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Class licence: ready or not!

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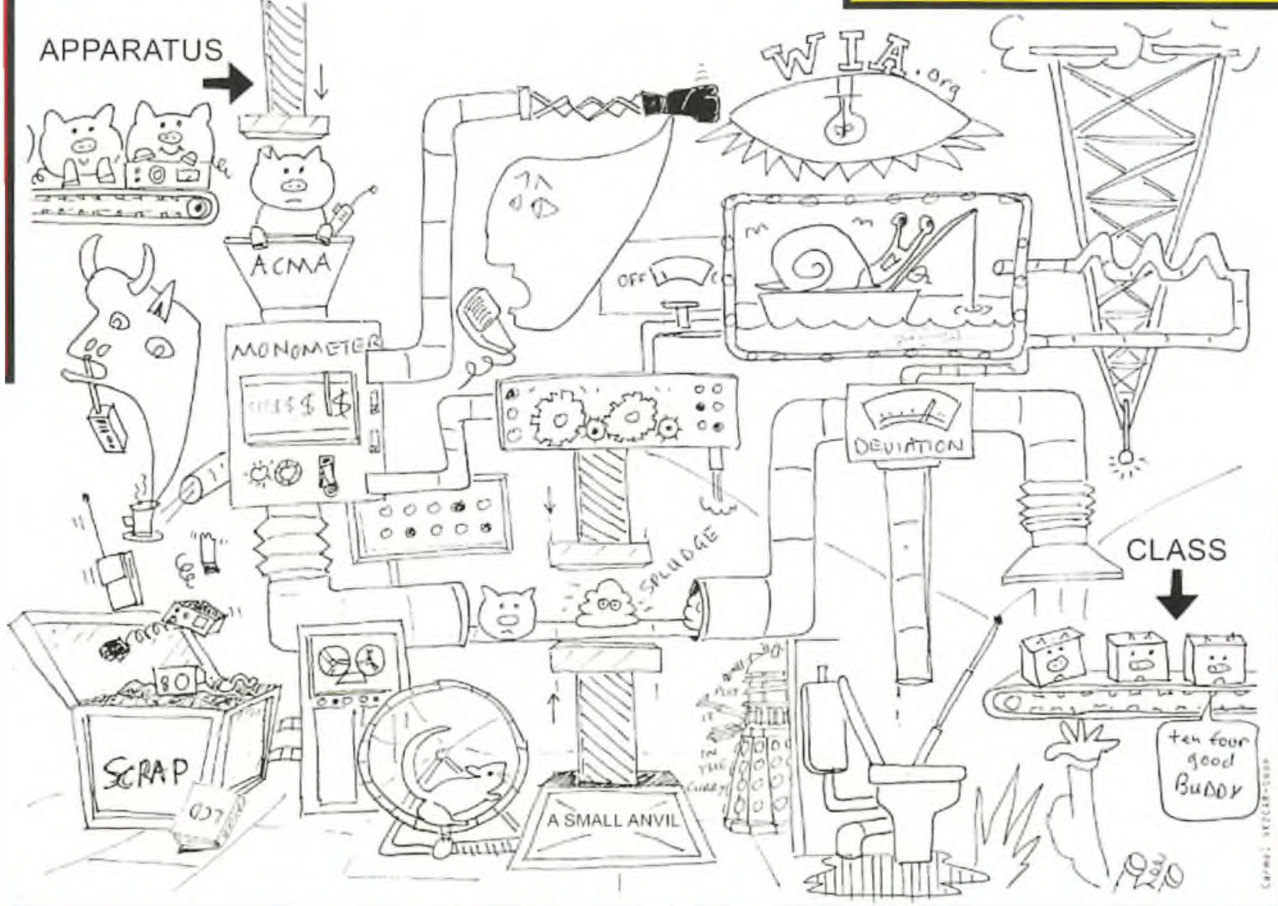

▶ Confounded by coils?

▶ Contest Calendar 2023

Season's Greetings

Volume 90 ◀ Number 6 ▶ 2022 Price: $14.50 incl GST

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AMATEUR Radio

Serving Australian radio amateurs since 1933

The Journal of the Wireless Institute of Australia

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Advocacy Education Support

Editorial

Production deadlines
All articles, columns, Hamads, and advertising bookings for Volume 91, No. 1 – 13 January 2023.

Columns

Collins S-line conservation and conversion - Job 2, by Phil Fitzherbert VK3FF, will appear in - Issue 1 for 2023.

This issue's cover: Cartoon by the incomparable Carmel VK2CAR. Design by Sergio VK3SO. Read all about it on Page 4.

General

Technical

NEXT ISSUE: Antennas & Propagation

Contributions to Amateur Radio

Amateur Radio is a forum for WIA members' amateur radio experiments, experiences, opinions and news. Manuscripts with drawings and/or photos are welcome and will be considered for publication. Articles attached to email are especially welcome. The WIA cannot be responsible for loss or damage to any material. Information on house style is available from Phil Fitzherbert.

Back Issues
Back issues are available directly from the WIA National Office (until stocks are exhausted), at $8.00 each (including postage within Australia) to members.

Photostat copies
If back issues are unavailable, photocopies of articles are available to members at $2.50 each (plus an additional $2 for each additional issue in which the article appears).

Amateur Radio Service

A radiocommunication service for the purpose of self-training, intercommunication and technical investigation carried out by amateurs; that is, by duly authorised persons interested in radio technique solely with a personal aim and without pecuniary interest.

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Editorial

Roger Harrison VK2ZRH

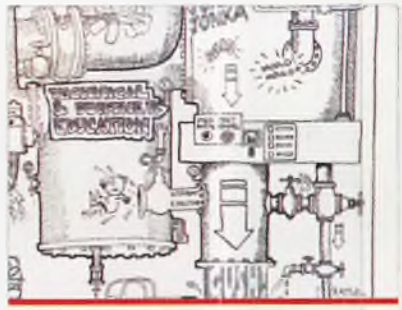
Art, science, technology and tomfoolery

The ACMA's proposed Class licensing for amateur radio will be a quantum step in the evolution of amateur licensing in Australia, such as we have not seen previously.

Accordingly, this called for a radical design concept for our cover, this issue. This has been addressed in two ways. Firstly, the central illustration of the issue at hand, with an exceptional *cartoon* by Carmel Morris VK2CAR. And secondly, an outstanding *graphical design* to frame the cartoon and stop readers turning the page – just for a moment, to contemplate what's happening in the world of amateur radio in Australia.

The concept and style of Carmel's cartoon is based on another visual meme that satirises the technical education system, originally published in a local electronics magazine. That was by Brendan Akhurst, once a policeman, who gained notoriety for the cartoons he produced for local technical publications that I edited in bygone decades, *CB Australia* and *Electronics Today International* (ETI). A detail from that cartoon is reproduced here.

Carmel has reprised Akhurst's concept of manufacturing machinery re-shaping students – in this case, rotund hams with apparatus licences are satirically refashioned into "cubic buddies" with Class licences. In addition, she has extended the illustrative metaphors with visual references to Picasso's *Guernica*. Observant readers will find the references to Van Gogh and Terrence Nation.



Akhurst, on education (detail).

Mondriaan; exemplar of *De Stijl*.

The graphical design concept framing Carmel's cartoon is adapted from the work of Dutch artist, Pietr Mondriaan, by our own highly skilled graphics artist, Sergio Fontana VK3SO. Mondriaan was co-founder of the *De Stijl* ('The Style') movement. From a century ago, he created a series of works that reduced scenes to the essentials of form and colour, simplifying compositions to vertical and horizontal, using only black, white and primary colours, and avoiding symmetry. Sergio's cover design is based on Mondriaan paintings such as the one shown here: *Composition with Large Red Plane, Yellow, Black, Grey and Blue* (public domain; Wikipedia).

ARRL releases 100th Handbook edition

Titled *The ARRL Handbook for Radio Communications*, the League has published it in a hardback "Collector's Edition" and a 6-volume paperback set, as well as e-book editions.

Handbook 100 is by far the most extensively revised and expanded edition in recent years, says the ARRL. It includes ". . new and revised topics, content, and projects. It is written by radio amateurs who share their experience, learning, and discovery from across the state-of-the-art and emerging technologies," the ARRL claims. Each chapter is authored and edited by experts in the subject.

Key topics cover: radio electronics theory and principles; antennas and transmission lines; signal transmission and propagation; digital modulation and protocols; circuit design and equipment; construction practices (including safe electrical and RF practices).

The chapter on radio propagation is apparently "all-new," covering a wide range of bands and modes. There are new and updated sections on electronic circuit simulation, new material on RFI and using SDR receivers to locate RFI sources. This 100th edition offers a balance between being a comprehensive RF engineering reference and a practical guidebook.

Each chapter covers the most up-to-date knowledge representative of the wide and ever-expanding range of interests among radio amateurs. There are practical, hands-on projects for all skill levels — from simple accessories and small power supplies to legal-limit amplifiers and high-gain antennas.

The hardcover Collector's Edition runs to 1280 pages; list price is US$79.95. The 6-volume softcover set totals 1344 pages; list price US$69.95. Check out: www.arrl.org.

30 years of texting

Unbelievable! It's 30 years since the first text message was sent! How did we live without SMS?

It's almost 30 years since the first text message was sent by 22-year-old UK software programmer, Neil Papworth, on 3rd December 1992, wishing his colleague 'Merry Christmas.'

Every day, nearly 20 billion text messages are sent worldwide, with more than 3000 emojis to choose from. Texting (SMS) is the single most used feature on a smartphone.

A new book, *Exploring Language in Global Contexts*, co-authored by University of South Australia academic, Dr Antonella Strambi, and Flinders University lecturer Dr Olga Sanchez Castro, explains how technology and young people have changed the way we communicate.

Originally limited to 160 characters, messages are now media-rich, including emojis, photos, videos and GIFs. Texting has morphed from private chit-chat to a useful communication tool for business and government.

In amateur radio, text-based WSJT digital protocols, launched initially in 2001, now dominate the bands from 3 to 30 MHz for 'everyday' contacts, and into the VHF-UHF bands, particularly for weak-signal operations.

Entry-level licence for Germany?

News from Germany tells us that a new entry-level 'Class 'N' licence is on its way.

Germany currently has two amateur licence grades: Class A – providing all bands, 750 Wpep and remote operation permitted; Class E – providing VHF-UHF-SHF and 'share HF', 100 Wpep.

The Deutsche Amateur Radio Club (DARC) reports that new Class N licensees will have access to the 144 and 430 MHz bands with a 10 Weirp limit, and allows home construction of their equipment.

"The new entry-level class should offer access to amateur radio in particular to young people and older people, in accordance with international requirements," DARC board member Ronny Jerke DG2RON, explained. The legally-stipulated self-build right is not restricted, so even beginners can develop, set up and put into operation radio devices or hotspots themselves.

The press release from Germany's Federal Ministry for Digital Affairs and Transport can be found at https://tinyurl.com/bddmjwjn

Peak in ham licences in Brazil

More amateurs than ever are on the air in Brazil and most of them are entry level operators (Class C licence), according to a recent study by the Jerked Liga de Amadores Brasileiros de Rádio Emissão (LABRE), the national amateur radio society.

The data shows that this year's amateur radio ranks grew by 2.2 percent over last year, with more than 40,000 now holding an amateur licence.

The state with the most licensees is São Paulo, where more than 10,000 amateurs reside. Likewise, the city of São Paulo has the most amateurs among Brazilian cities – with 2430 operators – followed by Rio de Janeiro, with 1521.

The number of stations also grew according to the data: There were about 60,000 stations in 2021. The number now exceeds 63,000, counting repeaters, mobile, fixed, beacons, and terrestrial stations – with more than 17,000 of them in the state of Sao Paulo. *Amateur Radio Newsline.*

Amateurs involved in scientific experiments

The High-frequency Active Auroral Research Program (HAARP) conducted a series of experiments in late October in which amateurs were invited to participate. A section of the HAARP antenna system is shown above.

During the 10 days over 19-28 October, amateurs were asked to monitor the times and signal quality of specific transmission experiments, including moonbounce, Jupiter bounce, HF ocean scatter and ionosphere satellite interactions.

"The October research campaign is our largest and most diverse to date, with researchers and citizen scientists collaborating from across the globe," said HAARP Program Manager Jessica Matthews.

HAARP is a scientific endeavour aimed at studying the properties and behaviour of the ionosphere. Visit: www.gi.alaska.edu

5G health impact unlikely

A team of scientists in Melbourne involved in a program of measuring the output from 5G cellphone towers have expressed confidence that upgrades to the cellular network do not pose a health risk.

In a program aimed at countering misinformation about the continuing rollout of the 5G cellphone network, technical experts from the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has surveyed the output from 50 5G sites across Melbourne.

The 5G rollout has been dogged by controversial protests about the location of towers, amongst other issues.

The Australian radiation standard sets a limit of between 2 W and 10 W per square metre, on average. This is based on the International Commission on Non-Ionising Radiation Protection (ICNIRP).

ARPANSA has found the Melbourne 5G measurements are between 700 and 2000 times lower.

Dr Stuart Henderson of ARPANSA said that "there is a lot of scaremongering out there about 5G and radio waves, but it's misplaced."

Professor of electrical engineering at the University of Melbourne, Stan Skafidas, said "all the evidence and studies suggest there are no ill effects.

"All the evidence suggests it's safe, but as a scientist you always have to keep an open mind," he said. Visit: www.arpansa.gov.au

Solar cycle 25 rising fast, peaking sooner?

Roger Harrison VK2ZRH

The consensus forecast of solar scientists a few short years ago had it that Solar Cycle 25 would be similar to the lacklustre Cycle 24. But now, it seems, there's a surprise looming.

To the disappointment of amateurs the world over, Cycle 24 peaked in April 2014 with a smoothed sunspot number (SSN) of 116.4 [1]. The consensus forecast for Cycle 25 is that it will peak in October 2023 with a smoothed sunspot number of 115.0, as developed by the expert panel convened by the US's National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA).

Australia's Space Weather Services (SWS), which tracks solar indices (sunspot numbers and 10.7 cm solar flux values), follows the NASA/NOAA trend, as seen in **Figure 1**, forecasting a maximum SSN of 115 in October 2023 [5, 6].

Before getting into what the forecasters are saying and what the Sun is actually doing, let's have a little recap on solar cycles.

SOLAR CYCLE FORECAST

Cycle	Solar_Min Year	Solar_Min Mth	Solar_Max Year	Solar_Max Mth	Max_SSN	Cycle_Length Years	Cycle_Length Mths	Min_to_Max Years	Min_to_Max Mths	Max_to_Min Years	Max_to_Min Mths
25	2019	Dec	2023	Oct	115.0			3.8	46		

Figure 1. Space Weather Services' Solar Cycle Forecast as at 01 Nov 2022 (10:09 UT). www.sws.bom.gov.au/Solar/1/6

Starting at the dip!

Sunspot cycles are measured from minimum to minimum. In terms of the peak amplitude and the period, *every one is different!*

The mean period of sunspot cycles is 11.1 years, 133 months. The shortest was 105 months – nearly 9 years – and as long as 168 months – 14 years! [1]. The longest in recent experience is solar cycle 23, which lasted 12.3 years – 148 months! – beginning in August 1996 and ending in December 2008.

We hit the last solar minimum in December 2019.

On the up

As seen in **Figure 2**, the rise of a sunspot cycle is steeper than the decline. The average period of the rise is around 4.8 years, but can be as short as 3 years. The average length of the declining phase is about 6.2 years, but can be longer than 7 years. For the mathematicians, the rising phase is a cubic function:

$$f(x) = ax^3 + bx^2 + cx + d$$

while the decline is an exponential function, $y = e^{-X}$ [1].

Since Solar Cycle 19 (1957-58), all following cycles have had double humps, as the appearance and decay of spots in the northern and southern hemispheres got out of sync.

The solar cycle is actually 22 years long, known as the Hale cycle, after the scientist who described it. The Sun's magnetic field flips the north and south poles when the sunspot cycle is near maximum, returning to its original state after two sunspot cycles [3].

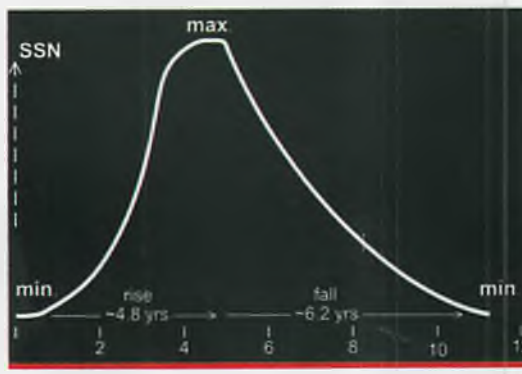


Figure 2. From minimum, the sunspot cycle rises steeply to the peak, then declines slowly.

What's happening

In announcing the start of Solar Cycle 25 in September 2020, NASA/NOAA's Solar Cycle Prediction Panel said Cycle 25 is anticipated to be as strong as Cycle 24, a below-average cycle, and would peak in July 2025.

Never mind that, moving forward to the present, the solar cycle progression figures reported by NASA's Space Weather Prediction Center (SWPC) in October 2022, shows Cycle 25 charging ahead of the prediction, as seen in **Figure 3**. At October 2022, actual SSN was 95.4, nearly double the forecast of 54.5.

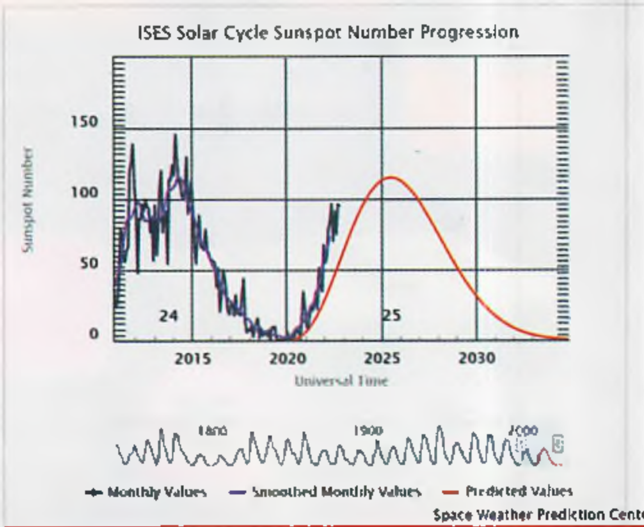


Figure 3. The Sun is not sticking to the rule book! The progression of actual solar activity – the jagged black line – is greater than forecast, with the SSN progression – blue line –significantly ahead of the forecast – red line.

Continued on page 43

The Wireless Institute of Australia

ACN 004 920 745

Election of Directors - Call for Nominations

Pursuant to clause 14.1 of the Constitution the WIA Board has determined that the election of directors shall be conducted by ballot.

Four directors retire at the conclusion of the next Annual General Meeting which will be held in May 2023, namely Scott Williams VK3KJ, Peter Clee VK8ZZ, Greg Kelly VK2GPK and Peter Schrader VK4EA. Each retiring director is eligible for re-election.

Nominations are called for from persons seeking election as a director of the WIA.

A director must be a voting member of the WIA and must hold an Australian amateur radio license and a Company Director Identification Number.

Any person wishing to nominate as a candidate for election as director of the WIA must deliver or cause to be delivered to the Returning Officer by not later than 2.00pm on 16th December 2022:

> A statement signed by the candidate signifying their willingness to be a candidate for election as a director together with; the full name, age, occupation, membership number, callsign of the Candidate and Company Director Identification Number, and such other biographical details or other information as the candidate wishes to accompany the ballot papers, but in all not exceeding 250 words.

A nomination form is available on the WIA web site.

Candidate information will be posted online and emailed to members. Members are requested to ensure that their email address is correctly recorded on the WIA membership register.

Delivery to the Returning Officer may be made by hand when the WIA national office is open at:

Unit 20
11-13 Havelock Road
Bayswater
Victoria 3153

or by mail to:
PO Box 2042
Bayswater
Victoria 3153

Nominations received by facsimile or by electronic means cannot be accepted.

Authorised by
John Marshall
WIA Returning Officer

Confounded by coils?

A review of some single-layer solenoid inductance calculations

Dale Hughes VK1DSH

Recently, I needed a 250 μH air-cored solenoid-style inductor and used a web-based calculator to design the coil; the number of turns, coil diameter and length being the design parameters. The calculator supplied the answer, and I made the coil, then measured the inductance – it was only about 150 μH instead of the 250 μH that I needed! What had gone wrong?

The search for the answer led to some interesting insights into calculating inductance that will be explained in the following text.

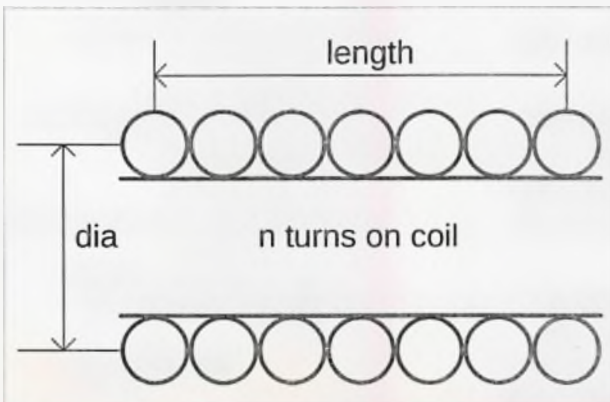


Figure 1: Geometry of a typical single-layer close-wound solenoid inductor, note that the dimensions are measured from the centre of the conductors. For both close-wound and spaced coils, the overall end-to-end length must include all the turns.

Noting that some texts and websites use *n* for the number of turns on the coil, while others use *N* turns/unit length, the 'first principles' formula for a single-layer 'long' inductor of the type shown in **Figure 1** is (Ref. 1). This equation applies to both close-wound and spaced coils:

$$L(H) = \frac{\mu_o \mu_r n^2 A}{l} \text{ or } L(H) = \mu_o \mu_r N^2 A l$$

Where

L is the calculated inductance of the coil in Henries

μ_o is the permeability of free space – *defined* as 4π x 10^7 henry/metre

μ_r is the relative permeability of the core material, which is very close to 1 in the case of air-cored coils and will be assumed to be 1 in the calculations that follow

n is the number of physical turns on the coil and *N* is turns per unit length

A is the cross-sectional area of the coil in square metres; i.e, $A = \pi d2/4$

l is the length of the coil in *metres*

But how long is a 'long' coil? I turned to the venerable *Radiotron Designers Handbook* (Ref. 2), and it provided the answer plus a chart giving correction factors based on the work of Professor Nagaoka.

It turns out that that coil geometry i.e., the diameter to length ratio (*d/l*), has a big effect on the calculated inductance and this was known to our forefathers. The definitive work on this was first published in 1909 by Prof Nagaoka (Ref. 3) who analysed the situation, and more importantly, produced a table of correction coefficients (*k*) for diameter to length ratios covering 0.01 to 10.

The answer to my question about how long is 'long' is given by Nagaoka's correction for an infinitely long skinny inductor (*d/l* = 0) *k* = 1.0 and for *d/l* = 0.01 i.e, 100 times as long as it is wide, *k* = 0.995769.

So, a 'long' coil in the context of the fundamental equation is at least 100 times as long as it is wide; not very convenient… The end result is that, for more useful length inductors, coefficient *k* is a number less than 1. Therefore, a more accurate equation to calculate inductance is:

$$L(H) = \frac{\mu_o k n^2 A}{l} \qquad \text{[Equation 1]}$$

Or, the number of turns for a given inductance is:

$$n = \sqrt{\frac{L(H) l}{\mu_o k A}}$$

Where *k* is the coefficient for the coil geometry and the other variables are described above.

While this gives the correct inductance or required turns, you need the tabulated list of coefficients *k*, or a suitable nomograph, to get the value of *k*. This is not useful if you want to automate the calculation process using a spreadsheet or computer application.

I did consider using the equations in Nagaoka's paper for *k*, but they are quite complex and don't appear to be easily implemented in a spreadsheet.

EXPLAINER

Wayward windings

Methods of winding inductors (or coils) used in RF circuitry have been developed to achieve certain desirable characteristics, to minimise one thing or to maximise another.
The single-layer, air-cored solenoid inductor is the simplest form, in which insulated wire is wound on a supporting cylindrical former, with the turns being close-wound or equally-spaced. With wire of sufficiently heavy gauge, self-supporting solenoid coils can be made. The simplest of these is just a loop.
Where coils are supported on a former, efforts may be made to ensure that the former is of a low-loss material in a general effort to reduce losses and maximise the inductor's *quality factor*, or Q.
In the early decades of radio technology development, many intriguing winding techniques were developed to minimize inter-winding and end-to-end capacitance of an inductor. The physical goal is almost always the same: try to figure out how to wind the required number of turns of wire while keeping each turn from running parallel to its neighbour.
Each turn of wire in a coil capacitively couples to those next to it. This can have a major effect on the inductor's behaviour. The combination of the coil's intended inductance and the winding's self-capacitance make a tuned circuit and thus a "self-resonant frequency". Often, the goal is to have that self-resonance way beyond the frequencies of interest in the circuit application.
The multilayer solenoid method of winding is avoided, where wire is close-wound down the length of the former, then jumps to a new layer and returns to the starting point, and so on, building layers, as in a relay magnet for example.
Possibly the most widely-used non-solenoid winding style for RF coils is basket winding, also known as honeycomb or, occasionally, scatter winding. These illustrations fill out the scene.

Roger Harrison VK2ZRH

Basket-wound, or honeycomb, coil made with fine Litz wire for a receiver IF transformer (Wikipedia). The winding itself is known in the trade as a "pi, or pie" (hence, "pi-wound"). The wires are laid down in a criss-cross way, reducing the capacitances between turns and layers.

Multi-pi windings: at left is a three-pi honeycomb wound RF choke, often found in the low-power stages of transmitters, and in receivers (surplussales.com). At right is a five-pi progressive-wound RF choke, designed for the DC feed to the plate circuit in an RF power amplifier (eBay). Multi-pi arrangements enable high inductance while maintaining a lower voltage differential per winding. In the progressive-wound RFC, each pi has a different self-resonance arising from the inherent multiple parasitic capacitances. In a multi-band transmitter, the array of self-resonances can be designed to occur outside the operating frequency bands.

The spiderweb coil at left is wound through the radial fingers of the flat former to reduce the inter-turn capacitances. At right, the **basketweave coil**, another method of reducing the capacitances between turns and layers, is arranged to be self-supporting (Wikimedia). These two examples also represent pancake-style coils. In the early days of radio, such coils also served as antennas in broadcast receivers, from crystal sets to superhets.

The pancake coil generally refers to a single layer helical coil (flat spiral) reminiscent of a watch spring (tdk.com). They are also wound with Litz wire. Famously, a pancake coil forms the primary of a Tesla coil transformer high voltage spark generator. Pancake coils find application where strong inter-coil coupling is required. Where a coil is wound such that its diameter greatly exceeds its length, it generally attracts the *pancake coil* label (Ref. 4).

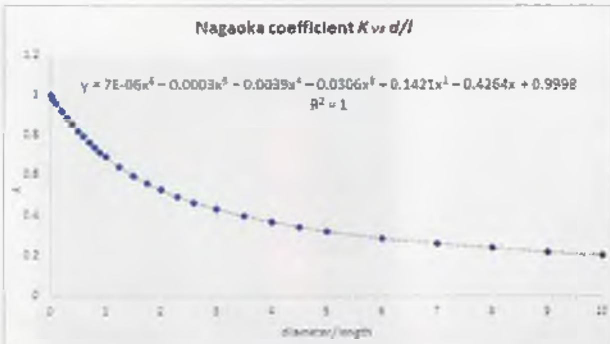


Figure 2: Values of Nagaoka's coefficient *k* over a 1000:1 range for solenoid type inductors with a 6th order polynomial fitted to the values. **Table 1** gives the polynomial coefficients to the necessary level of precision to calculate *k* over the displayed range of *d/l*.

Another solution is to generate a suitable equation from the table of *d/l* coefficients provided by Nagaoka. When the points are plotted on a graph, a polynomial that fits the curve generated by the *d/l* coefficients can be generated, as shown in **Figure 2**. This polynomial has the form:

$$k = A_6x^6 + A_5x^5 + A_4x^4 + A_3x^3 + A_2x^2 + A_1x + A_0$$

where *x* is the calculated or wanted diameter to length ratio (d/l) and the coefficients A0 through A6 are derived using a least-squares fitting process and are listed in **Table 1**.

By using the best-fit polynomial in a spreadsheet or other application, you can easily calculate the coefficient *k* for any *d/l* and then calculate the inductance of a coil using Equation 1.

Coefficient	Value
A_0	0.99977918
A_1	-0.42635193
A_2	0.14205206
A_3	-0.03059726
A_4	0.00389468
A_5	-0.00026333
A_6	0.00000725

Table 1: The coefficients for a 6th order polynomial to fit the tabulated vales of Nagaoka's *k* coefficients. The high degree of numerical precision is required for the polynomial to correctly calculate the coefficient *k* across a wide range of *d/l* values.

But wait! Isn't there another equation for calculating inductance or the number of turns for a required inductance? Yes, there are other methods, and the one most commonly used was developed by H.A. Wheeler in 1928. Again, these equations apply to solenoid coils, with both close-wound and spaced-turns:

$$L(\mu H) = \frac{r^2n^2}{9r+10l}$$

when using *coil radius* and *inches* for dimension (**Ref. 4**), or

$$L(\mu H) = \frac{d^2n^2}{18d+40l}$$

when using *coil diameter* and *inches* for dimension (**Ref. 5**), or

$$L(\mu H) = \frac{d^2n^2}{457.2d+1016l} \quad \text{[Equation 2]}$$

using *coil diameter* and *millimetres* for dimensions (**Ref. 6**). Equation 2 can be transposed to calculate the number of turns for a given inductance:

$$n = \sqrt{\frac{(457.2d + 1016l)L(\mu H)}{d^2}}$$

where the variables are as described in the previous section, except for *r* – the coil radius; the inductance *L* is in microhenries.

However, what is not often stated is that these equations are most accurate when *l/d* > 0.4 (or *d/l* < 2.5) i.e, a coil having a length of at least 0.4 times its diameter; for shorter coils, the accuracy decreases though it may be still acceptable for some applications.

As an aside, I find it quite amazing that these simple equations for inductance solve a complex problem, it would be interesting to understand the insight Wheeler had, or the analysis undertaken, when these equations were developed.

Comparison of methods

The inductance for a range of *d/l* values was calculated using Equations 1 and 2. The difference between the results is shown in **Figure 3**. It can be seen that the difference between the two methods is less than about 1% for *d/l* < 2.5 (or *l/d* > 0.4), which confirms the usage limitations suggested by Wheeler.

However, using the equation outside of this range may still be acceptable if a lower level of accuracy can be tolerated.

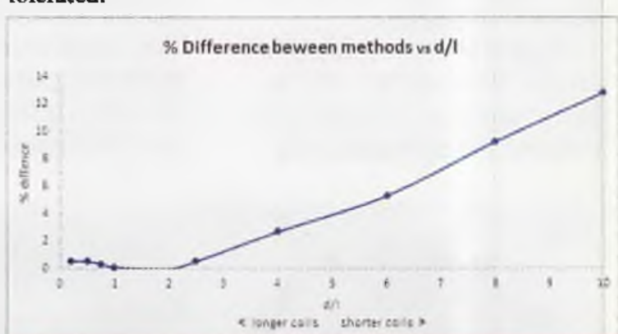


Figure 3: The difference between inductance calculated using Equations 1 and 2 over a range of coil diameter to length ratios. A *d/l* of 0.5 means that the coil is twice as long as it is wide, etc.

Measurement comparisons

Theory is fine, but how does it compare with measurements? The inductance of a number of coils with different geometries and winding styles (see **Figure 4**) were measured and compared with inductance calculated using the methods described above. Table 2 contains the results; considering the range of coil geometries, the results are in good agreement.

Conclusion

Given the importance of inductance in many aspects of radio engineering, it is important to be able to determine what the inductance of a given coil may be, or to be able to make your own single-layer solenoid type inductors for various applications.

The methods here can be used with confidence for most LF, MF and HF applications and can be easily automated if multiple calculations are required, even though, as the frequency of operation increases, issues such as parasitic capacitance and skin depth become important and are hard to include in calculations.

I thank Peter Pokorny VK2EMR for his review of this article and helpful comments.

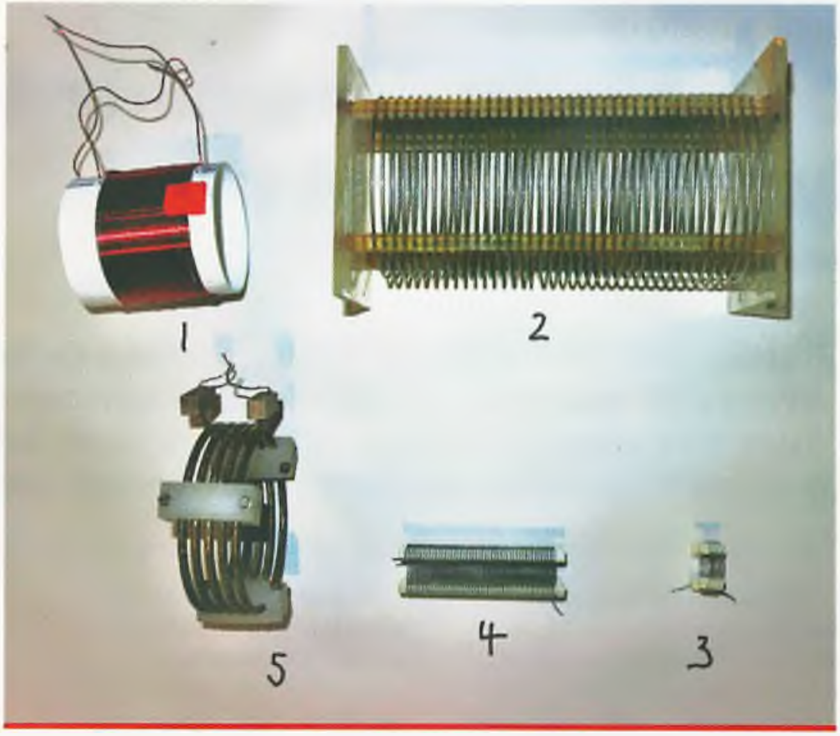


Figure 4: These single-layer solenoid coils, having both close-wound and spaced turns, were used to check the calculations and measurements listed in **Table 2**.

