NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

A COMPUTER ANALYSIS OF A CONICAL MONOPOLE
FOR USE AT NAVAL HIGH FREQUENCY
DIRECTION FINDING RECEIVING SITES
PART II

by

Panayiotis Petros Lemos

December, 1992

Thesis Advisor: Richard W. Adler

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ABSTRACT (Continue on reverse if necessary and identify by block number)

The Naval Security Group (NSG) High Frequency Direction Finding (HFDF) sites use large circularly disposed antenna arrays (CDAA) with moderate to high gain beams. Omnidirectional coverage is presently obtained by combining 8 to 120 elements of the CDAA. Recent measurements of site performance reveal that most HFDF sites suffer from high noise levels. Much of the noise is generated in the RF distribution system. This noise contaminates the CDAA omni signals, greatly reducing their effectiveness. One proposed solution to the problem is to use a semi-remotely located broadband conical monopole (CM), which does not connect through the noisy RF distribution system. A proof-of-performance comparing the CM and CDAA omnis is commencing at NSG.

In this thesis, the performance of the model 2012AA Conical Monopole

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19. cont.
Antenna is studied in the presence of finite ground using the Numerical Electromagnetics Code (NEC-3). Ground constants used in this study were obtained for two locations where the CM are installed; Northwest, VA, and Winter Harbor, ME. The performance of the combined antenna/ground system was simulated over a frequency range from 2 to 30 MHz (HF), for various ground constants, with particular emphasis on the elevation plane radiation patterns.

The study concludes that the CM operates effectively in the frequency range of interest with some exceptions. These occur at frequencies where there is probable transitional range where the mode of operation of the antenna is transferred from that of an inverted cone to that of a broad monopole.

Finally, this study confirms that in order for an antenna/ground model to provide a representative and effective simulation, the ground constants in the vicinity of the antenna should be carefully measured and averaged over an adequate number of samples.

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A Computer Analysis of a Conical Monopole for Use at Naval High Frequency Direction Finding Receiving Sites Part II

by

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Lieutenant, Hellenic Navy
B.S.E.E., Hellenic Naval Academy, 1984

Submitted in partial fulfillment
of the requirements for the degree of

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Author: ______________________
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Wilbur R. Vincent, Second Reader

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Michael A. Morgan, Chairman
Department of Electrical and Computer Engineering

ABSTRACT

The Naval Security Group (NSG) High Frequency Direction Finding (HFDF) sites use large circularly disposed antenna arrays (CDAA) with moderate to high gain beams. Omnidirectional coverage is presently obtained by combining 8 to 120 elements of the CDAA. Recent measurements of site performance reveal that most HFDF sites suffer from high noise levels. Much of the noise is generated in the RF distribution system. This noise contaminates the CDAA omni signals, greatly reducing their effectiveness. One proposed solution to the problem is to use a semi-remotely located broadband conical monopole (CM), which does not connect through the noisy RF distribution system. A proof-of-performance comparing the CM and CDAA omnis is commencing at NSG.

In this thesis, the performance of the model 2012AA Conical Monopole Antenna is studied in the presence of finite ground using the Numerical Electromagnetics Code (NEC-3). Ground constants used in this study were obtained for two locations where the CM are installed; Northwest, VA, and Winter Harbor, ME. The performance of the combined antenna/ground system was simulated over a frequency range from 2 to 30 MHz (HF), for various ground constants, with particular emphasis on the elevation plane radiation patterns.

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```
CM,  THE 2012AA CONICAL MONOPOLE
CM
CM, FROM HY-GAIN TELCONS AND THE MANUAL
CM
CM, PERFECT GROUND / SIX-FOLD SYMMETRY.
CM
CM,    ALL EQUI-RADII WIRES
CE
GW,100,16,0.,0.,71.,22.5,0.,28.25,.01, BEGIN CONES' GEOMETRY
GW,500,2,22.5,0.,28.25,18.85,0.,28.25,.01,
GW,500,6,18.85,0.,28.25,0.,0.,28.25,.01,
GM,200,1,0.,0.,0.,0.,0.,-1.,500,
GW,600,1,18.85,0.,28.25,18.85,0.,27.25,.01,
GW,200,14,0.,0.,.75,22.5,0.,27.25,.01,
GM,0,0,0.,0.,-30.,0.,0.,0.,000,
GW,101,15,0.,0.,71.,19.4856,0.,28.25,.01,
GW,202,14,0.,0.,.75,19.4856,0.,27.25,.01,
GW,201,14,0.,0.,.75,19.4856,-5.625,27.25,.01,
GW,203,14,0.,0.,.75,19.4856,5.625,27.25,.01,
GW,300,8,0.,-11.25,0.,0.,11.25,0.,.01,
GM,0,0,0.,0.,0.,19.4856,0.,28.25,300,
GM,100,1,0.,0.,0.,0.,0.,-1.,300,          END CONES' GEOMETRY
GR,0,6                          STRUCTURE TO BE ROTATED SIX TIMES
GW,900,3,0.,0.,0.,0.,0.,.75,.01,     BEGIN MAIN MAST GEOMETRY
GW,900,9,0.,0.,.75,0.,0.,27.25,.01,
GW,900,1,0.,0.,27.25,0.,0.,28.25,.01,
GW,900,14,0.,0.,28.25,0.,0.,71.,.01,  END MAIN MAST GEOMETRY
GS,0,0,0.3048,                               SCALING CONSTANT
GE,1,0,0.,
```

```
GN,1,                                              PERFECT GROUND
EX,0,900,1,01,1.,0.,0.,                            FEED SEGMENT
FR,0,1,0,0,30.0,0.,                                FREQUENCY CARD
RP,0,31,30,1502,0.,0.,3.,3.,0.,0., CARD FOR AVER. POWER GAIN
RP,0,181,1,1000,-90.,90.,1.,0.,0.,0.,  STD. VERTICAL PATTERN
RP,0,1,361,1000,90.,0.,0.,1.,0.,0.,  STD. HORIZONTAL PATTERN
EN
```

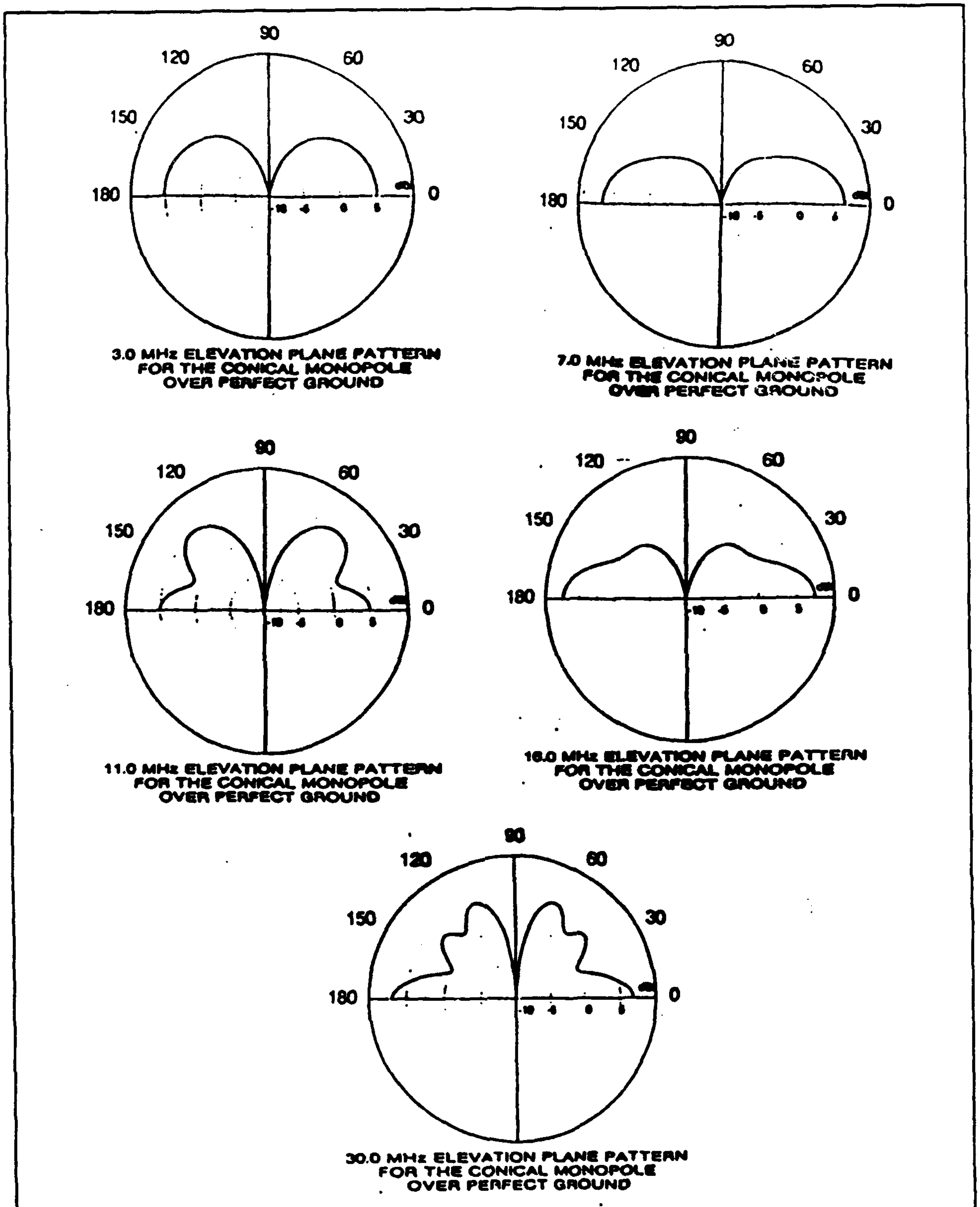
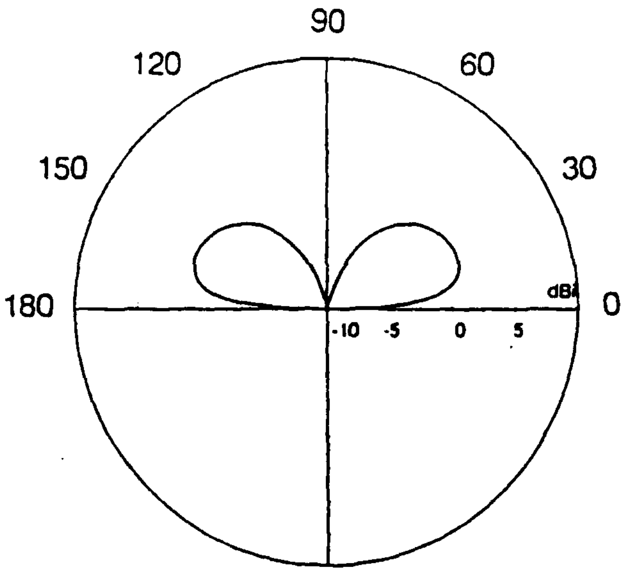


Figure 1. Elevation Plane Radiation Patterns for Selected Frequencies for the Conical Monopole Over Perfect Ground

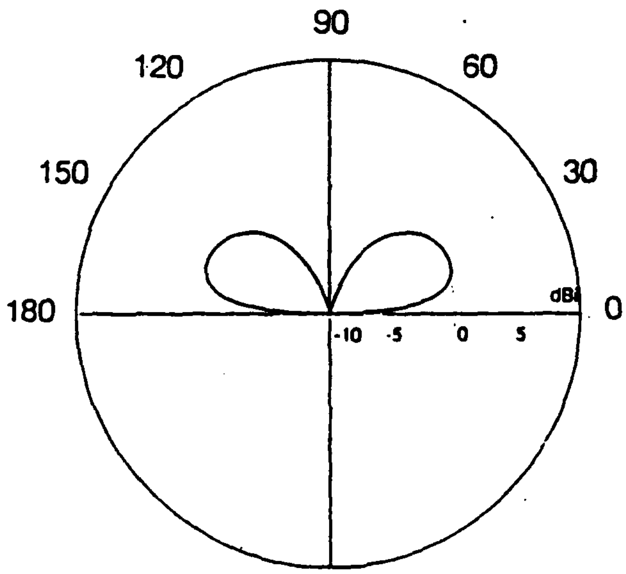
APPENDIX B. CONICAL MONOPOLE OVER FINITE GROUND

```
CM          THE 2012AA CONICAL MONOPOLE
CM
CM        FROM HY-GAIN TELCONS AND THE MANUAL
CM
CM             FOR DNPG2000 / GREENS FN
CM
CM          CATENARY/FIN. GND/SIX-FOLD SYMM
CM
CE              ALL EQUI-RADII WIRES
GW 100,16, 0,0,71, 22.5,0,28.25, .01  TOP CONEWIRE IN X-Z PL
GW 500,2, 22.5,0,28.25, 18.85,0,28.25, .01  TOP WAIST RADIAL
GW 500,6, 18.85,0,28.25, 0,0,28.25, .01       "    "     "
GM 200,1, 0,0,0, 0,0,-1, 500  BOT WAIST RADIAL WIRE (X-Z PL)
GW 600,1, 18.85,0,28.25, 18.85,0,27.25, .01   WAIST SHORTING
GW 200,14, 0,0,.75, 22.5,0,27.25, .01   BOT LONGEST CONEWIRE
GM 0,0, 0,0,-30, 0,0,0, 000             ROTATE INTO POSITION
GW 101,15, 0,0,71, 19.4856,0,28.25, .01       SHORT TOP CN WR
GW 202,14, 0,0,.75, 19.4856,0,27.25, .01      SHORT BOT CN WR
GW 201,14, 0,0,.75, 19.4856,-5.625,27.25, .01  MID BOT CN WR
GW 203,14, 0,0,.75, 19.4856,5.625,27.25, .01   MID BOT CN WR
GW 300,8, 0,-11.25,0, 0,11.25,0, .01 WAIST CIRC WIRE AT ORGN
GM 0,0, 0,0,0, 19.4856,0,28.25, 300        UP TO TOP LOCATION
GM 100,1, 0,0,0, 0,0,-1, 300     CREATE ONE FOR BOT LOCATION
GW 66,1 , 0,0,0, 1,0,-1, 0.01   THIS AND THE NEXT FOUR LINES
GW 77,10, 1,0,-1,80.0,0,-1, 0           ARE THE RADIAL WIRES
GC 0,0,1.4035,.01,.01                 CONNECTED AT THE BOTTOM
GM 0,0,0,0,30,0,0,0,066.077     OF THE ANTENNA 1 FOOT INSIDE
GM 1,5,0,0,-10,0,0,0,066.077                      THE GROUND
GR 0,6                         ROTATE THE STRUCTURE SIX TIMES
```

