Intro to Amateur Microwave Radio

"DXing on the One Inch Band" Mike Lavelle, K6ML

Intro to Amateur Microwave Radio
"DXing on the One Inch Band"

Mike Lavelle, K6ML

- WN2ZHL, 1967-68
- WB2ECU, 1968-83

- *USAF, 1973-78*
- *Silicon Valley, 1978-2009*

- AF6TX, 2009-11
- K6ML, 2011…

- NCDXC
- 50 MHz and Up Group

Why Amateur Microwave?

- New bands (be the second op to earn WAB!)
- Familiar *and* strange propagation
- Cool dish antennas
- Homebrewing
- Extra points in VHF/UHF Contests
- 10 GHz and Up Contest
- Experiment with new modes (ATV, digital, wideband)
- Spectrum: Use It or Lose It!

Our Microwave Ham Bands

- *Yes, there is life above the 440 MHz band!*
- 33cm: 902-928 MHz (26 MHz)
- 23cm: 1240-1300 MHz (60 MHz)
- 13cm: 2300-2310, 2390-2450 MHz (70 MHz)
- 9 cm: 3300-3500 MHz (200 MHz)
- 6 cm: 5650-5925 MHz (275 MHz)
- 3 cm(1”): 10.0-10.5 GHz (500 MHz)

Wait!!! There's More!!!

- 12 mm: 24.0-24.25 GHz (250 MHz)
- 6 mm: 47.0-47.2 GHz (200 MHz)
- 4 mm: 76-81 GHz (5 GHz)
- 2.4 mm: 122.25-123 GHz (750 MHz)
- 2.2 mm: 134-141 GHz (7 GHz)
- 1.2 mm: 241-250 GHz (9 GHz)
- All above 275 GHz ("to infinity and beyond!")

Operating Modes

- Wideband
  - WBFM
  - ATV
  - Digital
- Narrowband
  - CW
  - SSB
  - FM
  - JT65, other narrowband digital
- Light beams
  - LASER
  - LED

Propagation Modes

- First of All… Forget About the Ionosphere!
  - Ionosphere is transparent to microwaves
  - Microwaves just continue into Outer Space
  - That's why Radio Astronomers listen to microwaves
- Line of Sight (to Radio Horizon)
  - 100' high = 15 miles
  - Canada College = 40 miles
  - Mt Diablo = 85 miles
  - Frazier Peak = 125 miles
- Edge Refraction & Reflections
  - Mountains, ridges, other land masses
  - Towers, other structures

More Propagation Modes

- Tropo Enhancement
  - Inversion Layer Ducting
  - Over Water (Baja, Hawaii??)
- Tropo Scatter
  - Ice crystals, particles
- Rain Scatter
  - Raindrops are a fraction of a wavelength (doppler; WX radar)
- Aircraft Scatter
  - Forward scatter along body & path (doppler; radar again)
- EME (“moonbounce”)
  - The ultimate weak signal DX (doppler; libration spreading)

QSOs in the Wide Open Spaces

- Just like lower bands, two stations need the same …
  - –Time
  - –Direction
  - –Frequency
- … all at once
- Direction and Frequency are a bit more difficult than low bands.

Time: When will the QSO Be?

- Coordination
  - Skeds, Activity Days, Contests
  - Liaison by repeater systems (or direct VHF): agree time, freq
  - Station A sends a carrier, B looks for A, B peaks on A
  - B tells A to “reverse”
  - Station B sends carrier, A looks for B, A peaks on B
  - Have a QSO
  - Run other bands

Direction: Which Way to the QSO?

- ***Need to be within 4 degrees for typical 18" dish on 10 GHz***
- Azimuth Calibration
  - Compass & Landmarks
  - Beacons at known locations:
    - Mt Allison (Sunol), Mt Thayer (Leeson), Mt Vaca, Frazier Peak, various SoCal (LA, SD)
  - Stations at known locations (last QSO, home QTHs)
- Azimuth Aiming
  - Grid Subsquares (**Lat** & **Lon**: **CM87xg**) from sked/liason
  - Bearing/Distance Apps (my grid, your grid ➔ direct bearing to you)
- Oh, yeah … don't forget Elevation **also must be within 4 degrees!**
- Peak on CW carriers, but also …
  - Look for "bounces" … not always the direct path
  - Scatter: Rain, Aircraft, Ridges, Structures, Peaks
  - Work the angles like a pool shark ☺

Frequency: Where on the Dial?

- Narrowband (SSB, CW, NBFM)
  - Calling frequencies (10368.100)
  - Operating frequencies (10368.000 – 10368.200)
- Calibration:
  - Beacons (10368.200 – 10368.400)
  - GPS, Rubidium standards
- Stability:
  - Wind & Temp, Battery voltage variations
  - On 20 meters, **1 ppm** is just **14 Hz** error, but at 10 GHz that's ***10 kHz*** error!
  - Double Ovenized Crystal Oscillator to get a few (or less) **ppb**
    - **Warmup time (leave it on)**
    - **High stability "SC" cut xtal**
  - Long term stability, repeatability

Low Density Operating

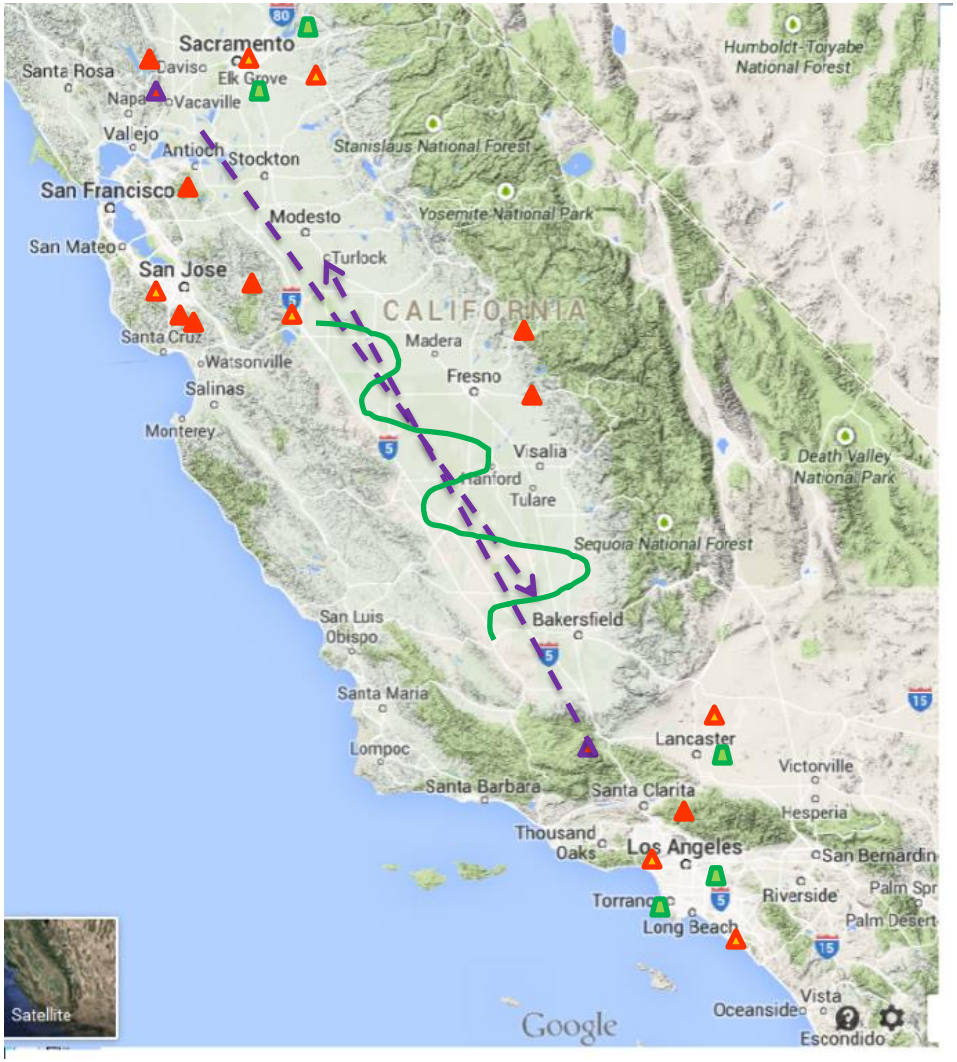
- Low population
  - Maybe 100 hams in CA on 10 GHz
  - Fewer on other bands
- Wide open spaces
  - Lots of MHz in each band
  - Many bands
- Narrow beams
  - 18” dish at 10 GHz has 4 degree beam width

