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Electromagnetics:
Electromagnetic Field Theory

Waveguide Introduction

1

Lecture Outline

- What is a waveguide?
- Examples of waveguides

2

What is a Waveguide?

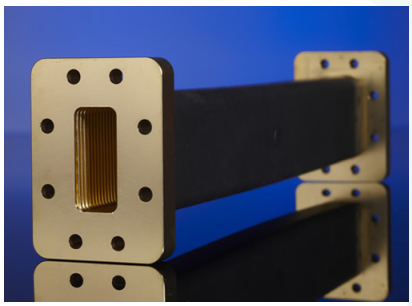
3

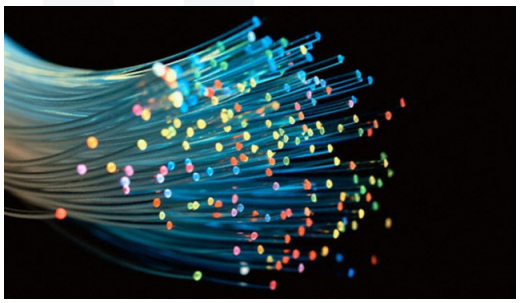
What is a Waveguide?

A waveguide is a structure that confines the propagation of waves to a single path.

They are “pipes” for electromagnetic waves.

Waveguides are useful because they allow electromagnetic waves to be transported long distances without suffering from power loss due to the wave “spreading” out.





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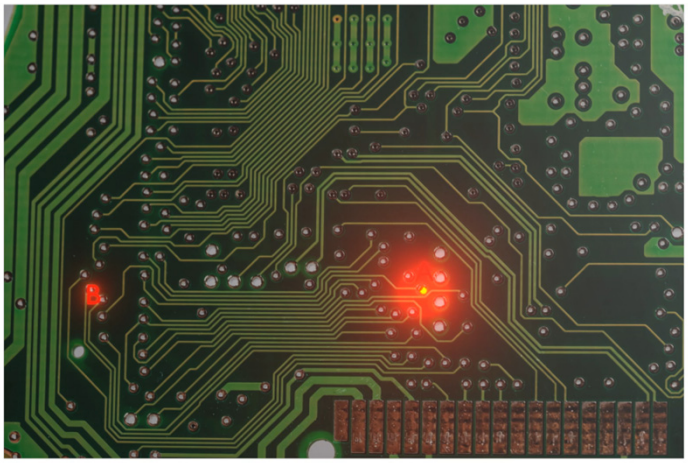
Purpose of Waveguides

Suppose it is desired to transport electromagnetic energy from point A to point B.

Unguided energy spreads out, making energy transport inefficient for this purpose.



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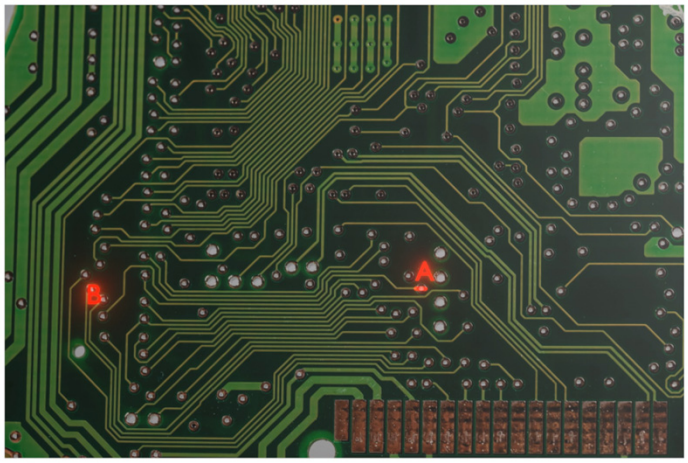
Purpose of Waveguides

Suppose it is desired to transport electromagnetic energy from point A to point B.

Energy is transported much more efficiently if it is guided. In the case of an electrical circuit, energy is guided along a transmission line.



