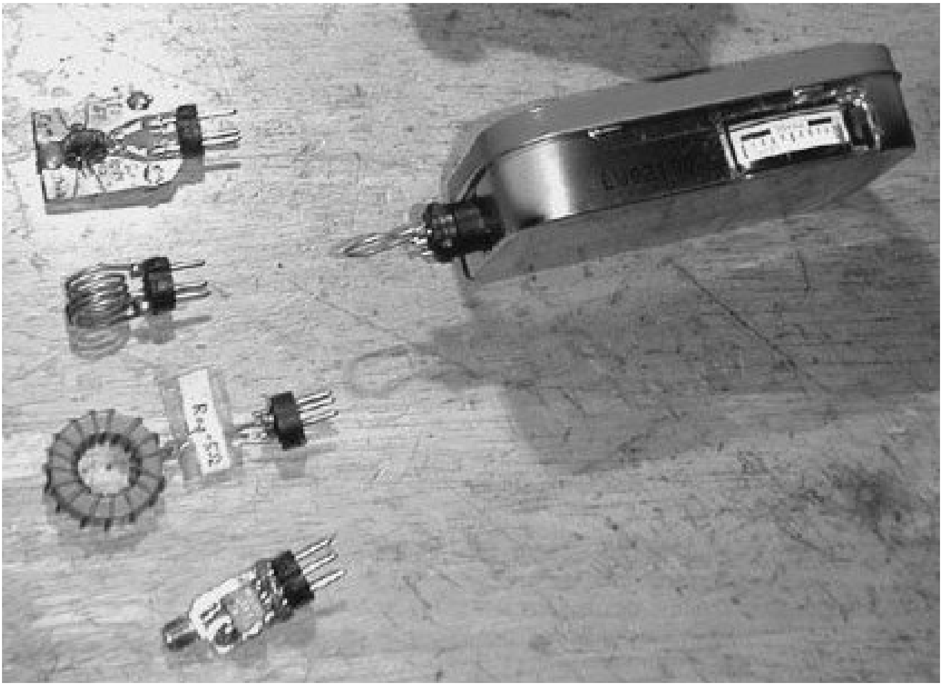
A Publication for the Radio Amateur Worldwide

Especially Covering VHF, UHF and Microwaves

VHF COMMUNICATIONS

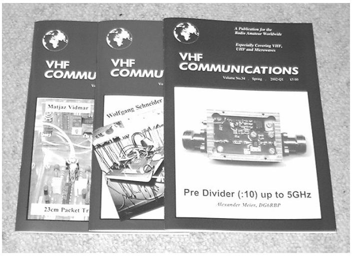
Volume No.36 . Spring . 2004-Q1 . £5.15



The Noble Art of Signal Detection

Carl G. Lodström, KQ6AX & SM6MOM

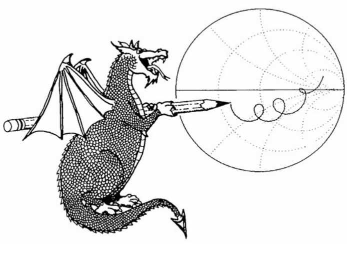
Back Issues



All issues ever published are now available as either photocopies or actual magazines. Issues from 1/1969 to 4/2002 are £1.00 each + postage. Issues from 1/2003 to 4/2003 are £4.70 each or £18.50 for all 4 issues + postage. See web site or page 63 for back issue list to see which issues are only available as photocopies. There are two back issue sets that contain the available "real" magazines at a reduced price, see web site for details.

Blue Binders

These binders hold 12 issues (3 years) and keep your library of VHF Communications neat and tidy. You will be able to find the issue that you want easily. Binders are £6.50 each + postage. (UK £0.90, Surface mail £1.60, Air mail to Europe £2.00, Air mail outside Europe £3.60)



PUFF Version 2.1 Microwave CAD Software

This software is used by many authors of articles in VHF Communications. It is supplied on 3.5 inch floppy disc with a full English handbook. PUFF is £20.00 + postage. (UK £1.00, Surface mail £1.30, Air mail to Europe £1.50, Air mail outside Europe £2.50)

VHF Communications Web Site
www.vhfcomm.co.uk

Visit the web site for more information on previous articles. There is a full index from 1969 to the present issue, it can be searched on line or downloaded to your own PC to search at your leisure. If you want to purchase back issues, kits or PUFF there is a secure order form or full details of how to contact us. The web site also contains a very useful list of site links, and downloads of some previous articles and supporting information.

Contents

This is my fifth year of editing the magazine and from the feedback on the subscription renewal forms it is still meeting most peoples requirements. I am still trying to find new authors to broaden the content, but they are difficult to find.

I have lost the only paying advertiser this year so there is an advertisement for new advertisers on page 30. I do not want to fill the magazine with adverts but it helps with the publication costs if there are some paid advertisements!

About the time that the summer issue is posted to you I will be at the Friedrichshafen exhibition so I hope to meet some of you there and to find some new subscribers.

73s - Andy

K M Publications, 63 Ringwood Road Luton, Beds, LU2 7BG, UK

Telephone / Fax +44 (0)1582 581051, email : andy@vhfcomm.co.uk

web : http://www.vhfcomm.co.uk

Paolo Pitacco, IW3QBN

An Array of 4 x 16 turn helix antennas for 2402MHz

1. Introduction

An antenna array project is an interesting challenge for design, manufacture and testing. You must first consider which items will be "mandatory" for the final result, with respect to material availability, mechanical tools and so on. My guidelines: no space for a parabolic reflector and easy mount/dismount characteristic in case of heavy wind (I live in a windy zone).

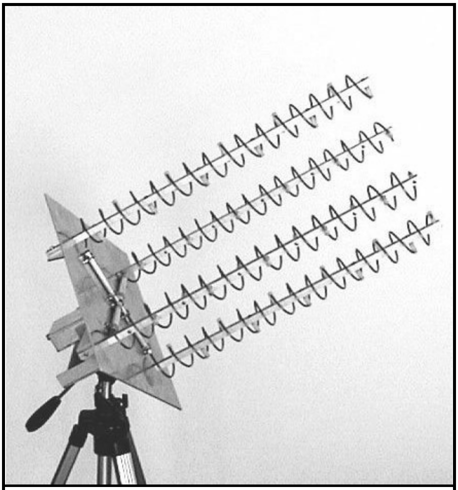


Fig 1: The complete 4 x 16 antenna.

The idea was to design a system capable of operating as a satellite and terrestrial antenna with discrete gain, good capture area and quick installation. As starting point I used a simple 16 turns helix antenna successfully made in 1998 [3] and used to hear DOVE signals (2401MHz) and to work with home made ATV systems. The endpoint is an array of four of these helices. (Fig 1)

2. Antenna design

Radio amateurs today have lots of "ready to use" programs available for helical antenna design, from simple DOS to complex and "mysterious" Windows or Linux applications. For reference it is possible to choose from any of the following techniques:

- Reproduce the design by G3RUH [1]
- Make a new design using KA1GT [2] program
- Use Peter Ward's Excel worksheet, "RF2"
- Follow design formulas from antenna engineering literature [4 & 5]

This excludes all commercial and costly programs. I followed a mix of these ways; to check the results from outputs of more programs and validate/refine using formulae [4]. I always used the same inputs (central frequency, number of turns and mechanical dimension).

The design was centred to 2402MHz, to obtain sufficient bandwidth to cover AO40 and ATV frequencies. Using this centre frequency, I choose a support diameter of 38mm, 31mm spacing between turns and a copper wire of 3mm diameter because it is “self supporting” without use any type of plastic tube. This last choice was used in order to avoid any “detuning” of the helix due to dielectric action (up to 15%) of other support rather than air.

3.

Coupling/Matching design

Matching a single helix isn’t difficult, with some simple features it is possible to achieve a broadband match without use of a network analyser or other measuring instruments, but the same isn’t that easy for helix arrays. Multiple antennas require a coupling system and finally matching to the transmission line. The first issue is correlated to the second; you must evaluate the Aperture Area of each antenna, and find a method to couple the sum to a single cable. Four ways are possible:

1) Each antenna matched to 50ohm with a 4:1 coupler to the feeder
2) Unmatched (Z~140ohm) with a coaxial quarter wavelength transformer and a 4:1 coupler to the feeder
3) Unmatched (Z~140ohm) with a wireline quarter wavelength transformer to the feeder
4) Unmatched (Z~140ohm) with a coaxial quarter wavelength transformer to the feeder

Solution 1) is easy and used by G6LVB; you need a lot of good connectors and cable plus great precision to make four equal helix antennas and cables.

Solution 2) is difficult and no longer used; you need mechanical tools to make a good transformer and a lot of good connectors and cable.

Solution 3) in a single pass you can match the helix antennas and feeder, considering a quarter wavelength transformer with output impedance equal to 4 x 50ohm; easy, but a wireline is a potential antenna.

Solution 4) as for last case, but using coaxial line you avoid any problem of radiation and a more stable impedance of matching line. It is a mechanically complex solution, but requires only one connector. This is my choice, which drives subsequent mechanical and electrical issues. As mentioned, I needed to place helices at a right distance, at the same time I needed to use a quarter wavelength transformer. For 2402MHz, lambda (λ) is 12.48cm and λ/4 is 3.12cm, but calculations indicate an Aperture Area of 1.4 or 17.5cm, so I had to find a mechanical solution: using an odd multiple for quarter wavelength, exactly 3/4λ (93mm) to maintain transformation properties and distance between helix.

4.

Matching transformers

Impedance matching with coaxial transformer is straightforward when mechanical machining isn’t a problem, using equation:

$$Z_m = \sqrt{Z_a \cdot (Z_1 \cdot N_a)} \qquad (1)$$

you can find the exact impedance value needed; Z_a stands for antenna impedance, N_a for the number of antennas, Z_1 the impedance of main feeder and Z_m the requested impedance for match. Subsequently, using equation:

$$Z_{coax} = \frac{138}{\sqrt{\varepsilon_r}} \cdot \log\left(\frac{D_g}{D_p}\right) \qquad (2)$$

it is possible to determine tube and conductor diameter to build this item. Because the computed helix impedance is 153ohm, a characteristic impedance of 173ohm is needed for this line.

5. Mechanical construction

For the quarter wavelength transformer I used a commercially available aluminium tube of 12mm external diameter (10mm inside) and a 0.6mm diameter silvered copper wire. This represent a good compromise (about 170ohm) and final solution (in equation (2) D_g stands for inner diameter of tube, D_p is diameter of wire, ε_r is 1.001 for air). Mechanically, the wire is held in position with a couple of thin (3mm) centre drilled nylon plugs, this means the transformer's dielectric will be near "air" (see Fig 2). All four transformers are locked in position (on the upper side of the reflector) by means of two "U" shaped brackets also used as a ground connection. One side is soldered on to "N" connector (see Fig 3). The reflector plate is a made of a 3mm thick square of aluminium sheet with 30cm sides. Each helix is made with 3mm diameter copper wire, wounded on a 35mm diameter support, then gently relaxed and loaded using 11 spacers (every 1 1/2 turns)(Fig 4). The spacers are small cylinders of nylon, 20mm long and 8mm diameter, each pre-drilled with a 3.2mm hole at 15.6mm of height (Fig 5). The first spacer is located at end of helix and last, one turn before the feed point. The spacers are subsequently locked on a square aluminium tube (10mm side, 1mm depth) pre-drilled with 3mm holes at distances of 47mm (one each 1 1/2 turns)(fig.6). This tube, 57cm long, has no effect on performance, and is used to hold the helix in position by

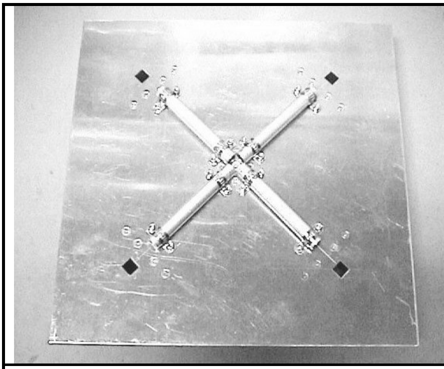


Fig 3 Mounting of the four quarter wavelength transformers.

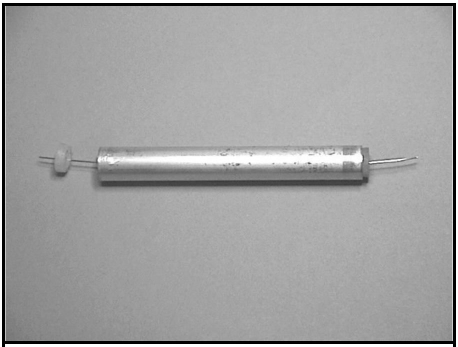


Fig 2: Quarter wavelength transformer.

Fig 4: Fitting spacers onto wound helix.

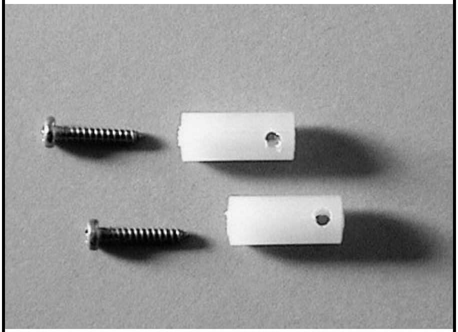


Fig 5: Spacers for helix.

means of an “L” shaped aluminium brackets (measuring 25x50mm). Another “U” shaped bracket is used to hold converters, preamplifiers or other devices, and as a mounting point (a tripod for example). All helices are wounded in the same direction (counter clockwise as seen from rear) in order to maintain the phase of feed point, Fig 7 shows electrical and mechanical connection between the helix and the coaxial transformer. I suggest rounding the edge of each helix and take attention to solder inner transformers conductor with 3mm copper wire, pre-solder this before! Fig.8 is a complete mechanical drawing of this array.

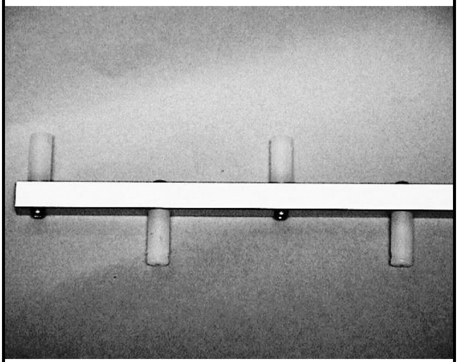


Fig 6: Aluminium support tube.

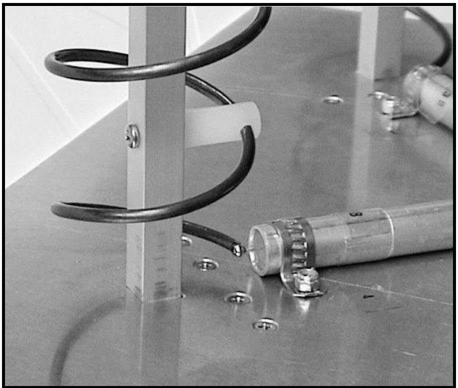


Fig 7: Close up view of connection to quarter wavelength transformer.

6.

Measurement and conclusion

The first measurement was made with the aid of a Network Analyser, Agilent E8714ES, and the results were near expected (I have lower confidence with mechanical works!) as shown in Fig 9. A low SWR is obtained on 2430MHz (near the centre of “S” band), but the antenna works properly on entire band with good results. Narrow band is due to the transformers that operate as filters. I have tried with other lengths of transformer (92 and 94 mm respectively), but 93mm represent the best compromise for amateur use. The calculated gain is 18dB (including losses), and tests on AO40 signals demonstrate this figure. Comparisons were made with a 80cm dish and a 3 turns helix gave 6-8 dB higher with this antenna and same Rx + converter. Subsequent duplications of this system by other friends demonstrated same results.

I hope with this article to help other interested OM’s in designing and building antenna arrays, and to suggest little new solutions.

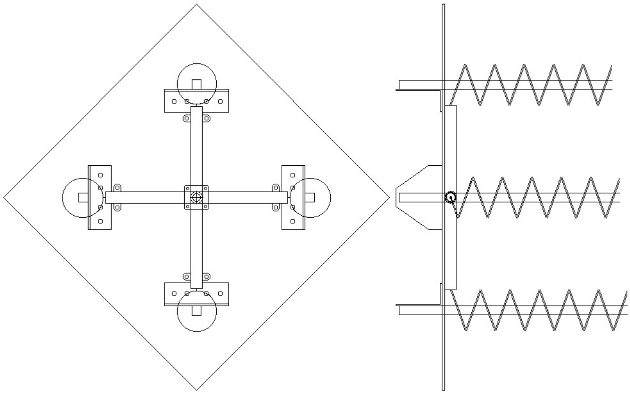


Fig 8: Complete mechanical drawing of the 4 x 16 helical array.

7. References

[1] Unelica di 16 spire per la banda S - G3RUH (transl. I0QIT) AMSAT-I News Vol5, N1 pag.19

[2] HELIX.BAS Basic program for Helix design - KA1GT - UHF/MICROWAVE EXPERIMENTERS MANUAL (ARRL) pag.9-49

[3] Antenne a elica, esperienze utili per tutti - IW3QBN - AMSAT-I News Vol8, N.3 pag.13

[4] Antennas - J.D. Kraus, R.J. Marhefka - McGraw Hill - 3th ed.

[5] Antenna Engineering - Jasik -

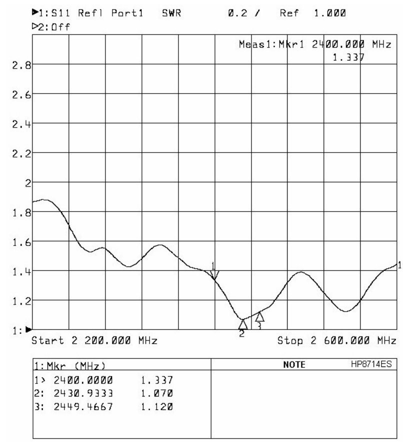


Fig 9: Results from network analyser.

Wolfgang Schneider, DJ8ES

Universal sound card interface for digital modes

Nowadays its scarcely possible to imagine a radio amateurs shack without a PC. Moreover it can be used for digital modes such as FAX, RTTY, WSJT, packet radio or CW. So for some time now modern applications have also favoured the sound card as the interface between the PC and the radio apparatus. The universal sound card interface for digital modes presented here is an isolated low frequency interface using opto-couplers and transformers for level matching requiring only a 12V supply.

1. Introduction

Modern PC sound cards, including their operating software, are efficient in that they have no difficulty in mastering the digital modes which are common in amateur radio, such as FAX, RTTY, WSJT, etc, for both transmission and reception. Good user software exists, with elegant user interfaces, for the interested radio amateur.

The universal sound card interface is isolated for transmission and reception, using low frequency transformers and opto-couplers. The control signals (for PTT and CW) can be optionally implemented through the serial interface COM1 or COM2.

It can happen that these COM interfaces are no longer available as a standard feature on modern laptops. These functions can be derived from the low frequency signals of the sound card using a system similar to VOX. The universal sound card interface also provides for this option.

2. Circuit description

The circuit for the sound card interface can be seen in Fig. 2. The sound card interface is controlled through the “Line-In” and “Line-Out” connections of the PCs sound card. In addition, the PTT changeover and the “Key” connection for CW signals use a serial interface on the PC, for example COM1. Alternatively, the sound card interface provides a VOX mode option. The control signal for CW can be obtained from the low frequency output signal.

Both low frequency signal paths are isolated using low frequency transformers; this avoids the possibility of leakage pickups.

The reception path, i.e. the loudspeaker output from the transceiver to the “Line-In” connection of the sound card, is also

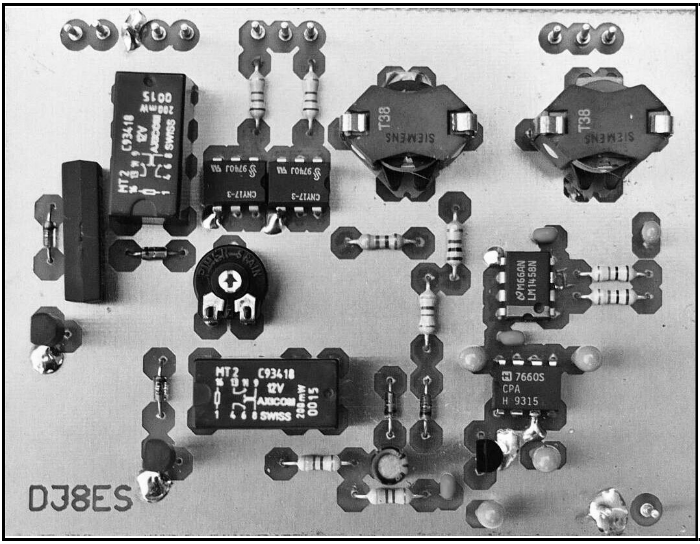


Fig 1: Completed universal sound card interface.

equipped with an LM1458N (IC3a) operational amplifier. With the given circuit resistance values, the amplification obtained with V=R4/R5 is V=1. If necessary, this value can easily be matched to the given circumstances. At the same time, this amplifier (IC3a) gives a high value input impedance, which can be used to connect the input in parallel with the loudspeaker in the transceiver. In practical operation, “overhearing“ a continuous but faint received signal has been found to be generally practical.

