Magic Antennas – A. Palm N1KSN

The attached CQ Review was sent to me by the US distributor of Comet antennas. It is a review of the Comet CHA250B HF/VHF vertical antenna.

- Look at the specs in Table I, especially the TX frequency range and SWR. Are you impressed? What is the length?
- Note the following comments in the On The Air section:
  - "As I proceeded down in frequency, it became more difficult to make long-haul QSOs."
  - "Surprisingly, it was easier to make contacts on 30 meters than on 17 and 20."
  - "Forty meters was more of a challenge, ..."
  - "The antenna also seemed 'quiet'."
  - "Another nice feature of the CHA250B is that not only is it resonant on the ham bands, but it is also resonant on the shortwave broadcast bands."
- Why do you think the first 4 comments are true? Why is the 5th comment false?

- Look at Table II in the review. About how many S units is the CHA250B below the two-element Yagi on 10 m, 15 m, and 20 m? If the gain of the Yagi is about 6 dB = 1 S unit over a reference dipole, about how many S-units is the CHA250B above a dipole?

- Look at Table III. About how many S-units is the CHA250B below the dipole on 30 m? On 40 m?

- In Photo B's caption the author mentions the "exceptionally small matching network" and "No extended radials..." What do you think is in that matching network?

If your ability to put up an HF antenna is restricted by too little space or too much regulation, consider this new no-radials vertical from Comet Antennas that covers 80 through 6 meters.

CQ Reviews:

The Comet CHA250B HF/VHF Vertical Antenna

BY DAN DANKERT,* N6PEQ

In February, Mick Stwertnik of NCG offered me the opportunity to test the new Comet CHA250B HF/VHF vertical antenna (photo A). With the ARRL SSB DX contest just a couple of weeks away, the timing was perfect! I had the opportunity to A/B test the CHA250B against my home antenna system knowing that plenty of DX stations around the world would be on the air.

The main selling points of this antenna are ease of assembly, simple installation, elimination of ground radials (see photo B) and an SWR of 1.5:1 or less from 3.5 MHz to 57 MHz. An antenna tuner is not needed, thus making portable operation that much easier.

I was intrigued by the possibility of this antenna being an answer for numerous hams who live in areas that frown upon large antennas. How would the CHA250B fare on a crowded HF band during a contest? Would the antenna be "quiet" on receive? Finally, how would it perform across all the ham bands from 6 meters to 80 meters?

Easy Setup

Once the antenna arrived at my home, I was anxious to learn how complex (or painless) the task of assembly would be. Since the instruction sheet is a single-page leaflet (front and back, see photo C), with one side comprised of the antenna's specifications, I asked myself, "How difficult could this be?" The antenna consists of five sections of aluminum tubing of various diameters. These five sections slide into one another and are fastened by either a hose clamp, self-tapping screws, or Allen screws. The bottom section of aluminum tubing is supplied with the matching network already mounted, which minimizes installation time. There are only two length measurements that need to be taken when fastening the sections together, and these are quite straightforward. Without exaggeration, the antenna was assembled in less than 10 minutes, including opening the box and removing any packaging material. I love efficiency and simplicity, and the CHA250B is the "aerial embodiment" of these two words!

Amateur Bands Covered: 6, 10, 12, 15, 17, 20, 30, 40, and 75/80 meters
Transmit Frequency Range: 3.5–57 MHz
Receive Frequency Range: 2.0–90 MHz
SWR: <1.5:1
Height: 23 ft. 5 in.
Weight: 7 lbs. 1 oz.
Wind Survival: 67 mph
Transmit Power Rating: 250 watts SSB and 125 watts FM
Country of Origin: Japan

Table I– The Comet CHA250B manufacturer's specifications.

The antenna is designed to mount to a mast with a diameter ranging from 1 inch to 2 inches. I decided to place the antenna atop some aluminum military mast sections that I have set aside for antenna projects. Using four sections of mast, the base of the antenna would be at approximately 15 feet, making the top of the vertical roughly 38 feet. I taped a few turns of coax to form an RF choke as indicated in the instructions, and then connected the coax to the antenna's SO-239 connector. Hoisting the antenna into position was a breeze thanks to the antenna's lightweight (7 lbs!) construction. I secured the anten-

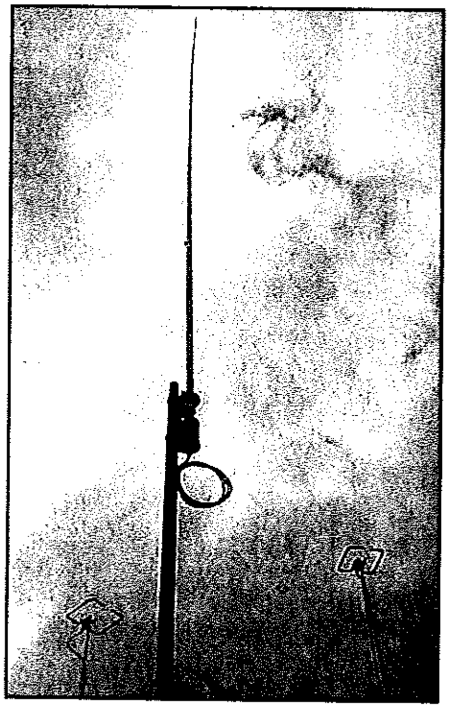


Photo A– The CHA250B mounted on the military mast. The antenna has a low wind foot print, and it almost seems to disappear into the air. This was the setup used for the A/B testing.

