Element IV

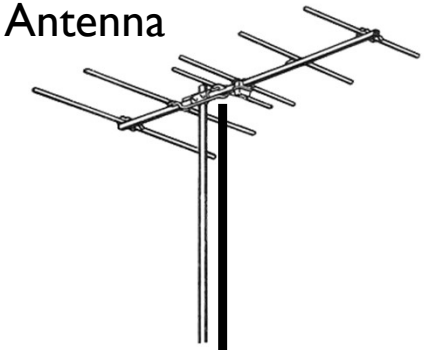
Amateur Radio Practice

Purpose

- Element IV will discuss:
  - Basic amateur radio station (ARS) setup
  - Test equipment
  - Safety practices

BASIC ARS SETUP

Antenna



DC power source

Transceiver

Transmission line

Portable radio

DC POWER SOURCE

- Batteries, or ***regulated*** power supplies connected to an AC source, can be used as power sources
  - Linear power supplies – bulky, more expensive
  - Switch-mode power supplies – cheaper, could be noisy

- Most mobile and base radios are powered by 12 – 13.8 volts DC; some have built-in power supplies
- Portables are powered by battery packs (7.2 – 9 volts DC)

DC POWER SOURCE

- Best practices
  - Observe polarities when connecting the DC power source to the radio!
  - Ensure that the DC source can handle the maximum current requirement of the radio
  - Always use fused power supply cables
  - Always use a fuse with the correct current rating
  - In vehicles, always connect the negative power line directly to the battery or the engine block ground strap

TRANSCEIVERS

- Transmitter and receiver (Tx/Rx) in one package
- There are many types, depending on the frequency and mode of operation, and output power
  - Operating modes
    - AM, FM, SSB, CW, RTTY/DATA
  - Base radios – up to 200 watts
  - Mobile radios – up to 80 watts
  - Portable radios – up to 12 watts

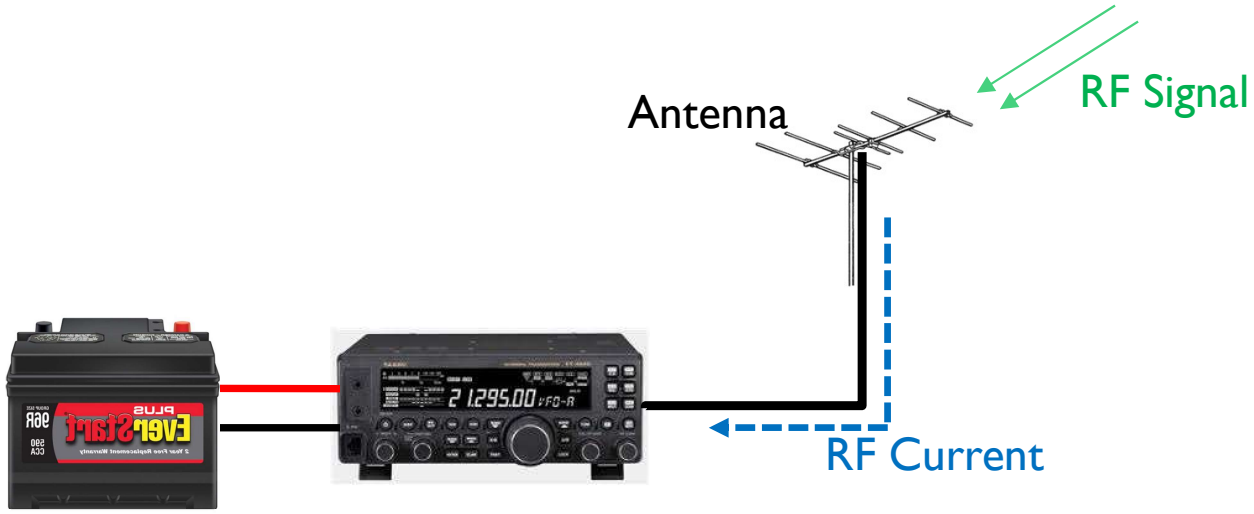
Tx/Rx

TRANSMISSION LINE

- Connects the transceiver to the antenna
  - Connects the transceiver to the antenna
  - The characteristic impedance of the cable ($\mathbf{Z_0}$) should match the output impedance of the transceiver and the input impedance of the antenna. This will ensure maximum power transfer.
  - Common types (and their $\mathbf{Z_0}$)
    - Coaxial (50 Ω, 75 Ω)
    - Parallel wires (300 Ω, 450 Ω)

