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G4HRS

# H A R C N E W S



**The Journal of  
Horsham Amateur Radio Club  
*August 2015***

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***Cover picture: Four Square Antenna***

## Editorial

Readers have responded well to requests for articles to arrive early. Well done and thank you! I have now tested my doublet on 160 and 60m and can confirm that it works on there too. Regarding the noise floor on 80m it does seem to actually have got a bit better recently and to be perfectly honest I don't think Ofcom would be able to help. The best solution is to have an SDR receiver such as Hack Green to hand!



To sum up on this type of antenna arrangement it comes highly recommended if you have the space! I have noticed for some time QRN across 87.5 – 108 MHz, basically the whole of Band II FM! It sounds something like a computer type noise and considering I use a roof mounted 5 element beam was surprised that I have this trouble. It affects some stations but not all and I think it includes some of the strong national services.

Now I do have a hand held transceiver that covers a wide range of VHF and UHF frequencies so will see what I can find with that. I can hear strange carriers sometimes across 2 metres but don't know if it's the same interference. This month you will find part 2 of the notes from the April meeting on Concorde after this segment and last month's notes on the quad antenna towards the end.

David G4JHI

### **Copy deadline for September edition 20th August**

For items sent by email please send to this address:

[harc.news@g4jhi.co.uk](mailto:harc.news@g4jhi.co.uk)

### **WANTED PLEASE!**

Articles along with photographs!

Articles along with photographs!

Articles along with photographs!

## Addendum

In HARCNEWS July 2015 edition at the bottom of page 2 the following was missing:  
*Cover picture: May Fox Hunt winners, left to right, Xanthe, Ian (MOIAD) and Andrea*

# April Meeting

## Concorde the Paris accident and subsequent Return to Service (part2)

In the first part of this article I described our April meeting when Jock Reid MBE a retired Senior Test Pilot with the CAA explained the events which led to the Air France Concorde crash in April 2000. Following a short break for coffee, Jock then concluded his lecture by explaining the process involved in returning the aircraft to flight.

The crash investigation and subsequent findings of the report led to a number of changes being implemented. Jock proceeded to explain each of these in detail.

1. The Brake fans must be switched off before take-off and landings. The circuit was inhibited on take-off and landing to prevent the risk of high voltage sparks from the electrical system.
2. A Tyre Deflection Detector System was made mandatory. This was a metal bar positioned in front of the wheels designed to deflect water and Foreign Objects away from the tyre.
3. The water defector was modified to remove the retaining cable on UK planes.
4. Modifications were made to the Fuel tanks. Tanks No.5 and 8 were lined with Kevlar and Tanks No.1 and 4 were fitted with internal partitions. Jock had a short film showing an engineer inside one of the tanks fitting the Kevlar sheets in very cramped conditions. This modification increased the overall aircraft weight and so had to be taken into consideration when calculating the load capacity.
5. The Landing gear wiring harness was modified to an armoured PTFE cable fitted in a stainless steel sleeve. To provide great protection from damage.
6. A new Near Zero Growth (NZG) tyre made by Michelin was fitted. These replaced the standard Dunlop tyres. These were designed to have less energy if they exploded and to be more resilient to cuts. This was tested using titanium knives.

One aircraft was chosen from the British Airways fleet to be used in the return to flight test programme. G-BOAF was selected as it was the youngest Concorde and the airframe had flown the least number of hours. The required modifications were fitted and a rigorous test programme was undertaken by Jock and a senior BA captain Mike Bannister.

Since the Concorde fleet had been officially grounded a Special Category Certificate of Airworthiness was issued by the CAA in order to conduct the tests. The main objectives of the testing were to heat soak the fuel and the aircraft structure while observing the effects. This was achieved on the first flight by flying at Mach2 for as long as possible.

The test flight highlighted that a result of the fuel tank modifications. A quantity of fuel which could not be pumped was left in the tank between the baffles. The next test flight required finding the hottest route for which they chose RAF Brize Norton (Oxfordshire) to London Heathrow and then back to Brize Norton, after a suitable pub lunch.

Once the tests were completed successfully the aircraft was given approval to return to flight operations. Due to the time which had elapsed since the Paris crash (April 2000) by August 2001 the flight crews were no longer current on this type of aircraft. So a refresher course was held at Shannon airport in Ireland. Jock and Mike Bannister conducted the training which consisted of a series of 3 Touch and Go landings.

The planned restart of scheduled services had been in September but due to the events of 911 this was delayed until November 2001.

Concorde remained in service until it was retired in October 2003.

After answering questions from the audience, the Chairman thanked Jock for a fascinating talk and the audience showed their appreciation.

**Paul G4TMC**

## SDR FOR LESS THAN A TENNER

Have you ever wanted to play around with Software Defined Radio but were not sure whether it was for you or not? Think it might cost a bomb to find out?

Well how about trying it out for less than a Tenner!

I have a requirement for a digital receiver in the licence-exempt band at around 868MHz and a cheap SDR Dongle was needed. This fits the bill quite nicely.



The unit that I purchased for this was the R820T2 SDR Dongle and covers the spectrum from 25MHz to 1.75GHz for the grand cost of £9.30 including post and packing from "Cosycave" <https://www.cosycave.co.uk> You could go out and buy more performance (improved filtering) and LF coverage with something like the FUNcube, however that is £150, so why not try this approach first to see if it's for you? Then go get a FUNcube.

You may have more interest in the HF bands below 28MHz, in which case a variation on this dongle would be required. With the R820T2 you can listen on all modes; Wide FM, Narrow band FM, i.e. 2 Metres, SSB, USB and LSB, AM, CW, you name it. With this you can listen to Band 2 FM complete with RDS station identification, Airband AM, VOR, 4 Metres, 2 Metres and up as well as 28MHz all modes. Digital radio and TV will need additional software.

The RF connector for these dongles is MCX and I found a short MCX to SMA lead on Ebay for a couple of pounds. No DC power is required as it runs from the USB supply.

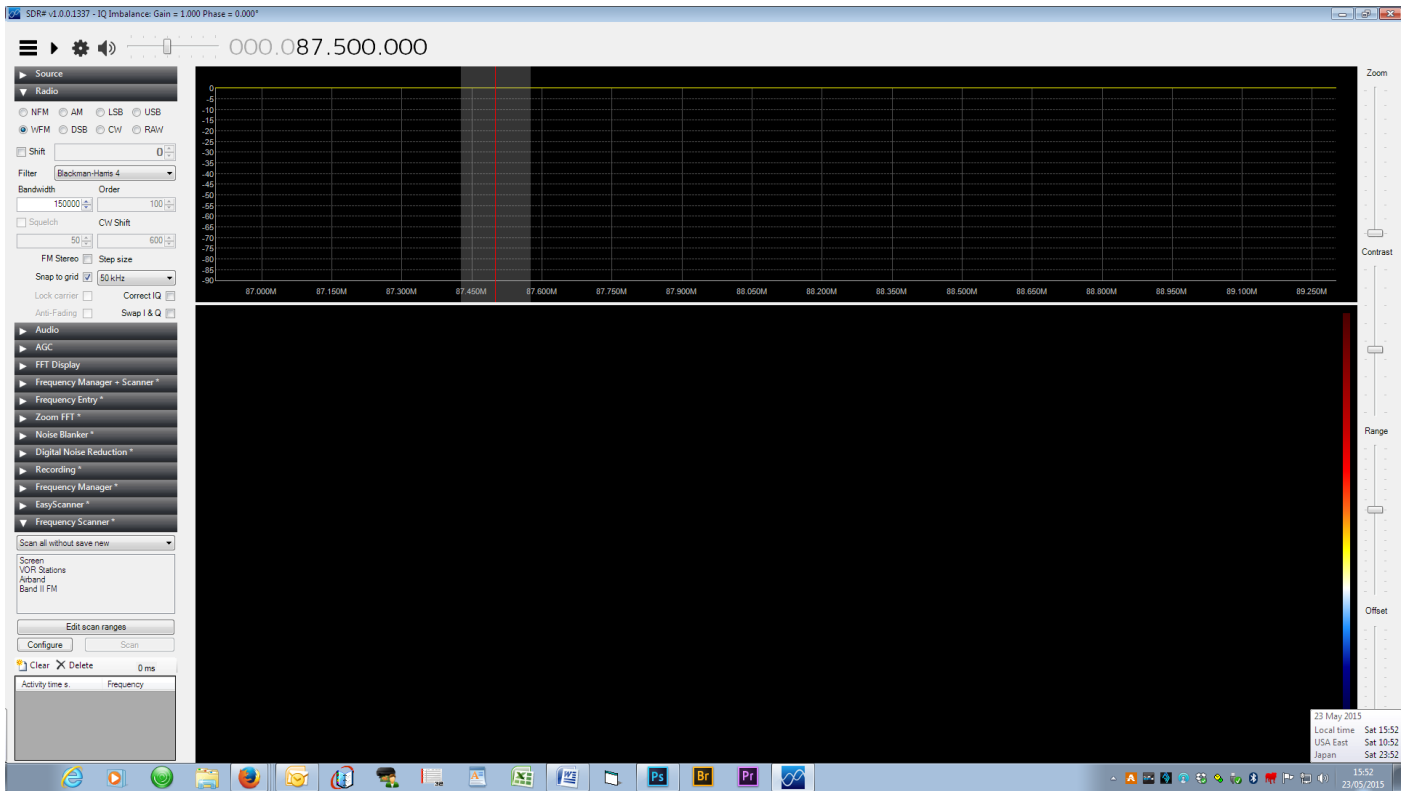
Installation is simple and I recommend using SDR sharp (SDR#) software with this dongle. It is free of charge and works well, just go here: <http://sdrsharp.com/#> download the zip file and extract it.

