"Status Report on EIA Broadband Modem Standards"

Harold W. Katz

Market Development Manager
Interactive Systems/3M, Ann Arbor, MI

In May 1978, the Broadband Communications Section of the EIA Communications Division authorized the formation of sub-committee TR 40.1 to develop industrial standards for data modems that would be used on broadband cable networks. A sub-committee comprising industrial end-user representatives and modem manufacturers was formed in late 1978. Three smaller groups were established to provide the initial recommendations on 1) channel allocation, 2) cable system parameters, and 3) modem parameters. The paper presents the current status of the committee's work which used, as a guideline, present CATV technical standards.

Introduction

Interest in the distribution of data via two-way CATV cable networks has been a topic at NCTA conventions for over ten years. However, only a very limited amount of hardware and associated application software has actually been implemented on CATV systems over this period of time. The technology has, nevertheless, undergone extensive development and practical utilization. This activity has taken place primarily in the industrial environment rather than within the CATV industry which originally developed the broadband cable technology. Large scale production plants (in the order of one to two million square feet) recognized the need for an economical medium which would permit the distribution of high speed data throughout the plant without the need for running individual twisted pairs in conduit. There was also a need for audio and television distribution but to a lesser degree. Various manufacturers responded to this requirement by developing and marketing data modems to the industrial and commercial world. In this process each modem vendor and user was utilizing the cable bandwidth in a different manner. The potential conflicts and incompatibilities were becoming evident to the growing number of users and modem vendors. As a result, the Broadband Committee of the EIA (Electronic Industry Association) established in May 1978 a technical committee TR 40.1 to develop standard for industrial and commerical modems which interface to the broadband CATV coax.

The objective of this paper is to outline the tentative results of the committee's activity. It is hoped that this would provide a vehicle for disseminating this information to the CATV technical community at an early date, and thus obtain critical feedback prior to final stages of the developement of the standard.

Committee Scope:

A committee was drawn together which consisted primarily of cable modem suppliers,and industrial users of in-house broadband cable networks. A broader spectrum of interested groups included representatives from goverment agencies, manufacturer of related hardware, etc. The initial scope was rather broad to include "engineering matters related to the transmission of digital data on broadband coaxial cable systems typically used in industrial and institutional applications". However, the initial focus was directed toward data modems as used in industry. The committee tentatively excluded the class of modems which may be used in the conventional city-wide CATV systems, because it felt that the transmission environment was so different from the industrial that separate standards would have to be developed. It was decided not to attempt both standards simultaneously.

After considerable discussion on the possible approaches to the standard, the committee was divided into three sub-committees to work on separate but related portions of the problem. One committee was assigned the area of channel allocation, the second to modem terminal parameters,

and the third to the cable system interface. A basic assumption for each committee was that the cable system to which the modem would be connected was designed in accordance with the standard TV signal and noise specification provided by the FCC and other organizations such as NCTA.

The following sections are a summary of the surrently proposed parameters which, as noted above, have not yet received official approval of EIA.

Sub-Committee #1 - Channel Allocation

a. Band Allocation
The designation of the conventional 6 MHz channels would be the same as that currently used in the CATV industry. For industrial use the cable system most commonly uses a mid-split configuration. An assignment of paired channels was made to provide full duplex operation, and where possible the standard TV channels 2-13 were not used for data as follows:

T-7/H
T-8/I
T-9/7
T-10/J
T-11/K
T-12/L
T-13/M
T-14/N

This assignment is also compatible with low-split networks.

b. Sub-Channel Designation
Since data channels normally occupy less than 6 MHz of bandwidth, each TV channel is sub-divided in 1 KHz increments with sub-channel zero at the lower baud edge and succeeding channels numbered one, two, etc.

c. Modem Spectral Designator
This is a numerical code assigned by the modem manufacturer to describe the frequency region over which the modem operates. The designator will have the following format:

TX - Channel Boundary - Sub Channel Displacement - Modem Channel Spacing - Modem Channel Bandwidth

RX - (same corresponding parameters)

Channel Boundary: The lower frequency edge of a channel expressed in MHz.

Sub-Channel Displacement: The number of sub-channels from the channel boundary to the center frequency of the modem.

Modem Channel Spacing: The number of sub-channels between the center frequencies of adjacent modems.

