By-the-Group Technician Class Amateur Radio License Study Guide

For the 2014 – 2018 Question Pool

Welcome,

So you want to get your Amateur Radio License. Good! This study guide is intended to help you prepare for the Technician Class license exam.

This study guide is without detailed explanation. Your class instructors, other study guides, and on-line websites can provide explanation of and insight to the many topics presented in this study guide.

Student self-testing has proven invaluable in passing the license exam. Self-testing has moved from in-class paper exams to on-line exams to smart phone apps. If you have a smartphone, use a ham exam app to check and to reinforce your knowledge.

The Technician Class License Exam

- The exam questions are drawn from a question pool of 426 questions
- The questions are organized into 35 groups
- One exam question is drawn from each group
- A Technician Class license exam, therefore, has 35 questions
- To pass, 26 questions must be answered correctly
- Morse code is no longer a part of the exam

FCC Registration Number (FRN)

- To take a license exam, you must have a FRN, that is, a Federal Communication Commission (FCC) Registration Number
- When you register, your contact address becomes a FCC public record and will be available on-line. For privacy, some amateur radio operators choose to register with a mailing address that is different from their home address
- To register, visit https://apps.fcc.gov/cores

Study Guides

- ***The No-Nonsense Technician Class License Study Guide*** by Dan Romanchik, KB6NU. For explanation of a topic, try this study guide first. A free version is available at http://kb6nu.com/study-guides/.
- ***Technician Class FCC License Preparation for Element 2 Technician Class Theory 8th Edition***, Gordon West, WB6NOA and Eric P. Nichols, KL7AJ, ISBN 978-0-945053-79-8
- ***ARRL Ham Radio License Manual 3rd Edition,*** ISBN 978-1-62595-013-0

Self-Testing – Smart Phone Apps

- Many are available
- Android example: ***Ham Test Prep***

Self-Testing – On line

- http://aa9pw.com/radio/technician/
- http://arrlexamreview.appspot.com/index.html
- http://hamexam.org/
- http://www.qrz.com/ht/
- http://www.eham.net/exams/
- https://hamstudy.org/

Exam Locations

- http://www.arrl.org/find-an-amateur-radio-license-exam-session

Best wishes for success,
Duane K. Allen, KK6EE

Version 1.02, May 15, 2017

Version 1.02, May 15, 2017

Group T5A – Basic Electricity

Electrical Current

- Current is the flow of electrons in an electric circuit
- The unit of electrical current is the ampere
- Direct current (DC) is an electrical current that flows in only one direction
- Alternating current (AC) is an electrical current that reverses direction on a regular basis
- Frequency is the number of times per second that an alternating current reverses direction

Voltage

- Voltage is the electromotive force (EMF) that causes electron flow
- The unit of electromotive force is the volt
- A mobile transceiver usually requires about 12 volts

Electrical Power

- Power is the rate at which electrical energy is used
- The unit of electrical power is the watt

Materials

- Copper is a good electrical conductor of electrical current
- Glass is a good electrical insulator

Group T5D – Ohm's Law

Calculating Voltage

- Voltage (E)[1] equals current (I) multiplied by resistance (R)

$$E = I \times R$$

- If 0.5 amperes flow through a 2-ohm resistor, the voltage across the resistor is 1 volt

$$E = 0.5\ \text{A} \times 2\ \Omega = 1\ \text{V}$$

- If 1 ampere flows through a 10-ohm resistor, the voltage across the resistor is 10 volts

$$E = 1\ \text{A} \times 10\ \Omega = 10\ \text{V}$$

- If 2 amperes flow through a 10-ohm resistor, the voltage across the resistor is 20 volts

$$E = 2\ \text{A} \times 10\ \Omega = 20\ \text{V}$$

Calculating Current

- Current (I) equals voltage (E) divided by resistance (R)

$$I = E \div R$$

- In a circuit with an applied voltage of 120 volts and a resistance of 80 ohms, the current flow is 1.5 amperes

$$I = 120\ \text{V} \div 80\ \Omega = 1.5\ \text{A}$$

- In a circuit with a 100-ohm resistor connected across 200 volts, the current flow is 2 amperes

$$I = 200\ \text{V} \div 100\ \Omega = 2\ \text{A}$$

- In a circuit with a 24-ohm resistor connected across 240 volts, the current flow is 10 amperes

$$I = 240\ \text{V} \div 24\ \Omega = 10\ \text{A}$$

Calculating Resistance

- Resistance (R) equals voltage (E) divided by current (I)

$$R = E \div I\ .$$

- If the source is 90 volts and the current through the resistor is 3 amperes, then the resistance is 30 ohms

$$R = 90\ \text{V} \div 3\ \text{A} = 30\ \Omega$$

- If applied voltage is 12 volts and the current flow is 1.5 amperes, then the resistance is 8 ohms

$$R = 12\ \text{V} \div 1.5\ \text{A} = 8\ \Omega$$

- If the source is 12 volts and the circuit draws 4 amperes, then the resistance is 3 ohms

$$R = 12\ \text{V} \div 4\ \text{A} = 3\ \Omega$$

[1] Some references, like Wikipedia, represent voltage with the letter V and Ohm's law as V = IR.

Group T5B – Units Conversion

Pico-, Nano-, and Micro- Units

- 1,000,000 picofarads is **1 microfarad**
  $1{,}000{,}000\ \text{pF} = 1{,}000\ \text{nf} = 1\ \mu\text{F}$
- A microvolt is **one one-millionth of a volt**
  $1\ \mu\text{V} = 0.001\ \text{mV} = 0.000\ 001\ \text{V}$

MIlli- Units

- 500 milliwatts is **0.5 watts**
  $500\ \text{mW} = 0.500\ \text{W} = 0.5\ \text{W}$
- A current of 1.5 amperes is **1,500 milliamperes**
  $1.5\ \text{A} = 1.500\ \text{A} = 1{,}500\ \text{mA}$
- If an ammeter is calibrated in amperes and is used to measure a 3000 milliampere current, then the meter would show a reading of **3 amperes**
  $3000\ \text{mA} = 3.000\ \text{A} = 3\ \text{A}$

Kilo- , Mega- , and Giga- Units

- One kilovolt is **one thousand volts**
  $1\ \text{kV} = 1.000\ \text{kV} = 1{,}000\ \text{V}$
- A radio signal frequency of 1,500,000 hertz is **1500 kHz**
  $1{,}5000{,}000\ \text{Hz} = 1{,}500.000\ \text{kHz} = 1{,}500\ \text{kHz}$
- If a frequency readout calibrated in megahertz shows a reading of 3.525 MHz, then it would show **3525 kHz** if it were calibrated in kilohertz
  $3.525\ \text{MHz} = 3525\ \text{kHz}$
- The frequency 28,400 kHz is **28.400 MHz**
  $28{,}400\ \text{kHz} = 28.400\ \text{MHz}$
- If a frequency readout shows a reading of 2425 MHz, then the frequency is **2.425 GHz**
  $2425\ \text{MHz} = 2.425\ \text{GHz}$

