

Homework 2 Solution Set

Blake Chapter 6 Problems 11-17

7 points (1 per problem)

11. A 75 ohm source is connected to a 50 ohm load (a spectrum analyzer) with a length of 75 ohm line. The source produces 10 mW. All impedances are resistive.

a) Calculate the SWR.

For resistive termination only, SWR can be calculated by:

$SWR = \frac{Z_R}{Z_0}$ or $SWR = \frac{Z_0}{Z_R}$, whichever gives a value of at least 1; therefore:

$$SWR = \frac{Z_0}{Z_R} = \frac{75\Omega}{50\Omega} = \underline{\underline{1.5:1}}$$

b) Calculate the voltage reflection coefficient.

$$\Gamma = \frac{Z_R - Z_0}{Z_R + Z_0} = \frac{50\Omega - 75\Omega}{50\Omega + 75\Omega} = \underline{\underline{-0.2}}$$

c) How much power will be reflected from the load?

$$P_{REF} = \frac{V_{REF}^2}{Z_0} = \frac{(\Gamma V_{FWD})^2}{Z_0} = \frac{(\Gamma \sqrt{P_{FWD} Z_0})^2}{Z_0} = \Gamma^2 P_{FWD} = (-0.2)^2 (10mW) = \underline{\underline{0.4mW}}$$

12. A transmitter delivers 50 W into a 600 ohm lossless line terminated with an antenna that has an impedance of 275 ohms purely resistive.

a) What is the coefficient of reflection?

$$\Gamma = \frac{Z_R - Z_0}{Z_R + Z_0} = \frac{275\Omega - 600\Omega}{275\Omega + 600\Omega} = \underline{\underline{-0.3714}}$$

b) How much of the power actually reaches the antenna?

Assuming that the generator output impedance is equal to Z_0 , the antenna power equals the forward power minus the reflected power:

$$P_{ANT} = P_{FWD} - P_{REF} = 50W - \Gamma^2 50W = 50W - (-0.3714)^2 (50W) = \underline{\underline{43.1W}}$$

This is generally an erroneous assumption to make. Transmitters rarely have output impedances equal to the transmission line's impedance. Generally, only laboratory signal generators have this characteristic. Typically, the reflected signal from the antenna will be again reflected forward from the transmitter, resulting in more power actually being delivered to the antenna. Recent editions of the *ARRL Handbook* contain a good explanation of this phenomenon.

13. A shorted stub acts as a parallel-resonant circuit at 100 MHz. What is its function at 200 MHz?

If the stub is parallel resonant (open circuit) at 100 MHz (assuming it is one-quarter of a wavelength at this frequency), then it will be series resonant (short circuit) at 200 MHz, since it will now be a half-wavelength.

14. A properly matched transmission line has a loss of 1.5 dB per 100 m. If a signal power of 10 W is supplied to end of the line, how much power reaches the load 27 meters away?

First calculate the loss:

$$LOSS(dB) = Length \times L_{SPEC} = 27m(1.5dB/100m) = 0.405dB$$

The power at the load can then be expressed using decibels:

$$P = P_{IN} \times 10^{(-LOSS(dB)/10)} = 10W \times 10^{(-0.405/10)} = \underline{\underline{9.1W}}$$

15. A receiver requires a signal of at least $0.5 \mu\text{V}$ for satisfactory reception. How strong (in μV) must the signal be at the antenna if the receiver is connected to the antenna by 25 m of matched line having an attenuation of 6 dB per 100 m?

First, find the attenuation in the line:

$$LOSS(dB) = Length \times L_{SPEC} = 25m(6dB/100m) = 1.5dB$$

Next, express the voltages in decibel form. Be careful; these are *voltages*. There are couple of hidden assumptions in this problem that are dangerous; we'll discuss them in a moment.

$$V_{IN} \geq V_{RCVR} \times 10^{(LOSS(dB)/20)} \geq 0.5\mu V \times 10^{(1.5dB/20)} \geq \underline{\underline{0.594\mu V}}$$

The hidden assumptions in this problem are (1) that there is no mismatch between the line and load; if this condition is present, you may need *much* more signal to satisfy the receiver! (2) Everything in the system is at the same impedance level (otherwise using voltage decibels would be meaningless, since they're only equivalent to power dB when all impedances are equal).

16. A transmitter with an output power of 50 W is connected to a matched load by means of 32 m of matched coaxial cable. It is found that only 35 W of power is dissipated in the load. Calculate the loss in the cable in dB/100 m.

First, find the loss in the cable:

$$LOSS(dB) = -10\log\left(\frac{P_{OUT}}{P_{IN}}\right) = -10\log\left(\frac{35W}{50W}\right) = 1.549dB$$

This loss occurred in a 32 m section of cable. Simply scale it up proportionally for a 100 m length:

$$L_{100m} = LOSS(dB) \times \frac{100m}{32m} = 1.549dB \times \frac{100m}{32m} = \underline{\underline{4.84dB/100m}}$$

17. RG-52/U waveguide is rectangular with an inner cross-section of 22.86 x 10.16 mm. Calculate the cutoff frequency for the dominant mode (TE_{10}) and the range of frequencies for which single mode propagation is possible.

The lower cutoff frequency for the TE_{10} mode of a waveguide is given as:

$$f_{LCO} = \frac{v}{2d} = \frac{3 \times 10^8 m/s}{2(22.86mm)} = \underline{\underline{6.56GHz}} \text{ (Use the longer of the two waveguide dimensions)}$$

$$f_{HCO} = 2f_{LCO} = 2(6.56GHz) = \underline{\underline{13.1GHz}}$$