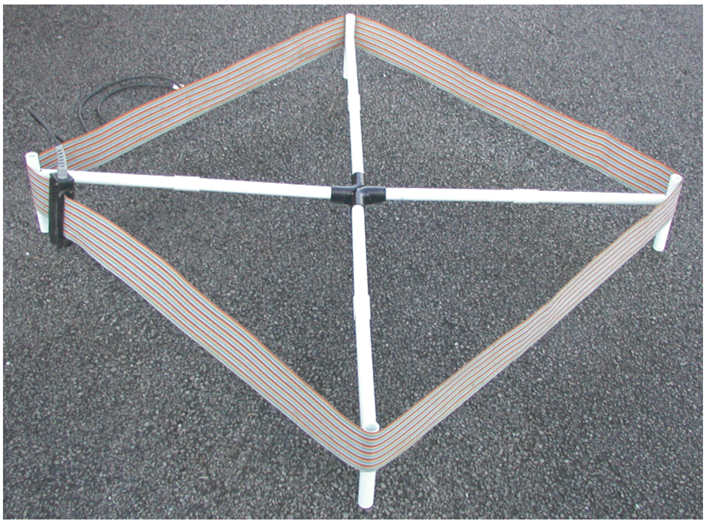
A Loop Antenna for the HeyPhone

Although earth electrodes are the preferred antenna option for the HeyPhone, it has also been designed to work with a loop. ***Mike Bedford*** *describes the construction of a suitable loop antenna based on information provided by* ***John Hey*** *and* ***Brian 'Jopo' Jopling****.*

The greater range of the HeyPhone compared to the Molefone has been attributed, in the main, to the use of earth electrodes as an antenna instead of a loop. However, the HeyPhone has also been designed to operate with a loop. Although the range will be reduced, the shorter set-up time will make this an attractive option in shallow caves. Here I describe a loop which has been designed to work with the HeyPhone. The electronic design is by John Hey and mechanical design of the spreader was carried out by Jopo. The BCRC does not have the manpower to provide ready-built loop antennas to its member rescue teams. The loop has been designed, therefore, so that it can easily be built by HeyPhone users. This article provides information on how to construct the loop.



Electronic Design

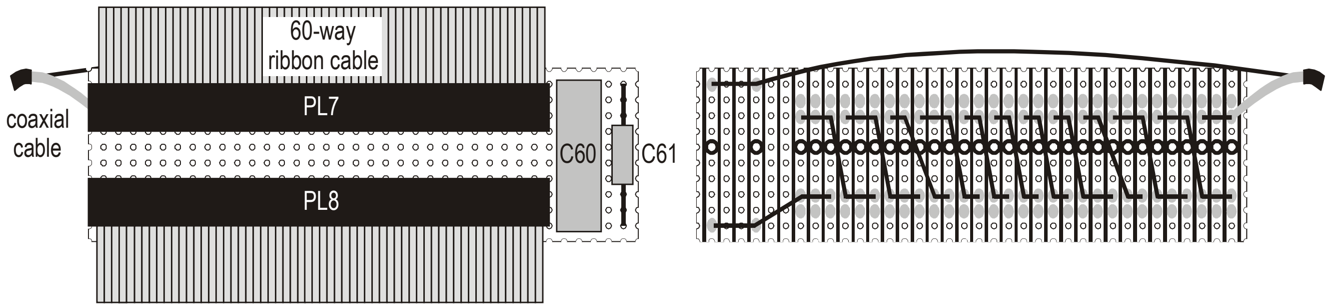
Most of the recently-constructed loops have been made from bunched stranded mains cable. At the request of the BCRC, the official HeyPhone loop has been designed around ribbon cable, much as the loops for the Molefone and Ogofone had been. We have also moved away from a hexagonal design to a square loop in order to simplify the design of the spreader.

