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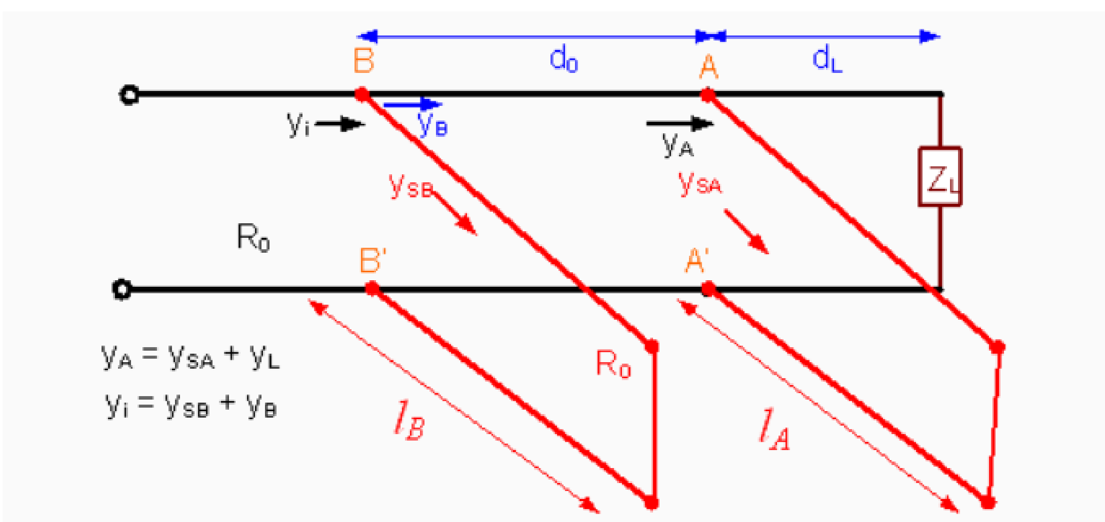
EXPERIMENT - 6

AIM - Study the behaviour of impedance matching for passive networks using Smith Chart (Double Stub Matching).

THEORY

A stub is a short-circuited section of a transmission line connected in parallel to the main transmission line. A stub of appropriate length is placed at some distance from the load such that the impedance seen beyond the stub is equal to the characteristic impedance.

Suppose we have a load impedance $\mathbf{Z_L}$ connected to a transmission line with characteristic impedance $\mathbf{Z_0}$. The objective here is that no reflection should be seen by the generator. In other words, even if there are standing waves in the vicinity of the load $\mathbf{Z_L}$, the standing waves must vanish beyond a certain distance from the load.



Conceptually this can be achieved by adding a stub to the main line such that the reflected wave from the short-circuit end of the stub and the reflected wave from the load on the main line completely cancel each other at point B to give no net reflected wave beyond point B towards the generator.

RESULTS AND DISCUSSIONS

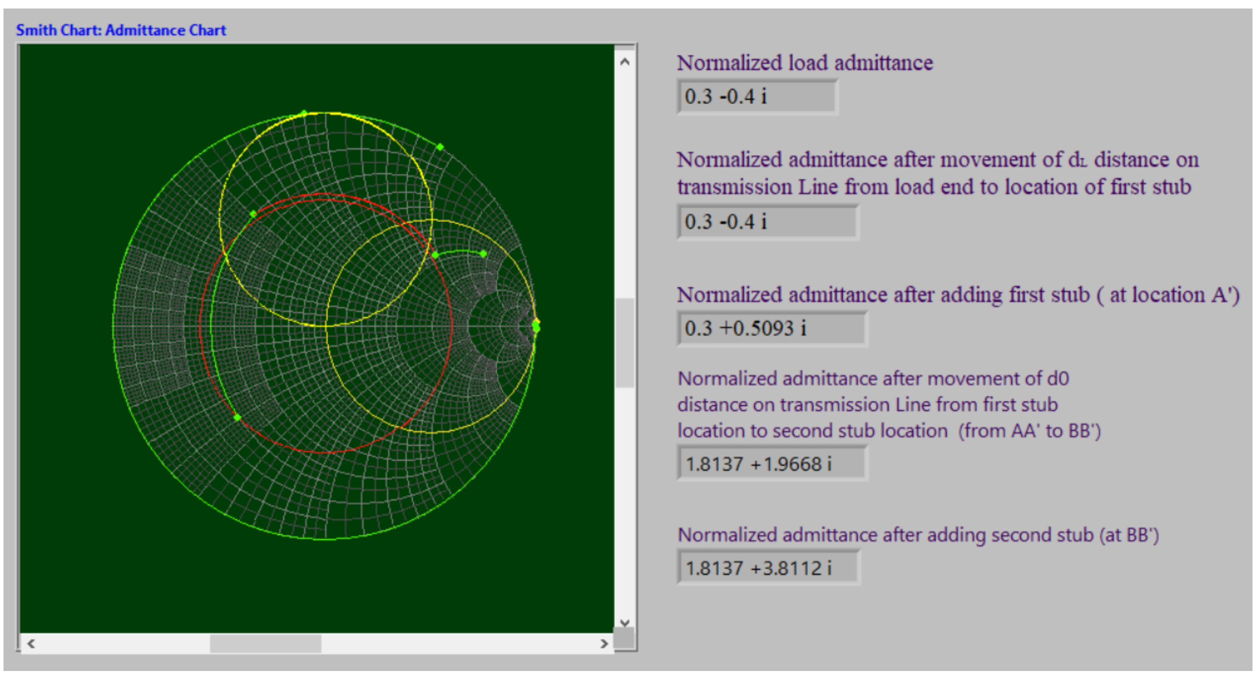
Case 1 : Characteristic Impedance (R_0)

