"SSB Transceiver"

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(Ed.Note: This paper was presented by Mr Jenness at "Nelcon 81" held at the University of Otago at Dunedin in August 1981. It won the N.Z. Electronics Institute annual award for the paper adjudged the best presented at the Conference)

Introduction

In 1974 the Physics and Engineering Laboratory of DSIR introduced the technology of thick film microcircuits to New Zealand. The laboratory set up a small thick film facility, and Professor Mike Lucas visited here, under an NRAC Fellowship, to demonstrate its use. Workshops and seminars were held and, stemming from this initiative, two commercial plants were established to use the technique. At least two teaching facilities have been established in New Zealand.

Despite this activity, thick film, which is basically a packaging technology, has yet to make a major impact in the New Zealand electronics industry. This is in contrast to overseas experience where, for example, it is 30% of the size of the monolothic silicon industry in the USA.

PEL is firmly committed to this technology, and most of the instruments and equipment produced here incorporate thick film circuits but, until now, it has not been used in an application that shows its full potential for reducing size and improving realiability. With this in mind, and a perceived need for a small inexpensive SSB transceiver for applications such as the Mountain Radio Service, PEL developed the set which is described in this paper.

The set is seen as a potential replacement for earlier A.M. transceivers which must be phased out at the end of this year, to comply with Post Office Regulations concerning SSB transmissions. In this prototype form it is a 1 watt PEP set operating on the two Mountain Radio Frequencies and its most obvious feature is its small size, approximately 140mm x 70 x 55, and weighing 600 gms. It is believed that this set meets the mandatory requirements of Post Office Specification RTA 19 and later models should satisfy the full specification. It is intended to be operated into a half wave dipole antenna and with the judiciously chosen operating schedules of the Mountain Radio Service, the communication distances achieved are more than adequate. The set is powered by 8 penlight cells which have sufficient life for most tramping and mountaineering expeditions in New Zealand.

We believe that this level of performance could only be achieved in a package this size, by the use of hybrid technology.

As you are aware, there are several methods by which SSB generation and detection may be achieved, and the first consideration was to select one which would be compatible with thick film technology. It happens that thick film resistors are amongst the most stable, with respect to both time and temperature, of those available to the electronic engineer. Given the right equipment, it is possible

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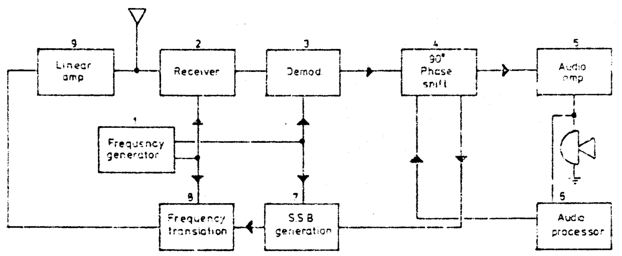
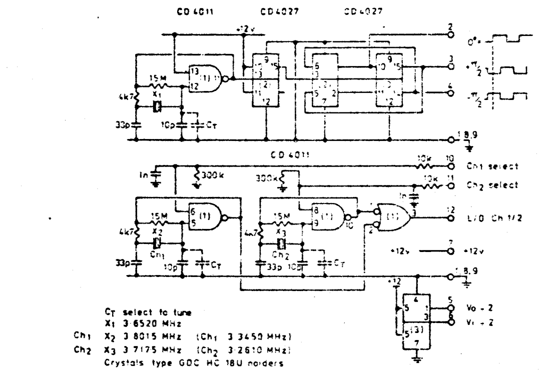
Mr C. A. Jenness is Senior Technical Officer also at P. E. L. and has recently rejoined the Thick Film Hybrid Section devoted to the application of this technology in the New Zealand electronic industry. The SSB transceiver described in this paper is an example.)



