PCL-848A/B

MULTIFUNCTION IEEE-488
INTERFACE CARD

PCL-848A/B MULTIFUNCTION
IEEE-488 INTERFACE CARD
USER'S MANUAL

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1. GENERAL INFORMATIQN

1.1. Introduction to the Product

The PCL-848A/B IEEE-488 interface card is a valuable addition to your PC that allows you to communicate with over 2000 products, made by over 200 manufacturers, in over 14 countries. The IEEE488-1978 standard that this IEEE-488 card implements is the most widely used international standard for information transfer between computer and electronic instruments. There are numerous publications and articles that may be used in conjunction with this manual to assist you to understand the interface standard. The IEEE reference document may be ordered by writing to the IEEE Service Center, 445 Uoes Piscataway, NJ 08854, USA.

The IEEE-488 interface card provides the hardware (electrical and mechanical) and software required for you to interface your PC to the IEEE-488 bus. The software is packaged in read-only-memory (firmware) to provide versatile and easy-to-use IEEE-488 function extensions for your current programming language or operating system. Firmware cannot be accidentally erased or overwritten and it is always available for use by application programs. This manual provides a programming reference (Section 3.) and programming techniques (Section 4. and 5.) to assist you in writing your own application programs.

The key features of this interface card include:

* Operating in one of the two modes (switch selectable).
  Mode A : Compatible with PCL-748 and use the on-board firmware driver.
  Mode N : Software compatible with National Instrument PC-II and IBM-PC GP-IB adaptor and use the driver and software developed for them.
* Implementation of the entire IEEE-488 standard.
* Powerful and easy-to-use software command set. Fewer arguments and simple initialization.
* Software driver is in on-board firmware. Requires no additional disk operation when using BASIC or Turbo Pascal.
* On-board RAM for working space. No system memory space is needed for the IEEE-488 interface operation.
* Built-in 16 bit digital output port provides a convenient and economical solution for signal switching and digital control applications. The D/O port is compatible with the daughter boards: PCLD-785 Relay Output Eoard, PCLD-786 SSR & Relay Driver Board and PCL-789 Amplifier Multiplexer Board.

BASICA, BASIC compiler and Quick-BASIC are supported as standard languages. C and Pascal language support packages can be ordered separately as PCL-748-C and PCL-748-P.

The software can change the PC printer port to an IEEE-488 device. The PrtSc (print screen) key, all print statements, word processing and spreadsheet programs that use printer driver in BIOS can use IEEE-488 printers.

* High speed direct memory access (DMA) with the ability to handle 64K byte arrays.
* Programmable system controller, active controller or device functions.
* All device functions, addresses, interrupt conditions, and parallel poll responses are programmable.
* Automatic initialization. Interface parameters are set to default when starting using the interface. Parameters can still be changed by calling the initialization routine.
* DIP switch selectable wait states (0/2/4/6 wait states) to ensure the compatibility to very high speed PC's.
* PCL-848A offers the connectors of the IEEE-488 standard while PCL-848B uses the 25 pin D type connectors for the IEC-625 standard.
* Each device on the IEEE-488 bus can be assigned with its own terminator.

1.2. Description of the Documentation

Information in this manual is given at several levels of detail and is organized to allow you to work through the TUTORIAL, PROGRAHMING REFERENCE and PROGRAMMING TECHNIQUES sections.

If you have no IEEE-488 experience, go to Section 9. after this section.

The IEEE-488 TUTORIAL in Section 9. is designed to give you a thorough understanding of how the IEEE-488 General Purpose Interface Bus (GP-IB) works. Topics in the TUTORIAL should be read in sequence if you have no IEEE-488 background and intend to write application programs. With a solid understanding of the basic IEEE-488 concepts, followed by returning to the PROGRAMMING REFERENCE, and the PROGRAMMING TECHNIQUES, you should be able to program almost any IEEE-488 bus system without interface problems.

If you are familiar with the basic concepts of the IEEE-488 bus you may want to begin reading the Section 3. PROGRaI~MING REFERENCE. This section describes the statement syntax and techniques to use the IEEE-488 driver in the firmware. Section 4. PROGRAMMING TECHNIQUES will show you how the functions are used in typical applications and also provide you with some useful program examples for your own applications. All the examples are written in BASICA language.

If you want to know more details about this IEEE-488 interface card, please refer to Section 5. ADVANCED PROGRAMMING TECHNIQUES. This section tells you how to set DMA, how to modify transfer speed and how to use interrupts.

This manual is intended to be accurate and is organized to give you a quick reference for programming ideas and the concepts of the IEEE-488 bus.

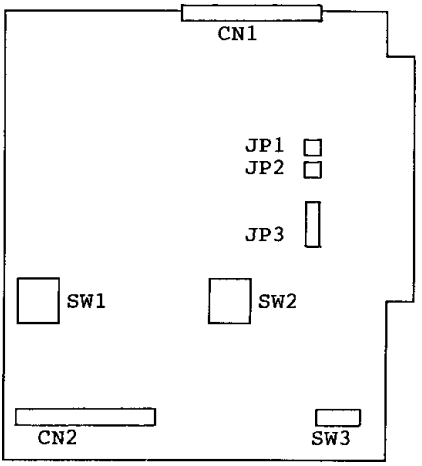
2. INSTALLATION

2.1. Inspection

When unpacking, check the unit for signs of shipping damage (damaged box, scratches, dents, etc). If there is any damage to the unit or it fails to meet specifications, notify your localt sales representative immediately. .

2.2. Switch and Jumper Setting

This IEEE-488 interface card has two DIP switch (SW1 and SW2), 1 one slide switch (SW3) and three jumpers (JP1, JP2 and JP3). The: setting must be coincident with the application program.



Legend:

CN1: GP-IB connector CN2: Digital output connector

SW1: I/O port base address and wait states SW2: Firmware base address SW3: Operation mode (PCL-748 or NI PCÑI I)

JP1: DACK channel JP2: DRQ channel JP3: IRQ level Fig. 2.2 . Location of switches and jumpers

Fig. 2.2 Location of switches and jumpers

2.2.1. I/O Base Address and Wait State Setting

The I/O ports base address and the number of wait states are selectable by the 8 position DIP switch SW1. The base address can be set anywhere in the I/O address area from hex 200 to hex 3F8 and the wait states can be set to 0, 2, 4, or 6. Refer to 3 Fig. 2.2. for the locations of the DIP switches SW1. Factory settings of these switches are hex 2B0 and zero wait state.

This multifunction interface card takes 16 addresses of I/O port following the base address. The digital output port takes the addresses of BASE+0 and BASE+1 and the IEEE-488 interface takes the addresses from BASE+8 to BASE+15. When using the IEEE-488 driver routines, the IEEE-488 interface base address must be set to BASE+8 where the BASE is the set by DIP switch SW1. The default address of the IEEE-488 interface is then hex 2B8.

The switch settings for various base addresses and wait states are illustrated as below:

Note : - 0N = 0, 0FF = 1
- 1..8 are switch positions
- W0..W1 correspond to wait state
- A4..A8 correspond to address lines of the PC bus
- * means factory setting

Switch position (SW1)

	1 A8	2 A7	3 A6	4 A5	5 A4	Occupied Addresses
	0	0	0	0	0	200-20F
	0	0	0	0	1	210-21F
			.			
			.			
			.			
*	0	1	0	1	1	2B0-2BF
			.			
			.			
	1	1	1	1	0	3E0-3EF
	1	1	1	1	1	3F0-3FF

Switch position (SW1)

	7 W1	8 Wait state(s) W0
*	0	0 0
	0	1 2
	1	0 4
	1	1 6

2.2.2. Firmware Address Setting

The IBEE-488 interface driver routine is stored in the on-board i EPROM. The memory address of this firmware can be selected by SW2. The memory segment of the firmware can be from hex 8000 to s hex FC00. Factory setting is hex D000.

The range of these locations is out of the 640K system memory of i the IBM PC, PC/XT and PC/AT. However, choice of this location must be made to avoid any conflict with other interface cards. When two or more IEEE-488 interface cards are used in one PC, the location settings must be different in order to have different working space although the firmware code is the same.

The SW2 positions l to 5 determine the address bits Al8 to Al4. ~ Address bit A19 is always 1. Address bits below A13 (included) are not cared.

Memory Location Segment (hex)		SW2-1 A18	SW2-2 Al7	SW2-3 A16	SW2-4 A15	SW 2-5 A14
	8000	0	0	0	0	0
	8400	0	0	0	0	1
	8800	0	0	0	1	0
	.					
	.					
Reserved	A000	0	1	0	0	0
	.					
	.					
CRT Display	B000	0	l	1	0	0
	.					
	.					
Factory Setting	D000	1	0	1	0	0
	.					
	.					
System ROM	F000	1	1	1	0	0
	FC00	1	1	1	1	1

* 0 : ON l : OFF

This multifunction IEEE-488 interface card takes 10K bytes of the memory space including 8K byte RON and 2K byte RAM. The starting . address of the working RAM is offset 8K bytes from the ROM starting address.

2.2.3. Operating Mode Setting

SW3 is a slide switch to select the operating mode. When it is set to “A”, this card is compatible with the easy-to-use PCL-748 IEEE-488 interface card except there is no real time clock. When SW3 is set to “N”, this card becomes NI PC-II compatible. 3

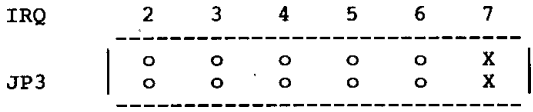
It depends on the users which mode is selected. If the software package is already developed for PC-II, then mode “N” can be used to eliminate the software effort. Dowever, for new software developing, mode “A” is recommended to get all the benefit of PCL-848A/B. PCL-848A/B does not support the software driver to use mode “N” and this manual offers the information for mode “A” 3 operation only.

2.2.4. DMA Level Setting

The PCL-848A/B is designed to permit DMA (Direct Memory Access) = data transfer between IEEE-488 bus and the system RAM of the PC. The DMA level is set by JP1 and JP2. The JP1 is for DACK signal path while the JP2 is for DRQ. The settings of JP1 and JP2 must be coincident. For example, if the JP1 is set to DACK 3, then JP2 must be set to DRQ 3.

2.2.5. Interrupt Level (IRQ) Setting

The PCL-848A/B is designed to permit access to interrupt level 2 up to level 7 and the interrupt is initiated by the NEC7210 GP-IB interface controller. The selection is made by setting JP3.



Note : Although the IRQ level can be set from IRQ 2 to IRQ 7 _ on the board, the firmware supports IRQ 2, 3, 5, and 7 only.

2.3. Installing the Card

2.3.1. Preparation

Discharge any static electricity by touching the back of the system unit before you handle the board. You should avoid contact with materials that create static electricity such as plastic, vinyl, and styrofoam.

The IEEE-488 interface card is setup at the factory of default setting:

Jumper/Switch	Selection	Default setting
SW1 1-5	I/O port base address	Hex 2B0
SW1 7-8	Wait states	0
SW2	Firmware base address	Hex D000
SW3	Operating mode	A
JP1	DACK level	1
JP2	DRQ level	1
JP3	IRQ level	7

Refer to Section 2.2. for other configurations.

2.3.2. Installing the Card into a PC

The procedure to install the IEEE-488 interface card is as following:

1. Turn off the computer and any peripheral devices (such as printers and monitors).
2. Disconnect the power cord and any other cables from the back of the computer. Turn the system unit so the back of the . unit faces you.
3. Remove the system unit cover (See your computer user's guide if necessary).
4. Locate the expansion slots at the rear of the unit and =; choose any unused slot.
5. Remove the screw that secures the expansion slot cover to the system unit. (Save the screw to secure the IEEE-488 interface card retaining bracket).
6. Carefully grasp the upper edge of the IEEE-488 interface 3 card. Align the hole in the retaining bracket with the hole on top of the expansion slot, and align the gold striped edge connector with the expansion slot socket. Press the board firmly into the socket.
7. Replace the screw in the expansion slot retaining bracket.
8. Replace the system unit cover. Connect the cables you ~emoved in step 2.

2.3.3. Function Check

Confirm proper operation by connecting an IEEE-488 instrument to i the bus and attempting to operate it with a program written in BASIC.

Here is an example procedure using an HP3478A digital voltmeter s and a short BASIC program.

