

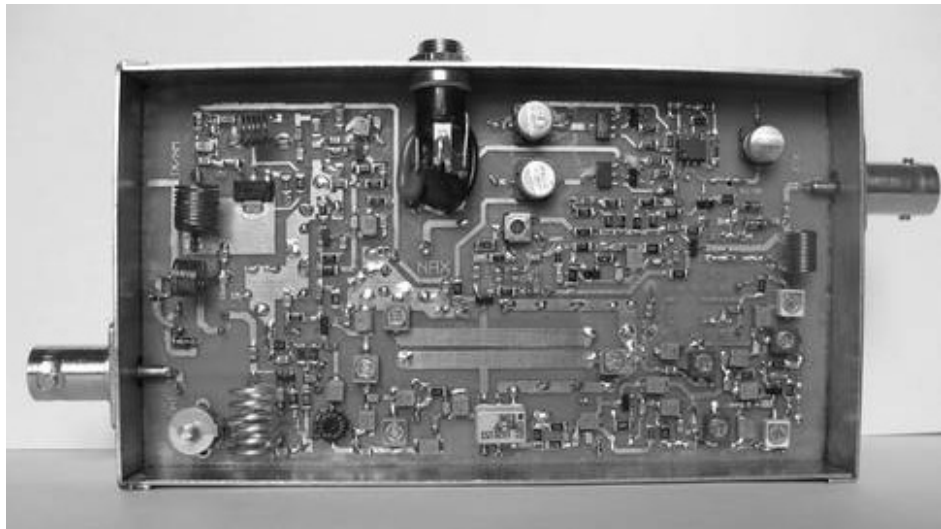


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T470/670 A 4m(6m) to 70cm transverter

Lapo Pieri, IK5NAX



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There are 5 articles from subscribers to this magazine in this issue, which is great to see. It brings a good variety of articles and some interesting new topics.

One of the articles from the German magazine describes HPIB/GPIB control software that is in German but Hans Ulrich Schmidt has help me to get English translations of the instructions on his web site to help anyone who wants to try the software. The instructions plus a link to his web site will also be on the VHF Communications web site.

73s - Andy



K M Publications, 503 Northdown Road, Margate, Kent, CT9 3HD, UK

Telephone / Fax +44 (0)1843 220080, email : andy@vhfcomm.co.uk

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



Paolo Petrini, IW1ACL

The Network Analyser

1.0

The Network analyser.

The Network Analyser is a very powerful instrument, a dream for most radio amateurs. It can be used for testing almost any circuit such as antennas, filters, amplifiers and cables. With a suitable test set it is possible to measure impedances and transfer functions (gain, attenuation) of coaxial and waveguide circuits.

There are two fundamental types of Network Analyser, scalar and vector. Scalar analysers measure the power of signals applied to its inputs, typically detectors, while vector analysers use a down converter to get a lower frequency (under 500kHz) where it is easier to measure amplitude and phase relationships with great accuracy (frequency converters maintain amplitude and phase relationship from input to output).

2.0

Scalar analyser.

Three important examples of scalar analysers are the HP8754, HP8755 and Wiltron 560 series. All these instruments require an RF generator (sweeper) and a

test set, typically an RF bridge. For the radio amateur this can be a good and cheap solution.

- The advantages are: lowest cost, easy to use, compact solution, broadband (bandwidth depending only on the sweeper and detectors)
 - The disadvantages are: impossible to measure impedances, impossible to implement error correcting techniques, just basic performance, limited dynamic range and no up-grade path.
-

3.0

Vector network analyser (VNA)

VNAs are complex machines containing the circuitry for broadband signal down conversion, and sophisticated signal processing in order to compute phase and amplitude relationship between two or more signals, one used as reference and the other (or more than one) used as measuring input(s). If the reference is connected to the “FDW” port of a dual directional coupler and the other to “REFL” the analyser will directly compute and display the reflection coefficient of the device connected to the main port of the coupler.



Fig 1: Scalar analyser with storage normaliser.

- Advantages: computes modulus and phase, high dynamic range higher performance, possibility for error correction, possibility for group delay measurement and other sophisticated techniques, greater precision.
- Disadvantages: higher cost, large and bulky instrument, tougher requirements on RF generators and the necessity of calibration kits.

The first VNA was produced by HP in the late sixties and was worth a fortune (like a nice cottage in a famous seaside resort), and named the HP8410A. After 40 years it still offers remarkable performance. It was an all-analogue machine that contained an immense quantity of engineering skill. In 1976, HP entered the market with a compact analyser that had an integrated generator and test set, but limited to 1300MHz, the HP8505A. In the mid eighties it was followed by the HP8510A, more compact and microprocessor based with built-in error correction. In this period also Anritsu (who had acquired Wiltron) and Rohde-Schwarz entered the market, now very competitive. The ultimate trends are towards multiport, nonlinear circuits, and 110GHz. The analysers are more and

more like a Personal computer with dedicated hardware, and a question arises: for how long can they be maintained? Remember that the older instruments are still usable after 40 years.

The average amateur has a very limited choice: HP8754 (see Fig 1), 8755 8410 8505 and Wiltron 560-61-62. The HP8510 [1] is still too expensive for the average amateur, and the instrument itself is locked to a few proprietary generators which are still very expensive. A budget of \$10,000 is just a minimum. Moreover, the machine is difficult and expensive to repair.

The 8505A is a good compromise for the radio amateur, and it is available at an affordable price and can be found for about \$1000 (complete with test set) on Ebay. Its main drawback is the "closed design" which makes it impossible for any upgrade, and the frequency is limited to 0.5 - 1300MHz, but adequate for most ham radio bands (see Fig 2).

The old analogue 8410 [2] is very bulky but can be found for even less than \$500 on Ebay or surplus dealers, complete with its 8412A phase magnitude display. The test set is worth another \$500, while a do-it-yourself solution can be much

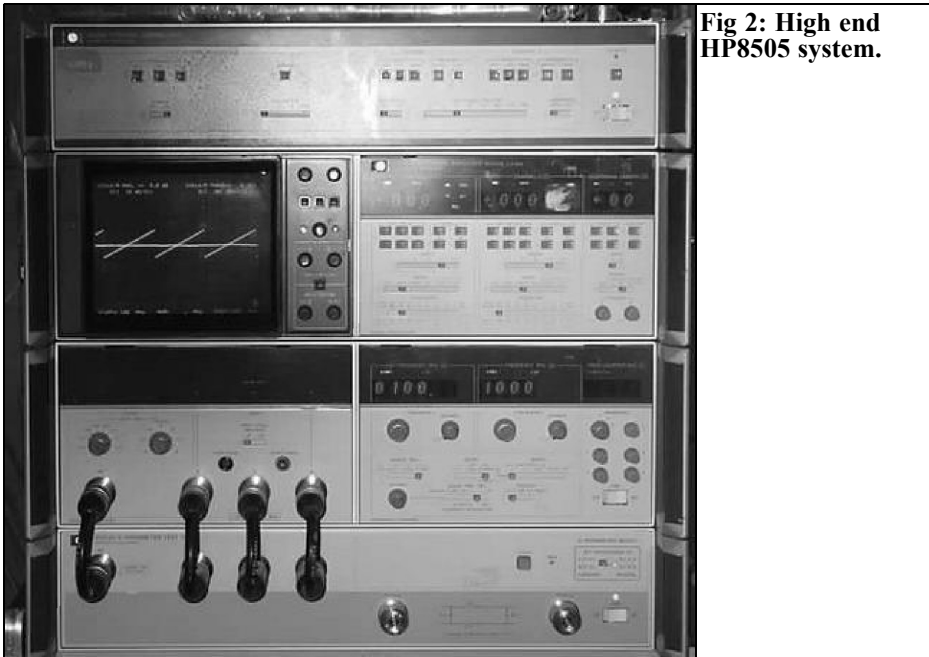


Fig 2: High end HP8505 system.

more expensive. It can be used with any generator, from the oldest BWO based sweeper to a modern synthesiser. Its design is transistor based and very easy to repair, the service manual is very complete with schematic, voltages and waveforms at test points and troubleshooting available. The only difficult to repair module is the 8411A frequency converter [3] ; due to the low prices it is more convenient to have a spare one. The display can be rectangular (amplitude in dB and or phase in degrees vs frequency) or polar on a Smith chart. A 0-10V ramp from the generator provides the frequency information for the display. I recommend the so-called phase magnitude display because it can be used for reflection and transmission measurements. The instrument also needs a test set, which can be constructed by the radio amateur or found on the surplus market. From the same manufacturer one can choose between transmission / reflection or S-parameter test sets. Transmission / reflection is my favourite because the so-called S-parameter test set is just

more complicated and I never had the need to measure the reverse gain or S22; in addition its internal layout is not compatible with the newer measurement techniques such as load pull (the new techniques require a common reference for all four power waves measured). The major problem with those old test sets is their frequency range: one has to choose between 0.1 - 2GHz (but usable to 3GHz) and 2 - 18GHz (usable to 0.5GHz). There is no special need to buy a test set like the 8743A (except the price and the fact of getting a ready made unit). A do-it-yourself unit built with SMA components requires about 1/10 of the space taken by the 7mm connector (APC7) based one. SMA is a requirement if we want to use the 8410 at 24GHz with some precautions. Extra hassle comes from the low directivity of most commercial and cheap couplers, so computer correction becomes a necessity. The last piece of equipment needed is a generator: here a larger budget means better performance. But remember that older and cheap sweepers still permit simple (and real



Fig 3: Entry level VNA.

time) measurements. I would recommend something like the 8350A with plug-ins for the interesting frequencies; this machine is still an analogue sweeper, but it can easily be computer controlled via GPIB. Buying cheaper and older sweepers is not convenient because they are less stable and make computer control more difficult.

Being an old style machine, the 8410 is very easy to interface: just a 2 channel analogue to digital converter, or two voltmeters (modulus output: 50mV/dB, phase output: 10mV/deg) are needed. Extra care is required if we want measure in multi-octave sweeps (e.g. 300 -

1500MHz): in this case we must provide the 8410 with “pre-tune” information with a ½V/GHz analogue signal (0.15 - 0.75V for the 300 - 1500MHz sweep).

4.0

Basic performance.

At this level, the user can measure and display, in real time, impedances or transfer functions as a function of frequency, with no error correction. Fig 3 shows an entry-level VNA. From top to

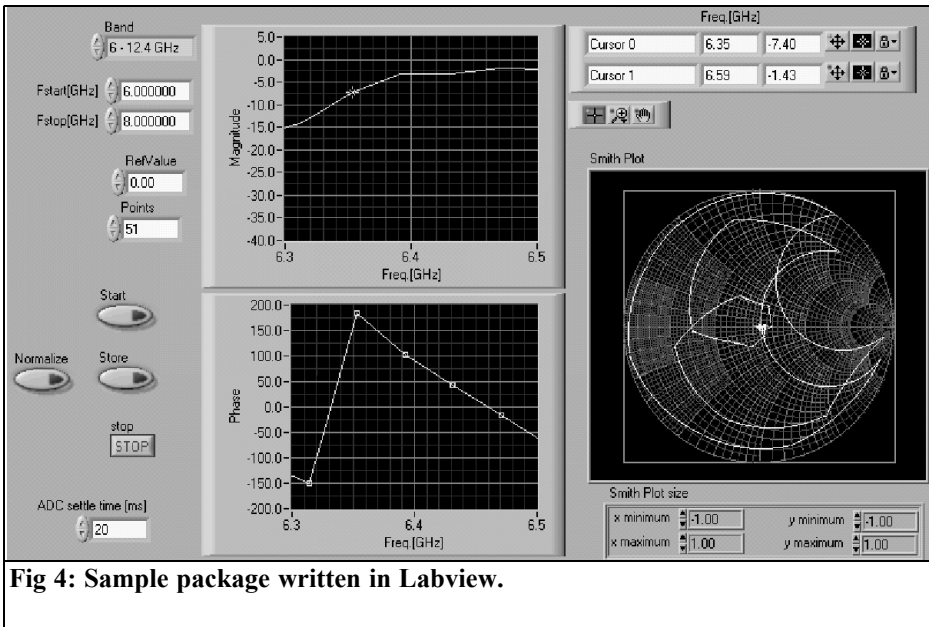


Fig 4: Sample package written in Labview.

bottom the reader can see an HP8620 solid-state sweeper, the 8410B main-frame and below the so-called transmission-reflection test set HP8743A (2 - 18GHz) that accommodates the frequency converter 8411A at the rear (part of the 8410 machine). Basic performance is well explained by the HP application note AN92 (a very old one and some proposed solutions are now unpractical; however the ideas behind are still valid).

4.1 Accessories.

Let us suppose that SMA (the same applies for N) will be the most used connector. As a minimum the following parts are needed:

- 2 x APC7 to SMA-F adapters (transforms the test set equipped with 7mm connectors to SMA)
- 1 x SMA short circuit
- 1 x SMA shielded open circuit
- 1 x SMA 50Ω load, high quality; it can be built mounting two 100Ω

0805 resistors in parallel on a flanged female connector, having acceptable performance to 20GHz.

- 1 x SMA sliding load (optional) 3-6-10-20dB SMA attenuators
- Quality flexible cables (can be substituted by .085" semirigid cables with SMA connectors)

These parts must be kept separated from the other components, in a clean box; before use they should be inspected and cleaned with isopropyl alcohol, or equivalent product. The test port for impedance must have the minimum necessary number of adapters (i.e. 7mm to N and N to SMA is to avoided if you are using SMA) If the budget allows for it, APC3.5 is a premium substitution for SMA, due to its reliability and repeatability.

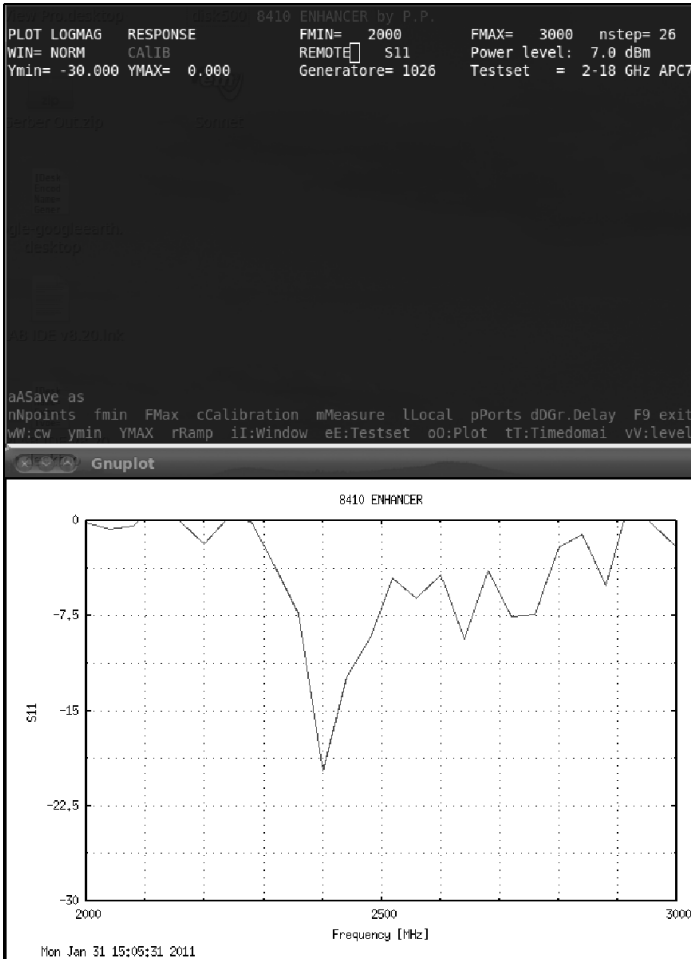


Fig 5: Sample package written in text mode Pascal.

5.0 Upgrade path.

Here I suggest an upgrade path starting with a basic 8410 system.

Step one.

If the radio amateur wants to invest some money in his or her setup, the best choice is to buy a medium performance synthesised sweeper (many models and manufacturers are available such as Gigatronics 610, 1026); consider a budget from

\$500 to \$2000. This gives a lot of advantages: the measurement becomes more stable and repeatable, seen also by the reduced size of the “dot” on the 8410 screen.

Step two.

The following step is a computer interface and control. Here we must be acquainted with a programming language like traditional C or Pascal, or proprietary (but easy to use) graphical packages like Labiew or Vee [4] (see Fig 4). I cannot recommend any language or software package because everybody has his or

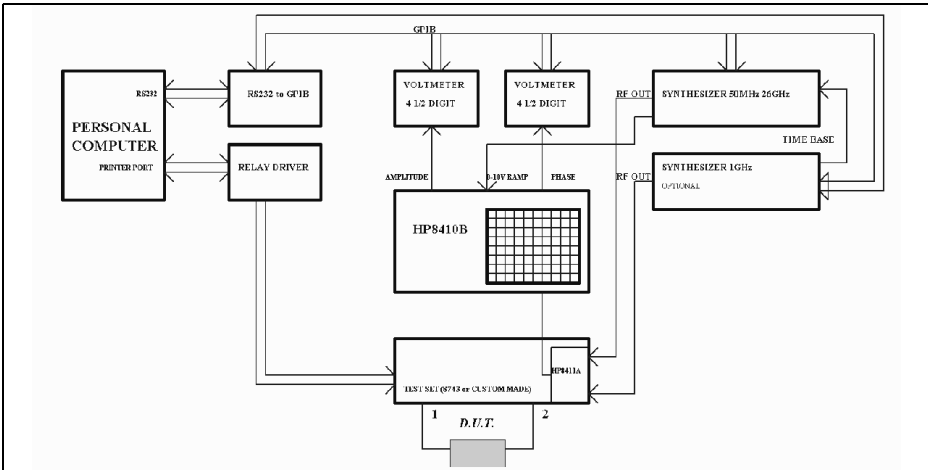


Fig 6: Block diagram of the authors setup.

her preferences. But be aware of the hassle caused by incompatibility between package and operating system or unsupported cards (sometimes there is no solution). My personal setup is very flexible and does not depend on a particular operating system or language or special cards. I use a RS232 to GPIB converter, and have written the software in Free-Pascal running under Linux (also available for Windows, OS2, Leopard and other operating systems); the graphic package is GnuPlot, available for free. See Fig 5. In the early days I used an ISA card with an 8 channel [5] 12bit Analogue to Digital converter plus D/A [6] and discrete I/O [7]. Later I changed the computer and the ISA interface disappeared. All the interfacing work done was lost. So I got an RS232 to GPIB converter and two 5-digit system voltmeters. Now my only requirement (!) is to get computers with wired RS232 and a printer port [8], however this is not an easy task. In worst case a so-called "industrial PC" is equipped with such interfaces. At this performance level many extra functions become feasible, such as response calibration, data smoothing and interpolation, data storage, power sweep [9] at single frequency,

group delay and time domain analysis.

Step three.

A further step is to get a low frequency synthesiser (<200MHz, such as HP8757A) and make a small modification to the 8410 to override the internal VCO (documented in the 8410B service manual & schematic), unless an 8410C is available. The second generator is tuned to a frequency whose nth harmonic is 20.278kHz from the frequency of interest, typically 100150MHz. This modification also avoids the ± 20.278 MHz ambiguity in the phase lock circuit, thus increasing the accuracy. This upgrade permits sweeps of any width (e.g. 1 - 18GHz) without phase lock problems, in particular at very high frequencies. This second generator must be tuneable with at least 10Hz increments. One of the two generators must have a high stability time base, which must be shared with the other [10]. Fig 6 shows the block diagram of my setup: the optional synthesiser is used in "step 3", while the voltmeters and realy driver in "step 2"; the 50MHz - 26GHz synthesiser is for "step 1" and substituting it with a sweeper one returns to the entry-level setup.

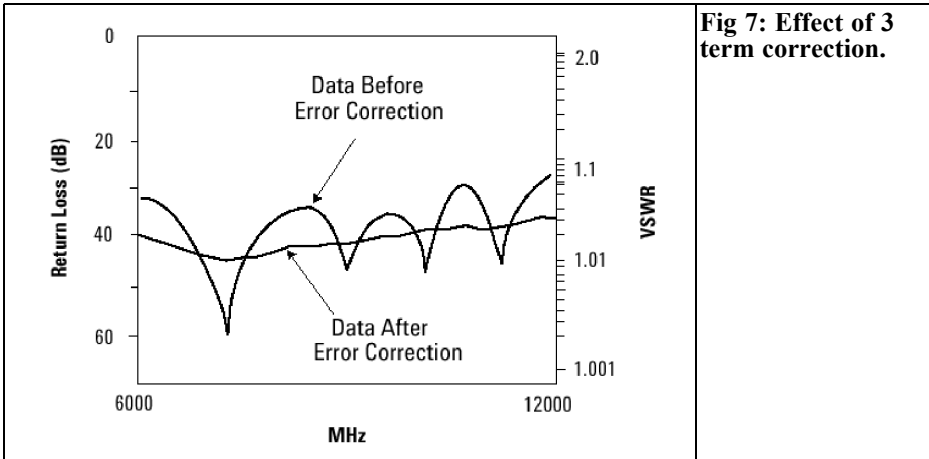


Fig 7: Effect of 3 term correction.

