Wellbrook Communications

SHORT WAVE MAGAZINE November 2001

## JW's Feedback Forum

**John Wilson investigates the relative strengths of two alternative l.f. antennas: the RF Systems LF-520 and the Wellbrook LFL1010.**

short wave magazine

### Whips & Loops - A second look


Green and pleasant lands. Not much by way of electrical noise to be found here.

This may sound like an invitation to a slightly unusual party, but is in fact a further delve into the relative performance of the two major types of active antenna found in the market place today; the H-field loop antenna and the E-field whip or rod antenna, both types having their particular band of followers.

Those of you who read my first encounter with the active loop antenna will remember how impressed I was with its performance compared to an expensive professional active rod antenna and also to a 'typical' 10 metre long wire fed through a 'magnetic balun' matching transformer. I followed this up with a more detailed assessment of the low noise performance and E-field rejection qualities of the loop after a reader complained to me that he found the loop antenna unsatisfactory when compared to his own long wire (75 metres long), and it was during this assessment that I found the exceptional ability of the loop when listening for low level signals close to the receiving system noise floor.


At the same time I began to find an interest in l.f. and v.l.f listening and discovered that the loop in question (Wellbrook ALA1530) seemed to perform well below its stated frequency limit of 500kHz. The outcome of this was that Wellbrook designed and manufactured a fully E-field screened active loop that I could use as a second measuring antenna alongside an expensive Rode & Schwartz HFH2-Z2 professional active loop in my day to day EMC measurements of radiated emissions down to 10kHz. Because of the stipulation in the marine test standards I was using, the loop diameter was limited to 600mm, but when I had the

Wellbrook l.f. loop calibrated to UKAS requirements I found that it performed every bit as well as the Rode & Schwartz antenna and I thought then that it wouldn't be too long before we would see a new Wellbrook active loop covering the v.l.f. frequency spectrum. By a bit of good fortune (for this reviewer) the eventual arrival of a sample of the new LFL1010 loop coincided with the announcement of a v.l.f. active whip antenna from RF Systems in Holland, so here was a real opportunity for me to test the antennas side by side and let you know what I found.

**Mechanical Construction**

The RF Systems LFA-520 antenna is typically well constructed and consists of a 2.1 metre long white plastic tube, 32mm in diameter and quite flexible. I would hazard a guess that the tube is a piece of standard white plumbing pipe of the type used for drainage from washbasins and baths, since RF Systems have already used plumbing parts in, for example, their MLB magnetic balun which is constructed from two 40mm grey plastic 'stop ends' cemented back to back.

The plastic tube is securely fixed at each end into aluminium sections, that at the top having four fixing holes for the curved metal rods which make up the capacity 'hat', and at the bottom the metal section contains the active amplifier with a PL-259 socket for connection of the coaxial feed to the receiver. When assembled, with the four curved capacitive elements in place, the LFA-520 looks rather like one of the 'onion' pinnacles on top of the Kremlin. A mast clamp is provided to enable the user to mount the antenna on a metal pole, but in the sample at the receiver end of the system is a coupling unit again made out of a section of plastic pipe, with a short length of RG-58 coaxial cable at one end, terminating in a PL-259 plug, and an SO-239 socket at the other end which connects to the coaxial cable going to the active whip.

Low voltage d.c. power is fed into the side of the coupling unit from a mains power supply, which in the case of the sample unit was of the type having the continental two pin and no earth type of mains connector. I would hope that UK supplies would have the correct 13A UK plug fitted because using the continental type in a typical mains adapter results in the weight of the power supply pulling itself out of the adapter every few minutes, as well as being a potential mains voltage hazard.

A little practical observation is that the d.c. power is carried on quite thin twin flex which is taken directly into the coupling unit without using a connector. In my experience, this thin flex is very prone to breakage at such a point and a break would entail dismantling the coupling unit to effect a repair. The unit itself appears to be firmly sealed, and I would recommend to RF Systems that they change this aspect of the design to avoid calls from irate owners when the d.c. lead breaks - as it surely will. Also buried inside this coupler are low pass filters to remove incoming signals above 500kHz, and I will return to this later in the review.