1. Connect the HP3478A DVM to the IEEE-488 bus connector Of this card on the back of the PC with a standard IEEE-488 s cable. On the PCL-848B, the connector is 25 pin D type defined by IEC-625 and a PCL-15488-2 IEC-625 to IEEE-488 cable must be used.
2. Set the device address of the HP3478A DVM to 23.
3. Turn on the HP3478A DVM and the PC.
4. Get into BASICA or GWBASIC environment.
5. Key in the following BASIC statements:

```
10      DEF SEG=&BD000
20      OUTPUT%=3 : ENTER%=6
30      ADDR%=23 'GP-IB address of up3478A
40      TMP$="F1" ~UP3478A DVM programming code
50      CALL OUTPUT%(ADDR%,TMP$)
60      FOR I=1 TO 10
70      D$=SPACE$(80)
80      CALL ENTER%(ADDR%,D$)
90      PRINT D$
100     NEXT I
110     END
```

6. Execute the program. It will display the 10 readings i measured by the HP3478A DVM and thus confirm proper ~ operation.

If the system fails this test, check for these common problems:

1. The instrument requires a special terminator. Check the instruments instruction manual and Section 3. of this manual.
2. The programming command syntax for the instrument may be incorrect. Check the examples in the instrument manual.
3. Check all electrical connections.

   If there is still any problem, contact your local sales representative for further assistance.

3. PROGRAMMING REFERENCE

3.1. Introduction

The PCL-848A/B interface card contains the resident firmware that provides IEEE-488 language extensions for your PC. The firmware (software programmed into a read-only-memory) appears transparent to the users and the function inside is called by the IEEE-488 commands.

All of the routines in the firmware are written in assembly language to insure maximum data transfer rates. Each routine combines bus error checking. The routines also check parameter values to insure that appropriate bus protocol is followed.

The routines in the firmware transfer commands and data on the IEEE-488 BUS through the use of statements that are given English I language names like OUTPUT, ENTER and INIT. Statement OUTPUT sends a data string to the IEEE-488 BUS in much the same way as <PRINT “string”> sends data to the screen. Statement ENTER looks] for data coming from the IEEE-488 BUS, similar to the way <INPUT X$> waits for a keyboard entry to assign to the string variable X$. Statement INIT clears the interface and sets up specific operating modes on the interface card as the CLS clears the screen and establishes specific operating conditions.

The data strings that you include in a SEND statement can be as general as the strings you would use in a <PRINT> statement. The SEND function interprets IEEE-488 commands and data in any order that you choose. It also allows you to build powerful commands that can be assigned to a single string variable that has a name and purpose that is meaningful to you. The IEEE-488 BUS commands are separated by one or more spaces. There is no difficult syntax to learn and only standard IEEE-488 mnemonics are used. The function of each mnemonic is performed exactly as defined in the IEEE-488-1978 standard.

The firmware converts your command and data strings to specific control codes for the IEEE-488 bus controller chip. It also passes back received data and interface status conditions to your program. Received information may be used directly by your program and the status codes (those returned by the STATUS function) may be used to determine various interface operating conditions or to detect syntax errors in the statements.

The next section discusses the CALL statement of BASICA and QuickBASIC. All of the examples are given in BASICA, the syntax and use of each function is similar to those of QuickBASIC version 2.0, 3.0 and 4.0.

3.2. Using the BASIC CALL Statement

The firmware routines on the IEEE-488 interface card, can be thought of as BASIC language extensions. The extensions consist i of the statements ABORT, CLEAR, ENTER, ENTERA, EOL, INIT, LLO, LOCAL, OUTPUT, OUTPUTA, PPOLL, PPOLLC, PPOLLU, REMOTE, SEND, SPOLL, STATUS, TIMEOUT, TRIGGER and ERRPTR. These routines allow ~ the PC to execute much faster because they are written in assembly language. Another advantage is that the statement names only represent address offsets and these offsets may be given any name that you prefer.

Calling the routines in the firmware when using BASICA requires three steps.

1. The location of the firmware routines must be defined using a DEF SEG statement. This statement defines the current is egment address of the firmware and it is determined by the setting of SW2. Since the factory setting is hex D000, as statement as following is required.

   DEF SEG = &HD000

Note: *In most cases, the default setting of SW2 (hex D000) i is all right for operation. Keep this setting unless another add-on card occupies this memory space and cannot be changed.*

2. The called routine must be located within the segment as defined by an offset variables. For example, the OUTPUT routines has an offset of 3 and a statement to define the offset variables is:

   OUTPUT% = 3

Note: *The OUTPUT% variabLe can be other variable names.*

3. The parameters needed by this routine must be defined ~‘ according to the requirement of the application. Then, the s routine is executed by using a CALL statement. The state ments are such as:

   ADDR% = 23
   D$ = “F1RA”
   CALL OUTPUT%(ADDR%,D$)

Additional information on the DEF SEG and CALL statements is available in your BASIC manual.

Every called routine must define its entry address with an offset from the current segment. For ease of reference all IEEE-488 routine offsets are at three byte increments and start at the top of the segment. For example, the INIT routine is at an offset of 0 (zero), the OUTPUT routine is at an offset of 3, the ENTER routine is at an offset of 6, and so on.

Please note that the program offsets must be entered exactly as shown for each interpreter routine. The offsets determine where the program will branch and an improper location can cause the PC to ignore all inputs except the power switch. This is true of all BASIC CALL subroutines and is not a limitation of the interface board. When you assign the offset, you are explicitly telling the CPU of the PC where to look for its next instruction. Because it is running an assembly language routine, it cannot check the validity, purpose, or use of each instruction the way it does as with BASIC instructions. For that reason, it depends on receiving the proper offset address and then assumes that the instructions are correct. The DEF SEG statement and all offset address may be assigned with a single BASIC statement and never require reassignment within your program. That means you can “set it and forget it” and get on with the job of solving your program rather than being concerned about addressing details.

Each routine also access the parameters those are received from or passed back to the BASIC program. These parameters are shown in parentheses following the program offset variable for each statement.

There are some limitations in BASICA that have, unfortunately, placed restrictions on the called routines.

* The order, number, and type of variables passed to the routines must be exactly as shown for each routine. This is because BASIC only passes pointers of variables and does not provide a variable type identifier.

* The BASIC interpreter and compiler (such as Compiled BASIC and QuickBASIC) have different string variable requirements. -t The default is for the BASIC interpreter. For the BASIC compiler, you must call the INIT routine to set the SETTING% bit 8 to be “1” to tell the firmware routines to handle the 3 parameters in a different way.

* Passed parameters must be variables and cannot be constants.

* BASIC may change its source code if a statement changes the contents of the passed string. This situation can be avoided by assigning a value to the string argument before calling the firmware routines. The statement to define a blank string to receive data is recommended is as:

  D$ = SPACE$(255).

The programming examples and interpreter routines have been written to work around these limitations and they should not placed any restrictions on your IEEE-488 applications.

3.3. Using QuickBASIC and BASIC Compiler

Calling the IEEE-488 routines in the firmware when using BASIC compiler or QuickBASIC is almost the same way as using BASICA except the following two areas.

1. When using the IEEE-488 routines in BASICA programming, the l; user does not need to call the INIT routine (initialization) except the default setting is not used. Uowever, the user need to call the INIT routine before calling any other IEEE488 routines when programming in BASIC compiler or QuickBASIC. When calling the INIT routine, the bit 8 of the parameter SETTING% must be set to “1”.

2. The syntax to call the IEEE-488 firmware routines when programming in BASICA is as:

   CALL OUTPUT%(ADDR%,D$)

however, in BASIC compiler or QuickBASIC, the syntax is: lt

   CALL ABSOLUTE(ADDR%, D$,0UTPUT%)

Note: When using QuickBASIC, the user needs to enter the developing environment by the command

   QB/L

to load the library USERLIB.EXE. Otherwise, the word “ABSOLUTE” cannot be recognized.

3.4. The Driver Routines

The following twenty one routines can be called by programs written in BASICA, BASIC Compiler or QuickBASIC to access the IEEE-488 interface. QuickBASIC has the same syntax as BASIC Compiler.

3.4.1. AHORT

Purpose:

This command aborts all activities on the interface bus bys

Offset :

AHORT%=9

Syntax :

CALL AHORT%	---BASIC
CALL AHSOLUTE(AHORT%)	---BASIC Compiler

Parameter:

None.

Bus Activity :

IFC is pulsed for 100 microseconds.

REN is set true

ATN is set false.

Remark :

This command can be called only in system controller mode An error will occur if this command is called in the nonsystem control mode.

3.4.2. DEVCLR (Device Clear) Purpose :

This command sends a Selective Device Clear (SDC) command to a specified device or sends a Device Clear (DCL) to the interface bus.

Offset :

DEVCLR%=15

Syntax :

CALL DEVCLR%(ADDR%)	---BASIC
CALL ABSOLUTE(ADDR%,DEVCLR%)	---BASIC Compiler

Parameter :

ADDR% - The address of the device to be cleared. If 0 <= ADDR% <= 30, it executes a Selective Device to the i device specified, otherwise, it executes a Device Clear to the bus.

Bus Activity :

- If 0 <= addr <= 30

ATN is set true.
UNL is sent.
LAD is sent.
MTA is sent.
SDC is sent.

- If addr < 0 or addr > 30

ATN is set true.
DCL is sent.

3.4.3. DEVICE

Purpose:

This command installs an IEEE-488 device driver in place of s the LPT1:, LPT2:, LPT3:, COM1: and COM2: driver. The IEEE-488 devices then can be accessed using the system commandst in MS-DOS.

Offset :

DEVICE%=57

Syntax:

CALL DEVCLR%(ADDR%,PORT%)—BASIC

CALL ABSOLUTE(ADDR%,PORT%,DEVCLR%) —BASIC Compiler~

Parameter:

ADDR% - The address of the device which is assigned to

LPTn: or COMn:. If ADDR% < 0 or ADDR% > 30, the replacement of LPTn: or COMn: is disabled.

PORT% - The port number which is to be replaced with the IEEE-488 device.

1 : assigned to LPT1:
2 : assigned to LPT2:
3 : assigned to LPT3:
4 : assigned to COM1:
5 : assigned to COM2:

Bus Activity:

None.

3.4.4. ENTER Purpose :

This command enters a string from a device or from the interface. Reading iB terminated upon receiving the terminator specified by the EOL command or the maximum length of data bytes is reached.

Offset :

ENTER%=6

Syntax :

CALL ENTER%(ADDR%,DS) ---BASIC

CALL ABSOLUTE(ADDR%,D$,ENTER%) ---BASIC Compiler

Parameter :

ADDR% - Device address. If 0 < ADDR% <= 30, then it enters the string from the specified device, ~ otherwise, it enters the string from the interface.

D$ - The string from the specified device or from the interface.

Bus Activity :

- If 0 <= addr <= 30

ATN is set true.
REN is set true.
UNL is sent.
TAD is sent.
MLA is set.
ATN is set false.
Data string is entered.

- If addr < 0 or addr > 30

ATN is set false.
Data string is entered.

Remark:

The entered string length can be read by STATUS.

3.4.5. ENTERA

Purpose :

This command enters a long string (can be up to 65535 bytes) from a specified device or from the interface. Reading is terminated upon receiving the terminator, or when the specified length is reached, or on timeout. The string is put into the specified segment in the memory. The starting address of the received string has offset 0 in that segment.

Offset :

ENTERA%=51

Syntax :

CALL ENTER%(ADDR%,DATASEG%,LENGTH%) ----BASIC

CALL ABSOLUTE(ADDR%,DATASEG%,LENGTH%,ENTERA%)

----EASIC Compiler

Parameter :

ADDR% -	The address of the device the input string comes from, If 0 <= ADDR% <= 30, the specified device is the talker, otherwise, the talker is the previously defined one.
DATASEG% -	The memory segment where the string is to be put. The starting address offset is 0.
LENGTH% -	The input string length. The range is from 0 to 65535.

Bus Activity :

- If 0 <= addr <= 30

  ATN is set true. UNL is sent. TAD is sent. MLA is set. ATN is set false. Data string is entered.

- If addr < 0 or addr > 30

  ATN is set false. Data string is entered.

Example:

```
10      DEF SEG=&HD000 ‘ Define location of firmware :
20      ENTERA%=51 : STATUS%=42 ‘ Define routine offset
.
.
40      ADDR%=8   ‘ GP-IB Device 8 as data source
50      DATASEG%=&u3000  ‘ Put data to this segment
60      LENGTH%=&RFFFF  ‘ Set buffer length 65535 byte
70      CALL ENTERA%(ADDR%,DATASEG%,LENGTu%) ‘Enter data
80      CONDITION%=9 : COUNT%=0
90      CALL STATUS%(CONDITION%,COUNT%) ‘Read data length
100     DEF SEG=&u3000 ‘ Define location of data
110     IF COUNT%<0 THEN CNT=655361+COUNT% ELSE CNT=COUNT%
120     FOR I= 1 TO CNT
130     PRINT CER$(PEEK(I-1)); ‘Print the data string
140     NEXT I
150     DEF SEG=&HD000
.
.
```

3.4.6. EOL

Purpose :

This command sets the terminators of input and output strings for the specified device. The terminators of all devices are set to default values if this command is not called.