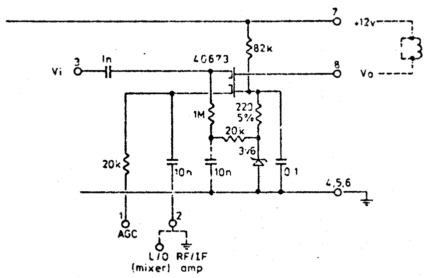
BLOCK DIAGRAM S.S.B. TRANSCEIVER

FIG. 1



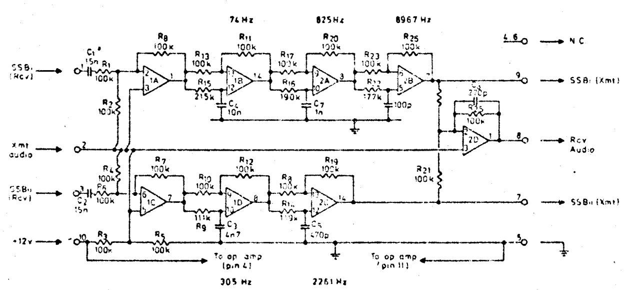
CRYSTAL OSCILLATOR SUBSTRATE (G)
(1103-4)

FIG. 2



RF/IF AMP + MIXER SUBSTRATE (A,B,C)
(1107-1)

FIG. 3



PHASE SPLITTER/COMBINER (F)
(1115-2)

FIG. 4

to trim these resistors to within 1% of a specified value, and it is also possible to carry out the process of Active Trimming. In this procedure, a thick film circuit is operated, in a test jig, and various resistors are trimmed to achieve a specified performance of the overall circuit. Our ability to carry out both static and active trimming of resistors, suggested that the phasing method of side band generation, would be particularly appropriate for our purposes, and so it has proven to be. In this system, the obtaining of good SSB performance can be reduced to the accurate trimming of stable resistors.

Figure 1 shows a block diagram of the SSB transceiver using the phasing method.

Block 1, Fig. 2, is the frequency generation section consisting of three crystal oscillators. The first is at four times the intermediate frequency, and this is divided digitally to produce quadrature components of the intermediate reference frequency, thus avoiding the need for an analogue control. The other two oscillators are at the nominal carrier plus intermediate frequencies. The complete circuit occupies on 31.8 x 13.3 mm substrate.

Block 2 is the receiver consisting of the RF amplifier, mixer and intermediate frequency amplifier and providing a gain of greater than 90 dB for the received signals.

The receiver uses three dual gates MOS Fets, Fig. 3 in chip form, to provide the required gain. Each one is mounted on an identical 20.3 x 7.1 mm substrate with the necessary bias and decoupling components. Tuning between channels is not required in this application, the input coil has a Q of 15 and a coupled pair with sufficient bandwidth is used between the RF stage and mixer. A ceramic filter is used between the mixer and IF stage to give the required skirt selectivity but the bandwidth of the receiver is determined in the audio stages.

Block 3, the Receiver Demodulator, multiplies the received intermediate frequency, single side band signal, by the reference, quadrature, intermediate frequencies, to give quadrature audio signals, which then pass to the audio phase shifter. For a description of the balanced modulator, of which two are used for this function, see the section on SSB operation.

Block 4, see Fig. 4, the 90° Audio Phase Shifter accepts the speech signal from the audio processor circuits in the transmit mode, and splits it into two quadrature components with 0.3° accuracy over the audio bandwidth. In the receive mode it accepts two quadrature audio signals from the receiver demodulator, shifts them by 90°, and combines them to give the resultant, single side band audio signal.

