THE

QUEENSLAND

VHF'er

The Newsletter of the Brisbane VHF Group

No 2 September 2006

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The Brisbane VHF Group are responsible for the following:

Beacons

VK4RTT **144.440** MHz - 25 Watts – Location: Bunya Mountains – Status: operational

VK4RBB **432.440** MHz - 8 Watts – Location: Murarrie, Brisbane – Status: on air testing

VK4RBB **1296.440** MHz - 8 Watts – Location: Murarrie, Brisbane – Status: on air testing

VK4RBB **2403.440** MHz - 2 Watts – Location: Murarrie, Brisbane – Status: soon operational

VK4RBB **10368.440** MHz - 1 Watt – Location: Murarrie, Brisbane – Status: planned for later in 2006

Repeaters

VK4RBN **147.000** MHz (600 KHz negative offset) – Location: Mt Glorious – Status: operational

VK4RBC **438.525** MHz (5 MHz negative offset) - Location: Mt Coot-tha – Status: operational

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Editors Chat

Welcome to the Second issue of “The Queensland VHF’er”

The aim of the Brisbane VHF Group is to promote the use of all modes of communication on all bands VHF and above.

Well, the first issue of the “new” newsletter was well received by all, and subs have come in from all over the country. Few spotted the deliberate? mistake in the first editorial when I described “advanced articles for the technically ***inept***”…..I should have used ***adept,*** but in hindsight, maybe I did actually use the correct word!

We posted out 57 paper copies to past and present member of the group, and a further 87 have been Emailed to locations all over the world. The editor of the North Texas Microwave Society newsletter (Kent WA5VJB) and the NZART Break-in VHF editor (Kevin ZL1UJG) have arranged with me an editorial “swap policy” for the benefit of all. The results of this co-operation are articles by Kevin himself and Peter (ZL1UKG) in this issue, and a very interesting piece on antenna tuning from Dick K2RIW (Who designed the 432 linear amp used by hundreds of hams around the world)

The feedback from the antenna “challenge” and the resultant (and on-going) discussion on the VK-VHF Reflector has certainly increased my knowledge of antenna design, tuning and operation.
The correspondence from many others both on and off reflector has show to me that if one is prepared to ask the right question, the knowledge base here in Australasia is the equal if not better than anywhere else in the world. I thank you all for your willingness to provide information when asked, not one person has declined to answer any of my questions. A true Amateur spirit we can be all proud of.

This second issue will be provided to all the recipitants of the first, but from the next issue it will only be sent to members of the Brisbane VHF group. The fees are only $10 per annum, a bargain by any standards. Members are encouraged to accept the E mail option, rather than the posted black and white snail mail version. The electronic version is in full vivid colour, with clickable electronic links to websites of interest. There are many other good reasons to join the group, aside from the newsletter. The group is presently soak testing the new 432 & 1296 beacons (yes we will change the spelling in the message before final installation) and the 2.4 and 10GHz ones are not far away. There are antenna test days planned, and even an alignment/tune-up day for all those pre-amps/transverters that are almost but not quite working well. When you look at the calibre of the stations in the area, how could we not all gain from being associated with a group of people such as these?

So fill in the form on the back page and get your $10 off to our Secretary.

This Second issue contains articles gleaned from various sources, and full acknowledgement is given to the author and source (where known). But in this age of litigation and refusal to accept responsibility for one’s own actions, I am told that some form of disclaimer is necessary to prevent the incompetent and the unwary from holding the author, editor and members of the group liable for the consequences of using any of the information contained in this magazine to injure or harm themselves, their equipment or any third party. You must accept that any consequences that occur through following any information in this magazine are entirely your own responsibility.

Having said all that, I hope you enjoy reading the following articles, and learn something of value to this great hobby of ours.

Graham VK4SG

“Big League” (Almost) Signal Generator

John Kirk VK4TK

On a personal level, I no longer sing the drifty low budget signal generator blues by virtue of the fact that I am custodian of the VK QRP club’s stash of surplus crystals. It’s a rare day that I cannot find a crystal in that stash that either hits the frequency of interest directly or on one of its harmonics. However, because of the harmonic relationship between most of our bands, I think you’ll find that a few judiciously placed rocks will fulfill most of your needs.

Many articles have been written on homebrew signal generators, and most resemble baby transmitters – resist the temptation to follow this course. Invariably, we have too much signal, not too little, and any additional stages after the oscillator only make it worse!

The next hurdle to overcome is the need to be able to predictably generate Pico-volt type output levels, and to be able to smoothly go from “ESP” to “rock crushing” levels on demand. I used to accomplish this by “going portable” with my test oscillator – across the room, around the yard, sometimes even in the next block! Besides the funny looks you get when you park your car down the road and walk back home, this method also introduces measurement uncertainty in the form of passing cars, pedestrians, gusts of wind etc. There has to be a better way!

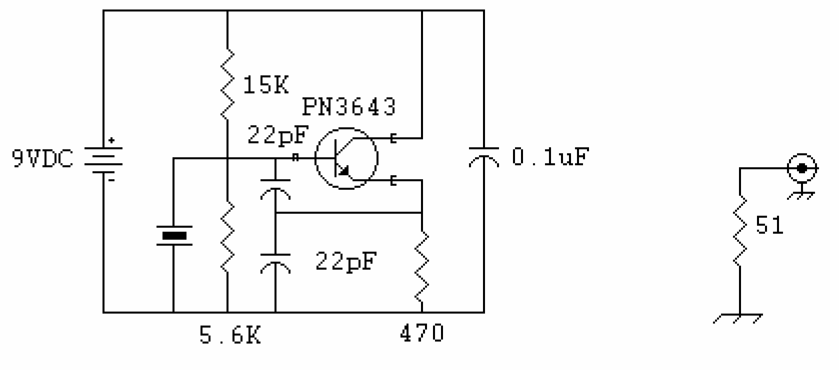
If we study the high-end kilo buck+ sig gennies (like anyone is likely to let us take one apart to study its innards!), they all seem to have two things in common:

- **a lot of shielding**
- **a piston attenuator**

Shielding we understand, but wots this piston thingy? It’s very simple, really – picture a capacitor where we have the ability to change at will the distance between the two plates. We can make the capacitance (and therefore coupling) very low, or snuggle up the two plates and get a whopper of a signal. Some prefer to think of the piston attenuator as a waveguide operating below cutoff, but the end result is the same regardless of your theoretical vantage point – a smoothly variable, stable output signal.

All very interesting, but it sounds like a horror to machine, you say. Not really. My piston attenuator morphed from a dumpster-bound coat rack made of 3 cm square steel stock, about 30 cm long. Office table legs are often made of the same material. You might even get lucky, and get an end cap for yours, but I had to fold some tin can lid sheet metal, drilled out to accept a BNC female, for mine. However you do it, ensure that the end cap is a snug fit, and fix it in place with several screws, as we don’t want the RF to have any other way out of the cave other than through the connector.

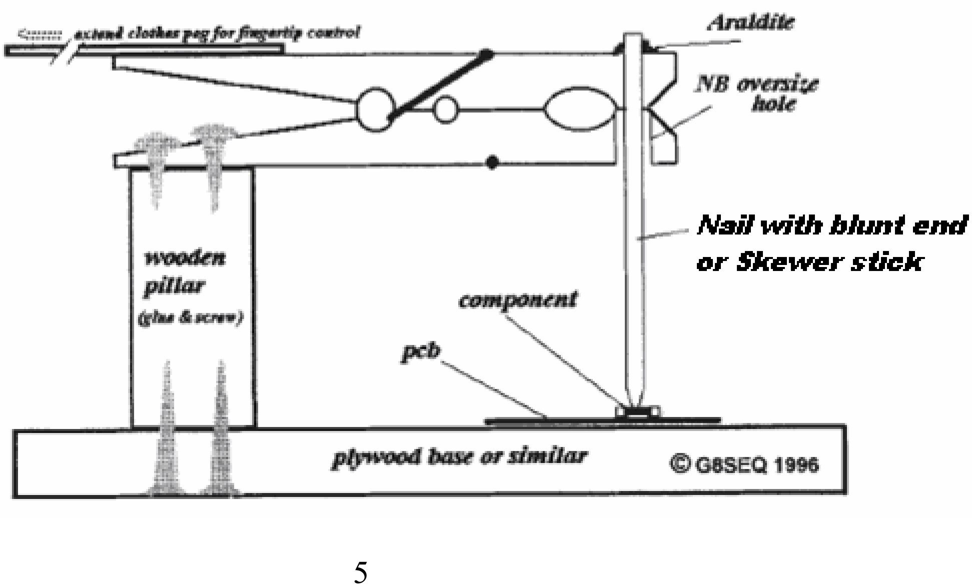
3 cm is an interesting dimension to work with, as its interior just passes a 9-volt battery – a good thing! We're going to negate the need for tedious shielding by building our simple one-transistor oscillator, power source and all, onto a little "sled", that we will push in and out of the attenuator with a stick. I used a chunk of that ubiquitous 100% unknown materials recycled plastic garden stake, but one of those trade show giveaway metre sticks might do even better, as we might then be able to come up with a rough calibration chart of cm to uV, assuming we have a friend at the big end of town with a Howling Packard or suchlike calibrated sig genny.



The schematic looks a tad unfinished, with no apparent gozouta, and a resistor and connector off by their lonesome. A rather conventional Colpitts oscillator does the honors this time around, but by all means use your own favorite – there's no magic here. Just remember that the parts must fit on our PC board sled, with a width not exceeding about 2.8 cm. The devil in this instance is in the mechanical detail, shown in the photo. No slave to fashion, I cobbled mine together ugly style. Arrange your components so that nothing with voltage on it can actually touch the 51-ohm resistor at full insertion, or place a bumper made of non-conductive material on the front end of your sled.

There you go! It's still only a comparative measurement, but we now have attributes of some of the best signal generators in town, but without the monster price tag usually associated with them. I'd love to think that the above was purely my own invention, but in truth, Bill Hoisington, K1CLL (SK) described a similar approach in the 1960's in the late 73 Magazine. It just took me this long to get around to trying it out.

Surface Mount component soldering aid from Sprat magazine (G QRP Club) circa 1996



Amateur Satellites – Hamsats – OSCAR what's it all about? (Part 2)

A basic introduction – Graham VK4SG

Last edition we talked about using the satellites as beacons, and reviewed the terminology and basic operating parameters of satellite operation. Today we are going to talk about using a computer program to track the satellites, and look at operating using the satellites as a "repeater in the sky".

