CSE311 Microwave Engineering

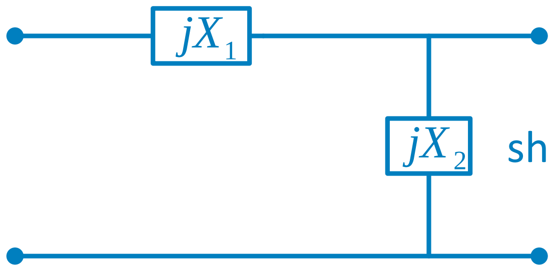
LEC (10)

Smith Chart (part II) - Matching

Lumped-Element Matching Circuits

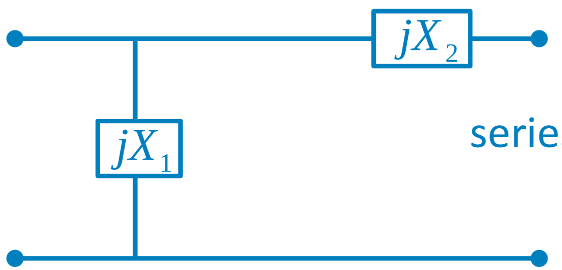
Examples

"ell"



shunt-series

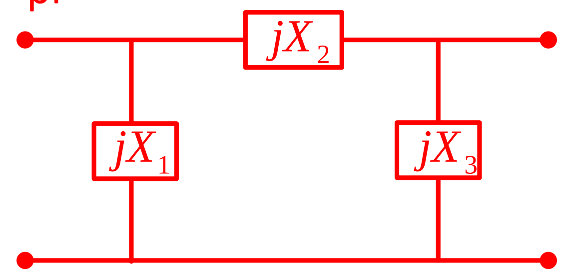
No flexibility



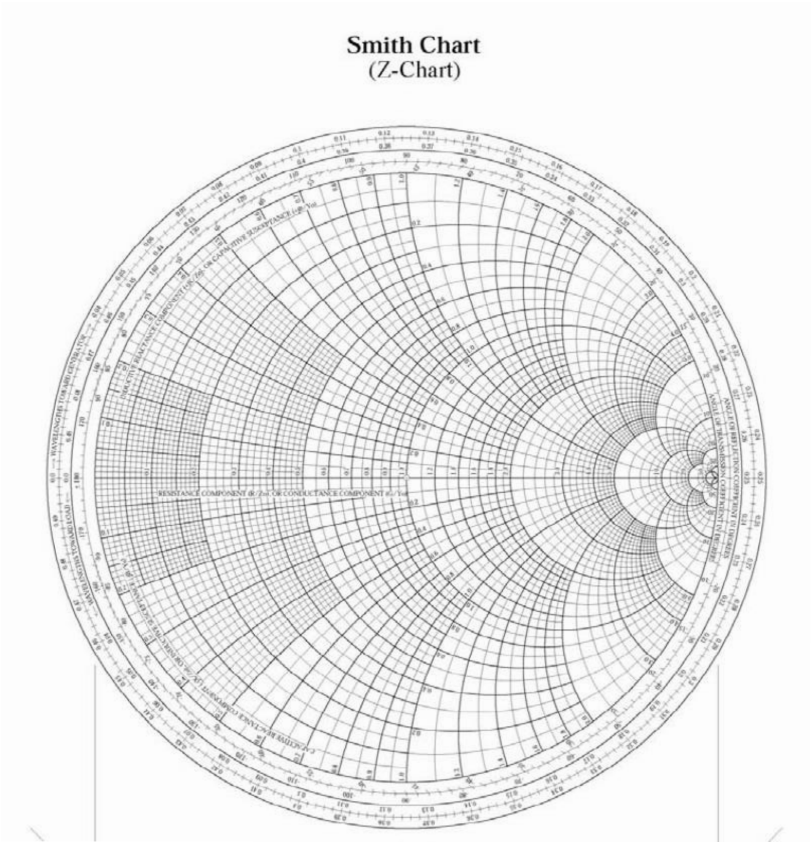
series-shunt

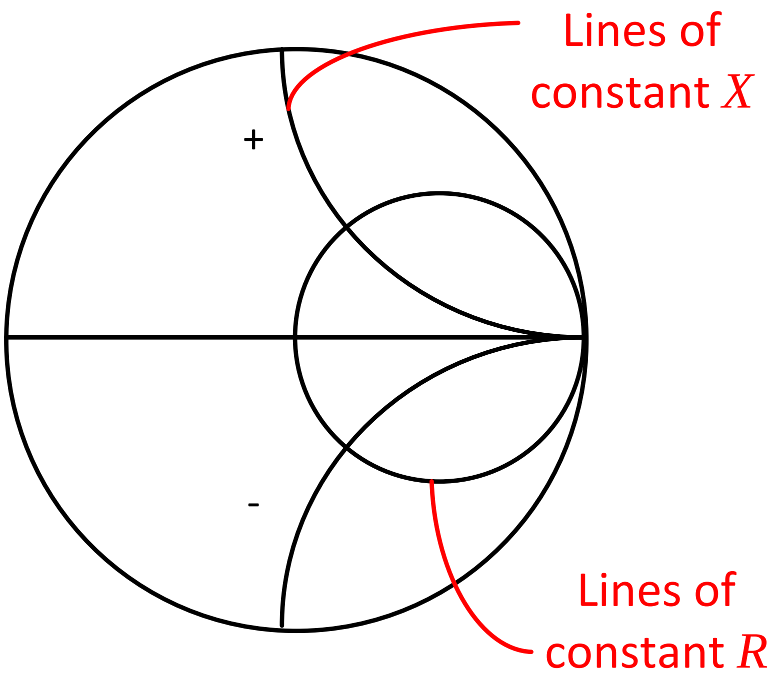
2 elements $\Rightarrow$ 2 degrees of freedom

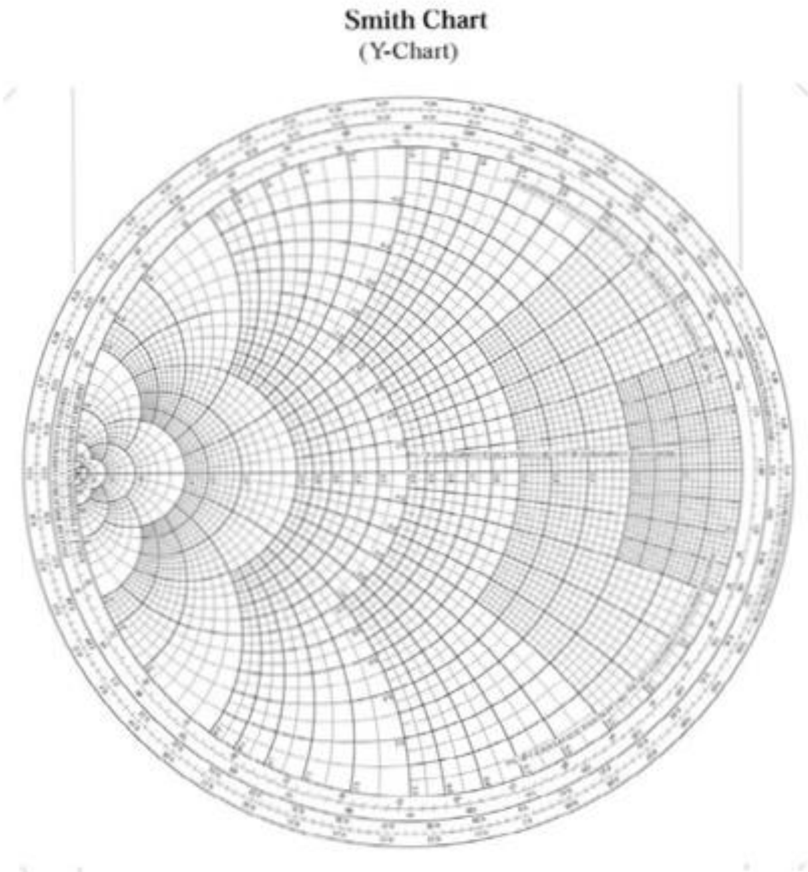
"pi"

