



# Mt. Union UHF Repeater

**2016 Upgrade Project  
YARC *Repeater Committee***

**Pete K6VVR – Trustee of W7YRC**

**John K7PRS – Experienced Repeater Wizard**

**Doug NO1D – Mt. Goat/presenter**

*With help from*

**YARC ARES/RACES Team Members  
Bud N7CW, Art KG6AY, Rob KG7LMI**

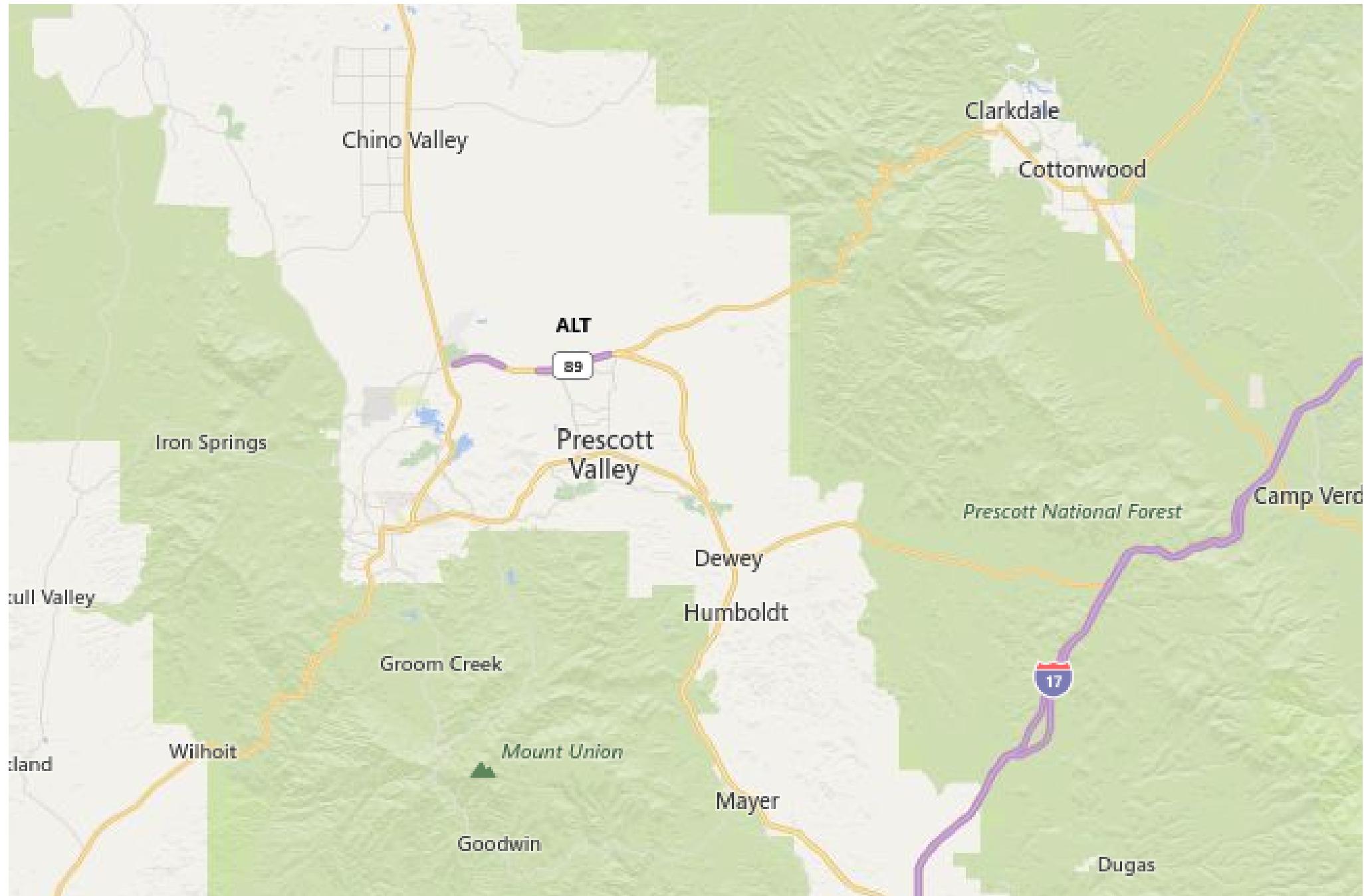
# Tonight's Agenda

- Background on UHF 447.65/442.65 Repeater
- 2016 Upgrade Plan
- Eq. Donations/Procurement and Refurbishing
- Photo's Spring Mt. Union Site Survey
- Photo's 2<sup>nd/3rd</sup> Trip Antenna / Duplexer upgrade
- Moving repeater into ARES/RACES Hut
- Enabling C4FM Digital Mode
- Futures

# Background

- UHF 442.65/447.65
  - Tx Tone: 100.0
  - Analog Only
- Operated on Mt. Union
  - ~ 8000ft elevation
- Fusion DR1x Repeater
- Mot T1500 Duplexer
- ~ 20W Power
- Comet CG6 Vertical
- Coverage was sub-optimal
- Improvement request Jan 16 meeting; Prescott Junction
- Possible Issues:
  - Duplexer
  - Low Power from DR1
  - Antenna
- Left with basic plan & list of options & research tasks
- Plenty to do while we await spring access to Mtn.

# Mt Union





# Yaesu Fusion DR1X Repeater

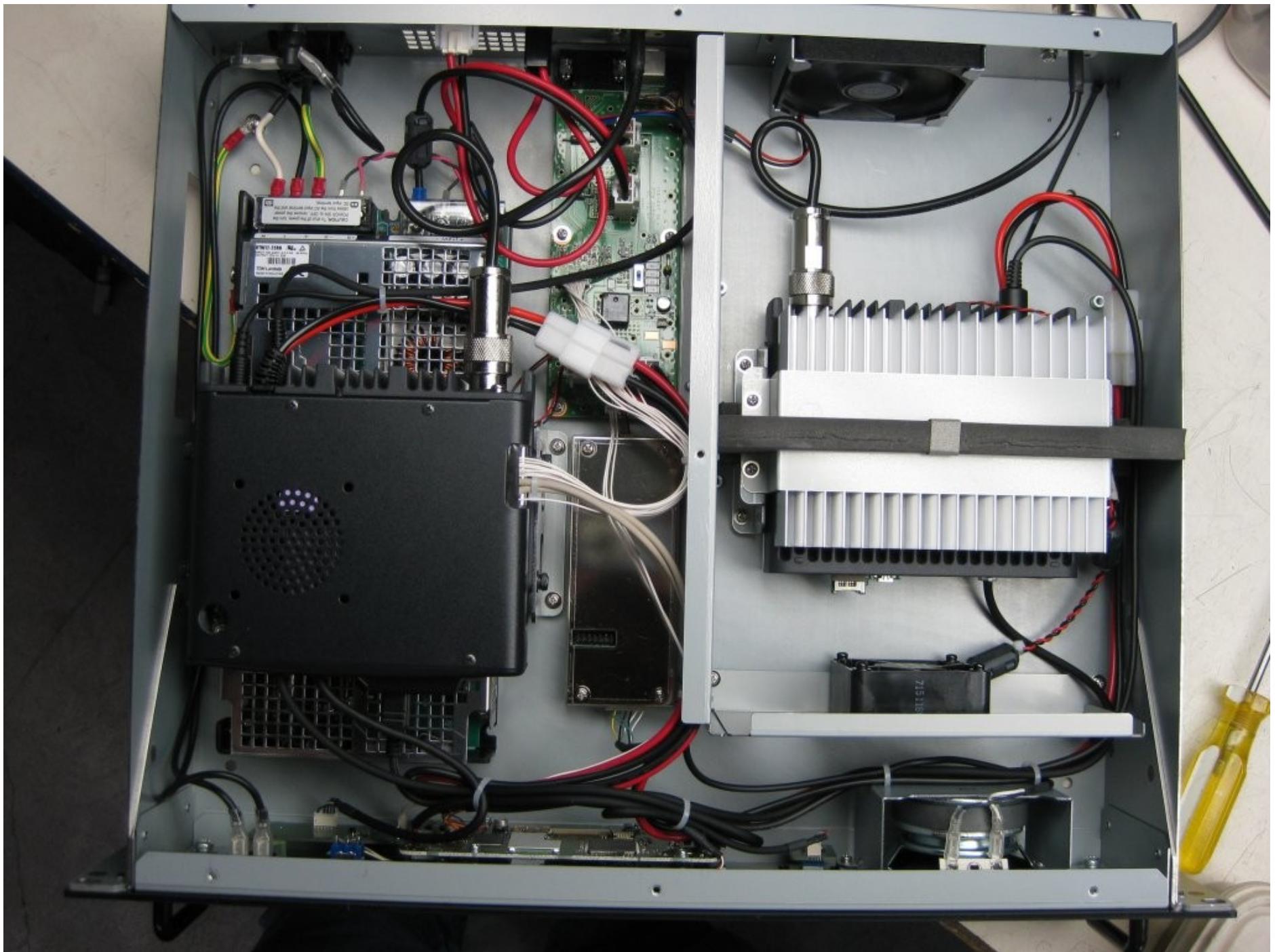
- Club purchased (2) units on special program to clubs by Yaesu
- Supports FM Analog and new C4FM digital Modes
- 2m & 70cm capable
- Basically (2) mobile FT400DR's in single chassis
- UHF high power **spec'd at 50% duty cycle; 50W**
- Infancy failures by ops running high power
- Desire to run at low power to improve longevity

# Yaesu DR1X



- 2U sized chassis
- Touch Screen control interface
- Mic, Vol & Speaker
- 115VAC and 12Vdc power
- Built in repeater controller; minimalistic

# Inside the DR1X



# Equipment Donations / K7PRS

- Motorola MSR 2000 Amplifier
- Micro/Mitrek UHF for Amplifier Spares
- 20W UHF Amplifier and Fans
- Notch Filters – 25dBm ea.
- Decibel Products 4076W Duplexer
- Feed lines, Hard line Connectors, UHF Cable