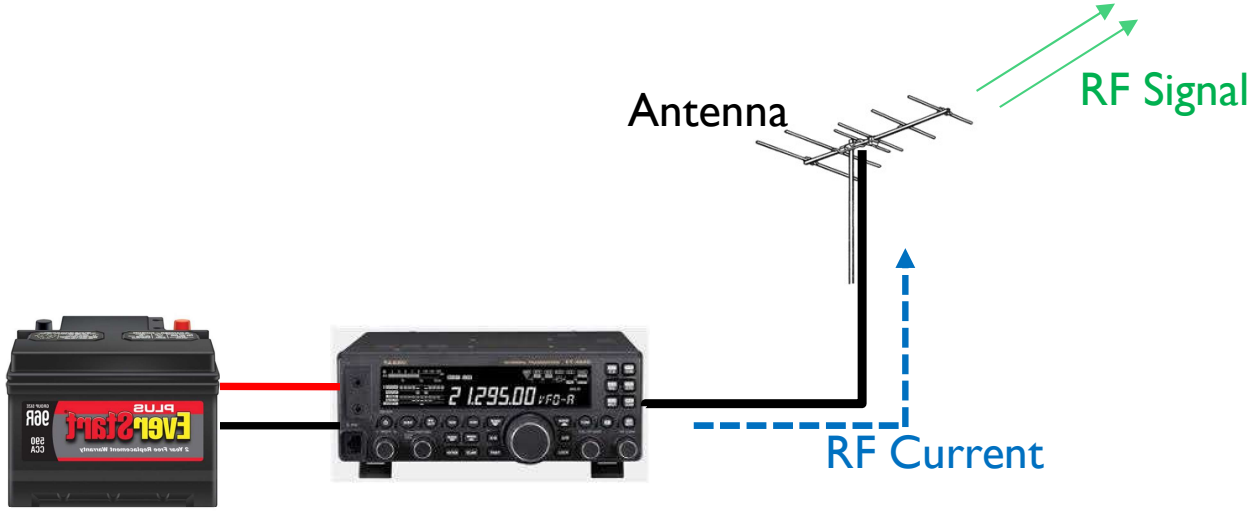
ANTENNA

- The transducer between radio waves propagating through space and electric currents moving in *metal conductors*
  - During the RX mode, it intercepts some power of the radio signal and converts it to alternating current (AC) that flows through the transmission line into the transceiver



ANTENNA

- The transducer between radio waves propagating through space and electric currents moving in *metal conductors*
  - During the TX mode, it receives AC from the transceiver passing through the transmission line and converts it to an RF signal which then travels through space



ANTENNA

- The transducer between radio waves propagating through space and electric currents moving in *metal conductors*
  - Type used will depend on:
    - Frequency of operation
    - Power output of the transceiver
    - Intended direction of signal propagation (unidirectional, omni-directional, bi-directional)

ANTENNA

HOW WELL MATCHED IS THE ANTENNA TO THE TRANSMISSION LINE?

- Ideally, the output impedance of the transceiver must equal the characteristic impedance of the transmission line, and the input impedance of the antenna.
- Matching the transceiver to the transmission line is easy.
- The transmission line may not always match the antenna. The amount of mismatch is expressed as a ratio called the Standing Wave Ratio (SWR).
  - A perfectly matched line and antenna will give an SWR of 1:1.
  - As the SWR becomes higher, it means the amount of mismatch is also getting worse.
  - The SWR can be measured directly by an SWR meter.

HOW WELL MATCHED IS THE ANTENNA TO THE TRANSMISSION LINE?

- For a purely resistive antenna (no reactance, R_L), the SWR can be computed directly by:

  SWR = R_L / Z_0 *for* $R_L > Z_0$
  SWR = Z_0 / R_L *for* $Z_0 > R_L$

- Example: What is the SWR when a 75-ohm coaxial cable is connected to an antenna with an input resistance of 50 ohms?

  SWR = 75 ohm / 50 ohms = 1.5:1

USING THE SWR METER

Most SWR meters also come with watt meters, that will allow the measurement of forward and reflected power. For best results, the reflected power should be kept as low as possible during transmission.

RADIO FREQUENCY BANDS

Band	Frequency range	Wavelength range
Extremely low frequency (ELF)	< 3 kHz	>100 km
Very low frequency (VLF)	3 - 30 Hz	10 - 100 krn
Low frequency(LF)	30 - 300 kHz	1 - 10 km
Medium frequency (MF)	300 kHz - 3 MHz	100m - 1km
High frequency (HF)	3 - 30 MHz	10 - 100m
Very high frequency (VHF)	30 - 300 MHz	1 - 10m
Ultra high frequency (UHF)	300 MHz - 3 GHz	10cm - 1m
Super high frequency (SHF)	3 - 30 GHz	1 - 10cm
Extremely high frequency (EHF)	30 - 300 GHz	1mm - 1cm

RF HARMONICS

- A harmonic is a signal or wave whose frequency is an integral (whole-number) multiple of the frequency of some reference signal or wave.
- For a signal whose fundamental frequency is f, the second harmonic has a frequency $2f$, the third harmonic has a frequency of $3f$, and so on.
- Signals occurring at frequencies of $2f$, $4f$, $6f$, etc. are called *even harmonics*; the signals at frequencies of $3f$, $5f$, $7f$, etc. are called *odd harmonics*.
- Example: What is the 7^{th} harmonic of a signal whose frequency is 3 MHz?

