3-IV A4

PROPAGATION TEST USING ASTRONOMICAL RADIO SOURCES AT 15.5 AND 31.6 GHZ

Hiroshi Yokoi, Toshio Satoh,
Matsuichi Yamada and Masataka Akagawa
Research and Development Laboratory
Kokusai Denshin Denwa Co., Ltd.
Tokyo, Japan

Introduction

Propagation tests for satellite communication at frequencies above 10 GHz have usually been conducted by observing the solar radio emission. But, it has been pointed out and recognized that the radio waves from large disc-type sources, like the sun or the moon, and that from a point source, like a satellite, have some different propagation characteristics[1]. This paper describes the results of measurements of the waves from the moon and Venus at 15.5 and 31.6 GHz, as well as some features of the measuring system including a 7-m antenna.

Experimental Configuration

Fig. 1 shows the blockdiagram of the equipment used. Dicke-type radiometer bandwidths are 100 MHz, and the minimum detectable temperatures are 0.03 (τ=1sec) and 0.5 (τ=3sec)$^{\circ}$K at 15 and 31 GHz, respectively. A liquid-nitrogen-cooled parametric amplifier, having noise temperature of 92°K, is provided as a preamplifier for 15 GHz system.

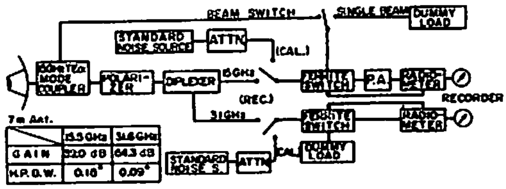

Fig.1 Block diagram of receiving circuit

The antenna is of a near-field Cassegrain type. The surface accuracy of the main reflector is 0.20 mm (r.m.s.), and it could be used up to some 100 GHz.

In addition, this antenna is equipped with a new beam switching system at 15 GHz. The outputs of a dominant (TE_{11}) mode beam, which has a main lobe at boresight, and a higher (TE_{01}) mode beam, which has a null at boresight, are electrically switched alternately to get the difference between them. Weak signals are successfully picked up as a result of the cancellation of background noise fluctuation of the atmosphere included in both beams.

Propagation Characteristics

Fig. 2 is a plot of the atmospheric attenuation obtained from observations of the moon and Venus. Measurements were made on clear days, when the absolute humidity and refractivity at the earth surface were nearly constant. K(θ) in the figure is the equivalent pathlength normalized to the zenith. It is seen in the figure that the attenuations obtained from the observations of Venus are much larger than those of the moon. The reason for this difference is considered to be as follows; Only the absorptive

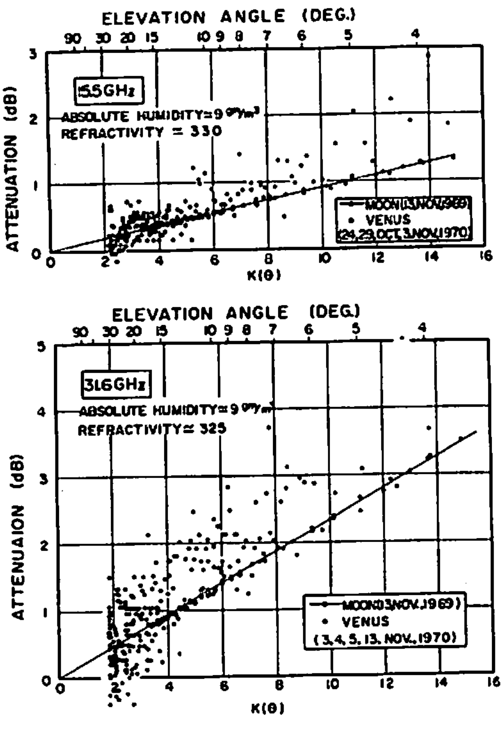

Fig.2 Observed plots of attenuation vs. K(θ)

attenuation is observed in the case of a large angular-size source, while the radio waves are further attenuated in the case of a point source, due to the divergence caused by vertical gradients of refractive index and the diffusion effect caused by turbulence in the atmosphere[1]. Fig. 3 shows the absorptive attenuations at zenith obtained from observations of lunar noise as a function of the absolute surface humidity. Attenuation at the absolute humidity of zero indicates the absorption due to oxygen, and their values are 0.055 and 0.14 dB at 15.5 and 31.6 GHz, respectively.

