BROTHERHOOD

A Series of Multimedia Constructions
by
Woody Vasulka

DRAFT
Reference Document

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONT.)

LIST OF TABLES

INTRODUCTION

This document describes an artistic presentation by Woody and Steina Vasulka of Santa Fe, NM. It is written solely from a technical point of view; no attempt at artistic interpretation is made or intended.

Each part of the presentation is multimedia, comprising a complex machine driven by electric motors and/or pneumatics, and augmented by visual and sound effects. The machines are interactive with the viewer in the sense that they include real-time input devices, such as proximity sensors, that influence their behavior in response to the viewer's position and motion. The machines are controlled by a set of personal computers, one for each machine, linked through a network The network is designed to allow maximum flexibility in access and control, and provides for real-time programming input both locally (via a System Display Host) and remote (via a Dial-in Host). The system concept is shown in Figure 1.

Each section of this document provides a description of one of the parts of the presentation. Included in each section are an overview of the machine, a schematic of the electrical and/or pneumatic component connections, and photographs with annotations. To the extent possible, the information included is intended to represent the as-built condition of the machines, and thereby facilitate troubleshooting. However, the presentation is continually being modified and improved so that the descriptions quickly become outdated. Appendices and a list of references are included to provide supplementary information.

Woody Vasulka

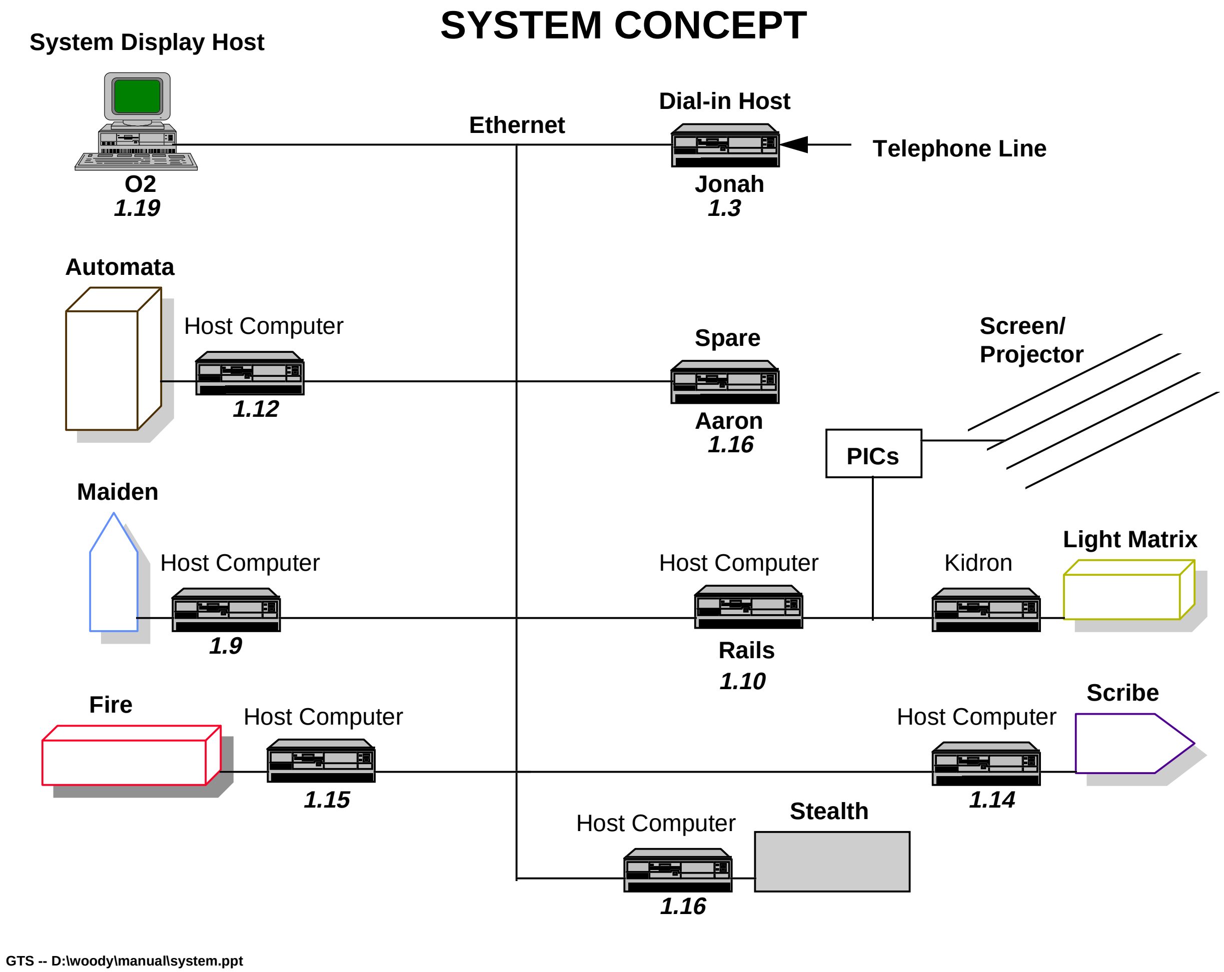


Figure 1. System Concept

I. AUTOMATA

OVERVIEW

Theater of Hybrid Automata is a multimedia presentation. First constructed in 1990, it comprises two subsystems: (1) a tubular steel frame structure, approximately 10 feet on a side, with a centrally located roll/pan/tilt (RPT) head, a video camera, targets, lights and speakers; and (2) a separate console containing various electronic equipment. It operates in a pre-programmed, non-interactive, mode. The frame subsystem setup is shown in Figure I-1.

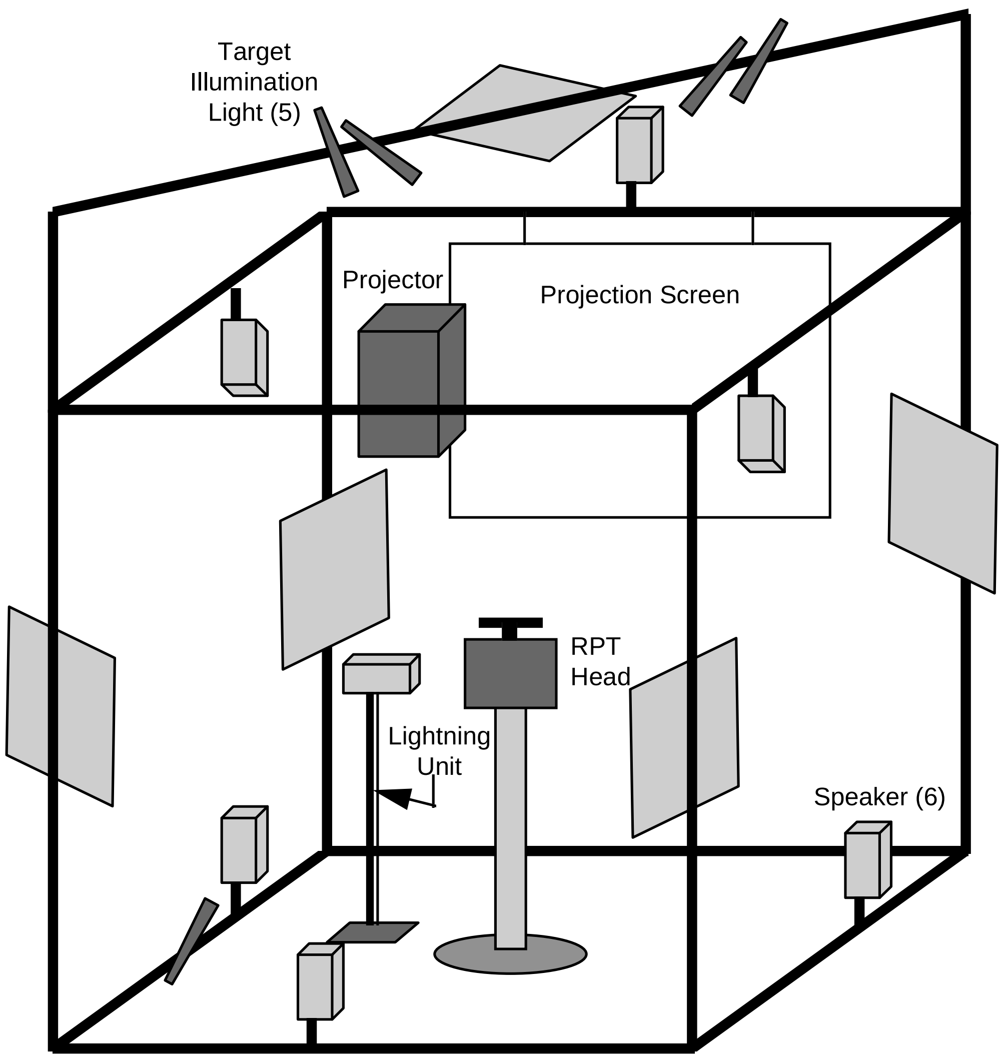


Fig. I-1. Theater of Hybrid Automata Setup

The Automata console is shown schematically in Figure I-2.

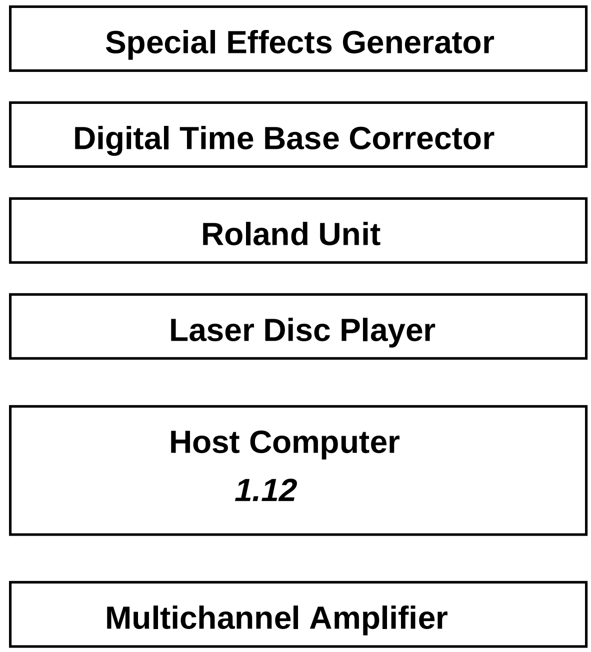


Fig. I-2. Electronics Console Setup

The electronic components are listed in Table I-1. A block electrical diagram of the system is given in Figure I-3.

Table I-1. AUTOMATA EQUIPMENT LIST

ITEM	DESCRIPTION
Special Effects Generator	Panasonic WJ-4600C
Digital Time Base Corrector	FOR.A Model FA-400
Digital Sampler	Roland Mod. S-330
Laser Disc Player	Pioneer Laser Vision Player LD-V8000 Ser. No. JH3904327
Host Computer	Custom -built
Camera Power Supply	Sony CMA-D1
Power Supply	Lambda
Multichannel Amplifier	RANE Model MA-6
Voice Box	MicroDyn II Speech Processing System
Speaker	Sony 2-way
Speakers (6)	JBL 2-way
Projector	SHARP LCD, Mod. XG-2000U, 105-210 mm Zoom lens, 1:4.5, Ser. No. 312922
Lightning Unit	Lightning Mod. 900, Ser. No. 1048
Video Camera	Sony CCD Mod. DCX-101, Ser. No. 12436
Stepper Driver	Custom-built
Light Controller	Custom-built
Transformer Bank	Custom-built
RPT Head	Custom-built

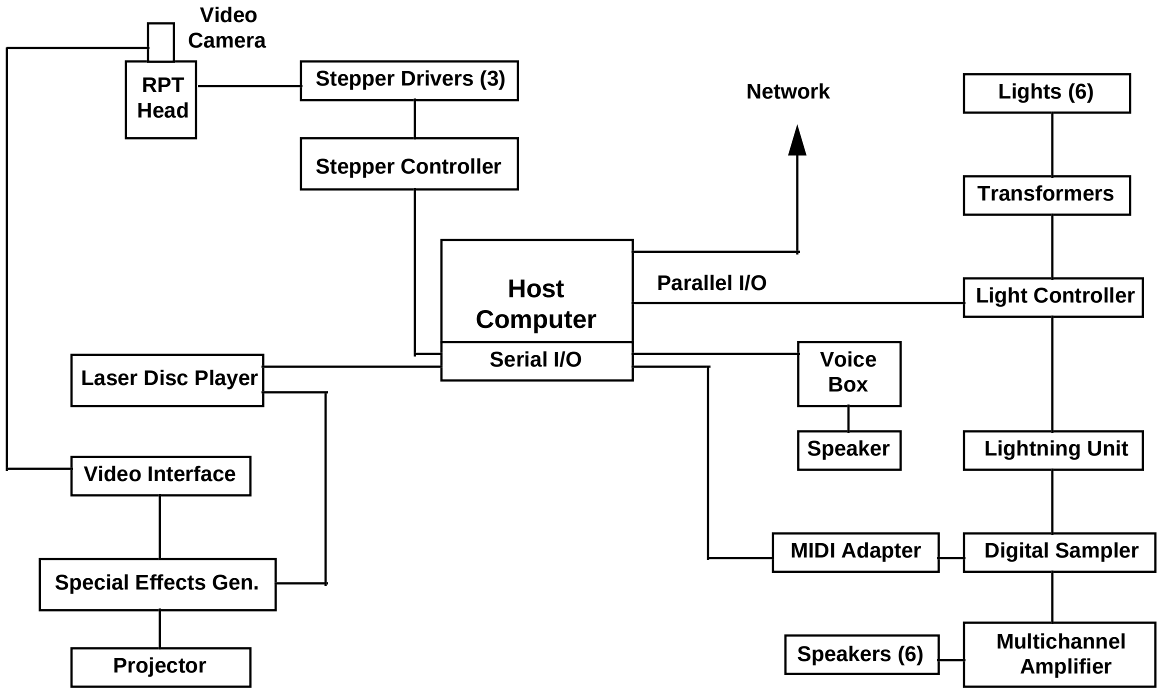


Fig. I-3. System Block Electrical Diagram

VIDEO DISPLAY

The video component of the presentation is provided by the combination of a prerecorded laser disc and the camera mounted on the RPT head. The mixed signals are then transmitted to the projector for projection onto the screen. The RPT camera can view each of the five targets as well as the display on the Lightning unit.

The RPT camera output is fed to the FA-400 Digital Time Base Corrector, shown just below the Special Effects Generator (SEG) in Figure I-4(a).

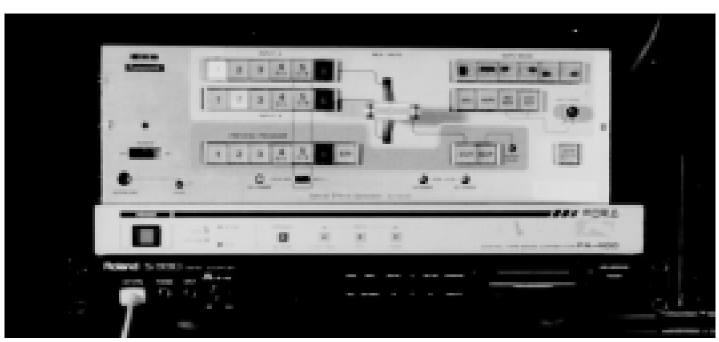


Fig. I-4(a) SEG and FA-400

The FA-400 back panel is shown schematically in Figure I-4(b).

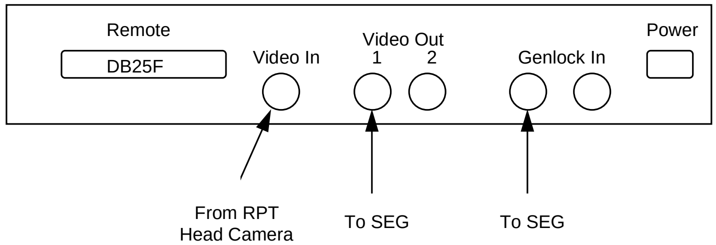


Fig. I-4(b) Digital Time Base Corrector

The SEG back panel, with connections indicated, is shown in Figure I-4(c).

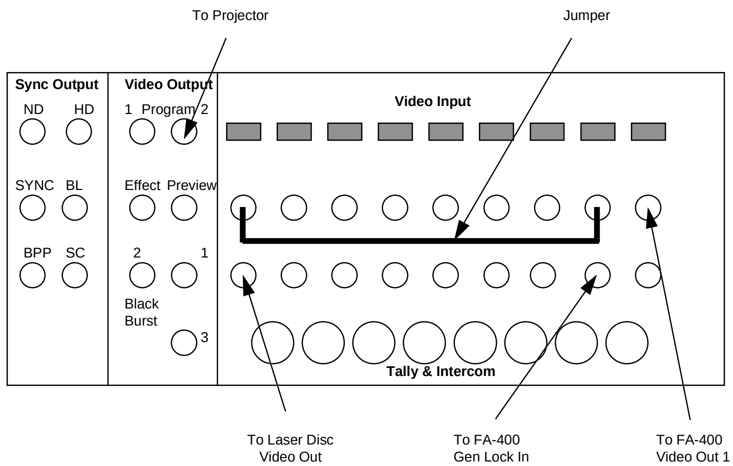


Fig. 1.4(c). Special Effects Generator

The video output of the SEG is directed to the overhead projector and screen arrangement indicated in Figure I-1. The projector back panel is shown in Figure I-5.

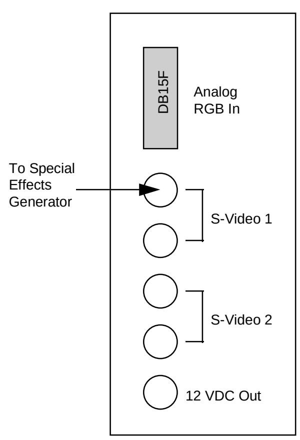


Fig. I-5. Back Panel of Projector

LIGHTING

As illustrated in Figure I-1, lights illuminate each of the five targets plus the RPT head. The lights are controlled by signals originating within the master controller relay card and passed to the lighting controller. The lighting controller output is fed to a bank of 120VAC/12VAC transformers which supplies power to the lights. The lighting controller is shown in Figure I-6.

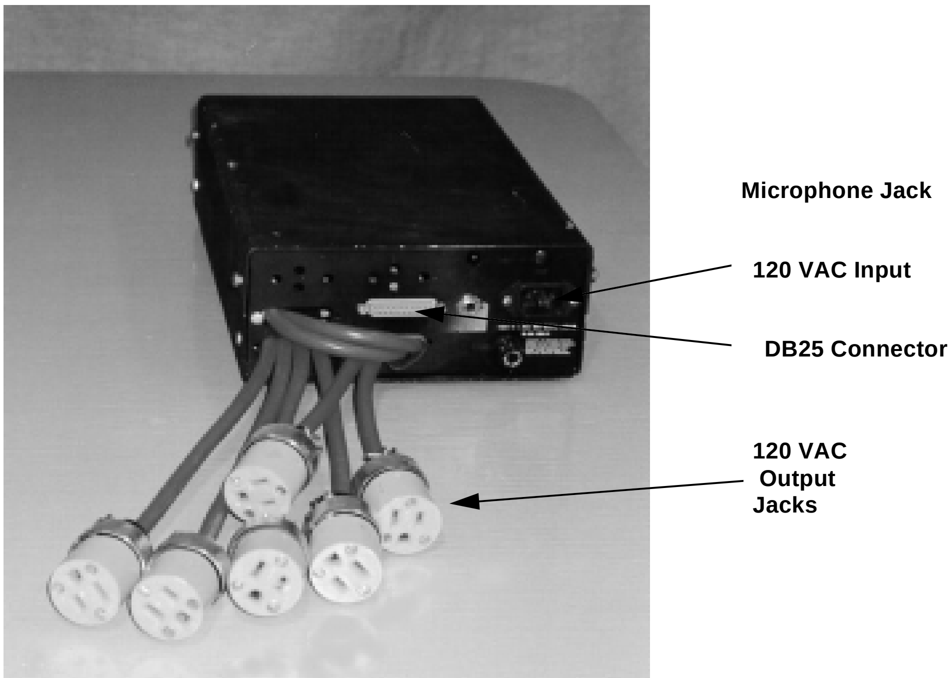


Fig. I-6. Lighting Controller

The major component of the lighting controller is an Opto22 relay board, model PB8. A block schematic of the light box layout is given in Figure I-7. Pin correspondences between the DB25 input connector to the light box and the 50-pin connector to the Opto22 board are given in Table I-2.

