PROPAGATION OF V.H.F. RADIO WAVES IN MOUNTAINOUS TERRAINS—POLARISATION EFFECTS

B. L. N. RAO*, B. K. ROY*, H. B. MATHUR*, U. C. GUPTA*, JAI PRAKASH† and P. P. VERMA.‡

Defence Research Laboratory, Landour Cantonment, Mussoorie

ABSTRACT

Diffraction plays an important part in V.H.F. radio wave propagation in mountainous terrains. The classical diffraction theory does not take into account the effect of polarisation. An experimental study of the effect of polarisation was made which indicates that horizontally polarised waves give greater diffracted fields than vertically polarised waves in the shadow region. The possible reasons for this were analysed.

INTRODUCTION

Communication paths in mountainous terrains often do not give line of sight conditions and diffraction plays an important part. Diffraction studies of V.H.F. radio waves over hilly terrain considered as knife edge, have been treated on Fresnel and Kirchoff's Classical Theory of Diffraction[1] which however does not consider the effect of polarisation. Some workers [2,3,4] tried to study this experimentally and their results are given below.

McPetrie *'et al'*, [2, 3] have shown that for short vertically polarised waves, a greater field strength is obtained in the shadow region in the immediate vicinity of an obstacle whereas at a point away from the shadow region horizontally polarised waves give greater field strengths.

Selvidge[4] found that in deep shadow regions, the horizontally polarised waves give greater field than vertically polarised waves. Wait and Conda[5] have theoretically computed the diffraction effects of Convex surfaces acting as obstacles taking into account the effect of polarisation and found that vertically polarised waves give rise to greater field strengths compared to horizontally polarised waves in the shadow region behind an obstacle.

In view of the seemingly contradictory results on the effect of polarisation on V.H.F. diffracted fields, further investigations were worthwhile in this direction. However, it is interesting to summarise that (1) in deep shadow regions horizontally polarized waves give greater field than vertically polarised waves according to Selvidge. (2) in the vicinity of the obstacle in the shadow region the reverse is the case according to McPetrie *'et al'* and (3) at a point away from the shadow region once again horizontally polarised waves give greater field, also according to McPetrie *'et al'*. While diffraction is a major factor in the propagation of V. H. F. Radio waves in mountainous terrains, other factors such as nature of terrain, vegetation etc., which are often inseparable from diffraction also are needed to be taken into account.

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*Presently in Propagation Field Research Station of Defence Electronics Research Laboratory, Hyderabad, at Landour Cantt., Mussoorie.

†Overseas Communication Service, New Delhi.

‡Defence Electronics Research Laboratory, Hyderabad.

EXPERIMENTAL

An Antenna Test Set (R. F. T. Type 5,002 a) with folded dipole antenna and calibrated with a standard signal generator (Ferris Microvolter Model 18 C) was used to measure the field strength. The Antenna Test Set is a heterodyne receiver with self oscillating mixing stage and a grounded grid input amplifier connected in series, a two stage I.F. Amplifier, a demodulator with output for headphones and a valve voltmeter. The test set has a frequency range of 37 to 230 Mc/s covered in six ranges and with indication of H. F. input voltage ranging from 3 μ V to 10 mV and extending to 100 mV with a 10 : 1 attenuator. It has an accuracy of $\pm$6 db on the unsymmetrical 70 ohm input. A plug-in input transformer makes the input adaptable to balanced 280 ohms impedance. The set has an I.F. bandwidth greater than 10 Kc/s with an I.F. operating at 100 Kc/s. Image frequency close to the main signal also can be received which simplified the construction by omitting the preselection in the first stage and associated special change over switch, the wear of which is unable to be controlled and increased thereby the reliability of the equipment. The equipment operates on 42 Volts, 50 cycles A. C. through an isolating transformer working from 220 Volts, 50 cycles A. C. and makes its handling safe. The accuracy of the test set may, however, be felt inadequate for precise measurements. But relative values being of interest in the present investigation rather than absolute values the test set is used as a reasonably good and sensitive indicator. The accuracy of the measurements is however enhanced by immediate calibration with the standard signal generator Ferris Microvolter Model 18 C and also running the equipment with A. C. Voltage stabiliser Model CVL/500.

