TABLE OF CONTENTS

INTRODUCTION

The GPIB Adapter Card enables the Texas Instruments home computer to function as part of any General Purpose Interface Bus (GPIB) system structured according to IEEE Standard 488-1978, an industry standard widely followed by makers of programmable instrumentation and other computer peripherals.

With this card installed in the Peripheral Expansion System, the home computer is compatible with several hundred other devices from a variety of manufacturers which conform to GPIB specifications. The computer can control power supply outputs, take readings from digital multimeters, operate relays, or send data to a printer, to name a few examples of the numerous possible applications.

The GPIB Adapter Card provides control over bus peripherals through TI BASIC program statements. It incorporates circuitry to translate BASIC statements and commands into instructions understandable by the various bus devices, to store data temporarily, and to convert logic levels and data formats to or from the forms specified by the IEEE-488 interface standard.

This manual begins with a summary of the GPIB structure and functions. Directions for installing, testing, and removing the adapter card are given next. A section dealing with the operation of the card follows, in which the address conventions, command mnemonics, and applicable BASIC statements are presented. A number of helpful appendices and a section of service information complete the manual.

GPIB OVERVIEW

The IEEE-488-1978 standard defines a general-purpose interface bus (GPIB) system for programmable digital equipment. The purpose of the standard is to facilitate electrical and mechanical compatibility among a wide range of devices from various manufacturers. The circuits, cables, connectors, control protocol, and message set of the bus system are all specified to ensure uniform and orderly communication among devices. Although the IEEE-488 specification originated out of a need for an industry-wide standard interface for programmable instrumentation, the GPIB has become widely used as a general-purpose computer I/O bus as well.

GPIB devices are designated as talkers, listeners, or controllers according to their function.

A device whose role is to transmit data, such as a digital voltmeter, is a talker. One which receives data--a printer, for instance--is a listener. The flow of information among talkers and listeners on the bus is regulated by a device acting as controller (assumed in this manual to be the home computer).

Devices capable of both receiving and transmitting may alternate between the roles of talker and listener in successive data transfers. There may be several listeners at once, but never more than a single talker at a given time. Talkers and listeners are designated by the controller at the start of each operation.

The IEEE-488 bus requires a cable with 24 conductors, of which 16 lines have data or control functions prescribed by the IEEE-488 standard. The remaining eight lines serve as shields or signal grounds.

Of these 16 lines, eight are provided for data and address information. Five are used for general bus management. The other three carry control signals used specifically in the three-wire handshake sequence which controls data transfers on the GPIB. The 16 lines and their functions are listed below.

- o DIO1-DIO8 (Data Input/Output)--Carry either data or addresses and commands, depending on the state of the ATN line.

- o ATN (Attention)--Communicates the nature of information on the DIO1-DIO8 lines. When ATN is true, these lines carry addresses or commands. When ATN is false, they carry data. Driven by the controller.

- o IFC (Interface Clear)--Places the talkers and listeners on the bus in an idle state. Driven by the controller.

- o SRQ (Service Request)--Signals the controller that a device on the bus requires its attention. Can be driven by any GPIB device enabled for service requests.

- o REN (Remote Enable)--Disables the panel controls of an instrument, allowing the device to accept programming data from the controller instead of from its own front panel. Driven by the controller.

- o EOI (End or Identify)--As End, signals the conclusion of a data transfer. As Identify, in conjunction with ATN, locates a device requesting service. Driven by talkers.

- o DAV (Data Valid handshake line)--Indicates to the listening device(s) that data is available on the DIO lines. Driven by talkers.

- NRFD (Not Ready for Data handshake line)--Shows whether all listeners involved in a data transfer are ready to receive data. Driven by listeners.

- NDAC (Not Data Accepted handshake line)--Shows whether data has been accepted by all devices involved in a data transfer. Driven by listeners.

Data is transferred asynchronously in bit-parallel, byte-serial form. It is possible for a number of devices to accept data simultaneously, and they may be devices with differing input/output speeds. The three-wire (DAV, NRFD, NDAC) handshake regulates each transfer of data.

The DAV line is controlled by the device functioning as talker in a given transaction, while the NRFD and NDAC lines are under the control of the listener(s). The handshake occurs in an interlocked sequence: one event in the sequence must be complete before the next can begin. This provision ensures first that each listener is ready to accept data, then that the data is valid, and finally that the data has been accepted by all listeners involved. Information is transferred only as quickly as the slowest listener can accept it. Further details on the three-wire handshake can be found in the IEEE-488-1978 specification.

A maximum of 15 devices can be attached to the bus at one time. The total cable length must be no more than 20 meters overall or no more than 2 meters per device, whichever is less.

The GPIB uses negative logic at TTL voltage levels. A logical zero corresponds to a TTL high state (equal to or greater than 2.4 volts). A logical one corresponds to a TTL low state (0.5 volts or less). The bus logic can be realized either in hardware or in software.

Messages are classified as either local or remote. Local messages are both issued and received within a given device, while remote messages are sent through the GPIB. Remote messages are grouped into three general types, as shown below.

- o Interface messages--Regulate GPIB configuration by assigning talkers and listeners, placing devices in remote or local mode, etc.
- o Device-dependent messages--Set range, function, etc. of GPIB instruments.
- o Data messages--Transferred among devices for processing, storage, printing, or display.

Of the above three types of remote messages, device-dependent and data messages are not specified by the IEEE-488 standard. They vary with device and manufacturer. Interface messages, however, are defined in the standard. They implement 10 different GPIB functions, which are listed below.

- o SH (Source Handshake)--Enables a talker to transfer data to one or more listeners by using the three handshake lines.
- o AH (Acceptor Handshake)--Enables a listener to receive data from a talker by using the three handshake lines.
- o T (Talker)--Enables a GPIB device to send status and data bytes when addressed to talk.
- o L (Listener)--Enables a device to receive data when addressed to listen.

- SR (Service Request)--Enables a GPIB device to issue a service request to the controller during regular program execution.

- RL (Remote/Local)--Enables a device either to be operated remotely by the controller or to be controlled locally from its own front panel.

- PP (Parallel Poll)--Enables a GPIB device to send one status bit to the controller. The device need not be enabled to talk and no handshake is necessary.