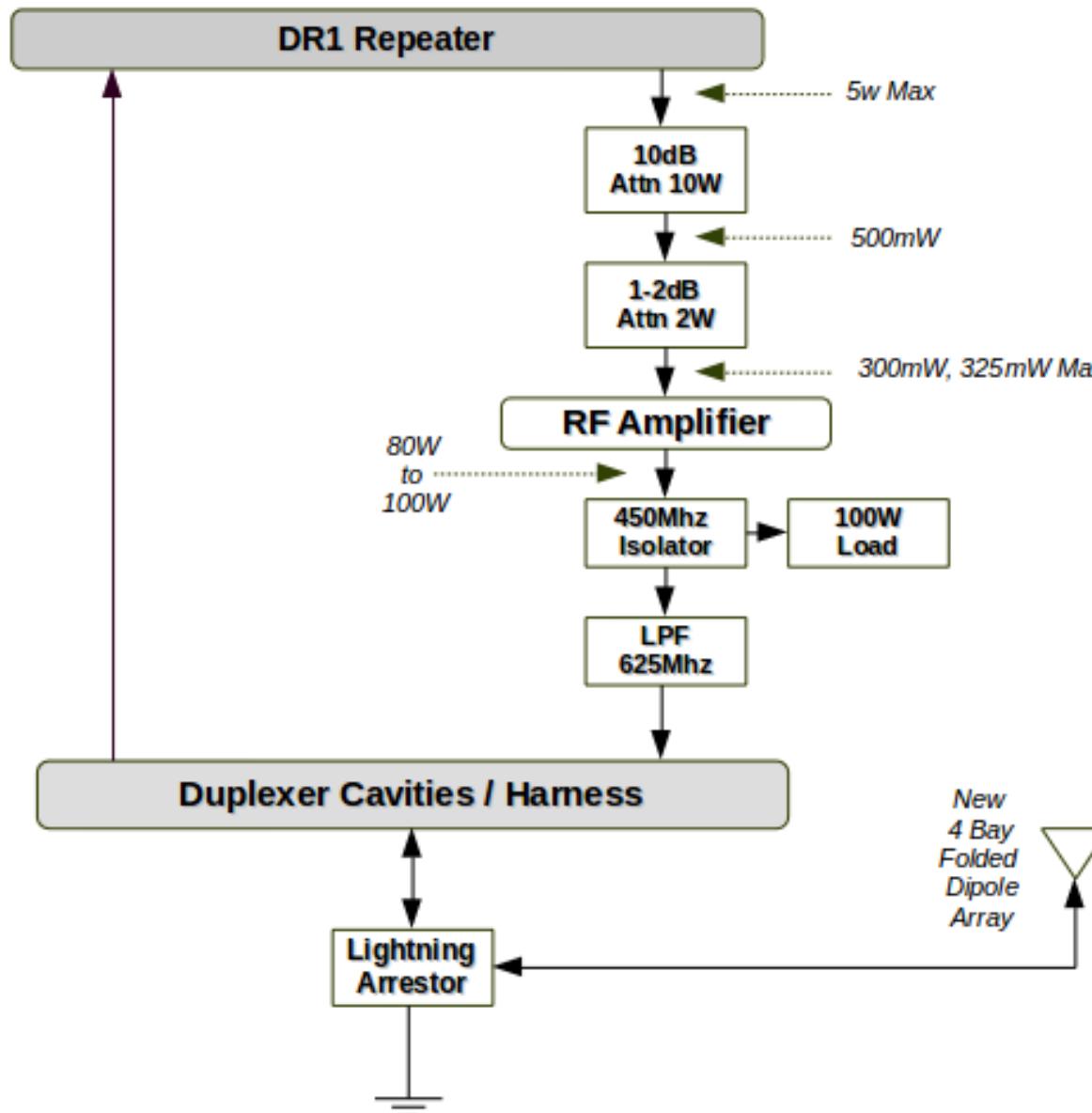
## In Addition

- Club also purchased several items, Isolator, LPF, Cables, Lightning Arrestors, loads, feed line and antenna
- 23" to 19" adapter brackets, Rig Runner, 100W load, 7/8" connectors, Z-Match, Attenuators, Rack Panels, Volt/Amp Meter, Shunt, SSR, 12v cables

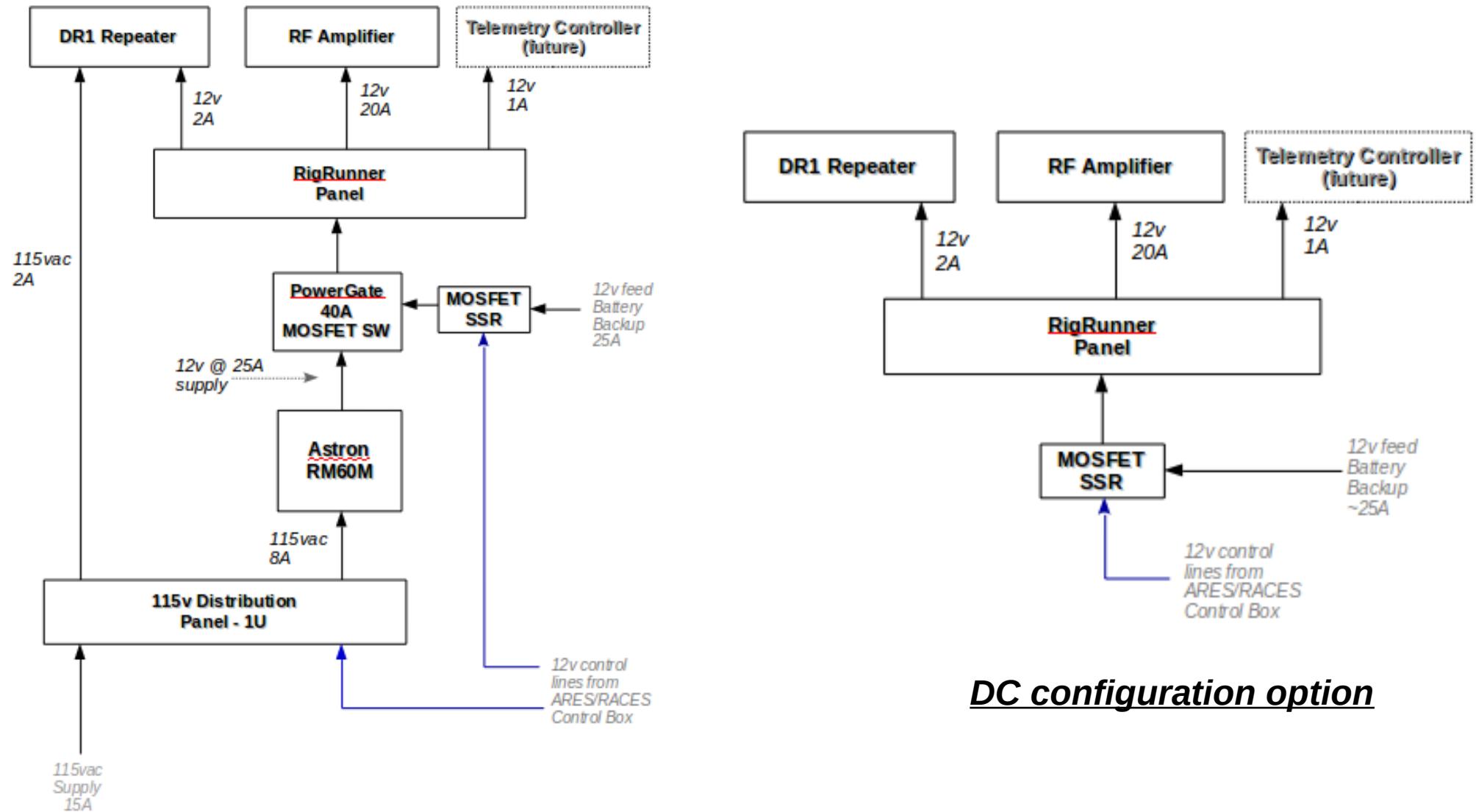
# Upgrade Plan

- Configure DR1x to run low power 5W
- Add commercial grade external amplifier capable of 100W
- Look into changing antenna; ideally 4 bay UHF folded dipole @ 9dBi gain or better
- Prepare spare UHF duplexer to swap out existing
- Build up spares list to keep this equipment running
- ARES/RACES team offered to house UHF repeater in S. Hut on the Mtn. Helping reduce monthly club operational costs
- New hut offers (AWESOME) battery backup supply
- Planned to perform site survey as soon as weather cleared in Spring

# RF Block Diagram



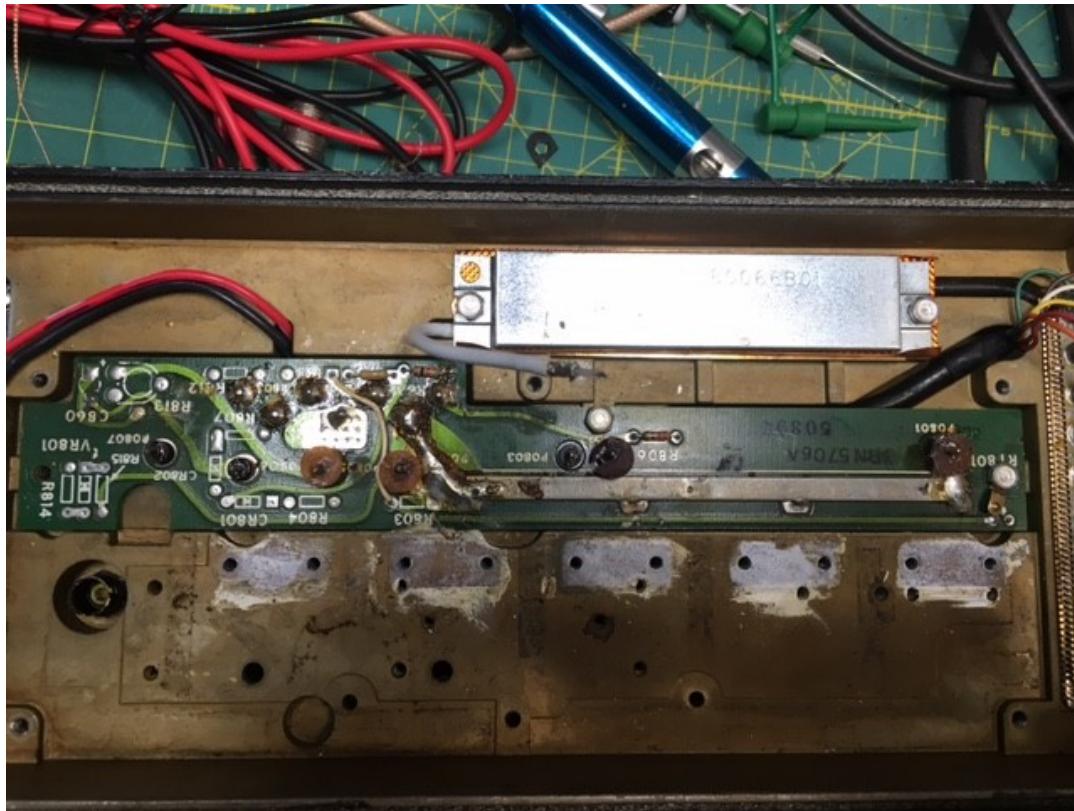
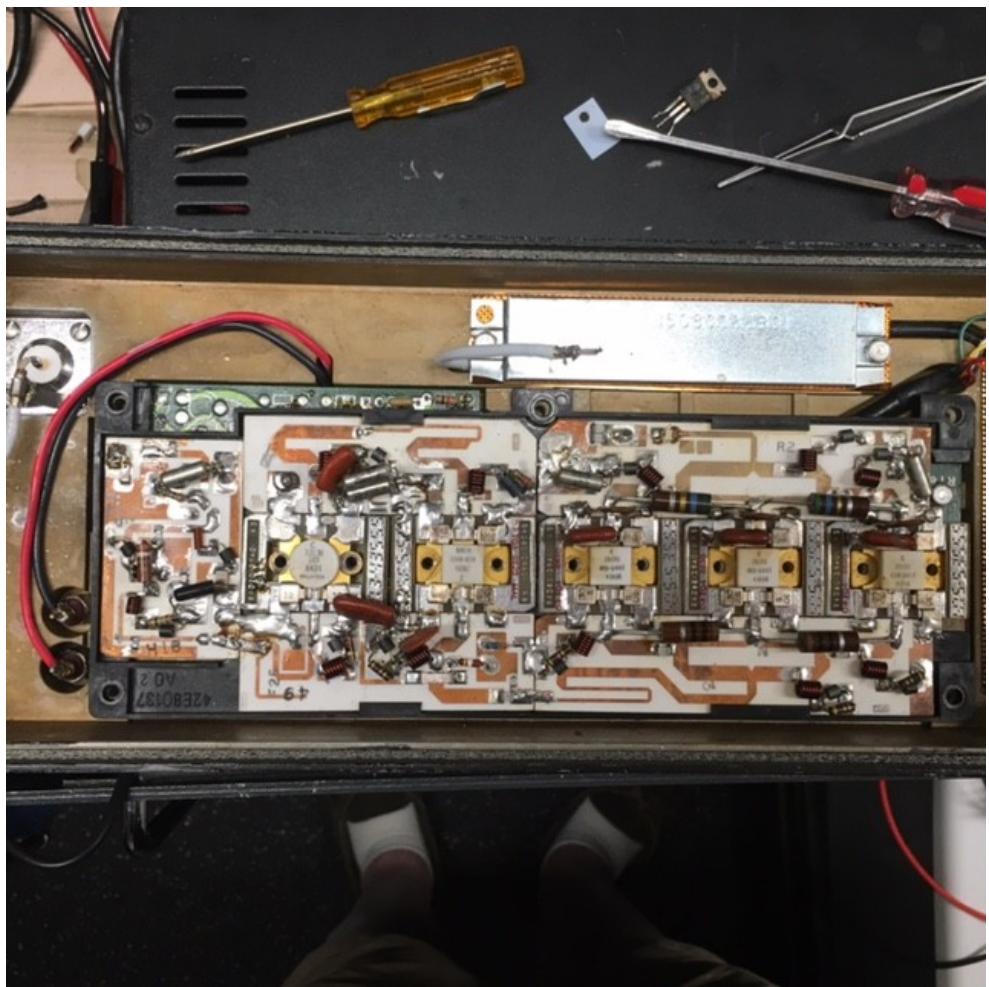
# Power Supply



