Roadmap to 10 and 24 GHz

Mike Lavelle, K6ML and Jim Moss, N9JIM

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10 GHz Rover Rig Requirements

- Portable
  - Light weight
  - Quick single person setup
  - Mobile powered (12V car battery)
  - Toss it in the back of your car
- Multimode (SSB, CW, FM, …)
- 10 GHz is the “Entry Band”
- Stable, accurate frequency
- Stable, accurate, easy pointing (Az – El)
- Hundreds of kilometers range
- Fun to Use
- Upgradable to 10/24 rig?

10 / 24 GHz Rover Rig Requirements

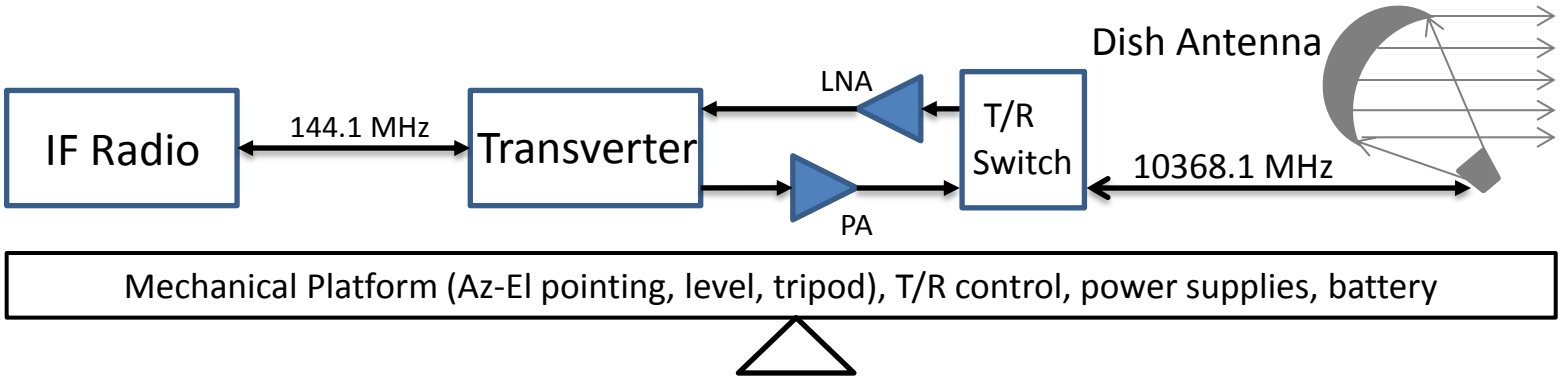
- ALL OF THE ABOVE !!!

- "Flip Switch" Multiband / crossband (10 and 24 GHz)
  - Stable, accurate, ***common*** frequency
  - Stable, accurate, easy, ***common*** pointing (Az – El)
    - Same dish size requires 2.4x more accurate & stable pointing
  - Crossband options for 24 GHz QSO setup
    - 24Tx/10Rx
    - 10Tx/24Rx

- Hundreds of kilometers range
- Fun to Use

Typical Rover Rig

- 2M multimode IF rig (eg, FT-817, other QRP transceivers)
- Transverter function: Tx attenuation, up/down conversion
- Transverter alternatives:
  - DB6NT (Kuhne Electronics) and DEMI (Down East Microwave) (assembled or kit)
  - Can build out of surplus modules (e.g., from Harris Farinon DVM-10 radios)
  - Or homebrew using more modern MMICs
  - For our time frame and for ease of entry, let's assume the first or second alternative

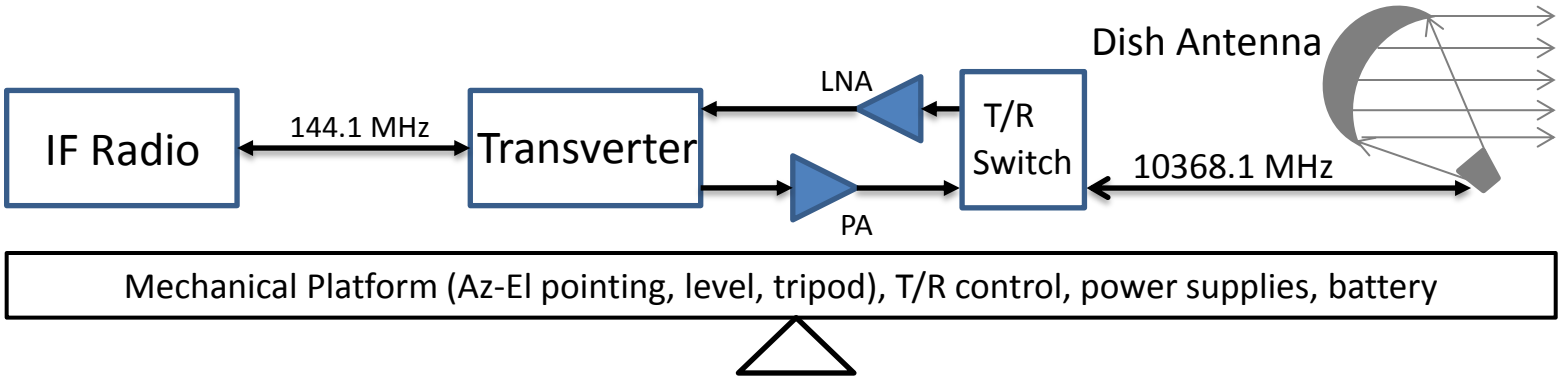


10 GHz Local Osc

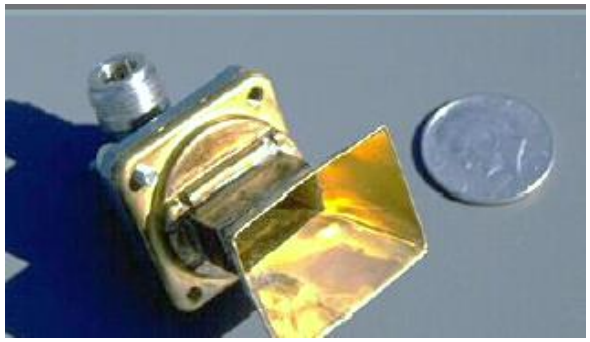
- Stable, accurate 10224 MHz Local Oscillator (inside transverter) is a key challenge
- Main Issue is stability (temperature and voltage drift)
- Accuracy and repeatability are valuable, too
  - It's really nice to be able to just dial in the frequency and then focus on pointing the dish
  - But you can get started by using beacons and fellow rovers as frequency standards
- Oh, yeah… we want decent phase noise, too… but don't obsess…
  - Reciprocal mixing can be a problem on mountaintops, not so much in the valley
- Some solutions:
  - LO is provided in DB6NT and DEMI rigs, but is often upgraded and/or locked by purchaser
  - Surplus 'brick' locks ~1700 MHz cavity osc to ~100 MHz xtal, multiplies that by 6 to 10224.
    Re-xtal, re-tune, regulate voltage (typ -20v supply) and improve thermal insulation.
    Can lock xtal to 10 MHz ref or do direct frequency synthesis (DFS) from 10 MHz ref.
  - Synthesizer at 1136 or 3408 (DEMI A32 or mod of the AA6IW/KK6MK 3600 synth),
    lock to 10 MHz ref, mult to 10224 (DEMI x9 chain, W1GHZ x9/x3 'beacon' (see below))