```
GS 1
GP
GE -1
GN 2,0,0,0,18.60,0.0827                         GROUND CONSTANTS
FR 0,0,0,0,30.0                                        FREQUENCY
WG
XQ
NX
CE
GF
GW 900,3, 0,0,0, 0,0,.75, .01                       FEED SEGGIE
GW 900,9, 0,0,.75, 0,0,27.25, .01   BOTTOM OF TWR ABOVE FEED
GW 900,1, 0,0,27.25, 0,0,28.25, .01      WAIST SEGGIE AT TWR
GW 900,14, 0,0,28.25, 0,0,71, .01 TOP OF TWR ABOVE WAIST BND
GS 1                                         SCALING FACTOR
GP
GE -1
EX 0,900,3,01, 1,0,50                              FEED SEGMENT
PT -1,1,1,1
PL3, 2, 0, 4
RP0,31, 30, 1502, 0,0,3,3        CARD FOR AVERAGE POWER GAIN
RP0,181,1,1000,-90,90,1,0,0,0      STD. VERTICAL PATTERN CUT
RP0,1,361,1000,90,0,0,1,0,0      STD. HORIZONTAL PATTERN CUT
XQ
EN
```



2 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



2 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 2. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 2.0 MHz)

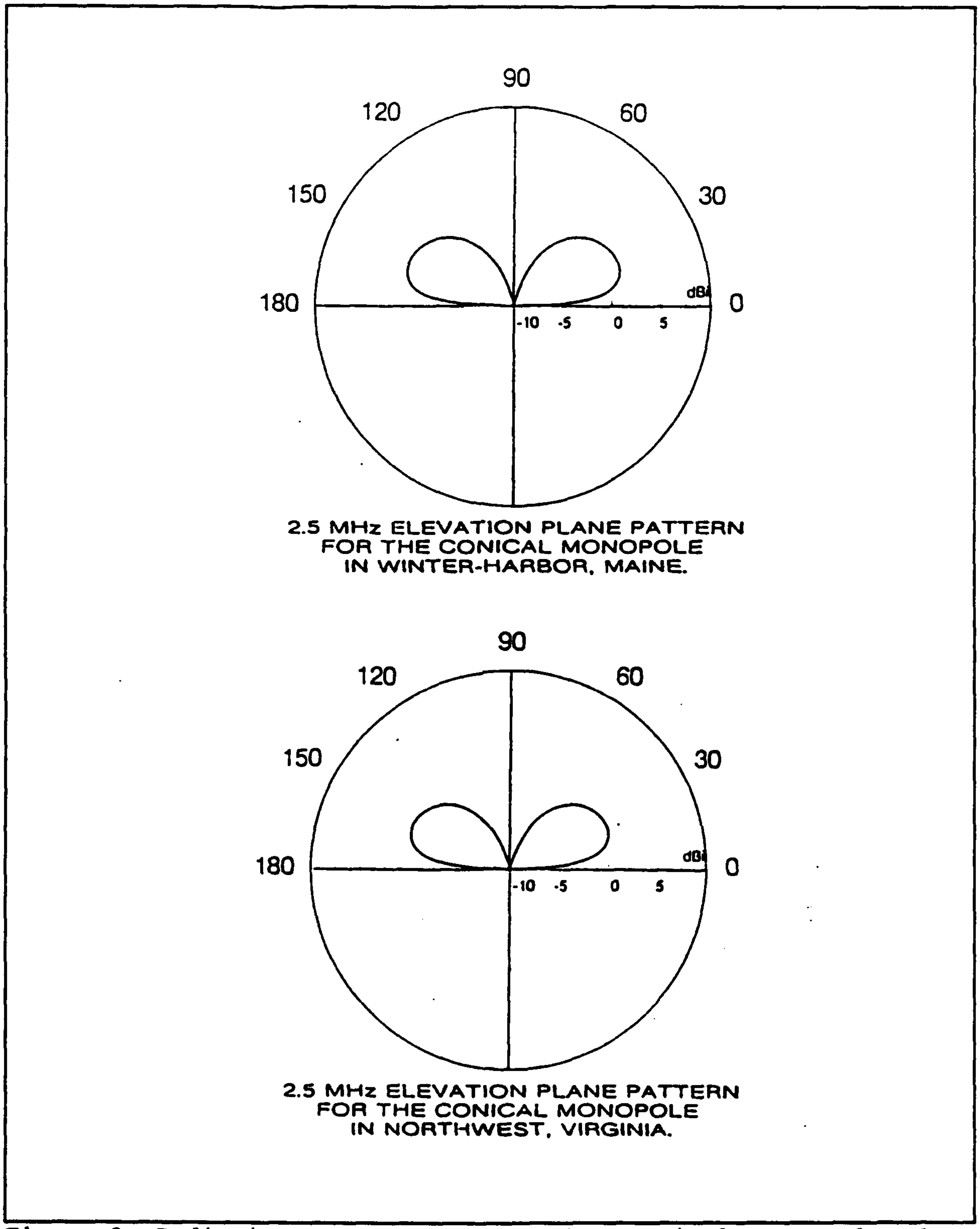


Figure 3. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 2.5 MHz)

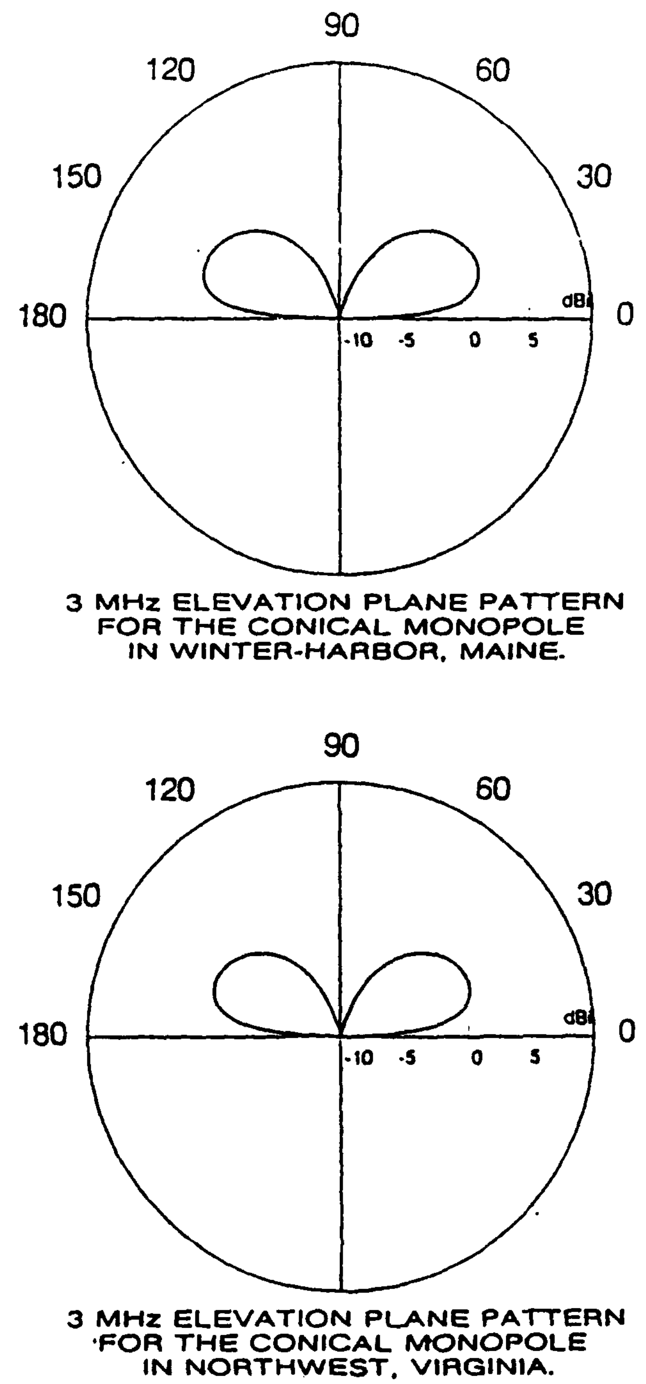
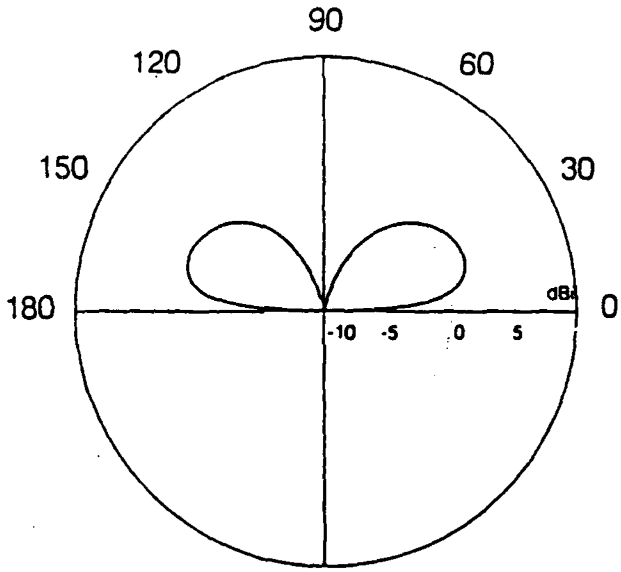
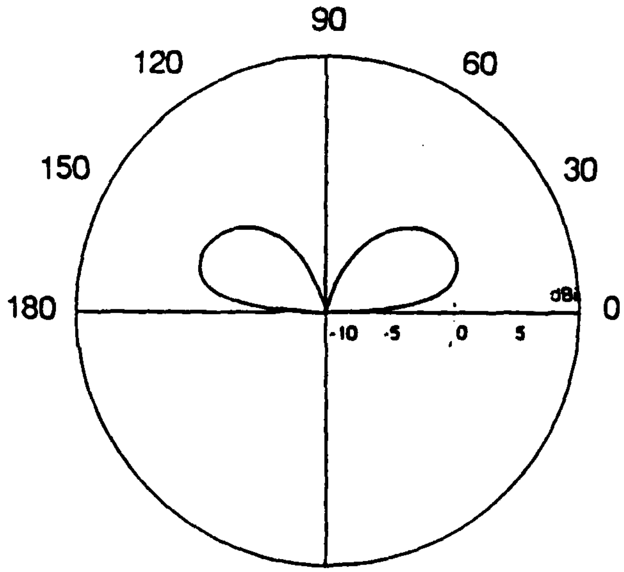


Figure 4. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 3.0 MHz)

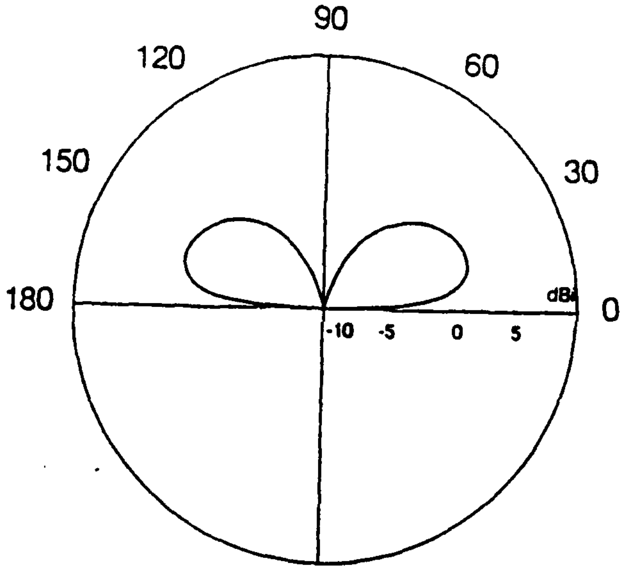


3.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

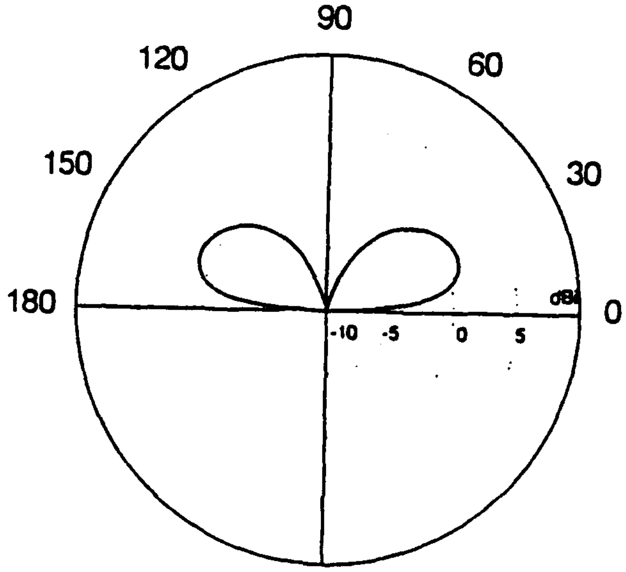


3.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 5. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 3.5 MHz)

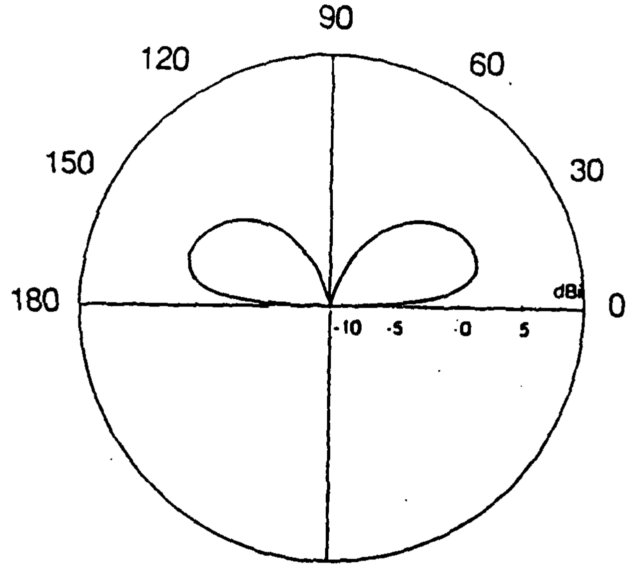


4 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

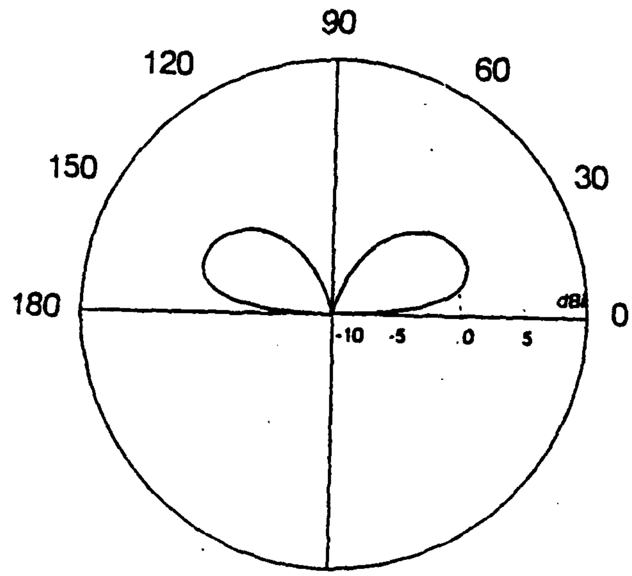


4 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 6. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 4.0 MHz)

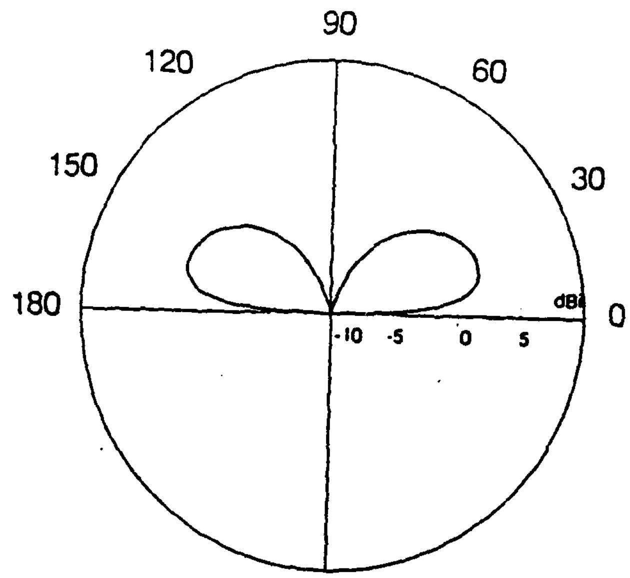


4.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

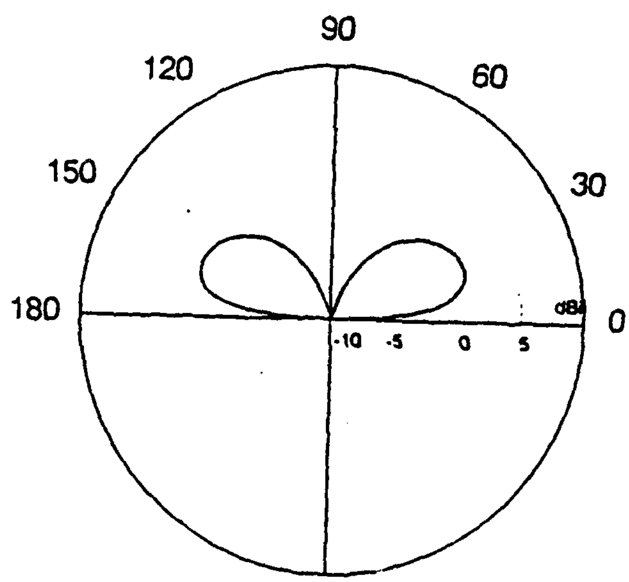


4.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 7. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 4.5 MHz)

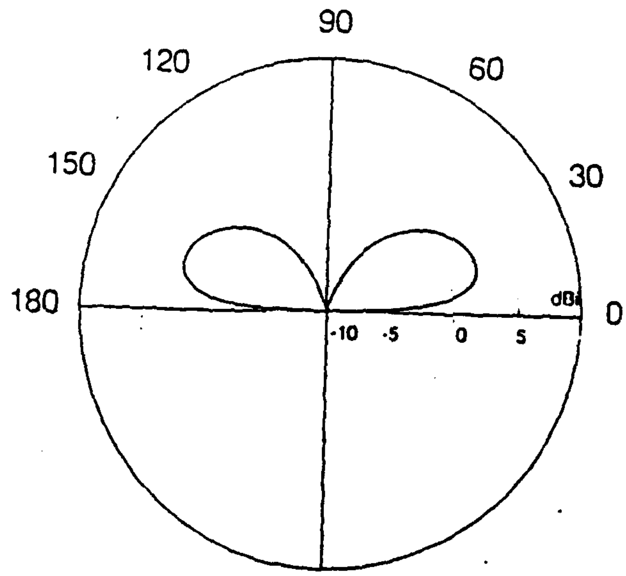


5 MHz ELEVATION PLANE PATTERN FOR THE CONICAL MONOPOLE IN WINTER-HARBOR, MAINE.

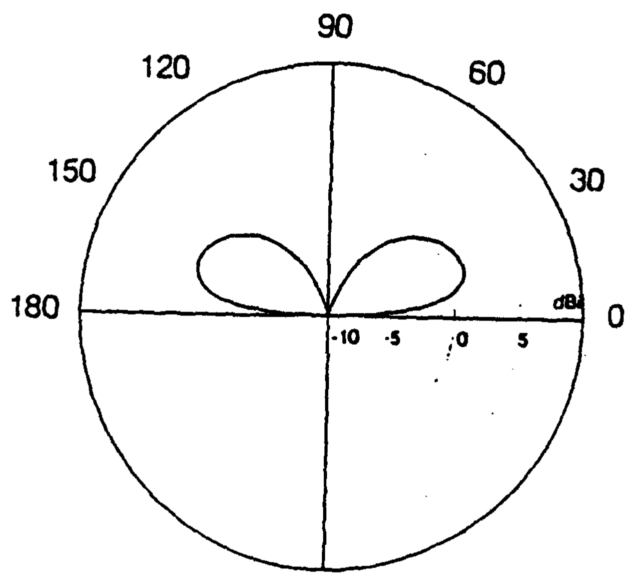


5 MHz ELEVATION PLANE PATTERN FOR THE CONICAL MONOPOLE IN NORTHWEST, VIRGINIA.

Figure 8. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 5.0 MHz)

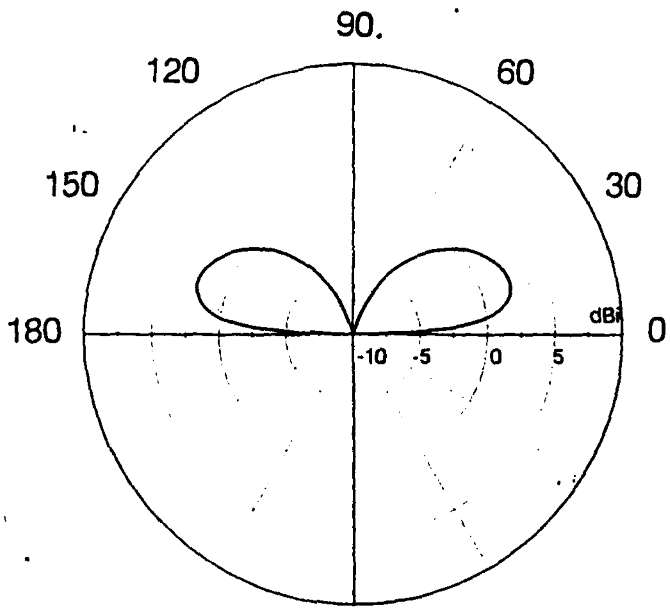


5.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

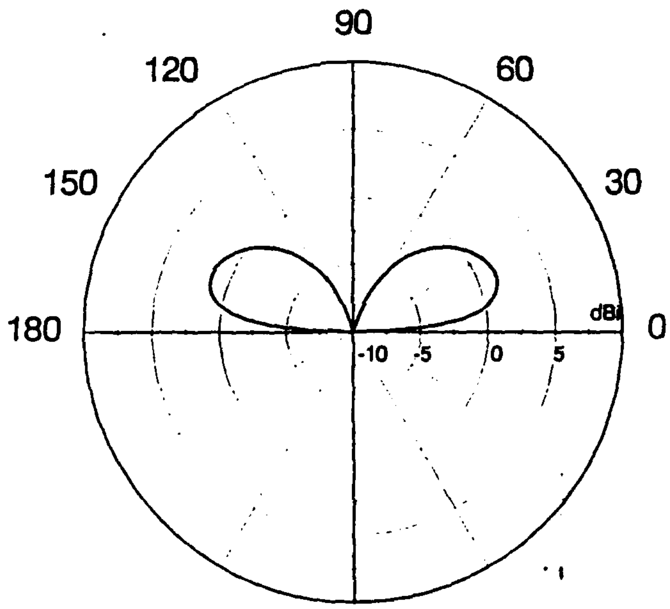


5.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 9. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 5.5 MHz)

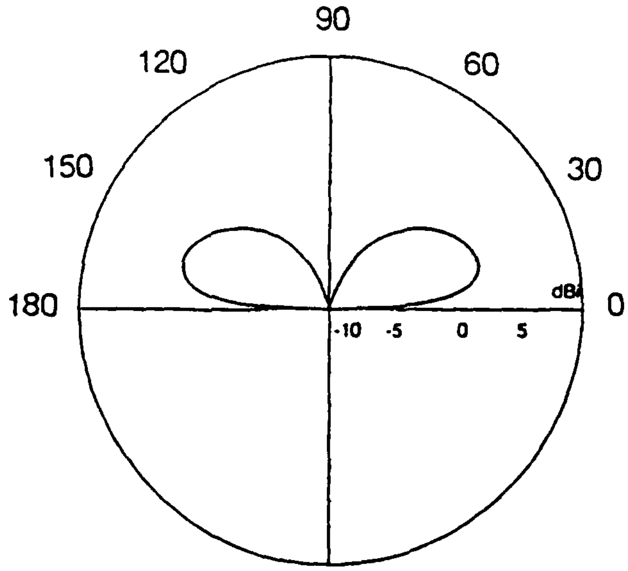


6 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

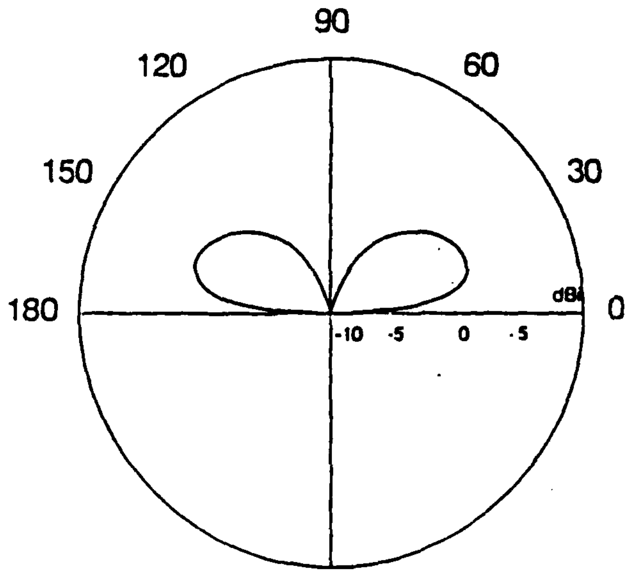


6 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 10. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 6.0 MHz)

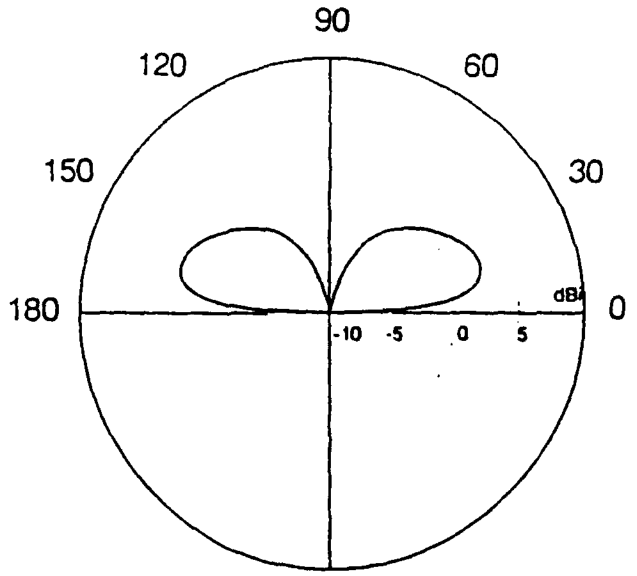


6.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

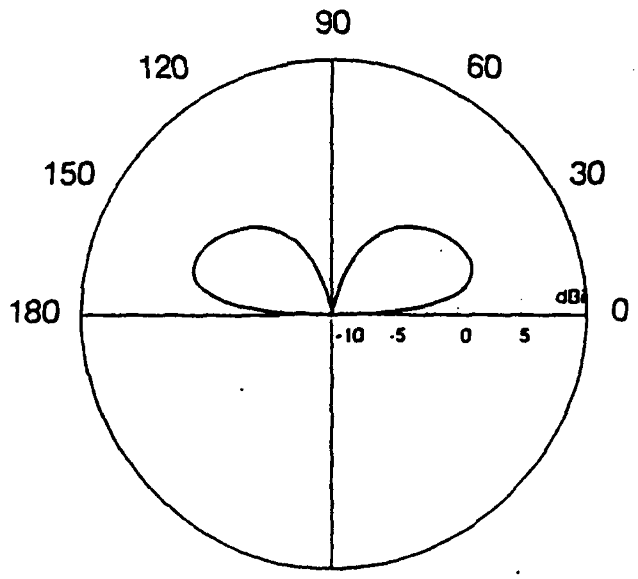


6.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 11. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 6.5 MHz)

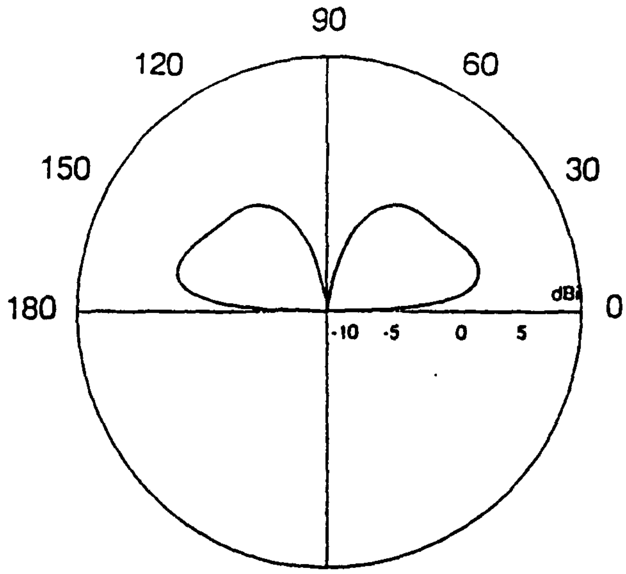


7 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

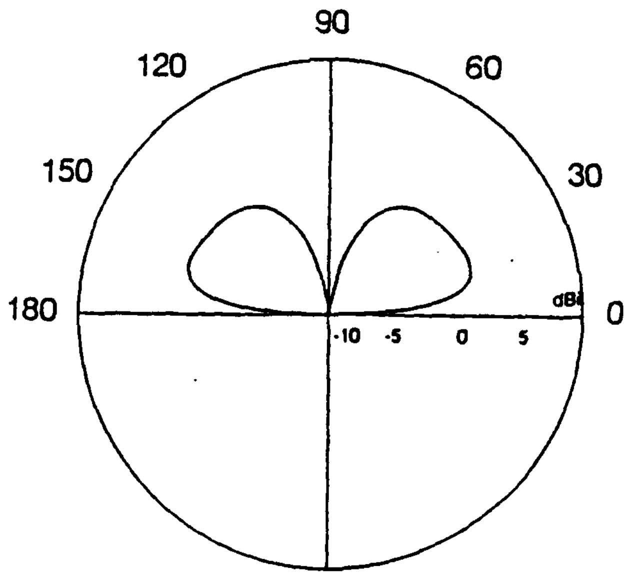


7 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 12. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 7.0 MHz)

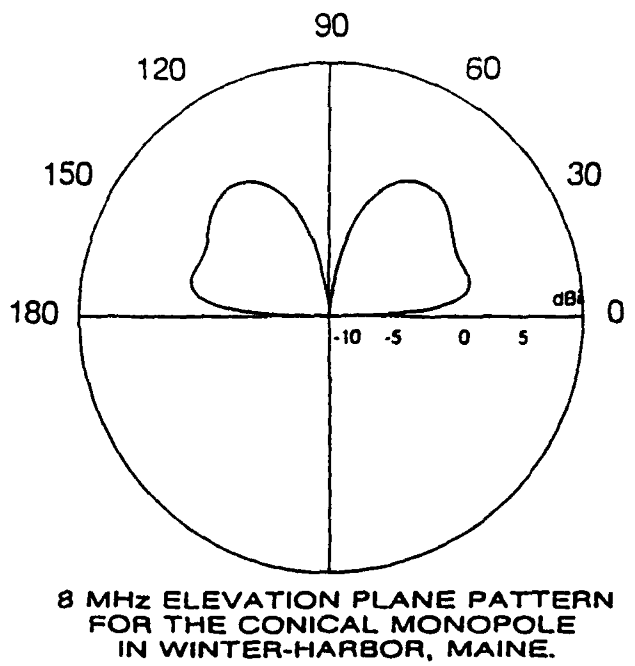


7.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



7.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 13. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 7.5 MHz)



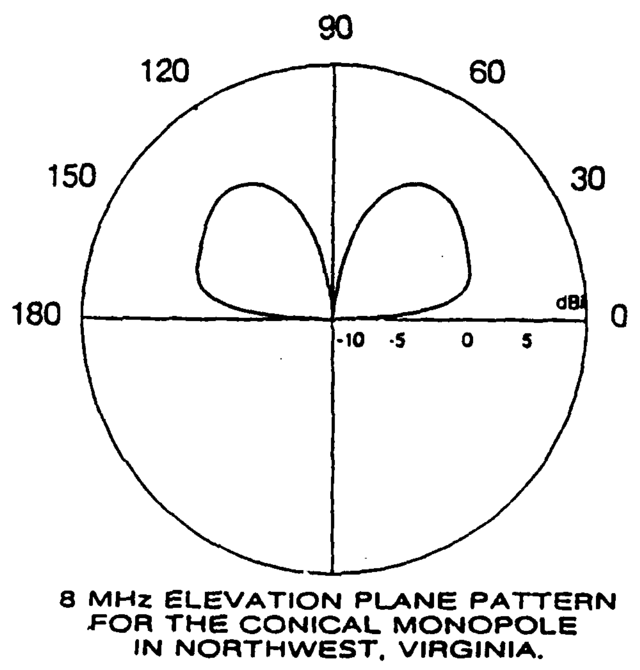
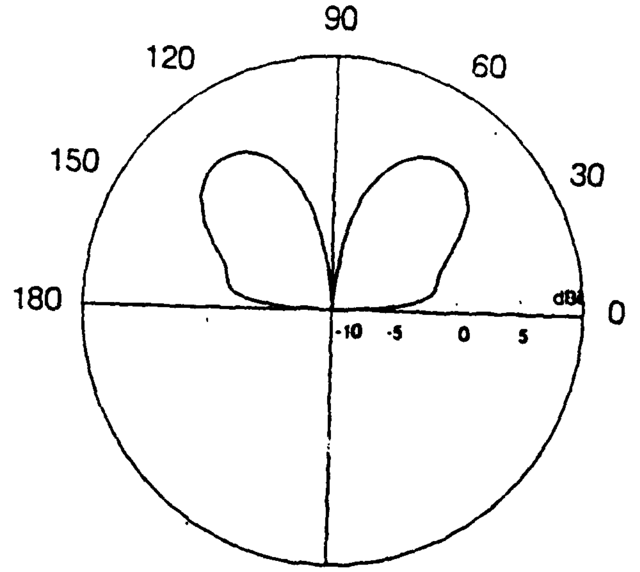
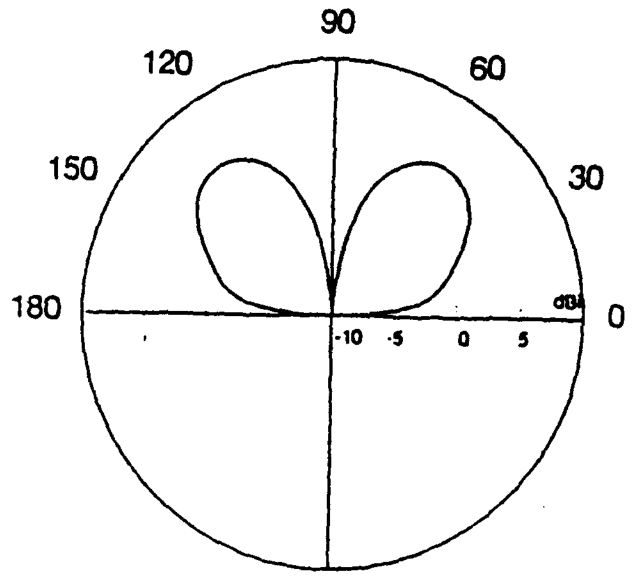


Figure 14. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 8.0 MHz)

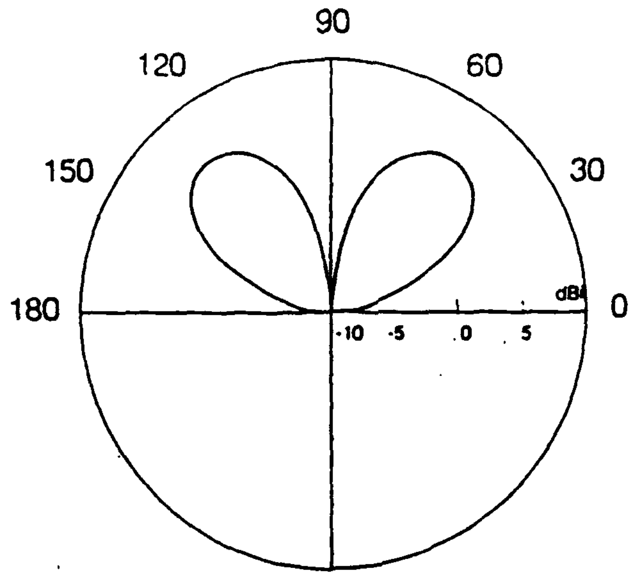


8.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

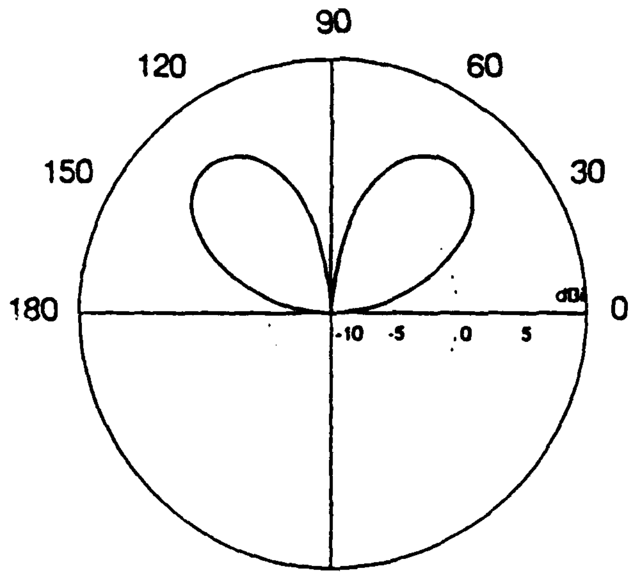


