Technician Licensing Class
Introduction

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Special thanks to K3DIO
The Plano Amateur Radio Klub (TX)
Some of this material comes from them
Electronic Fundamentals

- Terms and types
- Measuring, Power and Math
- Electronic components
- Electrical Safety
Electricity Terms

- **Voltage (V)**
  - How much “energy potential” there is
  - Similar to the height of a waterfall
  - Measured in “Volts”
  - *electromotive force (EMF) that causes electron flow*

- **Current (I)**
  - How much is *flowing*
  - Similar to the size of a waterfall
  - Measured in “Amps”
Types of Electricity

- **Direct Current (DC)**
  - Electrons flow from negative to positive
  - E.G. Batteries
  - Subject to voltage loss over distance
  - All electronics use DC internally

- **Alternating Current (AC)**
  - Electrons *reverse directions* (cycle)
  - E.g. U.S. Home Wall Sockets: 110V
  - Less prone to voltage loss over distance
  - Must be converted to DC for most usage
AC vs DC

Amplitude: the “peak” of the high and low cycles
Measuring Electricity

• **DC**
  • Is measured as a linear value
  • It doesn't change, so it's easy

• **AC**
  • The voltage/current constantly rise and fall
  • Normally measured by average amplitude
  • How fast it alternates is measured in time
    • “Hertz”: How many cycles per second
Power

- Power measures the energy
  - **Rate at which electrical energy is used**
  - Multiplication of:
    - How much current is flowing
    - How many volts
  - \( P = I \times V \)
    - Power = Current * Voltage
- Measured in “**Watts**”
Power = Voltage times Current

Low Voltage, High Current
(small height, lots of water)

High Voltage, Low Current
(big height, little water)

Power of both: Low!
Power = Voltage times Current

Lots of Voltage!
Lots of Current!

High Power!
Easy to Remember Helpers

- \( P = I \times E \)
- \( P = I \times I \times R \)
- \( P = E \times E / R \)
- Drawn in everyone-loves-pie order!
Test Time

• How much power is being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes?

• How much power is being used in a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes?

• How many amperes are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts?
Measuring Power: decibels

- Power difference is measured in “dB”
  - Logarithmic scale
  - 3dB = ~2x power
  - 6dB = ~4x power
  - 10dB = 10x power
  - 20dB = 100x power
  - 30dB = 1000x power

- Only makes sense with a reference!

- What is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts?
Circuit Schematics

- A circuit schematic **accurately** shows
  - how components are **interconnected**

- Symbols in a schematic
  - **Represent electrical components**
  - Sort of standardized, with differences
    - *U.S. symbols are sometimes slightly different*
  - **You need to know the symbols!**
Conductors and Insulators

- **Conductors:**
  - Very Low resistance (near 0)
  - Most metals (copper, gold!, aluminum)

- **Insulators:**
  - Very high resistance (near infinity)
  - Glass, ceramics, plastic, rubber
Switch

- Connects and disconnects circuits

Types
- Poles: how many circuit connections
- Throws: How many physical positions

Relay
- Switch controlled by an electromagnet

Symbol:

[Image of a single pole, single throw switch]
Fuse

- Protects a circuit from current overloads
  - Don't install a bigger fuse in place of a smaller one, excess current can cause fire
- All 110 AC should have a fuse
- Either breaks, or is resetable
- Symbol:
Resistance – Resistor

- Measures how “opposed” electricity is from flowing through an object
  - **Volume controls** are adjustable resistors!
  - **Potentiometer**: adjustable resistor
- Measured in “Ohms”
- Similar to small vs large water pipes
- \( V = I \times R \)
  - “Ohms Law”
- Symbol:
Easy to Remember Helpers

• $E = I \times R$
  • (Some use 'E', some use 'V')
  • Drawn in alphabetical order!
Test Time

- What formula is used to calculate resistance in a circuit?
- What is the resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts?
- What is the resistance in a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?
- What is the resistance of a circuit that draws 4 amperes from a 12-volt source?

9 questions like this!!!
- You will get one!
Capacitance – Capacitor

- Stores energy in an electric field
- Measured in “Farad”s
- 2 electric surfaces
  - With a good insulator between them
- “Schematic Symbols”:
Inductance – Inductor

- Stores energy in a magnetic field
- Measured in “Henry”s
- Built with a coil of wire
- Symbols:
Inductors and Capacitors

- Work wonders together
  - Tune a circuit to a frequency
Diode

- A “one way valve”
  - Current can **flow in only one direction**
- Two electrodes (connectors)
  - Anode and cathode
  - **Cathode lead: identified by a stripe**
- “Light Emitting Diode”
  - LED
  - A “visual indicator”
- Symbol:
Lamp

- A light. Big or small.
Transistor

- Controls current flow through it
  - Is controlled by voltage on a third pin
- Can amplify signals: “Gain”
- Can be used as an electronic switch
- Types:
  - Field Effect Transistor (FET)
    - Has a gate electrode
  - Bipolar junction transistor
    - Made with three layers of a semiconductor
    - Has an emitter electrode
Transistor