6.0

Following steps.

At this hardware performance level there are more possibilities (hardware and software), which are well above radio amateur's needs, and approaching those one can obtain by a modern analyser:

- Implementation of 3 term error correction for S11 (see Fig 7)
- Construction of a full S parameter test set
- Implementation of 12 term error correction
- Implementation of load pull
- Construction of waveguide or microstrip S-parameter test set
- Acquisition of a professional calibration kit

7.0

Conclusions.

The Network Analyser is a very powerful

instrument that can be very useful for most radio amateurs involved in RF construction; however thorough planning is necessary before making a choice and buying the instrument. Budget is first [11] , followed by performance needed [12], ease of use, space in the laboratory, and programming knowledge.

8.0

References

- [1] The 8510A is equipped with bubble memory and thus less reliable than B or C versions. The 8510B is equipped with CS80 mini cassettes for firmware-data storage. The 8510C is equipped with standard floppy disk
- [2] The recommended models are in order of preference: 8410C, 8410B and 8410A
- [3] Option 018, guaranteed to 18GHz, is recommended
- [4] These easy to use packages have a large library of drivers for many cards and instruments, but run only with certain configurations.
- [5] One channel for modulus, one for



phase and one sampling ramp signal

[6] Providing $\frac{1}{2}$ V per GHz for pre-tuning the 8410

[7] Providing stop-sweep signal and test set control

[8] USB and PCI interfaces are difficult to use for the average programmer.

[9] Used to determine the 1dB compression point

[11] In a typical ham radio laboratory the instrument will be switched on a few hours per week, so do not overestimate your needs

[12] Do not search for too high performance, e.g. 26GHz if you are not interested in 24GHz band, because all accessories will be very expensive, even on the surplus market. A good compromise is a 12GHz unit for the VHF-UHF-SHF amateur, and a 1 - 2GHz unit for the amateur working in HF-VHF. For HF only, there are modern and compact solutions such as those provided by N2PK

9.0

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André Jamet, F9HX

Microwave PCB gluing

1.0

Introduction

Microwave PCBs are located in boxes to avoid mechanical aggression and for Electromagnetic Compatibility.

For low power devices like LNA and up to 10GHz, tin plated boxes, usually called “Schubert” are used. For an SSPA and for higher frequencies, we use milled aluminium boxes.

In this second arrangement, power transistors are directly fixed to the milled box and the PCB must also be a tight fit. A good thermal contact is required because some components are dissipating power.

A good electrical contact is required to avoid instabilities. Fixing by screws is not enough and we have to glue the all surfaces.

Therefore, gluing must provide low thermal and electrical resistance between the PCB and the box. We need good conductive glue for heat and electricity.

2.0

Electrical Characteristics

2.1 Electrical conductive glues

They are known as ECA (Electrically

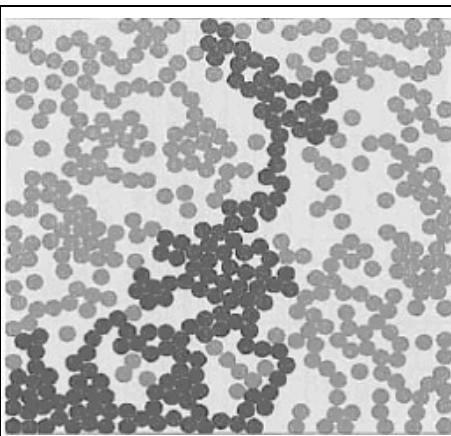


Fig 1: Microscopic cross-section view of a glued joint with circular particles.

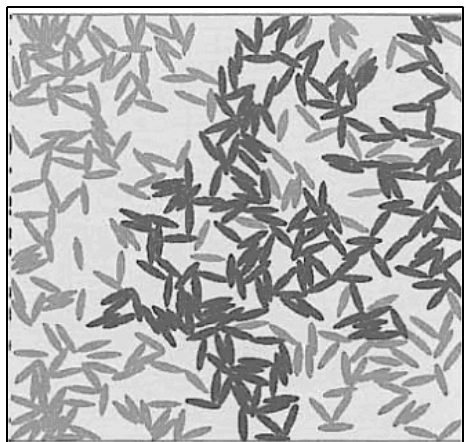


Fig 2: Microscopic cross-section view of a glued joint with elliptical particles.

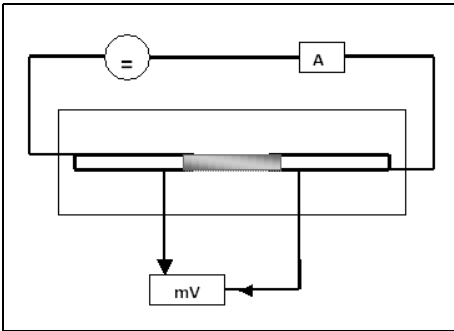


Fig 3: Test bench.

Conductive Adhesive) and ICA (Isotropically Conductive Adhesive) [1,2,3]. The principle is the same: to make a mixture with a conductive substance and an adhesive. Usually, the conductive substance is silver powder. As shown in Figs 1 and 2, the conduction is obtained when the metallic particles are touching. The electrical resistance is least when contacts are numerous and larger.

For our requirements, we can find two types of glue. The cheapest can be obtained from a DIY centre. It is a varnish used to repair rear window demisters. From the leaflet, we can also use that varnish for RF shielding, PCB track repairs, metallised holes and to glue SMD. Silver powder is mixed with a volatile adhesive. Drying can take place at the room temperature. It is contained in a 5ml small bottle. The published characteristics are:

- Resistivity: $0.01 \Omega \cdot \text{cm} = 10^{-4} \Omega \cdot \text{m}$
thickness: $25 \mu\text{m}$
- Operating temperature range: -40°C to $+135^\circ\text{C}$
- Dry take free: 20 minutes at ambient temperature
- Complete drying: 10 hours
- It is advisable to clean and dry the surface before application.

The second type of glue is a two-part epoxy resin filled with silver powder. It is quite expensive and must be purchased

from electronic components distributors. The published characteristics are:

- Resistivity: $<0.001 \Omega \cdot \text{cm} = 10^{-5} \Omega \cdot \text{cm}$
typical thickness: $130 \mu\text{m}$
- Operating temperature range: -91°C to $+100^\circ\text{C}$
- Shelf life: 12 months $<49^\circ\text{C}$
- Curing: $>25^\circ\text{C}$ for 4 hours maximum conductivity and bond strength in 24 hours

or

- For fastest curing times, maximum conductivity and adhesion, curing between $65 - 121^\circ\text{C}$ for 5 - 10 minutes
- Pot life: 8 - 10 minutes at 25°C after mixing
- Do not attempt to thin.
- Mix the two parts thoroughly for 2 minutes
- Cleaning: remove any surface contamination before glue application.

2.2 Conductivity of metals

It is interesting to compare glues electrical conductivities to usual metals ones.

- Silver: $1.4 \cdot 10^{-8} \Omega \cdot \text{cm}$
- Copper: $1.72 \cdot 10^{-8} \Omega \cdot \text{cm}$
- Aluminum: $2.8 \cdot 10^{-8} \Omega \cdot \text{cm}$
- Tin : $11.5 \cdot 10^{-8} \Omega \cdot \text{cm}$
- Constantan: $49 \cdot 10^{-8} \Omega \cdot \text{cm}$
- Conductive varnish: $10^{-4} \Omega \cdot \text{cm}$
- Conductive resin: $10^{-5} \Omega \cdot \text{cm}$

We can say those electrical glues are poor electrical conductors.

3.0

My measurements

In order to roughly check electrical performances of gluing, I designed a very simple test bench. A 3mm copper track is made on a FR4 glass-epoxy board. As shown in Fig 3, a 15mm gap breaks the line in its centre. The electrical circuit is restored with the glue under test. The



glue section should be very constant, that is harder with epoxy than with varnish owing to their respective fluidities.

Varnish can be deposited in successive coats to reach the required thickness. The epoxy resin can be filed for the same purpose.

After gluing, the resistance is very high and there is no current in the circuit. When the varnish solvent has evaporated and when the epoxy has cured, a 500mA DC current can be established and the voltage drop measured. An almost stabilized resistance value is obtained after 24 hours. In both cases, as advised in the leaflets, curing is beneficial.

The test is able to show a comparison between the leaflets values and those measured.

Varnish

- Width = 3mm = 10^{-3} m
- length = 15mm = 1.5×10^{-2} m
- thickness = 1mm = 10^{-3} m
- $\rho < 0.01 \Omega \cdot \text{cm} = 10^{-4} \Omega \cdot \text{m}$
- $R_{\text{calculated}} < 10^{-4} \times 1.5 \times 10^{-2} / (10^{-3} \times 3 \times 10^{-3}) = 0.5 \Omega$
- Measured value = at 0.5A the voltage drop is 93mV
- $R_{\text{measured}} = 93 \times 10^{-3} / 0.5 = 1.86 \times 10^{-2} = 186 \text{m}\Omega$

Epoxy resin

- Dimensions are the same but the thickness = 1.5mm = 15×10^{-3} m
- $\rho < 0.001 \Omega \cdot \text{cm} = 10^{-5} \Omega \cdot \text{m}$
- Measured value: at 0.5A the voltage drop is 53mV
- $R_{\text{measured}} = 53 \times 10^{-3} / 0.5 = 106 \text{m}\Omega$

We have to consider those values cautiously owing to the great uncertainty of the actual dimensions of the glue connection. Nevertheless, we can see the measured conductance is close for the two products although their published values are different. In fact for the varnish those values are questionable because ρ is given with < symbol.

Some users report a change over time.

Surface tidiness before gluing seems to be compulsory to avoid any corrosion.

I did test both samples for one month with this cycle: day - 0.5A, night - no current. For a week the resistance decreases by about 20% and progressively remains constant.

A quick test at 50°C has shown a low positive resistance temperature coefficient.

4.0

Thermal characteristics

Thermal measurements are harder than electrical ones. Therefore, only manufacturer's values will be given and compared with some others materials.

- Air : $0.0262 \cdot \text{m}^{-1} \cdot \text{K}^{-1}$
- Copper : 390
- Silver : 418
- Conductive varnish:
- Conductive epoxy resin: 1.6
- Epoxy resin: 0.25
- Silicon compound or grease: 0.7 to 0.9
- Silver loaded grease: > 2 to 3
- ICA: >60

We can see the absolute necessity to avoid any air pocket between a power transistor and its heat sink and the improvement provided by thermal conductive grease or compound carefully used.

5.0

Conclusion

Epoxy resin seems to be the best solution to glue a PCB onto a surface and get a definite bond.

Although not in this article field, PCB tracks can be established or repaired

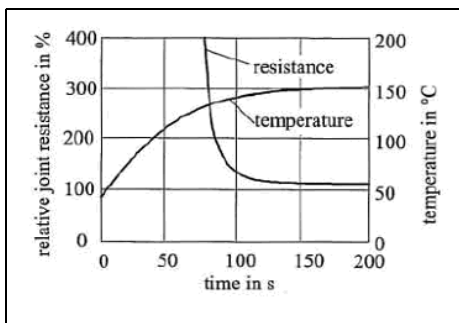


Fig 4: Change of joint resistance during the curing process.

using conductive glue. Varnish is more suitable owing to its fluidity. A special pen is available for this use.

A limitation of soldering becomes more and more evident for fine pitch components. Conductive adhesive bonding provides a new solution. Moreover, new regulation forbids the use of hazardous substances such as lead, cadmium and flux. Due to their composition, conductive adhesives are lead free and avoid flux residues without cleaning. However, as a long-term effect, the contact resistance on ignoble metal finishes can increase dramatically during exposure to elevated temperature and humidity.

6.0

Important notice

Owing to their working temperature limits, both products cannot be soldered with tin solder. We can join two tracks on a PCB but we cannot solder a component on glued track.

7.0

Appendix

Percolation is a very general term that

applies to fluid mechanic, math's, economy and even for the life (coffee maker, percolator).

In the present case, percolation means a crucial physical process. It describes, for a system, an abrupt transition between two states. It is a threshold phenomenon as shown Fig 4.

8.0


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Lapo Pieri, IK5NAX

T470/T670 - A 4m(6m) to 70cm Transverter

1.0

Introduction

In 2007 Italy gained the new 4m band so I immediately decided to build a simple converter to be used with one of my transceivers, so my choice was for a 4m/2m transverter. It was a bad choice because intermodulation products fall too close to the useful band.

So I lost a lot of time completely redesigning the transverter and this time I chose the 70cm band as the IF because intermodulation products are far enough away and I had a suitable transceiver, for portable operation on 70cm.

The transverter was built first as separated PCBs and then rebuild to fit in a compact shielded enclosure. In the meantime 2009 had gone and Italy was no longer allowed to use 4m band. The following year I wasn't able to spend much time on amateur radio and I didn't have the opportunity to test this transverter properly on the air. Nevertheless I think that measurements made are enough to present it to you!

2.0

Principle of operation

There is nothing special in this transverter configuration, it isn't a no-tune project but it uses easily available components, almost all SMT and doesn't require strange components that are difficult to obtain.

Fig 1 shows a sort of block diagram, actually the top level in circuit form. You can see six blocks: LO, mixer stage, LNA, PA driver, PA and those stages necessary to match the transverter to a transceiver.

The first idea was to use a 2m transceiver as IF using a 75MHz LO (translating the 4m band to the 145 - 146MHz portion). But analysing the RX spurious response it is easy to find the data shown in Table 1.

There are several spurious responses too close to the 70MHz band, mainly 65.00MHz, 71.67MHz and 72.50MHz that are difficult to filter out.

Instead, choosing an IF in the 70cm band the RX spurious products are shown in Table 2. The closest spurious is

Table 1: 2m IF RX spurious for 70MHz RF and 75MHz LO (up to fifth order shown).

Freq MHz	32.50	36.25	37.50	48.33	53.75	65.00	71.67	72.50	75.00	95.00	107.50	135.00
Spur order	5	4	3	3	5	4	4	2	2	5	3	5

Table 2: 70cm IF RX spurious for 70MHz RF and 360MHz LO (up to fifth order shown).

Freq MHz	35.00	70.00	96.67	107.50	143.33
Spur order	3	2	5	4	3

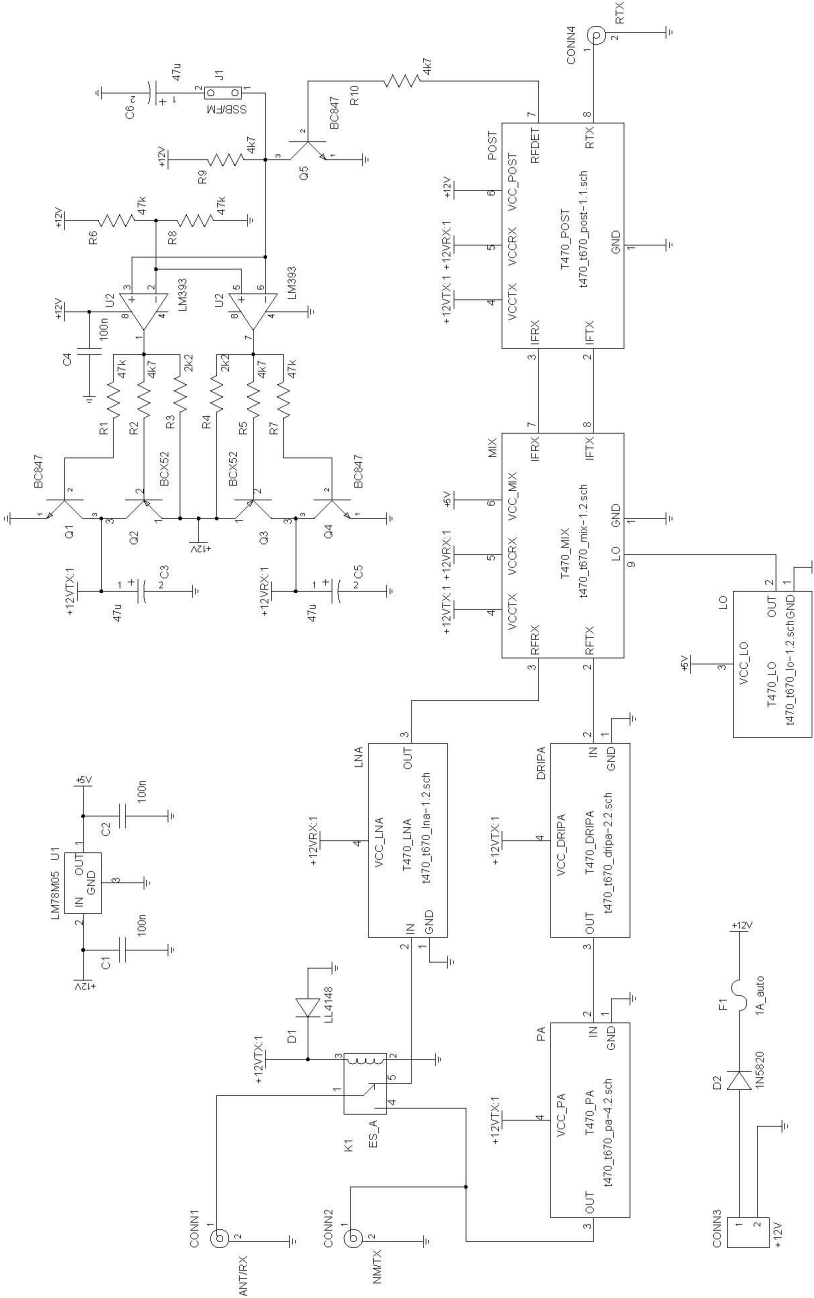


Fig 1: Block diagram of 4m transverter (top level hierarchy).

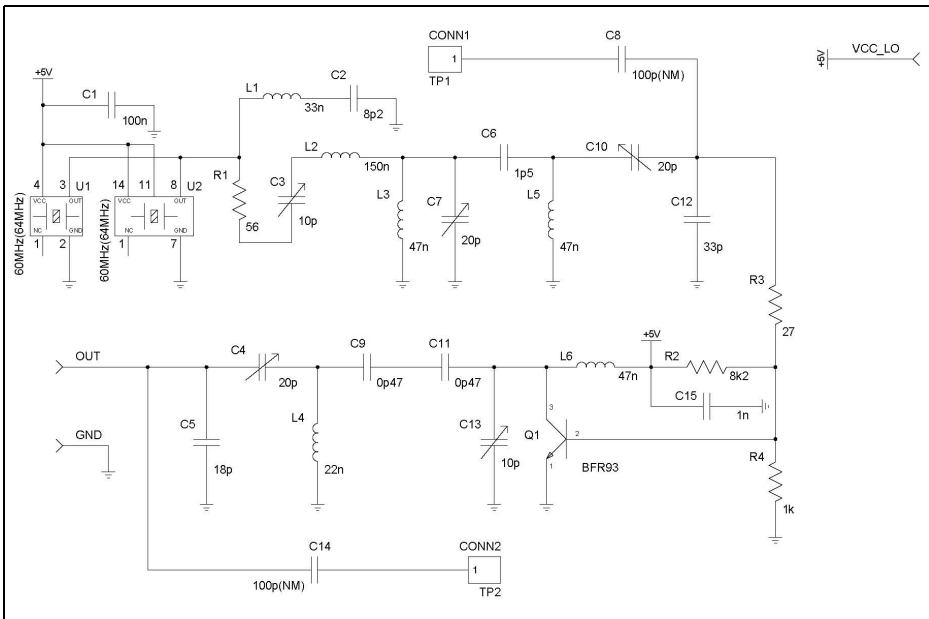


Fig 2: LO circuit diagram (4m).

96.67MHz that can easily be removed with a simple filter (no FM broadcast heard!).

So the project has been redeveloped for use with a 70cm transceiver; in order to use a standard crystal value (60MHz) the LO will be 360MHz and 70cm transceiver must be able to start from 430MHz. A 60MHz crystal followed by an x6 multiplier is used as LO chain.

To be sure of good performance, in terms of spurious and out of band signal rejection the RF filter must be tuned. Simple filtering has also been implemented at the IF.

This transverter was designed before I had decided what to do on this band, so a dual antenna connection has been provided. If an internal 0.5W PA is used the on board antenna relays can be used, otherwise two RF connectors (in/out) can be mounted on the same board.

3.0

Circuit Diagrams

Separate description of every stage will follow according to developing strategy used to design the final board. Note that that the same reference designator can be repeated in different circuit diagrams, a PCB prefix is used to distinguish between them.

