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MAR 72 D ANDERSON, G KINNISON  
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6 SONODIVER II Arrays Documentation

by

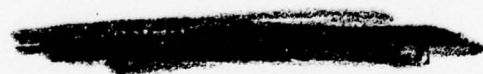
10 D. Anderson and G. Kinnison  
Spatial and Ambient Analysis Branch  
Code 5053

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# SONODIVER II Arrays Documentation

by

D. Anderson and G. Kinnison

## ABSTRACT

The vertical directionality of ocean ambient noise as a function of frequency, depth, geographical position, and season is desired to properly model candidate array systems performance. To allow such measurements independent of array suspension noises, the use of SONODIVER (Ref. 1) is planned. This note documents the potential capability of three array lengths to "cover" the frequency band 5Hz to 2000 Hz. Each array has five hydrophone sensors which will be instrumented and vertically suspended from the SONODIVER II vehicle, and recorded on analog magnetic tape. The data will be analyzed by sophisticated beamforming computer methods. The results show that this can be accomplished by randomizing the sensor placement along the vertical line and having array lengths of 300', 60' and 12'.

This note was generated as a means of explaining the methods involved in selecting the arrays for SONODIVER II.

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Single line bearing response (BR) plots are useful in the prediction of system performance in directional noise fields like those involved in SONODIVER II dives.

A BR plot is a display of adaptive and conventional beamforming responses to a specified directional noise field at a specified frequency. For simulated data, the directional noise field (the solid line on the plot) is generated by assuming deterministic, discrete sources from various directions. Uncorrelated noise is also simulated to account for the circuit noise floor, a noise component always present, however minutely, even in well-designed arrays. The uncorrelated noise could also be added to simulate flow noise across hydrophones when appropriate. Directional response outputs in all directions are obtained mathematically by use of adaptive and conventional beamforming techniques. It is not the purpose here to document the methods used to obtain the above. Therefore, detailed descriptions of analytical methods are not given; but they are not essential for an understanding of the results presented here. The interested reader is referred to Ref. 2 for such details.

In choosing array spacings for the 5-element SONODIVER II arrays, BR plots were chosen as a means of comparing candidate array spacings. BR's are given here for the following arrays: (1) regularly spaced 300' array ("75.0 FOOT SPACING" printed in lower left corner of plot); (2) randomly spaced 300' array ("RANDOM SPACINGS 1" printed in lower left corner of plot); (3) randomly spaced 60' array; and (4) randomly spaced 12' array. Random spacings were chosen instead of even spacings for the arrays to avoid possible ambiguity in the angle of signal arrival that arises from even spacings (see Fig. 12). This allows the range of useful frequencies to be extended. A number of different random placements were studied before making a final choice. The random placements shown (see Fig. 1) are the ones that give best results for the greatest number of frequencies.

The three different length arrays are designed to cover different frequency ranges. The 300' array will be used over the 5-50 Hz band, the 60' array will be used over the 50-250 Hz band, and the 12' array will be used over the 250-2000 Hz band.

All of the BR's presented in this report are for simulated data. With BR's for data collected at sea, there will not be a solid line on the plot for the noise field. To simulate the solid noise field line for this at-sea data, a representative BR plot will be selected for further study. A simulated noise field will be designed to give adaptive and conventional responses as close to those for the at-sea noise field as possible. After the appropriate simulated noise field has been obtained, a family of solid lines will be generated. These solid lines will differ only in the amount of uncorrelated noise which they contain. The solid lines thus generated will not be unique but will be in the proper class of lines for the particular noise field. The family of curves thus obtained should provide a "good estimate" of the overall shape of the at-sea noise field for the time and place at which the data were collected.

## REFERENCES

1. Naval Undersea R&D Center TP 278, Ocean Engineering, Ocean Technology Department, January 1972 (UNCL)
2. Edelblute, D. J., Shapard, J. M., and Kinnison, G. L., "Beam to Beam Normalization for Adaptive and Conventional Preformed Beams," Proceedings of the Optimal/Adaptive Space Processing Seminar, 12-14 August 1969 (CONF)

# SONODIVER SPACINGS

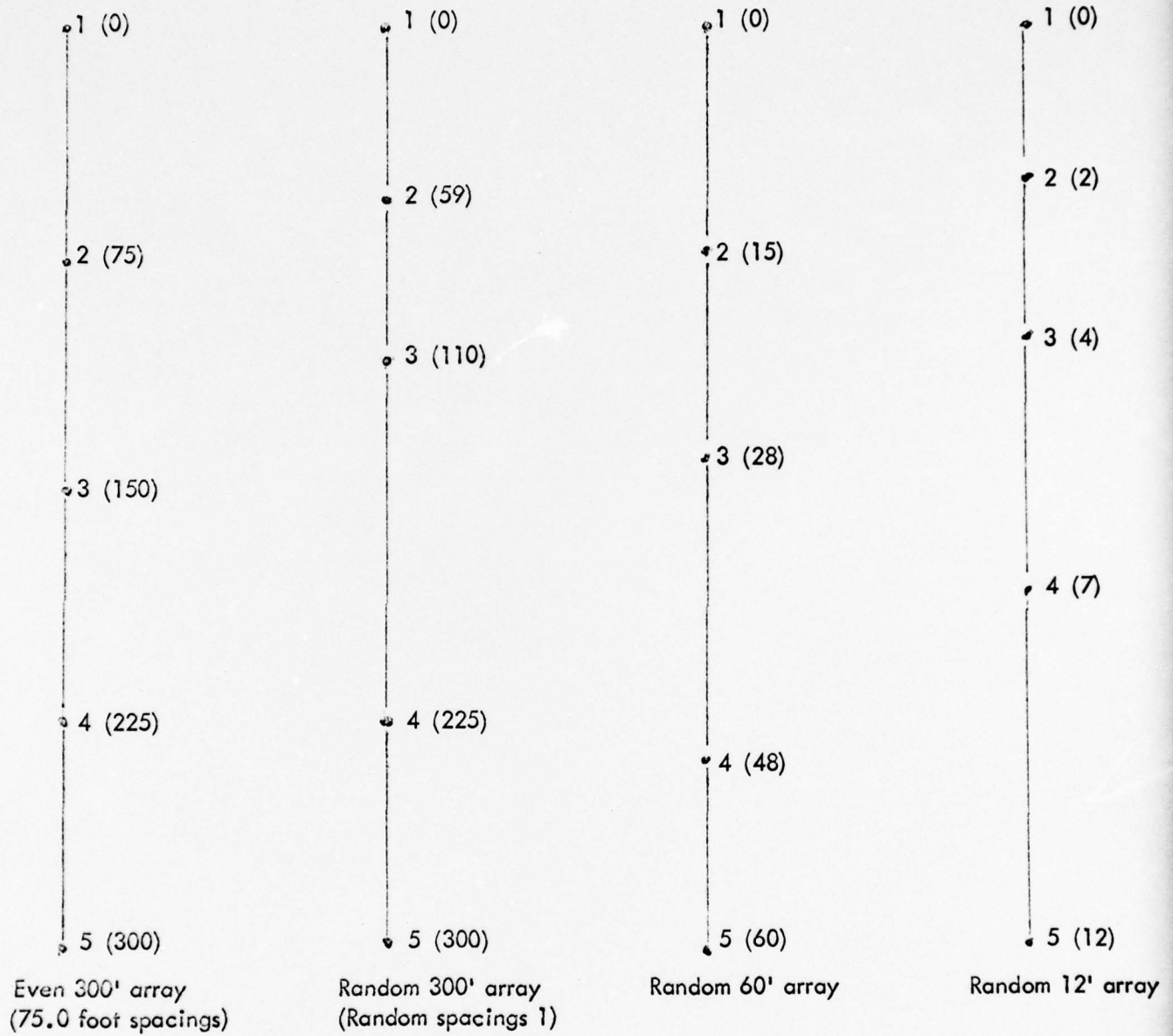


FIGURE 1

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 10 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 8  
PER STERADIAN  
-35 DB UNCOR

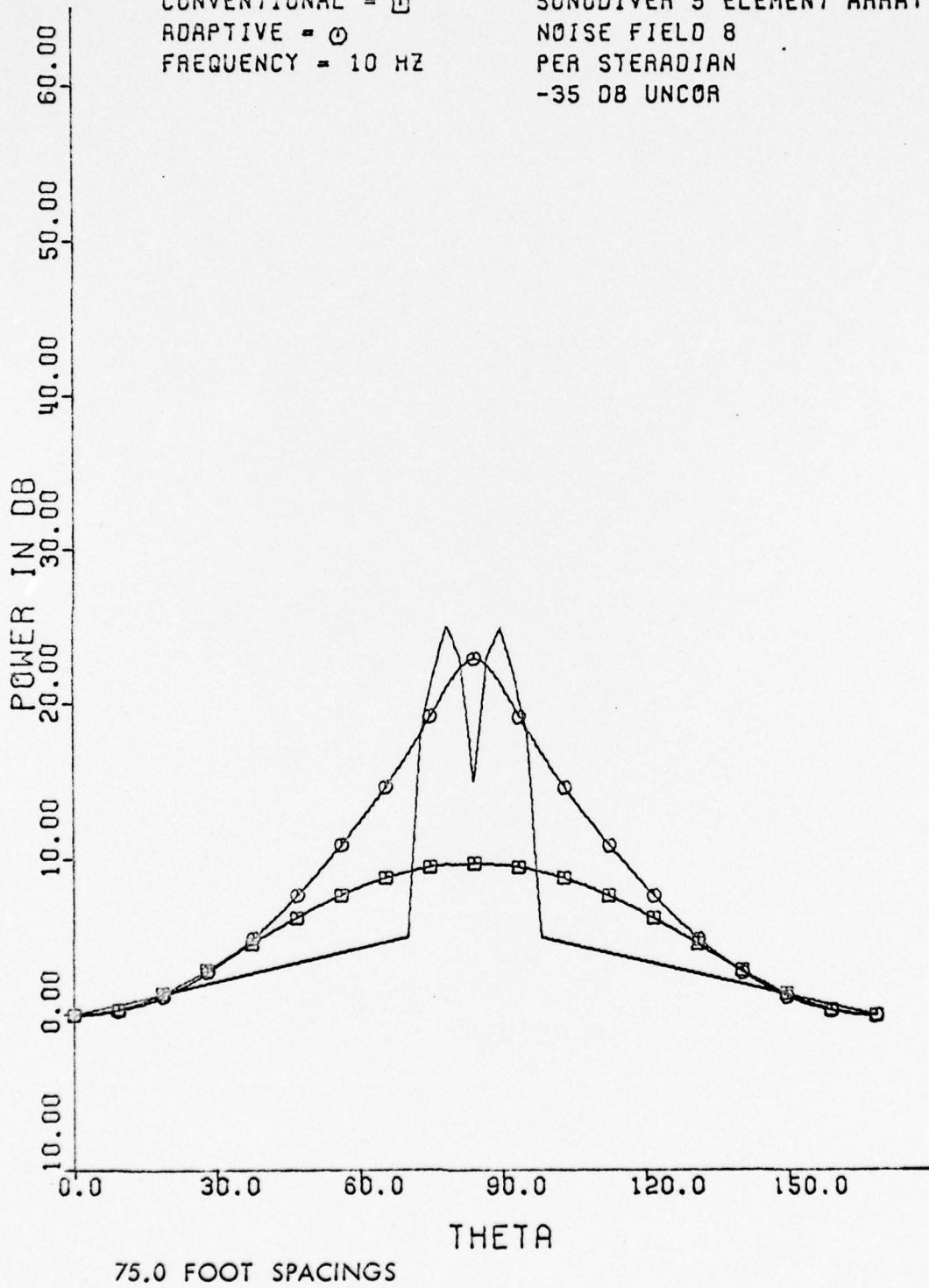


FIGURE 2



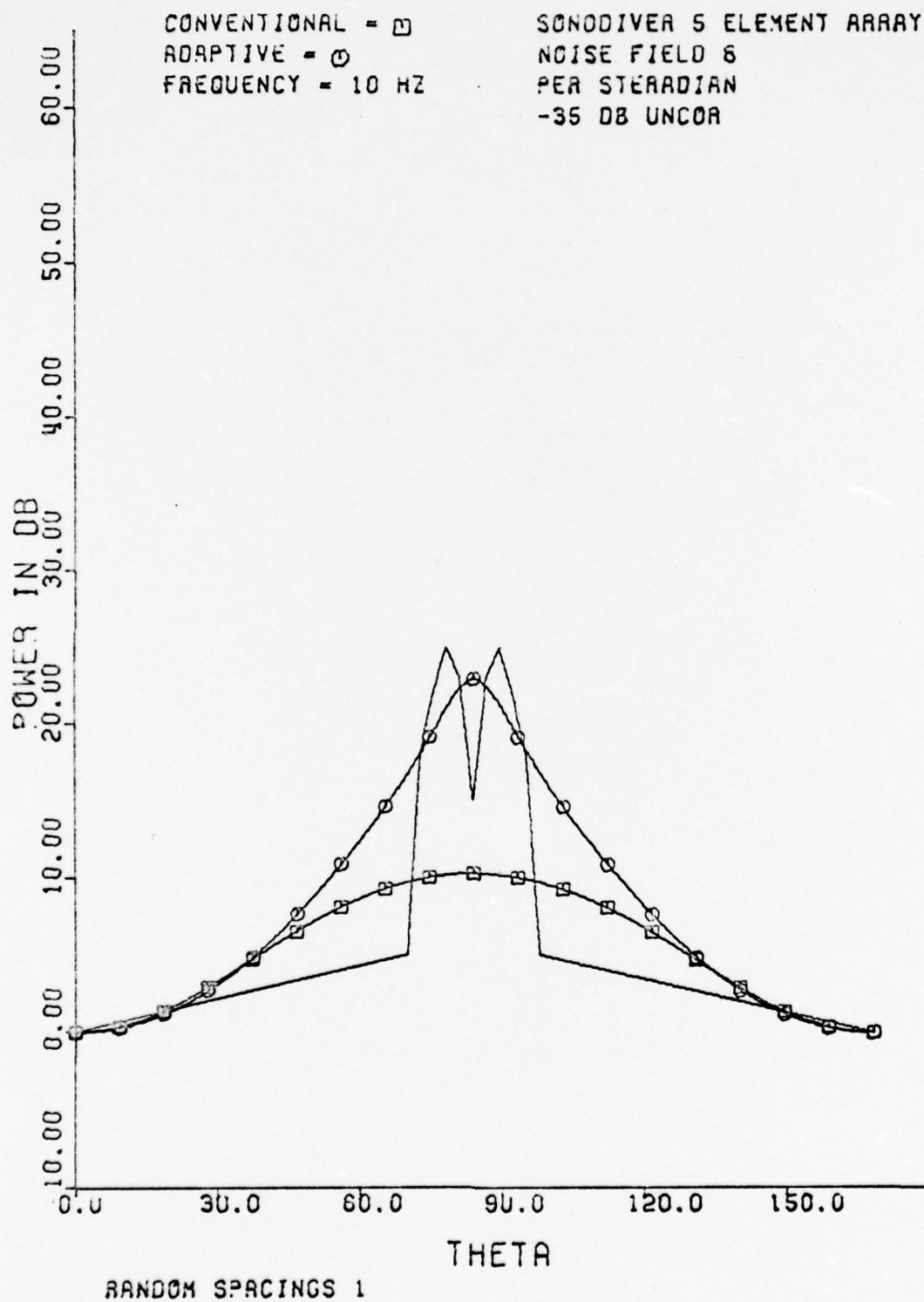


FIGURE 3

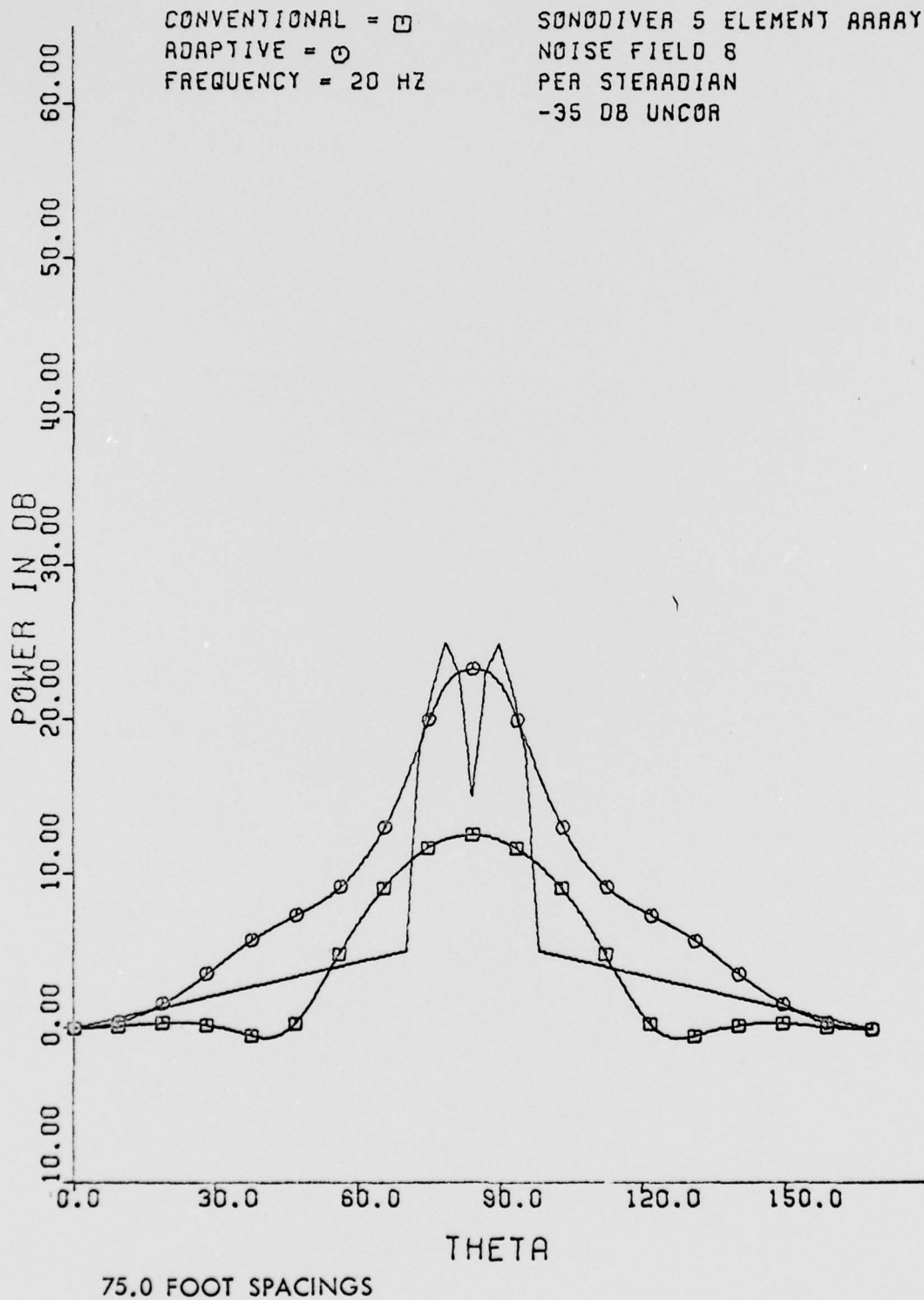
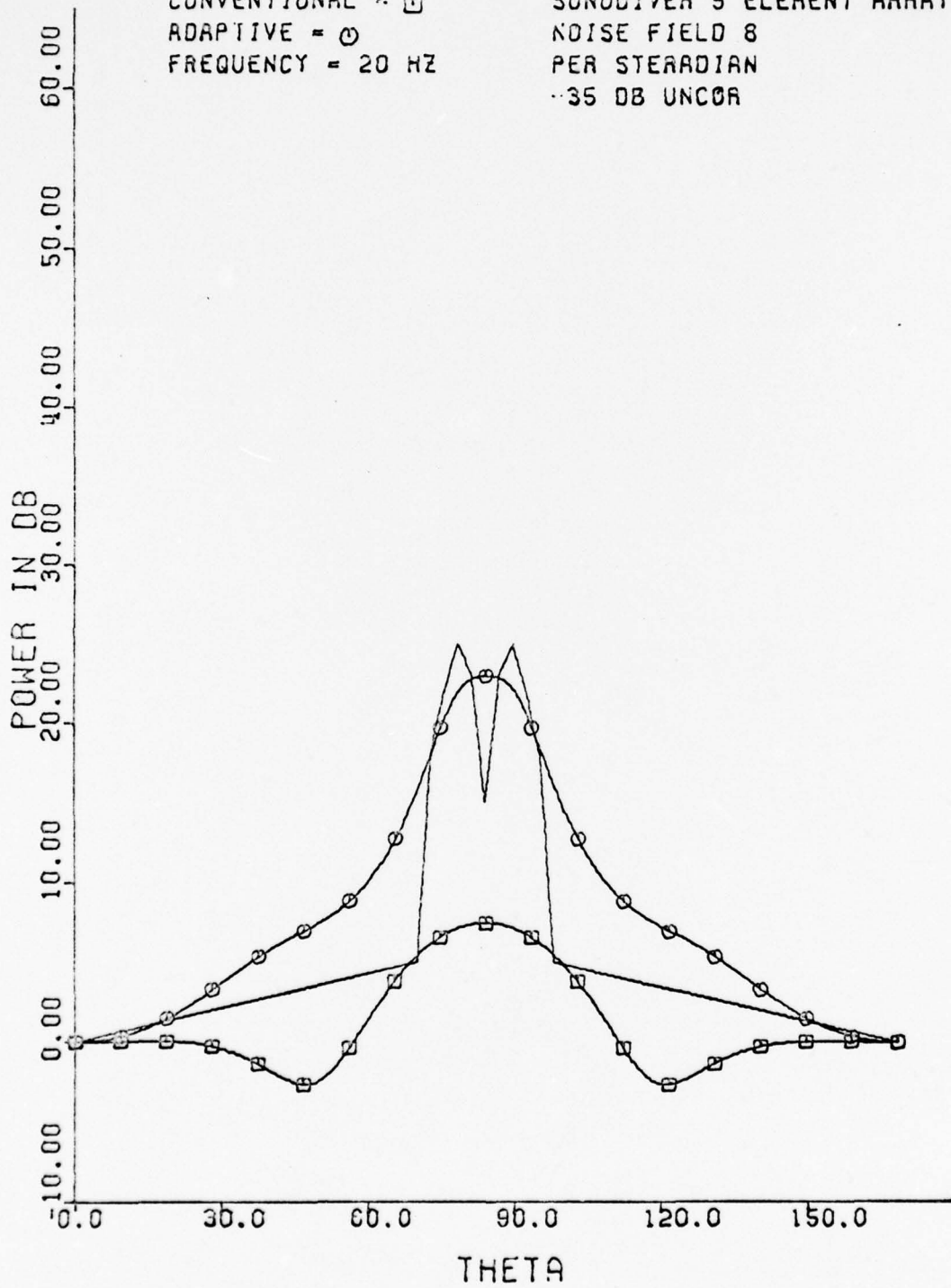


FIGURE 4

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 20 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 8  
PER STERADIAN  
-35 DB UNCOR



RANDOM SPACINGS 1

FIGURE 5

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 30 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 8  
PER STERADIAN  
-35 DB UNCOR

