Measured radiation patterns of a monopole antenna over a circular ground plane

Grunwald, A.; Steen, Margaret M.; Wong, J. Y.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/21276067
Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB), 1969-05

ERB - 810

UNCLASSIFIED

NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

MEASURED RADIATION PATTERNS OF A MONOPOLE ANTENNA OVER A CIRCULAR GROUND PLANE

A. GRUNWALD, MARGARET M. STEEN, AND J.Y. WONG

OTTAWA

MAY 1969

ERB–810

UNCLASSIFIED

NATIONAL RESEARCH COUNCIL OF CANADA

RADIO AND ELECTRICAL ENGINEERING DIVISION

MEASURED RADIATION PATTERNS OF A MONOPOLE ANTENNA OVER A CIRCULAR GROUND PLANE

– A. GRUNWALD, MARGARET M. STEEN, AND J. Y. WONG –

OTTAWA

MAY 1969

ABSTRACT

Measured radiation patterns are presented for a base-fed monopole antenna over a circular ground plane for five different monopole lengths and ground plane diameters in the range between 0.5λ and 4λ. The calculated directive gain is also given for each antenna configuration.

CONTENTS

FIGURES

MEASURED RADIATION PATTERNS OF A MONOPOLE ANTENNA OVER A CIRCULAR GROUND PLANE

– A. Grunwald, Margaret M. Steen, and J.Y. Wong –

Introduction

The radiation problem of a base-driven monopole antenna over a circular ground plane has been treated analytically by several authors. Leitner and Spence [1] derived expressions for the radiation pattern in terms of a series of spheroidal functions; however, their analysis suffers the disadvantage of slow convergence for ground plane diameters larger than about one wavelength. Moreover, their work is restricted to the particular case of a quarter-wavelength monopole. By using a variational formulation, Storer [2] obtained relatively simple expressions for estimating the angular position of the prominent lobes near the axis of large-diameter ground planes. An integral-equation formulation of the problem is given by Tang [3] and a solution for the radiation pattern is obtained using an asymptotic expansion approach. In all three papers, the authors give few numerical results useful to the antenna engineer. A paper by Adachi, Kouyoumjian, and Van Sickle [4] describes a theoretical and experimental study of a finite conical antenna. The antenna consists of a cone of finite length excited at the tip by a linear element. The monopole over a circular ground plane is simply a special case of this conical configuration. Radiation patterns are calculated by approximating the current distribution on the finite cone with that of an infinite cone. Although useful quantitative results are given the analysis is restricted to cone lengths which are large compared to a wavelength and to the length of the antenna at the tip of the cone. In this report we are concerned with ground plane sizes in the range between 0.5λ and 4λ and measured radiation patterns are presented for an extended range of monopole lengths and ground plane diameters.