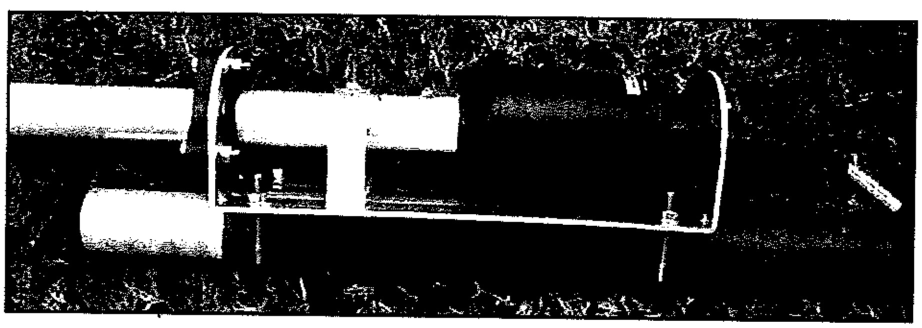


Photo B– Here is the base of the antenna mounted to an aluminum mast section. Notice the exceptionally small matching network (black cylindrical section) of the antenna. No extended radials; this is it!

*e-mail: <n6peq@dxer.com>

Reprinted with permission from CQ The Radio Amateur's Journal, June 2005.

na/mast assembly to the eave of my house, and connected the transceiver end of the coax to one of the remote antenna switches located at the base of my antenna tower. This would make for effortless switching between the CHA250B and other antennas when comparing signal levels.

With the antenna safely secured and the coax run, it was time to see how this antenna would perform! It was just past 0000Z, and the ARRL DX SSB contest had already started. I fired up the IC-7800 and switched to the CHA250B. I heard plenty of signals, and many were quite loud. I measured the SWR, and sure enough it was 1.3:1 or less across the entire 10-meter band. Hmmm . . . I wondered what it would read on the other bands? I checked 12 meters, then 15 meters and so on. Sure enough, the SWR was 1.3:1 or less on all bands from 6 meters to 40 meters. On 75/80 meters the SWR peaked at the low end of 80 meters with a reading of 1.5:1, and then gradually dropped across the band until it reached a minimum of 1.2:1 at the high end of 75 meters. I was beginning to wonder if this antenna was simply a real long dummy load, or if I would actually be able to work some DX with it. Time to go make some Qs!

On the Air

I set the transmitter output power to approximately 100 watts and began calling stations. Within a short period of time, from my QTH in southern California I had worked several stations in South America on 10 meters, and 15 meters provided contacts into Asia, South America, Central America, and the Caribbean. I generally made contact within one or two calls. So far, so good. Signal levels on 10 and 15 meters were definitely lower than on my tri-band Yagi, but the CHA250B is an easy to put up vertical designed to be quickly raised and lowered in areas that are "antenna unfriendly." You obviously cannot achieve this simplicity with a Yagi, rotator, and tower.

The following day brought many more contacts on 10, 15, and 20 meters. Approximately 90 countries were worked over the weekend with minimal operating time. Ten-meter contacts included R1ANF, 9Y4W, KH7X, HP3BS, PJ4G, and ZF2NT. Fifteen-meter contacts included OHØR, SKØX, ES5RW, S9SS, OH3RR, S58A, R1ANF, and 8R1EA. Twenty-meter contacts (see photo D) included TF3CW, EA8ZS, SO2R, OH6KN, UW2I, J68RI, RU1A, CN2R, and EI7M. Over the next week I made abundant contacts on bands from 10 through 30 meters using several modes, including SSB, CW, RTTY, and PSK, some of which included BG1JJR, ZD8AD, 9M6BG, YB7M, EA9EU, T77CD, HG3X, and 9Z4FE. I was pleasantly surprised at how well the antenna played on 30 meters. Some of the stations logged on 30 meters were: JWØHS, TO7C, XT2JZ, V31TR, FS/KT8X, VP2V/DL7DF, FG/F5CWU, CE/W3WKP/M, and even FT5XO on Kerguelen Island!

As I proceeded down in frequency, it became more difficult to make long-haul QSOs. On 10, 12, and 15 meters it was quite easy to work whatever DX stations I could copy. Seventeen and 20 meters were more difficult, usually taking a few more calls to establish a contact. The weaker stations tended not to respond to me. Surprsingly, it was easier to make contacts on 30 meters than on 17 and 20. This is most likely due to the less-crowded band conditions, plus the fact that stateside stations are limited to a maximum power of 200 watts output on 30. Forty meters was more of a challenge, although the signal levels seemed relatively decent, with stateside stations typically hearing my signal. I was able to work into Central America and the Caribbean as well, but that was the extent of the DX on 40 meters. As would be expected, 75/80 meters was very difficult. The antenna is only 23 feet tall, so the fact that the antenna loads up well and is broadbanded on this band is an accomplishment in itself. I was able to work west coast stateside stations on 75/80 meters, and I was able to work one station in Alaska. The antenna also seemed "quiet." I live in an area that is generally quiet as far as noise is concerned, and I did not seem to acquire any greater level of noise with the CHA250B. In addition, I did not appear to pick up any "new" noise.

