On-Line Microprocessor Control of Optical Disc Records and Players

1986

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*University of Central Florida*

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ON-LINE MICROPROCESSOR CONTROL OF OPTICAL DISC RECORDERS AND PLAYERS

BY

HOWARD LUEBCKE
B.S.E.E. Florida Atlantic University, 1977

RESEARCH REPORT

Submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering in the Graduate Studies Program of the College of Engineering University of Central Florida Orlando, Florida

Spring Term 1986
ABSTRACT

The goal of this paper is to document the work performed in the development of the software required to operate a video disc player and recorder in the on-line mode using a portable computer. Applications of video disc systems are discussed as are future improvements to the developed system.

This paper also includes a description of the hardware, functional requirements and design of the software, and the end result of the development of the software in the form of program listings.
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INTRODUCTION

The 1980s has brought about a revolution in the way information is stored and retrieved. The most instrumental technology responsible for this transition has been the optical video disc. It is now possible to store a gigabyte of data or the equivalent of 54,000 frames of video information on a single 12-inch video disc. The enormous impact this has on our ability to store and retrieve data has only begun to be felt.

The video disc is a "read only" device and, therefore, does have some limitations. Extreme care must be taken to assure that the data recorded on the disc is correct since it cannot be changed once it is recorded. On typical 12-inch video disc systems, a master tape is recorded, containing the information which one would want on the disc. This tape is created in a specific sequence and shipped to a mastering facility for creation of the initial disc. These facilities are expensive and, until recently, have restricted the number of participants in the mastering process. A breakthrough in technology was required to allow the end user to record and instantly play back video information.
This breakthrough is available in Panasonic's TQ series optical disc recorders. The recorders do not use the standard 12-inch disc, rather an 8-inch (200 millimeter) acrylic resin disc is used. This technology has allowed end users without large available capital to participate in the mastering of video discs. Each disc can contain up to 15,000 frames of video to be recorded in NTSC standard format.

The purpose of this project is to allow the video disc mastering process to become more simplified by using a personal computer to control the operation of the optical disc recorder and player in an on-line mode from a single work station.
SYSTEM DESCRIPTION

The hardware selection process, which would normally occur on a project of this type, was made simpler by an attempt to use available university resources. While this may not be the optimum solution, it does allow efficient and prudent use of scarce resources and assures compatibility with other computing equipment. The major hardware components are a Digital Equipment Corporation Pro 350 personal computer, Panasonic Optical Disc Recorder (TQ-2020FC), and a Panasonic Optical Disc Player (TQ-2024F). Figure 1 is a block diagram of the hardware configuration as used to develop and demonstrate the on-line control programs.

Optical Disc Recorder

The Panasonic TQ series optical disc recorder was used for this project to reduce the cost and complexity of mastering video discs. It is the only self-contained, desk-top unit with the capability to record video information. The recorder can be used in either the manual mode or on-line mode. In the manual mode all operations are controlled by the buttons on the top panel of the recorder. In the on-line mode, additional control is provided by a host computer. The commands available in the
Figure 1. Hardware Block Diagram
on-line mode are contained in Table 1. This table was derived from the optical memory disc recorder, operating instructions. The operating instructions also include a list of error conditions which are returned to the host computer in case of a procedural error or system malfunction. For the purpose of this project the system will only report that an error has occurred, at which time the operator can observe the display on the recorder to determine the type of error which has occurred.

**TABLE 1**

**OPTICAL DISC RECORDER COMMANDS**

<table>
<thead>
<tr>
<th>COMMAND</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Search for a target address</td>
</tr>
<tr>
<td>R</td>
<td>Change to the record mode</td>
</tr>
<tr>
<td>G</td>
<td>Record a picture</td>
</tr>
<tr>
<td>C</td>
<td>Cancel the record mode</td>
</tr>
<tr>
<td>A</td>
<td>Ask for the current address</td>
</tr>
</tbody>
</table>

The recorder utilizes TQ-FD22 optical discs made of acrylic resin. The disc is capable of recording 15,000 images or video frames. Images are recorded on the disc by using a laser to burn pits in the disc material less than 1 micron in diameter. The information is stored on the disc digitally and each pit cooresponds to a 0 or a 1. Each
track, or frame, is approximately 1.5 microns wide and contains all the data required to produce one video image. To produce a motion picture, the images are played back at a 30 Hertz rate, or 30 frames per second. Each disc, therefore, could produce 15,000 still pictures or 8.33 minutes of motion pictures. Once recorded, the discs are extremely durable and are not susceptible to many of the problems of video tape. The information on the disc is available randomly with average access time of 1/2 second.

