Technical Topics

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CLOUD-WARMING NVIS ANTENNAS

TRADITIONALLY, AMATEURS have, in theory, regarded the HF spectrum as a medium in which to strive to make long-distance contacts, seeking to erect antennas with their major radiation lobes at low vertical angles. Yet, in practice, much of our operation, at least on the 1.8, 3.5 and 7MHz bands, has been in the form of 'nets' or regular 'skeds' with friends located within our own or neighbouring countries, anywhere between a few miles and a few hundred miles distant. It is precisely this range that is subject to the variable silent or skip zone that may change markedly with the diurnal, seasonal and sunspot cycles. There is an increasing awareness that, for national rather than international working, far more reliable contacts can be made by exploiting NVIS (near-vertical incidence skywave propagation) by the use of antennas designed to radiate strongly in the vertical direction.

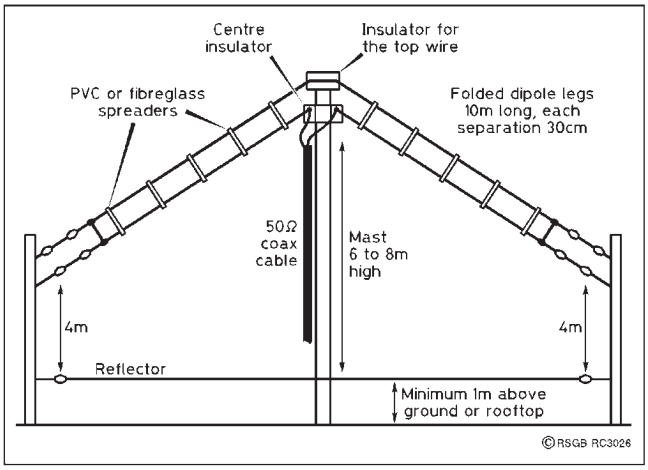

Fig 1: CO2KK's folded dipole plus reflector NVIS 'cloud warmer' antenna for 7MHz. If fed with open-wire line, it is usable also on 10MHz. Scale for 3.5MHz.

This shift in priorities is reflected in HF tactical communications by the military and for rescue, emergency and disaster-relief operations. An early application of NVIS was for tropical HF broadcasting and an excellent *RSGB Bulletin* article 'Skybeams, Moonbeams and Howitzers', by the late Paul Sollom, G3BGL/VS7PS, Part 1, July 1952 and Part 2, August 1952, described pioneering work in Ceylon (Sri Lanka). To quote an editorial introduction: "Popular misconceptions concerning the use of very high-angle radiation, and the inevitability of skip zones for short-wave communication, are exposed by the author in this description of his investigations into unconventional aerial and propagation techniques, carried out in Ceylon with the aid of local amateurs. Although erection of the aerial systems described may be beyond the scope of most readers, the article indicates how professional organisations sharing our low-frequency bands could increase efficiency and minimise interference, resulting in much mutual benefit."

G3BGL described the use of vertically-radiating multi-element arrays. Experimental antennas at VS7PS were designed for the 7MHz band, but the techniques developed were adapted for tropical broadcast services in the 90m, 60m, 49m, 41m and 31m bands.

'TT' has reported a number of times, most recently February 2001, on current military and professional interest in NVIS, for example by replacing the short vertical whips by various forms of loop and inclined whip antennas, 'TT' has also shown that a very low dipole antenna (a few feet above ground) radiates strongly in the vertical direction. Poor for DX but excellent for NVIS!

A recent article by Arnie Coro, CO2KK, 'Build a "Cloud Warmer" NVIS Antenna System' (*CQ*, May 2001, pp90-91) reports on the effective use by CO4BM of a 7MHz dipole "really close to the ground" during hurricane emergency operation, outperforming conventional dipoles at typical heights of 10 to 15 metres.

CO2KK also describes the system that he has used for some three years, designed explicitly for NVIS, comprising an inverted-V folded dipole plus closely-spaced reflector element: **Fig 1**. He reports that this antenna delivers a very strong signal during local daylight hours in the range from about 30 to 300km (20 to 200 miles) "while its behaviour during the ionospheric transitions that occur around sunrise and sunset make it particularly useful to keep communications running during emergencies". Note that, with a high power transmitter, there will be high RF voltages at the ends of the 'reflector' and care should be taken that this does not present a hazard to human beings or animals.

A novel if rather more complex antenna design for NVIS HF communications has been presented by Duncan Telfer, G0SIB, and Brian Austin, G0GSF - both of Liverpool University - at the 2nd International Conference on Advanced Engineering Design at Glasgow (June 2001). An experimental model has been built by G0SIB for the 7MHz band, and computer studies using NEC2 include use for mobile applications and for VHF/UHF. Two patent applications are pending.