A very good set of instructions for installation can be found here:

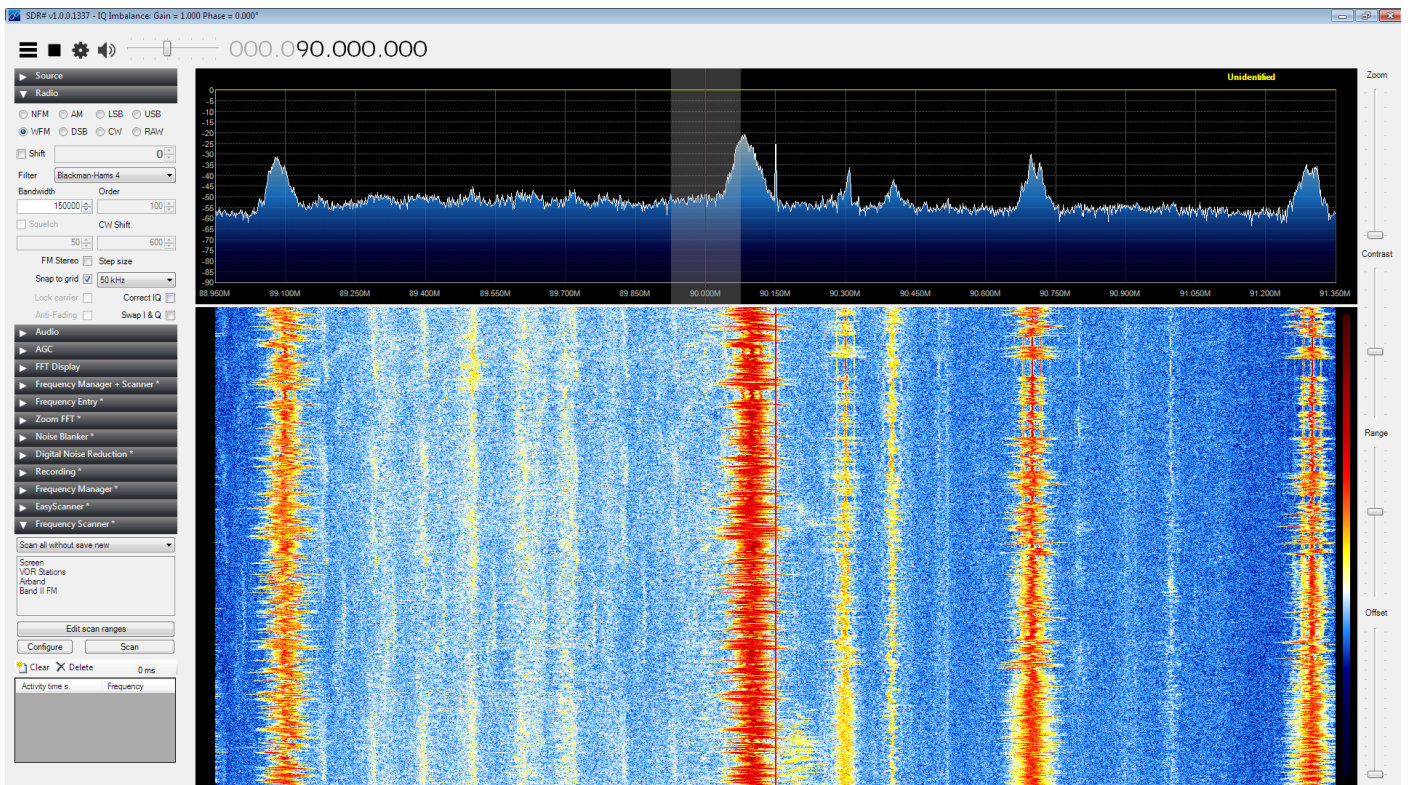
[www.rtl-sdr.com/tag/zadig/](http://www.rtl-sdr.com/tag/zadig/)

Just follow the instructions and the install should be trouble free.

When you run SDR# a window will open up that looks something like this:



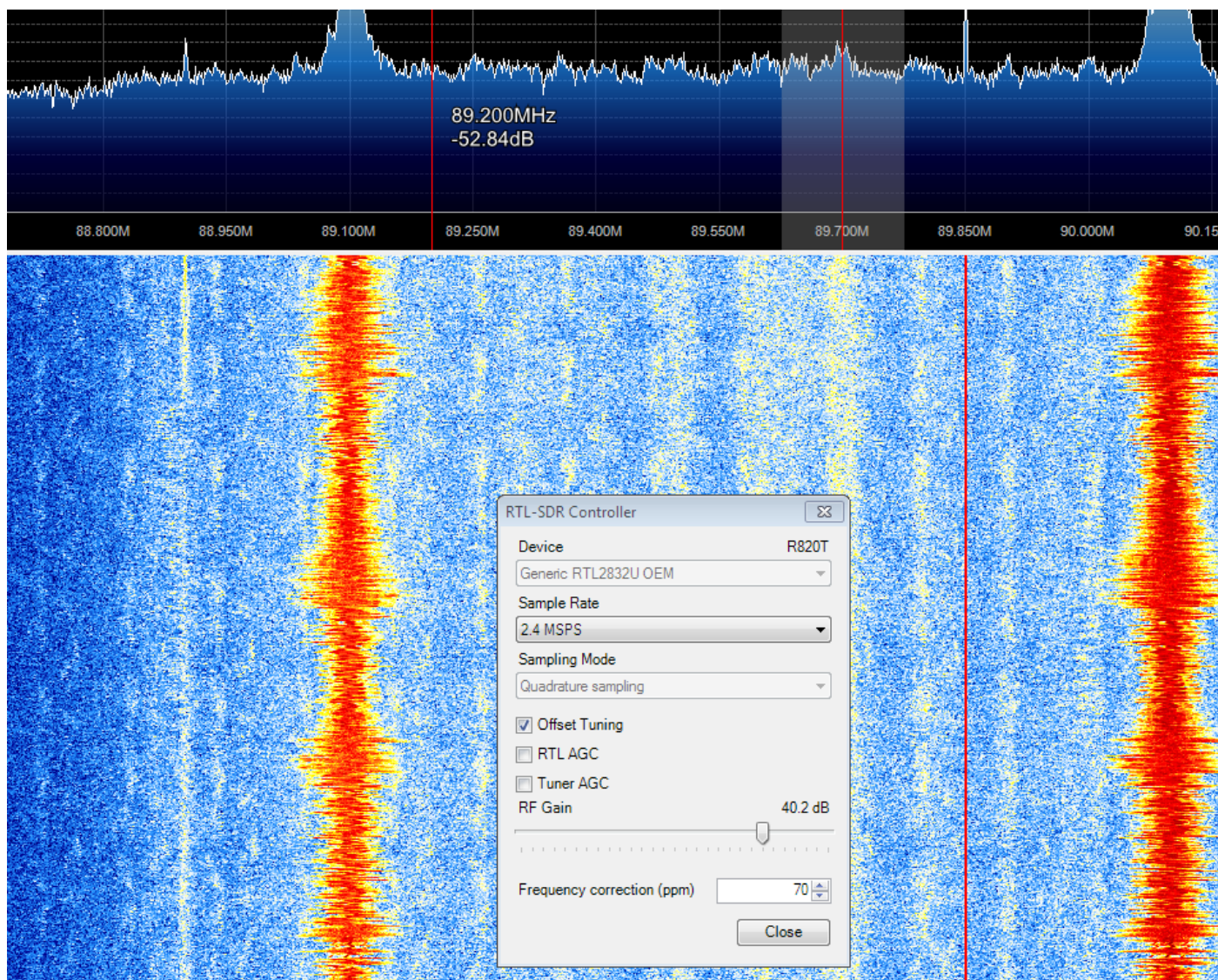
One thing to note is that when SDR# first opens up it is set with the RF gain at minimum, so when you start there will be no signals seen. Simply go into the configure menu (the cogged wheel in the top LHS) and move the RF gain slider up to around 30-40dB as a starting point. Connect an antenna (I use an FM dipole) and click the start button. Shown below is a screen capture centred on 90MHz FM.



This is a very inexpensive dongle, and as such, the frequency accuracy may be off by an unacceptable amount. Do not worry, this is easy to put right!

First find a station where the frequency is known (I use GB3VHF) open the "Configure window and adjust the Frequency correction (ppm) window until the centre frequency aligns correctly with the reference station. In my case this amounted to 70ppm.

Screenshot shown below.



As well as the plugins provided as standard, noise blanker, scanner, recorder etc, there are numerous other plugins that can be downloaded into SDR#. Just search for SDR# plugins and follow the instructions.

I am no Guru but if you need any help drop me a mail.

73

John G3WZT





## Broadcast Listener

News round up by David Ansell 2E0NKC

All times BST

Later this summer I shall be moving to a new QTH in Curzon Avenue, Horsham. A brand new shack is planned at the bottom of the garden. But that is a long way off! Life FM is a local FM station in Cork, Ireland. From 2300 nightly it is relayed by HCJB Germany on 7365 kHz. An interesting bulletin of local news was heard. For pop music fans Larry London's Border Crossings show is on the air Mondays to Fridays on 17895 kHz on the Voice of America at 1606 hours - This is from the VOA Botswana relay station in South Africa.

Radio Thailand broadcasts in English 2000 – 2100 and 2130 – 2145 on 9390 kHz. Transmitter site is Udorn Thani in NE Thailand. Reception is always good. **Europe on Shortwave – Albania** – English Monday to Saturday at 2100 on 7465 kHz. **Spain** – Spain left shortwave but after strong protests resumed again but only in Spanish; **Serbia** – transmissions of International Radio Serbia were due to start at the end of June, but the matter was debated in the Serbian parliament and a reprieve was granted. Still on at mid-July with English at 1930 on 6100 kHz.

**Romania** – daily English 5 times a day; **Bulgaria** – left short-wave but transmitters at Plodiv used by other broadcasters such as the Cyprus newspaper the Famagusta gazette for daily news in English. A newspaper on short-wave! **Vatican State** has English several times daily via Vatican Radio. The News in English daily except Sunday at 0630 on 15595 kHz and 1615 daily on the same frequency. BBC World Service heard at various times in Europe on short-wave but from relays in Africa and Asia.

This service is also heard on Long-Wave for night owls from 0100 – 0520 on 198 KHz via Droitwich. The actual transmitter site is in the village of Wychbold and the antenna best viewed from the church yard! **France** – Radio France International broadcasts in various languages but dropped English but has been reported recently at 0700 in the 22 metre band. **Germany** – Deutsche Welle only has English to Africa. In Germany there are several private stations running low power in the 75 metre, 49 and 41 metre bands. Some of these relay other broadcasters.

**Austria** – Radio Austria International. All that is left now is German 0500 – 0715 on 6155 KHz. **Belarus** – Radio Belarus has English from Minsk 2100 (or 2120) to 2300 on 11730 and 11930 kHz with low audio. **Greece** – Right through the troubles Greek Radio has continued although the government officially closed them down! The staff kept the transmitters on thought they had been sacked! Try 9420, 11645, 15630 and 15650 kHz. Programmes are in the Greek language and very erratic. Nigerian Armed Forces Radio has been heard on 13775 kHz at 0700 in English and Hausa languages. So you can see short-wave is still alive and well despite some cut-backs!



## BBC Local Radio by David Miller G4JHI

Since the closure and trials for potential closure of some medium wave services, several stations have appeared on the Freeview platform. These include Kent and Solent on channel 719 and London on 721 the latter having already been on air for some time and also on the Astra2 satellite. TV viewers tuned to the Midhurst transmitter will find BBC Radio Solent on their EPG.

### I heard a rumour

A few years ago when the editor was working at a factory in Crawley Industrial Estate the following was heard when a couple of colleagues were in conversation;

*" I see that Radio Mercury have moved from Broadfield House to a new premises just up the road "*.

*" Yeah I've seen the new building too "*.

*" It's a very good signal round here isn't it on 102.7 FM, I've had a look but can't see any aerial on the roof "*.

*" No, I couldn't see an aerial on the roof either "*.



## **Alles klar**

Germany has set a date to end their terrestrial service that broadcasts in the DVB-T format in favour of the DVB-T2 standard similar to that used in the UK for high definition TV. The date for completion of the switchover is set for 2019 and will make early equipment obsolete. Starting in 2017 the commercial broadcasters will switch off the DVB-T transmissions (SD) and will then only be available on this platform in HD and become subscription based.

The public service broadcasters such as ZDF and ARD will remain free to air. However there is good news for satellite viewers across Europe who watch TV from Germany. The standard definition versions of the commercial services such as RTL and Pro 7 will remain available to all until at least 2023.