**Optical Disc Player**

The Panasonic TQ-2024F Optical Disc Player has the capability to play back discs recorded on the Optical Disc Recorder. The player also can be used in the on-line or off-line mode. In either mode the operator can program the player to present sequences recorded on the disc in various order and sequences. A complete list of the functions provided by the player is contained in tables 2 through 4. This list was derived from the Optical Disc Player operating instructions.
<table>
<thead>
<tr>
<th>COMMAND</th>
<th>DESCRIPTION</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>JF</td>
<td>Jump forward</td>
<td>Length</td>
</tr>
<tr>
<td>JR</td>
<td>Jump backward</td>
<td>Length</td>
</tr>
<tr>
<td>LD</td>
<td>Load disc in player</td>
<td></td>
</tr>
<tr>
<td>EJ</td>
<td>Eject disc from player</td>
<td></td>
</tr>
<tr>
<td>RN</td>
<td>Execute a recorded program</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>Cancel execution mode</td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>Start writing a program</td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>End writing a program</td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>Report player status</td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>Clear all buffers</td>
<td></td>
</tr>
<tr>
<td>ON</td>
<td>Set on-line mode</td>
<td>Mode #</td>
</tr>
<tr>
<td>OF</td>
<td>Set off-line mode</td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>Report track address</td>
<td></td>
</tr>
<tr>
<td>COMMAND</td>
<td>DESCRIPTION</td>
<td>PARAMETERS</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>GO</td>
<td>Compulsary jump</td>
<td>Label #</td>
</tr>
<tr>
<td>EQ</td>
<td>Branch if equal to</td>
<td>Condition/Label #</td>
</tr>
<tr>
<td>LT</td>
<td>Branch if less than</td>
<td>Condition/Label #</td>
</tr>
<tr>
<td>ST</td>
<td>Store data to register #</td>
<td>Register #/Data</td>
</tr>
<tr>
<td>IN</td>
<td>Input data to register #</td>
<td>Register #</td>
</tr>
<tr>
<td>AD</td>
<td>Add data to register</td>
<td>Register #/Data</td>
</tr>
<tr>
<td>SB</td>
<td>Subtract data from register #</td>
<td>Register #/Data</td>
</tr>
<tr>
<td>CA</td>
<td>Execute subroutine at label #</td>
<td>Label #</td>
</tr>
<tr>
<td>RT</td>
<td>Return from subroutine</td>
<td></td>
</tr>
<tr>
<td>EN</td>
<td>End program run</td>
<td></td>
</tr>
<tr>
<td>MV</td>
<td>Move data of register #</td>
<td>Register #'s</td>
</tr>
<tr>
<td>COMMAND</td>
<td>DESCRIPTION</td>
<td>PARAMETERS</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>PF</td>
<td>Play Forward</td>
<td>Stop frame</td>
</tr>
<tr>
<td>PR</td>
<td>Play reverse</td>
<td>Stop frame</td>
</tr>
<tr>
<td>TF</td>
<td>Step forward</td>
<td>Time/Stop frame</td>
</tr>
<tr>
<td>TR</td>
<td>Step reverse</td>
<td>Time/Stop frame</td>
</tr>
<tr>
<td>LF</td>
<td>Slow forward</td>
<td>Speed/Stop frame</td>
</tr>
<tr>
<td>LR</td>
<td>Slow reverse</td>
<td>Speed/Stop frame</td>
</tr>
<tr>
<td>FF</td>
<td>Fast forward</td>
<td>Speed/Stop frame</td>
</tr>
<tr>
<td>FR</td>
<td>Fast reverse</td>
<td>Speed/Stop frame</td>
</tr>
<tr>
<td>SR</td>
<td>Search for a frame</td>
<td>Target frame</td>
</tr>
<tr>
<td>A2</td>
<td>Volume for channel 2</td>
<td>Volume data</td>
</tr>
<tr>
<td>A1</td>
<td>Volume for channel 1</td>
<td>Volume data</td>
</tr>
<tr>
<td>DS</td>
<td>Turn on display at player</td>
<td></td>
</tr>
<tr>
<td>DR</td>
<td>Turn off display at player</td>
<td></td>
</tr>
<tr>
<td>DW</td>
<td>Write characters to display</td>
<td>Line #/Characters</td>
</tr>
<tr>
<td>VS</td>
<td>Turn video on</td>
<td></td>
</tr>
<tr>
<td>VR</td>
<td>Mute video</td>
<td></td>
</tr>
<tr>
<td>HT</td>
<td>Halt player</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>Set internal video on</td>
<td></td>
</tr>
<tr>
<td>VE</td>
<td>Set external video on</td>
<td></td>
</tr>
</tbody>
</table>
Professional 350 Microcomputer

The Professional 350 personal computer was chosen for this project because of its communication ability and the ease with which it could be integrated with the VAX equipment already available. The Pro 350 is based on the F11 microprocessor which includes a floating point processor, 512 Kbytes of main memory and two 400 Kbyte diskette drives. The specifications for the Pro 350 can be found in the Professional Series Handbook (1985). The specific options required for this project are the P/OS professional operating system, version 1.2 or higher of Pro/Basic and Pro/Communications. Communication with peripheral equipment is performed either through the communications port or through the Realtime Interface option. While the Realtime Interface would have been a more eloquent solution to the problem the additional complexity brought about by the requirement to use the Pro/Tool Kit and Basic-Plus-2 made its use prohibitive for this project.
PERFORMANCE SPECIFICATION

The goal of this research project, as stated in the introduction, was to simplify the optical disc mastering process by using a microprocessor to control an optical disc recorder and player. This is best accomplished through the use of user-friendly menus from which the operator selects the tasks to be performed. The first menu queries the operator as to which device is to be used.