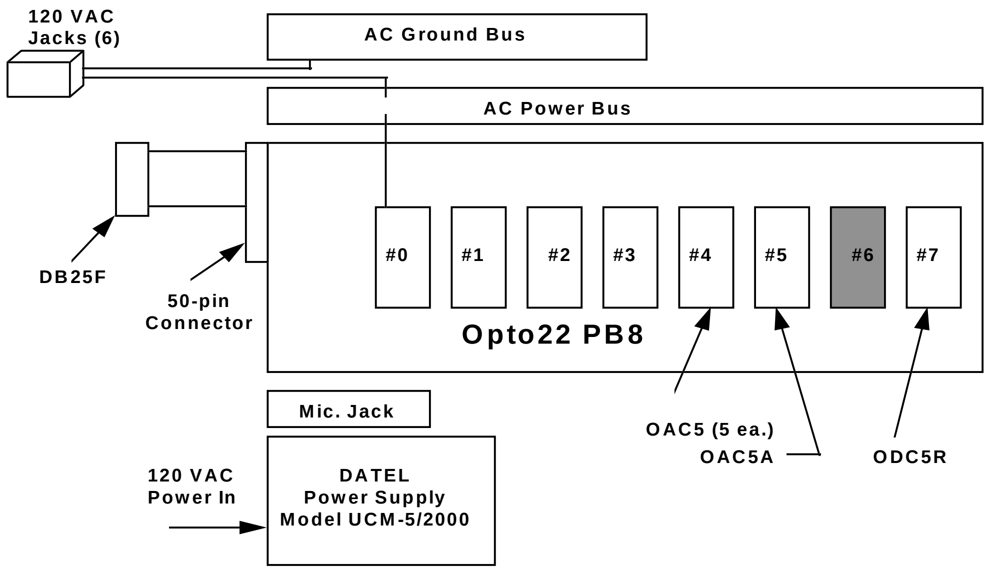


Fig. I-7 Block Schematic, Lighting Controller

Table I-2. Light Box Pin Correspondences

DB25 Pin No.	Opto 22 50-Pin Con. No.	Function	DB25 Pin No.	Opto 22 50-Pin Con. No.	Function
1	-	N/C	14	-	N/C
2	47	Control, Relay 0	15	-	N/C
3	45	Control, Relay 1	16	-	N/C
4	43	Control, Relay 2	17	-	N/C
5	41	Control, Relay 3	18	50	Ground
6	39	Control, Relay 4	19	48	Ground
7	37	Control, Relay 5	20	-	N/C
8	35	Control, Relay 6	21	44	Ground
9	33	Control, Relay 7	22	42	Ground
10	30	ACK (Gnd)	23	38	Ground
11	-	Busy (Gnd)	24	36	Ground
12	-	Paper Out (Gnd)	25	34	Ground
13	-	N/C			

AUDIO

Automata uses two principal audio sources: a speech processing system (herein called the Voice Box) with preprogrammed statements as determined by the Controller, and the Lightning unit.

The Voice Box back panel and connections are shown in Figure I-8.

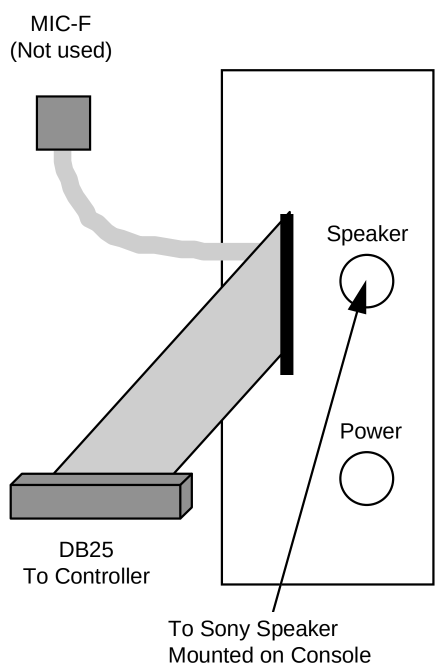


Fig. I-8. Voice Box Connections

Lightning is a MIDI controller that senses the movement of infrared sources in space and transforms the resultant information to MIDI signals for expressive control of electronic musical instrumentation.

Lightning operates on principles of optical triangulation, gathering its information by tracking tiny infrared transmitters. The transmitter used in Automata is located on top of the RPT head as indicated in Fig. I-1. Lightning senses horizontal and vertical location from each infrared source. From this information, its signal processor computes velocity and acceleration, performs some elementary analysis, and converts the information to MIDI signals.

The Lightning unit, shown in Fig. I-9(a), is mounted on a stand in proximity to the RPT head (See Fig. I-1). Communication is established with the video portion of the presentation through the RPT camera. A relay in the relay card located in the Master Controller is dedicated to the Lightning unit, and connection is made through the Light Controller. The back panel of the Lightning unit, with connections indicated, is shown in Figure I-9(b).

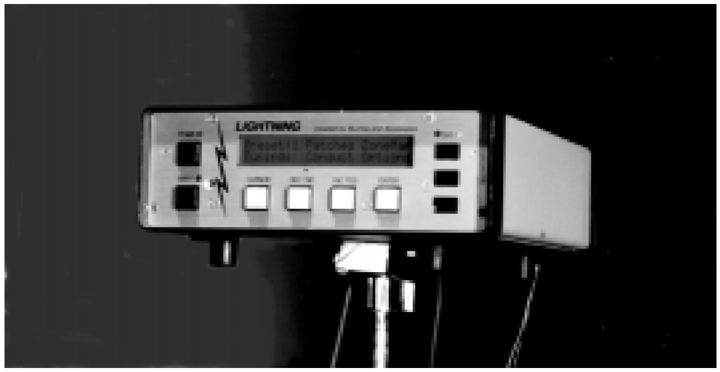


Fig. I-9(a). The Lightning Unit

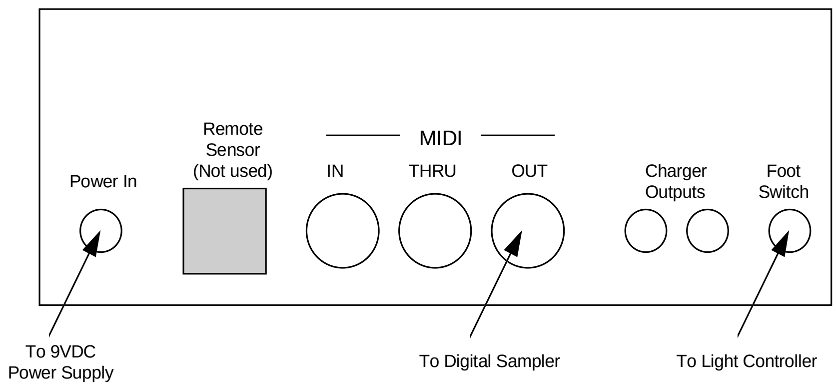


Fig. I-9(b). Back Panel of Lightning Unit

The remainder of the audio portion comprises the Digital Sampler, the Multichannel Amplifier, and the six JVC speakers, as shown in Figure I-10.

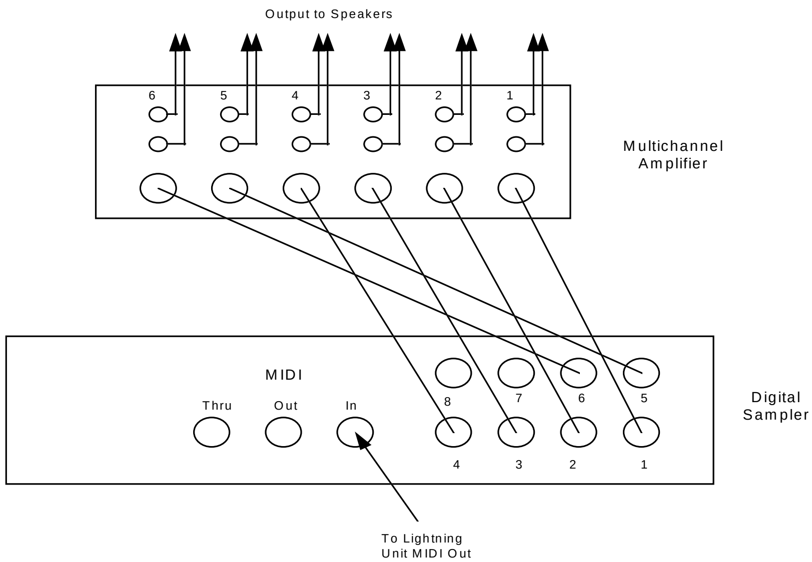


Fig. I-10. Audio Components and Connections

ROLL/PAN/TILT HEAD

Central to the Automata presentation is the roll/pan/tilt (RPT) head. This complex component comprises three stepper motors, associated slip rings and limit switches, and a video camera. It is mounted on a stand, and is positioned near the center of the tubular frame as illustrated in Figure I-1.

Figure I-11(a) shows the three axes of motion:

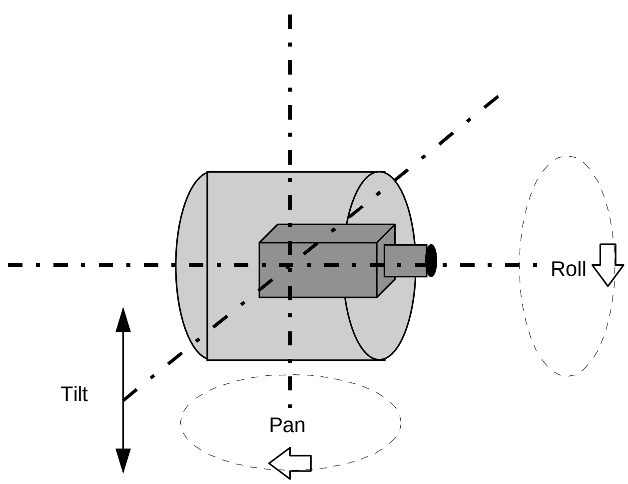


Fig. I-11(a) RPT Head Axes of Motion

The major components required to effect the three-axis motion are shown in the photographs given in Figures I-12(a) through I-12(d). They include stepper motors, slip ring assemblies, home position sensors, and intermediate connectors.

Stepper motor power, control signals and limit-switch cutoff signals are transmitted between the stepper driver and the RPT head by means of a multiconductor cable. The cable is terminated with a 37-pin connector at the RPT head and at the stepper controller.

The stepper controller and stepper driver modules are shown in Figure 11(b):

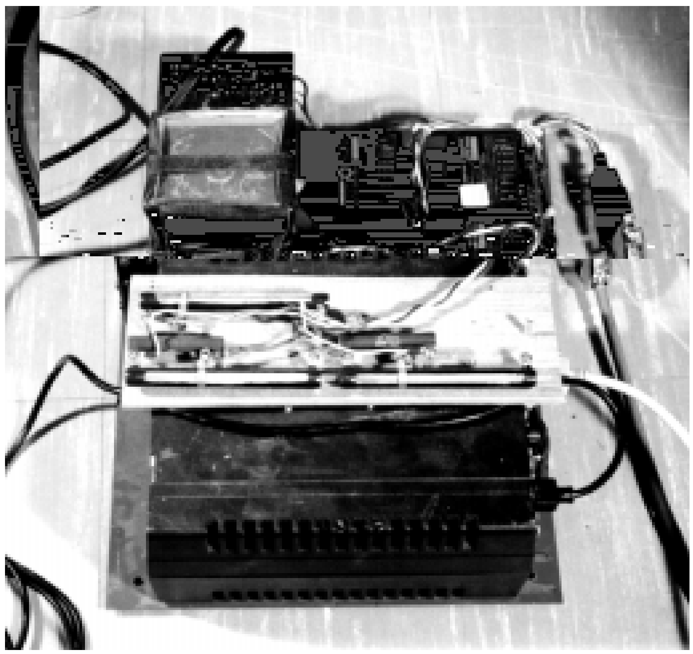


Fig. I-11(b). Automata Stepper Controller

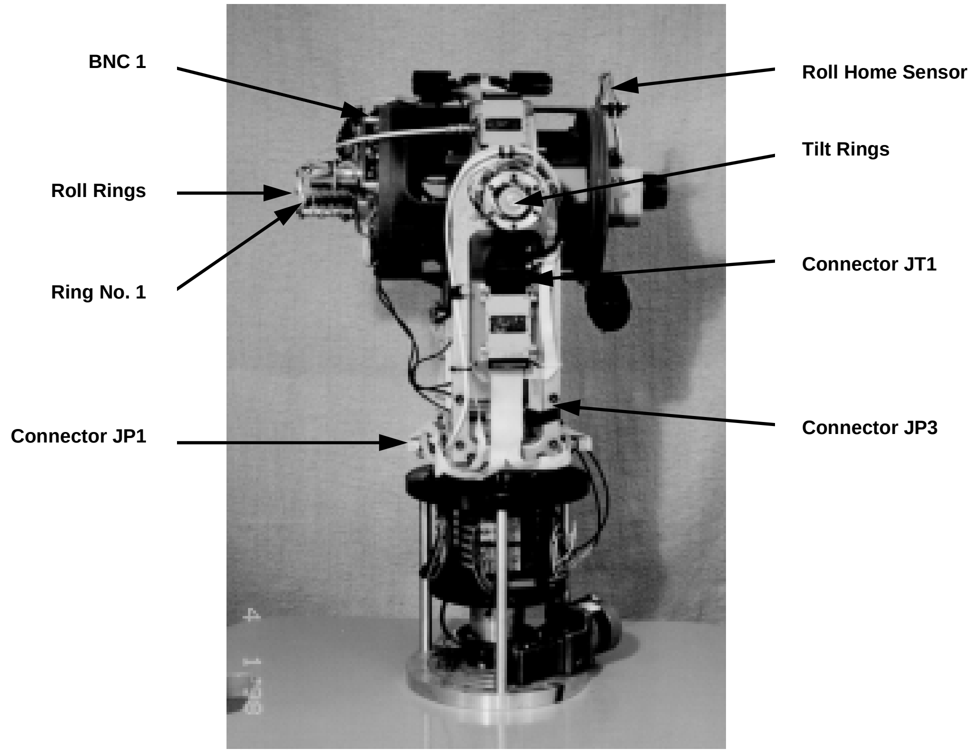


Fig. I-12(a) RPT Head Assembly

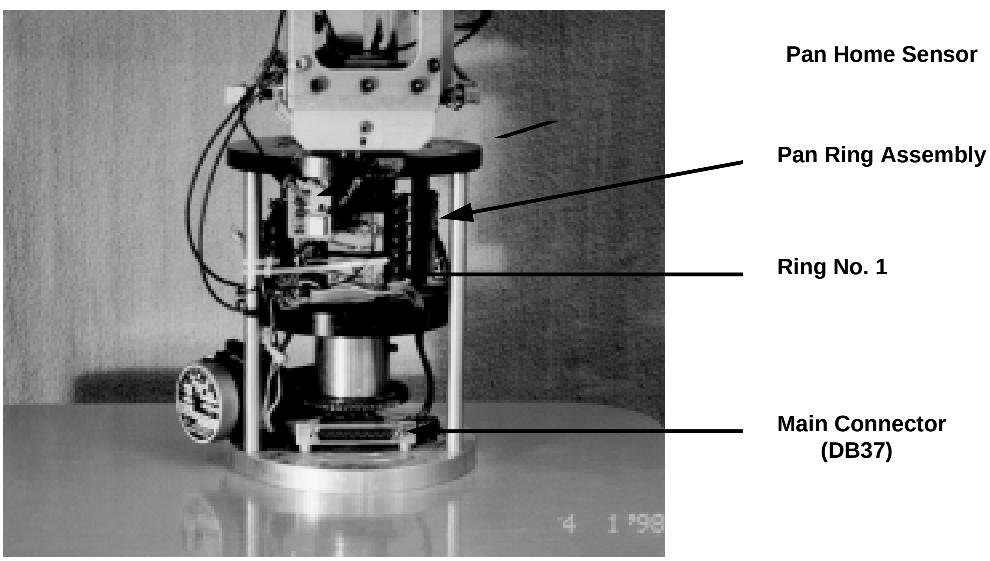


Fig. I-12(b) RPT Pan Ring Assembly

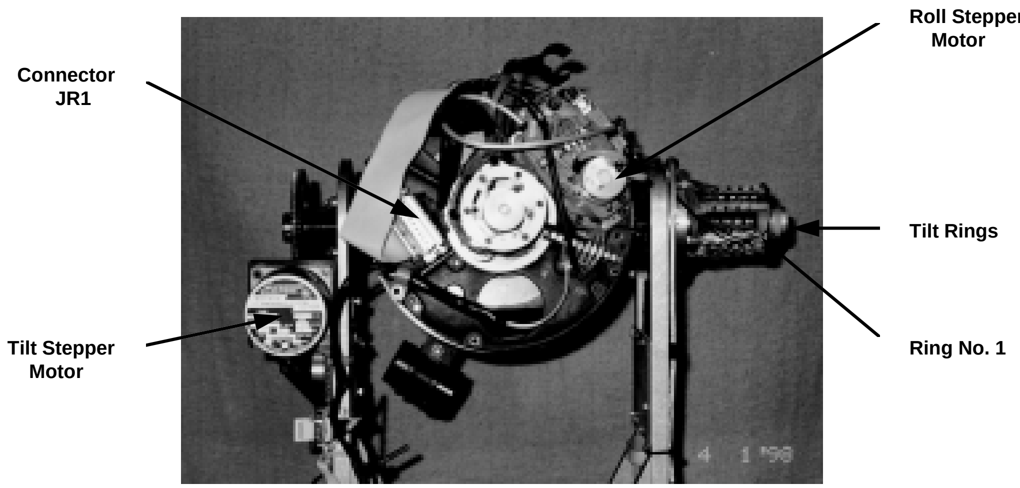


Fig. I-12(c) RPT Tilt and Roll Assembly

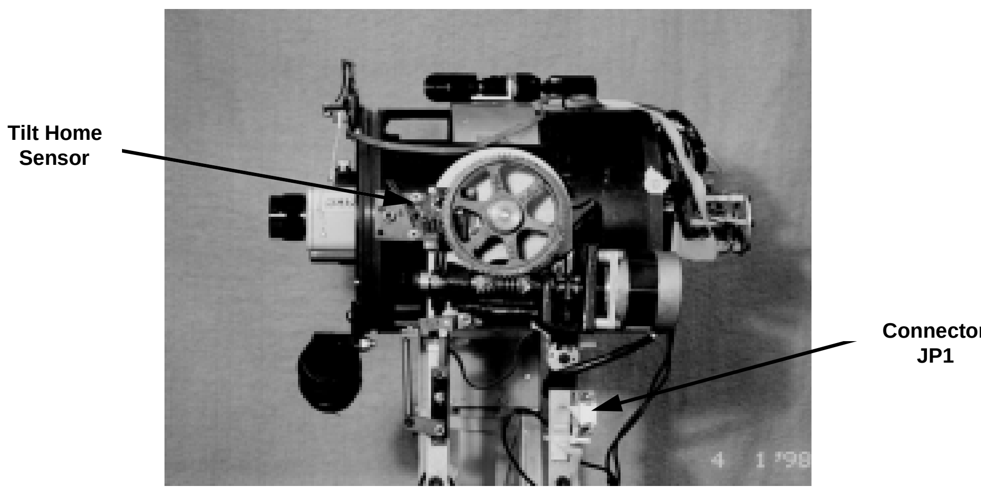


Fig. I-12(d) RPT Side View

SLIP RINGS

Three slip ring assemblies are an integral part of the RPT head and serve to provide continuous electrical paths regardless of the RPT head motion. The roll slip rings carry camera power and video signals. The tilt slip rings carry (1) camera signals, (2) roll stepper motor signals, and (3) the roll stepper “home” index signal. The pan slip rings carry all of the tilt slip ring signals, plus (1) the tilt stepper motor and tilt motor “home” index signals. All the signals are transmitted to the console via the 37-pin connector.

The roll slip ring assembly comprises 14 rings, although many are not used. The tilt slip ring assembly comprises 16 rings. For the purpose of identificaiton, the slip rings in each assembly are numbered sequentially, with the first ring (Ring #1) being the outermost ring, i.e., the ring farthest from the RPT head.

The pan slip ring assembly, Figure 12(b), comprises a stack of six discs. Each of the six discs carries four rings two on the bottom of the disc, and two on the top, as shown in Figure I-13 for a single disc.

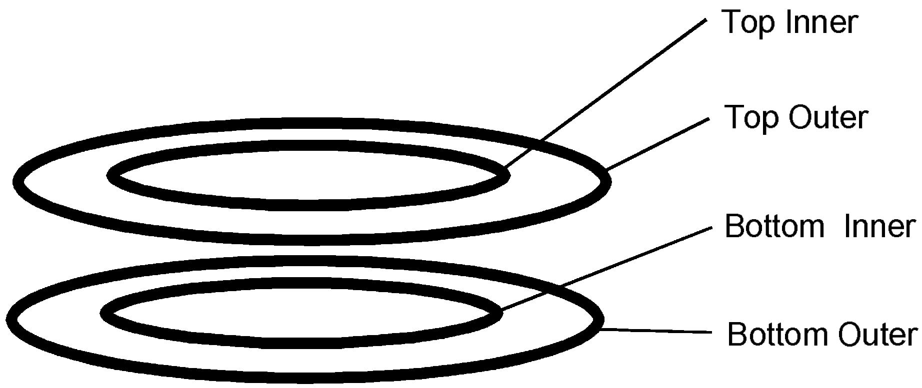


Fig. I-13. Ring Locations on a Single Pan Disc

The rings are numbered according to the disc number (disc #1 is at the bottom of the assembly) and position, as shown in Table I-3.

