IE-488

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IE-488 Manual

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by

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TABLE OF CONTENTS

TABLE OF CONTENTS

CHAPTER 5

1.0 GPIB IEEE488 INTERFACE CARD GENERAL DESCRIPTION

MetraByte's IE-488 General Interface (GPIB) I/O expansion board for the IBM-PC computer is designed to plug directly into one I/O slot inside the IBM-PC.The IE-488 has a built in 12 KbyteROM interpreter which handles all the required initialization and protocol functions required to use the IEEE488 Interface. No disk files with driver routines are needed and the interpreter allows all commands to be programmed in conventional high level IEEE488 command syntax e.g. REMOTE, ENTER etc. The IE-488 complies with the IEEE November 1978 standard. The Interpreter is a relocatable 16 Kbyte block of code which may be entered via a BASIC CALL statement or via DOS interrupt commands using assembly language programming. All commands are string coded for ease of use. The GPIB will handle up to 14 other talker/listener devices. The controller may be the IBM or any other of the 14 devices, any one of which control may also be transferred to or from. The IE488 interpreter includes a group of subroutines which may be used to to condition the data before data transfer when using assembly language programs. The IE488 interpreter is capable of implementing all twelve of the interface messages which are as follows:-

1. The Data Message ----------	The actual data information sent from the talker device to one or more listening devices on the GPIB.
2. The Trigger Message ----------	This message causes the listener device(s) to perform a device dependent action when addressed.
3. TheClear Message ----------	This message causes the addressed device or all the devices on the GBIB to return to their predefined state.
4. The Remote Message ----------	Causes the addressed device or devices to switch from front panel to remote program control.
5. The Local Message ----------	Causes the Remote Message to be cleared from the addressed device(s).
6. The Local Lockout Message -------	Prevents an operator from manually returning to local via front panel controls.

7. Clear Lockout (Local Message) --- Clears all devices on the GPIB and sets in local mode.

8. Service Request Message --------- Any device may send this at any time to request service from the controller. This is cleared by sending the device's Status Byte Msg. if the device no longer requires service.

9. Status Byte Message ------------- A data byte that represents the status of one device on the bus. Bit 6 is set if the device sent a Service Request Message, and the remaining bits are unique to the selected device.

10. The Status Bit Message --------- A byte which represents the operational conditions of a group of devices on the bus. Each bit represents a device on the bus. This is typical response to a Parallel Poll operation.

11. The Pass Control Message ------- This allows transfer of the bus management duties to another device on the bus.

12. The Abort Message -------------- The System controller takes unconditional control of the bus from the active controller. The message terminates communications with the bus and sends a Clear All message.

********* IEEE488 GPIB FUNCTION CLASSIFICATION TABLE ************

```
T6    -- Basic Talker, Serial Poll, Unaddressed if MLA
TE0   -- No extended talker function
L4    -- Basic Listener, Unaddressed if MTA
LE0   -- No extended listener function
SH1   -- Complete Source Handshake capability
AH1   -- Complete Acceptor Handshake capability
SR1   -- Complete Service Request capability
PP1   -- Parallel Poll Remote configuration capability
RL1   -- Complete Remote / Local capability
DC1   -- Complete Device Clear capability
DT1   -- Complete Device Trigger capability
C1,C2,C3,C4,C5 - CONTROLLER states
```

1.1 IEEE488 SYSTEM BUS OPERATIONS

The sequence of actions for all data transfer commands on the bus is as follows:

OUTPUT	INPUT
1. IBM-PC Talk Address	1. Device Talk Address
2. UNLISTEN	2. UNLISTEN
3. Device Listen Address(es)	3. IBM-PC Listen Address

After the transfer of data is complete the bus remains in the last programmed condition.

SECONDARY COMMANDS

When communicating to/from devices which use secondary addressing, the devices extended address is specified by separating the primary address with a "." (period). The use of extended addressing or secondary commands (maximum level of five) complies with the 1978 IEEE488 standard. The bus sequence for secondary or extended addressing is as follows:

1. IBM-PC Talk Address
2. Unlisten
3. Device Primary Address
4. Secondary Commands/Address
5. Data

NOT IN CONTROL ADDRESSING

When the IBM-PC is not the active controller on the bus, no other devices may be addressed by the IBM-PC (all controller commands). The IBM-PC may still transfer data as a talker/listener if setup by the controller in charge. During an ENTER command the IBM-PC waits until the active talker transmits the data if the IBM-PC was addressed by the talker/listener. If the address codes are not satisfied, &h9000 will be returned in the FLG% variable. This allows the user to perform a program wait loop for maximum efficiency in error handling. The OUTPUT statement waits until the controller addresses the IBM-PC to talk and the ENTER command waits until the controller addresses the IBM-PC to listen. The IBM-PC may assume control if the controller in charge sends the Take Control Message after it programs the IBM-PC as a Talker. During a DMA transfer the IBM will wait until addressed before data is transferred. A time out code is returned if the data is not accepted by the talker/listener. The programmer may use this return code for a time out loop also.

2.0 HARDWARE INSTALLATION

The IE488 board requires one slot in the IBM-PC and 16 consecutive address locations in I/O space. The board also requires a free 16 K-byte block of memory for the on board 12K-byte ROM interpreter and 4K-byte Static Ram. Some I/O address locations will be occupied by internal I/O and your other peripheral cards, so to provide flexibility in avoiding conflict with thesedevices the IE488 I/O address can be set by the Base Address D.I.P. switch to be on any 16 bit boundary in the IBM - PC decoded I/O space. This also makes possible the use of a second IE488 interface board in the same computer. The I/O map for IBM's standard Internal/External peripherals is listed on page 2-23 of the "IBM Technical Reference Manual".

Usually, a good choice is to put the IE488 at base address &H300 or &H310 (Decimal 768,784). (Note if you are using the IBM prototype interface board, it uses the hex 300 -31F address space and would be in conflict).

There are three groups of switches on the IE488 interface card. The Base Address switch is located on the top left corner and marked BASE ADDRESS. The switch settings are listed as follows:

	DEVICE I/O ADDRESS BITS						
	(msb)					(lsb)	
	A9	A8	A7	A6	A5	A4	Example shows
address bits	1	1	0	0	0	0	ADDRESS = &H300
switch pos.	dn	dn	up	up	up	up	

A switch in the up (on) position corresponds to a ZERO (0) in the address bit. Similarly, a ONE (1) is set in the address bit when the switch is in the down (off) position. The example switch setting above shows the address switch selecting &H300 (768 decimal) for the Base I/O Address.

******************* WARNING ***********************

NO CHECK IS MADE ON THE BASE ADDRESS WHEN INITIALIZED, BE SURE THAT THE BASE ADDRESS SELECTED DOES NOT CONFLICT WITH ANY OTHER PERIPHERALS.

The next switch is the MEMORY ADDRESS switch. This switch selects the 16 Kbyte block of memory on an even 16 Kbyte boundary. The addressing of the switches corresponds to the absolute20bit address location in 16 Kbyte increments. The MEMORY ADDRESS switch is located above the gold edge connector.

	MEMORY ADDRESS BITS						
	(msb)					(lsb)	
	A19	A18	A17	A16	A15	A14	Example for
address bits	1	1	0	0	0	0	MEMORY ADDRESS

switch settings dn dn up up up up = &HC0000

Refer to Section 2 of the IBM Technical Reference Manual for a complete system memory map layout. The address chosen in the above diagram is C0000 hex which is in the 192 Kbyte expansion area after the display buffers. This is usually a clear area on most IBM P.C.'s. **Make a note of the MEMORY ADDRESS and the BASE ADDRESS of the boards for initialization.**

********************* WARNING **********************

NO CHECK IS MADE ON THE MEMORY ADDRESS, MAKE SURE THERE IS NO OTHER MEMORY ASSIGNED TO THE SELECTED ADDRESS.

The next switch setting is for the interrupt vectors and DMA channel selection. The IBM-PC has eight (8) interrupt vector levels and two levels (0 & 1) are not accessible since they are used by the operating system. The remaining 6 vectors are available to the user. The IBM-PC interrupt vector map is as shown below with the standard assignments of function made by IBM.

