

# The versatile end fed wire



A piece of wire of almost any length can be used as an antenna on the HF bands. However, just because an antenna can be made to work is no guarantee that it will perform efficiently. This article will initially concentrate on the half wavelength of wire and its use as an effective multiband antenna. Information on a simple antenna coupling unit and tuning indicator for use with these antennas is provided towards the end of the article.

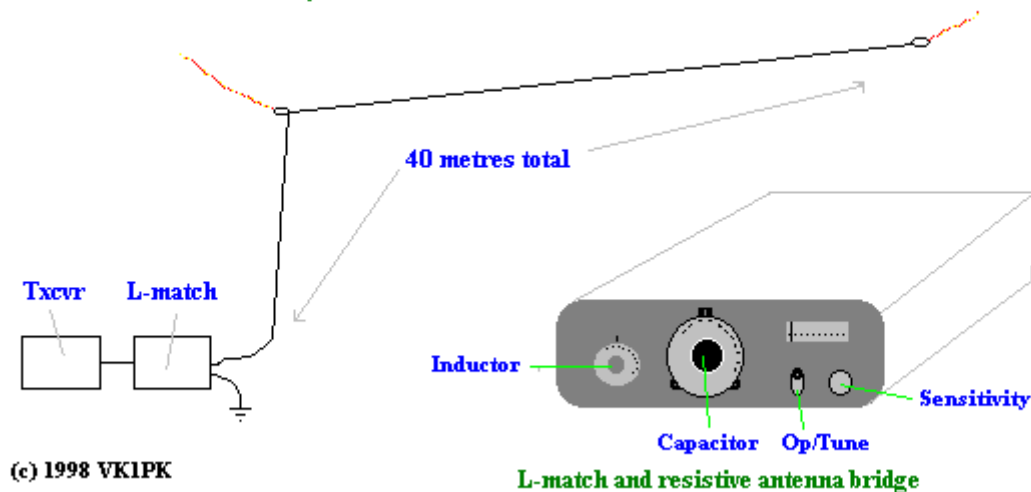
## Length

It was mentioned above that the actual length of wire used in an end-fed antenna is not critical. However, some lengths are easier to use than others, particularly if multiband capability is required. Also, very short antennas (significantly less than a quarter wavelength on the operating frequency) are inefficient, making it hard to put out a good signal.

A length of one quarter wavelength (ie 20 metres on the 80 metre band) is commonly suggested. Though such antennas do work, an extensive ground system or counterpoise is required for best performance. Ground systems can require considerable time and effort to install and detract from the extreme simplicity of these types of antennas.

An alternative is to use a wire of approximately one half wavelength in length on the lowest operating frequency. An extensive earth system becomes much less important. Indeed the author has had good results whilst using no earth at all. However, for certain other reasons (explained later) some earthing is desirable.