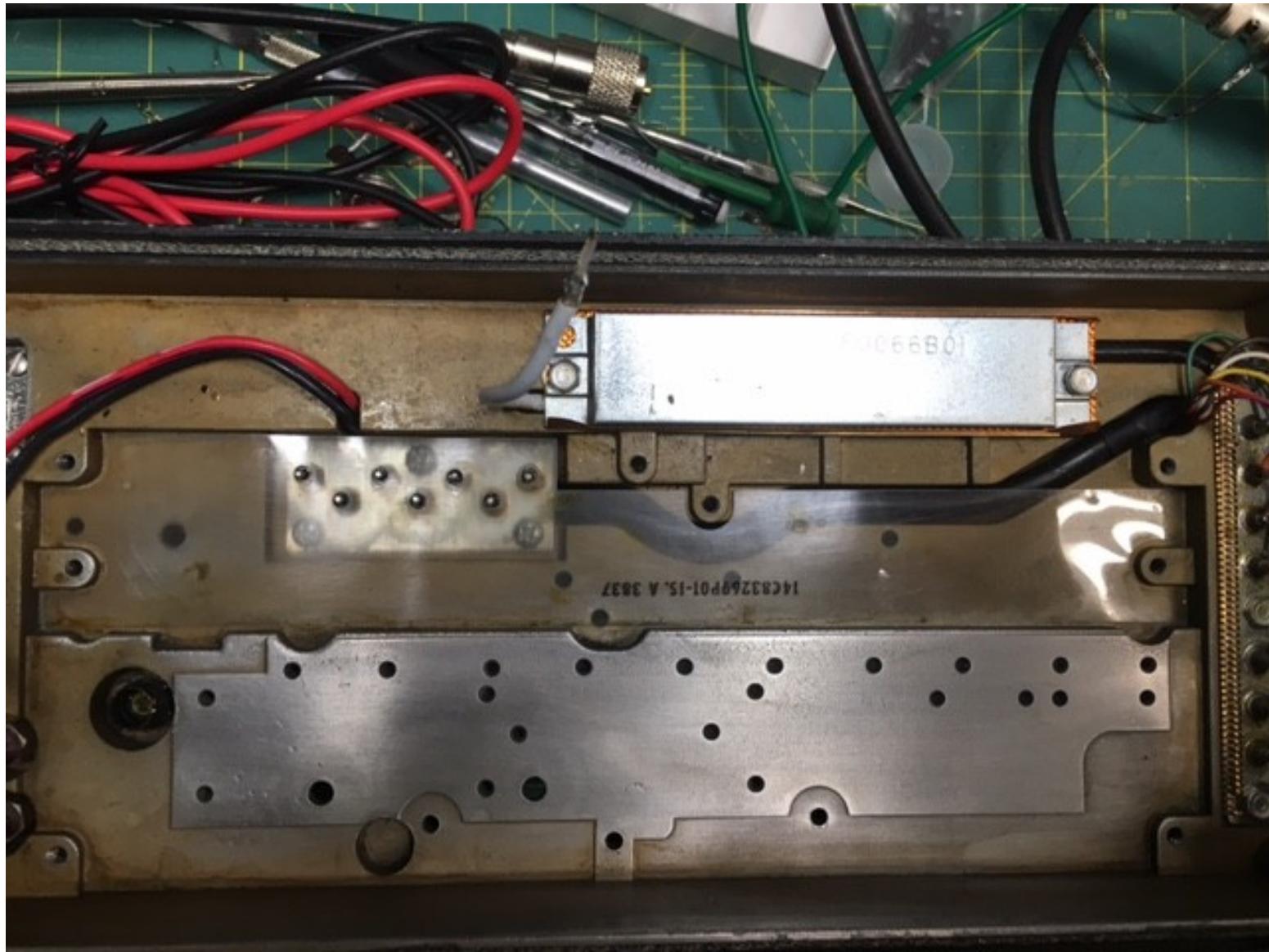
# Amplifier Refurbishment

- Before snow melted started work on MSR2000 amplifier
- Was in good shape; 40W of power but not up to spec
- Had some custom options & bypassed RF control board
  - So stripped it down
  - Removed customizations
  - Repaired RF control board
  - Added 9.5vdc supply
  - Added external 12v Fan
  - New Power cables
  - Bench test

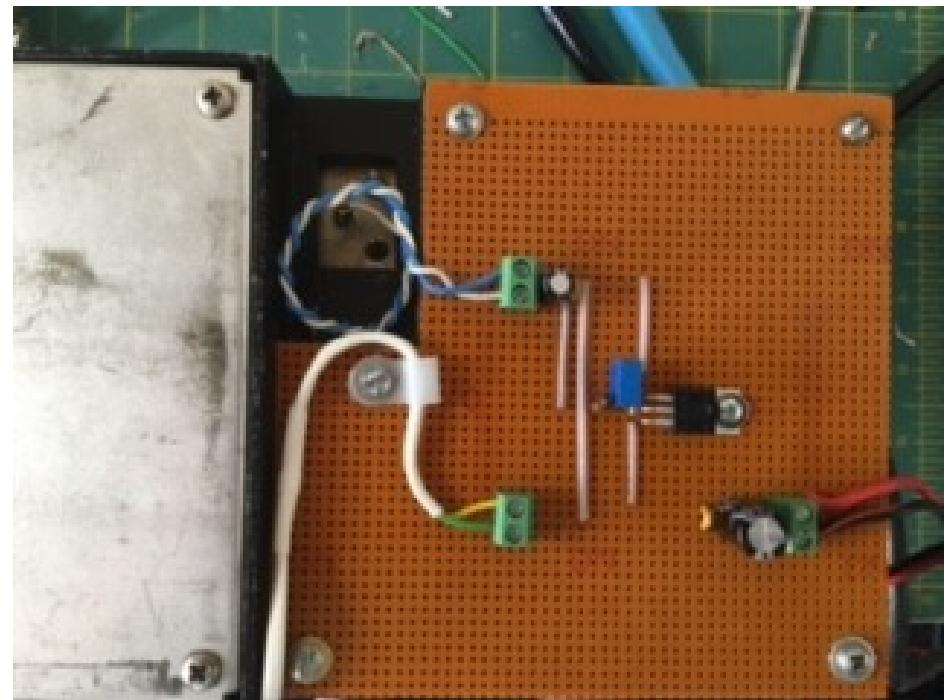
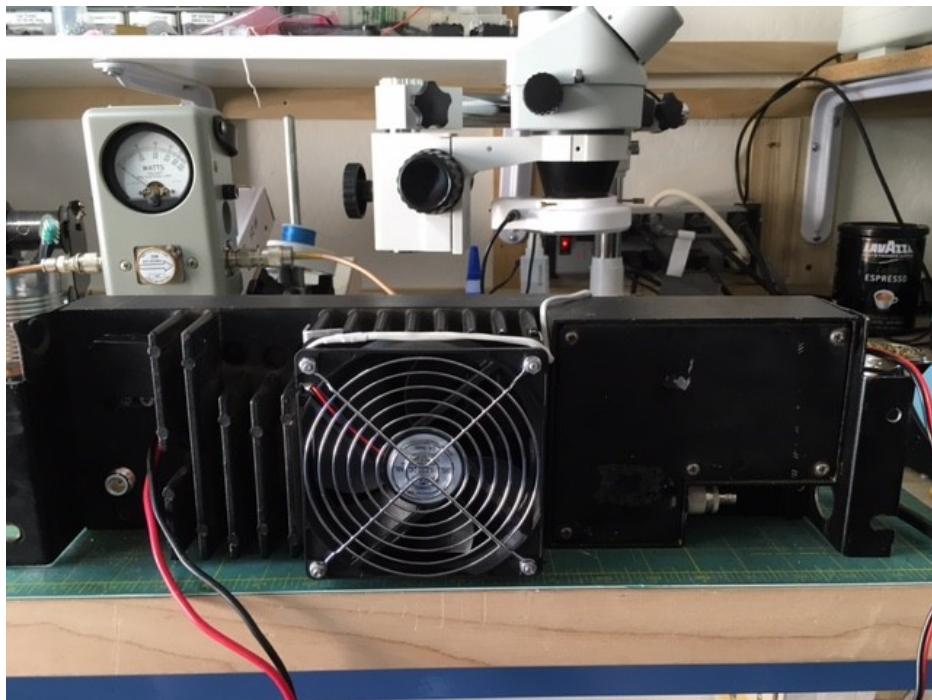
# MSR2000 Refurbishing



