Amateur Radio Technician Exam Preparation Course

ARRL
The National Association for Amateur Radio®

Amateur Radio Technician Exam Prep Course

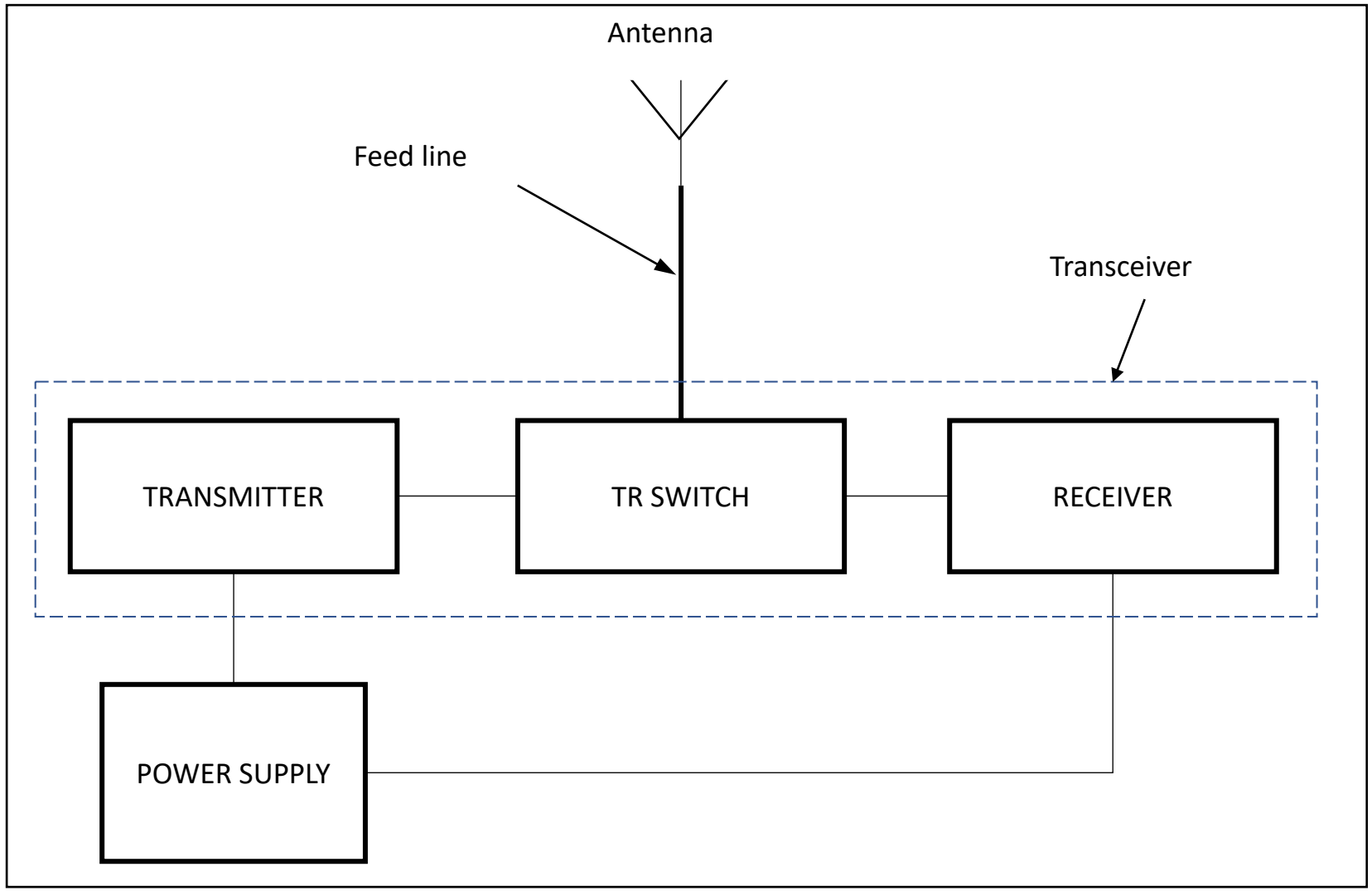
Module 5

Amateur Radio Equipment

5.1 Modulation
5.2 Transmitters and Receivers
5.3 Digital Communications
5.4 Power Supplies and Batteries

Modulation & Bandwidth

The Basic Radio Station



Review from previous module

What Happens During Radio Communication?

- Transmitting (sending a signal) …

- Information (voice, data, video, commands, etc.) is converted to electronic form
- The information in electronic form is added to a radio wave
- The radio wave carrying the information is sent from the station antenna into space

What Happens During Radio Communication? (cont.)

- Receiving …

- The radio wave carrying the information is intercepted by the receiving station's antenna
- The receiver extracts the information from the received wave
- The information is then presented to the user in a format that can be understood (sound, picture, words on a computer screen, response to a command, etc.)

What Happens During Radio Communication? (cont.)

- Adding and extracting the information can be simple or complex
- This makes ham radio fun … learning all about how radios work
- Don’t be intimidated. You will be required to only know the basics, but you can learn as much about the “art and science” of radio as you want.

Adding Information – Modulation

- When we add some information to the radio wave, (the carrier) we *modulate* the wave
  - Turn the wave on and off (Morse code)
  - Speech or music
  - Data
- Different modulation techniques vary different properties of the wave to add the information:
  - Amplitude, frequency, or phase
- A signal that doesn't carry any information is called *unmodulated*
- Recovering the information from a modulated signal is called *demodulation*

Continuous Wave (CW)

- The simplest type of modulation is a *continuous wave* turned ON and OFF in a coded pattern
- Morse code radio signals are called CW for that reason

