Fig. 4. Azimuth radiation patterns of flush-mounted antenna measured, --- theoretical.

TABLE I
FRONT-TO-BACK RATIO (IN dB) VERSUS FREQUENCY AND ELEVATION ANGLE

FREQ. (MHz)	ELEVATION ANGLE IN DEG.			
	0	10	20	30
1030	19.7	31.0	26.4	20.0
1060	25.6	>35	27.6	19.5
1090	23.0	>35	>35	27.6

GHz and elevation angle of 10° is plotted in Fig. 4 along with the theoretical cardioid pattern. The measured pattern is typical of those obtained over the frequency range of 1.03 through 1.09 GHz and elevation angles from 0° to 30° . Contrasted with the infinite theoretical front-to-back ratio, the measured front-to-back ratio of the antenna varied with frequency and elevation angle. This was the principal difference between the various measured patterns. Front-to-back ratios are presented in Table I, for the beam steered in an arbitrary direction. Null depths in excess of 35 dB were observed in some instances. Although the worst measured null was only 19.5 dB deep, most data tended toward 30 dB null depths. The elevation pattern shape agreed closely with that of a monopole over the same size ground plane in the elevation angle range of 0° to 30° . The measured gain of the antenna was -1.5 dB with respect to this monopole. In both instances (monopole or transponder antennas over a 4 ft ground plane) the elevation pattern maximum occurs near 30° with approximately 7 dB less radiation at 0° elevation angle.

SUMMARY

Standard flush-mounted beam transponder antennas, such as those used in air traffic control and military IFF systems, are omnidirectional in azimuth. The feasibility of replacing these antennas with an antenna which has direction finding and steerable cardioid pattern capability has been demonstrated. The new antenna could be flush-mounted as a direct mechanical replacement for the standard antenna and operates over the same band (1.03 through 1.09 GHz). Excellent cardioid pattern performance is obtainable, and simple reversion to an omnidirectional pattern is possible.

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An Orthogonal Mode (Dual-Sense) Helical Antenna

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Abstract—A helical antenna element, fed at both ends and situated above a ground plane, is used to generate both senses of circular polarization.

INTRODUCTION

An axial mode helical antenna element, situated above a ground plane, and fed at the end nearest the ground plane is a well established radiator of circular polarization [1]. The possibility of simultaneously feeding the end of the helix more remote from the ground plane, thus obtaining the opposite sense of circular polarization by reflection in the ground plane, has been examined. Feasibility of this design has been demonstrated with an experimental model of the helical antenna situated in a conical surround.

DESCRIPTION AND OPERATION

The essential features of the dual-sense helical antenna element are shown in Fig. 1. Feeding of a helix (C) at point 1 by means of a transmission line (A), with the helix located in front of a conducting ground plane (D), is the common configuration. This results in a circularly polarized wave of, say, right hand sense being radiated in direction A (the actual sense, of course, depends upon which way the helix is wound). If we feed this same helix at point 2 by means of a transmission line (B) a circularly polarized wave of the same sense (right hand) is radiated in direction B. Upon reflection from the conducting ground plane, however, the direction of propagation and the sense of circular polarization are reversed. This results in a circularly polarized wave of the opposite sense (left hand), to that obtained by feeding line A, being radiated in direction A. The feeding of the helix at point 2 may be accomplished by an axially located coaxial line, arranged as shown, without disturbing the usual properties of the helix. Thus, two terminals are provided for the helical antenna which allow the obtaining of dual-sense circular polarization.

EXPERIMENTAL MODEL

An experimental model of the antenna was constructed to verify the operation just predicted. This model was constructed

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Fig. 1. Diagram of the dual-sense helical antenna.

Fig. 2. Radiation patterns obtained from the two ports.

by modifying an existing helicone antenna, designed to operate at 5.06 GHz, to incorporate the additional feed. The model consisted of a helix wound of 0.060 in (0.15 cm) diameter wire. The helix was 6.5 turns long with a base diameter of 0.75 in (1.91 cm) tapering in the last 3.5 turns to a final diameter of approximately 0.4 in (1.02 cm) diameter. Semi-rigid coaxial lines of 0.141 in (0.36 cm) diameter were used for the feeding lines. The element was situated in a conducting metal cone (*E*) of base diameter 2.0 in (5.08 cm), height of 4.0 in (10.16 cm), and an aperture diameter of 4.0 in (10.16 cm). The helix in a cone geometry is frequently referred to as a helicone [2].

EXPERIMENTAL RESULTS

Radiation patterns measured at the design frequency of 5.06 GHz are shown in Fig. 2. The patterns were taken with rotating linear polarization. Good on-axis axis ratios (0.2 dB for port *A* and 0.6 dB for port *B*) were obtained with reasonable values of off-axis axial ratio. The *B* port (or added port) has significantly worse off-axis ratio than the normal port. This is attributed to imbalance in the feed and the excitation of currents along the axially located coax outer conductor.

The voltage standing-wave ratio (VSWR) at terminal *A* was 1.97 while that at terminal *B* was 1.26. Isolation between the two ports was 35 dB. Gain with respect to a circularly polarized isotrope was 13.7 dB for terminal *A* and 14.1 dB for terminal *B*. The gain difference agrees with that which would be expected from the difference in terminal VSWR. The data presented above are for the design frequency of 5.06 GHz. The bandwidth of the antenna has not been evaluated.

SUMMARY

The feasibility of obtaining both senses of circular polarization from a single helical antenna element has been demonstrated. This is accomplished by adding a second feed point at the opposite end of the helix from that normally used. Performance of this antenna appears promising.

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Closed Form Approximations to the Inverse Black Body Radiation Problem

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Abstract—The inverse black body radiation problem is the problem of determining the unknown area-temperature distribution of a black body from its radiated electromagnetic power spectrum. An exact iterative solution to this problem (the inverse Planck problem) was derived by this author in 1982. Recently Hamid and Ragheb derived a closed form approximation to this problem claimed to be valid for the Rayleigh-Jeans regime (the inverse Rayleigh-Jeans problems). It is shown that this Hamid-Ragheb solution is actually *far superior* to an inverse Rayleigh-Jeans approximation. A closed form approximation to the inverse black body radiation problem valid for the Wien regime (the inverse Wien problem) is presented, and shown to be equivalent to the leading term of the exact iterative solution of this author.

I. INTRODUCTION

The (direct) black body radiation problem is the problem of predicting the radiated electromagnetic power spectrum, given the area-temperature distribution of a black body. The solution to this problem is given by Planck's law of 1900. The inverse black body radiation problem is the problem of determining the unknown area-temperature distribution of a black body from its measured radiated electromagnetic power spectrum.

The latter inverse problem was solved exactly by an iterative process by this author [1] in 1982, thus constituting an inverse Planck solution. A closed form approximation claimed to be valid for the Rayleigh-Jeans regime was recently obtained by Hamid and Ragheb [2].

Unfortunately, however, Hamid and Ragheb failed to point out and/or recognize that their solution is *not* an inverse Rayleigh-Jeans (approximation) solution, but a *far superior* (to an inverse Rayleigh-Jeans) approximation.

This communication is addressed to the clarification of this point, and the derivation of a closed form inverse approximation valid for the Wien regime.

To this end, the organization of this communication is as follows. A brief historical summary of the (direct) black body radi-

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