Power Changes in Decibels (dB)

$$\text{Power change} = 10 \times \log\left(\frac{\text{Power}_{\text{END}}}{\text{Power}_{\text{BEGIN}}}\right) \text{dB}$$

- An increase from 5 watts to 10 watts is a power change of approximately of **3 dB**
$$10 \times \log\left(\frac{10\ \text{W}}{5\ \text{W}}\right) = 10 \times \log(2) = 3\ \text{dB}$$
- A decrease from 12 watts to 3 watts is a power change of approximately **- 6 dB**
$$10 \times \log\left(\frac{3\ \text{W}}{12\ \text{W}}\right) = 10 \times \log\left(\frac{1}{4}\right) = -6\ \text{dB}$$
- An increase from 20 watts to 200 watts is a power increase of **10 dB**
$$10 \times \log\left(\frac{200\ \text{W}}{20\ \text{W}}\right) = 10 \times \log(10) = 10\ \text{dB}$$

Group T5C – Electrical Units

Radio Frequencies

- A usual name for electromagnetic waves that travel through space is **radio waves**
- "RF" refers to **radio frequency signals** of all types
- The unit of frequency is the **hertz**

Impedance

- Impedance **is a measure of the opposition to AC current flow in a circuit**
- The units of impedance are **ohms**

Capacitance and Inductance

- The ability to store energy in an electric field is called **capacitance**
- The basic unit of capacitance is **the farad**
- The ability to store energy in a magnetic field is called **inductance**
- The basic unit of inductance is **the henry**

Electrical Power

- **Power (P) equals voltage (E) multiplied by current (I)**
$$P = E \times I$$
- If the applied voltage is 13.8 volts DC and the current is 10 amperes, then the power being used is **138 watts**
$$P = 13.8\ \text{V} \times 10\ \text{A} = 138\ \text{W}$$
- When the applied voltage is 12 volts DC and the current is 2.5 amperes, then the power is **30 watts**
$$P = 12\ \text{V} \times 2.5\ \text{A} = 30\ \text{W}$$
- When the applied voltage is 12 volts DC and the load is 120 watts, there are **10 amperes** flowing in the circuit
$$I = 120\ \text{W} \div 12\ \text{V} = 10\ \text{A}$$

Group T6A – Passive Components

Resistors

- A resistor is used to oppose the flow of current in a DC circuit
- A potentiometer is a type of variable resistor. A potentiometer is often used as an adjustable volume control
- Resistance is the electrical parameter is controlled by a potentiometer

Capacitors and Inductors

- A capacitor stores energy in an electric field
- A capacitor consists of two or more conductive surfaces separated by an insulator
- An inductor stores energy in a magnetic field
- An inductor is usually composed of a coil of wire

Switches and Fuses

- A switch is used to connect or disconnect electrical circuits
- A fuse is used to protect other circuit components from current overloads

Batteries

- All of the following battery types are rechargeable
  - Nickel-metal hydride
  - Lithium-ion
  - Lead-acid gel-cell
- A carbon-zinc battery type is not rechargeable

Group T6B – Active Components

Transistors

- Transistors are capable of using a voltage or current signal to control current flow
- The transistor can amplify signals
- The transistor can be used as an electronic switch or amplifier
- Gain is the term that describes a transistor's ability to amplify a signal

Field Effect Transistors

- The abbreviation FET stands for Field Effect Transistor
- The source, gate, and drain are the three electrodes of a field effect transistor

Bipolar Junction Transistors

- The three electrodes of a PNP or NPN transistor are the emitter, base, and collector
- The transistor can be made of three layers of semiconductor material

Diodes

- The diode allows current to flow in only one direction
- The names of the two electrodes of a diode are the anode and cathode
- The cathode lead of a semiconductor diode is usually identified with a stripe
- The abbreviation LED stands for Light Emitting Diode

Group T6C – Schematic Symbols

Schematics

- The name for standardized representations of components in an electrical wiring diagram is **schematic symbols**
- The symbols on an electrical circuit schematic diagram represent **electrical components**
- Electrical circuit schematic diagrams represent **the way components are interconnected**

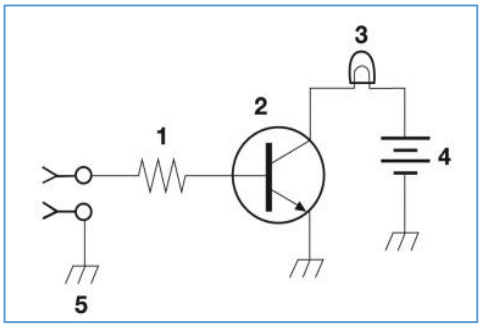

Figure T1

Resistors

- Figure T1, component 1 is a **resistor**
- Figure T2, component 9 is a **variable resistor**

Capacitors

- Figure T2, component 6 is a **capacitor**

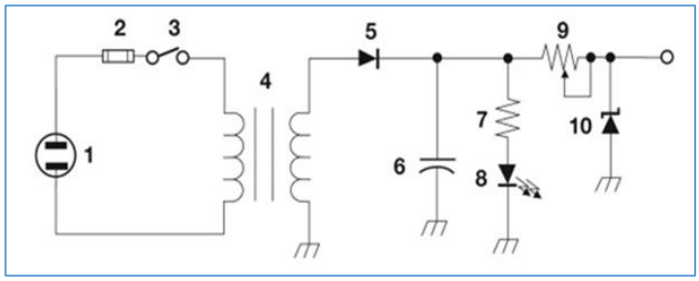

Figure T2

Inductors and Transformers

- Figure T2, component 4 is a **transformer**
- Figure T3, component 3 is a **variable inductor**

Semiconductors

- Figure T1, component 2 is a **transistor**
- Figure T2, component 8 is a **light emitting diode**

Some Other Components

- Figure T1, component 3 is a **lamp**
- Figure T1, component 4 is a **battery**
- Figure T3, component 4 is an **antenna**

