Part 3: antennas for MSF 60 kHz VLF

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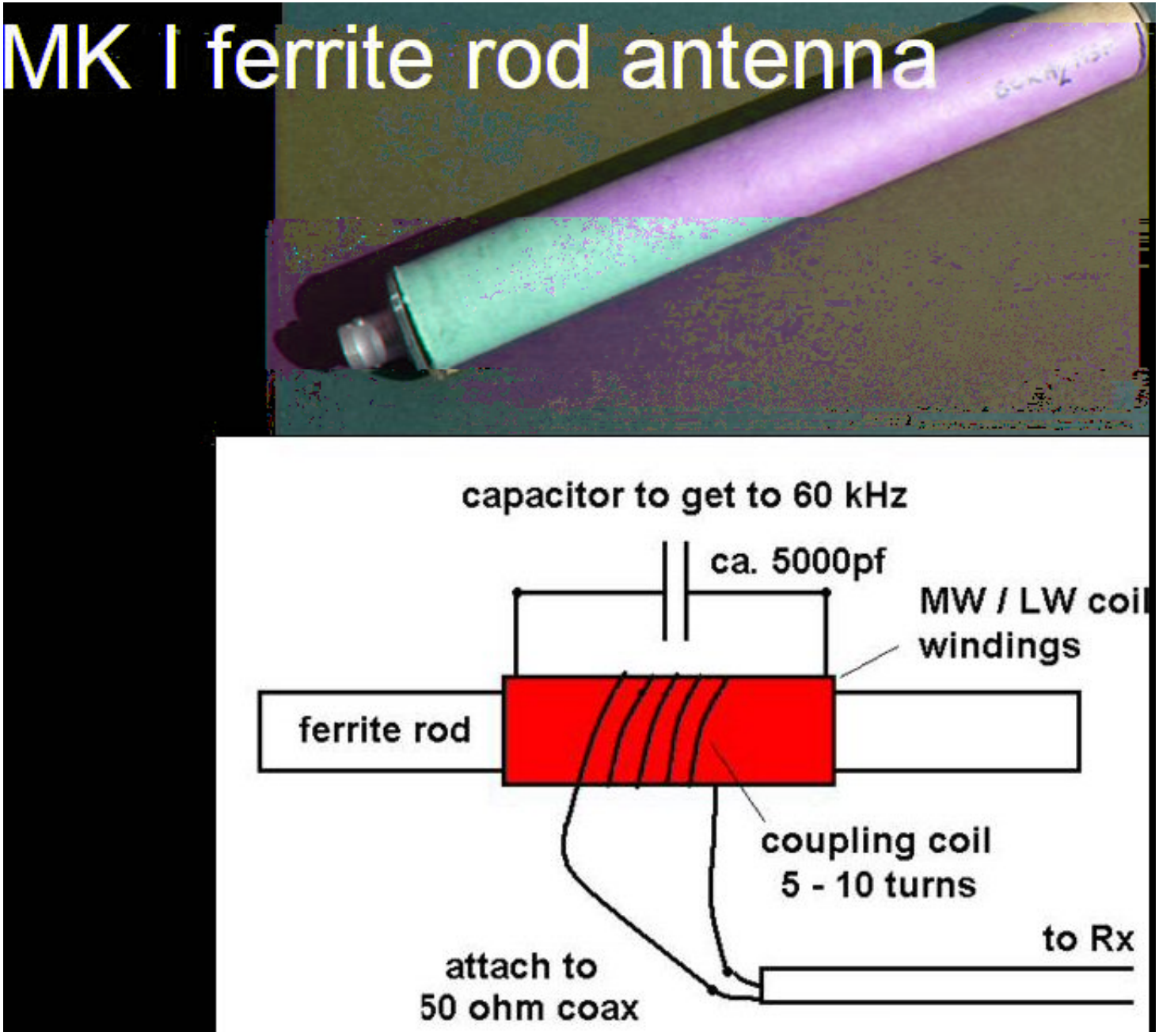
click here for the whole MSF series

Long wires' can be used to receive the LF MSF signal but at a wavelength of 5000m its unlikely that any of us will actual use a real 'long wire' which is defined as being many wavelengths long! The random wire, as it may better be know, is not ideal however because of other strong LF signals and local interference around 60 kHz for example from spurious signals from oscillators in: computers, Wi-fi equipment, broad-band network apparatus, switch-mode power supplies, TV's etc [1].

