PGSI

Power
Glove
Serial
Interface

by The Student Chapter of The Association for Computing Machinery
at the University of Illinois, Urbana-Champaign campus

The exciting new device bridging the gap between personal computers and Virtual Reality !

Version 1.0

FOREWORD

Welcome to a whole new plateau of computer-user interfacing in purchasing the PowerGlove™ Serial Interface. This interface will increase productivity in the workplace and open a new dimension in the computer entertainment interface arena. This device will also allow the personal computer or workstation user to easily open the door to the new arena of 3-dimensional scientific visualization and virtual reality software.

To ensure that the PGSI provides full and satisfying performance, read this manual carefully before using it. This manual consists of the following eight parts.

Part I - General
Explains the features of your interface and describes the conditions that must be satisfied before installing, for example, the type of power supply and the operating/storing environments.

Part II - Installation Procedures
Provides illustrations and an overview of the components and explains how to set up the interface.

Part III - Operation
Explains how to specify the emulation mode, packet length, and filter settings through software.

Part IV - Function
Explains the functions of the shorting blocks and details the two emulation modes supported by your interface.

Part V - Maintenance
Explains the maintenance procedures such as routine cleaning.

Part VI - Troubleshooting Guide
Describes potential difficulties in installing the PGSI and remedies. See this section first if you encounter problems.

Part VII - Specifications
Lists the detailed interface specifications.

Part VIII - Appendices
Explains how to design programs describes possible incompatibilities with earlier products, and details the history of this manual.

Acknowledgments

Throughout the development of this product, a number of people contributed in its design, development, and manufacture. These people will never receive any monetary compensation for their efforts, so ACM at UIUC wishes to strongly congratulate the following people for their contributions to this produce:

Teresa Johnson, now graduated with a degree in Electrical Engineering, for writing the serial interrupt code used for queued serial data transfer on the PGSI.

Mike Schaffstein, a senior in Computer Engineering, who chaired the group that spawned this project, helped construct prototypes, and served as liaison between the design team and the ACM general membership.

Chris Wilson, now graduated with a degree in Computer Science, who both tested versions of the code in the prototypes and wrote initial demonstration programs.

Ben Gross, a sophomore in Liberal Arts and Sciences, who proposed the initial project, served as liaison between the design team and the original PGSA designers, and headed up the development team.

Laura Kalman, now graduated with a degree in Electrical Engineering, who served as member-at-large with the development team and provided ideas and scope to the design.

Mike Stangel, a senior in Computer Engineering and Chair of ACM at UIUC, who utilized every opportunity to publicize the product and set tentative timetables for development.

Greg Newby, an assistant professor in the Graduate College of Lbrary and Information Sciences, who served as liaison between Ben Gross and the original PGSA designers (AGE), proposed the initial project to Ben, and shaped the design and manufacture of the PGSI.

Jay Kreibich, a sophomore in Computer Science, who designed the impressive cover art and sticker art.

Jim Brain, a senior in Computer Engineering and PGSI head designer, who spent the past year designing the hardware and software that now comprises the Power Glove Serial Interface (PGSI).

There are many more, such as those on the Internet, whom I should thank, for helping me and being patient through the entire production process.

Table of Contents

Table of Contents continued . . .

Part I-General

1. Features

1.1 The PowerGlove™ Interface System

The PowerGlove™ interface system allows the personal computer user to easily gather 3-dimensional input from the user's hand position and use it as a replacement for other input devices such as light pens, mice, touch screens, and trackballs. It also allows the user to use popular LCD shutter glasses as a means to provide the perception of a 3-dimensional video output device. The PowerGlove™ Serial Interface (PGSI) provides this functionality to users at a low cost, and uses available technologies to bring virtual reality to those without corporate budgets. It has many advantages over other devices currently on the market, including:

- The system can be purchased fully assembled upon delivery. This allows users with no hardware knowledge and users lacking confidence in their soldering skills to enjoy the use of a PowerGlove™ and LCD Shutter Glasses.

- The system is fast. Averaging 23 frames per second, it can keep up with today's faster processor speeds.

- The system requires no CPU time when it is gathering data. It only requires CPU clock cycles when data is read in from the interface.

- The system is compatible with many existing standards. Thus, it will easily work with software written for earlier technologies

- The system lends itself well to cross-platform applications. Since the interface is standardized and uses the EIA-232D specification for communications, minimal programming is needed to convert a program from one system to another.

1.2 Flexible Power Requirements

Your PowerGlove™ Serial Interface comes standard without a power supply due to the relative commonality of small "brick-style" power supplies used to power many small computer peripherals. The PGSI is designed to handle a wide variety of power supplies made for other uses. It will work with any power supply generating at least 6 volts AC or DC but not more than 28 volts AC or DC. The power supply can be set to either positive polarity or negative polarity, so the user need not worry whether the positive pin of the power supply matches the positive pin of the PGSI. The system will also work off battery power, so portable operation is possible.

1.3 Useful Options

Your interface comes standard without a power supply, so users may opt to purchase one with the system. This will eliminate the need to purchase a supply after receiving the unit, or to find a compatible supply from existing units.

Macintosh users can use the interface with the purchase of a small cable that converts the 8 pin mini-DIN modem connector on the back of Macintosh computers to the standard 25 pin DB-style connector on the PGSI.

A power supply adapter can be purchased to allow use of a power supply with a small coaxial plug to power the PGSI.

Users who cannot find the Nintendo© PowerGlove™ can purchase them to allow operation of the PGSI.

Users who cannot find a suitable pair of LCD shutter glasses may purchase them to enhance the operation of the PGSI from 3D TV (address listed in Appendix D).

1.4 Easy Setup

The PowerGlove™ Serial Interface can be attached to a personal computer in a matter of minutes with no hand tools. Just plug the unit into the adapter cable (if needed), plug the Nintendo© PowerGlove™ into the PGSI, plug the LCD shutter glasses into the PGSI (if needed), and plug the adapter cable into the serial port on the host computer.

2. Installation Requirements

Before using the PowerGlove™ Serial Interface, make sure that all of the following requirements are satisfied.

2.1 Power Supply

- Use a power supply generating at least 6 volts DC but not more than 35 volts DC at a maximum amperage of 1 Ampere, or use a power supply generating at least 4 volts AC but not more than 28 volts AC at a maximum amperage of 1 Ampere.

- Use a power supply terminated with a 1/8" (2.5mm) mono audio plug or use an adapter that provides the power supply with that style of connector.