Parameters taken :-

Load Impedance (Real) = 60 ohms
Load Impedance (Img) = 80 ohms
Characteristic Impedance = 50 ohms
Location of First Stub from Load End (d_L) = 0.5 m
Distance between two Stubs (d_0) = 0.125 m
Length of First Stub (l_A) = 0.367442
Length of Second Stub (l_B) = 0.42093

Admittance$_N$ contributed by First stub = 0.3 + 0.5093 i - (0.3 - 0.4 i)
= 0 + 0.9093 i

Admittance$_N$ contributed by Second stub = 1.8137 + 3.8112 i - (1.8137 + 1.9668 i)
= 0 + 1.8444 i



Observations :

a) Normalised load admittance will be 0.3 - 0.4 i.
b) Normalised admittance contributed by the first and second stub came out to be 0 + 0.9093 i and 0 + 1.8444 i respectively.
c) Equation $y_A = y_{SA} + y_L$ and $y_i = y_{SB} + y_B$ is satisfied.

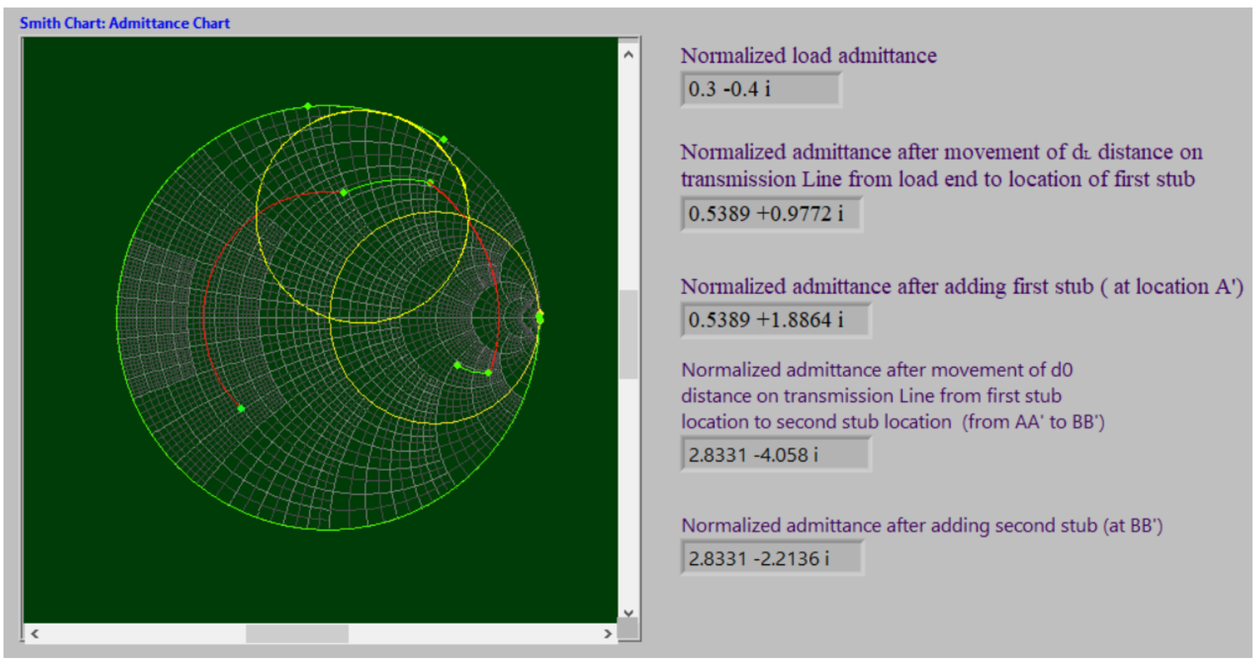
Case 2 : Location of Stub (d_L) and distance b/w two stubs

Parameters taken :-

Load Impedance (Real) = 60 ohms
Load Impedance (Img) = 80 ohms
Characteristic Impedance = 50 ohms
Location of First Stub from Load End (d_L) = 0.2 m
Distance between two Stubs (d_0) = 0.1 m
Length of First Stub (l_A) = 0.367442
Length of Second Stub (l_B) = 0.42093

Admittance$_N$ contributed by First stub = 0.5389 +1.8864 i - (0.5389 +0.9772 i)
= 0 + 0.9093 i

Admittance$_N$ contributed by Second stub = 2.8331 -2.2136 i - (2.8331 -4.058 i)
= 0 + 1.8444 i



Observations :

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- Normalised admittance contributed by first and second stub does not change with change in location of stubs and is same as previous result.
- On decreasing the location of first stub from load end, the normalized admittance of first stub also decreases.
- On increasing the distance between the two stubs, the normalized admittance of second stub increases.