	Coil 1	Coil 2	Coil 3	Coil 4	Coil 5
Turns	49	37	5	48	5
Length (mm)	46.5	176	7	76	32
Diameter (mm)	69	90	25	25	91
d/l	1.484	0.51	3.57	0.33	2.81
L Eqn 1 (µH)	144.9	50.7	0.86	16.3	2.78
L Eqn 2 (µH)	145.1	50.4	0.84*	16.2	2.75*
L Meas (µH)	149	54.7	0.94	19.7	3.1

Table 2: Calculated versus measured inductance: "Eqn 1" is **Equation 1**, and "Eqn 2" is Wheeler's formula. Values marked with an asterisk indicate that the *l/d* is outside of the suggested range for most accurate inductance calculation. The measurements were made using an Altronics K.2533 L-C meter assembled from a kit of a *Silicon Chip* magazine project and no particular opinion of its accuracy is expressed.

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Silent Key

Neil Conners VK8ZCU

Having held a licence continuously for 66 years, Neil Conners VK8ZCU passed away on Friday 3 June 2022. He was 81 years of age. A resident of Tennant Creek in the Northern Territory, Neil was very active on 6m and 2m over many years, according to another local, Len Holbrok VK8DK, and on the 15m band more recently.

His wife, Marjorie, advises that Neil first got his licence at age 15 as a schoolboy in Newcastle, NSW. No doubt, Neil was attracted by the thrills to be had on The Magic Band and his callsign is 'mentioned in despatches' over many years in the VHF/UHF column in Amateur Radio magazine. Neil certainly kept the profile of Tennant Creek well to the fore in the minds of VHF/UHF enthusiasts on 6m and 2m.

On six, he often worked stations all over the Asia-Pacific and VK8ZCU was well-recognised in ZL whenever the band opened. On two metres, he was always on the lookout to work interstate DX. In 1986, he reported that he had 10 GHz gear operational, but complained to VHF/UHF columnist Eric VK5LP (SK) there was no one to work!

In recent times, Neil was active on the 15m band, from home and mobile, working SOTA and WWFF enthusiasts, as a number of online blogs report. Valé Neil Conners VK8ZCU.

Confounded by coils?

On conductor skin depth and the lyricality of Litz wire

Dale Hughes VK1DSH

The phenomenon known as 'skin effect' is a characteristic of all conductors that carry alternating current. As the frequency increases, the current flows closer to the surface of the conductor instead of uniformly throughout. This reduces the effective cross-sectional area of the conductor – hence, skin depth – leading to an increase in the conductor resistance.

Understanding the issue of skin depth can assist in improving the efficiency of components such as inductors and transformers, thus obviating or preventing overheating due to high resistive losses. This article covers the simplified theory of skin effect and presents a recent application of the theory in a Class-E amplifier I built for the 137 kHz frequency band.

A little theory

The magnitude of the skin effect depends on the operating frequency and the conductivity of the conductor material. The following discussion will assume the use of copper conductors with a conductivity of 5.74×10^7 Siemens per metre (S/m) (Ref. 1).

The calculations that follow also assume that the skin depth is small compared to the total conductor thickness which, for 137 kHz, is not necessarily true (depending on the wire gauge being used). However, if certain boundary conditions are observed, the approximation is close enough to be useful for amateur practice.

At higher frequencies, the approximation is very close for commonly used wire sizes. The exact solutions to skin effect calculations are quite complex and probably beyond the needs of most amateur equipment builders.

Noting that the density of alternating current flowing in a conductor decreases in an exponential fashion away from the surface of the conductor, the skin depth is defined as the point at which the current in the conductor has fallen to a value of *1/e* (approximately 37%) of the total current in the conductor. The skin depth δ (in metres) can be calculated (Ref. 2) using:

$$\delta = \sqrt{\frac{2}{\mu\mu_0\sigma\omega}}$$

Where

μ is the relative permeability of the conductor

μ_0 is the permeability of free space = $4\pi \times 10^{-7}$

σ is the material conductivity, and

ω is the angular frequency ($2\pi f$).

Assuming copper is the conductor material (μ = 1) and the frequency f is in kilohertz, the equation for calculating skin depth δ becomes:

$$\delta = \frac{2.09 \times 10^{-3}}{\sqrt{f}}$$

Given the exponential decrease in the current through each skin depth, virtually all (~95 %) of the current flowing in the conductor flows in the area from the surface down to about 3δ below the surface, with most current (approximately *2/3*) within δ of the conductor surface.

Table 1 shows the calculated skin depth δ for copper at a number of frequencies of interest to amateurs. It can be seen that the skin depth, and therefore the effective conductor cross-sectional area, decreases rapidly as frequency increases.

F(kHz)	δ (m)	δ (mm)
0.05	0.009348	9.3
137	0.000179	0.18
475	9.59E-05	0.096
1850	4.86E-05	0.049

Table 1: Skin depth δ in copper as a function of frequency.

The decrease in the effective cross-sectional area of the conductor at radio frequencies is the reason that *Litzendraht* (usually abbreviated to just Litz) wire was invented.

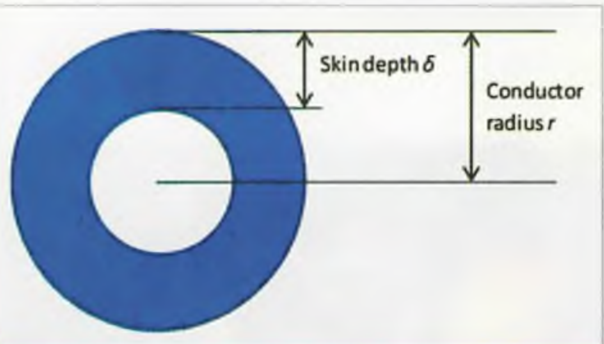
Litz wire is made up of many strands of very fine individually insulated wires woven so that, on average, each strand occupies all possible positions in the composite conductor area over its length (Ref. 3), a technique that makes the RF resistance approximately equal to the DC resistance of the conductor.

While commercial suppliers exist (Ref. 4 and various eBay outlets), Litz wire can be difficult and expensive for amateurs to obtain, though small lengths can sometimes

›e extracted from junked equipment.

Skin effect is also why a thin layer of silver is applied to :onductors operating at higher frequencies, at microwave requencies the skin depth is a faction of a micron, so ven a thin layer of silver plating is effective in reducing :onductor losses.

As previously noted, a full analysis of skin effect is nathematically complicated. To simplify analysis, it s convenient to assume that all of the current flows ıniformly in an annular area defined by the skin depth › and the conductor surface; i.e, the shaded area in 'igure 1, with no current elsewhere in the conductor. This is sometimes called the 'abrupt cutoff' model (**Ref.** ›), which provides a reasonable approximation of the ffective cross-sectional area of the conductor.



igure 1: The abrupt cutoff model assumes that all of the RF current in a onductor of radius *r* flows uniformly in the shaded annular area that has a ıickness δ and none flows closer to the center of the conductor. It can be een that the effective resistance at high frequencies is greater than the C resistance, where the current flows through all parts of the conductor.

)avid Knight G3YNH (**Ref.** 5) indicates that the model s applicable as long as the wire diameter is greater than wice the skin depth. Intuitively, this must be true as the onductor diameter must be at least 2. At 137 kHz, this ›oundary condition means that 0.4 mm is about the mallest wire diameter *d* for which the approximation is alid. Smaller wires can be used, but more sophisticated alculations may be required if skin effect is an issue.

However, don't let this stop you experimenting. More trands of finer wire will help, but analysis will be more ifficult and **Ref.** 5 gives more refined methods if you are ıclined towards complicated mathematics.

The abrupt cutoff model shown in **Figure 1** can be sed to calculate the ratio between the RF resistance R_{rf} and the DC resistance R_{dc}. At DC, the current flows hrough the entire cross-section of the conductor; the otal cross-sectional area of a single strand conductor of iameter *d* is:

$$A = \frac{\pi}{4}d^2$$

At RF, the cross-sectional area is reduced and the effective cross-sectional area A_e (shaded area of **Figure** 1) of a single solid conductor with diameter *d* and with a skin depth δ is:

$$A_e = \pi(d\delta - \delta^2)$$

The resistance of a cylindrical conductor (**Ref.** 6) can be calculated from its resistivity ρ (the reciprocal of conductivity σ), its length *L* and cross-sectional area *A*. So, considering the DC and RF cases, we have:

$$R_{dc} = \frac{\rho L}{A} \qquad \textit{and} \qquad R_{rf} = \frac{\rho L}{A_e}$$

Noting that the resistance of the conductor is proportional to its length and is inversely proportional to its cross-sectional area, the ratio of the RF resistance to DC resistance for a conductor is:

$$\frac{R_{rf}}{R_{dc}} = \frac{\rho L/A_e}{\rho L/A} = \frac{A}{A_e}$$

The chart in Figure 2 plots the R_{rf} versus R_{dc} ratio and the effective current carrying area A_e versus the total cross-sectional area *A* of the conductor over a range of conductor sizes. The graph shows that using thinner conductors makes better use of the copper; i.e, the ratio R_{rf}/R_{dc} gets closer to 1 as conductor diameter decreases.

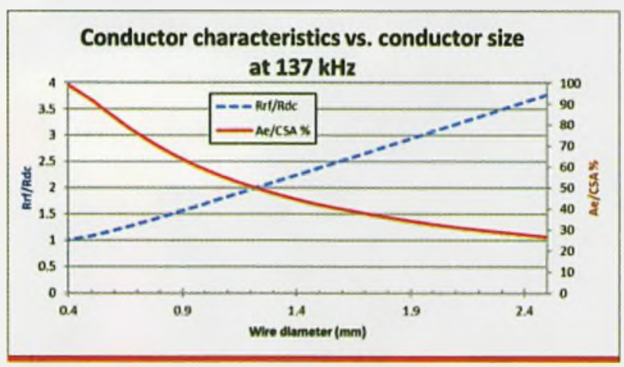


Figure 2: The characteristics of conductor resistance at 137 kHz over a range of typical single strand conductor sizes. The dashed line is the ratio of the RF resistance to DC resistance, while the solid line is the ratio of the effective current carrying area at 137 kHz to the conductor cross-sectional area. The chart covers the range of likely wire sizes used in amateur projects and complies with the requirement of the 'abrupt cutoff' model. It can be seen that thinner wires make better use of the available copper as the current flows through more of the available cross-sectional area.

The implication of this is that multiple smaller insulated conductors in parallel can be used to decrease the RF resistance, making it closer to the DC resistance. Since Litz wire isn't a commonly available off-the-shelf, an alternative compromise available to amateurs is to make a composite conductor using multiple insulated conductors of a suitable size twisted together instead of using a single solid conductor.

Increasing the number of strands decreases the RF resistance and this reduction in RF resistance translates directly to less resistive losses in a conductor. In high current applications like RF power amplifier inductors, it is a useful way to reduce resistive losses and operating temperature.

Use of the model allows us to calculate the number of strands to make the effective area A_e of the composite conductor approximately equivalent to the total cross-sectional area of the single large conductor; i.e, make the composite RF resistance R_{rf} equal the DC resistance R_{dc} (R_{rf}/R_{dc} ~ 1).

The number of required strands n can be calculated from the wire diameters and the skin depth:

$$x = \frac{A}{A_e} = \frac{d^2}{4\delta(d_1 - \delta)} \quad \& \quad n = roundup(x)$$

Where

d is the wanted wire diameter, e.g. 2.5 mm, and

d_1 is the strand diameter e.g. 0.4 mm

The number of strands is n which is x rounded up to the next higher integer.

Note: The values d, d1 and δ must be in the same units.

Original wire diameter (mm)	Strands of 0.4 mm diameter wire	R_{rf}/R_{dc}	Average composite wire diameter
2.5	40	0.988	2.56
2	26	0.973	2.08
1.5	15	0.948	1.60
0.9	6	0.854	1.05
0.7	4	0.775	0.89
0.6	3	0.759	0.77

Table 2: The number of individually insulated 0.4 mm conductors that can be used to make the RF resistance approximately equal to the DC resistance of a larger single conductor. Note: this table only applies for operation at 137 kHz, though values for other frequencies can be easily calculated using the equations.

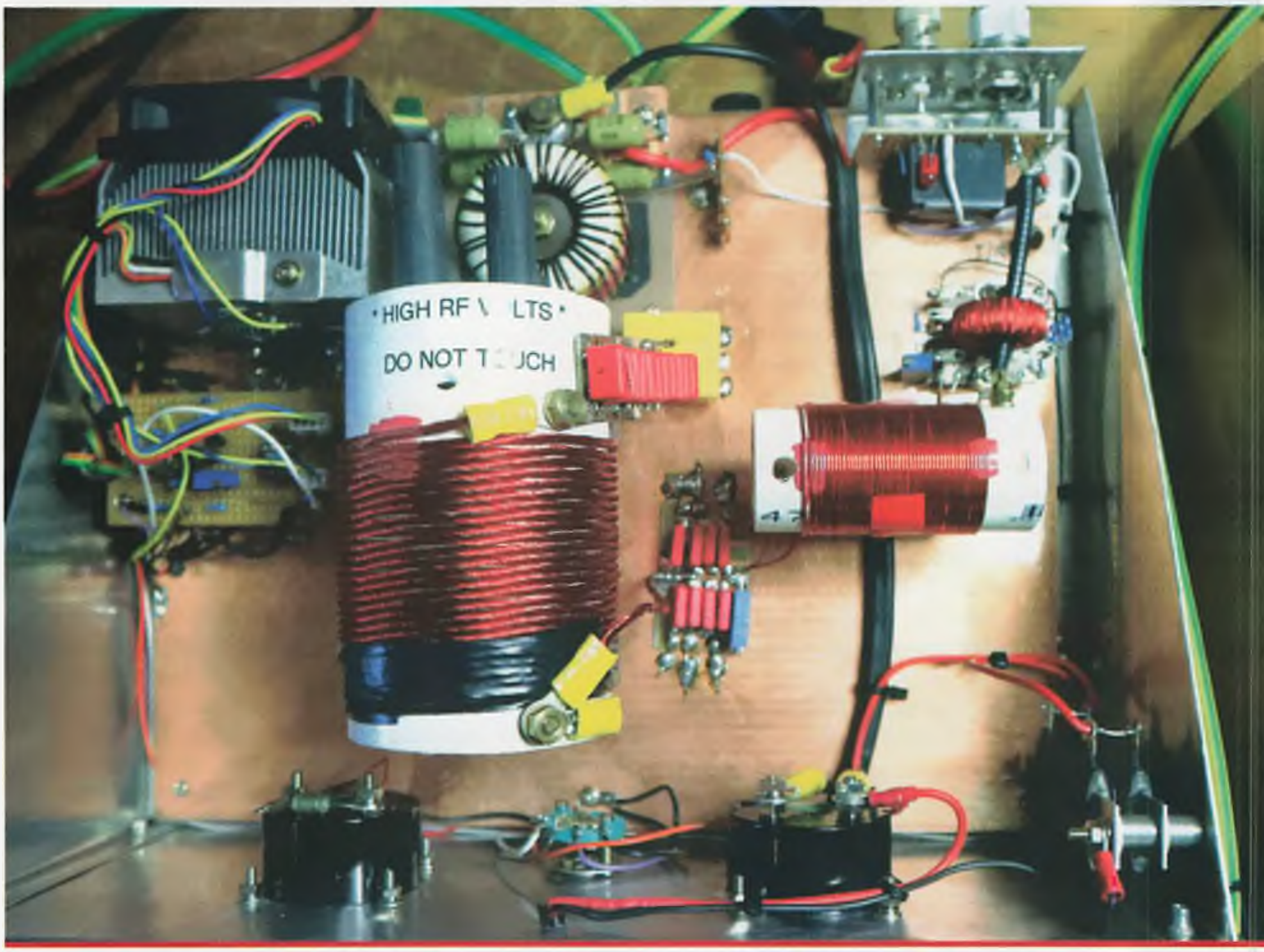


Figure 3: The 36 μH inductor is the large coil just left of center here. The smaller inductor to the right is part of the output matching circuit. It operates at a much lower current and does not get warm. This project is my 2200m transmitter with Class-E PA using low-cost FETs, described elsewhere in this issue. The ferrite rods poking out of the larger coil allow slight adjustment of the inductance to tune the amplifier to the correct conditions for Class-E operation. Correct Class-E operation is checked by observing the FET Drain waveform with an oscilloscope and adjusting the position of the ferrite rods to get the correct waveform as described in **Reference 7**.

The number of 0.4 mm diameter insulated wires needed to make various composite wire sizes that might be useful for amateurs is listed in **Table 2** here. For example, if you need to make the RF resistance of a composite conductor equal to the DC resistance of 1.5 mm diameter wire, 15 strands of 0.4 mm wire will be required and the resulting ratio of RF resistance to DC resistance (Rrf/Rdc) will be approximately 0.95.

Note, however, that the physical diameter of the composite conductor will be slightly greater than the size of the single strand wire; the right-hand column provides an estimation of the composite wire diameter based on a correction that takes into account the difference between the cross-sectional area of the original single wire and the sum of the cross-sectional areas of composite wire.

Composite conductors can be made by twisting identical lengths of copper wire together using a hand drill. Don't over twist the wires and use the minimum amount of twisting as too much will increase the required length of the individual wires and therefore reduce the effectiveness of the composite conductor.

Soldering the composite wire is made easier if the insulation on the wires is of the 'solder through' or self-fluxing enamelled copper wire variety (trade name "Lumex"; the enamel insulation becomes a flux when heated), in which case a large-tipped soldering iron or solder pot can be used to tin the collection of wires that make up the composite conductor.

A real-life example

I needed a 36 µH inductor for a Class-E amplifier for use on the 2200 m band (see **Figure 3**). The RF current in the inductor would be about 11 amps when the amplifier was operating at its design maximum RF output power of 350 watts.

Without really thinking about the operating conditions, an inductor was built with 0.91 mm diameter enameled copper wire. When the amplifier was powered up, two things happened: the output power was very low and the plastic coil former melted after a few seconds operation! A second version of the coil used 1.4 mm diameter wire, with more-or-less the same result…

The third version used 2.2 mm diameter wire and this time the output power was more-or-less correct but the coil still got too hot to touch!

At that point, I started thinking about what might be happening, which led to this article. The fourth and final coil used 26 turns of 25 strands of 0.35 mm wire (less than 0.4 mm, but I had it on hand…) twisted together on a 68 mm outside diameter tube. The amplifier then delivered the correct output power and the inductor barely got warm to touch; success! Clearly taking the skin effect into account was the significant factor in making the amplifier work.

Conclusion

Some background theory covering topics of interest to experimentally inclined amateurs has been presented. The application of this theory is relevant when working with relatively high-powered RF amplifiers.

The formal and full treatment of skin effect is mathematically complex, but by using some reasonable approximations and intuition, the application of the theory can be simplified significantly and made more usable for amateur purposes. While this article focuses on operation at 137 kHz, it is a simple matter to calculate the necessary values for other amateur band frequencies using the formulae presented above.

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(2) Electromagnetism. I. Grant and W. Phillips. John Wiley and Sons, 1975. ISBN 0 471 32246 6. p 381.

(3) Radio Engineers Handbook. F.E. Terman. First edition. McGraw-Hill Book Company, 1943, p 37.

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A Multi-Mode transmitter for the 2200 metre band with a Class-E final

Dale Hughes VK1DSH

The 2200 metre band (135.7 – 137.8 kHz) was allocated to the amateur service by the ITU's World Radiocommunications Conference 2007 (WRC-07). This resulted from a campaign by the International Amateur Radio Union (IARU) over some years. Subsequently, the ACMA added the allocation to the Australian Radiofrequency Spectrum Plan in January 2009 and, following advocacy by the WIA, Advanced licensees gained access to the band from June that year. Pursued by the WIA, the ACMA finally amended the licence conditions in December 2010 to include the band.

Before the formal allocation of the band at WRC-07, much experimental work was undertaken in various parts of the low frequency (LF) spectrum that showed the utility of an LF band for some amateur radio activities. Details of some Australian experimental LF activities by VK3ACA (SK) are given in Reference 1; there was also a lot of activity in the UK.

While the band is only 2.1 kHz wide, has a power limit of 1 Weirp (equivalent isotropic radiated power), and suffers from high levels of natural and man-made noise, a number of amateur stations are active on the band.

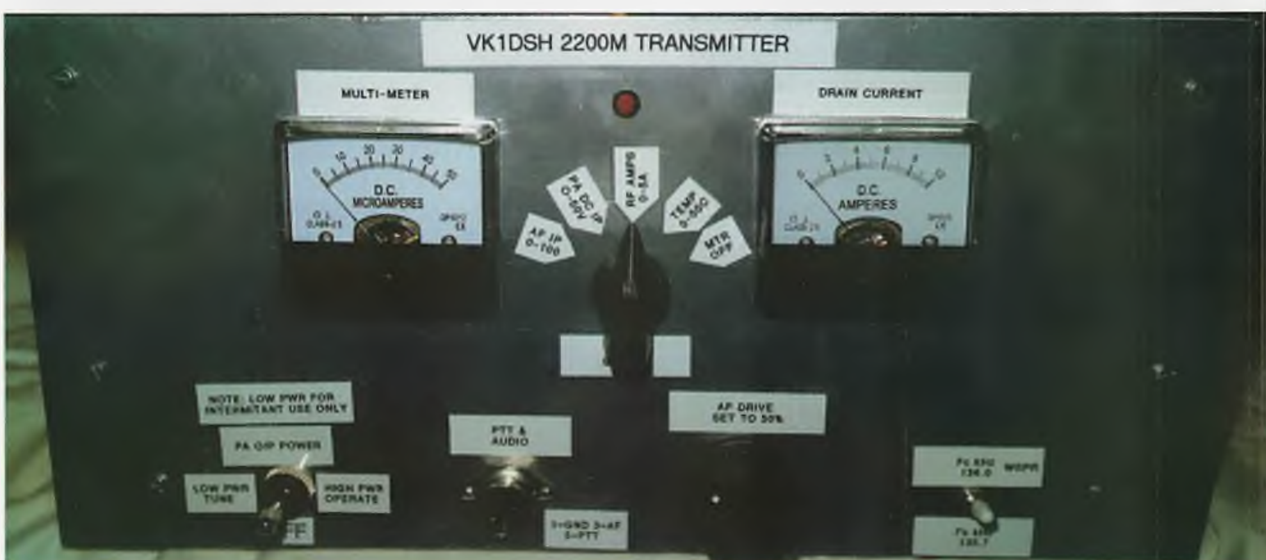
Because practical antennas that can used by amateurs on this band are electrically short and inefficient (a typical radiation efficiency might be 0.1 %), it's hard to radiate even 1 W. However, propagation losses at 137 kHz are very low and some global DX has been achieved.

Because of the limited supply of commercial equipment available for 2200m, most operators have to construct some or all of the radio equipment they use. This allows for a diversity of equipment design. For all these reasons, the 2200m band is challenging and fascinating to use.

About my rig

This article describes a transmitter with an RF output power of 350 watts. Instead of the more commonly used push-pull Class-D arrangement, this design uses the Class-E configuration because it is a largely unexplored idea in contemporary amateur LF technology.

The Class-E design was popularised by Nathan Sokal WA1HQC. He wrote a comprehensive article published in *QEX* magazine that describes Class-E amplifier theory and use (Ref. 2). If you want to minimise the number



I used conventional chassis-and-front panel construction for my project. The panel carries controls and metering, while the chassis separates the RF circuitry (top side) from the audio and control electronics (under chassis). The LED at top-centre indicates 'power on'.

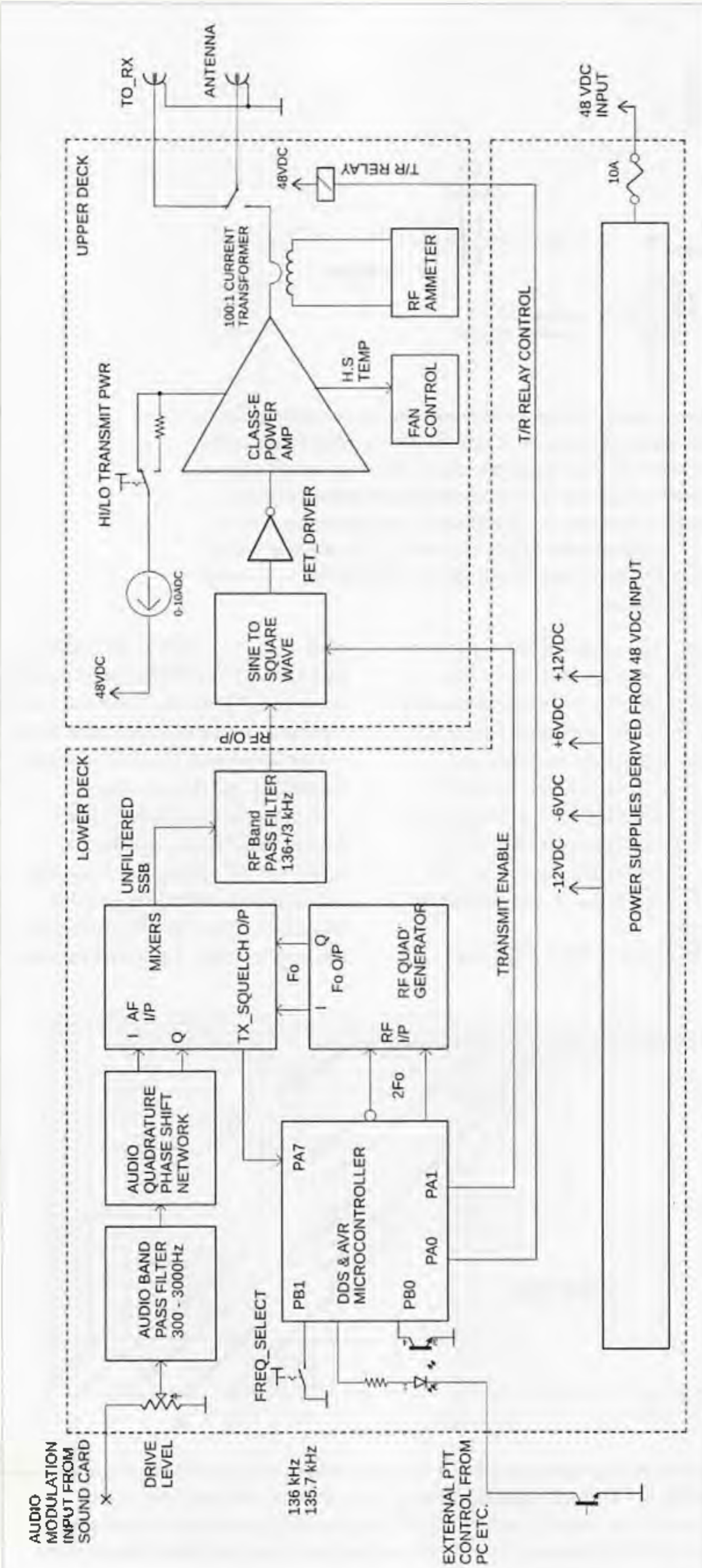


Figure 1: Block diagram of the 2200m multi-mode transmitter showing the main functional components. The dotted lines indicate the physical location of various modules in the transmitter assembly.

of blown transistors, reading and understanding the technical issues is a prerequisite for getting a high-power Class-E amplifier to work!

This Class-E amplifier design uses low-cost field-effect transistors. The drain voltage was chosen to be 48 VDC because this higher voltage (compared to 12 or 24 volts) raised the transmitter output impedance to a more convenient quantity.

At the maximum RF output of 350 watts, the amplifier DC drain current is about eight amps, implying a transmitter efficiency of about 91%. This is the key advantage of a Class-E amplifier. The main disadvantage of the basic Class-E configuration is that it is limited to constant amplitude transmission modes like JS8call, WSPR etc. It's *not* suitable for modes that require reasonable envelope linearity, such as PSK-31.

However, applications currently used on the 2200m band are almost entirely of the constant amplitude type, so using Class-E amplifiers is not a serious limitation.

The exciter

The transmitter exciter uses the phasing method of SSB generation. This works well at 137 kHz because it's relatively easy to make accurate quadrature phase-shift networks for both the limited audio bandwidth and low radio frequency. The MC1496 balanced modulator ICs used in the design have excellent carrier suppression at 137 kHz.

The overall block diagram of the transmitter is shown in **Figure 1**. The phasing type method of SSB generation and reception has been used in a number of transmitters and receivers described in a series of *QST* articles by Rick Campbell KK7B (**Ref. 3**). I have used some of those ideas in this transmitter.

Because the 2200m band is only 2.1 kHz wide, it's possible to fix the carrier 'dial frequency' and select the wanted transmission frequency by adjusting the audio frequency of the mode being used.

Two fixed dial frequencies were selected for transmitter operation: **135.7 kHz for all modes, and 136.0 kHz for WSPR and the other WSJT-X modes.**

For example, if using JS8call, the offset frequency selected might be 1000 Hz. So, with the base frequency of 135.7 kHz, the actual transmission frequency would be 136.7 kHz. If the WSPR 'dial frequency' of 136 kHz is used and the WSPR audio frequency is set to 1500 Hz, the transmit frequency will be 137.5 kHz.

In this way, any part of the band can be used by selecting the appropriate audio frequency for the desired transmission mode. The desired (suppressed) carrier frequency can be selected using a switch on the front panel of the transmitter.

While a complete transmitter is described in this article, the power amplifier can be easily adapted for use as part of a transverter or even a standard CW transmitter. In this case, the amplifier can be driven by a low-level RF signal fed to the input comparator, or even a logic-level signal to the input of the FET gate driver.

Similarly, the phasing-type exciter can be adapted to drive a linear power amplifier for transmission modes that require reasonable envelope linearity.

Details of the PA

The Class-E power amplifier stage was designed using the web-based calculator of Dimitris VK1SV (Ref. 4). It provided the prototype circuit shown in **Figure 2**; also shown are some key operational parameters that impacted component selection. The final version of the amplifier included impedance matching and filtering so that the amplifier could operate into a 50 ohm load and have adequate spectral purity.

Designing the circuit was the easy bit. The values of the capacitors and inductors are part of a more complicated story. The complications result from the operating frequency and the significant currents and voltages that arise in the amplifier circuit. For example, the voltage on the FET drains approaches 250 V peak, while the RF current at 137 kHz flowing in L2 is approximately 11 amps!

Selecting a suitable FET was fairly easy. Two 600 V, 20 A devices (Infineon SPW60N20S5) in parallel were used. However, the losses in the capacitors and inductors were more of a problem and there were some interesting puzzles to solve.

Firstly, the capacitors. Given the relatively large capacitance values for RF applications and the impossibility of finding suitable silver-mica types (ideally suited to this application), I selected various

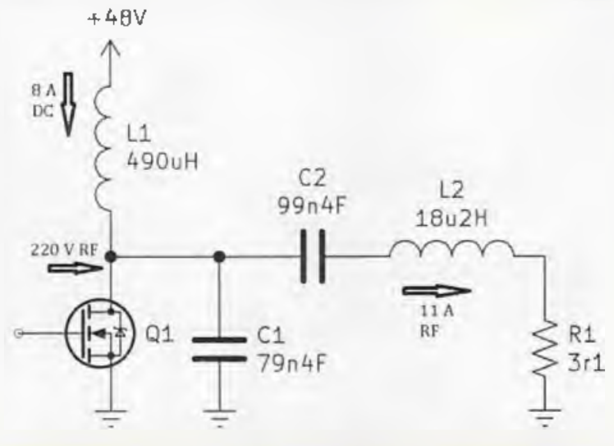


Figure 2: The prototype circuit for a 350 W Class-E amplifier for use on the 2200m band showing key design information. The circuit, as built, uses two transistors in parallel and includes additional impedance matching and filtering components. C1 (C10 in **Figure 4**) was made up of parallel 10 nF 1500 VDC capacitors and C2 (C11) was made up of parallel 10 nF 630 VDC capacitors. 'Fine tuning' was done by adding 3.3 nF 1000 VDC capacitors in parallel, as required.

