Technical Feature

Pic 'n' Mix Digital Injection System

*Part 2, by Peter Rhodes, BSc, G3XJP**

IN THIS PART the alternatives and techniques for mechanical construction are explored. These include a process for making one-off PCBs and for mounting the DDS chip on a DIL socket carrier.

OVERALL STRATEGY

WHEN IT COMES to the layout of the hardware, flexibility is a design objective. When it comes to the mounting of the DDS chip itself, a successful outcome is likely only if you absolutely follow the rules and allow me to adopt a somewhat dictatorial style.

Your first decision revolves around whether you are building an external injection source or are integrating it mechanically with your Tx/Rx. In either case, self-evidently, the tuning knob and keypad need to go on the front panel, with the display board immediately behind it.

The DDS board is the same size as the display board. It is designed for mounting parallel to and behind the display board, or at right-angles to it, or completely remotely from it and connected to it by ribbon cable. The last choice is not relevant in a self-contained external source.

The tuning knob may be mounted on either side of the display, the choice being governed simply by whether you are right or left-handed. The keypad should be mounted on the same side of the display as the tuning knob. Should you mount it on the opposite side of the display, although it may give some appearance of better aesthetic balance, you are courting an ergonomic disaster. Visual feedback of your key presses is given via the display and status LEDs, and your forearm will inevitably obscure the view.

In the photograph, you will note that my keypad is mounted contrary to these recommendations. This is a layout peculiar to my requirements, since I am unusual in being mostly ambidextrous, preferring twisting motions (eg screw drivers) with my right hand and pushing motions (eg sawing) with my left hand. In practice, I therefore use both hands, but most people would find this uncomfortable.

The second decision is whether to build the shaft encoder as an integral part of and mounted on the DDS and display boards - or to split them. The choice is yours and is governed mostly by where you are starting from. A 12in separation between the two presents no performance issues. If you want to take this approach, simply cut both boards, separate them and reconnect them using four flying leads or some ribbon cable. The four leads are +5V, 0V, Pulses and Direction. Obviously you could build them like this in the first place.

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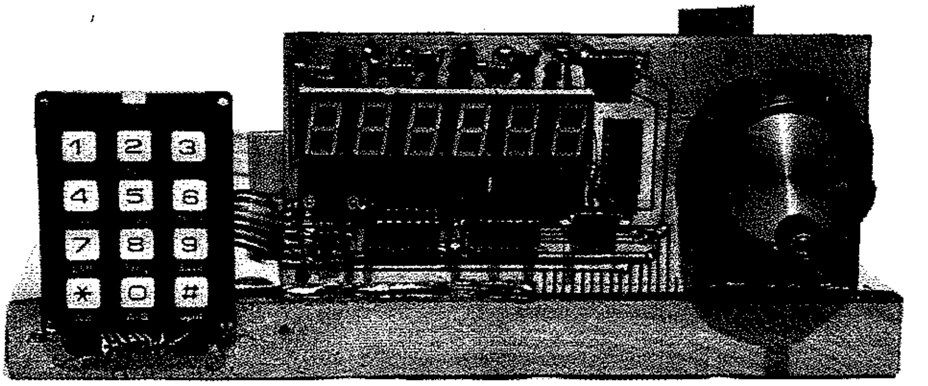

Front view of the 'Pic 'n' Mix'. Note the fact that almost all of the copper remains present after the display PCB has been etched.

The final consideration is the housing for a standalone unit. Those of us who have built so far have found no need for a screened enclosure, but it would obviously represent good practice. In any event, you will need to consider weighting or securing the box, since Newton's Second Law applies when you press the keys - and the last thing you want is the box skidding around.

DISPLAY BOARD MOUNTING

THE DISPLAY BOARD mounts immediately behind the front panel. You will need an aperture of 3in x 3/4in to view the frequency readout. Having cut the aperture, you need to back the hole with some optical filter material which either corresponds to the colour of your display (typically red or green) or - and preferably - is circularly polarised. The latter gives much superior performance in bright natural light, but for some reason has become expensive in recent years.

Fig 5 is a suggested front panel template, which also shows how I have accommodated the status LEDs. 3mm holes are drilled for these, the LEDs are inserted in the board but not soldered. The front panel is mounted into position, and the LEDs adjusted in their holes for equal protrusion. They are then tacked and finally soldered to the display board when fully aligned.