The HD versions are already encrypted and can be viewed by subscribing to the HD+ package available to residents living in Germany. The public service broadcasters on the Astra1 satellite continue in SD and HD format free to air.

[www.a516digital.com/2015/06/germany-sets-timeframe-for-end-of-dvb-t.html](http://www.a516digital.com/2015/06/germany-sets-timeframe-for-end-of-dvb-t.html)

*'I want to see the BBC downsized..... and governed by Ofcom'  
(Whittingdale, 2015)*

Thursday 16th July 2015 by Julian Thompson G1ODN

Announcing the Government's *Review*<sup>1</sup> of four key areas to downsize the BBC, and deflate its 'fat cat culture'; it's a foregone conclusion that Ofcom will take over governance, as the airwaves regulator.

*Are we entitled to see another release of gifted public sector radio spectrum?*

Previously, when BBC released the old analogue bands, we all went digital. Then MOD released vacant bands following the 'Cave Review' So the current *Review* would do well to consider release of all remaining BBC digital bands. It's a 'win-win' situation.

Sequestration from BBC TV and radio use could net Ofcom a windfall £1.3bn from a clock auction to the mobile operators market. A similar scenario to the one suggested in HARC News (February, 2015)<sup>2</sup>. *Bonus? That's to seal-the-deal before the European Commission steal-the-deal by announcing they intend to do exactly the same.*

*Is there any justification to hang on to the BBC licence fee?*

How the BBC is funded is an interesting question. I would agree it's an unfair tax on the poor, in stark contrast to the 'fat cats' it has sustained with 'jobs-for-life'. But what about refusing to de-criminalise non-payment? No fee would mean: no more 'licence fee criminals'. *Common sense!*

But I would want to go further. If you'd been paying an annual fee to invest in any successful organisation for fifty years, you would expect something in return. As an organisation that was created during the 20th century, BBC's enviable back catalogue must have enormous market value. Wildlife in particular will come alive once the sterile symphony sound has been over-dubbed and re-engineered. A case for employing hundreds of British graduate sound engineers, surely?

*What services and content it should provide?*

*HARC News* (May, 2015)<sup>3</sup> revealed that UK had more digital broadcast content streaming live on the internet, than any other EU country. Switch over to software defined internet TV solves two problems. Firstly you wouldn't need a switchover campaign and secondly (recognising that Polish is our second language)<sup>4</sup>, the BBC would never need to re-broadcast in other languages.

*Fit for the future?*

Finally we can answer the question about the overall purpose of the BBC that is fit to broadcast during the twenty-first century. Having already lost fifteen years, the answer has to be: "as little as possible for no licence fee". It was once widely accepted by marketing practitioners that any service organisation mimics an organic life cycle. It's given birth to, it grows, it matures and it dies. Not everyone subscribes to that view. What's the alternative? What is it exactly, that has made the BBC a continuously parasitic process?

Join the debate: see [www.bbc.co.uk/news/entertainment-arts-33551874](http://www.bbc.co.uk/news/entertainment-arts-33551874)

*Useful references:*

1. Government's *Green Paper on the corporation's future* see [www.bbc.co.uk/news/entertainment-arts-33551874](http://www.bbc.co.uk/news/entertainment-arts-33551874)
2. Update on Ofcom's planned changes to the Amateur Radio Licence: *Schedules 1&2: Removal from Schedule 1, Tables B&C etc;* HARC News, February 2015.
3. Miscounting radio stations streaming live on the internet; *HARC News*, May 2015
4. Polish becomes England's Second Language, *Guardian newspaper* 30 January 2013 (accessed 16.7.2015)  
[www.theguardian.com/uk/2013/jan/30/polish-becomes-englands-second-language](http://www.theguardian.com/uk/2013/jan/30/polish-becomes-englands-second-language)

# A 21 MHz Four Square Beam Antenna

*Achieving gain on 15 meters within a relatively small space.*

*Garth Swanson G3NPC*

The four square beam antenna is a square array of four vertical elements whose radiation pattern can be rapidly switched in direction by altering the relative phases of the four driving currents. The main beam relies on constructive interference of the signals from the elements where the relative phase of each is made up of the phase shift of the driving signal and the phase shift associated with the additional path length due to its spatial separation from the lead element.

At low frequencies where mechanical rotation is difficult for large structures phase control is an attractive possibility and is sometimes used on 80 meters. Typically, though not necessarily, the elements are positioned at the corners of a quarter wavelength square. At 21 MHz the antenna proves to be compact and can be easily accommodated in smaller yards and does not require a tower or a rotator. The array maintains the low angle radiation characteristic of a simple quarter wave vertical monopole but is able to manifest forward gain and reject noise and unwanted transmissions that would otherwise be received outside the main lobe.

This article considers design choices and explains how to design a practical feed system that takes into account the measured interactions between the four elements. The direction control system is also described. Far field measurements are presented that show the switched polar patterns to allow the actual performance to be compared with a theoretical model. A companion article in the September 2013 issue of *QST* presents a practical description of a 21 MHz four square antenna. That article can be found at [www.arrl.org/this-month-in-qex](http://www.arrl.org/this-month-in-qex).

## Design Choices

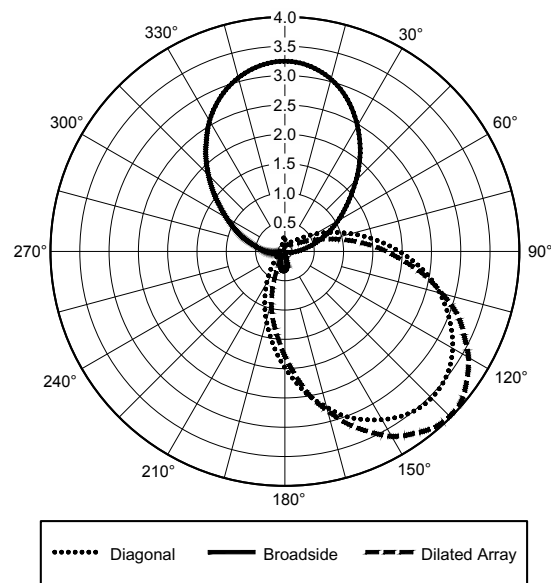
A design requires a basic decision as to whether the array is to be broadside or diagonally firing; each requires a different set of driving currents. A first order comparison can be made by considering the simple summation of four unit-amplitude plane waves launched with the specified phases from the element locations. See Table 1.

Figure 1 shows the expected polar variations of power gain for broadside and

**Table 1**

**Element Driving Current Phasings Required for Broadside and Diagonal Firing**

	NW	NE	SW	SE
Broadside (S Firing)	0	0	-90	-90
Diagonal (NE Firing)	-90	-180	0	-90



**Figure 1 — A simplified comparison of the energy density (P) polar patterns of broadside and diagonally firing four square antennas based on a quarter wavelength square, showing the effect of dilation by a factor of  $\sqrt{2}$ .**

diagonal firing from a quarter-wave square array. Diagonal firing gives about 10% more gain than broadside, but with a half power beamwidth of 90°, wider by 6°. Dilating the square by a factor of  $\sqrt{2}$  makes the diagonal length an exact half wavelength and allows waves in that direction to perfectly reinforce. The dashed-line plot shows that this leads to a further increase of gain of about 10% and narrowing of the beamwidth to 84°.

In view of the limited space available, the extra space taken by the enlarged array and its slightly poorer reverse response, I decided to base a design on the smaller diagonally firing array bounded by a quarter-wave square.

### The Antenna Array

The array was formed of four quarter wave vertical monopoles, each connected to its own set of quarter wavelength radials lying on the ground. See Figure 2. This basic element of the array was thoroughly characterized and reported in an article in the July 2011 issue of *RadCom*.<sup>1</sup> That study showed that a maximum radiation efficiency of 80% could be achieved with 13 or more ground radials. Purely for convenience, eight radials per monopole were selected for this design, reducing the radiation efficiency to 65%, equivalent to a small eventual loss of 0.9 dB. Figure 3 shows the parallel electrical response of one of the elements in isolation, with no coupling to its neighbors — this was ensured by open circuiting the neighboring driving points.

The design was centered on a frequency of approximately 21.2 MHz using monopole

elements adjusted to be resonant in isolation with a length of 3.34 meters. The side length of the array was 3.55 meters, a quarter wavelength in free space. In order to ensure as far as possible that the coupling between the elements was only electromagnetic, their radial systems were not connected directly to each other; each radial set was returned to its own ground mounting.

It is important to emphasize that because elements in an array interact electromagnetically their properties cannot be

considered to be independent of each other. Currents flowing in a particular element will induce voltages in its neighbors, causing components of current to flow in them and modifying any previously established terminal currents. The coupling between a pair of elements A and B can be expressed through a mutual impedance,  $Z_{ABm}$ . Equation 1 calculates the mutual impedance,  $Z_{ABm}$ , in terms of the measurements described below.

$$Z_{AB_m} = \sqrt{Z_{BB} (Z_{AB} - Z_{AA})} \quad [\text{Eq 1}]$$



Figure 2 — The disposition of the elements, feeders and sets of eight quarter wavelength radials.

<sup>1</sup>Notes appear on page 12.

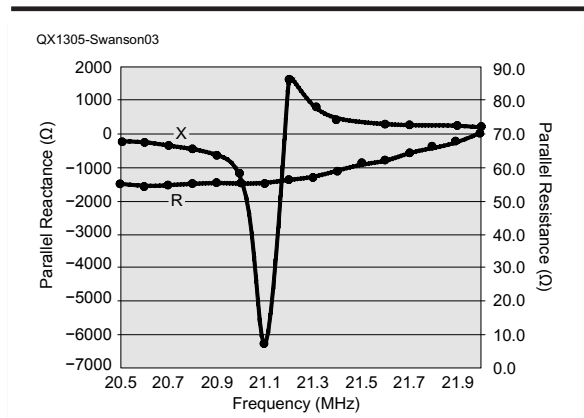


Figure 3 — The parallel electrical response of one of the elements with eight ground level radials when its three neighboring elements were open circuited.

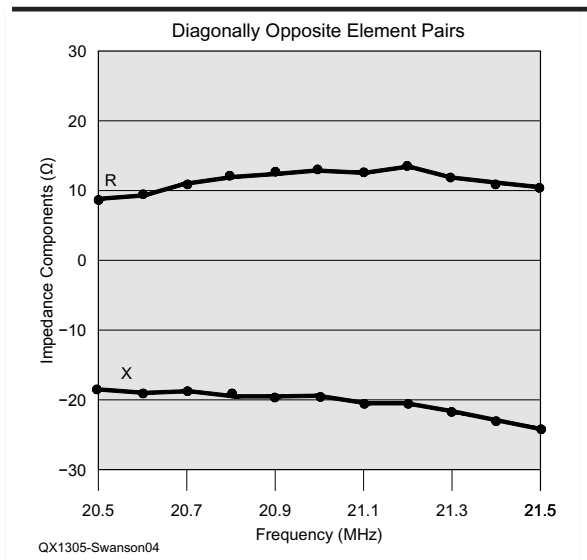


Figure 4 — Averaged measured components of the mutual impedance between pairs of diagonally opposite elements.

