ALL YOU NEED TO KNOW ABOUT TRIBANDER ANTENNAS & TRAPS

(WITH TROUBLESHOOTING EXAMPLES)

Two-band (10/15m) trap picture courtesy of Mosely Electronics Website

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DISCUSSION TOPICS

- What are triband antennas (tribander)?
- What are traps?
- How do traps work in Tribander antennas?
- Components of traps
- Checking traps
- Two troubleshooting examples

Tribander: Mosely TA-53 Five-band Antenna (bottom antenna)
Rotary Dipole: Trapped 40m dipole (top antenna)

Traps are typically known to shorten “electrical” antenna length, but are lossy

AMATEUR RADIO ANTENNAS (1 OF 2)

- HF antennas are well designed, but occasionally have electro-mechanical failures
- Monoband Yagi HF antennas (Hygain, Cushcraft, Telrex, KLM, Force-12, Ham-Pro, etc.) perform well, but are limited to one band, have much Gain, good directivity, and great Front to Back rejection
- Quad antenna are multiband HF antennas … may be home-made or purchased from Cubex or other manufacturers, but are fragile – hams say that "quads opens and closes the band(s)" - Bill Orr (W6SAI) in his book about cubical quads, said "a two-element cubical quad is equal to a pair of 2 element beams"
- Self-adjusting HF multi-band antennas such as SteppIR perform well, but can have electro-mechanical problems with the element expansion motor (expensive electro-mechanical stepper motor)

Note: Hygain, Cushcraft, Mosely, Telrex, Ham-pro, KLM, Cubex, SteppIR, etc. are registered trademarks of antenna suppliers& manufacturers

AMATEUR RADIO ANTENNAS (2 OF 2)

- Many HF multiband antennas use traps to allow for resonance on multiple bands.
- Tribander and Five-bander antennas (Mosely, Hygain, Wilson System I II or III, Cushcraft, KLM, etc.) provide 3 or 5 band capability have traps, but sometimes have trap issues

This discussion will delve into the Tribander and its primary component - the Trap

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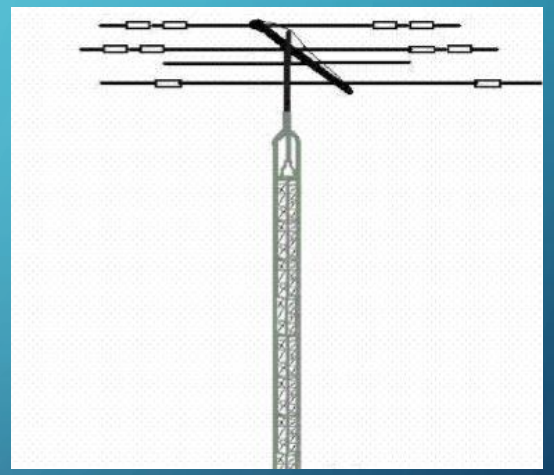
TRIBANDER ANTENNA CHARACTERISTICS (1 OF 2)

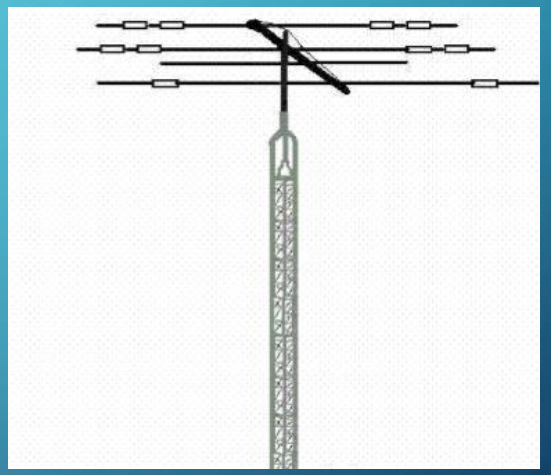
- Tribanders are NOT perfect antennas, but provide convenience
- Element Spacing: 20m - close; 15m - optimum; and 10m - wide spacing
- Trapped elements cannot be tuned for maximum performance on three (3) bands simultaneously for perfect matches
- Gain and front-to-back ratio are sacrificed to obtain a good match
- Inductors in the traps load the elements and elements are shorter than those of a monobander



Tribanders sacrifice performance for size

TRIBANDER ANTENNA CHARACTERISTICS (2 OF 2)

- Many Tribanders have two (2) driven-elements spaced 3 to 5 feet apart called a log-cell to obtain better SWR and provides slight increase in gain over typical triband antenna (Exclusive to Hygain TH-7 and KLM KT-34)
- Fact is a Tribander is <u>better than</u> a dipole for working DX entities due to its directivity to focus RF in the direction of the other station

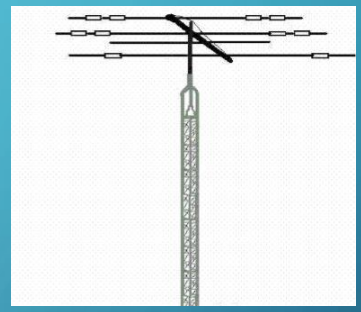


Tribanders are great for the typical ham!

IS A MONOBANDER BETTER THAN TRIBANDER?

- TESTING CONDUCTED TO SEE TRAP LOSSES -

- N4JA(sk) tested a monobander and tribander in the early-2000's to put to bed a myth that a monobander is significantly better than a tribander having equal boom lengths
- Test setup: Two 56 feet towers spaced 100 feet apart over equal: terrain; same antenna heights; boom lengths; frequency; coax length; and power level in 20m band
  - Tower 1: Hygain 204-BA 4el Monobander w/ 26 feet boom
  - Tower 2: Hygain TH-6 DXX 6 Element trapped tribander w/ 24 feet boom
- Transmitted signal: Carrier of 10 watts and held constant as antennas were "hot" switched several times to several DX stations and one local amateur 5 miles away
- Results: No difference in signal reception by DX stations & no difference as seen by Local station during dead 20m band [ability to see one dB difference on analog meter used]