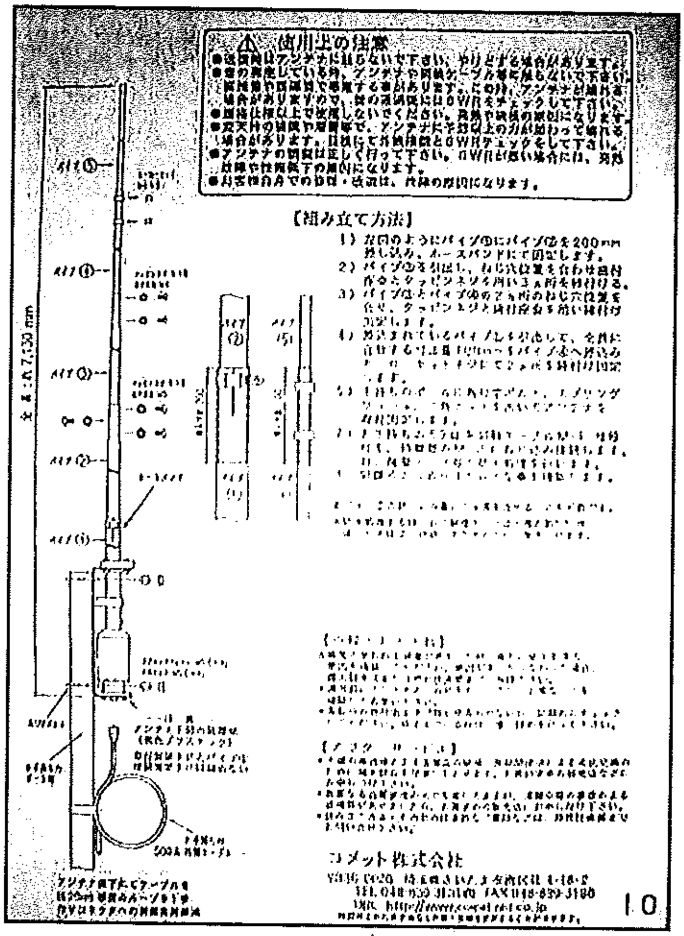


Photo C– This is the single sheet of instructions that is supplied with the antenna. Although it is printed in Japanese, the detailed drawing clearly indicates how the sections are joined together. Also specified are the two dimensions (in millimeters) that are to be measured during installation. You certainly do not need to know how to read Japanese in order to understand the assembly instructions. Ideally, it would be nice if in the future the instructions are provided in English.

I did not work any stations on 6 meters. This was not the fault of the antenna, but rather the fact that I live in southern California, which happens to be "the pits" for 6-meter propagation. However, I was able to verify that the antenna does load on this band.

Another nice feature of the CHA250B is that not only is it resonant on the ham bands, but it is also resonant on the shortwave broadcast bands. The CHA250B does an admirable job as an all-around receiving antenna for the shortwave broadcast bands. Signal levels were excellent on the major SWBC and UTE bands (see photo E). Being an avid shortwave listener, I found this to be a nice attribute. An SWL who would like an antenna that is "all bands in one," low profile, and simple to erect should find this antenna to fill the bill nicely.

Tables II, III, and IV show signal levels received on the CHA250B versus larger antennas at my station (Table I is the manufacturer's specifications for the antenna). As you can see, the signal levels on the CHA250B are consistently lower than those of the bigger antennas, as would be anticipated. In spite of this, I was still able to work many stations as well as numerous DXCC countries!

Conclusions

At the get-go of this antenna project I found myself pondering whether this antenna would radiate at all due to its small size and lack of a radial system. As we all know, bigger is better in the antenna world, and if you have room to install a large antenna

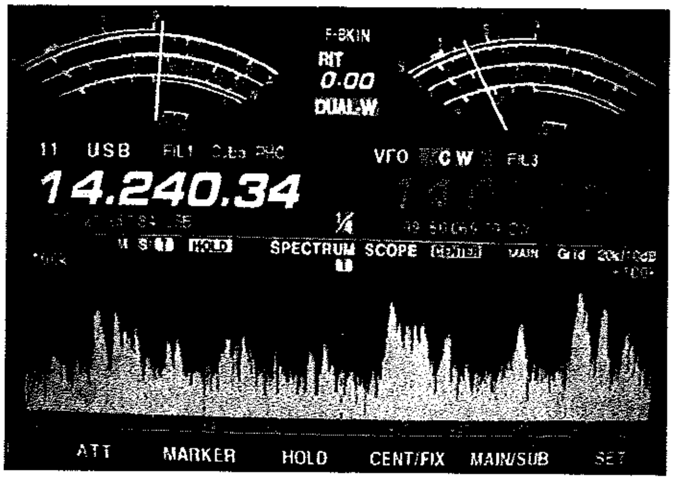


Photo D– A snapshot of the IC-7800 spectrum scope while on 20 meters with the CHA250B. The frequency range displayed is 14.140 to 14.340 MHz. Notice the large number of strong signals across the band.

