Reflections 3.0
How to add reactance and resistance,

or how to add *conductance and susceptance*

GOAL: The goal of this section is to show you how easy it is to
a) find the SWR of a antenna that has a known resistive, and reactive series compont

(b) understannd why just a few feet further back on the feedline those impedances WILL HAVE CHANGED -- and what stays constant?
Then be able to
(c) find the flip size (the admittance) of any impedance, whether resistive, reactive, or complex
(d) get a very beginning understanding of how we can show a parallel matching stub can bring an antenna into a much better match by eliminating parallel susceptance

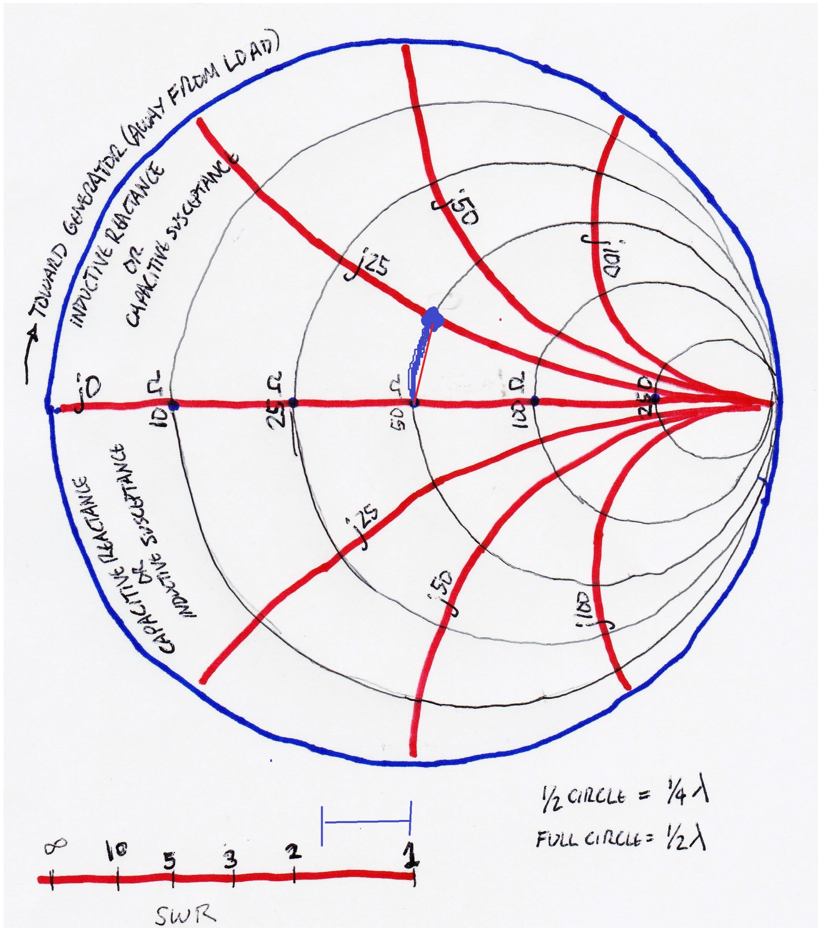
When we leave the world of simple resistances and enter the complex world that has reactances also, we need some new terms to explain what we are measuring.

Terms to Refer to Real World Impedances

Complex Total	**Only resistive**	**Only reactive**
IMPEDANCE is equal to	RESISTANCE plus	REACTANCE
ADMITTANCE is equal to	CONDUCTANCE plus	SUSCEPTANCE

IMPEDANCES IN SERIES
Remember that IMPEDANCES in series ADD.   Our chart makes it very easy for us to assess the impact on SWR of having a resistance in series with a reactance.

