SHEFFORD & DISTRICT AMATEUR RADIO SOCIETY

BALUNS AND CHOKES

by Richard, G3NII

Let's start off with the balun.

This is a device that matches an unbalanced feed to a balanced load hence the derivation of the word balun.

It is usually fitted between a feeder and its associated antenna.

Is it something that should be fitted to all antennas?

Possibly not !

Would my antenna benefit by having one?

Perhaps !

Well, this doesn't sound very helpful, so let's have a look at why a positive answer cannot be given to these questions.

If we are using a half wave dipole, it is recognised as a balanced antenna.

But anything remotely conductive in close proximity will unbalance it.

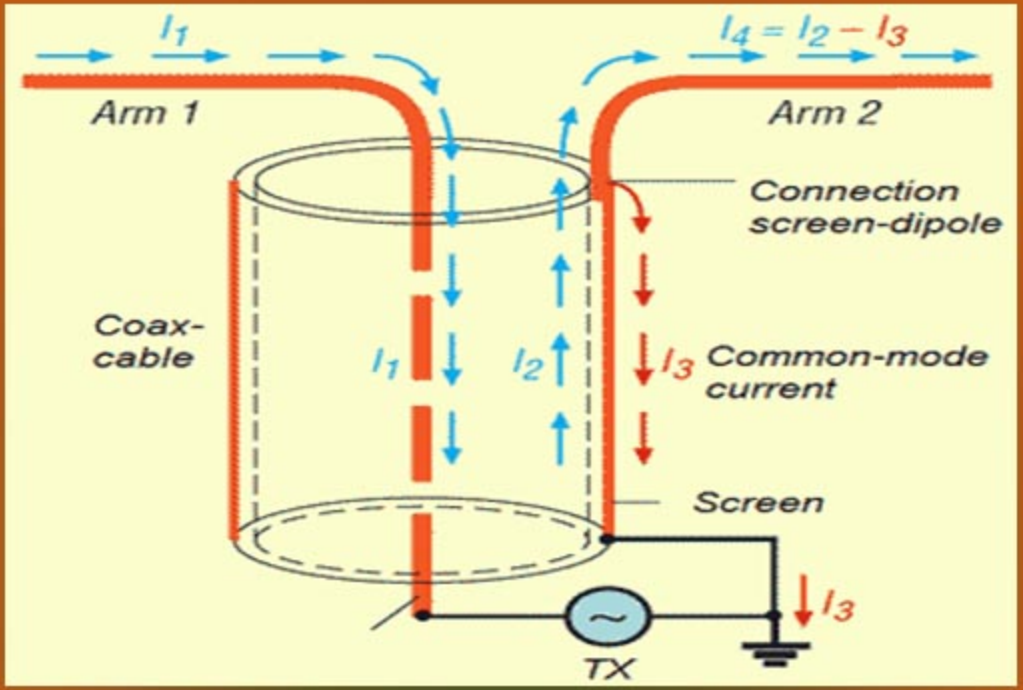
Which is a mite inconvenient !!

In addition, keep in mind that this antenna feedpoint is a current maxima.

So, how are we going to feed this antenna?

Well, in the majority of cases it's going to be coaxial cable – QED !

But wait a moment, lets go back to my talk in November, to see if we have something of a problem.

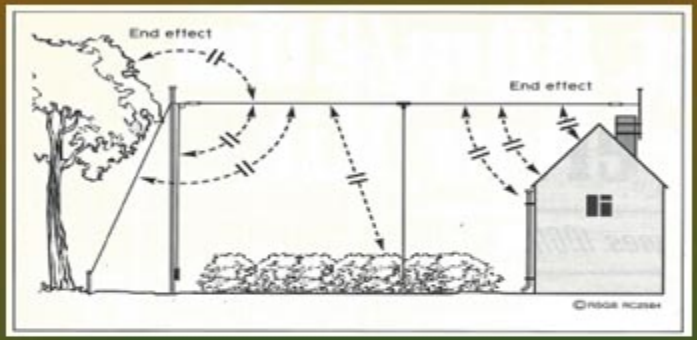

I_1
$I_4 = I_2 - I_3$
Arm 1
Arm 2
Connection screen-dipole
Coax-cable
I_1
I_2
I_3 Common-mode current
Screen
I_3
TX

By far the biggest problem is when using a coax cable feeder because a common mode current will appear on the outside of the braided screen. This will most definitely cause imbalance of the antenna, sometimes to a great degree.