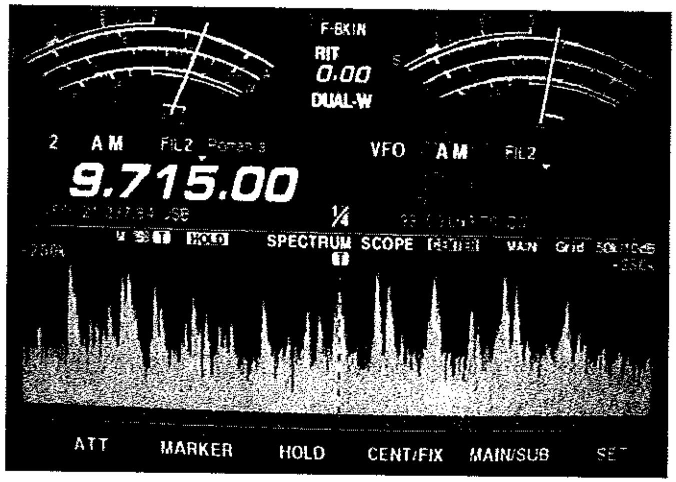


Photo E– A snapshot of the 31-meter shortwave broadcast band. The frequency range displayed is 9.465 to 9.965 MHz. Plenty of strong signals to listen to here!

system, I highly suggest your doing so. This antenna is not designed to replace a Yagi or any other full-size antenna, but rather is intended to assist a specific segment of the amateur market that is forced to manage with antenna or space restrictions. If you are a ham or SWL and live on a small lot or in an antenna-restricted area, or if you just prefer to operate incognito, without a question you will be forced to make significant compromises. I found the CHA250B to be an excellent choice for these circumstances. While we don't recommend violating any rules governing your QTH, one person can effortlessly raise the antenna at night when no one can spot it and take it down before daybreak. This antenna is also a great choice for portable operations, such as a quick and easy mini-DXpedition to a campground or a nice tropical island!

In short, the Comet CFA250B (estimated price $400 to $425) is simple to assemble, painless to elevate, and easy on the eyes, while at the same time getting you on 6 meters through 80 meters without the requirement of an antenna tuner and ground radials. You'll even be able to work some DX while you're at it!

More information on the Comet CHA250B can be obtained by contacting Comet's North American distributor: NCG Companies Inc., 1275 North Grove Street, Anaheim, CA 92806 (phone 1-800-962-2611, fax 714-630-7024, e-mail: <sales@natcommgroup.com>, on the web: <http://www. cometantenna.com>.

Band	DXCC QTH	Comet CHA250B	2-el Yagi @ 45'
10 m.	XE	S4	S9
10	LU	S3	S8
10	CE	S2	S7
10	W4	S3	S9
10	VE7	S4	S9
10	VK	S2	S7
15 m.	YB	S3	S8
15	W4	S7	S9+20
15	3D2	S3	S7
15	PY	S8	S9+20
15	JA	S4	S9
15	W7	S7	S9+20
15	9G	S2	S7
15	EA	S2	S7
20 m.	JW	S3	S8
20	JT	S3	S8
20	8R	S5	S9
20	W0	S7	S9+20
20	W4	S7	S9+20
20	V3	S6	S9+20
20	EA	S6	S9+20
20	G	S4	S9
20	JA	S6	S9+20

Differences are ~5 S-units

Table II– The A/B comparison of signal strength between the Comet CHA250B antenna and a triband Yagi for selected contacts on 10, 15, and 20 meters from the author's southern California QTH.

Band	DXCC QTH	Comet CHA250B	Rotatable Dipole @ 45'
30 m.	WØ	S9+10	S9+25
30	W4	S9+20	S9+20
30	UAØ	S7	S9
30	ON	S9	S9+10
30	YO	S6	S8
30	LU	S9+10	S9+20
40 m.	W7	S9+15	S9+35
40	W9	S8	S9+20
40	FT5X	S8	S9+10
40	JA	S9+10	S9+20
40	LU	S8	S9+10
40	OE	S7	S9+10

Difference 1 to 2 S units (30 m.)

2 to 4 S Units (40 m.)

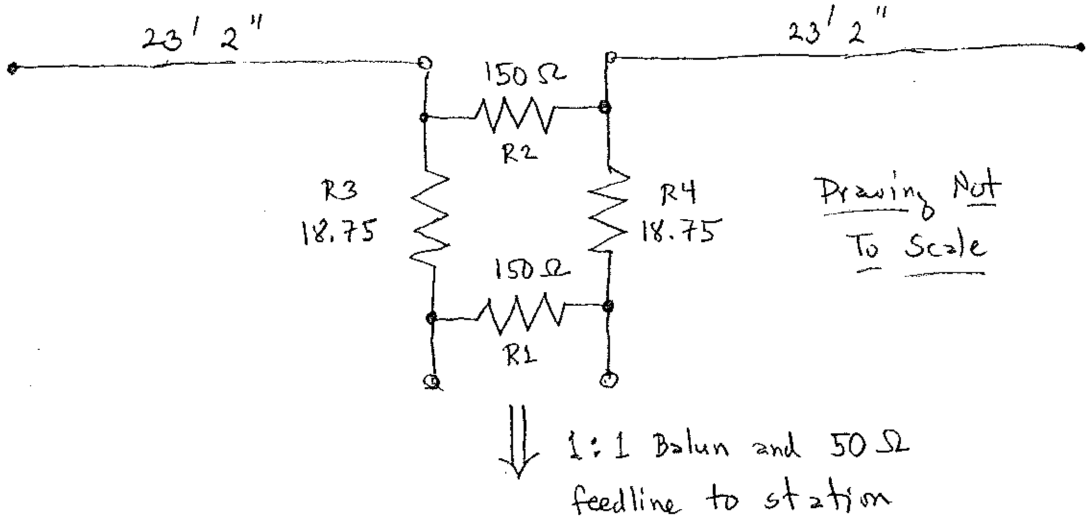
Table III– A/B comparisons on 40 and 30 meters between the Comet vertical and a two-band rotatable dipole.

