Welcome

What We Are Covering Tonight

- Equipment Definitions
- Basic Electricity
- Units and Components
- Power Supplies and Batteries

Equipment Definitions

Basic Station Organization

- Station Equipment
  - Receiver
  - Transmitter
  - Antenna
  - Power Supply (at the end)
- Accessory Station Equipment
- Digital Mode Stations

What happens during radio communication?

- Transmitting (sending a signal)
  - Information (voice, data, video, commands, etc.) is converted to electronic form
  - The information in electronic form is attached or imbedded on a radio wave (a carrier) by the *transmitter* (XMTR)
  - The radio wave is sent out from the station antenna into space

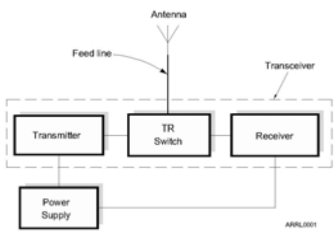
T4C02

What happens during radio communication?

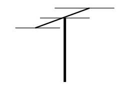
- Receiving end:
  - The radio wave (carrier) with the information is intercepted by the receiving station antenna
  - The *receiver* (RCVR)extracts the information from the carrier wave
  - The information is then presented to the user in a format that can be understood (sound, picture, words on a computer screen, response to a command)

T4C01

The basic radio station



Antenna



- The antenna serves two functions:
  - Turns radio signals from a transmitter into energy that travels through space
  - Also captures radio waves and turns them into signals that a receiver can work with
- Many times the transmitting and receiving antenna are the same antenna
- Connected to your station by a connecting wire called a feed line

The Transceiver

- Many of the controls of a transmitter and receiver are the same
- Many modern transmitters and receivers are combined in one unit – called a *transceiver* (XCVR)
  - Saves space
  - Cost less
- Many common electronic circuits are shared in the transceiver

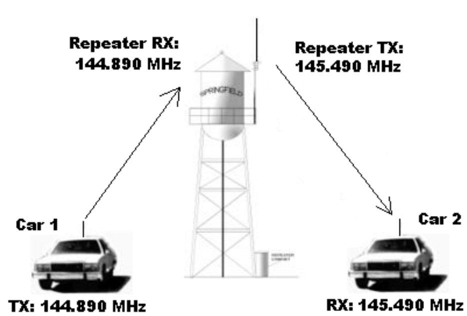
T4C03

Repeaters

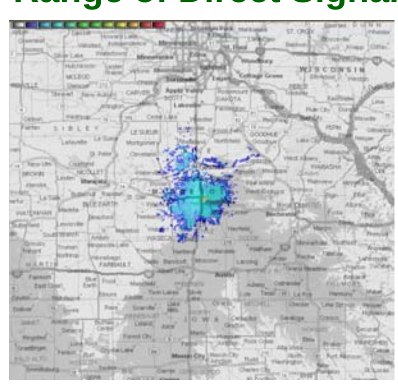
- Special stations that relay signals across a wide area
- Allows low powered handhelds and mobile stations to communicate with stations that they can't reach directly

T5C01

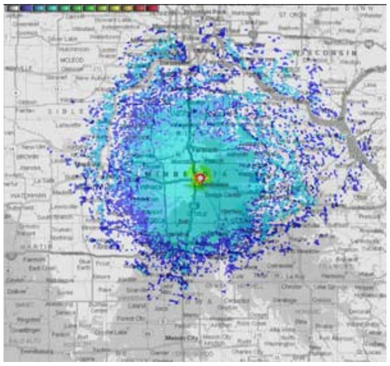
Repeaters



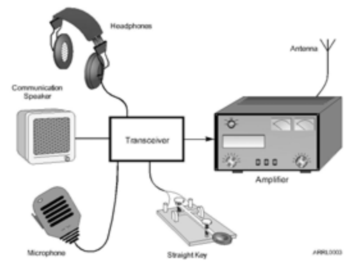
Range of Direct Signal



Range w/ Repeater



Accessory Radio Equipment



Accessory Radio Equipment

- A *microphone* (or mike or MIC) turns the operator's voice into an electrical signal, called audio, which the transmitter then adds to a radio signal. **T5A01**
- At the receiver's output, a *speaker* turns the electrical audio signal back into audio sound that the operator can hear. **T5A02**
- *Audio feedback* is the term that is used to describe what happens when a microphone and a speaker are too close to each other. **T5A03**
- *Headphones* are often used to make it easier to understand the audio in the presence of noise or interference and to avoid disturbing others. **T5A04**
- *Amplifiers* are circuits or equipment that increase the strength of a signal. **T4C05**

Basic Electricity

Fundamentals of Electricity

- When dealing with electricity we are referring to the flow of electrons through a conductor

Basic Components of Electricity

- There are three components to electricity
  - Voltage
  - Current
  - Resistance
- All three must be present for electrons to flow

Current

- The flow of electrons is called *current* (I).
- The unit of measure of current is the *ampere* (A).
- Current is measured with an *ammeter*.