Offset :
EOL%=12

Syntax :
CALL EOL%(ADDR%,OUTEOL%,OUTEOL$,INEOL%,INEOLBYTE%)
----BASIC
CALL ABSOLUTE(ADDR%,OUTEOL%,OUTEOLS,INEOL%,INEOLBYTE%,EOL%)
----BASIC Compiler

Parameter :

ADDR% - The address of device to be assigned the terminator. The range is from 0 to 30.

OUTEOL% - Terminator type appended to output string. The default value is 0.

0 Terminated with both OUTEOL$ and EOI.
1 Terminated with EOI only. OUTEOL$ not used. i;
2 Terminated with OUTEOL$ only. EOI is disabled.

OUTEOL$ - End-Of-Line string which is to be sent following output strings. The string can be 8 characters long at maximum. The default string is 13, 10 (CARRIAGE RETURN and LINE FEED).

INEOL% - The condition for which the input string is terminated. The default value is 0.

0 Terminated when INEOLBYTE$ received or EOI true or input string full.
1 Terminated when EOI true or input string full.

INEOLBYTE$ - The ASCII code of the character upon which the input string will be terminated when INEOL% is 0. The default is 10 (LINE FEED).

Bus Activity :

None.

3.4.7. INIT

Purpose :

This aommand initializes the interface card and sets the relative parameters. It can be neglected if the parameters used are all default values.

Offset :

INIT%=0

Syntax :

CALL INIT%(IOPORT%,MYADDR%,SETTING%) ----BASIC

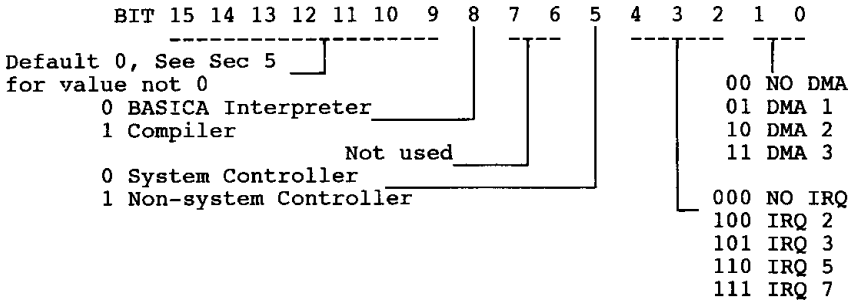
CALL ABSOLUTE(IOPORT%,NYADDR%,SETTING%,INIT%)
----HASIC Compiler

Parameter :

IOPORT% - I/O port of NEC7210, from hex 008 to hex 2F8 by increment of hex 010. The value is the I/O base address plus 8. The default value is hex 2B8 since the base address (determined by SW1) of this card is set to hex 2B0 at factory.

MYADDR% - IEEE-488 address of the IEEE-488 interface card. The range-is from 0 to 30. The default value is 21.

SETTING% - An integer (16 bit) to set the DMA LEVEL, IRQ LEVEL and other parameters. The default value is 0, i.e., 8ASIC interpreter, system controller, no IRQ and no DMA.



For more information about bit 12,14,15 of setting, please refer to Section 5. ADVANCED PROGRANMING TECUNIQUES.

Bus Activity :

This command takes following action when it is called.

1. Initialize the NEC7210 GP-IB controller.
2. Set relative parameters for the NEC7210.
3. Store the I/O base address, IRQ level and DMA level into working RAM.

Examples :

1) Set IEEE-488 interface card to mode : Non-system controller, No IRQ, No DMA. Bus address is 21. I/O port address is hex 2B8 (SW1 is set at hex 2B0).

```
50 INIT% = 0
60 MYADDR% = 21
70 IOPORT% = &u2B8
80 SETTING% = &H008F
90 CALL INIT%(IOPORT%,MYADDR%,SETTING%)
.
.
```

2) Set IEEE-488 interface card to mode : System controller, IRQ level 7 and DMA level 1. IEEE-488 address is 0. I/O port address is hex 3C8 (SW1 is set at hex 3C0).

```
.
.
50 INIT% = 0
60 MYADDR% = 0
70 IOPORT% = &H3C8
80 SETTING% = &H001D  ' Bit 0, 2, 3, 4 are all 1
90 CALL INIT%(IOPORT%,MYADDR%,SETTING%)
.
.
```

3) Set IEEE-488 interface card to BASIC Compiler mode, System controller, No IRQ, DMA level 2. Bus address is 21. I/O port address is hex 2B8.

```
.
.
50 INIT% = 0
60 MYADDR% = 21
70 IOPORT% = &H2B8
80 SETTING% = &H0102
90 CALL INIT%(IOPORT%,MYADDR%,SETTING%)
.
.
```

3.4.8. LLO

Purpose :

This command executes a Local Lockout (LLO) to disable a device's front panel. It is received by all devices on the bus, whether or not they are addressed to listen.

Offset :

LLO%=18

Syntax :

CALL LLO%	----BASIC
CALL ABSOLUTE(LLO%)	----BASIC Compiler

Parameter :

None.

Bus Activity :

ATN is set true. LLO is sent.

3.4.9. LOCAL

Purpose :

This command executes a Go To Local (GTL) or clears the REN line to enable a device's front panel controls.

Offset :

LOCAL%=21

Syntax :

CALL LOCAL%(ADDR%)	----BASIC
CALL ABSOLUTE(ADDR%,LOCAL%)	----BASIC Compiler

Parameter :

ADDR% - The address of the device to be set local. If 0 <= addr <=30, then it executes a Go To Local (GTL) command to the specified device. Otherwise, it sets the REN line false (High).

Bus Activity :

- If 0 <= addr <= 30
  ATN is set true.
  UNL is sent.
  LAD is sent.
  MTA is sent.
  GTL is sent.

- If addr < 0 or addr > 30
  REN is set false.
  ATN is set false.

3.4.10. OUTPUT Purpose :

This command outputs a string to the specified device or to the interface bus. After the string is sent, the terminator 3 specified by the EOL command is sent.

Offset :

OUTPUT%=3

Syntax :

CALL OUTPUTi(ADDR%,D$)	----BASIC
CALL ABSOLUTB(ADDR%D$,OUTPUT%)	----BASIC Compiler 3

Parameter :

ADDRt -	Device address. If 0 <= addr <= 30, then it outputs the string to the specified device. Otherwise, it outputs the string to the interface bus.
D$ -	The data string variable to be output.

Bus Activity :

- If 0 <= addr <= 30
  - ATN is set true.
  - REN is set true.
  - UNL is sent.
  - LAD is sent.
  - MTA is sent.
  - ATN is set false.
  - Data string is sent.
  - EOL string and/or EOI is sent.
- If addr < 0 or addr > 30
  - ATN is set false.
  - Data string is sent.
  - EOL string and/or EOI is sent.

3.4.11. OUTPUTA

Purpose :

This command outputs a long string (can be up to 65535 bytes) to a specified device or to the interface. The output string iB terminated when the length of the output string is approached, or when the bus handshake times out. The output string is in the memory area with the specified segment. The start address of the output string is at offset 0 in that segment.

Offset :

OUTPUTA%=54

Syntax :

CALL OUTPUTA%(ADDR%,DATASEG%,LENGTH%) ----BASIC
CALL ABSOLUTE(ADDR%,DATASEG%,LENGTH%,OUTPUTA%)
----BASIC Compiler

Parameter :

ADDR% -	The address of the device which the output string is sent to. If 0<=addr<=30, then the specified device is the listener. Otherwise, the listener(s) is(are) the previously defined one(s).
DATASEG% -	The memory segment where the output string is put. The start address offset is 0.
LENGTu% -	The output string length. The range is from 0 to 65535.

Bus Activity :

- If 0 <= addr <= 30
  ATN is set true.
  UNL is sent.
  LAD is sent.
  MTA is set.
  ATN is set false.
  Long string is sent.
- If addr < 0 or addr > 30
  ATN is set false.
  Long string sent.

Example:

```
10   ‘ This program loads a data file from disk into RAM
20   ‘ and then outputs this data to the IEEE-488 device 8
.
.
50   ADDR%=8
60   OPEN “DATA.001” FOR INPUT AS 12 ‘line 150 to 230
70   DEF SEG=&H4000      ‘read a data strinq
80   COUNT=0
90   WHILE NOT EOF(2)
100  A$=INPUT$(1,X2)     ‘read one byte
110  POKE COUNT,ASC(A$)          3
120  COUNT=COUNT+1
130  WEND
140  CLOSE #2
150  DEF SEG=&HD000
160  OUTPUTA%=54
170  DATASEG%=&H4000
180  IF COUNT < 327681 THEN LENGTH%=COUNT ELSE
     LENGTH%=COUNT -655361
190  CALL OUTPUTA%(ADDR%,DATASEG%,LENGTH%)
200  STOP
.
.
```

3.4.12. PPOLL

Purpose :

This command conducts a parallel poll of the interface bus. It returns the value (0-255) of an eight-bit byte represent- , ing the response of those devices of the interface which have been configured to respond to a parallel poll (see the PPOLLC command).

Offset :

PPOLL%=24

Syntax :

CALL PPOLL%(RESPONSE%)	----BASIC
CALL ABSOLUTE(RESPONSE%,PPOLL%)	----BASIC Compiler

Parameter :

RESPONSE% - An integer equals to the result of parallel polling. Value 0-255 of an eight bit byte represents the parallel poll response of the devices of the interface bus.

Bus Activity :

ATN and EOI are set true for 25 microseconds.
The parallel poll byte is read.
EOI is set false.
ATN is set false.

3.4.13. PPOLLC

Purpose:

This command performs a Parallel Poll Configure. In preparation for a parallel poll command, it enables you to tell a device how to respond to the parallel poll, and on which data line to respond. In general, it enables you to contfigure a parallel poll response byte to reflect the response ri of a desired arrangement of devices. You can define the ~ bits to reflect the responses of particular instruments or the logical-OR of several instrument responses.

Offset:

PPOLLC%=27

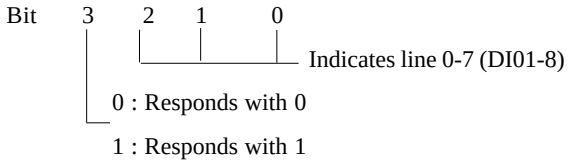
Syntax:

CALL PPOLLC&(ADDR%,CONFIG%) ----BASIC
CALL ABSOLUTE(ADDR%,CONFIG%,PPOLLC%) ----BASIC Compiler

Parameter:

ADDR% - The address of the device to be configured. If 0 i <= addr <= 30, then the specified device is configured. Otherwise, the previously defined s listener(s) are configured.

CONFIG% - An integer sent to configure the specified device indicating how and which data line to respond.



Bit 4-15 : Not used.

Bus Activity:

- If O <= addr <= 30

  ATN is set true.
  UNL is sent.
  LAD is sent.
  MTA is sent.
  PPC is sent.
  PPE is sent.

- If ADDR% < 0 or ADDR% >30

  ATN is set true.
  PPC is sent.
  PPE is sent.

3.4.14. PPOLLU

Purpose:

This command executes a Parallel Poll Unconfigure. It directs a device to not respond to a parallel poll. It can e be addressed to the interface bus or to a specific device.

Offset:

PPOLLU%=30

Syntax:

CALL PPOLLU%(ADDR%) ----BASIC

CALL ABSOLUTE(ADDR%,PPOLLU%) ----BASIC Compiler

Parameter:

ADDR' - The address of the device to be unconfigured. If s 0 <= addr <= 30, the specified device is uncon figured. Otherwise, all the devices are unconfigured.

Bus Activity:

- If 0 <= addr <= 30

ATN is set true.
UNL is sent.
LAD is sent.
MTA is sent.
PPC is sent.
PPD is sent.

- If addr < 0 or addr > 30

ATN is set true.
PPU is sent.

3.4.15. REHOTE

Purpose:

This command places a device in Remote Mode. It can be addressed to a specific device or to the interface, which just sets the REN line true.

Offset:

REMOTE%=33

Syntax :

CALL REMOTE&(ADDR%) ----BASIC

CALL ABSOLUTE(ADDR%,REMOTE%) ----BASIC Compiler

Parameter :

ADDR% - The address of the device to be set to remote. If 0<=addr<=30, the specified device is set to remote. Otherwise, just the REN line is set true.

Bus Activity :

- If 0 <= addr <= 30

  REN is set true.
  ATN is set true.
  UNL is sent.
  LAD is sent.
  MTA is sent.

- If addr < 0 or addr > 30

  REN is set true.

3.4.16. SEND

Purpose:

This command sends user specified IEEE-488 Interface commands to the interface. Eor example, to send an output string to several instruments simultaneously, you can establish multiple listener status with the SEND command, then issue the OUTPUT command with address <0 or >30.