3.1 Local oscillator

Fig 2 shows the LO stage: two footprints are shown for the oscillator, just one oscillator must be used. The network composed by R1, L1, C2, C3, L2, L3, C5, L5, C10 and C12 selects the 3rd harmonic from the oscillator output (you have to choose a square wave out rather than clipped sine wave). More precisely L3, C7, L5, C12 and C5 form a standard bandpass filter tuned to 180MHz while the remaining components are necessary

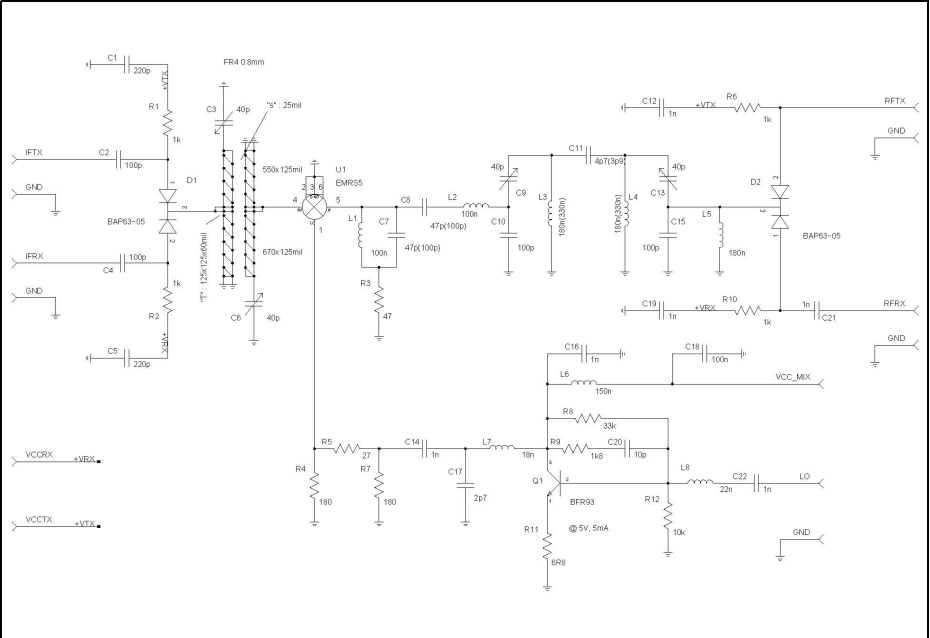


Fig 3: Mixer circuit diagram.

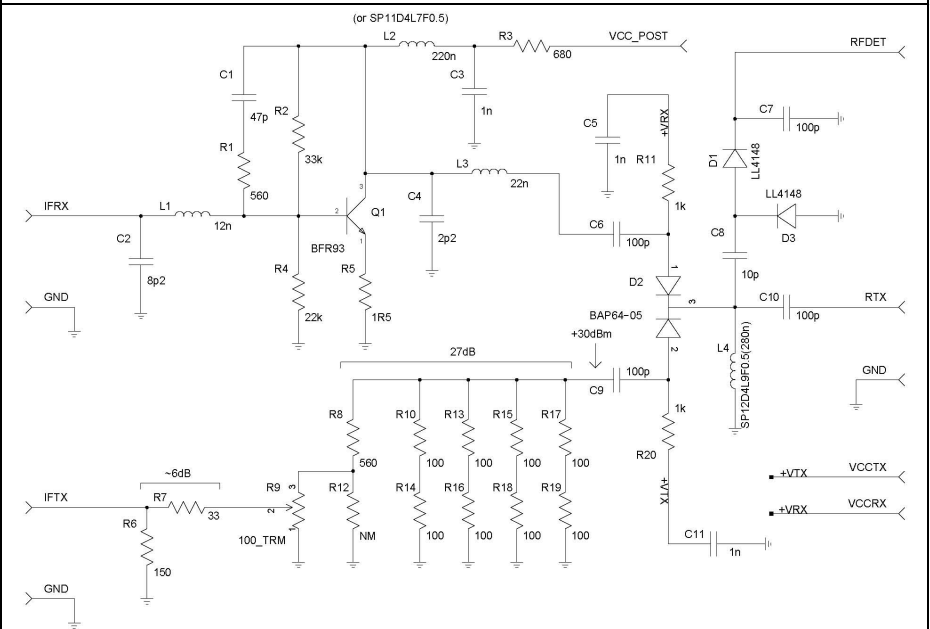


Fig 4: Post amplifier circuit diagram.

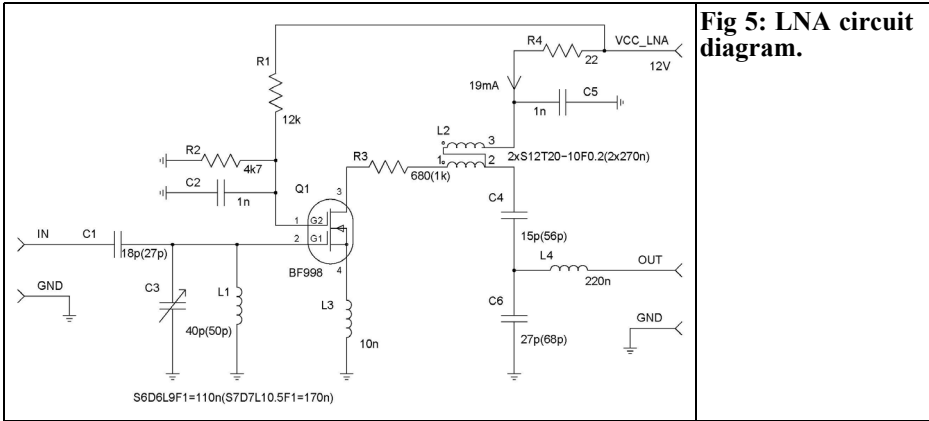


Fig 5: LNA circuit diagram.

for matching, spurious suppression and to load oscillator properly. The oscillator must be suitable for 5V (not 3.3V). The following stage built around Q1 is a parametric frequency doubler. C8 and C14 must not be mounted except for tuning, see below.

3.2 Mixer

Fig 3 shows the mixer stage complete with RF filter, diplexer, LO post amplifier and switches that allow a single mixer to be used for RX and TX. The IF filter is used to clean the signal a bit at IF: it might not be very useful but it isn't very expensive, so why not include it? It

has been realised with a printed coupled line and variable capacitors to adjust the centre frequency: it isn't critical at all.

A level of +10dBm at the mixer is used, so IMD performance is what one could be expected from but I found it is enough for the band. Several equivalent mixers can be used e.g. from Minicircuits or MaCom.

3.3 Post amplifier services

Post amplifier for RX and attenuator for TX are shown in Fig 4. All other service circuits are in the "block" diagram in Fig 1.

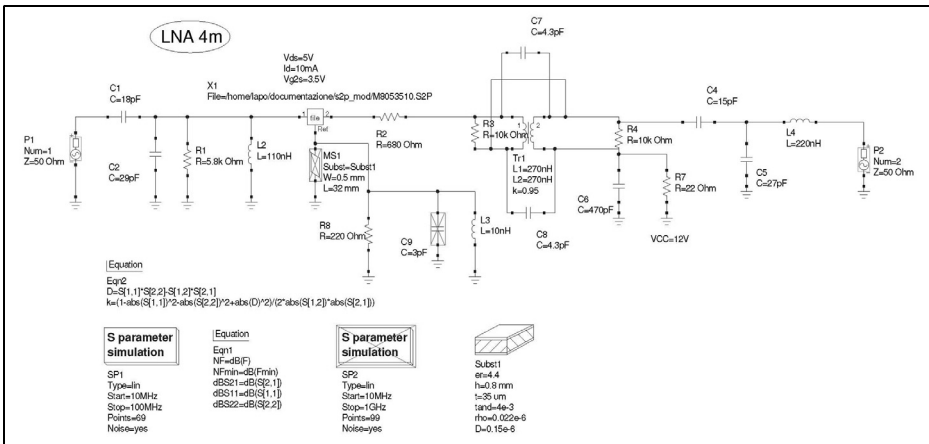


Fig 6: LNA simulation input.

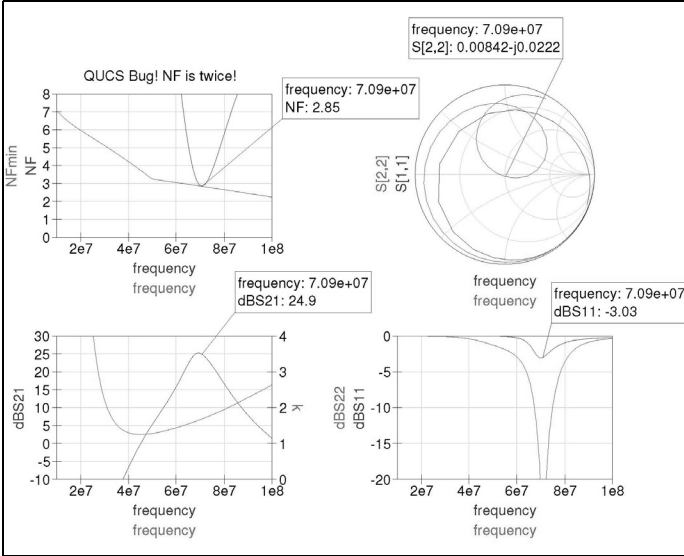


Fig 7: LNA simulation results.

Fig 4 shows an RX amplifier useful to compensate for mixer loss and to maintain an acceptable NF. In the TX path a variable attenuator is used to match the TX output power to mixer needs. Several inexpensive SMD 1206 100Ω resistors are used. A simple PIN switch is used to connect one of two paths to the transceiver. The same circuit diagram shows a detector for the VOX logic.

Fig 1 shows that the detected voltage (present when transmitting) drives a supply switch that allows only one path (RX or TX) is powered. Inserting jumper J1 a quit large capacitor (C6) sets a long enough decay necessary for SSB or CW. Positive 5V is generated on board for the

mixer and LO stages.

3.4 Front-end

The front-end comprises of an LNA, PA driver and PA that are shown, respectively, in Fig 5, 8 and 9.

The LNA circuit is classical based on a BF998 that performs something around 1.5dB NF as can be seen in the simulation shown in Figs 6 and 7 performed with qucs [1] and linear data from Philips/NXP [2]. An output transformer ensures amplifier stability and a good match to the mixer stage. Variable capacitor C3 must be a teflon capacitor so that the NF is not degraded.

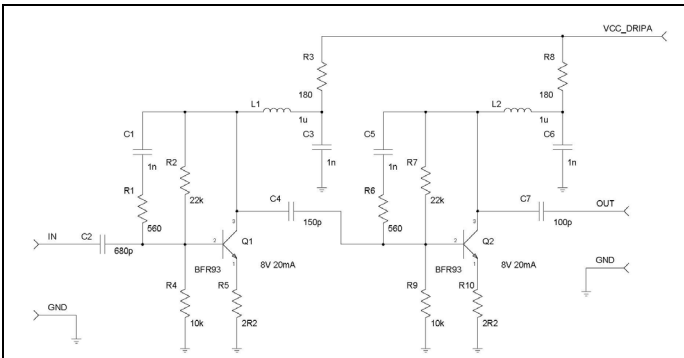


Fig 8: PA driver circuit diagram.

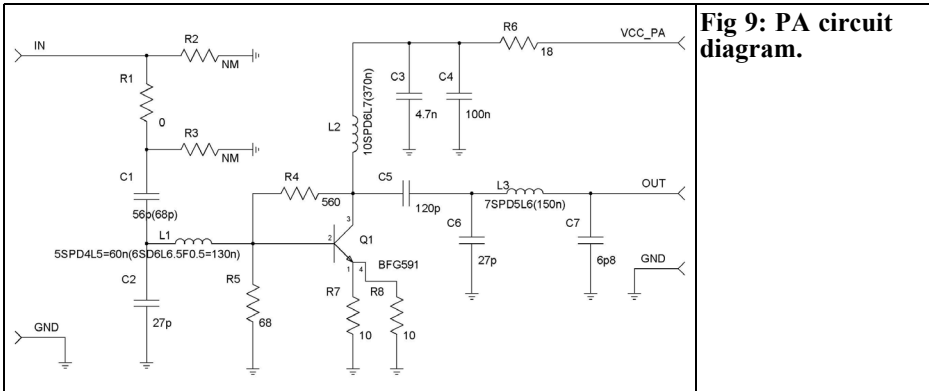


Fig 9: PA circuit diagram.

An almost aperiodic driver has been used to give enough power to the PA, it uses a couple of inexpensive BFR93s. This stage need no tuning and has very good stability.

The final amplifier has been designed to give only 0.5W, enough for this first test and small enough to make the transverter compact. It is based on a UHF transistor capable of high gain on 70MHz; a single stage low-pass filter is enough to keep the harmonics low. All inductors in the power path are air wound without support, fine tuning can carried out by adjusting the length, but this is not strictly necessary.

4.0 Construction and tuning

Early construction was done with separate PCBs and many interconnections (see Fig 10), it was a laboratory prototype but allowed me to make a first check in a SOTA expedition with Sandro 15MSH in 2008.

It all fits onto a single PCB that fit in a standard Teko enclosure 393.16 [3] as shown in Figs 11 and 12.

The PCB assembly shown in Fig 13

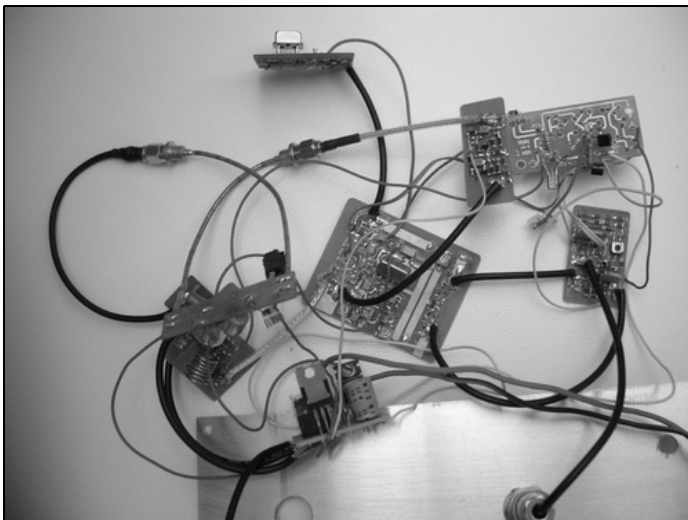


Fig 10: Early prototype.

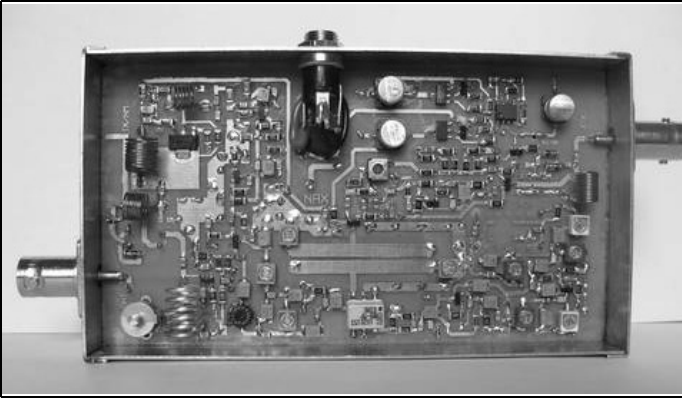


Fig 11: Finished 4m transverter in a Teko enclosure.

shows the component references with a prefix due to the circuit diagram hierarchy used. Please refer to the label in the upper left corner of each block in Fig 1 to understand the designation (e.g. LNA/C3 is the variable capacitor C3 in Fig 5).

Several jumpers must be placed on the rear of the PCB as shown in Fig 14 to avoid the cost of a multilayer PCB.

Tuning is carried out by mounting the components stage by stage. The power supply stage and VOX circuitry should be mounted and tested as a first step; next the local oscillator.

For the LO tune up a spectrum analyser can be used connected to TP1; prior to this remove R3 and add C8, then adjust C3, C7 and C10 for maximum 180MHz signal and lower harmonics/spurious content. Next, remove C8, reintroduce R3 and with the spectrum analyser on TP2

(and no other component installed in the mixer) adjust C13 and C4 with the same goal. To tell the truth a simple power meter and maybe a frequency meter (loosely coupled) to TP2 allow the same alignment in just one step: tune for the maximum signal at 360MHz and stable operation.

The same is true for other filters: maximum signal adjustment is the right way for all the other tuning except for the LNA where C3 must be adjusted for minimum NF: without an NF analyser try to enhance the MDS of a very low signal.

Sensitivity to transverter power can be adjusted using R9: start with the wiper close to ground!

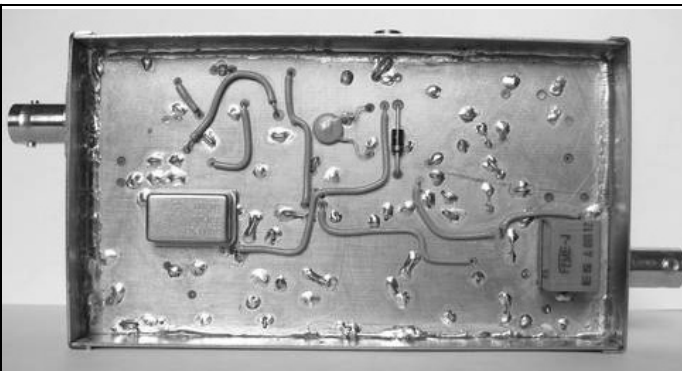


Fig 12: Rear view of the finished 4m transverter in a Teko enclosure.

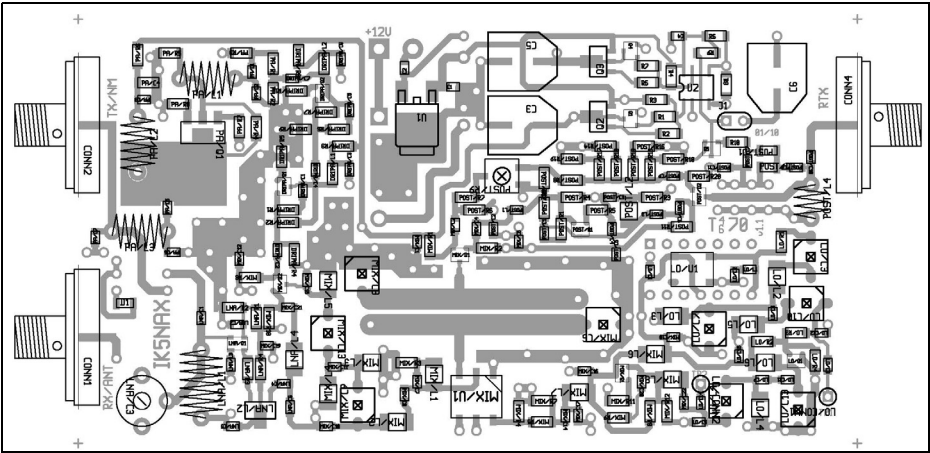


Fig 13: Top view of the PCB.

**5.0
Characteristics**

Tests on the prototype gave results shown in Table 3 after a fine-tuning. A simple investigation has been carried out to measure RX spurious response: results are in Table 4. Some spurious responses are due to standard IMD products, i.e. $n \times RF \pm m \times LO$, others are due to LO spurious products from the multiplication chain.

**6.0
6m version**

With few component changes the same circuit can be used for a 6m to 70cm transverter. Table 5 shows the necessary component changes: the same modified values are shown on the circuits in brackets (). All other characteristic are almost maintained.

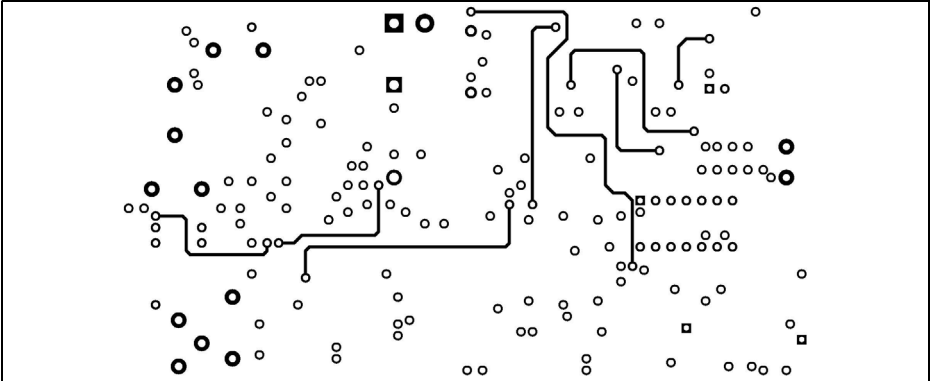


Fig 14: Jumpers on the bottom of the PCB.

**Table 3: Measured performance.****General**

Power supply:	12v DC, 115mA (RX) 260mA (TX)
Dimensions:	160 x 70 x 28mm
Passband:	10MHz
RX	
NF:	≈1.5 - 2dB
Gain:	22dB
TX	
Output power:	500mW
2 nd harmonic:	≤-30dBc
3 rd harmonic	≤-40dBc
Input power	0.1 - 1W

7.0**References**

[1] Quasi Universal Circuit Simulator,
<http://qucs.sourceforge.net/>

[2] BF998 data-sheet,
http://www.nxp.com/documents/data_sheet/BF998.pdf

Table 5: Component changes for 6m version.

