1 – 100 MHz 6 dB Hybrid Coupler

The couplers are commonly used to couple two or more different RF signals or divide an RF signal in different outputs a signal.
To do this with a three ports configuration you can typically use three methods:

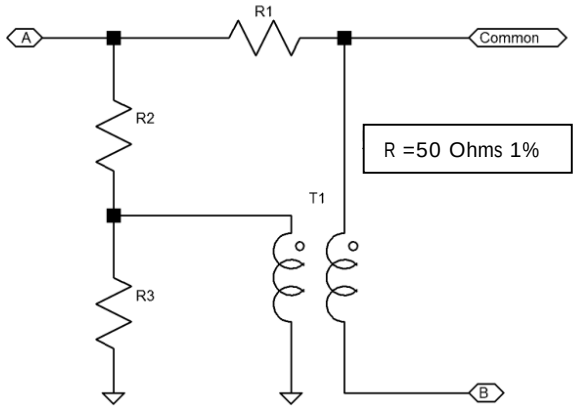
- Wilkinson divider
- 3 dB splitter
- 6 db Hybrid

The Wilkinson is a 3 dB divider/combiner over the components losses. It's use is limited by a small bandwidth for which is designed.
It has high balance between outputs when closed on its correct load.

The 3-dB lumped elements splitter, have a broad band but it has a medium/poor insulation, 20-30 dB, between the two outputs. It has high balance between outputs when closed on its correct load.

The 6 dB Hybrid has a double attenuation compared to the other two solutions, but has a high separation between the two output ports, about 40-50 dB. The balance between the ports A and B is not perfect because the circuit is not symmetrical as in other cases.

The characteristics of the Hybrid Coupler makes it very good for precision measurements, such as two-tone measures, IP2 or when you need a high separation between the two outputs from a single generator.



