CROSS BAND REPEATERS FOR EMERGENCY COMMUNICATIONS

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USE AND DISTRIBTION NOTICE

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Discussion Ground Rules

This presentation is intended to inform on ways to implement cross-banding while staying in compliance with my personal interpretation of FFC Part 97

There may be other opinions of how certain aspects may be implemented, this presentation is not intended to be a platform for debate about methods other than those included

In addition, the apparent lack of current enforcement actions by the FCC will not be tolerated as a justification to ignore Part 97

Overview

- What is cross-band repeating?
- How it can be deployed?
- The factors necessary to do it legally
- How the FCC addresses cross-band repeating
- Operating considerations
- Radio example

Why do we Care?

- It may enable you to set up communications where
  - Using an HT is difficult
  - A clear signal path is not available
  - Personal mobility away from a base station is needed
  - Current infrastructure does not meet the needs of an event

Review: A repeater receives a signal and re-transmits it

- On the same frequency with a delay
  - Digipeater, simplex voice repeater
- On the same band, simultaneously, but different frequency
  - Voice repeater like WØYL
- On a different band
  - Cross-band repeater
  - Locked-band repeater

Why Cross-Band Repeating?

- Quick and easy to set up
- One antenna (dual band)
- Easily relocated (can be mobile)
- A cross-band repeater is far less complex than a conventional repeater
  - No expensive filters or duplexers
  - Used for satellite repeaters (uplink-downlink)
  - Full duplex is possible
- No coordination issues
  - Uses simplex channels, operator at control point

Cross-Band vs. Locked-Band

- Cross-band
  - Two way A < > B
  - What is heard on A side is re-transmitted on B side
  - What is heard on B side is re-transmitted on A side
- Locked-band
  - One way A > B
  - What is heard on A side is re-transmitted on B side
  - What is heard on B side is NOT re-transmitted on A side
  - Can be configured B > A also in radio settings

Examples of Communication Problems

- My buddy on simplex can hear me but I can't hear him because of the interference around me
- I can hear the repeater but I can't reach it
- I can't hear the repeater but I can reach it
- A group of field operators must communicate with each other but some do not have a direct path to other team members
- I'm in a river valley and can't reach the repeater because of the terrain

Examples of Communication Problems

- We need a temporary VHF repeater because not everyone has a UHF radio for our event
- I would like to link a VHF and UHF repeater together for our event