T4A03, T4A01, T4A12

Voltage

- The pressure that forces electrons through a circuit is known as **electromotive force** or **EMF.**
- The unit of measure of EMF is the volt (V).
- The voltage (EMF) across two points is measured with a *voltmeter*.

T4A13

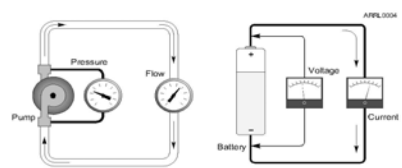
Resistance

- *Resistance* impedes the free flow of electrons (current) to some degree.
- Unit measured in *ohms* (Ω).
- Measured with an ohmmeter.

T4A11, T4A07

Basic Components of Electricity

- The flow of water through a hose is a good analogy to understand the three components of electricity and how they are related



Conductors

- Current can flow easily through conductors.
- Silver is an excellent conductor.
- Copper is cheaper and conducts almost as well as silver.
- Most metals are fairly good conductors, including steel, aluminum, mercury, zinc, tin and gold.

T4A09

Insulators

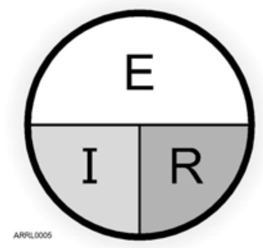
- Current does not flow easily through Insulators.
- Glass, rubber, plastic, ceramic, mica, wood and even air are insulators.

T4A10

Components of Electricity are Inter-related

- Voltage, current, and resistance must be present to have current flow
- Just like water flowing through a hose, changes in voltage, current, and resistance affect each other
- That effect is mathematically expressed in Ohm's Law

Ohm's Law

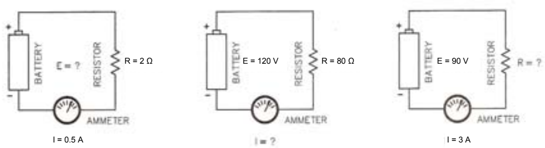


- E is voltage
  - Units-volts
- I is current
  - Units-ampere
- R is resistance
  - Units-ohms

- R=E/I
- I=E/R
- E=I x R

T4D01 – T4D03

Ohm's Law Examples



GIVEN: I = 0.5 A, R = 2 Ω	GIVEN: E = 120 V, R = 80 Ω	GIVEN: I = 3 A, E = 90 V
FIND: E (VOLTAGE)	FIND: I (CURRENT)	FIND: R (RESISTANCE)
E = I X R = 0.5 X 2 = 1	I = E / R = 120 / 80 = 1.5	R = E / I = 90 / 3 = 30
Voltage Equals 1 volt	Current Equals 1.5 Amperes	Resistance Equals 30 Ω
T4D07	T4D06	T4D04

Ohm's Law Examples

- **What is the resistance in a circuit where the applied voltage is 12 volts and the current flow is 1.5 amperes?**
  - **R = E / I** R = 12 / 1.5 = **8 volts** T4D05
- **What is the voltage across the resistor if a current of 1 ampere flows through a 10 ohm resistor?**
  - **V = I*R** V = 1 * 10 = **10 volts** T4D08
- **What is the current flowing through a 100 ohm resistor connected across 200 volts?**
  - **I = E / R** I = 200 / 100 = **2 amperes** T4D10

Ohm's Law Examples

- **What is the voltage across the resistor if a current of 2 ampere flows through a 10 ohm resistor?**
  - **V = I*R** V = 2 * 10 = **20 volts** T4D09
- **What is the current flowing through a 24 ohm resistor connected across 240 volts?**
  - **I = E / R** I = 240 / 24 = **10 amperes** T4D11

Moving Electrons Doing Something Useful

- Anytime energy is expended to do something - work is performed
- When moving electrons do some work, power is consumed
- The unit used to describe electrical *power* is the **Watt.**