Transreceiver set S. C. R. 522 operating at 126 Mc/s was used as mobile field transmitter, using quarter wave antenna with counterpoise earth. It is a four channel aircraft transreceiver with frequency range 100—156 Mc/s and with a transmitter output of about 6 watts. Field strength with both vertical and horizontal polarisation was measured as the voltage induced in the folded dipole antenna of the antenna test set, on six different communication paths, the profiles of which are attached. The path I was just in the shadow with obstacle height almost as zero. The rest of the paths were all diffraction paths and considered as knife edge diffraction paths by following the procedure given by Burrows[6] for multiple obstructions, in which tangential lines are drawn from the transmitting and receiving antenna radiation centres to the limiting elevations of the terrain and the intersecting point considered as position of knife edge diffraction obstacle. The quarter wave antenna with counterpoise earth was used to obtain transmission of horizontally polarised waves also, by orienting the antenna so that the radiating element is horizontal to ground and the antenna rotated about the vertical axis for pick up of maximum signal by antenna test set. This adjustment was possible by having inter-communication between the transmitting and receiving points and manually controlling the adjustment. The antenna configuration employed, while questionable in that whether it will admit only horizontal polarisation, will be permissible because even if vertically polarised waves are generated they will be eliminated at the receiving end due to configuration of the receiving antenna. This type of antenna is quite common with many mobile V. H. F. sets, and this could be the only way for generating horizontally polarised waves. The transmitting antenna in the field is about ten feet above ground and the receiving antenna at DRL about six feet from the roof or twenty feet from ground level.

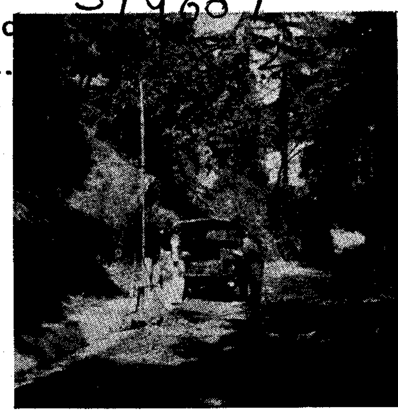
Measurements were taken by making transmissions at three or four scattered points at each location in an area of about twenty yards radius and polarisation changed at the same place. Precautions were taken to see that antenna is kept as far as practicable (5 to 10 yards) from the nearby objects so that their influence on the transmission is reduced. The measurements were spot readings for short run transmissions at each place. Long term statistical influences will be negligible for such short distance transmissions and spot readings were adequate enough.

TABLE I

COMPARISON OF FIELD STRENGTH MEASURED AT DRL FOR THE TWO TYPES OF POLARISATIONS

Sl. No.	Field Point No and Location	Measured Field Strength in Microvolts*	
		Vertical Polarisation	Horizontal Polarisation
1.	I Sister Bazar	240—310	250—340
2.	II Language School	100—200	50—300
3.	III Cemetry	26—42	120—190
4.	IV Childer's Lodge	14—32	34—140
5.	V Pt. No. 24 on Map	1·5—65	1·5—76
6.	VI MES Office	35—98	62—140

*Measured as vo[illegible] induced in [illegible] of antenna [illegible]

