Cable Television

ACQUISITION AND OPERATION OF CATV SYSTEMS

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Cable Television

To Margaret

Preface

In February 1972, the Federal Communications Commission adopted a set of comprehensive rules governing cable television which established a structure that will enable the industry to grow without serious hindrance. In the fall of 1972, Theta Cable of California commenced operating an experimental cable television system covering the city of El Segundo, California, which was built to operate with forty television channels downstream, fourteen television channels upstream, and two-way data communications with every subscriber. Governmental rulings and technological innovation are now bringing the cable television industry to the point where it can combine the importation of distant signals, massive expansion of television channel capacity, program origination, and two-way communications with every home to make economically viable opportunities out of previously unattractive markets. The result will be a transition of the industry from a group of primarily small businesses operating in small towns to major enterprises operating in every city in the country. Cable television, in short, is now beginning the process of transformation from community antenna television—the name by which it was originally known and which accurately described its original function—to broadband communications. This presents a major challenge and a major opportunity to everyone who is or would like to be associated with the industry—from city officials and investors to operators and individual employees.

Investors need to understand the industry well enough to be able to analyze opportunities in both new franchises and existing systems. City officials need to be able to understand and work with an industry that will have a major impact on the lives of their residents. And operators and system employees must develop operating practices and policies almost de novo; practices and policies which work well in the traditional system with fewer than two dozen employees are likely to be inadequate in a forty-channel system which has 200 employees and is engaged in program origination.

This book is written to give those who do not now have it an understanding of CATV basics, to suggest approaches to such comparatively new areas as program origination and advertising time sales, to suggest operating policies for CATV systems operating in larger cities, and to review such matters of current concern to all operators as marketing, personnel management, and installation and recovery of convertors.

No operating rule or practice should ever be regarded as fixed in concrete, and certainly not in a comparatively new industry such as cable television. The aim of this book is to give the individual using it a place from which to start in making his decisions; in time his own experiences and the particular situation facing him may well dictate different approaches.

I would like to express my appreciation to Robert Behringer, President of Theta Com of California and to John Penwell, Theta Cable of California Chief Engineer, for their advice on the chapter on Technology, and to Robert Evans, Vice President and General Counsel of the Columbia Broadcasting System, for his advice on the section on copyright.

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Contents

1
Technology

Significant Characteristics of a Television Signal

A television broadcast signal has essentially the same properties, and is subject to essentially the same limitations, when it travels by cable as when it travels through the air. Speaking generally, the signal is affected by the choice of medium in only one significant respect—attenuation: It weakens much more rapidly when traveling by cable than when traveling by air. However, certain characteristics are of particular significance in considering the transmission of television signals by cable:

1. The standard television signal (picture and sound) received on a home television set (the "home" television signal) uses 6 megahertz (MHz) of bandwidth. This takes a very large piece out of the broadcast spectrum. For example, the entire FM band (i.e., the section of the broadcast spectrum within which all FM stations broadcast) is only 20 MHz in width.

2. Attenuation of a television signal transmitted by cable is so great that it is necessary to reamplify the signal by passing it through an

amplifier at frequent intervals. Each time a signal is amplified, however, a small amount of "noise" is inserted which cannot be avoided or reversed by the amplification process. This noise and distortion appear on the home television screen in the form of snow. This deterioration in the signal is unnoticeable on a television set in a subscriber's home the first few times a signal is amplified; at some point, however, the deterioration becomes so serious that the subscriber will not accept it. In today's technology the normal number of amplifiers through which a television signal can be passed before it becomes unusable (the number of amplifiers in "cascade") has been approximately thirty-two. (Some systems have been built and operated with more than thirty-two amplifiers in cascade, but this results in many service calls and an excessive, and expensive, amount of maintenance, and even then the picture at the end of the cascade is likely to be unacceptable to anyone other than those who have no other source of television.) With amplifiers used in two-way communications, the maximum number of amplifiers in cascade should be no more than 20 to 25. (Note that this is not the total number of amplifiers in the system; it is the number of amplifiers through which the television signals actually pass before they reach a particular television set.) Amplifiers are set in the plant as far apart as permitted by the distance the highest-frequency television signal carried on the cable can travel (and the optimum gain from the amplifiers) before it must be reamplified (see paragraph 3). If the "headend" (see below) is located in the center of the city, the plant may look like a spider web, with many 32- (or 25-) amplifier cascades, each following a mazelike path. Satisfactory service beyond the last point permitted by cascade limitations can be provided only by building a new headend and transmitting from it.

3. A television signal transmitted at a high frequency will weaken sooner than a signal sent at a low frequency, given the same amount of power behind each signal. For example, for a Channel 70 signal to arrive at a home with the same quality as a Channel 2 signal, it must operate at higher power, the Channel 70 transmitter must be closer to the home, or both stations must be so close to the home that there is no detectable difference in the quality of their respective signals. For this

reason UHF television stations (Channels 14 and above), which operate in the 470- to 890-MHz band, are authorized by the FCC to operate at much higher power than VHF stations (Channels 2 to 13), which operate at below 216 MHz.