The Wellbrook LFL1010 looks virtually identical to their existing ALA1530, and consists of a 1m diameter (actual measurement 1.1m) loop element made from 19mm diameter hard aluminium tube, giving strength and rigidity to the whole structure.

The ends of the loop are terminated in a standard plastic conduit box within which is the balanced amplifier system totally potted in waterproof compound. The location of the amplifier relative to the loop makes for a completely balanced electrical layout and a symmetrical radiation pattern. The coaxial feeder is connected into the amplifier box via a professional BNC connector, and as in the LFA-520, d.c. power is 'phantom' fed via the coaxial cable. Mounting the LFL1010 is either by passing two long screws through the holes provided in the amplifier housing, or by using the supplied metal adaptor which converts the flat surface of the housing into a threaded pipe fitting - again an electrical conduit fitting for convenience.

Unlike the LFA-520 which specifies that you **must** mount the antenna on a securely grounded metal mast, even if this is on a chimney stack (how does one achieve this?), the Wellbrook antenna does not require any metalwork or grounding arrangements at the antenna, and in fact for the purposes of my measurements I simply strapped the loop to the top of a wooden fence pole using "Gaffer" tape. At the receiver end of the Wellbrook system is the necessary coupler to allow d.c. to be fed up the coaxial feeder to the antenna amplifier, and this is contained in a rectangular plastic enclosure with one metre of RG-58 coaxial cable terminated in a BNC connector to feed the receiver, and a BNC socket to connect the coaxial cable feeding the antenna.

Power is fed in via a proper concentric connector, and a fuse holder allows proper protection against short circuits on the antenna feeder. Changing a blown fuse in the LFA-520 involves dismantling the mains power supply unit (according to their instruction leaflet). The mains power supply provides regulated 12V d.c., and is one of the 'wall wart' blocks having an integral 13A UK mains connector (and therefore does not fall out of the mains socket). I know that some readers find the BNC connectors a bit fiddly to assemble, but if you use the type having a compression gland to hold the cable, and stay away from the type requiring a crimp tool to terminate, they are almost as easy to use as the ancient PL-259 and infinitely longer lasting, with a low v.s.w.r. performance extending into the GHz spectrum, perhaps not the most demanding requirements at the frequencies we are considering here, but important nonetheless.

This entire preamble is just for information; what you want to know is how they performed when connected to a receiver and used for real listening. Are you ready?

## Measured Performance

I mounted the LFA-520 on a grounded metal mast as recommended by RF Systems, and mounted the Wellbrook loop as described earlier, by simply taping it to the top of a wooden fence post about 1.5m above ground.

Both antennas were located some 20m from the building housing my test equipment. I ran identical lengths of RG-58 coaxial cable from both antennas into my measurement lab so that I could make instant comparisons between the two antennas, and used a Rohde & Schwarz FSA spectrum analyser to provide print-outs, with AR7030 and Racal RA1772 receivers to do the audible tests.

Signal to noise ratio was measured using an HP 8903B analyser and/or an HP 3400A true r.m.s. meter. I mention the test equipment because some of my findings and conclusions may be seen as controversial and I want to establish the measurement validity right from the start.

As always, I placed myself as a substitute for an average listening enthusiast, and concentrated on what, and how well, I could hear and interpret real off-air signals.I began listening and measuring in the band allocated to low power non-directional beacons (NDBs) between 190 and 400kHz, precisely because these are usually weak and difficult to hear, being close to the system noise floor.

