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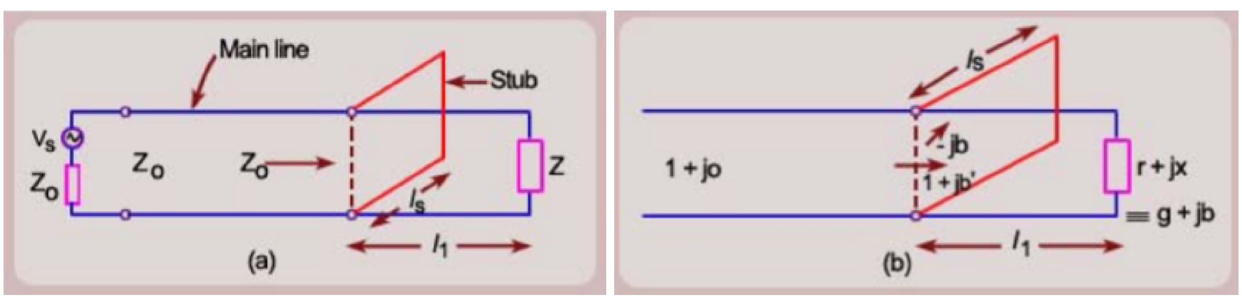
EXPERIMENT - 5

AIM - Study the behaviour of impedance matching for passive networks using Smith Chart (Single 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.

The single-stub matching technique is superior to the quarter wavelength transformer as it makes use of only one type of transmission line for the main line as well as the stub. This technique also in principle is capable of matching any complex load to the characteristic impedance/admittance.

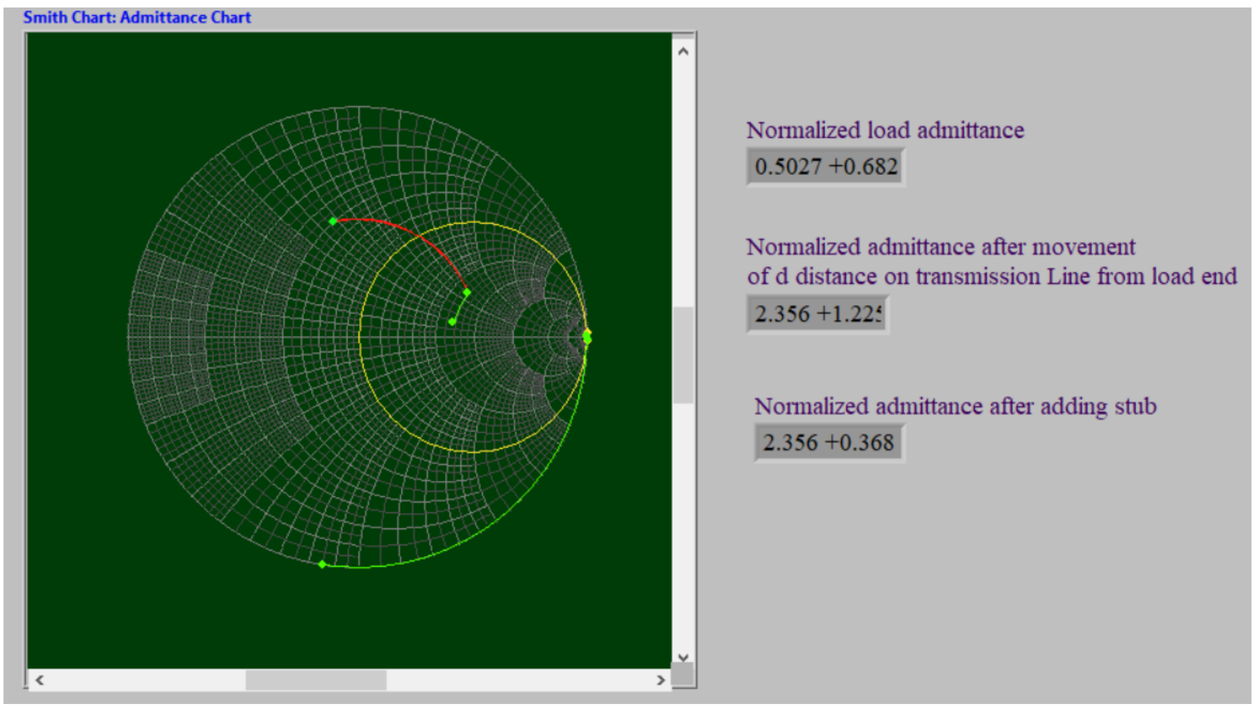
RESULTS AND DISCUSSIONS

Case 1 : Characteristic Impedance (R_0)