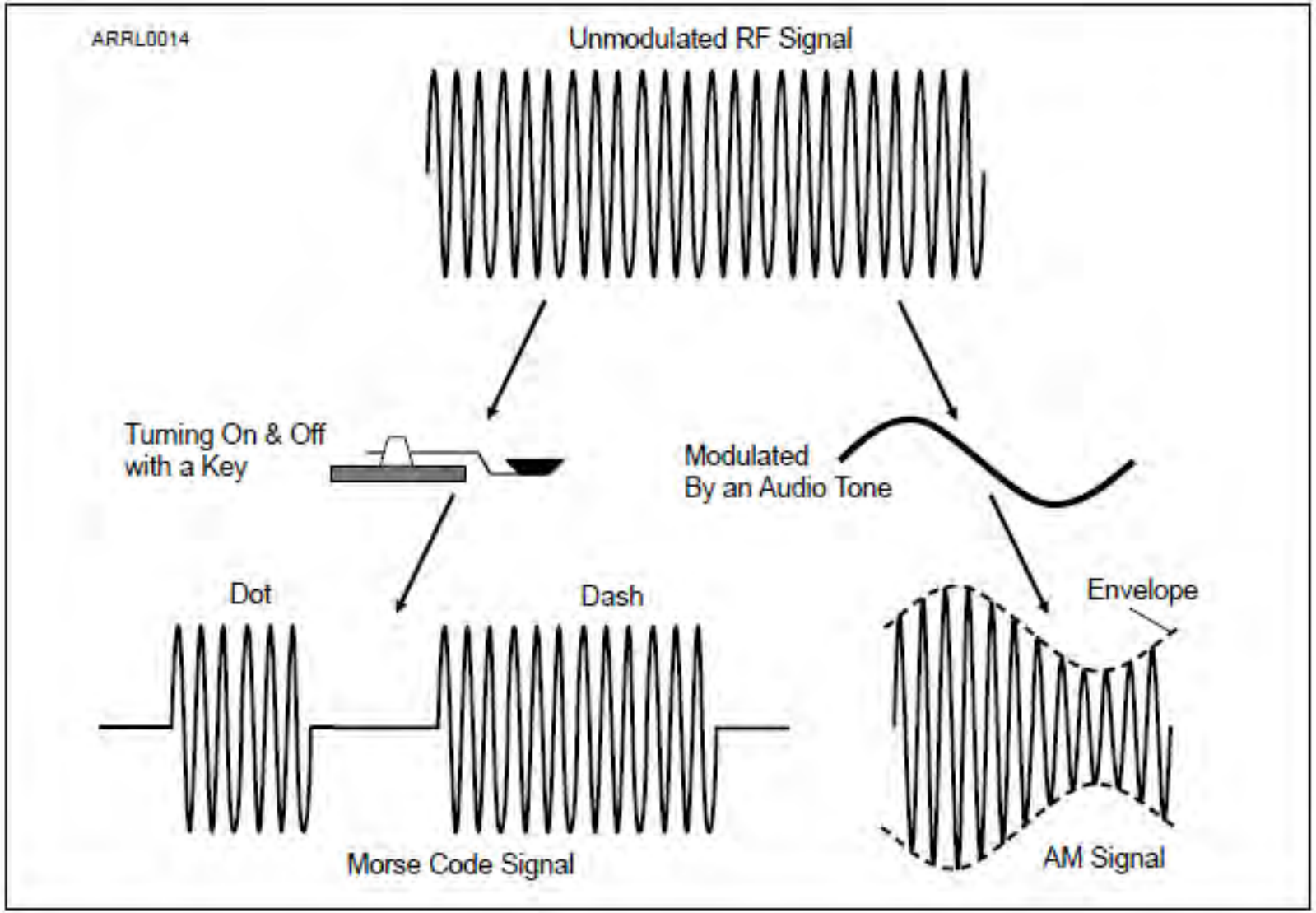
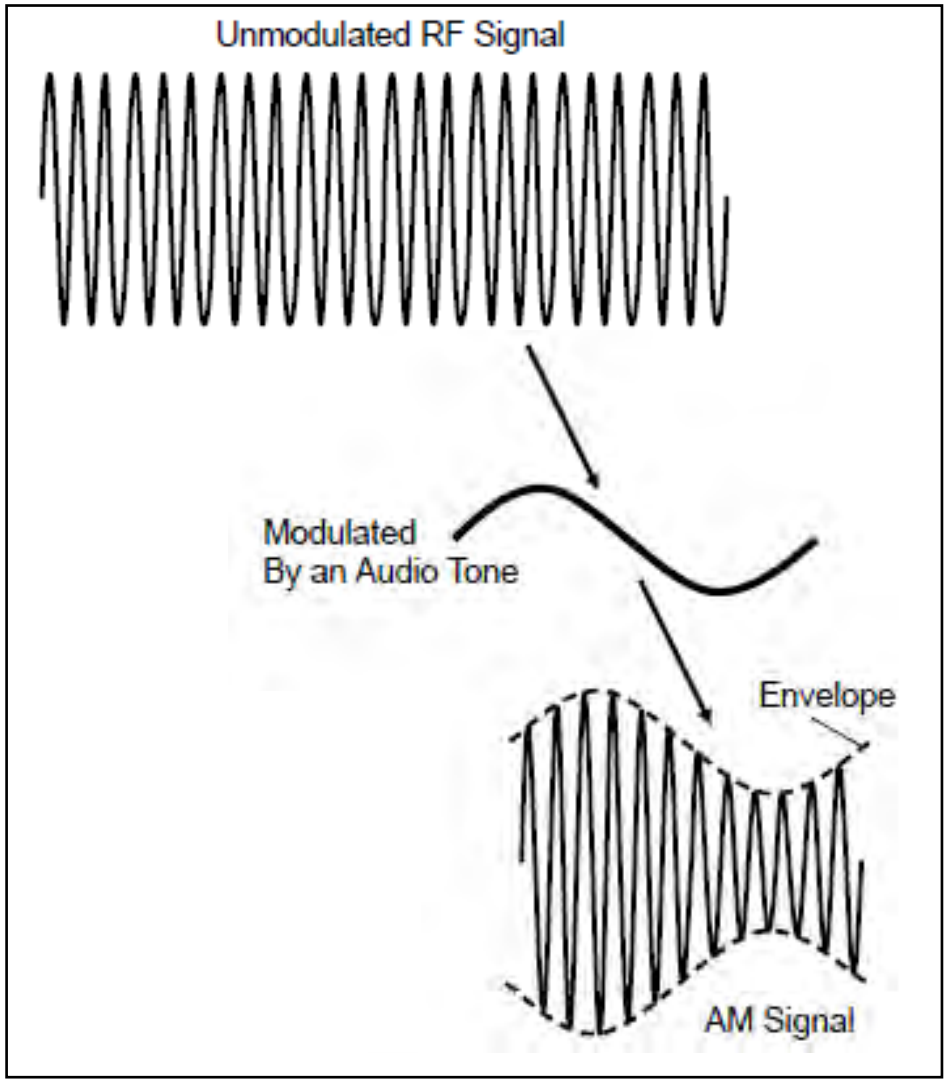


Figure 5.1 — Information can be added to an RF signal by modulating the signal's amplitude.

