Technician Class Course

Session 8

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RADIO WAVE PROPAGATION

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Radio Wave Propagation: Getting from Point A to Point B

- Radio waves propagate by many mechanisms.
  - The science of wave propagation has many facets.
- We will discuss three basic ways:
  - Line of sight
  - Ground wave
  - Sky-wave

Line-of-Sight

- If a source of radio energy can been seen by the receiver, then the radio energy will travel in a straight line from transmitter to receiver.
  - There is some attenuation of the signal as the radio wave travels
- This is the primary propagation mode for VHF and UHF signals.

VHF and UHF Propagation

- VHF & UHF propagation is principally line of sight.
- Range is slightly better than visual line of sight.
- UHF signals may work better inside buildings because of the shorter wavelength.
- Buildings may block line of sight, but reflections may help get past obstructions.
- Reflections from a transmitter that is moving cause multi-path which results in rapid fading of signal – known as “picket fencing.”

Ground Wave

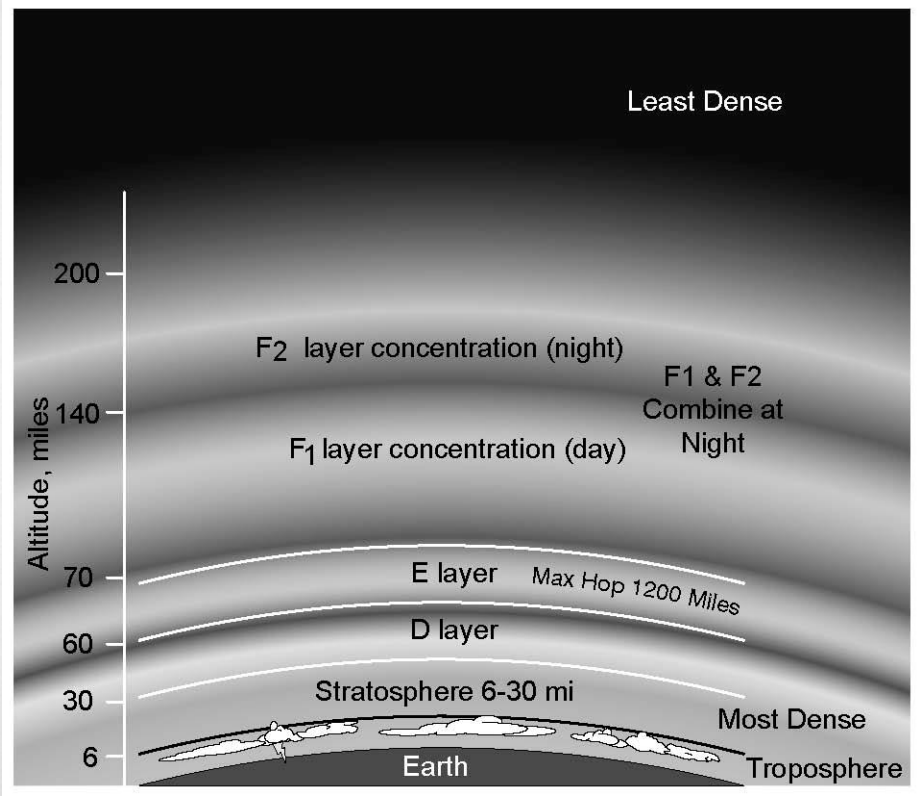
- Some radio frequency ranges (lower HF frequencies) will hug the earth's surface as they travel
- These waves will travel beyond the range of line-of-sight
- A few hundred miles

Ionosphere

- Radiation from the Sun momentarily will strip electrons away from the parent atom in the upper reaches of the atmosphere.
  - Creates ions
- The region where ionization occurs is called the ionosphere.

Levels of the Ionosphere

- Density of the atmosphere affects:
  - The intensity of the radiation that can penetrate to that level.
  - The amount of ionization that occurs.
  - How quickly the electrons recombine with the nucleus.



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The Ionosphere – An RF Mirror

- The ionized layers of the atmosphere actually act as an RF mirror that reflect certain frequencies back to earth.
- Sky-wave propagation is responsible for most long-range, over the horizon communication.
- Reflection depends on frequency and angle of incidence.

