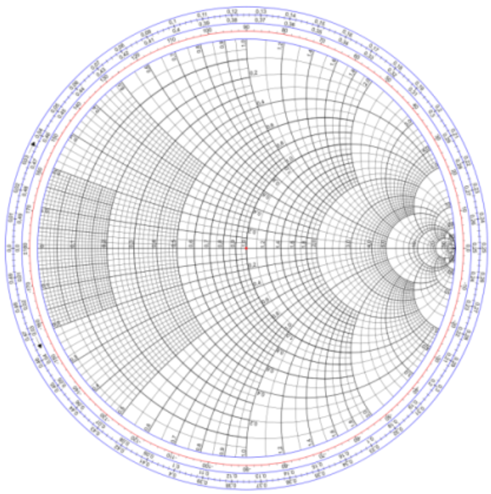
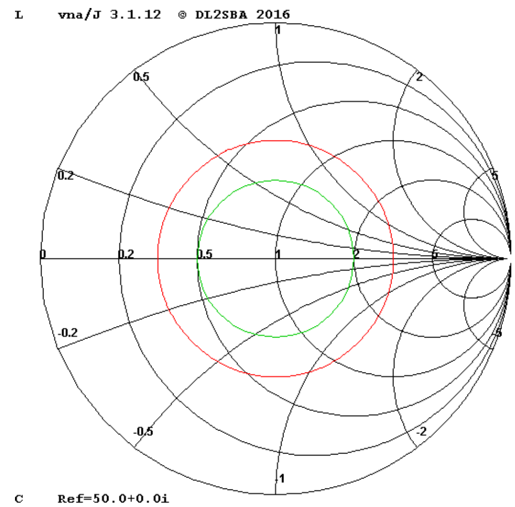
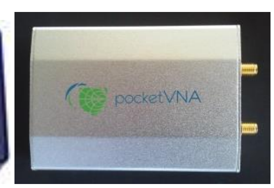
Smith Charts

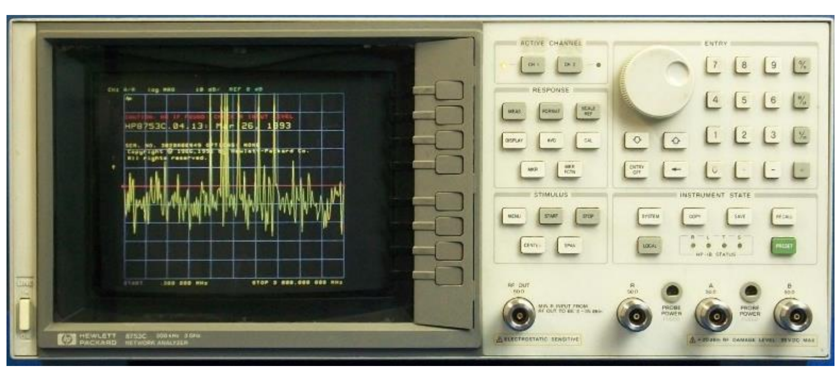




The **Smith chart** was invented 1939 by Phillip H. Smith. This graphical chart was originally designed to assist radio frequency (RF) engineers in solving problems with transmission lines and matching circuits. The Smith Chart shown above on the left side reminds me of the Slide Rule I used 60 years ago before invention of the electronic calculator. Today, most instruments that display Smith Charts, the graph will look like the one shown on the right side.