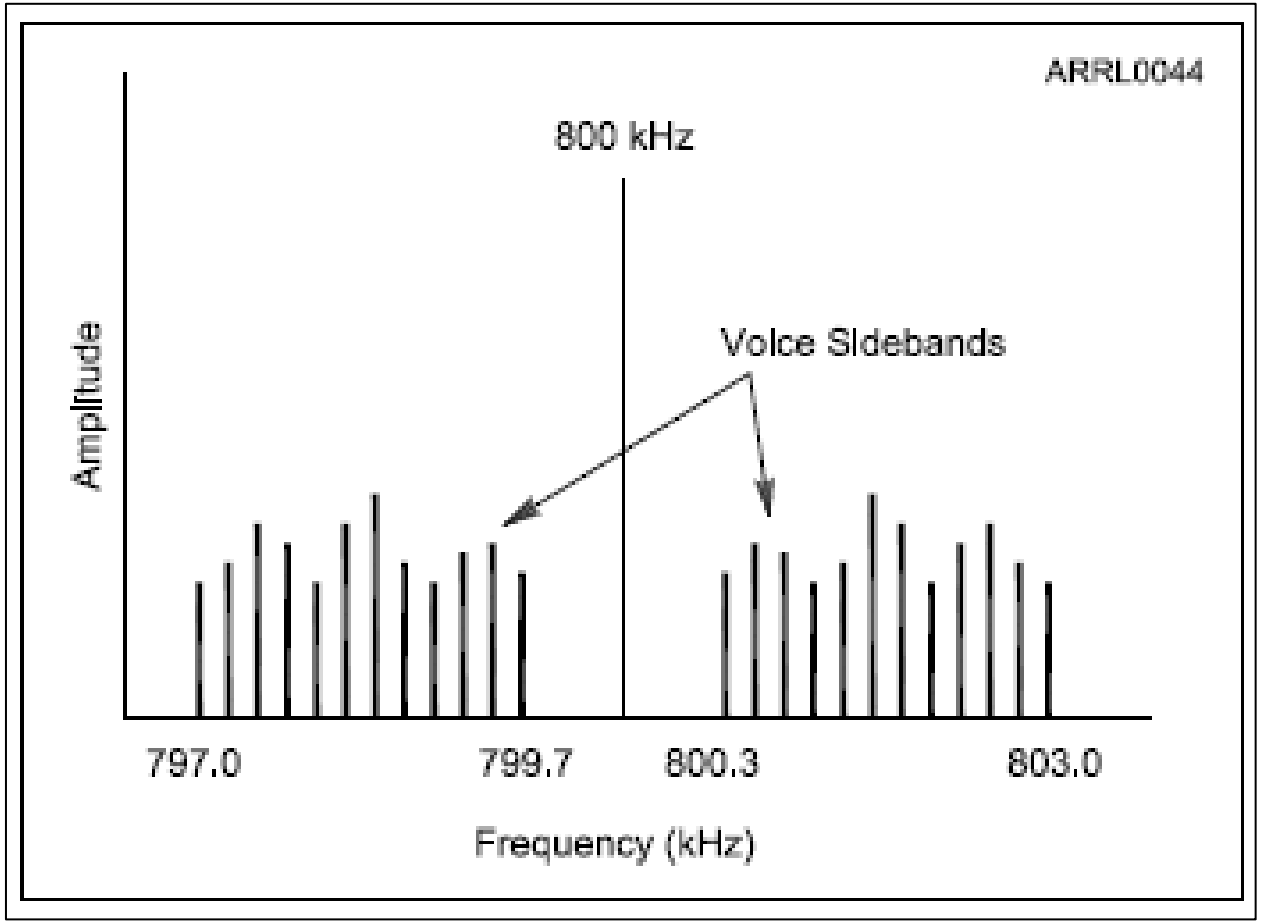
Amplitude Modulation (AM)

- In AM, the amplitude of the carrier wave is modified in step with the waveform of the information (the tone shown here)
- The information is contained in the outline or envelope of the resulting signal
- Recovering speech or music from the envelope of an AM signal is called *detection*



Composite Signals – Sidebands

- An actual AM signal is made up of three separate signals working together — a carrier and two *sidebands*
- The carrier is a steady, unmodulated signal
- The *upper sideband* or USB signal is higher in frequency than the carrier
- The *lower sideband* or LSB signal is lower in frequency than the carrier



SINGLE-SIDEBAND (SSB)

- In an AM signal the carrier doesn't carry any information
- Each sideband contains a copy of the modulating signal
- Only *one sideband* is needed to transmit the information
- All of the SSB signal's power is concentrated in the one sideband
  - SSB signals are effective for long-distance and weak signal voice contacts because of the additional power
- The *upper sideband* (USB) is used on VHF and UHF
- Both USB and LSB are used on the MF and HF bands

Frequency and Phase Modulation

- Modes that vary the frequency of a signal to add speech or data information are called *frequency modulation* or FM
- The frequency of an FM signal varies with the amplitude of the modulating signal
- *Phase modulation* varies a signal's phase instead of changing its frequency … in other words, very similar to FM
- FM is the mode used by most VHF and UHF repeaters
- Because of the way FM receivers work, only one signal can be received at a time. This is called the *capture effect* and if multiple signals are present, only the strongest will be heard in the receiver.

Bandwidth of Modulated Signals

- A signal can have both a frequency and a strength or amplitude
- Signals are spread out over a *range* of frequencies (called *bandwidth*)
- You can communicate with SSB over much longer ranges and in poorer conditions than with FM or AM, particularly on the VHF and UHF bands
- For even better range, extremely narrow CW signals are the easiest for a human operator to send and receive, particularly in noisy or fading conditions
- CW and SSB are considered *weak signal* modes because they are more effective than FM at low signal strengths

Bandwidth of Modulated Signals (cont.)

- If an SSB signal can use either an upper or lower sideband — which one should you use?
- Ham radio has standardized on the following *conventions* …
  - Below 10 MHz, LSB
  - Above 10 MHz, USB — including all of the VHF and UHF bands
    - One exception: amateurs are required to use USB on the five channels of the 60 meter band (5 MHz)

PRACTICE QUESTIONS

What is CW?

A. A type of electromagnetic propagation
B. A digital mode used primarily on 2 meter FM
C. A technique for coil winding
D. Another name for a Morse code transmission

T8D09 D 5-2

Which of the following is a form of amplitude modulation?

A. Spread spectrum
B. Packet radio
C. Single sideband
D. Phase shift keying (PSK)

T8A01 C 5-3

What type of modulation is commonly used for VHF packet radio transmissions?

A. FM or PM
B. SSB
C. AM
D. PSK

T8A02 A 5-4

Which type of modulation is commonly used for VHF and UHF voice repeaters?