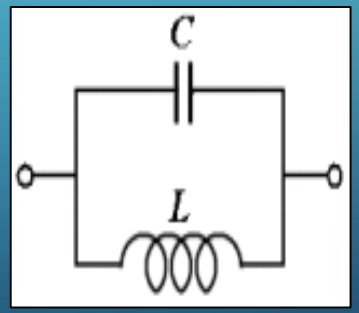
Versus

Conclusion: Tribander works as well as Monobander on 20m

LET'S LOOK INTO THE MAJOR COMPONENT OF THE TRIBANDER – THE TRAP

TRIBANDER TRAP ANTENNAS

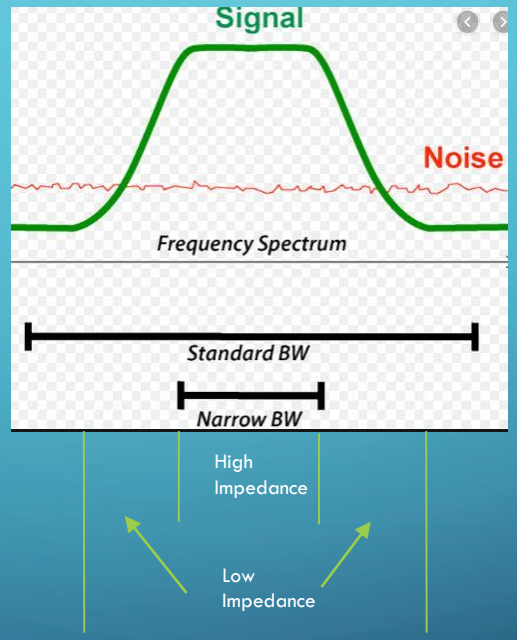
- A popular way of fabricating a multiband antennas is to install parallel tuned circuits called traps i.e. a series of ¼ wave elements joined together making a ½ wave element
- Quarter (1/4) wave elements may be broken at predetermined intervals with Insulators; Terminating the tubing; or Installing parallel resonant circuits
- When a certain amount of capacitance is connected in parallel with a certain amount of inductance, a very high resistance (impedance Hi-Z) results at a certain frequency

RF(? frequency) 

= high impedance (looks like an open circuit)

TRIBANDER TRAP ANTENNAS

- This “special high resistance” resistor (high impedance L/C) designed to work at narrow band of frequencies [acts as an insulator]



- Other frequencies above and below this frequency exhibit opposite conditions at a very low resistance (low impedance) [looks like a short circuit]

TRAP RESONANCE

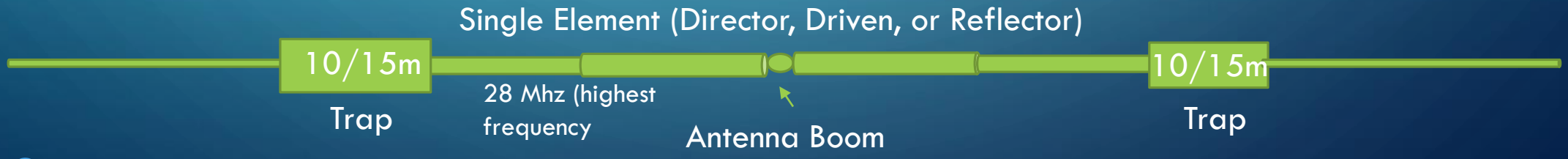
- Traps that resonate INSIDE the amateur bands – Each L/C combination is resonant & presents a high impedance, behaving as an ***insulator***
- Traps that resonate OUTSIDE the amateur bands – Trap behaves as an inductor or capacitor where inductive loading electrically lengthens the antenna or capacitive loading to shorten the electrical length of an antenna
- Additional traps can always be added to cover additional bands
- Efficiency of a trap system depends on Q values of tuned circuits; $Q=2 \pi f L/R$
- Low-loss, high Q coils should be used and capacitor losses low as possible

"Q" (Quality) is the ratio of inductance (L) to resistance (R) defining coil efficiency

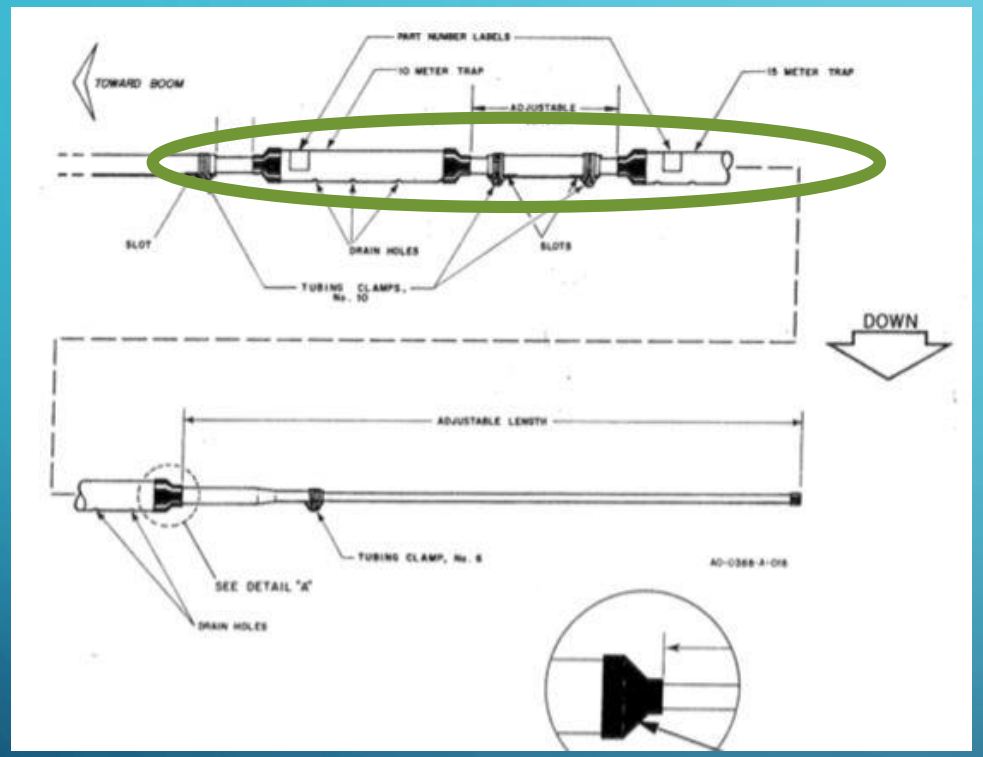
Higher Q value results in lower losses and better suitability as RF inductor