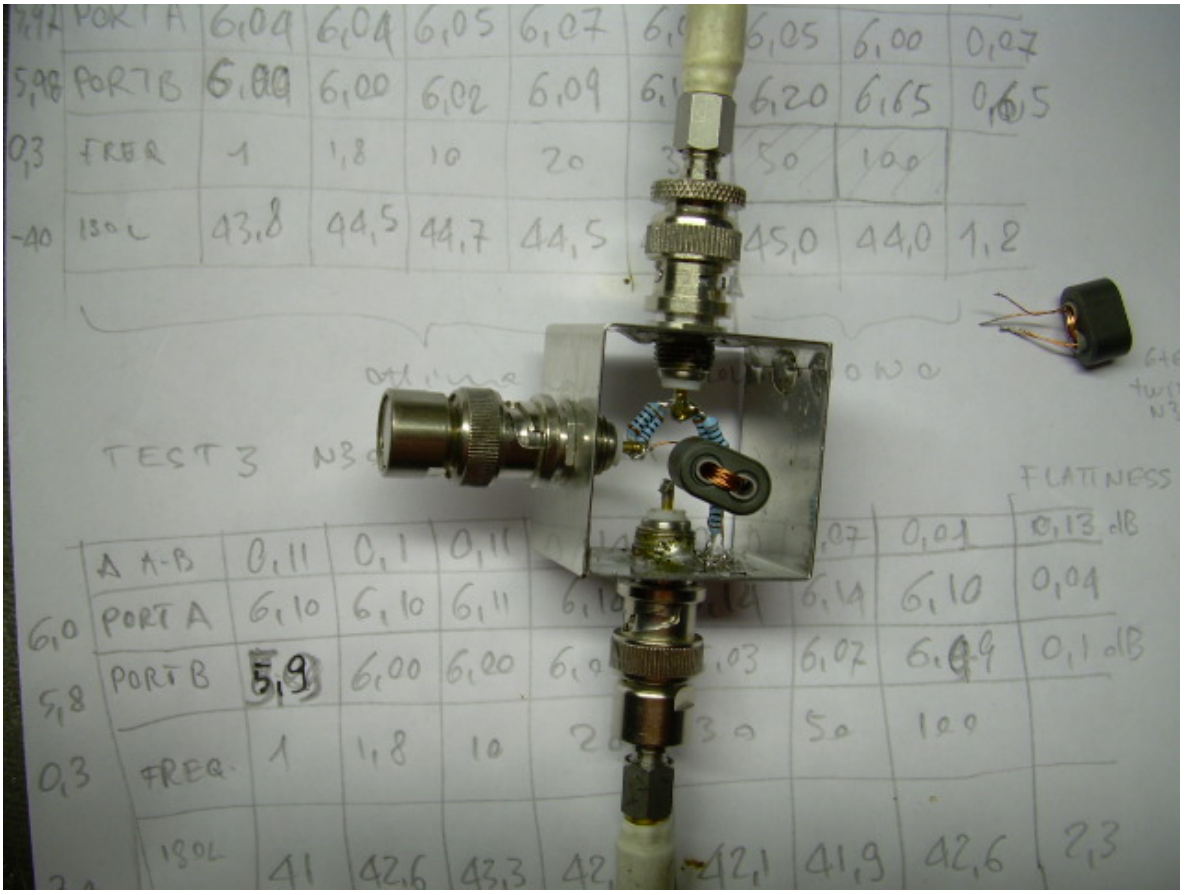
6 dB Hybrid Coupler/Divider schematic

Test Bench

R1, 2 and 3 were made by placing two 100 Ohms 1% resistor in parallel. Measure it with a digital multi-meter to make sure to stay within 1% tolerance.
Obviously the most critical component is the transformer, in terms of the magnetic core, by the number of turns and the type of winding. Built It with two bifilar windings.

Port A and B

The port A is characterized by a strong resistive impedance component, while the B from inductive component, so the linearity' in the frequency response will be better for port A.



