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PRACTICAL MEASUREMENTS OF BEAMPATTERNS FOR CONCURRENT TRANSMISSIONS

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Earlier reports have shown by computer simulation that it is possible to transmit a set of beams each pointing in a different direction and each of a different frequency. This report presents the results of some practical measurements on concurrent transmission using one of the flexible sonar transmitters which have been developed at the university.

INTRODUCTION

In the sector scanning sonar based on transmitter scanning TRANSCAN [1], a succession of pulses are transmitted each of a different frequency and each with the beam pointing in a different direction. The bandwidth available limits the minimum length of the pulse and hence for a 16 channel system the duration of the transmission is very significant, limiting the minimum range that can be observed. An earlier report [2] has shown by computer simulation it is possible to transmit all the signals concurrently as linear theory would predict.

In the practical system limitations in the memory meant that each sample of stored data was represented by only four bits and thus the effect of this quantization must be considered. A further report [3] showed that quantization to 4 bits does indeed cause some deterioration of the beams but surprisingly little and with 8 bit quantization the effects were hardly discernible.

It was decided to carry out a series of tests on the practical equipment to see if the results predicted by the simulation could be obtained in practise.

MEASURING EQUIPMENT

All measurements were made in the department test tank which measures approximately 9 by 6 metres by 2 metres deep.

The SONAR TRANSMITTER used was the low power version of the two equipments which have been developed at LUT. [4], It is based on a Nascom Microcomputer which generates the required waveform and stores them in 16 memory channels. The outputs from these memories after D/A conversion are, under system control, fed to the individual power amplifiers and so to the array.

The ARRAY used for these tests is a single line of 15 elements spaced at 37.5 mm. centres which is equal to 1 λ at 40 kHz. Over the range of frequencies to be used in the experiments there is a significant variation in response and this will have an effect on the intensity of the different beams.

CONCURRENT TRANSMISSION

The BEAMPATTERN MEASUREMENT SYSTEM is a unit developed at LUT which can measure the pattern of an array automatically and store the results. It includes a Pulse Gate which allows sampling of the direct wave and avoids errors from the multipath signals. This enables the measurements to be carried out in a relatively small tank.

The BANDPASS FILTER, GENERATOR and FREQUENCY CHANGER. These provide a narrow band receiving channel to isolate a particular frequency in the multifrequency transmission. The centre frequency of the bandpass filter is 2 kHz and the bandwidth is 200Hz. Adjusting the frequency of the generator allows each frequency to be selected. The transient time of the filter, determined by the bandwidth of 200 Hz, is approximately 7 ms. and thus the pulse length of the transmitted signal must be greater than this. Such a long pulse makes it difficult to separate the wanted signal from the interference and in order to remove some of the multipath signals a rubber tube was used as a simple shield. This reduced the interference by about 10 dB which allowed the measurements to proceed

Even with these precautions it was necessary to operate with the receiving hydrophone close to the array (about 2.5m) and hence the transmitted waves had to be focussed at this distance to simulate the far field conditions.

RESULTS

Fig.1 shows the beampattern measured at 2.5m using focussed data, the steered direction is 0° and the frequency 42 kHz. The pattern is not quite the same as would be predicted by theory but the array is known to have slight phase errors. This measurement serves to test the system and the sensitivity before each new set of results are taken. The maximum amplitude of the received signal can be observed on the oscilloscope so as to set the reference direction to the normal of the array.

Fig.2.1 shows the beampattern for two beams of different frequencies steered to -20 degrees(36 kHz.) and -15 degrees (37 kHz.). Figures 2.2 and 2.3 show the beampatterns measured after filtration and it can be seen that the individual beams can be separated with some small leakage due to the filter response.

