PAY-PER-VIEW (PPV) COPY PROTECTION IN THE CABLE SYSTEM ENVIRONMENT

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ABSTRACT

Video copy protection has become an essential component of cable's PPV technology infrastructure necessary for PPV to attract the competitive programming required for healthy growth. A specially designed modification of the PPV video signal assures non-recordability of copy protected programming, but still permits normal viewing operation of television receivers. The signal modification is optimized for compatible operation with cable system plant, with particular emphasis on the addressable descramblers used to control viewing of authorized PPV programs. Particular emphasis is placed on copy protection throughout cable plant, including distribution to multiple hubs.

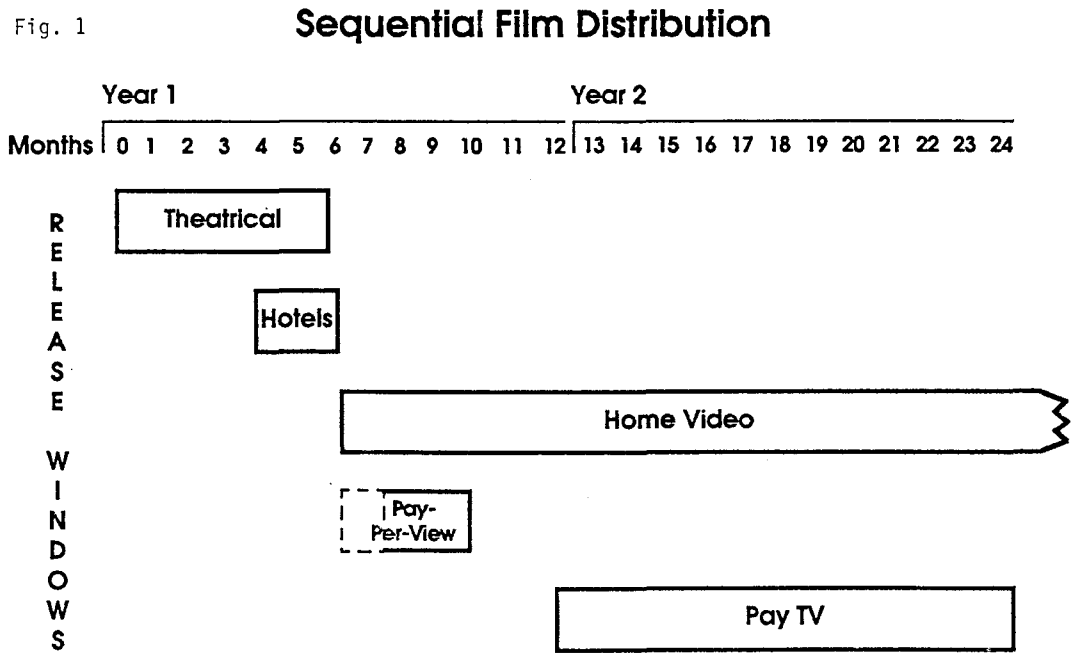
INTRODUCTION

The primary economic driving force of the PPV segment of the cable industry is the appetite of the consumer for recently released movies on television. Important though movies are to PPV, income from PPV presently represents only a very small percentage of the total revenues to Hollywood from movies. The principal revenue sources are:

- Home video tape rental;
- Theatrical;
- subscription pay TV;
- Cable PPV;
- Hotels.

Of these, home video rental is the largest revenue source.

Fig. 1



NOTE: Broadcast network distribution typically begins in Year 3 with rerelease to pay TV in year 6 and syndication in year 7.

Motion pictures are usually released to these various forms of distribution in a distinct sequence (see Fig. 1). The timing within the sequence is designed to maximize total revenues and to protect each distribution medium in turn. At the present time, home video rental movies are released to approximately 6 months after theatrical release. The release to pay-per-view was, in the past, close to the rental release, but has now slipped to 4-6 weeks later than home video. A major concern of the studios is the threat of unauthorized copying of PPV movies and the potential for such copies to erode the rental business. This concern has resulted in the steady trend of delay in PPV release dates relative to home video rental.

Compared with video rental, cable PPV has major advantages for the subscriber. Ordering and delivery of programming is extremely convenient, and PPV does not suffer from the "depth-of-copy" problem of home video rental. (The "depth-of-copy" problem refers to the availability at the video rental store of only a limited number of copies of any new release and the resulting wait.) However, because of the disparity in release dates, cable PPV is at a distinct disadvantage relative to video rental when it comes to newly released movie titles.