Table I-3. Pan Ring Identification

Disc No.	**Bottom Outer**	**Bottom Inner**	**Top Outer**	**Top Inner**
1	1	2	3	4
2	5	6	7	8
3	9	10	11	12
4	13	14	15	16
5	17	18	19	20
6	21	22	23	24

Connections between the slip rings are shown in Figure I-14:

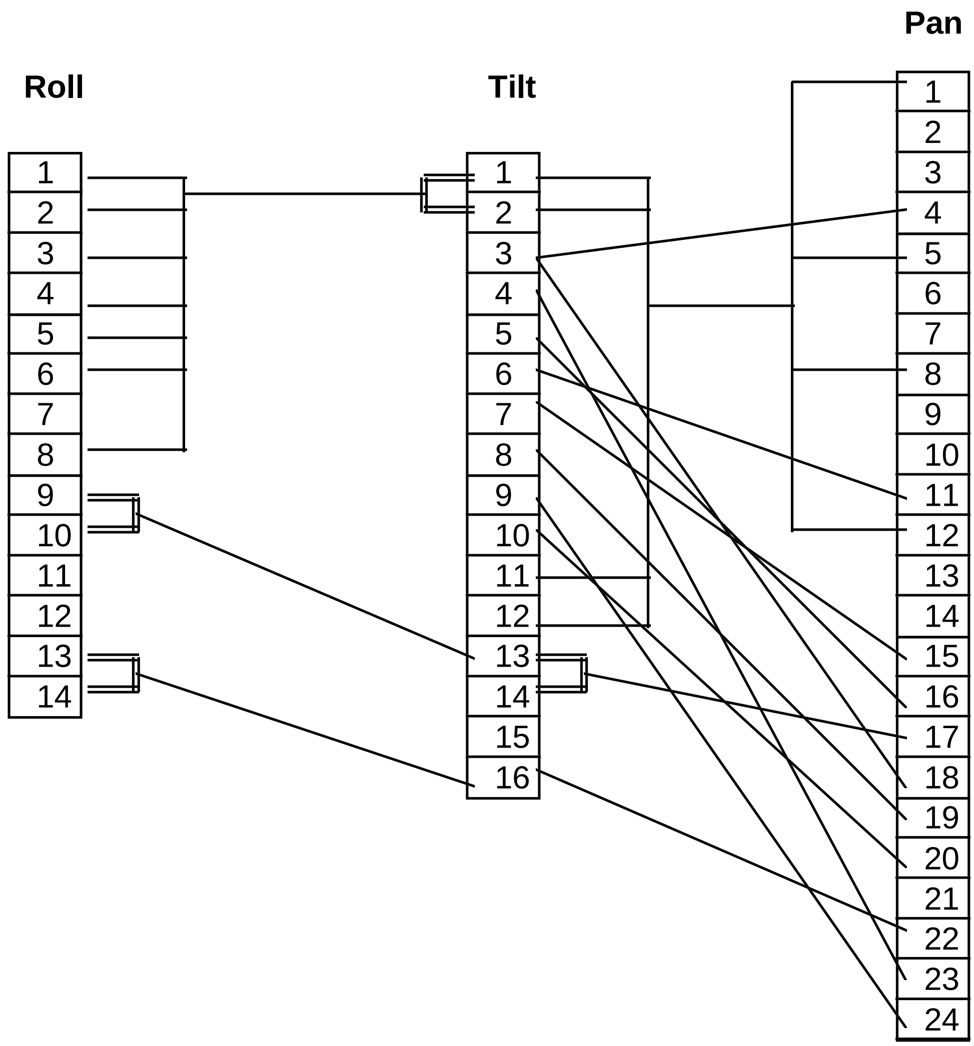


Fig. I-14. Slip Ring Interconnections

Interconnections between the main connector, the slip ring assemblies, and several intermediate connectors, are given in Table I-4.

Table I-4. RTP Pin and Slip Ring Connections

Main Connector (DB37) Pin No.	**Function**	**Pan Rings Ring No.**	**JP1 (DB15) Pin No.**	**JP2 (DB9) Pin No.**	**JP3 (DB15) Pin No.**	**JT1 (DB25) Pin No.**	**Tilt Rings Ring No.**	**Roll Rings Ring No.**	**JR1 (DB25) Pin No.**
								12	3
								11	4
1	Unconnected Wire								
2	Unconnected Wire								
3	None ?	13	3						
4	None ?	9	4						
5	Unconnected Wire								
6	Unconnected Wire								
7	Roll Home Sensor (ctr)	23			10	14	4		24
8	Roll Home Sensor (rt)	4,18			11	12	3		23
9	Camera DC-	1,5,8,12	5,8		12	5,6,16,17	1,2,11,12	1-6	9-12
10	Power DC-	1,5,8,12	6,7		13		1,2,11,12	1-6	
11	Roll Home Sensor (lt)	16			14	15	5		25
12	Roll Stepper Motor, red	20			15	7	10		16
13	Pan Home Sensor, gray								
14	Roll Stepper Motor, yellow	24	9			8	9		17
15	Roll Stepper Motor, black	19	10			9	8		18
16	Roll Stepper Motor, white	15	11			10	7		19
17	Roll Stepper Motor, green	11	12			11	6		20
18	Tilt Stepper Motor, red	7	13	1					
19	Tilt Stepper Motor, green	3	14	2					
20	Tilt Stepper Motor, ?	21		3	3				
21	Tilt Stepper Motor, ?	2		4	4				
22	Tilt Stepper Motor, ?	6		5	5				
23	Tilt Home Sensor	10		7	6				
24	Tilt Home Sensor	14		6	7				
25	Tilt Home Sensor	4,18		8	8		3		
26	Pan Stepper Motor, orange								

Main

Connector (DB37) Pin No.	Function	Pan Rings Ring No.	JP1 (DB15) Pin No.	JP2 (DB9) Pin No.	JP3 (DB15) Pin No.	JT1 (DB25) Pin No.	Tilt Rings Ring No.	Roll Rings Ring No.	JR1 (DB25) Pin No.
27	Pan Stepper Motor, green								
28	Pan Stepper Motor, wht/red								
29	Pan Stepper Motor, wht/grn								
30	Pan Stepper Motor, blk, wht								
31	Pan Home Sensor, red								
32	Pan Home Sensor, black								
33	Unconnected black wire								
34	Unconnected red wire								
35	Chassis ground								
36	Chassis ground								
37	Chassis ground								
BNC1	Camera Video Out	22					16	13,14	
BNC2	Camera DC+	17				3,4	13,14	9,10	5-8

II. FIRE

FIRE, formerly called Table 3, is a visual presentation incorporating 35mm slides and a video projector driven by a laser disk player. The table is shown in Fig. II-1 and schematically in Fig II-2. In Fig. II-1, the pneumatically activated screens are shown in the "down" position. They are raised (to a vertical position) and lowered sequentially as part of the FIRE program.

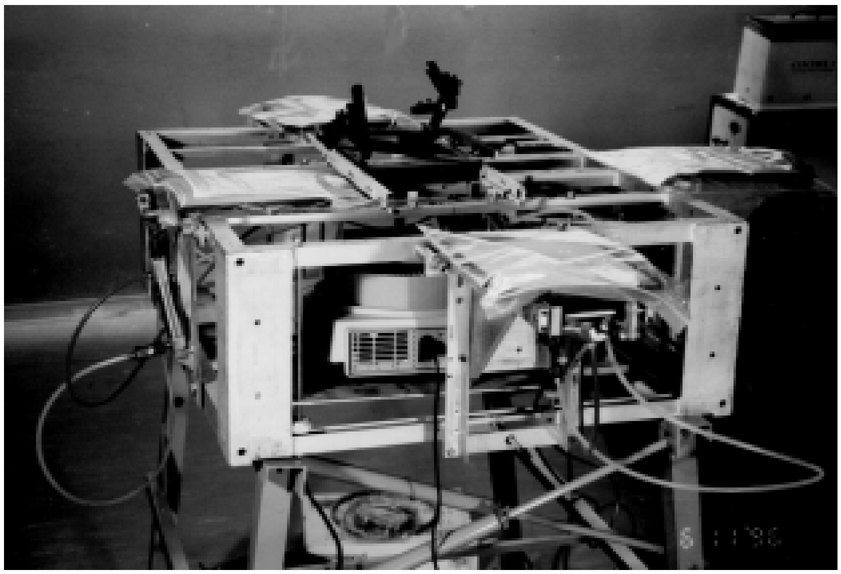


Figure II-1. The FIRE Table

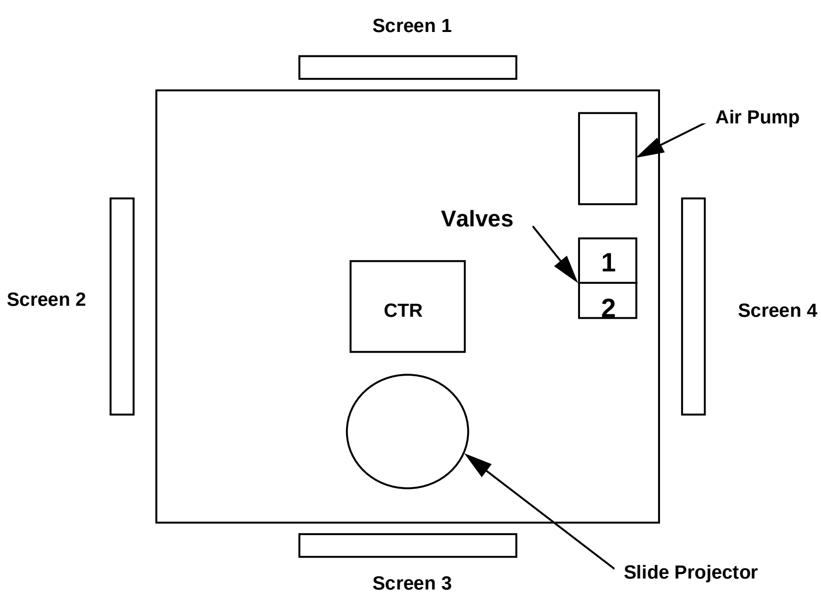


Figure II-2. FIRE Table Schematic

Other components of the FIRE presentation are shown schematically in Fig. II-3, and listed in Table II-1.

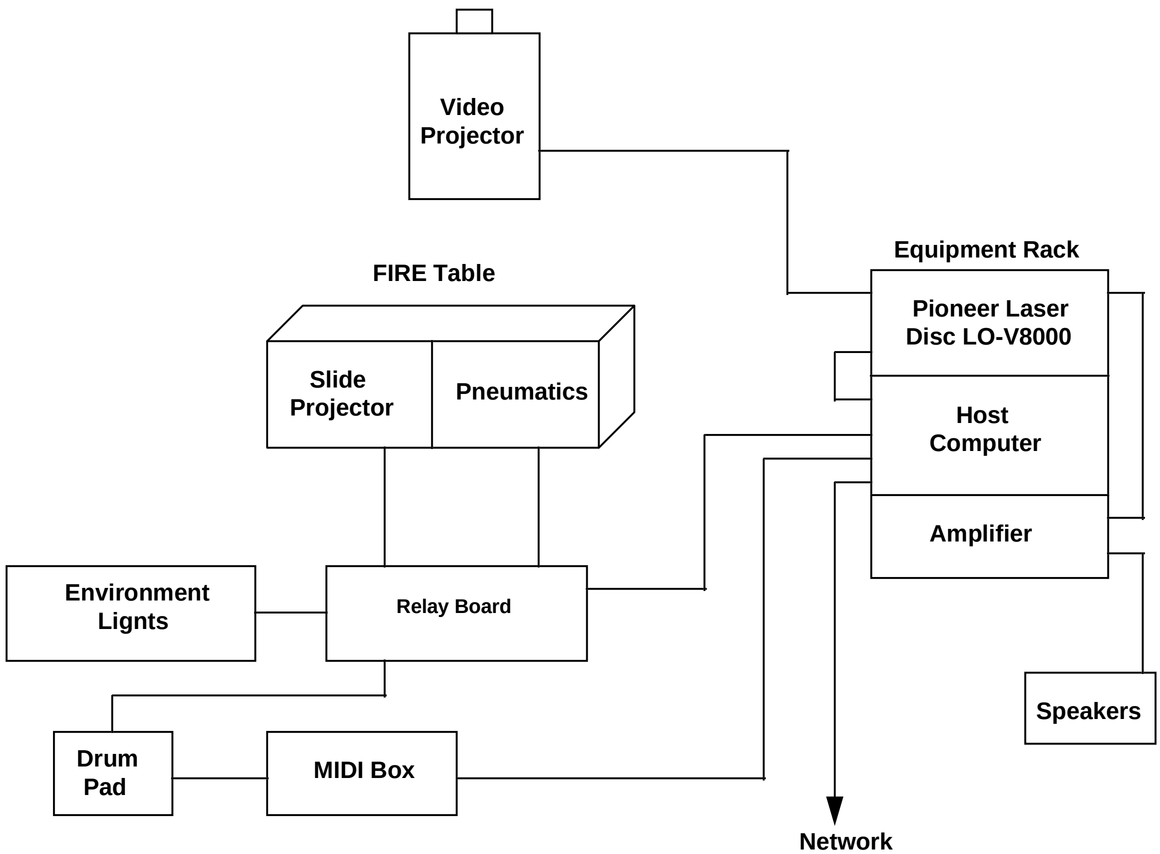


Figure II-3. FIRE System Schematic

Table II-1. FIRE Components

Component	**Manufacturer, Model**
Laser Disk Player	Pioneer, LO-V8000
Air Pump	Pneumotive, 9-3.8
Relay Board	Opto22, PB8
Relay Board Power Supply	Intronics, SME 1000/5D
Slide Projector	Kodak Ektagraphic, E-2
Video Projector	Sharp LCP, XV-100
Host Computer	Custom-built
Drum Pad	Roland, PAD-5
Amplifier/Speakers	To be determined
Midi Box	Portman PC Serial

The four projection screens are each operated pneumatically. Air is supplied by an air pump to a pair of electrically operated valves, one for pressurization of the cylinders and one for exhaust. Pressurized air is fed to a manifold and then distributed to the cylinders. The manifold is shown schematically in Fig. II-4.

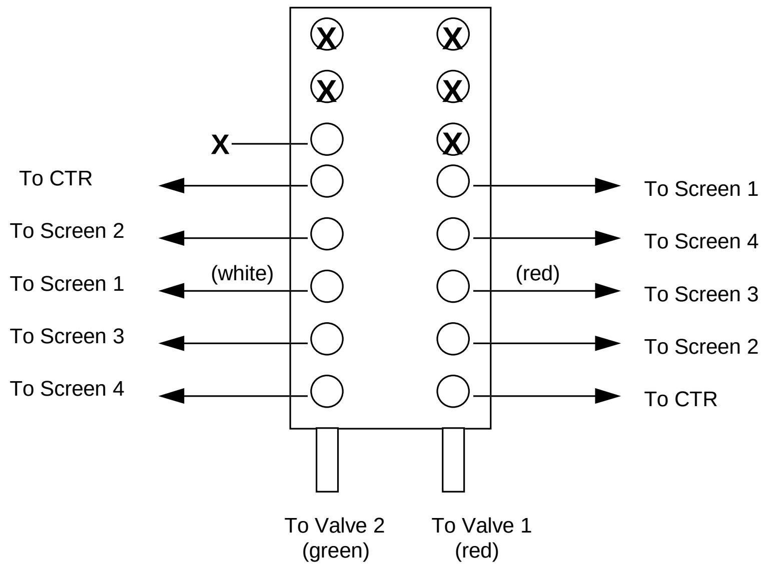


Figure II-4. Air Manifold

Control signals from the Host Computer are fed to an Opto22 PB8 solid-state relay board. Seven of the eight relay slots are used as shown in Fig. II-5.

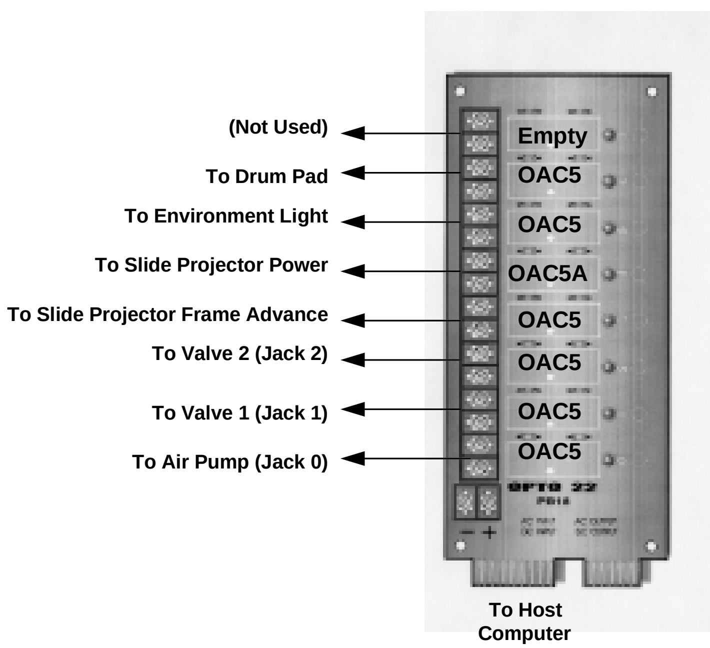


Figure II-5. Solid-State Relay Board

III. RAILS

The RAILS presentation comprises two major subsystems: A set of moving screens and moving video projectors that travel on a rail system, and a table with a square array (matrix) of lights and a video camera on an X-Y carriage. Both the screen/projector system and the light matrix are interactive in that they include proximity and motion sensors which provide input to the control system. The RAILS system is controlled by a Host Computer; the light matrix subsystem is directly controlled by a separate computer that communicates with the Host Computer.

The two major subsystems are shown schematically in Figs. III-1 and III-2.

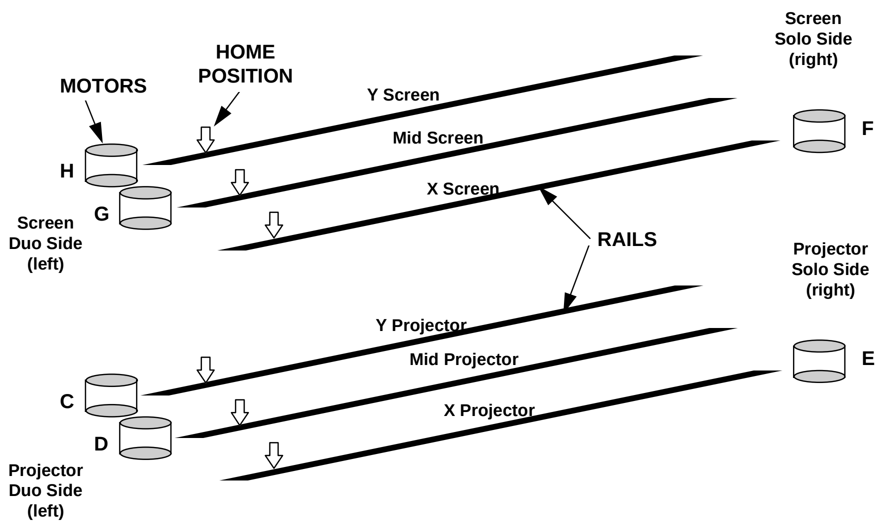


Figure III-1. Screen/Projector Schematic

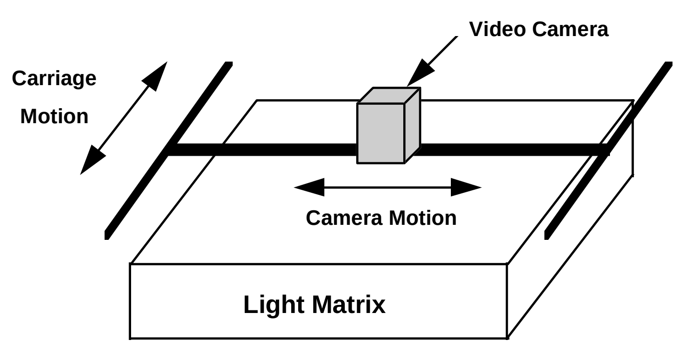


Figure III-2. Light Matrix Schematic

A typical screen rail is shown in Fig. III-3, and a close-up view of one of the motors is shown in Fig. III-4.

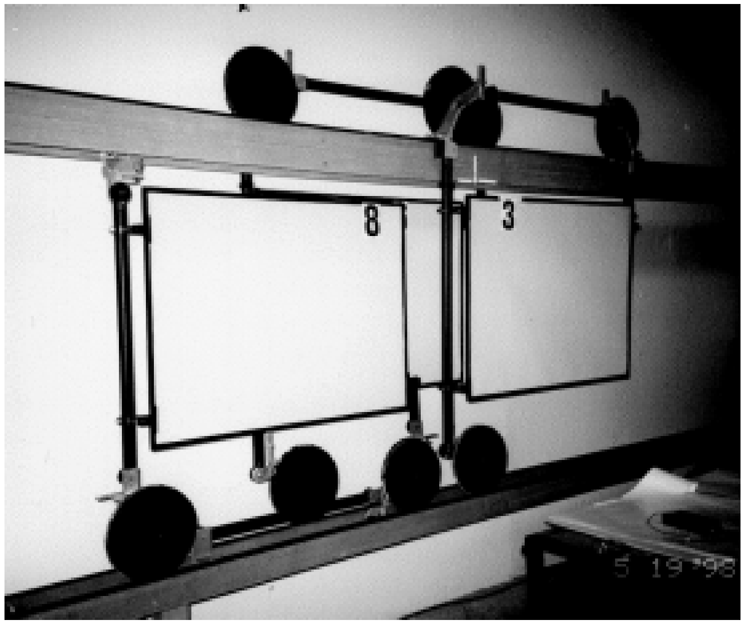


Figure III-3. Screens

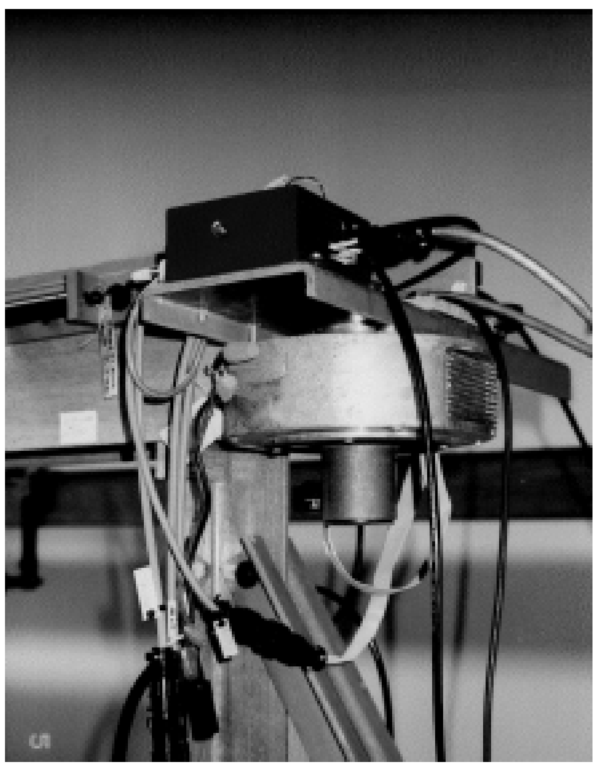


Figure III-4. Typical Motor Installation

The light matrix table is shown in Figure III-5.

