

# Amateur Radio Technician Class Training

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Based on the No-Nonsense Technician Class  
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AMATEUR RADIO DIGITAL COMMUNICATIONS

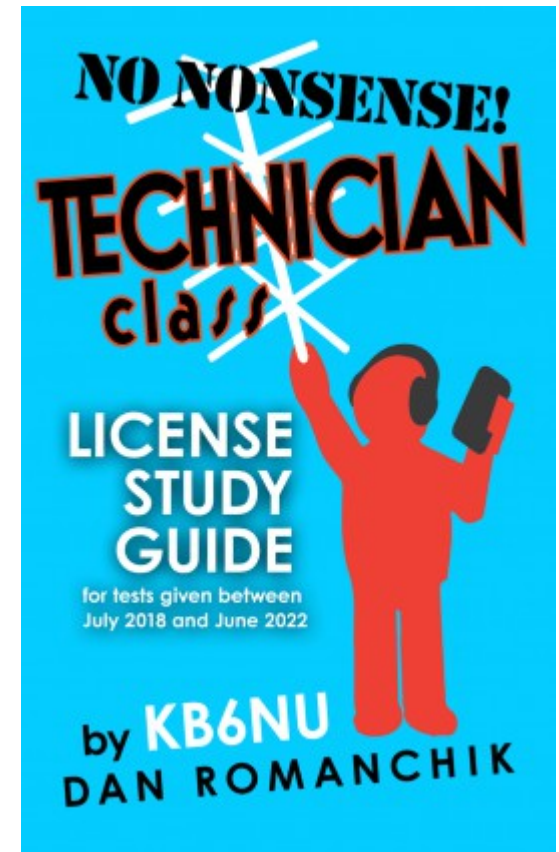


**Welcome to Session 5**

**Any Questions Before We Start?**

# Agenda

- Introduction
- Radio Wave Characteristics (RWC)
- Electronic Components and Circuits (ECCD)
- Electrical Principles (EP)
- Antennas and Feed Lines (AFL)
- Amateur Radio Signals (ARS)
- Electrical Safety (ES)
- Radio Practices and Station Setup (RPSS)
- **Station Equipment (SE)**
- **Operating Procedures (OP)**
- Rules and Regulations (RR)



# Station Equipment (SE)

- Receivers, Transmitters, Amplifiers
- Tx & Rx Problems
- Basic Repair & Testing

# Station Equipment

- Most basic pieces are **transmitter & receiver**
- When in one unit it is called a **transceiver**
- Antenna is (automatically) switched between transmitter and receiver



# RF Power Amplifier

- *Used to increase RF output from a low power device, such as handheld*
- *SSB/CW-FM switch sets up the amplifier for the appropriate mode*
- Fins are for heat dispersion



# Receiver Details

- Most important specs:

- **Sensitivity**

*Ability to detect a weak signal*

- **Selectivity**

*Ability to discriminate between multiple signals*

- **Preamplifier**

- Helps weak signal reception

*Installed between antenna and receiver*



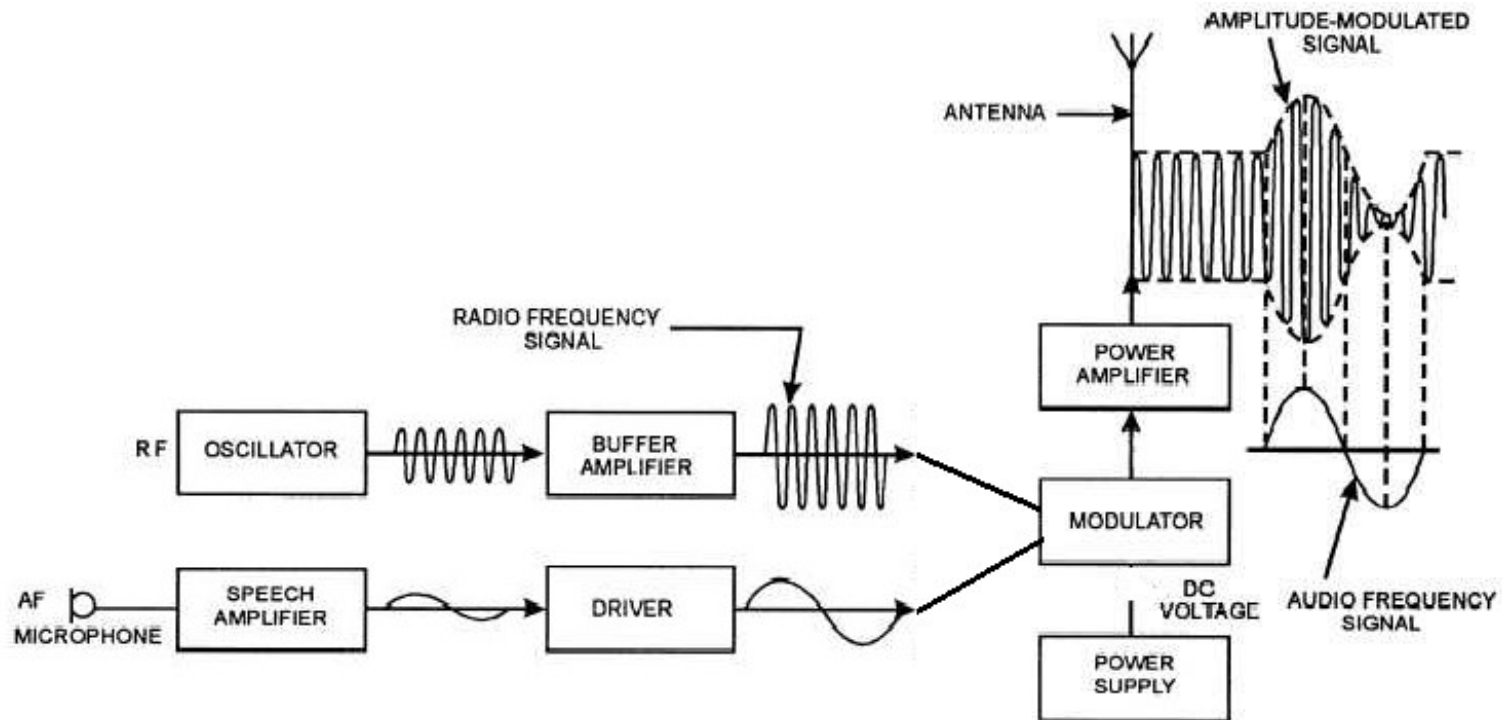
# Transceiver Internals

- **Mixer**
  - *Converts radio signal from one frequency to another*
- **Oscillator**
  - *Circuit that generates a signal at a specific frequency*
- **Modulator**
  - *Combines speech (or other signals) with an RF carrier*
  - *Often a type of mixer*





# Transmitter Functions



- Voice modes like *SSB* and *FM* need a modulator
- A **modulator** combines the RF carrier and the audio/speech signal

# Transverter

*Used to operate on a frequency for which a radio was not designed*

A **transverter** is a device that, for example, can take the output of a low-powered 28MHz SSB exciter and produces a 222MHz output signal

It also could convert an incoming 222MHz signal to a 28MHz signal for the receiver

# Some VHF & UHF Info...

- Most operation uses FM and Repeaters
- CW and SSB is also popular – often weak signals
- *The device most useful for VHF weak signal communications is a **multi-mode VHF transceiver***
- Handheld transceivers (HTs) have low power transmitters (5W or less), which limits range
- *The device that increases the low-power output from a handheld transceiver is an **RF power amplifier***

# Troubleshooting Common Problems

- Overload
- Distortion
- Feedback
- Interference
  - **What can cause radio frequency interference?**
    - *Fundamental overload*
    - *Harmonics*
    - *Spurious emissions*
  - Any of these can cause radio or TV interference

*If someone tells you that your transmissions are causing interference, you should first **make sure that your station is functioning properly and not causing interference to your own TV and radio***

