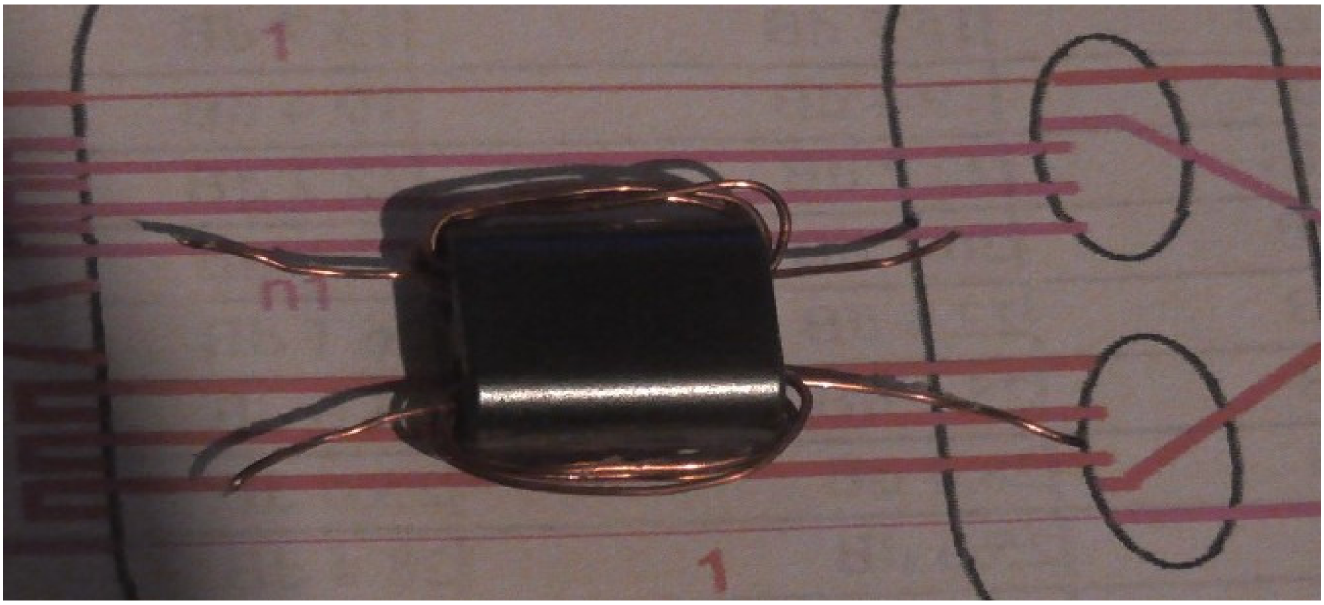
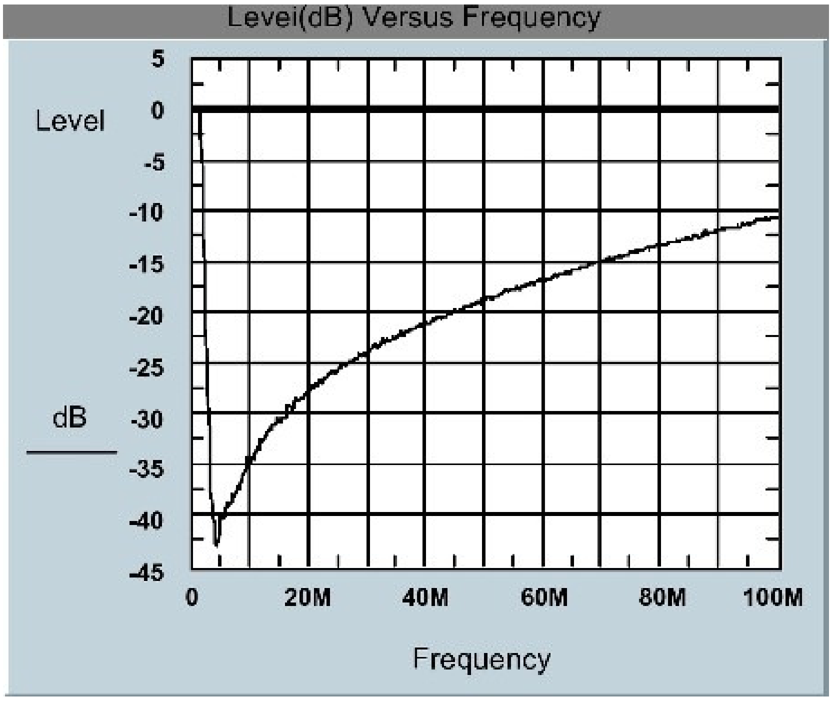
LF directional coupler