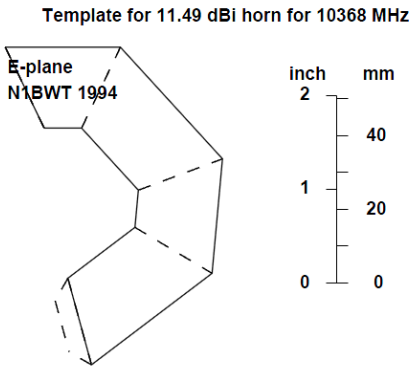
10 GHz Amps

- LNA
  - Terrestrial noise level plus min. feed loss is ~250 K
  - A few dB NF (~500 K) is OK for entry level (eg, Harris LNA)
  - 1 dB NF (~75 K) is better (many sources)
  - Feedline loss adds to system NF…
  - Place as close as possible to antenna to minimize loss
- PA
  - 250 mW entry level (eg, Harris LPA)
  - 2-8 W opens new doors (eg, Harris, Alcatel, Kuhne, DEMI)

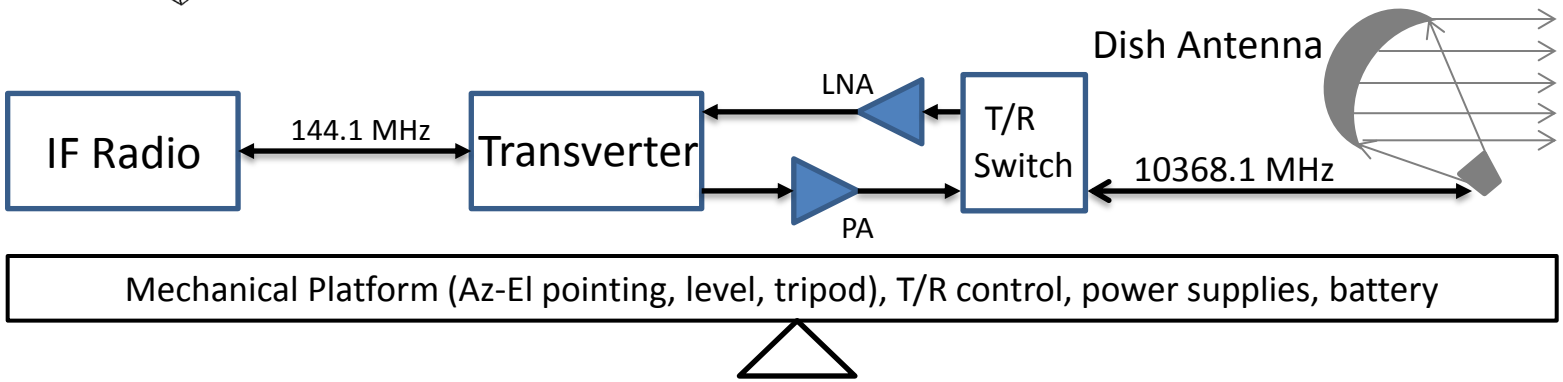


10 GHz Ant, T/R, Power



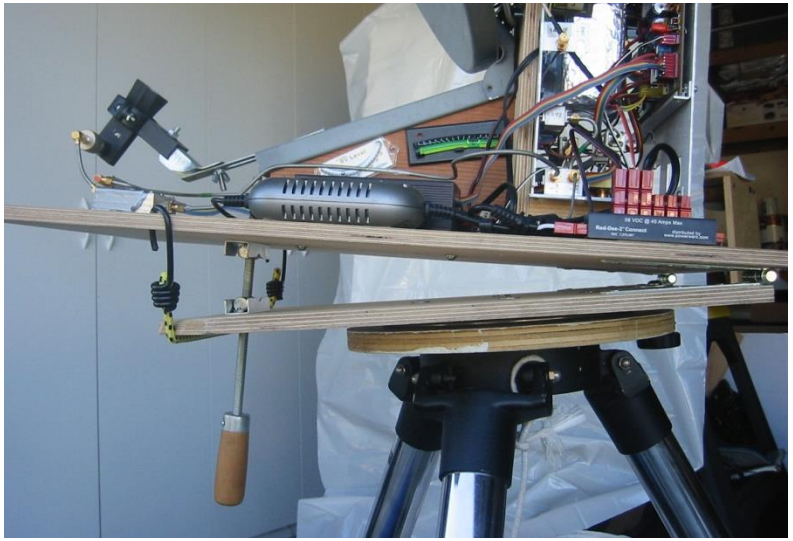


- Antenna
  - 18” offset feed satellite dish
  - Cheap/free, 3 lbs
  - 32 dBi, 4 degree beamwidth @ 10G
  - Homemade rectangular horn feed
  - Copper flashing cut per W1GHZ template, soldered to WG flange
- Antenna T/R switch
- T/R control/sequencing
- Power supplies (+12, +10, -5, -20, relays) from battery or AC inverter



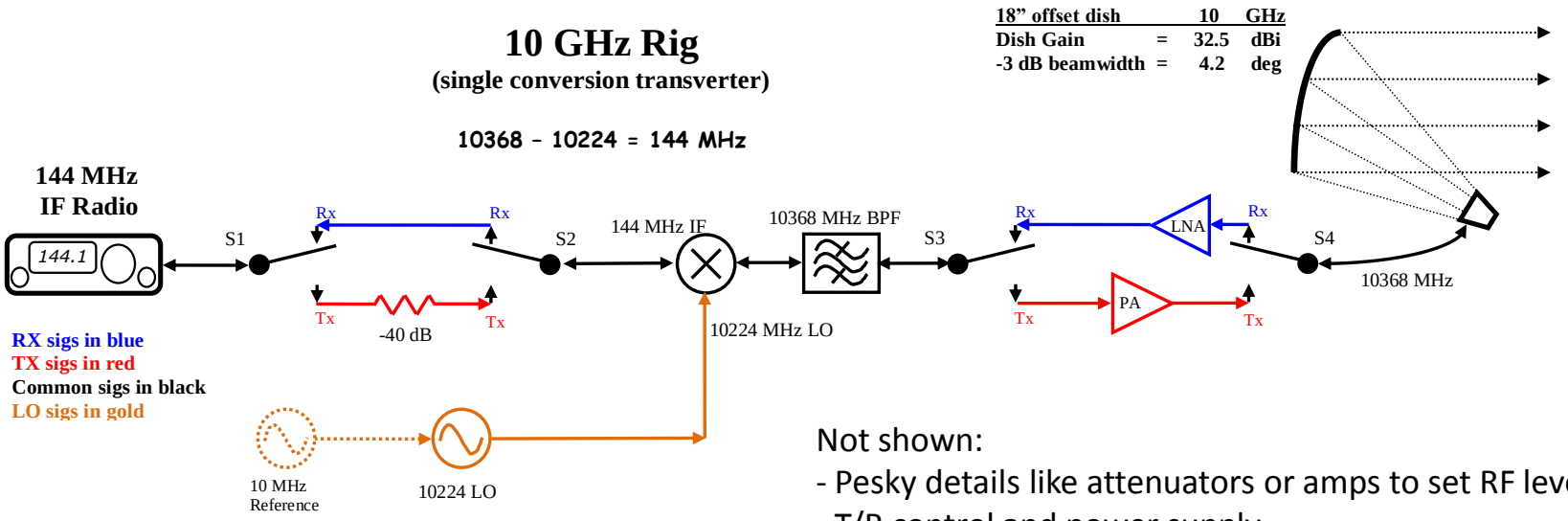
Rover Platform

- [LEFT PHOTO] Heavy Duty (Hercules) tripod
- [RIGHT PHOTO] Homemade Az-El mount on telescope tripod
- Don’t use a cheap 35mm camera tripod, unless you are desperate
- Leveling and pointing system (elevation & azimuth)
  - 1-2 degrees stable (dish acts like a sail in the wind)
  - Calibrated scales are really nice
  - Easy and quick to setup or stow (lightweight, modular, quick assembly at each rover stop)
  - Easy and quick to point (“Armstrong” rotor)
  - Carries load of antenna and (most or all of) rig



