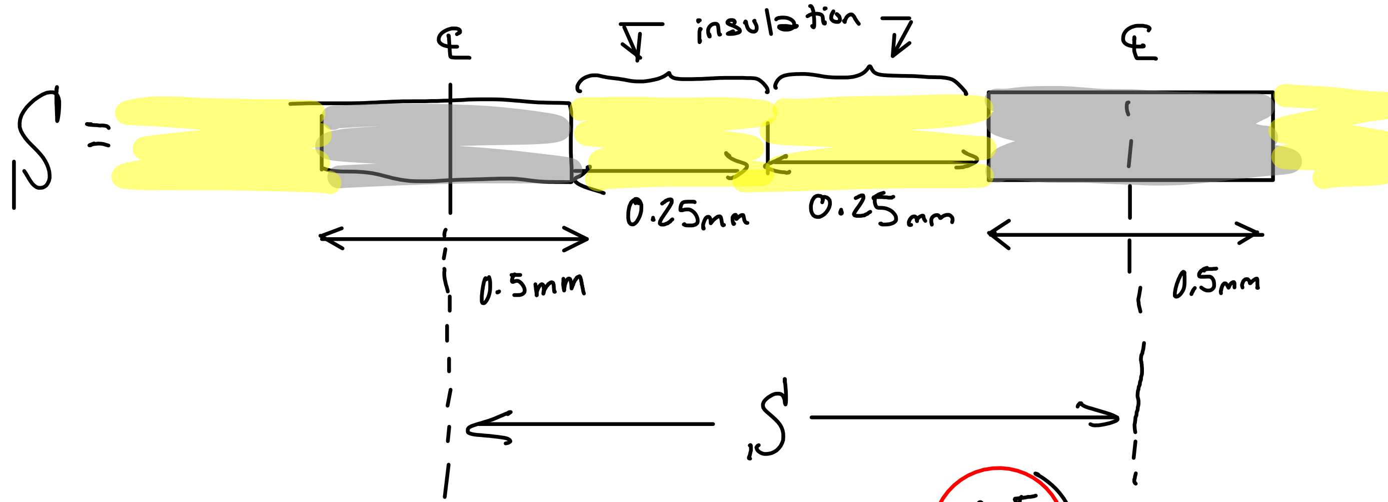
Lecture 2 Notes

Exercise 1: What is the characteristic impedance of UTP made from 24-gauge wire with polyethylene insulation ($\epsilon_r = 2.2$) of 0.25mm thickness?

$\varepsilon_r = 2.2$ 24 ga : $D = 0.5\,mm$



$$S = 2 \times \left(0.25 + \frac{0.5}{2}\right) = 1$$

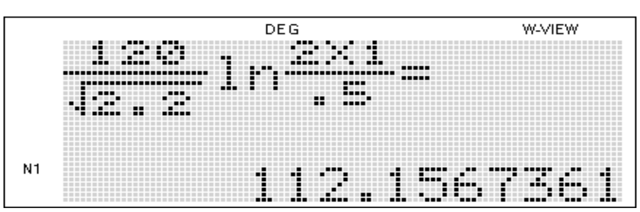
0.25: insulation; $\frac{0.5}{2}$: radius of wire

$$Z_0 = \frac{120}{\sqrt{\varepsilon_r}} \ln\left(\frac{2S}{D}\right) = \frac{120}{\sqrt{2.2}} \ln\left(\frac{2 \times 1}{0.5}\right) \approx 116\,\Omega$$

$110 \pm 10\,\Omega$

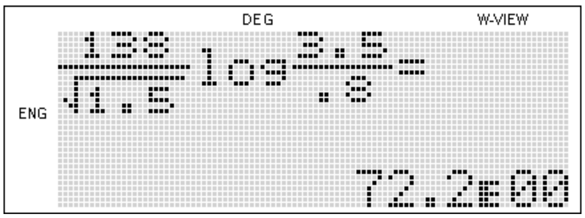
$S = 1 \pm 0.1$

$D = 0.5 \pm 0.1$

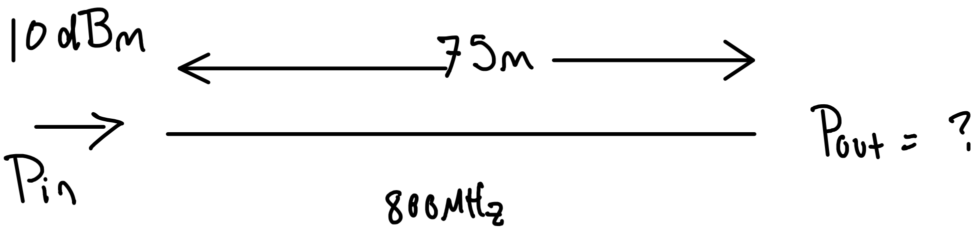


Exercise 2: What is the characteristic impedance of a co-ax cable with a 0.8mm diameter center conductor, 3.5mm diameter shield and foamed polyethylene between them that has a dielectric constant of 1.5?

