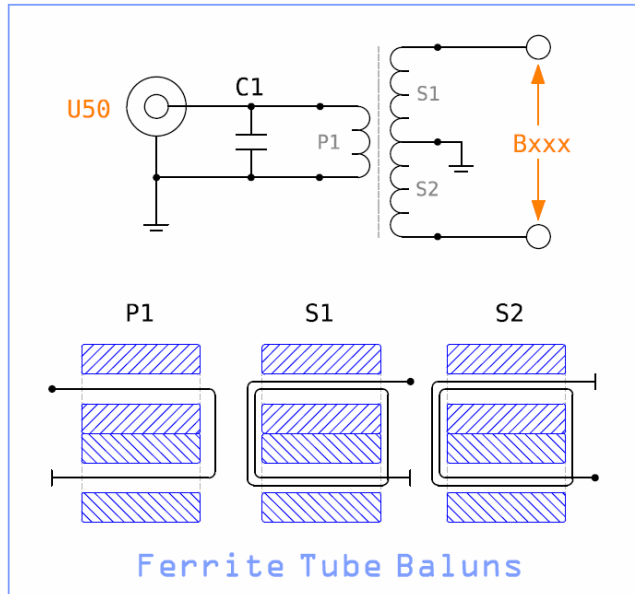


Ferrite Tube Baluns

Here is a short story of magnetic baluns, which we wound using parallel ferrite tubes. These baluns are typically used as impedance transformers with symmetrical, high-impedance HF transmitting antennas, like terminated V-beams, Rhombic's and T2FD's. If you are using some unequally loaded antenna, you may want to use Guanella-type current balun.



This construction is a **magnetic balun** (RF voltage transformer) with two secondary coils **S1** and **S2**, grounded at the center point. Unbalanced primary coil **P1** impedance is 50 Ω. The balanced secondary impedance depends on the turns of secondary coils. Primary turns must be full turns, in this case 1 to 3 turns. Secondary coils must be symmetrical. Secondary turns may be 2 x 1 to 2 x 6 turns, also half turns. While using half turns, you may start winding by grounding the start points at the primary side, so you get the high impedance output wires far from the primary side. With 1:1 and 1:4 baluns we get better results using Guanella-type.

Capacitor **C1** is used to compensate the winding capacitance and smooth the SWR curve. Capacitor values (E12) from 10 pF to 100 pF were selected with 100 pF variable capacitor. The final capacitor was disk ceramic, voltage rating 3 kV and up. Some experimental values follows in examples.

Next table shows turns for some practical impedance ratios:

Ratio	Impedance	P1	S1	S2
1:4	50 Ω to 200 Ω	1	1	1
1:4	50 Ω to 200 Ω	2	2	2
1:9	50 Ω to 450 Ω	1	1½	1½
1:9	50 Ω to 450 Ω	2	3	3
1:12	50 Ω to 612 Ω	2	3½	3½
1:16	50 Ω to 800 Ω	1	2	2
1:16	50 Ω to 800 Ω	2	4	4
1:16	50 Ω to 800 Ω	3	6	6

Ferrite Materials

During these tests we used only two easily available ferrite materials. The material permeability should be between $\mu=125$ to $\mu=850$, preferring lower values. Ferrite should tolerate hundreds of watts of output power. Iron powder materials have too narrow frequency range for higher impedance ratios, due the much lower permeability.

Ferroxcube TN23/14/7-4C65

Ferrite toroid, OD 23 mm, ID 14 mm, height 7 mm.

Material **4C65**, permeability $\mu=125$ (similar to 61).

Tubes stacked of 5 toroids, each. Tube total length 37 mm.

Better high frequency range. Works here best from 6 to 30 MHz.

Low core loss.

Würth 74270057

Ferrite tube, OD 19 mm, ID 11,5 mm, length 51 mm.

NiZn, material **4W620**, permeability $\mu=620$ (similar to 43).

Wider frequency range. Works here best from 1 to 30 MHz.

Medium core loss.

Winding Materials

We used coaxial cables center conductor for winding.

RG58 C/U

PE isolation, OD = 2.95 mm, test voltage 5.0 kV.

RG174 U

PE isolation, OD = 1.45 mm, test voltage 3.0 kV.

RG316 U

PTFE isolation, OD = 1.55 mm, test voltage 1.7 kV.

