MULTIRANGE TRAP ANTENNAS

Multirange trap antenna: history and fundamentals

Igor Grigorov, Rk3ZK
antentop@mail.ru

Recently multirange trap antennas are widespread among radioamateurs. As matter of fact, the type of antennas was invented in the USA by H. K. Morgan, US patent # 2229856, 1938 (by reference **[1]**). Probably the first article about a trap antenna was published in reference **[2]** at 1940. So, what is the antenna and how is it work? Let's see it on the example of a ham vertical trap antenna in order to simplify a problem. **Figure 1** shows us a schematic of such antenna.

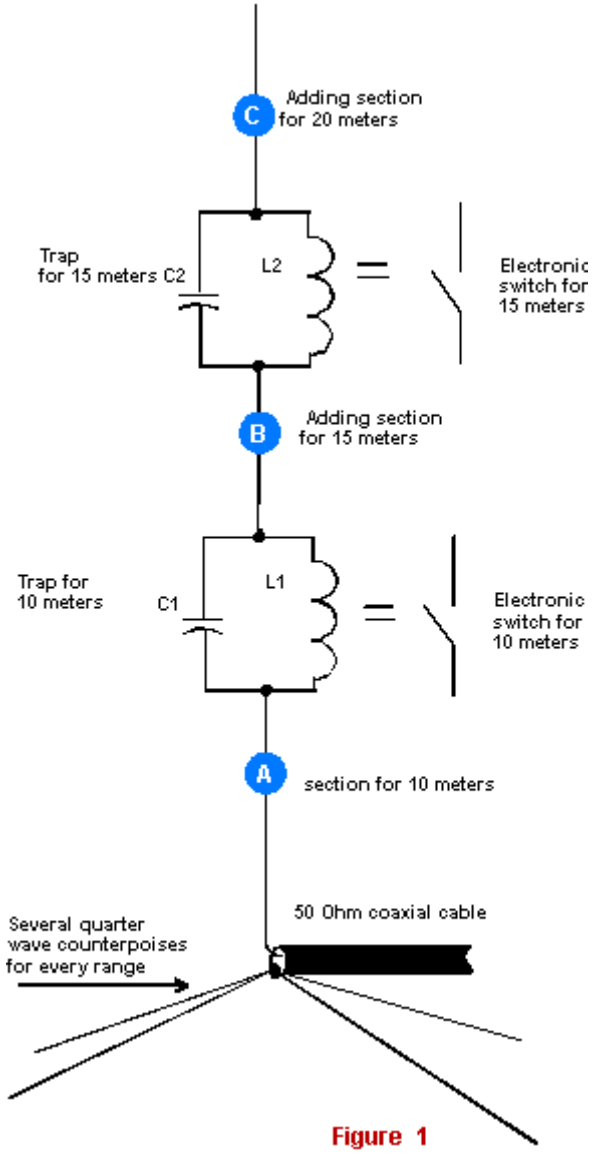


Figure 1 A ham vertical trap antenna

10 meters: Section A is tuned for operation on 10-meters by its length. Trap L1C1 turn off upper antenna parts behind the trap from operation of the antenna when 10 meters range is used.

15 meters: By length of the Section B we tune the antenna parts "Section 1 plus L1C1 plus Section B" to resonance to 15-meters. Trap L2C2 turn off upper antenna parts behind the trap from operation of the antenna when 15 meters range is used.

20 meters: By length of the Section C we tune the antenna parts "Section 1 plus L1C1 plus Section B plus Section C" to resonance to 20-meters.

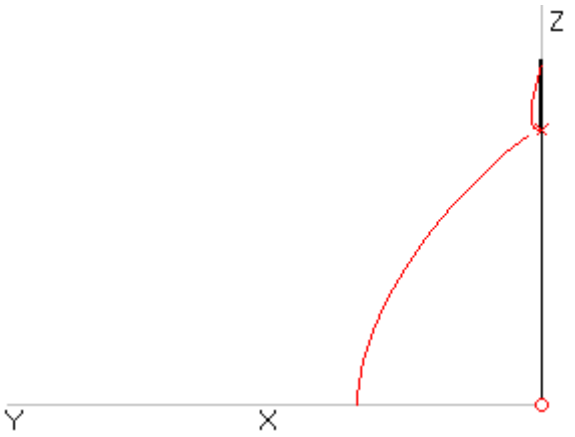
And so on for other ranges: In the similar way the antenna would be tuned for others ham HF- ranges. You see, it is possible to do an antenna for any number of HF- ranges! But there are several lacks. Upper parts of the antenna behind a proper trap do not use (or, practically do not use) for radiation. Another lack is that the antenna wire is broken at several places by trap circuits. Every trap circuits should be tune in to own resonance frequency. Trap circuits must have high temperature stability, because the antenna is used at the open air. Traps work at a resonance mode so a high level of RF voltage is across trap capacitors at transmission mode. Thereof it needs to use a high quality capacitor for every of the traps.

Vertical trap antenna WA1LNQ: One of the most popular sample vertical trap antenna is the antenna WA1LNQ **[2]**. The antenna is used on 10 and 15 meters. **Figure 2** shows the scheme for the antenna.

The antenna made from two insulated from each other metal tubes by length of 240,7 (section A) and 62,9 (section B) centimeters and in OD 18 to 25 millimeters. The length of an insulating insertion is 5,8 centimeters. Over the insulating part is spooled the trap spool. A copper tube in diameter of 3 to 5 mm is used for the spool, and the spool contains 2 turns with step 1 turn on 25-mm of winding. Average diameter of the trap spool is 55-mm. As a trap capacitor is used a length of a 50-Ohm coaxial cable with an initial length equal to 80 centimeters.

Tuning of the Antenna WA1LNQ: At first, tune the antenna in 10-m range. At the tuning the length of the coaxial cable, that makes the trap capacitor, is gradually shortened to minimum SWR in 10 meters. After this, tune the antenna to minimum SWR at 15 meters. It is possible to do by a small changing of the length of the upper section B.

Below you can see input impedance, SWR and DD of the antenna W1LNQ. The figures are obtained with the help of Free Antenna Simulation Program



Current Distribution at 10 meters

Current Distribution at 15 meters

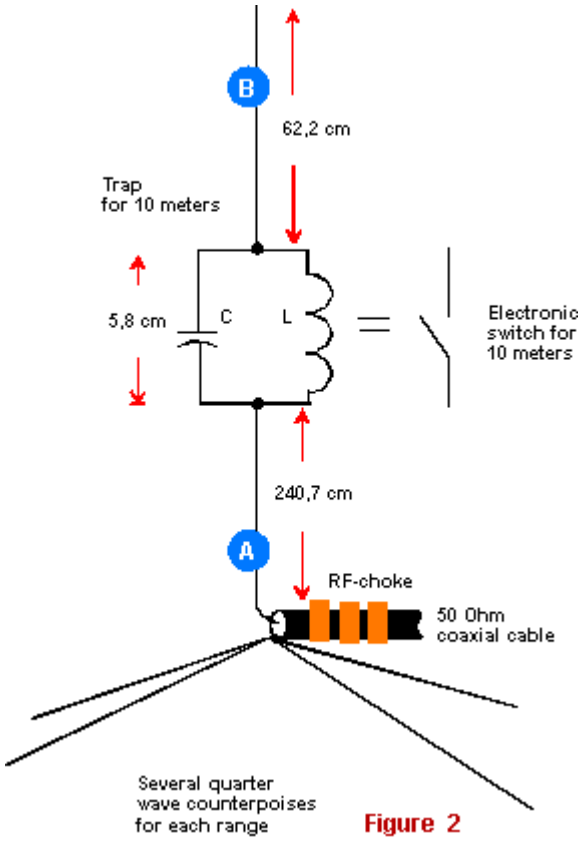
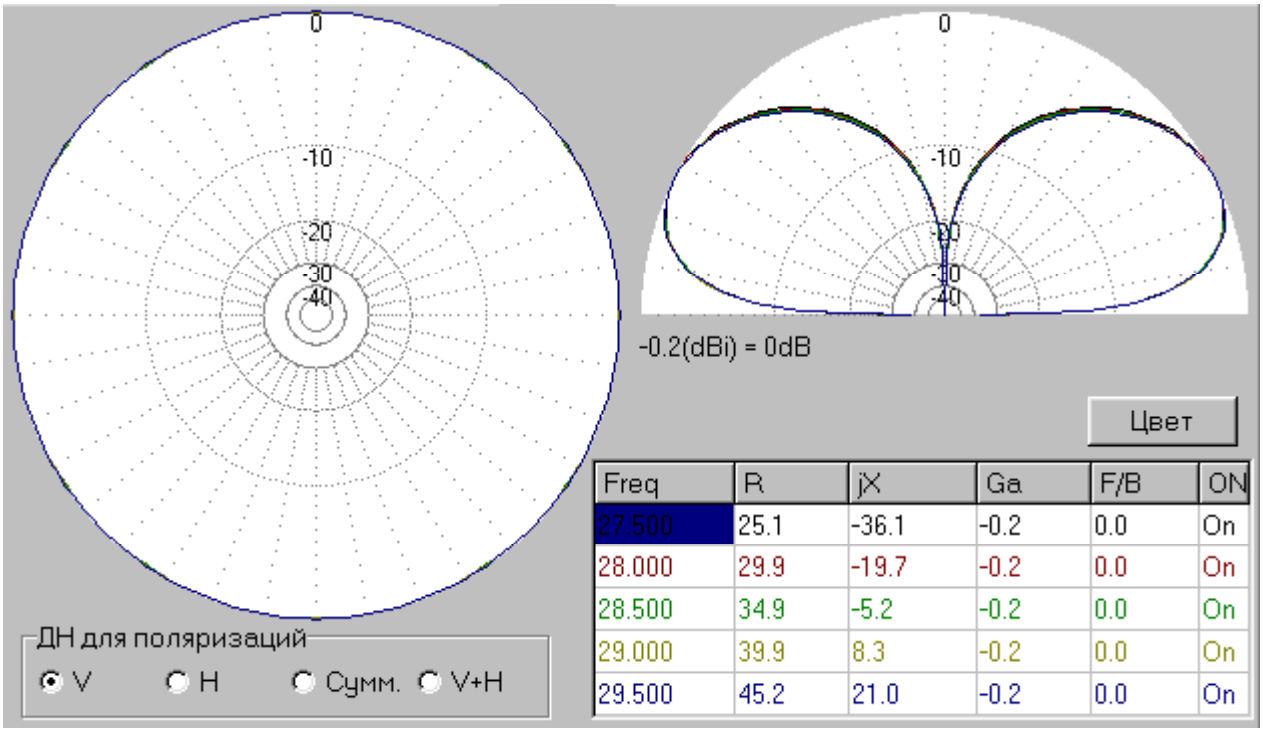


Figure 2 Antenna WA1LNQ

Diagram Directivity and Input Impedance at 10 meters W1LNQ Antenna



Freq	R	jX	Ga	F/B	ON
27.500	25.1	-36.1	-0.2	0.0	On
28.000	29.9	-19.7	-0.2	0.0	On
28.500	34.9	-5.2	-0.2	0.0	On
29.000	39.9	8.3	-0.2	0.0	On
29.500	45.2	21.0	-0.2	0.0	On

MMANA (MININEC based). Section A has diameter of 24 millimeters, section B has diameter of 18 millimeters.