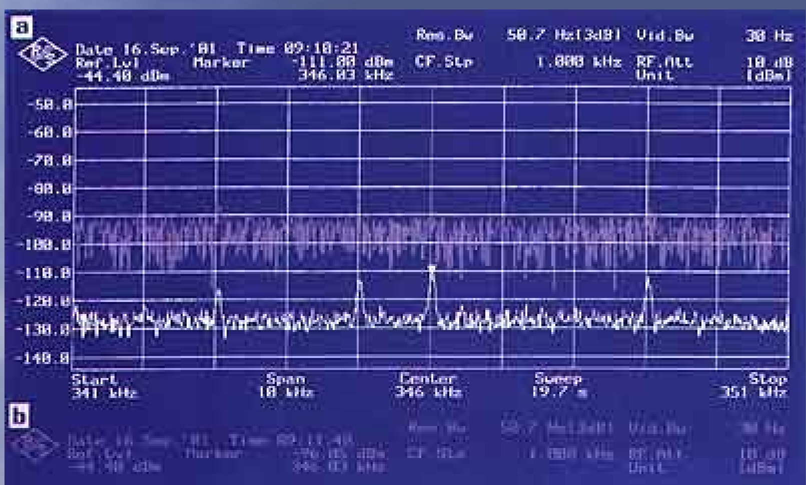


**Fig. 1(a) The Wellbrook shows the spectrum between 341 and 351kHz, with the marker set to call sign LHO at 346kHz at a signal level of -111dBm and a noise floor of about -128dBm.**

**Fig. 1(b) shows the same spectrum from the RF Systems antenna one minute later, with no sign of the beacon and a noise floor of about -95dBm.**

The plot **Fig. 1(a)** of the Wellbrook shows the spectrum between 341 and 351kHz, with the marker set to callsign **LHO** at 346kHz at a signal level of -111dBm and a noise floor of about -128dBm. The plot **Fig. 1(b)** shows the same spectrum from the RF Systems antenna one minute later, with no sign of the beacon and a noise floor of about -95dBm, some 30dB higher than the Wellbrook.

Right away you begin to understand the difference between E-field and H-field antennas in the real world. I repeated the measurements on the other beacons seen by the Wellbrook at 345kHz (callsign **LN**), and 349kHz (callsign **RS**), with the same results, i.e. in the clear and audible on the Wellbrook, inaudible on the RF Systems LFA-520.

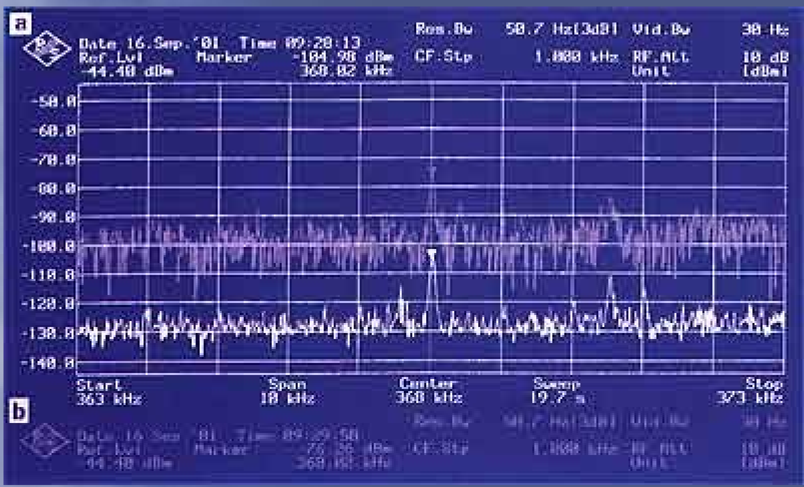


**Fig. 2(a) The Wellbrook LFL1010 and Fig. 2(b) from the RF Systems LFA-520 with a slightly stronger signal from Waterford (WTD) on 368kHz.**

I then went trawling for a slightly stronger signal and found Waterford (callsign **WTD**) on 368kHz as seen in **Fig.2(a)** with the Wellbrook and **Fig.2(b)** from the RF Systems. Once again you can see the noise level from the LFA-520 is some 30dB higher than that from the Wellbrook, but of course you can also see that the signal level of the Waterford Beacon is 28dB higher from the LFA-520. However, if you compare the signal level above noise in both cases, the S/N ratio of the Wellbrook is about 26dB whilst that of the LFA-520 is about 16dB, so the Wellbrook provides a better signal to noise ratio and a quieter background.

I again trawled for a stronger signal and located an RTTY carrier on 129kHz which was idle for several seconds in between giving a single 'gobble gobble', presumably a callsign. This enabled me to take SINAD measurements using the 8903B analyser which came out at 33dB for the signal from the Wellbrook and 12dB for the signal from the LFA-520, even though the LFA-520 signal was some 20dB higher in level. This 20dB difference kept appearing throughout all my tests and suggests that far too much gain has been designed into the LFA-520 in order to make received signals impressively high, and it's true that when first connected to a receiver one gets the impression that the signals are bouncing in. Unfortunately, the extra gain also increases the background noise to the point of pain, and the RF Systems brochure actually states that background noise will be up to S8, and I for one do not want to have a constant S8 background roar in my ears. The Wellbrook loop by comparison has a background noise level around 30dB lower making life much more pleasant, and incidentally enabling you to actually hear signals which are inaudible on the LFA-520. The plots **Fig.3(a)** and **Fig3(b)** show the 129MHz signal measured, and you should note the other signals at 131.8kHz and 133.3kHz clearly visible on the Wellbrook and barely present on the LFA-520.

