Generalized Transceiver Categories

- Single Band: VHF or UHF FM
- Dual Band: VHF/UHF FM
- Multi-mode: VHF/UHF
- Multi-band: HF and VHF/UHF
- Hand-held (HT): VHF/UHF
Single Band Transceiver

- Probably the most common starter rig.
- Operates from 12 volts dc, requires external power supply.
- Requires an external antenna.
- Can be operated mobile or as a base station.
- Limited to frequency modulation (FM) and either 2 meters or 70 cm bands.
- Up to approximately 50 watts output.
Dual Band Transceiver

- Same as the single band transceiver but includes additional band(s).
- Most common are 2 m and 70 cm bands.
- Could be tri-bander.
- Depending on antenna connectors, might require separate coax for each band or a duplexer for single coax.
Multi-Mode Transceiver

• Can be single or dual band.
• Main difference is that these rigs can operate on all major modes SSB/AM/FM, CW, Data, RTTY etc.
• More features add complexity and cost.
• Most flexible of the rigs that will allow you to explore new modes as you gain experience.
Multi-Band Transceiver

• Covers all bands – can be limited to HF or can be HF/VHF/UHF (even can listen on frequencies you can’t transmit on).

• Also covers all modes.

• Frequently 100 watts on HF, some power limitations on high bands (50 watts).

• Larger units have internal power supplies, smaller units require external power (12 V).
Hand-held (HT) Transceiver

- Small hand-held FM units.
- Can be single band or dual band (sometimes more).
- Limited power (usually 5 watts or less).
- Includes power (battery) and antenna in one package.
- An attractive first starter rig – but make sure it is what you want.
## Side-by-Side

<table>
<thead>
<tr>
<th></th>
<th>Single Band</th>
<th>Dual Band</th>
<th>Multi-mode</th>
<th>Multi-band</th>
<th>HT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freq Agility</strong></td>
<td>Limited</td>
<td>Medium</td>
<td>Medium</td>
<td>Full</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Functionality</strong></td>
<td>Limited</td>
<td>Limited</td>
<td>Full</td>
<td>Full</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Ease of Use</strong></td>
<td>Easy</td>
<td>Medium</td>
<td>Medium</td>
<td>Difficult</td>
<td>Easy</td>
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<tr>
<td><strong>Programming</strong></td>
<td>Easy</td>
<td>Easy</td>
<td>Medium</td>
<td>Challenging</td>
<td>Easy/Medium</td>
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<tr>
<td><strong>Power</strong></td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Low</td>
<td>Modest</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
Rig Vocabulary

• We will now go through some jargon and vocabulary specific to the functions and controls of a transmitter and receiver.
  – This is a way to discuss how to operate a transceiver.
• These controls, though separate, are combined in a transceiver.
Transmitter Controls and Functions

• Main tuning dial (both TX (trans) and RX (receive)):
  – Controls the frequency selection via the Variable Frequency Oscillator (VFO).
  – Could be an actual dial or key pad or programmed channels.
  – Variable frequency step size (tuning rate, resolution).
  – Could have more than one VFO (control more than one frequency at a time).
Transmitter Controls and Functions

• Mode selector (both TX and RX multi-mode rigs).
  – AM/FM/SSB (LSB or USB)
  – CW
  – Data (RTTY)
• Could be automatic based on recognized band plan.
Transmitter Controls and Functions

• Microphone controls
  – Gain
    • How loudly you need to talk to be heard.
  – Speech Compressor or Speech Processor
    • Compacting your speech into a narrow frequency range to enhance “punch.”
  – Too much gain or compression can cause problems.
    • Splatter
    • Over-deviation
    • Over-modulation
Transmitter Controls and Functions

• Automatic Level Control (ALC).
  – Automatically limits transmitter drive (output level) to prevent problems associated with too much gain or compression.

