Radio Theory The Basics
Radio Wave Propagation
Electromagnetic Spectrum

Electromagnetic Spectrum
Showing the Radio Frequency Spectrum

- electric waves
- RADIO WAVES
- infra-red
- visible light
- ultra-violet
- x-rays
- gamma rays
- cosmic rays

3kHz 30kHz 300kHz 3000kHz 30MHz 300MHz 3000MHz 30GHz 300GHz 3000GHz

VLF: Very Low Frequency, LF: Low Frequency, MF: Medium Frequency,
HF: High Frequency, VHF: Very High Frequency, UHF: Ultra High Frequency,
SHF: Super High Frequency, EHF: Extremely High Frequency
Radio Theory The Basics

UNITED STATES FREQUENCY ALLOCATIONS
THE RADIO SPECTRUM

U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Federal Communications Commission
October 2010
Radio Theory  The Basics

• Differences between Very High Frequency (VHF) and Ultra High Frequency (UHF).
• Difference between Amplitude Modulation (AM) and Frequency Modulation (FM).
• Interference and the best methods to reduce it.
• The purpose of a repeater and when it would be necessary.
VHF - Very High Frequency

- Range: 30 MHz - 300 MHz
- Government and public service operate primarily at 150 MHz to 174 MHz for incidents
- 150 MHz to 174 MHz used extensively in NIFC communications equipment
- VHF has the advantage of being able to pass through bushes and trees
- VHF has the disadvantage of not reliably passing through buildings
- 2 watt VHF hand-held radio is capable of transmitting understandably up to 30 miles, line-of-sight
VHF

ABSOLUTE MAXIMUM RANGE OF LINE-OF-SITE PORTABLE RADIO COMMUNICATIONS

165 MHz CAN TRANSMIT ABOUT 200 MILES
UHF - Ultra High Frequency

- 300 MHz - 3,000 MHz
- Government and public safety operate primarily at 400 MHz to 470 MHz for incidents
UHF - Ultra High Frequency

- 400 MHz to 420 MHz used in NIFC equipment primarily for logistical communications and linking
- Advantage of being able to transmit great distances (2 watt UHF hand-held can transmit 50 miles maximum...line-of-sight in ideal conditions)
- UHF signals tend to “bounce” off of buildings and objects, making them effective for incidents in urban areas
Radio Theory  The Basics

UHF
AM - Amplitude Modulation

- Government and public safety that operate primarily 118 MHz to 138 MHz use amplitude modulation for air operations.
- Major disadvantages are that AM is extremely susceptible to “noisy” interference from static, lightning, and other disturbances. The propagation properties also limit the effective distance.
- Referred to as “victor” frequencies by the aviation community.
FM - Frequency Modulation

- Used extensively in land-mobile radio and on incidents for command and logistical nets
- Advantage: not easily accessible to atmospheric and manmade interference - very little noise
Interference

• Primarily caused by other radio equipment operating on, or close to the same frequencies

• Reduce interference by physically separating the radio equipment
Interference & Repeaters

- VHF repeaters should be placed several hundred yards apart or should be shielded from each other by the terrain
- VHF and UHF repeaters on the same site
  - At least 10 yards separation
  - Directional antennas will help reduce interference even more
- Vertical separation vs. Horizontal separation
Shielding Equipment

Radio Theory

PORTABLE REPEATERS

EXISTING ANTENNAS

ROCK OUTCROP

100' SEPARATION

PORTABLE REPEATERS
Antenna Orientation

• Critical for the proper operation of the antenna
  – A hand-held radio lying on a vehicle seat is less effective than holding the hand-held upright

• The higher the antenna is above the surrounding terrain, the farther the signal will travel
Radio Theory The Basics

- Could talk up to 15 miles.
- Flat desert, 100 watt radios, Hi-band.
- Could talk up to 70 miles.
Directional Antennas

- Radiate and receive the majority of the radio signal in one direction
- The signal from directional antennas travel farther by concentrating or reflecting it in one direction
- Directional antennas provide isolation from interference by limiting receiving signals to a concentrated area
- The higher the signal is above the surrounding terrain, the farther the signal will travel
Repeaters - VHF and UHF

- Repeats the signal by receiving on one frequency and re-transmitting on a different frequency. For example, a repeater receives the radio signals on frequency 170.450, and then transmits the signal on 168.100.
- Used to cover greater distances when line-of-sight is not possible to cover the terrain.
Repeaters

Channel 5 transmits on 170.450 MHz.

Can't talk through mountain.

These two can talk direct using channel 4 - 168.100 MHz.

Repeater on command 2 frequencies. Repeats message on 168.100 MHz - channel 4.
Troubleshooting Problems

• Can’t hear repeater
• Rpt. Signal choppy/intermittent
• Unintelligible audio
• Low audio
• Rpt. Squelches
• Rpt. Locks Up
• No Tx or Rx
• Equipment automatically blows fuses

• Hearing adjacent traffic
• Rpt. Quits at specific times of day
• Remote does not work
• Aircraft radio link does not work
• Handheld radio does not work
Troubleshooting Causes

- Dead battery
- Loss of coverage
- Wiring shortage
- Transmitter failure
- Receiver failure
- Antenna installation failure
- Low or no modulation
- Low battery voltage
- Incorrect frequency
- Radio not operating properly
- Incorrect Channel
- Damage in transport
- Heat / Weather

- Batteries incorrectly wired
- Transmit switch in OFF position
- Theft of Equipment
- Animal Damage
- Interference
- Intermodulation
- Keyed radio (hot mic)
- Audio levels not set correctly
Radio
Use and
Incident
Safety
Incident Safety Concerns

- Lightning
- Driving hazards
- High voltage transmission lines
- Electromagnetic Radiation
Incident Safety Concerns

- PPE
- Hazards
- Basic and site specific hazards
- Heavy equipment
RADIO Communications & ICS

**SERVICE BRANCH**
- Communications Unit Leader
  - Incident Communications Technician
  - Incident Communications Center Manager
  - Radio Operator

**SUPPORT BRANCH**
- Medical Unit Leader
- Food Unit Leader
- Supply Unit Leader
- Facilities Unit Leader
- Ground Support Unit Leader

**Logistics Section Chief**
## Radio Communications Plan

**ICS 205**

<table>
<thead>
<tr>
<th>Radio Type</th>
<th>Channel</th>
<th>Function</th>
<th>Frequency</th>
<th>Assignment</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorola XTS 5000</td>
<td>2</td>
<td>Command Simplex</td>
<td>164.4500</td>
<td>Command</td>
<td></td>
</tr>
<tr>
<td>HT 1250</td>
<td>5</td>
<td>Tactical</td>
<td>166.4500</td>
<td>Entry/Decon</td>
<td></td>
</tr>
<tr>
<td>Visar</td>
<td>3</td>
<td>Tactical</td>
<td>162.7000</td>
<td>Logistics Support</td>
<td></td>
</tr>
<tr>
<td>HT 1250</td>
<td>9</td>
<td>Tactical</td>
<td>165.4125Tx</td>
<td>Recon.</td>
<td>Repeater Freq 173.9125 Rx</td>
</tr>
</tbody>
</table>

4. Prepared by (Communications Unit)  
Date / Time  
INCIDENT RADIO COMMUNICATIONS PLAN  
ICS 205-05

NOAA 12/00
OTHER ISSUES:
- APCO
- Encryption
- NTIA