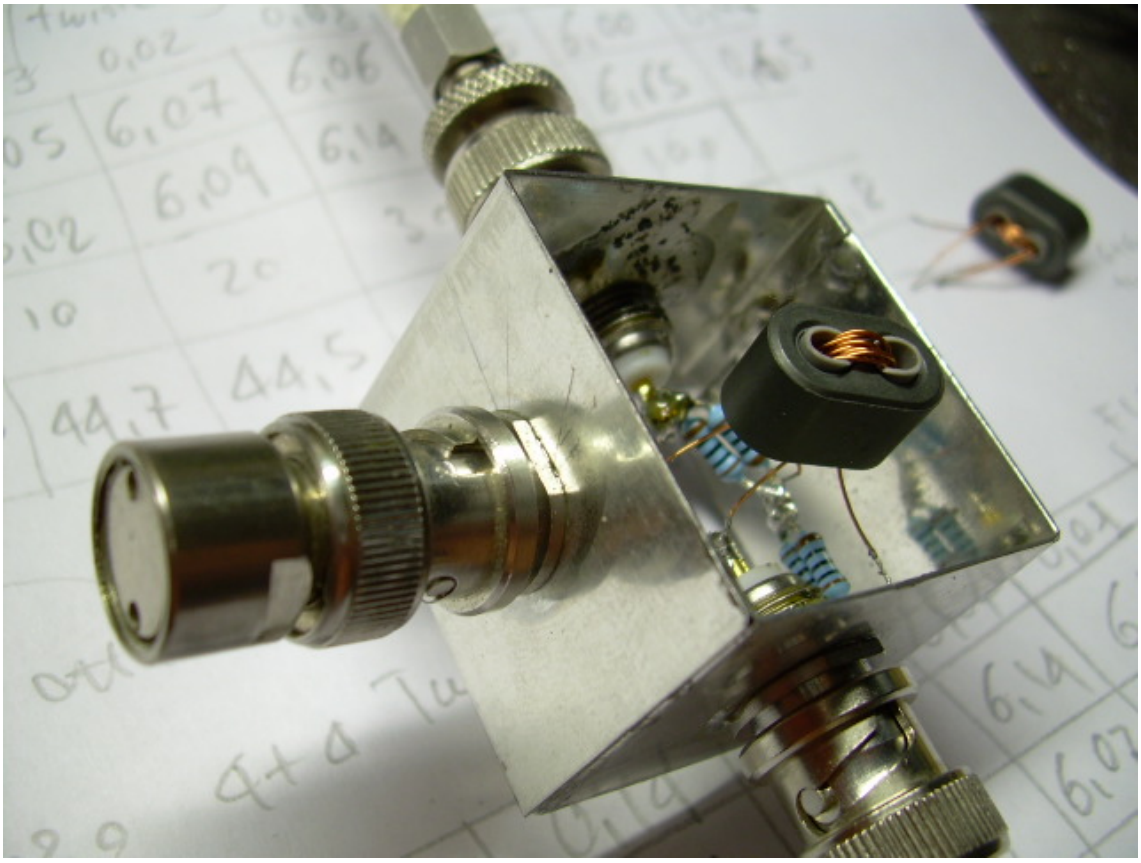
Test set

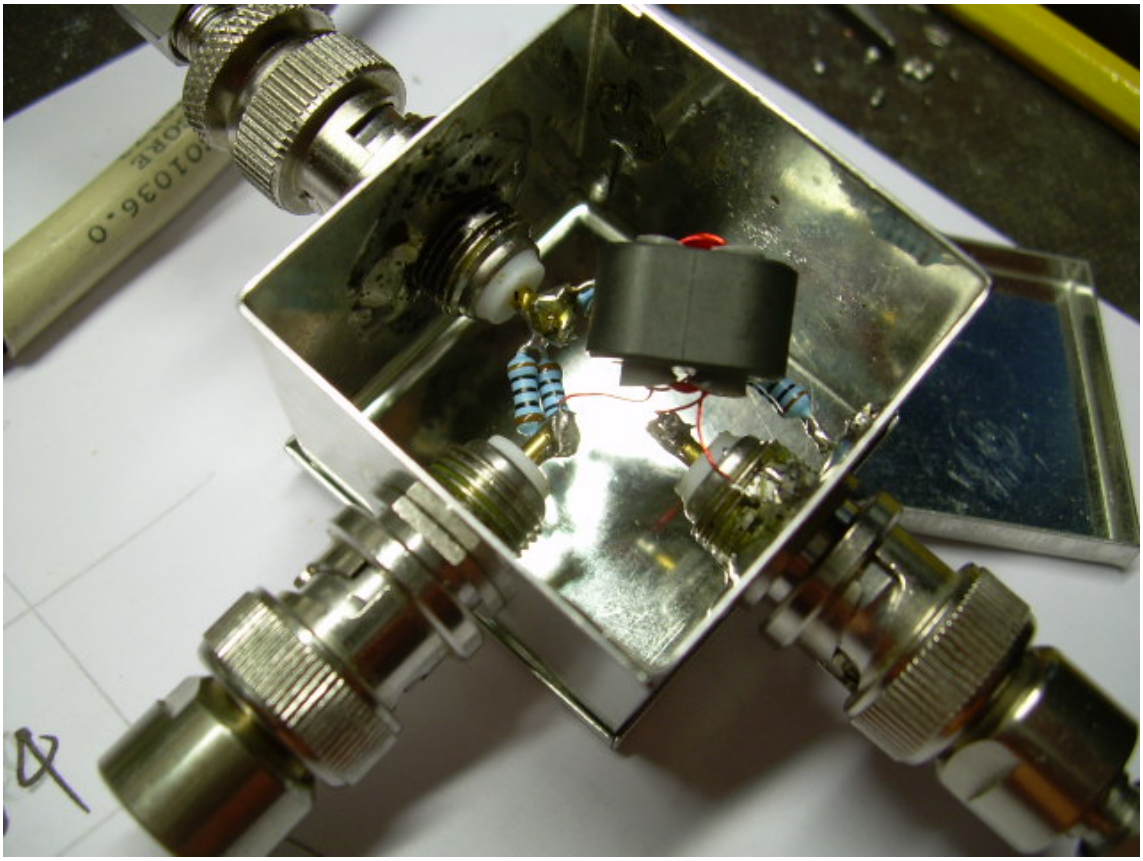
N30 Al 10000 Untwisted 6+6

Freq MHz	1	1.8	10	20	30	50	100	Delta value dB
Port A dB	6.04	6.05	6.06	6.08	6.07	6.03	5.96	0.12
Port B dB	5.98	6.00	6.03	6.11	6.18	6.28	6.90	0.92
Delta A-B dB	0.94	0.05	0.03	0.03	0.11	0.25	0.94	0.91
Isolation A-B dB	44.0	44.4	44.7	45.1	45.9	50.2	42.6	7.6