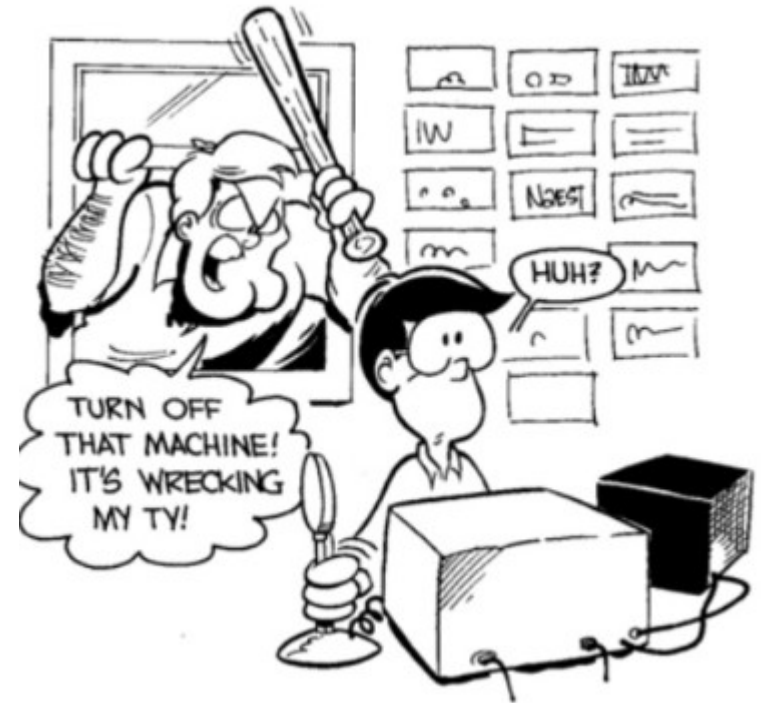
# Telephone Interference



- Telephones often experience interference
- *Most likely cause of interference to a non-cordless phone from a nearby transmitter is that the **telephone is acting like a radio receiver***
- Logical first step to cure radio interference on a telephone *is to install an RF filter at the telephone*

# Broadcast AM FM TV Interference

- Caused by receiver being unable to reject strong out-of-band signals
- Eliminate by installing a filter to block the amateur signal



# Addressing Interference

- Useful ways to cure RF interference:
  - *Make sure all TV coaxial connectors are installed properly*
  - *Snap-on ferrite chokes*
  - *Low-pass and high-pass filters*
  - *Band-reject and band-pass filters*
- **Fundamental Overload** *is interference caused by very strong signals injected into a receiver*

# Part 15 Devices

This device complies with part 15 of FCC Rules. Operation is subject to the following two conditions; (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.



- If a neighbor's device is causing interference with your equipment:
  - *Work with them to identify offending device*
  - *Politely inform them about the rules that require them to stop using the device if it causes interference*
  - *Check your station to ensure it meets standards of good amateur practice*



# Common Problems

- **Distorted / Noisy Audio**

- *Transmitter might be slightly off frequency*
- *Batteries might be running low*
- *You might be in a bad location*

- **Noise in digital transmissions causes bit errors**

- **BER:** *Bit error rate, the rate at which errors are occurring*

- **High pitched whine**

- *Noise from vehicle's electrical system, usually alternator*

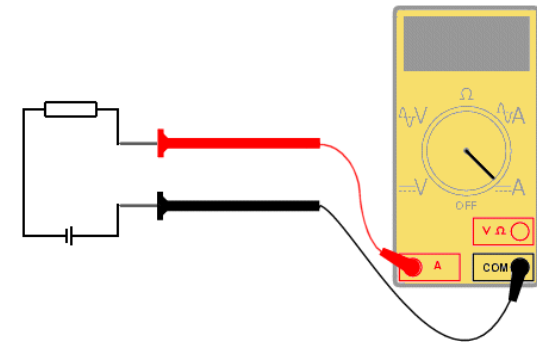
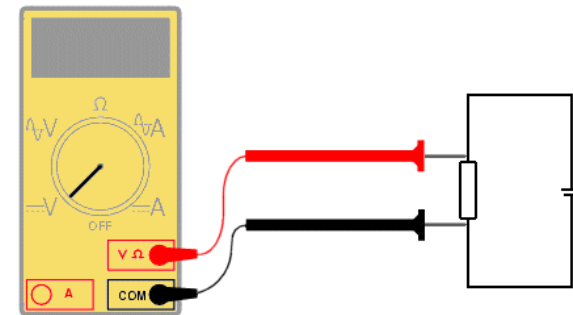