Antenna input impedance. Vertical Trap antenna: You can see that only first antenna part, it is section A at **Figure 1**, has length in λ/4. So, the input

SWR at 10 meters W1LNQ Antenna

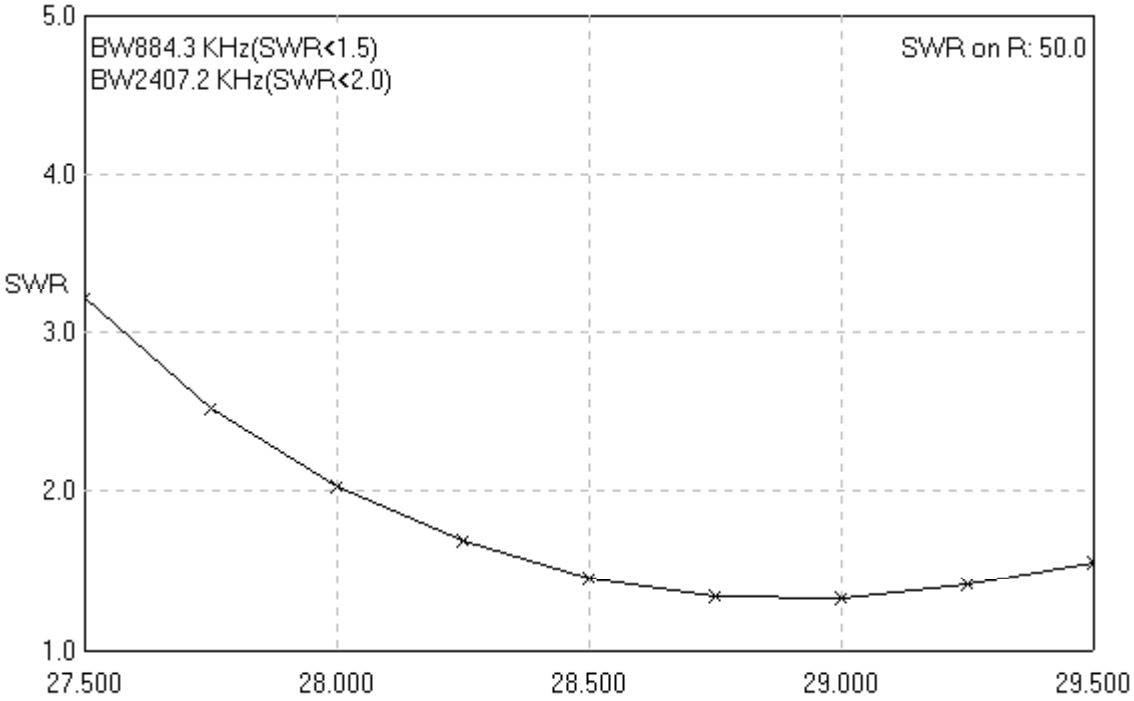
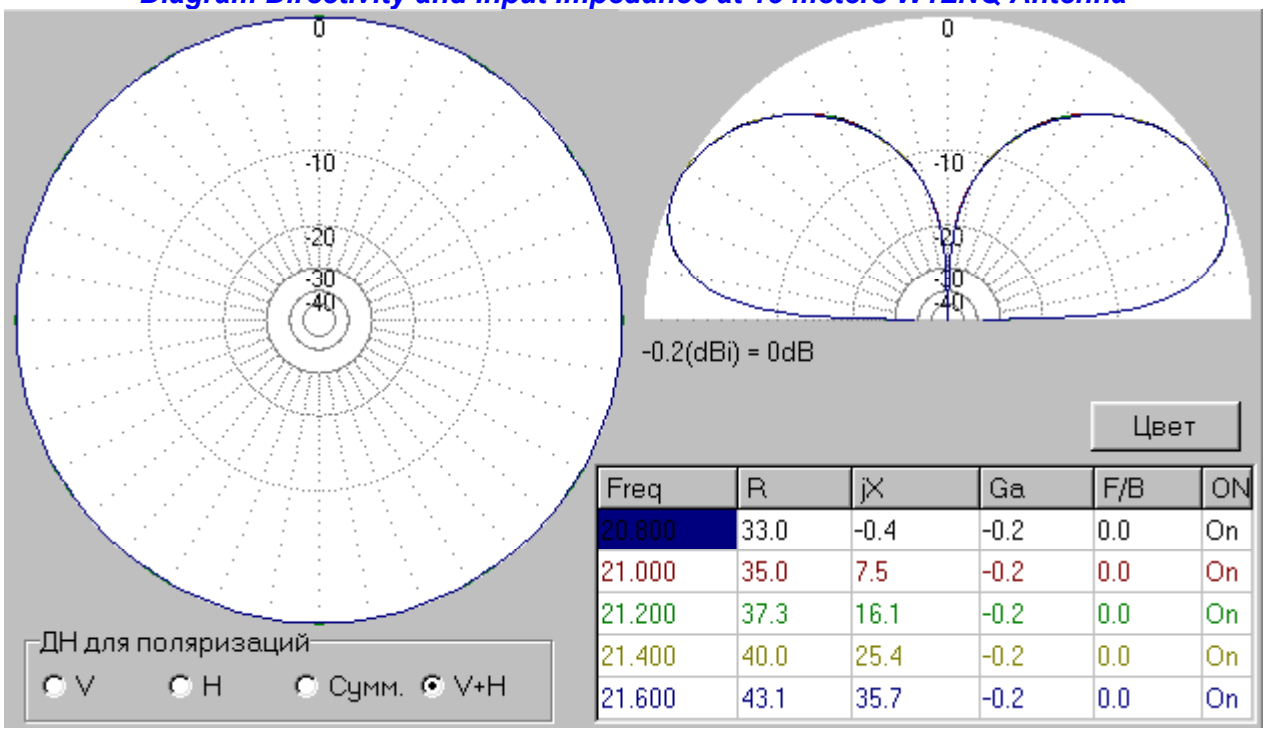


Diagram Directivity and Input Impedance at 15 meters W1LNQ Antenna

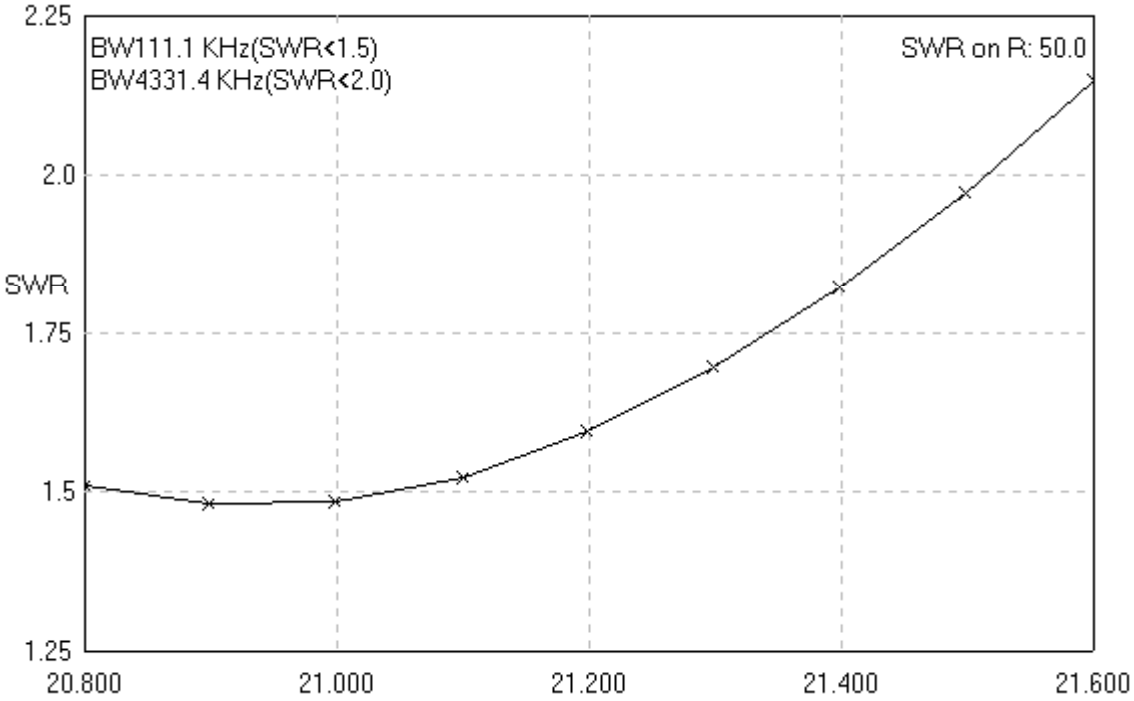


Freq	R	jX	Ga	F/B	ON
20.800	33.0	-0.4	-0.2	0.0	On
21.000	35.0	7.5	-0.2	0.0	On
21.200	37.3	16.1	-0.2	0.0	On
21.400	40.0	25.4	-0.2	0.0	On
21.600	43.1	35.7	-0.2	0.0	On

impedance of the antenna at 10 meters is close to 40-Ohms, and50-Ohms coaxial cable can be used for feeding of the antenna at the range. However, physical length of antenna consisting of another following section plus the previously section (or sections) is less then λ/4. Inductors of the traps work as a lengthening spools for the proper section. Input impedance of the antenna working at lower then 10 meters range is less then 30 Ohms in the theory, but in practice, the input impedance for 15 and 20 meters range is close to 40 Ohms because losses in antenna parts and antenna ground. So, a 50-Ohms coaxial cable can be used for feeding of the antenna at all of the ranges. For a proper work a vertical trap antenna must have several counterpoises for every of operation ranges, especially for low amateur HF ranges 40-, 80- and 160-m.

Antenna input impedance. Dipole Trap antenna: Morgan trap antenna **[1]** was done as a dipole. It is known, that a λ/2 (physical length) dipole antenna has input impedance close to 75 Ohms, see **Figure 3A**. A shortened by a lengthening spool dipole

SWR at 15 meters W1LNQ Antenna



antenna with electrical length in λ/2 (having physical length bit less then λ/2) has input impedance less them 75 Ohms and maybe, close to 60- 50-Ohms, see **Figure 3B**. So, for feeding a dipole trap antenna a 50-Ohms coaxial cable can be used with a high efficiency.

A dipole trap antenna is very easy for tuning and has high efficiency, however, radio amateurs very seldom make as a vertical as dipole trap antenna having a number of traps more than one. The reason is that the antenna sections should be electrically insulated from each other. It is hard enough to do a mechanical strength design of such antenna in radio amateur conditions. Radio amateurs usually prefer a W3DZZ antenna. The antenna has only one trap, and, as it seems by many hams, works at several amateur ranges. What is a W3DZZ?

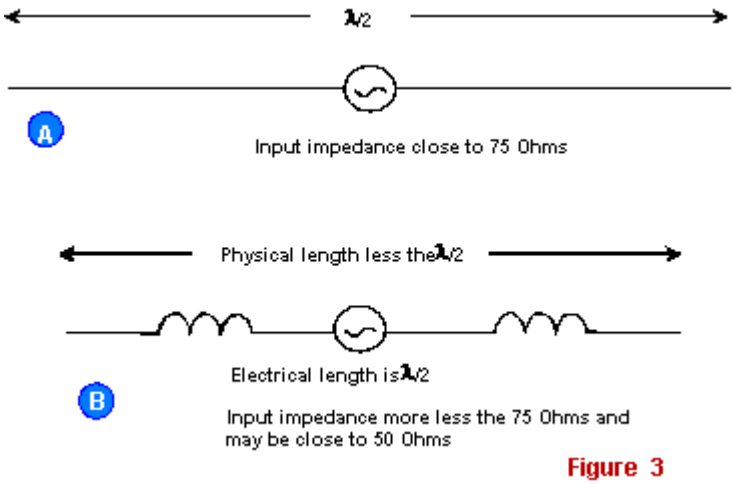


***Figure 3** A shortening and full size dipole antenna*

Antenna W3DZZ: In1955 C. L. Buchanan. W3DZZ, developed a multirange dipole antenna with only one trap, see reference **[4]**. Recently the antenna is known as "antenna W3DZZ." **Figure 4** shows schematic of the antenna W3DZZ.