- Always turn off power to the PGSI unit when not using it by unplugging the power supply from the line voltage first, then unplug it from the PGSI unit. Never unplug the power from the PGSI while the unit is still operational.

2.2 Communications Port

The host computer must be equipped with a standard EIA-232 port, commonly referred to as RS-232. Most IBM compatible computers and Amiga systems come equipped with at least one such communication port. Workstations such as the Silicon Graphics Personal Iris and Sun SPARCstation also come equipped with an RS-232 port. However, users of Apple Macintosh computers do not readily have access to a standard RS-232 port. This can be alleviated by purchasing a Macintosh Modem to RS-232 adapter cable. The PGSI can be plugged into this cable, and the cable can then be plugged into the Macintosh computer to allow operation of the PGSI.

2.3 Operating and Storing Environment

- Use the interface with the following temperature and humidity ranges.

Ambient temperature:	5° C to 35° C (41° F to 95° F)
Ambient humidity:	10% to 90% RH (no condensation)

- When installed near a window, put up a blind or curtain to protect the interface from sunlight.

- Do not leave the interface in automobiles because the temperature can suddenly rise there.

- Do not install the interface near devices which contain magnets or generate magnetic fields.

- Do not subject the interface to strong physical shock or vibration.

- Do not place objects on top of the interface.

Part II-Installation Procedure

1. Setup

1.1 Interface Components

Make sure the following parts are included in the packing box upon shipment:

a. One (1) PowerGlove™ Serial Interface
b. One (1) User's Manual

1.2 Installing the Interface

Install the interface according to the following procedure:

- Remove all packing material from the interface.
- Plug all adapter cabling into the DB-25 style RS-232 connector on the interface.
- Plug the Nintendo© PowerGlove™ into the interface.
- Plug the LCD shutter glasses (if available) into the interface.
- Plug the power supply into the interface.
- Make sure the host computer system is shut off.
- Attach either the PGSI or the adapter cabling to the host computer.
- Turn on the host computer.
- Plug the power supply into an outlet.

1.3 Parts and Controls

The PowerGlove™ Serial Interface has a minimum of parts (1) and employs no switches or other controls physically on the interface. There are a number of jumper pads which determine PGSI functionality available for user switching on the component side of the main circuit board.

2. Attaching the PowerGlove™

The PowerGlove™ comes standard with a 9 pin proprietary connector with which to connect it to the Nintendo© Entertainment System. This is NOT the same as the 9 pin D-subminature connector used to connect the physical glove to the L-bar receiver bracket. This non-standard connector mates with a connector attached to a wire coming out of the interface.

3. Attaching the LCD shutter glasses

The LCD shutter glasses come in many different shapes and sizes, ranging from the small element SEGA© glasses to the much improved (optically and physically) Toshiba© glasses to some wireless models offered on the market. Any pair of glasses that follows the SEGA© design in physical connections will work with the interface. Just plug the glasses into the 3.5 mm port on the side of the interface (the larger of the two ports).

4. Turning the Power On/Off

For cost reasons, the PowerGlove™ Serial Interface does not have an on/off switch located on the outside of the unit. Continuous operation of the interface is perfectly safe, but should the need arise to turn the unit off arise, please follow these simple steps:

- Unplug the power supply from the outlet.
- Disconnect the power supply from the interface.

Do not reverse the order, or damage to the interface may result!

Part III-Operation

1. Start up Message

The PowerGlove™ Serial Interface, upon powering up, outputs a small identification message through to the serial port of the interface. Any computer capable of reading information off the serial line will see this message, subject to change:

```
The PowerGlove Serial Interface:  1993 by the Student Chapter of ACM at UIUC
Contact:      ACM at UIUC, 1304 W. Springfield #1225, Urbana, IL   61801.
Designer:     Jim Brain, pgsi@uiuc.edu
Copyright:    Portions AGE Inc. 1987-90, Unlawful to reproduce
Model Number: 6682657378-2
Code Version:  1.1
Serial No#:  XXXXXXXX
```

2. Software Command Set

2.1 Emulation Mode

The PowerGlove™ Serial Interface is capable of emulating two very important earlier technologies in PowerGlove™ computer interfaces. The first, called AGE emulation, is so-named for the originators of the design of the Nintendo© PowerGlove™. AGE produced an interface box similar in function to this interface, called the PowerGlove™ Serial Adapter, with a limited production run. This interface contains portions of the code originally found in the PGSI, so that the emulation process would be unnoticeable to the end user. In addition to providing full AGE emulation, the PGSI also provides the emulation of a popular kit-based interface designed by Ron Menelli. Since major portions of Ron Menelli's code was used in a highly modified form to create this interface, users are encouraged to seek out the information pertaining to this design and look over the source code used to create the kit-form interface.

The PGSI transmits information through the RS-232 port in packets, which can be of different lengths depending on which emulation mode is in effect. Table 3.2.1, 3.2.2, and 3.2.3 describe the standard location and standard length of each field in each of the three packet types. Note that Menelli emulation has two distinct sizes for the packet, depending on which mode (continuous/request) the interface is in.

Below is description of some of the functions available to the user. They are also listed in Table 3.2.20

Position in Packet	Name	Description	Range
00	Header	Signals Start of Packet	0xA0
01	X	X-direction reading	-128 to 127
02	Y	Y-direction reading	-128 to 127
03	Z	Z-direction reading	-128 to 127
04	Rotation	Gives rotation value in 30 degree increments	0 to 11
05	Flex	Gives position of thumb and first three fingers (See Table 2.5)	(See Table 3.2.4)
06	Switch	Gives key codes	0 to 255

Table 3.2.1 - Packet Description in Menelli Emulation/Continuous mode

Position in Packet	Name	Description	Range
00	X	X-direction reading	-128 to 127
01	Y	Y-direction reading	-128 to 127
02	Z	Z-direction reading	-128 to 127
03	Rotation	Gives rotation value in 30 degree increments	0 to 11
04	Flex	Gives position of thumb and first three fingers (See Table 2.5)	(See Table 3.2.4)
05	Switch	Gives key codes	0 to 255

Table 3.2.2 - Packet Description in Menelli Emulation/Request mode

Position in Packet	Name	Description	Range
00	Header	Signals Start of Packet	0x5F
01	Header	Signals Start of Packet	0x5F
02	X	X-direction reading	-128 to 127
03	Y	Y-direction reading	-128 to 127
04	Z	Z-direction reading	-128 to 127
05	Rotation	Gives rotation value in 30 degree increments	0 to 11
06	Flex	Gives position of thumb and first three fingers (See Table 3.2.4)	(See Table 2.5)
07	Switch	Gives key codes	0 to 255
08	GSTAT1	General Status 1	0- if fingers out 1- if fingers in
09	GSTAT2	General Status 2	0
10	RECVALS	Receiver Values (See Table 3.2.6)	0 - 0x3F

