

Amateur Radio Basic Qualification – The Essentials

Section Three: Equipment and Fundamentals

University of Waterloo Amateur Radio Club

October 8, 2014

Contents

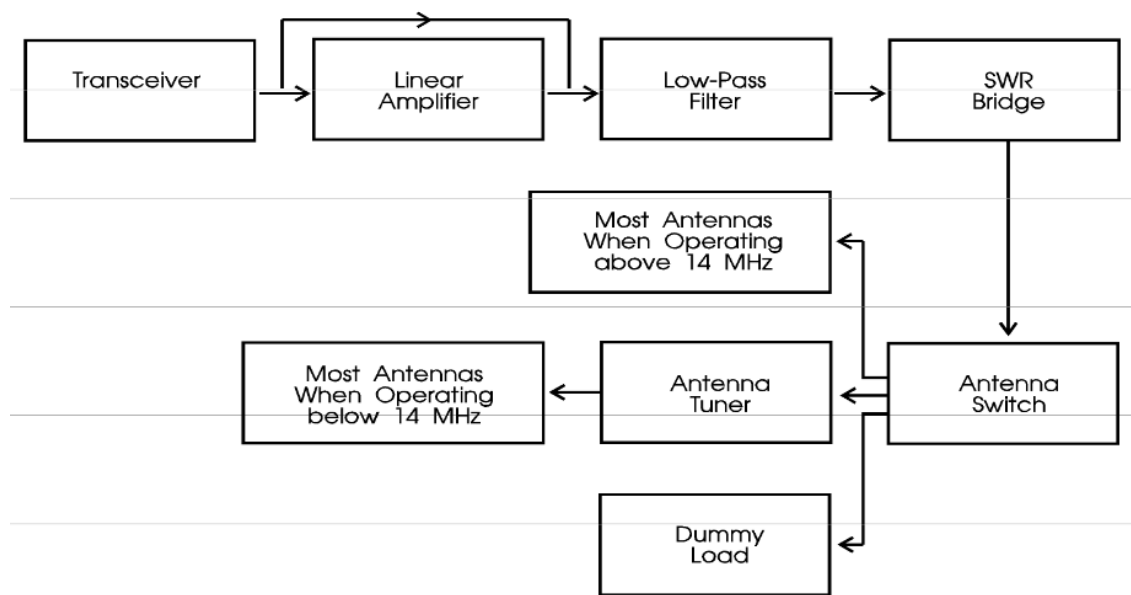
1	Introduction	2
2	The Essentials: Section Three	2
2.1	Components of an HF Station	2
2.2	Frequency Modulation Transmitter	2
2.3	Frequency Modulation Receiver	3
2.4	CW Transmitter	3
2.5	CW/SSB Receiver	4
2.6	SSB Transmitter	4
2.7	Digital System	5
2.8	Power Supply	5
2.9	Yagi-Uda Antenna	6
2.10	Receiver Fundamentals	6
2.11	Transmitter Fundamentals	7
2.12	Single Sideband	7
2.13	Frequency Modulation	8
2.14	Voice and CW Operation	8
2.15	Digital Operation	9
2.16	Introduction to Electricity	10
2.17	Power Supplies Again	11
2.18	Electricity Safety	12
2.19	Electrical Ground	12
2.20	Antenna, Tower, and Lightning Safety	13
2.21	Radiation Safety	13

1 Introduction

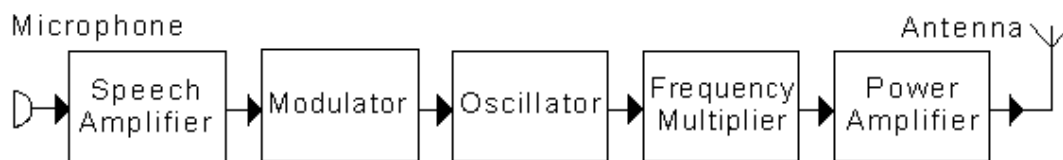
These notes were prepared from Issue 3 of RIC-7 “Basic Qualification Question Bank for Amateur Radio Operator Certificate Examinations”, published April 2007. They cover 100% of testable material on the Basic Qualification examination, but do not go beyond what is absolutely necessary to know in order to pass the examination. The candidate is encouraged to perform their own research on topics that are not fully covered here.

