TOWARDS A MORE ECONOMIC MICROWAVE SYSTEM FOR CATV

James F. Roche
Raytheon Service Company
Burlington, Massachusetts

ABSTRACT

Microwave system specifications have evolved from either handbook criteria or rigorous requirements for common carrier systems. While SSB and FM systems have been designed to satisfy some of the unique needs of CATV systems, in many instances there are not suitable design criteria or off-the-shelf equipment available.

Standards tailored for the industry can lead to the development of systems optimized for CATV.

One item which should be looked at is consideration of fade margins for CATV. What is a realistic acceptable outage? What are the resulting appropriate fade margins for specific path lenghts? This paper focuses areas where industry action can result in more economic systems.

INTRODUCTION

Design of microwave systems for CATV use are heavily influenced by the requirements of other services because of the absence of specific criteria pertinent to the specific needs of CATV.

In this paper attention is given to those areas where system design requirements, generally applied to communications, can be relaxed without danger of compromise of the needs of CATV service while achieving considerable savings.

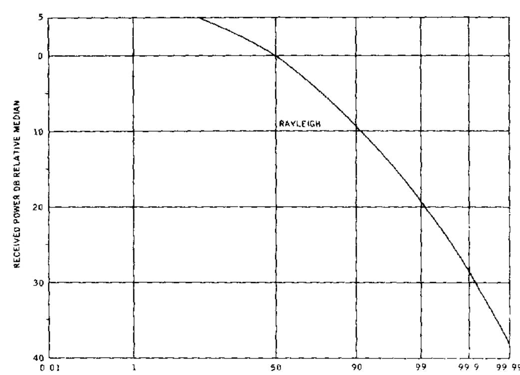
The objective is not to recommend specifications but only to identify those areas where savings are possible through reduction of over-design.

Consideration is given to path loss criteria, clearance requirements, tower design and equipment configuration.

Projected savings such as these cited can be realized through an industry created mechanism to formalize the requirements for CATV in appropriate standards and specifications.

PATH LOSS AND FADE MARGIN

In specifying microwave systems, great emphasis has been placed on path loss and fade margin to provide a given level of reliability. The most commonly used criterion is a Rayleigh distribution. This distribution which is illustrated in Figure 1 states that a 40 db margin provides 99.99% reliability, etc. In actuality, the cases where a Rayleigh distribution can be applied validly are limited and have no physical basis.



Distribution of Signal Level Received Over 8-10 Mile Path

Figure 1

Rayleigh developed his distribution as a description of the resultant amplitude produced by an infinite number of vectors of equal amplitude and random phase. There are few cases where such conditions are satisfied in actual application. In fact, there are many cases where long-term data indicates the Rayleigh distribution is not borne out.

As shown in Figure 2, a 99.99% reliability can be achieved with a 20 db margin. This indicates that a 40 db margin is an over-design of 10000% which certainly is not consistent with other reliability required.

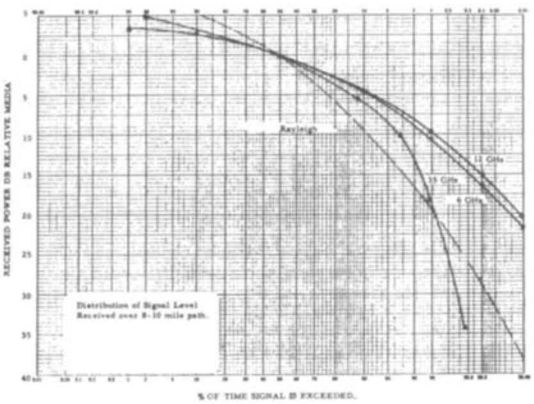


Figure 2

At this point one might also raise the issue of the sanctity of the 99.99% reliability issue. For example, is the increase in reliability from 99.95% to 99.99% important enough to the users to justify a 7 db or 6 times increase in system gain? This is especially important when one considers that most CATV systems are not operated 24 hours a day and further, the greatest probability of occurrence of outages is at hours outside the normal operating hours.

The effects of precipitation is another factor which probably has been overemphasized, especially in view of the paucity of rainfall rate and spatial correlation data. Almost all reference to rainfall attenuation goes back to the work of Hathaway and Evans[1] who demonstrated that operational systems confirmed the theoretical and empirical works of Ryde & Ryde[2] and Bussey[3].

Attenuation is stated in terms of db/km/mm per hour of attenuation based on statistics whose data base is not of sufficient size to justify universal application. A change of attenuation rate of 00.02db/km/mm will result in a 9 db increase in required margin over a 10 mile path. The derivation of the attenuation rates are not accurate to ±.02 db/km/mm, and should not be used as the basis of adding increase system gain.

It also should be noted that the atmospheric conditions which produce fading are not likely to occur simultaneously with precipitation.

PATH CLEARANCE

A second area of potential savings is path clearance. It is currently in vogue to use path clearance requirements assuring SUB-refraction conditions.