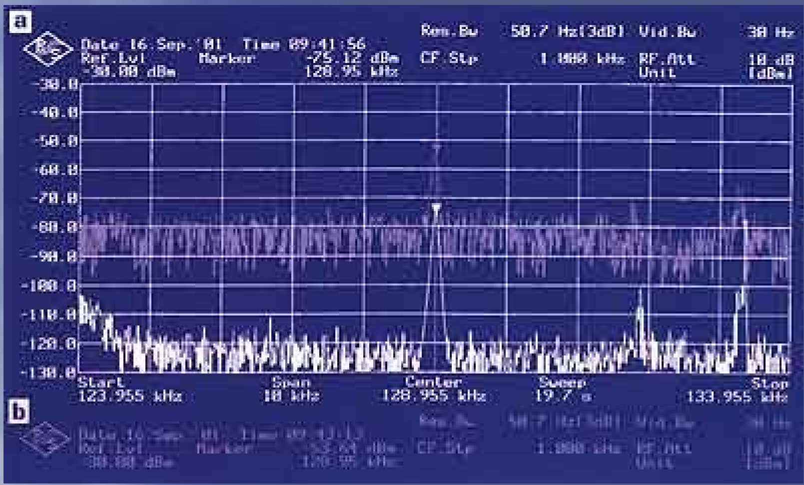


**Fig. 3(a) and show the 129kHz signal measured, note the other signals at 131.8kHz and 133.3kHz clearly visible on the Wellbrook and Fig 3(b) they are barely present on the LFA-520.**

### So Far So Good

You have noticed that the noise shown on the LFA-520 traces is much more 'spiky' than that from the Wellbrook, and this is probably because it results from E-field noise spikes which are simply not received by the Wellbrook H-field antenna. In order to look at performance in more detail I used the averaging facility on the spectrum analyser to 'average-out' the non coherent noise spikes whilst 'averaging-in' the coherent real signals. This gives an advantage to the LFA-520, but I really wanted to find out what the underlying performance was like.

I set up a spectrum sweep from 325 to 375kHz and having obtained clear signals present, listened to each one using both the AR7030 and RA1772 receivers so that I could identify them by their callsigns. The Wellbrook results can be seen in **Fig. 4(a)**, and the RF Systems LFA-520 are those shown in **Fig. 4(b)**. It's once again plain to see that there are loads of identifiable signals from the Wellbrook loop but only a few visible above the noise level from the LFA-520. I listened to and identified the following beacons on the Wellbrook:

326kHz (MVC and RSH), 328kHZ(HAV), 329kHz (JW), 334kHz(GMN), 337kHz(EX), 339kHz(BIA), 343kHz(OC), 345kHz(LN), 346kHz(LHO), 349kHz(RS), 352kHz(SB), 357kHz(LP), 358kHz(LOR), 359.5kHz(CDN), 361kHz(GRB), 362kHz(OB), 368kHz(WTD), 370.5kHz(AB). Listening on the same frequencies on the RF Systems antenna I could only hear and identify 337kHz(EX), 362kHz(OB) and 368kHz(WTD), the rest being obliterated by noise and completely inaudible.

Out of 19 identified beacons from the Wellbrook, I managed only three from the LFA-520. Having pursued the low signal performance of these antennas in the beacon band, I thought it wise to widen the study and look at other parts of the l.f. spectrum, although I had a sinking feeling that results would be equally unflattering for the LFA-520.

