

# ECE 5317-6351

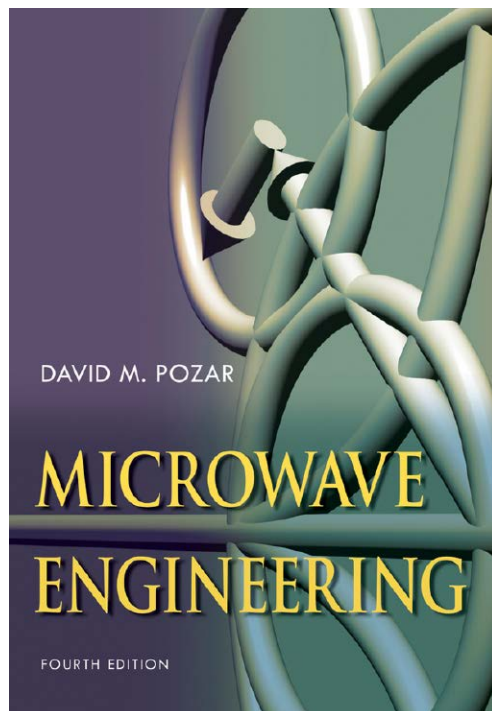
# Microwave Engineering

**Fall 2019**

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## Notes 1

## Waveguiding Systems



# Waveguiding Structures

A **waveguiding structure** is one that carries a signal (or power) from one point to another.

There are three common types:

- Transmission lines
- Fiber-optic guides
- Waveguides

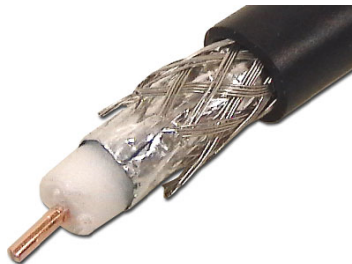
**Note:**

An alternative to using waveguiding structures is wireless transmission using antennas.  
(Wireless systems are discussed later. Antennas are discussed in ECE 5318.)

# Transmission Line

## Properties

- Has two conductors running parallel (one can be inside the other)
- Can propagate a signal at any frequency (in theory)
- Becomes lossy at high frequency
- Can handle low or moderate amounts of power
- Does not have signal distortion, unless there is loss (but there always is)
- May or may not be immune to interference (shielding property)
- Does not have  $E_z$  or  $H_z$  components of the fields (TEM<sub>z</sub>)

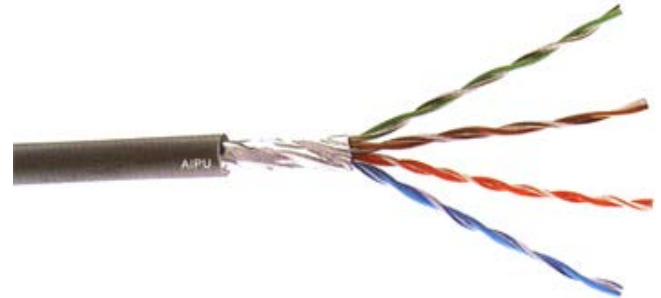


Coaxial cable (coax)



Twin lead  
(shown connected to a 4:1  
impedance-transforming balun)

# Transmission Line (cont.)

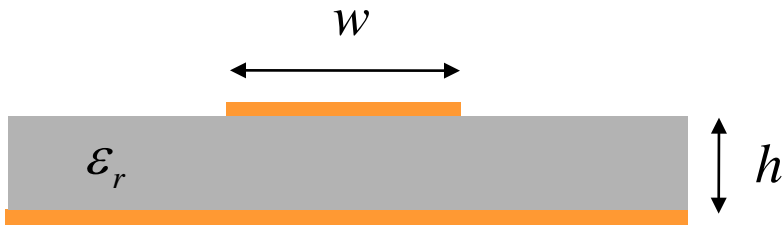


CAT 5 cable  
(twisted pair)

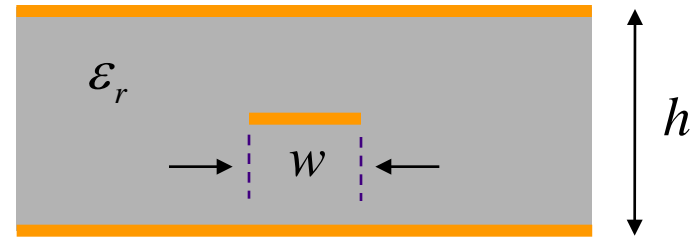
The two wires of the transmission line are twisted to reduce interference and radiation from discontinuities.