There are many programs available and they all have their own characteristic appearance and "feel", some have more bells and whistles than others but the one program that seems to have become the standard is called **Orbitron.** It is a card ware designated program and as such is a free download of approx 2 Meg…. Just type ***Orbitron*** in your search engine and follow the prompts.

Once you have downloaded the program, there are a couple of things you must do before you start using it. The first is to enter your location and either your 6 digit grid locator or latitude/longitude as well as height above sea level. You only need do this once and the more accurate your figures, the better the program will work. The next thing you will find is a message stating: ***Data over 30 days old use anyway? Y/N***.

Just press yes at this stage and the program will work, but not accurately. This is because the Keperlerian elements (data for each satellite) are old and you must supply new ones for the program to work properly. The program has an automatic function that will activate your web search program and go looking for new data from the website of your choice. The problem with this that it downloads data for 40 or so satellites when you really only need the 8 or 10 that you are intending to use.

I normally go to the AMSAT US web site, choose the ***KEPS*** Icon and download the ***NASA 2 line bare*** data. This is in .txt format and contains 40+ sets of data. I then edit this file by deleting the data for the satellites I will not be using, then save the edited file with a name like; 22Aug06keps.txt. I put this file in the TLE (two-line elements) folder of the Orbitron program.

Typical two line data sets for satellites look like this:

AO-51
1 28375U 04025K   06115.70403148 .00000043 00000-0 26015-4 0 05166
2 28375 098.1703 170.1219 0085091 006.9362 353.2984 14.40514483095614

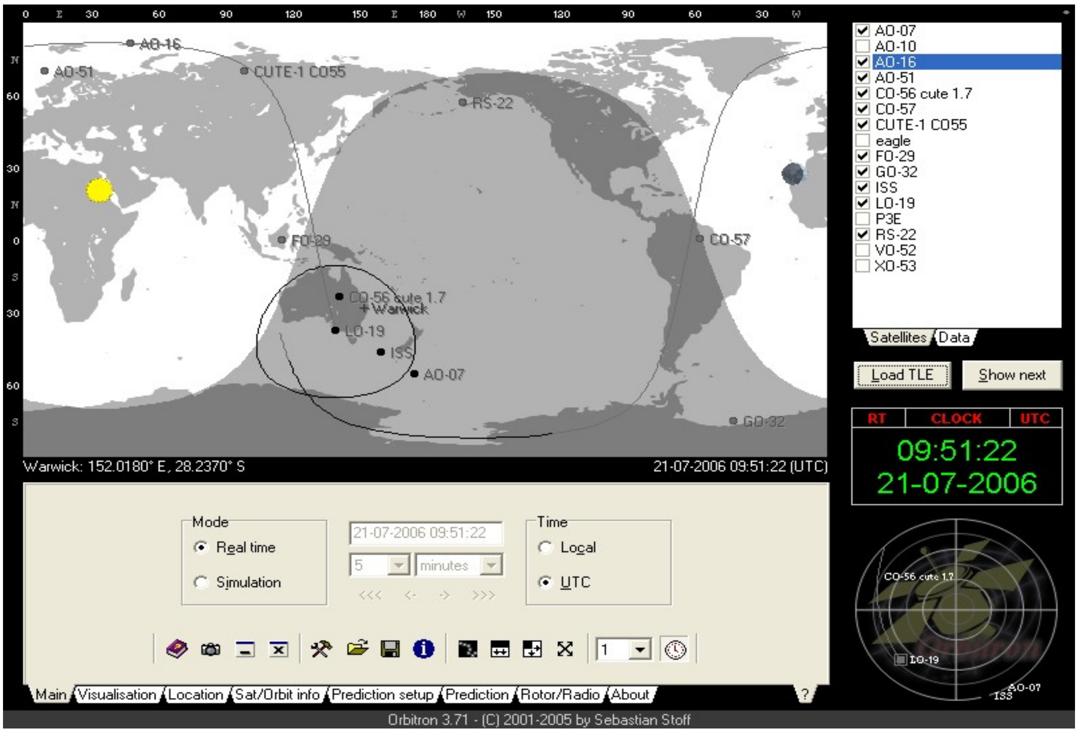
LO-19
1 20442U 90005G   05320.82975579 .00000016 00000-0 20983-4 0 05380
2 20442 098.2110 346.8545 0012871 105.3499 254.9098 14.31944101826067

UO-22
1 21575U 91050B   05320.70534582 .00000012 00000-0 17190-4 0 05563
2 21575 098.2661 280.4602 0007145 358.4984 001.6161 14.39518693752440

These figures contain information like; NASA reference number, decay (of the orbit), inclination, eccentricity, orbits per day and several other parameters that locate the satellite in a particular point in space at the time you require it….clever stuff.

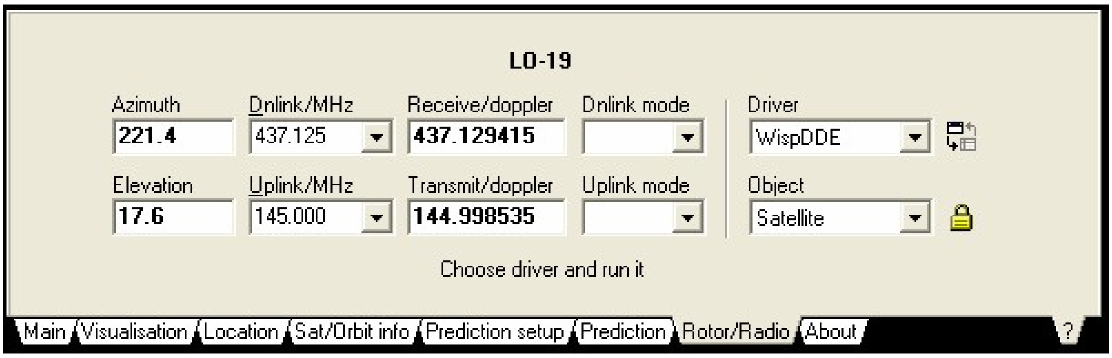
To get the program to accept the new data, just hit the ***"Load TLE"*** key and the directory of files in the TLE folder will appear, including the one that you have just saved. Just click on this file and the program loads it automagically.

The main program looks like this:



On this screen you can see that all the satellites chosen in the top right hand box are displayed on the screen, and that LO19 is displaying its ground coverage (the elliptical circle) as well as its future track for the next orbit. Any satellite on screen can be chosen to display its orbit and coverage by selecting it with a mouse click.

By choosing the Rotor/Radio menu, the most useful operating info appears:



Here we have the azimuth and elevation figures (for those using a beam) as well as the nominal downlink frequency with the Doppler corrected frequency alongside…note the 4.415 kHz difference in our example. The **Bold** Figures are dynamic and are continuously being updated. There are many other features in the program, the best thing is to just spend some time with it and have a "play".

Now what satellites can we use as "repeaters in the sky"?

At the moment (for voice communication) there are only 3 reliable satellites in full working order, these are:

SO-50	Mode V/U FM
AO-51	Mode V/U&S FM
SO-52	Mode U/V SSB

FO-29 (Mode V/U SSB) and AO-7 (Mode A or B SSB) are both working at times, depending on the time they spend in full sunlight to charge their batteries……actually AO-7 only uses its solar panels, not its batteries.

AO-7 was launched in Nov 1974, and performed well until the late 70's early 80's, when its NiCad batteries failed and shorted…over 20 years went by and suddenly, about 4 years ago the shorted batteries went open circuit and AO-7 started to work again whilst the solar arrays were in sunlight. This means that the satellite is usable but the SSB signals are subject to FM distortion at times.

What does this ***Mode*** thing mean? Well, in order to briefly describe the frequency range that the satellite would be using, a set of letters was adopted and some of the initial ones were:

A for 2 metres up, 10 metres down　　**B** for 70 cm up, 2 metres down
J for 2 metres up, 70 cm down　　**L** for 24 cm up, 70 cm down

The trouble with this is that there are more combinations than letters in the alphabet!! So what is done now is to use a 2 letter combination to describe the operating frequencies……Confusing? Well actually it's far easier to understand!!

H	is	HF or 29 MHz	**V**	is	VHF or 2 metres
U	is	UHF or 70 cm	**L**	is	24 cm or 1268 MHz
S	is	13 cm or 2401 MHz	**C**	is	6 cm or 5840 MHz
X	is	3 cm or 10.450 GHz	**R**	is	1.25 cm or 24 GHz

So now mode **V/U** means 2 metres up and 70 cm down, **L/S** means 24 cm up, 13 cm down, **U/S** means 70 cm up, 13 cm down…got it?

To find out which mode the satellite you wish to use is operating in, the easiest way is to download from the AMSAT website the monthly Schedule

AO 51 Schedule for June 2006

▼ Mode / Day* ▶	1 T	2 F	3 S	4 S	5 M	6 T	7 W	8 T	9 F	10 S	11 S	12 M	13 T	14 W	15 T	16 F	17 S	18 S	19 M	20 T	21 W	22 T	23 F	24 S	25 S	26 M	27 T	28 W	29 T	30 F
Voice Uplink	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
Voice Downlink	U	U	U	U	U	U	U	U	U	U	U	S	S	S	S	S	S	S	U	U	U	U	U	U	U	U	U	U	U	U

In the case of AO-51 **V** is 145.920 MHz FM uplink, **U** is 435.300 MHz FM downlink and **S** is 2401.200 MHz FM downlink.

AR has a six monthly update on satellite status (July 2006 was the last one) and the current modes of operation. The best way is to visit the AMSAT web site often, and when you are downloading the current keps, you can find the operating info and schedules for your satellites of interest …….Next edition will feature the new high orbit satellites due for launch in the next few months.

Now….About the challenge to antenna experts…. From VK4SG

Well what a can of worms this section opened up, and there's still more coming out of the woodwork!!! I had a piece written for this issue on lessons learnt and progress so far but then this article from Richard (Dick) Knadle K2RIW turned up and I just had to use it…….I think you will soon see why

Dick's Email:

Dear Dave, Lee, and the MW Gang,
It is a common misconception that adjusting the arm lengths of a T match will change only the Resistive portion of the impedance match to the Driven Element of a Yagi. This is almost untrue.