A normal 13.8V supply voltage is used. The plus/minus voltage (±5V) required internally for the operational amplifier is obtained using a 78L05 fixed voltage regulator (IC4) and an ICL7660 voltage inverter (IC5). This requires only minimal external circuitry using tantalum electrolytic capacitors.

In the transmit path, a relatively low level voltage is required for the microphone input of the transceiver. This is adjusted to the required value after the transformer (TR2) using the adjustable R2/R3 voltage divider.

The signal from the low frequency transformer (TR2) is taken off in parallel and fed to an LM1458N operational amplifier (IC3b). As a minimum, its amplification must be sufficient for the two subsequent rectifiers (D4, D5) and the T1 and T2 switching stages (BC549C). The amplification is fixed by means of the resistances, R6 and R7; the value selected here was: V = R7/R6 = 47.

The two capacitors, C2 and C3, should be calculated in such a way that they give an adequate time constant for the VOX control for CW. Their values are calculated as 22µF and 220nF.

The switching stages are relay RE1 for the PTT and the Reed relay RE3 for CW. In addition to the PTT of the connected transceiver, the signal activates an additional internal relay, RE2. This switches both the low frequency and the CW signal to the transceiver. This automatically triggers a sequencer function. As is usual with this type of control, the transmitter is switched on first, and only then the modulation!

The option for the VOX mode just described and this type of CW is optional. Normally these functions are controlled through the serial interface of the PC. Here the signal RTS (Ready to Send) for PTT and the signal DTR (Data Terminal Ready) for the CW key. In this

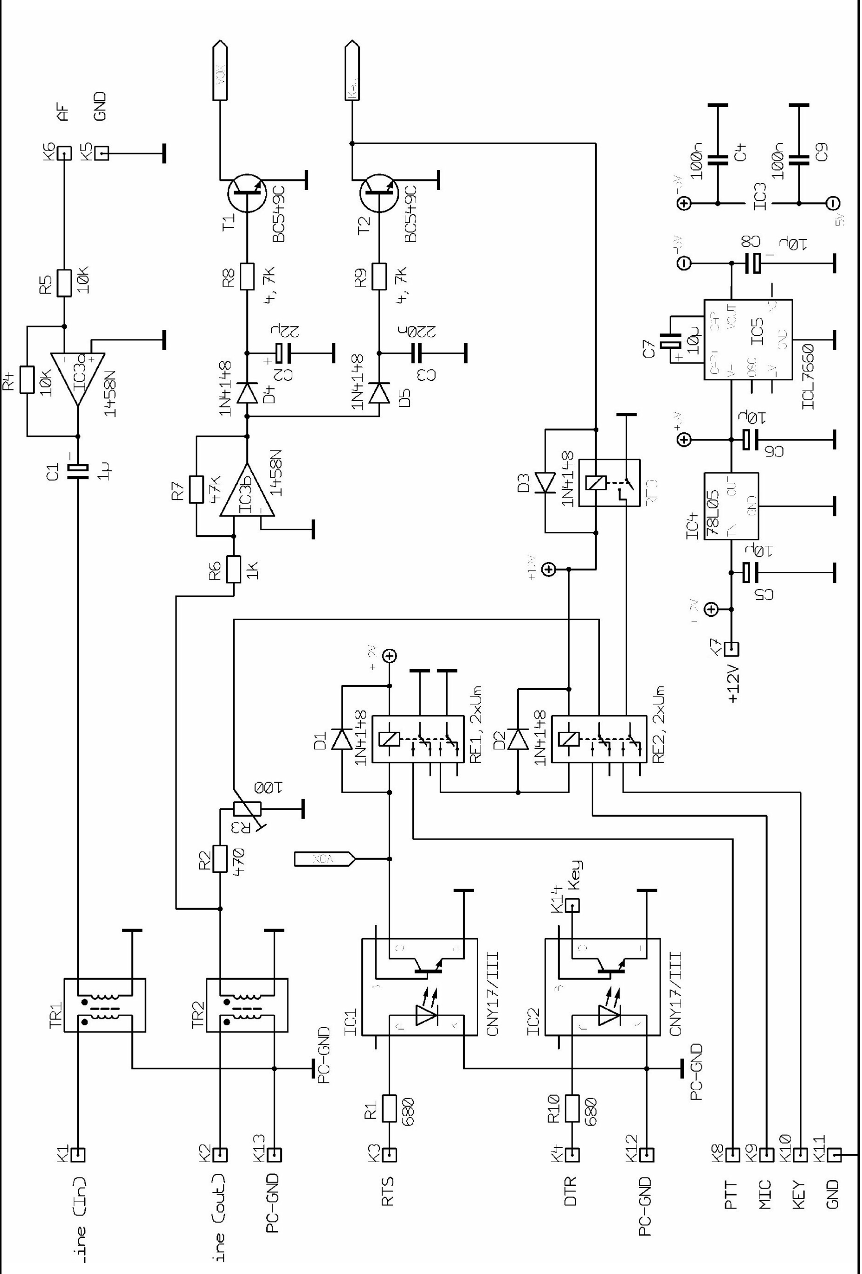


Fig 2: Circuit diagram of the universal sound card interface.

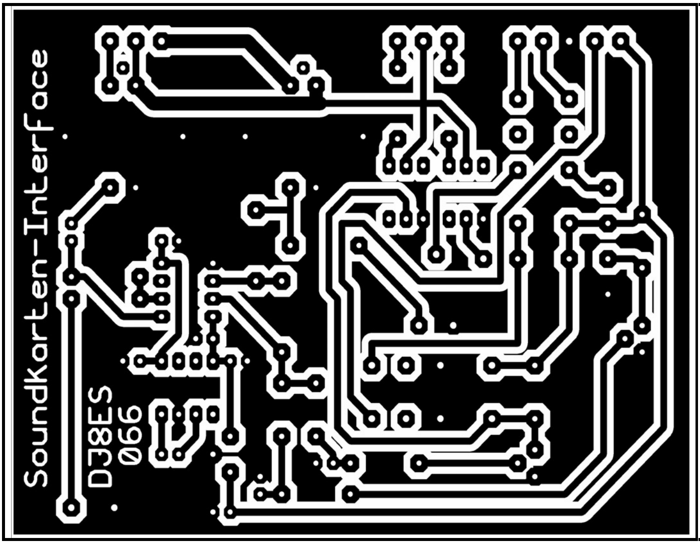


Fig 3: Track side of PCB for universal sound card interface. Board dimensions are 75mm x 100mm.

case, the two switching stages (T1, T2) are superfluous and should not be fitted. The K14 connection (Key) is connected to the collector contact of T2 by means of a jumper.

For isolation (and to protect the serial interface of the PC!) both the signals are fed through CNY17/III opto-couplers (IC1 and IC2). This gives complete potential isolation between the PC and the radio equipment.

3. Assembly instructions

The sound card interface circuit for digital modes is mounted on a 75mm x 100mm double sided copper coated epoxy printed circuit board (Figs. 3 and 4).

The specimen unit was mounted in a standard aluminium housing. All connections are fed to the rear face of the assembly.

Following the drilling of the circuit board with a 0.8mm or 1mm drill e.g. for terminal pins the components are fitted in no particular order, in accordance with the components drawing (Fig. 5).

At this point, see the corresponding passage in the circuit description above with regard to the optional VOX function (including CW).

4. Parts list

IC1,IC2	CNY17/III, Opto-coupler
IC3	LM1458N, Operational amplifier
IC4	78L05, Voltage regulator
IC5	ICL7660, Voltage inverter
T1,T2	BC549C
D1-D5	1N4148
TR1,TR2	Low frequency transformer, Siemens
RE1,RE2	Relay 2xUm
RE3	Reed relay, 1 x On
R3	Trimming potentiometer 100Ω , horizontal, RM5/10mm
C1	1nF/16V, RM 2.5, tantalum
C2	22nF/16V, RM 2.5 tantalum
C3	220nF, RM 2.5, ceramic

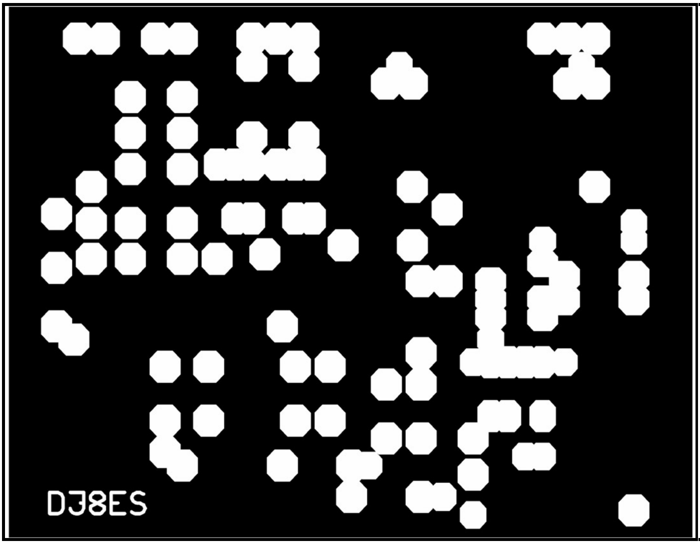


Fig 4: Copper side of PCB for universal sound card interface.

C4,C9	100nF, RM 2.5, ceramic
C5-C8	10nF/16V, RM 2.5, tantalum

1 x	PCB DJ8ES-066
14 x	Terminal pin 1 mm

Carbon resistors, 1/4 W, RM 10mm:

R1,R10	680Ω
R2	470Ω
R3	100Ω
R4,R5	10kΩ
R6	1kΩ
R7	47kΩ
R8,R9	4.7kΩ

5. Putting into operation and calibration

The sound card interface is put into operation for the first time, following a visual check of the circuit board. For the standard operating voltage in amateur radio of +13.8V, the current consumption of the assembly is approximately 6mA, and up to 40mA if the relay is wired up.

The interface is connected to the sound card connections “Line-In” and “Line-Out” on the PC. The PTT changeover and CW are detected on the PC side in the normal way by a serial interface (e.g. COM1). An alternative option here is to generate the control signals from the sound card low frequency (cf. circuit description).

On modern transceivers, with the exception of the CW key connection, all other necessary signals or voltages (Mic In, low frequency out, PTT and +13.8 V) are fed through the microphone socket on the front face of the apparatus. The manual for the individual transceiver can provide assistance here with regard to the pin layout and the level adjustment required.

The low frequency level for both the microphone (on Line-Out) and the low frequency output of the transceiver (on Line-In) are set by the software required for the individual mode. Should this variation range, not suffice, then the series resistances can be changed in the universal sound card interface circuit for example, resistances R4/R5 for the low frequency output. The given values cover numerous contemporary transceivers. The microphone level is pre-set using the R3 trimming potentiometer.

At this point, perhaps we may also be

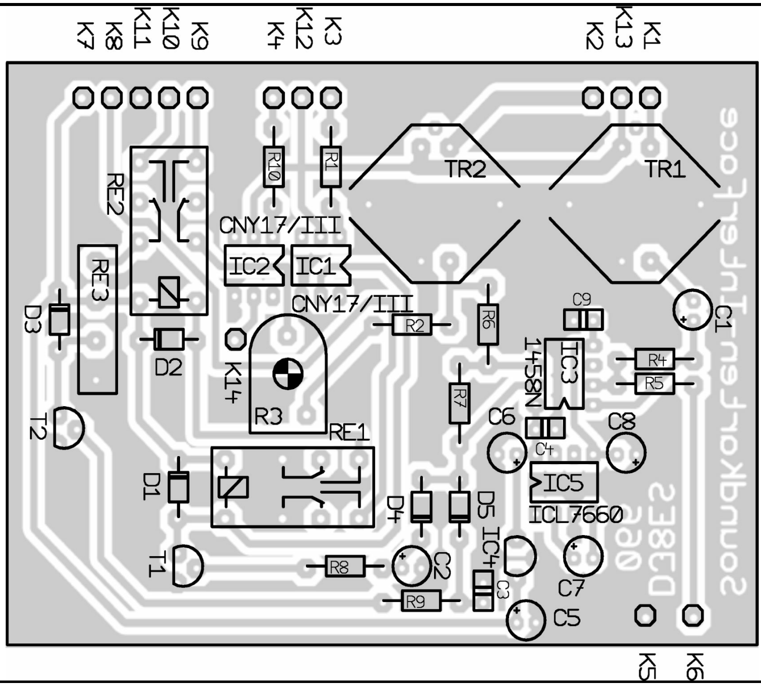


Fig 5: Component layout for universal sound card interface.

allowed to refer to the correct adjustment of the microphone. Saturation considerably impairs the modulation quality and also produces bandwidth that is not needed. Unfortunately, it is in narrow band applications such as, for example, PSK31 that this effect is more and more evident.

6. Literature references

[1] Kurt Kuhn, DL 4 VAB: SSTV/ PSK31 Interface for DF0SAR cq VFDB 3/2001, P. 19

[2] Dr. Reinhard Krause-Rehberg, DF5RK: MFSK16 A new digital mode for sound cards, *Funkamateur* 06/01, P. 610

[3] Ing. Klaus Raban, DG2XK: Sound cards and their use in the radio amateurs PC (2); *Funkamateur* 06/00, P. 614

[3] Ing. Klaus Raban, DG2XK: Sound cards and their use in the radio amateurs PC (3); *Funkamateur* 07/00, P. 734

Sigurd Werner, DL9MFV

Combining power at 76GHz: Three possible solutions discussed

Combining power at frequencies around 76GHz is not as trivial a matter as it might seem. Three simple methods were selected and their efficiency was investigated.

A planar coupling method on a crystal substrate (Wilkinson S structure) and two different waveguide combiners were tested. The three modules constructed for this test, which were all constructed as frequency doublers, displayed very different combination loss values, namely 2dB, 1.4dB and 0.6dB. In particular, the technique implemented in module 3, which was scarcely given any attention, adds together the power from two sources positioned at a distance of 1λg in the waveguide, has proved to be extremely efficient. The test pieces were constructed using two parallel operated type CHU3277 MMICs (from UMS), to generate a 90mW signal. Combining two of these provides a simple route (from the mechanical and electrical points of view) to provide output levels exceeding 100mW at 76GHz.

1. Introduction

MMIC components have been commercially available for a short time which amplify the power levels of frequencies exceeding 50GHz. There has already been one article[1] concerning a particularly interesting model from the manufacturer United Monolythic Semiconductor (UMS). Here output levels of up to 50mW were reached at 76GHz.

To enhance the signal further, several of these chips had to be interconnected, the power had to be combined, and then fed to the load with as low a loss as possible. What is a trivial task at "low frequencies" requires an original solution to the problem at 76GHz.

The following article investigates various options for power combination at 76GHz, using three example solutions. The aim is to obtain a low loss (i.e. efficient) and at the same time mechanically and electrically uncomplicated method of increasing the power.

2. Methods of power combination at higher frequencies

In principle, we can distinguish between two approaches to solutions:

- Joining together two (or more) power sources that are fed in planar striplines (e.g. on low loss ceramic

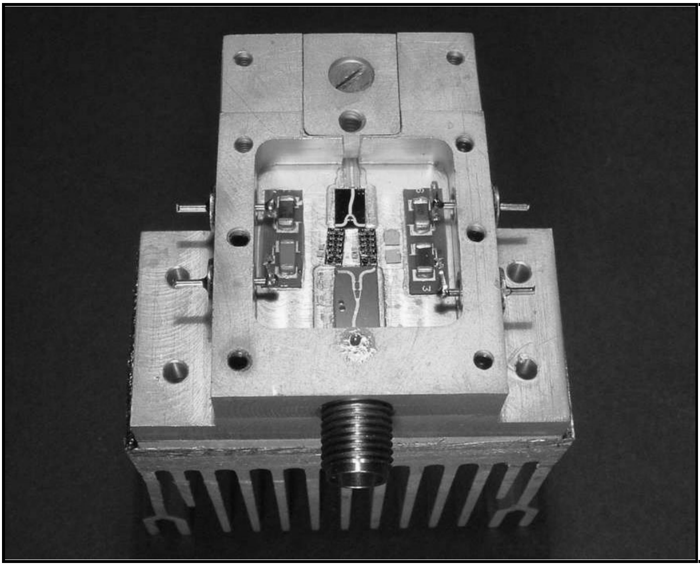


Fig 1: Photograph of module 1 showing the two MMICs acting as frequency doublers from 38GHz to 76GHz. Their output is combined with a Wilkinson combiner constructed on a crystal substrate and coupled by a stripline into the WR12 waveguide.

substrate).

- Power addition in waveguides.

Re. 1: Two microstrips can be merged into one feeder, provided attention is paid to the individual λ/4 transformations. This method, very popular in connection with the adding together antenna feds (“Plug-in circuits”) has been very successfully used by M. Kuhne (DB6NT)[2] to increase the output level of 24GHz amplifiers.
One only slightly more expensive and yet extremely efficient solution to the problem was found by Wilkinson[3] in 1960. This method has been undergoing continuous improvement right up to recent years (e.g. [4] and [5]). The 100Ω resistance required here can be successfully “etched out” from the substrate coating. The real problem is the pre set geometry of the λ/4 sections. When Al oxide or Al nitride is used as the substrate (εr ≈ 10), the distances required at a frequency of 76GHz become too small and can therefore scarcely be realised.

Things are different for a crystal substrate (e.g. with a thickness of 0.13mm). The ε value of approximately 3 of this carrier material makes it possible to manufacture a λ/4 Wilkinson combiner. Since the computer simulation of the construction predicted favourable coupling characteristics, this method of power addition was implemented in module 1.

Other types of coupling, e.g. using hybrid structures (branch line and rat race ring couplers) cannot be used since their dimensions at 76GHz are too small. Likewise mechanically complicated structures, e.g. inter-digital couplers based on length, or specific strip-slit couplers (table in [6]) are not being considered for the time being.

Re. 2: The simple solution here is a T shaped fork in the waveguide in the horizontal plane (3 port format as parallel branching). The waves propagated in the side arms are each reflected in one direction through a choke piston. The 4 port format is also known as the “magic tee” (for tables, see [7] and [8]). The 3 port version was tested in module 2 at 76GHz, using a WR12 waveguide.

A still simpler option for power addition (admittedly operating only on narrow band) might look like this: Use only one individual waveguide and couple the

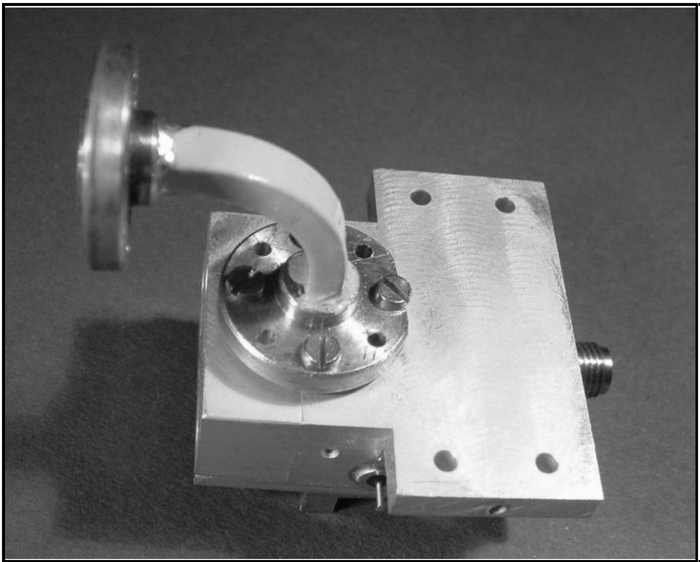


Fig 2: Rear view of module 1 showing waveguide output.

lines in separately twice (capacitively or inductively). The distance between the two output lines amounts to 1λg (WR12), so that the two waves stimulated can be added together phasewise. To prevent the waves from being propogated in one direction, another choke piston is used, which reflects one wave at a distance of λ/4 and the other at a distance of λ5/4. The amount that the feed ports are de-coupled is unknown. Interestingly, this simple construction has scarcely been utilised up to now. A quick search of patent applications has yielded no description of it to date. Nonetheless, I have checked this possible approach in module 3.

