CANCELLATION OF RAIN-ECHOES FROM 3-CM RADAR PERFORMANCE

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Abstract

This paper describes the use of circular polarisation to remove rain and cloud echoes from the display of 3-cm. radar sets. Reports from U. S. A. & U. K. on the use of G. C. A. for homing extremely high speed jet fighters in conditions of heavy precipitation have suggested that the aircraft echoes are being lost in the rain returns, and that the useful range of the equipment is seriously reduced.

The result of the investigation using circular polarisation by means of a $\frac{\lambda}{4}$ plate are very encouraging and show reduction of rain echoes by more than, 22 db. with very little apparent loss of the desired signal. It is therefore, suggested to extend this investigation on this and other frequencies in the microwave band.

Introduction

Since the invention of microwave radar in 1941, reports were very often published of the unwanted echoes received from the scattering effect of the precipitating clouds, rain, hail and snow. During the war, a limited amount of investigation of this phenomenon was undertaken to reduce the intensity of this effect on the performance of radar sets. Later researches indicate that radar equipments of wave length 6 cm. to downwards are particularly sensitive to such responses. Since then, various radar organisations and academic research laboratories are seriously engaged in the investigation to find out a device, which can eliminate or suppress rain responses.

Here an approach has been described to eliminate rain clutter using microwave lenses which consist of spaced quarter-wave conducting strips that are placed parallel to the electric field of the wave approaching the lens with a spacing slightly in excess of a half wave length. The wave entering the lens structure propagates through it, as though the lens was a large number of wave guides in parallel, with each hypothetical wave guide having a dimension in a direction perpendicular to the electric field corresponding to the spacing between the parallel strips. An extension of this lens technique has been investigated for the elimination of rain clutter by converting the plane polarized waves into circularly polarized waves.

Theory of Rain Responses

Before going to the micro-wave lens technique, a brief discussion is made regarding the radar echoes from rain, snow and hail as has been worked out by Ryde. He has shown that the echo intensity P_r obtained from precipitation, which completely fills the aerial beam is given by

$$P_r = \frac{P_o GANS\,(1-\cos\theta)H}{4\,R^2}$$

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Where P_o=Power radiated by radar transmitter.
A=Aperture of aerial (common trans-receiver).
G=Gain of aerial.
θ=Half angular aerial beam width.
R=Range of precipitation.
N=Number of scattering drops per unit volume.
S=Scatterig function of each drop in the direction of aerial.
H=Pulse Width.

Ryde simultaneously shows that,

$$NS=\frac{\Sigma\ N(D)\ D^6}{\lambda^4} f(m)$$

for drops, which are small compared with the wave length, where
D=Drop diameter
m=Dielectric constant of material of the drop at the wave length λ.

Rain, of course, comprises drops of various diameters ranging from 0·01 cm. 0·8 cm. in a very heavy rain in India. To evalute the expression Σ N(D) D^6 some knowledge of the drop size distribution is necessary.

The Ryde theory mentioned above indicates that the echo power from the reflecting particles is inversely proportional to the λ^4. Now considering rain cloud, the average rain-cloud is composed of water droplets of radii lying between 8 and 30 microns, there being 200 droplets per c.c. The Ryde theory now shows that a radar set having a peak power of 350 KW and on a wave length of 6 mm with an aerial 2·5 feet diameter gives an echo from an average non-precipitating cloud even at a range of 10,000 ft.

Lens Aerial and Circular Polarization

The various techniques of conversion of plane polarized wave into circularly polarized wave through the action of a metallic lens aerial is now-a-days wellknown. Through complicated mathematical analysis, it is an established fact that, in performing this function, the lens aerial first resolves the plane-polarized wave into two equal components, which are in phase shift of 90° in one of the components. Now the circularly polarized wave is formed on the recombination of those two components.

When microwave energies are scattered from an irregularly shaped target viz. a bomber plane, the returned wave is elliptically polarized. Now it is seen that, if a plane polarized wave is incident on a spherical rain drop, the returned energy is also plane polarized. But if a circularly polarized wave is thrown, the returned echo is also circularly polarized, but in the opposite way. A 3-cm radar equipment will respond to echoes simultaneously from rain and aeroplane, if it sends and receives plane polarized wave of the same plane of polarization, but it will acquire the power of discrimination against rain clutter, when the incident radiation is circularly polarized. During the experiment, it is observed that side lobes are slightly increased with the consequent fairly tolerable reduction in the vertical coverage pattern of the antenna, the quarter wave metal strips being placed diagonally on the mouth of the slotted wave guide feeding the paraboloid.

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