BENEFITS OF COMPRESSED VIDEO DATA TRANSMISSION THROUGH AML

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ABSTRACT

The advantages of digitized compressed video are particularly relevant to microwave transmission in that such formats permit transmission of many more than the maximum 79 channels which otherwise could be carried in the 500 MHz wide 13 GHz CARS band. A further advantage is the potential for significantly increased microwave fade margin when digitized video is utilized in place of analog VSBAM. Since under normal propagation conditions the noise contribution of AML is only a very small portion of the overall CATV system noise, the focus here must be on the performance of the digital modulation scheme under faded conditions. Transmission of the QPSK Skypix signal through AML systems has already been successfully demonstrated. Considerations relating to the carriage of higher level modulation formats such as 16 QAM through existing AML systems are explored. In this regard, the differences between CATV systems utilizing channelized transmitters and block conversion transmitters are analyzed.

DIGITAL VIDEO ADVANTAGES

The principal reason for the intense interest in digitized compressed video transmission through cable systems is the promise of greatly increased video channel capacity. Traditionally, cable systems have increased their channel capacity by extending the bandwidth. Alternatively, dual cable systems offered a way of getting around the limits of the existing technology. Since its introduction in 1971, AML microwave has been able to fulfill the channel requirements of the cable industry through both of these techniques. Starting with only 14 channels (2 to 13 plus J and K) at that time, AML microwave systems today span the full range between 54 and 552 MHz. This, however, fills up the 12.7 to 13.2 GHz CARS band so that continued bandwidth expansion at these frequencies is no longer possible due to the FCC regulatory limit. It is true that the 18.14 to 18.58 GHz band is also open to utilization by CATV operators, but such use would require a separate transmitter and receiver, much as in dual cable systems. At least the 13/18 GHz option is not limited by the site constraints of microwave frequency reuse as in the 120 channel AML system installed in Dallas some years ago.[1]

In fact, considerable development of broadband 18 GHz AML has taken place in the last year in response to the market demands generated by the authorization granted in 1991 for use of 18 GHz by SMATV operators. CATV systems, having had access to 13 GHz where both atmospheric propagation and equipment performance is better, had not, with one exception, utilized 18 GHz AML even though the band was open to them since 1985.[2] If a CATV operator wished to carry 150 VSBAM channels via AML, in theory he could do so by utilizing both 13 and 18 GHz. Nevertheless, it must be recognized that this approach is less attractive than if all 150 channels could be accommodated by a single 13 GHz transmitter/receiver pair with interface up to 1 GHz. Compressed digital video overcomes this problem by squeezing all 150 channels, or more, into the regulatory 500 MHz wide limit.

Another advantage of digital format is that it is not as susceptible to noise and interference as the VSBAM signal. The situation is similar to the so-called "FM improvement factor" which is obtainable at the expense of bandwidth. Indeed, if it were not for the large reduction in the number of bits through the video compression algorithms, the digital signal would have to occupy a much wider bandwidth than the standard VSBAM signal. For a given bit rate, the wider the bandwidth, the greater the immunity to noise and interference. That is why QPSK will be utilized in the satellite downlinks. Higher order digital modulation schemes such as 16 QAM are relatively less robust but should still be satisfactory for transportation through cable systems.

The above characteristic of digitally encoded signals is of particular advantage to AML microwave system operators since path fades are a factor which must be taken into account. With VSBAM, the signal quality degrades linearly with received signal level if the fade depth causes the microwave system's contribution to the overall CATV system C/N to become predominant. The standard design procedure includes a calculation of the probability of the fade causing the C/N to drop below a given value, usually 35 dB. This corresponds to a weighted S/N of 37 dB which, according to a recent survey[3], was judged to be between annoying and very annoying impairment of picture quality. An older survey judged a 38 dB S/N to be "slightly annoying" and the 1958 TASO study described a 28 dB S/N as "somewhat objectionable". This not only illustrates the fact that viewers' expectations have increased over the years, but also that the VSBAM signal is still viewable down to at least 25 dB C/N. By contrast, a digital signal would not degrade in quality as long as the C/N remained above threshold. A threshold of 20 dB has been reported[4] in an experiment involving a 16 QAM signal carried over a test cable system. In the test the VSBAM C/N was 30 dB but the digital signal was carried at a level of −10 dBc relative to the VSBAM pictures.