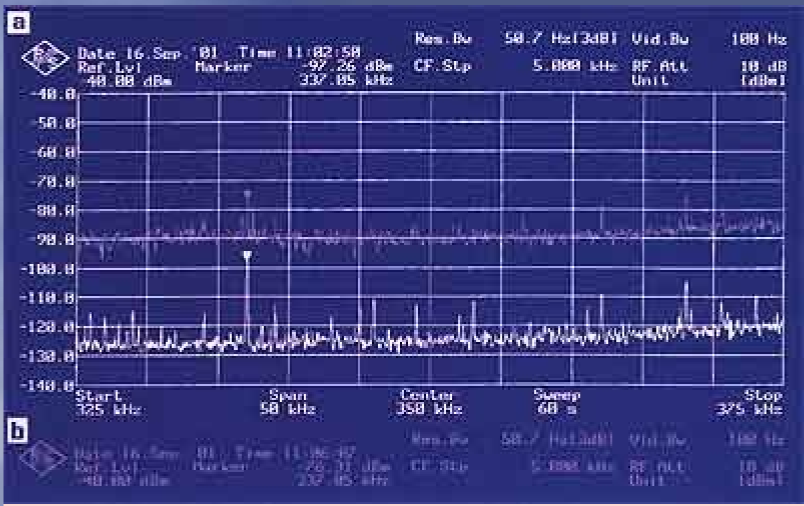


Fig. 4(a) shows the Wellbrook, and Fig. 4(b) the RF Systems LFA-520 with a spectrum sweep from 325 to 375kHz.

There are many identifiable signals from the Wellbrook loop but only a few visible above the noise level from the LFA-520.

**The following beacons were identifiable:**

| kHz | Wellbrook |
|---|---|
| 326 | MVC |
| 326 | RSH |
| 328 | HAV |
| 329 | JW |
| 334 | GMN |
| 337 | EX |
| 339 | BIA |
| 343 | OC |
| 345 | LN |
| 346 | LHO |
| 349 | RS |
| 352 | SB |
| 357 | LP |
| 358 | LOR |
| 359.5 | CDN |
| 361 | GRB |
| 362 | OB |
| 368 | WTD |
| 370.5 | AB |

**- signifies not heard.**

Bear in mind that all the subsequent measurements were made with spectrum analyser averaging on, which suppresses the peak noise and leaves only the average level. In real listening, the peak E-field noise from the LFA-520 would be higher than indicated. Both **Fig. 5(a)** and **Fig. 5(b)** show signals from 10 to 50kHz and you will note that the station on 16kHz is received at a higher level and with a better signal to noise ratio using the LFA-520.

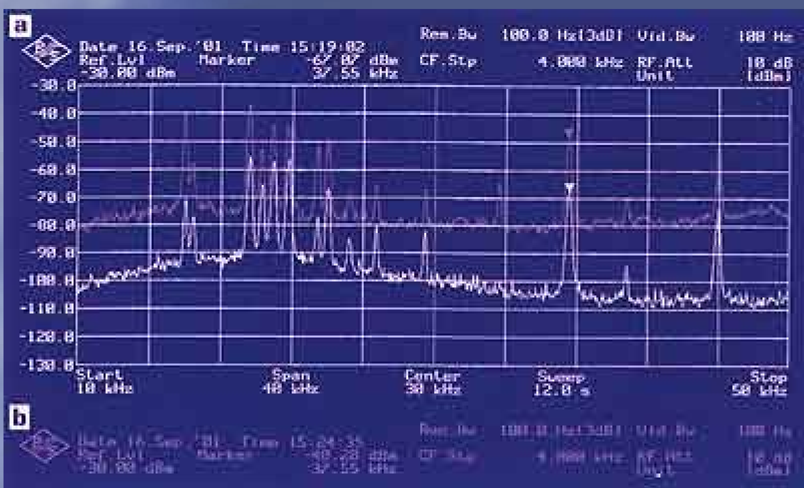


**Fig. 5(a) LFL1010 and Fig. 5(b) LFA-520, show signals from 10 to 50kHz and you will note that the station on 16kHz is received at a higher level and with a better signal to noise ratio using the LFA-520. However, by the**

**time we reach 37kHz, the Wellbrook has overtaken the LFA-520 both in terms of lower noise and higher signal to noise ratio.**

However, by the time we reach 37kHz, the Wellbrook has overtaken the LFA-520 both in terms of lower noise and higher signal to noise ratio, and from then on we have the 30dB lower noise floor from the loop. Note also that the LFA-520 noise level between 10 and 30kHz is the equivalent of S9 (-73dBm) on a normal receiver. Moving into the Long Wave broadcast spectrum, **Fig. 6(a)** and **Fig 6(b)** show signals between 150 and 300kHz.