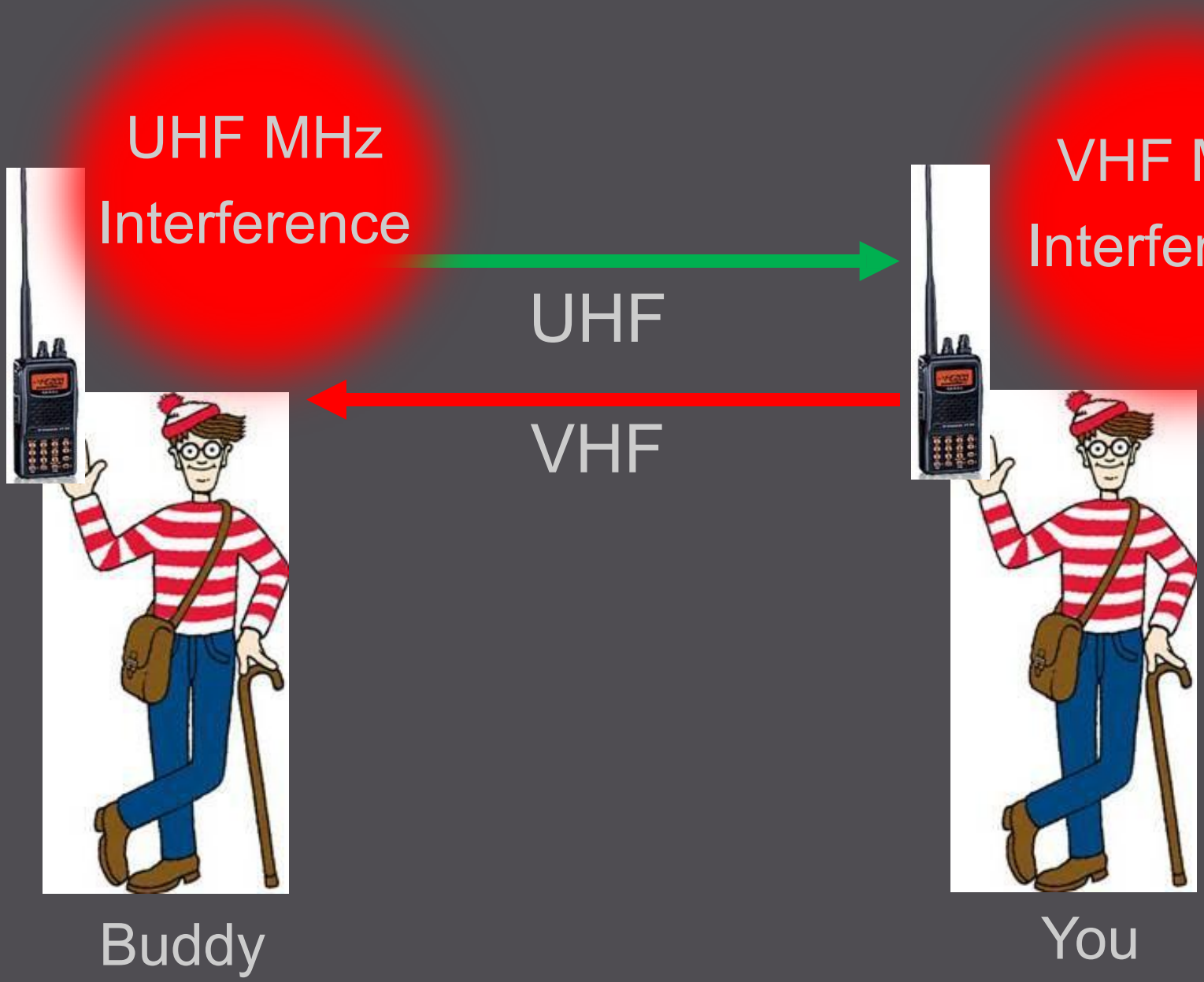
My buddy on simplex can hear me but I can't hear him because of the interference around me

- Cross-band operation can solve this problem
  - Transmit on one band – they can hear me
  - Receive on another band with no interference
  - Simplex operation
- Example – Event at a convention hall
  - Buddy can't hear you on UHF because of local interference in the parking lot
  - Buddy can hear you on VHF in the parking lot
  - You can't hear buddy on VHF because of local interference in the hall
  - You can hear buddy on UHF in the hall

My buddy on simplex can hear me but I can't hear him because of the interference around me

- Implementation
  - Buddy transmits on UHF, listens on VHF
  - You transmit on VHF, and listen on UHF
  - Program this into your radio using your memory channels
  - Or use a dual receive HT
  - *This is not really cross-band repeat

Cross-Band Operation Example



I can hear the voice repeater but I can't reach it

- Locked-band repeater (LBR) is the solution
  - LBR receives on side A, re-transmits on side B
  - LBR does not receive on side B and re-transmit on side A
  - Side B is set to the repeater input
  - You transmit simplex to side A
  - You listen to repeater output

I can hear the voice repeater but I can't reach it

- Example:
  - You want to use WØYL but you are inside Target
    - You can hear the repeater output
    - Your HT on low can not be picked up by the repeater
  - Use a locked-band repeater to take your low power HT and re-transmit it at a higher power
- Implementation
  - You transmit to a mobile rig in the parking lot on UHF
  - The mobile rig re-transmits on VHF to the repeater
  - You receive the repeater directly

Locked-Band Repeater Example

446.5

147.84

147.24

Locked Band Radio

Operator			Side A		Side B		Repeater - WØYL	
RCV Freq	147.24	446.5	RCV Freq		RCV Freq	147.24	147.84	RCV Freq
XMT Freq	446.5	~~446.5~~	XMT Freq		XMT Freq	147.84	147.24	XMT Freq
Sql Type	Tone	Tone	Sql Type		Sql Type	Tone	Tone SQL	Sql Type
Tone Freq	100	100	Tone Freq		Tone Freq	114.8	114.8	Tone Freq
		N/A	Man SQL		Man SQL	Sql for no sig		