Antenna W3DZZ works in several amateurs range with low SWR in its feeder. Proper choosing data of the trap turns the trap or to lengthening inductor at low range (ranges) or to shortening capacitor at high range (ranges), or to only a trap at a proper range. For the antenna shown at **Figure 4**, trap LC is the trap for 40

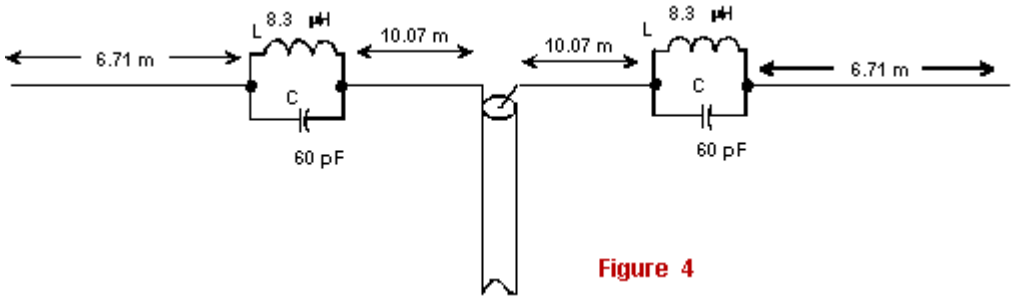
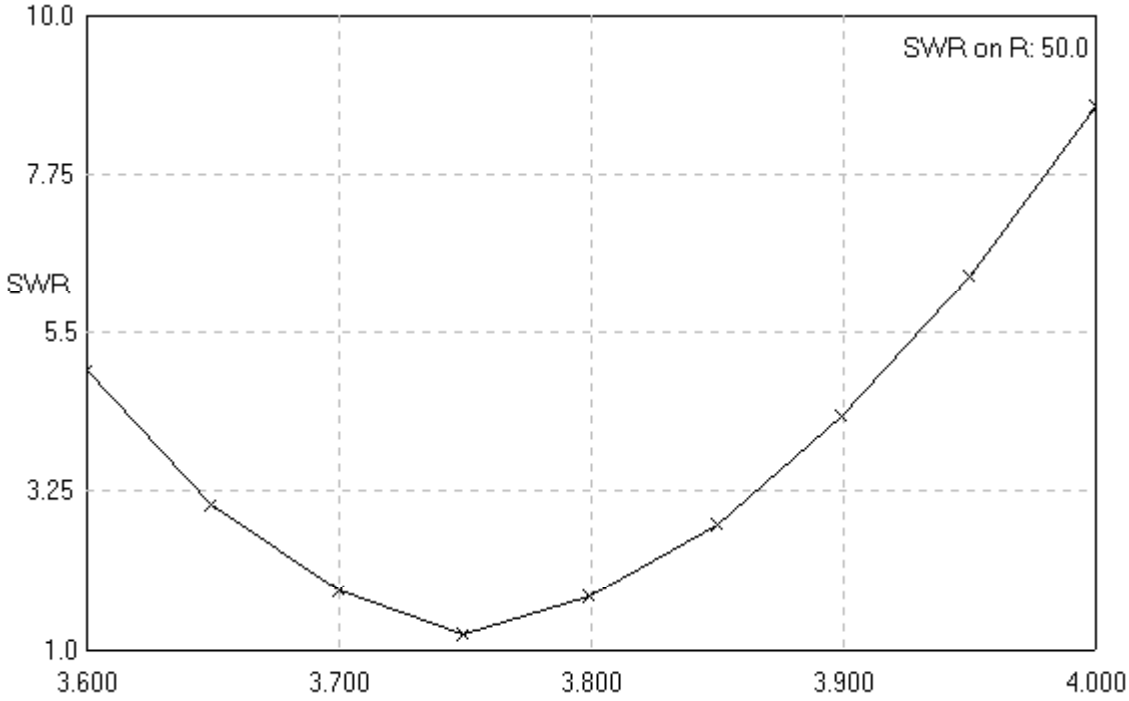
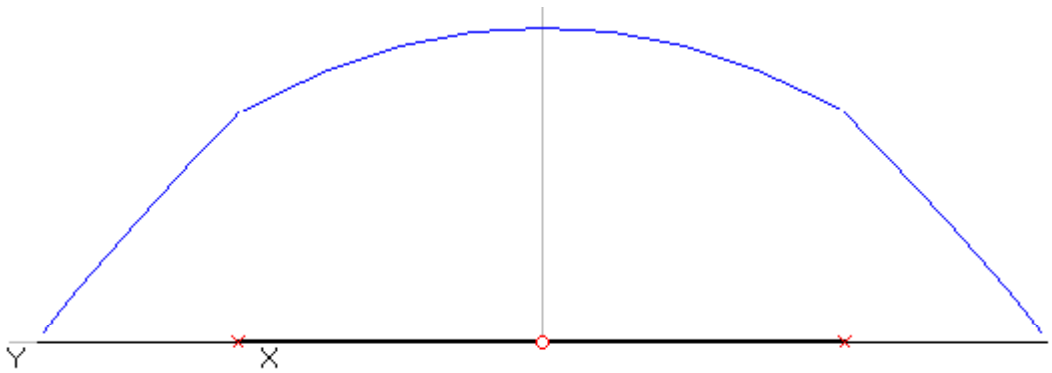


Figure 4 *Antenna W3DZZ*

meters, lengthening inductor for 80 meters, and shortening capacitor for 20, 15 and 10 meters. The antenna (**Figure 4)** does not work at WARC bands. However, the antenna does not work properly at 20, 15 and 10 meters. You can see data obtained with ***Free Antenna Simulation Program MMANA*** ***(MININEC based)*** for the W3DZZ (see **Figure 4**). Antenna wire has diameter of 2 millimeters. You can see, that a SWR at 20, 15 and 10 meters is too high. It is impossible to find such length of the antenna and data for trap that the antenna works at all of the ranges! So, an ATU and a good coax is need for the antenna if you work at 20, 15 and 10 meters.

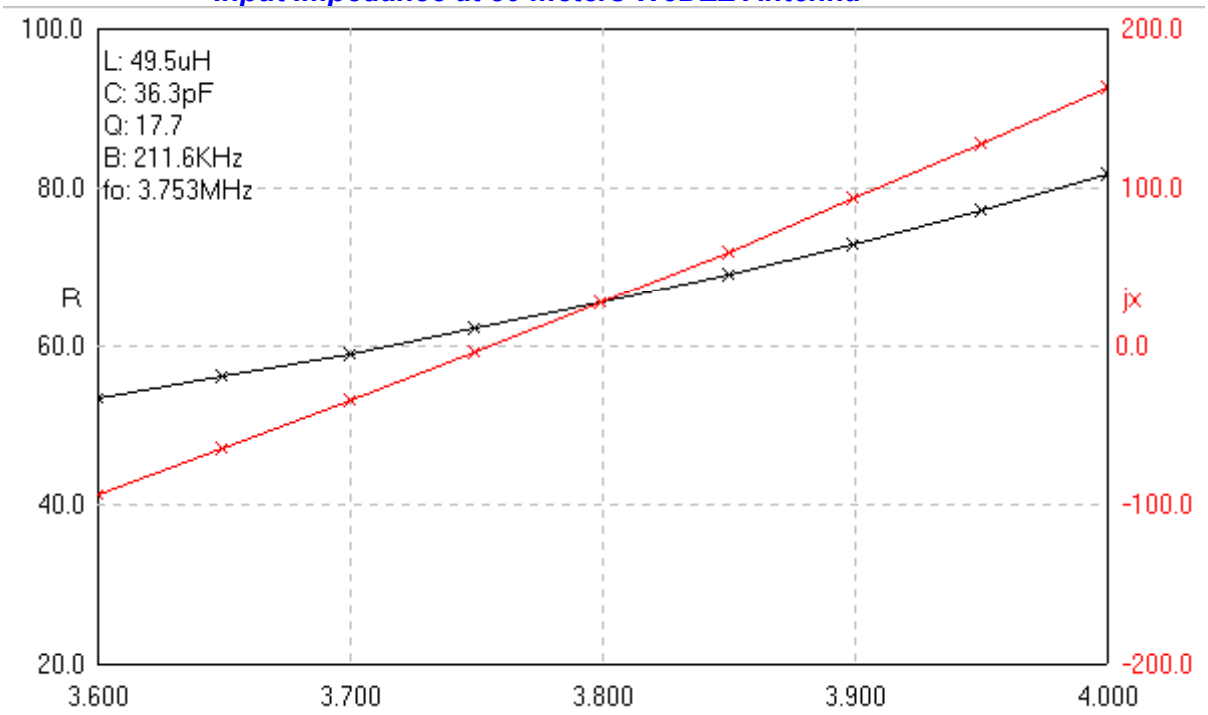
SWR at 80 meters W3DZZ Antenna



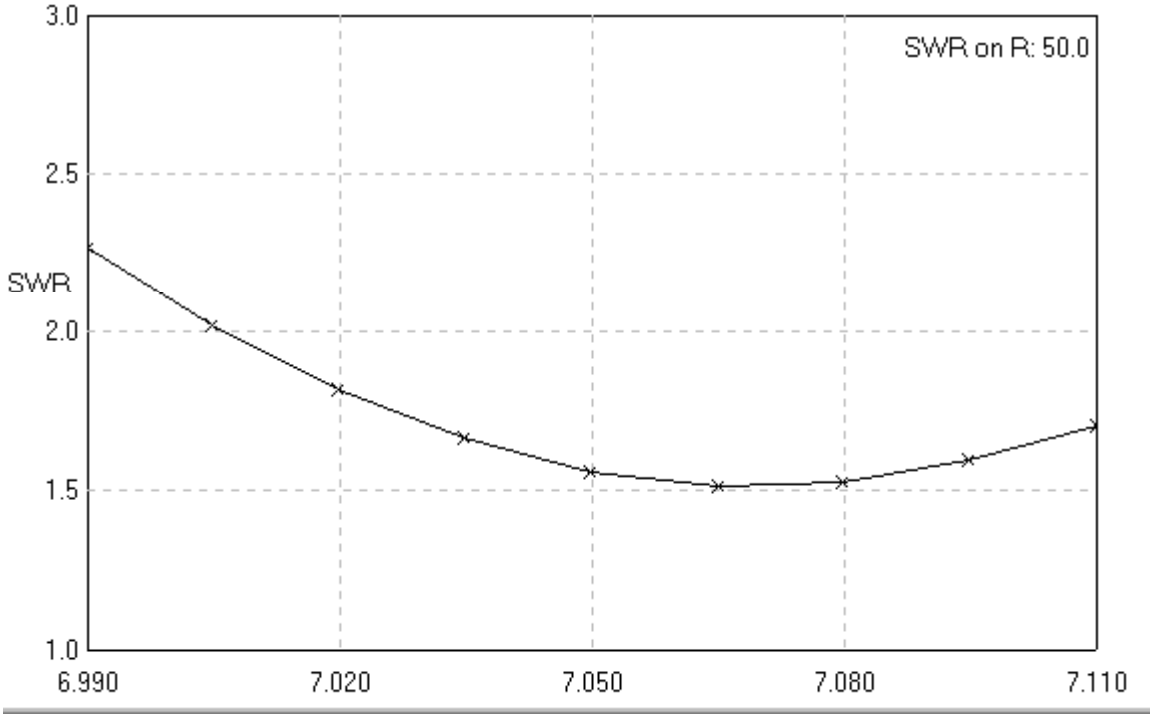


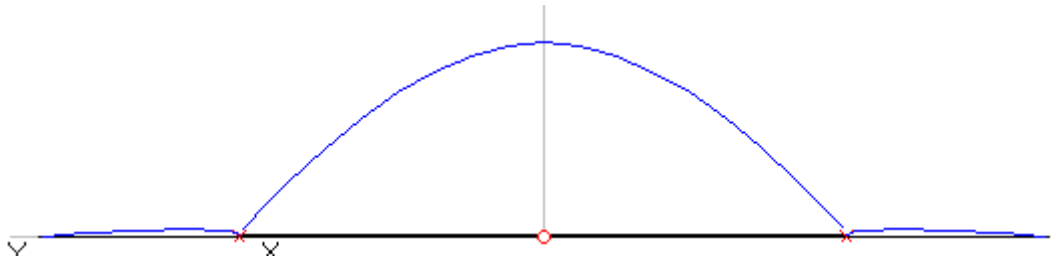
Current Distribution at 80 meters W3DZZ Antenna

