Advances in Videodisc Technology

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Abstract

Cable systems are becoming increasingly active in the local origination of both programming and commercials. Meanwhile, the technology available for video storage and playback is developing rapidly. This paper describes some of these advances, especially erasable video discs. A description of replicated and recordable video discs provides a baseline for comparison of the new technology of erasability. An understanding of all of these approaches should help the cable system operator to select the best technology for his applications.

INTRODUCTION

Since the early days of cable television, cable operators have concentrated on the distribution of programming that was originated elsewhere. Recognizing the economic potential of both commercial insertion and pay per view, cable operators are now considering new methods for sourcing programming right in their systems. This local recording and playback requires that the cable operator understand new technologies and apply them wisely.

Introduced over ten years ago, replicated video discs remain a high quality, reliable source of playback video. However, video discs are now available in other formats, the newest of which is the erasable video disc. To best understand the operation and advantages of this new format, it is helpful to review the earlier approaches.

REPLICATED VIDEO DISCS

Audio and video information on the disc takes the form of tiny "pits" measuring 0.4 micron wide and 0.1 micron deep. The lengths of these pits represent the analog video information, and the associated audio. Rows of these pits form a single track spiraling from the inside of the disc to the outside. The distance between adjacent tracks is approximately 1.6 microns.

Formats

There are two common formats for replicated video discs. They are Constant Angular Velocity (CAV) and Constant Linear Velocity (CLV). The CAV format of a 12 inch disc has a storage capacity of 54,000 frames of video. At a constant rotational speed of 1800 RPM, each revolution of the disc corresponds to one frame of video. The playtime of a CAV disc is 30 minutes per side. Refer to Figure 1 for a detailed illustration of the CAV format.

Generally referred to as standard play, some of the beneficial capabilities of the CAV mode are freeze frame, slow motion, and step frame.

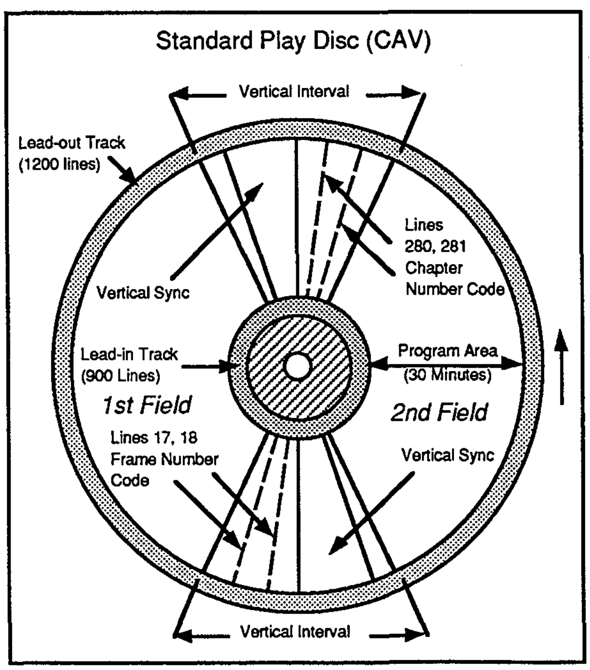

Figure 1: Standard play (CAV) format

When recording in the CLV format (extended play), one frame of video occupies the innermost track revolution. This linear distance is constant for all video frames on the disc. As a result, three frames of video occupy the outermost track revolution. Refer to Figure 2 for the CLV format. The rotational speed of the player varies from 1800 RPM at the center to 600 RPM at the outside edge. This compensates for the amount of information recorded per revolution. As a result, this format stores 60 minutes of play time per side of the disc. Without the use of additional electronics, such as frame store memories, the CLV format cannot do freeze frame, slow motion, or still step.