As you extent the T match adjusting clips, the main thing you are doing is adding capacitance to the ends of the driven element, which lowers its resonant frequency. This does raise the resistive component slightly, but more importantly it makes the Driven element more Inductive. Only on rare occasions will this adjustment alone, accomplish a good impedance match.

You will almost always require a second method of adjustment to remove the reactive component. And, a VSWR of 1.1:1 (or better) is worth seeking if you want to get full performance from that Low Noise Amplifier (LNA) that you so carefully tuned while it was connected to a nearly perfect 50 ohm Automatic Noise Figure Indicator (ANFI).

I have submitted an article on this subject to a number of publications who have all turned it down. They seem to believe the subject is boring, and that everyone knows how to get a great match to the Driven Element of any Yagi. The stories I hear tell me this is not so, particularly when someone makes any change in the materials used to construct the Yagi. Below is a copy of the article that no one wants to publish, that explains how to fix the problem. It also tries to de-mystify the crazy rumor that a Yagi can not give full performance if the Driven Element is as long (or longer) than the Reflector.

73 and Good VHF/UHF/SHF/EME DX, Dick, K2RIW

PERFECT IMPEDANCE MATCHING OF A YAGI

By K2RIW (SEPT 12th 05, edited AUG 12th 06)

INTRODUCTION -- Most Low Noise Amplifiers (LNA) only achieve top performance if they see particular input impedance. This fact should motivate EME operators to achieve a "perfect match" at the Driven Element of their Yagi antennas. There are often-used impedance matching procedures that disturb the Pattern and Gain performance of the Yagi; the procedure described here does not do that. This article describes an impedance matching subtlety that has been overlooked, and it describes the peculiar relationship between the length of the Driven Element and the Reflector.

It is amazing how unknown this impedance matching procedure is. You can understand the concept by viewing the Graphs (included), or by memorizing two rules about a Dipole:

(1) Longer makes the **R higher.**
(2) Longer makes the **X more Inductive.**

GRAPHICALLY -- The graphs are included here. When you are away from home you will also find them in any edition of the McGraw-Hill "Antenna Engineering Handbook" by Jasik (1st ed. 1961), Jasik & Johnson (2nd ed. 1984), or Johnson (3rd ed. 1993), on pages 3-7 and 3-8 of the first edition, and on pages 4-7 and 4-8 of the last two editions. These Graphs tell you the Impedance of essentially all Monopole Antennas, for all reasonable Lengths and Diameters.

A DIPOLE IS TWO MONOPOLES -- First, remember that a Dipole is simply two Monopoles back-to-back. Therefore, all Impedances and Lengths (in degrees) that you read from the Graphs should be doubled when considering a Dipole.
Figure 4-3 tells you the Resistive Component of the Impedance versus the Length (in degrees). Figure 4-4 tells you the Reactive Component of the Impedance versus the Length (in degrees).

THE GRAPHS SAY IT ALL

When you study Figure 4-3, you will notice something very interesting. The Resistive Component of the Impedance always gets Larger, as the antenna is made Longer, up to 180 degrees for a Monopole, which is equal to 360 Degrees (One Wavelength) for a Dipole. Therefore, you do not need any fancy Impedance Matching Networks in order to get a perfect Resistive Match for your particular Dipole; and it doesn't matter if you are using a 35, 50, 70, 200, 300, or 600 ohm transmission line. Choose the correct Length of the Dipole, and you will achieve that exact Resistive Component, anywhere from 1 ohm to over 1,000 ohms.

Dipoles and Monopoles 4-7

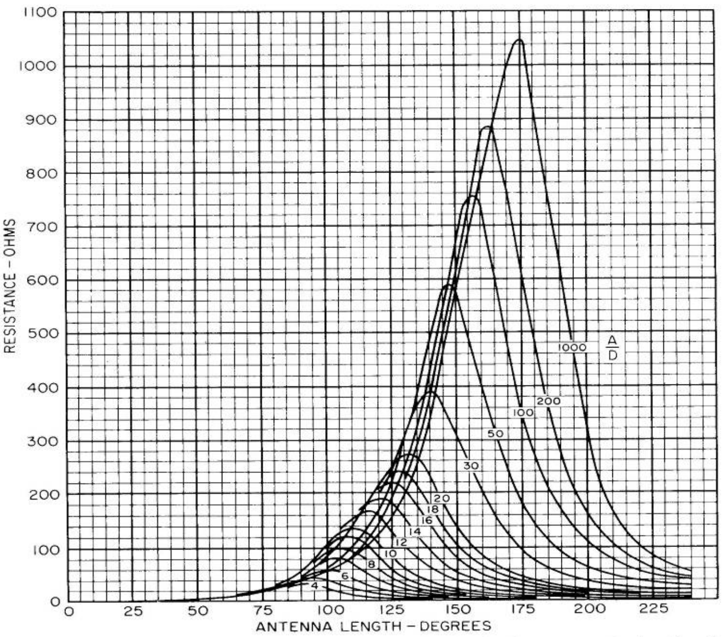


FIG. 4-3 Antenna resistance versus antenna length *A* when a constant ratio of length to diameter *A* / *D* is maintained. Here the length and diameter are held constant while the frequency is changed.

4-8 Types and Design Methods

THE REACTIVE COMPONENT

Then from Figure 4-4 you will notice that for your chosen length, the Dipole Impedance usually has a Reactive Component left over. You will also notice that for almost all Diameters of the antenna, the Reactive Component goes through zero at about 85 degrees of Length (for a Monopole), which equals 170 degrees for a Dipole (about 0.472 wavelength).
For shorter Lengths the Reactive Component is (-) [Capacitive], and for longer Lengths the Reactive Component is (+) [Inductive].

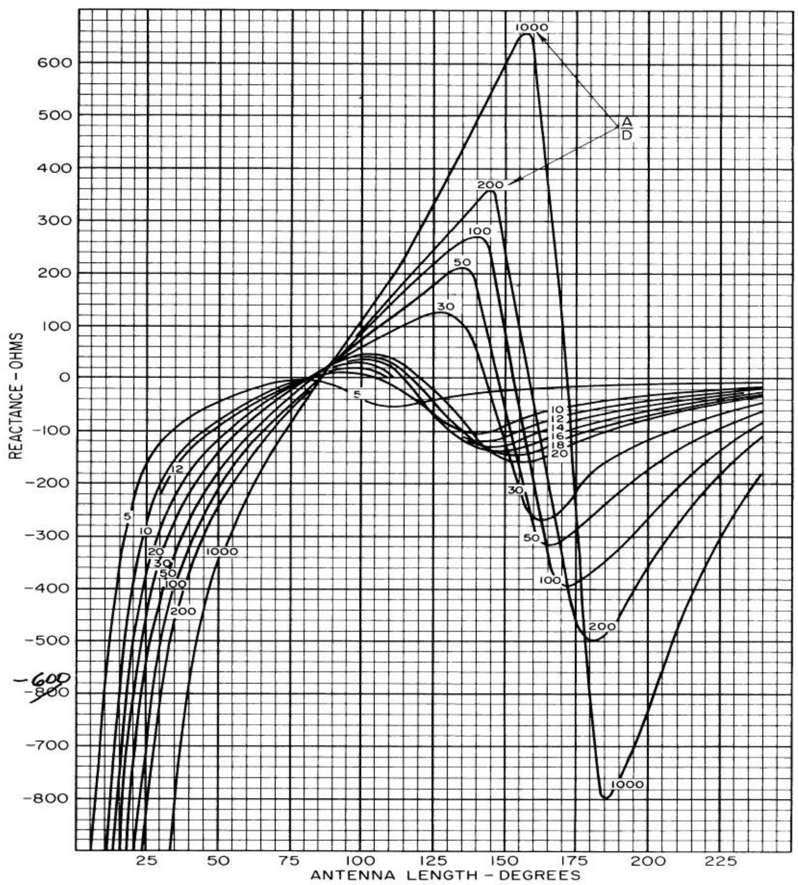


FIG. 4-4 Reactance curves corresponding to the resistance curves of Fig. 4-3.

LOW R IS BETTER -- I find that it is easier to live with the Inductive Dipole case. Therefore, any method that lowers the natural Resistive Component of the antenna's Impedance (relative to the transmission line) is desirable.
This can come about by using a fat Dipole, a higher impedance transmission line, an impedance-lowering device (such as a Delta March or a T Match), or choosing one of the Yagi designs that creates a Low Impedance Driven Element -- most of the good designs do this automatically.

LONGER IS INDUCTIVE -- Once the feed point of the Driven Element has a lower Resistive component than your transmission line Impedance, that will force you to lengthen the Dipole so as to raise it's Resistive component. This, in turn, will cause the Dipole's feed point to become Inductive. Then, all you have to do is to create a small Shunt Capacitor at the feed point, and you have a perfect match (a 1.0:1 VSWR), or a Reflection Coefficient (S11) of -30 dB, if that's what you desire.

AN EASY PROCEDURE -- The first time this is explained to you, it may seem complicated. Once you have performed the procedure once or twice, you will say, "Why hasn't someone told me this sooner?" A skilled operator, who is watching the Reflected Power on a Bird Watt Meter, a Directional Coupler, or the screen of Network Analyser, can perform the procedure in about 3 minutes. Be sure your instrumentation has High Directivity, or else the "perfect tuning" will be a "false perfection".

TUNING TRICKS -- Here are some additional tricks. You can always electrically lengthen your Dipole by placing small pieces of Copper Tape on the tips of the Dipole (capacitive Top Hats), or by placing sliding pieces of tubing in that area. You can create a Shunt Capacitor at the antenna's Feed Point by placing a piece of Copper Tape across the terminals of the feed point, after first insulating one of them with some paper tape. Your intention here is to prove that you can achieve a perfect impedance match to your Dipole. Once achieved, it is a simple matter to convert your "gimmick capacitors" into permanent fixtures that are mounted to the antenna in a weatherproof manner.

INDUCTIVE Z IS BETTER -- I like the Shunt Capacitor approach because it is very easy to create a variable capacitor by way of Copper Tape. The capacitor can be easily tuned under working conditions by poking an overlapping piece of Copper Tape with a thin diameter wooden stick, as you stand out of the way of the antenna's field. This also is the way to tune the pieces of Copper Tape that are placed on the tips of the Dipole (by bending them). The Dipole Tip-Tuning and the Feed point Shunt Capacitor Tuning will display some interaction. But, after a couple of tuning cycles, you will have a 1:1 VSWR within a few minutes.