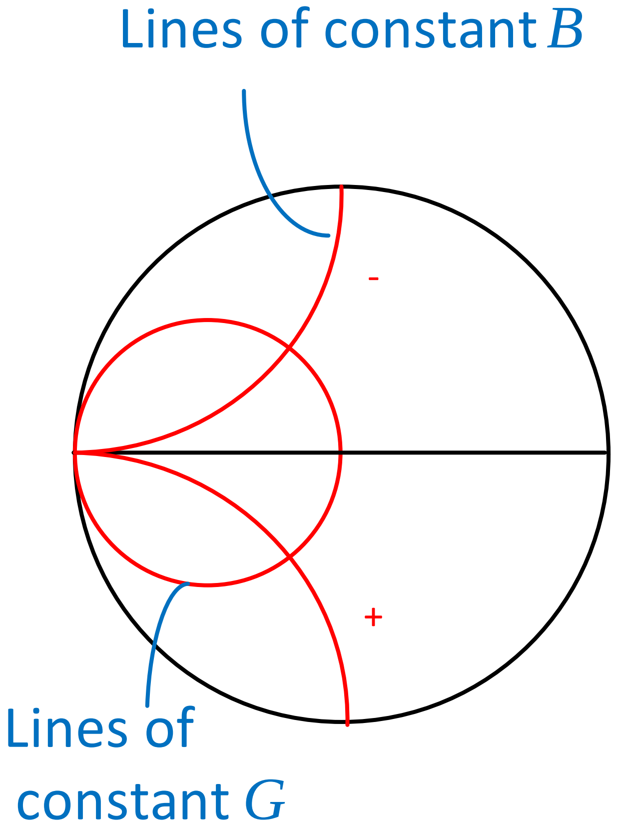


One extra degree of freedom

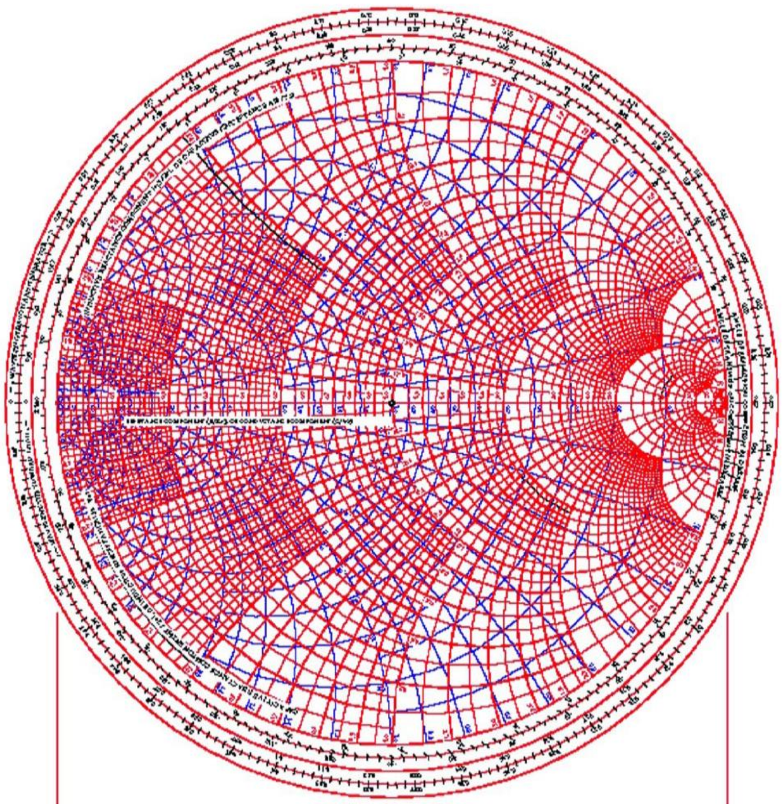

Smith Chart
(Z-Chart)