Table 3.2.3 - Packet Description in AGE Emulation/both modes

Bits in byte	Description
7:6	2 bit representation for thumb - (See Table 3.2.5)
5:4	2 bit representation for first finger - (See Table 3.2.5)
3:2	2 bit representation for second finger - (See Table 3.2.5)
1:0	2 bit representation for third finger - (See Table 3.2.5)

Table 3.2.4 - Bit representations for Flex byte

Bit Pair - X:X-1	Description
00	fully extended
01	partially extended
10	partially closed
11	fully closed

Table 3.2.5 - Bit Pair Descriptions

Bit Pair	Description
7:6	Not Used
5	Left Top Receiving Left Transmitter (See Table 3.2.7)
4	Right Bottom Receiving Left Transmitter (See Table 3.2.7)
3	Right Top Receiving Left Transmitter (See Table 3.2.7)
2	Left Top Receiving Right Transmitter (See Table 3.2.7)
1	Right Bottom Receiving Right Transmitter (See Table 3.2.7)
0	Right Top Receiving Right Transmitter (See Table 3.2.7)

Table 3.2.6 - Bit Pair Representations in RECVALS byte

Bit Value	Meaning
0	No reception of transmitted signal
1	Reception of transmitted signal

Table 3.2.7 - Receiver Values

2.2 Continuous/Request Mode

The PowerGlove™ Serial Interface can be placed into one of two modes for information retrieval. The first, called continuous mode, implies that the interface will send a new packet of information from the PowerGlove™ as soon as that information is received. The other mode, known as request mode, allows the users to dictate when a new packet is received by the host computer. The latter mode is recommended as the most efficient for information retrieval. The programmer knows exactly when the packet will be sent without needing to wait for a present packet to finish. There are four commands to set the PGSI's mode, two for AGE emulation and two for Menelli emulation. Since the emulation mode dictates the type and length of packets sent to the host computer, these commands implicitly switch emulation modes to send the correct type of packet. There is no way to change the emulation mode explicitly, and these commands are 2 of 4 that have the ability to switch emulation modes. This makes it possible to use Menelli emulation commands while in AGE mode, or (more likely) use AGE commands while in Menelli emulation mode. Although this complicates matters somewhat, it should not pose a problem to users who stick to one command set or the other.

A full listing of the commands for both command sets is given in Table 3.2.20.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x01	none	Place interface in continuous mode	AGE
0x02	none	Place interface in request mode	AGE
0x43	'C'	Place interface in continuous mode	Menelli
0x52	'R'	Place interface in request mode	Menelli

Table 3.2.8 - Continuous/Request mode commands

2.3 Rotation Filter On/Off

The AGE specification included a command to turn on and off the internal rotation value filter. This is useful while in noisy situations or for those who have earlier versions of the Nintendo© PowerGlove™ which did not have an internal rotation filter.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x08	none	Turn rotation filter on	AGE/Menelli
0x09	none	Turn rotation filter off	AGE/Menelli

Table 3.2.9 - Rotation Filter mode commands

2.4 Hysterisis Filter On/Off

The Menelli specification contains a hysterisis deglitching filter written by Dave Stampe. This has been preserved in the emulation and can be accessed from either emulation mode. It is recommended for those situations involving high noise levels or reflective surfaces behind the receivers.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x2B	'+'	Turn hysterisis deglitching on	AGE/Menelli
0x2D	'-'	Turn hysterisis deglitching off	AGE/Menelli

Table 3.2.10 - Continuous/Request mode commands

2.5 PowerGlove™ On/Off

It is possible to turn off the PowerGlove™ and not read data from it. This may be useful in situations where PowerGlove™ input is not needed in a program, but other aspects of the interface are being used to their maximum capacity.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x0A	none	Turn PowerGlove™ on for input	AGE/Menelli
0x0B	none	Turn PowerGlove™ off for input	AGE/Menelli

Table 3.2.11 - PowerGlove™ On/Off commands

2.6 LCD Lenses On/Off

It is possible, if the PGSI is properly set up, to control the LCD shutter glasses through software, completely eliminating the need for hardware I/O availability from the host computer. However, the user is warned that this method is not as fast as controlling the glasses via digital I/O. Nonetheless, some users may not have access to this hardware I/O or may not be skilled enough to exploit this feature on a particular computer system, so these commands were added to insure complete compatibility with all type of personal computer systems. There are a variety of these commands for the programmer to use in controlling the LCD shutter glasses.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x14	none	Turn left lens dark, leave right lens in current state	AGE/Menelli
0x15	none	Turn left lens clear, leave right lens in current state	AGE/Menelli
0x16	none	Turn right lens dark, leave left lens in current state	AGE/Menelli
0x17	none	Turn right lens clear, leave left lens in current state	AGE/Menelli
0x18	none	Turn both lenses dark	AGE/Menelli
0x19	none	Turn both lenses clear	AGE/Menelli
0x1A	none	Turn left lens dark and right lens clear	AGE/Menelli
0x1B	none	Turn left lens clear and right lens dark	AGE/Menelli
0x1D	none	Change chopping frequency of LCD lens driver circuitry, range: 16Hz to 5kHz.	AGE/Menelli

Table 3.2.12 - LCD shutter glasses commands

2.7 Packet Requests

When the PGSI is in request mode, the user or programmer must explicitly request a packet to be sent. The following commands can be used. Note that the AGE command to request a packet is the same as that used to put the system into AGE request mode. This means that each time you put the PGSI into AGE request mode, it will send out a packet of information. Also note that each request command implicitly changes the emulation mode to fit the command.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x02	none	Request a packet in AGE emulation	AGE
0x3F	'?'	Request a packet in Menelli emulation (Note that this has no effect if PGSI is in continuous mode for either emulation)	Menelli

Table 3.2.13 - Packet Request commands

2.8 Baud Rate Changes

The PGSI is equipped to handle a wide variety of baud rates. Although this command is not overly beneficial to users of version I PowerGlove™ Serial Interfaces, revision II users will find this beneficial for high speed serial data transfer. This is a two byte command, requiring the user or programmer to send two values to the PGSI. The first is the command while the second determines the new baud rate. The PGSI will not accept any other commands until both bytes have been transmitted.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x1C, 0x01-0x08	none	Change baud rate to value specified after command byte. See Table 3.2.15 for values.	AGE/Menelli