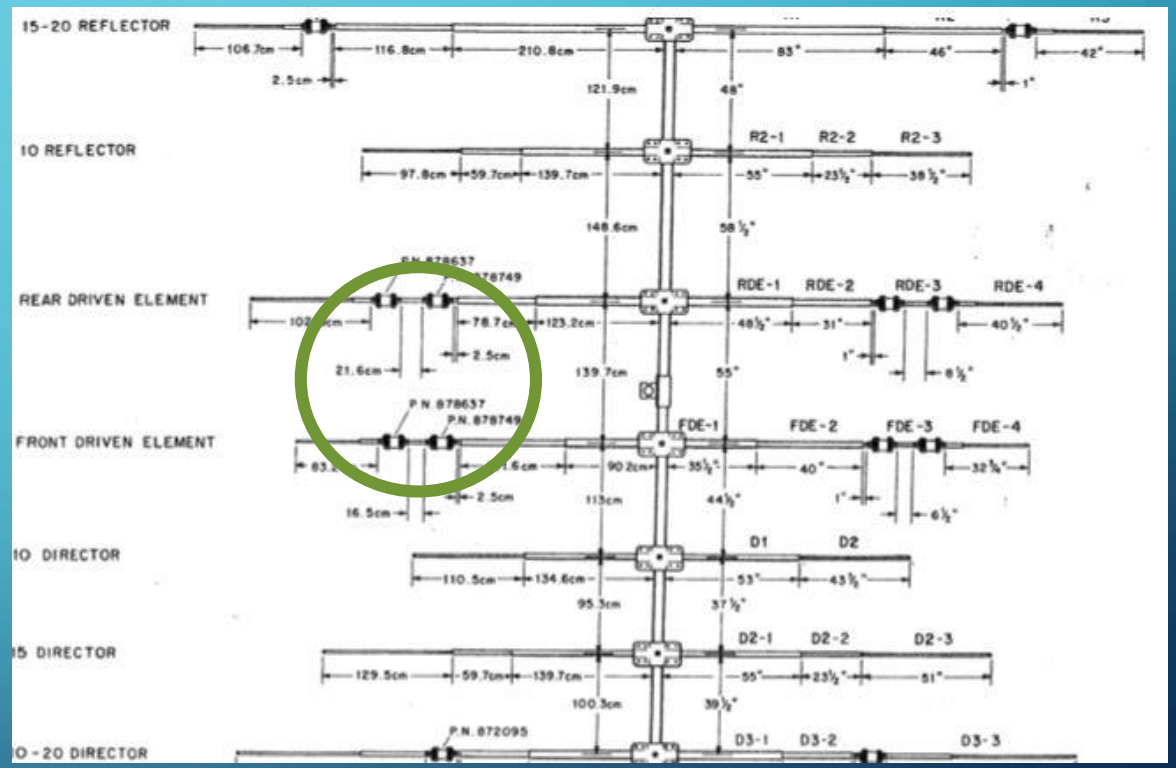
TRAPS FOR TRIBANDER DESIGNS

- Tribanders usually have at least six parallel circuits (L/C) – but depends on number of elements of the antenna (BW, Directivity, FB rejection, etc.) and the antenna brand
- The trap's resonant circuit operating the highest frequency is nearest the antenna center closest to the boom (10m traps closest to the boom); while the other end of the assembly another resonant circuit is found operating on the next lower frequency (15m or 20m) closest to the end of element [Reference trap schematic coming up in a few slides]
- Individual traps can be measured with VOM by measuring continuity or checked w/ Grid Dip Meter or antenna analyzers (Discussed later)
- Due to the circuitry of trap-type antennas, any malfunction on the highest resonant frequency may also cause the antenna to operate incorrectly on the lower resonant frequencies and vice versa



HYGAIN TH7DXX WITH TRAPS SHOWN



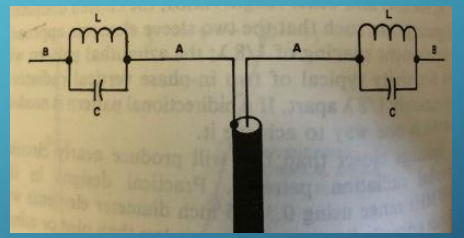


Schematics courtesy of Hygain TH7DXX Manual

These traps are the same for the active elements (DE & Reflector), but can be easily mixed up during the assembly process causing issues

EXAMPLES HOW TRAPS FUNCTION

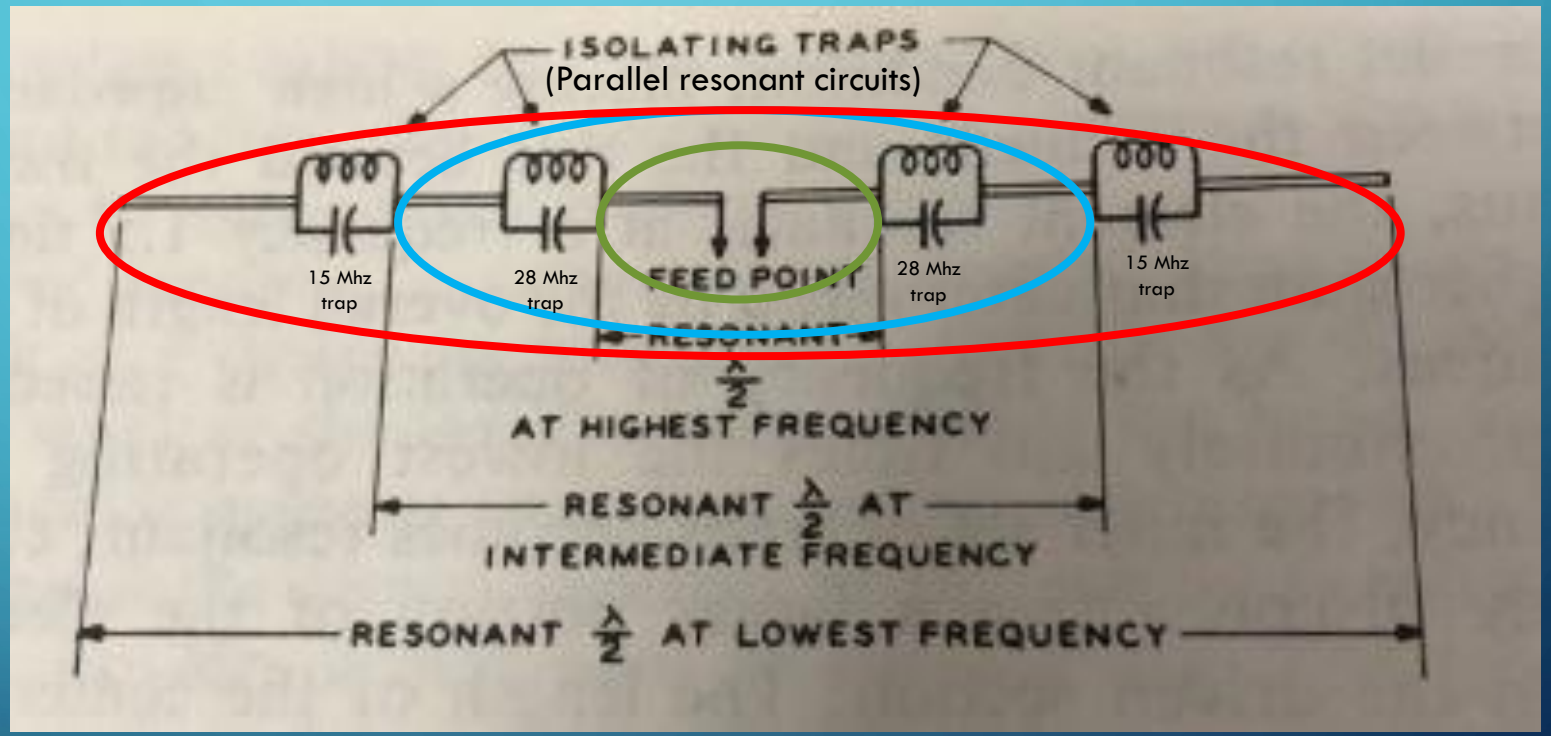
- Example 1:
  - Trap resonant in the amateur band: Antenna A=66 feet long; each L/C combination is resonant in 7Mhz band. Because of resonance, the trap presents a high impedance to antenna system. The affect is that the trap behaves as an insulator. Any lengths beyond the trap are invisible without any affect; thus the antenna is length A (66 feet long).
- Example 2:
  - Trap not resonant in the amateur band:
  - Antenna 3.5 Mhz, A=90 feet long; each L/C combination is resonant in 6Mhz band. Because of resonance, the trap act as inductors (or capacitance) to antenna system. The affect is the traps lengthen (or shorten) the antenna making an antenna with a length of A + B (or A minus B…Reference picture)