A balun will not, in this case, be the best choice in trying to recover this imbalance, it would be more advantageous to somehow reduce the common mode current. This we can do with a choke.

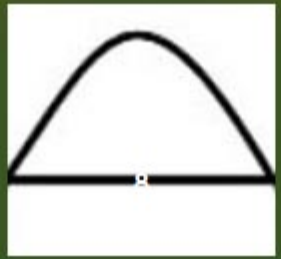
Keep in mind that common mode currents bring RF into the shack, it will cause the feeder to radiate as well as unbalancing the antenna.

Again, let's revert back to my talk last November.



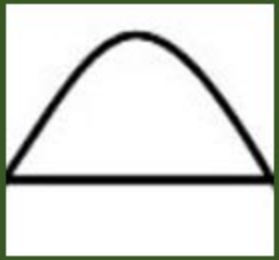
This is a stylised sketch showing the losses that might be experienced by an antenna due to its surroundings. But the level of losses and any incurred imbalance is quite difficult to quantify, measurements would be needed to find out. In most cases any imbalance would probably not be that great and thus any correction may not be worthwhile.

Just consider for a moment a sine wave that might represent the current distribution along an antenna. If this is a half wave dipole the current will be at a maximum at the centre



Not an ideal drawing, but sufficient to demonstrate that the rate of change in current around the centre point is very low. So what does this imply ?

Well if the 2 sides of the resonant antenna are not exactly equal in length the imbalance of current will be very small (provided that the difference in lengths is not too large) because the change of current at the mid point is small, so the imbalance will be of a level needing little concern.



So, without specific measurements of the current balance in an antenna, that is an easy measurement to make, it is difficult to ascertain whether a balun will truly be a useful addition to the antenna system.

As I mentioned earlier, especially when using a coax feeder, a major problem will be the common mode current and in many cases this is the area that that would most benefit by confronting.

Therefore. lets now have a look at chokes and see what effect and benefit they may have.

CHOKES

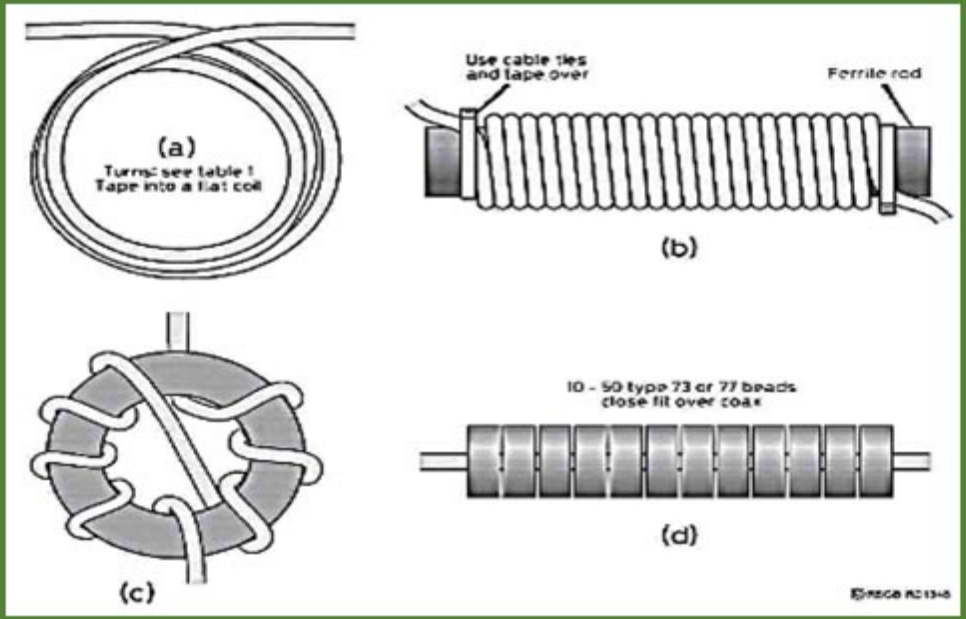
The primary function of a choke is to reduce the common mode current that appears on the outside of the braided screen of coax.

A choke reduces radiation from the coax produced by the CM current, it reduces reception of local QRM and QRN, and it reduces RF in the shack.

It can be made by winding a length of coax on a ferrite rod or a toroid, alternatively, winding several turns of the feeder to make an air cored coil (often referred to as an ugly choke!).