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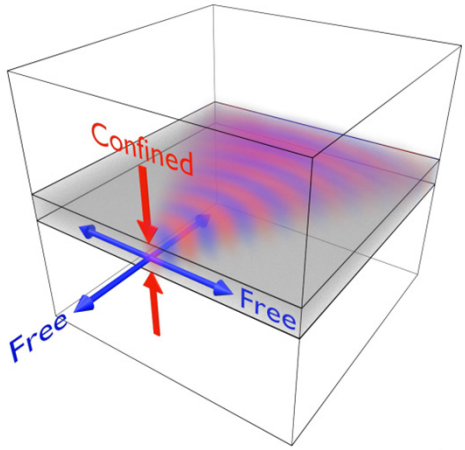
Slab Vs. Channel Waveguides

Slab waveguides confine waves along only one axis.



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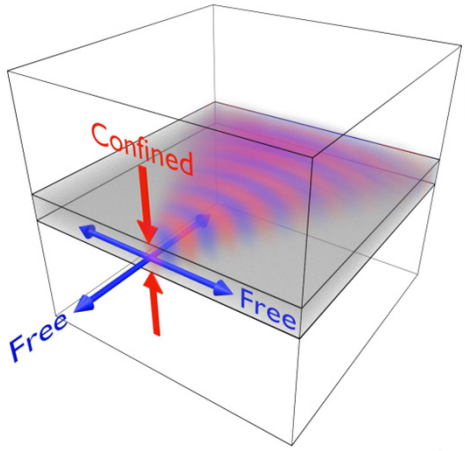
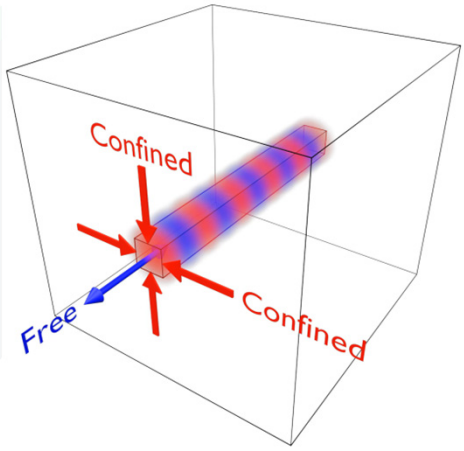
Slab Vs. Channel Waveguides

Slab waveguides confine waves along only one axis.



Channel waveguides confine waves along two axes.



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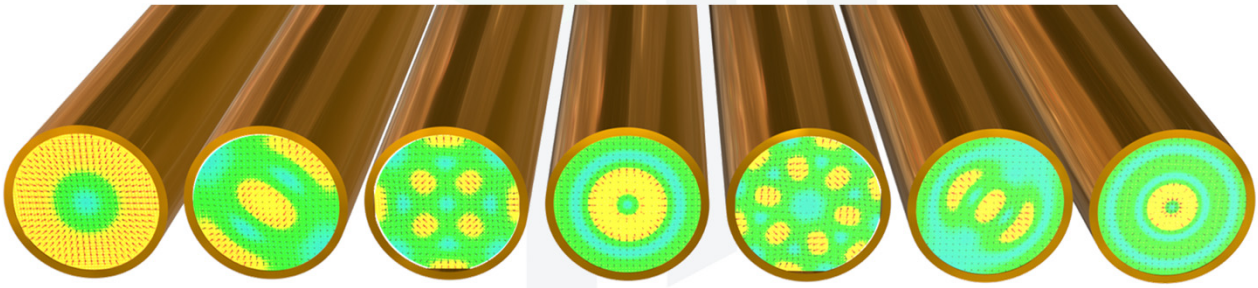
Waveguide Modes

The field inside a waveguide must obey Maxwell's equations. This limits what field configurations are possible into a discrete set. Each solution is called a *mode*. Each mode looks different and behaves differently inside the waveguide.