Mechanical Platform (Az-El pointing, level, tripod), T/R control, power supplies, battery

10 GHz Block Diagram



Not shown:
- Pesky details like attenuators or amps to set RF levels
- T/R control and power supply

Typical "surplus" design can use:

- DEMI TC kit for S1/atten/S2
- Surplus Mixer, filter, 250 mW PA and ~3 dB NF LNA from Harris DVM-10
- Surplus SMA relay for S4; SMA relay, circulator or splitter for S3
- Consider upgrading PA and LNA, but don't let that keep you from getting on the air
- LO alt #1: Retuned brick (new xtal)
  - Can get on the air without locking it, but do voltage reg and thermal insulation
  - Can be locked to 10 MHz using WA6CGR design or DFS from 10 MHz, or other
- LO alt #2: A32 (1136) or KK6MK (3408) synth plus W1GHZ "beacon" as x9 or x3 mult

T/R Sequencing Requirements

- Required Interlocks To Avoid Self Destruction
  - (Depletion mode devices) Gate Bias (-) before/after Drain Power (+)
  - (Power Amps) Power and Bias before/after RF input (from IF rig or driver stages)
  - (PA out, LNA in) PA to Ant before/after RF output

- Rx to Tx sequence (inhibit IF TX until end):
  PTT on>Ant TX, Gate Bias|>PA Drain|>enable IF TX

- Tx to Rx sequence (inhibit IF TX at beginning):
  PTT off>disable IF TX|>PA Drain|>Ant Rx, Gate Bias

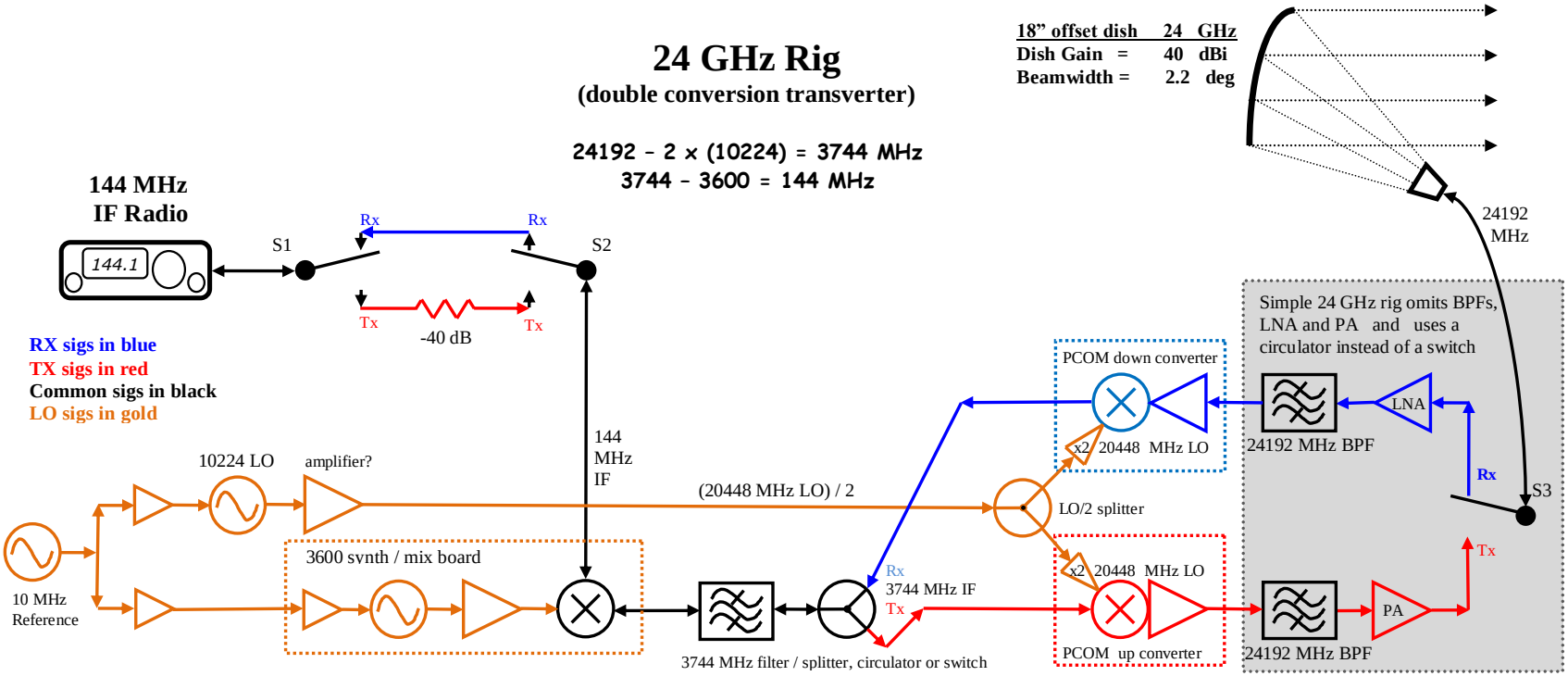
- Many solutions: relays, one shots, microcontrollers
  - Get advice from some one who has done it and lived to tell the tale

- Also make sure that:
  - Your IF rig TX inhibit method works w/o spikes
  - Your IF rig TX power out control doesn't have spikes

24 GHz

- Similar to 10 GHz, but double conversion transverter:
  24192 RF – 20448 LO = 3744 first IF (PCOM module mixer, amps)
  20448 = 2 * 10224 source (PCOM module internal 2x)
  3744 RF – 3600 LO = 144 second IF (“synth/mix” board)
- 10224 LO stability is even more important
- 3600 LO should be stable, too
- Locking to 10 MHz even more useful
- Could use smaller dish for same gain & beamwidth
- Simplest version uses barefoot PCOM up and down converters with a circulator for “T/R” coupling to antenna
- Upgraded version adds 24 GHz LNA (DB6NT, other?), Rx BPF
- Upgraded version adds 24 GHz PA (surplus, DB6NT, ?), Tx BPF and T/R switch (waveguide or SMA)