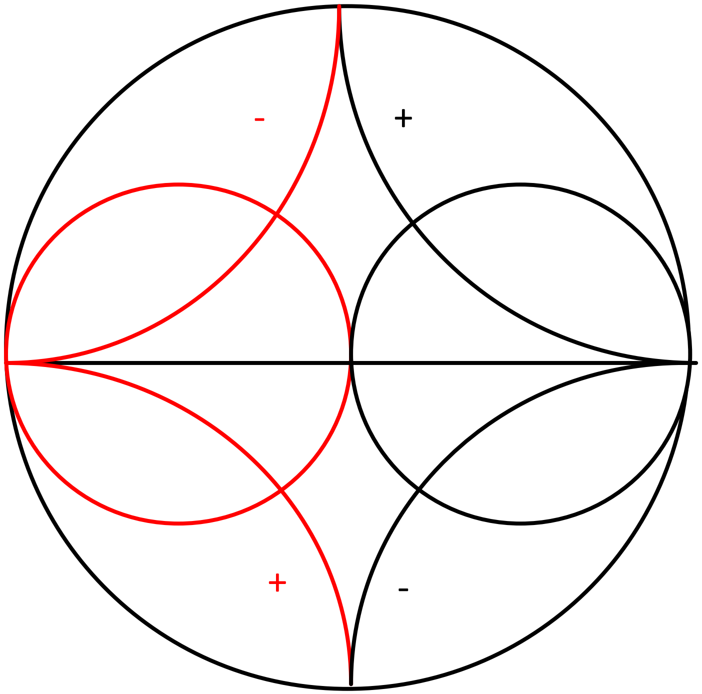

Lines of constant X
+
-
Lines of constant R


Smith Chart
(Y-Chart)


Lines of constant B
-
+
Lines of constant G

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



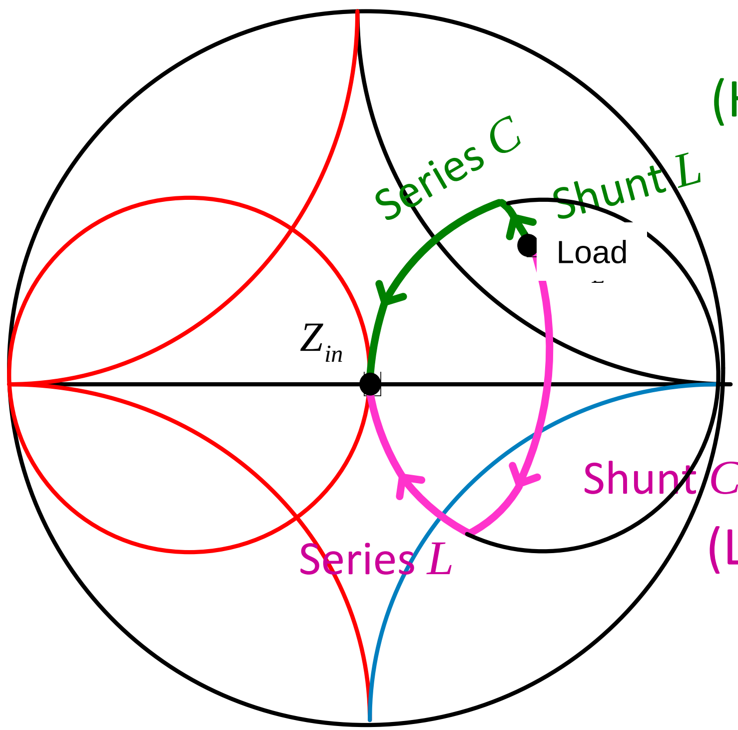


High Impedance to Low Impedance

Use when $G_L < Y_{in}$

(The load is outside of the red $G = 1$ circle.)

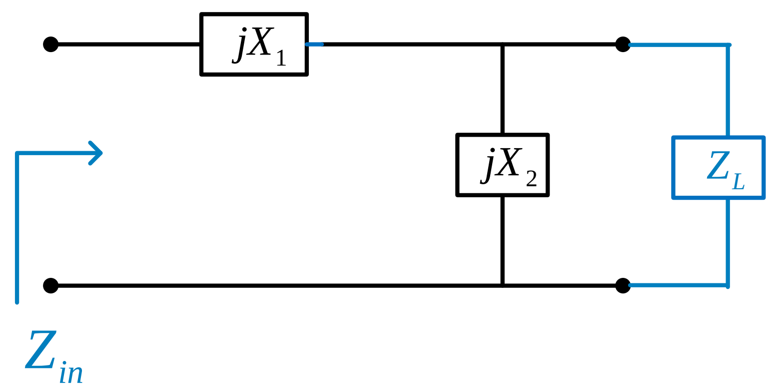
(High pass)



(Low pass)

$Z_0 \equiv Z_{in}$

Shunt-series "ell"