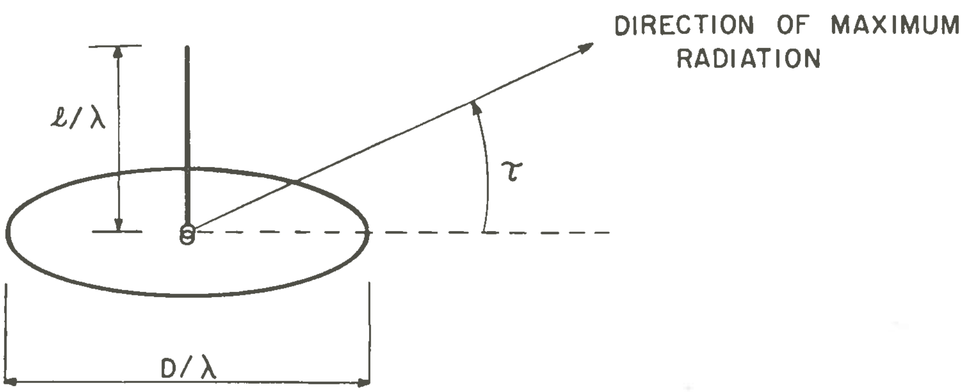
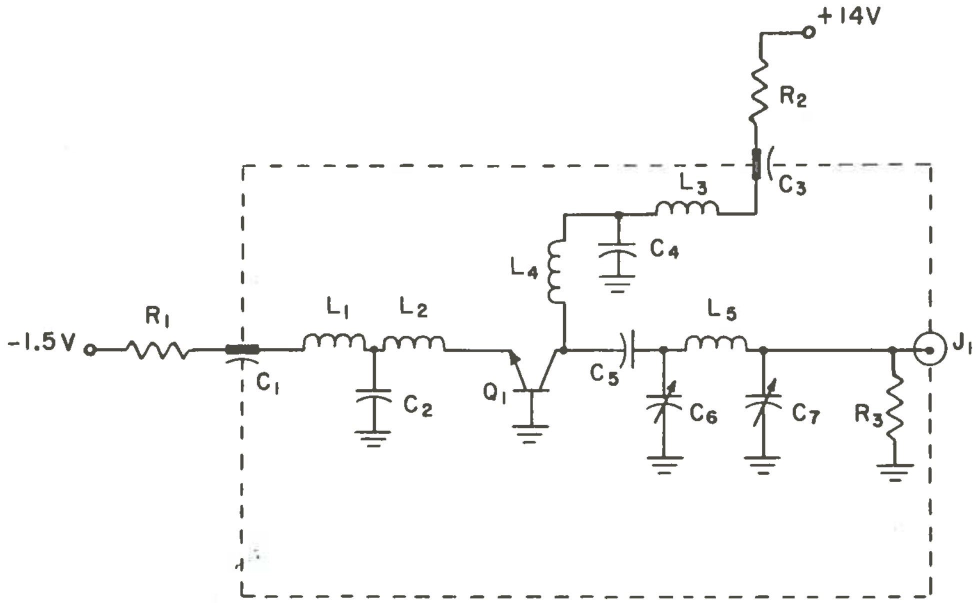


Figure 1 Antenna geometry of monopole over circular ground plane

Measurements

The antenna geometry used in the measurements is shown in Fig. 1. A total of 40 patterns were measured at a frequency of 900 MHz. In an effort to preserve pattern symmetry by avoiding distortion caused by the presence of a feed cable, the monopole was fed by a small oscillator located on the underside of the ground plane.



900 MHz OSCILLATOR

R_1 = 33Ω
R_2 = 120Ω
R_3 = 47Ω
C_1,C_3 = 1000pf FEEDTHROUGH
C_2,C_4 = 470pf STAND-OFF
C_5 = 120pf CERAMIC
C_6,C_7 = JOHANSON SC134-H2 PISTON CAP.
L_1,L_2,L_3,L_4 = .82μh R.F. CHOKES
L_5 = 6 TURNS NO.24 ENAMELED COPPER WIRE 5/32" DIA.
J_1 = UG-1094/U CONNECTOR
Q_1 = 2N3663

Figure 2 Schematic diagram of 900 MHz source oscillator

A schematic diagram of the source oscillator is given in Fig. 2. Five different monopole lengths corresponding to $\ell/\lambda = 0.25, 0.375, 0.50, 0.625$, and 0.75 and eight different ground plane diameters corresponding to $D/\lambda = 0.50, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5$, and 4.0 were used in the investigation.

Results

The patterns have been arranged so that for a given monopole length, the effect of the size of ground plane on the radiation pattern can be easily observed. The results are given in Figs. 3 - 7. In many applications the directive gain of the antenna is required and this quantity has been calculated for each case. The gain figure in decibels is shown on each pattern. Another quantity useful to the antenna engineer is the direction of the maximum radiation. In Fig 8 the beam tilt τ is plotted as a function of the ground plane diameter for three monopole lengths $\ell/\lambda = 0.25$, 0.50, and 0.75. The interesting feature to note about Fig. 8 is that the measured points do not fall on a smooth curve as one might have expected. (see Reference 4, Fig. 9). This fact is graphically illustrated for the case of the quarter-wavelength monopole. A reasonable argument for the apparent periodic behaviour of Fig. 8 can be advanced if one considers the radiation from the antenna as the superposition of a wave radiated directly from the monopole and a wave diffracted from the edge of the ground plane.