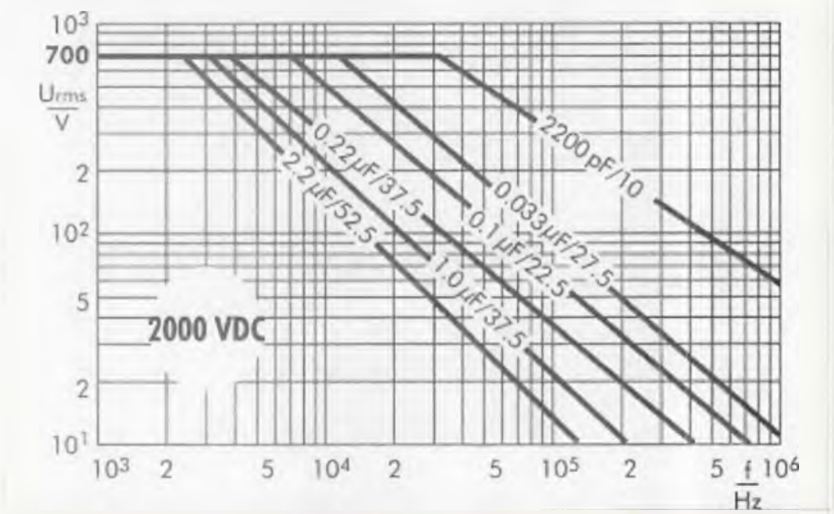


Figure 3: Typical WIMA MKP capacitor de-rating curves. It can be seen that, depending on capacitance value, a capacitor with a 2000 VDC rating can safely sustain a much lower operating voltage at 137 kHz. The impact of exceeding the voltage rating is increased power dissipation and potential failure due to overheating.

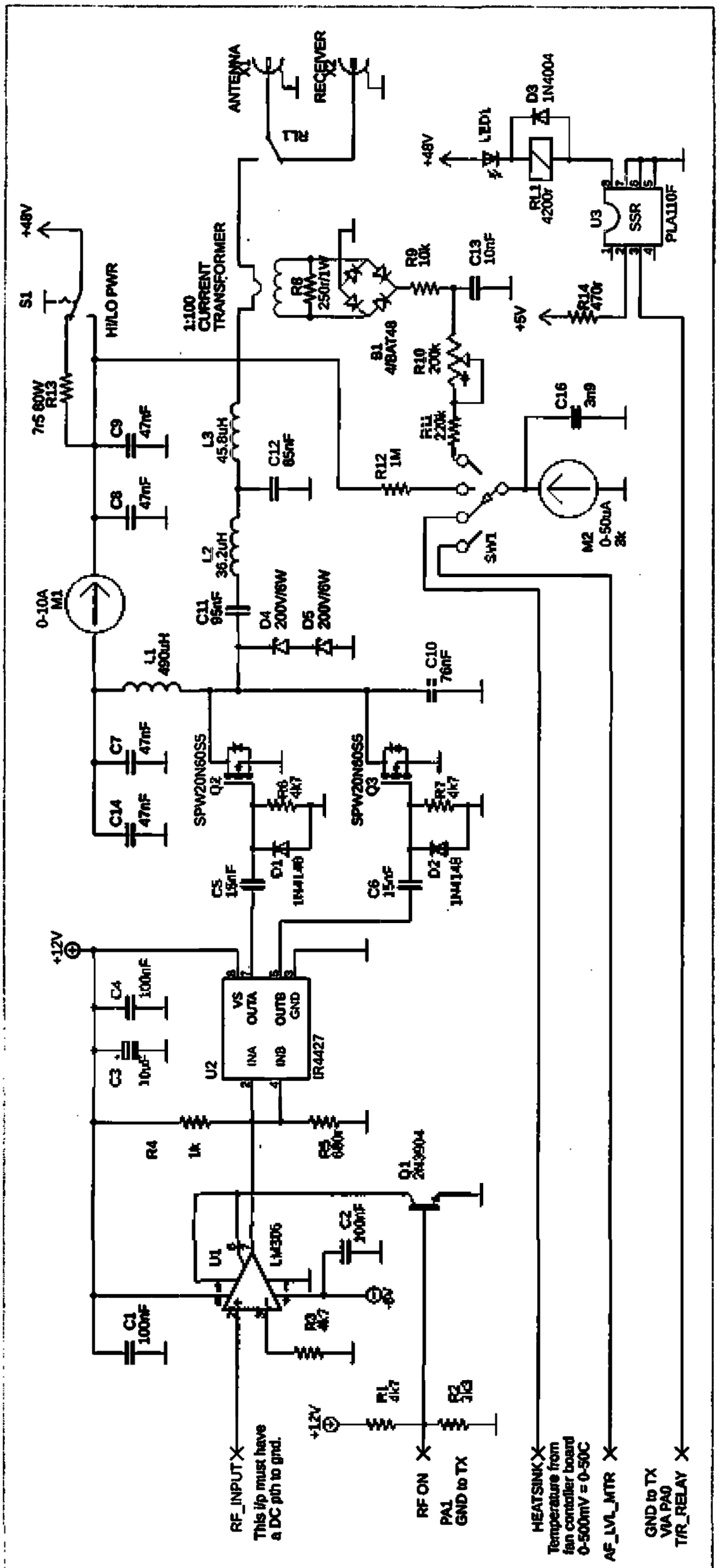


Figure 4: The complete schematic of the 2200m Class-E power amplifier. The drain choke L1 is wound on two stacked T184-26 iron-power toroids. L2 and L3 are air-cored inductors and the 1:100 current transformer is wound on a 25 mm 3C85 toroid. Capacitor C12 was made from 10 nF 630 VDC and 3.3 nF 1000 VDC units in parallel.

MKP pulse-rated polypropylene capacitors.

The capacitor datasheets showed that the de-rating of operating voltage versus operating frequency is quite severe and Figure 3 shows a typical example (Ref. 6). The voltage de-rating means that it is better to use multiple parallel capacitors of small values to achieve the required capacitance value; this was also useful because it allowed the capacitance values to be adjusted for best operation of the amplifier. Tuning was achieved by adding or subtracting parallel capacitors until the correct value was obtained.

Secondly, inductor L2 was a challenge; initial tests of the amplifier with L2 made using 0.91 mm copper wire resulted in a melted coil and low output power! An analysis of the situation showed that 'skin effect' in the copper wire was increasing the coil loss significantly because the RF resistance was much higher than the DC resistance.

The solution was, in the absence of Litz wire, to wind the coil with a composite conductor made up of 25 strands of 0.35 mm diameter enamelled copper wire. This reduced the RF resistance and therefore the power dissipation in L2 to an acceptable level.

I found that small adjustments of L2 were required to tune the amplifier for correct Class-E operation. This was done by mounting four short sections of ferrite rod in a wooden disk that fitted in the end of the tube holding L2; the rods only needed to be slightly inserted to increase the inductance enough to tune the amplifier. No power dissipation has been observed in the ferrite rods.

Figure 4 shows the complete amplifier, including the FET driver and output metering etc. The drains of the transistors are protected against over-voltage by two 200 V, 6 W Zener diodes in series to clamp the drain voltage to about 400 V. This provides an adequate safety margin for the 600 V-rated devices.

The two transistors are mounted on a small heatsink and fan assembly salvaged from a computer CPU chip. While not really necessary, the fan is thermostatically controlled so that it only runs when needed. In hindsight, because the power dissipated by each FET is relatively low, a simpler solution would have been to use a bigger heatsink and no fan.

The power amplifier output transistors are driven by a standard FET driver chip, but to protect the devices, the RF drive is AC-coupled to each FET gate. This prevents the gate from being biased on for a lengthy period of time which *will* result in blown transistors.

The drive to each FET gate is DC-restored by the diode between the gate and ground so that each FET is adequately driven and protected against a permanent DC bias. When the RF drive stops, the transistors are biased off.

The input for the FET driver is taken from a comparator that squares-up the sine wave input from the exciter board. The transmitter is also keyed on or off via the comparator *enable* pin and the Transmit/Receive sequence is that the T/R relay (RL1) is energised first, then the comparator is enabled about 50 ms later, so that the relay contacts have time to pull-in before being subjected to RF current.

Similarly, when turning off, the comparator is disabled first to remove RF current, then the T/R relay is released.

The comparator input is also controlled via a 'transmit squelch' function so that there has to be sufficient audio input to the exciter before the transmitter can transmit. This prevents random noise being transmitted if no modulation signal is present. In normal operation, the transmitter can run 'key down' at full power for lengthy periods without any issues.

Operation of the transmitter at low power for antenna tuning can be achieved by switching in a resistor to reduce the drain voltage by approximately half, which reduces the RF output power to about 80 W.

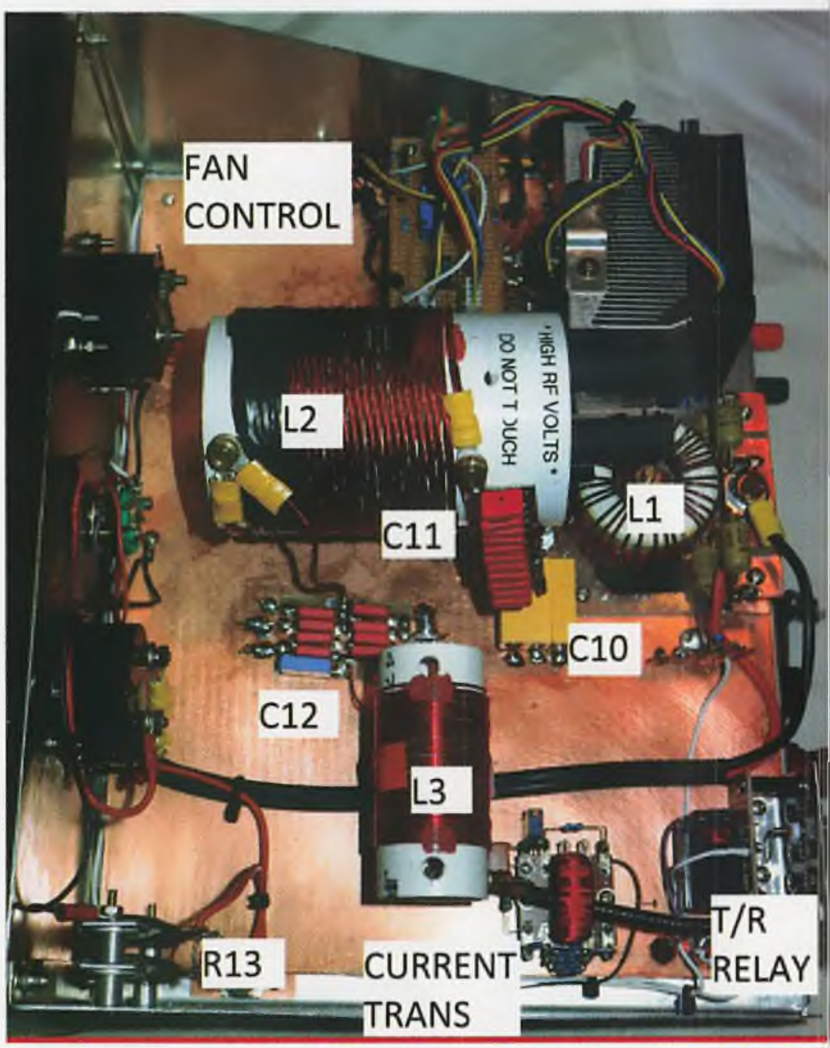


Figure 5: The power amplifier; note the use of multiple parallel capacitors for C10, C11 and C12, and the short pieces of ferrite rod mounted in the end of L2 for tuning.

Antenna adjustments can then be made with little chance of causing any damage to the transmitter. The tune mode is only intended for short, intermittent use because the voltage reducing resistor (R13) dissipates significant power.

RF output current from the amplifier is measured using a 100:1 current transformer and an RF ammeter. Drain voltage and heatsink temperature can also be measured by the metering circuit, which is useful during testing and operation of the amplifier.

Figure 5 shows the general construction of the amplifier which is built on a piece of blank printed circuit board laminate screwed to a piece of 3 mm aluminium plate. Using the circuit board laminate allowed the various connections to earth to be achieved via very low RF resistance paths, which is beneficial

Component	Value - µH	Details
L1	490	36 turns of 1.2 mm wire on two stacked T184-26 (Yellow/Green) cores
L2	18	26 close-wound turns of 25/0.35 mm wire on 68 mm outside diameter former (white PVC storm water pipe)
L3	46	48 close-wound turns of 0.91 mm wire on 33.5 mm outside diameter former (white PVC storm water pipe)

Table 1: PA inductor details.

because of the large circulating RF currents in the amplifier stage. Details of the inductors L1-L2-L3 used in the PA are given in Table 1.

References and Resources

1. The Day We Crossed the Tasman On Long Wave, John Adcock VK3ACA, Amateur Radio, April 1993.
2. Class-E RF power amplifiers, Nathan Sokal WA1HQC, QEX, January/February 2001.
3. A Multimode Phasing Exciter For 1 to 500 MHz, Rick Campbell KK7B, QST, April 1993; also see The MicroT2 -- A Compact Single-Band SSB Transmitter, QST, December 2006.
4. VK1SV web calculator https://people.physics.anu.edu.au/~dxt103/calculators/class-e.php OR: https://tinyurl.com/5fwdc232
5. A transceiver for 137 kHz, Dale Hughes VK1DSH, Amateur Radio, April 2011, and A phasing type transceiver for 144 MHz, Dale Hughes VK1DSH, Amateur Radio, August and September 2009.
6. WIMA capacitor information can be found at www.wima.de/en/our-product-range/pulse-capacitors/mkp-10/ OR: https://tinyurl.com/52urv949
7. LF today. A guide to success on the bands below 1 MHz, Mike Dennison G3XDV, Radio Society of Great Britain, ISBN 9781 9050 8693 1. 3rd Edition 2013.

NB: Issues of *Amateur Radio* magazine can be accessed online, via www.armag.vk6uu.id.au.

March 2008 – LF allocation: *WIA Comments on Draft Spectrum Plan*, https://tinyurl.com/y29p4pva

June 2009 – LF band access: *135.7 – 137.8 kHz Now Available to Advanced Licensees*, https://tinyurl.com/2jru4v2f

December 2010 – Amateur LCD amended: *ACMA has given effect to several matters first requested by the WIA in December 2008*, https://tinyurl.com/2s4zxyrj

And onto the real thing

Antenna Modelling using 4nec2 - Part 4

Gregory Mew VK4GRM and Michael Barbera

This is part 4 and the penultimate part of this series of articles that introduces 4nec2, the antenna modelling package that is freely available on the web, at no cost. **Although the original intention was to provide a four-part series, as things transpired, Part 5 will appear in the next issue (– Editor).**

- Part 1 provided a general introduction to antenna modelling and the various packages that are available.
- Part 2 identified where to get the 4nec2 package, a brief introduction on the way that antenna models can be created, plus the structure and some of the "cards" or commands that are available for your modelling.
- Part 3 delved deeper into 4nec2 by looking at how to model a 20-metre dipole fed with a 50 ohm coaxial cable. It also introduced some more of the commands that allow you to create models and visualise simulation results.

> The main benefit of using 4nec2 for antenna modelling is that the electronic model will get you much closer to the final answer quicker than can be achieved with the cut-and-try methods that have been used in the past.

This article looks first at modelling a 5-element 2m Yagi, then – in Part 5 – a 2m dipole, with the intent to investigate some of the other commands in NEC-2, and also some of the optimiser functions of 4nec2. Both antennas were built and tested, and the test results are compared with the results from the 4nec2 model. Elsewhere in this issue, is an article describing *A short-boom Yagi for FT8 on the 6m band.*

5-element 2m Yagi

Before we can build a Yagi in 4nec2, we need to have some basic information on Yagi design so that we can get in the ballpark. NT1K [1] shows us how to do this with instructions based on a document that helps with Yagi design [2]. Using this information, we have created the .nec file shown in **Figure 4-1.**

For typical antenna problems such as impedance matching or finding appropriate dimensions, a variation of geometrical parameters is required. For such problems, an optimiser is included in the 4nec2 package and it is necessary

```
Yagi_Step1-Opt1.nec - Notepad
File Edit Format View Help
CM Yagi Example
CM Simple 5 element 2m Yagi design based on initial model developed by NT1K
CM https://nt1k.com/homebrew-5-element-vhf-yagi/
CM Centre Frequency     146MHz
CM Free space model
CM Model by Michael Barberra and Greg Mew VK4GRM 04/07/2021
CM
CE
SY FREQ=146                     'Centre frequency of operation
SY WL=300/FREQ                  'Wavelength of centre frequency                                           = 2.055
SY DE_LENGTH=0.972              'Starting length for Driven Element = 0.473 x WL                          = 0.972
SY REFL_LENGTH=1.013            'Starting length Reflector Length = 0.493 x WL                           = 1.013
SY REFL_SEP=0.257               'Starting separation for Dipole to Reflector = 0.125 x WL                 = 0.257
SY DIR1_LENGTH=0.904            'Starting length for Director 1 = 0.440 x WL                              = 0.904
SY DIR1_SEP=0.257               'Starting separation for Director 1 from Driven Element = 0.125 x WL =    = 0.257
SY DIR2_LENGTH=0.894            'Starting length for Director 2 = 0.435 x WL                              = 0.894
SY DIR2_SEP=0.771               'Starting separation for Director 2 from Driven Element = 0.375 x WL      = 0.771
SY DIR3_LENGTH=0.884            'Starting length for Director 3 = 0.430 x WL                              = 0.884
SY DIR3_SEP=1.284               'Starting separation for Director 3 from Driven Element = 0.625 x WL      = 1.284
SY HEIGHT=0                     'Reference height - set to zero as this is in free space.
SY WIRE_RAD=0.005               'Antenna element radius.  Note we will be using 10mm aluminium tube so 5 mm is used here.


GW    1    9    0            -DE_LENGTH/2      HEIGHT    0            DE_LENGTH/2      HEIGHT  WIRE_RAD
GW    2    9    -REFL_SEP    -REFL_LENGTH/2    HEIGHT    -REFL_SEP    REFL_LENGTH/2    HEIGHT  WIRE_RAD
GW    3    9    DIR1_SEP     -DIR1_LENGTH/2    HEIGHT    DIR1_SEP     DIR1_LENGTH/2    HEIGHT  WIRE_RAD
GW    4    9    DIR2_SEP     -DIR2_LENGTH/2    HEIGHT    DIR2_SEP     DIR2_LENGTH/2    HEIGHT  WIRE_RAD
GW    5    9    DIR3_SEP     -DIR3_LENGTH/2    HEIGHT    DIR3_SEP     DIR3_LENGTH/2    HEIGHT  WIRE_RAD

GE    0

EK

LD    5    0    0    0    3.69E+07          'Set all materials to aluminium


EX    0    1    5    0    1    0
FR    0    41   0    0    144  0.1
RP    0    361  361  1000 0    0    1    1
EN
```

Figure 4-1. The 5-element 2m Yagi model – Starting Parameters.

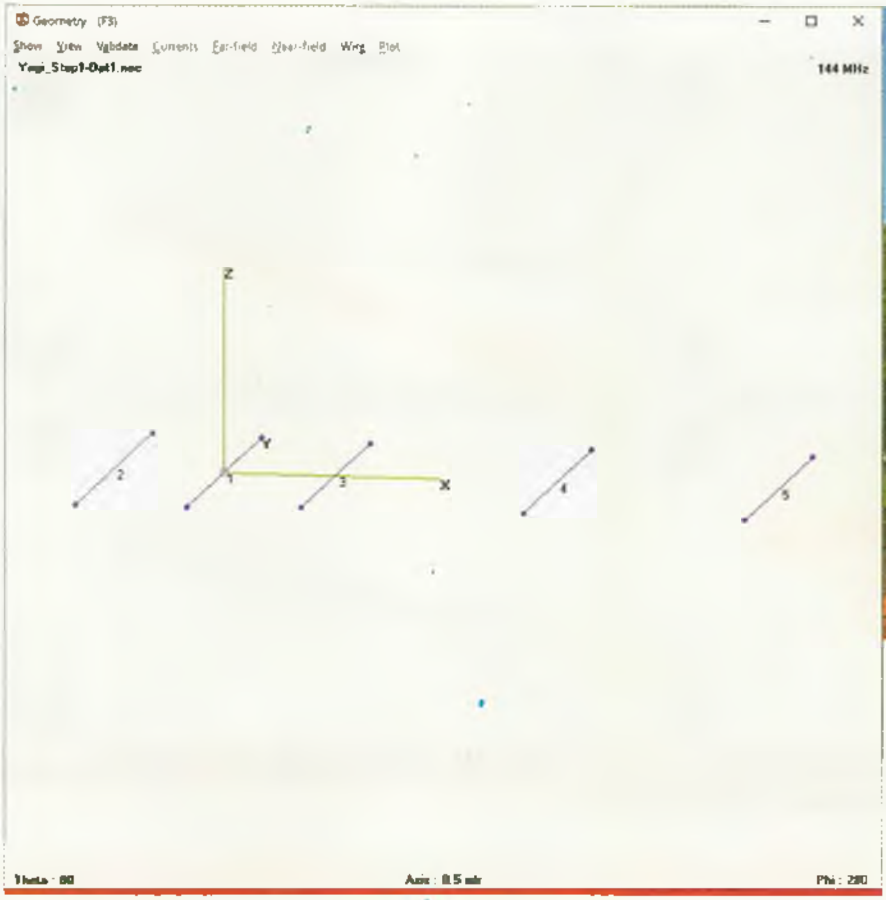


Figure 4-2. 5-element 2m Yagi model – Starting Parameters – Geometry Screen.

that some parameters (variables) need to be declared and be used in the optimiser. These parameters are varied by the optimiser automatically.

The parameters may be declared using a special symbol or SY-command, as shown in the "SY" lines of Figure 4-1.

You will notice that this SY command does not appear in the manual but its structure is very simple, just a variable name, equals sign and a formula or value as shown in Figure 4-1. Simple mathematical equations may also be used in the formulae.

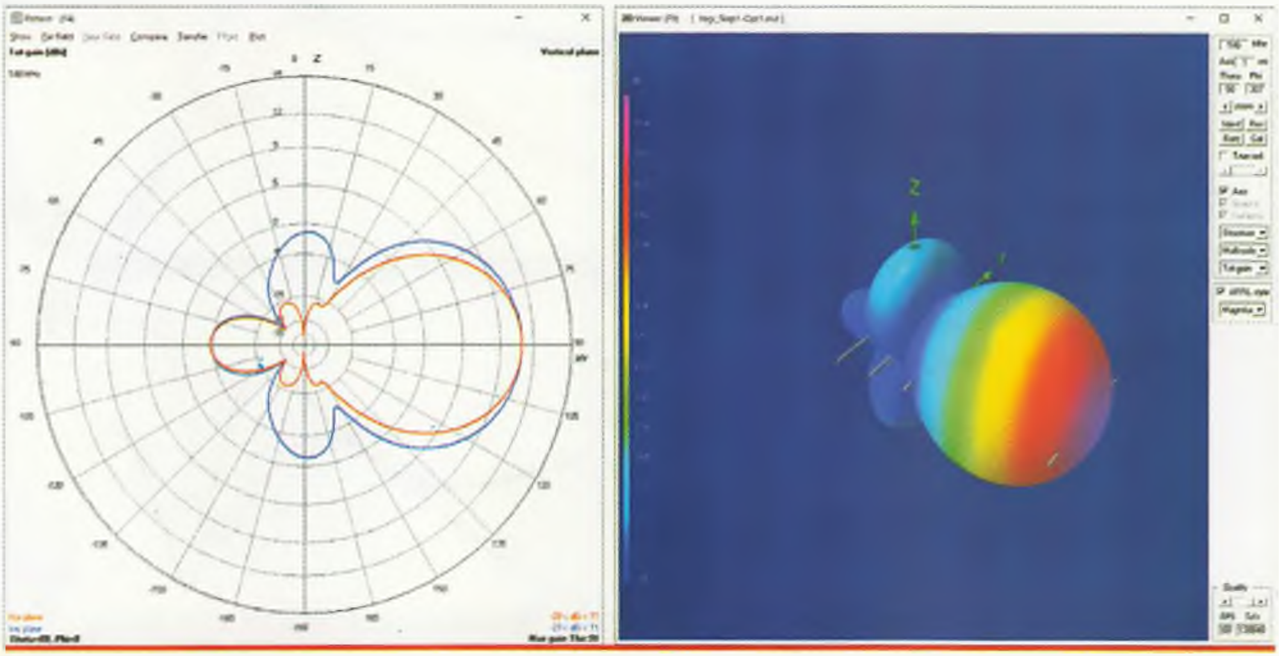


Figure 4-3. 5-element 2m Yagi model – Starting Parameters – Radiation Pattern.

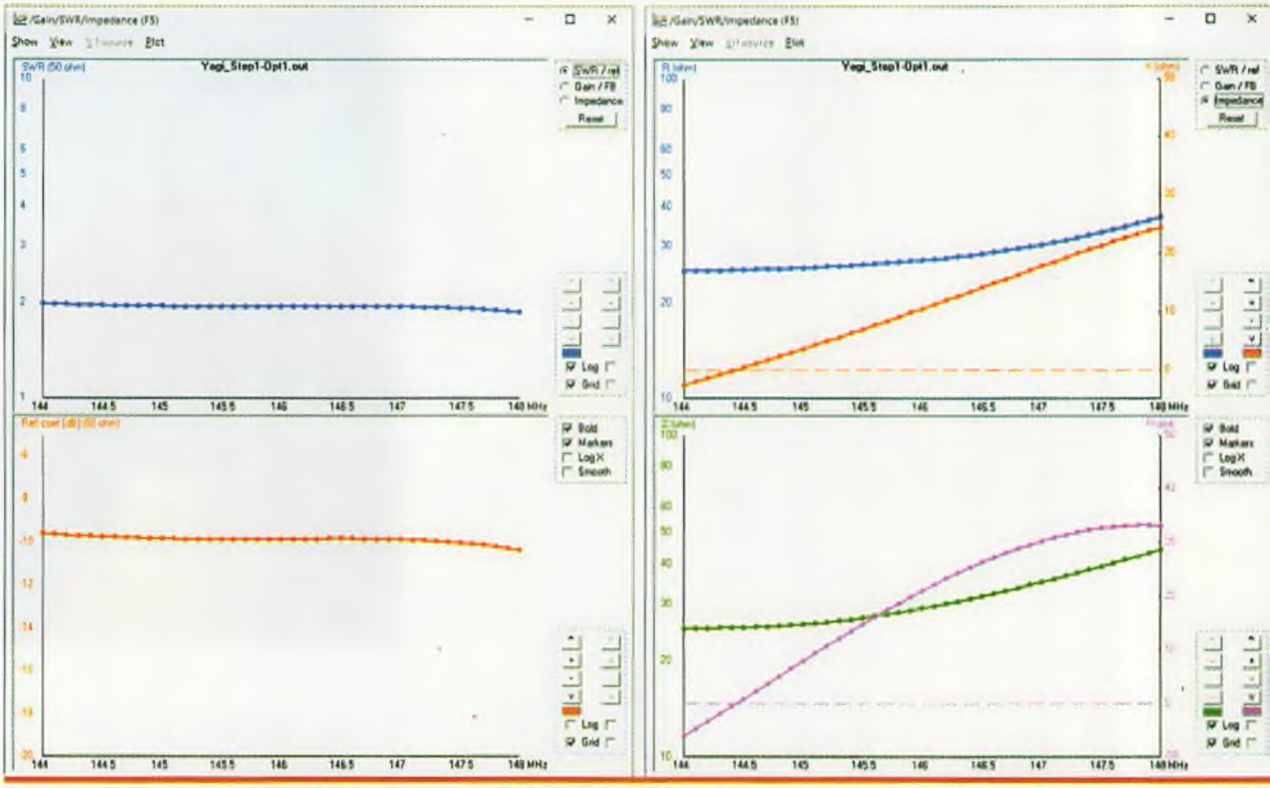


Figure 4-4. 5-element 2m Yagi model – Starting Parameters – SWR/Impedance Step 1.

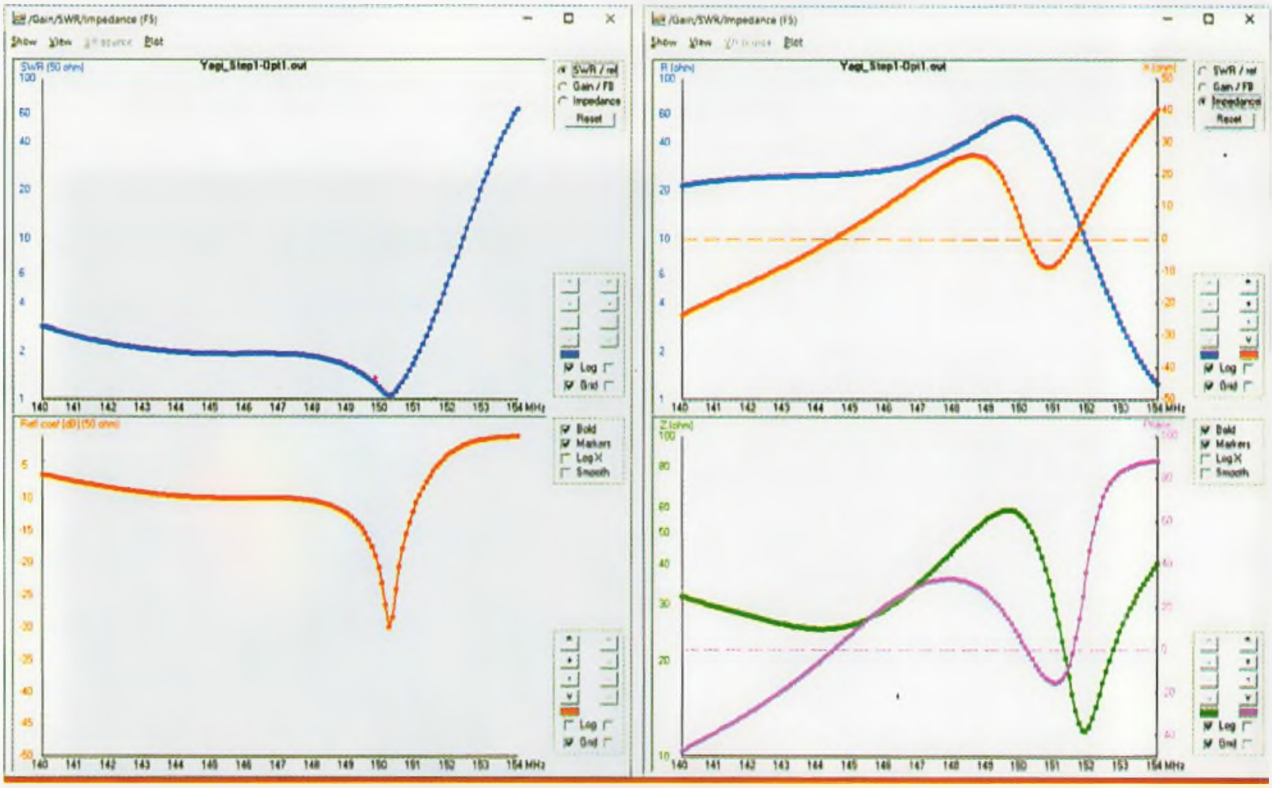


Figure 4-5. 5-element 2m Yagi model – Starting Parameters – SWR/Impedance, 100 steps.

You will note that all of the antenna element lengths have been set as variables as well as the separation distances between the individual elements. This is to allow the optimiser to try different values of each of these parameters with the aim of achieving the desired antenna gain and standing wave ratio.

The geometry screen (**Figure 4-2**) shows the arrangement of this antenna based on the dimensions provided in **Figure 4-1**. This figure has the Tag numbers turned on (using the **Geometry (F3)>Show>Tag-numbers**) so that the antenna elements can be correlated with the tag numbers used in the GW command lines in **Figure 4-1**.

If we calculate the performance of this antenna using **Main>Calculate>NEC Output Data F7>Use original file>Generate**, we get the radiation pattern shown in the left-hand image of **Figure 4-3**, which shows the azimuth and elevation views of the radiation pattern of the antenna. If you select **Main>3D** you can also get a three-dimensional view of the same antenna gain performance as is shown on the right-hand image of **Figure 4-3.**

To get the image shown, you need to select: Structure, Multi-colour and Tot-gain, as shown in the image (these are not the default values). Click and drag on the blue area to rotate the image. The parameters for **Figure 4-3** have been selected by using the Radiation Pattern (RP) command. In this case, we have asked for 361 steps in azimuth and also 361 steps in elevation, where each step is one degree.

Note that the step size needs to correspond with the number of steps, otherwise the calculations may wrap over themselves; 361 is used rather than 360 for a full rotation so that no gaps are formed between the final and first step.

Some more interesting data is also provided in the Gain/SWR/Impedance plots in **Figure 4-4.** The SWR is shown across the range of frequencies selected by the **FR** command. In this case, 41 steps of 0.1 MHz, starting at 144 MHz.

We can see that the SWR is essentially flat across the band; however, this is at a SWR of 2:1 that we should be able to improve through optimisation.

If you see that the SWR is flat across a frequency range it is always useful to have a look at a wider frequency range. We can do this by expanding the modelling frequency range selected in the **FR** command by setting the start frequency to 140 MHz and selecting 141 frequency steps to give a coverage from 140 MHz to 154 MHz in 100 kHz steps.

The change in the command line to achieve this is:

FR	0	141	0
0	140	0.1	

The resulting VSWR/Impedance plots in **Figure 4-5** show that the frequency where the SWR drops to 1:1 is actually just above 150 MHz, so in theory, the antenna elements are a little short for resonance, but they do provide a flat VSWR across the band of interest. This could be corrected with a balun to provide a suitable impedance change.

