2-IV B4

SOME TOPICS ON THE APPLICATION OF MILLIMETER WAVES IN TROPICAL AND EQUATORIAL REGIONS

Mauro S.Assis and Alvaro A.Salles
Catholic University
Rio de Janeiro
Brazil

In the theoretical analysis of rainfall attenuation at the millimeter band, it is necessary to specify two important points: temperature and precipitation rate. In tropical or equatorial regions, temperature up to 40°C or more must be considered, and the precipitation rate can achieve very high values. This paper intends to present some comments on this subject.

In order to calculate the rainfall attenuation Ryde's theory[1,2,3] was applied to several temperature values and frequencies between 10 and 300 GHz. Best's empirical formulae[4] for the terminal velocity of raindrops (in the case of summer tropical atmosphere) and Laws and Parsons' raindrop-size distributions[5] were also used. Although there are some questions about this theory, when we know the rain dispersion along the path, the calculation can be made with a high degree of approximation. Recent results from Bell Laboratories[6] seem to confirm this assumption. The refractive index and the absorption coefficient of water were calculated from Saxton and Lane's work (Figs. 1 and 2).

We have computed the rainfall attenuation for temperatures from 0 to 50°C and precipitation rates from 0,25 to 150 mm/h. In the band 30-300 GHz and precipitation rates greater than 10 mm/h, the calculated percentage change of attenuation (relative to the attenuation at 20°C) was smaller than 5% for all temperature values. For low precipitation rates (0,25 to 5 mm/h) and frequencies between 10 and 30 GHz we have obtained more elevated percentage values. Tables I and II present some results. The variation discussed above is probably due to the behaviour of the refractive index and absorption coefficient water with temperature (see Figures 1 and 2).

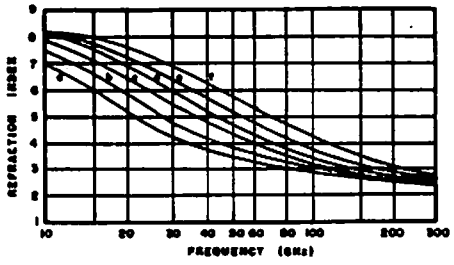

Fig. 1 - Refraction Index

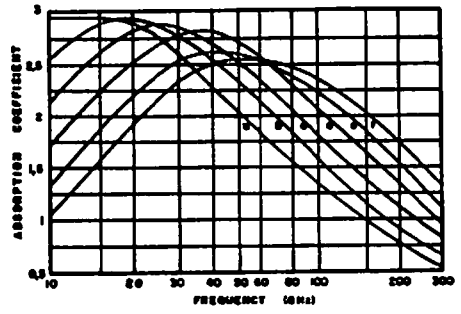

Fig. 2 - Absorption Coefficient
a=0°C, b=10°C, c=20°C,
d=30°C, e=40°C, f=50°C.

TABLE I (T = 30°C)

p (mm/h)	Frequency (GHz)		
	10	30	90
0,25	-19.79	3.44	-0.57
1,25	-13.93	3.78	-0.96
2,5	-10.38	2.98	-1.04
5,0	- 6.22	2.06	-1.11
12,5	- 1.86	0.63	-1.16
25,0	- 1.93	-0,24	-1.17
50,0	- 4.44	-0.91	-1.17
100,0	- 6.76	-1.19	-1.14
150,0	- 7.34	-1.22	-1.12

TABLE II (T = 40°C)

p (mm/h)	Frequency (GHz)		
	10	30	90
0,25	-34.09	7.11	-1.22
1,25	-26.04	7.60	-2.05
2,5	-20.73	6.08	-2.18
5,0	-13.87	4.37	-2.21
12,5	- 6.65	1.73	-2.32
25,0	0.66	0.13	-2.32
50,0	5.64	-1.11	-2.30
100,0	10.54	-1.63	-2.26
150,0	12.17	-1.73	-2.21

CALCULATED PERCENTAGE CHANGE OF ATTENUATION (RELATIVE TO THE ATTENUATION AT 20°C).

With the aid of Brazilian Meteorological Service (Ministry of Agriculture), the precipitation rates at several regions in Brazil were studied. Figure 3 shows the statistical data obtained in the following points:
(a) Belém (equatorial)
(b) Rio de Janeiro (tropical)
(c) Curitiba (sub-tropical)
(d) Quixeramobim (semi-arid).

Unfortunately, it was impossible to get instantaneous values and the curves in Figure 3 correspond to five minutes median values. However, for intense rain, this fact does not represent a problem because the precipitation rate changes very little in this period.

As a final conclusion, we can remark that the more important problem for the application of millimeter waves in tropical and equatorial regions is the precipitation rate. In order to

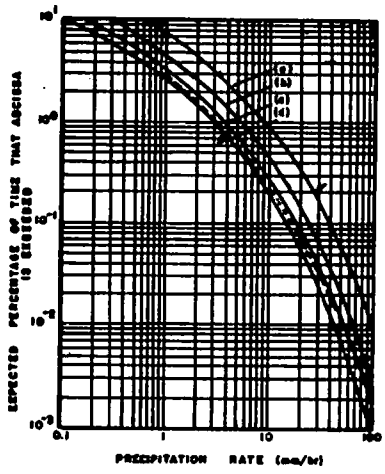

Fig.3 - Statistical Distribution of Precipitation Rates in Typical Brazilian Regions

b. Rio de Janeiro
a. Belém
c. Curitiba
d. Quixeramobim

make a comparison, the broken line in Figure 3 shows the data observed in Washington[8] (temperate climate). This effect of temperature can be neglected, at least in the range studied and for intense rain.

REFERENCES

1. Ryde,J.W., Rept.7831, GE Co., Res.Labs., Wembley,UK, October (1941).
2. Ryde,J.W.and D.Ryde,Rept.8516 GE Co.,Res.Labs.,Wembley, UK, August (1944).
3. Ryde,J.W.and D.Ryde,Rept.8670 GE Co.Res.Labs., Wembley,UK, May (1945).
4. Best,A.C.,Quart J.of Roy. Meteor.Soc.,*76*, 302 (1950).
5. Laws,J.O.and D.A.Parson,Trans. Am.Geophys.Un. *24*,432 (1950).
6. Freny,A.E.and J.D.Gable, BSTJ *48*, 1789 (1969).
7. Saxton,J.A.and J.A.Lane,Proc. Roy.Soc.*213* ,400 (1952).
8. Holzer,W.,Microwave J.*8*,119 , (1965).