

Polarization Coupling Loss at Medium Frequencies

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Sky wave field strength measurements and investigations conducted in India on a number of mf circuits over the years have shown that the polarization coupling losses are maximum for circuits whose direction of propagation is east-west and are negligible in north-south direction. For east-west circuits these losses are higher in the lower latitudes compared to the higher latitudes and for north-south circuits this effect is negligible. The measured values of the polarization coupling loss correlate well with the values predicted by using the CCIR formula of the modified USSR method of predicting nighttime sky wave field strength (CCIR Rep. 575 Rev. 1976).

1. Introduction

In order to predict the accurate value of sky wave field strength, various aspects of its propagation such as polarization coupling loss, sea gain, ionospheric absorption, etc. have to be carefully studied. Out of these, polarization coupling loss is extremely important especially when the propagation path is situated in the lower latitudes and in east-west directions. The study and investigation on this factor has been actively pursued by the Research Department of All India Radio (AIR) during the last couple of years. Field strength measurements have been conducted on a large number of transmitter frequencies at some selected stations of AIR. The paper describes the results of these measurements and investigations.

2. Theoretical Considerations

The medium frequency propagation is by the ordinary wave mode because extraordinary wave mode gets heavily absorbed at the higher levels of the E-region. The efficiency with which this ordinary wave is excited depends upon how close the incident polarization is to the polarization characteristics of the ordinary wave mode. The departure from the closeness results in additional losses due to inefficient coupling and such losses are termed as mismatch or polarization coupling loss.^{1,2} The characteristic polarization of the ordinary mode depends upon the magnetic bearing of the path, magnetic dip and angle of incidence apart from transmission frequency and gyro-frequency. Further mismatch or coupling loss occurs at the receiving terminal when the elliptically polarized ordinary wave, after emerging from the ionosphere, meets a receiving aerial

which is normally most sensitive to vertically polarized wave.

These losses are insignificant at European latitudes but they are quite serious near the magnetic equator, especially for east-west paths when the ordinary wave tends to be horizontally polarized, the incident wave being vertically polarized.

3. CCIR Formula

The CCIR has given the modified USSR method³ for the estimation of sky wave field strength which includes a formula for predicting polarization coupling loss. It takes into account only the value of the dip angle and the magnetic bearing as the main parameters. It is given below.

$$L_P = 180 (36 + \theta^2 + I^2)^{-1/2} - 2 \text{ (dB/terminal)}$$

where

L_P Polarization coupling loss

I Magnetic dip angle in degrees

θ Path azimuth measured in degrees from magnetic east-west direction, such that $|\theta| \leq 90^\circ$

for $|I| \geq 45^\circ$, $L_P = 0$

4. Measurements and Discussion

Research Department of All India Radio conducted extensive field strength measurements on a large number of Indian and foreign transmitters over the years as part of the propagation studies. The paper is based upon the measurements carried out on 29 radio circuits. Out of these, 20 transmitters were measured at Delhi during 1968-72, 3 at Madras during 1976-77, 2 each at Bombay and Rajkot during 1975-76 and 2 at Trivandrum during 1977-78.

The sky wave field strengths were measured during nighttime after 2100 hrs.

Annual median value of field strength for each circuit has been worked out from the measured data. Similar value for each circuit has also been estimated from the modified USSR method [CCIR rep. 575 (Rev. 76)] recommended for universal application for predicting sky wave field strength at medium frequencies, without taking into consideration the polarization coupling loss, L_P . The difference between field strength thus estimated and the corresponding measured field strength for the circuit has been taken as the "measured value of the polarization coupling loss" for that particular circuit. It may be mentioned here that the values of sea-gain at both the terminals for all the 29 circuits considered here are either zero or negligible. Measured values of L_P calculated as mentioned above together with the corresponding predicted values as per CCIR formula have been shown in Tables 1 and 2 for north-south and east-west circuits, respectively. The circuits have been grouped under these categories depending upon their direction of propagation for the sake of com-

Table 1 — Polarization Coupling Loss (L_P) on North-South Circuits

Transmitter and frequency (in kHz)	Receiver	Distance km	Measured loss dB	Predicted loss dB
Jullundur (870)	Delhi	343	-1.3	0.2
Ajmer (600)	do	334	-0.2	1.9
Srinagar (1120)	do	638	-0.1	0.2
Ahmedabad (850)	do	754	-0.4	1.4
Pune (785)	do	1166	-1.3	0.3
Hyderabad (740)	do	1231	2.6	0.3
Gulbarga (1110)	do	1256	-1.4	0.1
Sangli (1250)	do	1337	-0.5	0.3
Visakhapatnam (930)	do	1366	1.2	0.7
Cuddapah (900)	do	1588	-2.9	0.2
Madras (720)	do	1764	1.7	0.2
Hyderabad (1010) (Pak)	Rajkot	434	-2.6	1.6
Rajkot (1070)	Bombay	438	+3.2	1.6
Hyderabad (1010) (Pak)	do	872	-0.7	1.6
Visakhapatnam (930)	Madras	602	2.4	2.1
Bombay (550)	Trivandrum	1285	1.0	1.0

Table 2 — Polarization Coupling Loss (L_P) on East-West Circuits

Transmitter and frequency (in kHz)	Receiver	Distance km	Measured loss dB	Predicted loss dB
Lucknow (760)	Delhi	419	3.7	3.5
Gorakhpur (910)	do	658	8.1	3.5
Varanasi (1240)	do	686	0.1	3.1
Patna (620)	do	855	4.8	4.2
Bhagalpur (1470)	do	1051	9.9	4.5
Siliguri (1560)	do	1134	6.5	5.1
Gauhati (730)	do	1489	7.0	5.0
Calcutta (670)	do	1319	4.0	3.7
Dibrugarh (570)	do	1760	4.1	5.1
Karachi (830)	Rajkot	483	1.0	3.0
Bhadravati (800)	Madras	516	6.8	14.9
Alleppey (500)	do	581	5.1	4.8
Maho (640) (Sri Lanka)	Trivandrum	365	17.0	18.3

parison. It is evident from Tables 1 and 2 that the losses are maximum for circuits whose direction of propagation is east-west and are negligible in north-south direction. For east-west circuits these losses are higher in the lower latitudes compared to the higher ones and for north-south circuits this effect is negligible. A maximum value of 17 dB as polarization coupling loss has been measured on Maho (Srilanka)-Trivandrum circuit. A comparison between the measured and predicted values of L_P indicates that the accuracy of the CCIR formula is fairly good.

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