Antenna Traps, Baluns & Ununs

- **My background**
  - **First years in electronics and ham radio**
  - **Middle years in electronics**
  - **Now (old new ham)**

- **Disclaimers**
  - **Limited builds**
  - **Limited testing**
  - **No formal antenna education**

- **Goals**
  - **Desire for better performance than noted in posts or advertising required me to build and test**

- **Need test equipment…Antenna analyzer, RLC meter, Field strength meter etc.**

- **Need parts, toroids, wire, connectors, adapters, coax., capacitors, resistors etc.**

- **New antenna builds and planned builds**
  - **Built a 20/40 meter antenna with traps from Pacific Kits (no Balun design)**

  - **Built a two band 20/40 meter end fed vertical**
    - **Requires Unun (2450 ohm impedance)**
    - **Built Unun with excellent results SWR 1.03:1**
    - **Antenna (pivoting at base 65' fiberglass pole)**
    - **Now 20 meter only…top of pole too bendy**

- **40 meter folded dipole**

  - **Construction details …made from 300 (272) ohm ladder line with ladder line feeder**
  - **Required 5.44: 1 Balun (feeder to coax), 272 to 50 ohm**

- **10-20 meter dipole**

  - **Pole on chimney to pole on hill in back yard**
  - **Requires 2 ten meter traps, a 1:1 Balun and a 75:50 ohm impedance transformer (Unun)**
  - **Plan to add the 2 new 20 meter traps soon**

- **The following URLs provide a good description of antenna traps, what they can do and how they work.**

- **https://www.youtube.com/watch?v=EdcZDlNWlGo How does a trap work. Waters & Stanton**

- **https://www.youtube.com/watch?v=z86mYwFOlxQ How traps work. Dave Kasler**

- **https://www.youtube.com/watch?v=lZM-SxSyC5A How traps work.**

- **My summary of Traps:**
  - **They are very useful for multiband antennas.**
  - **They “narrow the bandwidth” a little.**
  - **They reduce the overall length of the antenna by anywhere from 10 to 25 %**
  - **Build the traps small to reduce wind profile**
  - **Don’t use coax for traps, easy but very big**
  - **Use polycarbonate tubing for coil form**
  - **Use magnet wire for the coil**
  - **Use high voltage (1-6 KV) capacitor inside coil form**

- **What I found on the internet and some books**

  - **Build your own Baluns, Ununs & Traps**
  - **What were the claims**
  - **What were the results of testing theirs and mine**
  - **See list of URLs …some very good** https://www.youtube.com/watch?v=P7wW4TtXmc8

- **What I started with and where I am now**

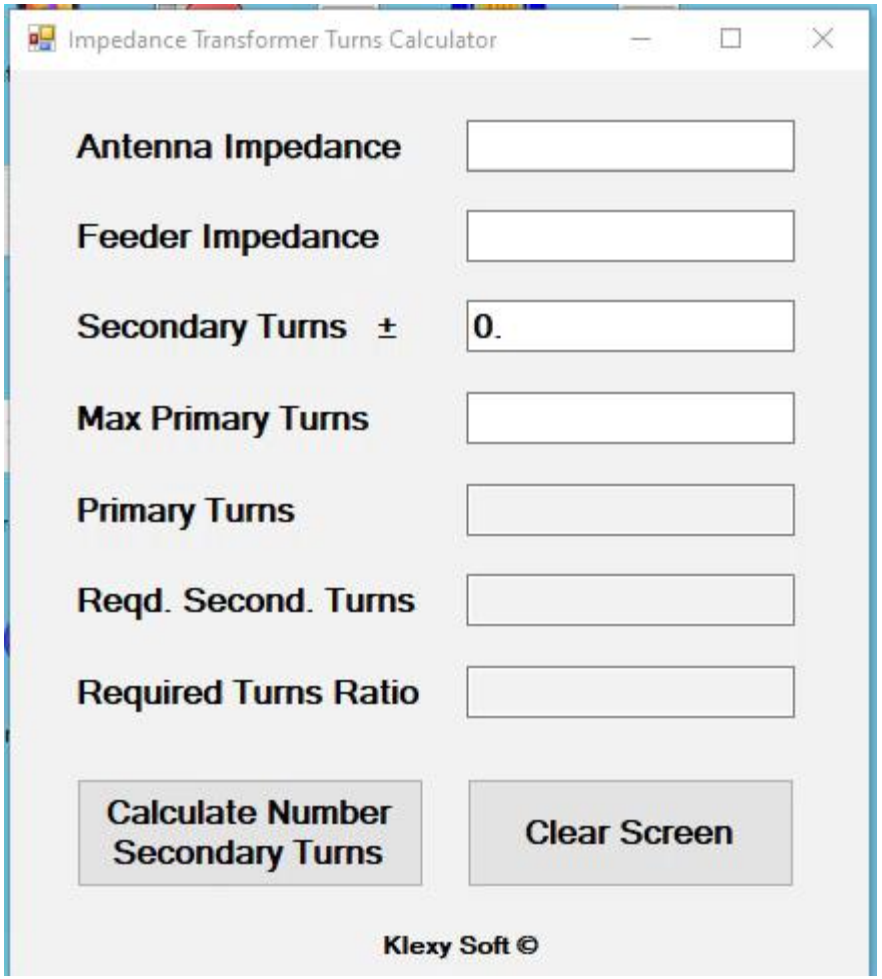
  - **Built many prototypes to gain experience**
  - **Desire to build exact impedance matches**
  - **Developed small program to eliminate the grunt work calculations**

➢ Impedance Transformer Turns Calculator Program

- **We need to calculate the impedances ratio and take the square root, because the square root gives us the required turns ratio**
- **Starting with a primary of 2 turns, calculate the number of secondary turns to satisfy the turns ratio calculated above**
- **Since the answer will probably be a decimal number, the decimal portion being a partial turn, we need to determine what decimal value is acceptable…I recommend less than 0.1 turn**
- **Determine an acceptable number of primary turns based on core size, wire size and power**

What does the program do…

- The program will run by increasing the primary turns by 1 and calculating the required number of secondary turns
- This process will continue until a satisfactory answer is obtained, showing the smallest number of primary turns and the corresponding number of secondary turns in a decimal number that meets the criteria entered for a fraction of a turn
- The program will also show the required turns ratio in a decimal number at the bottom
- You can readily see how much grunt work is eliminated


Impedance Transformer Turns Calculator
Antenna Impedance
Feeder Impedance
Secondary Turns ±
0.
Max Primary Turns
Primary Turns
Reqd. Second. Turns
Required Turns Ratio
Calculate Number Secondary Turns
Clear Screen
Klexy Soft ©

➢ What I have learned

- **Autotransformer what is it?**
- **Standard Transformer How is it different?**
- **How does bifiler, trifiler, quadrifiler, quintufiler winding differ from single winding**
- **How do you choose a core…Iron powder mix 2, 8 or Ferrite 31, 43, 61, K**
- **Test the core to find out what it is and how good is it for the band(s) of interest**
- **Should I stack up cores and if so how many?**
- **What size wire should I use and what kind of insulation?**

- **What are the results of my efforts**
  - **Many prototypes using different core materials, wire sizes and spacing**
  - **20 meter Unun SWR I.01:1 at 14.204 Mhz for vertical**
  - **40 meter Balun SWR 1.02:1 at 7.160 Mhz can be moved up in frequency with wire trimming**
  - **Small 10 meter traps built for 10/20 meter dipole**
  - **Prototypes: 1:1 Balun and 1.5:1 Unun Built for 10/20 meter dipole (now complete 1-11-2021)**

➢ Conclusions

- **It is very possible to use other turns ratios to obtain more exact impedance transfers**

- **Using a turns ratio of 17 turns primary and 40 turns secondary I obtained an exact match of 272 ohms to 50 ohms at 7.190 Mhz…SWR 1.01:1**

- **When building an auto transformer it doesn't matter if you tap the windings or repeat them…i.e., double the primary turns or twist them etc.**