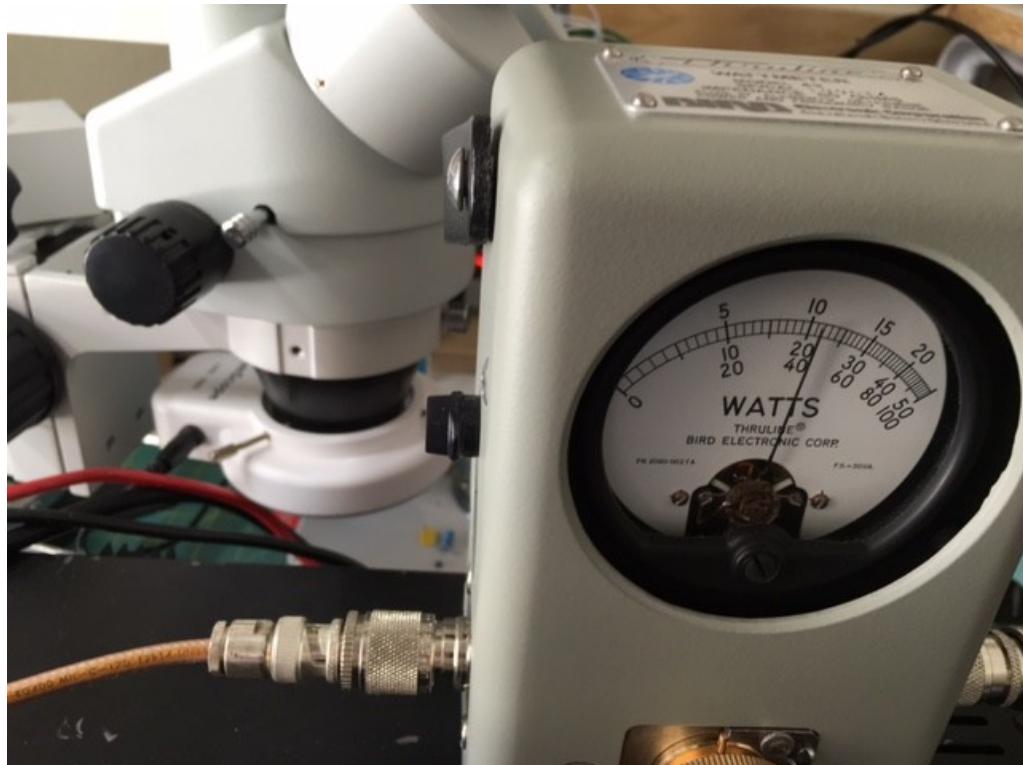
# Cleaning up heat sink



# End Result



# Before ~ 42W



# After Solid 100W



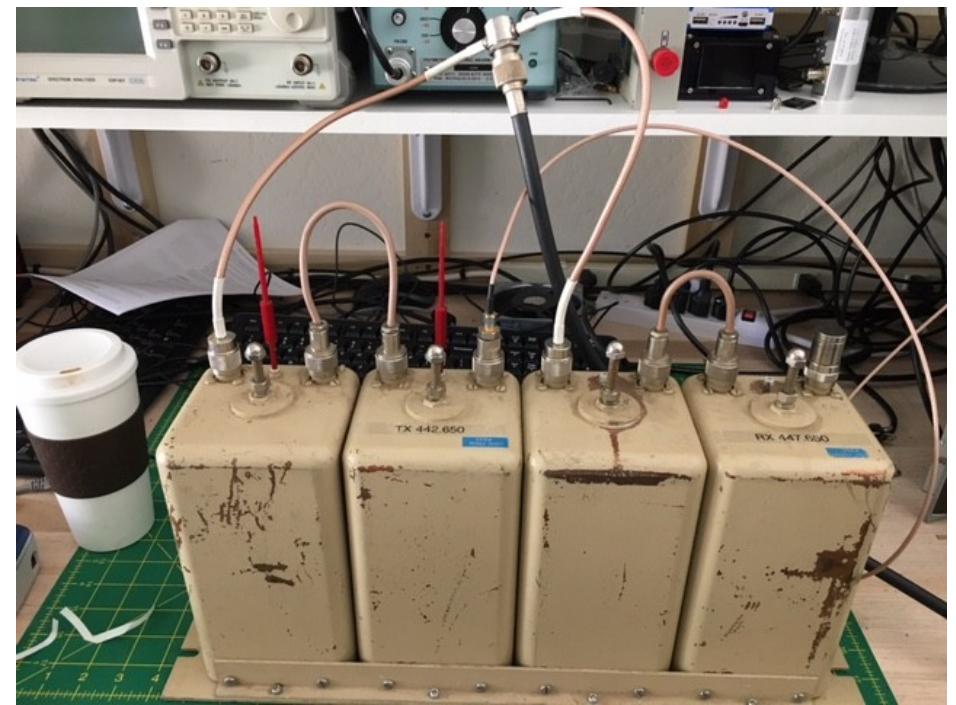
# Fusion Low Power Drive

- 5w output from DR1X too high for MSR2000
- Opted to use In-Line attenuators
  - Vs modification of Amp
- Calculated 14dB atten to get necessary 345mW power into Amplifier
- 10dB → 3dB → 1dB



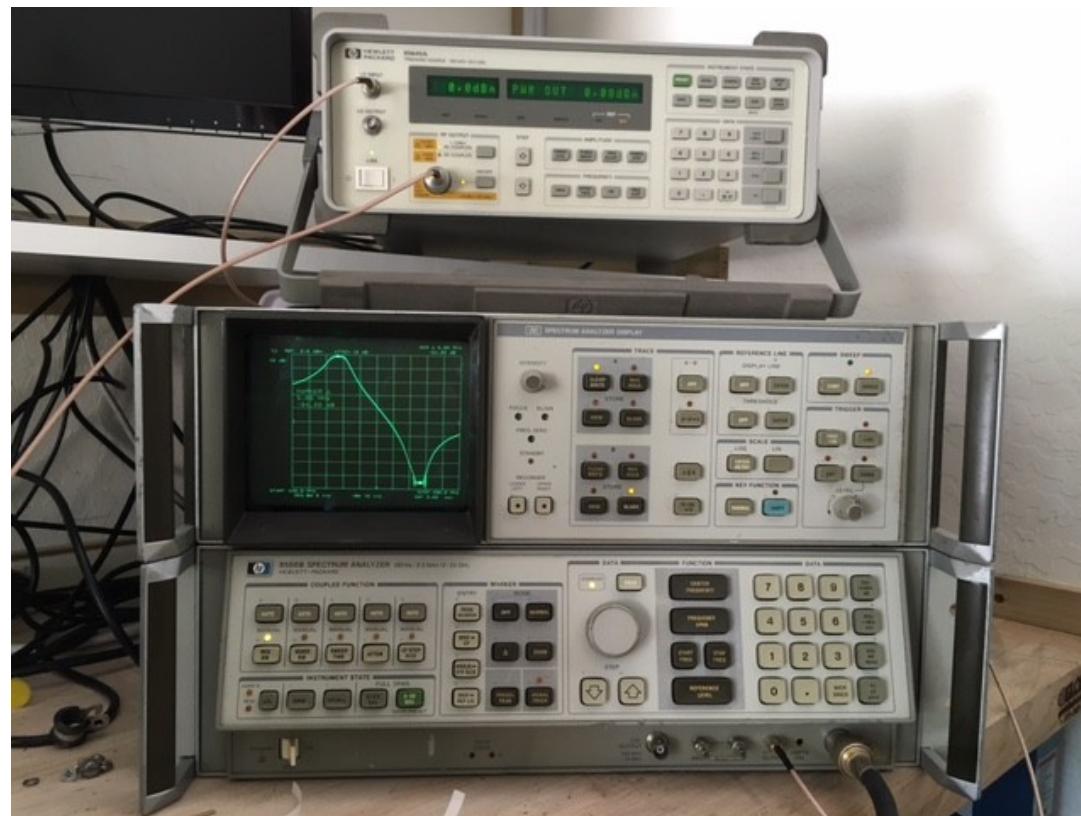
# Next Up, Duplexer

- Key to a repeaters performance
- Isolates Tx from Rx
- Poor isolation results in desense
  - Or worse, Rx damage
- 100dB isolation goal
- Performance can drift due to temperature extremes
- Good to check 1-2 times/yr
- Combination BPF and Notch

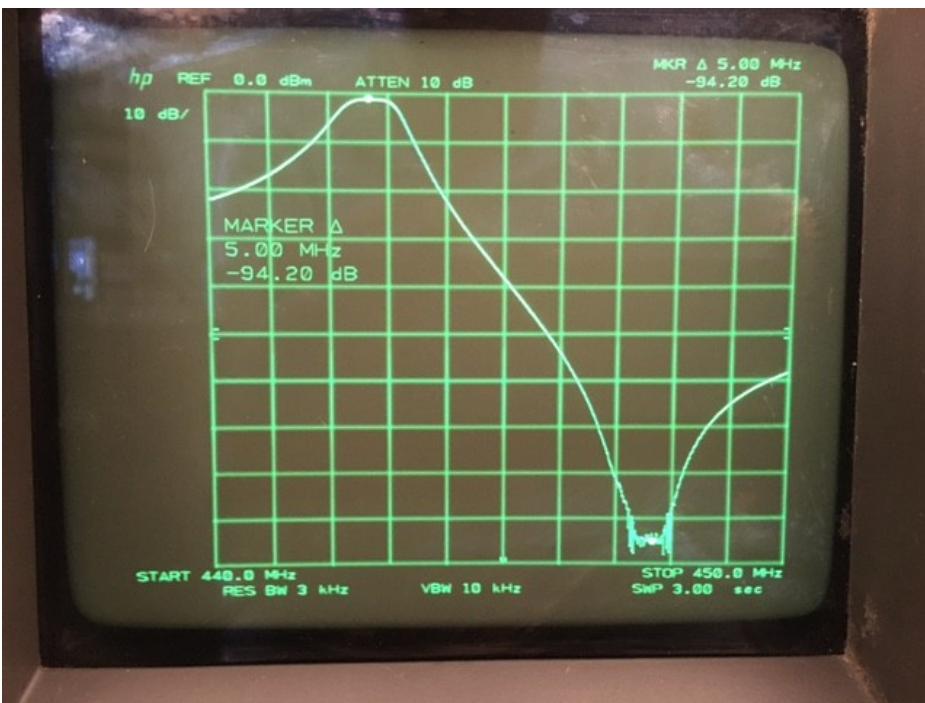


# Tuning Test Equipment

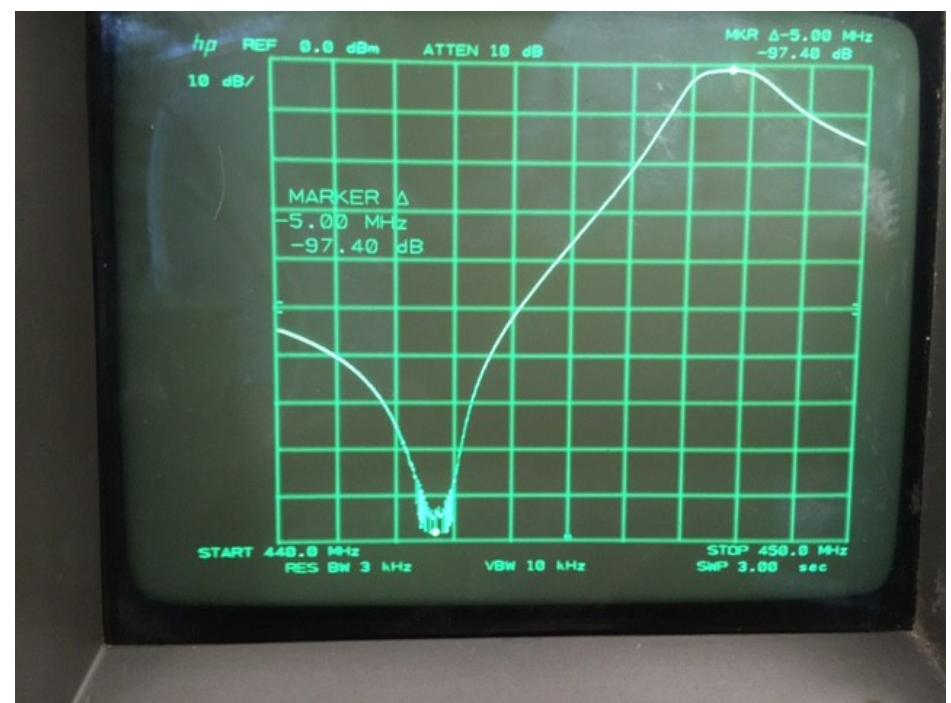
- HP 16475 Tracking Generator
- HP8566b Spectrum Analyzer
- Sweeping 440Mhz to 450Mhz
- 10dB/div, 3Khz BW
- Tune & Tweak



