3.3 SMITH CHART, SOLUTIONS OF PROBLEMS USING SMITH CHART

Smith Chart:

The Smith Chart is a fantastic tool for visualizing the impedance of a transmission line and antenna system as a function of frequency. Smith Charts can be used to increase understanding of transmission lines and how they behave from an impedance viewpoint. Smith Charts are also extremely helpful for impedance matching, as we will see. The Smith Chart is used to display a real antenna's impedance when measured on a Vector Network Analyzer (VNA).

Smith Charts were originally developed around 1940 by Phillip Smith as a useful tool for making the equations involved in transmission lines easier to manipulate. See, for instance, the input impedance equation for a load attached to a transmission line of length L and characteristic impedance Z0 is shown in Fig 3.3.1. With modern computers, the Smith Chart is no longer used to the simplify the calculation of transmission line equations; however, their value in visualizing the impedance of an antenna or a transmission line has not decreased.

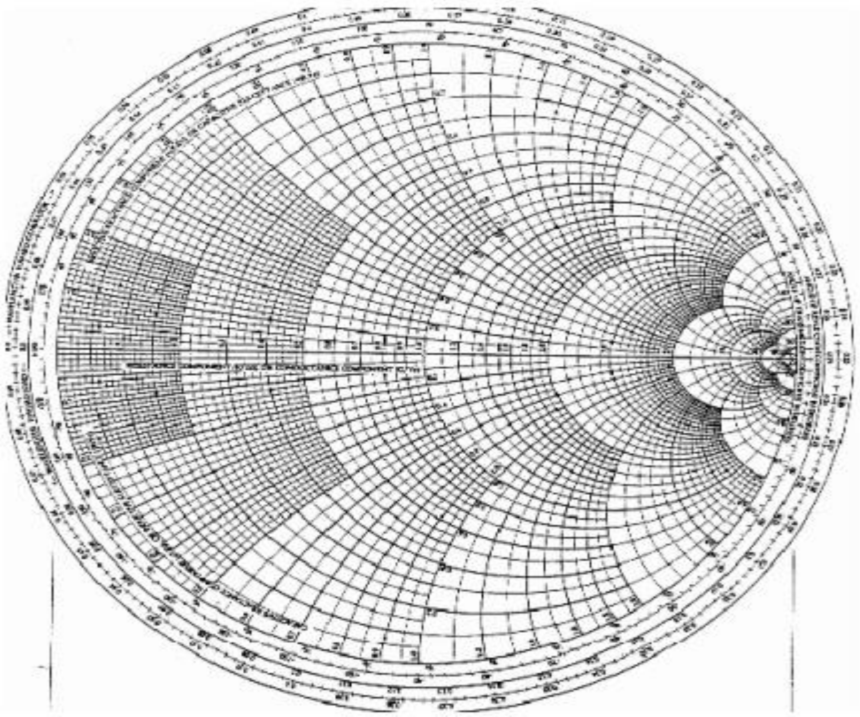

Fig: 3.3.1 The basic smith chart

Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

Figure should look a little intimidating, as it appears to be lines going everywhere. There is nothing to fear though. We will build up the Smith Chart from scratch, so that you can understand exactly what all of the lines mean. In fact, we are going to learn an even more complicated version of the Smith Chart known as the immitance Smith Chart, which is twice as complicated, but also twice as useful. But for now, just admire the Smith Chart and its curvy elegance. This section of the antenna theory site will present an intro to the Smith Chart basics.

THE CIRCLE DIAGRAM FOR DISSIPATION LESS LINE:

Constant Resistance Circles

For a given normalized load impedance zL, we can determine and plot it on the Smith Chart. Now, suppose we have the normalized load impedance given by:

$z_1 = 1 + iY$ …..(1)

n equation [1], Y is any real number. What would the curve corresponding to equation look like if we plotted it on the Smith Chart for all values of Y? That is, if we plotted z1 = 1 + 0*i, and z1 = 1 + 10*i, z1 = 1 - 5*i, z1 = 1 - .333*i, ... and any possible value for Y that you could think of, what is the resulting curve?