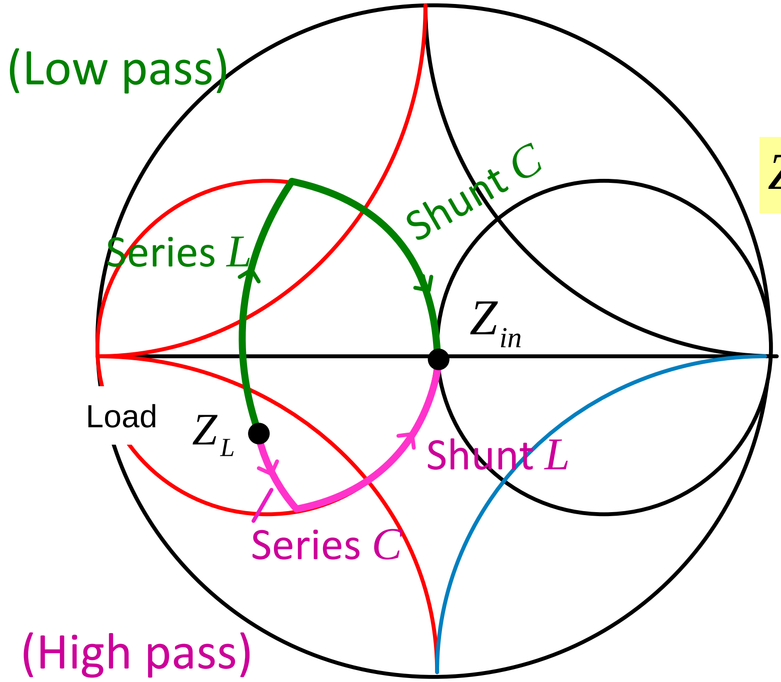
Two possibilities

The shunt element puts us on the $R = 1$ circle; the series element is used to "tune out" the unwanted reactance.

Low Impedance to High Impedance

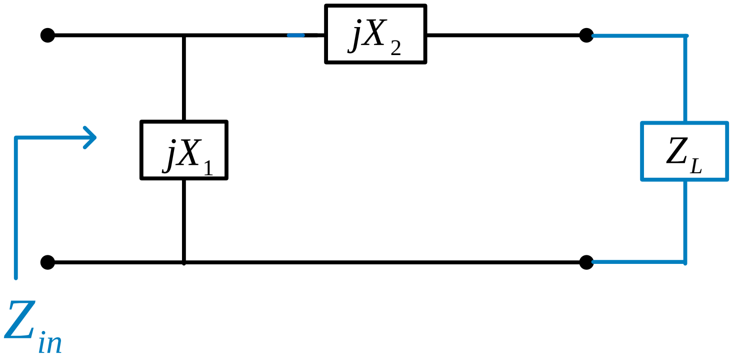
Use when $R_L < R_{in}$

(The load is outside of the black $R = 1$ circle.)



$Z_0 \equiv Z_{in}$

Series-shunt "ell"



Two possibilities

The series element puts us on the $G = 1$ circle; the shunt element is used to "tune out" the unwanted susceptance.

3.9 Smith Chart Analysis (Continued)

3.9.2 Smith Chart Application

(5) Matching the termination line using a $\lambda/4$ transformer

Example 3.15

A λ / 4 transformer is inserted to provide matching between a load impedance Z_L= 250 + j450 Ω and a transmission line of characteristic impedance Z_o = 300 Ω as shown in Fig. 3.23 (a). Find:

(a) The nearest point to the load at which the transformer is connected.

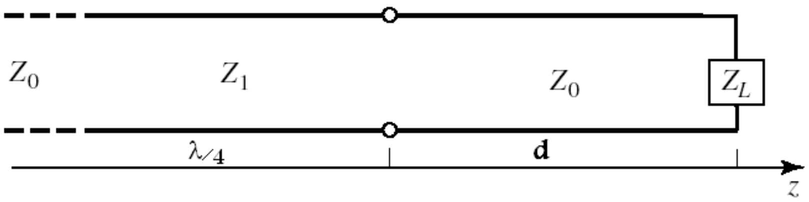
(b) The characteristic impedance Z_l of the transmission line to be used for the transformer.