# Tune for Max Tx / Rx Isolation & Minimal Insertion Loss



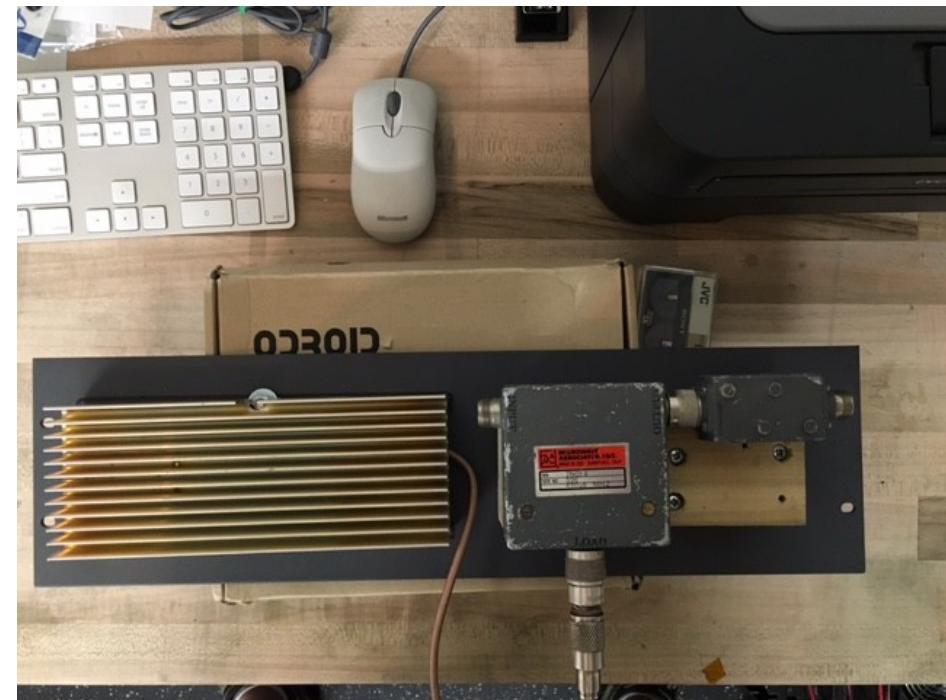
Rx Pass, Tx Notch



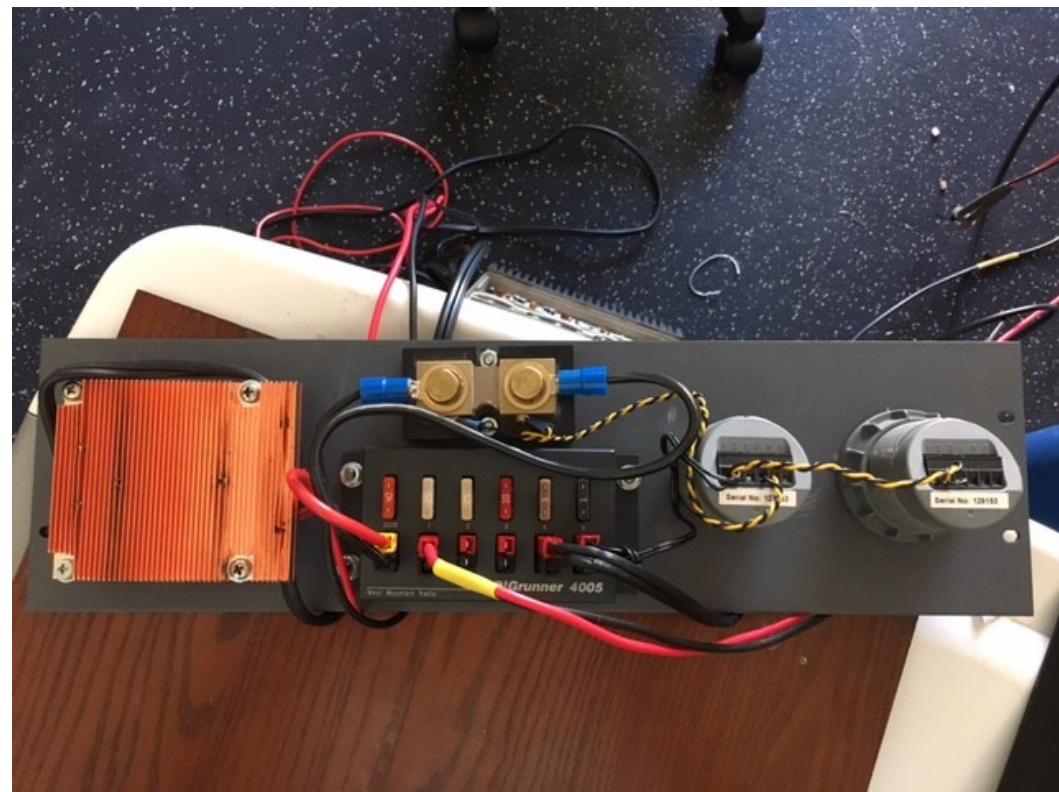
Rx Notch, Tx Pass

# Isolator, LPF and Load

- Isolator is 3-Port device; input, output, load
- Redirects RF power from Amplifier into Load on any VSWR
- Non-Linear Device
  - LPF needed due to harmonics generated
- Protects Amplifier
- Isolator is Ferrous/Magnetic so mounting panel should by non-ferrous
- LPF -3dB @ ~500Mhz



# Power Panel



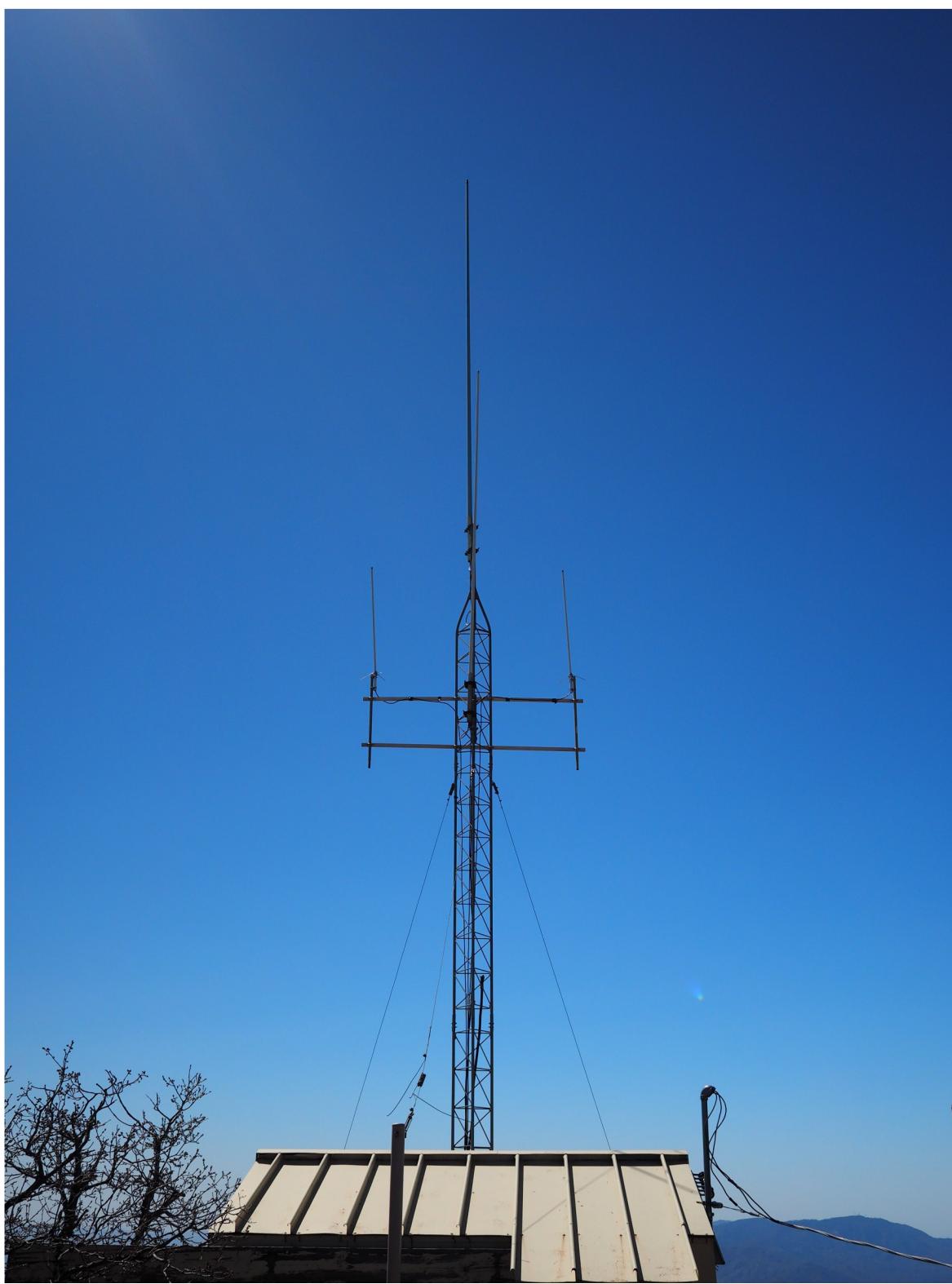
# **Site Survey**

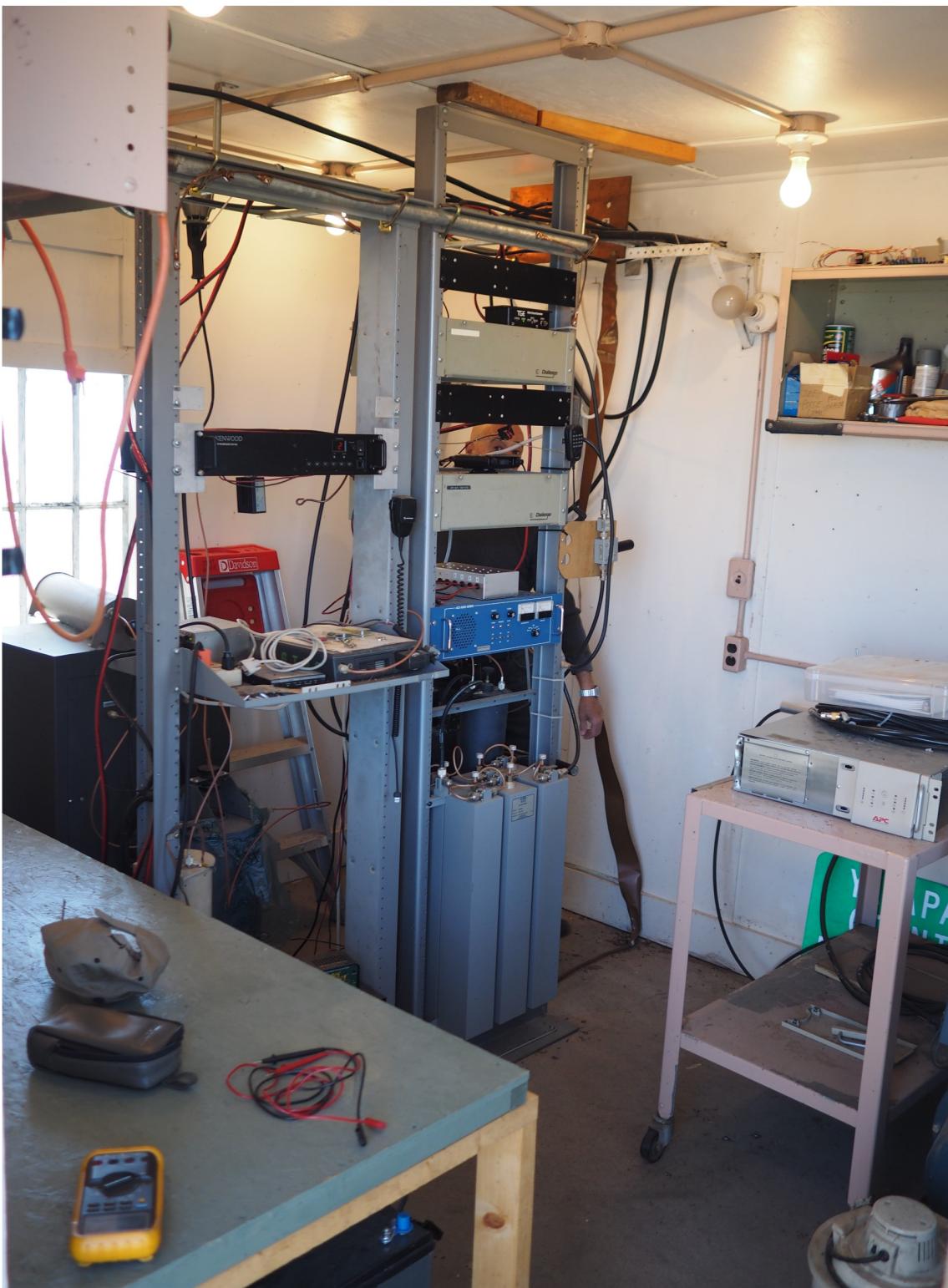
**Spring 2016 trip to Mt Union**





















# Feed line and Scala Antenna

- N2THD Chuck had some goodies for the club
- 50ft 7/8" feed line
- Several interesting UHF antennas
- Scala Omni Vertical
- Thanks to Mike K7QDX for Scala contact and data sheet !

**SCALA**  
PROFESSIONAL ANTENNA SYSTEMS FOR  
BROADCAST AND COMMUNICATIONS

The Scala OG6-450 and OGB6-460 are ruggedized omnidirectional antennas intended for use in professional fixed-station applications in the 406–470 MHz band. They feature:

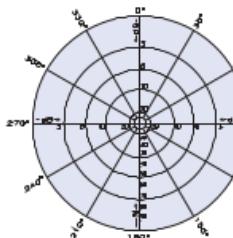
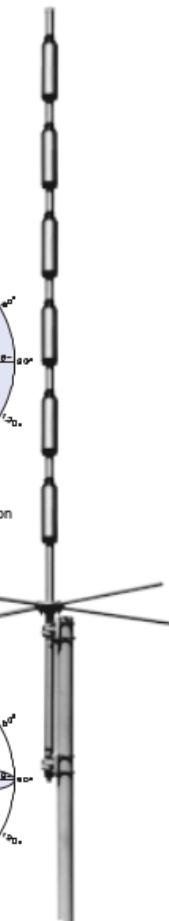
- Parallel-fed collinear dipole array.
- Unique coaxial feed system completely housed within the antenna.
- OGB6-460 broadband across 450–470 MHz.
- Parallel feed design ensures consistent element phasing, even in extreme icing conditions.
- Entire antenna at DC ground potential.
- Anodized for corrosion protection.
- Heavy duty aluminum castings.
- Stainless steel hardware and fasteners.
- Insulating materials chosen for high mechanical and electrical characteristics.
- Electrical downtilt versions of the OG6-450 are available.
- Special hardware and reflector kits are available for offset and bidirectional patterns.