In order to capitalize on its inherent advantages, cable PPV requires competitive release windows. One of the keys to advancing release dates to PPV is the assurance to the movie studios that PPV programming cannot be copied, and that the technology employed for copy protection cannot readily be circumvented.

During the past year, technology for effective video copy-protection has been demonstrated and tested in cable systems, and is now entering commercial use on a market test basis. The technical feasibility of copy-protection is no longer questioned. This paper describes the specific requirements and implementation of a copy protection system for use in cable.

REQUIREMENTS FOR COPY PROTECTION FOR CABLE PPV

The unique historical development of the cable industry, with the very substantial investment of equipment already in place, places some specific requirements on the design of a copy protection system for cable PPV.

Security

The industry's experience with signal piracy dictates a high level of security. Experience has shown that if a security scheme of any kind can readily be defeated or circumvented, then it's likely to be so! Copy protection must be inherently secure, costly to attempt to defeat, and leave no unprotected signals anywhere in the system.

Subscriber Hardware

Cable systems providing PPV have already invested in subscriber equipment (either in the home or outside). There must be no new hardware for the subscriber.

Compatibility

Whatever the modifications which are made to the video signal to achieve non-recordability, the signal must still be compatible with existing distribution systems, especially with the addressable descramblers already in place. Obviously, the copy protected signals must also be compatible with the large population of television receivers, of all makes and models, in subscribers' homes.

Ease of Operation

The addition of copy protection should not require additional operational steps in distributing PPV programs. Operation of the copy protection system should be automatic, i.e., protecting those PPV programs which require protection and leaving unmodified program material which does not require it.

Effectiveness

In order to achieve the goal of attracting more timely programming to cable PPV, a copy protection system must be effective in preventing VCR's from making useful tape copies of PPV programs. As compared with existing methods of protecting video tapes to deter duplication, the requirements for a PPV copy protection are more stringent. Absent some form of copy protection, copies are more easily made from PPV than from rental tapes. Copying of a tape requires two VCR's, presently found in less than 13% of U.S. homes. Copying of a pay-per-view movie, on the other hand, requires just one VCR, owned by more than 60% of cable subscribers. An additional highly desirable feature of a PPV copy protection system is prevention of recording by a CAM-CORDER directly from the TV screen.

SELECTION OF A METHOD

Because of the very different purposes of video cassette recorders and television receivers, there are just three fundamental differences in the way television signals are processed. Compared with a TV receiver, signal processing is optimized in VCR's in the following ways:

- Precise control of video signal levels is required for high quality recording and is usually achieved by measuring and controlling the amplitude of synchronizing pulses.

- For bandwidth-efficient recording, the VCR separates out the color component of video and records it in a different manner than the luminance. On playback, the color component is processed in a unique fashon to restore its frequency and phase.

- For efficient use of tape, and to minimize tape velocity, a mechanical scanning system is used to record in diagonal stripes across the tape. The mechanical scanning system in synchronized to the vertical sync component of the video waveform.

Various techniques have been devised (Ref. 2) to exploit each of these three differences between television receivers and VCR's.

1. The "PSEUDO-SYNC" AGC method exploits the VCR's unique ALC system by adding Pseudo-Sync pulses during several lines of the vertical blanking interval. The effect on an attempted recording is a weak looking video signal on replay. This technique has been used to deter duplication of video tapes. Its effectiveness is, however, quite dependent upon the specific VCR's used to record and playback.

2. The "COLOR STRIPE" method exploits the VCR's color restoration system by altering or selectively removing the back porch color burst signal. The effect on an attempted recording is loss of color or horizontal bands of color across the picture. It can, however, be negated by turning off the color on a TV receiver.

3. The "TIME BASE VARIATION" method exploits the synchronized diagonal scanning of the tape by a recording head mounted on a rotating drum. The vertical time base of the copy protected signal is time-varied by adding or deleting lines from frames. A momentary change of vertical frame rate disrupts the drum synchronization and servo systems of the VCR, causing it to miswrite the video recording and disturb control track information. The effect on an attempted recording is intermittent break-up of the picture, rolling artifacts caused by head switching and distortion of audio.

The TIME BASE VARIATION method has the following advantages by comparison with the other two:

- Effectiveness: a wide range of time-varying patterns can be used to confuse VCR's.

