**Thoughts on end fed antennas and the popular 49:1 and 64:1 ferrite core impedance transformers**

End fed antennas are definitely popular these days. Several factors seem have driven this. The typical “antenna farm” / back garden is much smaller these days with little room available for the extensive radial systems needed for good HF performance with a vertical. An end fed antenna offers the chance of operating over several harmonics of the base frequency with one wire antenna. It also “only” requires a limited counterpoise (or radial) to achieve loading.

Classical end fed antennas have been around from the early days (Zepp antenna matching systems….dating from the original German Zeppelin balloons of the First World War). Typically the matching systems will only tune frequency or Band at a time and require retuning of the matching network for another band.

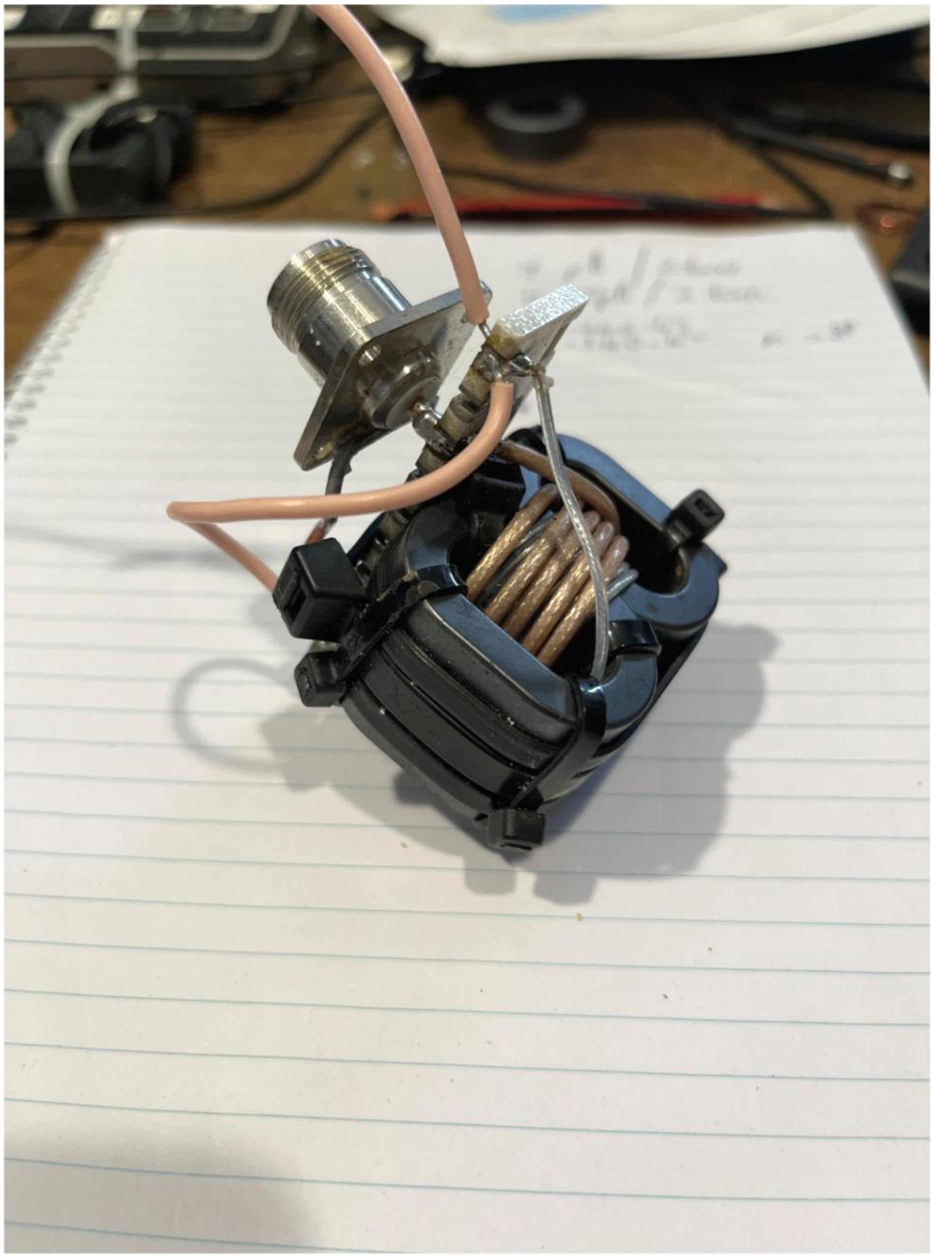
Enter the end fed balun. Actually that’s not correct, the designs popular in the magazines and on line are more correctly un-uns. (Balun being an acronym for balanced to unbalanced transformation). The device is unbalanced in and out but with a voltage transformer ratio of some 7 or 8 times to 1. This translates to an impedance transformation of 49 or 64:1. So typically a ferrite core with an “auto transformer” wound on it where the secondary is typically some 8 , 16 , 24 or 32 turns with a tap at one eighth of the turns for the primary.