The inference of mutual impedances makes use of the principle of superposition, which permits its determination for a particular pair of elements in the absence of the others. As an example, if the mutual impedance between an element A and another element B is to be inferred, the driving point impedance of element A is first measured in isolation with all other driving points open circuited; this gives the value  $Z_{AA}$ . Likewise for  $Z_{BB}$ . Then  $Z_{AB}$  is the impedance of A in the presence of B alone, when the latter is short circuited at its driving point and all other elements are open circuited.

Clearly, coupling to an element A in an array of four requires the determination of  $Z_{ABm}$ ,  $Z_{ACm}$  and  $Z_{ADm}$ . A similar statement can be made when element B is considered, and in turn three more values have to be ascertained when each of elements C and D are considered. Three mutual impedance values must be ascertained for each element, a total of 12.

These parameters vary with frequency so the procedure has to be repeated at every frequency at which the mutual impedance is required. Actually the determination of the necessary values is less laborious than it sounds. If the four elements are identical in structure and tested at the same location then  $Z_{AA} = Z_{BB} = Z_{CC} = Z_{DD}$  and if pairs A and C and B and D are diagonally opposite, their mutual impedances will be the same. The same reasoning is applicable to the side pairs. So one only needs to measure the isolated impedance values and ascertain the mutual impedances for an edge pair and a diagonally opposite pair. Of course this must be done at each frequency of interest.

The measurements were made with an MFJ-269 Antenna Analyzer remotely connected to the antenna by a length of RG58 coaxial cable, allowing the observer to stand well away from the antenna. The transforming effect of the coaxial cable was removed mathematically by taking into account its characteristic impedance, length, velocity factor and specific attenuation, all of which had been measured independently and found to be: 46  $\Omega$ , 10.52 meters, 0.657 and 0.06 dB/m respectively.

A spreadsheet allowed the raw data to be converted into the series elements of driving point impedance. Care was required in order to differentiate between positive(inductive) and negative(capacitive) reactance observations. Measurements were made point by point with frequencies set with an accuracy of  $\pm 10$  kHz. Figures 4 and 5 show the inferred components of the mutual impedances for diagonally opposite and edge pairs of elements. These are presented as averaged values; there were relatively small differences between the values obtained for

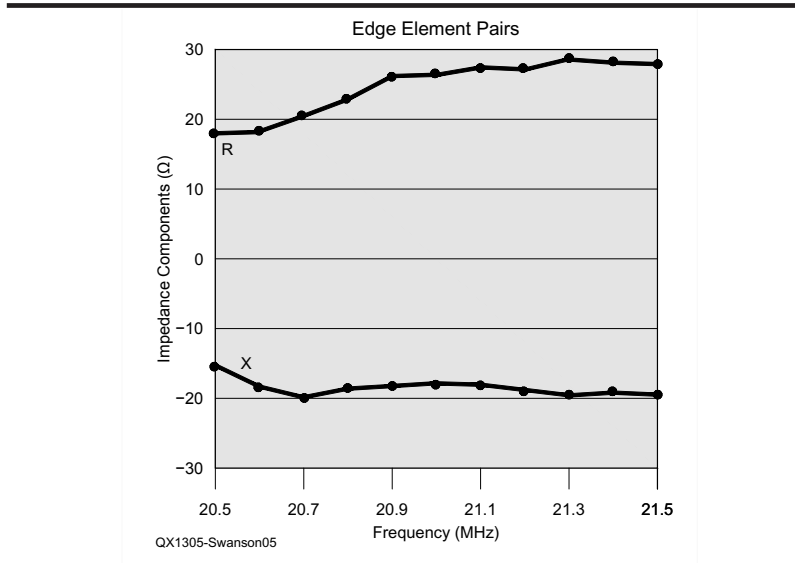


Figure 5 — Averaged measured components of the mutual impedance between pairs of elements at adjacent corners of the array.

particular pairs, perhaps because of small differences in their local environment. I used these averaged values in the design of the RF feed system.

#### The Feed System

A prerequisite for the design of the feed system of any antenna array is to know the driving point impedance of each element at the frequency of interest when every element is energized. The driving impedance of a particular element is affected by the mutual coupling with all other elements and is related to the mutual impedances by Equation 2, written here for element A.

$$Z_A = Z_{AA} + \frac{i_B}{i_A} Z_{ABm} + \frac{i_C}{i_A} Z_{ACm} + \frac{i_D}{i_A} Z_{ADm} \quad [\text{Eq 2}]$$

Thus the impedance of an element is controlled by the currents in its neighbors, which are set by the required radiation pattern of the array. The problem then becomes how to deliver these currents into the four driving point impedances.

Systems for driving arrays have been reviewed by John Devoldere, ON4UN, in *Low Band DXing*.<sup>2</sup> A particularly straightforward method that has been chosen here is to make use of a transmission line of an appropriate length to transform the current feeding an antenna element into a voltage that can be preset at the feeder input. The method is sometimes called “current forcing,” because the length of the feeder, the

load impedance and the feeder input voltage completely define the voltage distribution along the feeder and at its termination. It is this terminating voltage that forces the required current to flow into the element driving point. The first step is to calculate the driving point impedances using the four complex currents necessary for a particular radiation pattern.

The four elements have to be individually driven and four separate feeders are needed to provide the transformations that deliver the complex currents required at the driving points. The necessary feeder input voltage will depend on its length. Al Christman, KB8I (now K3LC), pointed out that the feeders, having different lengths, could only be brought together at a common node if the four voltages were equal in magnitude and phase.<sup>3</sup> In order to apply the Christman method, we need to be certain that points fulfilling these conditions will actually exist.

Based on the measured impedance parameters at 21.2 MHz, calculations of the four line voltage distributions have been made. Unit currents with the required phase shifts for diagonal firing will have defined the driving point impedances. The complex variations of line voltage are shown in Table 2. It is clear that in this case the magnitude and phase do not match simultaneously at any point. Having applied this method to a broadside firing four square array and a simple two element beam, the Christman method failed in those cases, too. John Devoldere also noted occasional failures of



the Christman method in *Low Band DXing*. See Note 2.

Nevertheless, the method provides a useful basis since points do exist here where the phases match well. These locations along the feeders are highlighted with bold type in Table 2. It requires only transforming the voltages at these equi-phase points to a unique voltage to be able to drive the four feeders from the same source. In this way the equi-phase and equi-voltage conditions would be met. This elaboration of the Christman method is novel and that is what I successfully implemented with my antenna.

Notice that the range of lower feeder lengths, up to 2.4 meters, is not useful because the cables would be too short to reach the four elements from a central point. Notice also that the two central, off axis, feeders require the same current, so only three feeder types are shown in this tabulation.

Table 2 shows the lengths of RG58 feeders that are required to establish the driving point current magnitudes and phase shifts for diagonal firing: they are 3.0 meters for the rear element, 5.2 meters for each of the central elements and 6.9 meters for the leading element. They will deliver the required complex currents to the element driving point impedances, which of course embody the mutual components arising from inter-element coupling. These impedances are shown in Table 3.

This design procedure is a key step in the design of this four square array. The modified Christman method has also been applied successfully to a practical two element design and theoretically to a broadside-firing four square array.

#### Arranging an Array Common Feed Point

Each element therefore has its own feeder with a length chosen so that it delivers the appropriate complex current to its element and has an input voltage that is in phase with the three other feeder input voltages. Because the feeder input voltage magnitudes differ, it is necessary to transform them to the same voltage, maintaining the same phase so that the array can be fed at a common node. The extent of the voltage adjustment is shown by Table 4.

There is a 3% difference in voltage between the required feeder input voltages for the rear and lead elements. The discrepancy is comparable with the accuracy of the calculations, so these feeder inputs could be simply paralleled. The two central element feeders have the same voltage and phase distributions, so their inputs can be paralleled together. These require a voltage about 20% larger, so scaling down was necessary and an

RF transformer was constructed to do this.

The combined impedance looking into the common feed-point must provide an acceptable match to the 50 Ω line from the transmitter, so not only was voltage scaling required but impedances needed to be scaled too.

An initial attempt to accomplish this using a transformer with two secondary windings was abandoned because it proved

very difficult to neutralize the inductive leakage reactances that were reflected from the secondaries to the primary winding to add to its leakage reactance. Because the two secondary windings shared the same primary winding there was an awkward interaction between the two neutralization steps.

It proved preferable to construct two transformers and to parallel their primary windings. The global leakage

**Table 2**  
**Voltage and Phase Along the Three Types of Feeder Showing the Locations of the Equal Phase Points in Bold Type.**

Length(meters)	Lead Element Feeder		Central Elements Feeder		Rear Element Feeder	
	Mag	Phase	Mag	Phase	Mag	Phase
0	108.7	-135.5	68.8	-105.8	31.2	-88.2
0.2	112.2	-133.2	66.8	-100.6	24.7	-87.6
0.4	113.8	-131.0	64.1	-95.1	17.8	-86.5
0.6	113.5	-128.9	61.0	-89.0	10.5	-83.9
0.8	111.3	-126.6	57.5	-82.2	3.2	-69.4
1	107.2	-124.3	53.9	-74.4	4.6	75.8
1.2	101.4	-121.6	50.5	-65.6	12.0	84.7
1.4	94.0	-118.6	47.5	-55.5	19.1	86.8
1.6	85.1	-114.9	45.3	-44.2	26.0	87.8
1.8	75.2	-110.4	44.1	-32.0	32.4	88.4
2	64.5	-104.3	44.3	-19.5	38.2	88.8
2.2	53.7	-95.8	45.7	-7.4	43.3	89.2
2.4	43.6	-83.0	48.1	3.7	47.6	89.5
2.6	36.1	-63.9	51.3	13.6	51.0	89.7
2.8	33.5	-38.7	54.9	22.3	53.5	90.0
<b>3</b>	37.2	-14.2	58.6	30.0	<b>55.0</b>	<b>90.3</b>
3.2	45.3	3.7	62.2	36.7	55.6	90.5
3.4	55.6	15.6	65.4	42.8	55.1	90.8
3.6	66.6	23.7	68.0	48.3	53.6	91.2
3.8	77.2	29.5	70.1	53.6	51.2	91.5
4	87.1	33.9	71.4	58.5	47.8	92.0
4.2	95.8	37.6	71.9	63.4	43.5	92.5
4.4	103.1	40.6	71.6	68.3	38.5	93.2
4.6	108.7	43.4	70.6	73.3	32.7	94.2
4.8	112.6	45.9	68.8	78.5	26.4	95.6
5	114.7	48.3	66.4	84.1	19.6	98.0
<b>5.2</b>	114.8	50.7	<b>63.4</b>	<b>90.2</b>	12.6	103.1
5.4	113.1	53.1	60.1	96.9	5.6	121.2
5.6	109.5	55.7	56.6	104.5	4.0	-137.1
5.8	104.2	58.5	53.2	113.1	10.6	-105.8
6	97.2	61.7	50.2	122.8	17.7	-99.0
6.2	88.8	65.5	47.9	133.6	24.6	-96.1
6.4	79.3	70.2	46.6	145.3	31.0	-94.4
6.6	63.7	80.0	46.8	163.4	39.7	-92.9
<b>6.8</b>	<b>58.5</b>	<b>84.4</b>	47.5	169.3	42.2	-92.5
<b>7</b>	<b>48.6</b>	<b>96.1</b>	49.6	-179.5	46.7	-91.8
7.2	40.9	113.1	52.5	-169.4	50.4	-91.2
7.4	37.3	135.4	55.9	-160.5	53.1	-90.6
7.6	39.3	158.7	59.5	-152.6	54.9	<b>-90.1</b>
7.8	46.1	177.4	63.0	-145.6	55.6	-89.6
8	55.5	-169.4	66.3	-139.2	55.4	-89.0
8.2	66.0	-160.2	69.0	-133.4	54.2	-88.5
8.4	76.5	-153.6	71.2	-128.0	51.9	-87.8
8.6	86.4	-148.5	72.6	-122.8	48.8	-87.1
8.8	95.3	-144.4	73.3	-117.8	44.7	-86.2
9	102.8	-140.9	73.2	-112.7	39.9	-85.1
9.2	108.8	-137.9	72.4	-107.6	34.3	-83.7
9.4	113.1	-135.1	70.8	-102.3	28.2	-81.7
9.6	115.5	-132.4	68.6	-96.7	21.6	-78.3
<b>9.8</b>	116.2	-129.8	65.9	<b>-90.6</b>	14.7	-72.0
10	114.9	-127.2	62.7	-84.0	8.1	-54.7