References

1. A. Leitner and R.D. Spence. Effect of circular ground plane on antenna radiation. J.Appl. Phys. 21: 1001 - 1006; 1950.
2. J.E. Storer. The radiation pattern of an antenna over a circular ground screen. J. Appl. Phys. 23: 588 - 593; 1952.
3. C.L. Tang. On the radiation pattern of a base-driven antenna over a circular conducting screen. J. Soc. Indust. Appl. Math., 10: 695 - 708; 1962.
4. S. Adachi, R.G. Kouyoumjian, and R.G. Van Sickle. The finite conical antenna. IRE Trans. on Antennas and Propagation, AP - 7: S406 - S411; 1959.

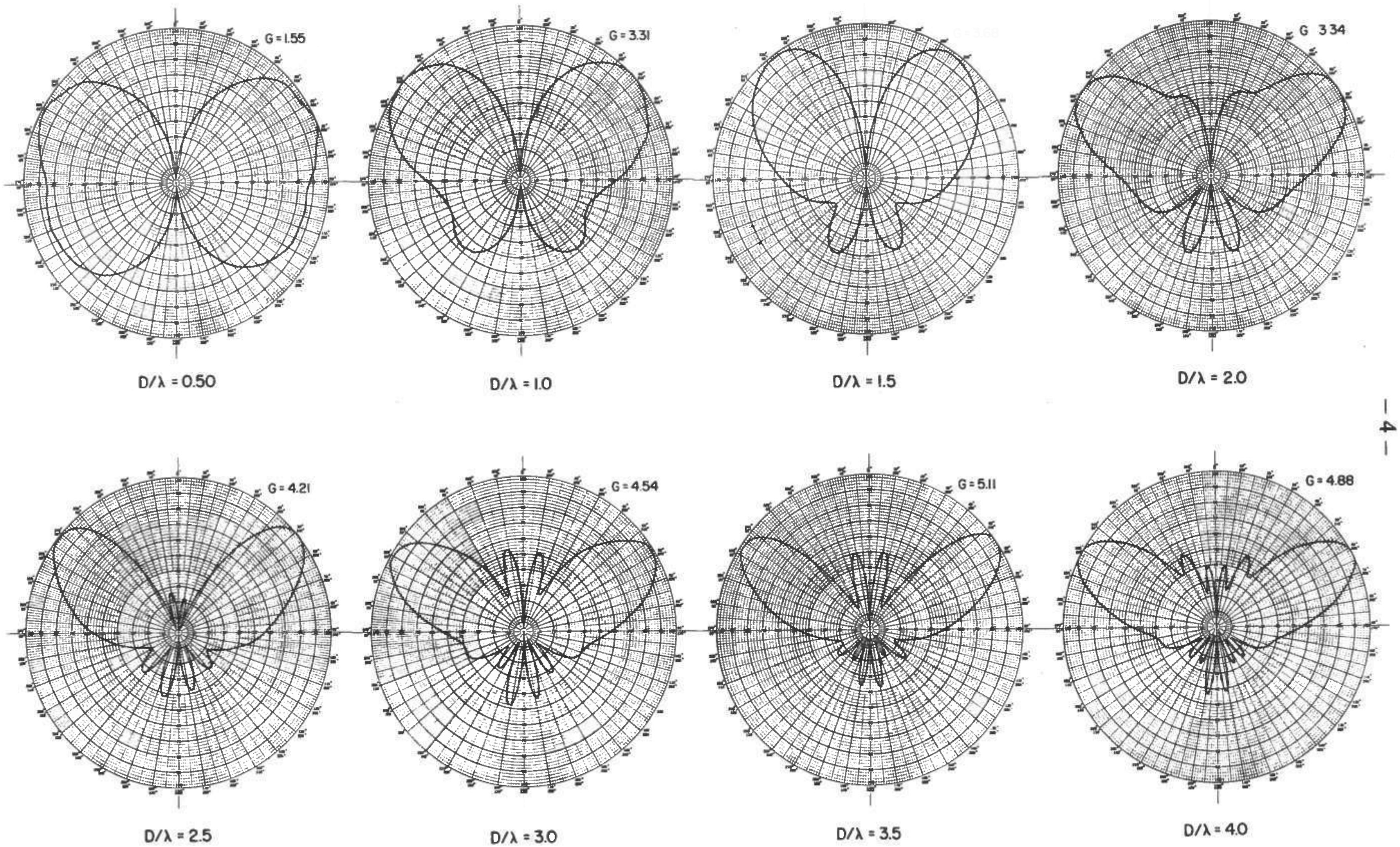


Figure 3 Radiation patterns of monopole over ground plane for ℓ/λ = 0.25

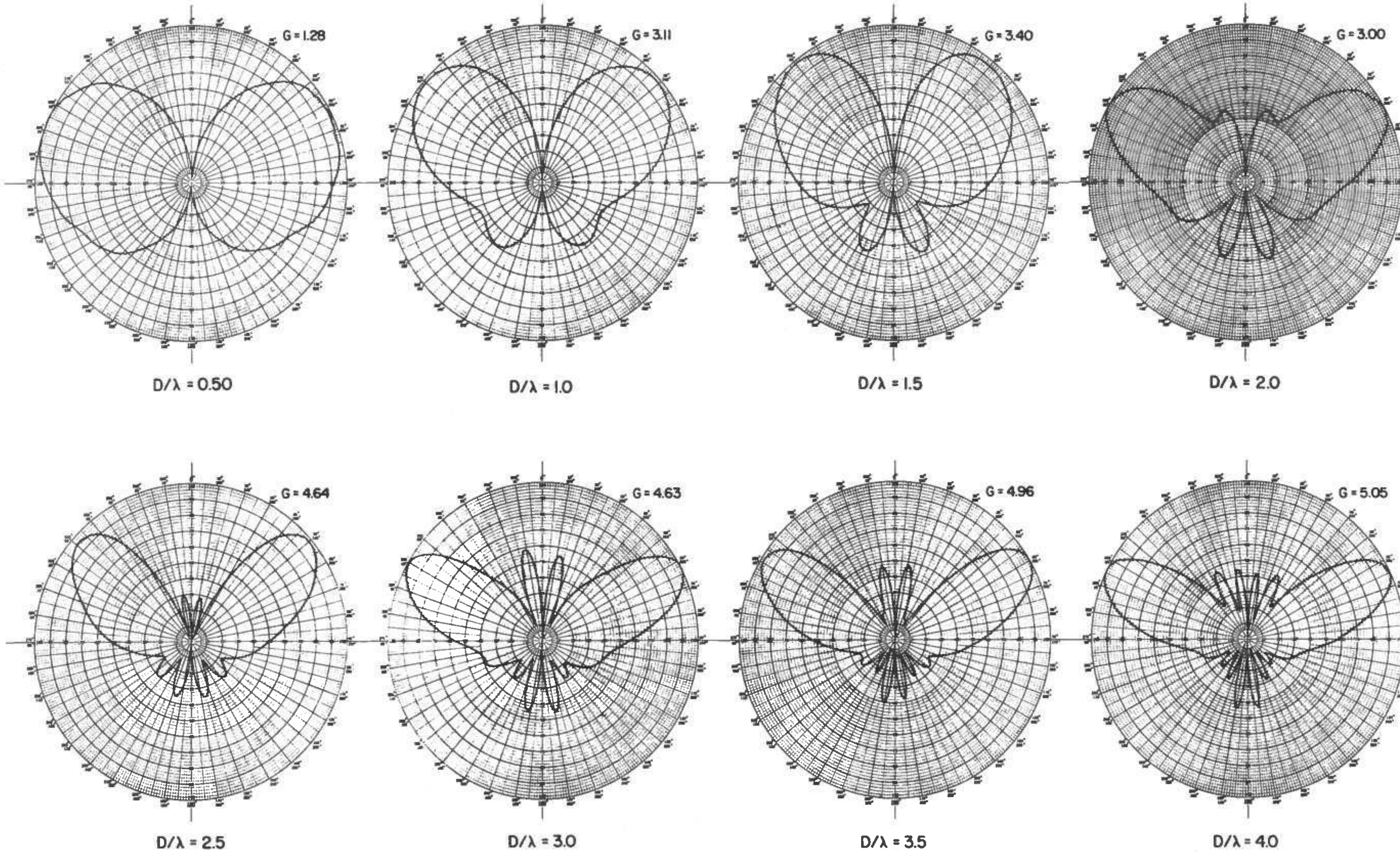


Figure 4 Radiation patterns of monopole over ground plane for $\ell/\lambda = 0.375$