In an actual cable system application the degree to which the digital signal level would have to be depressed relative to the VSBAM signal, if any, would depend on system loading considerations relative to the quality of the VSBAM signals. As reported, the test illustrates the relative immunity of the digital signal to CTB distortion generated by the VSBAM carriers. Thus, if a system were to carry only digital signals, the microwave transmitter power limiting linearity constraints would be greatly eased and the power output could be increased. This further increases the fade margin. When combined with the improved threshold level, the improvement in microwave path reliability could then in many cases exceed an order of magnitude; i.e., a predicted reliability of 99.9% would become better than 99.99%.

AML CARRIAGE OF DIGITAL SIGNALS

The fact that AML microwave can successfully carry digital signals is already well established by experiment. A 30 MHz wide Skypix compressed video QPSK digital signal was carried through a cable system which included two distinct AML hops in tandem.[5] It was shown that with the data signal 6 dB below the standard VSBAM video level, the signal could fade to a VSBAM 18 dB C/N before the data signal would start to exhibit tiling. The test illustrates that phase noise in Hughes AML equipment did not degrade the data even with a total of four frequency conversion operations.

Because of the required bandwidth, the above test did not include filters which might conceivably degrade the digital signal threshold. However, a 3 MHz wide digital audio service employing a nine-level QPR modulation is already widely carried in cable systems employing channelized AML transmitters. Two such signals can be accommodated within a standard video channel upconverter and up to six digital audio signals can be accommodated in channels employing wider bandwidth filters such as the standard 88 to 108 MHz FM broadcast channel. The main limitation is imposed by audio signal intermodulation products which fall in the adjacent video channels. For this reason the digital audio signals are carried at least 10 dB below video. The required channel flatness over the 3 MHz increments is readily obtainable with a minimum of care.

AML CHANNEL CHARACTERISTICS

As one progresses up the ladder of bandwidth efficiency from QPSK to 16 QAM and beyond, the digital system becomes more sensitive to noise and other channel impairments. RF channel characteristics such as AM/PM conversion, frequency response, return loss, and group delay may have to be improved in both the overall cable system and specifically on the AML link when the less robust modulation schemes are considered.

Broadband AML systems employing block upconverter type transmitters as well as the block downconversion receivers, are the least likely to encounter any difficulty in transport of higher order digital modulation signals. Considerations regarding such a system are essentially no different than those pertaining to the trunk portion of the cable plant other than the possibility of a microwave path fade which might temporarily reduce the C/N below 35 dB. This in itself may suggest that modulation schemes less robust than 16 QAM or 4 VSB-AM may not be compatible with existing cable systems.

Channelized AML transmitters employ narrow band filters which introduce group delay. The largest amount of delay can be expected in high power AML systems employing the STX-141 transmitter. This is because there are two such filters plus the klystron, all of which contribute to the delay, in each transmitter channel. Even carriage of 20 Mb/s 16 QAM may be somewhat problematic without filter modification. The STX-141S will be slightly better in this regard since the wide band FET amplifier replaces the narrow band klystron in this unit. The SSTX-145 is better yet with a typical 15-nanosecond delay within the inner 5 MHz of the 6 MHz wide channel. This is a consequence of utilizing a wider band filter in the upconverter stage. Similar performance can be expected of an MTX-132 transmitter channel. Thus it is distinctly possible that even some channelized AML systems may be essentially transparent to passage of digitized compressed video signals without any modification.

SUMMARY

Compressed video data transmission allows an increase in channel capacity and greater fade margin in AML microwave systems. These advantages can be expected with little or no modification to existing AML systems. It is however important that one recognizes the desirability of achieving a threshold C/N of less than 25 dB so that cable system subscribers will enjoy the full added quality benefits which digitized video is capable of providing.

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