- Difficulty to Remove: there's no simple method to remove the treatment. The treatment is not removed by signal processing within a TV set, thus, the program material cannot be recorded from signals within a TV receiver.

Typical EIDAK Time Profile

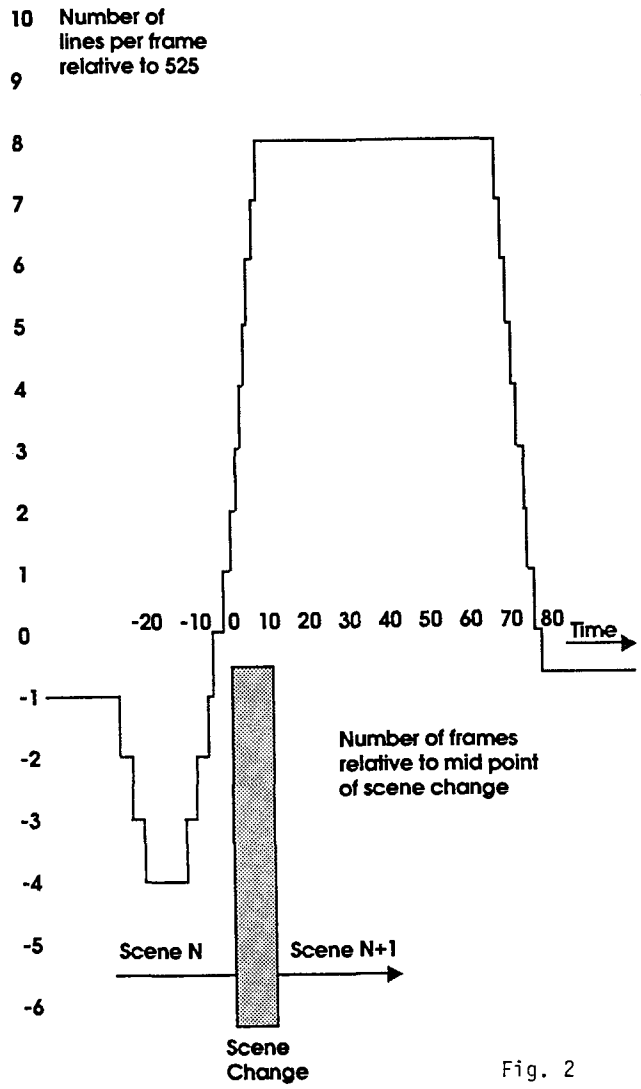


Fig. 2

- Works Against Camera Recording: an attempted recording from a TV screen is left with an objectionable moving pattern.

The TIME BASE VARIATION method is also the only one of the three methods which is not readily defeated with inexpensive components.

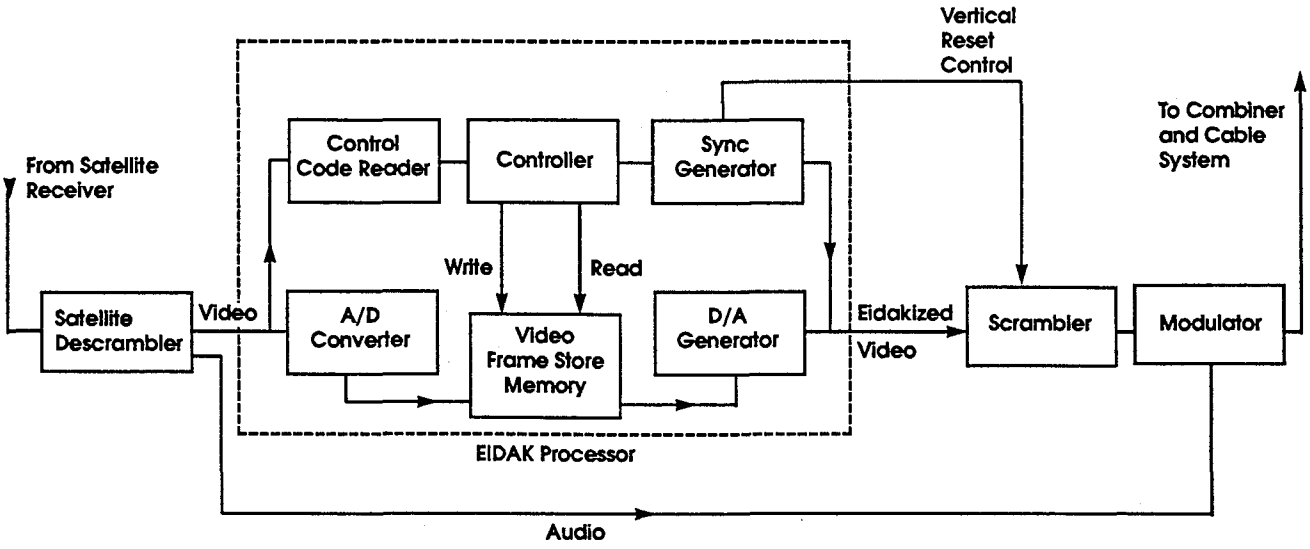
THE EIDAK CABLE PPV COPY PROTECTION SYSTEM