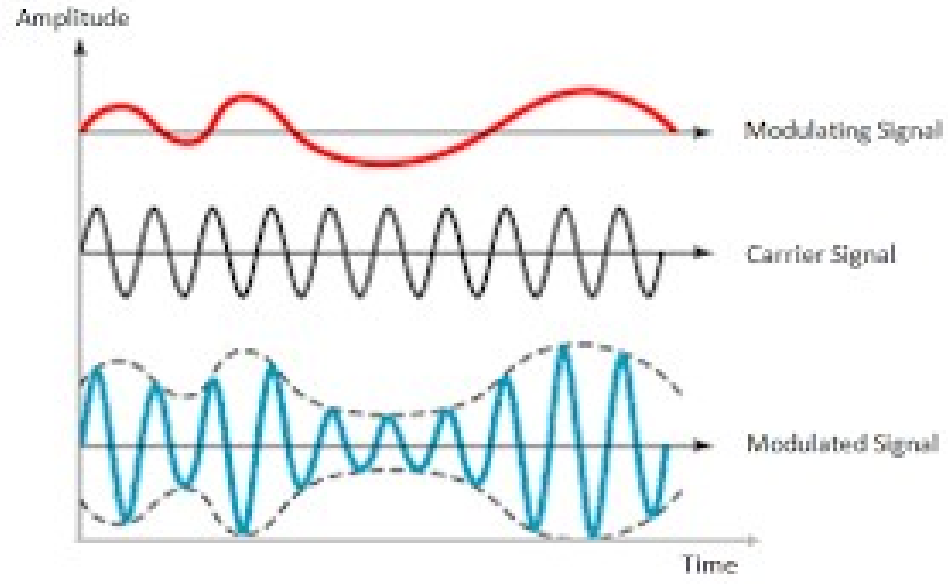
  Answer: 7^{th} harmonic = 7 x f = 7 x 3 MHz = 21 MHz

RF HARMONICS

- Signal output at harmonic frequencies can cause interference to other communications or broadcast signals.
  - A ham signal at 28 MHz can cause harmful interference due to harmonics at the local VHF TV channels, which start at 54 MHz.
  - A filter may be installed between the transmitter and the antenna to reduce harmonic emissions

TRANSMISSION MODES

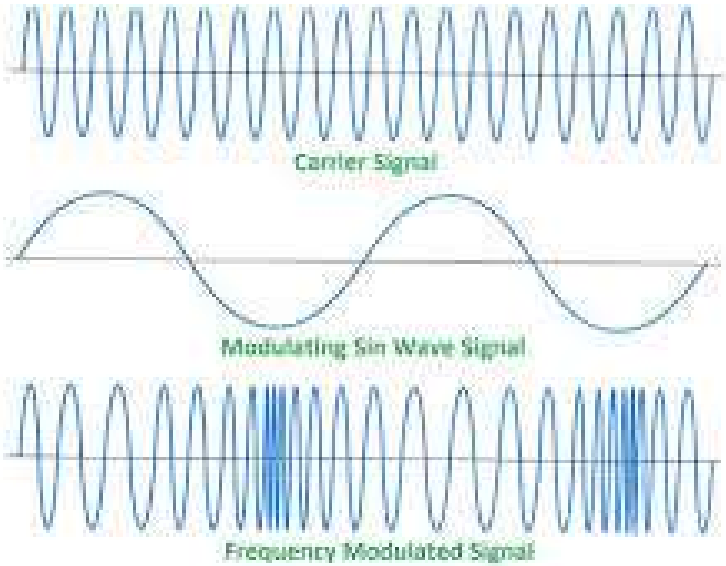
- Modulation - the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal that typically contains information to be transmitted.
- Amplitude Modulation (AM) – the amplitude (signal strength) of the carrier wave is varied in proportion to that of the message signal being transmitted



- Simple circuits
- Less bandwidth (30 kHz)
- Can be transmitted over long distances
- Susceptible to noise
- Poor sound quality

TRANSMISSION MODES

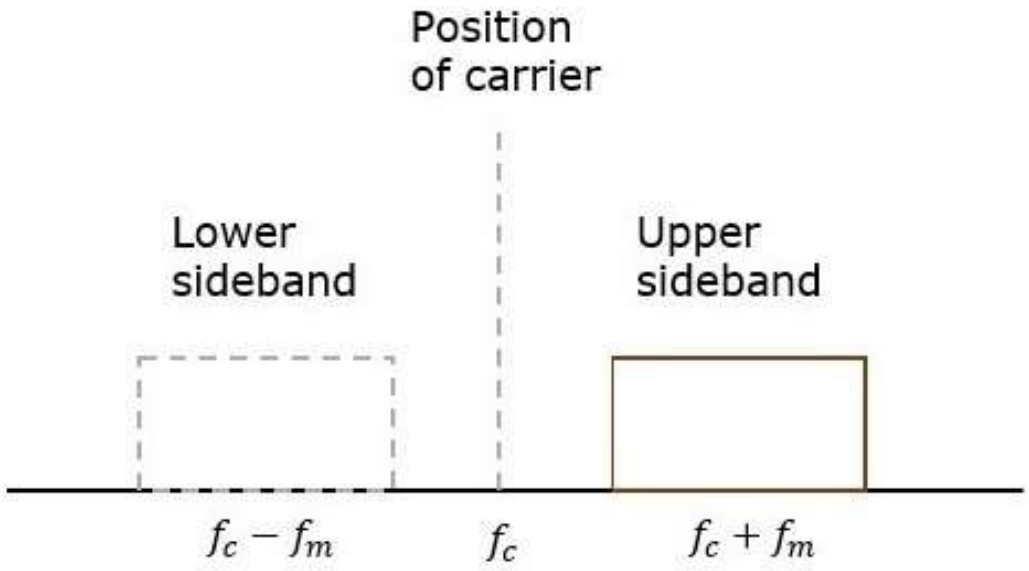
- Frequency Modulation (FM) - the frequency of the carrier wave is varied in proportion to that of the message signal being transmitted



- Complex circuits
- More bandwidth (180 kHz)
- Harder to transmit over long distances
- Less susceptible to noise
- Good sound quality

