VIDEODISC AND OPTICAL MEMORY SYSTEMS

Dr. Jordan Isailovič

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PREFACE

This book is the outcome of the author's experience in research and development in the area of videodisc systems. The idea for its writing was born during numerous trips between Belgrade and Los Angeles. At the start of each trip, I wondered whether I had with me "everything I needed." Thus, the idea was to write the book that would contain the basis of videodisc systems—that is, serve as an "exterior memory." The initial intention of the author in writing this book was to encompass, in a single text, the broad area joining videodisc systems. Among other items, signal processing, modulation theory, TV systems, image processing, and optics were planned to be discussed.

The recording of the videodisc is usually performed by a laser. Playback is done on the basis of various pickup sensors. They are either optical or capacitive pickups. The disc itself is usually a metallized plastic, so that it represents an inexpensive memory medium of very large capacity. At the present state of technology, a disc provides 30–120 minutes of TV programming in color with stereo sound reproduction. For application in computer techniques, they are nondestructive memories with a capacity of over 30 million bits. It could be expected that these numbers in the near future will be surpassed. The longest movie, for example, could be located on one disc, and in the same way, the complete data about all the inhabitants of Yugoslavia on one or two discs.

The application possibilities of a videodisc are fantastic: for the reproduction of films and other TV materials, for storing large quantities of data, for reproduction of educational material, for use in library science, medicine, culinary art, in military services, and so on. In computer techniques, with the memory (ROM) of such a large capacity, coupled with the possibility of very swift access and data rates of over 10^7 bits/second, some hitherto strict principles can be changed. For example, in many applications the necessity for lengthy subprograms will be removed, because all the necessary data could be "on hand." The selection of movable targets in stationary radars could be made on the basis of complete memorization of the ambient. The list of applications is limited only by the imagination.

Optical data storage systems that utilize a highly focused laser beam to record and instantaneously playback information are very attractive in computer mass storage technology. They offer very high storage density with very high data rates, rapid random access to the data, potential achieval properties, and the projected low cost of media. These systems are also attractive for the television broadcasters and other communications professionals, whose need to share and then retrieve extremely large quantities of video information, text or moving and/or stationary pictures (for example) is growing rapidly.

This book considers theoretical as well as practical aspects of the videodisc systems and optical data storage systems. Its purpose is to help engineers, scientists, students, and technicians. An additional purpose is to make videodisc systems and optical discs more widely known so that they may be advantageously used to perform many functions. A discussion of disc versus disk is given in Chapter 7. The book could serve as an auxiliary textbook for a course in Optoelectronics as well as for various courses on digital electronics/memories.

Originally, the book was written as sixteen chapters.

The first four chapters comprise the first part of the book covering record processes, basic materials for recording, and the principles of basic playback systems.

The second part, Chapters 5 and 6, covers the basis of optics and noise in system considerations.

In the third part (Chapters 7–10), modulation fundamentals are presented.

Chapters 11–14 make up the fourth part. Topics covered are the mathematics of continuous imaging, psychophysical properties of human vision, colorimetry, and the principles of forming TV images along with existing standards. Also discussed is the basic problem of standard TV recording, as well as extended play techniques.

The last part (Chapters 15 and 16) cover audio signal recording and playback and applications of videodisc as both analog and digital channel (storage).

In the Appendix, the overview of the optical data storage (nonerasable and erasable) and recording structures are given.

Publishing constraints forced me to split the materials into two books. This is the first one.

The first chapter is a short survey of the book—the basic problems and principles. The videodisc is first compared with the magnetic media, and then a comparison of main videodisc systems is given.

In Chapter 2 the videodisc is considered from the production point of view. The survey of basic recording materials and their characteristics are quoted. The basic stages of disc production are described for both optical and capacitive discs.

Chapter 3 contains the principles and descriptions of the basic optical playback system. The functioning of the basic servo systems is also given.

Chapter 4 contains the principles and the description of the basic capacitive playback system, both for a pregrooved system and a flat disc.

The second part consists of Chapters 5 and 6. Necessary bases of optics are presented in Chapter 5, while the problem of noise in the system are considered in Chapter 6.

In Chapter 7, the optical data storage (i.e., draw, write once/read many times, optical disc, and so on)—programmable and erasable—is discussed. The intended application of the system (whether for digital data or TV imaging) is noted only where necessary for clarity and understanding.

Thus, the book presents the basic principles and technologies of videodiscs, compact discs/digital audio discs, and optical memories.

