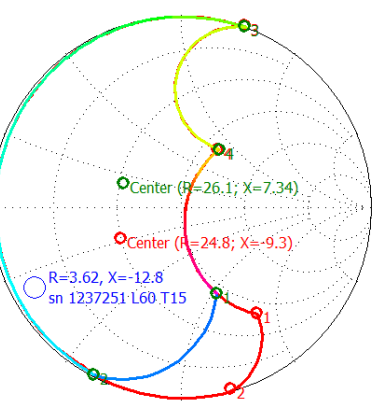
Corner points that move beyond the full mesh may indicate an issue with the capacitor movement overdrive in the matching network.



Misaligned Corners from Capacitor Movement Overdrive

If your matching network map has a different shape, incomplete corners, or jagged transitions compared to a known good matching network map, the match likely needs attention. Use of a match with these characteristics could result in production issues (See more troubleshooting on next page).

Troubleshooting

Example	Common Problem
	<p>Curve is Choppy</p> <p>The test was run too quickly or with too low of a sample rate. Change settings in Z'Analyze software to ensure enough samples are being collected. (See page 13)</p>
	<p>Curve is Incomplete or Broken</p> <p>Likely caused by sticking capacitor movements in the matching network. Match may need attention.</p>
	<p>Curve is Jagged</p> <p>Likely caused by Network Analyzer calibration, check the "Network Analyzer Calibration and Setup" Section. If this does not resolve the problem, it may be an issue with the match.</p>
	<p>Curve Varies Widely from Known Good Match / Missing Curves</p> <p>When a curve is significantly different from your map (colored with a gradient) compared to a known good matching network map (colored in red), the match may need attention.</p>