## ANTENNA AND WAVE PROPAGATION

0



- Thermal Noise
- Intermodulation noise
- Crosstalk
- Impulse Noise

#### Signal to Noise Ratio

0



## Thermal Noise

- Thermal noise due to agitation of electrons
- Present in all electronic devices and transmission media
- Cannot be eliminated
- Function of temperature
- Particularly significant for satellite communication

![](_page_4_Figure_0.jpeg)

### Thermal Noise

 Amount of thermal noise to be found in a bandwidth of IHz in any device or conductor is:

#### • $N_0 = kT(W/HZ)$ • $N_0$ = noise power density in watts per I Hz of bandwidth

- k = Boltzmann's constant =  $1.3803 \times 10^{-23} \text{ J/}^{\circ}\text{K}$
- T = temperature, in kelvins (absolute temperature)

![](_page_5_Figure_0.jpeg)

#### Thermal Noise

- Noise is assumed to be independent of frequency
- Thermal noise present in a bandwidth of *B* Hertz (in watts):

#### $N = \mathbf{k}TB$

• or, in decibel-watts

# $N = 10 \log k + 10 \log T + 10 \log B$ $= -228.6 \, \text{dBW} + 10 \log T + 10 \log B$

![](_page_6_Figure_0.jpeg)

# Noise Terminology

- Intermodulation noise
  - Occurs if signals with different frequencies share the same medium
- Crosstalk
  - Unwanted coupling between signal paths

![](_page_6_Figure_6.jpeg)

![](_page_7_Picture_0.jpeg)

# Noise Terminology

#### Impulse noise

- Irregular pulses or noise spikes
- Short duration and of relatively high amplitude
- Caused by external electromagnetic disturbances, or faults and flaws in the communications system

### Other Impairments

- Atmospheric absorption
  - Water vapor and oxygen contribute to attenuation
- Multipath
  - Obstacles reflect signals so that multiple copies with varying delays are received

#### Refraction

 Bending of radio waves as they propagate through the atmosphere

#### Antenna temperature

Power received from antenna as from a black body or the radiation resitance at temperature Ta

![](_page_9_Figure_2.jpeg)

# Fading in Mobile Environment

- Fading
  - Time variation of received signal power caused by changes in transmission medium or path(s)

![](_page_10_Figure_3.jpeg)

# Multipath Propagation (MP)

#### Reflection

 Occurs when signal encounters a surface that is large relative to the wavelength of the signal

#### Diffraction

 Occurs at the edge of an impenetrable body that is large compared to wavelength of radio wave

#### Scattering

 Occurs when incoming signal hits an object whose size is in the order of the wavelength of the signal or less

# The Effects of MP Propagation

- Multiple copies of a signal may arrive at different phases
  - If phases add destructively, the signal level relative to noise declines, making detection more difficult
  - Known as Intersymbol Interference (ISI)

![](_page_12_Figure_4.jpeg)

![](_page_13_Picture_0.jpeg)

# **Types of Fading**

- Fast fading
- Slow fading
- Flat fading
- Selective fading
- Rayleigh fading
- Rician fading

#### Fading

![](_page_14_Figure_1.jpeg)