- DC (Device Clear)--Enables selected devices to be reset by the controller.

- DT (Device Trigger)--Enables selected devices to be activated either synchronously as a group or singly.

- C (Controller)--Enables a device to function as manager of bus operations. Any devices with the ability to do so may act as controllers, but only one may be active at a given time.

Remote messages are encoded by talkers and decoded by listeners. This process involves the conversion of messages to or from the forms used within the GPIB system.

Certain remote messages require multiple lines while others can be sent over a single line. The voltages on the message lines within devices must also be translated to standard GPIB signal voltages. The forms of message coding that are part of the IEEE-488 specification allow only a fixed set of interface messages. The repertoire of interface messages available for use on the GPIB is listed on the following page.

INTERFACE MESSAGES

ATN--Attention

DAB--Data byte

DAC--Data accepted

DAV--Data valid

DCL--Device clear

END--End

GET--Group execute trigger

GTL--Go to local

IDY--Identify

IFC--Interface clear

LLO--Local lockout

MLA--My listen address

MSA--My secondary address

MTA--My talk address

OSA--Other secondary address

OTA--Other talk address

PCG--Primary command group

PPC--Parallel poll configure

PPD--Parallel poll disable

PPE--Parallel poll enable

PPRn--Parallel poll response n

PPU--Parallel poll unconfigure

REN--Remote Enable

RFD--Ready for data

RQS--Request service

SDC--Selected device clear

SPD--Serial poll disable

SPE--Serial poll enable

SQR--Service request

STB--Status byte

TCT--Take control

UNL--Unlisten

Details on interface message structure and coding can be found in IEEE standard 488-1978. The GPIB Adapter Card implements this repertoire of messages automatically by translating the instructions described in the Card Commands section.

A typical message sequence might involve a transfer of data from one device designated as talker to one or more other bus devices named as listeners. In such a case the controller first sets the ATN (Attention) control line low, so that all attached devices monitor the bus. The UNT (Untalk) and UNL (Unlisten) messages are sent next to terminate any previous bus configuration, followed by new listener and talker assignments to reconfigure the bus.

The controller then sets the ATN line high, allowing the talker to communicate with the designated listeners. The three-wire handshake sequence which accompanies each data transfer enables each listener to accept data at its own rate.

While the talker sends data to the listeners, the controller monitors the bus for the EOI (End or Identify) message signaling the end of the transmission. After the talker sends EOI, the controller reassumes control of the bus.

Polling

Many types of GPIB devices may be enabled for service requests. The GPIB supports two types of service interrupt protocols: serial and parallel polling. Serial polling can be done with slower GPIB devices. Parallel polling is generally used with faster devices.

The GPIB has a single service request (SRQ) line that may be asserted by any device on the bus. A serial poll is initiated when an instrument or instruments issue a service request on the SRQ line. If the BASIC program being run provides for serial polling, the controller responds to the service interrupt by sequentially polling all request-enabled devices to establish which one requires service. Devices are generally polled and serviced in the order of their importance. The poll occurs in the following sequence.

1. The universal unlisten command (UNL) is issued.

2. Each instrument in turn is addressed to talk and returns an eight-bit status byte over the bus.

3. By reading the service request message during reception of the status byte from each instrument, the controller determines which devices have requested service.

Parallel polling allows faster recognition of interrupting devices than is possible in serial polling because the GPIB can obtain status information from up to eight devices at a time. Each instrument returns one bit of status to the controller. Since more than one device can respond on the same status line, logical operations (AND, OR) may be performed on a group of instruments as well.

Because no equivalent of the SRQ line exists for this polling mode, a parallel poll is set in motion by the controller rather than by a bus peripheral. The controller must first configure the devices to be polled by assigning one of the eight data lines to each device concerned and establishing the sense (0 or 1) of the response bit from that device. The advantage of quick identification of interrupting devices is offset to some degree by the need to poll frequently.

To initiate a parallel poll, the controller issues the identify command (the EOI and ATN lines are active simultaneously). This causes all request-enabled instruments to place a single status bit on one of the eight data lines. Each status bit is monitored by the controller to identify the state or activity of a particular device.

Device Structure

Equipment designed for use in an IEEE-488 interface system can be considered to have four major levels of operation. These are known as the device, interface, message coding, and driver/receiver functions.

The device function is simply the particular application of a given instrument--multimeter, power supply, spectrum analyzer, and so on.

The interface logic ensures conformity between the device and the GPIB in such respects as data format, signal timing, device configuration (whether it operates as a listener, a talker, or a controller), and command repertoire.

The message coding function of a device involves the conversion of incoming messages to the forms used by that device and the translation of outgoing messages to the forms specified by the IEEE standard.

Drivers and receivers provide the termination networks and circuit characteristics necessary to satisfy the requirements of the IEEE-488-1978 standard. The standard specifies the range of acceptable values for circuit parameters such as voltage, current, capacitance, and impedance.

Open-collector drivers can be used on all lines. Three-state drivers are permissible for higher speeds (except on the SRQ, NRFD, and NDAC lines, which must retain open-collector drivers). If parallel polling is done at high speeds, the DIO lines must also have open-collector drivers.

SET-UP INSTRUCTIONS

The steps involved in inserting the GPIB Adapter Card into the Peripheral Expansion System and then checking its operation are included in this section. Please read the material completely before proceeding.

Note: The Peripheral Expansion System has eight slots into which accessory cards can be inserted. The Peripheral Expansion Card must occupy slot number 1. (For information on setting up the peripheral system, refer to the Peripheral Expansion System owner's manual.) If you have a Disk Memory Drive in the Peripheral Expansion System, the Disk Drive Controller Card must be in slot number 8. Other cards can be inserted in any of the remaining slots.

CAUTION

These electronic components can be damaged by discharges of static electricity. To avoid damage, do not touch the connector contacts.

After you have unpacked the unit, you are ready to insert the GPIB Adapter Card into the Peripheral Expansion System. (Save the packing material for storing or transporting the unit.)

Inserting the GPIB Card

1. First turn off the computer console and all attached devices.

2. WARNING: TO AVOID DAMAGING ACCESSORY CARDS, WAIT TWO (2) MINUTES AFTER TURNING OFF THE UNIT FOR THE POWER TO DISCHARGE BEFORE PROCEEDING.