The modified earth radius concept was introduced as a tool to account for refractive effects. This has been expanded to attempt to account for cases of SUB-refraction. The unfortunate use of the term "earth buldge fading" has been used indiscriminately to describe all types fading supposedly attributable to SUB-refractive conditions. Little simultaneous data of radio and atmospheric conditions are available.

Use of the true earth radius and .6 fresnel zone clearance will provide 99.98% reliability for 20 mile paths except in unusual cases. Such cases should be individually analyzed; but a severe clearance requirement should not be necessarily applied unless a clear relationship of improved reliability and increased clearance can be supported.

References:

1. Hathaway, S.D. and H. W. Evans, "Radio Attenuation at 11 kmc and Some Implications Affecting Radio Relay Engineering", BSTJ, Vol. 38, No. 1, Jan. 1959, pp. 73 - 97.

2. Ryde, J.W. and Ryde, D., "Attenuation of Centimetre and Millimetre Waves by Rain, Hail, Fog and Clouds", Gen. Elec. Corp., Res. Labl, London, Rep. No. 8670 (1945).

Reference:

3. Bussey, H.E., "Microwave Attenuation Estimated from Rainfall and Water Vapor Statistics", Proc. IRE, Vol. 38, pp. 781 - 785, 1950.

An example of the effects of clearance requirements on antenna heights are shown in Table 1.

TABLE I. ANTENNA HEIGHT REQUIREMENTS FOR VARIOUS DISTANCES AND EARTH CURVATURES

PATH LENGTH MI	ANTENNA HEIGHT REQUIRED (FT)		
	K = 4/3	K = 1	K = 2/3
10	31	35	47
15	50	61	80
20	78	97	128
40	238	298	438

(.6 FRESNEL ZONE CLEARANCE ASSUMED)

Table 1

TOWER DESIGN

At the present time, we have only EIA RS222 as a guide for tower design. This specification essentially requires sufficient freedom from deflection to maintain antenna position so that degradation due to wind does not exceed 10 db. In view of the fact that during high winds there is little likelihood of fading, this requirement greatly exceeds the margin necessary to maintain communications.

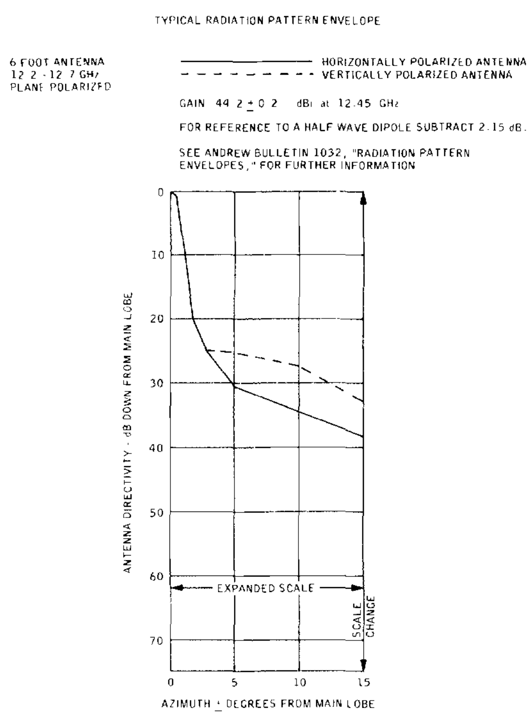


Figure 4

A degradation of as much as 30 db could still exceed the system threshold by 10 db. As shown in Figure 4, angular deviations up to 5° could be tolerated if 30 db degradation were acceptable. There, of course, could be conditions where rain attenuation and high wind occur simultaneously. Data which established the probability of such simultaneous occurance is not available.

The exact saving resulting from relaxation of deflection specifications is not readily identifiable. In one case, a reduction of 20% of the cost of a tower could be achieved with a relaxation of 20 db. There are probably many instances where towers designed for broadcast antennas could be shared for microwave systems without costly tower reinforcement.

EQUIPMENT CONFIGURATION

In addition to establishing equipment power requirements consistent with the needs of CATV, configuration of equipment in an optimum manner for all CATV services has not been achieved. Some manufacturers have developed systems which satisfy some of the needs of the operator but not all.

For example, how many video channels are typically required to be transmitted via microwave? A few studies have been carried out indicating that four channels could be a requirement in many cases. If this is confirmed and indicated as a need, it is quite likely that manufacturers will bring such a configuration to the market with some cost savings.

SUMMARY

In the foregoing, the areas where possible savings can be realized with modifications in the design of systems have been discussed qualitatively and quantitatively. These include path loss, path clearance, tower design and equipment configuration. The attendant reduction in system performance associated with relaxation of standards which have been developed for other services will not significantly affect services to subscribers. Operators of CATV services should have the opportunity of making these decisions through microwave system standards developed for its needs rather than being forced to design systems to the standards of other services.

This approach is not to suggest that we abdicate engineering principles, but rather that we develop standards consistent with the needs of the users and not saddle one service with the requirements of another because that is the only available standard.