- **Garbled, Distorted or Unintelligible Transmission**

- *RF Feedback*
- *Over-deviation on FM*
- *Back off the mic*

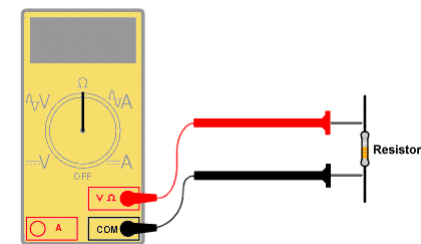
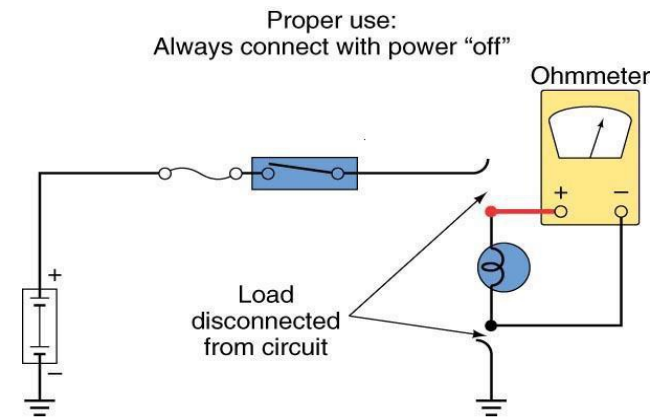
# Using a Multimeter or DMM

- **Multimeter** = voltmeter, ohmmeter and ammeter
- **DMM** = digital multimeter
- Measuring **voltage** and **resistance** are *common*
- *To measure **voltage**, the voltmeter is placed in parallel with the circuit*
- *Make sure that the voltmeter leads are rated for the voltage you are measuring*
- *To measure **current**, the ammeter is placed in series with the circuit*



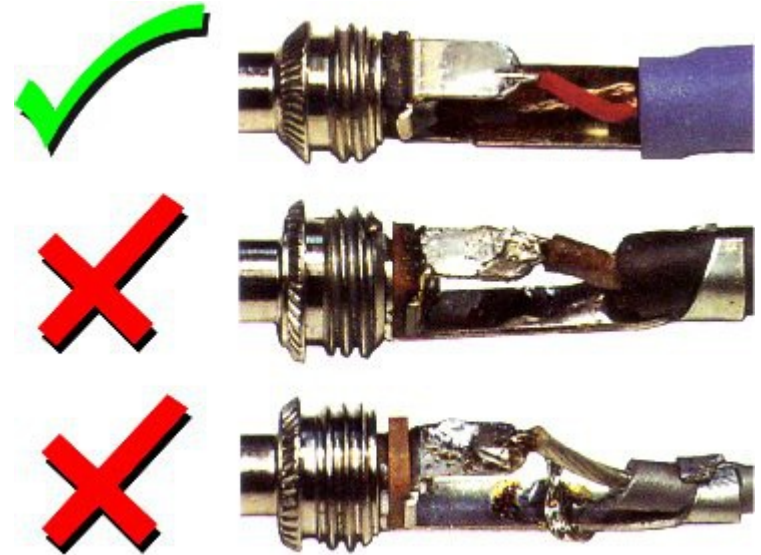
# Measuring Resistance

- **Ohmmeter** is used to measure *resistance*
- *Make sure the circuit is not powered*
- *Attempting to measure a voltage on the resistance setting might damage the meter*
- *When measuring **resistance**, an initial low reading that **slowly increases** means that the circuit contains a large capacitor*



# Soldering

- Good skill to have!
- ***Rosin-core solder*** is best for radio and electronic use
- Good “**joints**” should be smooth and shiny
- ***Dull or grainy*** surface is the characteristic appearance of a “**cold**” solder joint
- ***Let the solder flow!***



# Station Equipment Chapter End

Questions?

Let's Practice for the Exam!

# Operating Procedures (OP)

- FM Operation
- HF Operation
- Public Service & EmComm
- Satellite Operations
- Operating Activities

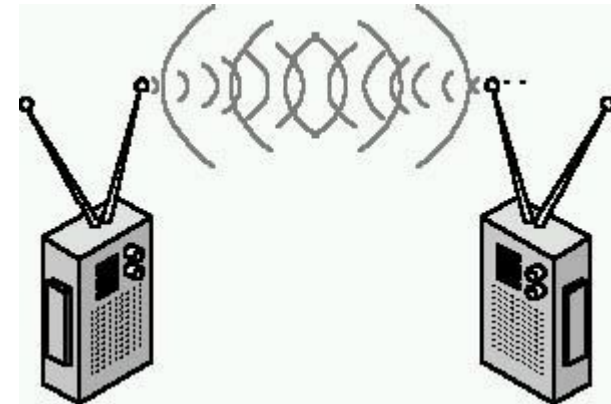
# Operating Procedures



Clockwise from upper left: Ham operating W1AW at ARRL Headquarters;  
7 yo Sharon Pakinas – youngest female Novice in 1953; Bharathi Prasad –  
setting contact records in India; Kids on air at the OMIK Radio Association,  
founded in 1952 by Black Hams.