Device Selection Menu

Recorder = R
Player = P
Exit = E

Recorder Control

Once the recorder has been selected from the first menu the user is presented with a menu that will allow information to be provided concerning the current address, change to the record mode or selection of an address on which to record. The optical disc recorder menu presents this choice in a clear format.

Optical Disc Recorder
Search For Target Address = S
Change To Record Mode = R
Ask The Current Address = A
End Session = E

If the record mode is selected from the previous menu then the operator has two choices. One is to verify that the proper address is selected and the other is to record a picture.

Record Menu
Record a Picture = G
Ask The Current Address = A
Cancel The Record Mode = C

Cancelling the record mode will return the operator to the optical disc recorder menu.

Player Control

There are three high-level functions that can be performed from the first menu. The first is to operate the disc drawer, the second is to switch modes of operation and the third is to select program or command mode of operation.

Optical Disc Player Main Menu
Load Optical Disc = LD
Eject Optical Disc = EJ
On Line Mode = ON
Off Line Mode = OF
Command Menu = C
Program Menu = P
End Player Session = Q

Selection of the "Load Optical Disc" option will close the disc drawer, while selection of the "Eject Optical Disc" option will close the disc drawer. Selection of the "Program Menu" provides the operator with capability to program the player to play back scenes in a specified sequence at various speeds and from various locations on the disc. The program menu allows the operator to run a previously recorded program or create a new program and store it in the player's memory.

Program Menu
Memory Start = MS
Memory End = ME
All Clear = AC
Program Run = RN
Cancel Execution = CS
Main Menu = M

Prior to beginning a programming sequence the memory should be cleared by selection of the "All Clear" option. To begin entering commands the "Memory Start" selection is made. Commands are then made sequentially and stored in the program buffer until a "Memory End" selection is made. Selection of the "Program Run" option will begin execution
of the command stored in program buffer. This operation will continue until execution is complete or until the "Cancel Execution" option is selected.

The commands available on the player are divided into two categories. The first are those commands that are used to control rate and direction of disc playback. The second are those commands that control the audio, display and video.

**Primary Command Menu**

Player Status = PS
Track Number = NO
Search = SR[Frame]
Jump Forward = JF[1-5]
Jump Reverse = JR[1-5]:
Play Forward = PF[Stop]:
Play Reverse = PR[Stop]:
Step Forward = TF[Step][Stop]:
Step Reverse = TR[Step][Stop]:
Slow Forward = LF[Speed][Stop]:
Slow Reverse = LR[Speed][Stop]:
Fast Forward = FF[Speed][Stop]:
Fast Reverse = FR[Speed][Stop]:
Secondary Menu = S
Main Menu = M
The "Player Status" option returns, to the operator, information concerning the present status of the player. This information includes play, step, slow, fast and direction of travel. It also will show whether the player is loading, ejecting or searching for an address. The lesser-used commands are provided by selecting the "Secondary Menu."

Secondary Menu

Audio Right = A2[Volume]:
Audio Left  = A1[Volume]:
Display Set = DS
Display Reset = DR
Display Write = DW[line#][Chr]:
Video Set  = VS
Halt = HT
Internal Video = VI
External Video = VE
Primary Menu = P

When the display is set the track address, input data, playback operation message and repeat execution number are displayed on the monitor. Resetting the display blanks out the data. Up to 12 characters can be written on the monitor by selecting the "Display Write" option. The video is turned on and off through the use of the "Video Set" and "Video Reset" options. Selection of the "External
Video" option allows video to be displayed from another source connected to the player.
DESIGN APPROACH

A user-friendly design philosophy was used in developing the structure of the program. All operator actions are selected from a series of menus as described in the previous chapter. As a selection is made from the menu, the program branches to the appropriate location to perform the action. For example, suppose the operator needs to know what track number the player is presently on. Starting with the "Device" menu he would select "P" for player. The "Optical Disc Player" menu would appear, from which he would select "C." A list of options would appear on the "Primary Command" menu from which he would select "NO," which is the code for "Track Number." The program then sends this command to the player and awaits a response. When the response has been received, the track number is displayed on the screen for a few seconds and then the "Primary Command" menu reappears. The hierarchy of menus is given in Figure 2.