# Transmission Line (cont.)

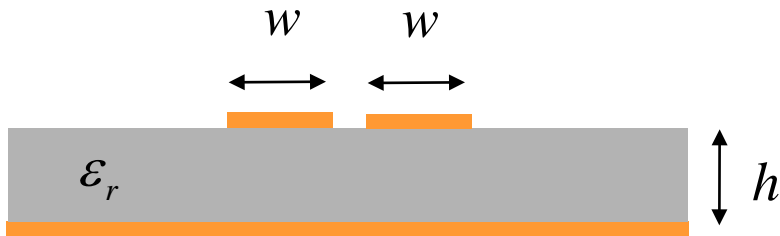
Transmission lines commonly met on printed-circuit boards



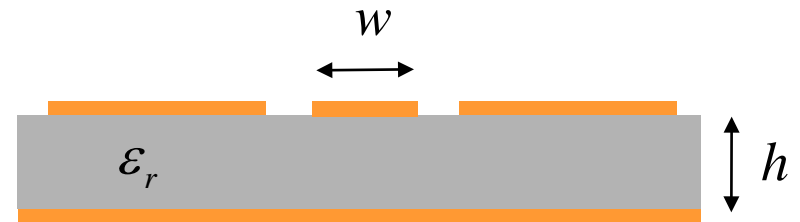
Microstrip



Stripline



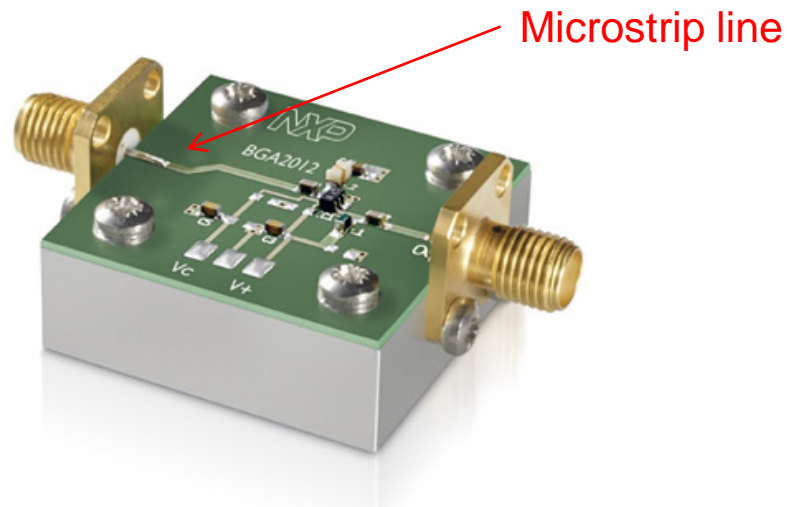
Coplanar strips



Coplanar waveguide (CPW)

# Transmission Line (cont.)

Transmission lines are commonly met on printed-circuit boards.

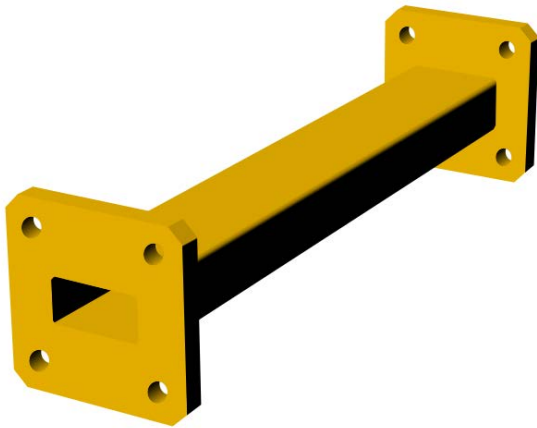


A microwave integrated circuit.

# Waveguides

## Properties

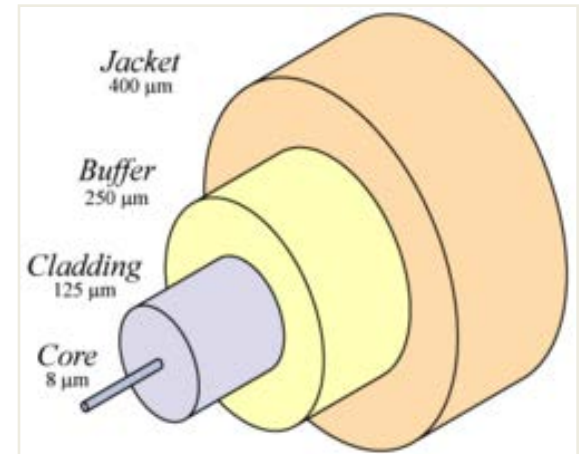
- Consists of a single hollow metal pipe
- Can propagate a signal only at high frequency:  $f > f_c$
- The width must be at least one-half of a wavelength
- Has signal distortion, even in the lossless case
- Immune to interference
- Can handle large amounts of power
- Has low loss (compared with a transmission line)
- Has either  $E_z$  or  $H_z$  component of the fields ( $TM_z$  or  $TE_z$ )



# Fiber-Optic Guide

## Properties

- Uses a dielectric rod
- Operates at optical (infrared) frequencies
- Can be made to have very low loss
- Has minimal signal distortion
- Has a very high bandwidth
- Very immune to interference
- Not suitable for high power
- Has both  $E_z$  and  $H_z$  components of the fields (“hybrid mode”)





# Fiber-Optic Guide (cont.)

## Two types of fiber-optic guides:

### 1) Single-mode fiber

Carries a single mode, as with the mode on a transmission line or waveguide. Requires the fiber diameter to be small relative to a wavelength.

### 2) Multi-mode fiber

Has a fiber diameter that is large relative to a wavelength. It operates on the principle of total internal reflection (critical angle effect).

**Note:** The carrier is at optical frequency, but the modulating (baseband) signal is often at microwave frequencies (e.g., TV, internet signal).

# Fiber-Optic Guide (cont.)

