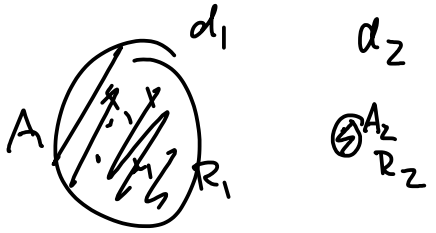
Common Transmission Media

Exercise 1: How much does a cable's resistance increase when the gauge size increases by 6? By 3? Hint: a wire's resistance is proportional to its cross-sectional area.



$= \frac{1}{4}$

$R_1 = \frac{k}{A_1}$ $\quad R_2 = \frac{k}{A_2}$ $\quad R = \frac{k}{A} = \frac{k}{\pi\left(\frac{d}{2}\right)^2}$

$$\frac{R_2}{R_1} = \frac{\frac{k}{A_2}}{\frac{k}{A_1}} = \frac{A_1}{A_2} \frac{\frac{k}{\pi\left(\frac{d_1}{2}\right)^2}}{\frac{k}{\pi\left(\frac{d_2}{2}\right)^2}} = \frac{\frac{1}{d_1^2}}{\frac{1}{d_2^2}} \left(\frac{d_2}{d_1}\right)^2$$

$$= \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

$\frac{R_2}{R_1} = \frac{1}{4}$

if AWG increases by 3

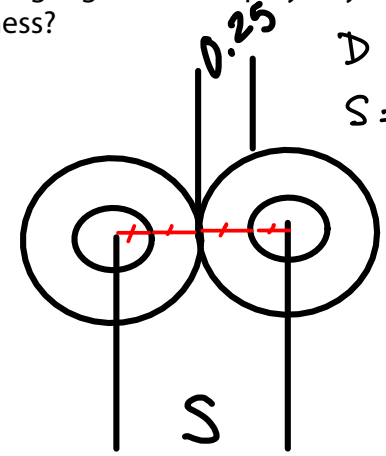
$\rightarrow$

Exercise 2: What is the characteristic impedance of a lossless cable with an inductance of 94 nH per foot and capacitance of 17pF/ft?

$$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{94 \times 10^{-9}}{17 \times 10^{-12}}} = 74 \quad \Omega$$

74.36

Exercise 3: What is the characteristic impedance of UTP made from 24-gauge wire with polyethylene insulation ($\varepsilon_r = 2.2$) of 0.25mm thickness?

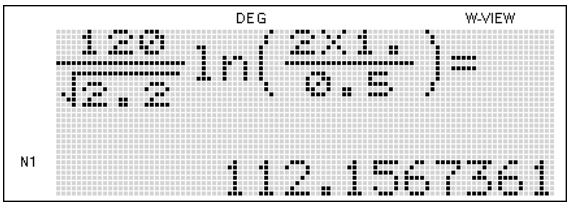


D = 24 AWG = 0.5mm

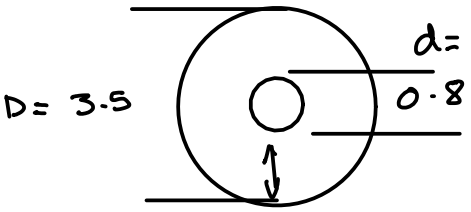
S = 4 x 0.25mm = 1.0 mm.

$$Z_0 \approx \frac{120}{\sqrt{\varepsilon_r}} \ln\left(\frac{2S}{D}\right) \quad \Omega$$

$$Z_0 = \frac{120}{\sqrt{2.2}} \ln\left(\frac{2 \times 1.0}{0.5}\right) \approx 112.5\Omega$$



Exercise 4: What is the characteristic impedance of a co-ax cable with a 0.8mm diameter center conductor, 3.5mm diameter shield and foamed polyethylene between them that has a dielectric constant of 1.5?

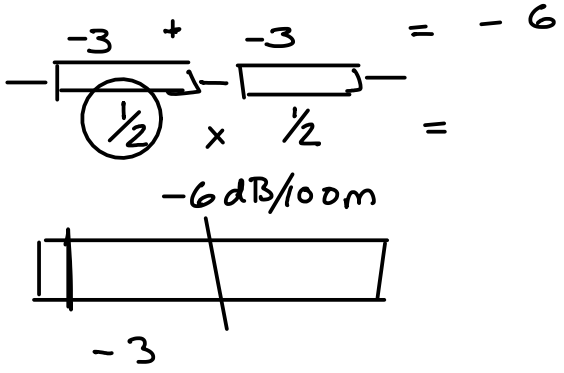


$$Z_0 \approx \frac{60}{\sqrt{\varepsilon_r}} \ln\left(\frac{D}{d}\right) \quad \Omega$$

$$= \frac{60}{\sqrt{1.5}} \ln\left(\frac{3.5}{0.8}\right)$$

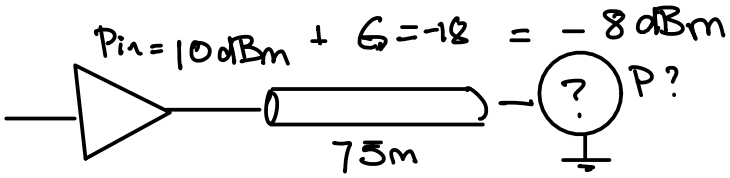
50 Ω ← maximum power

75 Ω ← lowest loss. = 72 Ω



Exercise 5: An 800 MHz signal is output from a CATV amplifier at a power level of 10dBm. What power level would you expect at the other end of a 75m run of co-ax whose loss is specified as 24dB/100m at 800 MHz? Hint: gain $G_{dB} = 10\log_{10}(P_{out}/P_{in})$.