The effect is to produce an impedance on the outside of the screen braid that will be resistive and reactive at a level sufficient to attenuate the common mode current. The inside of the coax is not affected.

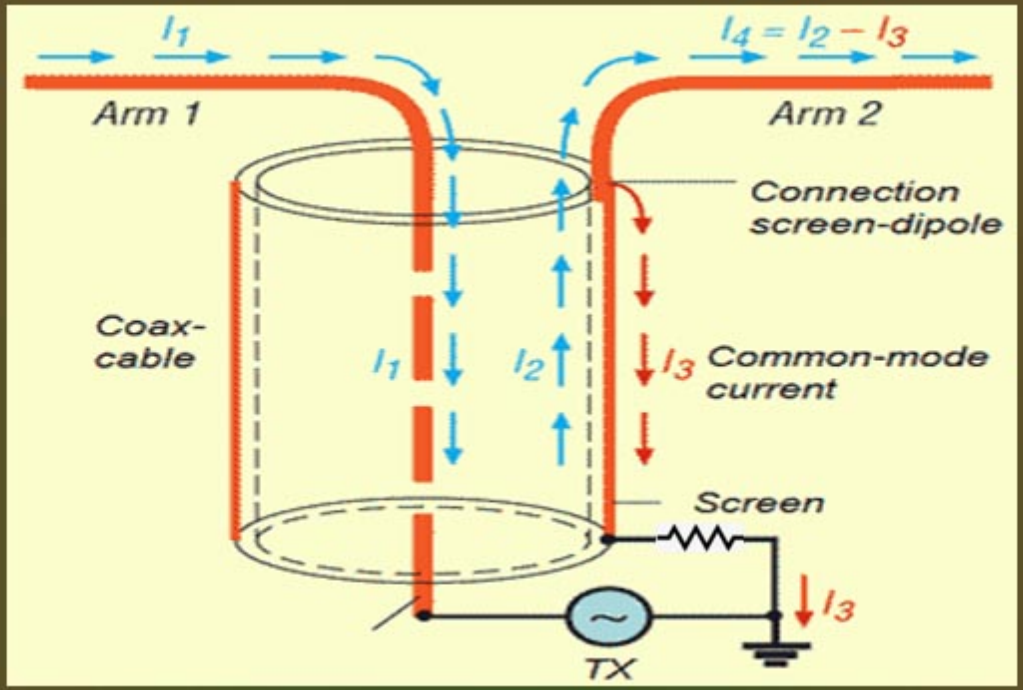
These are the typical configurations of chokes.



These chokes are sometimes referred to as choke baluns. This is not correct since they do not operate as a balun.

However, the 1:1 current balun does offer some choking action in addition to its balun function so it could be referred to as a choke balun.

So what does a choke actually do ;~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Arm 1
Arm 2
Connection screen-dipole
Coax-cable
I_1
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Screen
I_3
TX

What will a choke do for us ?

It will reduce the common mode current on the coax screen

It will re-instate the current robbed from the antenna

It will reduce the radiation from the coax feeder

It will reduce QRM and QRN when receiving

It will reduce RF in the shack

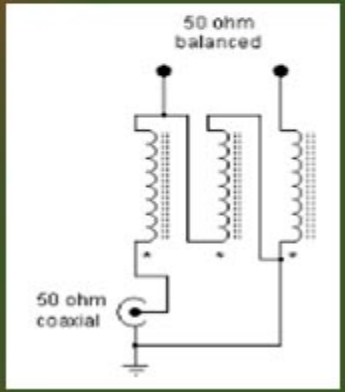
Altogether a major improvement of the antenna installation.

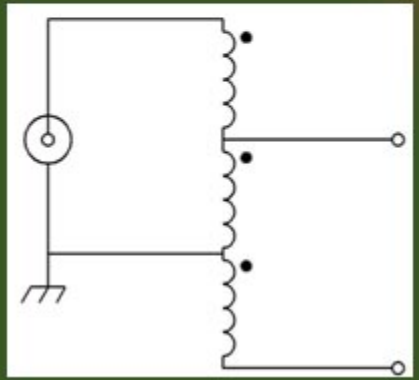
For some antennas, for instance the OCFD or other unbalanced antennas, it may be necessary to add 2 or 3 chokes to gain full advantage. In these cases a choke at the antenna connection with another half way along the coax feed and a third near the ATU in the shack might be worthwhile.