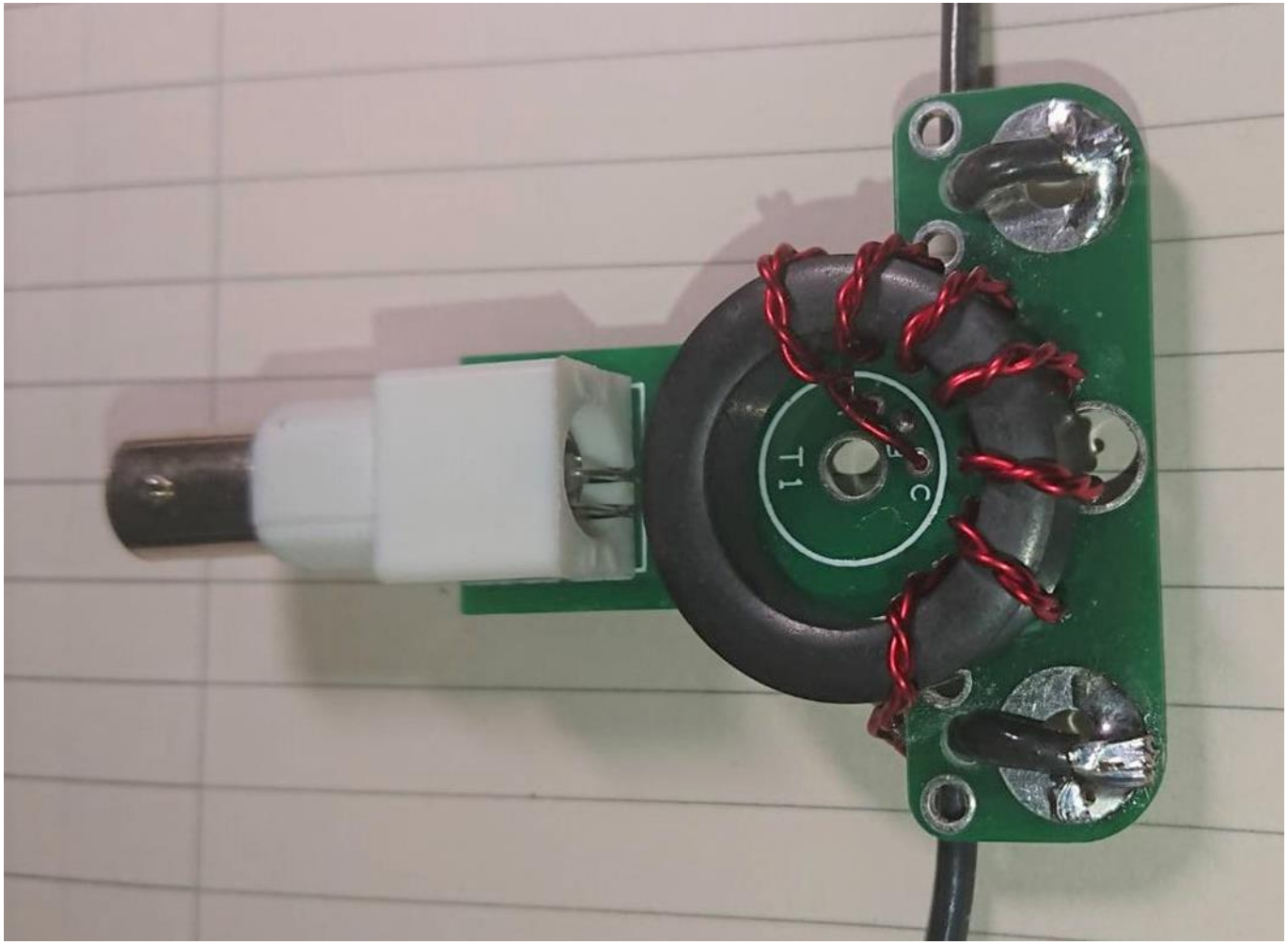
➢ Recommendations

- **Do what you want…wind your own**
- **Wind tight around the core**
- **Input side usually requires some capacitance Optimize value using antenna analyzer**
- **When winding bifilar, trifilar etc. keep spacing between adjacent wires tight but maximum space between winding groups**

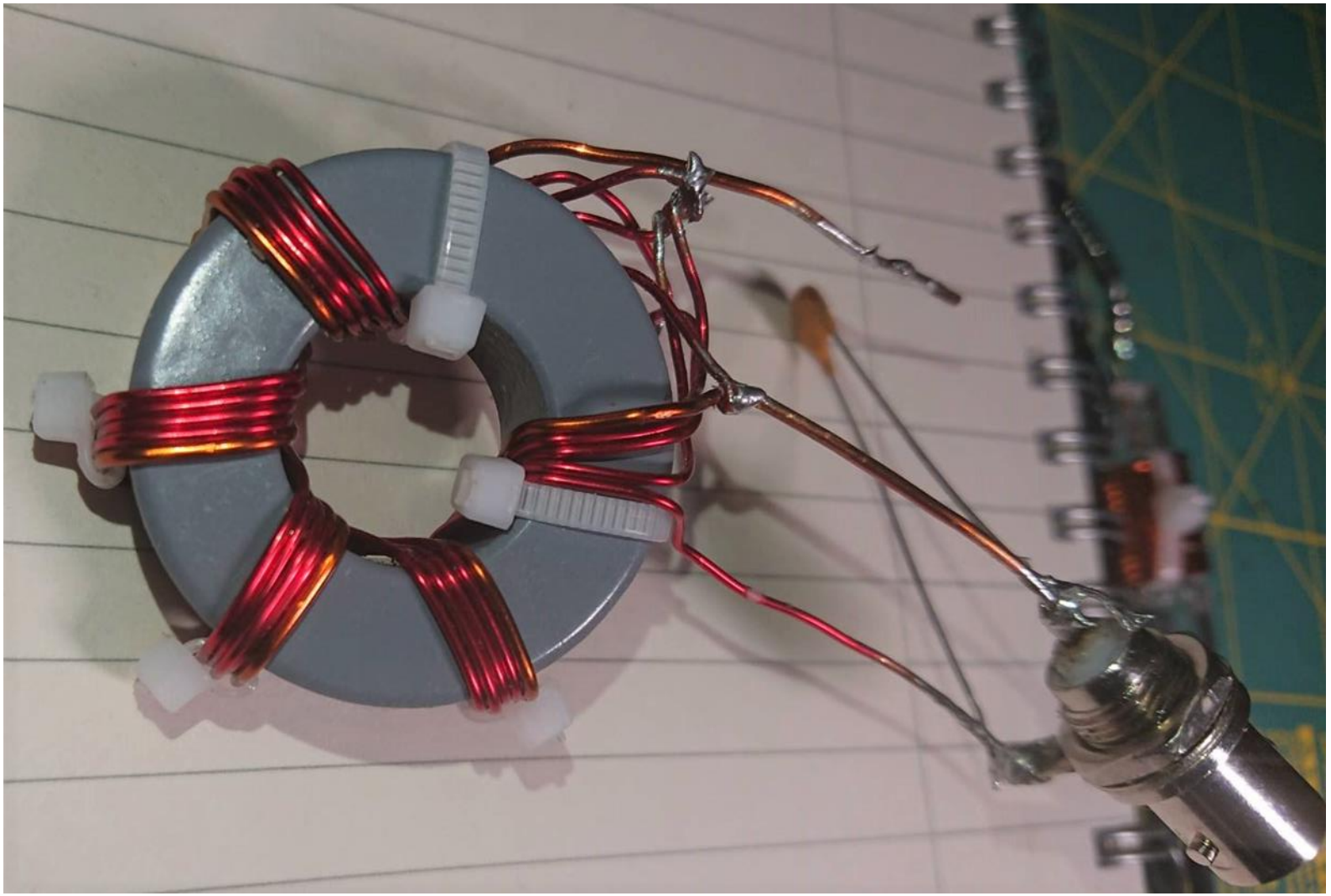
➢ Pictures of my efforts

- **Tee to hold feed line to folded dipole antenna**

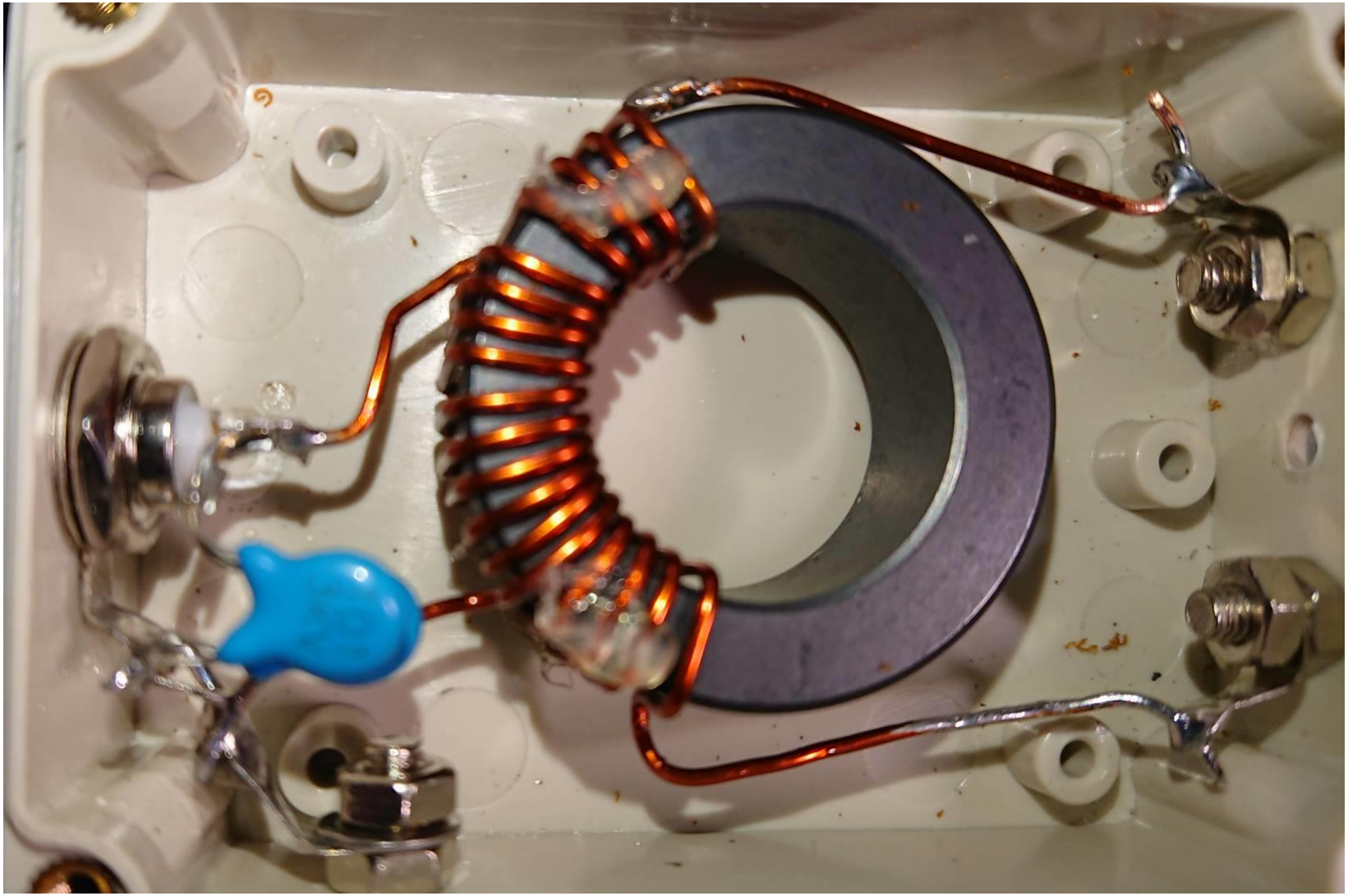
- **Tee to hold dipole and 1:1 Balun for $^{10}/_{20}$ meter antenna**