Ref	4m value	6m value
LO/U1	60MHz	64MHz
MIX/C7	47pF	100pF
Mix/C8	47pF	100pF
Mix/L3	180nH	330nH
Mix/L4	180nH	330nH
Mix/C11	4p7	3p9
LNA/C4	15pF	56pF
LNA/C6	27pF	68pF
LNA/R3	680Ω	1kΩ
LNA/L1	110nH	170nH
LNA/C1	18pF	27pF
LNA/C3	40pF	50pF (add 4p7 in parallel)
DRIPA/C4	150pF	220pF
DRIPA/C7	100pF	330pF
PA/C1	56pF	68pF
PA/L1	60nH	130nH

Table 4: Measured spurs.

Spur order	Frequency MHz	Level dBc
5	17.5	-64
4	23.3	-58
3	35	-60
	61.4	<<-75
	62.9	-69
	64.6	-60
	68.5	-61
	72.5	-72
	73.3	<<-75
	76.2	<<-75
	430	-65

[3] Teko enclosure model 393.16,
<http://www.tekoenclosures.com/>

Happy DIY!

Printed circuits files and other documentation are available upon request via email for free. I can be contacted: Lapo Pieri (IK5NAX) via delle Ortensie, 22 50142 FIRENZE T. +39 055 706881 ik5nax@virgilio.it

**The UK Six Metre Group****www.uksmg.com**

With over 700 members world-wide, the UK Six Metre Group is the world's largest organisation devoted to 50MHz. The ambition of the group, through the medium of its 56-page quarterly newsletter 'Six News' and through its web site www.uksmg.com, is to provide the best information available on all aspects of the band: including DX news and reports, beacon news, propagation & technical articles, six-metre equipment reviews, DXpedition news and technical articles.

Why not join the UKSMG and give us a try? For more information contact the secretary: Dave Toombs, G8FXM, 1 Chalgrove, Halifax Way, Welwyn Garden City AL7 2QJ, UK or visit the website.



Gunthard Kraus, DG8GB

An interesting program: Simulation and construction of a Helix antenna for 2.45GHz using 4NEC2

This article represents the revised and extended version of a lecture at the UKW conference 2010 in Bensheim. The article shows how a Helix antenna can be sketched with the 4NEC2 software. Followed by the construction of a sample antenna, measuring its characteristics and comparison with the simulation.

1.0

Simulation of wire antennas with NEC

NEC (Numerical Electric Code) was developed in 1981 by the Lawrence Livermore laboratory for the American Navy as a simulation method for wire antennas. The antenna is divided into very short pieces (segments) where the current and voltage change is almost linear. Amazingly accurate simulations can be accomplished, but naturally there are limits. Interestingly enough, a lower and an upper limit where the simulation becomes ever more inaccurate.

The lower frequency limit is defined by the recommendation that there are approximately 10 to 20 segments per wavelength but never more than 50 segments. If very low frequencies are used (e.g.

below 1MHz) the wavelength rises to 300m and a segment becomes at least 6m long. The program cannot react to any more refinements of the environment (it applies the rule of linear current on the smallest segment) and the simulation quickly becomes senseless.

With high and very high frequencies the concept of an infinitely thin antenna wire does not work in the simulation any more. A supplementary product for thicker wires, the Extended thin wire kernel can be used but as soon as the relationship between of the segment length to wire radius falls below 2.5, the program ends with an error message with wild warnings to the user about this problem

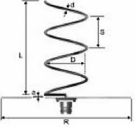
NEC2 is the standard free application software. Development has continued and the weaknesses of NEC2 (e.g. incorrect computation of structures that cross very closely or wires buried in soil) were only corrected with NEC4. NEC4 was restricted for a long time and was considered as secret. Today it is also available outside of the USA, but quite expensive (normally around the \$2000).

NEC2 can be downloaded from the Internet, but nothing can be done immediately. It is a pure calculating machine that was originally written in FORTRAN and available as a compiled coded program. Therefore many people added extensive



Design frequency	<input type="text" value="2450"/> MHz
Number of turns	<input type="text" value="6"/>
Turn spacing	<input type="text" value="0.25"/> wavelengths
<input type="button" value="Calculate"/>	

The results



Legend. The letters in the image are used in the table below.

To get a large version, click on the image.

Wavelength		<input type="text" value="122.4"/> mm
Ideal diameter (internal)	D=	<input type="text" value="41.6"/> mm
Gain		<input type="text" value="10.85"/> dBi
Conductor diameter	d=	<input type="text" value="2.4"/> mm
Winding step (between centers)	S=	<input type="text" value="30.6"/> mm
Separation of the adapter section	a=	<input type="text" value="1.1"/> mm
Total conductor length		<input type="text" value="806.5"/> mm
Minimum reflector diameter	R=	<input type="text" value="75.9"/> mm
Total antenna length	L=	<input type="text" value="183.6"/> mm

Fig 1: An online calculator like this makes the determination of the mechanical antenna data child's play.

operator interfaces and marketed these as Windows programs - some free of charge and some with substantial prices. 4NEC2 stands out by a long way because it is equipped with as many supplementary product features and facilities that it is astonishing that it is free. Therefore praise and thanks to the author of 4NEC2, Mr. Arie Voors!

Naturally such an enormous machine is not completely free from small errors, but they do not disturb and fortunately only express themselves in extreme cases (or contradictory commands e.g. moving something and forgetting the input). The software author requests that users inform him of such things immediately by email and then promptly investigates them.

2.0

The Helix antenna

2.1. Some initial words

It is a quite an interesting construction

with just as interesting characteristics. It is a spiral wire with turns a wavelength long at the operating frequency and at least 3 turns. More turns increase the gain and make the beamwidth angle smaller. The typical upward gradient is about $\frac{1}{4}$ the wavelength and the reflector is arranged at the beginning of the spiral with a diameter of a wavelength.

The antenna is interesting:

- It supplies circularly polarised radiation where the rotation of the spiral specifies the polarisation.
- It exhibits amazing constant data and characteristics within a range of approximately 20% of a wavelength.
- The radiation resistance is approximately 150Ω theoretically (the practical values are between 130Ω and 200Ω) and this changes only slowly.
- Blind spots are present and are periodical, these must be considered during adjustment. They are clearly smaller than the radiation resistance and rarely exceed a value of 50Ω
- There is almost always no backward radiation due to the metal reflector and therefore an outstanding advantage.

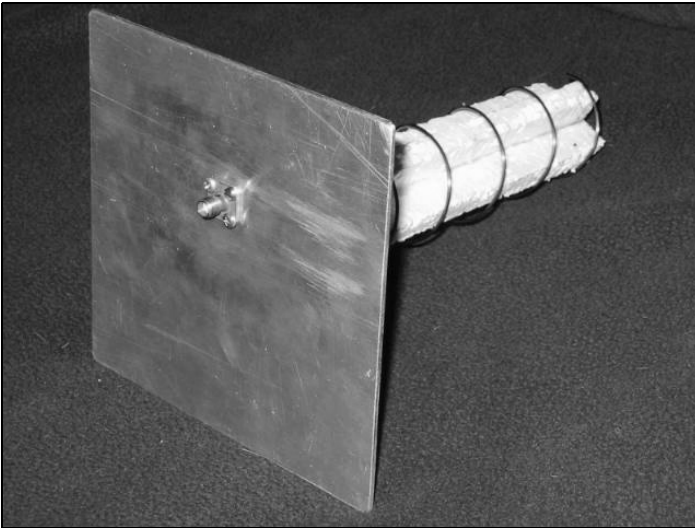


Fig 2: This is the end product, it is not a finished design but it serves as a sample to check the accuracy of the simulation.

- Altogether this antenna is extremely “good-natured” and “forgives” many errors during the mechanical conversion of the design.

Since there is usually “no rose without thorns”, here are the drawbacks:

- The mechanical dimensions are unfortunately not as delicate as with some other antenna forms.
- The directivity pattern can easily become baggy compared with other antennas with similar gain.
- The amazing wide bandwidth is paid for with a decreased antenna gain that can be classified as “not top class” but rather “between centre zone and point”.

2.2. Defaults

Today online calculators from the Internet can be used to design such antennas. The user only needs the intended operating frequency (here: 2.45GHz) and the number of the turns to enter (with rising number of turns there is more gain and a narrower beamwidth, but also a longer antenna). Therefore for training a simple 6 turns antenna is calculated, see Fig 1.

Result:

- Wavelength = 122.4mm for a centre

frequency of 2.45GHz

- Internal diameter = 41.6mm
- Gain = 10.85dBi
- Wire size = 2.4mm
- Upward gradient = 30.6mm
- Minimum reflector diameter = 75.9mm
- Entire antenna = 183.6mm = 6 x upward gradient of 30.6mm

(In the result list the entire wire length is given as well as the information that the structure was raised by 1.1mm to create a place for the feed).

For the practical construction copper wire with a diameter of 1.25mm was selected because the connection at the beginning of the spiral can be manufactured more easily to connect to an SMA plug without large diameter jumps. To accept this wire size NEC would like to know the middle diameter of the spiral (using the on-line Calculators results: 41.6mm + 2.4mm = 44mm).

This data was converted from the simulation into an experimental model. The reflector was a square aluminium plate 2mm thick and an edge length of 130mm (more than one wavelength as required). An SMA socket was screwed onto the

**Table 1: The NEC file for the Helix antenna project.**

```

CM Helix 2450MHz (6turns) over perfect ground
CM Helix starts 5mm above ground
CM Helix diameter = 44mm, spacing - 30.6mm
CM Wire with a diameter of 1.25mm added between helix and ground
CM Excitation at centre of this wire
CE
GH 1 120 0.0306 0.1836 0.022 0.022 0.022 0.0006125
GM 0 0 0 0 0 0 0 0.005 0
GW 150 1 .022 0 0 0.022 0 0.005 0.0006125
GE 1
GN 1
EK
EX 0 150 1 0 1. 0
FR 0 0 0 2450. 0

```

lower surface of this plate with the inner pin through the reflector plate and soldered to the start of the spiral. It is important for the simulation that the Helix is raised by 5mm in order to copy this solder joint.

The Helix is held by two 10mm polystyrene strips stuck onto the reflector plate with UHU glue. Fig 2 shows this in good detail.

Doubts about the polystyrene material can exist; it contains the insulation material polystyrene (Styroflex) useful at high frequencies but it is 80% air. Because of the high fusing temperature of the polystyrene at over 80°C, no air humidity will be enclosed in the large pores that could cause additional absorption.

3.0

Wire antenna simulation with 4NEC2

3.1. Start and first simulation

The software can be downloaded in zipped form from different places on the Internet (see note at the end). The nucleus program 4NEC2 is installed fol-

lowed by the installation of the supplementary product 4NEC2X. However 4NEC2X is always used because it gives the coloured 3D diagrams of the simulation results as well as the antenna structure.

3.2. Production of the NEC file and the first simulation

A simple text editor is enough (e.g. Notepad) and all the necessary instructions (Cards) are typed by hand. Naturally 4NEC2 contains other good editors with easy operation but Notepad is fastest and experienced user eventually always use this input method.

Note that NEC measures all dimensions entered in metres. If that is not desirable (e.g. working with inches), an additional scaling map must be used for suitable conversion. The input for the Helix is shown in Table 1.

Explanations:

- “CM” are comment cards and ignored by the program. “CE” means end of the comments.
- “GH” (Geometry of Helix) specifies the form of the Helix; the line required including the explanation is shown in Fig 3.
- “GM” (Geometry Move card) pushes the Helix upward by 5mm (Fig 4).

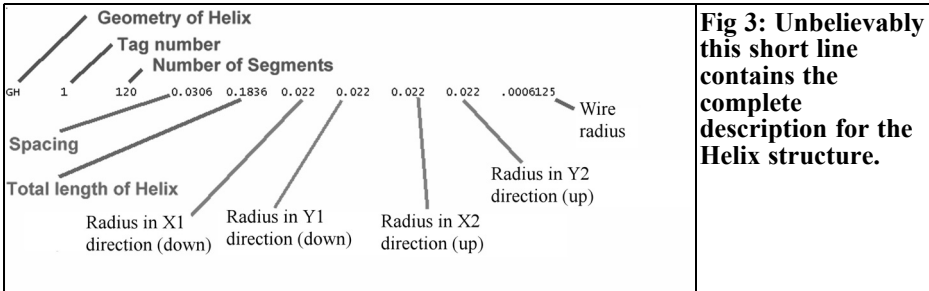


Fig 3: Unbelievably this short line contains the complete description for the Helix structure.

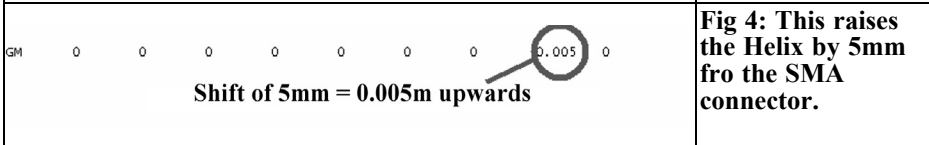


Fig 4: This raises the Helix by 5mm from the SMA connector.

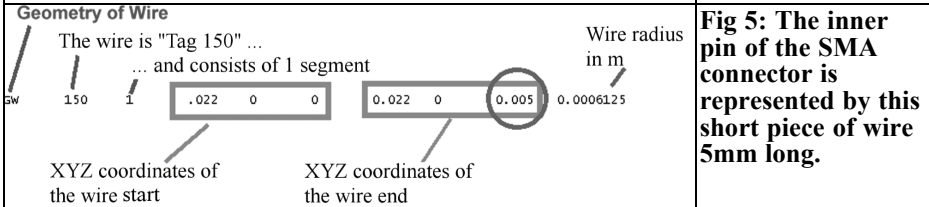


Fig 5: The inner pin of the SMA connector is represented by this short piece of wire 5mm long.

- “GW” (Geometry of Wire) for the connecting wire, see Fig 5. It represents the interior leader of the SMA socket and at the same time energizes the antenna. Its upper end is connected to the start of the Helix (coordinates of Helix and the upper end of the piece of wire the same). The lower end of the wire is put on the Ground level that is formed by the reflector. NEC automatically puts the feed point into the centre segment. Thus the upper end of the feed wire will meet the start of the Helix at a height of 5mm.
 - The next three entries; GE/GN/EK are all shown in Fig 6. They concern the end of the geometry data, also “the Ground” and the fact that the antenna wire is not infinitely thin.
 - From to Fig 7 the supply (Excitation) of the structure is programmed in the centre section of the connecting wire.
 - ... the conclusion (Fig 8), the indication of frequency as well as marking the end of the NEC file.
- The NEC file is now saved in a suitable

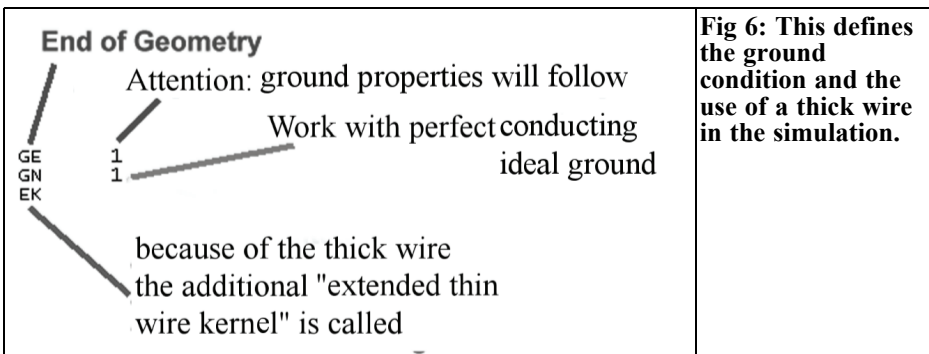


Fig 6: This defines the ground condition and the use of a thick wire in the simulation.

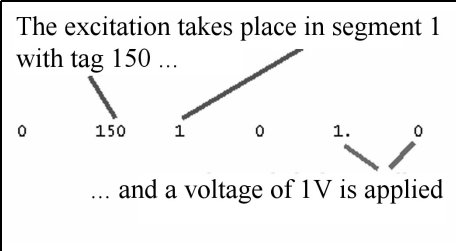


Fig 7: The excitation takes place in the middle of the wire.

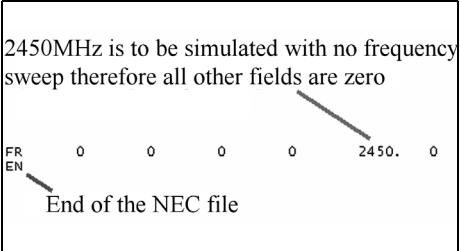


Fig 8: There is no frequency sweep, the frequency is set to 2450MHz.

place with the file extension “.nec” e.g. as “helix_2450MHz.nec”. 4NEC2X is started and the file loaded using “Main/file/open 4nec2 in/output file” and the path of this antenna file. Press F7 to start the simulation after entering the attribute (Far Field pattern/fill/resolution = 5 degrees) as shown in Fig 9 and pressing “Generate”.

The simulated far field radiation pattern (far field pattern) at a frequency of 2450MHz is shown in Fig 10. The azimuth angle “Phi” = zero degree (horizontal angle of rotation) is shown at the bottom on the left. The elevation

angle “Theta” is from 0 to 180 degrees or from 0 to -180 degrees is shown on the bottom right.

One of the most beautiful options of 4NEC2 is the coloured 3D picture that can be opened with the key F9. The first one (Fig 11) shows the antenna structure, it can easily be zoomed to show the individual segments that the antenna divided into for the simulation. Unfortunately the pictures in VHF Communications Magazine are in black and white but the program colours the feed point in violet at the centre segment of the feed wire that makes it very easy to see. The structure can be moved and rotated using

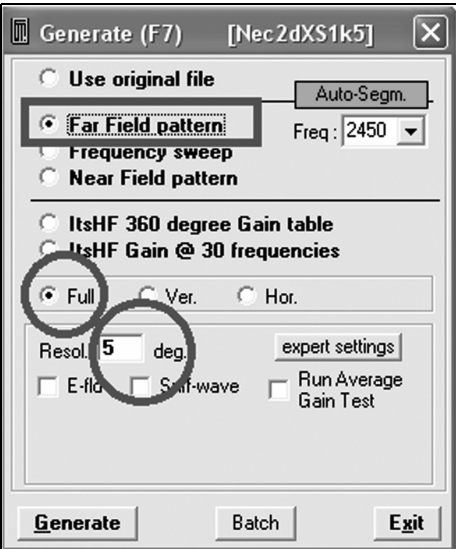


Fig 9: Pressing F7 displays these simulation parameters.

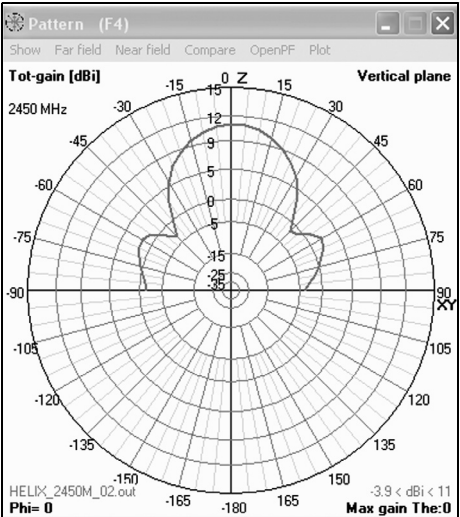


Fig 10: The simulated far field is displayed as a polar diagram.

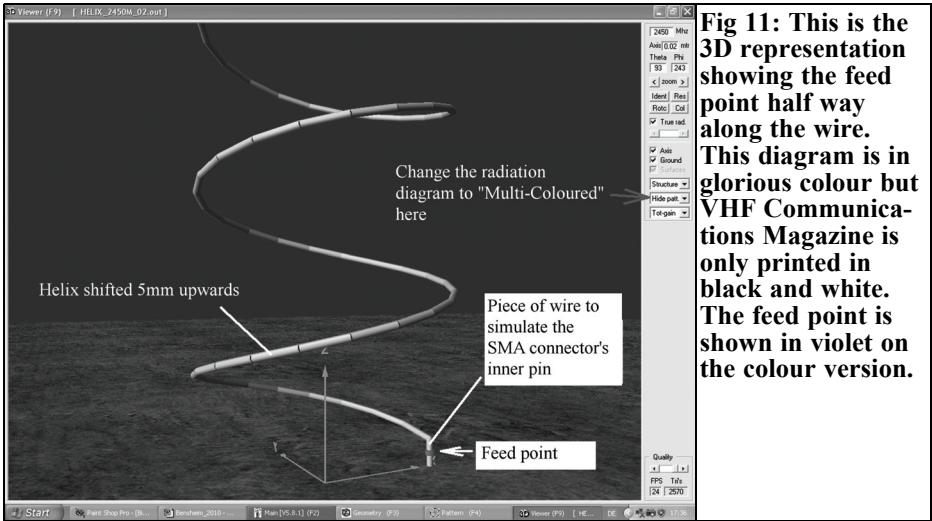


Fig 11: This is the 3D representation showing the feed point half way along the wire. This diagram is in glorious colour but VHF Communications Magazine is only printed in black and white. The feed point is shown in violet on the colour version.

the mouse buttons.

