United Kingdom
Microwave Group

Scatterpoint – *Issue 4*

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Dishes at BT Adastral Park Earth Station

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About the UKuG

The United Kingdom Microwave Group was formed in Autumn 1999.

Membership subscriptions are currently UKP12.00 per year.

The committee comprises of the following:

Chairman	***Membership Secretary***	***Newsletter Editor***
Sam Jewell, G4DDK Blenheim Cottage Kirton Road Falkenham Ipswich IP10 0QU jewell@btinternet.com	Lehane Kellett G8KMH Woodpeckers Church Lane Arborfield Berkshire RG2 9JA lehane@mm-wave.demon.co.uk	Martyn Kinder G0CZD 12 Jessop Way Haslington Crewe Cheshire CW1 5FU martyn@g0czd.clara.net Tel: 01270 505930

There are also six ordinary committee members;

Neil Whiting	G4BRK
Steve Davis	G4KNZ
Peter Blakeborough	G3PYB
David Wrigley	G6GKX
Alan Wyatt	G8LSD
Mike Willis	G0MJW

Membership enquiries and applications should be sent to the membership secretary.

A membership form is available at on http://www.microwavers.org/ukugmemb.htm

The UKuG web site is at http://www.microwavers.org

Contributions for Scatterpoint, letters, For Sale and Wanted should be addressed to the newsletter editor.

If you like what you see here, please tell others, if you don't like it, please tell me.
73, Martyn Kinder G0CZD

Front-end

I would like to take this opportunity to wish all members of the UkuG a very Happy New Year in this first year of the New Millennium.

Since my last Foreword in Scatterpoint two very significant events have happened. First, we had the first AGM of the UKuG. This took place at the Adastral Park Microwave Roundtable event in November. The existing committee was returned unchanged, thanks to the timely proposal of WA5VJB, who suggested an en-masse vote to save time and debate. The turn out for the AGM was excellent, due in part to the good attendance at the Roundtable but also to the enthusiasm of our members. Thanks folks!.

The second event of significance for the UKuG was the successful launch of P3D (now AO-40). Our constitution says that we will promote all forms of microwave activity, and AO-40 falls well within this category due to the full range of microwave receivers and transmitters that it carries.

AO-40 has not been without problems. With the loss of the VHF (145MHz) engineering beacon downlink in mid December it looked like the satellite had a serious failure. In spite of very optimistic statements from AMSAT over the next few weeks, deadlines for automatic restoration came and went with no sign of the beacon re-appearing. However, just after Christmas, we received the good news that the 2401MHz S2 beacon had been re-activated and signals were again being received from AO-40. Attempts to activate the 145MHz beacon had been unsuccessful. I believe it can only be good news for microwave enthusiasts that the satellite builders and controllers are now so willing to accept the use of the higher bands for communications with amateur satellites.

I think we can look forward to an interesting New Year, operating on AO-40 as well as pushing our capabilities in terrestrial operation.

This issue of Scatterpoint carries several articles on satellite microwave in the optimistic hope that we will have a fully functioning satellite with which to use our microwave equipment.

All the very best for 2001

73 de Sam Jewell, G4DDK
Chairman, UKuG

The DC Bands - 1.3 and 2.3GHz News

John Quarmby G3XDY

Conditions – what Conditions?

Last time out I was looking forward to some autumn tropo lifts to give the bands a boost, but this past year looks like breaking records in terms of high rainfall and poor tropo conditions. Unless you have a big system terrestrial DX is most easily achieved using ducting, and it is very disheartening to find the bands dead for weeks on end. The weather appeared to have locked itself into a continuous cycle of deep Atlantic depressions, with no interludes of high pressure in between. Perhaps it is all a consequence of global warming and could become more prevalent in future.

Participation in this years cumulatives seemed lower than in the recent past, possibly as a result of the poor weather and conditions. G8OHM/P braved the weather to operate from IO82QL and put out a very good signal on 1.3GHz. GD4GNH was around to provide a DX contact for the stations in the south, often providing the only signal audible from the Northwest. G0HNW/P and G3PHO/P were also out on local high spots for some of the events. On the fixed station side G3MEH, G4BRK, G7LRQ and M0GHZ (ex G8NEY) were all trying hard to stir up activity, and G4FRE appeared on the band having brought his 1.3GHz gear over from the USA. On 2.3GHz the conditions meant that many contacts were a struggle with weak signals and QSB, with aircraft scatter providing just enough enhancement to complete the exchange.

1.3GHz in VHF NFD

As I noted in my last column, participation on 1.3GHz in VHF NFD was well down this year (only 18 stations submitted logs compared with 38 last year). As predicted, many stations took the “easy” option of 50MHz instead, killing activity on the microwave front. As we go to press the rules for VHF NFD 2001 have still to be published, so whether the VHFCC will change anything to rectify the situation remains to be seen.

Phase 3D/ AO40

The Phase 3D satellite was successfully launched in November to become AO40 and telemetry has been heard on several bands. However contact with the satellite was lost for a time the day after a burn of the on board engine to place the satellite into an elliptical orbit, and so commissioning is being undertaken cautiously. Once the satellite is fully operational there will be several modes of interest to the keen microwaver. There are a number of beacons on 2.4GHz, and the prospect of transponders from 1255MHz to other bands. These should provide good results for stations with fairly modest antennas. I hope that we might hear some better news on the health of the satellite shortly. The latest issue of Dubus (4/00) has an article by

Simon GM4PLM which highlights the opportunities the new satellite should provide using the 1.3GHz and 2.4GHz transponders.

How much gain do you need in your preamp?

