# Amateur Radio Technician Class Training (Question Pool July 2018 – June 2022)

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Based on the No-Nonsense Technician Class Study Guide by Dan Romanchik, KB6NU

Updates by Rebecca Mercuri, Ph.D., K3RPM

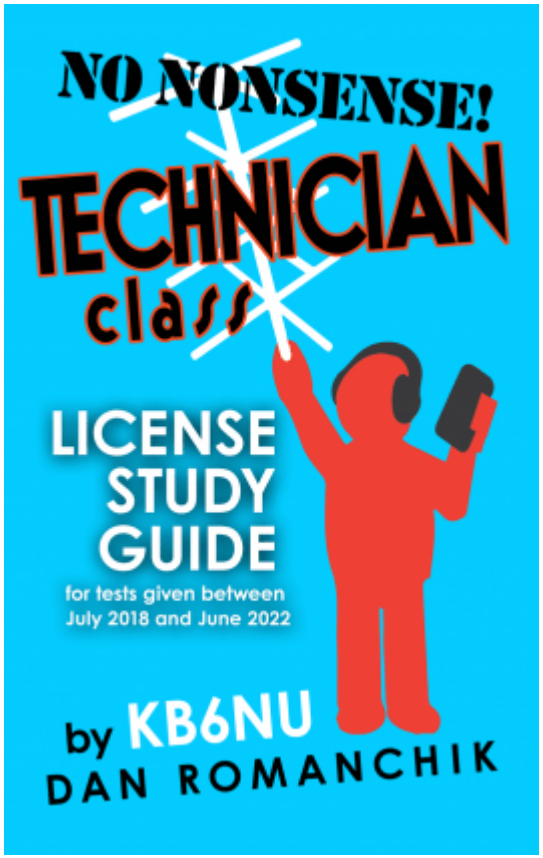


# Welcome to Session 4

Any Questions Before We Start?

# Agenda

- Introduction
- Electrical Principles (EP)
- Electronic Components and Circuits (ECCD)
- Radio Wave Characteristics (RWC)
- Antennas and Feed Lines (AFL)
- Amateur Radio Signals (ARS)
- **Electrical Safety (ES)**
- **Radio Practices and Station Setup (RPSS)**
- **Station Equipment (SE)**
- Operating Procedures (OP)
- Rules and Regulations (RR)



# Electrical Safety (ES)

- Hazards & Grounding
- Antenna & Tower Safety
- RF Hazards & Radiation

# Safety Concepts

- AC Power
- Hazardous Voltages
- Fuses
- Circuit Breakers
- Battery Safety
- Antennas & Towers
- Power Lines
- RF Safety

# General Electrical Safety

- Easy to come in contact with dangerous voltages
- **30 Volts** or more can result in dangerous shock
- **100mA** flowing through body can cause death

**How does current flowing in the body cause harm?**

*- Heating tissue*

*- Disrupts electrical function of cells*

*- Involuntary muscle contractions*

# AC Power Safety

- 3-wire outlets and plugs are safer than 2-wire
- 3rd wire is a **Safety Ground** (aka Equipment Ground)
- **Safety Ground** is often connected with a **green** wire
- Building or room outlets may not be properly grounded (check!)

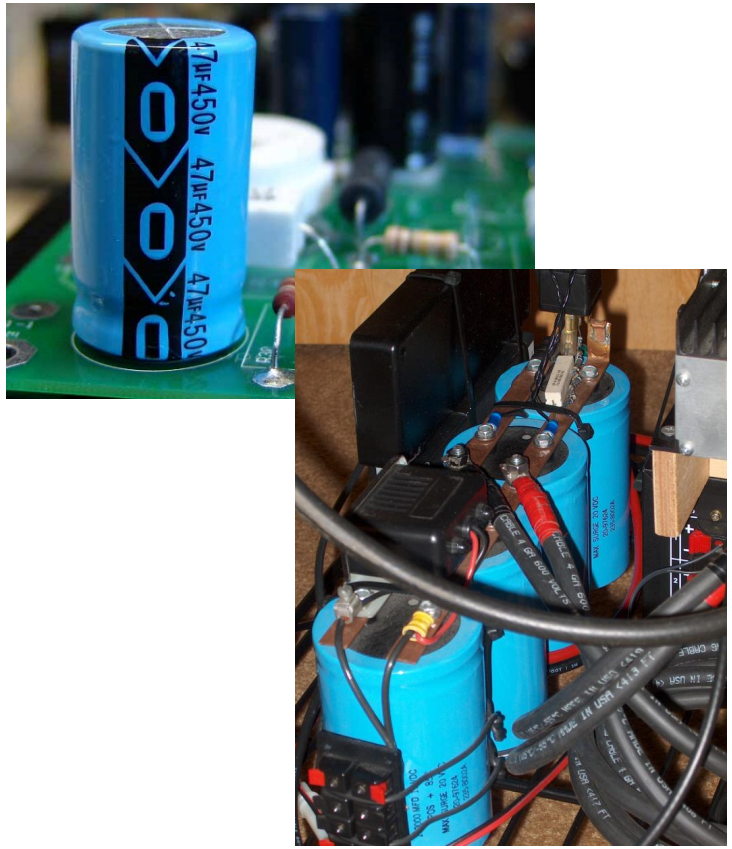
- Good ways to guard against electric shock:
  - *Use 3-wire cords & plugs for all AC eqpt.*
  - *Connect all AC powered eqpt. to a common safety ground*
  - *Use circuit protected by a ground-fault interrupter*