I can't hear the repeater but I can reach it

- Locked-band repeater is the solution again
  - Side A is set to the repeater output
  - You listen to side B simplex

I can't hear the repeater but I can reach it

- Example:
  - You want to use WØYL but you are inside MGMC
    - You can't hear the repeater output because of local VHF interference
  - Use a locked-band repeater to take the repeater output and re-transmit on UHF where you can hear it
- Implementation
  - You transmit to the VHF repeater
  - The mobile rig in the parking lot listens to the repeater output and re-transmits on UHF so you can hear

Locked-Band Repeater Example

147.84

446.5

147.24

Locked Band Radio

Operator			Side A		Side B		Repeater - WØYL	
RCV Freq	446.5	NA	RCV Freq		RCV Freq	147.24	147.84	RCV Freq
XMT Freq	147.84	446.5	XMT Freq		XMT Freq	NA	147.24	XMT Freq
Sql Type	Tone	Tone	Sql Type		Sql Type	Tone	Tone SQL	Sql Type
Tone Freq	100	100	Tone Freq		Tone Freq	114.8	114.8	Tone Freq
		N/A	Man SQL		Man SQL	Sql for no sig		

A group of field operators must communicate with each other but some do not have a direct path to other team members

- No infrastructure repeater
- Everyone transmits on UHF
- Everyone receives on VHF
- A locked-band radio is placed where it provides full area coverage
- The locked-band radio
  - Receives on UHF and simultaneously transmits on VHF

Locked-Band Field Use Example

Locked Band Radio Field Repeater

Operator			Side A		Side B			Local Field Team	
RCV Freq	147.540	446.5	RCV Freq		RCV Freq	N/A	147.54	RCV Freq
XMT Freq	446.500	N/A	XMT Freq		XMT Freq	147.540	446.500	XMT Freq
Sql Type	Tone	Tone	Sql Type		Sql Type	Tone	Tone SQL	Sql Type
Tone Freq	100	100	Tone Freq		Tone Freq	100	100	Tone Freq
		N/A	Man SQL		Man SQL	Sql for no sig		

I'm in a river valley and can't reach the repeater on an HT because of the terrain

- WØYL is the voice repeater
  - Transmits on 147.240, receives on 147.840
- A cross-band radio is added to the path to provide access to the voice repeater
- You transmit and receive on UHF
- The cross-band repeater
  - Receives on UHF, simultaneously transmits on 147.84
  - Receives on 147.24, simultaneously transmits on UHF
  - Note: For the WØYL side of the radio, these are your normal repeater settings

Cross-Band Repeater Example

446.5

446.5

147.24

147.84

Cross Band Radio To Voice Repeater

Operator			Side A		Side B		Repeater - WØYL	
RCV Freq	446.5	446.5	RCV Freq	RCV Freq	147.24	147.84	RCV Freq
XMT Freq	446.5	446.5	XMT Freq	XMT Freq	147.84	147.24	XMT Freq
Sql Type	Tone	Tone	Sql Type	Sql Type	Tone	Tone	Sql Type
Tone Freq	100	100	Tone Freq	Tone Freq	114.8	114.8	Tone Freq
		N/A	Man SQL	Man SQL	Sql for no sig		

We need a temporary VHF repeater because not everyone has a UHF radio for our event

- Two locked-band radios can work together to create a 600 kHz split, 2 meter repeater
- There must be physical separation between the two radios
- Radio 1
  - Receives on VHF, simultaneously transmits on UHF
- Radio 2
  - Receives on UHF, simultaneously transmits on VHF
- Automatic Repeater Offset works as normal on user's radios

2 Locked-Band Radios as VHF Repeater Example

144.65

446.5

145.25

Locked Band Radio Field Repeater

Operator			Side A Radio 1 Side B				Side A Radio 2 Side B				Operator	
RCV Freq	145.25	144.65	RCV Freq		RCV Freq		446.5	RCV Freq		RCV Freq		145.25	RCV Freq
XMT Freq	144.65	N/A	XMT Freq		XMT Freq	446.5	N/A	XMT Freq		XMT Freq	145.25	144.65	XMT Freq
Sql Type	Tone	Tone	Sql Type		Sql Type	Tone	Tone	Sql Type		Sql Type	Tone	Tone	Sql Type
Tone Freq	114.8	114.8	Tone Freq		Tone Freq	114.8	114.8	Tone Freq		Tone Freq	114.8	114.8	Tone Freq
		N/A	Man SQL		Man SQL		N/A	Man SQL		Man SQL			