Table 3.2.14 - Baud Rate Change command

Secondary Code (in HEX)	Secondary Code (in ASCII)	Description	Emulation Available in
0x01	none	9600 bps data transfer rate	AGE/Menelli
0x02	none	4800 bps data transfer rate	AGE/Menelli
0x03	none	2400 bps data transfer rate	AGE/Menelli
0x04	none	1200 bps data transfer rate	AGE/Menelli
0x05	none	0600 bps data transfer rate	AGE/Menelli
0x06	none	0300 bps data transfer rate	AGE/Menelli
0x07	none	0150 bps data transfer rate	AGE/Menelli
0x08	none	0075 bps data transfer rate	AGE/Menelli

Table 3.2.15a - Baud Rate Change secondary command code (Revision I PGSI)

Secondary Code (in HEX)	Secondary Code (in ASCII)	Description	Emulation Available in
0x01	none	38400 bps data transfer rate	AGE/Menelli
0x02	none	19200 bps data transfer rate	AGE/Menelli
0x03	none	09600 bps data transfer rate	AGE/Menelli
0x04	none	04800 bps data transfer rate	AGE/Menelli
0x05	none	02400 bps data transfer rate	AGE/Menelli
0x06	none	01200 bps data transfer rate	AGE/Menelli
0x07	none	00600 bps data transfer rate	AGE/Menelli
0x08	none	00300 bps data transfer rate	AGE/Menelli

Table 3.2.15b - Baud rate change secondary command code (Revision II PGSI)

2.9 Resetting the PGSI

The PGSI is designed to be completely software programmable, but there are some instances where a reset is beneficial. First, programmers and users are encouraged to initialize the PGSI via reset whenever launching a program. Second, extensive configuring may result in a inoperable unit. For these reasons and to adhere to AGE specifications, the following reset commands are available. Note that the second reset command implicitly changes the emulation to AGE emulation.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x04	none	This command resends the default initialization packet to the PowerGlove™.	AGE/Menelli
0x07	none	This commands resets the PGSI to the following parameters: Emulation: AGE Rotation Filter: On Deglitching Filter: On	AGE/Menelli

Table 3.2.16 - Reset commands

2.10 Digital Input

The PGSI, with the addition of an external I/O cable, is able to provide 8 bits of buffered digital TTL level input. This information is tacked on to the end of the data packet and appears as the last byte in the packet. Note that this is available in both emulations and increases the packet length.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x0E	none	Turn on digital inputs	AGE/Mcnclli
0x0F	none	Turn off digital inputs	AGE/Mcnclli

Table 3.2.17 - Digital Input Selection commands

2.11 Analog to Digital Inputs

The PGSI, with the addition of an external I/O cable, is able to provide 8 channels of 8 bit analog-to-digital conversion at sustained rates of up to 4000 Hz. However, current serial speeds limit this number. The A/D inputs are grouped into 2 meta-channels of 4 channels each. These can be read independently of one another or together. It is possible to read the 2nd meta-channel without reading the first. Note that this command works in both emulations and increases the packet length by a number determined by the number of meta-channels activated.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x10	none	Turn on first 4 channels of A/D	AGE/Mcnclli
0x11	none	Turn off first 4 channels of A/D	AGE/Mcnclli
0x12	none	Turn on second 4 channels of A/D	AGE/Mcnclli
0x13	none	Turn off second 4 channels of A/D	AGE/Mcnclli

Table 3.2.18 - Analog-to-Digital Input Selection commands

2.12 Digital Output

The PGSI, with the addition of an external I/O cable, is able to output 8 channels of digital TTL level output. The command to do this is a two byte command, the first byte being the command and the second being the value to place on the output port. Note that this works in both emulations and it is only possible to out all 8 channels at one time.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x1E,0x00-0xFF	none	Output digital data to output port (Second byte is value to output)	AGE/Mcnclli

Table 3.2.19 - Digital Output Selection commands

2.13 Glove Sampling Rate Changes

In the event that the PGSI user wishes to change the sampling rate of the glove for any reason, the PGSI can accommodate this change via a command sequence. The following command, followed by two bytes, will change the number of microseconds between samples. This is set at startup to be 43,768 microseconds, or 23 times a second. The two bytes following the command represent a two-byte unsigned integer, given low byte first, which indicates the new sampling time in microseconds.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x1F	none	Change to new sampling rate for glove	AGE/Mcnelli

2.14 LCD Shutter Glasses Square Wave Period Changes

The on-board generation of the AC voltage used to power the LCD shutter glasses can accommodate many different types of LCD shutter glasses. Should the manufacturer suggest anything other than a 400 hertz AC voltage to drive the LCD elements, this command can be used to change the period of the square wave generator. It is followed by a two-byte word, low byte first, which represents the new half-period of the square wave in microseconds.

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x1D	none	Changes the square wave period	AGE/Mcnelli

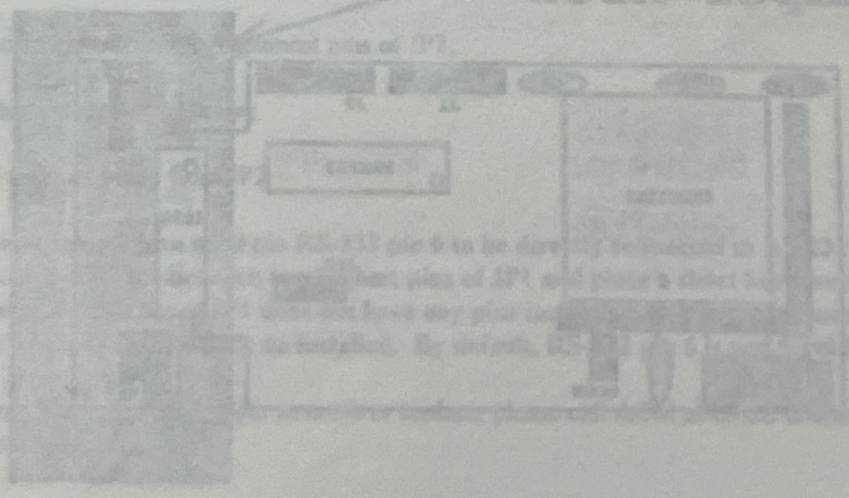
2.15 Command Set Overview

The following commands are available to the user of the PGSI through the RS-232 serial port:

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x01	none	Place interface in continuous mode	AGE
0x02	none	Place interface in request mode/request packet	AGE
0x04	none	Resend default initialization packet to the PowerGlove™	AGE/Menelli
0x05	none	not implemented	AGE/Menelli
0x06	none	not implemented	AGE/Menelli
0x07	none	Reset PowerGlove™ and PGSI to default configuration	AGE/Menelli
0x08	none	Turn rotation filter on	AGE/Menelli
0x09	none	Turn rotation filter off	AGE/Menelli
0x0A	none	Turn PowerGlove™ on for input	AGE/Menelli
0x0B	none	Turn PowerGlove™ off for input	AGE/Menelli
0x0C	none	not implemented	AGE/Menelli
0x0D	none	not implemented	AGE/Menelli
0x0E	none	Turn on digital inputs	AGE/Menelli
0x0F	none	Turn off digital inputs	AGE/Menelli
0x10	none	Turn on first 4 channels of A/D	AGE/Menelli
0x11	none	Turn off first 4 channels of A/D	AGE/Menelli
0x12	none	Turn on second 4 channels of A/D	AGE/Menelli
0x13	none	Turn off second 4 channels of A/D	AGE/Menelli
0x14	none	Turn left lens dark, leave right lens in current state	AGE/Menelli
0x15	none	Turn left lens clear, leave right lens in current state	AGE/Menelli
0x16	none	Turn right lens dark, leave left lens in current state	AGE/Menelli
0x17	none	Turn right lens clear, leave left lens in current state	AGE/Menelli
0x18	none	Turn both lenses dark	AGE/Menelli
0x19	none	Turn both lenses clear	AGE/Menelli
0x1A	none	Turn left lens dark and right lens clear	AGE/Menelli
0x1B	none	Turn left lens clear and right lens dark	AGE/Menelli
0x1C,0x01-0x08	none	Change baud rate to value specified after command byte	AGE/Menelli
0x1D	none	Change chopping frequency of LCD lens driver circuitry, range: 16Hz to 5kHz.	AGE/Menelli
0x1E,0x00-0xFF	none	Send digital data to output port (Second byte is value to send)	AGE/Menelli
0x1F	none	Change to new sampling rate for glove	AGE/Menelli
0x2B	'+'	Turn hysterisis deglitching on	AGE/Menelli
0x2D	'-'	Turn hysterisis deglitching off	AGE/Menelli
0x3F	'?'	Request a packet in Menelli emulation	Menelli
0x43	'C'	Place interface in continuous mode	Menelli
0x52	'R'	Place interface in request mode	Menelli

Table 3.2.20 - Command Set overview

Part IV-Function



1. Customizing the Interface

Since the PGSI has many configurations. Depending on what the user wishes to accomplish with it, the interface has a small group of shorting jumper pads located inside the case on the main circuit board. These can be fitted with jumper pins, or the user can make jumpers out of small wires. The jumpers are presorted using traces upon arrival, but the user has the ability to try out different settings.

1.1 Shorting Jumper Settings

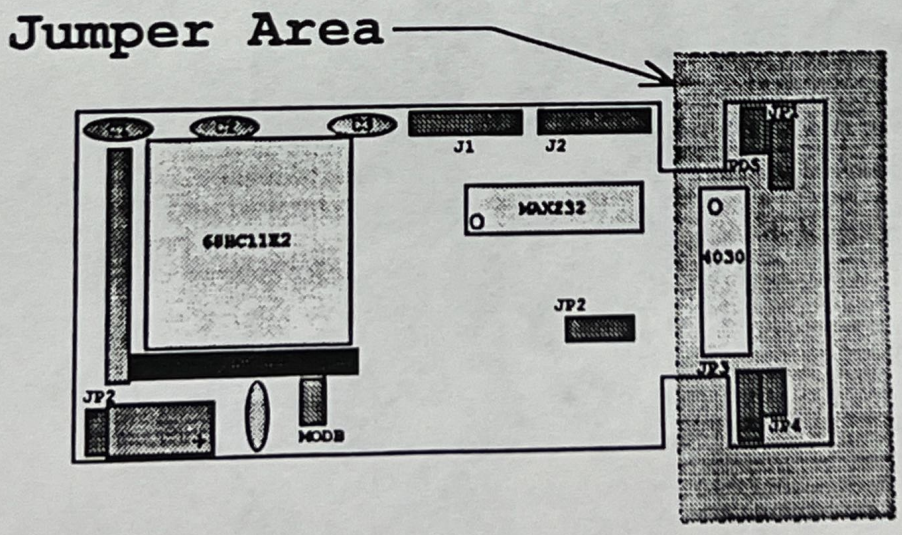
The device arrives configured for the following functions:

PowerGlove™ activated
LCD shutter glasses two line driver
Internal LCD lens voltage generation

1.2 Shorting Jumper Functions

Shorting jumpers provide the PGSI with a convenient way to change options that are semi-permanent, meaning that these options do not need to be changed on a daily basis. They may be changed with a hardware upgrade, purchase of new software, or purchase of newer peripheral devices. It should not be necessary to change these options, but the PGSI includes these jumpers to further increase configurability.

Upon removal of the top cover of the PGSI, one will notice the dense packing of circuitry on the printed circuit board. This may make location of the PGSI jumper pads tedious. Below, a drawing of the PGSI circuit board shows the location of the jumper pads. They are mostly located in the jumper area, the part of the PGSI circuit board near the DB-25 connector.



All PGSI units have jumper pins and shorting blocks attached to JP2, JP3, and JP4. JP1, PD2, PD5, and MODB do not have jumper pins and shorting blocks installed. Below are the descriptions of the various jumper pins:

JP1	This jumper is connects RS-232 pin 6 to +10 volts or to RS-232 pin 20.
JP2	This jumper selects between on-board LCD voltage generation or external voltage generation.
JP3	This jumper connects the right LCD input to either RS-232 pin 20 or the negation of the left LCD input.
JP4	This jumper connects the left LCD input to RS-232 pin 4.
PD2	This jumper is for future upgrades. It is not currently active
PD5	This jumper is for future upgrades. It is not currently active.
MODB	This jumper is shorted when loading a new program into the PGSI memory.

If you need to reposition some jumpers, please open your PGSI, position it so that the text printed on the circuit board can be read left-to-right, and follow the directions given in this manual.