**Table 3**  
**Calculated Driving Point Impedances for Diagonal Firing.**

Element	Driving Point Impedance ( $\Omega$ )
Leading	$77.5 + j76.2$
Central(off-axis)	$66.2 - j18.7$
Rear	$1.0 - j31.1$

reactance of each could be independently neutralized, ensuring that phase shifts in both transformers were zero. The ratio of their secondary turns was determined by the required voltage scaling ratio, in this case, nominally, 0.84. The absolute number of turns in the secondary windings was then determined by the number of primary turns. In practice 20 turns were selected for each transformer because these fit conveniently onto the chosen ferrite toroids. The numbers of secondary turns for the two transformers were then adjusted mathematically to achieve a suitable value for the paralleled primary reflected impedances, always preserving the required ratio between the two secondaries. This procedure led to a common node input impedance of  $(51 - j29) \Omega$ . The details of the transformers are shown in Table 5.

The transformers were constructed on Type 61 ferrite toroids having an outside diameter of 6 cm and an inside diameter of 4 cm. The primary windings were formed from a single strand of 22 SWG enameled copper wire and the secondaries were of four plaited strands of the same wire wound compactly onto the toroid in the same sense and interleaved with the primary turns. [Note that SWG is British Standard Wire Gauge, with a wire diameter of 0.028 inch. This is roughly equivalent to number 21 American Wire Gauge (AWG), with a diameter of 0.0285 inch. — Ed.] Care was taken to begin the ground ends of the two windings at the same position. This helped to minimize the local potential differences between the windings, ensuring that capacitive currents between the windings were minimized. The table shows that more primary turns were required than had been anticipated by a simple view of transformer design. This could be due to winding end effects where the end turns coupled inefficiently to the core. Careful adjustment of the number of turns was made as measurements checked the open circuit voltage ratio. Small errors in achieving the specification are due to an inability to realize fractional turns.

Figure 6 shows the interconnection of the two transformers and the placement of series preset 150 pF neutralizing capacitors. With the secondary short circuited, an oscilloscope was used to observe the primary voltage and current waveforms, and the neutralizing capacitor was adjusted until they

**Table 4**  
**Electrical Parameters at the Equal Phase Points.**

Position of Feed Point (meters)	Lead Feeder (V)	(degs)	Central Feeder (V)	(degs)	Rear Feeder (V)	(degs)
3.0					55.0	90.3
5.2			63.4	90.2		
6.9	53.5	90.3				
Input Z of feeder ( $\Omega$ )	$16.6 - j15.5$		$46.3 - j21.3$		$21.0 - j161.6$	

**Table 5**  
**Details of the Two Transformers Used for Voltage Scaling and Impedance Matching.**

	Theoretical Designs		Actual Designs	
	Lead/Rear	Center	Lead/Rear	Center
Primary Turns	20	20	23	23
Secondary Turns	8.4	10	8	10
Combined Input Z	$51 - j29 \Omega$			
OC Voltage Ratio	2.4	2.0	2.3	2.0
	Required	Required	Measured	Measured

**Table 6**  
**The Hybrid Ground Electrical Parameters Used for Simulation.**

	Relative Permittivity	Electrical Conductivity (S/m)
Inner zone	73	0.75
Outer zone	42	0.088

**Table 7**  
**The Actual Drive Currents.**

Beam Heading	Measured Elemental Drive Currents (Normalized Magnitude and Phase Angle With Respect to the Rear Element)			
	NE	SE	SW	NW
NE	1.0, $-180^\circ$	0.67, $-90^\circ$	1.0, $0^\circ$	0.77, $-90^\circ$
SE	0.93, $-105^\circ$	1.04, $-165^\circ$	0.89, $-90^\circ$	1.0, $0^\circ$
SW	1.0, $0^\circ$	0.69, $-97^\circ$	0.97, $-192^\circ$	0.70, $-90^\circ$
NW	0.86, $-90^\circ$	1.0, $0^\circ$	0.71, $-90^\circ$	1.07, $-180^\circ$

were in phase. The procedure was repeated for the second transformer; there was no interaction between these adjustments. The attenuation of each transformer was about 1.2 dB, equivalent to an efficiency of 76%. The paralleled connection of their primaries provided the driving point of the array.

The actual complex currents flowing into the four elements for the four different beam headings are shown below in Table 7 and discussed later.

#### The Direction Control System

Figure 7 shows the topology of a switching matrix for routing the three possible phase-shifted feeds to the appropriate elements for a particular direction of fire. The switches used were RF latching reed relays with

a carry current of 1.5 A and a switching time of 2 ms. They were chosen because of their ability to maintain a particular setting without being continuously energized and because they were hermetically sealed and suitable for operation outside. The switches had an actuation current of 16 mA, suitable for control by TTL pull-down devices. This matrix was built on glass-epoxy strip board.

The switch module required five control lines, one to reset the entire switch array and four to select the directions of fire. The direction control lines were routed to the inputs of 2-input NOR gates that energized the appropriate switches for a chosen firing direction. Energy for the switches and NOR gates was supplied by a 9 V battery from a hand held remote controller.

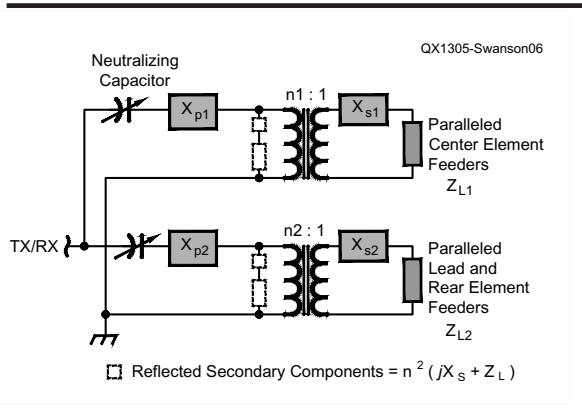


Figure 6 — The interconnection of the feeder transformers.

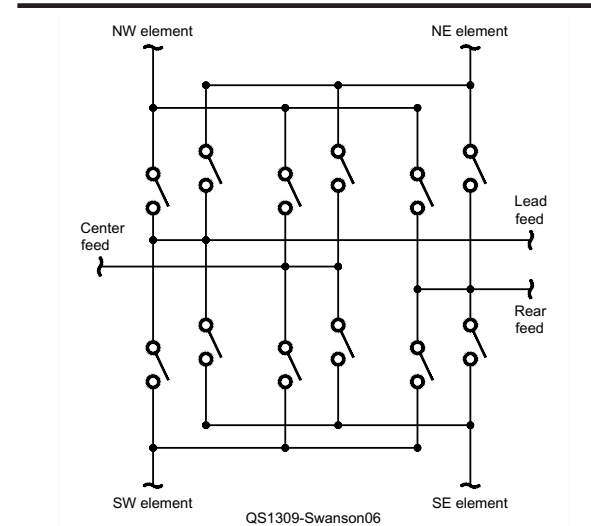


Figure 7 — The router switch array.

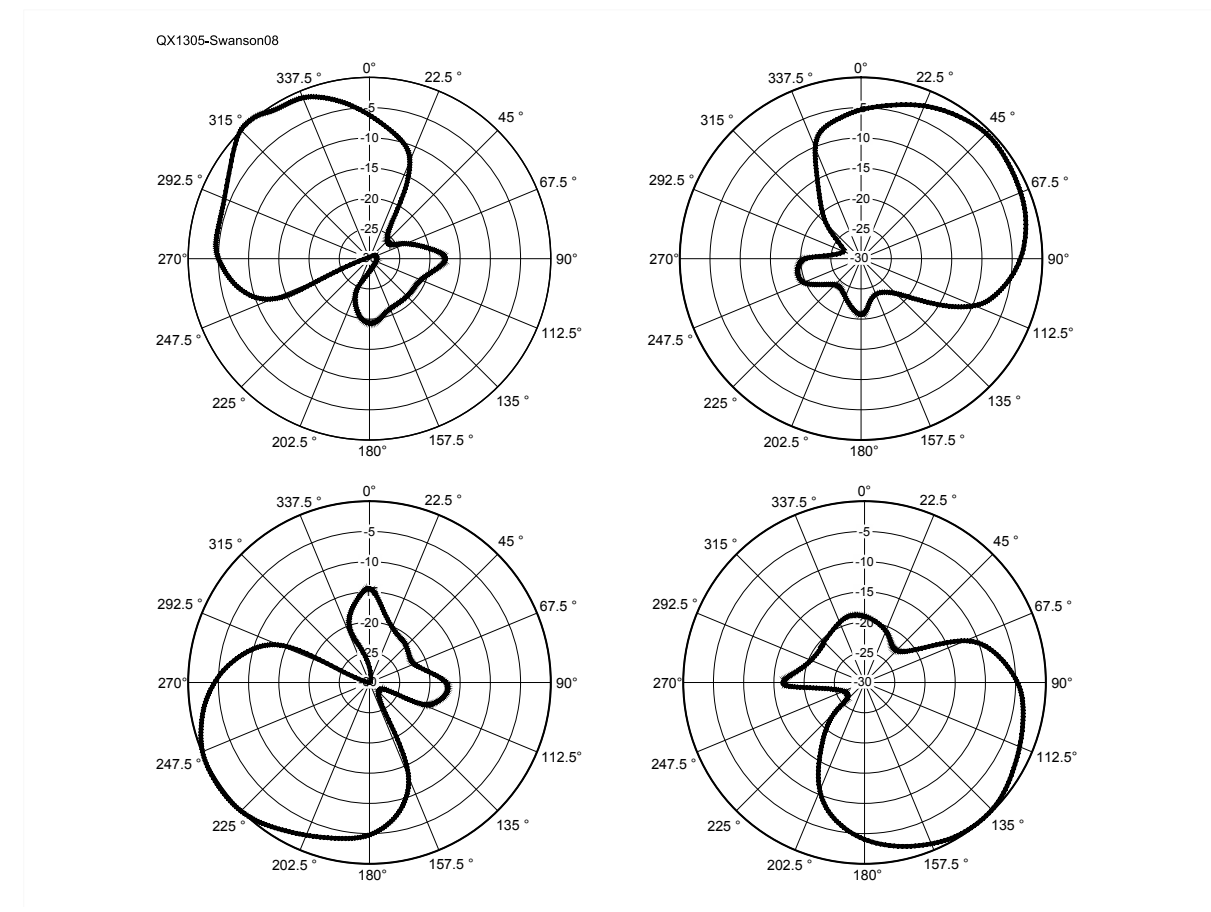


Figure 8 — Measured polar radiation patterns for the four diagonal beam headings.