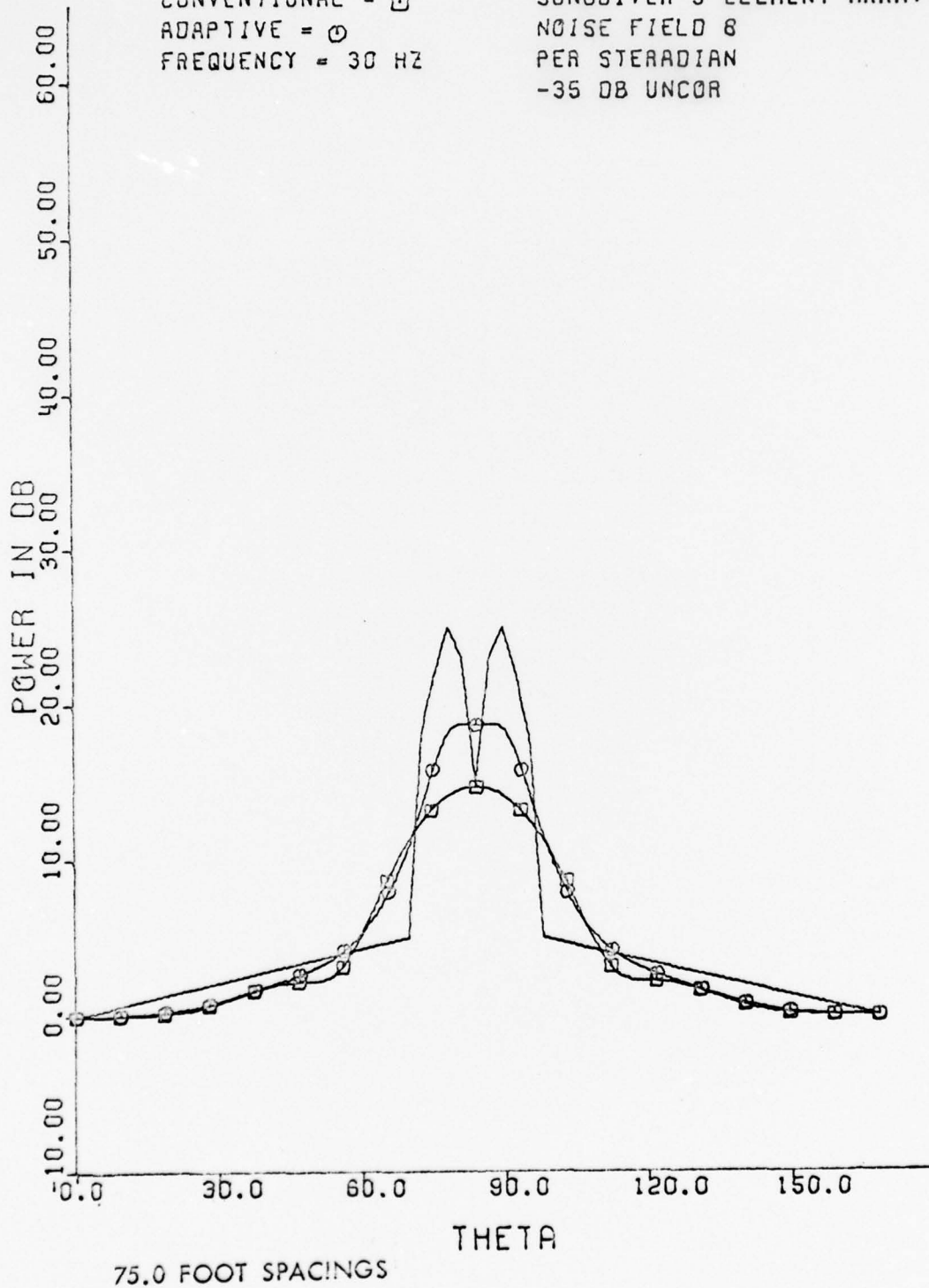


FIGURE 6

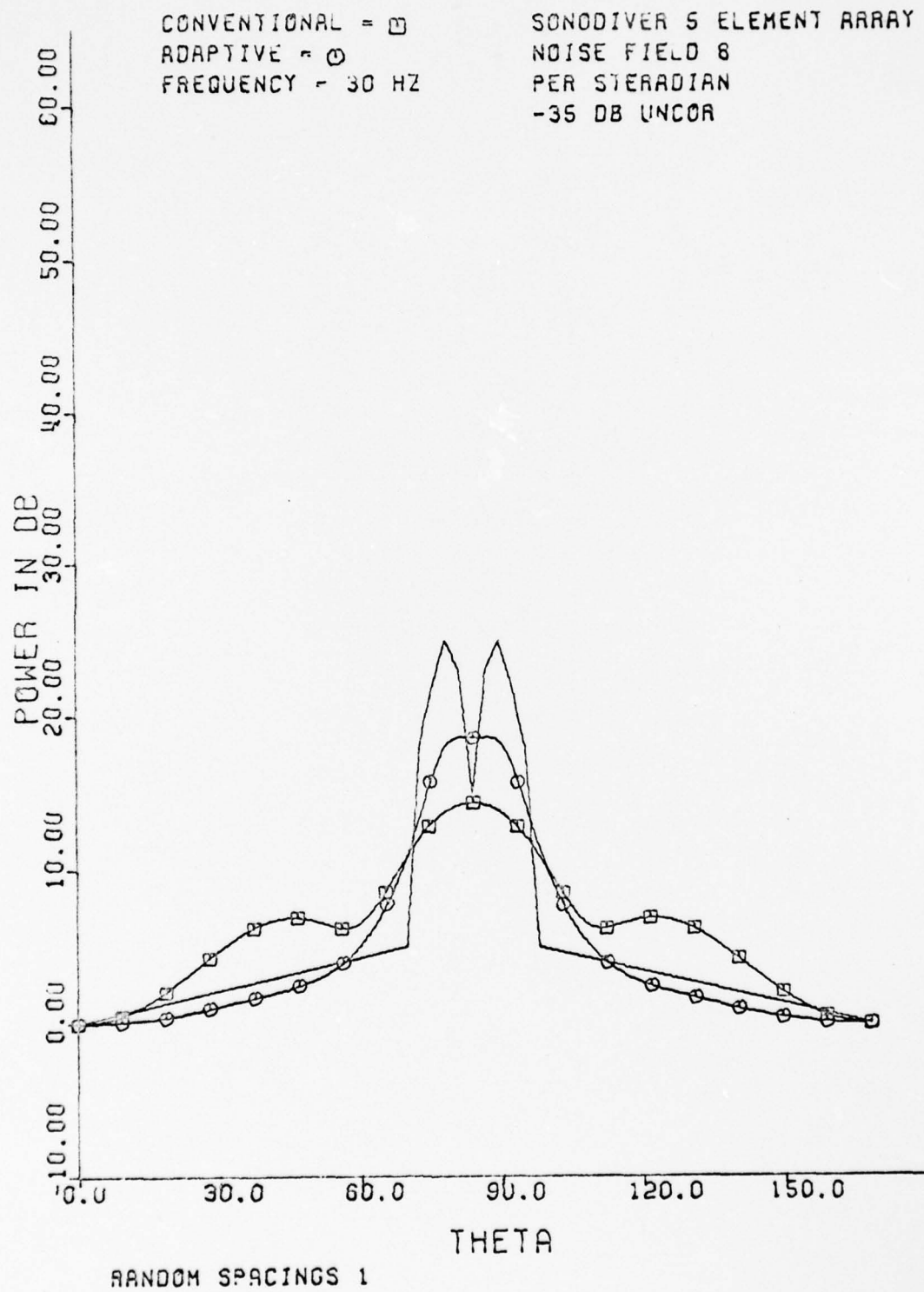


FIGURE 7

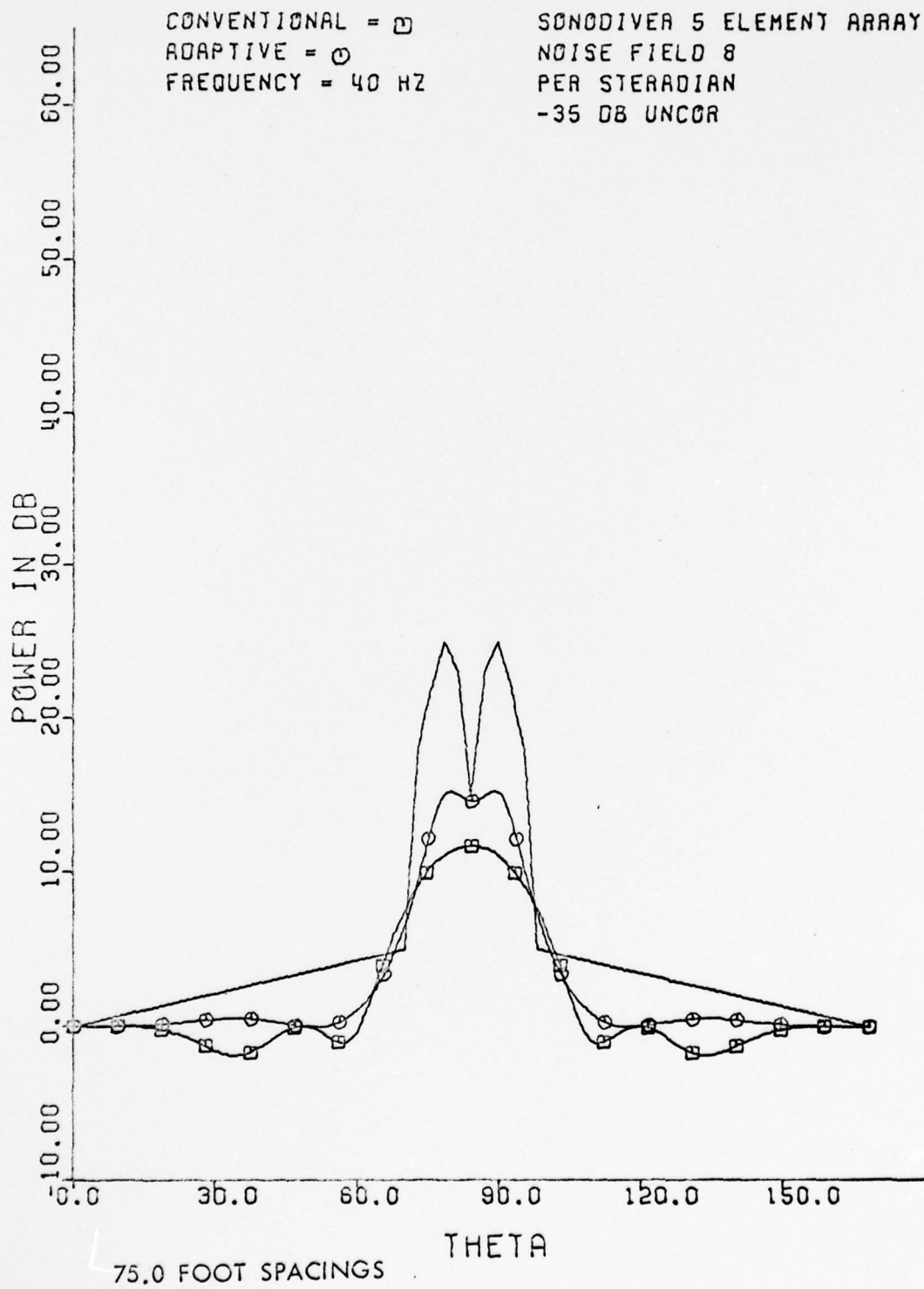
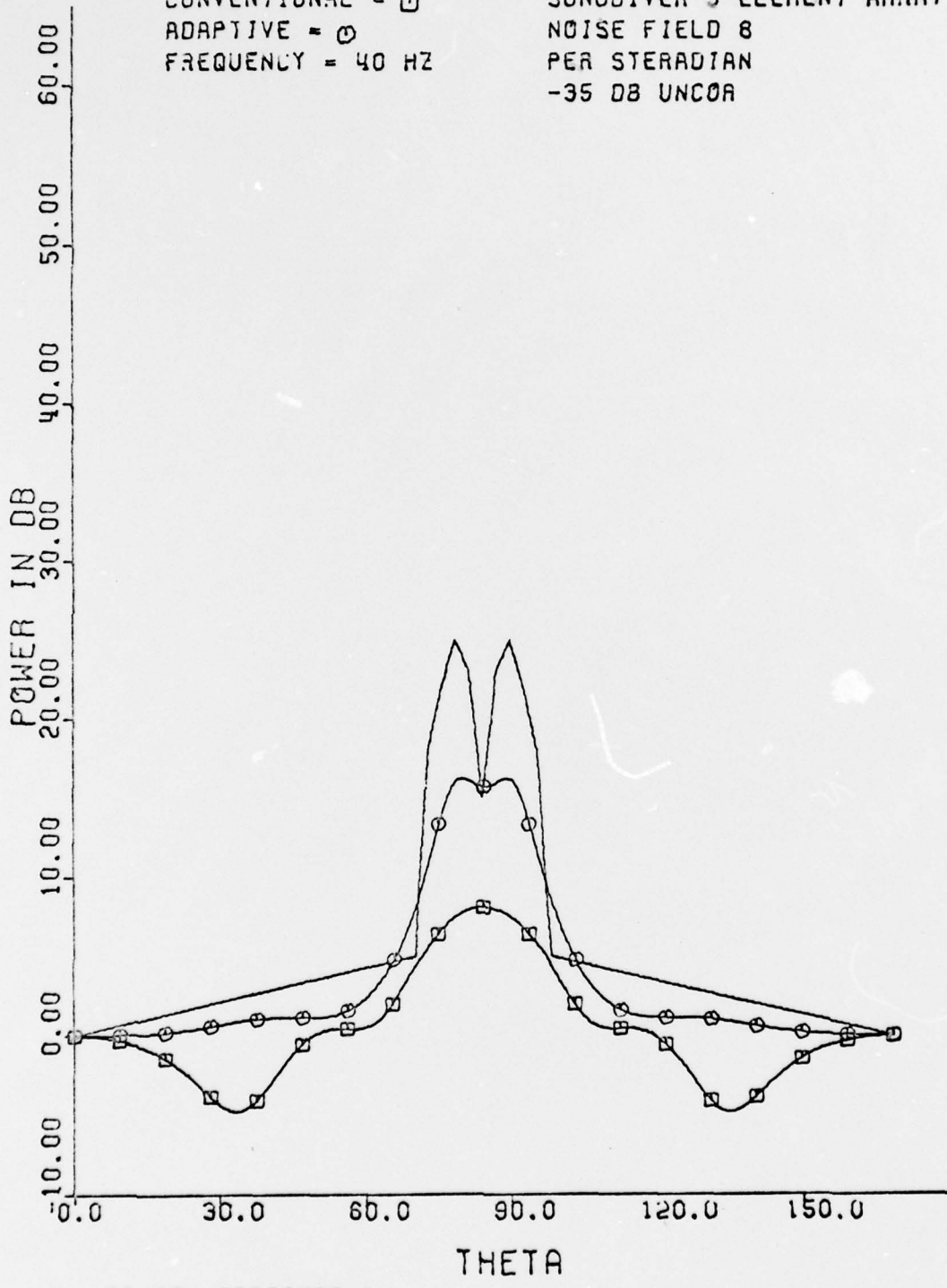


FIGURE 8

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 40 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 8  
PER STERADIAN  
-35 DB UNCOR



RANDOM SPACINGS 1

FIGURE 9

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 50 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 8  
PER STERADIAN  
-35 DB UNCOR

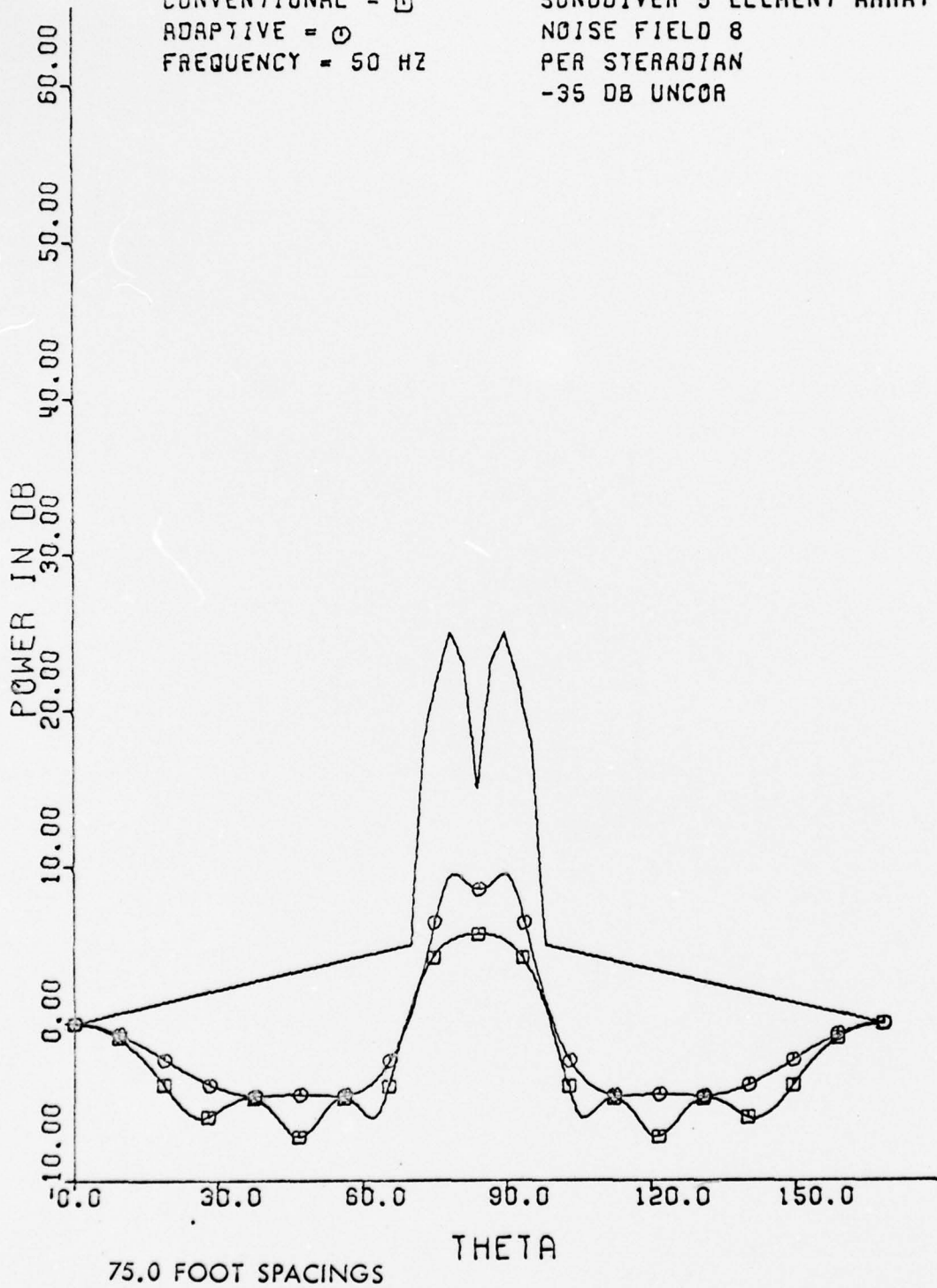
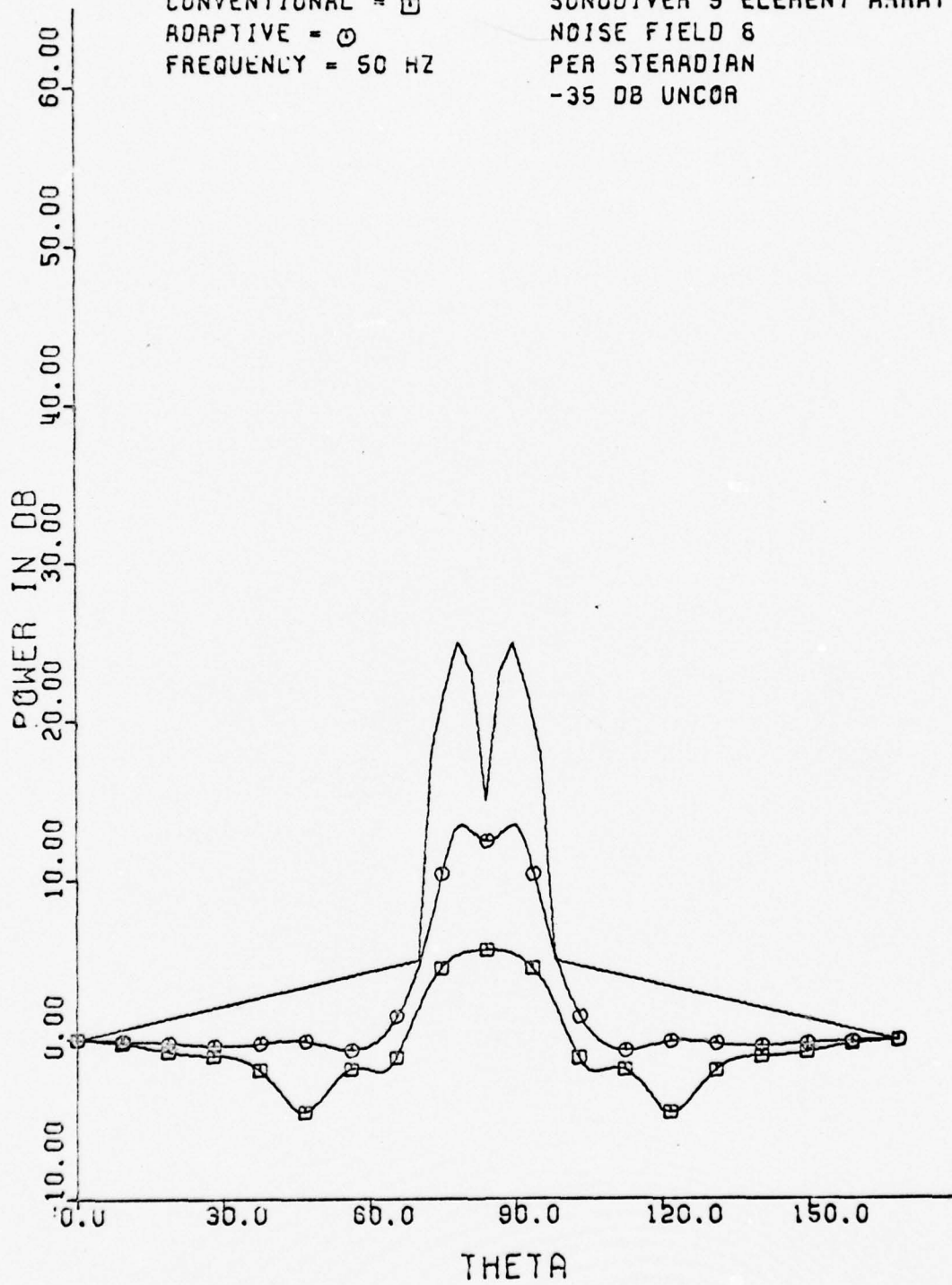


FIGURE 10



CONVENTIONAL = □  
ADAPTIVE = ⊙  
FREQUENCY = 50 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 6  
PER STERADIAN  
-35 DB UNCOR