The loop is made from 3142mm of 60-way ribbon cable (0.05" pitch) with the conductors grouped together to form 12 thicker turns. Because individually stripping 60 conductors at each end of the cable is a formidable task, and correctly joining them in series quite an awful prospect, IDC transition connectors were fitted to the ends. Ideally, of course, each turn would have contained five conductors. Because of the arrangement of the pins on the IDC connector, however, the following arrangement was used instead: 6-6-4-6-4-4-4-4-6-4-6-6. This makes it easy to wire the stripboard which accommodates the IDC connectors and the series-resonating capacitors. A 10nF, 1600V Type 376 polypropylene capacitor is used with a 400V 1n2 polyester capacitor in parallel. Although a loop constructed with capacitors of this nominal value will work, the tolerances may mean that it's not quite on resonance. This, in turn, will jeopardise performance. If you have access to the necessary test equipment, therefore, it's suggested that you select the value of the secondary capacitor (nominally 1n2) on test. The procedure is described in the box entitled *Resonating the Loop*.

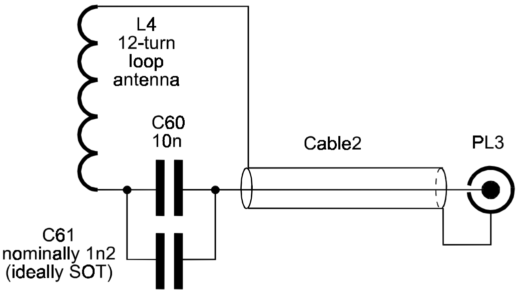
Loop Construction

The piece of stripboard which accommodates the IDC connectors and capacitors is housed in a small plastic box. Slots are cut in the sides of the box to allow the ribbon cable to enter. Since it will be impossible to pass the ribbon cable through the slots once the IDC connectors have been attached, the two ends of the cable must be inserted through the slots before starting on the electronic assembly. This, in turn, means that first job is to prepare the box. In addition to cutting the two slots, this also involves drilling a hole for the coaxial cable in one of the ends of the box.

IDC connectors are attached to the ribbon cable using a specialised and expensive tool. If you don't have access to the appropriate tool, construct a simple assembly jig as follows. Carefully mark a



Stripboard Layout. Left: Component Side; Right Solder Side. Note the non-conventional use of wire links on the solder side.



Loop Schematic

6mm thick strip of Perspex (Plexiglas) with the positions of the 60 holes of the IDC connector. There are two lines 0.1" apart and 0.1" spacing between centres. Now drill each with a 0.8mm hole.

Cut a 3142mm length of 60-way ribbon cable. Now attach an IDC connector to each end, making sure that you connect both with the pins pointing in the same direction. If you don't have the proper assembly tool, here's how to attach the connectors using the homebrew assembly jig. Drop the pins of the IDC transition connector into the drilled Perspex strip. It is essential to make sure the ribbon enters the grooves evenly and strictly at right angles. Now carefully slot the ribbon into the connector housing. Finally, lower the assembly into a vice and tighten. The ribbon top support will click into place once the vice has pushed the conductors into place.

Now prepare a piece of stripboard by cutting to size and breaking the conducting strips at the appropriate positions. Details are shown in the diagrams on the previous page. Solder the IDC connectors, the two capacitors, a 2m length of RG58 coaxial cable, and the various wire links onto the stripboard. Note that the links are fitted to the solder side of the board and should be partially insulated. Fit the strain relief grommet into the hole in the plastic box, pass the coaxial cable through and solder a PL259 connector onto the end of the cable.

Once the loop has been tested (and the secondary capacitor selected on test), the stripboard should be sealed before closing the box. The recommended method is to use the sealant which is sold for use in bathrooms. Choose a non-silicone product since silicone sealants release corrosive acetic acid during the curing process. This, of course, would damage the copper on the stripboard. First of all, encase the stripboard and its associated components in sealant and then apply sealant around the ribbon cable entry, around the coaxial cable entry and around the seal between the box and its lid.

The Spreader

The spreader has been designed so that it can be built without any machine tools. All that is required are a few simple hand tools and, ideally, a vice. It is constructed mainly from 20mm round electrical conduit and its associated fittings. These materials are readily available from a DIY store or an electrical wholesaler. The approximate cost is £10. It is designed so that it will collapse to a bundle approximately 300mm long for transport and can rapidly be assembled.

Spreader Construction

Cut eight pieces of 20mm diameter conduit, each 250mm long and four pieces 150mm long. Square smooth the ends – this is easiest on a lathe.