Subroutines

There are three functions which are required to be performed routinely throughout the program, communication with the player/recorder, handle error messages and delay to allow the operator to read messages. These functions
were coded as subroutines to reduce the amount of code and to reduce the probability of an error.

![Diagram of Hierarchy of Menus]

**Figure 2. Hierarchy of Menus**

Communication with the player/recorder is handled through the communication port of the Pro 350. This port can be accessed directly from a Basic program by opening the file called "XK:". Once the communication port has been reserved it is considered as just another file and the standard basic commands for file communication are valid. An example of communication port access is contained in Appendix F of the Pro Basic user's manual. This example was used as the foundation for the player/recorder communication subroutine.
Many of the responses from the player/recorder require that the operator read a message from the display. In order to provide adequate time to accomplish this task the program is suspended until the operator presses any key on the keyboard. The program will then return the operator to whatever menu was selected prior to the response being displayed.

Error messages are available from both the player and the recorder any time that communication occurs between the player and the host computer. When an error message is detected the error code is printed on the display along with directions to see the user manual for further instructions.

**Communications Protocol**

The communications port is an RS-232C interface. Both the player and recorder support this configuration. The player is programmable and supports various RS-232C configurations. The recorder, however, only supports one, therefore, both the player and recorder are used in the configuration of the recorder. The on-line connection is given in Figure 3.

In order to assure commonality in the communications subroutine the string structure to the player was selected to be the same as that for the recorder. This is performed by going to the "Optical Disc Player" menu and selecting
"ON12:". This puts the player in the on-line mode, does not add carriage returns or line feeds, eliminates the ACK and BCK responses, and uses the STX/ETX format. All communication to and from the player is preceded by STX and succeeded by ETX. The program adds these characters to the string received from the menu selection and deletes them from the string received from the player/recorder.

The default values established for the communication port do not match those that are required by the recorder. Pro/Communications is required to modify these conditions. The specifications listed in Table 5 must be set for the computer using Pro/Communications and for the player by setting the dip switches as described in Table 6.
TABLE 5
RS-232C FORMAT

<table>
<thead>
<tr>
<th>BITS PER SECOND</th>
<th>1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH</td>
<td>8</td>
</tr>
<tr>
<td>PARITY</td>
<td>ODD</td>
</tr>
<tr>
<td>STOP BITS</td>
<td>1</td>
</tr>
</tbody>
</table>

TABLE 6
PLAYER DIP SWITCH SETTINGS

1. ON
2. ON
3. OFF
4. ON
5. ON
6. OFF
7. OFF
8. OFF

Final Program Design

The final program listing is contained in Appendix 1. While all of the performance requirements discussed in Chapter 2 were met a number of potential improvements and modifications were discovered during the development process. These will be discussed in Chapter 5.
DEMONSTRATION PROCEDURE

The intent of this procedure is to verify the proper operation of the system as described in the previous chapters. Each item on each menu is selected to verify the proper handling of commands and program operation of the player. A picture is recorded to verify the proper control of the optical disc recorder. The detailed procedures are contained in Table 7. The communication port and the player must be set to 1200 BAUD, 8 data bits, 1 stop bit and odd parity. These initial conditions were chosen to match the recorder, which is not adjustable.