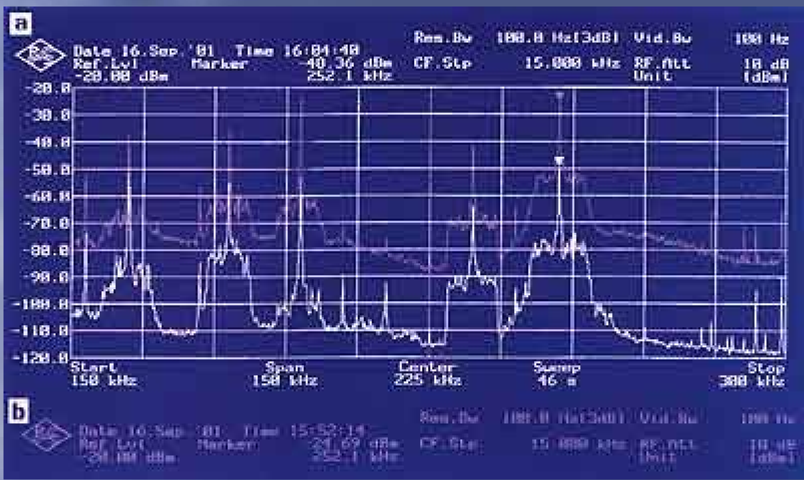


**Fig. 6(a) Wellbrook and Fig. 6(b) RF Systems, show signals between 150 and 300kHz.**

Once again the background noise level is 30dB higher from the LFA-520, and listening to the two stations visible at 207kHz and 216kHz revealed that they were loud and clear from the Wellbrook and virtually inaudible from the LFA-520.

Finally (which may be a relief for you) **Fig. 7(a)** and **Fig. 7(b)** show what happens from 500kHz to 1.5MHz, and it is easy to see the effect of the low pass filtering built in to the LFA-520 coupling unit where the noise output from the antenna dives down to the measuring system noise floor. I measured the filter characteristics and found that it gave essentially minimum loss from 10 to 500kHz, then dropped by 3dB at 520kHz and 35dB at 800kHz, so it performs its stated function very well indeed. However, this means that the LFA-520 is very specifically tailored for use only below 520kHz, whereas the Wellbrook LFL1010 carries on acting as a good H-field antenna up to 10MHz, and you can see the difference by looking at the medium wave signals above 500kHz. What do we make of all this?

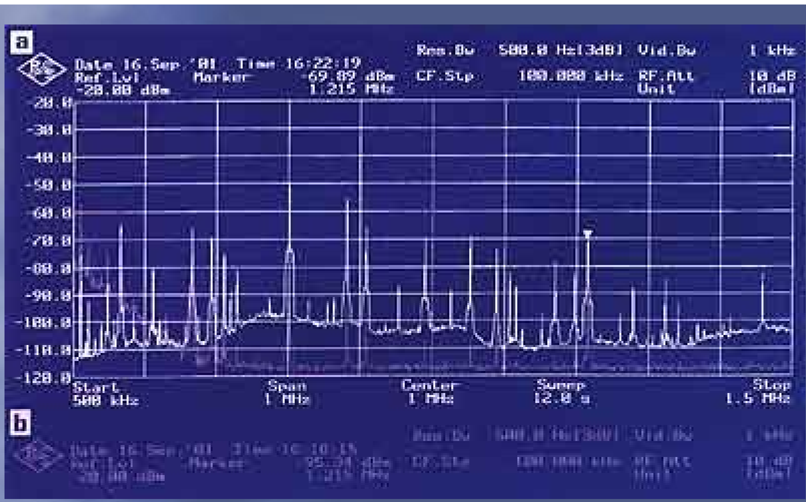


**Fig. 7(a) LFL1010 and Fig. 7(b) LFA-520 show what happens from 500kHz to 1.5MHz.**

## Fair Test?

First of all, have I been fair in my test procedures? I believe I have, in that I compared these two antennas under identical conditions using accurate measuring equipment, and also listening to them as an average enthusiast would. Have I missed something in the basic use of the two antennas?

