THE ZS6U MINISHACK SPECIAL

A Multiband End-fed Inverted-V Antenna System

By the late Colin Dickman ZS6U, BSc, C Eng., FIERE, MSAIEE

This article is reprinted from the January 1973 issue of RADIO ZS as a tribute to Colin Dickman, who recently passed away in the UK. His Minishack special became a byword amongst South African amateurs in the 70s and, even today, many minishack specials are in constant use. We trust that this reprint may rekindle interest amongst the adventurous amateurs and get them to try their hand at constructing an antenna that might get them on the air in awkward sites.

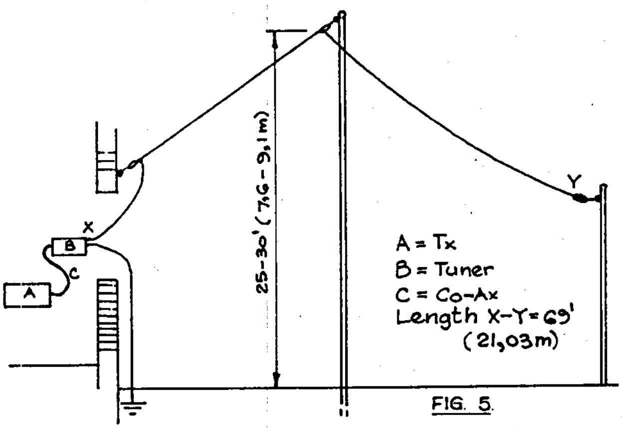


FIG. 5.

It is not without good reason that end-fed antennas requiring tuners have fallen from favour, to be replaced by systems using untuned transmission lines. Our transmitters and linears have enough knobs without adding the extra three or four to twiddle.

Yet, by judicious choice of wire length, we can produce a situation where the simplest of preset tuners can be used, resulting in a cheap, compact and easily constructed multiband antenna system with certain advantages over the commonly used multiband antenna.

1. CHOOSING THE TUNER

A tuner is a coupling network between the low impedance output of the transmitter (Zot) and the impedance of the input to the antenna (Zia). It must perform one or both of the following: a) act as an impedance matching transformer and b) resonate the antenna system by cancelling any reactance present in Zia.

If Zia is complex, containing widely different amounts of reactance and resisitance on each band, a complex tuner is required to cope with it. The less complex Zia, the simpler the tuner. In fact, if we can arrange to kep Zia always greater than Zot, we can use L-networks of the step-up variety as depeicted in figure 1, requiring onlytwo adjustments for each band. Both networks will perform the same function, but only that in Fig. 1A is capable of suppressing harmonics. So this is our obvious choice.

2. CHOOSING THE ANTENNA LENGTH

Fig. 2 depicts the input characteristics of an end-fed antenna, showing how the reactance, resistance and voltage change as the length is varied from 0 to 1 wavelength. The figure applies equally well if the wire length remains constant and the frequency is varied. It can be extended indefinitely to the left for lengths exceeding 1 wavelength.

(a) RANDOM LENGTHS

If the length of the antenna falls between the points O, A, B, C and D, the input impedance Zia contains reactance as well as resistance, either of which may be high or low, depending on the length and the frequency. Clearly, Zia may be low on one band and high on another. Furthermore, the reactance may be capacitive on one band and inductive on another, resulting in severe detuning of the tuner's natural resonance in order to provide the required reactance of the opposite sign. Apart from the fact that at least three variable elements are required in the tuner (eg. a Pi-network), the range of minmum to maximum inductance and tuning difficulties are likely at the lowest and highest frequencies. So much for random lengths!.

(b) RESONANT LENGTHS

OA, OB, OC and OD are all resonant lengths, inasmuch as the reactance is zero and Zia becomes a pure resistance, which we shall call Ria. For OA and OC, Ria is very low and these lengths lend themselves only to to odd-harmonic operation. On the other hand, lengths OB and OD, which are multiples of half wavelengths, are suitable for all harmonics and Ria is a high resistance on all bands. Just what we need for our L-network

From the above, we could choose a half wavelength on 80 metres, which would be 2 halfwaves on 40, 4 on 20, 6 on 15 and 8 on 10 metres. By making our length a 1/4 wave on 80, we can make our antenna half as long and, since Ria will be in the same order as Zot on 80 metres, we can arrange the switching in our L-network so that the antenna by-passes the network direct to the transmitter on that band.