- *A random “CQ” won’t work very often*

Creating Activity

- 1:1 Skeds (two ops)
- Microwave Activity Days (5-10 ops)
- Microwave Contests
  - Aug + Sep: 10 GHz and Up (over 50 ops in CA … da Big One!)
  - May: 2 GHz and Up
  - Jan, Jun, Aug?, Sep: VHF/UHF Contests (extra multipliers)
  - Oct: EME Contest
- Roving (100's of Q's)
  - Moving around produces more QSOs from the limited pool of operators
- Use FM Repeater Systems for Liaison
  - NC9RS (900), Cactus (440), other linked repeater systems
  - "Real time" skeds

Microwave Contesting



A Microwave Activity Day on steroids… more stations… longer DX… a chance to explore CA mountains and valleys… a road rally… car camping… competition.

10GHz & Up: Aug & Sep weekends
2 GHz & Up: May weekend
VHF: Jan, Jun, Sep weekends

Thanks to the tectonic plates, California's Central Valley (our playground) runs NW-SE, surrounded by mountains from Shasta to the Grapevine (and on to San Diego and Baja California).

Some folks pick a high spot for the day(s), others rove the valley (each move of >10 miles makes you a "new you").

Microwave scoring: distance + uniques
VHF scoring: grids x contacts

Roving and Mountain Topping

- Many of us don't have great microwave QTHs…
  - so we go a ramblin'
- Find a clear shot (no foliage, no blockage)
- Altitude is good, too
- Mobile, maybe even 4 wheel, or lug it up the hill
  - Quick setup, "rugged"
  - Battery, car or generator power

- *Let's look at a few rover stations and sites …*

Brian W6BY

Murphy Strikes

One of the hazards of rover operation is Mother Nature…
Here is the result when the wind blew W6BY's dish over.

Gary AD6FP

CM87UK Canada College

CM87VH Skyline Drive

CM97AV Mt Diablo

Andreas, N6NU

CM97AV Mt Diablo

CM97AV Mt Diablo

Dave, AF6KD

San Joaquin Valley

(NorCal Rover's Playground)

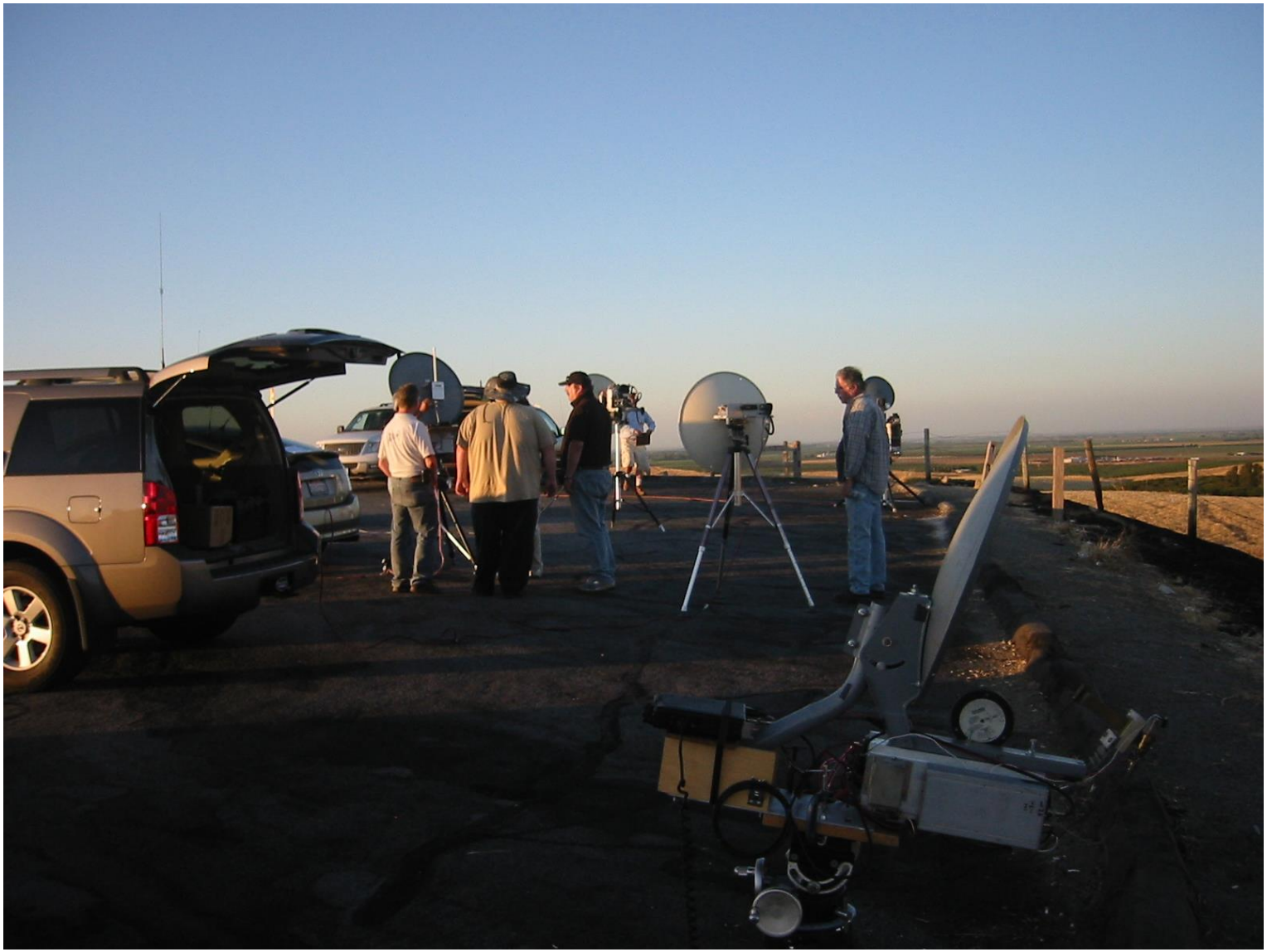
- **Altitude is nice, but** what's most important is …
  - a good "launch" (a bump on the flatland is OK)
  - and a "clear shot" (no foliage, obstructions)
- For example, an empty field
- Or the berms alongside an aqueduct
- Or a freeway rest stop parking vista…

CM97KH I-5 Vista

North of Los Banos / Santa Nella, 100 ft above I-5

CM97KH I-5 Vista

Three packs of rovers (~12 total) arrived for sunset



DM06BT West Fresno

KD6W, Joel, on top of a mound

Mountains Rim the Central Valley

Looking down on and across the Valley

- North:
  - Mt Shasta
  - Mt St Helena
  - Mt Vaca
  - Mt Diablo
- East: Sierras
- South: San Bernadino Mountains
  - Frazier Peak

DM88QQ Mt St Helena

DM04MS Frazier Peak

N to SJV; E to Hi Desert / Potosi; S to LA, SD, Mexico

Beyond the Central Valley

- East
  - High Desert
  - Las Vegas (Mt Potosi)
  - Arizona
- South
  - LA Basin
  - San Diego
  - Baja Mexico

