Technician License Class

Tulsa Amateur Radio Club

Slides by Tom White, K5EHX

Images from Wikipedia, Other Sources

Shoot for 2 hour and 30 minutes presentation time. Provide break at each hour, for about ten minutes. Estimating 10 minutes at beginning to handle signins and introductions.

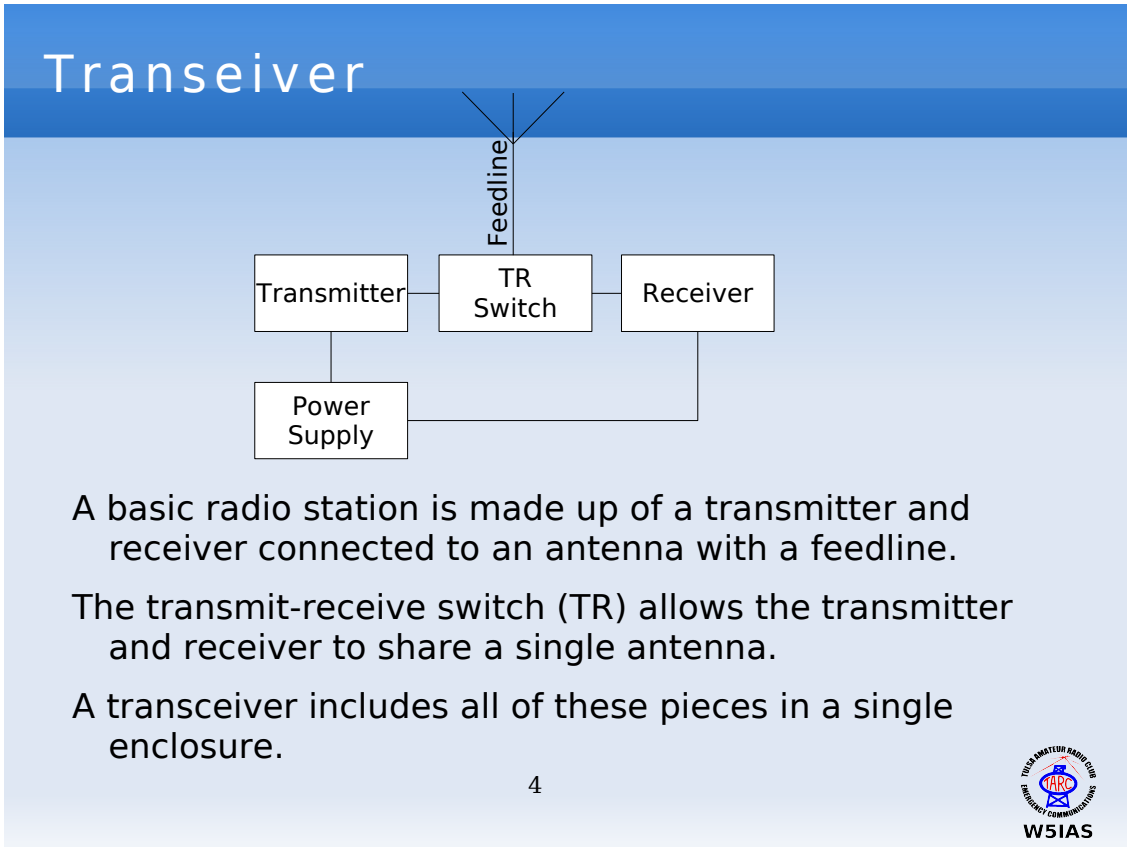
Chapter 2

Radio and Electronics Fundamentals

W5IAS

Chapter 2

2.1 Equipment Definitions



T4C01 What is used to convert radio signals into sounds we can hear? Receiver
T4C02 What is used to convert sounds from our voice into radio signals? Transmitter
T4C03 What two devices are combined into one unit in a transceiver? Receiver, transmitter
T4C04 What device is used to convert the alternating current from a wall outlet into low-voltage direct current? Power Supply

Amateur Station






Accessory equipment

- An amplifier to increase transmitted power
- A microphone for the transmitter
- A speaker to convert electrical signals to sound waves
- Headphones to copy signals in a noisy area
- A battery for emergency power

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T4C05 What device is used to increase the output of a 10 watt radio to 100 watts? Amplifier

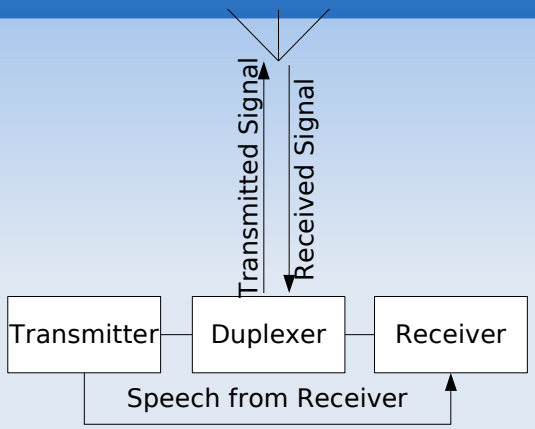
T5A01 What does a microphone connect to in a basic amateur radio station? The transmitter

T5A02 Which piece of station equipment converts electrical signals to sound waves? Speaker

T5A04 What could you use in place of a regular speaker to help you copy signals in a noisy area? A set of headphones

T4C06 Which of the battery types listed below offers the longest life when used with a hand-held radio, assuming each battery is the same physical size? Lithium-ion

Simple Repeater



In a repeater, audio from the receiver is immediately rebroadcast by the transmitter on a different frequency.

A repeater extends the usable range of portable and low-power stations.

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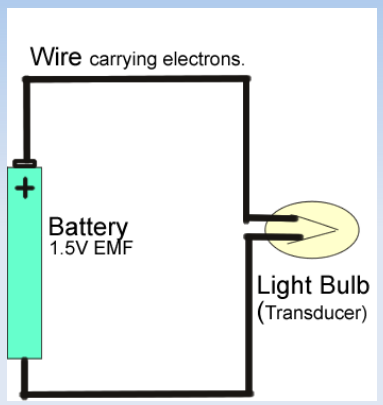
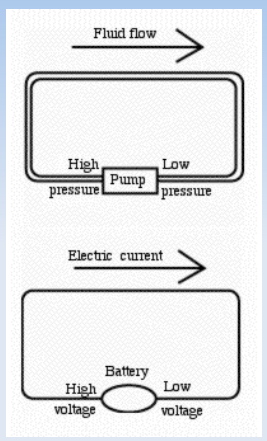
T5C01 What is one purpose of a repeater? To extend the usable range of mobile and low-power stations

Chapter 2

2.2 Electricity

Voltage and Current





Voltage is similar to water pressure in a pipe. Its unit of measure is the Volt.

Current is similar to flow in a pipe. Its unit of measure is the Ampere, or Amp.

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T4A01 Electrical current is measured in which of the following units? Amperes

T4A03 What is the name for the flow of electrons in an electric circuit? Current

Resistance and Conductance

- Resistance is opposition to current flow in ordinary conductors such as wires.
- The basic unit of resistance is the Ohm.
- Copper is an example of a good conductor.
- Glass is an example of a good insulator.