Offset:

SEND%=36

Syntax:

CALL SENDi(CMDS) ----BASIC

CALL ABSOLUTE(CMDS,SENDi) ----BASIC Compiler

Parameter:

CMD$ - Pointer of a string of standard mnemonic IEEE-488 interface commands. The following can be used:

LISTEN TALK DATA UNL UNT GET DCL GTL P PPD PPE PPU i REN SDC SPD SPE TCT MLA MTA IFC CMD LLO SEC EOI

Example:

CMD$=”UNL UNT MTA LISTEN 9 10 SEC 3 DATA ‘ABCD’EOI”

See Section 5.4. for more information.

Bus Activity :

- The following commands set ATN true then send out the corresponding character.

Mnemonic	UNL	UNT	GET	DCL	GTL	P	PPD	PPU
ASCII	?							
(Hex)	(3F)	(5F)	(08)	(14)	(01)	(05)	(70)	(15)

Mnemonic	SDC	SPD	SPE	TCT	*MLA		*MTA	LLO
ASCII					5		U	
(hex)	(04)	(19)	(18)	(09)	(35)	(55)	(11)	

* My address = 21

The following commands take some actions other than sending characters.

LISTEN	Take following values as listener address.
TALK	Take following values as talker address.
DATA	Set ATN false.
EOI	Set EOI true at last data byte.
PPE	Take following values as Parallel Poll Config.
IFC	Pulse IFC true for 100 microseconds.
CMD	Set ATN true.
SEC	Take following values as secondary commands.

3.4.17. SPOLL

Purpose :

This command conducts a serial poll of the interface bus. It returns the value (0-255) of an eight-bit byte representing the device's status.

Offset :

SPOLL%=39

Syntax :

CALL SPOLL%(ADDR%,RESPONSE%) ----BASIC

CALL ABSOLVTE(ADDR%,RESPONSE%,SPOLL%) ----BASIC Compiler

Parameter :

ADDR% - The address of the device to be serial polled. Must be within 0 and 30.

RESPONSE% - An integer with the value 0-255 of an eight bit byte representing the status of the device specified.

Bus Activity :

ATN is set true.
UNL is sent.
TAD is sent.
MLA is set.
SPE is sent.
ATN is set false.
Data byte is read.
ATN is set true.
SPD is sent.
UNT is sent.

3.4.18. STATUS Purpose :

Purpose :

This command reads the status from the interface and returns this value to the calling statement.

Offset :

STATUS%=42

Syntax :

CALL STATUS%(CONDITION%,5%) ----BASIC
CALL ABSOLUTE(CONDITION%,5%,5TATUS%) ----BASIC Compiler

Parameter :

CONDITION% - This number specifies which status is read.
0 - 7 : NEC7210 read register 0 - 7.
8 : Error Number of last called command.
9 : Count of string bytes that are output or entered.
10 : Timeout interval in milliseconds.
11 : I/O port address of NEC7210.
12 : DMA & IRQ setting.

S% - Variable which represents interface status 3 response.

Bus Activity :

None.

Remark :

The error number returned with condition 8 represents different types of errors.

Error Number	Error Type
0	No error
l	Handshake timeout
2	Interface error
3	Call ABORT when non-system controller
4	Invalid passed parameter(s)

3.4.19. TIMEOUT Purpose :

Purpose :

This command sets the timeout period. When the bus handshake is stuck, the called I/O functions will terminate at the time specified and the timeout flag will be set.

Offset :
TIMEOUT%=45

Syntax :

CALL TIMEOUT%(T%)	----BASIC
CALL ABSOLUTE(T%,TIMEOUT%)	----BASIC Compiler

Parameter:

T% - T% = 0 Disable the timeout command.
T% = 1 to 32767 Timeout period is T% units.
T% = -1 to -32767 Timeout period is (65536+T%) units.

Bus Activity :
None.

Remark :

1. The unit of the timeout period depends on the execution speed of the CPU. For PC/XT of 4.77 MHz clock rate, the unit is one millisecond. For PC/AT and higher clock rate CPU, the unit is less.
2. The timeout period is set to 10000 units each time the INIT command is called.

3.4.20. TRIGGER Purpose :

Purpose :

This command sends a Group Execute Trigger (GET) to a device or to the interface bus.

Offset :

TRIG%=48

Syntax:

CALL TRIGi(ADDRi)	----BASIC
CALL AHSOLUTE(ADDR',TRIG%)	----BASIC Compiler

Parameter :

ADDRi - The address of the specified device to be triggered. If 0 <= addr <= 30, the specified device is triggered. Otherwise, all the listeners of the bus are triggered.

Hus Activity :

- If 0 <= addr <= 30

  ATN is set true.

  UNL is sent.

  LAD is sent.

  MTA is sent.

  GET is sent.

- If addr < 0 or addr > 30

  ATN is set true.

  GET is sent.

3.4.21. ERRPTR

Purpose :
This command assigned variables for error number and count of string bytes.

Offset:
ERRPTR%=60

Syntax :

```
CALL ERRPTR%(IOERR%,IOCOUNT%)                  ----BASIC
CALL ABSOLUTE(IOERR%,IOCOUNT%,ERRPTR%)  ----BASIC Compiler
```

Parameter :

IOERR% -	Variable which represents the error number of last called command.
IOCOUNT% -	Variable which represents the count of string bytes that are outputed or entered.

Bus Activity :
None.

Remark:
This command must be executed before calling any other t~command except the "INIT" command.

ERROR NUMBER	ERROR TYPE
0	No error
1	Handshake timeout
2	Interface error
3	Call ABORT when non-system controller
4	Invalid passed parameter(s)

See the STATUS command (condition 8) for other information.

Example :

```
10    DEF SEG=&HD000
20    INIT%=0:OUTPUT%=3:ENTER%=6:ERRPTR%=60
30    ADDR%=23
40    CALL ERRPTR%(IOERR%,IOCOUNT%)
50    TMPS="FlRAT3NS"
60    CALL OUTPUT%(ADDR%,TMP$):GOSUB 100
70    ANs$=sPACE$(40)
80    CALL ENTER%(ADDR%,ANS$):GOSUH 100
85    PRINT ANS$
90    STOP
100   'Error number and string counts check routine
110   PRINT "TBE COUNT OF STRING BYTES = ";IOCOUNT%
120   IF IOERR%=0 TEEN PRINT "NO ERROR"
130   IF IOERR%=1 TREN PRINT "3ANDSBAKE TIMEOUT"
160   RETURN
170   END
```

4. PROGRAMMING TECBNIQUES

4.1. Interactive Data Transfer

```
10    'FILE NAME : EXAMPLE.1
20    'Program Example : INTERACTIVE DATA TRANSFER
40    'Purpose : This program outputs data strings entered by
50    users and enters data from the IEEE-488 bus.
70    '
80    'Initialization
90'
100   LIN.Y=1 : KEY OFF : CLS
110   DEF SEG=&BD000
120   ABORT%=9 : OUTPUTi=3 : ENTER%=6 : STATUS%=42
130   CALL ABORT'
140   '
150   'Command entry point
160
170   KEY(1) ON : KEY(2) ON : KEY(3) ON : KEY(4) ON : KEY(5) OFF
180   KEY(6) OFF: KEY(7) OFF: KEY(8) OFF: KEY(9) OFF: KEY(10) OFF
190   KEY 1 CLS .KEY 2 0UTPUT ¥KEY
200   KEY 5 .KEY 6.KEY 73  ENTER KEY 4 EXIT
210   KEY 9," ":KEY 10,"
220   ON KEY(1) GOSUB 390
230   ON REY(2) GOSUB 440
240   ON KEY(3) GOSUB 560
250   ON KEY(4) GOSUB 810
260   '
270   GOSUB 330
280   KEY ON
290   GOTO 290 'Loop here waiting function key
310   'Display message
320   '
330   COLOR 15,7:LOCATE 22,1,0:PRINT " ";SPACE$(79):LOCATE 22,1
340   PRINT "Select function key l":COLOR 7,0:LOCATE 1,1
350   RETURN
360   '
370   'Clear Screen
380   '
390   CLS:GOSUB 330
400   RETURN
410   '
```

```
420   'OUTPUT UTILITY
430   '
440   TMP$=SPACE$(80)
450   IF 22-LIN.Y<6 TREN CLS:LIN Y=1
460   LOCATE 22,1,0:PRINT " ";SPACE$(79):LOCATE LIN.Y,1
430   INPUT "To which address 7 ",ADDR
490   LINE INPUT ''OUTPUT string 7 ",TNP$
500   E.FG%=0 : CALL OUTPUT%(ADDR%,TMP$)
510   GOSUB 710
520   IF S%=0 THEN PRINT "Data transmitted 1"
530   PRINT : PRINT : LIN.Y=CSRLIN : GOSUB 330
540   RETURN
550   '
560   '
570   'ENTER UTILITY
580   '
590   PRINT
600   D$=SPACE$(80)
610   IF 22-LIN.Y<6 TUEN CLS : LIN.Y=1
620   LOCATE 22,1,0:PRINT " ";SPC(79):LOCATE LIN.Y,1
630   INPUT l'From which address 7 ",ADDR%  3
640   CALL ENTER%(ADDR%,D$)
650   GOSUB 710 'Error check
660   IF S%c>0 THEN 690 'Error happened
670   PRINT "ENTERED STRING :"
680   PRINT D$
690   PRINT : LIN.Y=CSRLIN : GOSUB 430
700   RETURN
710   '
720   '
730   'TIMEOUT CUECK ROUTINE
740   '
750   CONDITION%=8
760   CALL STATUS%(CONDITION%,S%)
770   IF S%=1 THEN PRINT "TIMEOUT 1"
780   IF S%<>0 AND S%<>1 THEN PRINT "INTERFACE ERROR l"
790   RETURN
800   '
810   END
820   '
830   'TUEN END OF THIS PROGRAM
```

4.2. Set IEEE-488 Printer

```
10    'FILE NAME : EXAMPLE.2
20    ' Program Example : SET IEEE-488 PRINTER
30    '
40    'Purpose : This program converts an IEEE-488 printer to a
50    'PC system printer
70    '
80    'Initialization
90
100   CLS
110   DEF SEG=&HD000
120   DEVICE%=57
130
140
150   Enter the IEEE-488 printer setting
170   INPUT "Enter the IEEE-488 printer address ? ",ADDR%
180   IF ADDR&<0 OR ADDR~~>30 THEN PRINT "Bad entry." ~ GOTO 170
190   INPUT "Enter the printer port ? (1/LPT1 2/LPT2;) ",N%\        -
200   IF N%<>1 OR N%<>2 TuEN PRINT "Bad entry.' . GOTO 19
220   '
230   'Setting the IEEE-488 printer
250   CALL DEVICE%(ADDR%,N%)
260   PRINT
270   PRINT "IEEE-488 printer is ready to use."
290   '
300   'Check the IEEE-488 printer function
320   PRINT
330   INPUT "Send string to printer ? (Y/N) ",Y$
340   IF Y$<>"y" AND Y$<>"Y" THEN END
350   LINE INPUT "Enter the string : ";D$
360   LPRINT D$
370   GOTO 320
380   '
390   END
```

4.3. Voltage Measurement with a DVM

```
10    'FILE NAME : EXAMPLE.3
20    'Program Example : VOLTAGE MEASUREMENT WIT)3 A DVM
30    '
40    'Purpose : This program measure 10 voltage readings
50    'and displays them
60    '
70    'Remark : This program is written for the HP3478A DVM. If
80    'another model of voltmeter is used, please check
90    'the operating manual and make necessary
100   'modification to this program.
110   '
120   'Initialization
130   '
140   CLS 150 DEF SEG=&HD000
160   ABORT%=9 : ENTER%=6 : OUTPUT%=3 : STATUS%=42 : TRIG-
      GER%=48
170   CALL ABORT%
180   '
190   ‘ Set the DVM
200   '
210   ADDR%=23
220   D$=l’FlT3RAN5''
230   CALL OUTPUT%(ADDR%,DS) ‘ Send instrument setting string
240   GOSUB 430 250 IF ER%<>0 T13EN PRINT “Error when setting DVM.” : END
260   '
270   'Measurement start
280   '
290   FOR I=1 TO 10
300   CALL TRIGGER%(ADDR%) Trigger the DVM.
310   D$=SPACE$(40)
320   CALL ENTER%(ADDR%,D$) Enter DVM reading
330   GOSUB 430   ‘Error check
340   IF ER%<> 0 TuEN PRINT “Error when reading DVM.” : END
350   PRINT I,D$   .
360   NEXT I
370
380   END
390   '
400   'Error check routine
410   '
420   CONDITION%=8 : ER%=0
430   CALL STATUS%(CONDITION%,ER%) ‘Read the error num’oer
440   IF ER%<>0 TSEN PRINT “Error “;ER%
450   IF ER%=1 T13EN PRINT “Device timeout 1”
460   RETURN
470   '
480   'End of this program
```