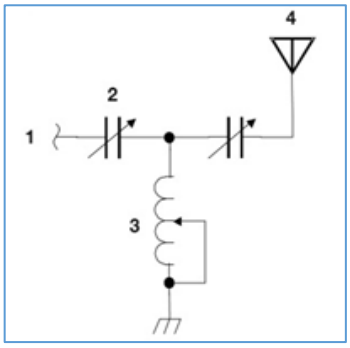

Figure T3

Group T6D – Component and Circuit Functions

Switches
- Figure T2, component 3 represents a single-pole single-throw switch
- A relay is a switch controlled by an electromagnet

Semiconductors
- The function of figure T1, component 2 (a transistor) is to control the flow of current
- A rectifier changes an alternating current into a varying direct current signal
- An integrated circuit combines several semiconductors and other components into one package

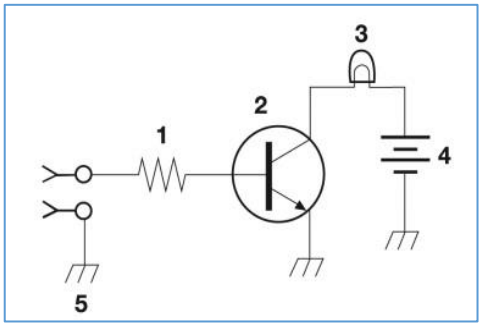

Figure T1

Indicators
- A LED is commonly used as a visual indicator
- A meter can be used to display signal strength on a numeric scale

Power Supplies
- A regulator circuit controls the amount of voltage from a power supply
- A transformer is commonly used to change 120V AC house current to a lower AC voltage for other uses

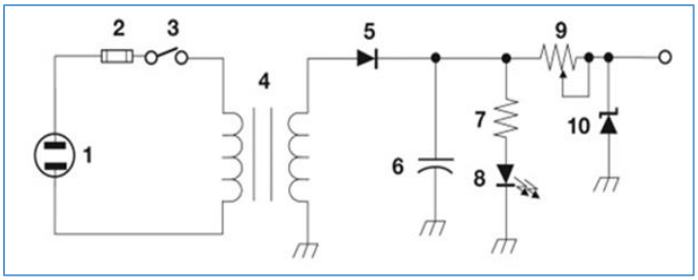

Figure T2

Tuned Circuit
- A simple resonant or tuned circuit is an inductor and a capacitor connected in series or parallel to form a filter
- A capacitor is used together with an inductor to make a tuned circuit

Shielding
- A common reason to use shielded wire is to prevent coupling of unwanted signals to or from the wire

➢ For a 4-meeting course, this point ends meeting 1.

Group T3B – Radio Waves

Electromagnetic Waves

- The two components of a radio wave are the **electric and magnetic fields**
- **The orientation of the electric field** of a radio wave is used to describe its polarization

Speed of Light (and Radio Waves)

- A radio wave travels through free space **at the speed of light**
- The approximate velocity of a radio wave as it travels through free space is **300,000,000 meters per second**

Radio Frequency Spectrum Designations

- The frequency range of the high frequency spectrum (HF) is **3 to 30 MHz** (Wavelength is 100 m to 10 m)
- The frequency range of the very high frequency spectrum (VHF) is **30 to 300 MHz** (Wavelength is 10 m to 1 m)
- The frequency range of the ultra-high frequency spectrum (UHF) is **300 to 3000 MHz** (Wavelength is 1 m to 10 cm)

Wavelength

- **Wavelength** is the distance a radio wave travels during one complete cycle
- The formula for converting frequency to approximate wavelength is **wavelength in meters equals 300 divided by frequency in megahertz**, that is,

$$\lambda = 300 \div f_{MHz}$$

where λ (lambda) is wavelength in meters and

f_{MHz} is frequency in megahertz.

- **The wavelength gets shorter as the frequency increases**
- **The approximate wavelength** of radio waves is often used to identify the different frequency bands

Group T3A – Radio Signals

Propagation

- **Electromagnetic** waves carry radio signals between transmitting and receiving stations
- Inside buildings, UHF signals are often more effective than VHF signals **because the shorter wavelength of UHF signals allows them to more easily penetrate the structure of buildings**
- When using a directional antenna, and if buildings or obstructions are blocking the direct line of sight path, your station may be able to access a distant repeater if you **try to find a path that reflects signals to the repeater**

Multi-Path Distortion

- If another operator reports that your station's 2 meter signals were strong just a moment ago, but now they are weak or distorted, the you should **try moving a few feet or changing the direction of your antenna if possible, as reflections may be causing multi-path distortion**
- The term **picket fencing** is commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting
- The part of the atmosphere that enables the propagation of radio signals around the world is **the ionosphere**
- A likely cause of irregular fading of signals that are being received by ionospheric reflection is the **random combining of signals arriving via different paths**
- If data signals propagate over multiple paths, **error rates are likely to increase**

Antenna Polarization

- If the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization, that is, both either horizontal or vertical, the **signals could be significantly weaker**
- **Horizontal** antenna polarization is normally used for long-distance weak-signal CW and SSB contacts using the VHF and UHF bands
- Because skip signals refracted from the ionosphere are elliptically polarized, **either vertically or horizontally polarized antennas may be used for transmission or reception**

Group T3C –Propagation and Environment

Direct Mode (Line-of-Sight)

- The radio horizon is the distance over which two stations can communicate by direct path
- VHF and UHF radio signals usually travel somewhat farther than the visual line of sight distance between two stations because the earth seems less curved to radio waves than to light
- The reason that direct UHF signals are rarely heard from stations outside your local coverage area is because UHF signals are usually not reflected by the ionosphere

Ionospheric Modes

- The ten and six meters bands may provide long distance communications during the peak of the sunspot cycle
- The best time generally for long-distance 10 meter band propagation via the F layer is from dawn to shortly after sunset during periods of high sunspot activity

Meteor Scattering

- The 6 meters band is best suited for communicating via meteor scatter

Auroral Backscatter

- A characteristic of VHF signals received via auroral reflection is that the signals exhibit rapid fluctuations of strength and often sound distorted

Sporadic E Propagation

- Often when VHF signals are being received from long distances, it is because the signals are being refracted from a sporadic E layer
- Sporadic E is most common cause of occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands

Tropospheric Ducting

- Tropospheric ducting is caused by temperature inversions in the atmosphere
- Tropospheric scatter is responsible for allowing over-the-horizon VHF and UHF communications to ranges of about 300 miles on a regular basis

Knife-Edge Diffraction

- Knife-edge diffraction might cause radio signals to be heard despite obstructions between the transmitting and receiving stations

➢ For a 3-meeting course, this point ends meeting 1.