# Fuses & Circuit Breakers

- *Interrupts power* in case of an overload
- Always replace fuses with *same type and rating*
- Putting a 20A fuse in place of a 5A fuse can cause a *fire* from excessive current flow
- Always include fuse or circuit breaker in home-made equipment
- Fuses in 120V AC powered equipment are used in the "hot" lead.

# Working on Equipment

- Disconnect from power
- **Capacitors** in power supplies can *store charge and shock you* – **even when disconnected!!!**
- Work with one hand



# Battery Safety


- 12V Lead-Acid Battery Hazards

  Explosive gas can collect if not vented

  *Shorting terminals can cause burns, fire, explosion*

  If charged/discharged too quickly – can overheat and give off flammable gas or explode

- If power is out, re-charge 12V battery by connecting to car battery and running the engine (in a well ventilated area)

# Antenna Safety: Installation

- Look for and stay clear of overhead electrical wires
- Keep 10ft of clearance to power lines, even if the antenna should fall
- Never use a utility pole as a support

What's wrong in this picture?

# Antenna Placement

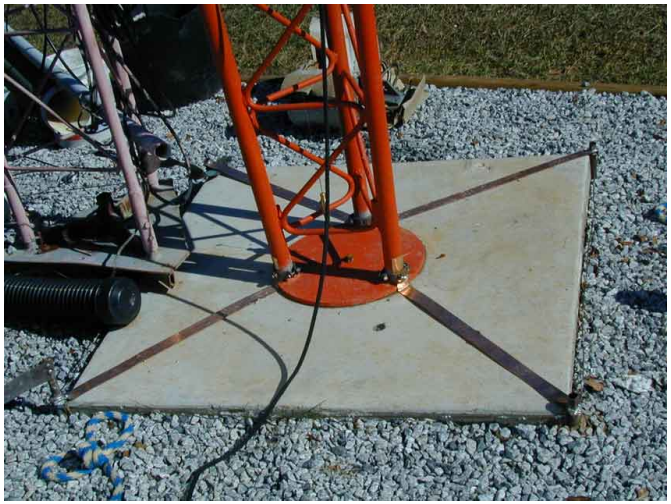
- Position antenna so no one can come in contact when transmitting
- RF burns can be painful and dangerous

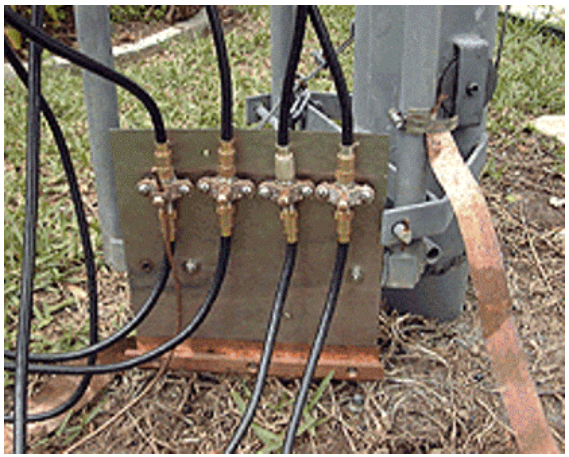
# Tower Work

- Use a **gin pole** to lift tower sections or antennas
- Always use **climbing harness**
- *Everyone* at the site wears **hard hat** and **safety glasses**
- ***Never climb alone***
- Crank-up towers must be fully *retracted* before climbing
- Use *safety wires* in turnbuckles to tension guy lines to prevent loosening

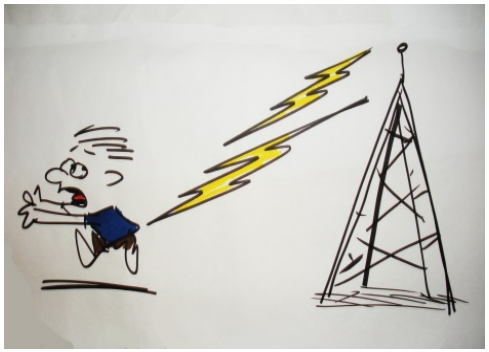
# Tower Grounding

- Very important – the tower is a *big lightning rod!*
- **Local electrical codes** should be consulted
- Separate 8’ ground rods per tower leg is good practice
- Bond all legs and rods together
- Short / direct connections
- Avoid sharp bends
- All feedline lightning protection devices should be mounted to a common plate and connected to an external ground