8.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 15. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 8.5 MHz)

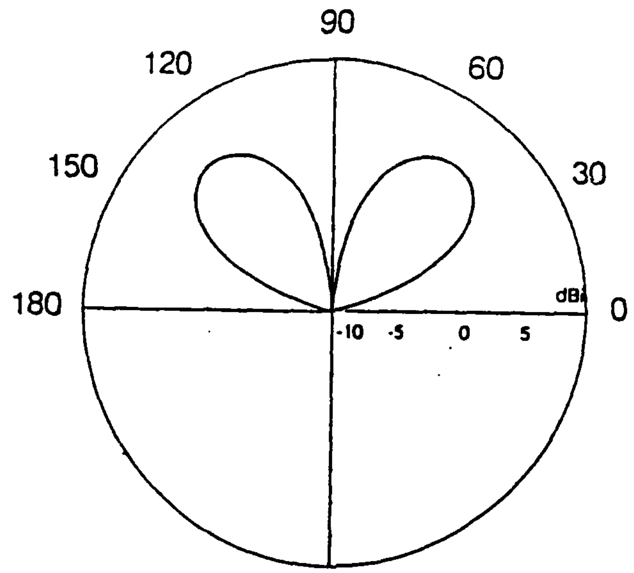


9 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

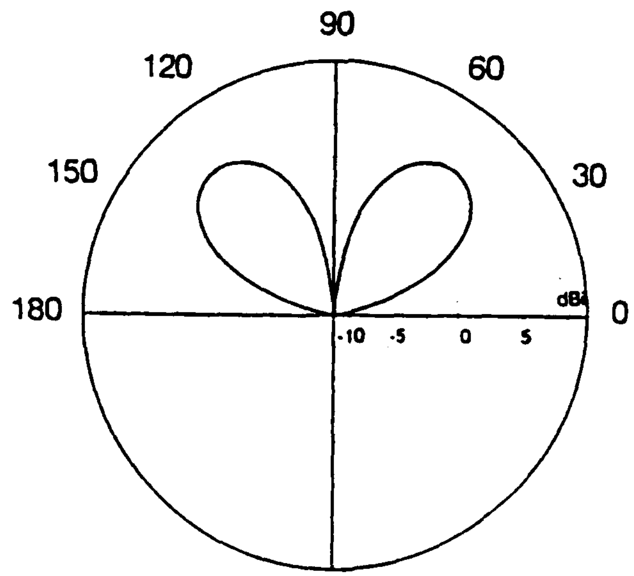


9 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 16. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 9.0 MHz)

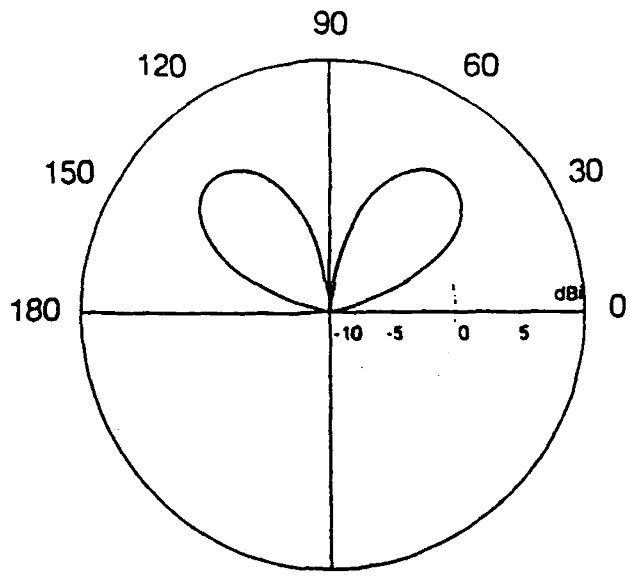


9.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

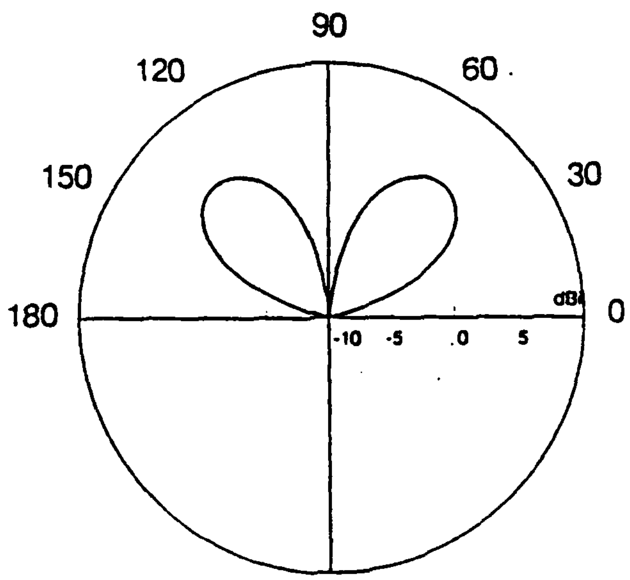


9.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 17. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 9.5 MHz)



10 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



10 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 18. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 10.0 MHz)

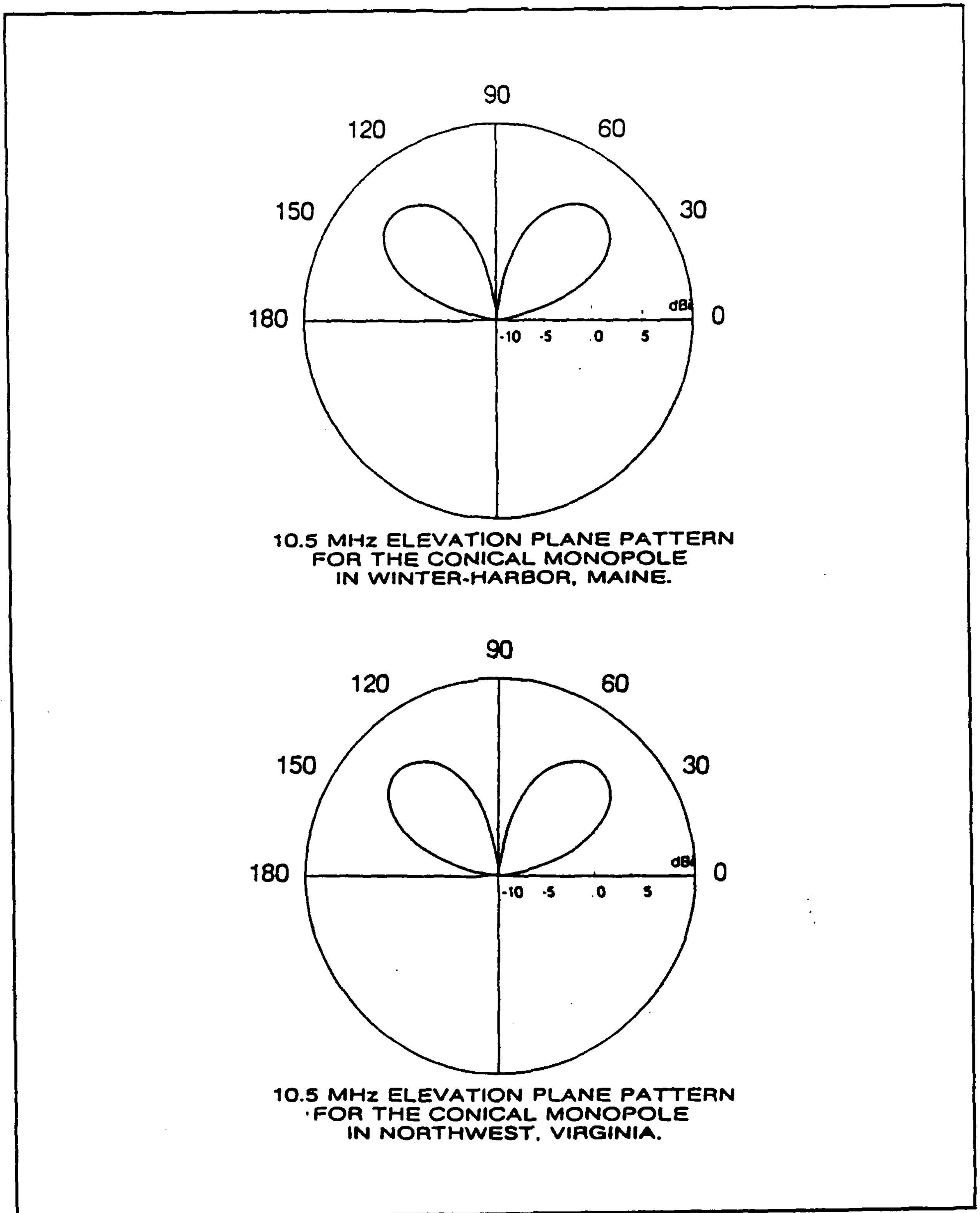
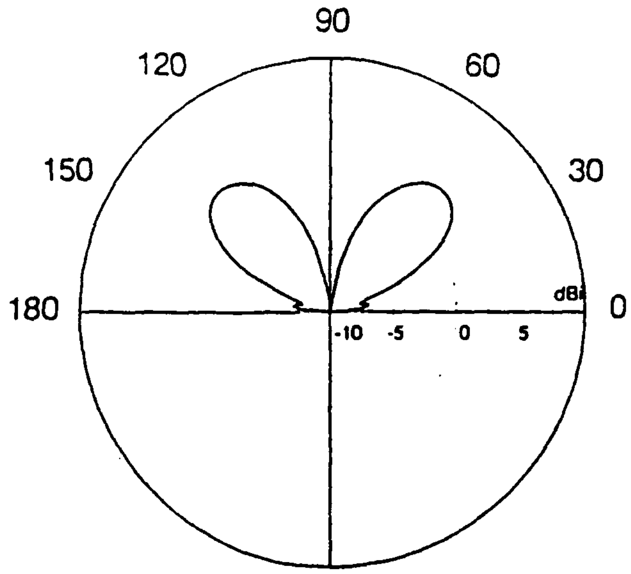
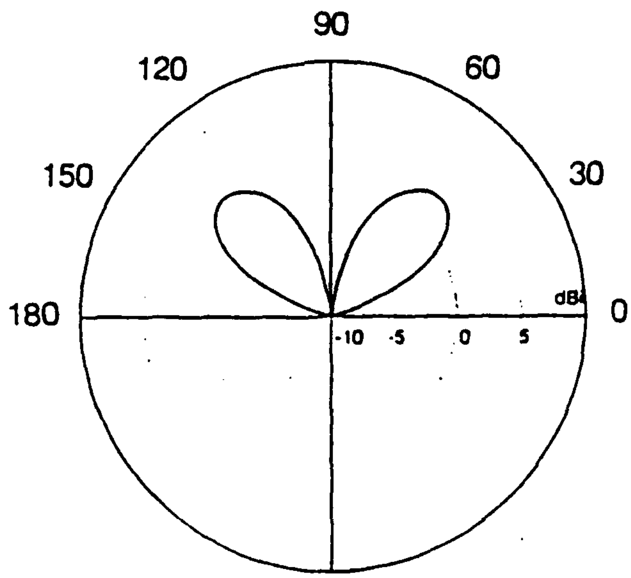


Figure 19. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 10.5)



11 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



11 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 20. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 11.0 MHz)

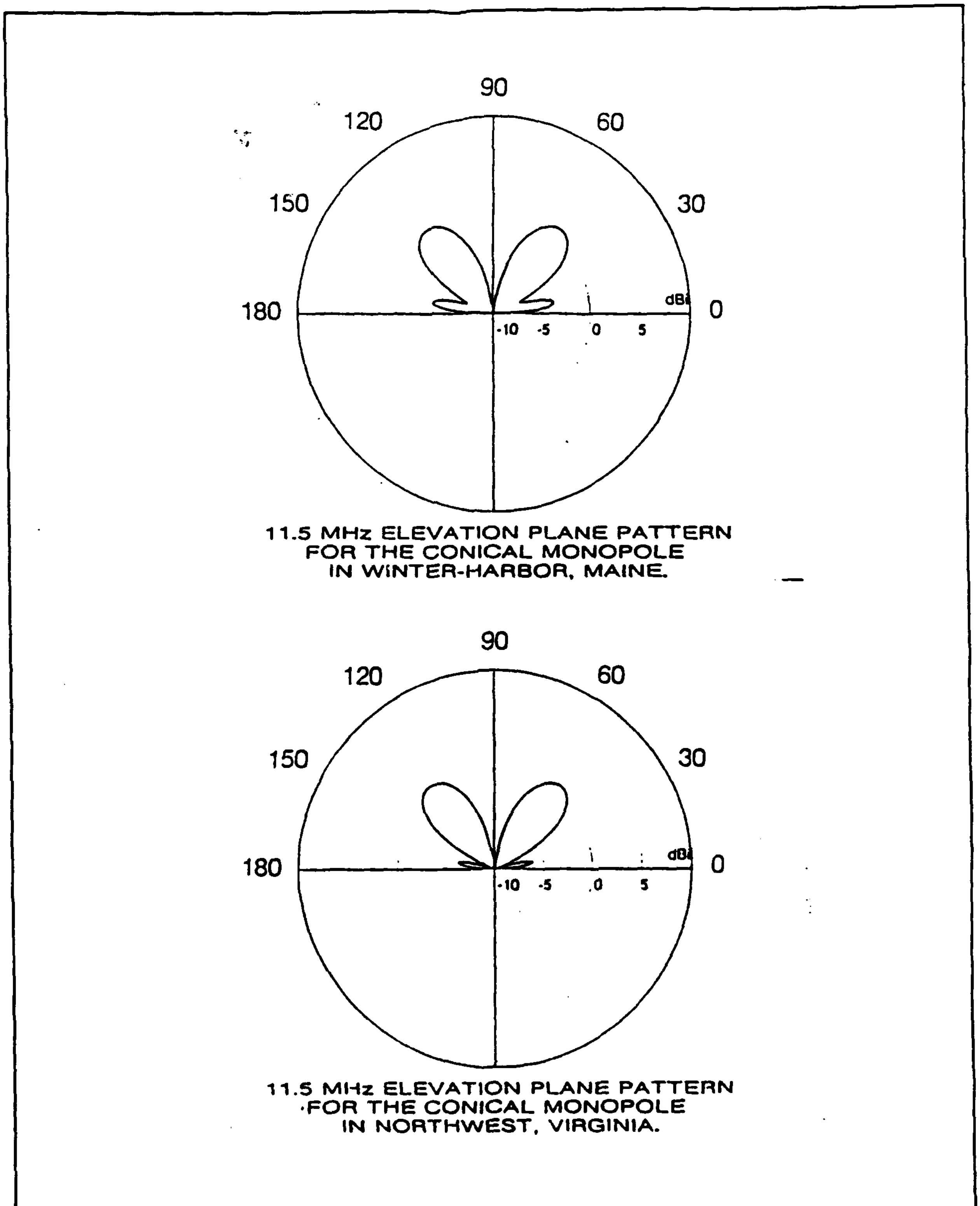
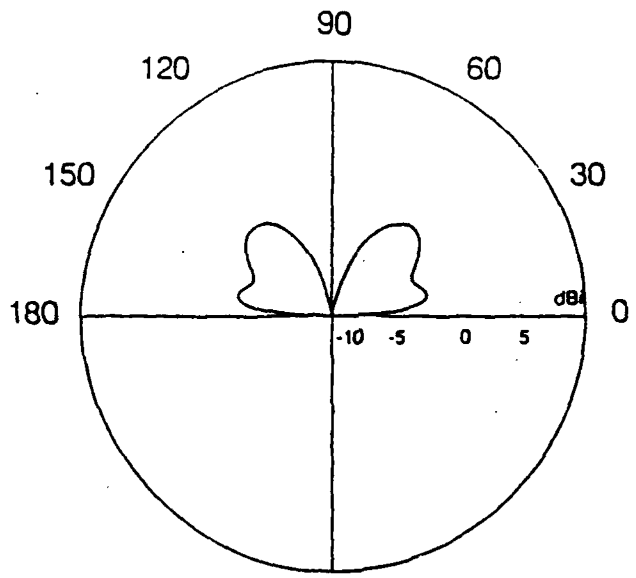
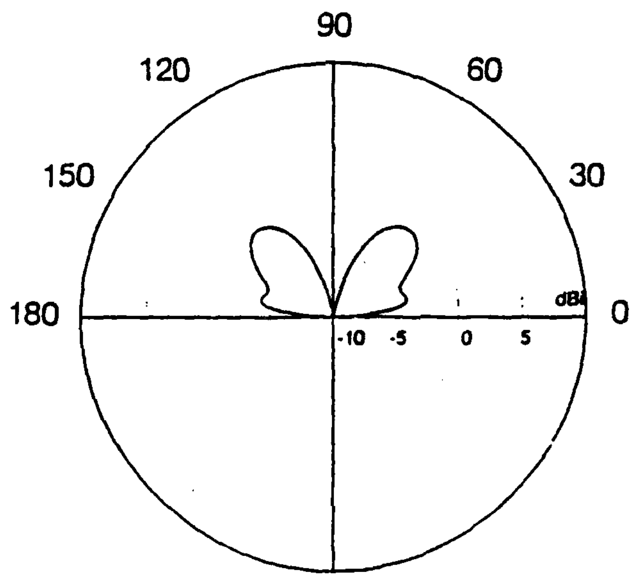


Figure 21. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 11.5 MHz)

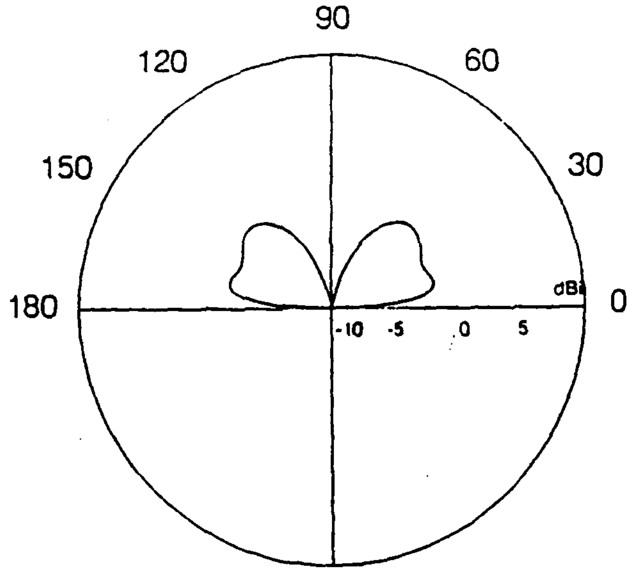


12 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

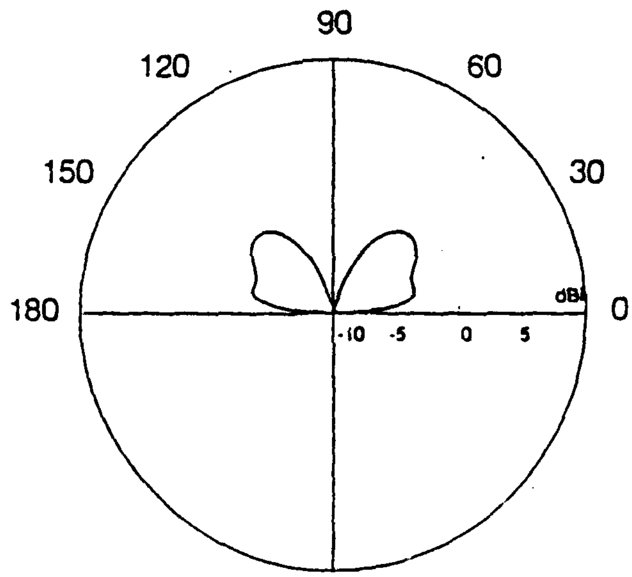


12 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 22. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 12.0 MHz)

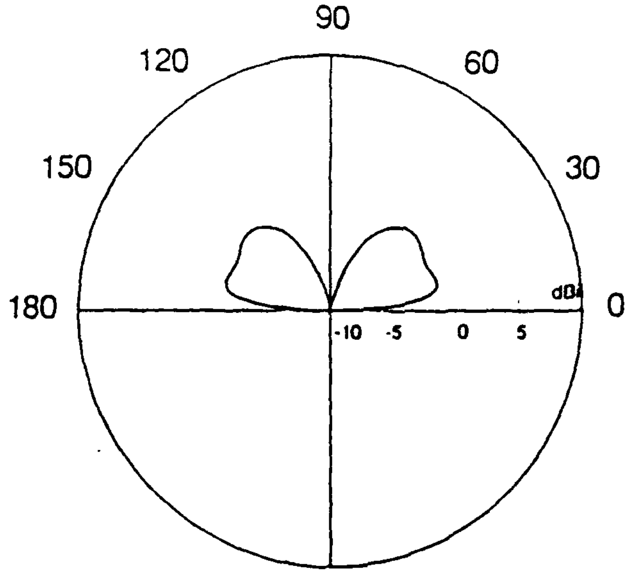


12.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

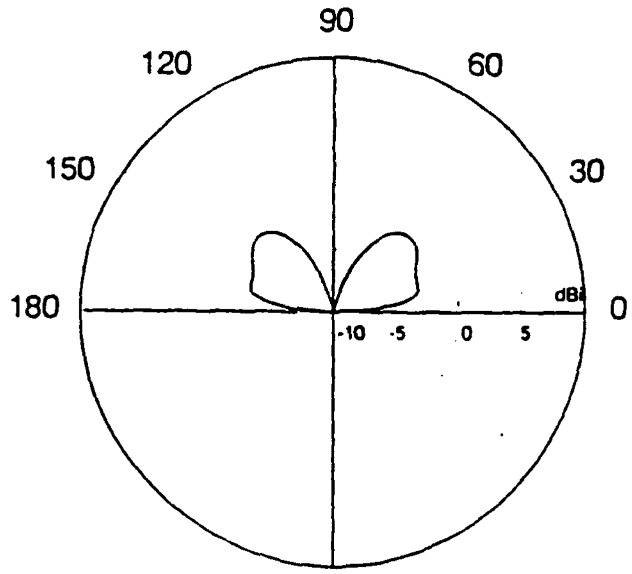


12.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 23. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 12.5 MHz)



13 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



13 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 24. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 13.0 MHz)

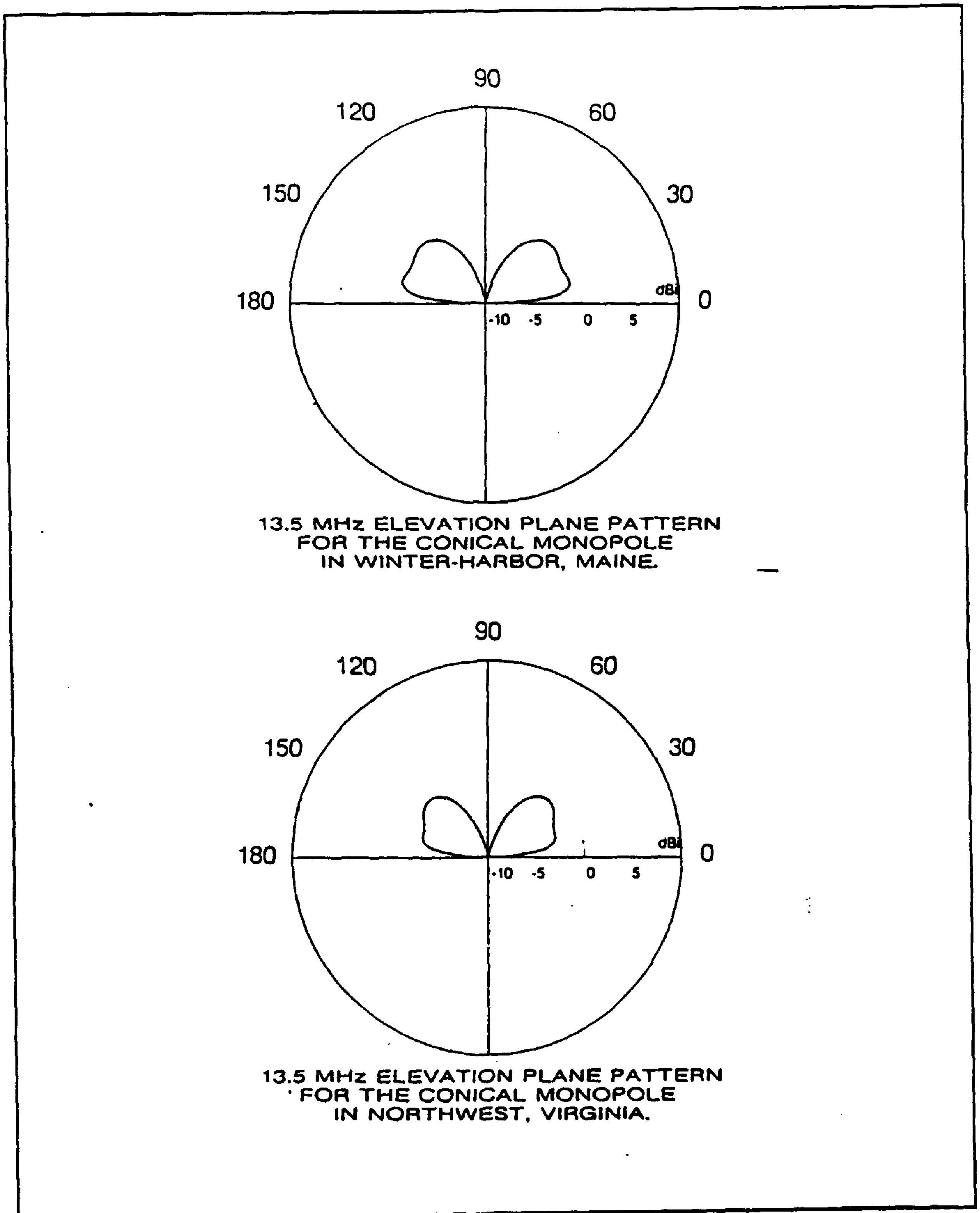
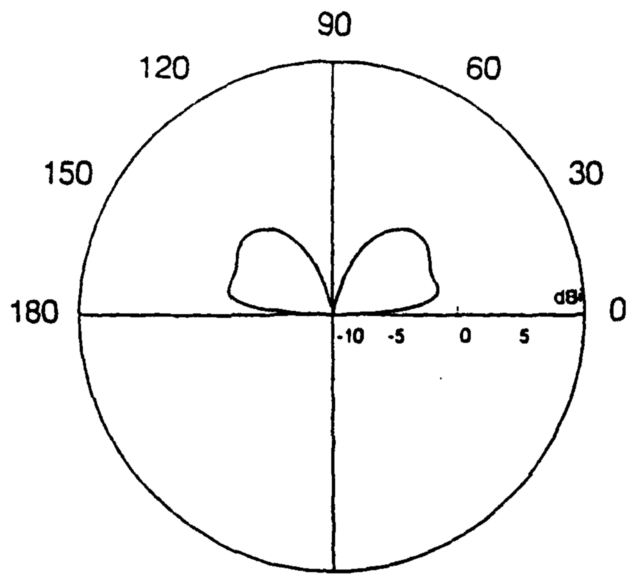
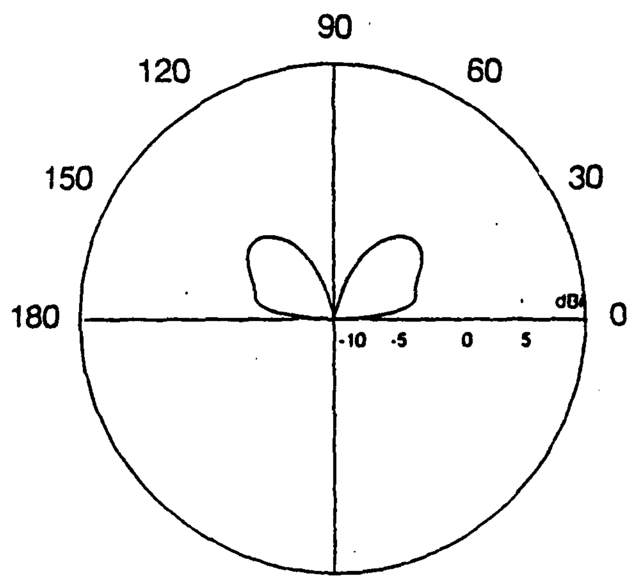


Figure 25. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 13.5 MHz)

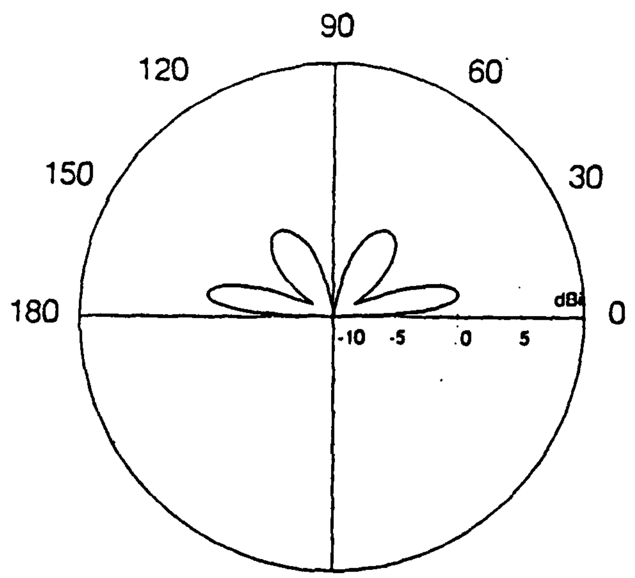


14 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

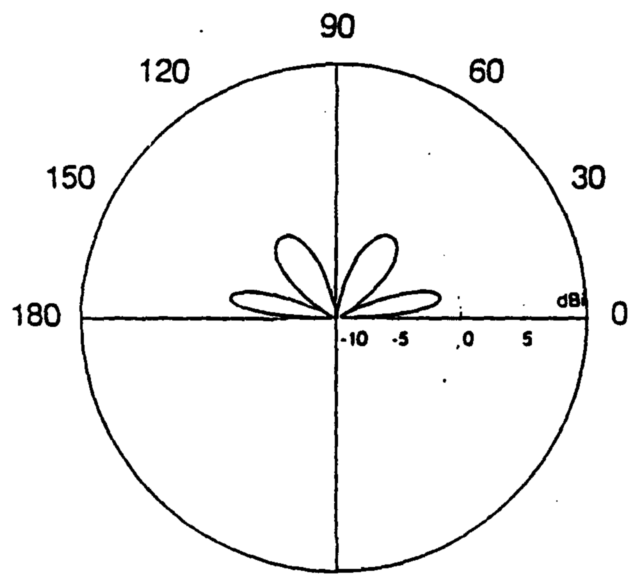


14 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 26. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 14.0 MHz)

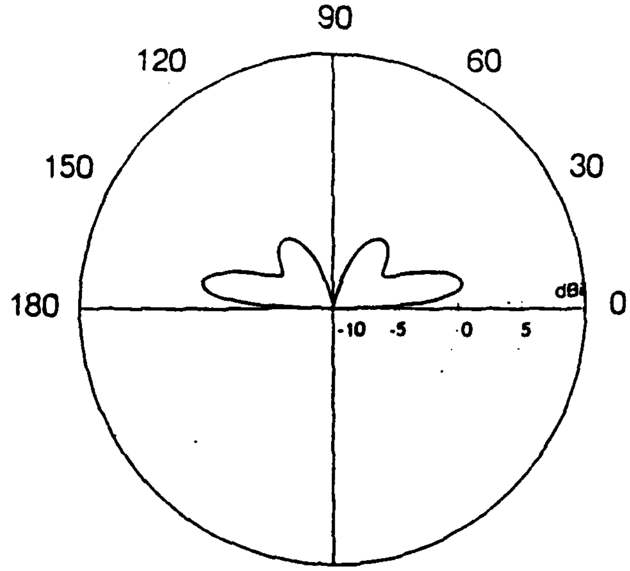


14.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

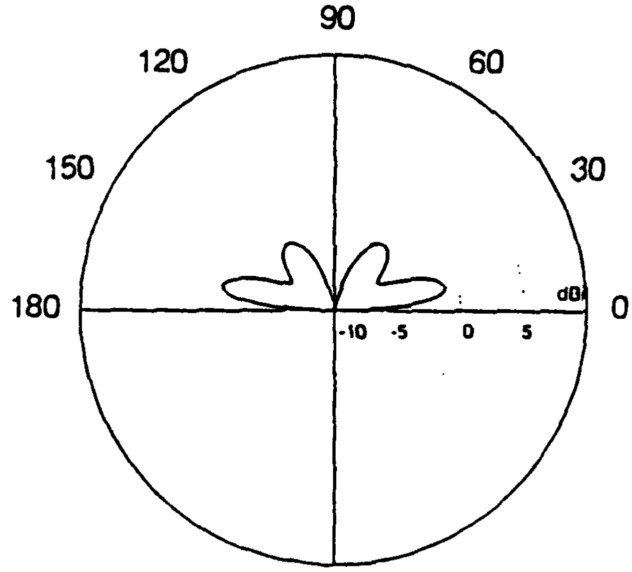


14.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 27. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 14.5 MHz)

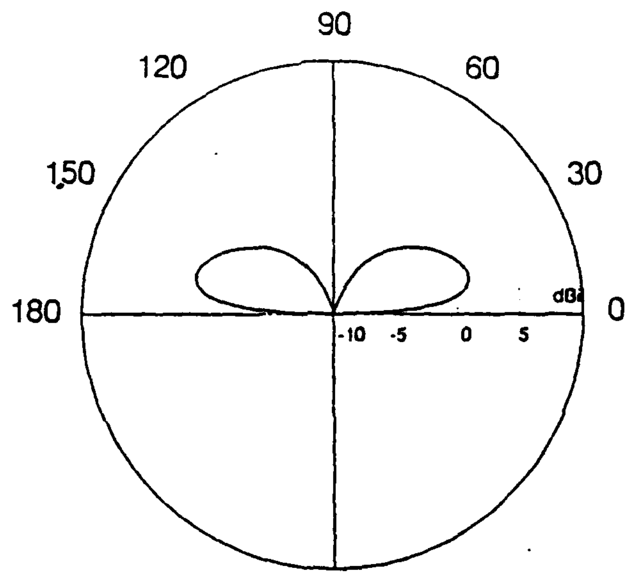


15 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

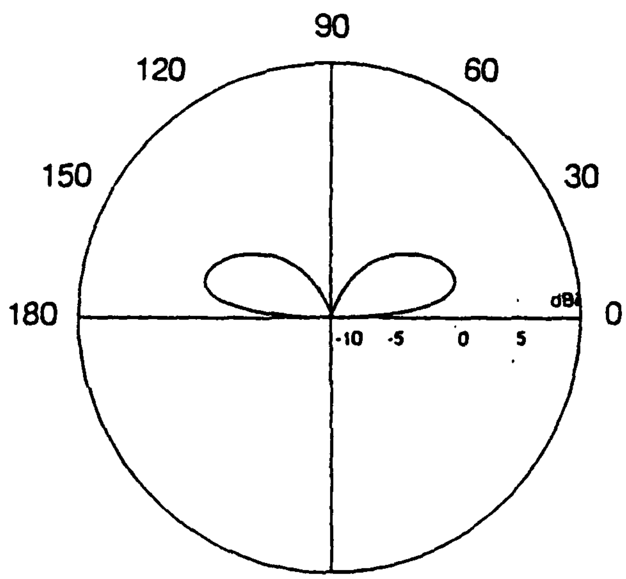


15 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 28. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 15.0 MHz)

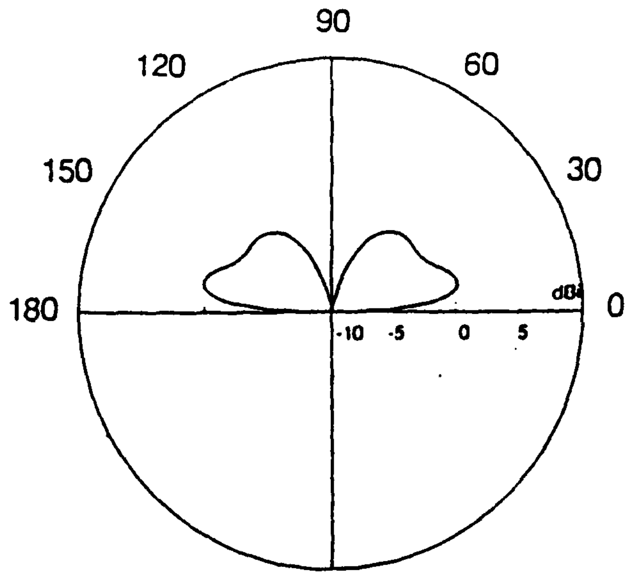


15.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

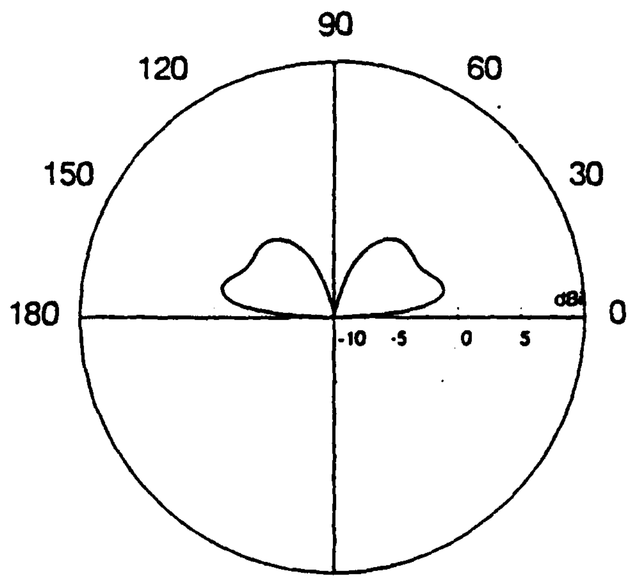


15.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 29. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 15.5 MHz)

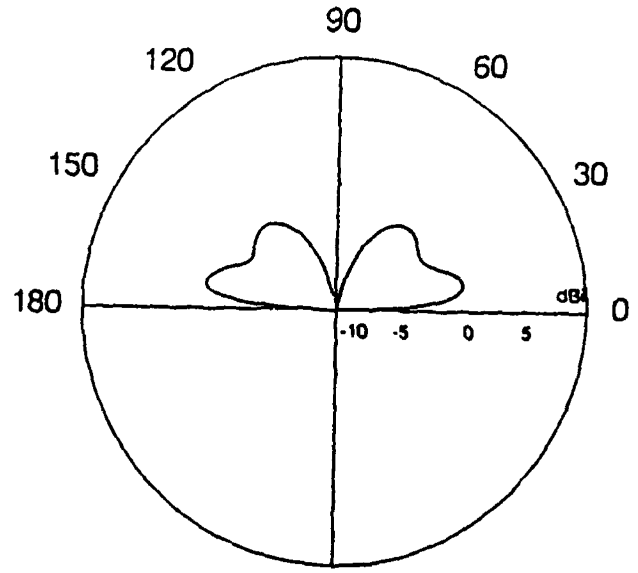


16 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

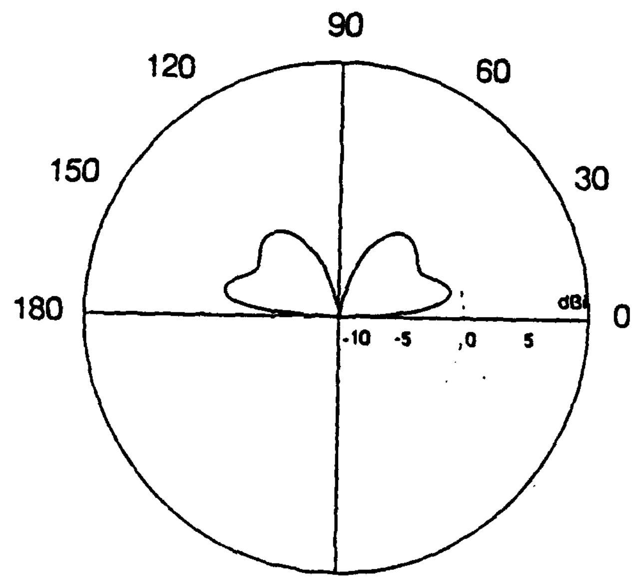


16 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 30. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 16.0 MHz)

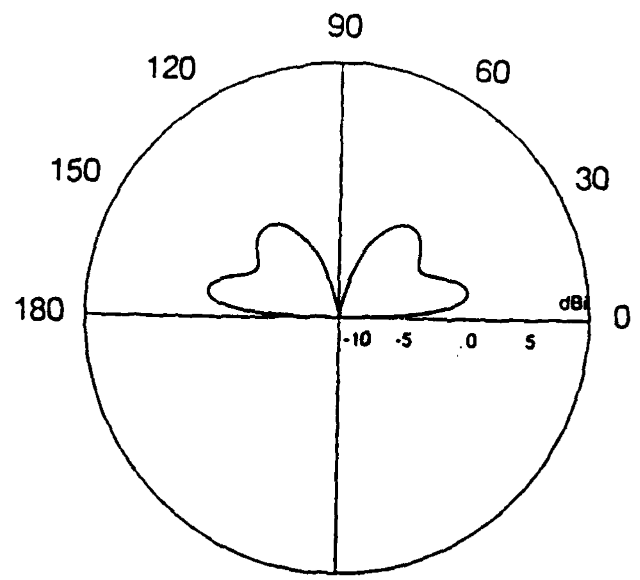


16.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

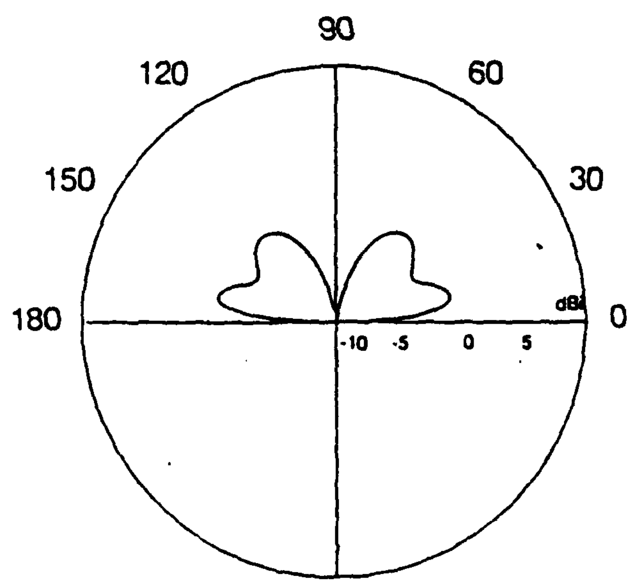


16.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 31. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 16.5 MHz)

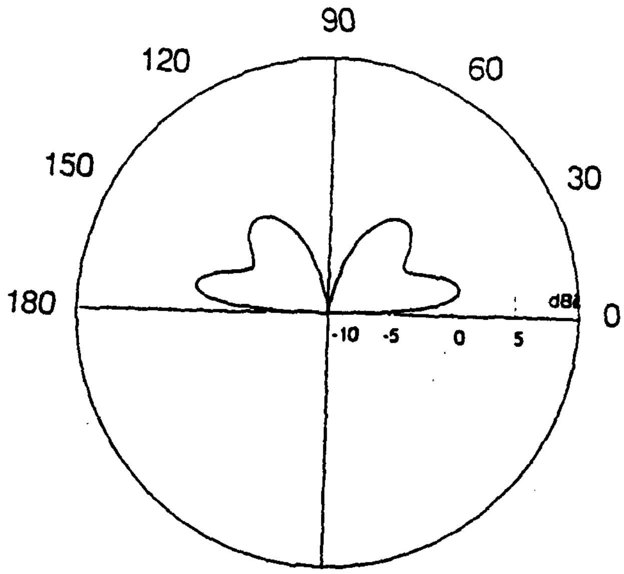