If this is used to feed the end fed antenna the high impedance found at the end of the wire can be transformed down to a value that will typically match the output of an HF transceiver without out too much work to be done. Indeed with a suitable counterpoise and trimming of the antenna length a very good match can be made on at least one band.

In should be noted and understood that as higher and higher bands are selected the resonant frequencies and actual impedances at those frequencies will shift slightly band by band, whilst the impedance offered up to the transceiver via the un-un will still be around 50 ohms it will not be a perfect match. It should still be an easy target for standard auto or manual tuner but one will be required.

One of the “problems” associated with using un-un’s is that one must be very careful in the pursuit of a perfect match tuning and tweaking everything in sight. The better the match that one can obtain on different bands without resorting to a tuner can be an indication of poor performance by the ferrite transformer ! I.E. if the ferrite transformer is lossy you may be fooling yourself with apparently good SWR results especially if those results come with a wide band width.

Previously my efforts at feeding an end fed antenna had revolved around using a pair of toroidal cores type “43” wound with two separate windings with a 4 : 1 ratio. The windings used coax inner conductors for high voltage handling and had enough turns that there was no chance of core saturation at the frequencies envisaged. Having reduced the end fed impedance by 16:1 the resulting impedance was then dealt with more normal matching networks on a band by band basis using relay switching. There was no real attempt to tune the length of the antenna to any particular frequency and the impedance presented to the matching networks was “complex” and of the order several hundreds of ohms on each band. The results were “good” in that operation on each band was effective up to a level of 400 watts without ferrite core heating, and lots of 5 9 plus reports were received with reports as far as New Zealand on 40 and 80  Metres.



ORIGINAL 16:1 TRANSFORMER

Many claims of superior operation…….some over very wide band widths were noted both in the press, over the internet, and by local operators. The end fed 64:1 Balun's were being offered by some as a cure to all of one's end fed woes.

I decided to build several of the examples available based on the most popular core materials …type"43" from Fair-Rite. I ordered two types the FT 140 -43 (used for lower power) and the FT 240-43 for higher power operation.

First out I needed to find out what material I was dealing with. My first test with anything magnetic…ferrite or iron is to put a few turns around it and measure its inductance, and from that the inductance per turn. So FT 140-43 2 X turns =4.00 uH and FT 240 -43 2X turns = 4.8 uH.

Dividing by 4 to get the inductance factor of one turn = 1.0 uH and 1.2 uH respectively.

Various designs seem to use 2 , 3 or 4 primary turns without much reason why.

If I use the 240 core with two turns then I'm looking at 4.8 uH of primary inductance. Transformer designers generally like to have the primary impedance to be between 5 and 10 times the source impedance at the lowest frequency of interest. In other words if my primary impedance is 50 ohms, then I would want at least 250 and preferably 500 ohms at my lowest frequency of operation.