A. AM
B. SSB
C. PSK
D. FM or PM

T8A04 D 5-4

Which of the following is a disadvantage of FM compared with single sideband?

A. Voice quality is poorer
B. Only one signal can be received at a time
C. FM signals are harder to tune
D. All these choices are correct

T8A12 B 5-4

Which type of voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands?

A. FM
B. DRM
C. SSB
D. PM

T8A03 C 5-4

Which of the following types of signal has the narrowest bandwidth?

A. FM voice
B. SSB voice
C. CW
D. Slow-scan TV

T8A05 C 5-4

Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?

A. Upper sideband
B. Lower sideband
C. Suppressed sideband
D. Inverted sideband

T8A06 A 5-4

What is a characteristic of single sideband (SSB) compared to FM?

A. SSB signals are easier to tune in correctly
B. SSB signals are less susceptible to interference
C. SSB signals have narrower bandwidth
D. All these choices are correct

T8A07 C 5-4

What is the approximate bandwidth of a typical single sideband (SSB) voice signal?

A. 1 kHz

B. 3 kHz

C. 6 kHz

D. 15 kHz

T8A08 B 5-4

What is the approximate bandwidth of a VHF repeater FM voice signal?

A. Less than 500 Hz
B. About 150 kHz
C. Between 10 and 15 kHz
D. Between 50 and 125 kHz

T8A09 C 5-4

What is the approximate bandwidth of AM fast-scan TV transmissions?

A. More than 10 MHz
B. About 6 MHz
C. About 3 MHz
D. About 1 MHz

T8A10 B 5-4

What is the approximate bandwidth required to transmit a CW signal?

A. 2.4 kHz

B. 150 Hz

C. 1000 Hz

D. 15 kHz

T8A11 B 5-4

Transmitters and Receivers

- Usually combined into one unit called a *transceiver*
- Give you control of *frequency* and *mode*
- Generalized categories
  - Mobile
  - Single band
  - Dual band
  - All band
  - Multi-mode
  - Handheld or HT

Single-Band Mobile

- Single-band, 2 meter … good starter radio
- Operates from 13.8 volts DC, requires external power supply or car battery
- Requires an external antenna
- Can be operated mobile or as a base station
- Limited to frequency modulation (FM) and usually either 2 meters or 70 cm bands
- Up to approximately 50 watts output
- Typical frequencies: VHF/UHF FM

Dual-Band Mobile

- Same as the single-band transceiver but includes additional band(s)
- Most common are 2 meter and 70 cm bands
- Often includes 6 meters, 222 MHz (1.25 meters) or 1.2 GHz bands
- Might have separate antenna connections for each band or a single connection for a dual-band antenna
- Up to approximately 50 watts output
- Typical frequencies: VHF/UHF FM

Multimode Transceiver

- Nearly all HF rigs are multimode
- VHF multimode operates on FM plus AM/SSB/CW modes
- Required for *weak-signal* operation on VHF/UHF
- More features add complexity and cost
- More flexibility will allow you to explore new modes as you gain experience (and increased license privileges)

Multiband Transceiver

- Covers many bands – usually refers to coverage of HF + VHF/UHF
- Also covers all modes
- Frequently 100 watts on HF, some power limitations on high bands (25-50 watts)
- Larger units have internal power supplies, smaller units need external power supply
- Some have built-in “tuners”

Handheld (HT) Transceiver

- Small handheld FM units
- Can be single band or dual band
- Limited power (usually 5 watts or less)
- Includes power (battery) and antenna in one package
- Often purchased as a starter rig but low power limits range
- Single, dual and multiband versions (with increasing cost and complexity)
- Some can receive outside the ham bands, such as aircraft, commercial FM broadcast, etc.

Handheld (HT) Transceiver (cont.)

- Very portable and self-contained
- Internal microphone and speaker
- Rubber duck antenna
- Battery powered
- Extra battery packs
  - AA cell pack useful in emergencies
- Drop-in, fast charger
- Extended antenna
- External microphone and speaker
- Headset

Side-By-Side Comparison

	SINGLE BAND	DUAL BAND	MULTIMODE	MULTIBAND	HANDHELD
FREQUENCY AGILITY	LIMITED	MEDIUM	MEDIUM	FULL	LIMITED
FUNCTION-ALITY	LIMITED	LIMITED	FULL	FULL	LIMITED
EASE OF USE	EASY	MEDIUM	MEDIUM	DIFFICULT	EASY
PROGRAM-MING	EASY	EASY	MEDIUM	CHALLENGING	EASY/MEDIUM
POWER	LOW	LOW	MEDIUM	HIGH	LOW
COST	LOW	MODEST	HIGH	HIGH	LOW

Sample Radios

DUAL BAND

HANDHELD (HT)

MULTIBAND

Selecting Band, Frequency and Mode

- Two functions common to all radios …
  - Control of *frequency* and *mode*
  - Amateurs can use many different modes … most other radio services are restricted to a single mode
- For multiband radios, begin by selecting the *band*
- Then, select a *frequency* within the band (called *tuning*)
  - Uses the *variable frequency oscillator* (VFO) and/or keypad (directly enter frequencies)
  - Memories or *memory channels* are used to store frequencies and modes for later recall (quickly tune to frequently used frequencies)
- For multimode radios, select the *mode*
  - SSB, AM, FM, CW, Data

Transmitter Functions

- Transmitter output power
  - In HF rigs and radios using AM/SSB and CW, controlled by an RF power control knob
  - FM handheld and mobile radios have selectable fixed power levels
- Microphone *gain* controls the level of speech audio of SSB transmitters
  - FM transmitters usually have a fixed microphone gain
- Switching between receive and transmit on voice …
  - Manual: Use *push-to-talk* (PTT) button
  - Automatic: *Voice-operated transmitter* control circuit (VOX)
  - On CW (Morse Code), use a key (an *electronic keyer* is faster than manual)
- Use a *dummy load* to avoid interfering with other stations while you're adjusting transmitter (heavy duty resistor that can absorb and dissipate output power)

Spurious Signals

- Excessive modulation results in distortion of transmitted speech (*spurious* outputs on adjacent frequencies) … called *splatter*
- Overmodulated FM signal has excessive deviation (overdeviating)
  - Usually caused by speaking too loudly into the microphone
- Overmodulation of an AM or SSB signal is caused by speaking too loudly or by setting the microphone gain or speech compression too high