Cable television amplifiers on the market today are operating at the optimum power with least distortion permitted by current broadband communications technology. Since power cannot be increased, if a television signal is added to an existing CATV system at a frequency higher than the highest frequency for which the spacing between amplifiers was planned when the system was originally built, the amplifiers must be moved closer together in order for that higher-frequency signal to arrive at the subscriber's television set with quality comparable to that of the lowest-frequency signal. (This is one of the reasons why UHF signals are converted to locally unused VHF frequencies at the CATV system's headend for transmission into the home at the lower frequencies.) Most CATV systems in operation today were designed for maximum spacing between amplifiers operating at between 54 and 216 MHz. Within the past two years amplifiers have come on the market which operate at above 216 MHz, such as the Jerrold Starline 20 amplifier, which is designed to operate at up to 260 MHz, and the Theta Com XR series amplifiers, which are designed to operate at up to 300 MHz. In order to get the full benefit of these amplifiers (i.e., the additional television channel capacity) in a rebuild of a system designed to 216-MHz operation, it may be necessary to insert the new amplifiers in the trunk closer to one another than the old amplifiers were, thus requiring that the trunk be cut for the new amplifiers and spliced where the old ones are taken out. This is an expensive operation and can cause major disruptions in service to subscribers. In addition, in extreme cases where redesigning the system in an effort to reduce cascades will not solve the problem, construction of a new headend will be necessary to feed areas cut off by the combination of cascade restrictions and shorter amplifier spacing.

One other point should be noted. Carrying television signals on cable at frequencies above 216 MHz is a comparatively recent development, and assertions by manufacturers of the new amplification equipment as to the number of satisfactory television pictures which their amplifiers will transmit to home television sets should be viewed with caution. Undoubtedly test signals in the laboratory support salesmen's statements. Whether the new amplifiers will in fact deliver the claimed number of television pictures in satisfactory quality to the subscriber's home in a normal operating situation, however, has yet to be proved in most cases. At this point the most that can be said is that good pictures can probably be delivered on twenty-eight channels using amplifiers designed for operation at 260 MHz or higher.

4. In addition to the problem of noise added to the signal by the amplification process, each time a television signal passes through a section of cable that is too short or too long, it irreversibly deteriorates to some extent. The more such sections the signal passes through in addition to amplifiers, the sooner it deteriorates to the point where it is unusable, and the smaller the area which can be covered by plant served by the particular headend. In order to maximize the area covered by the cable, the number of such odd lengths of cable used in the trunk must be held to a minimum, and, if possible, nothing should be put in main trunk cable except trunk amplifiers and connectors.

5. The tuner on a television set and the wire leading from the antenna terminals on the back of the set to the tuner act as very effective receiving antennas if they are too close to a television station transmitter. "Too close" for a set in a home with no major barriers between it and the transmitter is normally, although not always, about 30 miles. If that set is hooked up to cable, the television signal will arrive at the set by way of the tuner and wire leader a fraction of a second ahead of when it arrives via cable. The result is severe ghosting. In the past, small-town cable systems have handled this problem of a station which is too close simply by not using that station's channel on the cable and carrying the station on another channel. In larger cities, however, with many stations to be carried, use of the channel cannot be wasted in this way, especially in light of current FCC channel usage requirements, such as the requirement that channels be available for public access, education access, and government access. Sometimes the problem can be solved by increasing

the strength of the signal the cable delivers to the television set so that the cable signal overrides everything else, and sometimes it can be solved by replacing the wire leader with a specially shielded wire. If the transmitter is very close, however, and the signal is thus too strong, the problem can be solved only by using a specially shielded tuner—a "convertor" (see below).

6. Television signals are subject to the effects of the harmonic beat. For this reason the FCC has assigned Channels 2 to 6 to the 54- to 88-MHz band and Channels 7 to 13 to the 174- to 216-MHz band. The reason for this is that when a television signal is broadcast at between 108 and 174 MHz, it combines with one or more of the signals operating in the Channels 2 to 13 assigned frequencies to distort its own signal as well as the signal(s) with which it combines. Some cable systems, using a convertor, carry additional television stations or programming in the 144- to 162-MHz band, where the distortion is minimal and generally unobjectionable. Some systems may also use the 138- to 144-MHz band, although this will probably produce interference which would violate FCC rules requiring CATV systems to carry television station signals without material degradation. The new push-pull amplifier is designed to solve the beat problem on cable and permit the carriage of additional channels (nine on most current convertors) in this "midband" section, with the result that the cable system will be able to carry twenty-one television channels between 54 and 216 MHz.

7. The 6 MHz of bandwidth used for transmission of each television signal, the cascade problem, and the problems described in paragraph 3 all combine to limit the total number of television signals which can be carried on any CATV system to far below the number necessary to permit each subscriber to select his own program from some central library of programs whenever he so desires. Assuming the 300-MHz amplifier works as claimed, it should make possible the carriage of up to thirty-five television signals on one cable. If one channel were to be assigned to each family for its private use, one cable would then be able to take care of only thirty-five subscribers, too few to make such a system practical.