2 The Essentials: Section Three

2.1 Components of an HF Station

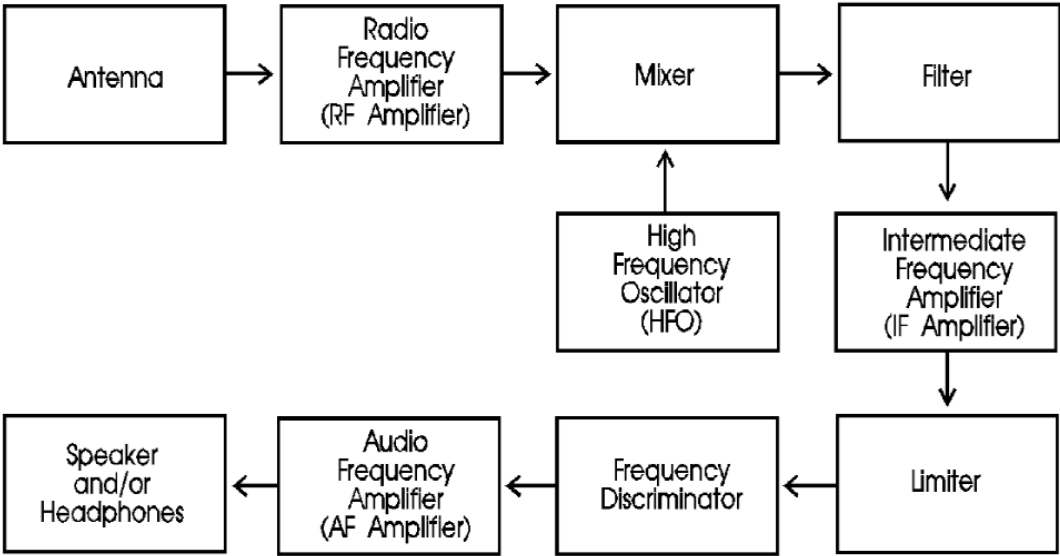


2.2 Frequency Modulation Transmitter

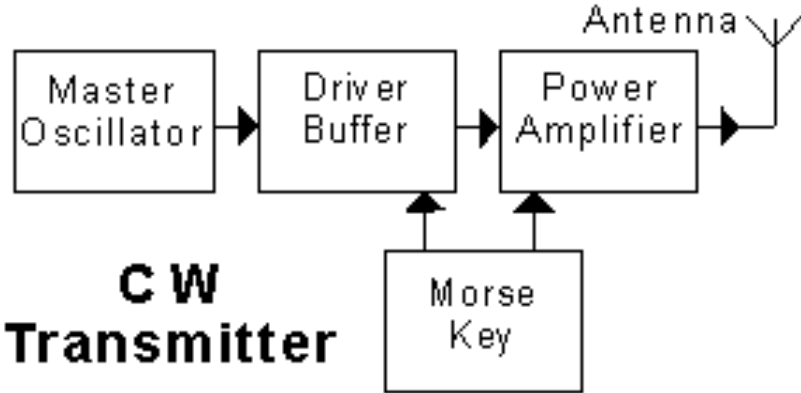


FM Transmitter

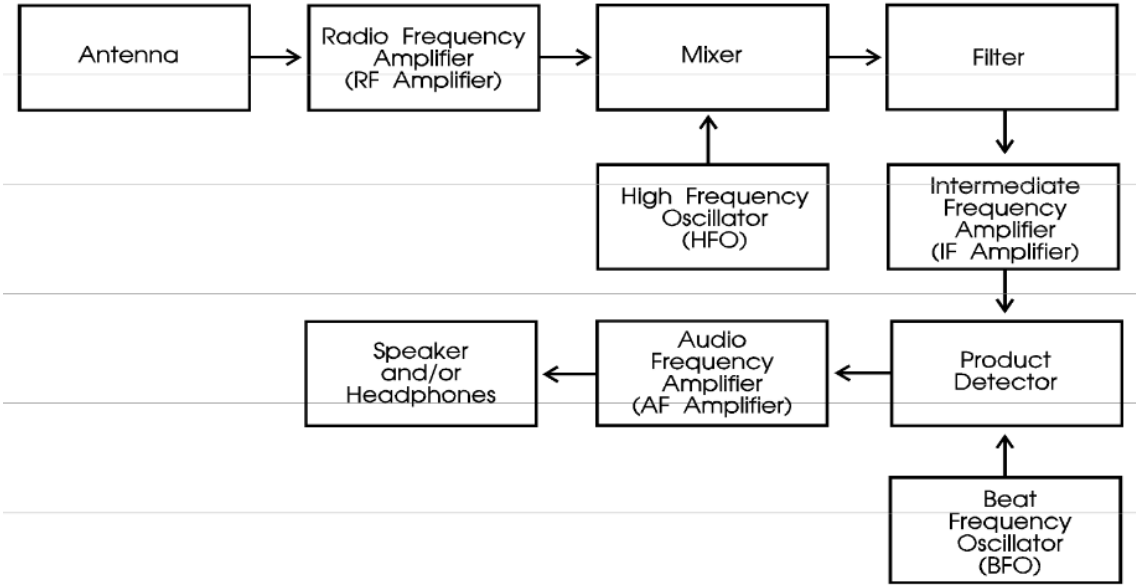
2.3 Frequency Modulation Receiver



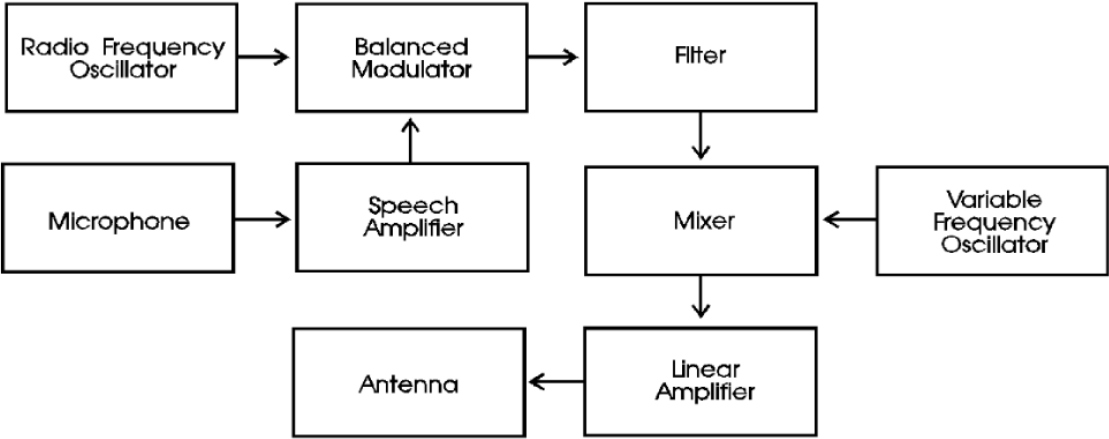
2.4 CW Transmitter



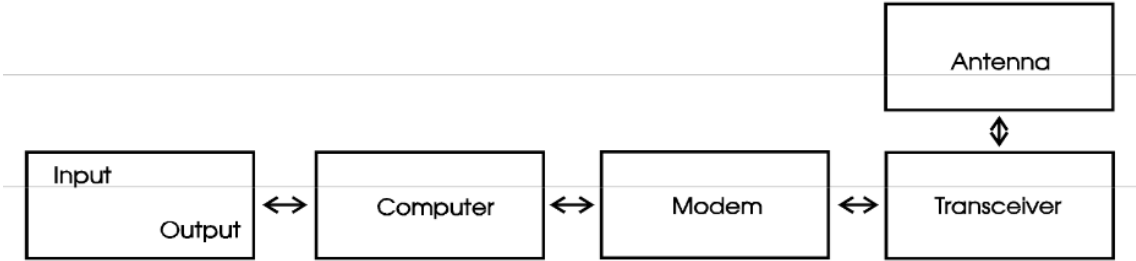
2.5 CW/SSB Receiver



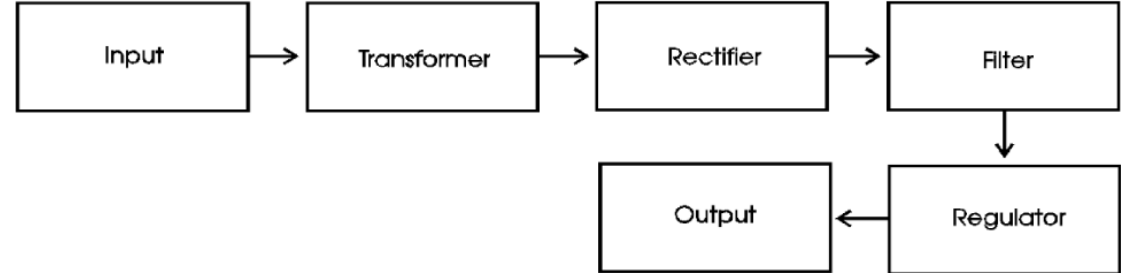
2.6 SSB Transmitter



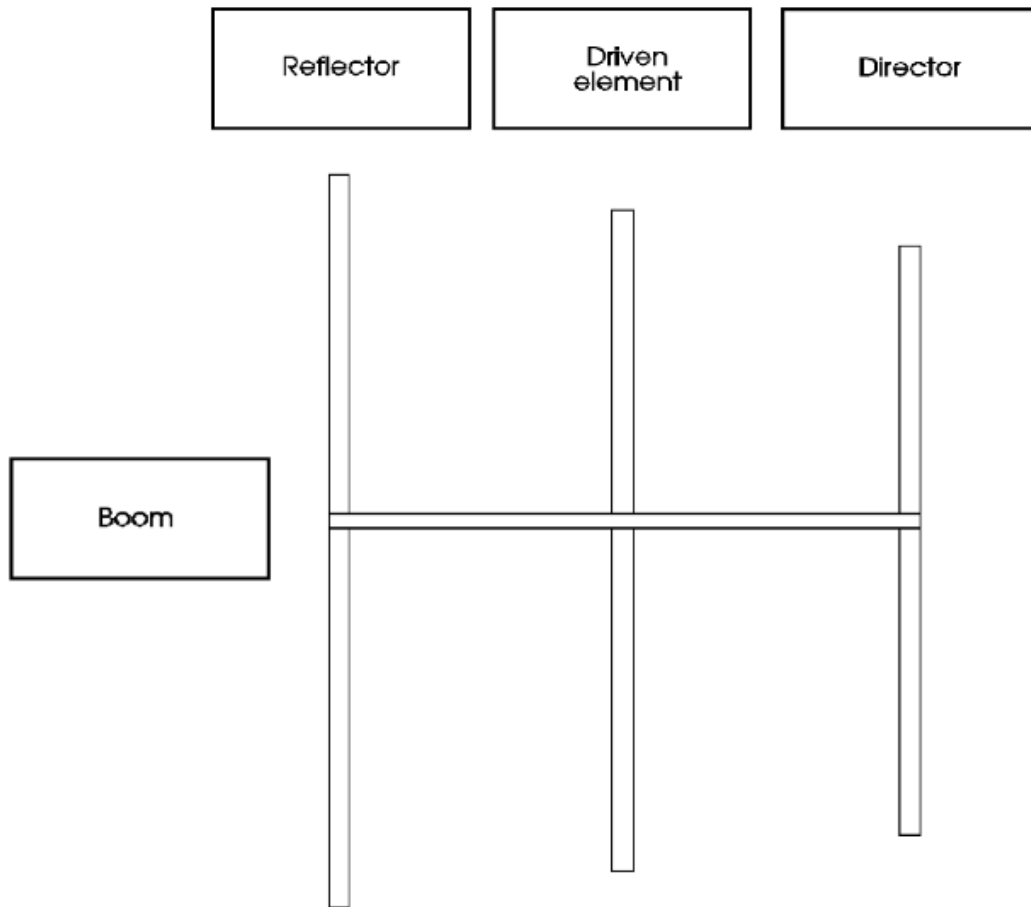
2.7 Digital System



2.8 Power Supply



2.9 Yagi-Uda Antenna



2.10 Receiver Fundamentals

- The three main parameters against which the quality of a receiver is measured are **sensitivity**, **selectivity**, and **stability**.
- In order from narrowest to widest bandwidth, typical radio emissions you might receive are CW, RTTY, SSB voice, and FM voice.
- The bandwidth of CW is about 250 Hz. A typical carrier frequency for CW is between 750 and 850 Hz.
- The bandwidth of single sideband is about 2.4 kHz.
- Signal-plus-noise to noise ratio (or just signal-to-noise ratio) is a measure of a receiver's sensitivity.

- If two receivers of different sensitivity are compared, the less sensitive receiver will produce less signal or more noise.
- Single sideband suppressed carrier is usually detected with a product detector.
