RECOMMENDATION ITU-R P.838-2

Specific attenuation model for rain for use in prediction methods

(Question ITU-R 201/3)

(1992-1999-2003)

The ITU Radiocommunication Assembly,

considering

a) that there is a need to calculate the attenuation due to rain from a knowledge of rain rates,

recommends

1 that the following procedure be used.

Specific attenuation γ_R (dB/km) is obtained from the rain rate R (mm/h) using the power-law relationship:

$$\gamma_R = kR^{\alpha} \tag{1}$$

The frequency-dependent coefficients k and α are given in Table 1 for linear polarizations (horizontal: H, vertical: V) and horizontal paths.

The values in Table 1 have been tested and found to be sufficiently accurate for attenuation prediction up to frequencies of 55 GHz.

The coefficients k and α may alternatively be determined, as a function of frequency, from the following equations, which have been derived from curve-fitting to power-law coefficients derived from scattering calculations:

$$\log k = \sum_{j=1}^{3}\left(a_j \exp\left[-\left(\frac{\log f - b_j}{c_j} \right)^2 \right] \right) + m_k \log f + c_k \tag{2}$$

$$\alpha = \sum_{i=1}^{4}\left(a_i \exp\left[-\left(\frac{\log f - b_i}{c_i} \right)^2 \right] \right) + m_\alpha \log f + c_\alpha \tag{3}$$

where:

f: frequency (GHz)

k: either k_H or k_V

α: either α_H or α_V.

TABLE 1

Frequency dependent coefficients for estimating specific attenuation using equations (4), (5) and (1)

Frequency (GHz)	k_H	k_V	α_H	α_V
1	0.0000387	0.0000352	0.9122	0.8801
1.5	0.0000868	0.0000784	0.9341	0.8905
2	0.0001543	0.0001388	0.9629	0.9230
2.5	0.0002416	0.0002169	0.9873	0.9594
3	0.0003504	0.0003145	1.0185	0.9927
4	0.0006479	0.0005807	1.1212	1.0749
5	0.001103	0.0009829	1.2338	1.1805
6	0.001813	0.001603	1.3068	1.2662
7	0.002915	0.002560	1.3334	1.3086
8	0.004567	0.003996	1.3275	1.3129
9	0.006916	0.006056	1.3044	1.2937
10	0.01006	0.008853	1.2747	1.2636
12	0.01882	0.01680	1.2168	1.1994
15	0.03689	0.03362	1.1549	1.1275
20	0.07504	0.06898	1.0995	1.0663
25	0.1237	0.1125	1.0604	1.0308
30	0.1864	0.1673	1.0202	0.9974
35	0.2632	0.2341	0.9789	0.9630
40	0.3504	0.3104	0.9394	0.9293
45	0.4426	0.3922	0.9040	0.8981
50	0.5346	0.4755	0.8735	0.8705
60	0.7039	0.6347	0.8266	0.8263
70	0.8440	0.7735	0.7943	0.7948
80	0.9552	0.8888	0.7719	0.7723
90	1.0432	0.9832	0.7557	0.7558
100	1.1142	1.0603	0.7434	0.7434
120	1.2218	1.1766	0.7255	0.7257
150	1.3293	1.2886	0.7080	0.7091
200	1.4126	1.3764	0.6930	0.6948
300	1.3737	1.3665	0.6862	0.6869
400	1.3163	1.3059	0.6840	0.6849

The remaining coefficients are given in Tables 2 and 3.

TABLE 2

Coefficients in equations (2) and (3) for horizontal polarization

	a	*b*	*c*	m_k	c_k	m_α	c_α
j = 1	0.3364	1.1274	0.2916	1.9925	–4.4123	–	–
2	0.7520	1.6644	0.5175				
3	–0.9466	2.8496	0.4315				
i = 1	0.5564	0.7741	0.4011	–	–	–0.08016	0.8993
2	0.2237	1.4023	0.3475				
3	–0.1961	0.5769	0.2372				
4	–0.02219	2.2959	0.2801				

TABLE 3

Coefficients in equations (2) and (3) for vertical polarization

	a	*b*	*c*	m_k	c_k	m_α	c_α
j = 1	0.3023	1.1402	0.2826	1.9710	–4.4535	–	–
2	0.7790	1.6723	0.5694				
3	–1.0022	2.9400	0.4823				
i = 1	0.5463	0.8017	0.3657	–	–	–0.07059	0.8756
2	0.2158	1.4080	0.3636				
3	–0.1693	0.6353	0.2155				
4	–0.01895	2.3105	0.2938				

For linear and circular polarization, and for all path geometries, the coefficients in equation (1) can be calculated from the values in Table 1 using the following equations:

$$k = [k_H + k_V + (k_H - k_V)\cos^2\theta\cos 2\tau]/2 \tag{4}$$

$$a = [k_H a_H + k_V a_V + (k_H a_H - k_V a_V)\cos^2\theta\cos 2\tau]/2k \tag{5}$$

where θ is the path elevation angle and τ is the polarization tilt angle relative to the horizontal ($\tau = 45°$ for circular polarization).