CAPACITIVE Z IS HARDER -- If you have to make the Dipole electrically shorter than 170 degrees (to match the antenna's Resistive Component for a transmission line that has a lower Impedance), that will force the antenna's Reactive Component to be Capacitive, and this will require a shunt or series Inductor to be placed at the Feed Point. I find that it is more difficult to make a variable Inductor gimmick tuning device. But, maybe some of the smarter EME'ers and Micro-wavers will also solve that problem.

YAGI TUNING -- Here are some notes concerning Yagi antennas. Many amateurs worry that gimmicky devices placed on the Driven Element will decrease the Gain, or change the Pattern of an otherwise well-designed Yagi. As long as lossless devices are used, this is not a problem. ***For a Yagi to work well, all that is required is for the Driven Element to:***

(1) Radiate in a Linear-Polarized, Dipole-like manner.
(2) Present a good impedance match to the transmission line.
(3) Present no Common Mode Currents that flow on the outside of the coaxial transmission line (Use a good Balun, like a 1/2 wave coax Balun).
(4) And for all of the Yagi's Parasitic Elements to be the right electrical lengths, and be in the right positions.

A PROBLEM: YAGI TUNING WITH THE DIRECTOR OR REFLECTOR -- You may have been told you can use the First Director (or two), or the Reflector, for adjusting the Impedance Match of the Driven Element. However, when you do this you are simultaneously changing the Yagi's Pattern, and its Front-to-Back Ratio.

Tuning the Yagi, and adjusting the Impedance Match of the Driven Element, really is two separate operations. A good number of experienced Yagi builders believe that the Gain and Pattern are not significantly impacted when tuning the First Director (only) as a means of improving the Impedance match. For some particular Yagi designs, where the First Director is very close, this may be true. I say, if you are smart enough, one operation doesn't have to contaminate the other; why take the chance when independently correcting the VSWR is so easy?

LENGTH OF THE DRIVEN ELEMENT VERSUS THE REFLECTOR -- When you follow this impedance matching procedure you will often find that the Driven Element ends up almost as long, or even longer, than the Reflector. This greatly disturbs many Yagi users, because they have come to believe that the Reflector must be longer for proper Yagi operation -- this is an incorrect belief.

THE EXPLODING YAGI? -- I have seen some very respected EME operators lengthen the Driven element, the Impedance match was getting better, the measured pattern did not change, but they would stop at the instant the length approached that of the Reflector -- they seemed to believe the antenna would ***EXPLODE*** if they went any further. Their mistaken belief in this area was that strong.

The Yagi will perform correctly if each of the Parasitic Elements has the correct Electrical Length, and each is in the correct position. ***The Driven Element only needs to radiate in a broadside manner to supply the signal that sets that process in motion; its physical length does not matter, as long as it is in the vicinity of one half wavelength long*** (for a conventional Yagi)**.**

ONE WAVELENGTH DRIVEN ELEMENT? -- Here is an exaggerated example to demonstrate some principles: If the Driven Element was made a full wavelength long, only then the Dipole might have a broadside null in it's Radiation Pattern (depending on how it was fed), and it might not properly excite the Parasitic Elements. However, with the proper feeding technique, a one wavelength Dipole will supply the proper Yagi excitation pattern (and a more narrow excitation beam width), and that pattern might be an improvement that could increase the performance. This is a whole new area that has not been investigated.

USE DUAL INSTRUMENTATION WHILE TUNING A YAGI -- If you are designing your own "Super Yagi", here is a procedure I recommend. A really smart technologist will use two pieces of instrumentation, or he will set up his Network Analyser so there are two traces on the screen (in different colors). Then he can simultaneously display the Gain and the Impedance Match, as he does the tuning of the individual Yagi elements. You will be amazed how often an adjustment of a Director will make the Gain jump up 1 dB, at the same time that the Driven Element VSWR goes from a 1.0 to a 1.5 (a loss of 0.18 dB).

The smart technologist will leave the Director tuning at the High Gain position, and then he will ***INDEPENDENTLY*** work on the Driven Element to bring the VSWR back down. At the end of this tuning procedure he will have a Yagi that has Maximum Gain, and the Best VSWR, without allowing one operation to contaminate the other.

LOSS TEST -- If you have any doubt that there may be lossy components within an antenna, a simple test will reveal that fact very fast. Simply put 100 watts into the antenna for 5 minutes. Then turn off the RF and quickly go over and touch the components of the antenna. The heat radiated by the lossy components will be revealed to you very quickly with that test.

LOSS TEST SENSITIVITY -- Here is an example of how sensitive that test is:

(1) Your hand can easily detect the temperature increase of a component that is dissipating one watt for 5 minutes.
(2) One watt of loss out of 100 watts represents 99% efficiency, or a loss of 0.04 dB.

CONCLUSION -- I hope you find this information to be useful. I think I have earned a small fortune over the years by using these techniques to tune the antennas for my consulting clients. They were amazed that I could achieve a 1.05 VSWR (and better), sometimes over a considerable bandwidth -- but that's another story. There are modern sophisticated receiver circuits that will only perform well when an extremely low VSWR is present.

73 and Good VHF/UHF/SHF/EHF/EME DX,

Dick, K2RIW

Web: http://www.consult-li.com/listings/RKnadle.htm

Spotted in the classified section of *"Feed Point"* the newsletter of the North Texas Microwave Society:

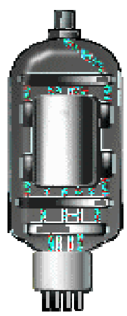
Trade wife for IC-7000. She's 5'11" Blond hair blue eyes, Weight 120lbs and hates ham radios. Would like to trade for a New IC-7000 or obo. Thanks George Long. Email: thevenderdude@cs.com

Some great contacts have made by 14 year old Tom VK4FTDX on 144 MHz SSB. Tom is the only foundation licensee we are aware of running 144 MHz SSB. I guess most of the new ones think VHF is only line of sight, but Tom is proving this theory wrong. Tom is located at Glenden, 100 or so Km west of Mackay and is running a 12 element yagi.
You can visit Tom's site here http://www.vk4ftdx.bravehost.com/ (WIA National News, 6th Aug)

Kevin Murphy ZL1UJG is editor of the New Zealand VHF Scene column and publishes a newsletter called **"Funewsletter"** which stands for:

Frequencies VHF, UHF, SHF Newsletter NZ

It's a very good read and it can be downloaded from Kevin's' website at www.qsl.net/zl1ujg



Question Section: ASK DOUG, (a regular feature)

By Doug VK4OE

Ron Meiring VK4KDD asks:

"Why do two 'good' 144 MHz receiving systems both generate wall-to-wall S9++ rough noise when attempting to operate recently on Mt Coot-tha in Brisbane, compared to no problems operating there two or more years ago?"

Doug's response:

This is most likely due to a new strong out-of-band signal in the area generating overload and/or intermodulation in 144 MHz receivers operating nearby. Apparent interference like this may be the result of:

[A] 'Dirty' signals spreading across 144 MHz from an out-of-band transmitter,

[B] The inability of the 144 MHz receiver to handle strong in-band or adjacent out-of-band signals (The most common cause), or

[C] In a 'hostile' RF environment such as Mt Coot-tha, many of the strong local signals can mix together in any of a number of situations like corroded contacts between wire fence components, so as to generate weak local mixing products which are loud when you have a receiver close to them.

Lots of investigation, both in laboratory and field situations, is necessary to fully understand what is or may be going on here. What follows is a summary of results of some limited investigations that Ron and I have conducted, and other enquiries I have made:

- Ron's 2M receivers are 'better than average', the first being an old Yaesu FT-225 modified with a Mutek front-end (a line of after-market products notable for being able to handle strong in-band signals), with the second being an off-the-shelf DB6NT 2m transverter system connected to a Kenwood TS-850 as the tunable IF.

- For comparison purposes, I have two Icom IC-970 radios which I can use either at home, or can take out portable. Although now ageing (c.1992), the 2M front end in the IC-970 still does very well in the intermodulation stakes and I remember reading a report from a European amateur radio journal from the mid 90's that put its performance equal or better than any other radio available at that time.

- At my place in Annerley, Ron and I did absolute sensitivity tests on our four 2M receiving systems. This was done through the use of a totally shielded (battery included) 8 MHz crystal oscillator and seeing how much attenuation could be inserted before the signal could no longer be detected by ear.

- The four systems were all very good, with Ron's FT-225/Mutek combination about 5 dB better than the others.

- Each receiving system was, in turn, connected to my 13 el DL6WU antenna as the antenna was panned across the general direction of Mt Coot-tha, about 6 km away. Comparisons were made and performance in terms of susceptibility to strong signal intermodulation (Intermodulation performance is best tested using two independent signal generators with outputs carefully combined and fed to the receiver under test).

- With Annerley being an area of strong signals from Mt Coot-tha, the method described of panning of the antenna past the general direction of the sources of RF is able to provide realistic comparisons between the different receiving systems. Results showed that Ron's FT-225 plus Mutek and his DB6NT plus TS-850 distinctly did not like the prevailing levels of RF. One of my IC-970's was better than the other and both were markedly better than Ron's equipment in terms of an ability to withstand the huge number of strong signals coming from Mt Coot-tha.

- Audible noise from the DB6NT transverter plus the TS-850 appeared to be improved when a 10 dB attenuator was inserted between the transverter and the HF radio, suggesting that intermodulation was occurring in the TS-850. (A similar effect is achieved when the internal attenuator is switched in.) If this was so, it is hardly surprising, given that the transverter is faithfully amplifying many signals (hopefully the 144 MHz ones more than others, but some others are still being amplified), and the HF radio, although a good one in its time, simply finds this all too much. However, more careful checking showed that there was essentially no difference in noise other than the natural difference in signal level. If strong signal intermodulation was happening, it must be in the transverter.

- When the coax from the 13 el antenna was connected to a spectrum analyser, the anticipated groupings of (a) FM broadcast stations, (b) 148 MHz pagers, (c) television transmissions, both analogue and digital, and (d) other communication services were all easily identifiable, with many peaking in strength when the beam was on Mt Coot-tha. Having previously done this spectrum analyser test several times before, one very strong signal down a little less than 130 MHz stood out as being new. The direction of this peaked about ten degrees south of the general Mt Coot-tha direction. Of itself, this observation is not conclusive, but will be considered later.