VECTOR LEVEL		FUNCTION
0	----------	[TIMER - SYSTEM ONLY]
1	----------	[KEYBOARD - SYSTEM ONLY]
2	----------	USER OR LPT2:
3	----------	COMM2: ADAPTER
4	----------	COMM1: ADAPTER
5	----------	FIXED DISK OR LPT3:
6	----------	FLOPPY DISKETTE DRIVES
7	----------	PRINTER #1 (LPT1:)

The INTERRUPT LEVEL & DMA selector switch is located in the bottom center of the board. The switch is marked INT (1 2 4) and is set as follows:-

INTERRUPT LEVEL	SW(2)-1	SW(3)-2	SW(4)-4	
0	up	up	up	RESERVED
1	dn	up	up	RESERVED
2	up	dn	up	
3	dn	dn	up	
4	up	up	dn	
5	**dn**	**up**	**dn**	
6	up	dn	dn	
7	dn	dn	dn	

The standard switch setting is vector level 5 and is shown in bold print. It is the users responsibility to select an interrupt level that does not conflict with the operating system hardware. If the system is using a spooler for the printer then Interrupt Level 7 will be in use. Note that the interrupts are only used during DMA transfers, therefore if DMA is not used the setting is irrelevant.

The last switch setting is the selected DMA channel. The switch is part of the bank of four switches used for the interrupts. The switch is marked DMA (1 - 3), up is Channel 3, down is channel 1. In IBM-PC's equipped with floppy disk(s) only, DMA level 3 should be used. Hard disk equipped machines (XT models) force the user to utilize DMA level 1. This is somewhat restrictive, since due to the hardware design of the IBM-PC, DMA level 1 page register is the same as DMA level 0 (memory refresh). For more information see Appendix A.

The board is shipped with the following switch settings.

MEMORY ADDRESS = C0000 hex
BASE ADDRESS = 300 hex
INTERRUPT # = 5
DMA CHANNEL = 3

Having made the switch settings, you can now install the IE-488 board. First remove the board from its protective electrostatic packaging. It is a good precaution to discharge any electrostatic charge you may have accumulated by touching the metal frame of your computer (you should have it grounded for safety). Next, if you have not already done so, **TURN OFF THE POWER** on your computer and take off the case (see IBM "Guide to Operations" for reference). Remove a vacant back plate by undoing the screw at the top and press the card guide supplied with the IE-488 board on the opposite side of the case (some models may not require this). Slip the IE-488 board in and secure the backplate. That completes the hardware installation.

One more precaution concerning storage and handling of the IE-488 interface board. MetraByte recommends that you retain the special electrostatically shielded package and use it for protective storage of the board if for any reason it is removed from your computer.

3.0 MODES OF OPERATION

In the interests of conciseness for the more experienced programmer and user, this section has been written as a reference and initially may be difficult to understand. If this is the case, refer to Appendix F where a step by step real programming example read together with this section provides an easier introduction.

All modes of operation are determined by an **ASCII STRING** in a command (COMMAND$ or CMD$) referenced within a CALL statement. The CALL statement format is:

xxx CALL IE488 (COMMAND$, var{$}(%), FLAG%, BASADR%)

where:

COMMAND$ - is the COMMAND including device addresses or secondary commands and [image terminators]. This is always a **STRING** and is decoded by the Command Line Interpreter in the IE-488 firmware (ROM). The COMMAND is separated from the operands (devices etc.) by one or more SPACES, any other delimiters will cause a SYNTAX error in command line. The separator for devices is always the comma "," and secondary address is always a period ".". The IMAGE string is identified by brackets "[]". The Command Line Interpreter is relatively tolerant of syntax error identification and will send back the appropriate error code to isolate the error. The format is:-

CMD$ = **"COMMAND dev1, dev2, ...,devn [image]"**

The **[image]** specifier allows the user to specify the variable field operations for the beginning and end of the data transfer variable. The variable may be a variable name, array identifier, numeric data value or a string. The user must match the image to the data type or an error will be generated in the data transfer. No check is made in the match of the image to the variable type, this is the responsibility of the user. The [image] codings are explained in section 3.1 (IMAGE SPECIFIERS).

var{$}(%) - isthe data variable OUTPUT/INPUT to be transferred from/to. Datais transferred as specified by the image terminator/specifier. If the image specifier is not used the data is treated as an integer. The data may be of String or Integer type.

FLAG% --- is the transfer status of the CALL statement. If an error occurs FLAG% will contain a **HEX** number representing the error condition. A set of error and

transfer message codes are generated at the completion of each CALL.

BASADR% -- is the address of the interface board being used. BASADR% may be 0 or 1, or actual base address e.g. 768.

3.1 IMAGE SPECIFIER

[$(p)(x),m,z] - Input/Output the number of Bytes to/from the variable string starting at position m and ending at position z, with parity p (E=even, O=odd, none). If m, z and p are omitted the entire string will be output as in the string variable$ as specified by the image terminator (x) without parity. If no terminator is used then the string will end with EOI.

[B(H/L)(x),m,z]- Input/Output the specified H/L number of Bytes to or from the the specified integer variable array starting at (m) array location and ending at the (z) position. The data transferred will not change the the other half of the 16 bit integer, only the byte specified is changed on an ENTER command. There is no change to the data with the OUTPUT command. [BL#,2,10] will transfer the low byte of position 2 thru position 10 of the integer variable array. Note, the number of bytes transferred is nine, position two and ten are included. Transfer termination is specified by the image terminator. It is the user's responsibility to insure that the array size and the type of array are correct. No check is made on data types. The values of m and z may be reversed which will transfer data in the reverse order. If m and z arethe same then only one word is transferred. If m and z are omitted then the integer variable is not considered an array and the variable is transferred with or without an EOI depending on the image terminator (x).

[W(x),m,z] - Input / Output the specified number of 16 bit words to / from the specified integer variable (array) starting with position (m) and ending with position (z). The number of words transferred is defined as {z - m + 1}. Termination is specified by the image terminator. It is the user's responsibility to insure that the array size and type of array are correct. No check is made on data types. The values of m and z may be reversed which will transfer data in the reverse order. If m and z are the same then only one word istransferred. Ifm and z are omitted then the integer variable is not considered an array and the variable is transferredwith or without an EOI depending on the image terminator (x).

3.2 IMAGE TERMINATORS

%(t) The % image terminator cancels both the line feed and EOI terminators during an OUTPUT command execution. During an INPUT command the entry will terminate when the array size or the input count is reached (m + count = z) or EOI. The line feed is entered as part of the array.

#(t) The # image terminator cancels the line feed only. The data is terminated by an EOI during the INPUT or OUTPUT command. The ENTER also terminates if the last item in data list is entered which sets the FLAG% variable with an error code of &H0020.

+(t) The + image terminator cancels the line feedand EOI during an OUTPUT command only. The INPUT command is in the default mode (INPUT terminates with EOI or last entry). If carriage return and line feed are part of the data being transferred they will be sent as normal data.

(t) The transfer terminator t determines the type of transfer the GPIB is to perform. The following transfer codes are available. If this specifier is not used the data transfer is under program control.

D = Direct Memory Access (DMA) to the specified array. The m and z specifiers must be used with this type of transfer. Structure programming must be used when this mode is active. All variables must be assigned before the CALL is executed and no new variables are allowed to be introduced after the execution of the CALL statement. See APPENDIX A for details on DMA transfers.

3.3 FLAG RETURN CODES

The following codes are returned in the FLAG% variable upon completion of the CALL statement. The flag return codes are grouped into 3 categories.