3. General mechanical and electrical characteristics of module

All modules (about the size of a matchbox) were milled from brass and then gold plated in my laboratory (Degussa process). Since, as already often reported (e.g. [1]), the generation of power levels at 38GHz does not lead to any kind of problems, all structures were laid out as frequency doublers. The input power at 38GHz (5-8dBm) is fed in through a K socket (2.8mm) and then distributed to two MMICs using a Wilkinson divider (on an Al nitride substrate). The MMICs used (CHU3277 from UMS) act as frequency doublers and also as multi-stage amplifiers. The power produced using the individual method investigated is fed to a power output meter through a waveguide. The waveguides in the modules are always made up of two metal blocks, with appropriate milling in one section and a dummy load as the second section.

The necessary DC voltages are fed into the housing through feedthrough capacitors (1 - 3nF), so that in each case the underside of the module (bearing surfaces of chip) remains free for the mounting of a heat sink. The DC is directly blocked on the MMICs using single layer capacitors (100pF) and again later using ceramic capacitors (100nF). The chips were connected to the substrates using 18µm gold wire and bonding technology (Hybond, Model 572).

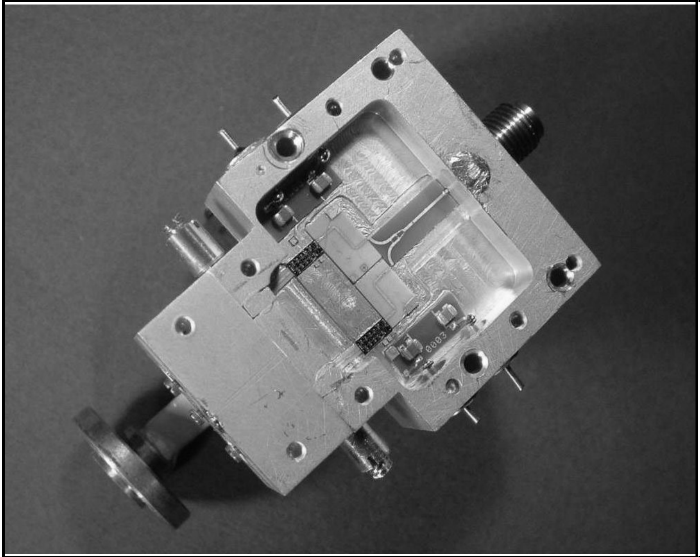


Fig 3: Photograph of module 2 showing the 76GHz outputs of the two MMICs combined using a T section of WR12 waveguide.

In the previous article [1], it was reported that the MMIC CHU3277 can also be used to increase the power at a somewhat higher operating voltages. The "limits" have recently been investigated. The maximum values specified in the data sheet [9] of 5V in each case (positive and negative) can be permanently increased (without damage) to 6V. At 6.5V though, there is a critical area (in particularly if there is an abrupt voltage change). The output of the chip can suffer a significant collapse. The weak point, amazingly, does not lie in the semiconductors but in the internal DC four wire network mounted on the MMIC. The miniaturised resistors mounted on the GaAs are damaged ("burnt out"). The chips can certainly still be operated (once the impedances have been re-matched!), but at a markedly reduced power.

So two output values are given in each case below, one for a voltage of 5V and then one for 6V. The current consumption for the positive supply should not significantly exceed a value of 340mA per MMIC. The negative supply currents amount to between 7 and 9mA.

The impedance matching of the RF feed was implemented using small gold lugs, as described (e.g. in [1]), which were fixed with a UV activable adhesive.

4. Results using individual modules

4.1 Module 1

Figs 1 and 2 show details of construction. The combined output from the two MMICs using the Wilkinson combiner (crystal substrate, 0.13mm) is coupled into the vertical WR12 waveguide through a stripline.

A 4/40" screw (2.8 mm) inserted from above (into a small lid) acts as a choke piston. .

The output obtained at 5V amounts to 53mW; at 6V the figure was just on 67mW. If we start from a maximum of 50mW per MMIC [1] (at a voltage of 6V), the loss amounts to approximately 2dB. Admittedly, the structure of the combiner can be further improved (the

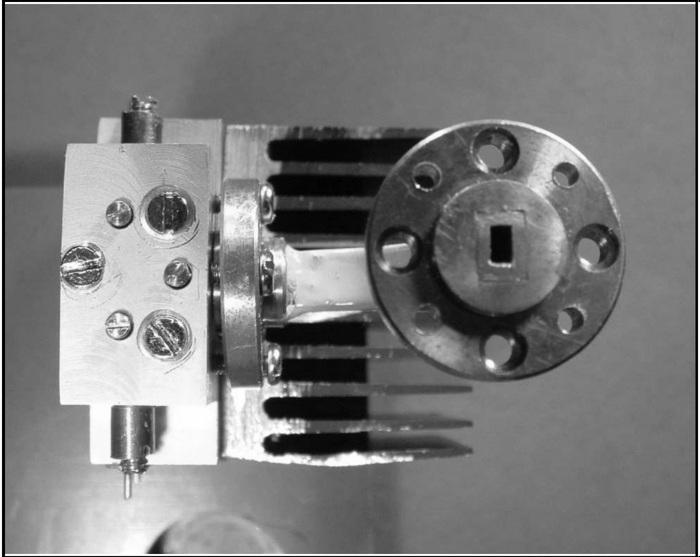


Fig 4: End view of module 2 showing the adjusting screws in the T section waveguide.

RF side operates rather poorly), but the ratio of the power obtained to the expenditure required remains disappointing.

4.2 Module 2

The output is individually coupled into the two horizontal T sections of the WR12 waveguide, using a stripline in each case (Figs. 3 and 4). The distance between the two microstrips is approximately 11mm (something over 2λg at 76GHz).

The laterally mounted 4/40" screws act as choke pistons in the two T arms. The output is fed vertically downwards in the waveguide (parallel T). A capacitive matching transformation is implemented,

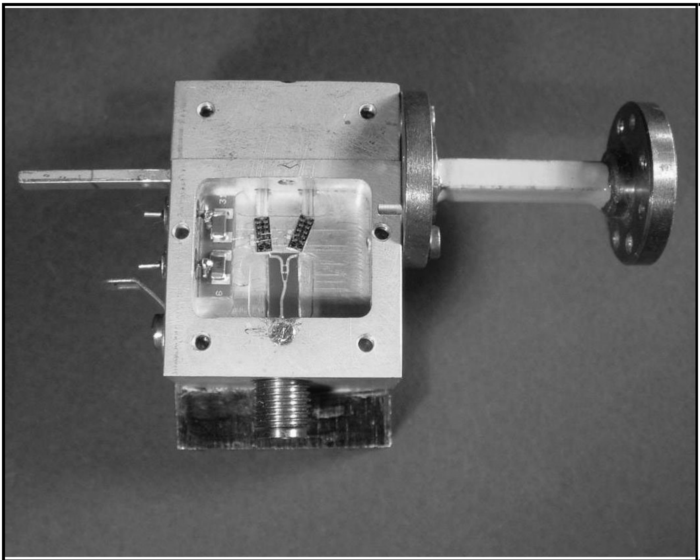


Fig 5: Photograph of module 3 showing the outputs from the two MMICs being combined by coupling into the WR12 waveguide at $1\lambda_g$ intervals.

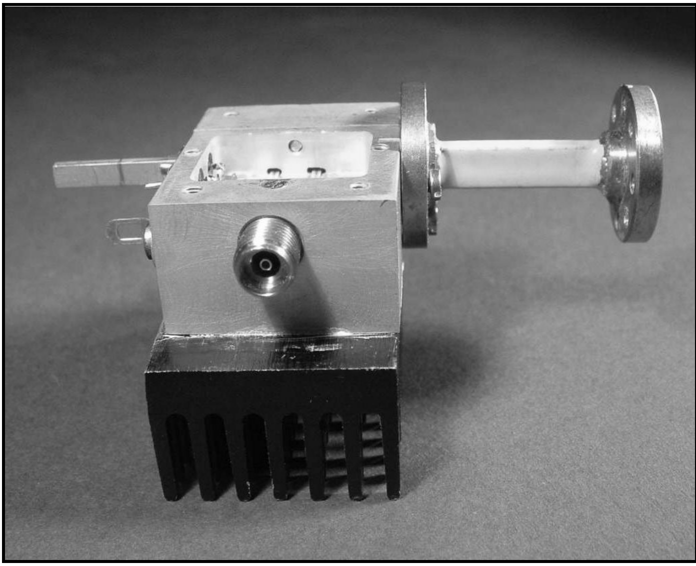


Fig 6: Side view of module 3 showng RF inputs and outputs.

using three M1 adjusting screws in the T sections of the waveguide.

The power obtained from the MMICs at 5V was 63mW, and at 6V it was 77mW. In the latter case, this corresponds to a loss of approximately 1.4dB. Here too, a mechanical improvement of the module (especially with regard to the short circuit screws!) could lead to another marked improvement in the power addition.

4.3 Module 3

Figs. 5, 6 and 7 illustrate the construction of module 3. Two slits (0.8 x 1.5mm.) were milled into the horizontally WR12 waveguide, the distance between them being precisely 1λg (corresponds to 5.1mm at 76GHz). They make it possible to feed power through the two striplines. The laterally mounted choke piston serves two operating points: the reflection of a wave at a distance of λ/4 and that of the second wave at a distance of λ5/4. In addition, two more M1 matching screws (each at a distance of λ3/4 from the power feed points) were screwed into the waveguide.

At a voltage of 5V for the two MMICs, produced 74mW, and at 6V a good 90mW. This gives a calculated loss (at 6V) of a mere 0.6dB!

5. Outlook and acknowledgments

Three very different methods were investigated in connection with power combination at 76GHz. Marked differences were established in the coupling losses, which could not be explained by the fact that the details of the test pieces certainly left something to be desired.

In general it can be said that at 76GHz the waveguides clearly have the advantage (Modules 2 and 3). The high efficiency of the extremely simple method used in module 3 was surprising. As regards the de-coupling of the power feed port, a more detailed investigation is still required.

In order to generate power levels of 100mW and above, it would be necessary, for example, to use 4 type CHU3277 MMICs in parallel. A combination of the techniques used in modules

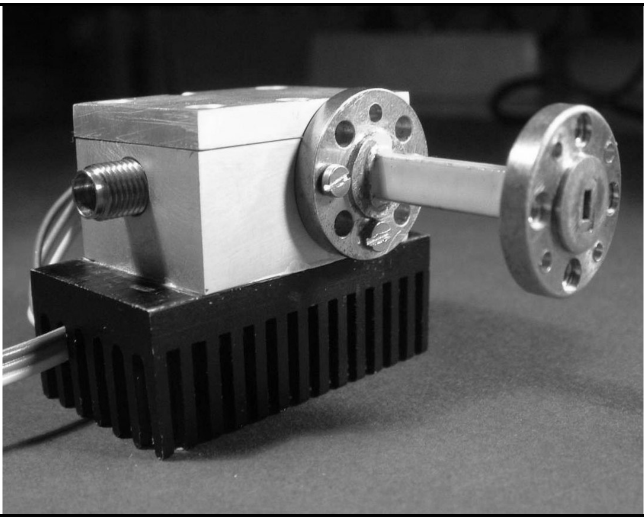


Fig 7: A view of the completed module 3.

2 and 3 looks like a suitable route to a solution in my view. A start has already been made on assembling the appropriate structures.

My thanks go first to the staff of Rohde & Schwarz (Munich), and particularly to Dr. Hechtfischer (DG4MGR) and to W. Hohenester for their constant support. I am particularly indebted to Dr. Jünemann (DK7AH), who oversaw the implementation of the Wilkinson structure for 76GHz and also supplied some valuable comments regarding the assembly of module 3. Finally, my thanks go to my friend J. Ehrlich (DK3CK), who was always available for discussions.

6. Literature references

[1] Sigurd Werner, DL9MFV: New transmitter with higher performance at 76GHz, VHF Communications 4/2003, pp. 194 - 198.

[2] Michael Kuhne, DB6NT, Personal report

[3] E.J. Wilkinson, An n-way hybrid power divider, IRE Trans. Microwave Theory and Tech. (1960) ,Vol. MTT-8, pp. 116 - 118.

[4] P.B. Kumar et al., Optimisation of microwave T-junction Power divider circuits (1995), IEEE MTT-S Int. Microwave Symp.Dig., pp. 1235 - 1238.

[5] H.-R. Ahn and I. Wolf, General design equations of three-port unequal power dividers terminated by arbitrary impedances (2000), IEEE MTT-S Int. Microwave Symp. Dig., pp. 1137 - 1140.

[6] Meinke/Grundlach, High-frequency engineering pocket book, 5th edition (1999), Chapter L

[7] D.M. Pozar, Microwave Engeneering, sec. Edition, 1998, chapter 7, pp. 351 - 421.

[8] M.W.Dixon (Ed.), G3PFR, Microwave Handbook, (1989), Vol. 1, chapters 5.9 and 5.10

[9] Data sheet from United Monolythic Semiconductors, S.A.S., Ref. DS-CHU3277391, 01-Apr-03

Note:
The description λg stands for the wavelength in the waveguide, as opposed to free space.

Gunthard Kraus, DG8GB

Practical Project: A patch antenna for 5.8GHz

This issue's contribution to the "Practical Projects" series describes the successful development of a patch antenna for the ISM band at 5.8GHz. It can replace the stalk antenna of the standard ISM module in commercial use.

1. Scope of the project

A patch antenna for the ISM band at 5.8GHz was developed for monitoring videos 2 storeys away in the new Tettnanger Electronic Museum. Since no holes could be bored and no slots could be cut out for cables in the historic museum building, we simply used the wall of the house opposite as the reflector for the 5.8GHz signal, the patch antenna was aligned with it. To give the result away in advance, it functioned as well as we had hoped.

2. Parameters for the antenna

Look for the frequency diagram for the 5.8GHz ISM band (Industrial Scientific Medicine Band) on the Internet, and you will find the following information:

The 5.8GHz ISM band contains 16 channels at 9MHz intervals. Channel 1 has a centre frequency of 5732MHz, and channel 16 has a frequency of 5867MHz.

The antenna thus has to display a self resonant frequency of 5800MHz and a bandwidth of approximately 140MHz (2.4%). Let the input resistance be 50Ω, with a semi-rigid cable having a soldered SMA plug. The circuit board should be made from Rogers R04003, which is a very stable material from the mechanical point of view and is easy to machine. It should have the following data:

- εr = 3.38
- Printed circuit board thickness = 32 MIL = 0.813mm
- Dieleectric loss factor = 0.001
- Copper coating = 35 micrometres

A λ/4 line transforms the antenna radiation resistance to the required 50Ω.The circuit board size should be 50mm x 50mm and so we also need a short 50Ω microstrip from the transformation line to the cable connection on the circuit board.

The finished product can be seen in Fig. 1 and makes the practical format selected clear.

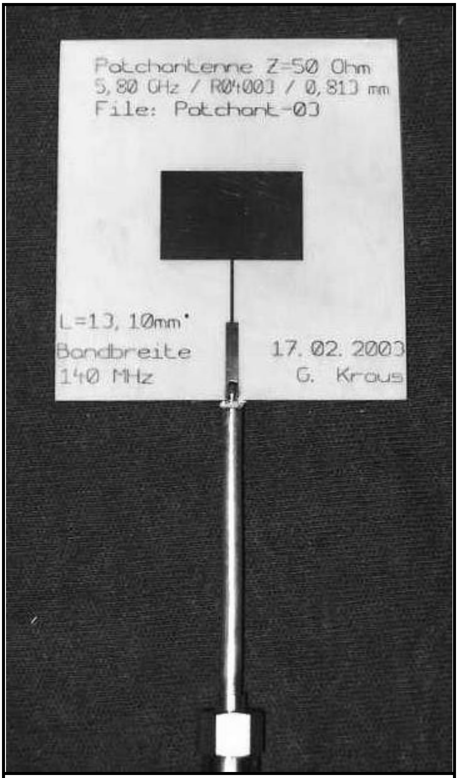


Fig 1: The finished patch antenna for 5.8GHz.

3. Development process

3.1. Design procedure

The basic principles for the procedure can be found in an article on the subject from VHF Communications [1], [2]. But first, using the Internet, you should download the parameters of the 5.8GHz ISM band:

16 channels at intervals of 9MHz. Channel 1 has a centre frequency of 5732MHz, Channel 16 has a centre frequency of 5867MHz.

The antenna should thus have a natural frequency of 5800MHz and a bandwidth of approximately 140MHz. This gives a relative bandwidth of 2.4%. So we did a little experimenting with the "Patch16" program from the Internet, and produced an initial design with the following characteristics:

The centre frequency is exactly 5800MHz, while the bandwidth has deliberately been somewhat increased and established at 2.9%.

All pre-set or calculated characteristics of the antenna can be seen in Figs. 2 and 3. The values that are required for the subsequent work using PUFF must first be converted from inches into millimetres:

- Patch width = 20.32mm
- Patch length = 13.39mm
- Total radiation resistance = 142.4Ω, which gives 284.8Ω on each patch edge.

Now we can use a text editor to open the setup file of PUFF2.1, to enter the R04003 material and circuit board data. Then PUFF is started up (work with the protected mode version by loading puff-p.exe) and the patch is modelled as a large width, lossy transmission line. The two radiation resistances positioned on the two patch edges and the centre frequency is set at 5.8GHz.

And this is what we do next:

- First the exclamation mark is omitted after the entry "Tl" in field F3, and we experiment with the characteristic impedance of the line until (once the

```
These are the design parameters:

 Length (L) =  .5271  inches
 Width (W) =  .8  inches
 Height (H) =  .032  inches
 Dielectric Constant (D) =  3.38
 Loss Tangent (T) =  .001
 Feedpoint Distance (F) =  0  inches

 Do you wish to edit any value? (Y/N):
```

Fig 2: The input parameters for "Patch 16".

```
The Resonant Frequency is   5.800 GHz
Qo is  26.0

The Edge Radiation Resistance is  142.42 ohms
Zc of Quarter-wave transformer is  84.4 ohms
Approx. width of the Quarter-wave transformer is 0.028 inches
Length of Quarter-wave transformer is 0.321 inches at the Resonant Freq.

Input Resistance at probe location is 142.42 ohms

The 2:1 VSWR Bandwidth is  2.9%
Upper Frequency Limit =  5.883 GHz
Lower Frequency Limit =  5.716 GHz


Press 'ENTER' to continue:
```

Fig 3: The simulation results for the patch antenna.

equals sign has been entered) a width of w = 20.32mm is set.

- Now the exclamation mark is replaced, and we vary the electrical length of the line until the configuration is as near as possible to resonance. This situation can easily be recognised, since then the phase angle of S11 is exactly zero degrees. But please select a swept frequency range as small as possible, and also try to obtain the highest possible resolution regarding the amplitude range for |S11|.

The process is clarified in Fig. 4, which immediately supplies the required data:

For a patch width of 20.32mm, we need a microstrip line with a characteristic impedance of 7.43Ω at low frequencies. A mechanical length of 14.36mm then gives exactly λ/2 as the electrical length at 5.8GHz.

Note:

If you're surprised by the big difference between this length value of 14.36mm and the "Patch16" suggestion of L = 13.39mm, let me clear up the mystery.

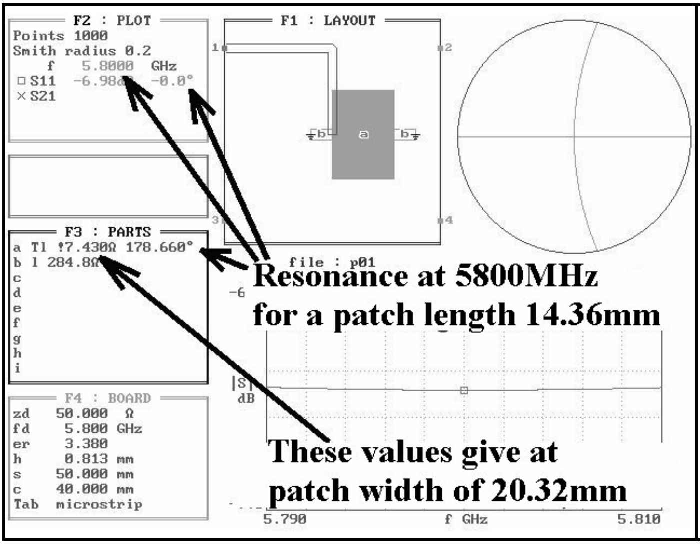


Fig 4:Simulation of the patch antenna using PUFF.

