Antennas

Is this the ultimate indoor antenna?

PHOTO 1: The large barn that houses W1GN's HF beam antenna.

THE ULTIMATE INDOOR ANTENNA. I often join the midday Mid Sussex Amateur Radio Club net on 21MHz. The net is run by Ken, G3WYN and many of the club members join in. I am some distance away down on the coast but I can just make it on ground wave.

David, W1GN (ex G3HWU) located in New Hampshire has, when conditions are favourable, been joining the net for some years now and is considered an honorary member. He puts in quite a good signal and, as it turned out, has a very interesting antenna arrangement. It seemed to me the ultimate indoor antenna.

W1GN uses a full size three-element single band Hy-Gain LJ-153BA Yagi, located in a barn. This is no ordinary barn, being some 75ft long (22.8m) and 45ft (13.7m) wide, as shown in **Photo 1**. The roof ridge is at 48ft (14.6m) above the concrete base. The covering consists of strips of galvanized metal with assumed poor electrical bonding. All walls, flooring, roof trusses and sheathing are made of wood.

The horizontal plane of the Yagi is 27ft (8.2m) above the concrete basement and is suspended by ropes at the barn's north end, across the 45ft width, with the director 2ft (0.6m) away from the wall as shown in **Photo 2**. The boom is about 21ft (6.4m) beneath the apex of the roof. The suspension ropes are attached to a short wooden boom, which is mounted on the metal boom, one at each end. There is no contact between the ropes and antenna elements.

However, the adjacent soil grade level with respect to the concrete base varies from 2ft (0.6m) to 6ft (1.8m). This reflects the natural, gently west to east sloping topography of this property. New Hampshire sits on granite and is known as the Granite State for good reason. Elevation is approximately 800ft ASL.

W1GN puts a good signal into Europe with this arrangement, which is quite surprising. My experiences of some roof antennas in some QTHs I have operated from are very varied. The slate roof of one QTH acted as a complete screen to RF – perhaps there was a lead content in the slate.

I wondered about the effect of a metal roof so I made a computer model, as shown in **Figure 1**. This model is very much simplified. The enclosure has for example a flat roof. I found constructing a sloping roof with an apex a bit beyond me! Even so, this simplified roof comprised a mesh of 170 wires with 700 segments. This method of modelling a sheet of metal is now well known and practised. In this model, the roof is 42ft (12.8m) high with the beam antenna 25ft (7.6m) high, about 17ft (5.2m) below the roof.

The result can be seen in the elevation diagram shown in **Figure 2**, which shows only a small 1dB loss in gain caused by the roof, provided the wall is transparent to RF, and the suppression of a high angle lobe. The probable reason the metal roof does not affect the elevation polar diagram that much is that this field strength pattern is formed by interaction with the earth at an area well clear of the building.

SKELETON SLOT ANTENNA. John Farrer, G3XHZ, e-mailed me about a HF skeleton slot he was considering building as per G3VCG 's website **[1]**. I checked out this website and found the antenna G3VCG had constructed based on a computer model was the same as one I described in *The ARRL Antenna Compendium, Vol. 6*. As my antenna was also based on a computer model, it is not surprising that the dimensions were the same.

The skeleton slot is very easy to construct and is a simple design with no traps or critical adjustments. This antenna has a turning radius of only 1.5m (5ft) although it is 14m (47ft) tall. However, its construction means that it has a much lower visual impact than a conventional multi-band beam. The antenna is bi-directional and has a calculated gain, over average ground, of 8dBi on 14MHz and 11dBi on 28MHz.

As far as I am aware, the skeleton slot antenna was proposed by Bill Sykes, G2HCG. This element was originally designed to be resonant on one frequency and formed the driven element for two stacked 144MHz 5-element beams **[2]**. An HF non-resonant version was built and documented by Bill Capstick, G3JYP **[3]**. His antenna was also the same size, achieved without the benefit of computer modelling.

My version of the HF skeleton slot uses wire for the vertical elements, resulting in a more simplified and rugged construction. I was at first concerned that this method of construction would not work because [3] gave minimum tube diameters for the elements. However, computer modelling with *EZNEC2* reassured me that this method of construction would be suitable for this particular application so I went ahead.

The antenna essentially comprises three aluminium tube elements fixed to the mast at 4.6m (15ft) intervals, with the lowest element only 4.6m from the ground. The mast is an integral part of the antenna, as a boom is to a Yagi. The general construction is shown in **Figure 3**.