## End-fed antenna system



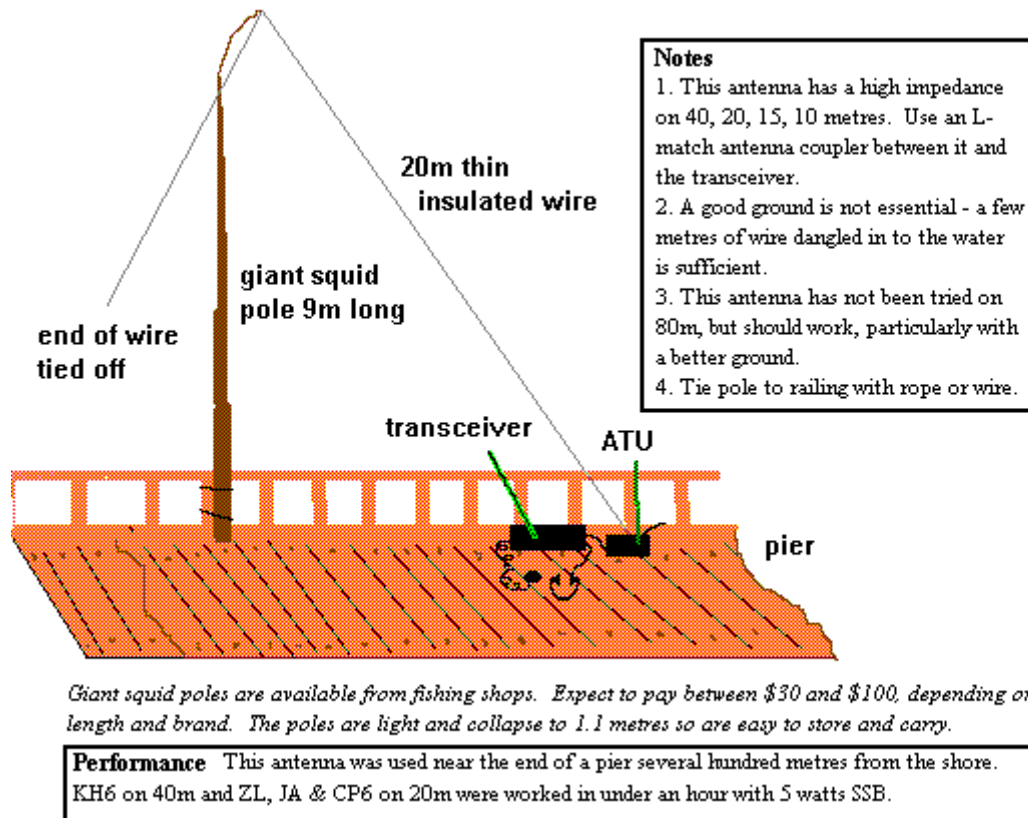
The antenna described here is forty metres long, or a half-wavelength at 3.5 MHz. As mentioned before, a substantial earth is not required. Because a half-wavelength piece of wire exhibits a very high impedance at the operating frequency (and its multiples), some form of coupling unit between the transceiver and antenna is required. Its function is to efficiently transform the transceiver's 50 ohm output impedance to the antenna's high feedpoint impedance. Whether a wire antenna has a high or low impedance is important because it affects the type of coupling unit required as well as the need for an earthing system.

So what is the impedance of this antenna on bands other than eighty metres? We already know that a wire that is a multiple of a half wavelength exhibits a high impedance at the feedpoint. At 21 MHz (15 metres) a forty metre wire is approximately six half-waves long. On 28 MHz (10 metres) it is eight half-wavelengths. Similarly, our wire is several multiples of a half wave on other HF bands such as 40 and 20 metres. This means that the antenna will always have a feedpoint impedance appreciably higher than 50 ohms and will not require much of a ground system to perform adequately. It is for these reasons that roughly 40 metres is a good length for an end-fed wire antenna for the 3.5 to 28 MHz HF bands.

If you're mainly interested in 7 MHz and up then about 20 metres of wire (ie a half wave on 40 metres) is recommended. The shorter length is lighter to carry when portable, doesn't get as badly tangled and can be more readily supported with a single lightweight 8 to 10 metre fishing pole. It doesn't have to be exactly 20 metres; 18 or 22 metres will perform just as well but may be easier to match as extremely high impedances are avoided.

## End-Fed Inverted Vee

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For higher bands like 20 or 15 metres, a length of around 9 - 10 metres will work. The advantage of this is the wire can be run vertically down a 9 metre squid pole. Especially if over water, such as operating from a pier, this should produce a lower angle of radiation, suitable for long distance DX contacts. Another benefit is there's no need to tie the wire off anywhere so your station takes up less room (good for a crowded location, such as a pier on a summer's afternoon).

### Benefits and limitations

Because it is fed at one end, people whose house is near one boundary of the block will probably find this antenna easier to put up than a half-wave dipole, which is fed in the centre. Another advantage of this antenna is that no separate feed line is required. This makes it particularly attractive for portable use as coaxial cable can be quite bulky.

What are the disadvantages of this type of antenna? The first is that it requires a matching unit to operate. Each time you change band you will need to adjust this for best impedance match between transmitter and antenna. Another risk with these types of antennas is RF in the shack. Nevertheless, these two problems are not insurmountable, and the end-fed wire is one of the most cost-effective multiband antennas available.

## **Erection of antenna**

The antenna should be as high as possible. Have as much of the wire as possible running horizontal, or nearly so. However, if this is not possible, don't despair; your antenna will still work. The antenna is not particularly directional, especially on the lower frequency bands, so orientation is not that critical.