The author has a Narda 50Mhz to 1Ghz directional coupler. After completing a wide band inverted cone antenna their was a need for a directional coupler for the lower frequencies, for opimising the wide band matching of said antenna. Some time ago there was an article put out by the “rfcandy” company which involved their binocular ferrite cores. The company is no longer on the internet but their coupler design is still available. This started a long protracted journey towards a suitable coupler design.

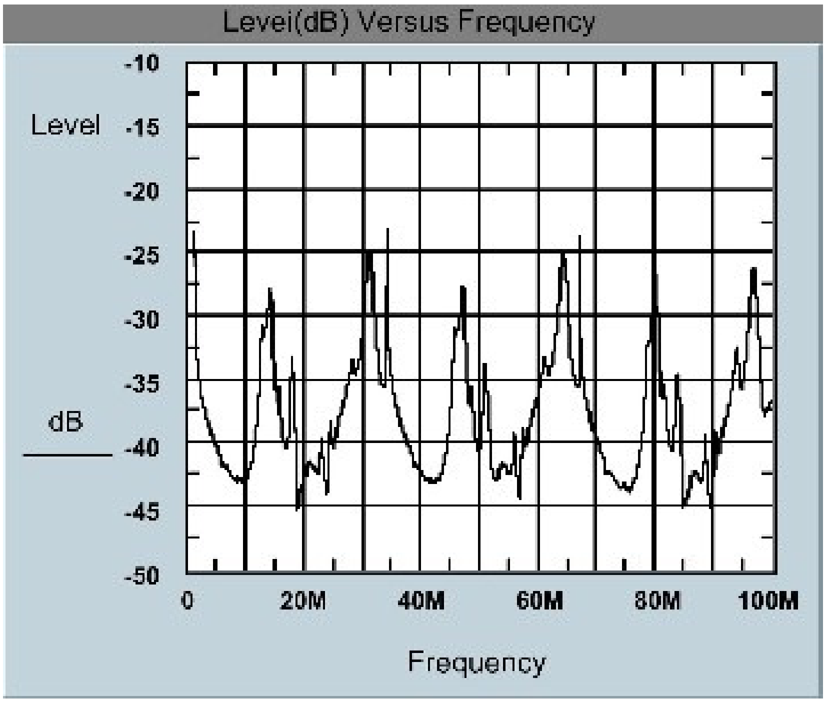
The HP8560 spectrum analyser with tracking generator forms the major part of performance measuring test equipment together with various terminations and certified co-axial attenuators. By nature sweeping a wide band of frequencies and retaining the results for comparative purposes is a laborious task. So a computer program using HP VEE was written so that design adjustments could be retained. Results comparable with the original Narda coupler (40dB) were considered to be acceptable, as the new coupler was intended to overlap with the Narda at low frequencies. The figure of 40dB directivity reprisents a value which is needed for error free test measurements in the field.

A total of 9 turns and a through turn were wound through each of the orifices of a 15mm binocular core. The wire was 30 swg and the through turn was plastic insulated. This should give a 20dB coupler with a directivity of 40dB according to the rfcandy chart. The results over 0-100MHz are however quite different. They show 40dB at the start deteriorating to less than 10dB directivity at 100MHz.



The coupler is barely usable from 5 to 10Mhz. What was the reason for this, too much self capacitance of windings coupling across the core apertures.

It was decided to measure coupling between the two core holes and 4 turns were wound on each.