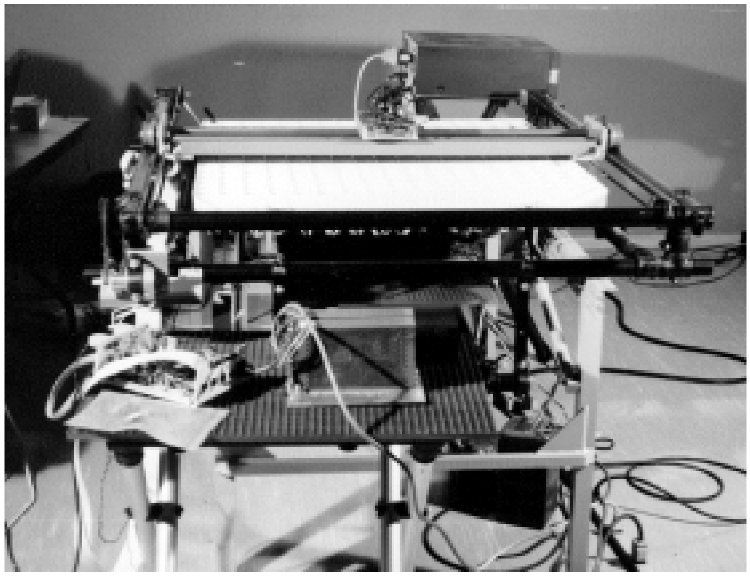


Figure III-5. Light Matrix Table

A block diagram of the entire system is given in Fig. III-6.

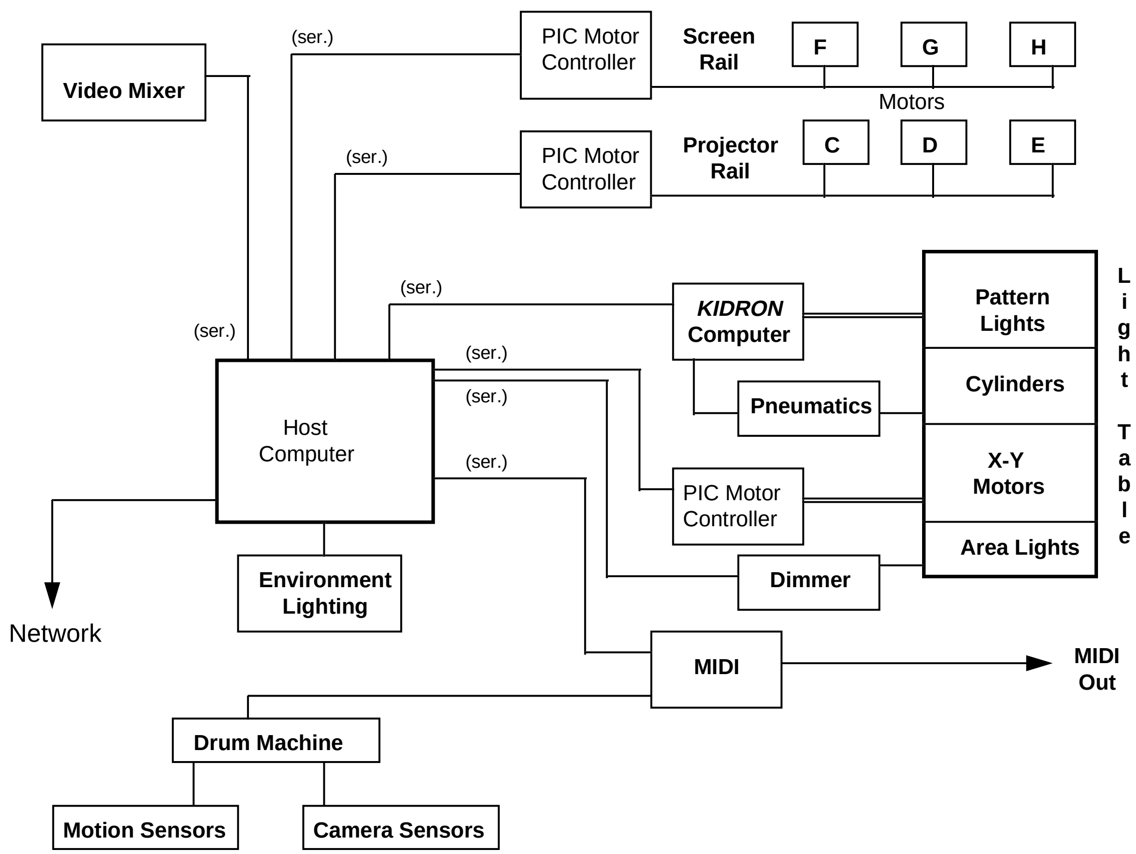


Figure III-6. The RAILS System

The light matrix is a 17 by 17 array of cells, each 2” square, and each containing two small lamps. One of the lamps is to illuminate the cell (area lamp), and the other is to provide a brighter display, i.e., to “light up” the cell (display lamp). The area lamps are electrically ganged into quadrants, but the display lamps are individually addressable. Figure III-7 shows the general layout.

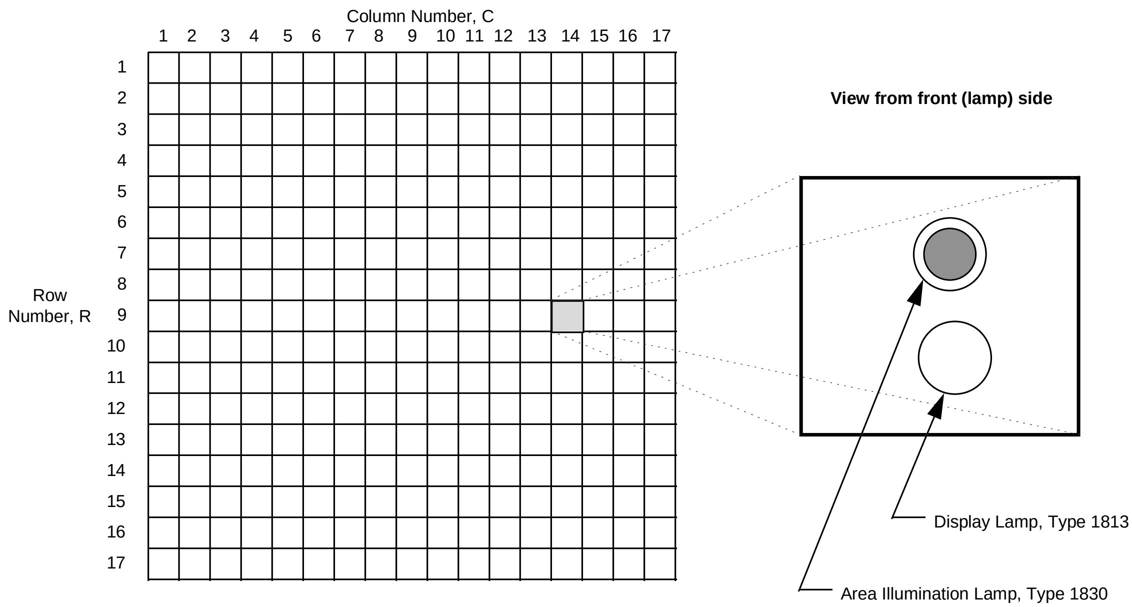
Power for the display lamps is provided by two driver modules, one for the rows and the other for the columns. The row driver module serves to switch the center terminal of all display lamps within a selected row to system ground. The column driver serves to provide power to the outside terminal of all display lamps within a selected column. When signals are passed to the drivers specifying the row and column of a cell, the display lamp in only that cell is lit.

Signals to the row and column drivers are provided by a separate computer (Kidron). Separately constructed data files that describe the complete 17 x 17 light pattern may be maintained on the computer’s hard drive. Software is provided to call up a specified data file and display it on the matrix.

The display software instructs the computer to load the specified data file into memory to determine which lamps are to be lit. It then loops through all the rows, and for each row it signals the row driver to activate that row. It then loops through all the columns, and for each column for which one or more lamps are to be lit it signals the column driver to activate that column. Only one row is lit at a time, and the column lamps are turned off when the next row is activated. When all rows (and columns) have been scanned, the desired light pattern is achieved. The computer then continues to cycle through the same set of instructions, thus “refreshing” the display lamps, until a new pattern is specified.

Power for the display lamps is provided by a DC power supply with an output of about 30 VDC and a current of several amperes. The power is input to the column driver module via the yellow (+) and blue (common) leads.

Power for the row and column drivers must be provided separately by a DC power supply with an output of 5 VDC at about 100 milliamperes. The power is input to the column driver module via the green (+) and brown (common) leads. The light matrix, both driver modules, and the power supply share a common chassis ground. No power is taken from the computer.



Display lamps are individually addressable. The row driver completes the ground circuit for all lamps in a specified row. The column driver supplies power to all lamps in a specified column.

Area illumination lamps are addressable in quadrants of the matrix. The quadrants are R1C1-R8C9, R1C10-R8C17, R9C1-R17C9, and R9C10-R17C17.

Figure III-7. Light Matrix Layout

IV. MAIDEN

MAIDEN is a presentation with complex mechanical motion, augmented by both visual and sound effects. The machine is driven by 12 pneumatic cylinders, each operating individually under computer control. The basic MAIDEN structure is shown in Fig. IV-1.

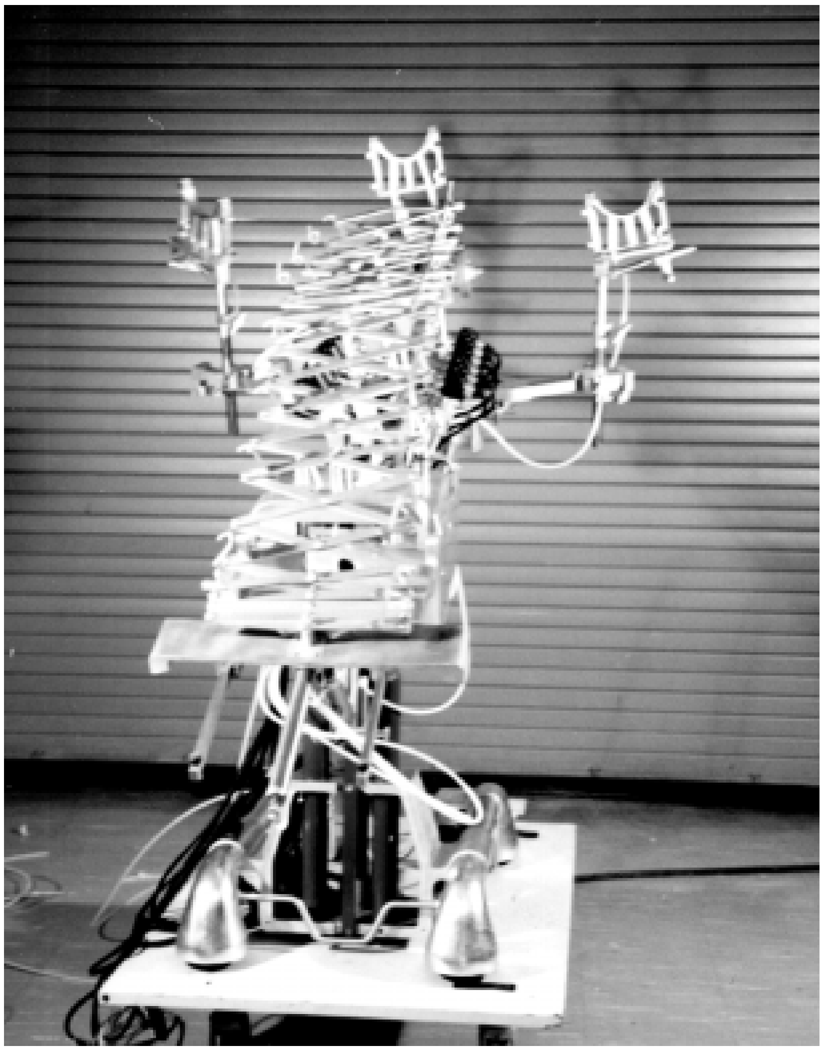


Figure IV-1. Basic MAIDEN Structure

The pneumatic cylinders are each controlled by electric solenoid valves. The valves are arranged in two banks of six each, with one bank located on each side of the machine as shown in Figure IV-2. The valves are numbered sequentially, with Valve 0 located in the lower left of Figure IV-2.

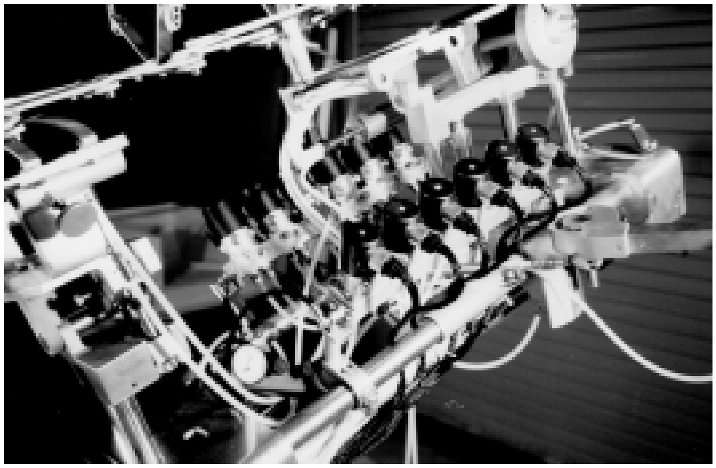


Figure IV-2. Pneumatic Solenoid Valves

A schematic drawing showing the approximate locations of the cylinders and the numbering sequence for the valves and cylinders is given in Figure IV-3. Cylinders shown as circles are mounted vertically, or nearly so. Cylinders shown as rectangles are mounted horizontally, or nearly so. Many are located below the mainframe of the machine.

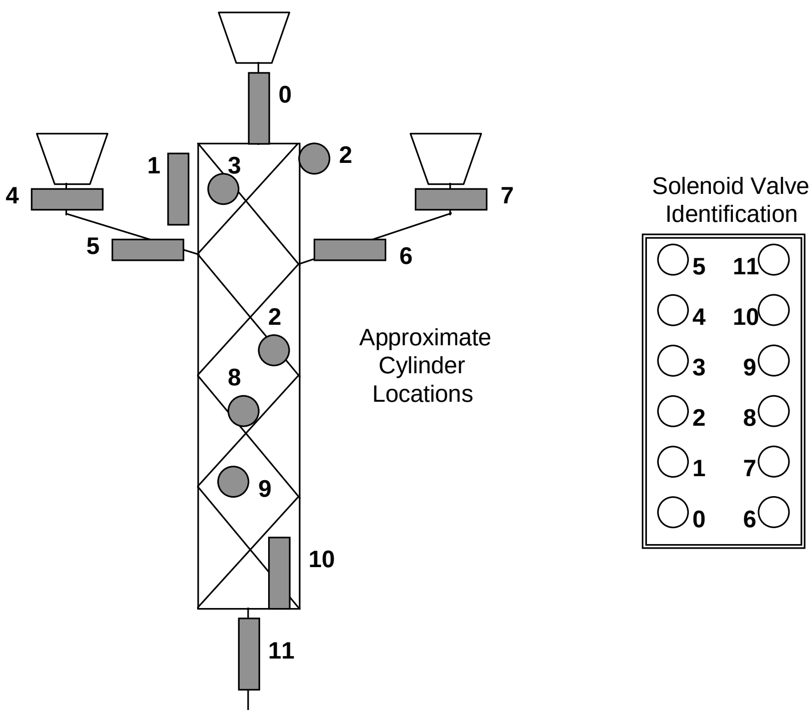


Figure IV-3. Cylinder-Valve Correspondences

The MAIDEN system is depicted schematically in Figure IV-4.

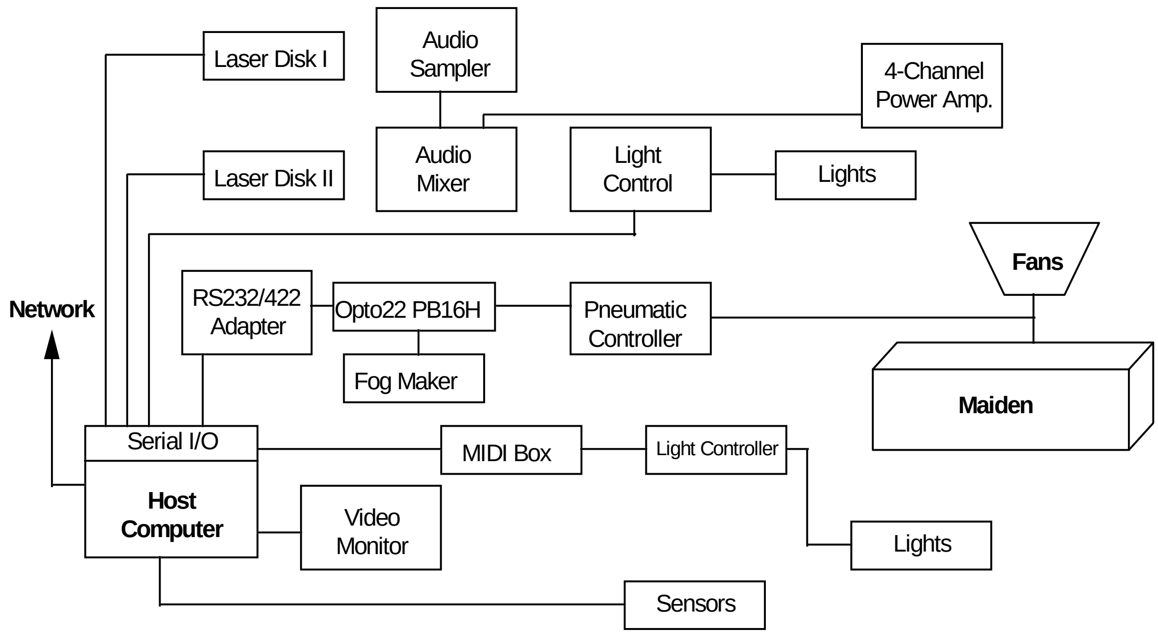


Figure IV-4. MAIDEN System Schematic

Control for MAIDEN is passed from its Host Computer to an Opto22 Brainboard and Opto22 PB16H solid-state relay board. They are shown in the left-hand side of Figure IV-5.

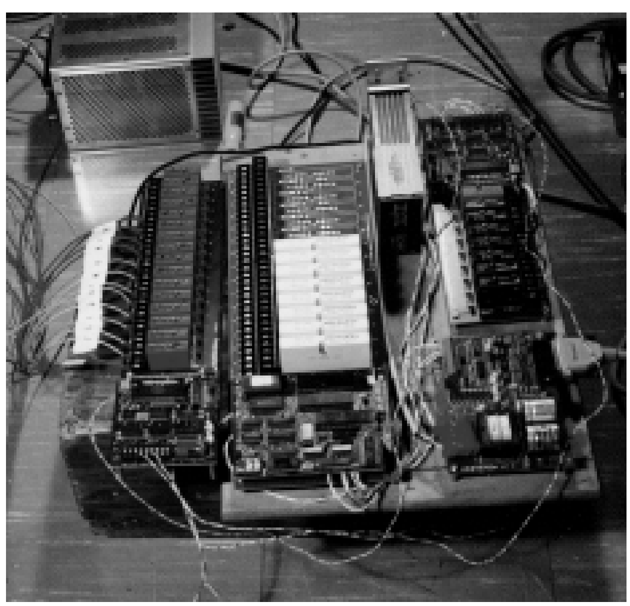


Figure IV-5. MAIDEN Solid-State Relay Board and Brainboard (left)

The brainboard is depicted in Fig. IV-6; and the solid-state relay board, with corresponding connections to the solenoid valves indicated, is shown in Fig. IV-7.

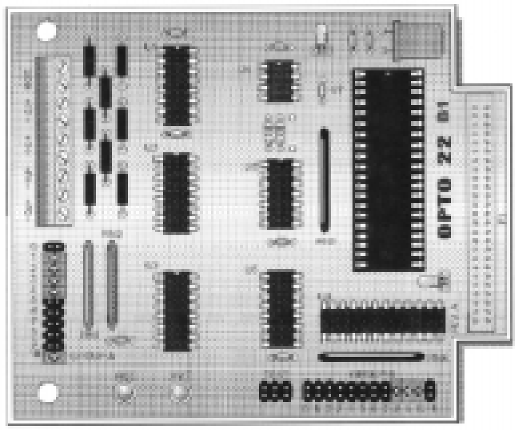


Figure IV-6. Opto22 Brainboard, Model B1

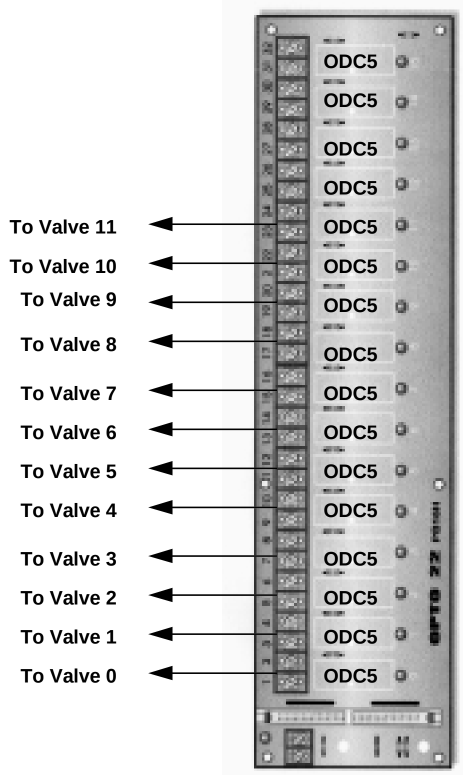


Figure IV-7. MAIDEN Solid-State Relay Board

V. SCRIBE

SCRIBE is complex opto-mechanical system currently under development. It is to be designed to view the pages of a book, turn the pages, and display the contents on an X-Y plotter. The way in which it does those things is influenced by various sensors placed in the vicinity.