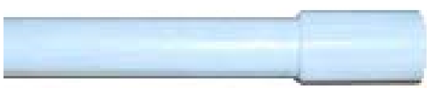
Cut off the radius on the two 90° inspection elbows, as shown, to allow the elbows to form a cross. Remove the inspection plates from the elbows. To allow flexibility it is better to cut a little extra off so the plate can flex.

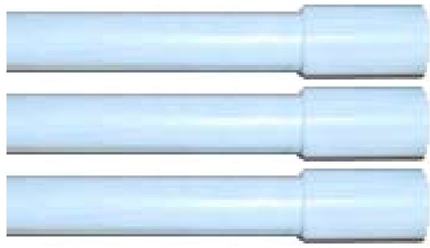
Using the inspection plates as a template, mark out four holes on the PVC sheeting which will form the support plate. Drill each with a 3mm hole. A little bit of "eyeing up" is required to get a good cross. You can mark out, but we are not making watches. Remember to leave a gap between the edges of the inspection plates when marking holes.

Using the screws from the 90° inspection elbows, fasten the elbows to the plate. Finally cut the support plate into a cross shape although, in reality, this is not important.

Two views of the central hub. Note the gap between the two 90° inspection elbows.

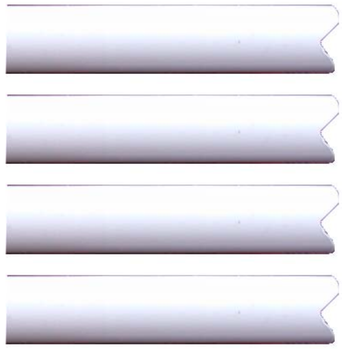
Using superglue, attach a straight connector onto four of the 250mm lengths of conduit.





Four lengths of conduit with straight connectors attached

Cut a "V", around 10mm deep, into one end of each of the 250mm lengths of conduit which do not have straight connectors attached.



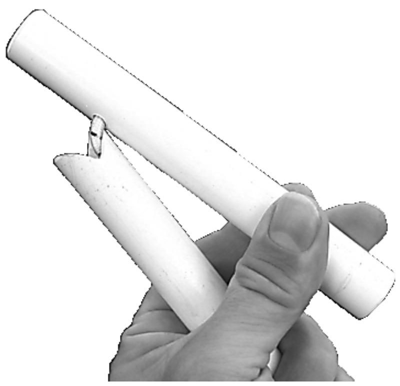
Four lengths of conduit with "V" notches cut in one end

Drill a 5mm hole through one wall of each of the 150mm lengths of conduit, about 40mm from one end.

The final job is to pass two lengths of shock cord through the assembly. Each shock cord retains the pieces which make up one of the two diagonal arms. So, for each leg, pass a length of shock cord through the following components in the order given:

1. A 250mm length of conduit without a straight connector attached. Start at the end with the "V".
2. A 250mm length of conduit with a straight connector attached. Start at the end with the connector.
3. The central hub.
4. A 250mm length of conduit with a straight connector attached. Start at the end without the connector.
5. A 250mm length of conduit without a straight connector attached. Start at the end without the "V".

Secure the ends of the shock cord inside each of the 150mm lengths of conduit by passing it through the hole into the inside of the conduit and then tying a knot which won't pass through the hole. Ensure that the shock cord is under tension (i.e. stretched) before tying the final knot. Do not be tempted to leave out the shock cord. Remember that the spreader consists of no fewer than 13 separate pieces and it would be all too easy to leave one behind when packing up if they were not all threaded onto the shock cords.



This completes the construction. Do not attempt to fix location plates to the antenna's ribbon cable. It is not necessary and it is difficult to get anything to stick to the ribbon cable. It also means that you won't end up bending the ribbon cable at the same point for each deployment and this should increase the lifetime of the loop.

Using the Loop

The spreader will adopt its correct shape as soon as it's taken out of its container, thanks to the shock cord. You may just need to ease a few of the pieces of conduit into their respective connectors. Rotate the legs, as necessary, to ensure that the four legs at the ends of the arms are all pointing downwards. Now open out the ribbon cable loop and place it around the spreader. It's possible to do this with one person but it's much easier with two.