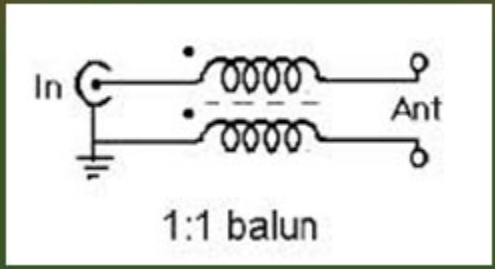
I will come to what I have in mind for the club project shortly, but before then let's go back and have a closer look at baluns.

The voltage balun ensures equal voltage to each arm of the antenna, it has a restricted bandwidth, it introduces phase shift in its output and it will cause an unbalanced current to the antenna.

The voltage balun relies on transformer action.







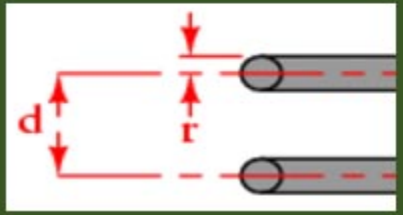
1:1 balun

This is the general arrangement of the current balun, being 2 identical windings on a ferrite toroid arranged such that the characteristic impedance is 50 ohms. The 2 dots define the start of each winding.

If the load is perfectly balanced then there is no flux generated in the toroid. If there is imbalance then flux will be generated that is the feedback to force the currents to balance. A simple but effective technique.

The current balun ensures equal currents to the antenna arms, has a wide bandwidth, produces no phase shift, can be used as a balun or an unun, exhibits a choking function and is the device of choice rather than voltage baluns by those that have studied baluns in detail. Current baluns rely on transmission line action not transformer action.

In construction the current balun is a little more difficult to make than the voltage balun. This is because we have to make a transmission line with a given characteristic impedance, most times 50 ohms.



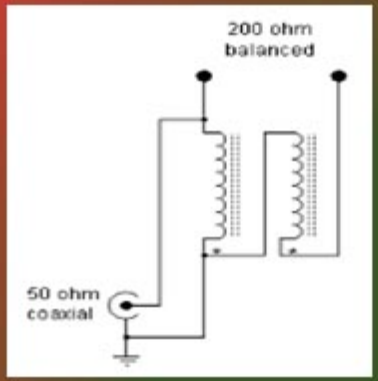
$$Z_0 = \frac{276}{\sqrt{k}} \log \frac{d}{r}$$

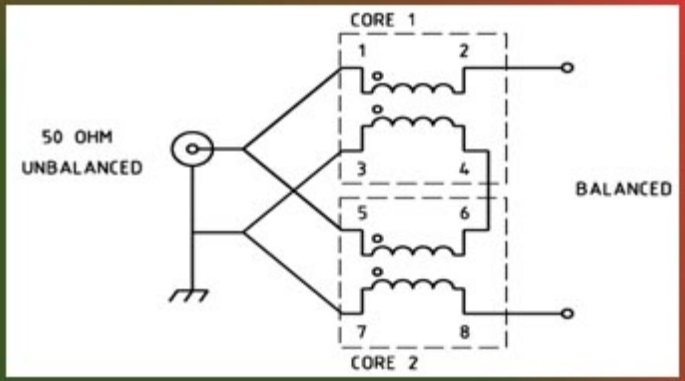
Keep in mind that a balun does not alter nor correct the VSWR or the tuning of the antenna. It is simply a balancing network balancing the feeder to the antenna.

Where this may seem to be a contradiction is when we have a balun that is not 1:1 in terms of impedance. As an example where we might want to feed an OCFD that typically has a feed-point impedance of 200 ohms so we construct a balun with an impedance ratio of 4:1 then our 50 ohm coax can feed the 200 ohm antenna and the VSWR will be kept close to 1:1. But, at various frequencies the feed-point impedance may rise to 300 ohms, our 4:1 balun can make no corrections for this so a VSWR in excess of 1.5:1 will result.

It is possible to make a balun with various impedance ratios. This is usually much easier to achieve with a voltage balun than it is with a current balun simply because the voltage balun uses transformer action and it is, therefore, easy to arrange any impedance ratio required with this type of balun.

But, even though we can match impedances with the voltage balun we still have the problem with the device in that it will promote current imbalance to the antenna, enhance common mode current problems and has a narrow frequency range.