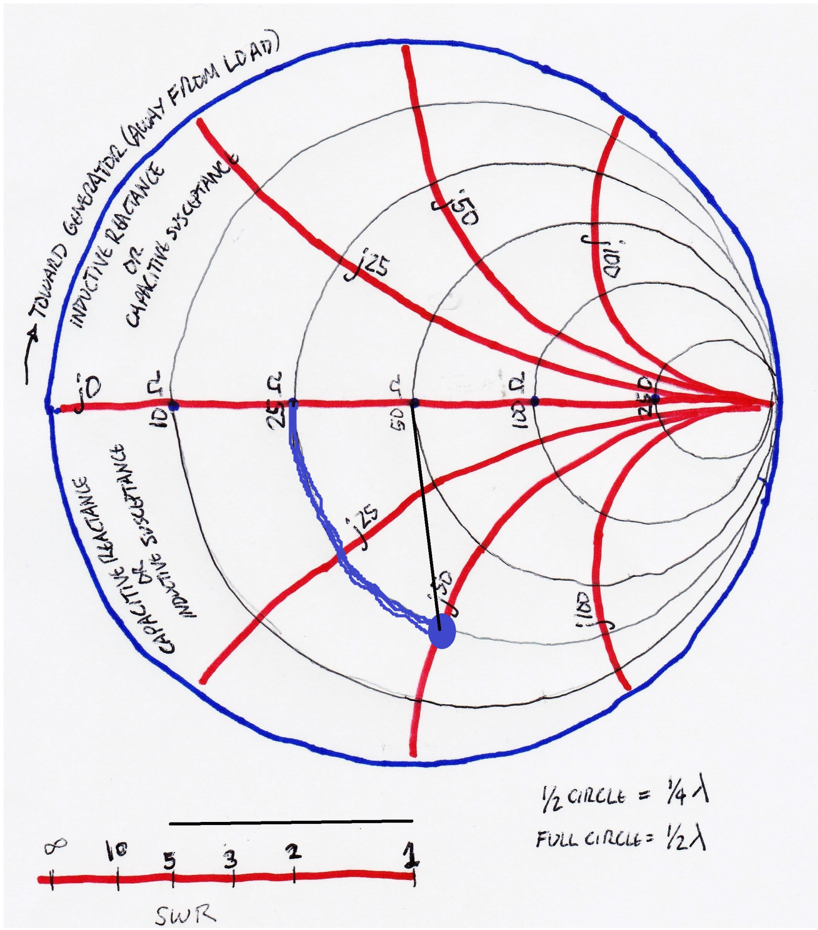
EXAMPLE #1
An inductive reactance of 25 ohms (the antenna is too long) is in series with a resistance of 50 ohms. What is the Standing Wave Ratio of this load, right at the load?



SOLUTION #1
We start with the 50 ohm resistance, and note the 50 ohm circle. We have to stay on that circle!. We look for the 25 ohm INDUCTIVE reactance (top of graph because inductive) and we travel on the 50 ohm resistive circle until we get to the 25 ohm inductive reactance. That point right there is the point of 50 ohms + j 25 ohms.

The SWR is determined by the STRAIGHT LINE DISTANCE from that point to the center of the graph. Measuring the straight line distance from the center of graph to that point, we conclude the SWR is somewhere just below 2.0, perhaps 1-3/4 or so.