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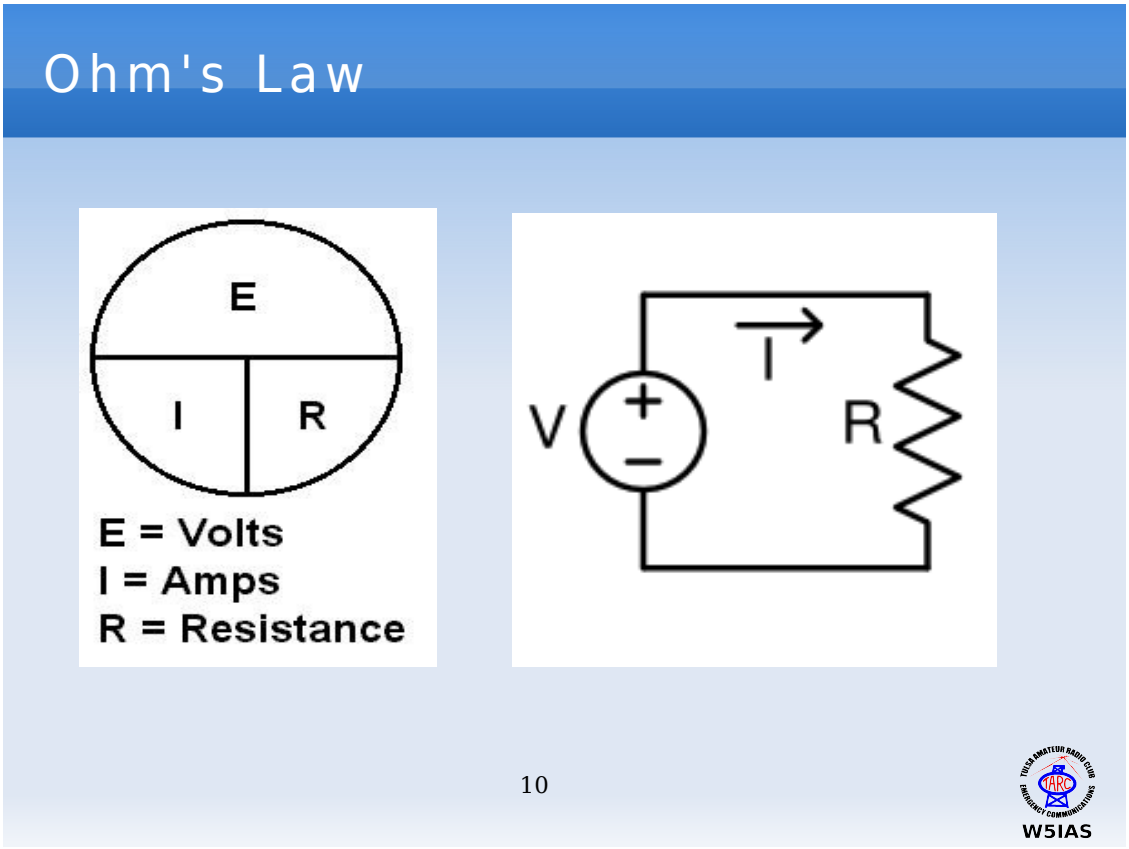
T4A07 What is the basic unit of resistance? The ohm
T4A09 Which of the following is a good electrical conductor? Copper
T4A10 Which of the following is a good electrical insulator? Glass
T4A11 What is the term used to describe opposition to current flow in ordinary conductors such as wires? Resistance



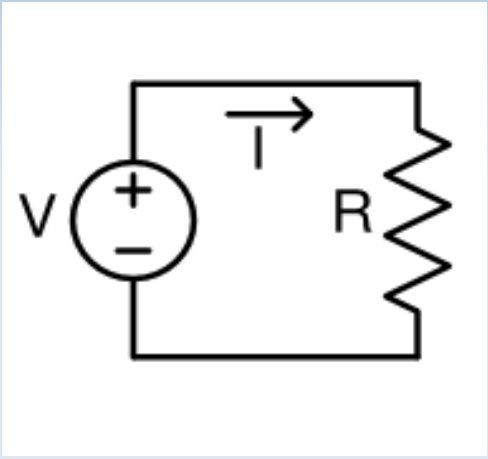
T4D01 What formula is used to calculate current in a circuit? Current (I) equals voltage (E) divided by resistance (R)

T4D02 What formula is used to calculate voltage in a circuit? Voltage (E) equals current (I) multiplied by resistance (R)

T4D03 What formula is used to calculate resistance in a circuit? Resistance (R) equals voltage (E) divided by current (I)

Ohm's Law Example

What is the voltage across the resistor if a current of 2 amperes flows through a 10 ohm resistor?



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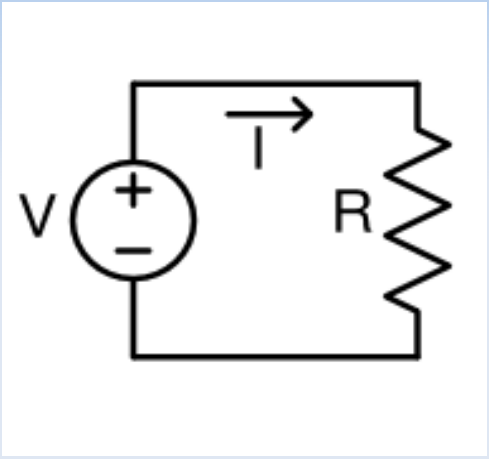
T4D07 What is the voltage across the resistor if a current of 0.5 amperes flows through a 2 ohm resistor? 1 volt
T4D08 What is the voltage across the resistor if a current of 1 ampere flows through a 10 ohm resistor? 10 volts
T4D09 What is the voltage across the resistor if a current of 2 amperes flows through a 10 ohm resistor? 20 volts

Ohm's Law Example

What is the current flowing through a 6 ohm resistor connected across 12 volts?



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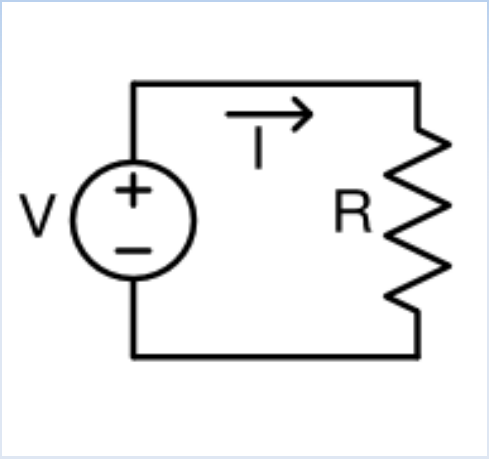
T4D06 What is the current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? 1.5 amperes

T4D10 What is the current flowing through a 100 ohm resistor connected across 200 volts? 2 amperes

T4D11 What is the current flowing through a 24 ohm resistor connected across 240 volts? 10 amperes

Ohm's Law Example

What is the resistance of a circuit when a current of 2 amperes flows through a resistor connected to 6 volts?