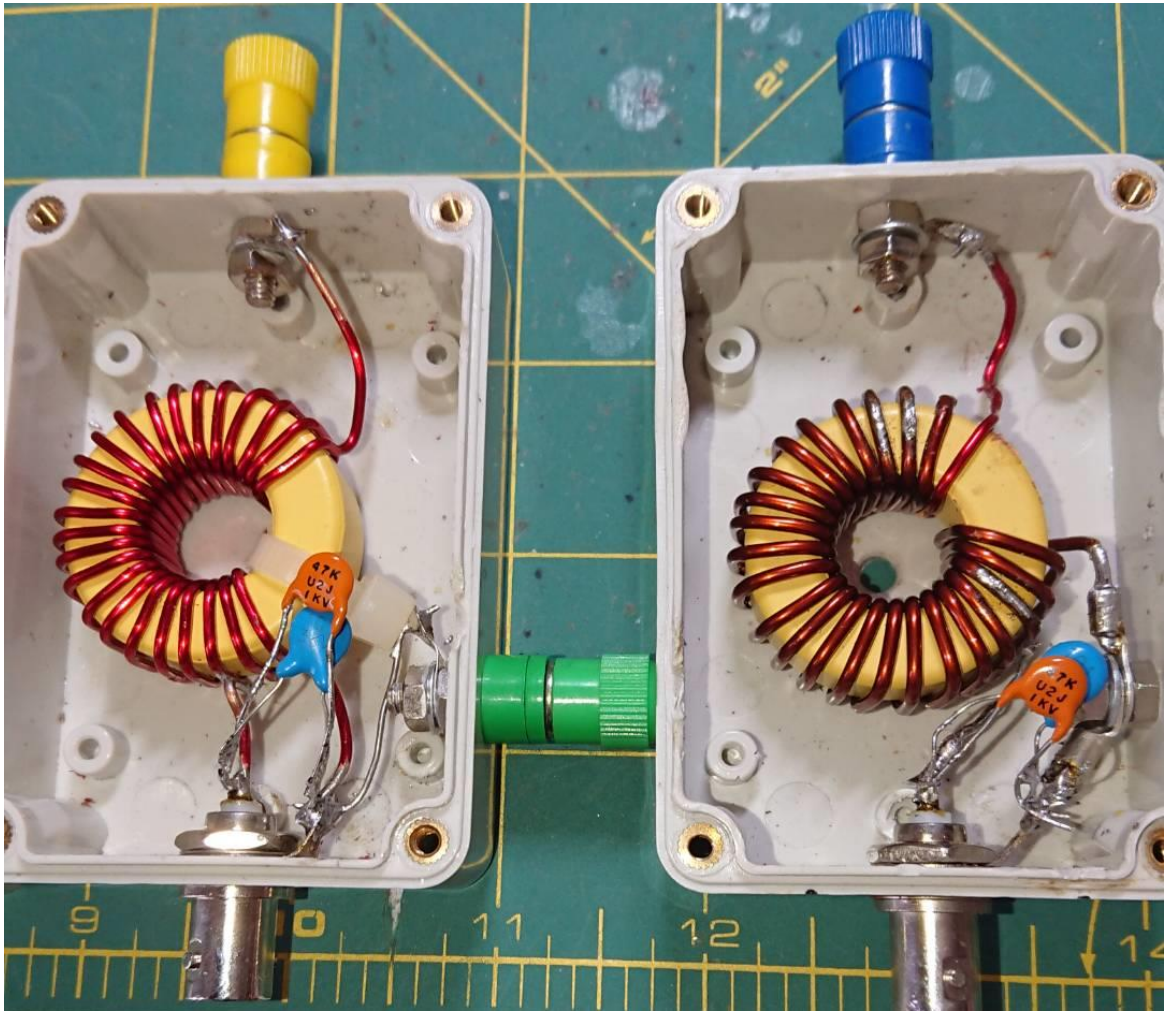
- **Prototype 50 to 75 ohm Unun for $^{10}/_{20}$ meter dipole**



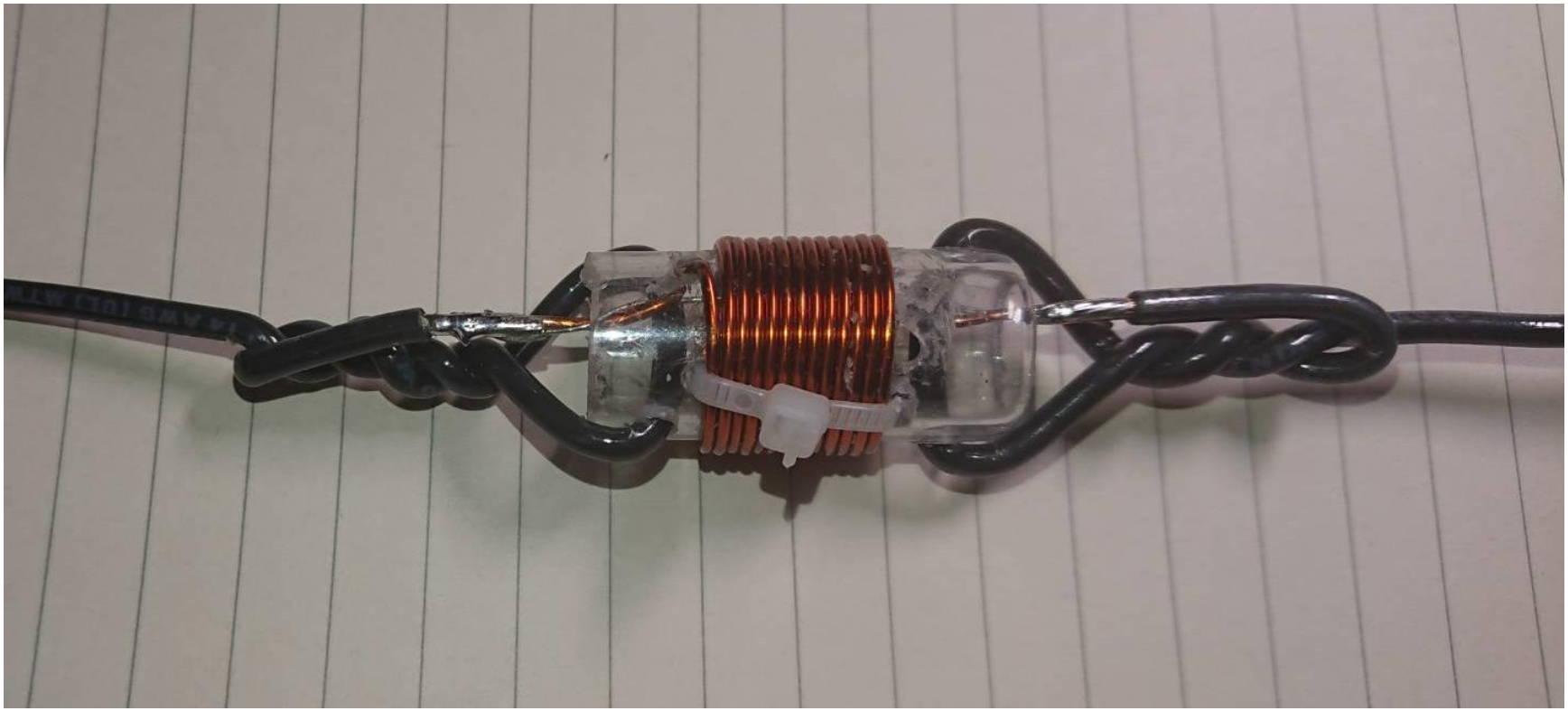
- **Impedance transformer 5 T 12 T interwoven**