Getting on the Air

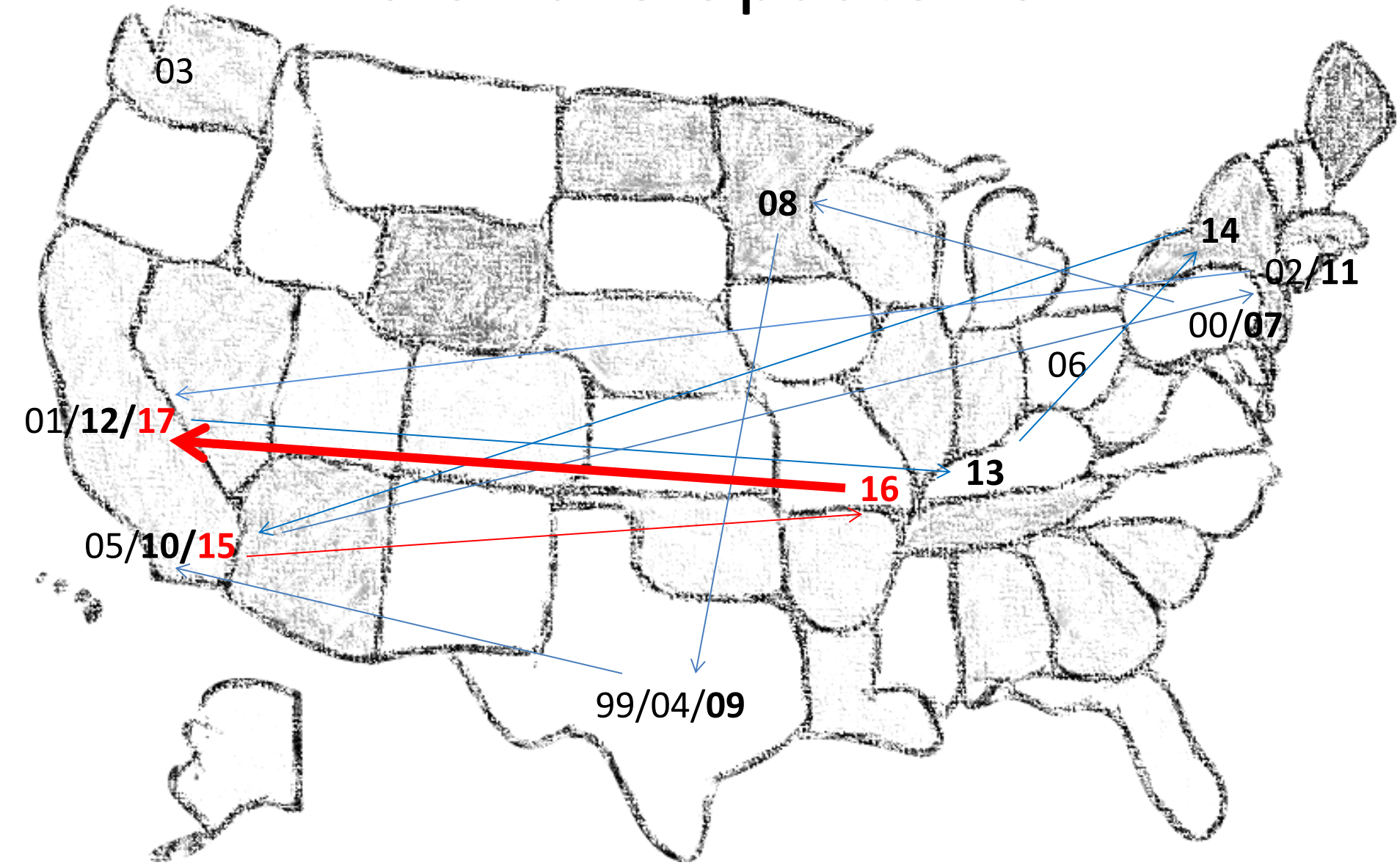
50 MHz and Up Group

- NorCal VHF/UHF/Microwave Club
- Microwave operation and construction
- Your friendly microwave “Elmers”
- Meets monthly at TI (NSC) Auditorium on Keifer Rd in Santa Clara
- Microwave Activity Days
- Club Projects
- www.50MhzAndUp.org

Tuneup Day at Canada College

- National Amateur Microwave Conference
  - 2106 (St Louis) is 31st year, moves around the country
  - Will be in Santa Clara in October 2017
  - International attendance
- Thurs: Tours and Hospitality Suite
- Fri/Sat: Technical Papers, Talks and Labs
- Sat Nite Banquet
- Fri/Sun: Swap Meets
- www.MicrowaveUpdate.org

Microwave Update 2017

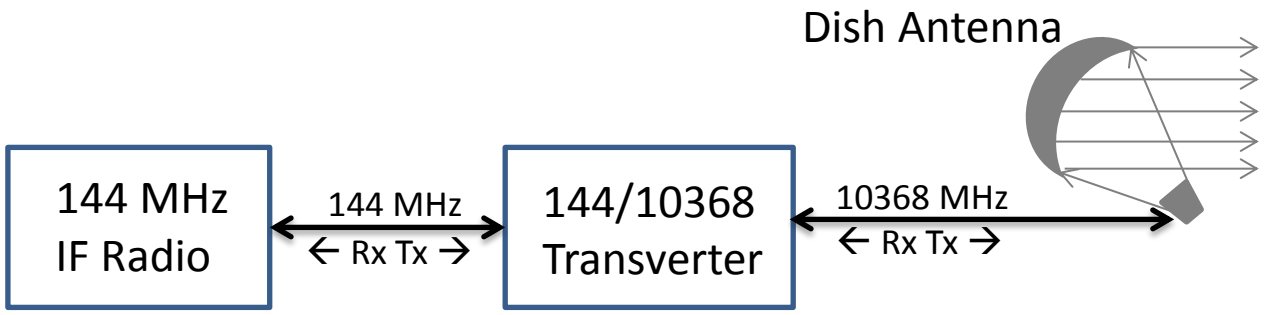


Some Print and Web Pointers

- QST “Microwavelengths” column
  - About every 3rd month in QST
  - Can download about 50-60 old columns from www.arrl.org QST archives
- www.w1ghz.org Paul Wade
  - Projects include QRP homebrew transverters
  - On Line Antenna Book: Dishes, Horns, etc
- www.wa1mba.org Tom Williams

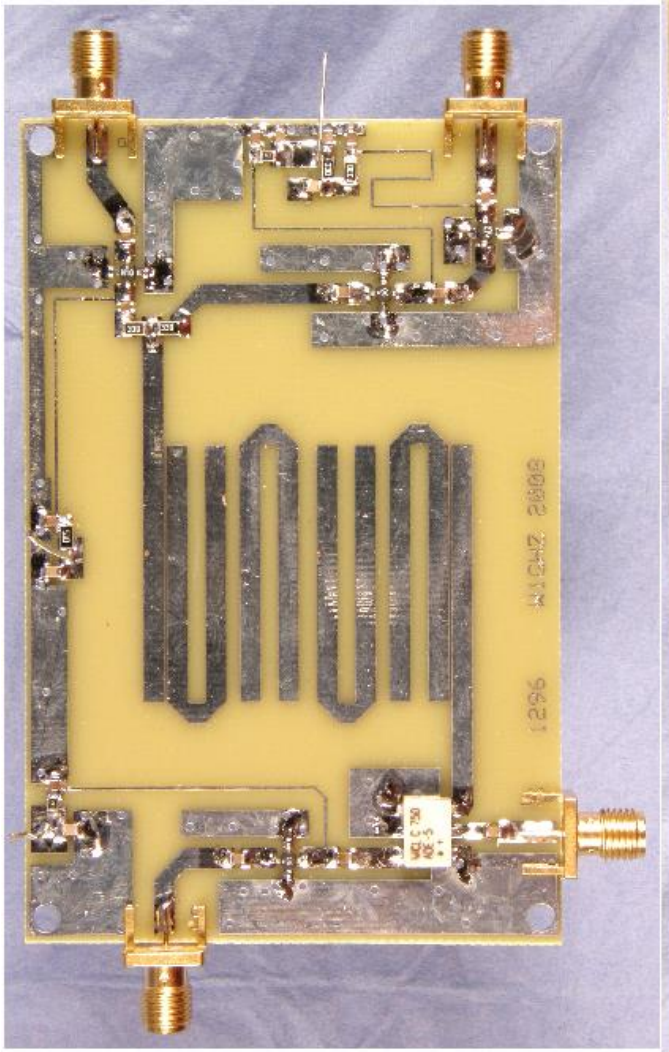
Rigs (SSB/CW/FM)

