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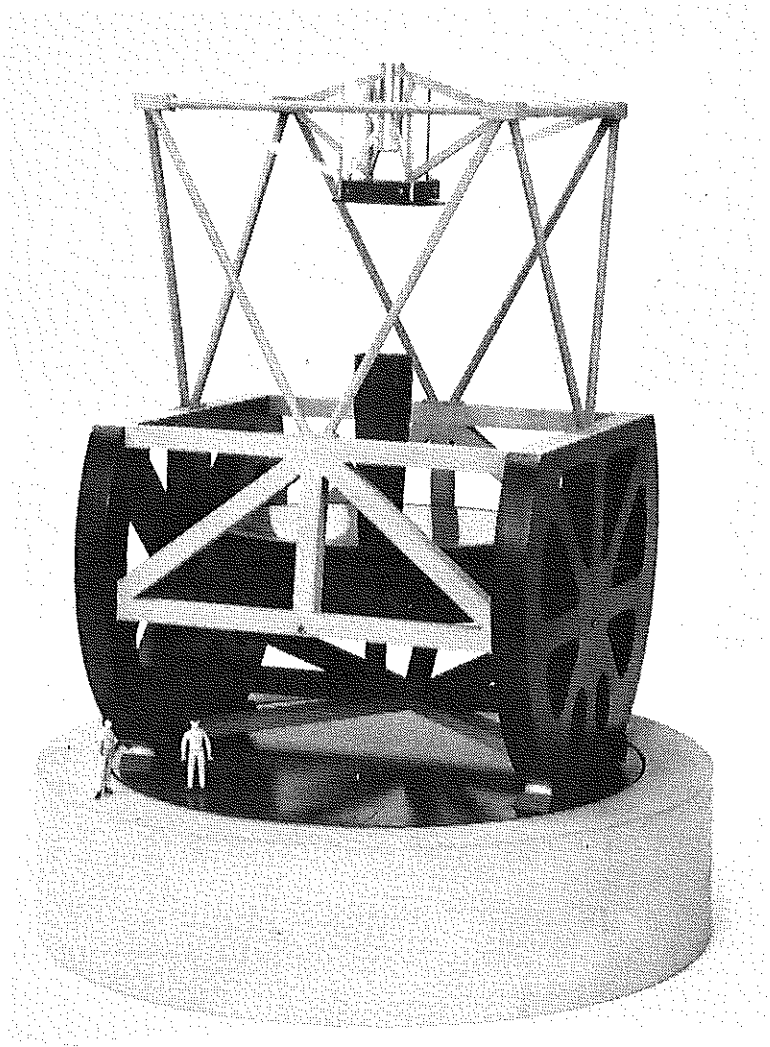

8752 Controller System

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TABLE OF CONTENTS

Subject	Page No.
1. ABSTRACT	1
2. INTRODUCTION	2
3. ABOUT THE INTEL 8752	3
4. 8752 CONTROLLER DESCRIPTION	4
5. SERIAL COMMUNICATIONS	5
6. CONTROL PANEL	6
7. MOTHER BOARD	7

1. ABSTRACT

The 8752 controller board is a small, economic board designed to run motors, lights, relays, read switches, make temperature measurements, etc. It is a device designed to operate and oversee an auxiliary instrument.

The general philosophy is to take the RS-232 communications interface and convert it to the standard of the industry RS-485 that uses a single twisted pair cable. This cable goes to many controllers receiving high level commands from a host control computer. This relieves the host from the time-consuming tasks such as motor control and encoder checking, etc.

The 8752 board is the main link of a complete system composed of the controller, a mother board, special purpose I/O interfaces as needed, and a control panel.

2. INTRODUCTION

There is a need in a modern telescope control system for operating and monitoring a large amount of electro-mechanical equipment with a minimum of signal wires coming from the control computers. The design of the 8752 based controller solves this need in slow to moderate speed control applications.

There are many commercially available controller boards on the market today, but they are complex and expensive. The need of a simpler controller tailored to The Observatory's particular requirements led to the present design.

