Amateur Radio Technician Class License Study Guide

Week 3

SUBELEMENT T7 – PRACTICAL CIRCUITS – [4 Exam Questions - 4 Groups]

March 21, 2023

Question pool section: T7

Terms and concepts:

T7A – Station equipment: receivers, transceivers, transmitter amplifiers, receive amplifiers, transverters; Basic radio circuit concepts and terminology: sensitivity, selectivity, mixers, oscillators, PTT, modulation

T7B – Symptoms, causes, and cures of common transmitter and receiver problems: overload and overdrive, distortion, interference and consumer electronics, RF feedback

T7C – Antenna and transmission line measurements and troubleshooting: measuring SWR, effects of high SWR, causes of feed line failures; Basic coaxial cable characteristics; Use of dummy loads when testing

T7D – Using basic test instruments: voltmeter, ammeter, and ohmmeter; Soldering

Corresponding pages of Gordon West book

T7: 65, 66, 117, 120-124, 129-133, 135, 137, 138, 165, 166, 177-183

Measurement tools

All of the basic units that enter into ohm's law can be easily measured with an appropriate meter. *A volt meter would be used measure electric potential, and is connected in parallel with a component to measure the applied voltage. An ammeter is used to measure electric current, and is connected in series with the component.* An ohmmeter is used to measure electrical resistance. Most bench measurements of these types are done with an instrument called a multimeter, or a Volt-Ohm meter (VOM). *Measurements made with a multimeter include voltage (EMF), current, and resistance.* Most multimeters have multiple ranges for each unit, measuring from millivolts to hundreds of volts, microamps to amps, and ohms to kilo ohms or megohms. Although analog VOM's exist, most new multimeters are digital (DMM).

When using a multimeter as a voltmeter to measure electrical potential or EMF, it should be connected to the circuit under test in parallel with the circuit. Make sure the voltage range selected is adequate for the expected voltage. If unsure of the expected voltage, begin measurements using the highest range on the meter. *When a multimeter is used* as an ammeter *to measure current, it should be connected in series with the component.* As with voltage measurements, observe proper polarity and select an appropriate range for the expected reading. When measuring high voltages with a voltmeter, ensure that the voltmeter and leads are rated for use at the voltages to be measured. Caution must be used to prevent the user from coming in contact with the circuit or test leads when measuring voltage.

Care needs to be exercised to avoid damage to the delicate circuits of multimeters. *If you attempt to measure voltage* in a powered circuit*, with your multimeter set to read resistance, the meter would likely be damaged. If an ohmmeter connected across* an <u>unpowered</u> circuit *indicates increasing resistance with time,* the circuit likely contains *a large discharged capacitor.*

Electrical connections between components typically utilize *solder*, a low melting point metal alloy. Traditionally a *lead-tin* alloy, many modern solders utilize a *tin-copper* blend to reduce exposure to the toxicity of lead. Regardless of the metallurgy, *only <u>rosin-core</u> solder should be used for radio and electronic work, as acid-core solder* (intended for plumbing) is unacceptable. Technique is important. Failure to add enough heat to while soldering may result in a *cold solder joint. Cold tin-lead solder joints, have a rough or lumpy surface, a*nd can produce poor or intermittent electrical connections. A properly soldered joint should have a bright, shiny appearance.

When working with antennas and feed lines, an *SWR (standing wave ratio)* meter (or bridge) is an indispensable measurement tool. SWR is a measure of how well a load (antenna) is matched to a transmission line (feed line). *An SWR reading of 1:1 indicates a perfect impedance match between the antenna and the feed line. A high SWR reading (4:1) indicates an impedance mismatch.* This means that RF energy being sent down the feed line to the antenna is being reflected back to the transmitter. Since this reflected energy could damage a solid-state transmitter, *most solid-state transmitters reduce output power as SWR increases beyond a certain level, to protect the output amplifier transistors.*

Additional instruments may be used to measure SWR or impedance match. *An antenna analyzer may be used to determine if an antenna is resonant* (has a good impedance match to the feed line) *at the desired operating frequency.* Antenna analyzers tend to cost more than an SWR meter, but can provide much more detailed information about the impedance match. *A directional wattmeter may also be used to measure SWR.* These meters can indicate “forward” power (going from the transmitter to the antenna) and “reflected” power (coming back from the antenna to the transmitter). Comparing the forward and reflected power measured with a directional wattmeter is another way to determine if a feed line and antenna are properly matched.

A high SWR reading may indicate a failure of the coaxial cable feedline. *Moisture contamination is a common cause of coaxial cable failure. This is why the outer jacket of coaxial cable needs to be resistant to ultraviolet light. If it were not resistant to ultraviolet light, the jacket could be damaged and allow water to enter the cable. Air core coaxial cable* may be used at VHF and UHF frequencies, as it has lower loss per foot *compared to solid or foam dielectric types, but special techniques are required to prevent moisture* from getting *in the cable.* Regardless if it's due to impedance mismatch or a failed cable, *power lost in a feed line is* wasted, as it's *converted into heat*.