4.4. AD500 PMU Programming

```
10    'FILE NAME : EXAMPLE.4
20    'Program Example : AD500 PMU PROGRAMMING
30    '
40    'Purpose : This program measures 16 channel of voltages and
50    'display them. If the voltage of any channel is
60    'greater than a certain level then it close a
70    'relay to drive an alarm.
80    '
90    'Remark : The AD500 has a 16 channel multiplexer in alot 0
100   'and 16 channel relay actuator in slot 1. The   };
110   'voltage measurement is done by an HP3478A DVM.
120   'The AD500 has an address of 9 and HP3478A has an
125   'address of 23.
130   '
140   'Initialization
150   '
160   CLS _
170   DIM V(16)
180   DEF SEG=&HD000
190   ABORT%=9 : ENTER%=6 : OUTPUT%=3: STATUS%=42: TRIGGER%=48
200   TIMEOUT%=45 : EOL%=12 : ADDR3478%=23 : ADDR500%=9
210   V.LIMIT=2 ‘ Voltage limit
220   'Set handshake timeout & init IEEE-488 bus
230   CALL ABORT% : FOR Y=0 TO 300 : NEXT Y ‘Wait for ADSOOA reset
240   T%=5000 : CALL TIMEOUT%(T%) ‘ Set timeout 5 sec.
250   'Init ADSOOA terminator
260   OUTEOL%=2 : OUTEOLS=CHR$(13) : INEOL%=0 : INEOLBYTE%=10
270   CALL EOL%(ADDR500%,OUTEOL%,OUTEOL$,INEOL%,INEOLBYTE%)
280   'Set the DVM and Multiplexer
290   '
300   D$=”FlT3RAN5"
310   CALL OUTPUT%(ADDR3478%,D$) ‘ Send DVM setting string
320   GOSUB 770 ‘ Error check
330   IF ER%<>0 THEN PRINT “Error when setting DVM.” : END
340   '
350   D$=”DW0,16;DW1,0";
360   CALL OUTPUT%(ADDR500%,D$) ‘ Open relays of Multiplexer
370   'and Actuator
380   GOSUB 770 ‘ Error check
390   IF ER%<>0 THEN PRINT “Error when setting AD500.” : END
400   '
410
```

```
420   'Measurement start
430   '
440   ALARM%=0
450   FOR I=0 TO 15
460   D$="DW0,"+STR$(I)
470   '
480   CALL OUTPUT%(ADDR500%,D$) ' Close channel I.
490   FOR K-1 TO 10 : NEXT K ' Delay for the relay operation.
500
510   CALL TRIGGER%(ADDR3478%) ' Trigger the DVM.
520
530   D$=SPACES(40) 540 CALL ENTER%(ADDR3478%,DS) ' Enter DVM reading
550   GOSUB 770 ' Error check
560   IF ER%0 THEN PRINT "Error when setting DVM." : END 570 ' 580
      V(I)=VAL(D$)
590   PRINT I,V(I),
600   IF V(I)>V.LIMIT THEN PRINT "ALARM1", : ALARM%=1
610   PRINT
620   NEXT I
630   PRINT
640   IF ALARM%=0 THEN 710
650   D$="DW1,1" :7
660   CALL OUTPUT%(ADDR500%,D$) ' Set the alarm
670   PRINT "Set Alarml" : PRINT
680   GOTO 420
690
700
710   D$="DW1,0"
720   CALL OUTPUT%(ADDR500%,D$) ' Reset the alarm
730   PRINT "Reset Alarmi" : PRINT
740   GOTO 420
750   '
760
770   'Error check routine
780
790   CONDITION%=8
800   CALL STATUS%(CONDITION%,ER%) ' Read the error number
810   IF ER%0 THEN PRINT "Error" ER%
820   IF ER%=1 THEN PRINT " Device timeoutt"
830   RETURN 4
840   '
850'
860 ' End of this program
```

4.5. Multiple Device Triggering

```
10    'FILE NAME : EXAMPLE.5
20    'Program Example : MULTIPLE DEVICE TRIGGERING
30    '
40    'Purpose : This program triggers 2 voltmeters at the same
50    'time to make the measurement simultaneously.
60    '
70    'Remark :     This program is written for the HP3478A DVM. If
80    '             another model of voltmeter is used, please check
90    '             the operating manual and make necessary
100   '             modification to this program.
110   '
120   'Initialization
130   '
140   CLS
150   DEF SEG=&HD000
160   ABORT%=9 : ENTER%=6 : OUTPUT%=3 : SEND%=36 : STATUS%=42
170   TRIGGER%=48
180   ADDR1%=23 : ADDR2%=24
190   CALL ABORT%
200   '
210   '
220   'Set the DVM's
230   '
240   D$=l'FlT3R2N5''
250   CALL OUTPUT%(ADDR1%,D$)          ' Send DVM #1 setting string
260   CALL OUTPUT%(ADDR2%,D$)          ' Send DVM #2 setting string
270   GOSUB 550   ' Error check
280   IF ER%<>0 TuEN PRINT "Error when setting DVM." : END
290   '
300   '
310   'Measurement start
320   '
330   FOR I=1 TO 10
340   '
350   CMD$='UNL UNT MTA LISTEN 23 24 GET"
360   CALL SEND%(CMD$) ' Trigger the DVM's
370   '
380   D1$=SPACE$(40)
390   CALL ENTER%(ADDR1%,D$)   ' Enter DVM #1 reading
400   GOSUB 550   ' Error check
410   IF ER%<>0 TuEN PRINT "Error when reading DVM #1." : END
```

```
420   '
430   D2$=SPACE$(40)
440   CALL ENTER%(ADDR2%,D$) ‘ Enter DVM #2 reading
450   GOSUB 550 ‘ Error check
460   IF ER%<>0 TEEN PRINT “Error when reading DVM #2.” : END
470   '
480   PRINT I,D1$,D2$
490   '
500    NEXT I
510   '
520   END
530
540   '
550   'Error check routine
560   '
570   CONDITION%=8 530 CA L STATUS%(CONDITION%,ER%) ‘ Read the
      error number
590   IF ER%0 TEEN PRINT “Error” ER%
600   IF ER%=1 TEEN PRINT “Device timeoutl”
610   RETURN
620   '
630   'End of thie program 570 CONDITION%=8
```

4.6. Interrupt Handling

```
10    'FILE NAME : EXAMPLE.6
20    'Program Example : INTERRUPT HANDLING
30    '
40    'Purpose : This program measures 100 voltage readings and
50    'displays them. It also goes to service
60    'subroutines when interrupts happen.
70    '
80    'Remark : The interrupt handing is for the Advanced BASIC
90    'Version A3.00 and higher only. For other BASIC
100   'Version, this may ont work because of the
110   'different memory arrangement.
120   'This program is written for the HP3478A DVM. If
130   'other models of voltmeters are used, please
140   'check the operating manual and make necessary ;
150   'modification to this program.
160   In this example, the program only shows when the
170   'interrupt happens. You can add more actions to
180   'the service routine to response to an interrupt.
190   '
200   'Initialization
210   '
220   CLS
230   DEF SEG=&HD000 240 ABORT%=9 : ENTER%=6 : OUTPUT%=3 :
      STATUS%=42 : TRIGGER%=48 250 SPOLL%=39 : DEVCLR%=15
260   INIT%=0

270   IOPORT%=&H2B8 : MYADDR%=21        E
280   SETTING%=&HE1C ‘ Enable Bus Error, Timeout & select IRQ7
290   'for SRQ interrupt
300   CALL INIT%(IOPORT%,MYADDR%,SETTING%)
310   '
320
330   'Set the DVM & UNMASK Front Panel SRQ bit
340   '
350   ADDR%=23
360   CALL DEVCLR%(ADDR%)
370   FOR II=1 TO 1000 : NEXT II
380   D$=”KM20FlT3RAN5"
390   CALL OUTPUT%(ADDR%,DS) ‘ Send instrument setting string          .
400   '
410   ON ERROR GOTO 580
420   ON KEY(l9) GOSUB 700 : KEY(l9) ON
430   ON KEY(20) GOSUB 770 : KEY(20) ON
440
450
```

```
460   'Measurement start
470   '
480   FOR I=1 TO 100
490   CALL TRIGGER%tADDR%)      ‘ Trigger the DVM.
500   ANS$=SPACE$(40)
450   '
510   CALL ENTER%(ADDR%,ANS$) ‘ Enter DVM reading
520   PRINT I,ANS$
530   NEXT I
540
550   END
560
570   '
580   'Error check routine
600   IF ERR<128 THEN PRINT “BASIC Error”;ERR ELSE ER%=ERR-128
610   IF ER%<>0 TuEN PRINT “Error” ; ER%
620   IF ER%=1 THEN PRINT “Device timeoutl”
630   IF ER%=2 TuEN PRINT “Interface Errorl
640    IF ER%=3 TBEN PRINT “Abort by Non-system Controllerl”
650   IF ER%=4 THEN PRINT “Invalid parameterel”
660   STOP
670    RETURN
680
690
700   'Timeout service routine
710   '
720   PRINT “Interface Timeoutl”
730
740   RETURN
750   '
760   '
770   SRQ service routine
780   '
790   PRINT “Interface SRQI”
800   RES’=0 : CALL SPOLL’(ADDR%,RES%)   .
810   PRINT “BP3478A STATUS BYTES IS”;RES%
820   A=INP(IOPORT%+2)   c
830   FOR CC=0 TO 500 : NEXT CC
840   RETURN
850   '
860   'End of this program
```

5. ADVANCED PROGRAMM1N TECBNIQUES

5.1. Direct Memory AcceAs (DMA)

Direct memory acaess (DHA) improves system performance by allow- ~ ing external devices to directly transfer information to or from 3 the system memory without operation of the system CPU. Any I/O ~ port can source data for DMA and any read-write memory location ~¤ can receive data. The IEEE-488 interface data transfer can be programmed to proceed with or without DMA. When you use DMA, the IEEE-488 interface card provides a number of unique and powerful features.

These features include :

1) The ability to run application programs and DMA simultaneously. It means the data transfer between PC and the IEEE-488 bus can be background operated.

2) Selection of two DMA operating modes : single byte transfer mode or block transfer mode.

3) The ability to run IEEE-488 DMA and disk DMA simultaneously.

4) The ability to continuously transmit or receive data blocks of up to 64K bytes without processor overhead.

These features can significantly improve system performance in applications where high speed transfers are required or large blocks of data must be moved.

This section describes how DMA works and how you can use it to your advantage. It also introduces and explains Bit 15 and 14 of <SETTING%> of the INIT routine described in Section 3.3.7.

DMA is controlled by the 8237 DMA controller chip on the PC's system board. It performs dynamic RAM refresh, and supports data transfer between floppy disks and hard disks in addition to serving the IEEE-488 interface.

Like all DMA chips, the 8237 DMA chip is designed to perform one basic function. That function is to transfer data between memory and I/O devices. It performs the transfer by simultaneously addressing the memory location and I/O device and providing the appropriate read and write signals.

The 8237 DMA chip has four DMA channels, four operating modes, and four operating conditions. Each channel has a mode register that determines the four operation conditions of the DMA channel.

These conditions are:

1) The direction of transfer (input or output).

2) The DMA operating mode (single, demand, block, and cascade).

3) Autoinitialization (enabled or disabled).

4) Address register direction (increment or decrement).

A little additional explanation is required to understand these key operating conditions.

This interface allows you to choose from three of the four possible DMA channels. Channel 0 is used by the PC's memory refresh controller, so channels 1, 2, and 3 are the only ones available to the peripherals. Bit 0 and l of <SETTING%> of INIT rout+ne make this selection.

The interface supports two of the four possible DMA operating modes:

l) Single-byte-transfer mode
In single-byte-transfer mode, the DMA chip and the system processor share control of the system bus. This allows both DMA and CPU processing to continue simultaneously.

2) Hlock-transfer mode
In block-transfer mode, transfers are activated by a request for service and continue until the number of bytes specified by the programmer are transferred. In block-transfer mode control of the system bus is returned to the microprocessor only after all data is transferred.

Demand-transfer mode and Cascade mode are not supported by this interface.

The IEEE-488 interface disables the auto-initialization function and uses only the address register increment direction on the 8237 chip because of the nature of IEEE-488 bus data transfer.

Bit 14 of <SETTING%> of the INIT routine determines the DMA operating mode. Setting the bit to "0" lets the DMA operate in single-byte-transfer mode for low DMA rate and high CPU throughput. Setting the bit to "1" lets the DMA operate in blocktransfer mode for high DMA rate and low CPU throughput.

