RAIN ATTENUATION OF MILLIMETER WAVES DURING MONSOON OVER CALCUTTA

A.K. Sen[1], A.Mitra[2], K.K. Majumdar[2], P.K. Tarafdar[3], G. Tarafdar[2], A. Ghosh[2], S.N. Ghosh[2] and J.S.Sehra[4]

I. INTRODUCTION

Attenuation of millimeter waves during rain imposes a severe limitation in establishing a reliable radio link at millimeter waves[1]. The clear air attenuation rate of millimeter for a horizontal path attains a minimum value of 0.4 dB/Km at 94 GHz, but shoots up to about 10 dB/Km with only 25 mm/hr rainfall rate, and may be about 40 dB/Km for a rain rate of 150 mm/hr[2]. For the last few years, we have been studying the millimeter wave propagation at 94 GHz. Theoretical estimates of the rain attenuation in the range 30-100 GHz have been made for various rain rates and drop size distributions[3,4]. Experimental observations of the rain attenuation were also made during the monsoon months, when the rain rate attains the heighest values and compared with the theoretical estimates. It has been observed that ~~observed~~ rain attenuation at 94 GHz in dB/Km increases nonlinearly with rain rate. The theoretical estimates at 30 GHz indicate a linear law of variation. The results are presented in this paper and discussed in the light of current knowledge about rain attenuation of millimeter waves.

II. MILLIMETER WAVE LINK

The millimeter wave link set up for the studies is shown schematically in Fig. 1.

A 50 mW C.W. IMPATT oscillator at 94 GHz, fed to a 25 dB horn antenna is employed at the transmitting station. At the

1. Institute of Radiophysics & Electronics, University of Calcutta, 92, Acharya Prafulla Chandra Road, Calcutta 700 009, INDIA.

2. Department of Applied Physics, University of Calcutta, 92, Acharya Prafulla Chandra Road, Calcutta 700 009.

3. Business Efficiency Services (P) Ltd, 24,A Shakespeare Sarani, Calcutta 700 071

4. Department of Electronics, Govt. of India, Lok Nayak Bhavan, Khan Market (3rd floor), New Delhi - 110 003, INDIA.

receiving station a superheterodyne receiver fed from a 25 dB horn receives the 94 GHz signal. The rain attenuation can be as large as 40-60 dB per km during extreme rain rates, while, the cross polar discrimation during the raining may be about 5-10 dB. Thus making the total rain attenuation under cross polar conditions to be as large as 70 dB (60 + 10). This large attenuation calls for a highly sensitive receiving system for the studies on rain attenuation at millimeter waves. Accordingly, the sensitivity of the receiving equipment has been increased by chopping the millimeter wave signal at 94 GHz at the receiving end by a rotating vane chopper placed in front of the receiving horn as shown in Fig. 1. The output of the detector at the chopping frequency of 1000 Hz is amplified by a narrow band amplifier and then detected by a phase sensitive detectors (PSD). The 1000 Hz local oscillator frequency for the PSD is derived from the generator driving the chopper. The DC output of the PSD is integrated with a time constant of 1 sec, amplified by a DC amplifier and recorded. The receiving system is similar to a Dick type radiometer[5].

III. OBSERVATIONS

Round the clock recording of the signal strength at the receiving station was undertaken with a chart speed of 10 cm/hr. The rain rate was measured by a fast response raingauge having a response time of 10 sec. Some of the typical records of the rain attenuation in the 94 GHz LOS link over a path length of 200 meters between the Institute of Radiophysics & Electronics (IRPE) and the Centre of Advanced Study (CAS) building of the Institute are shown in Fig. 2. The peak rain attenuation values for different cases are plotted against the respective peak rain rates causing the attenuation. The plot indicates a non-linear relationship between the rain attenuation and the rain rate, the exponent being about $\cdot 75$.