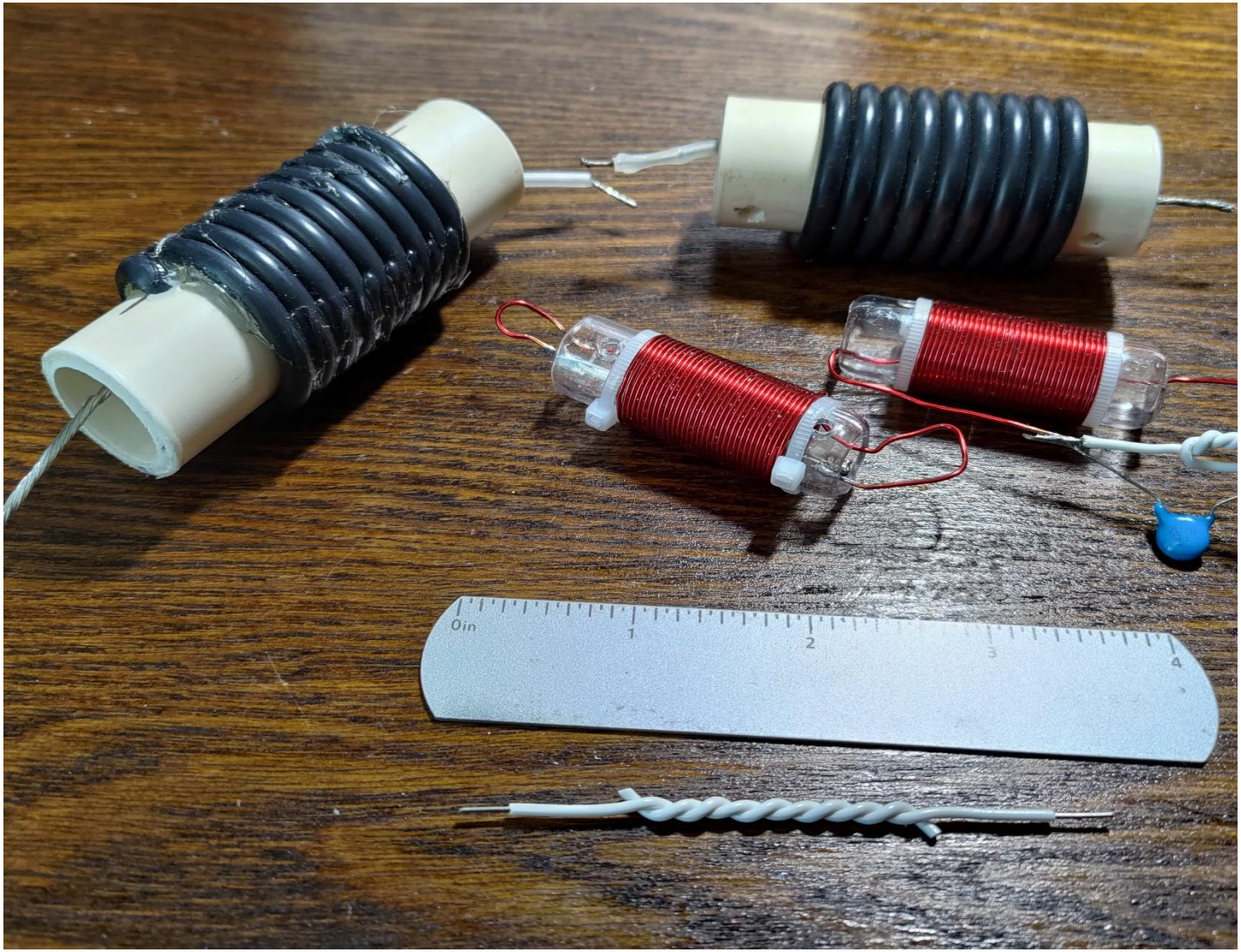
- **Auto transformers with tap on single winding**



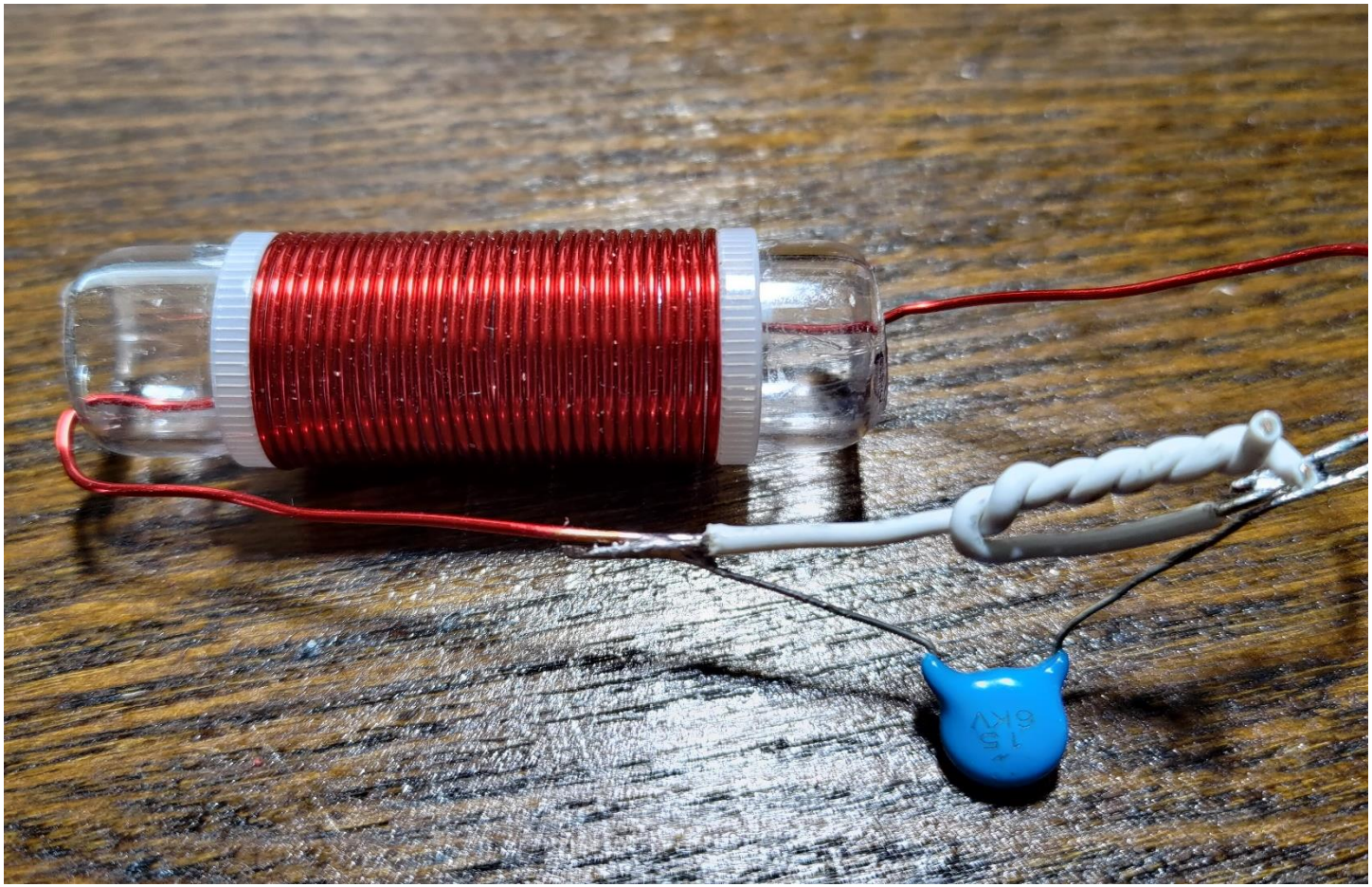
- **10 meter trap (15pf 6kv capacitor inside 5/8” polycarbonate form)**



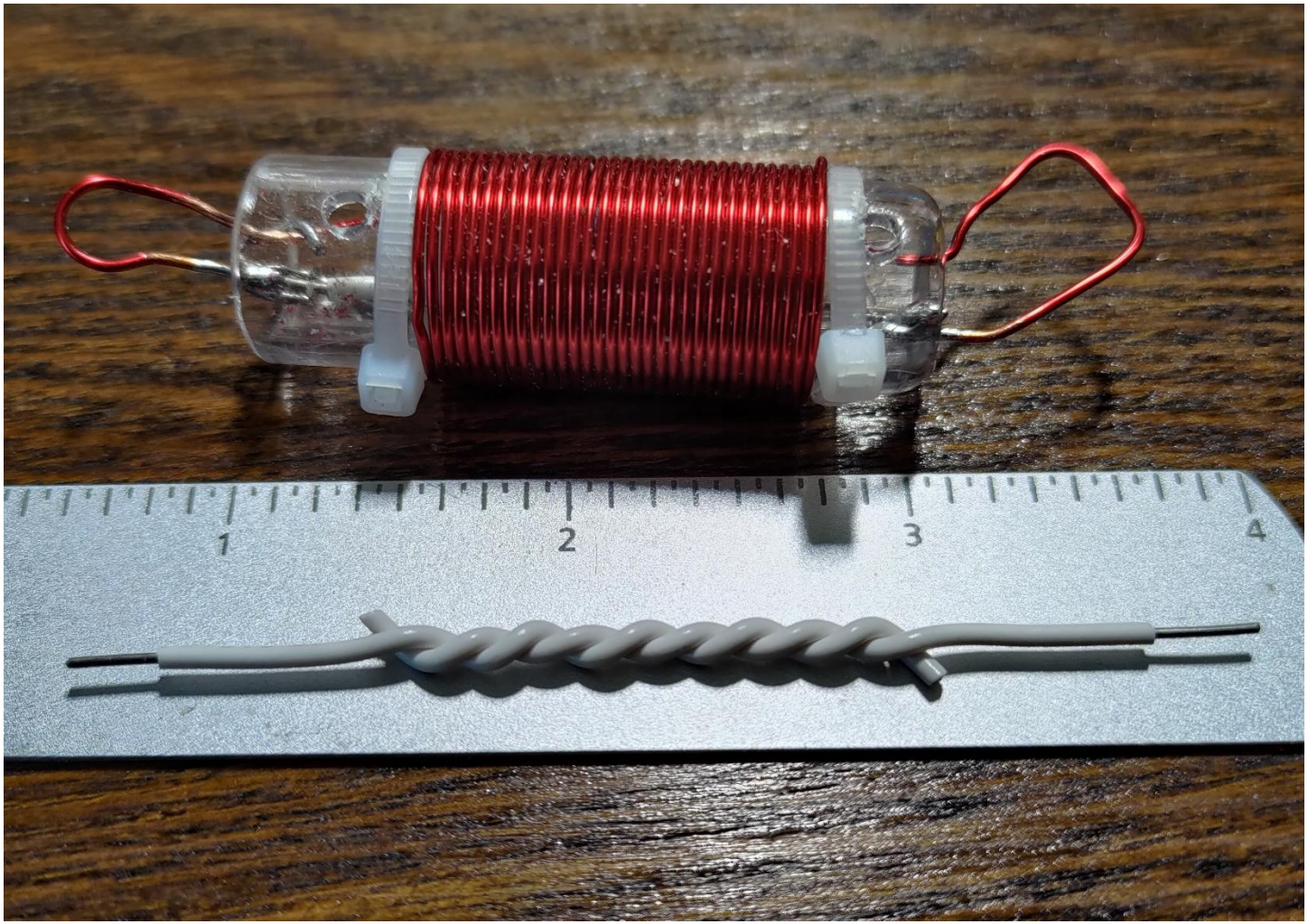
20M traps on PVC 1” pipe and 20M traps on 5/8” polycarbonate tubing