- A receiver designed for SSB reception must have a beat frequency oscillator (BFO) because the suppressed carrier must be replaced for detection.
- A notch filter is a very, very narrow band-stop filter; its function is to attenuate a specific frequency as much as possible. A notch filter can be used to attenuate an interfering carrier signal when receiving an SSB transmission.

2.11 Transmitter Fundamentals

- **Chirp** is a small, audible change in a transmitter's frequency each time it is keyed. A malfunctioning CW transmitter may exhibit chirp that can be heard on air as a shift in the carrier tone. To keep such a transmitter from chirping, the power supply voltages must be kept very steady.
- A VFO-controlled transmitter has a variable-frequency oscillator connected to a driver and a power amplifier.
- Amplitude modulation is a scheme that changes the amplitude of an RF wave for the purpose of conveying information.
- Morse code is usually transmitted by radio as an interrupted carrier.
- A mismatched antenna or feedline may present an incorrect load to the transmitter. Since less than 100% of the power from the power amplifier will be transmitted to the load, the antenna will not radiate with as much energy as with a proper matching. Additionally, the "lost" power will be reflected back through the feedline and dissipated as heat. The result may be excessive heat produced in the final transmitter stage or in the cable.
- An RF oscillator should be electrically and mechanically stable. This is to ensure that the oscillator does not drift in frequency.

2.12 Single Sideband

- An SSB transmitter that is operated with the microphone gain set too high will cause splatter interference to other stations operating near its frequency. The same result will be observed if too much speech processing is used.
- **Peak envelope power** is the average power supplied to an antenna transmission line during one RF cycle at the crest of the modulation envelope.

- Suppressing the carrier in a double-sideband phone transmission means that more power can be put into the sidebands (because the carrier contains no useful information).
- The automatic level control (ALC) in an SSB transmitter controls the peak audio input so that the final amplifier is not overdriven. The microphone gain control should be adjusted on a single-sideband phone transmitter for slight movement of the ALC meter on modulation peaks.

2.13 Frequency Modulation

- If an FM transmitter is operated with the microphone gain or deviation set too high, it may cause interference to other stations operating near its frequency. This is called “overdeviation”. If this is happening to you, talk farther away from the microphone or turn down the mic gain.
- An FM transmitter with a broken microphone produces an unmodulated carrier.
- FM voice is best for local VHF/UHF radio communications because it has high-fidelity audio which can be understood even when the signal is somewhat weak.
- The usual bandwidth of a frequency-modulated amateur signal is between 10 and 20 kHz. FM phone cannot be used below 29.5 MHz because the bandwidth would exceed limits in the regulations.
- FM receivers perform in an unusual manner when two or more stations are present. The loudest signal, even though it is only two or three times as loud as the other signals, will be the only transmission demodulated. This is called the **capture effect**.

2.14 Voice and CW Operation

- Many amateurs use an electronic keyer to help form good Morse code characters.
- It is a good idea to tune with a dummy load to reduce interference on the air. You can expect a dummy load to get warm when in use because it is essentially a giant resistor and dissipates RF energy as heat.
- A “VOX” circuit causes a transmitter to automatically transmit when an operator speaks into its microphone.
- A properly adjusted speech processor on a single-sideband transmitter will improve speech intelligibility at the receiver. If a single-sideband phone transmitter is 100% modulated, a speech processor will add nothing to the output power.