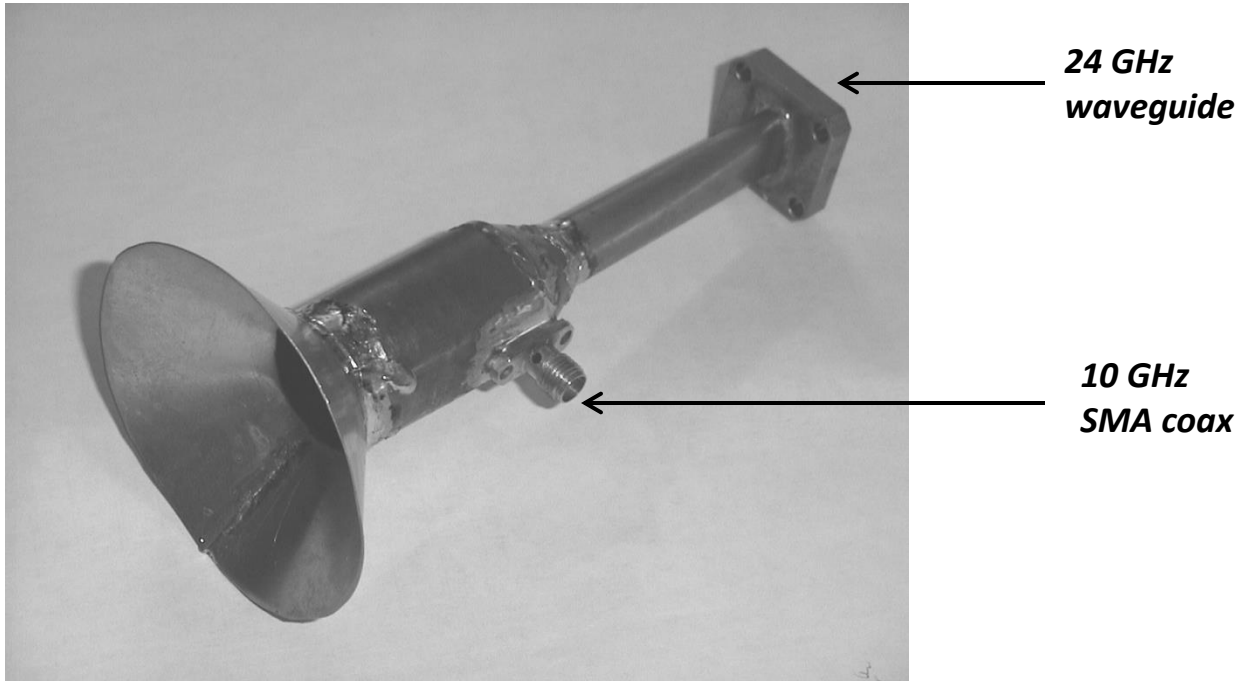
24 GHz Block Diagram



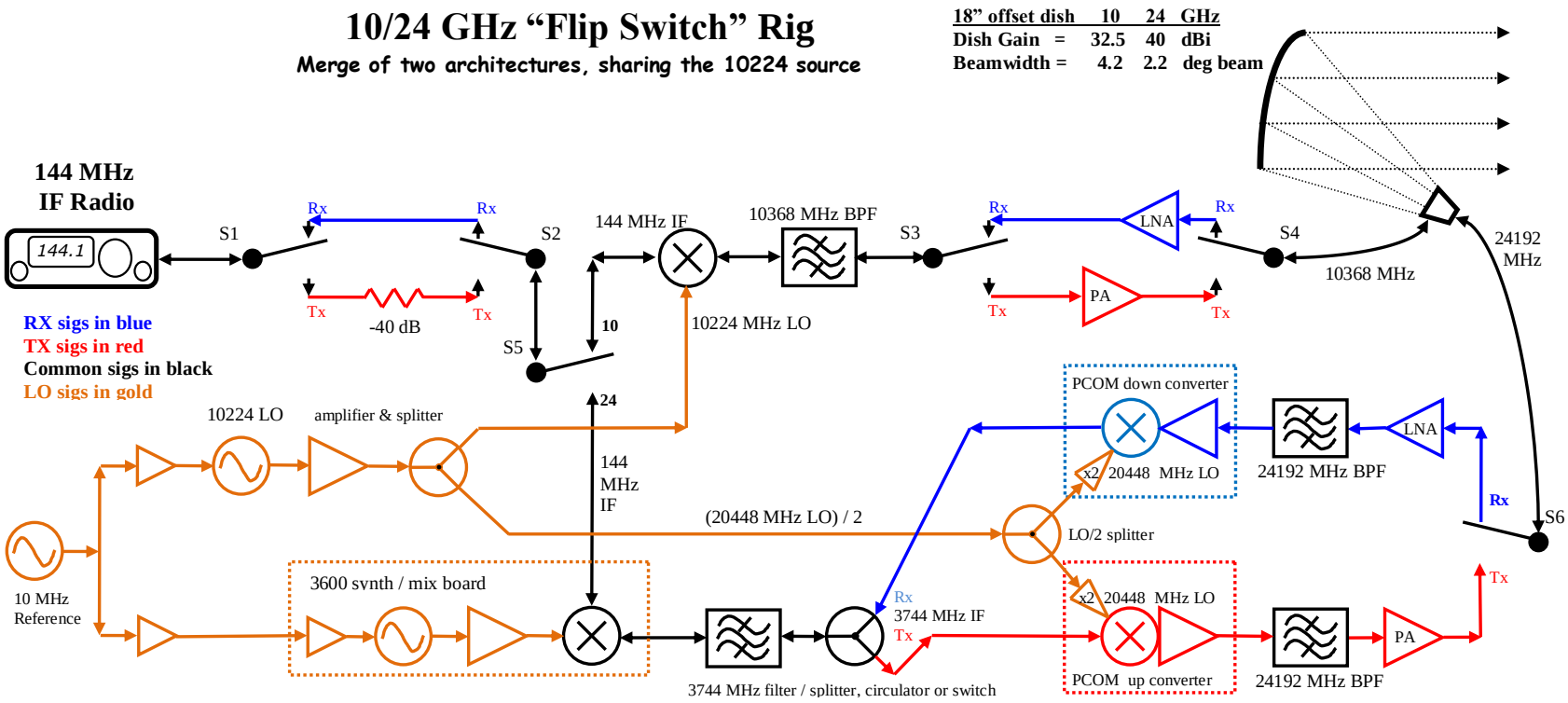
- PCOM modules for up/down conversion (3744 IF, 24192 IF, 20448 LO, internal 10224 doubler)
- 3600 synth / mix board for up/down conversion (144 IF, 3744 RF, 3600 LO)
- 3744 MHz LO leakage & image reject filter (pipe cap or retuned PCOM?)
- Split 3744 common to Rx, Tx using switch, circulator or splitter.
- 3408 or 1136 synth and x3 or x9 mult to get 10224 for PCOM LO/2 inputs
- Two loads on 10224 requires splitter; may require amplification
- Simplest 24 GHz rig uses a circulator instead of grey area (no ext. LNA, PA, BPFs; a few hundred mW out and higher NF); can upgrade with PA and/or LNA; PA requires S3 instead of circulator

10/24 GHz “Flip Switch” Rig

- Shares common dish antenna, so that once 10 GHz QSO is accomplished, we are aimed correctly for 24 GHz QSO
- 24 GHz is 2.4x harder to point for same size dish, but about 7 dB more gain
- Replace dish feed with 10/24 dual band feed (pictured below)
- Uses same frequency plan and RF blocks as previous 10 and 24 rigs
- Control for cross band (10tx/24rx, 24tx/10rx) as well as same band (10 or 24 tx/rx)



10/24 “Flip Switch” Rig



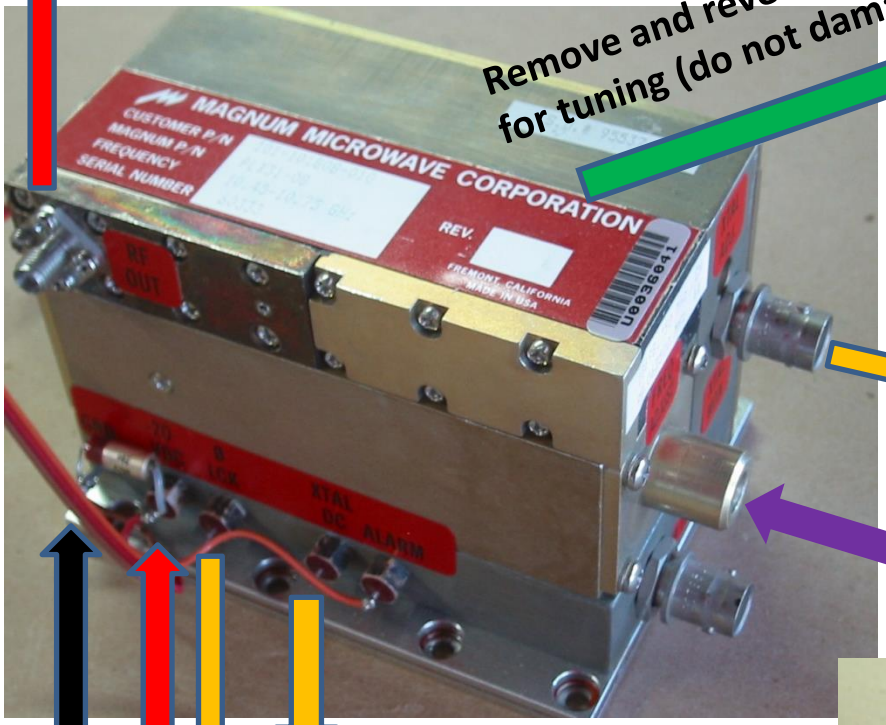
- Same as previous 10 + 24 rigs
- Three loads on 10224 requires splitters; may require amplification
- Simplest 24 GHz rig uses a circulator instead of external LNA, PA, BPFs
- Design control logic to support 10G, 24G or crossband (either way) T/R