TRANSMISSION MODES

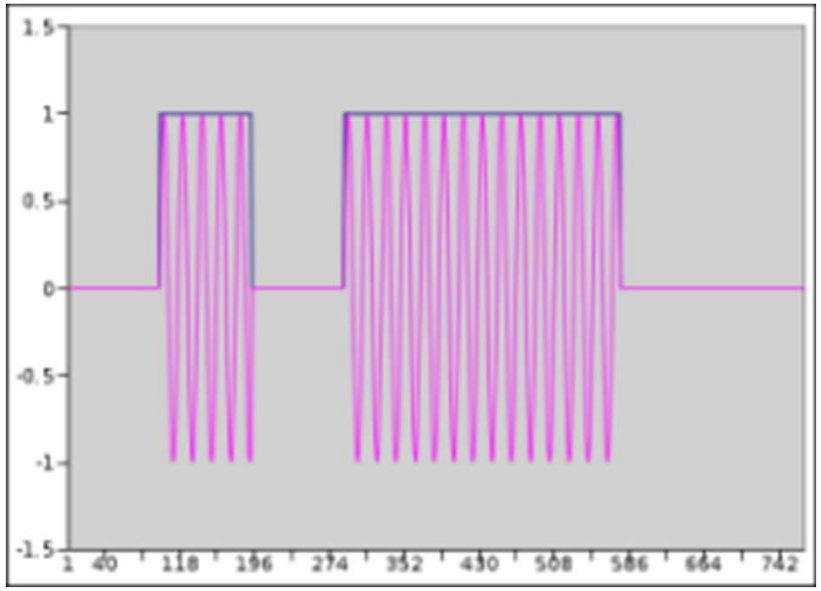
- Single Side Band (SSB) – a form of modulation where the carrier and one sideband of an AM signal is suppressed, so that only one sideband is transmitted (either USB or LSB)



- Requires less power to transmit information compared to AM
- Less bandwidth (15 kHz)
- Easier to transmit over long distances
- Still susceptible to noise
- Poor sound quality

TRANSMISSION MODES

- Continuous Wave (CW) – a form of modulation where the carrier is switched on and off, and information is carried in the varying duration of the on and off periods of the signal, for example by Morse code



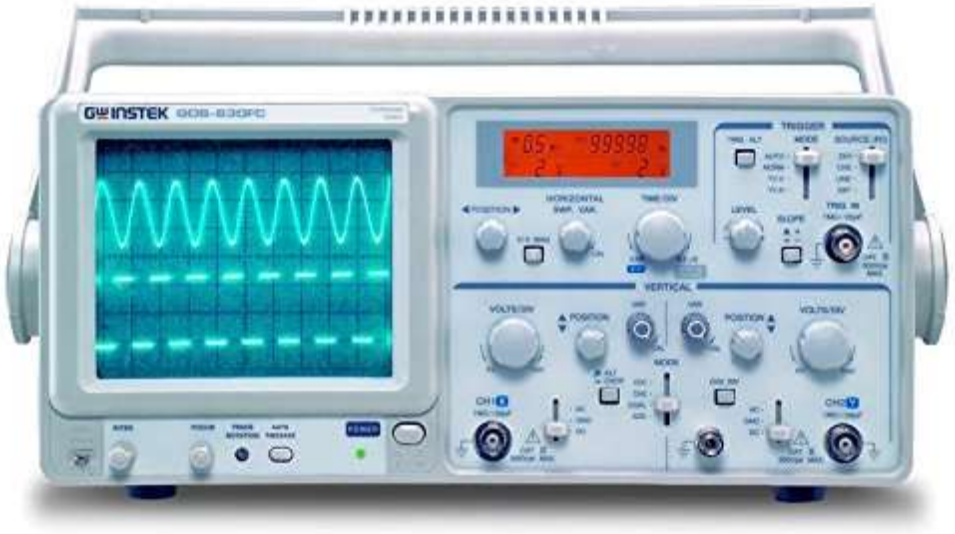
- Requires even less power to transmit information
- Can be received even with 500 Hz of bandwidth
- Very easy to transmit over long distances
- Can get through noise

TEST EQUIPMENT

- Multi-meter - the most often used piece of test equipment
  - Can be used as a voltmeter, an ammeter, or an ohmmeter
  - Can test resistors, capacitors (within certain limitations), diodes and transistors.

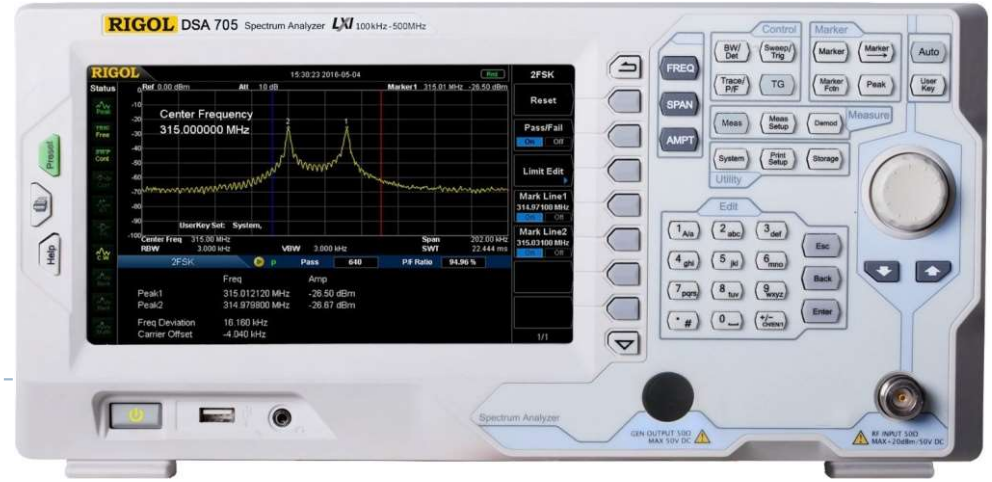
TEST EQUIPMENT

- Oscilloscope – or 'scope, is the second most often used piece of test equipment
  - Allows observation of varying signal voltages, usually as a two-dimensional plot of one or more signals as a function of time
  - The observed waveform can be analyzed for such properties as amplitude, frequency, rise time, time interval, distortion and others