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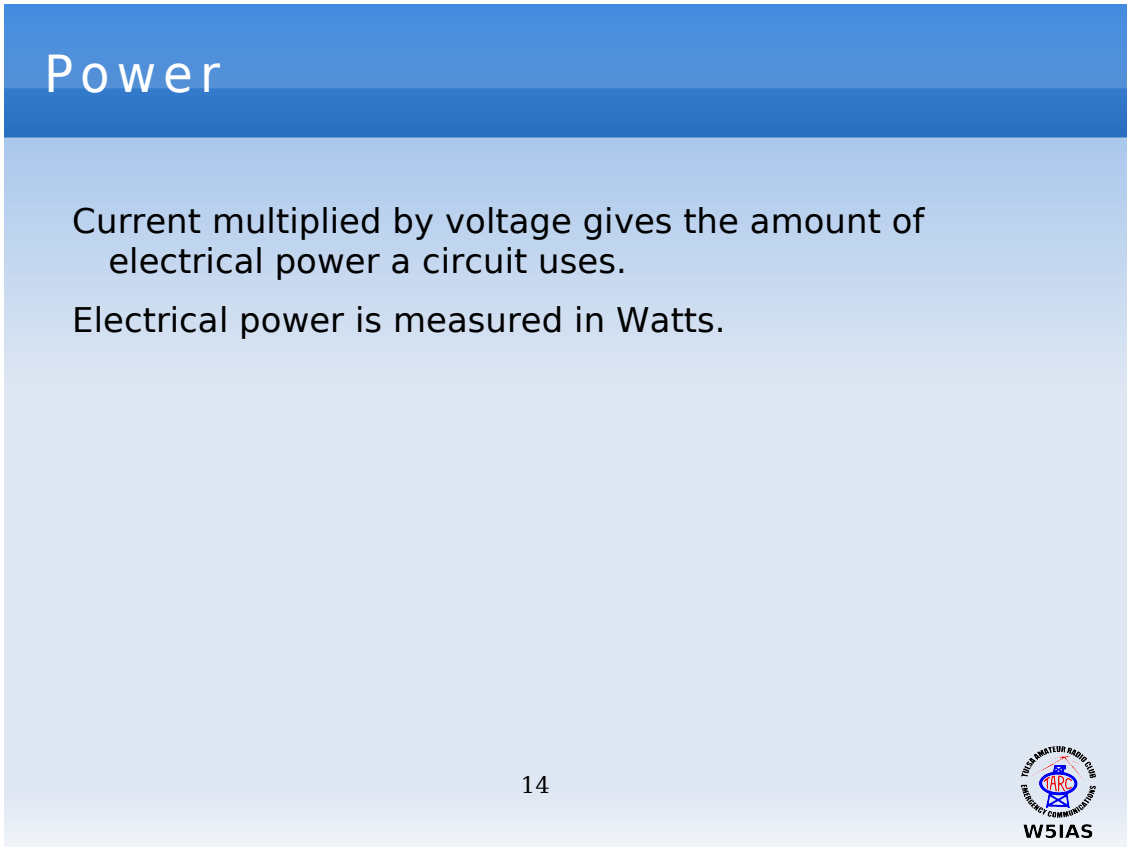
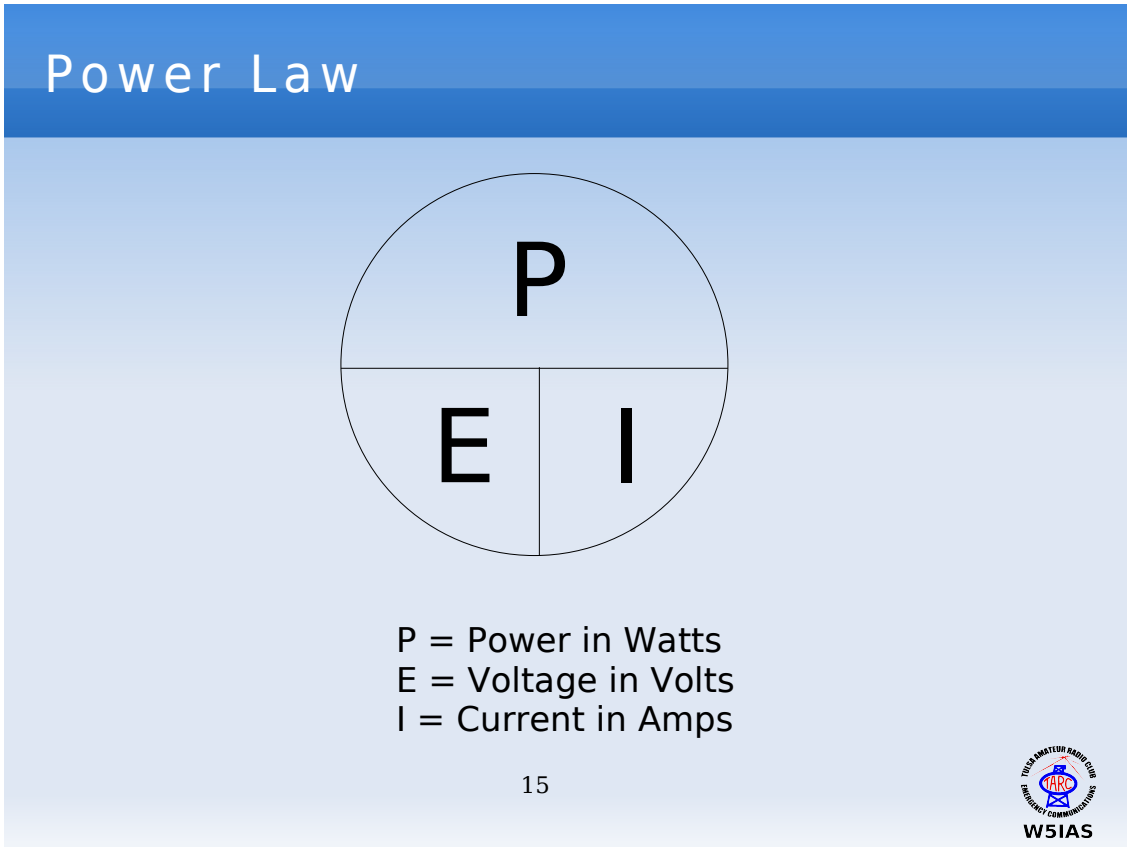
T4D04 What is the resistance of a circuit when a current of 3 amperes flows through a resistor connected to 90 volts? 30 ohms

T4D05 What is the resistance in a circuit where the applied voltage is 12 volts and the current flow is 1.5 amperes? 8 ohms



T4A02 Electrical Power is measured in which of the following units? Watts

T4E01 What unit is used to describe electrical power? Watt



T4E02 What is the formula used to calculate electrical power in a DC circuit? Power (P) equals voltage (E) multiplied by current (I)

Power Law Example

How much power is represented by a voltage of 13.8 volts DC and a current of 10 amperes?

How many amperes are flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts?

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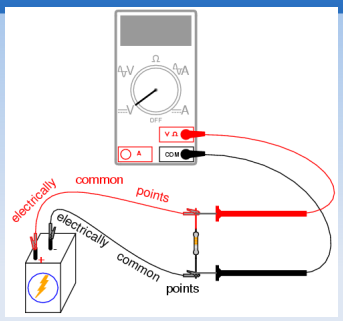
T4E03 How much power is represented by a voltage of 13.8 volts DC and a current of 10 amperes? 138 watts

T4E04 How much power is being used in a circuit when the voltage is 120 volts DC and the current is 2.5 amperes? 300 watts

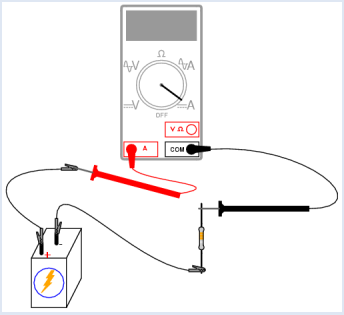
T4E06 How many amperes are flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts? 10 amperes

Measure Current and Voltage

To measure voltage, place a voltmeter in parallel with the circuit.