Group T9A – Antennas

Polarization

- A simple dipole mounted so the conductor is parallel to the Earth's surface is a horizontally polarized antenna
- For vertical antennas, the electric field is perpendicular to the Earth

Electrical Length

- A quarter-wavelength vertical antenna for 146 MHz has an approximate length of 19 inches

$$0.95 \times \lambda \div 4 = 0.95 \times (300 \div 146) \div 4 \times 39.37 \text{ in} = 19 \text{ in}$$

- A 6 meter 1/2-wavelength wire dipole antenna has an approximate length of 112 inches

$$0.95 \times \lambda \div 2 = 0.95 \times 6 \div 2 \times 39.37 \text{ in} = 112 \text{ in}$$

- To make a dipole antenna resonant on a higher frequency, you would shorten it
- "Loading" an antenna refers to inserting an inductor in the radiating portion of the antenna to make it electrically longer

Rubber Duck Antennas

- A disadvantage of the "rubber duck" antenna supplied with most handheld radio transceivers is that it does not transmit or receive as effectively as a full-sized antenna
- A good reason not to use a "rubber duck" antenna inside your car is that signals can be significantly weaker than when it is outside of the vehicle

Radiation Pattern

- The direction in which the radiation is strongest from a half-wave dipole antenna in free space is broadside to the antenna
- The gain of an antenna is the increase in signal strength in a specified direction when compared to a reference antenna
- A beam antenna is an antenna that concentrates signals in one direction
- The quad, Yagi, and dish antennas are directional antennas
- A reason to use a properly mounted 5/8 wavelength antenna for VHF or UHF mobile service is that it offers a lower angle of radiation and more gain than a 1/4 wavelength antenna and usually provides improved coverage
- VHF or UHF mobile antennas are often mounted in the center of the vehicle roof because a roof mounted antenna normally provides the most uniform radiation pattern

Group T9B – Coaxial Cable

Coaxial cables

- The reason that coaxial cable is used more often than any other feed line for amateur radio antenna systems is that it is easy to use and requires few special installation considerations
- As the frequency of a signal passing through coaxial cable is increased, the loss increases
- Air-insulated hard line has the lowest loss at VHF and UHF frequencies
- In typical amateur radio installations, the impedance of the most commonly used coaxial cable is 50 ohms
- The electrical difference between the smaller RG-58 and larger RG-8 coaxial cables is that the RG-8 cable has less loss at a given frequency

Connectors

- PL-259 type coax connectors are commonly used at HF frequencies
- A Type N connector is the more suitable connector for frequencies above 400 MHz
- Coax connectors that are exposed to the weather should be sealed against water intrusion to prevent an increase in feed line loss

Maintaining Low SWR (Standing Wave Ratio)

- In an antenna system that uses coaxial cable feed line, It is important to have a low SWR in order to allow the efficient transfer of power and reduce losses
- An antenna tuner matches the antenna system impedance to the transceiver's output impedance
- Erratic changes in SWR readings could be caused by a loose connection in an antenna or a feed line

Group T7C – Antenna Systems Measurements

Coaxial cable

- A common use of coaxial cable is carrying RF signals between a radio and antenna
- The power lost in a feed line is converted into heat
- The most common cause for failure of coaxial cables is moisture contamination
- The outer jacket of coaxial cable should be resistant to ultraviolet light because ultraviolet light can damage the jacket and allow water to enter the cable
- When compared to foam or solid dielectric types, a disadvantage of air core coaxial cable is that it requires special techniques to prevent water absorption

Antenna Analyzer

- An antenna analyzer can be used to determine if an antenna is resonant at the desired operating frequency

Standing Wave Ratio

- The standing wave ratio (SWR) is a measure of how well a load is matched to a transmission line
- A reading of 1 to 1 on an SWR meter indicates a perfect impedance match between the antenna and the feed line
- An approximate SWR value of 2 to 1 and above causes the protection circuits in most solid-state transmitters to begin to reduce transmitter power
- An SWR reading of 4:1 indicates an impedance mismatch
- Instead of an SWR meter you could use a directional wattmeter to determine if a feed line and antenna are properly matched

Dummy Load

- The primary purpose of a dummy load is to prevent the radiation of signals when making tests
- A dummy load consist of a non-inductive resistor and a heat sink

Group T8A – Radio Wave Modulation

Continuous Wave (CW)

- CW has the narrowest bandwidth
- The approximate maximum bandwidth required to transmit a CW signal is 150 Hz

Single Sideband (SSB)

- Single sideband is a form of amplitude modulation
- The approximate bandwidth of a single sideband voice signal is 3 kHz
- As a voice mode, SSB is most often used for long-distance (weak signal) contacts on the VHF and UHF bands
- For voice transmissions, the primary advantage of single sideband over FM is that SSB signals have narrower bandwidth
- Upper sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications

Frequency Modulation (FM)

- The approximate bandwidth of a VHF repeater FM phone signal is between 10 and 15 kHz
- FM is most commonly used for VHF and UHF voice repeaters
- FM is most commonly used for VHF packet radio transmissions

Television (TV)

The typical bandwidth of analog fast-scan TV transmissions on the 70 cm band is about 6 MHz

Group T8D – Digital Communications

CW

- CW is sent using International Morse code
- All of the following can be used to transmit CW in the amateur bands
  - Straight Key
  - Electronic Keyer
  - Computer Keyboard

Digital

- Digital communications methods include all of the following examples
  - Packet
  - PSK31
  - MFSK
- All the following may be included in packet transmissions
  - A check sum which permits error detection
  - A header which contains the call sign of the station to which the information is being sent
  - Automatic repeat request in case of error
- PSK means Phase Shift Keying
- PSK31 is a low-rate data transmission mode
- An ARQ transmission system is a digital scheme whereby the receiving station detects errors and sends a request to the sending station to retransmit the information

Automatic Packet Reporting System (APRS)

- "APRS" means Automatic Packet Reporting System
- An example of an application of APRS (Automatic Packet Reporting System) is providing real time tactical digital communications in conjunction with a map showing the locations of stations
- A Global Positioning System receiver provides data to the transmitter when sending automatic position reports from a mobile amateur radio station

TV

- The term NTSC refers to an analog fast scan color TV signal

Group T0A – Electrical Safety

Electrical Shock

- Current flowing through the body causes **all of the following** health hazards
  - By heating tissue
  - It disrupts the electrical functions of cells
  - It causes involuntary muscle contractions
- **All of the following** are good ways to guard against electrical shock at your station
  - Use three-wire cords and plugs for all AC powered equipment
  - Connect all AC powered station equipment to a common safety ground
  - Use a circuit protected by a ground-fault interrupter
- The green wire in a three-wire electrical AC plug is connected to the **safety ground**
- A hazard that might exist in a power supply when it is turned off and disconnected is that **you might receive an electric shock from the charged stored in large capacitors**

