THE VK2AOU and DJ2UT PERIODIC MULTIBAND ANTENNA SYSTEM

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History

THE first multiband beam antenna designs are known to have been tried out as early as 1942. They featured the trap principle and were operated successfully fed by a single line. Unfortunately, a design with traps in the elements will not satisfy the builder in every respect, as some inherent properties are outright contrary to each other: a high Q of the traps yields an undesired small bandwidth. For best results, however, the traps should be physically small, yet still be able to handle a fairly high amount of power. Radiation losses due to the drastically reduced antenna surface of a trap beam are most adversely felt on the 20m. band; here, the elements are shortened to a length of only 7.5m., representing quite a reduction as compared to their full-size lengths of around 10m. Physical size hi proportion to the wavelength, tied in with the effective surface of the antenna, are fundamentally consequential factors for the resulting radiation resistance, the formation of the radiation pattern and, finally, the obtainable gain.

It appeared to be obvious, that only a complete new design using full-size elements would have a chance of success. Here. VK2AOU (ex-DL1EZ) found already 20 years ago the leading conclusions towards a radically new multiband antenna system which rightfully carries his name. Several articles by DL1FK and DL7BB describing it were published at the time in DL-QTC. Rothammel, DM2ABK, has incorporated its complete design in detail into his antenna book.

It has, however, taken many years of experimenting and testing in order to render VK2AOU's ingenious idea entirely foolproof.

Although its operating principles are easily understood, a detailed description is given hereunder in order to do away with some misconceptions circulating about it.

The VK2AOU 3-Band-Element

The so-called "Fuchs" resonant circuit may be known to everyone. Suppose such a tuned parallel -resonance circuit (for example on 28 MHz) is being connected to the "hot" end of a half-wave radiator. Properly fed, it would result in a resonator length of some 5m. This simple antenna can easily be extended to a full wave system by adding a second radiator of 5m., length to the cold end of the coil. A collinear array with a 2 dB gain over a dipole will be obtained by feeding this system in the coil centre; obviously, this antenna of a length of 10m. can be used as a half wave dipole on 14 MHz. The centre resonance circuit tuned to 28 MHz will then be of neglible importance. This 2-band antenna by VK2AOU becomes a 3-band system by adding another parallel. resonant circuit to be placed in the centre of the radiator. The next best band would be 15 metres. An intelligent selection of the L/C ratio of both resonant circuits as well as a perfect approach to the correct element lengths will result in a 3-band element which covers 14, 21 and 28 MHz and is the basis of the VK2A0U W2UT multiband-beam. It is designed as a parasitic element and acts as a director.

In actual practice, the inductances needed consists of so-called "hair pins" made of 10 mm. old aluminium tubing with 7 mm. old aluminium bows, sliding in-and out on trombone fashion.

The "C" component is made of pieces of RG213/U co-ax cable placed inside the element. All the connections are made weather-proof and are effectively scaled. Fig. 1 shows the basic circuit diagram. The voltage distribution on each band shows clearly that the system is energized as a collinear full-wave element on both 10 metres and 15 metres, but as a typical half-wave dipole on 20m.

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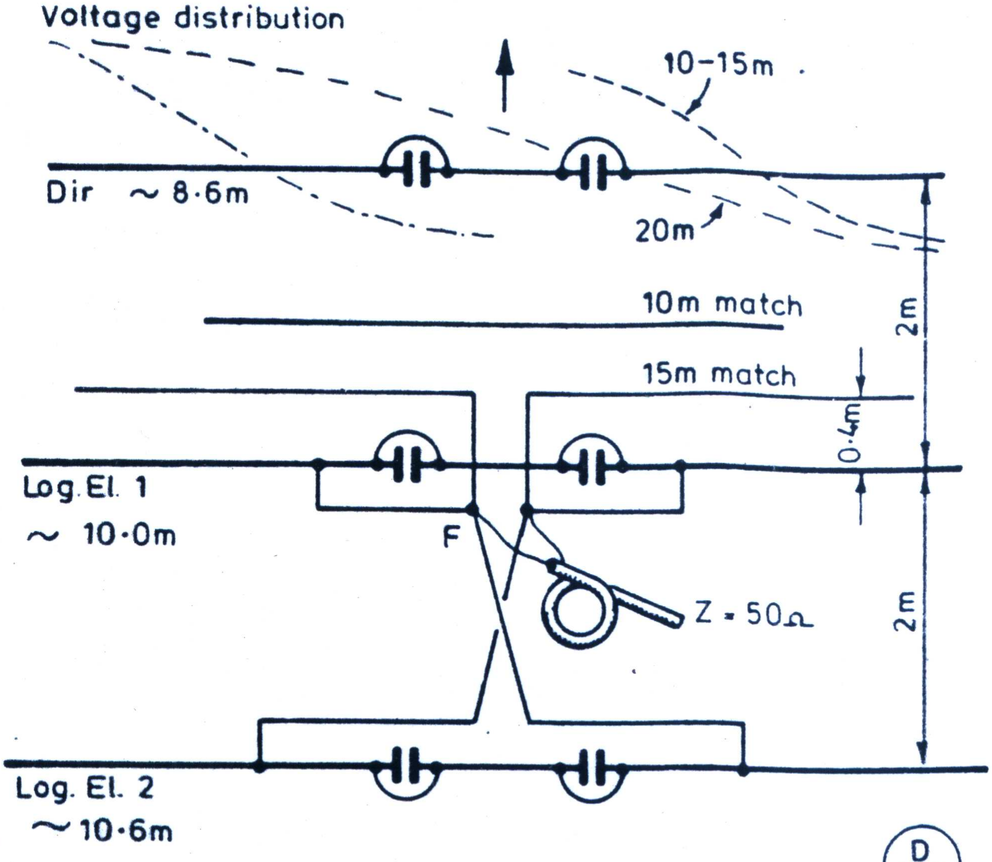
Imagine now three of the 3-band elements be put together to form a complete beam antenna. As a result, a different technical problem will appear on each of the 3 bands considered. As seen from Fig. 1, the Periodic 5 be^ antenna makes use of two more mono-band elements. Their function will be explained hereafter.



