A FLEXIBLE SONAR TRANSMITTER

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SUMMARY

The paper will describe the design and development of a flexible sonar transmitter. In the present system 15 separate linear power amplifiers drive individual tranducer elements. Separate computer memories supply the inputs to the power amplifiers via D/A converters and the memories are loaded from a dedicated micro-computer. The system is highly flexible in that a whole variety of different waveforms can be generated and transmitted.

INTRODUCTION

The rapid reduction in cost and size of electronic components has opened up many new possibilities- complicated circuits and systems may now be produced where previously the cost would have been prohibitive. This progress has been particularly apparent in digital circuitry but, although not so spectacular, there have also been very significant developments in analogue components. In particular power MOSFET amplifiers can now be made to cover a wide frequency range, have a reasonable power output and yet be compact and relatively cheap. These parallel developments in digital and analogue circuits has led us to develop and build a flexible sonar transmitter which uses a digital computer to generate the transmitted waveforms and in which a separate power amplifier is used to drive each of the elements of the transducer array. The system is highly flexible in that a whole variety of different waveforms can be generated and transmitted. The present amplifiers provide only 130 watts per channel but a larger version able to produce 1000 watts is under construction.
The amplifiers are driven via D/A converters from separate semiconductor memories which in turn are loaded from a micro-computer. Only four bits per sample have been used in this design for storing the data but, although this has proved reasonably satisfactory, in the newer design advantage has been taken of the further reductions in cost of semiconductor memory to increase the resolution to 8 bits. The microcomputer which is used to compute the waveforms is an extended version of the Lucas Nascom II based on the Z80 processor and most of the software has been written in Pascal. A block diagram of the system is shown in figure 1. Several different modes of operation have so far been tried on the low power equipment.

1) Simple beam steering to any direction within a 60 degree sector. The selected bearing can be maintained or changed on each transmission.

ii) Ripple firing in which a pulse of energy is transmitted sequentially on a number of bearings producing a stepped bearing transmission.

iii) Swept beam- in which the beam is scanned once (or several times if required) across a sector in a continuous manner during the transmitted pulse.

iv) Frequency modulated pulses.

v) Square wave modulated pulses to produce non-linear acoustic (NLA) effects.

vi) Focussed beams at any point.

viii) Shaded arrays etc. etc.

These possible modes of transmission illustrate only a few of the almost infinite possibilities of the system. The range of frequencies over which the system will operate is limited mainly by the transducer. For transmission it is important that the transducer should be reasonably efficient and this normally means that it must be resonant. The prototype array used transducers with a Q of about 10 but in order to accommodate wider band transmission modes the transducers in the large power array under construction have a Q of about 5. The centre frequency in both systems is about 40kHz.

RESULTS

Some of the results that have been obtained in preliminary trials are shown in figures 2 to 7.

The prototype transducer array comprises 15 circular elements spaced by one wavelength. Figure 2(a) shows the theoretical farfield broadside beampattern for this array. In figure 2(b) we see the beam pattern of the system measured in the broadside direction with a hydrophone placed at about 10 metres from the array and using the system described in reference 1. We see that the agreement is quite good and the beamwidth is close to that expected. The near field for this array will extend to about 7 metres so the measurements are taken only just outside this limit. In figure 3(b) we see the pattern with the beam steered to 16 degrees and the theoretical curve for this case is shown in figure 3(a). Figure 4 is a photographic sequence showing the output of the hydrophone when the ripple-fire mode was being used. In this a pulse of one millisecond duration was transmitted in each direction contiguously. The total duration of the transmission is therefore about 15 ms. Figure 5 is a photographic sequence showing the output from the hydrophone for a somewhat similar situation but this time the beam is swept continously during the total transmission time. The ability to focus the beam is illustrated in figure 6. Here the hydrophone was placed at one metre from the array. Figure 6(a) shows the unfocussed beampattern and figure 6(b) the focussed beampattern. Even with only 100 watts per element the intensity at the focus was very high and caused considerable disturbance of the water. A few experiments were carried out to show the potential for producing NLA. By using on/off modulation of the carrier at a relatively low frequency a series of harmonics of this modulation frequency are generated in the water by non-linear effects. The signal spectrum of the output of a hydrophone placed at a distance of about 800 metres is shown in figure 7. This low frequency beam can be steered in the same way as described above.