Fire Safety

- The purpose of a fuse in an electrical circuit is **to interrupt power in case of overload**
- It is unwise to install a 20-ampere fuse in the place of a 5-ampere fuse because **excessive current could cause a fire**
- Home-built equipment that is powered from 120V AC power circuits should always include **a fuse or circuit breaker in series with the AC hot conductor**

Battery safety

- A hazard that is presented by a conventional 12-volt storage battery is that **explosive gas can collect if not properly vented**
- If a lead-acid storage battery is charged or discharged too quickly **the battery could overheat and give off flammable gas or explode**
- A safety hazard of a 12-volt storage battery is that **shorting the terminals can cause burns, fire, or an explosion**

Lightning Protection

- A precaution that should be taken when installing devices for lightning protection in a coaxial cable feed line is to **ground all of the protectors to a common plate which is in turn connected to an external ground**

➢ **For a 4-meeting course, this point ends meeting 2.**
➢ **For a 2-meeting course, this point ends meeting 1.**

Group T0B – Antenna and Tower Safety

Antenna Location

- Establish a minimum safe distance from a power line when installing an antenna **so that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires**
- Avoid attaching an antenna to a utility pole because **the antenna could contact high-voltage power wires**

Work Crew Safety

- An important safety precaution to observe when putting up an antenna tower is to **look for and stay clear of any overhead electrical wires**
- A crank-up tower **must never be climbed unless it is in the fully retracted position**
- It is **never** safe to climb a tower without a helper or observer
- Before climbing an antenna tower, **put on a climbing harness and safety glasses**
- Members of a tower work team should wear hard hats and safety glasses **at all times when any work is being done on the tower**
- The purpose of a gin pole is **to lift tower sections or antennas**

Tower Grounding

- **Local electrical codes** establish grounding requirements for an amateur radio tower or antenna
- Proper grounding for a tower includes having **separate eight-foot long ground rods for each tower leg, bonded to the tower and each other**
- When installing ground wires on a tower for lightning protection, **ensure that connections are short and direct**
- **Sharp bends must be avoided** for the grounding conductors used for lightning protection

Group T0C – RF Safety

Health Risk

- RF radiation differs from ionizing radiation because **RF radiation does not have sufficient energy to cause genetic damage**
- VHF and UHF radio signals are **non-ionizing radiation**
- The exposure limits vary with frequency because **the human body absorbs more RF energy at some frequencies than at others**
- If a person accidentally touches your antenna while you are transmitting, **they might receive a painful RF burn**

Evaluating Risk

- **50 watts PEP at the antenna** is the maximum power level that an amateur radio station may use at VHF frequencies before an RF exposure evaluation is required
- **All of the following** are acceptable methods to determine that your station complies with FCC RF exposure regulations
  - By calculation based on FCC OET Bulletin 65
  - By calculation based on computer modeling
  - By measurement of field strength using calibrated equipment
- **All of the following** factors affect the RF exposure of people near an amateur station antenna:
  - Frequency and power level of the RF field
  - Distance from the antenna to a person
  - Radiation pattern of the antenna
- **50 MHz** has the lowest value for Maximum Permissible Exposure limit
- Duty cycle is one of the factors used to determine safe RF radiation exposure levels because **it affects the average exposure of people to radiation**
- In calculating the average time of RF exposure, the duty cycle is **the percentage of time that a transmitter is transmitting**

Managing Risk

- You can make sure your station stays in compliance with RF safety regulations **by re-evaluating the station whenever an item of equipment is changed**
- One way amateur operators can prevent exposure to RF radiation that exceed FCC-supplied limits is to **relocate antennas**
- If the averaging time for exposure is 6 minutes, **2 times as much** power density is permitted if the signal is present for 3 minutes and absent for 3 minutes rather than being present for the entire 6 minutes

Group T4A – Station Setup

Grounding and Power

- A **flat strap** is the best conductor to use for RF grounding
- For communications equipment, use a regulated power supply because **it prevents voltage fluctuations from reaching sensitive circuits**

Microphones

- Microphone connectors on amateur transceivers differ from each other because **some connectors include push-to-talk and voltages for powering the microphone**
- To cure distorted audio caused by RF current flowing on the shield of a microphone cable, install a **ferrite choke** on the cable

Computers

- The ways that a computer could be used in an amateur radio station include **all of the following**:
  - For logging contacts and contact information
  - For sending and/or receiving CW
  - For generating and decoding digital signals
- When using a computer in digital communications, the computer's **sound card provides audio to the microphone input and converts received audio to digital form**
- In packet radio stations, a **terminal node controller** (TNC) connects the computer to the transceiver

Between Transmitter and Antenna

- To monitor the standing wave ratio of the station antenna system, an in-line SWR meter should be installed **in series with the feed line, between the transmitter and antenna**
- A filter installed **between the transmitter and the antenna** can reduce any harmonic emission from your station

Mobile Installations

- The negative return connector of a mobile transceiver's power cable should be connected **at the battery or engine block ground strap**
- If a mobile transceiver's received audio has a high-pitched whine that varies with engine speed, then the source is **the alternator**
- if another operator reports a variable high-pitched whine on the audio from your mobile transmitter, then probably **noise from the vehicle's electrical system is being transmitted along with your speech audio**

Group T4B – Receive and Transmit Setup

Frequency Control

- The keypad or VFO knob can be used to enter the operating frequency on a modern transceiver
- A quick way to access a favorite frequency is to store it in a memory channel
- "Repeater offset" is the difference between the repeater's transmit and receive frequencies

Transmit Setup

- Setting the microphone gain too high may cause the output signal to become distorted

Receive Setup

- The function of automatic gain control (AGC) is to keep the received audio volume relatively constant
- The purpose of the squelch control is to mute receiver output noise when no signal is being received
- To reduce ignition interference, turn on the noise blanker
- "RIT" means Receiver Incremental Tuning
- The RIT or clarifier can be used if the voice pitch of a single-sideband signal seems too high or low
- The advantage of having multiple receive bandwidth choices on a multimode transceiver is that it permits noise or interference reduction by selecting a bandwidth matching the mode
- The appropriate receive bandwidth for SSB reception is 2400 Hz
- The appropriate receive bandwidth for CW reception is 500 Hz

Group T7A – Radio Subsystems

Oscillators and Mixers

- An oscillator is a circuit that generates a signal of a desired frequency
- A mixer is used to convert a radio signal from one frequency to another

Receivers

- Sensitivity describes the ability of a receiver to detect the presence of a signal
- Selectivity describes the ability of a receiver to discriminate between multiple signals
- An RF preamplifier is installed between the antenna and receiver