**Specifications:**

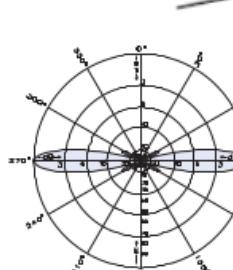
Frequency range	OG6-450	OGB6-460
	406 to 470 MHz (specify frequency) (other frequencies on request)	450–470 MHz (broadband)
Gain	6 dBD	
Impedance	50 ohms	
VSWR	< 1.5:1	
Polarization	Vertical	
Maximum input power	250 watts (at 50°C)	
H-plane beamwidth	Omni	
E-plane beamwidth	16 degrees (half-power)	
Electrical downtilt	7° or 11° (optional on OG6-450 only)	
Termination	N female	
Weight	14 lb (6.35 kg)	
Height	98 inches (2489 mm)	
Equivalent flat plate area	1.51 ft <sup>2</sup> (0.14 m <sup>2</sup> )	
Wind survival rating	100 mph (160 kph)	
Shipping dimensions	99 x 6 x 6 inches (2515 x 152 x 152 mm)	
Shipping weight	23 lb (10.4 kg)	
Mounting	For masts of 2.375 inches (60 mm) OD. <i>See reverse for order information.</i>	

**OG6-450  
OGB6-460**

OMNIDIRECTIONAL ANTENNA  
6 dBD gain  
406 to 470 MHz  
450–470 MHz (broadband)



H-plane  
Horizontal pattern – V-polarization

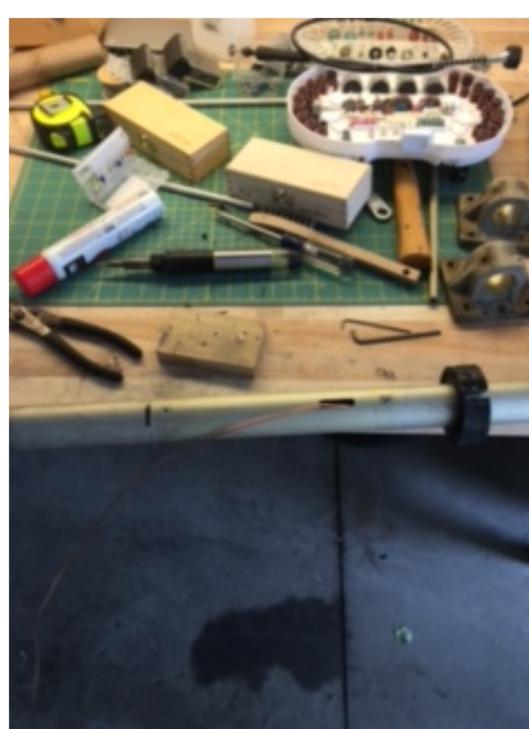
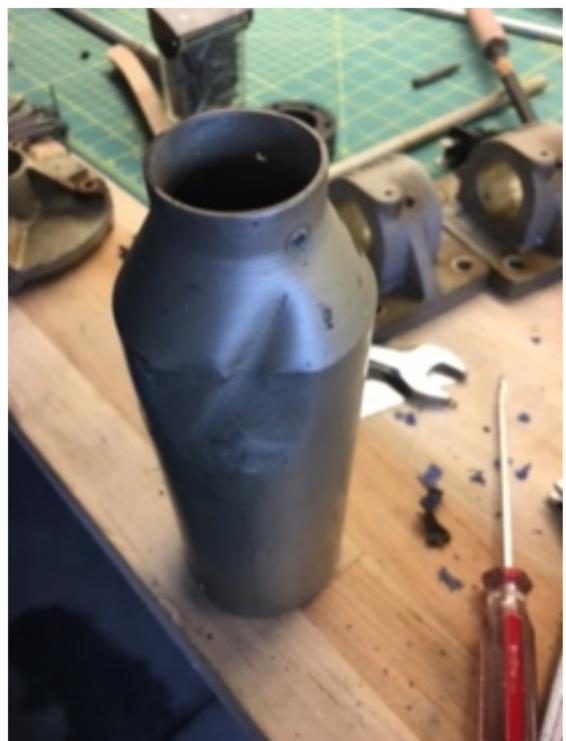


E-plane  
Vertical pattern – V-polarization

**SCALA ELECTRONIC CORPORATION**

Post Office Box 4580                      Phone: (541) 779-6500  
Medford, OR 97501 (USA)                Fax: (541) 779-3991  
<http://www.scala.net>

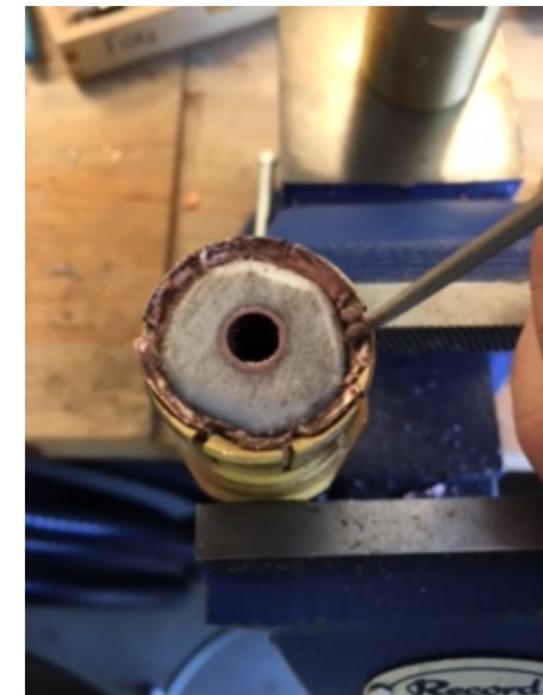
Scala Electronic Corporation is a member of the Kathrein Group

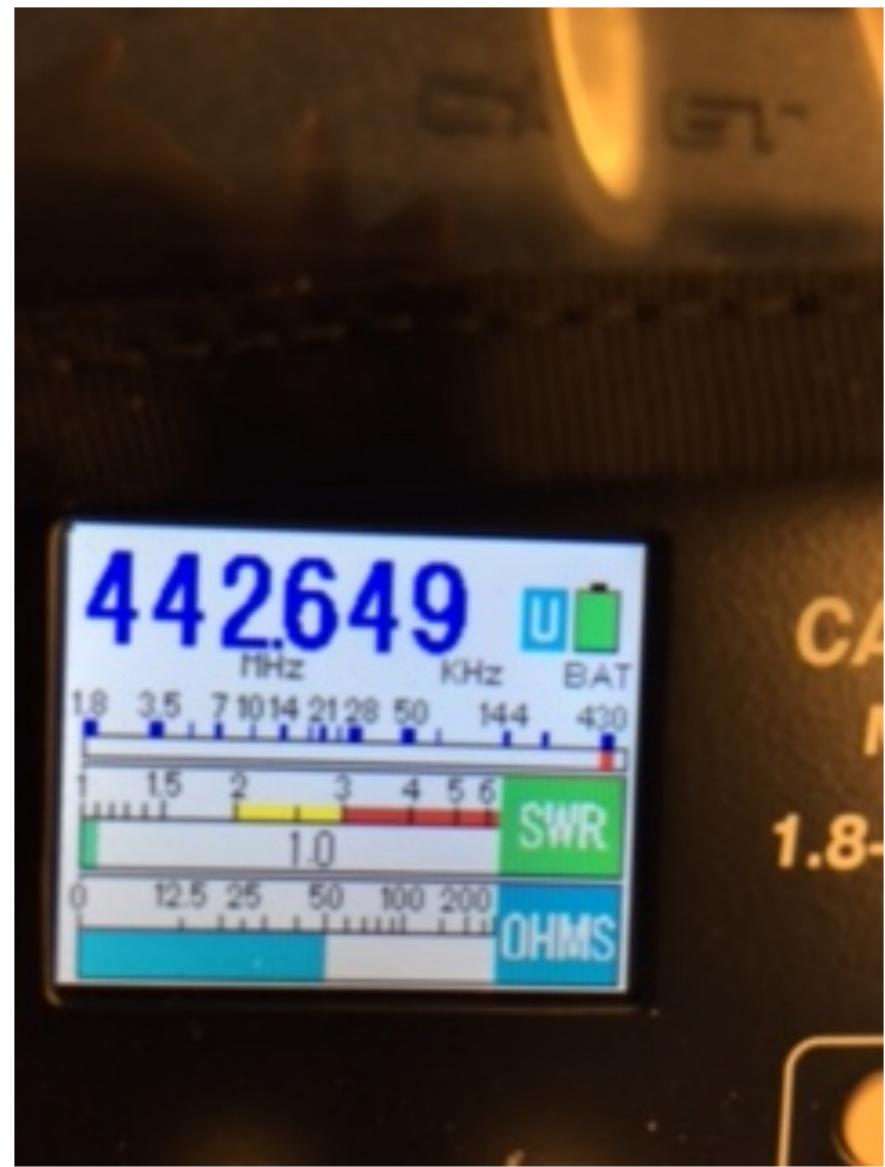


# Scala Antenna

- Brought home and began to strip it down
- 6 “cans” which act as folded dipole (or hairpin match)
- Removed dents best I could
- Cleaned and repaired connections
- Winterized/Sealed
- New SS HW and 4 new radials





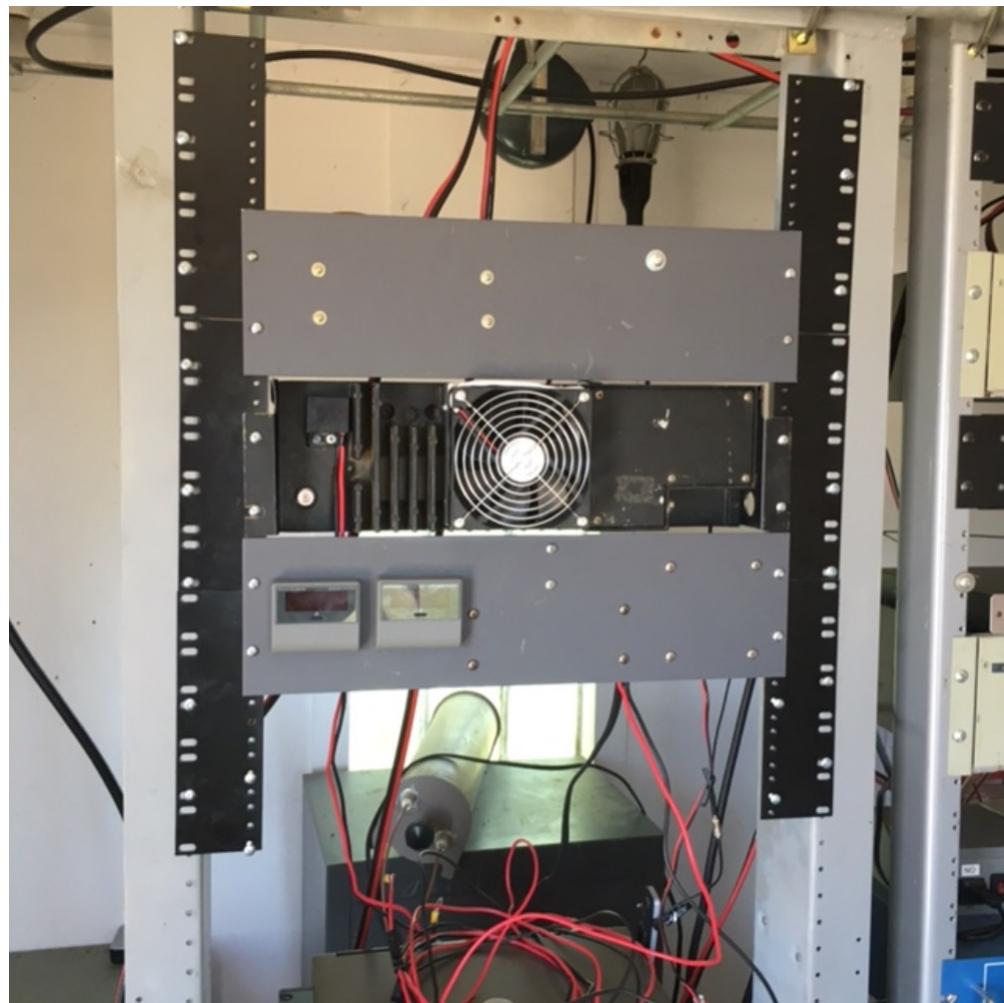


# Install Scala, Replace Duplexer

- Repeater was experiencing severe desense
- Replaced Duplexer
- Replaced Comet w/ Scala
- Took Several VSWR and Power Measurements
  - Tuned radials, Replaced/Tuned Tx → Duplexer cable
  - Increased from ~15W to 20W
- Results promising, much better coverage and overall improvement from upgrades during this trip
- Took opportunity to install several new components into ARES/RACES Hut