Receiver Functions

- AF Gain: *Volume control* (sets speaker or headphone listening level)
- RF Gain: Adjusts the sensitivity of the receiver to incoming signals
- Automatic Gain Control (AGC): Adjusts sensitivity to keep the output volume constant for both weak and strong signals
- Squelch: Mutes the receiver's audio output when no signal is present (eliminates continuous noise)
  - Many transceivers have a monitor switch that temporarily opens the squelch to hear weak signals

Selectivity and Sensitivity

- Receivers are compared on the basis of two primary characteristics: *sensitivity* and *selectivity*
- Sensitivity determines receiver's ability to detect signals
  - Specified as a minimum detectable signal level (in µV)
- A *preamplifier* (preamp) is used to boost sensitivity
- *Selectivity* is the ability of a receiver to discriminate between signals
- High selectivity means that a receiver can operate properly even in the presence of strong signals on nearby frequencies

Filtering and Tuning

- A receiver rejects unwanted signals through the use of *filters*
- Signals then pass through filters *narrow* enough (i.e., smaller bandwidth) to reject all but the desired signal
- Wide filters (around 2.4 kHz) are used for SSB reception
- Narrow filters (around 500 Hz) are used for CW and data mode
- Multiple filters allows you to reduce noise or interference by selecting a filter with just enough bandwidth to pass the desired signal
- *Receiver incremental tuning* (RIT … also called *clarifier*) is a fine-tuning control used for SSB or CW
  - Allows you to tune in a station that is slightly off frequency or to adjust the pitch of an operator's voice that seems too high or low

VHF/UHF RF Power Amplifiers

- *RF power amplifiers* can be used to increase the output power by a factor of five or more
- Many VHF/UHF power amplifiers can be used on all modes (including SSB and CW … switch between modes)
  - Caution 1: Be sure your antenna is capable of handling the higher power!
  - Caution 2: Be sure you learn about RF exposure!

Transverters

- By using *mixers*, it is possible to convert an entire transceiver to operate on a different band
  - Mixers are part of equipment called a *transverter*
- A *receiving converter mixer* shifts input signals to the desired band where they are received as regular signals by the transceiver
- Transverters allow one main transceiver to be used on one or more new bands

PRACTICE QUESTIONS

Which of the following can be used to enter a transceiver's operating frequency?

A. The keypad or VFO knob
B. The CTCSS or DTMF encoder
C. The Automatic Frequency Control
D. All these choices are correct

T4B02 A 5-5

What is a way to enable quick access to a favorite frequency or channel on your transceiver?

A. Enable the frequency offset
B. Store it in a memory channel
C. Enable the VOX
D. Use the scan mode to select the desired frequency

T4B04 B 5-5

What is an electronic keyer?

A. A device for switching antennas from transmit to receive
B. A device for voice activated switching from receive to transmit
C. A device that assists in manual sending of Morse code
D. An interlock to prevent unauthorized use of a radio

T4A12 C 5-7

What is the function of a transceiver’s PTT input?

A. Input for a key used to send CW
B. Switches transceiver from receive to transmit when grounded
C. Provides a transmit tuning tone when grounded
D. Input for a preamplifier tuning tone

T7A07 B 5-7

What is the primary purpose of a dummy load?

A. To prevent transmitting signals over the air when making tests
B. To prevent over-modulation of a transmitter
C. To improve the efficiency of an antenna
D. To improve the signal-to-noise ratio of a receiver

T7C01 A 5-7

What does a dummy load consist of?

A. A high-gain amplifier and a TR switch
B. A non-inductive resistor mounted on a heat sink
C. A low-voltage power supply and a DC relay
D. A 50-ohm reactance used to terminate a transmission line

T7C03 B 5-7

What would cause your FM transmission audio to be distorted on voice peaks?

A. Your repeater offset is inverted
B. You need to talk louder
C. You are talking too loudly
D. Your transmit power is too high

T2B05 C 5-8

What is the effect of excessive microphone gain on SSB transmissions?

A. Frequency instability
B. Distorted transmitted audio
C. Increased SWR
D. All these choices are correct

T4B01 B 5-8

What can you do if you are told your FM handheld or mobile transceiver is over-deviating?

A. Talk louder into the microphone
B. Let the transceiver cool off
C. Change to a higher power level
D. Talk farther away from the microphone

T7B01 D 5-8

What is the purpose of a squelch function?

A. Reduce a CW transmitter's key clicks
B. Mute the receiver audio when a signal is not present
C. Eliminate parasitic oscillations in an RF amplifier
D. Reduce interference from impulse noise

T2B13 B 5-8

How is squelch adjusted so that a weak FM signal can be heard?

A. Set the squelch threshold so that receiver output audio is on all the time
B. Turn up the audio level until it overcomes the squelch threshold
C. Turn on the anti-squelch function
D. Enable squelch enhancement

T4B03 A 5-8

Which term describes the ability of a receiver to detect the presence of a signal?

A. Linearity
B. Sensitivity
C. Selectivity
D. Total Harmonic Distortion

T7A01 B 5-9

Which term describes the ability of a receiver to discriminate between multiple signals?

A. Discrimination ratio
B. Sensitivity
C. Selectivity
D. Harmonic distortion

T7A04 C 5-9

Where is an RF preamplifier installed?

A. Between the antenna and receiver
B. At the output of the transmitter power amplifier
C. Between the transmitter and the antenna tuner
D. At the output of the receiver audio amplifier

T7A11 A 5-9

Which of the following controls could be used if the voice pitch of a single-sideband signal returning to your CQ call seems too high or low?

A. The AGC or limiter
B. The bandwidth selection
C. The tone squelch
D. The RIT or Clarifier

T4B06 D 5-9

What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?

A. Permits monitoring several modes at once by selecting a separate filter for each mode
B. Permits noise or interference reduction by selecting a bandwidth matching the mode
C. Increases the number of frequencies that can be stored in memory
D. Increases the amount of offset between receive and transmit frequencies

T4B08 B 5-9

Which of the following receiver filter bandwidths provides the best signal-to-noise ratio for SSB reception?

A. 500 Hz
B. 1000 Hz
C. 2400 Hz
D. 5000 Hz

T4B10 C 5-9

What is the result of tuning an FM receiver above or below a signal's frequency?

A. Change in audio pitch
B. Sideband inversion
C. Generation of a heterodyne tone
D. Distortion of the signal's audio

T4B12 D 5-9

What is the function of the SSB/CW-FM switch on a VHF power amplifier?

A. Change the mode of the transmitted signal

B. Set the amplifier for proper operation in the selected mode

C. Change the frequency range of the amplifier to operate in the proper segment of the band

D. Reduce the received signal noise

T7A09 B 5-10

What device increases the transmitted output power from a transceiver?