# RF Exposure



- When using high power:

  - you are *required* to perform an **RF Exposure evaluation**

  - even though VHF & UHF are **non-ionizing radiation** (ionizing radiation can cause genetic damage)

- On *VHF* you can run up to **50W PEP** at the antenna without performing an exposure evaluation

- RF Exposure Evaluation can be performed:

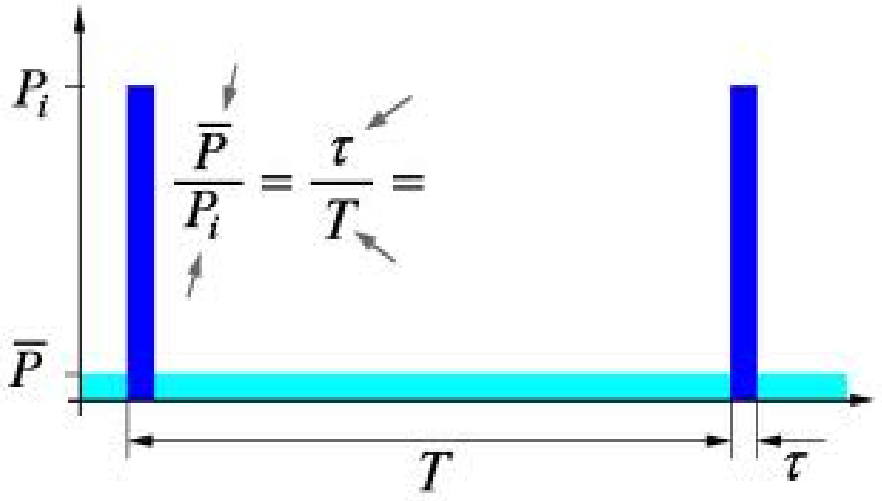
  - *Calculation based on FCC OET Bulletin 65*

  - *Calculation based on computer modeling*

  - *By measurement of field strength using calibrated equipment*

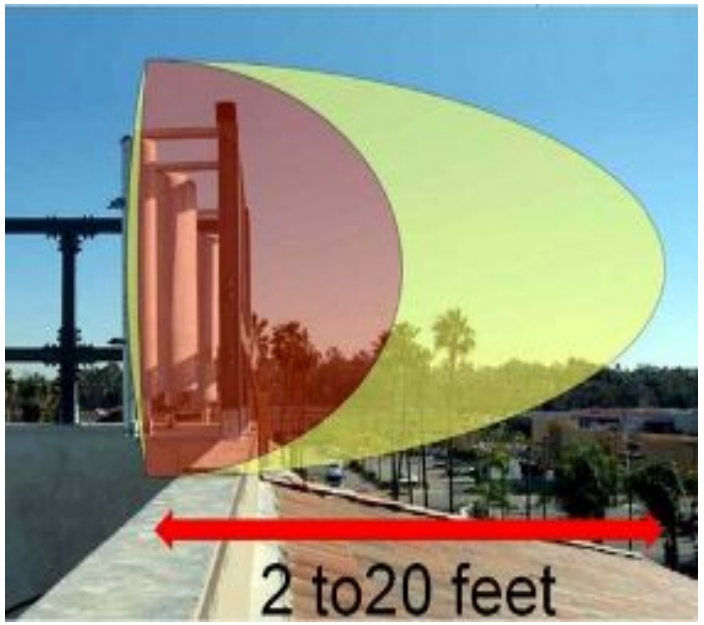
# RF Exposure: Duty Cycle

- Percentage of time the transmitter is transmitting
- **Duty Cycle** is factored into exposure because affects the *average exposure level*



# RF Exposure Limits

- Vary with Frequency
- The human body absorbs more energy at some frequencies than others
- The **50MHz** band has the *lowest* **Maximum Permitted Exposure Limit**




**Factors that Affect Exposure:**

- Frequency & Power level of RF Field
- Distance from antenna to person
- Radiation pattern of antenna

# Keeping Exposure Safe

- Relocate antennas
- Lower power levels
- Transmit less
- Re-evaluate if you make any changes in station or antenna setup

# Electrical Safety
# Chapter End

Questions?

Let's Practice for the Exam!