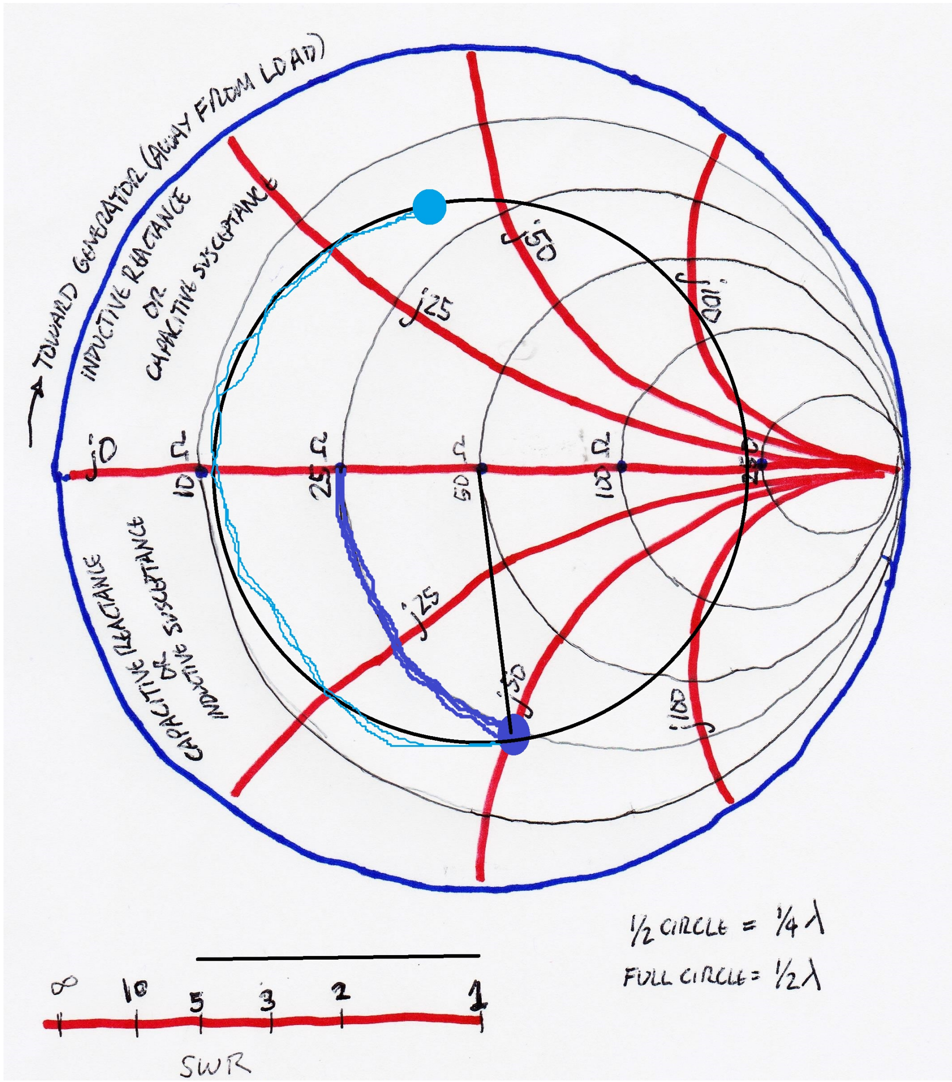
EXAMPLE 2. What will be the SWR of a 25 ohm resistance in series with a 50 ohm capacitive reactance (the antenna is too short) right at the antenna? (This example is similar to a too-short vertical on the top of a vehicle).



SOLUTION 2

We start from the 25 ohm point, move on the 25 ohm circle until we get to the 50 ohms capacitive reactance and draw the blue dot. Measuring the straight line distance (black line) from the center, we get an SWR of about 5:1 Pretty poor!!!

EXAMPLE 3. Using the poorly matched antenna of Example 2, what will be the impedance and SWR a half wavelength away on the 50 ohm feedline?



SOLUTION 3
We start from the antenna impedance point we found in Example 2. Of course, the SWR (barring lossy transmission line) NEVER CHANGES so as we leave the antenna and move toward the transmitter, we simply traverse a (black) CIRCLE (constant distance from the center, that is, constant swr!) until we have gone about 1/2 way round the circle (which is 1/4 wavelength).

With out blue pencil path we come to the blue dot point. The SWR is of course STILL 5,but now the impedance is maybe 20 ohms resistive in series with maybe 35 ohms INDUCTIVE reactance (since we are the top part of the curve). Wow! Our capacitive antenna now looks inductive to our transmitter

The key point for people using a tuner is this: the SWR doesn't change with the length of your transmission line – but the impedance to which you may need to match CHANGES DRASTICALLY if the antenna is poorly matched. It follows a circle around the Chart – constantly changing resistive and reactive components, and even switching from inductive to capacitive and back again over and over. No wonder that the SWR meter became the instrument of choice early on -- it is the ONLY thing that stays constant no matter the length of your transmission line.

And now you see why, if you wish to measure the impedance of an antenna.....you MUST do it very close to the antenna (unless it is a perfect 50 ohm match).

A perfect 50 ohm match has a circle of zero size – the impedance along the line is perfectly always 50 ohms. Everywhere. That is not true if there is a mismatch at the antenna between the transmission line and antenna.

Now let's move on to ADMITTANCES (the inverse of Impedance).

Terms to Refer to Real World Impedances

Complex Total	**Only resistive**	**Only reactive**
IMPEDANCE is equal to	RESISTANCE plus	REACTANCE
ADMITTANCE is equal to	CONDUCTANCE plus	SUSCEPTANCE

Conductance is simply 1 / (resistance). So the Conductance of 50 ohms is 1/50 = 0.02 mhos.

Susceptance is simply 1 / (reactance) So the Susceptance of 50 ohms inductive is 1/ 50 = 0.02 mhos inductive (we assign a positive number to inductive things, and a negative number to capacitive things, for reasons that have to do with trigonometry and polar coordinates, beyond what we need to discuss here).