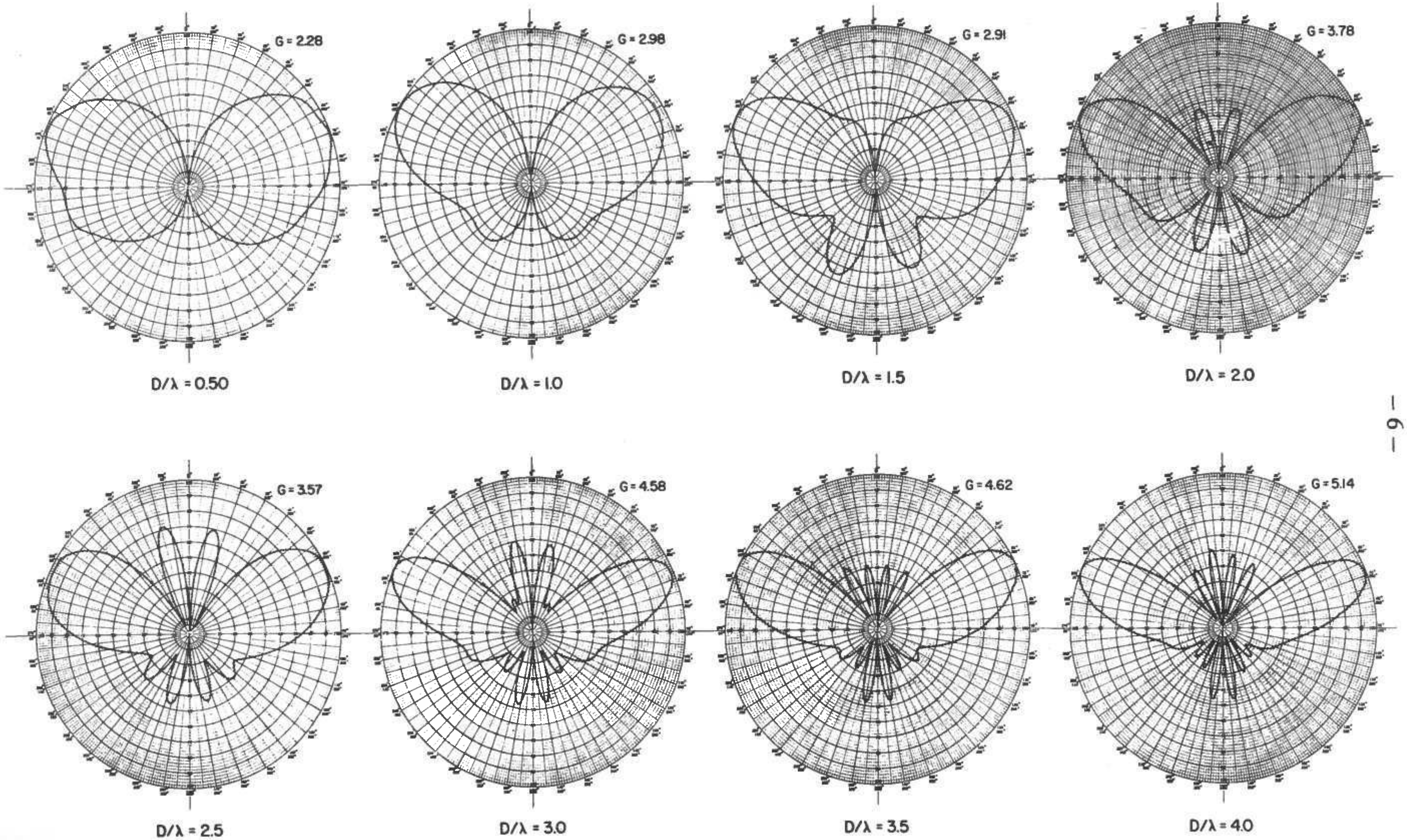


Figure 5 Radiation patterns of monopole over ground plane for $\ell/\lambda = 0.50$