Input Impedance at 80 meters W3DZZ Antenna



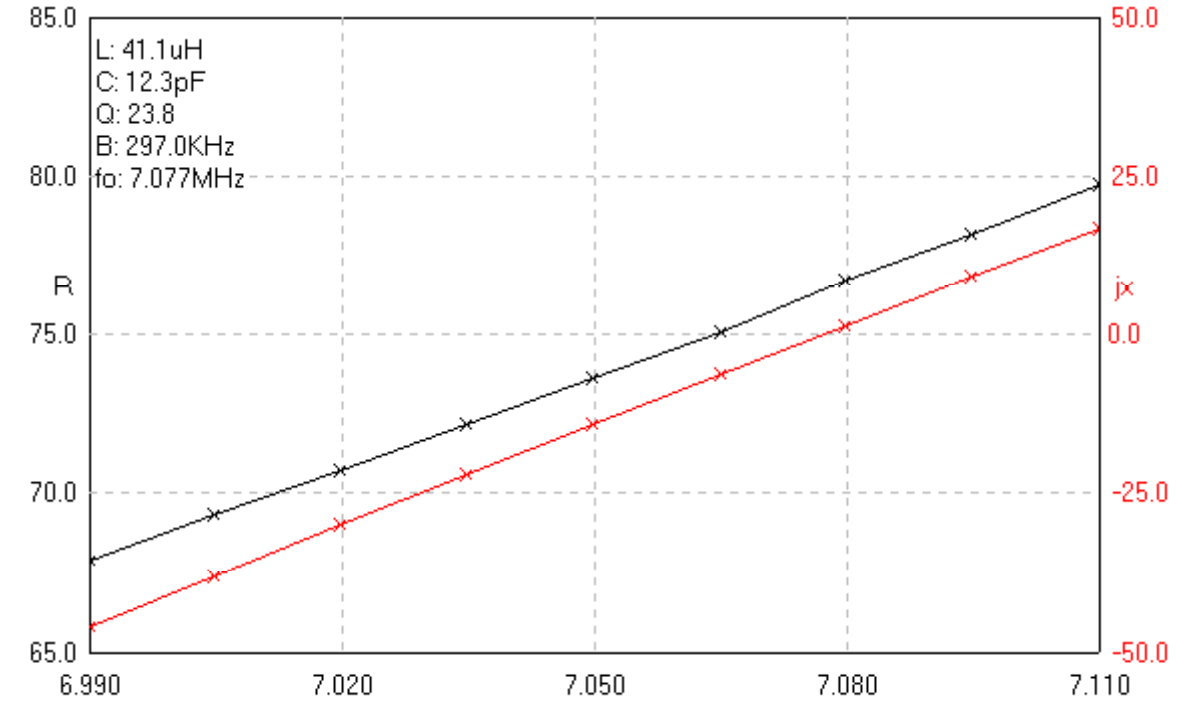
SWR at 40 meters W3DZZ Antenna



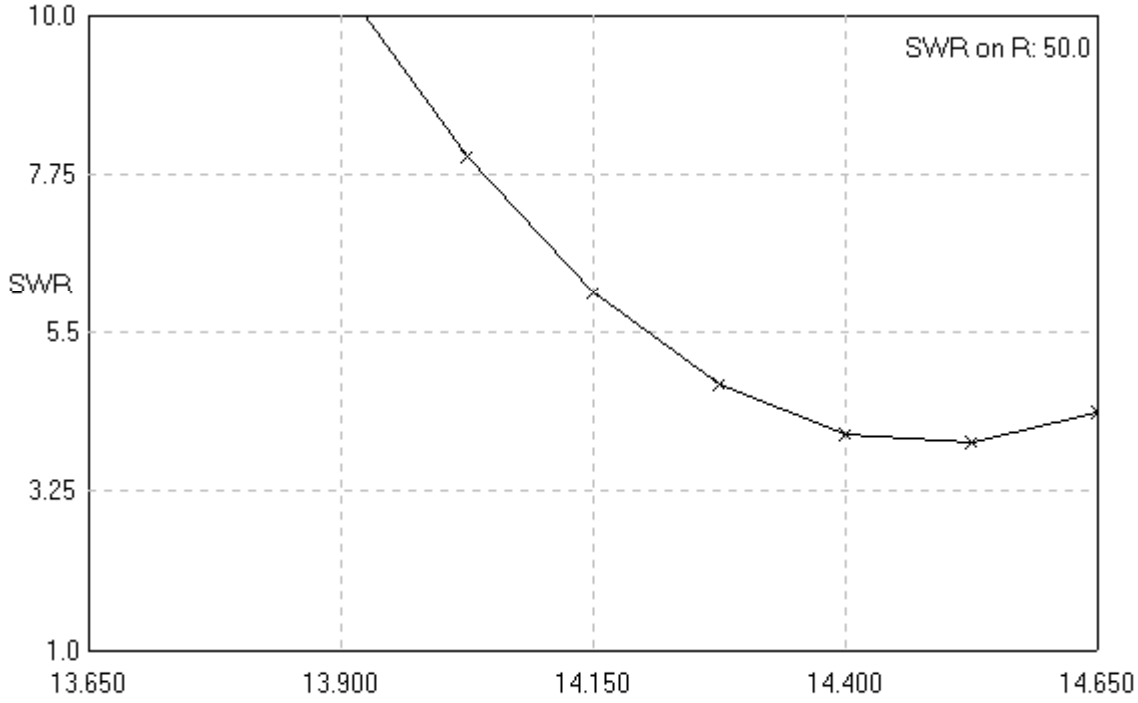


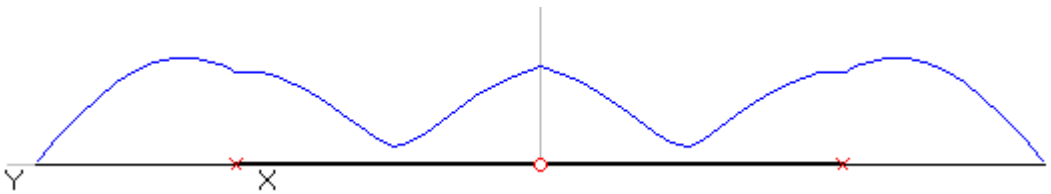
Current Distribution at 40 meters W3DZZ Antenna

Input Impedance at 40 meters W3DZZ Antenna



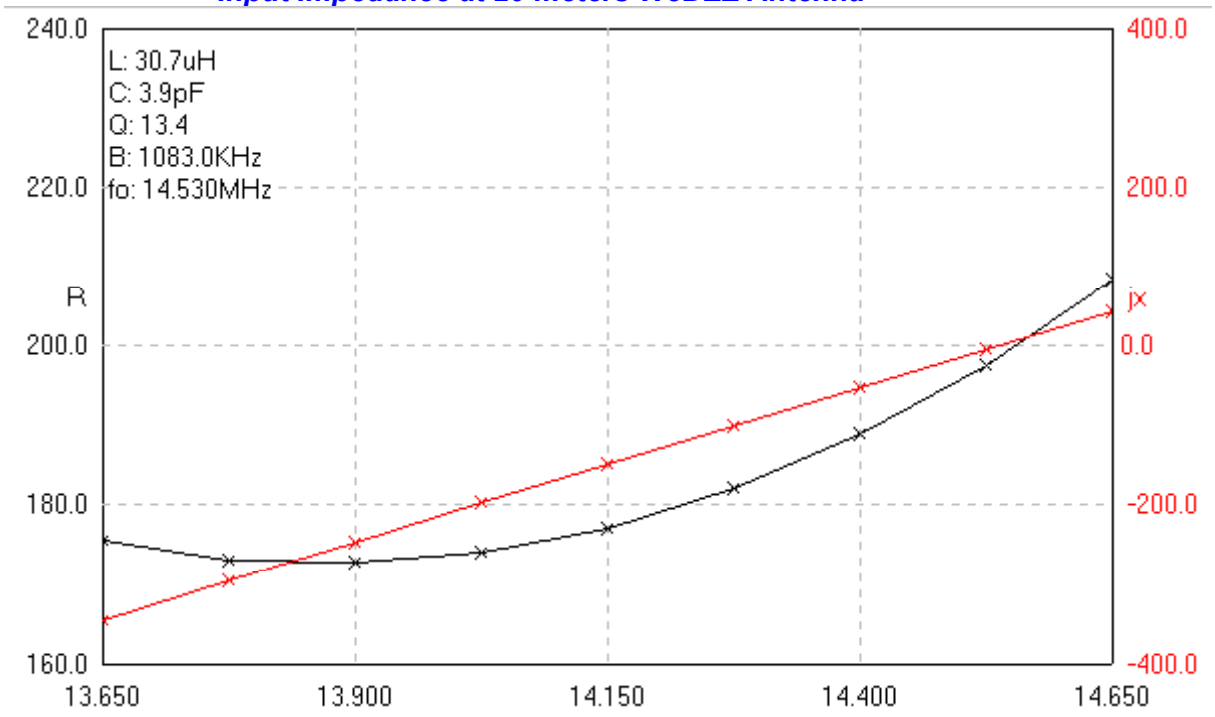
SWR at 20 meters W3DZZ Antenna



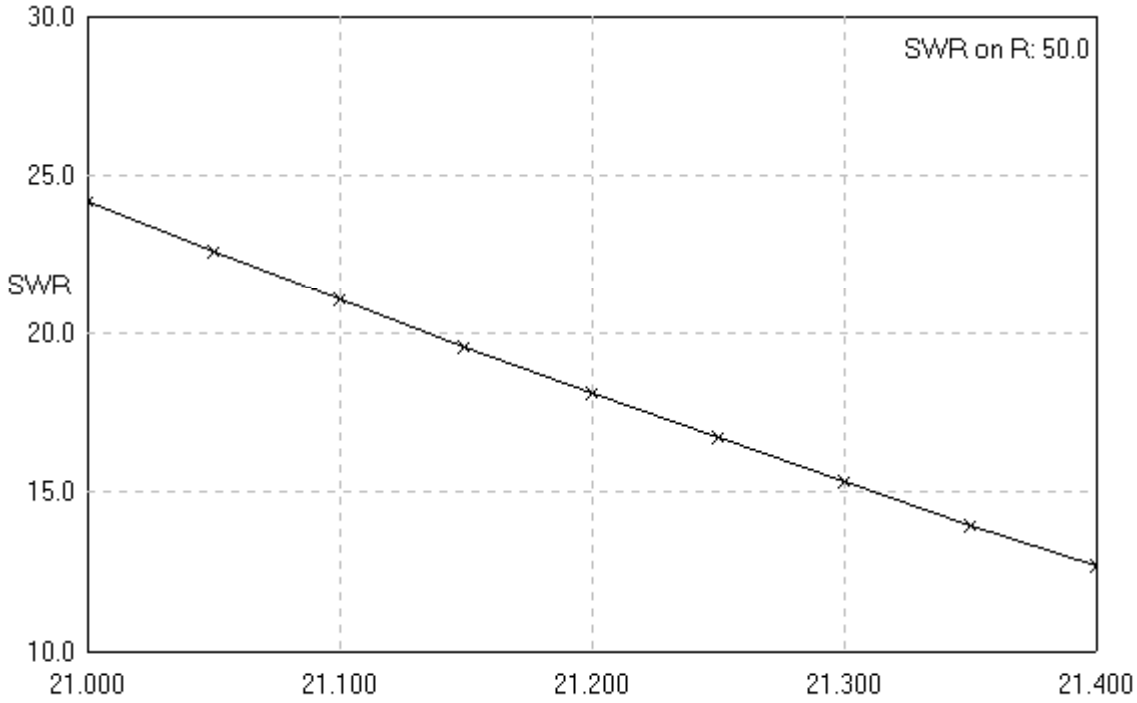


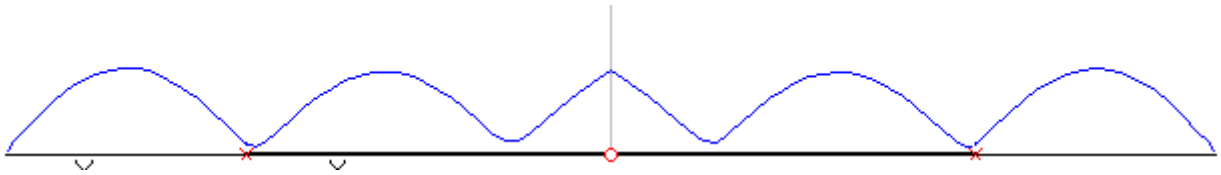
Current Distribution at 20 meters W3DZZ Antenna