Some recent tests I ran on my 2.3GHz system highlighted the need to have enough gain in the preamp to well exceed cable losses. My preamp is based on the OE9PMJ design in the Microwave Handbook Volume 3, P15.9, but with an NE64535 bipolar transistor second stage in place of a GaAsFET, and an MGF1402 in the first stage. This has worked well for many years, but earlier this year the NE64535 died, and not having a replacement to hand I bypassed it with a short length of semi-rigid coax, retuned the first stage and put it all back into service. I suspected it was rather deaf, as disconnecting the RX feeder at the transverter made little difference to the noise level. I was recently able to use an automatic NF meter to check the system in situ, and discovered that the overall system noise figure was 4dB measured at the antenna connector. This explained why I was having difficulty hearing stations! I decided to add a new second stage, this time using the MAR6 MMIC. After retuning the preamp I now have an overall system NF of 1dB. The improvement this provides in signal to noise ratio depends on what assumptions are made about the antenna noise temperature. With an antenna noise temperature of 290K, the SNR improvement is equal to the difference between the NF values, i.e. about 3dB. However, the actual noise temperature of an efficient antenna beaming at the horizon should be lower than this, as half the lobes point at cold sky (less than 10ºK at this frequency) and half at warm ground (say 290ºK), so the average noise temperature contributed by the antenna is about 150ºK. An NF of 4dB is equivalent to a noise temperature of 440ºK, whereas 1dB equates to 77ºK. In the first case the total receiver noise temperature is 590ºK, in the second it is 227ºK, a ratio of just over 4dB. So improving the NF by 3dB can actually provide 4dB of SNR improvement, and even bigger gains can be achieved by getting the RX NF lower still.

The result is that a fairly modest second stage device (3.5dB NF, 12dB gain) can provide a quite dramatic improvement in performance. A theoretical analysis of the receiver chain as shown below backs this up. As you can see I have a lot of feedline loss, which includes the effects of two triplexers which allow the same W103 cable to be used for 144 and 432MHz TX as well as 2320MHz RX. On the lower bands excessive receive gain can cause intermodulation and blocking problems in the presence of strong signals, but on microwaves lower activity and highly directive antennas make this less of a consideration. It is therefore preferable to err on the side of gain and noise figure rather than dynamic range, by adding extra gain stages to be sure that the front end dominates the overall equation. The MGF1402 is not state of the art these days, devices such as the NE32584, MGF4919 and FHX34 will achieve less than 0.5dB if carefully constructed. G3WDG has a kit for a preamp based on the DJ9BV design that can also include a MAR6 second stage, and there are also ready built units available from other suppliers. In general 2 stage preamps should fit the bill for most stations, but EME stations looking for every last fraction of a dB may benefit from going to 3 stages.

Forthcoming contests

The French are running a number of short 432/1296/2320MHz contests again in 2001, these take place from 0500 to 1100 GMT on 14th January and the 4th of February, and further events are scheduled for 20th May, 17th June and 21st October. These are a good opportunity to work some DX if conditions are reasonable.

In Germany there is a VHF Field day on the 3rd February, with activity on 1.3GHz from 0900 – 1100 and on 2.3GHz and up from 1100 –1300.

The Scandinavian activity contests run as usual in 2001, with 1.3GHz on the 3rd Tuesday of the month, from 1700-2100UTC.

The first weekend in March is a 144/432MHz event in the UK, but includes the microwave bands elsewhere in Europe, so again there is an opportunity to see what you can raise. Contest stations such as PA6NL are workable over quite large areas of the UK on 1.3GHz and would appreciate a few extra points.

Finally there is the European EME contest which includes 1.3GHz on 10th/11th March, and 2.3GHz on the 31st March/1st April.

Sign off

Can I take this opportunity to wish you all a happy and successful new year, with plenty of activity on the "DC Bands". If you have any input for this column, please let me know your news and views. I can be contacted as below.

73

John, G3XDY

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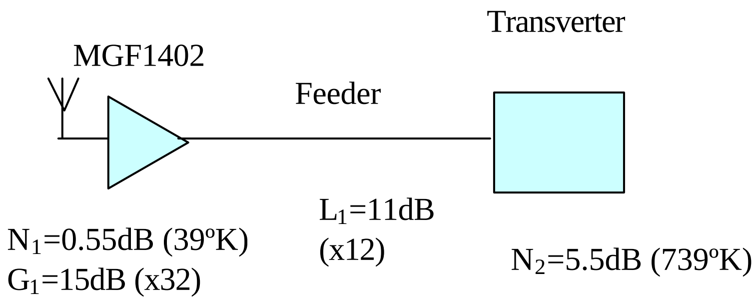
Post: John Quarmby, 12 Chestnut Close, Rushmere St. Andrew, Ipswich, IP5 1ED
Phone: 01473 717830 (between 18.30-21.00 preferred)

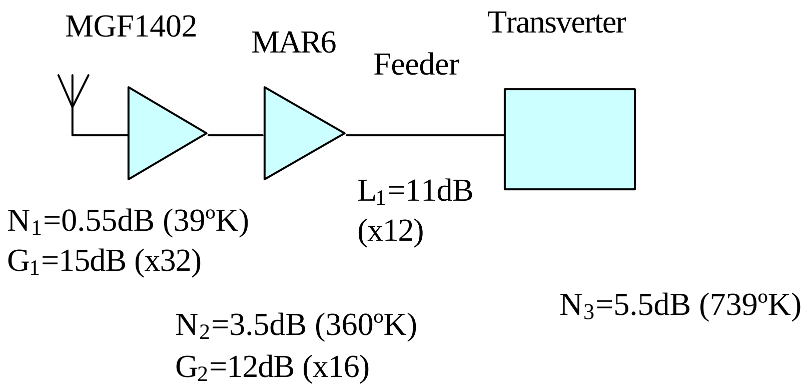
SINGLE STAGE PREAMP



$T_1=290((10^{N1/10})-1)$	T_1=39ºK
$T_2=290((10^{(L1+N2)/10})-1)$	T_2=12664ºK
$T= T_1+T_2/G_1$	T= 435ºK

N=4.0dB

TWO STAGE PREAMP



$T_1=290((10^{N1/10})-1)$	T_1=39ºK
$T_2=290((10^{N2/10})-1)$	T_2=360ºK
$T_3=290((10^{(L1+N2)/10})-1)$	T_3=12664ºK
$T= T_1+T_2/G_1+T_3/(G_1G_2)$	T= 39+11+25=75ºK

N=1.0dB

Tuned Audio Level Meter for RF Measurements

Roger Blackwell G4PMK

email:g4pmk@marsport.demon.co.uk

At the recent Round Table meeting at Adastral Park, great interest was generated by Kent Britain's (WA5VJB) talk on antenna gain measurements. Central to his theme was the use of tuned audio level meters such as the HP415 for measuring signal levels. I published a design for a home-brew 1 kHz audio level meter some time ago [1], which does the same job and can be used both for antenna range work and many other microwave measurements. So here is a revised and updated version. It's a tuned audio amplifier for use with 1 kHz modulated sources (both commercial signal generators and home-brewed sources) and an external diode detector. It has a dynamic range of over 50 dB. I'll cover the companion modulator and some of the uses of the meter in a future article.