RANDOM SPACINGS 1

FIGURE 11

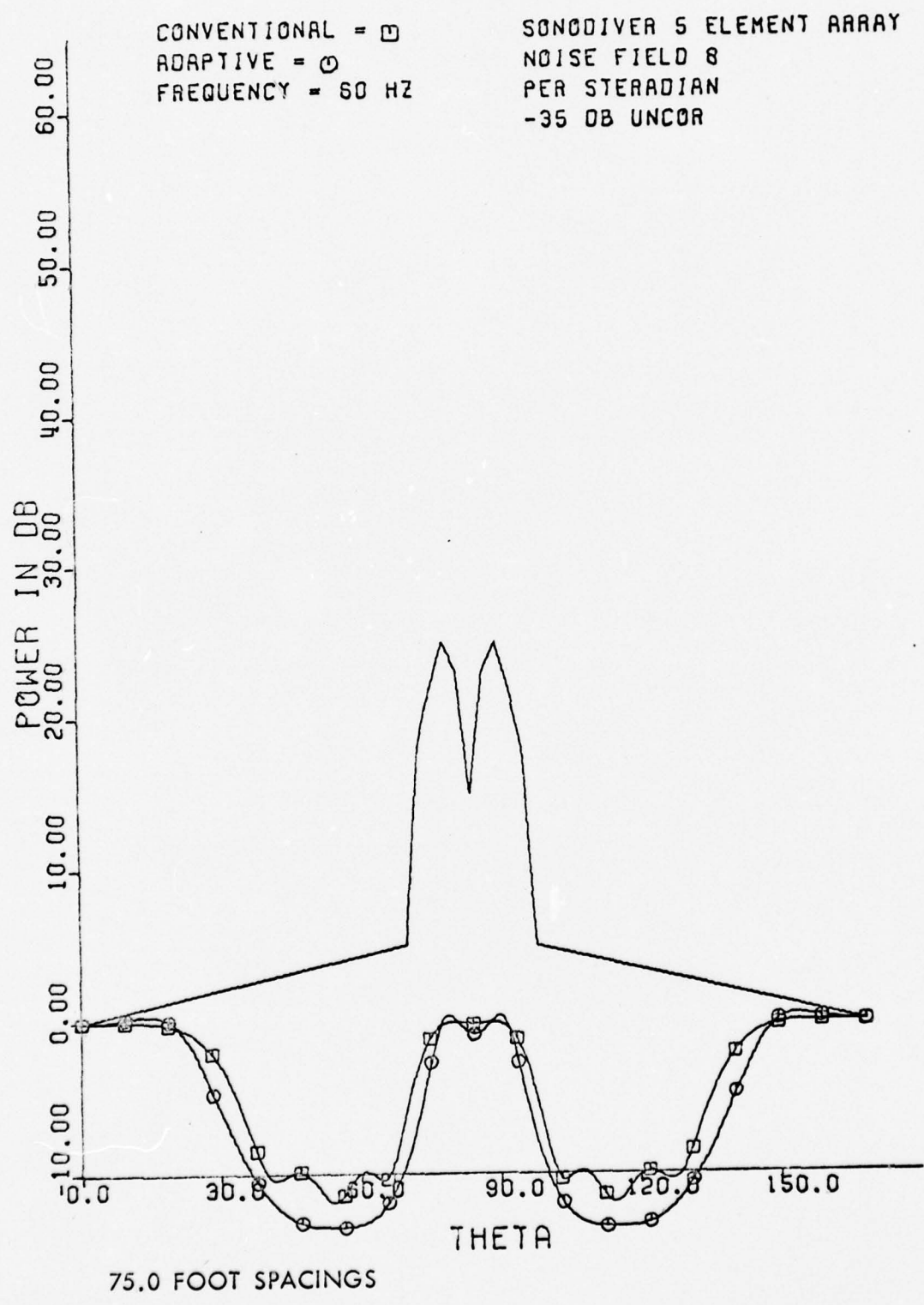


FIGURE 12

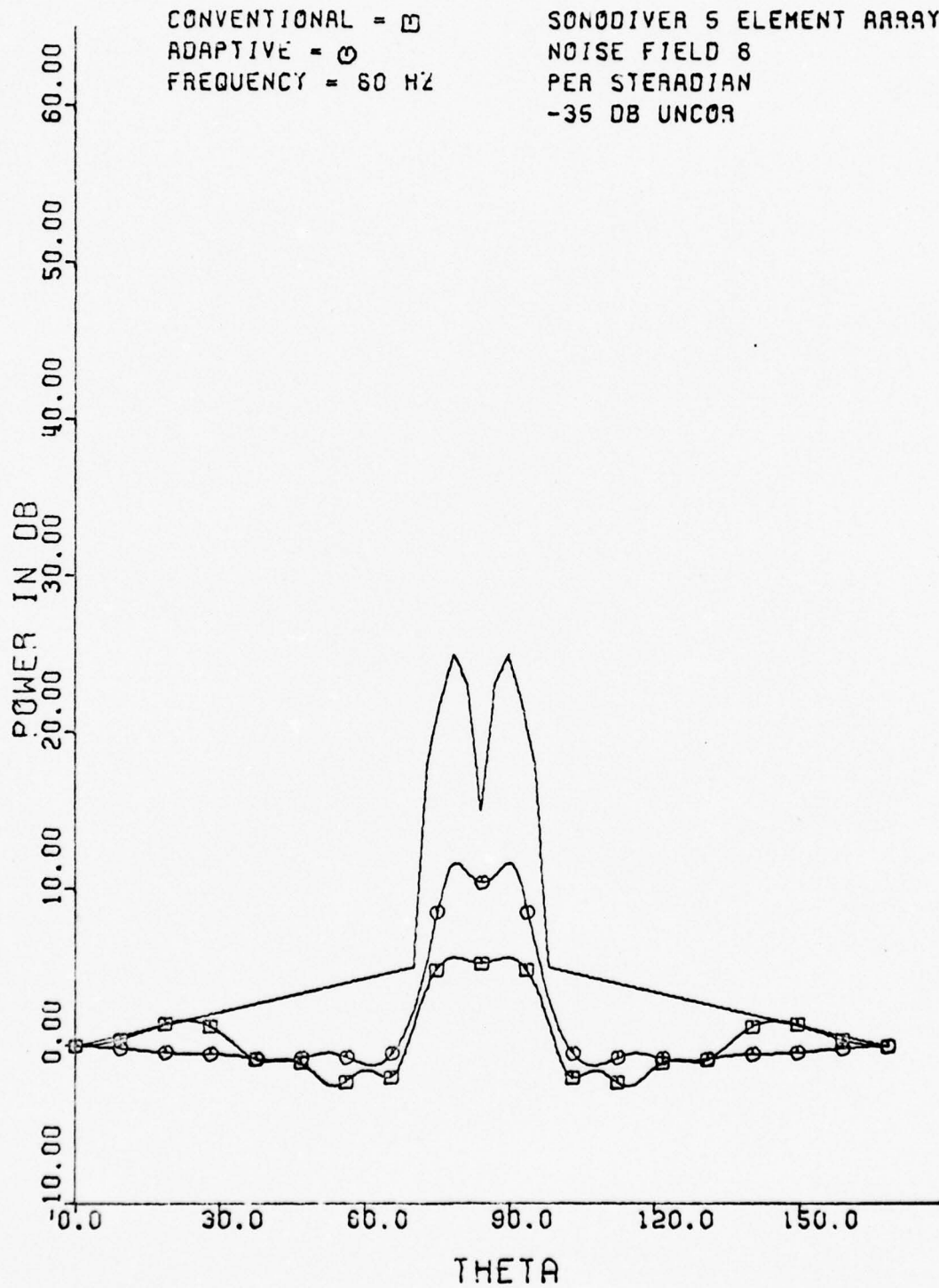


FIGURE 13

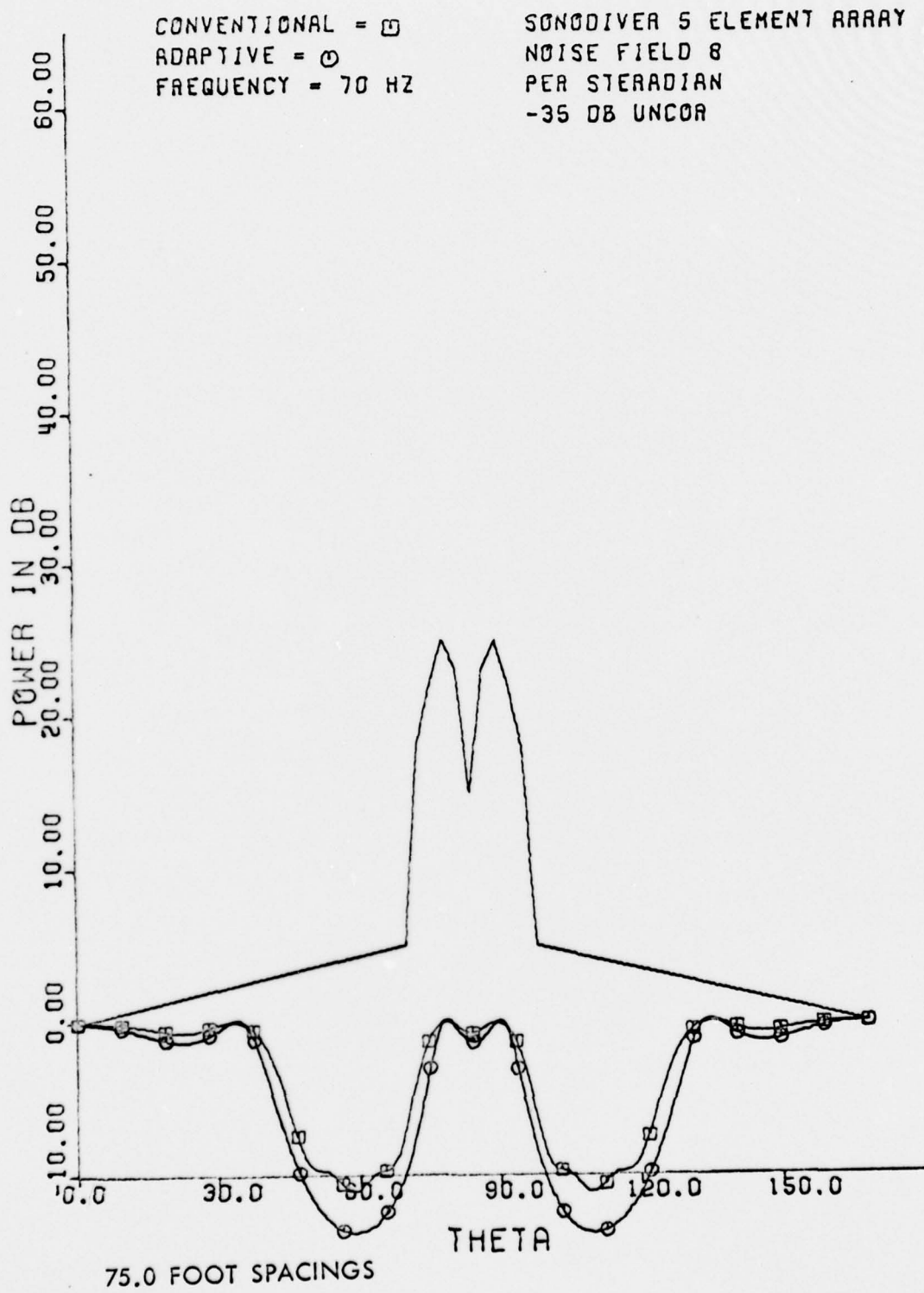


FIGURE 14

CONVENTIONAL - □  
ADAPTIVE - ○  
FREQUENCY = 70 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 8  
PER STERADIAN  
-35 DB UNCOR

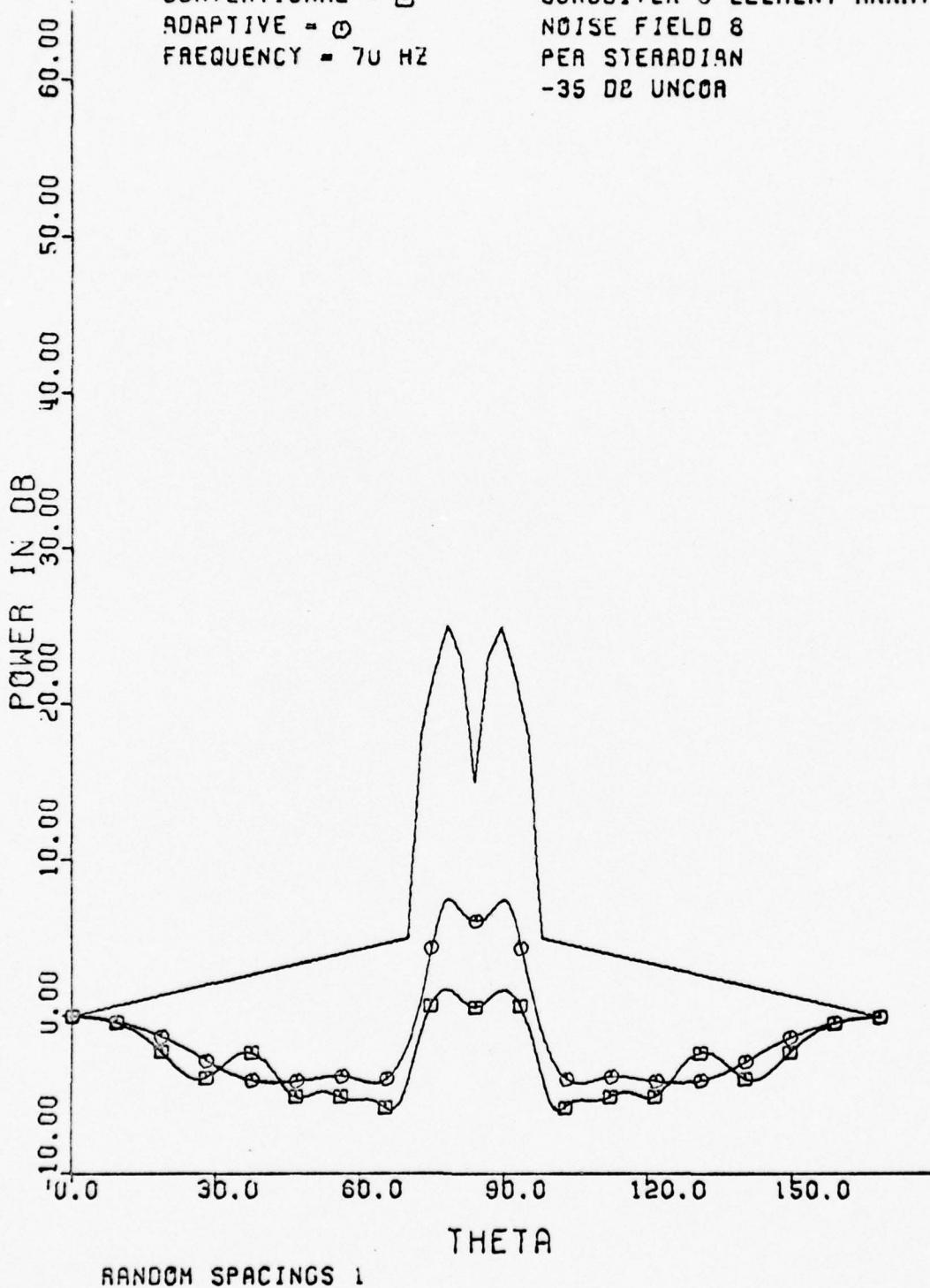


FIGURE 15

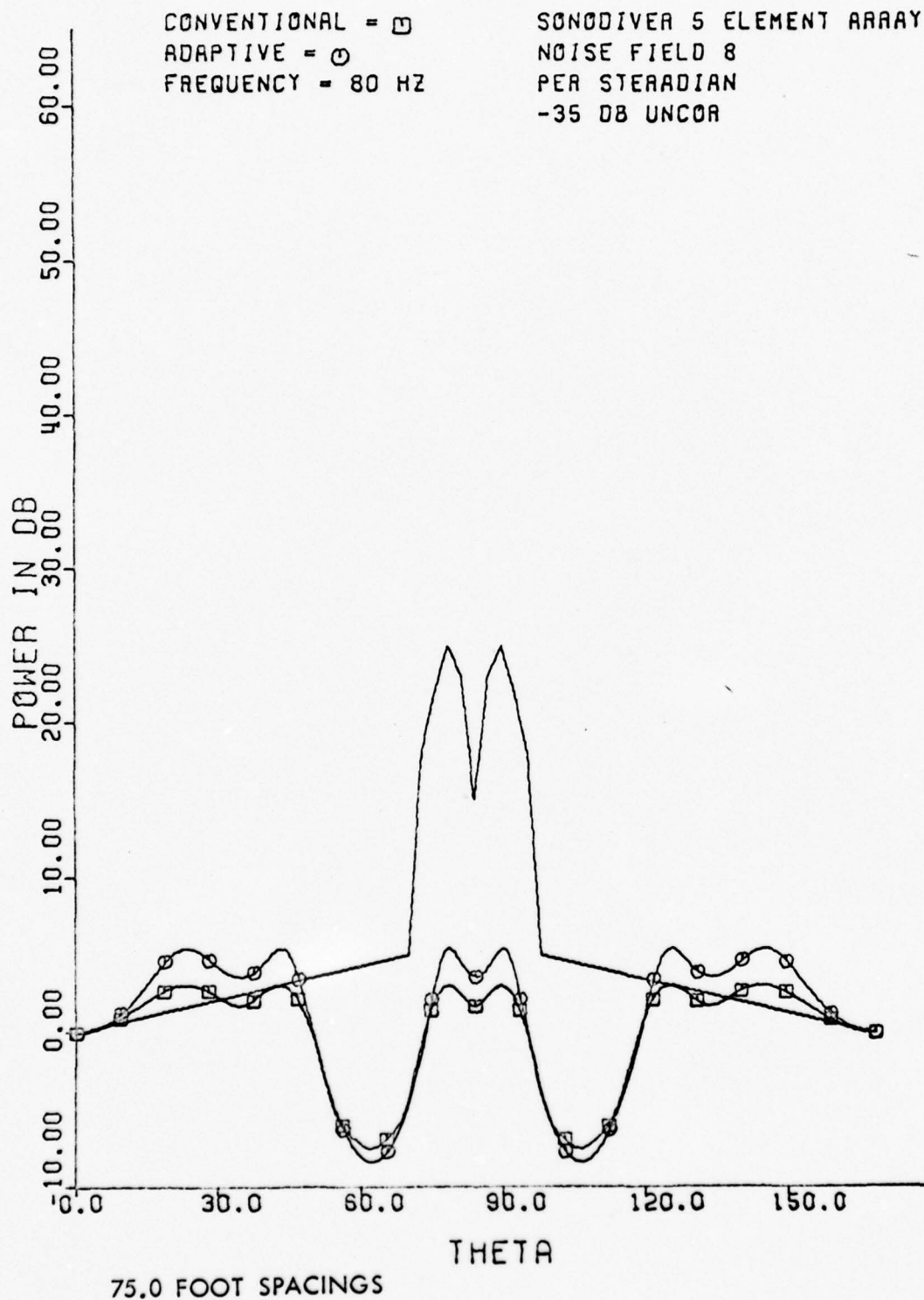


FIGURE 16

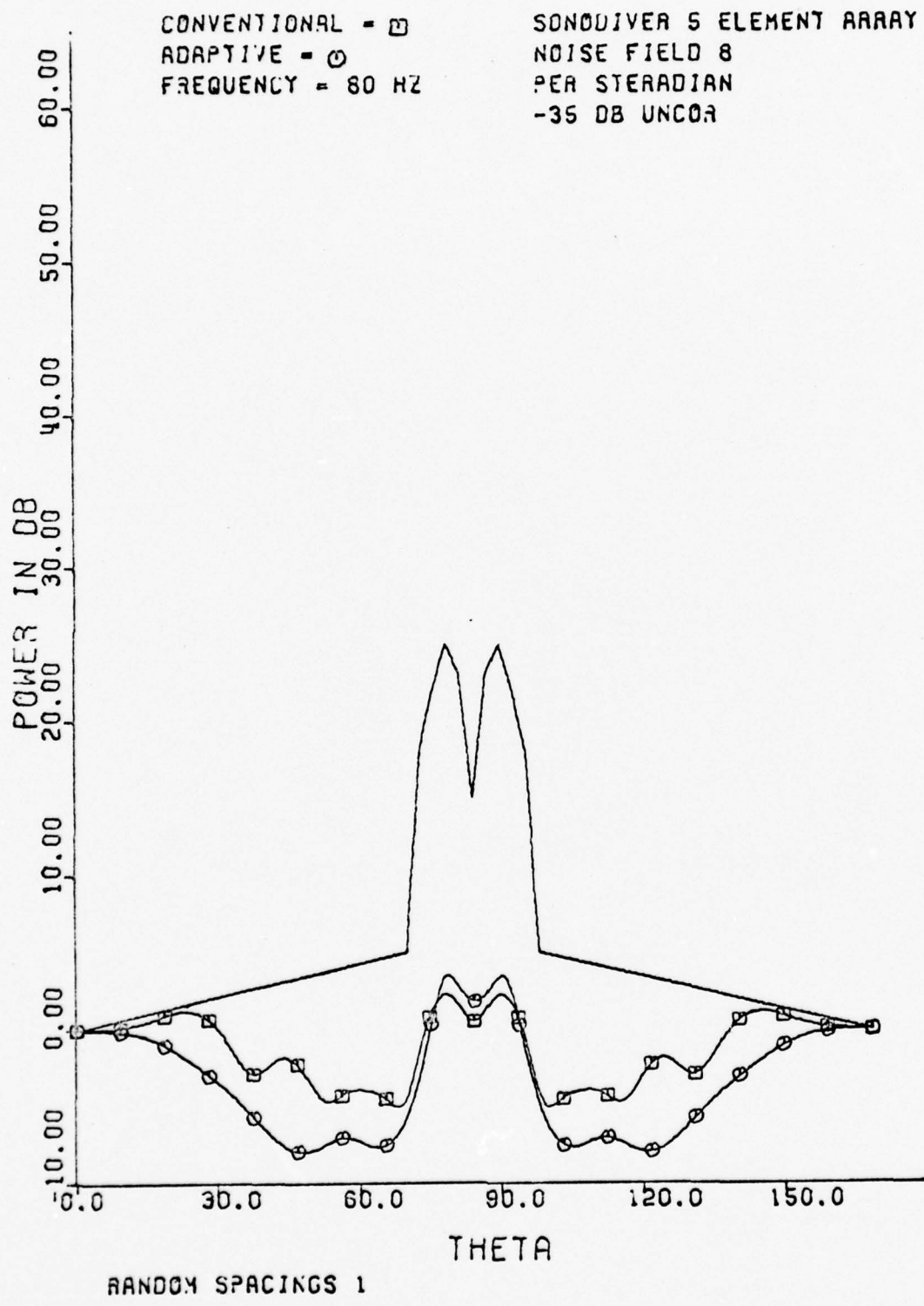


FIGURE 17

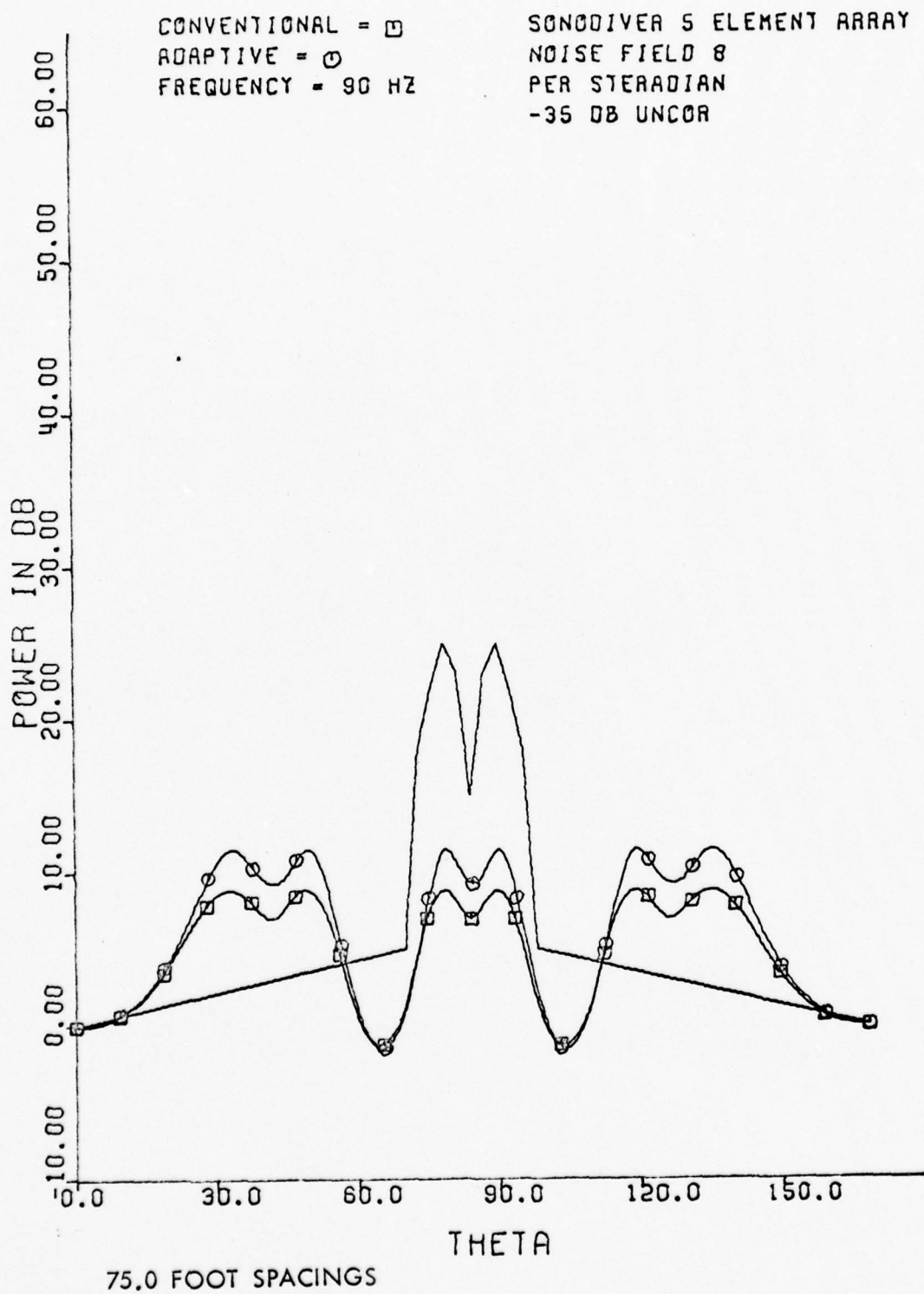
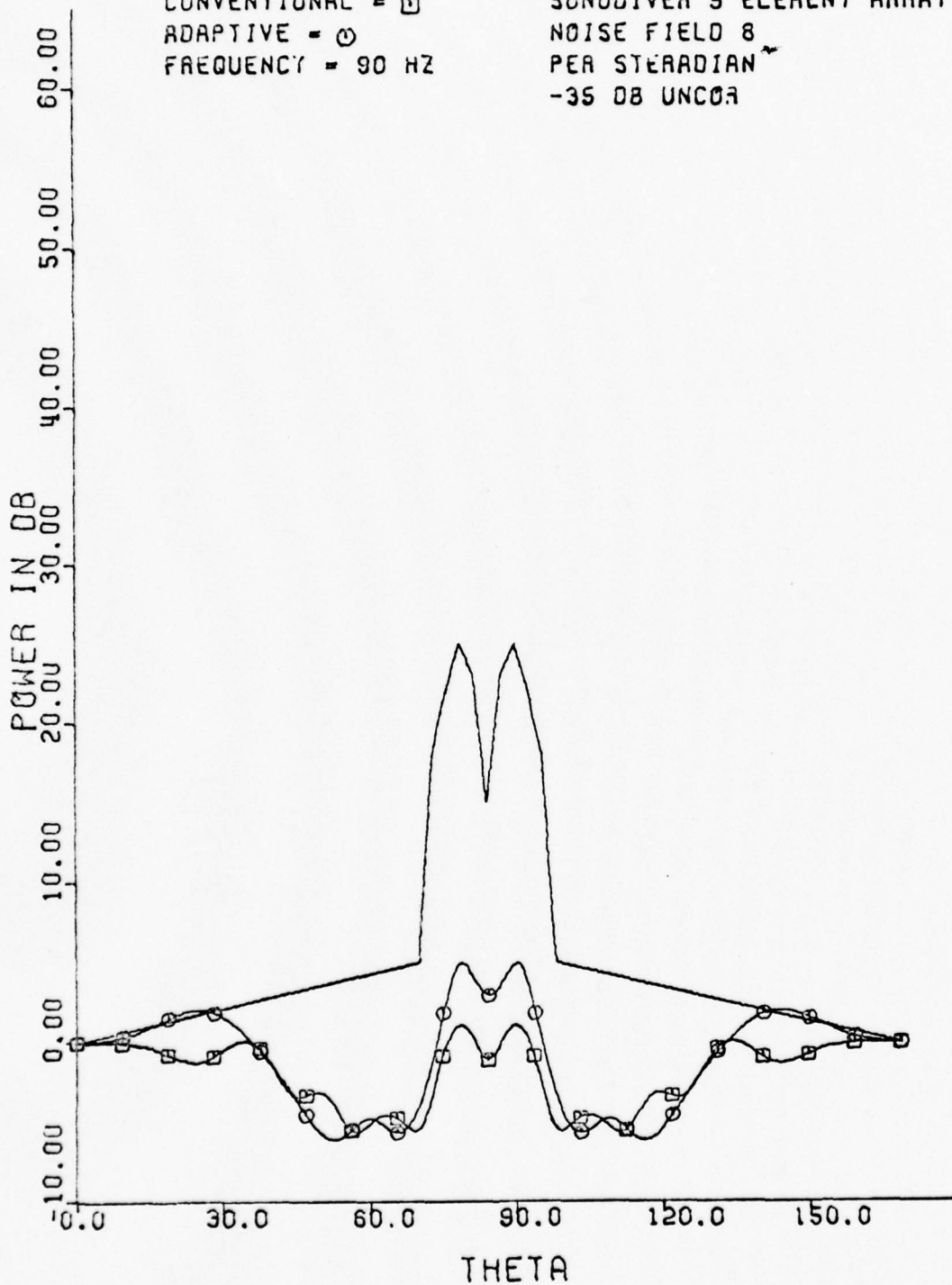