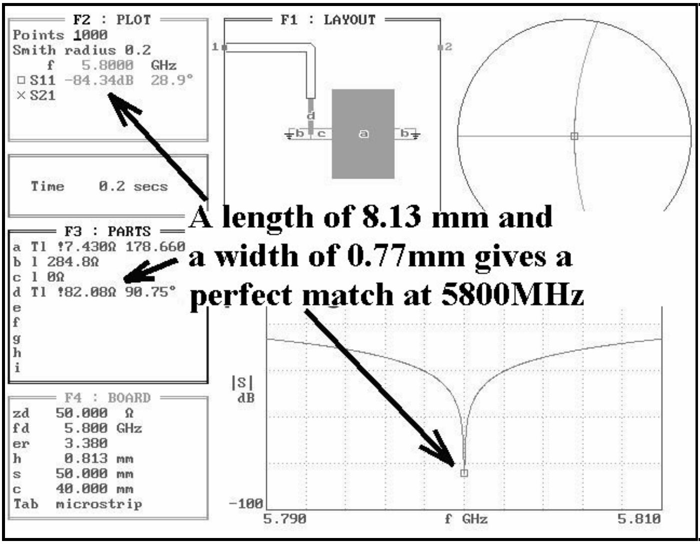


Fig 5: Using a λ/4 transmission line the input resistance is matched to 50Ω.

First the patch has to be shortened by the open-end extension on both sides. Well come back to this subject later, but we can give the result in advance: it is 0.41mm on each side. So now we have only 14.36mm - 2 x 0.41mm = 13.53mm. And if we then pay heed to a proposition discovered by chance in the specialist literature: ”....the difference between the patch resonance and the electrical length for the corresponding λ/2 microstrip is about 1%...”, then we get 0.99 x 13.53mm = 13.40mm.

Now, with the help of a λ/4 transformation line, we have to bring the input resistance of the configuration to precisely 50Ω. In Fig. 5, this has already happened, and the required line data are:

- Line length = 8.18mm
- Line width = 0.765mm

If we now also provide the configuration with a 50Ω feed (required length about 11mm. up to edge of board), then we have Fig. 6. From this, we can determine the width of the feed (once again, after removing the exclamation mark after “Tl” and pressing the equals sign....) at w = 1.89mm.

3.2. The first circuit board

First, we must determine the open-end extensions for the microstrip line. The quickest way is still to use the appropriate diagram from the PUFF manual. Fig. 7 shows the necessary procedure and also supplies the raw data required:

For a patch with Z = 7.4Ω, we need 51% of the board thickness of 0.813mm = 0.42mm
For the 50Ω feed, we need 45% of the board thickness of 0.813mm = 0.37mm

Since the transformation line displays the highest characteristic impedance and thus the smallest width, it must be extended by the following amounts at both ends (the correction formulae can be found on the same page in the PUFF manual):

- For the patch side, we obtain:

$$\Delta L = \left(1 - \frac{w2}{w1}\right) \cdot 0.42 = \left(1 - \frac{0.77}{20.32}\right) \cdot 0.42 = 0.41mm$$

- For the feed side, we obtain:

$$\Delta L = \left(1 - \frac{w2}{w1}\right) \cdot 0.37 = \left(1 - \frac{0.77}{1.89}\right) \cdot 0.37 = 0.22mm$$

So for the transformation line, we finally need a length of 8.18mm + 0.41mm +

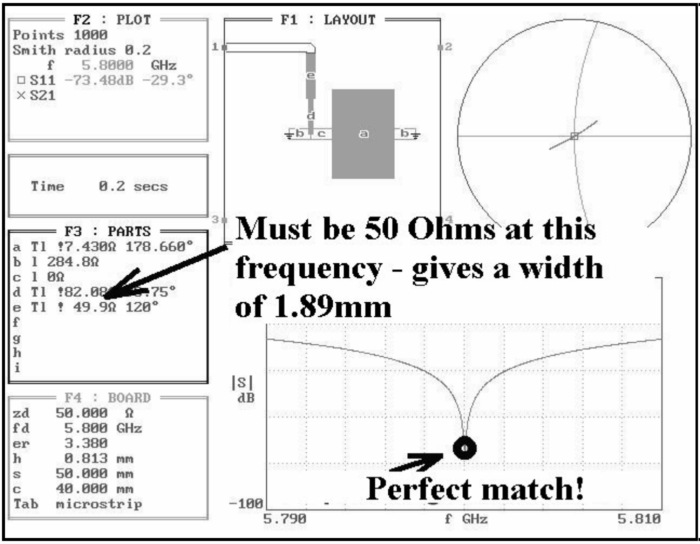


Fig 6: Matching to 50Ω.

0.22mm = 8.81mm, and its width is 0.77mm.

The best way to work on the patch is to use the length supplied by the "Patch16" program, i.e. 13.39mm, with a patch width of 20.32mm.

In the printed circuit board CAD program, the patch is now centred on the selected circuit board, with the dimensions 50mm x 50mm, the transformation line is added, and finally the feed line is connected, with a width of 1.89mm, up to the board edge. Please look at Fig. 1 again. Everything can be recognised very easily there.

Now the semi-rigid cable, with an SMA plug, must be connected to the circuit board with the minimum of electrical irregularities. The necessary information for solving this problem can be found in Fig. 8:

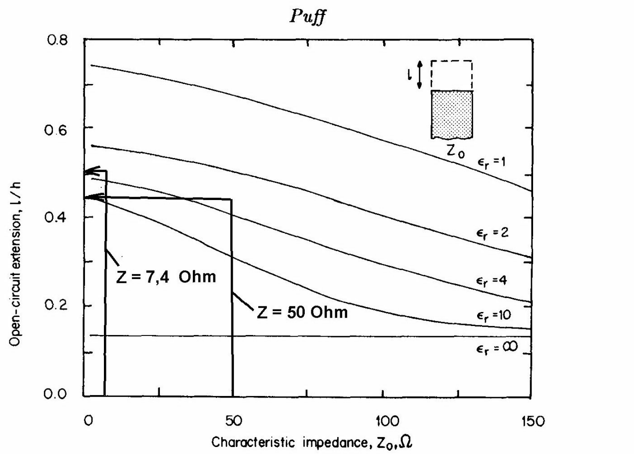


Figure 7.2 The open-circuit end correction in microstrip, plotted from (7.2). The artwork length correction in a parts list should be *negative*.

Fig 7: Determining the open end extension using the graph published in the PUFF manual.

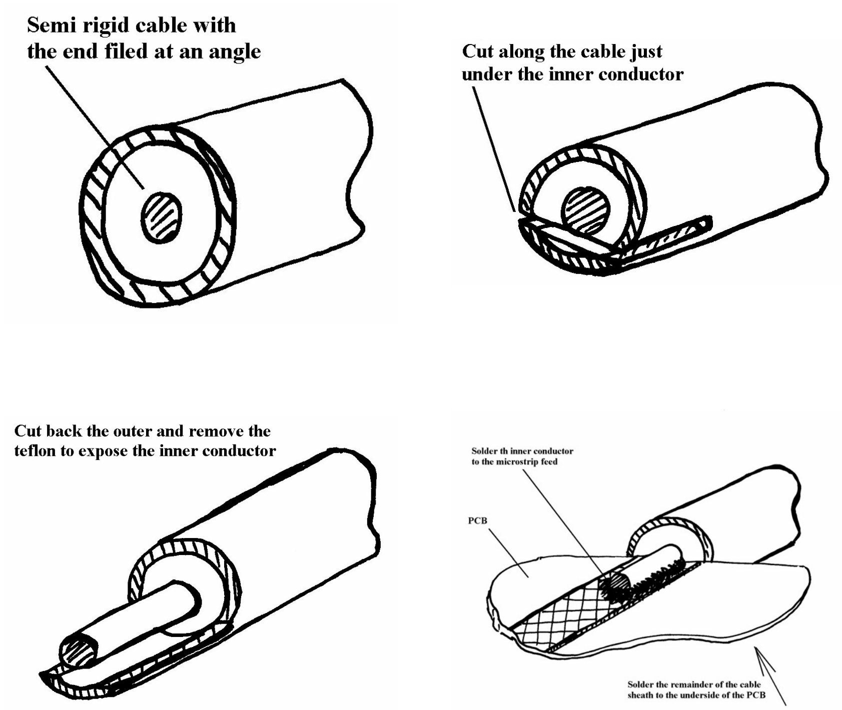


Fig 8: Details showing how to fit the semi rigid feeder.

- First, the cable is sawn off and the end is carefully filed flat at an angle. Naturally, you must not forget to trim it.
- Using a fine saw (e. g. a jig saw), make a cut parallel to the cable, precisely following the inner conductor and a few millimetres long.
- By means of a second, careful cut perpendicular to the cable, we now expose the inner conductor completely and remove the internal Teflon insulation.
- The circuit board is pushed into this cut and the inner conductor is soldered to the 50Ω microstrip feed line. Carefully solder the remainder of the cable sheathing to the underside.

3.3. Evaluation of test results and new design

An investigation of the antenna using an HP8410 network analyser, HP5245L microwave counter and an HP5257 transfer oscillator, gave the resonance at 5690MHz, with a value of |S11| = -16dB. A more precise examination, using a polar display, showed that the input resistance here exceeds the system resistance of 50Ω and consequently the radia-

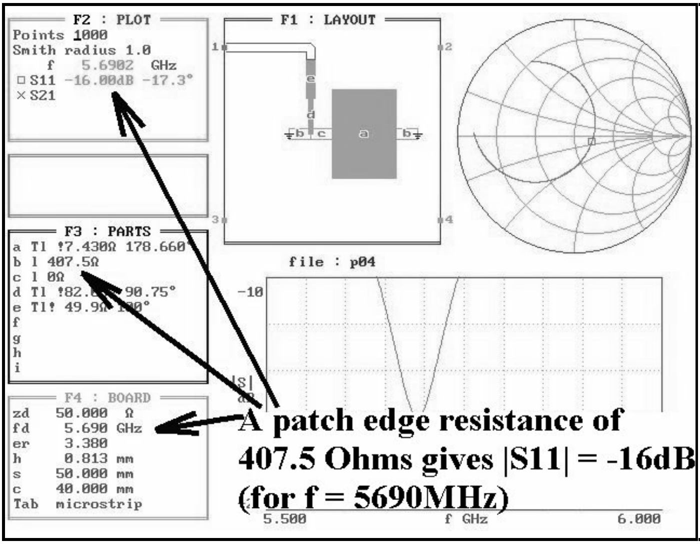


Fig 9: PUFF simulation showing the patch edge resistance of 407.5Ω and |S11| of -16dB.

tion resistance must have a higher value. These findings were immediately converted into a PUFF simulation, and it became clear that in reality a resistance of 407.5Ω should be assumed on each patch edge (Fig. 9).

We should have the patch length required for this frequency of 5890MHz displayed immediately in the F3 parts list it amounts to L = 14.65mm. Now in field F4 we simply change the design frequency to the required 5800MHz and thus once again simulate the patch resonance at this frequency. We can see from Fig. 10 that for this the length must be reduced to 14.36mm consequently, shortened by 0.29mm! Thus, in the printed circuit board CAD system, the length used for the initial design of 13.39mm is reduced to

13.39mm 0.29mm = 13.1mm

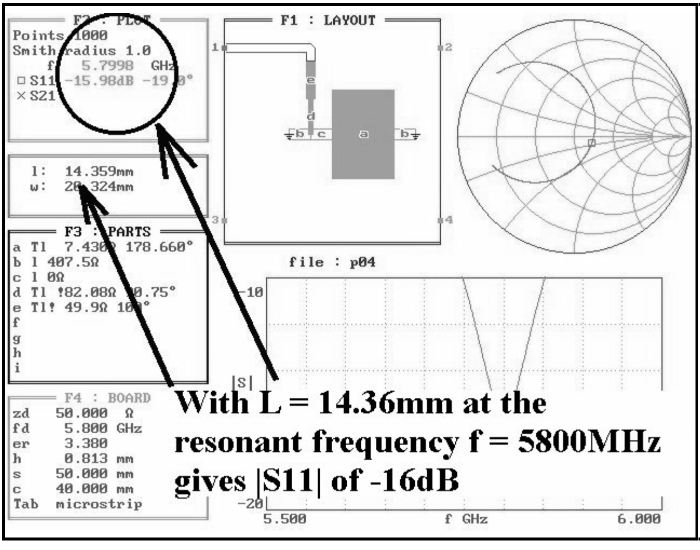


Fig 10: Changing the design frequency to 5800MHz gives a length of 14.36mm.

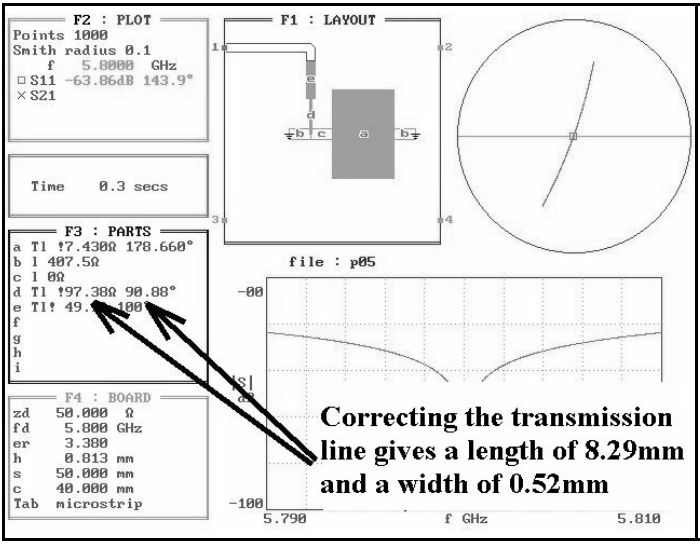


Fig 11: Correcting the matching transformer.

The patch width, naturally, remains at 20.32mm.

All that remains is the final change correcting the λ/4 transformation line to obtain better values for the matching of the measured - 16dB. This is also a very easy matter for PUFF, and the result can be seen in Fig. 11. The new values required are:

Length = 8.29mm and width = 0.52mm.

Naturally, the required open-end extension for each side must be added to this. For the patch connection, the value of 0.41mm used before is still valid, however something is altered on the feed side:

$$\Delta L = \left(1 - \frac{0.52}{1.89}\right) \cdot 0.37 = 0.27mm$$

The transformation line therefore has a width of 0.52mm and a length of 8.29mm + 0.41mm + 0.27mm = 8.97mm.

3.4. Test readings on second prototype

See Fig. 12 there is nothing more to say, and nothing more was done.

4. What do modern EM simulators say about this?

Two free EM simulation programs are available, "Mstrip40" and "Sonnet Lite", that have already been presented and/or used in projects in VHF Communications. Since SONNET is currently running an intensive publicity campaign

Fig 12: A good test result with theis antenna.

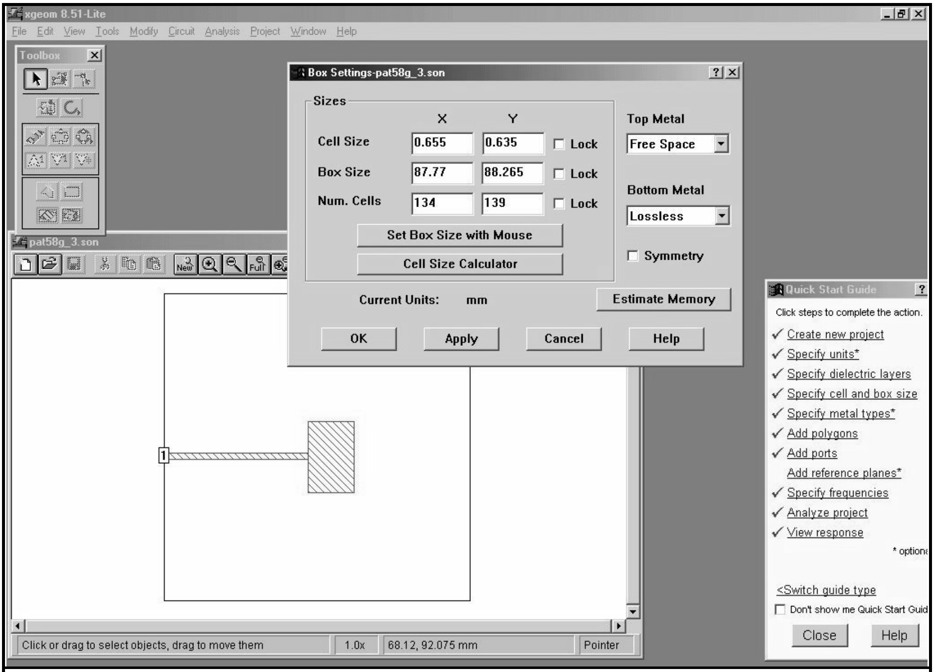


Fig 13: Using the Sonnet-Lite simulator for the patch antenna.

concerning the improvements in its newest version, it was used on the radiating patch, in order both to re-check the resonance frequency and to investigate the matter of the much higher radiation resistance. Using an online menu made it much easier to use this new version of the program, and indeed it was childs play provided you pay heed to the rules of the game as regards simulating such antenna structures in the SONNET manual. You can check up on them in the corresponding article [3]. In addition, you also need the additional license (obtainable free of charge) for extending the maximum usable PC working memory to 16 megabytes, in order to carry out the simulation successfully.

In Fig. 13, we see the SONNET editor screen with the selected box and cell dimensions, together with the new “Quick Start Guide”. Owing to the restrictions on the Lite version, the transformation line is simply omitted and replaced by a 50Ω power feed taken right up to the box wall. The actual radiation resistance of the antenna can then be determined easily and directly from the reflection factor determined in this way.

This is how to do it:

The simulation result can be seen in Fig. 14, with a resonance of 6.03GHz and |S11| = -4.4dB. This gives a reflection factor of

$$r = 10\frac{-4.4dB}{20dB} = 0.60$$

Because we are using a 50Ω feed, we now have to “cut back the circuit length” in our minds in the Smith diagram until we arrive at resistances exceeding 50Ω on the real axis. Then, in accordance with the following relationship, we have the total resistance on the patch edge:

$$R = \frac{1+r}{1-r}\cdot Z = \frac{1+0.6}{1-0.6}\cdot 50\Omega = 200\Omega$$

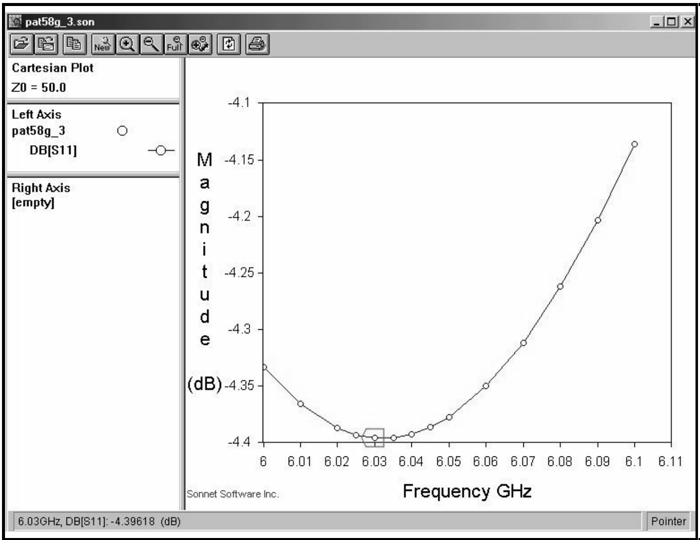


Fig 14: Simulation results from Sonnet-Lite.

Consequently, each radiating edge is affected by a radiation resistance of 400Ω. Compared with the measured value of 407.5Ω, this is an extremely satisfactory result, and thus confirms the validity of the measurement. The resonance frequency was simply predicted too high, with an error of

$$\frac{6030MHz - 5800MHz}{5800MHz} \cdot 100\% = 3.96\%$$

Well yes, thats the way with all EM simulators, to be sure (for a comparison simulation with the cell data used for SONNET used in the "mstrip40" program gives precisely this resonance frequency, but with rather larger discrepancies of approximately 10 to 15% in the radiation resistance).

5. Final observations

Nowadays, the most modern design aids are available, even to private developers without an expensive industrial scale test rig, and they will scarcely strain their budgets. Those willing to spend a little more time and to work their brains a bit harder (and to use measuring the latest generation instruments, or the generation before), can also create developments yielding data which need not fear comparison with professional products. The author hopes to have made some small contribution towards this with this article and to have encouraged people to be brave enough to carry out some critical experiments.