- When switching from receive to transmit, the receiver should be muted *first*, before the transmitter is enabled. This is a safety interlock that will save you from blowing up your receiver's front end.
- A speaker and a microphone are electrically identical. Yelling into a loudspeaker will cause it to function as a microphone, and vice versa.

2.15 Digital Operation

- A packet radio link is “connected” when a transmitting station is sending data to only one receiving station, which replies that the data is being received correctly.
- A packet radio station is “monitoring” when it is displaying messages that may not be sent to it and is not replying to any message.
- A **digipeater** is a packet radio station that retransmits only data that is marked to be retransmitted.
- A packet radio network connects multiple stations so that data can be sent over long distances.
- In packet radio, a transceiver and computer system are connected to a “terminal node controller” (TNC). The easiest and simplest way to accomplish this is to connect the TNC to the transceiver's microphone input and speaker/headphone output. Packet radio uses the ASCII encoding to express letters and numbers as digital information, and may also use a protocol called AX.25 to provide network control and link-level operations.
- RTTY communications should maintain a frequency separation of 250 to 500 Hz (center to center) from contacts in progress to minimize interference.
- Digital transmissions use signals called “mark” and “space” to transmit the states 1 and 0.
- AMTOR transmissions can be made in two modes. Mode A uses the “Automatic Repeat Request (ARQ)” protocol, and is normally used for communications after contact has been established (Mode B is faster but less reliable and is used for making calls).
- VHF packet communications most commonly use a data rate of 1200 baud. There is a very good reason for this. Most packet communications on VHF are done through a mode called “Audio Frequency Shift Keying (AFSK)”, which uses audible frequencies transmitted and received directly through the microphone and speaker. There is an upper limit on the frequency of audio that can be passed through a VHF transceiver (in order to maintain maximum bandwidth of the modulated signal), and using a

higher data rate would necessitate the use of audio frequencies that would cause overdeviation of the transmitter.

2.16 Introduction to Electricity

- Current is the flow of electrical charge in a circuit. The symbol for current is I .
- Current is measured “through” a point in the circuit.
- The unit of current is the ampere or amp.
- There are two types of current. **Direct current (DC)** flows in one direction and does not vary with time; **alternating current (AC)** changes direction and varies with time (usually sinusoidally).
- A battery is a source of “EMF”, or electromotive force. This is also known as “voltage”.
- A lot of hams use the symbol E for voltage. From an engineering point of view, this is completely wrong. Despite all evidence to the contrary that you may find in ham radio literature, the symbol for voltage is and has always been V .
- Voltage is measured as a “potential difference”, across two points in a circuit.
- The unit of voltage is the volt.
- A standard automobile battery supplies about 12 volts. An important distinction between this type of battery (a “lead acid battery”) and a conventional flashlight battery is that the lead acid battery can be repeatedly recharged.
- All batteries have an internal resistance, which essentially behaves as a resistor in series with the battery. This internal resistance can cause the supplied voltage of the battery to drop when the current is high.
- Batteries should never be short-circuited (connecting the terminals directly to each other).
- All batteries have discharge limits. Nickel-cadmium batteries should not be discharged to less than 1.0 volts per cell.
- To increase the current capacity of a cell, several cells should be connected in parallel. To increase the voltage output, several cells should be connected in series.