The Eidak Copy Protection System employs the TIME BASE VARIATION method, optimized for compatibility with TV receivers and cable distribution equipment. The vertical time base (frame rate)is varied by adding and deleting lines from video fields in a careful and systematic way. The specific time variation of lines-per-frame is called a "profile", an example is given in Figure 2. A variety of these "profiles" can be used to confuse the widest variety of VCR servo/synchronization systems. In the example shown, the number of lines per frame starts at 524 (one less than the standard 525) goes to 521 lines for a few frames, ramps rapidly to 533 lines (8 more than the standard 525) and then returns to 524 lines. It remains at 524 for several seconds before undergoing another similar "profile". This sudden variation in line count is sufficient to throw out the synchronization of the rotating recording head in a VCR and cause intermittent break-up of an attempted recording. At the same time that the number of lines is being changed, the position of the "real" active video within the field is varied in order to compensate for potential vertical movement of the picture on the TV screen. Without the vertical compensation, the TV picture would tend to move up or down with each change of field line count.

Variation of the frame length is accomplished digitally by changing the rates at which frames of digitized video are written into and out of a multiple frame store buffer memory. Up to ±3% variation in frame rate is achieved by adding or deleting up to 8 lines per frame. Lines are added or deleted from frames in pairs in order to maintain interlace. Although care is taken to keep the displayed picture centered on the TV screen to within about ±1 line, even this small variation may be noticeable. In order to mask the movement, the time varying pattern is applied usually at scene changes. For movies, identification of the exact timing of the profiles is achieved by analysis of the movie prior to transmission. Data identifying the profile timing is then keyed to the SMPTE time code track. (For live events, this process is performed in real time.)

Fig. 3

EIDAK Processor Block Diagram



A block diagram of the processor is shown in Fig. 3. The analog portion consists of an A/D converter, operating at 4x color subcarrier frequency, and a corresponding D/A on the output side. The memory section consists of eight video field buffers, configured as a FIFO. The control code reader extracts profile command data from the vertical blanking interval and passes it to the Controller (an Intel 88 Wildcard) which controls the television line read/write rates of the memory. A vertical reset sync generator is used to interface with cable scramblers.

System Characteristics

- Non-recordability for both movies and live events;
- high degree of copy protection;
- secure throughout the program distribution system;
- no new or modified hardware in subscribers' homes;
- compatible with cable scramblers/descramblers;
- transparent operation in wide variety of cable plant configurations;
- compatible with the wide range of TV receivers in subscribers' homes.

SIGNAL DISTRIBUTION (Fig. 4)

The steps of signal distribution are:

a. For PPV signals delivered to cable systems by satellite:
   - signal analysis, profile generation and control data insertion;
   - scrambling overlay for satellite transmission;
   - copy protection processing at the cable headend;
   - cable distribution.