- Several days later I made a radio visit to Mt Coot-tha with the two IC-970 radios and one portable 10 el beam. Receiving tests were conducted on 144.1 MHz to see if anything like the Ron's original experiences would be evident. Yes, there was a strong source of RF noise when beaming in a direction just east of South, that caused a large rise in background receiver noise as the antenna was rotated (one radio more than the other), but both radios were still quite useable when the antenna was aimed in other directions, e.g. beaming across the hill to the Mt Mowbullan beacon. Clearly, the IC-970 radios were doing better than Ron's 'hot' receivers under these conditions, which also correlates with the results observed from Annerley. On my many previous excursions to Mt Coot-tha, such an interfering signal was never experienced, suggesting that it is a new and very strong signal which is causing the reported intermodulation.

- By sheer chance, a week later I was in conversation with Peter, VK4ZDO, from the suburb of Bardon (adjacent to Mt Coot-tha) and he reported that he is trying to deal with a very strong local signal on approximately 125 MHz, a signal that it stronger than the 148 MHz pager transmitters that he is also trying to prevent from affecting his 144 MHz receiving equipment (an IC-275). He reports that this signal is not always 'on'.

- Peter is not presently able to get a directional 'fix' on these signals, but he is attempting to construct filters that 'notch' out all known signals that cause intermodulation in his 144 MHz radio. His observations match the spectrum analyser observations made from Annerley of a new strong signal down in the 125 MHz area.

- An ACMA data check did not show any recent frequency 'assignments' in the 125 MHz range so it is possible that the strong signal observed was a signal under some sort of short term test, or a rather bad spurious emission.

- At the time of preparing this report (about two weeks later), the strong signal was no longer evident from the Annerley QTH and Ron and I have made a special joint visit to the Mt Coot-tha site to conduct more tests. This time we experienced neither unexpected noises nor strong signals, indicating that the previous interference is no longer there. There was a background level of rough pulse type noise that we attributed to low level digital television sidebands, but a very weak test signal from Annerley was still able to be detected through the low level noise. Ron was also able to demonstrate that a two-stage helical band pass filter substantially reduced the background noise level in the hottest of his receivers, the FT-225 with Mutek front-end. Reduction of out-of-band signals in the 'hostile' RF environment of Mt Coot-tha did make that receiver quieter, which again suggests intermodulation from out-of-band signals as the culprit.

In summary: Compromised intermodulation performance of otherwise high sensitivity 144 MHz receiving systems is likely to be the reason for Ron's difficulties when on Mt Coot-tha, and that a transmitter (probably intermittently 'on') somewhere slightly to the South of Mt Coot-tha was the source of the very strong signal on approximately 125 MHz that led to the observed intermodulation. A tunable notch or band pass filter is the route towards reduction or elimination of this interference.

Perhaps these comments and experiences will assist someone else in tracking down what they see as strong signal intermodulation interference.

RETURN LOSS BRIDGE

Kevin Murphy ZL1UJG

(From VHF scene NZART BREAK IN magazine)

HF-UHF Version 1-500 MHz,   VHF-UHF Version 50 to 622 MHz

A common way of looking at the SWR of objects (such as antennas) is to use a VHF/UHF SWR Meter. These are most commonly built as a coupler. At HF, this may be via a RF toroidal transformer, while at VHF/UHF adjacent parallel lines are coupled to a primary line. One end of the parallel lines is terminated in a load and the other end is coupled to a detector such as a diode.

The VHF/UHF coupler has an optimum frequency for best performance. As the frequency increases, the parallel lines take more power while at the lower frequencies the lines take less.

Common HF/VHF SWR Meters, CB type meters and many other VHF/UHF SWR meters use this principle. Amateur VHF/UHF SWR meters give an indication of SWR only (Especially if the meters use SO239 connectors!) Professional units may extend the flat frequency response by modifying the physical construction of the coupler.

Disadvantages are: They require significant power for coupling into the detector (typically Watts if diode detectors are used) and frequency response is not flat.

Advantage: Can be left in circuit

An **alternative way** of looking at SWR is to use a **Return Loss Bridge (RLB).**

Advantage: The response may be quite flat from a few MHz and may extend up to 1 GHz or more, and the signal required for operation is low.

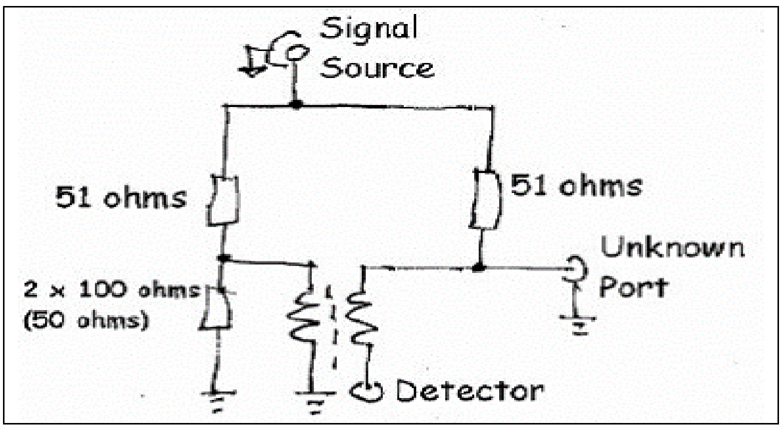
Disadvantage: Cannot be left in circuit due to losses associated with the bridge design.

The RLB is useful for checking impedances in circuitry, tuning filters, antennas and a whole myriad of other tests. The unit may have an internal detector (diode) or rely on an external detector, such as a diode, receiver, level meter or analyser.

The signal applied to the bridge, may be from a signal generator, such as for use with a receiver or other level indicator, or a low power transmitter (An FM transceiver on low power ~ 500mW max) when using a diode detector.

An alternative signal would be a noise source (similar to that in a noise bridge)

The unit typically consists of a 4 resistor bridge circuit, detector and signal source. Three resistors are of the circuit impedance (such as 50 or 75 ohms).



One of these resistors is a reference, which may be part of the bridge, or as a separate external resistor. One of the resistors is of course the unknown load. The signal source feeds the top of the bridge (This may be from a signal generator, low power TX, oscillator or a noise generator).

The detector is coupled across the centre of the bridge.

At balance (SWR= 1:1), ***return loss is infinite*** and the voltage appearing between the resistors is 0.

Whereas if the unknown port is shorted (***SWR is infinite***) and Return loss is 0 dB
(If the connector is left open there may be some radiation from the connector).

Return loss is a measure of how much power is reflected from the load.
If the load is perfectly matched (SWR = 1:1) then no power is reflected from it, so the returned signal is infinitely small, or has an infinite loss. The return loss is normally measured in dB.

A complete chart relating return loss to VSWR can be found at: www.wenzel.com/pdffiles/losschrt.pdf.

In practice a Return loss of 13 to 15 dB (VSWR ~ 1.6 to 1.4) is more than adequate as only 3 to 5 % of the power is reflected.

When the unknown port is shorted. The signal fed to the detector is typically –12 dB (1/16) of the input power.

Return Loss (dB)	VSWR	Power to load
0	∞	0 %
6	3:1	75
10	1.9	90
13	1.6	95
15	1.43	97
20	1.22	99
25	1.12	99.7
30	1.07	99.9
35	1.04	99.97
40	1.02	99.99

The detector may consist of a sensitive diode detector across the two points mentioned before. Alternatively it may consist of an external power indicator such as a sensitive power meter, spectrum analyser or a Receiver. If you have a modulated signal source, then the demodulated signal may be fed to an indicator such as an oscilloscope or a selective AF voltmeter (such as a HP 415 or a homemade unit).

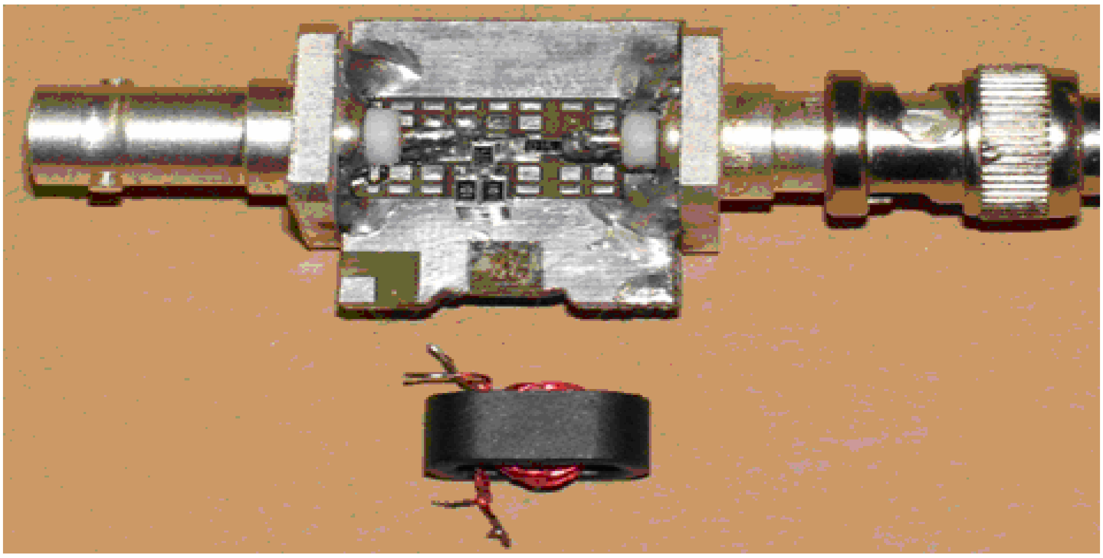
If a diode detector is used the Return loss can be calculated using the formula:

$$20 \times \log10 \text{ (V Shorted/V unknown load)}$$

The external indicators are generally connected via a balanced to unbalanced transformer (Balun) so that the bridge retains its balance... This balun may consist of the wires being feed through a number of ferrite beads or via a ferrite transformer suitable for the frequency of interest. The return loss bridge may be also used in this format as a signal combiner or splitter (such as combining two signal sources) If external detectors are used then the frequency range is somewhat dependent on the properties of the Balun.

Use

Apply your signal source to the Input port of the bridge. Short circuit the unknown port with either a homemade s/c coax connector (or carefully place a screwdriver across the connector, shorting the pin to the outside body).
This will give the maximum signal into the detector. If you are using a detector calibrated in dB, such as a power meter or other relative indicator, then return loss may be read directly. Apply the unknown load (such as an antenna) and then read the difference.