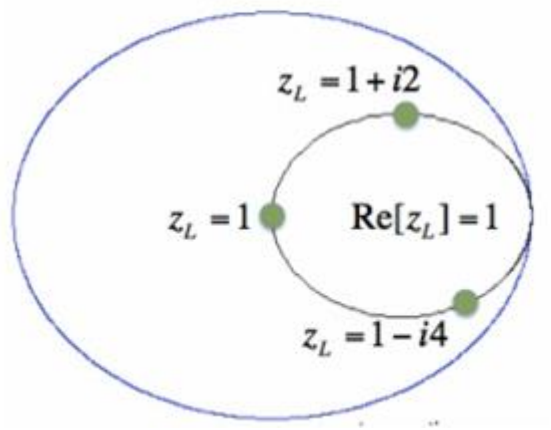

Fig: 3.3.2 Constant resistance circle zL = 1 on smith chart

Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

In Fig 3.3.2, the outer blue ring represents the boundary of the smith chart. The black curve is a constant resistance circle: this is where all values of z1 = 1 +

i*Y will lie on. Several points are plotted along this curve, z1 = 1, z1 = 1 + i*2, and zL = 1 - i*4. Suppose we want to know what the curve z2 = 0.3 + i*Y looks like on the Smith Chart. The result is shown in Fig 3.3.3:

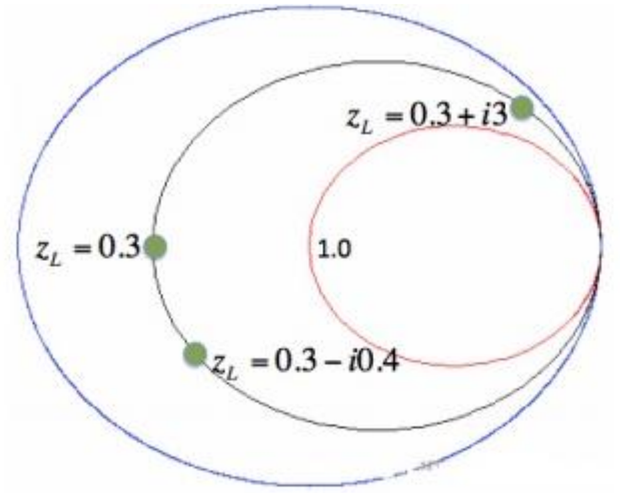

Fig : 3.3.3 Constant resistance circle zL = 0.3 on smith chart

Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

In Fig 3.3.3, the black ring represents the set of all impedances where the real part of z2 equals 0.3. A few points along the circle are plotted. We've left the resistance circle of 1.0 in red on the Smith Chart. These circles are called constant resistance curves. The real part of the load impedance is constant along each of these curves. We'll now add several values for the constant resistance, as shown in Fig 3.3.4:

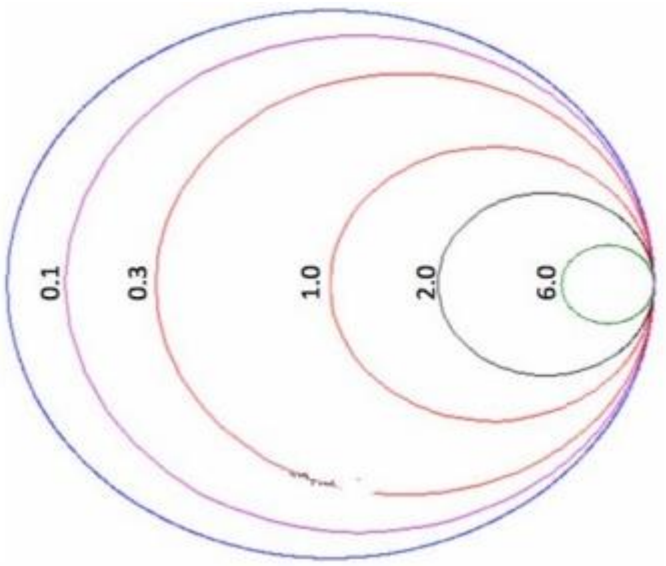

Fig: 3.3.4 Constant resistance circle on smith chart

Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

In Fig 3.3.4, the zL=0.1 resistance circle has been added in purple. The zL=6 resistance circle has been added in green, and zL=2 resistance circle is in black. look at the set of curves defined by zL = R + iY, where Y is held constant and R varies from 0 to infinity. Since R cannot be negative for antennas or passive devices, we will restrict R to be greater than or equal to zero. As a first example, let zL = R + i. The curve defined by this set of impedances is shown in Fig 3.3.4:

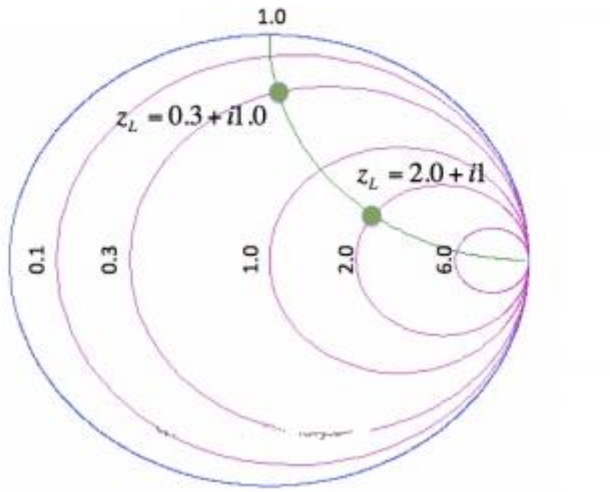

Fig: 3.3.4 Constant resistance Curve zL = R + i*1
Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

The resulting curve zL = R + i is plotted in green in Fig 3.3.4. A few points along the curve are illustrated as well. Observe that zL = 0.3 + i is at the intersection of the Re[zL] = 0.3 circle and the Im[zL]=1 curve. Similarly, observe that the zL = 2 + i point is at the intersection of the Re[zL]=2 circle and the Im[zL]=1 curve. (For a quick reminder of real and imaginary parts of complex numbers, see complex math primer.) The constant reactance curve, defined by Im[zL]=-1 is shown in Fig 3.3.5:

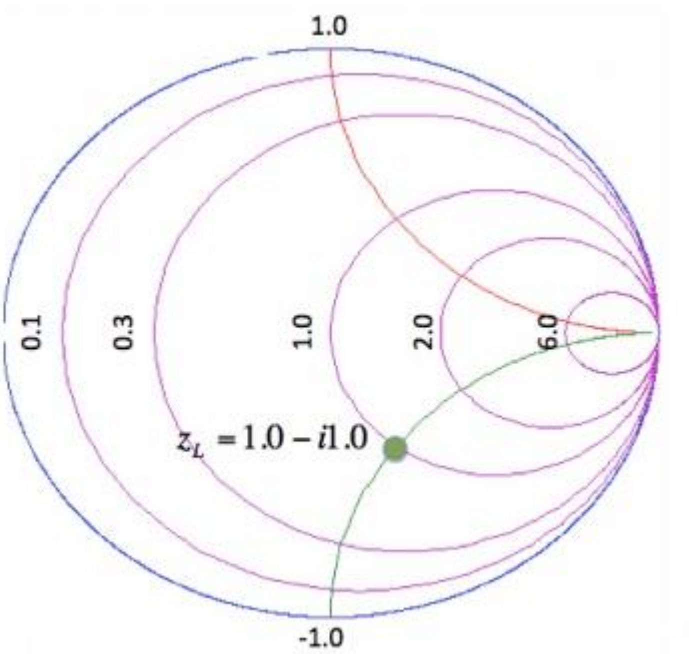

Fig: 3.3.5 Constant reactance Curve zL = R - i

Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

The resulting curve for Im[zL]=-1 is plotted in green in Figure 3.3.5. The point zL=1-i is placed on the Smith Chart, which is at the intersection of the Re[zL]=1 circle and the Im[zL]=-1 curve.