******************** DATA TRANSFER ********************

&H0000	=	TRANSFERRED OK
&H0020	=	NO INPUT EOI or LINE FEED
&H0030	=	DEVICE TIME OUT
&H0040	=	RESERVED
&H0050	=	DMA CHANNEL BUSY
&H0060	=	GPIB BUSY

********************** HARDWARE ***********************

&H0100	=	HARDWARE FAILURE
&H0200	=	TIME OUT ON DATA TRANSFER
&H0300	=	DEVICE NOT ACTIVE CONTROLLER
&H0400	=	IBM-PC ACTIVE CONTROLLER
&H0500	=	SYSTEM NOT INITIALIZED
&H0600	=	CONFIGURATION ERROR

********************* FORMAT ***********************

&H1000	=	UNDEFINED COMMAND
&H1100	=	SYNTAX ERROR IN COMMAND LINE
&H2000	=	UNDEFINED IMAGE
&H3000	=	DEVICE RANGE ERROR
&H3100	=	TOO MANY DEVICES
&H3200	=	TALKER/LISTENER CONFLICT
&H4000	=	COMMAND/DATA OUT OF RANGE
&H5000	=	COMMAND REQUIRES DEVICE
&H6000	=	UNDEFINED DEVICE CODE
&H7000	=	INPUT ARRAY NOT INITIALIZED
&H9000	=	IBM MUST BE TALKER or LISTENER

4.0 USER COMMANDS

The following user commands are available. The string variable **COMMAND$** is the same string format as described in the IBM-PC BASIC manual. A typical command string would be as follows. Please note that all commands must be assigned in string form before using the CALL statement.

COMMAND$= "OUTPUT 03.13.20,05[WD#,2,20]"

This command string would output integer words (16 bit) two thru and including word 20 to device primary address 03 with secondary addresses 13 and 20 and also to device primary address 05. The data transfer uses the DMA (SEE APPENDIX A) mode for fast access. The device codes must be in decimal within the range of 00 to 30. This allows the user a maximum of 31 device addresses to choose from. However the maximum number of devices which may physically be connected to the bus is 15.

The transfer of String data is limited to single element arrays and must be initialized. The Maximum string size is 255 bytes as defined in the IBM-PC Basic manual. The user may transfer a string inside of an array such as VAR$(2,3), which would transfer the string data contents of array element (2,3). An error code of &H7000 will be returned in the FLAG% variable if the stringarray element is not initialized.

EXAMPLES OF LEGAL STRING DATA TRANSFER:

```
xxx10 COMMAND$ = "OUTPUT 11.01[$E+,9,22]"
xxx20 VAR$(2,8) ="THIS IS ARRAY ELEMENT 2,8"
xxx30 CALL IE488 (COMMAND$, VAR$(2,8), FLG%, BRD%)
```

This command will output the bytes "ARRAY ELEMENT" then return to the user program.

```
xx100 VAR$(1) = "This is a single array element"
xx110 CALL IE488 (COMMAND$, VAR$(1), FLG%, BRD%)
```

This command will output the bytes " single ar" then return to the user program.

```
xx200 COMMAND$ = "OUTPUT 11.01[$E,22,9]"
xx210 VAR$ = "THIS IS ALSO A SINGLE ARRAY TEST"
xx220 CALL IE488 (COMMAND$, VAR$, FLG%, BRD%)
```

This example will output the bytes "NIS A OSLA" i.e backwards, then return to the user program.

ABORT - Terminate the current command issued by the IBM. The command executes an IFC and resets the IBM board addressed. DMA and Interrupts are disabled. The IBM-PC is assumed to be the main system controller and unconditionally takes control of the bus and remains the controller in charge until PASCTL command is executed.No device is necessary.

COMMAND$ FORMAT:

"ABORT"

EXAMPLE:

```
xxx10 CMD$ ="ABORT"                              'command format
xxx20 DEF SEG = &HC000                           'driver subroutine
xxx30 CALL IE488 (CMD$, VAR%, FLG%, BRD%)        'execute command
xxx40 IF NOT FLG% THEN 100                       'test for errors ?
xxx50 PRINT "ERROR ";HEX$(FLG%);" IN LINE 70"
xxx60 END

xx100 ..... user program continues .........
```

Note: The VAR% is used as a dummy variable and no change occurs to the contents of VAR%. This variable may be first declared inside the CALL statement at execution for convenience.

CLEAR - Clear or Reset the selected devices or all devices. If no device is given the GPIB is cleared. The IBM PC must be the active controller or an error message will be generated.

COMMAND$ FORMAT:

"CLEAR dev1,dev2,.....devN"

EXAMPLE:

```
xx200 CMD$ = "CLEAR 10,12,14"                'command format
xx210 BRD% = 0                               'board #
xx220 CALL IE488 (CMD$, VAR%, FLG%, BRD%)    'execute command
xx230 IF NOT FLG% THEN 300                   'test for errors ?
xx240 PRINT "ERROR ";HEX$(FLG%);" IN LINE 220"
xx250 END

xx300     ..... users program continues .......
```

CONFIG - Configure the GPIB to the devices specified in the command string. The GPIB will remain in this state until reconfigured by issuing an ENTER or OUTPUT command. The VAR% variable is not changed in this command. If the TALK = dev1 is omitted the IBM-PC is assumed to be the controller only. The user may enter MTA to make the IBM-PC the talker or enter the actual device number using the TALK variable name. The IBM-PC may be addressed as a listener by using the name MLA as the last device in the COMMAND string. The FLAG% variable will contain the error code if any conflicts occur.

COMMAND$ FORMAT:

"CONFIG (TALK=dev1 /MTA,)LISTEN=dev2,dev3,...,(MLA)"

EXAMPLE:

```
xx10 BRD% = 0
xx20 CMD$ = "CONFIG MTA,LISTEN = 10,12.34,5,7"
xx30 CALL IE488 (CMD$, VAR%, FLAG%, BRD%)
xx40 IF NOT FLAG% THEN 100
xx50 PRINT "ERROR ";HEX$(FLAG%);" IN LINE 30"
xx60 END

x100 ........ program continues here if no errors ..........
```

The above program sets the IBM-PC as a talker and devices 10, 12.34, 5 and 7 as listeners. The MTA variable is internally interpreted as the MAD set in the initialization of the GPIB using the SYSCON command.

```
xx20 CMD$ = "CONFIG TALK=6,LISTEN=12,14,5,MLA"
```

This CONFIG command sets device address 6 as a talker and devices 12, 14, 5 and IBM-PC as listeners. The string MTA is internally interpreted as MAD set in the initialization of the GPIB using the SYSCON command.

ENTER - Input GPIB data from selected talker to specified string array. The string array must have been previously dimensioned. The FLAG% will contain error codes if an error occurs. The IBM - PC must have been previously programmed as a listener. If the IBM - PC is not the controller then the ENTER command will return error code 9000H to inform the caller that the IBM is not in the listen mode. The command may be re-entered until the controller in charge programs the IBM to listen. Only one device is allowed with this command.

COMMAND$ FORMAT:

"ENTER dev.secad [image]"

EXAMPLE:

```
xxx10 DVM$ = SPACE$(25)                          'Dimension array
xxx20 CMD$ = "ENTER 12[$,0,18]"                  'Command String
xxx30 CALL IE488 (CMD$, DVM$, FLG%, BRD%)
xxx40 IF NOT FLG% THEN 140                       'test for errors ?
xxx50 PRINT "ERROR ";HEX$(FLG%);" IN LINE 30"
xxx60 END

xx140  ........ user program continues ........
```

The above program will fill DVM$ array elements 0 to 18, If all is successful the FLG% variable will contain 0. If an error should occur the FLG% would be coded according to the error. The data in DVM$ will be incomplete with error codes > = 100 hex.

DMA is ONLY allowed for WORD integer arrays less than 32767, (64 k bytes). See APPENDIX A for DMA DATA TRANSFERS.

EOI - Sends a data byte on the selected device with EOI asserted. The bus must have been programmed to talk before the command is executed. The variable contains the data to be transferred. It is the users responsibility to insure the data and type match. If a string variable is used the entire string is transferred ending with an EOI. If Integer mode is used only one transfer (byte) or two (word) will be executed. The limit parameters are ignored. Only one device is allowed. No device is generally required if the Talker (IBM-PC) has been previously programmed to talk by the controller in charge. If the IBM-PC is not the controller in charge and not programmed as a talker then an error code &h9000 will be returned until the controller in charge programs the IBM-PC as a talker before data is transferred.