The design consists of an input section, three amplifier-filter sections and a precision rectifier and meter buffer. The input section includes provision of a small amount of forward bias of either polarity, which will improve the square-law response of most common detectors. The audio driver transformer provides a suitable AC load for the detector, allows injection of this bias to the detector and provides a modest voltage step-up. The 10 dB step attenuator is split across the signal chain in the interests of best dynamic range. The circuit runs from two alkaline PP3 batteries which allows portability. Kent mentioned how useful an audio output was when making antenna measurements, so this design has an audio output, intended for use with one of the ubiquitous battery-powered PC/personal stereo active speakers. This output provides about 100 mV pk-pk into a 5k load when the meter reads 100% FSD.

The instrument should be constructed in a metal case using good audio construction techniques, including a single common connection for the case and circuit at the input socket, which ought to be a BNC or similar type. You can build the circuit on matrix board if you wish (as was one of the prototypes), although a PCB artwork should be available via the Internet [2] by the time you read this. All connections to the input circuit, step attenuator and set level control should use screened leads. Some of the components require a bit of care in selection. The 10nF capacitors in the filter stages (2 per stage, a total of 6) should be ±5% or better tolerance types. Resistors should be ± 2% or better, metal film or similar. The three presets are used to trim the filter centre frequencies and can be small cermet types. The 10 dB step attenuation switch should be a two-wafer type so as to maximise the isolation between sections. The bias switch is a single pole centre-off type. The input transformer used in the prototypes was the venerable LT44 transistor inter-stage transformer, still available from Maplin (HX82D) as are other suitable transformers (PX79L or PX80B). The PCB layout and prototypes used an LT44. It makes sense to get the best and largest meter you can find for this project, since you will be taking measurements directly off the meter scale. The 4u7 electrolytic across the meter terminals was added to damp out jitter due to noise; depending on your meter movement and personal preference you may find it unnecessary.

The meter will need re-calibrating in dB according to the following table:

%FSD	dB	%FSD	dB
100	0.0	25.1	-6.0
79.4	-1.0	20.0	-7.0
63.1	-2.0	15.9	-8.0
50.1	-3.0	12.6	-9.0
39.8	-4.0	10.0	-10.0
31.6	-5.0	1.0	-20.0

If you leave the original scale in place, then any reading can be converted to dB with the formula

$$dB = 10.\log_{10}\left(\frac{\%FSD}{100}\right)$$

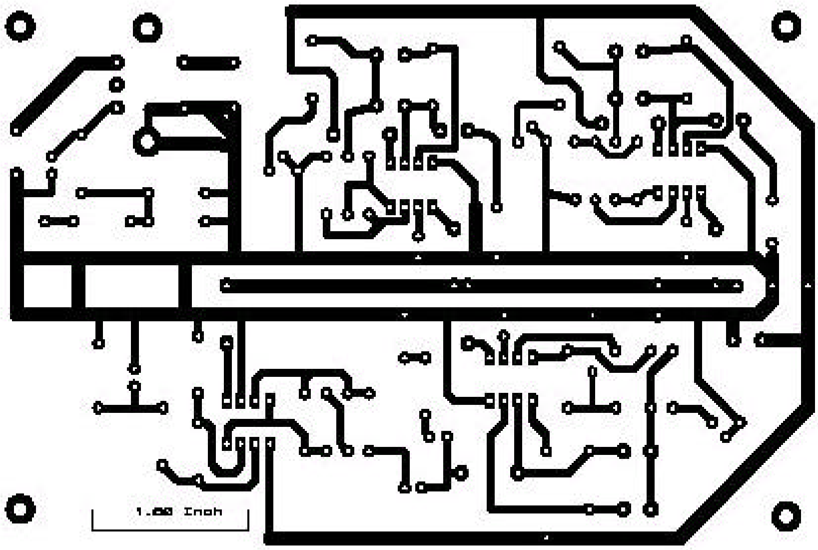
which is easy enough with a calculator.

Setting up the meter is quite simple. Inject a low-level (few mV) 1 kHz tone into the input, and adjust the attenuator and level set control for an on-scale reading. Ideally do this with the 1 kHz modulating source you plan to use. Now peak each of the three filters in turn by adjusting the 500R presets. Check that with a short-circuited input residual circuit noise is about 20% FSD on the 0dB attenuator range with the level control set to about 50%. That's all there is to it! The prototype sensitivity was such that about 100 mV RMS gave 50% FSD on the -50 dB setting with the set level control at mid range.