The Abstract of the paper (pages 357 to 362 of the Conference Proceedings) reads: "NVIS propagation for HF radio communication is gaining interest as an effective alternative mode for rescue, emergency services, disaster relief and tactical military operation in situations where the ground-wave path fails. By using the right frequencies and near-vertically directed antennas, NVIS can virtually eliminate the skip dead-zone, as use is made of those parts of the ionosphere at higher elevations. Favoured antennas have included near-ground and buried horizontal dipoles and inclined whips, the latter for mobile operations. In this paper, a novel type of alternative antenna is discussed, for which theoretical calculations (NEC2) predict near-spherical vertically-directed far-field patterns. Comparisons with practical tests demonstrate that the design concept, which embraces an antenna 'family', is particularly well suited to NVIS. Design constraints for vehicular operation are also discussed, as are variations of the design for linear and circular polarisation, and instantiations for use on other frequencies (VHF/UHF)."

Basically, the approach used in this new family of designs is based on configurations featuring inwardly-tilted (non-touching) vertical, folded (tapered), monopoles, one fed at the base, the other(s) parasitically excited: **Fig 2**. To quote the Conference paper: "Theoretical predictions using the EZNEC implementation of the NEC2 'method of moments' calculations suggest that antenna 'families' of this kind can be constructed with near-spherical far-field patterns. On-

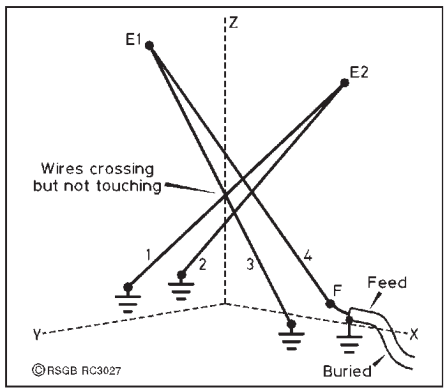

Fig 2: Basic form of the novel NVIS antenna as developed (patent applied for) by G0SIB for 7MHz, comprising inclined dual-folded (tapered) monopoles, one fed between point F and earth, the other parasitically excited. Note that the wires cross without touching. Described in association with G0GSF at the 2nd International Conference on Advanced Engineering Design (Glasgow, June 2001). It provides the desirable near-spherical far-field pattern with maximum gain at 90-deg elevation.

axis (Z) gains of around 8dBi can be realised with half-power beamwidths of between 55 and 90°: **Fig 3**. With the arrangement shown, the phases of the antenna currents in the quarter-wavelength monopole elements lead to field cancellation in the XY plane and reinforcement in the Z direction. Conveniently, the SWR can be readily adjusted for direct unbalanced feed with standard 50Ω coaxial cable between point F and earth. Wider frequency range using the same antenna can be achieved by maintaining antiphase (180°) feed between point F and earth and between point 1 and earth. Instantiations of the scheme for practical tests use supported wires for HF, and reduced-scale VHF/UHF versions with an artificial groundplane."

A completed 7MHz wire-antenna at the home of G0SIB is suspended from a polypropylene cord that runs between a house chimney and a vertical tilt-over mast. Although conducting, the mast is sufficiently shorter than a quarter wavelength not to affect adversely the NVIS properties of the far-field pattern. Practical tests were carried out in the 7MHz amateur band between G0SIB and G0GSF (20km apart); between G0SIB and M1DZH (30km); and through several other 'inter-G' contacts. Rigorous testing would require, for example, RF field monitoring using a transmitter supported by a tethered balloon and will be the subject of future work. Meanwhile, other tests carried out on VHF and UHF versions of the design have demonstrated good agreement with the NEC2 predictions. NEC2 predictions suggest that HF NVIS operation would be practicable, with this design, from Land Rover-type vehicles using loading coils, although this would significantly limit the operational bandwidth. Another proposed application is for ionosonde or riometer antennas using a symmetrical multi-element inclined monopole design.

G0SIB and G0GSF summarise their work and conclusions as follows: "In NVIS, ionospheric reflection near the critical frequency (f_{0_E} or f_{0_F}) overcomes difficulties posed by ground-wave attenuation or obstruction by intervening terrain and is a technique of particular interest when suitable satellite-relay facilities are unavailable. Successful exploitation of NVIS for disaster relief and emergency services requires reliance on, and access to, reliable data sources for critical frequency values peculiar to the times and locations of the communication paths. A novel antenna design based on inwardly-inclined quarter-wave monopoles provides the necessary vertically-directed far-field pattern over a useful frequency range, subject to maintaining antiphase feed in each element. Viable support structure options – a catenary insulator rope, or radial insulating ropes from a central mast – allow flexibility of choice and ease of assembly. The design of a variant for circular polarisation yields a particularly symmetrical far-field pattern, and is proposed for ionosonde and riometer applications."