# Radio Practices & Station Setup (RPSS)

- Station Setup
- Operating Controls

# Radio Practices & Station Setup (RPSS)

- Station accessories
- Dealing with Interference
- Grounding
- Operating controls
- Station Equipment
- Troubleshooting
- Repair & Testing

# Station Accessories

- Power Supply
  - Use *heavy gauge wire* to avoid voltage drop that would prevent proper operation
  - Minimum current capacity:

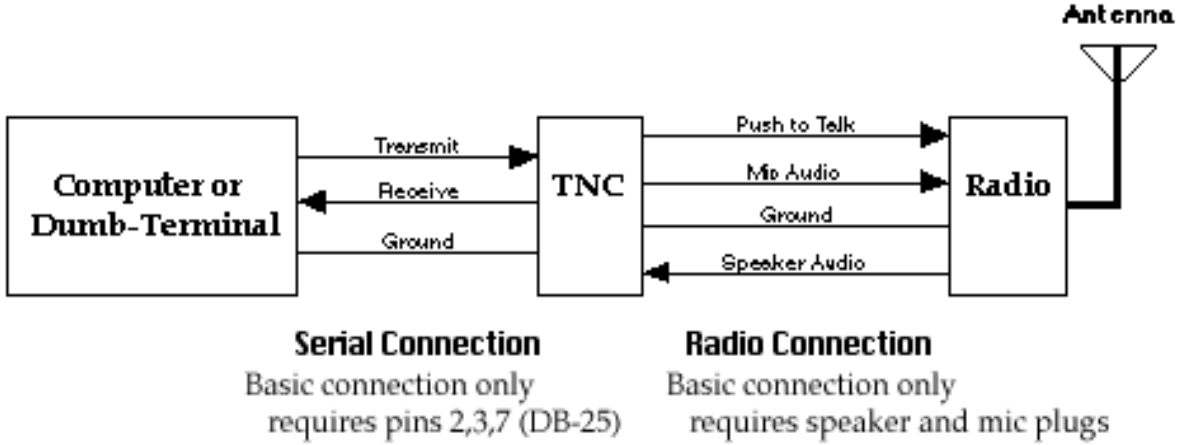
    Transmitter efficiency, receiver and control circuit power, regulation and heat dissipation


- Headphones
  - Helps copy in *noisy areas*
- Microphone
  - Rig connector includes push-to-talk and maybe power for mic

# Computer in the Hamshack

- Logging contacts
- Looking up info
- Sending and receiving CW
- Generating and decoding digital signals

# Digital Mode Accessories




- **Packet**
  - Terminal Node Controller (TNC)
  - Converts 1's and 0's to audio tones
- **RTTY or PSK31**, etc.
  - *Sound card* often performs TNC/modem function
  - Provides audio to microphone input, converts received audio to digital
  - Often an audio interface is used to adjust audio levels and provide some ground isolation

# Interference Killers

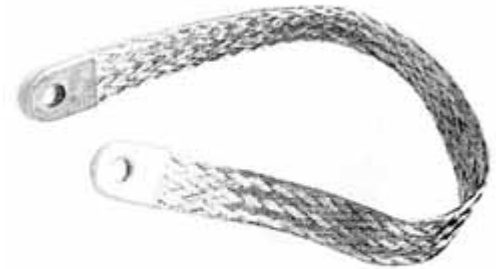
- Ferrite chokes
  - *Help eliminate stray RF from audio, power supply and other cables*
  - *Reduce RF flowing on shield of audio cables*
- Low Pass Filter
  - *Used between the transmitter and antenna to eliminate harmonic emissions*

# More Interference Killers

- TV Interference
  - *Band-Reject* filter at TV input
  - Helps prevent overload from nearby transmitter

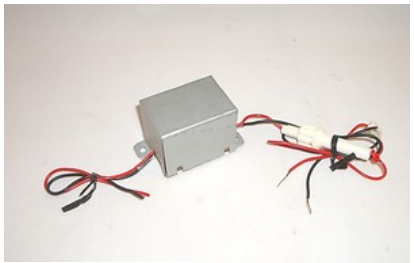
# Grounding helps too...

- Flat strap is best
- Connect all equipment to a common ground
- Car installations
  - Radio ground connection to chassis or engine block strap
  - Bond all grounds



# More Car Installation Tips

- Positive supply
  - Direct to battery
  - Unused fusebox terminal
- Alternator noise/whine
  - *Varies with RPM*
  - *Filters help*
- Ignition noise
  - *Pulsing/ticking*
  - *Noise Blanker helps*




# Operating Controls

**RIT**: *Receive Incremental Tuning* used to fine tune receive frequency (not transmit frequency). Sometimes called *Clarifier.* Helpful if a SSB signal is high or low pitched.