TABLE 7
DEMONSTRATION PROCEDURES

<table>
<thead>
<tr>
<th>Step</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select Pro Basic</td>
<td>Ready appears on the CRT</td>
</tr>
<tr>
<td>2. Type Old rpcomb</td>
<td>Ready appears on the CRT</td>
</tr>
<tr>
<td>3. Type run</td>
<td>Device menu appears on CRT</td>
</tr>
<tr>
<td>4. Select P</td>
<td>Player menu appears on CRT</td>
</tr>
<tr>
<td>5. Select ON</td>
<td>ON-LINE light on at player</td>
</tr>
<tr>
<td>6. Load a disc in the player and select LD</td>
<td>Player door closes</td>
</tr>
<tr>
<td>7. Select SP</td>
<td>1st frame appears on monitor</td>
</tr>
<tr>
<td>STEP</td>
<td>REACTION</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>8. Select C</td>
<td>Primary Command Menu appears</td>
</tr>
<tr>
<td>9. Select NO</td>
<td>Track number appears on CRT</td>
</tr>
<tr>
<td>10. Select SR00005:</td>
<td>Player at track 00005</td>
</tr>
<tr>
<td>11. Select JF2:</td>
<td>Player jumps two tracks</td>
</tr>
<tr>
<td>12. Select JR2:</td>
<td>Player at track 00005</td>
</tr>
<tr>
<td>13. Select PF00010:</td>
<td>Player stops at track 00010</td>
</tr>
<tr>
<td>14. Select PRO0005:</td>
<td>Player stops at track 00005</td>
</tr>
<tr>
<td>15. Select TF1:00010</td>
<td>Steps forward at 1 second</td>
</tr>
<tr>
<td>16. Select TR1:00005:</td>
<td>Step reverse at 1 second</td>
</tr>
<tr>
<td>17. Select LF30:00010:</td>
<td>Forward at 1 second</td>
</tr>
<tr>
<td>18. Select LR30:00005:</td>
<td>Reverse at 1 second</td>
</tr>
<tr>
<td>19. Select FF10:06005:</td>
<td>Play 20 seconds</td>
</tr>
<tr>
<td>20. Select FR10:00005:</td>
<td>Reverse 20 seconds</td>
</tr>
<tr>
<td>21. Select PS (before 20 seconds)</td>
<td>Fast Reverse on CRT</td>
</tr>
<tr>
<td>22. Select S</td>
<td>Secondary menu appears</td>
</tr>
<tr>
<td>23. Select DS</td>
<td>Data displayed on monitor</td>
</tr>
<tr>
<td>24. Select DR</td>
<td>No data on monitor</td>
</tr>
<tr>
<td>25. Select DW3:TEST:</td>
<td>&quot;TEST&quot; appears on monitor</td>
</tr>
<tr>
<td>26. Select DW3:</td>
<td>No &quot;TEST&quot; on monitor</td>
</tr>
<tr>
<td>27. Select P</td>
<td>Primary menu</td>
</tr>
<tr>
<td>28. Select SR00005:</td>
<td>Track number 00005</td>
</tr>
<tr>
<td>29. Select S</td>
<td>Secondary menu</td>
</tr>
<tr>
<td>STEP</td>
<td>REACTION</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>30. Select VR</td>
<td>No video on monitor</td>
</tr>
<tr>
<td>31. Select VS</td>
<td>Video on monitor</td>
</tr>
<tr>
<td>32. Select P</td>
<td>Primary menu</td>
</tr>
<tr>
<td>33. Select M</td>
<td>Player main menu</td>
</tr>
<tr>
<td>34. Select P</td>
<td>Program menu</td>
</tr>
<tr>
<td>35. Select AC</td>
<td>None</td>
</tr>
<tr>
<td>36. Select MS</td>
<td>&quot;ENTER COMMAND&quot;</td>
</tr>
<tr>
<td>37. Type ST1:0:</td>
<td>&quot;ENTER COMMAND&quot;</td>
</tr>
<tr>
<td>38. Type 1:SR:00005:</td>
<td>&quot;ENTER COMMAND&quot;</td>
</tr>
<tr>
<td>39. Type PF00305:</td>
<td>&quot;ENTER COMMAND&quot;</td>
</tr>
<tr>
<td>40. Type AD1:1:</td>
<td>&quot;ENTER COMMAND&quot;</td>
</tr>
<tr>
<td>41. Type LT3:1:</td>
<td>&quot;ENTER COMMAND&quot;</td>
</tr>
<tr>
<td>42. Type EN</td>
<td>Program menu</td>
</tr>
<tr>
<td>43. Type ME</td>
<td>Program will run three times</td>
</tr>
<tr>
<td>44. Select RN</td>
<td>repeating tracks 5 to 305</td>
</tr>
<tr>
<td>45. Select RN</td>
<td>Program runs</td>
</tr>
<tr>
<td>46. Select CS</td>
<td>Program halts prior to end</td>
</tr>
<tr>
<td>47. Select M</td>
<td>Player main menu appears</td>
</tr>
<tr>
<td>48. Select Q</td>
<td>Device menu appears</td>
</tr>
<tr>
<td>49. Select R</td>
<td>Record menu appears</td>
</tr>
<tr>
<td>50. Select S00005</td>
<td>00005 displayed on recorder</td>
</tr>
<tr>
<td>51. Select A</td>
<td>5 displayed on CRT</td>
</tr>
<tr>
<td>STEP</td>
<td>REACTION</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>52. Select R</td>
<td>Record menu appears on CRT</td>
</tr>
<tr>
<td>53. Connect video camera and prepare to record a picture</td>
<td></td>
</tr>
<tr>
<td>54. Select G</td>
<td>Recorder menu appears on CRT</td>
</tr>
<tr>
<td>55. Select C</td>
<td>Recorded picture on monitor</td>
</tr>
<tr>
<td>56. Select S00005</td>
<td>Device menu appears on CRT</td>
</tr>
<tr>
<td>57. Select E</td>
<td></td>
</tr>
<tr>
<td>58. Select E</td>
<td>TEST COMPLETE</td>
</tr>
</tbody>
</table>
SUMMARY

The objective of this project was to simplify the mastering of video discs, and this goal has been accomplished. As with any project, hindsight leads one to simpler methodologies or improved performance characteristics. Use of the Realtime Interface module would have eliminated the need for manually switching cables when changing control between the player and the recorder. The Realtime Interface contains two RS232 ports addressable from the computer. The use of a more structured language would have been advantageous. This would have assured greater modularity and transportability for future enhancements. This program will be most useful when programming the player and in developing programs of instruction for discs that are already recorded. There is little advantage in using the Pro 350 to record since the same number of keystrokes are used on the PRO 350 as would be used by operating the recorder in the manual mode.
APPENDIX 1