17 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

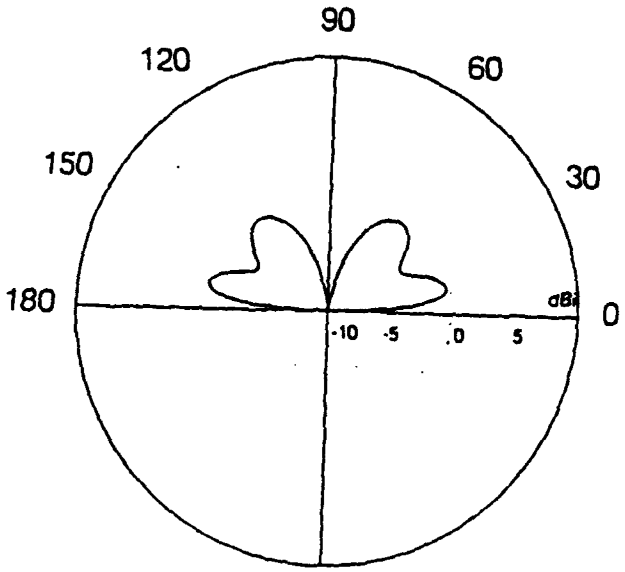


17 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 32. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 17.0 MHz)

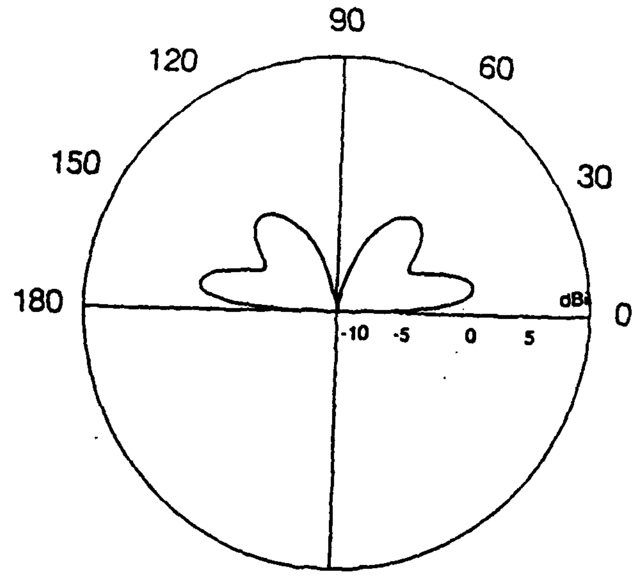


17.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

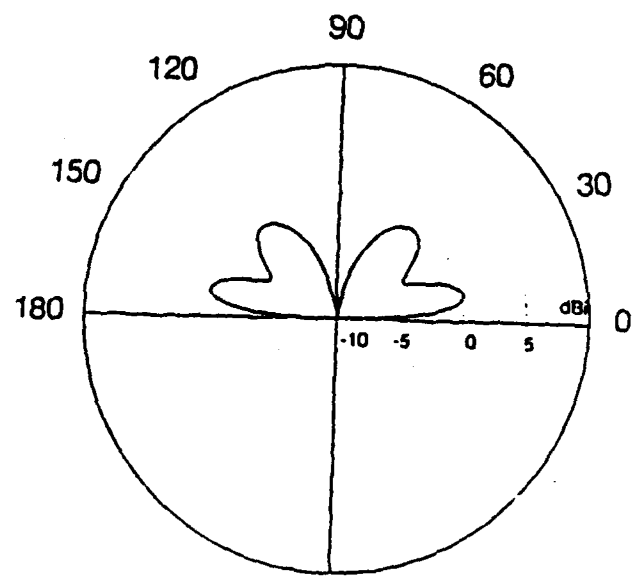


17.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 33. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 17.5 MHz)

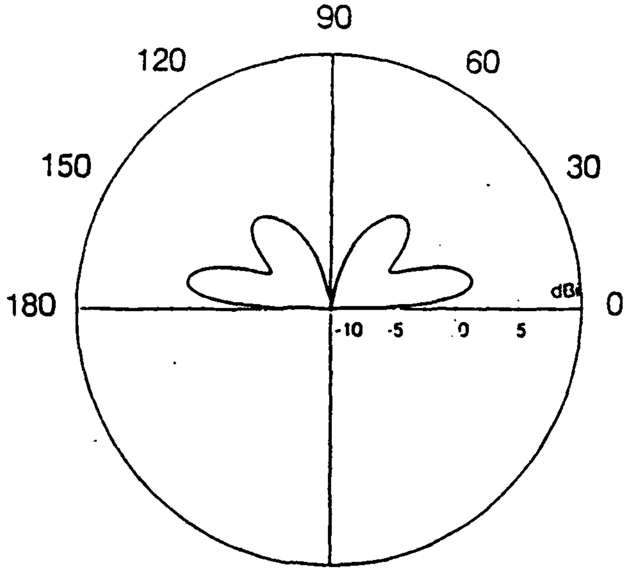


18 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

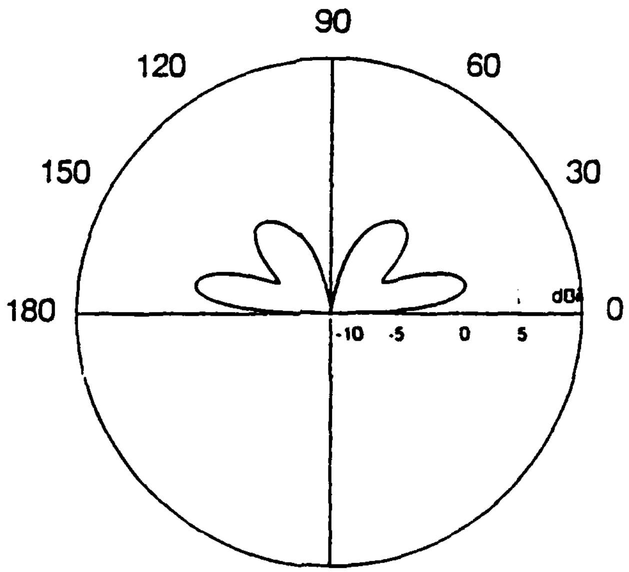


18 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 34. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 18.0 MHz)

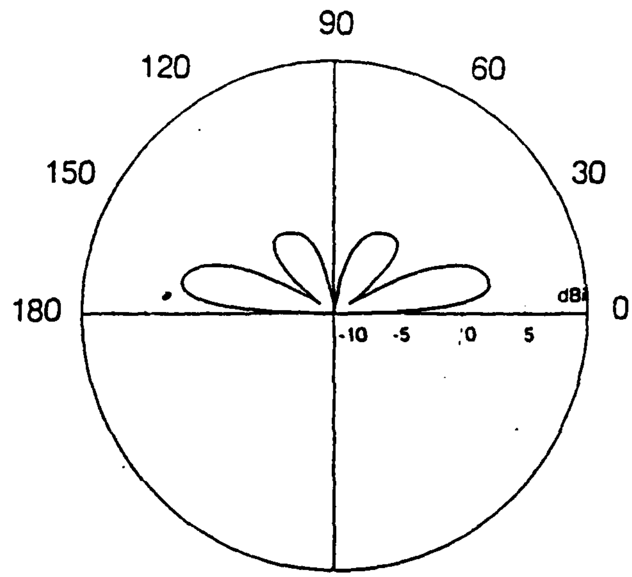


18.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

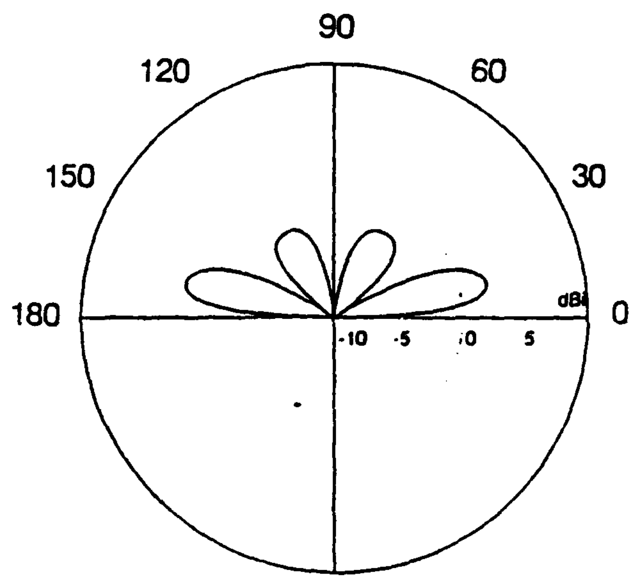


18.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 35. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 18.5 MHz)

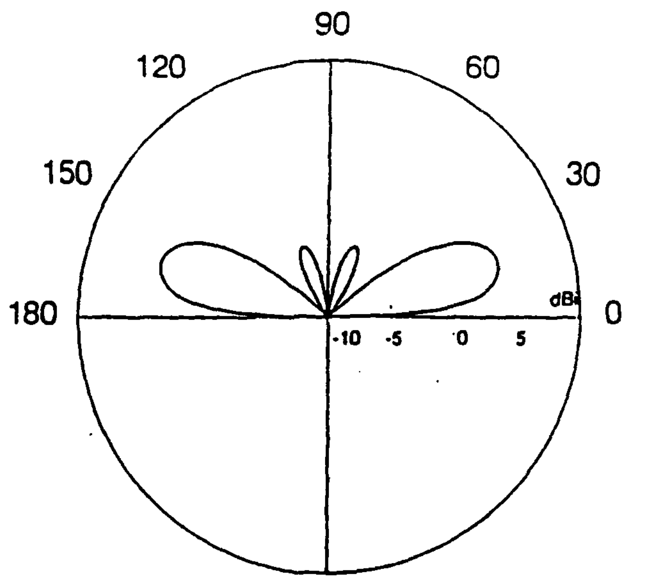


19 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

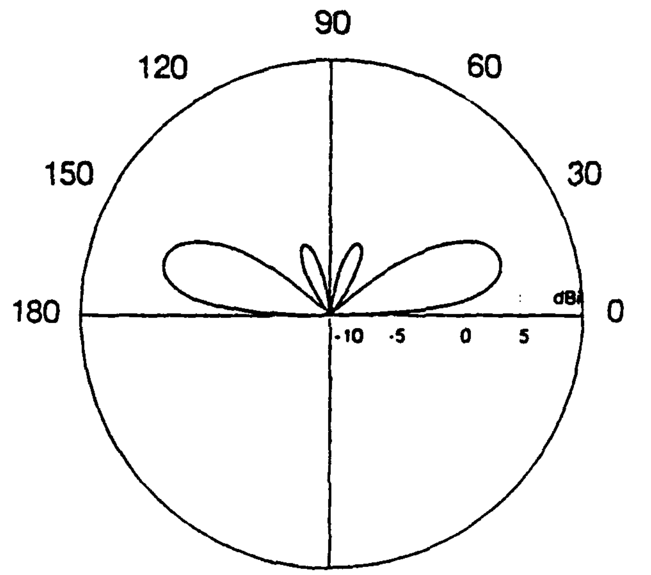


19 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 36. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 19.0 MHz)



19.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



19.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 37. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 19.5 MHz)

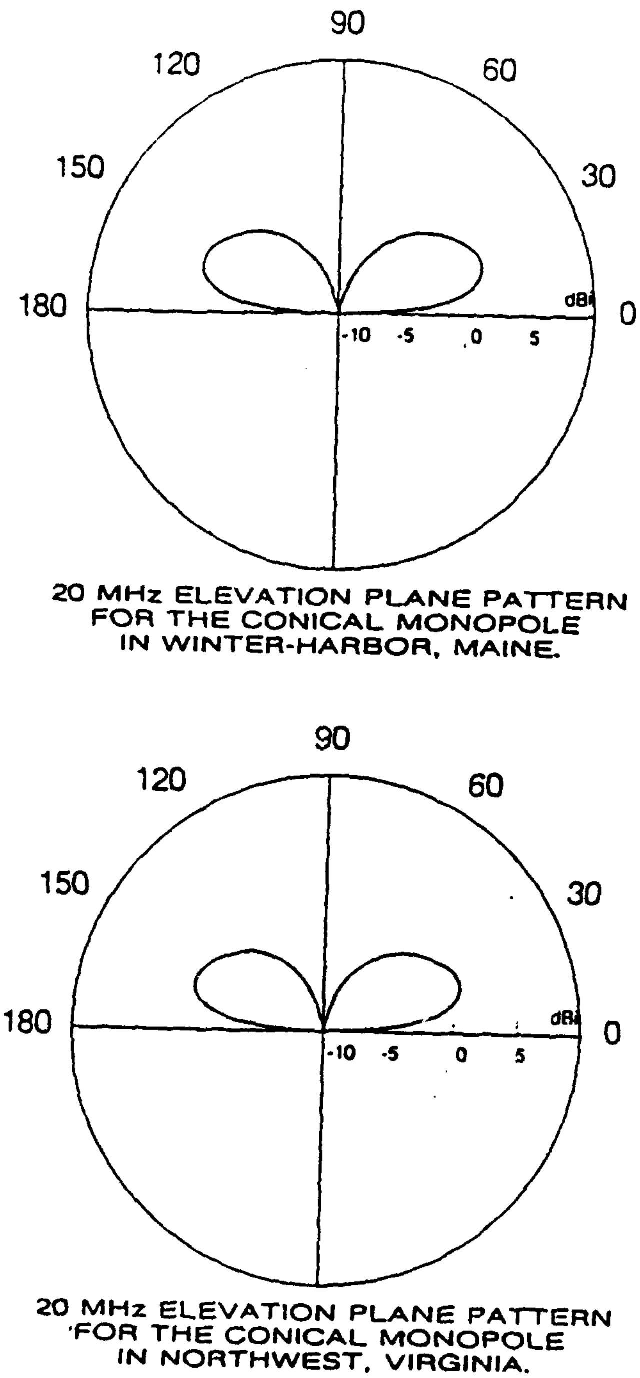
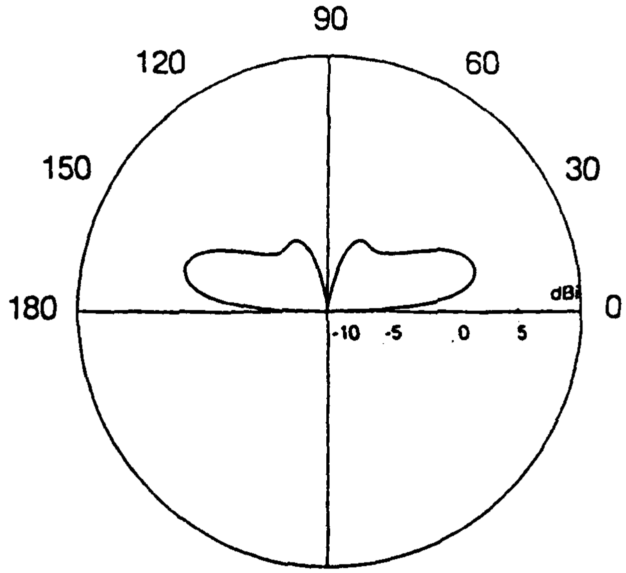
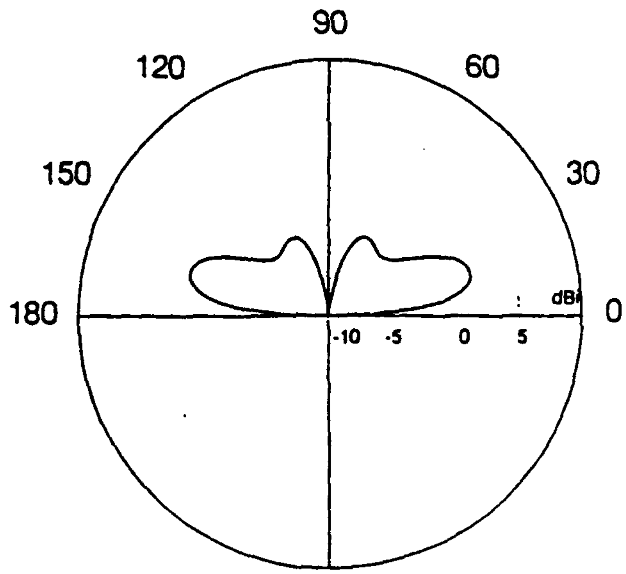


Figure 38. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 20.0 MHz)

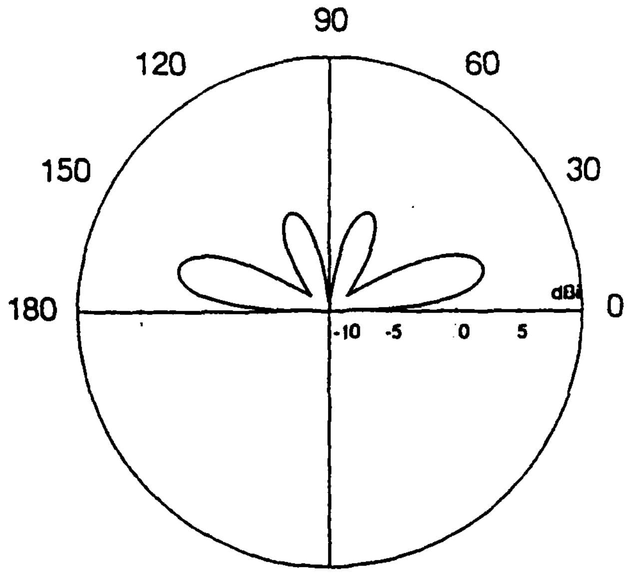


20.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

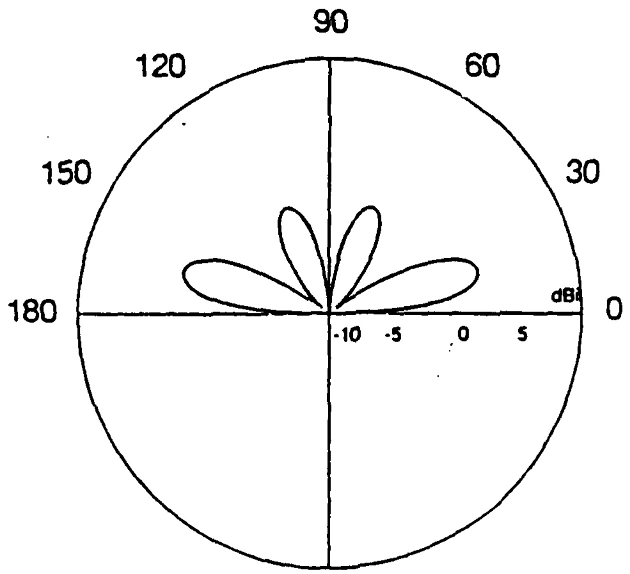


20.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 39. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 20.5 MHz)

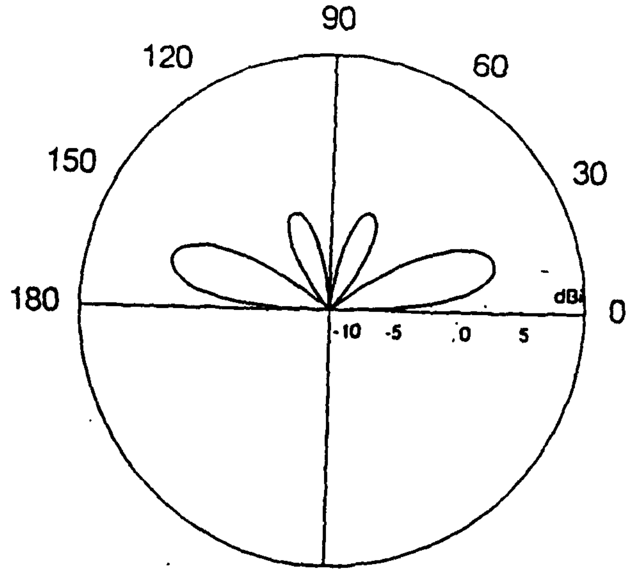


21 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

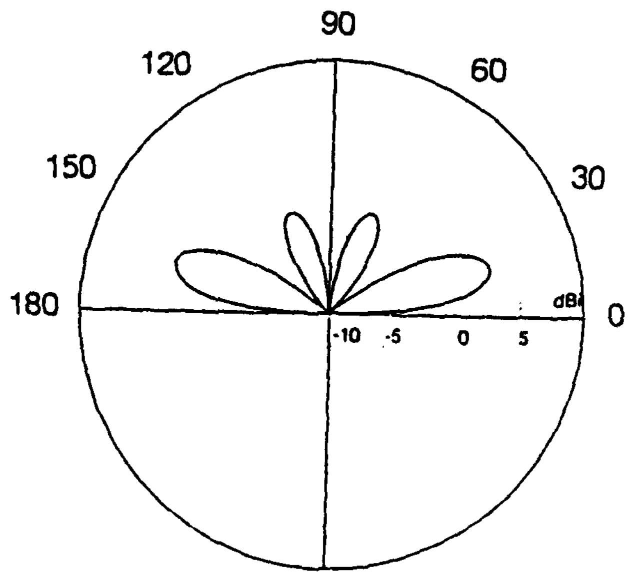


21 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 40. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 21.0 MHz)

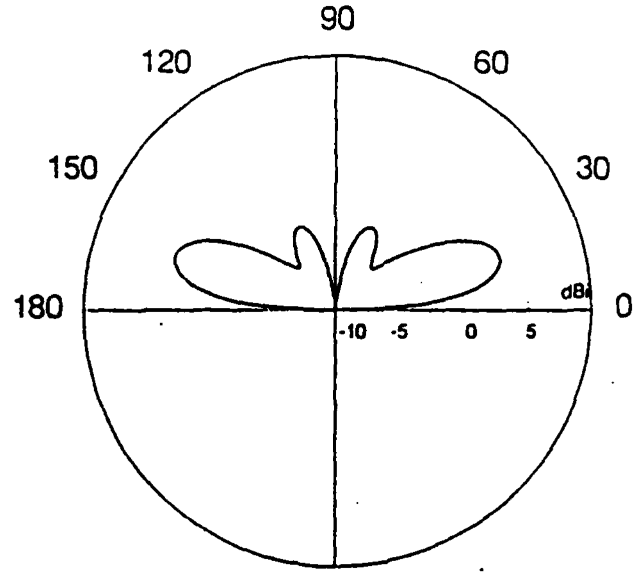


21.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

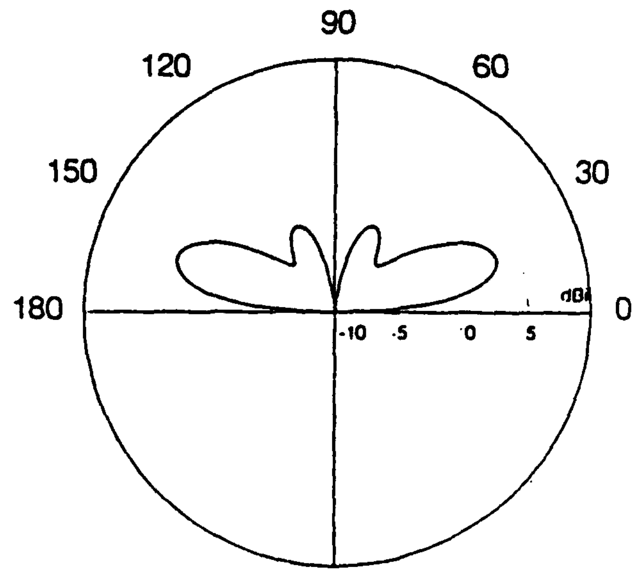


21.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 41. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 21.5 MHz)

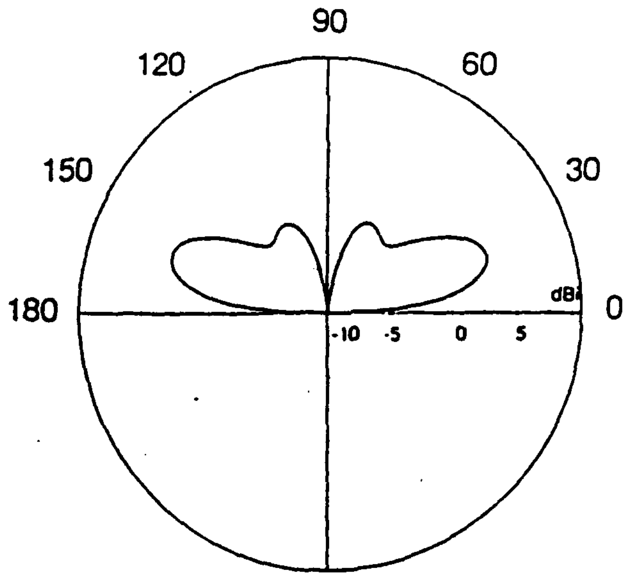


22 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

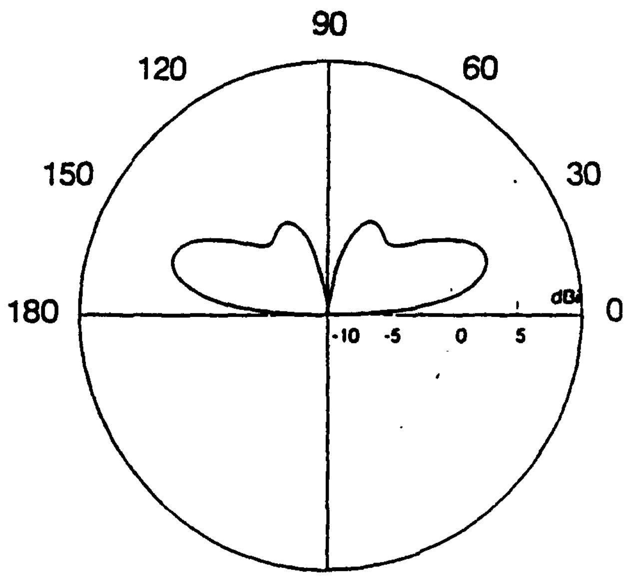


22 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 42. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 22.0 MHz)



22.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



22.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 43. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 22.5 MHz)

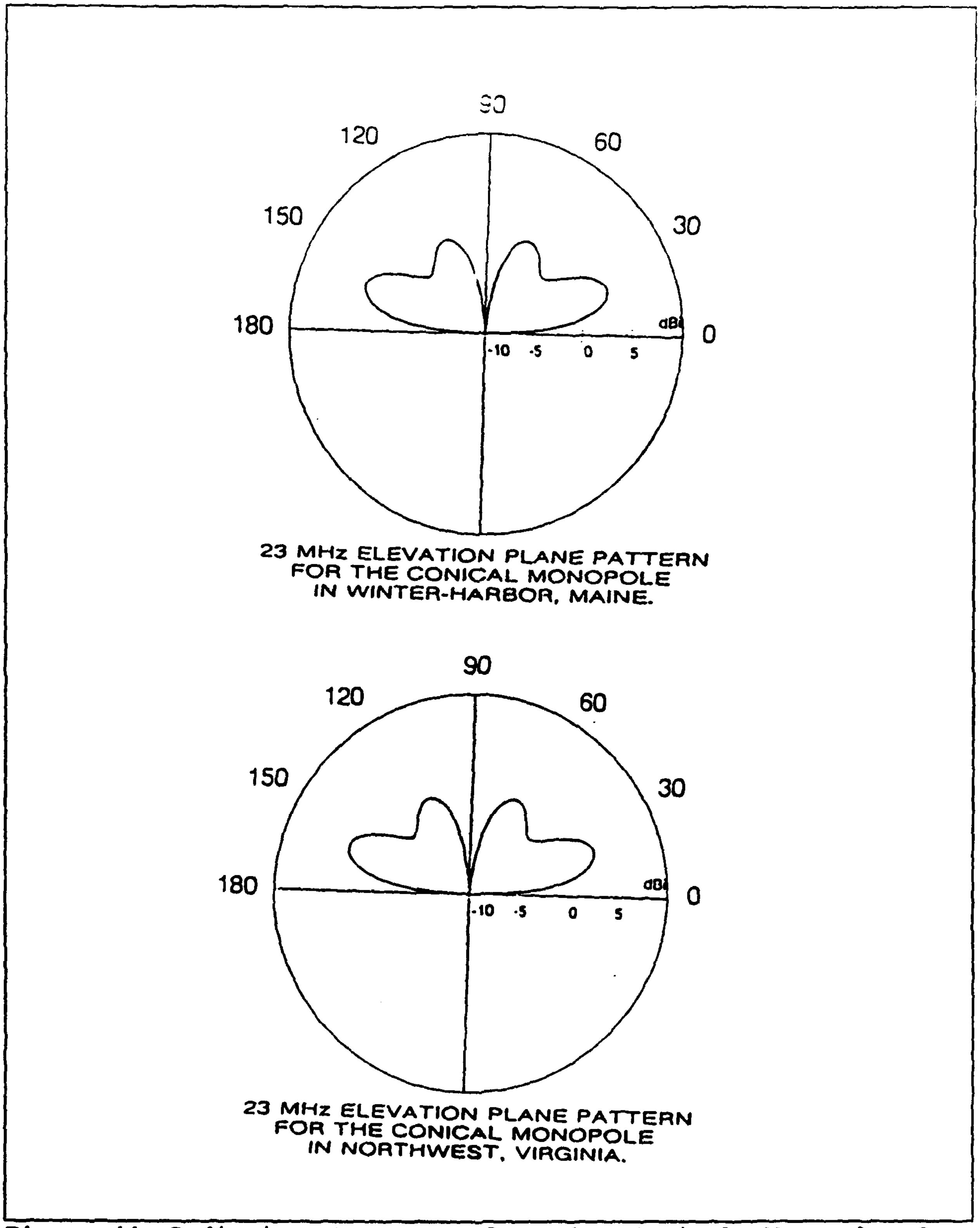
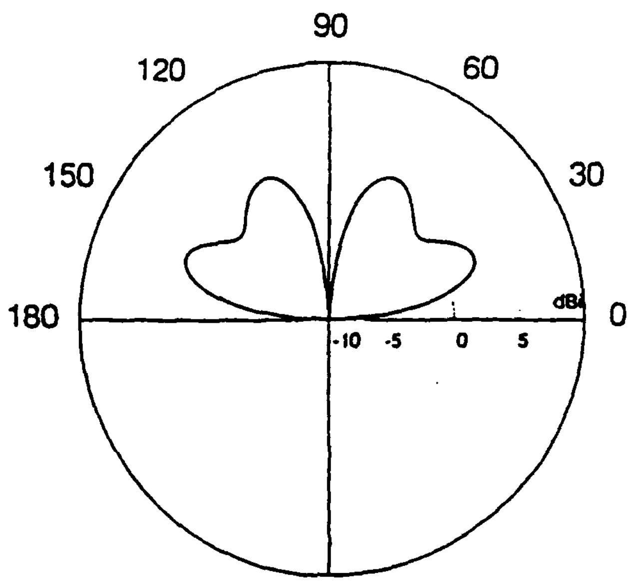
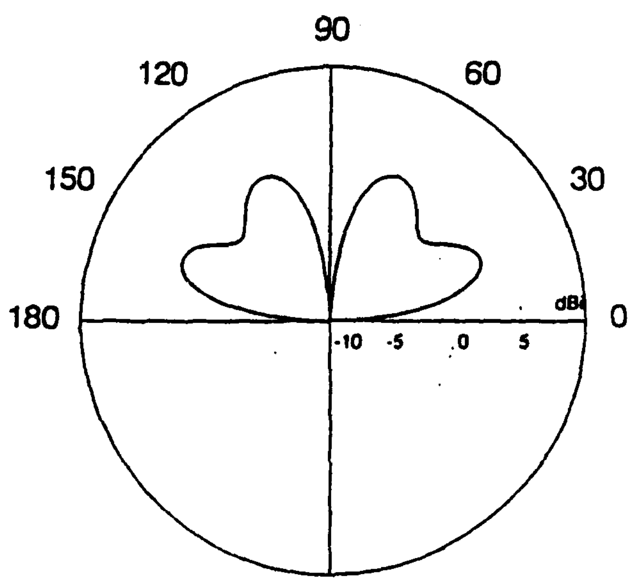


Figure 44. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 23.0 MHz)



23.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



23.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 45. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 23.5 MHz)

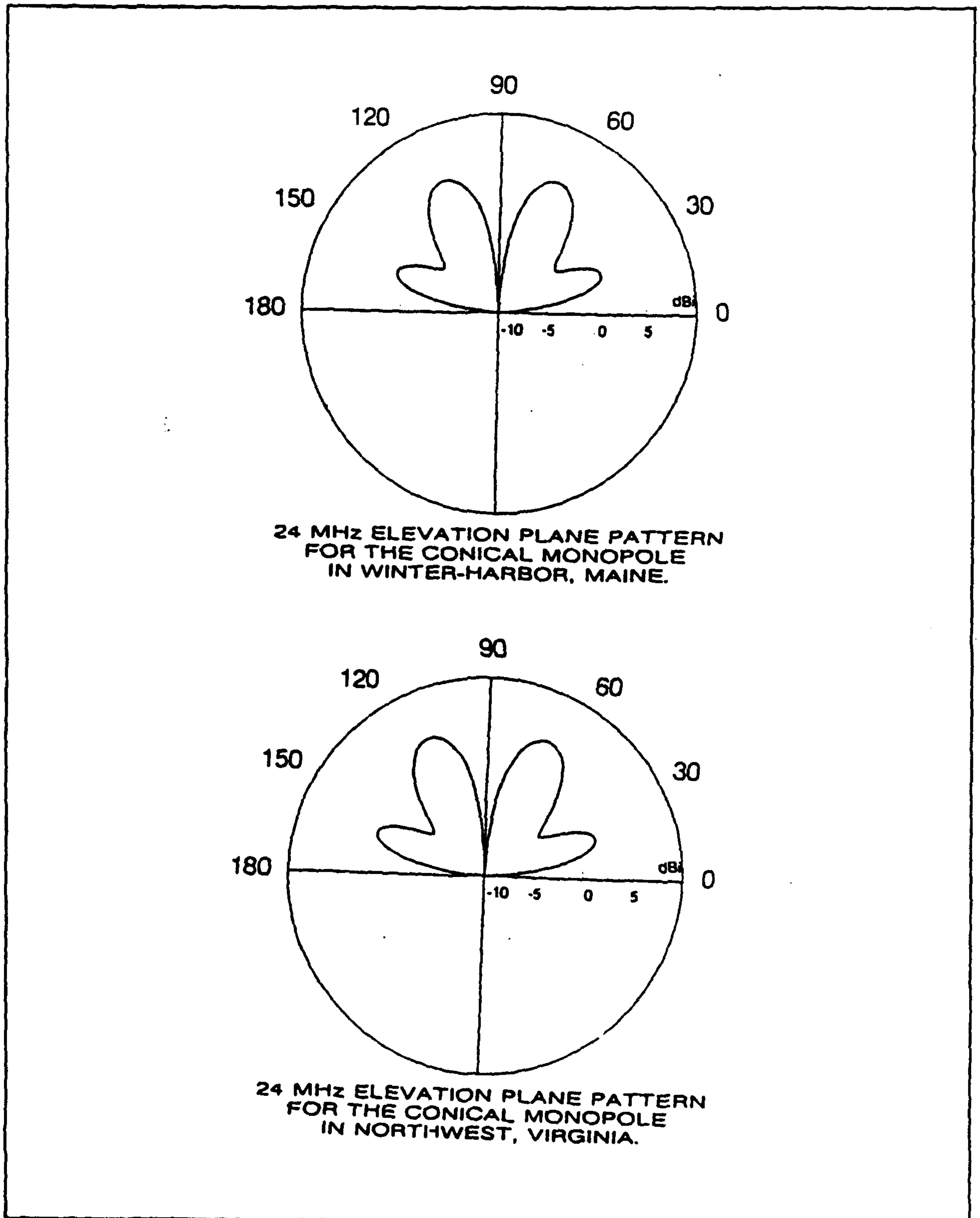
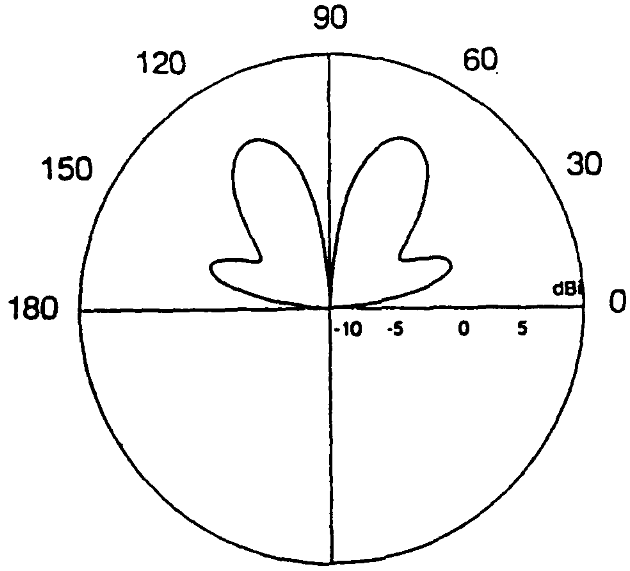
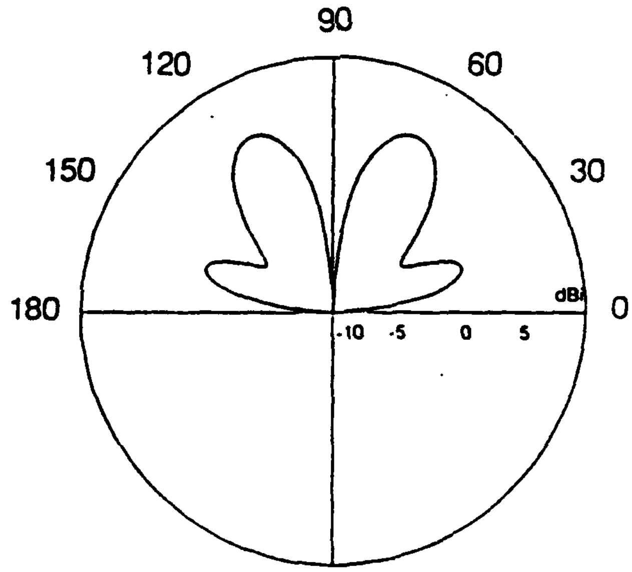


Figure 46. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 24.0 MHz)

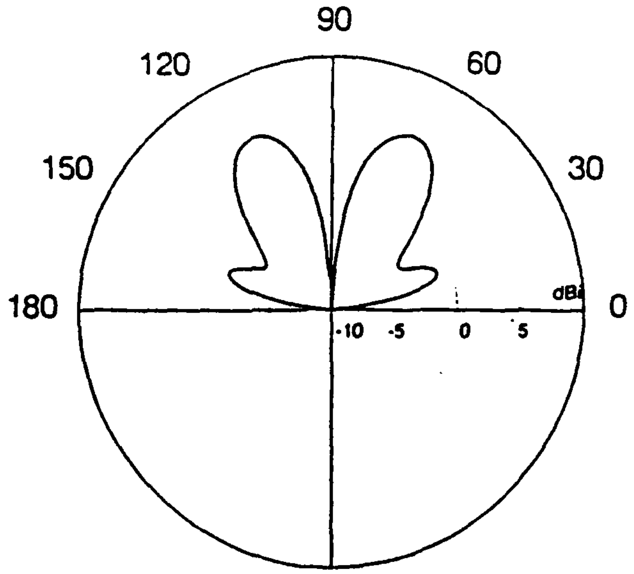


24.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

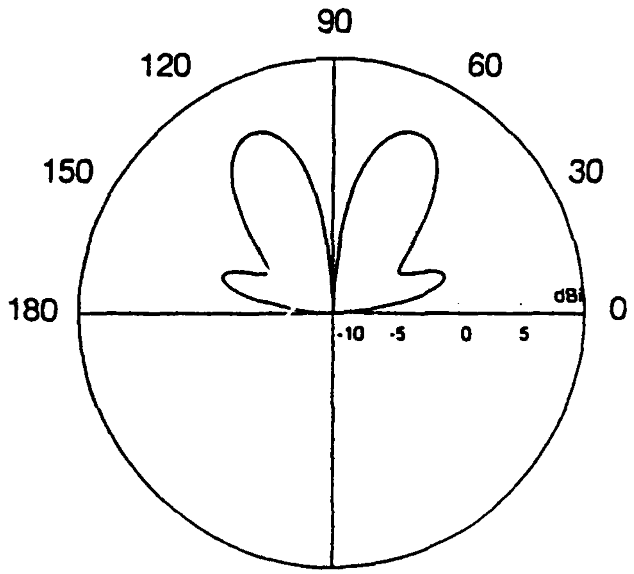


24.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 47. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 24.5 MHz)

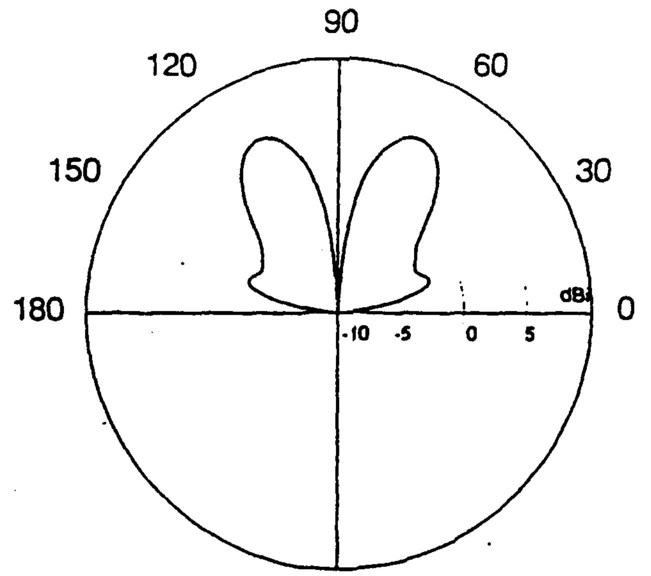


25 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

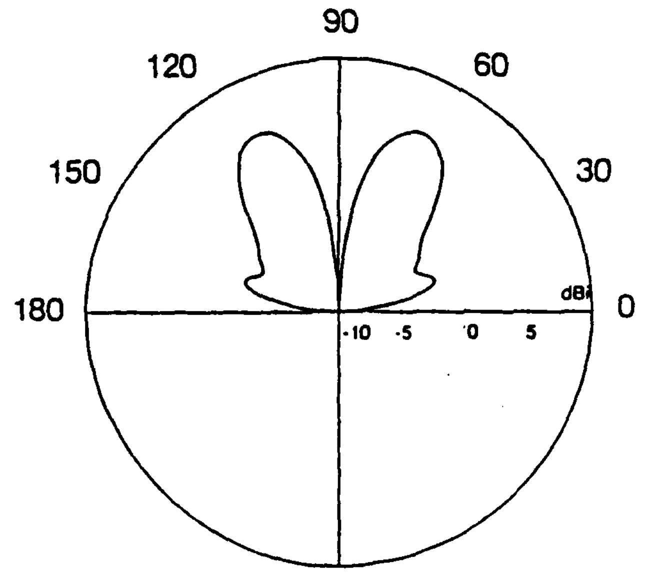