**AF**: Audio Frequency gain – just a fancy name for Volume control

**AGC**: Keeps received audio relatively constant


Sets RF power output

**Microphone Gain**: *too high and your signal will be distorted*

Adjusts Receiver gain

**Squelch**: *mutes the receiver when no signal is being received. Don't set it too high, or you'll miss weak signals!*

# Operating Controls (cont'd)

HF Transceivers often have a selection of filters which *permits noise or interference reduction by selecting a filter bandwidth that matches the mode.*

*Examples:*

**2400Hz for SSB**

**500Hz for CW**

**Operating Frequency** is set by *VFO knob or keypad entry*

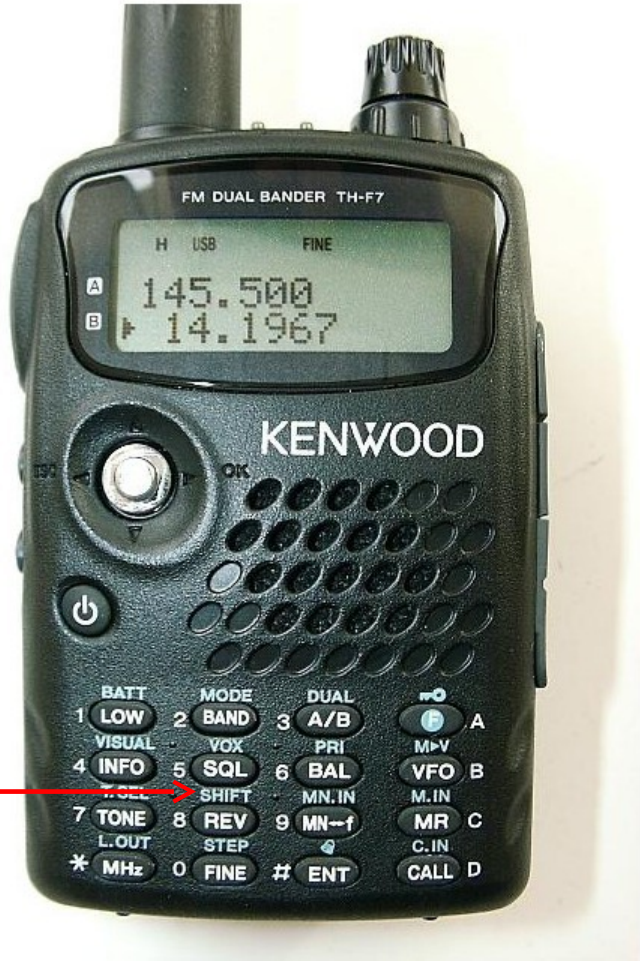
*Favorite frequencies can be stored in a memory channel for easy access*

# Operating Controls

**Offset Frequency**: *the difference between a repeater's transmit and receive frequencies*

The transceiver's offset is set by an Offset or Shift control.

The REVerse control toggles between transmit and receive frequencies



# Radio Practices & Station Setup
# Chapter End

Questions?

Let's Practice for the Exam!

# Station Equipment (SE)

- Receivers, Transmitters, Amplifiers
- Tx & Rx Problems
- Basic Repair & Testing

# Station Equipment

- Most basic pieces are **transmitter** & **receiver**
- When in one unit it is called a **transceiver**
- Antenna is (automatically) switched between transmitter and receiver

# RF Power Amplifier

- *Used to increase RF output* from a low power device, such as *handheld*
- *SSB/CW-FM* switch sets up the amplifier for the appropriate mode
- Fins are for heat dispersion

# Receiver Details


- Most important specs:
  - **Sensitivity**

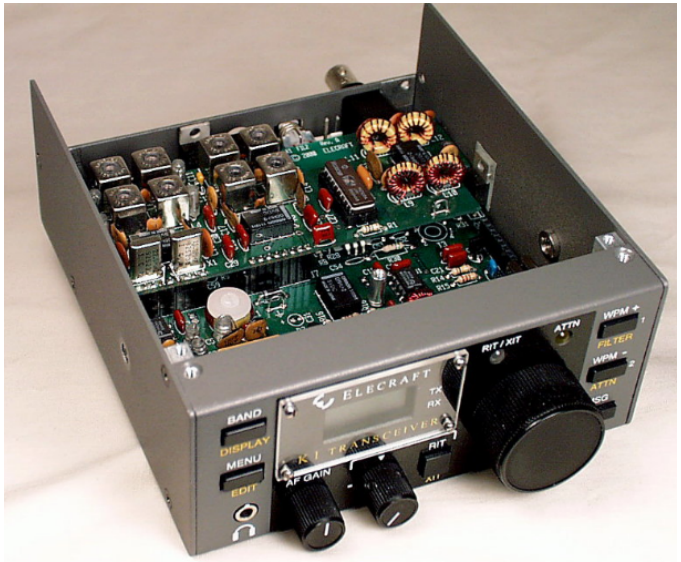
    *Ability to detect a weak signal*
  - **Selectivity**

    *Ability to discriminate between multiple signals*
- **Preamplifier**
  - Helps weak signal reception