ACKNOWLEDGMENT

I am deeply indebted to my colleagues whose encouragement, discussions, inspirations, and support have contributed to the preparation of this book. These contributions have taken many forms, and an attempt to list all of their names would be impractical. I would like to single out a few to whom I am particularly indebted. They are listed more or less according to the chronology of their contributions.

From the beginning, Mr. Paul Obradović was my main inspiration to write this book. Many hours have been spent discussing different subjects in this book with Mr. Ray Dakin—one of the founders of the videodisc technology known as MCA technology. Mr. Scott Golding-Zlatić made the first version of the book readable in English.

Special thanks to Mr. John Raniseski, Director of Research and Development Laboratory at Discovision Associates who made it a very pleasant atmosphere in which to work. Mr. Ronald Clark, Patent Attorney for Discovision, was very helpful in supplying me with the information needed including several hundred patents on videodisc technology.

Considerable time was contributed by Mr. Milan Topalovic—from Belgrade TV—in helping me and discussing with me techniques on TV signal recording on videodiscs. The following colleagues have reviewed with enthusiasm, selected chapters of the manuscript, and gave to me useful comments and suggestions: Mr. John Winslow, Mr. Richard L. Wilkison, Mr. Carl Eberly, Mr. Michael Michalchik, Mr. Richard Allen, all members of Discovision Research and Development Laboratory; Dr. Tim Strand of the University of Southern California; Dr. Zrilić from Ljubljana; Prof. Mysore Lakshminarayana of the California State Polytechnic University of Pomona; and Mr. Paul Thomsen of Conrac Corporation.

Dr. William V. Smith, author or coauthor of two books in laser technology, with his tremendous experience and patience, encouraged me to complete this book. Also, Dr. Smith left to me, from his collection, a great number of papers and other material relevant to this subject.

Special thanks to those who typed and retyped all those revisions, Nada Obradović, from Electrotechnical faculty, University of Belgrade, Lenka Golding-Zlatić, and Word Processing at DVA, Shari LaBranche, who did the greatest share of it.

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Chapter 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

The initial aim in the development of the videodisc was to get a system that records audio-video information on a disc, replicates this disc accurately and inexpensively on plastic, and finally plays the replicas on home television screens by means of a disc player attachment. Beginning efforts were directed toward exploring the development of new types of video equipment which would permit the packaging and marketing of entertainment, educational, and industrial audiovisual programs. These initial efforts marked the beginning of a communications evolution: the first wholesale exodus away from the printed media since Gutenberg invented his crude, but innovative, press. Today, the videodisc represents one of the most advanced communications systems. It represents a revolutionary breakthrough in audiovisual communications for the 1980s. For the first time, commercial, industrial, and institutional programmers have the tools with which to tailor high-quality pictures and sound to the specific levels and interests of their audience. The result is a new dimension of persuasion and influence: a new ability to inform, educate, to sell, and to entertain.

Every so often a system appears that inspires dreams across a wide area—a technology whose potential stirs speculation in dozens of disciplines. The transistor is one example, microprocessors another, and the videodisc and optical memories appear to be another. In consumer electronics the videodisc is the most important development since the introduction of color television.

Many disciplines are involved in videodisc technology. Among them are TV systems, communications theory, signal processing, image processing, and optoelectronics. Although this field is still growing, the fundamentals are established. The set of topics presented in this book are chosen to enable the reader to develop a firm base in the fundamentals and to begin to develop an appreciation for the wide scope of applications and future directions for the field.

1.2 THE VIDEODISC SYSTEM

The enormous popularity of the phonograph record and its playback equipment, together with the rapid growth of television, led directly to investigating the possibility of recording video signals on a disc. What makes the disc so interesting is the potential combination of three properties: very low cost, very high information density, and the possibility of instant access to any portion of a long recording. In general, videodisc systems offer:

- Up to 2 hours of play on a single disc
- Color video
- Stereo sound
- Special features
- Direct, rapid access
- External computer control

Basically, the videodisc (VD) system (Fig. 1–1) is similar to the long playing (LP)–audio system. As a result of the recording process, inexpensive plastic discs in large quantity are obtained. Recorded programs are then played back through a specially designed system, a player.