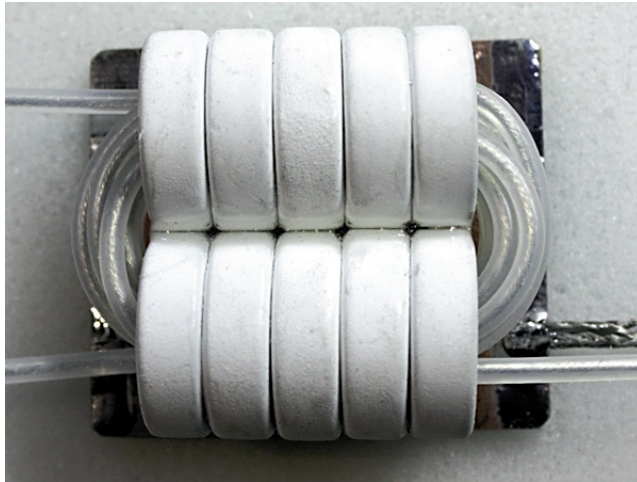
With 1 kW power the output from 1:16 balun is near 1 A 900 V. The OD 1.5 mm conductor might not be enough for 1 kW power. With low ratio baluns the OD 3 mm conductor works well enough; with some high ratio baluns we had to use the OD 1.5 mm PTFE insulated conductor. Anyway, do carefully the wiring.

Structure

Both ferrite tubes were clued parallel on class-fiber circuit board material, on the copper side. This solid copper foil was used as ground plane for all ground connections, including the incoming heavy ground track from BNC coaxial connector. The capacitor C1 was soldered directly into the BNC connector. Details on pictures.

Common Mode Choke (CMC)

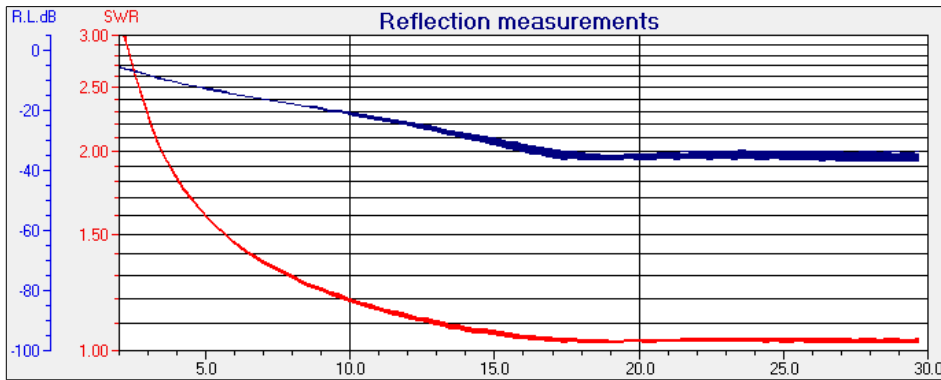
This type balun may need an external filter to prevent coaxial mantle radiation, especially with less symmetric antennas. You may want to install a set of ferrite tubes over the coaxial cable near the connector, or use some CMC component.



Ferroxcube TN23/14/7-4C65.
Material **4C65**, permeability $\mu=125$.

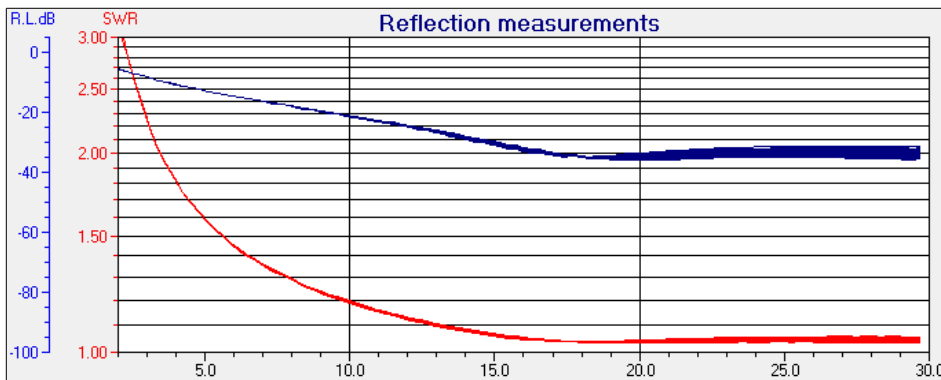
Tests:

Ratio	Out	P1	S1	S2	Wire	C1	Fmin	Fmax
1:9	450 Ω	2	3	3	RG58	47	5,6	47,0
1:9	450 Ω	2	3	3	RG174	47	5,6	46,0
1:12	612 Ω	2	3½	3½	RG58	47	5,8	50,0
1:12	612 Ω	2	3½	3½	RG174	47	5,8	48,0
1:16	800 Ω	2	4	4	RG58	47	5,5	50,0
1:16	800 Ω	2	4	4	RG174	47	5,6	50,0
1:16	800 Ω	3	6	6	RG174	56	2,6	30,0



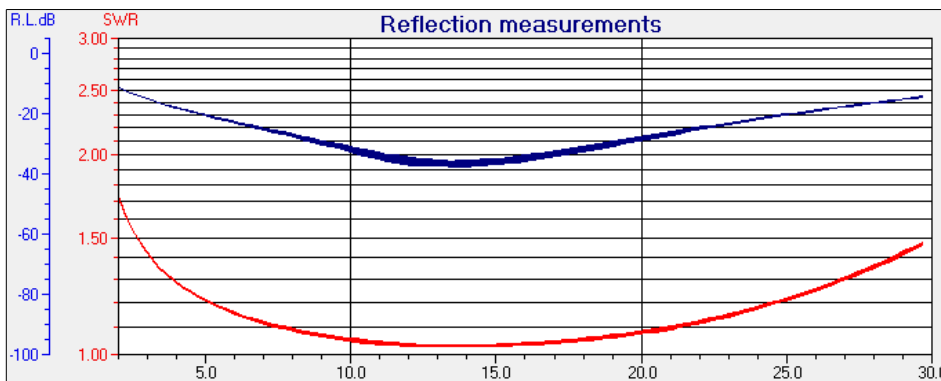
Balun 1:12, 50 Ω to 612 Ω

2 - 3½ - 3½ turns, wire RG58
C1 = 47 pF
3,6 MHz to 57 MHz (SWR < 2,0)
5,8 MHz to 50 MHz (SWR < 1,5)
Min. SWR 1,03 @ 19,4 MHz
Best for 7 - 30 MHz



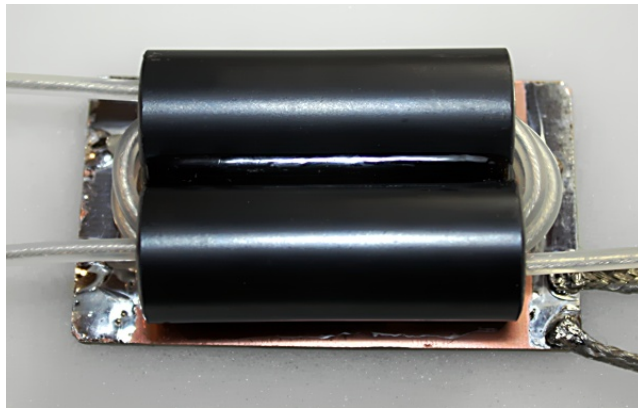
Balun 1:16, 50 Ω to 800 Ω

2 - 4 - 4 turns, wire RG174
C1 = 47 pF
3,5 MHz to 56 MHz (SWR < 2,0)
5,6 MHz to 50 MHz (SWR < 1,5)
Min. SWR 1,03 @ 29,0 MHz
Best for 7 - 30 MHz



Balun 1:16, 50 Ω to 800 Ω

3 - 6 - 6 turns, wire RG174
C1 = 56 pF
1,8 MHz to 35 MHz (SWR < 2,0)
2,6 MHz to 30 MHz (SWR < 1,5)
Min. SWR 1,04 @ 14,0 MHz.
Best for 3.5 to 28 MHz

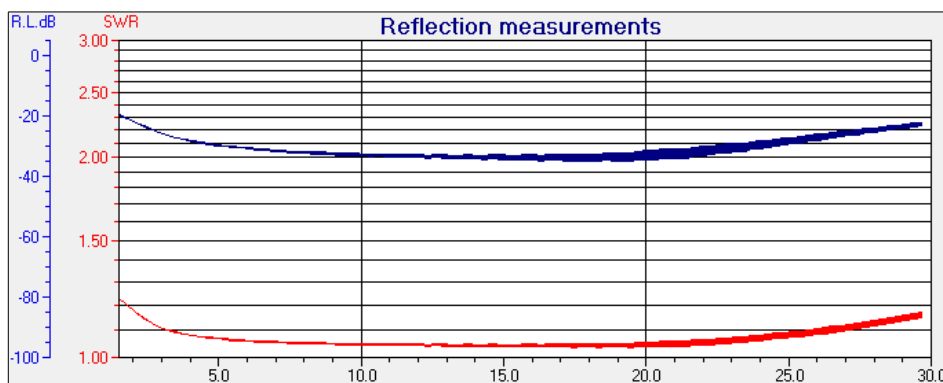


Wurth 74270057

NiZn, material **4W620**, permeability $\mu=620$ (similar to 43).