To set PGSI up for 2-wire hardware control of LCD glasses (default):

Place a shorting block over JP4 and place a shorting block on the two lowest pins in JP3.

To set PGSI up for 1-wire hardware control of LCD glasses (Macintosh users):

Remove shorting jumper from JP4 and place shorting jumper on two highest pins of JP3.

To set PGSI up for no-wire software control of LCD glasses (Workstations and others):

Remove shorting blocks from JP3 and JP4.

To set PGSI up for on-board LCD voltage generation (default):

Place shorting block on two leftmost pins of JP2.

To set PGSI up for external LCD voltage generation (if lenses are not darkening enough):

Place shorting block on two rightmost pins of JP2.

To disable voltage generation:

Remove shorting block from JP2.

If, for some reason, you need pin RS-232 pin 6 to be directly connected to RS-232 pin 20, you must scratch off trace between two highest pins of JP1 and place a short between the two lowest pins of JP1. Since JP1 does not have any pins installed, a piece of wire must be soldered in place or pins must be installed. By default, RS-232 pin 6 is tied to +10 volts.

If you are unsure of what jumper to move or replace, please call ACM at UIUC and they will be happy to help you.

2. Interface Control Modes

2.1 Software Alterations

The PowerGlove™ Serial Interface is designed to be trouble free from the moment of arrival, technology continues to advance, and software bugs have been known to appear in the most heavily tested programs. For this reason, the interface includes the ability to reprogram the firmware installed in the PGSI from a personal computer by merely plugging the interface into the serial port and downloading a new program. This option is called "field programming" and is selected by a shorting jumper position. This option was made inaccessible without opening the PGSI, since unwanted operation in this mode could erase the control firmware. If any such updates to the firmware become necessary or advantageous, they will be made available to owners of the PGSI with complete instructions on how to accomplish this re-programming of the PGSI.

2.2 Data Packet Summary

The PowerGlove™ Serial Interface, in addition to providing the 3 standard packet types for complete AGE and Menelli emulation, the interface provides an extension to each of the 3 standard packet types to allow for enhancements like A/D and digital input readings. The three main packet types and their extensions are displayed below to aid programmers and users in understanding the features of the different packet types.

Position in Packet	Name	Description	Range
00	Header	Signals Start of Packet	0xA0
01	X	X-direction reading	-128 to 127
02	Y	Y-direction reading	-128 to 127
03	Z	Z-direction reading	-128 to 127
04	Rotation	Gives rotation value in 30 degree increments	0 to 11
05	Flex	Gives position of thumb and first three fingers (See Table 3.2.4)	(See Table 3.2.4)
06	Switch	Gives key codes	0 to 255
07	A/D port 1 info	Give value of first A/D port	0-255
08	A/D port 2 info	Give value of second A/D port	0-255
09	A/D port 3 info	Give value of third A/D port	0-255
10	A/D port 4 info	Give value of fourth A/D port	0-255
11	A/D port 5 info	Give value of fifth A/D port	0-255
12	A/D port 6 info	Give value of sixth A/D port	0-255
13	A/D port 7 info	Give value of seventh A/D port	0-255
14	A/D port 8 info	Give value of eighth A/D port	0-255
15	Input byte	Give value of 8 bit input port	0-255

Table 4.2.1 - Complete Packet Description in Menelli Emulation/Continuous mode

Note that the packet can change length depending on what is turned on. For instance, say the user turns off the PowerGlove™ for input. Then, A/D port 1 will be at position 01 instead of 07. The same holds for turning on and off other options that affect packet size. There is no way to gather reliable packet data without knowing what parts of the packet are active, so the programmer must know what modes are on before a packet is requested. However, the programmer will never need to know what order the options are turned on, because the packet cannot be rearranged. That means that the input byte will always appear last if is enabled, A/D ports 1-4 will always precede A/D port 5-8 and so forth. The breaks in the packet are indicated by blank lines.

Position in Packet	Name	Description	Range
00	X	X-direction reading	-128 to 127
01	Y	Y-direction reading	-128 to 127
02	Z	Z-direction reading	-128 to 127
03	Rotation	Gives rotation value in 30 degree increments	0 to 11
04	Flex	Gives position of thumb and first three fingers (See Table 3.2.4)	(See Table 3.2.4)
05	Switch	Gives key codes	0 to 255
06	A/D port 1 info	Give value of first A/D port	0-255
07	A/D port 2 info	Give value of second A/D port	0-255
08	A/D port 3 info	Give value of third A/D port	0-255
09	A/D port 4 info	Give value of fourth A/D port	0-255
10	A/D port 5 info	Give value of fifth A/D port	0-255
11	A/D port 6 info	Give value of sixth A/D port	0-255
12	A/D port 7 info	Give value of seventh A/D port	0-255
13	A/D port 8 info	Give value of eighth A/D port	0-255
14	Input byte	Give value of 8 bit input port	0-255

Table 4.2.2 - Packet Description in Menelli Emulation/Request mode

Position in Packet	Name	Description	Range
00	Header	Signals Start of Packet	0x5F
01	Header	Signals Start of Packet	0x5F
02	X	X-direction reading	-128 to 127
03	Y	Y-direction reading	-128 to 127
04	Z	Z-direction reading	-128 to 127
05	Rotation	Gives rotation value in 30 degree increments	0 to 11
06	Flex	Gives position of thumb and first three fingers (See Table 3.2.4)	(See Table 3.2.4)
07	Switch	Gives key codes	0 to 255
08	GSTAT1	General Status 1	0- if fingers out 1- if fingers in
09	GSTAT2	General Status 2	0
10	RECVALS	Receiver Values (See Table 3.2.6)	0 - 0x3F
11	A/D port 1 info	Give value of first A/D port	0-255
12	A/D port 2 info	Give value of second A/D port	0-255
13	A/D port 3 info	Give value of third A/D port	0-255
14	A/D port 4 info	Give value of fourth A/D port	0-255
15	A/D port 5 info	Give value of fifth A/D port	0-255
16	A/D port 6 info	Give value of sixth A/D port	0-255
17	A/D port 7 info	Give value of seventh A/D port	0-255
18	A/D port 8 info	Give value of eighth A/D port	0-255
19	Input byte	Give value of 8 bit input port	0-255