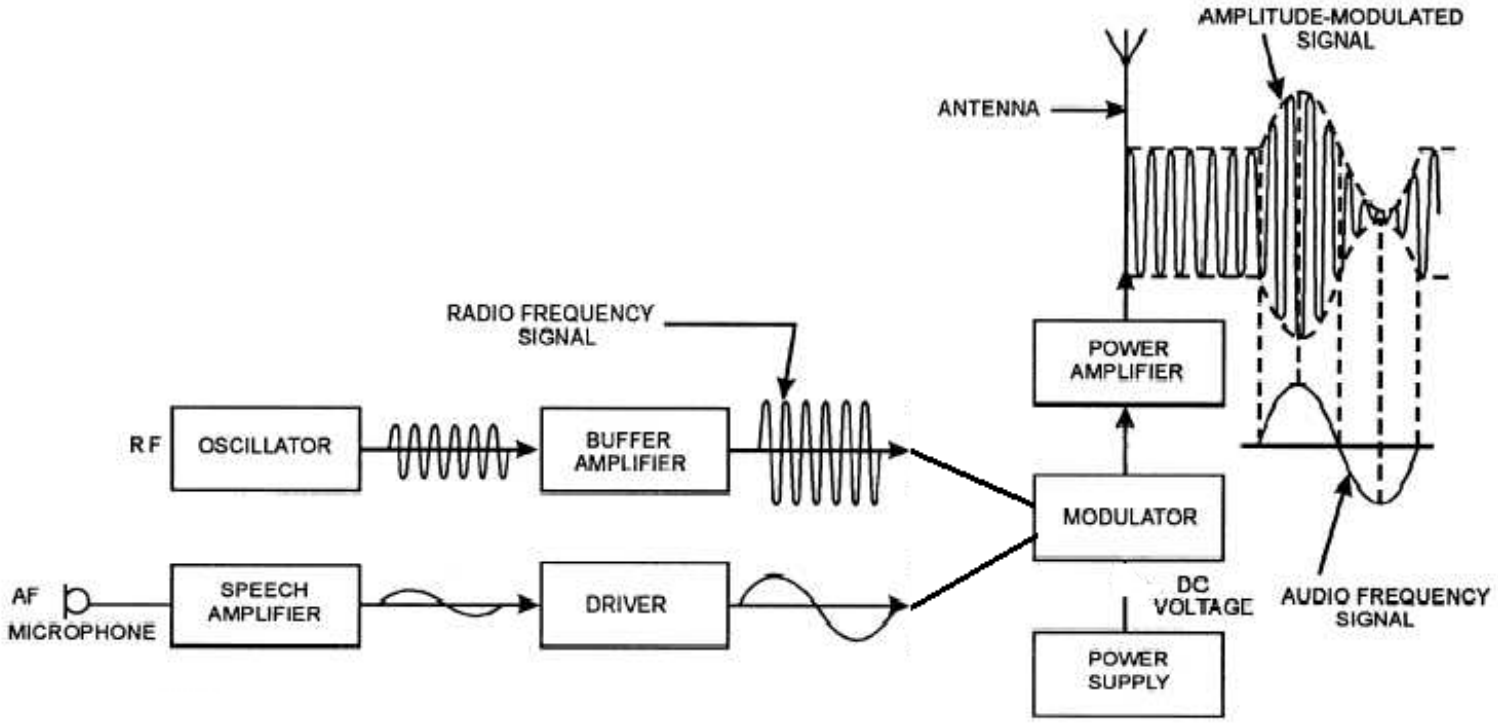
    *Installed between antenna and receiver*

# Transceiver Internals

- **Mixer**
  - *Converts radio signal from one frequency to another*
- **Oscillator**
  - *Circuit that generates a signal at a specific frequency*
- **Modulator**
  - *Combines speech (or other signals) with an RF carrier*
  - *Often a type of mixer*



# Transmitter Functions




- Voice modes like *SSB* and *FM* need a modulator
- A **modulator** *combines the RF carrier and the audio/speech signal*

# Transverter

*Used to operate on a frequency for which a radio was not designed*

A **transverter** is a device that, for example, can take the output of a low-powered 28MHz SSB exciter and produces a 222MHz output signal

It also could convert an incoming 222MHz signal to a 28MHz signal for the receiver

# Some VHF & UHF Info...

- Most operation uses FM and Repeaters
- CW and SSB is also popular – often weak signals
- *The device most useful for VHF weak signal communications is a **multi-mode VHF transceiver***
- Handheld transceivers (HTs) have low power transmitters (5W or less), which limits range
- *The device that increases the low-power output from a handheld transceiver is an **RF power amplifier***

# Troubleshooting Common Problems

- Overload
- Distortion
- Feedback
- Interference

- **What can cause radio frequency interference?**
  - *Fundamental overload*
  - *Harmonics*
  - *Spurious emissions*
- Any of these can cause radio or TV interference

*If someone tells you that your transmissions are causing interference, you should first* ***make sure that your station is functioning properly and not causing interference to your own TV and radio***