3. Remove the top from the Peripheral Expansion System by depressing the latches at the back edge of the top and lifting up.

4. The label identifying the GPIB card is on top of the card. On the front of the card is an indicator light that is seen from the front of the Peripheral Expansion System when the card is active. Hold the GPIB card with the indicator light facing the front of the peripheral system.

(Illustration of card, showing indicator light)

5. Carefully align the card with the desired slot and press the card firmly down into the slot.

(Illustration of expansion box, showing card in slot)

6. Replace the top of the Peripheral Expansion System by sliding the front edge under the extension on the front of the unit and firmly pressing down on the back edge of the top. Do not run the system without the top in place because the top ensures proper ventilation. Note: If the top does not fit properly, remove the card and realign it in the slot, remembering to press down firmly until the connection is made.

CAUTION

Always disconnect the Peripheral Expansion System before moving the computer console. The cable connecting the console and peripheral system is not designed to support the weight of the units. To prevent damage, always disconnect all devices before moving any part of the Home Computer system. For long-distance moves, remove all cards from the Peripheral Expansion System. Then repack the devices in their original packing material.

Testing the GPIB Card

1. The power switch is located on the front of the Peripheral Expansion System in the lower left-hand corner. Turn on the peripheral system, monitor, and console in that order.

2. A light should briefly come on in the position where you have inserted the GPIB card. Each time the computer system accesses the GPIB card, its corresponding light comes on. Note that the intensity and duration of the light vary, depending on the operation being performed within the system.

3. If the light does not come on, the corresponding card may not be properly inserted. Repeat the set-up procedure. If you still have difficulty, refer to the In Case of Difficulty section.

Removing the GPIB Card

1. Turn off the Peripheral Expansion System, computer console, monitor, and any other attached devices.

2. Wait two minutes and then remove the top from the peripheral system.

3. Remove any cabling attached to the GPIB Adapter Card.

4. Pull up the wire handles on the ends of the card.

5. Firmly pull on the handles to remove the card from its slot in the peripheral system.

Connecting GPIB Devices

After the GPIB Adapter Card is properly inserted into the Peripheral Expansion System, other GPIB devices can be attached by cable to the connector on the back of the card. As specified in the IEEE-488-1978 standard, only cable connectors with metric threads (identifiable by their black finish) should be attached to the card.

Appendix B contains reference information about GPIB cables and cabling configurations. Appendix C provides pin diagrams.

OPERATION

Most of the commands, message protocol, and so on which are set forth in IEEE specifications for the bus system are taken care of automatically by interface circuitry on the GPIB card. The user simply employs the set of messages recognized by this card and follows the addressing methods applicable to specific GPIB peripherals.

In programming of a GPIB system from BASIC, the GPIB card is first enabled for operation by an OPEN statement. After the card is enabled for operation, data and instructions can be placed on the bus and routed to specific devices by subsequent INPUT, PRINT, or LIST instructions. The INPUT statement takes data from the bus and places it in computer memory. The PRINT statement sends data through the bus to a selected device or devices. The LIST command copies programs to bus peripherals for display or printing.

The OPEN Statement

The GPIB Adapter Card is made ready for operation by an OPEN statement in the following format.

OPEN #file number,"GPIB[.options]"

It is possible to have two active GPIB Adapter Cards in the same Peripheral Expansion System. In such a case, one of the cards is opened as "GPIB" or "GPIB/1" and the other is opened under a different file number as "GPIB/2". The "GPIB/2" feature is a repair depot option.

The OPEN options are a group of functional parameters that the user may define for optimal use of the GPIB's capabilities. They are described below.

- .DE=XX or .DEVICE=XX--Lets the user specify the address of the GPIB card as any number from 01 through 30. The default is 00. Although the computer scans only the first two letters, the entire word may be used for clarity. This option is useful when, for example, two computers are to share a single GPIB. Without distinct device numbers, communication between the computers would be impossible.

- .SC--Specifies the GPIB device to be configured as system controller. Normally the home computer powers up as system controller, but the computer may turn control over to another device after the system is in operation. If that is done, this option must be used.

- .DRIVER=PU--Allows the user to configure GPIB I/O drivers (normally open-collector) as totem-pole devices. Produces a pull-up effect that allows faster operation (with longer cables) and more uniform impedance among devices (so that devices not in use may be turned off without negative effects on GPIB functions).

- .LF--Deletes the line feed that normally occurs after a carriage return. This is a useful feature in such applications as the printing of graphics or the operation of printers that generate their own linefeed characters.

- .EOS=X--Allows a character other than the customary line feed to be selected as the end-of-string indicator. X represents the character specified. When this option is selected, only the specified EOS character is transmitted--no line feed is sent.

- .LIST=XX--Allows a TI Impact Printer (when equipped with its GPIB interface) or any other GPIB-compatible printer to be used in execution of the printing options available through the RS232 card (listing programs, printing files, cataloging disks, etc.). The value of XX corresponds to the GPIB address of the printer.

  Note: The GPIB interface for the TI Impact Printer is an optional board available separately. The printer is normally set up as device 01.

The PRINT and INPUT Statements

PRINT and INPUT address the adapter card itself. The device-specific data or instructions are in the form of character strings appended to the PRINT and INPUT statements. A statement such as

```
100 PRINT #1:"WRT16;INIT"
```

where INIT is a device-dependent command could serve to initialize some device (number 16 in this example) on the GPIB before the start of operations. A sequence such as

```
110 PRINT #1:"RED10;"
120 INPUT #1:H$
```

could be used to read data from some GPIB device. Additional examples of PRINT and INPUT used with the GPIB Adapter Card can be found in the Card Commands section.

The LIST Command

The lines of a program in computer memory can be placed on the bus for printing or display by a GPIB peripheral through use of the LIST command in the following format.

LIST "GPIB.LI=(device-number)[.options]"

Device-number corresponds to the address of the GPIB peripheral at which the program is to be listed. The options available in the OPEN statement, such as ".LF" and ".EOS=", are also applicable to LIST.

The LIST command automatically supplies an OPEN statement for the GPIB card, followed by a string of zero length which causes the printer to execute a linefeed (if the ".LF" option is not used). The program is then transmitted and a CLOSE statement is sent to the GPIB card.

