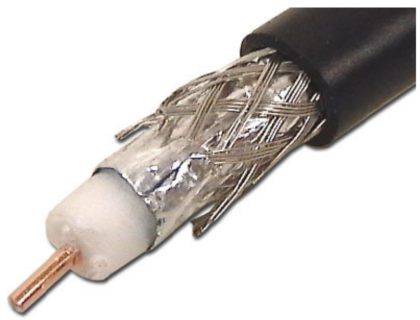
When do you use rectangular waveguides, and when do you use coaxial cables?

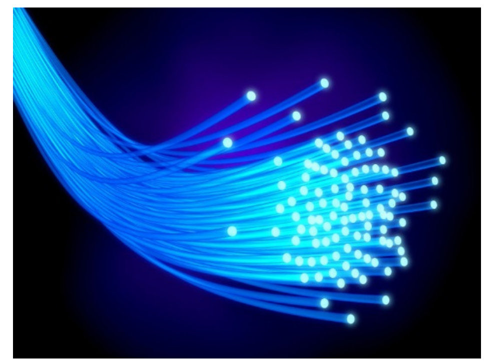
Coax cables have <u>no cutoff frequency</u> – usable with any signal

Rectangular waveguides – less loss, but
can only realistically be used at microwave frequencies (vs RF)

Vocabulary note: Two-conductor waveguides (parallel plate, coax) sometimes referred to as *transmission lines*

Microwave radiation





Radio frequency (RF)

Optical frequencies

How do you know which waveguide is lossier?

Waveguide losses are Ohmic – I^2R style losses from induced currents in imperfect conductors

Induced currents come from $\vec{B}_{1,||} - \vec{B}_{2,||} = \mu_0 \hat{n} \times \vec{K}$, and so are proportional to perpendicular components of B evaluated at the surface

In a rectangular waveguide, why TM/TE?

TE. Always TE. Why? Two reasons

First reason: TEM can't exist in a rectangular waveguide. Can only exist in waveguides composed of two distinct conductors.

Second: Most waveguide operations are single mode – build the waveguide so that at the application frequency, only one mode can propagate (all others have $\omega_c > \omega$)

Rectangular waveguides: Find that TE(1,0) has lowest cutoff frequency, if a is the long dimension

Lowest TM mode: TM(1,1). TM(0,n) or TM(m,0) can't exist

Why single mode operation?

Lower modes have weaker surface fields – less surface current, less Ohmic loss

Different modes with the same ω have different group velocities – a signal composed of many modes will get blurry as different modes get ahead/lag behind

Why rectangular, not square?

Rectangular waveguides can't be made single mode

Mode degeneracy – different combos of m,n with same cutoff frequency

$$\omega_c = \sqrt{\left(\frac{m\pi c}{a}\right)^2 + \left(\frac{n\pi c}{b}\right)^2}$$

$$\xrightarrow[a=b]{} \qquad \omega_c = \frac{\pi c}{a}\sqrt{m^2 + n^2}$$