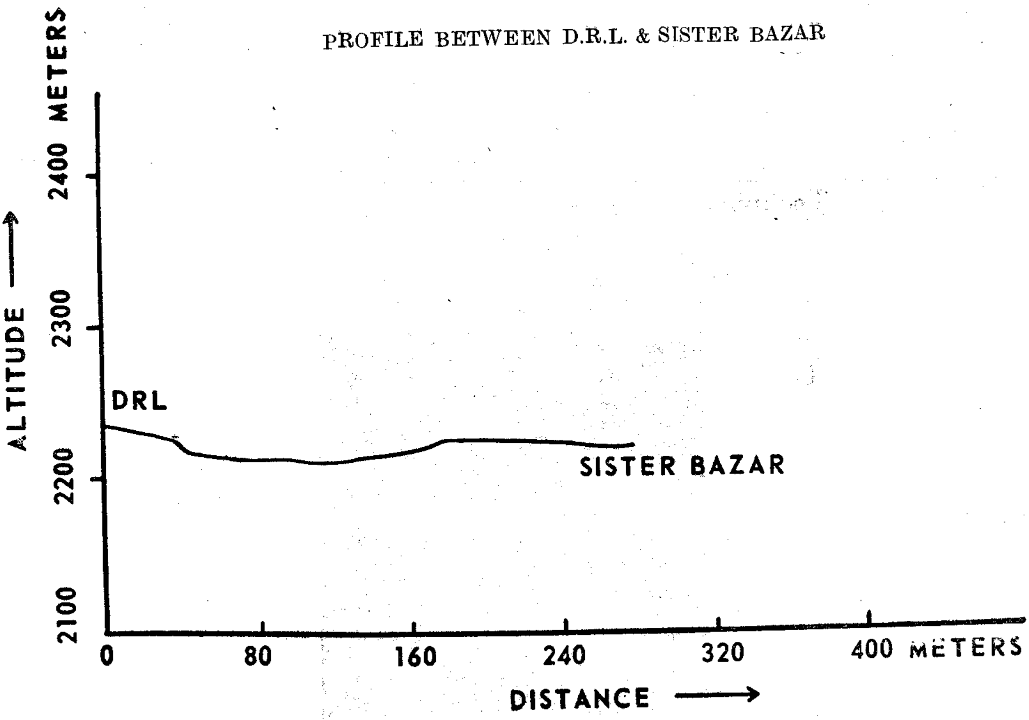


PHOTOGRAPH 1. EQUIPMENTS AT A FIELD POINT

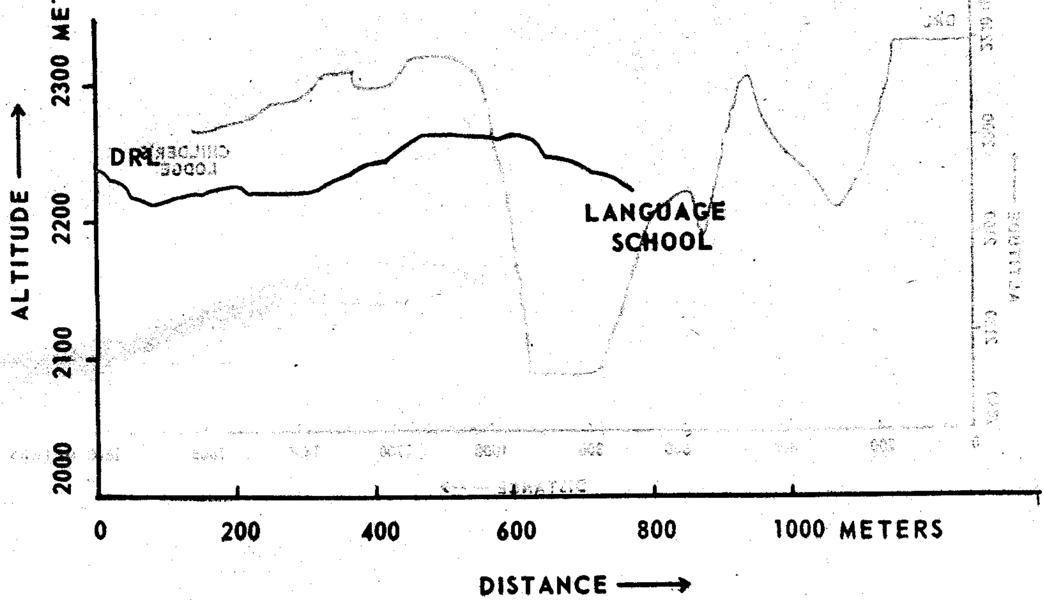
PHOTOGRAPH 2. ANTENNA TEST SET AT D.R.L.