$$Z_0 = \frac{138}{\sqrt{\varepsilon_r}} \log_{10}\left(\frac{D}{d}\right) = \frac{138}{\sqrt{1.5}} \log_{10}\left(\frac{3.5}{0.8}\right) = 72\,\Omega$$



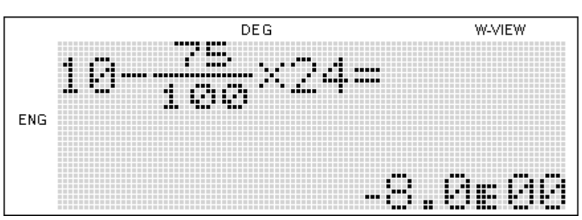
Exercise 3: An 800 MHz signal is output from a CATV amplifier at a power level of 10dBm. What power level would you expect at the other end of a 75m run of co-ax whose loss is specified as 24dB/100m at 800 MHz?



loss is 24 dB/100m.

loss for 75m is $\frac{75}{100} \cdot 24 = 18\,dB$

$P_{out} = P_{in} - Loss(dB) = 10 - 18 = -8\ dBm$



Exercise 4: What is the velocity factor for a cable with polyethylene insulation ($\epsilon_r = 2.2$)? How long would it take for a signal to propagate 100m? For a cable with air dielectric?

$$VF = \frac{1}{\sqrt{\varepsilon_r}} = \frac{1}{\sqrt{2.2}} = 0.67$$

$$VF = \frac{v}{c} \qquad v = VF \cdot c = 0.67 \cdot 3\times10^8 = 2\times10^8 \ m/s$$

$$t \overset{?}{=} \frac{v}{d} \quad \frac{m/s}{m} \Rightarrow \frac{1}{s} \qquad t \overset{?}{=} \frac{d}{v} \quad \frac{m}{m/s} = \frac{1}{1/s} = s \ \checkmark$$

$$t = \frac{100m}{2\times10^8 m/s} = 50\times10^{-8} = 50\times10^{2}\times10^{-2}\times10^{-8} = 0.5\times10^{-6}$$

$$= 0.5\mu s.$$

500ns.

for air dielectric $VF = 1$ $v = 3\times10^8$

$$t = \frac{100m}{3\times10^8} \approx 0.3\mu s.$$

Exercise 5: What is the characteristic impedance of a lossless cable with an inductance of 94 nH per foot and capacitance of 17pF/ft?

$$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{94\times10^{-9}}{17\times10^{-12}}} = 74\Omega$$

Exercise 6: If the optical signal wavelength is 1330nm what is the frequency?

$$\lambda = \frac{c}{f} \qquad f = \frac{c}{\lambda} = \frac{3\times10^8}{1.3\times10^{-6}} \approx 2\times10^{14} \approx 200\times10^{12}$$

200 THz　　　1 GHz

$$\frac{0.1}{200}$$

Exercise 7: 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.

	Δg gauge increases by	ΔD diameter increases by	$(\Delta D)^2$ area increases by	$\left(\frac{1}{\Delta D}\right)^2$ resistance increases by
24	0	1	1	1
30ga	+6	$\frac{1}{2}$	$\frac{1}{4}$	4
18ga	−6	2	4	$\frac{1}{4}$
27ga	+3	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	2

27ga : $\frac{1}{4}$? 0.75 ? exponentional? } what is the answer?

try:

$$\Delta D = \left(\frac{1}{2}\right)^{\frac{\Delta g}{6}}$$

for $\Delta g = -3$ $\quad \Delta D = \left(\frac{1}{2}\right)^{\frac{+3}{6}} = \left(\frac{1}{2}\right)^{+\frac{1}{2}} = \frac{1}{\sqrt{2}}$

Exercise 8: 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 the receiver?

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{3\times10^9} = 10^{-1}$$

10cm

$d = ?$ assume $1\ km = 10^3 m$

$P_T = 1W$

$G_T = 20dB = 10^{\frac{20}{10}} = 100$

$G_R = 20dB$

$G(dB) = 10\log\left(\frac{P_1}{P_2}\right)$ ← ratio is gain in linear units

$G = 10^{\left(\frac{G(dB)}{10}\right)}$

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

$$= 1 \cdot 10^2 \cdot 10^2 \left(\frac{10^{-1}}{4\pi\, 10^3}\right)^2$$

$$= 10^4 \left(\frac{10^{-4}}{4\pi}\right)^2 = \frac{10^{-4}}{16\,\pi^2}$$

$$\approx \frac{10^{-4}}{20 \cdot 10} \approx 0.5\times10^{-6}$$

round off all values to get an approximate answer $\left(\pi^2 \approx 10,\ 16 \approx 20, \ldots\right)$

$= 0.5\mu W$ ← approximate estimate

$= 500nW$

$630nW$ ← calculator answer