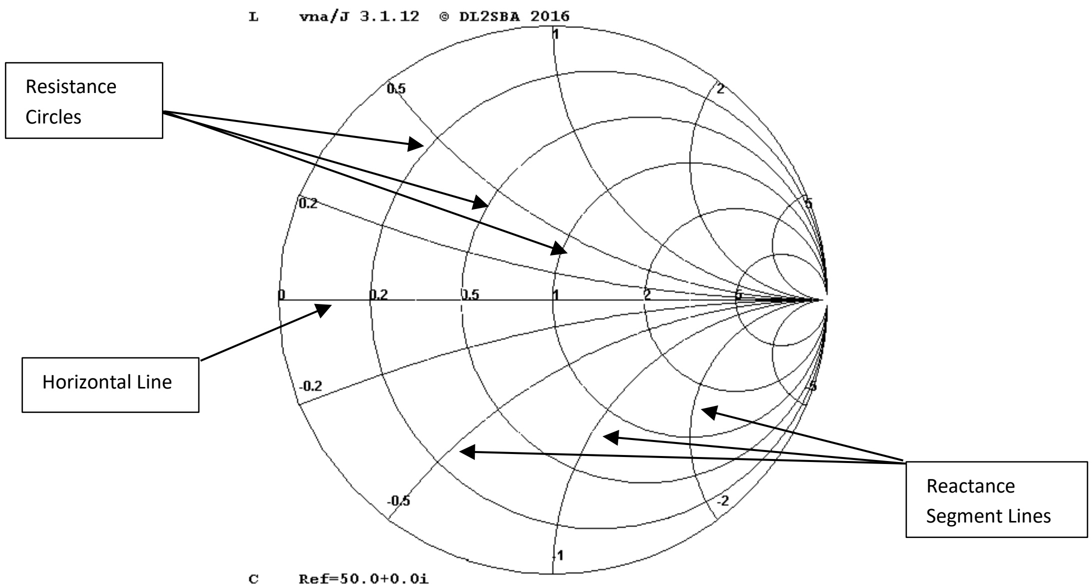
In the 1970’s, Hewlett-Packard (HP) developed a Vector Network Analyzer (VNA) that would measure, calculate and display the results on a Smith chart. Even 46 years later, the VNA is still the primary instrument that’s being used to display Smith Charts. In the past purchasing a VNA was very expensive, but thanks to modern digital technology these instruments have become affordable. VNA’s that work with your laptop, tablet or smartphone are now available at prices an amateur might consider. A few of these VNA instruments are shown below.





Antenna Basics – Your radio operates at its maximum efficiency when the antenna port is connected to an Impedance **(Z)** of 50 ohms. Antennas are actually a "resonant frequency" circuit which has series resistance **(Rs)**, capacitive and inductive inductance **(X)** which results in an Impedance **(Z)** value. All of these values are measured ohms **(Ω)** which can be confusing. For an amateur radio operator, impedance is a very important value to measure.

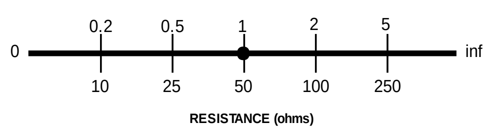
Smith Charts – Today, the use of "markers" has simplified how data is derived from a from Smith Chart graph. The graphs that most instruments display have also been reduced a few lines and circles.



MiniVNA Smith Chart

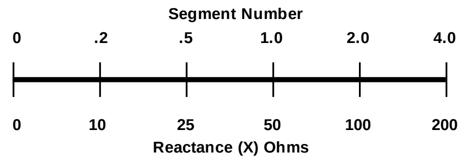
The purpose of each line and circle is explained as follows:

The Horizonal Line – There's only one horizonal line on the graph and it's the true resistance (Ω) line. This means that the capacitive or inductive reactance (X) equals 0 ohms and only resistance is present. This horizonal line is sometimes idenified as the "resonant frequency" line because an antennas resonant frequency occurs when (X) equals 0 ohms. Notice that a "C" located at bottom left corner of the graph and a "L" at the top. Any signal trace that falls below the horizonal line will contain capacitve reactance (Ω) and inductive reactance (Ω) above the line. The graph below shows what the line numbers represent in resistance values. Number 1 represents 50 ohms because the measurement reference is 50 ohms. The resistance values vary from 0 ohms on left side to infinity on the right