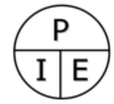
T4A02, T4E01

Power Formula

- Power is the product of voltage and current.
  - P = E x I
  - E = P / I
  - I = P / R

T4E02

Power Formula Examples



- **How much power is represented by a voltage of 13.8 volts and a current of 10 amperes?**
  - **P = E * I** P = 13.8 * 10 = **138 watts** T4E03
- **How much power is being used in a circuit when the voltage is 120 volts DC and the current is 2.5 amperes?**
  - **P = E * I** P = 120 * 2.5 = **300 watts** T4E04
- **How many amperes are flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts?**
  - **I = P / E** I = 1200 / 120 = **10 amperes** T4E06

Power Formula, cont.

- You can determine how many watts are being drawn [consumed] by your transceiver when you are transmitting by measuring the DC voltage **at** the transceiver and multiplying by the current drawn when you transmit.

T4E05

Two Basic Kinds of Current

- When current flows in only one direction, it is called Direct Current (DC)
  - Batteries are a common source of DC
- When current flows alternatively in one direction than in the opposite direction, it is called Alternating Current (AC)
  - Your household current is AC

T4A04, T4A08

DC and AC

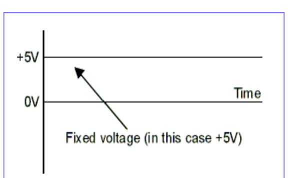


Figure 2: A DC Waveform

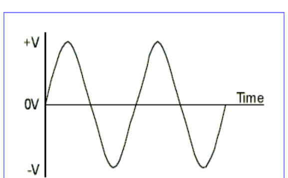


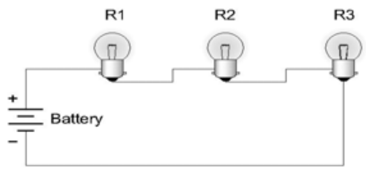
Figure 1: An AC Waveform

The Electric Circuit-Electronic Roadmap

- For current to flow, there must be a path from one side of the source of the current to the other side of the source – this path is called a circuit
  - There must be a hose (conductive path) through which the water (current) to flow

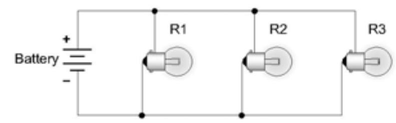
Series Circuits

- Series circuits provide one and only one path for current flow



Parallel Circuits

- Parallel circuits provide alternative paths for current flow



Short and Open Circuits

- When there is an unintentional current path that by-passes areas of the circuit – this is a short circuit condition
- When the current path is broken so that there is a gap that the electrons can not jump – this is an open circuit condition

Units & Components

Dealing with Very Big and Very Small Numeric Values

- In electronics we deal with incredibly large and incredibly small numbers
- The international metric system allows for short hand dealing with the range of values

Prefixes

Metric	**Exponent**	**English**
Tera	10^{12}	Trillion
Giga	10^{9}	Billion
Mega	10^{6}	**Million**
Kilo	10^{3}	**Thousand**
Centi	10^{-2}	Hundredth
Milli	10^{-3}	**Thousandth**
Micro	10^{-6}	**Millionth**
Nano	10^{-9}	Billionth
Pico	10^{-12}	Trillionth

Why Metric Prefixes?

- Standard prefixes for all measurements
- Larger or smaller quantities expressed by multiplying or dividing the basic unit by factors of 10…(10, 100, 1000, 10,000…)
- Simply move the decimal point to the left or right the appropriate number of places!

Scientific Notation

1,000,000,000.	10^{9}	GIGA
1,000,000.	$\mathbf{10^{6}}$	**MEGA**
1,000.	$\mathbf{10^{3}}$	**KILO**
1.	$\mathbf{10^{0}}$	**UNIT**
.01	10^{-2}	CENTI
.001	$\mathbf{10^{-3}}$	**MILLI**
.000001	$\mathbf{10^{-6}}$	**MICRO**
.00000001	10^{-9}	NANO
.000000000001	10^{-12}	PICO

Prefixes Revisited

- System is based on powers of 10.
- We are interested in steps of 1,000.
- Each "step" is 1,000 larger or smaller.

