ANOMALOUS PROPAGATION FADING IN CARS BAND LOCAL DISTRIBUTION SERVICE

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Fading phenomena, due both to rainfall and to atmospheric conditions constitute a basic limitation on the reliability of CARS band Local Distribution Service. Long paths are of particular interest since both fading mechanisms are critically dependent on path length.

This paper describes the results of several months of continuous observation of fading over a 24 mile path in eastern Connecticut. Fades have been correlated with rainfall and those due to this source have been separated as non-contributory to the body of information already available. All other fades are summarized by number of fades, total duration, and by daily time slots corresponding generally to different television viewing habits.

Empirical expressions are derived describing the occurance of anomalous propagation fading and the effect on path reliability.

I. INTRODUCTION

The increasing use of microwave local distribution service (LDS) to reduce the required length of trunk runs to population centers generates the need for data from which transmission reliability can be predicted. Paths have generally been limited to 10 to 15 miles because of fears that outages will be of a frequency and duration sufficient to affect subscriber retention. If the path can be increased to 20 to 25 miles, with good reliability, it would be possible to provide service to many communities not economically viable if another head end were required.

This very situation was encountered in eastern Connecticut. It prompted the establishment of a 24 mile long path over which signal fluctuations were continuously recorded for a period of several months.

II. FRANCHISE GEOGRAPHY

This franchise as awarded by the Public Utilities Commission of the State of Connecticut is outlined in Figure 1. It is 50 air miles between extremities and bisected by a franchise of another company. The northern towns are sparsely populated and would not be generally considered a viable cable television area if not subsidized by the more densely populated southern towns. Furthermore, the northern towns lie in a river valley with an elevation of 150-200 feet AMSL and surrounded by hills of 500-800 feet elevation. This geography dictates use of either a very tall tower situated in the valley or a tower in the hills. Hilltop sites would be sufficiently remote from the towns to require either microwave distribution or two head ends. The combination of sparse population and high head end costs to provide service to those northern towns required a search for an alternative which would reduce costs while still providing satisfactory service.

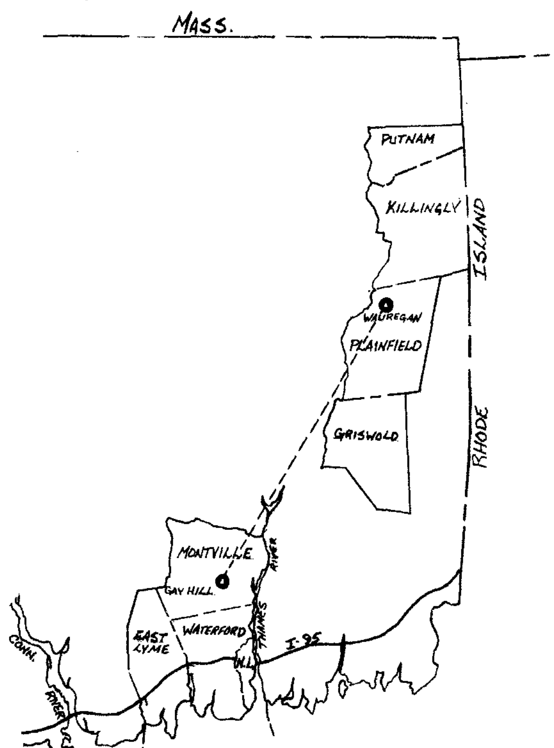
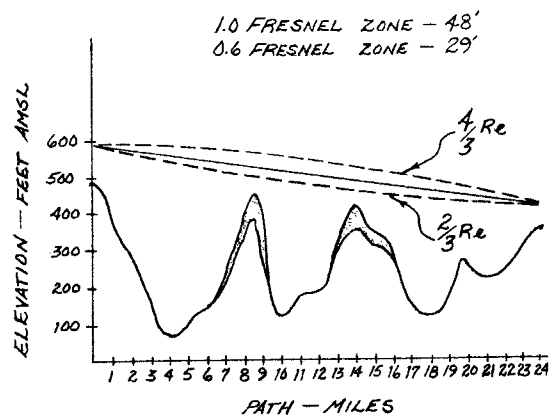


FIGURE 1

The head end located in the town of Montville in the southern town area already contained an LDS microwave system which distributes the signal to those parts of the towns of New London, Waterford, and East Lyme lying south of Interstate 95.

The path profile from the existing head end to a centrally located site in the northern towns is shown in Figure 2. The terrain is hilly but not mountainous, the shaded area on the two highest hills represents trees. Drawn on the profile are dashed lines which represent the clearances for refractive conditions equivalent to 4/3 and 2/3 earth's radius bending. It is seen that the minimum clearance for 2/3 earth radius bending is about 45 feet. Since a 0.6 fresnel zone height is 29 feet, adequate clearance is achieved for any of the above refractive conditions.



PATH PROFILE

FIGURE 2

III. FADING CAUSES

Microwave path reliability is dependent on two fading sources, rain attenuation and fading due to abnormal atmospheric conditions.