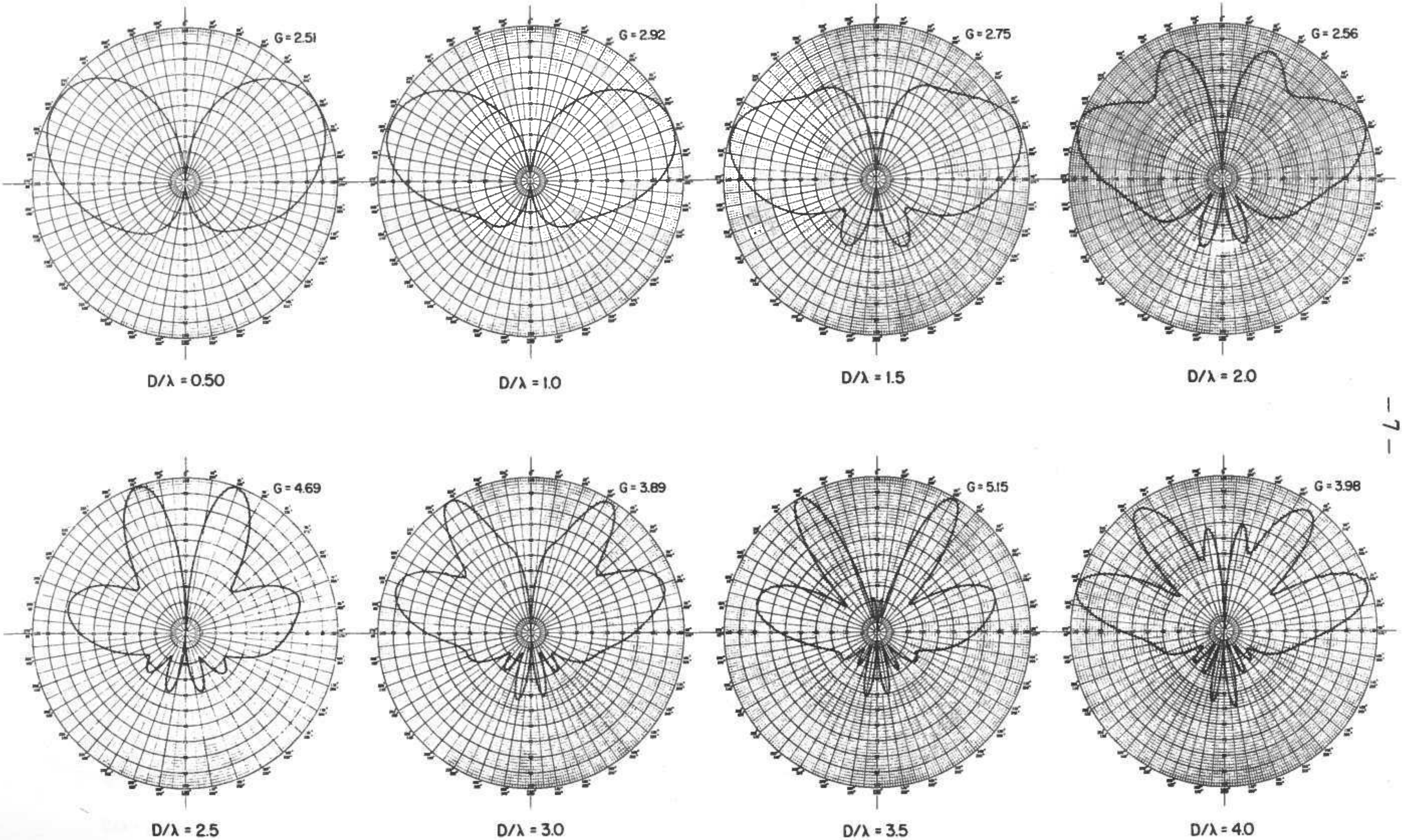


Figure 6 Radiation patterns of monopole over ground plane for $\ell/\lambda = 0.625$