For convenience, a quick estimate of values of k and α at frequencies other than those in Table 1, can be obtained from Figs. 1 to 4.

FIGURE 1

k coefficient for horizontal polarization as a function of frequency

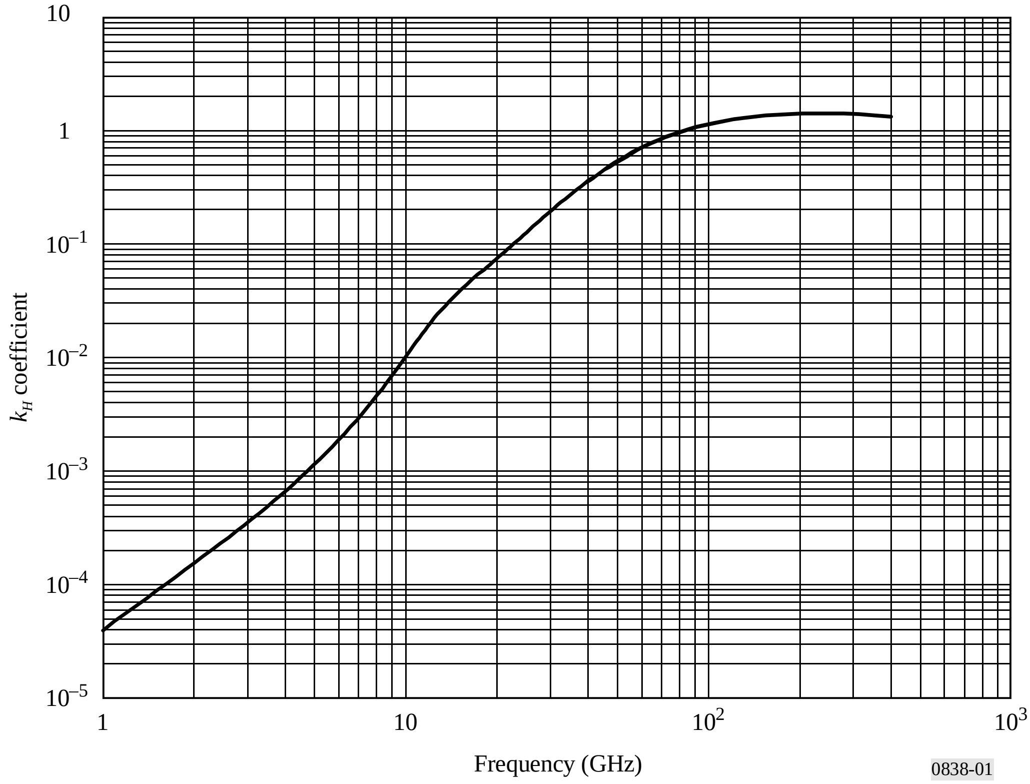

FIGURE 2