To measure current, place an ammeter in series with the circuit.



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T4A12 What instrument is used to measure the flow of current in an electrical circuit? Ammeter

T4A13 What instrument is used to measure Electromotive Force (EMF) between two points such as the poles of a battery? Voltmeter

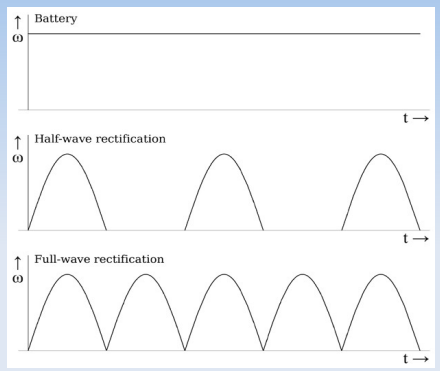
T4E05 How can you determine how many watts are being drawn by your transceiver when you are transmitting? Measure the DC voltage at the transceiver and multiply by the current drawn when you transmit

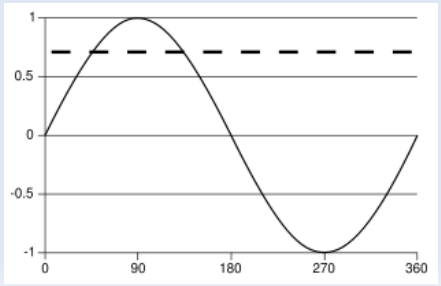
T4E06 How many amperes are flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts? 10 amperes

AC/DC Current

Direct current flows in only one direction.

Alternating current reverses direction on a regular basis.





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T4A04 What is the name of a current that flows only in one direction? A direct current

T4A08 What is the name of a current that reverses direction on a regular basis? An alternating current

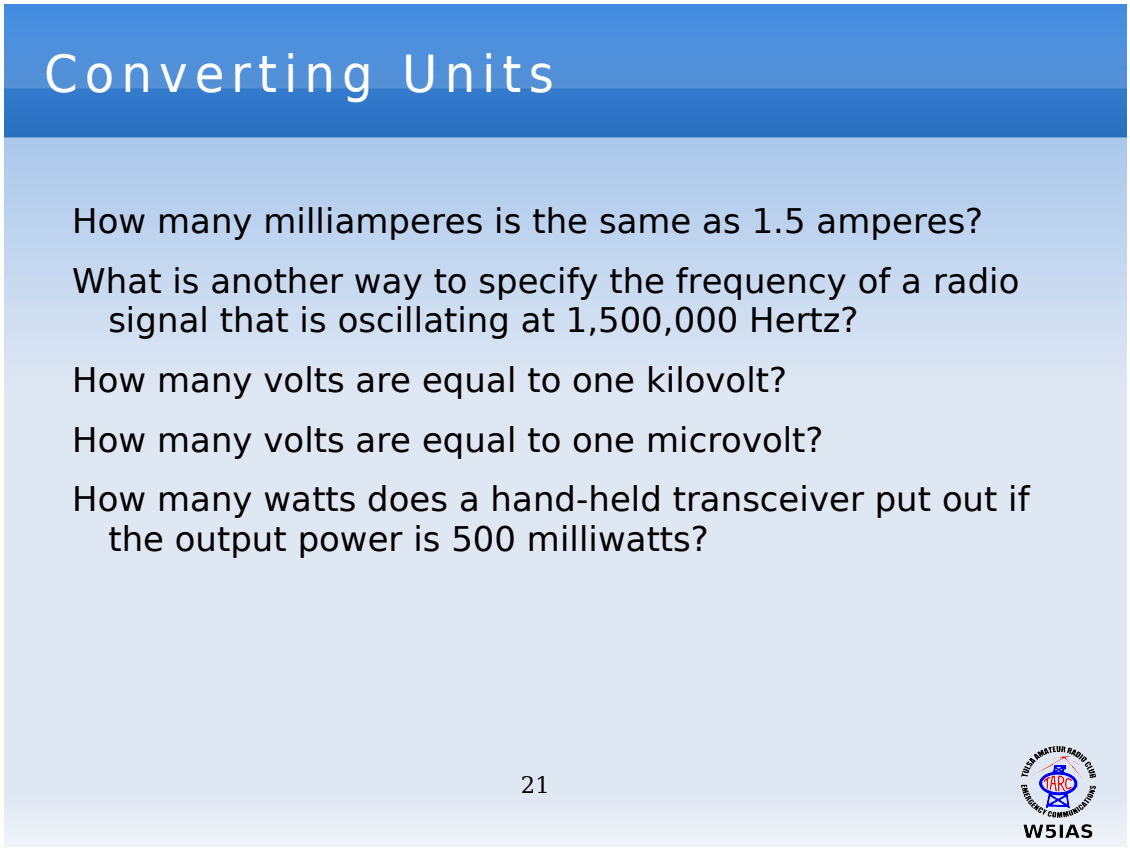
Chapter 2

2.3 Units and Components

Unit Prefixes

Power	Prefix	Symbol	Name	Decimal equivalent
10^{12}	tera	T	Trillion	1 000 000 000 000
10^{9}	giga	G	Billion	1 000 000 000
10^{6}	mega	M	Million	1 000 000
10^{3}	kilo	k	Thousand	1 000
10^{2}	hecto	h	Hundred	100
10^{1}	deca, deka	da	Ten	10
10^{0}	(none)	(none)	One	1
10^{-1}	deci	d	Tenth	0.1
10^{-2}	centi	c	Hundredth	0.01
10^{-3}	milli	m	Thousandth	0.001
10^{-6}	micro	μ (u)	Millionth	0.000 001
10^{-9}	nano	n	Billionth	0.000 000 001
10^{-12}	pico	p	Trillionth	0.000 000 000 001

Only milli, kilo, micro are on test.



T4E07 How many milliamperes is the same as 1.5 amperes? 1500 milliamperes

T4E08 What is another way to specify the frequency of a radio signal that is oscillating at 1,500,000 Hertz? 1500 kHz

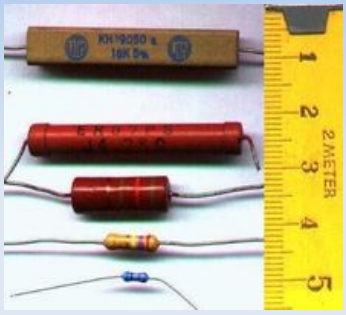
T4E09 How many volts are equal to one kilovolt? one thousand volts

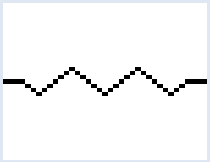
T4E10 How many volts are equal to one microvolt? one one-millionth of a volt

T4E11 How many watts does a hand-held transceiver put out if the output power is 500 milliwatts? 0.5 watts

Resistors

A resistor opposes the flow of electrical current.