The major mechanical components of SCRIBE are shown in Fig. V-1.

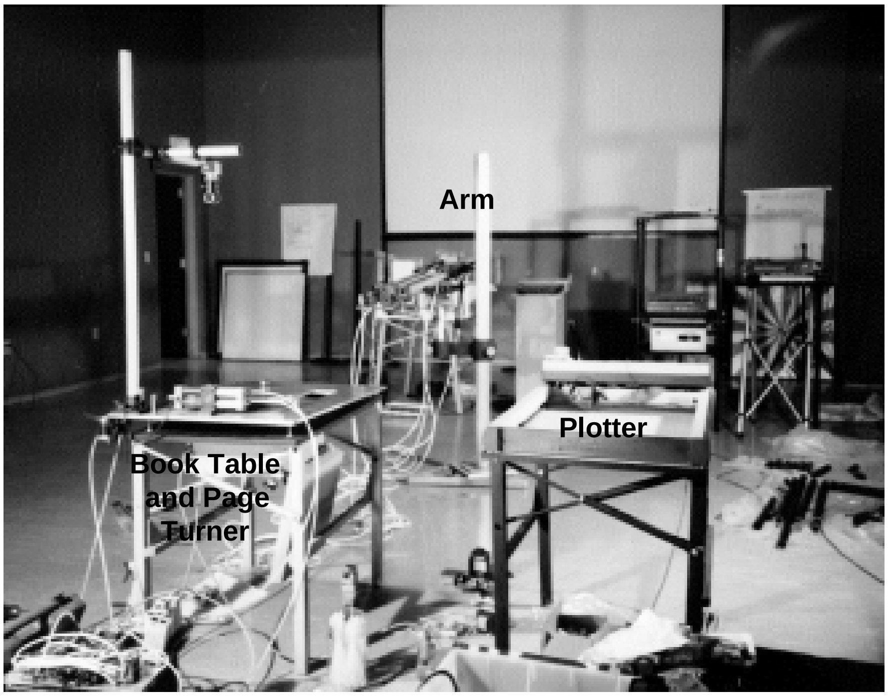


Figure V-1. Major SCRIBE components

The Arm is shown in more detail in Fig. V-2:

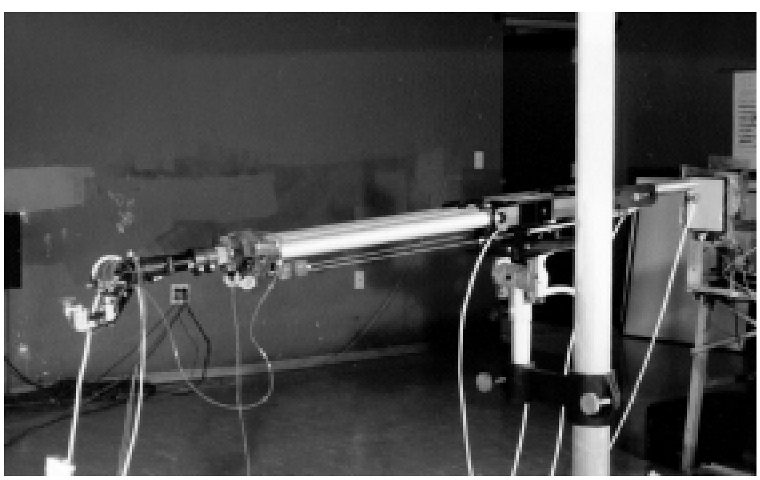


Figure V-2. SCRIBE Arm

Other major components of the SCRIBE presentation are indicated schematically in Fig. V-3.

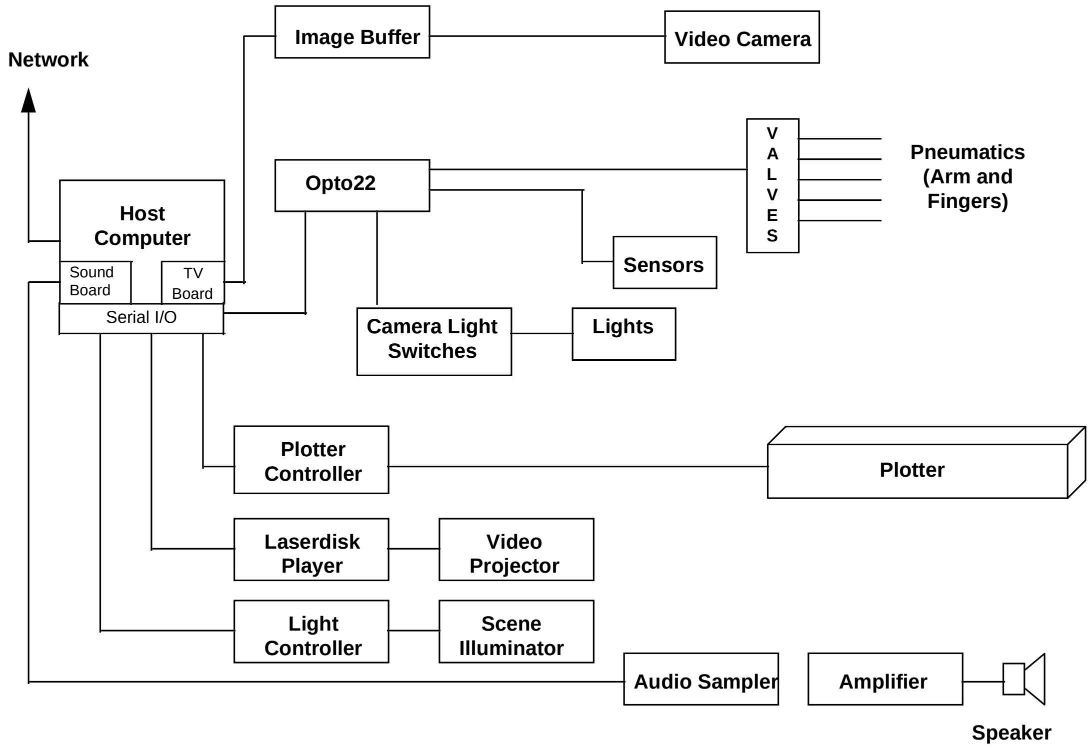


Figure V-3. Preliminary SCRIBE System Schematic

Control of SCRIBE is passed from the Host Computer to a Opto22 PB8 solid-state relay board and Opto22 B1 Brainboard, shown in Fig. V-4.

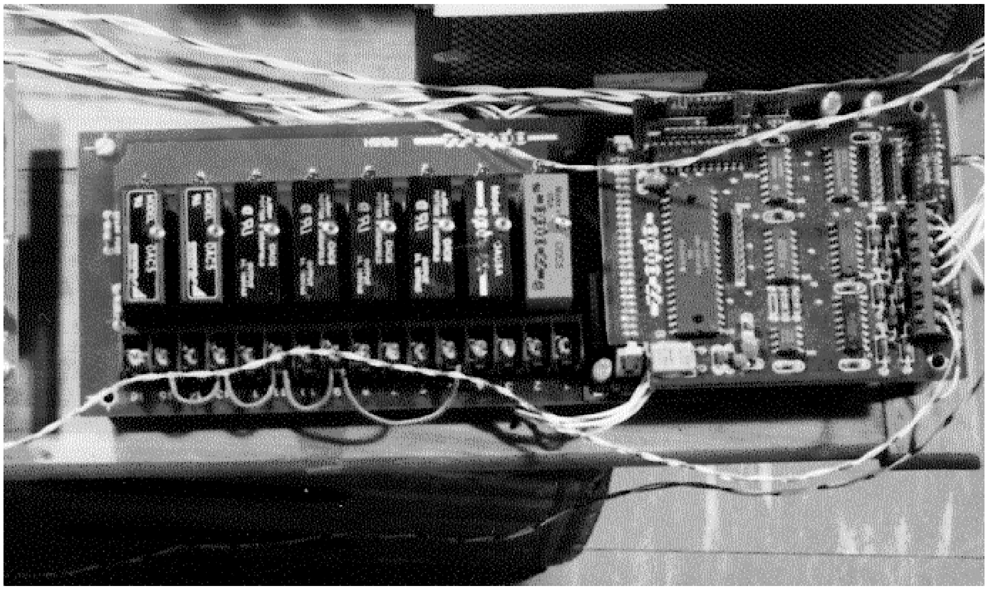


Figure V-4. SCRIBE Relay Board and Brainboard

VI. STEALTH

STEALTH is a multimedia presentation that is both preprogrammed and interactive. It comprises an X-Y scanning table and a third scanning rail, all with video cameras. It includes an array of phototransistor and infrared sensors and a pair of joysticks as input devices, and both audio and visual outputs. As it is now configured, STEALTH is shown pictorially in Figure VI-1 and schematically in Figure VI-2.

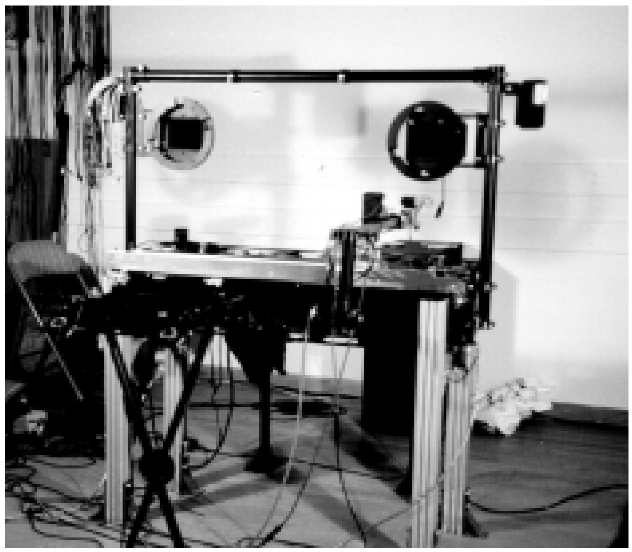


Fig. VI-1. The STEALTH Table

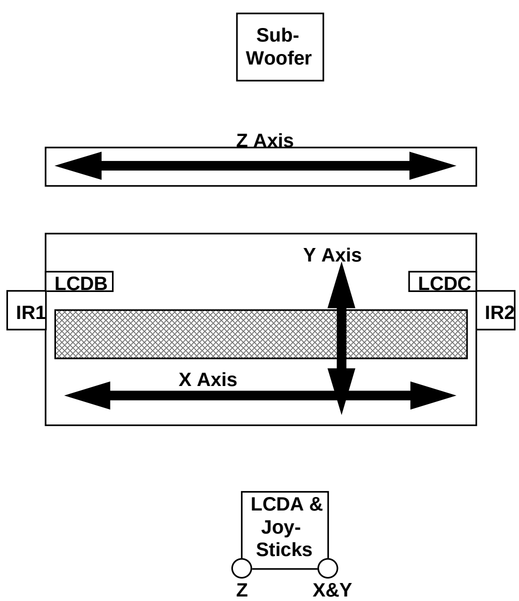


Fig. VI-2. STEALTH Layout

The STEALTH system concept allows for a great deal of flexibility in how the components are arranged and operate. Communication between components is in the MIDI format, allowing interchangeability between quite different functions. A preliminary schematic of the system is shown in Figure VI-3.

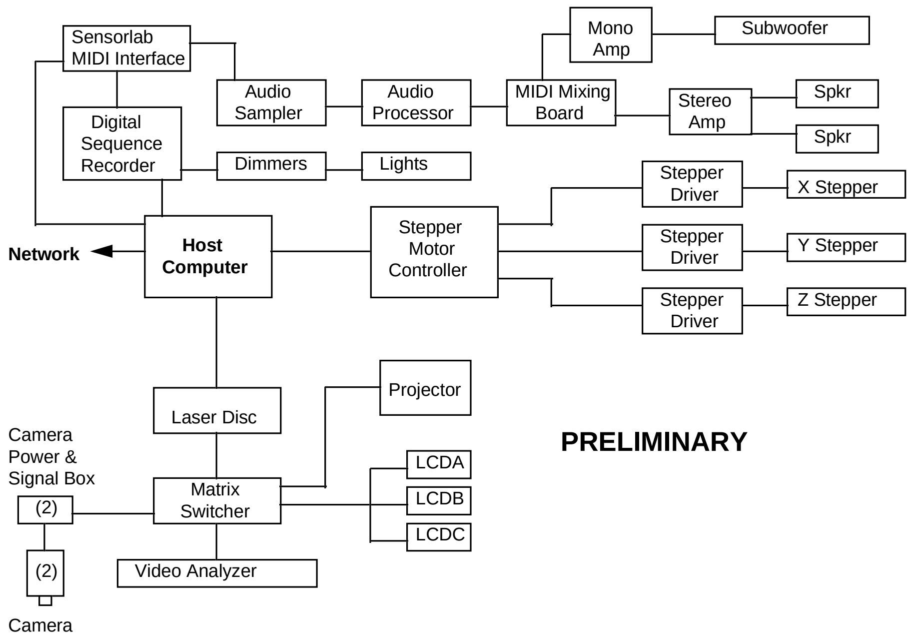


Fig. VI-3. STEALTH System Schematic

Major components are listed in Table VI-1.

Table VI-1. Major STEALTH Components

Component	Manufacturer, Model
Host Computer	Custom built
Stepper Controller	Oregon Microsystems, SRX-4
Stepper Motor Drivers	Centent, CN0142
Laser Disc Player	Pioneer, LD-V8000
MIDI Mixing Board	Yamaha, DMP7
Audio Processor	Alesis, Q2
Audio Sampler	Peavey, SP
Digital Sequence Recorder	Yamaha, QX21
Mono Amplifier	Carver, M400
Stereo Amplifier	Fuhrman, SP-20A
Light Dimmers	Leprecon
MIDI Interface	Sensorlab
MIDI Patch Panel	Custom built
Video Camera Power/Signal Box	Custom built
Power Supplies	TDK, 24-4R5GB and 05-20RGB
Stepper Motors	ASTROSYN , 23LM-C001

Environmental lights are controlled through two six-outlet MIDI light dimmers. The dimmers and controller are shown in Figure VI-4. The X-, Y- and Z-axis stepper motors are operated by the host computer via the stepper controller, shown in Figure VI-5.

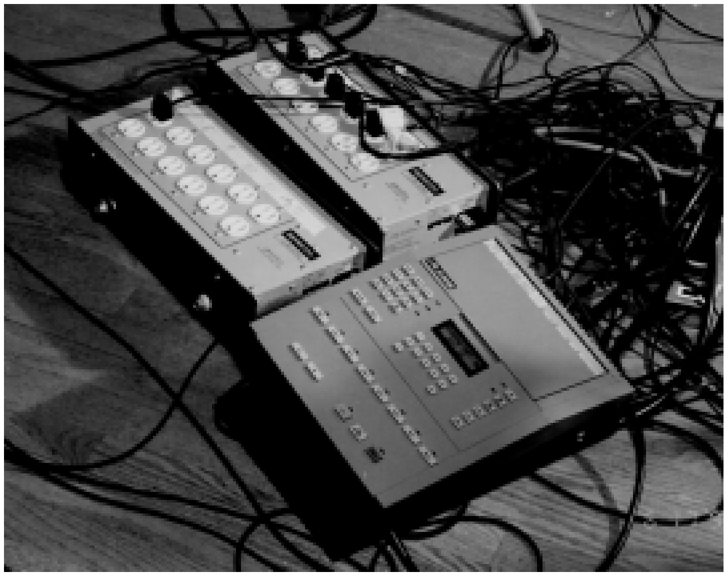


Fig. VI-4. MIDI Light Dimmers and Controller

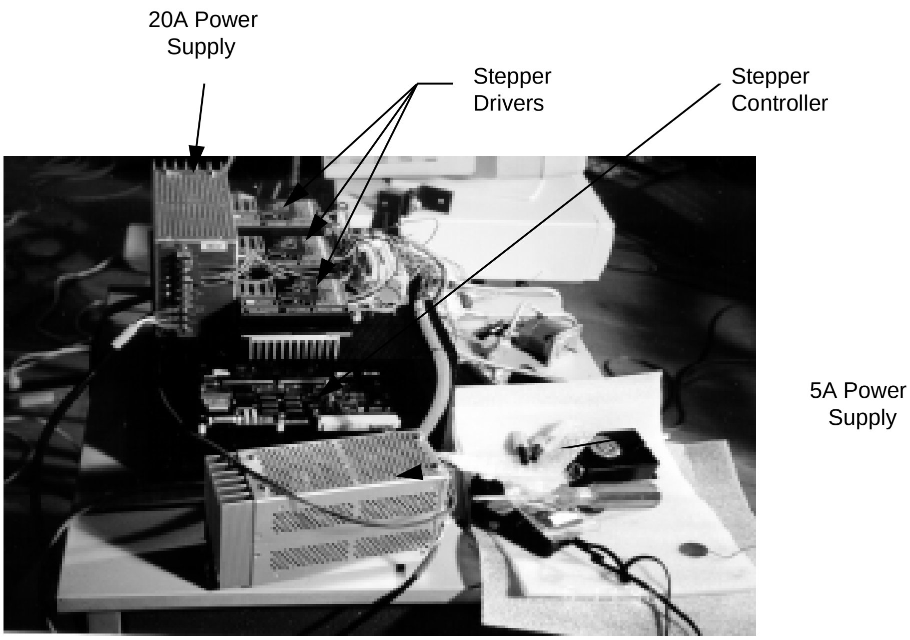


Fig. VI-5. Stepper Motor Drivers and Controller

STEALTH will operate in a pre-programmed mode if there is no sensor input arising from an action on the part of the viewer. However, phototransistor and infrared motion sensors and joysticks are provided to enable viewer interaction. The joysticks are mounted on a separate stand, along with a liquid crystal display screen that provides feedback to the viewer. They are shown in Figure VI-6.

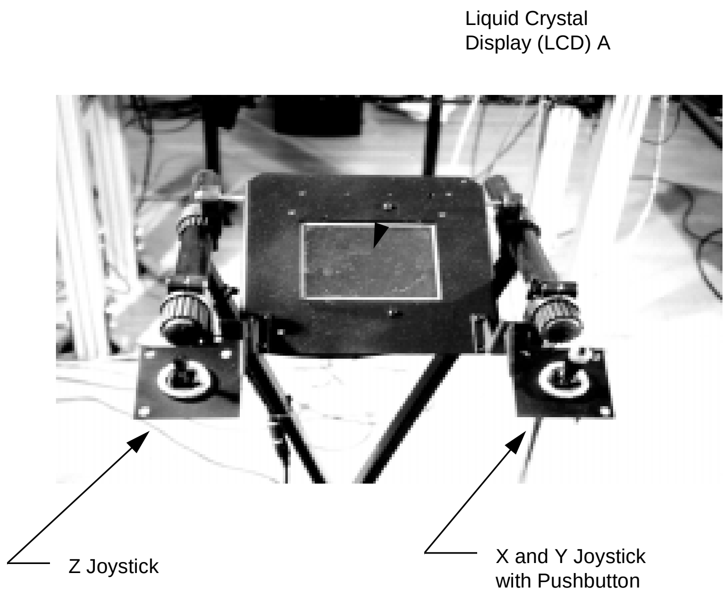


Fig. VI-6. Joysticks and LCDA

Several phototransistor sensors are mounted on the front of the table, pointed toward a viewer standing at the joysticks. They are indicated in Figure VI-7, along with several other components.

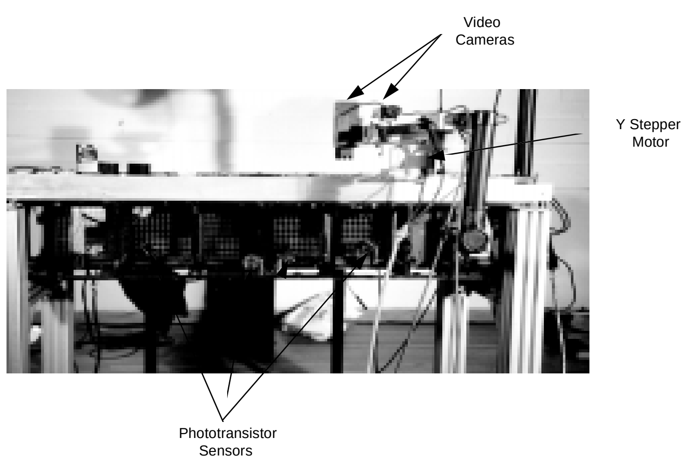


Fig. VI-7. Phototransistor Sensor Location

Much of the video processing equipment is located in an equipment rack. The host computer and stepper motor controller/drivers constitute another major block of equipment, as does the audio processing equipment. Although the equipment rack is shown in Figure VI-8, the individual pieces of equipment remain to be identified and labeled.

