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Wireless Radio Technology

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Key terms

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- **Wave**
- **Watt**
- **Decibel**
- **Frequency**
- **BPSK**
- **CCK**
- **OFDM**
- **CSMA/CA**
- **RTS**
- **CTS**
- **PCF**

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Wave Definition

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Wave:

A disturbance or variation that transfers energy progressively from point to point in a medium. A wave may take the form of an elastic deformation or of a variation of pressure, electric or magnetic intensity, electric potential, or temperature.

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Key Terms

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Amplitude — The distance from zero to the maximum value of each alternation is called the amplitude. The amplitude of the positive alternation and the amplitude of the negative alternation are the same.

Period — The time it takes for a sine wave to complete one cycle is defined as the period of the waveform. The distance traveled by the sine wave during this period is referred to as its wavelength.

Wavelength — Wavelength, indicated by the Greek lambda symbol λ, is the distance along the waveform from one point to the same point on the next cycle.

Frequency — The number of repetitions or cycles per unit time is the frequency, typically expressed in cycles per second, or Hz

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Frequency vs. Time Calculation

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The inverse relationship between time (t), the period in seconds, and frequency (f), in Hz, is indicated by the following formulas:

$$t = 1/f$$

$$f = 1/t$$

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Sine Wave

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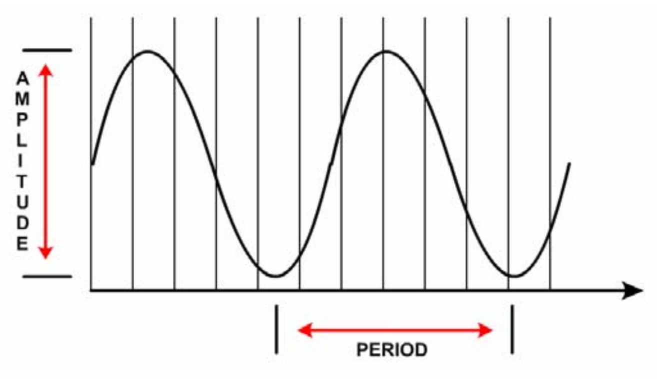

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Watt

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A watt is the basic unit of power, and power is related to energy. However, power is a rate, and energy is a quantity. The formula for power is

$$P = DE / Dt$$

DE is the amount of energy transferred (in Joules)

Dt is the time interval over which that energy is transferred.

Example: One Joule of energy is transferred in one second, this is one watt (W) of power

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Calculating dB

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The formula for calculating dB is as follows:

$$dB = 10 \log10 (Pfinal/Pref)$$

dB = The amount of decibels. This usually represents a loss in power, as the wave travels or interacts with matter, but it can also represent a gain, as when traveling through an amplifier.

Pfinal = The final power. This is the delivered power after some process has occurred.

Pref = The reference power. This is the original power.

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Decibel Reference

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- dB milliWatt (dBm) —unit of measurement for signal strength or power level.
- dB dipole (dBd) —the gain an antenna has, as compared to a dipole antenna at the same frequency. A dipole antenna is the smallest, least gain practical antenna that can be made.
- dB isotropic (dBi) —the gain a given antenna has, as compared to a theoretical isotropic, or point source, antenna.
- Effective Isotropic Radiated Power (EIRP) —the effective power found in the main lobe of a transmitter antenna. It is equal to the sum of the antenna gain, in dBi, plus the power level, in dBm, into that antenna.
- Gain —the amount of increase in energy that an antenna appears to add to an RF signal. Cisco Aironet wireless is standardized on dBi to specify gain measurements. Some antennas are rated in dBd. To convert any number from dBd to dBi, simply add 2.14 to the dBd number.

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Frequency vs. Wavelength

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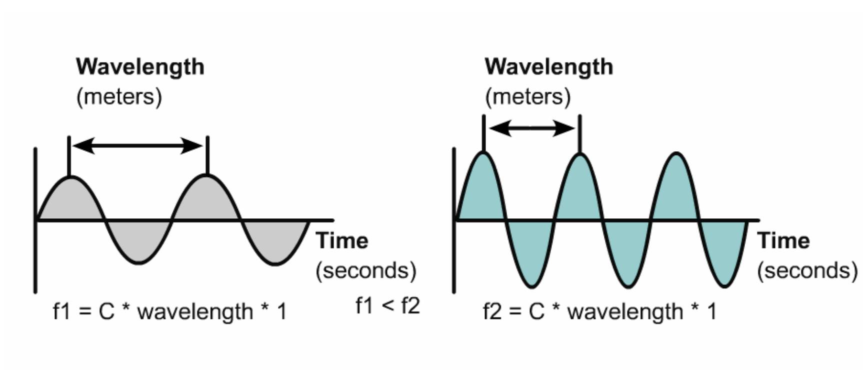