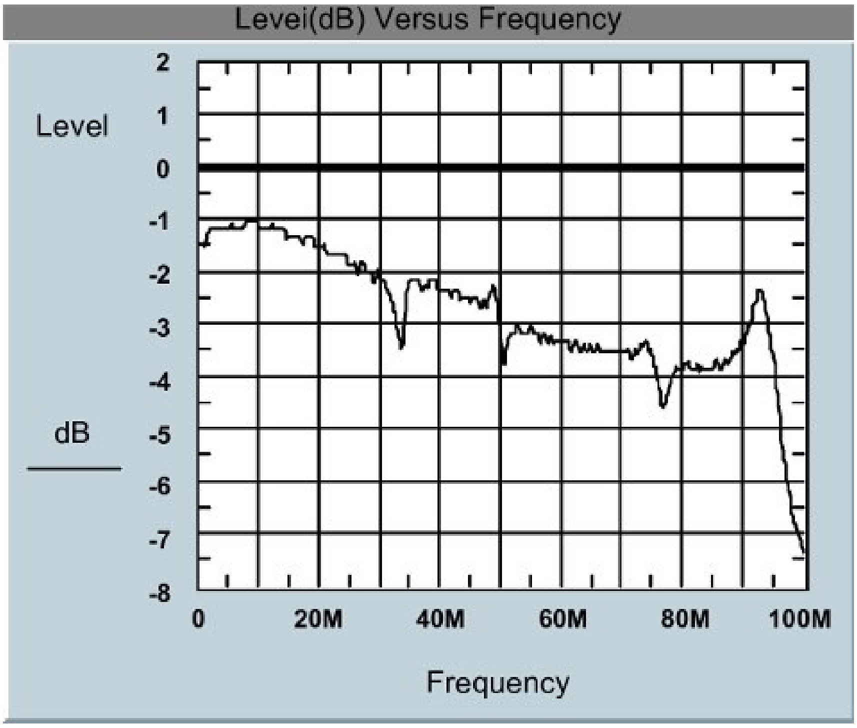
There is some interaction which must be considered since the original design was based on two separate cores where there would have been no interaction. At this stage it was considered that the whole project should be tried with separate much larger ferrite cores. Plastic insulated wire could be used thus reducing self capacitance. A large core was taken from a computer power supply feed wires. This was too large for the enclosure so it was chopped in half with the tile cutting blade of an angle grinder. **Note suitable headgear was worn.**

Core dimensions-----

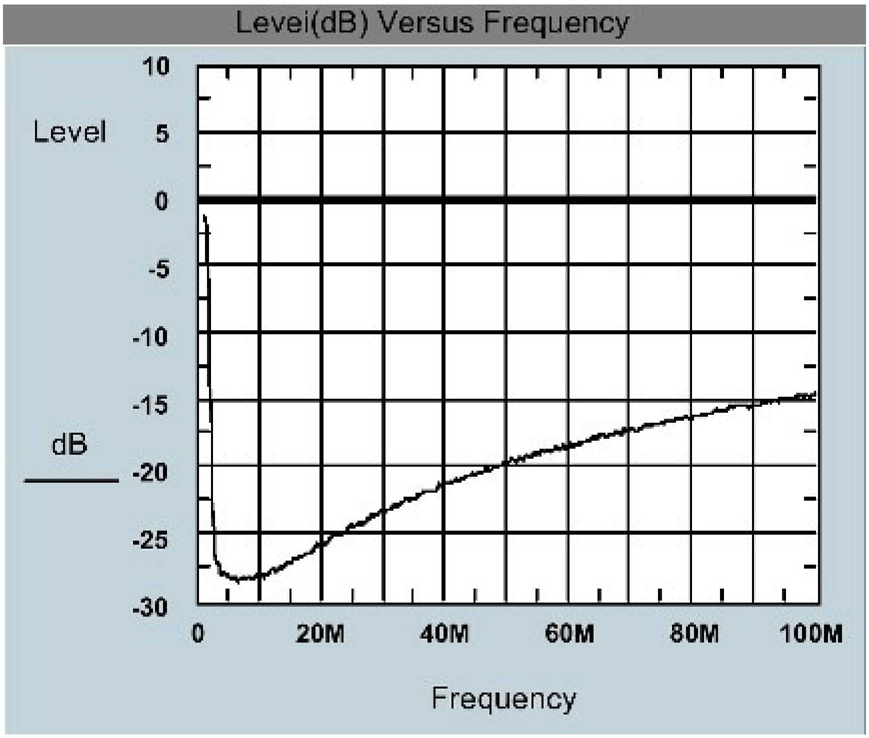
10mm inside diameter
25mm long (a half core is shown here

To check the capability of the half core as a transformer 4 turns were wound on each side.