Transmitters

- Modulation describes combining speech with an RF carrier signal
- A transverter takes the output of a low-powered 28 MHz SSB exciter and produces a 222 MHz output signal
- An RF power amplifier increases the low-power output from a handheld transceiver

Transceivers

- A transceiver is a unit combining the functions of a transmitter and a receiver
- A multi-mode VHF transceiver is most useful for VHF weak-signal communication
- "PTT" refers to the push-to-talk function, which switches between receive and transmit

Group T7B – Radio Frequency Interference (RFI)

Creating a Clean Signal

- If you are told your FM handheld or mobile transceiver is over-deviating, you can **talk farther away from the microphone**
- **All of the following** may be a cause of radio frequency interference
  - Fundamental overload
  - Harmonics
  - Spurious emissions
- A symptom of RF feedback in a transmitter or transceiver is **reports of garbled, distorted, or unintelligible transmissions**
- **All of the following** might be the problem if you receive a report that your audio signal through the repeater is distorted or unintelligible
  - Your transmitter may be slightly off frequency
  - Your batteries may be running low
  - You could be in a bad location
- **All of the following** may be useful in correcting a radio frequency interference problem:
  - Snap-on ferrite chokes
  - Low-pass and high-pass filters
  - Band-reject and band-pass filters

Reducing Susceptibility

- If a neighbor tells you that your station's transmissions are interfering with their radio or TV reception, you should **make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel**
- A broadcast AM or FM radio could unintentionally receive an amateur radio transmission if **the receiver is unable to reject strong signals outside the AM or FM band**
- To reduced or eliminated the overload of a non-amateur radio or TV receiver by an amateur signal, **block the amateur signal with a filter at the antenna input of the affected receiver**
- A first step to resolve cable TV interference from your ham radio transmission is to **be sure all TV coaxial connectors are installed properly**
- A way to reduce or eliminate interference by an amateur transmitter to a nearby telephone is to **put a RF filter on the telephone**

Mitigating RF Noise

- A Part 15 device is **an unlicensed device that may emit low powered radio signals on frequencies used by a licensed service**
- If something in a neighbor's home is causing harmful interference to your amateur station, **all of the following** are correct actions:
  - Work with your neighbor to identify the offending device
  - Politely inform your neighbor about the rules that prohibit the use of devices which cause interference
  - Check your station and make sure it meets the standards of good amateur practice

Group T7D – At the Workbench

Voltage Measurement

- You would use **a voltmeter** to measure an electric potential or electromotive force
- The correct way to connect a voltmeter to a circuit is **in parallel with the circuit**
- When measuring high voltages with a voltmeter, **ensure that the voltmeter and leads are rated for use at the voltages to be measured**

Current Measurement

- **An ammeter** is used to measure electric current
- An ammeter is usually connected **in series with the circuit** being measured

Resistance Measurement

- **An ohmmeter** is used to measure resistance
- When measuring circuit resistance with an ohmmeter, **ensure that the circuit is not powered**
- If an ohmmeter, connected across an unpowered circuit, initially indicates a low resistance and then shows increasing resistance with time, then probably **the circuit contains a large capacitor**

Multimeters

- **Voltage and resistance** measurements are commonly made using a multimeter
- **Attempting to measure voltage when using the resistance setting** can damage a multimeter

Solder

- **Rosin-core solder** is best for radio and electronic use
- The characteristic appearance of a cold solder joint is **a grainy or dull surface**

➢ **For a 3-meeting course, this point ends meeting 2.**

Group T2A – Transmitting

Repeater Offset

- The most common repeater frequency offset in the 2 meter band is **plus or minus 600 kHz**
- A common repeater frequency offset in the 70 cm band is **plus or minus 5 MHz**

CQ

- The procedural signal "CQ" means **calling any station**
- When responding to a station calling CQ, you should **transmit the other station's call sign followed by your call sign**
- **All of the following** guidelines apply when choosing an operating frequency for calling CQ:
  - Listen first to be sure that no one else is using the frequency
  - Ask if the frequency is in use
  - Make sure you are in your assigned band

Contacting via Repeater

- An appropriate way to call another station on a repeater if you know the other station's call sign is to **say the station's call sign then identify with your call sign**
- To indicate that you are listening on a repeater, instead of "CQ", give **your call sign**

Test Transmissions

- When making on-air transmissions to test equipment or antennas, an amateur operator must **properly identify the transmitting station**
- When making a test transmission, **station identification is required at least every ten minutes during the test and at the end of the test**

Appropriate Power

- The FCC rule regarding power levels used in the amateur bands under normal, non-distress circumstances require, **while not exceeding the maximum power levels used on a given band, use only the minimum power necessary to carry out the desired communication**

Band Plans

- A band plan is **a voluntary guideline for using different modes or activities within an amateur band** that are more specific than the privileges established by the FCC
- The national calling frequency for FM simplex operations in the 70 cm band is **446.000 MHz**

Group T2B – Phone Operations

Courtesy

- When two stations transmitting on the same frequency interfere with each other, **common courtesy should prevail, but no one has absolute right to an amateur frequency**

Simplex

- **Simplex communication** describes an amateur station that is transmitting and receiving on the same frequency
- You should consider communicating via simplex **when stations can communicate directly without using a repeater**

FM and SSB Phone

- **The amplitude of the modulating signal** determines the amount of deviation of an FM signal
- When the deviation of an FM transmitter is increased, **its signal occupies more bandwidth**
- **If the microphone gain is too high, causing over-deviation** of the FM signal, then the result is interference to stations on nearby frequencies
- SSB phone **is permitted in at least some portion of all amateur bands above 50 MHz**

Squelch

- **Carrier squelch** describes the muting of receiver audio controlled solely by the presence or absence of an RF signal

Access Tones

- **CTCSS** (Continuous Tone-Coded Squelch System) describes the use of a sub-audible tone transmitted with normal voice audio to open the squelch of a receiver
- **All of the following** common problems might cause you to be able to hear but not access a repeater even when transmitting with the proper offset:
  - The repeater receiver may require audio tone burst for access
  - The repeater receiver may require a CTCSS tone for access
  - The repeater receiver may require a DCS (Digital Coded Sequence) tone sequence for access

Phonetics and Q codes

- The FCC encourages the **use of a phonetic alphabet** when identifying your station using phone
- The Q signal ***QRM*** indicates that you are receiving interference from other stations

The Q signal ***QSY*** indicates that you are changing frequency

Group T2C – Public Service Communications

Operations

- The **FCC rules always apply** to the operation of an amateur station
- Amateur station control operators are permitted to operate outside the frequency privileges of their license class **only if necessary in situations involving the immediate safety of human life or protection of property**
- If the commercial power is out, one way to recharge a 12-volt lead-acid station battery is to **connect the battery in parallel with a vehicle's battery and run the engine**