COMMAND$ FORMAT:

"EOI dev [image]"

EXAMPLE:

```
xx100 VAR$ = "THIS IS A STRING"     'define last byte to transfer
xx110 CMD$ = "EOI 12[$]"            'define command
xx120 CALL IE488 (CMD$, VAR$, FLG%, BRD%)
xx130 IF NOT FLG% THEN 200
xx140 PRINT "ERROR ";HEX$(FLG%);" IN LINE 120"
xx150 END

xx200  ......... continue users program ...........
```

This routine will transfer the STRING in the VAR$ variable and issue an EOI command with the last byte of the STRING to signal the receiver on the bus that the data transfer will end.

The image specifiers for the removal of the line feeds and carriage returns are ignored during the command, no parity is used.

LOCAL - Set selected device(s) to the local state. If no device is specified then all devices on the bus are set to local. The IBM-PC must be the active controller or an error message will be generated.

COMMAND$ FORMAT:

"LOCAL dev1,dev2,.....devN"

EXAMPLE:

```
xx100 CMD$ = "LOCAL 10,11,12,14"            'define command
xx120 CALL IE488 (CMD$, VAR%, FLG%, BRD%)   'execute command
xx130 IF NOT FLG% THEN 200                  'test for errors
xx140 PRINT "ERROR ";HEX$(FLG%);" IN LINE 120"
xx150 END

xx200  ..... continue users program ........
```

The above program sets devices 10,11,12,14 to the local state and returns to the user's program. The LOCKOUT command is very similar in structure to the LOCAL command except the LOCKOUT does not allow the user to manually select the device to local.

LOCKOUT - Local Lockout the specified device. If no device is given all devices on the bus will be set to local lockout. The IBM-PC must be the active controller or an error message will be generated. The devices cannot be set to local except by the GPIB controller. The FLG% variable contain the error code.

COMMAND$ FORMAT:

"LOCKOUT dev1,dev2,.....devN"

This command is the same as the LOCAL command except the user is NOT allowed to manually select the device to local.

OUTPUT - Output selected string to selected listener(s) on GPIB. The variable will contain the data to be transferred. The image specifier will contain the data type and terminators. The FLAG% will contain the error codes if an error occurs. Up to 14 devices may be accessed in the list. If the IBM-PC is not the controller in charge, the IBM-PC must be programmed by the controller in charge before data is transferred.

COMMANDS$ FORMAT:

"OUTPUT dev1.secad,dev2...[image]"

EXAMPLE:

```
xx100 VAR$ = "THIS IS A TEST"           'define bytes to transfer
xx110 CMD$ = "OUTPUT 12,11[$E]"         'define command
xx120 CALL IE488 (CMD$, VAR$, FLG%, BRD%)
xx130 IF NOT FLG% THEN 200
xx140 PRINT "ERROR ";HEX$(FLG%);"  IN LINE 120" : END

'This command line will output the entire string "THIS IS A TEST"
'using even parity and ending with a EOI code to show the end of
'the string. The FLG% variable will have any error transfer codes
'if an error was detected during transfer.

xx200  ......... continue users program ...........

xx400 DIM MYDATA%(2,400)                'my integer data array
xx410 CMD$ = "OUTPUT 12,11[BL,0,100]"   'setup image

' output data in 2,0 from element 0 to 100 low byte only
xx420 CALL IE488 (CMD$, MYDATA%(2,0), FLG%, BRD%)
xx430IFNOT FLG% THEN 500
xx440 PRINT"ERROR ";HEX$(FLG%);" IN 420" : END

          ......continue users program.......
xx500 'setup for DMA transfer
xx510 CMD$ = "OUTPUT 12,10,15[WD,0,8192]"  'DECIMAL ONLY
xx520 DIM DMAPTR%(2)
xx530 DMAPTR%(0) = DATASEGMENT%     'setup data segment
xx540 MDAPTR%(1) = DATAOFFSET%      'setup data offset

' transfer data in DMA mode
xx550 CALL IE488 (CMD$, DMAPTR%(0), FLG%, BRD% )
xx560 IF NOT FLG% THEN 600
xx570 PRINT "ERROR ";HEX$(FLG%);" IN LINE 550 " : END
'If error code in DMA is not &H50 or 0 then issue an ABORT
command to clear interface device.
600     ........ user program continues ......
```

PARPOL - Reads the 8 Status Bit messages for the devices on the GPIB which have been set for parallel poll configuration. The VAR$ (string) will contain the 8 bit message. The IBM-PC must be the active controller or an error will occur.

COMMAND$ FORMAT:

"PARPOL"

PROGRAMMING EXAMPLE:

```
100 VAR$ = CHR$(&H0)      'Parallel Poll return byte initialized
110 CMD$ = "PARPOL"
120 CALL IE488 (CMD$, VAR$, FLG%, BRD%)
130 IF NOT FLG% THEN 200

'if error, the flag is printed out.

140 PRINT "ERROR ";HEX$(FLG%);" IN LINE 120" : END

200 'process parallel poll return byte code in VAR$
                .....
                .....
```

This command responds as programmed in the parallel configuration command. The VAR$ will contain the eight bit poll response. See the Parallel Poll Configure command (PPCONF) for the details of the bit pattern.

PASCTL - The Active control of the GPIB is transferred to the specified device address and the IBM-PC becomes the standard listener/talker but not controller. The IBM - PC must be the active controller or an error will occur. The IBM-PC is not allowed to Talk until programmed by the controller in charge.

COMMAND$ FORMAT:

"PASCTL dev"

EXAMPLE:

```
100 CMD$ = "PASCTL 6"
110 CALL IEE488 (CMD$, X%, FLG%, BRD%)
120 IF NOT FLG% THEN 200
130 PRINT "ERROR ";HEX$(FLG%);" IN LINE 110" : END

xx200  ............... continue users program ..................
```

The IBM-PC is inactive at this point and no controller commands are allowed. To receive control back the command RXCTL must be used as follows.

```
xx300 CMD$ = "RXCTL"                              'define command
xx310 VAR% = 0                                   'set VAR$ to false

xx320 WHILE NOT VAR%                              'control test loop
xx330 CALL IE488 (CMD$, VAR%, FLG%, BRD%)         'test for control
xx340 IF NOT FLG% THEN 360
xx350 PRINT "ERROR ";HEX$(FLG%);" IN LINE 330" : END

xx360  ..... user continues program ......
                  ......
                  ......

xx500 WEND                                        'Last test
xx510  ..... WHEN IBM IS IN CONTROL PROGRAM CONTINUES HERE ....
xxxx                        ......
```

Note: It is the responsibility of the controller in charge to program the IBM-PC to the talk mode before the transfer of control is executed.

PPCONF - Sets up the desired parallel poll bus configuration for the user. The VAR$ (string) contains the poll sequence (00-FF). IBM-PC must be the active controller or an error will occur.
COMMAND$ FORMAT:
"PPCONF dev"

The PARALLEL POLL function provides a means of sending one bit of status information if the controller is requesting the response. Unlike SERIAL POLL, which is initiated by the device, the parallel poll is initiated by the controller in charge. There are two methods to configure a device for parallel poll, remote and local configurations. In remote configuration (PPI), he controller uses the following bit codes to configure the device addressed.

msb	B6	B5	B4	B3	B2	B1	lsb
X	1	1	0	S	P3	P2	P1

Were Pn = the device bit code 0 to 7 for PPR1 to PPR8 and S is the Send of the Parallel Poll Response, S = response. Adevice may be configured so that it never responds to a parallel poll. PPD (&H70) is the parallel poll disable command, which places the device in the parallel poll idle state (PPIS). The value of the individual status (IST) can be set by bit B4 in the VAR$ byte.