Sunspot Cycle

- The level of ionization depends on the radiation intensity of the Sun.
- Radiation from the Sun is connected to the number of sunspots on the Sun's surface.
  - High number of sunspots, high ionizing radiation emitted from the Sun.
- Sunspot activity follows an 11-year cycle.

SAFETY

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Electrical Safety

- Avoiding contact is the most effective way of practicing electrical safety.
- Most modern radio equipment uses currents that are not as dangerous as older equipment but precautions still must be taken.

Electrical Injuries

- Shocks.
- Burns.
- Even small currents can cause problems

Table 7-1

Effects of Electric Current Through the Body of an Average Person

Current (1 Second Contact)	*Effect*
1 mA	Just Perceptible.
5 mA	Maximum harmless current.
10 - 20 mA	Lower limit for sustained muscular contractions.
30 - 50 mA	Pain
50 mA	Pain, possible fainting. “Can’t let go” current.
100 - 300 mA	Normal heart rhythm disrupted. Electrocution if sustained current.
6 A	Sustained heart contractions. Burns if current density is high.

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Mitigating Electrical Hazards

- **TURN OFF POWER WHEN WORKING INSIDE EQUIPMENT!!!!!!**
- **MAKE SURE EQUIPMENT IS PROPERLY GROUNDED AND CIRCUIT PROTECTED!!!!!**
- If power is required:
  - Remove jewelry.
  - Avoid unintentional touching of circuitry.
  - Never bypass safety interlocks.
  - Capacitors hold a charge even when power is off.
  - Storage batteries are dangerous when shorted.

Responding to Electrical Injury

- **REMOVE POWER!**
  - Have ON/OFF switches and circuit breakers clearly marked.
- Call for help.
- Learn CPR and first aid.

Electrical Grounding and Circuit Protection (in the home)

- Make sure your home is “up to code.”
- Most ham equipment does not require special wiring or circuits.
  - Use 3-wire power cords.
  - Use circuit breakers, circuit breaker outlets, or Ground Fault Interrupter (GFI) circuit breakers.
  - Use proper fuse or circuit breaker size.
  - Don’t overload single outlets.

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Electrical Grounding and Circuit Protection (in the car)

- Car batteries hold lots of energy – shorting a battery could cause a fire.
- Special requirements for safe car wiring:
  - Fuse both positive and negative leads.
  - Connect radio's negative lead to where the battery ground connection is made (*see comments about ELD*).
  - Use grommets or protective sleeves to prevent wire chafing, especially through firewall.
  - Don't assume all metal in the car is grounded; modern cars are as much plastic as metal.

Electrical Grounding and Circuit Protection (in the car)

- The reason for the fuse, is that **if the vehicle grounding from the battery to the car frame/engine should fail**, either partially or completely, the radios negative lead "ground", in some cases, become the return path to the battery for the vehicle, causing the wire to burn.
- The fuse in the negative lead is recommended when connecting the negative lead directly to the battery. If the starter motor negative lead were to open (or become corroded and high resistance) **then starter motor current (which can be a hundred amps or more) would flow through the radio's other grounds (antenna, mount, etc), the radio chassis, and the radio's negative lead back to the battery.** This high current is not a good thing for any of the hardware or wiring involved. If you have a 20A fuse in the negative lead then the fuse will blow and protect the equipment and wiring once the current reaches 20A.

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Vehicle Wiring and Grounding

- *Do not use cigar lighter or "Power Point" receptacles as power sources for any radio communication equipment.*
- The arrow is pointing to what is left of a power point plug, and its attached wiring.

http://www.k0bg.com/wiring.html

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Vehicle Wiring and Grounding

Battery monitoring systems (BMS) are now a universal subsystem in every modern vehicle, due in part to the fed-mandated Engine Idle Shutdown (EIS). The load current is measured with an Electrical Load Detector (ELD), typically a Hall device mounted as part of the negative battery connector, or around the ground lead itself as shown in the photos below. The measured data is fed to the engine CPU (known by a variety of names). This allows a more precise fuel-air adjustments for changing accessory loads (AC for example), the condition of the battery can also be monitored (Coulomb Counted). It is imperative that the ELD not be bypassed when wiring amateur radio equipment, so typical wiring recommendations found in [radio] Owner's Manuals *should not be followed*!

