065

‘Ultima’ loopstick VLF antenna

Design:
Richard Q. Marris G2BZQ

With its 30 cm long, 3.2 cm diameter (12 x 1¼ inch) ‘bundled’ ferrite core, the ‘Ultima’ high-performance loopstick antenna covers much interesting activity between 50 kHz and 195 kHz. The ‘Ultima’ is ideal for home, portable, holiday and overseas travel. It also covers the new 136 kHz band with excellent results, but for *reception only*.

An increasing number of radio amateurs in the UK and several European mainland counties are now actively using a new VLF (Very Low Frequency) band at 136 kHz (135.7 – 137.8 kHz). The big challenge at these extremely long wavelengths is to make transmitter antennas with reasonable *efficiency*. In fact, anything greater than 1 per cent is considered a feat! As to receiver antennas, the emphasis is on *noise elimination*. Recently, distances of almost 2,000 km have been covered by amateurs using CW and modest transmitter powers (EI0CF – OH1TN, 2-way CW QSO on 137.2 kHz). To amateurs in the UK, the station DA0LF in Germany is a good ‘DX target’. Lots of useful information on VLF Dx-ing may be found in *RadCom*, the magazine published by the Radio Society of Great Britain (RSGB). In the US, a group calling themselves ‘Lowfers’ has been active for many years collecting valuable information on the quirks of ‘their’ 1,750-metre band.

The ‘feel’ of the radio spectrum below 150 kHz or so (approx. 2,000 metres) is totally different from anything you may have experienced on higher frequencies. Although you will not fail to notice a complete lack of AM broadcast stations, the most prominent feature is the huge noise level which can, on occasion, have a devastating effect on reception.

For reception, a specially-designed type of receiving antenna will be found desirable, especially in urban areas where levels of man-made noise can be diabolical, especially when using a long-wire antenna. Noise experienced below about 150 kHz is either internal or external. *Internal noise* is either generated in the receiver, or enters via the AC mains power wiring. Remedial action can be taken. *External noise* is different kettle of fish. Entering by way of the antenna, it is either man-made or atmospheric. Man-made noise, in its simplest forms, is QRM from another station. Otherwise, especially in urban areas, man-made noise can be from just about any electrical/electronic source such as TVs, computers, calculators, thermostats, light dimmers, vacuum cleaners, lawn mowers, electric power tools, traffic, power lines and may other sources in the immediate neighbourhood. Atmospheric noise, including electric storms, is a natural phenomenon, which, at its worst, can obliterate reception.

Space to many amateurs is at a premium, and a multi-turn tuned frame loop antenna of, say, 1.2 m x 1.2 m will be the absolute size limit. Despite all its obvious advantages, including sensitivity and good selectivity, such a directional antenna can be a cumbersome brute, and inconvenient to store when not