FIGURE 18



CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 90 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 8  
PER STERADIAN  
-35 DB UNCOR



RANDOM SPACINGS 1

FIGURE 19

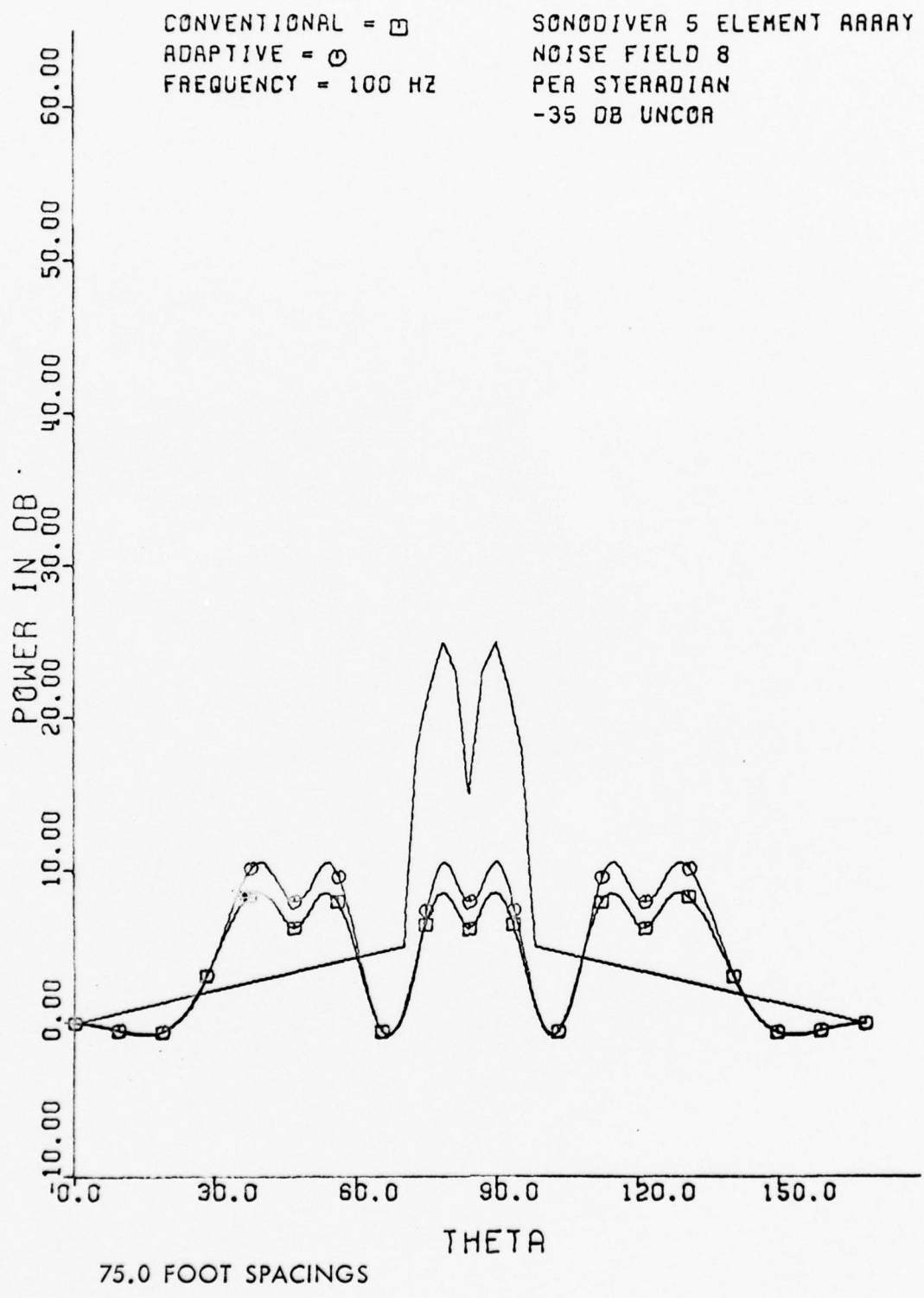


FIGURE 20

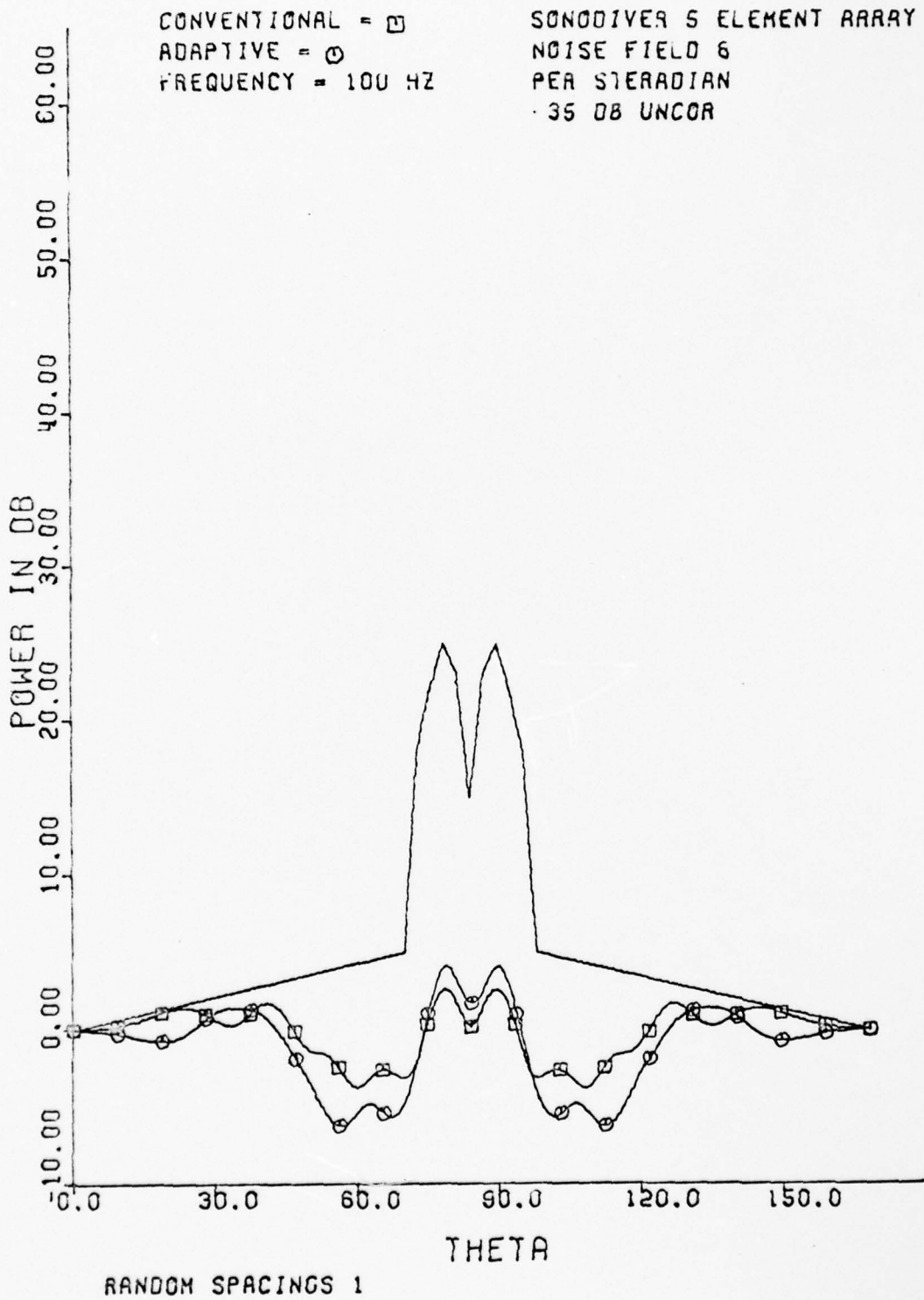
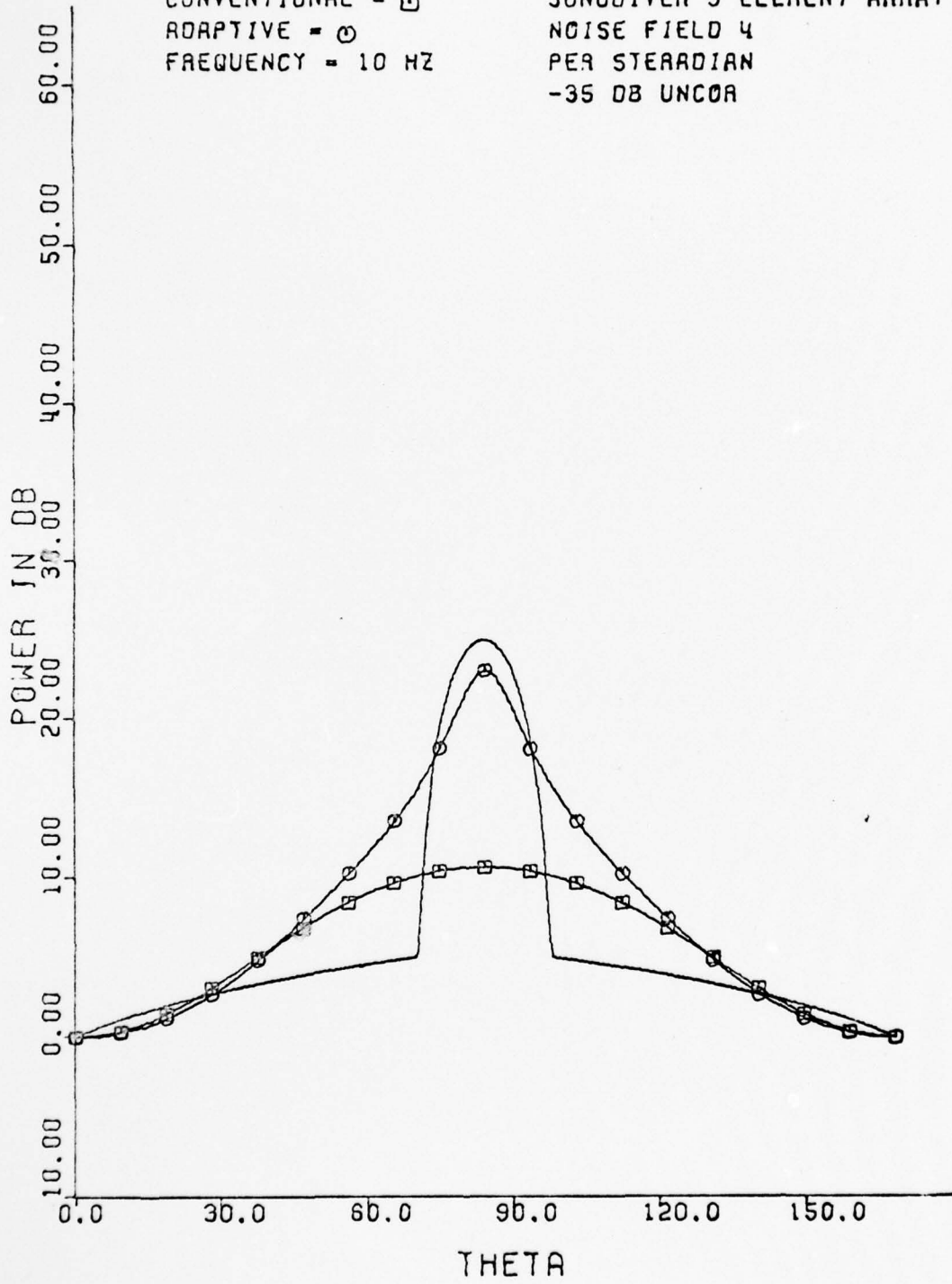


FIGURE 21

CONVENTIONAL - □  
ADAPTIVE - ○  
FREQUENCY = 10 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 4  
PER STERADIAN  
-35 DB UNCOR

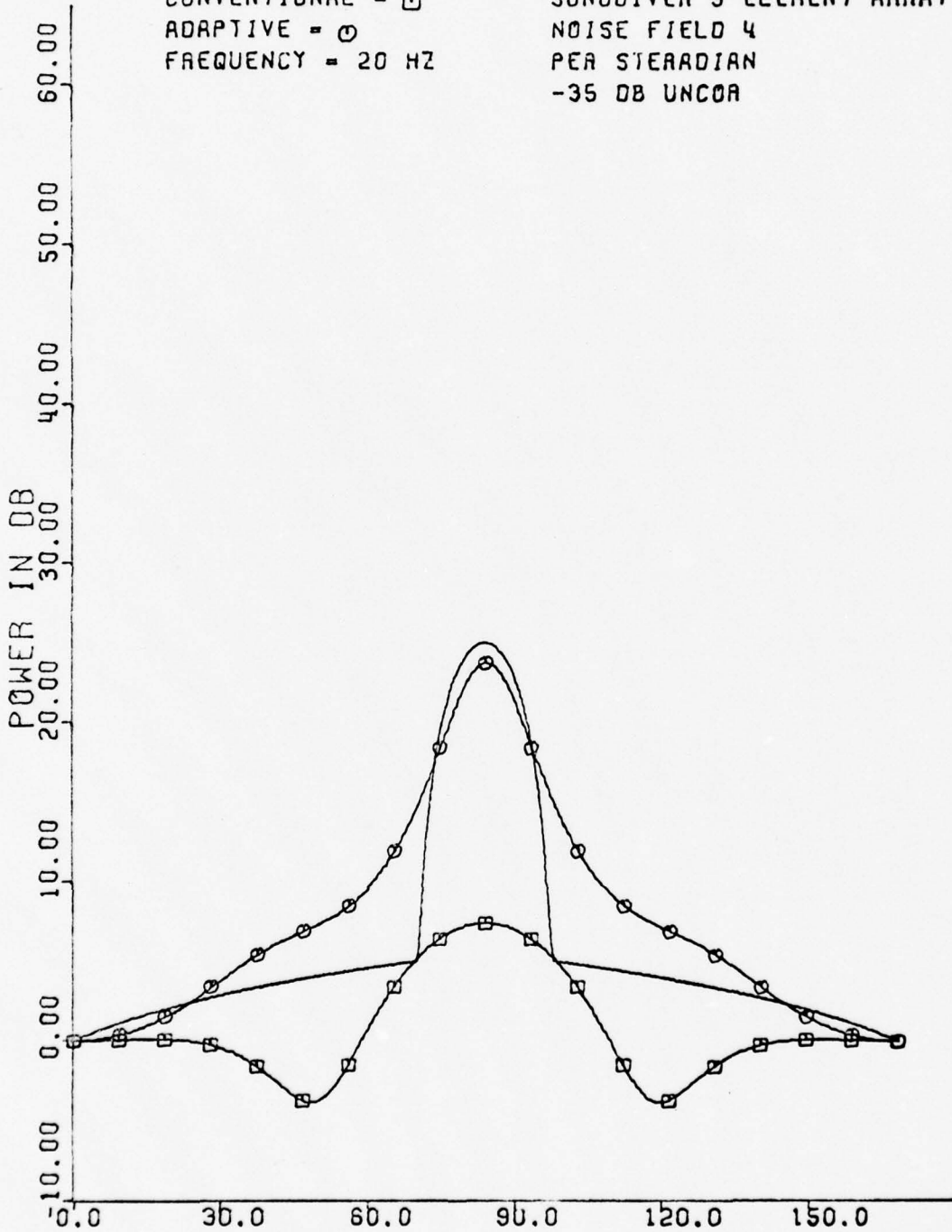


RANDOM SPACINGS 1

FIGURE 22

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 20 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 4  
PER STERADIAN  
-35 DB UNCOR



RANDOM SPACINGS 1

THETA

FIGURE 23

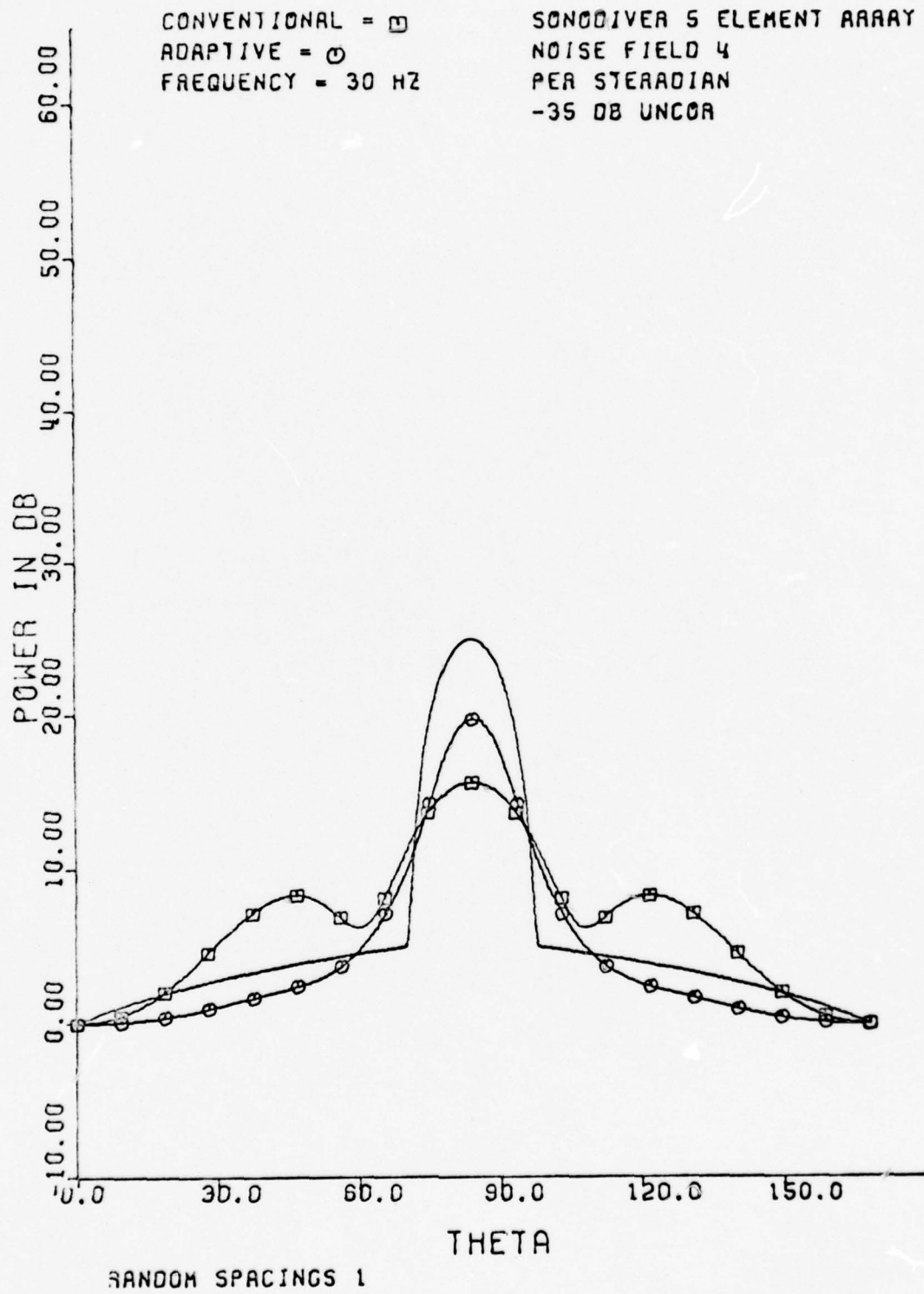


FIGURE 24

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 40 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 4  
PER STERADIAN  
-35 DB UNCOR