Optimiser

We will now have a look at the optimiser and what it can achieve. The approach we will use is to start with a 2m dipole and to add individual elements to achieve a 5-element Yagi with a low VSWR across 144–148 MHz. We will start with the Driven Element (DE), as shown in **Figure 4-6.**

If we run this model using **Main>Calculate>NEC output Data F7>Use Original file**, we get the

```
Yagi_Build*.nec - Notepad
File Edit Format View Help
CM Yagi Example Driven Element
CM Simple Yagi design built from the dipole by adding elements
CM Yagi is in free space
CM Bandwidth 144 to 148MHz
CM Maximum Boom length 1.3m
CM Build 1 is dipole only
CM
CE
SY FREQ=146                     'Centre Frequency
SY WL=300/FREQ                  'Wavelength is 300/Frequency
SY DIPOLE_LENGTH=1.027          'Start dipole length 0.5 x WL
SY WIRE_RAD=0.005               'Dipole Radius
SY HEIGHT=0

GW    1    9    0    -DIPOLE_LENGTH/2    HEIGHT    0    DIPOLE_LENGTH/2    HEIGHT    WIRE_RAD

GE    0

EK

LD    5    0    0    0    3.69E+07          'Set all materials to aluminium


EX    0    1    5    0    1    0
FR    0    41   0    0    144  0.1
RP    0    361  361  1000 0    0    1    1
EN
```

Figure 4-6. The Driven Element model.

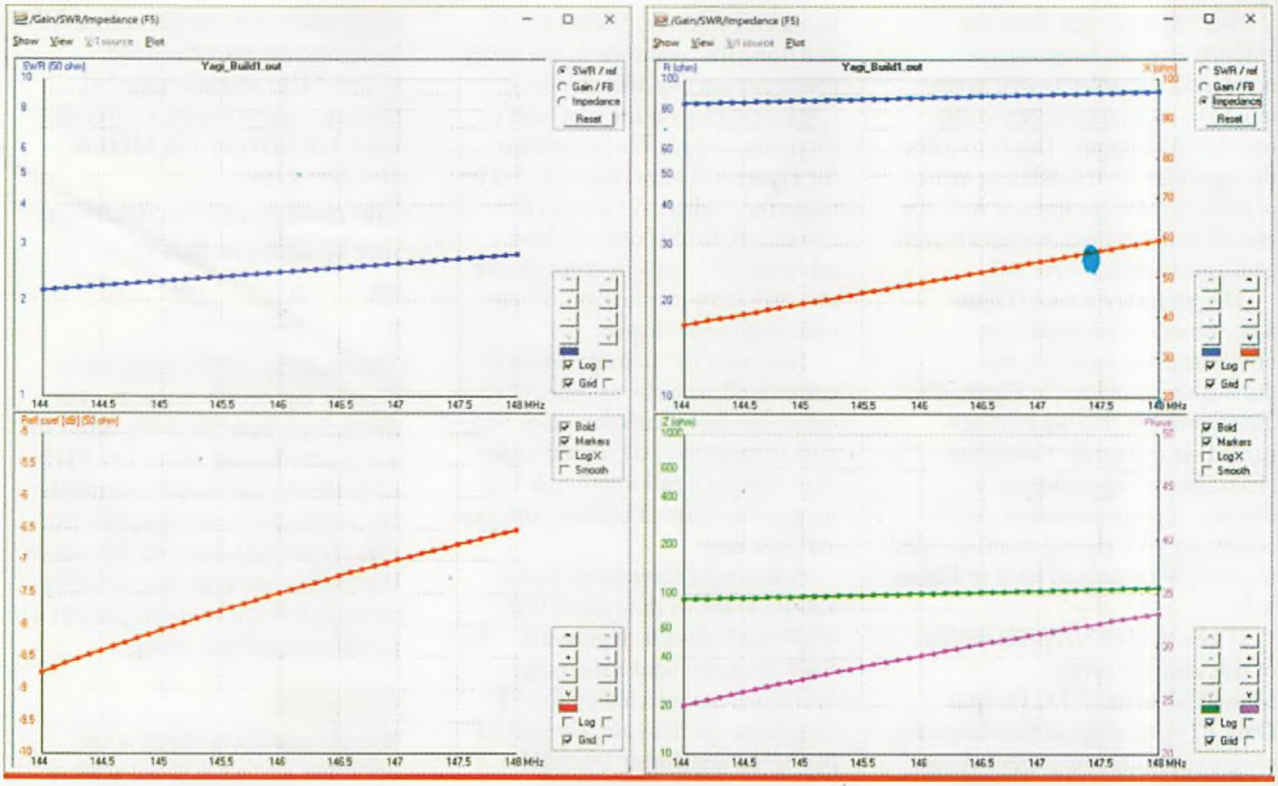


Figure 4-7. DE Starting Performance.

SWR and Impedance as shown in **Figure** 4-7. The SWR is above 2:1 right across the band and needs to be improved.

Let us now run the optimiser to see how we can improve the performance of this element by itself. To run the optimiser, select **Main>Calculate>Start Optimiser F12** and set the parameters as shown in **Figure** 4-8.

Four different options are provided in the Optimiser Window:

1. **Optimize** – Use the traditional hill-climbing method to optimise your design.
2. **Evolve** – Use Genetic Algorithms to evolve (optimise) your antenna design.
3. **Sweep** – Use the Sweeper to visualize the effect of user specified design/variable changes.
4. **Conv-test** – To validate your model by running an automatic Convergence-test.

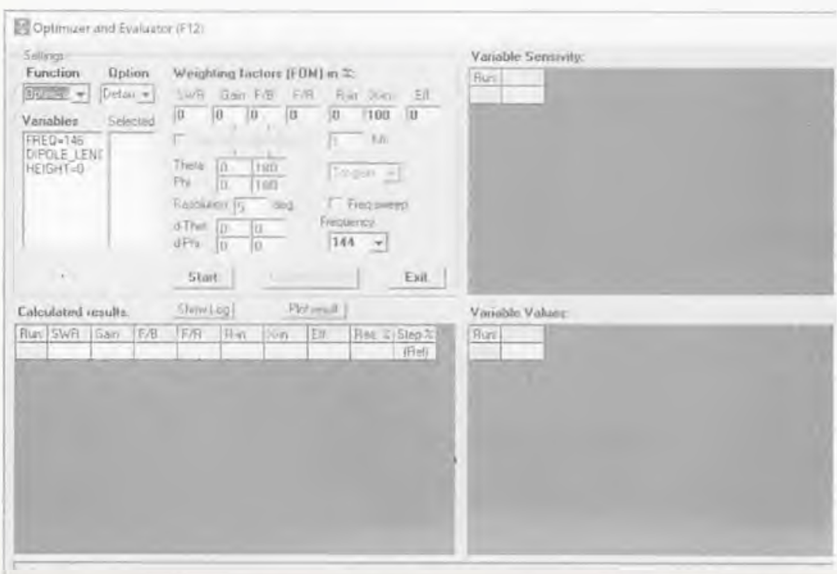


Figure 4-8. The Optimiser Window.

You may select between each of these options with the "Function" box on the upper-left of the optimiser window. In our case, we have selected **Optimise.** With the "Option" box you can select between different sub-options. For most cases 'Default' will be an appropriate choice.

For those that prefer to watch a YouTube video, there is much more detail on optimising provided by Justin G0KSC [3]. This is the fifth part of a series of YouTube videos which covers the use of 4nec2.

We need to select the relevant variables to optimise by clicking on the variables in the Variables box. In this case we have only one variable to optimise and that is the Driven

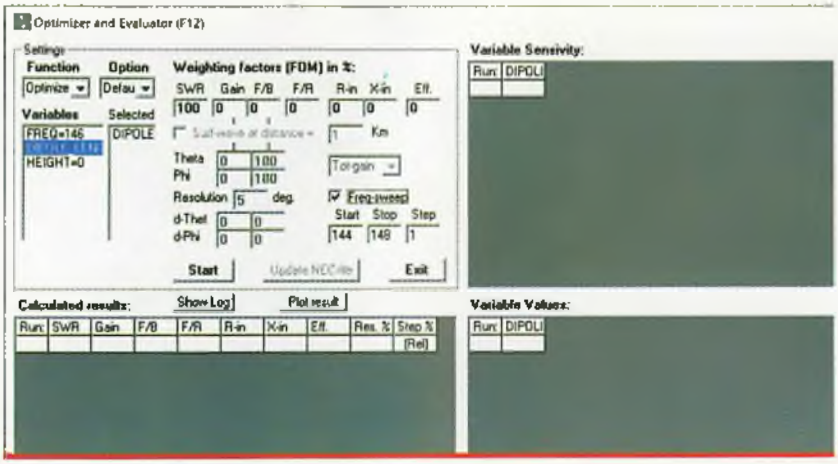


Figure 4-9. Optimiser Settings.

Element length called DIPOLE_LENGTH. Clicking on this will move it to the "Selected" window.

Now we are looking for the best SWR across the band, so we will select the weighting factors to achieve this. In this case we select SWR at 100 and set all of the other factors to zero. Further we want to optimise across the whole band so we can check the Frequency Sweep and select the start and stop frequencies to 144 and 148 and the Step size to 1MHz. These settings are all shown in **Figure 4-9**. Click the Start button to start the optimiser.

A small popup will appear when the optimiser has completed its work, telling you how many steps and how long it has taken to optimise. Click OK to clear this. We have the Optimiser results in **Figure 4-10**. You can use the sliders to move through the data that has been tested. However, the best result for the dipole length is shown in Run 4-1 at the bottom of the Variable Values table. This is 0.9555 metres.

You will see that there is a button (**Plot Result**) to plot the results that generates another small window allowing you to select the properties you want to plot. In our case, we select SWR in the first window, and DIPOLE_LENGTH in the second, which gets these variables plotted as shown in **Figure 4-11**.

Observing Figure 4-11 shows that a Dipole Length of 0.9555 metres provides the best SWR after changing a few settings in the popup window. If this does not work, you may have to go back to https://www.qsl.net/4nec2/ and install Gnuplot 2D/3D plotting, which is found at the bottom of the web page. Note that the installation simply consists of extracting the .zip archive and pasting the gnuplot directory to the root of your C:\ drive.

This process was followed by progressively adding each element to build the 5-element Yagi and optimising at each stage. You can optimise multiple variables, or all of your variables if you want, but sometimes it is better to optimise the element lengths keeping all other variables fixed and then optimise the element spacing's to achieve the final result.

The more variables you try to optimise, the longer the processing will take. Once you are happy with the results of the optimisation process, you have the option to save the results to your .nec file by using the **Update NEC-file** button. This will change the original **SY** variable data in the .nec file to the results of the optimisation process for the variable that you have selected to optimise.

It is recommended that you save

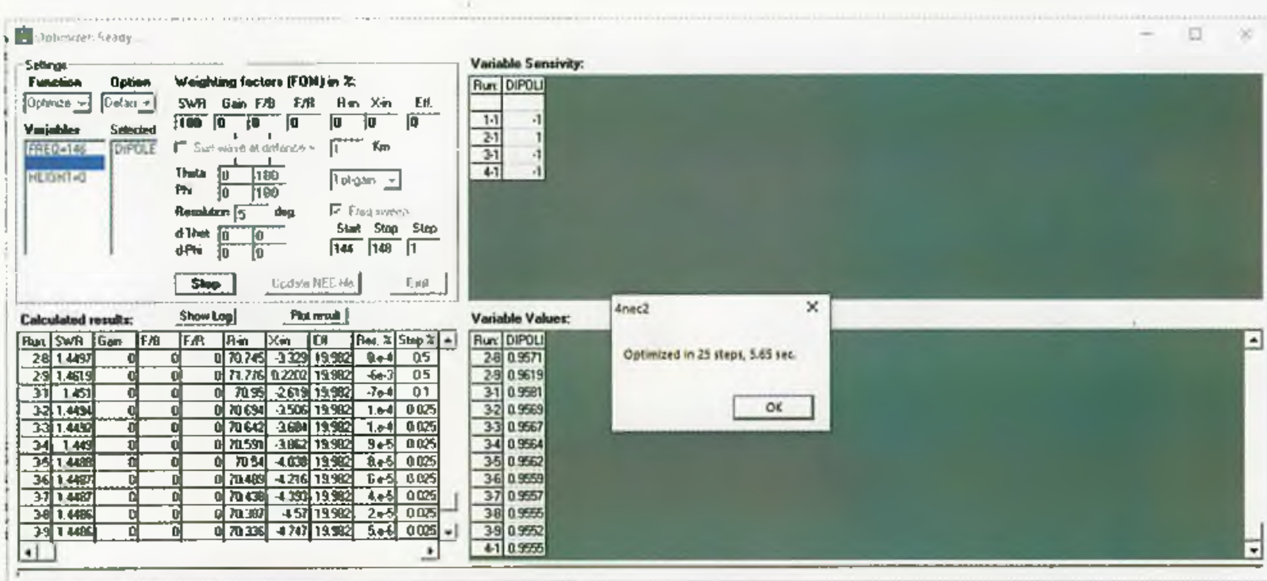


Figure 4-10. Optimiser Results.

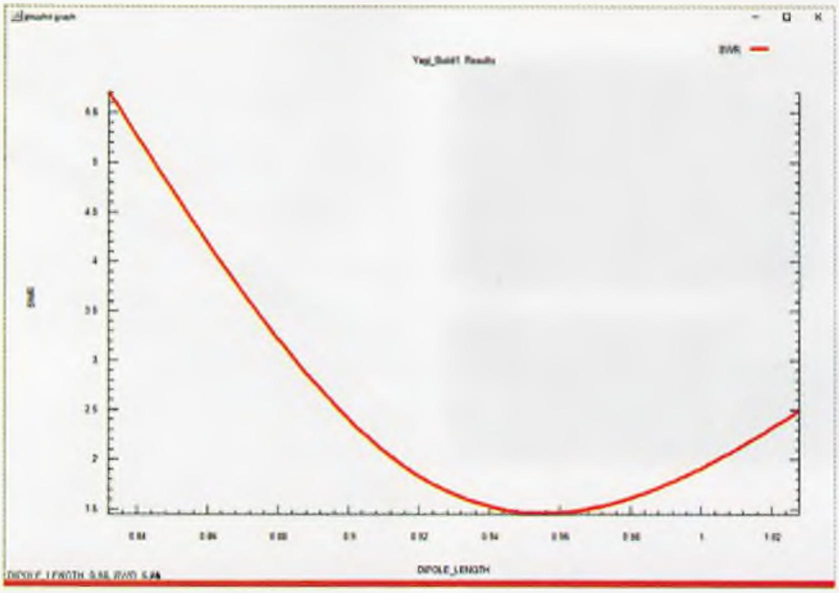


Figure 4-11. Plotted Optimiser results.

this file with a different name so that you have a record of your starting point in case you need to go back to try a different set of variables.

This series would be much longer if we showed all of these steps, so, suffice it to say that the .nec file for the final optimised solution, which is also now based on the final cut lengths and element spacings, is shown in **Figure 4-12**.

The performance of the optimised model is shown in **Figure 4-13** and **Figure 4-14**. Note also that we have increased the number of segments for each of the tags in **Figure 4-12** from 9 to 29 to improve model "adequacy".

For further details on model adequacy, look up the works of L. B. Cebik W4RNL (SK) [4] [5]. While the information provided by W4RNL pre-dates 4nec2, the information on how to prepare models and to test them is highly recommended reading.

References

[1] NT1K, "Homebrew 5 Element VHF Yagi," 30 January 2012. [Online]. Available: https://nt1k.com/homebrew-5-element-vhf-yagi/. [Accessed 19 April 2022].

[2] P. P. Viezbicke, "National Bureau of Standards "Technical Note 688 - Yagi Antenna Deisgn"," December 1976. [Online]. Available: https://tf.nist.gov/general/pdf/451.pdf. [Accessed 19 April 2022].

[3] J. Johnson, "Antenna Modelling with 4NEC2 Finalising Symbols and Optimising Justin G0KSC," 5 December 2020. [Online]. Available: https://www.youtube.com/watch?v=azoSyF9XWEk. [Accessed 19 April 2022].

[4] W. L. B. Cebik, "Antenna Options," QEX, [Online]. Available: http://on5au.be/Cebic/Cebik-Antenna-Options.pdf. [Accessed 19 April 2022].

[5] W. L. B. Cebik, "20. The Average Gain Test," [Online]. Available: http://www.antentop.org/w4rnl.001/amod20.html. [Accessed 19 April 2022].

Contact Details

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```
*Yagi 4aBuilt.nec - Notepad
File Edit Format View Help
SY REF_LEN=1.122                 'Start Reflector length = 95% x 0.5 x WL
SY REF_SEP=0.392                 'Start Reflector separation distance from DE = 0.2 WL
SY DIR1_LEN=0.934                'Start Director 1 length = 95% x 0.5 WL
SY DIR1_SEP=0.369                'Start Director 1 separation distance from DE = 0.15 WL
SY DIR2_LEN=0.917                'Start Director 2 length = DIR1 Length
SY DIR2_SEP=0.163                'Start Director 2 separation distance from DE = DIR1_SEP
SY DIR3_LEN=0.896                'Start Director 3 length = DIR1 length
SY DIR3_SEP=0.210                'Start Director 3 separation = 1.2m-Reflector Separation /3
SY WIRE_RAD=0.5*10E-3            'Dipole Radius
SY HEIGHT=0
SY DIR1=REF_SEP+DIR1_SEP
SY DIR2=REF_SEP+DIR1_SEP+DIR2_SEP
SY DIR3=REF_SEP+DIR1_SEP+DIR2_SEP+DIR3_SEP

GW   1   29   0         -REF_LEN/2    HEIGHT   0         REF_LEN/2    HEIGHT  WIRE_RAD 'Reflector
GW   2   29   REF_SEP   -DE_LEN/2     HEIGHT   REF_SEP   DE_LEN/2     HEIGHT  WIRE_RAD 'Driven Element
GW   3   29   DIR1      -DIR1_LEN/2   HEIGHT   DIR1      DIR1_LEN/2   HEIGHT  WIRE_RAD 'Director 1
GW   4   29   DIR2      -DIR2_LEN/2   HEIGHT   DIR2      DIR2_LEN/2   HEIGHT  WIRE_RAD 'Director 2
GW   5   29   DIR3      -DIR3_LEN/2   HEIGHT   DIR3      DIR3_LEN/2   HEIGHT  WIRE_RAD 'Director 3