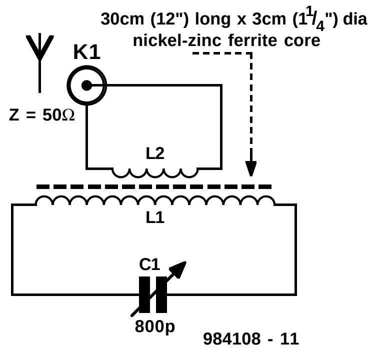


Figure 1. Schematic of the Ultima ferrite-rod VLF antenna

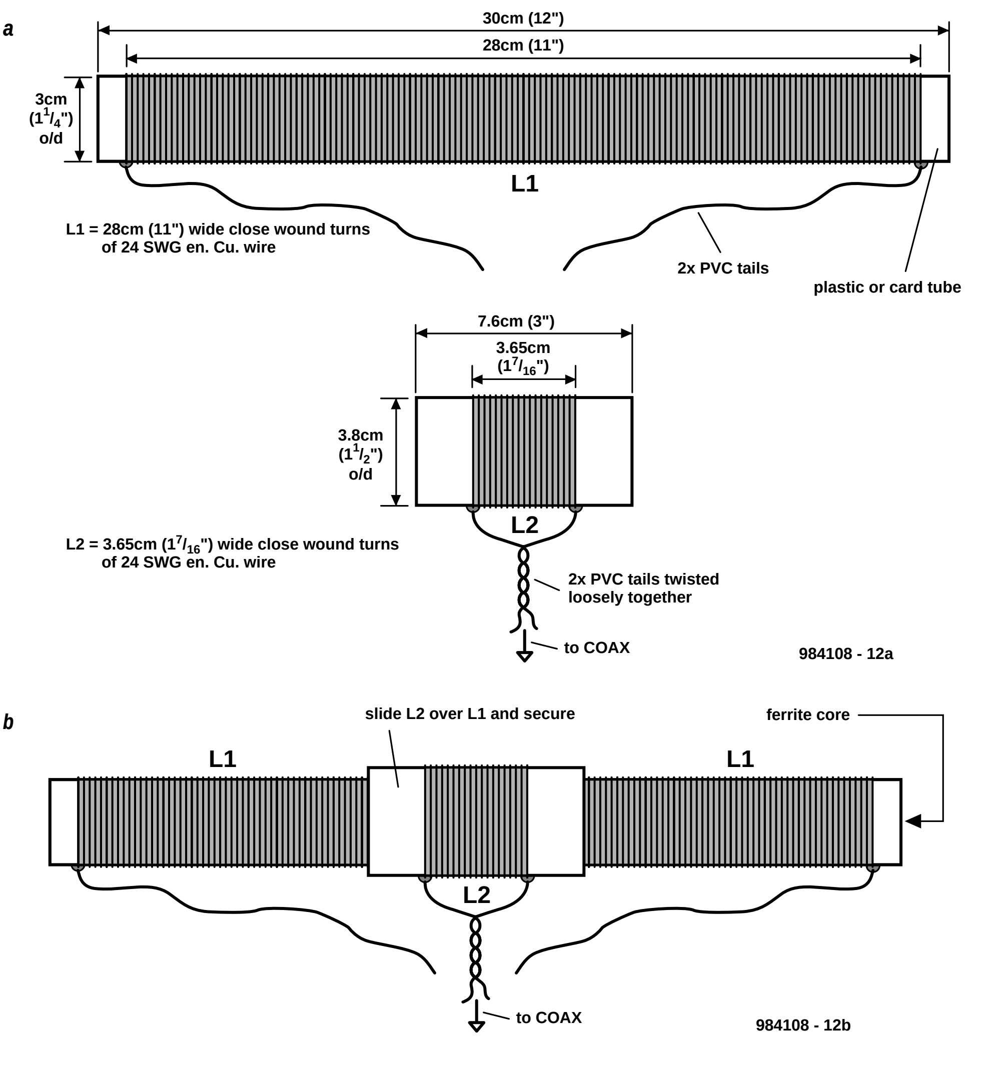


Figure 2. (a) winding L1 and L2; (b) L1 and L2 assembly.