The production process for a videodisc is more or less comparable with that used for conventional audio records. First, a master recording is made from a master tape (Fig. 1–2). Theoretically, any source material may be used for mastering, including 16mm or 35mm film slides, off-air TV signals, videotape, a camera, an electronically generated signal, and so on. From a practical standpoint, however, most mastering is accomplished by transferring any of the potential sources to 1-inch—C format videotape. Alternatively, 2-inch helical or 2-inch quadruplex tape can be used. In this process, material may be edited together from several sources; color correction, if any, may be accomplished; audio may be added or changed; and frame-by-frame address codes can be inserted in the programming. A master disc can be used directly as a stamper, or as a basis ("mother") for the production of many stampers. Also, in source mastering processes, the recorded pattern can be "directly read after writing" (DRAW), a very convenient property. Further, stampers are used to replicate recorded patterns in inexpensive plastic video records.

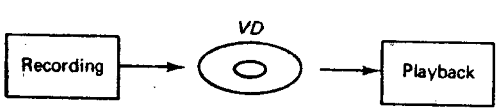

Figure 1–1 Videodisc system.

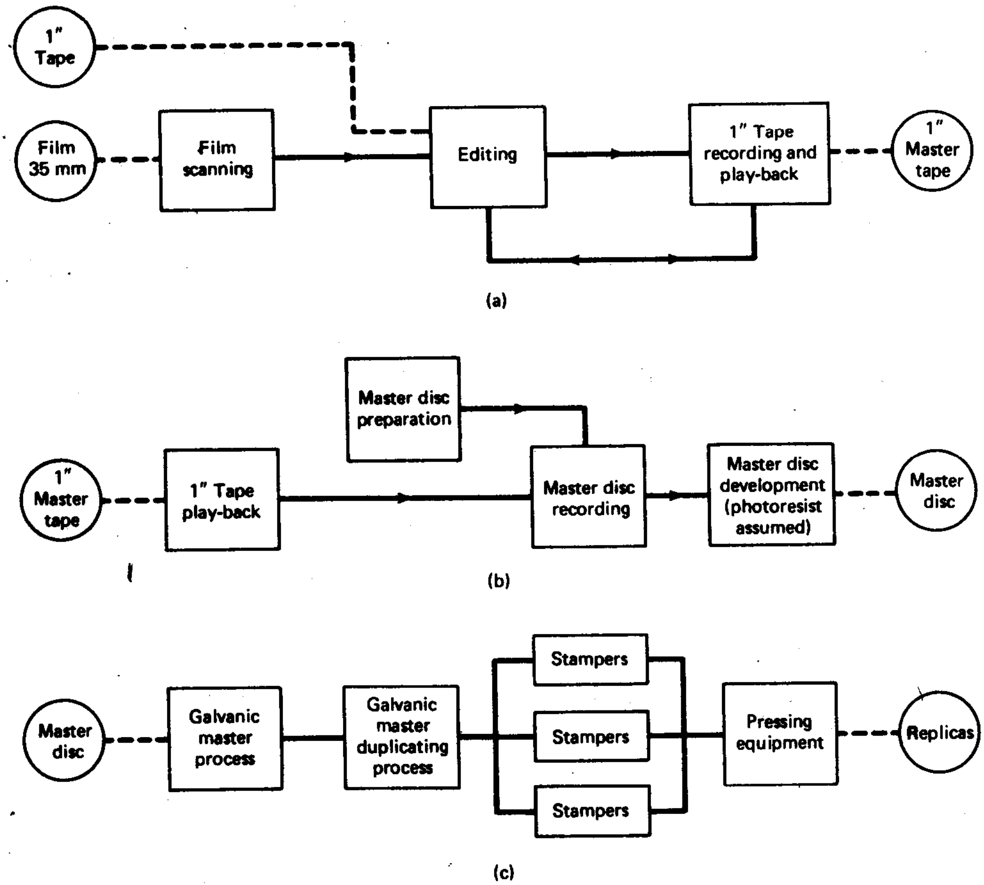

Figure 1–2 Videodisc mastering and replication.

The videodisc player is self-contained and is designed to be connected to the antenna terminals of any domestic color television receiver to provide playback of replicated videodiscs. The essential elements of the playback system are a pickup, a means for spinning the videodisc at the correct speed, a means for positioning a pickup (stylus) on the disc surface, the electronics necessary to process the signal for a TV or other receiver (or user), the controls, and the power electronics to operate the unit.

Although detailed models for the reading process depend, among other things, on the pickup, it is possible to construct a generalized model independent of these details. Such a model is shown in Fig. 1–3. An oscillator generates a signal with a very high carrier frequency. This carrier is (for example) amplitude modulated by the mechanically stored information pattern on the disc. This change on the carrier, called mechanical modulation (MM), is detected by the pit pattern to electrical signal