B4 = 0 IST = Parallel Poll Flag
B4 = 1 IST = SRQS

EXAMPLE:

```
110 BRD% = 0
120 A$ = CHR$(&HA)       'parallel configure bit code for dev 14
130 CMD$ = "PPCONF 14"
140 CALL IE488 (CMD$, A$, FLG%, BRD%)
150 IF NOT FLG% THEN 170
160 PRINT "ERROR ";HEX$ (FLG%);" IN LINE 140" : END

170 ..... continue program .........
```

In the local configuration (PP2), the specifications are made from the device. Writing 0 11 U S P3 P2 P1 to the VAR$ configures the controller for a Parallel Poll Response. When U = 0, this command is the LPE (local poll enable) local message. When U = 1, the TLC does not respond to the poll. The TLC is configured in the S bit. The PPRn will be sent true only if the Parallel Poll Flag (IST individual status local message) matches this bit. During normal operation, The value of VAR$ on entry will set or clear PPF (IST if B4 = 0) according to the device's need for service.

PPUNCF - Resets the parallel poll type configuration of the selected device. The IBM-PC must be the active controller or an error will occur. The specified device will not respond to a parallel poll command.

COMMAND$ FORMAT:

"PPUNCF dev"

PROGRAMMING EXAMPLE:

```
100 BRD% = 0
110 A$ = CHR$(&HA)
120 CMD$ = "PPUNCF 14"
130 CALL IE488 ( CMD$, A$, FLG%, BRD% )
140 IF NOT FLG% THEN 300

' error is processed here
150 PRINT "ERROR ";HEX$(FLG%);" IN LINE 130"
160 END

300 'program continues here if ok
310    ......................
        ......................
```

This routine will only disable device 14 to respond to a Parallel Poll command. If no device code is used the entire bus is disabled.

REMOTE - Sets the selected devices or device on the GPIB to go into the remote position. The IBM must be theactive controller or an error will occur. If an erroroccurs the FLAG% will contain the error code.

COMMAND$ FORMAT:

"REMOTE dev1,dev2,.....devN"

EXAMPLE:

```
xx100 VAR% = 0                          'dummy variable not used
xx120 BRD% = 0                          'define board number
xx130 CMD$ = "REMOTE 10,12,14"          'define command
xx140 CALL IE488 (CMD$, VAR$, FLG%, BRD%)
xx150 IF NOT FLG% THEN 200
xx160 PRINT "ERROR ";HEX$(FLG%);" IN LINE 140"
xx170 END


xx200  ......... continue users program ...........
```

This command is the counterpart to the LOCAL command. Devices 10,12,14 are set in the remote state and ready for a command sequence. The error flag FLG% will contain any error codes if an error was detected.

REQUEST - The GPIB may request service from the active controller on the bus by executing the "REQUEST n" command. This command has two modes. the first when "n" is omitted which may be executed any time to monitor the status of the IBM interface board. The VAR% (INTEGER) contains the status bits for the GPIB board addressed, [Hi Byte] = on board hardware registers, [Lo Byte] contains the IBM GPIB serial poll register status byte. The second mode when n is any number (0-31). This allows the user to set a serial poll status word to the controller in charge. The Low byte of the variable will contain the STATUS byte to be transferred to the controller.

msb GPIB ON BOARD								SERIAL POLL REGISTER lsb							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00

BIT 08 = INTERRUPT ENABLED 1 = on
BIT 09 = DMA ENABLED 1 = on
BIT 10 = DMA CHANNEL
1=chan #1, 0=chan #3
BIT 11 = INTERRUPT vector level (1)
BIT 12 = INTERRUPT vector level (2)
BIT 13 = INTERRUPT vector level (4)
BIT 14 = srq (CIC=1) PEND bit (CIC=0)
BIT 15 = Controller In Charge (CIC)
1 = yes, 0 = not in charge

BIT 00 = S0 BIT
BIT 01 = S1 BIT
BIT 02 = S2 BIT
BIT 03 = S3 BIT
BIT 04 = S4 BIT
BIT 05 = S5 BIT
BIT 06 = rsv on send
PEND on receive
BIT 07 = S7 BIT

EXAMPLE 1: ------- IBM NOT IN CONTROL --------

```
110 BRD%=0 :  X% = (SERIAL POLL BIT PATTERN)
120 CMD$ = "REQUEST 1"
130 CALL IE488 (CMD$, X%, FLG%, BRD%)
140 IF NOT FLG% THEN 200
150 PRINT "ERROR ";HEX$(FLG%);" IN LINE 130" : END
200 PRINT "REQUEST 1 FLAG CODE = HEX ";HEX$ (X%)
```

EXAMPLE 2: -------- IBM IS CONTROLLER IN CHARGE ---------

```
110 BRD%=0
120 CMD$ = "REQUEST"
130 CALL IE488 (CMD$, X%, FLG%, BRD%)
140 IF NOT FLG% THEN 300
150 PRINT "ERROR ";HEX$(FLG%);" IN LINE 130" : END
300 PRINT "REQUEST STATUS CODE = HEX";HEX$(X%)
```

Bit 09 would be used to determine if the DMA data transfer is complete (0 = off, 1 = on). The user may use the instruction at any time to monitor the state of the IBM-PC GPIB.

```
140 IF X% AND &H0200 THEN 130  ' this will loop until the DMA is
                               ' done.
```

RXCTL - Receive control of the bus.The VAR% (integer) is set true if the IBM regains control of the bus else VAR% is false.

COMMANDS$ FORMAT:

"RXCTL"

EXAMPLE:

```
xx120 BRD% = 0                          'define board number
xx140 CMD$ = "RXCTL"                    'define command

xx145 WHILE NOT VAR%
xx150 CALL IE488 (CMD$, VAR$, FLG%, BRD%)

xx160 IF NOT FLG% THEN 200
xx170 PRINT "ERROR ";HEX$(FLG%);" IN LINE 150" : END

xx200   ... continue users program until IBM is controller ...
xx210                          ......
xx220 WEND              ' the last instruction before control
xx300    ..... THIS IS WHERE THE PROGRAM WILL CONTINUE .....
         .....    WHEN THE IBM RECEIVES CONTROL        .....
xx310          ........ user program continues .......
xxxxx                         ......
```

When control is received the IBM may issue all commands as outlined. The RXCTL command may be issued at any time to determine the state of the IEEE488 BUS.

STATUS - A serial polled devices status byte is read into the selectedvariable. The variable% will contain the Statusbyte of the device specified as a serial poll. TheIBM-PC must be the active controller or an error will occur. Only one device is allowed with one secondary address. If no device is specified an error will occur.

COMMAND$ FORMAT:

"STATUS dev.secad"

EXAMPLE:

```
' three command sequence for Keithly Model 175 DVM
110 BRD% = 0
120 A$ = "M33X"
130 CMD$ = "REMOTE 12"
140 DVMEOI$ = "EOI 12[$]"
150 DVMSTATUS$ = "STATUS 12"

160 CALL IE488 (CMD$, A$, FLG%, BRD% )

170 IF NOT FLG% THEN 190
180 PRINT "ERROR ";HEX$(FLG%);" IN LINE 160" : END

190 CALL IE488 (DVMEOI$, A$, FLG%, BRD% )
200 IF NOT FLG% THEN 220
210 PRINT "ERROR ";HEX$ (FLG%);" IN LINE 190" : END

'  Status command issued here
220 CALL IE488 (DVMSTATUS$, X%, FLG%, BRD% )
230 IF NOT FLG% THEN 250
240 PRINT "ERROR ";HEX$ (FLG%);" IN LINE 220" : END
220 PRINT "STATUS BYTE CODE RETURNED IS   =  HEX ";HEX$(X%)
```

The above routine selects the DVM, sends out Set status info "M33X" then the status (serial poll) is executed on the device.

SYSCON - SYStem CONfiguration and initialization of the GPIB. The user must run this command once before using the GPIB. IF this is not run first an error will be generated. Base address data BAx is in HEX(&H) or DECIMAL. The SYSCON command checks for the conflict of all parameters if two boards are used. These are the BAS0, BAS1, interrupt vector and DMA channel settings which must be different. The BRD% and data variable are not used in this CALL since they have been defined in the COMMAND string.