10-15-20m director length 8·6m
10m matching element length 4·9m
15m " " length 6·7m
10-15-20m log element 1 (driver/radiator) length 10·0m
10-15-20m " " 2 (reflector) length 10·6m
10-15-20m reflector (only on Periodic 6 CZ antenna) 11·6m

Fig.1 P5 ANTENNA by VK2AOU - DJ2UT

On 20m. the Periodic 5 operates quite similar to a ZL special (HB9CV) antenna, in fact like a log periodic broadband system. The heart of the antenna is a so-called "periodic log cell". consisting of two 3-band elements being fed by a phasing line. The director element being itself a 3-band element, is placed 2 metres in front of the log cell. The multiband phasing lines are hardly 19 active, even when operating on 20 metres.

Element spacing, as well as element lengths, have been designed to favour a best possible forward gain within the bands whilst keeping a most favourable front-to-back ratio. Although log periodic antennas are known to possess exceptionally large band widths, some of the width reaching frequencies out of band was forsaken in order to insure forward gain. An expensive double T-match system permits offering an almost purely resistive load to a 50 ohms coax cable. The log elements 1 and 2 have been cut to the customary mono band antenna lengths of 10m. and 10.6m. respectively.

On 10m. the 3-band elements are energized in collinear fashion. Each voltage "null" lies at about 2.50m. as measured from each element tip. The tie-in points of the double T-match feed fines have been selected

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to present an impedance of between 250 and 400 ohms. At this feed-point, a unique 50 ohms matching impedance equally suitable for all bands cannot be obtained without applying a fairly simple trick. It permits getting the Z down to an acceptable 50 Ohms without altering any 15m. or 20m. settings. An additional parasitic element, being cut to the correct length and adjusted to the right spacing, acting as a director only on 10m. leads to a perfect 50 ohms match. It is self understood that the introduction of a parasitic element increases both antenna surface and gain.

Operating on 10m, the phasing line has a length of 0.2A, which yields slightly more pronounced horizontal and vertical apertures of the radiation pattern. By means of scaled down antennas, increased apertures can be reproduced easily. Unfortunately, this type of measuring procedure has no really significant meaning as far as the antenna gain for DX communications is concerned. Be it as it may, the Periodic 5 antenna has a gain on the 10m. band, which corresponds to the gain of a 3-element full-size beam. The low-loss multiband phasing lines allow operation of the antenna also on 10m. using input powers which may without fear be "Californian Kilowatts."

For perfect operation on 15 metres, still another parasitic element comes into play. It is placed 0.4m. in front of the log element 1 and is actively fed, just like the latter. The log element 1 as well as the 15m. matching element present either predominant C or L properties on their respective resonance frequencies. As a net result, the antenna offers a purely resistive load of about 50 Ohms within the amateur band. Placing the 15m. matching element in front of the log element 1 and 2 had another important reason. The phasing section between log element 1 and 2 has not got the required length on 15m. by virtue of the elapsed time taken by the HF-energy to travel to the matching element sitting at 0.40m. distance, the effective electrical length of this phasing section is shortened to 1.6m. which equals a desirable phase-shift of 0.1 lambda. thus creating again an ideal matching condition.

At the outset it was feared, that the parasitic as well as the forced coupling of elements would give rise to undesired side lobes. However, this was not the case; the performance of the Periodic 5 antenna equals a full-size 3-element beam. There are no input power restrictions on 15m. either. The antenna is fed by 50 ohms co-ax cable at feed point F, through a decoupling coil which is absolutely indispensable for a correct functioning of the array. Omission of the choke coil renders the beam almost useless. It must be realised that the element centres on 15m. and 10m. carry voltage loops and are thus high-impedance points.

The designer must insure that the feed point - at which there is also a voltage loop - stays well decoupled from the feeder line itself. Otherwise the outer braid of the co-ax cable, located close to the metal antenna support would badly detune the antenna. The feed line would become a parasitic element, and uncontrollable standing wave problems would appear.