• Also can control external power amplifier operation.
Transmitter Controls and Functions

• Transmitter on/off
  – Push-to-Talk (PTT)
  – Voice-Operated Transmission (VOX)
    • VOX Gain (beefs up your speech)
    • VOX Delay (reduces sending background beeps)
    • Anti-VOX (won’t retransmit when your speaker is live – no echoes)
  – Key jack (to plug in your CW keyer)
Transmitter Controls and Functions

• Microphones (Mic)
  – Hand mics
  – Desk mics
    • Preamplified desk mikes
  – Speaker-mics
  – Headsets or boom-sets
  – Internal mikes

• Speak across the mic, not into the mic.
Transmitter Controls and Functions

• Morse Keys
  – Straight
  – Semi-automatic (Bug)
  – Electronic keyer, paddle
    – One paddle dash, one paddle dot
    – Can be reversed for lefties
Receiver Controls and Functions

• **AF Gain or Volume**
  – Controls the audio level to the speaker or headphones.

• **RF Gain**
  – Controls the strength of radio signal entering the receiver.
  – Used to limit (attenuate) very strong local signals.
  – Usually operated in the full-open position.
Receiver Controls and Functions

- **Automatic Gain Control (AGC)**
  - Automatically limits the incoming signals during signal (voice) peaks.
    - Prevents peaks from capturing the receiver and limiting reception of lower level portions of the incoming signal.
  - Fast setting for CW.
  - Slow settings for SSB and AM.
  - Not used in FM because of the type of signal used in FM.
Receiver Controls and Functions

- **Squelch**
  - Turns off audio to speaker when signal is not present.
- **Used in FM primarily**
  - Open – allows very weak signals to pass through (along with noise).
  - Tight – allows only the strongest signals to pass through.
- **Advance the squelch control until the noise just disappears.**
Receiver Controls and Functions

• Filters
  – Band-pass filter
    • Used to narrow the width of signal that is passed.
    • Can attenuate adjacent interference.
  – Notch filter
    • Very narrow filter that can be moved over an interfering signal to attenuate it.
  – Noise blanker or limiter
    • Limits signal spikes that are frequently associated with random naturally generated noise.
Receiver Controls and Functions

• Reception and Transmission Meter.
  – In transmit, indicates output power or ALC or other functions as selected by switch setting.

• In receive - indicates signal strength.
  – In “S” units S1 through S9 – S9 is strongest.
  – Also have dB over S9 to cover very strong signals.
Receiver Controls and Functions

- Receivers can be limited to ham bands or can cover other parts of the spectrum.
- General coverage receivers cover a wide area of the spectrum and can be used for shortwave listening (SWL).
What is a Repeater?

- Specialized transmitter/receiver interconnected by computer controller.
- Generally located at a high place.
- Receives your signal and simultaneously retransmits your signal on a different frequency (standard offsets: .6 Mhz VHF).
- Dramatically extends line-of-sight range.
  - If both users can see the repeater site.
A Little Vocabulary First

• Simplex
  – Transmitting and receiving on the same frequency.
  – Each user takes turns to transmit.
  – Is the preferred method if it works.
  – National VHF simplex frequency: 146.52
A Little Vocabulary First

- **Duplex**
  - Transmitting on one frequency while simultaneously listening on a different frequency.
  - Repeaters use duplex (and some DX sites too).
  - **Output frequency** – the frequency the repeater transmits on and you listen to (shown in the list).
  - **Input frequency** – the frequency the repeater listens to and you transmit on. (In a list often shown as + or – the standard shift.)
Things to Know to Use a Repeater

• Output frequency.
• Frequency split.
  – and therefore the input frequency.
• Repeater access tones (if any).
  • Generally PL (steady) subaudible tones
  • Rarely coded tones
Repeater Output Frequency

• Repeaters are frequently identified by their output frequency.
  – “Meet you on the 443.50 machine.”
    • Here the specific frequency is used.
  – “Let’s go to 94.”
    • Here an abbreviation for a standard repeater channel is used meaning 146.94 MHz.
  – “How about the NARL repeater?”
    • Here the repeater is referenced by the sponsoring club name.
Repeater Frequency Split

- The split, shifts, or offset frequencies are standardized to help facilitate repeater use.
- There are + and – shifts depending on the plan.
- Different bands have different standardized amounts of shift.