With a prototype 50 to 622 MHz RLB (as seen in the image), a professional 50 ohm termination indicated a return loss of ~ 28 dB at 50 and 622 MHz, while at 144 and 432 MHz this figure exceeded 30 dB. A 50 ohm PC LAN termination (DSE) indicated ~ 20 dB across the same frequency range.

Deterioration of the return loss at the low frequencies is due to insufficient inductance in the balun, while stray capacitance limits the high frequency end

Parts suggestion

General Purpose Double Sided PCB board, from Waikato VHF Group. (PO Box 606 Hamilton, NZ) Plain copper PCB, either double (or single sided at a pinch) could be used as an alternative. Copper tape is used around the edges to join earth planes *(This also looks like a good prototyping PCB for those pre-amps we keep frying – Graham)*

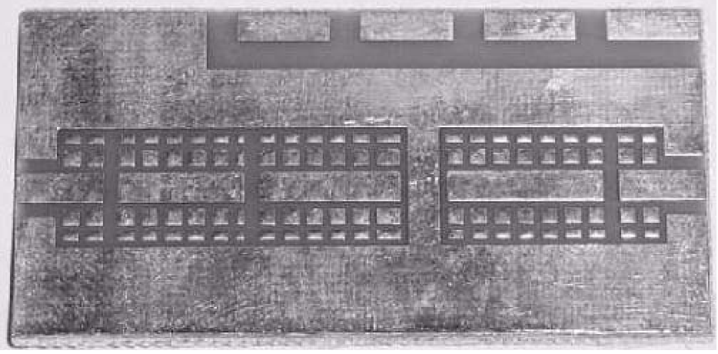
Ferrite Balun Cores:
For 50 to 622 MHz coverage, use a core from an old TV balun or Jaycar/Sicom LF1222
For 1 to 500 MHz use BN-73-202 and BN-73-2402 from Amidon

Enameled Wire: 0.4 to 0.63mm Twisted ~ 6 TPI (turns per inch) with hand or battery drill.
Pass through core 3.5 times (ie 3.5 "U" turns)

Suitable coaxial connectors: BNC, N, SMA. (Not SO239!).
The connectors may be soldered directly onto the PCB as shown in the prototype or may be installed in a suitable enclosure with care taken with the coax terminations especially at the unknown port

The double sided, plated, prototyping PCB boards are available from Waikato VHF Group. (PO Box 606 Hamilton, NZ) $3.50 each or 3 for $10 Contact Kevin at www.nzart.org.nz/zl1ujg re postage etc.

(The PCB shown is an earlier one for MCL MAR or ERA MMIC devices. Later PCB's also take SOT-89 devices such as MCL GALI)



QRP EME (Almost) From Trevor VK4AFL

Hello Graham - for those with concerns about EMR compliance ***QRP EME*** might be just the ticket!

Rex VK7MO, a noted authority on the use of WSJT, & myself VK4AFL, have been experimenting with very low power communication via the moon on 1296 MHz using JT65C.

Initial tests were made a few months ago at the 50w level which at the time we thought was not too bad however there was quite a bit left in it. Later, contacts were made with 20w which proved to be fairly easy & repeatable plus definitely putting us in the low power category.

The next reduction by 3db to 10w was a bit more problematic. After a few attempts we managed 10w at one end with 20w at the other & after some e-mail communication between Rex & Joe Taylor, a new Version (5.9.5) of WSJT was released which amongst other improvements (especially in false decodes which now appear not to exist) is more suited to 1296 MHz.

Problems at this frequency include libration (multi-pathing effects due to the rough surface of the moon) & equipment stability which compared with 144 MHz makes operation of WSJT more difficult. At about the same time Rex fabricated & installed a choke ring on his septum feed which he felt improved his receive performance slightly & subsequent tests showed that we are now able to complete QSO's on a reasonably regular basis with just 10w at each end even with the moon near apogee.

QRP by definition means a power level of 5 watts or less & this is our goal.

During the last session (Aug 7th) we both operated at 5w for 90 minutes during which Rex had 1 decode & I had 15, the best being - 27db which is approx 2db to 3db in reserve so we are possibly not far away. A VE4MA feed is under consideration at VK7MO`s end to see if receive performance (always the most difficult aspect of any form of EME) can be stepped up a notch & I may also build the newer version VE4MA "super feed" to get a bit extra also. At this signal level absolutely anything in the way of extra gain (however small) plus a bit of luck helps & hopefully a 5w contact can be reported in a future newsletter!

Trevor VK4AFL 3.7 meter TV Dish

Home brew VE4MA feed, 0.4db preamp & solid state power.

Rex VK7MO 2.3 meter TV Dish

Home brew septum feed, 0.4db preamp & solid state power.

Got an old Pay-TV dish lying around doing nothing?

(Images from uhf-satcom.com & M0EYT)

Well, a few enterprising hams in the UK (Paul M0EYT, being one) decided to listen to the odd inter-planetary space probe!!! Initially at only ***7 million kM*** distance, and later ***148 million kM.*** This resulted initially with the reception of the tracking signal from Venus Express at 8.4GHz on the 5th Dec 2005 at 15:50UTC. Later, Paul and fellow amateur Bertrand Pinel, F5PL, received X-band signals from the Venus Express spacecraft just as it was entering orbit around Venus

The space craft set off on its journey to Venus on 9th November 2005, arriving at the planet on 11th April 2006. Venus Express transmits a tracking / telemetry beacon on 8419.074074 MHz. The antenna on the space craft is 1.3m diameter, with an approximate gain of 41.2 dBi (EIRP about 516 kW)

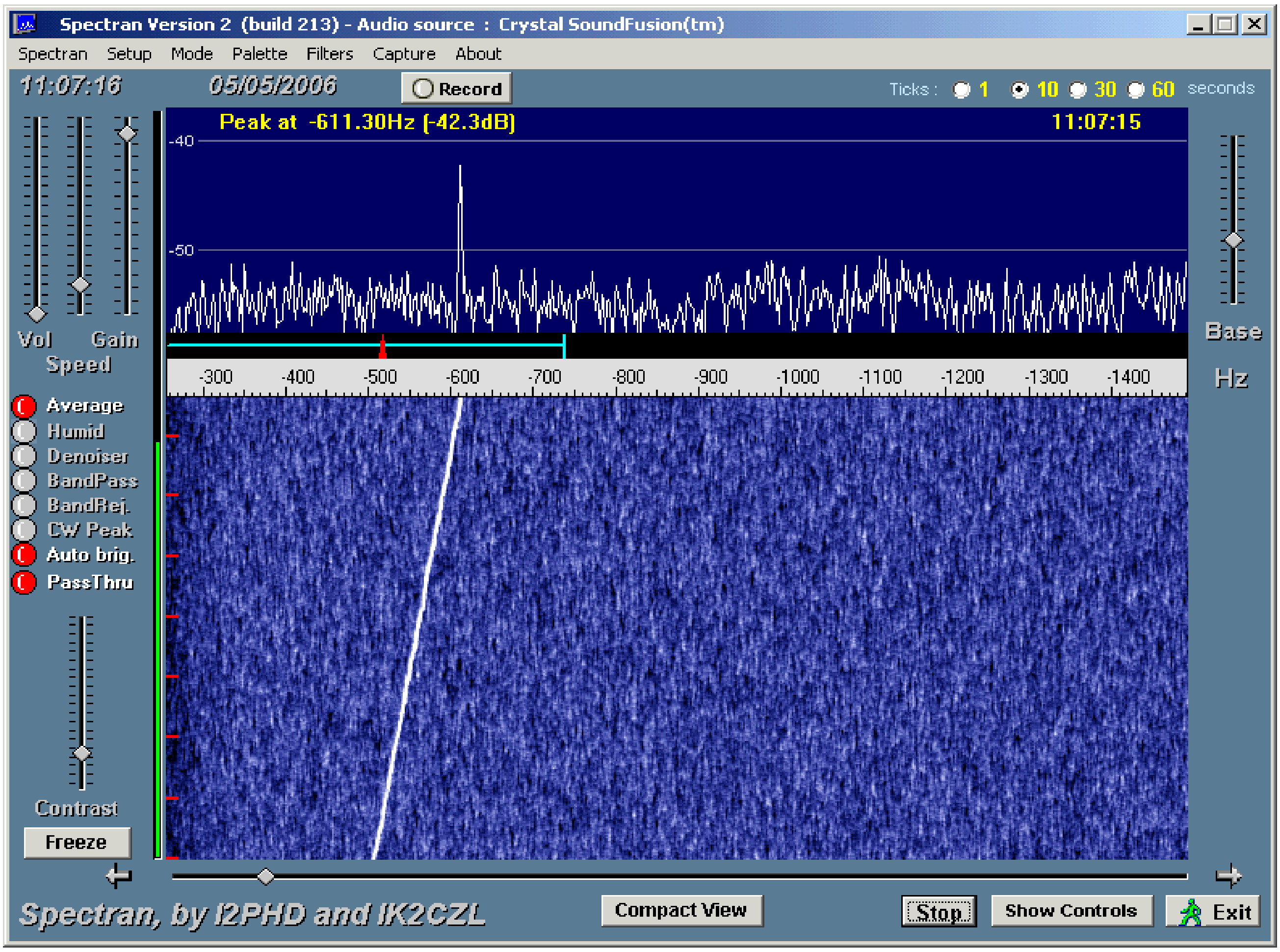
The first receive system basically consisted of a modified LNA and down converter that was used for 11GHz TV reception but with the addition of a 8420MHz band pass filter.

The receive antenna used for the first reception was a 1m fibreglass offset dish, with circular polarity feed. The feed with 'integrated' LNA can be seen. The LNA has been removed from a Marconi Ku band LNA used for satellite TV reception. The LNA stages have been retuned for 8GHz by tabbing them with copper foil, and an 8GHz RF output has been added after the third stage.

The down converter was loosely tied to the feed arm of the dish. The oscillator in the down converter runs at 8GHz and is fed with an 80MHz reference from a GPS locked source / frequency synthesizer.

The band pass filter designed with G3JVL filter software. It is a 2 cavity filter built in WG16. Once the filter had been tuned up, it had 0.5dB through loss at 8420MHz, with a bandwidth of about 50MHz.