At 1.8 MHz 500 ohms = 1 / 2X Pi X 1.8 MHz X uH = 44uH

At 3.5 MHz 500 ohms = 1/ 2X Pi X 3.5MHz X uH = 22.7uH

At 7.0 MHz 500 ohms = 1 / 2X Pi X 7.0MHz X uH =11.3 uH

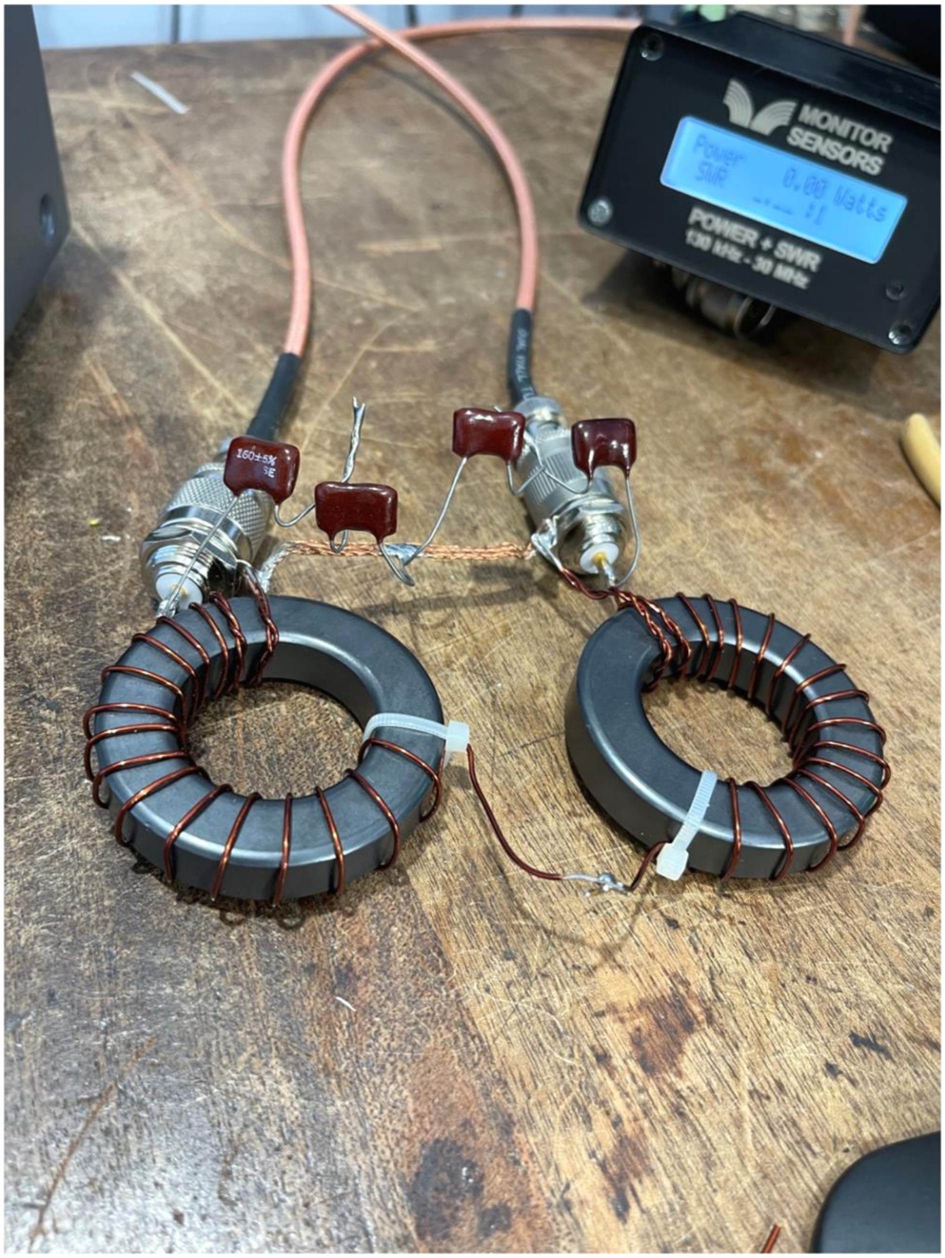
So with two turns and 4.75 uH the core is going to be limited to operation at 7 MHz and above having ~ 250 ohms of primary impedance at that frequency.