Community Antenna TV



0 dBm = 1mW

$10 \log\left(\frac{P_{out}}{P_{in}}\right)$

loss = 24 dB/100m @ 800MHz

$24 \times \frac{75}{100} = 18$ dB loss

$P_{dBm} = 10\log\left(\frac{10\,mW}{1\,mW}\right)$

$= 10$ dBm.

$P = \frac{V^2}{R \to Z_0}$

$I = \frac{V}{R \to Z_0}$

$V = \sqrt{P \cdot Z_0}$

$P_{in} = 10$ dBm $= 10$mW $= 0.010$W

$Z_0 = 75\,\Omega$

$V_{in} = \sqrt{0.01 \cdot 75} = \sqrt{0.75} = 0.86$V

$I_{in} = \frac{0.86}{75} = 11$mA

$P_{out} = -8$dBm.

V_{out}

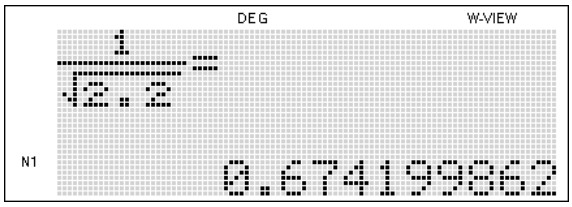
I_{out}

Exercise 6: Assuming the transmission line in the above example is properly terminated, what are the voltage and current at the input and output of the cable? Hint: $P = V^2/R$.

Exercise 7: What is the velocity factor for a cable with polyethylene insulation ($\varepsilon_r = 2.2$)? How long would it take for a signal to propagate 100m? For a cable with air dielectric?

$\varepsilon_r = 2.2$

$VF = \frac{1}{\sqrt{\varepsilon_r}} = \frac{1}{\sqrt{2.2}}$

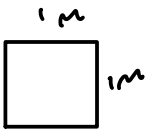


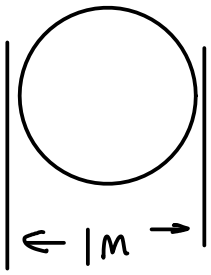
for $\varepsilon_r = 1$

$VF = \frac{1}{\sqrt{1}} = 1$

Exercise 8: If the optical signal wavelength is 1330nm what is the frequency? Note that the wavelength is specified in free space, not in the fiber.

Exercise 9: For some types of antennas, such as reflectors, the effective aperture is closely approximated by the physical area of the antenna. What are the approximate effective aperture and gain of a 1-m diameter Ku-band (≈ 15 GHz) satellite dish?





$f = 15$ GHz

$A_e \approx A = \pi r^2 = \pi\left(\frac{1}{2}\right)^2 = \pi\left(\frac{1}{2}\right)^2 = \frac{\pi}{4}$

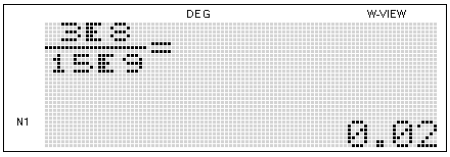
Gain = ?

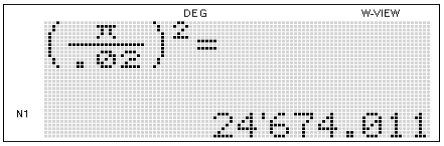
$$G = \frac{4\pi A_e}{\lambda^2}$$

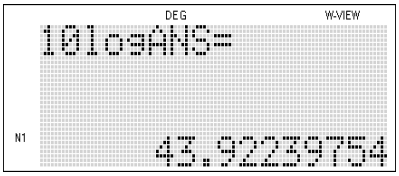
$$\lambda = \frac{c}{f} = \frac{3\times10^8 \text{ m/s}}{15\times10^9} \text{ m.} = 0.02$$

$$= \frac{4\pi\frac{\pi}{4}}{(.02)^2}$$

$$= \frac{\pi^2}{(.02)^2} =$$







dB

Exercise 10: A point-to-point link uses a transmit power of 1 Watt, transmit and receive antennas with gains of 20dB and operates at 3 GHz. How much power is received by a receiver 300m away?

$P_T = 1W$ $G_T = 20dB$ $G_R = 20dB$ $P_R = ?$

$f = 3\,GHz$ 300 m

$\lambda = ?$

$= \frac{c}{f} = \frac{3 \times 10^8}{3 \times 10^9}$

$= 0.1\,m$

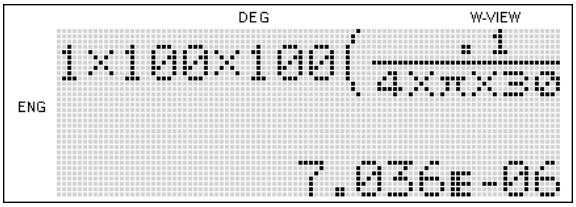
$G_R = G_T = 10^{\left(\frac{20}{10}\right)}$

$= 100$

$$P_R = P_T\, G_T\, G_R \left(\frac{\lambda}{4\pi d}\right)^2$$

$$= 1 \cdot 100 \cdot 100 \left(\frac{0.1}{4 \cdot \pi \cdot 300}\right)^2$$

$=$



Exercise 11: Rank each of twisted-pair, co-ax, optical fiber and free space media according to cost of the medium, cost of the interface, media size and immunity to interference.

	cost of medium	cost g i/f	media size	immunity to interference.
TP				
Co-ax				
optical fibre				
wireless	Lowest			