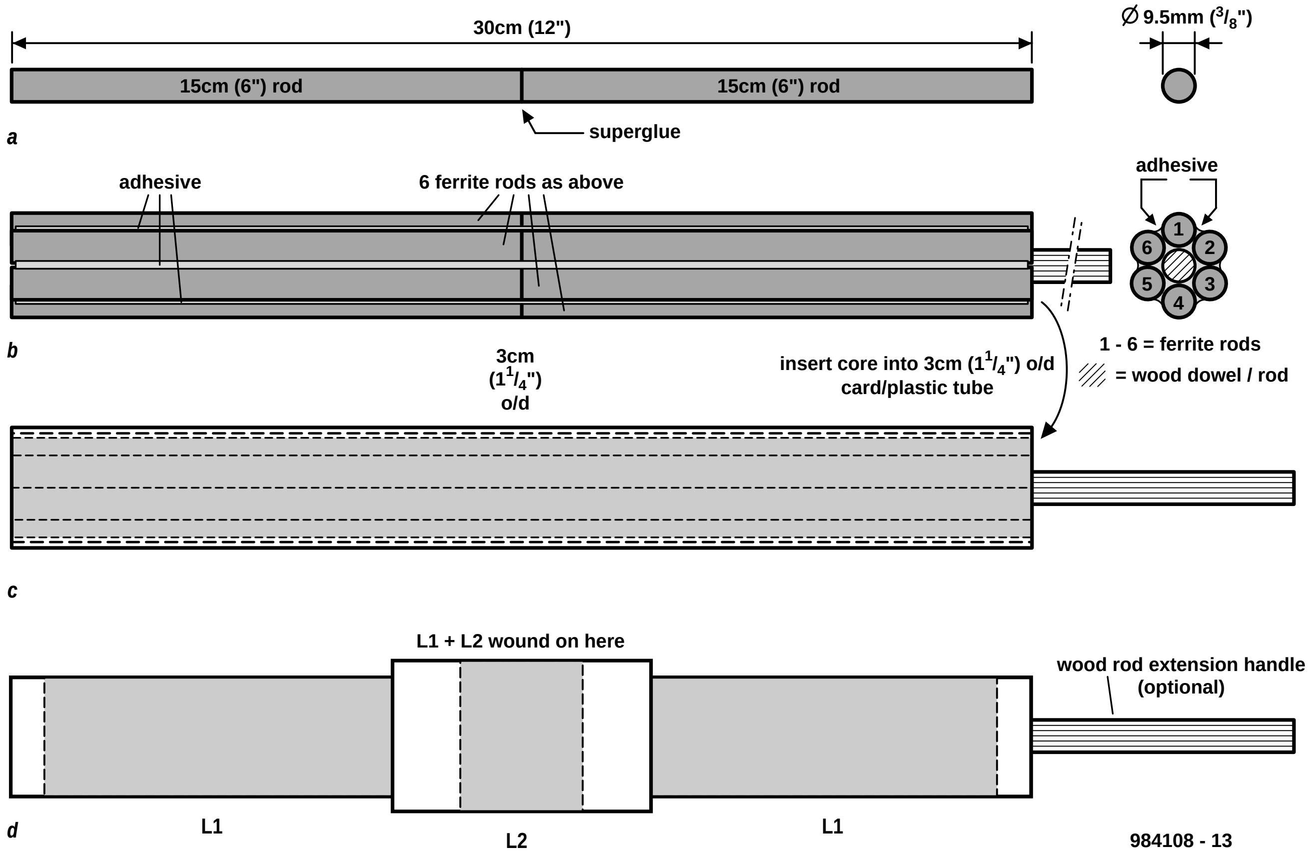


Figure 3. Build the Ultima in this order. Forming a single 30 x 1 cm (a); and a single 30 x 3.2 cm ferrite core (b). Drawing (c) shows the 30 x 3.2 cm ferrite winding assembly, and drawing (d) the format of the final ferrite core.

in use.

An alternative is a ferrite-rod loop ('loopstick'), which in its original form is less sensitive than a frame loop. However a highly sensitive ferrite loop can be designed with careful selection of ferrite core materials and dimensions. To put it simply, the ferrite loop then has to be *large* at, say, 30 x 2.5 cm (12 x 1 inch). Unfortunately, such ferrite rods are not only few and far between but also astronomically expensive. The size of affordable manganese-zinc or nickel-zinc ferrite rods stocked by radio parts retailers is usually either 20 x 1 cm (8 x ⅜ inch) or 20 x 1.25 cm (8 x ½ inch). It was decided to home-brew a 30 cm long, 3.2 cm diameter (12 x 1¼ inch) rod by bundling a number of smaller zinc-nickel rods. The target inductance was 26+ mH.

In the basic loopstick circuit shown in **Figure 1**, coil L1 is brought to resonance by variable capacitor C1. The core of L1 is the above mentioned 'bundled' giant loopstick. Over the centre of L1 is wound coupling coil L2, which provides the coaxial connection to the receiver or VLF up-converter. The coil assembly (Figure 2) is wound on a 30 cm long x 3.2 cm diameter thin wall cardboard tube (Clingfilm tubing!). L1 has a width of 28 cm, and consists of an estimated 466 close-wound turns of 24 SWG (0.6 mm) enamelled copper wire (**Figure 2a**). The winding is terminated with leadouts of PVC covered hook-up wire. In practice the winding ends were held in place with a spot of SuperGlue, with other spots every 2.5 cm or so along the winding. This is necessary as winding the coil is a lengthy process. The coupling coil, L2, is wound on a 7.6-cm (3-inch) length of cardboard tube of a diameter which just slips over L1. L2 is a 3.6-cm (1 7/16 inch) wide close-wound winding of 24 SWG enamelled copper wire, terminated with hook-up wire leads lightly twisted together. The whole coil assembly is shown in **Figure 2b**.