# Duplex and Simplex

- Duplex Communication
  - Tx & Rx on two different frequencies
- Simplex Communication
  - Tx & Rx on the same frequency
- National simplex frequencies
  - 446.000MHz on 70cm
  - 146.520MHz on 2m





# Some VHF/UHF TRx Controls

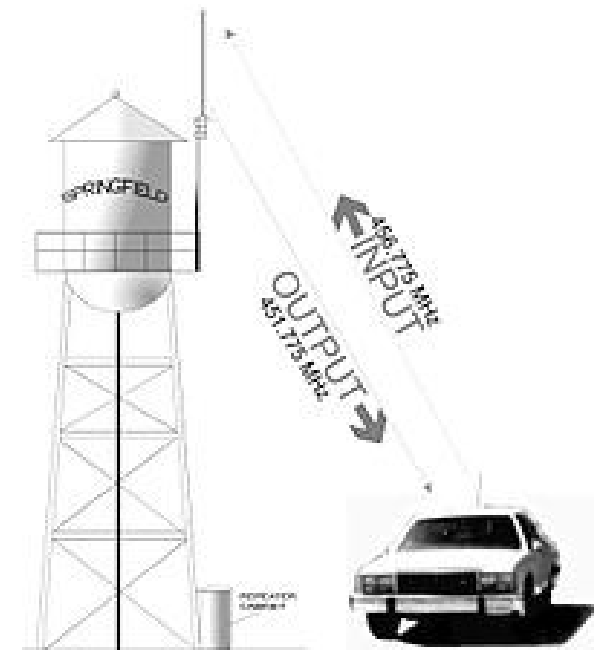


- **Carrier Squelch**
  - Mutes Rx in the absence of an RF signal
- **Microphone Gain**
  - Changes the *amplitude* of the modulating signal
  - Determines the amount of **FM deviation**
  - If **deviation is increased**, the signal **occupies more bandwidth**

# FM Operation

- **Repeaters**
  - Listen to you on one frequency (*Input*)
  - Re-broadcast you on another frequency (*Output*)
- **Your Radio must:**
  - Transmit on the *Input*
  - Receive on the *Output*
- **Difference** between *Input* and *Output* frequencies is called the **Split**

*Most new Technicians start with a VHF/UHF FM transceiver*



# Repeater Information

- Stations that automatically retransmit signals
  - *Repeaters*
  - *Auxiliary Stations*
  - *Space Stations (satellites)*
- **Common Repeater Splits**
  - +/- **600kHz** for the **2m** band
  - +/- **5MHz** for the **70cm** band



# Repeater Details

**CTCSS** = Continuous Tone Coded Squelch System

**DCS** = Digital Coded Squelch

- **CTCSS** tones
  - *Sub-audible tone sent with your voice to open the squelch on repeater*
  - Also called PL (private line) tone
- **Reasons why you can *hear* a repeater, but can't talk on it:**
  - *Improper transceiver offset*
  - *Repeater req's CTCSS for access*
  - *Repeater may require a DCS tone sequence for access*
- If a station **isn't strong enough** to open squelch, how might you be able to hear it?
  - *Try listening on the repeater's input frequency*
- If your signal is breaking up, you may be **over-deviating** by *talking too loudly*, or the *Mic Gain may be set too high*.

# Repeater Operation



- How to strike up a conversation...
  - CQ isn't used much on repeaters
  - Say your **call sign** to indicate that you're listening
- To call someone...

Say **their call sign, identify** with **your call sign.**

# HF Operation

- **CQ** means *"calling any station"*
  - "CQ, CQ, CQ, this is W2AEW calling CQ"
- Always:
  - *Listen first*
  - *Ask if frequency is in use*
  - *Make sure you're in an assigned band*
- **Responding to a CQ**
  - *Transmit the other station's call sign, followed by yours*



Alice Bourke (b.1891 d.1956) W9DXX  
Chicago Tribune police beat reporter  
and avid HF and CW operator  
in her custom-built radio shack

# Station Identification

Always **properly identify when transmitting**, even when testing

Identify at least **every 10 minutes** of operating, and when you **end** operating



Rufus Turner (b.1907 d.1982)  
W3LF, in 1926. Inventor and  
1st African-American Radio Operator

