OXYGEN AND WATER VAPOR ABSORPTION OF RADIO WAVES IN THE ATMOSPHERE (*)

by B. R. Bean & R. Abbott (**)

Summary — Calculated values of the gaseous atmospheric absorption are presented for the frequency range 100 to 50,000 Mc at elevations above ground up to at least 130,000 feet, for average conditions during February and August at Bismarck, N. D., and Washington, D. C. Total radio path absorptions are presented for tropospheric forward scatter communication links for distances of 100, 300 and 1000 miles. The total path absorptions were calculated by summing the absorption contributed by each portion of the atmosphere traversed by a radio ray passing from a 60 foot parabolic antenna resting on the ground to the scattering center and then to a similar receiving antenna. A correlation of total path absorption with the surface value of absolute humidity is developed, thus providing estimates of the range of absorption values in different geographic areas. Maps of average absolute humidity for the world are presented. Previous work on rain absorption is then combined with the present study to provide estimates of the radio power loss due to absorption expected to be exceeded 1 per cent of the time.

1. Introduction and objectives — The recent advent of tropospheric forward scatter techniques has made possible communication over longer distances with higher frequencies than has been heretofore thought practicable. The limitations imposed by gaseous atmospheric absorption upon the power requirements of communications systems for this application become more important with increasing distance and frequency. It has been common in the past to evaluate the propagation path attenuation due to absorption by multiplying the ground separation of the terminals by the value of absorption calculated for surface meteorological conditions (1) or avoid the problem by restricting the communication system estimates to frequencies that are essentially free of absorption (2). It is the purpose of this paper to: (a), examine the geographic and seasonal variations of gaseous atmospheric absorption; (b), derive estimates of radio propagation path absorption loss by following a radio ray through the atmosphere from transmitter to scatter-

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ing center to receiver; and (c), present meteorological statistics as a means of estimating seasonal and geographic variations of absorption from standard meteorological measurements.

2. Absorption theory — For the frequencies considered in this paper, 100 to 50,000 Mc, the gaseous absorption arises principally from the 1.35 cm line (22,200 Mc) of water vapor and the 0.5 cm line (60,000 Mc) of oxygen. The variations of these absorptions with frequency, pressure, temperature, and humidity are described by the VAN VLECK (8) theory of absorption. The frequency dependence of these absorptions is shown in Fig. 1.

![Diagram of atmospheric absorption by the 1.35 cm line of water vapor and the 0.5 cm line of oxygen. Water vapor absorption calculated for the mean absolute humidity at Washington, D. C.](image)

Fig. 1 - Atmospheric absorption by the 1.35 cm line of water vapor and the 0.5 cm line of oxygen. Water vapor absorption calculated for the mean absolute humidity at Washington, D. C.

The water vapor absorption has been adjusted to correspond to the mean absolute humidity (grams of water vapor per cubic meter) for Washington, D. C. It is important to note that the water vapor absorption exceeds the oxygen absorption in the frequency range 13,000 Mc to 32,000 Mc and the total absorption will be most sensitive to changes in the water vapor content of the air, while outside