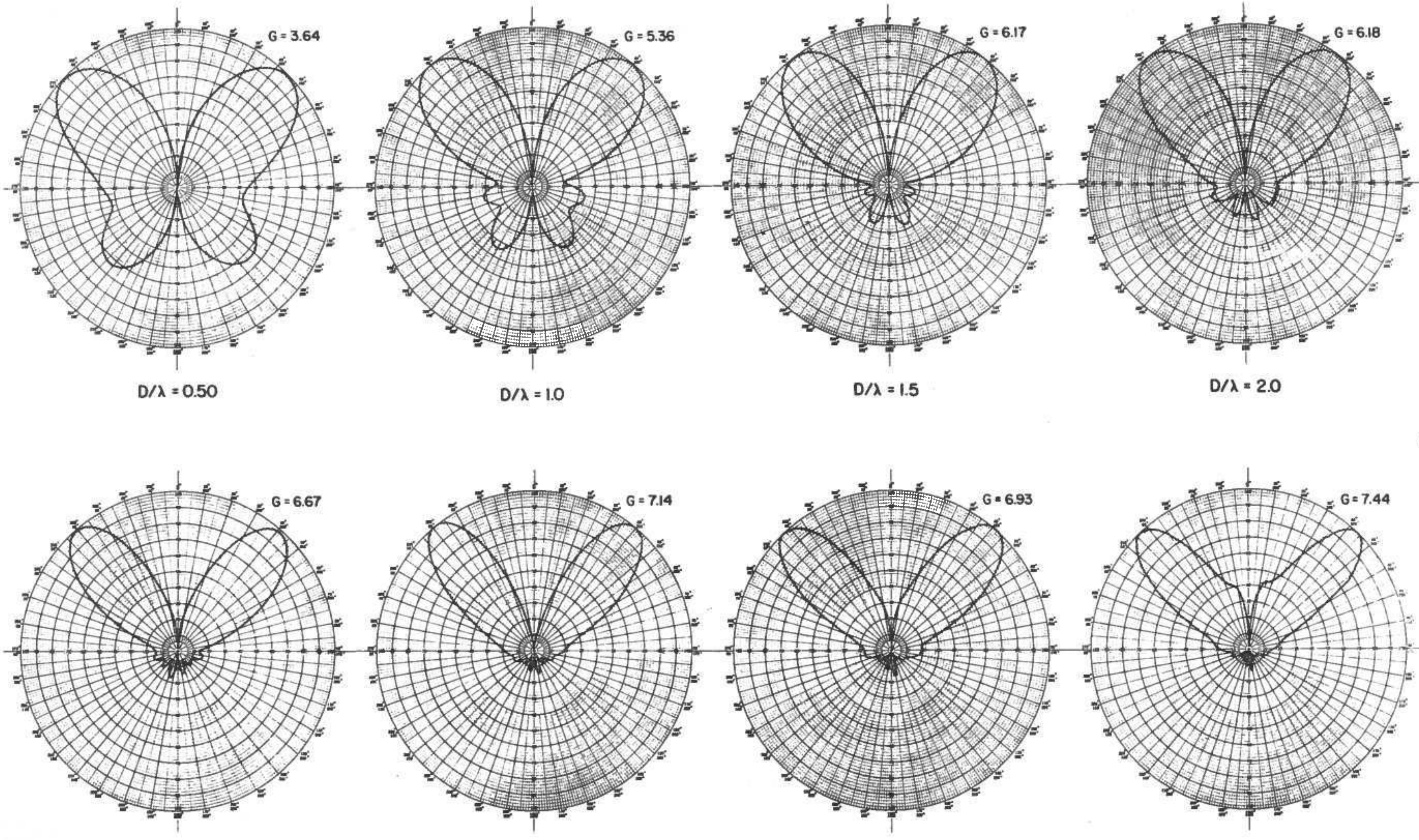


Figure 7 Radiation patterns of monopole over ground plane for $\ell/\lambda = 0.75$