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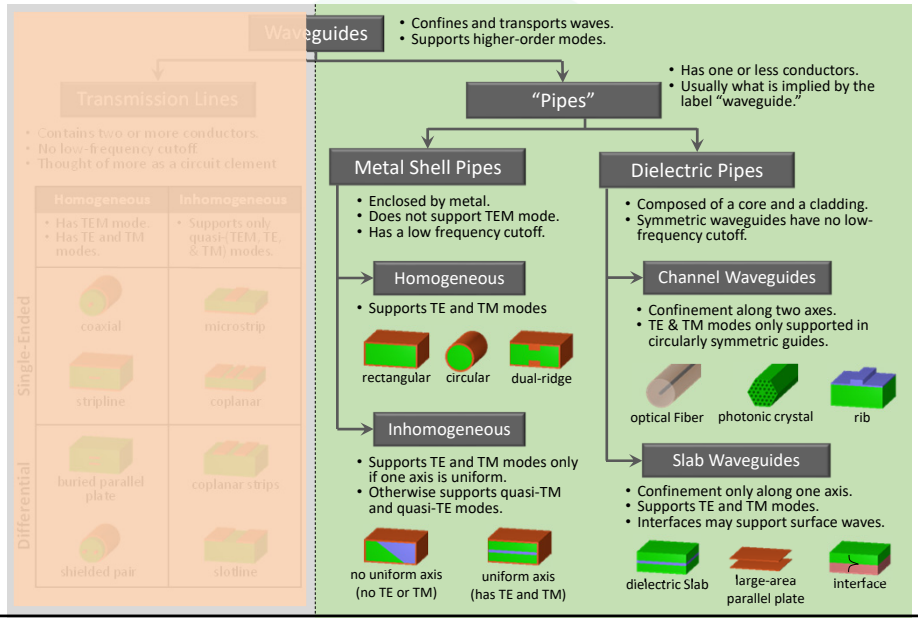
Map of Waveguides (LI Media)



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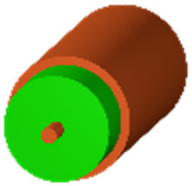
Notes on Transmission Lines

- Contains two or more conductors
- No low frequency cutoff. Works down to DC.
- Supports TEM, TE, and TM modes when the dielectric is homogeneous
- Supports higher-order modes, not just TEM.
- Serve more as a circuit element than a wave device
- Very compact for low frequency signals
- Tend to be lossy at very high frequencies (> 10 GHz) due to skin effect and dielectric loss



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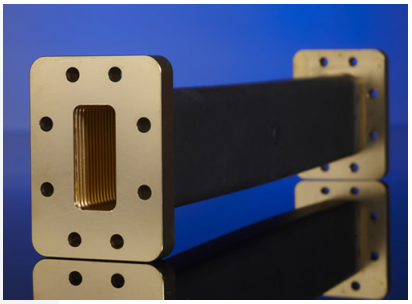
Notes on Metal Pipe Waveguides

- Contains on a single conductor
- Has a low frequency cutoff below which there is no propagation of waves
- Supports TE and TM waves only if dielectric is homogeneous
- Field confined to inside of the waveguide
- Less lossy for very high frequency waves
- Prohibitively large size at low frequencies



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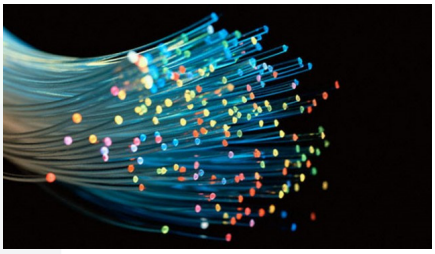
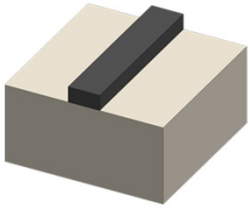
Notes on Dielectric Waveguides



- Does not contain any metals
- Symmetric dielectric waveguides have no low-frequency cutoff
- Symmetric waveguides (e.g. slabs & circularly symmetric) support TE and TM modes
- Most have a low frequency cutoff below which no waves can propagate
- Hybrid modes still tend to be strongly linearly polarized
- Optical fibers are dielectric waveguides
- Field extends outside of the core



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Examples of Waveguides

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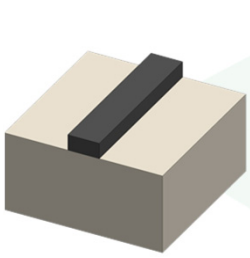
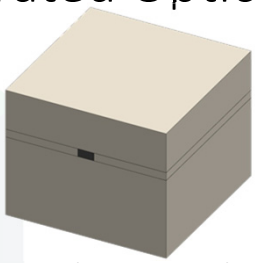
Channel Waveguides for Integrated Optics