Input Impedance at 20 meters W3DZZ Antenna



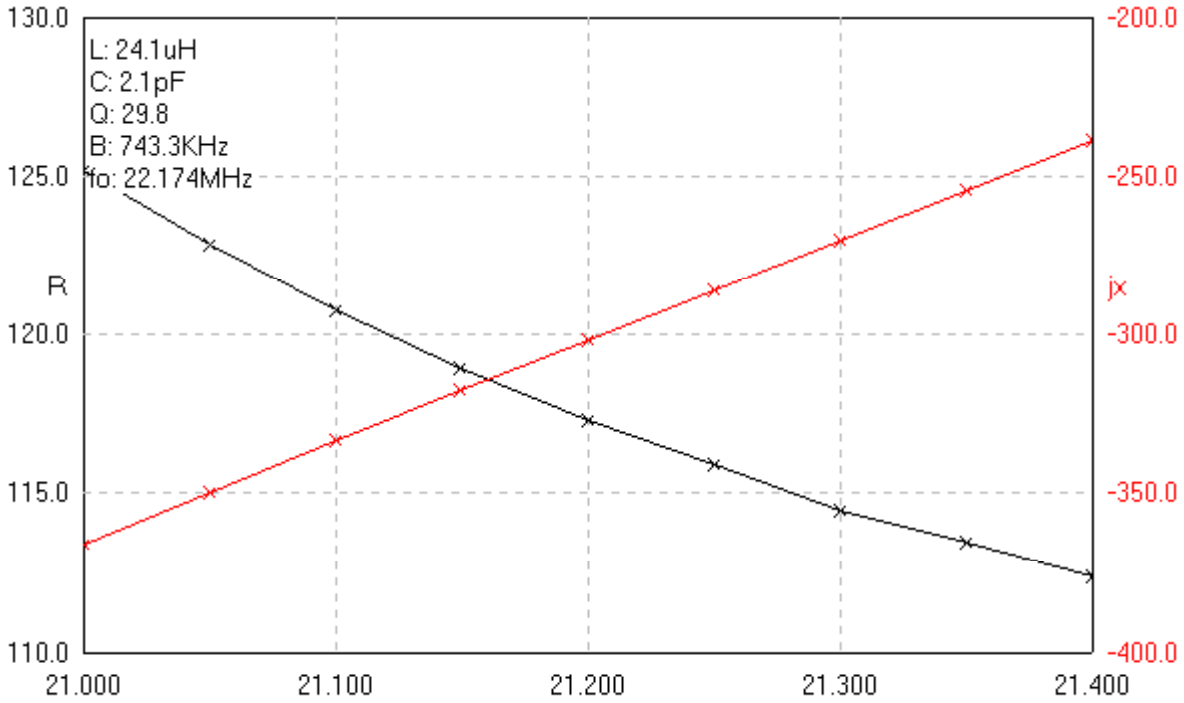
SWR at 15 meters W3DZZ Antenna



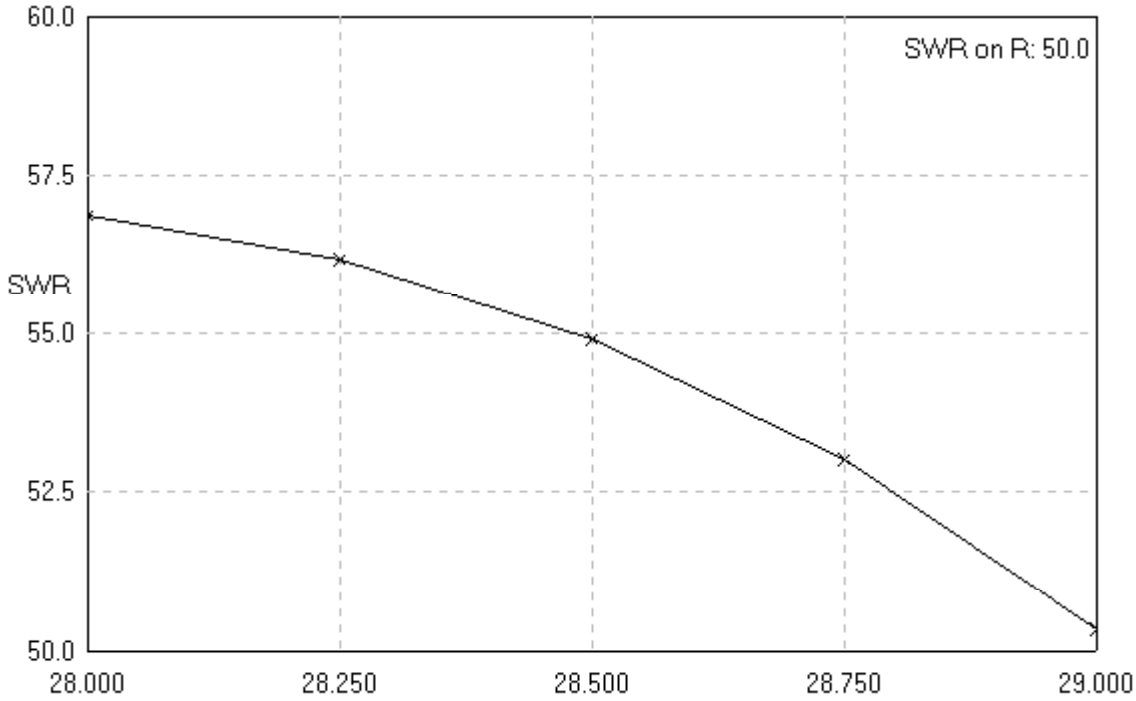


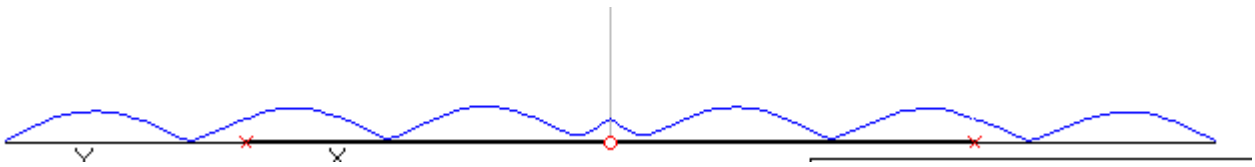
Current Distribution at 15 meters W3DZZ Antenna

Input Impedance at 15 meters W3DZZ Antenna



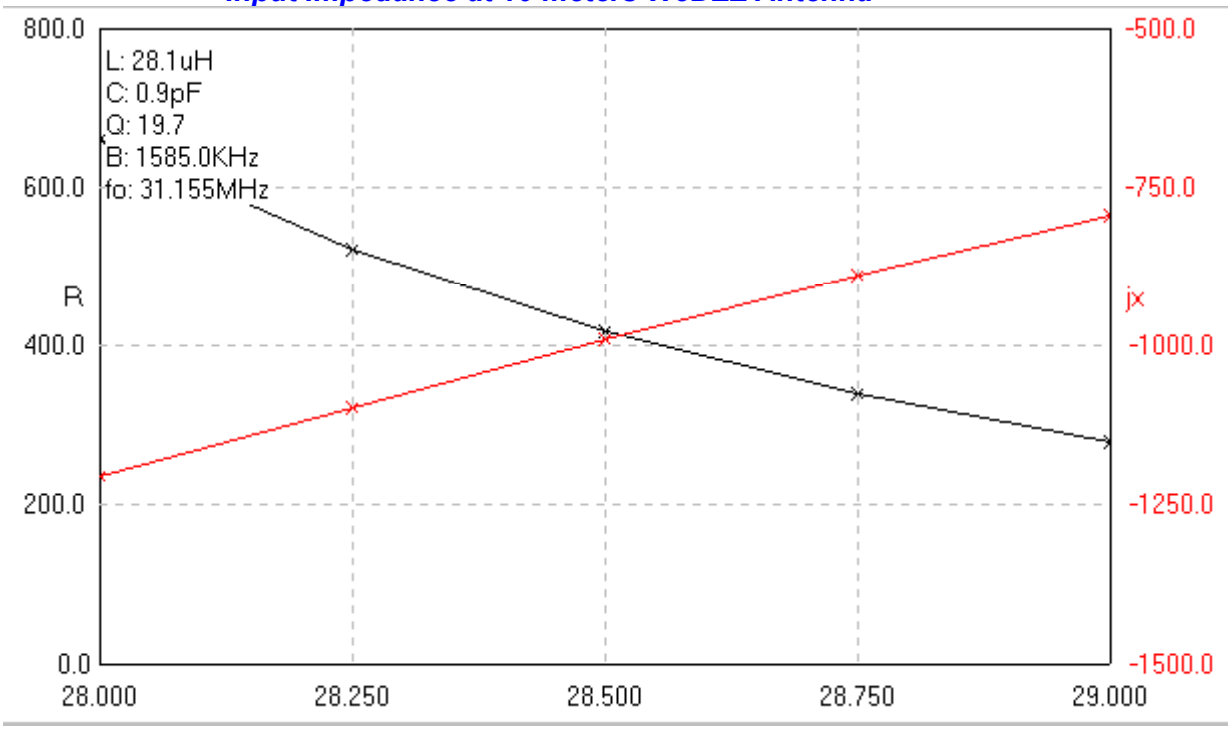
SWR at 15 meters W3DZZ Antenna





Current Distribution at 10 meters W3DZZ Antenna

Input Impedance at 10 meters W3DZZ Antenna



Antenna W3DZZ has input impedance close to 60 Ohms at 80 and 75 at 40, , so, a 75-Ohms coaxial cable can be used for feeding of the antenna.

Hams make antenna W3DZZ also in a vertical installation, where the antenna has input impedance close to 30- 40 Ohms (in twice less the dipole design), so a 50-Ohms coaxial cable can be used for feeding of the antenna at all of the ranges. For a proper work a vertical trap antenna must have several counterpoises for every of operation ranges, especially for low amateur HF ranges 40-, 80- and 160-m.