6. Literature references

[1]: Modern patch antenna design, Part 1; Gunthard Kraus, DG8GB; VHF Communications 1/2001, Pages 49 - 63

[2]: Modern patch antenna design, Part 2; Gunthard Kraus, DG8GB; VHF Communications 2/2001, Pages 66 - 86

[3]: Section 4.3 on Page 155

VHF Communications at Friedrichshafen June 25th - 27th 2004

- I will be attending the exhibition this year for the first time.
- I am sharing a stall in the Flea Market area with Franco Rota of R F Elettronica, the Italian agent for VHF Communications.
- Visit the stall to meet your editor.
- Send your friends and colleagues along to the stall to see what the magazine contains and sign up for a subscription.

Advertise in VHF Communications

- Advertise your products for Radio Amateurs or electronics professionals.
- Worldwide circulation
- Half page, full page or inside cover advertisements
- Attractive advertising rates: inside cover £110.00, full page £90.00, half page £45.00.
- Contact Andy Barter, email andy@vhfcomm.co.uk

Index of Volume 35 (2003)

Filters

Fundamentals

Measuring Technology

Miscellaneous

A complete index for VHF Communications from 1969 to the current issue is available on the VHF Communications Web site - http://www.vhfcomm.co.uk. The index can be searched on line or downloaded in pdf of Excel format so that it can be printed or searched on your own PC. If you are not connected to The Internet you can write or fax K. M. Publications for a printed copy of the index which will cost £2.50 plus postage.

K.M. Publications, 63 Ringwood Road, Luton, Beds, LU2 7BG, UK.

Fax +44 (0)1582 581051

VHF Communications Back Issues

- Thanks to assistance from subscribers who have loaned old magazines to be copied, all back issues are now available either as actual magazines or as photocopies in magazine format. A list is maintained on the web site showing the issues that are photocopies, that list is reproduced on page 63.
- Locate interesting articles by searching the full index on the web site, then order the magazines using the secure form on the web site. You can also order by post or fax.
- If you are new to VHF Communications magazine or have missed some volumes or issues, choose one of the back issue sets or individual magazines to complete your collection.
- Keep your magazines in good condition with Blue Binders that hold 12 issues, £6.50 each + P&P.
- Single issues from 1969 to 2002, £1.00 each + P&P.
- Single issues from 2003 volume, £4.70 each + P&P.
- Complete 2003 volume, £18.50 + P&P.
- Back issue set up to 2002 (57 magazines), £45.00 + P&P.
- Back issue set up to 2003 (61 magazines), £65.00 + P&P.

K. M. Publications, 63 Ringwood Road, Luton, Beds, LU2 7BG, UK.

Tel / Fax +44 (0)1582 581051

Web site http://www.vhfcomm.co.uk

Alexander Meier, DG6RBP

12GHz divide by 10 prescaler

The number of divider ICs on offer is continually growing, and they can be obtained for ever higher frequencies and with the most widely varied divider factors. Divider ICs going up to 12GHz are currently available at favourable prices, and are thus interesting for radio amateurs, such as those on offer from HITTITE [3]. Two new, interesting ICs have recently become available from this manufacturer: the HMC364 divides frequencies up to 12.5GHz and above by 2 and the HMC438 divides those up to 7GHz and above by 5. This provides the motivation for constructing a 12GHz frequency divider with a divider factor of 10, which is described below.

1. Introduction

A 5GHz divide by 10 prescaler [1] and a 12GHz divide by 1000 prescaler [2] have already been presented. This range has now been extended by a further variant in the shape of this new 12GHz frequency divider with a divider factor of 10.

If the divider is being used for frequency measurement, you need a frequency counter with a counting range of minimum of 1.25GHz if you are to be able to make full use of the new divider component. This has recently become a standard feature of all modern counters. There is no requirement for complicated calculation with the decimal divider factor (divide by 10). A display of, for example, 1.040GHz would correspond to an input frequency of 10.40GHz. Thus you need only move the decimal point one place.

But the biggest advantage of the divider by 10 is certainly its simple construction. The SMD ICs used are still (relatively) large and can thus be fitted easily. But since these also have an earthing surface on their underside, they have to be mounted on a hotplate, using some solder paste.

2. Circuit description

The circuit diagram for the 12GHz prescaler can be seen in Fig. 1. It consists of the two divider ICs from HITTITE, type HMC364 (U1) and HMC438 (U2). The input signal, in the range 0.5 to 12.5GHz, is first divided by 2 in U1 and then by 5 in U2, which gives a total divider factor of 10. The output level of U2 is approximately 1dBm, corresponding to 0.8mW.

If the dividers are not receiving an input signal, they have a tendency to oscillate. As we have already seen with the divide

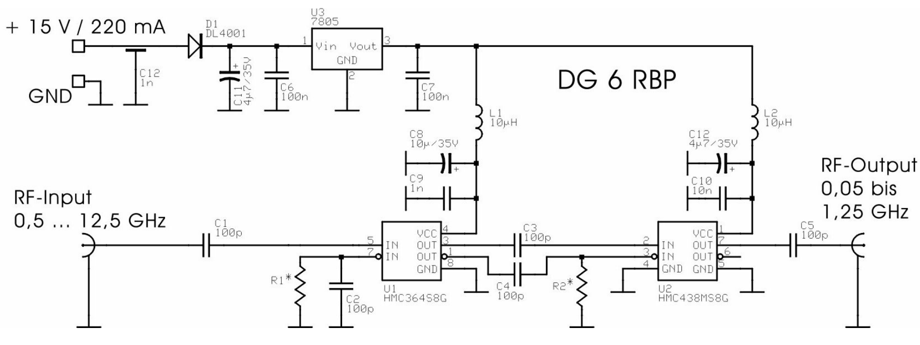


Fig 1: Circuit diagram for the 12GHz divide by 10 prescaler.

by 1000 unit, the oscillation can stopped without an input signal. This also applies to the new frequency dividers. The resistors, R1 and R2, are used for this.

The supply voltage can be in the range from approximately 9 to 15V and is connected through the feed through type capacitor, C12 to the voltage regulator, U3, which then gives a stabilised voltage of 5V available for the divider ICs. The diode, D1, acts as reverse battery protection.

3. Assembly

The circuit is mounted on a 45mm x 30mm printed circuit board 0.51mm thick (Fig. 2) made from ROGERS substrate RO4003.

Due to the dimensions, the housing used is the existing milled housing for the 5GHz divider [1]. Since the divider components get very hot, a solid aluminium milled housing is preferred to a tinplate housing. Here too, N sockets were used, but only high quality types because of the high frequency range.

The component diagram for the circuit board can be seen in Fig. 3. First the two divider ICs are mounted. The simplest option here is to use solder paste and a hotplate. First apply some solder paste to the earthing surface of the circuit board between the connection pads. Now mount the divider ICs and use the hotplate to heat the circuit board to just above 200°C. The solder paste melts and connects the earthing surface on the underside of the IC with the circuit board. Now the connecting legs of the ICs can be soldered on quite normally using a soldering iron.

Finally the other SMD components are mounted, with the exception of the SMD resistors, R1 and R2. Because of the specific scatter levels of the divider ICs, these are only finally selected through trials and are then mounted.

Lastly, the solder residues are carefully cleaned off the circuit board and the board is screwed into the housing. Then the voltage regulator, U3, the feed through capacitor, C12 and the N sockets are fitted and soldered on.

Now the frequency divider can be put into operation. For a supply voltage of 15V, if everything is working properly, the current should be about 200mA.

A spectrum analyser is now connected to PIN 3 of U1. The frequency divider input remains open circuit. One or more lines can be seen on the screen. The value of the resistance, R1, is now determined

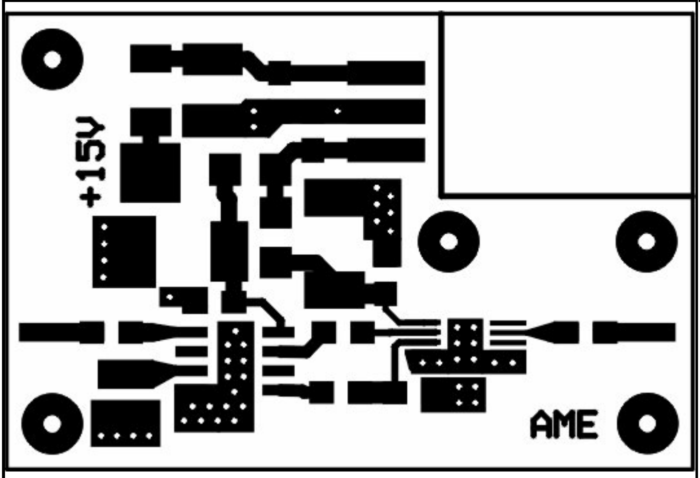


Fig 2: PCB layout for the 12GHz divide by 10 prescaler.

through trials in such a way that these oscillations on the screen disappear. The resistance value involved will lie between app. 27kOhm and 82kOhm. Finally the analyser is connected to the output of the divider module, and the process is repeated for resistance R2.

Following a successful function test, the divider is ready for use. A specimen unit (prior to the determining of resistances R1 and R2) is shown in Fig. 4.

Fig. 5 shows the minimum level required on the prototype for satisfactory operation, together with the maximum level. If the minimum level is not reached, false divider factors can arise, whilst too high a level can lead to a defect in the divider.

4. Parts list

C1-C5	100pF SMD 0805
C9	1nF SMD 0805
C10	10nF SMD 0805
C6,C7	100nF SMD 0805
C12	4.7µF/35V SMD Tantalum

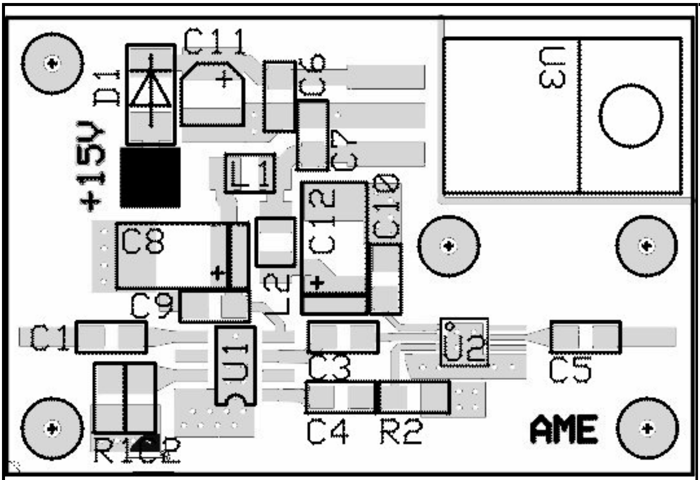


Fig 3: Component layout for the 12GHz divide by 10 prescaler.

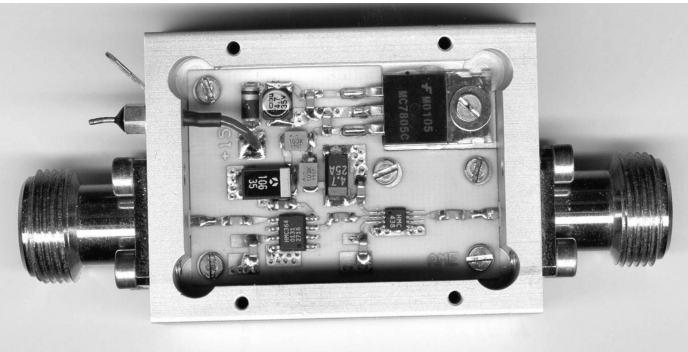


Fig 4: Complete 12GHz divide by 10 prescaler.

C8	10µF/35V SMD Tantalum
C11	4.7µF/35V SMD Electrolytic capacitor
C12	DF-C 1nF, M3
R1,R2	see text, 27kΩ up to 82kΩ
L1,L2	10µH
D1	DL4001
U1	HMC364 S8G
U2	HMC438 MS8G
U3	7805
2 x	N flanged sockets
1 x	Aluminium milled housing
1 x	DG6RBP-007 PCB

5. Literature references

[1] Meier, Alexander: Pre divider (:10) up to 5GHz, VHF Communications 1/20 02, pp 22 - 26

[2] Meier, Alexander: 12GHz divide by 1000 prescaler, VHF Communications 4/2003, pp 199 - 206

[3] HITTITE Microwave Corporation, 12 Elizabeth Drive, Chelmsford, MA 01824

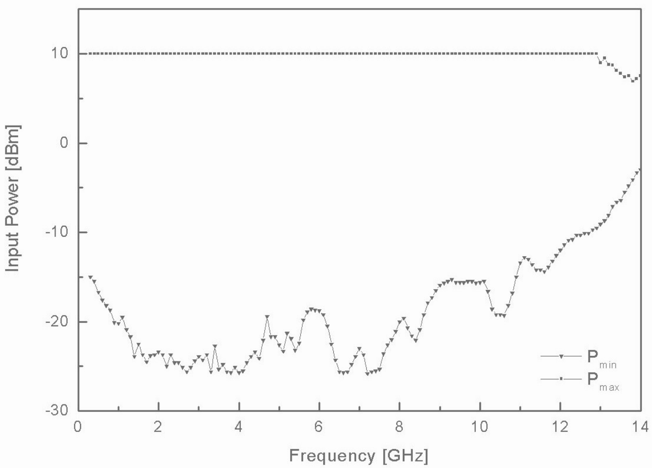


Fig 5: Graph of maximum and minimum input levels for the 12GHz divide by 10 prescaler.

Peter Greil, DL7UHU

Amateur use of the optical spectrum, part II

Update

If the proposed draft version of the amateur radio ordinance (Amateurfunkverordnung = AFuV) avoids any "changes" and comes into force at the end of 2003 or the beginning of 2004 as the AFuV, the situation will be as follows:

The amateur radio range starts at 444GHz, with a few gaps being reserved for radio-astronomy and earth resources radio services. From 956GHz to 1,667PHz, the optical range is then fully available without any restrictions on frequency, even for operating and transmission modes that are not yet in existence!

Once the new amateur radio ordinance comes into effect, an existing amateur radio callsign is sufficient for the "lower" laser classes, and no applications need be made for confirmations, approvals and the like.

For amateur radio operation in laser class 3B, which could involve a higher risk of personal injury, an application should be made under Paragraph 17 of the AFuV. Permission will not be granted for activities involving laser class 4.

The term "laser classe(s)" from (DIN) European standard EN 60825/1 is used here, no lasers need be used. Even in this case, they are mainly to be used for other activities (LED, copying, and the like) see also Part I in VHF Communications 1/2003, Page 19.

Continuation from Part I:

2.8. Eyes and optical instruments (binoculars)

If at least 25 photons make contact with an eye which has been acclimatised for at least 30 minutes, 8 of those photons will reach the retina and a light stimulus is registered. Changes in the light intensity in the ratio of 1:10,000,000,000 can be detected! The eye can not be beaten for individual photon detection except by very good photo multipliers and avalanche photodiodes.

So what makes a good pair of binoculars? The ratio of the objective lens diameter to the eyepiece lense diameter gives the magnification, which is specified as the first number. This means that the lens is seen as if from a shorter distance, in accordance with the lens distance/magnification ratio. For Earth observations with the naked eye, the eypiece lens diameter, which is made approximately the same size as the users pupil in mm, is specified as the second number, and defines the maximum meaningful magnification. For astronomical observations, and when only low definition is required, the value should be doubled. From low values up to approximately 125mm objective lens diameter, the definition improves linearly. Subsequently, massive increases in the diameter of the objective lens are necessary in order to increase the definition any further [30].

Unfortunately, binoculars are on sale which do not fulfil these conditions. “Magnification to spare”, “more magnification than you need” thats what the salespeople say. The effective eypiece lens diameter (Austrittspupille = AP) is obtained by dividing the objective lens diameter by the magnification. In the course of a lifetime, the maximum possible pupil diameter of a healthy person changes from approximately 7mm to approximately 2mm. A person (usually an older person) with a pupil of a maximum 2mm uses only 8% of the capacity of a pair of 7x50 binoculars, usually identified as a night glass, since the effective eypiece diameter is 7mm! Now its clear what a good pair of binoculars are!

You should just check for yourself what your maximum pupil diameter is, in the twilight hours, after at least 30 minutes.

A light filter matching the wavelength of the light to be received can be attached to the lens to heighten the contrast not only when there is interference due to external light sources with a different wavelength, but also to target prominent points. Such a filter was supplied, for example, with the ZEISS Glas 6x30 from Li Spr. It was described as a “monocular filter”. Filter combinations can also be of assistance here. Filter goggles naturally do the same job, but are uncomfortable. (Often wrongly described as “protective goggles”, suitable filter goggles are supplied with laser spirit levels. Protective goggles must naturally have green filters for this purpose). Edmund Optics (www.edmundoptics.com) is a good source of filters outside Germany - Ed.

The twilight output (Dämmerungszahl = DZ) is the product obtained if the magnification is multiplied by the lens diameter. Additional physiological factors are taken into account here, which influence night vision. The higher the product the better, but take account of the comments made on the meaningful size of the exit pupil to obtain the twilight output. So the twilight index (DI) = DZ x AP takes account of the real eye.

2.9. Received power and intensity of irradiation

To obtain a general idea of what is feasible, we can calculate the fraction of the transmitting power arriving at the receiver under ideal conditions, the received power.

See also Section (B) - Calculations

At 660nm, the background radiation under ideal conditions, on a moonless night, is approximately 7µW/m². [18]. 16kcd/m² can be taken as being the maximum horizontal luminance for a clear day [25]. The higher usable sensitivity of very good avalanche photodiodes, (APDs) and photo multipliers, (PMTs) can not be utilised except at night using the modulation processes specified here. They are less suitable for daytime use than PIN diodes.

But first we must look into standard PIN diode technology. Its a short cut to finding useful devices.

2.10. Locations and location specifications, searching for and finding remote stations

As regards specifying the location for the locator, use WGS84, and if possible use 8 digit references for short distances [8]. (Microfield, TNL enhancement) The meaning of the 7th and 8th digits is analogous to that of the 3rd and 4th digits. Logbook programs have recently been developed which can be used for the 8 digit locator and also for THz. (The Log, HAMMAP). The WGS84 height is not suitable for height specifications. It is not a working height. So dont be surprised if GPS equipment appears to give false height readings. The standard datum zero (Normalhöhennull = NHN) has taken over from the HN and NN as a working height. Even modern maps still have data taken from different reference systems, so dont be surprised [2].

With the disappearance of visible boundaries in the “undergrowth”, there may be problems in the determination of the political location, the provincial boundary. Here you should refer to maps from the UTM experts or showing the UTM grid [31]. Since 1998, topographical maps have been available in bookshops and from land survey offices in WGS84 with a UTM grid! GPS equipment can also be used to call up prominent points later and read them off as UTM, locator, Gauß/Krüger and other data, which is considerably more comfortable than carrying out calculations. Displays in “mil”, (compass point) are usually more accurate than those in “°”, (e.g. Trex Legend GPS equipment) The UTM expert/grid data can also be used in “undergrowth” without any problems, since a fmap slide/scale with a length of 5cm. is also suitable for 1:20,000.

A map slide is better than a scale; it can always be used directly for 2 scales without any calculation. You can easily make one yourself.

In the spirit of HAM, every station should have one or more triple systems to use as remote stations. It is particularly effective to receive a sufficiently strong echo by impulse modulation with a corresponding transmitter pulse width repetition rate, it is radar with light (LIDAR). This provides more security than listening to the 625Hz tone of the normal inherent modulation.

With regard to radio stations in urban areas and “on the flat”, we usually quickly get to the point where these can no longer be seen and thus located, since the roofs “all look the same”.

An opaque balloon filled with balloon gas, helium or hydrogen is quickly lifted by the wind. Normal balloons are unsuitable, since insufficient contrast is present when light shines through them. So its better to inflate them with air; a suitable visual target is (for example) a group of balloons providing a contrast, fastened to the end of a long fishing rod. The tip can be more securely anchored using an attached “truncated pyramid” of material, with an additional fastening, in addition to the visual target.

Its not only on stony mountains that there are problems determining the direction using a magnetic compass. It may be possible to solve the problem by taking a bearing on at least one prominent object (in Berlin and the surrounding area this is usually the television tower).

However, if you do not mount the optical transmitter on one of the types of equipment below it is preferable to use a Protractor (on a stand), or a bearing plate, a levelling instrument with a horizontal (Hz) circle, or, if things are really difficult, a theodolite. An illuminating device (also for the cross-lines of the telescope) can be fitted and it makes sense to use one even in daylight. Equipment that is too precise may be too complicated in its operation. By calculating in “paces”, like the artillery used, discrepancies in the determination of the angle can be eliminated, providing there is a not inconsiderable distance between the optical transmitter unit and the position finding device.

Flak telescopes make an excellent starting point. They have a horizontal circle, a full circle of (360°/400g) /6000 or 6,400 compass points or the like, and an almost 90° vertical circle, together with an illuminated bearing plate.