If, like me, you deprecate the idea of screw heads showing on the front panel, you will need to glue some nuts or threaded pillars to the back of the front panel to mount the display board. I find nut rivets ideal for this, since they have a large surface area which makes for strong and permanent adhesion using Superglue®.

DDS BOARD MOUNTING

FOR RIGHT ANGLE mounting, **Fig 6** shows the configuration and for parallel mounting refer to **Fig 7**. To ensure full access during commissioning I would strongly recommend that you avoid the parallel mounting configuration to start with. If this is your target configuration, join the two boards with a short length of 0.1in pitch ribbon cable. This allows access to both sides of both boards for testing.

If you are mounting the two boards at right angles in close proximity, then the best approach is to permanently solder the two boards together as shown in Fig 6. Butt the two boards to form a small 'T' junction (not an 'L'), tack them lightly together, check the angle and then run beads of solder along the full length of both sides to intimately join the ground planes. Join the edge connectors with a small solder bridge and test for shorts.

A further advantage of taking this approach is that the display board need not be secured to the front panel. Mounting the DDS board to a horizontal base with the display ICs touching the rear of the optical filter provides effective location.

MAKING THE PCBs

IN MY ARTICLE on the Third Method Transceiver [7], I described an approach to constructing boards without etching which proved

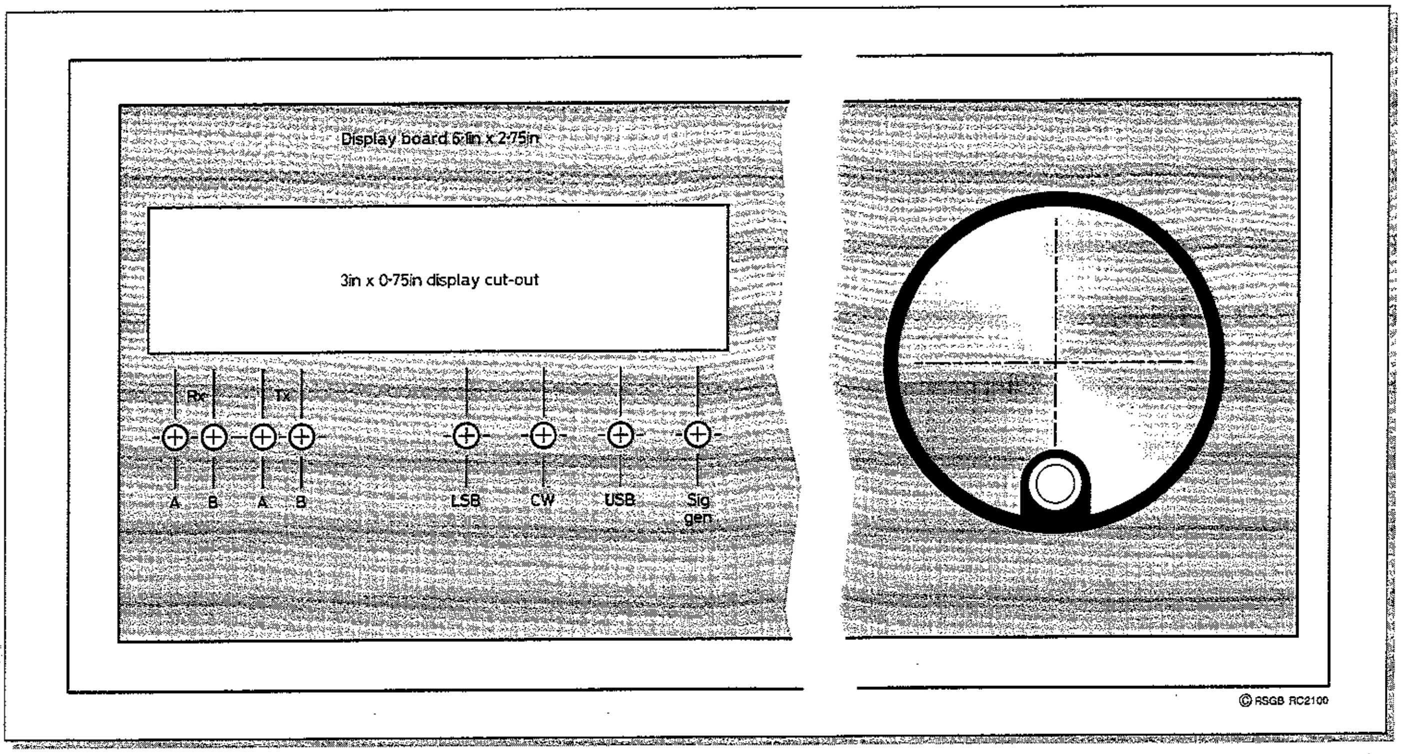

Fig 5: Drilling template for the front panel. The position of the tuning knob shown assumes you are mounting the shaft encoder on the display and DDS boards. It could be much further to the right, or on the opposite side of the display.

