Loop counterpoises for low noise vertical HF antennas

I've worked with vertical antennas over many years and I've noticed that in small restricted locations such as the back yard of my house (which is only 7.5 x 4.5m), straight radials or counterpoises can pick up a lot of local RF noise (including VDSL noise). Elevated radials are particularly bad at this. I suspect it's caused by capacitive coupling between the high impedance end of the radial to nearby electrical wiring.

A few years ago I installed two Loop on the Ground (LoG) antennas **[1]** designed by Matt Roberts, KK5JY: one at home and at my workshop. The LoG antenna is a simple square of insulated wire with 4.5m long sides, laid directly on the surface of the ground. Being mounted so close to the ground cancels out any horizontally polarised signals; it responds to vertically polarised signals in a similar way to a Beverage antenna. Both LoG antennas gave very good results on HF receive, with very low noise.

Just as the Covid-19 lockdown was starting, my family business was launching a new high-Z antenna amplifier intended for contest stations building phased vertical arrays for directional HF receive. As it wouldn't be possible for customers to nip out to their local hardware store during lockdown, I tried the prototype antenna using both ends of the LoG antenna connected together to the ground terminal as a loop counterpoise. For comparison testing antennas I use a signal to noise measurement of a local medium wave station within ground wave range as a reference. The signal to noise measurement using the loop counterpoise gave the best measurement I had ever recorded with any antenna at that location due to the very low background noise floor.

Following this I tried both my LoG antennas at home and the workshop connected as loop counterpoises to the ground terminal of the antenna amplifier – with the same low noise result.

PHOTO 1: General layout of my two-loop restricted space vertical with two grounding loops. Yellow marks the G7FEK vertical antenna; red and green denote the two loops, with the rightmost (green) loop running around my back yard behind the gate. The transformer (not shown) is at the base of the vertical.

I've used the spare time available during lockdown to investigate and refine the principle and now it can be applied to *any* vertical antenna and can be used for transmit and receive.

As an example, I made a G7FEK vertical antenna **[2]** using two loop counterpoises. The first loop counterpoise was the original LoG antenna with 4.5m sides of insulated wire in a square laid on the dirt track behind my back yard. The second was laid on the concrete flagstones in the back yard in a rectangle of insulated wire with 7.5 and 4.5m sides. **Photo 1** gives a general idea of the setup in situ and **Figure 1** shows it in diagrammatic form. During testing I also laid

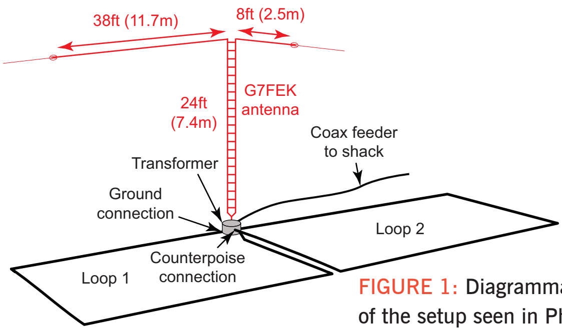

FIGURE 1: Diagrammatic view of the setup seen in Photo 1.

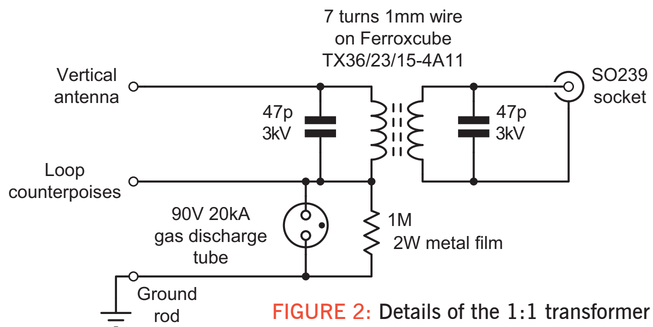

FIGURE 2: Details of the 1:1 transformer and associated parts (see text)

PHOTO 2: **The 1:1 transformer and associated parts. The black wires connect to the SO239 input socket and the grey wires to the loop counterpoises and vertical antenna.**

PHOTO 3: **Using a loop counterpoise from a parked car (inset shows the alligator clip connecting the loop to the ground part of the antenna mount).**

a third loop counterpoise over the other two counterpoises, which proved that they can be overlapped. As the loop counterpoises are not resonant, their size, shape or any overlap is not critical. Just use the area you have available to lay insulated wire in loops.