Picture: Diagram of a dipole or rotary dipole

SCHEMATIC OF TRIBANDER SINGLE ELEMENT

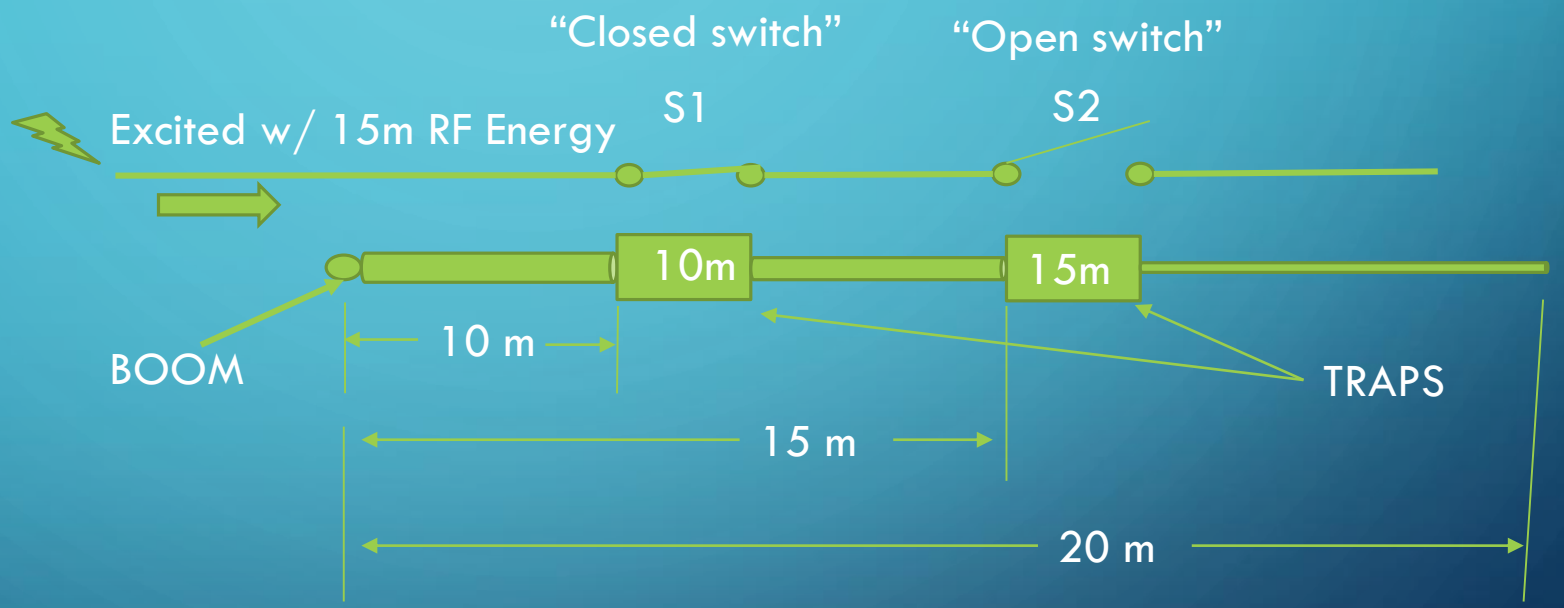
Resonance @:
Green = Highest Frequency(28Mhz)
Blue = Intermediate Frequency (15Mhz)
Red = Lowest Frequency (14Mhz)



By only using parallel resonant circuits can the antenna automatically change bands

TRAP RESONATE PARALLEL NETWORK FUNCTION ANALOGY

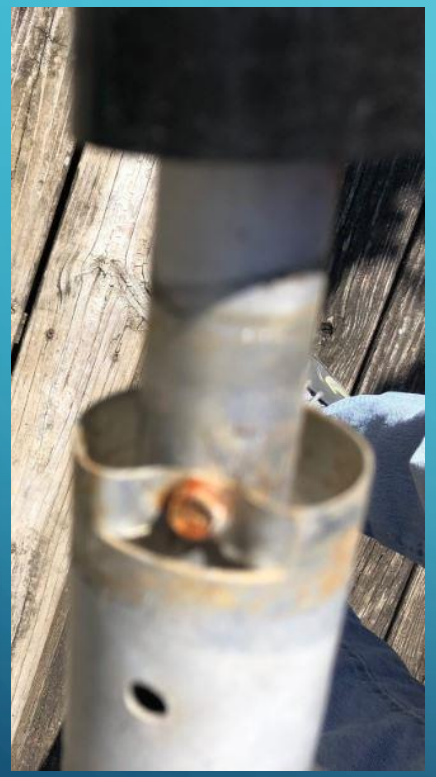
- EXAMPLE :
- Tribander excited with 21Mhz RF energy, only the length of element to the 21Mhz trap is used – Trap is situated ¼ wave length from the boom and is similar to an open switch
- For 14Mhz excitation energy, the 21Mhz and 28 Mhz traps act as closed switches and uses the whole length of the element(~33 feet)



MULTI-BAND ANTENNA excited with same frequency as trap, trap acts as open (high impedance). ANTENNA excited with different frequency as trap, trap acts as short (low impedance)

FULL VIEW OF HY-GAIN TH7DXX TRAP

TRAP ASSEMBLY DETAILS



End caps removed and requires removing rusty screw & bending tab to disassemble trap

TYPICAL TRAP COMPONENTS

Trap with End Caps being Removed

Where does trap get L and C?

- L inductance is naturally inherit to the coil
- C capacitance comes from placing protective tube with drain holes over coil (25pf@3500V)

Mosely Trap(s)

CHECKING TRAPS

SIGNS OF TRAP ISSUES

- Initial signs of tri-bander antenna problems may be attributed to higher than normal SWR readings
- When checking SWR, use an accurate measuring instrument. Nothing should be installed between the SWR meter and antenna except the connecting transmission line (coax)
- Note: Some SWR instruments do not indicate minimum SWR at true resonant frequency

High SWR clued me to check the traps

VARYING SWR INDICATORS

- Bad SWR nay indicate:
  - Trap is faulty or mistuned
  - Length of radiator has changed(possibly becoming shorter due to a loose clamp or corroded connection at trap-element tubing)
  - Mistake in the assembly
- Always troubleshoot a trap problem working from the highest frequency to the lowest
- If antenna works on the next lower band, then the trap is good
- If the next lower frequency does not function correctly, then the trap coil may be open

INSTRUMENTS TO ~~CHECK~~ ID TRAPS

- Volt Ohmmeter can check continuity of the trap coil and other connections
- Grid Dip Meter (otherwise called Grid Dip Oscillator) measures resonant frequency of unconnected RF circuits. GDO is a variable frequency oscillator that sends a small amplitude RF signal through an exposed coil interacting with adjacent circuitry. When the oscillator loses power due to being near a resonant circuit, a meter registers the dip.
- Modern antenna analyzers can measure SWR dips of RF circuits at resonant frequencies by sending small RF signal to the circuit. User can monitor frequency readout of SWR dip.