The centre element is fed in the centre with balanced feeder and the upper and lower elements are fed at the ends by copper wire

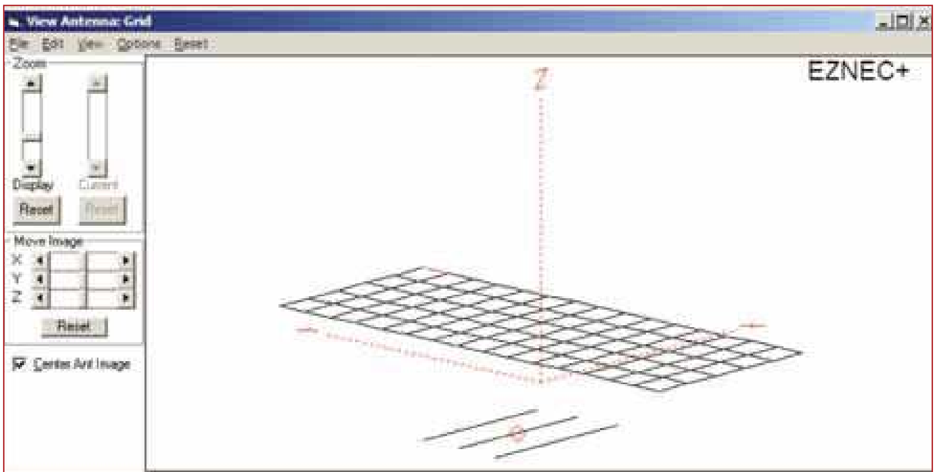

FIGURE 1: Computer model of 21MHz three-element beam located under a sheet metal roof.

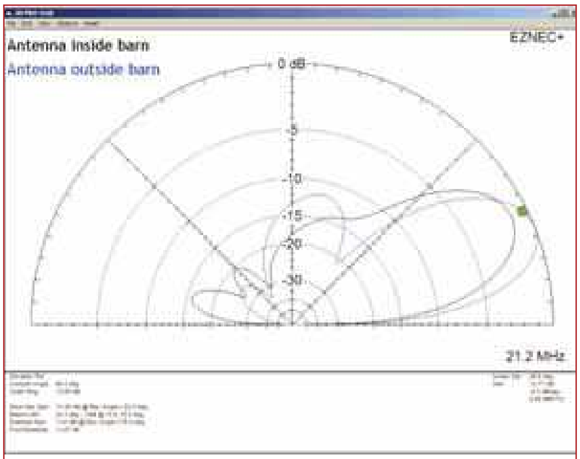

FIGURE 2: Comparison elevation diagram of a normally mounted three-element beam compared with one located in a building with a metal roof.

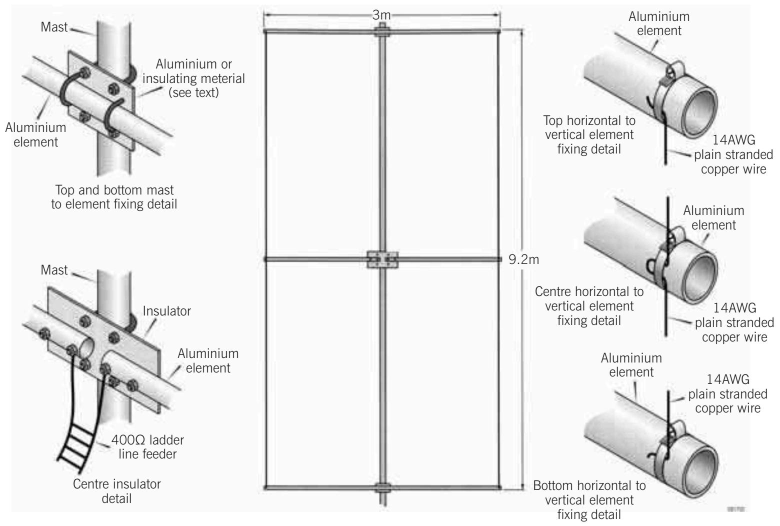

FIGURE 3: The G3LDO multiband skeleton slot antenna for 14 to 28MHz. The elements are fixed to the mast and the whole mast is rotated.

from the driven dipole. The aluminium tubing and copper wire are fixed using hose clips. These dissimilar metal connections should not present corrosion problems provided they are well coated with grease to keep moisture out.