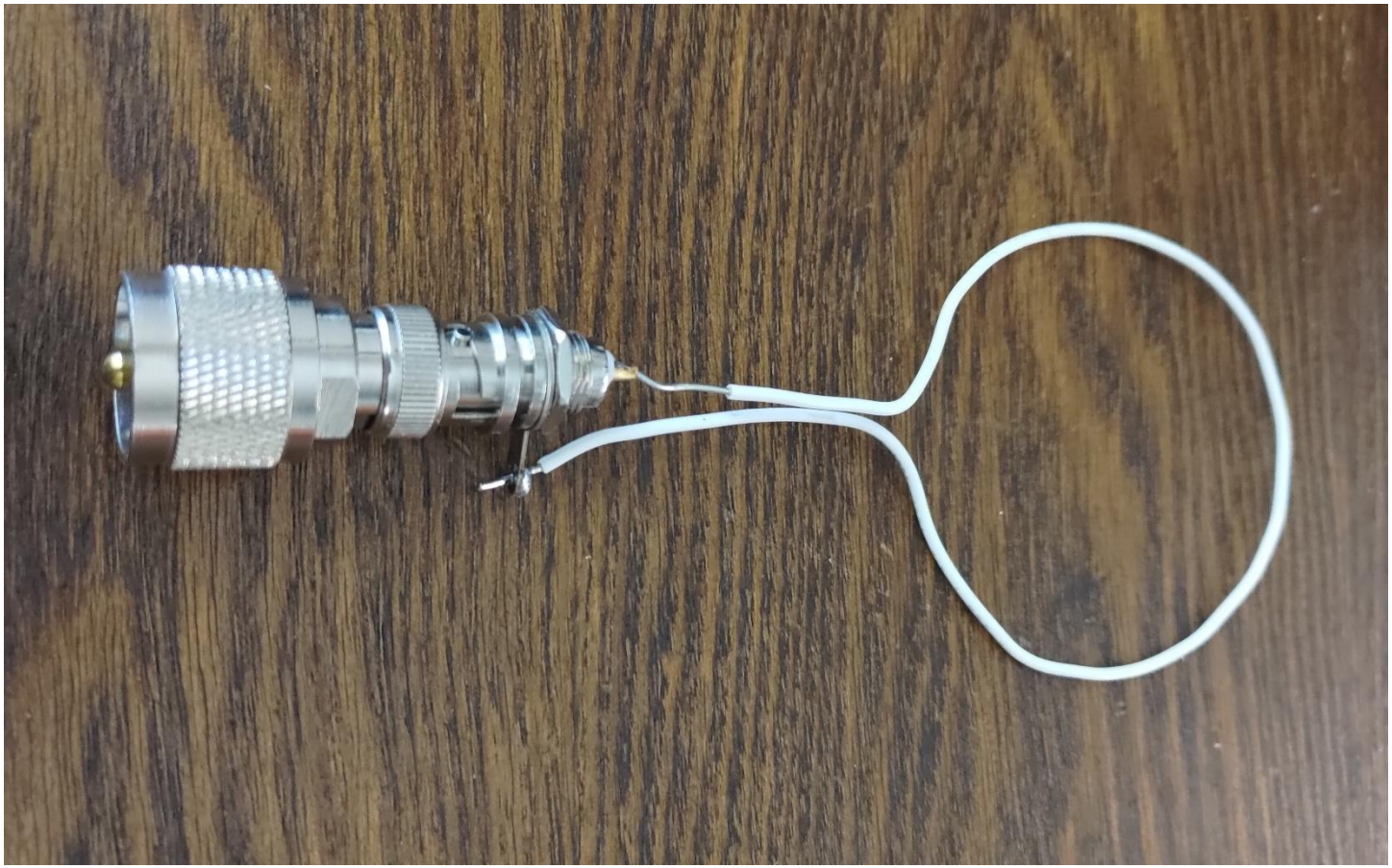
20 meter trap with 15pf 6kv and 2.7pf 1.2kv cap 5/8” dia form



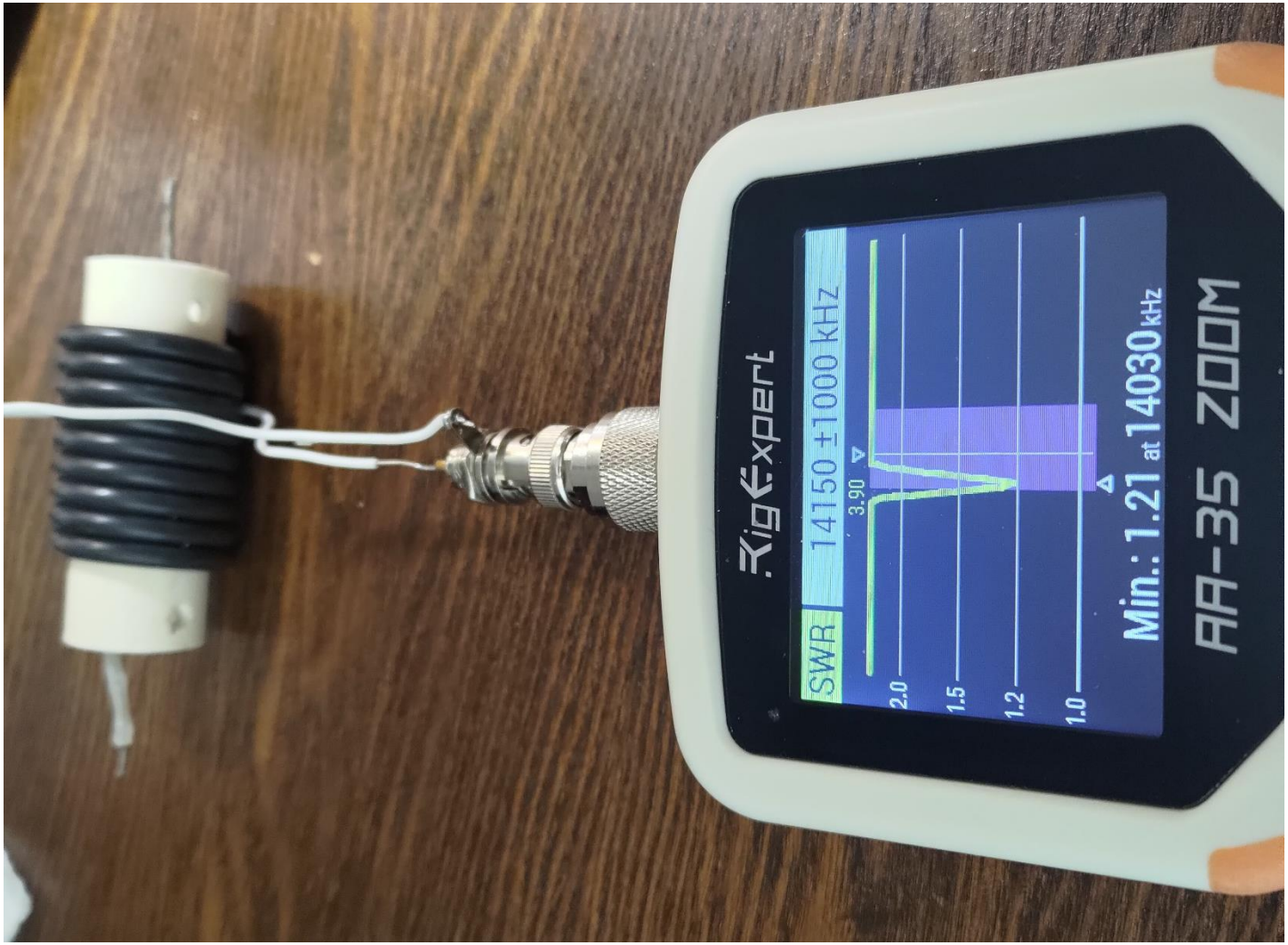
20M trap with 20 ga magnet wire on 5/8 dia polycarbonate tube
4.7pf 1.2kv cap made with 20 ga hookup wire for tuning 15pf inside