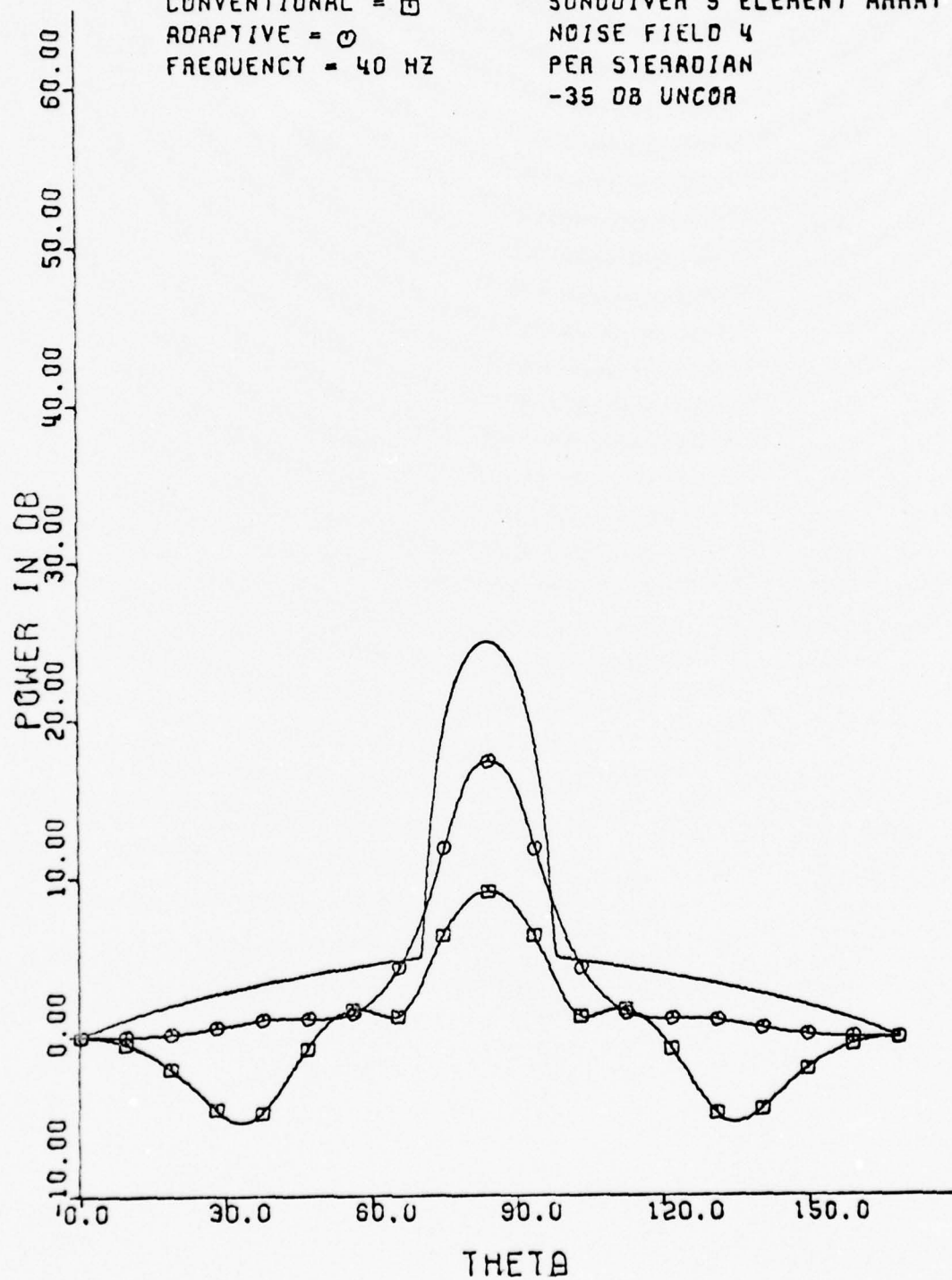


FIGURE 25

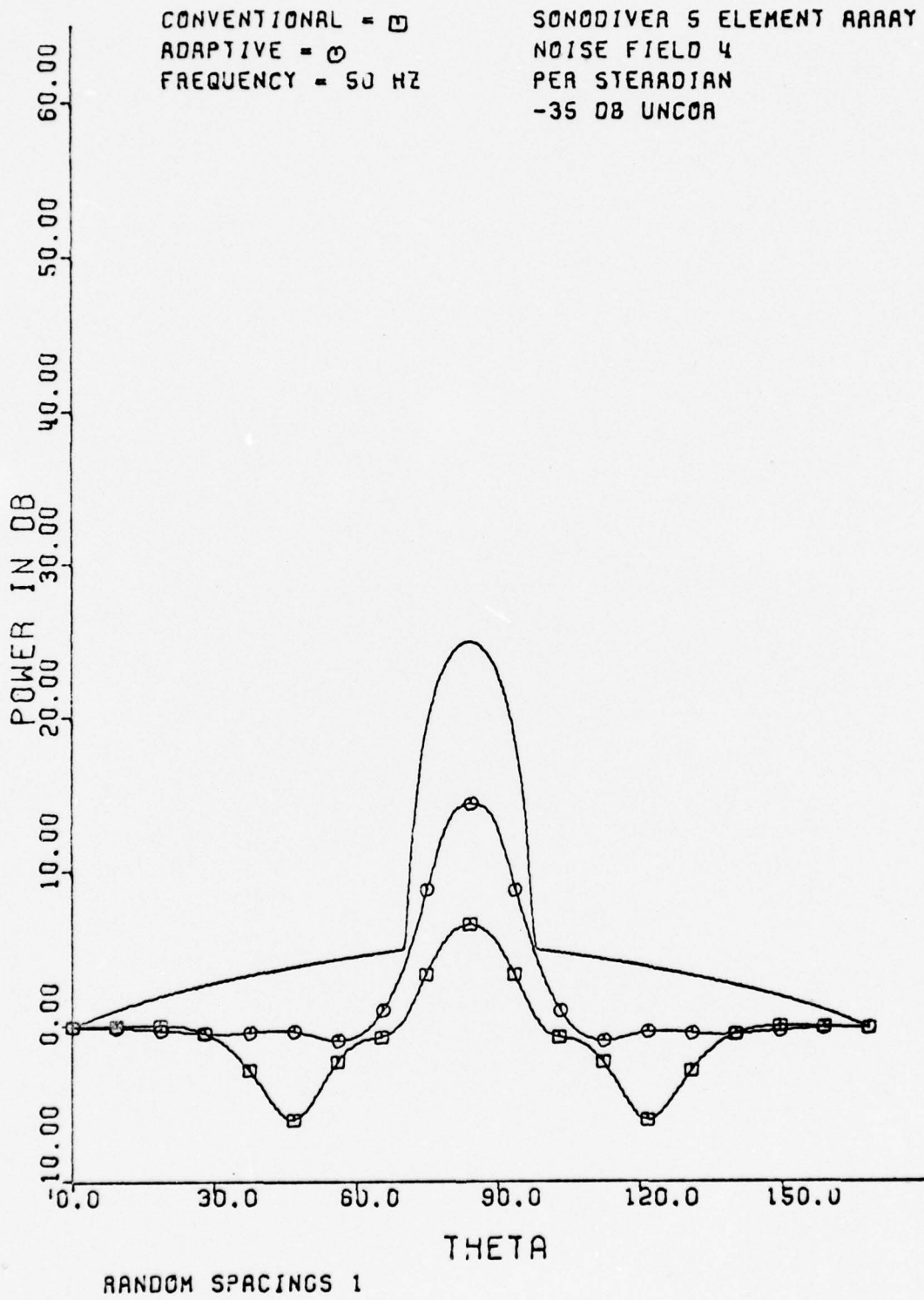


FIGURE 26



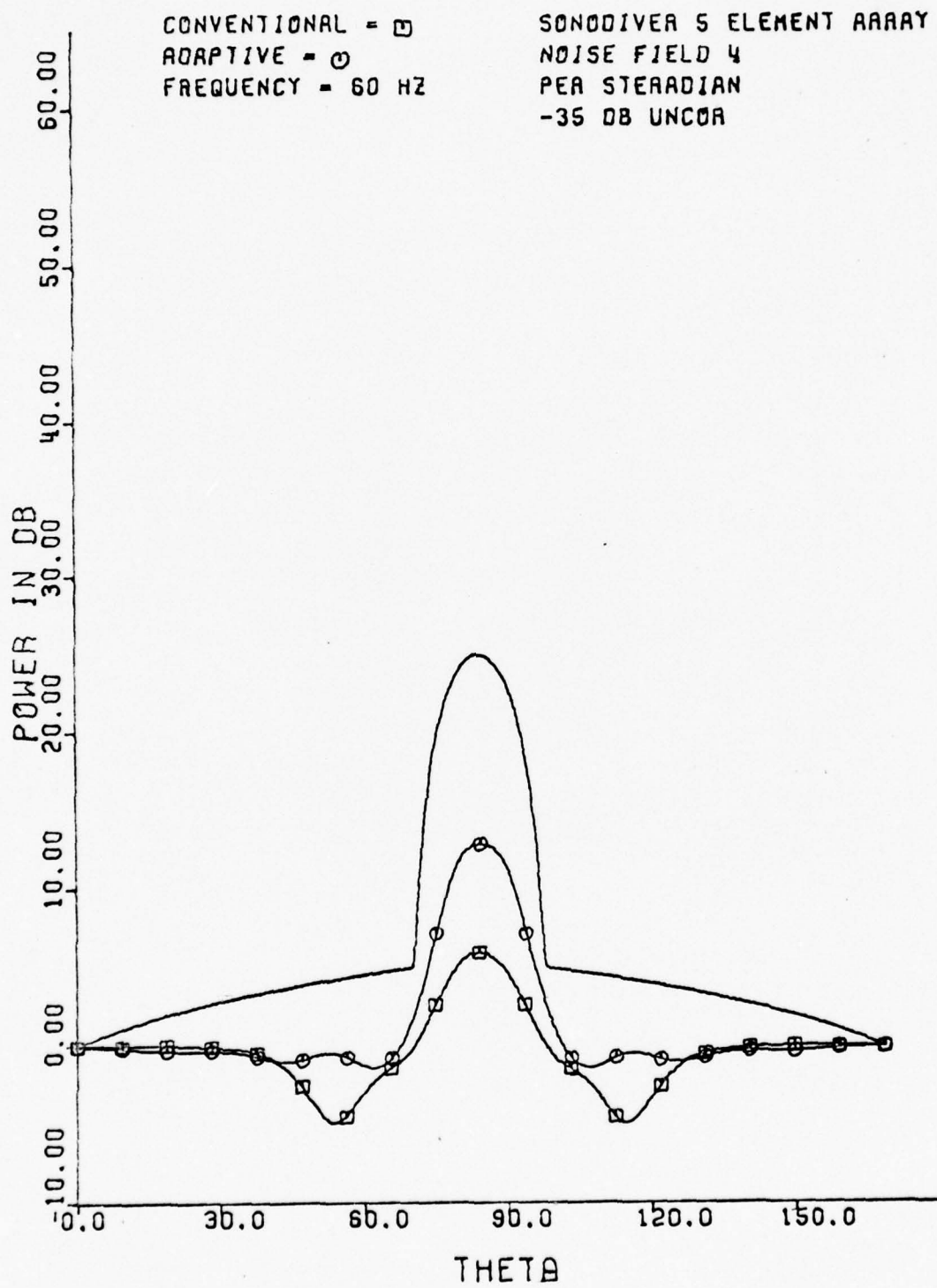


FIGURE 27

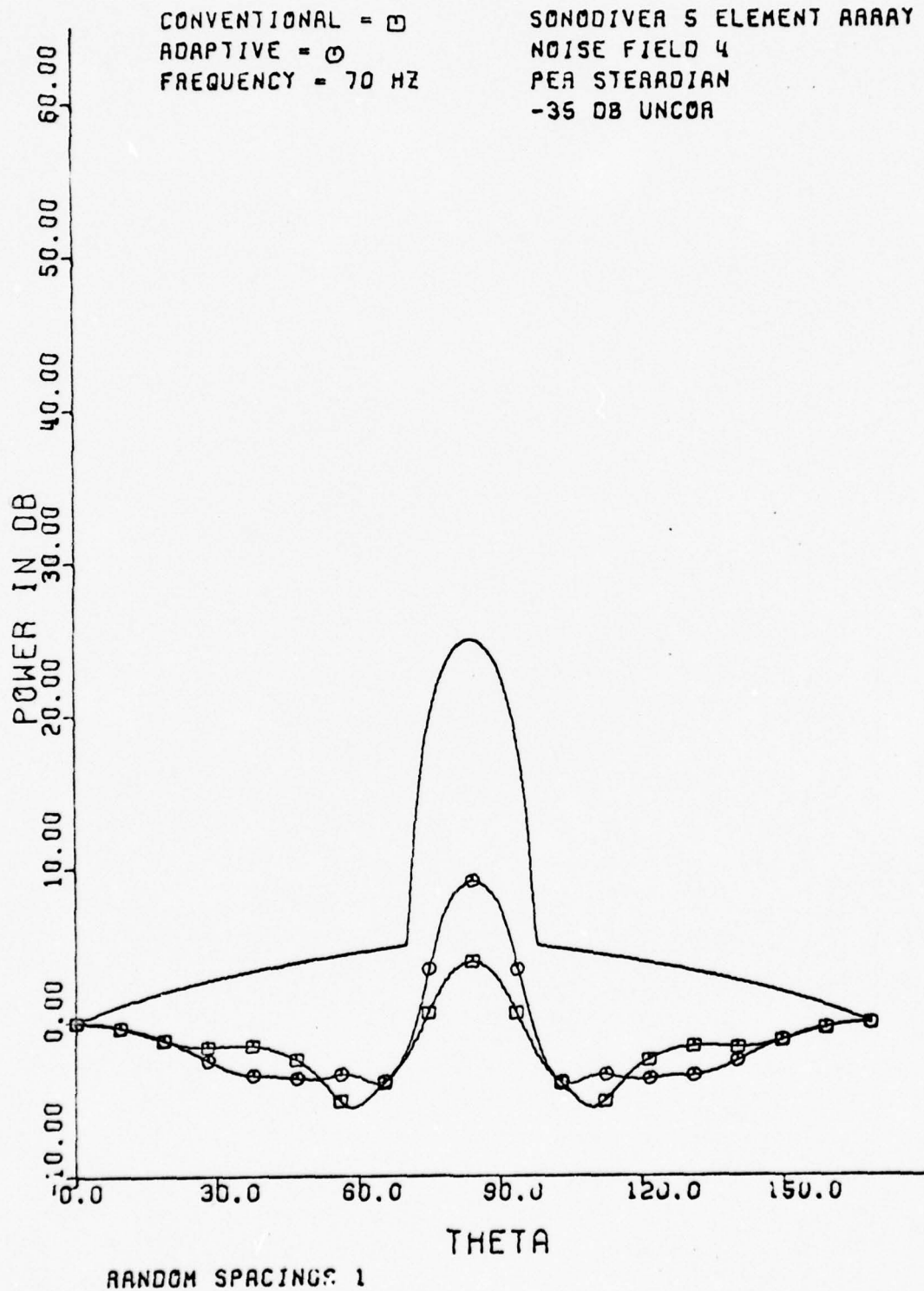


FIGURE 28

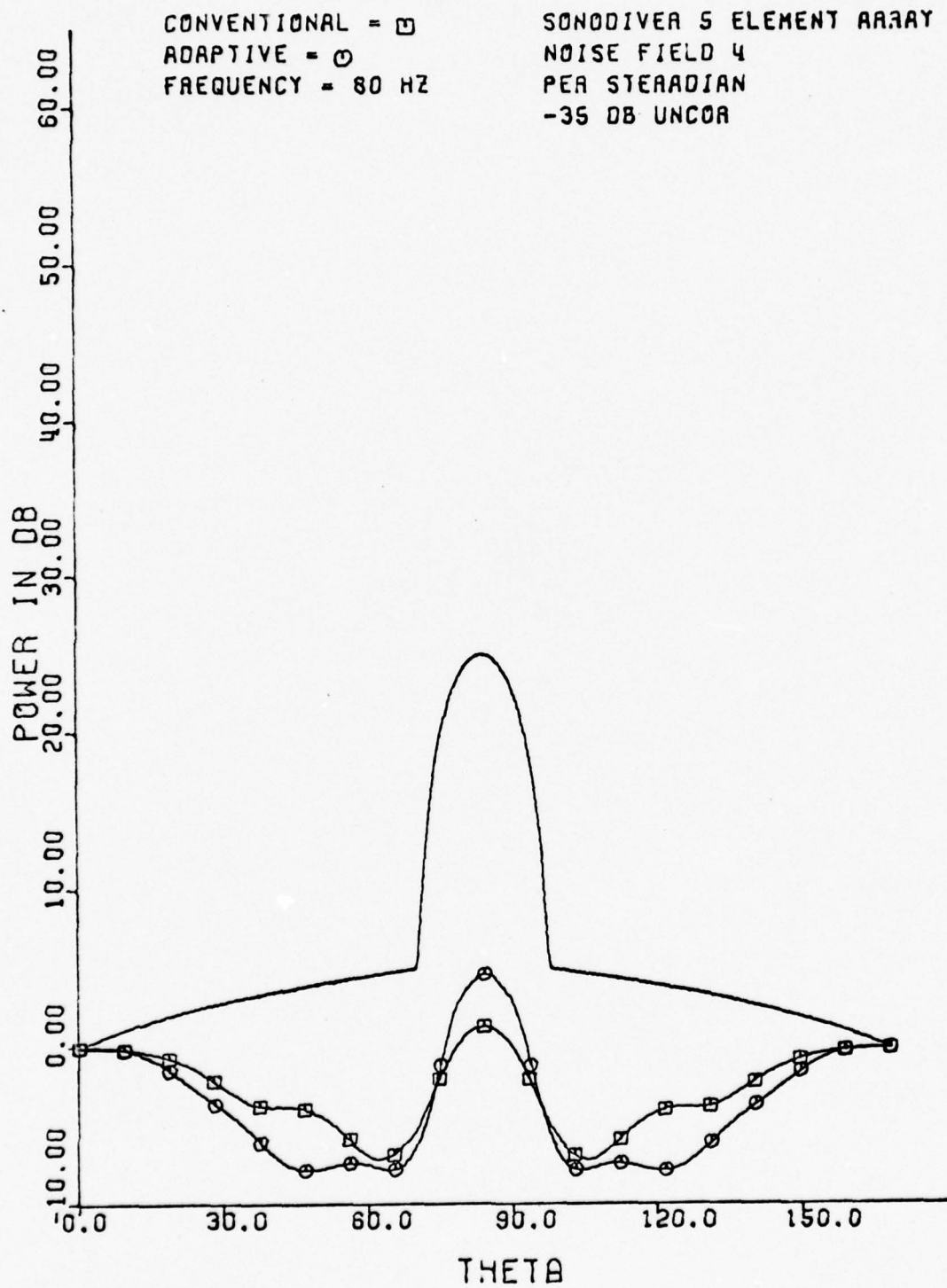


FIGURE 29

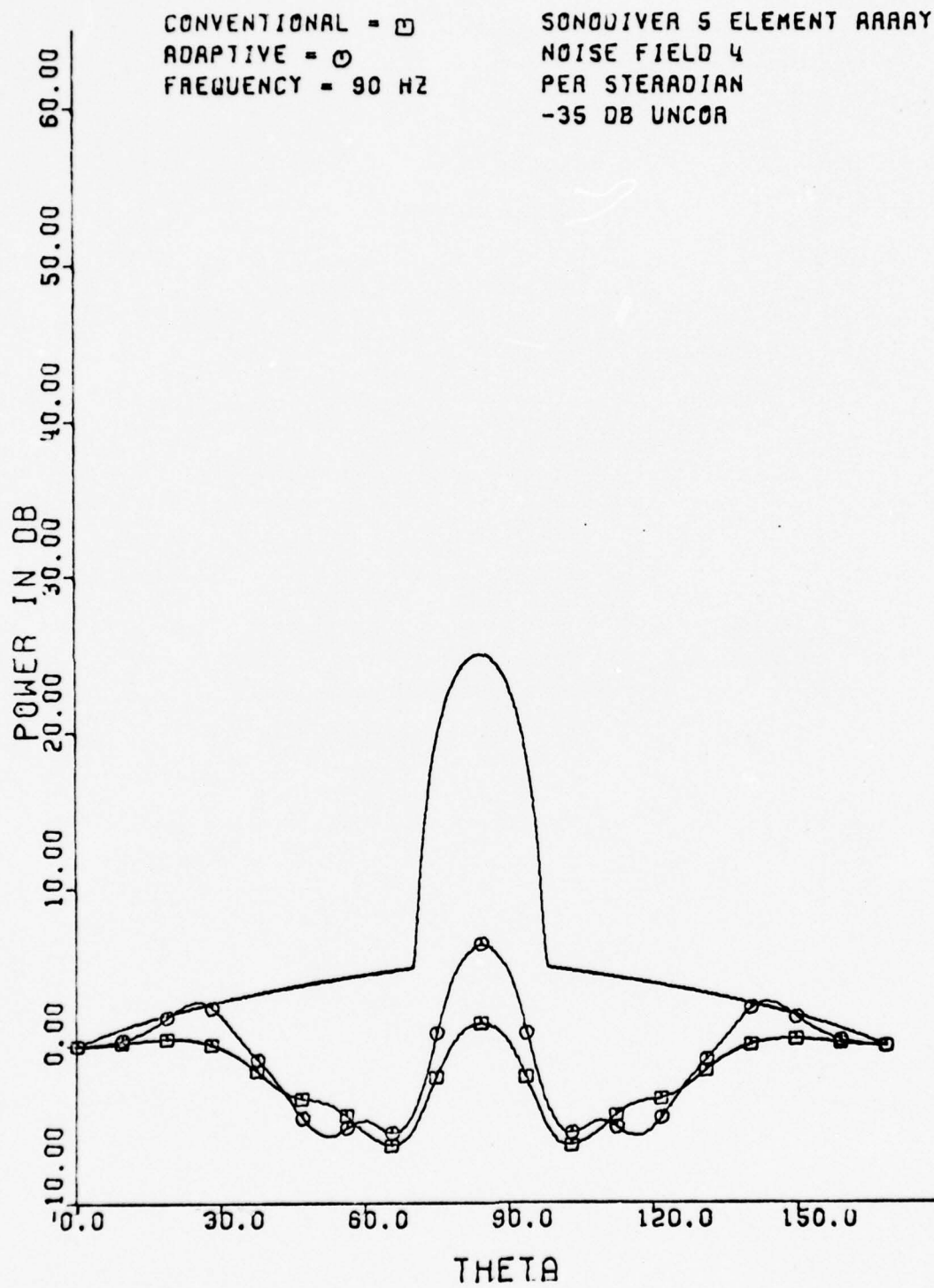
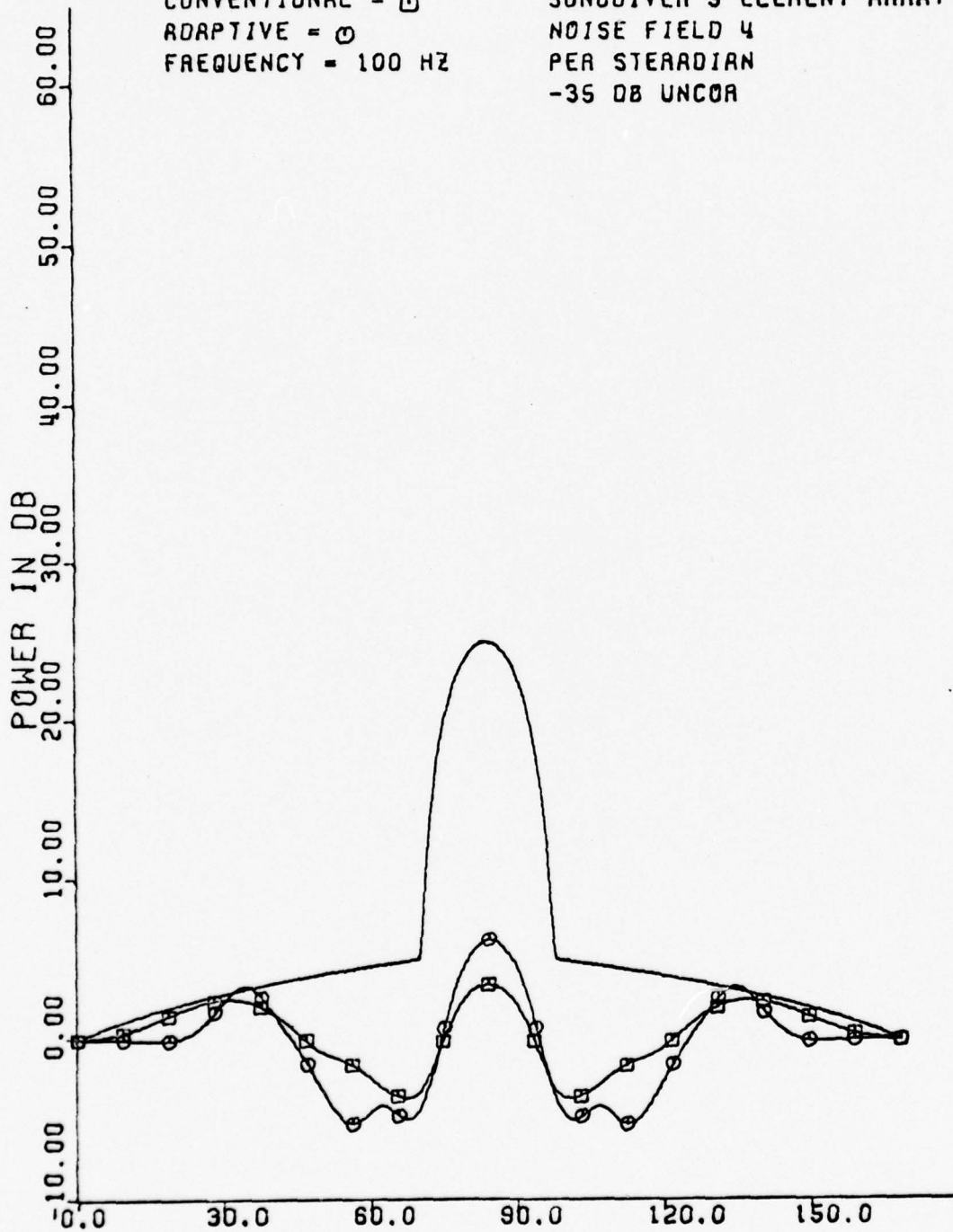


FIGURE 30

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 100 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 4  
PER STERADIAN  
-35 DB UNCOR



