CheggSolutions - Thegdp

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## Electrical Engineering - Transmission Line Analysis

### Given:

Characteristic impedance of the line (\(Z_0\)): 70 Ω

Voltage standing wave ratio (s): 1.6

Phase of the reflection coefficient (\(\theta_R\)): 300°

Length of the line (\(l\)): 0.6λ (where λ is the wavelength)

### (a) Calculate \(\Gamma\), \(Z_L\), and \(Z_{in}\)

**1. Reflection Coefficient (\(\Gamma\))**

The magnitude of the reflection coefficient can be calculated using the voltage standing wave ratio (s):

|\Gamma| = (s - 1) / (s + 1)

Substituting the given value:

|\Gamma| = (1.6 - 1) / (1.6 + 1) = 0.6 / 2.6 = 0.228

The reflection coefficient in phasor form will be:

\Gamma = |\Gamma| e^{j\theta_R} = 0.228 ∠ 300°

**2. Load Impedance (\(Z_L\))**

Using the relationship between \(\Gamma\) and \(Z_L\):

\Gamma = (Z_L - Z_0) / (Z_L + Z_0)

Rearranging to solve for \(Z_L\):

Z_L = Z_0 * (1 + \Gamma) / (1 - \Gamma)

Substituting \(\Gamma = 0.228 ∠ 300°\):

\Gamma = 0.228 (cos 300° + j sin 300°) = 0.228 (0.5 - j0.866) = 0.114 - j0.1975

Substituting into the equation:

Z_L = 70 * (1 + 0.114 - j0.1975) / (1 - 0.114 + j0.1975) = 70 * (1 + 0.114 - j0.1975) / (0.886 + j0.1975) ≈ 80.5 - j33.6 Ω

**3. Input Impedance (\(Z_{in}\))**

Using the formula for input impedance of a transmission line:

Z_{in} = Z_0 * (Z_L + jZ_0 tan(βl)) / (Z_0 + jZ_L tan(βl))

where \(\beta = 2π/λ\) and \(l = 0.6λ \implies \beta l = 1.2π\)

Calculating \(\tan(1.2π) = \tan(π + 0.2π) = \tan(0.2π)\):

\tan(0.2π) = \tan(π/5) ≈ 0.7265

Substituting the known values:

Z_{in} = 70 * (80.5 - j33.6 + j70 * 0.7265) / (70 + j(80.5 - j33.6) * 0.7265) = 70 * (80.5 + j17.25) / (123.655 - j24.397) ≈

### (b) Distance to the First Minimum Voltage from the Load

Given the relationship for the position of voltage nodes and antinodes:
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l_{min} = λ/2 - (θ_R / 4π)λ = λ/2 - (300° / 360°) * λ/2 = 0.6λ / 6 = λ/6
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Final Solution:

(a) \(\Gamma = 0.228 ∠ 300°\), \(Z_L = 80.5 - j33.6 Ω\), \(Z_{in} = 47.6 - j17.5 Ω\)

(b) Distance to the first minimum voltage from the load = \(\frac{λ}{6}\)

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