Ferrite rod antennas

Ferrite rod antennas are much better than 'random wires'. The signal might be less but the drop in noise level makes up for that. The ferrite rods inherent directivity usually means that a good signal to noise can be arranged quite easily simply by moving / rotating the antenna.



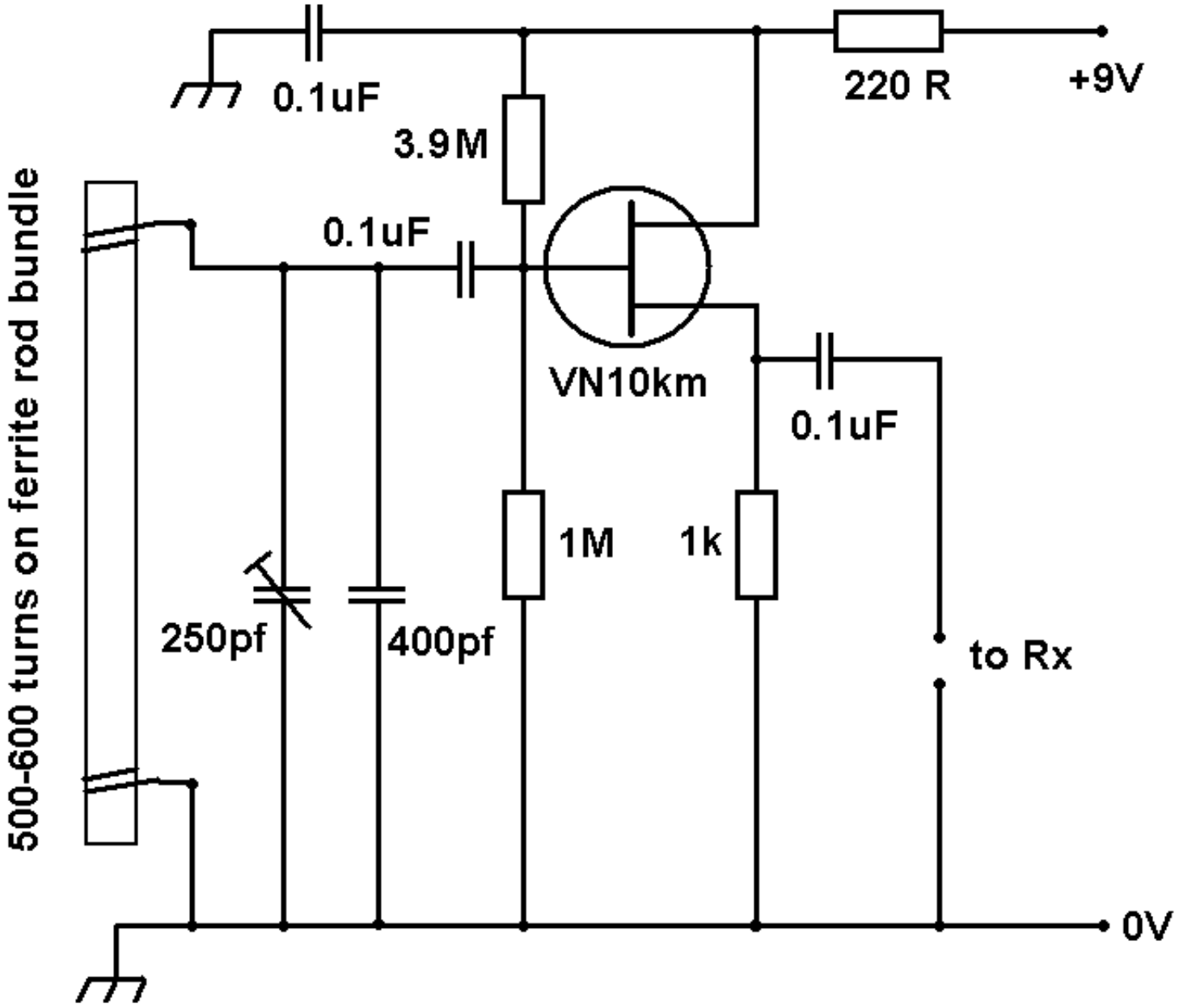
The simplest ferrite rod antenna. Simply take a standard LW radio coil and add ca. 5000pf in parallel to get resonance at 60 kHz. A 5-20 turn coil around the main windings allows coax cable to be coupled.

