1:1 VOLTAGE BALUN

1:1 Ruthroff voltage balun. Install July 2012.

Requiring a balun to feed a balanced feed line with an un-balanced T-Match network a 1:1 Ruthroff voltage balun design using a T200-2 Toroid core was selected. While the 4:1 ratio is often referred to for the interface between T-Match network and a balanced antenna system it will often not be the ideal choice when very low impedances are encountered. It is for this reason that I chose to not include the balun as an integral feature of the T-Match network, opting for the flexibility of an outboard balun and the ability to trial various baluns subject to the antenna system and impedances presented.

Construction

The T-200-2 powdered iron toroid core was tightly rapped in a lay of overlapping PVC electrical tape to prevent the enamelled copper wire's insulation being damaged during winding and to offer some additional electrical insulation with core.
The triple bifilar winding of 17 turns are wound evenly spaced around the toroid core with the two individual windings wound close together.

The length of enamelled copper wire per winding for the T-200-2 powdered iron toroid core is determined by length per winder = 50mm per turn plus 200mm tails
The exact number of turns is not critical but the numbers listed in the preceding table should yield good results. It is possible to exceed the power ratings listed above but the performance of the balun may be degraded during high SWR causing heating of the core.

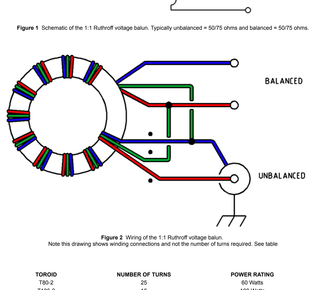

Figure 1 Schematic of the 1:1 Ruthroff voltage balun. Typically unbalanced = 50/75 ohms and balanced = 50/75 ohms.

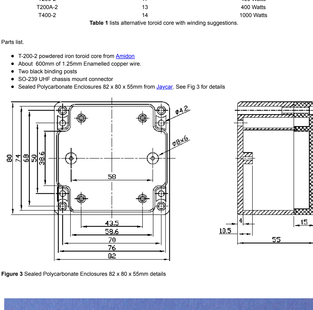

Figure 2 Wiring of the 1:1 Ruthroff voltage balun.
Note this drawing shows winding connections and not the number of turns required. See table

TOROID	NUMBER OF TURNS	POWER RATING
T80-2	25	60 Watts
T106-2	16	100 Watts
T130-2	18	150 Watts
T157-2	16	250 Watts
T200-2	17	400 Watts
T200A-2	13	400 Watts
T400-2	14	1000 Watts

Table 1 lists alternative toroid core with winding suggestions.

Parts list.

- T-200-2 powdered iron toroid core from Amidon
- About 600mm of 1.25mm Enamelled copper wire.
- Two black binding posts
- SO-239 UHF chassis mount connector
- Sealed Polycarbonate Enclosures 82 x 80 x 55mm from Jaycar. See Fig 3 for details

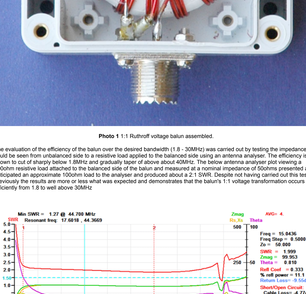

Figure 3 Sealed Polycarbonate Enclosures 82 x 80 x 55mm details

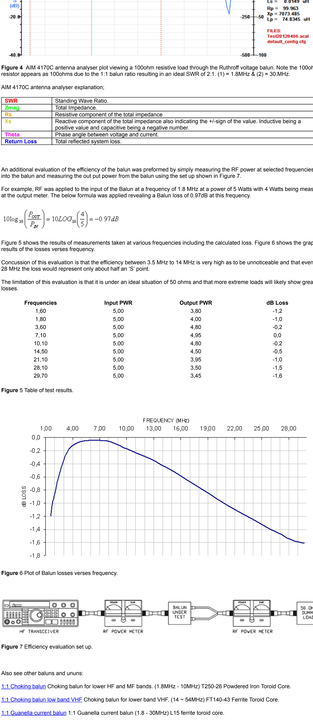

Photo 1 1:1 Ruthroff voltage balun assembled.