Changing over the menu to “Multi Colour” shows the radiation pattern as well as the colours for the gain scale in dBi (Fig 12).

3.2. Simulation of gain, SWR and impedance

Start the simulation menu by pressing the key F7 (Fig 13); then adjusts the following:

- Frequency sweep
- Gain (simply click to remove the message “No front/back ratio data is generated”)
- Resolution = 5 degrees

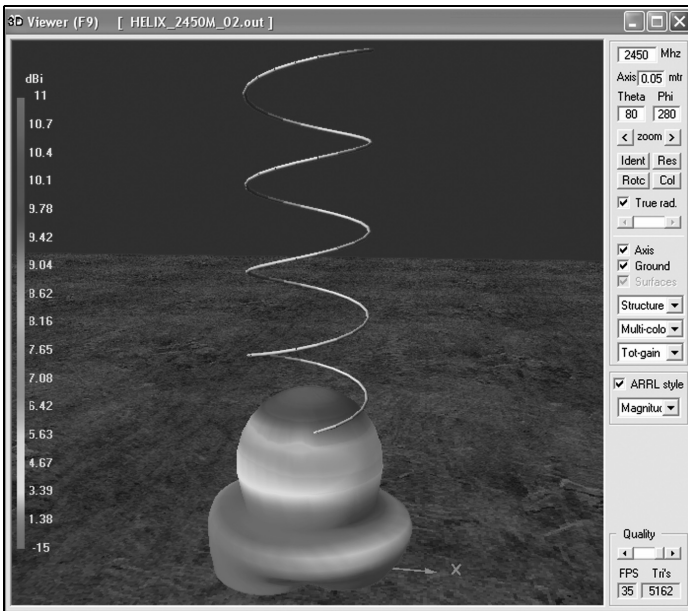


Fig 12: This is a very good view of the structure including the 3D radiation pattern. It can be moved in any direction using the mouse.

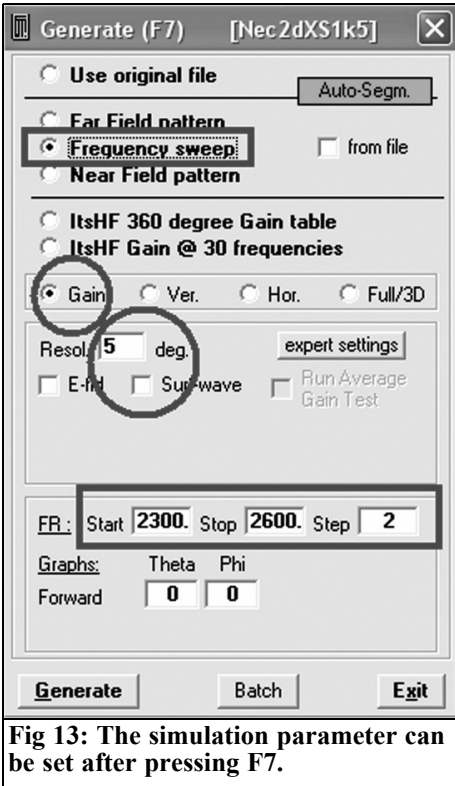


Fig 13: The simulation parameter can be set after pressing F7.

- Start = 2300MHz,
- Stop = 2600MHz,
- Step = 2 MHz

(a maximum of 150 steps are possible,

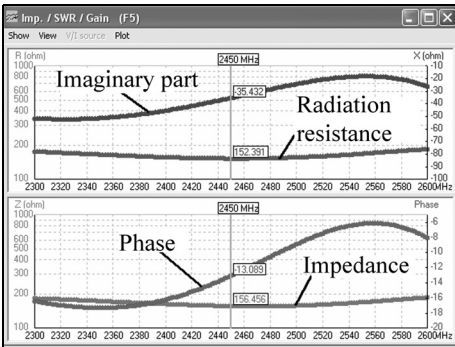


Fig 15: The mystery of the helix is the radiation resistance of 150Ω that is the cause of the large reflections.

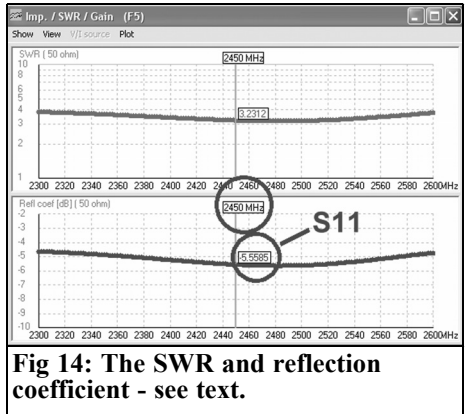


Fig 14: The SWR and reflection coefficient - see text.

therefore the increment cannot be too large)

Click “Generate” to start the NEC calculating machine. Following successful simulation the screen showing the SWR and reflection coefficient is displayed (Fig 14). SWR = 3.2 and S11 = -5.85dB is relatively bad at 2450MHz but that does not have to be a bad indication: theoretically the radiation resistance is approximately 150Ω and therefore such values are to be expected.

The feed impedance (Fig 15) can be found using the “Show” menu in the top left hand corner. The theory is confirmed very beautifully because the radiation resistance is maintained between 150Ω and 190Ω over the entire frequency range from 2300 to 2600MHz. The im-

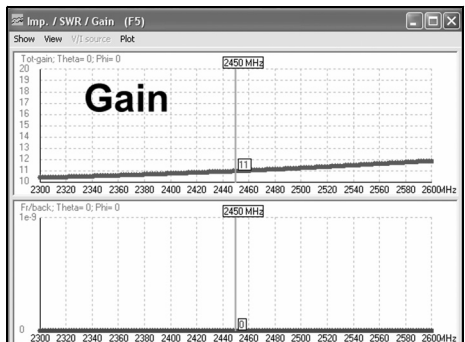


Fig 16: The gain is as promised very wide band.

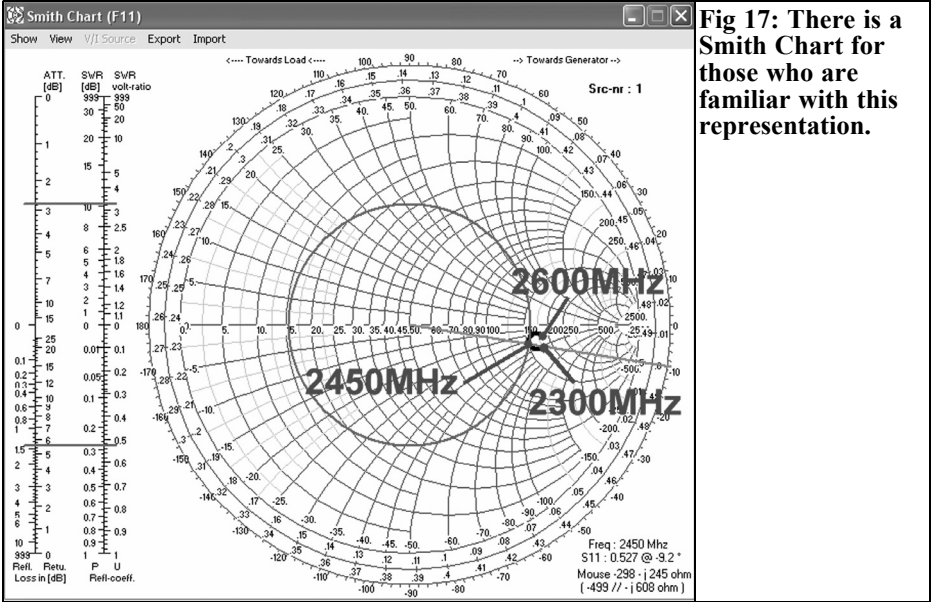


Fig 17: There is a Smith Chart for those who are familiar with this representation.

aginary portion only increases to $-j50\Omega$ at the lower end of the range.

Fig 16 shows the antenna gain that is accessed using the “Show” menu. The wide bandwidth of the antenna is shown because the gain rises from 10.5dBi at 2300MHz to approximately 12dBi at 2600MHz. At 2450MHz it is exactly 11dBi. The lower diagram is empty because the earlier message stated that no front to back data would be calculated.

A Smith chart can also be displayed using the relevant button (Fig 17). This shows even better how the feed impedance behaves if the frequency is changed.

3.3. Results of measurement of the experimental model

3.3.1. Feed impedance

An HP 8410 network analyser with a magnitude and phase display module was used with a transmission reflection

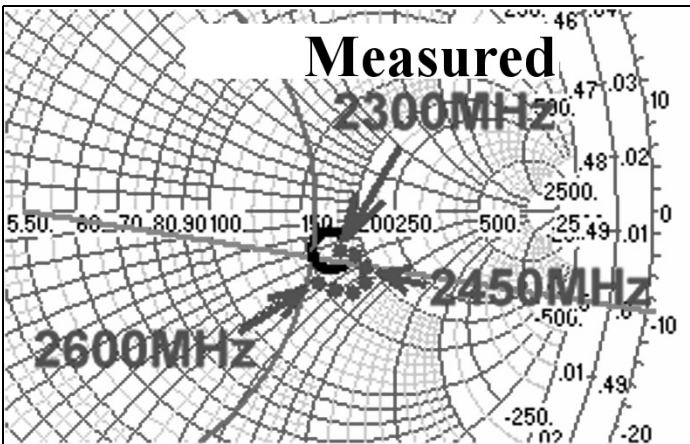


Fig 18: This shows the measured impedance on a Smith Chart from 2300 to 2600MHz.

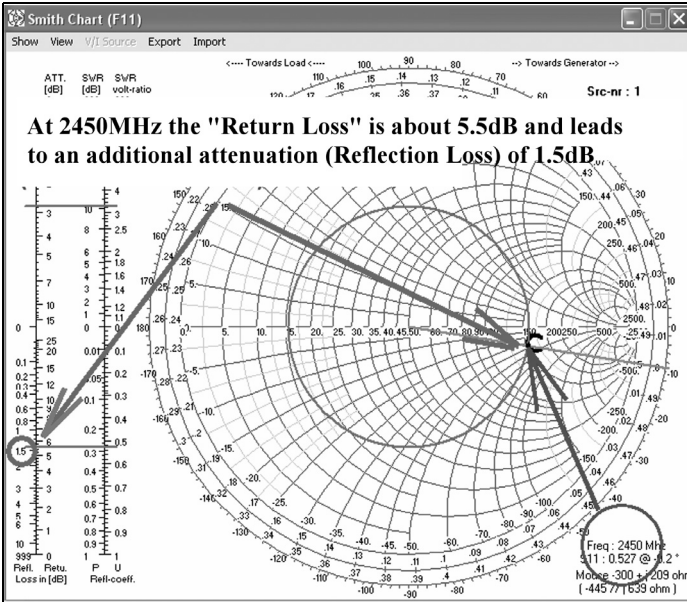


Fig 19: This shows how to determine the additional attenuation caused by the reflection.

bridge for 2 to 12.4GHz. An HP 8690 sweeper supplied the excitation signal with a module for 2 to 4GHz. The desired frequency range was carefully controlled from 2300 to 2600MHz by a frequency counter. This counter received its signal from the sweeper using a 10dB directional coupler.

The measuring set was calibrated carefully:

Perfect adjustment using a Watkins Johnson SMA termination with more than 30dB reflection attenuation up to more than 12GHz (the expert immediately recognises these rare parts at the electronics flea market by the blue lacquer finish). Thus the bright spot was centred carefully in the centre of the magnitude and phase display.

Now the termination was replaced by a short piece of SMA semi rigid cable with the same SMA connector as used on the Helix antenna fitted to the end. First 100% reflection is exactly calibrated (bright curved path must be exactly on the outside diameter of the magnitude and phase display) AND the reference

plane set by rotating the correct control on the measuring bridge to the point of the inner pin of the SMA socket (the curve diminishes to a bright spot). This exactly measures at the beginning of the Helix spiral when the antenna is attached for measurement. The result of the measurement can be seen in Fig 18 and the comment: "Not at all bad" is surely deserved.

3.3.2. Determining the antenna gain

An antenna measuring range would normally be required to determine the gain of this antenna. Unfortunately this is missing in the domestic cellar workshop. Thus the following cheat was used:

The wavelength is 122.4mm for a frequency of 2450MHz. If a transmission circuit consisting of transmitter, receiver and two identical antennas is developed with a path distance between the transmitting and receiving antenna of 120cm that corresponds to a distance of approximately 10 wavelengths and thus "genuine" far field propagation. But the following applies:

Since the radiated energy distributes over

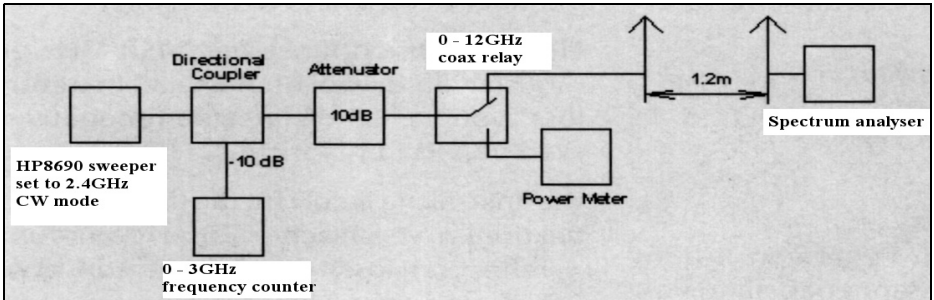


Fig 20: A block diagram of the antenna test setup.

an ever-increasing solid angles when moving away from the transmitting antenna the energy per unit area decreases according to the Friis transmission equation at the receiving antenna. This is the famous formula for free space path loss. If the gain of transmitting and receiving antenna is included it reads:

$$P_{Receiver} = P_{Transmitter} \cdot G_{Transmit-antenna} \cdot G_{Receive-antenna} \cdot \left(\frac{\lambda}{4\pi \cdot d} \right)^2$$

“d” is the distance between sending and receiving antennas and “λ” is the wavelength that will be used for the calculation being the speed of light divided by the transmitter frequency.

Using logarithmic representation in dB (with gain in dBm) for this arrangement:

$$Receivpower = Transmitpower + 2xAntennagain + 20 \cdot \log\left(\frac{\lambda}{4\pi \cdot d}\right) \text{ in dB}$$

Re-arranging for the gain:

$$Antennagain = \frac{Receivpower - Transmitpower - 20 \cdot \log\left(\frac{\lambda}{4\pi \cdot d}\right)}{2} \text{ in dB}$$

Using two completely identically manufactured patch antennas with a resonant frequency of 2.45GHz and an input reflection of less than 3% at this frequency, in the measuring position. An advantage of the patch antenna is their affiliation to the family of the planar array antennas. That means that the patch surface is at the starting point for the radiation leaving the antenna (technically the phase centre).

With a level of 0dBm and the antenna distance of 120cm the result is:



$Antennagain = \frac{Re ceivepower - 20 \cdot \log\left(\frac{12.24cm}{4 \cdot \pi \cdot 120cm}\right)}{2} = \frac{Re ceivepower + 41.8dB}{2}$	transmitter signal. After an attenuator
------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------

With a measurement of -29dBm at the receiver (Spectrum Analyser calibrated at 2.45GHz) gives an antenna gain of 6.4dBi for the patch antenna that is about the value in the textbooks (usually: 6.5 to 7dBi, depending upon form, material and losses).

With the transmitting antenna replaced by the Helix antenna the level measured at the receiver rose to around +2dB. The input impedance of the Helix must be considered, this is approximately 150Ω therefore a large part of the available power (0dBm = 1mW) is reflected back into the generator. Calculating the additional attenuation is therefore child's play, because on the left of the Smith diagram of the 4NEC2-Simulation there are some nomograms (Fig 19). The two lower ones are important and they will be considered more closely:

For the point on the curve for 2450MHz there is a point on the right hand scale "return loss" of approximately 5.5dB that corresponds to the negative value of S11.

The left scale gives (by the reflections causing auxiliary absorption = reflection loss) the value of approximately 1.5dB and thus a measured gain for the Helix antenna of 6.4dBi + 2dB + 1.5dB = 9.9dBi.

That is approximately 1dB less than the simulation stated (11 dBi) but not too far away. 1dB deviation correspond to 10% change of the voltage or approximately 20% of power... and the losses in the polystyrene mounting have not been considered... and the skin effect at this frequency...

The layout of the measuring setup is shown in Fig 20. The principle is quite clear:

A counter is connected via a directional coupler to indicate the frequency of the

(to reduce mismatching) there is a coax relay. In the lower switch position the transmit level can be measured and adjusted to 0dBm. In the upper switch position this output of 1mW goes to the antenna for transmitting. The feed lines to the wattmeter and the patch antenna are of identical lengths but as short as possible and low-loss SMA semi rigid cables are used.

The accurately measured level of 0dBm = 1mW is now fed to the transmitting helix antenna. On the receive side the patch antenna is screwed directly onto the analyser input. The two antennas are accurately aligned at a distance 1.2m apart in poor reflection environment.

Note: The connection between the generator and the antenna was made as short as possible otherwise the mismatch (the helix antenna has a radiation resistance of 150Ω) may cause further unexpected attenuations. The reflections lead to "standing waves" in the cable and at each maximum additional loss due to the increased power dissipation at these points will occur (because the voltage and current amplitudes are increased there and power raises with the square of the voltage or current). This can increase the overall attenuation by over 4dB even if the cable attenuation is only 1dB with correct adjustment. This effect is described in the chapter "Additional power Loss due to SWR" in [2], there are also formulas and arithmetical examples as well as a beautiful auxiliary attenuation diagram for the consideration of this unpleasant effect.



4.0

Conclusion

NEC is also useful for wire antennas; no blind tests are necessary, because the NEC simulation decreases the largest part of the work and supplies, as shown, useful results.

However the learning effort is substantial and pitfalls lurk everywhere that lead to simulation errors. Often NEC or 4NEC2 does not warn of these and special knowledge of the user is required.

Also only a tiny fraction of this tremendously efficient program with its possibilities could be presented. A constantly growing 4NEC2 tutorial can be downloaded from [3] with all possible simulation examples and appropriate practical references. However if all possibilities and refinement of the program were to be discussed it would take more than 1000 sides.

Designing wire antennas with 4NEC2 makes for much joy and increases your personal knowledge. Much fun is due to

my friend and 4NEC2 specialist, Hardy Lau of the Duale Hochschule Baden Württemberg (DHBW) in Friedrichshafen. Without his knowledge and patient help with problems or questions and his notes on critical cases when the author was not sure or made incorrect assumptions this antenna would not work probably yet.

5.0

Literature

[1] John D. Kraus and Ronald J. Marhefka: "Antennas for all Applications". McGraw Hill Higher Education. ISBN No.: 0-07-232103-2

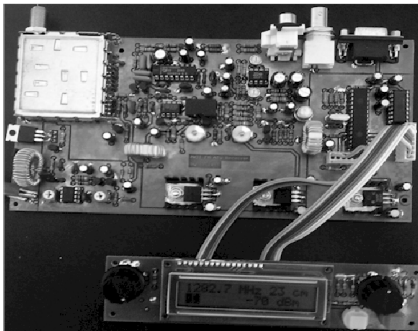
[2] The ARRL Antenna Book, 21st edition. Page 24-10

[3] Homepage of the author www.elektronikschule.de/~krausg.

Download address for 4NEC2: <http://home.ict.nl/~arivoors/Home.htm>

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Carl G. Lodström, KQ6AX & SM6MOM

A useful Doppler radar module

1.0

Introduction

In a recent consulting job I needed to detect a movement. Of course I was aware of microwave Doppler modules, but they are usually quite costly, so I tried all kinds of other solutions. Then I found this, very moderately priced, Chinese, Doppler module on eBay!

I bought a couple and they worked well, but were not very sensitive. To make it useful for my purposes I found a simple way, which I will describe below, to add quite a bit of LF gain to the detected signal.

This proved to be a trap as the output DC bias, derived from the internal detector diode(s), varies with the proximity to fixed objects nearby. Unless the reflections are just right, making the IF output 0 Volt, it cannot be amplified by much or



Fig 1: The Doppler radar module.