ADMITTANCE is the inverse of IMPEDANCE	CONDUCTANCE is the inverse of RESISTANCE	SUSCEPTANCE is the inverse of REACTANCE
The Chart makes it easy to convert a complex impedance into its complex ADMITTANCE (you draw a line through the center and jump to the equidistance opposite side)	50 ohms has a conductance of 0.02 mhos.	50 ohms inductive reactance is equal to 0.02 mhos inductive susceptance

To convert any impedance (whether resistive, reactive, or both) into its equivalent ADMITTANCE (whether purely conductive, purely susceptive, or both) all you have to do is draw a straight line from your impedance through the center point and go the exact same distance to the other side of center.

Top half of the Chart is Inductive REACTANCE
Bottom half of the Chart is Inductive SUSCEPTANCE

IMPEDANCES in series ADD.

ADMITTANCES in parallel ADD.

We always try to work in a situation where all we have to do is ADD.   So if we have two components in SERIES, we prefer to deal with them in their IMPEDANCE measure.

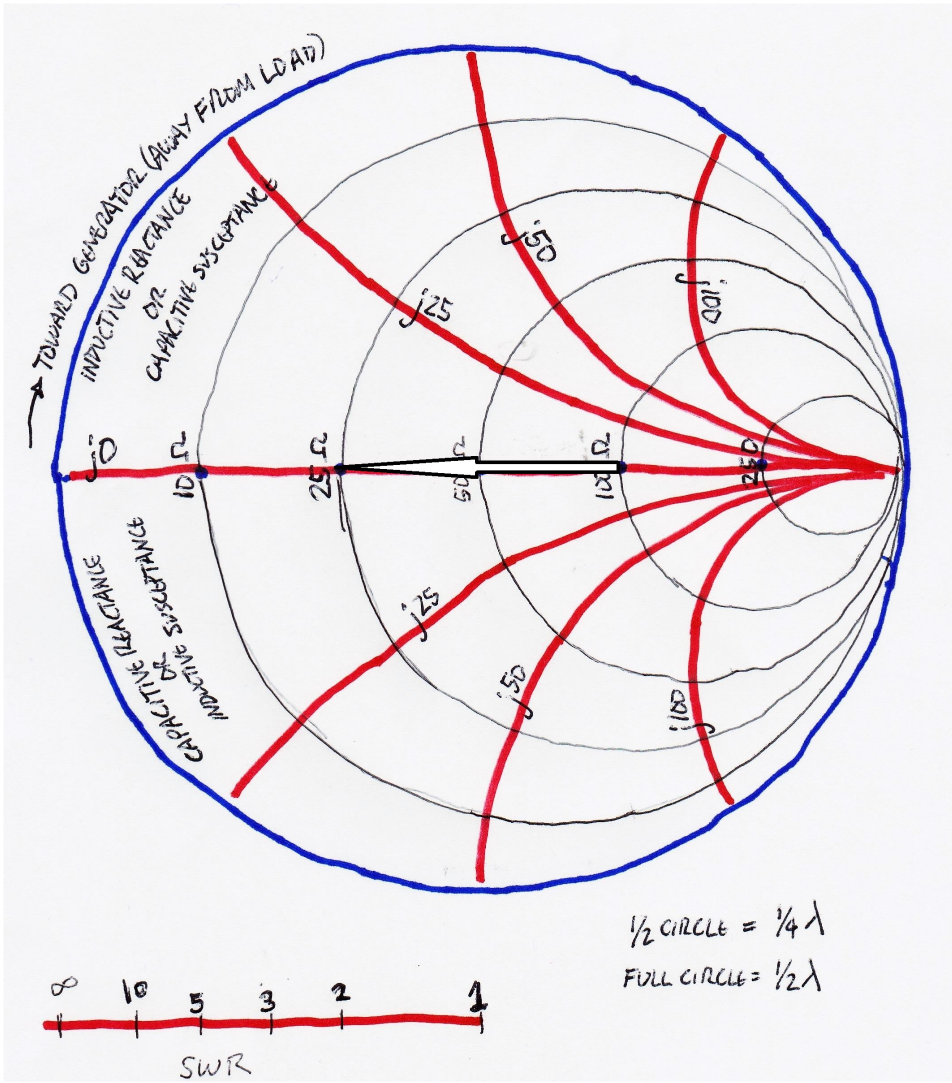
If we have two components in parallel, we prefer to deal with them in their ADMITTANCE measure.