IV. DISCUSSION

The rain attenuation A of radio waves in the microwave and millimeter wave band can be expressed by the relation

$$A = \gamma R_L^{\eta}$$ where γ and η are constants each of which depends on the frequency and polarisation

and $R_L = \frac{1}{L}\int R\, dL$ is the near instantaneous

rain rate along the path L of the radio link.

For vertical polarisation, the values of γ varies from about ·01 at 10 GHz to about 1·0 at 100 GHz while the exponent varies from 1.25 - 0.73 in the same range of 10 - 100 GHz. At 30 GHz, the lower limit of millimeter waves, the expenent η is 1 indicating a linear relationship between attenuation and rain rates. At 94 GHz the exponent is slightly less than unity (about ·75) while γ is about 5 times larger than that at 30 GHz. The attenuation at 94 GHz is, therefore, nearly 4-5 times than that at 30 GHz. It may be mentioned here, that the values of γ and η at 30 GHz has been estimated from measured rain attenuation values round the world due to Hoggs[6]. It was found that, indeed the relationship is linear indicating a value of $\eta = 1$, the slope of the regression line being ·18 $dBkm^{-1}/mmhr^{-1}$.

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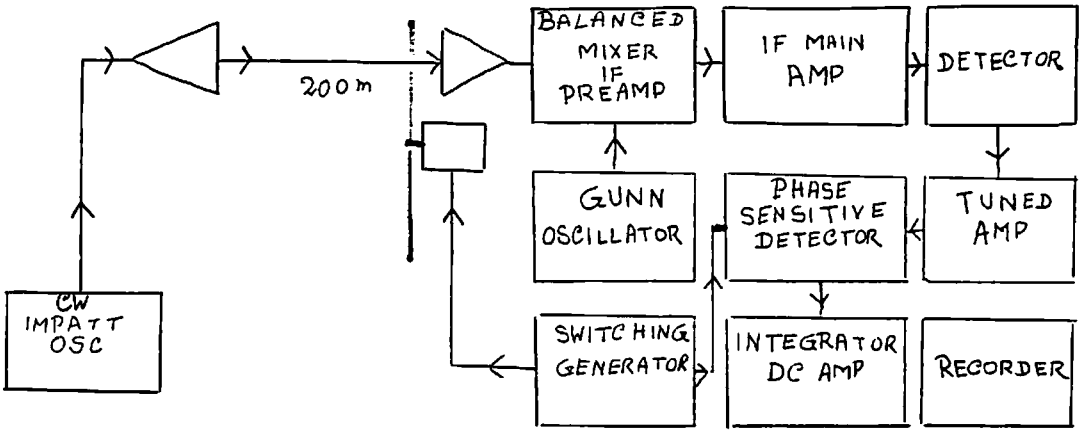

FIG.1 Millimetre Wave Link

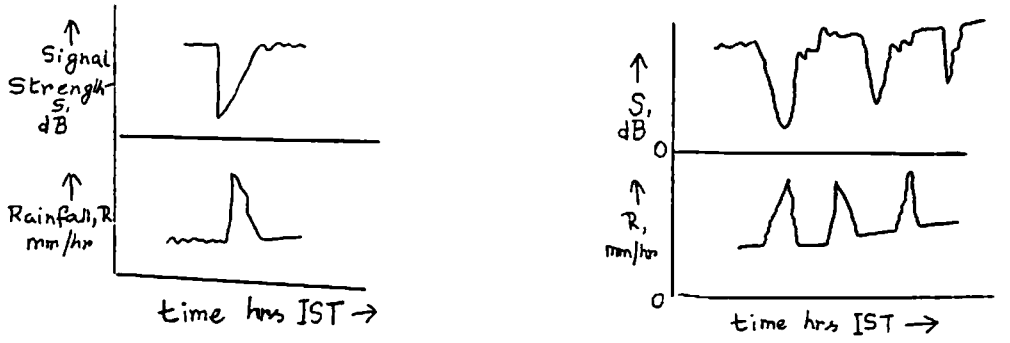

FIG.2. Typical records