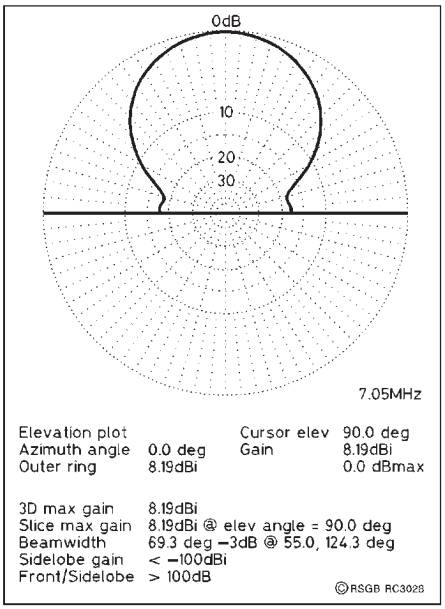

Fig 3: Sectional far-field EZNEC plot for the inclined dual-folded monopoles above perfect ground.

Duncan Telfer, G0SIB, adds some additional information: "The XYL is still quite happy (well, tolerant) to have the linearly-polarised 7MHz version adorning the back garden, and we have configured the garden design, including a pebble bed for potted plants, around the antenna. This also prevents people from tripping over the feed point, which is about 6in above ground and connected to buried unbalanced 50Ω coaxial cable. The 'ground stakes' at the earth ends of the wires are actually buried steel girders with protruding hooks for zinc-plated turnbuckles (courtesy of B&Q DIY stores) which tension the wires. With an MFJ Versa Tuner, it fires up nicely on the 3.5, 14, 21 and 28MHz bands, but with far-field radiation patterns different from that on its design frequency of 7MHz. A more detailed constructional article is planned."

I cannot help feeling that the cause of NVIS for emergency and relief operations (or for UK inter-G working by amateurs) would be strengthened if a small frequency allocation around 5MHz could be negotiated at a future ITU World Radiocommunication Conference. As we descend again towards the sunspot minimum, daytime critical frequencies can be expected increasingly to be significantly below 7MHz for much of the time. It is perhaps too much to hope for a similar additional allocation somewhere in the region of 2.75MHz!

AGC FOR D-C RECEIVERS

ERIC CHRISTER, Z21FO, provides information on a simple AGC system that he has found quite effective when used on a direct-conversion receiver. He writes: "In the arrangement shown in **Fig 4**, the purpose of the diodes in the input to the circuit is to prevent low-volume audio causing the AGC to operate. The components, values etc are not critical, but some experimentation would be helpful in matching to the characteristics of the particular receiver. As a start, simply feed a DC voltage to the PIN diode (or any diode) via the 470Ω resistor and determine the attenuation of the signal that can be obtained before deciding to build the complete circuit. Wiring of the components at the antenna input should be kept as short as possible to create a low impedance path. Change the value of 220µF electrolytic capacitor in order to slow down or speed up the AGC decay time. The brightness of the LED gives some indication of the signal strength."

POTENTIOMETER TUNES WIEN BRIDGE AF OSCILLATOR

A NOVEL FORM of Wien Bridge oscillator (**Fig 5**) that is tuned by a single-track potentiometer from about 500 to 6000Hz was described in *Electronics World* (De-

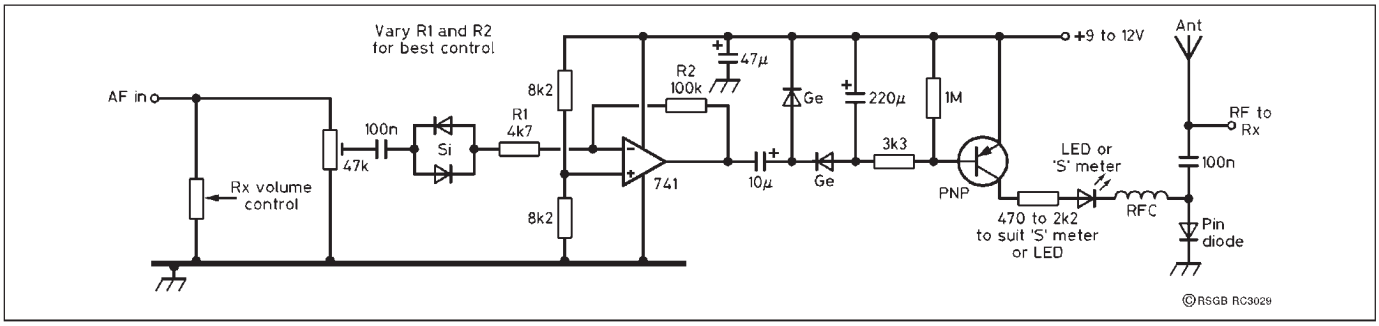

Fig 4: Z21FO's simple AGC system for direct conversion receivers.