α coefficient for horizontal polarization as a function of frequency

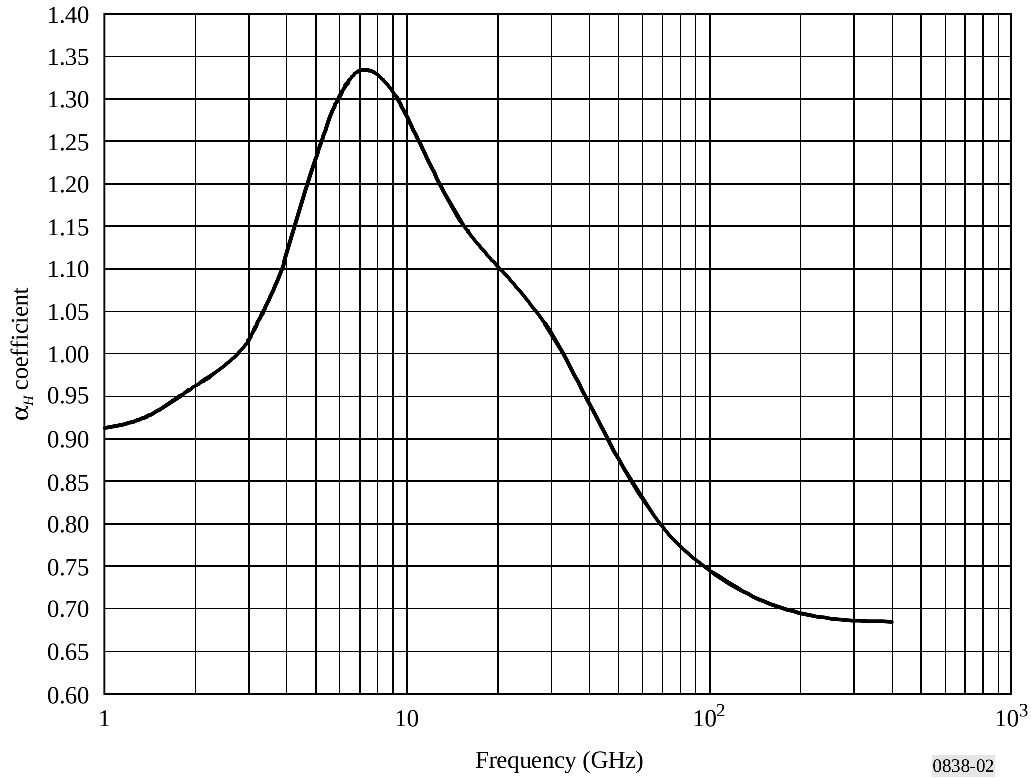

FIGURE 3

***k* coefficient for vertical polarization as a function of frequency**

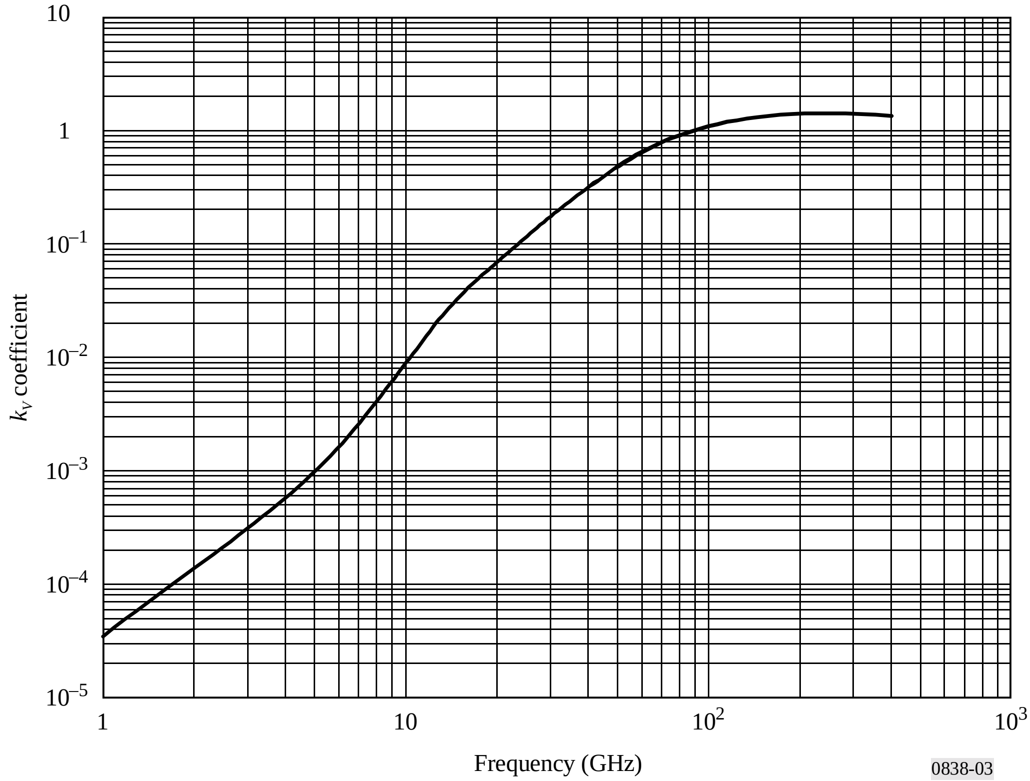

FIGURE 4

α coefficient for vertical polarization as a function of frequency