N30 Al 10000 Twisted 6+6

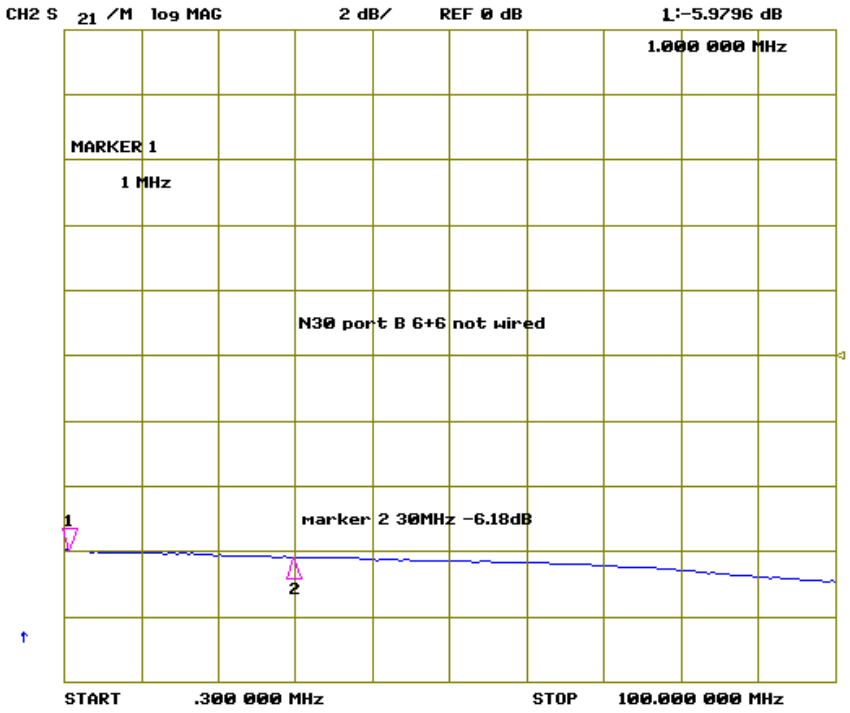
Freq MHz	1	1.8	10	20	30	50	100	Delta value dB
Port A dB	6.04	6.04	6.05	6.07	6.06	6.05	6.00	0.07
Port B dB	6.00	6.00	6.02	6.09	6.14	6.20	6.65	0.65
Delta A-B dB	0.04	0.04	0.03	0.02	0.08	0.15	0.65	0.63
Isolation A-B dB	43.8	44.5	44.7	44.5	44.6	45.0	44.0	1.2