I f go for three turns then the inductance will be 1.2 uH X 3 X 3 or 10.8 uH (measured at 10.29 uH) which will just about "do" for operation at 3.5 MHz.

4 turns should give me 1.2 uH X 4 X 4 = 19.2 uH (measured at 18.24 uH) which would be OK for 1.8 MHz.

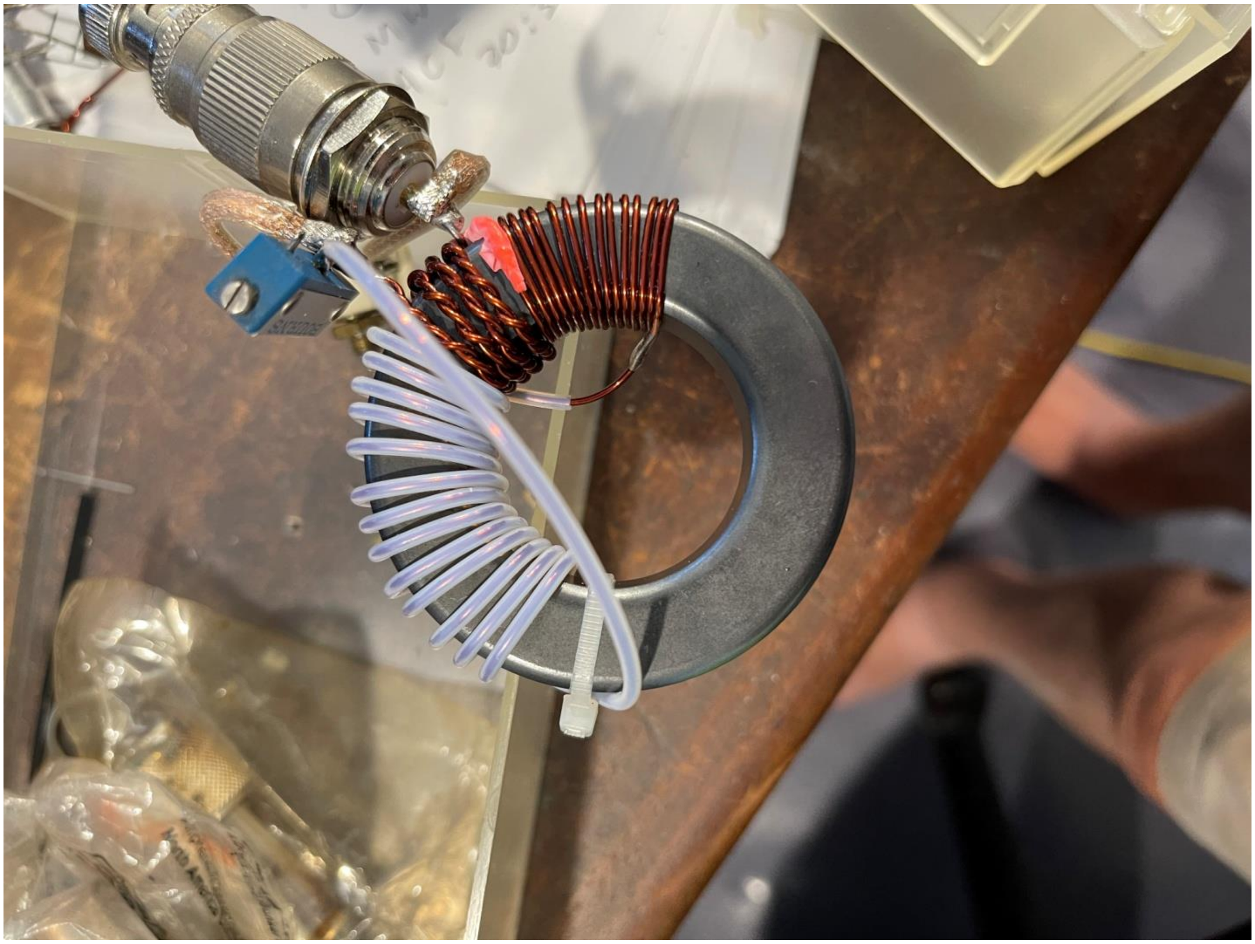
I want to have a core that will work down to 1.8 MHz so I'm going to have to use a 4 turn primary and a total of 32 turns if it's going to be a 64:1, and 28 turns if it's going to be a 49:1 "Balun"