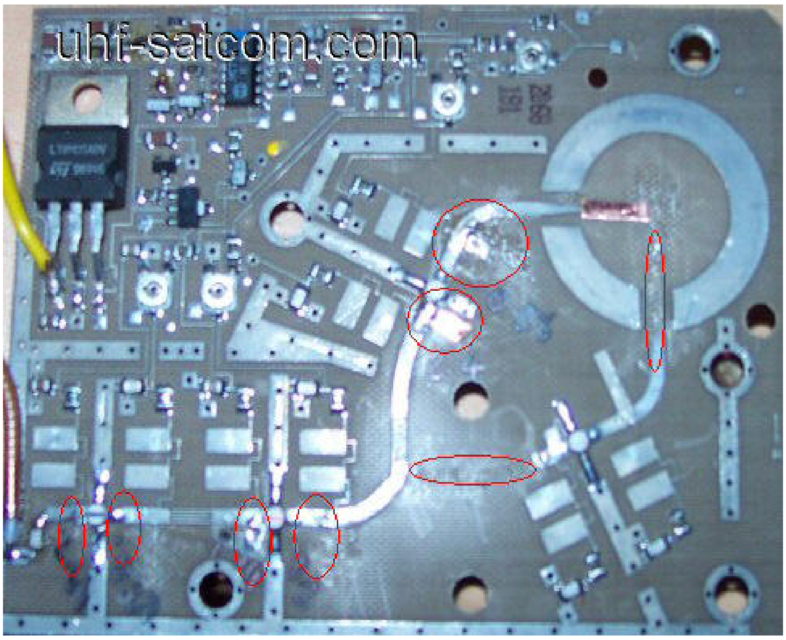
VEX continues to be an easy to receive!!! space-craft. The signals are consistently 15 to 20dB above the noise. Venus Explorer is currently 148,095,198.4kM away from Earth (5th May 2006)



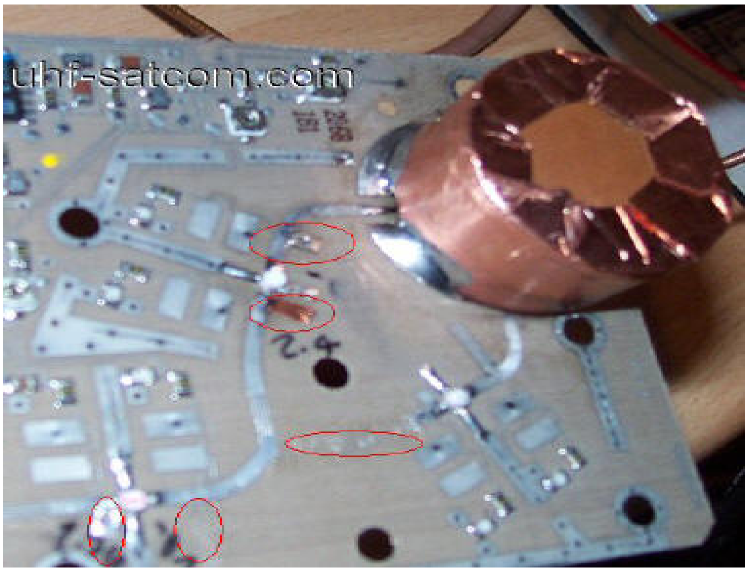
The spectran plot clearly shows the carrier drifting in frequency as the relative position / motion of the Earth and the Venus Express probe changes.

The LNA is made by modifying a Marconi Ku band LNB.

Basically the modifications involve chopping out the DRO, IF amplifier, 11GHz filter and the mixer assembly, removing the tuning tabs around each Gasfet, and replacing the waveguide / antenna assembly with one more suitable for 8GHz. For the new waveguide, 28mm copper water pipe couplers are soldered together. The LNA is tuned up on a weak signal by experimenting with the positioning of the tabbing around the active devices, whilst monitoring the output on a receiver or spectrum analyser.

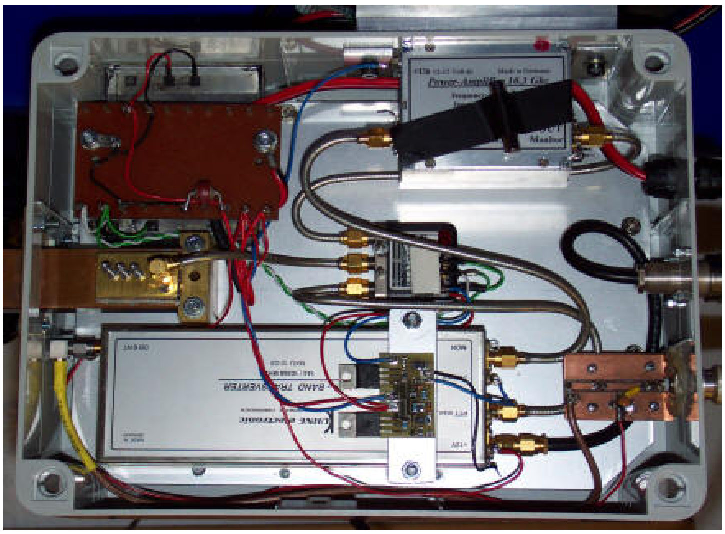


Red circles in the photos indicate where a modification had taken place, by adding tuning tabs or removing tracks. The output of the 3 stage LNA is coupled to coax using a suitable DC blocking SMD capacitor - in this case it was from the same board, located next to the mixer. The 1/4 wave probe also had to be lengthened due to the slightly lower frequency



Just in case you think Paul M0EYT (at right) is a serious professional RF engineer, Paul tops up the tanks on 747's for a living and is a member of the Flight Refuelling Amateur Radio Society (FRARS) which was founded in 1982 by employees of Flight Refuelling (Now Cobham PLC)

The latest receiving setup at M0EYT is a DB6NT transverter kit



Doug VK4OE recently sent me an excerpt from the US microwave reflector that complained that**:**

"Maybe if QST would stop featuring a new twist on how to build a dipole month after month after month and present a feature on shop tools we might all benefit."*…..This lit up something in my memory banks…..I had read just such an article…… It just goes to show that Peter ZL1UK had that same thought 3 years ago, and wrote this excellent paper in response- Graham*

This article is taken from a presentation given at a 2003 Technology Conference (Hamilton Amateur Radio Club NZ) the article was published in Issue 12 "Funewsletter" June 2003. (www.qsl.net/zl1ujg)

VHF to MICROWAVE MEASUREMENTS at low cost

Peter Loveridge ZL1UKG

(Judicious buying to assist with amateur research and development)

This paper will set out to show some of the areas where being able to make measurements will enable the debugging of hardware designs so that they perform as predicted by that article or discussion that inspired you to buy the components and pick up the tools. It will cover the use of attenuators, power measurement, directional couplers and sweep generators. In this case the low cost is achieved by buying older commercial instruments, but accessories may have to be built to support them.

A short summary of Microwave Test Equipment can be found in Chapter 11 of the ARRL UHF/Microwave Experimenter's Manual.

Attenuators (1) Attenuators can be found with the commonly used connector series BNC, N and SMA. The same frequency limitations apply to the connectors as they do for cable use ie BNC to 2 GHz, N to 18 GHz for precision made units, SMA typically to 18 GHz. Lower spec ratings will be found for any of these connectors due to the nature of the internal construction of the device.

The ARRL Handbook prints tables of Pi and T network attenuator values in the Reference section. These are a good start to checking on the accuracy of your latest purchase. Attenuators are rated from DC to an upper frequency. An ohm-meter will reveal whether the series and parallel combinations of internal elements agree with the markings on the case. Attenuators have a power rating. If this has been exceeded, the elements may have changed or be open circuit. Caveat Emptor!

Typical values are 3, 6, 10, 20 dB, but others may be found. Don't pass up the 4, 8, 16 values when preferred values are gone. 30, 40 dB may be found, but good cables and shielding becomes necessary to prevent leakage around the attenuator.

Good performing low power attenuators can be made with SMT resistors connecting PCB tracks on double –sided board. More than one link to the ground plane is required as the desired frequency of operation rises. A few cents worth does wonders at GPS frequencies (1.575 GHz) compared with a commercial unit @ NZ$30.

Examples of use

(1.1) A project to build the ultimate 2m backpack Yagi was begun. Backpack implies hilltop where front to back ratio becomes important, as stations on either side of the hill may not be able to hear each other and simultaneous operation of both may interfere with your QRP ability to work them. A suitable hilltop was chosen with visibility of a weak beacon. An attenuator is inserted in the antenna lead and the resulting signal to noise ratio (SNR) memorised. The antenna is rotated 180' and the attenuator removed. Chose attenuator values which make the attenuated direct and back lobe levels sound similar. Minor rear lobes and nulls can be checked in the same way. A protractor mounted on the mast will allow recording of the angles.

(1.2) You are working on a 23cm antenna. You need a power source for measurements. You don't wish to stress the power block in the transverter so you insert attenuators in the IF radio input to the transverter. In this way you reduce heat generation and run the output stage in a less vulnerable manner when dealing with unknown antennas.

(1.3) You are assessing your latest low noise creation with the help of the free signal generator in the daytime sky, using an AC scale multi-meter in the headphone socket and attenuators for an approximate result. With the antenna pointed at a cold region of the sky you set the volume control to give some convenient reading. Now point the antenna at the sun and as the reading on the meter increases, insert attenuators to bring the noise value back to the cold sky value. You have offset the value of "Sun Noise" with attenuators for a measure of performance. "Note that using noise of a narrow (voice) bandwidth will lead to more variability in amplitude with time than for a wide-band IF. Noise measuring instruments typically have a 1 -6 MHz bandwidth. The increased bandwidth is necessary for repeatability and accuracy."

(1.4) You have a Power Meter of unknown linearity. Insert attenuators between the source and sensor and see that the scale reading changes in keeping with the attenuator value. You may find that some of your attenuators have had a calibration certificate on them, and even frequency related results are recorded. Attenuators are amongst the least recognised pieces of precision test equipment.

The Power Meter (2)

When starting out in Amateur Radio, an SWR meter was one of the things you knew you needed to have for checking radios and antennas. They came in flavours like 3 -150 MHz, 20 or 200W full scale, or 140-525 MHz, with single or twin needle displays. Buying something useful above the 70 cm band wasn't possible. The fabled Bird 43 meter wasn't often seen and its plethora of slugs were like currency.