RANDOM SPACINGS 1

THETA

FIGURE 31

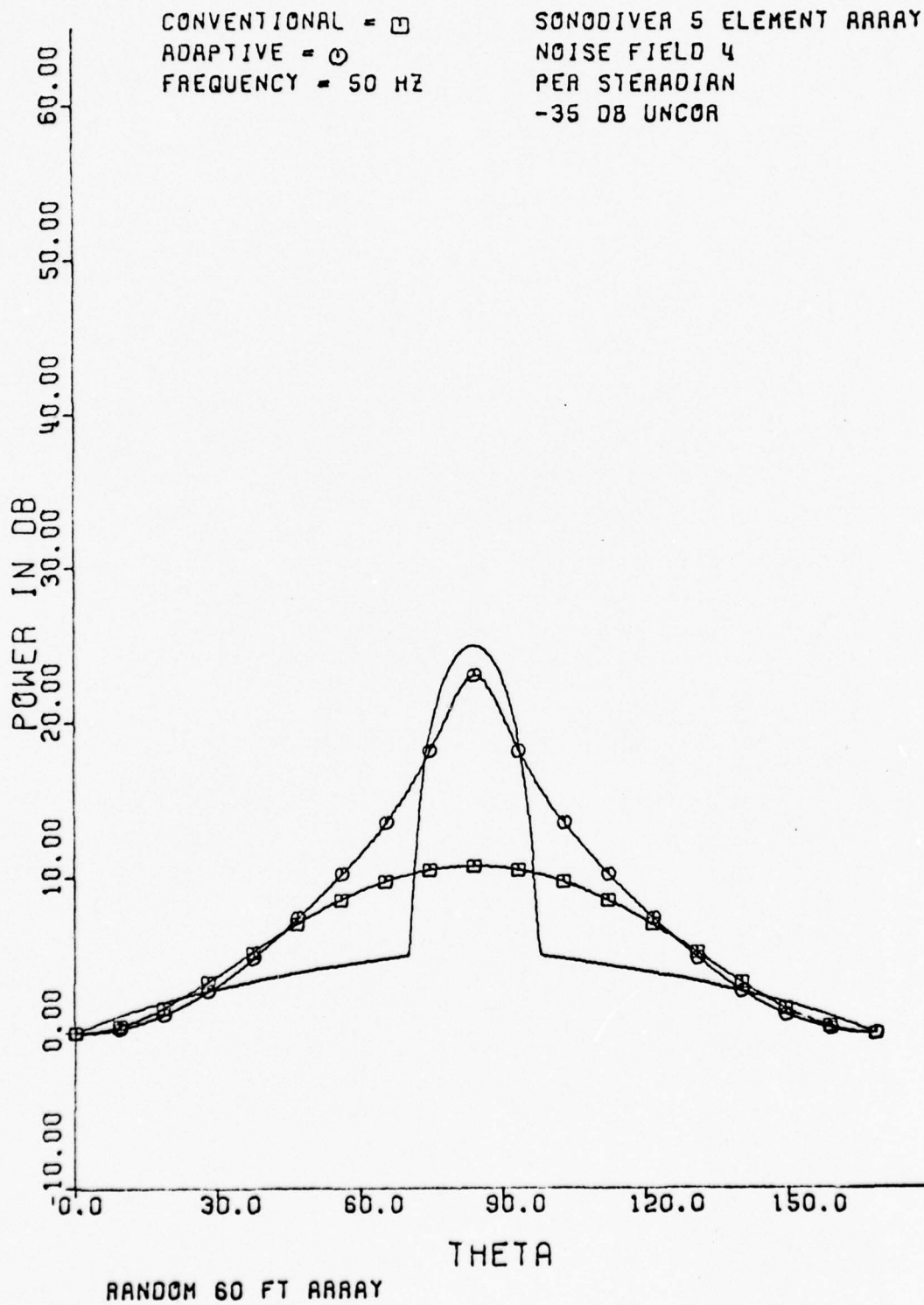


FIGURE 32

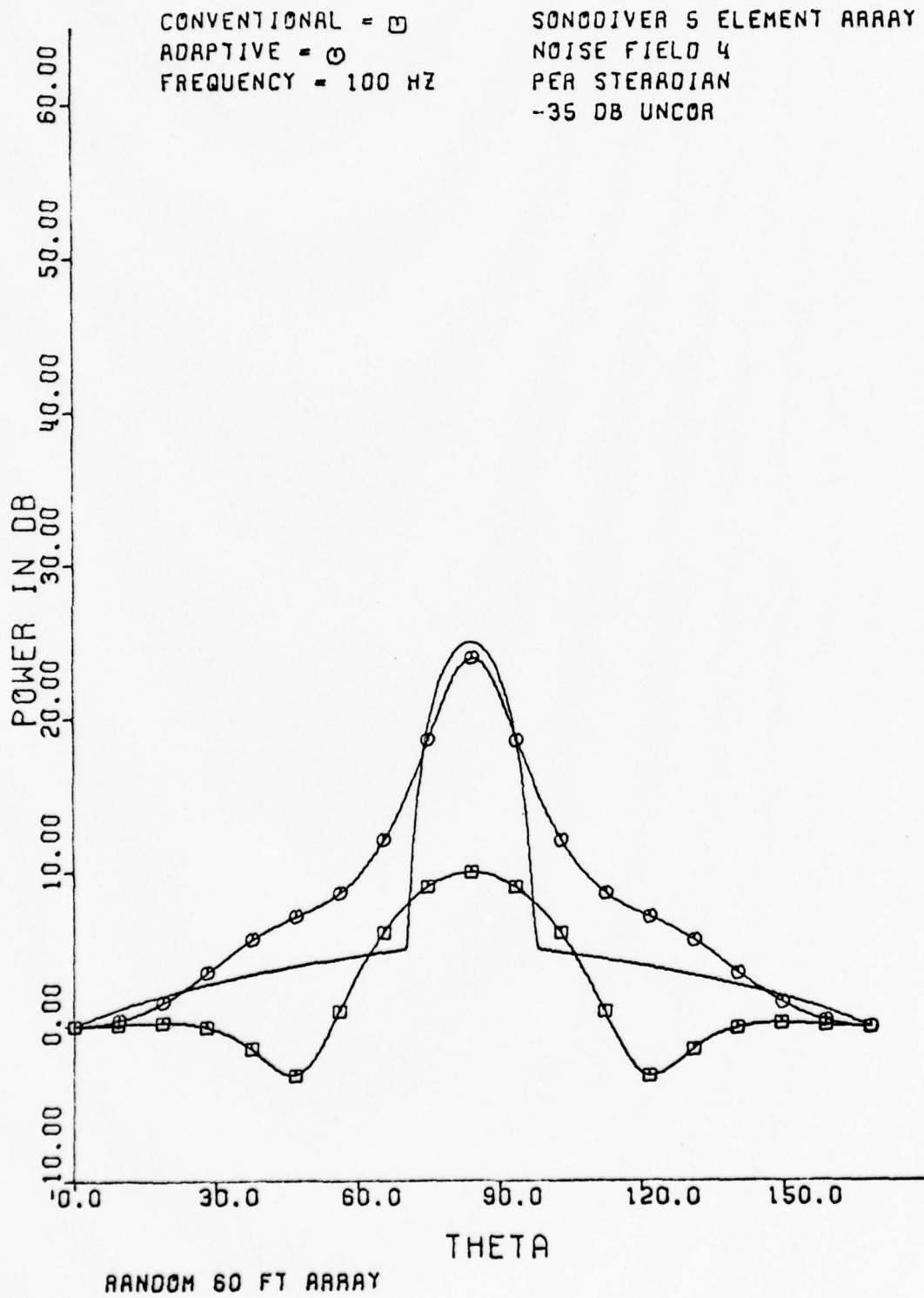


FIGURE 33

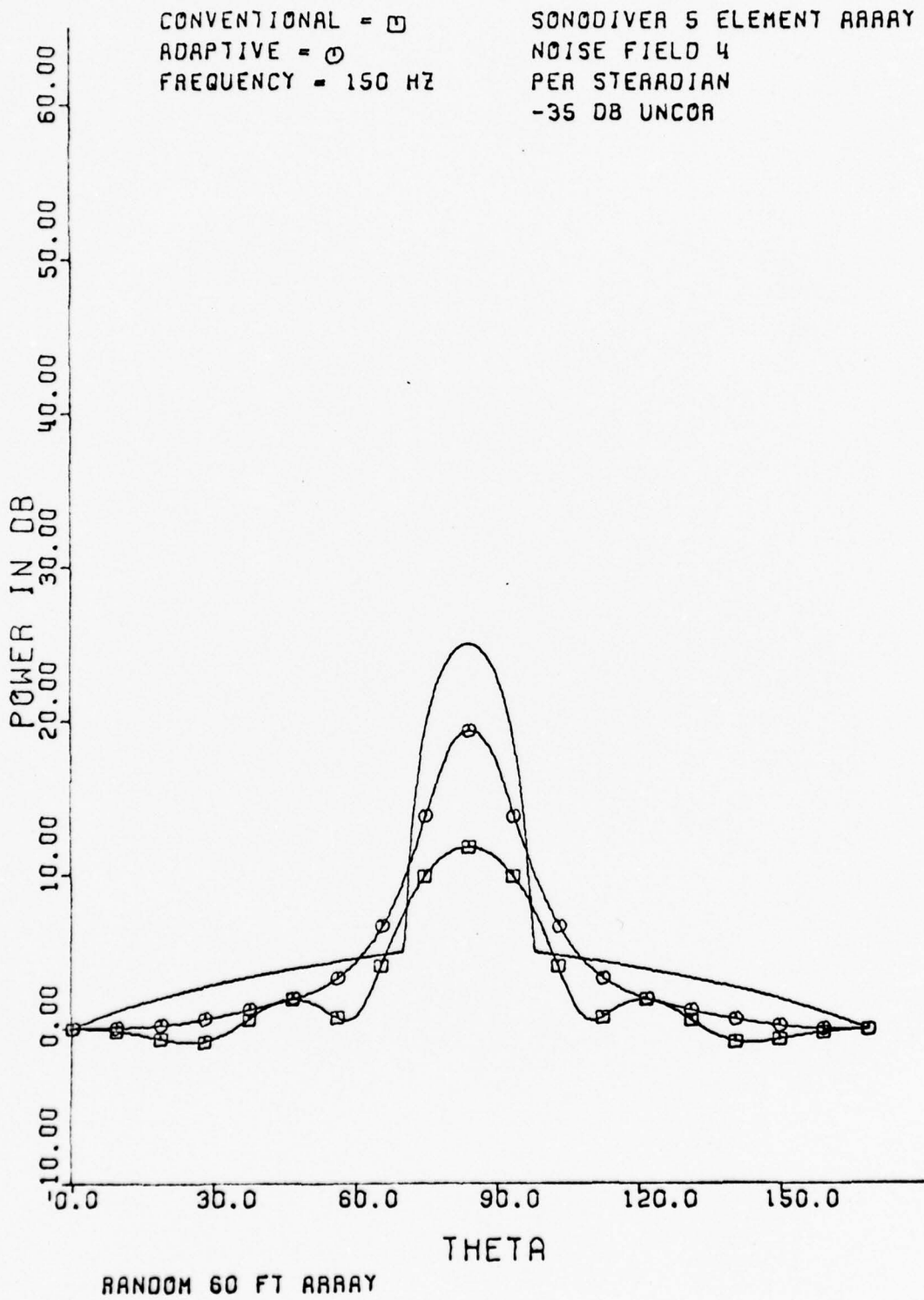


FIGURE 34



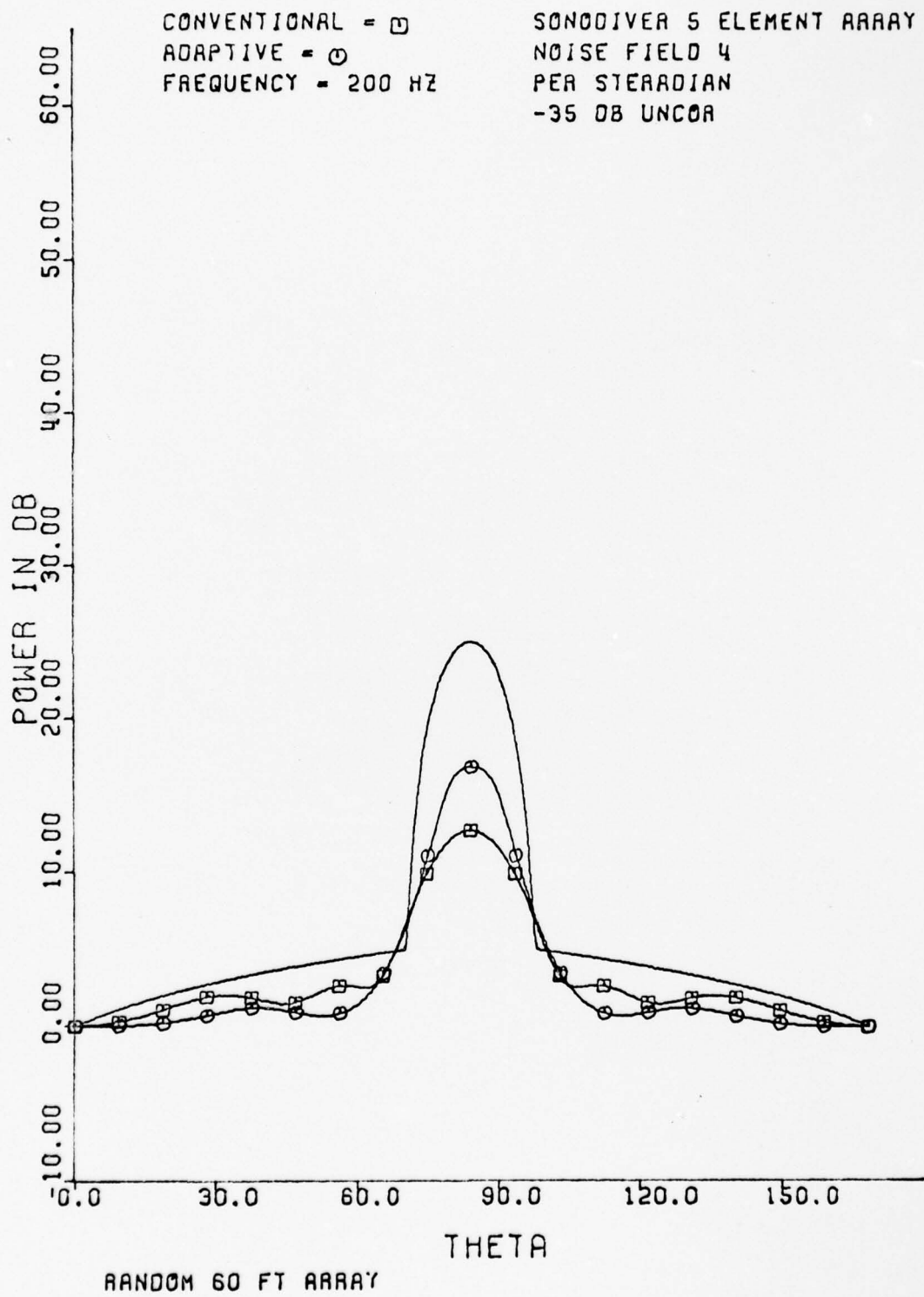


FIGURE 35

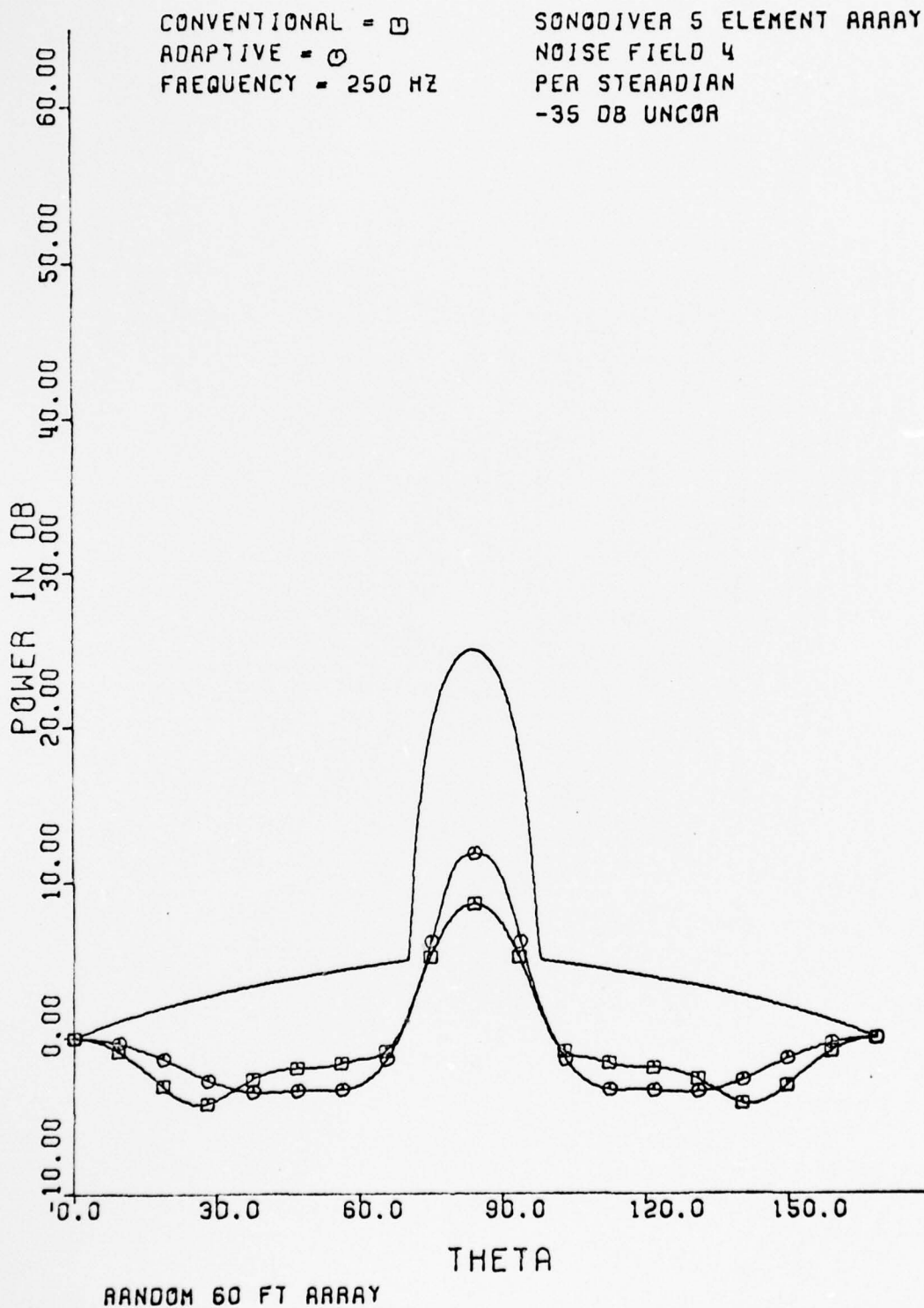


FIGURE 36

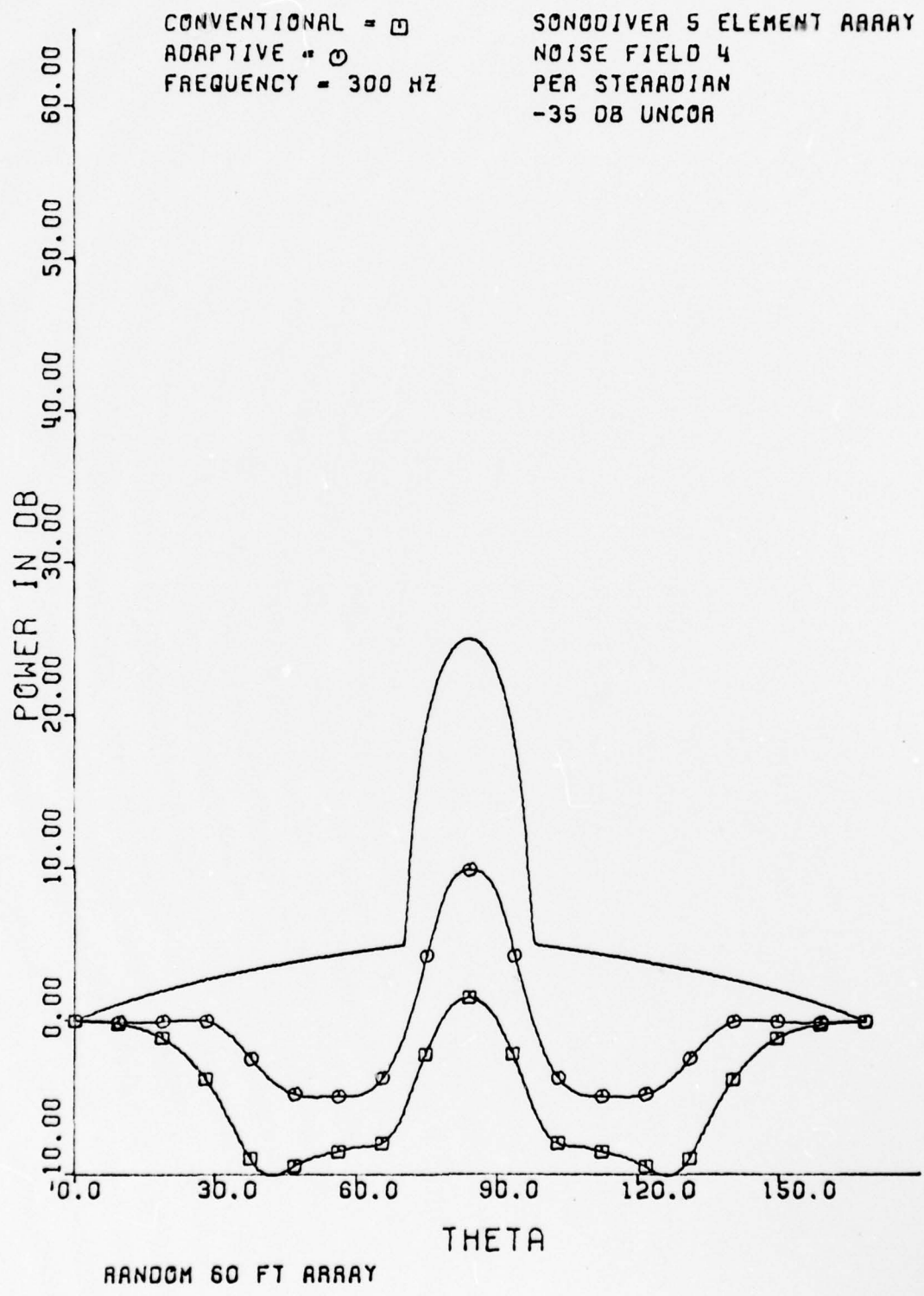
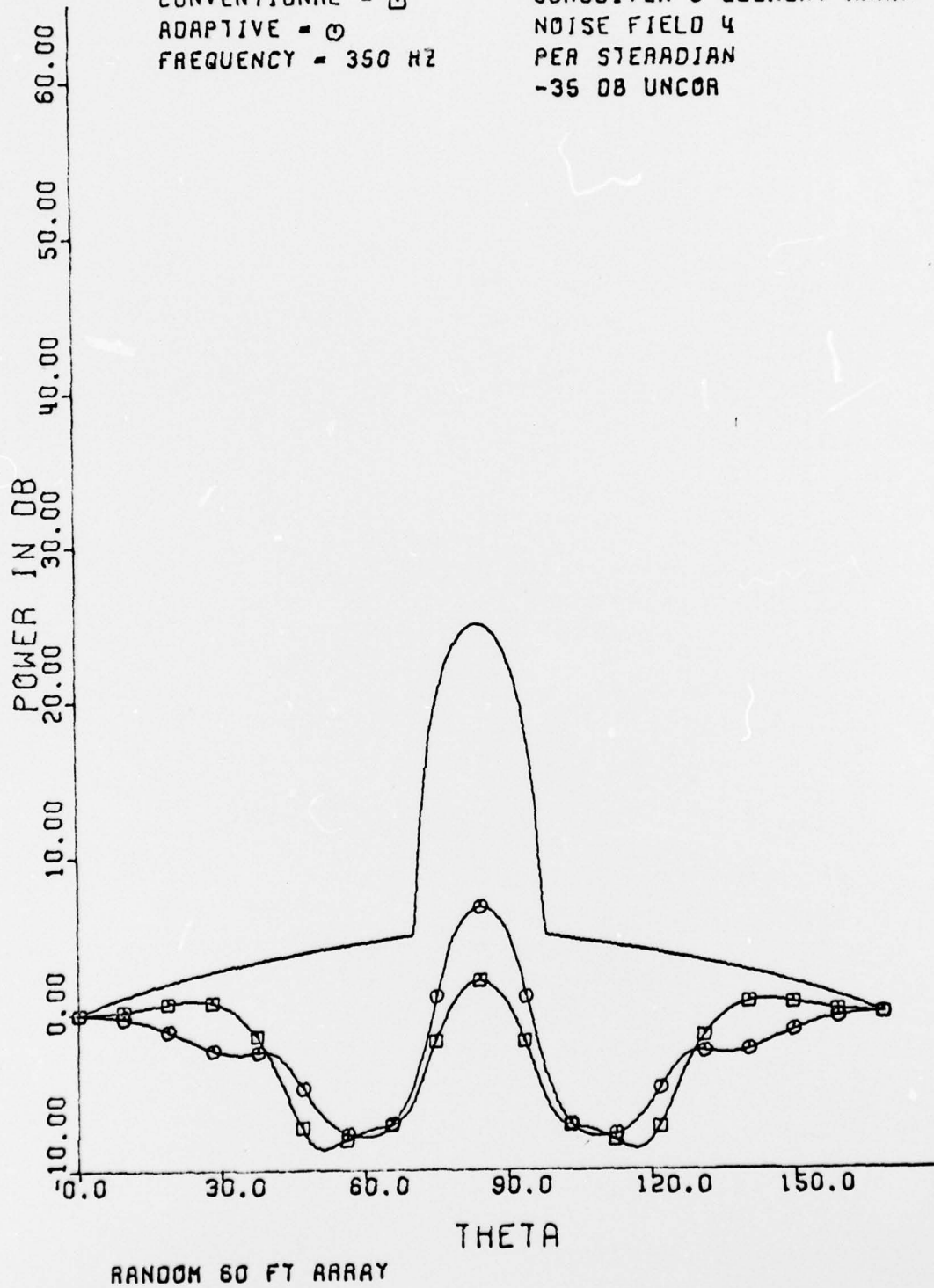


FIGURE 37

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 350 KHZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 4  
PER STERADIAN  
-35 DB UNCOR