I would like to link a VHF and UHF repeater together for our event

- Crossed-band repeater is the solution again
  - Side A is set to the UHF repeater pair
  - Side B is set to the VHF repeater pair
  - These are your normal repeater memory settings
- USE WITH CATION!
  - Potential for repeater squelch tails to ping-pong continuously after first transmission
  - Keep hang time short
  - Test extensively before relying on this solution

Cross-Band Repeater Example

448.25

443.25

147.24

147.84

Cross Band Radio To Voice Repeater

Repeater – KI0Q			Side A		Side B		Repeater - WØYL	
RCV Freq	448.25	443.25	RCV Freq	RCV Freq	147.24	147.84	RCV Freq
XMT Freq	443.25	448.25	XMT Freq	XMT Freq	147.84	147.24	XMT Freq
Sql Type	Tone	Tone	Sql Type	Sql Type	Tone	Tone	Sql Type
Tone Freq	100	100	Tone Freq	Tone Freq	114.8	114.8	Tone Freq
		N/A	Man SQL	Man SQL	Sql for no sig		

Keeping it Legal

- CAVEAT: Not a lawyer, nor an expert on FCC rules
- Technically: A cross-band repeater is not a ‘repeater’ per Part 97
  - It’s officially considered a remote base station, so it follows Auxiliary Station rules
- Remote Base
  - Remotely Controlled Station
- Input is considered control and voice uplink, therefore must comply with 97.201

Keeping it Legal

- Control operator
  - Must be able to control the station
  - May authorize others to use the station
  - Is responsible for ID, not the other users
- If control operator is remote, a 3 min timer must be employed
- An auxiliary station may transmit only on the 2 m and shorter wavelength bands, except the 144.0-144.5 MHz, 145.8-146.0 MHz, 219-220 MHz, 222.00-222.15 MHz, 431-433 MHz, and 435-438 MHz segments

What Does The FCC Say?

§ 97.119 Station identification

(a) Each amateur station….,must transmit its assigned call sign on its transmitting channel at the end of each communication, and at least every 10 minutes during a communication, for the purpose of clearly making the source of the transmissions from the station known to those receiving the transmissions. No station may transmit unidentified communications or signals, or transmit as the station call sign, any call sign not authorized to the station…..

Identification Techniques

- Automatic CW ID if the radio supports it
  - Several Kenwood radios support CW ID
- Voice ID
  - Local control operator identifies
    - using cross-band radio microphone
    - on both cross-band radio output frequencies
- Add-on controller

Identification Techniques

- Control Operator's ID over the input frequency also serves to ID the output of the locked-band repeater
- On a cross-band repeater there is no way for the control operator to remotely ID both outputs
  - Some form of automatic ID must be employed [97.119]
- If your radio does not support internal CW ID, then you must use an add-on controller

Identification Techniques

THIS TRANSMISSION IS NOT PROPERLY IDENTIFIED!

WØYL

KØGR

WØYL

KØGR

THIS TRANSMISSION IS PROPERLY IDENTIFIED!

Operating Considerations

- When operating through a standard repeater, squelch tail must be very short
  - Cross-band repeater will not switch from TX to RX until repeater drops
- Manually adjust squelch settings to prevent unintended cross-band transmissions

Operating Considerations

- Always configure tone squelch on the input of your cross-band repeater to avoid unintended transmissions on the output frequency
- All users must transmit tone when talking through the cross-band repeater
- Some radios open the microphone when cross-banding, so consider unplugging microphone in this case

Operating Considerations

- Operating in cross-band mode will have very high duty-cycle
- All traffic on both UHF and VHF causes cross-band repeater to transmit
  - Be careful of battery usage on cross-band repeater, especially if you're using your car's battery
  - Best to use dedicated battery so you don't get stranded with a dead battery
  - Be careful of over-heating. Many mobiles are not designed for high duty-cycle, high-power operations
  - Smart location choice or placement of cross-band repeater may allow you to transmit at lower power