The loop counterpoise laid on the ground doesn´t appear to have the high impedance high RF voltage that the end of a conventional radial has. This dramatically reduces the capacitive coupling to nearby electrical wiring.

Unfortunately it is almost impossible to model this setup in most of the antenna modelling software available to radio amateurs due to the close proximity of the loop wires to the ground. Even high-end software models such as the latest NEC v5.0 have problems modelling the boundary conditions between air and ground, so it wasn´t possible to accurately model the antenna. I had to rely on good old-fashioned on-air measurements and testing instead.

During testing I found that the quietest low external noise results came when the wire in the loop counterpoises were insulated from the ground (including the connection back to the mains earth at the transceiver). To do this I've built and fitted a 1:1 isolation transformer at the base of the vertical section of the antenna. The primary winding is connected to the incoming coax feed. One end of the secondary winding is connected to the vertical antenna and the other end is connected to the loop counterpoises. For safety I've added another terminal so that the ground side of the secondary winding can be connected to an earth rod via a 1M resistor and a gas discharge tube. This drains away any electrostatic charge on the antenna and counterpoises and would offer a safer path to ground for any lightning strikes. **Figure 2** shows the circuit diagram and **Photo 2** is the practical implementation.

TABLE 1: Measured noise levels.

Band	Noise level (2400Hz bandwidth)	S-meter reading
160m	-100dBm	S5
80m	-93dBm	S6
60m	-104dBm	S4
40m	-97dBm	S5
30m	-97dBm	S5
20m	-107dBm	S4
17m	-115dBm	S3
15m	-115dBm	S3
12m	-117dBm	S2
10m	-123dBm	S0

This antenna is now very quiet. The noise floor is down to rural levels – for the first time ever at this location. I can switch off the mains supply to the house with no change to the background noise. The VDSL noise from the BT Openreach wires at the front of the house has also gone!

This design also has the benefit of isolating the antenna from the mains earth in the building.

Measurements

Previous measured noise levels using the G7FEK vertical antenna with straight wire radials and earth rods were a constant S8 level of noise on all bands. **Table 1** shows the noise measurements of the antenna with insulated loop counterpoises, taken with a Xiegu G90 SDR transceiver with the receiver S-meter checked against a calibrated signal generator.

Transformer design

Although I have a commercial interest in a company that makes radio equipment (Cross Country Wireless), I consider it important to share this antenna design, as it could help many radio amateurs cope with nearby RF noise sources. Therefore I'm sharing it under an 'open source' philosophy so anyone can make one for themselves.

The transformer uses a Ferroxcube TX36/23/15-4A11 core. Although other cores may work, I recommend this specific core as it is epoxy coated, giving DC isolation up to 2000V between the core and the windings. It will easily handle the UK legal power limit and has very low loss – important for QRP work and to avoid overheating in higher power use. It also has the correct permeability to make an efficient transformer for the LF and HF bands.

Two insulated wires are wound on the core as a 7 turn bifilar winding. In Photo 2 the grey wires go to the stainless steel bolts on either side of the polycarbonate box, connecting to the antenna on the left side and the loop counterpoises on the right. The black wires go to the SO239 input socket.

The ground rod connects to the top bolt and the 1M resistor and gas discharge tube connect to the ground side of the secondary winding. Two high voltage 47pF capacitors are connected across each winding to cancel out the leakage inductance in the transformer. This improves the VSWR match to 50Ω and also makes the transformer act as a useful VHF low pass filter.

Portable use

In addition to the home and workshop installations, I've also tested the loop counterpoise as a way of increasing the efficiency of a mobile HF antenna on a vehicle when parked up. A loop counterpoise laid on the tarmac around the vehicle and connected to the ground at the base of the antenna gives a far better ground 'connection' than just relying on the capacitance of the car body to ground. In the case of a car it doesn't need the isolation transformer as the car body is already insulated from ground by the tyres. **Photo 3** shows a typical setup for a parked car, surrounded by an untuned loop that's connected to the earthy side of the antenna mount via an alligator clip.

[Note: as mentioned last month in the article by G8IDL on using a short vertical mobile antenna at HF, be aware that there could be a very significant voltage between the car body & loop and the physical ground when you are transmitting, so make sure nobody touches the car or the loop wire or gets in or out of the vehicle whilst you're on the air – Ed].

Websearch

[1] Loop on the Ground antenna by KK5JY http://kk5jy.net/LoG/
[2] http://www.g7fek.co.uk/software/G7FEK%20 antenna.pdf

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