The length formula for an end-fed antenna is:

Length (feet) = 492 (n - 0,025) / f (MHz)

where n = number of half wavelengths

The length we require is one which will accommodate 4 halfwaves on 10 metres. Taking f = 28,5 MHz, then length = 492 x (4 - 0,025) x (28,5 = 68,62 feet or near enough to 69 feet. Although the wire will be a few percent too long at the lower frequencies, the reactance introduced is small enough to be cancelled by the tuner without serious detuning effects.

Having made a prudent choice of tuner and wire length, let us proceed to a practical design of this happy partnership.

3. DESIGNING THE L-NETWORK

The behaviour of an end-fed harmonic antenna is best understood in terms of transmission line theory. Any single wire parallel to ground forms a characteristic impedance Zo = 138 log 2h/r, where h = height of the wire above ground and r = radius of the conductor in the same units. Typically, for a wire radius of 0,024 inches and an antenna height of 25 feet, Zo = 607 ohms.

Such a transmission line, although physically open circuit at the far end, is in effect terminated by the equivalent of a resistance related to the power lost from the wire by radiation. As with all transmission lines, this fictitious resistance reduces as the line is lengthened in terms of the wavelength and approaches the Zo of the line as the line approaches infinity. For any line a multiple of a half wavelength long, this resistance is repeated at the input end and is, in fact, our previously mentioned Ria. Measured with a bridge, the input resistance that can be expected, is shown in Table 1.

Fig. 1A depicts the basic circuit of the L-network when matched between the output load impedance of the transmitter (Zot) and the imput resistance of the antenna wire (Ria). When Ria is very much greater that Zot, the equations for the circuit simplify to:

$2\pi fL = \sqrt{Ria \times Zot}$

and $1/2\pi fc = \sqrt{Ria \times Zot}$

with which we can find what inductance and capacitance to use in our tuner on each band. Select the value for Zot arbitrarily as 52 ohms and find the value of Ria from Table 1. A typical set of results is shown in Table 2. It should be borne in mind that these results may be modified in practice by (a) stray capacities and inductance in the tuner and (b) reactance at the antenna input. After constructing the L-network, the actual value of Zot may not be 52 ohms as planned, but somewhere between 35 and 75 ohms. This is of no consequence, as the loading control of the transmitter is quite capable of matching any pure resisitance over such a range.

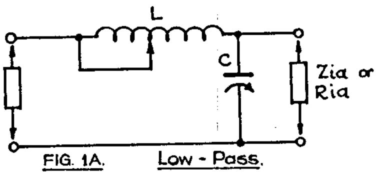


FIG. 1A. Low - Pass.

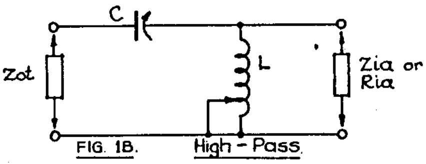


FIG. 1B. High - Pass.

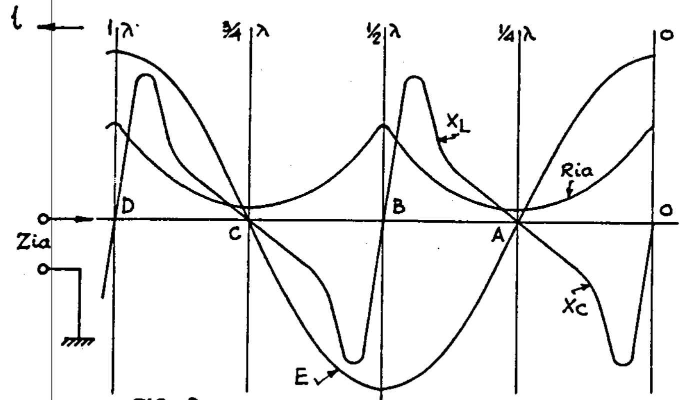


FIG. 2.