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EM Spectrum

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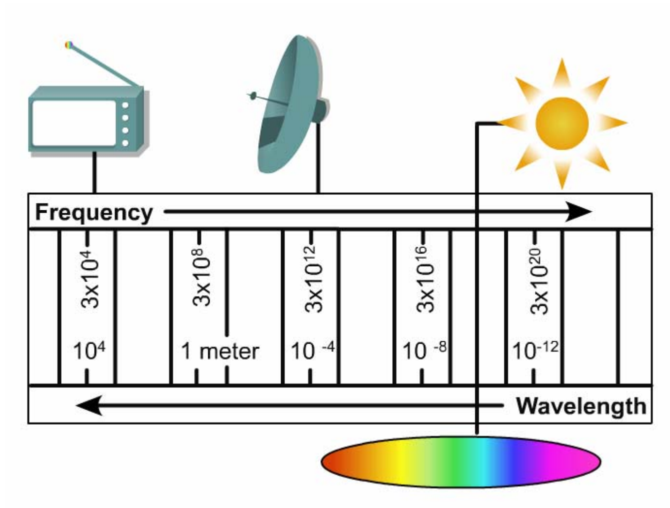

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FWL 1.0—3-11

Fourier Synthesis

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- When two EM waves occupy the same space, their effects combine to form a new wave of a different shape.
- A special sum of sine waves, of harmonically related frequencies, could be added together to create any wave pattern. Harmonically related frequencies are simply frequencies that are multiples of some basic frequency. Complex waves can be built out of simple waves.
- The sum is called a Fourier Series

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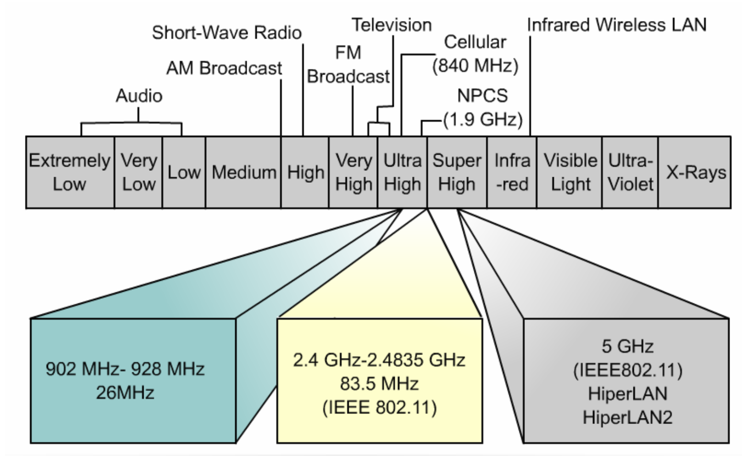
Unlicensed Frequency Band



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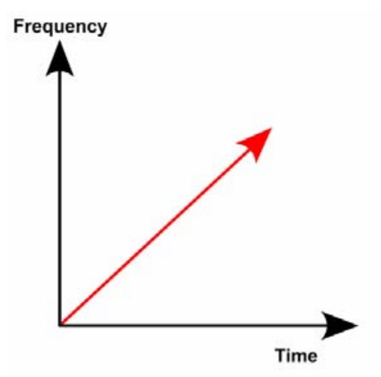
Frequency and time



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Digital Signals in Time

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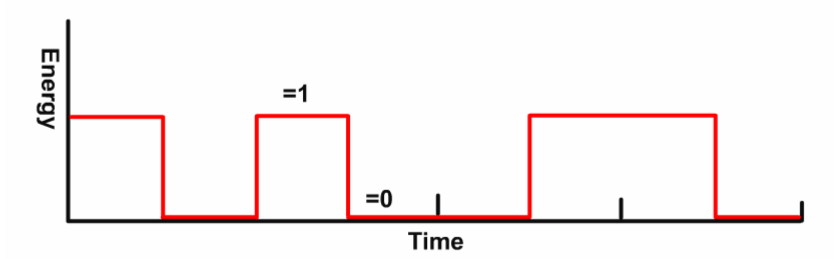

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Carrier frequency

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A carrier frequency is an electronic wave that is combined with the information signal and carries it across the communications channel.