That decided, it's then time to make a few designs windings. So lots and lots of tests winding an identical pair of cores each time with the same winding details.



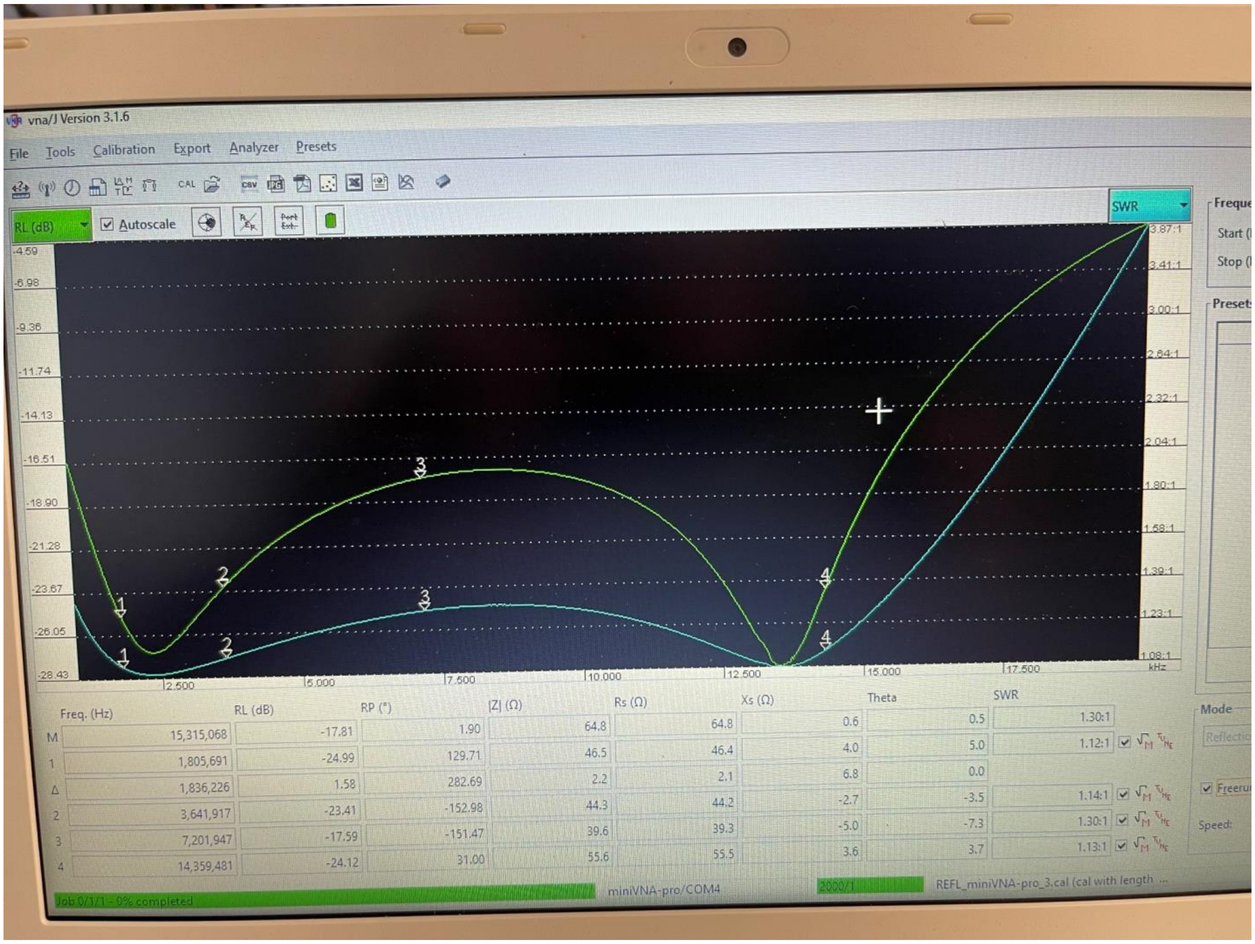

To get the best bandwidth, by test (that is winding lots of different designs by trial and error….mostly error) I have arrived at the best results by ….

1 Splitting the secondary into two sections and winding back across the core.
2 Keeping all of the windings close together.
3 Using ~ 150 pF as turning element to get the best SWR at 20 Metres.
4 Covering the second section of secondary wire with PTFE tubing to improve voltage breakdown. Good results were also obtained with PTFE covered wire for the second wire section.