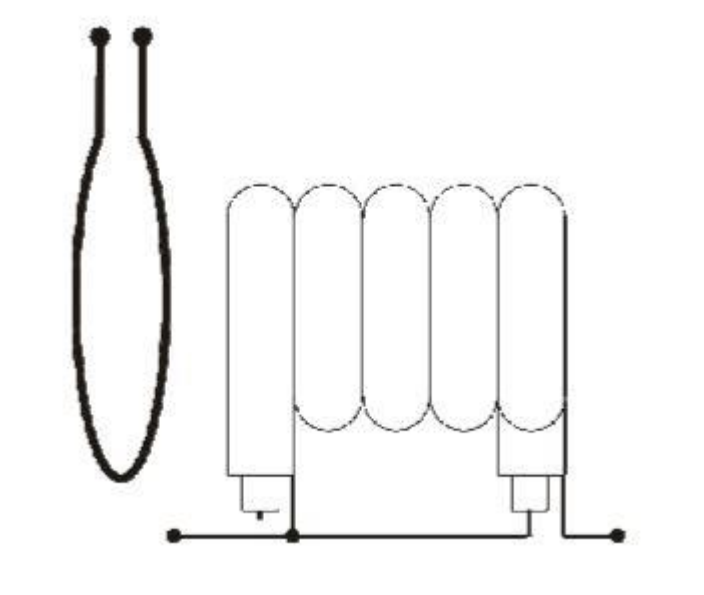
Use GDM or Antenna Analyzer needed if characteristics of trap are unknown

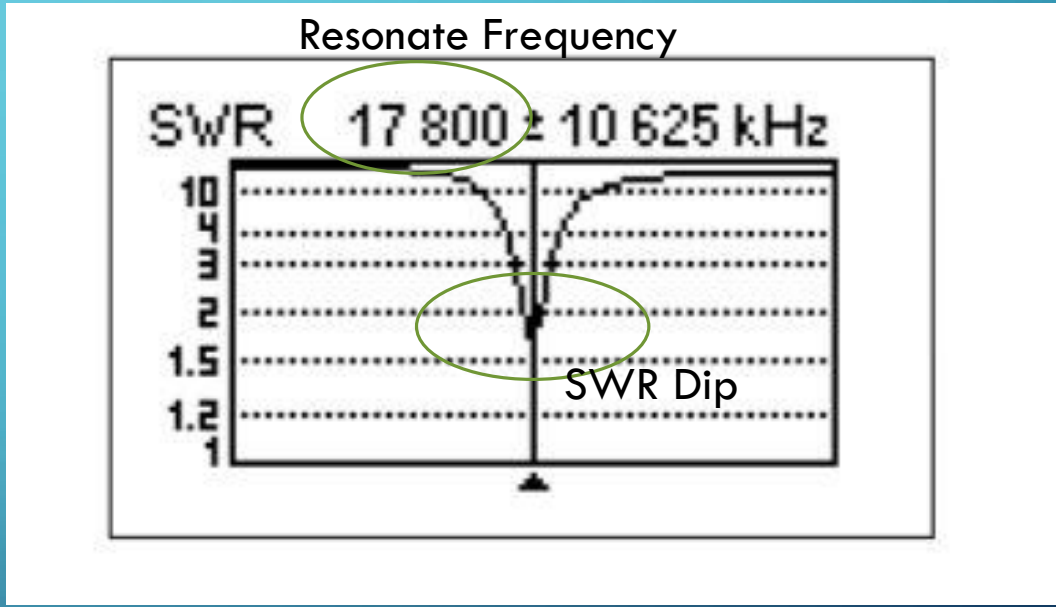
USE RIG EXPERT ANALYZER TO ~~CHECK~~ ID TRAP

10cm loop connected to a Rig Expert Antenna Analyzer ready to conduct SWR sweep finding SWR dip

Perform SWR sweep using your Rig Expert Antenna Analyzer to find SWR dip. Dip is located at resonate frequency.