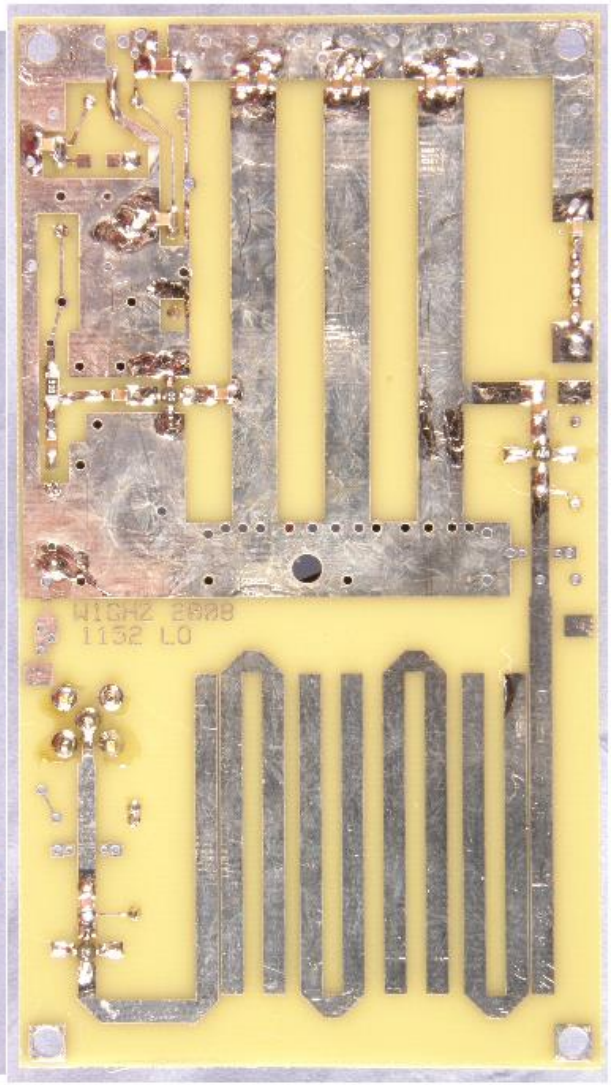
- IF Rig (144 or 432 multimode, example: FT-817)
- Transverter (144 MHz ⇔ 10 GHz)
  - Surplus conversion (microwave phone/data links)
  - PCB Kits (W1GHZ, DEMI, DB6NT)
  - Assembled & Tested (DEMI, DB6NT)
- Dish Antenna (modified satellite TV dish)



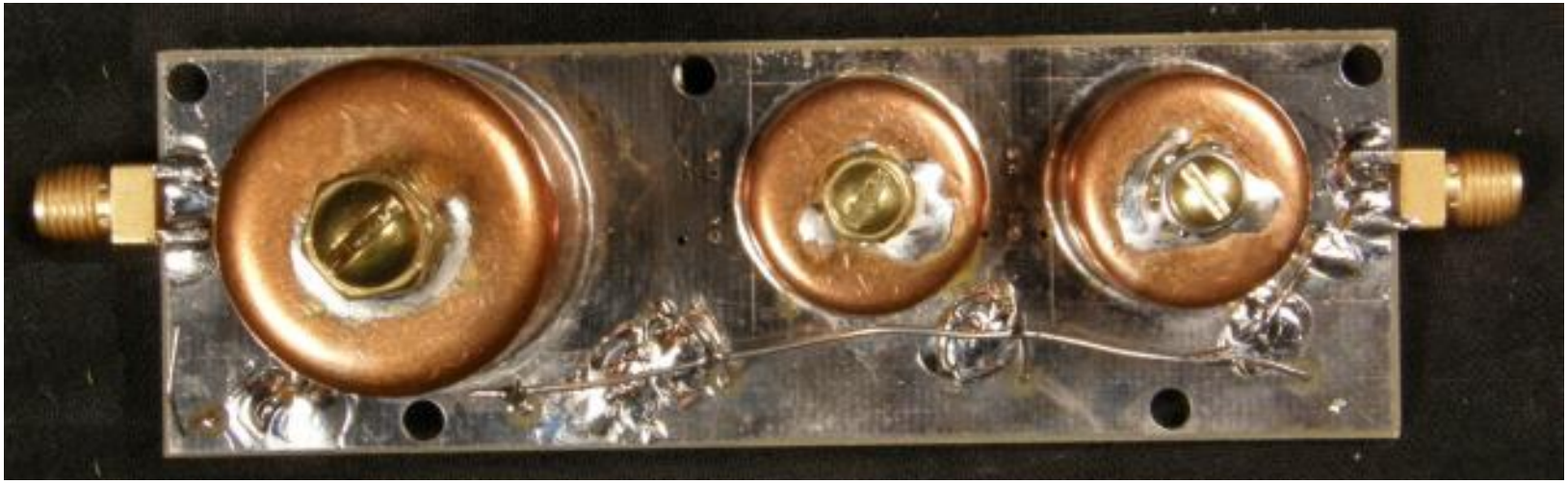
Some Technology

1296 Transverter, MMICs, Hairpin Filters, LO Board





“Pipe Cap” Cavity Filters

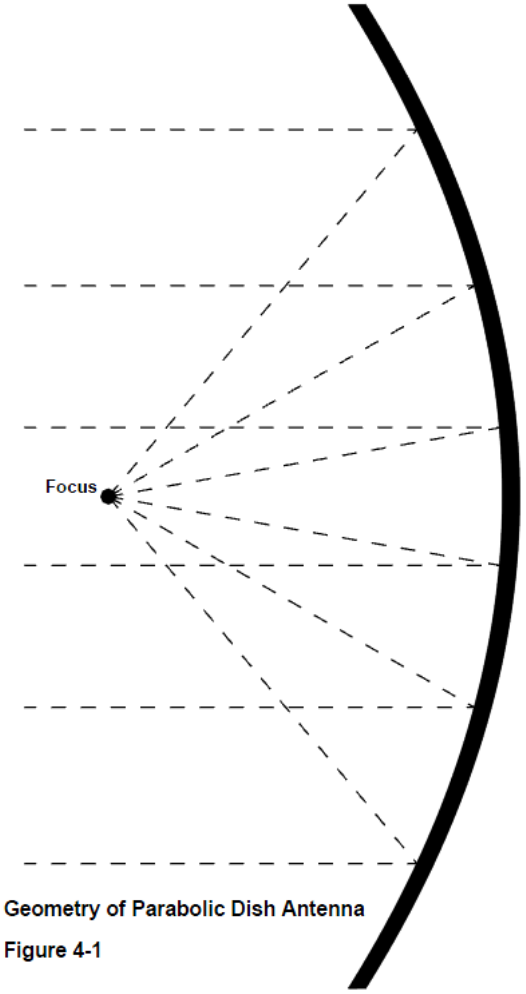


Antenna and Feed

- Antennas
  - Yagis to a few GHz
  - Dishes & horns from 1 GHz
    - Typical 18-20” Sat. TV dish: >30 dBi & 3-4 deg at 10 GHz
    - ~15 wavelengths (3 football fields at 20M, 100’ at 2M)
  - Slotted Waveguide Omni (mobile, beacons)
- Transmission lines
  - Coax gets lossy fast
    - Inches matter … minimize length
    - Use thin hardline, SMA
  - Waveguide