ACKNOWLEDGEMENT

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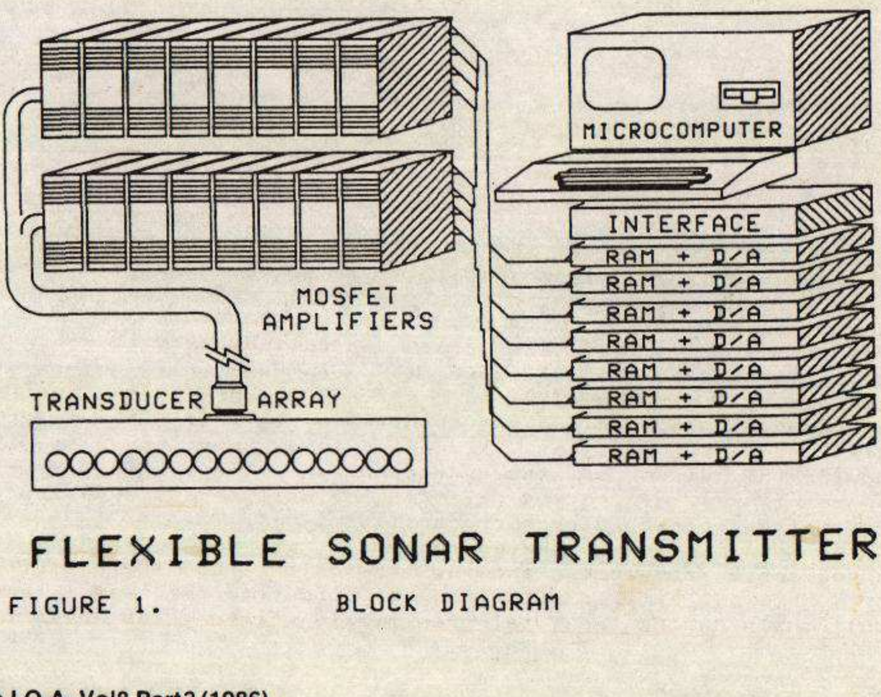
REFERENCES

1) P.J. Hill. "An automatic beam-plotting system". Institute of Acoustics spring conference, 1986.