Modem Channel Bandwidth: The number of sub-channels occupied by the modem. (See sub-committee #2 summary)

The approach given above permits the vendor and/or user to assign the center frequency of the modem anywhere in the 6 MHz channel, and also allows a comparison between vendor modems to determine spectrum compatibility. Since each vendor uses a different modulation technique, it did not appear feasible to standardize on specific sub-channel center frequencies and bandwidth for different modem data rates.

Sub-Committee #2 - Modem Parameters

This group concerned itself with the possible standards which would apply to the RF and digital terminals of the modem, i.e., the external characteristics of the modem. It did not appear either feasible or desirable to attempt to standardize the internal modulation and demodulation techniques for each class of modem. One factor influencing the decision was the wide range in costs associated with the more sophisticated approaches which could be employed to reduce the amount of cable bandwidth for a given data rate. Furthermore, the availability of cable bandwidth has not been to date a limiting factor in the use of broadband coax by industry.

The following sections list the modem parameters deemed to be most important.

a. Nominal Transmit Power and Adjustment Range.

The nominal modem transmitter power output should not be a parameter for standardization but shall be specified by the manufacturer. The adjustability range shall be a minimum of 30 dB below the specified nominal maximum power output of the modem. Any specific level within this range should be settable within $\pm$0.5 dB.

Bulletin Note: It is not clear at this date what the optimum criteria is for establishing levels of data channels relative to video or nominal

video levels in a given system. Constant power density has been used however there is some question as to whether this loading is acceptable particularly in conditions where the modem transmissions include coherent products. The technical bulletin to be published in addition to the standard will contain a discussion of power levels normally encountered and criteria for cable system loading.

b. Transmitter Bandwidth

The bandwidth is tentatively to be described at the 3 dB and 40 dB points. Further consideration has to be given to this measurement, particularly with respect to the affects of the carrier turn on and turn off as well as modulation products.

c. Out-of-Channel Spurious Output - 5-500 MHz

The manufacturer shall specify the output of the modem by assigning frequencies to the following envelope. These frequencies shall be stated in integral multiples of the subchannel increments (1 KHz) and measured from the channel center frequency assignment. Full power is allowable from center frequency to $\pm f_1$; -40 dB maximum is allowable from $\pm$ (f_1 to f_2); -65 or -5 dBmV whichever is greater at frequencies more than f_2 from the channel center frequency. These conditions shall be met at any possible output level including "Carrier Off". Spurious outputs from the receiver portion of the modem shall be governed by the transmitter output spurious envelope (based upon the transmit channel assignment).

Bulletin Note: The technical bulletin should discuss what are considered good operating numbers for the above.

d. Off Condition Output

The manufacturer shall specify the in-channel output of the modem under "Carrier Off" conditions in addition to the requirements of item c. It is the manufacturer's responsibility to assess the effects of Off Condition output in conditions of shared channel operation. The manufacturer shall specify any limitations brought about by in-band, off condition transmitter output.

Bulletin Note: A more complete discussion of the above, particularly as related to polled operation will be contained in the bulletin.

e. Minimum Receive Level and Operating Range

The minimum receive level shall be specified by the manufacturer and must be defined in terms of achieving rated bit error rate (BER) as a function of S/N. The resultant is an absolute level stated in dBmV. Performance equal to or better than the above specification shall be guaranteed through a range of at least 30 dB in excess of the minimum receive level without manual adjustment of the modem.

Bulletin Note: The technical bulletin will discuss performance degradation caused by decreased S/N. The discussion should also include information to alert the user to the effects of impulse noise on data transmission performance.

f. Receive Carrier Detect Level and Adjustability

We do not feel that this value should be standardized, however, statement of this value should be standardized when the feature is present. A range relative to minimum operating level of -10 dB to +20 dB is suggested.

g. Channel Spacing of Similar Modems and Allowable Level Differences

The channel spacing has been previously considered. The allowable level difference we feel should not be standardized, however, this requirement shall be clearly stated by each modem manufacturer. This specification shall include:

a) Adjacent channel operation with a like modem, and
b) An envelope of acceptable adjacent CW carrier levels versus frequency displacement from the carrier frequency or band edge.

Bulletin Note: The technical bulletin will discuss problems arising from data signals operating adjacent to video channels. Of specific concern is the problem of TV interference from adjacent channel data signals where the cause of the problem is the TV set's inability to reject relatively high signal levels in the adjacent channel.

h. Receiver Frequency Tolerance

Modem vendors shall specify the receiver frequency tolerance including the ability of the modem to accommodate changes within the envelope specified.