RIG EXPERT ANALYZER TO ~~CHECK~~ ID TRAP

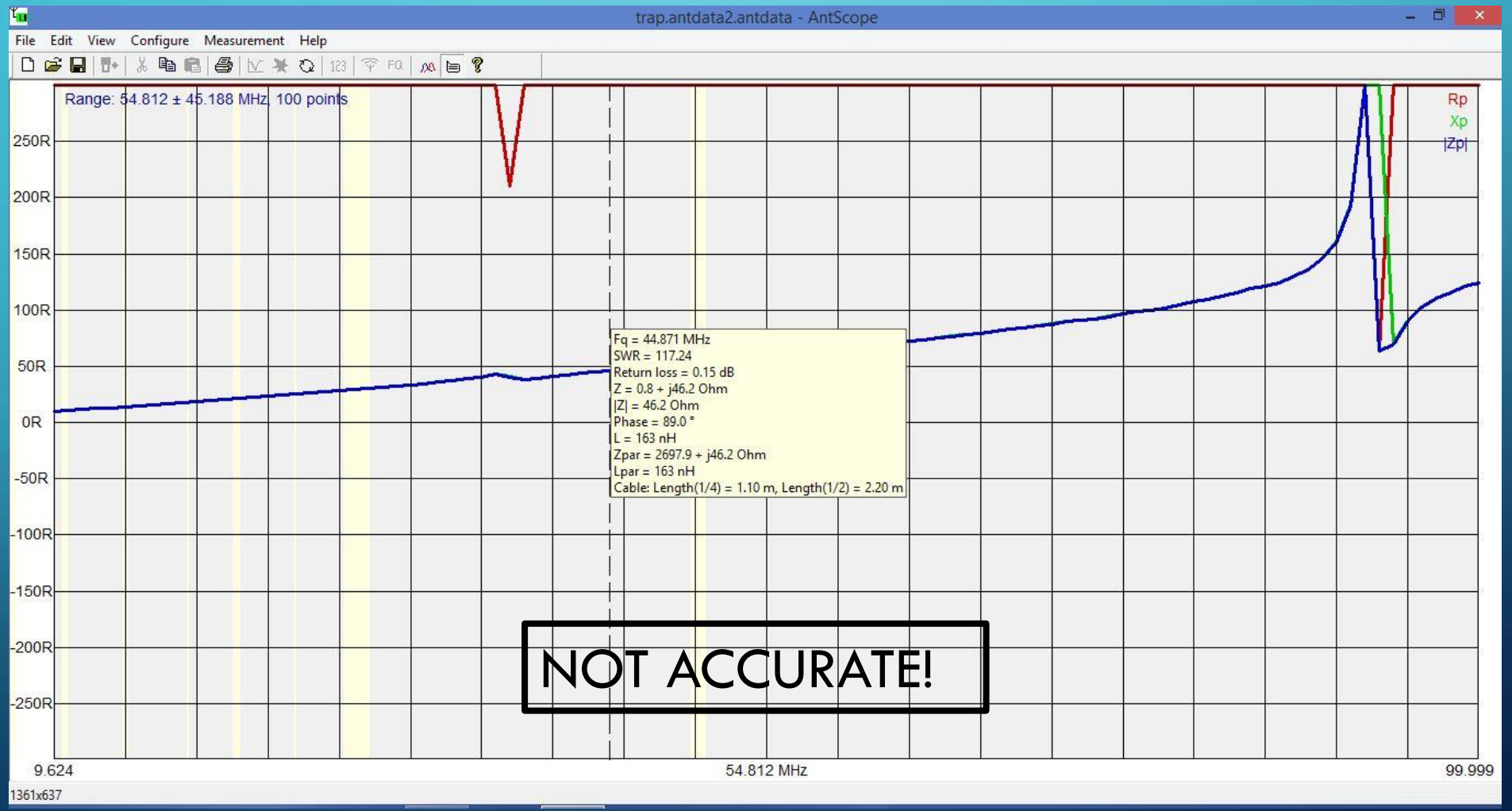




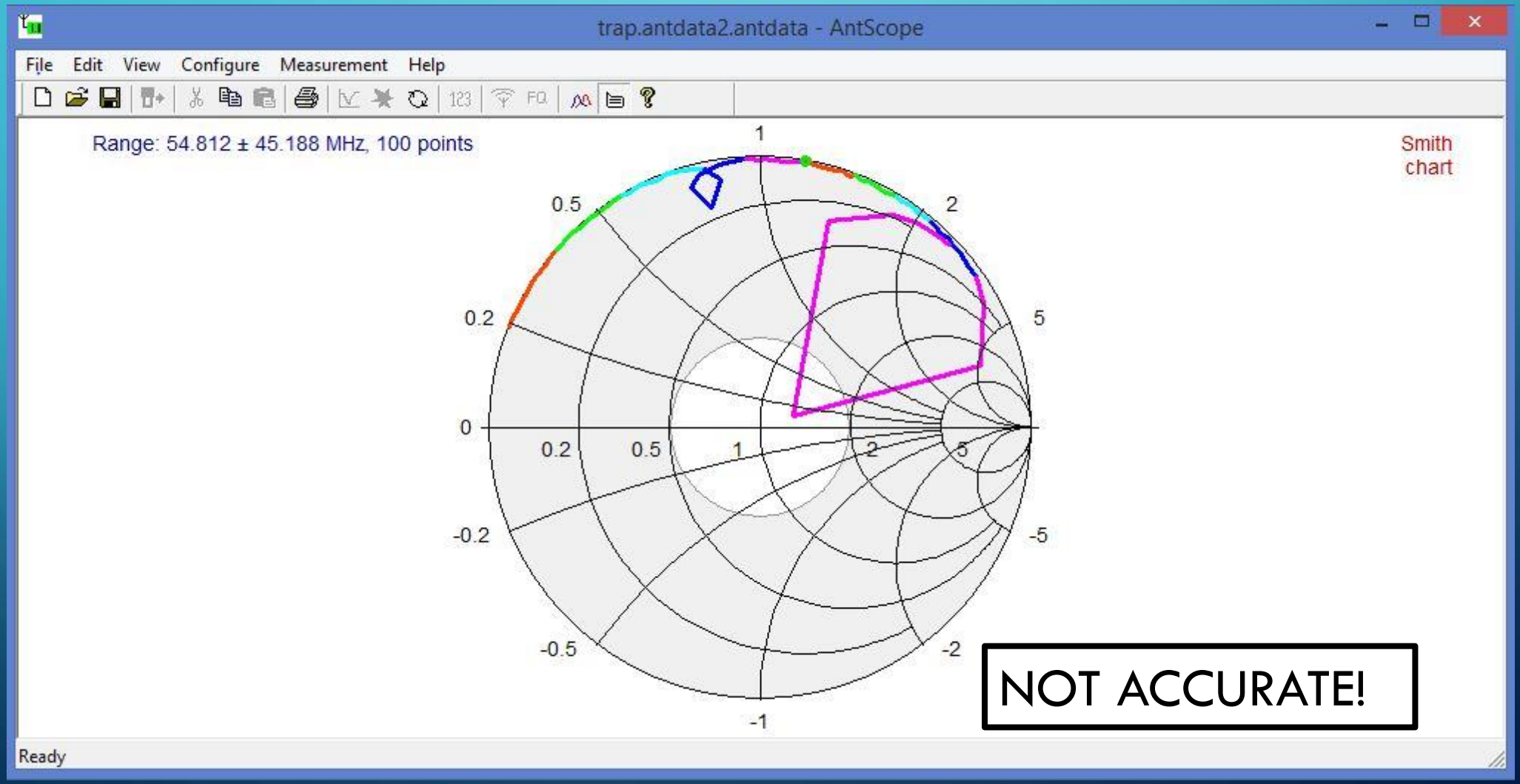
Need a 10cm loop connected coaxially to a Rig Expert Antenna Analyzer (per Rig Expert manual