Organizations

- **Both RACES and ARES may provide communications during emergencies**
- The Amateur Radio Emergency Service (ARES) is **licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service**
- **All of the following** describes the Radio Amateur Civil Emergency Service (RACES):
  - A radio service using amateur frequencies for emergency management or civil defense communications
  - A radio service using amateur stations for emergency management or civil defense communications
  - An emergency service using amateur operators certified by a civil defense organization as being enrolled in that organization

Networks

- The accepted practice for an amateur operator who has checked into an emergency traffic net is to **remain on frequency without transmitting until asked to do so by the net control station**
- The accepted practice to get the immediate attention of a net control station when reporting an emergency is to **begin the transmission by saying "Priority" or "Emergency" followed by your call sign**

Handling Message Traffic

- A characteristic of good emergency traffic handling is **passing messages exactly as received**
- The preamble in a formal traffic message refers to **the information needed to track the message as it passes through the amateur radio traffic handling system**
- In reference to a formal traffic message, **the "check" is a count of the number of words or word equivalents in the text portion of the message**
- To insure that voice message traffic containing proper names and unusual words are copied correctly by the receiving station, **such words and terms should be spelled out using a standard phonetic alphabet**

➢ **For a 4-meeting course, this point ends meeting 3.**

Group T8B – Space Communications

Privilege

- **Any amateur whose license privileges allow them to transmit on the satellite uplink frequency** may be the control operator of a station communicating through an amateur satellite or space station
- **Any amateur holding a Technician or higher class license** may make contact with an amateur station on the International Space Station using 2 meter and 70 cm band amateur radio frequencies

Software Programs

- **All of the following** are provided by satellite tracking programs
  - Maps showing the real-time position of the satellite track over the earth
  - The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
  - The apparent frequency of the satellite transmission, including effects of Doppler shift
- **The Keplerian elements** (satellite orbit parameters) are inputs to a satellite tracking program

Practices

- That a satellite is operating in mode U/V means that **the satellite uplink is in the 70 cm band and the downlink is in the 2 meter band**
- The transmitter power used on the uplink frequency of an amateur satellite or space station should be **the minimum amount of power needed to complete the contact**
- **FM Packet** is a commonly used method of sending signals to and from a digital satellite

Satellite specific

- In satellite communications, Doppler shift is **an observed change in signal frequency caused by relative motion between the satellite and the earth station**
- Spin fading is caused by **rotation of the satellite and its antennas**
- The initials LEO indicate that **the satellite is in a Low Earth Orbit**
- A satellite beacon is **a transmission from a space station that contains information about a satellite**

Group T8C – Amateur Activities

Direction Finding

- Radio direction finding is used to locate sources of noise interference or jamming
- A directional antenna is useful for a hidden transmitter hunt

Contesting

- Contesting is a popular operating activity that involves contacting as many stations as possible during a specified period of time
- When contacting another station in a radio contest, send only the minimum information needed for proper identification and the contest exchange
- A grid locator is a letter-number designator assigned to a geographic location

Radio Control Models

- The maximum power allowed when transmitting telecommand signals to radio controlled models is 1 watt
- When sending signals to a radio control model using amateur frequencies, instead of on-air station identification, a label indicating the licensee's name, call sign, and address must be affixed to the transmitter

Voice Over Internet Protocol (VoIP)

- As used in amateur radio, Voice Over Internet Protocol (VoIP) is a method of delivering voice communications over the Internet using digital techniques
- A gateway is an amateur radio station that is used to connect other amateur stations to the Internet
- You might obtain a list of active nodes that use VoIP from a repeater directory

Internet Radio Linking Project (IRLP)

- Internet Radio Linking Project (IRLP) is a technique to connect amateur radio systems, such as repeaters, via the Internet using Voice Over Internet Protocol
- Access to an IRLP node is accomplished by using DTMF signals
- To select a specific IRLP node when using a portable transceiver, use the keypad to transmit the IRLP node ID

Group T1A – The Amateur Radio Service

Purpose

- The Amateur Radio Service allows a person to conduct radio experiments and to communicate with other license hams around the world
- A purpose of the Amateur Radio Service is advancing skills in the technical and communications phases of the radio art
- A purpose of the Amateur Radio Service is enhancing international goodwill

The Federal Communications Commission (FCC)

- The FCC regulates and enforces the rules for the Amateur Radio Service in the United States
- Part 97 of the FCC regulations contains the rules and regulations governing the Amateur Radio Service

Definitions

- An *amateur station* is a station in the Amateur Radio Service consisting of the apparatus necessary for carrying on radio communications
- A *telecommand* is a one-way transmission to initiate, modify or terminate functions of a device at a distance
- *Telemetry* is a one-way transmission of measurements at a distance from the measuring instrument

Frequency Coordination

- A *frequency coordinator* is an entity (person or group) who recommends transmit/receive channels and other parameters for auxiliary and repeater stations
- A frequency coordinator is selected by amateur operators in a local or regional area whose stations are eligible to be auxiliary or repeater stations

Interference

- *Harmful interference* is that which seriously degrades, obstructs, or repeatedly interrupts a radio communication service operating in accordance with the Radio Regulations
- At no time is willful interference to other amateur radio stations permitted
- The Radionavigation Service is protected from interference by amateur signals under all circumstances
- If you are interfering with a radio location station outside the United States, then you must stop operating or take steps to eliminate the harmful interference

Group T1B – VHF/UHF Spectrum Allocation

VHF/UHF Frequency Bands

6 meters

50 MHz	to	54 MHz

- 52.525 MHz is within the 6 meter band

2 meters

144 MHz	to	148 MHz

- 146.52 MHz is within the 2 meter band

1.25 meters (often called the 220 band)

219-220	222 MHz to 225 MHz

- 223.50 MHz is within the 1.25 meter band

70 centimeters (often called the 440 band)

420 MHz	to	450 MHz

- 443.350 MHz is an authorized 70 cm frequency in ITU region 2.

23 centimeters (often called the 1.2 GHz band)

1240 MHz	to	1300 MHz

- 1296 MHz is an authorized 23 cm frequency.