Mega	kilo	Base Unit	milli	micro
10^{6}	10^{3}	Volts, Amps, Hertz, Watts, Ohms	10^{-3}	10^{-6}
1,000,000	1,000		0.001	0.000001

Working with the Prefixes

- Identify the movement from the **known** to the **unknown**.
- If you move to the left in the diagram, move the decimal to the left.
- If you move to the right in the diagram, move the decimal to the right.

Mega	kilo	Base Unit	milli	micro
10^{6}	10^{3}	Volts, Amps, Hertz, Watts, Ohms	10^{-3}	10^{-6}
1,000,000	1,000		0.001	0.000001

Example 1

How many milliamperes is the same as 1.5 amperes? T4E07

- 1.5 amps = ?? milli-amps
- Moving from the **base unit** to milli, or to the right.
- Move the decimal place 1 step (3 places) to the right.
- 1.500 A = 1,500. mA

Mega	kilo	Base Unit	milli	micro
10^{6}	10^{3}	Volts, Amps, Hertz, Watts, Ohms	10^{-3}	10^{-6}
1,000,000	1,000		0.001	0.000001

Example 2

How many **kilo**hertz are in 1,500,000 **Hertz**? T4E08

- 1,500,000 hertz = ?? **Kilo**hertz
- Moving from the **base unit** to **Kilo**, or to the left.
- Move the decimal place 1 step (3 places) to the left.
- 1,500,000 Hz = 1,500.000 KHz

Mega	kilo	Base Unit	milli	micro
10^{6}	10^{3}	Volts, Amps, Hertz, Watts, Ohms	10^{-3}	10^{-6}
1,000,000	1,000		0.001	0.000001

Example 3

How many volts are equal to one **kilo**volt? T4E09

- 1 **Kilo**volt = ?? volts
- Moving from **Kilo** to the base unit, or to the right.
- Move the decimal place 1 step (3 places) to the right.
- 1.000 KV = 1,000. V

Mega	kilo	Base Unit	milli	micro
10^6	10^3	Volts, Amps, Hertz, Watts, Ohms	10^{-3}	10^{-6}
1,000,000	1,000		0.001	0.000001

Example 4

How many volts are equal to one **micro**volt? T4E10

- 1 **micro**-volt = ?? volts
- Moving from **micro** to the base unit, or to the left.
- Move the decimal place 2 steps (6 places) to the left.
- 000 000 1. µV = 0.000 001 V

Mega	kilo	Base Unit	milli	micro
10^6	10^3	Volts, Amps, Hertz, Watts, Ohms	10^{-3}	10^{-6}
1,000,000	1,000		0.001	0.000001

Example 5

If you have a hand-held transceiver with an output of 500 **milli**watts, how many watts would this be? T4E11

- 500 **milli**watts = ?? watts
- Moving from **milli** to the base unit, or to the left.
- Move the decimal place 1 steps (3 places) to the left.
- 500. milliwatts = 0.5 watts

Mega	kilo	Base Unit	milli	micro
10^6	10^3	Volts, Amps, Hertz, Watts, Ohms	10^{-3}	10^{-6}
1,000,000	1,000		0.001	0.000001

The Decibel

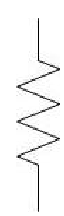
- In electronics, the decibel (dB) is used as a comparison of power, voltage and current levels.
- dB = 10*log (power ratio)
- dB = 20*log (voltage or current ratio)
- Positive dB values means the ratio is >1
- Negative dB values means the ratio is <1

Electronics Controlling the Flow of Current

- To make an electronic device (like a radio) do something useful (like a receiver), we need to control and manipulate the flow of current
- There are a number of different electronic components that we use to do this

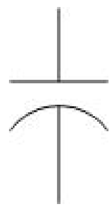
The Resistor

- The function of the resistor is to restrict (limit) the flow of current through it



The Capacitor

- The function of the capacitor is to temporarily store electric current
  - Like a very temporary storage battery
  - Store energy in an electrostatic field
- Circuit Symbol

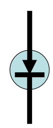


The Inductor

- The function of the inductor is to temporarily store electric current
  - Is basically a coil of wire
  - Stores energy in a magnetic field
- Circuit Symbol

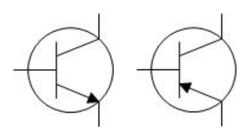
Diodes

- Diodes allow current to flow in only one direction.
- The diode changes an alternating current signal into a varying direct current signal. The diode will rectify an AC signal so diodes are sometimes called rectifiers.
- Circuit Symbol



The Transistor

- The function of the transistor is to variably control the flow of current
  - Much like an electronically controlled valve
  - An analogy, the faucet in your sinks
- Circuit Symbol



The Integrated Circuit

- The Integrated circuit is a collection of components contained in one device that accomplishes a specific task
  - Acts like a “black-box”

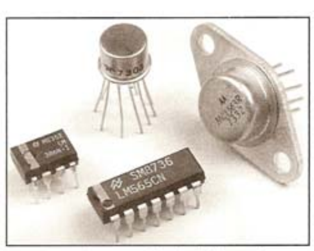
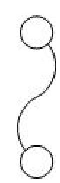


Figure 7.21 — Integrated circuits (ICs) come in a variety of package styles.