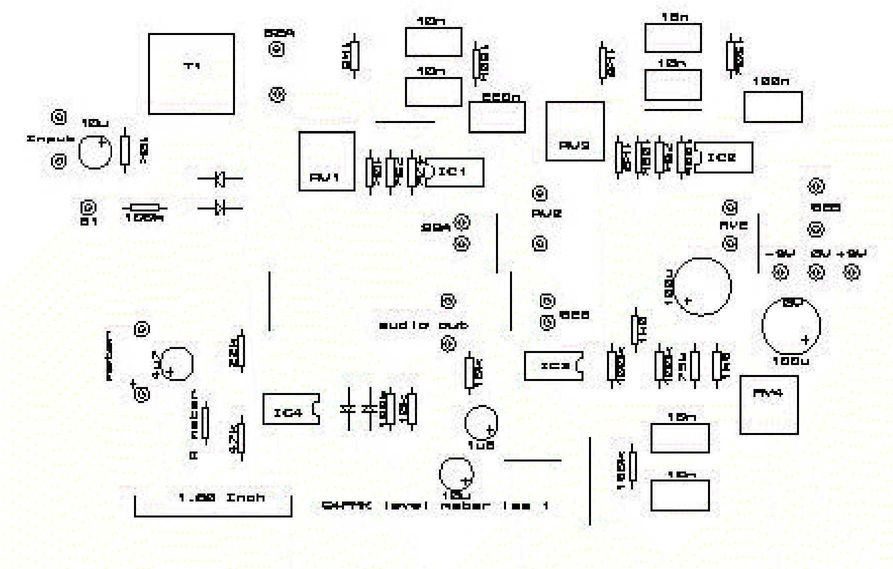
[1] Receiver Measurements, Ch 12, The VHF/UHF DX Book, edited by G3SEK, RSGB.

[2] Look at http://www.marsport.demon.co.uk/projects.htm for details of the PCB layout.

Tuned Audio Level Meter Layout Drawings



Track Layout



Component Layout

2.5GHz TV converters for amateur satellite reception

Sam Jewell, G4DDK

Introduction

When this article was being written (early new year) AO-40 was still recovering from it's pre-Christmas communications problem. The 2.4GHz middle beacon on 2401.318MHz was the only reliable downlink from the satellite and much effort was being devoted to monitoring the beacon, analysing its characteristics and using the information to try to determine what had gone wrong on board AO-40. The importance of the S band beacon was clear. Against this background it was felt that it would be a good idea to try and persuade a few more members to have a go at receiving 2.4GHz satellite signals.

Figure 1. Drake 2880 converter together with replacement crystal for the PLL and the ceramic 2.4GHz RF filter

Receive converters

Back in 1997 I published a construction article for a 2.3/2.4GHz receive converter for satellite and terrestrial use. The construction article was published in the Proceedings of the Weinheimer Tagung 42. This converter was similar to the design published in the RSGB Microwave Newsletter that same year by Dave Bowman, G0MRF, but I elected to use a 144MHz IF rather than 435MHz. I felt that a 144MHz IF was more appropriate for a mode S satellite receiver since it was my belief that 435MHz would be a more popular uplink band than 1269MHz. Consequently using 435MHz as the receiver IF would require the use of two 435MHz-capable transceivers (or transceiver and one multi-mode receiver/scanner) in order to operate effectively. Time will tell if this assumption is right. The current problem with the AO-40 435MHz link doesn't look too promising.

Several months after I published my converter design I was at Microwave Update '98 in Sandusky, Ohio, when Toshi, JA1AAH and his friends appeared with several boxes of the Drake 2880 2.5GHz converters for sale at $25 each. Of course I had to have one.

When I got home I modified mine in accordance with the instructions on the JN1GKZ Website. The PLL crystal was changed to 8.8125MHz to give a local oscillator injection frequency of 2256MHz. The IF filter modifications of removing the two coils and capacitors was also done.

I wasn't too impressed with the measured performance, but it was clear that with its compact weatherproof construction, it would be a very useful 2.4GHz converter when P3D finally got aloft. I put the Drake converter safely away, as the P3D launch was on hold yet again and I didn't have any immediate need for another 2.4GHz converter. My own one worked just fine.

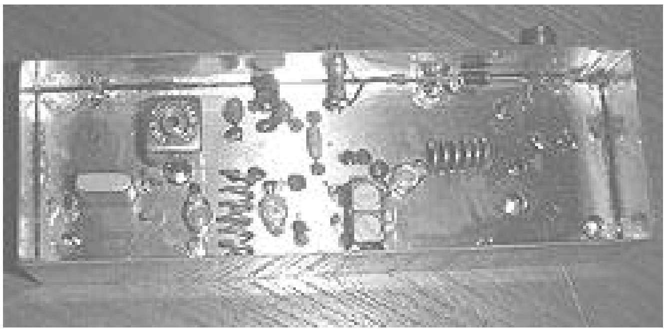


Fig 2 The G4DDK 2.4GHz receive converter

Together with Lehane, G8KMH, I was providing the microwave measurements at the AMSAT-UK Satellite Colloquium at the University of Surrey in 1998. We were both surprised at the large number of Drake converters that appeared courtesy of Richard, G3RWL. Richard had already converted several units and Lehane and I, together with Dave, G0MRF, were able to measure their noise figure and insertion gain using a HP8970A noise figure meter and HP346A noise head.

I think it would be true to say that the results were also a little disappointing. We measured converters both in unmodified form as well as those that had been modified according to the JN1GKZ instructions. The general spread of results showed that using the original published modifications, you could expect a noise figure of around 6.5dB and an insertion gain of about 18dB. These are highly averaged figures. Unmodified Drake's measured at 2.5GHz RF and 200MHz IF showed that the units would comfortably meet their original specification if used within the intended band.

Dave and I did many measurements of IF and RF response using sweepers, detectors and regular network analysers and concluded that the IF filter rolled off rapidly below 200MHz, and it also exhibited a marked dip around 145MHz! The RF filter also rolled off rapidly below 2.5GHz. These measurements led Dave to try some suggested modifications to the filtering which resulted in the noise figure of the test unit falling to around 3dB and the insertion gain climbing to a more comfortable 25dB. These modifications were published on the 'World above 1000MHz' web site www.g3pho.free-online.co.uk/microwaves/ of G3PHO. Essentially, these modifications involved lengthening the lines of the printed RF filter and adding one extra IF filter capacitor.

A further modification was to change the front end GaAs FET for an Agilent MGA 86576 GaAs FET MMIC. Although less straightforward than the filtering changes, the resulting improvement in noise figure is worth having. It should be noted, the length and quality of the grounding connection between the source leads of the MGA86576 and the ground plane on the reverse of the board must be short and clean (no excess solder) or the device will self oscillate - guaranteed!