TEST EQUIPMENT

- Spectrum analyzer – like an oscilloscope, it visually presents an electrical signal through graphic representation, but for a range of frequencies
  - Used to present test signals in frequency domain
  - The primary use is to measure the power of the spectrum of known and unknown signals over a range of frequencies.
  - Modern transceivers include a spectrum display, a basic form of a spectrum analyzer.



TEST EQUIPMENT

- Signal Generators – although may have many uses, in troubleshooting, they are most often used for signal injection and alignment.
  - It is designed to produce a range of frequencies in the RF and AF bands.

TEST EQUIPMENT

- Grid-dip meter - often called a transistor dip meter or a grid-dip oscillator from vacuum-tube days.
  - Used to measure the resonant frequency of an LC tank circuit
  - Can also serve as an absorption frequency meter.

TEST EQUIPMENT

- Logic probe - a hand-held test probe used for analyzing and troubleshooting the logical states (high or low) of a digital circuit.
  - There are usually three differently-colored LEDs on the probe's body:
    - Red and green LEDs indicate high (1) and low (0) logic states respectively
    - Amber LED indicates a pulse

TEST EQUIPMENT

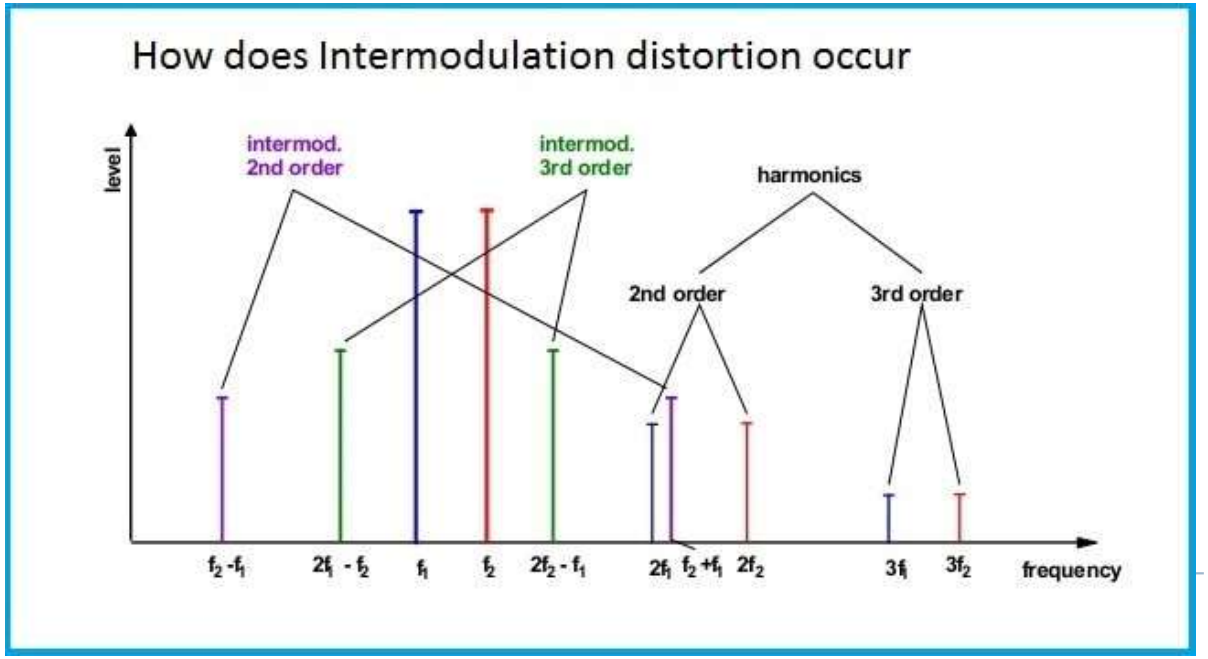
- Frequency Counter - one of the most accurate means of measuring frequency
  - Capable of numerically displaying the frequency of the signal supplied to its input.
  - In order to ensure that the amateur radio station is operating within the authorized band limits, the licensed amateur may use a frequency counter.

ELECTROMAGNETIC INTERFERENCE

- Any interference (sometimes referred to as "noise") caused by external sources of electromagnetic nature
  - Also called Radio Frequency Interference (RFI) when in the radio frequency spectrum
  - Will cause performance degradation in communications equipment
  - Could be natural or man-made. Typical sources include:
    - Lightning
    - Solar flares
    - Auroras
    - Ignition systems
    - Cellular networks
    - Devices that unintentionally emit RF signals

ELECTROMAGNETIC INTERFERENCE

- Inter-modulation - the interference brought by the resultant signal from addition and subtraction of the fundamental and harmonics of two or more signals.
  - The two original signals may be perfectly legal, but the resulting inter-modulation distortion products may occur on the frequencies used by other signals and cause interference in the same way as a spurious signal from a transmitter.