very popular. It would be perfectly viable to use this technique for the display board in this project, but wholly inappropriate for the DDS board, so what follows is a technique I have used for many years for making one-off PCBs without the expense of UV exposure techniques. I must emphasise that this approach is viable only for one-offs and is hopeless if you need greater quantities. I would also be very surprised if these particular boards can be made using an etch-resist pen, since some of the tracking is very fine.

The technique revolves around removal of material where you want to remove copper - rather than applying resist where you want to retain copper.

The board is firstly cut to size and then drilled. For any surface mounting areas, the board may be gently punched but not drilled. The idea is to give yourself guides to draw the artwork directly onto the board.

With the board clean but not polished, it is sprayed both sides with an aerosol of car paint. Matt black is best for a contrast colour against the copper. It is important to put on a light enough coat to just cover it, but not to get any substantial build up of paint thickness.

Then, only after the paint is truly dry, the paint is removed between the tracks using a scribing tool. You use the holes, punch marks and master artwork as a guide. You only need to remove a fine line of paint. In fact if you stand a few feet back from the finished board, it looks substantially like continuous copper. Note that if, for example, you have two parallel tracks, you would need three scribed lines to implement it.

The technique takes a little getting used to, but if you should make a mistake, simply repaint the affected area with a small brush and do it again - differently!

There are some important tips:-

- Tape the board down to a reasonable block of wood to stop it skidding around and to prevent scratching the paint on the reverse side.
- You can also use a square against the edge of the wood if you want posh lines - but the square needs to be transparent if you want to avoid frustration.
- Use a piece of Veroboard as a guide if you need to scribe edge connectors.
- Scribe the board at a good room temperature - certainly never cold. The heat from a desk light makes it even easier and helps prevent paint chipping.
- Finally, the scribing tool itself is important. It needs to be pointed but not incredibly so. And it also wants to retain the point. I find the best tool is to take a masonry nail - which is hard steel - cut the head off and grip it in a draughtsman's clutch-pencil. Failing that, a long masonry nail through a cork is pretty comfortable.

Sharpen the point with a rotate and drag motion on a piece of emery, and when you have got it as sharp as you can, blunt it ever so slightly on a piece of fine wet and dry. Try it on a piece of scrap, holding the scribe at about 45°, and you should get a clean fine line. Resist gouging out the copper - you are only trying to remove paint! Repeat the sharpening process every 10 minutes or so. You will feel when it is not cutting the paint cleanly. By the way, for really fine work (you won't need it here) a sewing needle is excellent, as is an old gramo-

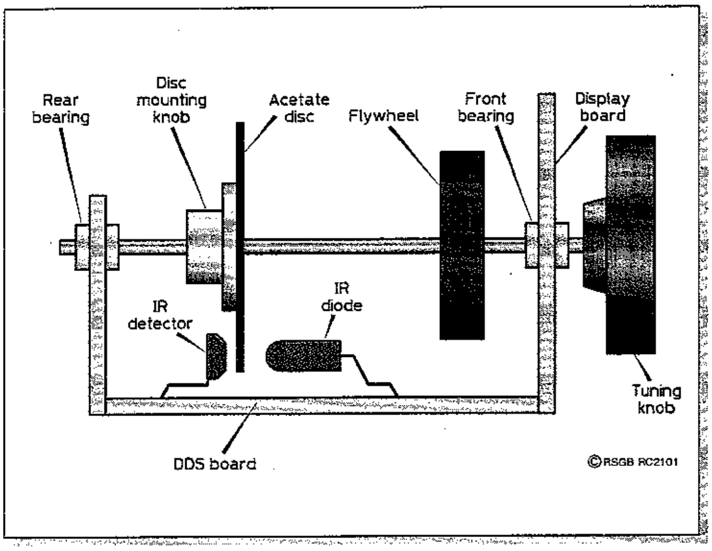

Fig 6: The DDS board mounted at right angles to and integral with the display board. Also a suggested mounting method (not to scale) for the shaft encoder disc, infra red LED and detector. Note the long lead lengths of the latter, to give simple adjustment of the diode and detector positions relative to the disc. The disc needs to be mounted near enough to the display board to clear the crystal oscillator enclosure (to be described later). The rear bearing is mounted on a piece of PCB, soldered to the DDS board and/or the rear of the crystal oscillator enclosure.