Examples:

LIST "GPIB.LI=04"
Lists a program at GPIB device 4.

LIST "GPIB.LI=01.LF"
Lists a program at GPIB device 1, deleting the automatic linefeed.

Addressing

Each GPIB device has a unique primary address, a two-digit decimal number in the range 00-30. Some GPIB devices also have a similar range of secondary addresses that designate subsections within the unit. Multiple addresses in a program statement are separated by commas. A semicolon serves as delimiter in single as well as in multiple addressing.

"WRT01,02;", for example, addresses devices 1 and 2 on the GPIB. "WRT0102;" addresses section 2 within device 1. "WRT0102,02;" addresses section 2 within device 1 and also addresses device 2.

The sample statements in the Card Commands section give additional examples of both single and multiple addressing formats.

Card Commands

Listed and described on the following pages are the commands which allow the user of the home computer to operate the GPIB Adapter Card. Each command has the form of a three-letter mnemonic which is appended to a BASIC-language PRINT statement for execution.

WRT (Write)

The write command sends data from the computer to all peripherals addressed as listeners. It is issued within a PRINT statement and may have either of the following formats.

"WRT(listener device numbers;)(data)"

"WRT(listener device numbers;)"(;variable name)

The final character, added automatically after transmission of the last data byte, is normally a linefeed following a carriage return. It can, however, be any ASCII character declared in the OPEN statement with the ".EOS=" option. The EOI (End or Identify) GPIB control signal is automatically sent with the final character.

Examples:

```
200 PRINT #1: "WRT03;";B1
```

Sends the contents of variable B1 to device 3 on the GPIB.

```
210 PRINT #1: "WRT03;B1"
```

Sends first an ASCII "B", then an ASCII "1" to device 3 on the GPIB.

In execution of the write command, the following steps are performed.

1. The universal unlisten (UNL) message is sent over the bus.
2. The listener addresses are issued one after another.
3. The first data byte is sent, then the next, and so on.
4. The EOI line and EOS character announce the end of the transmission.

RED (Read)

The read command is used to take data from a GPIB device designated as talker in the command. It is issued within a PRINT statement, which is followed by an INPUT statement to accept the actual data from the bus. The read command has the following format.

"RED(talker device number;)"

When the read sequence is executed, data is input until an EOS character, a BASIC delimiter such as a comma, or the EOI control signal arrives at the GPIB card.

Examples:

The sequence

```
300 PRINT #1: "RED16;"
310 INPUT #1: A$
```

inputs data from device 16 on the GPIB and assigns the data to string variable A$.

The sequence

```
300 PRINT #1: "RED16;"
310 INPUT #1: B$;C$
320 A$=B$&C$
```

could be used to read two groups of data separated by a comma, such as the input "1,1E+2". The value "1," constitutes B$ and "1E+2" becomes C$. The value of A$ is then "1,1E+2", the original input.

In execution of the read command, the following steps are performed.

1. The universal unlisten (UNL) message is issued.
2. The talk address is sent over the bus.
3. Input data, followed by EOS and EOI, is placed on the bus, received by the GPIB card, and placed in a buffer area in memory.
4. The INPUT statement transfers the data to a BASIC variable.

XFR (Transfer)

In transfers of data from one bus peripheral to another, it is not necessary that the information pass through the controller. The transfer command can be used to move data directly from one GPIB device, designated as talker, to one or more other bus devices that function as listeners. It has the following format.

"XFR(talker,)(listeners;)"

The talker automatically sets the EOI line true at the close of the data transfer. This tells listener devices that the transmission is ended and returns bus control to the home computer. The GPIB card monitors the bus until an EOI signal occurs, then retakes control of the bus.

Examples:

```
400 PRINT #1: "XFR16,01;"
```

Moves data from device 16 to device 1 on the GPIB.

```
410 PRINT #1: "XFR16,01,02;"
```

Transfers data from device 16 to devices 1 and 2 on the GPIB.

In execution of the XFR command, the following steps are performed.

1. The talk address is placed on the bus.
2. The universal unlisten (UNL) message is issued.
3. The listener addresses are sent in sequence.
4. Data is transferred one byte after another.
5. EOS and EOI are sent.
6. The controller reassumes command of the bus.

TRG (Trigger Selected Devices)

Some GPIB instruments, when ready to operate, require a special activating signal to begin execution. Certain system applications require that several devices on the bus commence operations at the same time. In cases such as these, the trigger command is used. It has the following format.

"TRG(listener device numbers;)"

Examples:

```
500 PRINT #1: "TRG10;"
```
Actuates device 10 on the GPIB.

```
510 PRINT #1: "TRG03,04,10;"
```
Triggers devices 3, 4, and 10 on the bus.

In execution of the trigger command, the following steps are performed.

1. The universal unlisten (UNL) message is issued.
2. The listener addresses are placed on the bus.
3. The group execute trigger (GET) message is sent.

CLA (Clear All Devices)

This command resets all GPIB peripherals to an idle state. Since it affects all devices on the bus, no specific addresses are necessary.

Example:

```
600 PRINT #1: "CLA"
```

Clears all devices on the GPIB.

CLR (Clear Selected Devices)

In contrast to the clear all command, CLR clears only the devices named in its address list. This command has the following format.

"CLR(listener device numbers;)"

Example:

```
700 PRINT #1: "CLR02,06,10;"
```

Clears devices 2, 6, and 10 on the GPIB.

In execution of the CLR command, the universal unlisten (UNL) message is issued first, followed by the addresses of the devices to be cleared. The device clear (DCL) GPIB message is then placed on the bus.

REA (Remote Enable All)

The remote enable all command, by setting the REN control line true, collectively prepares the GPIB peripherals to be programmed from the home computer rather than from their respective front panels. Since it concerns all devices on the bus, no specific addresses need to be sent with this command.

Example:

```
800 PRINT #1: "REA"
```

Transmits the remote enable all command to all GPIB devices.

REM (Remote Enable Selected Devices)

This remote enable command sets the REN line true and sends the addresses of specific devices which are to be controlled by the home computer. It has the following format.

"REM(listener device numbers;)"

Example:

```
900 PRINT #1: "REM10,16;"
```

Enables GPIB devices 10 and 16 for remote operation from the computer console.