The antenna design depends critically on transmission lines that have definite lengths, 3.0 meters, 5.2 meters and 6.9 meters. Locating the switching module centrally required that the lengths of the feeders connecting the switch module to the elements should be no less than 2.5 meters, leaving lengths of 0.5 meters, 2.7 meters and 4.0 meters between the module and the common driving point. The latter lengths of feed line were housed with the switch matrix and transformer power splitter modules in a weather-proof box located on the ground centrally between the elements.

The beam is steered by resetting the switches and then briefly energizing the appropriate direction control line to set the required switch configuration. All switching is carried out in the absence of RF excitation to avoid the possibility of contact damage caused by arcing. The system has been in use for two years without any degradation. In principle, the direction of fire could be changed in as little as 4 ms.

The overall measured RF loss from the power splitter output to the elements via the switching matrix was no greater than 0.8 dB and depends slightly on the selected direction. Thus, from the power splitter input to the element inputs there is a loss of about 2 dB, a feed system efficiency of 63%. Since the elements each have a radiation efficiency of about 70% the effective radiation efficiency of the antenna array measured at its feed point is 42%.

### Directional Behavior

Polar radiation patterns of an antenna should be measured in the far field of the antenna so that phase differences between signals arriving from parts of the antenna that are off axis are small compared with the phase shifts that would have occurred had they been on the axis. If  $\Delta$  is the off-axis deviation and  $R$  is the range, the phase error in degrees is given by Equation 3.

$$\text{Phase Error (Degrees)} = \frac{180 \Delta^2}{\lambda R} \quad [\text{Eq 3}]$$

The site available for these measurements allowed a range of 38 meters. For this four square array at 21.2 MHz, the maximum phase error at this distance would be no more than 2°. Distortions in the pattern to be measured would therefore be negligible.

Stations were established at 22.5° intervals at a radius of 38 meters from the array center. Measurements were made using a tripod mounted field strength meter with a dynamic range of 90 dB. At each location in turn the received signal — a relative measure of the signal strength — was recorded for each of the four beam headings, with good reproducibility.

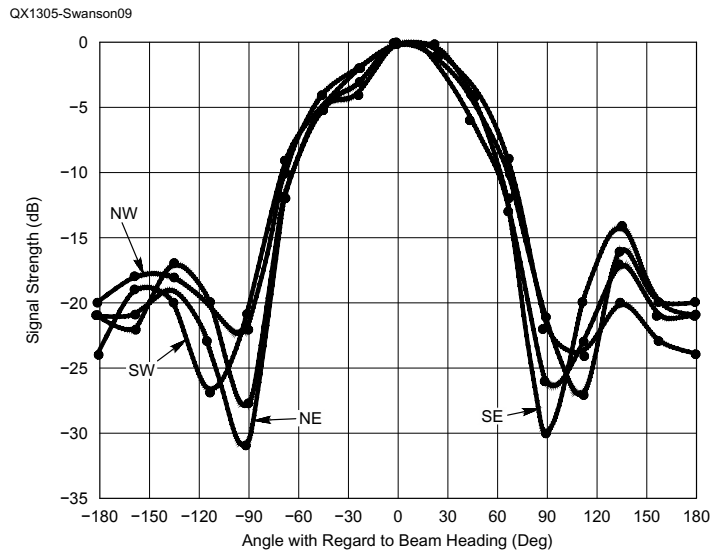


Figure 9 — The four measured patterns overlaid for comparison.

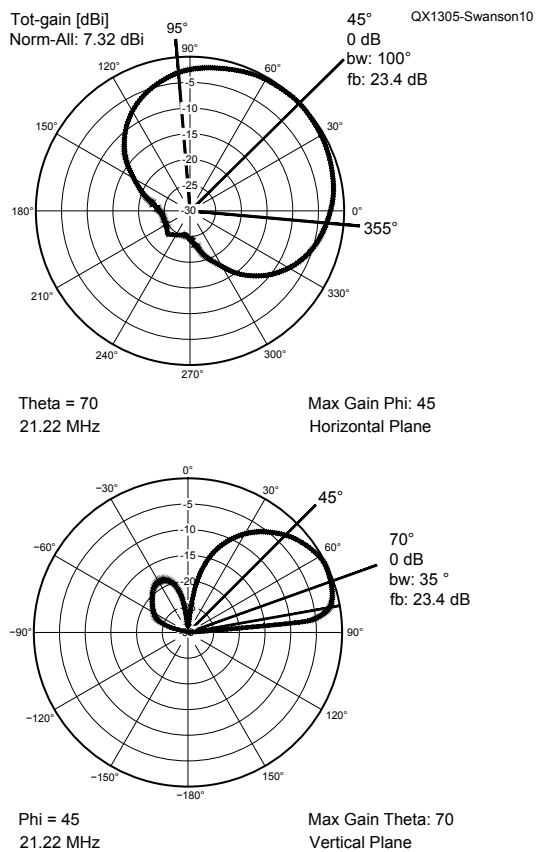


Figure 10 — Computed ideal radiation patterns on the hybrid ground with perfectly defined driving currents.

Figure 8 shows the observed polar patterns for each beam heading. Each is formed from sixteen measured points and data smoothing has been used to help visualize the patterns. Caution is required in interpreting some of the finer angular detail. They are very similar and show clear evidence that switching occurred as intended. They are plots of relative field strength and do not reveal

that the maximum signal strength at each diagonal angle was actually the same,  $\pm 1$  dB. The front to back ratio for each pattern was at least 20 dB. These are logarithmic plots, which intrinsically exaggerate detail in the rear sectors; remember that these features are about a hundred times smaller than the main lobes. The half-power beamwidths were about  $90^\circ$  in each case, very close to that

anticipated from a first order analysis earlier in this article. See Figure 1.

Figure 9 represents the superimposed data on rectilinear axes to aid comparison. There is significant and consistent detail in the rear sector. The overall impression is of similarity in the main lobes for the four beam headings.

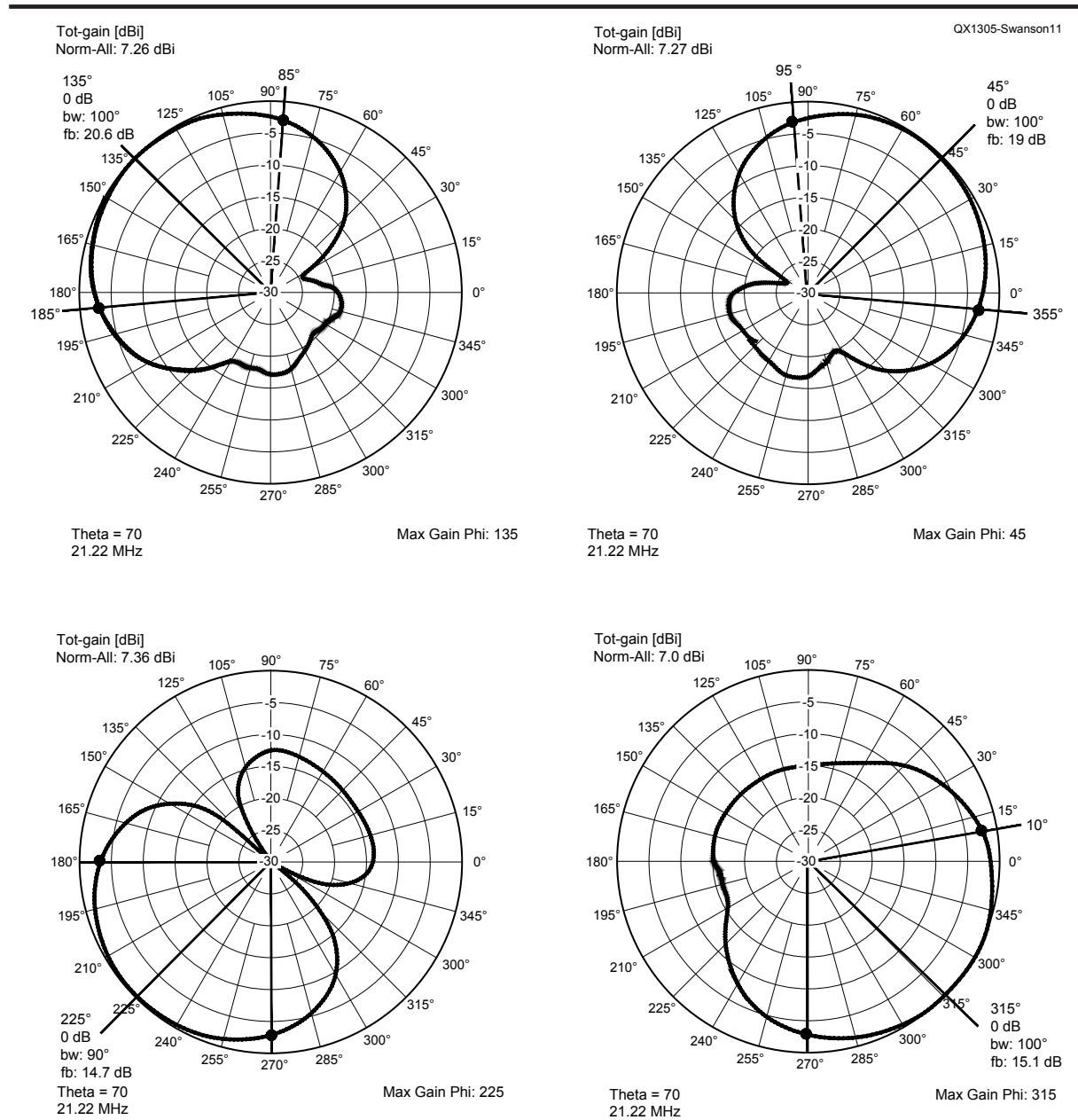


Figure 11 — Computed radiation patterns with the actual driving currents using the hybrid ground. These are all horizontal plane radiation patterns.

### Simulation and Modeling

A valid computer model allows experiment and refinement without the effort and time involved in making alterations and new measurements. The *4NEC2* package based on the *NEC2* electromagnetic modeling code offers the advantage of setting current as well as voltage excitations, and is freely available.