If the underground and the surface station are both using loops, the loops should be positioned horizontally. For optimum performance, either the surface loop should be directly above the underground loop or both should be in the same horizontal plane. If the surface station is using earth electrodes as antennas, you will normally find that a vertical underground loop is more appropriate. In this case you should rotate the loop to find the optimum position.

The loop has been designed to give the best performance when it's arranged as a square. Furthermore, the performance is quite sensitive to shape. For example, the received signal strength will be around 10dB lower if it is arranged as a circle. If at all possible, therefore, you should use the spreader in order to guarantee the correct shape. You should also make use of the spreader's legs to keep the loop from making undue contact with the ground as this will also jeopardise performance.

Parts List

The Loop

C60	10nF, 1600V, high performance polypropylene, Philips 376 series (FEC 577-832)
C61	1n2, 400V, ployester This is a nominal value. Ideally it should be selected on test for resonance.
L4	786mm square loop of 60-way ribbon cable configured as a 12-turn loop by paralleling groups of adjacent conductors. Constructed from Cable3, PL7 and PL8.
PL3	PL259 UHF
Cable2	2m length RG58 coaxial cable
Cable3	3.142m 60-way ribbon cable. required for optional loop antenna. This is used in the construction of L4.
PL7, PL8	60-pin, 2-row IDC transition (0.05" ribbon cable to PCB) connector (FEC 327-1500). These are used in the construction of L4.
Box2	124mm x 33mm x 30mm ABS box (Maplin FT31J)
Relief1	Strain relief grommet for Cable 2 (FEC 152-374)
Strip1	0.1" strip board, 10 holes x 36 holes, copper strips parallel to short edge

NB. The part numbers refer to the HeyPhone as a whole and are compatible with the published parts list. This is why they don't start with C1, L1 etc.

The Spreader

Two metre length of 20mm round electrical conduit cut to the following lengths:

250mm – 8 off

150mm – 4 off

90° inspection elbows for 20mm round electrical conduit– 2 off

3mm PVC or similar sheet – 90x90mm

Straight connectors for 20mm round electrical conduit – 4 off

5mm shock cord – 2m

Superglue

NB. This assembly is referred to as Spreader1 in the published HeyPhone parts list.

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Resonating the Loop

The loop is tuned to resonance with a main 10n capacitor (C60) and a secondary capacitor with a nominal value of 1.2n (C61). For optimum performance the secondary capacitor should be selected on test. The following procedure allows you to determine the resonant frequency (and, optionally, the Q) of the loop. Having determined the resonant frequency, increase C61 to lower the resonant frequency; decrease it to increase the resonant frequency.

In the following instructions, the outer screen of the coaxial cable (which is connected to the outer of the PL259 plug and one end of the loop) is called EARTH.

Signal generators designed for audio use often have an output resistance of 600 ohms. Generators intended for radio use, though both covering our 87kHz, have an output resistance of 75 ohms in older models, and 50 ohms in newer versions; much too great in both cases.

The output resistance of the HeyPhone is 0.5 ohms. Help is at hand, using the HeyPhone's built in transformer. If the loop is connected to the HeyPhone's loop socket in the normal way, and the signal generator (either RF or AF) connected to the earth electrode sockets with the radio switched off, we can measure the resonant frequency and the Q of the loop.

Connect either an oscilloscope or millivoltmeter (or both) between EARTH and the HOT end at the junction of C60 and L4. Inject a signal of say a couple of hundred millivolts; swing the generator through our working frequency and note a sharp response from the instruments.

If the generator is accurately calibrated or an external counter is connected, the peak response is the resonant frequency. We try for about 88kHz. A kilohertz either way makes little or no discernable difference; if much greater than this, then adjustment of the capacitor is indicated.

To establish the Q, adjust the generator's output and the meter sensitivity for a reading of 0dB. Raise the generator frequency till the reading drops 3dB, noting the reading. Now reduce the frequency past the peak till again it drops 3dB, again noting the reading. Subtract the lower from the higher, then divide your answer into the resonant frequency; this is the Q of the loop.