In execution of the REM command, the universal unlisten (UNL) message is issued first, followed by the addresses of the devices to be enabled for remote operation. The REN bus line is then asserted by the controller.

LLO (Local Lockout All Devices)

The LLO command places all bus peripherals in local lockout mode, a state in which they do not respond to the front panel controls. LLO is often sent after devices are enabled for remote operation to ensure that commands can come only from the controller--not from the front panel. Since this command affects all devices on the GPIB, no addresses are necessary.

Example:

```
100 PRINT #1: "LLO"
```

Disables the front panel controls of all peripherals on the GPIB.

LMA (Local Mode All Devices)

This command sets the REN line false and puts all bus peripherals in local mode. Each device is then free to respond to its own front panel controls. Since LMA affects all peripherals on the GPIB, no addresses need to accompany this command.

Example:

```
110 PRINT #1: "LMA"
```

Returns all GPIB peripherals to front panel control.

LCL (Local Mode Selected Devices)

In contrast to the LMA command, LCL places only selected peripherals in local mode. The devices named as listeners are freed to respond to their respective front panel controls. This command has the following format.

"LCL(listener addresses;)"

Examples:

```
120 PRINT #1: "LCL16;"
```

Enables device 16 on the GPIB for local operation.

```
130 PRINT #1: "LCL03,04,10;"
```

Places devices 3, 4, and 10 in local mode.

In execution of the LCL command the universal unlisten (UNL) message is issued first, followed by the addresses of the devices to be placed in local mode. The go to local (GTL) GPIB message is then sent.

RQS (Request Service)

The RQS command is used to determine whether any devices on the GPIB have issued service requests. RQS tests the SRQ control line and returns an ASCII T if SRQ is set true, indicating that a service request has in fact been sent. If SRQ is false, an ASCII F is returned. Since the RQS command concerns all GPIB devices enabled for service requests, no specific addresses are necessary.

Example:

The sequence

```
300 PRINT #1: "RQS"
310 INPUT #1: RQS$
320 IF ASC(RQS$)=70 THEN 200 ELSE 250
```

tests the SRQ bus line to see whether any service requests have been issued. The number 70 is the ASCII code for the letter F.

RDS (Read Status)

After the controller has confirmed reception of a service request, it may initiate a serial poll using the read status command to determine which particular device is the source of that request. The peripherals are polled one at a time. Each device addressed returns a status message indicating whether it requires service.

A read status command has the following format. It is followed by an INPUT statement which places the device status indication in computer memory.

```
"RDS(listener addresses;)"
```

Examples:
The sequence

```
400 PRINT #1: "RDS16;"
410 INPUT #1: STATUS$
```

polls GPIB device 16 for a service request and places the device status in the variable STATUS$. The sequence

```
500 PRINT #1: "RDS10,16;"
510 INPUT #1: S10$;S16$
```

polls devices 10 and 16 for service requests and places their status indications in the respective variables.

In execution of the read status command, the following steps are performed.

1. The serial poll enable (SPE) GPIB message is issued.
2. The universal unlisten (UNL) GPIB message is issued.
3. The listen address of the controller is placed on the bus.
4. The talk address of the first device to be serially polled is sent.
5. A status byte from that device is sent to the controller.
6. The talk address of the next device to be serially polled is placed on the bus.
7. A status byte from that device is sent to the controller.
8. Steps 6 and 7 are repeated until all devices listed in the RED command have been polled.
9. The serial poll disable (SPD) GPIB message is sent.

POL (Parallel Poll)

The controller can poll up to eight peripherals at a time by using the parallel poll command. Each of the eight GPIB data lines may input a status bit from a separate device. Device status is received by an INPUT statement which follows POL.

Example:

The sequence

```
600 PRINT #1: "POL"
610 INPUT #1: STATUS$
```

executes a parallel poll of the GPIB and places device status into the variable STATUS$. The devices polled are those which have been set up for parallel polling by the parallel poll configure command described next.

PPC (Parallel Poll Configure)

The PPC command is used with GPIB peripherals which support parallel polling as specified by the PP1 subset (remote polling) of the IEEE-488 standard. Issued in advance of the POL command, it prepares devices for parallel polling and allocates the eight available status bits among them. The PPC command has the following format.

"PPC(listener address.response sense-status line;)"

Example:

```
700 PRINT #1: "PPC10.01,20.18;"
```

Tells device 10 to respond with a "0" on status line 1 and device 20 to respond with a "1" on status line 8.

In execution of the parallel poll configure command, the following steps are performed.

1. The universal unlisten (UNL) GPIB message is sent by the controller.
2. The address of the first device to be set up for parallel polling is placed on the bus.
3. The parallel poll configure (PPC) GPIB message is issued, followed by the parallel poll enable (PPE) message.
4. Steps 2 and 3 are repeated until all devices listed have been configured.

PPD (Parallel Poll Disable, Single Device)

This command prevents the GPIB device addressed as a listener from responding to parallel polls. It has the following format.

"PPD(listener address;)"

Example:

```
800 PRINT #1: "PPD16;"
```

Disables device 16 from responding to parallel polls.

In execution of the PPD command the universal unlisten (UNL) GPIB message is issued first, followed by the listener address of the device whose parallel poll response is to be disabled. The parallel poll disable (PPD) bus message is then sent.

PPU (Parallel Poll Unconfigure All Devices)

The parallel poll unconfigure command nullifies the polling configuration established by the PPE command and prevents all devices on the bus from responding to a parallel poll. Since PPU is a universal command, no address list is needed.

Example:

```
900 PRINT #1: "PPU"
```

Disables the parallel poll response of all devices on the bus.

PCT (Pass Control)

It is possible for the computer to temporarily relinquish its bus-controller function to any other GPIB device capable of acting as controller. This is done in two stages. First the device to assume control is addressed; then the actual transfer of control takes place.

The pass control command prepares a designated GPIB device to act as controller of bus operations. The command has the format shown below.

"PCT(listener address;)"

Example:

```
200 PRINT #1: "PCT10;"
```

Transfers bus control to device 10.

TCT(Take Control)

The TCT command enables the home computer to take or retake control of the bus from another GPIB device. No address is necessary with TCT, because only the home computer responds to this command.