It will be of interest to note that some amount of scintillation was observed for the Venus signal below 10° of elevation angle, which never appeared in the lunar noise.

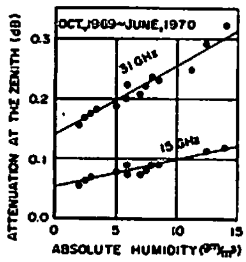

Fig.3 Attenuation at the zenith vs. absolute humidity

In treating the rainfall attenuation in the space-to-earth path, the vertical extent of rainfall and rain clouds should be taken into account. The rainfall attenuation Ar can be expressed as:

$$Ar = \alpha R^{\beta} D_0 K(\theta) + Cr(\theta) \quad [dB],$$

where α and β are constants related to frequencies, R the rainfall rate in mm/h, D_0 the equivalent vartical extent of rainfall in Km, Cr the attenuation due to rain clouds, and θ the elevation angle. Fig. 4 shows the relations between attenuation and rainfall rate

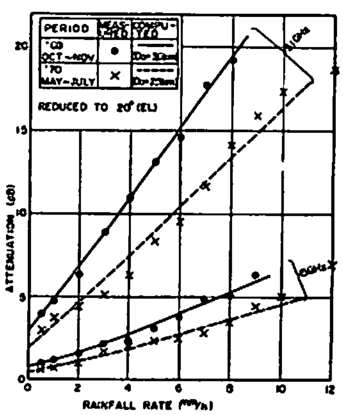

Fig.4 Attenuation vs. rainfall rate

obtained from lunar noise observations in rainy seasons, automn in 1969 and early summer in 1970, where attenuations are reduced to the values at an elevation angle of 20°. Parameters for these computations[2] are shown in Table 1.

	α	β	Cr (dB) D_0=2.5Km	Cr (dB) D_0=3.6Km
15.5GHz	0.037	1.18	0.5	0.8
31.6GHz	0.185	1.03	2.0	3.0

Table 1

In Fig. 5 the measured values of attenuation due to rain clouds are plotted on the calculated curves[3], where water vapor density is assumed to be 1.5 gm/m³ and the equivalent thickness 1 Km.

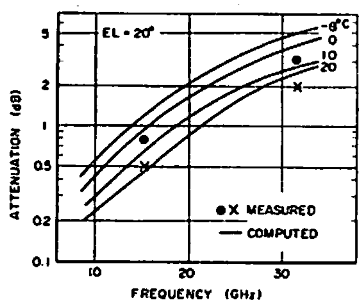

Fig.5 Attenuation due to rain clouds

Conclusion

Measurements of atmospheric attenuation in the clear sky have been made by observing the radio noise from Venus and the moon. The measuring techniques to separate the absorption from other attenuations are of great importance. Attenuations due to rainfall and rain clouds and the vertical extent of rainfall have also been measured from observations of lunar noise. Observation periods, however, were not long enough, and further measurements are required to obtain more statistical data.

Experiments are under way now to clarify the rainfall attenuation characteristics for the radio waves from a point source by receiving the noise of celestial radio source Cas A and Tau A.

References

1. H. Yokoi, M. Yamada and T. Satoh; Publ. Astr. Soc., Japan, 22, 511-524 (1970)

2. T. Oguchi; J. Radio Res. Labs., 11, 19-37 (1964)

3. Gunn and East; J. Roy. Meteorol. Soc., 80, 522-545 (1954)