### Table 3-2

<table>
<thead>
<tr>
<th>Band</th>
<th>Offset</th>
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<tbody>
<tr>
<td>10 Meters</td>
<td>−100 kHz</td>
</tr>
<tr>
<td>6 Meters</td>
<td>Varies by region: −500 kHz, −1 MHz, −1.7 MHz</td>
</tr>
<tr>
<td>2 Meters</td>
<td>+ or −600 kHz</td>
</tr>
<tr>
<td>1.25 Meters</td>
<td>−1.6 MHz</td>
</tr>
<tr>
<td>70 cm</td>
<td>+ or −5 MHz</td>
</tr>
<tr>
<td>902 MHz</td>
<td>12 MHz</td>
</tr>
<tr>
<td>1296 MHz</td>
<td>12 MHz</td>
</tr>
</tbody>
</table>
Repeater Access Tones

- Sometimes multiple repeaters can be accessed at the same time unintentionally.
- To preclude unintentional access, some repeaters require a special subaudible tone to be present before the repeater controller will recognize the signal as a valid signal and turn on the repeater.
- These tones are called by various names (depending on equipment manufacturer).
  - CTCSS
  - PL
  - Privacy codes or tones
Repeater Access Tones

• Access tones are usually published along with repeater frequencies.

• Could also be announced when the repeater identifies.
  – “PL is 123.0”

• Tones are generally programmed into the radio along with frequency and offset.
Repeater Controller

• Computer that controls the repeater operation.
  – Station identification (Morse code or synthesized voice).
    • Same ID requirements as you have.
  – Time-out protection.
    • Sometimes called the alligator.
    • Protects against continuous transmission in the event of a stuck PTT or long winded hams.
  – Courtesy tone – repeater time-out timer reset.
Data Modes

• Connecting computers via ham radio.
  – Some systems use radio to connect to Internet gateways.
• The bulk of the work is done by specialized modems or computer software/sound card.
  – Terminal Node Controller (TNC).
  – Multiple Protocol Controller (MPC).
TNC – MPC

• Provide digital interface between computer and radio.
  – Package the data into proper format.
  – Convert digital data into audio tones representing 1s and 0s of digital data.
  – Send/receive tones to transceiver.
  – Control the transceiver.
Data Station Setup

Diagram showing the setup of a data station with a transceiver, control data, COM or USB connections, computer, TNC or MPC, audio interface, and connection to the Internet and broadband.
Antennas: The Dipole

• Most basic antenna.
  – Two conductive, equal length parts.
  – Feed line connected in the middle.

• Total length is $\frac{1}{2}$ wavelength ($1/2 \lambda$).

• Length (in feet) = $\frac{468}{\text{Frequency (in MHz)}}$. 
The Dipole
The Ground-Plane

• Simply a dipole that is oriented perpendicular (vertical to the Earth’s surface).

• One half of the dipole is replaced by the ground-plane.
  – Earth
  – Car roof or trunk lid or other metal surface.
  – Radial wires.

• Length (in feet) = 234 / Frequency (in MHz).
The Ground-Plane
Loop Antennas – Dipole Variations

• Quad (4 legs)
• Delta (3 legs)
• Horizontal (generally 4 legs around a rooftop)
Directional (Beam) Antennas

- Beam antennas focus or direct RF energy in a desired direction.
  - Gain
    - An apparent increase in power in the desired direction (both transmit and receive).
- Yagi (rod-like elements – TV antennas).
- Quad (square wire loop elements).
Directional (Beam) Antennas

Yagi – beams towards the shortest elements

Multiples – beams away from the reflector

Driven Element (Overall FT) = \( \frac{1005}{f \text{ (MHz)}} \)

Reflector (Overall FT) = \( \frac{1030}{f \text{ (MHz)}} \)
Directional (Beam) Antennas

• All beam antennas have parts called elements.
  – Driven element connected to the radio by the feed line.
  – Reflector element is on the back side.
  – Director element is on the front side toward the desired direction.
Coax Feed Lines

• RG-58
• RG-8
• RG-213
• RG-174
• Hardline
• (differ in thickness, resistance to UV or outgassing)
Coax Connectors

- SO-239/PL259
- BNC
- N
- SMA
Feed Line Devices

• Balun (Balanced to Unbalanced…. Needed for ladder lines)
• Duplexer (one antenna, two feeds)
• Antenna switches
• SWR meter
• Antenna analyzer
• Antenna tuners
Antenna Supports