SET NO DOUB
10 CLEAR
20 PRINT ,, 'DEVICE MENU'
30 PRINT
40 PRINT ,, 'RECORDER = R'
50 PRINT ,, 'PLAYER = P'
60 PRINT ,, 'END DISC SESSION = Q'
70 PRINT
80 PRINT ,, ENTER SELECTION'
90 INPUT $0, CHOICES
100 IF CHOICES= 'P' THEN GOTO 130
110 IF CHOICES= 'R' THEN GOTO 1870
120 IF CHOICES= 'Q' THEN GOTO 1830
130 CLEAR
140 PRINT ,, 'OPTICAL DISK PLAYER MAIN MENU'
150 PRINT
160 PRINT ,, 'LOAD OPTICAL DISK = LD'
170 PRINT ,, 'EJECT OPTICAL DISK = EJ'
180 PRINT ,, 'ON LINE MODE = ON'
190 PRINT ,, 'OFF LINE MODE = OF'
195 PRINT ,, 'START PLAYER = SP'
200 PRINT ,, 'COMMAND MENU = C'
210 PRINT ,, 'PROGRAM MENU = P'
220 PRINT ,, 'END PLAYER SESSION = Q'
230 PRINT
240 PRINT ,, ENTER SELECTION'
250 REM
260 REM THIS SECTION TRANSMITS THE COMMAND TO THE PLAYER, MOVES TO ANOTHER MENU OR ENDS THE PLAYER SESSION. AFTER THE COMMAND HAS BEEN SENT A MESSAGE IS PRINTED ON THE DISPLAY DEPENDING ON WHAT COMMAND IS SENT.
270 REM
280 INPUT $0, COMANDS
290 REM
300 IF COMANDS='C' THEN GOTO 740
310 IF COMANDS='P' THEN GOTO 500
320 IF COMANDS='Q' THEN GOTO 10
330 TIME%=2000
331 IF COMANDS='LD' THEN GOSUB 1380\ GOTO 350
332 IF COMANDS='EJ' THEN GOSUB 1380 \ GOTO 350
333 TIME%=2500
334 IF COMANDS='SP' THEN COMANDS='TF1:1:'\ GOSUB 1380
335 TIME%=300
336 IF MID$(COMANDS,1%,2%)='ON' THEN GOSUB 1380\ GOTO 350
337 TIME%=300
338 IF MID$(COMANDS,1%,2%)='OFF' THEN GOSUB 1380\ GOTO 350
339 CLEAR \ PRINT "INVALID ENTRY TRY AGAIN" \ GOTO 130
340 CLEAR
350 REM
360 COMRES$=MID$(COMRES$,1%,2%)\ 'DISK LOADED' \ GOTO 430
370 IF COMRES$='LD' THEN PRINT 'DISK LOADED' \ GOTO 430
380 IF COMRES$='EJ' THEN PRINT 'DISK EJECTED' \ GOTO 430
390 IF COMRES$='ON' THEN PRINT 'PLAYER IS ON LINE' \ GOTO 430
400 IF COMRES$='OF' THEN PRINT 'PLAYER IS OFF LINE' \ GOTO 430
410 CLEAR
420 PRINT 'INVALID ENTRY'
430 GOSUB 1760 \ GOTO 130
440 REM
450 REM THIS MENU IS USED FOR ENTERING PROGRAM COMMANDS TO THE PLAYER.
460 REM IT SHOULD BE USED IN CONJUNCTION WITH THE USERS MANUAL. EACH COMMAND IS ENTERED ONE AT A TIME UNTIL THE MEMORY END COMMAND IS ISSUED. CONTROL IS THEN PASSED TO THE PROGRAM MENU.
470 REM
480 CLEAR
490 PRINT ,, 'PROGRAM MENU'
500 PRINT
510 PRINT ,, 'MEMORY START = MS'
540 PRINT,,'ALL CLEAR' =AC'
550 PRINT,,'PROGRAM RUN' =RN'
560 PRINT,,'CANCEL EXECUTION' =CS'
570 PRINT,,'MAIN MENU' =M'
580 PRINT
590 PRINT,,' ENTER SELECTION'
600 INPUT $0,COMAND$
605 TIME%=300
610 IF COMAND$='MS' THEN GOSUB 1380 ELSE GOTO 670
620 CLEAR
630 PRINT,,ENTER COMAND OR ENTER ME TO END PROGRAM MODE
640 INPUT $0,COMAND$
650 IF COMAND$='ME' THEN GOSUB 1380 GOTO 500
660 GOSUB 1480 GOTO 620
665 CLEAR
670 IF COMAND$='M' THEN GOTO 130 ELSE GOSUB 1380
680 GOTO 500
690 REM
700 REM THIS SECTION OF CODE IS USED TO PASS COMMANDS TO THE PLAYER