4:1 voltage balun

4:1 current balun

This plainly shows that the configuration of the voltage balun is much simpler than the current balun that uses 2 toroids for the necessary 2 sets of 100 ohm transmission lines.

So why would we want a balun?

Well, it would only be required where the antenna is significantly unbalanced, but in many cases a choke will correct most of the antenna problems such that a balun may not be the best choice.

Where would we put a balun?

The ideal place would be at the junction of the antenna and its feeder. That is the place where we want our feedpoint currents to be balanced, with the added advantage that the choking function of a current balun will help to reduce the common mode currents on the feeder.

So, for our project for 2019 I would like to propose making chokes for use by those using coax as their feeder – I think that covers most of us. Perhaps this should be the way forward for our Club Project.

However, anyone who has a specific requirement please let me know and I will see what I can do to help. If you need 4:1 or 1:4 baluns at HF I can help. By the way, you cannot use a 4:1 current balun backwards as a 1:4 balun as is suggested on the internet and, whatever you do, please do not make a 4:1 current balun on a single toroid it will not work.

These are the chokes designed by W2VJN back in 2010, but promoted by GM3SEK in one of his RadCom article in 2011 or thereabouts.

They are intended for use on HF with the small one for the high frequencies, the middle size for the mid frequencies and the largest for the low frequency region of HF.

On the face of it these chokes look relatively easy to make, indeed I did try and had no real problems in making them.

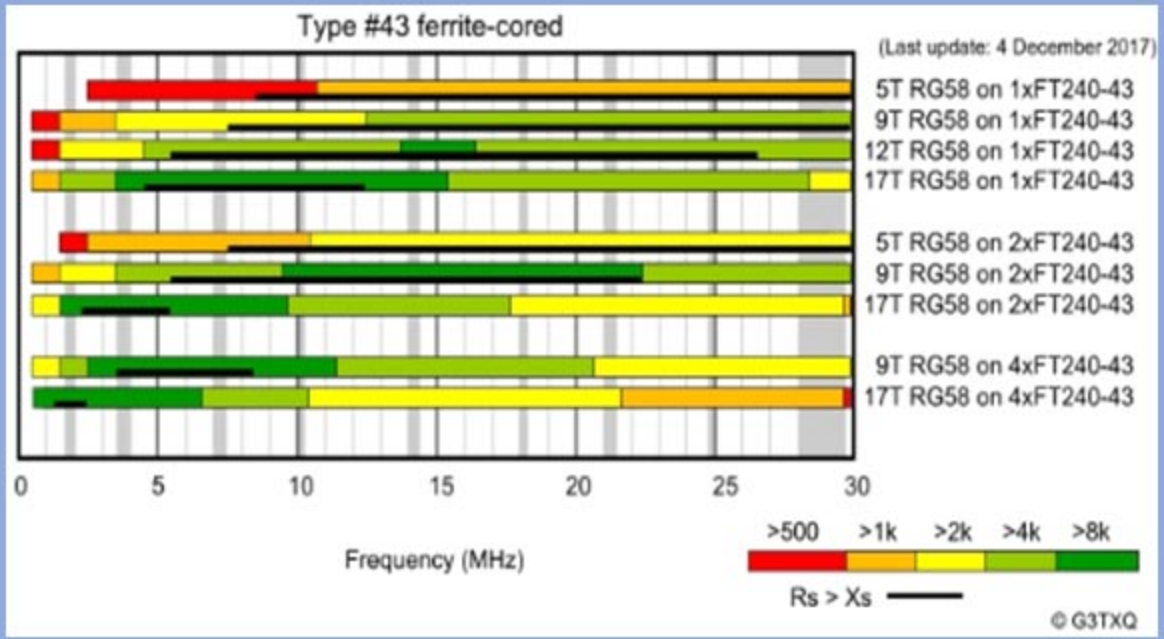
But, 2 things surfaced. To cover the whole of HF the weight of the ferrites is very high, furthermore the ferrite cores cost upwards of £5 each in small quantities, about £3.50 each in quantities of 50. Thus the cost begins to become somewhat unacceptable.

So

an alternative has to be found that can be easily produced, not too heavy and at a reasonable cost.

I focused on the work that has been done by Steve Hunt, G3TXQ (now alas SK) on chokes. He produced colourful data on a range of configurations that show the usefulness of the different designs and using various types of ferrite toroids. After much deliberation I settled on #43 as perhaps the best for our purpose.