# More HF Details

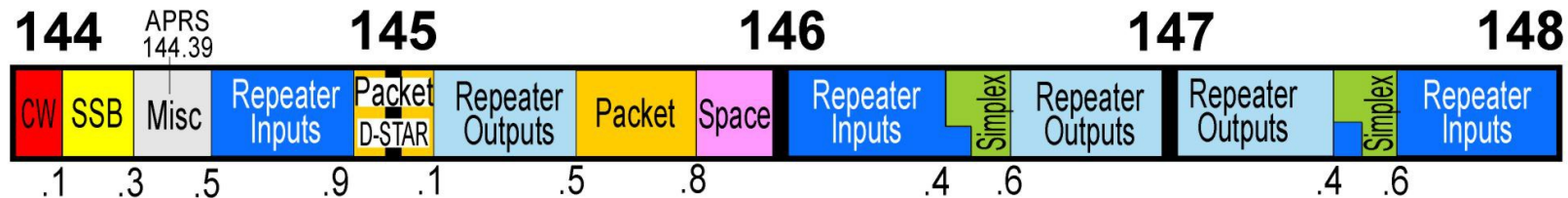
- Techs can operate CW on 80/40/15/10m
- **Q-Signals** are used as shorthand
  - **QRM** indicates your getting interference from other stations
  - **QSY** indicates you are changing frequency





# General Guidelines

- **Band Plan:** a voluntary guideline for different modes and activities in an amateur band
- Amateurs must use **minimum power necessary** to carry out desired communication
  - Allowed up to 1500W on VHF and above, 200W on HF (peak envelope output power)



# More Guidelines



- *Stay Clean*
  - If you get a report of causing splatter or interference, **check your transmitter for off-frequency operation or spurious emissions**
  - If you unintentionally cause interference, then **properly identify yourself and move to a different frequency**
- Use of the **phonetic alphabet** is encouraged by the FCC
  - *Learn it, use it!*

A - ALPHA	N - NOVEMBER
B - BRAVO	O - OSCAR
C - CHARLIE	P - PAPA
D - DELTA	Q - QUEBEC
E - ECHO	R - ROMEO
F - FOXTROT	S - SIERRA
G - GOLF	T - TANGO
H - HOTEL	U - UNIFORM
I - INDIA	V - VICTOR
J - JULIET	W - WHISKEY
K - KILO	X - X-RAY
L - LIMA	Y - YANKEE
M - MIKE	Z - ZULU

# Public Service Emergency & Non-Emergency

Amateur radio operators are uniquely qualified to help provide assistance

FCC Rules still apply when using amateur radio for public service purposes

May use any means necessary for essential communication when there is immediate danger to life, safety and property damage



*When all else fails,  
Amateur radio is there!*

# RACES & ARES

- RACES: **R**adio **A**mateur **C**ivil **E**mergency **S**ervice
- Amateur stations for emergency mgmt or civil defense communications
- ARES: **A**mateur **R**adio **E**mergency **S**ervice
- Both **RACES** & **ARES** may provide communications during emergencies



Common for these groups to form a network, or "*net*"

Orchestrated by a "*net control station, or NCS*"

Messages passed during these operations are called "*traffic*"

After checking in, remain on frequency in case you're needed by NCS

# Message / Traffic Handling

- Informal & Formal
- Most important: **pass messages exactly as written, spoken or received**
- Always use proper phonetic alphabet

PBL	(opt.)	(call sign)	(signatory location)	(opt.) (UTC)	(UTC)			
NR (1)	PREC (2)	HX (3)	STN ORIG (4)	CK (5)	PLACE OF ORIG (6)	TIME FILED (7)	MON (8)	DT (9)
TO						THIS RADIO MESSAGE WAS RECEIVED AT: AMATEUR STATION _____ TEL _____ NAME _____ STREET ADDRESS _____ CITY/STATE/ZIP _____		
TEL								
OP NOTE (10)								
TXT								
_____								
_____								
_____								
_____								
_____								
_____								
SIG								
OP NOTE (11)								
RCVD FROM		NET	DATE/TIME		SENT TO		NET	DATE/TIME
ORIG FROM - DATE/TIME					DLVD TO - DATE/TIME			

- Formal Messages
  - Preamble
  - Address
  - Text
  - Signature

# Formal Traffic Messages

- **Preamble** used to **track** the msg as it passes thru the amateur traffic handling system
  - The preamble **check** is the **number of words or word equivalents in the text** of the message
- **Address** is the name/address of the recipient
- **Text** is the body of the message
- **Signature** identifies the originator