(and it is easy to switch back and forth by simply shooting through the middle of the chart)

Our Chart has been set for "50 ohms"   and we can use it to INVERT any Admittance by just drawing a line through the center, jumping to the point equidistance on the OTHER SIDE, and dividing by 50^2 that is, dividing by 2500.

EXAMPLE 4

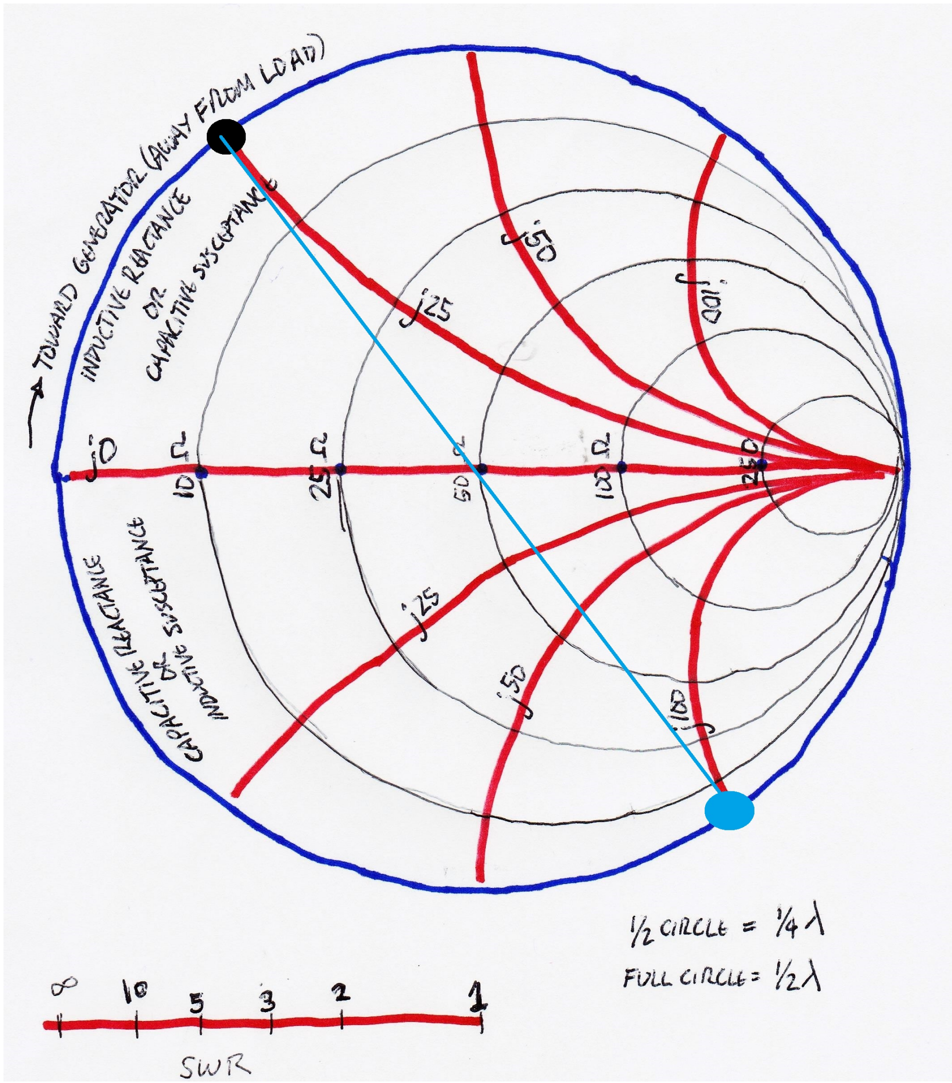
CONVERT 100 OHMS into the equivalent CONDUCTANCE.
So 100 ohms resistive becomes 25/2500 = 0.01 mhos resistive. (mho is ohm spelled backwards)



100 ohms becomes 25/2500 = 0.01 mhos

SOLUTION 4.
Start at 100 ohms. Jump through the center point to the equidistant point. here it is "25" -- divide by 2500 to get the constants correct for MHOS and you have 0.01 mhos. The same trick works for reactive values also.

EXAMPLE 5
CONVERT INDUCTIVE REACTANCE OF J25 OHMS INTO SUSCEPTANCE
Now here is an example of inverting an inductive reactance (top of curve) of j25 ohms....