Again I have to say that I can not see that I have, but I'm always open to properly informed comment. The results of my tests, and I carried out many more spectrum sweeps than I have shown here, confirm my belief that for low frequency listening, the E-field rejection of a good loop antenna will always make it a better antenna, since it is readily acknowledged (even by RF Systems) that most near field interference exists in the E-field. My experiences with a number of active loop and active rod antennas both in the professional and hobby environments have confirmed in every case that the H-field antenna will produce better results, except where the loop area becomes very small relative to the wavelength being received, and this can just be seen in the performance of the Wellbrook loop at 16kHz compared to the active rod antenna from RF Systems. Perhaps I tested the two antennas in a noisy E-field environment? Take a look at the photograph of the installed loop antenna at my home and you would agree that it could hardly be more rural. The far horizon is Exmoor at some 19km distant. This incidentally means that if you install an active rod antenna such as the LFA-520 in a more built-up location, its performance would be even worse than that shown in these tests.

## Conclusions

I can see no good reason why, given the choice, a listener would not choose the Wellbrook LFL1010 every time.

The loop is easier to install, has no grounding requirements, and has a not-mentioned advantage in that it has two extremely deep nulls in its response which can be used to notch out unwanted signals, which is an excellent facility when you are beacon hunting with two or more beacons on the same frequency. Yes, it means that you have to buy a lightweight rotator, but it's still a hugely powerful operating advantage. The loop incidentally performs equally well at ground level. I'm almost embarrassed to go on, but I simply must mention the operating leaflet which came with the RF Systems LFA-520.

There is nothing wrong with a manufacturer saying nice things about his own product, and pointing out features which make it special or different from other, similar products. The leaflet from RF Systems is at best misleading, and at worst disgraceful in that it uses quasi-scientific language to make a case for the superiority of E-field antennas over H-field antennas, i.e. the loop.

*Let me quote:*

"The electromagnetic radio waves, vertically polarised by most long wave transmitters, consist of an electrical field component and a magnetic field component. These have in the far field a fixed ratio of strength with respect to each other. The electrical field component is $120\pi$ (377 times) stronger compared to the magnetic field component at distances of more than one wavelength from the transmitting antenna. The active E-field antenna responds only to the electrical field component of the radio waves, while the magnetic loop (or ferrite rod) antenna responds only to the magnetic field of the radio waves. As the E-field is 377 times stronger, the advantage of an active E-field antenna (like the LFA-520) is that this type of antenna delivers a much higher signal strength compared to a loop or ferrite rod antenna."

Frankly, this is utter nonsense. The $120\pi$ referred to is the accepted value for the impedance of free space ($377\Omega$), and has nothing to do with the relative strength of E and H fields. What matters in an antenna is the power density, and as a rule of thumb a loop antenna having an aperture area of one square metre will produce the same induced power as a rod antenna of one metre in length. All antenna systems rely on both induced voltage and current. However, this is all in the far field which is normally taken to exist at a distance of $\lambda/2\pi$, or approximately one sixth of a wavelength from an antenna.

RF Systems assume the far field to exist at a distance of one wavelength from the antenna, which is being suitably cautious. In the near field, the relationship between E and H fields changes, with the E-field impedance rising to several thousand ohms which increases the E-field signal strength, so any local E-field noise will rise above the H-field component (for which the impedance falls), and severely degrade the signal performance of an E-field antenna. All this has been covered in many professional studies, and confirmed by practical experience over too many years to count.

RF Systems then go on to admit that the E-field antenna is prone to locally generated interference.

*I quote:*

"Not only radio transmitters produce electromagnetic waves, also many household appliances like light dimmers, thermostats, TV sets, fluorescent lighting and computers produce electromagnetic radiation. This is called man-made noise. The E-field from these man-made noise sources at a distance more than one wavelength is sometimes even stronger. This means that an E-field antenna like the LFA-520 must be placed as far as possible from noise and interference sources like TV sets, FL(TL) lighting, computers and so on, to obtain the highest possible signal to noise ratio. In most situations this type of antenna performs at its best if it is placed high, preferably at least 1 metre above the roof of the building. Even better is the placement on a pole or shed in the garden, as far away as possible from houses. Then there is no need to place the antenna high: three metres is mostly sufficient. It is not possible to use the antenna indoors. Locations with a high man-made noise level such as the middle of big cities, with tram and overhead power lines, neon lighting and so on, are in fact not suited for long wave reception. The LFA-520 cannot alter that situation. Besides that, the standing pole on which the LFA-520 is mounted must be grounded. At the other hand: if there is not much local man-made noise, the LFA-520 delivers superior reception with high signal strengths from long distance stations due to the 377 times stronger E-field of e.l.f. and v.l.f. radio stations.