Protective Components – Intentional Open Circuits

- Fuse and circuit breakers are designed to interrupt the flow of current if the current becomes excessive or uncontrolled
  - Fuses blow – one time protection
  - Circuit breaker trip – can be reset and reused
- Using a larger value fuse to replace a blown fuse can cause damage to the equipment or start a fire.



T0A04, T0A05

Power Supplies
&
Batteries

Power Supply

- Most modern radios operate on 12 volts direct current (DC)
- Household current is 120 volts AC
- A *power supply* converts household current to the type of current and the correct voltage to operate your station
  - Could be internal, might be external

T4C04

Power Supply Ratings Voltage and Current

- Continuous duty – how much current can be supplied over the long term
- Intermittent duty – how much surge current can be supplied over the short term
- Regulation – how well the power supply can handle rapid current changes

Power Supplies

- *Regulated power supplies* are the best power sources for radios because the output voltage changes very little when the output current changes. T5A05

Types of Power Supplies

- Linear
  - Transformers
  - Heavy (physically)
  - Heavy duty current
  - Expensive
- Switching
  - Electronics instead of transformers
  - Light weight and small
  - Not as robust
  - Less expensive

Generators & Inverters

- Used for portable and emergency operation.
- A generator turns energy from an engine into AC or DC power.
- An inverter turns DC power into AC power.
- Make sure the power rating is high enough for the equipment being used.

Batteries

- A chemical reaction in a battery is used to generate current.
- Three types of batteries:
  - Disposables – use them up one time and then must be discarded.
  - Rechargeables – chemical reaction can be reversed, recharging the battery.
  - Storage Batteries – rechargeable batteries used for long term energy storage.
- Power capabilities rated in Ampere-hours
  - Amps X time

Batteries – cont.

- Rechargeable battery packs for handheld radios are available with several different types of internal batteries:
  - **Ni-Cad (Nickel-Cadnium)**
  - **Ni-MH (Nickel-Metal Hydride)**
  - **Li-ion (Lithium-ion)**
- For a given size of battery pack, Li-ion has the highest energy capacity, followed by Ni-MH and Ni-Cad. T4C06
- The higher the energy capacity, the longer the battery pack will last.
- Disposable alkaline batteries have about the same energy capacity as Ni-MH rechargeables.
- Alkaline and Carbon-Zinc batteries are not designed to be recharged. T4C08

Batteries – cont.

- Nominal full charge voltage:

– AAA, AA, C, D Alkaline	1.5V	
– 9V Alkaline	9.0V	
– AA Carbon-Zinc	1.5V	
– ***AA Ni-Cad***	***1.2V***	T4C07
– 9V Ni-Cad	9.0V (8.4V)	
– AA Ni-MH	1.2V	
– 9V Ni-MH	9.0V (8.4V)	
– AA Li-ion	3.3 – 3.6V	
– Coin Cells Li-ion	3.0 – 3.3V	

Batteries – cont.

- To get the most energy from a battery, limit the amount of current drawn from it. T4C10
- To maximize battery life and capacity:
  - Store them in a cool, dry place
  - Regularly inspect batteries for damage or leakage
  - Give them an occasional (minimum of once every 6 months) maintenance charge

T4C09

Storage Batteries

- A conventional 12-volt storage battery: T0A10
  - It contains dangerous acid that can spill and cause injury.
  - Short circuits can damage wiring and possibly cause a fire.
  - Explosive gas can collect if not properly vented.
- If a storage battery is charged or discharged too quickly, the battery could overheat and give off dangerous gas or explode. T0A11
- A car battery is a storage battery and usually supplies 12 volts. T4A06

Next Time

- Signals and Waves
- Antennas and Feed Lines
- Propagation
- Read Sections 2.4, 2.5, 2.6