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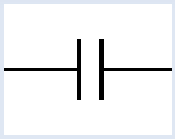
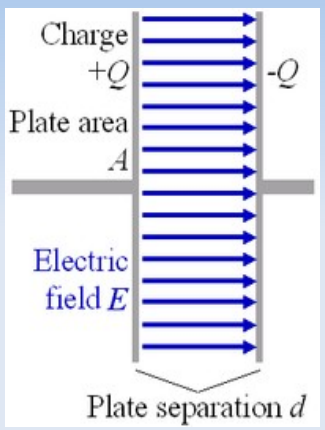
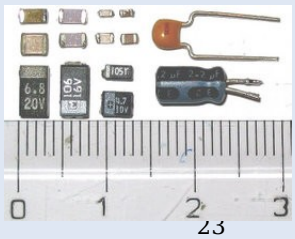
NO QUESTIONS ON EXAM

Capacitors

A capacitor stores electrical energy and smooths out changes







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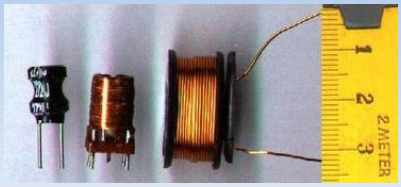
NO QUESTIONS ON EXAM

Inductors

An inductor stores magnetic energy and smooths out changes in current.



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NO QUESTIONS ON EXAM

Protective Components

A fuse interrupts power in the case of an overload.

Installing a fuse higher than the rating could allow excessive current and cause a fire.

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T0A04 What is the purpose of a fuse in an electrical circuit? To interrupt power in case of overload

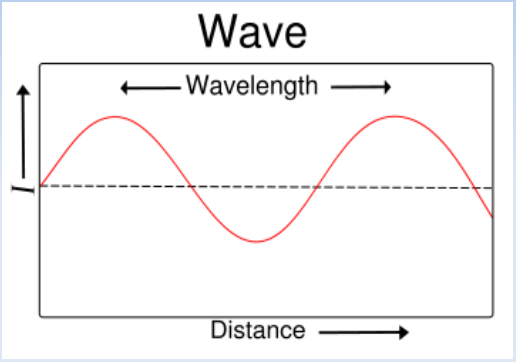
T0A05 What might happen if you install a 20-ampere fuse in your transceiver in the place of a 5-ampere fuse? Excessive current could cause a fire

Chapter 2

2.4 Signals and Waves

Frequency and Period

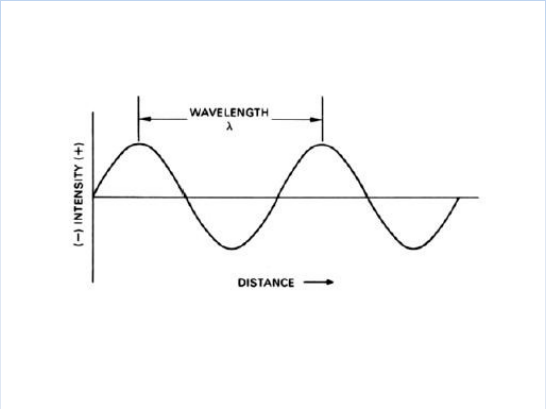
- The standard unit of frequency is the *Hertz*, or cycles per second.
- The time of an AC cycle is measured in Hertz.
- For example, 60 Hertz means that the direction changes 60 times per second.



W5IAS

T4A05 What is the standard unit of frequency? The Hertz
T4B02 What term describes the number of times that an alternating current flows back and forth per second? Frequency
T4B03 What does 60 hertz (Hz) mean? 60 cycles per second

Wavelength



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T4B01 What is the name for the distance a radio wave travels during one complete cycle? Wavelength
T4B05 How fast does a radio wave travel through space? At the speed of light
T4B06 How does the wavelength of a radio wave relate to its frequency? The wavelength gets shorter as the frequency increases
T4B07 What is the formula for converting frequency to wavelength in meters? Wavelength in meters equals 300 divided by frequency in megahertz

Spectrum Ranges

Legend:
γ = Gamma rays
HX = Hard X-rays
SX = Soft X-Rays
EUV = Extreme ultraviolet
NUV = Near ultraviolet
Visible light
NIR = Near infrared
MIR = Moderate infrared
FIR = Far infrared

Radio waves:
EHF = Extremely high frequency (Microwaves)
SHF = Super high frequency (Microwaves)
UHF = Ultrahigh frequency
VHF = Very high frequency
HF = High frequency
MF = Medium frequency
LF = Low frequency
VLF = Very low frequency
VF = Voice frequency
ELF = Extremely low frequency

CLASS	FREQUENCY	WAVELENGTH	ENERGY
γ	300 EHz	1 pm	1.24 MeV
HX	30 EHz	10 pm	124 keV
	3 EHz	100 pm	12.4 keV
SX	300 PHz	1 nm	1.24 keV
	30 PHz	10 nm	124 eV
EUV	3 PHz	100 nm	12.4 eV
NUV	300 THz	1 μm	1.24 eV
NIR	30 THz	10 μm	124 meV
MIR	3 THz	100 μm	12.4 meV
FIR	300 GHz	1 mm	1.24 meV
EHF	30 GHz	1 cm	124 μeV
SHF	3 GHz	1 dm	12.4 μeV
UHF	300 MHz	1 m	1.24 μeV
VHF	30 MHz	1 dam	124 neV
HF	3 MHz	1 hm	12.4 neV
MF	300 kHz	1 km	1.24 neV
LF	30 kHz	10 km	124 peV
VLF	3 kHz	100 km	12.4 peV
VF	300 Hz	1 Mm	1.24 peV
ELF	30 Hz	10 Mm	124 feV

W5IAS

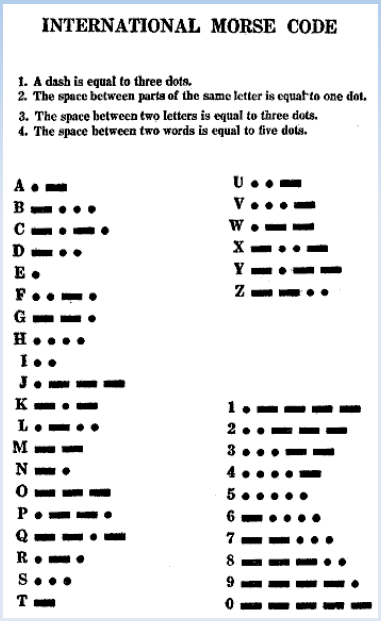
T4B04 Electromagnetic waves that oscillate more than 20,000 times per second as they travel through space are generally referred to as what? Radio waves

T4B08 What are sound waves in the range between 300 and 3000 Hertz called? Voice frequencies

T4B09 What property of a radio wave is often used to identify the different bands amateur radio operators use? The physical length of the wave

CW

Morse code is sent by turning a single frequency wave (continuous wave) on and off.