What is needed is a low power, wide band instrument like the HP 432A with 478A sensor head. This is a "Bolometer" instrument where the measurement is due to heating of a sensor element. The 432 contains a chopper stabilised amplifier to detect tiny changes in bridge balance due to RF heating. A superb meter movement is calibrated in mW linear with a logging scale below. Older instruments 430, 431 are not as stable as the 432. More recent instruments are more stable, and expensive.

The 10 mW level is no handicap. To measure higher power levels, just insert an attenuator in front of the sensor. "N" attenuators are typically rated at 1W max. A 20 dB attenuator will extend your meter to 1W from 10 mW. Power attenuators are now a useful luxury. 5 to 50W models can extend the range of the sensor accordingly. They will not be cheap! Power attenuators generally have lower frequency ratings as the size of the internal elements increase. They don't degrade gracefully in performance as frequency rises when parasitic values of the elements come into play.

It becomes progressively more difficult to generate power as frequency rises, so being able to measure low levels is highly desirable.

The simplest form of power meter is a diode detector. Diodes like the HP 5082 -2800 are usable to low microwave frequencies, but have a threshold below which they don't detect. Some MMIC gain in front of the diode can cope with this. Commercial diode mounts can also be found, with N, SMA or wave guide terminations usable up to 10 GHz or more.

Examples of Use

(2.1) Your IF radio needs to be checked for input to a mixer that can tolerate 1 mW maximum. What amount of attenuation do you need before the mixer? The meter and power attenuator lets you measure 2.8W say, from a Yaesu FT290.

(2.2) Someone says “lets run an antenna range at the next convention” with no idea of how to do it. It transpires that with the backpack yagi across the lawn from the clubrooms and 5W of carrier lets the antennas under test pick up a few mW, easily readable on the power meter. The results are relative to each other, but after measuring a dipole, some reasonable calculations can be done.

(2.3) You have a collection of assorted coax relays. What project are they best for? Do they provide the isolation to prevent frying the GaAs Fet on the input to the transverter during transmit? With 1 -2W from the transverter at frequency of interest passing through the relay to a dummy load, how much is picked up on the other port? Some insurance is useful here in the form of an attenuator before the power sensor, in case more than 10mW would damage the sensor. Once safety is determined, power down to 1 -2uW can be detected, so that isolation of at least 60dB can be measured.

(2.4) You must adjust the circularity of your 23 cm dish feed. You have two short helical antennas wound in opposite sense sitting in the garden driven by a transverter, pointing at the dish feed. Connect the power meter to the receive probe. Adjust the polarising stub depths until minimum power is received at the probe (W2IMU design). Swap left and right circular feeds to check that the received power difference is more than 20 dB.

The Directional Coupler (3)

The directional Coupler can do two things for you.

It will extract a sample of the energy passing through the device. (With a known attenuation from the input signal of say 10 -20 dB, it can allow higher powers to be measured)

It will take the sample from the input port, largely ignoring the output port returned power.
The “directivity” of the coupler will typically be 15 -25 dB for a broadband unit and higher values are found in the more limited range such as 1 octave couplers. You can now check on the matching of input circuits and antennas.

The SWR meters mentioned above are built around directional couplers. With a little ingenuity, some MMIC amplifiers might be placed inside them to increase their sensitivity, but they don’t extend into the microwave region. If not much power is available, a high attenuation at the sample port should be avoided when you can only detect down to 10uW.

Power handling of up to 20W is typical of a small coupler. A set of adapters and short cables is required to insert a coupler into the circuit and connect to the power meter. The best results are obtained when the coupler is placed right at the device to be measured. Impedance transformations by cable lengths are thus avoided.

The author has found a particular broadband coupler that was not flat over its specified range. Until you can confirm this by checking against another coupler, the results can be very confusing. It appeared that the directivity reduced to a very low value at one frequency. There is an interesting table in the recently published International Microwave Handbook (p202), of the range of true return loss values likely to exist for a measured return loss. EG: measured return loss 14 dB, directivity 20 dB True loss range 10.5 to 20dB.

Examples of use

(3.1) You have just assembled a Loop-Yagi kitset. Can your transverter live with it? Reduce the output of the transverter to 10 -100mW. Measure the forward power sample into the antenna. Turn the coupler around. Measure the reflected power sample from the antenna. The “Return Loss” can be calculated from the two power levels. Some ARRL manuals contain tables to convert Return Loss to SWR. EG 10 db loss = SWR 1.9:1, 20 dB loss = SWR 1.2:1.

(3.2) You notice that one 10 GHz dish feed is producing instability in the receiver while another one is fine. Measure as described above. Find Return Loss of 6 to 7 dB. Instability is being provoked in the amplifier. It is time to place 3 tuning stub screws to adjust the matching. Adjust for maximum Return Loss.

The Sweep Generator (4)

Many people will have a signal generator. They are fine test instruments, but very slow to use in some circumstances. Where filters and antennas are to be worked on and adjusted it helps a great deal to see the effect of a change on the whole range at once, to see if it has helped or hindered the overall result.

The ability to sweep the frequency used to mean lower "Q" frequency determining components. Instruments that are now affordable would have used mixing techniques from much higher frequencies down to the working frequency. The output from such an instrument will have lots more phase noise present than a similar signal generator. Setting the sweep to 144.2 MHz produced a rushing noise in the IF receiver rather than a pure tone. This does not matter as such narrow band measurements are not being made here. Dial setting accuracy is also compromised, but this is made up for with Markers being inserted on the display on multiples of a crystal oscillator. The main dial need only be settable closely enough to identify the markers.

An older instrument may cover 500 MHz in one band, with several overlapping bands to cater for needing to sweep past the band edge of a lower or higher band. The display will be an external oscilloscope, with the X axis sweep provided by a sawtooth wave from the sweep generator. Not all scopes have external input for the X axis. The Y axis is output from the sweep generator also, after insertion of the markers. A detector input is required on the front panel. This is where the making of accessories may be required.

To complete the set up a detector is required. This can be as simple as a diode, by convention with negative going output. The negative output is input to the sweep generator and appears on the scope with increased response = +ve y deflection. For passive components, the maximum output of the sweep generator may be only just enough for the diode to conduct. The detector needs a gain block in front of it. MMICs may be used for the purpose these days with total gain of 20 to 40 dB.

The POS series VCOs from Mini-Circuits may be candidates for making a sweep generator from scratch. Other forms of voltage tuned oscillators include YIG modules. Experience with sawtooth generators shows that plastic film capacitors are required to escape from dielectric storage effects seen with electrolytic capacitors. Op Amp buffering is required to keep real loads away from linear charging circuits. A simple example can be built with a constant current source and a UJT discharge device. Scour those ham fests for 10 turn pots for easily reset-able tuning.

Examples of use

(4.1) A US design no-tune transverter kitset for 902 MHz was purchased for use on 925 MHz. In order to scale the filters for a 23 MHz higher IF, a calculation was made for the amount to cut from the legs of the printed filter. An investigation showed that the peak response of the LO chain filter was at 690 MHz where 780 MHz was required. The 7th harmonic at 682.5 MHz was passed much more strongly than 780 MHz. Result equals more cell phones than you could shake a stick at, on 826.5 MHz. Two small copper pads were joined to a Perspex rod to cause changes to the tuning of each individual filter. The changing peaks on the scope display could determine which filter leg was responsible for the different humps on the scope display. A Stanley Knife then trimmed the legs of the filters. Some of these were determined to now be too short; pieces of copper were soldered on to the ends of the filter legs and could be moved with a hot iron. Result: better filter shape overall, and on frequency.

(4.2) The return loss and coupling between the RX and TX probes must be adjusted for a W2IMU horn. A directional coupler was mounted on the probes via an adapter. With gain block and detector in place, the effect of trimming the probe length had only slight effect on return loss. More effect was seen by moving the probe and it's mounting in and out from the position of flush with the inside the feed horn. I have been told that this form of adjustment is not strictly kosher. A position could be found where return loss was at least 20 dB. When later checked the result could not be improved on using an Anritsu "Site Master" costing many thousands of dollars.

Putting it all together

A YIG tuned source covering 8-18 GHz at 1GHz per volt had been purchased cheaply at a US junk sale. A sawtooth generator as described above was applied to the tuning terminal. About 12 -14 dBm output was available. This is enough for a simple diode detector. A directional coupler covering 2 -18 GHz was available. The scope could show best return loss for a ½ wave slot at 10.3 GHz after adjustment with a small file. The sheet metal with slot was placed across the end of a coax transition to waveguide. Now having the means to investigate, an update on the Clavin Feed for deeper dishes of f/D 0.3 -0.4 could be investigated. It turns out that the original dimensions from UHF/Microwave Projects Vol 2 p1 -15 appear to call for dimensions suitable for a lower frequency than 10.3 GHz. I have measured my kitchen table and find that it is 60 * 90 wavelengths. This is enough for an indoor antenna range over the winter months ahead. (Watch this space for an improved set of dimensions)

Having 12-14 dBm @ 10.3 GHz allows the power meter to be used to determine the pattern of a feed. A small horn from p1-7 of the same manual was folded up from copper sheet. It was driven by the YIG source and pointed at the feed under test. The feed was connected to the power meter sensor. About 10 wavelengths separation could be used to get a full scale reading on the meter when beamed at the feed. The feed was rotated while received power at several angles was measured. This technique is described in the proceedings of Microwave Update 99. A small file was created for input to FEEDPATT, an evaluation program available from www.w1ghz.org. The efficiency of feed and f/D can be determined.

There are many other projects that could be tackled, depending on the needs of the occasion.

Summary

On a limited power budget, a Spectrum Analyser would be a more sensitive detector. This lifts the equipment out of the "low cost" target of this paper. The devices described here have been purchased for about US$500 at various US Ham Fests. This is not a great outlay until you include Air Fares and Accommodation, and some of the supporting equipment like a scope, adapters, cables, gain block….. It does show that a little test equipment can make the difference between guesswork and guided work, leading to a satisfying result. A literature search for an exact model to copy does not need to be found. Adaptations can be made and verified later. I hope that these ideas encourage people to spend a little bit on other than ready made radios and antennas.

Peter Loveridge ZL1UKG

Feedback and comments on the content and presentation of this magazine are always welcome to:
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Editorial contributions are welcome, even if it is only a link to a website of interest. Remember that the ongoing success and life of this magazine depends on the contributions of you, the reader. So tell me about your latest project, rough notes will do, I can put the words together. We can all benefit from sharing of knowledge- Graham VK4SG

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