Parameters taken :-

Load Impedance (Real) = 35 ohms
Load Impedance (Img) = -47.5 ohms
Characteristic Impedance = 50 ohms
Location of Stub from Load End (d) = 0.110599 m
Length of Stub (l) = 0.137209 m

Normalised admittance contributed by stub = 2.356 + 1.225i - 2.356 + 0.368i
= 0 - 0.8572 i



Observations :

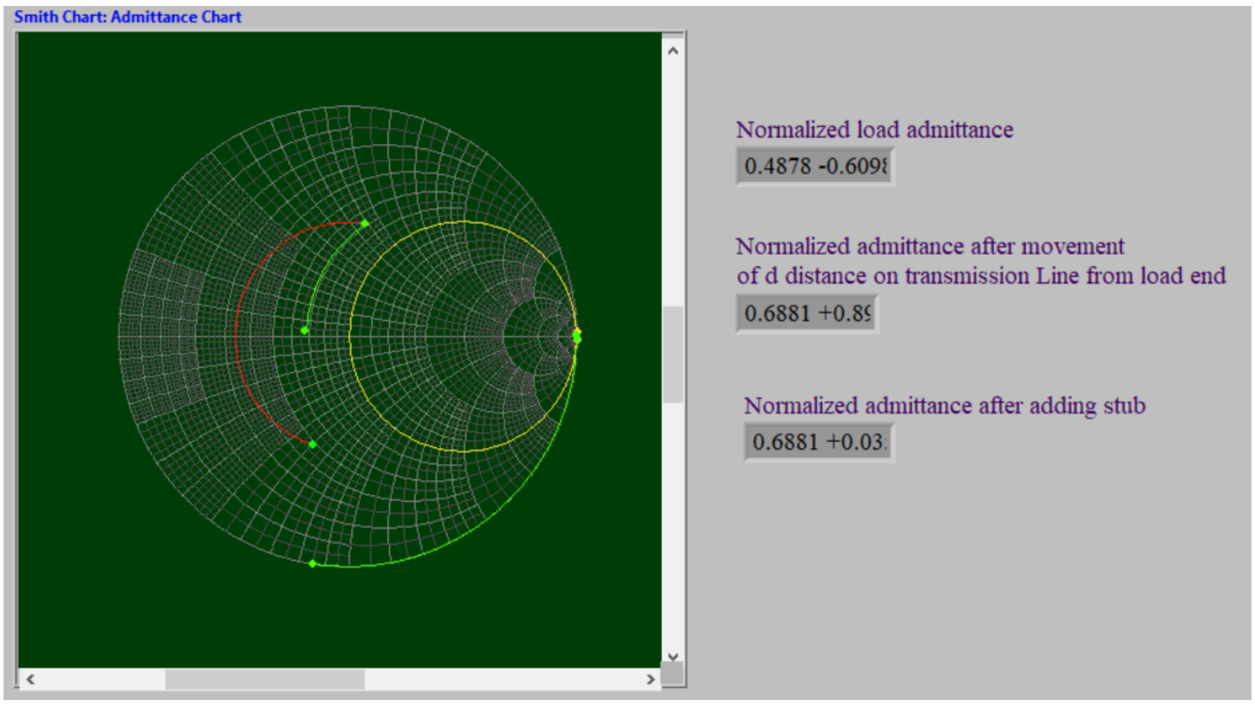
a) Since we have a parallel connection of transmission lines, we solve the problem using admittances rather than impedances for convenience using Smith Chart.
b) Normalised Load admittance will be 0.5027 + 0.682 i.
c) Normalised admittance contributed by stub came out to be 0 - 0.8572 i.

Case 2 : Location of Stub (d)

Parameters taken :-

Load Impedance (Real) = 40 ohms
Load Impedance (Img) = 50 ohms
Characteristic Impedance = 50 ohms
Location of Stub from Load End (d) = 0.237327 m
Length of Stub (l) = 0.137209 m

Normalised admittance contributed by stub = 0.6881 +0.8929 i - 0.6881 +0.03564 i
= 0 - 0.8572 i



Observations :