Simple Ferrite Rod Antenna

You can make a basic ferrite rod antenna by adding about 5000pf of capacitance to a standard long wave (LW) radio ferrite rod coil. This will bring it into resonance at about 60 kHz. You may need to experiment a bit and use something like a 4700 pf + 400pf pre-set in parallel to get the precise resonance for MSF.

When you have done this make a coupling coil of about 5-20 turns of enamelled wire around the middle of the LW coil windings. The two ends of the coupling coil can go directly to coax cable and then on to the receiver.

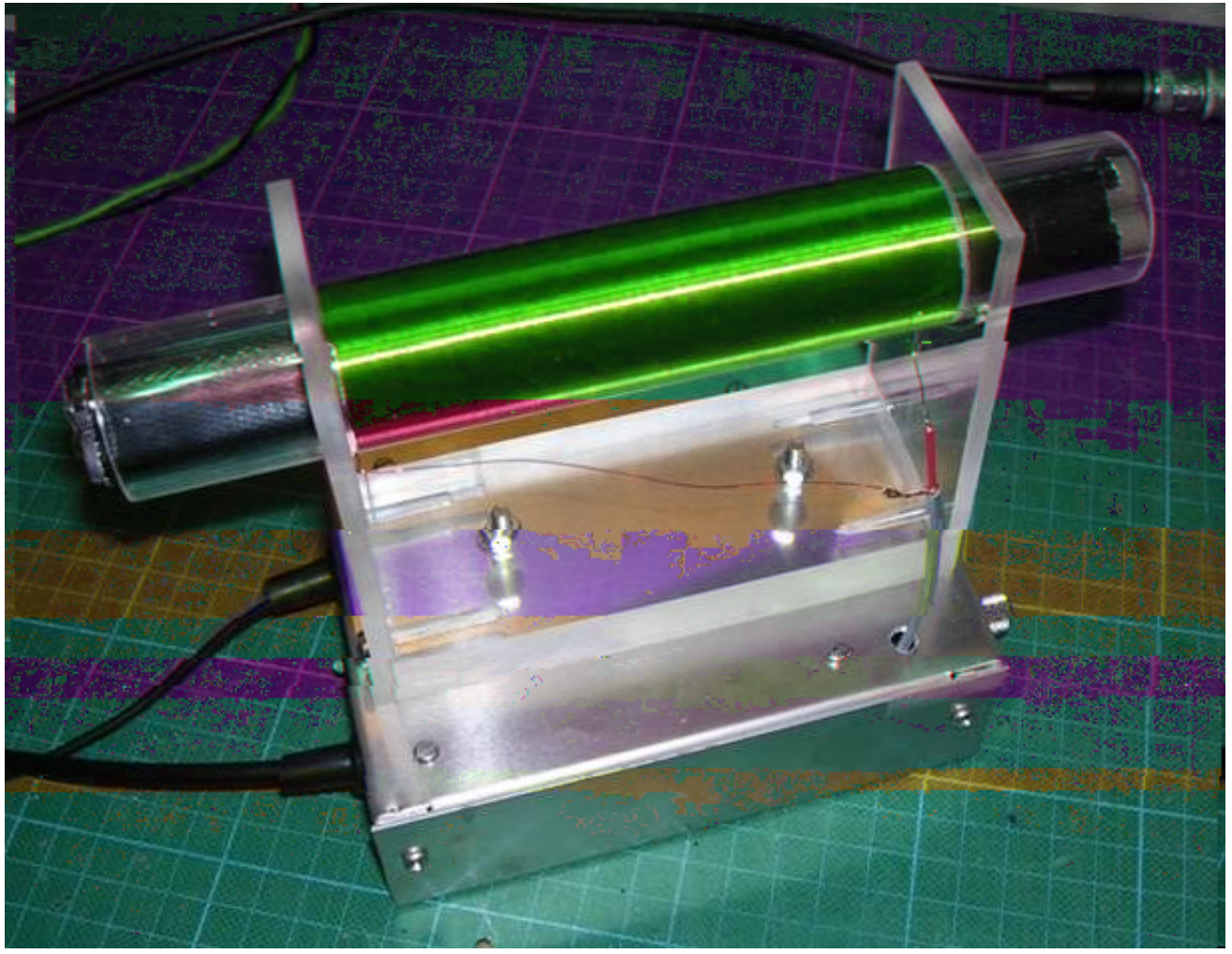
This simple antenna used to give a good signal in Sussex when the MSF transmitter was located at Rugby in central England. When MSF moved to Anthorn in 2007 I found it was weaker. As a result you might consider the more sensitive design described below.