GE   0

EK

LD   5   0    0    0    3.69E+07            'Set all materials to aluminium


EX   0   2    15   0    1     0
FR   0   41   0    0    144   0.1
RP   0   361  361  1000 0     0     1   1
EN
```

Figure 4-12. Final 5-element Yagi – Optimised Solution.

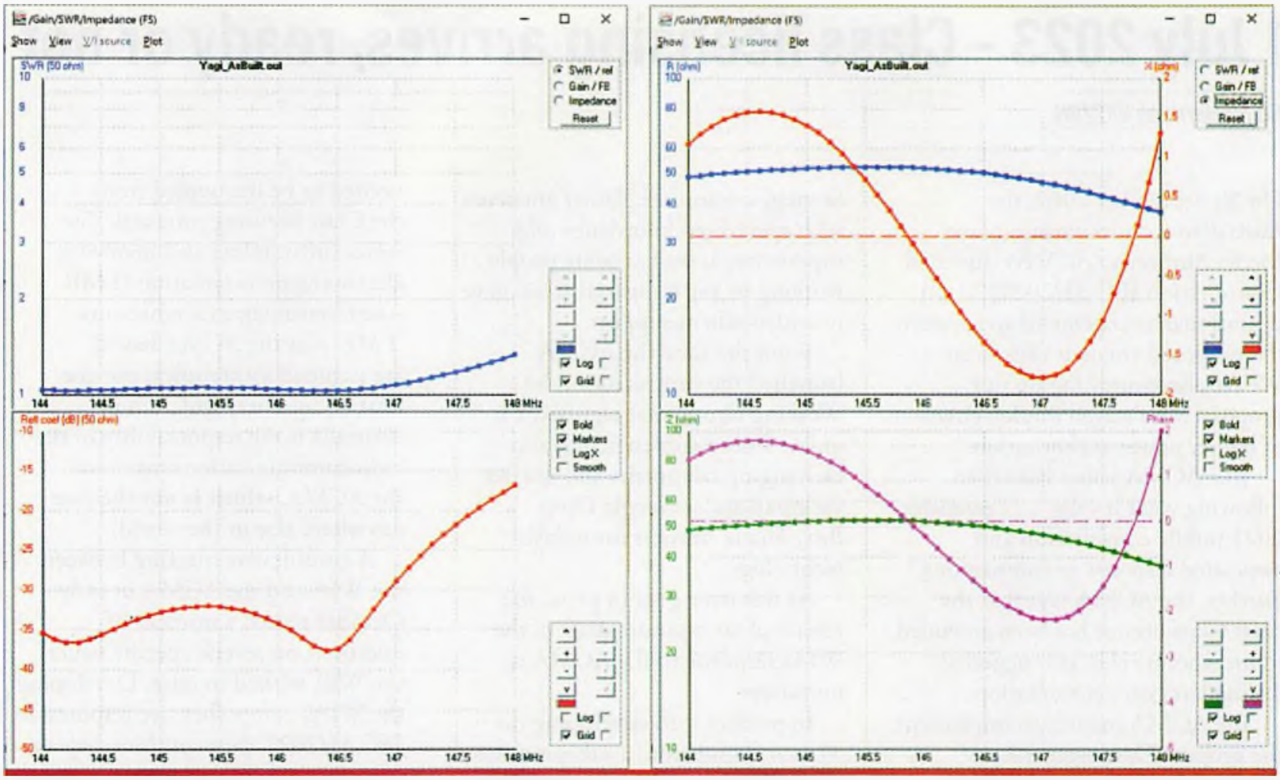


Figure 4-13. Optimised 5 Element Yagi – Return Loss and Impedance.

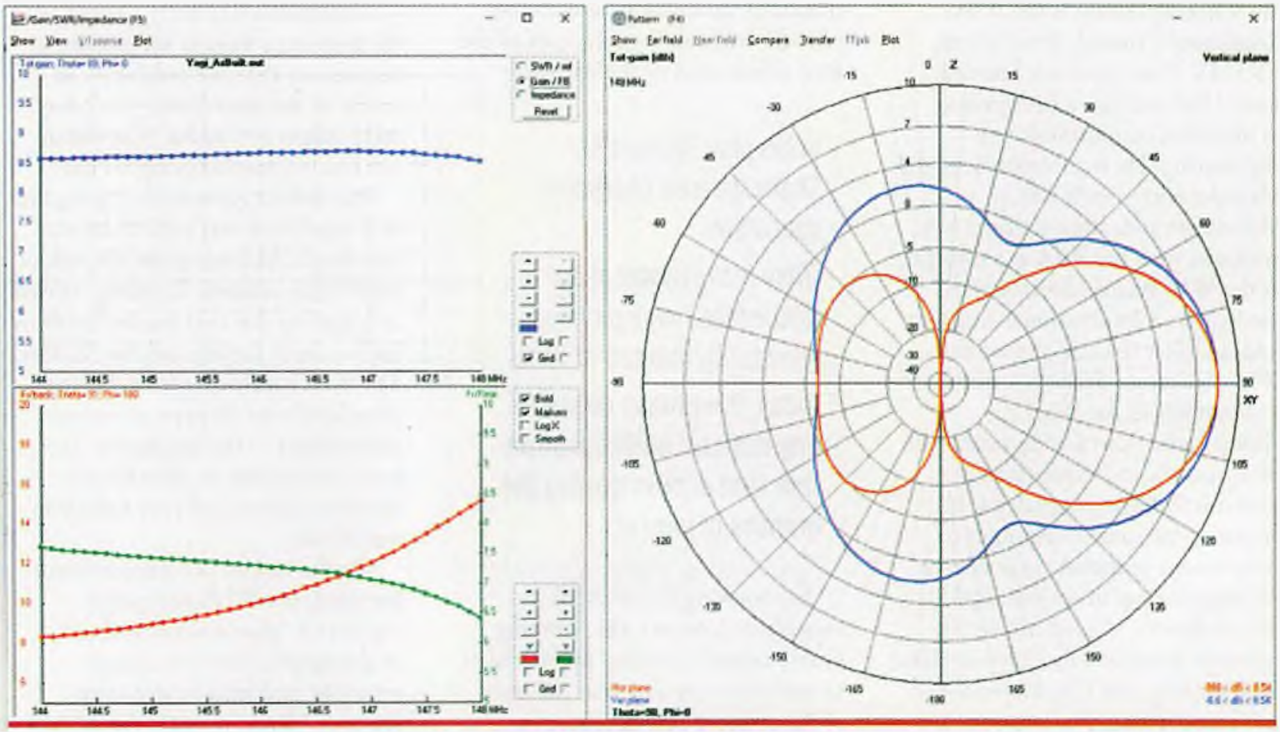


Figure 4-14. Final Optimised Solution, Gain and Radiation Pattern.

1 July 2023 – Class licensing arrives, ready or not

Roger Harrison VK2ZRH

On 29 September 2002, the Australian Communications and Media Authority (ACMA) launched Consultation IFC 31/2022, ". . on operational arrangements to support the proposed amateur class licence. We are also consulting on our proposal for a staged implementation of higher power authorisation."

This ACMA paper has arisen following what it calls ". . . extensive 2021 public consultation and associated response to submissions." Further, the ACMA says that the draft Class licence has been amended to incorporate changes suggested during last year's consultation.

The ACMA intends to implement the proposed arrangements from 1 July 2023. The deadline for responding to the ACMA's consultation is 29 November.

The WIA hit the ground running with a Working Group meeting to develop the Wireless Institute of Australia's response. Leading the Working Group is the WIA's Regulatory Counsel, Peter Young VK3MV. Peter has been licensed since 1965 and has a background in maritime communications engineering. He is a former Regional Manager with the ACMA in Melbourne and, since retiring, held positions with the WIA as a director in the WIA Board, director with the Region 3 International Amateur Radio Union (IARU) and on the WIA's Spectrum Strategy committee.

Members of the Working Group come from a wide variety of backgrounds and experience, but particularly having experience in preparing persuasive responses to government proposals, expertise in RF engineering, in science, and in the machinery of government. In addition, members also have interests in contesting and DX, home design and construction, and propagation. Many are from the Spectrum Strategy committee. Other amateurs with specialised knowledge and experience, as well as some people working in key industrial areas, have provided salient support.

From the time the ACMA launched the consultation, the Working Group met regularly by online Zoom conferencing, also exchanging comments and queries via email and a Google Drop Box. Thank heavens for today's technology.

As this issue goes to press, the release of an exposure draft of the WIA's response to the ACMA is imminent.

In parallel with developing the written submission, a subcommittee of the Working Group prepared an online survey, to be released in conjunction with the exposure draft in order to gain community views and reactions, to help the WIA Board finalise policy, help the Working Group finalise the Institute's submission, and also to provide evidence forming part of the final submission to the ACMA.

> In his play, Richard III, Shakespeare's character speculates
>
> *"Now is the winter of our discontent, made glorious summer by this sun of York."*
>
> Today, this phrase **refers to any difficult political situation that occurs during the months of winter.**

In reviewing the ACMA's consultation papers, the Working Group noted a number of anomalies, as well as concluding that the issue of " . . . staged implementation of higher power authorisation" needed to be uncoupled from the Class licensing proposal. The issues surrounding and involving electromagnetic radiation (EMR – or electromagnetic emissions, 'EME' – as the ACMA has it) are particularly complex, not the least because its regulation in Australia is the responsibility of the radiocommunications regulator, the ACMA, **which is not the case anywhere else in the world!**

A consultative meeting between the WIA and the ACMA in early October settled a number of questions on several specific issues the WIA wished to raise. Developing the WIA's comprehensive response to IFC 31/2022 then continued apace.

History recalled, or recanted?

In February 2021, many readers will recall that the ACMA began a "Review of non-assigned amateur and outpost regulatory arrangements – consultation 01/2021". Ahead of the Institute's written submission in response to that, we published an article in *Amateur Radio*, No.2 for 2021, pages 6-9, titled "Get out of our hair – Class licensing for all?"

The federal government's program of deregulation was well under way and the ACMA was given the task of simplifying amateur licensing, as well as removing the 'cost burden' both to the Amateur Service and the ACMA. The WIA hardly disagreed, having advocated over 20 years in various submissions to the regulators. The issue came down to what form/s the deregulation and cost reduction would take.

On the matter of future amateur licensing, the WIA's key policy was that it *"should not be reduced or downgraded from the current principles embodied in Apparatus licensing."* Back in 2021, the ACMA proposed to *"preserve the current* *operational utility for licensees."* So, whatever transpired had to 'pass the shack test'.

In the 2021 exercise, the ACMA put up three options for the Australian radio amateur community to consider:

- **Option A** was to change nothing; but this didn't meet the ACMA's key objectives.
- **Option B** was to simplify the then-existing licence conditions by re-writing the LCD, but no detail on how it could achieve the objectives was provided.
- **Option C** was to transition amateur licensing to a Class licensing arrangement (except for beacons and repeaters); this was clearly the ACMA's preferred option.

The WIA's submission to that 2021 consultation challenged many of the inherent assumptions in the ACMA's proposals – *especially* the one that said amateur stations would be operating on a *"no interference, no protection"* basis as pertained to all other Class licences (garage door openers, remote controls, RC toys et al). As the issue caused some controversy in the radio amateur community, discussions with the ACMA at the time saw to it that the proposed condition was removed.

In March 2021, the WIA conducted a poll of both members and non-members concerning the ACMA's proposed options, asking two questions. The first asked which of the three options would best maintain the existing rights of licensees and facilitate continuation of the Australian Amateur Service for the next decade. Question 2 asked if participants supported the WIA exploring options of a streamlined amateur licensing system that could deliver benefits to both licensees and the ACMA.

Understandably, the response to Question 1 was:

- 84% favoured Option A
- 9% favoured Option B
- 7% favoured Option C.

The response to Question 2 was encouraging:

- 83% indicated "Yes"
- 15% indicated "No"
- 2% did not respond.

Where to from here?

So here we are, working to get the best outcome for the Australian radio amateur community, present and future, under a Class licensing system.

As this will be a quantum step in the evolution of amateur licensing in Australia, such as we have not seen previously, the details of the latest ACMA consultation paper need close and careful consideration.

It is notable that a number of issues to improve amateur privileges that the WIA has doggedly pursued over a decade or more are included in the ACMA's proposal – like access to the whole 6m band for Standard licensees, for example.

Work has been completed comparing the existing licence conditions (apparatus licensing) to the ACMA's draft Radiocommunications (Amateur Stations) Class Licence 2022, which will serve to inform development of the WIA's response.

The WIA's amateur community survey seeks to gather viewpoints and suggestions from individuals, groups and WIA Affiliated Clubs. Part of the reason for doing this is that we note the ACMA's stated view that they don't wish to deal with large numbers of form letter responses to the consultation.

An *exposure draft* of the WIA's response to the ACMA was planned to be available as this issue of *AR* went to press, including the amateur community survey. Amateur radio is your passion and your interest. Get involved. We all look forward to it.

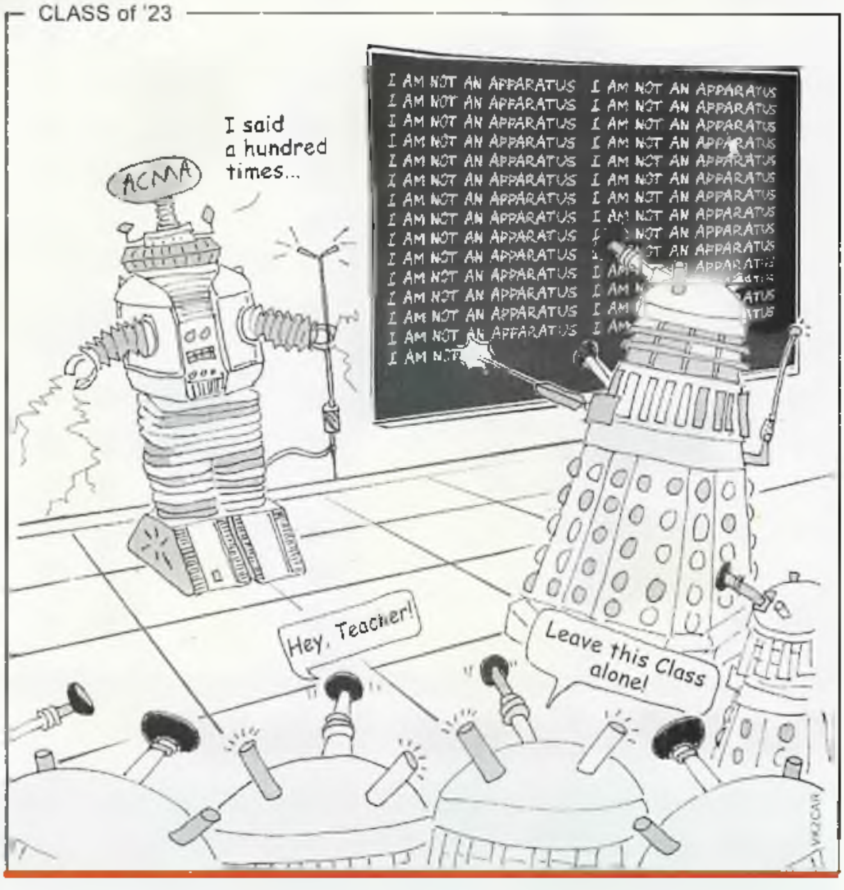


Illustration by Carmel Morris VK2CAR. Some of you may recall sources for the metaphors she's used.

VK4SN's 2023 VK and POPULAR CONTESTS. Las

January			February			March			April			May			June		
1	S	ROSS HULL	1	W		1	W		1	S	EA	1	M		1	T	
2	M	all January	2	T		2	T		2	S	RTTY	2	T		2	F	
3	T		3	F		3	F		3	M		3	W		3	S	P R
4	W		4	S		4	S	ARRL DX	4	T		4	T		4	S	G
5	T		5	S		5	S	SSB	5	W		5	F		5	M	
6	F	YB DX 24Hr	6	M		6	M		6	T		6	S	HA MEM	6	T	
7	S	ARRL	7	T		7	T		7	F		7	S	Don Edwards	7	W	
8	S	RTTY	8	W		8	W		8	S	QRP HRS	8	M	CW	8	T	
9	M	DARC 10M	9	T		9	T		9	S	JIDX CW	9	T		9	F	
10	T		10	F		10	F		10	M		10	W		10	S	VK S
11	W		11	S	CQ WPX	11	S	BERU	11	T		11	T		11	S	DL F
12	T		12	S	RTTY	12	S	YB RTTY	12	W		12	F		12	M	
13	F		13	M		13	M		13	T		13	S		13	T	
14	S	V/UHF FD	14	T		14	T		14	F	PARC	14	S		14	W	
15	S	V/UHF FD	15	W		15	W		15	S	QRS	15	M		15	T	
16	M		16	T		16	T		16	S	CQMM	16	T		16	F	
17	T		17	F		17	F		17	M		17	W		17	S	AI
18	W		18	S	ARRL DX CW	18	S	JMMFD	18	T		18	T		18	S	
19	T		19	S	RU PSK	19	S	RU DX	19	W		19	F		19	M	
20	F		20	M		20	M		20	T		20	S		20	T	
21	S	BARTG	21	T		21	T		21	F		21	S		21	W	
22	S	RTTY 24hr	22	W		22	W		22	S	SP DX	22	M		22	T	
23	M		23	T		23	T		23	S	RTTY	23	T		23	F	
24	T		24	F	CQWW 160	24	F		24	M		24	W		24	S	V
25	W		25	S	SSB	25	S	CQ WPX	25	T		25	T		25	S	
26	T	AX DAY	26	S		26	S	SSB	26	W		26	F		26	M	
27	F		27	M		27	M		27	T		27	S	CQ WPX	27	T	
28	S	CQWW 160	28	T		28	T		28	F		28	S	CW	28	W	
29	S	CW				29	W		29	S		29	M		29	T	
30	M					30	T		30	S		30	T		30	F	
31	T					31	F					31	W			S	

The 2023 Contest Calendar

This annual calendar of contests popularly patronised in Australia (E&OE) has been prepared and provided by Alan Shannon VK4SN, WIA Contest Committee Chairman. All times are in UTC. Alan publishes his contest calendar annually on his website: www.vk4sn.com/Contests/Calendar

Lift-out As this pair of pages is the centre sheet o magazine, you can easily lift it out and post it to th noticeboard in your shack, on the door of your fri anywhere at-hand.

All mode | SSB | CW | DIGITAL

y	August			September			October			November			December		
NZART	1	T		1	F		1	S		1	W		1	F	
MEMORIAL	2	W		2	S	ALL ASIA	2	M		2	T		2	S	FT
	3	T		3	S	SSB	3	T		3	F		3	S	ROUNDUP
	4	F		4	M		4	W		4	S		4	M	
	5	S	BATAVIA FT8	5	T		5	T		5	S		5	T	
	6	S		6	W		6	F		6	M		6	W	
	7	M		7	T		7	S	OCEANIA	7	T		7	T	
IARU	8	T		8	F		8	S	SSB	8	W		8	F	
HF CHAMP	9	W		9	S	WAE	9	M		9	T		9	S	ARRL 10
	10	T		10	S	SSB	10	T		10	F		10	S	
	11	F		11	M		11	W		11	S	JIDX SSB	11	M	
	12	S	RD CONTEST	12	T		12	T		12	S	WAE RTTY	12	T	
	13	S	WAE CW	13	W		13	F		13	M		13	W	
	14	M		14	T		14	S	OCEANIA	14	T		14	T	
VK T-TAS	15	T		15	F		15	S	CW	15	W		15	F	
AKARTA DX	16	W		16	S		16	M		16	T		16	S	OK RTTY
	17	T		17	S		17	T		17	F		17	S	
	18	F		18	M		18	W		18	S		18	M	
	19	S		19	T		19	T	JARTS	19	S		19	T	
	20	S		20	W		20	F	RTTY	20	M		20	W	
	21	M		21	T		21	S	Makrothen	21	T		21	T	
	22	T		22	F		22	S	RTTY	22	W		22	F	
	23	W		23	S	CQWW	23	M	QRP HRS	23	T		23	S	
	24	T		24	S	RTTY	24	T		24	F	V/UHF FD	24	S	
	25	F	WW DIGI DX	25	M		25	W		25	S	CQWW	25	M	
	26	S	ALARA	26	T		26	T		26	S	CW	26	T	
	27	S	SCC RTTY	27	W		27	F		27	M		27	W	
	28	M		28	T		28	S	CQWW	28	T		28	T	
RSGB	29	T		29	F		29	S	SSB	29	W		29	F	
IOTA	30	W		30	S		30	M		30	T		30	S	
	31	T					31	T					31	S	

o the contesters!
lighty are their preparations
ising early, they head shackwards
ull of great expectations
re-appear muttering
Q contest - QRZ - QRZ - again!
nd the truth is not in them!

fter *anonymous* 'Ode to fishermen').

FT4 + FT8 in contesting

The popular *'express exchange'* digital protocols of FT4 and FT8 have found favour with contesters the world over. Indeed, FT4, introduced into the WSJT-X digital protocols suite in 2019, is designed especially for radio contests. Consult: https://physics.princeton.edu/pulsar/k1jt/FT4_FT8_QEX.pdf

Continued on page 36

2023 Australia Day Contest

After last year's successful running of the Australia Day contest, comments were in favour of making the contest a global event. There was a strong indication for distance-based scoring and the inclusion of FT8/4.

A suggested rule set was forwarded to the WIA Contest Committee for its input. On agreement with the new rules, we now have the following outcome:

Thursday 26 January 2023
2200 UTC 25 January to 1000 UTC 26th January

1. The contest is open to all amateurs worldwide, on 160, 80, 40, 20, 15 and 10 meters.
2. Scoring is based on distance, calculated on 4-character grid squares exchange.
3. Phone, CW and Mixed categories with a separate digital category for FT8/FT4.
   a. A log can contain all modes and, on submission, digital contacts will be pulled from the log and put into the digital category while also keeping an operator in the phone and CW sections.
4. WSJT-X users can operate as normal as the .adi file can be imported into N1MM logger for scoring and log creation. Make sure a new .adi file is used for the contest. As no serial number is needed, the standard 4-character grid square used during normal operation is all that's required.
5. VKCL will not cater for this contest, so make sure N1MM logger is ready to go.
6. The User Defined Contest (UDC) required to be loaded with N1MM will be available from vk4sn.com under 'contests'.
7. It is evident that a lot of operators are migrating to N1MM. For new users, a N1MM help file for this contest is available at the end of the rules. Download it from the WIA contest pages: www.wia.org.au/members/contests/australiaday/

The contest is the first Australian distance-based scored and digital contest.

– Alan Shannon VK4SN

Continued from page 35

FT4 + FT8 in contesting

FT4 + FT8 have only recently been adopted by VHF-and-above contesters entering the Australian VHF-UHF Field Days, following in the footsteps of European VHF+ contesters. To use FT4 or FT8 in the WIA VHF-UHF Field Days, you need to be running WSJT-X and select the 'Advanced' tab in configuration *and* select 'EU VHF'. Your exchanges will then be spot-on. Note that, on 6m, the frequency will default to 50.323 MHz and the word TEST is added to the CQ call. Visit: https://europeanft8club.wordpress.com/user-guide/

Further, if you're entering the **2023 Ross Hull VHF-UHF Marathon**, advice on using these digital protocols is online here: https://tinyurl.com/2p8kuwcb

– Trent Sampson VK4TS, VK4T

AX prefix use in contests

For contests occurring on dates when the substitution of AX for the VK prefix in licensees' callsigns is permitted, the Licence Conditions Determination (LCD) of 2015 applies. Using AX *only* applies to the operator's issued callsign on the licence; thus, if you have obtained a 2x1 call with a VK prefix (e.g, VK1Z), you *cannot* use the AX prefix in lieu of the VK prefix.

Here is the relevant section of the LCD (www.legislation.gov.au/Details/F2020C00376):

Part 2 Conditions for every amateur licence

•

•

8 Operation of an amateur station

Call signs

(1A) For the purposes of this section, the licensee of an amateur station (other than an amateur beacon station or amateur repeater station) may, on the following days, substitute the prefix letters VK in the call sign of the station with the prefix letters AX:

(a) 26 January;
(b) 25 April;
(c) 17 May.

Example If the call sign specified in the licensee's licence is VK1ZZZ, the licensee may use the call sign AX1ZZZ on the days mentioned in paragraphs (a) to (c) above.

Note 26 January is Australia Day, 25 April is Anzac Day and 17 May i World Telecommunication Day.

Contesting

On VHF-UHF – no contesting below 0.150

What constitutes a 'contest'?

Are you a newcomer to amateur radio? Maybe you are an old timer and finally decide to try this 'contesting thing'. Perhaps you have just got yourself a shiny new 2x1 'Contest Callsign'?

Let's see in simple terms what – in fact – is a *contest*.

The Cambridge Dictionary states that a 'Contest' as: "a competition to do better than other people, usually in which prizes are given."

The Dictionary also defines 'Prize' as: "something that is given to someone who succeeds in a competition or game or that is given to someone as a reward for doing very good work'

So, it is really that simple? It should be.

What type of amateur radio 'contests' can we enter with our new 2x1 Contest Callsign then to compete against other amateur radio operators locally and around the world where there are prizes for winning categories and competitive performance is rewarded?

Many contests offer prestigious trophies and plaques for your efforts.

Some contests even offer ham radio equipment as prizes for winners and place getters.

The "prize" could simply be a certificate to officially recognise your standing within the various category results.

One of the most comprehensive contesting listings is found at https://www.contestcalendar.com/

Peruse some 'typical' contests, listed below:

- The QRP Hours Contest with a duration of 1 hour CW and 1-hour SSB.
- The Harry Angel "sprint", with a duration of 106 minutes.
- The Trans-Tasman with a duration of 6 hours.
- The John Moyle Field Day with a duration of 12 or 24 hours.
- The Oceania DX Contest with a duration of 24 hours.
- The CQ World Wide (CQWW) contest with a duration of 48 hours.
- The WIA Ross Hull Contest with a duration of 31 days, the full month of January.
- The Ted Powell Contest with a duration of 3 months, 4 times per year.
- The WIA Marathon or CQ Marathon, a contest of 365 days duration every year.

From the above it seems that a 'contest' can therefore be as short as only one hour, as in the case of the QRP Hours Contest, or as long as 365 days, as in the case of the WIA and CQ Marathons.

Now, that brings us to the next point of "what is 'accepted' operational use" of a Contest Callsign?

Contest Callsign use

The AMC's 2x1 use policy is simple*. AMC define use as:

- "Callsigns must only be used during contests. For all other amateur radio use, the licensee must use their 'general' amateur callsign."

So, as we can see, very little thought was put into this 2x1 Callsign operational policy as contest duration has not been well defined.

The UK's RSGB has a well defined and simple rule of callsign use:

"This call sign may only be used in amateur radio contests of no more than 48 hours duration, run with the aim of contacting as many other stations as possible in a given period of time and run by an amateur radio club, national or international amateur radio association or another organisation (including amateur radio publications), generally accepted within the amateur radio hobby (locally, nationally or internationally) as being a bona fide contest organiser."

The RSGB also has excellent qualifying criteria; see: https://tinyurl.com/27zt2nc8

It is understood that AMC was given some very good advice on simple implementation and operational criteria for the 2x1 callsigns well prior to its 'policy' being released, which would have easily alleviated any misconceptions, but for some reason chose not to use the information.

So now, by AMC's own definition, it seems we can use a 2x1 'every day' as we could be participating in the WIA or CQ Marathon contests (defined above).

To be a self-regulating service, as the ACMA is currently advocating along with the proposed Class Licence, that the Amateur Service needs to be "Self Regulating"

We do this now with Gentlemen's Agreements, such as operational Band Plans and specific frequencies deemed for IOTA, POTA, SOTA, and other specific uses like DXpeditions, RTTY, SSTV, satellite sub-bands, calling frequencies on the VHF-UHF bands, FM simplex and repeater channels, and so on.

Gentleman's Agreements are not legally binding operational policies or law like the Licence Condition Determination (LCD) or the RadCom Act; they are just guidelines to create harmonious operation between amateurs on the bands. Some bands can be congested on occasions over the year during major contests and other activities, like JOTA and DXpeditions.

So, should the use of the 2x1 'Contest Callsigns' also be subject to simply a Gentleman's Agreement, or does it need to be firmly and clearly stated as "48 hours duration"?

In future, the policy writers need to consult with experienced and knowledgeable people within their fields of expertise and get the correct advice for the topics at hand.

Whatever your operating preference, get active get on the bands and "CQ Contest", but remember, you decide when and where to use your allocated 2x1 contest callsign and stay compliant with any current AMC Amateur 2x1 contest Callsign Policy.

– Flapjaw Knopfloch

* https://tinyurl.com/mr23mb7t

Contesting

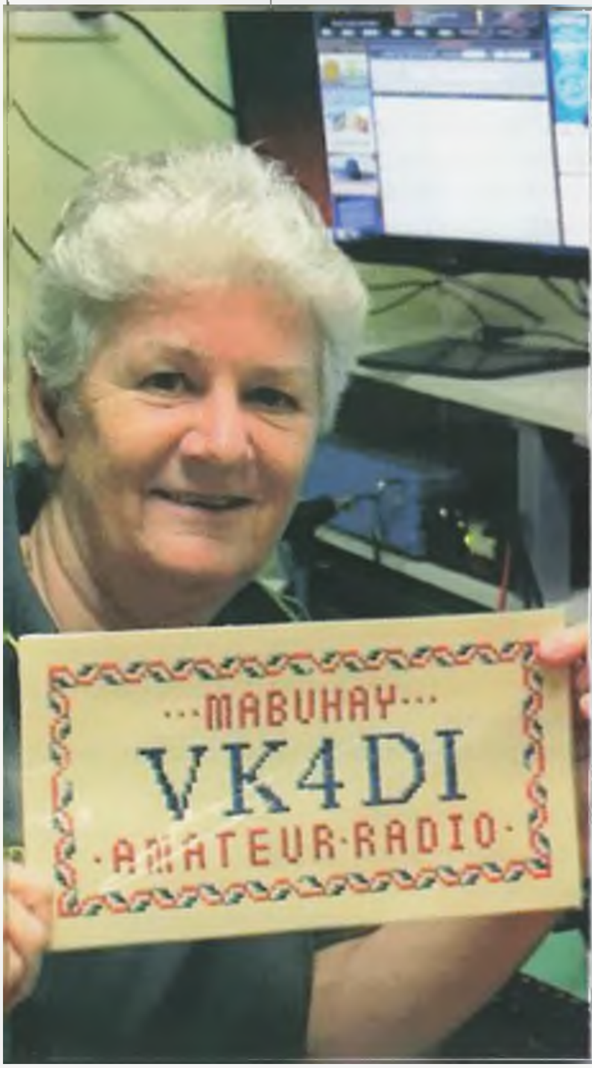
CQ Contest responsibly

CONTESTERS' CHECKLIST

iane MainVK4DI

Action	Reason
Check the Current Rules (online), then and download and print them.	Covid 19, new regulations or a new contest manager may see rule changes.
READ the rules.	Sounds like a No Brainer: BUT the exchanges in different contests are not always a simple Serial # starting at 001.
Repeat the above x2.	Because we are human and sometimes miss the pertinent points.
My suggestion: PRINT the rules and highlight the times, frequencies and exchanges required.	So that you can give the correct exchange and not lose points or time. I do this every contest even though I've been contesting for 40 years-plus.
Ditch the paper log!	Transcribing post-contest leads to callsign inconsistencies, incorrect time stamps AND loss of points for the sender and receiver.
Use the recommended contest logging software.	It makes life easier for the manager and means the results are able to be released earlier. All contest logs can be exported to ADIF and imported to your preferred logging program. The reverse does not work!
Check for software updates **at least** 5 days before the contest.	Rules change, and being able to export the correctly formatted Cabrillo File. If using N1MM, check for the latest UDC (User Defined Contest File). Alan VK4SN is the person who usually does these files for VK contests for which N1MM can be used.
Ensure the Log is in **UTC**.	This is a problem when the PC is not calibrated correctly, or the log is entered post-contest.
Check for updates to contest logging software at least 5 days beforehand.	Altered rules. Don't blame the software if you are using an old version.
Log EVERY CONTACT.	If you take a break and then decide to "give out numbers" but not log them and then submit a log excluding those contacts, then those contacts will cause the receiving station to lose points as they do not correspond to your submitted log.
USE PHONETICS. No exceptions.	Yes! It is in CAPS. Not using phonetics is lazy, AND causes incorrect logging of callsigns VK0NM better heard as Victor Kilo Zero November Mike.
	Phonetics also reduces the number of repeat requests for the callsign.
Relying on the previously logged call popping up in the log without properly listening. heard/	Stations have been constantly mis-logged because the receiving station misheard the original call and then presumed that it was the correct call all the way through the contest. The originating call gets the points and the receiving station that mis- mis-logged the contact loses points.
What is a Multiplier?	A multiplier is a process of multiplying your points. Each contest has a unique set of conditions for multipliers. Multipliers can take various forms. Two examples are listed below. 1. The total # of unique prefixes contacted; so, if VK1X and VL1X are each worth 1 point per contact and they are also multipliers. So, you get 2 points plus 2 multipliers – a total of 4 points (2 x 2).

Action	Reason
What is a Multiplier?	2. The # of CQ Zones (in VK we have 2 CQ zones – Zone 29 which is basically VK6 and VK8, with the rest of VK being CQ Zone 30. So, working a VK6 station and multiple VK1, 2, 3 stations would only be 2 multipliers, as each CQ Zone is counted as a multiplier only on the first contact. Some contests allow the first contact with a CQ Zone on each band to be counted. For example: you make 20 contacts each worth 1 point and also work 10 multipliers. The result is 20 x 10 = 200 points.
What is a "Block"?	Once again, this depends on the contest. A simple definition is the time allowed before you can contact the same station on the same band and mode for additional points (no extra multipliers are allocated to the contact). 1. A block can be either time limited, where reworking a contact is allowed after (as an example) 2 or 3 hours from the last contact. OR 2. Designated blocks of time; for example: from 0000-0359 and then from 0400-0739. So, you could work a station at 0345 and then again at 0415, but no further contact can be made until after 0800.
Don't rush.	Talking too quickly is not always easy to understand and results in a slower contact rate. You will log more accurate contacts than if you rush the call without using phonetics.
Logging errors.	When logging contacts, if someone says portable VK3: usually it would be logged as VK4DI/3 If you log VK4DI/P3 the log checkers see that as Cyprus. If someone is portable in their own state then /P is appropriate. If someone is mobile, then use /M.



2023 John Moyle Memorial National Field Day Rules

Denis Johnstone VK4AE/VK3ZUX

18–19 March, 2023
0100 UTC Sat – 0059 Sun

wish all entrants good luck, and ook forward to hearing some of you on air during the contest!

NOTE new email address: jmfd@ via.org.au will only be set up close o the event for entries and you can heck out latest info at http://www. via.org.au/contests/. However, the lder address jmfd2022@wia.org.au till seems to work.

Overview

1. The aim is to encourage and provide familiarisation with portable operation, and provide training for emergency situations. The rules are therefore designed to encourage field and portable operation.
2. The contest takes place on the 3rd full weekend in March each year, and runs from 0100 UTC Saturday to 0059 UTC Sunday, 18 – 19 March, 2023.
3. The contest is open to all VK, ZL and P2 stations. Other stations are welcome to participate, but can only claim points for contacts with VK, ZL and P2 stations.
4. Single operator portable entries shall consist of ONE choice from each of the following (e.g., 6 hours, portable, phone, VHF/UHF):
   a. 24 or 6 hours;
   b. Phone, CW, Digital or All modes;
   c. HF, VHF/UHF or All Bands.
5. Multi-operator portable entries shall consist of ONE choice from each of the following (e.g., 24 hours, portable, phone, VHF/UHF):
   a. 24 or 6 hours;
   b. Phone, CW, Digital or All modes;
   c. HF, VHF/UHF or All Bands.
6. Home and SWL entries shall consist of ONE choice from each of the following (e.g., 24 hours, portable, phone, VHF/UHF):
   a. 24 or 6 hours;
   b. All modes;
   c. HF, VHF/UHF or All Bands.

Multi-operator stations are NOT permitted in the Home Category.

If a Home Station works the same station regularly during the contest on any band or any mode, they should submit their log to verify those contacts. (See sect. 18 below.)

Scoring

7. Portable HF stations shall score 2 points per QSO. CW only contacts to score 4 points per QSO for contacts with either home or portable stations.
8. On VHF/UHF portable stations for Phone and Digital each contact scores 2 points per contact, and CW contacts score 4 points. In addition, the VHF/UHF Portable stations shall add a distance score of the following on (50 MHz – 6m):
   a. 0-49 km, 2 points per QSO;
   b. 50-99 km, 5 points per QSO;
   c. 100-149 km 10 points per QSO;
   d. 150-299 km 20 points per QSO;
   e. 300-499 km 30 points per QSO;
   f. 500 km and greater, 2 points per QSO.
9. Portable stations shall add an additional distance score on 144 MHz and higher:
   a. 0 to 49 km, 2 points per QSO;
   b. 50 to 99 km, 5 points per QSO;
   c. 100 to 149 km, 10 points per QSO;
   d. 150 to 299 km, 20 points per QSO.
   e. 300 km and greater, 30 points per QSO.
10. For each VHF/UHF QSO where more than 2 points are claimed, both the latitude and longitude of the station contacted or other satisfactory proof of distance, such as the 6-figure Maidenhead Locator, must be supplied.
11. Home stations shall score:
    a. Two points per QSO with each portable station.
    b. One point per QSO with other home stations.
    c. For VHF/UHF QSO Home stations shall add as a distance score on 6 m:
       i. 0-49 km, 1 point per QSO;
       ii. 50-99 km, 2 points per QSO;
       iii. 100-149 km 5 points per QSO;
       iv. 150-299 km 10 points per QSO;
       v. 300-499 km 15 points per QSO;
       vi. 500 km and greater, 2 per QSO.
    d. Home stations shall add as a distance score on 144 MHz and higher:
       i. 0 to 49 km, 1 point per QSO;

ii. 50 to 99 km, 2 points per QSO;
iii. 100 to 149 km, 5 points per QSO;
iv. 150 to 299 km, 10 points per QSO.
v. 300 km and greater, 15 points per QSO.

Log submission

12. For each contact: UTC time, frequency, station worked, RST/serial numbers sent/received and claimed score. (VHF and above – location of other station and distance showing the Lat/Long or Maidenhead Locator to 6 figures for the station worked.)
13. All logs must be accompanied by a summary sheet showing: callsign, name, mailing address, section entered, number of contacts, claimed score, location of the station during the contest, and equipment used, and a signed declaration stating "I hereby declare that this station was operated in accordance with the rules and spirit of the contest and that the contest manager's decision will be accepted as final". For **multi-operator stations, the FULL names, and all callsigns (legible) of all operators must be listed.**
14. The email address for this year's JMMFD contest jmfd@wia.org.au should be setup a few days before the contest, and I would suggest to those who will be sending in your Logs electronically, to send in a test email with the words "TEST JMMFD 2023", in subject the line and also set the "REQUEST READ RECEIPT" flag (if it is available on your e-mail system.). Your callsign can then be added into the database for this year's contest. **When submitting your log for the contest, if you do not receive an e-mail acknowledging receipt of your log, then the log may not have been received and you should resubmit.**
15. Paper logs may be posted to "John Moyle Contest Manager, 27 Laguna Ave, Kirwan 4817 QLD". Alternatively, logs may be e-mailed jmfd@wia.org.au, or to the older address of jmfd2022@wia.org.au, or vk4ae@wia.org.au, or snail mailed via the WIA Contest Manager, JMMFD, PO Box 2042 Bayswater, VIC 3153. Club stations must forward in the first instance an electronic version of their log. Club Stations that submit only a paper log will have that log returned as unreadable, due to the very large amount of work involved in entering and checking large paper logs.
16. The following formats are acceptable: Microsoft Excel or Word, ASCII text or the print log output file from electronic log programs such as VK Contest Log (VKCL). Logs sent by disc or e-mail must include a summary sheet and declaration, but the operator's full name (legible) is acceptable in lieu of a signature. A PDF copy of a handwritten log is also not acceptable and will also be rejected as it is an image and hence computer unreadable.
17. Because of the publishing lead time of AR Magazine, Logs must be postmarked no later than 7th April 2023, **and as the post is now so slow and unreliable, logs despatched on the last day might not arrive in time.** Electronic versions of the log will be received until midnight 11th April 2023. Any logs received after this date will be returned as ineligible.
18. If any station works the same station multiple times on any band or on any mode, both stations should each enter a log to verify those contacts. This rule was introduced to overcome a problem experienced in previous contests where a portable station worked a significant number of home stations, but those home stations did not enter a log, so there were a very large number of unverifiable contacts.

Certificates and Trophy

19. At the discretion of the Contest Manager, certificates may be awarded to the winners of each portable section. Additional certificates may be awarded where operation merits it. Note that entrants in a 24-hour section are ineligible for awards in a 6-hour section.
20. The Australian WIA Affiliated club station with the highest overall score will be awarded the President's Shield, a perpetual trophy held at the Executive Office, and will receive an individually inscribed wall plaque as permanent recognition.

Disqualification

21. General WIA contest disqualification criteria, as has been published in *Amateur Radio* and on the WIA website from time to time, applies to entries in this contest. Logs that are illegible or excessively untidy are also liable to be disqualified.

Definitions

22. A portable station comprises field equipment operating only from a portable power source, e.g, batteries, portable generator, solar power, wind power, independent of any permanent facilities and which is not the normal location of any amateur station. ***Mains power supply is not to be used for any part of the portable installation, or lighting or even battery-charging.***
23. All equipment comprising the portable station must be located within an 800 metre diameter circle.
24. A single operator station is where one person performs all operating, logging and spotting functions.
25. A single operator may only use a call-sign of which he/she is the official holder. A single operator may not use a callsign belonging to any group, club, or organisation for which he/she is a member, except as part of a multi-operator entry.
26. A multi-operator station is where more than one person operates, checks for duplicates, keeps the log, performs spotting, etc.
27. A multi-operator station may use only one callsign during the contest.
28. Multi-operator stations may only use one transmitter on each band at any one time, regardless of the mode in use.
29. All multi-operator stations must submit a separate log for each band. Single operator stations should submit a separate log for each band.

30. Logs submitted electronically can use a separate Excel worksheet for each band linked to a summary sheet. A typical example is shown at www.wia.org.au/members/contests/johnmoyle, which can be copied and adapted for the individual use of either a single or multi-operator station as required.
31. Any station operated by a club, group, or organisation will be considered to be multi-operator by default and must not use any of the permanent club facilities.
32. None of the portable field equipment may be erected on the site earlier than 28 hours before the beginning of the contest.
33. Single operator stations may receive moderate assistance prior to and during the contest, except for operating, logging, and spotting. The practice of clubs or groups providing massive logistic support to a single operator is, however, totally against the spirit of the contest. Offenders may be disqualified, and at the discretion of the Contest Committee, may be banned from further participation in the contest for a period of up to three years.
34. Phone includes SSB, AM, Simplex FM and Simplex D-Star.
35. CW includes CW hand or computer generated. Fully automatic CW operation is not permitted. CW contacts will score 4 points for HF and 4 points for VHF & UHF contacts plus the distance points.
36. Digital modes such as PSK31, RTTY, and packet may be used in the contest, but if they are, they shall be classed as Digital. Other modes such as ATV may be used and will be classed as Digital for scoring. Digital contacts will score points at the same rate as Phone.
37. The new fully automatic modes, such as FT8/FT4 etc and others, simply cannot transfer sufficient information to be eligible as a valid contact at present. Further, they are rarely worked by other stations and so are not verifiable. This may be reviewed in the future.
38. All amateur bands may be used except 10, 18 and 24 MHz. VHF/UHF means all amateur bands above 30 MHz. Note: On 50 MHz, the region below 50.150 has been declared a contest free zone, and contest CQs and exchanges may only take place above this frequency. Stations violating this rule may be disqualified.
39. Cross-band, cross-mode and contacts made via repeaters or satellites are not permitted for contest credit. However, repeaters may be used to arrange a contact on another frequency where a repeater is not used for the actual contact.
40. Stations may make repeat contacts and claim full points for each one. For this purpose, the contest is divided into eight consecutive three-hour blocks: 0100-0359, 0400-0659, 07000959, 1000-1259, 1300-1559, 1600-1859, 1900-2159, 2200-0059 UTC. If you work a station at 0359 UTC a repeat contact may be made after the start of a new block providing, they are not consecutive, or are separated by at least five minutes from the previous valid contact with that station on the same band and mode.
41. Stations operating on Phone must exchange ciphers comprising RS plus a 3-digit number commencing at 001 for each band and incrementing by one for each contact.
42. Stations operating on CW must exchange ciphers comprising RST plus a 3-digit number commencing at 001 for each band and incrementing by one for each contact. Where the CW contact is with an overseas station that is unwilling or unable to give a valid serial number, the serial number for that station shall be assumed to be 001.
43. Portable stations shall add the letter "P" to their own cipher, e.g., 599001P.
44. Multi-operator stations are to commence numbering on each band with 001.
45. Receiving stations must record the ciphers sent by both stations being logged. QSO points will be on the same basis as for Home Stations, unless the receiving station is in fact portable.
46. The practice of commencing operation and later selecting the most profitable operational period within the allocated contest times is not in the spirit of the contest, and may result in disqualification. The period of operation commences with the first contact on any band or mode, and finishes either 6 or 24 hours later.

If anyone wishes to contact me privately to discuss rules etc, my home phone number is (07) 4723 4229, and my snail mail and e-mail address are as shown in the Log Submission section above.

Continued from page 8

Solar cycle 25 rising fast, peaking sooner?

However, solar cycle forecasts have long attracted dissenters, renegades who beg to differ. A group of five scientists, led by Scott McIntosh of the National Center for Atmospheric Research in Boulder, Colorado, made an audacious prediction in 2020 [4], saying "... we deduce that sunspot cycle 25 will have a magnitude that rivals the top few since records began . . in stark contrast to the community consensus estimate . . ."

Their method involves identifying the "termination event" in a 22-year Hale cycle, from which they can compile a forecast for the next cycle. They predict with 95% confidence that the Cycle 25 amplitude (SSN) will fall between 153 and 305 – in the top five of those observed from 1755.

References and Resources

[1] McNamara, L.F. and Harrison, R. 1987, "Kiss your last big solar maximum goodbye!", Amateur Radio magazine, January, pp 14-17. www.armag.vk6uu.id.au

[2] www.swpc.noaa.gov/products/solar-cycle-progression

[3] McNamara, L.F. and Harrison, R. 1985, "Radio Communicators' Guide to the Ionosphere", Australian Electronics Monthly, October pp 100-106.

[4] McIntosh, S.W. et al, 2020, "Overlapping Magnetic Activity Cycles and the Sunspot Number: Forecasting Sunspot Cycle 25 Amplitude", Space Physics, 13 October. https://arxiv.org/pdf/2006.15263.pdf

[5] Poole, I. G3YWX, 2002, "Understanding Solar Indices", QST, September. https://tinyurl.com/y95ypu96

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Ross Hull Memorial VHF-UHF Marathon 2023 rules

Ross Hull 3JU pioneered use of the amateur bands above 30 MHz and demonstrated that atmospheric conditions extended propagation beyond the line-of-sight horizon.

The Contest runs through the month of January, hence 'marathon'. Get on the VHF+ bands and work as many local and DX stations as you can, then send in your *entire* log. Your log will be entered automatically into all applicable categories. Logs are due in by **February 14th.**

Contest background

The WIA maintains a perpetual trophy in honour of the late Ross A Hull and his pioneering achievements in VHF and UHF operation. The contest is open to all amateurs worldwide.

An article about Hull's exploits at the ARRL's QST magazine over the 1930s was published in Amateur Radio magazine, Issue 1 for 2022. You can download a copy from the magazine website, here: www.wia.org.au/members/armag/2022/january/

PDF certificates will be awarded to all entrants. The winner of the Ross Hull Trophy will be the highest scoring single operator in category A (this is a function of the log checking software).

Duration every year

00:00 UTC 1 January to 23:59 UTC 31 January.

Sections

Single Operator
Single transmitter on-air rule applies.

7-day

A Best 7 days, All Modes (total score in categories BCD and FGH).

B Best 7 days, SSB/FM/AM (Phone).

C Best 7 days, CW.

D Best 7 days, digital.

2-day

E Best 2 days, All Modes (total score category FGH).

F Best 2 days, SSB/FM/AM (Phone).

G Best 2 days, CW.'

H Best 2 days, digital.

Multiple Operator
Best 7 days, All Modes, SSB/FM/AM (Phone) + CW + digital.

Digital modes are defined as those in which the decoding of the received signal is done by a computer (not including CW).

General Rules

Can be found on the website: www.wia.org.au/members/contests/rosshull/

All rulings of the Contest Manager will be regarded as final.

Contest Exchange

Entrants must exchange RS (or RST) reports plus a serial number and the log must show a six-digit Maidenhead locator for the station. Owing to variations in different modes, the serial number must be exchanged, but the Grid Square can be sourced by alternate means.

Logs

Station callsign must head the log. The following details must be recorded for each contact in the log:

- Date and UTC time.
- Mode, band or frequency, and call sign of station worked.
- Reports and serial numbers sent and received.
- The contesting station must include the 6-digit grid location of both ends of each contact in the log for the purposes of checking distance claims.

Important: the log must include *all* contacts.

Scoring

Scoring will be based on the best tallies for 2 or 7 UTC days. For each contact, score 1 point per 100 km, or part thereof (i.e., up to 99 km: 1 point, 100 – 199 km: 2 points, etc.).

Multiply the total by the band multiplier as follows:

6m	2m	70cm	23cm	Higher bands
2	3	5	8	10

Then: total the scores for all bands.

Entries

Logs are due in by February 14th. Electronic logs can be emailed to: rosshull@wia.org.au.

Acceptable log formats include Cabrillo 3:0, VKCL.

Complete details

www.wia.org.au/members/contests/rosshull/

VHF/UHF - An Expanding World

David K Minchin VK5KK
e david@vk5kk.com

n this edition we have reports on mmWave activity in VK5 and VK7, the next instalment of the construction series with a 40 – 100 MHz PLL-locked VCTCXO, and the latest anthology of what happened 20 years ago with ATV activity on 5.8 GHz.

134 GHz Australian DX record extended (again)!

n the last column, I reported on the initial 134 GHz contact between VK5ZD and VK5KK in July extending he distance record for 20.9 km with 599 CW reports both ways. Clearly, with signals at this level, there was plenty of room to improve this distance. However, he wet weather across south-eastern Australia delayed another attempt until October 2022.

On 2/10/22 at 05:15 UTC, VK5ZD at 34.6481S, 138.6579E (near Bunnings, Munno Para) worked VK5KK at 34.9316S, 138.6972E (Coach Rd, Skye) over 31.7 km on 134,000.150MHz, to set a new national distance record. The mode was CW, with 519/559 reports. Dew point was about 12C.

Conditions were nowhere near optimal. Contacts were repeated on separate 450 mm Edmond and 600 mm dishes, on both 122 and 134 GHz with different transceivers, all at similar levels.

Construction Series Part 9: 40–100 MHz PLL VCTCXO

As discussed previously in this column, raising the reference/phase detector (PD) frequency directly improves he phase noise of any PLL system, especially those

Photo 1. VK5KK's 450 & 600 mm 134 GHz systems - 31 km to VK5ZD, for a new DX record.

used on mmWave frequencies. Our common reference frequency of 10 MHz is convenient, but too low for direct locking a microwave PLL for good phase noise performance.

In the worst case, the phase noise can be the significant component of the power radiated and should the reference oscillator have digital artifacts, the system is further compromised. The commonly available GPSDOs are not suitable for mmWave work. The better scheme is to use a clean OCXO that is aligned against a GPSDO before going out into the field.

Commercial microwave PLLs use as high as possible phase detector frequencies for the same PLL chips we use; i.e, the ADF4159 and ADF41513 PLL can have a PD 80–100MHz. However, suitable stable OCXOs on those frequencies are rare, so we need an intermediate step to create a ~100 MHz reference locked to a 10 MHz reference.

The alternative is to multiply a 10 MHz reference. But, as we usually want an even multiple at 8 or 10 times this, it's not a simple matter. I have done a few experiments; all ended up being big and complex to align.

The PLL designed by Hans OE2JOM, published in DUBUS 4/2012, that can lock a 5th overtone (80 to 120 MHz) crystal to a 10 MHz reference is an excellent start.

Photo 2. The 40-100 MHz PLL VCTCXO PCB installed on VK5KK's 122 GHz PCB.

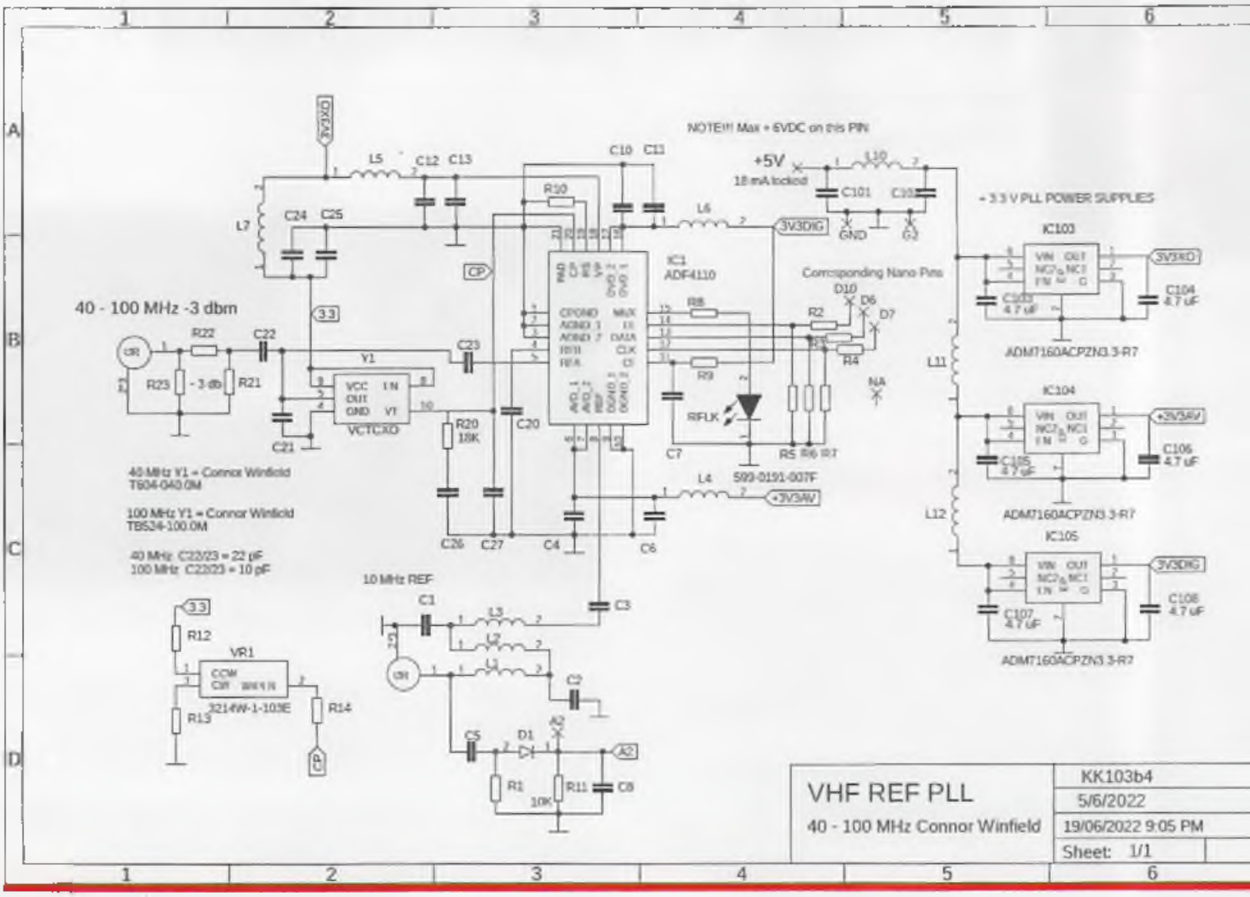
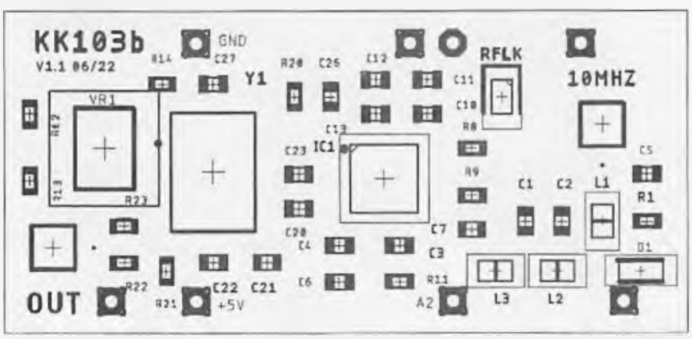
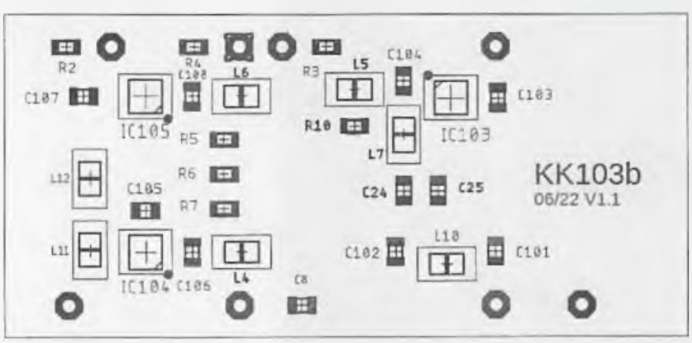


Photo 3. 40-100 MHz PLL VCTCXO schematic.



KK103b Top Layout



KK103b Bottom Layout

Photo 4. 40-100 MHz PLL VCTCXO PCB layout, top and bottom.

Tests with this design showed near spectrum pha noise could be lowered dramatically (> 10 db).

Experimenting with the various 122 GHz system power can be increased to the point where most of the power was in a single carrier! 80 MHz was used for most experiments as 100 MHz was found to hav some limitation with the commonly used ADF415 PLL.

The phase detector does not work reliably at 100 MHz, requiring the REF divide-by-2 function. As the PD works well at 80 MHz, the more commonly available 40 MHz VCTCXOs can be used and doubled internally in the PLL to a PD of 80 MHz.

The mini project presented here has been developed for the VK5KK 122/134 GHz transceive but can equally be used as a stand-alone unit by simply adding the PCB to the underside of an Arduino Nano that acts as the controller.

An ADF4110 PLL is used to lock the VCTCXO with separate low PSSR 3.3 V regulators running from the Arduino's 5 V rail.

The PLL serial control lines connect directly to t Nano with the DATA(D6), CLK(D7) and LE(D10 pin. The PLL registers are loaded on boot up and th Nano goes into sleep mode and so minimise noise. The PCB itself is the same size as a Nano, with a U.FL connector for 10 MHz in and 40 MHz out.

Premade U.FL-to-SMA panel-mount female leads are available online in lengths from 50 – 200 mm, just be careful you get decent quality ones as some aren't crimped well.

Two PCBs have been created, one for the Connor Winfield T604-040.0M and one for the Abracon AST3TQ-V-40.000MHZ-28 VCTCXO footprints. Both have 0.28 ppm temperature stability, more than adequate for PLL locking, but also giving flexibility to use the oscillator unlocked. Short-term drift is only a few kHz at 122 GHz, more than adequate for short range FM use. Other frequency Connor Winfield or Abracon VCTCXOs could be used, so long as they have the same footprint and are 3.3 V logic.

To allow unlocked operation, a simple circuit was suggested by Iain VK5ZD to detect the presence of 10 MHz. A Schottky diode supplies a small voltage (~ 250 mV) to A2 of the Nano. If no voltage is present, the software instructs the PLL MUXOUT to go into TRISTATE mode (open circuit) to allow the multiturn trim-pot to set the 40 MHz frequency. When 10 MHz is detected, the PLL is configured normally.

I have included the schematics and PCB layouts in the column as a teaser. If you are interested in making one for a specific project, drop me an email with the frequency you would like, and I will send the BOM/Arduino sketch to match.

What happened 20 years ago

Continuing in the series of what happened 20 years ago, from November 2002 Barry, VK5BQ (SK) reports on microwave ATV activity.

> You may be interested to know that I have been able to get a signal over 86 km from Stansbury, across St Vincent's Gulf to Maitland, VK5AO, in Adelaide on 5.8 GHz.
>
> The mind-boggling thing is that Maitland has received my ATV signal on just a 5.8 GHz chaparral feed tied on to a pole 30 feet up his tower as no dish was available. The received signal strength varies from nothing to P5. The main problem is that his converter and Sat. RX are also up the tower, the sun is belting the daylights out of the converters oscillator and causing frequency drift, or that's what we think.
>
> Not bad for a distance of over 86 kilometres being received on just a waveguide feed. For the sake of this historical event and I think it would be a first, the recorded time was 11.10 AM Tues, Nov 5, 2002, witnessed by the following personalities. VK5JD (SK), VK5RO (SK), VK5KGS (SK) and VK5ZDG. I tried with Don, but his setup wasn't successful.
>
> The witnesses observed the event via relays on 2.4 GHz and 1250 MHz.
>
> The final amplifier seems to be going ok with the power supplies and protection circuits, with about 4 Watts output. I can now operate on three ATV bands simultaneously with separately controlled antennae (1250, 2400, and 5800) and also receive only on 10 GHz.

More on what happened 20 years ago next issue.

Stop Press – mmWave activity in VK7

The Tassie Ham Radio Conference and Expo is being held in Hobart on the 5th and 6th of November 2022, just as the magazine goes to press. According to the organisers, over 150 attendees have registered to attend from all over Australia. Various presentations are to be held live or virtually, with an emphasis on technology.

This column is being written a few days beforehand, so a full report on VHF and above presentations will appear in the next edition.

Those familiar with Hobart will know that Mt Wellington (1271 m ASL) towers over the city, an instant attraction for mmWave (above 30 GHz) operation over short to medium distances. It is arguably the best spot next to any capital city in Australia.

As mmWave equipment is to be discussed at the conference, Iain VK5ZD and David VK5KK arrived on the 1st of November with some mmWave kit to do some operating in and around Hobart prior to the conference. Given the weight and space restrictions of flying, operation was restricted to 47, 76, 122, and 134 GHz, using a common backfeed 400 mm prime focus dish with Cassegrain reflector.

The X factor with mmWave operation is always weather. From a few days out, it was apparent that Hobart was going to be cold and wet, so access to Mt Wellington could be an issue. On the day we arrived, the main gate at the bottom of the mountain was apparently closed,

Photo 5. VK5KK/VK7 system at Mt Wellington (134 GHz configured).

Photo 6. VK5ZD/VK7 system at Rosny Park, Hobart (47 GHz configured).

according to social media, but re-opened late in the day.

Tuesday morning, it was do-or-die to beat the weather, so VK5KK went up to a lookout just below the mountain, on Pinnacle Rd (1100 m ASL). VK5ZD went to Rosny Park near the Tasman Bridge.

Contacts were had on 47, 122, and 134 GHz, with 59 signals over a distance of 11.1 km, setting inaugural VK7 distance records on each band. At the VK5KK Mt Wellington end, the temperature dropped to nearly zero and light snow was experienced. Over such a short distance, it made no impact on signals.

A YouTube video of signals on 134 GHz from the VK5KK end can be found here: https://tinyurl.com/yx5t5rev

Later in the day, 76 GHz was repeated between Rosny Park and Mt Nelson Signal Hill over a 6 km path. Operation was cut short by heavy rain and hail! More in the next issue.

In closing

A reminder that **Kevin VK4UH has volunteered as the VHF-UHF Records Manager; the new email for all record applications is:** distancerecords@wia.org.au

Feel free to drop me a line if you have something to report or a project you are working on, it doesn't take much to put a few lines together and helps with the diversity of this column. Just email me at: david@vk5kk.com

Silent Key

John Martin VK3KM

On Monday 15 August 2022, his cousins, their families, and friends gathered in the Melbourne Eastern Suburbs to say farewell to John Martin VK3KM.

John, an only child, was born in July 1948 and passed away on 23 July 2022, aged 74, after a little over a decade of dealing with serious medical health issues. He was never one to openly question his predicament, having been initially diagnosed in 1998.

In his own inimitable way, he was prepared for the end time. John had written his own eulogy, the opening line stating: "Hello everyone; thank you very much for coming. Even though I don't know who is there, I appreciate it!" It set the mood as we listened to his version of his life.

He had grown up loving reading and interesting gadgets that he found in the garage, a phonograph and a mantel radio. These piqued his interests and became the pathway to his lifetime fascination with radio.

Among other interests, John have time for languages and Jazz, and played piano and organ.

John shared remembrances of his beach holidays and the delight of "living things" in rock pools.

After graduating from Melbourne University, John began his teaching career at Box Hill High School, primarily in Humanities; however, opportunities developed for him in setting up the audio/video department (playing with gadgets), and in computer studies. John was a very shy person, and he could never understand how he took a job teaching, but the A/V department provided for his specialities.

Retiring early with health issues in 1991, John filled his days with amateur radio, computers, music and movies, and time with close friends. He cared for his parents in their final years. They had died in 1998 and 2000.

John had joined the Eastern & Mountain District Radio Club (EMDRC) in the late 1960s, licensed as VK3ZJC. He contributed to Club endeavours and also joined the WIA National Technical Advisory Committee (NTAC) in 1974. He was very proud that he was the first to make contact between Melbourne and Sydney, then Melbourne and Canberra, on the 23 cm band. He was active on a number of different transmission modes, an early acceptor of new opportunities and technologies.

In 1993, he adopted VK3KWA as his callsign, then in 2005 obtained VK3KM.

John also served on the WIA's VHF Advisory Committee, then TAC, as well as running VHF/UHF Field Day contests, all of which gave him much enjoyment. John commented on how much he valued the friendships that he made through amateur radio, whether local or international.

John had selected a few pictures to be shared with the gathering and acknowledged his dislike of cameras, despite spending 15 years in the school A/V department. Quite ironical, he thought. He'd also selected the music for his service and hoped we'd all enjoy it. We did. John acknowledged all his memories would go with him and hoped the few he shared would help us to remember him.

In closing, John "thanked folks for attending" and wished everyone "all the best".

Ham radio friends from the EMDRC and the WIA, some of whom travelled from VK4 and VK5, farewelled John.

He will be missed from the airwaves. Valé John VK3KM.

Geoff Atkinson VK3TL

Antenna Modelling with 4nec2 – finally, 'the real thing'

A short-boom Yagi for FT8 on the 6m band

Gregory Mew VK4GRM

I received some feedback from the first article on *Antenna Modelling using 4nec2 – Part 1* [1] where the question was raised: where do you start with modelling an antenna? This article attempts to address that question by describing an antenna I built from readily available hardware components based on a design developed using 4nec2.

With the introduction of the digital modes (FT8 drew my attention) and the improved propagation due to the rising solar index, I became interested in the 6m band. For an antenna, initially, I built a simple quarter wave groundplane antenna, comprising a copper wire vertical element taped to a squid pole, with the groundplane made from two, three metre lengths of 10 mm diameter aluminium tube sourced from Bunnings. This sufficed for 12 months or more, but I wondered what I could do with a little more gain.

I found an article on the web by L B Cebik W4RNL (SK) [2] that outlined the design of a three-element Yagi. It was intended for the FM operator, so designed for the top end of the band, but covered the 6m band with reasonable performance; usefully, it had a 50 ohm feedpoint impedance. The Yagi was vertically oriented, and all mast elements were nonconductive.

Cebik says, "Evaluating a beam design requires an appreciation of three ingredients:

- your needs on a particular band,
- general beam antenna behaviour, and
- reasonable expectations to have of a beam once installed."

All good advice, as I explain in this article.

I followed Cebik's advice and explored each of the ingredients:

Needs on a particular band

I was primarily interested in using FT8, so that set my centre frequency to 50.313 MHz, with an expectation that some coverage would also be available across the rest of the band.

In addition, I would be looking at a horizontally polarised antenna, whereas Cebik's Yagi was vertically polarised. The use of non-conducting components would also simplify the modelling exercise as there would be no need to include a metallic boom in the 4nec2 design.

General beam antenna behaviour

To simplify feeding from a 50 ohm coaxial cable, I required a 50 ohm input impedance to the antenna. Further, a reasonable gain was also a requirement, but this was of lesser importance as I planned to optimise the design for a low VSWR at the centre frequency to simplify the feed arrangement to the antenna.