However, it was obvious that the noise figure could be further improved. At the 1999 Amsat-UK Colloquium Dave introduced the ceramic filter change. This involved replacing the existing, lossy, printed RF (image) filter with a small ceramic dielectric filter meant for 2.4 - 2.45GHz LAN products. When this filter was incorporated the noise figure of the converter fell to around 1.8dB, which is close to the claimed noise figure for the MGA86576 device. The converter also became more 'docile', possibly indicating less radiation loss from the printed filter, with it's always present potential for instability.

With the modifications above the Drake 2880 is a very worthy converter for use with AO-40. However, there are still several pitfalls for the unwary.

Dave Bowman, G0MRF has further details of the Drake conversions on his web site www.g0mrf.freeserve.co.uk/ and may also have some of the conversion filters, MMICs and crystals for sale

Beware the helix antenna

The MGA86576 is susceptible to input mismatch instability. One very popular UK produced multi-turn helical antenna has been measured with a very low input return loss of only a few dB. A Drake converter attached to one of these antennas will self-oscillate. The use of several feet of lossy coax between the antenna and the converter will stop the oscillation, but is self defeating in so much as the overall system noise figure may then be unacceptable. The converter needs to be right at the feedpoint for optimum results.

The commonly accepted feed point impedance of the multi-turn helix of 140R is only obtained when the helix is centre fed[1] . The more popular method of feeding on the periphery produces a much higher feed impedance requiring the use of a 1/4 turn matching section on the first 1/4 turn of the helix. This has to be very carefully tuned by bending the matching section towards or away from the reflector plate to obtain an acceptable match. A carefully matched section will start close spaced to the reflector and progressively further away at the other end.

A few further notes of caution must be mentioned when talking about helix antennas. WA5VJB has made measurements on many of the popular G3RUH helix fed dishes in the USA. Very few of these have produced the expected results in terms of gain and circularity (and match?). Whilst G3RUH went to great trouble to get his design right for publication, it seems that many builders of these antennas don't follow the instructions. If you are using a helix fed dish and are not receiving the AO-40 S2 beacon very well when others are, it may be your dish feed! Also, the axial-mode helix is not always an axial mode! A long axial mode helix can behave like a normal-mode helix (rubber duck) at some much lower frequency and may inadvertently receive high levels of lower frequency signals, especially since the axial mode helix is probably beaming into the sky and then looks and works for all the world like a vertical rubber duck antenna! A low loss, 2GHz high pass, filter between the helix and the converter may be a good idea in areas where there are lots of commercial VHF transmitters. This is especially true if you use a very wideband preamplifier in front of your 2.4GHz converter.

Converter supplies

It seems like the supply of Drake 2880 converters has, at least temporarily, dried up. I understand an alternative device has been found in the USA. However, in Eire, there is a similar 2.5GHz MMDS service to that in the USA. I have seen at least one design of MMDS converter in Eire that looks like it could also convert to 2.4GHz. I don't know if it has the same design PLL local oscillator to that in the Drake (many of these designs are similar) but maybe one of our Irish friends could investigate this possible source of converters?

Close

Receiving and analysing signals from the 2.4GHz satellites is both fascinating and easy, but it can be full of pitfalls for the unwary. If you don't get the results you expect, do check out what I have said above.

73 de Sam

[1] The satellite experimenters handbook,, Martin Davidoff. Published by ARRL. Chapter 6, page 17. Helix antennas.

A Low Cost Noise Source for VHF through 10 Ghz Based on Qualcomm Surplus Material

K. Banke N6IZW 12/18/00

During Our November 2000 San Diego Microwave Group meeting we held a session on noise figure measurement. During problem solving activities in the following weeks, it became obvious that others in our group could make good use of a calibrated noise source. I began looking for an alternative to loaning out the noise source used with my Sanders noise figure meter. I did a quick scan of articles on home brew noise generators and studied in particular Paul Wade's article "Noise: Measurement and Generation" which is available on his website as well as in the ARRL 2nd Microwave Projects Manual.

In his excellent article, Paul describes what he went through to build various homebrew noise generators, which included dismantling a commercial unit. As soon as I finished the article, an idea hit me that I felt might solve the problems of obtaining high frequency diodes and high quality microwave circuit board material as described in the article. My thought was to use a small section cut from a 14.5 GHz upconverter mixer circuit board used in the early Qualcomm Omnitraks units. This mixer is not useful at 10 GHz and is not readily modified to do so but does contain two very good microwave diodes (good through 24 Ghz) mounted on 15 mil Teflon circuit board

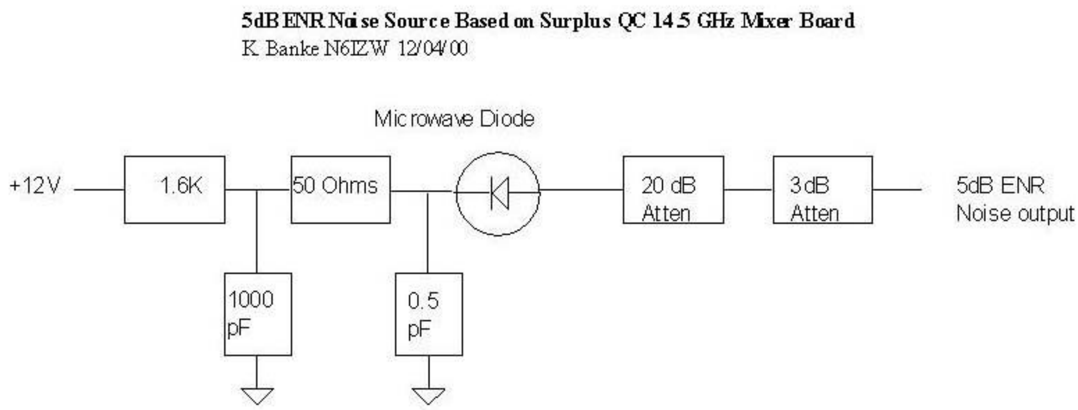


Figure1. Circuit Diagram

The idea was to see how well this mixer diode would perform as a broadband noise source when operated at the breakdown point with reverse bias.