# Net Operation / Protocol

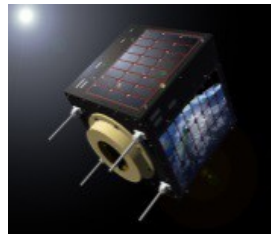
- All communications through net control
- **Only transmit when directed by the NCS**
- If your emergency can't wait – get **attention** of **NCS** by begin your transmission with “**Priority**” or “**Emergency**” followed by your **call sign**



# Amateur Satellites



- Repeater in space
  - Uplink & downlink frequencies
  - Often on different bands
  - **U/V mode:**
    - uplink* in **70cm** band
    - downlink* in **2m** band
- Need license **privileges** to transmit on *uplink frequency*
  - Use minimum power necessary
- Most are *FM*, some operate on other modes (*SSB, CW, Data*)

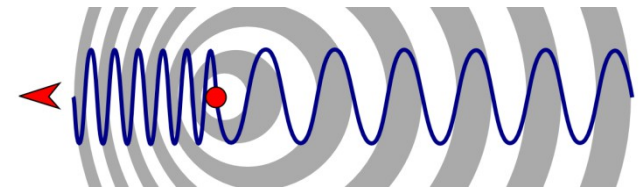




# More Satellite Info

- **Satellite Beacon:**

- Transmission from a space station/satellite that contains **information** about itself
- Health and Status info
- Anyone can receive this telemetry



## **Common Problems...**

### **Doppler Shift**

Observed *change in frequency* due to relative motion between satellite and earth station

### **Spin Fading**

Caused by *rotation* of the satellite and its antenna

# Satellite Operating Information

- Don't use **too much power**
  - *You might block access by others*
  - *Your signal strength on the downlink should be the same as the beacon*
- **FM Packet mode** is commonly used to send to/from digital satellite
- **Satellite tracking program/software** offers:
  - *Maps that show real-time position over the earth*
  - *Time, Azimuth, Elevation at start, max altitude & end of pass*
  - *Apparent frequency of transmission, including Doppler Shift*
  - *Takes **Keplerian elements** as input*



# International Space Station (ISS)

Any **Technician** class  
Ham can make  
contact with the ISS  
on **70cm** and **2m**

ISS is a **Low Earth Orbit**  
(**LEO**) satellite

Astronaut Susan Helms KK6HNZ  
speaking to Hams from the ISS



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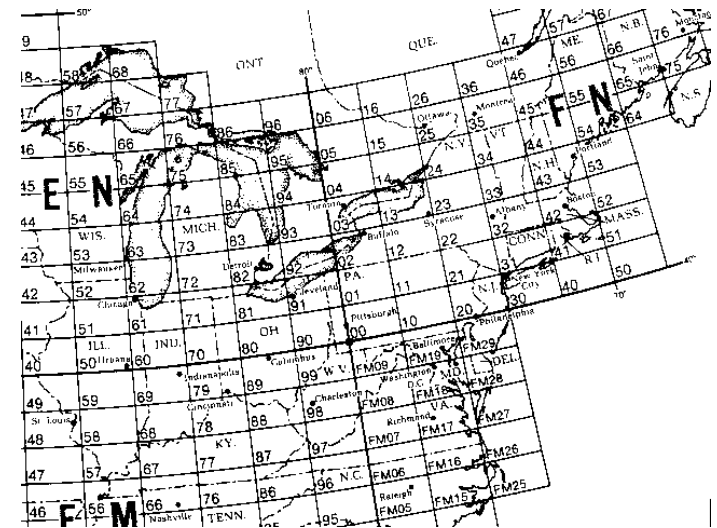
# Fun Activities

- **Contesting**

- Make many contacts in a *specific time period*
- Good practice: send only **minimum amount of info req'd** for ID and contest exchange
- Be mindful of others on the band

- **VHF/UHF Contests**

- Often use grid locators: **letter-number designation** for geographic location



# More Fun Activities

- **Special Event Stations**
  - 1x1 call signs
  - Often for events of **special significance** to amateur community
- **Collecting QSL Cards & Certificates**
  - Worked All States
  - DXCC (100+ countries)
  - National Parks On The Air
  - International Lighthouse Lightship Weekend