Horn Antennas

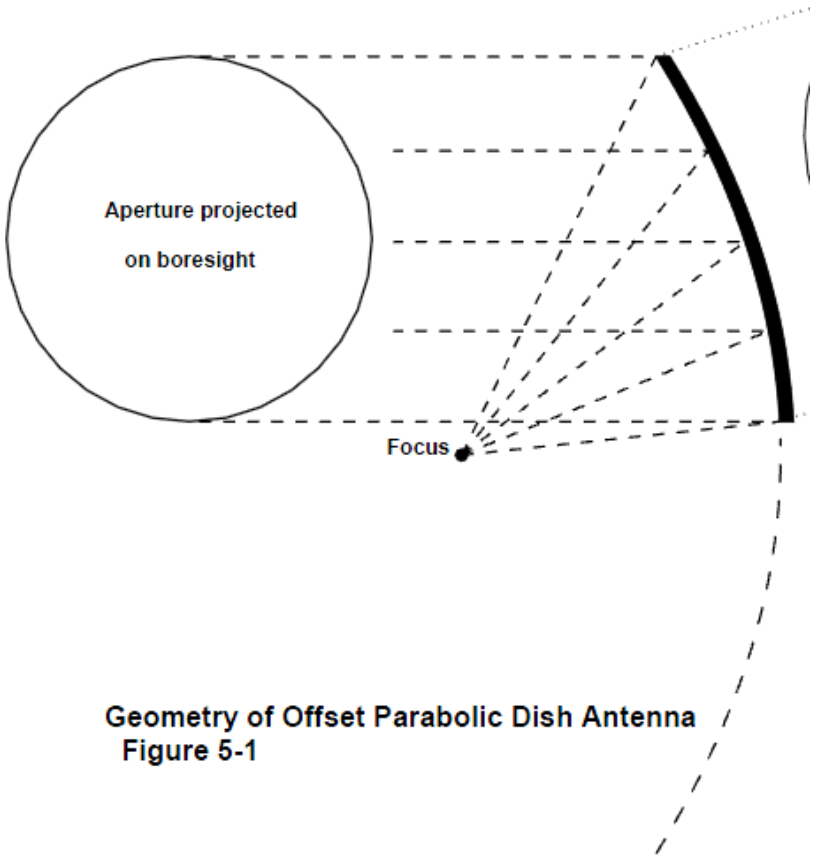
Parabolic Reflector



Geometry of Parabolic Dish Antenna

Figure 4-1

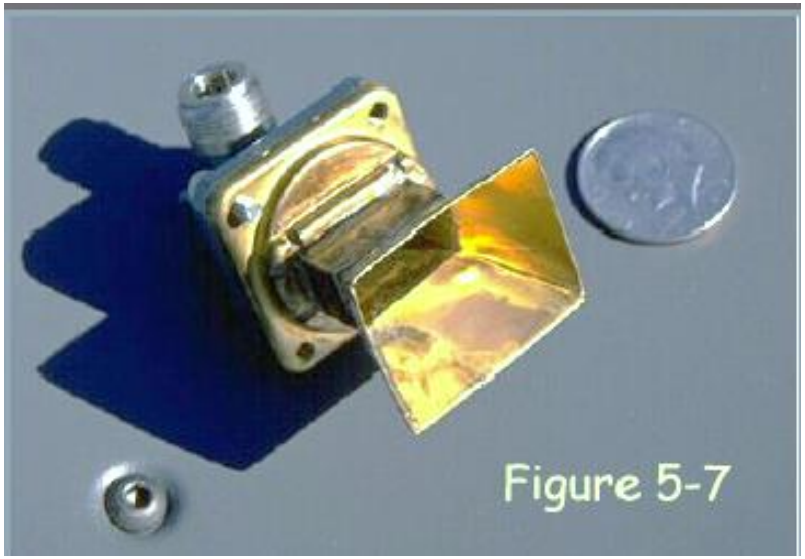
Offset Parabolic (Sat TV Dish)



Geometry of Offset Parabolic Dish Antenna
Figure 5-1

10 GHz Horn Feed

(W1GHZ)



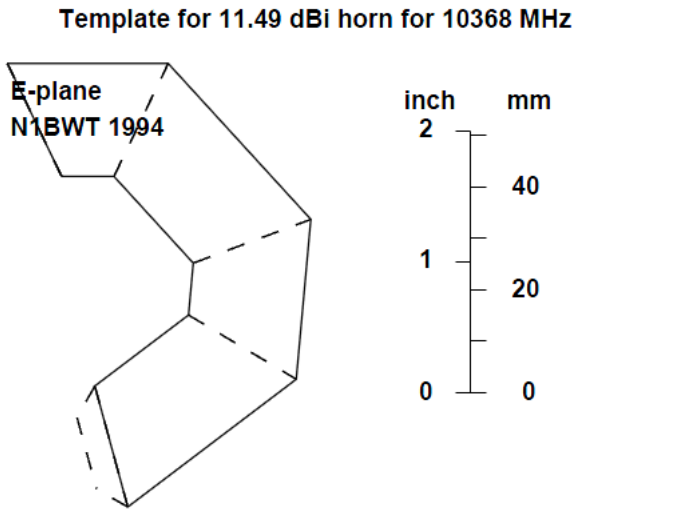
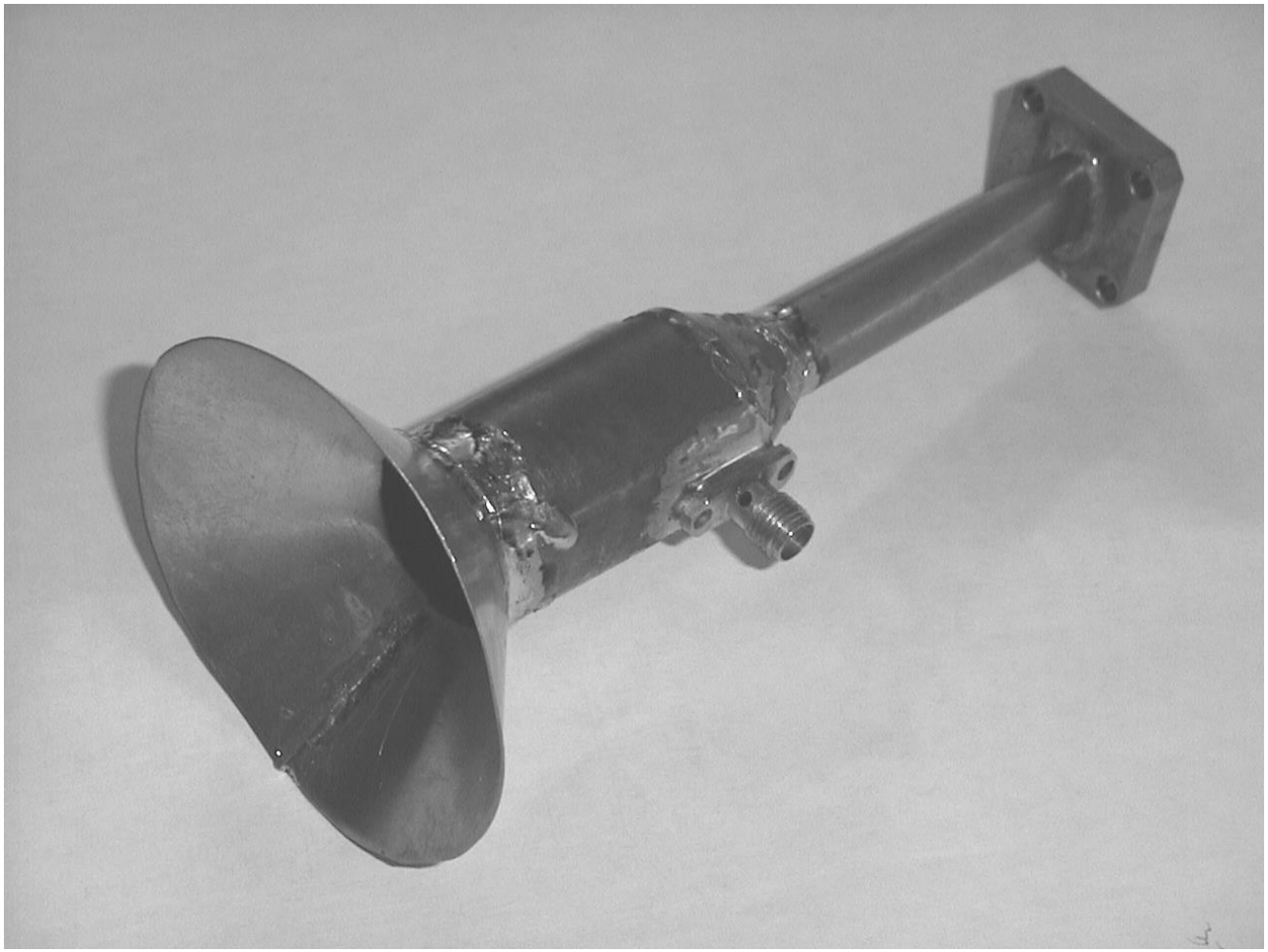