10 Ghz Workshop

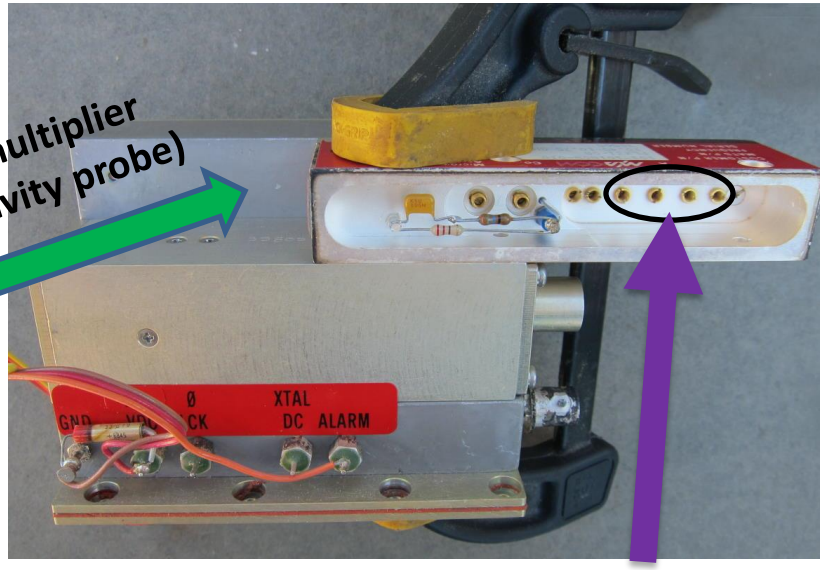
- 10 GHz Brick and Filter Tuning on Sunday, 4/28
  - KK6DNY, AA6PZ, K1YQP, W6PDC, N6KLD, KB6BA, W6RXQ, K6CLS, K6ML
  - Thanks to Paul, W6PDC, for bringing his VNA and tuning filters
- ~8 Bricks retuned to 10224
  - Most gave +14 to +15 dBm output
  - Used SA, counter, scope, DVM, power meter; temporary 106.5 xtals
  - Retuned cavity osc to 1704 MHz, repeaked mult out filter at 10224 MHz
  - Most were MACOM/Magnum PLX31-08 internal xtal (from Harris)
  - One external, one 11 GHz, one eBay…
- Harris Farinon chassis conversions, waveguide filters
  - Retuned or checked ~8 waveguide filters
    - 0.7 to 1.3 dB insertion loss, ~30-40 MHz passband
    - About 110 Mhz wide at -40 dB down, 150-175 MHz at -60 down (VNA limit)
  - Rewired a couple of Harris units on the spot for Rx, one heard the beacon
- Also checked a DB6NT PA

Brick Tuning

10224 MHz @ +15 dBm



Remove and reverse output multiplier for tuning (do not damage cavity probe)

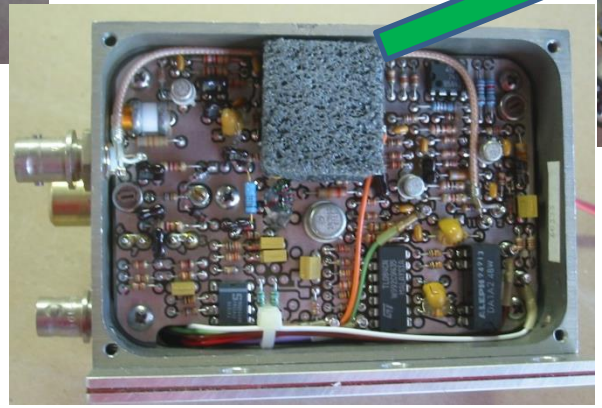


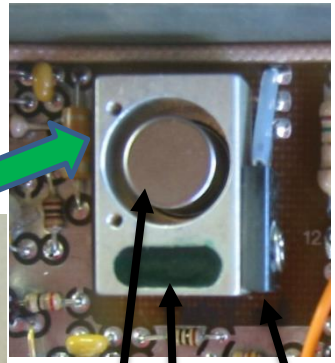
Tune these four screws
X6 Mult Out filter (10224)

Xtal osc freq mon

Cavity Osc Tune (1704 MHz)

Xtal oven





heater

temp sense

Xtal (106.5 MHz)

GND

-20V
(replace cap before it blows!)

Xtal osc level det

PLL Error Voltage
(set for -8 to -9 DC; AC wave when not locked)

10224 Bricks

- Nineteen 106.5 MHz crystals (for PLX31-08) due by end of May
  - Delivery at June meeting or by other arrangement ($40 ea)
  - Will hold another “insertion/tuning” workshop in June
  - Trim leads carefully (.15” +/- .03”, have worked out a jig) to fit oven socket w/o shorting
  - Recommend additional internal and external foam insulation to reduce temp drift
  - Recommend tuning oven temp to min drift point of xtal

- Brick Power Supply
  - Brian/Duncan found Mean Well SD-25A-24 12VDC-24VDC converter
    - $21 at TRC electronics or Jameco
    - Looks clean on SA, sounds good on air tests
  - Build and mount a -20 V linear regulator at brick power pins
    - Filters out converter hash and wiring IR drop to avoid FM, spurs and voltage drift
    - Use 3 term regulator or Duncan’s multi-terminal regulator design
    - Replace old cap on brick -20V (they often blow out)

10224 Bricks

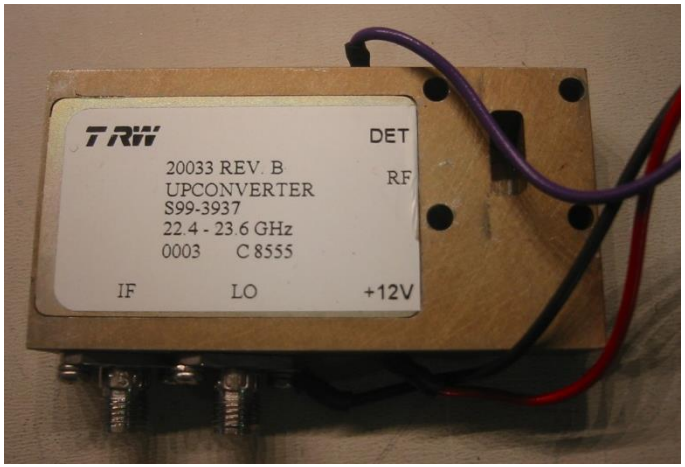
- Preliminary Measurements of Temperature drift at 10224 MHz
  - Wrong xtal package and temp, open cover, poor oven fit:
    - ***~8 kHz over 20 deg F***
  - Right xtal pkg, ? Xtal temp, sealed and insulated brick:
    - ***~4 kHz over 20 deg F***
  - Correct pkg & temp, correct oven temp, insulated brick:
    - ***TBD in June***