710 REM AND TO DETERMINE PLAYER STATUS. THE BRACKETS NEXT TO THE COMMANDS
720 REM SHOULD CONTAIN THE INFORMATION AS SPECIFIED IN THE PLAYER USERS
730 REM MANUAL.
740 CLEAR
750 PRINT,,'PRIMARY COMMAND MENU'
760 PRINT
770 PRINT,,'PLAYER STATUS' = PS'
780 PRINT,,'TRACK NUMBER' = NO'
790 PRINT,,'SEARCH' = SR[FRAME]:'
800 PRINT,,'JUMP FORWARD' = JF[1-5]:'
810 PRINT,,'JUMP REVERSE' = JR[1-5]:'
820 PRINT,,'PLAY FORWARD' = PF[STOP]:'
830 PRINT,,'PLAY REVERSE' = PR[STOP]:'
840 PRINT,,'STEP FORWARD' = TF[STEP]:[STOP]:'
850 PRINT,,'STEP REVERSE' = TR[STEP]:[STOP]:'
860 PRINT,,'SLOW FORWARD' = LF[SPEED]:[STOP]:'
870 PRINT,,'SLOW REVERSE' = LR[SPEED]:[STOP]:'
880 PRINT,,'FAST FORWARD' = FF[SPEED]:[STOP]:'
890 PRINT,,'FAST REVERSE' = FR[SPEED]:[STOP]:'
900 PRINT,,'SECONDARY MENU' = S'
910 PRINT,,'MAIN MENU' = M'
920 PRINT
930 PRINT,,' ENTER SELECTION'
940 INPUT $0,COMAND$
950 CLEAR
955 TIME%=500
960 IF COMAND$='S' THEN GOTO 1120
970 IF COMAND$='M' THEN GOTO 130
980 IF COMAND$='PS' THEN GOSUB 1550 \ GOSUB 1760 \ GOTO 740
990 IF COMAND$='NO' THEN GOSUB 1380 \ GOSUB 1380 ELSE GOSUB 1480 \ GOTO 740
1000 REM
1010 REM THE NEXT 3 LINES OF CODE ARE USED TO STRIP THE TRACK NUMBER FROM
1020 REM THE COMPLETION RESPONSE (COMRES$) AND PRINT IT ON THE DISPLAY.
1030 REM
1040 TRKNUM$=MIDS(COMRES$,4%,5%) 
1050 PRINT 'TRACK NUMBER IS ';TRKNUM$
1060 GOSUB 1760 \ GOTO 740
1070 REM
1080 REM THE FOLLOWING CODE CONTAINS THOSE COMMANDS NOT LIKELY TO BE
1090 REM TO BE USED TO OFTEN. THEY ARE PLACED HERE SO THAT THE PRIMARY
1100 REM MENU IS NOT CLUTTERED.
1110 REM
1120 CLEAR
1130 PRINT,,'SECONDARY COMMAND MENU'
1140 PRINT
1150 PRINT " 'AUDIO RIGHT = A2 [VOLUME]' 
1160 PRINT " 'AUDIO LEFT = A1 [VOLUME]' 
1170 PRINT " 'DISPLAY SET = DS' 
1180 PRINT " 'DISPLAY RESET = DR' 
1190 PRINT " 'DISPLAY WRITE = DW [LINE]: [CHR]' 
1200 PRINT " 'VIDEO SET = VS' 
1210 PRINT " 'HALT = HT' 
1215 PRINT " 'ALL CLEAR = AC' 
1220 PRINT " 'INTERNAL VIDEO = VI' 
1230 PRINT " 'EXTERNAL VIDEO = VE' 
1240 PRINT " 'PRIMARY MENU = P' 
1250 PRINT 
1260 PRINT " 'ENTER SELECTION' 
1265 TIME%= 500 
1270 INPUT #0, COMAND$ 
1280 IF COMAND$ = "P" THEN GOTO 740 
1290 CLEAR 
1300 GOSUB 1380 \ GOTO 1110 
1310 REM 
1320 REM THIS SUBROUTINE IS USED TO COMMUNICATE WITH THE PLAYER THRU 
1330 REM THE RS232 PORT. THIS METHOD WAS FOUND IN THE PRO/BASIC USER'S 
1340 REM MANUAL (VERSION 1.2) PAGE 305. THE STX AND ETX CHARACTERS ARE 
1350 REM ARE STRIPPED FROM THE COMPLETION RESPONSE PRIOR TO BEING SENT 
1360 REM BACK TO THE CALLING SUBROUTINE. 
1370 REM 
1380 OPEN 'XK:' AS FILE #1 
1400 PRINT #1, CHR$(2)+COMAND$+CHR$(3) 
1410 FOR I=1 TO TIME\B=B+1 \ NEXT I 
1420 COMRES$="" 