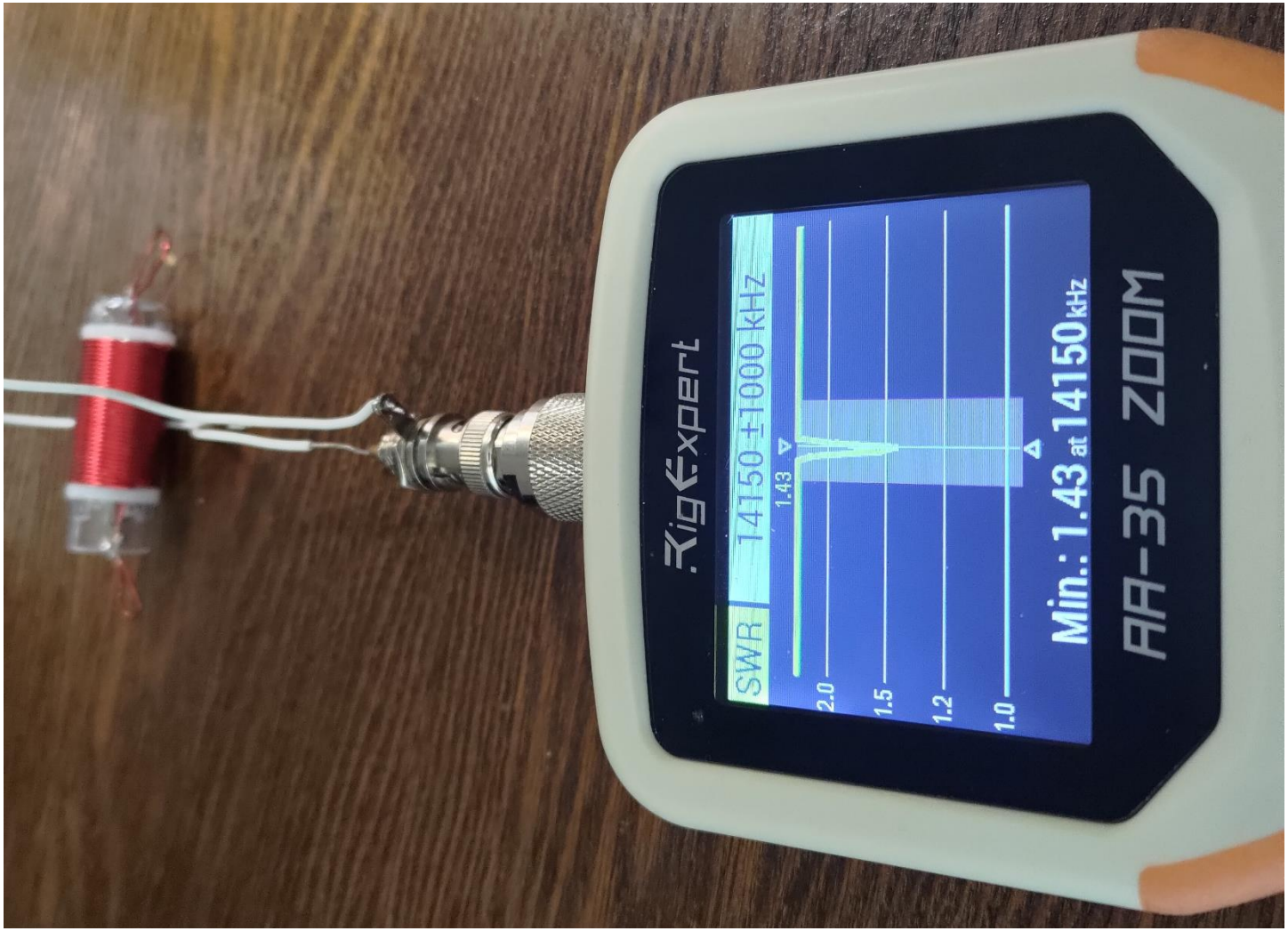
Loop for measuring resonate frequency of trap connect to Antenna analyzer



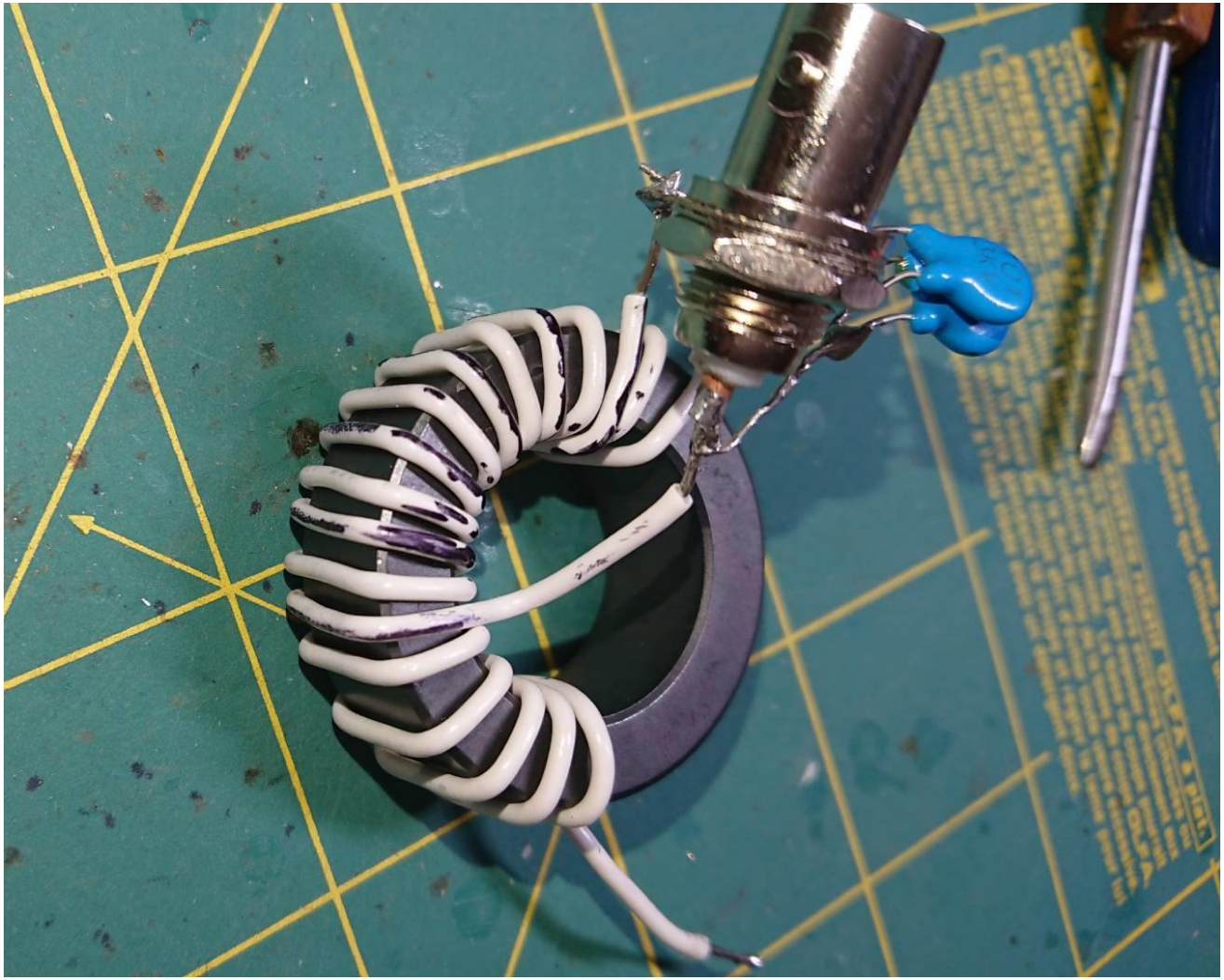
Measuring resonate frequency 14.030 MHz on “large” trap