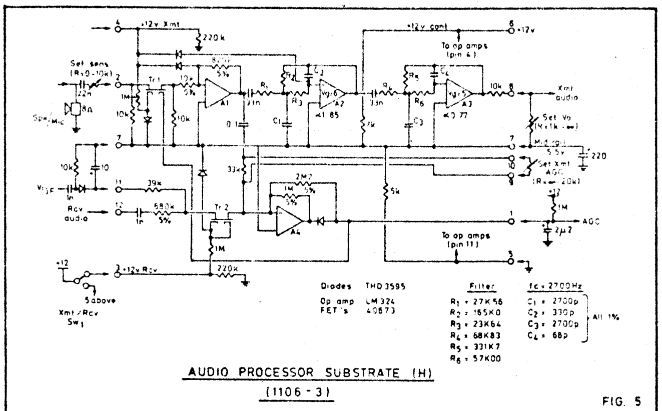


FIG. 5

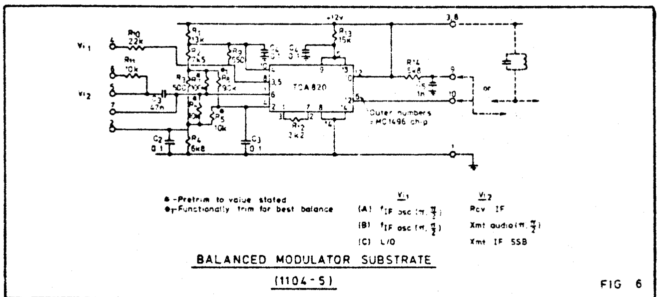


FIG 6

The design of this circuit, shown in figure 3, is based on an article by R. K. Dickey, reference 1, and is particularly appropriate for thick film. The gain of the first phase shift stage may be brought exactly to 1 by adjustment of R11 and R13 to the same resistance, 100k. This is a static trimming operation and is repeated on each phase shifter stage, the buffers and combiner. Once this has been done, the circuit is completed and made operational, and then for the first phase shifter R15 is adjusted until the stage gives a phase shift of exactly 90° at 74 Hz. This process is then repeated for the other four stages, at the frequencies shown, by which tme the circuit will exhibit a phase shift difference of 90° over the audio band from 200 Hz to 3400 Hz. Buffer stages are provided at the input to accept signals from both the receiver demodulators and the audio processor. A combining stage is provided at the output to add the signals from the 2 channels of the phase shifter to produce the audio output. The complete circuit is produced on a 25 mm x 12.5 mm substrate.

Block 5 is a monolithic audio output stage taking its signal from the audio combiner of the audio phase shifter, block 4, and raising it to the 400 mW level.