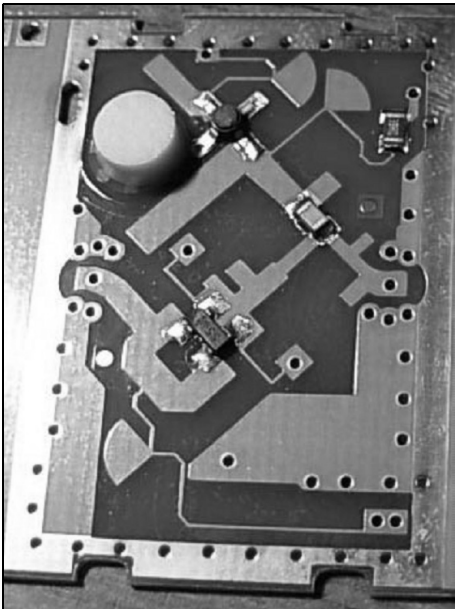


Fig 2: Component side of Doppler radar module PCB.

the output will be saturated to either rail! Besides the LF gain, I also needed some Automatic Level Control, keeping the DC of the output to a level near GND!

This unit also can be useful to the Ham operator, as a 10GHz source and to make a simple link, using a second unit, I will describe what I have done and found out about it.

2.0

The Doppler module.

Fig 1 shows the module, under the QC sticker is a 7/64" hex screw for frequency adjustment, in some of the modules! Since all the modules are at about 10.25 – 10.27GHz it is necessary with a little tweak to get them to 10.525 if this is important to you! The advertised specification is:

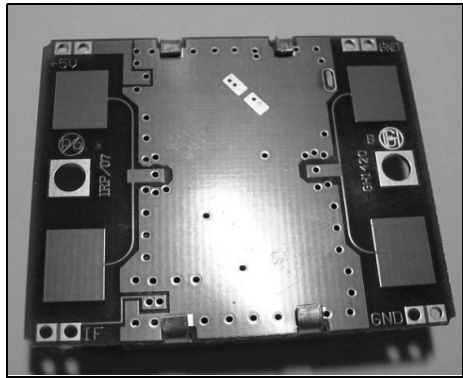


Fig 3: Antennae side of Doppler radar PCB.

Transmitter

- Frequency : 10.525GHz
- Frequency Setting Accuracy : 3MHz
- Power Output (Min.) : 13dBm EIRP
- Operating Voltage : +5V +/- 0.25V
- Operating Current (CW): 60mA max, 37mA typical
- Harmonic Emissions: -10dBm
- Weight : 6 grams.
- Dimensions : 37 x 45 x 8mm

The frequency claim is not accurate. I do not know about the rest.

Fig 2 shows the component side of the PCB and Fig 3 shows the antennae. The right side antennae is connected to the detector diodes, the resulting signal coming out on the IF port in the lower left corner.

The published specification is probably originates from the manufacturer. It is a beautiful example of “what did I say”! There is a bad habit, here in the U.S., to skip leading zeros before a decimal point. 0.8 becomes .8 and in the next iteration



the decimal point is gone because somebody missed it! Guess what the “8mm” above was initially? 0.8mm, which is the thickness of the board, that seems to be FR4 by the way. The entire module, with aluminium shield, is about 9mm thick.

The left side antenna pair is connected to the oscillator, so where these antennae are connected, the island just next to the right side mounting hole, is the point that can deliver RF if the module is used as a source.

They claim a 13dBm (20mW) output, and it is possible. The oscillator is a FET governed by a Dielectric Resonator.

3.0

The detector.

I found the output port (IF) goes about 0.2 V negative, when operating in free air. The only supply is +5V this negative voltage must be created by RF on the detector diode(s). It appears on the IF port in one corner of the board. I found that it could be “pulled up” to some +0.4V by means of a resistor to +5V. With about a few k Ω it was pulled up to about GND level, 0V. Be careful to include the resistor, not to put +5V directly on this port, or it will kill the detector diodes!

4.0

The oscillator

Normally microwave Doppler modules use a Gunn diode, in a resonator cavity, for an RF source. Because this is a relaxation oscillator, using the negative resistance region of the diode, the signal is noisy.

The oscillator at hand is a FET transistor with a dielectric “puck”, a high Q resonator,

for frequency determination. As an analogue, low noise, linear device, it has a much cleaner signal than the Gunn diode. I do not have a spectrum analyser good enough to resolve the difference, but it has got to be considerable, in favour of the unit described here. If any reader can put some numbers to this, I will be interested to hear about it.

The specifications, published by the sellers on the eBay postings (there are many sellers who have these units, some are quite expensive) are all in error about the frequency! They say 10.525GHz but all modules I have tested (using two different kinds of cavity frequency meters of mine) show 10.27GHz, give or take a MHz! I later found that there is no adjustment screw above the resonator in all but one module, so it cannot be adjusted either! Even later I found that removing the aluminium cover makes the frequency drop a few hundred MHz! I would have thought that it would increase due to the lesser capacitance.

I am not sure what to do, but it seems to me that grinding down the top of the resonator ought to increase the frequency. A Dremel (a high speed electric hand drill) with a diamond-grit tool ought to do it. I have only one working module left and cannot afford to lose it, with one month to go to the article deadline! So I will not make that modification now at least. It should work though.

The modules that have an adjustment screw have a 7/64” hex head screw that is not M4! It is close to M4 but the thread has a finer pitch than M4!

They claim an oscillator power of +13dBm, which is not bad. In the Fig 2 we can see the Gate stub to the upper left of the transistor, the Drain stub to the lower left and the “puck” resonator between these stubs. It is ~5.12mm diameter and ~3mm high. The chip resistor in series with the Drain supply is 39 Ω . I tried to raise the supply voltage to see if one could get more power out. At +6V I got a dead transistor, so it is probably not

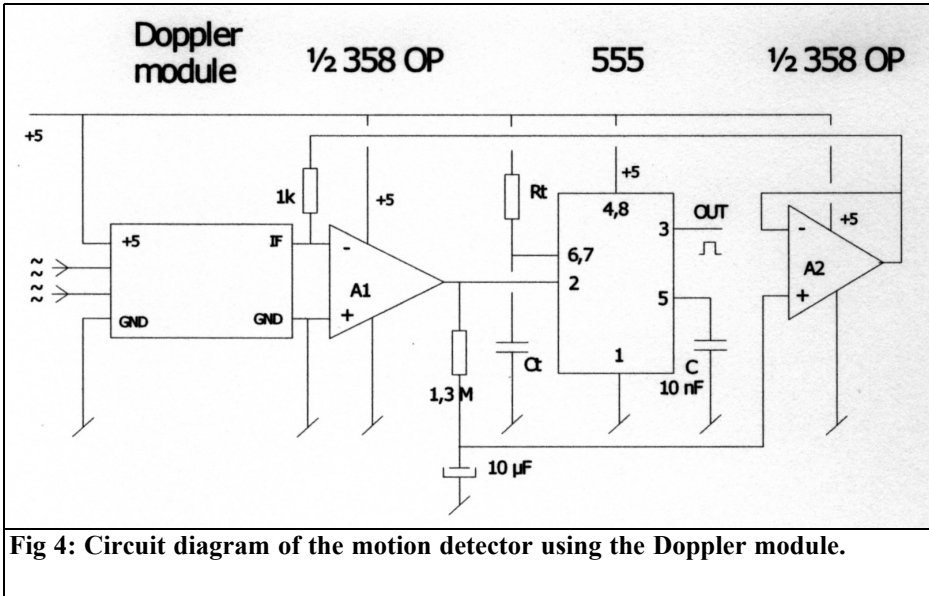


Fig 4: Circuit diagram of the motion detector using the Doppler module.

a good idea to mess with it! The frequency increased a little, some 10MHz so it may be possible to do just a little FM this way, but not by much.

With the IF port pulled up to 0V I could now use the inputs of a “simple” OP amp between the IF port and the GND. The raw gain in the OP amp would do just fine! For a run of the mill dual OP amp such as LM358 the gain is about 25 ~ 100k (94 ~ 100dB), which suits us fine! It is not a tightly specified parameter. Different manufacturers and batches may have different gain. Normally the gain does not matter much, as the OP amp is mostly used with feedback, setting the circuit gain to a much lesser, but stable and well-defined, value. Too much gain here may lead to instability, and I have not tried it. The LT1630, for example, is an excellent amplifier with a raw gain of some 1.5 million. That could be interesting to try!

This approach, of amplifying the DC output, proved to be a dead end as the output became pegged to either rail unless the IF was perfectly adjusted to 0V to begin with! I did this either by adjust-

ing the R (now 1kΩ or the proximity of objects nearby for just the right amount and the phase of reflections.

Sine the 358 (among others) is a dual amplifier; I got the idea to use the other half of it as an Automatic Level Control! It worked like a charm. Observing the DC level at the output of A2, it is clear how it (slowly) adjusts to whatever value is needed for to bring the IF port to the vicinity of GND. When done the detector is very sensitive (as the A1 output is not pegged to either rail) to small movements and variations. The choice of R = 1.3MΩ and C = 10μF are arbitrary, giving a quite long time constant and adding the 1kΩ to the IF did not load it by much, so the sensitivity remains.

5.0

The circuit diagram

I also needed a pulse generator, delivering a positive mono pulse when a signal was detected. If the A1 output goes



above $2/3V+$, a pulse is generated by the 555 circuit when the A1 goes low again. Rt and Ct determine the pulse length from the 555 circuit, should you want to use this function

In the schematic diagram we can see that A1 delivers its raw gain from the Doppler module detector. The RC on the A1 output generates an average of this output signal. The A2 output is allowed to pull on the IF port, via $1k\Omega$, so it is striving for the IF to become GND level as well. Observing the A1 output with a voltmeter, or an oscilloscope, one can see that the average DC level is highly dependent of what is around the antennae! If the output is saturated, A2 is busy pulling it in from saturation. It can take a minute!

6.0

Where to find a module.

The Doppler module I found is sold for less than US\$ 10 total by the eBay seller "cw7406". It is sold for more by many, some are quite expensive.

Beware that they divide the cost for shipping, and the price of the module, back and forth, so add it up before you buy. For this reason, the shipping may be partially a payment for the module too, so combined shipping of several modules, at the same price, may not apply. If somebody finds out who makes this module, maybe you can let me know! They seem to be all over the place!



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Hans Ulrich Schmidt, DJ6TA

Computer control of HPIB/GPIB measuring instruments with the program MESSZEIT

Note from the editor: MESSZEIT is only available in German. Hans has encouraged me to translate his article because he thinks that MESSZEIT will be useful to radio amateurs. He will provide help, by email, to anyone who want to use his program.

Where the German word will help the understanding of the program when it is in use I have put the English translation in square brackets. Andy

It is possible to control many measuring instruments with a GPIB/HPIB interface from a PC using the program MESSZEIT or to just pick up data. The actions of a measuring position are defined on the computer by registering standardised measuring instructions in tables therefore programming knowledge is not necessary. The program also offers routines for evaluation, conversion and producing diagrams from measurement data.

1.0

Introduction

Radio amateurs, in particular those who want to build equipment for the higher frequency ranges, are frequently dependent on high-quality measuring instru-

ments such as signal generators, RF power meters, spectrum analysers and network analysers. Fortunately these devices are quite inexpensive on the surplus market from well-known manufacturers such as HP/Agilent, Rohde & Schwartz, Tektronix, Wiltron/Anritsu and others. These measuring instruments are used throughout industry and have many features e.g. the possibility of control and reading by computer. This is especially interesting for devices e.g. oscilloscopes, spectrum or network analysers that digitally store a complete result of a measurement. This result can be picked up as a file by the computer, converted and be represented or printed out for documentation in many different formats. This is better than the display of the screen contents on an HPIB plotter or printer.

Simpler devices such as signal generators and wattmeters can be controlled by a computer to take measurements that are not possible by hand such as reflection measurements e.g. error corrected, normalised transfer function measurements, see Fig 1.

For thirty years these measuring instruments have been equipped with a standard interface for computer control that was called HPIB (Hewlett-Packard Interface Bus) by its inventor. In the today's language it is usually GPIB (General Purpose Interface Bus) or IEC-bus (IEC-



Fig 1: A typical measurement setup using GPIB devices.

625) shown in Figs 2 and 3. It has an 8-bit parallel bus system with additional handshaking lines that permit addressing up to 30 devices by a control computer. Because of bus loading, a maximum of 16 devices can be operated at the same time when interfaced to a computer. The cable length between two devices should be a maximum of 2m (in exceptional cases up to 4m).

The devices are interconnected and connected to the computer over a shielded multi-way GPIB cable with piggyback plug connectors having 24 pins, see Figs

4 and 5. Both the hardware (24 pin connectors) the TTL levels and transmission protocol are an international standard (IEEE-488.1 and IEC-625). Newer devices also use a uniform syntax for the control instructions (IEEE-488.2).

A so-called bus Extender using coaxial cables, fibre-optic cables or Ethernet can be used to connect to remote devices. Interface cards for the GPIB are available for most types of computers; naturally they are available for the PC (Figs 6 and 7).



Fig 2: A GPIB (HPIB) bus socket.

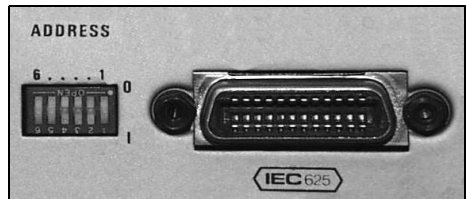


Fig 3: A GPIB (HPIB) bus socket showing address setup switches.

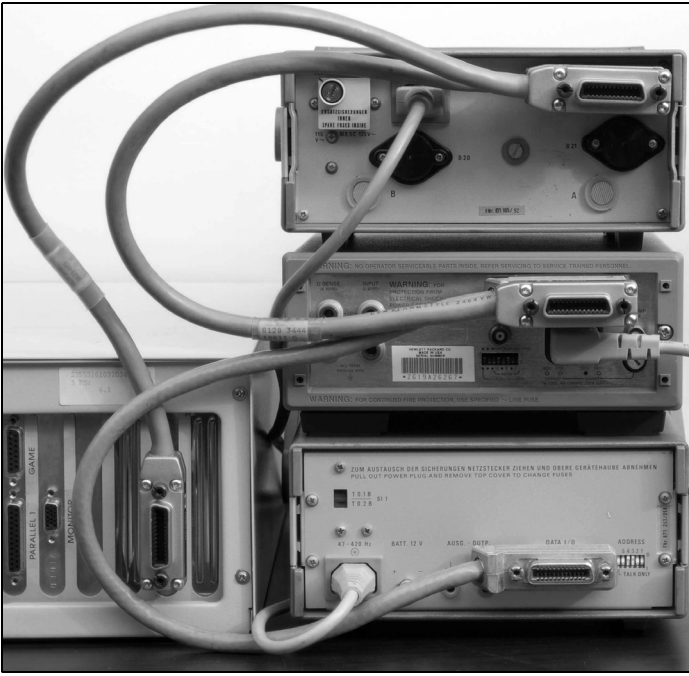


Fig 4: Picture showing several devices connected with GPIB bus cables.

Radio amateurs hardly ever use the interface for control and data capture except to connect them to HP-IB plotters or HP-IB printers, which nowadays are no longer available. The reason for the lack

of use is probably that no ham versions of programs are available for computer control and reading of these measuring instruments.

At the start of this technology the programs necessary were usually written in the laboratories of companies and research establishments (typically in the programming language HP BASIC). This generally led to special programs for

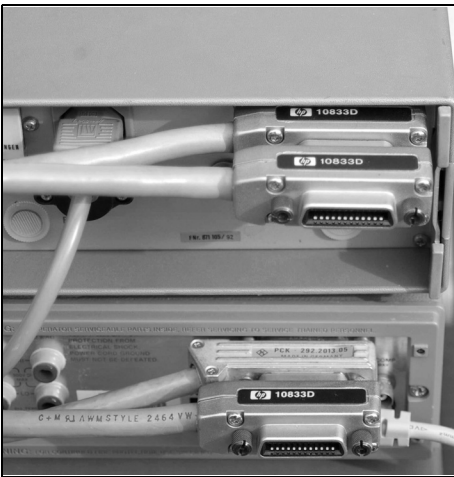


Fig 5: Piggy back GPIB bus cables.

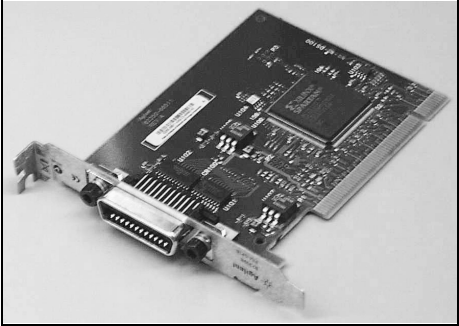


Fig 6: A GPIB PCI interface card for a PC (Agilent 82350).



Fig 7: A USB GPIB adaptor (Agilent 82357B).

dedicated devices and special applications. Later measuring instrument manufacturers offered programs for certain measurements (e.g. EMV measurement by R&S) these were frequently only for certain individual measuring instruments. The prices for the programs were frequently of the same order as the devices themselves.

In the last few years programming languages have become available for graphic programming of GPIB systems such as HP/Agilent VEE and National Instruments Lab-View. It must be noted that these products are not user programs but are programming languages like HP BASIC to produce measuring programs.

For interested radio amateurs it is possible to get results by self-programming with these languages or the classical programming languages or the use of manufacturer user programs that are available to the amateur market.

An example of a universally usable and freely available program is the program, MESSZEIT presented here. It does not conform to the latest standards of Windows programs but it fulfils all the main requirements required for measuring tasks.

2.0

The origins of MESSZEIT

The origins of the program MESSZEIT go back to around 1980. At that time the job of the author involved computer controlled measuring techniques with HPIB/GPIB devices. After a large number of special programs were developed for certain tasks and devices it was decided that a standard program should be developed to cover the majority of measuring tasks. It should be device independent in order to be able to merge both existing as well as later measuring instruments. The program should fulfil the following requirements:

- Time-dependent measurements with several devices at the same time, e.g. change of RF or DC voltages over time, incremental frequency shift of oscillators, etc.
- Measurements with several devices as a function of setup of the first device (parameter measurements), e.g. RF gain at several measuring points as a function of the frequency of a signal generator (transfer functions), power output of amplifiers as a function of the input power from a signal generator (compression measurements), return loss measurements with directional couplers or measuring bridges as a function of the frequency, antenna patterns (antenna output voltage as a function of the angular position of a turntable or a rotor).
- Direct data read out of spectrum and network analysers, oscilloscopes and similar devices with digital memory that send a whole file on instruction.
- Operation of all existing GPIB devices using appropriate device drivers and the ability to merge new device drivers into the program.
- Operation of most devices with a set of standardised instruction words that are accepted by all device drivers.



- Configuration of the measurement setup and the measuring instructions using input tables in order to avoid programming work by the end user.

The control computer (at that time extremely expensive) was an HP 9000 Workstation (the PC had not been invented yet!), these were equipped as standard with HPIB interfaces and the programming environment HP BASIC giving an ideal way of programming measuring instrument in a high-level language. HP BASIC contains a large number of instructions for easy operation the HPIB/GPIB so that the programmer does not have to worry about the details of the bus. The servers used the HP-UX operating system with HP BASIC as a programming language.

The HP 900 computer family (series 200 and 300) as well as HP BASIC were maintained and developed up to the end of HP as a measuring instrument manufacturer in 2000, many measuring systems in industry use these computers up to now.

In order to be able to re-use the substantial software investments in the company laboratory the standard programming language/programming environment was made available as HP BASIC on PCs by the company Transera since the end of the 1990s and today HT BASIC on a PC practically emulates the HP BASIC environment of the HP 9000 and user programs like MESSZEIT run within this environment.

The company Tams converted HP BASIC to run on a PC under the LINUX operating system in the same way. At the authors company new measuring systems used HT BASIC and older ones were changed over. The software was extended in such that it worked without change on all systems.

3.0

Characteristics of MESSZEIT

3.1. Basic functions of MESSZEIT

The MESSZEIT program consists of a nucleus program for execution of measurements, an evaluation part for diagrams and conversion of the measuring files (also HPGRAFIK is individually executable), a large number of device drivers (at present over 100 types - see appendix), an equipment list file and various support and configuration files.

After the program starts the following actions are implemented or offered as options:

- Up to 16 devices can be selected from the equipment list to be used for measurements. The sequence of the selection determines the order used by the computer to responding to the devices.
- The devices are examined for their initial setup.
- Manual adjustments can be made to any selected devices that are switched on using a standard computer menu (frequently easier than the front panel controls and provides a standard approach).
- Sub menu mode for time-dependent measurements
- Sub menu mode for parameter measurements
- Sub menu for the interpretation program HPGRAFIK

3.2. Time-dependent measurements mode

The task of this mode is the execution of actions in several measuring instruments at regular intervals (measurement cycle). Examples are the measurement of the incremental frequency shift of an oscillator with a frequency counter, the monitoring of battery voltages with digital voltmeters, the fluctuations in level on an



RF transmitter etc.