INTERNATIONAL MORSE CODE

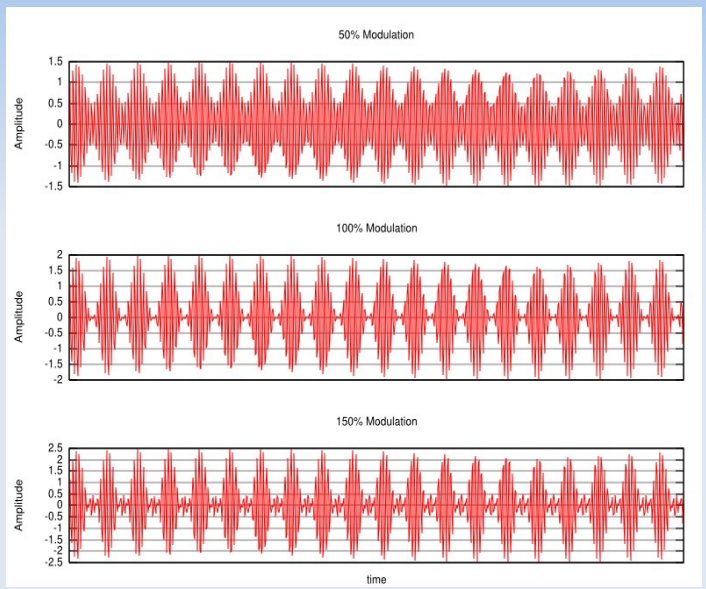
1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

A • —	U • • —
B — • • •	V • • • —
C — • — •	W • — —
D — • •	X — • • —
E •	Y — • — —
F • • — •	Z — — • •
G — — •	
H • • • •	
I • •	
J • — — —	
K — • —	1 • — — — —
L • — • •	2 • • — — —
M — —	3 • • • — —
N — •	4 • • • • —
O — — —	5 • • • • •
P • — — •	6 — • • • •
Q — — • —	7 — — • • •
R • — •	8 — — — • •
S • • •	9 — — — — •
T —	0 — — — — —

W5IAS

AM Phone

Amplitude modulation is the simplest type of transmitter to make, and varies the volume (amplitude) of the signal according to the input wave form.



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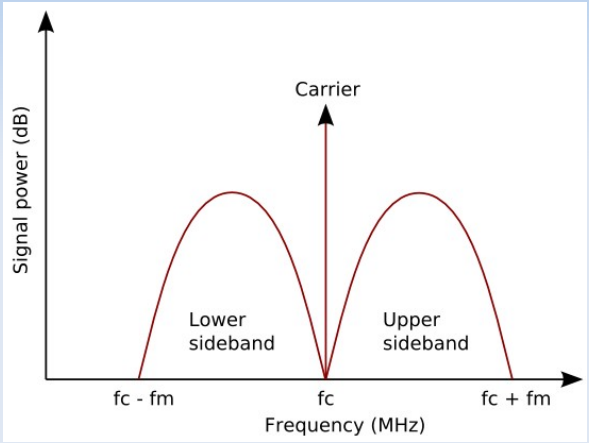
T6A01 What are phone transmissions? Voice transmissions by radio

SSB

Single Sideband modifies an AM carrier to remove redundant and wasteful information. It removes the carrier and one of the side bands.



W5IAS

T6A02 Which of the following is a form of amplitude modulation? Single sideband

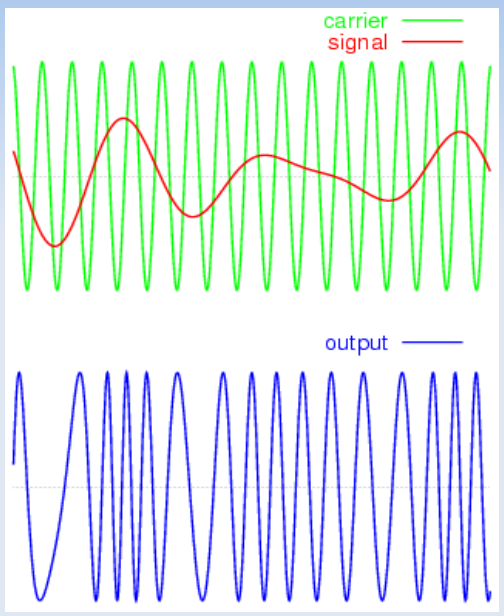
T6A04 Which type of voice modulation is most often used for long distance and weak signal contacts on the VHF and UHF bands? SSB

T6A07 Which sideband is normally used for VHF and UHF SSB communications? Upper sideband

T6A08 What is the primary advantage of single sideband over FM for voice transmissions? SSB signals use much less bandwidth than FM signals

FM

Frequency Modulation modifies the frequency of the carrier according to the input waveform.



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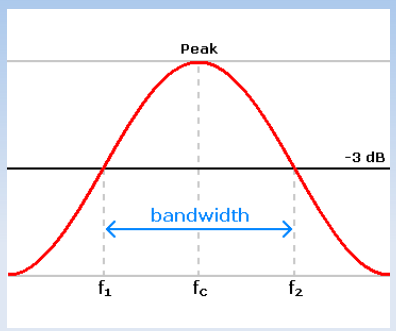
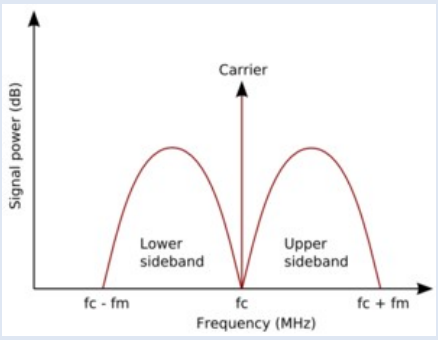
T6A05 Which type of modulation is most commonly used for VHF and UHF voice repeaters? FM

Bandwidth

Bandwidth is the amount of frequency spectrum taken up by a signal





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W5IAS

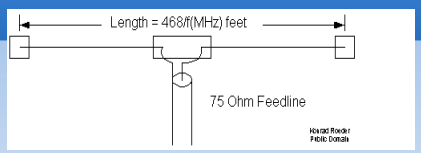
T6A09 What is the approximate bandwidth of a single-sideband voice signal? Between 2 and 3 kHz
T6A10 What is the approximate bandwidth of a frequency-modulated voice signal? Between 5 and 15 kHz
T6A06 Which emission type has the narrowest bandwidth? CW

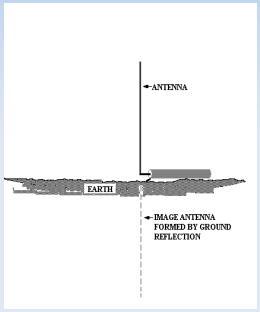
Chapter 2

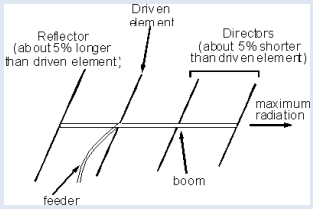
2.5 Antennas and Feedlines

Antenna Types

- A simple dipole is mounted so that the elements are parallel to the Earth's surface.
- A quarter wave whip replaces half of the dipole with a ground or groundplane (conductive surface)
- A Yagi antenna uses “parasitic elements” to direct the signal on both transmit and receive in a particular direction.