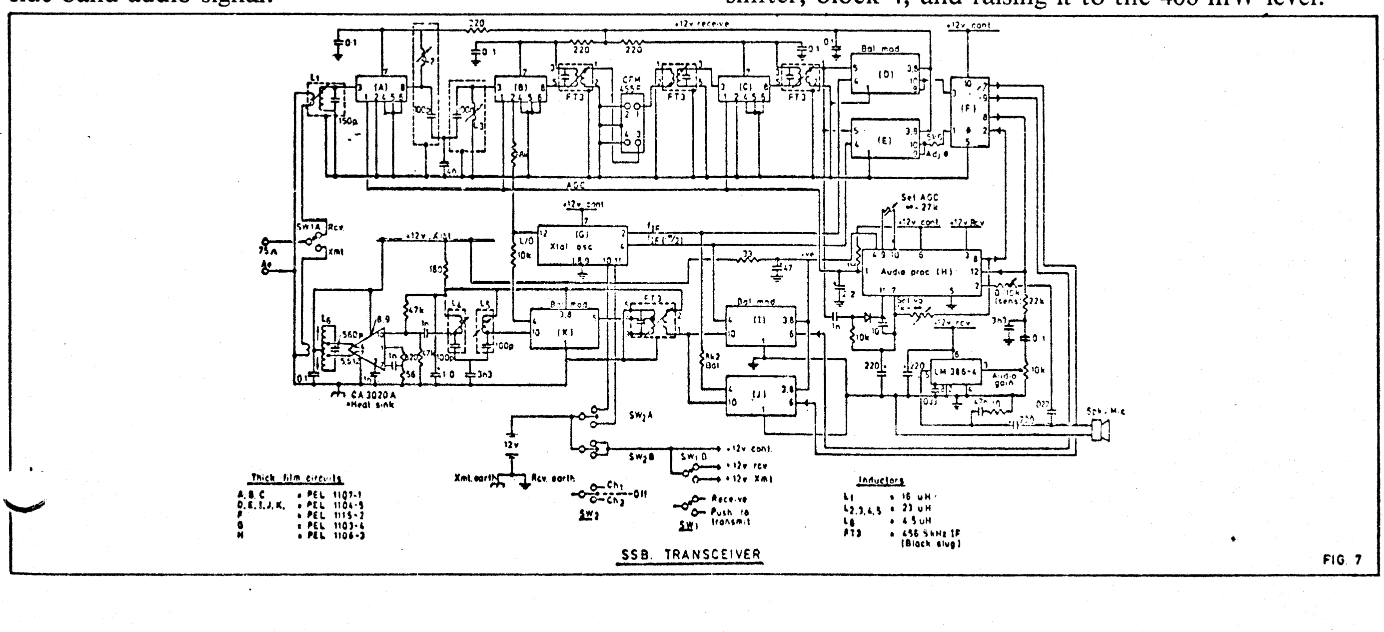


FIG 7

Block 6, Fig. 5, is the Audio Processor which, on "Transmit", accepts a signal from the combined microphone/loudspeaker, applies automatic gain control, and limits the frequency response, before passing it to the audio phase shifter, block 4. On "Receive", it monitors the received audio signal and derives an AGC signal which it applies to the RF stges of the receiver.

Trl, a dual gate MOS Fet, is both a switch and the gain control stage on Transmit and follows the microphone directly. A1 provides gain, A2 and A3 form a low pass filter with a cut-off frequency of 2700 Hz and also provide gain, Tr2 is the receive A.G.C. switch, and A4 the active rectifier developing an A.G.C. voltage applied to Trl on "Transmit" and the 3 receiver stages on "Receive". On "Receive" TR2 passes the audio signal from the audio combiner of the 90° Phase Shifter, Block 4. The diagram also shows an optional A.G.C. circuit which operates on A.M. signals. Resistors R1, 2, 3, 4, 5 and 6 in the L.P. filters are all trimmed to 1%. The substrate size is 31.8 x 13.3mm.

Block 7, the SSB generator, multiplies the quadrature audio signals, from the audio phase shifter, with the quadrature intermediate reference frequencies, to produce a single side band signal, at the IF frequency.

This circuit contains two double balanced mixers, Fig. 6, each one uses the Motorola MC1496 chip. Using active trimming either R7 or R8 is adjusted to give maximum rejection of the reference frequency applied to input 1. In this unit each double balanced mixer is mounted on a seperate 25 x 12.5mm substrate. Identical balanced mixers are used in blocks 3 and 8 and will not be described further. Using this technique, the Post Office requirements for carrier rejection, etc., are comfortably met.

Block 8, the Frequency Translator multiplies the single side band intermediate frequency signal by a crystal frequency, to translate the SSB signal to the upper side band of the selected channel.

Block 9 is the Linear Amplifier which takes the low level single side band signal from Block 8, and increases its power level to 1 watt PEP. The design of this is conventional, but it is worth noting that because of the close spacing of the two channels, in this application, the tuning of the transmitter is fixed. Transitional coupling is used between the tuned circuits at the output of the frequency translator to give these the necessary bandwidth.

A complete circuit diagram is shown in Fig. 7.

Conclusion

This transceiver was developed to show the size advantages of using thick film technology, and we believe that this has been accomplished. Although it is a very simple set, its performance is, we believe, comparable with those available overseas. It could obviously be made more versatile by incorporating one of the modern frequency synthesiser chips, although in this case tuning of the RF circuits would be required. The transceiver has been tested in the mountains and found to operate satisfactorily with reliable communication being established, for example, between Mt Cook and Lower Hutt, and New Plymouth and Invercargill. A New Zealand manufacturer is now considering production.

References

1. Electronics, Vol 48 No. 17, August 21 1975, p.82, Dickey R. K.
2. Figures nos 1–7 are shown.