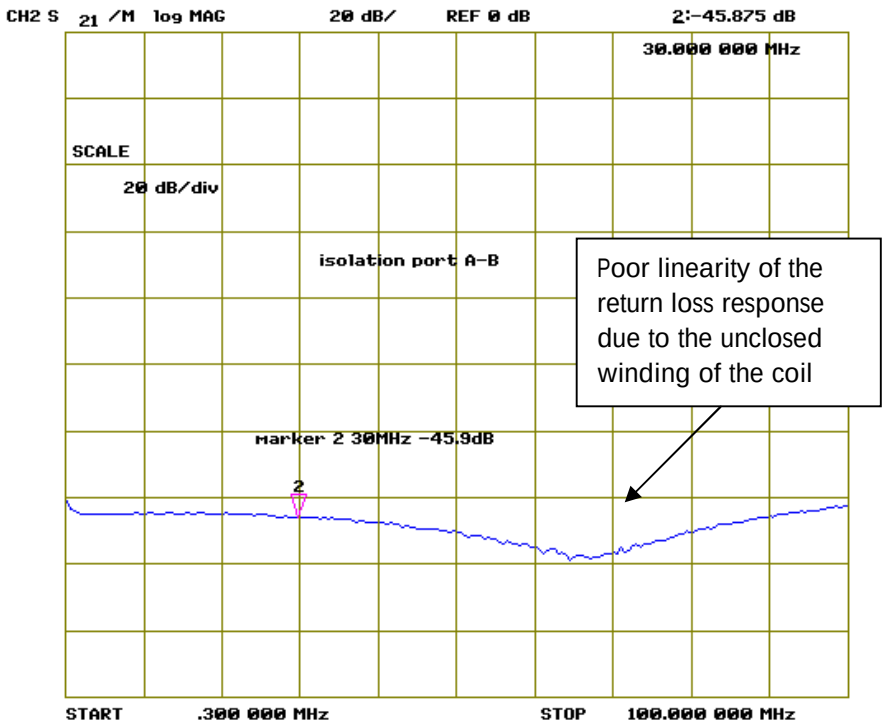


Test set

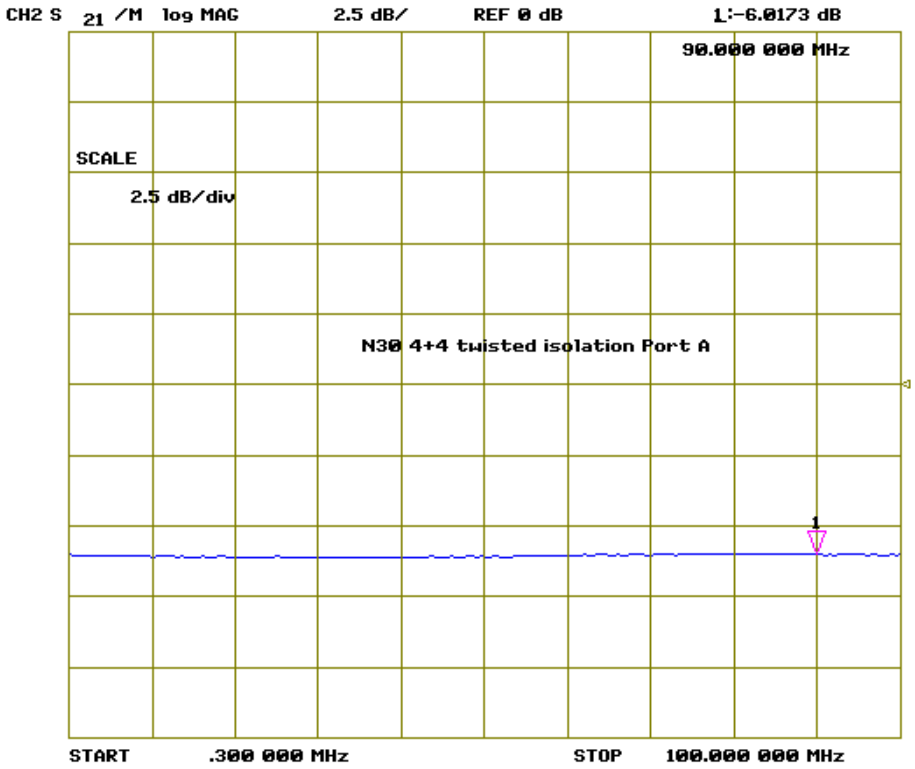
Material N30 Al 10000 binocular two 6 turns parallel wire
Wire not twisted