http://www.k0bg.com/wiring.html

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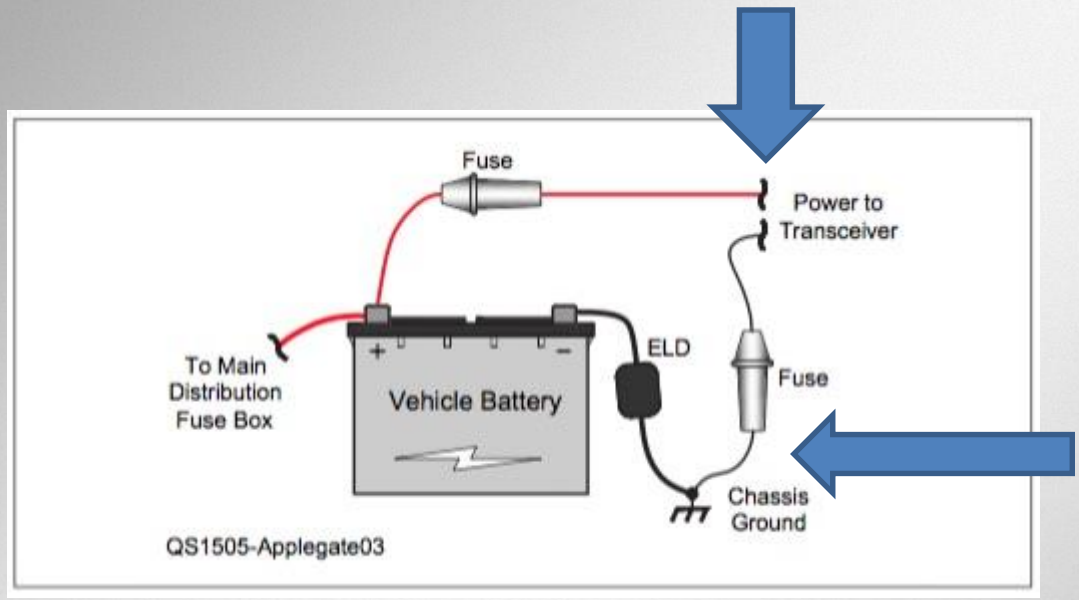
Vehicle Wiring and Grounding

Firewall



Older vehicles (without ELD): negative fuse lead directly to battery negative terminal.

Negative fuse here:

The reason is, if the grounding point should lose its integrity, excessive current could flow through the transceiver's negative lead. It also prevents a minor ground loop between the leads.

http://www.k0bg.com/wiring.html

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RF Safety

- Proper Grounding.
- Important not only for protection of equipment and people, any wires connected to the radio potentially becomes part of the antenna and can radiate RF where it is not intended.

Lightning Safety

- Antennas are not struck any more frequently than trees or tall structures.
- Ground all antennas.
- Use lightning arrestors.
- Disconnect antenna cables and power cords during storms.
- Disconnect telephone lines from computer modems.

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RF Exposure

- Exposure to high levels of RF can cause problems.
- If equipment is operated properly, RF exposure is minimal and not dangerous.
- Problem is RF energy can heat body tissues.
  - Heating depends on the RF intensity and frequency.

RF Intensity

- Power Density
  - Actual transmitter power.
    - Higher power, higher risk.
  - Antenna gain and proximity.
    - Beam antennas focus available energy.
    - Being physically close or standing in the beam direction increases risk.
  - Mode duty cycle.
    - The more time the power output is at high level, the higher the risk.

Antenna Proximity

- Controlled Environment.
  - You know where people are standing in relation to your antenna and you can do something about it.
  - More power is allowed because you can make adjustments if needed.
- Uncontrolled Environment.
  - You have no idea, or have no control of people near your antenna.
  - Less power is allowed because you have to assume the worse case scenario.

Mode Duty Cycle

- The more time the transmitted power is at high levels, the greater the duty cycle, and the greater the exposure risk.

