Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

$Z_0 = \sqrt{\dfrac{400\times10^{-9}}{40\times10^{-12}}} = \mathbf{100}\ \Omega$; $v = \dfrac{1}{\sqrt{400\times10^{-9}\times40\times10^{-12}}} = \mathbf{2.5\times10^{8}\ m/s}$; $T = \dfrac{0.50}{2.5\times10^{8}} = \mathbf{2.0\ ns}$

2.2

$\Gamma = \dfrac{25-50}{25+50} = -\mathbf{\frac{1}{3}}$; VSWR $= \dfrac{1+1/3}{1-1/3} = \mathbf{2.0}$; $RL = -20\log\frac{1}{3} = \mathbf{9.5\ dB}$

2.3

$\Gamma = \dfrac{j50}{100+j50} = 0.2+j0.4 = \mathbf{0.447\angle 63.4}°$; VSWR $= \dfrac{1.447}{0.553} = \mathbf{2.6}$

2.4

$jZ_0\tan\beta l = j50$, so $\tan\beta l = 1$ and $l = \dfrac{\lambda}{8}$; $\lambda = \dfrac{2.0\times10^{8}}{3.0\times10^{9}} = 6.67$ cm, so $l = \mathbf{8.3\ mm}$; $L = \dfrac{50}{2\pi\times3.0\times10^{9}} = \mathbf{2.7\ nH}$

3.1

$T = \dfrac{30}{2.0\times10^{8}} = 150$ ns; $V^{+} = 12\times\dfrac{75}{100} = 9.0$ V

$\Gamma_L = \dfrac{225}{375} = 0.6$, $\Gamma_S = \dfrac{-50}{100} = -0.5$

at T: $9.0+5.4 = \mathbf{14.4\ V}$

the 5.4 V wave returns as -2.7 V and reaches the load with its reflection: $14.4 + (-2.7)(1.6) = \mathbf{10.1\ V}$ at $3T$

the bounces die out towards the dc divider value $12\times\dfrac{300}{325} = \mathbf{11.1\ V}$

3.2

$Z_{in} = \dfrac{Z_q^2}{Z_L} = 50$, so $Z_q = \sqrt{50\times112.5} = \mathbf{75}\ \Omega$

$\lambda = \dfrac{2.0\times10^{8}}{9.0\times10^{8}} = 22.2$ cm, $l = \dfrac{\lambda}{4} = \mathbf{5.6\ cm}$

check: $\dfrac{75^2}{112.5} = 50\ \Omega$

at 1.0 GHz $|\Gamma| = \left|\dfrac{0.9+j7.2}{100.9+j7.2}\right| = 0.072$, VSWR **1.16**: still good, but the match works only near one frequency

3.3

(a) $\Gamma = \dfrac{75-50}{75+50} = 0.20$; $RL = -20\log0.20 = \mathbf{14.0\ dB}$; mismatch loss $-10\log(1-0.04) = \mathbf{0.18\ dB}$

(b) the reflection loses $2\times1.0 = 2.0$ dB more: $RL = \mathbf{16.0\ dB}$; $|\Gamma| = 10^{-16/20} = 0.16$; VSWR $= \dfrac{1.16}{0.84} = \mathbf{1.38}$

(c) the cable's loss shrinks the reflection on its way back, so a lossy cable makes any load look better matched than it is; measure at the antenna end, or remove the cable's effect by calibration (or use time-domain reflectometry to see the antenna's own reflection)

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