ELECTROMAGNETIC INTERFERENCE

- Cross modulation - the inter-modulation distortion caused by multiple carriers within the same bandwidth.
  - This can happen when strong nearby unwanted signal gets added (modulated) with the wanted signal.
  - The effect will be observed on the weaker input signal.

- Receive desensitizing - a situation in which a radio receiver receives a very strong interfering signal and its automatic gain control circuits react to reduce the gain not only for unwanted signals but also for wanted ones, with the result that a weak wanted signal may be lost completely

ELECTROMAGNETIC INTERFERENCE

- Ignition noise - created by fast-rise-time pulses of coil current discharging across air gaps (distributor and spark plug).
  - Generated by ignition sparks and fuel injector activation
  - Manifests as a regular, periodic "ticking" in the receiver audio output, which varies with engine RPM

- Alternator whine – noise generated by brush-type motors that employ sliding contacts. The resulting spark is primarily responsible for the "hash" noise associated with these devices.

ELECTROMAGNETIC INTERFERENCE

- Static – noise produced in a radio or television receiver by atmospheric or various natural or man-made electrical disturbances

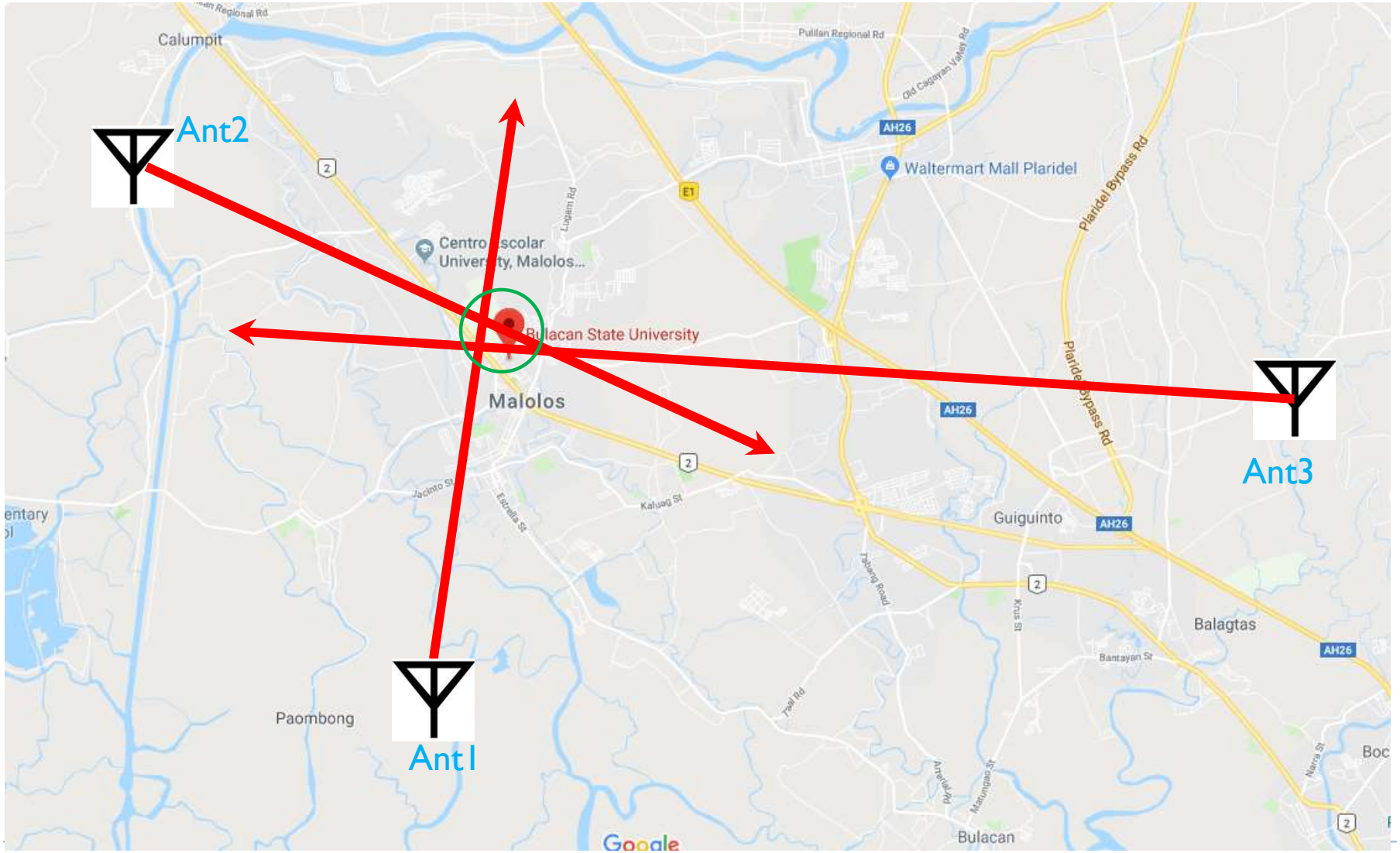
- Audio rectification - a common phenomenon in which an electronic circuit, usually an amplifier, is suddenly affected by unwanted external radio signals.
  - If the equipment is surrounded by an intense radio signal, the wiring or one of the circuit components may act as an antenna and pick up an unwanted signal.
  - Proper filters and shielding can solve the problem
    - Snap-on ferrite chokes
    - Low-pass and high-pass filters
    - Band-reject and band-pass filters

RADIO DIRECTION-FINDING

- The art of locating a signal or noise source by tracking it with portable receivers and/or directional antennas.
- DF techniques can come into play when tracking down sources of interference — intentional or inadvertent — or when there's a suspected "pirate" (unlicensed station) in the area.
- The location of an interfering station can be pinpointed by using direction finders and utilizing triangulation.