THETA

RANDOM 60 FT ARRAY

FIGURE 38

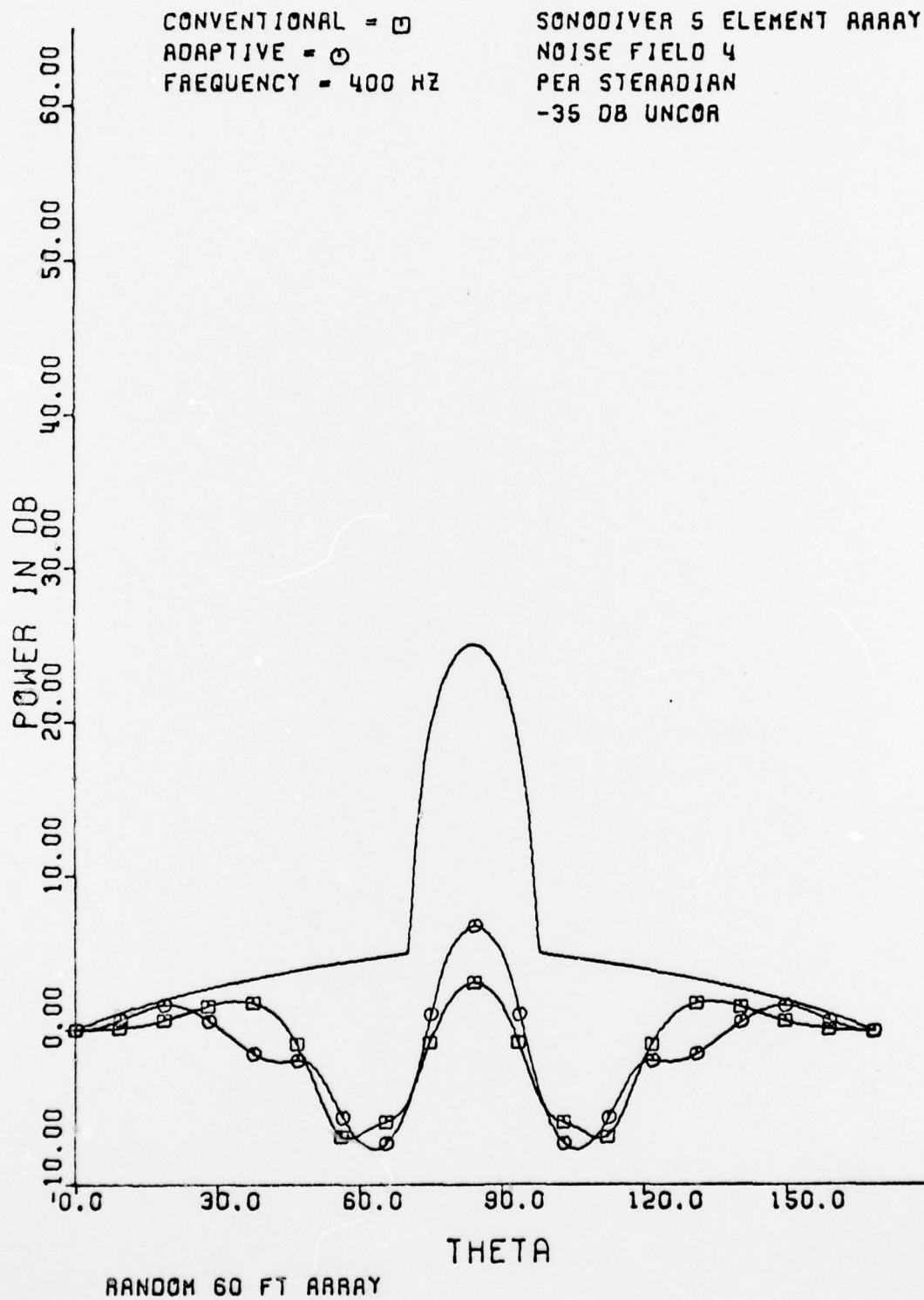
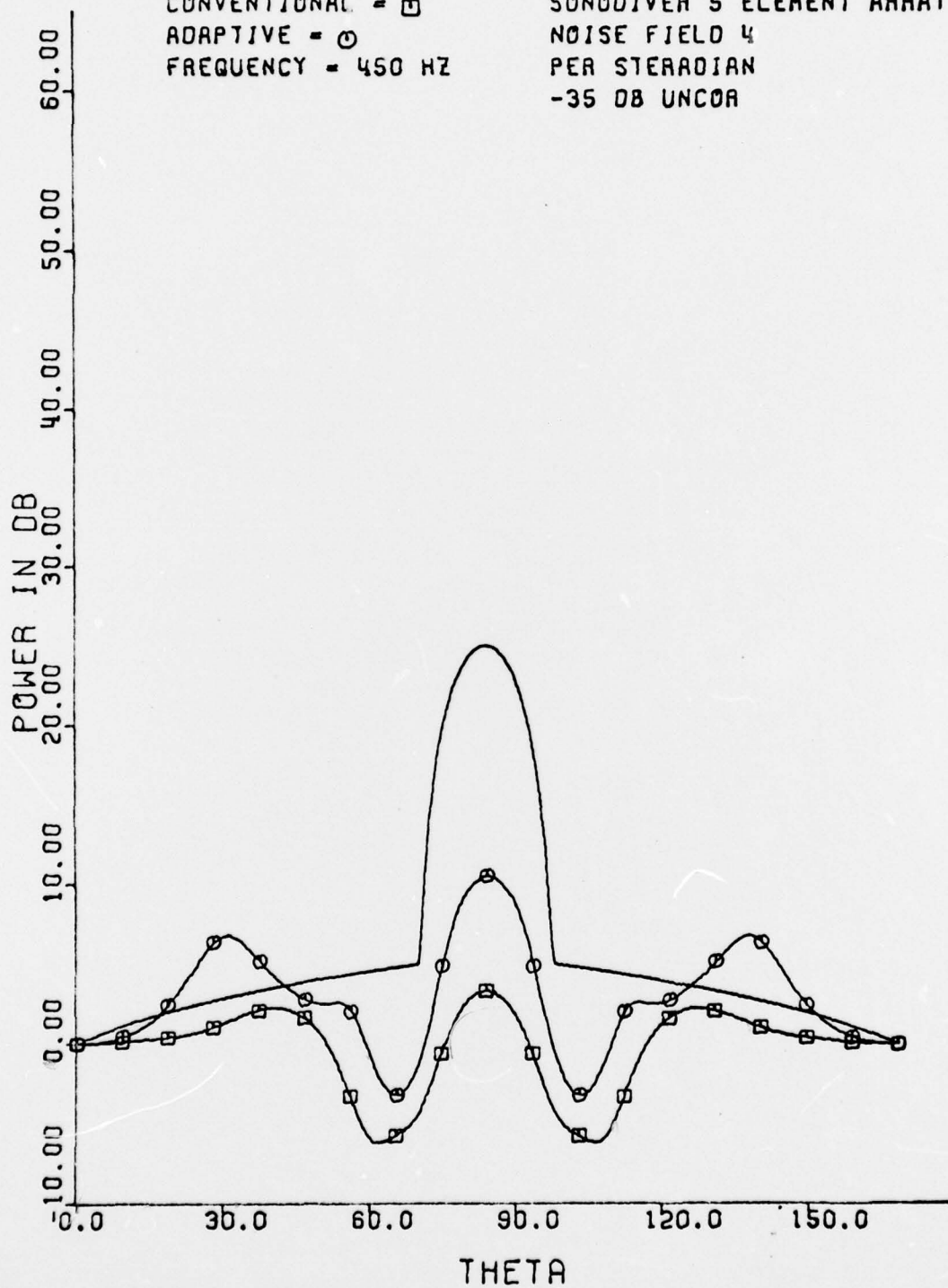


FIGURE 39

CONVENTIONAL = □  
ADAPTIVE = ○  
FREQUENCY = 450 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 4  
PER STERADIAN  
-35 DB UNCOR