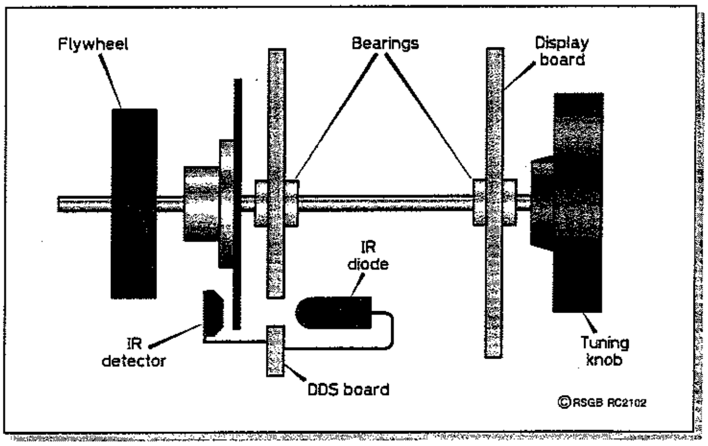

Fig 7: Alternative mounting method (not to scale), where the DDS board is mounted parallel to the display board on spacers (not shown). A small hole is drilled in the DDS board to pass the infra red, and the rear bearings are fitted to the DDS board. The leads for the detector pass through the board to the tracks, which are cut to avoid interference with the rear bearing. The detail will become apparent then the DDS board is described.

phone needle.

When you have scribed both sides of the board and checked it meticulously, etch the board in the conventional manner with ferric chloride. You will find you will get through very little FeCl, because the total amount of copper removed is very small. Observe all the usual safety precautions. Keep the board and FeCl solution gently on the move all the time, to get an even etch, and have the courage to over-etch it slightly if anything. Make sure both sides are fully etched before removal.

Wash the board thoroughly in cold water, inspect and etch further if necessary. Finally, wash the board with hot water and then clean off all the paint using cellulose thinners. A small paint brush helps to get the paint out of the holes, but being a good insulator, this is not critical. Polish the board with fine wet and dry (used wet) or a polishing block.

Now for the important stage. Using a continuity tester, check for isolation between each and every adjacent track. If you find any shorts that are obvious, clear them with a sharp blade. If they are not obvious, my practice (which I hesitate to publicise) is to connect two test probes to a car battery and then blow off the short. Be careful!

The end result is an individual piece of craftsmanship - produced with no greater effort or time than is needed to draw the artwork onto film in the first place. And it is homebrew! You end up with much more ground plane than is typical with other approaches - which can only be to the good. And there are no critical processes in the sense that you can see what is happening all the time and can avoid moving on until you have got it right. I commend it to you.

AD9850 CHIP CARRIER

CAUTION: ANALOG DEVICES recommend taking proper anti-static precautions when handling the AD9850. It would be folly to ignore this advice with a chip of such value.

- Take a 28-pin, 0.6in wide turned-pin DIL socket and fit a piece of PCB, copper side up into the recess between the pins. It needs to be a snug fit. Most sockets have small moulding pimples adjacent to pins 1 and 14. These should be removed with a sharp knife to allow the PCB to lie flat.
- When the PCB is the correct size for fitting, clean the copper surface and handle it only by the edges thereafter.
- Secure the PCB to the socket by soldering some tinned copper wires between pins 1 and 28 - and pins 14 and 15. Solder the wire to the PCB also. This secures the PCB in place on the socket and establishes an earth connection point on each corner.
- Take the socket and secure it to something heavy enough to allow you to work on it without it sliding around. I use a small block of wood with some anti-static foam stuck to it - and press the legs of the socket into the foam to secure it.
- Take the AD9850, turn it over and mark pin 1 on the underside with a dab of paint or similar. This ensures that even when the chip is upside down, you are still sure which is pin 1, thus preventing you from connecting it up rotated by 180°.
- Place the chip centrally on the PCB at right angles to the socket between pins 7, 8 and 21, 22.
- Mark the position of the chip moulding under its pins - on the PCB, using a sharp pencil.
- Remove the chip.
- Tin the PCB evenly in two strips about 4mm wide under where the chip pins will be - up to but not under the marked moulding position. This is to facilitate soldering the earthy pins of the chip later.
- Secure the chip upside down with a trace of Superglue® to the PCB. Make absolutely certain that pin 1 on the chip is in the same corner as pin 1 on the socket. Check it again!