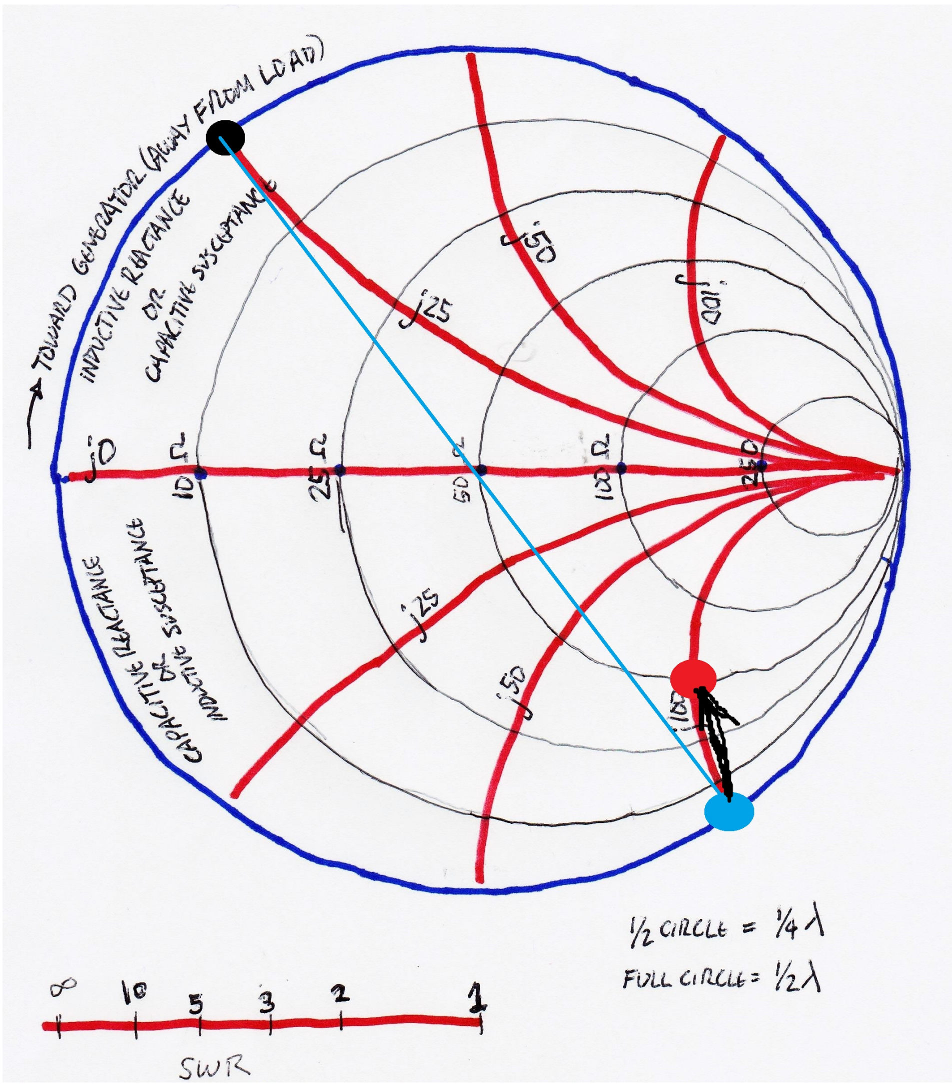


SOLUTION 5.
BLACK DOT is a simple reactance of j25 ohms inductive. Series resistance is 0 (just the wires) so it is on the outside of the curve (R = 0) and of course the SWR is infinite. (It can't absorb any power at all -- it has no resistive component). When we convert it to an admittance it become a susceptance of 100/2500 = 0.04 mhos inductive susceptance (there is no resistive conductance). And the SWR is still infinite even when looked at as an admittance!

The ADMITTANCE side of things makes it easy to add things in PARALLEL because admittances in parallel ADD just like IMPEDANCES in SERIES also add....

EXAMPLE 6
YOUR ANTENNA APPEARS TO BE 0.04 MHO INDUCTIVE IN PARALLEL WITH 0.02 MHOS PURE CONDUCTANCE -- WHAT IS YOUR SWR?