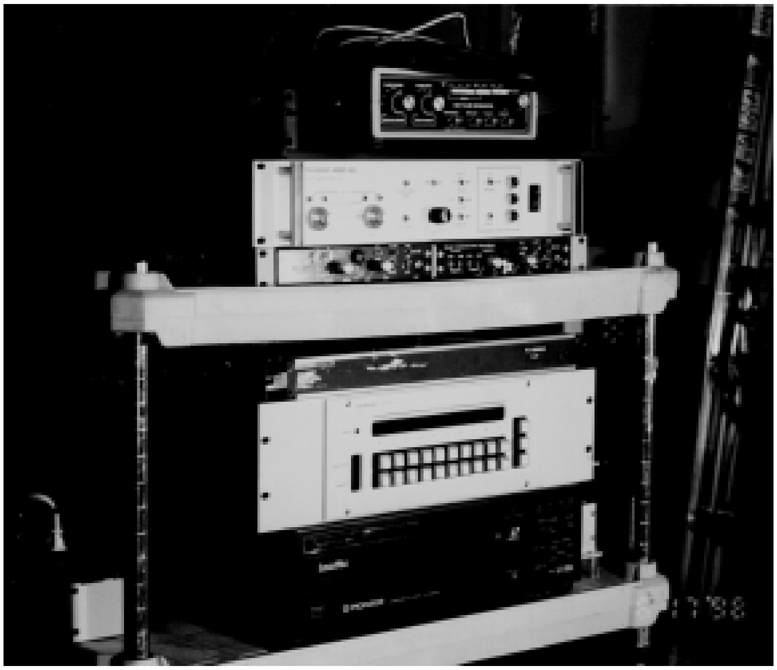


Fig. VI-8. Video Processing Equipment Rack

STEALTH, like most of the other presentations, is evolving. A possible addition is one or two “Islands,” each of which includes a low-power laser and beam splitting apparatus. Just how the Islands will be used remains to be determined. One of the Islands is shown in Figure VI-9.

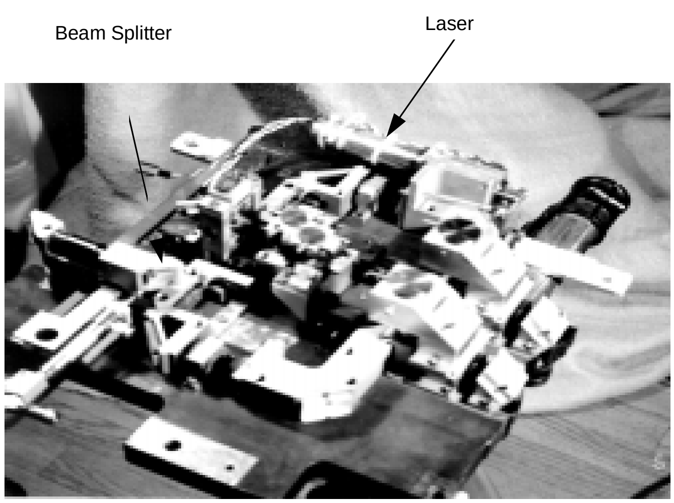


Fig. VI-9. Island

APPENDICES

Subject	File Name
OPTO22 PB8 Data Sheets	PB8.pdf
OPTO22 PB16H Data Sheets	PB16H.pdf
B1 Digital Optomux Brain Board Data Sheets	B1brain.pdf
Laser Disc Player Interface Connector Terminals	lsrdsk.pdf
Lightning Technical Specifications	lghtng.pdf
PIC-SERVO Motor Control Board Documentation	PICservo.pdf

SHAPING THE FUTURE OF INDUSTRIAL AUTOMATION

OPTO 22

RACKS
CLASSIC
STANDARD DIGITAL

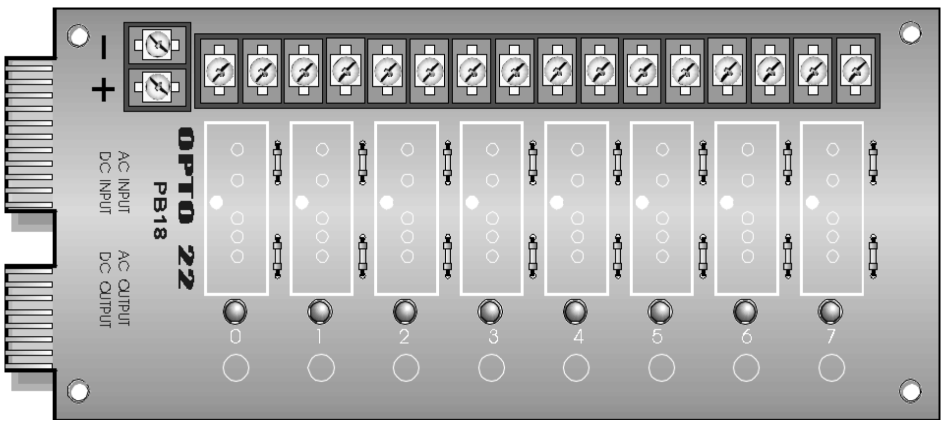
DATA SHEET

Form 511-980128

Description

Part Number	Description
PB4R	4-Channel Output Module Rack, Isolated

The PB8 I/O mounting rack accommodates up to eight Standard single channel I/O modules. The PB8 I/O mounting rack uses a 26-pin or 50-pin card edge connector for interface to computer I/O ports. Features include an LED indicator and a plug-in fuse for each I/O module position.



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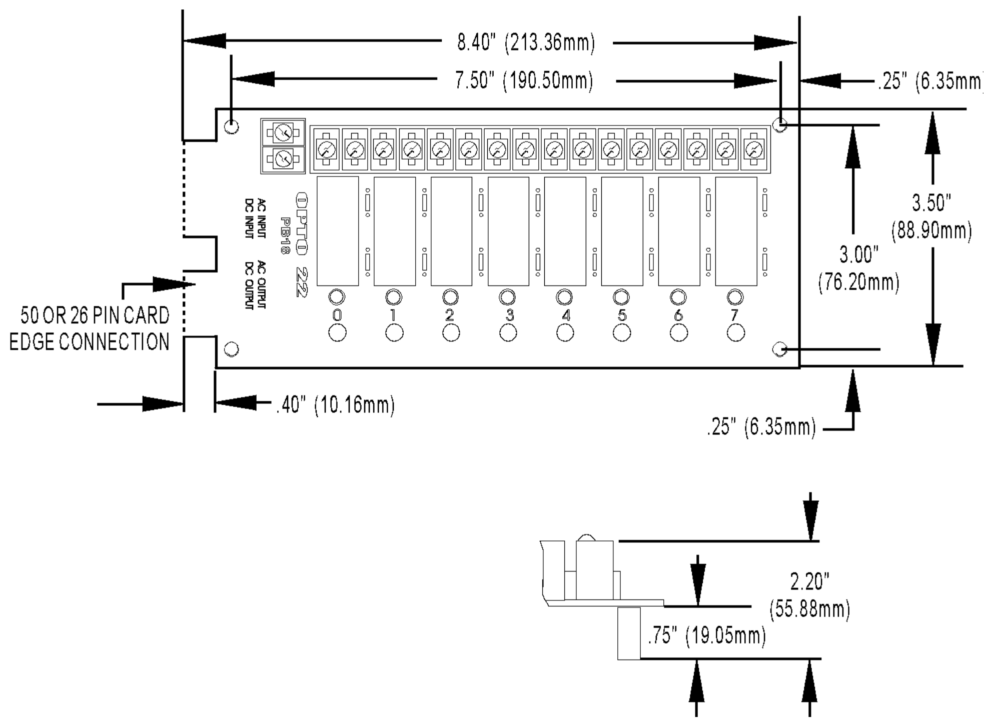
Specifications

General Specifications

Operating Temperature	0° to 70° C 95% relative humidity Non-condensing
Interface Connector Field	6-32 screw terminals
Logic	26- or 50-conductor edge card connector

Dimensions

PB8 DIMENSIONS

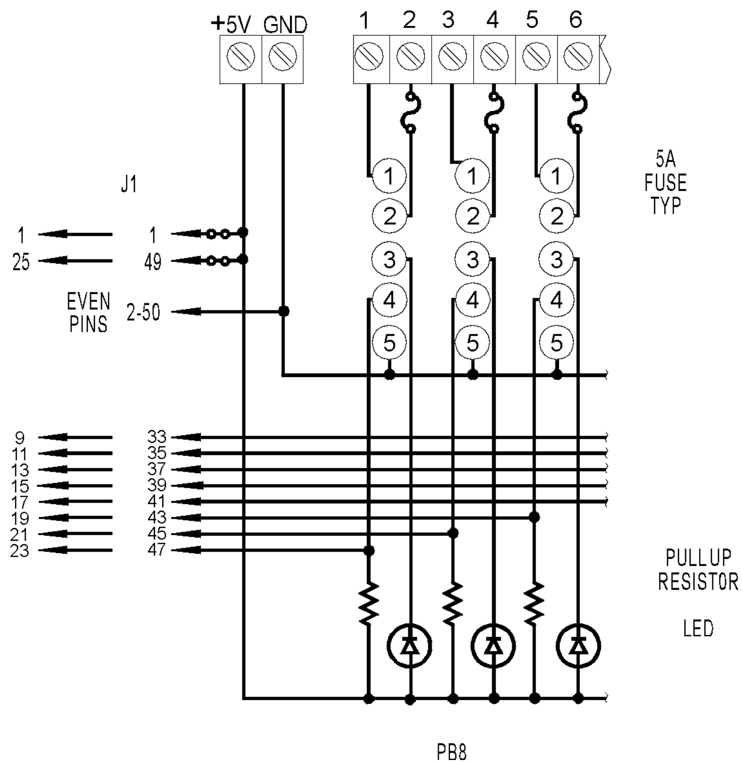


Connections

Module Position	Control (Edge Connector)	Field (Terminal Strip)
0	47	1 & 2
1	45	3 & 4
2	43	5 & 6
3	41	7 & 8
4	39	9 & 10
5	37	11 & 12
6	35	13 & 14
7	33	15 & 16

Schematics

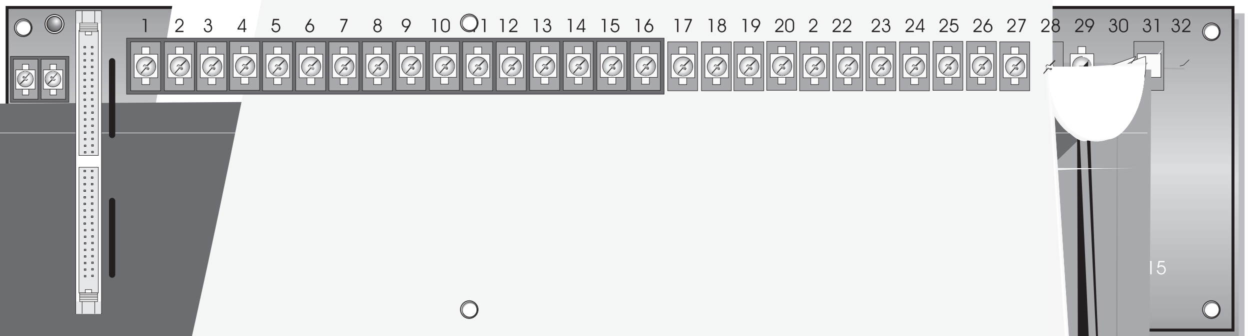
1. Even pins on control connector are connected by etch to common.
2. +VCC and return connected to two point terminal strips marked "+5V" and "GND".
3. At each module position on the field terminal strip, the lower number is always connected to pin 1 of the I/O module.



Part Number	Description
PB16H	16-Channel Rack With Header Connector

Description

The PB16H I/O ... gital I/O modules. The PB16H I/O mountir ... (B5), or Mistic (B100) protocol brain boa



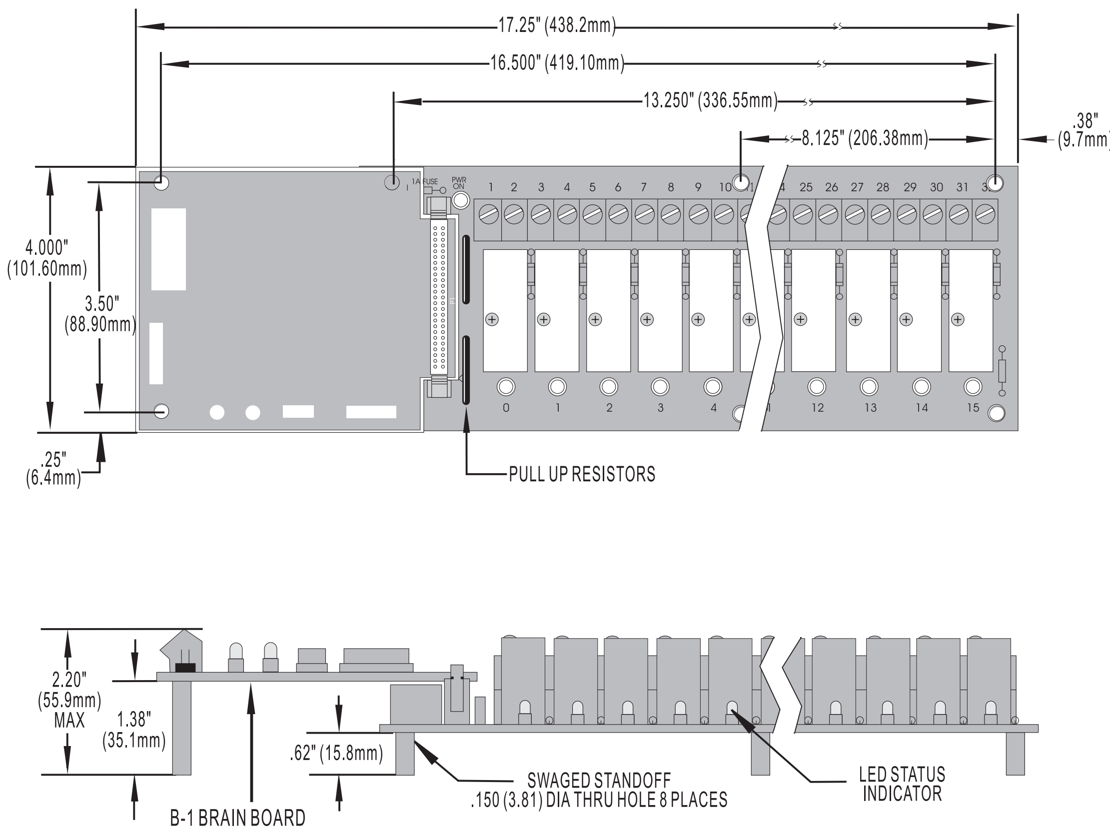
Specifications

PB16H Specifications

Operating Temperature	0° to 70° C 95% Relative Humidity Non-condensing
Interface Connectors Field Control Power	 6 - 32 Screw Terminals 50-conductor Header Connector 2-position Screw Terminal or Opto 22 PBSA/B/C Power Supply

Dimensions

PB16H WITH B1 BRAIN BOARD



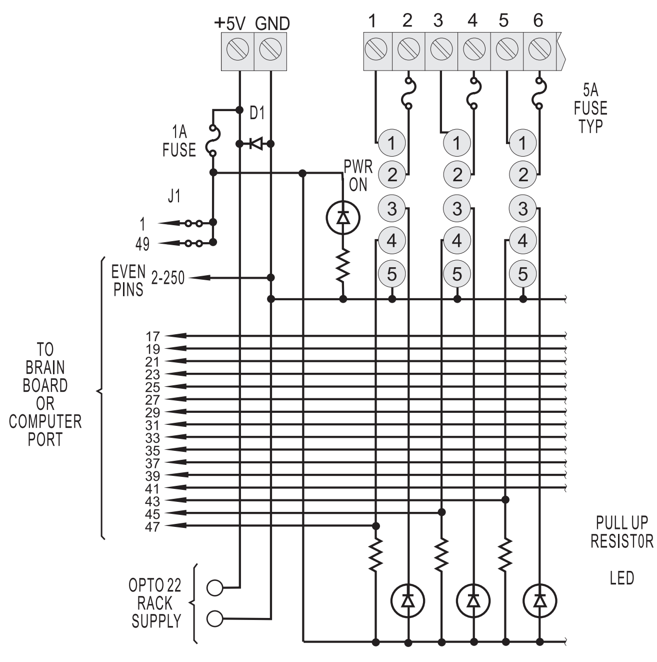
Connections

Module Position	Control (Header Connector)	Field (Terminal Strip)
0	47	1 & 2
1	45	3 & 4
2	43	5 & 6
3	41	7 & 8
4	39	9 & 10
5	37	11 & 12
6	35	13 & 14
7	33	15 & 16

Module Position	Control (Header Connector)	Field (Terminal Strip)
8	31	17 & 18
9	29	19 & 20
10	27	21 & 22
11	25	23 & 24
12	23	25 & 26
13	21	27 & 28
14	19	29 & 30
15	17	31 & 32

1. Even pins on control connector are connected by etch to common.
2. +VCC and return connected to two-point terminal strips marked "+5V" and "GND".
3. At each module position on the field terminal strip, the lower number is always connected to pin 1 of the I/O module.

Schematics PB16



PB16H

Part Number	Description
B1	16-channel Digital Optomux Protocol Brain Board

Description

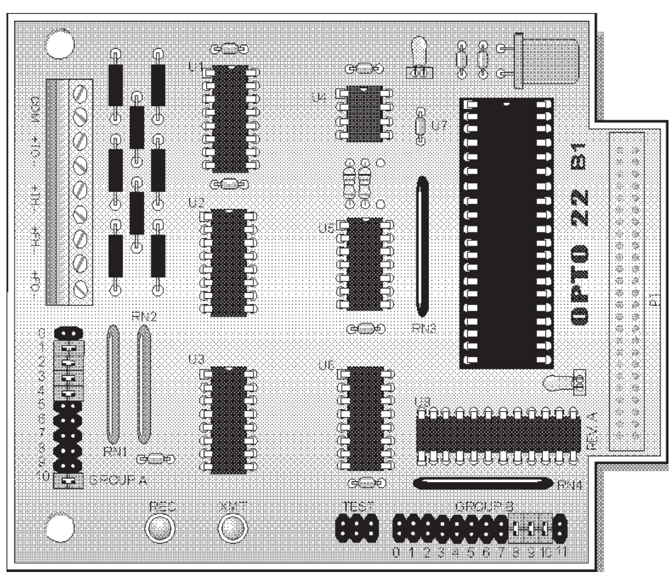
The B1 Digital Optomux brain board is an intelligent digital controller that operates as a slave device to a host computer. Each B1 contains a microprocessor that provides the necessary intelligence to carry out serial communications with a host computer and also perform control functions at each channel of I/O. The B1 brain boards are designed to mount on most Opto 22 I/O mounting racks that have header connectors. I/O mounting racks that accept single-channel Standard and G4 I/O modules, Quad Pak I/O modules, SNAP I/O modules or have built-in integrated I/O circuitry are all available.

When combined with an I/O mounting rack, the B1 brain board can perform the following functions:

- Read Inputs
- Write Outputs
- Latching
- Counting
- Pulse Measurement
- Time Delays
- Pulsed Outputs

Communication with a host computer is via an RS422/485 serial link composed of a dual twisted pair line that connects to each Optomux station. The serial data link operates at selectable baud rates from 300 to 38.4k baud. Optomux stations can be configured for either multidrop or repeat mode operation. In multidrop mode, up to 100 Optomux stations can be networked over a total line length of up to 5,000 feet. In repeat mode operation, up to 256 Optomux stations can be networked with up to 5,000 feet between stations.

B1 DIGITAL BRAIN BOARD



Specifications

B1 Specifications

Power Requirements	5 VDC ± 0.1 V @ 0.5 amps (includes module requirements)
Operating Temperature	0° C to 70° C 95% humidity, non-condensing
Interface	RS-422/485 communications 50-pin female header connector to I/O mounting rack
Data Rates	300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 baud
Cable Length Multidrop Repeat Mode	Up to 5,000 feet total length * 100 Optomux stations maximum * Up to 5,000 feet between stations 256 Optomux stations maximum
Communications	Full duplex, two twisted pairs, and a ground
Indicators	Power, receive, and transmit
Options Jumper selectable	Address (0 to 255) Baud rates Multidrop or repeat mode 2 or 4-pass protocol

* Extend line length and/or number of OPTOMUX stations with the AC30A/B network adapter.