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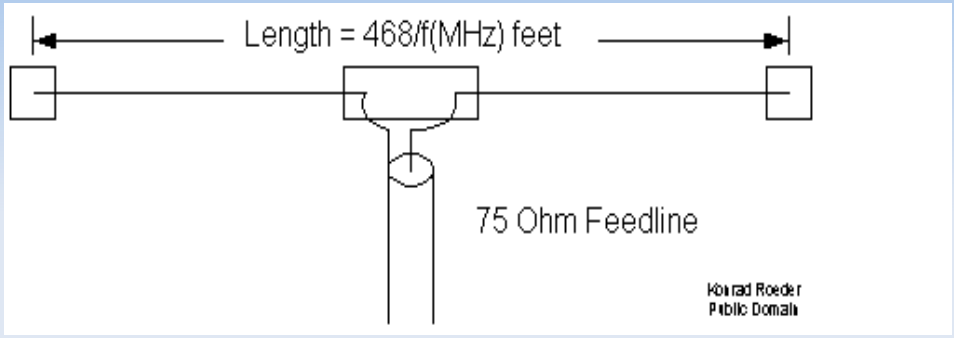
T9A03 What type of antenna is a simple dipole mounted so the elements are parallel to the Earth's surface? A horizontal antenna

Antenna Size



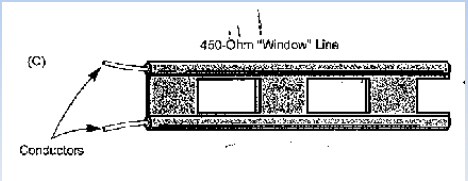
The size of a dipole decreases as the frequency increases.

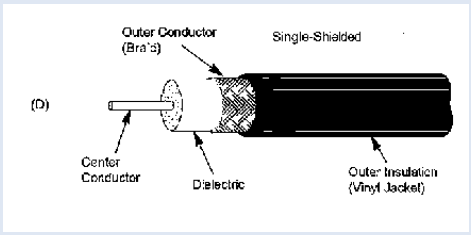
W5IAS

T9A05 How does the physical size of half-wave dipole antenna change with operating frequency? It becomes shorter as the frequency increases

Feedlines

- Coax is the most common feedline because it is easy to use and requires few special considerations.
- Coax is usually 50 ohms.
- High SWR in a feedline does not allow efficient power transfer and causes loss of power.





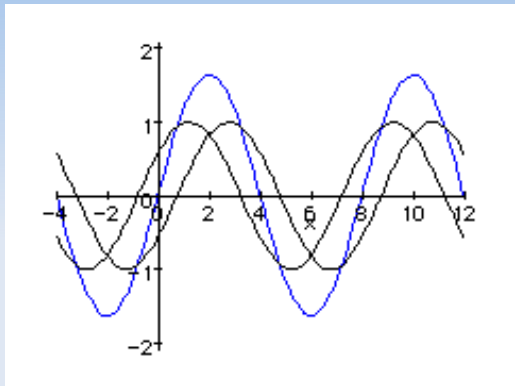
W5IAS

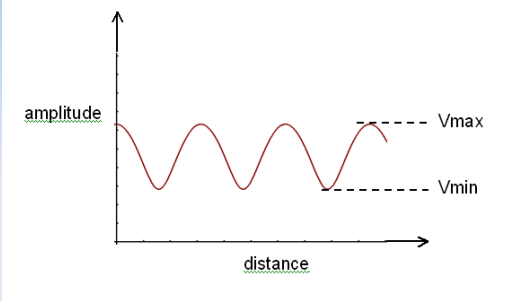
T9C08 Why is it important to have a low SWR in an antenna system that uses coaxial cable feedline? To allow the efficient transfer of power and reduce losses

T9C11 What is the impedance of the most commonly used coaxial cable in typical amateur radio installations? 50 Ohms

T9C12 Why is coaxial cable used more often than any other feed line for amateur radio antenna systems? It is easy to use and requires few special installation considerations

SWR





A Standing Wave Ratio (SRW) tells us how well matched an antenna system (load) is to a transmitter.

W5IAS

T9C01 What, in general terms, is standing wave ratio (SWR)? A measure of how well a load is matched to a transmitter

If possible, show movie swr11.mov (quicktime format) http://www.csupomona.edu/~ajm/materials/animations/stwaves.html

Measuring SWR

An SWR meter can be used to measure the SWR of an antenna for a particular frequency, or some readios have a meter built in.

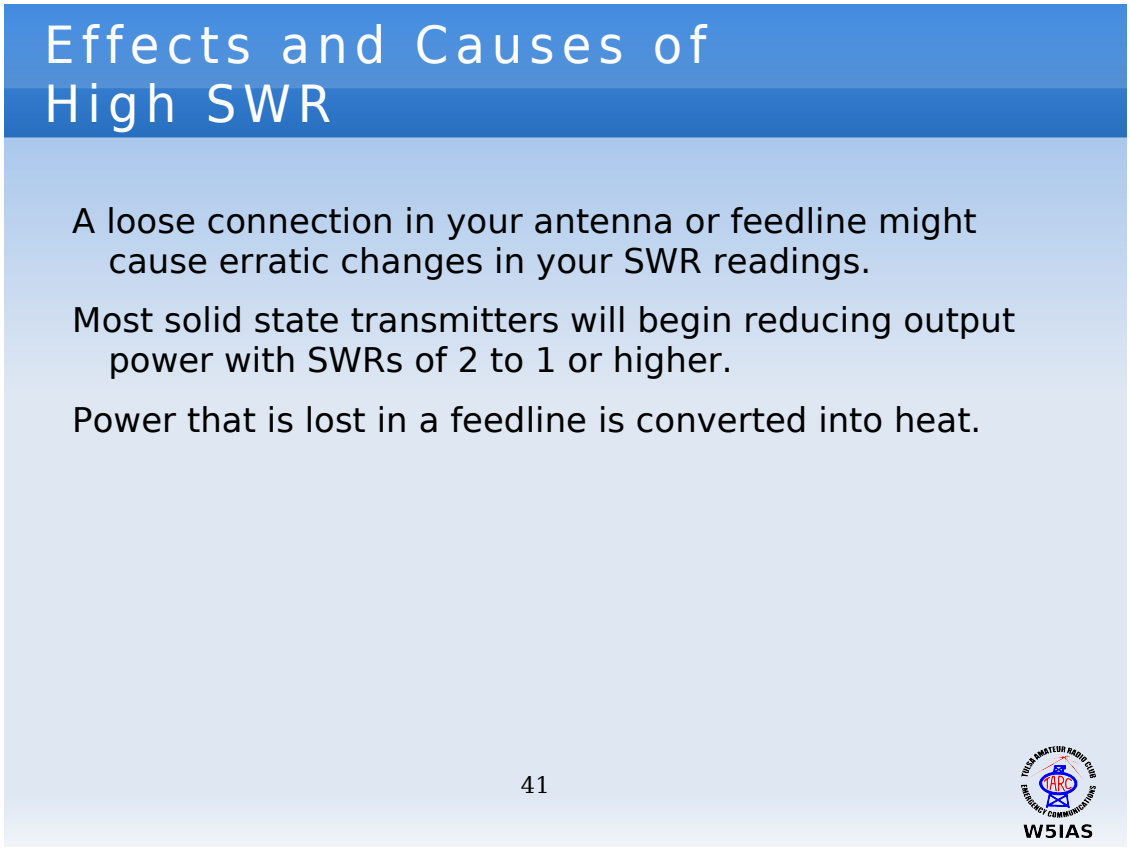
A perfect impedance match gives an SWR of 1 to 1.

You can also calculate SWR by using a directional wattmeter.