LC trap design: Trap spool has 8.3-μH and contains 19 turns of silvered copper wire of diameter in 3-mm. Diameter of winding is 50-mm. Length of winding is 80-mm. The trap should be tuned to resonance to the frequency 7,05 (7.2 for USA) MHz. It is possible use a GDO for the tuning. A capacitor at 3-pF is bridged to trap capacitor when the trap is tuning to the resonance. The capacitor is simulated a stray capacitance of the antenna sections.

Antenna tuning: At first, with the help of a GDO tune trap to 7,05 (7.2 for USA) MHz. Trap is tuned separately from antenna. At second, get a minimum SWR on 40 meters by length A. At third, get a minimum

SWR on 80 meters by length B. At thus, you can get SWR (well, see in the above figures, the SWR is not so at 20, 15 and 10 meters.

Four band vertical one-trap antenna:

Hams often use a shortened sample of the W3DZZ antenna intended for 40, 20, 15, and 10 meters. At radio amateurs literature there are several description of the antenna, as at dipole as at vertical installation. However, the first description, which I found off for a vertical four band trap antenna, was made by K2GU in reference **[5]**. **Figure 5** shows the schematic of the antenna.

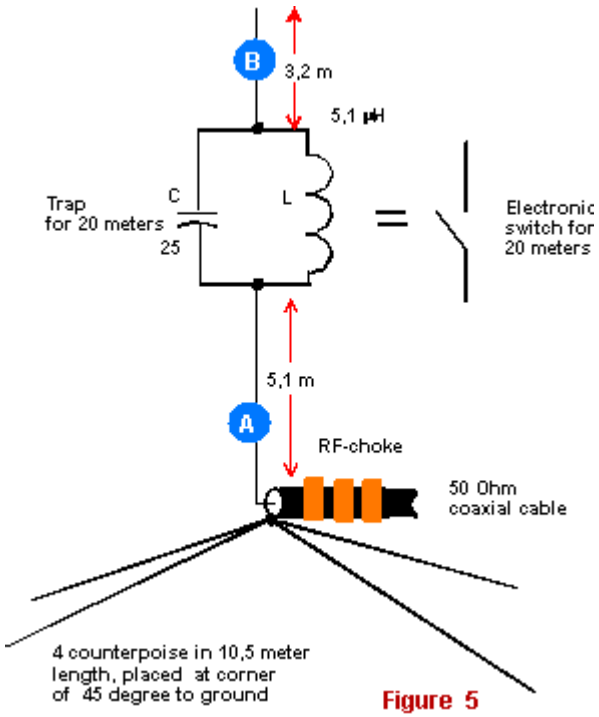


***Figure 5** A four-band trap vertical antenna*

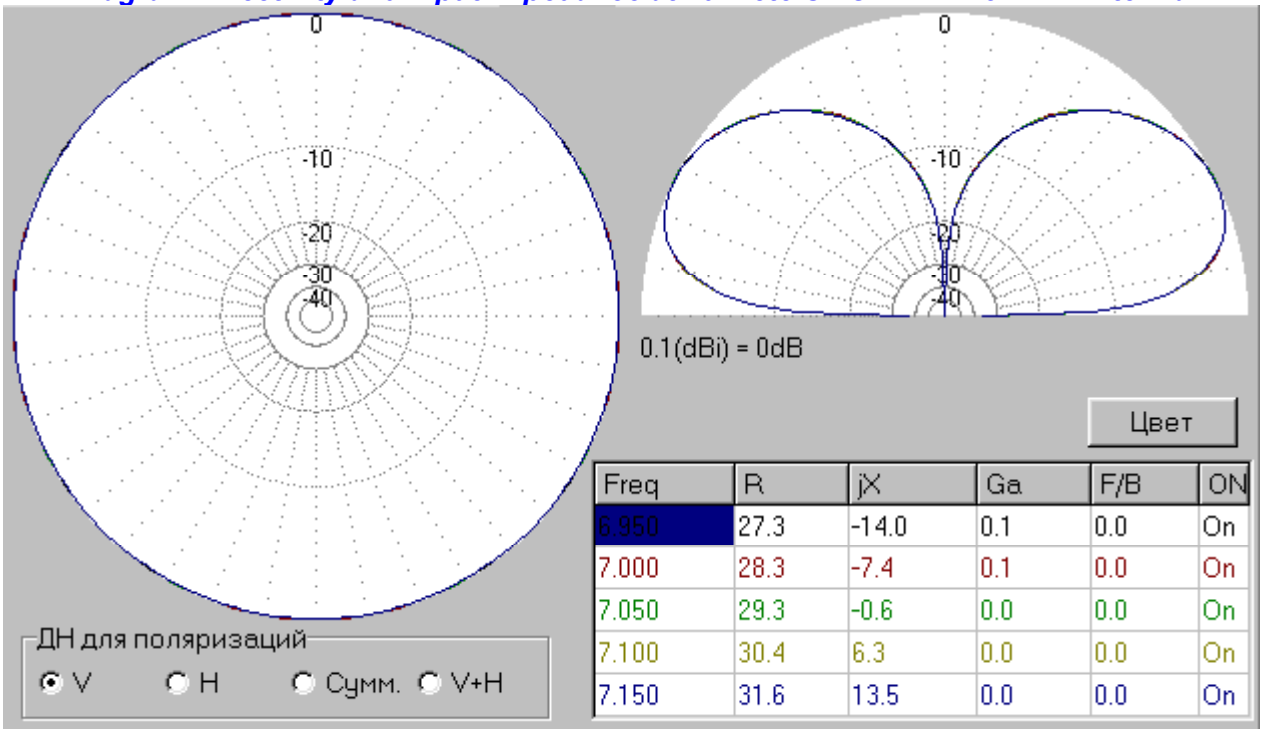
20 meters: Section A is tuned for operation on 20-meters by its length. Trap LC turn off upper antenna parts behind the trap from operation of the antenna when 10 meters range is used.

40 meters: By length of the Section B we tune the antenna parts “Section 1 plus LC plus Section B” to resonance to 40-meters.

15 and 10 meters: The trap serves as a shortening capacitor at that ranges.

Below you can see input impedance, SWR and DD of the antenna W1LNQ. The figures are obtained with the help of Free Antenna Simulation Program MMANA (MININEC based). Section A has diameter of 20 millimeters, section B has diameter of 10 millimeters. You can see, that a SWR at 15 meters is too high. It is impossible to find such length of the antenna and data for trap that the antenna works at all of the ranges. So, an ATU and a good coax is need for the antenna if you work at 15 meters. A 50-Ohm coaxial cable can be used for feeding of the antenna at all of the ranges.

Diagram Directivity and Input Impedance at 40 meters FOR 4B- W3DZZ Antenna



Freq	R	jX	Ga	F/B	ON
6.950	27.3	-14.0	0.1	0.0	On
7.000	28.3	-7.4	0.1	0.0	On
7.050	29.3	-0.6	0.0	0.0	On
7.100	30.4	6.3	0.0	0.0	On
7.150	31.6	13.5	0.0	0.0	On

SWR at 40 meters FOR 4B- W3DZZ Antenna

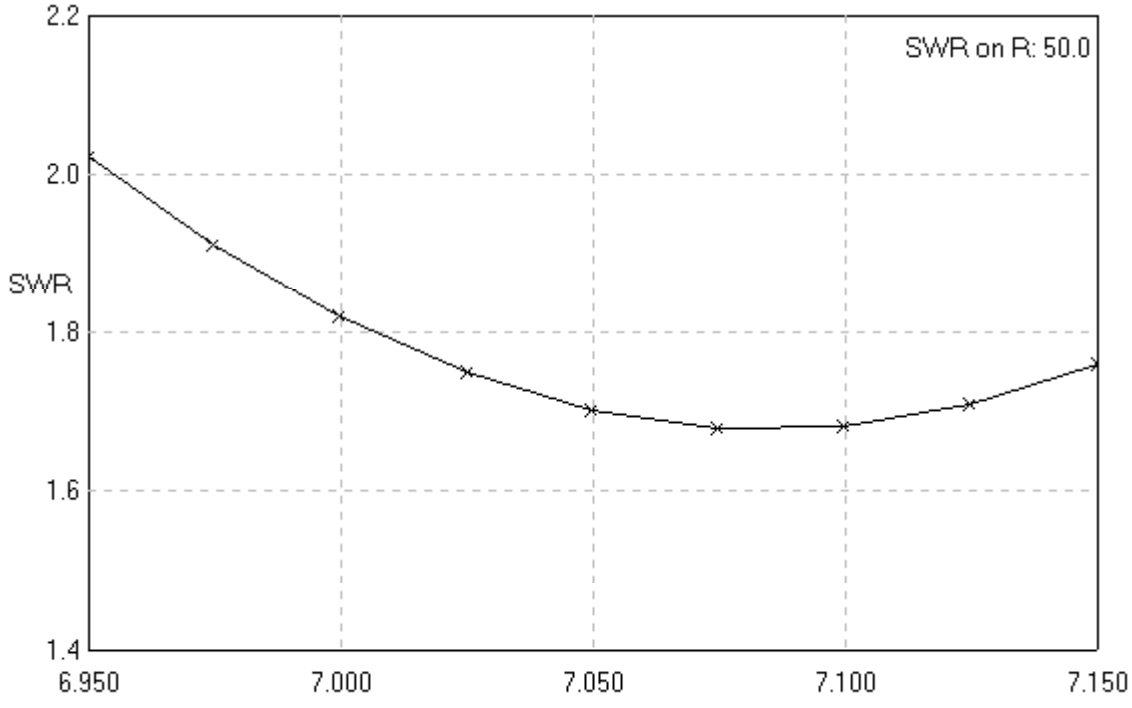
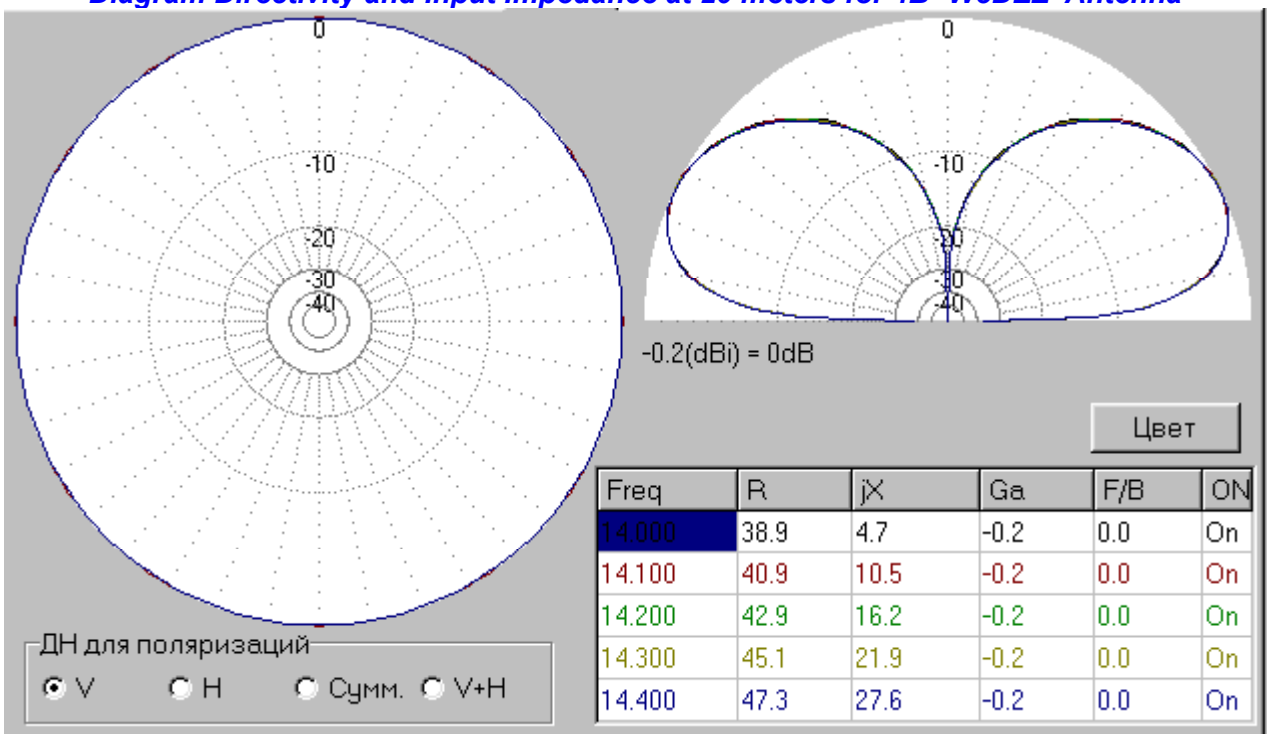
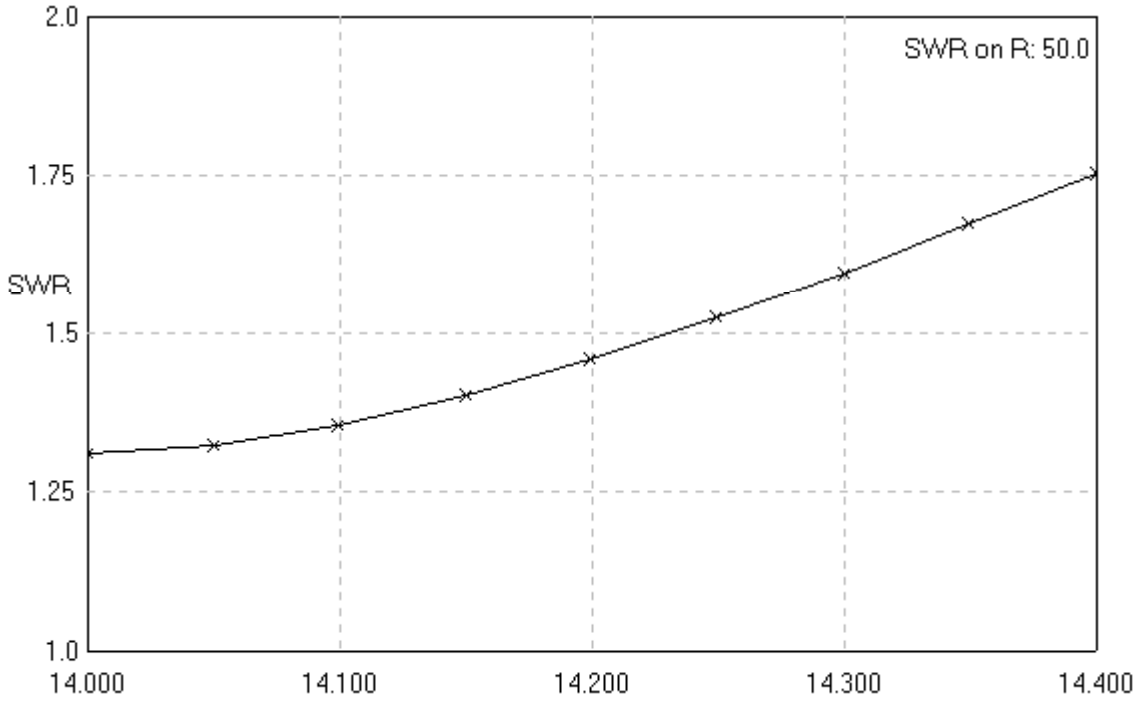