Operating Duty Factor of Modes Common	
Mode	*Duty Cycle*
Conversational SSB	20%
Conversational SSB	40%
SSB AFSK	100%
SSB SSTV	100%
Voice AM, 50% modulation	50%
Voice AM, 100% modulation	25%
Voice AM, no modulation	100%
Voice FM	100%
Digital FM	100%
ATV, video portion, image	60%
ATV, video portion, black screen	80%
Conversational CW	40%
Carrier	100%

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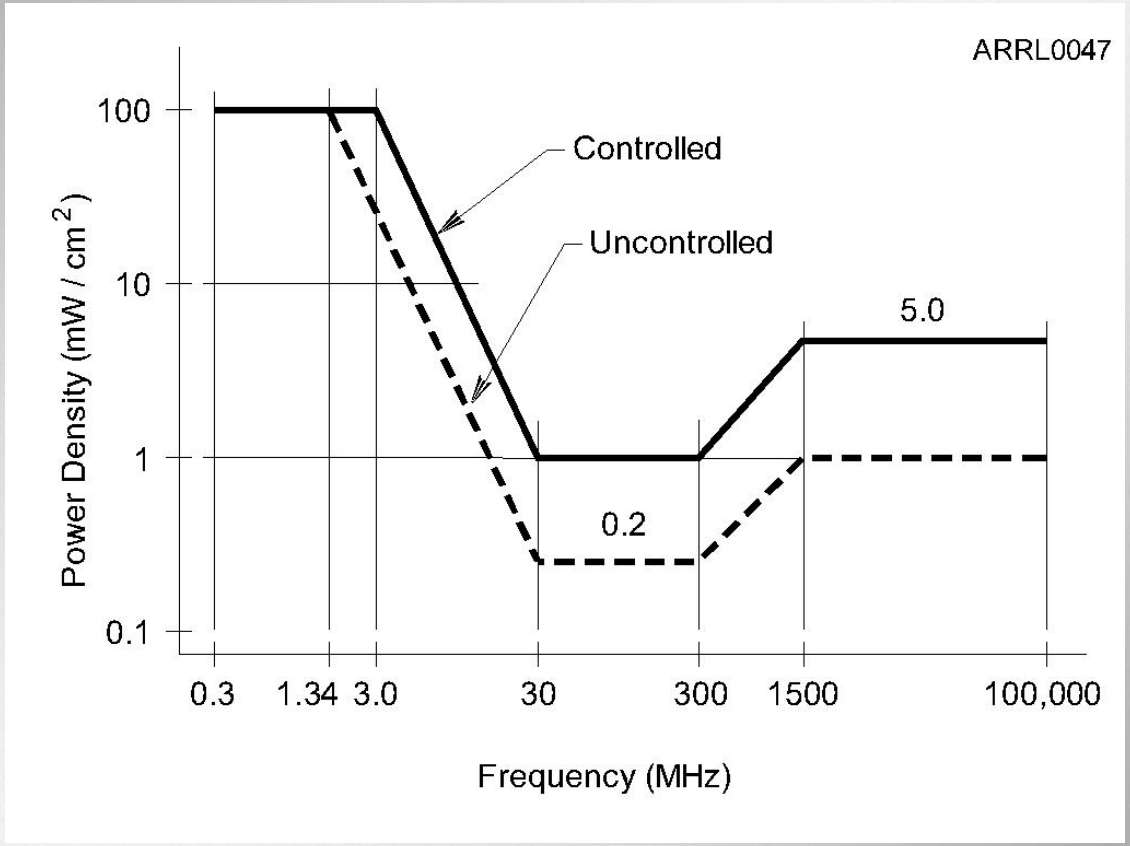
RF Exposure and Frequency

- When body parts act like antennas, those parts absorb RF energy at certain frequencies (wavelengths) more efficiently and increase risk.
- RF exposure risk varies with frequency.
  - More caution is dictated at some frequencies more than other frequencies.

RF Exposure and Frequency



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http://www.arrl.org/other-rf-safety-related-sites

Physical Safety

- Mobile Installations.
  - Secure all equipment.
  - Location, location, location.
- Antenna installation.
  - Clear of trees and power lines.
  - If it falls it won't hit anyone or cross power lines.
- Tower climbing considerations
  - Wear an approved safety harness.

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