An important curve is given by Im[zL]=0. That is, the set of all impedances given by zL = R, where the imaginary part is zero and the real part (the resistance) is greater than or equal to zero. The result is shown in Fig 3.3.6:

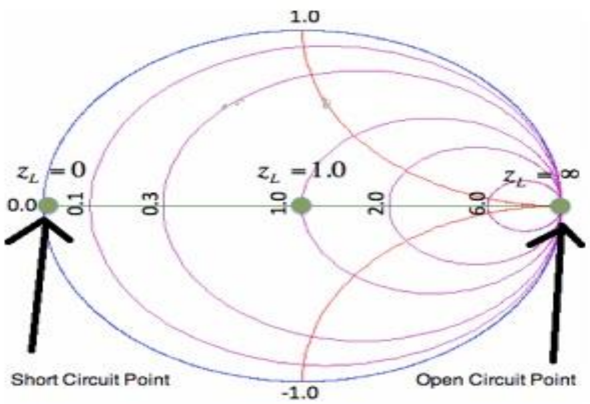

Fig 3.3.6 Constant Reactance Curve for zL=R

Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

Fig 3.3.6. Constant Reactance Curve for zL=R. The reactance curve given by Im[zL]=0 is a straight line across the Smith Chart. There are 3 special points along this curve. On the far left, where zL = 0 + i0, this is the point where the load is a short circuit, and thus the magnitude of is 1, so all power is reflected. In the center of the Smith Chart, we have the point given by zL = 1. At this location, is 0, so the load is exactly matched to the transmission line. No power is reflected at this point.

The point on the far right in Fig 3.3.6 is given by zL = infinity. This is the open circuit location. Again, the magnitude of is 1, so all power is reflected at this point, as expected. Finally, we'll add a bunch of constant reactance curves on the Smith Chart, as shown in Fig 3.3.7.

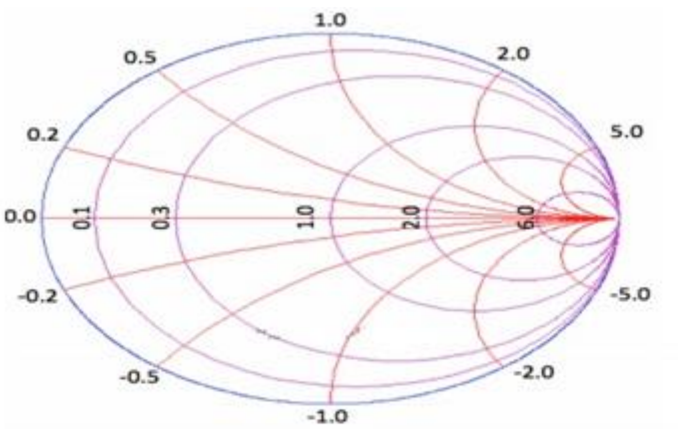

Fig 3.3.7 Smith chart with reactance curves and Resistance circles
Source: John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015

In Fig 3.3.7, we added constant reactance curves for Im[zL]=2, Im[zL]=5, Im[zL]=0.2, Im[zL]=0.5, Im[zL]=-2, Im[zL]=-5, Im[zL]=-0.2, and Im[zL] = -0.5. Figure 4 shows the fundamental curves of the Smith Chart.

SINGLE AND DOUBLE STUB MATCHING USING SMITH CHART:

Applications of smith Chart:

- Plotting an impedance

- Measurement of VSWR
- Measurement of reflection coefficient (magnitude and phase)
- Measurement of input impedance of the line
- It is used to find the input impendence and input admittance of the line.
- The smith chart may also be used for lossy lines and the locus of points on a line then follows a spiral path towards the chart center, due to attenuation.
- The difficulties of the smith chart are

Single stub impedance matching requires the stub to be located at a definite point on the line. This requirement frequently calls for placement of the stub at an undesirable place from a mechanical view point.

For a coaxial line, it is not possible to determine the location of a voltage minimum without a slotted line section, so that placement of a stub at the exact required point is difficult

In the case of the single stub it was mentioned that two adjustments were required, these being location and length of the stub.