FLEXIBLE SONAR TRANSMITTER

FIGURE 1. BLOCK DIAGRAM

A FLEXIBLE SONAR TRANSMITTER

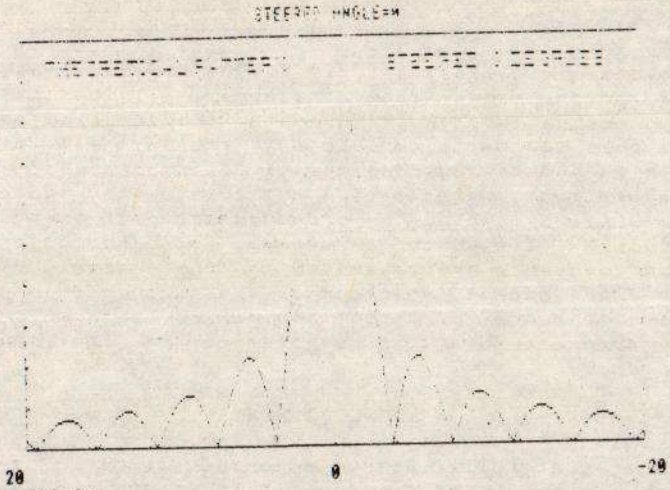


FIG. 2 a

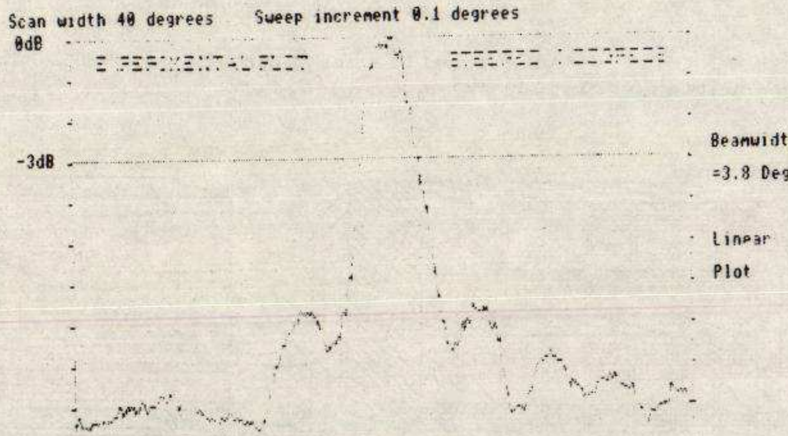


FIG. 2 b

A FLEXIBLE SONAR TRANSMITTER

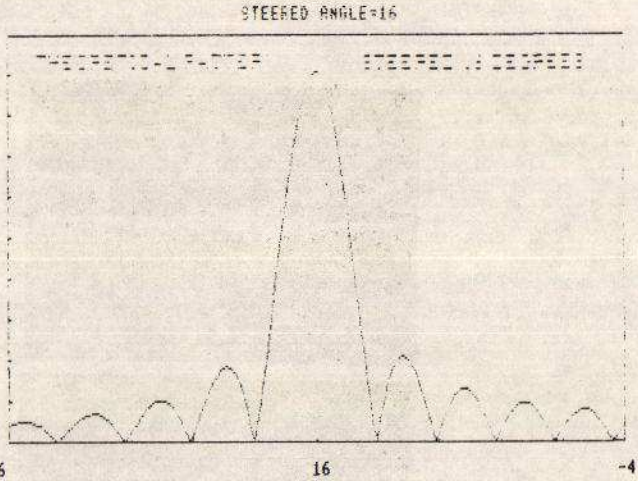


FIG. 3(a)

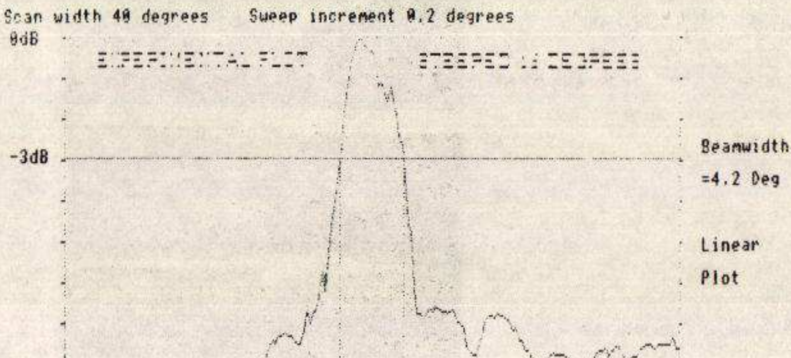


FIG. 3(b)

Photo Sequence:
2 Blocks/pulse
5 ms/cm, 0.1 V/cm

Photo 56:
Azim=80
0 degrees offset

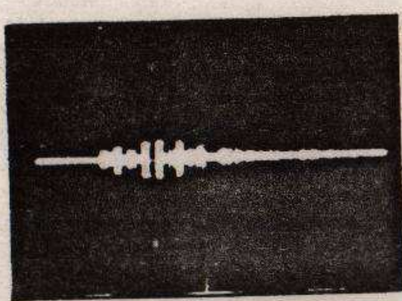


Photo 45
Azim=76
4 degree offset

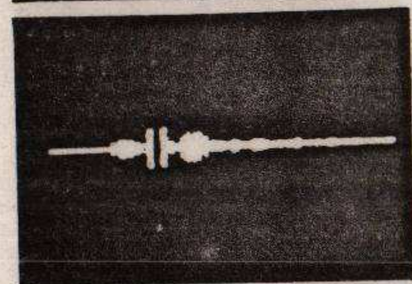


Photo 46
Azim=72
8 degrees offset

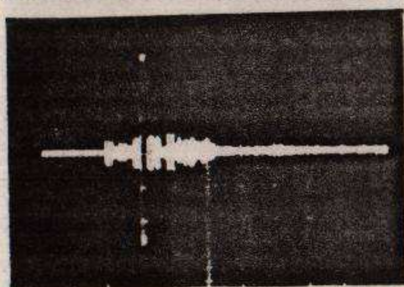
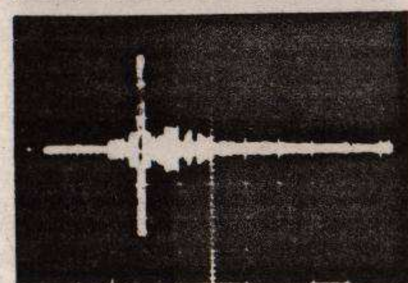