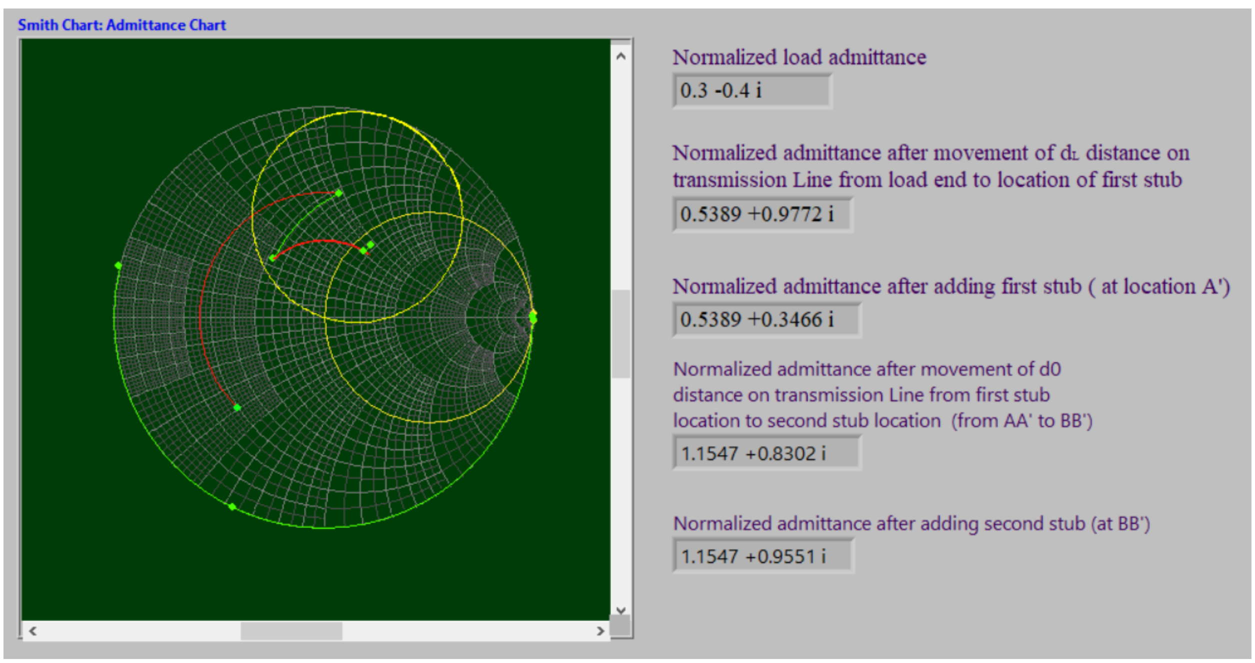
Case 3 : Length of Stubs (l_A and l_B)

Parameters taken :-

Load Impedance (Real) = 60 ohms
Load Impedance (Img) = 80 ohms
Characteristic Impedance = 50 ohms
Location of First Stub from Load End (d_L) = 0.2 m
Distance between two Stubs (d_0) = 0.1 m
Length of First Stub (l_A) = 0.160465
Length of Second Stub (l_B) = 0.269767

Admittance_N contributed by First stub = 0.5389 +0.3466 i - (0.5389 +0.9772 i)
= 0 - 0.6305 i

Admittance_N contributed by Second stub = 1.1547 +0.9551 i - (1.1547 +0.8302 i)
= 0 + 0.1248 i



Observations :

- Normalised admittance contributed by first and second stub came out to be 0 - 0.6305 i and 0 + 0.1248 i respectively.
- On increasing length of first stub imaginary part of normal admittance due to first stub increases, and normal admittance of second stub also increases.
- On increasing l_B, only the imaginary part of the second stub normal admittance increases.

CONCLUSIONS

In the double stub configuration, the stubs are inserted at predetermined locations. In this way, if the load impedance is changed, one simply has to replace the stubs with another set of different length. The length of the first stub is selected so that the admittance at the location of the second stub (before the second stub is inserted) has a real part equal to the characteristic admittance of the line.

$$y_A = y_{SA} + y_L$$
$$y_i = y_{SB} + y_B$$

On changing the Location of Stub from the Load End :-

- On decreasing the location of first stub from load end, the normalized admittance of first stub also decreases.
- On increasing the distance between the two stubs, the normalized admittance of second stub increases.

On changing the Length of Stub :-

- On increasing length of first stub imaginary part of normal admittance due to first stub increases, and normal admittance of second stub also increases.
- On increasing length of second stub l_B, only the imaginary part of the second stub normal admittance increases.

Drawbacks :-
The drawback of double stub tuning is that a certain range of load admittances cannot be matched once the stub locations are fixed. If the normalized admittance of the line, at the first stub location, falls inside a certain forbidden conductance circle tangent to the auxiliary circle, it is not possible to find a value for the first stub that can bring the normalized admittance to the auxiliary circle. Three stubs are necessary to guarantee that a match is always possible.

END