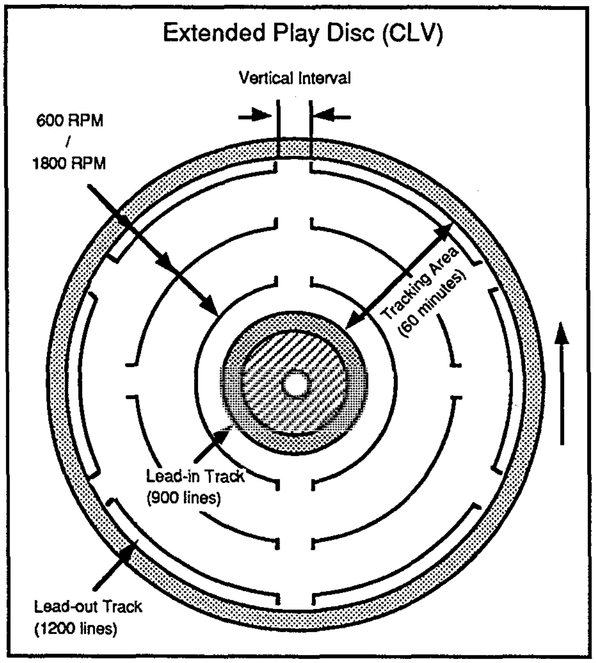

Figure 2: Extended play (CLV) format

Playback Process

The surface of a video disc contains billions of tiny pits of uniform width and depth. The length of each pit, and spacing between each pit, varies according to the modulated video and audio signals represented on the disc. As a laser beam shines on the surface of a disc, 80% of the incident light normally reflects into a detection lens. When the beam passes over a pit, however, only about 20% of the incident light reflects into the detection lens. These detected changes in reflected light modulate the photo diode current of the pickup, regenerating video and audio signals from the playback circuits.

Finished discs have two sides, of course. Manufacturing of each side, however, occurs independently. Only the final stage of production adhesively bonds the two sides together. The clear polymethyl-methacrylate (PMMA) protective coating used in the molding process is susceptible to shrinking and warping in humid conditions. Therefore, the process of bonding two discs together is necessary to insure that the video disc will not warp, causing the disc's vertical acceleration to change during playback.

Generation of Master

There are various methods of mastering and reproducing video discs. A cross sectional diagram of a replicated disc is shown in Figure 3.

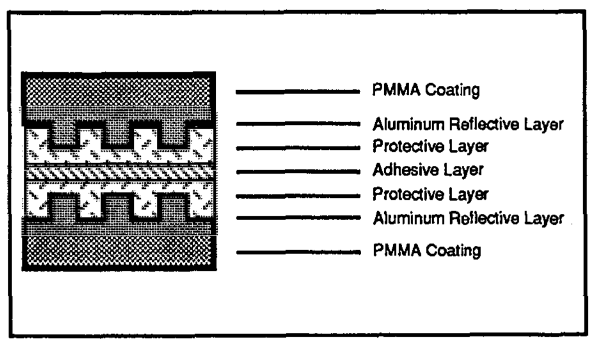

Figure 3: Cross section of the replicated video disc

Because it can replicate video discs in mass quantities, the photo resistive replication technique is used on most discs on the market today. This process, shown in Figure 4, starts with cleaning and polishing a piece of glass to a flat smooth finish. Application of a photo resistive (PR) material forms a thin layer on the glass. The thickness of the PR material is crucial in determining the C/N of the signals during playback. For optimum C/N performance, the material thickness needs to be 1/4 wavelength of the laser used to read the disc.

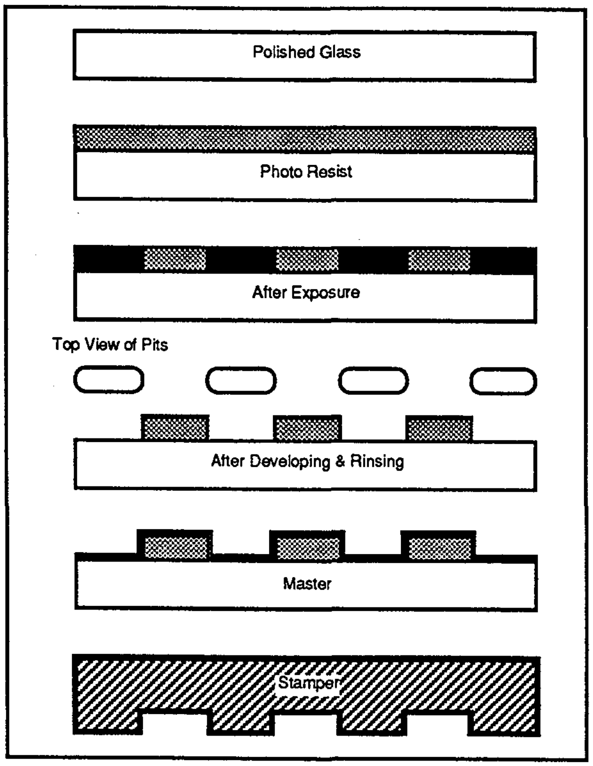

Figure 4: Production of stamper for replicated disc

Recording Process

The recording process begins by using an FM modulated composite audio/video signal to modulate the recording laser beam. The laser beam modulations soften the exposed photo-sensitive surface areas of the master disc. A chemical developer solution washes the disc to remove the softened photo-sensitive material. This step actually forms the pits. In a vacuum deposition chamber, a vaporized finish of nickel or silver covers the glass master, making the surface conductive.