Simple Mosfet pre-amp circuit (taken from reference 2). It provides a high z i/p for the coil and some useful gain at 60 kHz.

Mosfet pre-amp

This is not a state-of-the-art pre-amp but it does provide a cheap and 'perky' system to get a decent received signal on 60 kHz MSF [2]. It uses a VN10KM mosfet to provide a high impedance input and some useful gain. I have built a couple of variations on this designs using 2 and 8 ferrite rods. The first design used two 14cm rods end-to-end wrapped in a single layer of sellotape. Around these were coiled a single layer of 500 turns (ca. 30 SWG copper enamelled wire) and ca. 250pf and a 100 pf pre-set cap to get resonance.



This is as 400 turn (30 SWG) coil wound around a (ca. 30mm diameter) perspex tube within which are 8 x 10cm ferrite rods. The rods are bundled up in two sets of four rods. The coil is connected to the simple (high Z input) mosfet amp. This antenna works really well.

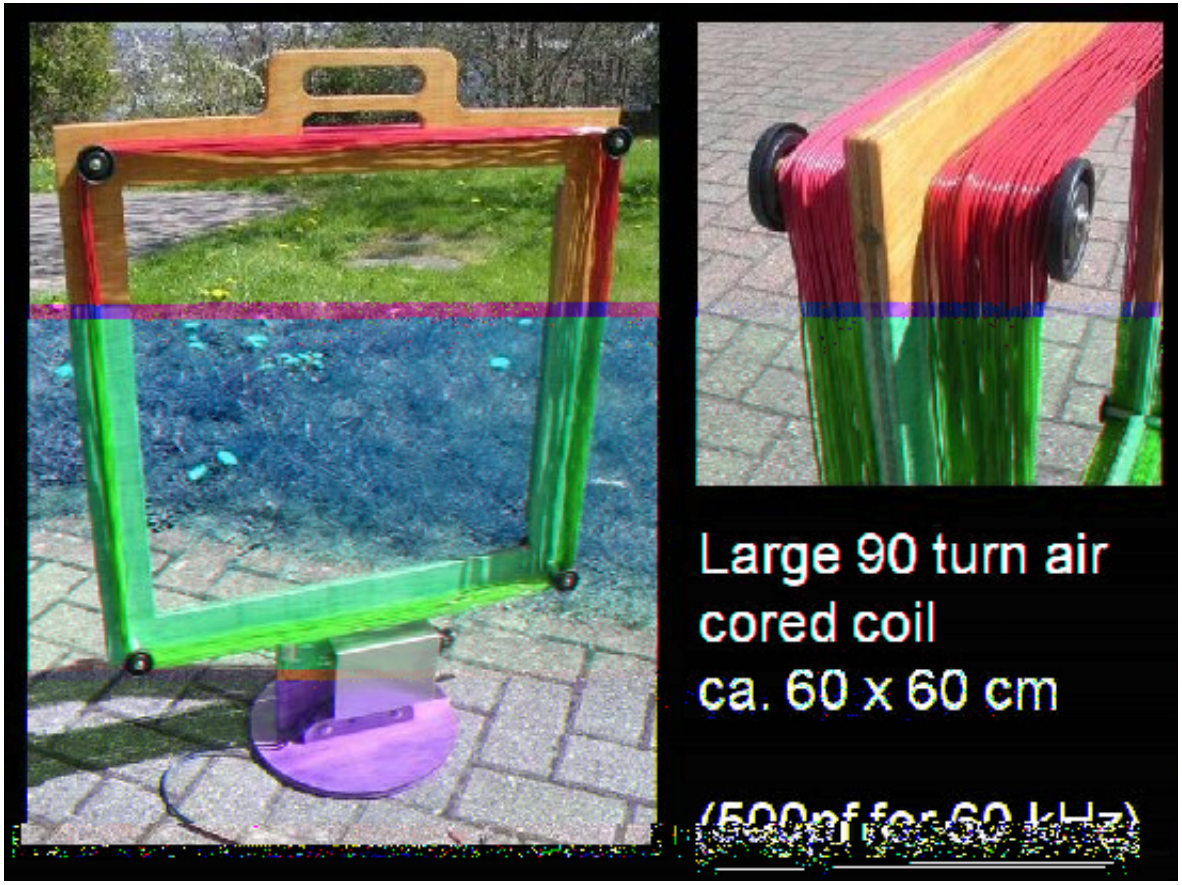
The MKII design (above) uses 8 x 10cm rods (4 wrapped together and then joined end to end with another set of four). These were slipped inside a piece of 30mm OD Perspex tube. Around the middle section of this tube were wound in a single layer coil of ca. 400 - 500 turns of wire (30 SWG, ca. 11cm long and ca. 3cm diameter). I have tried Litz wire but didn't find it performed any better than 30 SWG enamelled copper wire.