```
6mYagi.nec - Notepad
File Edit Format View Help
CM 6m Yagi - Driven Element Design
CM Model starts with basic information to determine approximate length of driven element.
CM Optimisation will be used to determine the Driven element length.
CM Nominal Bandwidth 50 to 54MHz
CM Maximum Boom length 1.0m
CM Dipole length determined in free space.
CE
SY FREQ=50.313                  'Centre Frequency
SY WL=300/FREQ                  'Wavelength is 300/Frequency
SY DE_LEN=3.0                   'Start driven element length 0.5 x WL
SY WIRE_RAD=0.005               'Driven Element Radius
SY HEIGHT=0

GW      1       29      0       -DE_LEN/2       HEIGHT  0       DE_LEN/2        HEIGHT  WIRE_RAD        'Driven Element


GE      0                                                       'No ground plance is present
EK                                                              'Initiates use of the extended thin-wire kernel

LD      5       0       0       0       3.69E+07                'Set all materials to aluminium


EX      0       1       15      0       1       0               'Specifies the Excitation for the Driven Element
FR      0       1       0       0       50.313  1               'Specifies the frequency of operation
RP      0       361     361     1000    0       0       1       1       'Specifies the radiation pattern sampling parameters
EN                                                              'End of data entry.
```

Figure 1. Initial 4nec2 model for 6m driven element.

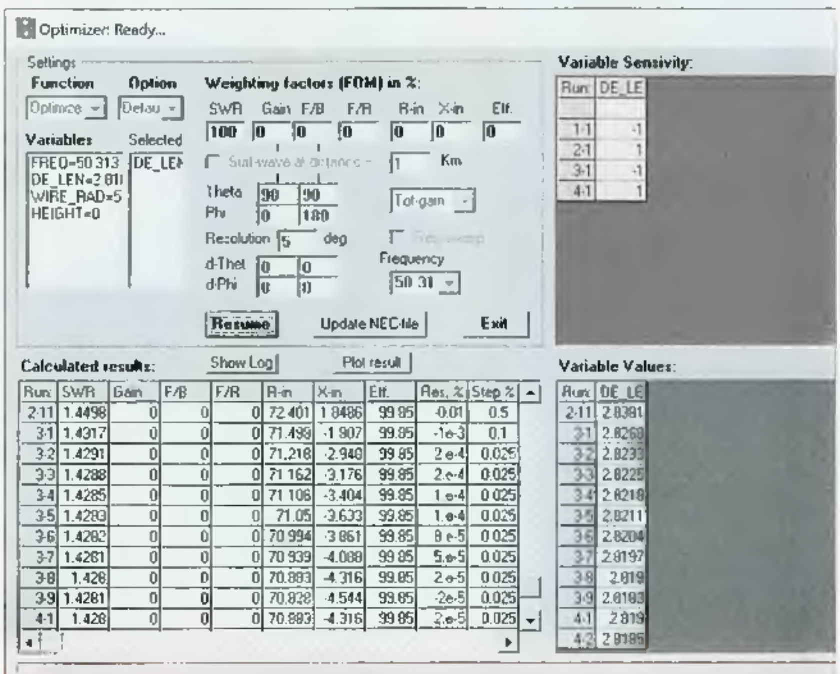


Figure 2. Results of driven element optimiser run.

Expectations once installed

The antenna needed to be as small as possible, consistent with the limitations of the available component parts that could be sourced from either Bunnings or from what I had available. A short boom length would help achieve this. I had some PVC conduit that could be used.

I had a five metre long 'one inch' diameter water pipe to use as a mast and some assorted mounting brackets to connect the antenna to the mast. Further, no antenna element could be longer than three metres, based on the available materials.

4nec2 Modelling

The first step in modelling is to determine what you want to achieve in your antenna and any limitations. In this case I had some constraints on the design.

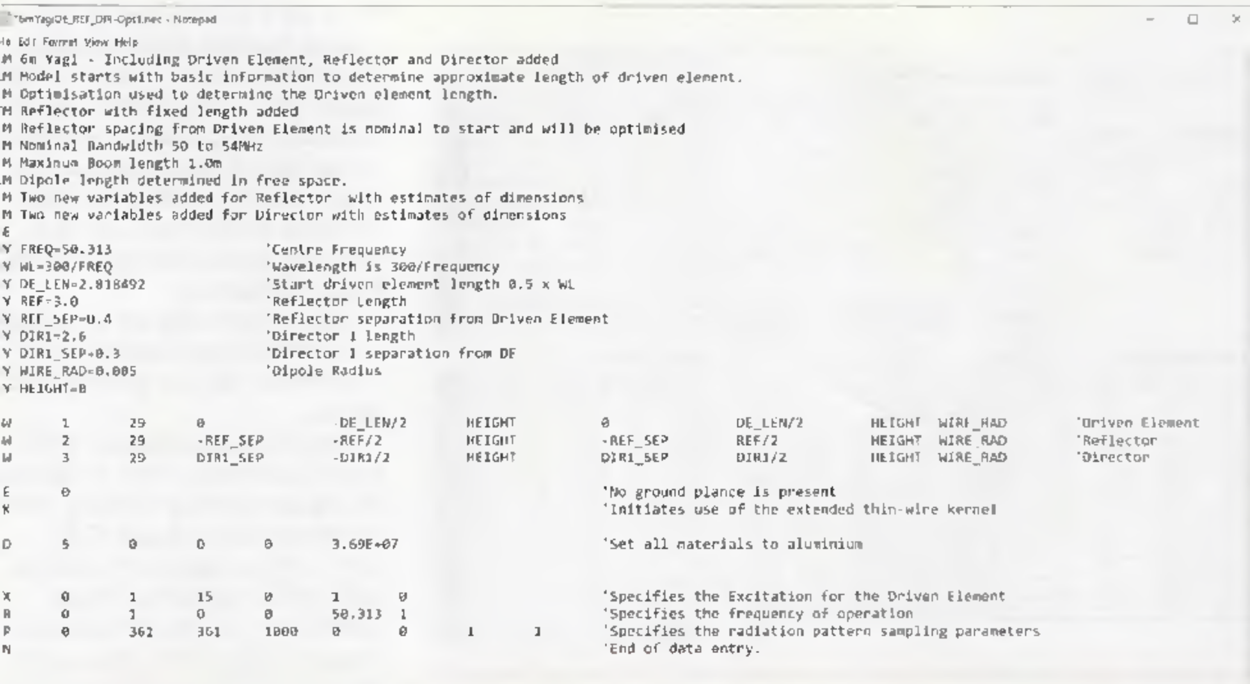
Materials

Bunnings had 10 mm aluminium tube but only available in three metre lengths, so that set the maximum reflector length. The dipole element and director should be less than that, so all-good in this regard. The groundplane from the old quarter wave whip would provide two 3 m lengths of aluminium and I would only need ı buy one more.

A search through my assorted junk under the house revealed some 40 mm plastic conduit about 900 mm long that would do for the boom. I would need a trip to Bunnings to get some suitable U-clamps to match the outside diameter of the conduit, and I had some plastic insulating material at home that would be repurposed foı the mounting brackets.

Dipole element length

It is not the intention of this article to describe the modelling process which has been discussed in some



```
*6mYagiDE_REF_DIR-Opt1.nec - Notepad
ile Edit Format View Help
CM 6m Yagi - Including Driven Element, Reflector and Director added
CM Model starts with basic information to determine approximate length of driven element.
CM Optimisation used to determine the Driven element length.
CM Reflector with fixed length added
CM Reflector spacing from Driven Element is nominal to start and will be optimised
CM Nominal Bandwidth 50 to 54MHz
CM Maximum Boom length 1.0m
CM Dipole length determined in free space.
CM Two new variables added for Reflector  with estimates of dimensions
CM Two new variables added for Director with estimates of dimensions
CE
SY FREQ=50.313                  'Centre Frequency
SY WL=300/FREQ                  'Wavelength is 300/Frequency
SY DE_LEN=2.818492              'Start driven element length 0.5 x WL
SY REF=3.0                      'Reflector Length
SY REF_SEP=0.4                  'Reflector separation from Driven Element
SY DIR1=2.6                     'Director 1 length
SY DIR1_SEP=0.3                 'Director 1 separation from DE
SY WIRE_RAD=0.005               'Dipole Radius
SY HEIGHT=0

GW  1  29  0         -DE_LEN/2  HEIGHT  0         DE_LEN/2  HEIGHT  WIRE_RAD  'Driven Element
GW  2  29  -REF_SEP  -REF/2     HEIGHT  -REF_SEP  REF/2     HEIGHT  WIRE_RAD  'Reflector
GW  3  29  DIR1_SEP  -DIR1/2    HEIGHT  DIR1_SEP  DIR1/2    HEIGHT  WIRE_RAD  'Director

GE  0                                   'No ground plance is present
EK                                      'Initiates use of the extended thin-wire kernel

LD  5  0  0  0  3.69E+07                'Set all materials to aluminium

EX  0  1    15   0     1       0        'Specifies the Excitation for the Driven Element
FR  0  1    0    0     50.313  1        'Specifies the frequency of operation
RP  0  362  361  1000  0       0  1  1  'Specifies the radiation pattern sampling parameters
EN                                      'End of data entry.
```

Figure 3. NEC Model for three-element Yagi.

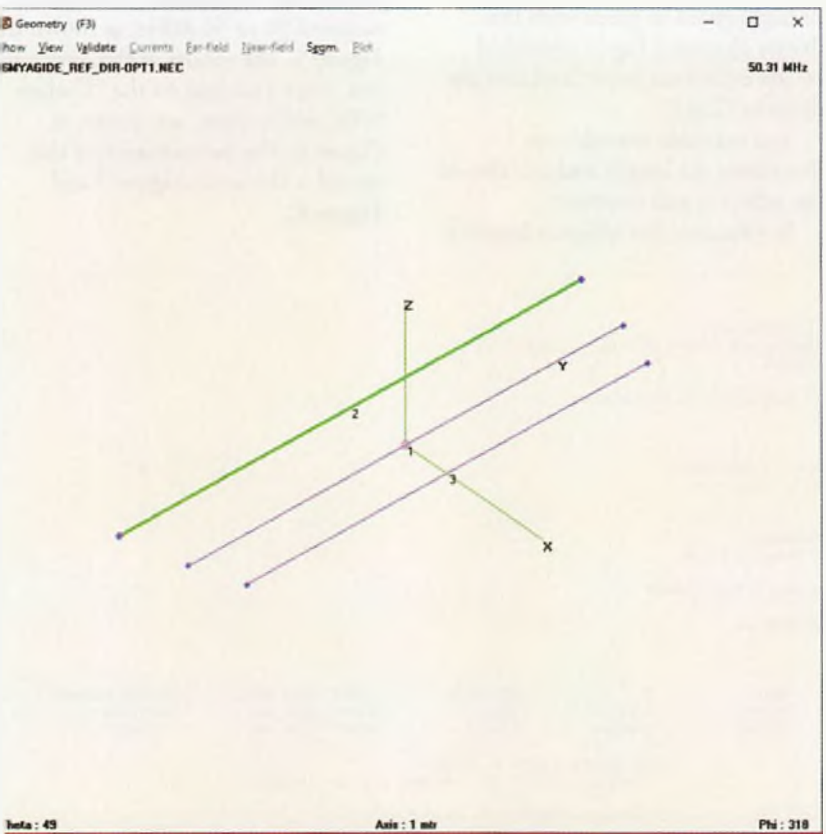


Figure 4. Geometry Screen, showing the three-element Yagi.

etail in my AR articles *Antenna Modelling using 4nec2* [1],[3],[4],[5].

The first step in developing the model was to get an indication of the length of the dipole. A very simple model was created as shown in **Figure 1** and the optimiser was then run with the driven element length as the variable to determine the 'approximate' length required. The results of this run are shown in **Figure 2**.

We see that the driven element length is 2.81 m long, so well within our three metre limit for the available aluminium tube. Note that, in **Figure 2**, the driven element was optimised only against SWR. All other optimisation variables were set to zero. Also, the frequency was set to the desired 50.313 MHz. The results of this optimisation run were saved by clicking the "Update NEC-file" button and creating a new file name, called *6mYagi-Opt1.nec*, to distinguish it from the starting file.

Adding the reflector and director

The next step is to add the reflector and the director to the Yagi design. The model for this is shown in **Figure 3**. The length of the driven element is now set at 2.818492 m from the first optimisation. You will note that two more wire specifications (GW) have been added to the model, with associated

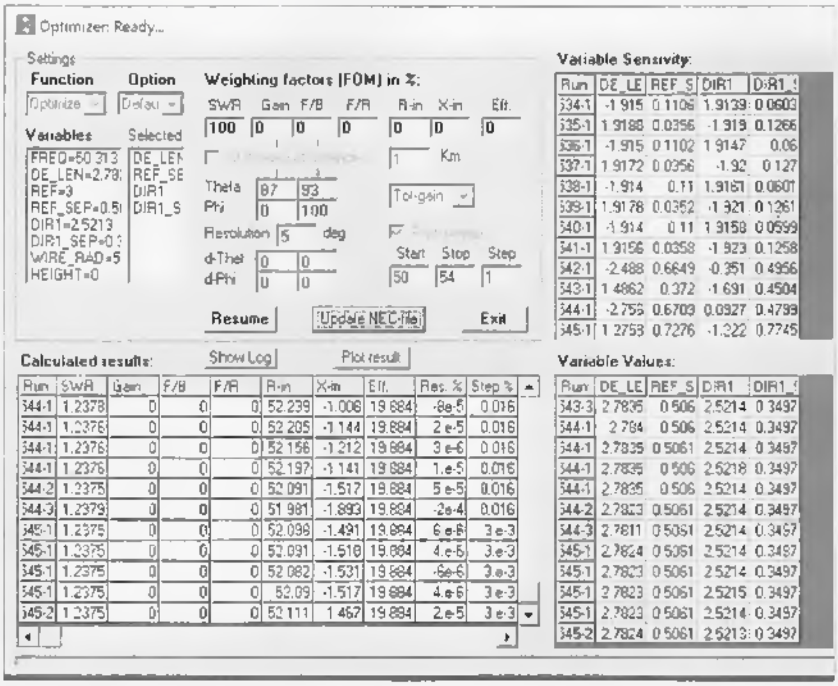


Figure 5. The second Optimiser run.

variables (SY) for length and position of the reflector and director. The variables are required as we want to use the optimiser again to determine the preferred design solution for our Yagi.

The Geometry Screen in **Figure 4** shows the reflector (Tag 2) highlighted in green with the driven element (Tag 1) identified by the excitation point, and also the director (Tag 3).

You may ask: how do you determine the length and position of the reflector and director?

In this case, the reflector length is set by our 3 m limit; the separation distance from the driven element is 0.4 m (400 mm), as I wanted a short boom. The spacing for the director is similarly indicative for the first run of your model. Simply select a value that is, say, 10 percent shorter than the driven element and a position that is the same, or shorter, than the reflector separation.

These initial values are not critical as they will be optimised by 4nec2 to determine the final positions and lengths.

Next, I ran the optimiser. SWR was selected with a 100% weighting. The chosen optimiser variables were the driven element length (DE_LEN), reflector separation distance (REF_SEP), the director length (DIR1), and the director separation distance (DIR1_SEP), which allows further development of this model. At this stage we are also running the model over the operating frequency range of 50 to 54 MHz, as shown in **Figure 5**. The results of the optimiser run, once I clicked on the "Update NEC-file" button, are shown in **Figure 6**. The performance of this model is shown in **Figure 7** and **Figure 8**.