25 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 48. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 25.0 MHz)



25.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



25.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 49. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 25.5 MHz)

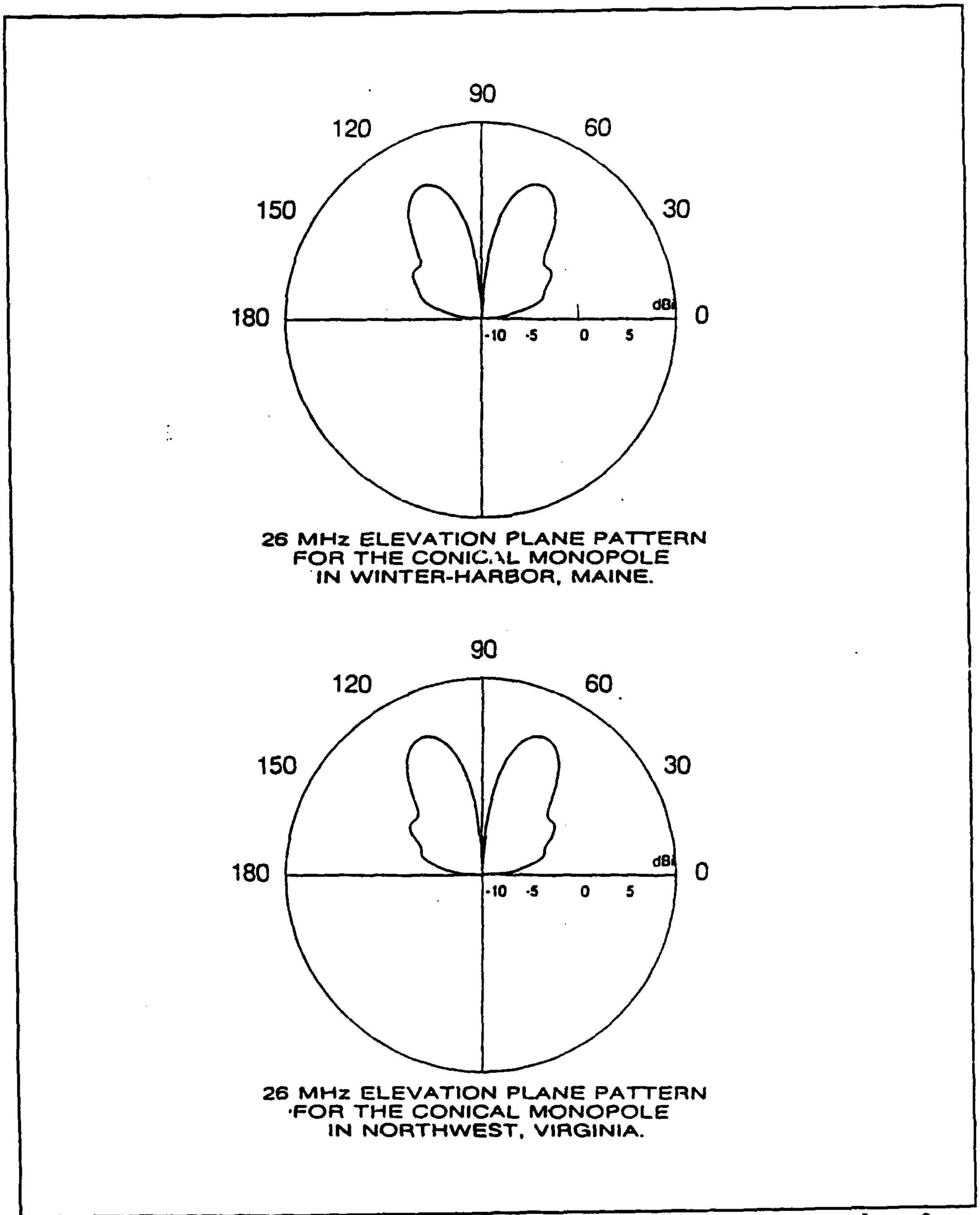
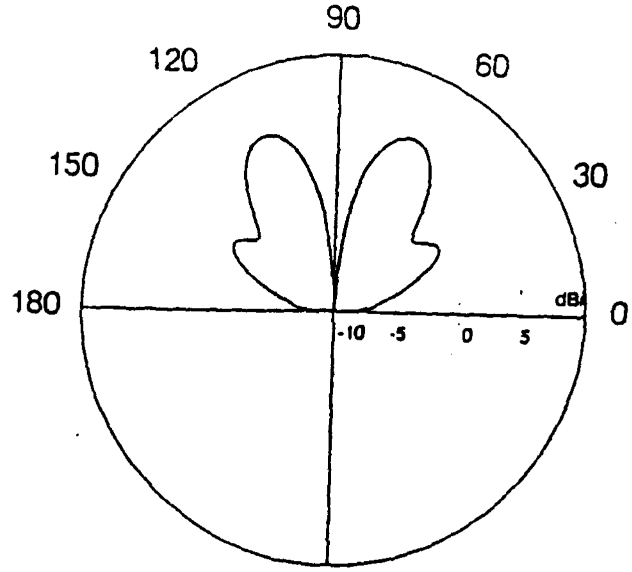
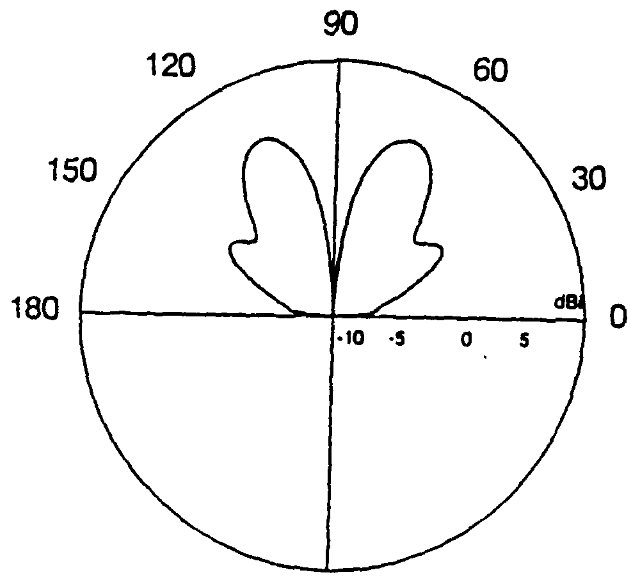


Figure 50. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 26.0 MHz)

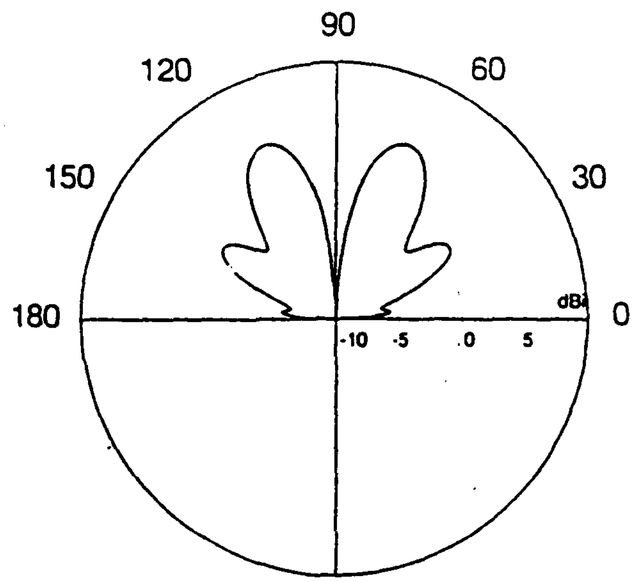


26.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

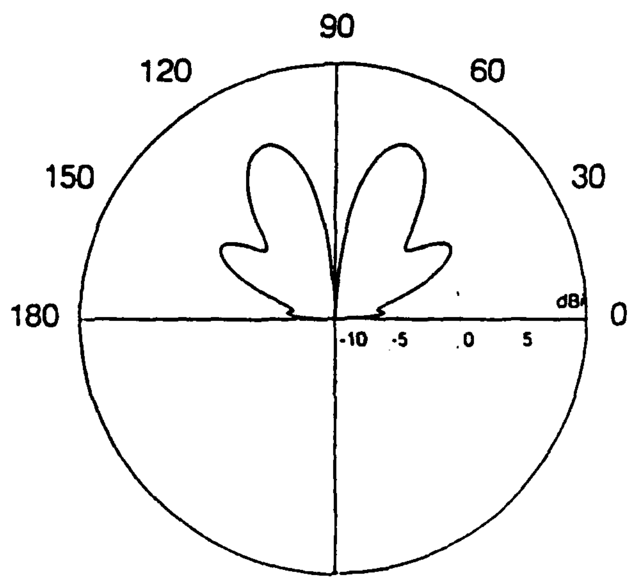


26.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 51. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 26.5 MHz)

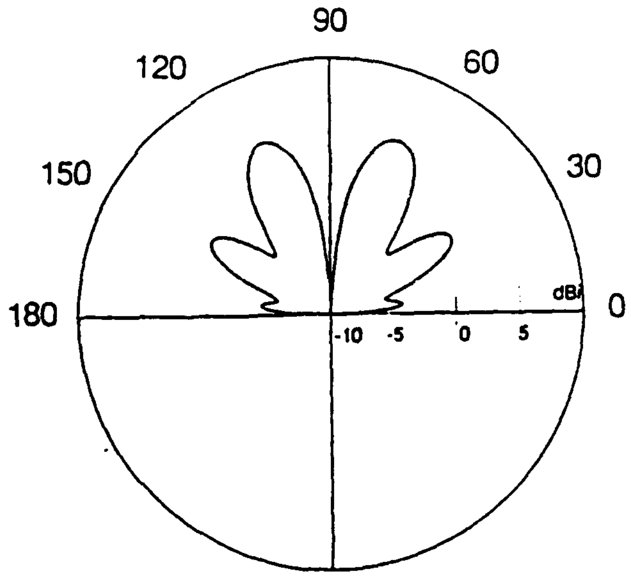


27 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

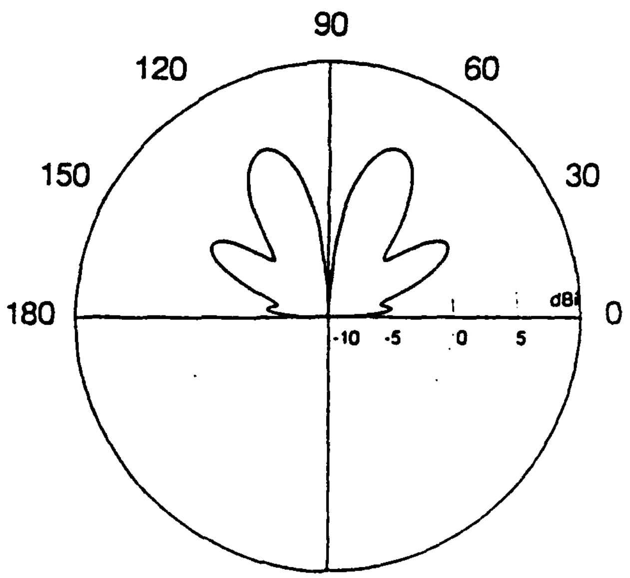


27 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 52. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 27.0 MHz)

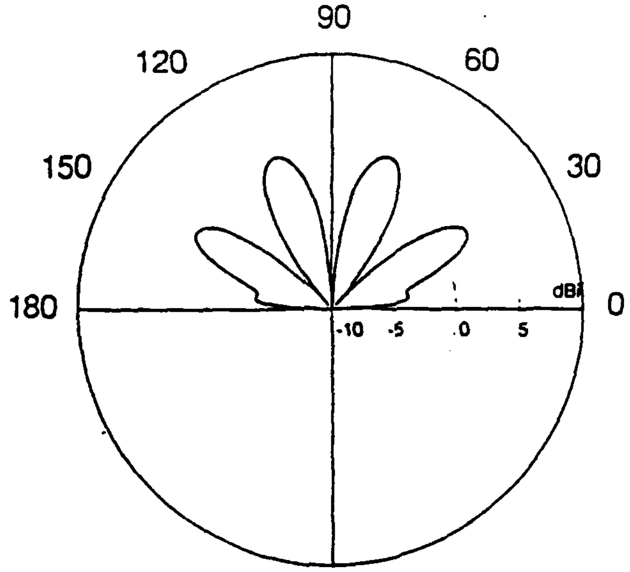


27.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

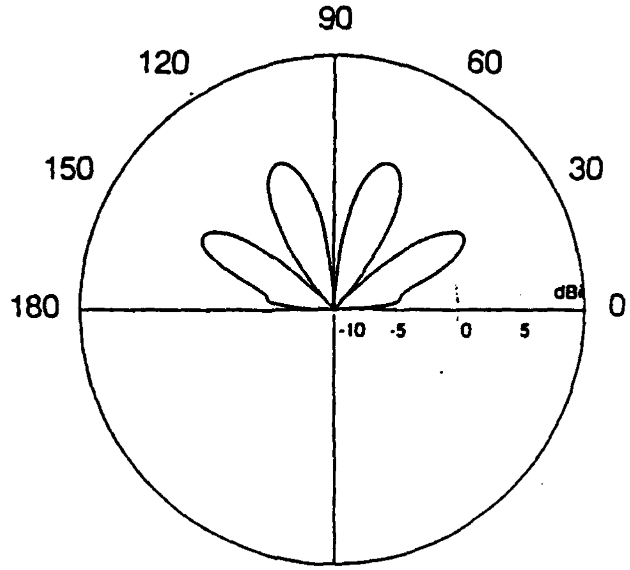


27.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 53. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 27.5 MHz)



28 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



28 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 54. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 28.0 MHz)

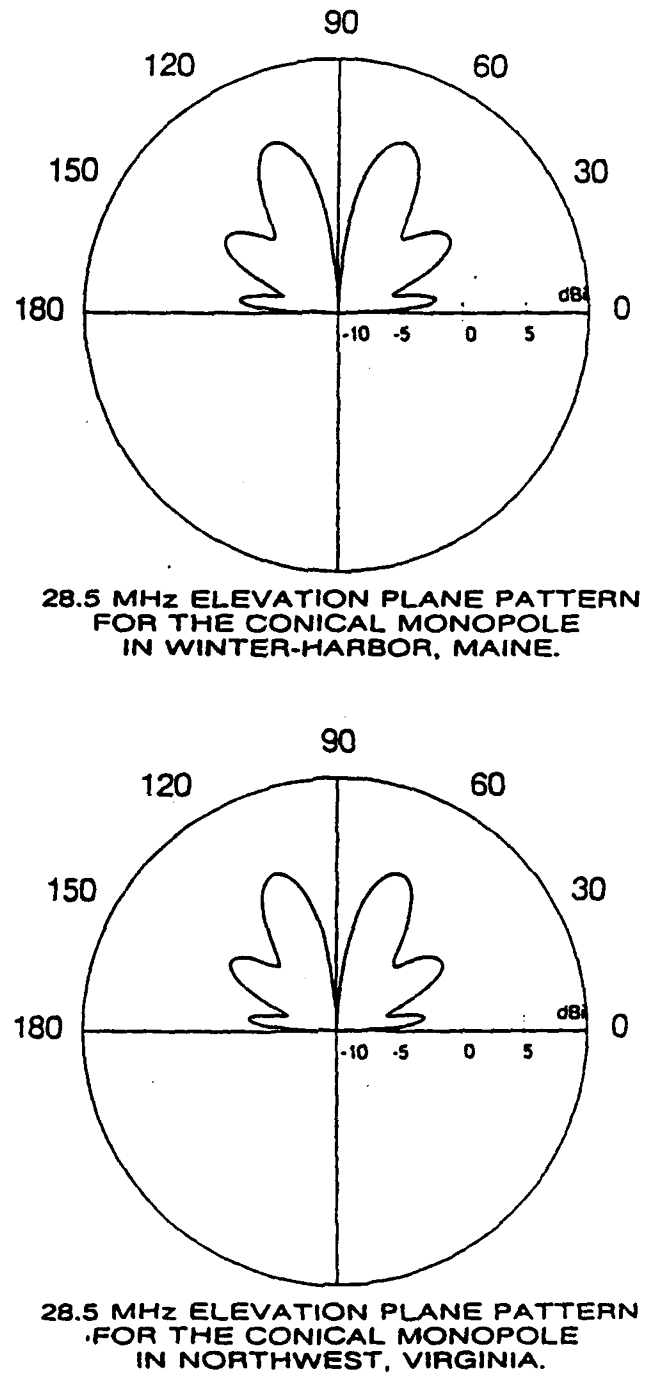
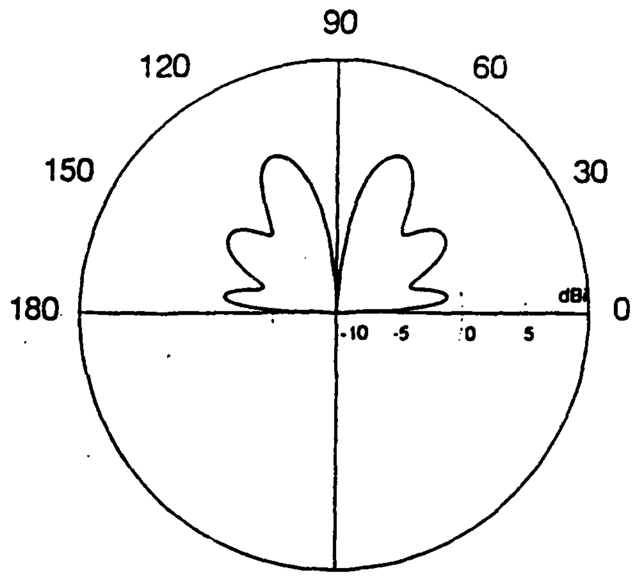
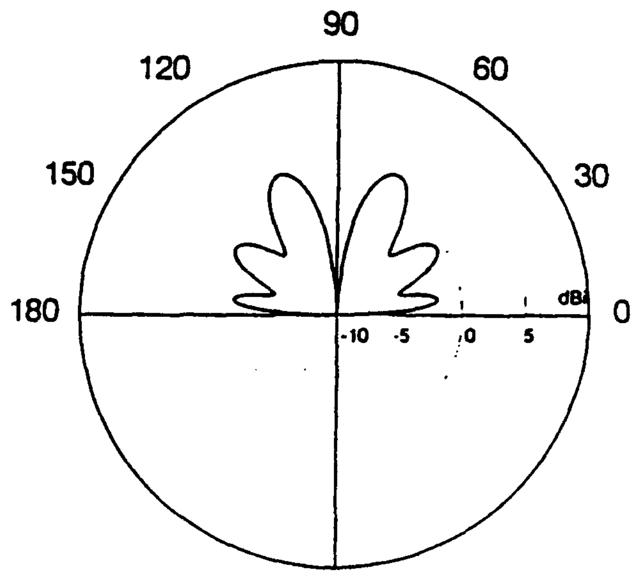


Figure 55. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 28.5 MHz)

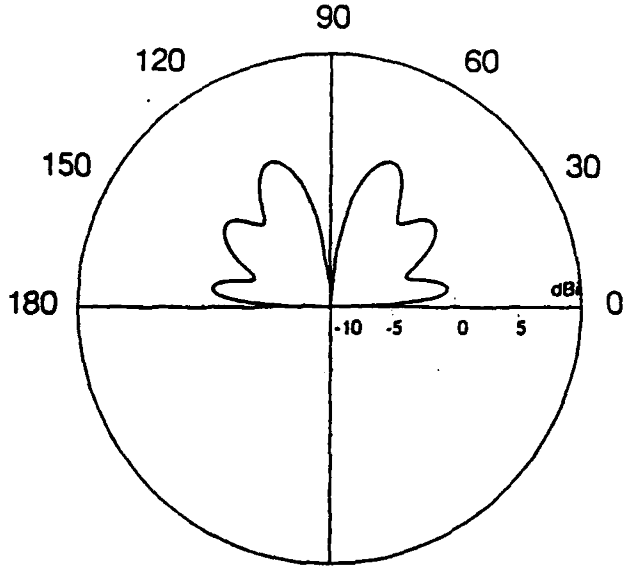


29 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.

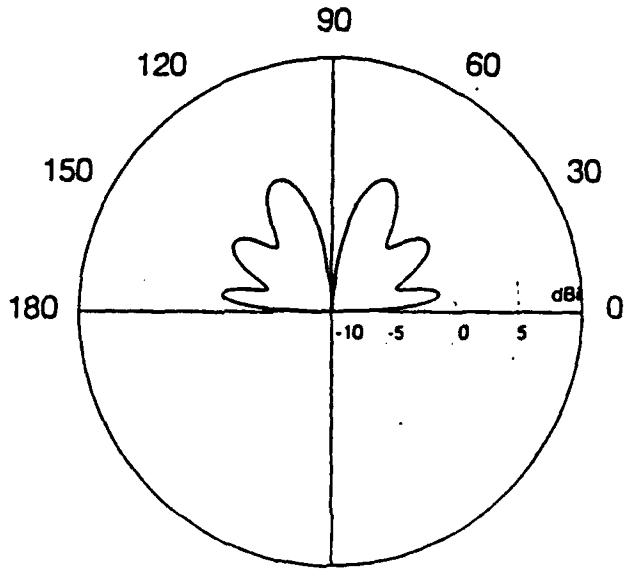


29 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 56. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 29.0 MHz)



29.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN WINTER-HARBOR, MAINE.



29.5 MHz ELEVATION PLANE PATTERN
FOR THE CONICAL MONOPOLE
IN NORTHWEST, VIRGINIA.

Figure 57. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 29.5 MHz)

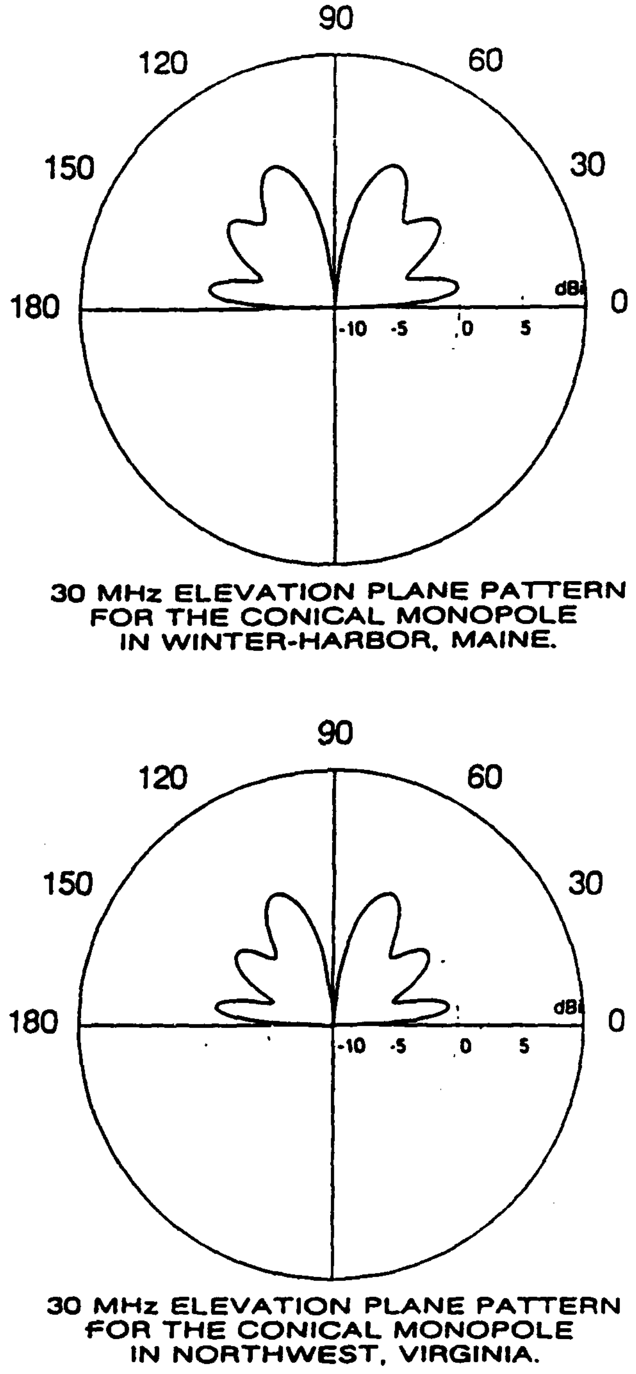


Figure 58. Radiation Patterns for the Conical Monopole Over Finite Ground at Winter Harbor, ME, and Northwest, VA. (Frequency = 30.0 MHz)

APPENDIX C. MEASURED INPUT IMPEDANCE AND VSWR AT WINTER HARBOR, ME, AND NORTHWEST, VA.

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY AT NSGA, WINTER HARBOR, ME.

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
2.00	45.0	-74.4	7.3
2.10	38.4	-70.5	6.0
2.20	32.5	-65.6	5.1
2.30	27.5	-58.3	4.3
2.40	23.7	-48.8	3.6
2.50	21.1	-38.0	3.2
2.60	19.9	-24.2	2.8
2.70	20.2	-10.8	2.5
2.80	21.4	1.4	2.3
2.90	24.0	11.3	2.1
3.00	26.9	18.0	2.0
3.10	30.4	23.4	1.9
3.20	34.1	27.3	1.9
3.30	38.1	29.2	1.8
3.40	42.4	30.8	1.8
3.50	46.7	31.6	1.8
3.60	50.9	31.9	1.8
3.70	55.3	31.6	1.8
3.80	59.7	30.8	1.8
3.90	63.9	29.7	1.8
4.00	68.2	28.6	1.8
4.10	72.1	26.9	1.9
4.20	76.0	24.9	1.9
4.30	79.7	22.9	1.9
4.40	83.0	20.7	1.9
4.50	86.0	18.3	1.9
4.60	88.7	15.7	1.9
4.70	90.9	13.2	1.9
4.80	92.4	10.5	1.9
4.90	93.5	7.8	1.9
5.00	94.1	5.2	1.9
5.10	94.2	2.2	1.9
5.20	93.6	-0.4	1.9
5.30	93.0	-2.8	1.9
5.40	91.0	-4.8	1.8
5.50	87.8	-6.2	1.8
5.60	88.0	-8.2	1.8
5.70	86.0	-10.2	1.8
5.80	84.1	-11.5	1.8
5.90	81.9	-13.0	1.7

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, WINTER HARBOR, ME.
(Continued)

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
6.00	79.6	-14.1	1.7
6.10	77.3	-15.0	1.7
6.20	74.8	-16.0	1.6
6.30	72.2	-16.7	1.6
6.40	69.8	-17.2	1.6
6.50	67.0	-17.3	1.5
6.60	64.3	-17.4	1.5
6.70	61.5	-16.9	1.4
6.80	59.1	-16.2	1.4
6.90	56.6	-15.2	1.3
7.00	54.4	-13.9	1.3
7.10	52.5	-12.1	1.2
7.20	50.7	-9.8	1.2
7.30	49.3	-7.2	1.1
7.40	48.1	-4.3	1.1
7.50	47.4	-1.2	1.1
7.60	47.1	2.1	1.1
7.70	47.3	4.9	1.1
7.80	47.8	9.2	1.2
7.90	49.5	13.7	1.3
8.00	50.9	16.0	1.3
8.10	53.4	18.9	1.4
8.20	56.5	21.3	1.5
8.30	60.2	23.3	1.6
8.40	64.4	24.5	1.7