Bit 15 of <SETTING%> of INIT routine determines the sequence of software to handle a DMA. When bit 15 is set to "0", the software waits for the completion of DMA before it goes further. When bit 15 is set to "1", the software initializes the DMA and then goes away. It is also called BACXGROUND operation. When data transfer is timing related with the software, BACKGROUND operation cannot be used.

The DMA operation of this IEEE-488 interface is quite transparent to users. Once you select the DMA mode by calling INIT routine, all further data transfer proceeds in this mode. Bowever, when you select block-transfer mode, the DMA channel 0 memory refresh may be held long enough to corrupt RAM memory content. Do not use block-transfer mode unless you have confidence that the data transfer will be completed within the time limits of memory refresh.

When using background operation, the CPU does not care about the data transfer. The data string can be terminated by byte count only. The data format problem then must be handled by users. It is safe to use DMA in single-byte-transfer and non-background operation mode (the default condition). The other modes can be used only when you have solid understanding of the PC, 8237 DMA chip and your IEEE-488 devices. We do not recommend using these modes.

5.2. Transfer Speed

The data transfer speed is determined by several factors:

1) The instruction execution speed of the computers. (4.77 MBz PC/XT to 16 MHz PC/AT to ?)

2) The software overhead.

3) The interface chip operating speed.

4) The clock rate of the DMA chip. (3 to 8 MBz)

5) DMA operating mode.

6) The operating speed of other processors that may be occupying the data bus. (e.g. 8087 coprocessor)

7) The speed of handshake of the peripheral devices.

8) The IEEE-488 cable length and capacitance.

Factors l), 4), and 6) are the nature of the PC. Factors 7) and 8) are determined by your choice of devices and cables. For factor 5), you can choose block-transfer mode DMA to get maximum speed with the risk that the PC may be hung. For factor 2), the interface driver routine is written with a lot of effort to maximize execution speed by handling the overhead effectively. For factor 3), the NEC7210 was chosen because it is an interface chip that can operate handshaking with 2 speeds. The user can choose an appropriate speed according to the actual situation by setting bit 12 of <SETTING%> when calling INIT routine. This setting will change the handshake timing T1, T6, T7 and T9.

Bit 12 Speed :	O	Slow
	1	Fast

5.3. Interrupt

The interface has the capability to interrupt the PC's processor when certain event happen. Dowever, most of the version of BASIC language in MS-DOS operating system only handles the interrupts from keyboard, light pen, communication port, game port and BASIC error. To use interrupt capability in BASIC, the software can replace Function Key 19 and 20 interrupts and can add some ERROR's to inform BASIC that there is an interrupt from the IEEE488 interface. When these interrupts are enabled, Function Keys 19 and 20 cannot be used in their normal mode or the program will 34 be confused.

EVENTS	INTERRUPT
ERROR	Error. This interface detects an error. The error number is ERR 128. Check 3-3-18 STATUS routine for the error type.
Fl9	Timeout. The IEEE-488 handshake is hung.
F20	SRQ. The IEEE-488 SRQ line is pulled low active by some device.

The default condition disables all these interrupts. To enable these interrupts, you must set bits 9,10 and 11 of SETTING' when calling the INIT routine.

Bit Set O Set 1	IEEE-488 Interrupt	Function Key
9 disable enable	SRQ	F20
10 disable enable	Timeout	Fl9
11 disable enable	Error	Error

The BASIC syntax to claim interrupt traps are

```
ON KEY (20) GOSUB 100          'Handle SRQ
ON KEY (19) GOSUB 200          'Handle Timeout
ON ERROR GOSUB 300             'Handle Error
```

The interrupt handling of the IEEE-488 interface software is written for IBM BASICA Version A3.0 & A3.3 only. Since other BASIC versions may have different traps for the Function Keys and different address of error number, the IEEE-488 interface inter- 44 rupt handling discussed above may not work.

5.4. Hore about the SEND Command

The SEND routine allows the user to control the IEEE-488 interface directly. Therefore, some unusual functions of the IEEE-488 function can be done by calling SBND.

An example is PASSING CONTROL to another device. This can be done by executing the following statements. This example passes control to device 22.

```
SEND%=36
CND$=”UNL UNT TALK 22 TCT”
CALL SEND%(CMD$)
```

Some instruments use secondary addressing technique. To write a data string to secondary address 03 with primary address 23, the program is as follows:

```
SEND%=36 : OUTPUT%=3
ADDR%=-1 ‘ OUTPUT to pre-defined listeners
D$=”ABCD”
CND$=”UNL UNT MTA LISTEN 23 SEC 03"
CALL SEND%(CMD$)
CALL OUTPUT%(ADDR%,D$)
```

If your computer intermittently fails to execute this code, you are having a timing problem. To avoid this, put the data from D$ in CMD$ after the DATA statement.

```
CMD$=”UNL UNT MTA LISTEN 23 SEC 03 DATA ‘ABCD’”
```

The SEND command allows you to program all the BUS activities. The IEEE-488 interface does not have special functions to handle PASS CONTROL and secondary addressing. They are done by calling SEND.

6. DIGITAL OUTPUT

The PCL-848A/B provides 16 digital output channels. These i digital output channels use the I/O port registers at address BASE+0 and BASE+1. The register's data format is listed below.

BASE + O (write port)	D7	D6	DS	D4	D3	D2	D1	DO
D/O low byte	D07	D06	D05	D04	D03	D02	DO1	D00
BASE + 1 (write port)	D7	D6	DS	D4	D3	D2	D1	DO
D/O high byte	D015	D014	D013	D012	DOll	D010	DO9	D08

It is fairly straight forward to use your PCL-848A/B digital ~ output functions. Some areas requires your attentions are the . pin assignment.

Connector 2 (CN2) - Digital Output

D/O 0	1	2	D/O 1
D/O 2	3	4	D/O 3
D/O 4	5	6	D/O 5
D/O 6	7	8	D/O 7
D/O 8	9	10	D/O 9
D/O 10	11	12	D/O 11
D/O 12	13	14	D/O 13
D/O 14	15	16	D/O 15
D.GND	17	18	D.GND
+ 5V	19	20	+12V

The programming is quite easy and it needs only the BASIC statement 'OUT'. For example, to set all the output channels high:

```
IOPORT%=&U2B0
OUT IOPORT%, &hFF
OUT IOPORT%+1, &hFF
.
.
```

7. TBEORY OP OPERATION

7.1. Introduction

This section describes the operation theory of this IEEE-488 t interface card. A thorough understanding of the theory will increase its usefulness and help avoid future problems.

7.2. Block Diagram Description

Figure 7.1. is the block diagram of this interface card. The i interface transfers data in a bi-directional fashion between the PC-Bus and the IEEE-488 instrument bus. The IEEE-488 bus driver is stored in the on-board ROM. When the application program calls the bus driver, the driver routines generates the necessary bus command sequence and then transparently passes the data ~ string to or from the bus device.

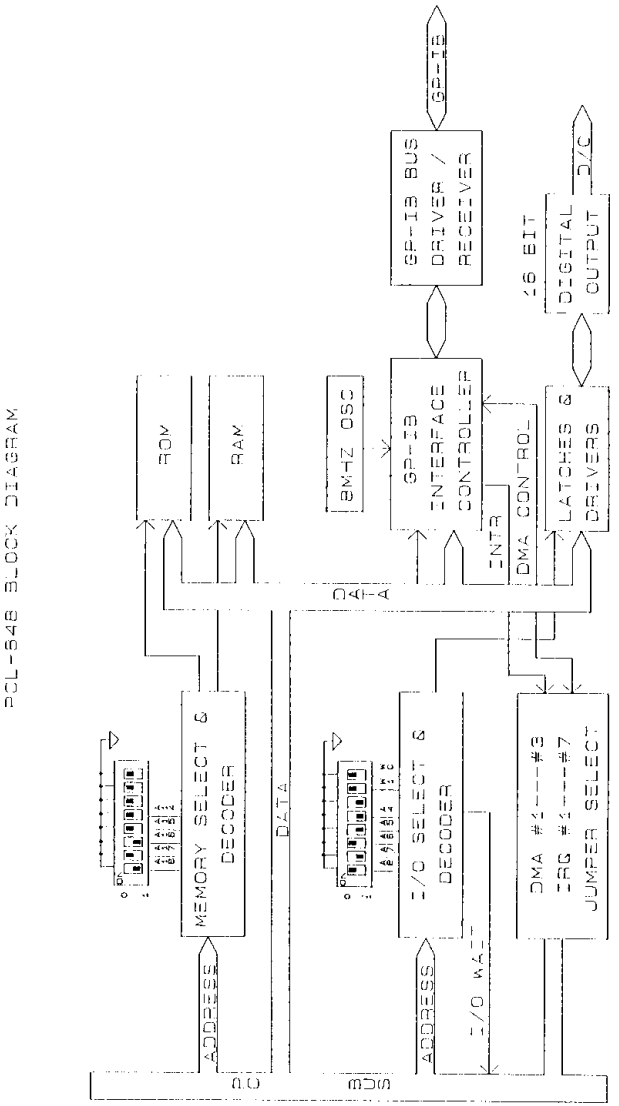
All of the major elements of this card are interconnected by the data bus of the PC bus.

When an IEEE-488 bus driver routine is called, the CPU starts the t routine stored in the ROM. The driver routine controls the IEEE-488 INTERFACE CONTROLLER to execute the necessary command E sequence.

The on-board RAM is for the storage of the interface parameters, such as the IEEE-488 address of the controller. The IEEE-488 INTERFACE CONTROLLER is an IC chip which provides an interface ; between a microprocessor system and the IEEE-488 interface bus. This IC is controlled and configured through 8-bit I/O mapped registers and enables all aspects of the IEEE-488 standard to be implemented, including talker, listener and controller functions.

When the computer executes a data output from the PC to a bus device, the driver routine writes the data byte to the IEEE-488 interface controller chip and the chip will handshake the byte out to the bus via the IEEE-488 bus driver/receiver. When entering data from a bus device, the driver routine sets the IEEE-488 interface controller chip to accept data and waits for . the handshake to be completed. The data byte is received via the bus driver/receiver and then is put into the system memory.

Fig. 7-1`PCL-848A/B Block Diagram



8. TROUBLESHOOTING

8.1. Introduction

This section provides information on maintaining, troubleshooting and repairing the IEEE-488 interface card.

8.2. Periodia Maintenance

The IEEE-488 interface card has no internal adjustment and does not require periodic calibration. Bowever, the following actions are recommended for preventive maintenance on a once-a-year basis (or more often, in high humidity environments).

The IEEE-488 bus connector (CN1) and the golden fingers for the PC I/O slot should be cleaned to prevent wax and dirt build-up. Spray the contacts lightly with a good contact cleaner, such as trichflorethlyene and use a cotton swab to rub off the dirt and excess cleaner.

8.3. Troubleshooting Procedure

The majority of problems are due to poor cabling, contacts or incorrect device programming.

The remedy for these two problems is to keep the connector and golden fingers clean and tight and also to read each device's manual to gain an understanding of its unique initialization and setup requirements. For other problems, the troubleshooting guide lists the symptom, probable cause and suggested corrective action.

SYmDtom	Possible Fault	Check
Computer hangs up when calling driver routine	Bad connections between golden fingers and PC slot	Clean wax on golden fingers
	On-board firmware address switch setup not the same as software setup	Change the switch setup or the softis ware
	The firmware address or I/O address set-conflict with other add-on cards	Change the firmware or I/O address settings tings
Instrument does not response	Wrong instrument address	Instrument address setting
	Bad bus connections	Check bus data with bus analyzer
	Wrong instrument programming sequence	Verify with instrument manual .
Instrument hangs up when sending data	Instrument output control not set OK	Send instrument a Selective Device Clear
	Instrument output terminates on wrong characters	Use EOL procedure to change terminator
		Change instrument terminator if possible

8.4. Part List

Item No.	Oty	Description	Mfr
C1-C6, C8-C21	20	0.1 microfarad capacitors	
C7,C22, C23	3	10 microfarad capacitors	
C24	1	470 picofarad capacitor	
R1	1	0 ohm resistor	
R2	1	51 ohm resistor	
RP1,RP3	2	4.7 Rohm resistor array (9 pin)	
RP2	1	4.7 Kohm resistor array (5 pin)	
OSC1	1	8 Muz OSC	
U1,U5	2	74LS273	
U2	1	74LS08	
U3	1	74LS126	
U4	1	74LS04	
U6	1	74LS164	
U7	1	74LS138	
U8,U12, U15,U17	4	PEEL 18CV8PC-25	AMI
U9	1	75160A	TI
U10	1	75162B	TI
U11	1	16K SRAM, 150ns	NEC4016C-3 or Equ.
U13	1	GP-IB Interface Controller NEC NEC7210C	
U14	1	64K EPROM 150ns,	NEC2764 or Equ.
U16,U18	2	74LS244	

Item No.	Qty	Description	Mfr
U19	1	74LS245	
SW1,SW2	2	DIP switches (16 pins)	
SW3	1	Slide switch	
JP1,JP2	2	3 by 2 pin headers	
JP3	1	6 by 2 pin header	
CN1	1	24 pin ribbon connector (IEEE-488) for PCL-848A or 25 pin D type connector (IEC-625) for PCL-848B	
CN2	1	20 pin header with socket	

9. BUS TUTORIAL

9.1. General BUB DeBCriPtiOn

The IEEE-488 bus is easy to use and allows great flexibility in data communications between independent devices. These features have made it one of the world's most popular methods for connecting multiple devices to one interface.