I have recently made a 150 turn version of the 8 x ferrite rod antenna using three sets of tuning capacitors (2 x 500pf + 2 x 250pf + 100pf) in parallel to provide course, medium and fine tuning from ca. 60 – 200 kHz. This part of the LF spectrum is really interesting and I also hope to use it to monitor the new 136 kHz band.

Temperature stability

A main limitation of the ferrite rod tuned circuit is that the ferrite can have relatively poor temperature stability [1]. Simply put the MSF ferrite rod antenna will drift with changes in temperature. If the antenna is fitted outside, the Q is very high and the signal is weak this could lead to periods of signal drop-out.

Now if your MSF receiver / decider can run on an internal clock while there is no signal this may not matter too much. Many of the very simple receivers built into the commercial MSF wall clocks may not constantly receive the MSF signal (of course it will depend where they are, location etc.). Much of the time they may run on their internal clock and update every so often when they get a reliable MSF signal again.



Without the high permeability ferrite the air cored loop has to be ca. 500 times the size for an equivalent ferrite rod amtenna. This one has 90 turns in total. I used the same Mosfet pre-amp with this. It works well, about as good as the two, but not as good as the eight, ferrite rod antenna.

Large Loop

If you have the space and you want a stable and sensitive antenna a large loop is the best option. This is large because we don't have the high permeability ferrite to shrink the coil size and so we need to get enough inductance from an air cored coil. As the permeability is a factor of 500 or so it means the loop has to have an area of about 500 times greater than that of the ferrite rod antenna for similar number of turns.

I used about 100 turns (actually two lots of 46 turns each from a 100m reel of 16 stranded plastic coated) of household wire on a 60cm x 60 cm wooden former. The same 250pf + 50pf variable / pre-set cap seemed to be able to bring the loop into resonance at 60 kHz.

I used the mosfet pre-amp described in the ferrite rod antenna but wired it into the air cored coil. I also incorporated a phase reverse switch at the coil as 'sods-law' will often mean that the only decent signal position is when the antenna is not in a convenient position. The switch allows for skewing the response by 180 degrees. Now in principle a 180 change should not make any difference but in practice the loop responce isnt exactly symmetrical and so the switch may provide a slightly more convenient angle for nulling the noise.
This air cored coil provides about the same signal as the MKI two ferrite rod mosfet antenna described above but falls short of the 8 ferrite rod design.

Note: the large air cored loop is most sensitive in line with the direction of the coils of wire while the ferrite rod is most sensitive broadside to the coils of wire. The useful null is therefore broadside to the large loop and in-line with the coils of wire for the ferrite rod antenna.

I am using this loop for long-term signal strength measurements of MSF. There is a curious signal change that takes place most days early in the morning and I am interested in recording / exploring this further [3].

Next time we discuss receivers and converters to pick up the 60 kHz MSF signal.

References and links

[1] For the Time and frequency section of the NPL and also for the MSF data sheet (PDF)
[2] Encyclopaedia of Electronic circuits, Volume 5, R F Graf and W Sheets. For the MSF antenna and pre-amp see page 33.
[3] personal communication from staff at the Time and Frequency section of the NPL on 28th November 2007 UKAS Open day

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