Bulletin Note: The bulletin will discuss the possible problems arising from translator frequency error or drift and other frequency errors or drifts might be encountered in microwave transportation. Incidental FM introduced at power or other frequencies should also be considered.

i. Maximum RTS/CTS Delay and Adjustability

This is not a matter of standarization however it is recommeded that this be part of the manufacturer's statement of specification.

j. Carrier Turn Off Delay

Modem manufacturers shall specify the actual time required after the removal of the carrier control signal for the modem output to decay to the levels specified in Item 16.

Bulletin Note: Technical bulletin will discuss turn off delays relative to bandwidth restrictions, polling delays, and shared channel operation.

k. Modulation Type

The manufacturer shall specify the following items relative to the modulation of the modem transmitter. These parameters are requested to aid the system designer is assessing the effects of distortion, etc. upon total coax system performance.

1. General Modulation Type (AM, FM, FSK, etc.)
2. Number of modulation levels
3. Percentage modulation (for AM)
4. Maximum modulation index (for PM and FM type signals)
5. Does modulation contain coherent products?

l. Digital Interface

The manufacturer shall supply a complete digital interface specification including mechanical factors such as the connector. Reference to standard specs such as RS-232C, etc. is acceptable however, further definition of options such as controls used, leads used, etc. must be included. Other factors such as sync or async, half or full duplex, etc. should be included.

Bulletin Note: The discussion of various factors to be considered in establishing digital interfaces have many options. There may be installation problems arising from incomplete interface specification by the user or the modem manufacturer.

m. Operating Environment

Manufacturer should specify temperature and humidity limits. It might be possible to standardize on several ranges of temperature and associated humidity conditions perhaps called Classes A, B, C, and D or the like. These would move from room temperature to extreme outdoor environment and have a category for special environments. Further investigation of applicable specifications is in order.

n. Single or Dual Cable

Part of manufacturers normal specification

Sub-Committee #3 - Cable System

The objective of this committee was to specify the parameters of the cable system which could influence the performance of the model described by the manufacturer in the items discussed by Sub-Committee #2. The group delineated the following categories:

a. Mechanical Interface

The cable system shall present a type F male connector to mate with the corresponding F female connector on the modem.

Where the coaxial cable or device center conductor is used to enter the F connector, the diameter shall be limited to that of a standard RG-6 cable. It is recommended that the female F connector should accommodate RG-6 or RG-59 coax.

b. Electric Interface - ohmic

1. The coaxial cable shield shall present a low resistance earth ground to the modem terminal. (A numerical value is required for the final standard).

2. The coaxial cable center

conductor impedance is undefined and may range from a low resistance to an open circuit. The center conductor nominally carries signal potential only but may be exposed to system cable powering voltages and/or potentials induced by incidental ground fault currents. This lack of definition suggest that modem manufacturers should consider DC isolation of the center conductor with a minimum breakdown value of 500V.

3. The problem of receiving modem power from the coax system will be discussed in a separate bulletin.

c. Electric Interface - RF

1. Impedance

The impedance of the system shall be nominally 75 ohms, unbalanced, over the specified operating range of frequencies.

2. Match

The system match shall be specified in dB return loss across the specified cable system operating frequency range. The recommended minimum match at the modem interface is -16 dB.

A bulletin will be added to discuss the mismatch in the reverse direction for low value taps and the impedance of the modems outside of its operating range.

d. Signal Level

The cable system shall be designed to provide a nominal level of 0 to +10 dBmV at all taps outlets for forward direction TV channel operation across the band of operating frequencies.

No recommendation was reached for return signal level requirements. It was tentatively stated that difference between the transmit and receive modem levels should be no greater than 50 dB.

e. Other System Considerations

The following topics have not yet been fully resolved:

1. Intermodulation distortion products and their effect on on system performance with high channel loading.

2. Specification of cable signal/noise

3. Interface to standard TV channels

The brief review of the statues of standard Committee TR 40.1 presented above represents the efforts to-date of many members of the Committee. In particular I would like to extend my appreciation for the work of the chairman of each of the Sub-Committees:

Mr. Carl Schoenberger - ToCom
Mr. Robert Dickinson - E-Com
Mr. Allan Pawlowski - Jerrold