[Diagram of a transistor with labels B, C, and E]
Transformer

- Transfers energy between two circuits
  - Uses electromagnetic conduction
  - Can be used to **change voltages**
  - Wire wrapped around a common core

- Symbol:
Antenna

- We'll talk much much more about this
- Symbol:
Sources of Power

- Power supplies
  - Deliver AC power at 110V or 220V
- Batteries
  - AA, AAA batteries: ~1.5V
  - Car batteries: ~12V
- Generators
- Solar cells
- Wind
- ...
Batteries

- Symbol

\[\text{\textbullet} \quad \text{Symbol}\]

\[\text{\textbullet} \quad \text{Symbol}\]

\[\text{\textbullet} \quad \text{Symbol}\]
## Batteries

<table>
<thead>
<tr>
<th>Type</th>
<th>Rechargable?</th>
<th>Nominal Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline</td>
<td>N</td>
<td>1.5V</td>
</tr>
<tr>
<td>Carbon-Zinc</td>
<td>N</td>
<td>1.2V</td>
</tr>
<tr>
<td>Nickel-cadmium (NiCad)</td>
<td>Y</td>
<td><strong>1.2V</strong></td>
</tr>
<tr>
<td>Lithium Ion</td>
<td>Y</td>
<td>3.6V</td>
</tr>
</tbody>
</table>
Equipment

A **Power Supply** is the device used to convert the alternating current from a wall outlet into low-voltage direct current.

An **RF Power Amplifier** is a device used to increase the output of a 10 watt radio to 100 watts.
A **Lithium-ion battery** offers the longest life when used with a hand-held radio, when comparing battery types of the same physical size.

Recharge your **12-volt battery with your car** if the power is out.

Conventional 12 volt batteries **need venting: explosive gasses can build up**.
Battery Care

• In order to keep rechargeable batteries in good condition and ready for emergencies:
  • They must be inspected for physical damage and replaced if necessary
  • They should be stored in a cool and dry location
  • They must be given a maintenance recharge at least every 6 months
• The best way to get the most amount of energy from a battery is to draw current from the battery at the slowest rate needed.
Measuring Electricity

- Displaying signal strength
  - Numerically: A “meter”
- Measuring voltage (EM force)
  - A voltmeter
- Measuring current
  - A ammeter
- Measuring Resistance
  - An ohmmeter or potentiometer
- A multi-meter does all 3
Measuring Electricity: multi-meters

Be sure it is set properly to read what is being measured.

If it is set to the resistance setting and voltage is measured the meter could be damaged!

Ensure the circuit is operating at the correct frequency when measuring resistance!
Measuring Voltage

- Measured between two points
- Can be done without changing the circuit
- Connect in parallel
Measuring Current

- To measure current you MUST interrupt the circuit to put the meter between two points
  - It becomes part of the circuit
  - **Connect in series**
Measuring Resistance

- Measures across the resistor
  - Puts voltage across it
  - Measures the current through it
  - If the resistance changes,
    - The circuit containing a capacitor
    - i.e. the voltage is getting stored in the capacitor slowly until it's full
Circuits – Connecting it all together

- Previous slides were about “parts”
- Circuits connect components together
  - Integrated circuits **combine several components together** into one package
  - Motherboards, etc
- Larger parts are soldered together or to a circuit board
  - A **rosin-core** solder is best to use
  - “**cold**” solder joints are **grainy or dull**
Electricity Safety

• Power supplies have charge when turned off
  • Capacitors hold charge for a while

• To prevent electric shock
  • Use 3-wire cords for all AC equipment
  • Connect station equipment to a common ground
  • Use a ground-fault interrupter
Electricity Safety

• Current kills more than voltage
  • (but they're related, obviously)
• Heats tissue
• Disrupts electrical functions in the cells
• Involuntary muscle contractions

• Lowest safe current
  • Only 100 milliamps!!

• Lowest shock voltage
  • 30 volts

• Green wire of a 3-wire cord is ground
Electrical Safety

- In a three wire AC electrical line:
  - Black is HOT
  - White is NEUTRAL
  - Green is Chassis Ground

Breaker box Service Disconnect on left.
Lightening Safety

• To protect equipment against lightning
  • **Ground everything to a common plate**

• To protect you:
  • **Disconnect the antenna cables from your station and move them away from your radio equipment**
  • Unplug all power cords from AC outlets
  • Stop using your radio equipment and move to another room until the storm passes

• If you hear it, it can harm your radio!
Grounding

Low-impedance conductor, as short as possible

Three-wire grounded power outlets connected to grounded house electrical system

6’ to 8’

Ground bus (1/2” copper pipe)

Hose clamp

Braid to equipment (see text)

External

Inside
Grounding

- Lightening grounding vs RF grounding
  - Lightening grounding:
    - for protection
  - RF grounding:
    - For better transmissions / reception
    - For shock safety
    - **Flat Strap** ground cable is best
Questions?