Example:

```
210 PRINT #1: "TCT"
```

Gives control of the GPIB to the home computer.

Device-Dependent Code

While the BASIC-language segments of programs are quite consistent, the addressing methods and data formats for individual bus peripherals may vary to a considerable degree depending on the function and manufacturer of the device in question. A message such as PRINT #1: "WRT11;A3B5C7D" might be used to set a relay matrix, for instance, while a spectrum analyzer might respond to PRINT #1: "WRT13;SIGSWP;WAIT;FIB 100;CENSIG;REP 2". Some peripherals must be initialized with special commands in order to function, and others may have to be placed in certain operational modes before they can respond to instructions from the home computer.

Refer to the user's manuals of the various devices for specifics about data formats and command repertoire.

SERVICE INFORMATION

In Case of Difficulty

If the GPIB Adapter Card or attached GPIB devices do not appear to be working properly, check the following.

1. Power--Be sure the Peripheral Expansion System is plugged in and turned on. Also check to be sure that the fuse is not blown, by looking at the fuse to see if the filament is broken or by listening for the fan.

2. Card Position--Turn the power off, wait two minutes, and remove the top from the peripheral system. Verify that all cards are inserted properly and then replace the top.

3. Home Computer--Check to see that the Home Computer works properly with all peripherals and accessories disconnected.

4. Peripheral Expansion System--Check for proper connection between the console and peripheral system.

5. Cables--Be sure that proper GPIB cabling is being used. Check for loose or broken leads. Verify that cables are securely connected.

6. Test Mode--If an attached GPIB instrument has a test or local mode, use it to verify that the device is working properly when disconnected from the bus.

If the GPIB Adapter Card or attached devices still do not appear to be working properly, first turn all power off. Next, disconnect the GPIB Adapter Card from the bus and remove the card from the Peripheral Expansion System. Then follow these steps.

1. See if the Home Computer is working properly with only the Peripheral Expansion System connected. Turn off the Home Computer. Disconnect all devices except the Peripheral Expansion System. Check that the expansion system (without the GPIB Adapter Card in its slot) is connected. Turn on the Home Computer. Press any key and the master selection list appears. Now select TI BASIC. Type OPEN #1:"GPIB" and press ENTER. The error message "I/O ERROR 00" should be displayed, indicating that the device named cannot be opened. (This is the result expected if the GPIB Adapter Card is not inserted in the Peripheral Expansion System.)

2. Check that the GPIB adapter card is working properly. Refer to the Set-Up Instructions section and reconnect the GPIB Adapter Card. Type OPEN #1:"GPIB" and press ENTER. Contents of the screen should scroll up two lines, indicating that the device named has been opened.

3. If any device when reattached to the GPIB Adapter Card still does not work, then the device or its cable may be faulty. Cable pin connections (pinouts) are defined in Appendix C. Check the user's manual of the device for additional troubleshooting suggestions.

4. If none of the above procedures correct the difficulty, refer to If You Have Questions or Need Assistance in this manual or see the Maintenance and Service Information section of the User's Reference Guide.

Exchange Centers (Local Service Options)

If your GPIB Adapter Card requires service, instead of returning the unit to a service facility for repair or replacement, you may elect to exchange the unit for a factory-reconditioned GPIB Adapter Card of the same model (or equivalent model specified by TI) by going in person to one of the exchange centers which have been established across the United States. A handling fee will be charged by the exchange center for in-warranty exchanges of the GPIB Adapter Card. Out-of-warranty exchanges will be charged at the rates in effect at the time of the exchange. Please refer to the enclosed Exchange Service listing or call the Consumer Relations Department for exchange fee information and the location of the nearest exchange center.

If You Have Questions or Need Assistance

If you have questions concerning GPIB Adapter Card repair or peripheral, accessory, or software purchase, please call our Customer Relations Department at 800-858-1802 (toll free within the contiguous United States except Texas) or 800-692-1353 within Texas. The operators at these numbers cannot provide technical assistance.

For technical questions such as programming, specific applications, etc., you can call 806-741-4800. Please note that this is not a toll-free number, and collect calls cannot be accepted.

As an alternative, you can write to

Consumer Relations Department
Texas Instruments Incorporated
P.O. Box 53
Lubbock, Texas 79408

Because of the number of suggestions which come to Texas Instruments from many sources containing both new and old ideas, Texas Instruments will consider such suggestions only if they are freely given to Texas Instruments. It is the policy of Texas Instruments to refuse to receive any suggestions in confidence. Therefore, if you wish to share your suggestions with Texas Instruments, or if you wish us to review any BASIC language program which you have developed, please include the following statement in your letter.

"All of the information forwarded herewith is presented to Texas Instruments on a nonconfidential, nonobligatory basis; no relationship, confidential or otherwise, expressed or implied, is established with Texas Instruments by this presentation. Texas Instruments may use, copyright, distribute, publish, reproduce, or dispose of the information in any way without compensation to me."

APPENDIX A: Error Codes

Listed below are the error codes related to the operation of TI BASIC programs that use the GPIB Adapter Card.

OPEN:

CODE 00--Device named in the statement or command cannot be opened.
CODE 02--A software switch option entry is in error.
CODE 06--A hardware error occurred and the device cannot be opened.

INPUT:

CODE 24--A record of INTERNAL data type is too large to be read into the buffer space allocated.
CODE 26--Some type of hardware error occurred. Also caused by pressing [CLEAR] to stop an input operation either pending or in progress.

PRINT:

CODE 36--See INPUT code 26.

MISCELLANEOUS ERROR CODES:

CODE 43, 73, 83, 93--An attempt to execute an illegal command was made.

*****THIS LIST TO BE VERIFIED*****

APPENDIX B: GPIB Cabling

Cables used to connect other devices to the GPIB Adapter Card must be fitted with 24-pin dual connectors of the Amphenol or Cinch Series 57 type. These allow more than one cable to be attached to a single device and accommodate a wide variety of physical layouts.

The IEEE-488-1978 standard requires that metric threads be used in all GPIB connectors. Connectors that fulfill the metric requirement can be identified by their black finish.