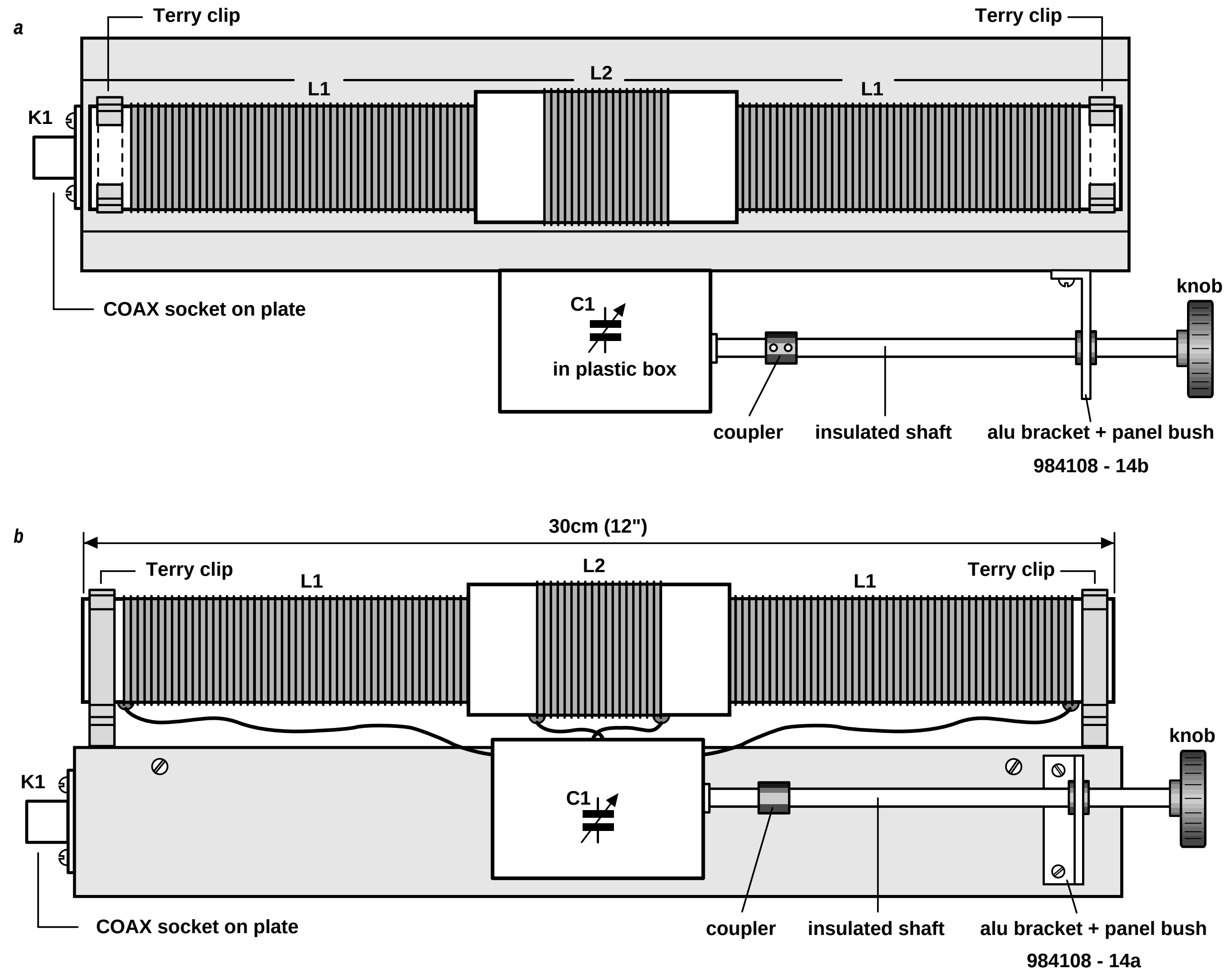
The next step is to build the bundled ferrite core — this is illustrated in **Figure 3**. It consists of six 30 cm long, 1 cm diameter ferrite rods glued together to form one solid 30 cm x 3.2 cm (approx.) core. MMG F14 grade nickel-zinc material was used. An alternative would be the US type 61 material. At these low frequencies, the difference in performance between the F14 and 61 materials is small. Each 30-cm rod is made from two 15-cm rods, secured end-to-end with SuperGlue. The rod ends should first be lightly rubbed down with a fine glass paper in order to remove any grease, etc. (see **Figure 3a**). This technique effectively produces one long rod from two shorter ones. Other combinations of length could be used such as 20 + 10 cm, the 10-cm section being cut from a 20-cm rod using a hacksaw. In this way, three 20-cm rods would make two 30-cm rods.