PHOTOGRAPH 3. VEGETATION AT A FIELD POINT

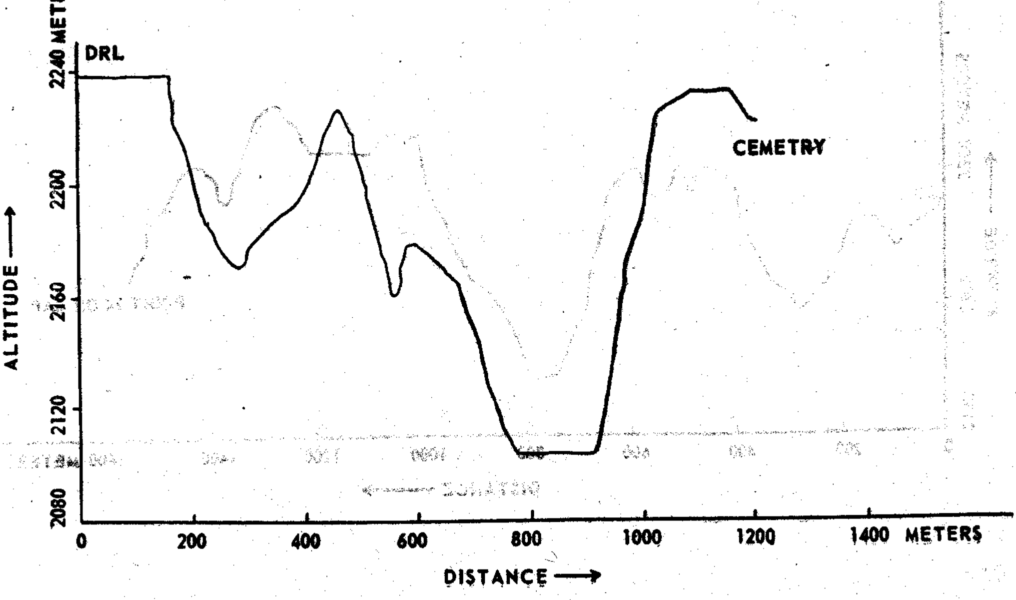
PROFILE BETWEEN D.R.L. & SISTER BAZAR



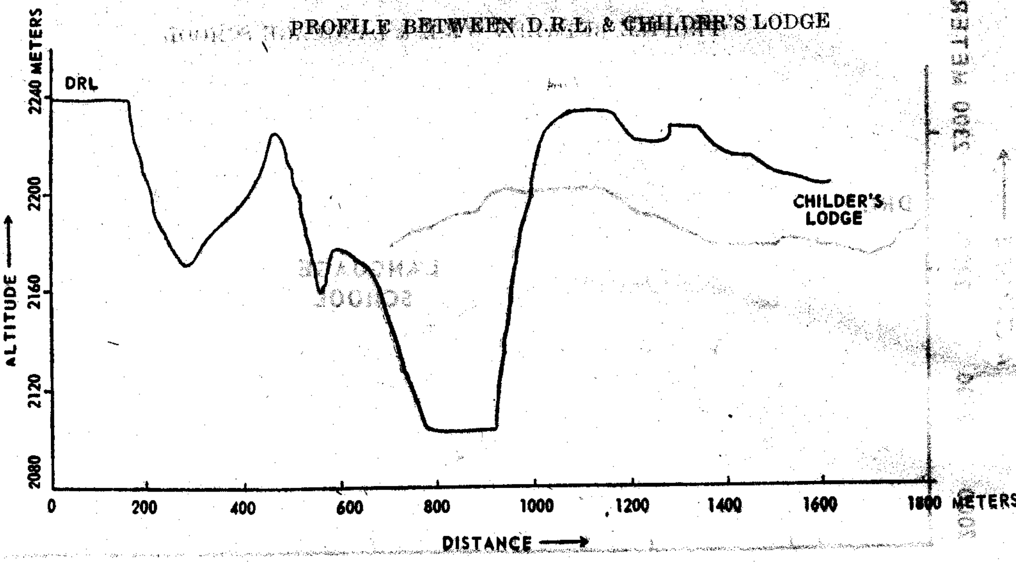
PROFILE BETWEEN D.R.L. & LANGUAGE SCHOOL