Band	DXCC QTH	Comet CHA250B	82' Long Dipole @ 35' (NW/SE)
75/80 m.	W7	S9+20	S9+35
75/80	BV	S4	S7
75/80	UAØ	S7	S9+10
75/80	YV	S7	S9+10
75/80	VK	S5	S9
75/80	EI	S7	S9+10

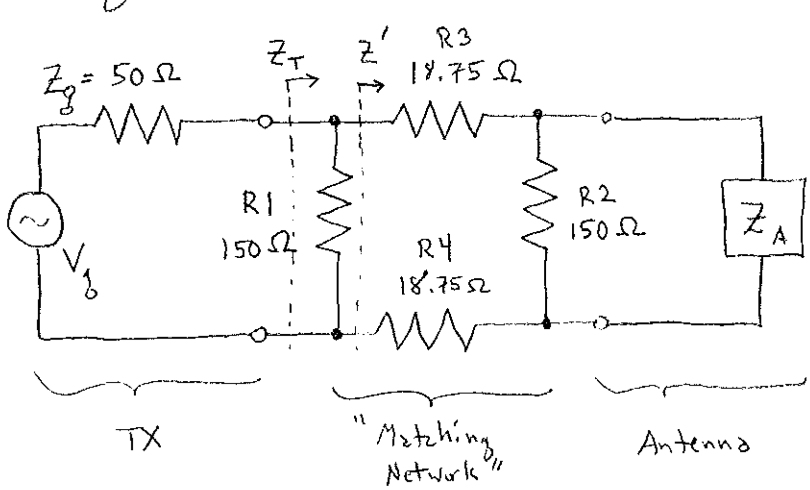
Table IV– A/B comparison on 80/75 meters between the CHA250B and a much-less-than quarter-wave dipole.

- I decided to design the <u>N1KSN</u> <u>Magic</u> <u>Dipole</u>. To make it similar to the CHA250B the dipole will have legs that are a bit over 23 feet long. The "matching network" will be at the center of the dipole.

- The "matching network" looks like this:



- To avoid feedline and line matching issues, we will pretend that the transceiver is connected directly to the matching network. The equivalent circuit is:



- Let Z' be the impedance looking toward the antenna just to the right of R1. Then Z' consists of R3 and R4 in series with the parallel combination of R2 and the antenna impedance Z_A. Thus

$$Z' = R3 + R4 + (R2 \parallel Z_A)$$

$$= R3 + R4 + \frac{R2 \cdot Z_A}{R2 + Z_A} = 37.5 + \frac{150 \cdot Z_A}{150 + Z_A}$$

- Let Z_T be the impedance looking into the network — the impedance seen by the transmitter. Then Z_T is the parallel combination of R1 and Z' or

$$Z_T = R1 \parallel Z' = \frac{150 \cdot Z'}{150 + Z'}$$

- If we "do the math" we get

$$Z_T = \frac{28125 \cdot Z_A + 843750}{337.5 \cdot Z_A + 28125}$$

- To find the SWR seen by the transmitter we first calculate the reflection coefficient

$$\Gamma = \frac{Z_T - Z_g}{Z_T + Z_g} = \frac{Z_T - 50}{Z_T + 50}$$

- After some tedious arithmetic we get

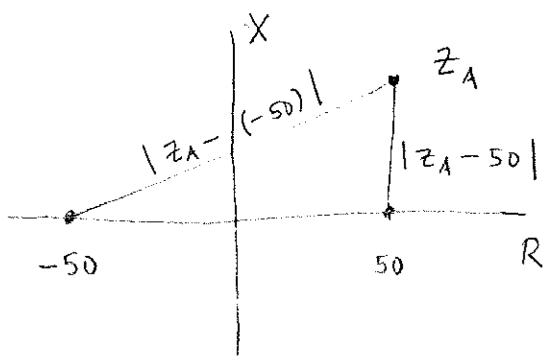
$$\Gamma = \frac{Z_T - 50}{Z_T + 50} = \frac{11250 \cdot Z_A - 562500}{45000 \cdot Z_A + 2250000}$$

$$= \frac{Z_A - 50}{4 Z_A + 200} = \frac{1}{4}\left(\frac{Z_A - 50}{Z_A + 50}\right)$$

- Since the real part of Z_A, the antenna resistance, is always ≥ 0, we have

$$|Z_A - 50| \leq |Z_A - (-50)| = |Z_A + 50|$$

because in the impedance (complex) plane the distance from Z_A to -50 is $\geq$ the distance from Z_A to 50.