Lets look at the data that Steve produced on chokes using #43 for various bands coverage ;~


Type #43 ferrite-cored
(Last update: 4 December 2017)
5T RG58 on 1xFT240-43
9T RG58 on 1xFT240-43
12T RG58 on 1xFT240-43
17T RG58 on 1xFT240-43
5T RG58 on 2xFT240-43
9T RG58 on 2xFT240-43
17T RG58 on 2xFT240-43
9T RG58 on 4xFT240-43
17T RG58 on 4xFT240-43
0
5
10
15
20
25
30
Frequency (MHz)
>500
>1k
>2k
>4k
>8k
Rs > Xs
© G3TXQ

From Steve's chart I decided on the 3rd option that has a wide operating range that covers virtually the whole of the HF bands with a typical choking impedance of around 6k ohms.

This choke only needs one ferrite toroid costing approximately £8 so offering a more cost effective arrangement than the previously mentioned chokes.

By the way the enclosure for chokes must not be made of conductive material since a metal box will effectively short out the choke and render it useless !

The anticipated cost including box and SO239 connectors will be approximately £17 (somewhat dependant on how Brexit goes!!).

DOs AND DON'Ts

For chokes and baluns use only ferrite cores NOT powdered iron. The prefix for ferrite is FT, for powdered iron T. We will be using type FT240-43. The 240 signifies that the outer diameter is 2.4 inches.

It is important that the transceiver's operational mode, the power, the maximum frequency and worst case VSWR are known so that the correct material ratings of baluns and chokes can be determined.

A general rule is that if the ferrite toroid's temperature exceeds 60 deg C, pretty hot to the touch, then the size of the ferrite needs to be increased or another toroid added. The Curie point for many ferrites is in the region of 130 deg C, but this temperature is far too hot to handle.

Beware and Be aware

When you buy a 100W rig this rating only applies to SSB. If you use any other mode, CW, FM, AM, Data and so on then be aware that the rig may not produce its full 100W output. This will, of course, depend on the robustness of the design of the PA. A study of the rig's specification will show that the output for AM is much lower than the 100W, but it may not give much more information on the derating for other modes.

The whole of the antenna system, including the ATU, filters, traps, loading coils, baluns, chokes and the feeder must all be derated if any mode other than SSB is used. In addition the VSWR and operating frequency will have a further impact necessitating a further derating.

Thus, be aware that you must beware of your total system rating. Take note that if you increase your power output to the full 400W using a Data mode with a VSWR of 3:1 then the necessary rating of all the antenna components would need to be slightly more than 2kW !

For instance ;~

The following derating applies not only to your rig, but also the antenna system,

SSB	full power.
Morse	derate to 85%.
CW	derate to 50%, this assumes 50% mark space ratio.
Data	derate to 32%, this includes AM, FM, RTTY, all FSK operations.

To this we must factor in the VSWR that require a further derating by the square root of the VSWR. Thus for a VSWR of 9:1 you must derate by 3 times. So for RTTY feeding a VSWR of 9:1 your power should not exceed 10.7 watts if you have a 100 watt system ! ;

But what about the feeder ?

Indeed, the feeder must also be derated according to frequency, operating mode and VSWR.

Just considering frequency the following list is applicable ;~

Coax	1MHz	10MHz	30MHz	
RG142	19kW	9kW	4kW	
RG213	11kW	3.5kW	2.2kW	
RG8 mini	4kW	1.5kW	1k	
RG58	3.2kW	1kW	700W	<<
RG316	1.5kW	770W	600W	
RG174	1kW	350W	230W	

So, using RG58 at 30MHz on RTTY with a VSWR of 3:1 the feeder is only suitable for handling **175W.** Be aware !

That concludes tonight's talk. I hope that you have found it interesting.

If you would like to take part in the Club Project there is a short questionnaire to fill in that will help me. Please be sure to include your email address in case I need to contact you

The Club Project construction night is Thursday 4th July. This will be devoted to winding the ferrite cores, so quite a clean and straightforward activity.

My talk on' Earthing and RF' is on 11th July. This will look at some fairly controversial issues of earthing and some aspects and limitations that need to be very carefully considered. It will be an evening not to be missed. I will also discuss chokes for mains power choking as part of the topic.

Thank you

and

Good Night.