4. L-NETWORK CONSTRUCTION

Fig. 3 gives the coil dimensions and layout of a practical L-network for the 69 foot antenna. Fig. 4 shows the circuit diagram. The values given for L in Table 2 have been translated into turns using a suitable abac. The RF choke is included to prevent static

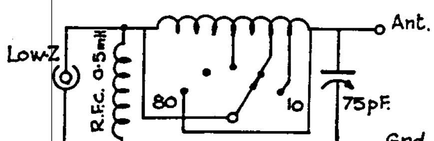
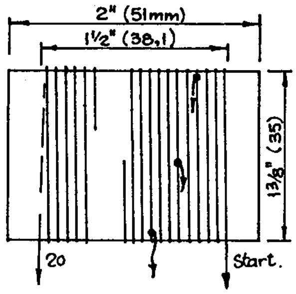


FIG. 4.

charges building up on the antenna wire during storms. Its reactance at the lowest frequency is about 20 times higher than the Low-Z input, so it introduces no measurable loss. The switch is arranged to short out all but the required number of

13½ T.P.I.	
Turns	Band.
20	40
8	20
5¼	15
3½	10
Wire	0·036"



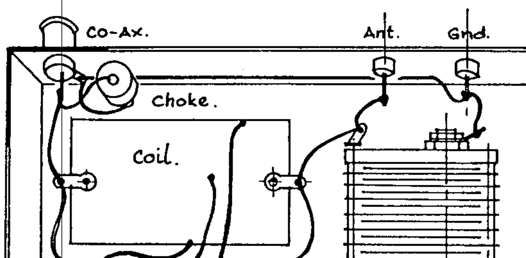


FIG. 3.

turns on 10, 15 and 20 metres. No connection is made to the 40 metre switch contact, so that on this band the full coil is operative. In the 80 metre position the whole coil is shorted out to provide the direct connection as described in Section 2.

The tuning condenser has the highest voltage across it on the 40 metre band, where Ria is 2800 ohms. Using the equation Epk = 1,4 √WR, it can be seen that the condenser must withstand a peak voltage of about 1500 volts when the tranmitter output is about 400 watts PEP. A 0,02 inch spacing between plates is adequate and the small capacity permits the use of small physical size. A straight-line-wavelength type is preferable to one withcircular plates as it allows greater sepAration between the higher frequency settings.

The whole unit was built into a plastic box measuring 5" x 3" x 2". There is no need to use a metal box, but if one is used, the coil should clear the metal by at least 1 inch on all sides.

5. PUTTING UP THE ANTENNA

The size of the wire is not critical, about 0,05 inch diameter being typical. As a portion of the wire will be in the shack, it is advisable to use an insulated variety. The conductor may be solid or stranded.

Take a length of wire in excess of 69 feet and attach an antenna insulator. Anchor to some suitable point and stretch the wire a little. Accurately measure off 69 feet and cut off.

A typical installation is shown in Fig. 5. Although the antenna will load and perform in almost any configuration,I have taken advantage of the true Inverted- V configuration (as distinct from the drooping dipole). Reference to long wire antennas in the usual literature will show that on 10 metres this configuration, also known as a "half Rhombic", can provide low-angle, vertically polarised, endfire radiation with a gain of some 6dB over a ground plane antenna.

The antenna tends to become more omni-directional as the frequency is lowered, but radiation on all bands tends to be greatest in the direction of the free end of the wire. Even on

TABLE I

Length of Wire Wavelengths	Ria Ohms
.25	60
.5	2800
1	1700
1.5	1200
2	900
3	750
4	700

TABLE II

Freq MHz	Ria Ohms	XL or Xc Ohms	L uH	C Pf
3.7	60	0	0	0
7.075	2800	380	8.6	60
14.2	1700	297	3.3	38
21.3	1200	250	1.8	31
28.6	900	216	1.2	26

Zot = 52 Ohms; length = 69 ft.

80 metres this diminutive antenna performs as well as a 132 foot dipole at the same virtual height, provided you have an effective ground system. Of course there is nothing to stop you from making a double size ZS6U special, using the information given, to modify the coil, condenser and switching accordingly. A pole is often unnecessary if you can find something highter than your antenna, to hold up the apex with nylon cord. This type of support may result in a sloping plane for the V, which is no disadvantage.

LIVE IN AN APARTMENT?

As an alternative to the Inverted-V, if you are keen to beam your signal on 20 and 15, as well as on 10, use an upward sloping configuration at an angle of about 30 degrees to the horizontal towards the desired direction. Or if you live in an apartment several storeys above ground, you can use a downward slope. For field days and temporary installations, take your "box" and 69 foot of wire with you.