COMMAND$ FORMAT:

"SYSCON MAD=dev,CIC=(0/1/2/3),NOB=(1/2),BA0=&Hdddd(,BA1=&Hdddd)"

where:

dev = the address of the IBM 00 to 30 decimal
MAD = My (IBM) device address
NOB = number of IE488 boards (1 or 2)
BA0 = base address for board 1
BA1 = base address for board 2
CIC = controller in charge, 0=none, 1=brd#1, 2=brd#2, 3=(brd#1 and brd#2) (separate GPIB busses).

EXAMPLE:

```
100 DEF SEG = &HC000        'starting segment of ROM CALL routine
110 CMD$ = "SYSCON  MAD=3, CIC=1, NOB=1, BA0=&H300"
120 IE488 = 0
130 CALL IE488 (CMD$, A%, FLG%, BRD% )
140 IF NOT FLG% THEN 200
150 PRINT "ERROR  ";HEX$ (FLG%);" IN LINE 130" : END

'The above lines of initialization code should always be placed
'at the beginning of your programs and precede any use of the IE-
'488. Note the DEF SEG = &HC000 before initiating the CALL and
'the CALL OFFSET variable IE488 is zero.

200 ..... continue users program .............
210              ............
220              ............
```

TRIGGER - Sends a trigger message to the selected device or a group of devices. The IBM-PC must be the active controller or an error will occur.

COMMAND$ FORMAT:

"TRIGGER dev1, dev2,..... devN"

EXAMPLE:

```
xx120 BRD% = 0                          'define board number
xx140 CMD$ = "TRIGGER 11,12,15"         'define command
xx150 CALL IE488 (CMD$, VAR%, FLG%, BRD%)

    ..... devices 11,12,13 are triggered at the same time .....

xx160 IF NOT FLG% THEN 200
xx170 PRINT "ERROR ";HEX$(FLG%);"  IN LINE 160" : END

xx200  ......... continue users program ...........
```

5.0 8086/8088 ASSEMBLY LANGUAGE CALL FORMAT

TheIE488 interface card also allows the user to use all the user commands as described in section 4.0 (USER COMMANDS) using the same parameter passing conventions as the BASIC Interpreter. The user should be familiar with the 8086/8088 assembly language format before attempting to utilize this function. The user will initiate a FAR CALL to the ROM (the address of the switch settings selected for the ROM segment on the IE488). The Stack is used to transfer all variable pointers and data. The DS register is the data segment pointer for the variable. Interrupt vector 0FEH is set to point to 0BB8H (utility vector). The segment will be the same value as the switch setting on the IE488 interface board. The user should save any register contents which he does not want destroyed.

EXAMPLE:

```
;------------------------ BOARD CONTROL DATA -------------------

     IE488_ROM_SEG: DD   0C0000000H   ;C000:0000 pointer to ROMS

     RTN_FLAG:      DW   0000         ;return flag code variable
     BASE_ADDRESS:  DW   0000         ;board number 0 (first board)

;------------------------  COMMAND STRING ----------------------

     CMD_STRING:    DB   'OUTPUT 11,12,14[$,2,15]'

     CMD_DESCRP:    DB   $ - CMD_STRING              ;Byte count
                    DW   CMD_STRING

;---------------- STRING DESCRIPTER / DATA ARRAY ----------------

     DATA_ARRAY:    DB   'THIS  IS THE DATA TO TRANSFER',CR,LF

     DATA_DESCRP:   DB  $ - DATA_ARRAY          ;byte count
                    DW  DATA_ARRAY              ;pointer to data

;------------------- VARIABLE POINTERS FOR COMMAND -------------

     VARIABLE_1:    DW   OFFSET CMD_DESCRPT       'command
     VARIABLE_2:    DW   OFFSET STRING_DATA       'data string
     VARIABLE_3:    DW   OFFSET RTN_FLAG          'return flags
     VARIABLE_4:    DW   OFFSET BASE_ADDRESS      'board number
```

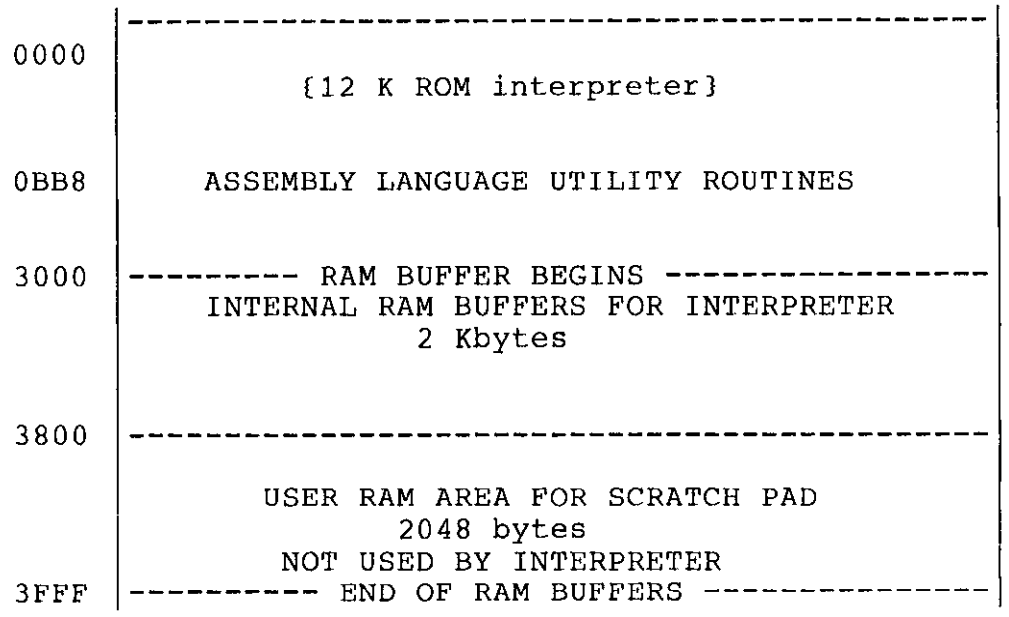
```
;------------------ SETUP STACK AND EXECUTE COMMAND ------------

IE488:    MOV SI,OFFSET VARIABLE_1      ;get pointers
          PUSH [SI]                     ;put on stack
          PUSH [SI+2]                   ;var'#2
          PUSH [SI+4]
          PUSH [SI+6]                   ;ready to exec
          CALL DWORD IE488_ROM_SEG      ;call device driver

RETURN:   CMP RTN_FLAG,00               ;any errors on return ?
          JNE ERROR_HANDLER             ;exit to error handler
     .... continue users program ......
```

There is also available an assembly language macro library for the IEEE488 interface board which allows the use of MACRO's similar to the Basic CALL statement for all the commands. This IEEE488 MACRO library allows the user to link to fortran and assembly language with simple easy to understand english language.

5.1 ROM/RAM MEMORY MAP

The following is a memory layout of the 16 K byte IE488 interpreter. The GPIB Interpreter contains 12 K byte of ROM and 4 K bytes of static ram.

GPIB IEEE488 16 K BYTE INTERPRETER MAP



5.2 STACK SEGMENT MAP

The stack is used to transfer the variable pointers to and from the IE488 interpreter and must be of sufficient size to handle the interrupt and DMA vectors used in the interpreter. The interpreter uses 20H words (32 decimal) of stack for the subroutine link. The stack memory map upon entry to the IE488 interpreter is shown below.

This is the stack layout at entry and upon exit to/from the IE488 interpreter:-

```
SP+6 =    VARIABLE_1     [ COMMAND STRING POINTER ]
SP+4 =    VARIABLE_2     [ DATA VARIABLE POINTER ]
SP+2 =    VARIABLE_3     [ RETURN FLAG POINTER ]
SP   =    VARIABLE_4     [ BOARD BASE ADDRESS POINTER ]
```

5.3 RETURN FLAG CODES

The return flag codes are the same as the codes used in the BASIC CALL statement (see section 3.3).

