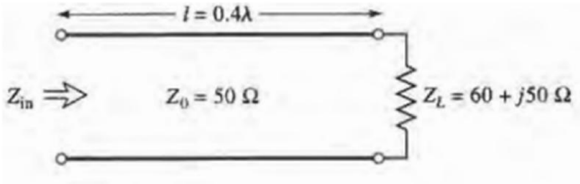
Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Department

Microwave fundamentals
3rd Year Communications
(2013-2014)

Sheet 3 - Solution

1 Use the Smith chart to find the following quantities for the transmission line circuit below:

(a) The SWR on the line.
(b) The reflection coefficient at the load.
(c) The load admittance.
(d) The input impedance of the line.
(e) The distance from the load to the first voltage minimum.
(f) The distance from the load to the first voltage maximum.



$Z_0 = 50\Omega$, $Z_L = 60 + j50\Omega$, $l = 0.4\lambda$

From Smith chart, ($z_L = 1.2 + j1.0$)

a) $SWR = 2.46$ ✓

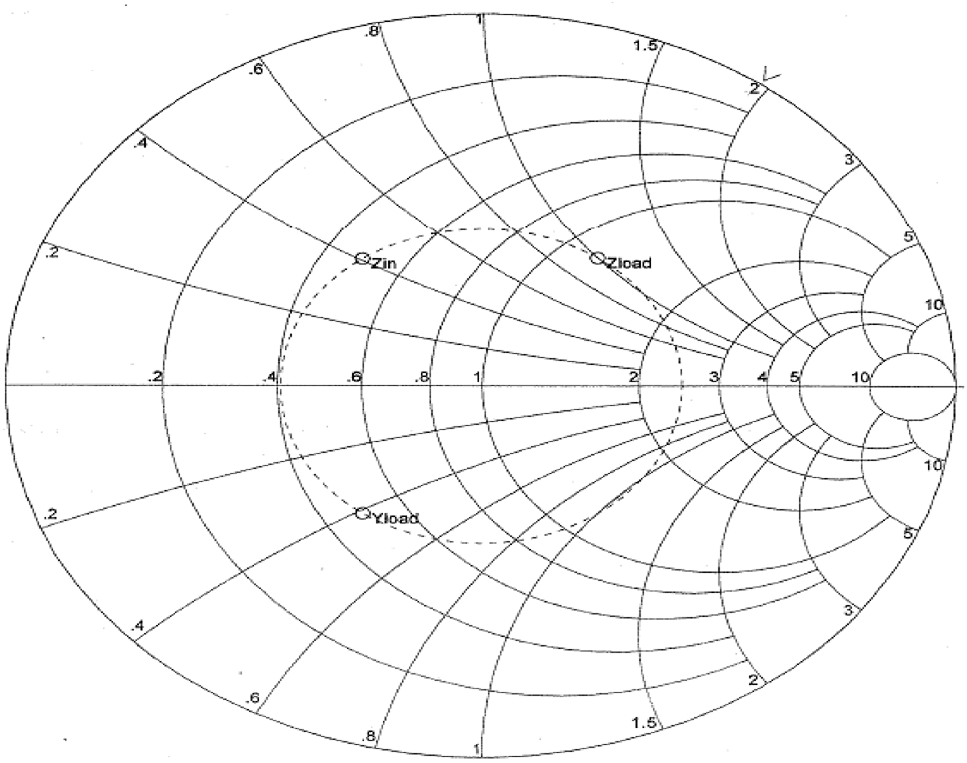
b) $\Gamma = 0.422 \angle 54°$ ✓

c) $Y_L = (.492 - j.410)/50 = 9.84 - j\,8.2$ mS ✓

d) $Z_{in} = 24.5 + j\,20.3\ \Omega$

e) $l_{min} = 0.325\lambda$

f) $l_{max} = 0.075\lambda$



2 Repeat problem (1) for $Z_L = 40 - j30\Omega$. ***(REPORT)***

$Z_o = 50\Omega$, $Z_L = 40 - j30\Omega$, $l = 0.4\lambda$

From Smith chart, ($z_L = 0.80 - j0.60$)

