

$$\frac{1}{k} \frac{h_m h_b^2}{r_1^4 f_1^2} = k \frac{h_m h_b^2}{r_2^4 f_2^2} \quad d_2 = 2 f_1$$

$$4 r_2^4 = r_1^4$$

$\frac{x_2}{\pi r}$

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$$VSWR = \frac{1 + |p|}{1 - |p|}$$

$$|p| = \frac{VSWR - 1}{VSWR + 1} = \frac{2 - 1}{2 + 1} = \frac{1}{3}$$

$$P_r = \frac{P_i}{9}$$

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$$VSWR = \frac{1 + |p|}{1 - |p|} \approx 2.16$$

$$\rho = \frac{Z_a - Z_s}{Z_a + Z_s} = \frac{73 + j42.5 - 50}{73 + j42.5 + 50}$$

$$|p| = 0.37$$

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$$A_e = \frac{G}{4\pi} \lambda^2 \Leftrightarrow G = \frac{4\pi A_e}{\lambda^2} \quad A_e = 0.65 \pi r^2$$

$$= 0.65 \frac{4\pi^2 r^2}{(c/f)^2}$$

$\frac{2.7}{\pi r}$

$$G_{dB} = 10 \log_{10} \left(0.65 \left(\frac{2\pi r f}{c} \right)^2 \right) = 20 \log_{10} \left(0.65 \frac{2\pi r f}{c} \right)$$

$$f = 14 \text{ GHz} : G \approx 50$$

$$f = 12 \text{ GHz} : G \approx 48.7$$

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