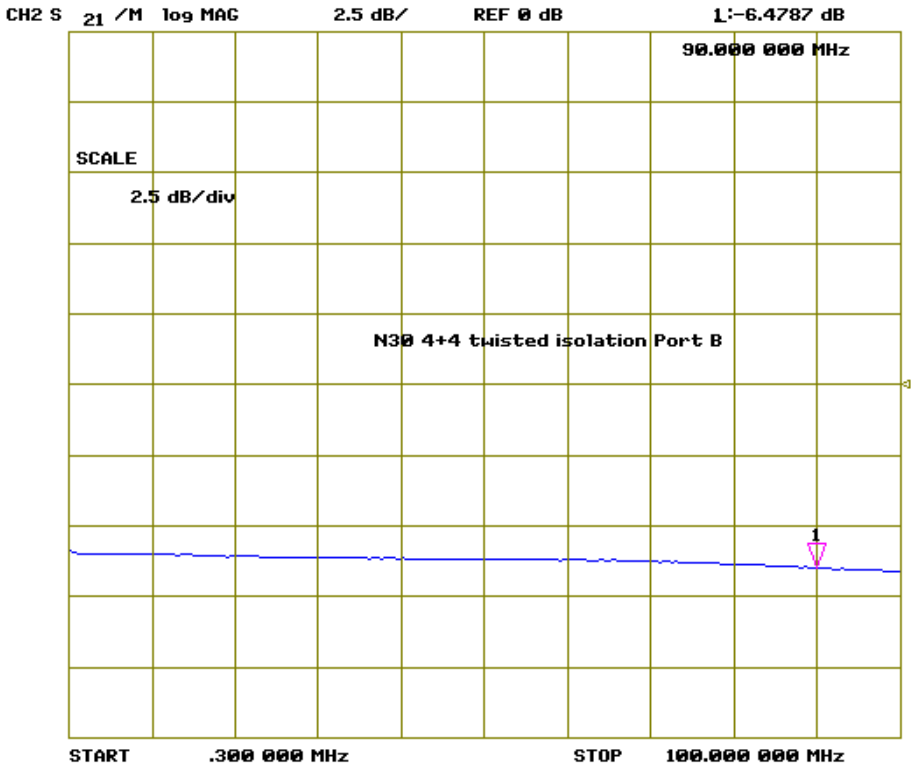
N30 6+6 turn untwisted wires **Port B** output



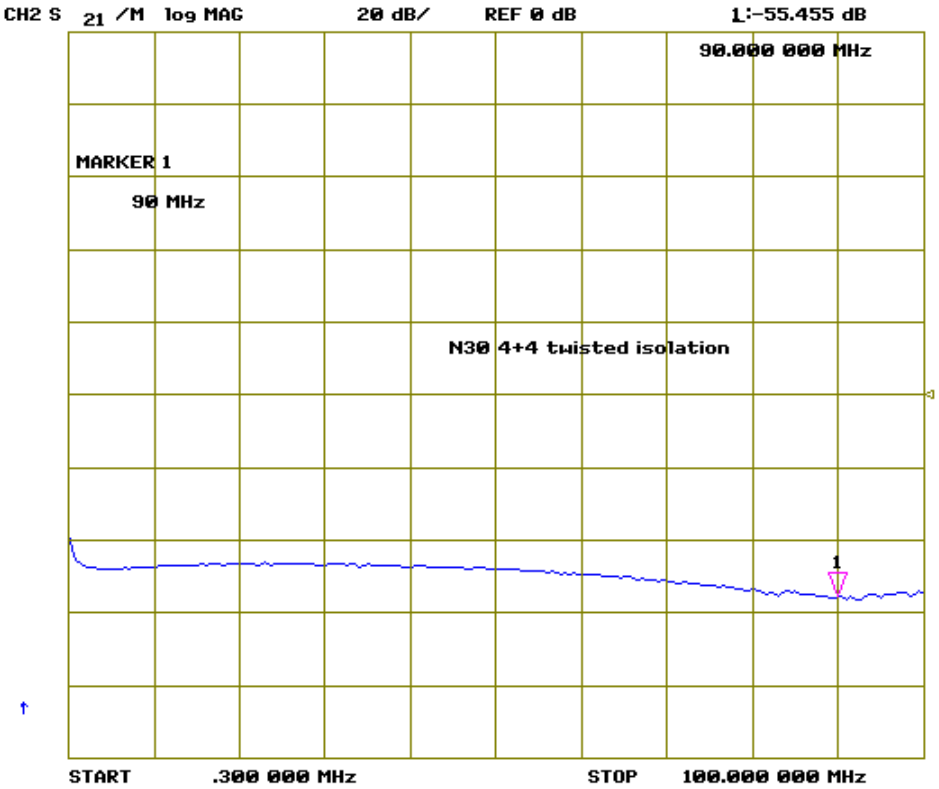
N30 **6+6** turns untwisted **isolation Port A versus B** (common terminated 50 Ohms)