The IEEE-488 bus's popularity comes from its ability to act as an interface between the computer and the computer's peripherals. Every interface should handle the hardware book keeping and timing while maintaining four areas of compatibility between the computer and its peripherals. These areas include:

Electrical - to insure the proper voltage and current requirements.

Mechanical - a connector to physically connect the computer to its peripherals.

Functional - hardware and software to convert computer data to bus data and vice versa.

Operational - commands and data on the bus are interpreted in similar ways by all devices in the system.

This interface card implements IEEE-488 interface standard and does all of these well.

Electrically, this card uses IEEE-488 bus drivers that are designed to drive long cables and receive noisy data without error. The data, address, and control bus interface between the board and the PC has been designed for minimum current loading and maximum speed. Mechanically, it has a connector that is identical to all other connectors of the IEEE-488 standard. This allows devices to be quickly and easily added or removed from the system. The connector is designed to withstand over 1000 insertions and provide maximum electromagnetic radiation protection when used with a shielded cable.

Functionally, this card provides the complete computer to peripheral interface by using an IEEE-488 bus controller chip. The IEEE-488 bus chip provides complete compliance with the latest update to the IEEE-488 standard. Full compliance with the interface standard means that the PC can control any IEEE-488 compatible peripheral or become a device that may be controlled by other computers. The PC can send data to multiple devices simultaneously or instruct devices to send data to each without supervision by the computer. Full compliance means that fourteen devices may be attached to one interface card. Multiple inter face cards may be used in one PC.

Operationally, the interface is thoughtfully supported with professional software support package. The software provides high level language extensions that support IEEE-488 bus data and i command transmission and reception. The function mnemonics are identical to those found in the IEEE-488 standard. These mnemonics are used by most manufacturers of IEEE-488 compatible equip ment.

To solve your interface problems you need a standard that goes beyond hardware and software to provide consistency between different equipment manufacturers. The world's largest manufacturers of instrumentation, computers, and computer peripherals have chosen the IEEE-488 bus as the means for transferring information between dissimilar devices. This gives you the ability to attach a printer from one manufacturer, a plotter from another, and instruments from a third and know that the system will work. When you compare this to the number of serial and parallel interface cards it would take to support fifteen incompatible peripherals, the decision to use the IEEE-488 bus becomes obvious.

The IEEE-488 bus is a carefully defined instrumentation interface which simplifies the integration of instruments, peripherals and computers into systems. It minimizes compatibility problems between devices and has sufficient flexibility to accommodate future products. The bus has been formally accepted by the International Electrotechnical Commission (I.E.C.), as an international standard, and by the Institute of Electrical and Electronic Engineers (I.E.E.E.) as an American standard.

The IEEE-488 bus employs a 16 line to interconnect up to 15 instruments. This bus is normally the sole communication link between the interconnected units. Each instrument in the bus is connected in parallel to the 16 lines of the bus. Eight of the lines are used to transmit data and the remaining eight are used for communication timing and control.

Data is transmitted on the eight data lines as a series of eightbit characters referred to as "bytes". Normally, a seven-bit ASCII (American Standard Code for Information Interchange) code is used with the eighth bit available for a parity check, if desired. Data is transferred by means of an interlocked "handshake" technique. This sequence permits asynchronous communication over a wide range of data rates.

Communication between devices on the IEEE-488 bus employs the three basic functional elements listed below. Every device on the bus must be able to perform at least one of these functions:

1) LISTENER. A device capable of receiving data from other devices. Typical listeners are printers, programmable power supplies, programmable signal generators and the like.

2) TALKER. A device capable of transmitting data to other devices. Typical talkers are voltmeters,counters, audio analyzers and many other measurement instruments.

3) CONTROLLER. A device capable of managing communications over the IEEB-488 bus such as addressing and sending commands. A PC with the IEEE-488 interface is typically a controller.

An IEEE-488 bus system allows only one device at a time to active talker, but it allows multiple listeners receiving the same data at the same time. Only one controller can be active at a time.

9.2. Bus Structure

An IEEE-488 bus has 24 lines including 7 ground return lines and one shield line. The 16 lines with signals are 8 data lines, 3 handshake lines and 5 management lines.

9.2.1. IEEE-488 Connector Pin Assignment

The IEEE-488 standard uses 24 pin ribbon connector as the standard and the signal assignment is :

DATA	Lines Pin No.
DIO1	1
DI02	2
DI03	3
DI04	4
DI05	13
DI06	14
DI07	15
DI08	16

MANAGEMENT Lines	Pin No.
IFC	9
REN	17
ATN	11
SRQ	10
EOI	5

HANDS8AKE Lines	Pin No.
DAV	6
NRFD	7
NDAC	8

9.2.2. IEC-625 Connector Pin Assignment

The IEC-625 standard uses 25 pin D type connector as the standard and the signal assignment is:

DATA Lines	Pin No.
DIO1	1
DI02	2
DI03	3
DI04	4
DI05	14
DI06	15
DI07	16
DI08	17

MANAGEMENT Lines	Pin No.
IFC	10
REN	5
ATN	12
SRQ	11
EOI	6

HANDSHAKE Lines	Pin No.
DAV	7
NRFD	8
NDAC	9

9.3. Management Lines

The active controller manages all bus communications. The state of the ATN line, driven by the controller, determines whether the data on the data lines will be interpreted as a bus command or received by other devices as data. When ATN is true, the IEEE-488 bus is in COMMAND mode. Otherwise, the bus is in DATA mode. In COMMAND mode the controller is active and all other devices are waiting for instructions. COMMAND mode instructions which can be issued by the controller include:

1) Talk Address. A byte transmitted by the controller enables a specified device to talk. Only one device can be the talker at a time. When a new talker is assigned, the old one is disabled.

2) Listen Address. A byte transmitted by the controller enables a specified device to listen. The IEEE-488 bus allows multiple listeners. When new listeners are assigned, the old listeners are still active.

3) Universal Commands. All devices on the bus will respond to these commands whether they are addressed or not.

4) Address Commands. These commands are recognized only by the devices that are addressed as listeners. A few commands are recognized only by the talker.

5) Unaddress Commands. ASCII "?" unaddresses all listeners that have been previously addressed to listen. This command is called "Unlisten" (UNL). ASCII " " unaddresses any talker that has been previously addressed to talk. This command is called "Untalk" (UNT).

9.4. Bus Commands

In COMMAND mode, bus commands can be placed on the bus and sent to all devices. These commands have the same meaning regardless of the kind of device. Each device is designed to respond to those commands that have a useful meaning to the device and will ignore all others. The operating manual of each device will state those commands it can recognize.

Bus Command Table

Type	Mnemo	ASC	Bex	Purpose
Universal	LLO	DC1	11	Local Lockout. Disable front panel local key of the devices.
Universal	DCL	DC4	14	Device Clear. All devices are set to a known state.
Universal	PPU	NAK	15	Parallel Poll Unconfigure.
Universal	SPE	CAN	18	Serial Poll Enable.
Universal	SPD	EM	19	Serial Poll Disable.
Address	SDC	EOT	04	Selective Device Clear. Clear the listeners to a known state.
Address	GTL	SOE	01	Go To Local. Set all listeners into local mode.
Address	GET	BS	08	Group Execute Trigger. Trigger all listeners on the bus.
Address	PPC	ENQ	05	Parallel Poll Configure. Configure a device to respond to parallel poll.
Address	TCT	ET	09	Take Control. Transfer control to another device.
Unaddress	UNL	?	3F	Unlisten. Unaddress the current listeners.
Unaddress	UNT	_	SF	Untalk. Unaddress the current talker.

9.5. Servioe Request and Serial Polling

Some IEEE-488 devices have the ability to request service from the controller. A device may request service when it has completed a measurement, or when it has detected a critical condition, or for other reasons. An IEEE-488 device requests controller service by setting the SRQ line low. The controller has to determine when and how a service request will be serviced.

The following sequence is used to respond to a service request:

1) The controller checks for the presence of a service request.

2) If a service request i8 present, the controller sets the serial poll mode. The serial poll mode is initiated by the r controller sending the command SPE (Serial Poll Enable).

3) The controller sequentially polls those devices that may a have requested service. Each polled device responds with the status byte. The controller then checks the bit 6 (weight 64) of the byte to see if service was requested by this device.

4) For each device that has requested service, the controller takes appropriate action.

5) When all devices have been polled, the controller terminates the serial poll mode by issuing the command SPD (Serial Poll Disable).

The full sequence of operations is not necessary in all cases. If the reason for a request is simple and the controller knows the action, serial polling is not necessary. For software convenience, the controller sends SPD just after the status byte is read by the computer.

9.6. Parallel Polling

Parallel polling permits the status of up to eight devices on the bus to be checked simultaneously. Each device is assigned a data line (DIO1 to DI08) during parallel poll configure. When the controller conducts a parallel poll (ATN and EOI set low at same time), the device sets the assigned data line low or high to indicate if it requires service. If more than eight devices are used with their parallel poll capability, some of them can share one data line. Very few instruments have the capability to respond to a parallel poll. Therefore, you can neglect the parallel poll now and only study it when it becomes necessary.

9.7. Code Summary

A code assignment is shown in the table on the next page. These assignments apply only in command mode. In data mode there are no specific code assignments and data strings are recognized by the devices which receive the data.

The set of codes labeled “Primary Command Group” are the codes commonly used to communicate on the bus. The “Secondary Command Group” is used when addressing extended listeners and talkers, or enabling the Parallel Poll Mode (PPE).

ASCII — IEEE 488 BUS MESSAGES (COMMANDS AND ADDRESSES) HEX CODES

MSD / LSD	0 ASCII	0 MSG	1 ASCII	1 MSG	2 ASCII	2 MSG[1]	3 ASCII	3 MSG[1]	4 ASCII	4 MSG[1]	5 ASCII	5 MSG[1]	6 ASCII	6 MSG	7 ASCII	7 MSG
0	NUL		DLE		SP	00	0	16	@	00	P	16	`		p	
1	SOH	GTL	DC1	LLO	!	01	1	17	A	01	Q	17	a		q	
2	STX		DC2		"	02	2	18	B	02	R	18	b		r	
3	ETX		DC3		#	03	3	19	C	03	S	19	c		s	
4	EOT	SDC	DC4	DCL	$	04	4	20	D	04	T	20	d		t	
5	ENQ	PPC	NAK	PPU	%	05	5	21	E	05	U	21	e		u	
6	ACK		SYN		&	06	6	22	F	06	V	22	f		v	
7	BEL		ETB		'	07	7	23	G	07	W	23	g		w	
8	BS	GET	CAN	SPE	(	08	8	24	H	08	X	24	h		x	
9	HT	TCT	EM	SPD	)	09	9	25	I	09	Y	25	i		y	
A	LF		SUB		*	10	:	26	J	10	Z	26	j		z	
B	VT		ESC		+	11	;	27	K	11	[	27	k		{	
C	FF		FS		,	12	<	28	L	12	\	28	l		|	
D	CR		GS		-	13	=	29	M	13	]	29	m		}	
E	SO		RS		.	14	>	30	N	14	^	30	n		~	
F	SI		US		/	15	?	UNL	O	15	_	UNT	o		DEL	

MEANING DEFINED BY PCG CODE

MEANING DEFINED BY PCG CODE

ADDRESSED COMMAND GROUP

UNIVERSAL COMMAND GROUP

LISTEN ADDRESS GROUP

TALK ADDRESS GROUP

SECONDARY COMMAND GROUP

PRIMARY COMMAND GROUP (PCG)

Notes:

1. Device Address messages shown in decimal
2. Message codes are:
   DCL — Devices Clear
   GET — Device Trigger
   GTL — Go to Local
   LLO — Local Lockout
   PPC — Parallel Poll Configure
   PPU — Parallel Poll Unconfigure
   SDC — Selected Device Clear
   SPD — Serial Poll Disable
   SPE — Serial Poll Enable
3. ATN off, Bus data is ASCII; ATN on, Bus data is an IEEE MSG.