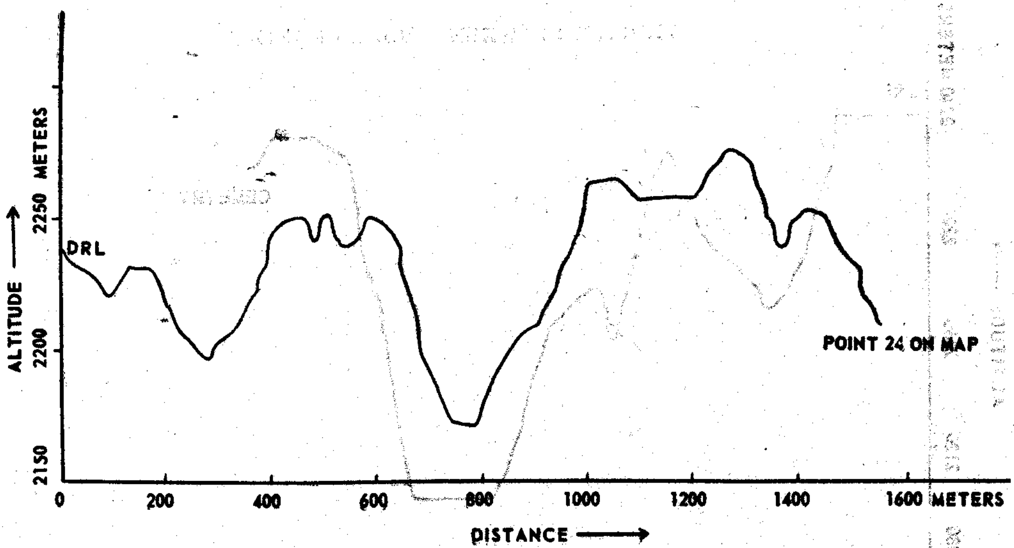
PROFILE BETWEEN D.R.L. & CEMETRY

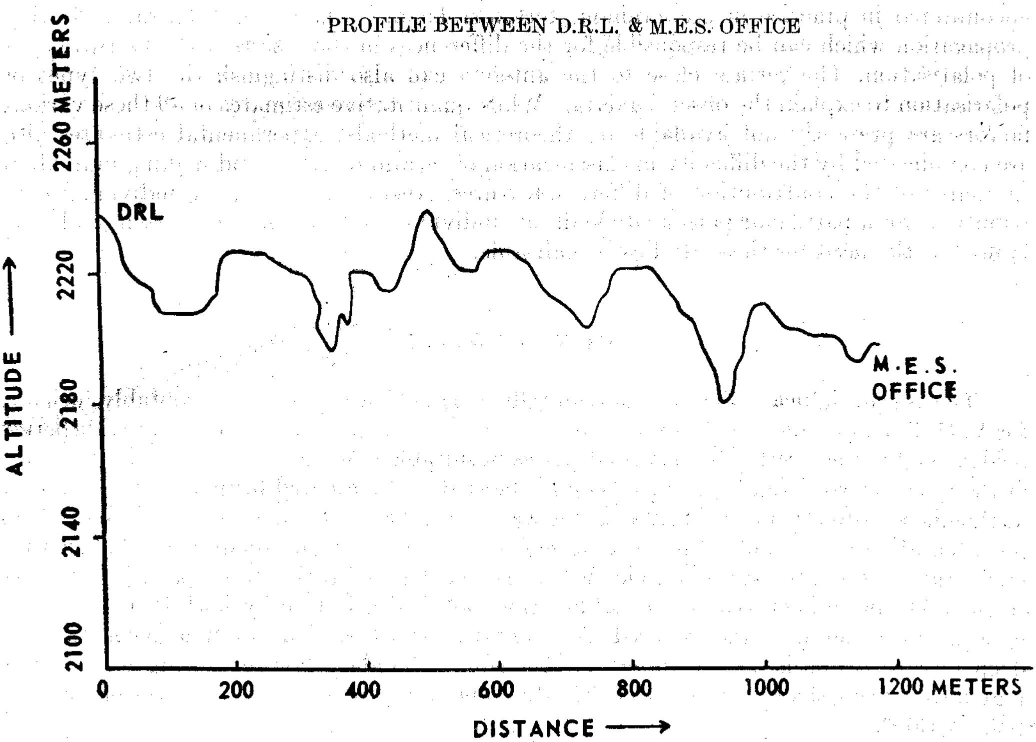


PROFILE BETWEEN D.R.L. & CHILDER'S LODGE



PROFILE BETWEEN D.R.L. & P.T. 24 ON MAP





DISCUSSIONS

It is observed from Table I that the field due to the horizontally polarised waves is more than vertically polarised waves. While observations at locations III, IV, VI indicate definite improvement of signal with horizontal polarisation, observations at locations I, II, V indicate comparable signals for vertical and horizontal polarisation. However, it is not difficult to see the general indication of higher field strength with horizontal polarisation even at locations I, II, V. Ranges of field strength are given in view of the variation of field strength from one point to another at any one location. This variation can be due to differences in the profile shape and terrain features that can occur in rugged terrain even for slight differences in position. This also indicates the importance of proper choice of place for obtaining maximum field strength by trial at a number of scattered points at any given location. As regards the differences in field strengths obtained with the two polarisations, it is expected that the "rolling-over-effect[1]" on a wedge can play a part in that the horizontally polarised waves give greater field strength than vertically polarised waves. Also it is difficult to separate the absorption due to vegetation from the diffracted field. As such it can be expected that absorption of the vertically polarised waves can be more than the horizontally polarised waves, resulting in greater fields for the latter. All the paths under investigation have considerable vegetation on the path even though the density may somewhat vary from place to place as can be seen from photograph III and this supports the explanation given. Also Burrows[6] has indicated greater absorption of vertically polarised waves due to vegetation as compared to absorption of horizontally polarised waves from certain experiments conducted in thick jungles where skyline is not visible.