8.50	69.2	25.0	1.8
8.60	74.2	24.8	1.8
8.70	79.7	23.9	1.9
8.80	85.0	22.4	2.0
8.90	90.0	20.3	2.0
9.00	94.6	17.9	2.1
9.10	98.0	14.8	2.1
9.20	101.1	11.6	2.1
9.30	103.1	8.4	2.1
9.40	103.5	4.9	2.1
9.50	102.9	1.7	2.1
9.60	101.0	-1.4	2.0
9.70	97.3	-3.6	2.0
9.80	92.6	-4.7	1.9
9.90	87.8	-3.8	1.8

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, WINTER HARBOR, ME.
(Continued)

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
10.00	85.1	0.7	1.7
10.10	94.3	8.7	1.9
10.20	119.6	5.4	2.4
10.30	125.6	-10.4	2.6
10.40	112.7	-18.1	2.4
10.50	101.1	-21.2	2.3
10.60	92.7	-21.8	2.1
10.70	85.8	-19.8	1.9
10.80	99.5	-23.5	2.3
10.90	79.5	-26.3	2.0
11.00	72.9	-23.8	1.8
11.10	68.4	-20.6	1.6
11.20	65.3	-16.7	1.5
11.30	64.1	-11.9	1.4
11.40	65.1	-6.6	1.3
11.50	69.1	-2.1	1.4
11.60	75.8	0.3	1.5
11.70	83.8	-0.2	1.7
11.80	90.4	-1.7	1.8
11.90	95.7	-6.0	1.9
12.00	99.0	-10.2	2.0
12.10	99.5	-14.6	2.1
12.20	98.2	-18.4	2.1
12.30	95.7	-21.5	2.2
12.40	92.8	-23.9	2.2
12.50	89.8	-26.0	2.2
12.60	86.7	-27.5	2.1
12.70	83.8	-28.7	2.1
12.80	81.0	-29.8	2.1
12.90	78.4	-30.5	2.1
13.00	76.0	-31.1	2.1
13.10	73.7	-31.5	2.0
13.20	71.5	-31.8	2.0
13.30	69.3	-31.9	2.0
13.40	67.4	-32.0	2.0
13.50	65.4	-32.2	1.9
13.60	63.4	-32.0	1.9
13.70	61.4	-31.8	1.9
13.80	59.6	-31.5	1.8
13.90	57.5	-30.9	1.8

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, WINTER HARBOR, ME.
(Continued)

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
14.00	55.6	-30.1	1.8
14.10	53.3	-29.0	1.7
14.20	50.5	-26.7	1.6
14.30	47.8	-21.2	1.5
14.40	50.1	-9.7	1.2
14.50	67.6	-9.9	1.4
14.60	69.1	-22.8	1.7
14.70	64.1	-27.1	1.7
14.80	60.4	-28.3	1.7
14.90	57.7	-28.5	1.7
15.00	55.8	-28.5	1.7
15.10	54.2	-28.0	1.7
15.20	52.8	-27.4	1.7
15.30	51.9	-26.6	1.6
15.40	51.3	-26.1	1.6
15.50	50.6	-25.5	1.6
15.60	49.6	-25.0	1.6
15.70	48.9	-24.0	1.5
15.80	48.8	-22.9	1.5
15.90	49.6	-22.1	1.5
16.00	51.4	-23.9	1.5
16.10	48.6	-27.7	1.7
16.20	45.0	-26.5	1.6
16.30	43.5	-24.3	1.6
16.40	42.9	-22.3	1.5
16.50	42.7	-21.0	1.5
16.60	42.2	-19.7	1.5
16.70	42.0	-18.6	1.5
16.80	41.6	-17.1	1.4
16.90	41.5	-16.3	1.4
17.00	41.2	-15.4	1.4
17.10	41.3	-14.1	1.4
17.20	41.1	-13.2	1.4
17.30	41.0	-12.2	1.3
17.40	41.0	-11.2	1.3
17.50	41.1	-10.4	1.3
17.60	41.1	-9.5	1.3
17.70	41.1	-8.7	1.3
17.80	41.2	-8.1	1.3
17.90	41.3	-7.1	1.3

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, WINTER HARBOR, ME.
(Continued)

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
18.00	41.6	-6.3	1.2
18.10	41.5	-5.6	1.2
18.20	41.6	-4.8	1.2
18.30	41.7	-3.9	1.2
18.40	42.0	-3.1	1.2
18.50	42.2	-2.3	1.2
18.60	42.4	-1.5	1.2
18.70	42.8	-0.6	1.2
18.80	43.1	0.2	1.2
18.90	43.6	0.9	1.1
19.00	44.2	1.7	1.1
19.10	44.7	2.5	1.1
19.20	45.4	3.1	1.1
19.30	46.1	3.8	1.1
19.40	46.9	4.3	1.1
19.50	47.9	4.8	1.1
19.60	48.9	5.2	1.1
19.70	50.1	5.6	1.1
19.80	51.4	5.8	1.1
19.90	52.9	5.8	1.1
20.00	54.7	5.5	1.1
20.10	56.9	4.9	1.2
20.20	59.4	4.0	1.2
20.30	62.5	2.2	1.3
20.40	66.1	-1.4	1.3
20.50	68.1	-8.1	1.4
20.60	63.2	-15.5	1.4
20.70	55.8	-16.9	1.4
20.80	52.2	-14.7	1.3
20.90	50.9	-13.5	1.3
21.00	49.7	-13.4	1.3
21.10	47.2	-13.2	1.3
21.20	44.8	-10.1	1.2
21.30	45.6	-6.1	1.2
21.40	47.3	-4.8	1.1
21.50	48.6	-4.5	1.1
21.60	49.4	-4.8	1.1
21.70	49.9	-5.2	1.1
21.80	50.3	-5.6	1.1
21.90	50.4	-5.9	1.1

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, WINTER HARBOR, ME.
(Continued)

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
22.00	50.2	-6.3	1.1
22.10	50.4	-6.6	1.1
22.20	50.5	-6.8	1.1
22.30	50.3	-7.1	1.1
22.40	50.2	-7.4	1.1
22.50	50.2	-7.6	1.1
22.60	50.0	-7.7	1.1
22.70	50.0	-7.9	1.1
22.80	49.9	-8.1	1.2
22.90	49.8	-8.2	1.2
23.00	49.7	-8.4	1.2
23.10	49.8	-8.7	1.2
23.20	49.8	-9.0	1.2
23.30	49.7	-9.2	1.2
23.40	49.6	-9.5	1.2
23.50	49.5	-9.8	1.2
23.60	49.3	-10.0	1.2
23.70	49.2	-10.1	1.2
23.80	49.2	-10.0	1.2
23.90	49.5	-10.0	1.2
24.00	49.9	-10.4	1.2
24.10	50.6	-10.9	1.2
24.20	51.0	-11.9	1.2
24.30	51.3	-13.0	1.3
24.40	51.3	-14.4	1.3
24.50	51.2	-15.9	1.3
24.60	50.9	-17.3	1.4
24.70	50.3	-18.8	1.4
24.80	49.6	-20.5	1.4
24.90	48.8	-22.0	1.5
25.00	47.6	-23.8	1.5
25.10	46.4	-25.0	1.6
25.20	45.0	-26.2	1.6
25.30	43.6	-27.4	1.7