Please follow the rest of this process without creativity. The result is illustrated in **Fig 8**. I have hand mounted about 10 chips to optimise the process and carefully observed others deviate (on practice chips) and get it wrong. The source of error is always operating on the wrong pin. Although this may seem surprising, when you have tried it yourself you will understand why.

From now on, work only in full natural daylight. The idea is to work down one side of the chip, never taking your eyes off the job. Should you do so and have to start re-counting the pins, this has proved to be the single largest source of errors.

You only get one chance to get it right, so you must get some help to dictate the following sequence to you - so you can stay focused on the job.

The best tool for bending pins is a Stanley knife blade. Push on the end of the pin with the point of the blade in the required direction.

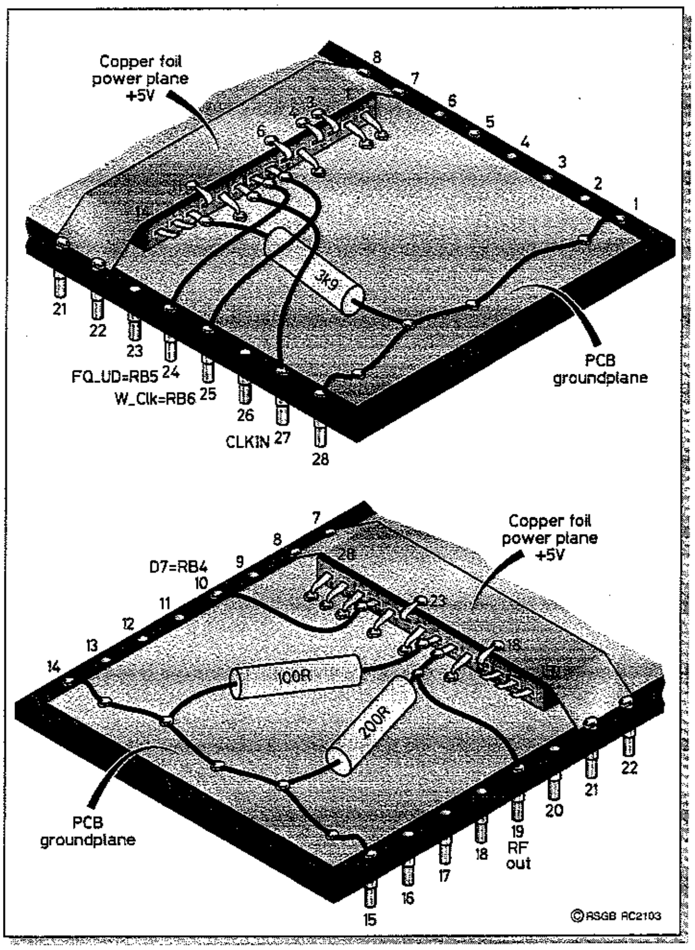

Fig 8: DDS Assembly. The DDS chip is mounted upside down (dead bug) on the PCB ground plane. A strip of copper foil provides a low impedance power plane. Not shown is a 1nF decoupling capacitor, connected between the ground and power planes adjacent to pin 1 on the chip.

Not far at this stage; just enough to be sure of the intended direction later.

In this sequence, 'down' means bend the pin towards the PCB. 'Up' means bend it away from the board, approximately vertically upwards. 'Leave' means do nothing.

1	down
2	down
3	up
4	up
5	down
6	up
7	leave
8	leave
9	leave
10	down
11	up
12	leave
13	leave
14	leave

Now focus on infinity and walk around for several minutes before addressing the other side.

15	leave
16	leave
17	leave
18	up
19	down
20	leave
21	leave
22	down
23	up
24	down
25	leave
26	down
27	down
28	down

That completes the tricky bit!

Bend down pins 1 and 2 to within about 1mm of the tinned surface and then solder them to the PCB.

To solder the pins to the copper, the best technique is to place the iron on the board about 2mm back from the pin(s) and hold it there for a couple of seconds to heat the mass of the PCB. Then form a small blob of solder on the PCB and push it towards the pins. On contact, remove the iron almost immediately.

Repeat this process for pins 19, 26-28, 10, 22, 5 and 24 in that order. Make very sure you are operating on the correct legs. You can bend them up and down perhaps once before risking amputation, but it is not worth the risk.