Restricted Mode Sub-Bands

- The 6 meter, 2 meter, and 1.25 meter bands have mode-restricted sub-bands
- Only CW emission mode (Morse code) is permitted in the mode-restricted sub-bands at 50.0 to 50.1 MHz and 144.0 to 144.1 MHz
- Only a data emission mode may be used between 219 and 220 MHz

Transmissions Near Band Edges

- You should not set your transmit frequency to be exactly at the edge of an amateur band or sub-band for all of the following reasons:
  - To allow for calibration error in the transmitter frequency display
  - So that modulation sidebands do not extend beyond the band edge
  - To allow for transmitter frequency drift

International Telecommunication Union (ITU)

- The ITU is a United Nations agency for information and communication technology issues
- Frequency assignments for U.S. maritime mobile stations are not the same everywhere in the world because amateur frequency assignments can vary among the three ITU regions
- Frequency assignments for U.S. Territories may differ from those in the 50 U.S. States because some U.S. Territories are located in ITU regions other than region 2

Spectrum Sharing

- Because the amateur service is secondary in some portions of the 70 cm band, U.S. amateurs may find non-amateur stations in the bands and must avoid interfering with them

Group T1C – Licenses

New Licenses

- New amateur radio licenses that are currently issued by the FCC are the Technician, General, and Amateur Extra class licenses.
- After passing the examination required for your first amateur radio license, you may operate a transmitter on an amateur service frequency as soon as your operator/station license grant appears in the FCC's license database
- The normal term for an FCC-issued primary station/operator license is ten years

License Lapse

- Following the expiration of an amateur license, there is a two year grace period during which the license can be renewed
- During the grace period, transmitting is not allowed until the FCC license database shows that the license has been renewed
- If correspondence from the FCC is returned as undeliverable because the grantee failed to provide a correct mailing address, then the result may be revocation of the station license or suspension of the operator license

Call Signs

- A U.S. amateur call sign is a prefix of the letter K, W, N, or A and a possible second letter, a digit 0 through 9, and a suffix of.one, two, or three letters.
- W3ABC is a valid US amateur radio station call sign
- A special event call sign has a single letter in both the prefix and suffix. It is a one by one call sign, that is, one letter in the prefix and one letter in the suffix.

Vanity Call Signs

- Any licensed amateur may select a desired call sign under the vanity call sign rules
- An example of vanity call sign available to a technician class operator is K1XXX but neither KA1X nor W1XX
- Only the person named as trustee on a club station license grant may select a vanity call sign for the club station

International

- International communications are permitted by an FCC-licensed amateur station if they are communications incidental to the purposes of the amateur service and remarks of a personal character
- You are allowed to operate your amateur station in a foreign country when the foreign country authorizes it
- In addition to places where the FCC regulates communications, an FCC-licensed amateur station may transmit from any vessel or craft located in international waters and documented or registered in the United States

Group T1D – Permitted and Prohibited Transmissions

Prohibited Transmissions

- FCC-licensed amateur stations are prohibited from communications with **any country whose administration has notified the ITU that it objects to such communications**
- In regards to transmissions of language that may be considered indecent or obscene, **any such language is prohibited**

Permitted Transmissions

- **During an Armed Forces Day Communications Test**, an FCC-licensed amateur station may exchange messages with a U.S. military station.
- The transmission by an amateur station of codes or ciphers that hide the meaning of a message is allowed **only when transmitting control commands to space stations or radio control craft**
- An amateur station is authorized to transmit music only **when incidental to an authorized retransmission of manned spacecraft communications**
- **Auxiliary, repeater, or space stations** are allowed to automatically retransmit the signals of other amateur stations
- An amateur station may transmit without identifying **when transmitting to control a model craft**
- Amateur stations are authorized to transmit signals related to broadcasting, program production, or news gathering **only where such communications directly relate to the immediate safety of human life or protection of property** and no other means is available.

Pecuniary Interest

- The control operator of an amateur station may receive compensation for operating the station **when the communication is incidental to classroom instruction at an educational institution**
- Amateur radio operators may use their stations to notify other amateurs of the availability of equipment for sale or trade **when the equipment is normally used in an amateur station and such activity is not conducted on a regular basis**

Broadcasting

- Broadcasting is defined as **transmissions intended for reception by the general public**
- An amateur radio station may engage in broadcasting **when transmitting code practice, information bulletins, or transmissions necessary to provide emergency communications**

Group T1E – The Control Operator

Control Operator Required

- An amateur station is **never** permitted to transmit without a control operator
- **The class of license held by the control operator** determines the transmitting privileges of an amateur station
- Under normal circumstances, **at no time** may a Technician Class licensee be the control operator of a station operating in an exclusive Extra class operator segment of the amateur bands

Designation of Control Operator

- Only **the station licensee** may designate the station control operator
- In designating a control operator, the station licensee may designate **only a person for who an amateur operator/primary station license grant appears in the FCC database or who is authorized for alien reciprocal operation**
- The FCC presumes **the station licensee** is the control operator of an amateur station, unless documentation to the contrary is in the station records
- When the control operator is not the station licensee, both **the control operator and station licensee are equally responsible** for the proper operation of the station

Types of Station Control

- An amateur station control point is **the location at which the control operator function is performed**
- When the control operator is at the control point, the control type is **local control**
- An example of remote control is **operating the station over the internet**
- **Repeater operation** is an example of automatic control
- Operation of an APRS (Automatic Packet Reporting System) network digipeater is an example of **automatic** control.

Group T1F – Station Identification

Station Identification

- An amateur station is required to transmit its assigned call sign **at least every 10 minutes during and at the end of a communication**
- The method for a station transmitting phone signals is to **send the call sign using CW or phone emission**
- When operating in a phone sub-band, **the English language** is the acceptable language to use for station identification
- **All of the following** self-assigned indicators are acceptable when identifying using a phone transmission:
  - KL7CC stroke W3
  - KL7CC slant W3
  - KL7CC slash W3
- When identifying a station on the air as "Race Headquarters", the type of identification is a **tactical call sign**
- If you are using tactical identifiers, you must transmit the station's FCC-assigned call sign **at the end of each communication and every ten minutes during a communication**
- If you upgrade your license, after your call sign transmit **/KT, /AE or /AG when using new license privileges earned by CSCE while waiting for an upgrade to a previously issued license to appear in the FCC license database**

Repeaters

- A **repeater station** simultaneously retransmits the signal of another amateur station on a different channel or channels
- If a repeater inadvertently retransmit communications that violate the FCC rules, **the control operator of the originating station** is accountable

Third-Party Communications

- The FCC rules authorize the transmission of non-emergency third party communications to **any foreign station whose government permits such communications**
- When a non-licensed person is allow to speak to a foreign station, **the foreign station must be in a country with which the U.S. has signed a third-party agreement**

Club Stations

- **At least 4** persons are required to be members of a club for a club station license to be issued by the FCC

FCC Inspection

- **At any time upon request by an FCC representative**, a station licensee must make the station and its records available for FCC inspection