ONE OF THE FINAL DESIGNS 49:1 ON VNA TEST

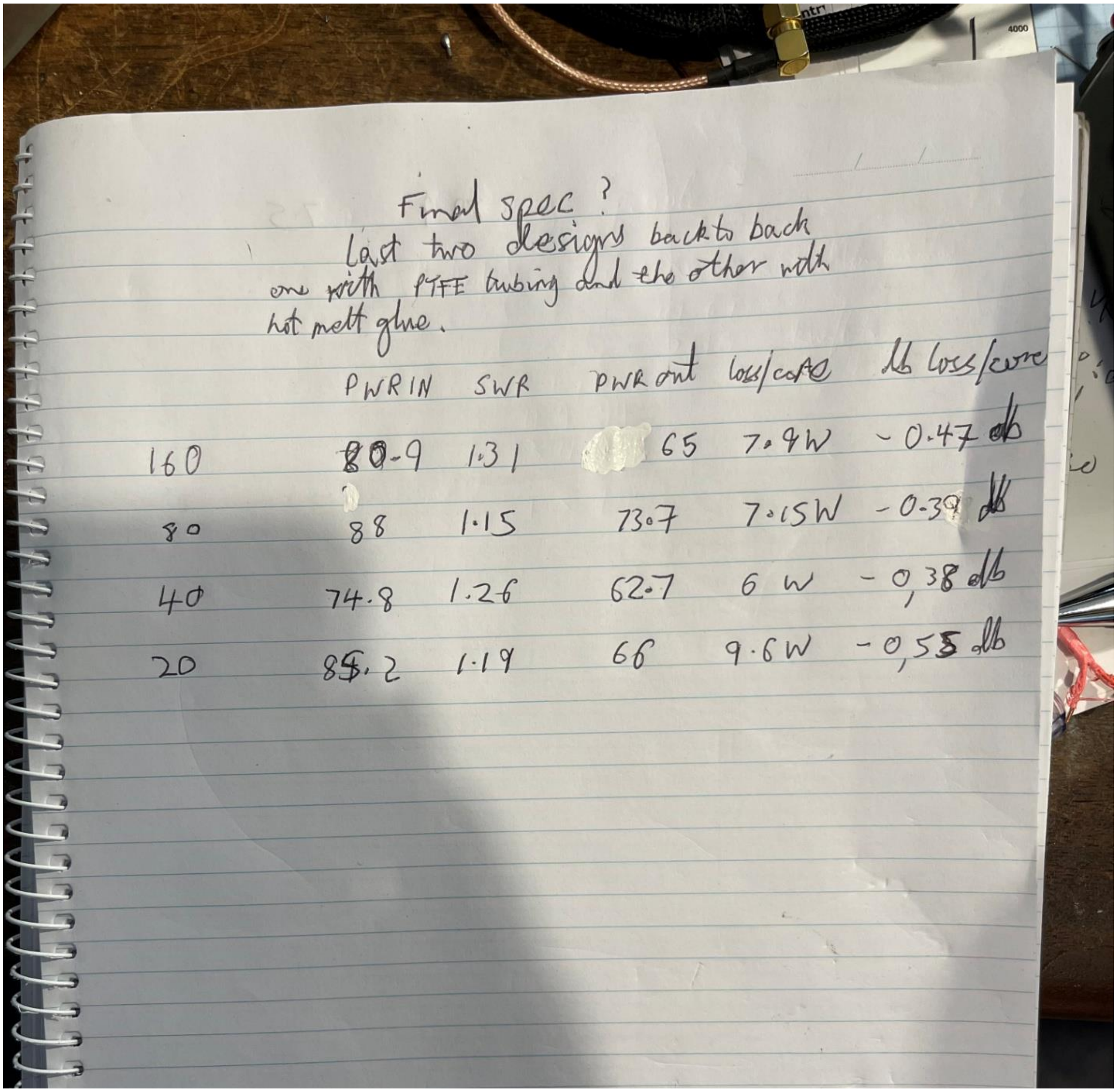
Testing was done two ways. Band width check by doing a VNA scan using a miniature linear pot (10 K ohm) set to 2.45 K ohms. The other was to make two identical units and connect them back to back. Power was then applied and measured into the first unit and out of the second unit connected into a 50 ohm load. The watt meters were identical digital units with good accuracy. Losses and SWR were recorded for the 160, 80, 40 and 20 metre bands at levels up to 100 watts. Success with one type of measurement did not always mean that the other would also be good!