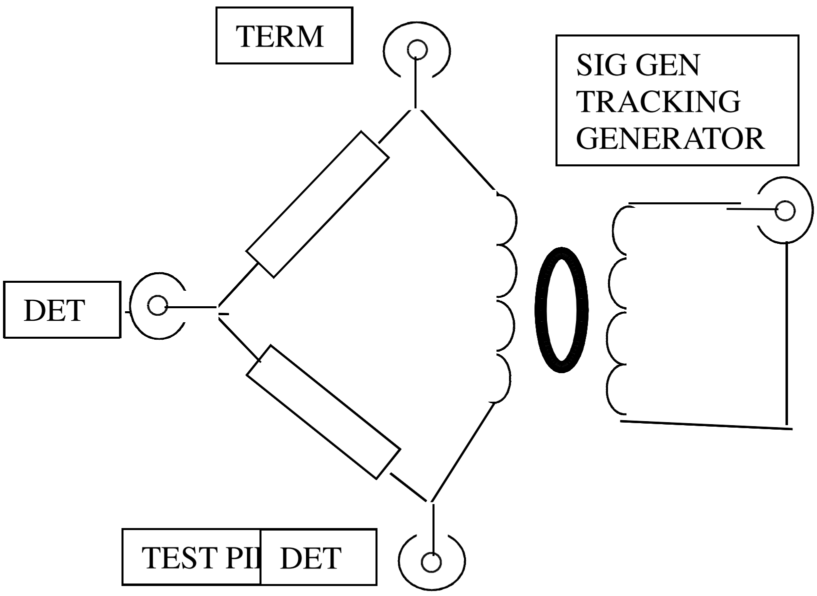
Note the variation is only 3dB up to 90Mhz

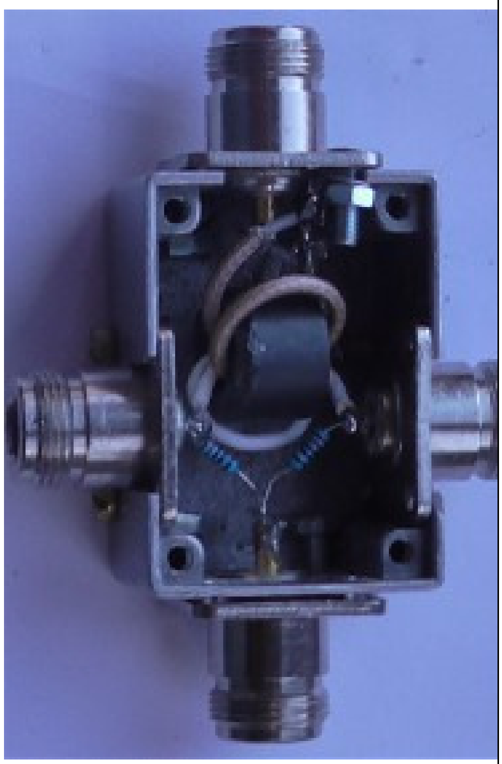


The next coupler used 2 cores wound with 9 turns on each and a wire between output /input forward and reflected. According to the rfcandy chart this should give 18dB coupling with 40dB directivity.



Only 27dB directivity max deteriorating to 15dB at 100Mhz hardly useable. Then a combination of the 2 resistor and coupling transformer design was tried