The theoretical calculations for diffraction are also idealised cases which are never encountered in practice in mountainous terrains. There is change of polarisation during propagation which can be responsible for the differences in the results with the two types of polarisation. The terrain close to the antenna can also distinguish the two types of polarisation to explain the observed data. While quantitative estimates of all these various factors are presently not available by theoretical methods, experimental estimates also are complicated by the difficulty in classification of terrain features, and making individual estimates of the contribution of different features. Also synthesising the individual contributions for a particular path is difficult as individual effects are not often additive. However, the need for these studies is realisable.

CONCLUSIONS

The results indicate that the horizontally polarised waves can be profitably utilised for V. H. F. communication purposes in hilly terrain in shadow regions, to provide better field strengths than vertically polarised waves in suitable cases. However, the disadvantage of their use is also noted that the antenna is needed to be oriented for maximum radiation in the chosen direction each time and this was found inconvenient without suitable set up for orientation of antenna. While the present studies were mainly qualitative the need for quantitative estimates of the individual factors causing differences in propagation characteristics of the radio waves of vertical and horizontal polarisation by both theoretical and experimental methods, was realised. Also detailed analysis of diffraction mechanism in deep shadow region is needed to get an idea of the boundary line separating near shadow region and deep shadow region to cause differences in propagation for waves of the two polarisations.

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