I used Paul's circuit which has the anode of the diode connected directly to the 20dB attenuator. The cathode is RF bypassed to ground and receives bias through a series resistor. Following Paul's article I found that for the first unit 1.2 milliamps produced the maximum output at 10 Ghz so a series resistor was selected (1.6K) to provide 1.2 ma with a 12v power supply.

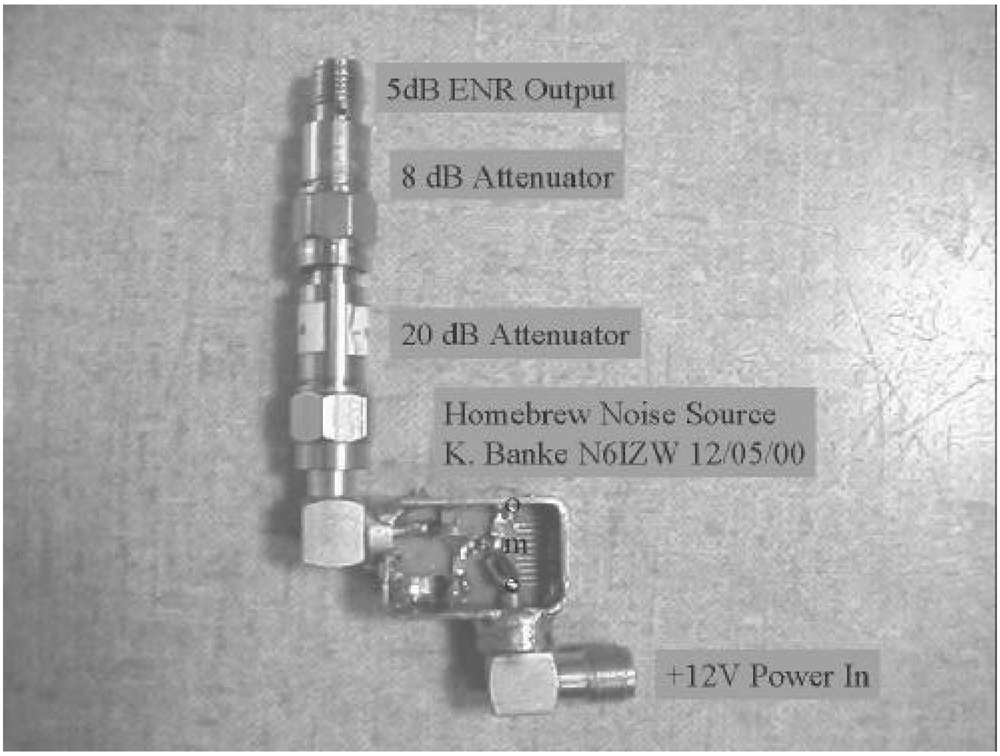


Figure2. Completed Unit

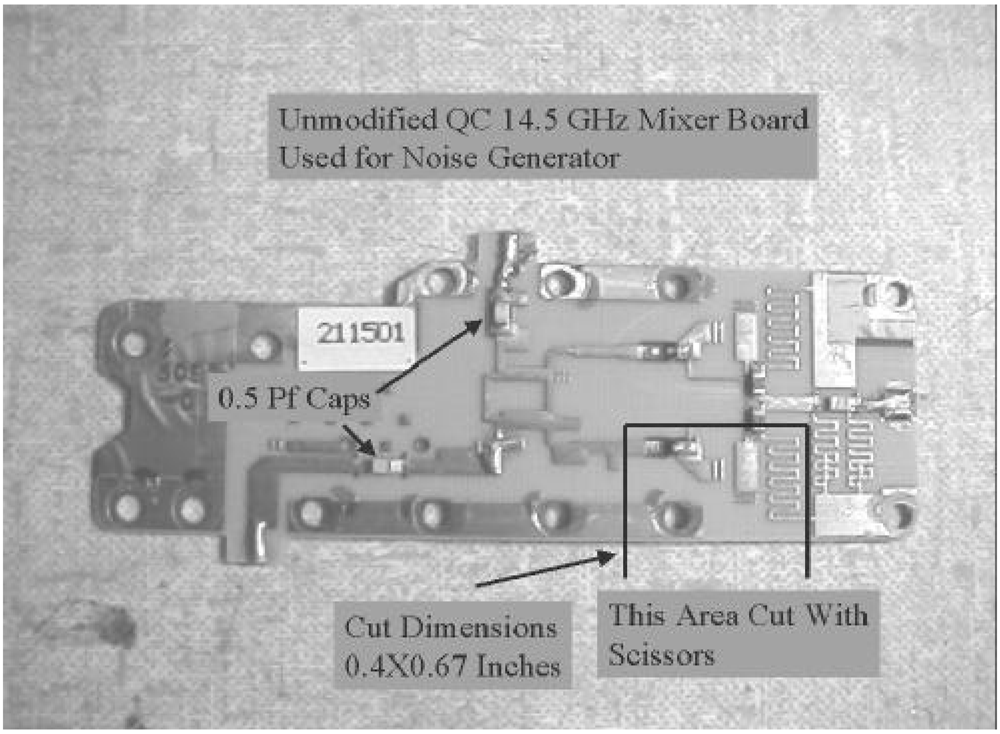


Figure 3. The Original Board.