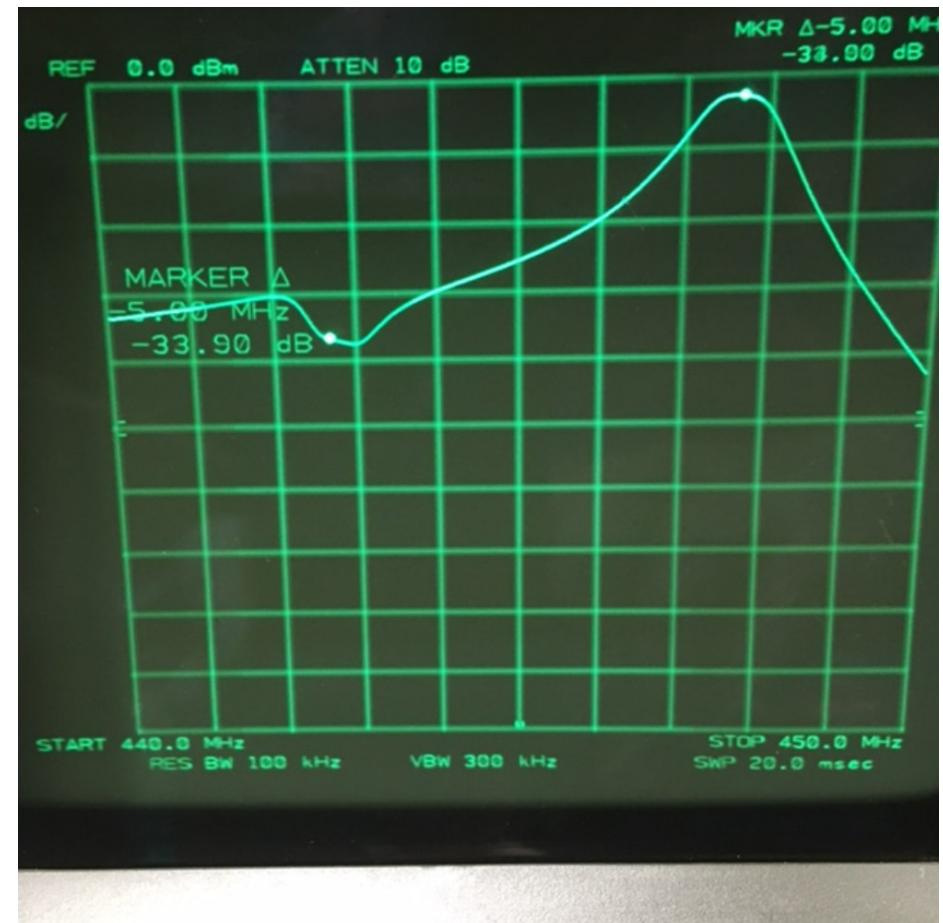
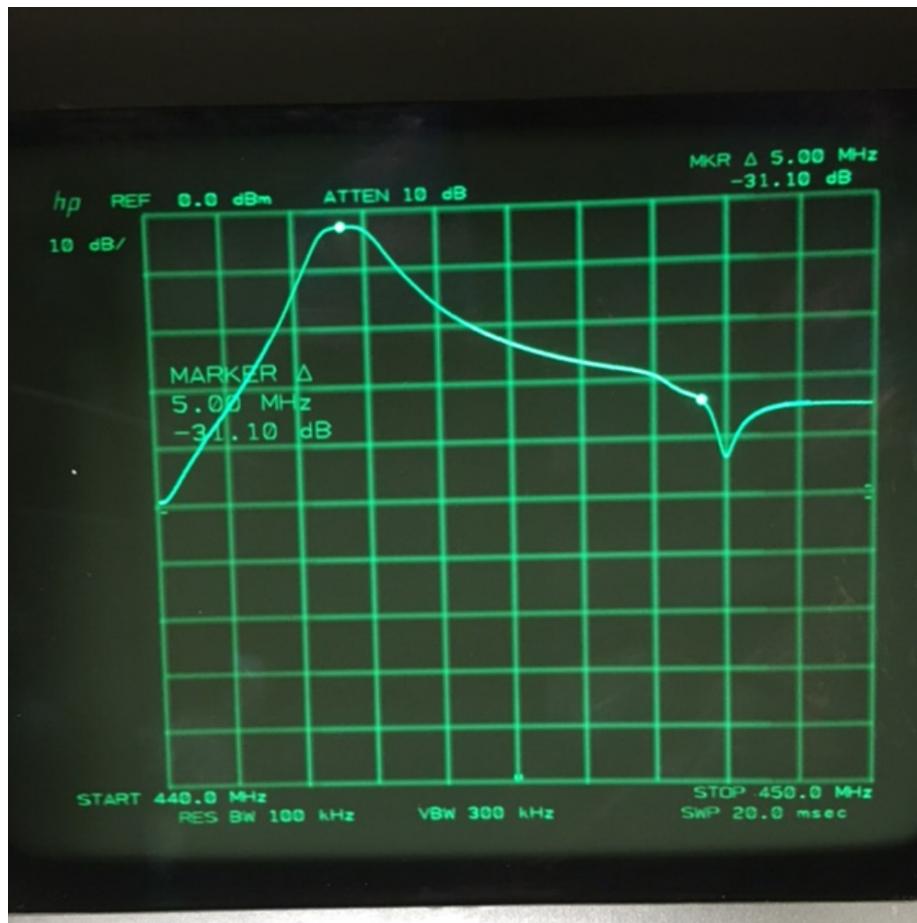




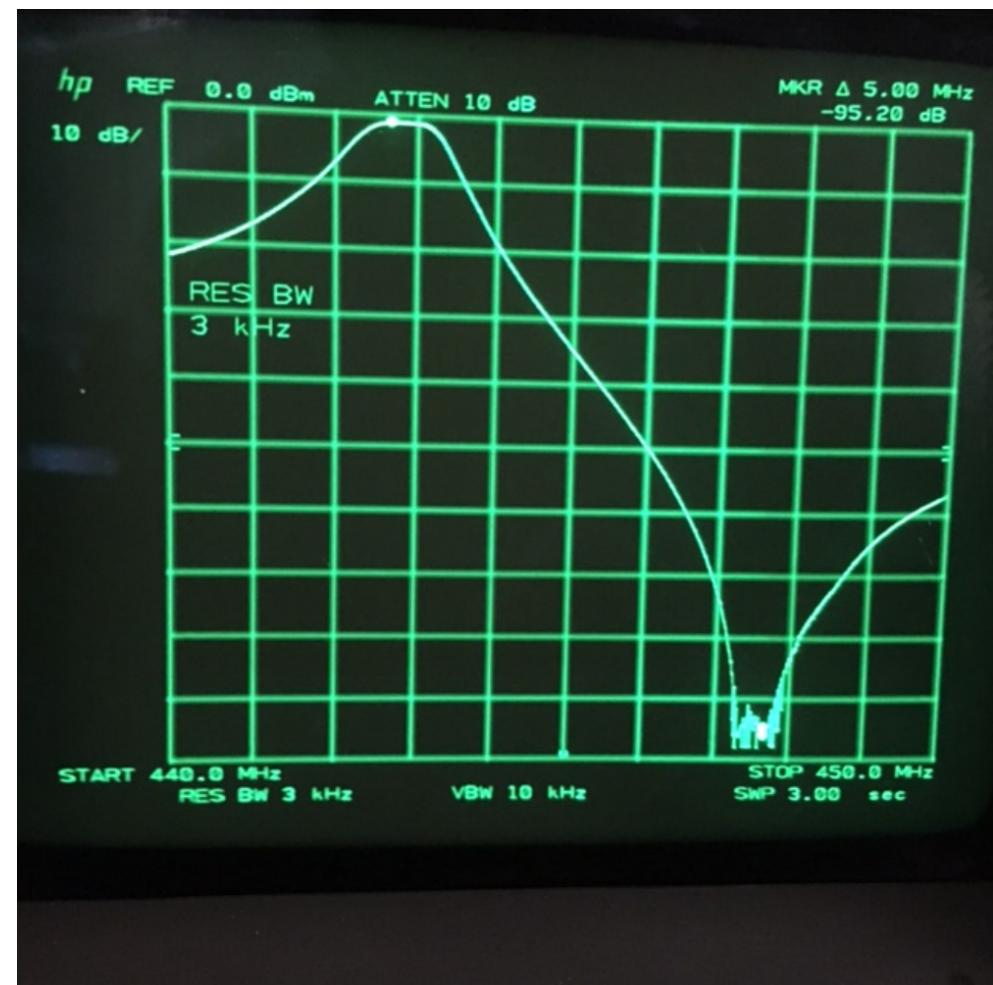
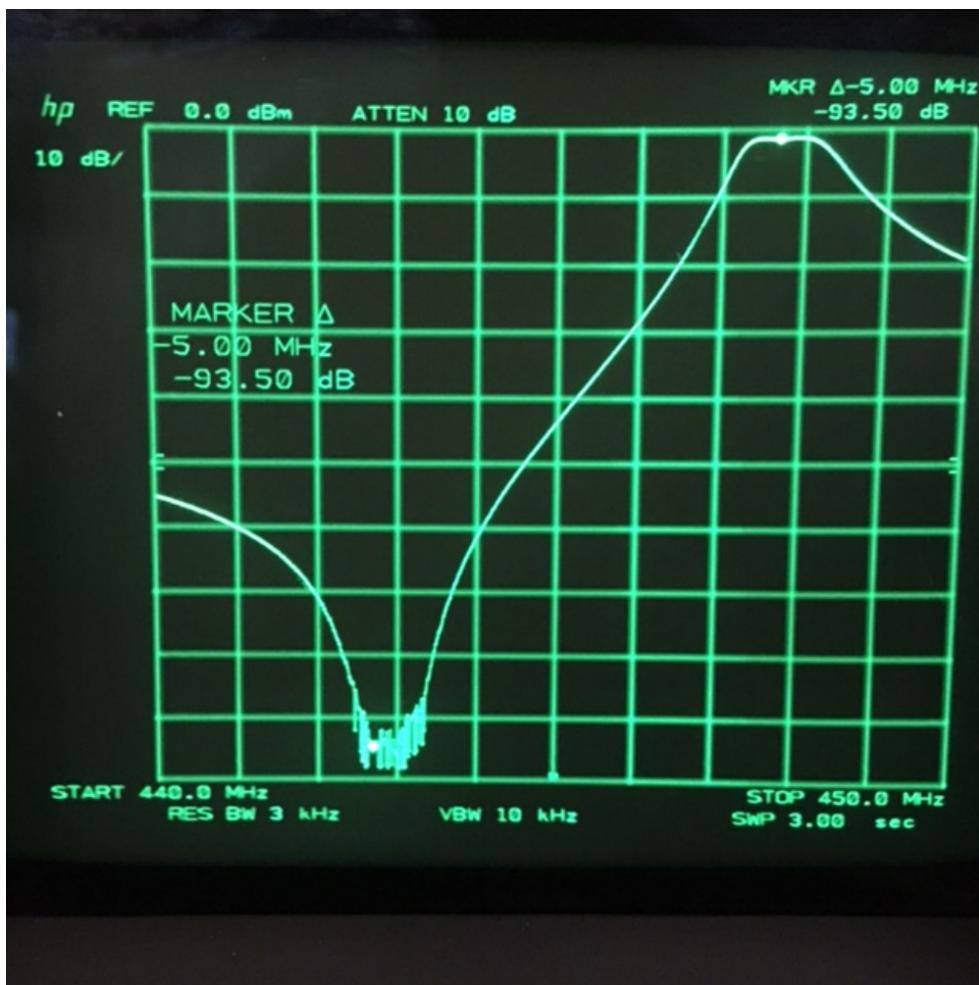