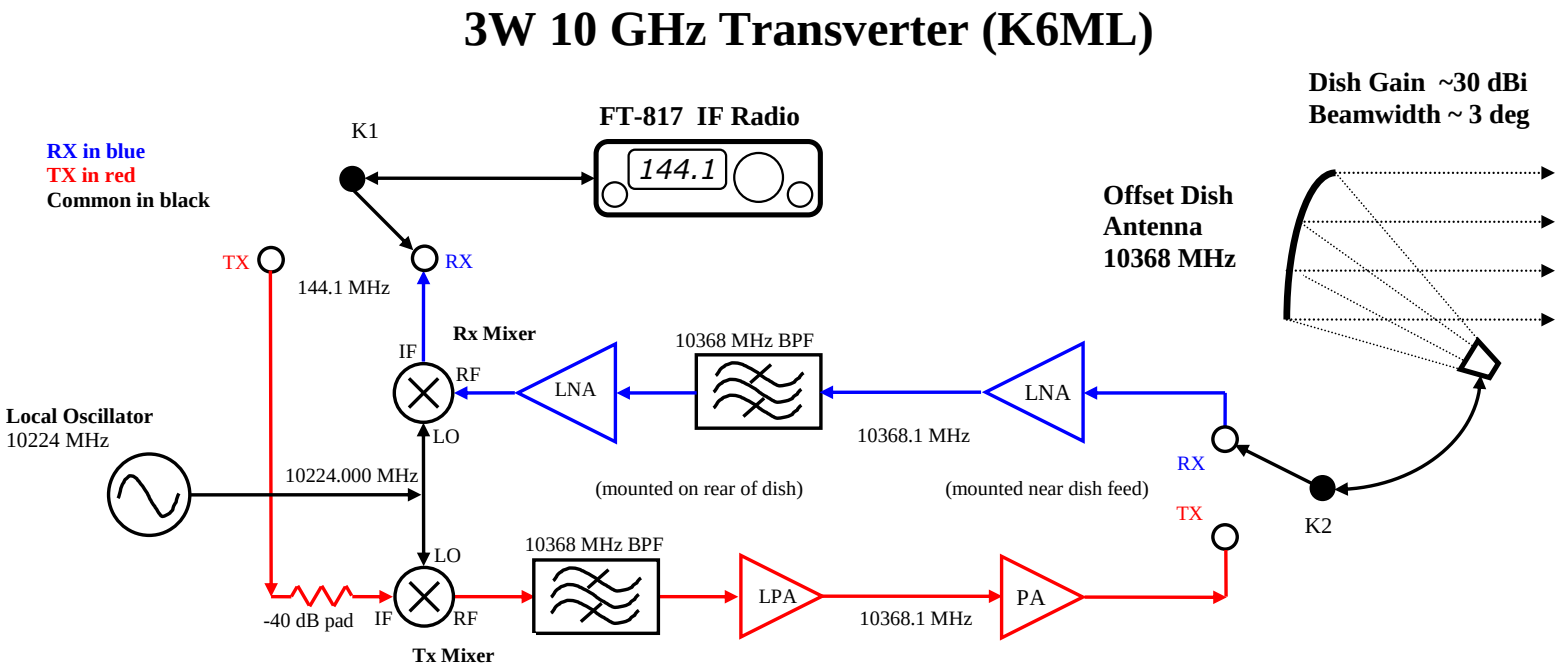
Figure 5-6. Feedhorn Template for RCA DSS Offset Dish (WR-90 Waveguide)

10 / 24 GHz Dual Band Horn Feed

(AD6FP and AA6IW)