Rain fading has been exhaustively studied by many investigators dating back to the 1940's and is well understood. It can be readily predicted over a period of time if the rainfall statistics for the area are known. This 24 mile path should experience about 9 hours a year when the signal is faded 20 dB by rainfall.

Fading due to atmospheric conditions can result from substandard refraction conditions or from multipath effects. The former occurs when the transmitted beam is bent upward sufficiently far to be no longer intercepted by the receiving antenna. It is called inverse bending and appears to be a relatively rare phenomenon. When it does occur, however, it may last for several hours. Multipath fading occurs when signals from the transmitter traverse two or more paths to the receiver and interfere destructively upon combination. It will occur regardless of the height of the path above the terrain since the interfering signal generally traverses a path above that of the direct signal.

The most significant study of multipath propagation near CARS band frequencies was done by Bell Telephone Laboratories. The work centered upon worst-case fading for time of day and time of year so that extrapolation to yearly television viewing reliability is not possible.

Because multipath fading is proportional to the cube of the path length, this 24 mile path is generally considered long for CARS band LDS distribution and an appropriate one to study the effect.

IV. MEASUREMENT ARRANGEMENT

The equipment employed in making measurements were the Theta-Com Model AML-TC-121 transmitter and Model RC-230 receiver. Both transmitting and receiving antennas were 10 feet in diameter.

The unfaded signal to noise ratio at the pilot tone with the AGC disengaged was 55 dB, the AGC was set for 6 dB to a S/N of 49 dB out of the receiver.

The AGC voltage was calibrated with respect to signal level then continuously recorded. The data was reduced to number of fades and duration of fading when fade depths were greater than 6 dB. Since fade outage time is proportional to the power ratio of the fade except for a 15% correction factor at low fade level, the 6 dB fade data can be readily extrapolated to outage times for greater fade depths. A 20 dB fade depth was taken to define true microwave outage time since it results in a 35 dB S/N which is noisy but still watchable.

Rain fading was separated from atmospheric fading by keeping a record of weather conditions over the general area. Rain fading is readily distinguishable from multipath fading as the latter is always accompanied by large fluctuations of signal level while rain fading causes the signal to smoothly enter the fade condition.

V. DATA SUMMARY

Unlike telephone service which requires essentially constant reliability throughout the day, the nature of television viewing is such that certain times are much less important than others. Thus, if a large portion of signal fading occurs in the 1 a.m. to 7 a.m. time period, overall performance may be acceptable. For this reason, the data has been accumulated by daily time periods corresponding roughly to different viewing habits.

Table 1 is a summary of the collected data by time period. The last column is an extrapolation to yearly outage time.

TABLE 1

Time Period	Data Base	# of Fades	Total Fade Time	Hours/Year @ 20 dB
7 am-1 pm	37,800 min.	22	366 min.	0.977 hrs.
1 pm-7 pm	39,000	4	25	0.060
7 pm-10 pm	19,620	32	170	0.438
10 pm-1 am	19,620	27	420	1.078
1 am-7 am	37,440	106	1887	5.077
TOTALS	153,480 min.	191	2868 min.	7.63 hrs.

Based on the above, it is expected that 7.6 hours per year will experience fades greater than 20 dB with 5.1 of those hours occurring in the 1 a.m. to 7 a.m. period.

There was multipath fading on 24 of the 119 data days.

There were 3 days during which either inverse bending or stable multipath fading occurred. These long term fades constituted 22.5 hours of the total 47.8 hours of anomalous fading observed. These fades existed from 4 a.m. to 7:30 a.m., 10 p.m. to 10:30 a.m., and 12 p.m. to 7 a.m. respectively. The depth of these fades is not known; but no reports of outages were received from a number of observers on the cable.

Based on the observations, the fractional outage time for all periods of the day can be expressed by

(1) $$P = 6.30 \times 10^{-6} D^3 L \quad \text{for } L \leqq .01$$

where

P = fractional outage time

D = path length in miles

L = power ratio of fade depth

If 1 a.m. - 7 a.m. fade time is removed as unimportant to viewing reliability, the following equation describes the outage time:

$$P = 2.11 \times 10^{-6} D^3 L$$

CONCLUSIONS

Data collected over a 24 mile path for nearly 1/3 of a year indicate a total yearly outage time for anomalous fading of about 7½ hours. This added to a predicted 9 hours of rainfall fading indicates less than 17 hours per year during which viewing is interrupted. Since 2/3 of the anomalous fading and a part of rain fading will occur during non-viewing hours, this projected outage time does not seem excessive. Although anomalous propagation fading is a function of the character of the terrain and of the temperature and humidity conditions of an area, it is to be expected that the bulk of this kind of fading will occur during the early morning hours when propagation reliability is of less importance.

Although each system designer will have to judge whether the expected outage time on a long path is acceptable, it does appear that a more aggressive approach may often be of economic advantage to the operator.

REFERENCES

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