25.40	42.1	-28.2	1.7
25.50	40.5	-29.0	1.8
25.60	38.9	-29.6	1.8
25.70	37.3	-29.9	1.9
25.80	35.8	-30.0	1.9
25.90	34.2	-29.9	2.0

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, WINTER HARBOR, ME.
(Continued)

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
26.00	33.0	-29.6	2.0
26.10	31.5	-28.9	2.0
26.20	30.2	-28.2	2.1
26.30	28.9	-27.3	2.1
26.40	27.8	-26.1	2.2
26.50	26.8	-24.7	2.2
26.60	25.9	-23.4	2.2
26.70	25.0	-21.4	2.2
26.80	24.2	-19.4	2.3
26.90	23.6	-17.6	2.3
27.00	23.0	-15.7	2.3
27.10	22.5	-13.6	2.3
27.20	22.1	-11.3	2.3
27.30	21.8	-9.2	2.3
27.40	21.5	-7.1	2.4
27.50	21.3	-4.7	2.4
27.60	21.1	-2.5	2.4
27.70	21.0	-0.3	2.4
27.80	21.0	1.9	2.4
27.90	20.8	4.2	2.4
28.00	20.7	7.1	2.4
28.10	20.7	10.4	2.5
28.20	21.3	14.8	2.5
28.30	23.3	17.5	2.3
28.40	24.4	15.9	2.2
28.50	25.1	16.4	2.1
28.60	25.9	14.8	2.0
28.70	25.7	13.9	2.0
28.80	25.7	13.9	2.0
28.90	25.5	13.9	2.1
29.00	25.4	14.9	2.1
29.10	25.4	15.2	2.1
29.20	25.5	15.8	2.1
29.30	25.5	16.6	2.1
29.40	25.5	17.1	2.1
29.50	25.5	17.7	2.1
29.60	25.6	18.4	2.1
29.70	25.6	18.8	2.1
29.80	25.8	18.7	2.1
29.90	25.8	19.3	2.1

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, WINTER HARBOR, ME.
(Continued)

FREQ (MHz)	Z (ohms)	THETA (deg)	VSWR (Z:50)
30.00	24.9	20.0	2.2
30.10	24.3	20.5	2.3
30.20	25.2	21.2	2.2
30.30	26.7	25.3	2.2
30.40	28.5	29.7	2.2
30.50	29.1	35.2	2.4
30.60	29.9	25.1	2.0
30.70	28.2	24.5	2.1
30.80	27.1	24.7	2.2
30.90	26.9	26.2	2.2

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, NORTHWEST, VA.

Frequency (MHz)	Z (ohms)	Theta (deg.)	VSWR (Z:50)
2.00	41.3	-75.4	8.0
2.10	35.7	-70.3	6.1
2.20	30.2	-64.0	5.0
2.30	25.5	-56.1	4.2
2.40	21.9	-45.7	3.6
2.50	19.6	-32.3	3.2
2.60	19.4	-17.5	2.7
2.70	19.6	-4.9	2.6
2.80	21.9	7.3	2.3
2.90	24.6	16.1	2.2
3.00	28.0	22.1	2.0
3.10	31.8	26.3	2.0
3.20	35.0	29.5	1.9
3.30	39.9	30.9	1.8
3.40	39.1	20.0	1.5
3.50	48.5	32.7	1.8
3.60	52.9	32.0	1.8
3.70	56.7	31.2	1.8
3.80	62.1	31.0	1.8
3.90	65.4	29.2	1.8
4.00	70.0	27.8	1.8
4.10	73.7	26.0	1.9
4.20	77.4	24.1	1.9
4.30	80.5	22.2	1.9
4.40	83.3	19.8	1.9
4.50	86.8	17.2	1.9
4.60	89.0	14.7	1.9
4.70	91.1	12.1	1.9
4.80	89.4	10.6	1.8
4.90	92.1	6.1	1.9
5.00	93.4	4.4	1.9
5.10	93.0	1.7	1.9
5.20	87.6	1.6	1.8
5.30	91.6	-3.7	1.8
5.40	89.2	-5.2	1.8
5.50	86.1	-7.8	1.8
5.60	87.4	-9.7	1.8
5.70	84.7	-10.8	1.8
5.80	82.4	-12.6	1.7
5.90	80.3	-13.9	1.7

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, NORTHWEST, VA.
(Continued)

Frequency (MHz)	Z (ohms)	Theta (deg.)	VSWR (Z:50)
6.00	77.2	-14.3	1.7
6.10	74.3	-15.5	1.6
6.20	72.6	-16.1	1.6
6.30	69.6	-16.7	1.6
6.40	66.9	-16.4	1.5
6.50	64.8	-16.5	1.5
6.60	62.8	-16.4	1.4
6.70	60.5	-16.6	1.4
6.80	59.7	-14.5	1.4
6.90	56.5	-13.5	1.3
7.00	54.4	-12.4	1.3
7.10	52.8	-10.4	1.2
7.20	41.5	-16.1	1.4
7.30	49.7	-5.8	1.1
7.40	49.0	-3.2	1.1
7.50	47.8	0.6	1.0
7.60	48.3	3.5	1.1
7.70	49.1	6.4	1.1
7.80	37.7	-1.7	1.3
7.90	51.8	12.7	1.3
8.00	54.2	15.6	1.3
8.10	57.6	18.2	1.4
8.20	60.5	19.2	1.5
8.30	63.8	20.6	1.6
8.40	68.4	20.4	1.6
8.50	72.6	19.3	1.7
8.60	76.5	19.5	1.7
8.70	78.7	18.6	1.8
8.80	84.6	16.2	1.8
8.90	87.1	13.3	1.8
9.00	91.8	12.3	1.9
9.10	92.8	8.6	1.9
9.20	95.2	6.6	1.9
9.30	95.3	3.0	1.9
9.40	95.7	0.2	1.9
9.50	95.1	-2.2	1.9
9.60	65.3	-4.9	1.3
9.70	90.3	-5.4	1.8
9.80	88.9	-5.9	1.8
9.90	84.8	-6.1	1.7

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, NORTHWEST, VA.
(Continued)

Frequency (MHz)	Z (ohms)	Theta (deg.)	VSWR (Z:50)
10.00	82.5	-3.4	1.7
10.10	88.8	1.6	1.8
10.20	112.1	-0.2	2.2
10.30	113.9	-15.9	2.4
10.40	56.9	-10.3	1.2
10.50	90.0	-23.7	2.1
10.60	57.9	-20.0	1.5
10.70	76.2	-20.1	1.8
10.80	64.5	-9.4	1.4
10.90	76.7	-27.8	2.0
11.00	69.7	-25.6	1.8
11.10	65.2	-23.1	1.6
11.20	61.4	-19.7	1.5
11.30	60.7	-15.0	1.4
11.40	61.3	-10.1	1.3
11.50	63.5	-5.3	1.3
11.60	68.8	-1.7	1.4
11.70	48.1	7.2	1.1
11.80	83.3	-2.8	1.7
11.90	88.6	-6.2	1.8
12.00	91.3	-10.2	1.9
12.10	93.2	-14.6	2.0
12.20	91.8	-18.5	2.0
12.30	89.9	-21.8	2.0
12.40	87.2	-24.3	2.1
12.50	84.0	-26.5	2.1
12.60	81.0	-27.8	2.0
12.70	78.2	-28.9	2.0
12.80	75.6	-29.8	2.0
12.90	73.0	-30.5	2.0
13.00	70.7	-30.8	2.0
13.10	67.9	-31.6	1.9