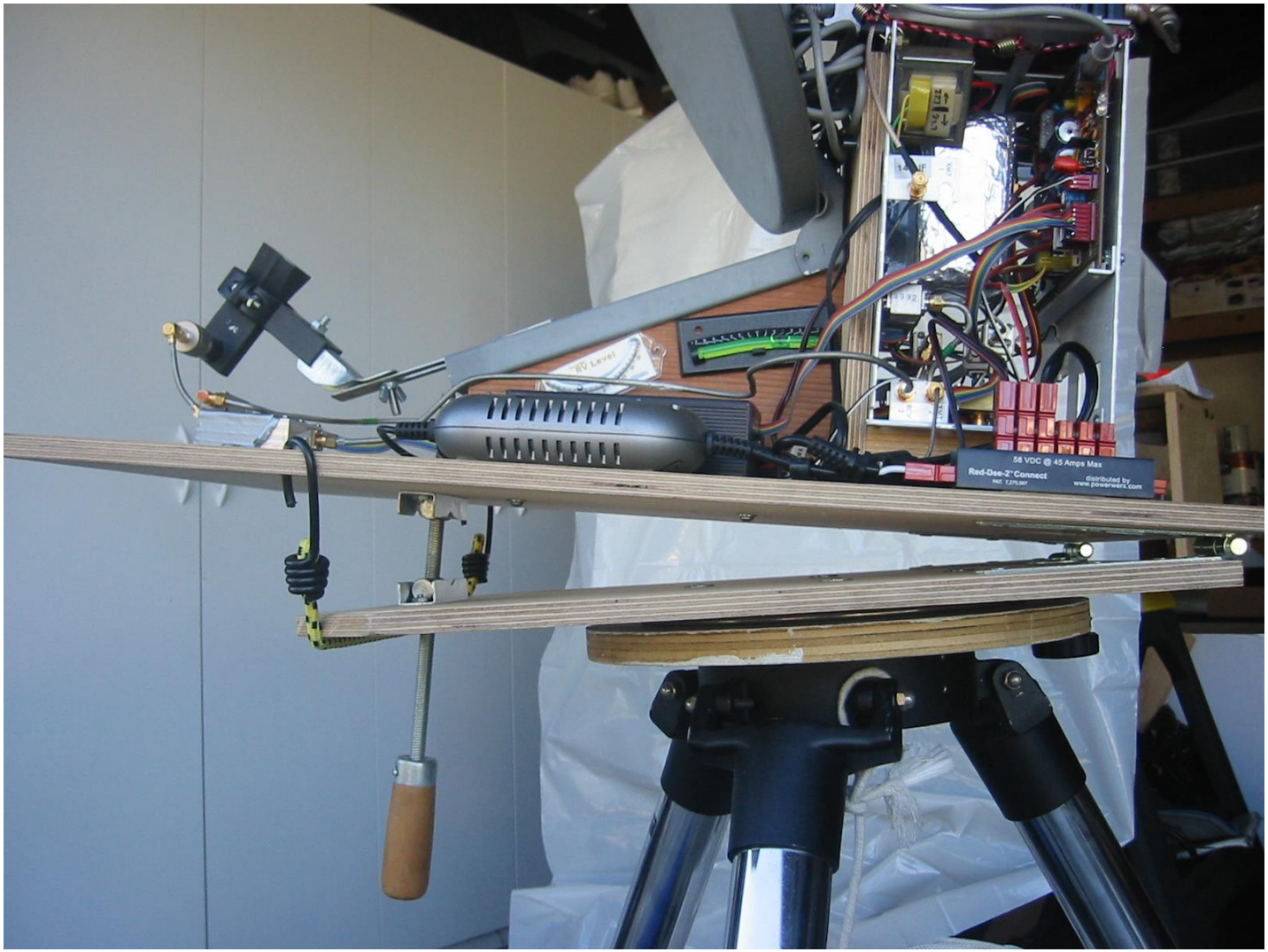
3 Watt 10 GHz Radio



Longest Range SSB Voice Contact using ~3W: ~320 miles (so far)