A. A voltage divider
B. An RF power amplifier
C. An impedance network
D. All these choices are correct

T7A10 B 5-10

What device converts the RF input and output of a transceiver to another band?

A. High-pass filter
B. Low-pass filter
C. Transverter
D. Phase converter

T7A06 C 5-11

Digital Communications

- Why use digital modes?

- Special codes and characters embedded in the stream of data allow the receiving modem to detect [and correct] errors
- Amateurs have developed or adapted techniques for exchanging digital data by transforming the 1s and 0s of data into tones that are in the same frequency range as the human voice

Amateur Digital Modes

- Different combinations of protocols, codes, and modulation, such as SSB or FM, are used to create digital modes
- Popular *HF* digital modes
  - RTTY (radioteletype)
  - PSK31 (keyboard-to-keyboard)
  - FT8 and WSPR (weak signal modes)
  - PACTOR or WINMOR (for Winlink messaging)
- Popular *VHF/UHF* digital modes
  - Packet radio
  - B2F protocol (for Winlink)
  - JT65 for moon-bounce and MSK144 for scatter paths
  - IEEE 802.11 (Wi-Fi) adapted to amateur use on microwave bands
- Popular *Voice* digital modes
  - AOR and FreeDV (HF)
  - D-STAR, System Fusion (C4FM), DMR, and P25 (VHF/UHF)

Packet and Packet Networks

- On VHF and UHF, the most common digital mode is *packet radio*
- Data characters are transmitted in groups called *packets*
- *Frequency-shift keying* (FSK) is used to transmit individual characters
- Each packet consists of a *header*, *data*, and *checksum*
- If an error is detected, the receiver automatically requests the packet be retransmitted until the data is received properly (ARQ or *automatic repeat request*)

Keyboard-to-Keyboard Modes

- Digital modes that are designed for real-time person-to-person communication are called *keyboard-to-keyboard* modes
- Most popular on HF bands
- Most are generated by computer software using a *sound card* and an interface to a transceiver's audio input and output
- Radioteletype (RTTY) is the oldest
- Most popular is PSK31 (phase shift keying, 31 baud)
  - Works very well in noisy conditions

Automatic Packet Reporting System (APRS)

- Uses packet radio to transmit the position information from a moving or portable station
- Basically a packet radio station combined with a *Global Positioning System* (GPS) receiver … can transmit GPS position data
- Can also transmit weather information and short text messages
- A common public service application of APRS is to provide maps of station locations while they are providing real-time tactical communications