Figure 3.1 shows the overall pattern when five beams are transmitted and in figures 3.2 to 3.6 we see the results after appropriate filtration. There are obviously some unwanted sidelobes but in most cases this is associated with the diffraction secondaries rather than being due to the simultaneous transmission. In order to obtain as narrow a transmitted beam as possible with a fixed number of elements a decision had been made to use an array with 1 lambda spacing even though this can lead occasionally to some ambiguity due to diffraction secondaries. Thus when the beam is steered to +30 degrees there is an equal amplitude diffraction secondary at -30 degrees and vice versa.

In the results presented so far the calculations to obtain the beams had assumed the elements were point sources and hence had not taken into account the effect of the beam pattern of the individual elements. Thus although the beams were designed to have the same amplitude it is clear from the results that as the beam is steered further from the normal its amplitude reduces.

Fig.4 and Fig.5 show the resulting beampatterns when 15 beams are transmitted concurrently. In Fig.4 the frequency range is from 36.5 to 43.5 kHz, spaced at 0.5 kHz; similarly Fig.5 show the results when the frequencies transmitted range from 36 to 50 kHz with a spacing of 1 kHz. The spacing of the beams in angle is based on $\sin(\alpha)$ rather than α. Thus they are set at intervals of $\sin\alpha = 1/14$ between -1 to +1 i.e., between $-30°$ and $+30°$. It will be noticed that there is a clear difference between the results for the two frequency ranges.

CONCLUSION

It is fairly clear from the results obtained in these experiments that even with the limitation of the 4 bit resolution in the memory it is possible to transmit a number of beams of different frequencies at the same time and to separate out each beam on reception by suitable filtration.

ACKNOWLEDGEMENT

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REFERENCES

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Fig.1 The beampattern measured at 2.5m using focussed data, beam direction 0deg. frequency 42 kHz

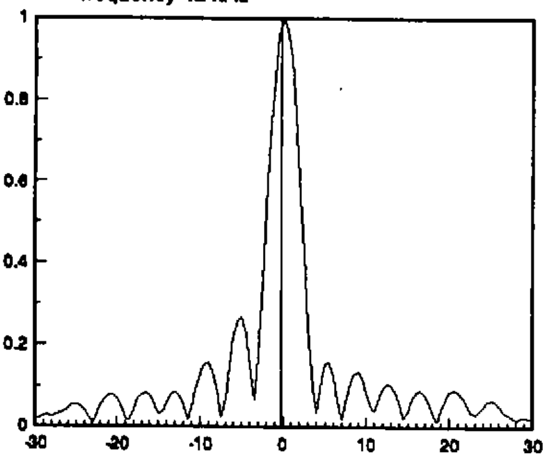

Fig.2.1 Overall beampattern for two beams beam direction -20, -15 deg. beam frequency 36, 37 kHz

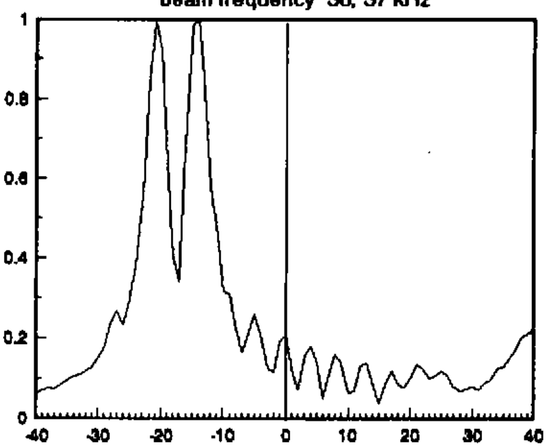

Fig.2.2 After 37 kHz filter, beam direction -15deg.

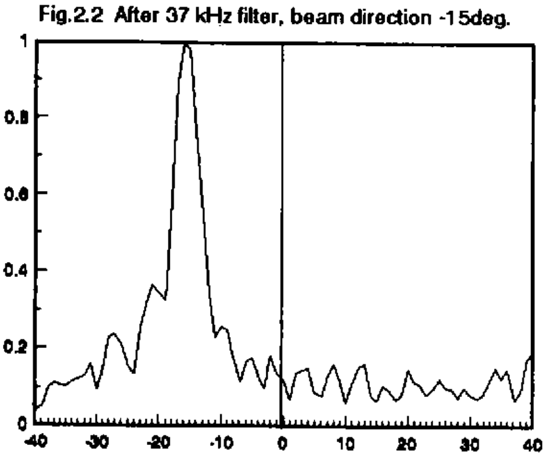

Fig.2.3 After 36 kHz filter, beam direction -20deg.