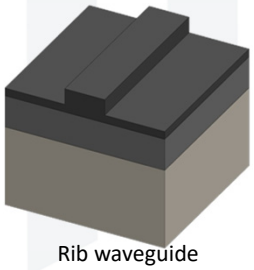
Stripe waveguide

Diffused waveguide

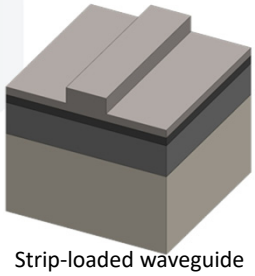


Buried-strip waveguide

Buried-rib waveguide



Rib waveguide



Strip-loaded waveguide

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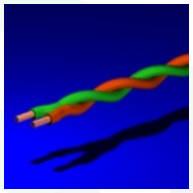
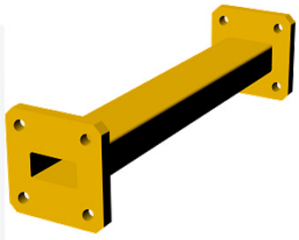
Channel Waveguides for Radio Frequencies

Isolated Wire

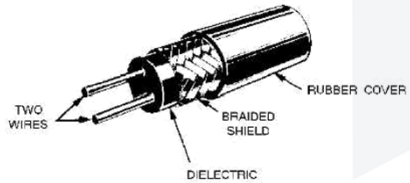
Twisted Pair Transmission Line



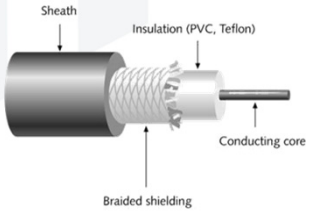
Rectangular Waveguide



Shielded-Pair Transmission Line



Coaxial Cable



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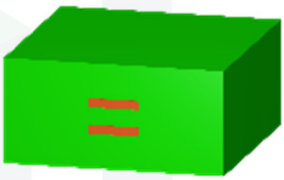
Channel Waveguides for Electrical Circuits

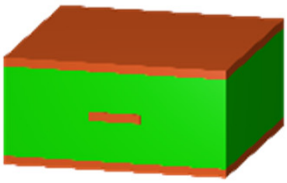
Transmission lines are metallic structures that guide electromagnetic waves from DC to very high frequencies.

Microstrip

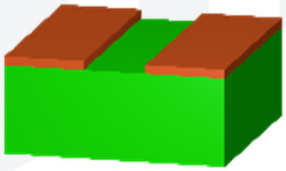
Parallel-Plate Transmission Line



Stripline



Slot Line



Coplanar Line

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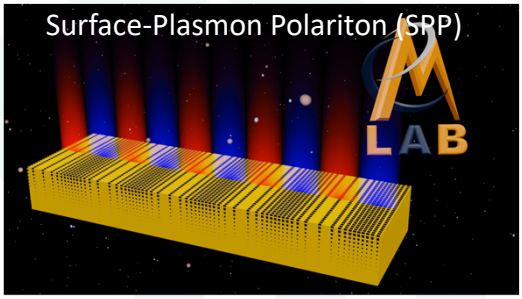
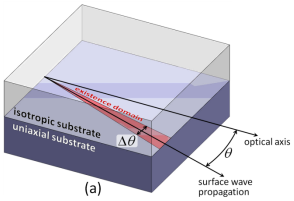
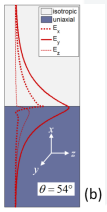
Structures Supporting Surface Waves

Surface-Plasmon Polariton (SPP)

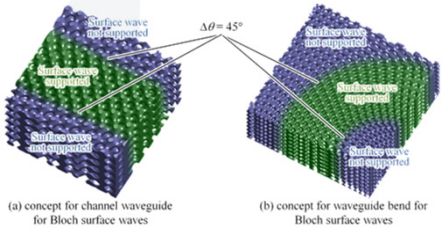


Dyakonov Surface Wave





Bloch Surface Wave



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Notes on Waveguides

- Everything that "pipes" electromagnetic energy is a waveguide
- The label "waveguide" usually refers to waveguides that are not transmission lines
- Waveguides support an infinite number of discrete modes
- Most modes have cutoff frequencies, below which they are not supported and decay very quickly

THANK YOU!!

Course Website:
https://empossible.net/emp3302/

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