RADIO DIRECTION FINDING

- Triangulation



SAFETY

- Electrical wiring safety
  - ✓ Use approved cable sizes, properly installed in conduit and junction boxes, and within a chassis with a cover or lid
  - ✓ Switch off the circuit breaker or remove the fuse and take positive steps to ensure that others do not restore the power while you are working

SAFETY

- Grounding
  - ✓ A must for all amateur stations
  - ✓ Reduces the possibility of electrical shock if a piece of equipment should fail and the chassis or cabinet becomes "hot." (bonding ground)
  - ✓ Provides a low-impedance path to ground for any stray RF current inside the station (RF return or antenna ground)
  - ✓ To prevent ground loops, connect all ground contacts to a single point
  - ✓ Other types of ground connections
    - Common reference potential (chassis ground)
    - Lightning and transient dissipation ground

SAFETY

- Grounding

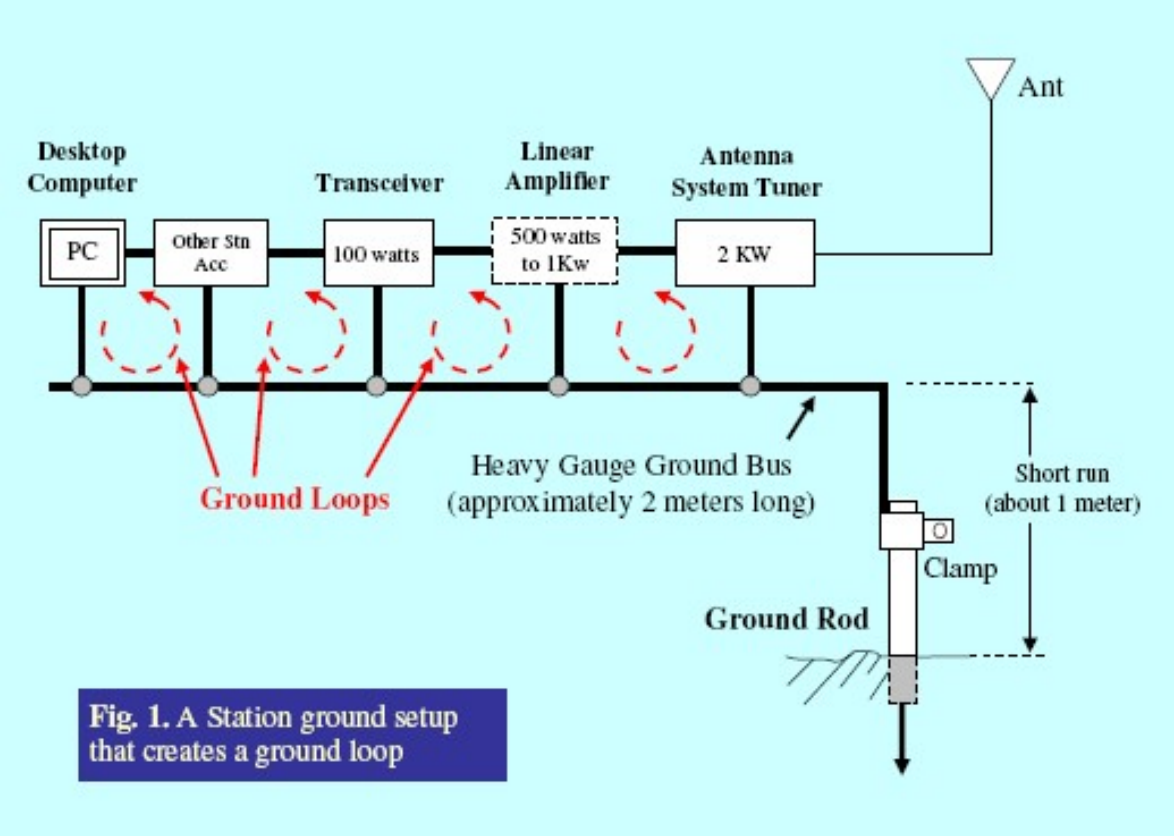


Fig. 1. A Station ground setup that creates a ground loop

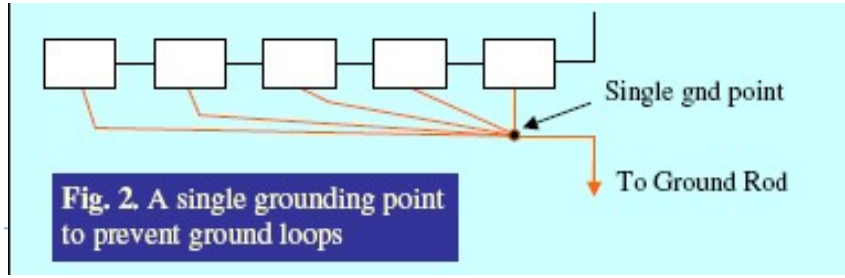


Fig. 2. A single grounding point to prevent ground loops

SAFETY

- Lightning protection
  - ✓ All antenna systems must have a means of draining static charges from the antenna system.
  - ✓ An antenna discharge unit (lightning arrestor) may be installed on each lead-in conductor that is not protected by a permanently and effectively grounded metallic shield
  - ✓ Best of all: DISCONNECT ALL cables from the equipment during thunderstorms.