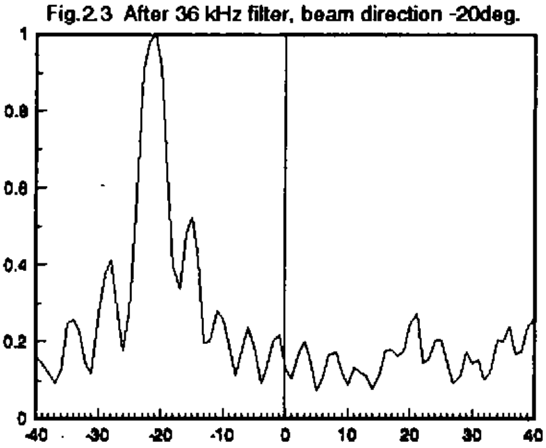

Fig.3 The beampattern for five beams of different frequency steered to five different directions and results after filtration (pulse length 8.2ms)

Fig.3.1 Overall beampattern for five beams
beam direction -30, -15, 0, 15, 30 deg.
beam frequency 39, 45, 48, 42, 36 kHz

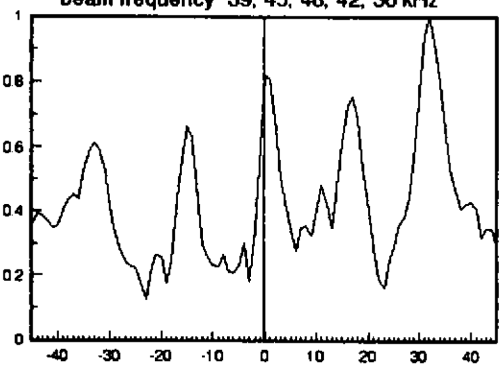

Fig.3.2 After 45 kHz filter, beam direction -15 deg.

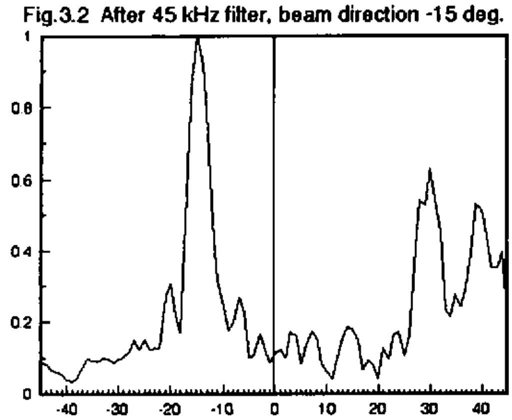

Fig.3.3 After 48 kHz filter, beam direction 0 deg.

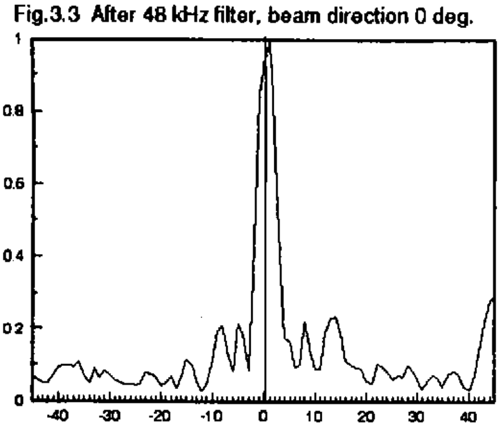

Fig.3.4 After 42 kHz filter, beam direction +15 deg.