N.B. Depending on the date of manufacture and the province/military organisation, 6,000 or 6,400 compass points are used for the full circle.

North seeking gyro-compasses are in use

for mobile radar equipment. Their accuracy is relatively high, even for our purposes.

To make the "manual labour" easier, Erich, HB9MIN proposed a beam scanner [19], among other things, which can be used from a station located at a prominent visible point. Provided both stations have a triple system, they can both also use a beam scanner (simultaneously, of course) if neither station is visible. It should then be possible to locate the optimal alignment in adequate comfort, and sufficiently fast and accurately.

The first stage is to find the possible locations using the "Radiomobile" 17 program. Help for the first steps was compiled by Michael Oetjen, DH6XS, for this procedure. The precision work can then be carried out in an excellent manner using "TOP 50" or "TOP 25".

The "Top50" program is on sale in bookshops for everyone in Germany. In the "Top 25" ‚Baden/Württemberg is there on a 1:25,000 scale, 360 maps with UTM. In the "TOP50", from version 3 onwards, gradient diagrams can also be entered and, naturally, printed out. From the location specifications, the position of the cursor displays details of the location each time (with an appropriate setting) and allows the angles between the locations and between the locations and the prominent object to be read off on the screen and/or calculated more precisely. The automatically displayed angle unfortunately has a resolution of 1°. So it is a simple matter to align the optical transmitter approximately with the remote station, even when this is not visible.

(Errors in TOP50: Brandenburg/Berlin, Version 3, at 1:50.000 printed out values of minutes after decimal point in representation in degrees and minutes without seconds can be wrong please switch to representation showing degrees, minutes and seconds!)

Since WGS84 is used for the locator, it makes sense to calculate the angle from the WGS84 co-ordinates of 3 locations. Include length and width in degrees/(minutes) or values for UTM with the associated heights in m. But it may be necessary to use elements of spherical trigonometry for this, in a transformation or during the actual calculation process.

In order to get by without spherical trigonometry, you can use the co-ordinates of the locations in UTM. The angle can quickly be determined with the normal angle references for flat surfaces, using the top values and right hand values of 3 points. If the height is not taken into account, an additional error can arise. Only the angle is correct. The North direction, however, the paths/distances, and thus the areas on the map, are wrong.

The top value is the distance to the Equator, the right hand value is the distance from a specific meridian which lies to the left.

The program in HAMMAP18 makes it possible, not only to integrate the Top50 maps and the re-calculation of various co-ordinate systems, but also to calculate the locator (2 to 12(14) places), the angle and the precise distance, among other things.

3. Assemblies in an optical transmitter

We suggest the following:

Receiver, consisting of the detector head and the optical section (if applicable, sighting device), in theory can function on its own;

Transmitter, consisting of transmitter head, laser or LED module with mechanism (if applicable, sighting device), in theory can function on its own;

Sighting device, if not present on transmitter or receiver;

Operating element, size of a hand microphone, includes sound selection, amplifier, microphone, key, modulator with sound generator, possibly with internal power supply, and can operate with various receivers and transmitters.

Power supply external, optional;

Accessories can be attached to operating element, such as headphones, microphone (transmit receive combination), key;

Basic mechanism, adjustment option for side and height, seat for stand screw, connection between receiver and transmitter.

Stand, stand rail, fastening for theodolite

3.1. Receiver

The detector head includes the detector with pre-amplifier, and is replaceable. It can be advantageous to combine it with screen, tube and filter(s).

The actual detector usually receives from behind as well, please fasten it from below! If the sensitivity of the photodiode in short circuit mode is set to 1, it is 7 x less when idling and 50 x less in diode mode [13]. This does not exclude the possibility of using idling and diode mode as well. The option of receiving constant light may not be provided for not even for measuring purposes as it will destroy the optimal layout. A2 and A3 do not really get into their stride below 350Hz, while FM certainly lies considerably higher.

The NEP (Noise equivalent power) can be determined from the data sheets of the diodes or calculated.

See also Calculations section (C)

The dark current, IR , is given for a specific blocking voltage. With a small active area, the dark current is lower. It is recommended that diode measurements are carried out. This is advantageous if the noise is mainly determined by the diodes. Often the subsequent amplifier plays too great a part in this if it is not designed correctly. For our purposes, the bias currents must be low. (LF 356, LT 1028, OP 27, OPA 111, OPA 627) N.B.! The maximum permissible blocking voltage for photodiodes is often smaller than 1V which gives a risk of destruction.

Using a trans-conductance amplifier, the degeneration resistance is increased and the bandwidth is decreased, with a simultaneous increase in the amplification [9].

The slope resistance should be at least 10 x greater than the diode resistance. This can rarely be achieved with silicon diodes. So maximum sensitivity can always be attained, depending on the upper limiting frequency required. Changeover should be carried out in the detector head, preferably through a relay. One side effect is the associated change in the amplification. One range for AM, 350Hz to 2.7kHz and one for FM and other modulation processes (30kHz) … 32.768kHz ... (40kHz).

There are well-priced solutions available for remote control systems, photodiodes, trans-conductance amplifiers and band pass filters, for a frequency between 30kHz and 40kHz. Most have infra red filters, all integrated in one housing. Unfortunately these are mainly suitable for telegraphy, and apparently only for the 214THz band Using the Burr Brown OPT101 and OPT210 is simple photodiodes and trans-conductance amplifier, with access to bandwidth and sensitivity in one housing.

Replaceable at any time thanks to the mechanical separation of the operating element, and/or another operating element can be used for amplification and de-modulation via cable permanently fastened to detector head with pin-and-socket connector

Make sure that the frequency response of the system is appropriate for the transmission mode. A series circuit of

560Ohm at 47nF sets the lower limiting frequency at 6kHz and is thus not suitable for AM, but is OK for FM.

Things are different in the "basic optical path". It is not necessary to make trial systems with small lenses or other limitations. This wont change the laws of optics, although it may mean simpler equations can be used. If you are working in the sunshine for a range exceeding 2km, the limiting sensitivity means that the receiver's area diameter must be >58mm to reduce interference. These occur due to atmospheric turbulence effects which arise because we are using a wavelength of 660nm, corresponding to >80mm diameter at 920nm. For use during snow, rain and hail, the receiver area should also be large. Multiple reception is better, with several "small" receiver apertures being used instead of one "big" one. Two optics/lenses with a diameter of, for example, 80mm, are usually cheaper than one optic/lens which has a diameter of 113mm but have the same total area.

As the effective area of the light collector increases, for lenses (or lens systems) and mirrors (or mirror systems) the sensitivity theoretically increases. There are losses due to reflections on the air/glass surfaces and/or air/plastic surfaces. These can be reduced by an anti-reflection coating of approximately 8% on 1% of each contact surface. Additional losses occur if the light does not strike the photo sensitive surface vertically, details are usually given in the data sheets for the detectors. Thus concentrating reflectors are normally not able to make very good use of the light source provided, since only a very small cross-section can be used. I know of only one such system used in practice.

Please do not forget that no stray light should enter the receiver diode, a small reception angle should be aimed for. If this is not be possible, a screen usually helps.

The receiver (transmitter) angle for the receiver area (transmitter area) is determined by the areas size and by the focus.

See also Section Calculations (D)

Reputable commercial equipment (JO 4.02, -03) has the same angle on receive and transmit sides for illumination/imaging.

Optical systems which, for example, illuminate a small image measuring 24mm x 36mm, are thus naturally not needed; systems lighting up only a few mm² are sufficient, as for television cameras with small chip areas.

Some flea markets still have objective lenses with long focal lengths from DDR observation cameras, some simultaneously corrected for 546nm and 850nm and are usable in the 394THz and 214THz bands.

You should keep it in mind that the source of the remote station images should image a diameter in the nm/µm range under ideal conditions. Anything more on the detector reduces the signal/noise ratio and thus the range!

It is also important to use a screen and to keep the focus wide. A screen may sometimes be dispensable, but only for small area photodiodes.

For detectors with optical waveguides, the lenses are selected in accordance with the aperture number.

See also Section Calculations (E)

This is applicable if one end of an optical waveguide is fitted at the focal point of a lens (even a large one) as the receiver. By using an additional lens/optic, the active diameter of the optical waveguide, which measures only a few tenths of a mm, can be increased to even out tolerances (see above equation with note). There are highly sensitive broadband receiver modules which can be used for this.

Photographic objective lenses can have excessively high losses, compared to mirror objectives, because they have several contact surfaces, particularly old ones which have not been coated. High quality optical corrections are usually not necessary, since the laser and the LED are emitting radiation on almost the same wavelength. Simple lenses, telescope lenses, telescope (air) achromatic lenses and telescope mirrors can be more suitable as high quality lens photographic objectives. Newtonian systems use a paraboloid reflector (with a plane mirror), Cassegrain systems use a concentrating reflector with a convex hyperboloid mirror. The Maksutow mirror system uses a meniscus lens instead of the Schmidt plate. Fresnel lenses (for continuously corrected lenses) and, if applicable, simply constructed projection objectives can be suitable. Favourably priced magnifying glasses may contain lenses that are more suitable for us than magnifying glasses from well known manufacturers; these are constructed for the magnifying glass application and are then not suitable for us. The effective aperture, the ratio of the diameter to the focus, is usually large. Both factors combine to prevent the focussing of radiation from infinity. Thus an efficient screen can not be used, because the radiation can not be focussed sharply, in order to make optimal use of small area screens and detectors.

The only error in a lens that can cause problems is the aperture error, also known as spherical aberration. The intersection of the edge radiation, zone radiation and central radiation forms a focal surface (caustic surface, which can become visible in a round white cup full of coffee!). The radiation lying further out (edge radiation) is more intensely refracted (prismatic effect), in contrast with the radiation lying further in (zone and central radiation). The focus is nearer to the lens. When the sine condition is met, the error is eliminated.

If the receiver lens is only illuminated by radiation of a wavelength that is parallel to the axis, other lens errors have no negative influence.

Detectors that are very interesting for us have light sensitive areas with a diameter of 0.3mm and below! Thanks to the small diameter of the light sensitive area, in the same way as with the large area detectors with a screen, the influence of stray light is very much reduced.

If a large area detector, e.g. OPT 101, is used without a screen or a tube, this means that you can only work well at night. The bandwidth obtainable by day is too low.

So my advice is always to check the focusing characteristics by imaging a distant object (e.g. the Moon) if the focusing characteristics are not known. A reflex camera can be used to carry out some excellent tests here.

This can not be done quickly, since you must make sure that the lens/optic and the white reception area are parallel to one another, the imaging takes place in the centre of the reception area, and the correct side of the optic/lens must be selected. To make sure there is enough contrast, a piece of tube, or better two, should be used. It is only in special cases that you can determine the aperture via the imaging of the Sun. If you image an object 1:1, and divide the distance between the object and the image by 4, that is the aperture. A suitable object might be the writing on the cap of a lit incandescent bulb.

As regards simple lenses, an aspherical lens for minimal aperture error at the wavelength in use would be ideal. A very suitable lens is the “best form lens”, also known as “the lens with the most advantageous shape”. Here one surface is convex and one only slightly curved or plano-convex. The surface which is more curved points to the remote station!

Some good results have been obtained using spherical, plano-convex spectacle lenses. If material is available with the right refractive index (refractive index 1.685 at the corresponding wavelength for thin lenses), the aperture error is minimum. Modern, point focal lenses are not at all suitable and bi-convex lenses, in which both surfaces are equally convex, are not suitable for large apertures.

Obtaining plano-convex spectacle lenses from ZEISS with minimal aperture errors, aperture approximately 300mm, diameter 70mm/75mm, has not been practicable because they are very expensive. It can be more advantageous to get hold of telescopes from a junk shop and to extract the lens. Standard optical multilayer anti-reflection coatings for visible light are almost always useless in the infra-red, as their dimming effect is too great.

The fact that lenses (lens systems) and back lens mirrors (mirror systems) (as opposed to surface mirrors) usually image different wavelengths in different planes can have advantages and disadvantages. There is less interference from undesirable wavelengths if they are not imaged in the plane. If various wavelengths are received as well as the wanted signal, it may be necessary to re-adjust the focus.

In practice, a screen can be necessary during the day if the active area of the detector is larger than the area derived from the screen diameters below, and interference irradiation can occur. It is the plane on which imaging takes place. Imagine that the remote station must be in the open air on a mountain, with the Sun almost behind it... The screen should have a diameter small enough to give the desired reception angle and the material must be very thin. The minimum possible diameter is determined by the mechanical stability and the imaging characteristics of the lens and the aperture error. The diffraction occurring with very small screen apertures is nothing to worry about in practice.

See also Section Calculations (G)

Fitting a filter is necessary in order to keep light with interference wavelengths away from the detector (usually in the daytime), provided that the detector does not have a suitable filter of its own. A few mm² is sufficient if it is attached to the screen, and the filter can be replaceable if applicable. Metal interference filters (Dielectric filters) are very small approximately 0.3nm to 25nm but the mean transmission is only 40%, for composite interference filters the mean figure is only 20%, whereas "normal" filters can have transmission levels exceeding 95%. Inclining the interference filter displaces the transmission range into longer wavelengths. Graduated filters utilise this effect. So for a metal interference filter to become fully efficient in terms of its data, the light must travel parallel to it. With high aperture lenses, then, it is better if the filter is positioned in front of the lens. If the filter is positioned near the detector, the basic optical qualities no longer play any role. Gelatine filters can be used. Since the wavelength of the laser diodes alters in response to changes in the current and the temperature, filters that are too small can cause problems. The laser runs out [19].

The coloured "cover surfaces" of the 7 segment displays can be very suitable, but they <u>must</u> be measured in advance. If applicable, they are tested by being brought into the beam. The variation is observed on a power output meter. They have the characteristics of a low pass filter, based on the wavelength.

Undesirable infra red radiation should be attenuated using infra red stop filters made for CCD cameras and heat protection filters. Heat protection filters are usually fitted as glass strips in slide projectors. They heat up through the heat radiation of the bulb and protect themselves by dissipating the heat to the slide mounting. In practice, lens and mirror systems are also used which consist of tinted glass or "Woods glass". They are optically effective as low pass filters, and there is usually no need for an additional filter.

Reputable dB specifications relating to

the improvement of the signal/noise ratio through the use of filters for a specific case can be calculated, provided that the interference radiation is emitted by the sun. Taking into account the location for the background radiation and the influence of the time of day takes a lot of effort. If the latter influencing variables are disregarded, an improvement of 6dB was obtained in a specific case by means of a metal interference filter (compared to a normal low pass filter).

Nevertheless, almost all measured specifications published are very subjective and can tell us nothing unless the weather conditions and other environmental conditions are specified. There can be an improvement only in the case of incidence of external interference light. But since its intensity can usually not be predicted and can usually not be reproduced, the results remain unclear. On an ideal night, a filter scarcely provides an advantage but in daylight it is usually advantageous.

To reduce scattered interference light, it is necessary to position a “tube” in front of the detector; this is a complement to the tube in front of the lens, which is absolutely necessary. The best dimensions can be determined graphically and/ or by calculation, depending on the receiver angle and the aperture of the lens, as a tube length and a tube diameter.

(See Section Calculations (D))

Metal should be used, or some material combined with metal, if you dont know the materials’ infra red properties, since many materials are very infra red permeable. The detectors are usually particularly sensitive in the infra red, there may be problems. Coatings that are effective in visible light can be ineffective in the invisible spectrum and vice versa.

The surface of surface mirrors and the like can be made damaged even by a very soft paint brush or by breathing on them.

Some of the above instructions can not be applied to the infra red range at present. The use of night vision aids/ image converters and/or IR cameras/ CCD cameras/camcorders with IR stop filters turned off (NIGHTSHOT) can be advantageous.

To be continued.

X. Literature, references (continued)

[29] Amateur Radio Ordinance, (Comes into force end of 2003, beginning of 2004)

[30] Herrmann, Joachim, dtv Atlas on astronomy, Deutscher Taschenbuchverlag, March 1973, P. 20

[31] ADAC Atlas 2004/2005, ISBN 3-82 64-1373-3

Note from the editor:

This article has been difficult to translate and edit because it is in “note” form and the technology is not in my field. I have had some assistance from Carl Lödstrom with the terminology, while emailing copies of his article for approval and he kindly offered to help. I hope that the end result is acceptable for those interested in the optical bands.

Carl G. Lodström, KQ6AX & SM6MOM

The Noble Art of Signal Detection

The device described here is intended as a RF detector. It works fine to above 700MHz, but it actually works very well for DC and audio signals as well! In this article we will basically consider it a RF detector. If nothing else, I must try to restore my sliding reputation after only having written about DC and HF devices lately...

1. Background

This device saw the light of day because I got a few samples of the AD8307 in the wrong package! I assumed they were going to be on the Small Outline format, SO-8 package, for surface mount. Instead they came in the standard, 8 pin, DIL package!

A bit down the road, as I was working with rechargeable Lithium batteries for another project, I became impressed by the capacity of these batteries. Not only quite a few mAh in a small package, they hold 4 to 3V during the discharge cycle, remaining around 3.6 for a good while, and rechargeable as well! The higher voltage alone doubles, almost triples, the capacity as compared to Alkaline and NiCd cells.

The thoughts went on: could the AD8307, a “5V device”, possibly work on these voltages? A look in the data sheet reveals: “Min 2.7V”! This got all four grey cells engaged, and here is what they came up with!

2. Construction

I got the idea to put it all in an Altoid box, and to use a rechargeable 900mAh Lithium-ion battery (Unitrode UBC543483-C or B14FT00200) and a little edge meter that fitted very nicely (Fig 1).

The output from the AD8307 is only approximately 2µA per dB, about 200µA for full range. The output voltage on pin 4 is created by putting this current through an on-chip 12.5kΩ resistor. In my application I want to drive a meter. The one I found, of suitable size, had been waiting for a project like this in my Noble Junk Box! It was a 1mA meter. Well, an NPN transistor in between provided the needed boost! The first one, in the box of various NPN transistors, was a 2N2222. This is way more than needed, it can handle 1A, but will do. An added advantage of using a transistor here is that the AD8307 has a constant approximately 0.9V output with no signal. The V_{BE} of the transistor then takes

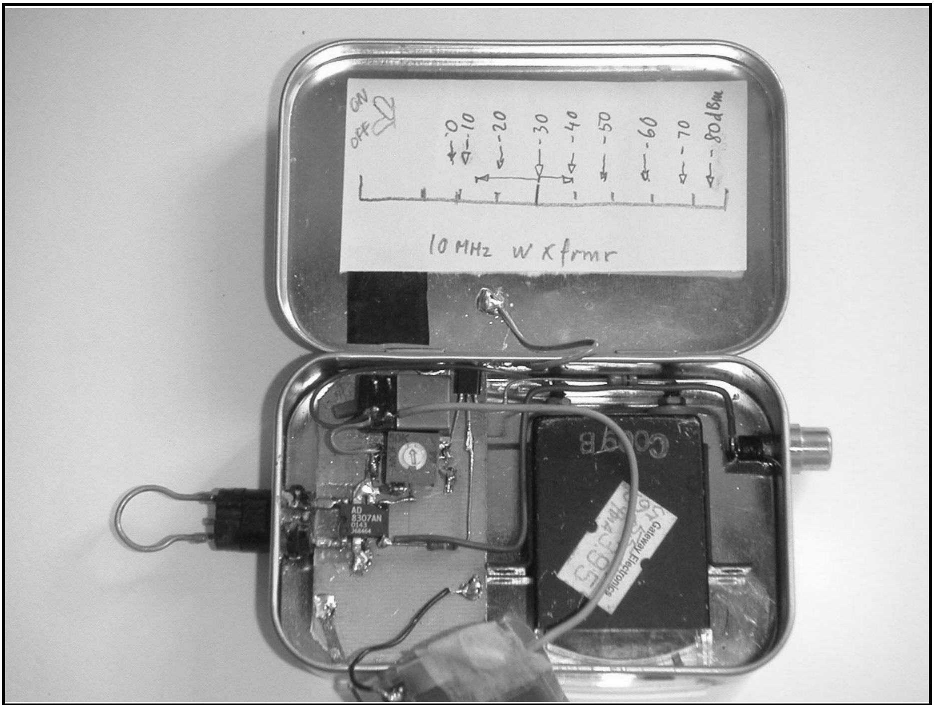


Fig 1: Picture of the Signal Detector in it's Altoid box.

care of some 2/3rd of this voltage. I calculated the resistors and it came close enough. Fig 2 show the circuit diagram of the signal detector.