Solution

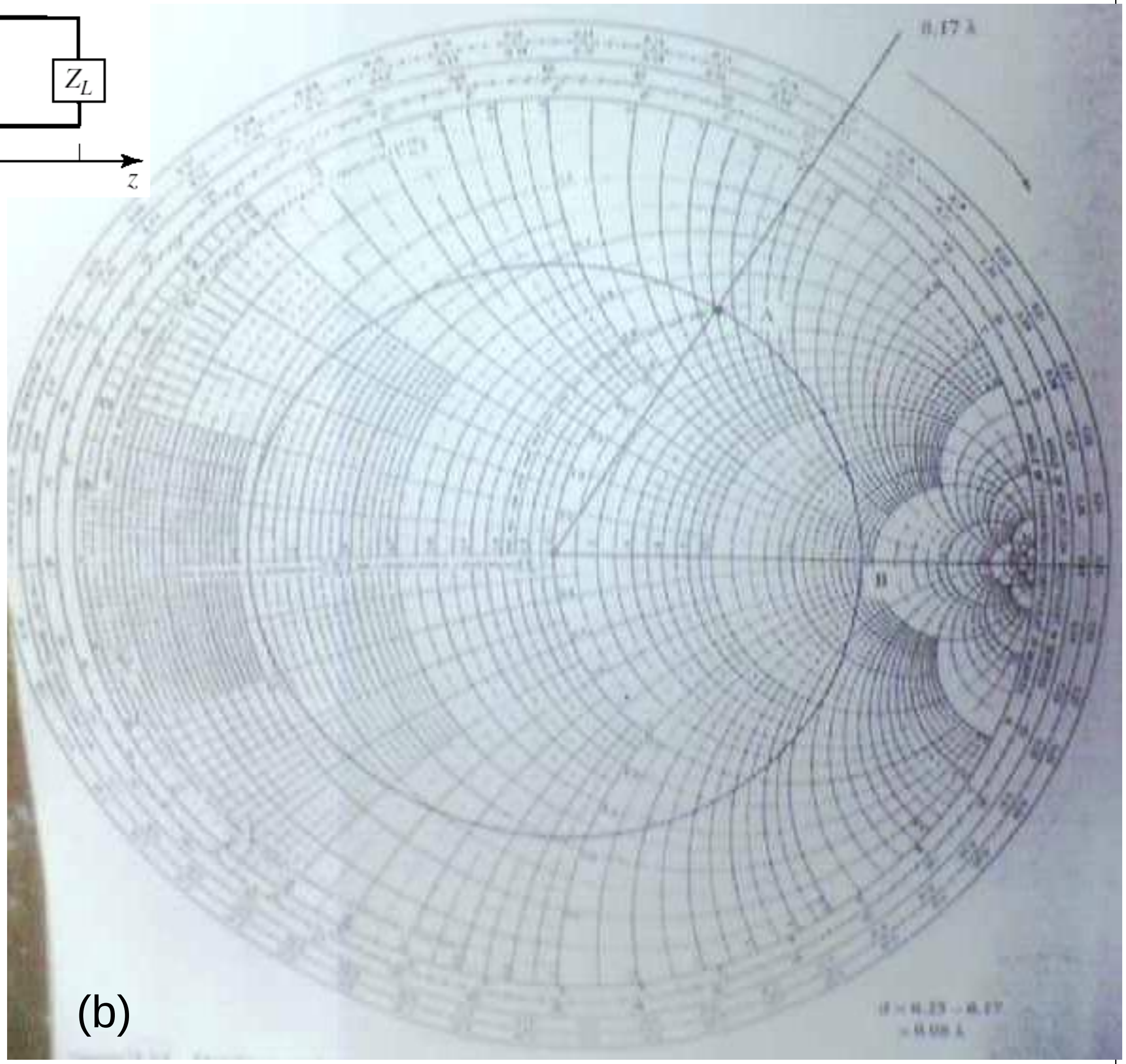
1. Normalize Z_L (divide Z_L by Z_o) then $z_L = Z_L / Z_o$ = (250 + j450) / 300 =0.83 + j1.5.
2. Plot z_L on the Smith chart (the point of intersection of the circle r = 0.83 and the arc marked x =1.5). This the point A in Fig. 3.23 (b).
3. Draw VSWR for this load.
4. Move toward the generator (clockwise) from Point A to find the nearest point at which the line impedance is purely resistive. This is on the diameter line where this line crosses the VSWR circle on the right side, labeled point B.
5. Measure the distance between points A and Point B in wavelengths (d = 0.25 λ – 0.17 λ = 0.08 λ). *Answer to part (a).*
6. At point B, z_{in} = r = 4.75, convert this normalized resistance into actual resistance by multiplying by Z_o. Then Z_{in} = r x Z_o = 4.75 x 300 = 1425 Ω.
7. The characteristic impedance Z_l of the transmission line to be used for the transformer is given by: $Z_I = \sqrt{Z_o Z_{in}} = \sqrt{(300)(1425)} = 654\Omega$ *Ans. (b)*