W5IAS

T9C02 What reading on a SWR meter indicates a perfect impedance match between the antenna and the feed line? 1 to 1

T9C06 What instrument other than a SWR meter could you use to determine if your feedline and antenna are properly matched? Directional wattmeter



T9C03 What might be indicated by erratic changes in SWR readings? A loose connection in your antenna or feedline

T9C04 What is the SWR value where the protection circuits in most solid-state transmitters begin to reduce transmitter power? 2 to 1

T9C05 What happens to the power lost in a feed line? It is converted into heat by losses in the line

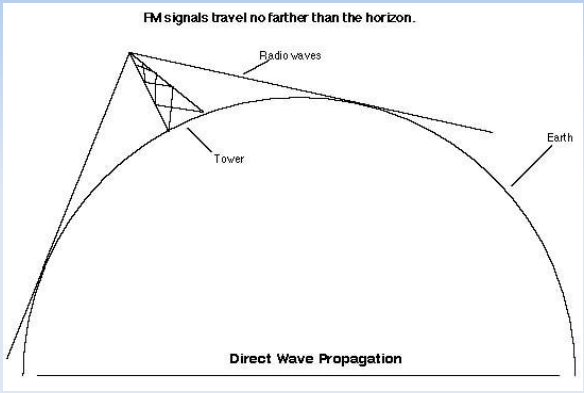
Chapter 2

2.6 Propogation

What is propagation?

The path that radio waves travel from one station to another.

Line of Sight

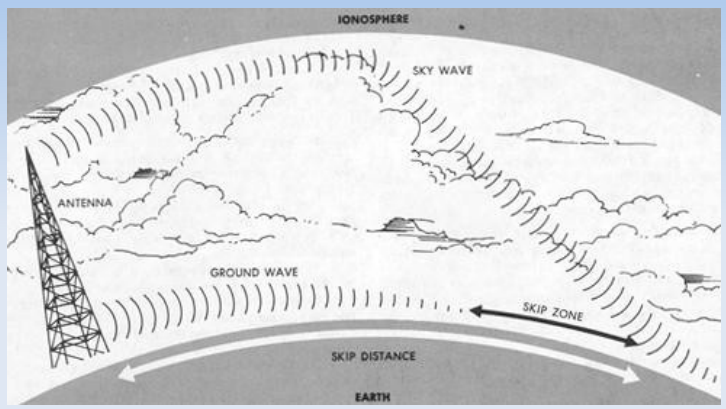


Radio waves travel directly through space from one station to another.

W5IAS

T9B04 What is the radio horizon? The point where radio signals between two points are blocked by the curvature of the Earth

Ground Wave

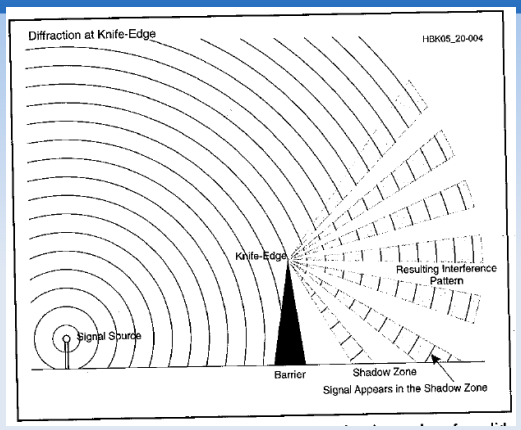


Ground wave radios bend slightly to follow the curve of the earth.

W5IAS

T9B11 Why do VHF and UHF Radio signals usually travel about a third farther than the visual line of sight distance between 2 stations? The Earth seems less curved to radio waves than to light

Knife Edge



- Random reflections or diffractions may cause multi-path distortion, and moving just a few feet may make your signal better.
- Multi-path may cause a rapid fluttering sound in mobile stations, this is referred to as “picket fencing”.

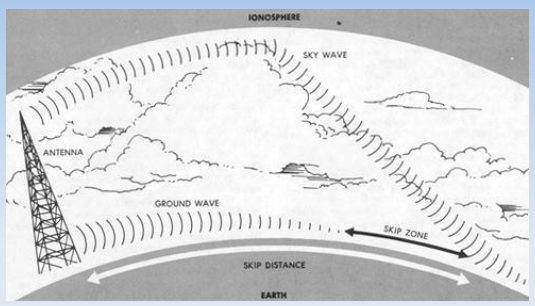
W5IAS

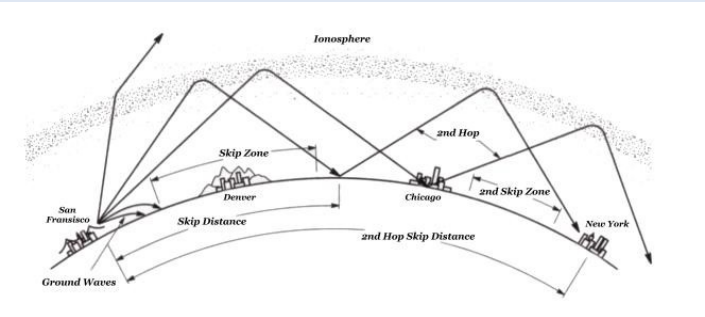
T9B05 What should you do if a station reports that your signals were strong just a moment ago, but now they are weak or distorted? Try moving a few feet, random reflections may be causing multi-path distortion.

T9B10 What term is commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting? Picket fencing

Skywave

- The atmosphere reflects or passes different frequencies of radio waves.





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W5IAS

T9B01 Why are VHF/UHF signals not normally heard over long distances? VHF and UHF signals are usually not reflected by the ionosphere

Sporadic E

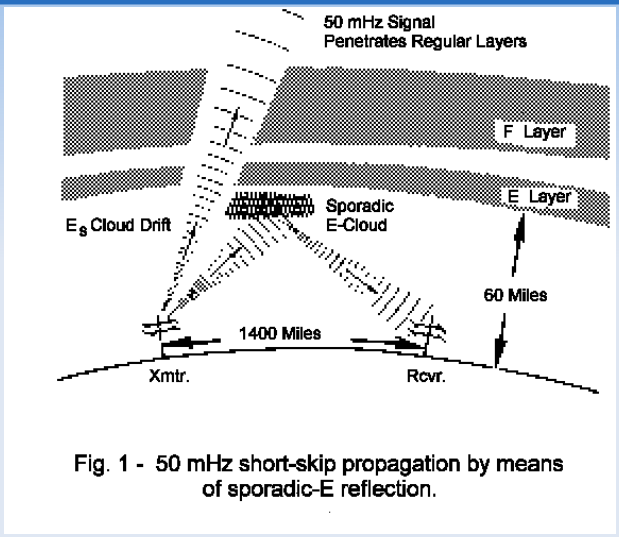

Fig. 1 - 50 mHz short-skip propagation by means of sporadic-E reflection.

- Sporadic E propagation can cause VHF signals to be heard over long distances.

W5IAS

T9B02 What might be happening when we hear a VHF signal from long distances? A possible cause is sporadic E reflection from a layer in the ionosphere

Penetration

- The shorter wavelength of UHF signals allows them to more easily penetrate urban areas and buildings.
- VHF and higher frequencies can more easily penetrate the ionosphere.

W5IAS

T9B06 Why do UHF signals often work better inside of buildings than VHF signals? The shorter wavelength of UHF signals allows them to more easily penetrate urban areas and buildings

Chapter 2

The End