The minimum 8752 controller system consists of a Central Processing Unit (CPU) board, a card edge connector, and a five volt power supply. To operate motors it needs the proper solid state relays to switch the motor power. For example, this minimum system would be capable of controlling up to eight motors and reading their respective opto-switches giving position information.

The system can be expanded using a mother board and other special purpose boards, i.e. Memory, IO, Control panel, etc. Prototype boards for digital PID (Proportional Integral Derivative) control and general purpose encoder interfacing currently exist.

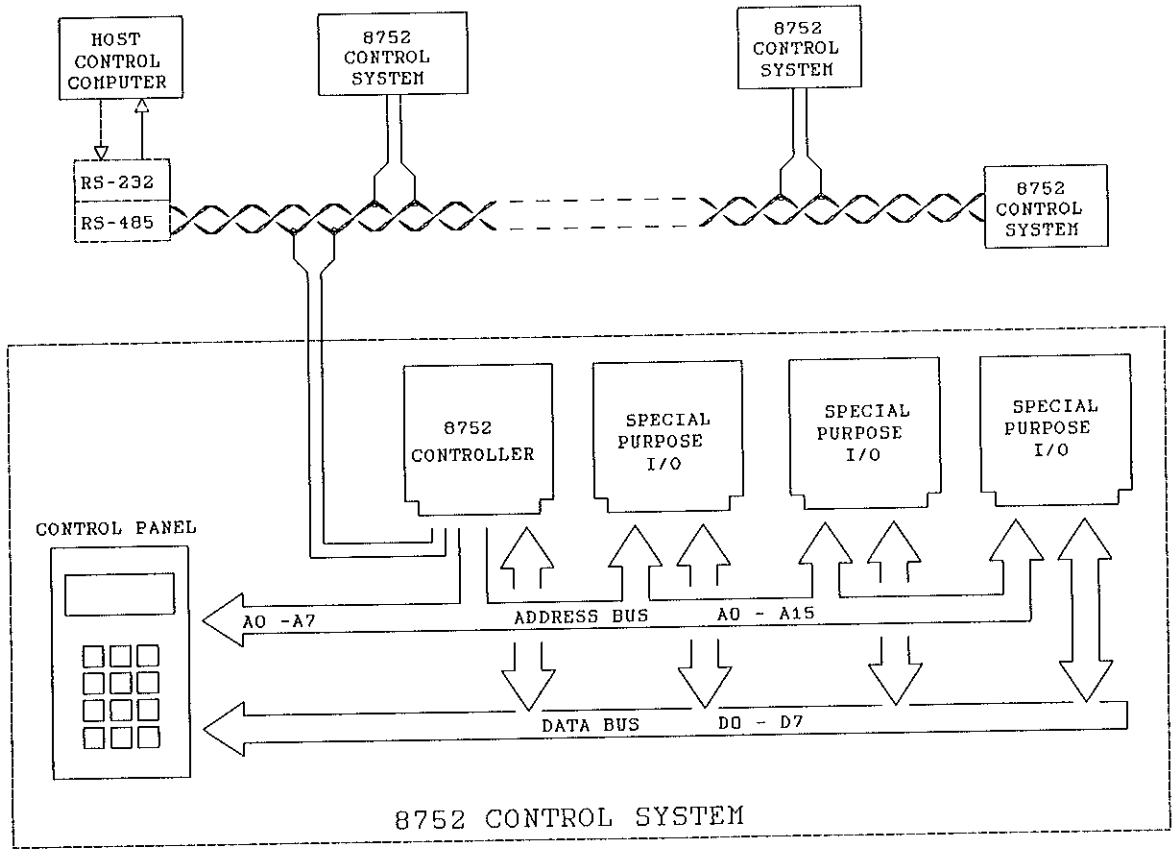

Figure 1: 8752 Based control system

3. ABOUT THE INTEL 8752

The Intel 8051 family of 8 bit microcontrollers have been a proven industry standard for many years. They are now available from a large number of sources in a wide variety of configurations. The part chosen for this controller, but are not limited to, is the D8752BH (referred to as "8752").