13.20	66.5	-31.3	1.9
13.30	64.6	-31.2	1.9
13.40	62.8	-31.3	1.9
13.50	61.1	-31.1	1.8
13.60	59.4	-30.8	1.8
13.70	42.5	3.8	1.2
13.80	56.3	-30.2	1.8
13.90	54.5	-29.9	1.7

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, NORTHWEST, VA.
(Continued)

Frequency (MHz)	Z (ohms)	Theta (deg.)	VSWR (Z:50)
14.00	52.6	-29.2	1.7
14.10	50.5	-28.3	1.7
14.20	48.0	-26.8	1.6
14.30	45.0	-23.4	1.5
14.40	36.7	-11.9	1.5
14.50	52.8	0.9	1.1
14.60	68.8	-12.9	1.5
14.70	64.4	-22.1	1.6
14.80	60.3	-24.9	1.6
14.90	57.1	-25.4	1.6
15.00	54.9	-25.5	1.6
15.10	53.4	-25.5	1.6
15.20	52.2	-25.2	1.6
15.30	49.1	-26.0	1.6
15.40	50.3	-24.4	1.6
15.50	49.9	-23.7	1.5
15.60	43.2	-18.7	1.4
15.70	47.8	-21.1	1.5
15.80	46.3	-20.5	1.5
15.90	47.1	-20.5	1.4
16.00	48.1	-21.1	1.5
16.10	47.4	-24.3	1.6
16.20	43.3	-23.8	1.6
16.30	42.8	-21.7	1.5
16.40	43.4	-20.8	1.5
16.50	42.9	-20.3	1.5
16.60	42.8	-19.1	1.5
16.70	42.0	-18.7	1.5
16.80	41.7	-17.8	1.4
16.90	41.4	-16.8	1.4
17.00	41.0	-15.9	1.4
17.10	40.8	-15.0	1.4
17.20	40.5	-13.8	1.4
17.30	40.4	-13.3	1.4
17.40	40.0	-12.7	1.4
17.50	40.0	-11.6	1.4
17.60	39.7	-10.9	1.4
17.70	39.7	-9.7	1.3
17.80	39.6	-8.8	1.3
17.90	39.6	-7.7	1.3

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, NORTHWEST, VA.
(Continued)

Frequency (MHz)	Z (ohms)	Theta (deg.)	VSWR (Z:50)
18.00	39.7	-6.7	1.3
18.10	39.7	-5.7	1.3
18.20	39.7	-4.8	1.3
18.30	40.0	-3.8	1.3
18.40	40.1	-2.6	1.3
18.50	40.4	-1.8	1.2
18.60	40.8	-0.7	1.2
18.70	41.3	0.2	1.2
18.80	41.9	1.0	1.2
18.90	42.4	1.8	1.2
19.00	43.1	2.5	1.2
19.10	43.9	2.9	1.1
19.20	42.1	6.1	1.2
19.30	45.5	3.9	1.1
19.40	45.5	4.8	1.1
19.50	47.4	4.2	1.1
19.60	48.3	4.1	1.1
19.70	48.9	4.1	1.1
19.80	50.4	3.7	1.1
19.90	51.5	3.3	1.1
20.00	52.5	2.7	1.1
20.10	54.0	2.0	1.1
20.20	55.5	1.1	1.1
20.30	57.6	-0.4	1.2
20.40	60.6	-3.1	1.2
20.50	62.8	-10.0	1.3
20.60	55.7	-18.1	1.4
20.70	48.4	-15.9	1.3
20.80	44.5	-11.8	1.3
20.90	46.3	-12.0	1.3
21.00	44.7	-11.8	1.3
21.10	42.1	-9.3	1.3
21.20	42.4	-4.6	1.2
21.30	43.5	-2.8	1.2
21.40	45.8	-2.2	1.1
21.50	46.8	-3.0	1.1
21.60	47.2	-3.6	1.1
21.70	47.5	-4.0	1.1
21.80	47.5	-4.0	1.1
21.90	47.7	-4.6	1.1

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, NORTHWEST, VA.
(Continued)

Frequency (MHz)	Z (ohms)	Theta (deg.)	VSWR (Z:50)
22.00	47.6	-4.8	1.1
22.10	47.7	-5.2	1.1
22.20	47.6	-5.3	1.1
22.30	30.6	-9.7	1.7
22.40	47.4	-5.6	1.1
22.50	47.4	-5.9	1.1
22.60	47.4	-6.0	1.1
22.70	47.3	-6.2	1.1
22.80	47.1	-6.4	1.1
22.90	47.1	-6.7	1.1
23.00	46.9	-7.0	1.1
23.10	46.9	-7.2	1.2
23.20	46.8	-7.4	1.2
23.30	46.5	-7.6	1.2
23.40	46.4	-11.5	1.2
23.50	47.1	-7.6	1.2
23.60	45.9	-4.9	1.1
23.70	44.2	-6.3	1.2
23.80	44.0	-6.2	1.2
23.90	43.9	-5.8	1.2
24.00	41.9	-4.7	1.2
24.10	44.7	-5.8	1.2
24.20	45.1	-6.1	1.2
24.30	45.1	-4.7	1.1
24.40	47.7	-8.2	1.2
24.50	47.4	-11.1	1.2
24.60	46.5	-12.4	1.3
24.70	46.4	-12.9	1.3
24.80	46.0	-14.2	1.3
24.90	45.4	-15.4	1.3
25.00	44.6	-16.4	1.4
25.10	43.8	-17.8	1.4
25.20	42.7	-18.4	1.4
25.30	41.8	-19.2	1.5
25.40	40.6	-19.9	1.5
25.50	39.5	-20.6	1.6
25.60	38.4	-20.9	1.6
25.70	37.2	-21.5	1.6
25.80	36.0	-21.1	1.7
25.90	34.4	-22.3	1.7

CM INPUT IMPEDANCE AND VSWR vs FREQUENCY
AT NSGA, NORTHWEST, VA.
(Continued)

Frequency (MHz)	Z (ohms)	Theta (deg.)	VSWR (Z:50)
26.00	33.8	-21.0	1.7
26.10	32.8	-20.9	1.8
26.20	31.8	-20.4	1.8
26.30	30.8	-20.0	1.8
26.40	29.9	-19.0	1.9
26.50	29.0	-17.6	1.9
26.60	28.1	-17.6	1.9
26.70	28.0	-16.6	1.9
26.80	28.0	-11.1	1.8
26.90	25.9	-9.0	2.0
27.00	25.3	-8.4	2.0
27.10	24.8	-6.9	2.0
27.20	25.5	-4.7	2.0
27.30	24.8	-8.3	2.1
27.40	25.6	-4.6	2.0
27.50	23.0	-4.8	2.2
27.60	22.7	-3.0	2.2
27.70	22.3	-1.4	2.2
27.80	22.0	0.4	2.3
27.90	21.4	3.0	2.3
28.00	20.9	6.0	2.4
28.10	29.6	-6.5	1.7
28.20	20.9	15.4	2.5
28.30	22.4	21.1	2.5
28.40	25.7	22.4	2.2
28.50	27.3	18.6	2.0
28.60	28.0	17.5	1.9
28.70	28.0	14.1	1.9
28.80	27.3	17.1	2.0
28.90	27.1	13.5	1.9
29.00	26.8	13.9	2.0
29.10	26.6	15.3	2.0
29.20	26.6	14.8	2.0
29.30	26.4	15.5	2.0
29.40	26.4	16.2	2.0
29.50	26.4	16.6	2.0
29.60	25.8	17.0	2.1
29.70	26.4	17.6	2.1
29.80	26.4	18.1	2.1
29.90	26.4	18.3	2.1

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