Two common interconnection patterns are the "star" and "daisy chain" configurations illustrated below. In the star configuration all GPIB devices are cabled directly to the bus controller (normally the home computer). The connectors are stacked at the back of the GPIB Adapter Card. In the daisy chain method the first GPIB device is cabled directly to the controller, the second device is attached to the first, and so on.

(Space for illustrations of star and daisy chain cabling configurations)

APPENDIX C: Pin Connections

The 24-pin GPIB connectors are wired as listed below.

Pin	Signal	Pin	Signal
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI	17	REN
6	DAV	18	Gnd 6
7	NRFD	19	Gnd 7
8	NDAC	20	Gnd 8
9	IFC	21	Gnd 9
10	SRQ	22	Gnd 10
11	ATN	23	Gnd 11
12	Shield	24	Logic Gnd

The lines are cabled in a twisted-pair configuration (1-13, 2-14, etc.) for better noise protection. Pins 18-23 are signal grounds for pins 6-11 respectively. Pin 24 serves as ground return for pins 5 and 12.

THREE-MONTH LIMITED WARRANTY

THIS TEXAS INSTRUMENTS GPIB ADAPTER CARD WARRANTY EXTENDS TO THE ORIGINAL CONSUMER PURCHASER OF THE ACCESSORY.

WARRANTY DURATION

This GPIB Adapter Card is warranted for a period of three (3) months from the date of the original purchase by the consumer.

WARRANTY COVERAGE

This GPIB Adapter Card is warranted against defective materials or workmanship. THIS WARRANTY IS VOID IF THE ACCESSORY HAS BEEN DAMAGED BY ACCIDENT, UNREASONABLE USE, NEGLECT, IMPROPER SERVICE OR OTHER CAUSES NOT ARISING OUT OF DEFECTS IN MATERIALS OR WORKMANSHIP.

WARRANTY DISCLAIMERS

ANY IMPLIED WARRANTIES ARISING OUT OF THIS SALE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO THE ABOVE THREE-MONTH PERIOD. TEXAS INSTRUMENTS SHALL NOT BE LIABLE FOR LOSS OF USE OF THE HARDWARE OR OTHER INCIDENTAL OR CONSEQUENTIAL COSTS, EXPENSES, OR DAMAGES INCURRED BY THE CONSUMER OR ANY OTHER USER.

Some states do not allow the exclusion or limitation of implied warranties or consequential damages, so the above limitations or exclusions may not apply to you in those states.

LEGAL REMEDIES

This warranty gives you specific legal rights, and you may also have other rights that vary from state to state.

WARRANTY PERFORMANCE

During the above three-month warranty period, your GPIB Adapter Card will be repaired or replaced with a new or reconditioned unit of the same or equivalent model (at TI's option) when the unit is returned by prepaid shipment to a Texas Instruments Service Facility listed below. The repaired or replacement unit will be warranted for three months from date of repair or replacement. Other than the postage requirement, no charge will be made for the repair or replacement of in-warranty units.

Texas Instruments strongly recommends that you insure the unit for value, prior to shipment.

TEXAS INSTRUMENTS CONSUMER SERVICE FACILITIES

U.S. Residents

Texas Instruments Service Facility
2303 North University
Lubbock, Texas 79415

Canadian Residents

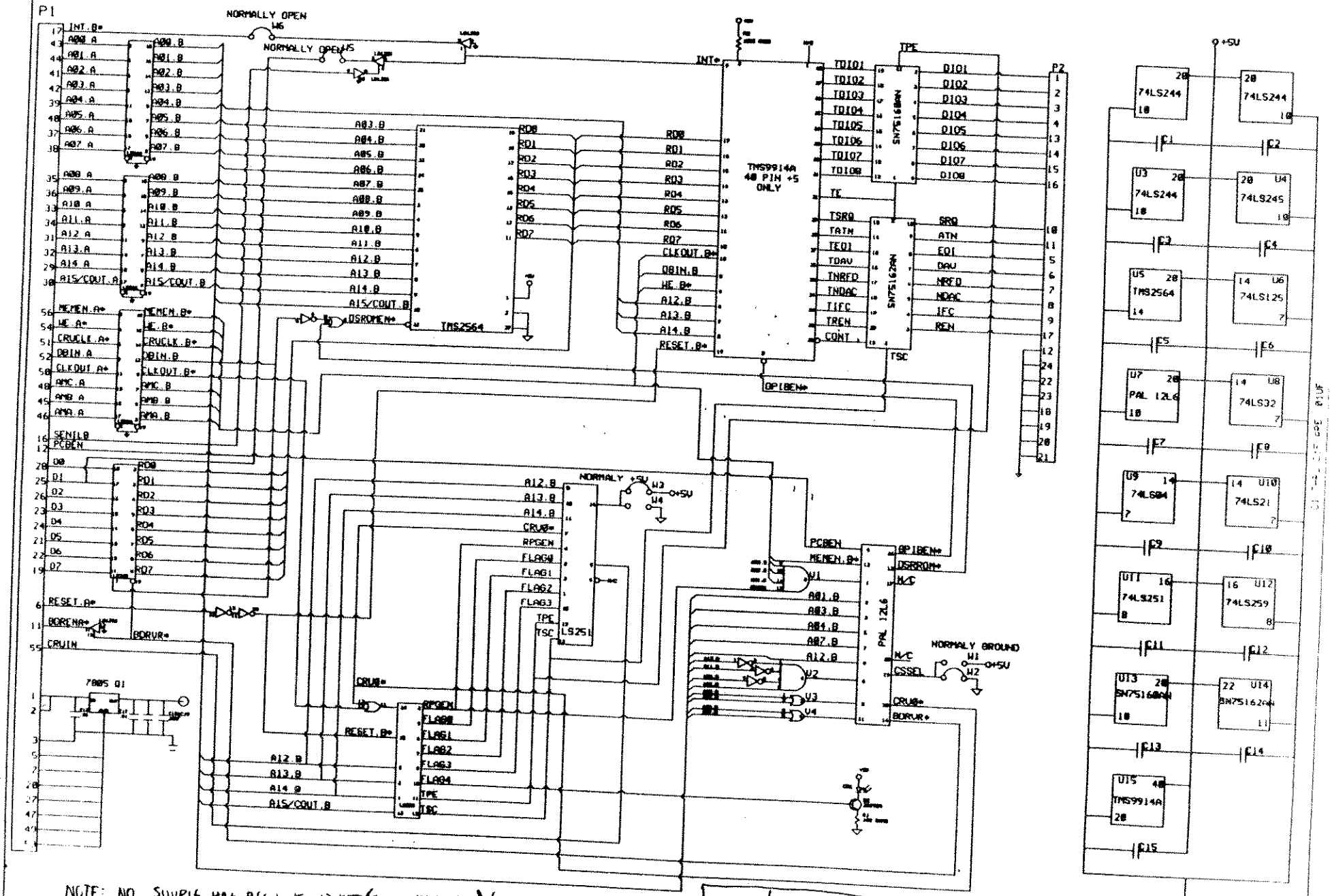
Geophysical Services Incorporated
41 Shelley Road
Richmond Hill, Ontario, Canada L4C5G4

Consumers in California and Oregon may contact the following Texas Instruments offices for additional assistance or information.