Perform SWR sweep using your Rig Expert Antenna Analyzer to find SWR dip

RX (PARALLEL) CHART OF TRAP

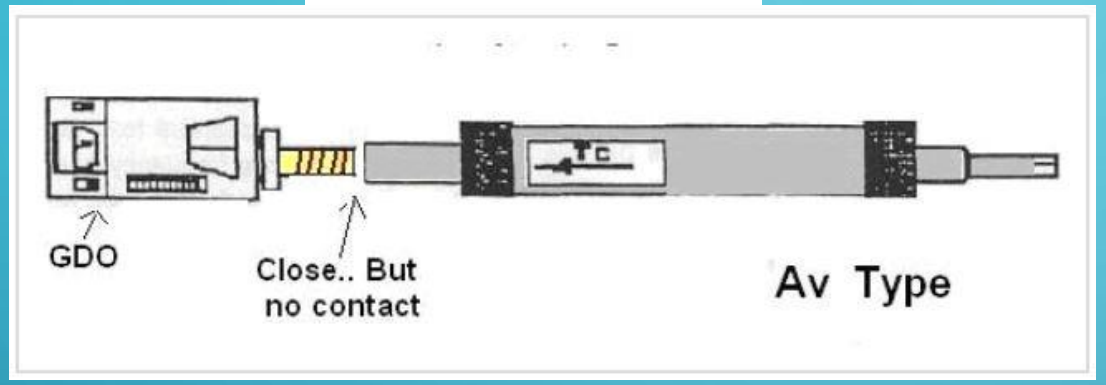


SMITH CHART OF TRAP

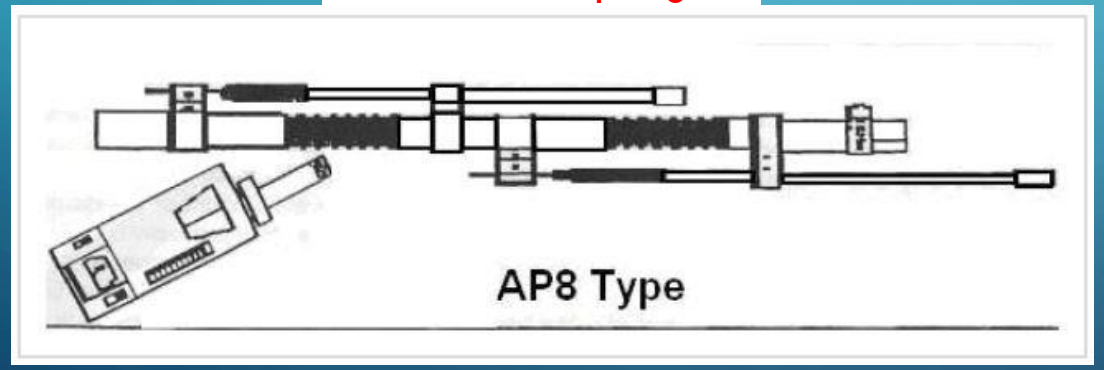


GRID DIP METER (GDM) TO COUPLE TO TRAP & ~~CHECK~~ ID TRAPS

Capacitive Coupling



Inductive Coupling



Capacitive coupling requires the tip of the GDM slightly inserted into lower end of aluminum tubing of the trap (see diagram)

Measurements:
GDM frequency is lower than operational frequency of a trap and the trap loads the dip oscillator to lower its frequency

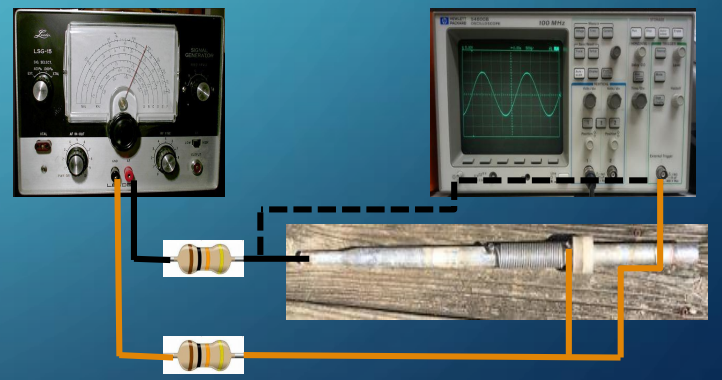
If readings within +/- 100 KHz the affect is minimal – GOOD TRAP
Shorted turns or other defects will cause 1 or 2 MHz swing indicating a BAD TRAP

Inductive coupling measurements are as shown using inductive pickup placing GDO near the trap

Not Best Method: GDM produces quick dip that can be missed and cannot find resonant point

BEST METHOD TO CHECK TRAPS

- Use Vector Network Analyzer (Too difficult to find)
- GDO or Signal Generator and Oscilloscope (O-Scope)
- Attach signal generator to end of trap via two 10K series resistors
  - Place one 10K resistor in series with each lead [Use to isolate the low impedance output of the signal generator from device under tests making easy to see voltage peaks]
  - Attach leads to O-Scope
- Tune signal generator while watching O-Scope for waveform voltage peak
- Resonant frequency of the trap can be read directly from the signal generator



CUSHCRAFT TRAPS & RESONANT FREQUENCIES

Trap	Operating Frequency (Mhz)	Oscillator Frequency (Mhz)	Oscillator Coupling
TF	28.8	27.87	Capacitive
TG	21.3	20.17	Capacitive
TH	14.2	12.92	Capacitive
TJ	7.20	5.81	Capacitive
TR	21.3	20.23	Capacitive
TQ	28.7	26.8	Inductive
	24.65	23.5	Inductive
TS	21.25	20.1	Inductive
	18.11	17.5	Inductive
TT	14.47	13.49	Inductive
TU	10.19	9.9	Inductive
TV	7.3	5.8	Capacitive

AC4G TRAP TROUBLE-SHOOTING

DIRTY TRAPS CAN CAUSE TRAP ISSUES

- End caps & protective weather preventions techniques tend to break down with time
- Antenna traps tend to corrode and get contaminated internally over time
- Trap screws loosen

Traps need to be cleaned periodically

EXAMPLE 1: DIRTY TRAPS CLEANED TO RESTORE FUNCTION

- A few years ago, was having SWR problems with my Cushcraft D3W WARC Band Rotary Dipole
- The tale-tale sign was high and fluctuating SWR on 30m band
- Lowered antenna to ground & checked feedline
- Disassembled traps to find insects and grass looking material inside traps and the suspicious trap(s)
- Cleaned traps to restore antenna back to normal function
- Antenna exhibited flat, low SWR across the WARC bands

EXAMPLE 2: QUESTIONABLE TRI-BAND TRAP

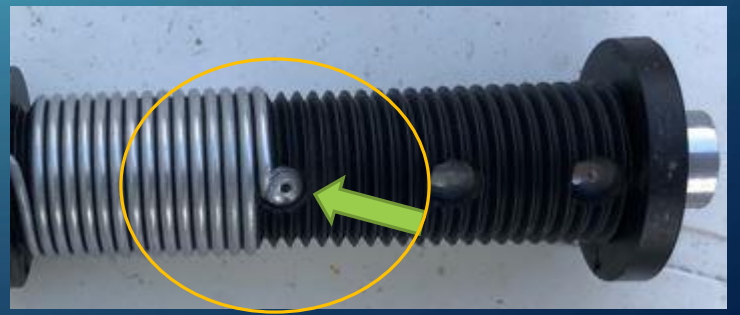
- Reference picture on right
- Problem trap is from a Mosely Classic 33 having issues
- Mosely traps are wound using No. 10 wire on grooved forms molded of high-impact polystyrene
- VOM used to check coil wire
- Element along with trap casing comprises the fixed capacitance ~25pf

Mosely CL-33 Trap

MOSELY TRI-BAND TRAP CAUSING 20M ISSUES

- Failure Investigation led to suspect issues with 10/15m trap on driven element
- Trap coil was disassembled and was not burnt into (VOM measured continuity)
- Further investigation revealed faulty rivet connection
- Rivet looks good, but no connection to tubing causing high SWR on 20m band. Measured “no continuity” with Ohmmeter
- Drilled rivet head and removed rivet
- Cleaned area around rivet hole in trap tubing
- Re-riveted end of coil to trap tubing