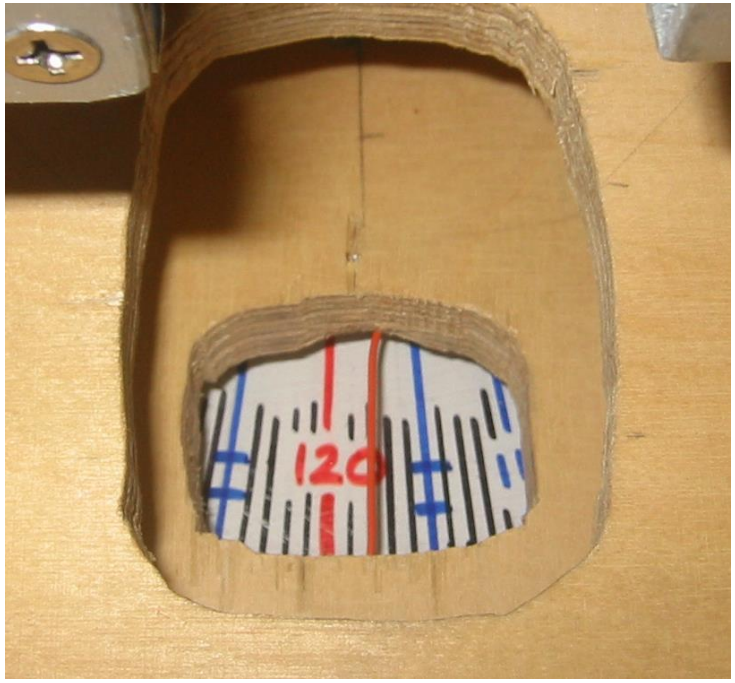
Tripod Mount

Wood Clamp Elevation Adjust; Lazy Susan “Armstrong” Rotation



Driver's Seat View

Azimuth scale, Transverter controls,
IF Radio, Key and Mic



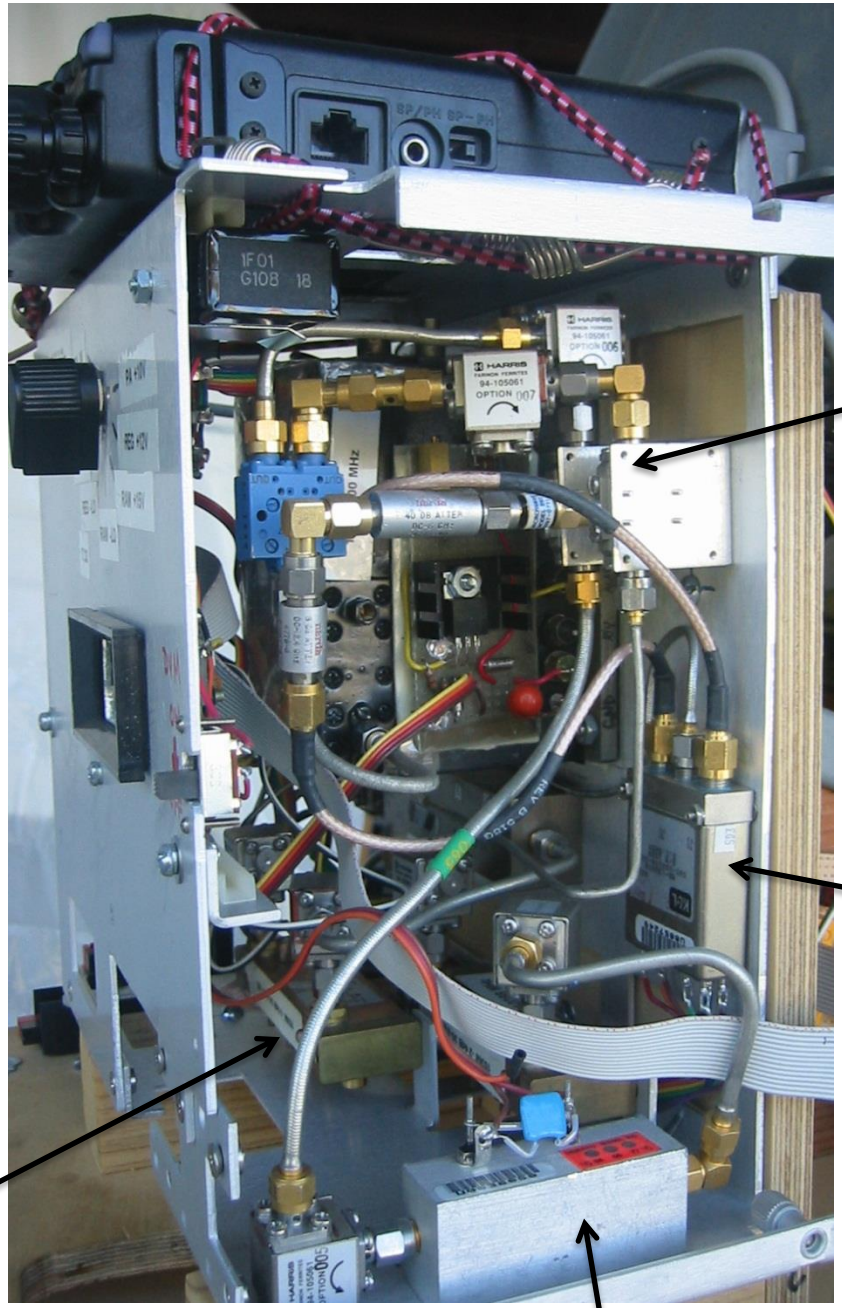
Azimuth Readout

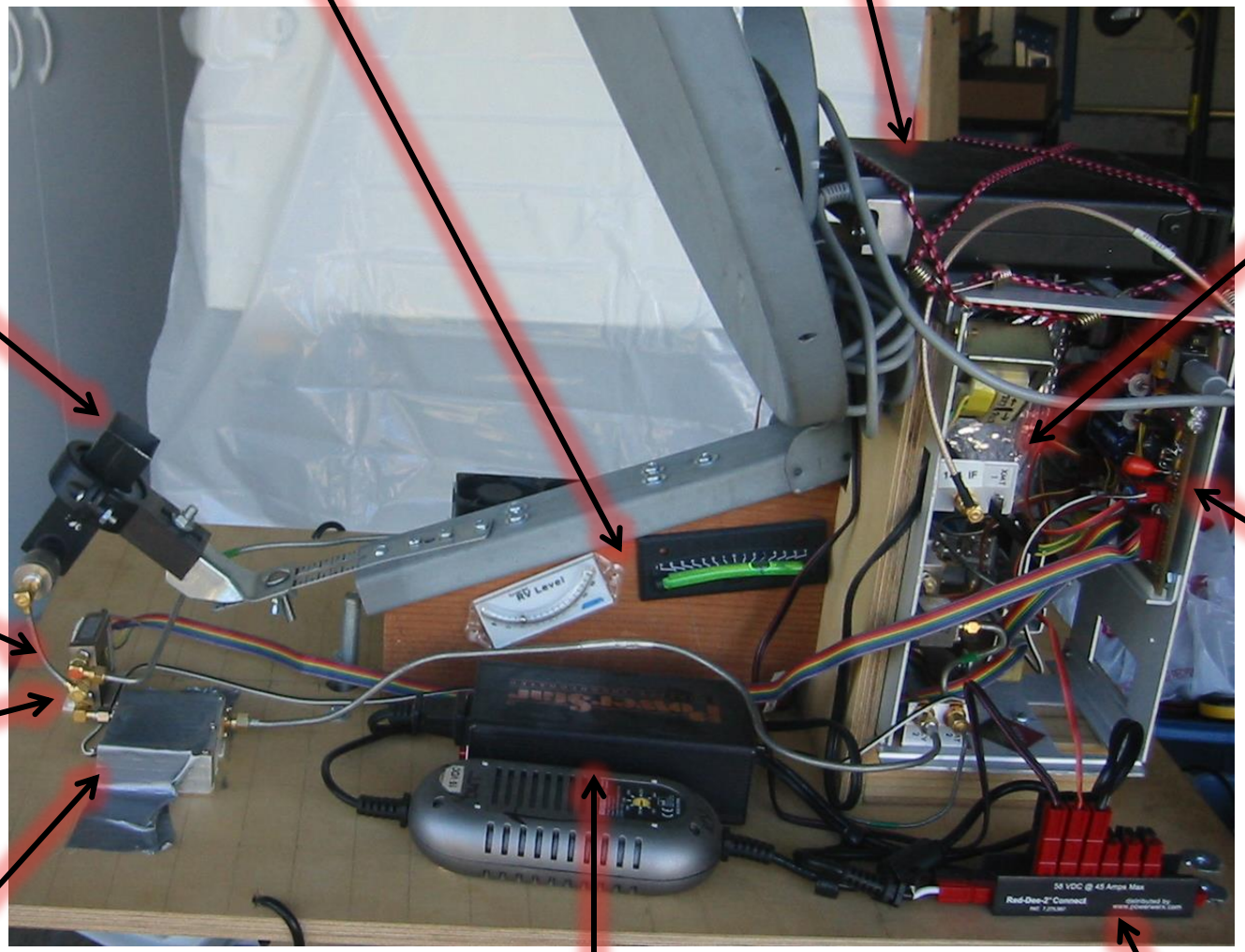
"Armstrong" Rotor = *Push To Turn* (PTT ☺)

Azimuth Clutch

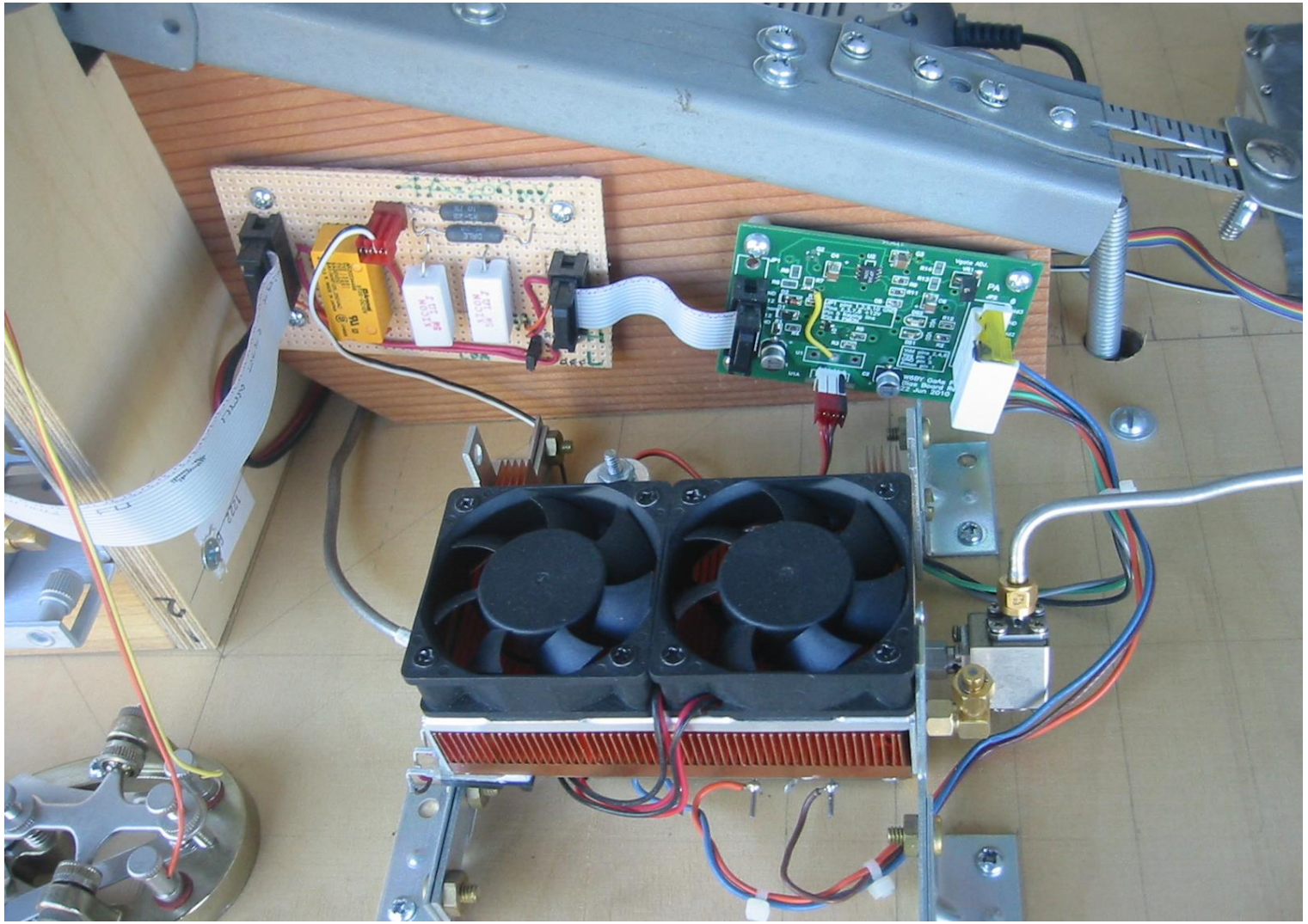
IF Radio and Transverter

DVM and Plumbing




RV BUBBLE LEVELS
2M IF RADIO
LO “BRICK”
FEEDHORN
at dish focus
Shortest
Possible
Coax
CONTROL
& POWER
T/R RELAY
LNA
12DC-110AC
12DC-15DC
12V POWER

More Power! 3W PA



CQ, CQ …

A few dB NF, 3W out,
20” dish:
30 dB gain,
3 degree beam width,
3 kW ERP

Personal best DX so far (SSB):
10 GHz from I-5 rest stop
N of Los Banos
to
Mt Potosi (Vegas)
and to
Mt Shasta,
each ~325 miles

FYI: W6 records are:
10 GHz 1460 km (875 mi)
24 Ghz 543 km (325 mi)

Contact Info & Current Events

- **50 MHz and Up Group**
  - NorCal VHF/UHF/Microwave Club
  - TI (NSC) Auditorium in Santa Clara, usually first Thursdays
- **10G and 10/24G builder's projects**
  - Beginners welcome
- Website: www.50MHzAndUp.org

  or Mike Lavelle, K6ML (email good in qrz.com)