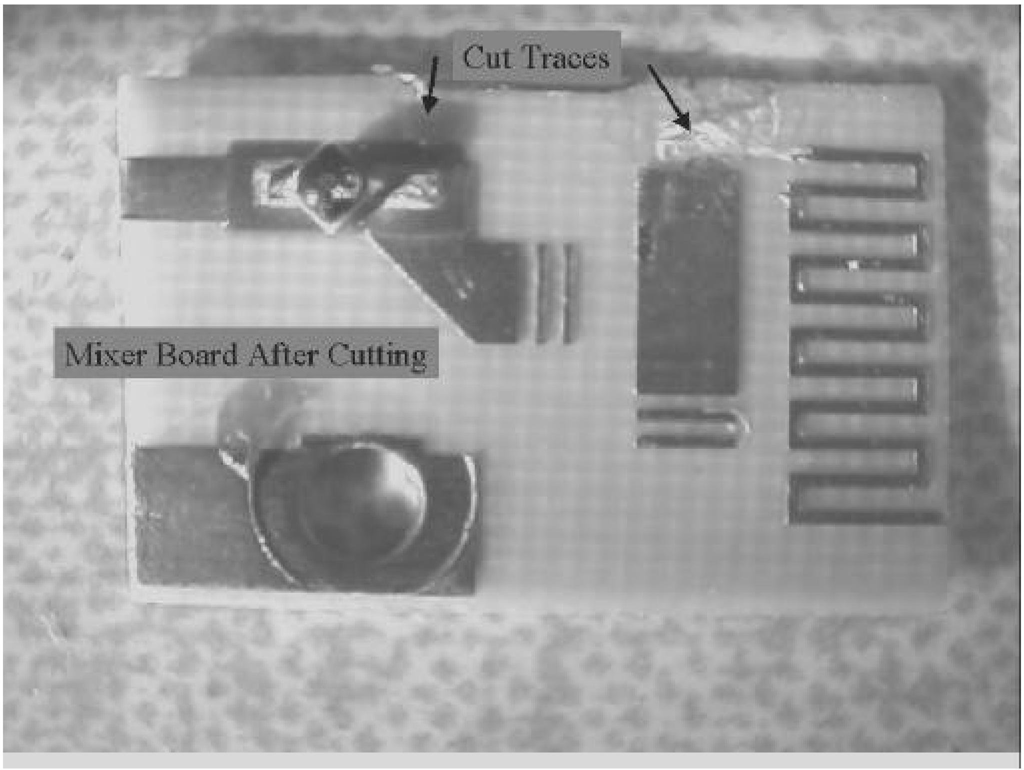


Figure 4. The board after cutting

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Probably the most critical aspect of construction is having as short of paths to ground as possible for the RF bypassing and to the SMA output connector. The 0.5 pF capacitor needs to be a good quality microwave type and is removed from another part of the 14.5 GHz mixer board. I made the housing as small as possible to prevent unwanted resonances and also aid in good grounding. The quality of the output attenuator is also a big factor in flatness of frequency response.

Half of the battle is building a good noise source & the other half is calibrating it. The approach I decided to use for calibration over the 145 MHz -10 GHz Ham bands was to use enough broad band amplification ahead of a spectrum analyser (set for 1 dB/div) to provide a Y-Factor of about 3 dB with a source ENR of 5dB (about a 5 dB NF). My setup consisted of two, three stage MMIC amps built by removing the FETs from QC surplus "GOLD Board" LNAs and replacing them with HP MGA-86576 devices. I found that working with two broadband amps with considerable gain creates intermodulation products from noise when used without a filter between the amplifiers. For 145 MHz-3456 MHz I was able to use one amplifier without a filter and controlled the gain by varying the power supply voltage. The gain was increased only as needed to get a Y-Factor in the order of at least 3dB. For 5.7 and 10 GHz, a filter was inserted between the two amplifiers and the gain again adjusted to the minimum capable of doing the job.