The model of the four square antenna that is used here is built on the behavior of independent monopoles, each with their own set of radial wires lying on the ground. This basic unit has been thoroughly characterized and was described in my July 2011 *RadCom* article. See Note 1. Because the *NEC2* code cannot model structures with ground based radial conductors, the ground system has been modeled as a hybrid ground with two concentric ground regions, each with defined electrical parameters. It is convenient that modeling of hybrid concentric grounds is a feature of *4NEC2*.

The electrical parameters of the outer zone, extending to infinity, were obtained by measuring the terminal parameters and resonance frequency of one of the monopoles without any radials at all. Optimization was carried out using the simulator to adjust the ground parameters until the required terminal parameters were obtained. See Note 1.

The central region, a quarter wavelength in radius, is made quasi-metallic by the radials. The optimizer was used again, in this case with the two-zone model, to adjust the parameters of this inner zone until the measured terminal impedance of the element with its eight radials was obtained,

the outer zone parameters being set at the values that had already been determined. The appropriate two-zone parameters for the hybrid ground are stated in Table 6. They represent the behavior of the monopole with eight radials operating at 21.2 MHz on the imperfect ground.

Figure 10 shows the computed behavior of the antenna on the hybrid ground when driven with a perfectly defined set of drive

currents. It provides a basis for comparison when the actual currents were used. The actual complex drive current for each element was measured at each directional setting and used in the simulation to arrive at calculated polar patterns for the four directions, again on the hybrid ground. The normalized currents, which sometimes deviated from the intended values, are listed in Table 7.

The modeled polar patterns using the

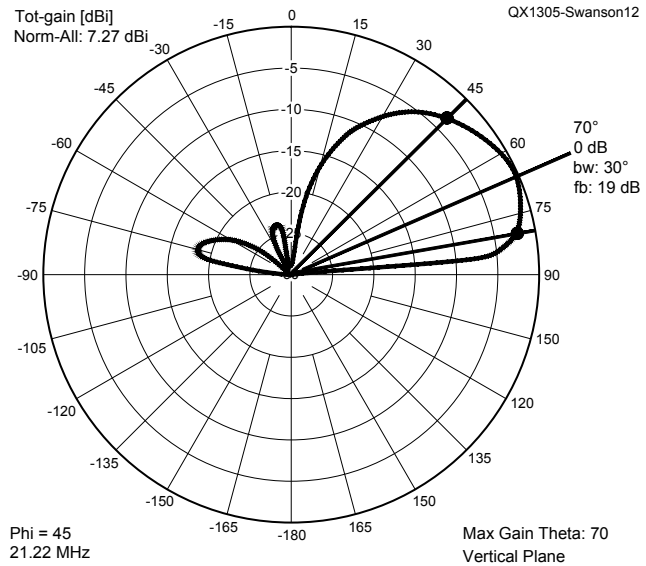


Figure 12 — Computed vertical radiation pattern with the actual driving currents using the hybrid ground.

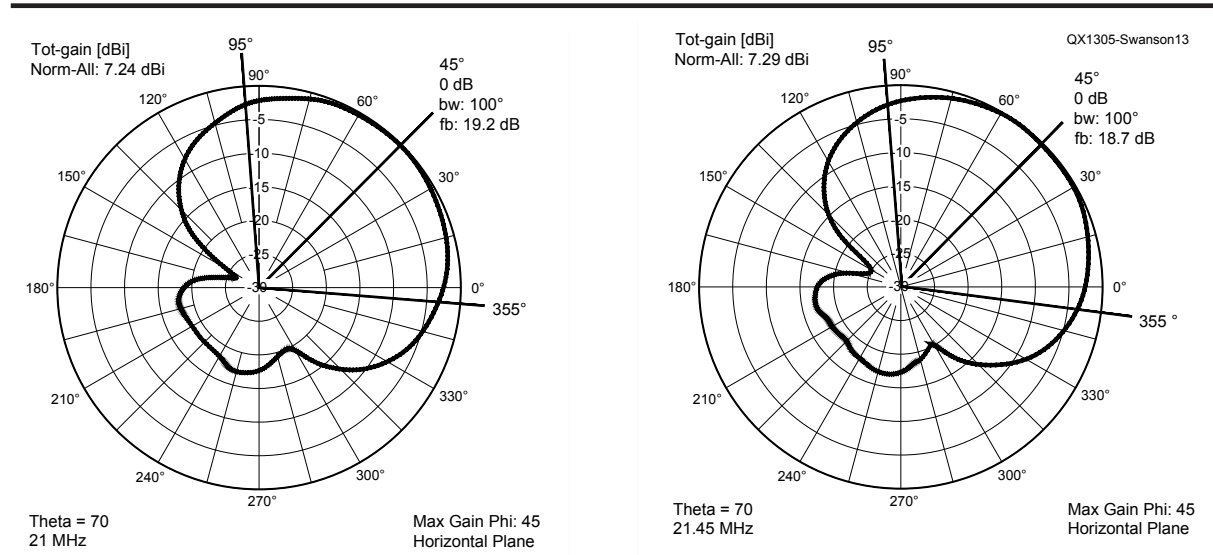


Figure 13 — The computed horizontal radiation patterns at the extremities of the 21 MHz band using the hybrid ground.

actual drive currents are shown in Figure 11. There is good agreement between these and the measured plots shown in Figure 8. The front to back ratios span the range from 20.6 to 14.7 and are somewhat smaller and less consistent than the actual values. See Figure 8. The beamwidths are in very good agreement with the measurements. Predicted, but not measured, are the forward gains; these are very similar for the four directions, ranging between 7.00 and 7.36 dBi.

The simulation also provides the elevation of the main lobe above the horizon. Although the only pattern presented here — Figure 12 — is for the NE direction the elevation is close to 20° for all beam headings, with a half power vertical beamwidth of 35°.

A very useful indication of the insensitivity to frequency as the 21 MHz band was traversed is provided by the two NE polar patterns shown in Figure 13. This 2% change of frequency caused a change of only 0.5 dB in the front to back ratio and a negligible change in gain of only 0.05 dB.

### Discussion

The antenna behavior on the hybrid ground, but with a perfect set of drive currents, provides a basis for discussion. See Figure 10, which shows that the forward gain is 7.32 dB, the highest attainable value on this practical ground. The behavior in the rear section is determined by the degree of cancellation of the fields from the four elements. It is here that small differences between the field components become apparent and reflect imperfections in the array and its feed system that result in errors in the drive currents.

Despite the discrepancies between the actual drive currents and those intended, they were used in the simulation and the predicted gain values come close to the maximum attainable on the hybrid ground. Compare Figures 10 and 11. The observed front to back ratios were at least 20 dB on this ground and Figure 10 suggests that an improvement by 3 to 4 dB might be achievable. Although appreciable, it is questionable if this improvement would have practical value when the ratio was already 20 dB. It is interesting to note that with a perfectly defined set of drive currents and a perfect ground the best possible gain and front to back ratio would be 10.8 dBi and 29.8 dB.

In Table 5 the off-axis element drive currents are highlighted. They are invariably low compared with the on-axis elements. It should be relatively easy to correct this by increasing the number of secondary turns of

the appropriate transformer and should lead to an improved front to back ratio. This will undoubtedly disturb the transformation of the central element feeder impedances, however, and measures will be needed to ensure that the transformed impedances combine in parallel to approach 50 Ω.

Harder to understand are the off-axis current asymmetries. These elements are driven from the same secondary winding through two feeders that have the same lengths and should deliver very similar drive currents. The asymmetries are not reversed or replicated when the beam heading is oppositely directed. Had they been due to different local environments for the pair of axis elements the asymmetry would have persisted when the feeders were interchanged, but this did not occur.

No account was taken in the design of the delays introduced by the switching matrix. Although they would be relatively small, the path lengths through the matrix were not equal for the four signals and depended on the pattern of switch closures. It is possible that this is a source of asymmetry and a careful study of these pathways is needed.

There are strong indications from modeling on a practical ground that the forward gain is between 7 and 8 dBi, but this needs to be confirmed by measurement and will require reference to a standard antenna.

### Conclusions

An electronically steerable four square phased array antenna has been realized for use at 21 MHz. The antenna has a diagonal fire configuration with a main beam that can be switched rapidly to one of four orthogonal directions. The antenna makes use of a novel feed system that uses two RF transformers to ensure that the element feeders are driven with the same voltage and phase. The overall loss from the array feed point to the element inputs was 2 dB. This elaboration of the Christman method allows it to be used universally in situations where only equi-phase points exist on the set of feeders.

On an imperfect practical ground the antenna achieved a measured front to back ratio in excess of 20 dB — a value consistent with listening and on-air use that showed differences of between 3 and 4 S units. I have not yet measured the forward gain; however, based upon computer modeling using a hybrid model to represent the practical ground, its gain is estimated to be 7 to 8 dBi. The horizontal and vertical half power beamwidths are 90° and 35° respectively with a vertical beam elevation of 20°. Modeling has also predicted that the

antenna characteristics vary only slightly across the operating bandwidth of 0.45 MHz at 21 MHz. The directional properties of the antenna accorded well with computer modeling, which points the way to further improvement.

The performance of another four element beam, the four-element Yagi, provides an interesting comparison. Modeling of the Yagi indicates a gain of 11 dBi, a front-to-back ratio of 20 to 25 dB and a half power beamwidth of 60°. Practical corresponding values claimed for the four element 21 MHz SteppIR antenna are 10.2 dBi, 27 dB and 60°.

In comparison with the Yagi, the diagonally firing four square antenna at 21 MHz is likely to have a gain 2 to 3 dB lower; it has a similar FB ratio and a half power main beamwidth that is 30° wider. While there is scope for further refinement of this implementation of the four square antenna it is doubtful if the resulting improvements would significantly affect the gain and beamwidth but could improve the observed front-to-back ratio by 3 to 4 dB.

*J. Garth Swanson was born in 1941 and obtained a full transmitting license at the age of 16. He graduated from Imperial College London with a BSc (Engineering) in 1963 where he was awarded a PhD in Electrical Engineering in 1967.*

*He then worked at the Westinghouse Research Laboratory in Pittsburgh, PA for four years, working on thin film electronic devices. On returning to the UK he spent a year in industry and then moved to a career in academia. Garth eventually became chairman of the Electrical Engineering department at King's College in the University of London, where he was a Professor of Physical Electronics with research interests in electronic and optoelectronic materials. He has spent two sabbatical periods at French research laboratories. On his retirement in 2001 he became Professor Emeritus at King's College and has pursued an interest in phased array HF antennas.*

### Notes

<sup>1</sup>Garth Swanson, G3NPC, "The Ground Mounted Quarter Wave Vertical Antenna," *RadCom*, July 2011, pp 60-64.

<sup>2</sup>John Devoldere, ON4UN, *Low-Band DXing*, 2nd edition, ARRL, 1995.

<sup>3</sup>Al Christman, KB8I (now K3LC), "Feeding Phased Arrays — An Alternate Method," *Ham Radio*, May 1985, p.58.

<sup>4</sup>ARRL *Antenna Book*, 16th edition, 1991.