So Lets take our 0.04 mho inductive susceptance that we found in the last page, and add to it a conductance of 0.02 mhos pure conductive (no reactance!) in PARALLEL:

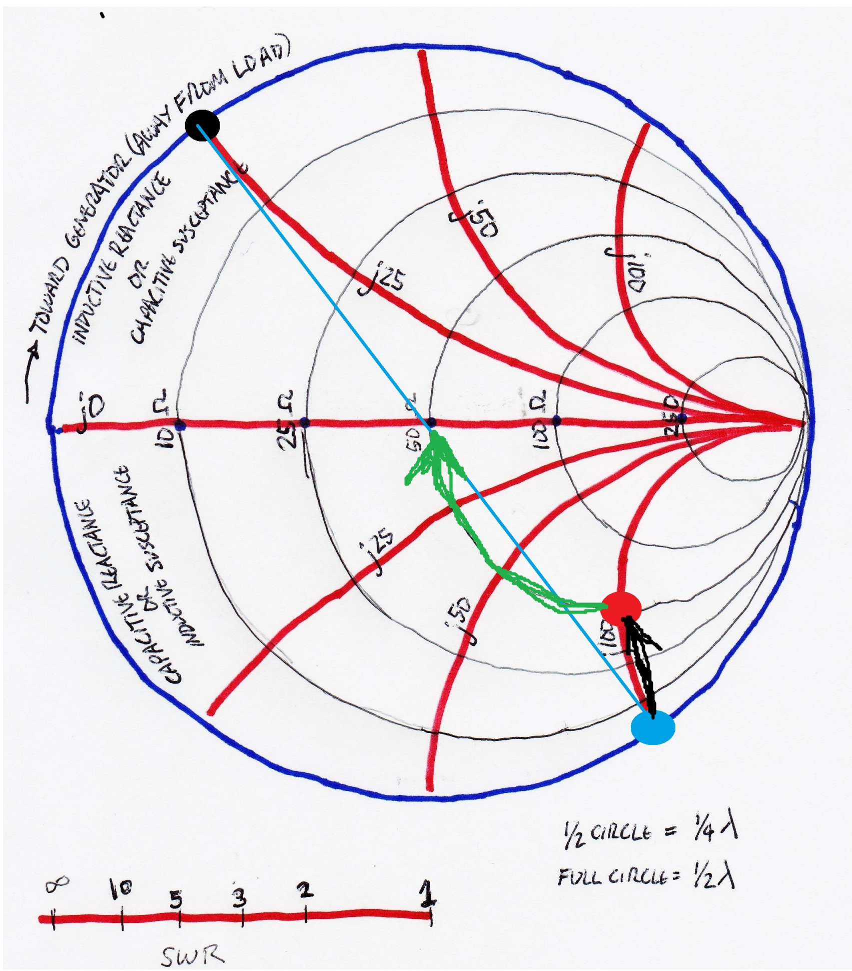


We have to STAY on the red line of our inductive susceptance, and we travel along that line until we get to the CONDUCTANCE line of 0.02 mhos (the conductance of 50 ohms) -- and we arrive at the RED DOT which is our final ADMITTANCE = 0.02 mhos conductance + 0.04 mhos inductive susceptance. And if you look at where we are in a straight line distance from the center.... the SWR is between 5 and 10, maybe 7:1

Thinking in ADMITTANCE is quite unusual for most of us – but the advantage is that if we want to calculate a PARALLEL STUB to add to an antenna, it is very easy to figure it out now. If your antenna presents an inductive susceptance, you can simply add a capacitive susceptance in parallel, and bingo, they cancel leaving only the pure conductance remaining. Adding things in parallel to the feed point of an antenna is very easy to do, and hams have been dong it for many many years.

EXAMPLE 7

WHAT PARALLEL REACTANCE MUST BE ADDED TO NULL OUT THE REACTANCE OF THE ANTENNA IN EXAMPLE 6 AND WHAT WILL BE THE RESULTANT SWR?



Since the antenna has 0.04 mhos of inductive susceptance in parallel with a conducatance, all we have to do is add 0.04 mhos of capacitive susceptive IN PARALLEL (as a stub!) at the antenna feedpoint terminals and the two will form a parallel resonant circuit,, effectively disappearing from the picture because the impedance of a parallel resonant circuit is extremely high -- so all that will be left is the

0.02 mho of conducatance --- hence we travel the curved green path, arriving at the center of the graph, a perfectly matched antenna now, with an SWR of 1:1

For extra credit -- if you start out with a shorted stub (far left hand side of the curve) you'll discover that one of approximately 1/6 around the circle (or 1/12 of a wavelength) will give you the parallel capacitive susceptance that you need.....