At the shack end of the antenna you will need an anchor to take the strain. Use nylon cord with an egg insulator, securing the wire to the latter before the last few feet drop into the shack through an air brick, fanlight or whichever entry point you consider best. The L-network should stand close to the entry point and the transmitter should be close to the L-network so that as little as possible co-ax may be used to couple between the two. A length of about two feet is typical.

6. CALIBRATING THE L-NETWORK

There is only one way to positively calibrate your L-network so that it presents a pure resistance to your transmitter and that is by means of an SWR bridge of the appropriate impedance inserted in the short piece of co-ax.

Switch to the 40 metre band and roughly set the condenser by peaking up on reception. Switch the SWR bridge to the reflected power position, set up your transmitter in mid-band to provide a small carrier and rotate the L-network condenser to give a minimum reflected reading. Leave it there while you load up your transmitter to full power. Now check for the minmum again and mark the scale. Repeat the procedure for 20, 15 and 10 metres. Finally set the condenser to minimum and switch to 80 metres. If it will not fully load the transmitter, it means that you do not have an effective earth system and it's time you did something about it anyway.

You are all set! To change bands, simply switch to the required band and set the condenser to the mark, remembering that the mark for 80 is at minimum capacity. Once set, the tuner will provide the correct load for your transmitter tune-up and it should not be fiddled with. The SWR you measured might have been anything from 1:1 (meaning your pure resistance was the same as the bridge) to 2:1 (meaning it was either half or double the bridge resistance). No matter what the reading, ignore it if your rig loaded up nicely. However, if you have one of those rigs without a loading control, designed optimistically to work only into a 52 ohm resistive load, you might have to move the taps until you have a 1:1 ratio on a 52 ohm bridge on all bands. If you borrowed the bridge, you can now return it to the owner.

7. CONCLUSION

At the start I hinted that this system has certain advantages, several of which have so far emerged in the text, such as a purely resistive load and no tranmission line matching problems and losses. Obviously the antenna is cheap, is smaller than other antennas that include 80 metres and is an effective harmonic suppressor. Less obvious are the advantages in reception, where not only does the system provide additional front end selectivity, but sensitivity as well. The latter derives from the fact that the effective captive area remains fairly constant over its range, whereas that of a trap dipole or vertical reduces in proportion to the square of the wavelength. This accounts for the lively receiver performance, particularly at the higher frequencies. RF in the shack? As reactance is absent, a field strength meter will show no greater stray RF than conventional antennas. This goes for BCI too.

I can take no credit for the well worn principles expounded here. But I hope that it will provide a popular alternative multibander for the greater enjoyment of our hobby.

RADIO AMATEUR CALLSIGNS - NAMIBIA

PLEASE CUT OUT AND PASTE IN YOUR 1993 SARL CALLBOOK

V50AS NEL, JAAP, P O BOX 792, WINDHOEK
V50AT TROMP, J, P O BOX 1674, WINDHOEK
V50AV GRAF, S G W, P O BOX 57, KOMBAT
V51AE DE ALMEIDA, C E G, P.O. BOX 27519, SUNNYSIDE, PRETORIA,0132
V51BG JORDAN, KARL HW, P O BOX 2177, WINDHOEK
V51BH HAMMOND, B S,P O BOX 165, SWAKOPMUND
V51BI KOELLMANN, A B, P O BOX 1533, SWAKOPMUND
V51C SUTHERLAND, IAN, P O BOX 2327, WALVIS BAY
V51CU LUBBE, DAVID S, P O BOX 20780, WINDHOEK
V51DF FOURIE, DANIE J, POSBUS 145, OKAHANDJA
V51DM MOORE, DEREK, P O BOX 22951, WINDHOEK
V51E DU BUISSON, JACOBUS C, POSBUS 350, OUTJO
V51ED DIEKMANN, EMIL D G, P O BOX 6136, WINDHOEK
V51EG GALLARDO, ERNESTO M, P O BOX 1214, SWAKOPMUND
V51EK BERTRAM, HEIN AA, P O BOX 59, MALTAHOHE
V51GB BRUNS, GHE, P O BOX 1165, TSUMEB
V51H LUTZ, HW, P O BOX 33, TSUMEB
V51IL LUTZ, I S, P O BOX 33, TSUMEB
V51J HEINONEN, LEO, P O BOX 1187, PARKHURST,2121,
V51JB BERNING, JOHN, P O BOX 988, SWAKOPMUND
V51JS SINDEN, JACK, P O BOX 224, IRENE
V51KC ANDERSON, JACK, BOX 509, OKAHANDJA
V51M SMITH, MARTIN H, P O BOX 495, ESHOWE,3815
V51MA ALBERTS, MIKE, P O BOX 17, KOMBAT
V51NF FORSTER, NORBERT, P O BOX 15, TSUMEB
V51P HOFFMANN, KP, P O BOX 9080, TSUMEB
V51TT TAYLOR, TRUSTY, C/O MASTERS OFFICE, P/BAG 13190, WINDHOEK
V51TW ANSTEY, BENJAMIN, P O BOX 20305, WINDHOEK
V51TX SWART, MICHAEL W, POSBUS 61, GOBABIS
V51W WIECHERS, RUDY, P O BOX 3425, WINDHOEK
V51WC COETZEE, WILLEM, POSBUS 30068, WINDHOEK
V51XX NAMBIBIA AMATEUR RADIO LEAGUE, P O BOX 1100, WINDHOEK
V51Y, vd WESTHUIZEN, FLIP, POSBUS 3638, WINDHOEK
V51Z BURGER, CHRIS, POSBUS 4485, PRETORIA, 0001
V51BH HAMMOND, BRENDAN S, P O BOX 165, SWAKOPMUND