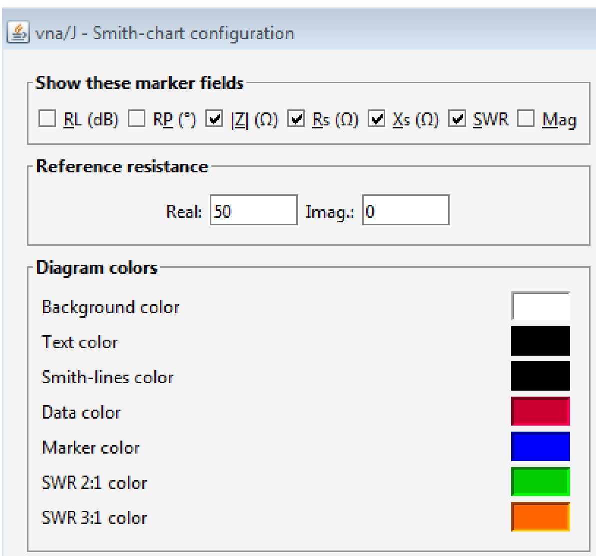


Resistance Circles - Each **circle** represents a resistance value in ohms (Ω), so you have 10, 25, 50 100 and 250 circles. Any time the signal trace intersects with one of these circles, the resistance (Rs) value will be equal to that circle. The impedance (Z) will be different because either capacitance or inductance will be added to the ohms value. Example: My 80m antenna at 3.808 MHz is very close to the 50 ohm circle with a (Rs) of 57Ω, the inductive reactance (X) is 61Ω and the impedance (Z) **83.9Ω**. This is not something my radio would like.

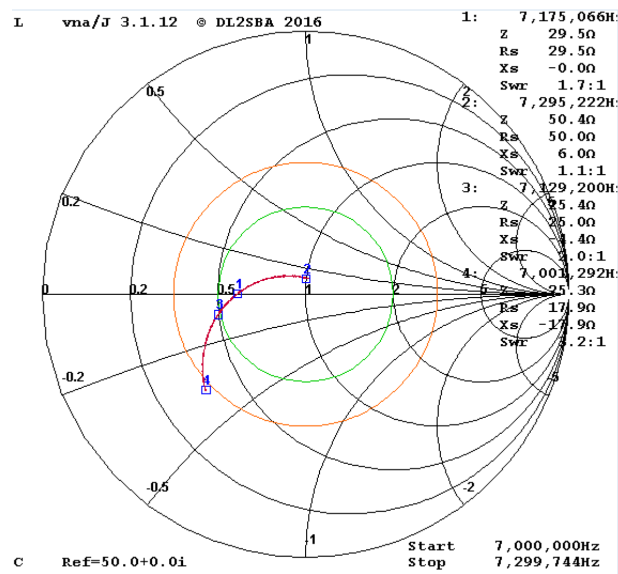
Reactance Segments – The curved segment lines represent reactance (X) in ohms (Ω). The graph below shows the relationship between segment numbers and value reactance in ohms (Ω).



Smith Chart Configuration – The MiniVNA Tiny has the Smith Chart Configuration screen shown below. This chart allows me to select what marker data will be displayed and the diagram colors. In this case, I have selected Impedance (Z), Resistance (Rs), Reactance (Xs) and SWR. This chart also allows you to change the reference resistance value to something other than 50 ohms. SWR circles (2:1 and 3:1) can be added to Smith Chart graph.



Configuration Panel



Alpha Delta DX-DD 40m Smith Chart

The DX-DD 40m antenna Smith Chart verifies some of the basic Smith Chart characteristics described in this document. Marker 1 shows the "resonant frequency" of this antenna. At this point, there's 0 reactance (X), and the impedance (Z) and resistance (R) is 29.5Ω. It is not unusual for an antenna's resonant frequency to occur at an impedance other than 50Ω. Markers 2 & 3 intersect the 50Ω and 25Ω circles, which is reflected by the (Rs) readings. Marker 4 shows that the SWR is 3.2:1 which is outside the range of my TS-590GS tuner range. The best SWR was 1.1:1 at 7.295 MHz's. Conclusion: The antenna is too long and the impedance could be improved by changing the height of the antenna ends.

Summary – At first glance, the old Smith Chart might appear overwhelming, but the Smith Chart graphs used by most modern instruments are very simple. Using my MFJ-259B to plot the same information displayed by the Smith Chart would be extremely time consuming if not impossible. With MFJ-259 set for the 4-10 MHz frequency range, the tuning knob covered the entire 40m band in 1/8 of a turn. A lot of the antenna test analyzers do not cover the UHF band. The MiniVNA Tiny used in this article covers a frequency range of 1 MHz to 3 GHz's.

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