In an electro-forming bath, a thick coating of electroplated nickel covers the surface of the master, forming the stamper. After additional steps to protectively seal, cut, and punch the stamper, it is ready for mounting in an injection molding machine, and the start of the mass production process.

Mass Production

Figure 5 shows the steps for mass production. The first step consists of an injection molding or hot press operation. A hot plastic compound (PMMA) enters the mold cavity under high pressure. Once the plastic solidifies and cools, the disc is ready for removal and metalization with a layer of aluminum. Finally, the addition of a layer of protective overcoating to the aluminum completes one side of the disc.

The adhesive bonding of the protective layers of two sides of a disc forms a complete replicated disc. A quality assurance inspector performs a final check on all discs to insure they meet all standards.

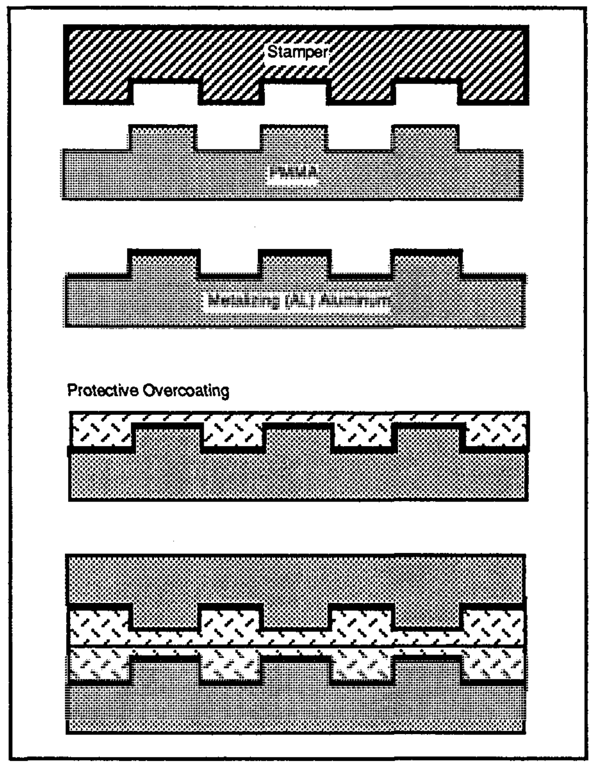

Figure 5: Mass production process for replicated disc

REAL TIME VIDEO DISC REPLICATION

The real time recording process uses a Direct Read After Write (DRAW) optical system to record onto a blank video disc. Immediately after recording, a disc is ready for playback on any standard laser disc player and produces the same image quality as a mass produced video disc. Real time disc replication is a relatively fast and inexpensive alternative to replication of single copy and low volume disc orders.

The real time videodisc recording system records all source material onto a blank disc in one process. Blank discs are available in either plastic (PMMA) or glass substrates. The recording medium consists of a dye-polymer/metal bi-layer. The dye-polymer layer is thermally reactive to the exposure of laser light. Upon contact of laser light, the surface reacts by converting solids to gas-forming pits with no debris.

ERASABLE RE-WRITEABLE VIDEO DISC

The most recent entry into the video market is the magneto-optical disc, an erasable / re-writeable technology. As the term magneto-optical implies, magnetic and optical principles combine to achieve recordability.

One of the major benefits of this new technology is that it offers the user the ability to erase and rewrite over one million times to a single disc, with no degradation to the re-writeable media. Other advantages associated with magneto-optical technology are high quality video, frame by frame recording capability, and independent digital audio recording.

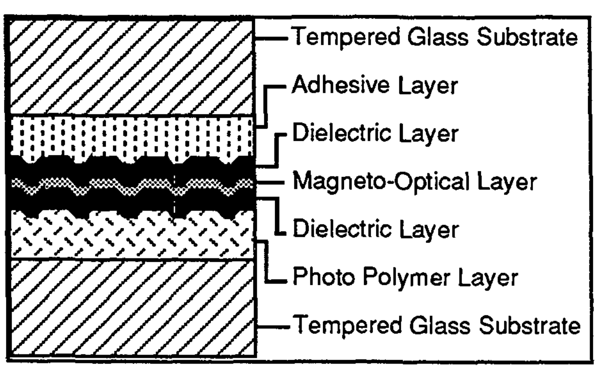

Figure 6: Magneto-optical disc composition

Disc Composition

Layers of magneto-optical, dielectric, adhesive, and photo polymer materials make up the disc. The addition of a chemically strengthened glass substrate provides durability against warping and bending. Figure 6 illustrates a cross section of the disc.