1. A Time Table is set up:

- Table input of the total measurement time and the cycle, simple measurements only require a line:
e.g. 120, 5 (for a total interval of 120s measure every 5s)
- If several lines are entered then several sequential measuring intervals are defined that are processed successively. Different times can be used.
e.g. 120, 5 (for a total interval of 120s measure every 5s)
1000, 30 (for a total interval of 1000s measure every 30s);
60, 5 (for a total interval of 60s measure every 5s)
10, 11 (Only 1 measurement, the cycle time > interval time)

2. Set up a Command Table or Tables

- A table is completed for each connected and switched on device to describe the action to be implemented during the measuring period:
e.g. AUSLESEN [READ] (read the measured value from the device with unsolicited triggering)
or MESSEN [MEASURE] (unique triggering of the device and reading of the measured value)
- The number of lines in the command table for the device corresponds to the number of lines (measuring intervals) in the Time Table.

3. When measurements start in the Time Table the individual devices are addressed repeatedly and the selected results are stored by device (or by measuring channel for multi-channel devices) in their own file.

When the devices respond to the measuring instruction several measuring instrument classes must be differentiated:

- Normal measuring instruments (N)
These supply a measured value (e.g. digital voltmeter, frequency counter, wattmeter) with an action.
Devices with a source (e.g. signal

generators, voltage supplies) belong to this class. These are adjusted with an instruction such as FREQUENZ [FREQUENCY] or SPANNUNG [VOLTAGE], they send back the adjusted value as a measured value (e.g. frequency, voltage, power).

- T or Tr devices (T)
These devices have their own digital memory for measured values and usually a screen display for the contents, e.g. digital oscilloscopes, network spectrum analysers. They return a complete measured value file with a command (e.g. AUSLESEN [READ]).
- Devices with no data output e.g. relay switches
These devices are addressed via instructions such as SCHALTEN [SWITCH] but do not return a measured value.

Most measurement actions are relatively independent of the individual device. Therefore key words were defined by general measuring instructions that are understood by each device driver. Beyond that there are special measuring instructions that are only understood by a few devices. Typical measuring instructions for the individual device classes are:

Normal measuring instruments (N)

AUSLESEN [READ], Read an existing value

AUSLESEN,2,1,A.2.B [READ,2,1, A, 2, B], Read two measuring channels

MESSEN [MEASURE], 1x trigger and selection. The values read are written into the Y column of a matrix, the associated times into the X column. At end of the measurement this can be stored in a file.

Sources as N class devices

FREQUENZ,1,1,145MHZ [FREQUENCY,1,1,145MHZ], Adjust the frequency and value read



PEGEL,1,1,-60dBm
[LEVEL,1,1,-60dBm], Adjust the level and value read

SPANNUNG,1,1,2.75V
[VOLTAGE,1,1,2.75V], Adjust the voltage and value read

INCREMENT_F,1,1,1MHz
[INCREMENT_F,1,1,1MHz], Increase the frequency and value read

INCREMENT_P,1,1,1dBm
[INCREMENT_P,1,1,1dBm], Increase the level and value read

T or Tr devices (T)

AUSLESEN [READ], Read a complete data record into a file

AUSLESEN,2,1,A,2,B
[READ,2,1,A,2,B], Read two measuring channels in two files

MESSEN [MEASURE], 1x trigger, read data in file

Devices without data output

SCHALTEN,2,1,EIN,2,AUS
[SWITCH,2,1,OFF,2,ON], Turn switch on channel 1 on and switch on channel 2 off

3.3. Parameter measurements mode

The task of this mode is the execution of actions in several measuring instruments as a function of the settings of the first device, e.g. the measurement of the RF power with a wattmeter as a function of the frequency of a signal generator (transfer function).

A Source Table for the first measuring instrument must be set up using a menu. The information is:

- Initial value of the source (e.g. starting frequency)
- Final value of the source (e.g. stop frequency)
- Increment (e.g. step frequency)
- Dimension of the source value (e.g. MHz)

A Command Table is then required as in

3.1 for each other measuring device.

After the measuring starts the source is shifted up as indicated by the increment and the other devices are selected in sequence after each step. At the end of the measurement the results are written per device (or per measuring channel) into their own file.

3.4. Representation of measurement results

After completion of a measurement as described in 3.2. or 3.3. the final result for each channel or each device can be plotted, stored and printed out. The diagrams correspond to the appropriate part of the HPGRAFIK analysis program.

3.5. Immediate reading of screen contents for measuring devices

In the program menus for time-dependent and parameter measurements there is a menu option for “last measurement again”. The results for several device measurements from the last measurement session can be represented.

For T devices (e.g. spectrum/network analysers, oscilloscopes) the complete momentary measurement from the equipment is recalled and it can be displayed and stored on the computer (Fig 8). To pick out only the stored results of measurement for this type of device no table is required, i.e. after a program starts reading of the devices begins only this menu option is to be selected.

3.6. Evaluation of measurement results

The evaluation part of MESSZEIT (also separately by HPGRAFIK) has the following tasks:

- Diagrams from measurements already stored
- Expressions on measurement diagrams
- Manipulation of measurement files, Addition, Subtraction and Multiplication of files (e.g. to normalise a

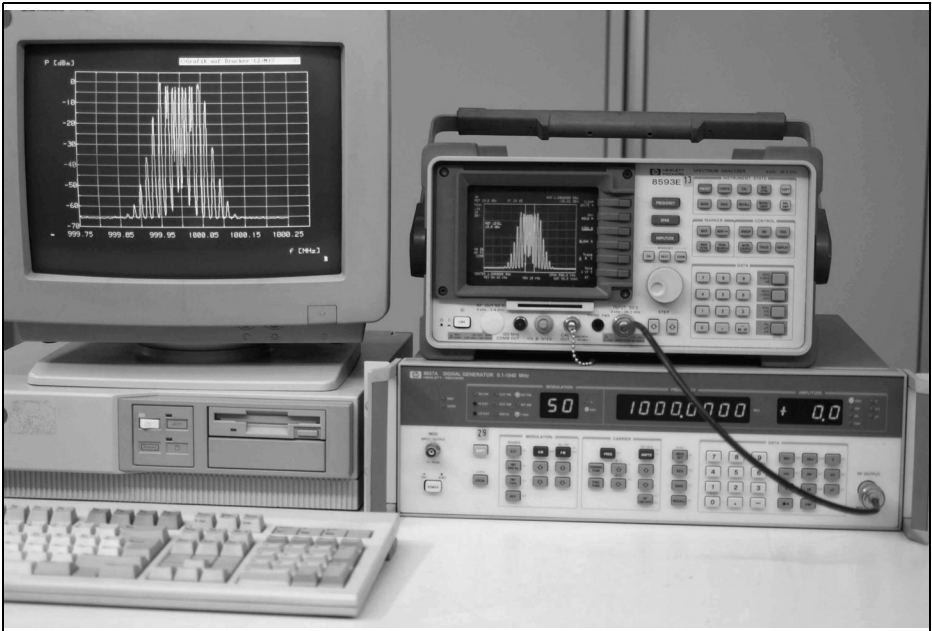


Fig 8: A display being picked up from a T class device and displayed on the PC as well as the device display screen.

transfer function measurement)

- Smoothing, curve fitting, integration, deviation,
- Conversions, e.g. dB to SWR, dBm to W
- Linking, cohering files
- Additional editing and re-entry of data

Diagrams can also be stored as HPGL files or in normal PC diagram formats and merged in text files. Some examples are shown in Figs 9 - 12

4.0

Using MESSZEIT on a PC with HTB

A PC that has High Tech Basic installed (HTB from Transera) can be used by radio amateurs to run MESSZEIT. HTB

operates like an HP 9000 system on a DOS or Windows PC. The DOS version is no longer available individually but is part of the Windows installation CD. The programs and the files produced are compatibly, so it can be quite useful to run MESSZEIT on a DOS computer (less expensive GPIB interface) and transfer the files over a network to a Windows computer and use HPGRAFIK for evaluation and diagrams.

System requirements for the DOS version (HTB-6):

- 386/486/Pentium PC with ISA-BUS,
- MSDOS 5 or 6, WIN 95 or WIN 98 (in the DOS mode)
- GPIB interface 8 Bit ISA (or some 16 Bit ISA),

HTB-6 or HTB-6 Demo Version

System requirements for the Windows version (HTB-7 or higher):

- Pentium PC with ISA or PCI bus
- NT-4, WIN 2000, XP (WIN 98 with

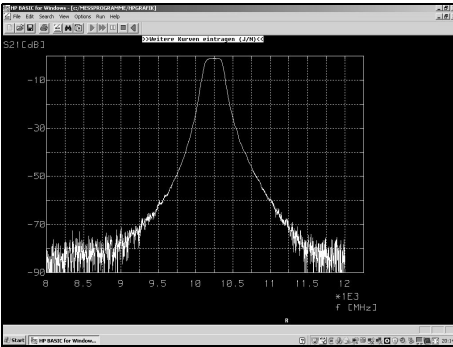


Fig 9: Display of a 10GHz transmission graph.

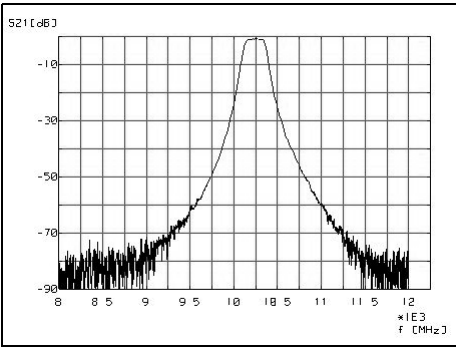


Fig 10: Printed version of a 10GHz transmission graph.

many restrictions)

- GPIB interface 16 Bit ISA, PCI, PCMCIA, USB, LAN
- HTB-7.x, HTB-8.x, HTB-9.x or the demo versions
- For all GPIB interfaces an NT device driver must be installed under Windows.

5.0

HTB versions

The latest Windows version of HTB is available from [1]. The older Windows and DOS versions are available on the installation CD from Transera. The HTB-

6 DOS programs on that CD can only be run under MS-DOS (5/6) and in the DOS mode of Windows 95 and Windows 98. The programs are compatible with the Windows versions; this does not apply to older DOS versions. A free demonstration version of HTB-6 exists, which exhibits the following restrictions: it runs for a half hour and is then terminates but can be started as often as required. Programs produced by the program editor cannot be stored. This restriction has no meaning for use with manufacturers programs such as MESSZEIT.

MESSZEIT can be used without restrictions with all Windows versions from version HTB-7. The latest full version is HTB-9.x from Transera, there is also an HTB-9.x-Run-time-Version that only permits execution of manufacturers pro-

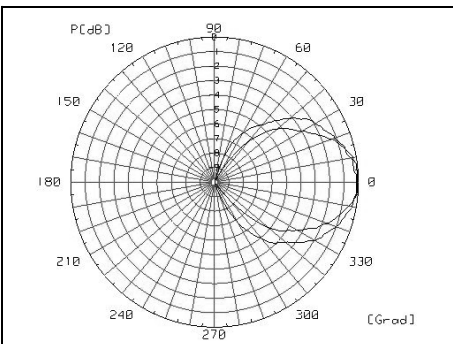


Fig 11: Printed polar diagram of a 6cm exciter.

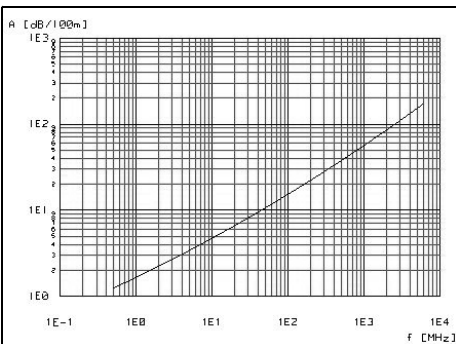


Fig 12: Printer transmission graph for RG 58 coax cable.



grams and contains no program editor. It is clearly less expensive. The HTB-7.1 version was available briefly before the end of Hewlett Packard (approximately 2000) under licence from Transera as HP BASIC for Windows. This was obviously as a replacement for the forthcoming HP-9000 offering. All HP customers with an HP basic service contract for this product were sent a copy free of charge at that time.

The demonstration version of the Windows HTB has the half hour running time and is prevented from using user memory. Demonstration CDs for versions HTB-7.1 and HTB-9.0 as well as HTB-9.0 Runtime are available on the Internet [1].

All full and demo versions are installed by an installation routine onto the computer hard disc. A manufacturer specific NT device driver for the GPIB interface must be installed and configured under Windows.

6.0

Availability of programs and prices

The latest version of HTB can be found from [1], they also supply free demonstration CDs. The programs MESSZEIT, HPGRAFIK, ZPVWOB (for Vector Network Analyser with R&S ZPV and a signal generator) are available free of charge from [2] plus further information, e.g. the supported measuring instruments and interface cards.

Unfortunately there is a cost to connect a GPIB device to a computer. A GPIB interface card must be purchased. The ex-factory prices lie between €300 and €600 [4], and used equipment companies can supply them in the range of €100 to €200. It should be possible to pick them up quite cheaply from a flea market or

Internet auction site. I have seen NI-AT interfaces for under €50. The GPIB cables are not cheap ex-factory however they are a few Euros from used equipment companies or flea markets.

The HTB demonstration versions are free but only run for half an hour. If this is a problem or you want to do your own program development the quite expensive full licensed versions is €800 - €900. Packages with five run time versions are offered that could be divided with colleagues for a more acceptable cost.

All photos taken by the author DJ6TA

7.0

References

[1] TechSoft GmbH, Karmeliterweg 114, 13465 Berlin; www.htbasic.de; E-Mail: htb@techsoft.de

[2] www.mydarc.de/DJ6TA

[3] H.U.Schmidt, DJ6TA: Computer control of measuring instruments, the program MESSZEIT; Conference program of the 32nd GHz conference, Dorsten 2009

[4] www.meilhaus.de

[5] www.rosenkranz-elektronik.de

[6] www.htb-elektronik.de

8.0

Appendix

The following table shows the HPIB / GPIB devices that currently have device drivers available for MESSZEIT.



MESSZEIT equipment list 15/6/2010.

Pseudo-Geräte [Pseudo devices]:

BUSTRIGGER [Bus Trigger], for triggering several HPIB device
 MESSZAEHLER [Measurement counter]

Advantest:

ADVANTEST-Q8381, Optical spectrum analyser
 ADVANTEST-Q8460, OTDR

Anritsu:

ANRITSU-MS4644A, Network Analyser

HP / Agilent:

HP-436A, Thermal power meter
 HP-437B, Thermal power meter
 HP-438A, Thermal power meter
 HP-853A, Spectrum analyser mainframe
 HP-3314A, Function generator
 HP-3437A, System digital voltmeter
 HP-3478A, Digital voltmeter
 HP-3488A, Relay matrix
 HP-3577A, Network analyser
 HP-5180A, Waveform-Recorder
 HP-5316A, Frequency counter
 HP-5343A, Microwave Frequency counter
 HP-5344A, Synchroniser unit
 HP-5351B, Microwave Frequency counter
 HP-5384A, Frequency counter
 HP-8116A, Pulse function generator
 HP-8152A, Optical Power meter
 HP-8153A, Optical Power meter
 HP-8158B, Optical attenuator
 HP-8340A, Microwave sweep generator
 HP-8350B, Microwave sweep generator
 HP-8563A, Spectrum analyser (HP-856x)
 HP-8569B, Spectrum analyser
 HP-8593E, Spectrum analyser (HP-859x)
 HP-8620A, Microwave sweep generator with external DAC
 HP-8620C, Microwave sweep generator
 HP-8657A, Signal generator 0.1 - 1040MHz
 HP-8702B, Optical/electrical Network analyser
 HP-8714ES, Network analyser 0.3-3000 MHz
 HP-8720C, Network analyser 0.05-20 GHz
 HP-8755C, Scalar network analyser with external ADC HP-59313A
 HP-8757C, Scalar network analyser
 HP-8901A, Modulation analyser

HP-33120A, Arbitrary function generator
 HP-33250A, Arbitrary function generator
 HP-34401A, Digital multimeter
 HP-34970A, Digital voltmeter relays
 HP-53131A, Frequency counter
 HP-54502A, Digital oscilloscope
 HP-54720D, Digital oscilloscope
 HP-59301A, ASCII parallel converter
 HP-59306A, Relay driver
 HP-59307A, VHF switch
 HP-59313A, Analogue to digital converter
 HP-59501A, Digital to analogue converter
 HP-83630A, Microwave sweep generator (HP-836x)
 HP-83712A, Microwave signal generator (HP-8371x)
 HP-85645A, Microwave tracking generator
 HP-81110A, Pulse generator
 HP-DSO6000, Digital oscilloscope
 HP-E3631A, Triple power supply unit
 HP-E3641A, 35V-60V power supply
 HP-E4407B, Spectrum analyser (E440x)
 HP-E4419B, RF/Microwave power meter (E441x)
 HP-E5062A, Network analyser (E506x)
 HP-E8257D, Microwave signal generator

Keithley:

Keithley-181, Digital nano-voltmeter
 Keithley-182, Digital nano-voltmeter
 Keithley-195, Digital multimeter
 Keithley-197, Digital multimeter
 Keithley-617, Digital electro-meter power supply unit
 Keithley-705E, Relay scanner
 Keithley-2410, SMU (Digital voltmeter + power supply)

Ortec:

ORTEC-879, Counter interface
 ORTEC-974, Quad counter timer
 ORTEC-996, Counter timer

Rohde & Schwarz:

R&S-DPSP, RF step attenuator
 R&S-FSP, Spectrum analyser
 R&S-NAP, Power meter
 R&S-NGPV, Power supply unit
 R&S-NRVD, RF power meter
 R&S-NRVS, RF power meter
 R&S-PCW, Code converter
 R&S-PSN, Relay matrix
 R&S-RSG, RF step attenuator



R&S-SMC100A,	Signal generator 9kHz – 3.3GHz
R&S-SMDS,	Signal generator 10kHz - 1GHz
R&S-SMDW,	Signal generator 10kHz - 500MHz
R&S-SML,	Signal generator 9kHz – 3.3GHz
R&S-SMLU,	Signal generator 25 - 1000MHz
R&S-SMPC,	Signal generator 5kHz - 1.3GHz
R&S-SMPU,	Signal generator 50kHz - 1GHz
R&S-SMR,	Signal generator 10MHz - 40GHz
R&S-SMS,	Signal generator 0.4 - 1040MHz
R&S-SMT,	Signal generator 5kHz - 6GHz
R&S-SMX,	Signal generator 0.1 - 1000MHz
R&S-SPN,	Signal generator 1Hz - 1.3MHz
R&S-SWP,	Sweeper 0.4 - 2500MHz
R&S-UDS-5,	Digital multimeter
R&S-URV4,	RF milli-voltmeter
R&S-URV5,	RF milli-voltmeter
R&S-UVZ,	Relay scanner
R&S-XPC,	Signal generator 5kHz - 1.3GHz
R&S-ZVRE,	Network analyser
Tektronix:	
TEK-RTD710A,	Transient recorder
TEK-CSA803 ,	Sampling oscilloscope
TEK-TDS350 ,	Digital oscilloscope
TEK-TDS380 ,	Digital oscilloscope
TEK-TDS640A,	Digital oscilloscope
TEK-TDS694C,	Digital oscilloscope

TEK-TDS784D,	Digital oscilloscope
TEK-TDS1012,	Digital oscilloscope (TDS1xxx)
TEK-TDS5104B,	Digital oscilloscope (TDS5xxx)
TEK-TDS6604B,	Digital oscilloscope (TDS6xxx)
TEK-7612D,	Transient recorder
TEK-7912AD,	Transient recorder

Wandel & Goltermann / Narda:

WG-EMR300,	Field strength meter with ext. RS232-GPIB interface
WG-EMC300,	Field strength meter with ext. RS232-GPIB interface

Other manufacturers:

ANT-SP-797,	Fibre optical insertion loss measurement equipment
BIOMATION-8100,	Transient recorder
BONN-BSA-1001,	RF power amplifier
DELTA-PSC44,	ADC - DAC for power supply control
FUG-HCN3EM,	Programmable power supply
FUG-MCN140,	Programmable power supply 1250V
ICS-4823,	Parallel interface
ICS-4833,	Parallel interface
LDX-3207B,	Power supply (Laser, LED)
LDT-5910,	Temperature regulator
NAT-3,	Relay matrix
Newport-2832,	Optical power meter
OMRON-E5CK,	Temperature regulator
PHD-1975XQ,	Optical attenuator



André Jamet F9HX

My future 15W 10GHz SSPA will not run too hot!

1.0

Introduction

The fashion is for large microwave SSPAs [1]. It is who wants to achieve a 15W or a 30W SSPA at 10GHz, and also on 5.7GHz. I intended to make a 3-stages 15W 10GHz SSPA housed in a milled aluminium case: 77 x 98 x 25mm. I got advice from F5BQP who gives an example of a perfect example and provides very valuable measurement results [2].

An important point was not raised so far: the cooling of SSPA.

2.0

What is the problem?

It is simple: their efficiency is very low and lost power is large. It is compulsory to properly remove the heat produced so that junction temperatures exceeding the maximum value given by the manufacturer are not reached.