SAFETY

- Antenna installation safety
  - ✓ Never install or dismantling antenna near power lines. Minimum safe distance is (antenna height + antenna length + 10 feet)
  - ✓ Never use a utility pole as a support for an antenna or guy wire. Never climb a utility pole.
  - ✓ Dress properly with rubber soled shoes, rubber gloves, and long sleeve shirt. Always USE an approved safety belt.
  - ✓ Do NOT work on a wet or windy day or if a thunderstorm is approaching.
  - ✓ Do NOT use a metal ladder.
  - ✓ Never do the installation/dismantling alone.
  - ✓ Height or other restrictions on antennas may apply to your installation depending on your proximity to an airport, or local ordinances.

SAFETY

- Antenna-installation safety
  - ✓ If the assembly starts to drop, get away from it and let it fall. Remember that the antenna, mast, cable, and guy wires are all excellent conductors of electrical current.
  - ✓ If any part of the antenna should come in contact with a power line, DON'T TOUCH IT OR TRY TO REMOVE IT YOURSELF. Call your local power company immediately.
  - ✓ Should an electrical accident occur, DON'T TOUCH THE PERSON IN CONTACT WITH THE POWER LINE, or you too can become electrocuted. Instead, use a DRY board, stick, or rope to push or pull the victim away from the power lines and antenna. Once clear, check the victim. If he has stopped breathing, immediately administer cardiopulmonary resuscitation (CPR) and stay with it. Have someone else call for medical help.

SAFETY

- Antenna-installation safety
  - ✓ Remember that guyed towers are NOT self-supporting at any height.
  - ✓ Install wire antennas high enough that they will not be "walked into" by people.
  - ✓ Do not install wire antennas over or under utility lines.

SAFETY

- Safety from an unauthorized use of the ARS
  - It is advisable to provide a radio transmitter with an on-and-off switch with lock and key to prevent unauthorized operation.

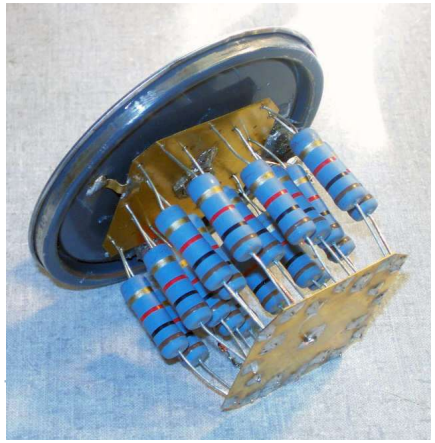
- For mobile operation, it is best to use a headset with an attached microphone and VOX control to allow for hands-free operation while driving.

STATION ACCESSORIES

- Antenna tuner - a device that matches the antenna system input impedance to the transmitter, receiver or transceiver output impedance.
  - Also called as antenna matching network, trans-match, ATU, or matchbox.
  - Remember that the use of an antenna tuner at the transmitter does not tune the antenna, reduce SWR on the feed line, or reduce feed line losses.
  - It is always BEST to use a properly tuned antenna.

STATION ACCESSORIES

- Dummy load – a resistor or set of resistors used in place of an antenna to test a transmitter without radiating any electromagnetic energy into the air.
  - A "dummy" or "phantom" load is a necessity in any shack. Do not put a signal on the air while repairing equipment. Defective equipment can generate signals that interfere with other hams or other radio services.
  - Also provides a known, matched load (usually 50 Ω) for use during adjustments.

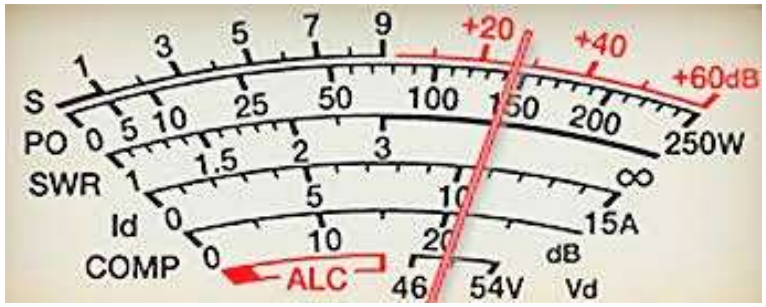


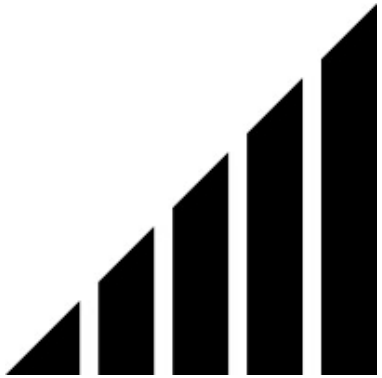
STATION ACCESSORIES

- Field Strength Meter - an instrument that measures the electric field strength emanating from a transmitter.
  - For accurate readings, the meter and its antenna must be properly calibrated.

STATION ACCESSORIES

- Signal Strength Meter - or an "S-meter", an instrument used to measure the relative received signal strength.
  - Most ham radios have one built-in
  - May be analog or digital





QUESTIONS?