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Modulation Aspects and Techniques

There are three aspects of the basic carrier wave that can be modulated:

- Amplitude
- Frequency
- Phase or angle

The three corresponding techniques are as follows:

- Amplitude modulation (AM)
- Frequency modulation (FM)
- Phase modulation (PM)

Other modulation techniques

- Amplitude shift keying (ASK) — Turning the amplitude all the way off
- Frequency shift keying (FSK) — Hopping to an extreme frequency
- Phase shift keying (PSK) — Shifting the phase 180 degrees

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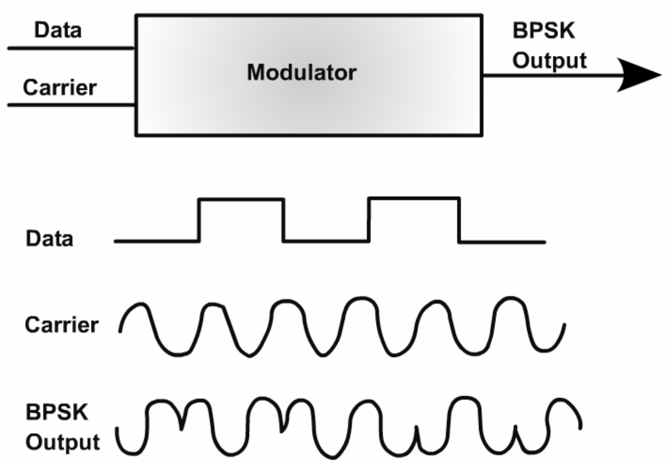
Binary Phase Shift Key Modulation



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FHSS

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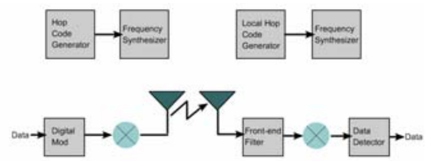
FHSS is a spread spectrum technique that uses frequency agility to spread data over more than 83 MHz of spectrum. Frequency agility is the ability of a radio to change transmission frequency quickly, within the useable RF frequency band.



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DSSS

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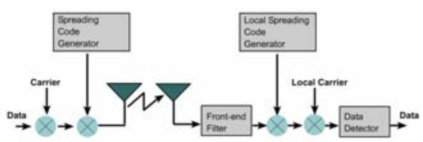
DSSS uses a wide frequency range of 22 MHz all of the time. The signal is spread out across the different frequencies. Each data bit becomes a chipping sequence, or a string of chips that are transmitted in parallel, across the frequency range. This is sometimes referred to as the chipping code.

Regulating agencies set a minimum chipping rate for the different supported speeds. IEEE 802.11 uses 11 chips. For example, the minimum chip rate for 802.11 DSSS, per the FCC, is ten chips for 1 and 2 Mbps (BPSK/QPSK) and eight chips for 11 Mbps (CCK).



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802.11b

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802.11b uses three different types of modulation, depending upon the data rate used:

- Binary phase shift keyed (BPSK) — BPSK uses one phase to represent a binary 1 and another to represent a binary 0, for a total of one bit of binary data. This is utilized to transmit data at 1 Mbps.
- Quadrature phase shift keying (QPSK) — With QPSK, the carrier undergoes four changes in phase and can thus represent two binary bits of data. This is utilized to transmit data at 2 Mbps.
- Complementary code keying (CCK) — CCK uses a complex set of functions known as complementary codes to send more data. One of the advantages of CCK over similar modulation techniques is that it suffers less from multipath distortion. Multipath distortion will be discussed later. CCK is utilized to transmit data at 5.5 Mbps and 11 Mbps.