Setting Up For Digital Modes

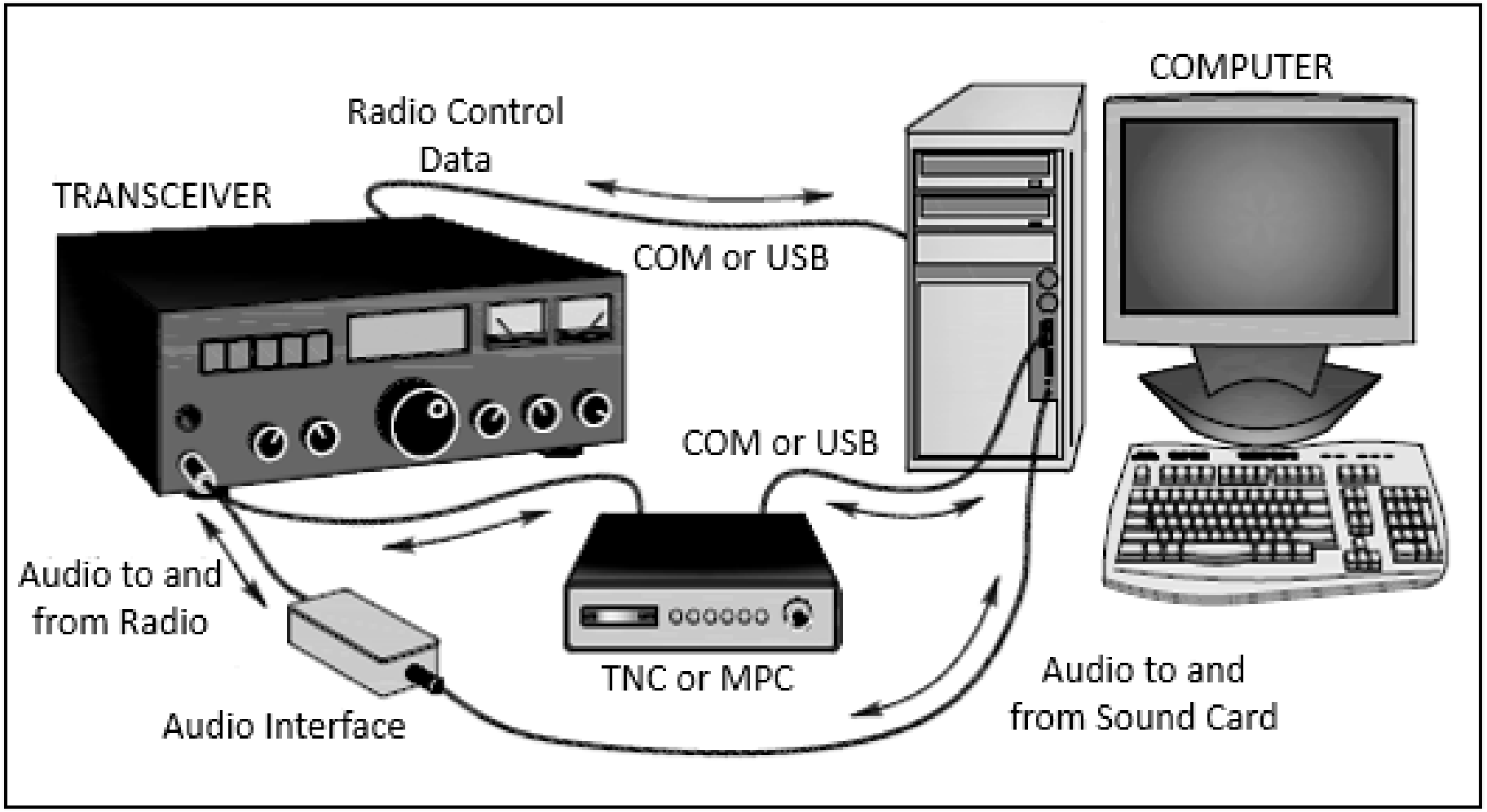


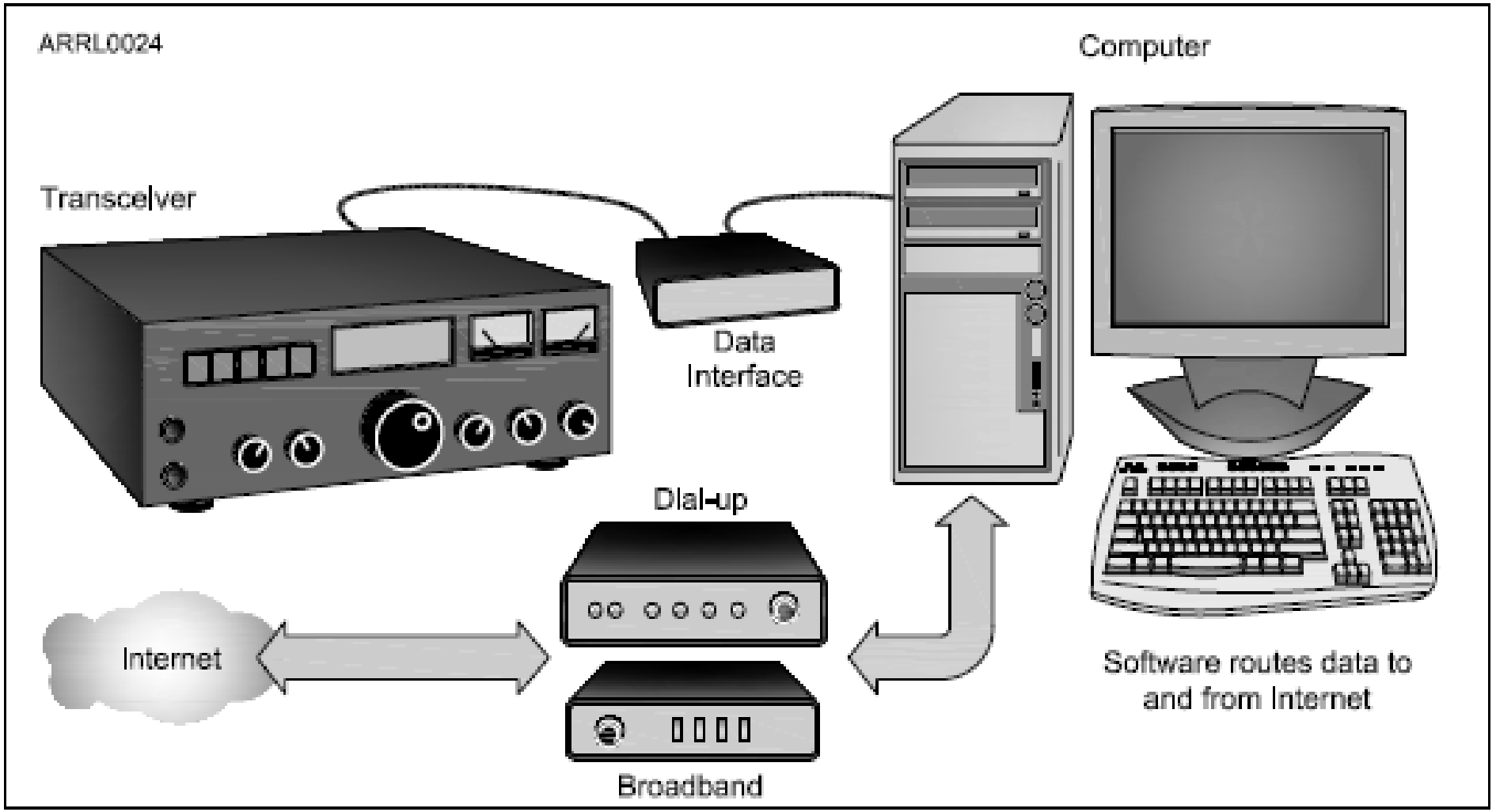
Figure 5.10 … Typical Digital Mode Set Up

Data interfaces are connected between the transceiver's audio inputs and outputs and the computer's data connections (USB or COM ports) or sound card jacks. A TNC or MPC (multiprotocol controller) converts between data and audio. An audio interface isolates the computer sound card from the radio to prevent hum.

Setting Up For Digital Modes (cont.)

- A very popular example of a “sound card mode” is FT8
- If you use a sound card, you may need a digital communications interface to supply the PTT (push-to-talk) signal for keying the transmitter

Gateways



An internet gateway station is a regular digital mode station and also runs software that relays data to and from the internet. The most common example of gateway stations are APRS gateways and Winlink RMS stations.

Figure 5.11 … Typical Gateway Set Up

Gateways (cont.)

- The gateway shown in Figure 5.11 is a special kind of digital station that provides a connection to the internet via Amateur Radio
- Most gateways are set up to *forward* messages
- All of the rules and regulations about commercial and business-related messages and communications apply to internet gateways (*follow the Amateur Radio rules*)

PRACTICE QUESTIONS

Which of the following is a digital communications mode?

A. Packet radio
B. IEEE 802.11
C. FT8
D. All these choices are correct

T8D01 D 5-11

Which of the following best describes an amateur radio mesh network?

A. An amateur-radio based data network using commercial Wi-Fi equipment with modified firmware

B. A wide-bandwidth digital voice mode employing DMR protocols

C. A satellite communications network using modified commercial satellite TV hardware

D. An internet linking protocol used to network repeaters

T8D12 A 5-12

Which of the following operating activities is supported by digital mode software in the WSJT-X software suite?

A. Earth-Moon-Earth
B. Weak signal propagation beacons
C. Meteor scatter
D. All these choices are correct

T8D10 D 5-12

What is FT8?

A. A wideband FM voice mode
B. A digital mode capable of low signal-to-noise operation
C. An eight channel multiplex mode for FM repeaters
D. A digital slow-scan TV mode with forward error correction and automatic color compensation

T8D13 B 5-12

Which of the following is included in packet radio transmissions?

A. A check sum that permits error detection
B. A header that contains the call sign of the station to which the information is being sent
C. Automatic repeat request in case of error
D. All these choices are correct

T8D08 D 5-12

What is an ARQ transmission system?

A. A special transmission format limited to video signals
B. A system used to encrypt command signals to an amateur radio satellite
C. An error correction method in which the receiving station detects errors and sends a request for retransmission
D. A method of compressing data using autonomous reiterative Q codes prior to final encoding

T8D11 C 5-12

What does the abbreviation “PSK” mean?

A. Pulse Shift Keying
B. Phase Shift Keying
C. Packet Short Keying
D. Phased Slide Keying

T8D06 B 5-13

What kind of data can be transmitted by APRS?