Obtain a small strip of copper foil. Copper or brass shim stock would suffice. In the worst case, a suitable strip can be removed from a piece of scrap PCB with a sharp knife or stripped from some foil braided coax.

It needs to be long enough to solder to pins 7 and 8 of the socket, pass over the chip and down the other side to solder to pins 21 and 22. The width needs to be the same as (or, if anything, a whisker more than) the chip moulding width. It can be trimmed to size and trial fitted for width with a pair of scissors. Excess length can be removed later.

Fix the foil to the chip moulding using a trace of super glue. When set, bend the ends down, trim to length, and solder to the +5V pins on the DIL socket (7 and 8, 21 and 22), making sure that it does not touch the PCB ground plane.

Bend up completely all the +5V pins on the chip, namely 3, 4, 6, 11, 18, 23 and then quickly solder each one to the foil.

There now remains only to attach 7 signal pins and to ease the process, some pins are bent down a little to near horizontal and some up a few degrees. This gives more clearance to get the soldering iron in. Bend pins 8, 21, 25 up a little and pins 7, 9, 12, 20 down a little.

Trim the three resistors to size and solder down their earthy ends with the pin end just touching the end of the target pin, bending the resistors leads as necessary to get a touch on the end of the pins. Quickly solder the resistors to the pins.

Take some enamelled copper wire, very thin but not critically so. Vero wire is ideal. Make off the end of the wire on the DIL socket end first and then trim the wire to length. With the end of the wire and the end of the pin both pre-tinned, and a clean tinned iron, solder the wire to the pin (and in one case, to the resistor lead). The best order is 7, 9, 25, 20, 8.

Pins 13-17 are not connected.

CORRECTION

LAST MONTH (page 18, column 1), the required band noise at the mixer RF port was incorrectly given as 2mV. It should have read 2μV. The difference is critical.

YET TO COME

FULL CIRCUIT diagrams, PCB layouts, how to make your own shaft encoder and full operating instructions.

REFERENCE

[7] 'Third-Method SSB HF Transceiver' by Peter Rhodes, G3XJP, *RadCom*, June-October 1996. ♦

technical**feedback**

EUROTEK

RADCOM, OCTOBER 1998

The article by DF4ZS, translated by G4LQI, was of particular interest to me, as about 35 years have elapsed since I first built an RF speech processor for exactly the same purpose. Operating portable with RF-processed equipment has provided greater interest than any other aspects of my 70 years in ham radio, with the demonstration of *reliable* antipodal communication using powers of one watt or less as its main feature.

Sad to relate, RF speech processing is a technical minefield. Some 20 years have elapsed since I was one of those trying to find a way through it. So far as I know Walter Schreurer, K1YZW, is the only one to have fully succeeded, probably because after inventing the Comdel (the first RF processor to be marketed) he replaced it by the Vomax. This makes use of an entirely different principle, the audio band being divided into four, which are then separately limited, filtered and recombined. Despite very favourable reviews, it is no longer available. The Plessey SL613 clipping IC which used to make RF processing much easier has also disappeared.

I think it right for this topic to remain an open issue, but the hazards cannot be ignored. Venturing onto such dangerous ground without access to what is already known is, to put it mildly, ill advised. For those seeking further explanations and guidelines, the list below (though far from complete) should be helpful.

1. J Daguet and K Gilabert, 'La Parole a Niveau Constant dans Emitteurs a Bande Laterale Unique', *L'Onde Electrique*, May 1961.

2. P Marcou and J Daguet, 'New Methods of Speech Transmission', Information Theory (Third London Symposium), Butterworth Scientific Publications, London, 1956.

3. EW Pappenfuss et al, 'Single Sideband Principles and Circuits', McGraw-Hill, NY, 1961.

4. Pat Hawker, 'Technical Topics', *Radio Communication*, January 1972.

5. J Horwood, G3FRB, A Clipper and Filter for Transistorised SSB Exciters', *Radio Communication*, February 1972.

6. G6XN, 'Performance of RF Speech Clippers', *Ham Radio*, November 1972.

7. Walter Schreurer, K1YZW, Speech Clipping in SSB Equipment', *Ham Radio*, February 1971.

8. Jim Fisk, Editor in Chief, 'A review of SSB speech processing techniques and a look at the new approach', *Ham Radio*, June 1976.

To end on a note of warning, simple clipping of the audio signal (though often suggested as a second best and suitable for DSB modulation) can be expected to generate large peaks when one sideband is suppressed.

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