The type of wire used is also not critical. Medium gauge stranded insulated wire has given good service in the author's antennas. Ordinary egg-type insulators can be used to suspend the wire. As an alternative to purchasing these new, insulators can be made from short lengths of plastic water pipe or conduit.

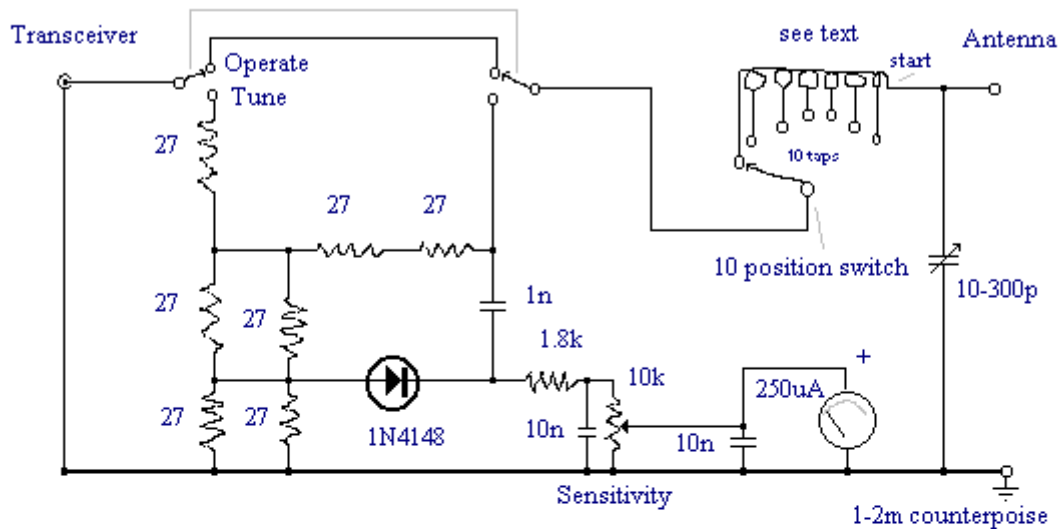
Either trees, chimneys or specially-made masts can be used to support the wire. Two such supports are normally required for these antennas unless your radio shack is on a second or third storey. In many cases the second support can be a tree in the backyard. It is not necessary to climb this to mount the antenna; with a small lead sinker a fishing line can be thrown over a convenient branch. The sinker is then removed and the line tied to the antenna's insulator. While observing the sag in the antenna wire, pull the fishing line tight. Then release it a little and tie it off at a convenient point. Some sag should be allowed for in wire antennas to allow for movement of the supporting branch in the wind. Always observe the usual precautions about keeping the antenna away from power lines and public thoroughfares.

The quickest way of getting an antenna wire up, especially for experimental home or portable use, does not involve climbing or throwing things over trees at all. Instead you simply buy a 8 to 10 metre fishing pole and tie it to a tree or fence post. Lightweight poles will adequately support 20 metres of thin insulated wire end-fed and cost around \$50. A recommended supplier is <http://www.haverford.com.au> who will send anywhere in Australia.

## **Coupling unit and resistive bridge**

The purpose of the coupling unit described here is to transform the transceiver's output impedance of 50 ohms to the higher impedance of the wire antenna. Between the matching unit and the transceiver is a resistive antenna bridge that is switched in to aid the adjustment of the coupling unit.

## Schematic diagram of L-match and antenna coupler



An L-match circuit consisting of one adjustable inductor and one variable capacitor is used here. This is simpler than most other antenna coupling units which require two or more variable capacitors, a number of inductors and possibly a switch. This simple approach is possible as the unit is only required to match a limited range of antenna impedances.

The resistive bridge is used to show when the L-match is properly adjusted. Using it is similar to a standard SWR bridge in that you initially adjust the sensitivity control for full scale on the meter and adjust the L-match until the reading on the meter is zero (or close to it). However, the resistive bridge is unlike an SWR meter in that it does not have a forward/reverse switch. Also, it cannot be left in line while transmitting. If your rig already has an inbuilt SWR indicator the resistive bridge (diode, resistors, meter etc part of the circuit) is optional and only the L-match constructed. Further information on operating the resistive bridge is given later.