The major features of the 8752 are:

8K bytes of on chip program memory
256 bytes of on chip data memory
On chip oscillator
32 I/O lines
64K address space for external data memory
64K address space for external program memory
Three 16-bit timer/counters
Five interrupt sources
Full duplex serial port

The 8752 instruction set contains many boolean type commands that are extremely useful in controller applications. It has a unique and powerful instruction set; it is both bit and byte-oriented which accounts for its unique capability as a controller. This ability to control addressable BITS makes it the ideal processor for controlling contacts, indicators, motors, digital-type on-off IO devices, etc. It also has enhanced arithmetic capability, signed arithmetic, overflow detection, multiply and divide instructions.

Refer to the Intel Microcontroller handbook for a more detailed description of the 8051 family of controllers.

4. 8752 CONTROLLER DESCRIPTION

The 8752 controller is a two layer PC board measuring 4.5 inches square. It runs at a clock speed of 12 mhz, and faster processors are available. The board contains all the logic necessary for serial IO, 8 bit parallel IO, two interrupt lines, and two timer/counter IO lines. Most of the logic for driving the bus line, IO lines and decoding chip selects has been built into a single Altera programmable logic device (PLD). A 72 contact edge connector is used to connect the controller board to the mother board. Three Light Emitting Diodes (LED) on the board show power, and activity of the serial line, transmit and receive. There is a momentary contact switch to reset the system.

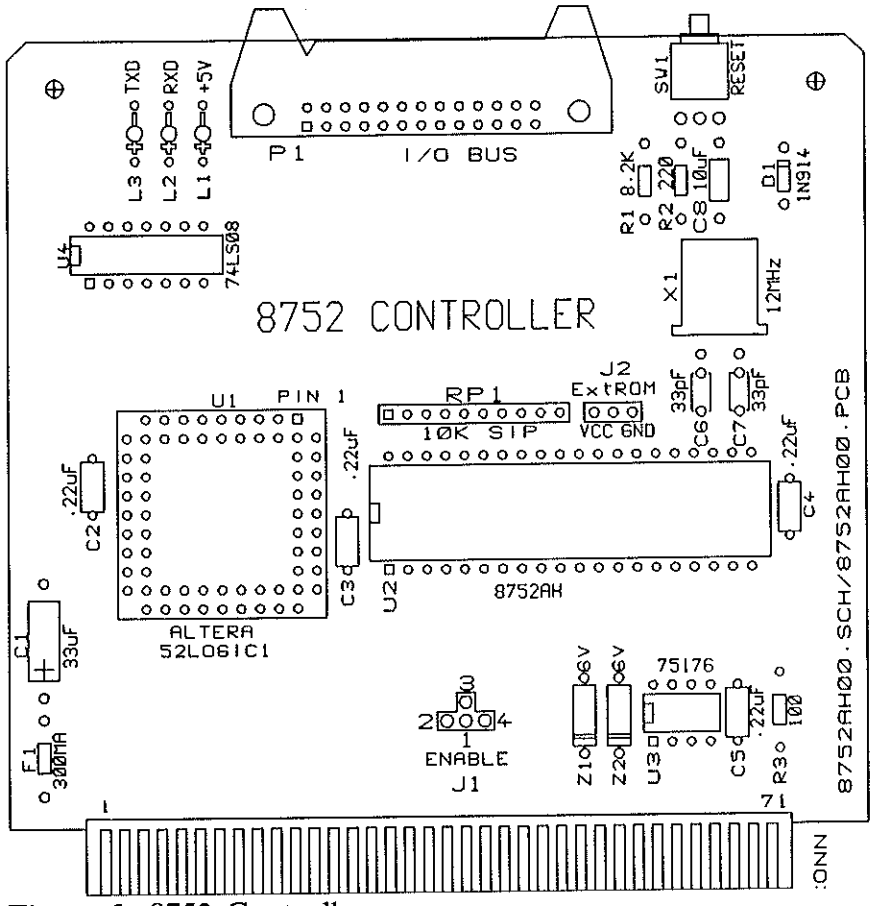

Figure 2: 8752 Controller

The industry has a variety of development systems to write, assemble, link and debug program code for this processor. The fastest way to write control software is in the C programming language. There are routines written in C for the Serial IO, control panel keyboard, and control panel display. The built-in EPROM can hold about 1000 lines of C code. This number will vary greatly depending on the type of code, the functions that are called, and memory model used. As an example of what can be controlled with just the built-in EPROM, the IR CAMERA recently built at The Observatories had six motors, six four bit encoders, and a control panel with approximately 2K of program memory left over.