a) SWR = 2.00

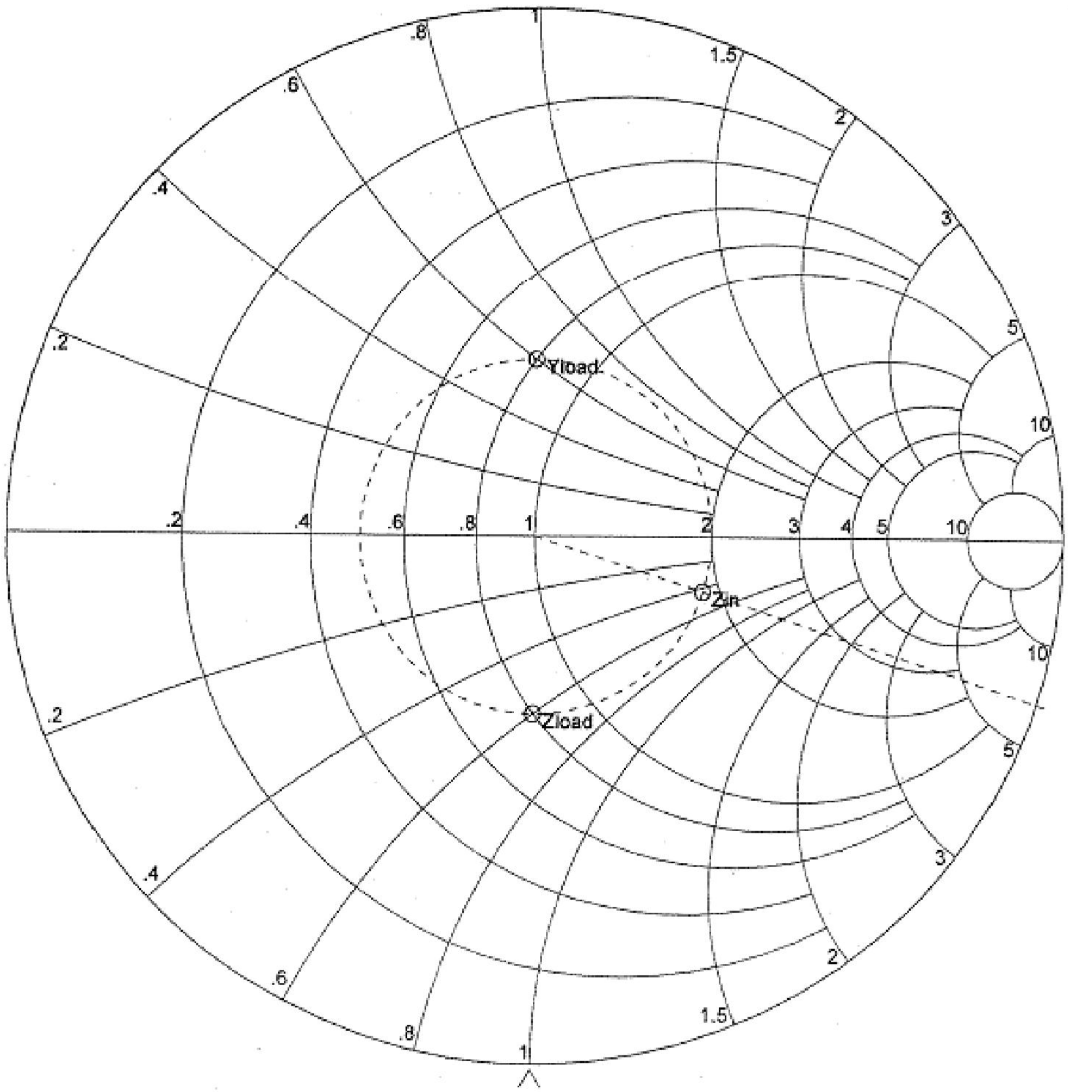
b) $\Gamma = 0.333 \angle 270°$

c) $Y_L = (.800 + j.600)/50 = 16.0 + j12.0$ mS ✓

d) $Z_{in} = 93.2 - j21.6\ \Omega$

e) $l_{MIN} = 0.125\lambda$

f) $l_{MAX} = 0.375\lambda$



3 Repeat problem (1) for ℓ= 1.8λ. ***(REPORT)***

$Z_0 = 50\Omega$, $Z_L = 60 + j50\Omega$, $\ell = 1.8\lambda$

From Smith chart, ($z_L = 1.2 + j1.0$)