The photo above shows the completed L-match and resistive bridge. The variable capacitor adjustment is in the centre of the front panel. To its left is the ten-position rotary switch for the adjustment of the L-match inductor. The right-hand third of the panel is taken up by the resistive antenna bridge. Below the meter movement is the tune/operate switch and the meter's sensitivity control.

The home-made tapped inductor is mounted just behind the rotary switch. Alongside the coil, behind the vernier drive, is the variable capacitor. Most of the remaining space inside the box is occupied by a piece of matrix board that holds the parts used in the antenna bridge. Because light weight was important, the prototype is housed in a commercially-available plastic box. Note that to accommodate the top of the vernier drive, some plastic has had to be shaved off inside the top lid of the box. This is slightly visible in the photo.

The variable capacitor used is a rare transmitting-type unit. Unfortunately, these can be hard to come by. Sources include hamfests, vintage radio swapmeets, valve receivers and even one of the older transistorised sets. If you're using low power (up to 5 watts or so) the small plastic dielectric types used in modern AM transistor radios are suitable.

Most variable capacitors that you'll see will have two or three sections or 'gangs'. Simply use only one gang and ignore the rest. The actual value of the variable capacitor is not important provided its maximum capacitance exceeds 150 or 200 picofarads.

A vernier reduction drive and dial adds greatly to the appearance of the finished product and makes adjustment easier. Unfortunately they are rare and expensive new. However if your budget is tight and you are unable to find

suitable second-hand reduction drives (they are quite rare), this part can be omitted.

The rotary switch used was a salvaged wafer switch having ten positions. The switch originally had several sections, so the unwanted ones were removed and the rear of the shaft cut to size. It is desirable to have a switch with as many positions as possible to allow more precise adjustment of the coil. If you are unable to salvage a suitable switch, an alligator clip and wander lead will be just as effective as the switch, though somewhat less convenient to use.

The tapped inductor is the other main component of the L-match. The coil in the photograph was wound on a piece of 25-30 mm diameter plastic tube. Ordinary thin insulated wire was used in the prototype. The number of taps needed is always one less than the number of positions available in your rotary switch - thus the coil here has nine taps. To make a tap, simply remove about 1 cm of insulation with a knife, form the bare portion of the wire into a hairpin loop, twist and solder. Hold the iron on the joint for only the minimum amount of time necessary to prevent the insulation melting off the wire.

The following table gives the coil taps used on the prototype. Note that the start of the coil is connected to the antenna socket and variable capacitor and the wiper of the switch is wired to the antenna section of the Tune/Operate switch.

#### **Switch position - No. turns from start of coil**

1 (fully anti-clockwise) - 55 turns

2 - 30 turns

3 - 20 turns

4 - 13 turns

5 - 9 turns

6 - 6 turns

7 - 4 turns

8 - 3 turns

9 - 2 turns

10 (fully clockwise) - 1 turn

The end of the coil whose taps are closest together should be nearest the switch. The reason for this is that these taps are likely to be used on the higher frequency bands, where the effects of stray inductance are more significant. It is also for this reason that all connections between the switch and the coil should be short and thick. The coil is attached to the bottom of the case with a pair of bolts, nuts and 10 mm stand-offs, which can be made from an old straight-sided ball point pen.

Transceivers with rotary band switches normally have the lower frequency bands (eg 80 metres) near the anticlockwise-most end of the switch's rotation and the higher bands (eg 10 metres) selected when the switch is turned clockwise. Similarly, when you turn the VFO knob of your transceiver clockwise, the frequency selected will increase.

The controls on the prototype behave in a similar way. This is achieved by switching in the whole coil (which may be required on low frequency bands) when the rotary switch is turned to its anticlockwise-most position (position 1 in the table above) and successively smaller portions of the coil as the switch is moved clockwise (position 10 on the table above). These smaller sections of the coil will be required when operating on higher frequency bands such as 10 and 15 metres.

The variable capacitor is configured in a similar way; as the reduction drive is turned clockwise, the capacitance is reduced, and the unit is tuned to a higher frequency. However, it is important to note that this cannot be achieved with some variable capacitors because a clockwise movement in the shaft increases rather than decreases the capacitance.