CISKEI

S42ABF TOTTLE PETER, 28 THORNYCROFT ROAD, SUMMERPRIDE, EAST LONDON, 5200,
S42ALH SMIDT M
S42AM STURRET A
S42DSI DIGGS DOROTHY, FORT COX AGRICULTURAL COLL., MIDDLEDRIFT, CISKEI
S42EM WALLACE M, 14 SANDSMITH HOUSE, ST PETERS ROAD, SOUTHERNWOOD, 5201
S42EW WARD RALPH, P O BOX 2134, KING WILLIAMS TOWN, 5600,
S42GY KATZ, HOWARD I, FORT COX AGRICULTURAL COLL., MIDDLEDRIFT, CISKEI
S42HZR CHURCH, DAVID J, BOX 592, MEXICO, NEW YORK 13114, USA
S42LK KNOPH, K
S42Q DIGGS, ROBERT S, 89 RIVERSIDE DRIVE, NORTH EAST, MARYLAND 21901, USA
S42T DE KLERK, LEN, P O BOX 750, KING WILLIAMS TOWN, 5600
S42U AKERS, AL, 53 CLARENCE STREET, WESTERING, PORT ELIZABETH, 6025

VHF QSO PARTY 2-3 OCTOBER 1993

by Al Akers ZS2U

The main purpose for organising this QSO party was to provided an opportunity for amateurs, in the East Cape particularly, to make many simplex contacts on two metres. In this regard it has proven to be a resounding success. Twenty logs have been received and at least sixty stations participated. To my knowledge, no previous two metre event has been so well supported in the east Cape.

Unfortunately, 6 metre activity was a bit low and it would have been nice to see more activity in the East London area. Band conditions were not good, but nevertheless, a few Port Elizabeth stations managed to contact John ZS2AH and Erich ZS2EF in East London, John ZS2J in Bathurst and Van ZS2JC and Paul ZS2ABY in Humansdorp. Highlights were that Mike ZS2FM managed to contact Mike ZR5ADQ in Umbumbulu and Leroy ZS6XJ in Randburg on 6 metres. Mike ZR2MBM was heard in Cape Town on 2 metres.

It was great to see several newcomers to Amateur Radio put up a very creditable performance. Here are the results:

ZONE A FIXED STATION 2M

STATION	CONTACTS	POINTS
ZS2SZ	45	59
ZS2ABU	36	54
ZR2DCB	30	40
ZS2Y	28	38
ZS2FM	15	36
ZR2ABT	23	33
ZS2BWB	20	30
ZR2BG	23	29
ZS2F	16	26
ZS2DD	13	24
ZR2KA	13	23

ZONE A PORTABLE 2M

STATION	CONTACTS	POINTS
ZS2U	43	137
ZR2MBM	43	130
ZR2PF	43	130
ZR2AAR	18	76

ZONE A FIXED 6M

STATION	CONTACTS	POINTS
ZS2FM	9	40
ZR2ABT	6	12

ZONE A PORTABLE 6M

STATION	CONTACTS	POINTS
ZS2U	7	23
ZR2MBM	4	12
ZR2PF	4	12

No logs were received from Zone B or from other divisions.