a) SWR = 2.46

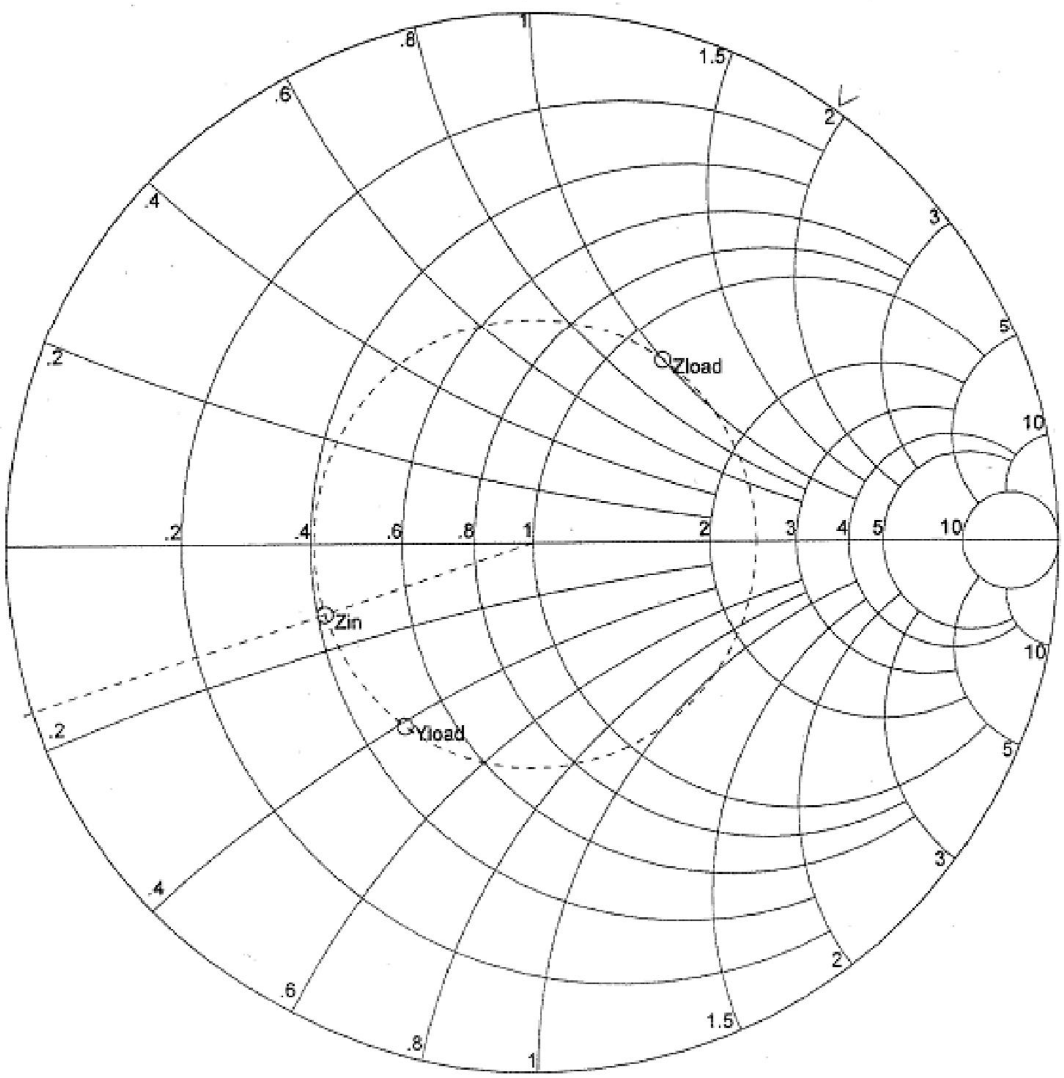
b) $\Gamma = 0.422\underline{/54^\circ}$

c) $Y_L = (.492 - j\,.410)/50 = 9.84 - j\,8.2$ mS ✓

d) $Z_{in} = 20.8 - j6.7\,\Omega$

e) $\ell_{MIN} = 0.325\lambda$

f) $\ell_{MAX} = 0.075\lambda$



4 Use the Smith chart to find the shortest lengths of a short-circuited 75 Ω line to give the following input impedance:

(a) Z_{in}= 0.
(b) Z_{in}= ∞.
(c) Z_{in}= j75 Q.
(d) Z_{in}= -j50 Ω
(e) Z_{in}= j10 Ω.

a) $\ell = 0$ or $\ell = 0.5\lambda$ ✓
b) $\ell = 0.25\lambda$ ✓
c) $\ell = 0.125\lambda$ ✓
d) $\ell = 0.406\lambda$ ✓
e) $\ell = 0.021\lambda$ ✓

These results check with $Z_{in} = jZ_0 \tan \beta\ell$.

5 Repeat Problem (4) for an open-circuited length of 75 Ω line. ***(REPORT)***

a) $\ell = 0.25\lambda$ ✓
b) $\ell = 0\lambda$ or 0.5λ ✓
c) $\ell = 0.375\lambda$ ✓
d) $\ell = 0.656\lambda - 0.5\lambda = 0.156\lambda$ ✓
e) $\ell = 0.271\lambda$ ✓

(add $\lambda/4$ to results of problem 4
(also check with $Z_{in} = -jZ_0 \cot \beta\ell$)

6 A slotted-line experiment is performed with the following results: distance between successive minima = 2.1 cm; distance of first voltage minimum from load = 0.9 cm; SWR of load, = 2.5. If Zo = 50 Ω, find the load impedance.

$\lambda = 4.2$ cm. From the Smith chart, $\ell_{MIN} = .9/4.2 = 0.214\lambda$ from the load, So $z_L = 2 - j.9 \Rightarrow Z_L = 100 - j45\ \Omega$ ✓

Analytically, using (2.58)-(2.60),

$\Gamma = |\Gamma| e^{j\theta}$, $|\Gamma| = \frac{2.5-1}{2.5+1} = 0.428$

$\theta = \pi + 2\beta\ell_{MIN} = 180 + 2(360)(.214) = -26°$ ✓

Then,

$Z_L = \frac{1 + .428\angle -26°}{1 - .428\angle -26°}(50) = 50\frac{1.4\angle -7.7°}{.643\angle 17°} = 109\angle -25°$

$= 99 - j46\ \Omega$

Good Luck

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