<sup>5</sup>SteppIR Antennas Inc, 2112 116th Ave NE, Bellevue, WA, USA. [www.steppir.com/4-element-yagi](http://www.steppir.com/4-element-yagi)

# Diary

August 6th, Club Night: BBC Outside Broadcasting - Tony Crake G00VA

August 12th, 80m Club Sprint CW 20:00 - 21:00 QRG 3.520-3.560MHz

August 13th, Committee Meeting - G3ZBU

August 20th, Social Evening: The Countryman - Shipley  
[www.countrymanshipley.co.uk](http://www.countrymanshipley.co.uk)

August 27th, 80m Club Sprint SSB 20:00 - 21:00 QRG 3.600-3.650 & 3.700-3.775MHz

August 30th, The Milton Keynes Rally - Hammond Park 10:00  
[www.mkars.org.uk/mkars/rally](http://www.mkars.org.uk/mkars/rally)

September 3rd, Club Night: To Be Announced

September 5-6th, SSB Field Day

For details on the above contests use this link and follow to the appropriate section  
<http://rsgb.org/main/radio-sport>

All above times are BST

Committee/Club Meetings and Socials start at 20:00 except



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FT-857...All bander HF/VHF/UHF mobile.£689.95  
FT-817ND...Top selling all mode portable TX.£524.95  
FT-450D...100W HF/6m with ATU/DSP.....£639.95  
FT-7900E...Twinband 2m/7cms mobile.....£219.95  
FT-2900...High power 75W 2m mobile.....£149.95

## nevada® Power Supplies



**Nevada PS-08**  
6-8 amp linear PSU  
with meter & cigar  
socket

**£34.95**

- Input power: 230V 50Hz
  - Output voltage: DC 13.8V
  - Output current: 6A~8A Max
  - Dimensions: 140 x 110 x 250mm WHD
  - Weight: 4kg
- PS-40M...35-40 amp Linear Supply...£129.95 £116.95  
PS-30M...25-30 amp Linear Supply.....£99.95  
PS-30...25-30A Switch Mode Supply.£89.95 £79.95  
PS-30H...25-30A Switch Mode Supply.£79.95 £69.95  
PSW-50...40-50A Switch Mode.....£139.95 £125.95  
PSW-07...Switch Mode Supply.....£29.95 £26.95  
PSW-04...Switch Mode Supply.....£24.95 £22.95

## nevada® Antennas



**KX-3300**  
Folded  
Dipole Kit  
1.8-30MHz

**£134.95**

- GP-2500F...broadband 3.5-57MHz fibregl...£279.95  
GP-2500A...broadband 3.5-57MHz Alumin.....£259.95  
HVU-8...8 band base/portable 3.5-433MHz.£199.95  
MA-3800...7-433MHz portable/mobile ant...£69.95  
8010...Special Windom hi power 132ft...£99.95  
4010...Special Windom hi power 66ft...£79.95  
X-200...145/433MHz 2-piece fibregl...£99.95  
X30-RADAR100...1090MHz receive fibregl...£69.95  
X-50...45/433MHz 1-piece 1.7m lth...£69.95  
X-30...145/433MHz 1-piece 1.3m lth...£59.95  
NEV4M-RING...4m(70MHz) 5/8wave vertical.£57.95  
NEV-4END...4m(70MHz) end fed vertical...£49.95  
G5RV\_F\_POL...full size 102ft polyweave...£37.95  
G5RV\_H\_POL...half size 51ft polyweave...£29.95  
G5RV\_F\_HAR...full size 102ft hard drawn...£26.95  
G5RV\_H\_HAR...half size 51ft hard drawn...£19.95

## nevada® Cables



- Ecoflex 15**  
per metre...£5.99 price per 102m drum...£539  
PL259 connector (Part: 7350).....£8.95  
N type connector (Part: 7395).....£9.95
- Ecoflex 10**  
per metre...£2.89 price per 102m drum...£289  
PL259 connector (part: 7378).....£5.95  
N type connector (part: 7367).....£6.50  
BNC type connector (part: 7379).....£6.50
- Aircell 7**  
per metre...£1.99 price per 102m drum...£179  
PL259 connector (part: 7390).....£2.65  
N type connector (part: 7392).....£5.25  
BNC type connector (part: 7391).....£5.25
- Aircell 5**  
per metre...£1.39 price per 102m drum...£125  
PL259 connector (part: 7760).....£2.25  
N type connector (part: 7700).....£3.95  
BNC type connector (part: 7720).....£3.25

### OTHER 100M DRUMS

- Westflex 103...Ultra low loss...£139.95  
RG-213™...Low loss...£89.95  
RG-213U...Mil spec...£116.00  
RG-Mini 8...Super XX...£59.95  
RG58/CU...Mil spec...£39.95  
450 Ohm...Twin feeder...£89.00  
300 Ohm...Twin feeder...£76.50  
Coated flexweave...Antenna wire...£59.95

## nevada® Antenna Wire

Military style, low visibility, antenna wire, uses central fibres of Aramid (Kevlar) for incredible strength. With green outer jacket for low visibility.



- Nevada 28...2.8mm 2kW per metre...£0.99  
Nevada 28D 2.8mm 2kW 100m Drum...£89.95  
Nevada 32...3.2mm 5kW per metre...£1.20  
Nevada 32D 3.2mm 5kW 100m Drum...£110

## MASTRANT

### M-Series

revolutionary high-strength guy rope using 'Dyneema Max' technology

#### 100m Drums

- M2...2mm 240kg B/s...£37.95  
M3...3mm 100m 390kg Drum...£58.95  
M4...4mm 900kg B/s...£125.95  
M5...5mm 1150kg B/s...£189.95  
M6...6mm 1850kg B/s...£237.95  
M8...8mm 2600kg B/s...£336.95



#### 100m Drums

- P2...2mm 100kg B/s...£16.50  
P3...3mm 200kg B/s...£24.95  
P4...4mm 400kg B/s 100m Drum...£34.95  
P5...5mm 500kg B/s...£46.95  
P6...6mm 850kg B/s...£84.95  
P8...8mm 1,300kg B/s...£99.95



**NOW AVAILABLE IN 100 ft drums**



- M-2...2mm 240kg B/s 31m Drum...£11.95  
M-3...3mm 390kg B/s 31m Drum...£18.50  
P-4...4mm 400kg B/s 31m Drum...£10.95

## LDG



**Z11-Pro2**  
(160 - 6m) 125W

**£167.95**

- AL-100...NEW Auto Tuner for Alinco...£149.99  
AT100 Pro II(160-6m) 125W...£209.95  
AT897 Plus...for Yaesu FT897...£187.95  
AT1200...for FT450/FTDX1200...£199.95  
IT100...for Icom Models 125W...£167.95  
RT100...100W Remote Tuner...£189.95  
YT 100...Yaesu Models 125W...£177.95  
Z817...QRP for FT817 160 - 6m...£124.95  
Balun 1:1 or 4:1...200W Power Handling .£34.95

MONDAY - FRIDAY 9AM - 5.30PM

# www.nevadaradio.co.uk

UNIT 1 FITZHERBERT SPUR FARLINGTON PORTSMOUTH PO6 1TT PHONE 023 9231 3090

# Club Champs 2015 - Horsham Club Scores

Issue: 28th July 2015 Rev A

PARTICIPANTS	FEBRUARY			MARCH			APRIL			MAY			JUNE			JULY			TOTAL POINTS	%	MODE TOTALS		
	SSB	Data	CW	SSB	Data	CW	SSB	Data	CW	SSB	Data	CW	SSB	Data	CW	SSB	Data	CW			SSB	DATA	CW
G3LET Pete			939						831	587	1000	388							3745	8.8	975	0	2770
G3OGP Robin			588		288	343	432	566	577	463	110		373						3740	8.8	1268	964	1508
G3SWC Bryn	650	723	847	967	723	869	901	889	817	884	688	868	701						10527	24.8	4103	3023	3401
G3VQO Les			448	196	370	476	192		406			341	213						2642	6.2	601	370	1671
G3WZT John			870			745			725										2340	5.5	0	0	2340
G3ZBU Alister	358	708	725	496	916	664	550	927	697	496	945		694						8176	19.2	2594	3496	2086
G4LRP Adrian	204			512			342	516		537	313								2424	5.7	1595	829	0
G4TPO Steve	654			603		146	585			437	240		296						2961	7.0	2575	0	386
G7DFV Gavin				132			207						30						369	0.9	369	0	0
G8CKT Mike	299	443	221		614	190	360	289		355	378								3149	7.4	1014	1724	411
G8HQJ Barry	445			231				467											1143	2.7	676	467	0
M0GJH Andrew													403						403	0.9	403	0	0
M0GUZ Dominic													164						164	0.4	164	0	0
M0TWM Jon	197	501																	698	1.6	197	501	0

<b>Mode totals</b>	2807	2375	4638	3137	2911	3433	3569	3654	4053	3759	2434	2449	3262	0	0	0	0	0	0	<b>42481</b>		<b>16534</b>	<b>11374</b>	<b>14573</b>
<b>Month totals to date</b>			9820			9481			11276			8642			3262			0				39%	27%	34%

**Contest dates/times** 2nd 11th 19th 19th 2nd 11th 15th 23rd 6th 4th 13th 21st 18th 1st 10th 15th 23rd 6th - Start times are all 2000 clock time, ending 2130 local

HARC overall position after above results announced	1/26	1/29	1/31	2/34	1/32	1/32	2/36	2/36	1/35	2/36	2/37	2/37	2/37	← <b>HARC POSITION Steady at No. 2</b>		
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**All entries to be uploaded with the Contest Robot at:-** [www.rsgbcc.org/cgi-bin/hfenter.pl](http://www.rsgbcc.org/cgi-bin/hfenter.pl) Latest robot entries may be viewed at:- [www.rsgbcc.org/cgi-bin/hfposted.pl](http://www.rsgbcc.org/cgi-bin/hfposted.pl)

**Contest results may be viewed at:-** <http://www.rsgbcc.org/hf/> **Contest rules may be viewed at:-** <http://www.rsgbcc.org/hf/rules/2015/r80mcc.shtml>

**This update: May CW and June SSB added.**

**This contest series has now ended and the full results are awaited. HARC will however be placed 2nd - well done everyone! Dependant on the RSGB, the full results should be available next month.**

**Don't forget that the 1 hour Sprint contests start in August - 12th CW & 27th SSB - full details here <http://www.rsgbcc.org/hf/rules/2015/rsprint.shtml>**

THE TOP EIGHT CLUBS - LOCAL CLUB SECTION out of approx 37 participating in this section (84 total all club participation)					
Pos	Club Name	Total	SSB	DATA	CW
1	Tall Trees CG	48541	21,405	13785	13,351
2	Horsham ARC	42481	16,534	11374	14,573
3	RAF Waddington ARC	28175	13,094	8385	6,696
4	Torbay ARS	28108	10,580	9012	8,516
5	Sheffield & DWS	22206	13,134	5037	4,035
6	Reading & DARC	21123	6,211	4454	10,458
7	Weston-super-Mare	17507	6,507	4445	6,555
8	Scunthorpe Steel ARC	16470	4,016	6480	5,974

(all results data courtesy of RSGB website)

prep by: G3SWC