RANDOM 60 FT ARRAY

FIGURE 40

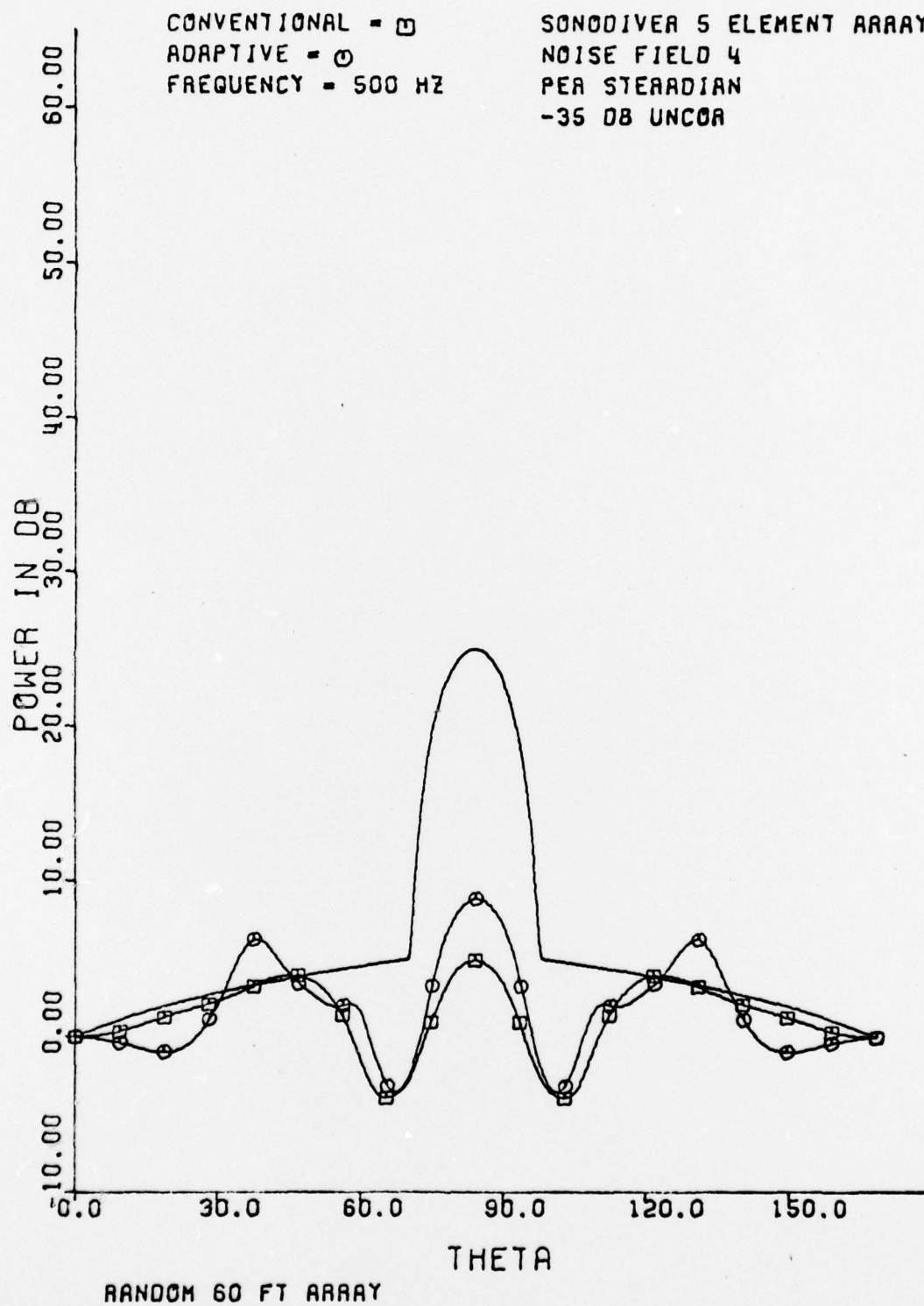


FIGURE 41

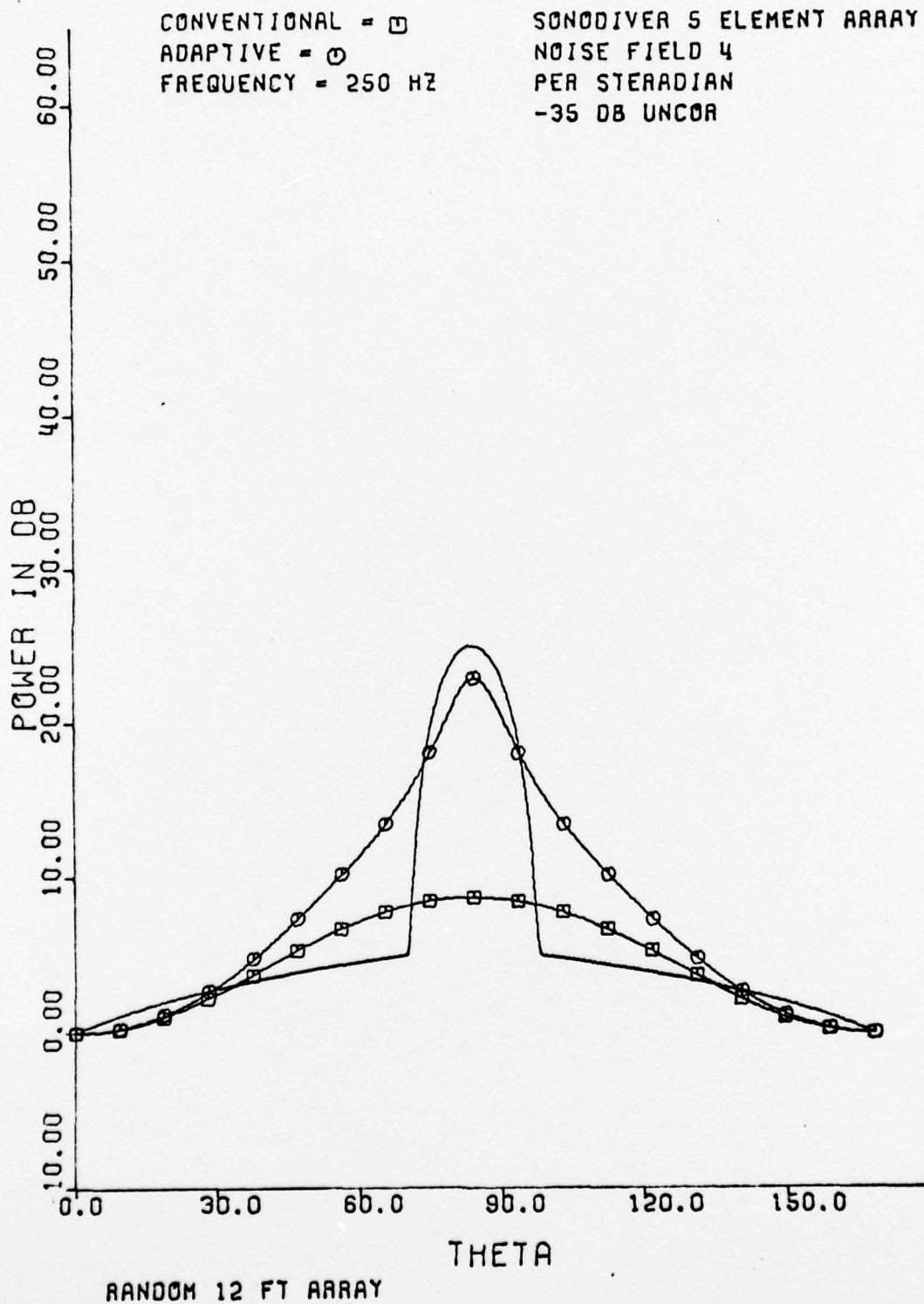


FIGURE 42



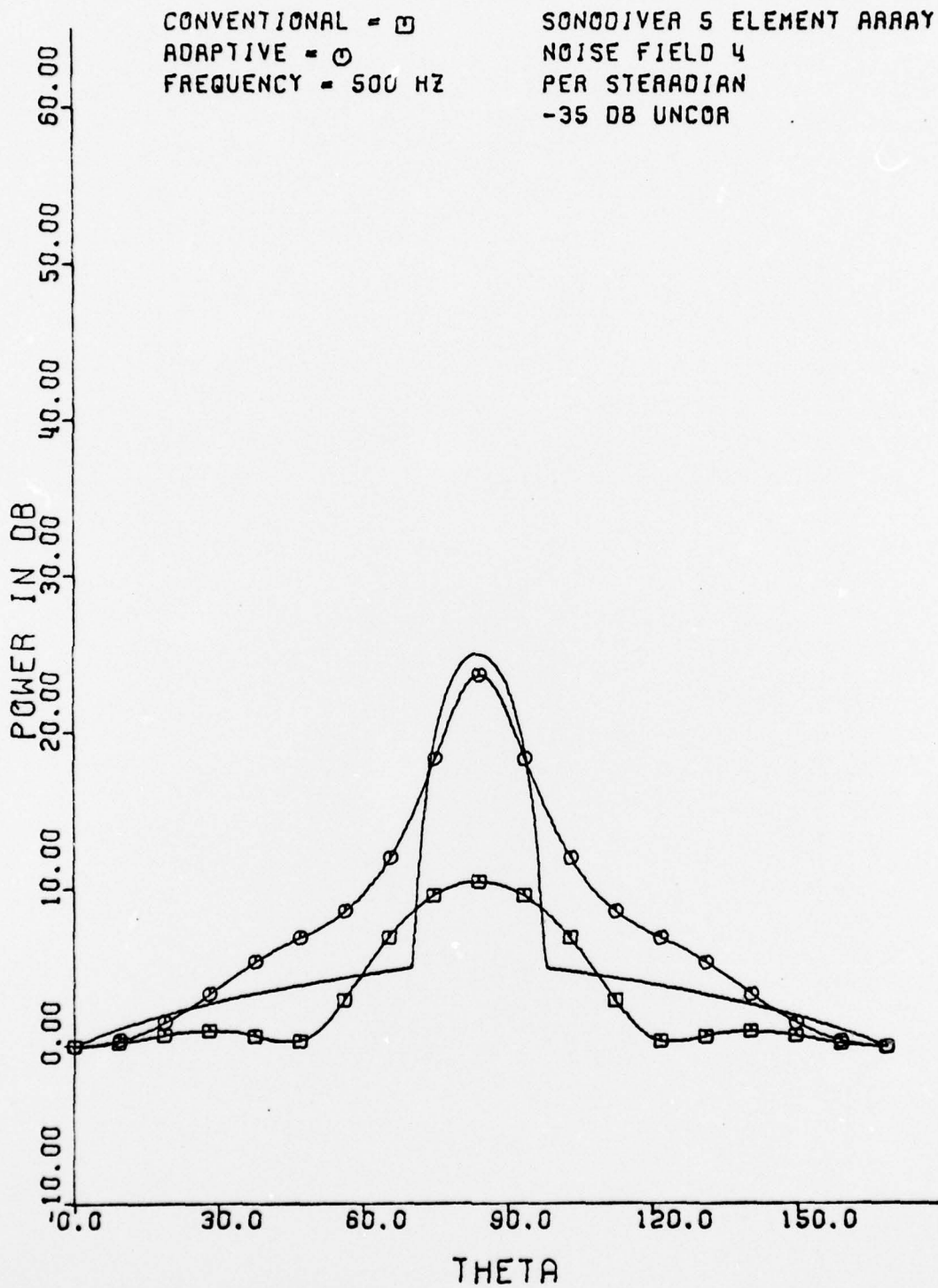


FIGURE 43

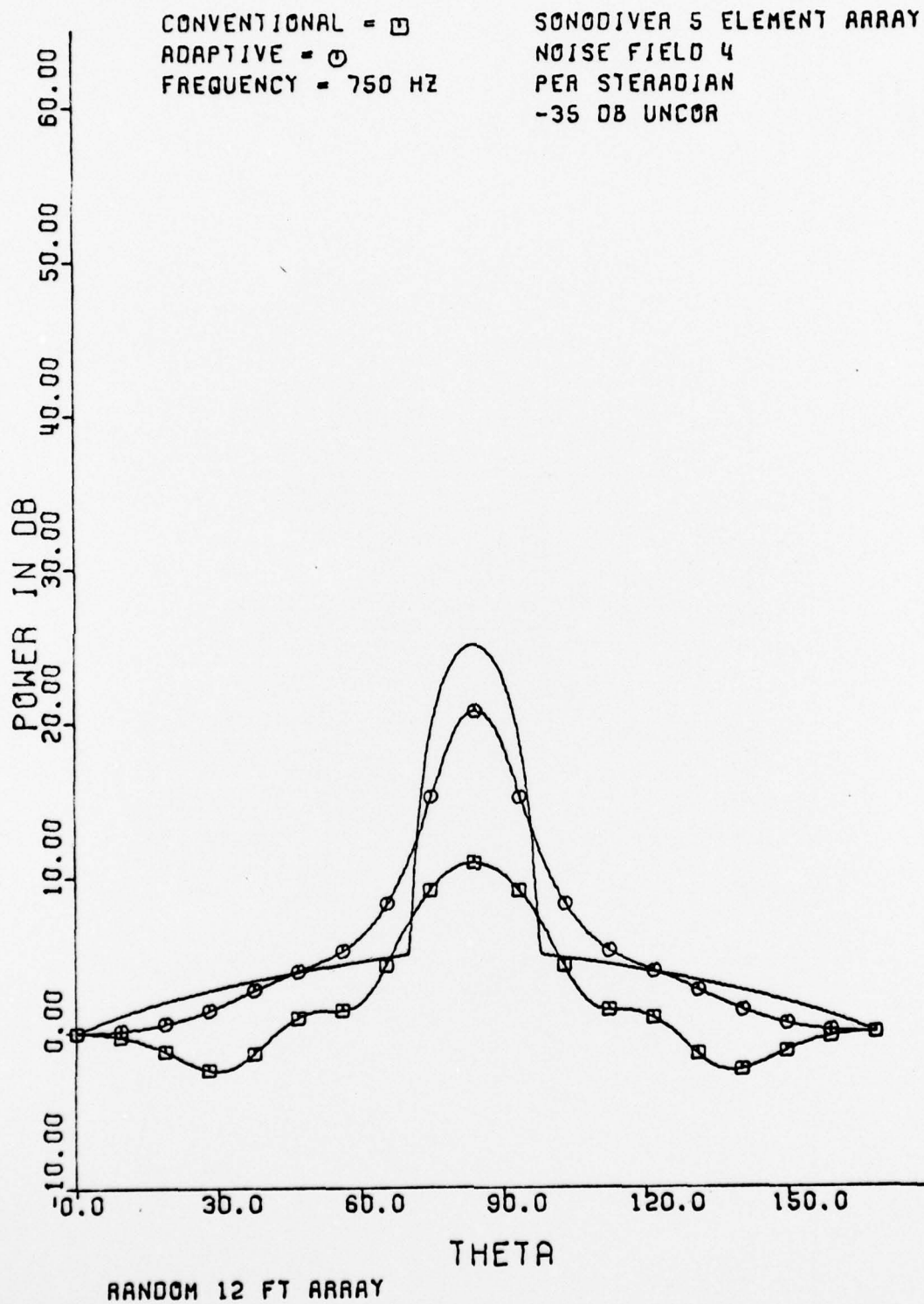


FIGURE 44

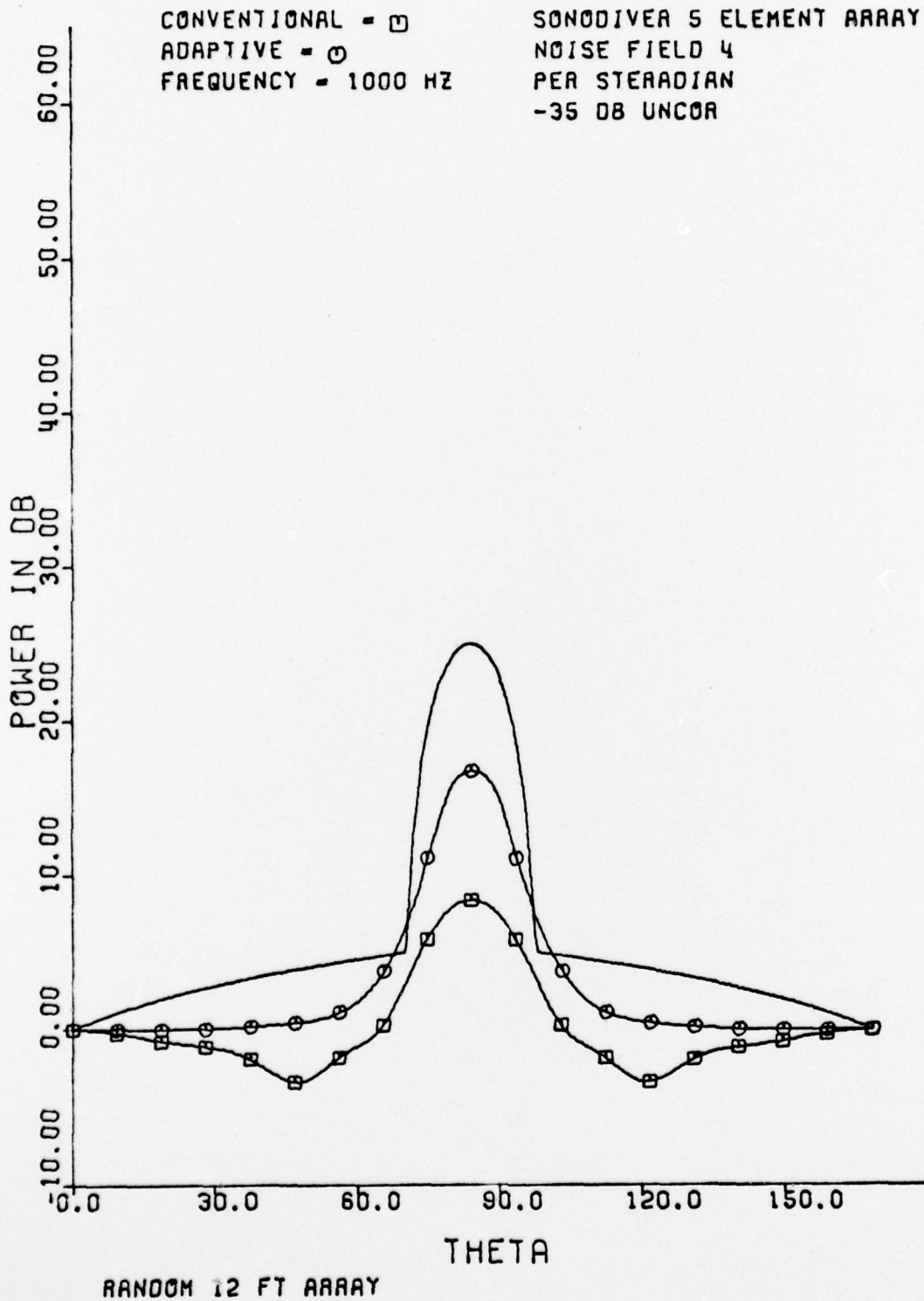


FIGURE 45

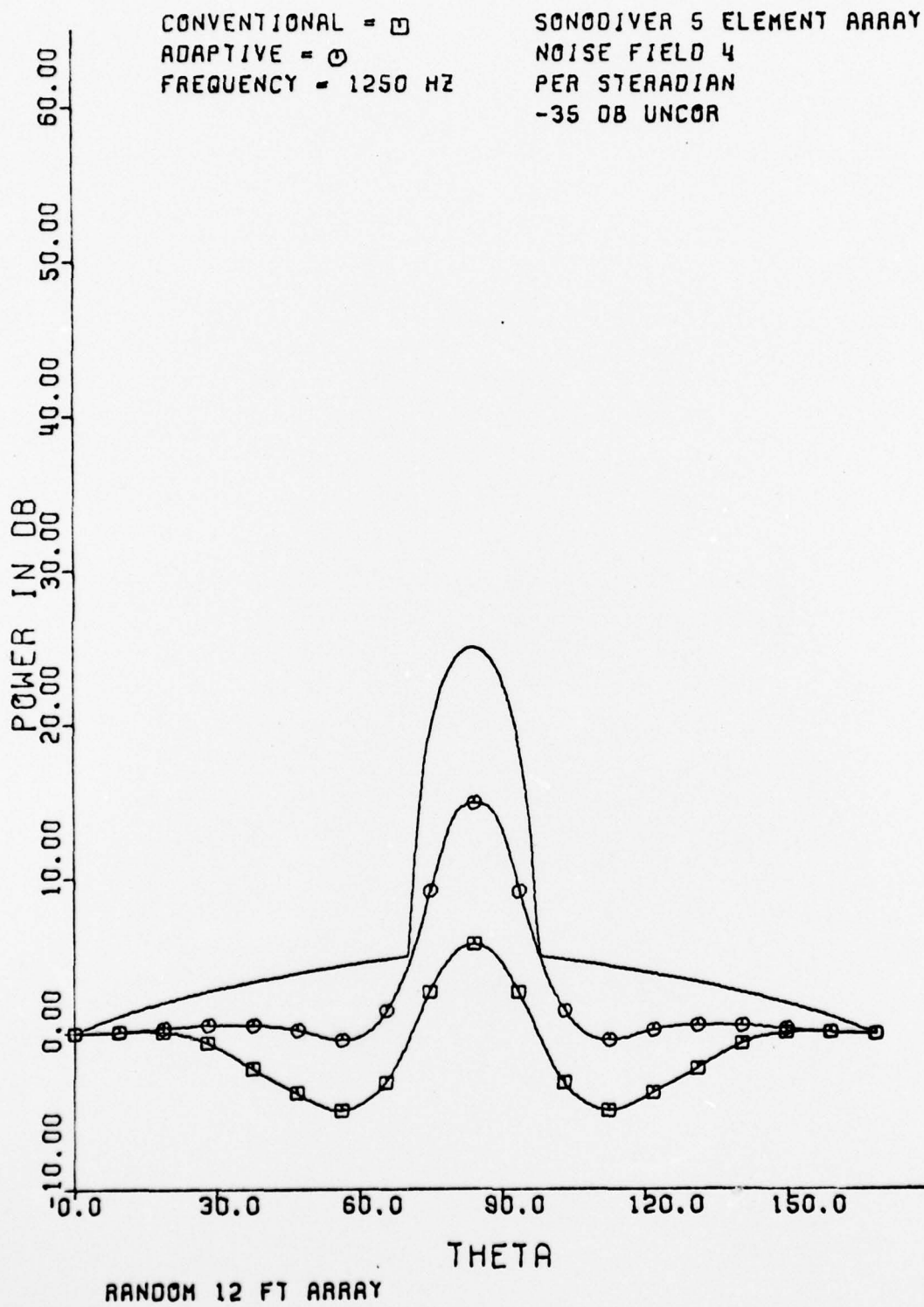


FIGURE 46

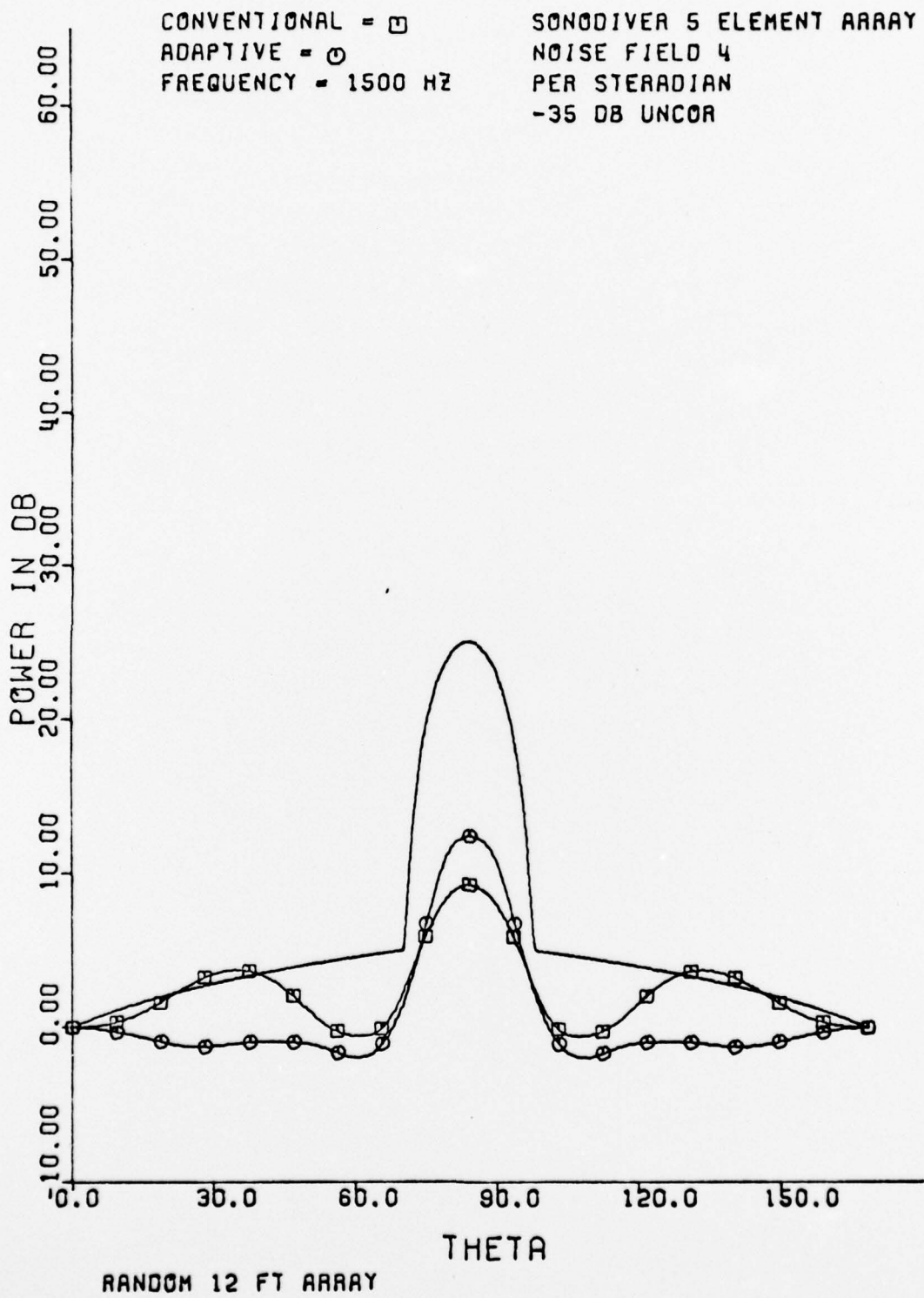


FIGURE 47

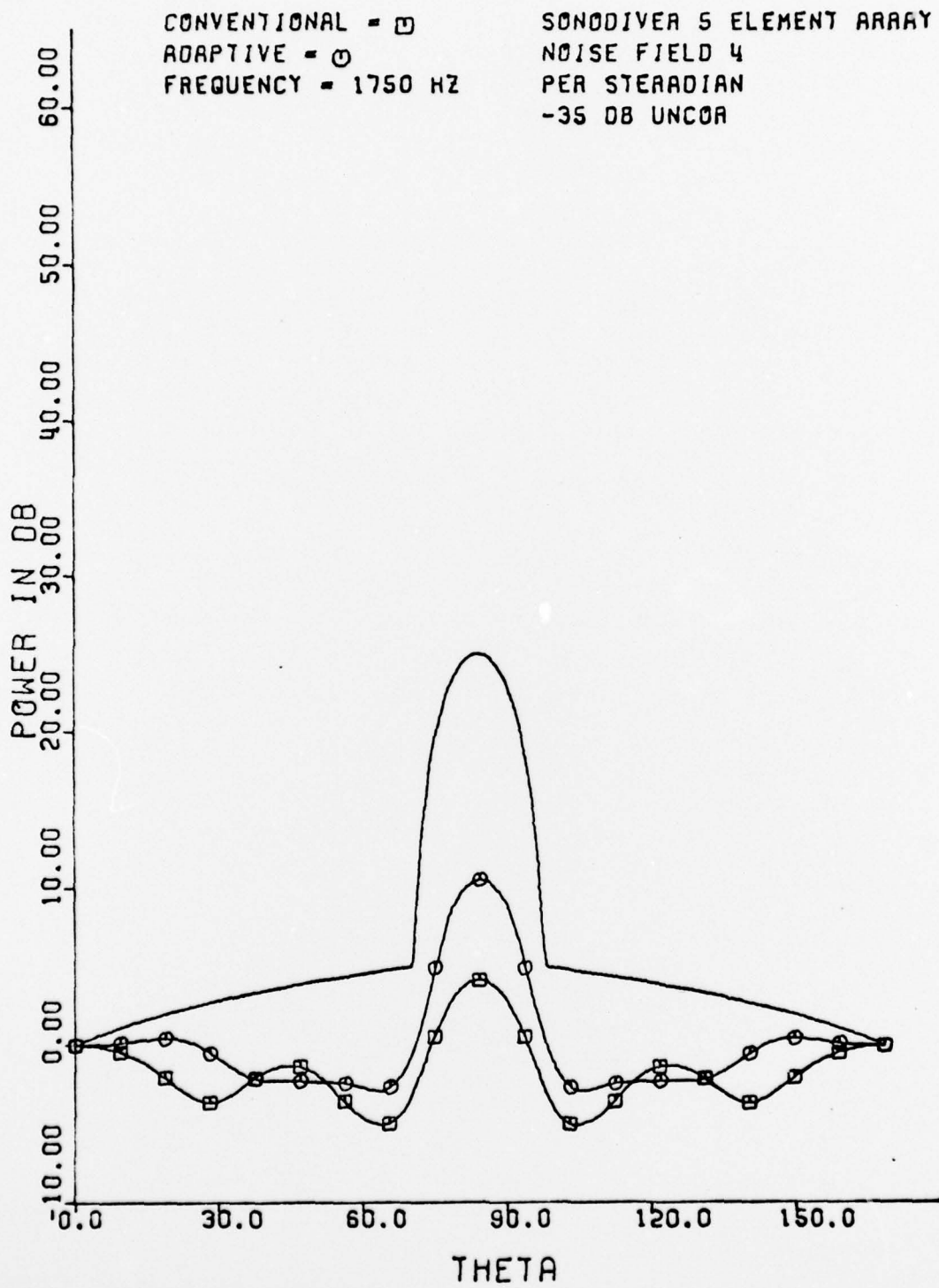


FIGURE 48

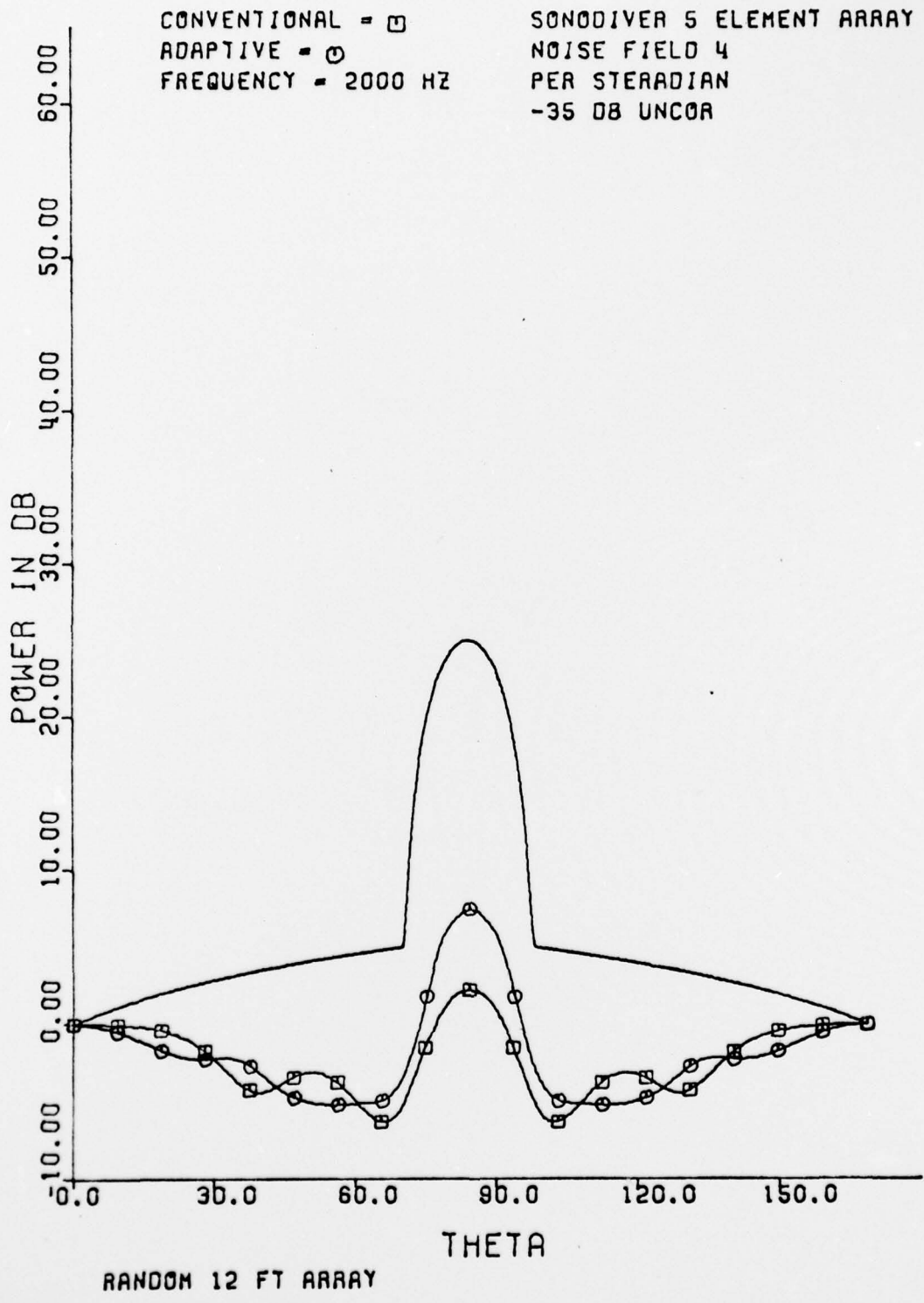
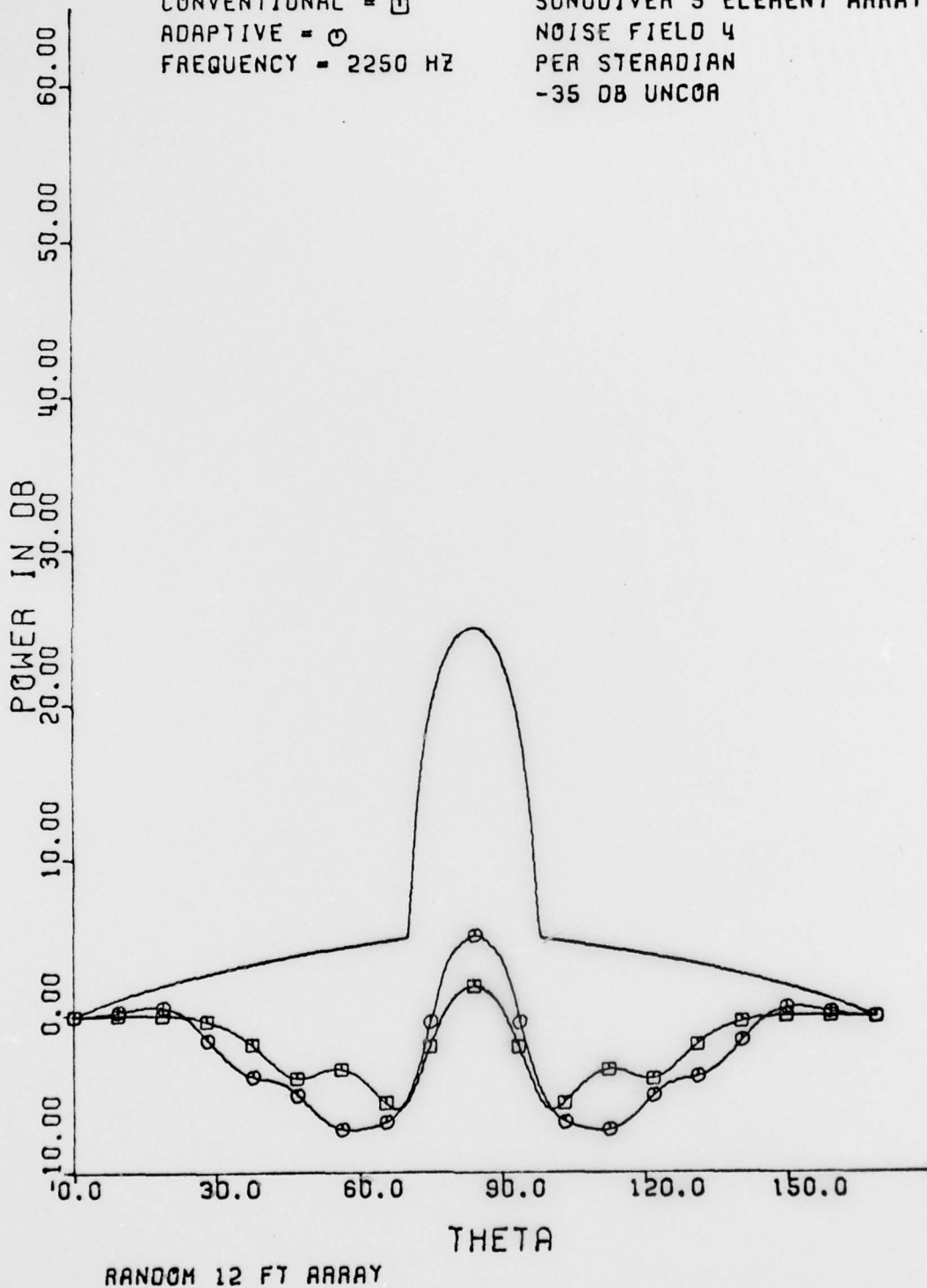


FIGURE 49

CONVENTIONAL = □  
ADAPTIVE = ⊙  
FREQUENCY = 2250 HZ

SONODIVER 5 ELEMENT ARRAY  
NOISE FIELD 4  
PER STERADIAN  
-35 DB UNCOR



RANDOM 12 FT ARRAY

THETA

FIGURE 50



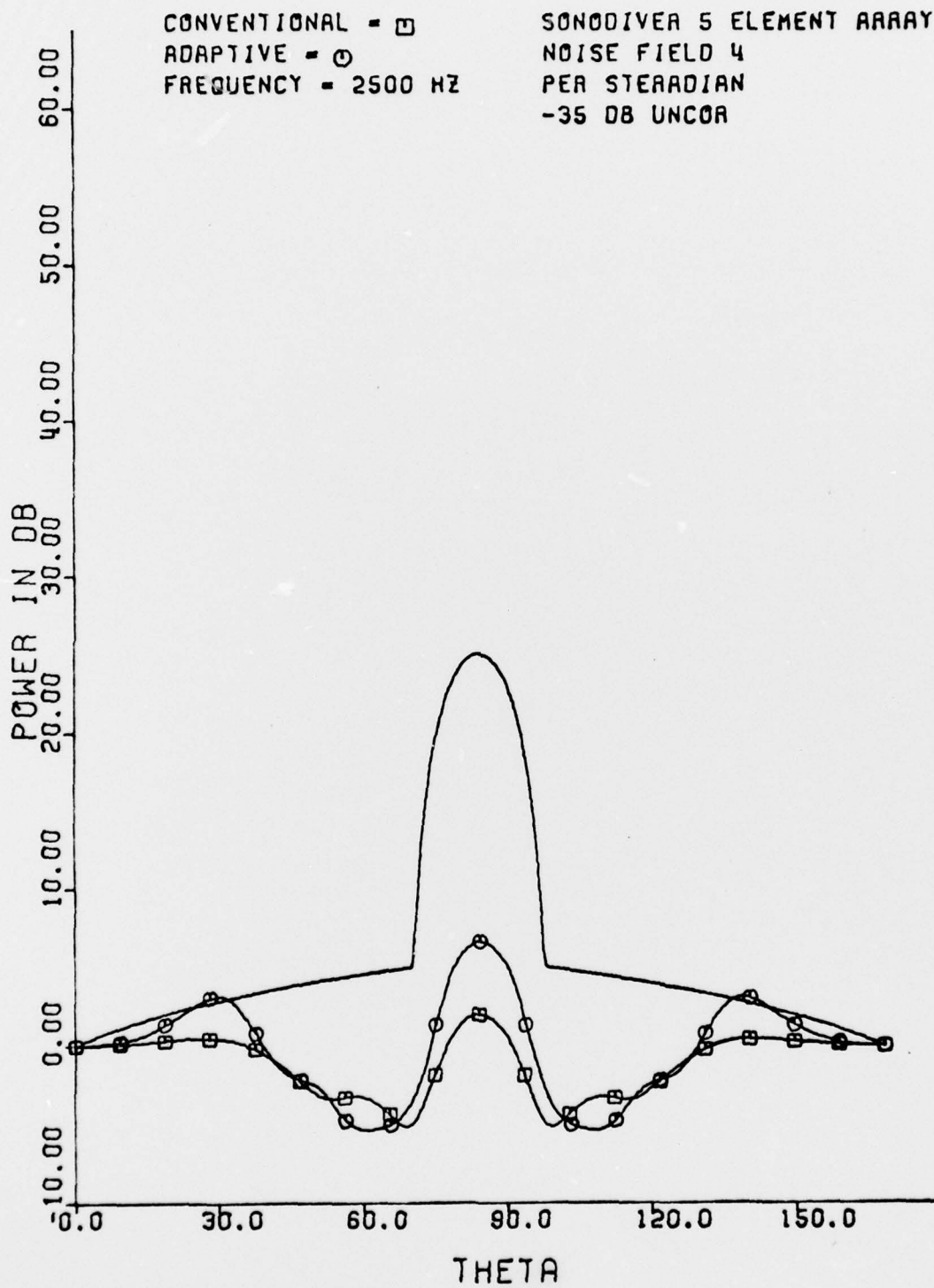


FIGURE 51