Table 4.2.3 - Packet Description in AGE Emulation/both modes

2.3 Interface Command Code Summary

Command Code (in HEX)	Command Code (in ASCII)	Description	Emulation Available in
0x01	none	Place interface in continuous mode	AGE
0x02	none	Place interface in request mode/request packet	AGE
0x04	none	Resend default initialization packet to the PowerGlove™	AGE/Menelli
0x05	none	not implemented	AGE/Menelli
0x06	none	not implemented	AGE/Menelli
0x07	none	Reset PowerGlove™ and PGSI to default configuration	AGE/Menelli
0x08	none	Turn rotation filter on	AGE/Menelli
0x09	none	Turn rotation filter off	AGE/Menelli
0x0A	none	Turn PowerGlove™ on for input	AGE/Menelli
0x0B	none	Turn PowerGlove™ off for input	AGE/Menelli
0x0C	none	not implemented	AGE/Menelli
0x0D	none	not implemented	AGE/Menelli
0x0E	none	Turn on digital inputs	AGE/Menelli
0x0F	none	Turn off digital inputs	AGE/Menelli
0x10	none	Turn on first 4 channels of A/D	AGE/Menelli
0x11	none	Turn off first 4 channels of A/D	AGE/Menelli
0x12	none	Turn on second 4 channels of A/D	AGE/Menelli
0x13	none	Turn off second 4 channels of A/D	AGE/Menelli
0x14	none	Turn left lens dark, leave right lens in current state	AGE/Menelli
0x15	none	Turn left lens clear, leave right lens in current state	AGE/Menelli
0x16	none	Turn right lens dark, leave left lens in current state	AGE/Menelli
0x17	none	Turn right lens clear, leave left lens in current state	AGE/Menelli
0x18	none	Turn both lenses dark	AGE/Menelli
0x19	none	Turn both lenses clear	AGE/Menelli
0x1A	none	Turn left lens dark and right lens clear	AGE/Menelli
0x1B	none	Turn left lens clear and right lens dark	AGE/Menelli
0x1C,0x01-0x08	none	Change baud rate to value specified after command byte	AGE/Menelli
0x1D	none	Change chopping frequency of LCD lens driver circuitry, range: 16Hz to 5kHz.	AGE/Menelli
0x1E,0x00-0xFF	none	Send digital data to output port (Second byte is value to send)	AGE/Menelli
0x1F	none	Change to new sampling rate for glove	AGE/Menelli
0x2B	'+'	Turn hysterisis deglitching on	AGE/Menelli
0x2D	'-'	Turn hysterisis deglitching off	AGE/Menelli
0x3F	'?'	Request a packet in Menelli emulation	Menelli
0x43	'C'	Place interface in continuous mode	Menelli
0x52	'R'	Place interface in request mode	Menelli

Table 4.2.4 - Command Set

2.4 Emulation Restrictions

Since the PowerGlove™ Serial Interface allows users to choose between two emulation modes, some restrictions are imposed to ensure proper operation of the interface:

- All commands available in one mode or the other, but not both, can be initiated from any mode, but those commands will immediately change the emulation mode to reflect the emulation mode native to the command selected

- Since the PGSI powers up in AGE emulation mode, all programs that assume Menelli emulation at start-up, will not work correctly unless the said program is preceded by either programmed or manual switching of the emulation mode to Menelli emulation.

Part V-Maintenance

1. Cleaning the Power Supply Contacts

After continued use of the PGSI, the user may notice an erratic behavior in the PGSI's operation, ranging from a spontaneous reset to complete power loss. This may be caused by corrosion on the power supply contacts. Periodically, the user should remove the power supply plug from the PGSI and clean the contacts with either a light eraser or rubbing alcohol. After cleaning debris and moisture away after cleaning, the plug may be re-inserted into the PGSI for continued operation.

2. Cleaning the LCD Shutter Glasses Contacts

If, after continued use of the PGSI with a pair of LCD shutter glasses, the shutter lenses glitch or seem to lose contrast, the user should remove the shutter glasses connecting plug from the PGSI and clean with either a light eraser or rubbing alcohol. After allowing to dry and cleaning eraser residue away, the user should re-insert the plug for operation of the PGSI and the shutter glasses.

Part VI-Troubleshooting Guide

1. Computer/Interface Communications Problems

If you should encounter trouble in getting the PGSI to interface with a personal computer, make sure the following conditions for operation of the PGSI have been fulfilled:

- The correct power source is attached to the PGSI and turned on.
- The PGSI is connected to the host CPU via a "pass-through" modem cable.
- The host CPU is EIA-232 compliant.

2. LCD Shutter Glasses/Interface Communications Problems

If repeated attempts to use the LCD shutter glasses fail, please check the following list:

- Is your CPU capable of the LCD control selected: 1 wire, 2 wire, no wire ? (Some computers cannot utilize some modes. example: Macintosh computers cannot use two wire mode.)
- Is the interface cable plugged in ?
- Are the LCD shutter glasses plugged into the PGSI?

3. PowerGlove™/Interface Communications Problems

After starting up with an introductory screen sent over the serial connection to the host system, the PGSI will try to initialize the PowerGlove™. The glove should beep at least once and could beep until the glove is placed in front of the L-bar so that the receivers can detect the ultrasonic emissions from the glove. If repeated attempts to use the PGSI with a glove fail to exhibit this behavior, please check the following items:

- Is the glove connected to the PGSI?
- Is the power supply turned on and plugged in.

If these items check out, try to look at the output of the PGSI with a standard terminal program such as ProComm™, Telix™, or MicroPhone™. The unit should power up with the introductory screen, and then continuously send packets with two '_' characters as prefix characters. If the unit does not respond through a communications program, please contact ACM at UIUC and ask for assistance.

Part VII-Specifications

1. Hardware Specifications

The PowerGlove™ Serial Interface is built around the Motorola MC68HC811E2 microprocessor, an 8 bit central processing unit, ideally suited for embedded systems like the PGSI. It has many features useful in the PGSI, including:

- On board RAM capacity of 512 bytes
- On board RS-232 interface.
- On board 2 kilobytes of Electrically Erasable Read Only Memory (EEPROM)
- 32 bits of general-purpose buffered digital input/output
- 8 channels of 8 bit digital to analog conversion.
- 5 volt DC operation.
- clock speeds up to 8 MHz.
- Small printed circuit board footprint in 52 PLCC version.

2. Interface Specifications

The PGSI uses a standard EIA-232 serial communications protocol to interface itself to the host system. The data rate is 9600 bps, no parity, 1 stop bit, and 8 data bits. Although the typical voltages used in RS-232 are +10 and -10 volts DC, the PGSI will accept voltages as small as +5 to -5 volts DC. The unit can be programmed to operate at lower baud rates.