TheIE488 DMA data transfer hardware allows the user to transfer data anywhere within the 20 bit address range with a word count of 32767 (64 Kbyte). The DMA transfer parameters are passed to the interpreter via the VAR% array variable. The VAR% is setup as follows. All simple variables must be declared before the CALL to setup the DMA transfer is executed and NO simple variables may be declared after the CALL has been executed. Failure to comply with this outline will generate unpredictable errors. The reason for this is that BASIC stores array variables above simple variables in memory, and on declaring a new simple variable, BASIC relocates all array variables and string descriptors. If the DMA is in process to a variable that suddenly relocates, disaster ensues!

NOTE: DMA channel 1 shares the same page register as DMA channel 0 (memory refresh) and is limited to the first 64K of memory. DMA channel 3 is used by and cannot be shared with the hard disk in XT computers, in floppy only machines it is free. These are system limitations of the IBM-PC. In floppy based machines, DMA is no problem but DMA transfers modes are more restricted in hard disk machines. It is the user's responsibility to insure that disk transfers and IE488 DMA transfers do not conflict.

VAR%(0) = DMA DATA SEGMENT TO BE TRANSFERRED.
IF THE SEGMENT IS SET TO &HFFFF THEN THE BASIC DATA SEGMENT IS USED. This allows the user to transfer string data internal to BASIC.

VAR%(1) = DMA OFFSET INTO DATA SEGMENT THE TRANSFER IS TO BE REFERENCED. This is the value the limits use as a reference starting point.

IMAGE SPECIFIERS

The Image specifier for a DMA transfer is the [WD,m,z] only. If no limits are used the DMA transfer is ignored and the normal transfer is executed. If the limits difference is less than 1 word then the DMA is ignored and error code &H4000 is returned. The limits (m,z) must be in the increment mode (m > z), else an error &H2000 (image error) will be returned in the FLG% variable. If BASIC's data segment is to be used then **NO SIMPLE VARIABLES ARE ALLOWED TO BE INSERTED AFTER THE VAR% ARRAY HAS BEEN INITIALIZEDELSE UNPREDICTABLE SYSTEM FAULTS WILL OCCUR.** String variables may be transferred by the use of the VARPTR(var) command in the BASIC reference manual. No EOI is generated with the last byte transferred in DMA. It is the responsibility of the user to generate an EOI using the EOI command.

To transfer a string to a device the maximum length is 255

(&HFF), the user would use the VARPTR command as shown.

```
10 DIM X%(2)
20 IE488 = 0 : BRD% = 0 : FLG% = 0
30 CMD$ = "OUTPUT dev#[WD,0,15]"  'word = 2 bytes
40 A$ = "THIS IS THE STRING TO TRANSFER IN DMA"+CHR$(13)+CHR$(10)
50 X%(1) = (VARPTR(A$) + 1)
60 X%(0) = &HFFFF    'use basic's data segment
70 CALL IE488 (CMD$, X%(0), FLG%,BRD%)
```

Linking the IE488 interface with compiled programs generally requires an .OBJ file of the assembled driver. Since the main program is in ROM the user must write a small program to jump to the ROM segment to execute the command line interpreter. Some compilers allow a direct jump (call) to a segment and offset defined by the programmer, however the variable pointers must be positioned the same as BASIC(A) CALL requires. To allow all types of compilers to use the IE488 ROM command line interpreter, an assembly language link facility is available (see assembly language call chapter 5) to reposition the stack. Do to the string descriptor differences in the IBM Basic interpreter and the IBM Basic compiler a straight foward approach is not possible.However the following patch may be used when linking the compiled programs and the labels need not be changed.

To compile a Basic program using the IE488 is a straightforward procedure using CALL IE488 (CMD$, VAR$(%), FLG%, BRD%). Refer to the BASIC Compiler manual for the CALL command. The IE488 variable is not passed and is always = 0. The DEF SEG = (ROM Command Line Interpreter segment), may be removed from the compiled program since the linker will determine the starting segment of the program. This requires very little modification to the main program. The following program may be used to call the IEEE488 card.

Step 1. Using any word processor or editor generate the following assembly language program.

```
IE488SEG  SEGMENT BYTE 'IEEE488_DVR'
          ASSUME CS:IE488SEG, DS:IE488SEG
          PUBLIC    IE488

IE488     PROC      FAR

;-------------------------------------------------------------
; CHANGE THIS ROM SEGMENT IF THE ROM SWITCHES ON THE BOARD HAVE
; BEEN CHANGED

      ROM_SEG = 0C000H    ;IEEE 488 ROM SEGMENT
;-------------------------------------------------------------

      IE_BUSY = 309AH     ;INTERNAL POINTERS
      BASADR  = 300AH     ;INTERNAL POINTERS
      ERRFLG  = 300CH     ;INTERNAL POINTERS
      VARPTR  = 300EH     ;INTERNAL POINTERS
      DATSEG  = 3010H     ;INTERNAL POINTERS

      PUSH BP
      MOV SP,BP                          ;pointers
      PUSH ES
      PUSH SS
      PUSH DS
      MOV AX,ROM_SEG                     ;get IEEE rom segment
```

```
        MOV DS,AX                           ;DS points to ROM SEG
        MOV SI,IE_BUSY                      ;internal pointer
        CMP DS:[SI],0001H                   ;BUSY ?
        JE IEEE_RTN                         ;return to caller
        MOV WORD PTR DS:[SI],0001H          ;now were busy

        POP DS                              ;basic data seg
        PUSH DS                             ;restore stack
        MOV BX,[BP]+12                      ;string descpt ptr
        MOV AX,[BP]+10                      ;ARG #2
        MOV CX,[BP]+8                       ;ARG #3
        MOV SI,[BP]+6                       ;address of interface
        MOV DX,[SI]                         ;base address, device
        MOV AX,ROM_SEG                      ;get rom seg address
        MOV DS,AX                           ;new data seg
        MOV SI,BASADR                       ;internal pointer
        MOV DS:[SI],DX                      ;save base address
        MOV SI,ERRFLG
        MOV DS:[SI],CX                      ;save flag ptr
        MOV SI,VARPTR
        MOV DS:[SI],AX                      ;variable pointer
        POP AX                              ;BASIC data seg
        PUSH AX
        MOV SI,DATSEG
        MOV DS:[SI],AX                      ;save data seg.
        MOV DX,ROM_SEG
        MOV ES,DX
        MOV DS,AX                           ;BASIC DATA SEG
        SUB CX,CX                           ;CX = 0
        MOV CX,[BX]                         ;BYTE COUNT WORD
        MOV SI,2[BX]                        ;cmd string pointer
        JMP DWORD PTR IEE488_PROG           ;START PROGRAM

IEEE_RTN:

     MOV AX,0060H                           ;BUSY RTN CODE
     JMP DWORD PTR IOERTN                   ;long error return

     IEE488_PROG:  DD   0C0000048H          ;point to ROM START
     IOERTN:       DD   0C0000B90H          ;error return handler

     IE488     ENDP
     IE488SEG  ENDS
               END
```

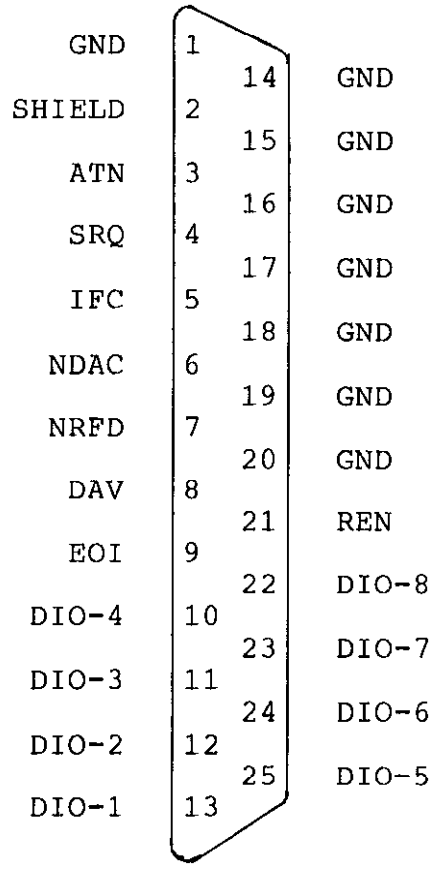
Step 2. Assemble the above module and name the file IE488 then use the linker to combine the Basic compiled program.OBJ and IE488.OBJ

The Assembly language link using basic is outlined in the BASIC Reference manual and also in the IBM BASIC COMPILER reference manual.