Use of a constant angular velocity (CAV) disc format for the magneto-optical technology fixes the speed of rotation at 1800 RPM. Each rotation of the disc contains one frame of video. A thirty-two minute disc capacity, then, equates to 57,600 individual frames of video. The CAV format permits frame by frame recording, as well as slow motion, freeze frame and random search features.

All discs are pre-grooved with precisely formed microscopic "valleys" in the surface. This allows the disc recorder to record and play information accurately in a spiral track.

Features

The constant rotation speed also allows for the use of two separate heads. The second head is one half rotation away from the first. The first head can erase or play. The second can record or play. Together, the two heads make possible seamless playback cuts from one area of the disc to another. Recording can occur at the same time as erasing on a used disc. The two heads can even copy from one portion of the disc to a, previously erased, section of the disc.

The player and disc together provide several approaches to accurate timing. First, each disc contains permanently pre-etched frame numbers. The drive uses these frame numbers to derive elapsed time for precise time searches to any section of the disc. Secondly, a portion of the VBI may store the SMPTE time code. Playback restores the original time code, whether linear or VITC.

Component Video

Video is recorded on the disc in an analog time compressed component form. Refer to Figure 7 for details on the recording process.

process. The recorder first separates luminance and color components of the video. It then time compresses these and separately records them within each line of video.

Recording and playback in component form eliminates cross color and cross luminance problems. These normally result from interference between luminance information and color subcarrier frequency. The component approach also avoids chroma dot crawl and 2-field jitter problems associated with phase relationship between color subcarriers. As a result, recording in the time compressed component form produces image quality equivalent to that of professional broadcast video.

PCM Audio

The recorder converts two channels of analog audio to a PCM format. It then time base compresses these audio channels and records them within a portion of the vertical blanking interval, independent of the video signal. Refer to Figure 7.

During the playback mode, the reverse process occurs. The quality of this recorded audio is equivalent to Hi-8 digital audio, with a dynamic range of 85 dB at a bandwidth of 15 kHz.

Comparison to Replicated Discs

The technology associated with magneto-optical is not compatible with, nor similar to, replicated discs, other than disc size and format (CAV). The MO disc contains billions of individual segments, where each can be magnetically polarized.

Playback Process

Even the operation of the laser pickup differs in the MO approach. When reading information from a MO disc, all laser light equally reflects off the surface of the disc. As shown in figure 8, playback circuits detect the spatial coherence of the reflected light between segments, producing an FM signal. When demodulated and decompressed, this FM signal reveals the video signal in its original component form.