```
6mYagiDE_REF_DIR-Opt2.nec - Notepad
File Edit Format View Help
CM 6m Yagi - Including Driven Element, Reflector and Director added
CM Model starts with basic information to determine approximate length of driven element.
CM Optimisation used to determine the Driven element length.
CM Reflector with fixed length added
CM Reflector spacing from Driven Element is nominal to start and will be optimised
CM Nominal Bandwidth 50 to 54MHz
CM Maximum Boom length 1.0m
CM Dipole length determined in free space.
CM Two new variables added for Reflector  with estimates of dimensions
CM Two new variables added for Director with estimates of dimensions
CE
SY FREQ=50.313                  'Centre Frequency
SY WL=300/FREQ                  'Wavelength is 300/Frequency
SY DE_LEN=2.782394              'Start driven element length 0.5 x WL
SY REF=3.0                      'Reflector Length
SY REF_SEP=0.506069             'Reflector separation from Driven Element
SY DIR1=2.521302                'Director 1 length
SY DIR1_SEP=0.349716            'Director 1 separation from DE
SY WIRE_RAD=0.005               'Dipole Radius
SY HEIGHT=0

GW   1   29   0          -DE_LEN/2   HEIGHT   0          DE_LEN/2   HEIGHT  WIRE_RAD   'Driven Element
GW   2   29   -REF_SEP   -REF/2      HEIGHT   -REF_SEP   REF/2      HEIGHT  WIRE_RAD   'Reflector
GW   3   29   DIR1_SEP   -DIR1/2     HEIGHT   DIR1_SEP   DIR1/2     HEIGHT  WIRE_RAD   'Director

GE   0                                        'No ground plance is present
EK                                            'Initiates use of the extended thin-wire kernel

LD   5   0    0    0    3.69E+07              'Set all materials to aluminium


EX   0   1    15   0    1      0              'Specifies the Excitation for the Driven Element
FR   0   41   0    0    50.0   0.1            'Specifies the frequency of operation
RP   0   361  361  1000 0      0    1    1    'Specifies the radiation pattern sampling parameters
EN                                            'End of data entry.
```

Figure 6. Results from the second Optimiser run.

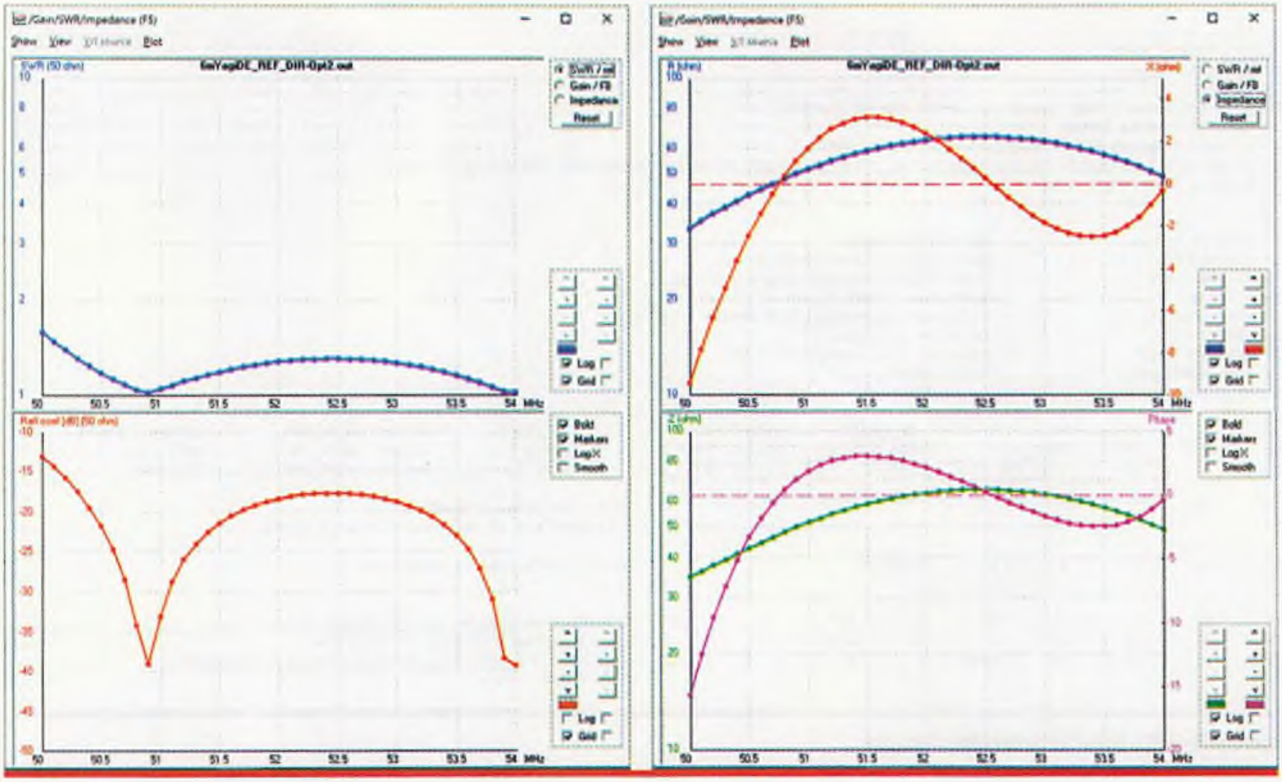
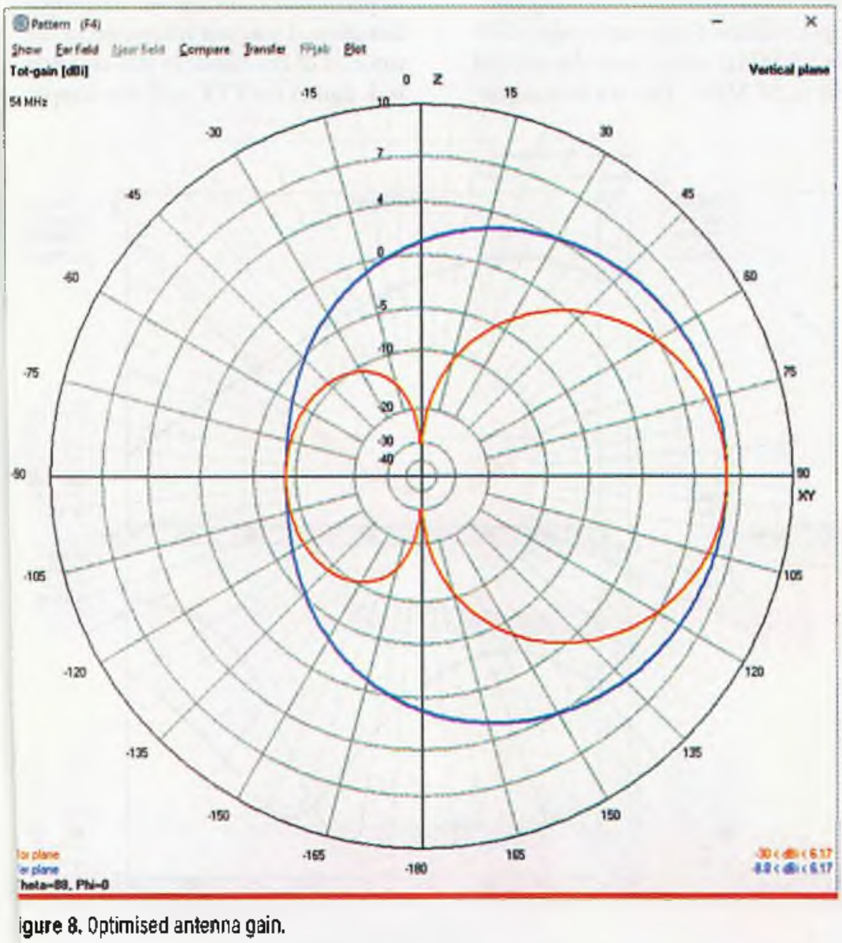


Figure 7. Antenna performance results following optimisation.



igure 8. Optimised antenna gain.

We have a VSWR across the band of less than 1.58:1 and a gain of 6.17 dBi at 54 MHz. The separation between the reflector and the director is 0.855 m. So, effectively, we have met our design requirements after running the optimiser a couple of times. As a first pass, I would be reasonably happy with that.

You can run the optimiser many times and change only one or two variables at a time to see what the effects are on the design. This is the greatest benefit of the optimiser as it allows you to try different parameters to see what effects you can achieve.

The final design

As you may expect, I had not thought of writing this article when I first started thinking about the design of a new 6m Yagi for my QTH.

Needless to say, I embarked on a completely different set of optimiser solutions, which resulted in a different antenna design than was actually built. The .nec file for that design is provided in **Figure 9**, and the results of the model are shown in **Figure 10** and **Figure 11**.

```
6mYagi-FINAL.nec - Notepad
File Edit Format View Help
CM 6m Yagi
CM Simple 3 Element Yagi design optimised for 50 ohm feed.
CM Bandwidth 50 to 54MHz
CM Optimised design for three elements with low SWR
CM Based on 6mYagi-Opt13-1MHz with Reflector fixed in length to 3m and dimensions rounded to the mm.
CM Maximum Boom length 1.0m
CM
CE
SY FREQ=50.313                    'Centre Frequency
SY WL=300/FREQ                    'Wavelength is 300/Frequency
SY DE_LEN=2.871                   'Start driven element length 0.5 x WL
SY REF=3.0                        'Reflector length fixed
SY REF_SEP=0.357                  'Reflector separation from Driven Element
SY DIR1=2.687                     'Director 1 length
SY DIR1_SEP=0.297                 'Director 1 separation from DE
SY WIRE_RAD=0.005                 'Dipole Radius
SY HEIGHT=0

GW    1    29    0           -DE_LEN/2    HEIGHT  0           DE_LEN/2    HEIGHT  WIRE_RAD    'Driven Element
GW    2    29    -REF_SEP    -REF/2       HEIGHT  -REF_SEP    REF/2       HEIGHT  WIRE_RAD    'Reflector
GW    3    29    DIR1_SEP    -DIR1/2      HEIGHT  DIR1_SEP    DIR1/2      HEIGHT  WIRE_RAD    'Director

GE    0                                                  'No ground plane present
EK                                                       'Initiates use of extended thin wire kernal

LD    5    0     0     0      3.69E+07                   'Set all materials to aluminium