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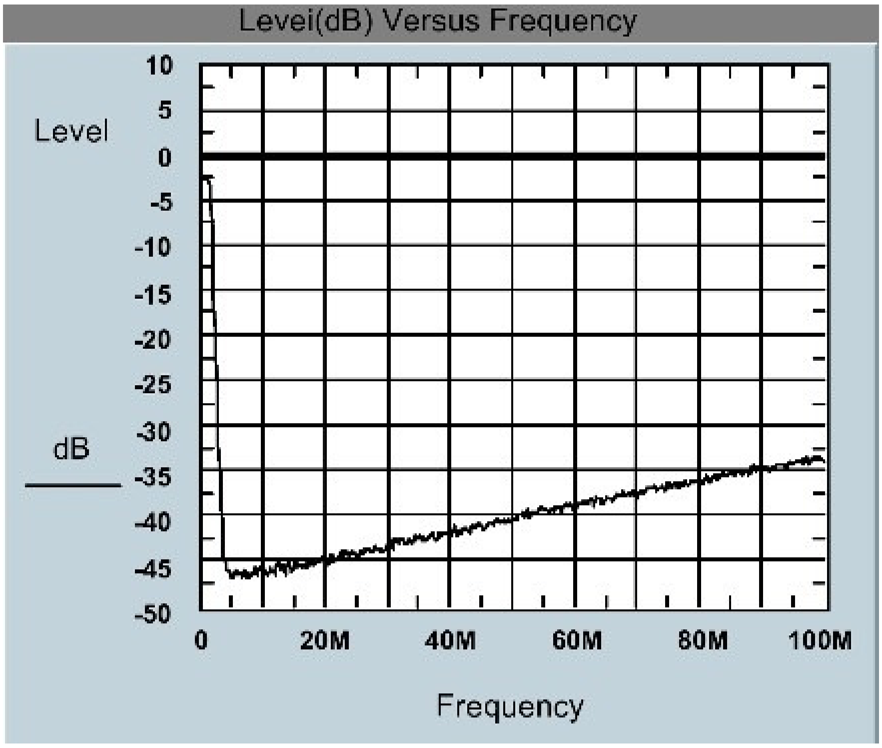
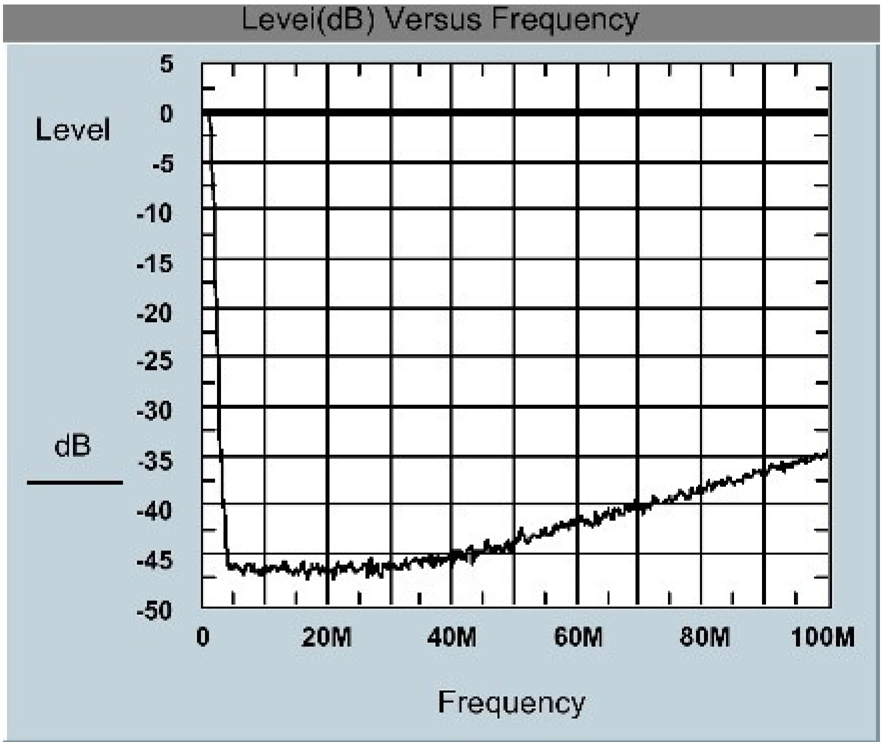
The circuit resembles a Wheatstone bridge with a transformer to feed in a balanced signal. With only 2 turns for primary and secondary on opposite sides of the core this was a big improvement on previous designs. The resistors are 130ohms chosen for equality.



The results for a 2 + 2 turn transformer. This is more like it ! The rising characteristic up to 33dB at 100Mhz would probably be due to stray capacitance.

A further improvement can be had by making the transformer primary from miniature screened co-axial cable.

There was one further test with the secondary centre tapped to ground but this shorted out the signal and was abandoned.



Test equipment HP8560 spectrum analyser with tracking generator
HP 8491B n-type attenuator(20dB for 40 return loss)
Narda 3020A directional coupler
Marconi 6534/3 10dB attenuator (for isolation)
Weinshel 10dB
HP 20dB all N-type