- Trees.
- Towers or masts.
- Covenants and antenna restrictions must be considered.
- 200 ft TX limit (aircraft)

(note ground plane wires to allow a short vertical high up on a mast)
Power Supplies

- Most modern radio equipment runs from 12 volts dc.
- Household current is 120 volts ac.
- Power supplies convert 120 volts ac to 12 volts dc.
  - 13.8 volts dc is the common voltage you will see.
  - This is the charging voltage for motorized vehicles.
  - Most equipment can handle 11-14 V
Power Supply Ratings
Voltage and Current

• Continuous duty – how much current can be supplied over the long term.
• Intermittent duty – how much surge current can be supplied over the short term.
• Regulation – how well the power supply can handle rapid current changes.
Types of Power Supplies

• Linear:
  – Transformers
  – Heavy (physically)
  – Heavy duty current
  – Expensive

• Switching:
  – Electronics instead of transformers
  – Light weight and small
  – Not as robust
  – Less expensive
Inverters and Generators

• Inverters convert dc into ac.
  – Square, triangle, sine-wave inverters.
  – Can be choppy

• Generators create ac.
  – Gas powered.
  – Various voltage and current ratings.
  – Special precautions.
Batteries

• Create current through a chemical reaction.
  – Made up of individual cells (approximately 1.5 volts per cell) connected in series or parallel.

• Battery types.
  – Disposable.
  – Rechargeable.
  – Storage.

• Power capabilities rated in Ampere-hours.
  – Amps * time. (longer usage if you use less power)
Battery Charging

• Some batteries can be recharged, some cannot.
• Use the proper charger for the battery being charged.
• Batteries will wear out over time.
• Best if batteries are maintained fully charged.
  – Over-charging will cause heating and could damage the battery.
• Some batteries (lead-acid) may release toxic (or explosive) fumes during charging so require ventilation.
Handheld Transceivers

- Single, dual and multi-band versions (with increasing cost and complexity).
  - Some have expanded receiver coverage (wide-band receive: “DC to daylight”).

- Very portable and self-contained.
  - Internal microphone and speaker.
  - Rubber duck antenna (short).
  - (can attach to external mag-mount antenna on car)
  - Battery powered.
Nice to have handheld accessories

- Extra battery packs.
- Drop-in, fast charger.
- Extended antenna.
- External microphone and speaker.
- Headset.
Radio Frequency Interference (RFI)

- Unwanted, unintentional signals from some electronic device that interferes with radio wave reception.
- You can prevent creating RFI by operating your transmitting equipment properly.
RFI Mitigation

• Filters
  – Filters attenuate (reduce) interfering signals – but do not totally eliminate them.

• High-pass – generally on the receive side.
  (e.g. filter out car ignition noise)

• Low-pass – generally on the transmit side.

• Band-pass – used within most radio equipment.
Types of RFI

• Direct detection – offending signals get into the electronics circuits to cause interference.
• Overload – strong signal that overpowers the weaker, wanted signal.
• Harmonics – even multiples of the offending signal that coincide with the wanted signal.
Cable TV Interference

• Usually the result of broken shielding somewhere in the cable.
  – Loose connections.
  – Broken connections.
  – Corroded connections.

• Usually solved by proper cable maintenance by cable supplier.
  – If the subscriber is a legitimate subscriber.
Noise Sources

• Electrical arcs (motors, thermostats, electric fences, neon signs).
• Power lines. (NEW concern: BPL = internet on power lines)
• Motor vehicle ignitions.
• Motor vehicle alternators.
• Switching power supplies.
• Computers, networks, and TV sets.
• Hospital equipment
Dealing with RFI

• Make sure you operate your equipment properly.
• Eliminate interference in your own home first.
Dealing with RFI

- Take interference complaints seriously.
- Make sure that you’re really not the cause (demonstrate that you don’t interfere within your own home).
- Offer to help eliminate the RFI, even if you are not at fault.
- Consult ARRL RFI Resources for help and assistance.
What the Rules Say

• RFI from and to unlicensed devices is the responsibility of the users of such devices
• Bottom line – If your station is operating properly, you are protected against interference complaints
• BUT – Be a good neighbor because they may (probably) not be familiar with Part 15 rules and regulations