Suspect rivet causing an issue



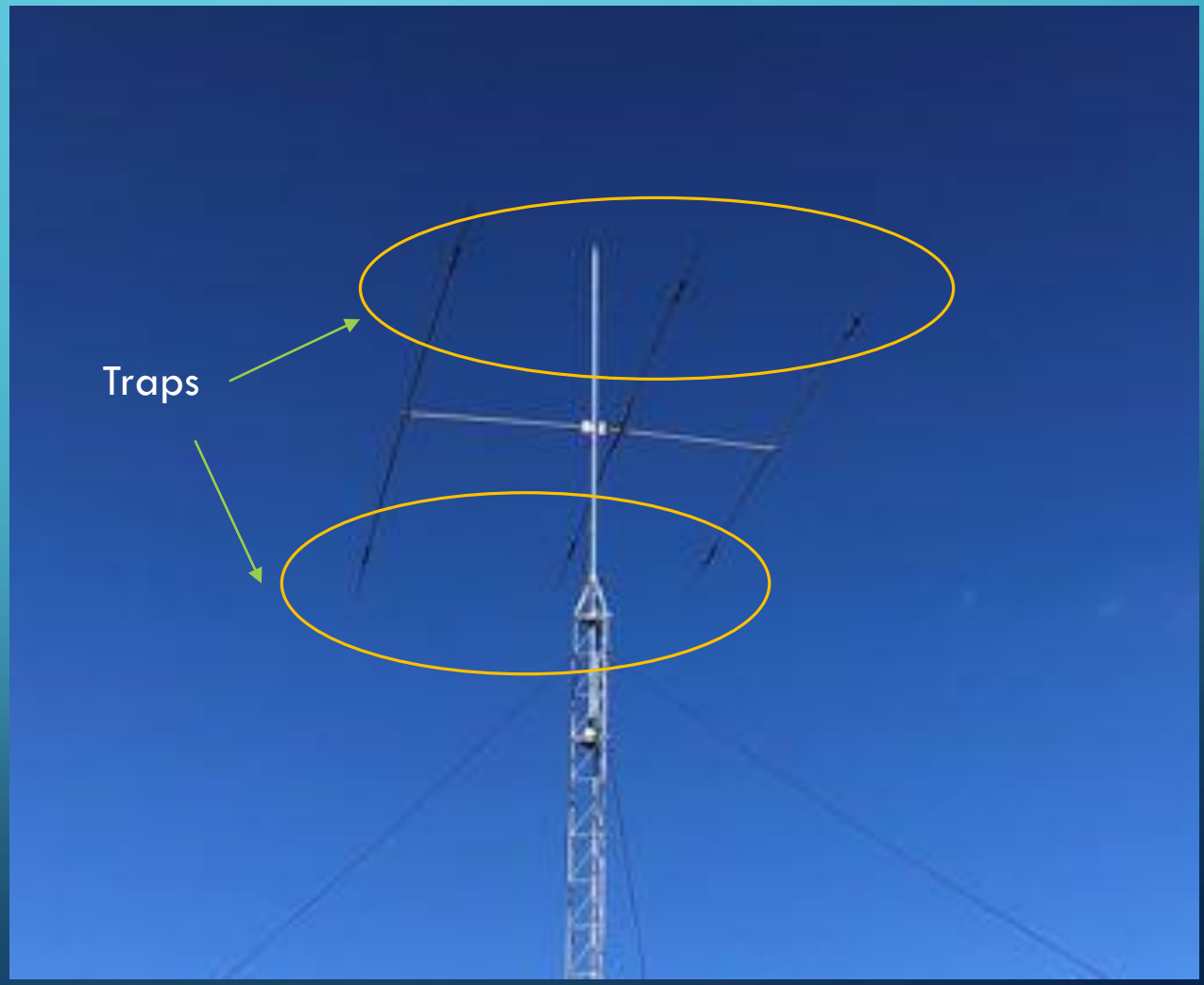
MOSELY TRI-BAND TRAP CAUSING 20M ISSUES

- Used Ohmmeter to ensure connection of coil end to tubing
- Reassembled trap component into trap & trap back onto antenna element
- SWR check using antenna analyzer and transceiver revealed working, functioning 10/15m trap allowing 20m to work properly
- QSOs made w/ triband antenna using low during normal operating
- ~650 QSOs made w/ triband using high power (1KW) in both the 2019 CQWW SSB Contest & 2019 CQWW CW Contest operating on 10/15/20m

Grid Dip Meter or Antenna Analyzer was not needed since this issue was due to faulty coil connection to the trap

MOSELY TRI-BANDER PERFORMING WELL

- ALL TRAPS checked, cleaned, & new end caps installed
- One trap rivet repaired with new rivet
- Old rusty screws replaced with stainless steel screws to hold protective trap tube in place



FOUR (4) KEY THINGS TO REMEMBER

RF Energy

1. Tribander trap's resonant circuit operating the highest frequency is closest to the boom (10m traps closest to the boom)
2. Tribander trap's lowest frequency (20m) is found operating closest to the end of element
3. Trap acts as a "open" switch (high Z state) if RF energy fed is equal to the trap's resonant frequency
4. Trap acts as an "closed" switch (low impedance) if RF energy fed is at a frequency other than the traps resonant frequency

Conclusions

- Now you know all you need to know about tribander & traps…
- Almost every ham at one point in the hobby has owned or used a tribander with good performance
- Tribanders can help DXers achieve DXCC & Honor Roll on multiple bands if maintained [concept also applies to wire dipoles]

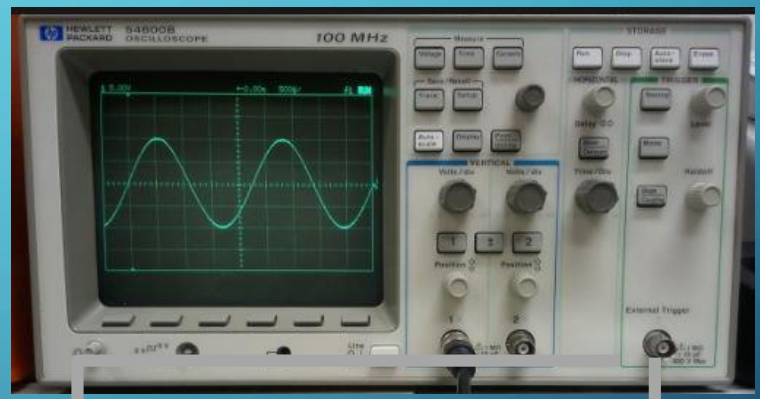
Continue to use those tribanders (new or old)
GUD DX!

REFERENCES

- ARRL Antenna Handbook
- ARRL Handbook
- W6SAI Antenna Handbook (Hard Cover)
- Other…Various internet articles
  - http://www.mosley-electronics.com
  - http://www.hy-gain.com
  - http://www.arrl.org
- Coaxial Trap Designer by VE6YP (Tony Fields)

QUESTIONS?

TRAP TEST SET-UP



LIVE DEMO CHECKING TRAP

- Items needed for demo:
  - Rig Expert Antenna Analyzer with 10cm coil installed
  - Trap
  - Good ideas & recommendations