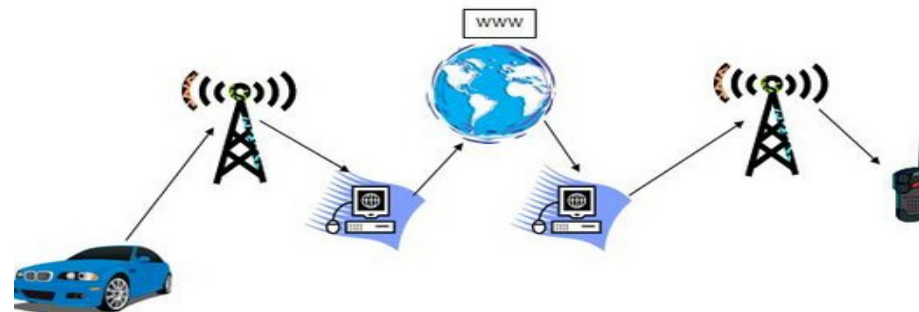
# Even More Fun ...

- **Radio Direction Finding** (Fox Hunting)
  - Local contests
  - Good skill for **interference** and **jammer** hunting
  - Uses a **directional** antenna to hunt for a hidden transmitter



# Internet Activities

- **IRLP: Internet Repeater Linking Project**
  - Uses **VoIP** – voice over internet protocol (deliver voice over internet via digital techniques)
  - Repeater **directory** will list active nodes, as well as *online lists* and info from the *local repeater frequency coordinator*
  - **DTMF tone via Keypad** on radio used to dial up a node

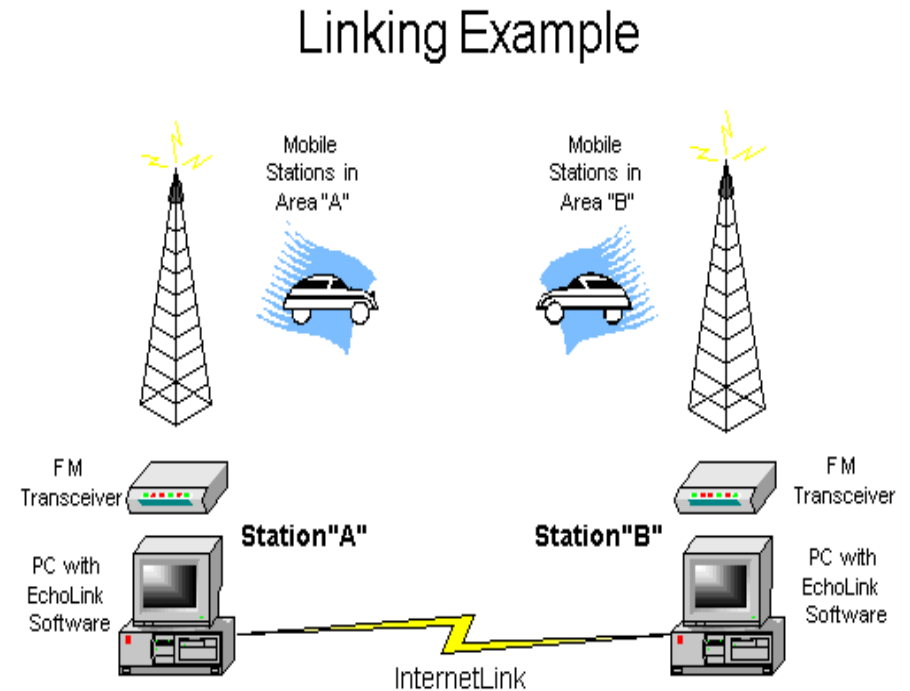


# More Internet Activities

- **Echolink**

- Radio or Computer links
- You must register your call sign and provide proof of license

- A **Gateway** is a station that links to other stations via Internet





# Read MORE About It

Guest Operation at ARRL Headquarters

<http://www.arrl.org/visit-us>

Young Female Hams

<https://www.rfcafe.com/references/qst/youngest-yl-amateur-radio-licensee-qst-october-1953.htm>

Women Hams in India

<https://scroll.in/article/815565/women-hams-ride-the-radio-wave-in-india>

OMIK Amateur Radio Association

<https://sites.google.com/view/omik-amateur-radio>

Alice Bourke

<http://hamgallery.com/Tribute/W9DXX/w9dxx.pdf>

Rufus Turner

<http://www.arrl.org/news/article-profiles-first-african-american-radio-amateur-rufus-turner-w3lf>

Susan Helms

<https://www.af.mil/About-Us/Biographies/Display/Article/107959/lieutenant-general-susan-j-helms/>

# Operating Procedures

## Chapter End

Questions?

Let's Practice for the Exam!