Most of the parts for the resistive antenna bridge are mounted on a piece of unclad matrix board, which is mounted to the case with screws and stand-offs. Component values are not particularly critical except for the seven 27 ohm resistors. The function of these resistors is to provide a reasonably constant 50 ohm load for the transceiver when the L-match is being adjusted. For this reason they will be required to dissipate a fair amount of RF power. Two-watt resistors were used in the prototype. This proved adequate for use with a twenty watt transceiver provided the carrier was wound down to 5-10 watts and tuning-up was completed in a reasonably short length of time. Many modern 100-watt transceivers can be wound back to produce the few watts required for this tune-up process.

No accidents have been had with the prototype unit. However, if you routinely wish to use it with high power equipment, and have a habit of forgetting to wind the power back, it should be possible to replace each 27 ohm resistor with four two-watt 100 ohm resistors to increase the unit's power handling capacity. Do not be tempted to use wire-wound resistors - their power ratings may look attractive, but their self-inductance makes them unsuitable for a project such as this.

The Tune/Operate switch is a medium-sized DPDT unit. Again, this has given reliable service with 20 watt equipment. However, it might be wise to use a larger type if you intend to use this unit with 100 watt gear.

Other parts are not critical. The panel meter in the prototype was salvaged from a non-working CB transceiver. The scale was whited out (using correction fluid) and a new one written over it with biro. This operation calls for a fair degree of manual dexterity - it is easy to damage the meter movement if you are careless. If in doubt, leave the meter as is. The variable



resistor could also be a salvaged item; in this case the volume control from a radio or a tape recorder will be fine.

A pair of binding posts was used for the antenna and earth terminals. Use colour coding to avoid confusion. The connection to the transceiver is either via a BNC or SO239 socket. Coaxial cable should be used between this and the transmitter section of the Tune/Operate switch to minimise stray capacitance and inductance. Either RG58 or RG174 will be satisfactory.

### **Adjustment and use**

Adjusting L-type couplers is simple. Set the inductance for maximum noise on the receiver. Then adjust the variable capacitor to obtain a further increase in noise. Apply a few watts carrier and switch to 'Tune'. Position the sensitivity control so that the meter is reading full scale. Adjust the variable capacitor for a dip in the reading on the meter. If it is not possible to get a zero reading, try a different combination of coil and capacitor settings until this can be achieved. At this point the system is tuned up, and the unit may be switched to 'operate'. This step bypasses the resistive bridge and allows the full output from the transceiver to reach the antenna. Note that when changing bands or making significant frequency changes within a band, this process should be repeated to assure full power transfer.

A counterpoise may or may not be required. Because the antenna is high impedance, adding one will not normally boost radiation efficiency or materially affect the settings of the L-match. However, in some cases, going without a counterpoise can cause RF to get back into the transceiver and spoil operation. A short length of insulated wire connected to the earth terminal of the L-match minimises this risk. One or two metres is usually enough.

In practice, the system described has proved easy to use, and represents a good way of getting multi band operation from a single length of wire. There are no lossy traps or feedlines, and the antenna is easy to erect. Interstate SSB contacts have been made with this antenna on both eighty and forty metres with powers of between two and twenty watts. European and American DX has been worked on the higher HF bands.

While no detailed measurements have been made, performance on the lower bands seems to be roughly similar to a horizontal half-wave dipole at the same height. Theoretically there may be some gain off the far end of the wire on the higher bands, but whether this is useful depends on the wire's orientation and height.

Videos demonstrating end-fed half wave wire antennas appear at [youtube.com/vk3ye](https://www.youtube.com/vk3ye)

Search for the following:

- \* A small L-match for end-feds
- \* DX with an end-fed: 30 & 17m
- \* DX with an end-fed: 12 & 10m
- \* 40/20/10m multiband end-fed
- \* 20/10m multiband no-tune end-fed

References and further reading

1. Moxon, LA HF Antennas for All Locations, RSGB, 1982, page 154
2. The Radio Amateur's Handbook - 1977, ARRL, 1976, page 599
3. Cook, R & Fisher, R Amateur Radio, May 1997, page 20
4. Butler, L Amateur Radio, September 1997, page 15

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