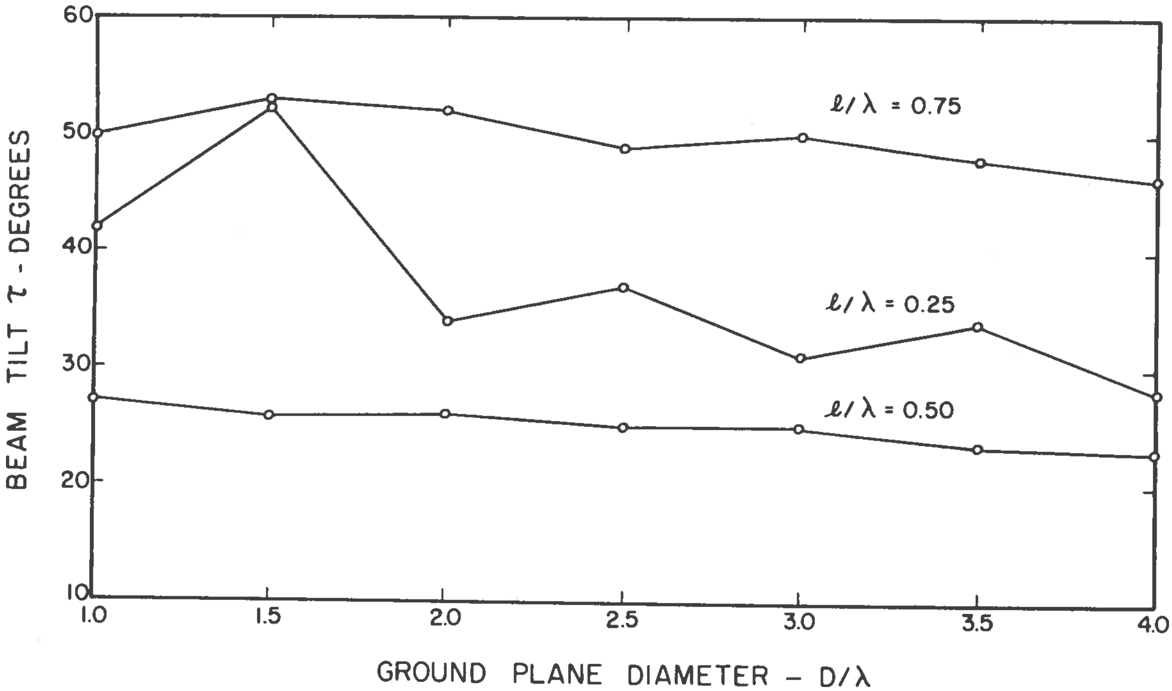


Figure 8 Effect of ground plane diameter and monopole length on beam tilt