I hope you all read that very carefully, because it reveals several pertinent facts. First of all, RF Systems are admitting that an E-field antenna is sensitive to locally generated noise, and suggest placement at one wavelength from noise sources. At 60kHz one wavelength is five kilometres, or more than three miles. That's a hell of a long feeder run to get away from the noise source.

The statement that cities are "not suited for long wave reception" is almost unbelievable. What is really being stated is that the LFA-520 antenna is not suitable for use within a normally noisy environment. How can they blame the city for being noisy? A loop antenna will perform extremely well in noisy E-field environments without any excuses.

There are many more examples in the leaflet attempting to denigrate the H-field loop whilst excusing the inadequacies of the active E-field rod, such as the following, which actually starts out with a positive view of loops:

"The advantage of the magnetic field antenna is that this type of antenna is less sensitive to the E-field interference generated by electrical household appliances...This rejection works fine for short wave loops but for frequencies below 300kHz there is a problem. For these low frequencies it is nearly impossible to maintain the symmetry of the loop, because all metal objects and buildings within one wavelength (600 metres or more) from the antenna disturb the symmetry of the loop. The result is that the loop or ferrite rod antenna will also partly respond to the E-field. This reduces the immunity for interference."

Let me lead you to the international standards document for antenna calibration, IEE-291 which deals with all aspects of calibration of loop (and other) antennas. On page 21 covering accuracy of receive loop calibration using a standard single turn transmitting loop we read:

"An antenna separation distance d of one to two metres is normally used. Since the induction field strength decreases essentially as the inverse cube of d, the distance to the nearest reflecting object need only be two or three times the antenna separation distance."

In other words, about two to six metres away.

Precision measuring loop antennas are normally calibrated at two metres above ground and are often used in this configuration above a solid metal ground plane in a metal screened room. The RF Systems statement about 600 metre distances is simply not true, and is not supported by the facts. Another quote from IEEE-291 on page 13, talking about measurements of field strength below 30MHz:

"Measurements using electrically shielded loop antennas are usually influenced less by surrounding objects than those using rod antennas."

Which is the exact opposite of the statement from RF Systems. On a simple practical note, why is it that aircraft DF systems use loop antennas mounted close to, or even inside the hull of the aircraft? Surely if loop antennas were disturbed by nearby objects they would be a totally unsuitable antenna for aircraft applications?

**You Choose**

If you think I am being rather savage with my comments, it stems from the fact that I spent more years than most as a leading retailer in this hobby, and one of our company principles was that if a product was less than satisfactory, we would say so, and not try to hide behind techno-babble. There is more rubbish printed by advertisers about antennas than in any other field of listening activity, and I simply will not support false or misleading claims.

I leave you to make up your own mind which antenna to choose if you want to listen below 500kHz. I already have. Caveat Emptor.

---

I wish to thank both RF Systems and Wellbrook Communications for the loan of their respective products for review.

You can buy the LFA-520 from the **RF Systems UK agents Haydon Communications, Unit 1 Thurrock Commercial Park, Purfleet**

**Industrial Estate, London Road, Nr. Aveley, Essex RM15 4YD.**
**Tel: (01708) 862524**.

The LFL1010 is available from **Wellbrook Communications,**
**The Farthings,**
**Beulah,**
**Llanwrtyd Wells,**
**Powys,**
**Wales, LD5 4YD,**
**UK,**
**Phone 01591 620316** or **www.wellbrook.uk.com**

---

John Wilson's article featured in the November 2001 edition of **Short Wave Magazine**, and is reproduced here by kind permission of Short Wave Magazine and PW Publishing Ltd - see their Website for details about how to obtain back issues.