5. SERIAL COMMUNICATIONS

The 8752 controller system uses the RS-485 serial communications interface for receiving and responding to commands from the host control computer. Because of limits set by the test PCs a 19.2K baud rate is used, although the 8752 system is capable of much faster baud rates. The RS-485 interface allows up to 32 controllers to be connected to a single twisted pair, with distances of up to 4000 ft. and 10 Megabits-per-second. Repeaters can be added to expand this number to a limit set by the addressing scheme of the controller system.

To send commands to a controller the host computer outputs ASCII controller address and command data via the RS-232 port. The RS-232 levels (single ended unbalanced) are converted to RS-485 (balanced differential receivers and drivers) in a small converter box next to the host computer. The controller then returns the appropriate response back to the host computer. The serial transmission format is:

8 bits, 1 stop bit, No parity, 19.2K baud.

The general message format is: PADDD...<CR>

P = prompt character:	
21H through 29H	! " # $ % & ' ( )
3AH through 3BH	: ;
7BH through 7EH	{ | } ~
A = address character:	
30H through 39H	0 through 9
41H through 5AH	A through Z
61H through 7AH	a through z
D = data (any length)	
<CR> = carriage return	

There are 930 possible prompt / address combinations. The prompt character sent by the host computer to the controllers is a dollar sign ($). The prompt character from the controllers to the host computer is an asterisk (*).

Rules of operation:

1. A bottom line controller may transmit a message only in response to a message from a branch computer. This prevents the possibility of messages colliding on the communications line.
2. After a bottom line controller returns a response, (i.e. after a <cr>), the branch computer must wait at least 5 microseconds before transmitting a message. This permits the bottom line controller to remove its transmitter from the communications line.

6. CONTROL PANEL

The purpose of the control panel is to allow local testing of the instrument. The program to communicate with the 8752 controller resides within the 8752 and the host computer has no authority over the control panel. It is connected to the controller through the mother board via a 26 conductor flat ribbon cable. The cable provides the address bus, data bus, and device enable signals.