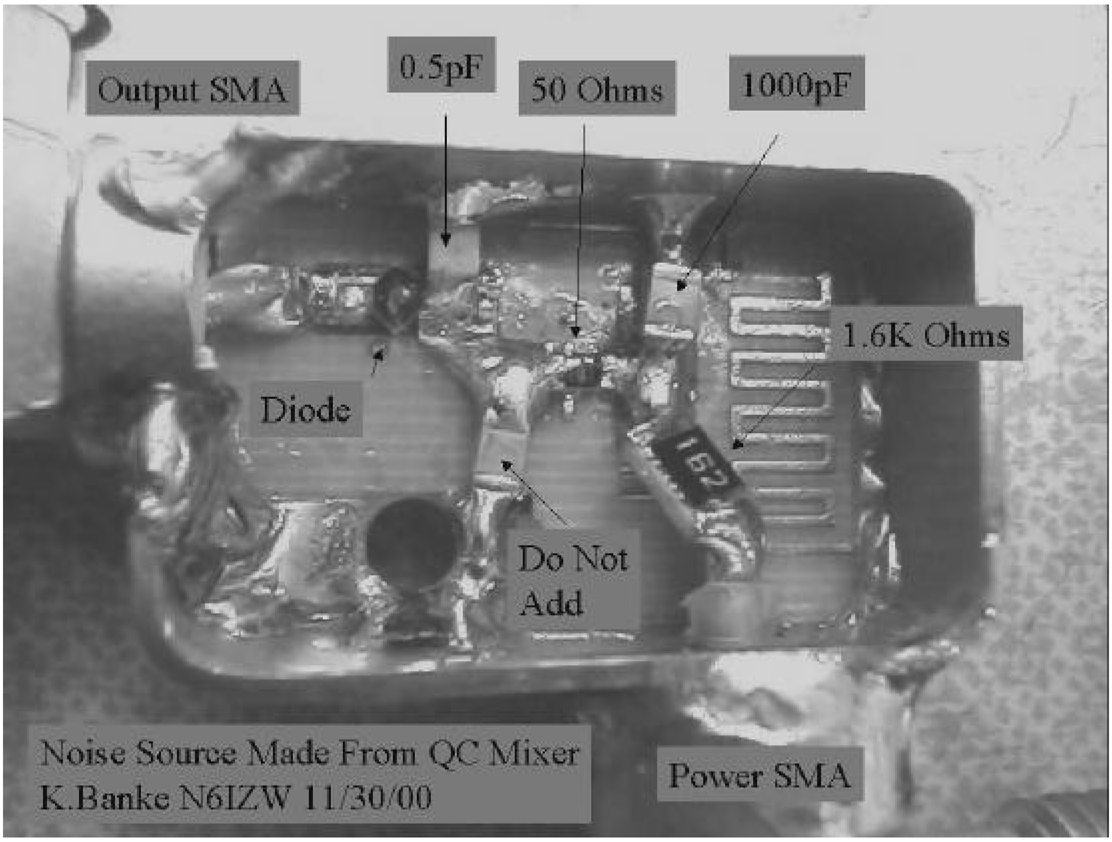


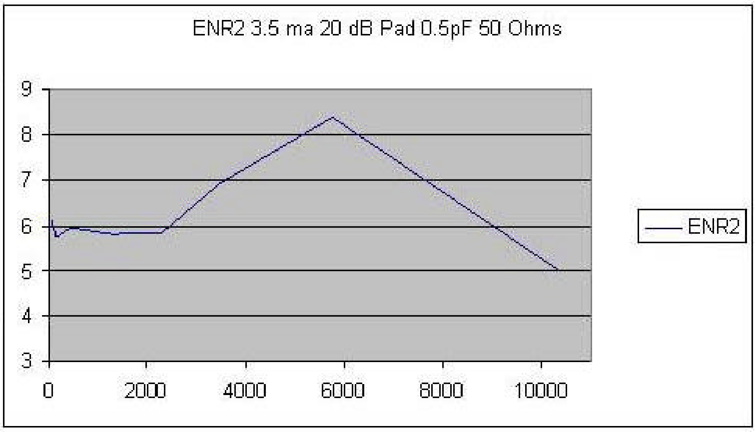
Figure 5. A close-up view of the assembled unit.

A goal of 5dB ENR was set as this should be useful for measurement of most preamps in the 1- 10 dB NF range. . It was found that a total of 23 dB of attenuation matched the output of the uncalibrated unit to the calibrated noise source at an arbitrary frequency of 2304 MHz. Other values could certainly be used to match the requirements of particular noise figure measuring units. My experience with the Sanders unit is that it is quite fussy about levels and such and may give erroneous readings unless careful attention is given to the measurement setup. For this reason I tend to use a spectrum analyser or power meter to measure the Y-Factor and calculate the Noise figure. This is not very convenient though when trying to make adjustments on the fly but allows measurement of most amplifiers and transverters.

I generated an Excel spreadsheet (available from Martyn Kinder G0CZD or http://www.ham-radio.com/sbms/sd/nfcalc2.zip) to aid in calibrating against a known source. The Y-Factor was recorded for both a calibrated source (5 dB ENR) and the uncalibrated unit at each frequency of interest. The Y-Factor values along with the ENR of the calibrated source were entered into the sheet which calculated the ENR of the uncalibrated unit. Other approaches certainly could be used such as using a transverter with the noise sources and measuring the Y-factor at the IF or at the audio output of the IF radio.

The results of the first units showed a variation of +/- 1.5 dB over the 50 MHz to 10 GHz range. I believe that with more work the output can be made even flatter across the range.

Freq	ENR2
50	6.129442
145	5.737358
436	5.95036
1296	5.802763
2304	5.842822
3456	6.89793
5760	8.371454
10368	5



Construction:

There are actually two useable diodes on the mixer board. Only one is mounted as to easily accept a positive bias supply. The other can be used either with a negative supply or can be carefully removed and re-soldered in the opposite direction. The white dot (cathode) needs to be connected to the RF bypass/ bias network for a positive supply.

Remove the Chip capacitors from the mixer board before cutting with a scissors. (See Figure 3.)

The board dimensions of 0.4X0.67 inches are not too critical but should be followed to keep the RF paths very short. After cutting the board, cut/remove the two traces shown in the picture. Cut the centre pin off the output SMA connector so as to not overlap onto the diode. Position & solder the centre pin onto the board trace and then solder the outside of the connector to the bottom of the board. Use ¬' wide hobby brass which is .01-. 025 thick to make a box around the board as shown. Position the brass & then tack in place in a couple of locations until satisfied with the positioning. Solder the brass to the bottom side of the board and also the output connector. Drill a 0.065 dia hole in about the position shown to mount the bias connector. Small coax could probably also be run directly out of the noise generator for bias rather than using a SMA connector.

Install the capacitors and resistors as shown in Figure 5. Temporarily install a 1K resistor in place of the 1.6 K resistor until the required bias current is determined. Connect a current meter in series with the 1-k resistor and a variable supply. Turn on the supply and increase the voltage until the current reaches about 1 milliamp.]

Connect the noise generator output through about 25 dB of attenuation to the setup which will be used to calibrate the ENR and adjust the supply voltage for maximum noise output at the maximum frequency of interest (I used 10368 MHz). Replace the

1k resistor with a resistor as required to operate the noise source at that current form the desired bias supply (I used a regulated 12V).

Calibration

Connect the calibrated noise source (5dB ENR assumed at this point) to the test setup and note the Y-factor. Connect the uncalibrated noise source and change the 25-dB attenuator as required to match the Y-Factor of the calibrated source as close as possible. I performed calibration at the following frequencies which were of particular interest for me and for which I had equipment available: 50 MHz, 145 MHz, 436 MHz, 1296 MHz, 2304 MHz, 3456 MHz, 5760 MHz, 10368 MHz. Paul's article goes into the precautions that must be taken when using broad band amplifiers with noise sources to prevent erroneous readings. At each frequency of calibration, the Y-Factor is noted for both the calibrated and uncalibrated source and entered in to the spreadsheet to calculate the ENR for the uncalibrated unit.

The formulas used in the spreadsheet are given below:
Noise Figure Calculation
NF = ENR-10Log(Y-1)
NF = Noise Figure in dB
ENR = Excess noise source in dB
Y = ratio of levels with noise source on/off (not dB)
Equation used for Excel program to calculate NF:
NF = ENR-(10*Log(10^(YdB/10)-1))
YdB is the ratio of levels with noise source on/off in dB

Equation used for calibrating an unknown ENR source against a calibrated unit.
ENRucs=(ENRcs-10*(LOG(10^(YdBcs/10)- 1))+
(10*(LOG(10^(YdBucs/10)-1)))
ENRucs is the calculated ENR in dB of the uncalibrated source.
ENRcs is the ENR in dB of the calibrated source.
YdBcs is the Y-Factor (dB) produced by the calibrated source.
YdBucs is the Y-Factor (dB) produced by the uncalibrated source.