1430 LINPUT #1, COMRES$ 
1450 IF COMRES$="" THEN GOTO 1410 
1455 IF MID$(COMRES$,2%,2%)="EJ" THEN GOTO 1470 
1460 IF MID$(COMRES$,2%,1%)=CHR$(69) THEN GOSUB 1820 \ GOSUB 1760 \ RETURN 
1470 RETURN 
1480 OPEN 'XK:' AS FILE #1 
1490 PRINT #1, CHR$(2)+COMAND$+CHR$(3) 
1495 FOR I=1 TO 300 \ B=B+1 \ NEXT I 
1496 LINPUT #1, COMRES$ 
1500 RETURN 
1510 REM 
1520 REM THIS SUBROUTINE IS USED TO PRINT THE PLAYER STATUS MESSAGES 
1530 REM BASED ON THE COMPLETION RESPONSE RECEIVE FROM THE PLAYER. 
1540 REM 
1550 GOSUB 1380 
1560 COMRES$=MID$(COMRES$,3%,2%) 
1570 PS= 'PLAYER STATUS IS ' 
1580 IF COMRES$= 'PF' THEN PRINT PS+'FORWARD PLAY' 
1590 IF COMRES$= 'PR' THEN PRINT PS+'REVERSE PLAY' 
1600 IF COMRES$= 'TF' THEN PRINT PS+'FORWARD STEP' 
1610 IF COMRES$= 'TR' THEN PRINT PS+'REVERSE STEP' 
1620 IF COMRES$= 'LF' THEN PRINT PS+'FORWARD SLOW' 
1630 IF COMRES$= 'LR' THEN PRINT PS+'REVERSE SLOW' 
1640 IF COMRES$= 'FF' THEN PRINT PS+'FORWARD FAST' 
1650 IF COMRES$= 'FR' THEN PRINT PS+'REVERSE FAST' 
1660 IF COMRES$= 'SR' THEN PRINT PS+'SEARCH' 
1670 IF COMRES$= 'LD' THEN PRINT PS+'LOADING' 
1680 IF COMRES$= 'EJ' THEN PRINT PS+'EJECT' 
1690 IF COMRES$= 'HT' THEN PRINT PS+'HALT' 
1700 IF COMRES$= 'SD' THEN PRINT PS+'SYSTEM DOWN' 
1710 RETURN 
1720 REM 
1730 REM THIS SUBROUTINE PROVIDES A DELAY TO ALLOW THE USER TO READ THE 
1740 REM THE MESSAGE APPEARING ON THE DISPLAY.
REM
PRINT
PRINT 'PRESS ANY KEY TO CONTINUE'
CALL INKEY (DELAY$)
IF DELAYS='' THEN GOTO 1763 ELSE RETURN
REM
REM THIS SUBROUTINE WILL PRINT THE ERROR NUMBER RECEIVED FROM THE
REM PLAYER. THE USER WILL HAVE TO USE THE MANUAL TO DECODE THE ERROR.
REM
CLEAR
PRINT 'ERROR NUMBER IS '+COMRES$+
RETURN
END
REM
REM THIS SECTION OF CODE IS USED FOR THE OPERATION OF THE RECORDER
REM
PRINT ,,, OPTICAL DISC RECORDER'
PRINT ,,, SEARCH FOR TARGET ADDRESS = S'
PRINT ,,, CHANGE TO RECORD MODE = R'
PRINT ,,, ASK THE CURRENT ADDRESS = A'
PRINT ,,, DEVICE MENU = D'
PRINT ,,, ENTER SELECTION'
TIME%=300
INPUT #0,COMAND$
IF COMAND$='D' THEN GOTO 10
IF COMAND$='A' THEN GOTO 1990 ELSE GOTO 2000
GOSUB 1380\ CLEAR
PRINT 'THE CURRENT ADDRESS IS '+COMRES$\ GOSUB 1760\ GOTO 1870
IF MID$(COMAND$,1%,1%)='S' THEN GOSUB 1380\ GOTO 1870
IF COMAND$='R' THEN GOSUB 1380\ GOTO 2030
PRINT ,,, INVALID ENTRY\ GOSUB 1760\ GOTO 1870
CLEAR
PRINT ,,, RECORD MENU'
PRINT ,,, RECORD A PICTURE = G'
PRINT ,,, ASK THE CURRENT ADDRESS = A'
PRINT ,,, CANCEL THE RECORD MODE = C'
PRINT ,,, ENTER SELECTION'
INPUT #0,COMAND$
IF COMAND$='A' THEN GOTO 2120 ELSE GOTO 2130
GOSUB 1380\ CLEAR
PRINT 'THE CURRENT ADDRESS IS '+COMRES$\ GOSUB 1760\ GOTO 2030
IF COMAND$='G' THEN GOSUB 1380\ GOTO 2030
IF COMAND$='C' THEN GOSUB 1380\ GOTO 1870