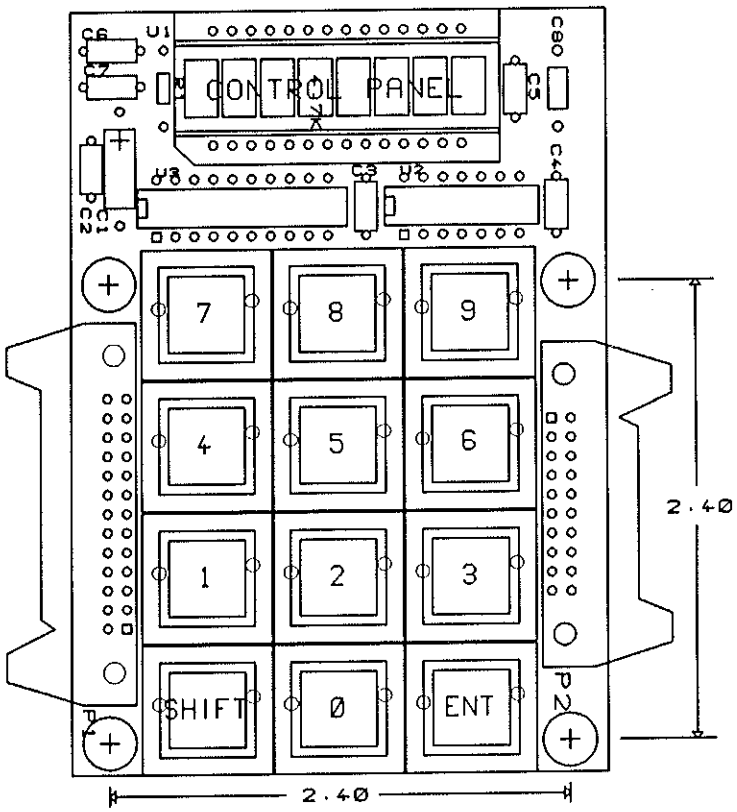

Figure 3: Control Panel for 8752

The control panel as seen on the figure at right has 12 keys, and an eight digit fully alphanumeric 5x7 dot matrix LED display. The display has a 16 character RAM so the 8752 controller can download any special character that can be designed within the 5x7 matrix for each character. Actually any number of characters can be downloaded and used as needed. The total number available at any one time is 16. The functions of the key are dictated by the 8752 program.

The electrical power (5 volts) for the logic to read the keyboard and control the display is provided through the flat ribbon cable connected to connector P1 on the left side. The integrated circuit used to decode the switch matrix allows reading up to 16 switches, so the capability of reading the other four unused switches are read through connector P2 on the right side of the board.

7. MOTHER BOARD

The mother board links the 8752 controller with up to three special purpose I/O cards. This board also has the connectors to communicate with the control panel and the serial RS-485 port for communications with the host computer and/or other 8752 controllers.

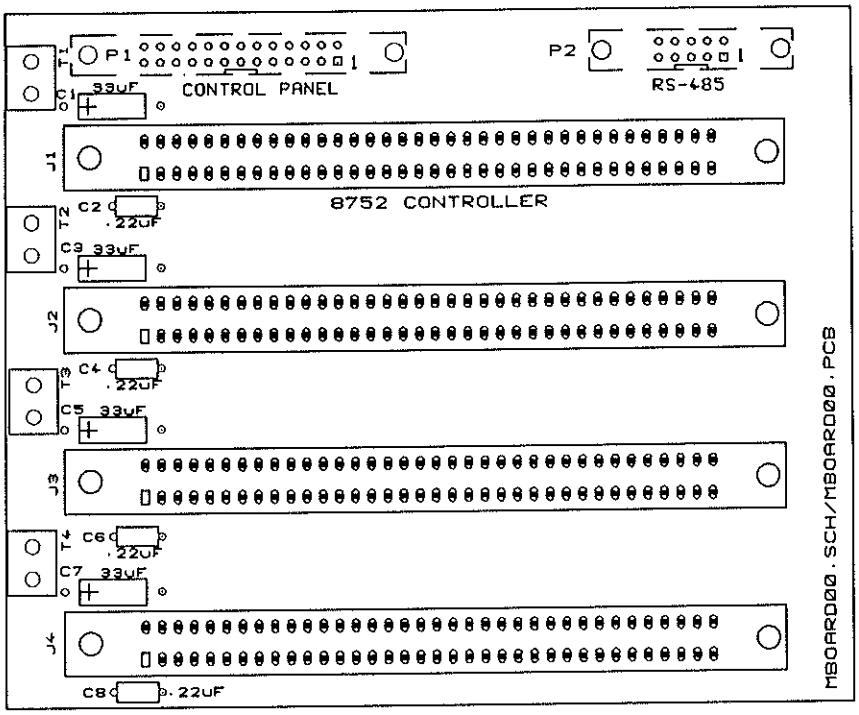

Figure 4: Mother board for 8752 controller

The board has connectors to receive and distribute +5V power to all the cards and other devices or card cages. It is designed to be mounted in a card cage or free standing with individual card guides for each card. It is also designed with the idea of cutting the mother board down if, for example, only two cards are used.

The design allows the RS-485 and Control Panel connectors to be placed on either side of the board. There are filter capacitors on either side of the each card edge connector to filter the +5V supply. No other sources of power are available. If other voltages are needed they can be brought directly through the wire wrap pins using push-on connectors, or using DC-DC converters as needed.