3.9 Smith Chart Analysis (Continued)

3.9.2 Smith Chart Application; (5) Matching using a λ/4 transformer; *Example 3.15 Solution*



(a)



(b)

Fig. 3.23 Matching via λ/4 transformer

3.9 Smith Chart Analysis (Continued)

3.9.2 Smith Chart Application

(6) Matching the termination line a single stub tuner.

Example 3.16

Determine d and d_1 dimensions in wavelengths, of a short-circuit single stub tuner in order to effect a matching between a load impedance Z_L= 35 - j40 Ω and a transmission line of characteristic impedance Z_o = 50 Ω as shown in Fig. 3.24 (a).

Solution

1. Normalize Z_L (divide Z_L by Z_o) then $z_L = Z_L / Z_o$ = (35 + j40) / 50 =0.7 – j0.8.
2. Plot z_L on the Smith chart (the point of intersection of the circle r = 0.7 and the arc marked x = -0.8). This the point A in Fig. 3.24 (b).
3. Draw VSWR for this load.
4. Locate y_L (normalized admittance) opposite z_L as point B which is located at relative position 0.118 λ toward the generator.
5. From the point B move clockwise (WTG) around the VSWR circle, and note that there are two points on the circle where the y_L has a G = 1.0. One of these occurs above the centerline and the other below it. These two points are labeled P_1 and P_2 respectively. The distance in λ from B to either of these points represents the length for distance d [Fig. 3.24(a)]. Only one of these two points needs to be considered, and usually the one that is shorter distance from the load is preferred. We will use P_1 which is located at relative position 0.164 λ toward the generator.

3.9 Smith Chart Analysis (Continued)

3.9.2 Smith Chart Application

(6) Matching the termination line a single stub tuner.

Example 3.16 Solution (Continued)

6. Calculate the length for d as:

$$d = P_1 - B = 0.164\,\lambda - 0.118\,\lambda = 0.046\,\lambda.$$

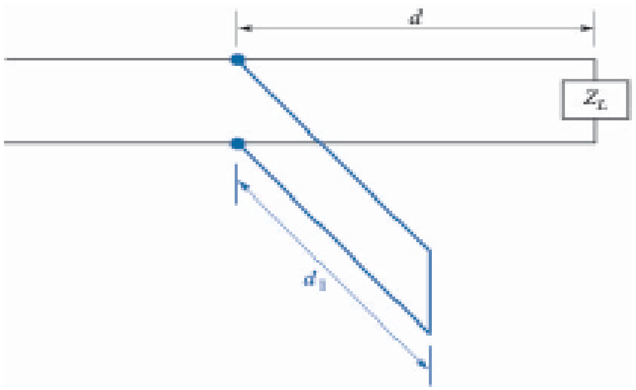
7. The point P_1 has an admittance of 1.0 + j1.06 and the j1.06 represents the susceptance that needs to be cancelled out.
8. Locate and label the point of equal and opposite susceptance, -j1.06, as P_3, the conjugate of the value at P_1.
9. Locate and label the point of infinite short- circuit conductance, which is also the point where the VSWR = ∞. The stub acts as a reactance, thus its VSWR = ∞, this point P_{sc} (0.25 λ) located to the extreme right end of the diameter line.
10. Calculate the length of the short-circuited stub to provide –j1.06 susceptance as:

$$d_1 = P_3 - P_{sc} = 0.37\,\lambda - 0.25\,\lambda = 0.12\,\lambda$$

3.9 Smith Chart Analysis (Continued)

3.9.2 Smith Chart Application; (6) Matching using a single stub tuner;

Example 3.16 Solution



(a)

Fig. 3.24 Matching using a single short-circuit stub tuner