2.17 Power Supplies Again

- Power is the amount of energy per unit time delivered to a device. The symbol for power is P .
- Power is measured in watts.
- The power delivered to an electrical device such as a resistor is equal to the voltage across its terminals multiplied by the current passing through it: $P = IV$. Knowing how to calculate power is important for determining what components to use – for example, most resistors have a specified “maximum power”, and if more power is put through the resistor than the maximum, the resistor will blow up. The same is true of power supplies. If you want to supply 12 volts of power at 5 amperes of current, your power supply must be rated higher than 60 watts for safe operation.
- If your mobile transceiver works in your car but not in your home, the first thing to check is the power supply.
- A power supply converts household current (AC) into 12-volt DC.
- Transceivers usually need lots of power and therefore require heavy-duty power supplies.
- The diode is an important part of a simple power supply, and you will learn more about it in the section on semiconductors. It converts AC to DC, since it allows electrons to flow in only one direction (from cathode to anode).
- Power line voltages have been made standard over the years, and the voltages generally supplied to homes are approximately 120 and 240 volts. Power lines in North America provide alternating current power at a frequency of 60 Hz.
- So-called “transformerless” power supplies are used in some applications. When working on such equipment, one should be very careful because one side of the line cord is connected to the chassis.
- An autotransformer can be used as an efficient method of increasing or decreasing a voltage. They are especially useful in areas with poor electrical service when wall voltages are consistently high or low.
- Since power supplies use low-frequency alternating current, a very loud low-frequency hum in a transmission is almost certainly coming from the power supply.

2.18 Electricity Safety

- The best way to keep unauthorized individuals from using an amateur station at home is to use a key-operated on/off switch in the main power line.
- To lock out a mobile station, disconnect the microphone and lock it up when not in use.
- High-voltage power supplies often use a safety interlock consisting of a switch that breaks contact if the case is opened. This is to prevent anyone opening the cabinet from coming into contact with dangerous high voltages.
- As little as 0.1 A of current can be fatal to the human body.
- The heart is especially sensitive to very small amounts of electrical current, and can be fatally affected.
- The minimum voltage which is usually dangerous to humans is 30 V.
- If you discover someone being burned by high voltage, don't touch them or the wires; turn off the power, call for emergency help, and give CPR if needed.
- The safest method to remove an unconscious person from contact with a high voltage source is *turning off the power first*.
- The safest way to work on a transmitter or a power supply is *turning off the power first*.

2.19 Electrical Ground

- For best protection from electrical shock, all station equipment should be “grounded”. This means that the chassis of the equipment is connected with a wire to an electrical ground. This can be a cold water pipe or an “earthing rod” driven into the ground.
- Earthing rods are typically made of copper-clad steel for superior electrical conductivity.
- A long ground wire can act like an antenna; this is especially notorious on HF bands, where stations that are in tall buildings are installed with long ground wires that are resonant on several HF bands and radiate RF energy, resulting in inexplicable RF burns. It is recommended to keep ground wires as short as possible.
- On mains-operated power supplies, the ground wire should be connected to the metal chassis of the power supply. This ensures that in case there is a fault in the power supply, the chassis does not develop a high voltage with respect to the ground.

- The purpose of using a three-wire power cord and plug on amateur radio equipment is to prevent the chassis from becoming live in case of an internal short (the third prong on the plug is a ground connection).

2.20 Antenna, Tower, and Lightning Safety

- All antenna and rotor cables should be grounded when not in use to protect the station and building from lightning damage.
- When working on an antenna tower, it is necessary to wear approved equipment in accordance with provincial safety standards concerning climbing.
- A safety belt should be worn when working on an antenna tower to prevent you from accidentally falling.
- A hard hat should be worn when working on an antenna tower to protect your head from something dropped from the tower.
- Horizontal wire antennas should be placed high enough so that no one can touch any part of the antenna from the ground. Touching an antenna can cause RF burns.
- Before beginning repairs on an antenna, turn off the transmitter and disconnect the feedline.

2.21 Radiation Safety

- When operating at 1200 MHz or above, keep the antenna away from your eyes when RF is applied. These frequencies are microwave and can cause tissue damage to your eyes.
- Before removing the shielding on a power amplifier, make sure the amplifier cannot accidentally be turned on.
- You should make sure the antenna of a handheld transceiver is not close to your head when transmitting in order to reduce your exposure to RF energy. The antenna should be positioned away from your head and away from others.
- Exposure to a large amount of RF energy will heat body tissue. The eyes are the most likely to be damaged from the heating effects of RF radiation.
- If you operate your amateur station with indoor antennas, locate them as far away as possible from living spaces that will be occupied while you are operating.
- Directional high-gain antennas should be mounted higher than nearby structures so they will not direct RF energy toward people in those structures.

- The ends and center of a dipole antenna should be as high as possible to prevent people from coming into contact with the antenna.