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802.11b Channels—FCC

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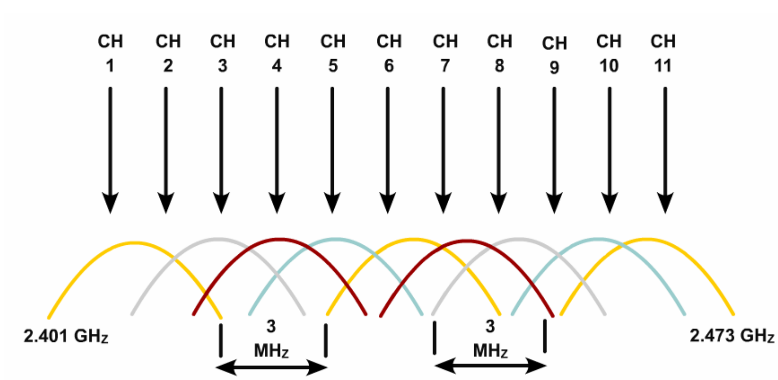

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Chipping Code

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If the data bit was: 1001

Chipping code is: 1=00110011011   0=11001100100

Transmitted data would be:

00110011011	11001100100	11001100100	00110011011
1	0	0	1

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OFDM

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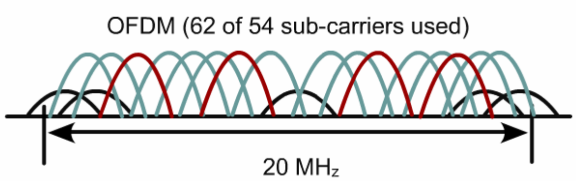

Usage of the 64 subcarriers

- 12 zero subcarriers (in black) on sides and center
- 48 data subcarriers (in green) per symbol
- 4 pilot subcarriers (in red) per symbol, for synchronizing/tracking

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OFDM Modulation and Data Rates

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Modulation with Sub Channels	Data Rate Per Subchannel (Kbps)	Total Data Rate (Mbps)
BPSK	125	6
BPSK	187.5	9
QBPSK	250	12
QBPSK	375	18
16QAM	500	24
16QAM	750	36
64QAM	1000	48
64QAM	1125	54

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Multiple Access Technologies

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- Time Division Multiple Access (TDMA) — Each device can use the entire available spectrum in the cell, but only for a short period of time.
- Frequency Division Multiple Access (FDMA) — Each device can use a portion of the available spectrum, for as long as the device needs to, while in the cell.
- Code Division Multiple Access (CDMA) — This technique is really a combination of the previous two. This is the most advanced scheme and the one that is leading to Third Generation (3G) mobile wireless technologies.

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CSMA/CA

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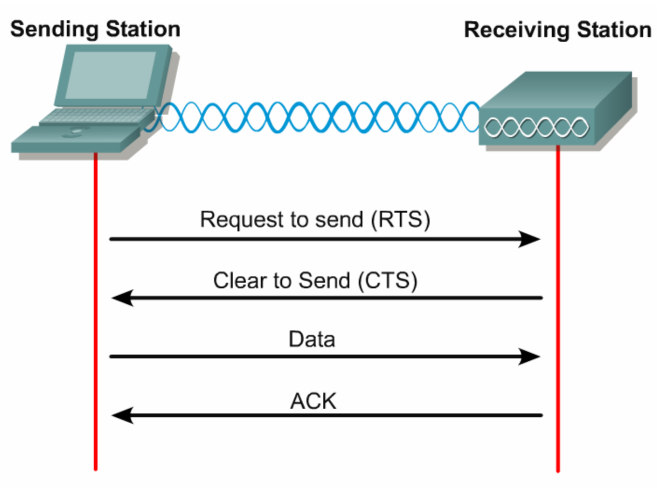

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Application Bandwidth Needs

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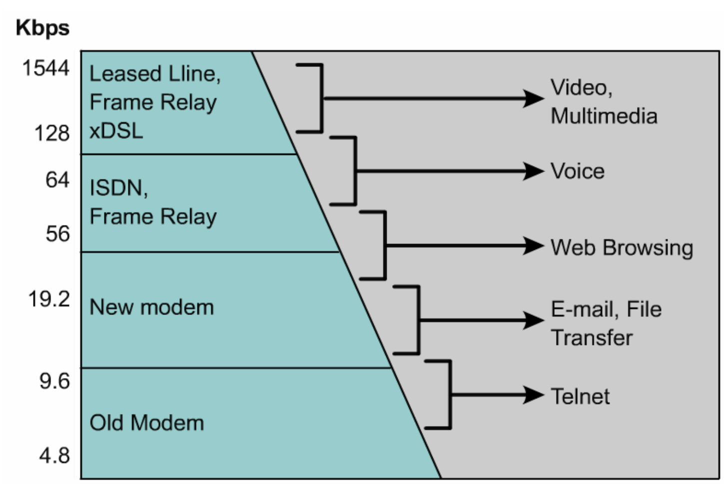

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RF Phenomena

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When RF travels through transparent matter, some of the waves are altered. Therefore, the velocity of 2.4 GHz and 5 GHz microwaves also changes, as the waves travel through matter. However, the amount of alteration depends heavily on the frequency of the waves and the matter.