Part VIII-Appendices

A. Options and Supplies

1. Battery Pack

Since the PGSI imposes a very small current drain on the power supply, the unit can be operated from conventional 9-volt batteries. Although neither ACM at UIUC nor SIGARCH at ACM at UIUC sell an adapter that will allow use of batteries, one can be constructed quite simply from parts purchased at a local electronics store. The required parts are:

1 9 volt battery adapter connector (called a 9-volt pigtail)
1 2.5 mm mono audio plug
1 9-volt battery

Merely solder the two wires from the 9-volt connector to the audio plug and plug in. (polarity is not important). Note, however, that battery power is depleted rather quickly, even for items such as the PGSI, so plan accordingly.

2. Power Supply

The PGSI is designed to work with a simple wall adapter type of power supply. ACM at UIUC sells adequate units, although any such power supply with a 2.5 mm audio plug will suffice.

3. Macintosh Adapter

The PGSI is designed to connect to any system that has a conventional EIA-232D compliant connector. Unfortunately, Apple Macintosh computers use a small DIN plug for serial communications, so ACM at UIUC sells an adapter cable that will convert the DIN connector to the standard 25 pin D type connector. These cables can also be purchased from Apple computer stores or any other store that sells a 'modem adapter cable" for the Apple Macintosh.

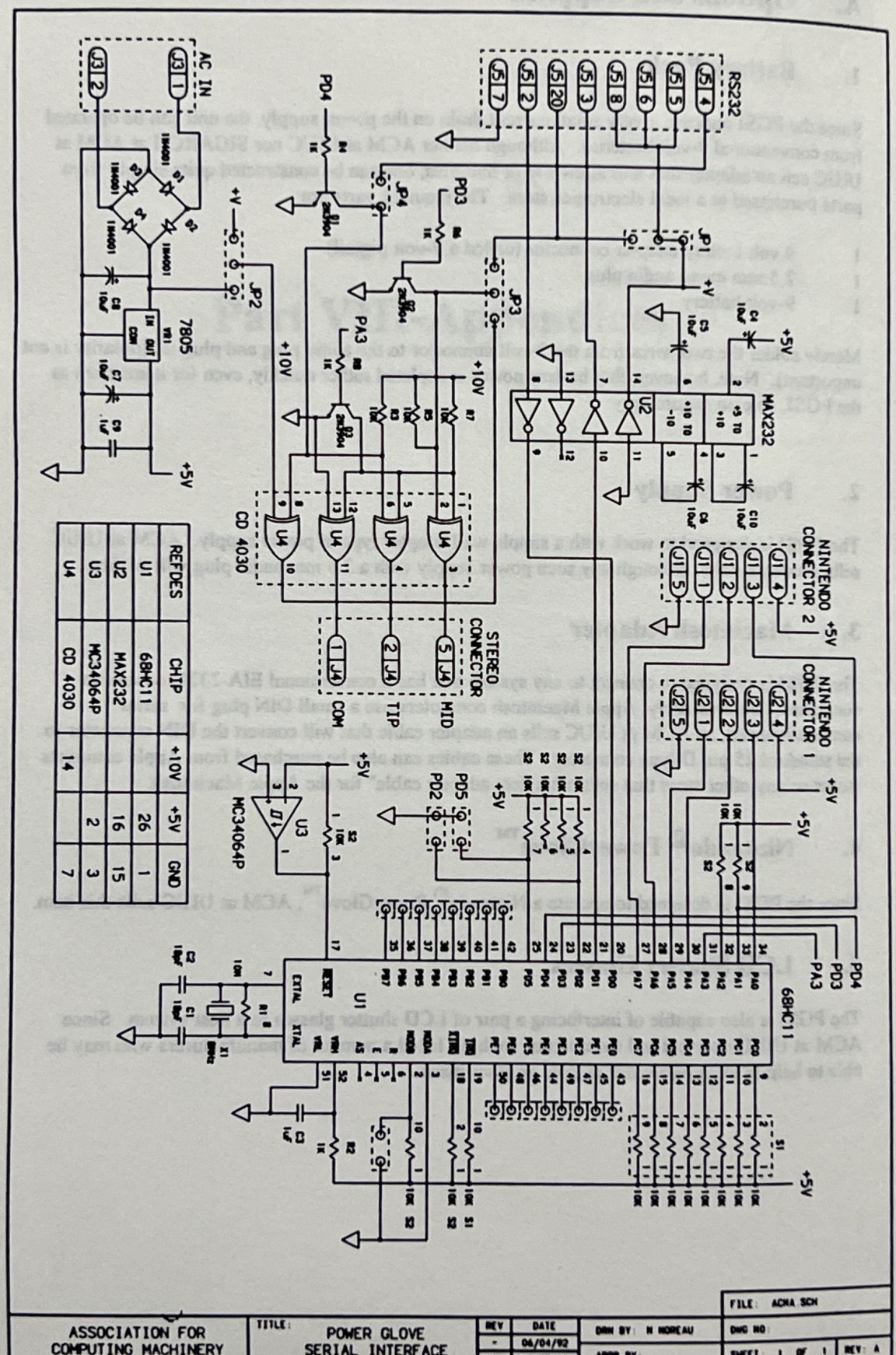
4. Nintendo© PowerGlove™

Since the PGSI is designed to operate a Nintendo© PowerGlove™, ACM at UIUC sells this item.

5. LCD Shutter Glasses

The PGSI is also capable of interfacing a pair of LCD shutter glasses to a host system. Since ACM at UIUC does not sell these items, we have listed a number of manufacturers who may be able to help in locating shutter glasses or other items:

B. PowerGlove Serial Interface Schematic



REFDES	CHIP	+10V	+5V	GND
U1	68HC11		26	1
U2	MAX232		16	15
U3	MC34064P		2	3
U4	CD 4030	14		7

C. History of this document

Version 1.0 This document was prepared on Microsoft Word for Windows 2.0, over the course of the two semesters spanning from August 1992 to May 1993. It is the final copy that was directly edited by Jim Brain, and is the first version to be packaged with actual units. I wish I had more time to fortify it with knowledge, but I must let others take over the work. If you see any deficiency in this draft of the manual (likely, since I do not do this for a living) please follow up to ACM at UIUC in written form. That way, your suggestions will not get "lost in the shuffle". I hope this user manual makes the use of the PGSI easier, and I hope to add a few chapters later on. Nonetheless, it must go out with the orders, so time has ended for rewrites. It is 4:40 AM, so this will be it. Hope you like it!

Jim Brain