The centres of the upper and lower elements can be fixed directly to a metal mast using an aluminium plate and U-bolts as shown in Figure 3. The dimension of this antenna regarding aluminium tube/wire diameters and length are not critical.

The antenna requires a balanced feed such as 450Ω slotted line, although the feeder impedance is not critical. The feeder should be fixed on standoff insulators about 6in (150mm) from the mast until clear of the lower element to prevent it blowing about in the wind and affecting the impedance. An ATU with a balanced output is required when using this arrangement. I tried various ATUs located at the bottom of the mast because it was inconvenient to bring a balanced feeder all the way from the antenna to the shack. Another way of feeding the antenna is to use a good quality coax from the ATU to the antenna feedpoint with a current choke (balun) at the feedpoint. The feeder from the ATU to the antenna feedpoint should be as short as practicable to reduce the SWR losses.

The dimensions shown in Figure 3 seem near optimum for the five higher HF frequency bands, see the elevation diagrams in **Figure 4**. While the DX performance of this antenna is good up to 30MHz it deteriorates at frequencies higher than this. The azimuth diagram is very similar to a dipole, with deep side nulls that can be used to minimise QRM from some locations.

When this antenna was first used in 1995, the sunspots were reasonably high and the conditions on the upper HF bands were good. On the 21, 24 and 28MHz bands the antenna performed very well, particularly when conditions were marginal. On 21MHz, DX stations consistently gave 2 S-points better than received when using a linear. Early morning contacts with the Pacific had noticeable echoes, possibly due to the bi-directional nature of the antenna.

G3XHZ asked if the dimensions of this antenna could be increased so that it would give a reasonable performance on 7MHz even at the expense of the higher frequencies. The existing dimensions will allow this antenna to work on 7 and 10MHz but the performance is not too good. I consulted *EZNEC* again and found that increasing the dimensions by a factor of 1.5 resulted in reasonable performance on 7MHz and that the upper cut off frequency occurred just above 21MHz.

The only downside to this antenna is that it really has to be mounted on a rotatable self-supporting mast. However, some guying can be accommodated because the antenna can obtain full coverage with a rotation limit of 90°.

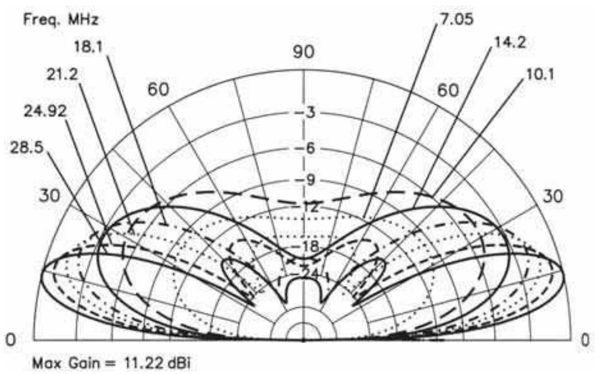

FIGURE 4: Elevation diagrams for the HF skeleton slot using the dimensions shown in Figure 3.

NEIGHBOUR WARS. Those of us who live in suburban houses with a garden often don't realise the difficulties some radio amateurs have with difficult QTH-related antenna problems.

One such gentleman wrote to me recently. He is a keen HF operator who lives on the third floor of a multi-storey block. There is no balcony. He has been experimenting with various antennas and one of these was a top fed quarter wave vertical. It consisted simply of a quarter wavelength of wire hanging from the window, fed against radials (presumably routed around the floor of the apartment). This arrangement worked reasonably well until he moved to a lower frequency band, necessitating a longer piece of wire.

PHOTO 2: W1GN's full sized three-element single band Hygain LJ-153BA indoor Yagi.

The end of the wire now ended against a neighbour's window on a lower floor. This neighbour reacted by grabbing the wire and giving it a good tug, which resulted in some of the amateur's radio equipment being pulled off the operating table and on to the floor.

He is now considering a more compact loaded antenna system.

REFERENCES
[1] www.drwilks.freeuk.com/
[2] *Skeleton Slot Aerials*, B. Sykes, RSGB Bulletin (forerunner of *RadCom*), January 1953
[3] *The HF Skeleton Slot Antenna*, Bill Capstick, G3JYP, *RadCom* June 1996.
[4] *The ARRL Antenna Compendium, Vol. 6*