It follows that the length of Γ satisfies

$$|\Gamma| = \frac{1}{4}\left|\frac{Z_A - 50}{Z_A + 50}\right| = \frac{1}{4}\,\frac{|Z_A - 50|}{|Z_A + 50|} \leq \frac{1}{4} \cdot 1 = \frac{1}{4}$$

- Hence

$$1 + |\Gamma| \le \frac{5}{4} \quad \text{and} \quad 1 - |\Gamma| \ge \frac{3}{4}$$

and so

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} \le \frac{5/4}{3/4} = \frac{5}{3} \cong 1.67$$

- This shows that the SWR seen by the rig is always 1.67 : 1 or less, <u>no matter what the antenna impedance is</u>. Note that if a 1:1 balun and 50 Ω feedline are put between the "matching network" and the rig, the SWR seen at the rig will be even less, depending on feedline losses.

- Is the great or what!? This means that the SWR seen by the rig is 1.67 : 1 or less no matter what frequency we are on. This is nearly as good as the Comet CHA250B.

- Can you think why you might <u>not</u> want such a "matching network"? Let's look at where our transmit power goes.

- Let I_i denote the current through R_i. Let I_A be the current through the antenna, and let I_g be the current from the transmitter. We can use the current splitting equation to get

$$I1 = I_g \left(\frac{Z'}{R1 + Z'} \right)$$

$$I3 = I_g - I1 = I_g \left(\frac{R1}{R1 + Z'} \right)$$

$$I2 = I3 \left(\frac{Z_A}{R2 + Z_A} \right) = I_g \left(\frac{R1}{R1 + Z'} \right) \left(\frac{Z_A}{R2 + Z_A} \right)$$

$$I_A = I3 - I2 = I3 \left(\frac{R2}{R2 + Z_A} \right)$$

$$= I_g \left(\frac{R1}{R1 + Z'} \right) \left(\frac{R2}{R2 + Z_A} \right)$$

$$I4 = I2 + I_A = I2 + (I3 - I2) = I3$$

These give the current in each resistor and the antenna as functions of the transmitter current I_g and the impedances.

- The power loss in resistor R_i is $\frac{1}{2}|I_i|^2 R_i$ when $|I_i|$ is the peak current. (Drop the factor $1/2$ if $|I_i|$ is in RMS units.) Let P_i be this power loss and let $P_A = \frac{1}{2}|I_A|^2 R_A$ be the power into the antenna, $Z_A = R_A + jX_A$.

- The fraction of transmit power reaching the antenna is

$$\frac{P_A}{P1 + P2 + P3 + P4 + P_A}$$

and the "matching network" loss in decibels is

$$-10 \log_{10}\left(\frac{P_A}{P1 + P2 + P3 + P4 + P_A}\right)$$

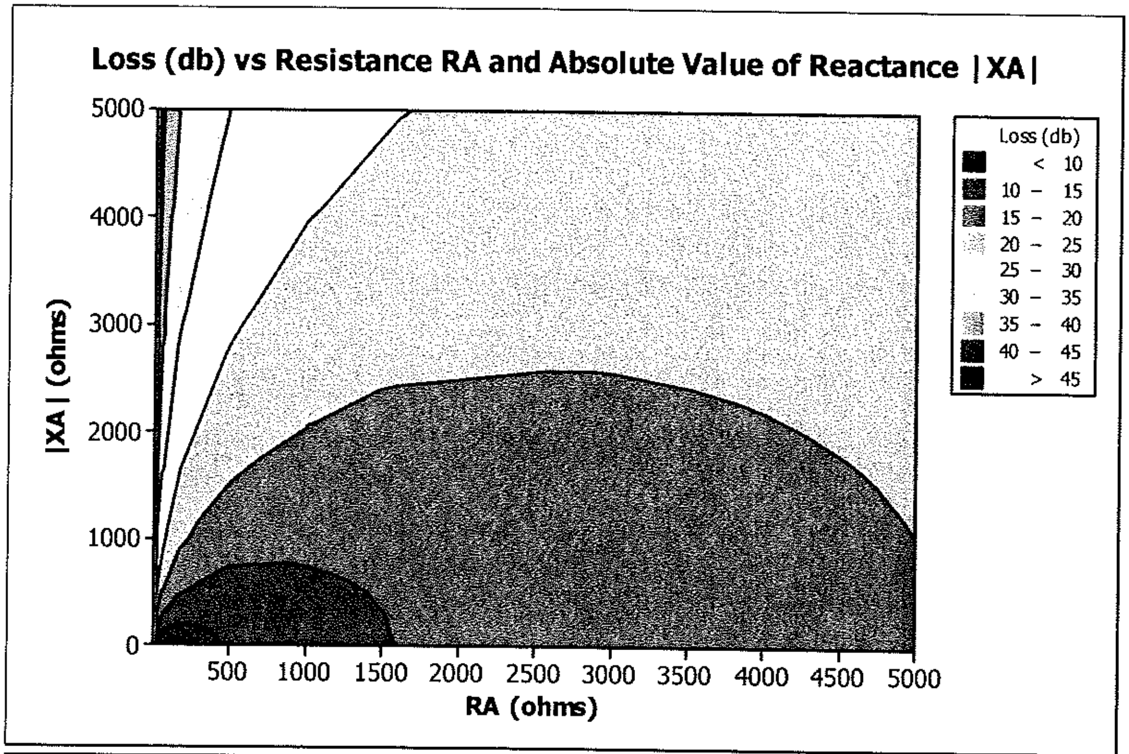
- The table on the next page shows the "matching network" loss for a wide range of antenna resistances R_A and reactances X_A. The table only shows inductive reactances ($X_A \geq 0$), but the loss is the same if X_A is changed to $-X_A$. The loss is also shown in S-units with 1 S-unit = 6 dB.