For the above reasons it is understood, that probes for impedance - or SWR - measurements cannot be connected directly to feed-point F but only via the indispensable decoupling coil which is in fact an integral part of the antenna It permits decoupling the feed-point from the co-ax feeder line and must be manufactured of exactly the same type of co-ax cable as the feeder itself; normally, co-ax cables of the types RG8/U or RG213/U are used. The decoupling choke has 6 turns and a diameter of 0.2m. which equals a cable length of some 3.5m, representing 1/4 on 15m.; the 6 turns are wound close-spaced. The choke coil is then connected to the feed-point F.

Many amateurs possess some lengths of 60 or 75 ohm co-ax and would like to feed their Periodic 5 antenna with it. Experience, however, has shown that the SWR rises out of proportion using

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that type of co-ax and can only be controlled by altering the spacing of the beam element as well as the phasing section.

A 1:1 balun could replace the decoupling coil. However, none of the known baluns are either sufficiently broad banded or flat enough as a coupling device to stand up to the not exactly prudish power levels sometimes use by some individuals. Finally, no other decoupling device is as practical and cheap as the choke coil made of a few turns of co-ax cable.

Mechanical Considerations

In comparison with trap-beams where the longest elements measure only about 7.5m., the Periodic 5 antenna, with its full-size elements throughout, requires another approach as to tapering-off of the aluminium tubing. By a sensible choice of outer diameters and thicknesses as well as top quality alloys, it can be ensured that the entire array would not only 'give' in a heavy storm, but that the elements would 'flex in response to sudden gusts. A very heavy line squall in northern Rhenania in 1972 proved these considerations to be important. An 18m. high heavy steel tower at DJ2NN was twisted by 55 degrees in azimuth despite its guy wires; the Periodic 5 antenna elements took momentarily the form of half moons, element tips moved at times ± 3m. horizontally. When everything was over, it was found that the beam had not suffered in any way at all. In contrast to that, a 20-element. 144 MHz Cush-Craft array with a very much smaller wind surface area was entirely destroyed.

The Periodic 5 aluminium tubing is tapered off as follows: 30 mm. o /d by 26 mm. i /d, 25 mm. o /d by 2 1 mm. i /d , 20 mm. o /d by 17 mm. i/d, 15 mm. o/d by 13 mm. i/d, 12 mm. o/d by 10 mm. i/d. The boom consists of two parallel 25 mm. o/d by 2 1 mm. i/d tubing possessing the inherent elasticity to give way should a twisting motion be induced. No superfluous masses should be installed on top of a tower. The Periodic 5 antenna fulfils this requirement and represents statically and dynamically the option obtainable in this respect. Darnage due to high winds or even nasty line squalls are the exception indeed. A boom to mast plate of heavy aluminium angle stock accepts masts up to 50 mm. o/d.

Problems and Limiting Areas

Every system has its physical limits, and the Periodic 5 antenna is no exception. We need not underline the need for an installation location free of parasitic wires or high-tension lines. Yet, there are always a few thoughtless radio amateurs who would install their DX-antenna a few metres above a steel-rein forced roof; still others would install a 40m. dipole horizontally just 1 m. under or 3m. over the beam. We have seen a W3DZZ-antenna installed in the immediate vicinity of the beam. Well, everything is possible, but the beam would loose its properties and its owner become disappointed!

A thumb rule in TV-antenna construction tells of a one to two wavelength minimum distance required between two antennas. Transforming this rule into HF-antenna considerations, a distance of only 3m. to the skin of a metal roof or to an open wire line would just be a nonsense. Nobody would attempt to mount a 2m. Yagi antenna just 0.30m. above a sheet metal roof.

The Periodic 5 antenna is highly adaptable to varying locations, though every beam must be pre-tuned at manufacture. However, a fine tuning can be performed at the operating location itself. For instance on 10m. within the relatively large amateur band from 28.0 to 29.7 MHz, the gain of the antenna is not distributed in an equal fashion. An adjustment is possible, permitting

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an increase of antenna gain commensurate with an increasing frequency up to a point around 29.6 MHz where the gain drops rapidly. On the other hand, its gain may be optimized on 28.5 MHz with a marked decrease around 29.0 MHz. Intermediate settings are possible. This is not inherent in the Periodic 5 antenna. Quite contrary, however, most mono band-and trap-Yagis exhibit smaller bandwidths. They permit only CW- or Phone-settings. The Periodic 5 covers a full megahertz within which its SWR stays well within 1:2 or better. Still better SWR-curves are maintained on the much smaller 15m. and 20m. bands.

Even at rather confined operating locations, the Periodic 5 antenna can be optimized easily within each of the bands. Granted, to optimize doesn't mean to arrange for best conditions surrounding the beam. It is a fact that especially low-loss beams with their increased absorption surface are very sensitive to a disadvantageous operating location. It appears that compromise antennas react much less violently to poor surroundings than a high-class low-loss beam. Be it as it may, an excellent 50 ohms dummy-load doesn't react either to poor surroundings and nobody would ever consider it to be a good antenna.

Taken from
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