It might be helpful to compare cable in a CATV system to a bundle of thirty-five water pipes tied together, each pipe carrying a different flavor of water. Anyone connected to the system can tap any one of the pipes and get that flavor of water, but he has to select from what is being offered. It is possible to give a subscriber the right to determine what flavor of water is carried in one of the pipes, but in that case, since that pipe cannot be used to carry any other flavor of water at the same time, either other subscribers on the system must be allowed to tap that pipe and have access to that water, or their selection of types of water will be reduced to thirty-four. If everyone is given the opportunity to select his own flavor on a first-come, first-served basis, as soon as thirty-five selections have been made, all other subscribers must either take what others have selected or wait until a pipe is free.

A system similar to the telephone central switching system has been proposed, with a "dedicated" line running from each home to a central switcher, where the subscriber would be able to take over a trunk channel and thus have access to a program library serving the community. The program would be selected by the subscriber (perhaps dialed like a telephone call), and while it is being viewed by the subscriber, that program and the trunk channel being used by that subscriber would be unavailable to other homes. Even with the number of trunk channels less than the number of dedicated lines into the home, the great number of cables required to serve any substantial number of homes simultaneously during likely periods of peak use (evening hours) would make it practically unworkable (for example, twelve 3/4-inch trunk cables would aggregate approximately 4 inches in diameter and serve only 420 homes). And the telephone user who becomes angry when circuits are busy is likely to become infuriated if he cannot watch a television program when he wants to because all trunks serving his switching center are in use.

Description of a CATV System

A CATV system consists of a headend to receive and process television signals and a plant to distribute them. Some systems also use CARS

(Cable Television Relay Service) microwave to obtain television signals whose transmitters are too distant for the signals to be picked up off the air and the Theta Com Amplitude Modulation Link (AML) to distribute signals to areas which are too difficult or expensive to reach by trunk cable or which cannot be satisfactorily served because of cascade problems.

Headend

The headend consists of a small building and, standing next to it, a tower on which are mounted the antennas which pick up the signals of the television stations carried by the system. Depending upon the distance of the transmitter of the most distant television station which the system wishes to carry, the tower may be anything from a 30-foot telephone pole to a 500-foot steel tower, or the antennas may even be located on top of the headend building. If the television stations are some distance away, the tower will carry a separate antenna for each television station, specifically designed to pick up that station's signal with maximum efficiency and carefully pointed at the station's transmitting antenna. If the stations are nearby, a carefully designed but ordinary antenna will be used.

A separate, very special television receiver (with no picture tube) for each station the system carries is placed in the headend building. The signals pass through these receivers and other related equipment and thence into the cable. A good-sized headend building would be 20 by 20 feet and, in addition to the receivers, would have in it a small workbench, a television monitor (so pictures can be easily checked at the receivers by maintenance technicians), a heater, an air-conditioning unit, and, ideally, a standby power generator to protect against power failure.

CARS Microwave

Microwave television may be described as narrow-band television broadcasting operating in frequencies above those assigned to UHF television. A microwave signal bears much the same relationship to the signal of a commercial television station as a pencil flashlight bears to an unshaded lightbulb. CARS, which stands for Cable Television Relay Service, is that part of the microwave broadcast band which has been specifically designated by the FCC for use by CATV systems. CARS microwave is used by cable television to pick up and relay to CATV systems the signals of television stations whose transmitting antennas are too distant for their signals to be picked up off the air by receiving antennas hung on the system's headend tower.

Television antennas are hung on the first tower in a microwave relay system to pick up the signals of the desired television stations. Each signal goes from the antenna to a special receiver in the tower building, where it is amplified and sent back up the tower to a special microwave transmitting antenna, or "dish," which in turn sends it on a tight beam, like the pencil flashlight, to the next microwave station. Depending upon the exact frequency used and terrain and weather propagation characteristics of the area, the stations in a microwave relay system will normally be between 15 and 30 miles apart. Except that the receiving antenna at subsequent stations is a special microwave dish, each station in a line of microwave relay stations has exactly the same equipment. Using microwave relay equipment, a television signal may be sent across the entire country; network television programs, for example, are distributed throughout the country by microwave relay. (Amplification equipment used in microwave relay systems produces much less noise than the best amplifiers available for cable broadband communications.)

At each microwave station in a microwave relay service except the last one, the television signal is relayed to the next station, and in addition (1) the signal may be fed to one or more nearby CATV systems by cable; (2) one or more CATV systems may be fed by microwave from the microwave tower by a "power split" without substantial increase in the station's capital cost and with practically no increase in operating cost; (3) the television signal may be fed by a power split to a new line of microwave stations headed in a different direction; (4) all three of these possibilities may occur; or (5) the station may serve as nothing more than a relay point to the next station.