# Root Cause Found

## T1500 Duplexer Bench Scan



# Improvement



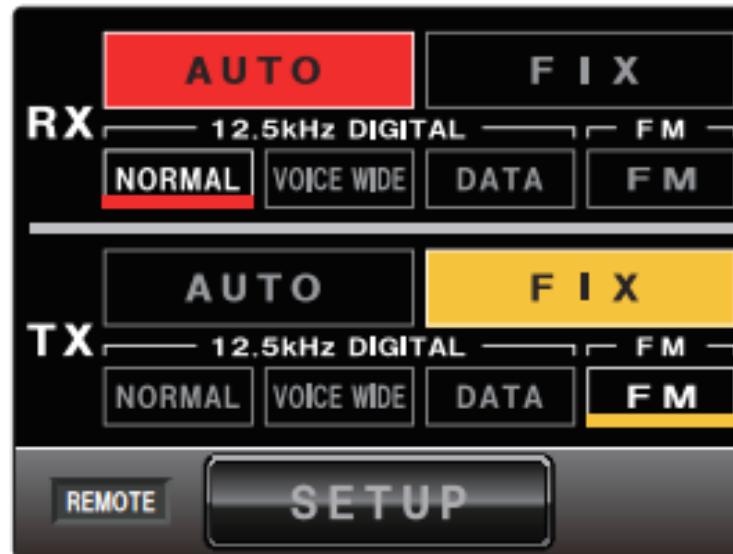
# Moving into ARES/RACES Hut

- Would like to do this ASAP
- Antenna Mounting bracket being made
- Big job, need WX to cooperate & plan to be safe
  - Team to meet prior to review tasks/duties
- Will need UHF capable stations to be available afternoon of installation for signal reports
- Run new feed line up tower
- Move/mount Scala on tower
- Secure feed line into hut
- Move repeater and Duplexer
- Connect to power supply
  - Verify power controller
- RF Interconnects and Lightning arrestor
- Measure performance
- Enable C4FM AMS mode

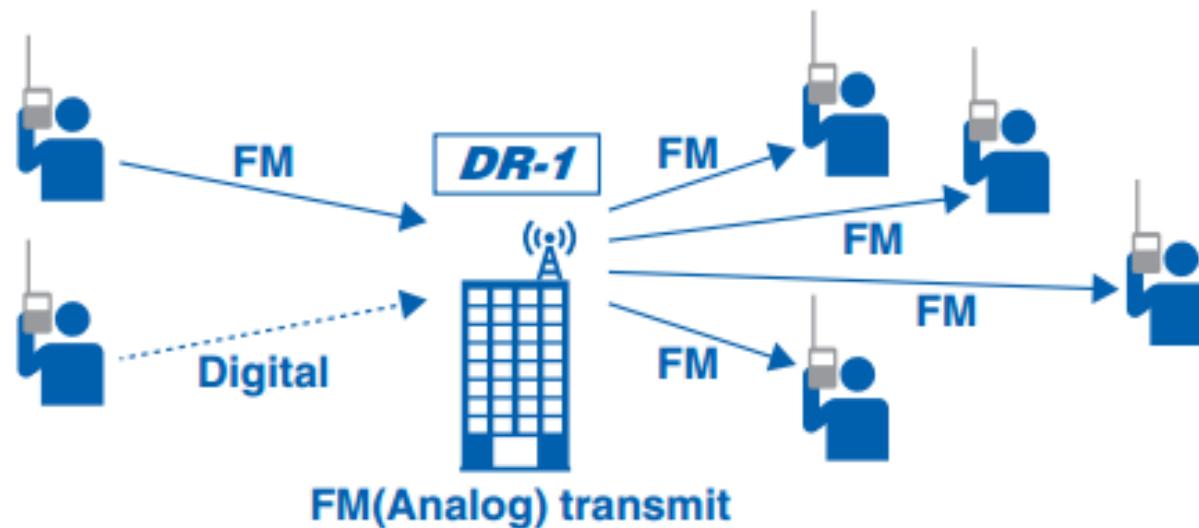
# Let's Talk C4FM Digital

- Continuous 4level Frequency Modulation
  - A type of 4 level FSK
  - Similar to Phase 1 P25 (not compatible)
- Automatic Mode Selection (**AMS**)
  - **FM Analog Fixed mode**  
(current config)
  - **AMS Rx, FM Tx**
    - a) FM Analog to FM Analog
    - b) C4FM Digital to FM Analog (no digital info transfer)
  - **AMS Rx, AMS Tx**
    - a) FM Analog to FM Analog
    - b) C4FM Digital to C4FM Digital
  - Out of the Box, C4FM is not compatible w/ D-Star or other Digital modes
    - w/ hardware and internet we can interface with other systems
  - C4FM digital info; GPS, Callsign, images
  - C4FM provides high quality audio w/ error correcting
    - High quality audio or
    - Data transmission mode
  - Images via C4FM with appropriate equipment.

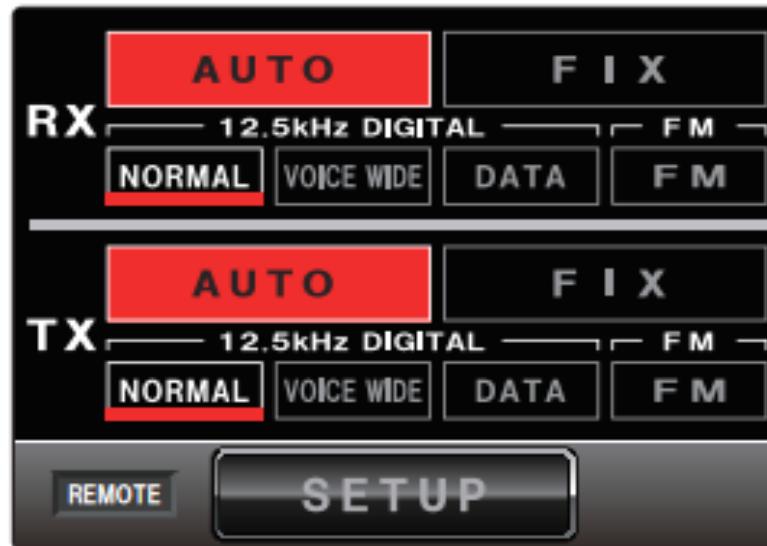
# AMS FM Tx Mode



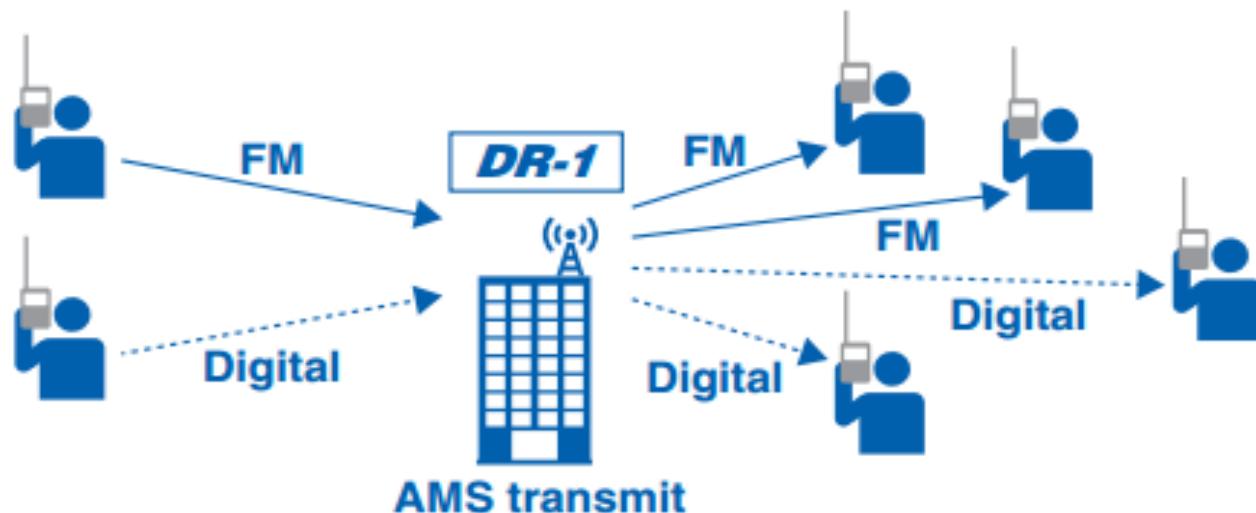
AMS receive → FM transmit



# AMS Tx Mode



AMS receive → AMS transmit



# **W7YRC UHF Repeater Configuration**

- Full AMS mode enabled
  - C4FM ==> C4FM, digital to digital
  - FM Analog ==> FM Analog
- FM Analog, looking for 100.0 PL on Receiver
- FM Analog, sends 100.0 PL from Transmitter
- There is no priority, digital vs analog

# Analog FM Users

- Remember to enable RX CTCSS T-SQL to prevent squelch opening during C4FM transmissions
  - RX T-SQL: 100.0 Hz PL same as TX
- Failure to use RX T-SQL you will hear digital burst opening your squelch during digital coms
- Continue to use TX CTCSS PL Tone 100.0 Hz
- Double check S-Meter before TX as digital coms may be underway and your squelch will not be open

# Yaesu Digital Users

- Read up on capabilities of your rig; **AMS Mode**
  - **DN** mode: Digital Audio w/ error correction
  - **VW** mode: Digital Audio, Full 12.5Khz BW high qual
  - **DW** mode: High Speed Data coms, auto for video
  - **FM** mode: Analog FM mode, if your digital cuts out, fall back
- **AMS Auto Tx** mode allows you to answer in mode last received
  - Useful when there's analog users mixed in with digital users
  - You can override and force your Tx to only be sent digitally however leaving in Auto Tx mode will help include analog only users into coms/nets.
  - Experimentation to gain experience needed
- Full C4FM mode should exchange GPS coords as well as call sign information.

# Futures

- Performance Mapping
  - Radio Model, SPLAT
  - Actual Field Measurements
- Add Telemetry via embedded system based controller
- D-Star / AllStar interfaces
  - Perhaps IRLP if there is desire.
  - Wires-X to C4FM
- Dependent upon Internet Access to Mt.
  - High Speed Mesh Network?
- Maintenance Visits
  - Antenna, Power and Duplexer checking
- Build inventory of VHF / UHF gear as spares / deployments
- Deploy Spare Fusion repeater for 2<sup>nd</sup> C4FM repeater, somewhere...

# Closing

- ✓ Remember to turn on RX T-SQL when we turn on C4FM
- ✓ C4FM capable rigs please give it a try; use AMS
- ✓ Send us your feedback, suggestions, recommendations / requests.

Email: [no1d.doug@gmail.com](mailto:no1d.doug@gmail.com)

*or find me on Mt. Union 447.65/442.65*

73, thanks, ***W7YRC Repeater Committee***