Small 20M trap shows resonance at 14.150 MHz



- **Test of primary turns between secondary turns**



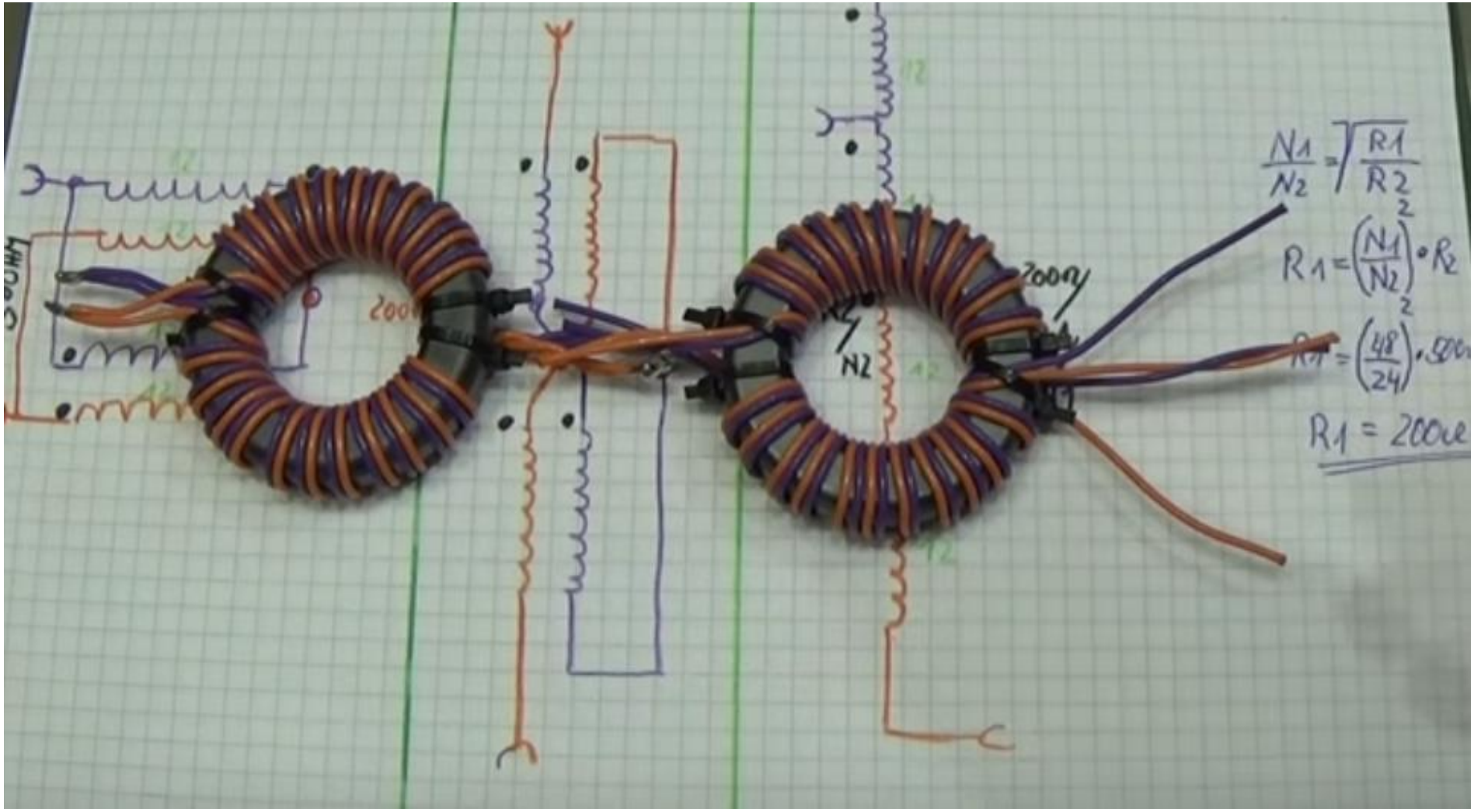
- **Sevick Says (in my words)**

  - **Magnetically coupled transformers will transform impedances with a typical/expected loss of 1 db.**

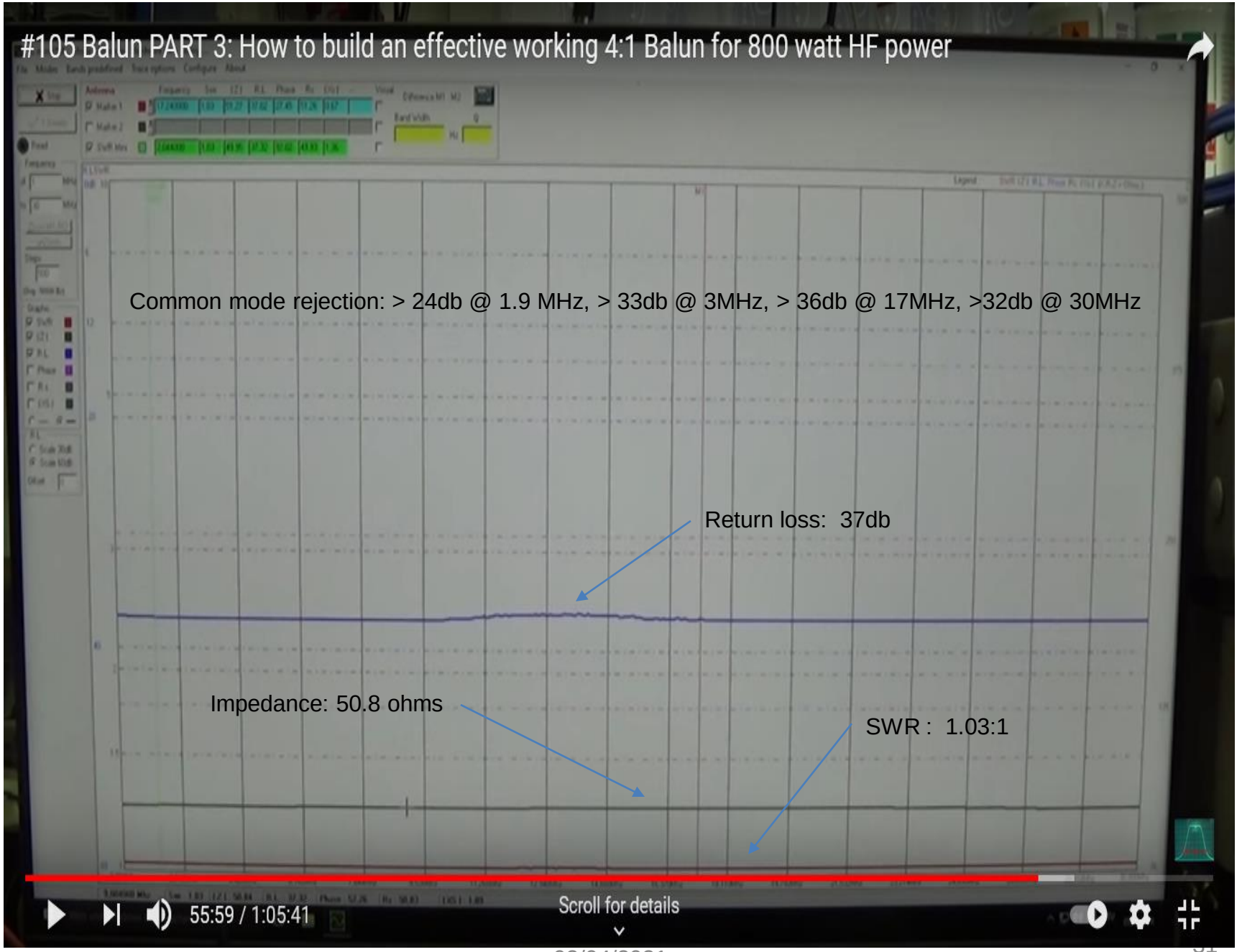
  - **Since they use magnetic flux for transferring energy to the output, the flux capability of the core is very important. Permeability of iron powder cores are generally too low. Ferrites cores are required.**

  - **Transformers using bifilar, trifilar, quadrifilar or quintufilar type windings behave like transmission lines. This means more power can be transformed with less cross-sectional area core material, (magnetic flux).**

- **Sevick says (continued in my words)**
  - **Wire spacing is critical in multifilar winding transformers**
  - **Transmission line transformers can have a loss as little as 0.2 db over the range of 1 to 200MHz, much better than their magnetic counterparts.**
  - **Transmission line transformers exhibit far wider bandwidths and much greater efficiencies**.
  - **Sevik's basic building block is the Guanella 1:1 balun (current balun)**
  - **See the build and the test results of TRX Bench Test frequency sweep is 1 MHz to 30 MHz**


N1/N2 = √(R1/R2)
R1 = (N1/N2)² · R2
R1 = (48/24)² · 50Ω
R1 = 200Ω
200Ω
N2


#105 Balun PART 3: How to build an effective working 4:1 Balun for 800 watt HF power
53:11 / 1:05:41
Scroll for details


#105 Balun PART 3: How to build an effective working 4:1 Balun for 800 watt HF power
Common mode rejection: > 24db @ 1.9 MHz, > 33db @ 3MHz, > 36db @ 17MHz, >32db @ 30MHz
Return loss: 37db
Impedance: 50.8 ohms
SWR : 1.03:1
55:59 / 1:05:41
Scroll for details

➢ What's next

- **Rebuild some of my conventional baluns and ununs using the transmission line transformer concepts**
- **Add a coaxial antenna switch … done**
- **Watch carefully for any degradation or change in performance of my antennas, baluns, ununs or traps**
- **Consider adding a linear amplifier … done**

URL References

https://www.youtube.com/watch?v=hdTXQ9W_VsQ	Look for counterpoise information near end various ununs
https://www.youtube.com/watch?v=xfqlun3bdI0	HWEF antennas
https://www.youtube.com/watch?v=BpdpkUEW39o	Australian HWEF Vertical on 20 meters
https://www.youtube.com/watch?v=V0LkXnEZ0Nk	End-Fed Wire
https://www.youtube.com/watch?v=0zF7bDoqkG4	EF Multiband
https://www.youtube.com/watch?v=qddvFMgGKJo	9:1 Unun
https://www.youtube.com/watch?v=2M9Aep6DHz8	Another 9:1 Unun
https://www.youtube.com/watch?v=MOSf-k3ofUY	MYANTENNAS EFHW-8010 End Fed Antenna
https://www.youtube.com/watch?v=QLwwzUXN3rU	EFHW Compensation Coil Experiment
https://www.youtube.com/watch?v=Z7-FYm6r5jc	End Fed Half Wave Antenna -11 Bands
https://www.youtube.com/watch?v=Ree8NtpEEW4	Balun's magic and how to wind an effective working Balun
https://www.youtube.com/watch?v=JhAPJISUjB8	4:1 Balun Bifilar VERY GOOD RESULTS FT-240-43
https://www.youtube.com/watch?v=P7wW4TtXmc8	Testing 9:1 UNUNs, T106-2 VS FT-140-43
https://www.youtube.com/watch?v=wXELRYBBunQ	Type 43 vs type 2 toroids, comparing 9:1 UNUNs
https://www.youtube.com/watch?v=T_oxbMS5J6o	A Look At A 9:1 Un-Un Bad core
https://www.youtube.com/watch?v=B8hM7CvX7zY	1:1 Baluns. Myths, Facts and Fiction
https://www.youtube.com/watch?v=q_Wn9c8HwcA	The effect of a 1:1 balun on a resonant dipole
https://www.youtube.com/watch?v=QFOx7vjchy0	1:1 Balun for HF Dipole Antennas, Part 3 of 5
https://www.youtube.com/watch?v=0pC1UzxiMOE	Pacific Antenna 20/40 Meter Dipole
https://www.youtube.com/watch?v=2VFeNmgstgA	

URL Reverences, Cont..