Let us consider an example to determine the order of magnitude of these losses. The DC input power of the 15W 10GHz SSPA with no RF input and therefore

without output, is about 4.6A at 12V, that is to say 55.2W. For the best compromise chosen by F5BQP the current will rise to 6.3A for 15W output but the dissipation of the final transistor will not increase as its current, because it will deliver the RF. This class AB operation is very interesting because it reduces the DC quiescent current at the price of a lower gain and reduced linearity. Digital modes that require excellent linearity are not yet widespread on the microwave bands.

Consider that this operating point is the worst case to evaluate the losses. I had a look for a heat sink (Fig 1) in the catalogue of a distributor of electronic components. I found a model that seemed to me adequate because its dimensions cope with my SSPA case. Its thermal resistance is 1°C/W. This means a temperature rise of 55.2°C for 55.2W. If the ambient temperature is 30°C, this puts the surface of the heat sink to

$$t_{\text{surface}} = 30 + (1 \times 55.2) = 85.2^{\circ}\text{C}$$

To account for various thermal resistances between the transistor junction and

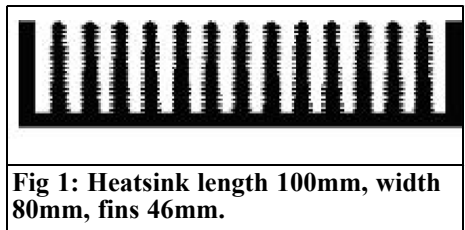


Fig 1: Heatsink length 100mm, width 80mm, fins 46mm.

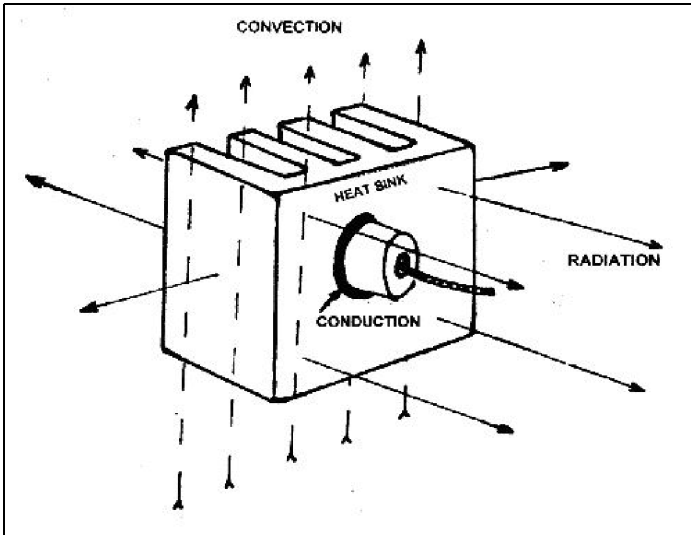


Fig 2: Three modes of heat transfer.

the heatsink surface see Fig2 and 3:

$$t_{\text{junction}} = t_{\text{ambient}} + (\sum \text{various thermal resistances} \times P) \text{ t in } ^\circ\text{C},$$

thermal resistance in $^\circ\text{C/W}$ and P in watts.

For the final transistor, its internal thermal resistance is 2°C/W and its mounting gives 0.1°C/W of resistance. The thermal resistance of the bottom of the milled aluminium case is given by:

$$R_{\text{th bottom}} = L / (\lambda A)$$

with:

$$A = \text{case transistor surface: } 1.2 \times 1.2 = 1.44 \text{ cm}^2$$

$$R_{\text{th bottom}} = 1 / (0.22 \times 1.44) \approx 0.3^\circ\text{C/W}$$

The collector current transistor is 3.5A (minimum recommended quiescent value by F5BQP) at 8.5V.

It must dissipate:

$$P_{\text{lost}} = [(8.5 \times 3.5)] = 29.75\text{W}$$

and:

$$t_{\text{junction}} = 85.2 + [(2 + 0.1 + 0.3) \times 29.75] \approx 157^\circ\text{C}$$

The temperature limit given by the manufacturer for the junction is 175°C . It is too close to this limit.

Worse still, the component side of the circuit will have a high temperature because its copper surface is close to 85.2°C . Tantalum capacitors do not appreciate having the feet so warm!

3.0

What to do?

These temperatures are reached only after a progressive rise given the thermal inertia of all parts when subjected to the heat. This time constant reaches several minutes. If one is not talkative and do not have a long and difficult QSOs, it may be acceptable. For security, however, there must be greater margins for the duration of transmission.

We can increase the heat sink size choosing a lower thermal resistance model. It then becomes enormous and very heavy. The model I chose above is already a beautiful beast. Looking at the photos of the 15W F6BVA SSPA it can be estimated at 100mm in high, 240mm long with 50mm fins. It is used as a side of the enclosure. It is a great solution because it

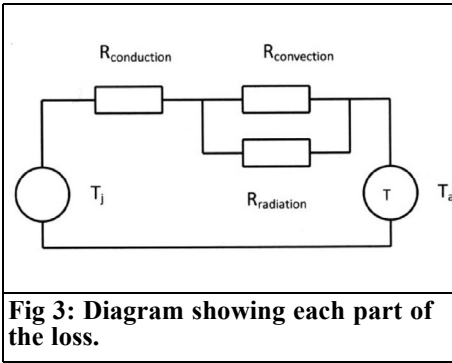


Fig 3: Diagram showing each part of the loss.

avoids most of the heat remaining in the enclosure. But, what clutter and what weight!

Some will think of the Peltier effect modules and heat pipes, expensive and impractical.

Here is my solution: air forced convection, simple, effective and low cost.

4.0

You said thermodynamics?

The heat transfer process is at least as complicated as our radio waves. But a lecture course on thermodynamics is not necessary. A few good principles and common sense are sufficient [3,4].

To "extract" heat from a device transforming energy into heat, three modes are used as shown in Fig 2 and 3:

- conduction
- convection
- radiation.

In our case, the first mode is the one that conducts heat from the transistor junction to the heat sink surface. The second is the heat transmission in ambient air. The third is heat loss by radiation, infrared for temperatures below 500°C , to the media surrounding the source of heat.

Conduction is aided by a good thermal

contact between the heat source and the elements responsible for convection and radiation. To avoid pockets of air, a poor conductor of heat, a hint of grease or thermal compound is placed between the heat sink and the transistor flange.

Convection is related to the characteristics of fluid causing convection, air or liquid and its velocity, natural or forced.

Radiation is linked to the emissive properties of the hot surface. The nature of the material and its state of surface are the factors governing the emissivity. Heat transfer is very roughly divided equally between convection and radiation [5,6]. In forced convection, radiation is less involved with the heat transfer. However, the heat sink is black anodised aluminium and can also be sprayed with matt black paint.

We will "visit" the second way to use it well.

5.0

Forced air convection

For forced and natural convection, the efficiency depends on several parameters:

- the hot surface
- shape and roughness this surface
- the mass of air used: therefore its density (temperature depending) and its flow rate.

The manufacturer of the heat sink gives us its thermal resistance. Most often, it is given in natural ventilation for heat sinks that interest us and are not specified for the ventilation used in high power electronics. The influence of air velocity is therefore the parameter that we must consider. The engineer has a series of formulae based on typical configurations (flat plate, flow around a cylinder...) to derive the thermal transfer coefficient

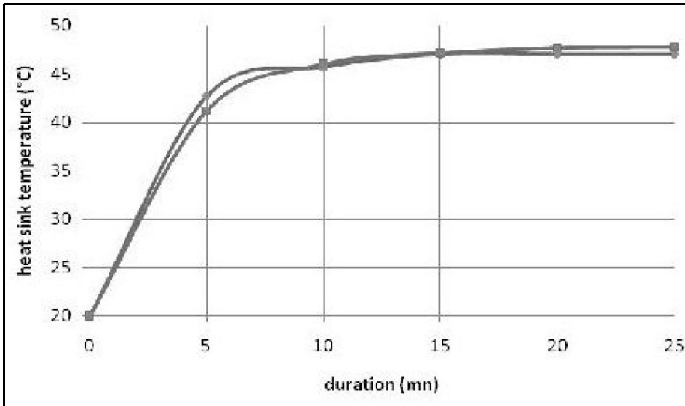


Fig 4: Heatsink temperature versus "on" time. Round dots, horizontal position. Square dots, vertical position.

Unfortunately, the available formulas apply well to simple configurations. Their application to finned heat sinks is a great art and published values were obtained by conducting measurements. Then, we will use them empirically to the end!

It was found that the thermal resistance decreased with air velocity approximately according to the curve in Fig 4. The order of 1.5m/s velocity brought down the thermal resistance of a heat sink to half of its value in natural convection.

In these conditions, with a thermal resistance of 0.5°C/W for our heat sink in forced convection, the paragraph 2 calculations become:

$$t_{\text{surface}} = 30 + (0.5 \times 55.2) = 57.6^{\circ}\text{C}$$

(see paragraph 10, measured 48°C to $t_a = 20^{\circ}\text{C}$)

$$t_{\text{junction}} = 57.6 + [(2+0.1+0.3) \times 29.75] = 128.4^{\circ}\text{C}$$

(see paragraph 10, can be calculated $\approx 118^{\circ}\text{C}$)

This becomes more acceptable.

To obtain this speed two fans of 40 x 40mm with a 37mm diameter propeller must be used:

$$\text{Total air passage across the surface} = \pi \times 37 \times 37 \times 2 / 4 = 2150\text{mm}^2 = 2.15 \times 10^{-3} \text{m}^2$$

$$\text{Total necessary flow} = 2.15 \times 10^{-3} \times 1.5 \times$$

$$3600 = 11.6 \text{ m}^3/\text{h (loaded)}$$

The required velocity that must be obtained with two fans is a flow of 11.6 m³/h in the "labyrinth" formed by the heat sink and any other part of the air route.

It remains to determine what fans will be able to produce this airflow. The documentation often gives "open-mouthed" flow i.e. without load. This data must be reduced because the fins will halt the passage of air and reduce the flow.

6.0

Fan location

It must enter ambient air and evacuate the hot air through all possible fins. A kind of cowling can be used to receive the fan and force air through the entire surface. To avoid the fan being submitted to the warmer air, it will be placed at the entrance to "push" the fresh air and not to the exit to pull hot air. It is not always possible to achieve this arrangement if it is decided to install the SSPA in a box with other modules, the antenna relay, etc. The fans arrangement must give a logical solution.

For my part, using a dish with a shepherded crook feed all 10GHz equipment

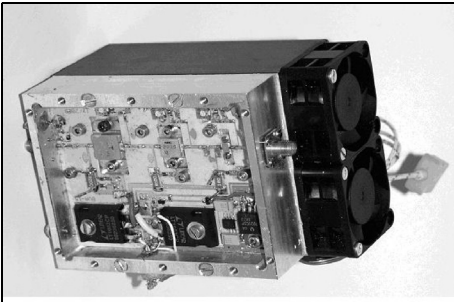


Fig 5: SSPA with two fans. K thermocouple connector on the right.

- XINDA 12VDC at 90mA
- 40 x 40 x 20mm 5500 RPM
- 6.1 m³/hour
- pressure 3.5mmH₂O
- noise 27.5dBA

Table 1 shows the results of measurements with a K type thermocouple housed under the centre of the package through a hole in the heat sink. Two positions were tested. The most favourable is where the fins are in the vertical direction, fans below blowing in fresh air and out at the top. Horizontal mounting with input and output of air on the sides does not really degraded this as shown in the measurements and the calculation of the final transistor junction temperatures.

is placed behind the dish on a plate. The SSPA is not in a cabinet and the fans will be glued or screwed under the heatsink.

Horizontal position: $48 + [(2+0,1+0,3) \times (8.5 \times 3.5)] \approx 119^{\circ}\text{C}$

Vertical position: $47 + [(2+0,1+0,3) \times (8.5 \times 3.5)] \approx 118^{\circ}\text{C}$

7.0

Measurement

These values can seem high and could be reduced with more powerful fans. But, as the SSPA is not on 100% of the time for traffic, it will probably not reach its maximum temperature.

Although the final transistor choice seems really difficult, I have finalised the heat management of my SSPA. I am still dissipating as much with a good transistor and the wrong TIM 1001-15 serves me only as a heater. It is one of these counterfeit goods manufactured in Asia. The price was affordable (\$150) but the transistor doesn't work! To get a good one you have to pay much more from Toshiba. Therefore, I am still waiting for a good solution.

The two fans are screwed in tapped holes in the sink each fan:

8.0

Influence of altitude

As the density of air decreases with altitude its heat removing capacity is reduced and must be taken into account for use in high places. If the density is

Table 1: Results of temperature measurements.

Location of the temperature	Horizontal position	Vertical position
Measurement on the upper surface of the heatsink (by hole)	48°C	47°C
Calculated final transistor junction tempertaure	118°C	118°C
Test duration	25min	25min



given as 1 at zero altitude, it drops to 0.83 to 1500m and 0.78 at 2000m. The required air volume must be multiplied by 1.2 and 1.3 respectively.

9.0

Conclusion

The use of fans, even of modest dimensions, to reduce the temperature of the SSPA without resorting to a large heat sink is a good solution. However, the forced air convection can cause some difficulties, such as the introduction of dust and insects. Taking this into account use filters if necessary.

And now... Well, my SSPA is on a shelf in the expectation of this rare bird of a transistor!

I will not describe it on the pages of this magazine until a good transistor is in my possession and I obtained RF in quantity!

10.0

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[1] PA ...d'OMsss! (5.7 et 10GHz), F6BVA, CJ Proceeding 2010

[2] [www.ham - hyper .com /...boosters-preamplifiers/166-amplifier-10-ghz- 3-tiered15w- type-f6bva-measures-a-la-compression-by-f5dqk -](http://www.ham-hyper.com/...boosters-preamplifiers/166-amplifier-10-ghz-3-tiered15w-type-f6bva-measures-a-la-compression-by-f5dqk)

[3] Techniques de l'ingénieur, Transmission de l'énergie thermique

[4] Evacuation de la chaleur dissipée dans les équipements électroniques, S.Elberg & P. Mahonnet, Eyrolles 1978

[5] Faut-il réellement peindre en noir le dissipateur d'un semi-conducteur de puissance ? Really need paint black heat sink to a power semiconductor? F9HX, Radio-REF 6/2001

[6] Une peinture mate? F9HX Radio-REF 11/2001

11.0

Appendix

F5BQP and my own tests were conducted with a power supply delivering 12 volts. This already leads to a loss of:

$12 - 8.5 = 3.5V$ in the DC regulator, is $3.5 \times 6 = 21W$.

It is advisable not to use a power supply giving 13.8V because it would lead to:

$13.8 - 8.5 = 5.3V$ to fall and $5.3 \times 6 = 31.8W$ to evacuate.



Gunthard Kraus, DG8GB

Internet Treasure Trove

Ansoft designer SV

This software does not need much introduction. It the Student Version (SV) and therefore free of charge. It is the first choice for specialists and radio amateurs for RF simulation and microwave circuits. Above all it is because it is a complete linear simulator with hundreds of components and examples available.

It is difficult to understand but because of a change of Ansoft management policy this software suddenly disappeared from their homepage and from the entire Internet. Fortunately the author has received permission to use it in the context of his German and English Tutorial and offer the download to the order.

Address:
<http://www.elektronikschule.de/~krausg>

Introduction to IQ-demodulation of RF data

Modern communications use different types of modulation, among other things QAM (Quadrature Amplitude Modulation). A good manual is useful for those who would like to train themselves or gain some experience.

Here is one that is not only accurate but also written to be easily understood. It is actually part of a manual for a piece of equipment.

Address:

<http://folk.ntnu.no/htorp/Undervising/TTK10/IQdemodulation.pdf>

Silicone lab

This is a company who develop and manufactures a most diverse range of ICs. Most people are looking for something new to investigate. Look no further for here they have complete receivers with all accessories on a chip, everything for AM, FM, short wave, long wave or weather band – it works with them all.

Address:

<http://www.silabs.com/products/audiovideo/amfmreceivers/Pages/default.aspx>

Hoverman HDTV UHF antenna

You never stop learning in the field of communications and this is no exception. If you have never heard of this antenna before it is worth investigating its properties.

Addresses:

<http://www.jedsoft.org/fun/antennas/dtv/gh.html#toc-3>

<http://www.digitalhome.ca/ota/superantenna/index.htm>



Orban Microwave/The basics of patch antennas (updated)

There was a basic article about patch antennas that can also be found in many publications from other authors on this topic and it has been in their bibliography for a long time. This led to many letters making suggestions for extensions and corrections. Orban have now revised this application note and published it again. The result is first class.

Their homepage also contains other interesting literature on offer from the company on....

Address:

http://www.orbanmicrowave.com/assets/Pdfs/Technical_Articles/Orban-Patch-Antennas-2009-rev.pdf

Circularly Polarised Microstrip Antenna for Cordless Phones

This is a very beautiful patch antenna, but this time in the form of a presentation. It is worthwhile to take a look

Address:

<http://ndl.ee.ucr.edu/kelly.pdf>

pcaad21.zip

This is actually an old DOS program for computation, design and analysis of all possible forms of antenna up to horn radiators. It still works easily and efficiently and therefore it is still interesting but difficult to find. I was very surprised to find it hidden in the crowded download list of products in a computer magazine.

The greatest surprise was the individual topics in this download list that stretch as

far as astronomy...

Address:

<http://shareware.pcmag.com/product.php%5Bid%5D45169%5Bcid%5D93%5BSiteID%5Dpcmag>

Radio-Electronics.com

This homepage always has some new topics. It is a genuine "Pandora's Box" that can consume lots of time. The small sample here shows to the topic of "Receivers":

Address:

<http://www.radio-electronics.com/info/receivers/index.php>

Analog Devices

A regular view of this homepage seems to be an obligation because this company obviously takes its company name seriously. The Application Notes and the Technical Articles about communications are very interesting:

Address:

<http://communications.analog.com/en/segment/cmmn.html>

Broadwave Technologies

An Application Note on different kinds of power dividers (up to the two-stage Wilkinson divider) from this company is very interesting.

Address:

http://www.broadwavetechnologies.com/CataloguesPDF/application_notes_power_dividers.pdf

In addition there are many good things if



you look thoroughly enough. An example is a Power Conversion Table and Reflection Loss Chart that is already makes its way round the RF enthusiasts.

Address:

<http://www.broadwavetechnologies.com/CataloguesPDF/ConversionChart.pdf>

Designspark

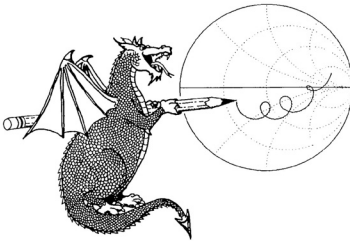
There is a free circuit diagram and printed circuit board layout program called DESIGN PARK available after registration. The operation is very similar to the well-known EASY PC, however iot is not compatible.

Address:

<http://www.designspark.de>

Note: Owing to the fact that Internet content changes very fast, it is not always possible to list the most recent developments. We therefore apologise for any inconvenience if Internet addresses are no longer accessible or have recently been altered by the operators in question.

We wish to point out that neither the compiler nor the publisher has any liability for the correctness of any details listed or for the contents of the sites referred to!



PUFF Version 2.1 Microwave CAD Software

This software is used by many authors of articles in VHF Communications Magazine. It is supplied on 3,5 inch floppy disc or CD with full English handbook. PUFF is £20.00 + postage (UK £0.70, Surface Mail £1.45, Air mail to Europe £1.60, Air mail outside Europe £2.60).



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KM PUBLICATIONS,
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Tel: +44 (0) 1843 220080
Fax: +44 (0) 1843 220080

Email:
andy@vhfcomm.co.uk

Editor

Andy Barter G8ATD

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BELGIUM - UKW-BERICHTE, POB 80, D-91081 BAIERSDORF, Germany. Tel: 09133 7798-0. Fax: 09133 779833.
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Fax: +44 1843 220080. Email: andy@vhfcomm.co.uk

FRANCE - Christiane Michel F5SM, Les Pilets, 89240 PARLY, France
Tel: (33) 03 86 44 06 91, email christiane.michel.s5sm@orange.fr

FINLAND - KM PUBLICATIONS, 503 Northdown Road, Margate, Kent, CT9 3HD, UK. Tel: +44 1843 220080.
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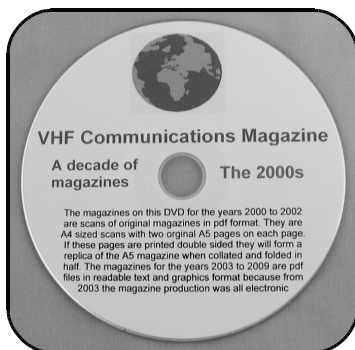


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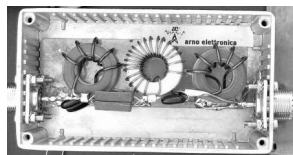


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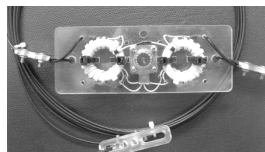


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