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Research Article

Smith Chart and its use in Complex Math

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Abstract

This paper presents Smith Chart as a graph based method of simplifying the complex math needed to describe the characteristics of microwave components. Smith Chart can look imposing; it's nothing more than a special type of 2-D graph, much as polar and semi log-log scales constitute special type of 2-D graphs. We have shown the utitlity of Smith Chart with the help of different graphs and figures.

Keywords: *Smith Chart spectral simulation antenna parameters.*

1. Introduction

The Smith Chart (Smith, 1939, 1944) is a graphical aid or nomogram designed for electrical and electronics engineers specializing in radio frequency to assist in solving problems with transmission lines and matching circuits (Ramo *et al,* 1965). It is an alternative to using tabular information. The Smith Chart can be used to represent many parameters including impedances, admittances, reflection coefficient, $S_n$scattering parameters, noise figure circles, constant gain contours and regions for unconditional stability (Pozar, 2005; Gonzalez, 1997).

The Smith Chart is plotted on the complex reflection coefficient plane in two dimensions and is scaled in normalized impedance (the most common), normalized admittance or both, using different colours to distinguish between them. These are often known as the Z, Y and YZ Smith Charts respectively. Normalised scaling allows the Smith Chart to be used for problems involving any characteristics impedance or system impedance, although by far the most commonly used is 50 ohms. With relatively simple graphical construction it is straightforward to convert between normalized impedance (or normalized admittance) and the corresponding complex voltage reflection coefficient (Gonzalez). The purpose of this paper is to give the basic idea of Smith Chart and to show its importance in antenna technology.

Analysis

It is the graphical technique that indicates the impedance of a transmission line and of the corresponding reflection coefficient as one moves along the line. Instead of having separate Smith charts for transmissions line with different characteristic impedances, a normalized chart in which all impedances are normalized with respect to the characteristic impedance Z_0 of the particular line is used. For the load impedance Z_L, the normalized impedance Z_L is given by:

$$Z_L = Z_L/Z_0 \quad = r+jX$$

Where
r = resistance
X = reactance

The following points are considered about the Smith chart.

(i) At extreme left on the chart r=0, x=0 i.e. Z_L =0 +j0, represents a short circuit on the transmission line. At extreme right on the chart r=∞, x= ∞ i.e. ZL = ∞+J∞, represents an open circuit on the line.
(ii) A complete revolution (360^0) around the Smith chart represents a distance of $\lambda/2$ on the line. Clockwise movement on the chart is considered as moving toward the generator (or away from the load), indicated in figure. Similarly, counterclockwise (anticlockwise) movement on the chart corresponds to moving toward the load (or away from the generator), indicated in figure.
(iii) There are three scales around the periphery of the Smith chart as in figure. For calculation one scale is sufficient and using the protractor (the innermost scale) for all calculations. The outermost scale is used to determine the distance on the line from the generator end in terms of wavelengths and the next scale determines the distance from the load end in terms of wavelengths.

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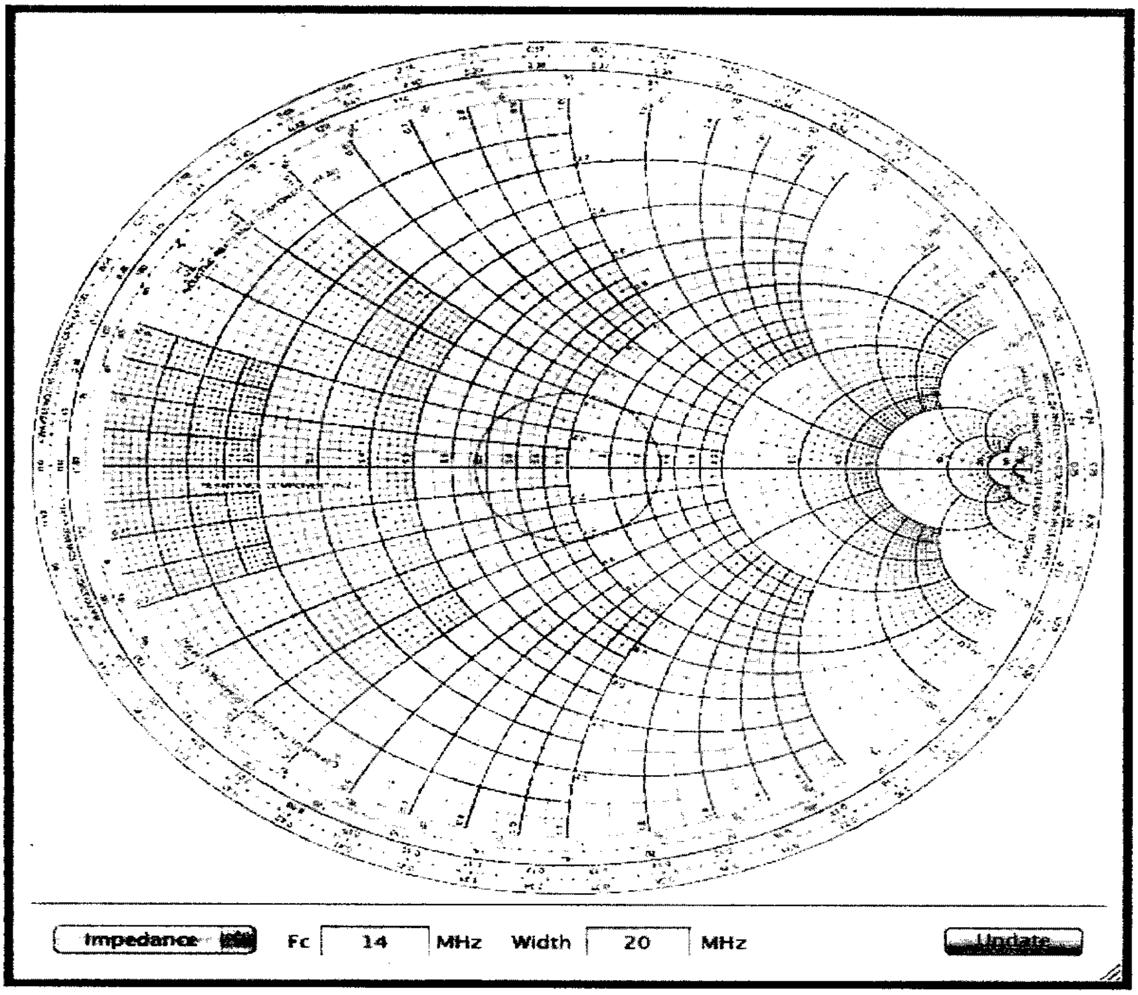

Figure 1 Smith Chart

(iv) The centre on the Smith chart is indicated by a digit 1. The left side from the centre line gives the value of V_{min}, I_{max}, Z_{min}, 1/SWR and the right side from the centre line gives the value of V_{max}, I_{min}, Z_{max}, SWR

(v) The circle around the horizontal line which passes through the centre indicates the resistive part whereas the circle away from the centre indicates reactive part. The upper circle away from the centre line indicates inductive part whereas the lower circle away from the centre line indicates capacitive part.

(vi) The Smith chart is also used as admittance chart (as Y=1/Z).

Conclusion

Smith Chart keeps the chart relevant for today's instrumentation and design automation applications. It is nothing more than a special type of 2-D graph. The coexistence of complex-impedance and complex reflection coefficient information on has single graph allows us to easily determine how values of one affect the other.

Typically we might want to know that complex reflection coefficient would result from connecting particular road impedance to a system having given characteristics impedance.

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