Station equipment and circuits

The most basic equipment in a working ham station is a receiver to receive signals and a transmitter to generate signals. *Transmitting and receiving fuctions are often combined in single unit known as a transceiver. The ability of a receiver to detect the presence of a signal is known as sensitivity. The ability of that receiver to discriminate between multiple signals is known as selectivity.* There are several types of circuits in a transceiver. One of the most basic circuit is an *oscillator, which generates a signal at a specific frequency. A mixer may be used to convert a signal from one frequency to another.*

The transmitter in a transceiver also contains a modulator circuit. *Modulation is the process of combining speech* (or other information) *with an RF carrier signal. Most transceivers utilize a PTT (push to talk) input, which switches the transceiver from receive to transmit when grounded.* The PTT switch is is usually a bar or button on the side of the microphone.

Amplifiers are circuits that are used to increase the power of a signal. *An RF preamplifier is* used to boost the level of an incoming signal, and is *installed between the antenna and the receiver. An RF power amplifer is a device which increases the transmitted output power from a transceiver.* Some *VHF power amplifiers have a SSB/CW-FM switch. This is used to set the amplifier for proper operation in the selected mode*.

A specialized device, known as *a transverter* (transceiving converter)*, is used to convert the RF input and output of a transceiver to another band*. This often a cost effective way to be able to operate on a different band. A microwave transverter may be used with a 144 MHz transceiver to operate on the 10 GHz band.

Common transmitter/receiver problems and interference

While on the air, you may receive reports that there is a problem with your signal. Over-deviation can result in distortion or a signal that breaks up. *If you are told that your FM handheld or mobile transceiver is over-deviating, all you need to do is speak farther away from the microphone. Reports of a garbled, distorted, or unintelligible voice transmission may be a symptom of RF feedback in a transmitter or transceiver.* In some cases, *distorted audio may be caused by RF current on the shield of a microphone cable*. This can be *cured by installing a ferrite choke*.

There are other possible causes of distorted signals. *If you receive a report that your audio signal through an FM repeater is distorted or unintelligible, it could be that your transmitter is slightly off frequency, that your batteries are running low, or that you are simply in a bad location.*

Regardless of which end you are on, interference can be a real headache. One of the simplest ways to reduce interference on the amateur bands is to use a *dummy load* when making test transmissions. *A dummy load* (or dummy antenna) *consists of a non-inductive resistor and a heatsink.* The resistor takes the place of the antenna, converting the RF energy to heat and *preventing signals from being transmitted over the air when making test* transmissions.

A common problem with amateur stations is radio frequency interference (RFI) or television interference (TVI). This is when interference results from the operation of your amateur radio station. *Most interference results from harmonic radiation, spurious emissions or fundamental overload.* Harmonic radiation is defined as unwanted signals at frequencies that are multiples of the fundamental (chosen) frequency. As an example, the third harmonic of a 15 meter signal is 3 times 21 MHz = 63 MHz. This falls in the range of the low VHF channels on a television. Spurious emissions are unwanted signals that are transmitted along with the desired signal, and are usually generated by the transmitter. Fundamental overload is interference which is caused by a strong signal from a nearby source.

A variety of devices may be useful in correcting radio frequency interference problems. These include snap-on ferrite chokes, low-pass and high-pass filters or band-reject and band-pass filters. *A broadcast AM or FM radio may unintentionally receive an amateur radio transmission because it is unable to reject strong signals outside the AM or FM band. Fundamental overload of a non-amateur radio or TV receiver by an amateur signal may be reduced or eliminated by blocking the amateur signal with a filter at the antenna input of the affected receiver. If your VHF transceiver is experiencing overload from a nearby FM broadcast station, installation of a band-reject filter may solve the problem.*

If you are told by a neighbor that your amateur station is causing interference to their radio or TV reception, you should investigate immediately. First, *make sure that your station is operating properly, and that it does not cause interference on your own radio or TV when it is tuned to the same channel*. On the other hand, *what should you do if something in a neighbor's home is causing harmful interference to your amateur station? The first step is to check your station and make sure it meets the standards of good amateur practice. Then*

work with your neighbor to identify the offending device, and politely inform your neighbor that FCC rules prohibit the use of devices that cause interference.

Cable television interference is a different case altogether. Many interference problems with cable TV systems can be related to loose or corroded connections, so *the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission is to make sure all TV feed line coaxial connectors are installed properly.* A break in the cable TV transmission line or the shield on a cable transmission line can cause problems for either party. With such breaks, television interference can result when the amateur station is transmitting or interference may occur in the amateur receiver. Regardless of the source, an amateur radio operator should be responsive to any complaint of interference. This is good for amateur radio and good for your neighborhood.