- Future project:
  - Lock 106.5 osc to 10 MHz double oven ref for better stability
  - Upgrade for:
    - Bricks (int/ext VCXO)
    - DB6NT/DEMI rigs (ext VCXO)

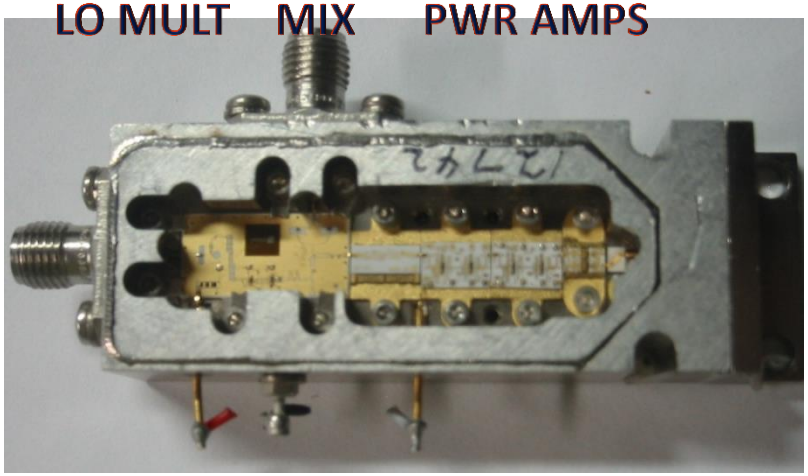
24 Ghz Workshop

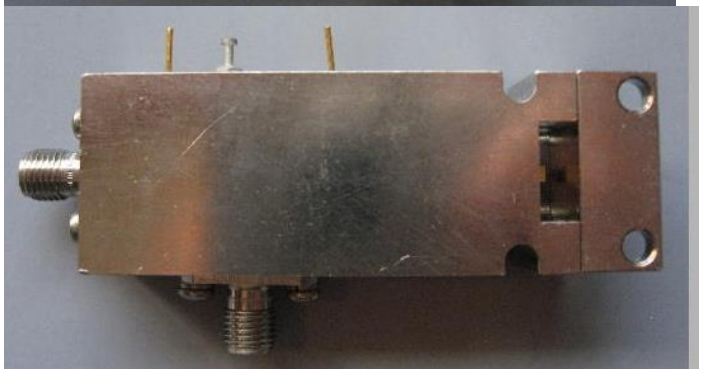
- 24 GHz Testing on Saturday, 4/27
  - N9JIM, KD6W, W6RXQ, K6MGM, K6ML
  - Thanks to Will for source, filter, atten, dncvtrs
  - Thanks to Joel for 24 GHz SA
- Upconverters (3744 + 10224 -> 24192)
- Downconverters (24.2 - 10224 -> 3744 SA)

“PCOM” Up Converter Mug Shots



WR42/34/28 RF OUT, SMA LO & IF IN



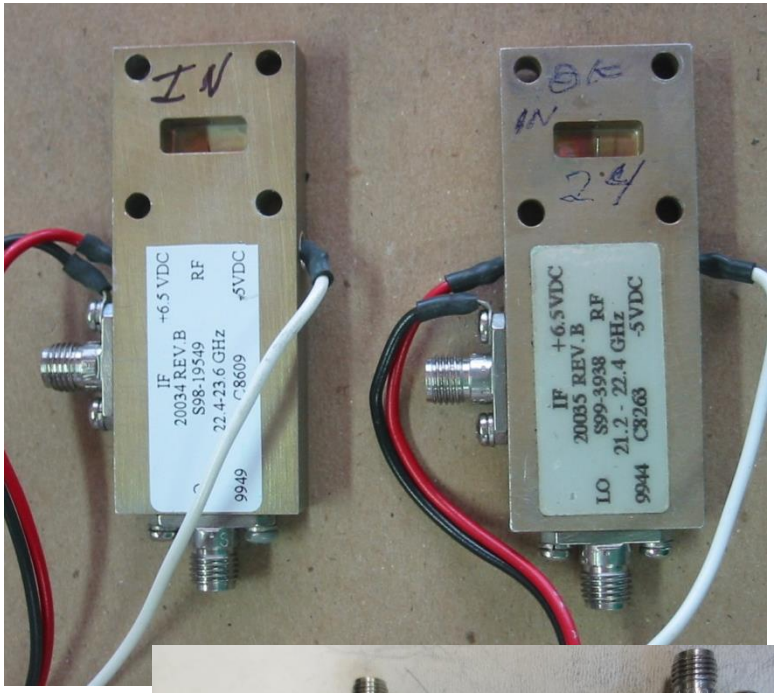


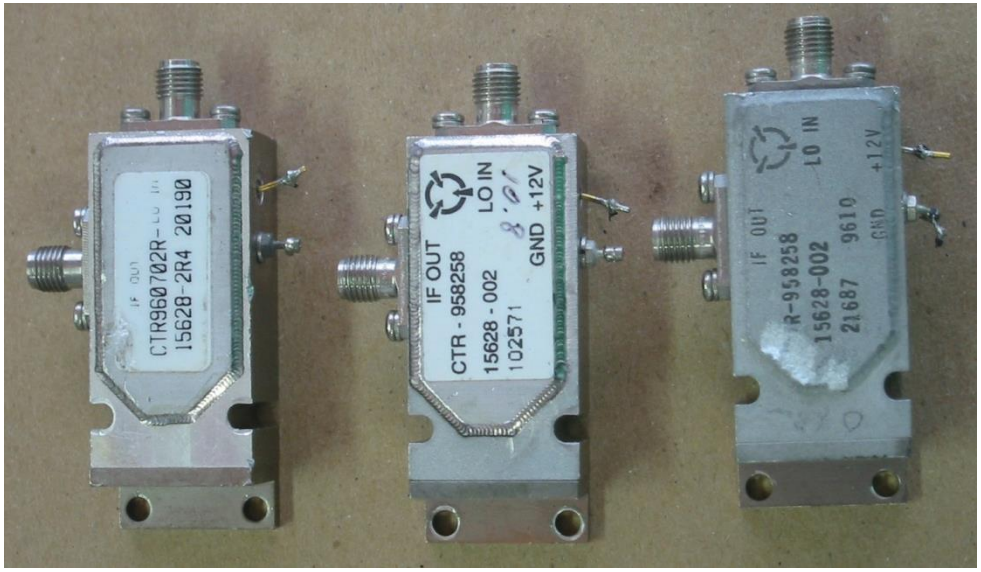
24 Ghz Workshop

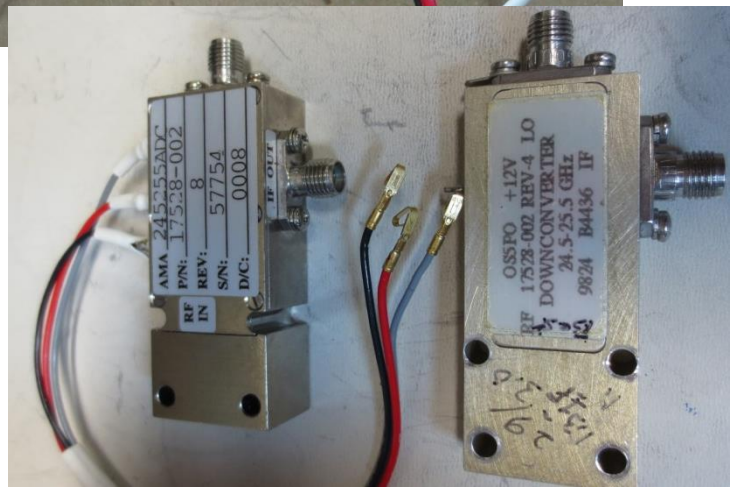
Tested 13 Upconverters (3744 + 10224 -> 24192)