SWR AND RETURN LOSS WHEN MATCHED INTO 2.45 K OHMS FINAL DESIGN

The final design gives a good low SWR across the 160 …20 metre Bands and as importantly insertion losses of below 0.5db across the 160 …20 metre Bands. Which means that the core will not overheat unduly when running up to 400 Watts SSB, (Not RTTY or F8!!).

At the same time 0.5db of losses will not noticeably degrade incoming signals. It will however mean that whatever impedance the un-un sees on its high voltage side it will faithfully transform down to the primary side divided down by 49 times. This is unlikely to be exactly 50 ohms and will almost always need a tuner for a final match. If good matches are noted without a tuner then it is likely that the core has significant losses and is affecting the results.



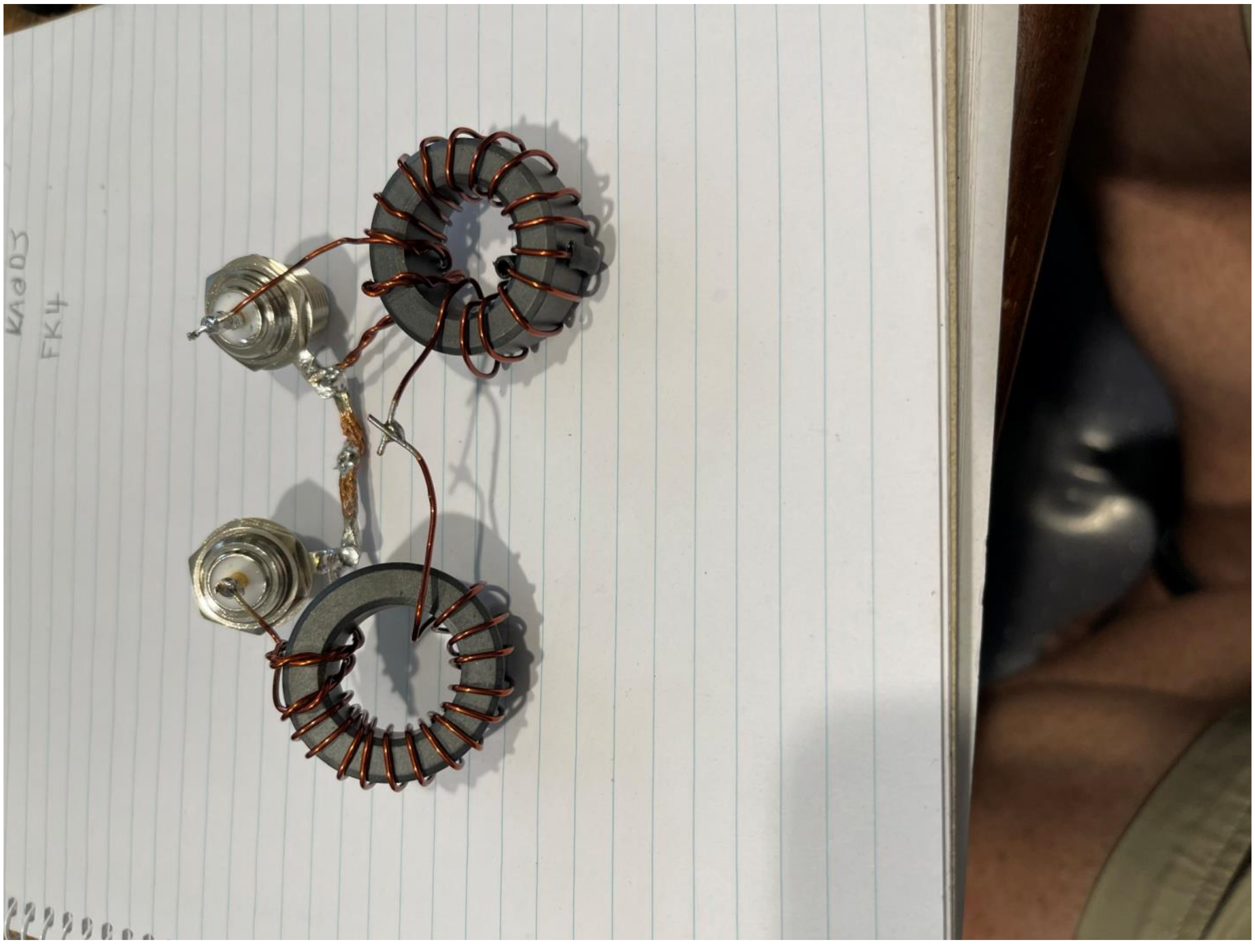
Final spec ?
Last two designs back to back
one with PTFE tubing and the other with
hot melt glue.

| | PWR IN | SWR | PWR out | loss/core | db loss/core |
|---|---|---|---|---|---|
| 160 | 80.9 | 1.31 | 65 | 7.9W | -0.47 db |
| 80 | 88 | 1.15 | 73.7 | 7.15W | -0.39 db |
| 40 | 74.8 | 1.26 | 62.7 | 6 W | -0,38 db |
| 20 | 85.2 | 1.19 | 66 | 9.6W | -0,55 db |

BACK TO BACK POWER TEST RESULTS

By tuning the length of my antenna I can now get a good swr (below 1.2: 1) for the middle of the 40 metre Band and have to make small amounts of tuning for the other bands that I use. I have confidence now that what I am seeing at the end of the coax is what is coming from the antenna and little else added in.

Winding space on the smaller core is more restricted and apart from a couple of test windings with two turn primaries I have not tried to go further.



BACK TO BACK TEST WITH FT-140-43 CORES

With a similar amount of inductance per turn as the larger core I would expect good results using a 2 turn primary and operation from 7.00 MHz and up.

Claims of operation at 80 and 160 Metres with two turn primary windings should be looked at with interest!

Of course other types of ferrite cores may be used …..certainly ones with more inductance per turn will help with the lower frequencies of operation.

This is not a “final word” on the topic…………. Merely the personal results of a lot of core winding and testing with X 2 cores wound for every test. My design works for me……your mileage may vary.

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