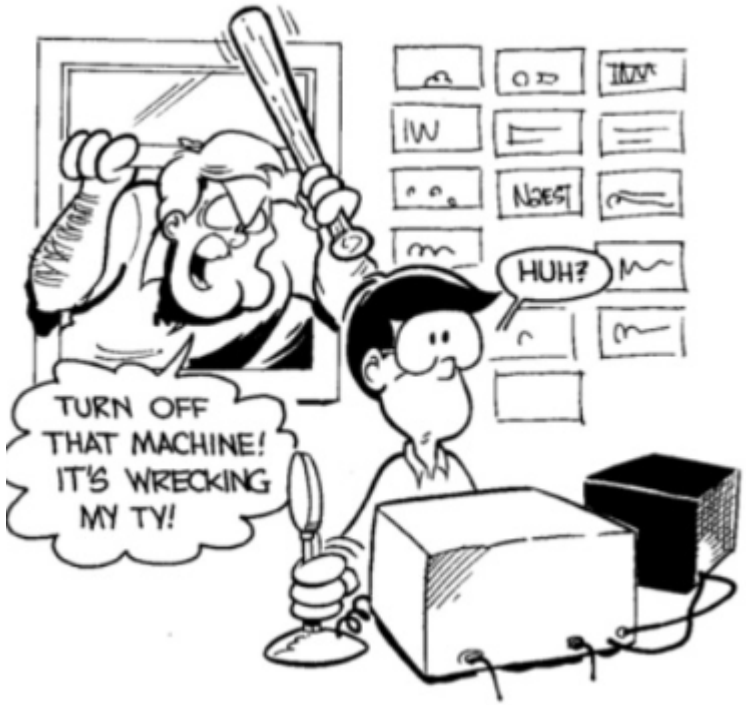
# Telephone Interference

Unprotected Telephone

- Telephones often experience interference
- *Most likely cause of interference to a non-cordless phone from a nearby transmitter is that the* ***telephone is acting like a radio receiver***
- Logical first step to cure radio interference on a telephone *is to install an RF filter at the telephone*

# Broadcast AM FM TV Interference

- Caused by receiver being unable to reject strong out-of-band signals
- Eliminate by installing a filter to block the amateur signal



# Addressing Interference

- Useful ways to cure RF interference:
  - *Make sure all TV coaxial connectors are installed properly*
  - *Snap-on ferrite chokes*
  - *Low-pass and high-pass filters*
  - *Band-reject and band-pass filters*
- **Fundamental Overload** *is interference caused by very strong signals injected into a receiver*

# Part 15 Devices

This device complies with part 15 of FCC Rules. Operation is subject to the following two conditions; (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

- If a neighbor's device is causing interference with your equipment:
  - *Work with them to identify offending device*
  - *Politely inform them about the rules that require them to stop using the device if it causes interference*
  - *Check your station to ensure it meets standards of good amateur practice*

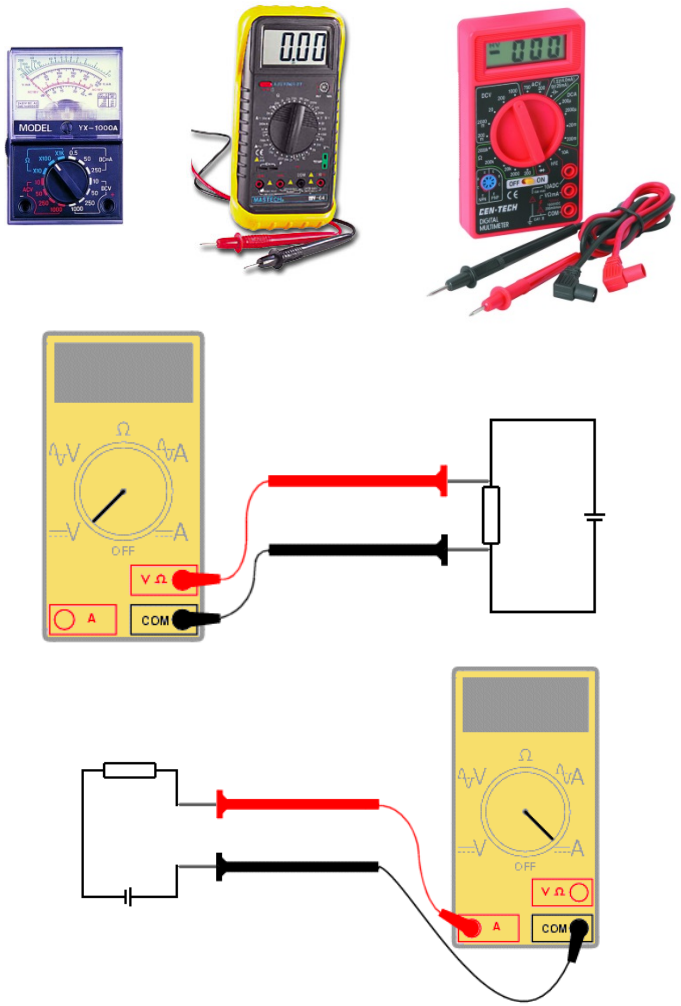
# Common Problems

- **Distorted / Noisy Audio**
  - *Transmitter might be slightly off frequency*
  - *Batteries might be running low*
  - *You might be in a bad location*
- **Noise in digital transmissions causes bit errors**
  - **BER**: *Bit error rate, the rate at which errors are occurring*
- **High pitched whine**
  - *Noise from vehicle's electrical system, usually alternator*