Graph. 3 N30 **4+4** turns **twisted** Port A output



N30 **4+4** turns **twisted** Port B output



N30 **4+4** turns **twisted isolation** Port A versus B (common terminated 50 Ohms)

N30 Al 10000 Twisted 4+4

Freq MHz	1	1.8	10	20	30	50	100	Delta value dB
Port A dB	6.10	6.10	6.11	6.14	6.14	6.14	6.10	0.04
Port B dB	5.90	6.00	6.00	6.00	6.03	6.07	6.09	0.10
Delta A-B dB	0.11	0.10	0.11	0.14	0.11	0. 07	0.01	0.13
Isolation A-B dB	41.0	42.6	43.3	42.5	42.1	41.9	42.6	2.3

This configuration shows a greater imbalance between A and B would probably not accurate due to the twisting of the wires, but a greater linearity as a function of frequency. The isolation between A and B loses about 2 dB.

Final Version

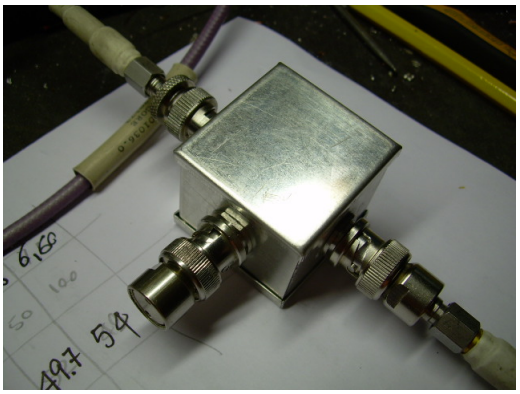
A good compromise for the final version is to use a transformer with 5 twisted turns.

N30 Al 10000 Twisted 5+5

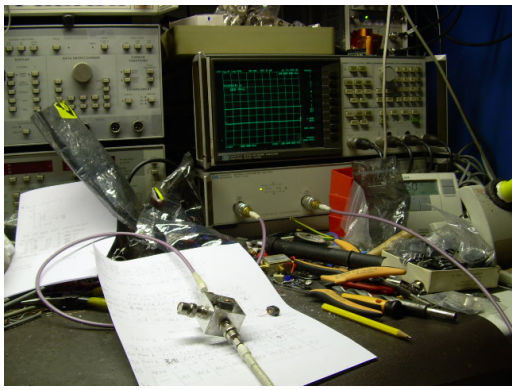
Freq MHz	1	1.8	10	20	30	50	100	Delta value dB
Port A dB	6.07	6.07	6.07	6.09	6.10	6.08	6.04	0.06
Port B dB	6.00	6.00	6.01	6.06	6.12	6.18	6.60	0.60
Delta A-B dB	0.07	0.07	0.06	0.03	0.02	0.10	0.56	0.54
Isolation A-B dB	45.6	47.7	48.3	47.8	47.7	49.7	54.0	7.6

This configuration have:

- Isolation min. 45 dB
- Flattness port A = 0.06 dB
- Flattness Port B = 0.60 dB
- Loss mismatch A vs B = 0.56 dB (0-30 MHz = 0.07 dB)
- Delta loss Port A vs B max = 0.54 dB (0-50 MHz = 0.08 dB)



It's done


Lab.

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