https://www.youtube.com/watch?v=rI-nl0DFjEM&feature=emb_rel_end
Conventional Transformers vs Auto…
http://www.aa5tb.com/efha.html The End Fed Half Wave Antenna
https://www.huyettm.net/end-fed-half-wave-antenna.html Building an End Fed Half Wave Antenna
https://m0ukd.com/homebrew/baluns-and-ununs/end-fed-half-wave-antenna-tuned-coupler-efhw/
https://www.youtube.com/watch?v=PKJ77POxQdE How to shorten the antenna with a loading coil
http://www.catzco.com/toroids.htm Toroid core information
https://coil32.net/online-calculators/determine-toroid-core-permeability.html
Calculating characteristics of an unknown ferrite
https://www.mwrf.com/technologies/components/article/21846619/designing-wideband-rf-impedance-transformers Very good article
https://duckduckgo.com/?t=ffab&q=how+to+chose+a+toroid+core&iax=videos&ia=videos&iai=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DYh7_XuHqbRI Core analysis
http://toroids.info/T200-2.php Toroid table (standard sizes)
https://www.youtube.com/watch?v=XjtE_SZjQ-g Antenna Loading with Coils
https://www.edn.com/book-excerpt-sevicks-transmission-line-transformers-baluns/
GOOD STUFF
https://www.edn.com/book-excerpt-sevicks-transmission-line-transformers-chapter-9-baluns-part-2/
https://www.eznec.com/Amateur/Articles/Baluns.pdf Old but good article on baluns

Text References

- Quotes from Sevick's Transmission Line Transformers Theory and Practice 5th Edition

There are two basic methods for constructing broadband impedance matching transformers. One employs the conventional magnetically coupled transformer that transmits energy to the output circuit by flux linkage; the other uses a transmission line transformer to transmit energy by transverse transmission line mode. Conventional transformers have been constructed to perform over wide bandwidths by exploiting high magnetic efficiency of modern materials. Losses on the order of 1 dB can exist over a range from a few kilohertz to over 200 MHz. Throughout a considerable portion of this range, the losses are only 0.2 dB. Transmission line transformers exhibit far wider bandwidths and much greater efficiencies. The stray inductances and interwinding capacitances are generally absorbed into the characteristic impedance of the transmission line. The flux is effectively canceled out in the core with a transmission line transformer, so extremely high efficiencies are possible over large portions of the passband —losses of only 0.02-0.04 dB with certain core materials.

Text References continued

Quotes from Jerry Sevick's W2FMI Transmission Line Transformers

Transmission line transformers have been in existence for more than four decades. The earliest presentation on transmission line transformers (TLT) was by Guanella in 1944. He said TLTs are basically low-impedance devices. TLTs are unilateral devices. For example, a 4:1 transformer is designed for 50 ohms to 12.5 ohms or 50 ohms to 200 ohms. But not both. The bandwidth in the favored direction will be twice as great as in the other direction.

Sevik's theory, have the characteristic impedance of the transmission line equal to the value of the load and to have the choking reactance much greater than the load, resulting in a flat line high frequency response and maximum efficiency since conventional transformer currents are suppressed.

TLTs are completely different from conventional transformers. They are a combination of RF chokes and a configuration of transmission lines. Therefore, their designs and applications involve conventional transmission line theory, RF choke limitations, core losses and parasitics.

Sevik's basic building block is the Guanella 1:1 balun (current balun)

Text References continued

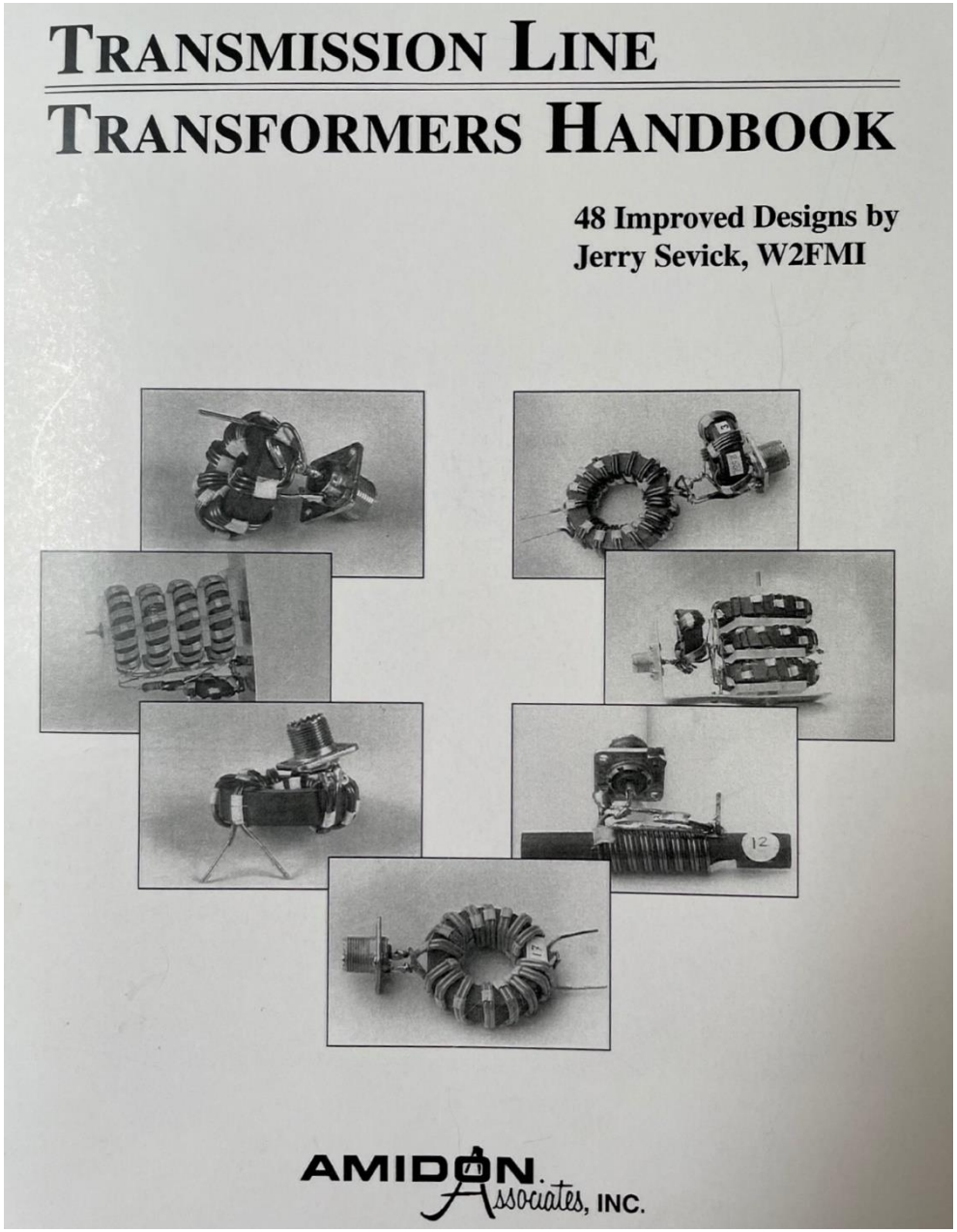
- Quotes from Jerry Sevik W2FMI continued

By combining coiled transmission lines in parallel-series arrangements, Guanella was able to demonstrate very broadband baluns. Having sufficient separation between bifilar windings on a core, results in near ideal transformers Further, Guanella's baluns can also be easily converted to very broadband ununs by accounting for their low-frequency circuit models.

TLTs are difficult to construct because of the sensitivity of their high-frequency responses to the characteristic impedances of the windings and hence the spacing of the windings.

At low characteristic impedance levels, a difference of only 6 mils in spacing can change the characteristic impedance from 45 ohms to 55 ohms. This could lower the high frequency response from 30 MHz to 20 MHz.

According to Amidon Associates, Inc., ferrite cores with permeabilities in the range of 250-300 are best for these transformers/baluns/ununs. Using cores with permeabilities below 40, e.g., iron powder cores, results in poor low frequency response.


TRANSMISSION LINE
TRANSFORMERS HANDBOOK
48 Improved Designs by
Jerry Sevick, W2FMI
AMIDON Associates, INC.

Impedance Transformer Calculator Instructions

The task is to determine how many turns of a primary winding and how many turns of a secondary winding will provide a very close match of an input and an output impedance. These are the steps to perform and the algorithm performed by the Impedance Transformer Calculator.

1. Enter the antenna impedance at the feed point, e.g., 74 ohms at the center feed point of a dipole.
2. Enter the feed line impedance where the feed line connects to the antenna, e.g., 50 ohms.
3. The program will divide the antenna feed point impedance value by the feed line impedance value.
4. The square root of this division is the desired turns ratio for the Balun or Unun.
5. Enter the maximum turns fraction you will allow, e.g., 0.02 turns. This means you will not allow a half turn (0.5) in the number required for the secondary but you will tolerate a plus or minus 2% of a turn in you calculation.
6. Enter the maximum number of turns you will allow on the primary. The maximum possible value that the toroid can hold can be found on the internet…look for toroid charts. The maximum number is based on wire size and the diameter of the toroid. The Impedance Transformer Calculator program will look for the lowest number that meets the turns fraction that you entered in 5. above.
7. Click on the calculate button and the program will start with 2 turns on the primary. It will multiply the two turns by the result of the calculation in step 4 above.
8. The program will compare the results of step 7 with the maximum allowable partial turn entered in step 5. If the calculation results exceed the value in 5 above it will try 3 turns for the primary and then compare again. This will continue until the value of number of turns fraction, i.e., 2% in this example are not exceeded. The number of primary and secondary turns will be shown. Note the secondary turns number will be a decimal number with the decimal portion of the number less than or equal to the value in 5 above.
9. We now know how many primary and how many secondary turns we need to match very closely the two impedances.
10. There are many other important factors to consider, core material, core size etc.