The evaluation of the efficiency of the balun over the desired bandwidth (1.8 - 30MHz) was carried out by testing the impedance that could be seen from unbalanced side to a resistive load applied to the balanced side using an antenna analyser. The efficiency is shown to cut of sharply below 1.8MHz and gradually taper of above about 40MHz. The below antenna analyser plot viewing a 100ohm resistive load attached to the balanced side of the balun and measured at a nominal impedance of 50ohms presented as anticipated an approximate 100ohm load to the analyser and produced about a 2:1 SWR. Despite not having carried out this test previously the results are more or less what was expected and demonstrates that the balun's 1:1 voltage transformation occurs efficiently from 1.8 to well above 30MHz

Figure 4 AIM 4170C antenna analyser plot viewing a 100ohm resistive load through the Ruthroff voltage balun. Note the 100ohm resistor appears as 100ohms due to the 1:1 balun ratio resulting in an ideal SWR of 2:1. (1) = 1.8MHz & (2) = 30.8MHz.

AIM 4170C antenna analyser explanation;

SWR	Standing Wave Ratio.
Zmag	Total impedance.
Rs	Resistive component of the total impedance.
Xs	Reactive component of the total impedance plus indicating the +/-sign of the value. Inductive being a positive value and capacitive being a negative number.
Theta	Phase angle between voltage and current.
Return Loss	Total reflected system loss.

An additional evaluation of the efficiency of the balun was preformed by simply measuring the RF power at selected frequencies fed into the balun and measuring the out put power from the balun using the set up shown in Figure 7

For example, RF was applied to the input of the Balun at a frequency of 1.8 MHz at a power of 5 Watts with 4 Watts being measured at the output meter. The below formula was applied revealing a Balun loss of 0.97dB at this frequency.

$$10\log_{10}\left(\frac{P_{OUT}}{P_{IN}}\right) = 10LOG_{10}\left(\frac{4}{5}\right) = -0.97dB$$

Figure 5 shows the results of measurements taken at various frequencies including the calculated loss. Figure 6 shows the graphed results of the losses verses frequency.

Concussion of this evaluation is that the efficiency between 3.5 MHz to 14 MHz is very high as to be unnoticeable and that even at 28 MHz the loss would represent only about half an 'S' point.

The limitation of this evaluation is that it is under an ideal situation of 50 ohms and that more extreme loads will likely show greater losses.

Frequencies	Input PWR	Output PWR	dB Loss
1,60	5,00	3,80	-1,2
1,80	5,00	4,00	-1,0
3,60	5,00	4,80	-0,2
7,10	5,00	4,95	0,0
10,10	5,00	4,80	-0,2
14,50	5,00	4,50	-0,5
21,10	5,00	3,95	-1,0
28,10	5,00	3,50	-1,5
29,70	5,00	3,45	-1,6

Figure 5 Table of test results.

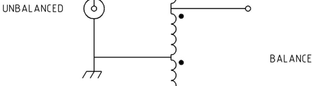

Figure 6 Plot of Balun losses verses frequency.

Figure 7 Efficiency evaluation set up.

Also see other baluns and ununs:

1:1 Choking balun Choking balun for lower HF and MF bands. (1.8MHz - 10MHz) T250-26 Powdered Iron Toroid Core.

1:1 Choking balun low band VHF Choking balun for lower band VHF. (14 ~ 54MHz) FT140-43 Ferrite Toroid Core.

1:1 Guanella current balun 1:1 Guanella current balun (1.8 - 30MHz) L15 ferrite toroid core.

1:4 Guanella current balun 1:4 Guanella current balun (1.8 - 30MHz) L15 ferrite toroid core.

1:1 Ruthroff voltage balun. 1:1 Ruthroff voltage balun (1.8 - 30MHz) T-200-2 powdered iron toroid core.

4:1 Ruthroff voltage balun 4:1 Ruthroff voltage balun (1.8 - 30MHz) T-200-2 powdered iron toroid core.

6:1 Ruthroff voltage balun 6:1 Ruthroff voltage balun (1.8 - 30MHz) L15 ferrite toroid core.

1:9 voltage unun_v1 9:1 voltage unun (1.8 - 30MHz) T-200-2 powdered iron toroid core. Version 1

1:9 voltage unun_v2 9:1 voltage unun (1.8 - 30MHz) L15 ferrite toroid core. Version 2

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