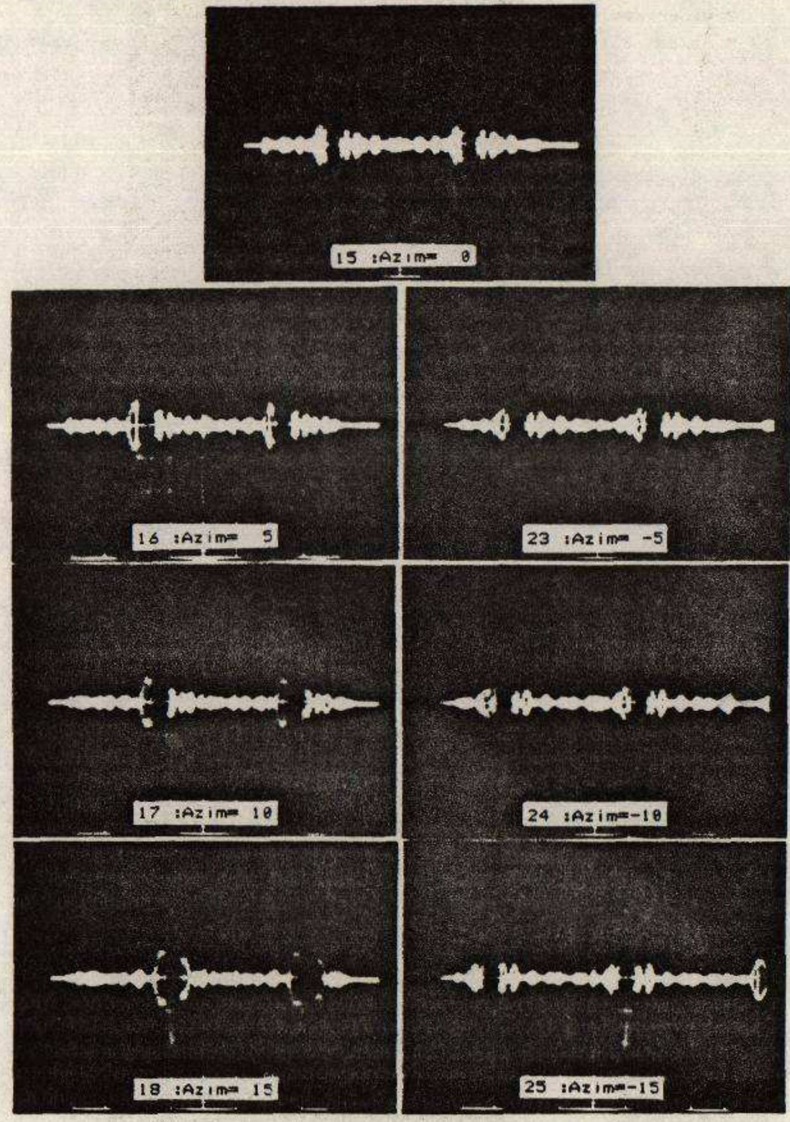
Photo 47
Azim=68
12 degrees offset



RIPPLE FIRE

FIG. 4

SWEEP MODE - 2 ms x 2 (sweep repeated) - files mc1SWJ > mc8SWJ used.