For my particular 1mA meter the resistor in series would have to limit the battery current (at a little more than 3V) to 1mA when the transistor turns on fully; so 3kΩ in series with the meter. It is a fair assumption that a small transistor has a current gain of 100 in this range. The full output voltage (from a 12.5kΩ source) is approximately 200µA x 12.5kΩ ~ 2.5V. Say 3V and the base needs 10µA for IC=1mA. Say 300kΩ. It should really be more like 220kΩ. It worked well, but later I changed the resistors to 3k9 and 240k.

Naturally, for different meters and transistors, different values would be proper. If your meter is sensitive enough, FS=100µA or less, you may not need the transistor, but a diode, or two Schottky diodes, in the forward direction, in series with the meter will absorb most of the constant 0.9V on the output. Although, see under “Conclusions” for more about this issue!

This detector circuit is insensitive to the supply voltage range, as it can vary with Li battery, but for the meter part where a low voltage will limit maximum deflection. For small deflections, due to small signals, (one division on my meter) B+ can drop to 2.8V before the meter drops. At about 8 divisions (out of 10) the meter begins to drop at 3.8V. So it is quite well adapted to life with a Lithium battery.

Using AD8307 in the SO-8 package is of course perfectly fine too. It will likely increase the upper frequency limit somewhat, in comparison to the performance of the N-8 package.

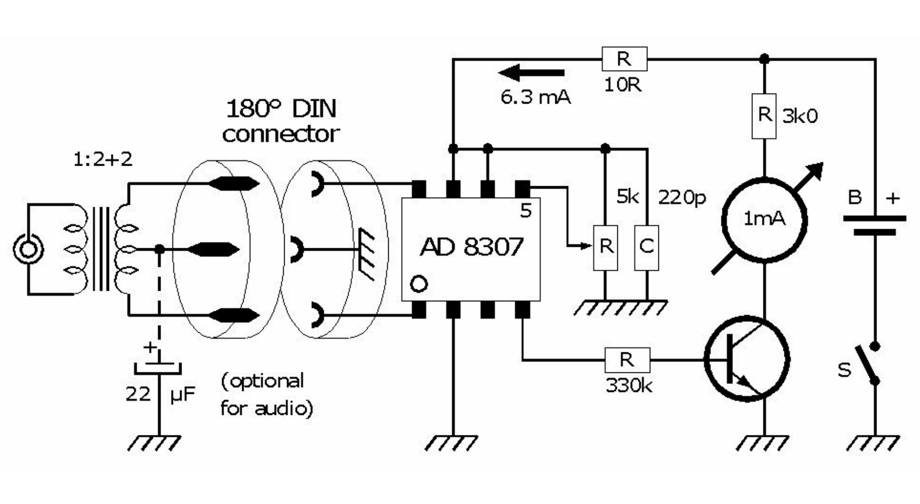


Fig 2: Circuit diagram of the Signal Detector.

3. Plugins

The inputs are purely differential, and although one is marked + and the other - in the data sheet, the output is the logarithm of the voltage difference between them. So either input polarity will result in a positive output. Inputting a differential sine wave will result in an output signal similar to a full-wave rectified wave if the frequency is low enough.

The tracks, on the circuit board, between the pins and the DIN connector, were cleared by hand using a pocket knife. Remove the copper under these pads, minimising the input capacitance.

Notice that the inputs are internally biased some 2.7V above ground and you can destroy the IC by forcing them below ground or above B+, maybe even to the B+. They can be forced to ground. Although the device is floating, when not connected to anything else, beware of touching un-insulated pick-up coils to points of high voltage or where static electricity can be discharged. By its very nature, this is an ESD sensitive device.

Even though the 5 pin, 180°, DIN audio socket is by no means a RF connector, I have found it very practical to use for projects like this. One can easily, and inexpensively, make all kinds of plug-in devices! There are low cost shielded cables available, with this type of connectors mounted. They are at least good for HF! For particular applications, buy a 2 metre long one and cut it in half! You now have two good 1m cables for your bridges or reflectometers!

According to the data sheet, the differential impedance of the inputs is some 1.1kΩ and 1.4pF to ground from either pin. Maybe the DIN connector and the circuit board add a pF between the pins?

In Fig 3 we can see some plug-in accessories. Pick up coils with 1 and 5 turns. The former is useable in detecting signals up to 1GHz, although the detector sensitivity is down quite a bit by then.

The plug-in with a balanced RF transformer (Mini Circuits T4-1) is a 4:1 (impedance) with no centre tap on either side. It is connected to a SMA connector

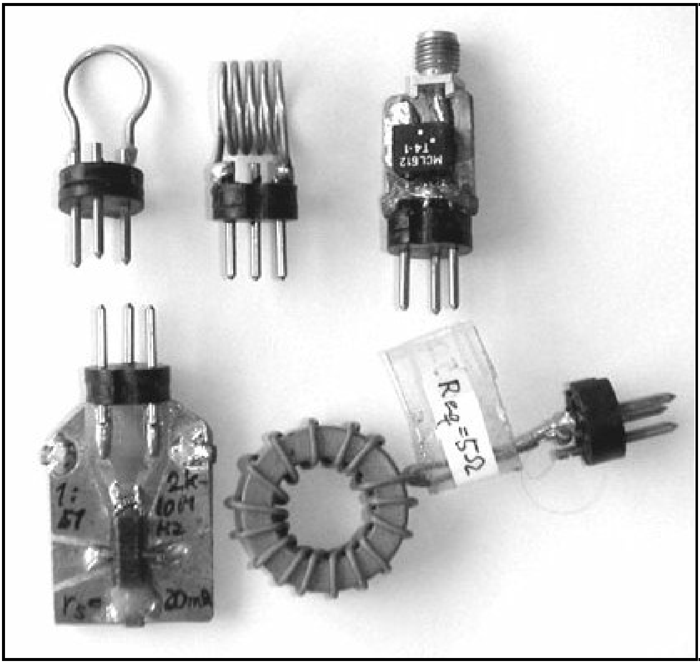


Fig 3: A selection of plug-ins for the Signal Detector. From left to right, top to bottom: single turn loop, 5 turn loop, Mini Circuits RF transformer, "small" current transformer, "large" current transformer.

on the 1 side. Mini Circuits data sheet specifies the 3dB frequency range for this transformer as 0.2 to 350MHz. My measurements agree. In my version it is not properly terminated. With 50Ω on the 1 side and 1.1kΩ of the IC inputs on the 4 side, there is quite a mis-match. If one desire a better 50Ω input, one can put a 240Ω resistor across the DIN connector on the 4 side. Mini Circuits also have 16:1 (impedance) transformers that would fit better, but they quit at some 80 or 120MHz. Your choice.

For current measurements I have prepared a few toroidal current transformers. They work like textbook examples! I put a 50Ω resistor through the core and connected it to a signal generator. Applying 50mV should result in 1mA and it was easily detected! If I loosen either the ground end or the hot end of the resistor, the meter drops to zero. If I move the resistor around within the toroid, the reading is exactly the same. So it is truly the resistor current that is detected, not some capacitive coupling to the windings. This is true up to past 500MHz in spite of the “not RF proper” hookup! This ought to be a really good tool for to determine currents in antenna elements, at least up to the 70cm band. One can excite the antenna with a regular signal generator (or a sweep generator) and see the magnitude of the resulting current (Figs 4 and 5).

The toroid must be wound along its full length, not just over a sector of it. There must be a resistor across the winding, and the inputs to the detector are connected across this winding and resistor. As with all transformers, the turns ratio squared equals the impedance ratio. These transformers induce a “resistance” in series with the conductor measured. See the conductor through the toroid as a “one turn winding”! Assume there are 33 turns on the toroid, and 10Ω across it! The turns ratio is 1:33. The impedance ratio is thus $1:33^2$ or ~ 1:1000. The “resistance” transformed into the conductor is thus 10/1000 = 1/100Ω or 10mΩ. See it as a shunt with a transformer!

Fig 4: Signal Detector measuring current in an HB9CV antenna.

For pick-up of electric fields, as opposed to magnetic fields, one can plug in a wire antenna in one of the input holes, or simply offset a pick up coil so it contacts one input only.

One plug-in unit is a 1:1 audio transformer with centre tapped windings (Fig 6). The secondary CT is grounded to the DIN connector mid pin via a tantalum electrolytic (+ to CT). I am not sure this is needed, but it may keep some noise down. The primary has a twisted pair and a 3.5mm phono plug. This is very useful for receiver measurements, as the transformer prevents potential ground loops and stops common mode noise. The plug goes into the tape recorder or external loudspeaker outlet of the receiver. Measuring, and trimming, a FM receiver 20dB quieting, for example, is now really easy. Note the deflection from the noise at no RF in to the receiver. Apply a CW RF and adjust the level so the reading is lowered by 20dB! Read off the RF level! Done! Actually, this is only an approximately correct reading as the detector, measuring the noise, is not a true RMS detector, but the result on regular noise is not much different. This point, where the FM receiver is quieted some 10 - 20dB by the weak CW signal in, is a very good point at which to trim the front end, and to compare different pre-amplifiers. The point is very sensitive to signal levels; with a slope of almost 2dB on the output per 1dB in for some receivers, and the NF of the pre-amp is included in the measurement. Even if it has a 20dB gain, but no better NF than the receiver input in itself, comparing the receiver with and without the pre-amp by this method will be very revealing! All you need, besides the detector, is a good, stable generator with a calibrated output attenuator!

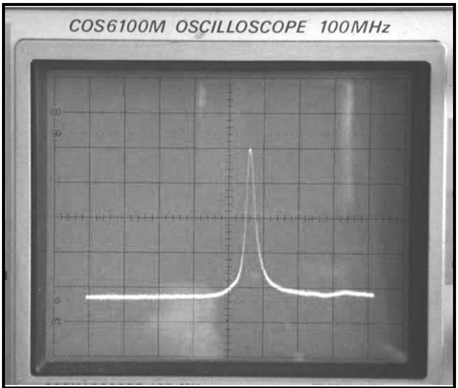


Fig 5: Output of antenna measurement on an osilloscope.

The magnetic fields from a resonator, fed -30dBm at 500MHz, is easily detected! (Fig 7)

4.

Applications, Reflectometer

You can make a simple but good Scalar Network Analyser (Reflectometer) with one Directional Coupler and a VCO (both available at Mini Circuits) in addition to this detector. An oscilloscope sweeps the VCO, or another slow oscilla-

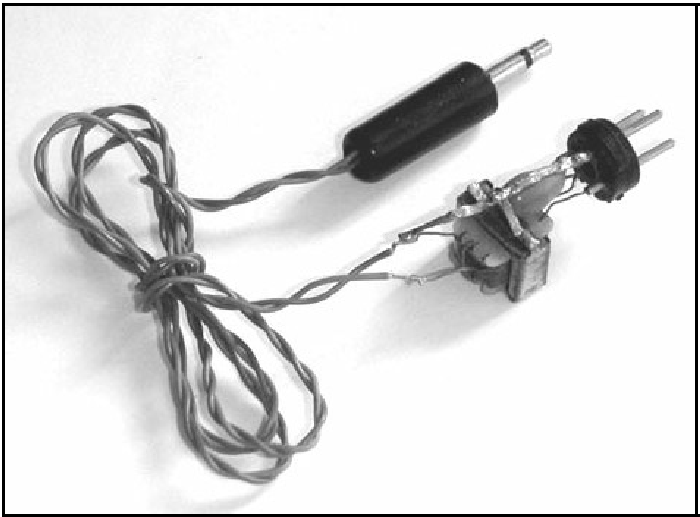


Fig 6: Audio transformer plug-in for Signal Detector.

tor sweeps them both. The RF signal reflected from, or transmitted through, the device under test is detected and nicely plotted on a logarithmic graph that can be up to 70 - 80dB deep with this detector! Connect the scope vertical input to the AD8307 pin 4, using a probe.

A few tips for the builder: the second tone from the VCO may be at some -20dBc (relative to the carrier) so when you tune your DUT to a Return Loss to better than 20dB, you will see a flat bottom on the graph! It is the second tone (and others) for which the DUT is not a good match! The detector is sensitive to them as well. A 50Ω terminating resistor will terminate all energy and a return loss of 35dB or better is a good result, verifying the function. (Notice that return loss is a loss, so it is already negative!)

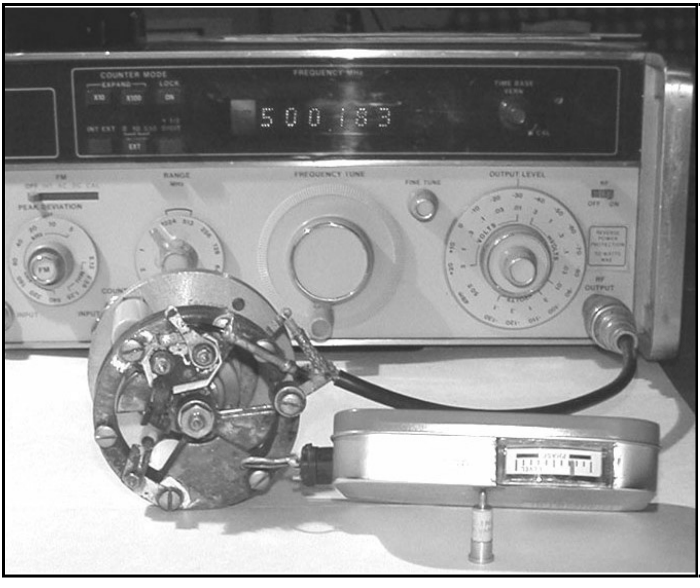


Fig 7: Measuring the magnetic field from a resonator fed only -30dBm at 500MHz. The deflection on the meter is clearly visible.

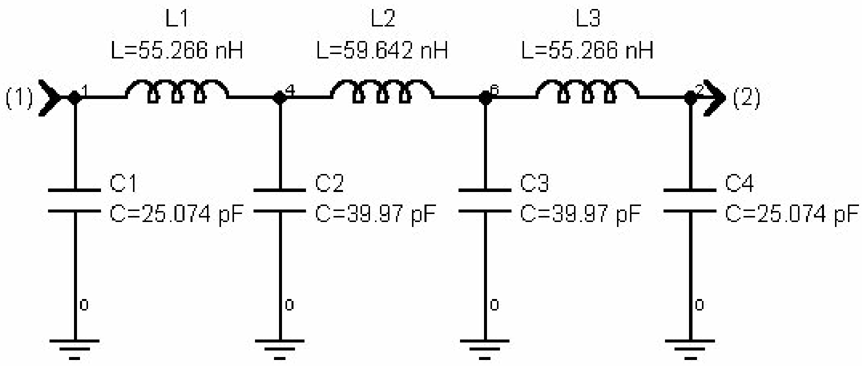


Fig 8: Circuit diagram of the low pass filter.

For good results you will probably need a low pass filter. When using a 100 - 200MHz VCO the filter should be at 200MHz of course, and a 7 pole Chebyshev filter is easy to build and will do very well. Let us settle for a 0.3 dB pass band ripple! Courtesy of Eaglewares GENESYS it is a matter of seconds to calculate it! (Figs 8 and 9) This is for 50Ω in and out. Here it may be good to keep in mind that a filter like this is not the filter you think it is unless it is reasonably well terminated!

The output from a VCO, like the ones I

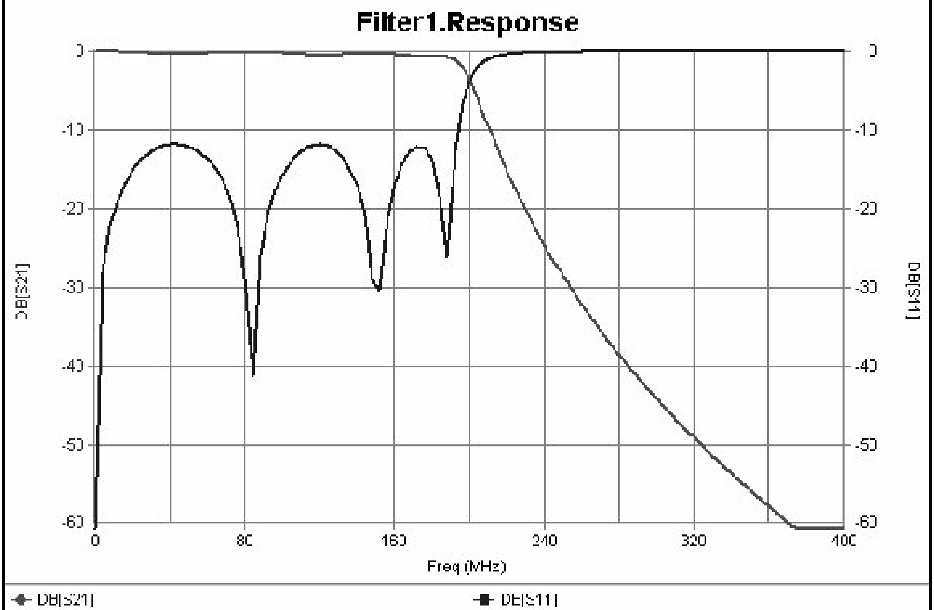


Fig 9: Response curve of the low pass filter.

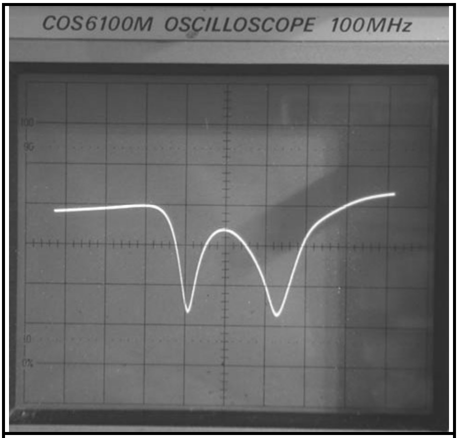


Fig 10: Return loss of a band pass filter. The span of the display is about 50MHz. It shows that the filter is no good because the return loss rises to zero between the dips, it should dip through the entire band.

have suggested, has a lot of output power. The POS-200, in "½ crystal can", covers 100 - 200MHz and produces an output of 10dBm! Harmonics are typically -24dBc for this one and for $12 you can probably not make a better one yourself! While you are planning the shopping list anyway it is a very good idea to include a few of their small, fixed, attenuators. Padding the filter on each side with a 5dB attenuator will leave -2dBm for output (a dB is lost in the filter!) and ensure a good operating environment for the filter as well as a good 50Ω output port for the analyser.

The reason for padding the filter with attenuators is that neither the VCO, nor the load, may be very accurately 50Ω.

We can see that at 150MHz the second harmonic (300MHz) will be approximately ~45dB down. -24dBc was promised in the spec already, it will now be -69dBc, and the signal is very pure and good enough for our measurements! For the third harmonic the filter will of course attenuate even more, some 80 - 90dB.

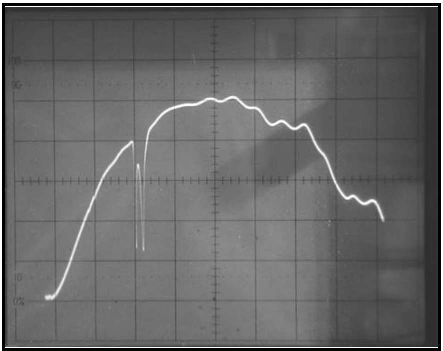


Fig 11: Return Loss of a band pass filter. The span of the display is some 500MHz. It shows that the filter has no spurious responses in this range.

This filter can be realised with 24 and 39pF capacitors and all coils wound with three turns of 0.5mm Cu on a 5mm mandrel. The first and last coils are spread to 2.7mm length, the middle to 2.4mm. 27pF (instead of 24pF) works, but not as well.

The return loss of this filter, approximately 12dB, cannot be improved. Selecting a lower pass-band ripple would improve it, but the skirts of the filter would worsen! It is good enough and a result of how much pass band ripple it was calculated for! The resulting cut-off is pretty good though, and it is all a set of compromises!

One way to realise the filter is to build it on a little piece of PCB laminate. FR4 is fine! Temporarily terminate one end with two 100Ω resistors, one each way to ground! This is a lot better than one single 50Ω resistor! Even when using small SM components.

Put your Network Analyser (Reflectometer) to the other end and tweak the coils for best (lowest reading) of return loss in the pass band! This is a better, and more sensitive, way than to tune for maximum transmission. Which in the end should be checked anyway of course. This filter will have an Insertion Loss of some 0.4dB for most of the band and 0.6dB at worst.

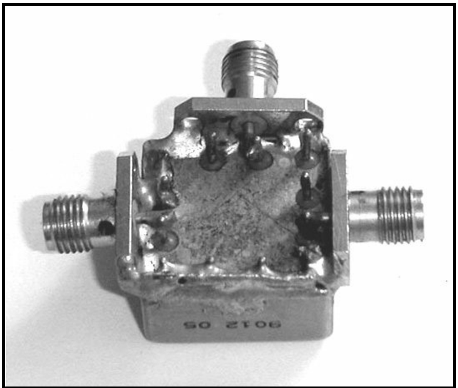


Fig 12: Mini Circuits reflectometer P/N: PDC-20A-5.