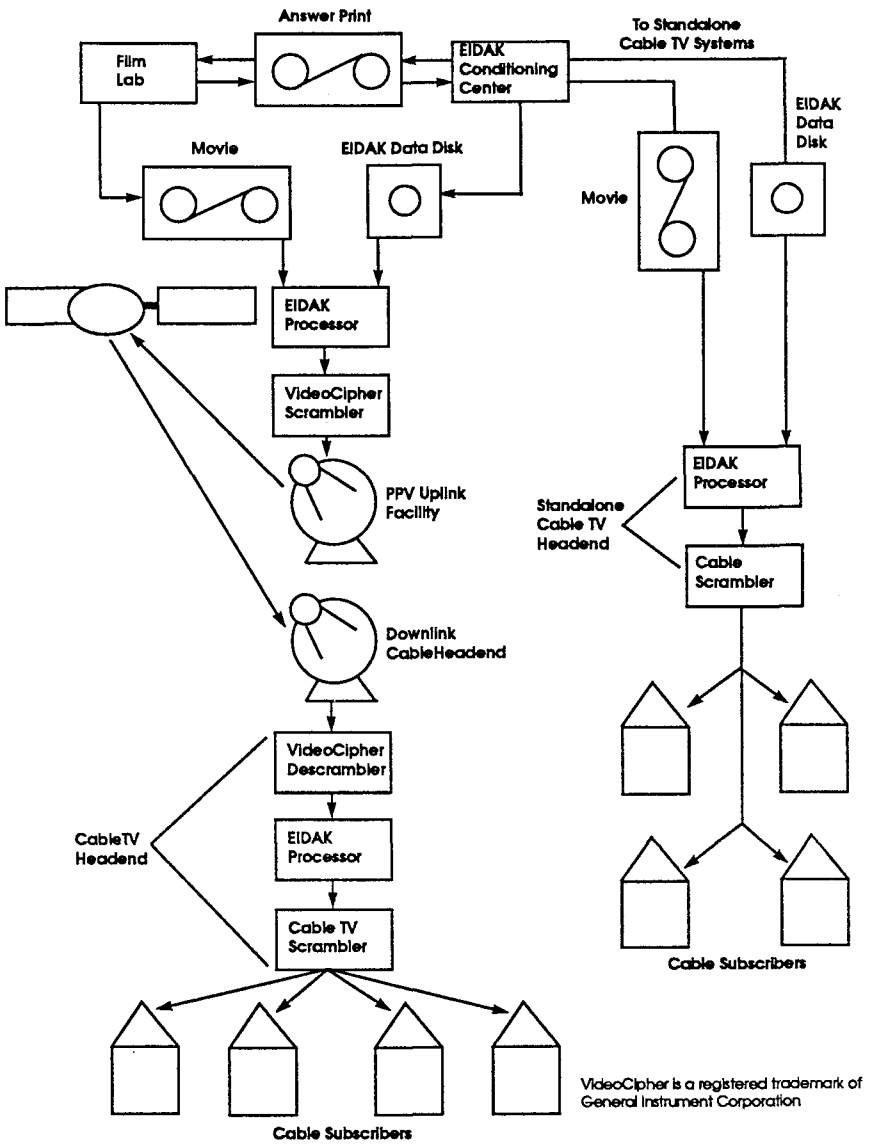
b. For standalone cable systems:
   - signal analysis, profile generation, and control data diskette;
   - copy protection processing at the cable headend;
   - cable distribution.

Signal Analysis

Movies (and other pre-recorded program material) are analyzed prior to transmission to determine the optimum timing of "profiles". This analysis is performed at a conditioning center which generates data defining the location of profiles throughout a program keyed to time code. At transmission time, this data is sent simultaneously with the movie over the satellite link. (For live events, the data is generated by real time analysis of the video signal.) Upon receipt at the cable head end, the data is used in the copy protection processor to generate the profiles which define the patterns of varying line count.