- **Garbled, Distorted or Unintelligible Transmission**
  - *RF Feedback*
  - Over-deviation on FM
  - *Back off the mic*

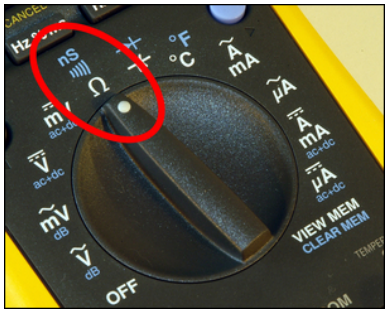
# Using a Multimeter or DMM

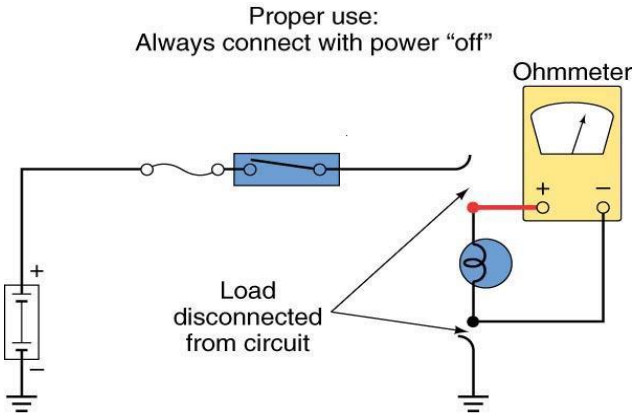
- **Multimeter** = voltmeter, ohmmeter and ammeter
- **DMM** = digital multimeter
- Measuring **voltage** and **resistance** are *common*
- *To measure **voltage**, the voltmeter is placed in parallel with the circuit*
- *Make sure that the voltmeter leads are rated for the voltage you are measuring*
- *To measure **current**, the ammeter is placed in series with the circuit*

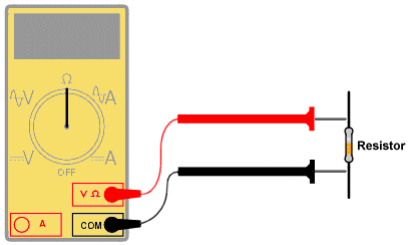


# Measuring Resistance

- **Ohmmeter** is used to measure *resistance*
- *Make sure the circuit is <u>not</u> powered*
- *Attempting to measure a <u>voltage</u> on the <u>resistance</u> setting might damage the meter*
- *When measuring **resistance**, an initial low reading that **slowly increases** means that the circuit contains a large capacitor*

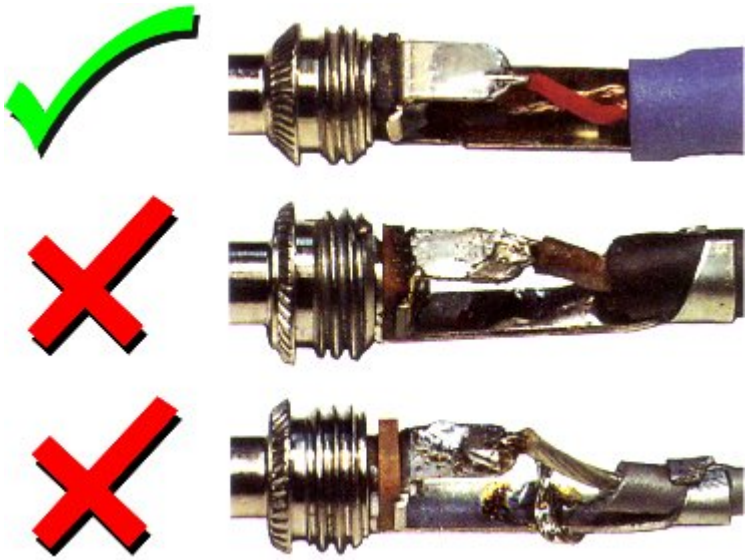


# Soldering

- Good skill to have!
- ***Rosin-core solder*** *is best for radio and electronic use*
- Good "**joints**" should be smooth and shiny
- ***Dull*** *or* ***grainy*** *surface is the characteristic appearance of a "**cold**" solder joint*
- *Let the solder **flow**!*



# Station Equipment
# Chapter End

Questions?

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