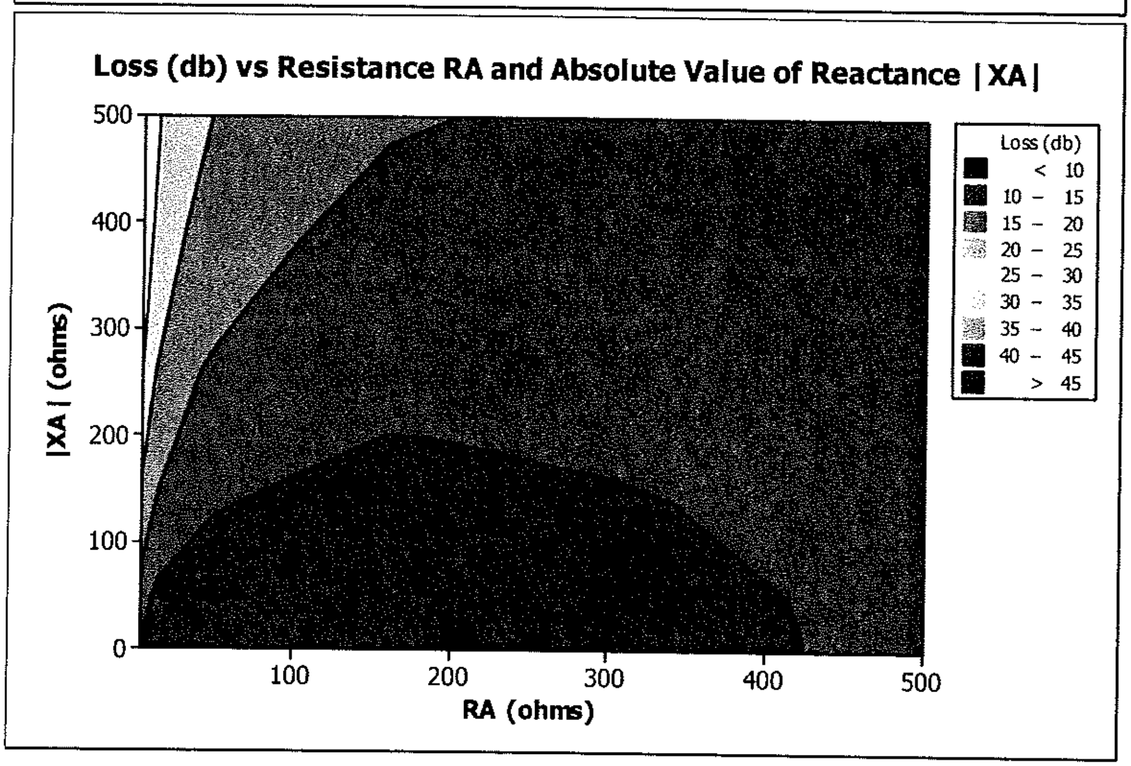
- There are also two contour plots showing the same data as are in the table. The second plot is an enlargement of the first for small Z_A.

- How do the losses in S-units compare to the losses in Tables II and III of the review? Note that our table of losses does not include losses due to antenna efficiency.

R_A	X_A	Loss (db)	Loss (S)
5	0	10.64	1.77
16	0	7.29	1.21
50	0	6.02	1.00
160	0	7.34	1.22
500	0	10.64	1.77
1000	0	13.21	2.20
1600	0	15.07	2.51
3000	0	17.66	2.94
4000	0	18.87	3.15
5000	0	19.82	3.30
5	16	10.99	1.83
16	16	7.52	1.25
50	16	6.12	1.02
160	16	7.36	1.23
500	16	10.65	1.77
1000	16	13.21	2.20
1600	16	15.07	2.51
3000	16	17.66	2.94
4000	16	18.87	3.15
5000	16	19.82	3.30
5	50	13.22	2.20
16	50	9.18	1.53
50	50	6.94	1.16
160	50	7.57	1.26
500	50	10.68	1.78
1000	50	13.22	2.20
1600	50	15.08	2.51
3000	50	17.66	2.94
4000	50	18.87	3.15
5000	50	19.82	3.30
5	160	20.32	3.39
16	160	15.48	2.58
50	160	11.34	1.89
160	160	9.25	1.54
500	160	10.99	1.83
1000	160	13.30	2.22
1600	160	15.11	2.52
3000	160	17.68	2.95
4000	160	18.88	3.15
5000	160	19.82	3.30
5	500	29.77	4.96
16	500	24.75	4.12
50	500	19.90	3.32
160	500	15.41	2.57
500	500	13.22	2.20
1000	500	14.08	2.35
1600	500	15.45	2.58
3000	500	17.78	2.96
4000	500	18.94	3.16
5000	500	19.86	3.31