Diagram Directivity and Input Impedance at 20 meters for 4B- W3DZZ Antenna

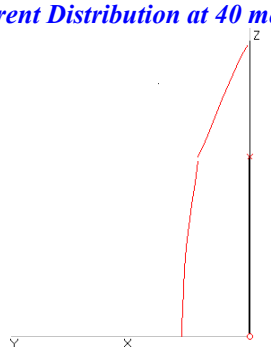


Freq	R	jX	Ga	F/B	ON
14.000	38.9	4.7	-0.2	0.0	On
14.100	40.9	10.5	-0.2	0.0	On
14.200	42.9	16.2	-0.2	0.0	On
14.300	45.1	21.9	-0.2	0.0	On
14.400	47.3	27.6	-0.2	0.0	On

SWR at 20 meters FOR 4B- W3DZZ Antenna



Current Distribution at 40 meters



Current Distribution at 20 meters

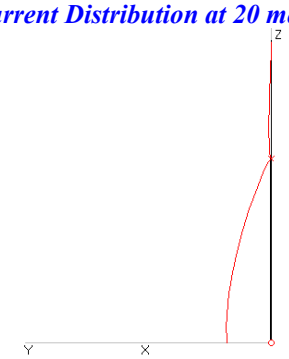
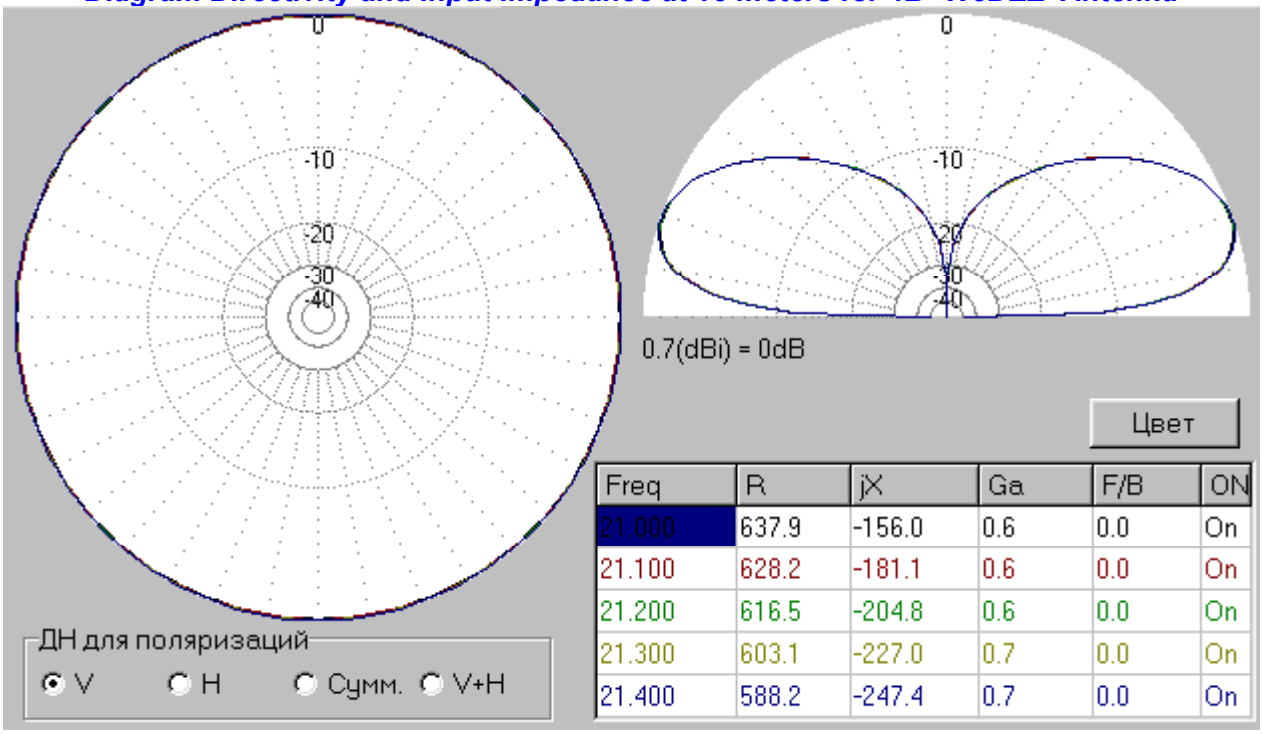
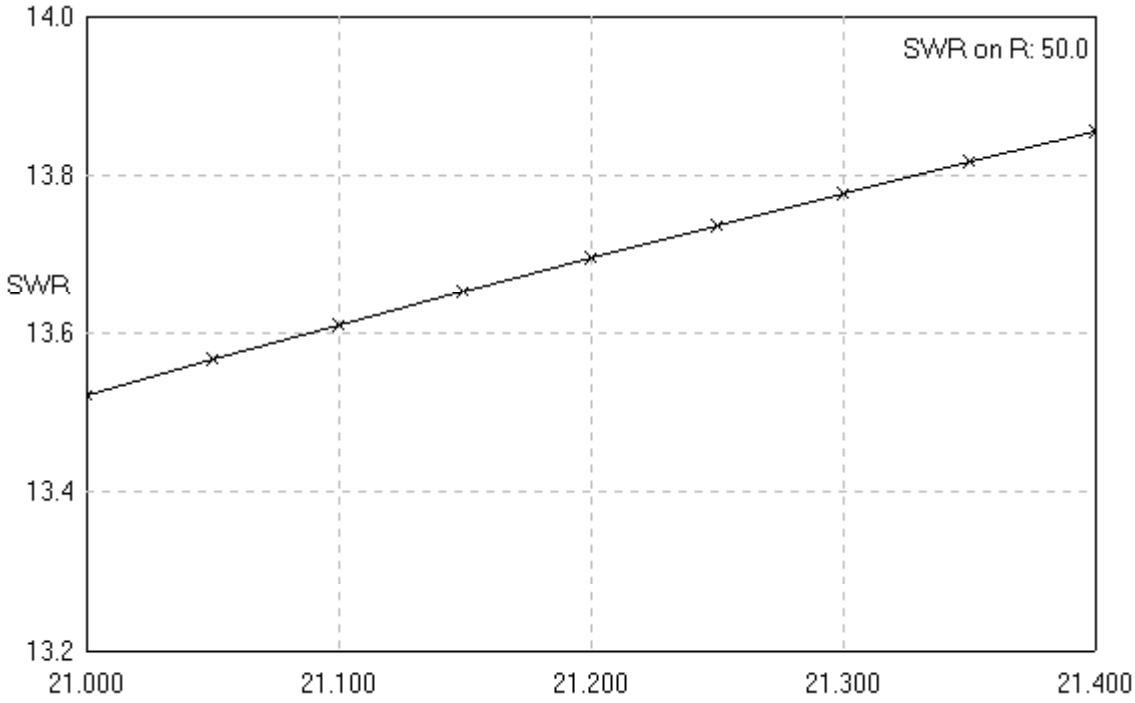


Diagram Directivity and Input Impedance at 15 meters for 4B- W3DZZ Antenna

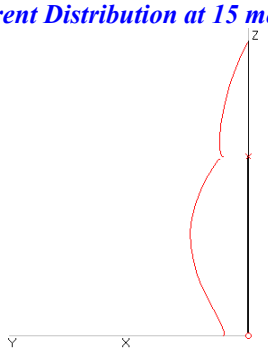


Freq	R	jX	Ga	F/B	ON
21.000	637.9	-156.0	0.6	0.0	On
21.100	628.2	-181.1	0.6	0.0	On
21.200	616.5	-204.8	0.6	0.0	On
21.300	603.1	-227.0	0.7	0.0	On
21.400	588.2	-247.4	0.7	0.0	On