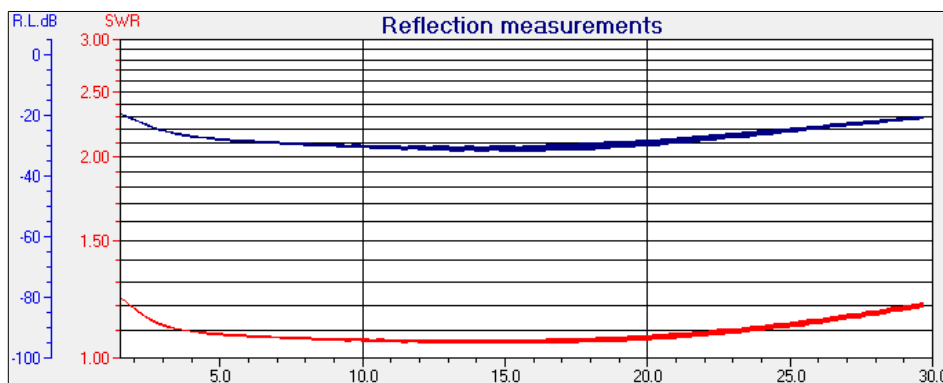
Tests:

Ratio	Out	P1	S1	S2	Wire	C1	Fmin	Fmax
1:9	450 Ω	1	1½	1½	RG58	22	2,9	60,0
1:9	450 Ω	2	3	3	RG316	68	< 1,0	38,0
1:12	612 Ω	2	3½	3½	RG316	68	< 1,0	38,0
1:16	800 Ω	1	2	2	RG58	22	2,9	38,0
1:16	800 Ω	2	4	4	RG316	68	< 1,0	38,0



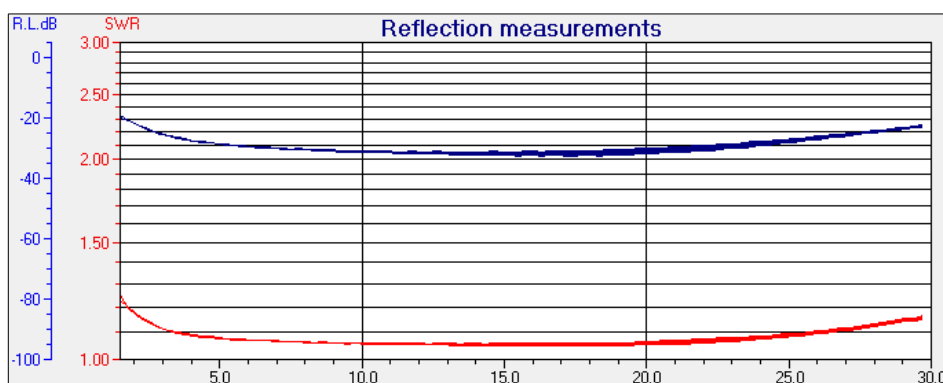
Balun 1:9, 50 Ω to 450 Ω

2 - 3 - 3 turns, wire RG316
 C1 = 68 pF
 < 1,0 MHz to 44,0 MHz (SWR < 2,0)
 < 1,0 MHz to 38,0 MHz (SWR < 1,5)
 Min. SWR 1,04 @ 15,4 MHz
 Wide range



Balun 1:12, 50 Ω to 612 Ω

2 - 3½ - 3½ turns, wire RG316
 C1 = 68 pF
 < 1,0 MHz to 45 MHz (SWR < 2,0)
 < 1,0 MHz to 38 MHz (SWR < 1,5)
 Min. SWR 1,06 @ 13,5 MHz.
 Wide range



Balun 1:16, 50 Ω to 800 Ω

2 - 4 - 4 turns, wire RG316
 C1 = 68 pF
 < 1,0 MHz to 46 MHz (SWR < 2,0)
 < 1,0 MHz to 38 MHz (SWR < 1,5)
 Min. SWR 1,05 @ 15,4 MHz.
 Wide range