ERROR CODES

Optomux Detected Errors:

- -1 Power Up Clear Expected
- -2 Undefined Command
- -3 Checksum Error
- -4 Input Buffer Overrun
- -5 Non-printable ASCII Character Received
- -6 Data Field Error
- -7 Serial Watchdog Timeout
- -8 Invalid Limit Set

OptoWare Driver Detected Errors:

- -20 Invalid Command Number
- -21 Invalid Module Position
- -22 Data Range Error
- -23 Invalid First Modifier
- -24 Invalid Second Modifier
- -25 Invalid Address
- -27 Not Enough Return Data
- -28 Invalid Return Data
- -29 Turnaround Time Out (Optomux did not respond within the specified time interval)
- -30 Input Buffer Overrun
- -31 Checksum Error
- -33 Send Error (Message cannot be sent out; probable serial port problem)
- -34 Incorrect Command Echo In Four-Pass

Specifications DIGITAL COMMAND SET

System Commands
POWER UP CLEAR
RESET
SET TURNAROUND DELAY
SET DIGITAL WATCHDOG DELAY
SET ENHANCED DIGITAL WATCHDOG TIMEOUT
SET OPTOMUX PROTOCOL
IDENTIFY OPTOMUX TYPE
SET TIMER RESOLUTION

Configure Commands
CONFIGURE POSITIONS
CONFIGURE AS INPUTS
CONFIGURE AS OUTPUTS

Read and Write Commands
WRITE DIGITAL OUTPUTS
WRITE BINARY OUTPUTS
ACTIVATE DIGITAL OUTPUTS
DEACTIVATE DIGITAL OUTPUTS
READ ON/OFF STATUS
READ BINARY ON/OFF STATUS
READ CONFIGURATION

Latch Commands
SET LATCH EDGES
SET OFF-TO-ON LATCHES
SET ON-TO-OFF LATCHES
READ LATCHES
READ AND CLEAR LATCHES
CLEAR LATCHES
READ BINARY LATCHES
READ AND CLEAR BINARY LATCHES

Counting Commands
START AND STOP COUNTERS
START COUNTERS
STOP COUNTERS
READ COUNTERS
READ AND CLEAR COUNTERS
CLEAR COUNTERS

Time Delay And Pulse Commands
SET TIME DELAY
INITIATE SQUARE WAVE
TURN OFF TIME DELAY/SQUARE WAVE
HIGH RESOLUTION SQUARE WAVE
RETRIGGER TIME DELAY
GENERATE N PULSES
START ON PULSE
START OFF PULSE

Duration Measurement Commands
SET PULSE TRIGGER POLARITY
TRIGGER ON POSITIVE PULSE
TRIGGER ON NEGATIVE PULSE
READ PULSE COMPLETE BITS
READ PULSE DURATION COUNTERS
READ AND CLEAR DURATION COUNTERS
CLEAR DURATION COUNTERS

Driver Commands
COMMAND NUMBERS
SET DRIVER PROTOCOL
SET TURNAROUND DELAY
SET SERIAL PORT NUMBER
SET NUMBER OF RETRIES
CONFIGURE SERIAL PORT

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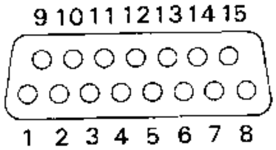
INTERFACE CONNECTOR TERMINALS

Used when external control is performed by using a controller or computer.

[Shape]

15 pin D-SUB connector (JAE DALC-J15SAF)



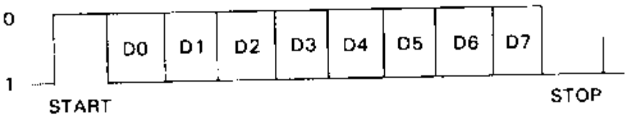
[Matched plugs] JAE DA-15PF-N

[Terminal names]

Pin No.	Terminal	I/O	Level
1	GND	—	—
2	TxD	Output	RS-232C
3	RxD	Input	RS-232C
4	DTR	Output	+PULL UP
5	Not used	—	—
6	Not used	—	—
7	Not used	—	—
8	Not used	—	—
9	TxD	Output	TTL
10	RxD	Input	TTL
11	GND	—	—
12	Not used	—	—
13	Not used	—	—
14	Not used	—	—
15	GND	—	—

- Signals for both the RS-232C level (No. 2 and 3) and TTL level (No. 9 and 10) are provided. However, they cannot be used at the same time. They also cannot be connected together.
- The following is the data format:

1 START + 8 DATA + 1 STOP



The following can be selected by the function switch on the rear panel:

Baud rate:

OFF	position	-	4,800	bit/sec
ON	position	-	1,200	bit/sec

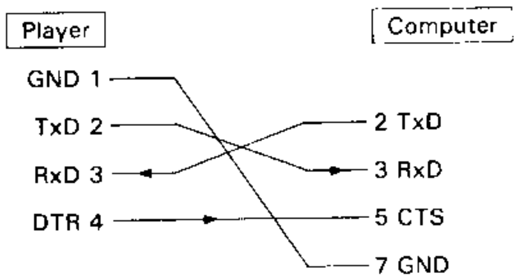
[Function]

1. GND : Ground (TxD, RxD use)
2. TxD : Transmitted Data (RS-232C)
3. RxD : Received Data (RS-232C)
4. DTR : Data Terminal Ready
1 kΩ + 10 V Pull up
9. TxD : Transmitted data (TTL)
10. RxD : Received data (TTL)
11. GND : Ground
15. GND : Ground

NOTE:
- *Do not connect terminals 5~8 and 12 to ground; make sure it is free.*
- *Be sure to perform plugging and unplugging when the power is turned off.*

CONNECTIONS TO COMPUTER RS-232C PORTS

Connect the player TxD, RxD and GND to the computer RxD, TxD and GND respectively.
Although TxD and RxD are provided for both RS-232C and TTL levels, they cannot be used at the same time. The player DTR (Terminal 4) is connected to the computer CTS (Clear To Send), if necessary. (Use a sold separately interface cable.)



CONTROL COMMANDS

RxD Terminal Control Command Input

Explanation of commands

Below is the list of the commands that can be carried out on the LD-V2200.

	Command	Mnemonic
1	OPEN	OP
2	REJECT	RJ
3	START	SA
4	PLAY	(address) PL
5	PAUSE	PA
6	STILL	ST
7	STEP FORWARD	SF
8	STEP REVERSE	SR
9	SCAN FORWARD	NF
10	SCAN REVERSE	NR
11	MULTI-SPEED FORWARD	(address) MF
12	MULTI-SPEED REVERSE	(address) MR
13	SPEED	argument SP
14	SEARCH	address SE
15	STOP MARKER	address SM
16	FRAME	FR
17	TIME	TM
18	CHAPTER	CH
19	AUDIO CONTROL	argument AD
20	VIDEO CONTROL	argument VD
21	DISPLAY CONTROL	argument DS
22	CLEAR	CL
23	FRAME NUMBER REQUEST	?F
24	TIME CODE REQUEST	?T
25	CHAPTER NUMBER REQUEST	?C
26	PLAYER ACTIVE MODE REQUEST	?P
27	DISC STATUS REQUEST	?D
28	COMMUNICATION CONTROL	argument CM
29	CCR MODE REQUEST	?M
30	DOOR CLOSE	CO
31	LVP MODEL NAME REQUEST	?X
32	KEY LOCK	argument KL
33	REG. A SET (DISPLAY)	argument RA
34	REG. B SET (SQ CONT)	argument RB
35	REG. C SET (MISCELLANY)	argument RC
36	CLEAR SCREEN	CS
37	PRINT	argument PR
38	LEAD OUT SYMBOL	LO
39	REG. A REQUEST (DISPLAY)	$A
40	REG. B REQUEST (SQ CONT)	$B
41	REG. C REQUEST (MISCELLANY)	$C

- Command mnemonics use ASCII alpha characters, the ? and the $ symbol. There is no distinction between capitals and small letters.
- The argument and address are decimal and use ASCII numerals.
- An address indicated by ( ) can be omitted.
- A command line can have up to 20 characters and is terminated with CR code (ODH).
- Refer to the "Users Manual" for the control protocol and command explanation.

LIGHTNING TECHNICAL SPECIFICATIONS

Input / Output Facilities

MIDI Interconnections: 1 Input, 1 Output, 1 Through.
Foot Switch Input: accommodates a standard (normally open) footswitch

Physical Characteristics

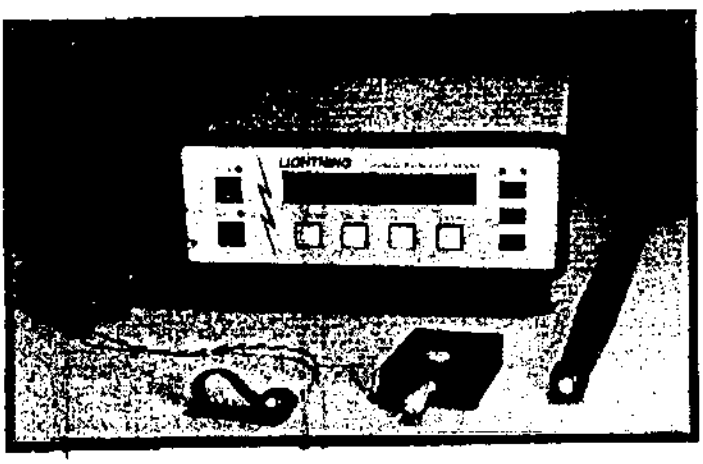
Receiver: dimensions are 2.7 x 7.5 x 10 inches (h,w,d); weight is 3 pounds.
Ring transmitter: .7 inches long x .3 inches diameter; weight is .1 ounce; battery pack for ring is 2.3 x 1.5 x .5 inches (h,w,d); weight is 2 ounces.
Wand transmitter: 3.3 x 1.5 x .5 inches (h,w,d); weight is 2 ounces.
Stick transmitter: 16.3 inches long x .7 inches diameter; weight is 5 ounces.

Power Requirements

Receiver: 9 volts D.C. at .4 amperes, or 110 volts A.C. at .04 amperes, or 220 volts A.C. at .02 amperes (A.C. adaptor is included)
Transmitters: powered with internal rechargeable batteries (battery pack for ring is worn on wrist); playing time is 8 hours; recharge time is 5 hours; charging facility is built into receiver.

Circuitry and Architecture

Supervisory control and signal processing: TMS370 microcontroller.
Internal memory: 8448 bytes of RAM; 49,152 bytes of PROM.
Software: BOLT, a high level performance optimized user interface language.
Editing inputs: four dedicated panel switches.
Displays: 48 character backlighted liquid crystal display, four discrete LED's.



illustrated is a LIGHTNING receiver and 3 transmitters: (from l. to r.) a radiant ring, a spacewand, and a drumstick.

Specifications are subject to change.
For additional information, please contact the manufacturer:

ZETA
Zeta Music Systems, Inc.
2230 Livingston Street, Oakland, CA 94606
415.261.1702 800.622.6434 Fax: 415.261.1708

LIGHTNING DESCRIPTION

LIGHTNING is a MIDI controller that senses the movement of hands in space and transforms the resultant information to MIDI signals for expressive control of electronic musical instrumentation.

LIGHTNING is housed in a small cabinet designed to be mounted in front of a performer. Operating on principles of optical triangulation, LIGHTNING gathers its information by tracking tiny infrared transmitters that are built into hand-held wands or drumsticks or into rings worn on a performer's index fingers. The wand version is most appropriate for performing with LIGHTNING alone or for conducting real or virtual ensembles; drumsticks are the obvious choice for the percussionist, and the rings have the advantage of allowing simultaneous, unencumbered access to keyboards, THUNDER, or other exotic controllers. The size of LIGHTNING'S playing field is readily varied, and can range from 2 feet to 8 feet in the horizontal dimension.

Basically, LIGHTNING senses horizontal and vertical location from each hand, for a total of four independent coordinates. From this information, LIGHTNING'S digital signal processor computes velocity and acceleration, and performs some elementary analysis of gesture. A sophisticated user interface language allows the user to define relationships between gesture and musical response.

In one sort of implementation, LIGHTNING'S coordinates might be mapped to various MIDI controllers on multiple channels. Spatial pitch wheels and modulation wheels are easily defined and great fun to play in conjunction with keyboards or with THUNDER. Or one might apply LIGHTNING'S multi-dimensional zoning capability to define different musical responses in each of several regions. Everything you need to create a spatial conceptual percussion ensemble (an invisible, but sonic virtual reality).

Also included is a special conducting program that can analyze a conductor's gestures, display deviations from a preset tempo and signal errors such as missed beats. And while monitoring conducting patterns, LIGHTNING can transmit a synchronous MIDI clock and output programmed note data for each beat within a measure.

To facilitate its use in conjunction with other controllers, LIGHTNING has intelligent MIDI merging capability. Additionally, a comprehensive system exclusive implementation enables LIGHTNING configurations to be stored and retrieved with external computers and sequencers.

PIC-SERVO Motor Control Board
Z232-485 Serial Port Converter

The ***PIC-SERVO*** Motor Control board is a full-function servo control system with the following features:

- ***PIC-SERVO*** chipset providing servo control of DC motors with incremental encoders, including trapezoidal and velocity profiling.
- LMD18201 amplifier capable of driving 3 amps continuously, 6 amps peak at up to 48vdc. Built-in thermal, overcurrent and undervoltage protection.
- PWM and DIR signals are provided for use with other external amplifiers.
- RS485 serial interface allows up to 32 motors to be controlled from a single serial port. Connects to an RS232 port through commonly available adapters or using the ***Z232-485*** converter board described in *Section 4*.
- General purpose analog input channel with pre-amplifier. Two general purpose I/O bits for limit switch inputs or control outputs.
- Its small size (2" x 3") allows it to be mounted near motors, reducing noise and simplifying wiring.
- Windows test software provided including Visual Basic (v3.0) source code. DOS based C code is also available.

1. Quick Start

What you will need:

PIC-SERVO Motor Control Board
Z232-485 Converter Board (or equivalent)
DC Motor (48v max., 3 amp continuous current max.) with TTL compatible encoder
Motor power supply (12v min. - 48vdc max.)
Logic power supply (7.5 - 9vdc, 500 ma)
Motor/encoder cable (DB15 male connects to your motor)
10 pin flat ribbon cable with standard IDC socket connectors at both ends
Straight DB9 male / DB9 female cable to PC COM port
PC compatible computer ('386 or higher) running DOS or Windows
Test software - Nettest for Windows, PSTEST for DOS
(available for download from http://www.jrkerr.com)

Most of the cables are available from computer or electronics stores. However, you will probably have to make your own motor/encoder cable to connect to your particular motor. Refer to *Section 2.1* for the connector pin definitions. To start off, you only need to connect M+, M-, Encoder A, Encoder B, Encoder +5v and Encoder GND. Other connections can be made as needed. Note that when testing, you may have to swap the M+ and M- leads to correct for the polarity of your motor.

CAUTION

The ***PIC-SERVO*** Experimenter's board does not incorporate safeguards for fail-safe operation. As such, this board should not be used in any device which could cause injury, loss of life, or property damage. J.R. Kerr makes no warranties whatsoever regarding the performance, operation, or fitness of this board for any particular purpose.

Interconnections and Jumpers:
Basic interconnections and jumpers are shown in *Figure 1* for both a single controller and for a multiple controller configuration. On the ***Z232-485*** converter, jumpers JP3 and JP4 are installed in the 1-2 position for use as a simple converter. (See *Section 4.2* for use with the optional SmartCore processor.) Jumper JP5 is installed to distribute logic power to the controller boards over the communications cable. Logic power is supplied on connector JP6.

On the ***PIC-SERVO*** controller board, jumpers JP6 and JP7 are installed to connect logic power supplied by the communications cable to the board's logic supply. Jumper JP8 should be left uninstalled. In the *single* controller configuration, the three jumpers labeled JP3 should be installed as shown. In the *multiple* controller configuration, these jumpers should only be installed on *last* controller furthest from the PC host. On all intermediate controllers, jumpers on JP3 should be left *uninstalled*. Jumper JP9 and connector JP10 are used for an external amplifier and can be left unconnected.

Motor power should be connected to the two screw terminals, with 12 - 48vdc connected to the terminal towards the edge of the board and GND connected to the terminal towards the center as shown in *Figure 1*.

Loading and Running Software:
If you are running DOS, unzip (using PKUNZIP) PSCODE.ZIP into a single directory, or if you are running Windows, unzip NETTEST.ZIP into a single directory. Before starting up the test code, make sure all of your jumpers and interconnections are as shown in *Figure 1*. Also make sure you have logic power supplied to the ***Z232-485*** converter.

Windows Users:
If using Windows, run the program Nettest.EXE. The program uses port COM 2 as the default. If you are using a different COM port, you will get an error message saying no modules were found. If this is the case, click on the "Communications Settings" button and set the COM port to the correct value. Then click on the "Reset Network" button to repeat the search for controller modules. The program will attempt to locate controllers on the RS485 network and will respond with the number of controllers found. If the number of controllers reported does not match the number connected, re-check the interconnections, jumpers and power, and then try again.

The list box on the left side of the window will display the list of motors found. ***PIC-SERVO*** module 1 will be the last controller which is furthest from the host PC. Clicking on different controllers will display the status and controls for that particular motor. Click on ***PIC-SERVO*** 1 and spin the motor shaft by hand. See that the position changes accordingly in the status panel.

Before enabling the motor servo make sure that the motor is disconnected from any mechanism which might be damaged. To test the motor, first turn on the motor power. You should see the "Motor Power" box checked in the status panel. Next, click on the "Enable Amplifier" box in the Motion Command panel. Now click on the "STOP!" button. Try turning the motor shaft by hand. If the motor jerks and stops, or spins out of control, turn off the motor power and try swapping the M+ and M- leads on the motor. Turn the power back on, click on "STOP!" again. The motor should attempt to hold a fixed position. If it does, click on "Pos" mode, type in a position value of 1000, and then click on "GO". The motor should move to position 1000 (or close to it, depending on how the gains are set). Try moving to a bunch of different positions until you are satisfied that the motor is moving as it should.

The control gains, and maximum velocities and accelerations are set to default values which are reasonable for most small motors. Please refer to the ***PIC-SERVO*** datasheet for details on the values for the gains, velocities and accelerations. The online help also has a great deal of information about the ***PIC-SERVO*** controller.

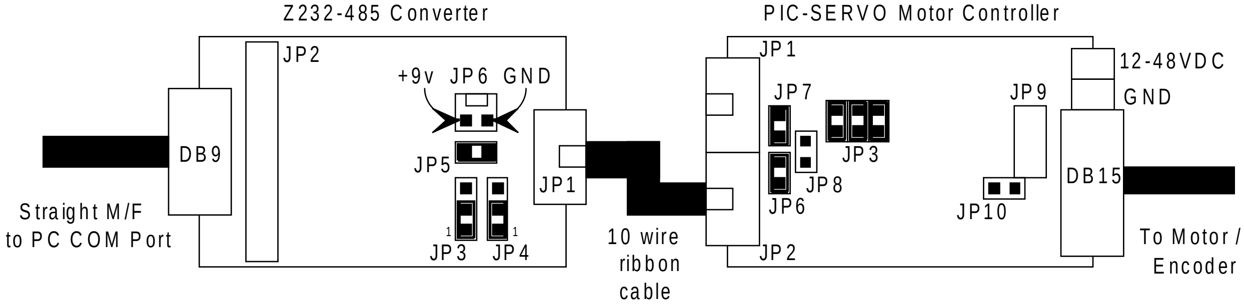
DOS Users:
If using DOS, run the program PSTEST.EXE. You will be prompted for which COM port you are using (1 or 2). You will also be asked if the amplifier enable signal is active HIGH - answer "y". (Other ***PIC-SERVO*** based controller boards may have this signal inverted.) The program will then attempt to locate controllers on the RS485 network, and it will respond with the number of controllers found. If the number of controllers reported does not match the number connected, re-check the interconnections, jumpers and power, and then try again.

If the correct number of controllers is found, try reading a motor position by typing "pos 1". 1 is the address of the last motor in the chain. Other motor addresses will increase from there. Repeatedly spin the motor shaft by hand and repeatedly issue the command "pos 1" until you are satisfied that you are reading the correct position.

Before enabling the motor servo, make sure that the motor is disconnected from any mechanism which might be damaged. To test the motor, turn on the motor power and then issue the command "enable 1". Try turning the motor shaft by hand. If the motor jerks and stops, or spins out of control, turn off the motor power and try swapping the M+ and M- leads on the motor. Turn the power back on, and issue the command "enable 1" again. The motor should attempt to hold a fixed position. If it does, type the command "move 1 1000" to move the motor to encoder count position 1000. Try moving to a bunch of different positions until you are satisfied that the motor is moving as it should.

The control gains, and maximum velocities and accelerations are set to default values which are reasonable for most small motors. Typing "?" or "help" will give you a list of commands for changing the gains, velocities and accelerations. Please refer to the PIC-SERVO data sheet for details on the values for the gains, velocities and accelerations. The default values used by PSTEST.EXE are: accel = 100, vel = 100000, gains = 200 1000 32 1000 255 0 16383 1.