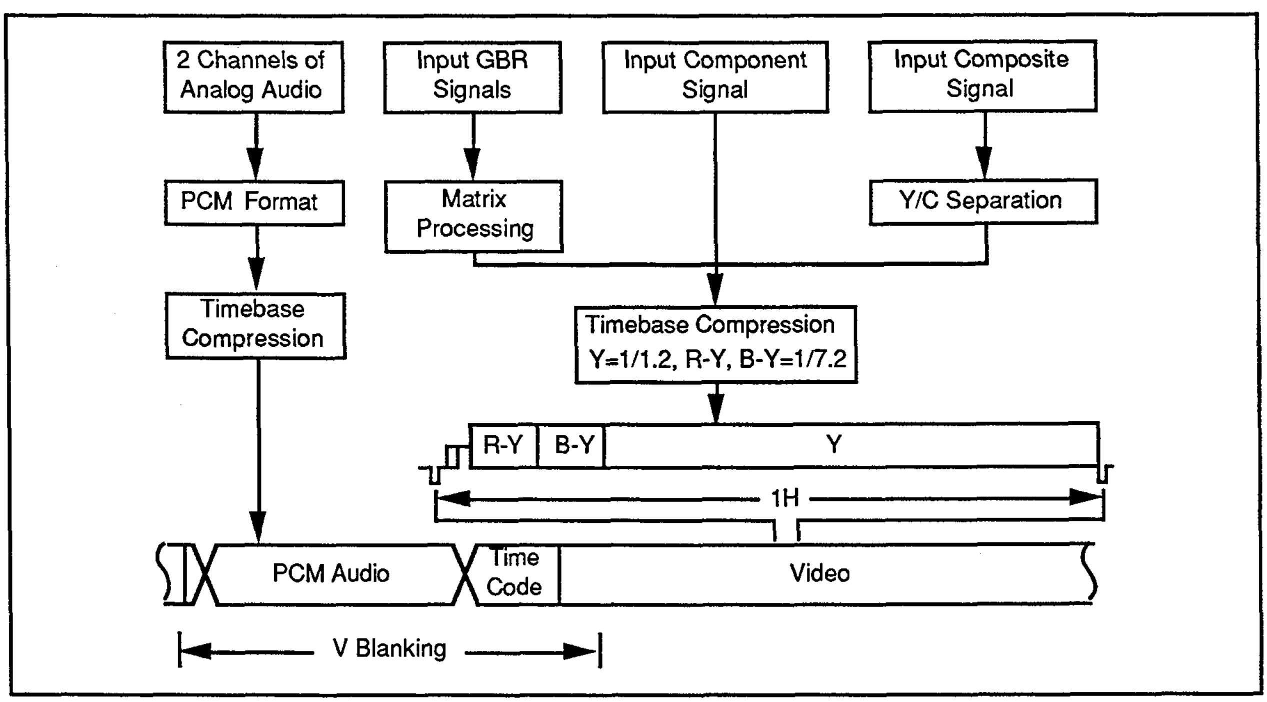

Figure 7: Magneto-optical disc recording process

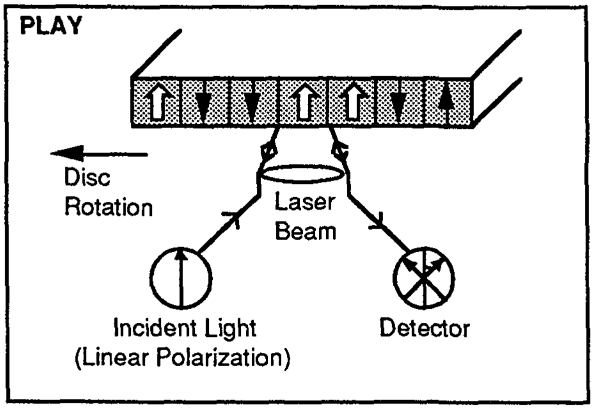

Figure 8: Playback of magneto-optical disc

Recording Process

Figure 9 shows the record method. While heating a segment of the disc with a laser beam, application of a magnetic field changes the orientation of the north and south poles of that segment. As the segment cools, the changed orientation remains, permanently storing the information.

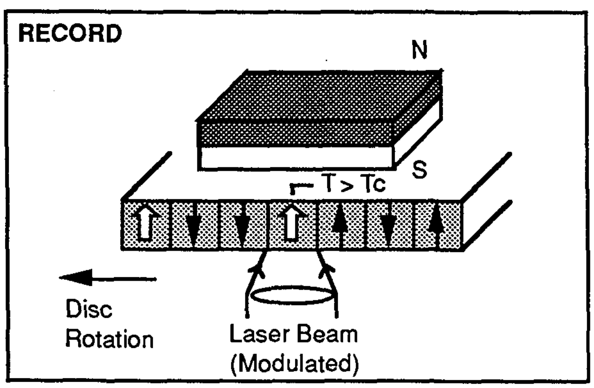

Figure 9: Recording of magneto-optical disc

Erasure Process

Laser and magnetic fields again combine to erase a segment as Figure 10 illustrates. As a laser beam heats the segment, the applied magnetic field reorients the polarity of the segment to its north pole position. On blank or erased discs, all segments have the same, north pole, polarization.

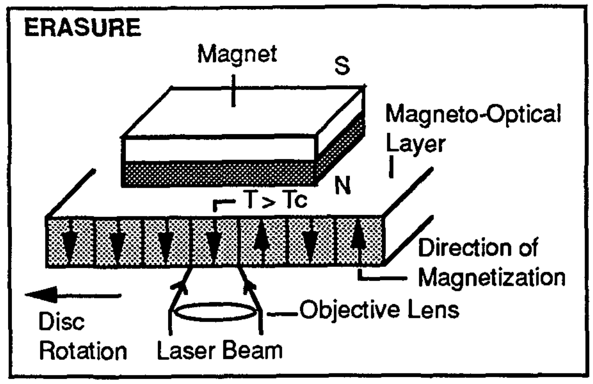

Figure 10: Erasing magneto-optical disc

This recording approach allows one million erase/rewrite operations with no degradation to the media. Thus, the use of laser optics and magnetic polarization can provide significant video recording and playback capabilities.

CONCLUSIONS

The storage and playback of video continues to grow in importance as commercial insertion and local origination spread. Advances in this area now offer significant alternatives to cable operators. The erasable, re-writeable video disc using magneto-optical technology provides many benefits which deserve consideration.

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REFERENCE

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