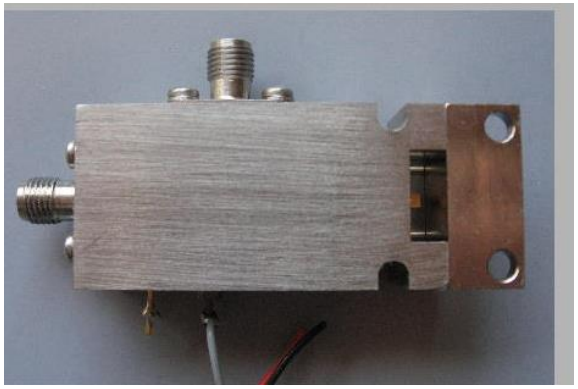
- IF Input @ 3744 MHz:
  - +10 dBm (most units)
  - -5 to -1 dBm (some)
- LO/2 input @ 10224 MHz:
  - +10.6 dBm (most, some less)
- 24192 MHz RF Output varied from < 1 to 150 mW:
  - +22 dBm (3 units), +20(3), +17.5, +14, +13(2), +10, +1, -2 dBm
  - Strong LO leakage @ 20.4 seen in output
  - No image @ 16.7 seen in output

“PCOM” Down Converter Mug Shots









WR42/34/28 RF IN

SMA LO IN & IF OUT

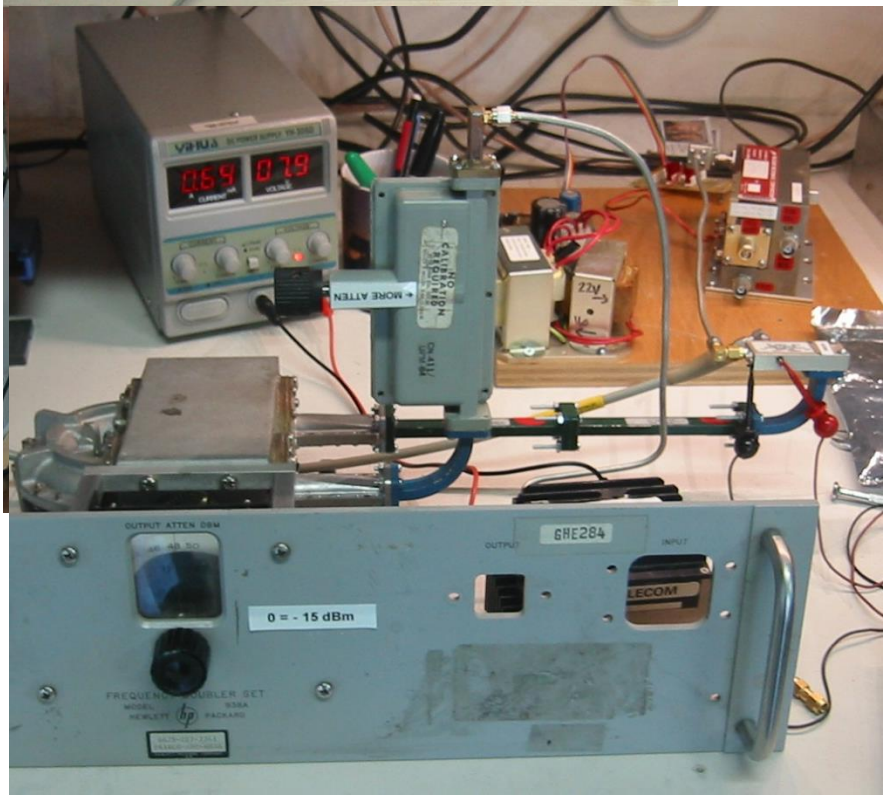
Usually shorter than upconverters

24 Ghz Workshop

Tested 12 Downconverters (24.2 - 10224 -> 3744)

- Not set up to measure NF at this time
- MDS test limits:
  - Attenuator leakage (-95 dBm) @ RF set the MDS test limit
  - Spectrum Analyzer's MDS @ IF
- Supplied +11 dBm LO/2 input @ 10224
  - some units were OK with +8, two with +5 dBm
- Conversion loss/gain results varied over wide range:
  - From "deaf" thru -15, -6, -2, +5, +8, +11 dB loss/gain