Single Controller Configuration



Multiple Controller Configuration

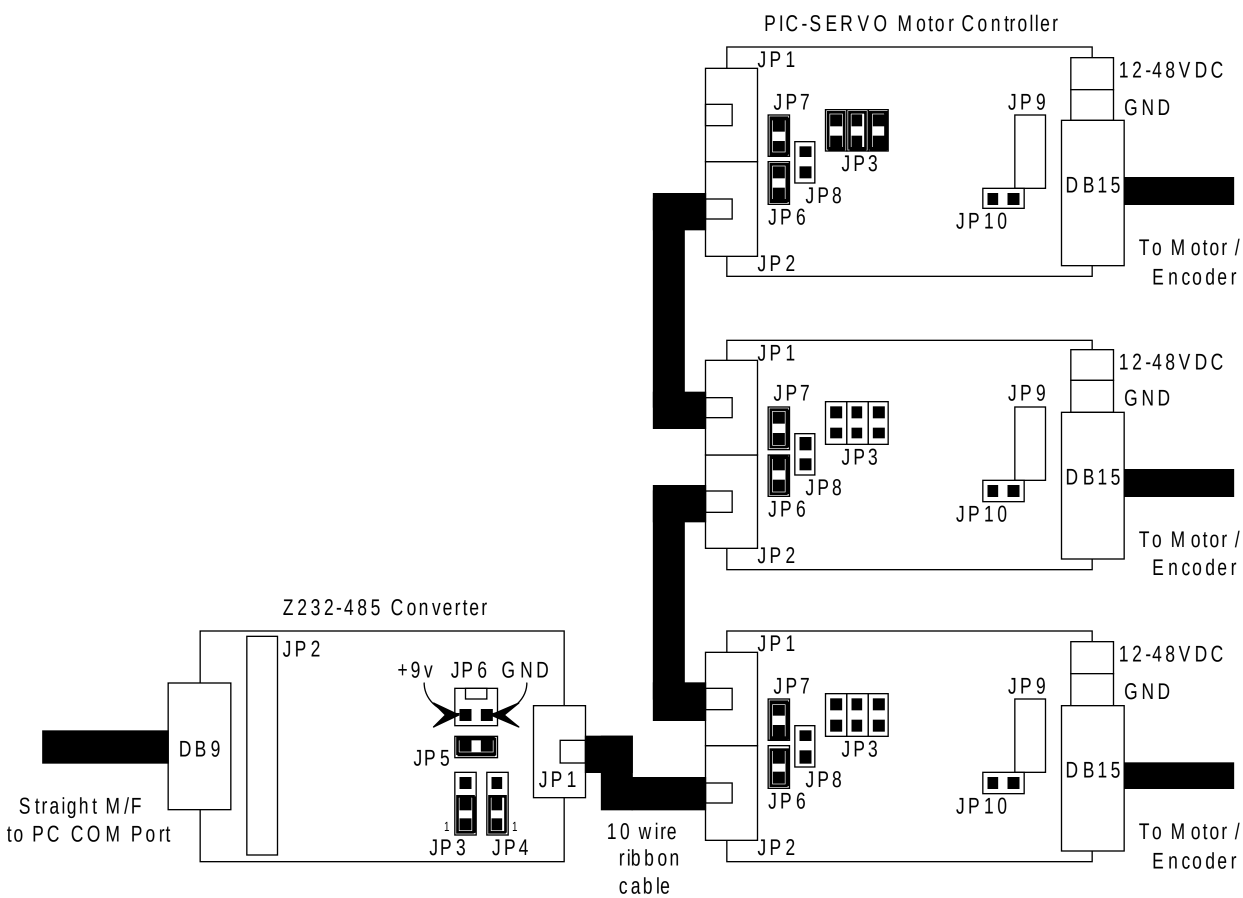


Figure 1 - Basic Interconnections.

2. Connectors and Jumpers

2.1 Pinouts

Motor Connector: ***PIC-SERVO*** Motor Control Board P1

Pin	*Definition*
1	Motor Output (M+)
2	Motor Output (M+)
3	LED power - pulled up to 5v with a 330 ohm resistor (for use with opto-interrupt type switches)
4	Limit Switch 1 (pulled up to 5v with a 4.7k resistor)
5	Encoder Channel A
6	Encoder Channel B
7	Limit Switch 2 (pulled up to 5v with a 4.7k resistor)
8	Encoder Index (pulled up to 5v with a 4.7k resistor)
9	Motor Output (M-)
10	Motor Output (M-)
11	GND
12	GND
13	GND (supplied to encoder)
14	+5v (supplied to encoder)
15	GND

Network Connectors: ***PIC-SERVO*** Motor Control Board JP1, JP2
Z232-485 Converter Board JP1

Pin	*Definition*
1	***PIC-SERVO*** RCV+ (***Z232-485*** XMT+)
2	***PIC-SERVO*** RCV- (***Z232-485*** XMT-)
3	***PIC-SERVO*** XMT+ (***Z232-485*** RCV+)
4	***PIC-SERVO*** XMT- (***Z232-485*** RCV-)
5	***PIC-SERVO*** ADDR_IN on JP1, ADDR_OUT on JP2 (***Z232-485*** N.C.)
6	GND
7	Logic power (7.5 - 12vdc)
8	GND
9	Logic power (7.5 - 12vdc)
10	GND

External Amplifier Connector: ***PIC-SERVO*** Motor Control Board JP9

Pin	*Definition*
1	PWM Output
2	Direction Output
3	Amplifier Enable Output
4	Analog Input (to inverting pre-amplifier - see *Section 3.4*)
5	+5v
6	GND

Motor Power Connector: ***PIC-SERVO*** Motor Control Board Screw Terminals

Pin	*Definition*
1	Motor Power 12 - 48vdc (at edge of board)
2	Motor Power Ground (connected internally to logic ground)

Logic Power Connector: ***Z232-485*** Converter Board JP6

Pin	*Definition*
1	Ground
2	7.5 - 12vdc

Logic Power Connector: ***PIC-SERVO*** Motor Control Board JP8

Pin	*Definition*
1	Ground
2	7.5 - 12vdc

RS232 Connector: ***Z232-485*** Converter Board P1

Pin	*Definition*
1	N.C.
2	XMT
3	RCV
4	N.C.
5	Ground
6	N.C.
7	N.C.
8	N.C.
9	N.C.

SmartCore Socket: ***Z232-485*** Converter Board JP2 - See *Section 4.2* for details

2.2 Jumpers

PIC-SERVO Motor Control Board Jumpers:

Jumper	*Description*
JP3 - 1	Connects ADDR_IN to GND. Insert jumper for the last ***PIC-SERVO*** on the network (or if only 1 ***PIC-SERVO*** is used)
JP3 - 2,3	Enables termination resistors on RX and TX. Insert these jumpers for the last ***PIC-SERVO*** on the network (or if only 1 ***PIC-SERVO*** is used).
JP6,JP7	Logic power interconnection. Inserting JP6 connects logic power to network connector JP2. Inserting JP7 connects logic power to JP1. These are used to control the distribution of logic power over the network cables. Normally both these jumpers are installed.
JP10	Amp Enable pull-down. This jumper supplies a pull-down resistor for external amplifiers requiring one for when motor power is on and logic power is off.

Z232-485 Converter Board Jumpers:

Jumper	*Description*
JP3,JP4	Jumper in the 1-2 position for normal use Jumper in the 2-3 position for use with optional SmartCore Processor
JP5	Logic power interconnection. Inserting JP5 connects logic power to network connector JP1.
JP10	Amp Enable pull-down. This jumper supplies a pull-down resistor for external amplifiers requiring one for when motor power is on and logic power is off.

3. ***PIC-SERVO*** Motor Control Board Description

The ***PIC-SERVO*** Motor Control board is a complete motor servo control system including a servo controller, amplifier, serial communications interface, optical encoder interface, limit switch inputs, and an auxiliary analog input with pre-amplifier. The board is designed so that up to 32 controllers can be connected directly to a single standard serial port (using an RS232-RS485 converter if necessary).

3.1 ***PIC-SERVO*** Chipset

The ***PIC-SERVO*** chipset forms the core of the controller. The ***PIC-ENC*** performs the time critical encoder counting task, while the ***PIC-SERVO*** executes the servo control, the communications interface, and outputs a 20 KHz PWM and Direction signal to the amplifier. Please refer to the ***PIC-SERVO*** datasheet for complete details on the theory of operation of the servo control and motion profiling algorithms. You should also refer to the ***PIC-SERVO*** Programmer's Application Note for details on sending commands and receiving data from the ***PIC-SERVO***.

3.2 Communications Interface

The ***PIC-SERVO*** uses an RS485 multidrop interface for allowing multiple control modules to communicate over the same RS485 communication port. The host computer sends commands out over a dedicated pair of transmit wires, and all data comes back over a shared pair of receive wires. Because the host has a dedicated transmit line, a standard RS232 serial port can be used with simple RS242-RS485 converter.

With multiple controllers on a single network, each controller must have a unique address for sending commands. Rather than using dipswitches or jumpers to assign addresses, the ***PIC-SERVO*** uses a method of daisy-chaining an ADDR_IN signal and an ADDR_OUT signal for dynamically assigning addresses. With the controllers interconnected as shown in *Figure 1*, the ADDR_OUT signal of one board is connected to ADDR_IN of the next board. The very last board has ADDR_IN jumpered to GND. On powerup, all boards with ADDR_IN held high will have their communications disabled. Therefore, only the last board will be able to communicate with a default address of 0.

To initialize the network, a command is sent to the last controller (with address 0) to change its address to a value of 1. This has the side effect of causing its ADDR_OUT to lower, enabling communications with the next controller. The next command sent to address 0 will now be sent to the second-to-last controller. This process of assigning addresses is repeated until all controllers have been given a unique address.

3.3 Amplifier

The ***PIC-SERVO*** Motor Control board uses an LMD18201 H-bridge amplifier to drive DC brush-type motors with up to 3 amps continuously, 6 amps peak, at up to 48v. This amplifier has overcurrent, overtemperature and undervoltage protection. If you are driving more than 500 ma, however, you will likely need to mount a heatsink to the tab of the amplifier. This tab is electrically isolated, so it may also be bolted directly to a metal enclosure.

If greater than 3 amps is required, the ***PIC-SERVO*** Motor Control board can be used with an external amplifier. External amplifiers may be for brush or *brushless* motors. PWM, Direction and enable signals are provided on connector JP9. This connector also has a pin connected to the analog input pre-amplifier for use with amplifiers that have current sense feedback. This feedback can be used by the ***PIC-SERVO*** to prevent the amplifier from latching up in an overcurrent protection mode.

Jumper JP10 connects a pull-down resistor to the amplifier enable pin of the external amplifier connector. This prevents some amplifiers from being enabled when motor power is on but logic power is off. Installation of this jumper may not be necessary with all external amplifiers.

3.4 Analog Input

One of the pins on JP9 is connected to an analog input pre-amplifier. The pre-amplifier consists of a high impedance follower, followed by an inverting amplifier. The potentiometer at the edge of the board, R6, is used to adjust the amplifier offset. The potentiometer inboard, R5, is used to adjust the amplifier gain. The output of this amplifier goes to the A/D input pin of the ***PIC-SERVO*** where it is converted to an 8-bit value. This A/D input can be used as a general purpose analog input, or if connected to the current sense output of an external amplifier, it can be used to limit the amplifier output current. The analog input range is 0 - +5v. Please refer to the schematic diagram in *Figure 2* for amplifier details.

3.5 Physical Dimensions

The ***PIC-SERVO*** Motor Control board is 2.1" x 3.1" with 0.132 " dia. mounting holes at 1.8" x 2.45". The board comes with 0.25" stand-offs, giving it an overall height of 1.15".

4. Z232-485 Serial Port Converter Board Description

4.1 Use as a Simple Converter

With jumpers JP3 and JP4 in the 1-2 position, the Z232-485 board acts as simple converter, changing the RS232 single ended transmit signal into an RS485 differential transmit signal, and converting the RS485 differential receive signal to an RS232 single ended receive signal. Connector P1 connects directly to a 9-pin PC style COM port connector using a straight DB9 male/female extension cable. Connector JP1 connects directly to the ***PIC-SERVO*** board with a 10 pin ribbon cable. Logic power supplied to the board can also be distributed to the controller boards over the communications cable by inserting jumper JP5.

4.2 Use with an Optional SmartCore Processor

Connector JP2 is a socket for using an optional SmartCore processor board from Z-World Engineering. The SmartCore processor is a Z180 microprocessor with program and data memory, a small amount of EEPROM, two serial ports, and a variety of other peripherals. It can be programmed in C using Z-World's Dynamic C development system.

If jumpers JP3 and JP4 on the ***Z232-485*** are installed in the 2-3 position, the RS232 connector will be connected to serial port 0 of the Z180, and the RS485 connector will be connected to serial port 1 of the Z180. In this configuration, the SmartCore can be used as an intelligent command processor between the host and the network of motor controllers. Alternately, the SmartCore could be used as a completely stand-alone controller for the network of motor control modules.

In this configuration, the SmartCore will have to operate the protocol for communication with the ***PIC-SERVO*** controllers, but the communications interface between the SmartCore and the Host can be completely defined by the user. Because the SmartCore is well suited for real-time control and coordination, it can be most effectively used to unburden the host processor from time critical real-time coordination tasks.

The SmartCore processor and the Dynamic C programming environment are available directly from Z-World Engineering (see *Section 5* for contact information).

4.3 High Speed Operation

The ***PIC-SERVO*** can communicate at rates up to 115,200 Baud, but not all PC COM ports can run at this speed. In addition, some processors cannot keep up with high data input rates and may drop characters. Therefore, a COM port which uses a 16550 UART (with a 16 byte buffer) is recommended. Another potential problem is that some COM port RS232 drivers do not have a sufficient signal rise time to operate reliably at 115,200 Baud. A simple hack which may solve this problem is to connect a 2.0K ohm resistor between pins 2 and pin 13 of the MAX232 I.C. (on the ***Z232-485*** converter), effectively providing a boost to the RS232 transmit signal. Please refer to the schematic in *Figure 3* for details.

4.4 Physical Dimensions

The ***Z232-485*** converter board is 2.1" x 3.1" with 0.132 " dia. mounting holes at 1.8" x 2.45". The board comes with 0.25" stand-offs, giving it an overall height of 1.15".

5. Contact Information

Additional information may be found from these sources:

J R Kerr Web Site **http://www.jrkerr.com**
Overview of the ***PIC-SERVO*** and ordering information for the PIC-SERVO chipset and related products. Datasheets, application notes and test code may be downloaded from: "http://www.jrkerr.com/docs.html". Technical support is provided via e-mail. Send your questions to "techsupport@jrkerr.com".

Microchip **http://www.microchip.com**
The ***PIC-SERVO*** is based on the Microchip PIC16C73 microcontroller and the ***PIC-ENC*** is based on the PIC16C54 microcontroller. Please refer to the Microchip data sheets for these devices for complete electrical, timing, dimensional and environmental specifications.

National Semiconductor **http://www.nsc.com**
Datasheet for the LMD18201 PWM amplifiers.

Z-World Engineering **http://www.zworld.com**
Information regarding the Z-World Z180 SmartCore processor and its C code development tools.

Servo Systems **1-800-922-1103**
Their catalog contains a good selection of new and surplus motors, gearheads, encoders and amplifiers.

HdB Electronics **1-800-287-9432**
Distributor of ***PIC-SERVO*** products as well as of other electronic components, accessories and tools. Fax: 1-415-368-1347, Phone (from outside US): 1-415-368-1388.

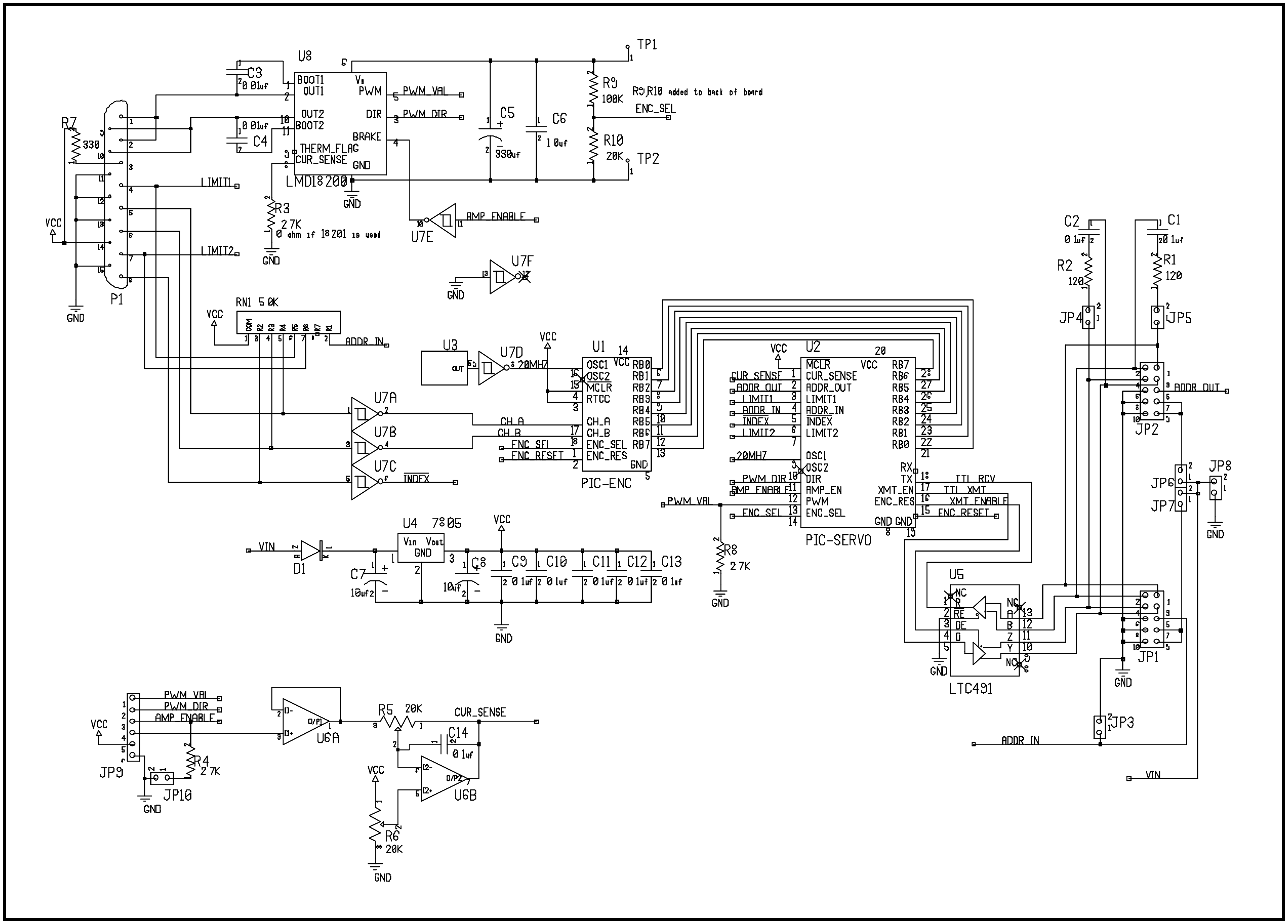


Figure 2 - ***PIC-SERVO*** Motor Control Board Schematic

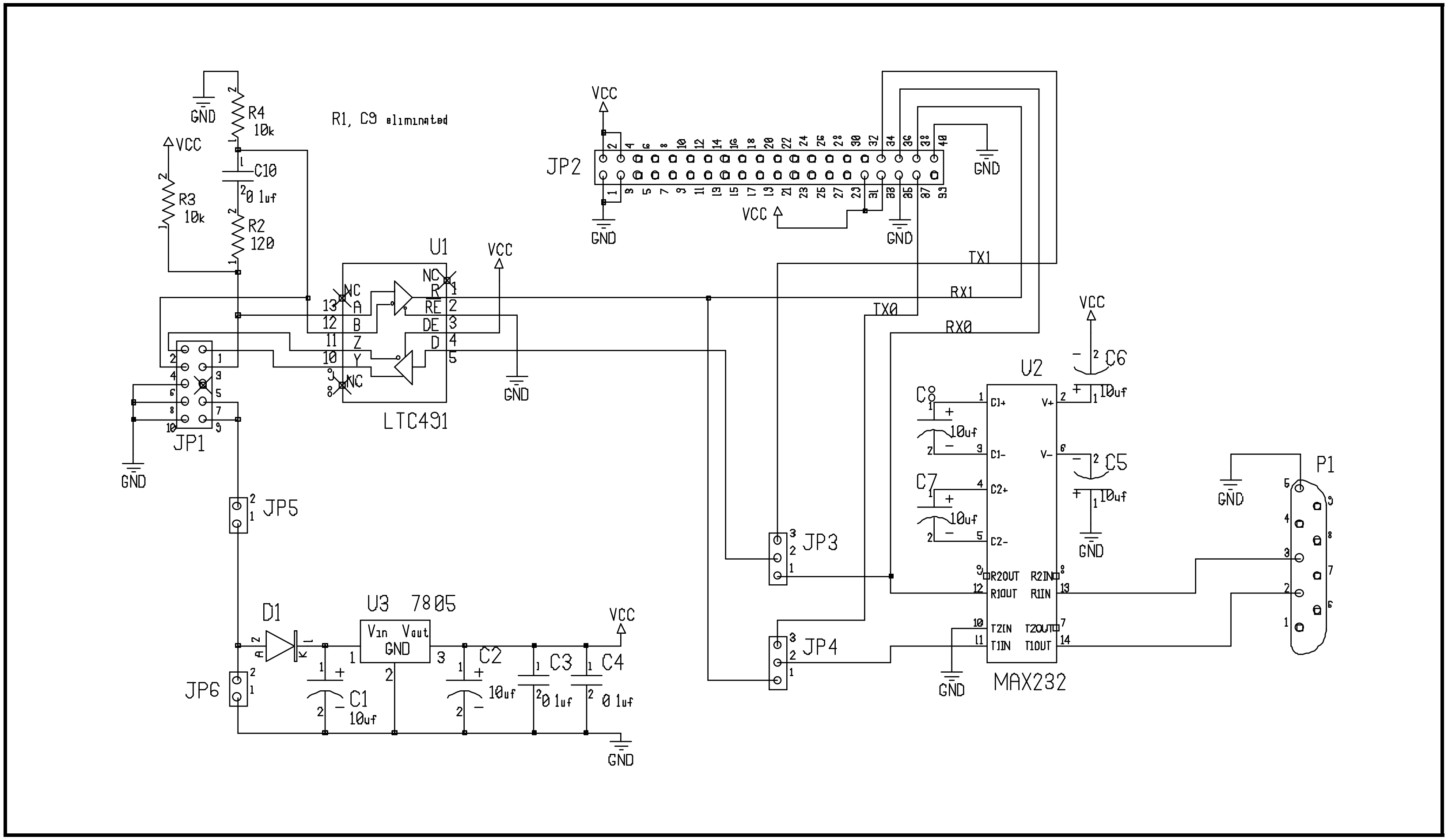


Figure 3 - ***Z232-485*** Converter Board Schematic