Some of the phenomena that can affect WLAN radio waves as they travel through matter include refraction, reflection, diffraction, scattering, and multipath.

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Refraction

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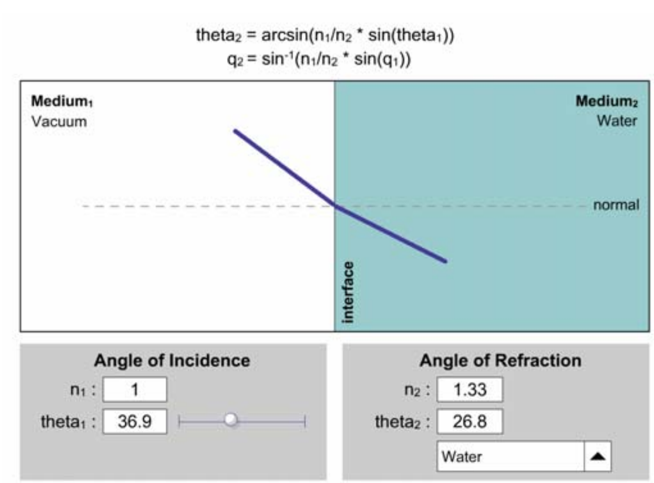

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Reflection

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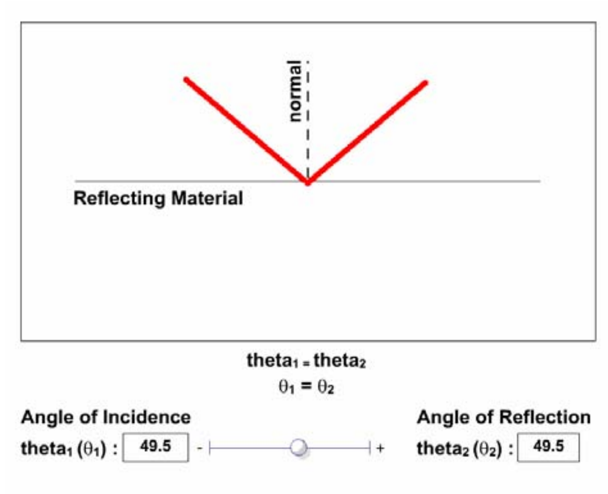

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Diffraction and Scattering

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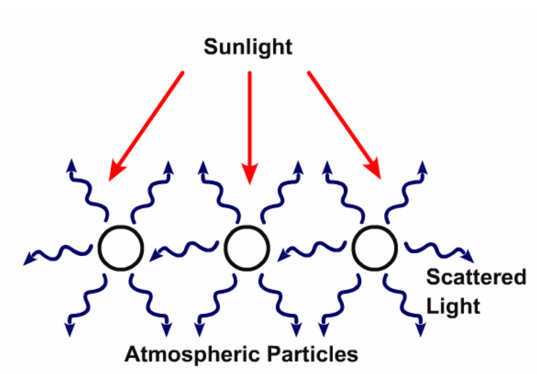

- The spreading out of a wave around an obstacle is called diffraction
- When light hits small particles a phenomenon called scattering is possible

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Multipath Distortion

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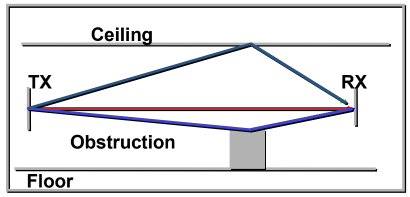
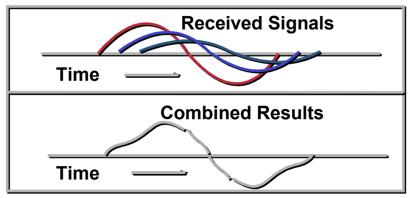
- Occurs when an RF signal has more than one path between a receiver and a transmitter
- RF take more than one path
- Multiple signals cause distortion of the signal
- Can cause high signal strength yet low signal quality





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Free Space Loss

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$$\text{Free Space Loss} = 20\text{Log}_{10}(\text{Frequency in MHz}) + 20\text{Log}_{10}(\text{Distance in Miles}) + 36.6$$

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