Fig. 4

The EIDAK System

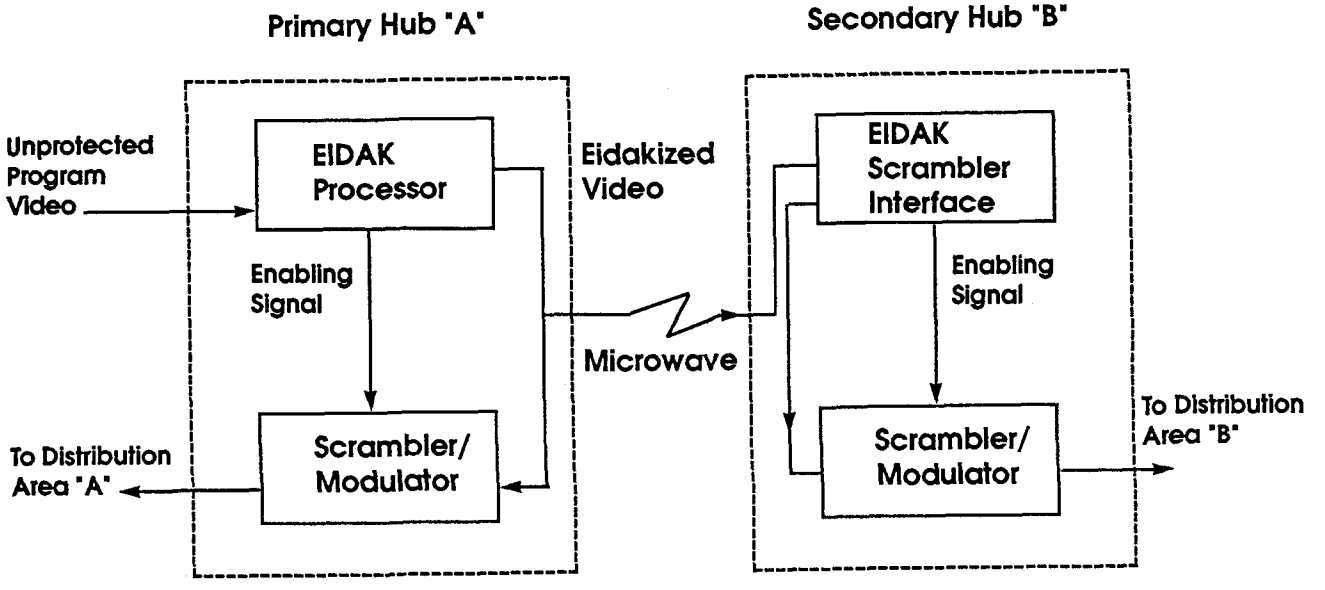


Satellite Distribution and the Scrambling Overlay

Satellite distribution of PPV programs presents a specific challenge regarding copy protection. Because the copy protection is applied at cable headends, there exists in the satellite link signals which have the potential to be copied, either at cable headends (prior to copy protection treatment), or through signal piracy. In order to guard against these possibilities, a "scrambling overlay" is applied prior to the uplink satellite scrambling. This overlay can only be removed by passing the signal through an authorized copy protection processor. Thus, received signals have either the overlay scrambling or are copy protected. A useful signal is thus available for distribution only when it has been copy protected. The use of the overlay (and associated control signals) makes system operation completely automatic at the cable headend.

Fig. 5

EIDAK Processing in Hub Systems



Standalone Systems

Distribution of PPV programming to standalone cable systems is by videotape. The tape and a diskette with profile data are delivered to the system. The diskette loads the copy protection processor with date necessary to generate the time varying frame length variation as the tape is played.

Cable Scramblers

Most addressable cable scramblers generate and use field rate signals, either for scrambling/descrambling or for control signalling. In most cases, the circuit implementation of the scrambler is designed around standard NTSC (525 line) video. The use of a non-standard line count requires a timing signal to re-set the circuits which determine the vertical interval timing. This re-set timing signal is generated by the copy protection processor (or by the scrambler interface in the case of multiple hub systems).

Multi-hub System Operation

As cable systems are consolidated, and as they are built to cover ever expanding areas, a strong trend in system architecture has been the use of hubs. Distribution of signals to hubs is usually by one of two means:

(a) AM modulated RF signals (e.g., RF supertrunk and AML;
(b) baseband-video fed transmission links (e.g., FM microwave).

The copy protected RF signals can be transmitted transparently through the RF links. However, in the case of baseband-fed links, it is usual to employ a scrambler at each hub location. In this case, it is necessary to provide each scrambler with an enabling signal (see Fig. 5). At the primary hub, the enabling signal is generated by the processor. The copy protected baseband video signal is fed by microwave to one or more hubs. At each hub, a scrambling interface device generates the enabling signal for the cable scrambler. The enabling reset signal from the received copy protected video. Thus, PPV program video is copy protected throughout the hub distribution system.

CONCLUSION

The need for copy protection as part of the technology infrastructure of PPV is well established. In the cable environment, a copy protection system must be secure, and compatible with the wide range of equipment used in the construction of cable systems. The timebase variation method is effective and secure and has been optimized for compatible operation with addressable descramblers. A system configuration has been described which leaves no unprotected signals, even in a multi-hub distribution environment.

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2. "Copy Protection - What's in Store for PPV"; G.S. Stubbs, CED Magazine, February, 1989.

3. "Pay-Per-View Copy Protection"; G.S. Stubbs, Communications Technology, March, 1989.