SWEPT BEAMS - (DOUBLE SWEEP)

FIG. 5

A FLEXIBLE SONAR TRANSMITTER

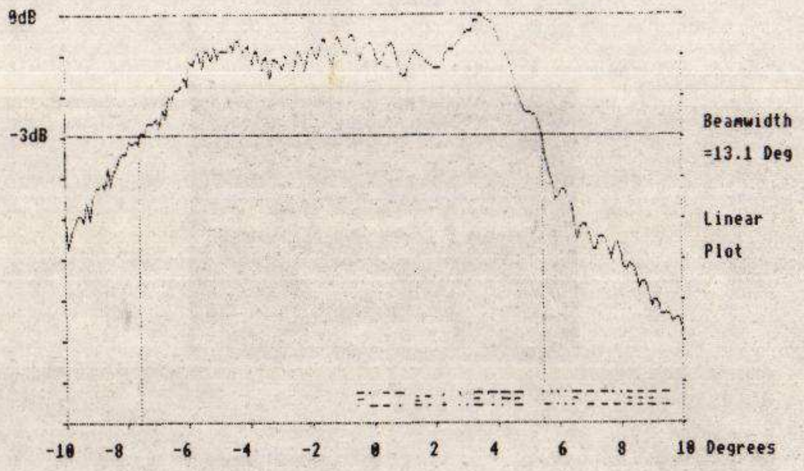


FIG. [illegible]

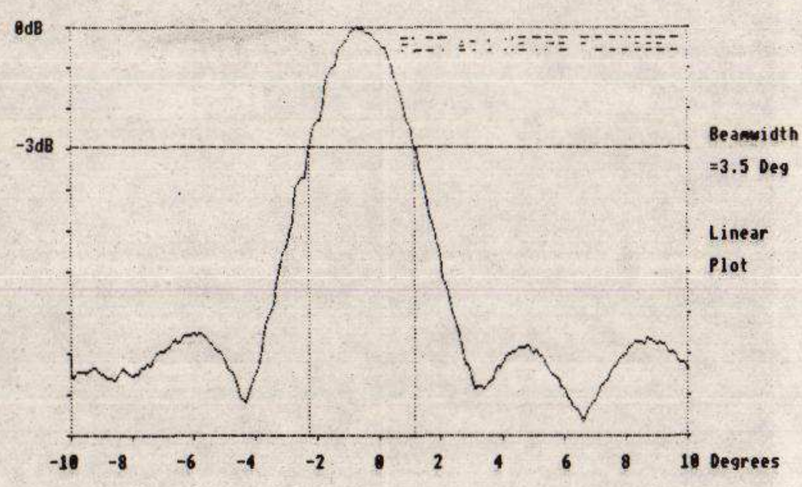


FIG. [illegible]

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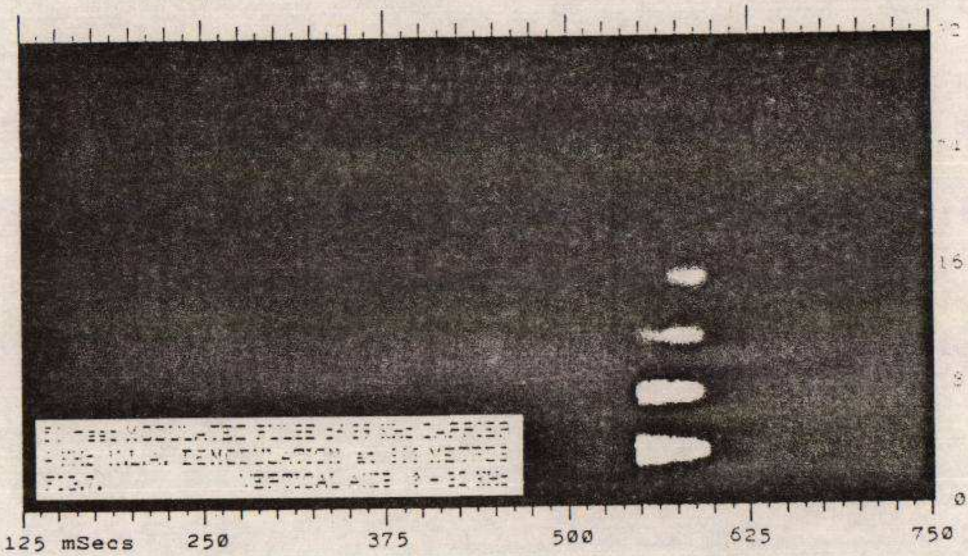

SPECTROGRAPH of TAPED RECORDED HYDROPHONE SIGNAL