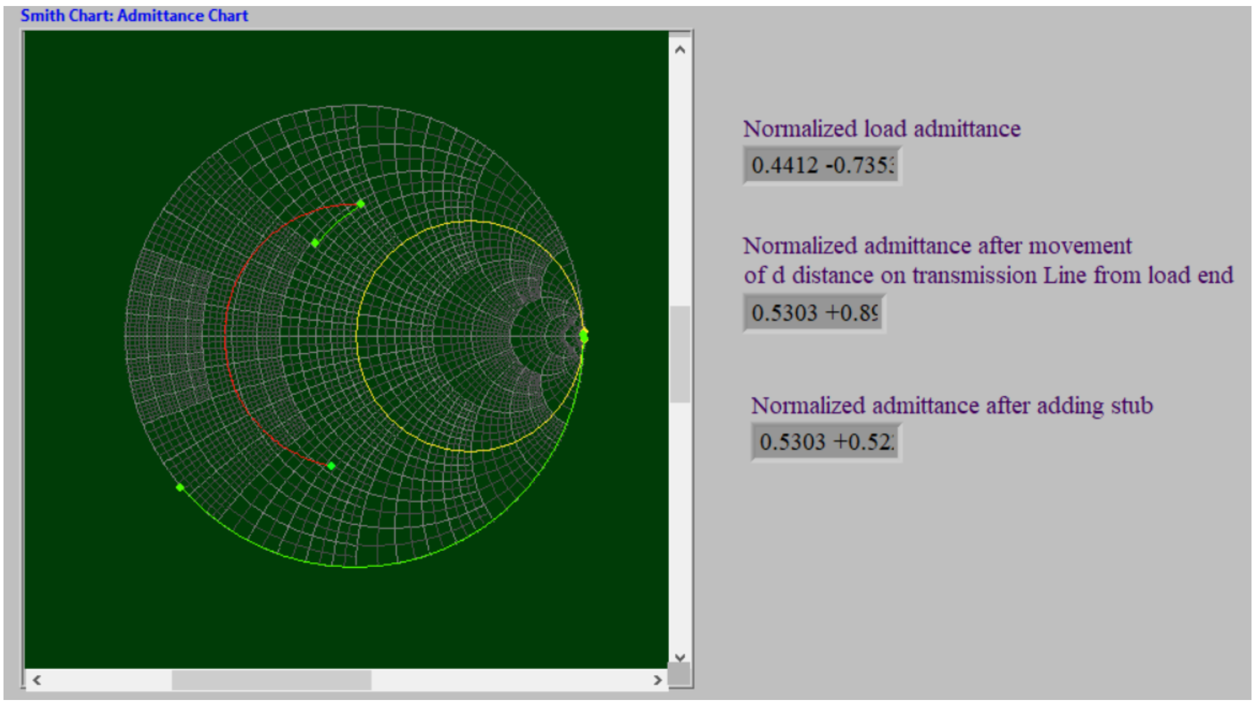
- Load admittance which is normalized will be 0.4878 - 0.6098 i.
- Normalised admittance contributed by stub came out to be 0 - 0.8572 i.
- By changing location of stub the normalized admittance after movement of d distance and after adding stub changes, but the contribution by stub remains constant.
- By increasing the value of d, the red circle in the smith chart becomes more complete.

Case 3 : Length of Stub (l)

Parameters taken :-

Load Impedance (Real) = 30 ohms
Load Impedance (Img) = 50 ohms
Characteristic Impedance = 50 ohms
Location of Stub from Load End (d) = 0.237327 m
Length of Stub (l) = 0.193023 m

Normalised admittance contributed by stub = 0.5303 +0.897 i - 0.5303 +0.5229 i
= 0 - 0.3741 i



Observations :

- Load admittance which is normalized will be 0.4412 - 0.7353 i.
- Normalised admittance contributed by stub came out to be 0 - 0.3741 i.
- By changing length of stub the normalized admittance after movement of d distance and after adding stub changes, also the contribution by stub increases with the increase in length of stub.
- By increasing the value of l, the outer circle in the smith chart becomes more complete.

CONCLUSIONS

The parallel combination of a line terminated in Z_L and a stub at points suggest that it is advantageous to analyze the matching requirements in terms of admittances. Hence, we convert the impedance to admittance and use Smith chart to avoid any analytical calculation. The basic requirement is

$$Y_i = Y_B + Y_S \quad = Y_0 = 1/R_0.$$

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

- By changing location of stub the normalized admittance after movement of d distance and after adding stub changes, but the contribution by stub remains constant.
- By increasing the value of d, the red circle in the smith chart becomes more complete.

On changing the Length of Stub :-

- By changing length of stub the normalized admittance after movement of d distance and after adding stub changes, also the contribution by stub increases with the increase in length of stub.
- By increasing the value of l, the outer circle in the smith chart becomes more complete.

Drawbacks :-

The single stub matching technique still is not suitable for matching variable impedances. A change in load impedance results in a change in the length as well as the location of the stub. Even if changing length of a stub is a simpler task, changing the location of a stub may not be easy in certain transmission line configurations. For example, if the transmission line is a coaxial cable, the connection of a stub would need drilling of a hole in the outer conductor.

END