Down Converter Test



IF out to spectrum analyzer

LO in from brick

24 GHz source into 3 cascade vane attenuators

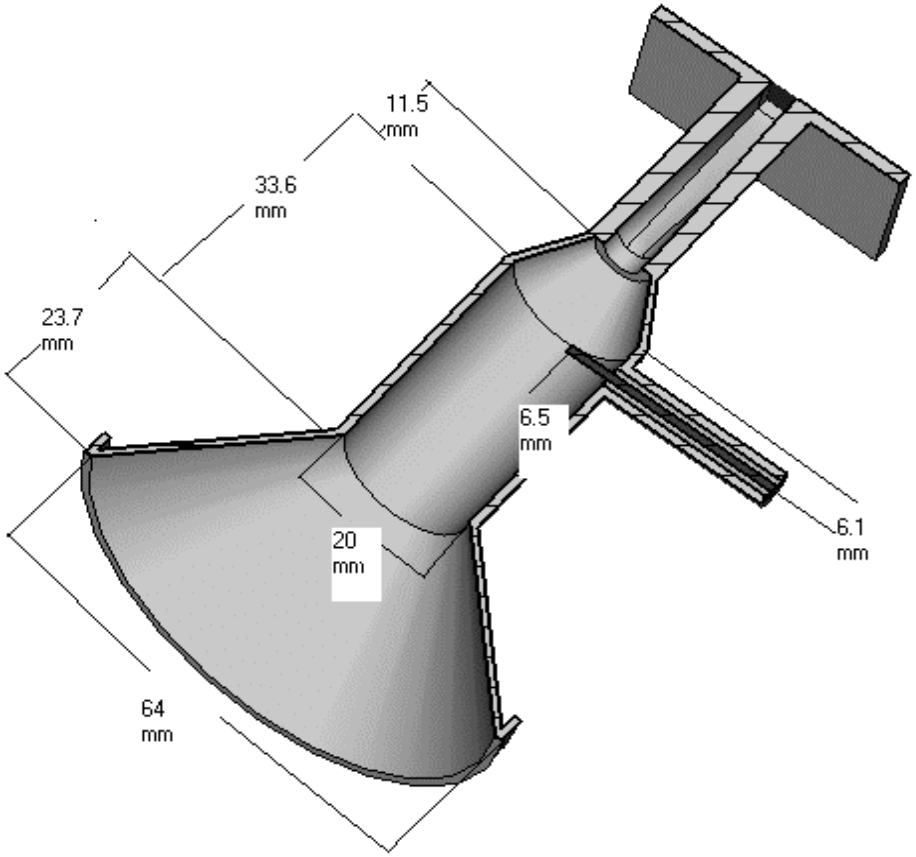
Dish Feed Workshops

Status: 10/24 GHz Dual Frequency Dish Feeds

Steve Shyvers

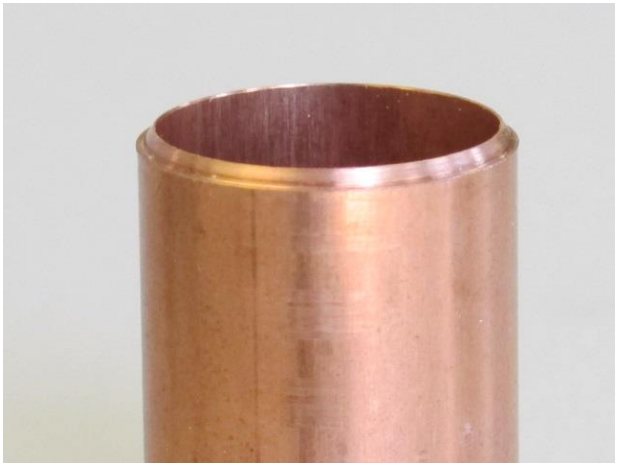
n6kld

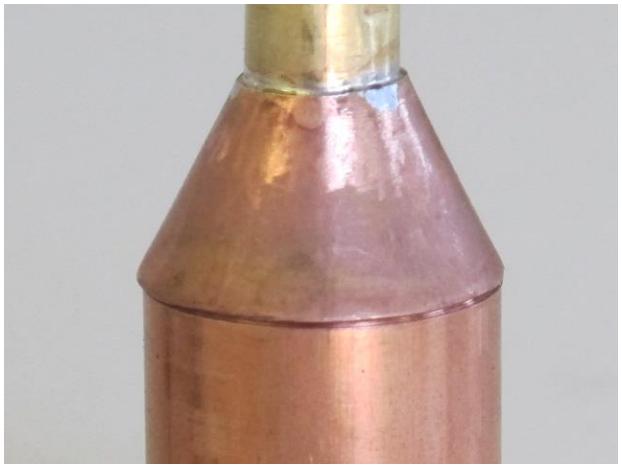
10/24 GHz Dual Frequency Design from Gary's and Lars' 2001 Presentation

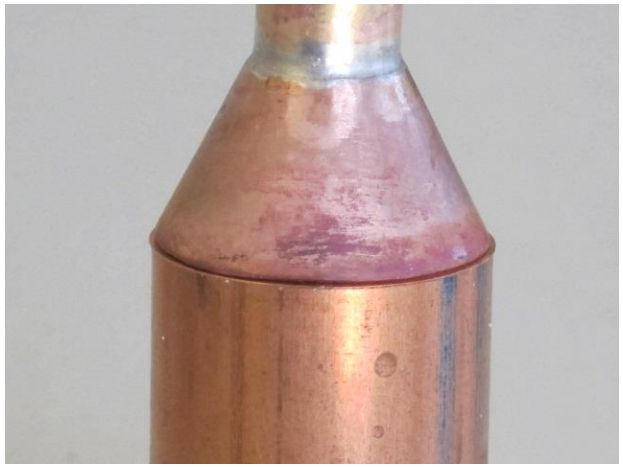


Silver-Soldered 24 GHz to WR-42 Transitions

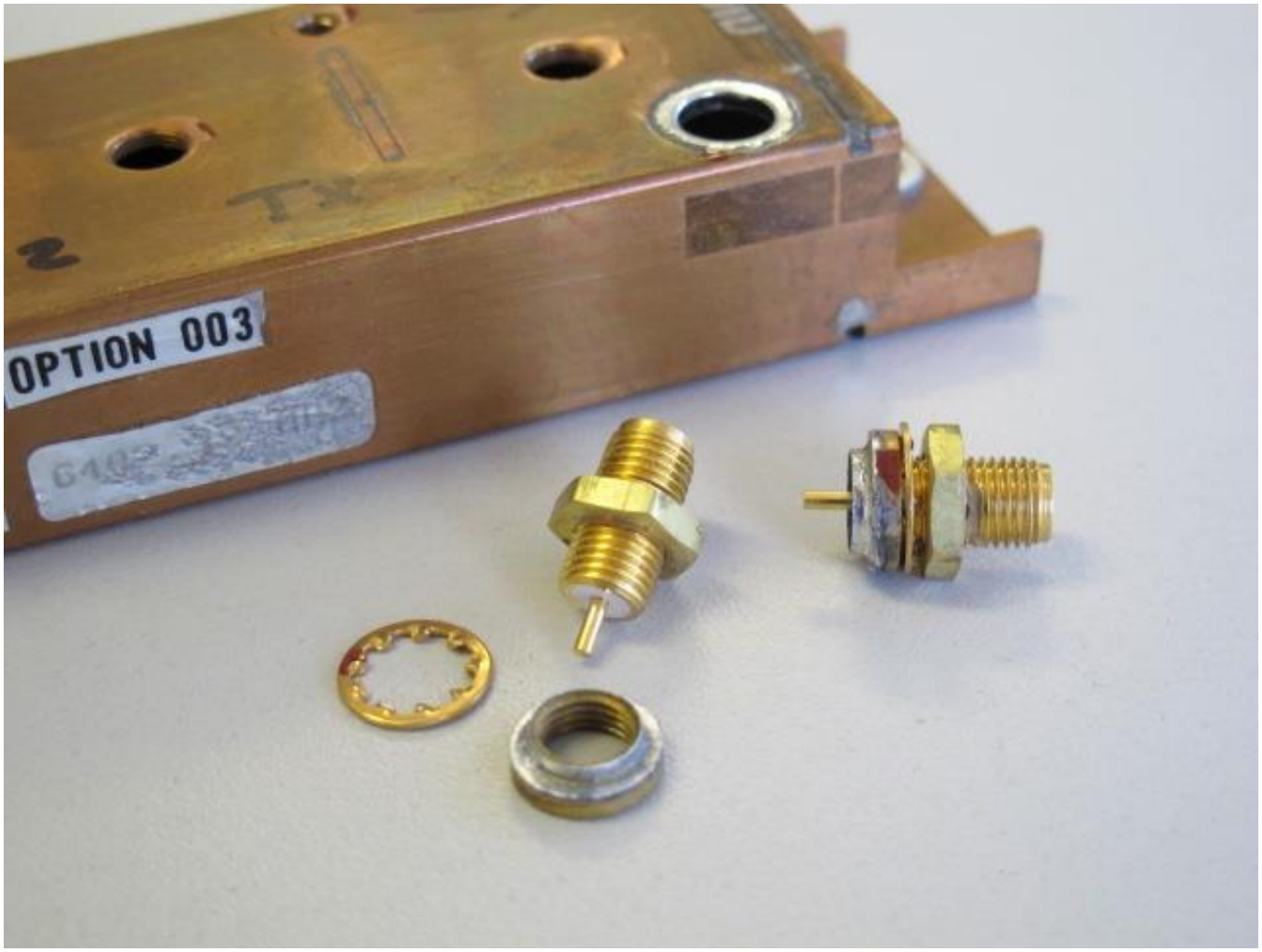
Fitting Small Cone to ¾" Pipe







SMA Connectors from 6.4 GHz Harris Filter



Chapparal Corrugated Cone Feed
(useful for front of 10/24 or for 10)

chaparral.net http://www.chaparral.net/feed-horns/offset-straight-feedhorn/

11/12 GHz Offset Straight Feedhorn

Designed for reception of signals in the extended Ku-Band range of 10.7 – 12.95 GHz, the 11/12GHz Offset provides internationally renowned Chaparral quality and reliability.

Specifications

Part Number	13-4016-1
Frequency Range	10.7-12.95 GHz
Reflector Type	Offset
Insertion Loss	Less than 0.1 dB
VSWR	Less than 1.3 to 1
f/D Range	0.60 to 0.90
RF Ports	WR75
Size	70mm x 108mm
Mounting Diameter	27mm
Weight	6oz/166grams

Ku Offset

Price: $30.00

Buy Now

Applications

The Offset Feedhorn is ideally suited to deliver exceptional performance with any high stability LNB downloading high speed internet data or the latest in digital television.

Features

- Single polarity reception
- Weather tight throat cover
- Economical
- Easy to install