SWR at 15 meters FOR 4B- W3DZZ Antenna



Current Distribution at 15 meters



Current Distribution at 10 meters

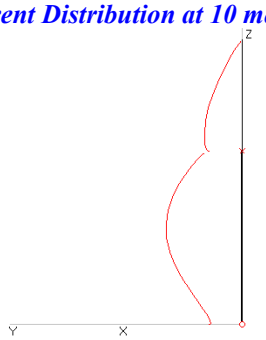
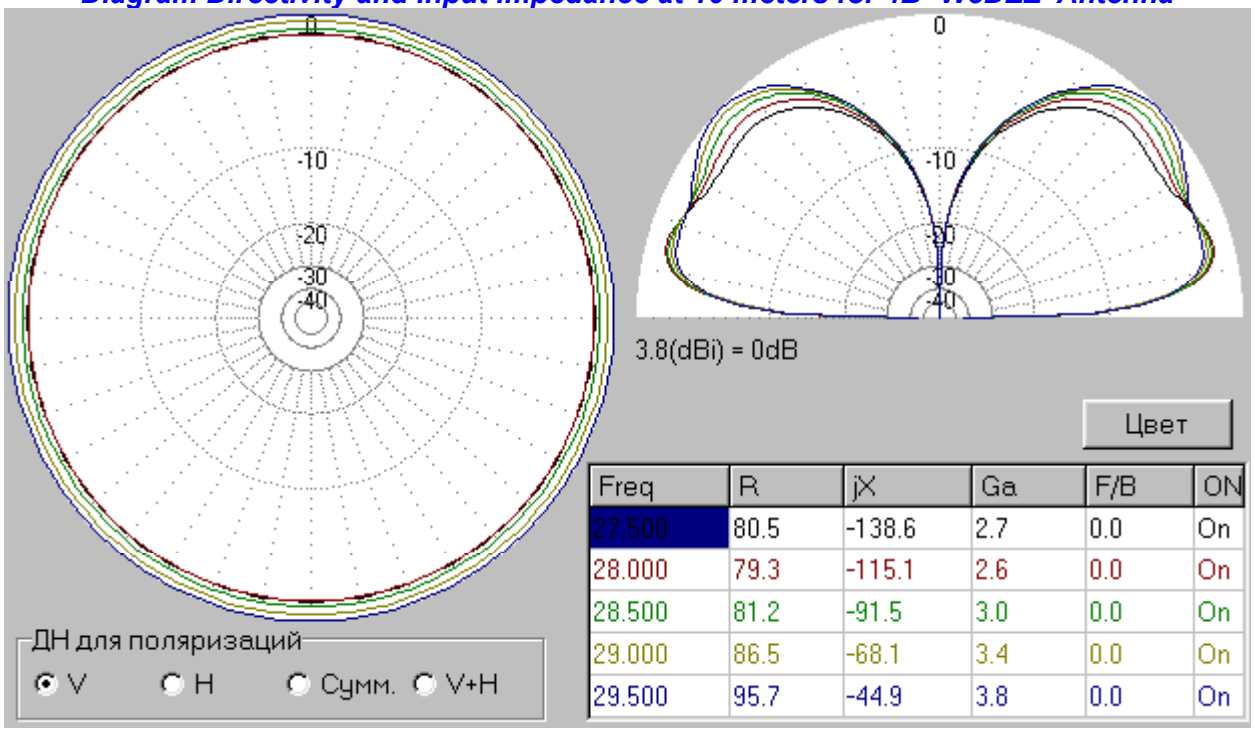
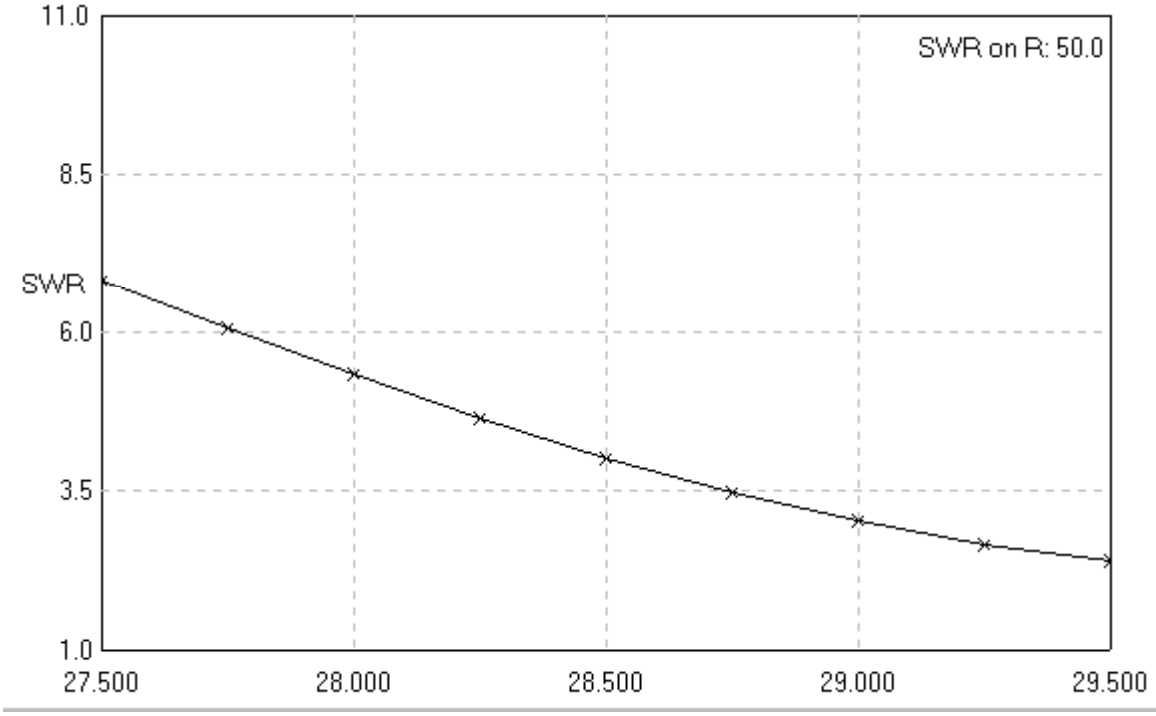


Diagram Directivity and Input Impedance at 10 meters for 4B- W3DZZ Antenna



Freq	R	jX	Ga	F/B	ON
27.500	80.5	-138.6	2.7	0.0	On
28.000	79.3	-115.1	2.6	0.0	On
28.500	81.2	-91.5	3.0	0.0	On
29.000	86.5	-68.1	3.4	0.0	On
29.500	95.7	-44.9	3.8	0.0	On

SWR at 10 meters FOR 4B- W3DZZ Antenna



Trap design: Trap spool contains 10 turns of copper wire diameter in diameter of 2-mm, form of the spool has diameter of 60-mm, distance between turn is 4 mm. The LC circuit should be tuned to frequency of 14.2-MHz. It is possible use a GDO for the tuning. A capacitor at 3-pF is bridged to trap capacitor when the trap is tuning to the resonance. The capacitor is simulated a stray capacitance of the antenna sections. It is necessary to safe trap capacitor from the atmospheric effect.

Antenna tuning: At first, with the help of a GDO tune trap to 14.2-MHz. The circuit tune separately from antenna. At second, tune length A to a minimum SWR in 20 meters. At third tune length of the Section B to minimum SWR at 40 meters.

Common notice for vertical multi range trap antennas

Counterpoises: For a proper work a vertical trap

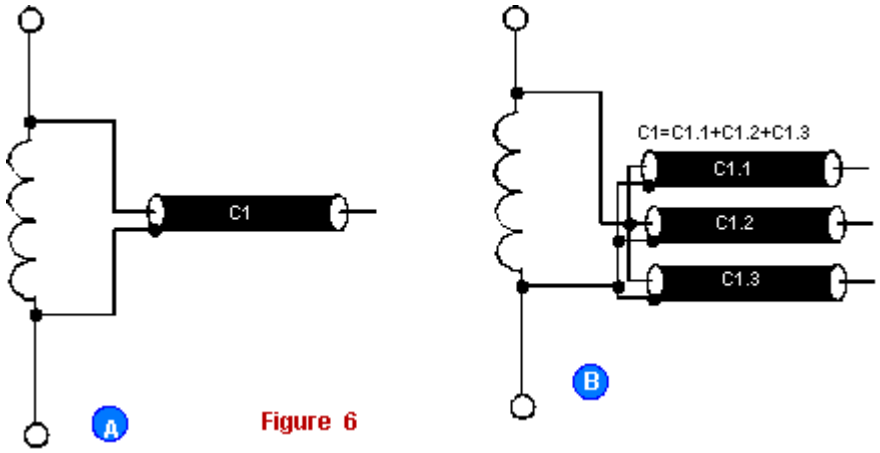


Figure 6

Figure 6 *A coaxial cable capacitor*

antenna need resonance (a quarter wave) counterpoises for each operation range. Use not less than two counterpoises. If the antenna is placed at a small altitude above a metal roof and braiding of feeding coaxial cable have good electrical contact with the metal roof, the antenna can be used without any counterpoises.

Antenna feeding: Quite possible to use a 50- Ohm coaxial cable for vertical trap antenna feeding. Also it is possible to use a two wire line for dipole and vertical trap antenna feeding. In this case it need ATU between the line and the transceiver.

A trap capacitor: A high voltage is at a trap capacitor when the antenna works to transmission. So it need a high voltage capacitor trap to be used at a trap. Such capacitor is costly and rather rare. Hams often use a length of a coaxial cable instead of a high-voltage capacitor. A 50- 0hm coax has near 100-pF/meter, a 75- 0hm coax has near 70-pF/meter. Coaxial cable capacity can be find off from a data sheet for the coaxial cable or is metered practically. **Figure 6** shows a coaxial cable capacitor. For a capacitor with a small capacity (up to 30-pF) it is possible to use whole coaxial cable length, see **Figure 6A**. For a capacitor with a high capacity cut the coaxial cable on to several lengths, as it shown in **Figure 6B.**As a high-voltage capacitor in trap it is possible to use a bilateral PC-board by width of 1 to 3 millimeters. In this case capacitor get more bulky the made on coaxial cable basis. It is possible to tune the PC – capacitor on necessary capacity by slitting a foil on one of two sides of this capacitor. Do not forget about atmospheric protection of the trap capacitor.

Other way for trap design: It seems to me in the end of 70s in different radio amateur literature were appeared articles about using “coaxial cable trap” for W3DZZ. There is very simple method for trap making. **Figure 7** shows the trap. It is wise way for trap design, but radio amateur should have an experience using the method. In different radio amateur literature there are a lot of data for design of the trap, but classical methods are described at reference **[6]**.

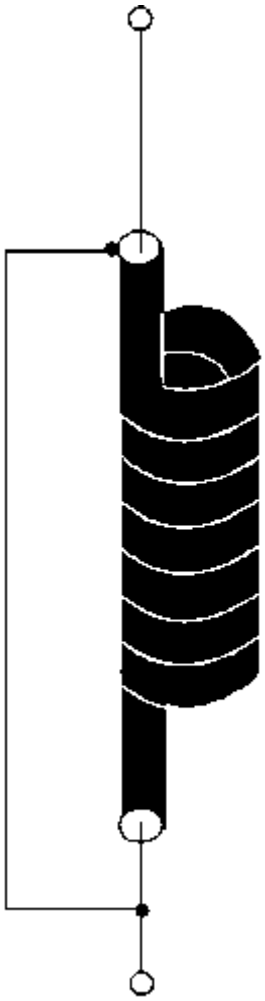


Figure 7

Figure 7 *A coaxial cable trap*

References:

1. By Alois Krischke : Rothammels Antennenbuch.- Franckh – Kosmos, V GmbH@Co., Stuttgart, 1995, 11 edition.
2. Jay Rusgrove, WA1LNQ: The Cheapie GP // QST, 1976, February, p31.
3. Morgan h. K. : Multifrequency Tuned Antenna System. - Electronics, vol. 13, August 1940, pp. 42-50.
4. Buchman C. L., W3DZZ : The multimatch Antenna System. // QST, March 1955, pp.22-23, 130.
5. The Radio Amateur’s Handbook, 1970, by ARRL publication.
6. The ARRRL Antenna Book, 19 Editions // ARRL Amateur Radio, 2000.