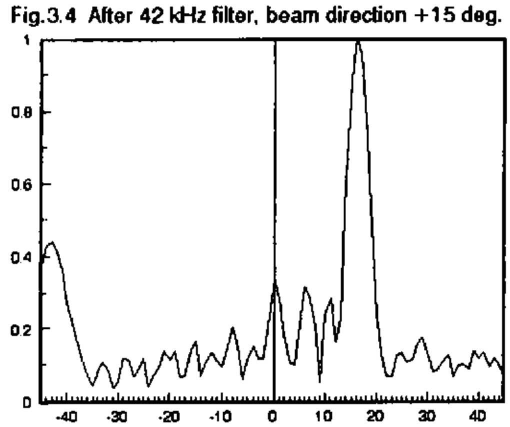

Fig.3.5 After 39 kHz filter, beam direction -30 deg.

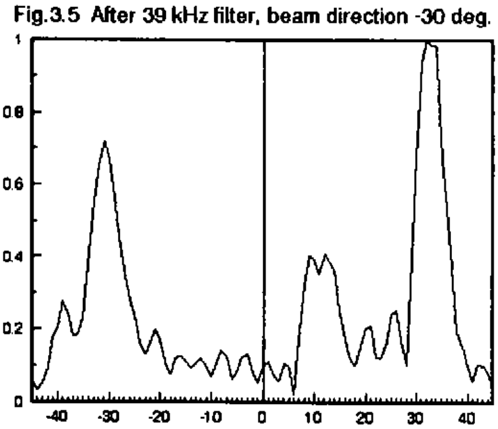

Fig.3.6 After 36 kHz filter, beam direction +30 deg.

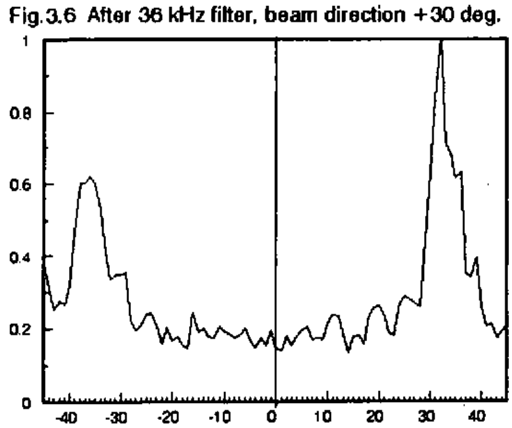

Fig.4 Overall beampattern for 15 beams
beam direction -30 to 30 deg. spacing sin(B)=1/14
beam frequency 36.5 to 43.5 kHz, spacing 0.5 kHz

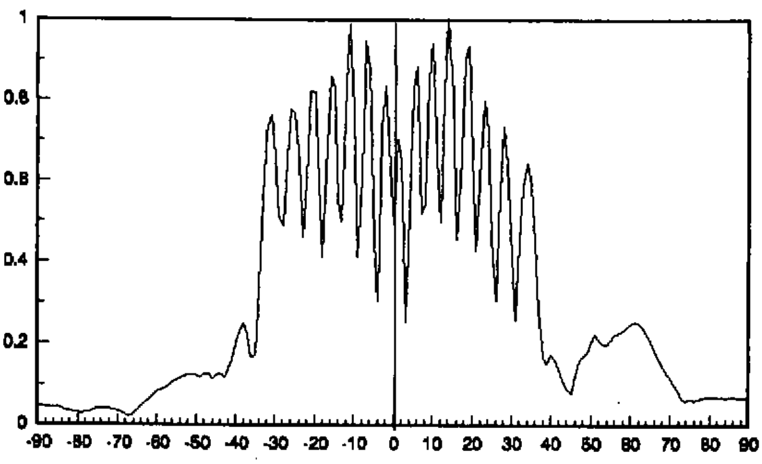

Fig.5 Overall beampattern for 15 beams
beam direction -30 to 30 deg. spacing sin(B)=1/14
beam frequency 36 to 50 kHz, spacing 1 kHz