EX    0    1     15    0      1     0                    'Specifies excitation for the Driven Element
FR    0    41    0     0      50    0.1                  'Specifies the frequency of operation
RP    0    361   361   1000   0     0     1     1        'Specifies the radiation pattern sampling parameters
EN                                                       'End of data entry
```

Figure 9. Final NEC Model for three element 6m Yagi.

As can be seen from **Figures 9, 10 and 11**, the performance of the model is acceptable.

You will note that this model is optimised at 50.5 MHz, rather than 50.9 MHz, as indicated in **Figure 7**. This was achieved by selecting the optimisation frequency range of 49 to 53 MHz, rather than the normal 50 to 54 MHz. This is a technique you can use to try for improvements in performance in a given frequency direction. I was not interested in the top end of the band, as this antenna is designed for FT8, so I was happy

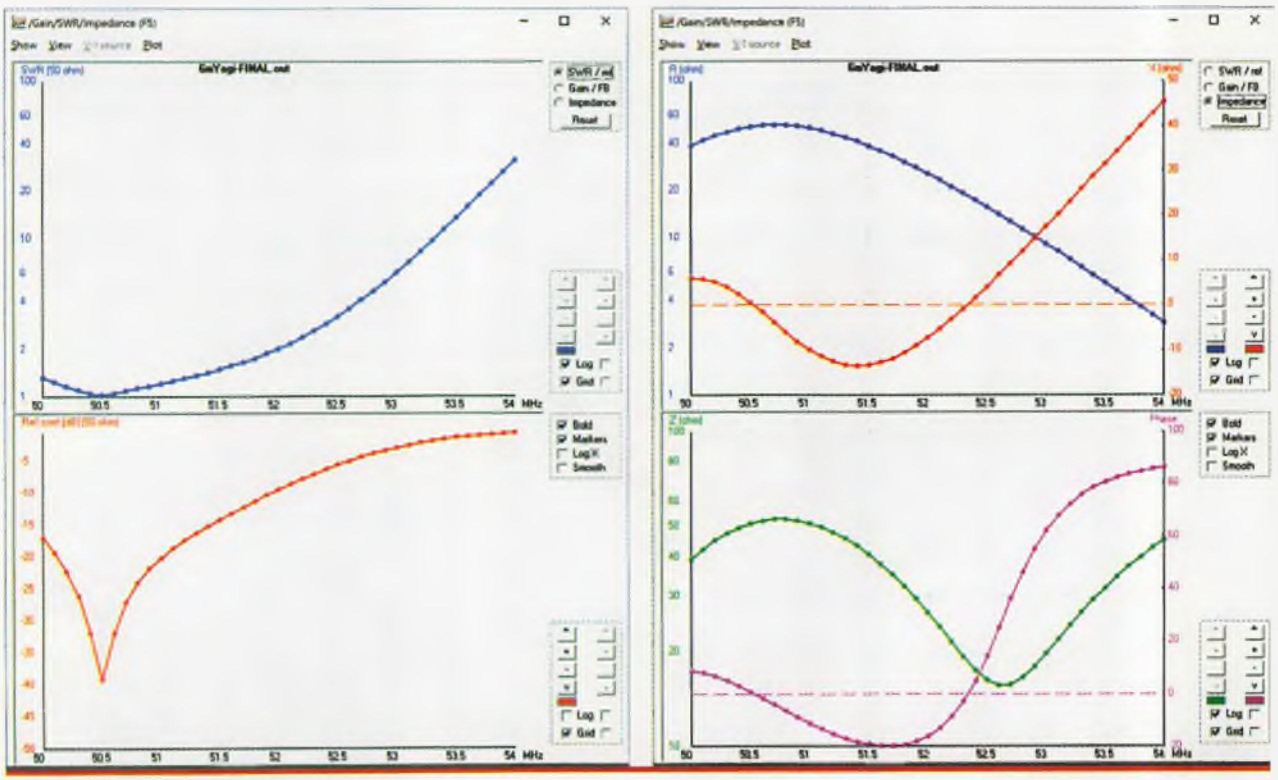
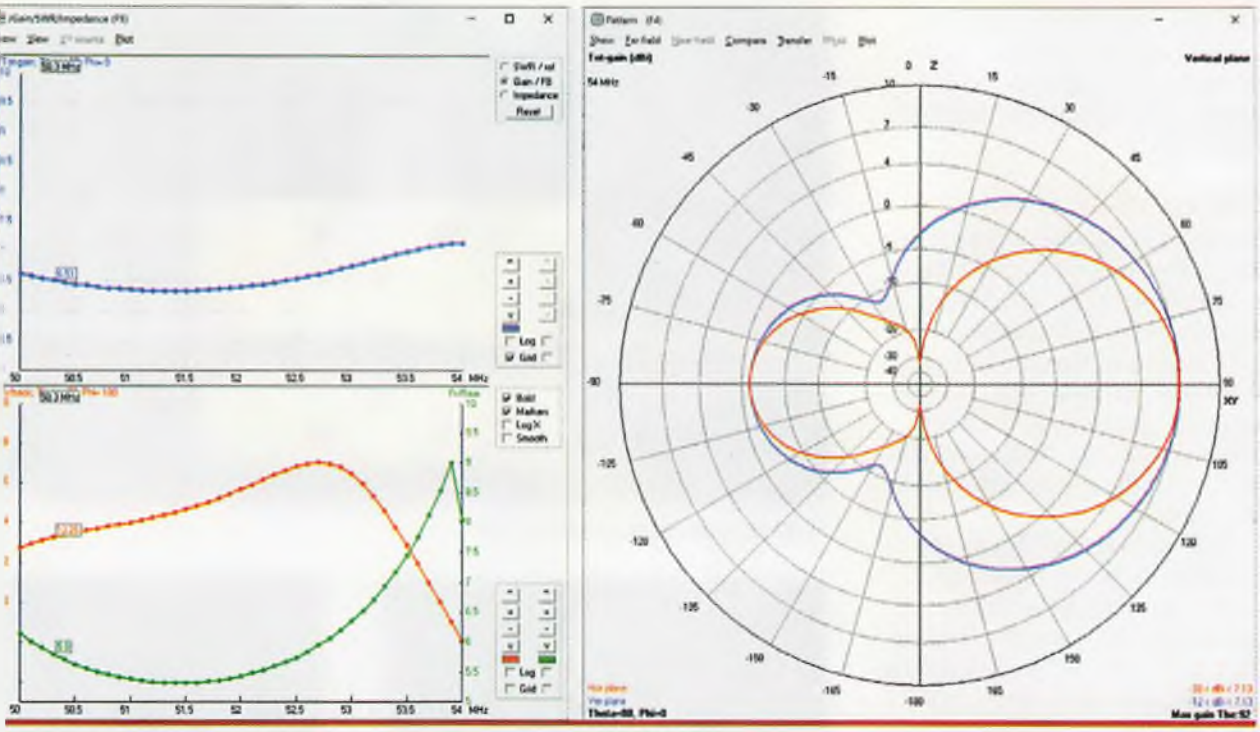


Figure 10. SWR impedance plot for final design.



ure 11. Antenna gain for the final model.

ith the final result.

Note also in **Figure 9** that all of e dimensions have been rounded the nearest millimetre. This will ake slight changes to the final rformance results.

uilding the Antenna

onstructing the antenna was asonably straightforward and used n-conducting materials wherever ssible.

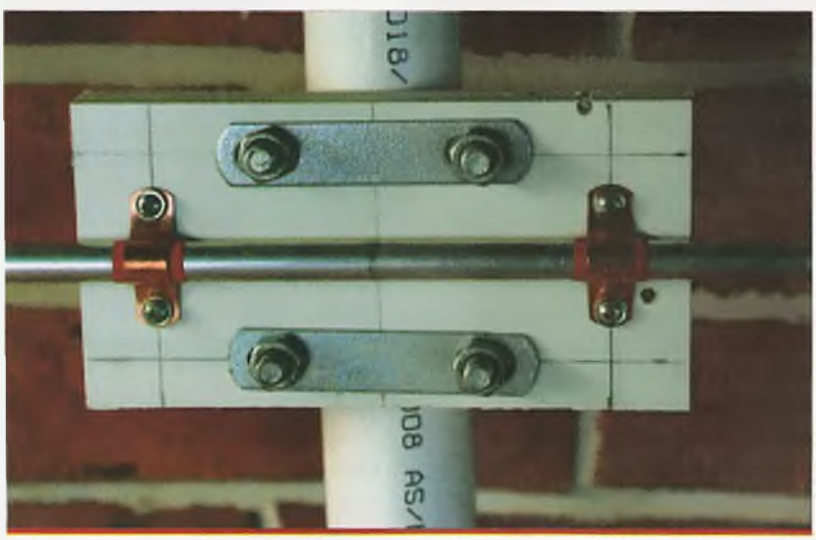
Figure 12 shows the technique to attach the director and reflector to the boom. Note the use of 10 mm saddle clamps to hold the elements to the mounting plate. These were copper as it was the only correct size material available at Bunnings. I insulated the copper from the aluminium element with electrical tape to reduce the possibility of galvanic corrosion.

The driven element used a similar technique, as shown in **Figure 13**, but in this case, it was necessary to place a nylon insert between the elements to keep them parallel. The nylon insert was a short length of 8 mm knitting needle turned down slightly on the lathe so that it would slide into the 10 mm diameter aluminium tube.

I turned up a brass jig on my lathe to allow accurate drilling of the holes through both the aluminium tube and the nylon insert. This then allowed for the connection of the feed cable to the elements.

The feeder cable was weatherproofed using Nitto Self-fusing Butyl Rubber tape around the screen and also the centre conductor; the ends were soldered to some terminals for connection to the antenna. Ignore the Rhino-Rack U-Bolt kits seen in **Figure 13** as these were for another project. The U-Bolts that were used to clamp the mounting plates to the boom are shown adjacent to these in **Figure 13**.

The feeder cable connection to the driven element is shown in **Figure 14**. The feeder here is RG58C/U, with three ferrite cylinders to form



ure 12. Director and reflector mounting arrangements.

a current choke sheath. I also built a small cover for the feedpoint of the antenna to help with weather proofing the termination, visible in Figure 15.

Current choke sheath

The decision I needed to make was how to feed this antenna as it has a simple dipole for the driven element. Two options present themselves: a balun of some form, or a simple sheath current choke. The simplest approach appears to be the latter, which uses ferrite cylinders that can be slid over the coaxial cable feeding the antenna.

Serge Stroobandt ON4AA [6] provides a review of differential modes and common modes on transmission lines and the problems they cause. Serge notes the following: that a decently-made and properly rated (frequency and power) current balun at our antenna feed point will be the first broadband defence against common-mode sheath (screen) current on the coax.

For the sake of clarity; a current balun and a sheath current choke are two different devices.

Figure 13. Driven element mounting details.

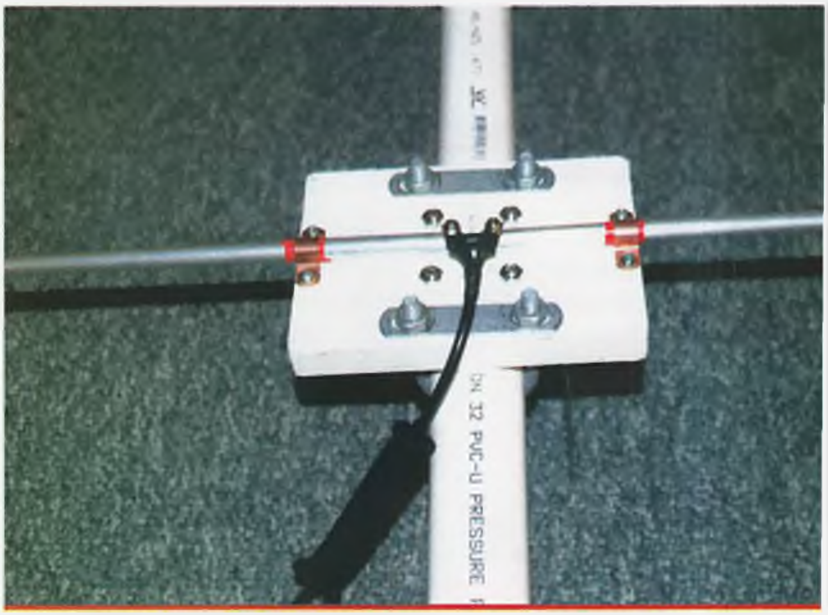


Figure 14. Feed cable and sleeve balun.

Figure 15. My 3-element Yagi antenna mounted on a mast.

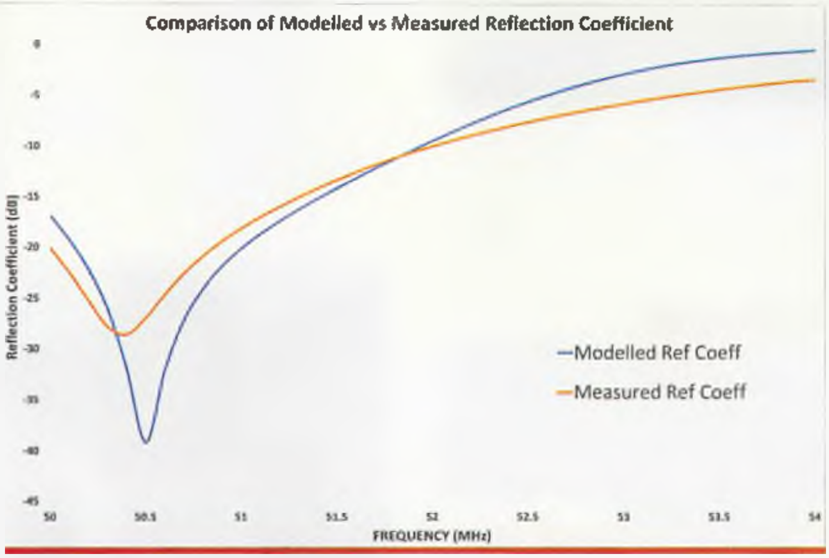
He further notes that sheath current chokes close to the antenna feedpoint will help to preserve the radiation pattern of the antenna. Sheath current chokes closer to the shack may help better against RFI.

At the end of his article, he discusses methods to measure choke impedances and refers to the work of Steve Hunt G3TXQ (SK) who devised a more precise method for measuring choke impedance using both ports on a VNA. He also published the mathematical derivation for this method and a helpful spreadsheet.

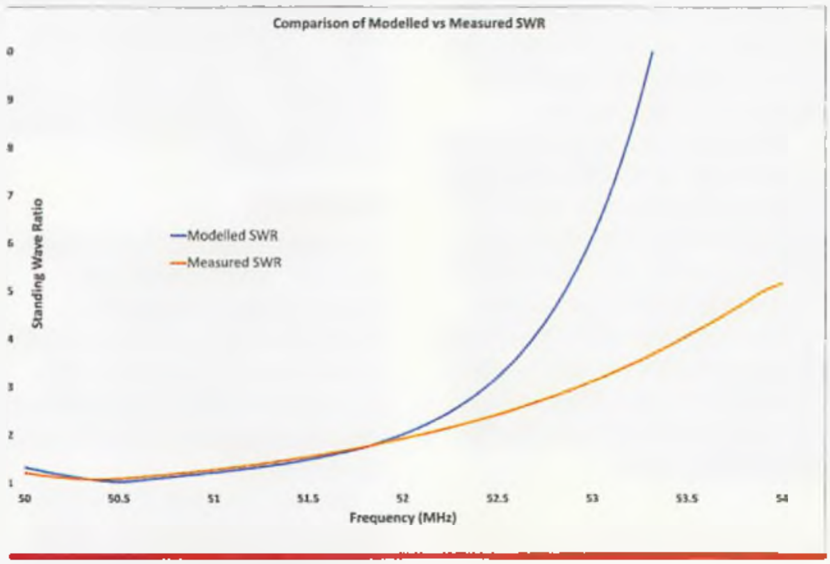
I used Steve Hunt's method to measure the sheath current choke impedance on some typical 29 mm long ferrite sleeves available from Jaycar (Part Number LF1260). For this, I determined that three would give an impedance of around 600 Ohms, which should be adequate if placed close to the antenna feed-point.

Test results

Once the antenna was built, I had t wait for some rain-free days before could test it.



igure 16. Comparison of modelled versus measured reflection coefficient.



gure 17. Comparison of modelled versus measured SWR.

Figure 16 shows the comparison ⁻ modelled performance versus ːeasured Reflection Coefficient, as easured using a DG8SAQ Vector etwork Analyser.

Owing to manufacturing ·lerances, the deeper dip at sonance would not be expected · be as good as the modelled ːrformance. **Figure 17** shows the me data as an SWR comparison.

As can be seen, the results are ıite good, especially at the bottom ıd of the band where the design cus was placed to achieve a low ⅣR for the FT8 digital mode.

Given the similarity of these results, it would be expected that the modelled gain identified in **Figure 11** would be expected to be realised, as would also the radiation pattern. This is subject to any impacts from common mode currents that the sheath balun was unable to prevent.

Conclusion

This article started by looking at Cebik's approach to building a six metre Yagi for the FM portion of the band and took his three key ingredients: needs, behaviour and expectations, to develop a 4nec2 model, just to see how good a result could be achieved.

After using the optimisation function of 4nec2, a design was established, built and tested using a Vector Network Analyser. The measured Reflection Coefficient test results showed considerable similarity to the predicted performance identified by 4nec2, indicating that the predicted gain and performance should be realisable.

My thanks to Michael Barbera for reviewing this article before submission.

References

[1] Michael Barbera and Gregory Mew VK4GRM, "Antenna Modelling using 4nec2 – Part 1," Amateur Radio Magazine Volume 90, Number 3, 2022.

[2] L.B. Cebik, "A Short Boom, Wideband 3 Element Yagi for 6m", [Online]. Available: www.spirat.com.au/vk5fq/image/6mYagi.pdf [Accessed 01 June 2022].

[3] Gregory Mew VK4GRM and Michael Barbera, "Antenna Modelling using 4nec2 – Part 2," Amateur Radio Magazine Volume 90, Number 4, 2022.

[4] Gregory Mew VK4GRM and Michael Barbera, "Antenna Modelling using 4nec2 – Part 3," Amateur Radio Magazine Volume 90, Number 5, 2022.

[5] Gregory Mew VK4GRM and Michael Barbera, "Antenna Modelling using 4nec2 – Part 4," Amateur Radio Magazine Volume 90, Number 6, 2022.

[6] S. Stroobandt, "Common Mode Chokes,". [Online]. Available: https://hamwaves.com/chokes/en/index.html [Accessed 06 June 2022].

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Newcomers' Notebook

They always ring true
Resonant circuits

Jules Perrin VK3JFP

An important element of any radio communications equipment is the LC circuit. The **L** stands for *inductance*, quoted in Henries (H) and named after the scientist Joseph Henry (1797–1878). The symbol L for inductance was chosen to honour the physicist Heinrich Lenz (1804–1865), who pioneered work in electromagnetic induction. The **C** of LC stands for *capacitance*, quoted in Farads (F) and named after the English physicist Michael Faraday (1791-1867).

As the symbolism implies, the components in a resonant circuit are an inductor and a capacitor. Depending on how the components are connected dictates how the circuit operates. Simple explanation without complex mathematics.

In RF circuits, the values of L are generally specified in very small fractions – microhenries (uH) and millihenries (mH); occasionally, in nanohenries (nH). Likewise with the values of C – generally, picofarads (pF – million-millionths) and nanofarads (nF – 1000-millionths). You'll get used to it.

A quick rehash

A capacitor is a component with two plates separated by a dielectric (an insulator). The capacitor will block DC and can store energy. The governing factors for capacitance are the size of the plates, the distance between them and the type of dielectric.

Inductors generally comprise a coil of wire that may be wound onto a 'former' that serves to hold it conveniently (often a cylinder), which attracts the generic name – *solenoid*. If wire of a sufficiently heavy gauge is use, the coil can be self-supporting; the simplest is just a single-turn loop.

Inductors also store energy and can block AC signals. Inductance is determined largely by the number of turns on the coil. A rod of special material (e.g, ferrite) may be placed in the coil centre, or used as the coil former, to increase the inductance by interacting with the magnetic field. Ferrite toroids enable high-value inductors to be made in a small volume; they have very low interaction with other material or coils nearby because the magnetic field is 'closed.'

Figure 1: Various capacitors encountered in resonant circuits used in radiocommunications equipment.

Figure 2: Various inductors that may be seen used in resonant circuits. The toroid at the top, with a few turns of heavy wire wound on it, ma be used as a 'choke' to block RF current above a certain frequency.

Impedance

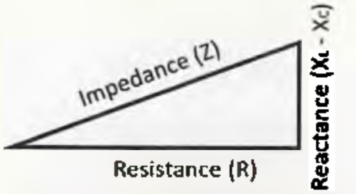
Every electrical and electronic component has a direct current resistance value measured in Ohms. The opposition to alternating current by inductors or capacito is called *reactance*. The reactance value, also measured in Ohms, is dependent on th types and makeup of the components used, and the frequency.

Reactance is designated with the letter **X**, so capacitive reactance is X_C, indicated with a negative number, while inductive reactance is X_L, indicated with a positive number. Where you have inductance and capacitance in the circuit, the total reactanc is the difference between the inductive reactance and capacitive reactance.

The total opposition (resistance and reactance) to alternating current in a circuit of two or more components, is called *impedance* (**Z**) and is also measured in Ohms. This is graphically shown in **Figure 3** as a triangle.

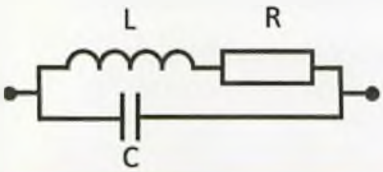
Series or Parallel

The components for an LC circuit can be connected in series or in parallel. An uncomplicated way to identify if the components are in series or parallel, is to

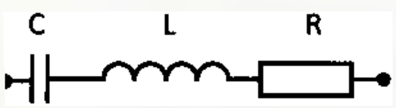


igure 3: The 'impedance triangle'.

ook at the current path. If the current in the ircuit splits and goes through the inductor ınd capacitor separately, this is a parallel ircuit, as illustrated in **Figure 4**. If all the urrent goes through one component then he other, then it's a series circuit, as seen in igure 5.



igure 4: A parallel LC circuit. You'll often ee them referred to as a 'tuned circuit', or ccasionally a 'tank circuit'.



igure 5: A series LC circuit.

esonant frequency

he useful thing about LC circuits is that, with ny combination of the values of C value and ıe L, they will have a *resonant frequency*. t this frequency, the circuits act differently ıan the components individually. The ırmula for these values is available on the ıternet – look for "LC resonant frequency".

A parallel LC circuit, such as **Figure 4**, ill block any signal that is operating on the esonant frequency. In a parallel LC circuit at esonance, the time taken for the capacitor to harge and discharge, is the same time taken ır the inductor to charge and discharge.

The energy in the circuit will charge the apacitor and, as the capacitor discharges, ıe energy will charge the inductor. As the ıductor discharges, the energy recharges ıe capacitor. So, at the resonant frequency, the LC circuit will oscillate. The combined reactance is high, increasing the impedance as illustrated in **Figure 3**. So, at resonance, the parallel tuned circuit has a high impedance. A signal at any other frequency will pass through the parallel LC circuit.

In a series LC circuit, **Figure 5**, the energy goes through one component then the next. Any signal below the resonant frequency will be blocked by the capacitor. Signals above the resonant frequency will be blocked by the inductor. Signals at the resonant frequency are not blocked by the capacitor or the inductor.

At resonance in the series tuned circuit, the reactances cancel each other, leaving only resistance in the circuit. So, this circuit has a low impedance to the alternating signal.

About 'Q'

In an operational circuit, the ratio of the reactance to the resistance is called the **Q** (Quality Factor) of the circuit. If the current in the circuit is plotted against frequency, either side of the resonant frequency, the result will be a Q plot resembling a bell curve. The base of the bell and the height of the bell indicate the *bandwidth* of the circuit.

A sample Q plot of a series tuned circuit is shown in **Figure 6**. As the frequency drops, the capacitive reactance Xc is predominant, while the inductive reactance XL, is predominant in the higher frequencies.

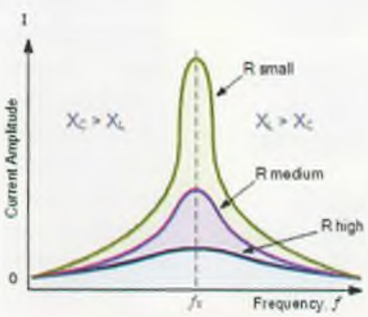


Figure 6: Sample Q plot – frequency versus current for a series tuned circuit.

Applications

These LC circuits are an essential building block in communications equipment. They can function as filters, tuning circuits for a receiver, or the basis of an oscillator. **Figure 7** shows a parallel tuned circuit – L1 and C1 – used to set the frequency of an oscillator. The smaller coil, L2, provides regenerative feedback for the circuit to maintain the tuned circuit oscillations. Sometimes, L2 is referred to as the 'tickler' coil.

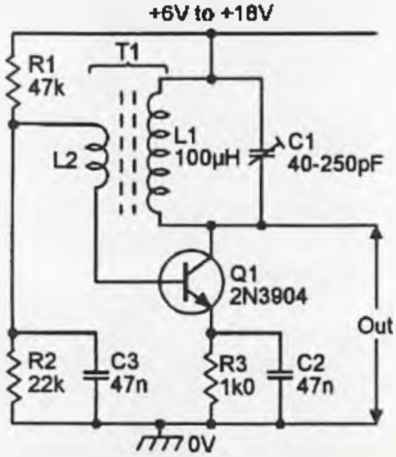


Figure 7: A parallel tuned circuit oscillator application.

Similarly, **Figure 8** shows a series tuned circuit – L1-C3 – in an oscillator circuit. At the resonant frequency, the tuned circuit is a very low impedance, allowing feedback between the transistor's collector and base, thus enabling oscillation. At frequencies away from resonance, the tuned circuit is a high impedance and C1-C2 will shunt signals to earth.

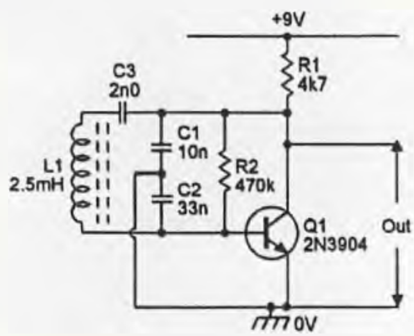


Figure 8: A series tuned circuit oscillator application.

If you have a topic you would like to be covered in a future instalment of Newcomers' Notebook, email Jules at jp.bqt@bigpond.net.au

Have fun and stay safe.

Over to you

Why I renewed my membership

Hello there.

I've just renewed my WIA membership for another year, though I very nearly decided not to. Here's what I was thinking:

The WIA has become much less relevant to me lately. I'm not very active and I never use any of the WIA's services, while AR magazine – it might be more accurately titled "Roger's Rag" – is less interesting than, and not as professionally presented as, some of the local radio club newsletters I receive from the UK and elsewhere.

In my years as a member, I've watched with growing dismay as infighting and rancorous disagreement over seemingly everything that the WIA does has undermined and all but destroyed the organisation. This has led to the establishment of a competing national association whose existence can only serve to further divide us and devalue Amateur Radio's reputation and credibility with the ACMA and on the international stage. As an example of this, the WIA's inept handling of the relationship with the ACMA has led to some serious failures, not the least of which was the refusal to implement the internationally allocated 5 MHz band.

In my view, the WIA is most certainly keeping the 'Amateur' in Amateur Radio, but we seriously cannot afford to take an amateur approach to dealing with our licencing authority or with our international partners in the IARU and, through them, with the ITU. 'Amateur' doesn't cut it in that environment. Professionalism is required. Infighting and an inept and divided approach to dealing with the authorities will only lead to further sidelining of the Amateur Radio Service in Australia.

In short, I am not satisfied with the way the WIA operates and I am very unhappy with the way the Institute goes about representing the interests of the Amateur Radio Service.

So, why did I renew my membership this year?

I renewed because in my opinion someone must represent us and with its long history the WIA is obviously the best organisation to do that, despite its many shortcomings.

A strong national society is vital for the health of the Amateur Radio Service here in Australia just as it is in every other jurisdiction around the world. If we look around, we can see obvious examples of where strong national societies are, through cultivating respectful and professional relationships with the relevant authorities, not just maintaining but also improving the legislative and administrative arrangements under which the Amateur Service operates: the RSGB in the UK, for example, or the ARRL in the USA. We need that kind of representation here.

What is required is a revitalised WIA and, despite the many shortcomings, I do see hopeful signs that the Board understands this. Clearly, the Board cannot do it on their own. Support from the membership is necessary, even if that support is only to pay the annual subscription; after all, the WIA cannot achieve anything at all without funds.

I do not believe that the WIA is a lost cause, though it undoubtedly will become so if I, and those who have similar opinions, simply let our memberships lapse.

In short, if I quit then I'm merely contributing to the problem.

And so I remain a member, albeit a not very happy one and one with a nagging sense that I, personally, could be doing more to support and strengthen the WIA.

I do not know what more I could do, but I can do this much: I can speak out, let my opinions be known, and call for everyone with an interest in Amateur Radio in Australia to join in supporting and strengthening the WIA in whatever way we can. If we value the Amateur Radio Service and the privileges accorded to us through our licences, it's the least we can do.

73

Bernard Kates VK2IB / G4LGK

Thank you, Bernard, for sharing your views. If AR was "Roger's Rag", then the majority, if not all, the articles would be written by me. Obviously, they're not. They're written by members (mostly). Production of *AR* is a team effort - see p.3. When publication of *AR* fell into a hiatus in 2020, for the very reasons you outline above, I volunteered to help out and was appointed Editor in Chief (I didn't 'apply' for the specific role), presumably because of knowledge of my background in a prior career editing and publishing technical magazines (*Electronics Today International, Australian Electronics Monthly, CB Australia, Electronics News, Medical Imaging & Monitoring, Manufacturer's Monthly etc*).

Clearly, you have views on how *Amateur Radio* magazine might be better presented - please share!

I have to take issue with your view about the 5 MHz amateur allocation.

WIA's advocacy for gaining a secondary allocation of the 5 MHz band in Australia (indeed, globally) has been wholly professional. WIA member Dale Hughes VK1DSH **chaired the key Working Group in the ACMA's ITU delegation to WRC-15** (see https://tinyurl.com/5fx57c2n).

Dale is also on the WIA Spectrum Strategy Committee that prepared the WIA's submissions to the ACMA's consultations over 2016-2020. I asked Dale to provide an "Explainer" on the 5 MHz issue, which follows here.

Perhaps you are also unaware that a "competing national association" ***advocated against* allocation of the 5 MHz band** to amateurs in Australia!

If you have formed the view that the WIA has not been professional, or taken a professional approach, *"in dealing with authorities"* as you say, then perhaps it's a "failure to communicate", as Prison Governor Struther Martin said to errant prisoner Luke (Paul Newman) in the 1967 movie *Cool Hand Luke*. Are you able to assist in this field?

In the meantime, I encourage you – and other readers/ members – to consider the ***many and diverse areas*** where the WIA has been instrumental in gaining key new allocations and privileges – for example:

- introducing the Foundation licence when the regulator reformed amateur licensing in 2003-04;
- gaining the 10-18-24 MHz 'WARC' bands thanks to ITU work by David Wardlaw VK3ADW and Michael Owen VK3KI;
- the 60m DX Window;
- the 137 kHz and 475 kHz bands;
- returned access to 50-52 MHz; and
- recent further modernising of privileges for licensees not enjoyed in other nations such as removing mode restrictions and relaxing permitted bandwidths for all license grades.

For more, take a look at our inside back cover, or the website news pages.

It's no secret that the competing national association was set up by those individuals engaged in infighting and rancorous disagreement in the WIA; they did not have the skills to convince sufficient others to support their views or proposals. Unfortunately, this association engaged recently in a frivolous exercise that encouraged amateurs to use the AX prefix in breach of the licence conditions, to break the law, in a hollow memorial on the death of Queen Elizabeth II.

Some amateurs claim they're not a member of the WIA, or don't want to be, chiefly because of one or perhaps a few issues; they often underpin that by citing … contentious generalities (infighting, rancorous disagreement, et al).

The WIA is not some amorphous entity to which the members belong, the *members* **are** the WIA!

Perhaps the WIA Board would be interested in your approach to revitalising how the WIA works and how it "goes about representing the interests of the Amateur Radio Service" by committing your proposals to paper.

Roger VK2ZRH

Explainer – the 60 metre band in VK

The 5351.5-5366.5 kHz frequency band was allocated on a secondary basis to the amateur service by WRC-15. Going into WRC-15, the Australian position was that no more than 10 kHz should be allocated to the amateur service on a secondary basis in some part of the 5275-5450 kHz frequency band. The outcome of WRC-15 was that 15 kHz was allocated in a part of the band that already had a significant number of incumbent Australian users.

Possible use of the 5351.5-5366.5 kHz frequency band by Australian amateurs was the subject of ACMA public consultation 13/2020 (1). The WIA and many Australian amateur operators submitted their views to the ACMA in response to the call for comment. In their analysis of the situation, the ACMA considered the needs of the incumbent users and the amateur service and decided:

"… When weighing up spectrum use, the ACMA considers the objects of the Radiocommunications Act 1992. This includes:

- Maximising public benefit from the use of the radio spectrum.
- Making provision for spectrum use by Australian defence or national security agencies. This was of high importance in this matter.

In balancing defence's existing use of the 5351.5–5366.5 kHz band against the impacts of introducing use by the amateur service, the ACMA has decided not to support amateur use in the band. …"

Defence use of the HF band by radiolocation systems (like 'over the horizon radar') is permitted under footnote AUS57 of the Australian Radio Frequency Spectrum Plan (2).

HF radiolocation systems apparently require a significant amount of contiguous spectrum and the Department of Defence may be concerned that occupancy of parts of the 60m band by amateurs would decrease the available free spectrum for radiolocation. This fact, along with the need to protect the other incumbent users, which includes ambulance and fire services, led the ACMA to decide that Australian amateurs would not be allowed to use the 60m band, despite the ITU-R allocation.

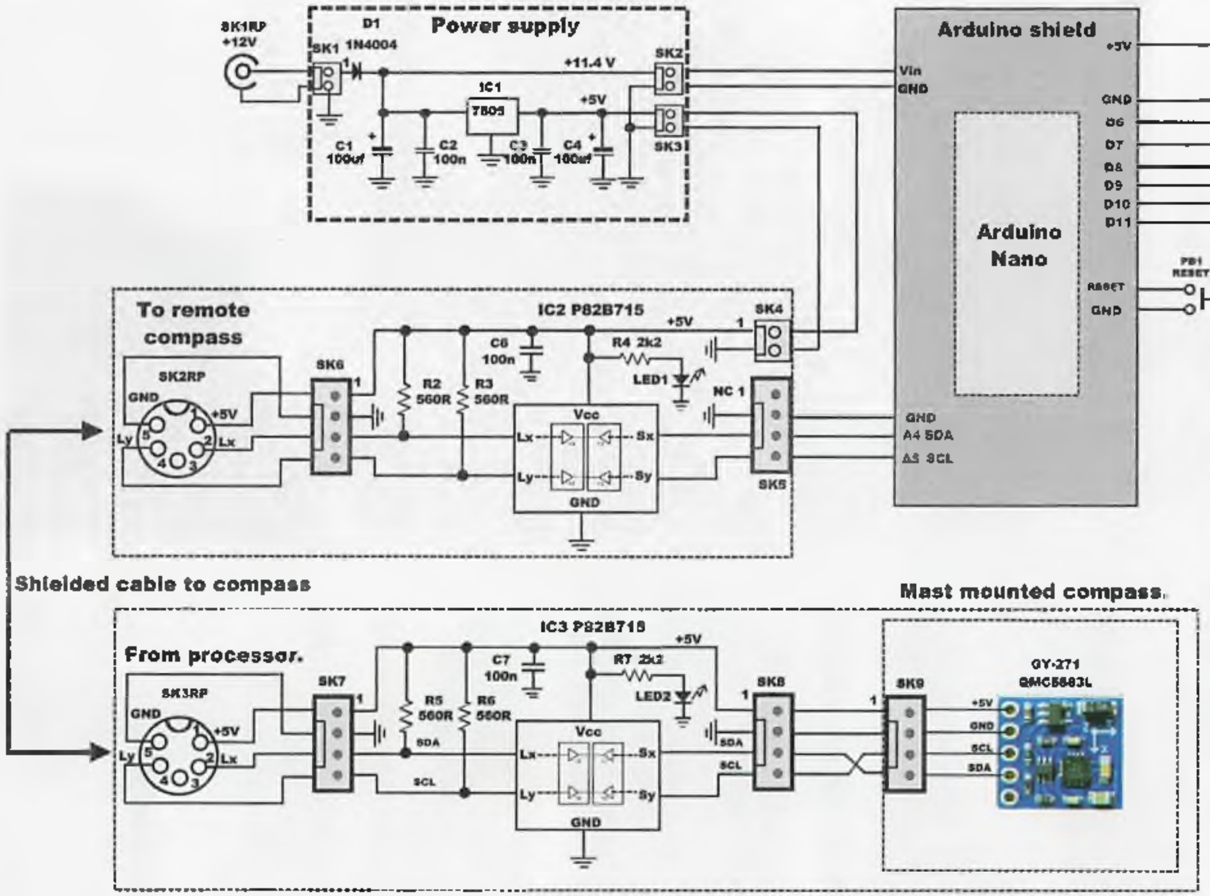
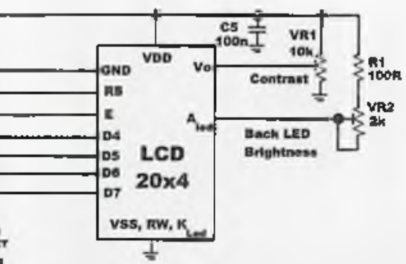
(1) https://tinyurl.com/ryxshbfx
(2) https://tinyurl.com/mu9uvpyb

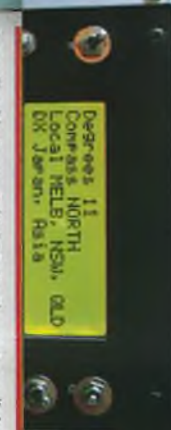
Dale Hughes VK1DSH, ITU Conference & Study Group Coordinator for the WIA.

Well-connected: Dale VK1DSH took this photo of his friend and ITU colleague, Barry Lewis G4SJH, at the GB70E station at Home Park adjacent Windsor Castle, celebrating the Platinum Jubilee of the late Queen Elizabeth II last June (see Issue 4, p.45). Barry is Chair of the IARU Region 1 Spectrum Affairs Group and RSGB Microwave Manager.

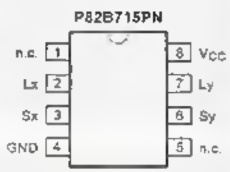
More on page 66

Arduino Nano QMC5883 compass processor.



Described in Issue 5 (Vol.90, No.5), my *Easy digita[l] compass for an antenna rotator* project centred on a 'surplus' video camera pan-and-tilt unit that I repurposed as an antenna rotator, using its contro[ller] as the rotator controller, to which I added a 20x4 L[CD] indicator (inset).



R2,R3,R5,R6. Values calculated for I2C Bus cable capacitance of 1300 pf and 1uS pulse rise times. As per formula in Data sheet.

Sx = Short SDA Bus.
Lx = Long SDA Bus.
Sy = Short SCL Bus.
Ly = Long SCL Bus.

Digital compass for an antenna rotator - follow-up

Lou Destefano VK3AQZ

On the left-hand page here is the circuit of the rotator compass project, showing the Arduino compass display processor and LCD, plus the cable drivers between the processor and the mast-mounted 3-axis digital compass module.

For convenience, a complete parts list is provided in Table 1. References consulted during design and construction of this project are included below.

Reference.	Value	Notes.
Main processor	ArduinoTM Nano	Nano with shield.
LCD display	20x4	"To suit Arduino, HD44780U or similar."
"C1,4"	100uF	Electrolytic 25 volt.
"C2,3,5,6,7"	100nF	Monolithic ceramic.
D1	1N4004	
IC1	7805	5 volt 3 terminal regulator.
"IC2,3"	P82B715P	"I2C-bus extender, 8 pin DIL."
IC4	QMC5883L	Magnetic compass GY-271.
"LED1,2"	3mm Red or Green LED	
PB1	Momentary push button	Arduino reset.
R1	100R 5% 0.5W	
"R2,3,5,6"	560R 0.5W 5%	
"R4,7"	2k2 0.5W 5%	
SK1RP	2.1mm DC socket	
"SK2RP,3RP"	5 pin mic connectors	
"SK1,2,3,4"	KF2510-2	2 pin KF2510 polarised connector.
"SK5,6,7,8,9"	KF2510-4	4 pin KF2510 polarised connector.
SK misc	"KF2510-2,3,4"	"Connections to shield, LCD, etc."
Sk IC skts	8 pin DIL	"IC2,3 - 8 pin DIL sockets."
VR1	10k	Contrast.
VR2	2k	Back light brightness.

Compass module mounted in weatherproof case on mast.
Display unit mounted in suitable case.
4-wire shielded connecting cable between remote compass and display unit.

Table 1: List of rotator compass components.

Photo 4. Rear view inside the digital compass display unit.

Photo 5. The Arduino Nano and Shield pulled out of the case showing the general arrangements.

References

[1] J. Rowe, Two tiny Electronic Compass modules", *Silicon Chip*, pp72-77, November 2018.
[2] Julie Gonzales VK3FOWL and Joe Gonzales VK3YSP, "A mini satellite-antenna rotator", *Amateur Radio*, WIA, pp11-16, May 2016.
[3] D. Hughes VK1DSH, "Arduino based antenna rotator controller", *Amateur Radio*, WIA, pp10-15, July 2015.
[4] J. F. Drew VK5DJ, " Beam rotator controller" accessed 11 April 20221, https://www.vk5dj.com/beam.html/
[5] QMC5883L magnetometer datasheet. Available from the manufacturer, QST Corporation, Shanghai: www.qstcorp.com/. Also from component suppliers online.
[6] Arduino sketch by Douglas Thain: https://github.com/dthain and https://github.com/dthain/QMC5883L/releases
[7] P82B715 Product data sheet, P82B715_8 release 20091109, NXP Semiconductors, formerly Philips, accessed online; available on several sites.

The Arduino sketch can be obtained on request from destefano@dodo.com.au or downloaded from the *Amateur Radio* magazine website, at: www.wia.org.au/members/armag/about/

Photo 6. The 10-element 144 MHz Yagi atop its small mast.

ALARA

Jenny Wardrop, VK3WQ
e secretary@alara.org.au
w www.alara.org.au

ALARAmeet 2023, Hobart, update

Linda VK7QP advises: "Planning continues for the 2023 ALARAmeet. Jane VK7BJ, Kathy VK7KJJ and I visited the *Female Factory* recently. We wanted to see what they offered, and to judge the timing for ALARAmeet next year.

"We had an interesting morning learning about the female convict history of Tasmania and were captivated by a dramatized presentation of convict life. The site tells the story of the forced migration of convict women and girls from England and Ireland, and their contribution to the history of Australia.

"Approximately 13,000 female convicts came to Van Diemen's Land between 1803 and 1863 and more than half of these women spent time at the *Female Factory*. We look forward to sharing their stories at ALARAmeet November next year," says Linda.

YLs with a 'YL' suffix

In *Amateur Radio* magazine for July 2010, Christine VK5CTY took an interesting look at YLs in most Australian States, who took out the callsigns VKnYL; i.e, VK1YL, VK2YL etc. Some further information has come our way since that time.

A senior maths teacher, Denise Robertson, VK1YL and VK5YL

VK1YL was first held by Denise Robertson in the 1950s and 60s. Prior to the mid-50s, amateurs located in the ACT were VK2s. Denise was highly qualified, employed at Australia's Weapons Research Establishment and later a highly respected senior Mathematics teacher. She also worked with Sir Mark Oliphant (later Governor of SA) who was then involved with nuclear physics.

There is a story that, while ill in hospital, she surreptitiously learnt CW while under the bed covers so that she could communicate with her OM David VK1ATR. Later they moved to South Australia and Denise became VK5YL, David already holding VK5RN.

A really active VK1YL was Sue Britton, who gained her amateur licence while still at school. Her father had been a WWII radio operator, so to some extent she had grown up with radio communications. Sue held her licence for about 20 years from 1975 and was a well sought-after contact. However, she let her licence lapse to study Medicine.

From 1996, the holder of VK1YL was Ruth Mitchel Worthington. She was an ALARA member for many years, and lived for much of that time in Western Australia.

The first VK2YL was *not* a YL, but Harry Hawkins of Cessnock, who had worked all six continents and 69 countries on 40m before 1936. He held the callsign until around 1975.

The best alternative callsign for a YL had the 'YG' suffix (Young Girl). This was the case with Miss L N Litchfield, listed in the 1938 Callbook as VK2YG. The current holder of VK2YL is Norma O'Hare, founder of ALARA and mother of our current President, Michelle VK2AYL.

Award-winning homebrewer, Austine Henry VK3YL

The original VK3YL was Austine Henry, née Marshall. Listed in the 1938 Callbook, she won awards for her home-built radio equipment in a number of competitions. She held her licence for 40 years, was the first woman recruited into the Royal Australian Airforce Reserve, and was an early member of ALARA.

Madeline McKenzie (no relation to Florence VK2FV) was the first VK4YL, obtaining her licence as a 12 year-old – at the first attempt! She was the youngest YL in the British Empire at that time, no doubt helped by Dad, Mac VK4GK. Madeline won a number of prestigious awards in the British Empire Radio Union contests befor WWII, but let her licence lapse afte the war.

In the February 1942 issue of *AR*, a brief paragraph on wartime activities states: "I believe Miss 4YL has to help dad (Mac VK4GK) with the Women's Fire Fighting Auxiliary". This came as no surprise after discovering that her address in the 1938 Callbook was "Fire Statio Wynnum."

There have been three VK5YLs. The first was Betty Geisel, from Murray Bridge, who got her licence as an 18 year-old, before WWII. Sh was later employed as a Technician in one of Adelaide's leading electronics stores. Denise Robertso as we mentioned before, was VK1Y and, after spending a couple of year in the ACT and the USA, she and the family returned to live in VK5

lts 2022
RA Contest

	Callsign	Results	Notes
ther	VK7QP	930	Top Scoring Australian YL (trophy), Top YL Overall, Top VK7 Member, Top YL Phone only
mmonds	VK5MAZ	648	Top VK5 Member
cGuiness	VK2LDM	511	Top VK2 Member
ompson	VK2TOT	464	
	VK7AKT	375	Top Scoring Foundation Licence ALARA Member (Trophy)
eftrunk	LU9DKU	271	Top score DX YL
hley	VK2FASH	270	
rahams	VK6DEE	263	Top VK6 Member
hare	VK2YL	251	
	VK7HSD	244	Top VK7 OM
Hammond	VK7C/VK4	229	
ry	ZL2UIT	171	Top New Zealand YL
ld	VK7KPC	166	
atwin	VK2SJC	162	
Vardrop	VK3WQ	155	Top VK3 Member
it	VK5LOL	138	
s	VK2YW	115	Top VK2 OM
llister	VK2DWP	110	
ash	VK3SCP	105	
en	VK3LSN	105	Top VK3 OM
n	VK7LEE	98	
nphries	VK2LIL	93	
p	VK2DB	87	
gellas	VK5YL	86	
owlett	VK7ZBX	70	
ld	VK3KRL	67	
er	VK7IF	65	
la Bere	VK7FAMP	43	
attinson	VK3SPX	40	
son	VK3DL	35	
riott	VK7BM	35	
sleazzi	VK4GUE	30	Top VK4 OM
ser	VK2XSM	25	
n	VK3LSR	25	
thers	VK2JEH	20	
son	VK2DNE	19	
	VK4SWE	18	Top VK4 Member
	VK7PEP	15	
lard	VK1CB	10	Top VK1 Member
	VK2XGB	10	
rd	VK3YV	10	

Foxhunting anyone? Gill Weaver VK6YL.

to become the second VK5YL from about 1969. After Denise became a Silent Key, the VK5YL callsign was taken up by Shirley Tregellas in 2010. She was persuaded by some of the ALARA members to take over the callsign as she was, and is, an active Member of ALARA (currently, Vice President) and a keen DXer.

Vicki Harris, later Page, née Longley, was the first licenced YL in VK6 and became VK6YL in 1936. One of her claims to fame was that she beat professional Australian billiards sportsman, Walter Lindrum, at billiards by 31 points (but as he had given her 750 points to help her….!).

During WWII, Vicki was the first woman to join the WAAAF (Women's Auxiliary Australian Airforce). She gained her commission as an Aircraft Woman in 1942 and was in Melbourne receiving signals from Darwin when Darwin was bombed. The message she allegedly received was: "Hold it! I'm just ducking under the table, the Japs are bombing us". Back in Perth, Viki was the first woman there to teach Morse code to Air Training Corps Cadets.

VK6YL was later held by a very active Gill Weaver, who encouraged many new amateurs to the bands, me included, in the early 1980s.

Joy Batchler (née Crowder) VK7YL, the first YL in VK7, was a teacher, a wife, a mother, and a radio pioneer in Tasmania. Joy was active for a short time before WWII, holding an amateur radio licence from 1936 to 1991, although not active for all of the 55 years.

A radio pioneer, Joy Batchler VK7YL.

When the 2008 ALARAmeet was held in Ulverston, Tasmania, Justin VK7TW visited Joy and recorded a message from her, which was played to the ALARAmeet attendees with acclamation (thanks Justin).

I guess all of us who are YLs in this day and age should 'take our hats off' to these pioneering women amateur radio operators, especially the early ladies who had to build their equipment.

I would be happy to hear from anyone who has information on other VKnYLs, or corrections to those I have mentioned.

My thanks also to my 'researcher', who searched dozens of Callbooks to verify much of this information.

Overall winner of the 2022 ALARA Contest, Linda VK7QP.

Over to you

Enjoyed Issue 5

Hi Roger,
The latest mag turned up today (21 September – Ed).

I just thought I would drop you a line to say what a good mix of articles. From Mike's (VK4MIK) AM/CW for Anzac Day to Mike's (VK3BDL) QSL Card Anthology, let alone Phil's (VK3FF) article on revamping a pair of Collins classic workhorses.

All encompassing; a very nostalgic mental read and walk, indeed.

Keep up the good work that you and your team are doing, Roger.

Cheers and 73.
Mike Charteris VK4QS

Hello Roger,
The current issue is wonderful under your editorship.
Kind Regards
Ian Jeffrey VK2IJ

Hi Roger,
I wanted to say how much I enjoyed the technical content in the September/October edition of AR.

Chris Skeer VK5MC's article on the story behind the Wilkinson Award was both fascinating and inspiring. Dale Hughes VK1DSH's article on his Arduino-based 12-line automatic home telephone intercom exchange brought back some memories with the use of uniselectors.

When I was young, my father used to bring home uniselectors and relays from work for me to tinker with. He worked at the SEC at the time, and they were removing this old equipment by the skipful! Presumably, it had been used for internal exchanges and/or telemetry applications. I remember discovering what back EMF was all about on a uniselector with the back EMF diode removed when I disconnected the clip lead used to apply 48 VDC!

Keep up with the great content!
Regards,
Richard VK3ZCL

Hamads

FOR FREE - VIC

VK Amateur Radio Mags (AR & ARA) - free to collect.

Two cartons of Aussie amateur radio magazines, mostly complete years spanning mid-1980s thru mid-1990s.

Amateur Radio about 100 issues and Amateur Radio Action- about 70 issues.

And a further approx. 120 issues of Amateur Radio magazine in mostly complete years spanning 2005-2020.All are used, and offered as-is. Some are well-thumbed; most are in good-to-excellent condition.

Location is Macleod, suburban NE Melbourne. Would prefer not to split. Nicholas VK3ANL.

FOR SALE - NSW

WARS Powerpole Distribution Box kit.

Kit includes all the parts needed to make one DC power distribution box, in a supplied 3D Printed Case. The case is made with either PETG or ABS, both tough and durable materials that withstand up to about 80 deg C and have high impact & chemical resistance.

1. One input connector may be replaced by a direct cable input.
2. 6 outputs.
3. Each output is fused with a standard blade fuse.
4. Each fuse has a red LED indicator under it to indicate a fuse failed condition.
5. Main Indicator LED to indicate power present and correct polarity. GREEN= Power is available at the correct polarity. RED= Power available but reverse polarity.
6. Designed to fit inside included 3D Printed box(approx L111x W55x H33mm). Assembled weight 100 grams.
7. All components are supplied (including 7 Anderson Powerpole connectors) for mounting on the double-sided PCB with double thickness tracks (2oz copper) and all plated through holes. PCB is also RoHS compliant.
8. Voltmeter (included) installable in the box.

Please note that this is still all in kit form, soldering and assembly are required and you may need something to hold the meter in place, hot glue, or Araldite.

To order, visit: https://vk2bv.org/home/store/ or email treasurer@vk2bv.org

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- WIA policy recommends that the serial number of all equipment for sale should be included.
- QTHR means the address is correct in the ACMA Register of Radio Licences: https://web.acma.gov.au/rrl/register_search.main_page
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- Copy must be received by the deadline on page 3 of each issue of AR.
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- Always acting to have intruders removed from our bands
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- Memnet - member-exclusive email bulletins

WIA history

Our origins go back to 1910, when the first Institute was formed to represent wireless experimenters to the government. Major reform of the Radiocommunications Act over the early 2000s, and to amateur radio licensing worldwide, saw a single national organisation formed in 2004 to meet the emerging challenges

WIA around the world

The WIA represents you internationally. We're a member of the International Amateur Radio Union (IARU), which advocates for amateurs' interests to the International Telecommunications Union, particularly at its World Radio Conferences. These determine global radio regulations and frequency allocations.

The WIA is the only Australian amateur radio body with membership of the International Amateur Radio Union.

WIA national office: Unit 20, 11-13 Havelock Road, Bayswater, Victoria 3153
Hours: 9am-5pm EAST, Mon-Fri. Postal: PO Box 2042, Bayswater, Vic 3153

Join or renew / encourage a friend

Use our Online Membership system, visit:
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eur Radio Operator, SWL or other interested party and at any
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If this is you, or someone you know, all that is needed is to complete a WIA membership application form (hard or soft copy) along with a copy of the relevant AOCP qualification (or equivalent if applicable) showing the date of qualification attainment and send them to the WIA head office for processing.
Join now and start receiving all the benefits of WIA membership.

(* Subject to WIA Membership being approved and WIA Membership Terms and Conditions being fully met.)