A. GPS position data
B. Text messages
C. Weather data
D. All these choices are correct

T8D03 D 5-13

Which of the following is an application of APRS?

A. Providing real-time tactical digital communications in conjunction with a map showing the locations of stations
B. Showing automatically the number of packets transmitted via PACTOR during a specific time interval
C. Providing voice over internet connection between repeaters
D. Providing information on the number of stations signed into a repeater

T8D05 A 5-13

How are the transceiver audio input and output connected in a station configured to operate using FT8?

A. To a computer running a terminal program and connected to a terminal node controller unit

B. To the audio input and output of a computer running WSJT-X software

C. To an FT8 conversion unit, a keyboard, and a computer monitor

D. To a computer connected to the FT8converter.com website

T4A04 B 5-14

What signals are used in a computer-radio interface for digital mode operation?

A. Receive and transmit mode, status, and location
B. Antenna and RF power
C. Receive audio, transmit audio, and transmitter keying
D. NMEA GPS location and DC power

T4A06 C 5-14

Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes?

A. Computer “line out” to transceiver push-to-talk
B. Computer “line in” to transceiver push-to-talk
C. Computer “line in” to transceiver speaker connector
D. Computer “line out” to transceiver speaker connector

T4A07 C 5-14

What is an amateur radio station that connects other amateur stations to the internet?

A. A gateway
B. A repeater
C. A digipeater
D. A beacon

T8C11 A 5-15

Power Supplies

- A solid power source is important for a clean, noise-free transmitted signal and better reception
- Converts the AC input power to DC current for the radio equipment
- Two main ratings:
  - Output voltage
  - Amount of current it can supply continuously
- Radios that operate from a “12 V” supply may actually work best at the slightly higher voltage of 13.8 V typical of vehicle power systems with the engine running
- If you don’t know the amount of current a radio can draw … divide output power by input voltage, then double the resulting current value and round up to the nearest amp (generally, anything above 8A will work for a 50-watt mobile rig)

Power Supplies (cont.)

- A supply's output voltage changes with the amount of output current
- A *regulated supply* uses a *regulator circuit* to minimize the amount of voltage change
- If more than just one piece of equipment is hooked up to the supply and turned on at the same time, add all of the equipment maximum current needs together

Mobile Power Wiring

- Radio equipment can draw large currents when transmitting
- If wire is too thin, its resistance (R) will create a voltage drop ($V = I \times R$)
- The resulting lower voltage at the radio can cause it to operate improperly (distorting output signal or creating interference)
- General guidelines for mobile wiring …
  - Fuse should be present in both the positive and negative leads of your radio
  - Connect the radio's negative lead to the negative battery terminal or where the battery ground lead is connected to the vehicle body
  - Use grommets or sleeves to protect wiring from chafing or rubbing on exposed metal
  - Don't assume all metal is connected to the battery's negative terminal

Batteries

- Batteries are made up of one or more *cells*
- How long will a fully-charged battery power your equipment? Check out Table 5.3 (next slide) …
  - Divide the *energy rating* in ampere-hours (Ah) by the total current needs of the equipment. Remember to use average current draw for transceivers since you won't be transmitting all the time.
- *Storage batteries* are often used as an emergency power source … cautions:
  - Contain strong acids that can be hazardous if spilled or allowed to leak
  - Can release or vent flammable hydrogen gas, that can cause an explosion
  - Accidentally short-circuiting a storage battery with a tool or faulty wiring can easily cause a fire and damage the battery

Table 5.3: Battery Types and Characteristics

(most common types used by hams)

Battery Style	*Chemistry Type*	*Fully-Charged Voltage*	*Energy Rating (average)*
AAA	Alkaline – Disposable	1.5 V	1100 mAh
AA	Alkaline – Disposable	1.5 V	2600 – 3200 mAh
AA	Carbon-Zinc – Disposable	1.5 V	600 mAh
AA	Nickel-Cadmium (NiCd) – Rechargeable	1.2 V	700 mAh
AA	Nickel-Metal Hydride (NiMH) – Rechargeable	1.2 V	1500 – 2200 mAh
C	Alkaline – Disposable	1.5 V	7500 mAh
D	Alkaline – Disposable	1.5 V	14000 mAh
9 V	Alkaline – Disposable	9 V	580 mAh
9 V	Nickel-Cadmium (NiCd) – Rechargeable	9 V	110 mAh
9 V	Nickel-Metal Hydride – Rechargeable	9 V	150 mAh
Coin Cells	Lithium — Disposable	3 – 3.3 V	25 – 1000 mAh
Packs	Lithium ion (Li-ion) – Rechargeable	3.3 – 3.6 V per cell	Varies
Storage	Lead-acid – Rechargeable	2 V per cell	Varies

PRACTICE QUESTIONS

Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver?

A. 24.0 volts at 4 amperes
B. 13.8 volts at 4 amperes
C. 24.0 volts at 12 amperes
D. 13.8 volts at 12 amperes

T4A01 D 5-16

What type of circuit controls the amount of voltage from a power supply?

A. Regulator
B. Oscillator
C. Filter
D. Phase inverter

T6D05 A 5-16

Why are short, heavy-gauge wires used for a transceiver's DC power connection?

A. To minimize voltage drop when transmitting
B. To provide a good counterpoise for the antenna
C. To avoid RF interference
D. All these choices are correct

T4A03 A 5-17

Where should the negative power return of a mobile transceiver be connected in a vehicle?

A. At the 12 volt battery chassis ground
B. At the antenna mount
C. To any metal part of the vehicle
D. Through the transceiver's mounting bracket

T4A11 A 5-17

What hazard is caused by charging or discharging a battery too quickly?

A. Overheating or out-gassing
B. Excess output ripple
C. Half-wave rectification
D. Inverse memory effect

T0A10 A 5-17

How can you determine the length of time that equipment can be powered from a battery?

A. Divide the watt-hour rating of the battery by the peak power consumption of the equipment

B. Divide the battery ampere-hour rating by the average current draw of the equipment

C. Multiply the watts per hour consumed by the equipment by the battery power rating

D. Multiply the square of the current rating of the battery by the input resistance of the equipment

T4A09 B 5-17

Which of the following battery chemistries is rechargeable?

A. Nickel-metal hydride
B. Lithium-ion
C. Lead-acid
D. All these choices are correct

T6A10 D 5-17

Which of the following battery chemistries is not rechargeable?

A. Nickel-cadmium
B. Carbon-zinc
C. Lead-acid
D. Lithium-ion

T6A11 B 5-17

END OF MODULE 5

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