R_A	X_A	Loss (db)	Loss (S)
5	1000	35.75	5.96
16	1000	30.71	5.12
50	1000	25.79	4.30
160	1000	20.89	3.48
500	1000	16.91	2.82
1000	1000	15.98	2.66
1600	1000	16.42	2.74
3000	1000	18.11	3.02
4000	1000	19.13	3.19
5000	1000	19.98	3.33
5	1600	39.83	6.64
16	1600	34.78	5.80
50	1600	29.84	4.97
160	1600	24.85	4.14
500	1600	20.32	3.39
1000	1600	18.38	3.06
1600	1600	17.93	2.99
3000	1600	18.72	3.12
4000	1600	19.50	3.25
5000	1600	20.23	3.37
5	3000	45.28	7.55
16	3000	40.23	6.71
50	3000	35.29	5.88
160	3000	30.25	5.04
500	3000	25.43	4.24
1000	3000	22.78	3.80
1600	3000	21.39	3.56
3000	3000	20.59	3.43
4000	3000	20.77	3.46
5000	3000	21.13	3.52
5	4000	47.78	7.96
16	4000	42.73	7.12
50	4000	37.78	6.30
160	4000	32.74	5.46
500	4000	27.86	4.64
1000	4000	25.06	4.18
1600	4000	23.42	3.90
3000	4000	22.00	3.67
4000	4000	21.82	3.64
5000	4000	21.93	3.65
5	5000	49.72	8.29
16	5000	44.67	7.44
50	5000	39.72	6.62
160	5000	34.68	5.78
500	5000	29.77	4.96
1000	5000	26.90	4.48
1600	5000	25.12	4.19
3000	5000	23.32	3.89
4000	5000	22.89	3.81
5000	5000	22.78	3.80


Loss (db) vs Resistance RA and Absolute Value of Reactance |XA|
5000
4000
3000
2000
1000
0
|XA| (ohms)
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
RA (ohms)
Loss (db)
< 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
> 45


Loss (db) vs Resistance RA and Absolute Value of Reactance |XA|
500
400
300
200
100
0
|XA| (ohms)
100
200
300
400
500
RA (ohms)
Loss (db)
< 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
> 45

- If we are on the 30m band the dipole is resonant and Z_A is about 50Ω resistive.
  - What is the loss in the table for $R_A = 50$, $X_A = 0$?
  - Can you guess where my "matching network" came from?
  - Are there any lower losses in the table?
  - With a 100 W rig, how many watts go to the antenna?
  - Does this help explain why the Comet CHA250B did well on 30m? Should this be "surprising"?

- If you want to build an N1KSN Magic Dipole, be sure that you use non-inductive power resistors. With 50 watts from the rig, resistor R1 will need to dissipate as much as 28.5 watts. (You can try finding this by letting $V_g = 141.42\ V_{peak} = 100\ V_{RMS}$ and setting $I_g = \dfrac{V_g}{Z_g + Z_T} = \dfrac{141.42}{50 + Z_T}$. Then calculate the currents through the resistors using I_g and the impedances.) Given the expense of power resistors, I decided not to build a prototype. If I want to operate QRP, I'll use a QRP rig and a good antenna!

Example Calculations for N1KSN Magic Dipole

R_1	150	Ω	R_1	150	Ω	"Matching network"
R_2	150	Ω	R_2	150	Ω	
R_3	18.75	Ω	R_3	18.75	Ω	
R_4	18.75	Ω	R_4	18.75	Ω	
R_g	50	Ω	R_g	50	Ω	Transmitter
V_g	141.4214	v peak	V_g	141.4214	v peak	
R_A	50	Ω	R_A	5000	Ω	Antenna feedpoint impedance
X_A	0	Ω	X_A	1000	Ω	
Z_A	50		Z_A	5000+1000j		
	37.5			145.789808338632+0.817512943954947j		
Z'	75		Z'	183.289808338632+0.817512943954947j		
Z_T	50		Z_T	82.4915912031048+0.165588615782665j		
Γ	0		Γ	0.245236298462409+9.43307235166493E-004j		
VSWR	1		VSWR	1.649842		
I_g	1.41421356237309		I_g	1.06739706310138-1.33403788545712E-003j		Currents
I_1	0.47140452079103		I_1	0.58701002054827+4.44679295152379E-004j		
I_2	0.235702260395515		I_2	0.466913259909993+8.8935859030475E-004j		
I_3	0.94280904158206		I_3	0.48038704255311-1.7787171806095E-003j		
I_4	0.94280904158206		I_4	0.48038704255311-1.7787171806095E-003j		
I_A	0.707106781186545		I_A	1.3473782643117E-002-2.66807577091425E-003j		
P_g	50		P_g	28.48346		Power
P_1	16.66667		P_1	25.84357		
P_2	4.166667		P_2	16.35066		
P_3	8.333333		P_3	2.163514		
P_4	8.333333		P_4	2.163514		
P_A	12.5		P_A	0.471654		
P_{tot}	50		P_{tot}	46.99291		
P_A / P_{tot}	0.25		P_A / P_{tot}	0.010037		
Loss	6.021	dB	Loss	19.984	dB	
Loss	1.00	S units	Loss	3.33	S units	
	↑ Antenna is resonant			↑ Antenna feedpoint with high resistance and reactance		