Operating Considerations

- When possible, use locked-band mode
  - Uses less battery power – only transmits when traffic is on the input
  - Reduces squelch-tail problems – monitoring received signal directly, so no need to wait for cross-band repeater to switch from TX->RX
  - Easier to stay legal – no need to ID on the 2nd input
- Use tone squelch on cross-band repeater's input to avoid accidental triggers
- Use tone encode only on the HT so you can hear if the frequency is in use by others

Frequency Choice

- ARRL band-plan:
  - 445.00-447.00 Shared by auxiliary and control links, repeaters and simplex (local option)
  - Several states' band-plans advise 445.975 and 446.025 for cross-band
- Best to stick with the simplex band-plan
- Using repeater input or output will trigger auto repeater offset on most radios
  - Need to disable auto repeater offset
  - Or program simplex frequency into memory
- Avoid harmonics (e.g., 147.5 and 442.5)

Partial list of Cross-band Capable Radios

- Yaesu- FT8800, FT8900, FTM 350 (one line in manual), FTM400 (not in manual)
- Kenwood- TM D710, TM D700, TM V71A, TS 2000
- ICOM- IC 2730, W32a (not in manual)
- ADI- AT-600
- Alinco- DR635

- Not a complete list and may not be current

Demonstration

				Locked Band Radio Field Repeater						
Operator				Side A			Side B		Local Field Team	
RCV Freq	147.540		446.5	RCV Freq		RCV Freq	N/A		147.54	RCV Freq
XMT Freq	446.500		N/A	XMT Freq		XMT Freq	147.540		446.500	XMT Freq
Sql Type	Tone		Tone	Sql Type		Sql Type	Tone		Tone SQL	Sql Type
Tone Freq	100		100	Tone Freq		Tone Freq	100		100	Tone Freq
			N/A	Man SQL		Man SQL	Sql for no sig			

- Menu Mode 403 for Cross-band vs. Locked-band
- Menu Mode 404 for TX HOLD (squelch tail)
- Menu Mode 406 for TX ID
- Menu Mode 405 for entering Repeater ID

References

- http://www.arrl.org/auxiliary-station-faq

Kenwood TM-D710

- Instructions in PDF on Disk
  - Cross-band (K Type)-E.PDF
- Multiple Menu Modes
  - Menu Mode 403 for Cross-band
  - Menu Mode 404 for TX HOLD
  - Menu Mode 406 for TX ID
  - Menu Mode 405 for entering Repeater ID
- In Cross-band mode, 3 min TX timer is locked on.
- Turning off does not cancel Cross-band
- Must turn off and press [Tone] + Power on to reset

Yaesu FTM-350R

- Disable APRS by turning the APRS modem OFF
- Set frequency and squelch for left and right, VHF/UHF
- To Activate
  - Turn OFF
  - Hold the button left of the yellow power button
  - Press Power button
  - Select Special Menu 11 XBAND-RPTR with left dial
  - Rotate left dial to ON, press left dial (radio will reboot itself)
- To disable,
  - Turn OFF
  - Hold the button left of the yellow power button
  - Press Power button
  - Select Special Menu 11 XBAND-RPTR with left dial
  - Rotate left dial to OFF, press left dial (radio will reboot itself)

Yaesu FTM-400D

- Disable APRS by turning the APRS modem OFF
- Set frequency and squelch for top and bottom
- Disconnect microphone, turn volume down
- To Activate
  - Turn OFF
  - Hold the DISP, F, and GM buttons
  - Press Power button
  - X-BAND Repeater message should display
- To disable,
  - Turn OFF
  - Hold the DISP, F, and GM buttons
  - Press Power button
  - X-BAND Repeater message is not displayed

Yaesu FT-8800

- First set up VHF* on Left and UHF* on Right
  - * Either band may be on either side
  - Freq, squelch type, squelch freq
  - Override repeater offset
- Press SET
  - Rotate main dial to menu 45 (X-RPT)
- Press main dial knob will show X-start
- Press main dial knob again to activate
- To exit press SET