Texas Instruments Consumer Service
831 South Douglas Street
El Segundo, California 90245
(213) 973-1803

Texas Instruments Consumer Service
10700 Southwest Beaverton Highway
Park Plaza West
Beaverton, Oregon 97005
(503) 643-6758

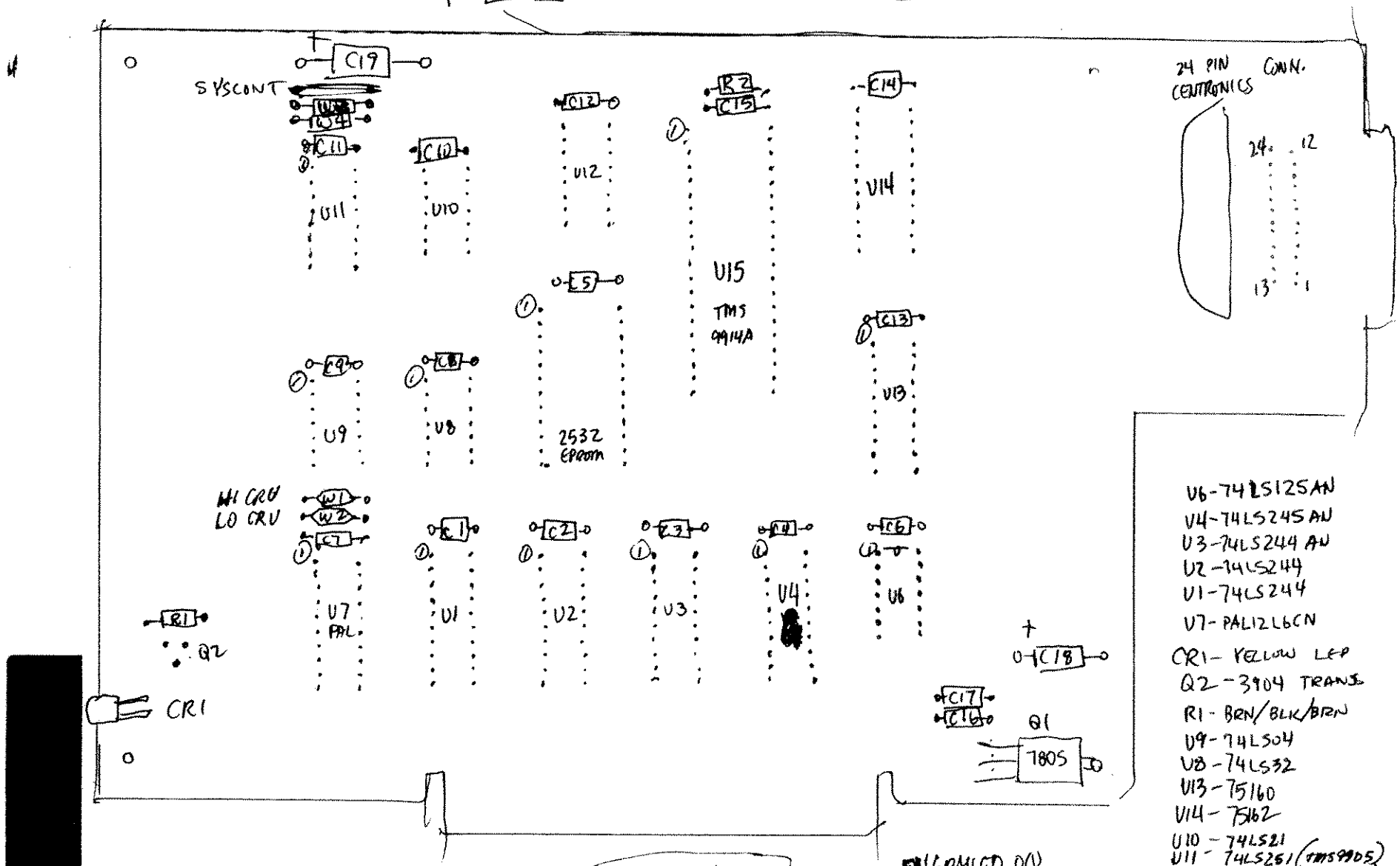
FOR MORE INFO:
CONTACT: R. FLEETWOOD
PO BOX 181662
DALLAS, TX 75218



NOTE: NO SOURCE HAS BEEN FOUND YET (EVEN DOD T.I.) for THE TMS 9914 CHIP. This is the heart of this interface. The search will continue.

TI 99/4A - IEEE-488 INTERFACE CARD SCHEMATIC

(1) IEEE-488 BOARD LAYOUT



U6 - 74LS125AN
U4 - 74LS245 AN
U3 - 74LS244 AN
U2 - 74LS244
U1 - 74LS244
U7 - PAL12L6CN
CR1 - YELLOW LED
Q2 - 3904 TRANS
R1 - BRN/BLK/BRN
U9 - 74LS04
U8 - 74LS32
U13 - 75160
U14 - 75162
U10 - 74LS21
U11 - 74LS251 (TMS9905)
U12 - 74LS259 (TMS9906)
C18 - 22uF, 25V ELEC
C19 - 22uF, 25V ELEC

PC BOARD # 1039427-2

IEEE-488

ENGRAVED ON SERIAL # 039

[redacted]

PMC 4382
near 245 chip

LABEL GD. BD H.L.P. 8-13-83