The solid 30-cm long, 3.2 cm diameter ferrite rod consists of six 30-cm rods wrapped around a wood dowel, and temporarily held in position with a couple of elastic bands, see **Figures 3b, 3c and 3d**. Next, the rods and dowel are adhered together to form one solid core, by cementation with a 15-minute setting adhesive such as Uhu. The adhesive is run along between all mating rod and dowel surfaces, by easing them gently apart with a thin blade. It is important to ensure that the surfaces have the adhesive between them. Several strong elastic bands are put around the rods, making sure that the circular rod formation is maintained. The assembly should be left in a warm place for at least 24 hours to make sure that the adhesive is thoroughly cured. The elastic bands are then cut away.

The core is then inserted into L1, with any slight looseness being eliminated with masking tape. On the prototype, the wood dowel was made a few centimetres longer than the rods, so that the core can be extracted from the coil if and when necessary, for example, for experiments.

The simple final assembly is clearly shown in **Figures 4a, 4b and 4c**. Three identical strips of wood are fastened together with wood screws to form an inverted 'U' shape chassis. Coil L1/L2 is mounted on the top with two narrow type plastic coated Terry clips fastened at the chassis ends. The twisted ends of L2 are dropped through a hole drilled in the chassis top, and taken to the coaxial socket mounted on a piece of thin board, screwed to the chassis end.

The 800-pF tuning capacitor, C1, is mounted on the chassis side as shown in Figure 4. On the prototype, a rigid air-spaced 800-P tuning capacitor (392+11+392+11 pF AM/FM



COMPONENTS LIST

12 off F14 or 61 grade ferrite rods, 15 cm long, 1 cm diameter (6 x ⅜ inch)
1 off 3.2 cm (1 ¼ inch) thin wall cardboard tube (e.g., Cling-film tubing)
SuperGlue
Slow setting glue, e.g. Uhu
1 off 800pF tuning capacitor (see text) with shaft coupler, insulated extension shaft, metal bracket, panel bush and knob
1 off 38 cm (15 inch) length of 1 cm (⅜ inch) o/d wood dowel
1 off coaxial socket
2 off narrow 2.5-cm (1 inch) plastic coated Terry clips
Reel of 24 SWG (0.6 mm) enamelled copper wire.

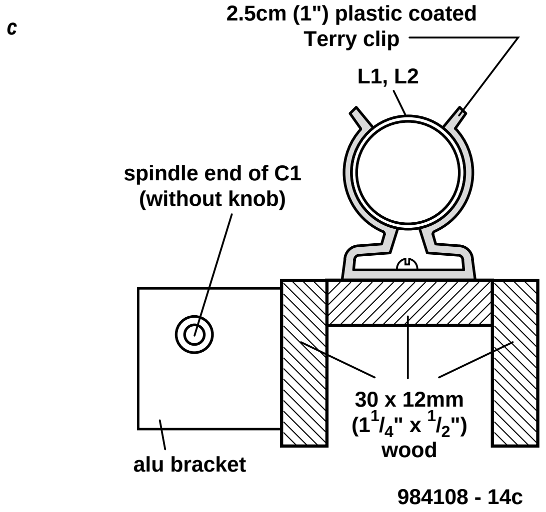


Figure 4. Details of the final assembly.

type wired in parallel) is attached to the chassis side. It is fitted with a shaft coupler and an insulated shaft passing through a panel bush in a small bracket to the control knob. A 1,000-pF (500 + 500 pF) tuning capacitor would also be satisfactory. The tuning capacitor is enclosed in a plastic dust-cover box. The ends of L1 are taken to the tuning capacitor connections.

The tuning range of the prototype was 50 kHz to 195 kHz. The 'Ultima' is used with a Palomar VLF up-converter whose output frequency is in the 80-m (3.5-MHz) amateur radio band. A simple turntable is an advantage to be able to turn the loop, which is directional. The frequency range was carefully selected. At the LF end is the 60 kHz MSF Rugby Standard Time/Frequency station, which produces a mighty signal as might be expected. Moving up-frequency the tuning range passes through the 73-kHz band where various Time/Frequency Standard stations can be received, and much else of interest. Next comes the 2,000-m European Amateur band around 136 kHz which has recently arrived.

As compared with a traditional 20 x 1.25 cm diameter loop-stick, the 'Ultima' features dramatically increased signal strength, with atmospheric and man-made noise being mostly eliminated, or reduced to an acceptable level by simple loop rotation.

(984108-1;W)