9.8. Randshake Lines

Each character byte transferred on the bus data lines employs the three wire handshake sequence. This sequence has the following characteristics:

1) Data transfer is asynchronous. Data can be transferred at any rate suitable for the devices operating on the bus. The devices wait for others to complete a byte transfer.
2) Devices with different input and output speeds can be interconnected. Data transfer rate is determined by the 3 slowest active device.
3) Multiple devices can accept data at the same time.

The following definitions are used when discussing IEEE-488 bus:

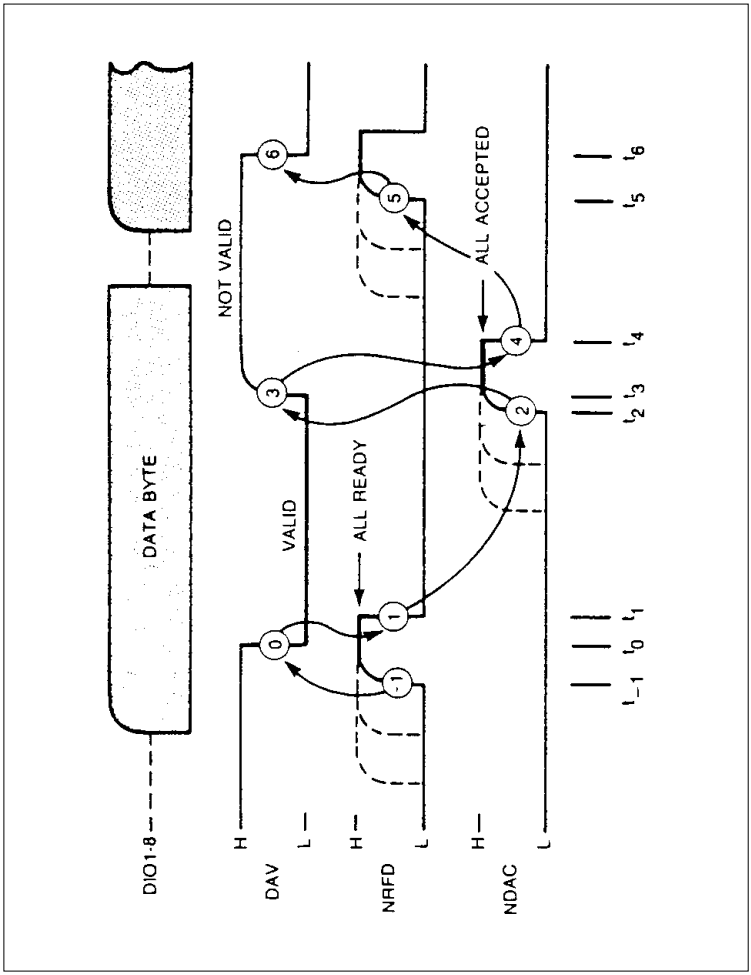
1) SOURCE. A device sending information on the bus in either the command or data mode.
2) TALKER. A device addressed to talk in the data mode.
3) ACCEPTOR. A device receiving information on the bus in either the command or data mode.
4) LISTENER. A device addressed to listen in the data mode.

The handshake lines have the following name and meaning:

DAV Data Valid
NRFD Not Ready For Data
NDAC Not Data Accepted

The handshake timing sequence is shown as following:

Handshake Timing Sequence



9.9. Other Bus Lines

The three remaining bus lines are:

1) REN (Remote Enable) The system controller sets REN low and then addresses the devices to listen before they will operate under remote control.

2) IFC (Interface Clear) Only the system controller can activate this line. When IFC is set true, all talkers, listeners and active controllers go to their inactive states.

3) EOI (End or Identify) This line is used to indicate the end of a multiple byte transfer sequence or, in conjunction with ATN, to execute a parallel poll sequence.

9.10. Bus Operating Considerations

When a device is powered on during system operation, it may activate IFC and cause the active controller on the bus to halt with an error. The controller must send IFC to regain active control.

Prior to addressing new listeners it is recommended that all previous listeners be unaddressed using the UNL command (?).

only one talker can be addressed at a time. When a new talker is addressed the former talker is automatically unaddressed.

The maximum cumulative length of the IEEE-488 bus cable in any system must not exceed more than 2 meters of cable per device or 20 meters, whichever is less, unless bus Expanders or Extenders are used.

For more information about the IEEE-488 bus, please refer to the IEEE reference document.

10. ASCII TABLE

CHAR	BINARY	UEX	DEC	COMMAND	CHAR	BINARY	HEX	DEC	COMMAND
NULL	0000000	00	0		SPACE	0100000	20	32	LA0
SOU	0000001	01	1	GTL	!	0100001	21	33	LA1
STX	0000010	02	2		“	0100010	22	34	LA2
ETX	0000011	03	3		#	0100011	23	35	LA3
EOT	0000100	04	4	SDC	$	0100100	24	36	LA4
ENQ	0000101	05	5	PPC	%	0100101	25	37	LA5
ACK	0000110	06	6		&	0100110	26	38	LA6
BELL	0000111	07	7		‘	0100111	27	39	LA7
BS	0001000	08	8	GET	(	0101000	28	40	LA8
UT	0001001	09	9	TCT	)	0101001	29	41	LA9
LF	0001010	OA	10		*	0101010	2A	42	LA10
VT	0001011	OB	11		+	0101011	2B	43	LA11
FF	0001100	0C	12		,	0101100	2C	44	LA12
CR	0001101	0D	13		-	0101101	2D	45	LA13
50	0001110	OE	14		.	0101110	2E	46	LA14
SI	0001111	0F	15		/	0101111	2F	47	LA15
DLE	0010000	10	16		0	0110000	30	48	LA16
DC1	0010001	11	17	LLO	1	0110001	31	49	LA17
DC2	0010010	12	18		2	0110010	32	50	LA18
DC3	0010011	13	19		3	0110011	33	51	LA19
DC4	0010100	14	20	DCL	4	0110100	34	52	LA20
NAK	0010101	15	21	PPU	5	0110101	35	53	LA21
SYNC	0010110	16	22		6	0110110	36	54	LA22
ETB	0010111	17	23		7	0110111	37	55	LA23
CAN	0011000	18	24	SPE	8	0111000	38	56	LA24
EM	0011001	19	25	SPD	9	0111001	39	57	LA25
SUB	0011010	1A	26		:	0111010	3A	58	LA26
ESC	0011011	1B	27		;	0111011	3B	59	LA27
FS	0011100	1C	28		<	0111100	3C	60	LA28
GS	0011101	1D	29		=	0111101	3D	61	LA29
RS	0011110	1E	30		>	0111110	3E	62	LA30
US	0011111	1F	31		?	0111111	3F	63	UNL

CHAR	BINARY	UEX	DEC	COMMAND	CHAR	BINARY	HEX	DEC	COMMAND
@	1000000	40	64	TA0		1100000	60	96	SC0
A	1000001	41	65	TA1	a	1100001	61	97	SC1
B	1000010	42	66	TA2	b	1100010	62	98	SC2
C	1000011	43	67	TA3	c	1100011	63	99	SC3
D	1000100	44	68	TA4	d	1100100	64	100	SC4
E	1000101	45	69	TA5	e	1100101	65	101	SC5
F	1000110	46	70	TA6	f	1100110	66	102	SC6
G	1000111	47	71	TA7	g	1100111	67	103	SC7
H	1001000	48	72	TA8	h	1101000	68	104	SC8
I	1001001	49	73	TA9	i	1101001	69	105	SC9
J	1001010	4A	74	TA10	j	1101010	6A	106	SC10
K	1001011	4H	75	TAll	k	1101011	6B	107	SCll
L	1001100	4C	76	TA12	1	1101100	6C	108	SC12
M	1001101	4D	77	TA13	m	1101101	6D	109	SC13
N	1001110	4E	78	TA14	n	1101110	6E	110	SC14
O	1001111	4F	79	TA15	c	1101111	6F	111	SC15
P	1010000	50	80	TA16	p	1110000	70	112	SC16
Q	1010001	51	81	TA17	q	1110001	71	113	SC17
R	1010010	52	82	TA18	r	1110010	72	114	SC18
5	1010011	53	83	TAl9	s	1110011	73	115	SCl9
T	1010100	54	84	TA20	t	1110100	74	116	SC20
U	1010101	55	85	TA21	u	1110101	75	117	SC21
V	1010110	56	86	TA22	v	1110110	76	118	SC22
W	1010111	57	87	TA23	w	1110111	77	119	SC23
X	1011000	58	88	TA24	x	1111000	78	120	SC24
Y	1011001	59	89	TA25	y	1111001	79	121	SC25
Z	1011010	SA	90	TA26	z	1111010	7A	122	SC26
[	1011011	SB	91	TA27	{	1111011	7B	123	SC27
\	1011100	SC	92	TA28	1	1111100	7C	124	SC28
]	1011101	SD	93	TA29	}	1111101	7D	125	SC29
^	1011110	SE	94	TA30	~	1111110	7E	126	SC30
_	1011111	SF	95	UNT	DEL	1111111	7F	127	SC31

11. NEC7210 RBAD / WRITE REGISTSR

Read Register		Bit Contents							
		7	6	5	4	3	2	1	0
0	Data In	DI7	DI6	DI5	DI4	DI3	DI2	DIl	DI0
	Status 1	CPT	APT	DET	END	DEC	ERR	DO	DI
	Status 2	INT	SRQI	LOK	REM	CO	LOKC	REMC	ADSC
3	Serial Poll	S8	PEND	S6	S5	S4	S3	S2	S1
4	Address	CIC	ATN	SPMS	LPAS	TPAS	LA	TA	MJMN
5	Command Pass Through	CPT7	CPT6	CPT5	CPT4	CPT3	CPT2	CPT1	CPT0
6	Address 0	X	DT0	DL0	AD50	AD40	AD30	AD20	AD10
7	Address 1	EOI	DTl	DL1	AD51	AD41	AD31	AD21	AD11

Write Register		Bit Contents							
		7	6	5	4	3	2	1	0
0	Hyte Out	BO7	BO6	BO5	BO4	BO3	BO2	BO1	BO0
1	Interrupt Mask 1	CPT	APT	DET	END	DEC	ERR	DO	DI
2	Interrupt Mask 2	0	SRQI	DMAO	DMAI	CO	LOKC	REMC	ADSC
3	Serial Poll	S8	rsv	S6	S5	S4	S3	S2	Mode
4	Address Mode	ton	lon	TRM1	TRM0	0	0	ADM1	ADM0
5	Auxiliary Mode	CNT2	CNT1	CNT0	COM4	COM3	COM2	COM1	COM0
6	Address 0/1	ARS	DT0	DL	AD5	AD4	AD3	AD2	AD1
7	End of String	EC7	EC6	EC5	EC4	EC3	EC2	EC1	EC0

12. SUMMARY OF THE IEEE-488 LIBRARY FUNCTIONS

Routins	Offset	Parameters	Activity
ABORT	9	None	Aborts all bus activity by pulsing the IFC line.
DEVCLR	15	ADDR%	Device clear or selective device clear.
DEVICE	57	ADDR%,PORT%	Replaces an LPTn: or COMn: port with an IEEE-488 device.
ENTER	6	ADDR%,D$	Enters data from a device.
ENTERA	51	ADDR%,DATASEG%, LENGTB%	Enters a long string from a device.
EOL	12	ADDR%,OVTEOL%, OUTEOL$,INEOL%, INEOLBYTE%	Sets the terminators of input and output string of a device
INIT	0	IOPORT%,MYADDR%, SETTING%	Initializes the interface and sets parameters.
LLO	18	None	Local Lockout.
LOCAL	21	ADDR%	Sets a device to local mode or releases the REN line.
OUTPUT	3	ADDR%,D$	Outputs data to a device.
OUTPUTA	54	ADDR%,DATASEG%, LENGTB%	Outputs a long string of data to a device.
PPOLL	24	RESPONSE%	Parallel Poll.
PPOLLC	27	ADDR%,CONFIG%	Parallel Poll Configure.
PPOLLU	30	ADDR%	Parallel Poll Unconfigure.
RENOTE	33	ADDR%	Sets a device to remote mode and sets the REN line.
SEND	36	CMD$	Sends the IEEE-488 mnemonics commands to the bus.

Routins	Offset	Parameters	Activity
SPOLL	39	ADDR%,RESPONSE%	Serial Poll.
STATUS	42	CONDITION%,5%	Reads the status of the interface.
TIMEOUT	45	T%	Sets timeout interval.
TRIGGER	48	ADDR%	Triggers a device or devices
ERRPTR	60	IOERR%,IOCOUNT%	Assign variables for error number and count of string bytes.