The filter in Figs 10 and 11, swept as I suggested, was intended to keep some strong FM station out of the receiver while I picked up 137.62MHz Weather Satellite signals. For reasons long forgotten, it is too wide, 120 - 140MHz, and not very good, as you can see. But it kept the 94.1MHz out...

It may well be beneficial to build filters of this topology as a "fish skeleton" with the inductors lined up as a backbone and each capacitor realised by two components in parallel, one to each side ground plane. This will also allow for tweaking odd component values. 10pF + 15pF (or 12 + 13) is 25pF for example. And 22 + 18 = 40.

This is a lot of filter talk for a detector article, but if you want to make a Reflectometer, this is what you will face sooner or later, so you may just as well plan for the filter from the beginning! It

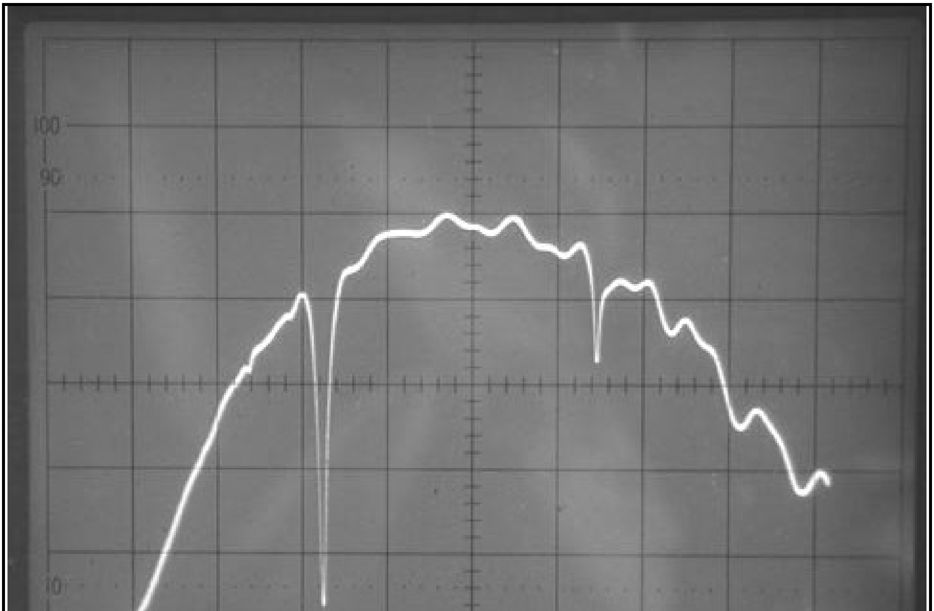


Fig 13: Return Loss of the 145MHz HB9CV antenna shown in Fig 4. The span is approximately 500MHz. The main dip is at 145MHz with a small dip at 450MHz.

does not cost much anyway.

With the low cost of VCOs and home built filters, one might as well make one little board for each octave of interest (Fig 12). The sweeper, directional coupler and the detector can serve all of them. It will be a lot simpler, and less expensive, than to try to make some one clever device covering DC to light...

The sweep is about 0 - 500MHz and we can see the 3f entry where the antenna (HB9CV) goes into resonance again. The match at 145MHz is better than RL 20dB, or near “perfect” (Fig 13).

5. Conclusion

A very inexpensive detector with a wide range of applications has been described. It is simple project to complete, and it can be as fancy or elaborate as the constructor desires.

The very wide dynamic range, up to 92dB, and logarithmic (“linear dB”) output is very attractive to the experimenting amateur and has a wide range of applications. Not only for measurements, but for such things as level control of signal sources as well.

The detector is virtually frequency independent up to 500MHz and predictable to 1GHz.

It may be said that: “If you want to gain a more intimate insight in your little projects, try writing an article about them!” As I wrote this, and took the pictures, it became clear that a simple plug for to connecting the output to a scope, or a recorder, would be a good idea. I added an RCA plug and found that the 1MΩ input of the scope loaded down the output of the AD8307 so I only got some 40dB range on the meter (and the scope). Therefore, the OP I mentioned earlier is probably more than a good idea! Skip the transistor all together!

Pick a resistor between the OP output and the meter so the meter gives a full deflection for the full input to the AD8307, about 2V differentially. Or select it to give some nice dB scale factor on your meter! Also: put a 100Ω or so in series with the OP output and the plug to the scope/recorder. This way the OP will never see a capacitive load (=> instability!) with long, shielded, lines.

Finally: it was a good move to add a few kΩ trim pot (10kΩ would be fine) to pin 5! The DC level of the output can now conveniently be adjusted and no diodes are required... Sensitivity remained unchanged by this.

6. References

[1] The AD8307 is a very versatile circuit and it has so many abilities that I cannot list them all here. I suggest that you download the 20 page PDF data sheet from http://www.analog.com or

http://www.analog.com/Analog_Root/productPage/productHome/0%2C2121%2CAD8307%2C00.html

[2] Mini Circuits http://www.minicircuits.com

Letter from Carl Langley, G3XGK, about component supply

Hi Andy

I guess it's that time again, so I have included my new subscription for next year. Many thanks for running the VHF COMMS for us all, and 73 for 2004. Recently I had purchased for me as a present, your two new microwave books "International microwaves handbook" and "Microwave projects". I find these are really excellent, and seem to fill a need, continuing from where the RSGB collection left off. It's also really nice to see English publications, as it seemed until now, that all new microwave books were destined to come from the USA.

I would like to make a suggestion for an additional chapter next time or maybe it could be a feature from time to time in VHF COMMS.

Over the years (G3XGK 1968) I have mainly been interested in construction and operating vhf - microwaves, antennas to transverters etc. Nowadays, we are very lucky; we can sit at a PC and emulate using inexpensive software (e.g. PUFF) everything from a stripline filter to a GaAsfet amp. Together, with designs by the dozen in our dedicated magazines, but one major item is missing. The components!

Most books/magazines tell us how lucky we are because of the professional development in microwave bands (cellular) makes available the useful parts for the amateur constructors. This may be true in Germany and the USA, but I personally don't see much evidence of it in the UK.

A good example of this is 23cms LDMOS. With the demise of the bipolar module market, clearly the way forward is LDMOS. 50W on 23cms, with a high efficiency 26V PA, which can be easily mounted at the antenna position. Probably equivalent to a pair of 2C39A in the shack! Super, but where are the parts?

Cynical colleagues have suggested that this is due to the fact that we can only make good sandwiches and software in the UK now. Perhaps there is something in this? Most major communication manufactures seem to have folded here now. Even the RSGB microwave components service seems to have deserted major microwave events e.g. Martlesham annual roundtable, to supply parts.

I think what is needed is a new version of the old amateur radio bulk buying group, for microwave constructors, with a low postage rate. Yes, sure you can buy some SMD from people like Famell Direct, and others. But they mostly want you to buy 3000 part reels of l0pF 0805 SMD!

So, is it just possible others may be noticing the same trend now, or is it just me who wants to still experiment? Perhaps a directory of UK small suppliers (SMD) could be compiled that could be useful to both microwave constructors and suppliers, and made available to all readers. Rather than it would seem, the exclusive authors of designs in our publications. Your views on this would be interesting.

Carl

Response from Andy Barter, G8ATD, editor of VHF Communications

I think the supply of parts is a problem, certainly in The UK and also in many of the other countries where VHF Communications is read. I often receive request for specific components via my web site and try to help when I can. The Italian agent for VHF Communications keeps a wide range of components but there is a real problem when it comes to supplying small quantities of, for example, SMD parts.

I would be happy to publish a component suppliers directory in VHF Communications but need information from the readers about potential suppliers. I already act as an agent for the UKW Berichte kits and would be happy to do the same for any other suppliers.

If anyone reading this letter has an information to help build up a component directory, please send me an email or letter and I will report back in the next issue.

The other things I am always looking for are good articles to publish in VHF Communications. Nearly all the reader feedback says that the practical constructional articles are the best. If you have built a piece of equipment recently I can help turn that into an article for the magazine, just send some photographs and a brief description of the project and I will help turn it into an article. When I work directly with an author I send copies of the article before it is published so that it can be amended until it is satisfactory. This week I have been emailing Carl Lödstrom copies of his article for this issue and it has resulted in a very good article.

Andy

Gunthard Kraus, DG8GB

Internet Treasure Trove

SONNET

There's some very important news for those using the free Lite version of this familiar EM simulation program: the newest update gives you free access to something people have been waiting for a long time. Now you can finally connect an exciter port into the centre of the structure as well, and not just (as until now) to the wall of the metal box which is required for the simulation. So now, for example, patch antennas can also be powered directly on the patch and not just via a tiresome long supply line. That's really a concession worth having!

Address:
http://www.sonnetusa.com

University of Ulm

And now for something completely different: here you can find the processes taking place in waveguides, couplers, circuits and filters, etc, presented in vivid animated form. And to round things off, both a demo version of the analysis program in use (TLM = Transmission Line Matrix Method) and a link relating to the animation program are available. Very informative and amusing, even as revision for people who already know everything!

Address:
http://mwt.e-technik.uni-ulm.de/lehre/hf-anim/mefisto/

Engineers Heaven

The heading for this homepage, run by a Turkish university, makes an interesting promise. Just looking at the sections on offer is a pleasure, as you contemplate the data available concerning microwave technology.

Address:
http://www.ee.bilkent.edu.tr/~microwave/magnetic.htm

EMC Technology

This website has some interesting application notes, which you can study and download, they are mainly concerned with couplers and circulators. But they also include information on the practical fitting of SMD components on microwave printed circuit boards.

Address:
http://www.emct.com/softwaretools.htm

TMEG

This is an acronym for “The Millenium Education Group” and consequently there are some very nice tutorials. The two sections on “Transmission Lines” and “Antennas” are particularly interesting, but there is also “Babylonian Mathematics” or “an electronic needle gun”. So, for anyone who's interested .....

Address:
http://www.tmeg.com/index.html

RF Tools

Another of those homepages where you almost find yourself feeling giddy: innumerable RF tools and documents of all kinds are on show for interested users to sniff out and download. You just can't count everything there is here. I recommend you set aside sufficient time, then just open up the site.

Address:
http://rfengineer.cc/rftools.htm

Chenjian's Electronic Packaging

Anyone looking for up-to-date information on the state of manufacturing technology, including housings for integrated RF components (amplifiers with integrated coils, capacitors and resistors, couplers, etc.) should have a look at this site. The content ranges from information on trends, technologies, production processes and opinions on reliability right through to material trials, and finally an "Online Dictionary".

Address:
http://chenjian.virtualave.net/packaging/tech/other/rf/rf.htm

Faustus

The classical touch extends beyond the company's name to its product, MEFiSTo. This is (another...!) EM simulator, but here, for a change, the company has found a different way to awaken customers' interest. They're currently introducing the most recent version onto the market as a 3D simulator, and so they're giving away an older, fully operational "Classic 2D Version", to be downloaded free of charge. Quite an interesting move!

Address:
http://www.faustcorp.com/downloads/index.html

MURI

Or, to reveal its full title: "The Multidisciplinary University Research Initiative (MURI) for High Power, Broadband, Linear, Solid State Amplifiers at the Cornell University".

Fortunately, these friendly people do not lock their findings and their documents away in the safe but make them freely available. But clearly not without reservations, or maybe an enthusiast for memory games is in charge of the homepage! There is no index, and everything is actually hidden away behind anonymous report numbers in a huge file, and it really is like playing some game. You have to uncover and examine everything first to find out whether you can get anything out of it. Luckily, the hit rate is really excellent......

Address:
http://iiiv.tn.cornell.edu/www/schaff/muri/reports/

Jim Hardy's Homepage

For once, something from a private individual, very nice and amusingly put together. Not just links to many of our areas (it turns out the man is also a radio ham!), but also a lot of funny material. The following section is particularly worth reading: "How Things would be different if Microsoft built cars" Its true you have to root around a bit, but its worth it for what you can find.

Address:
http://www.surfsouth.com/~jhardy/index.htm

Software for the Radio Amateur

Here's another link for people who like to spend hours surfing and rooting around. Luckily, everything is listed alphabetically, and so you can carry out a targeted search.

Address:
http://www.estpak.ee/~andrew/ham/software.htm

VHF Communications Back Issues Available

Year	Q1	Q2	Q3	Q4
2003	Y	Y	Y	Y
2002	Y	Y	Y	Y
2001	Y	Y	Y	Y
2000	Y	Y	Y	Y
1999	Y	Y	Y	Y
1998	Y	Y	Y	Y
1997	Y	Y	Y	Y
1996	Y	Y	Y	Y
1995	Y	Y	Y	Y
1994	Y	Y	Y	Y
1993	Y	P	Y	P
1992	Y	Y	Y	Y
1991	P	P	P	P
1990	P	P	L	P
1989	P	P	P	L
1988	P	P	P	L
1987	P	P	P	P
1986	Y	Y	Y	Y
1985	Y	Y	Y	Y
1984	Y	Y	Y	Y
1983	P	Y	Y	Y
1982	P	P	P	P
1981	P	L	P	P
1980	P	P	P	P
1979	L	P	L	P
1978	P	P	P	P
1977	P	P	P	P
1976	P	P	P	P
1975	P	P	L	P
1974	L	P	P	P
1973	P	P	P	P
1972	P	P	P	P
1971	P	P	P	P
1970	P	P	P	P
1969	P	P	P	P

Key

Y = Available **L = Low quantity** **P = Photocopy**

The back issue sets contain issues marked Y. Issues marked L or P must be ordered separately.

VHF COMMUNICATIONS

A Publication for the Radio Amateur Worldwide

Especially Covering VHF, UHF and Microwaves

Volume No.36 Spring Edition 2004-Q1

Publishers: KM PUBLICATIONS, 63 Ringwood Road, Luton, LU2 7BG, United Kingdom
Tel: +44 1582 581051
Fax: +44 1582 581051

Email: andy.@vhfcomm.co.uk

Editor: Andy Barter G8ATD

VHF *COMMUNICATIONS*: The international edition of the German publication UKW-Berichte is a quarterly amateur radio magazine, especially catering for the VHF/UHF/SHF technology. It is owned and published in the United Kingdom in Spring, Summer, Autumn and Winter by KM PUBLICATIONS.

The 2004 subscription price is £20.60, or national equivalent. Individual copies are available at £5.15, or national equivalent each. Subscriptions should be addressed to the national representative shown in the next column. Orders for individual copies of the magazine , back issues, kits, binders, or any other enquiries should be addressed directly to the publishers.

NOTICE: No guarantee is given that the circuits, plans and PCB designs published are free of intellectual property rights. Commercial supply of these designs without the agreement of the Author and Publisher is not allowed. Users should also take notice of all relevant laws and regulations when designing, constructing and operating radio devices.

Translated by: Inter-Ling Services, 62 Caldecott Street, Rugby, CV21 3TH, UK

Printed in the United Kingdom by: Cramphorn Colour Printers Ltd., 15a Boughton Road Industrial Estate, Rugby CV21 1BQ, UK.

AUSTRALIA - Mark Spooner c/o, W.I.A SA/NT Division, GPO Box 1234, Adelaide, SA 5001, Australia Tel/Fax 08 8261 1998

BELGIUM - UKW-BERICHTE, POB 80, D-91081 BAIERSDORF, Germany. Tel: 09133-77980. Fax: 09133-779833 . Postgiro Nbg. 30445-858.

DENMARK - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

FRANCE - Christiane Michel F5SM, Les Pillets, 89240 PARLY, France
Fax: (33) 03 86 44 08 82 Tel: (33) 03 86 44 06 91

FINLAND - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

GERMANY - UKW-BERICHTE, POB 80, D-91081 BAIERSDORF, Germany. Tel: 09133 7798-0. Fax: 09133 779833.

GREECE - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

HOLLAND - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

ITALY - R.F. Elettronica di Rota Franco, Via Dante 5 - 20030 Senago, MI, Italy
Fax 0299 48 92 76 Tel. 02 99 48 75 15

NEW ZEALAND - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

NORWAY - WAVELINE AB, Box 60224, S-216 09 MALMÖ, Sweden. Tel: +46 40 16 42 66. Fax: +46 40 15 05 07. GSM: 0705 16 42 66
e-mail: waveline@algonet.se http://www.algonet.se/~waveline

SOUTH AFRICA - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

SPAIN & PORTUGAL - JULIO A. PRIETO ALONSO EA4CJ, Donoso Cortes 58 5° -B, MADRID 15, Spain. Tel: 543 83 84

SWEDEN - WAVELINE AB, Box 60224, S-216 09 MALMÖ, Sweden. Tel: 040 16 42 66. Fax: 040 15 05 07. GSM: 0705 16 42 66 e-mail: waveline@algonet.se http://www.algonet.se/~waveline

SWITZERLAND - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

UNITED KINGDOM - KM PUBLICATIONS , 63 Ringwood Road, LUTON, LU2 7BG, UK. Tel: +44 1582 581051. Fax: +44 1582 581051. Email: vhfsubs@vhfcomm.co.uk

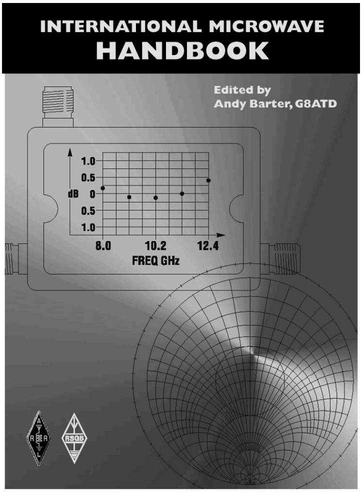
U.S.A. - GENE HARLAN, ATVQ Magazine, 5931 Alma Drive, Rockford, IL 61108, USA. Tel: Toll free USA only: 800 557 9469; Elsewhere: +1 815 398 2683; Fax: +1 815 398 2688
Email: atvq@aol.com

ELSEWHERE - KM PUBLICATIONS, address as for the U.K.

WWW: http://www.vhfcomm.co.uk

ISSN 0177-7505

The International Microwave Handbook



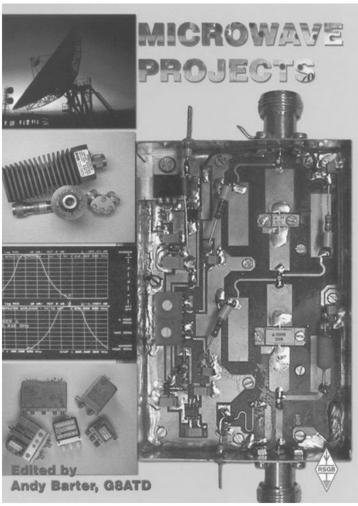
The microwave bands are an excellent area for radio amateurs who want to experiment and construct their own equipment. The RSGB in partnership with the ARRL has produced this invaluable source of reference information for those interested in this area, along with excellent designs from around the world to fire the imagination. Material has been drawn from many sources including the RSGB journal RadCom and the ARRL publications QST & QEX. Alongside this material a truly international range of sources have been used including items from Germany, Denmark, New Zealand, Slovenian and many more.

The earlier chapters of the book provide invaluable reference material required by all interested in this exciting area of experimentation. Techniques and devices are covered in depth, leading the reader to understand better the wide range of equipment and techniques now available to the microwave experimenter. This book contains a wide selection of designs using the latest technology that can reasonably be used by radio amateurs and ranges from ones that can be reproduced by most radio amateurs to those that require a high degree of skill to make.

With the explosion in consumer electronics using microwave frequencies the opportunity to experiment has never been greater and this book is simply the best guide to the area of microwave radio.

Available in the UK for £24.99 from www.rsgb.org/shop and in the USA for $39.95 from www.arrl.org ISBN 1-872309-83-6

Microwave Projects



Microwave Projects is aimed at those who are interested in building equipment for the amateur radio microwave bands.

Packed full of ideas from around the world this book covers the subject with a variety of projects. The book has many contributors who have a wealth of experience in this area and they have produced many projects, design ideas, complete designs and modifications of commercial equipment, for the book.

This title provides much useful information as to what can be achieved effectively and economically. Aimed at both the relative novice and the "old hand" the book also covers useful theory of designing microwave circuit and test equipment for the projects. The book includes chapters covering:

• Signal Sources • Transverters • Power Amplifiers

• Test Equipment • Design

Microwave projects is a must have book for all those who are already active on the microwave bands and those looking for interesting projects to embark on.

Available for £14.99 from www.rsgb.org/shop ISBN 1-872309-90-9