MAIN IEEE488 BUS CONNECTIONS **APPENDIX C**

The slots on the rear of the IBM P.C. are slightly too narrow to accommodate a standard IEEE-488 connector directly. To make connections a standard 25 pin D type female is used on the backplate (similar to RS232 type connector) and a special adapter cable, MetraByte part # C88-01, is used between the D connector and the standard IEEE-488 male/female. For details of this adapter cable see Appendix D.

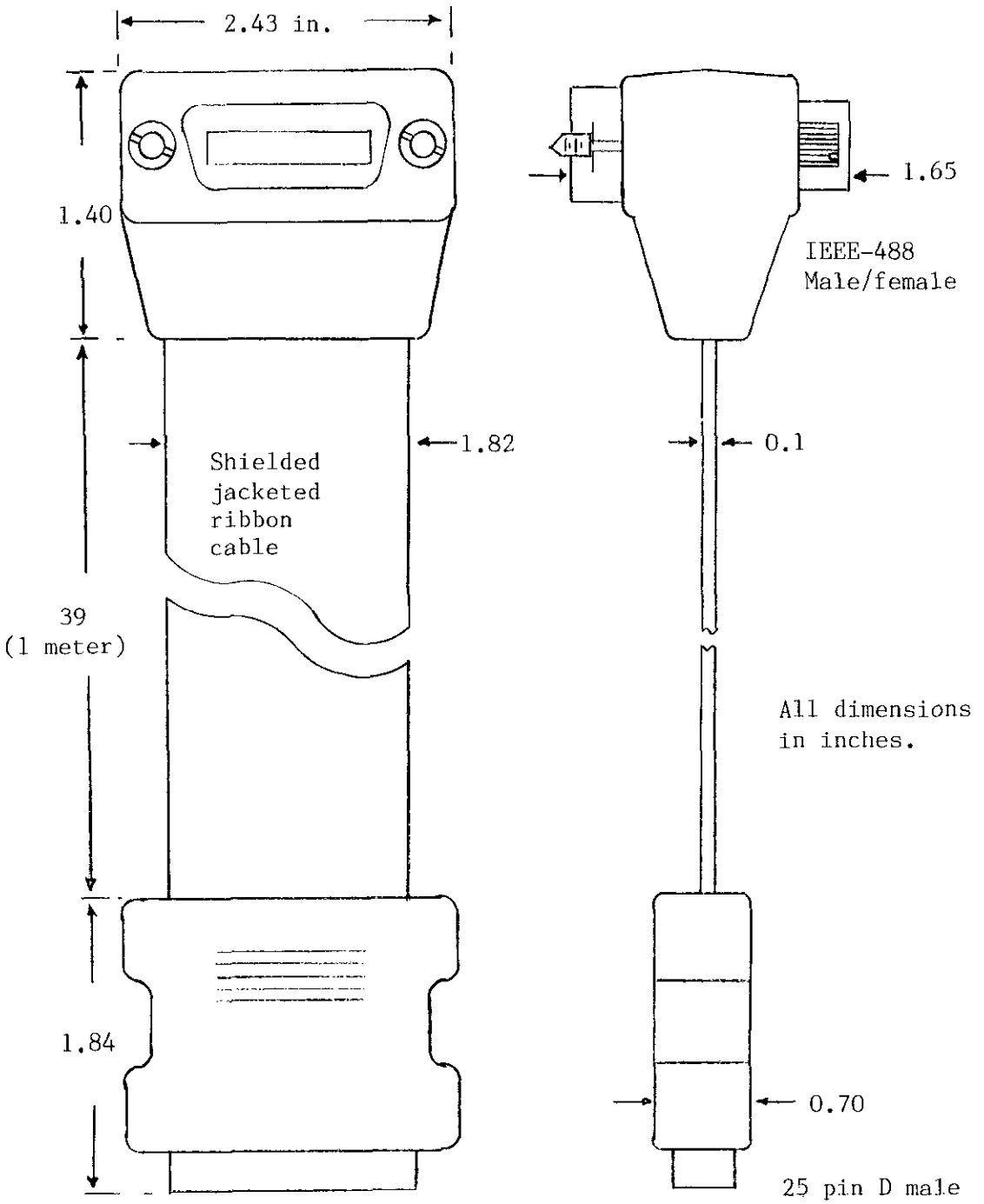
A rear view of the D connector pin assignments is shown below:-



Note that although the above connector is of the same type as specified by IEC-625, the pinout is different. An adapter cable is required for IEC-625 instruments.

C88-01 GPIB CONNECTOR CABLE **APPENDIX D**

A drawing of Metrabyte's C88-01 adapter cable is shown below. The cable is of flat shielded type and has a standard length of 1 meter (approx. 3 feet). Different lengths are available to special order, specify C88-xx where xx = length in meters.



The IE488 ROM Command Line Interpreter is designed to handle 2 IE488 boards, therefore the ROM Interpreter on the second board must be disabled. This is done by the removal of U19 (74LS245). This will disable the second ROM. The user is also free to use this ROM location for any programs which are to remain permanent. The address decoding may be set to select a different 16 k byte block of memory. There is 12 Kbytes of ROM and 4 Kbytes of static RAM which the Control-Alt-Del reset will have no effect on. The user may also use the last 2 Kbytes of static RAM on the first board for similar programs or a scratch pad. This allows maximum flexibility for a turn key system involving up to 30 GPIB selectable devices. When two boards are used the DMA and interrupt vectors must be different or else the boards will not initialize using the SYSCON command. The user may perform a DMA out on board 1 and a DMA in on board 2 (or vice-versa) at the same time without conflict.

The terms IEEE-488 buss and GPIB (General purpose interface buss) are used synonymously in this manual. The IEEE-488 buss was developed by the Hewlett Packard Company and was initially known as the HP-IB (Hewlett Packard Interface Buss). As its use spread to other instrument companies, the buss structure earned itself the name GPIB (General Purpose Interface Buss) and finally the Institute of Electrical and Electronic Engineers (IEEE) generated standard number 488 covering all aspects of buss configuration and operation, hence IEEE-488. In Europe, the International Electrotechnical Commission developed an equivalent standard, IEC 625-2 which defines an interconnect buss that is electrically similar to IEEE-488 but uses a different connector system.

As an example, we shall examine a program to read data from a Keithley Model 175 digital multimeter setup on the buss as device #12. The first step is to initialize the IE-488 board, this applies whatever you intend to do later and would usually be performed at the beginning of a program. It is not necessary to repeat this operation unless your computer is turned off. To initialize, we make use of the SYSCON (system configuration) command.

```
100 DEF SEG = &HC000

    'This first line tells the CALL statement that follows
     where to find the IE-488 ROM firmware routine. The
     address Hex C000 corresponds to the setting of the
     MEMORY ADDRESS switch on the board. See the IBM BASIC
     manual for the action of DEF SEG.

110 CMD$ = "SYSCON MAD=3, CIC=1, NOB=1, BA0=&H300"

    'The command string does the following:-

            SYSCON = command

            MAD = 3 sets the IBM talk/listen address to 3.
                    The device address for the IBM is set
                    in software instead of by switch.

            CIC =1  specifies that the board will be the
                    buss controller. Only one device can
                    be controller at a time.

            NOB = 1  We only have 1 IE-488 board  installed
                    in our computer.

            BA0  = &H300  The base I/O address through which
                    all data will be transferred must be
                    known by the firmware. This
                    corresponds to the setting of the BASE
                    ADDRESS switch on the board.
```

```
120 IE488 = 0
130 A% = 0 : FLG% = 0 : BRD% = 0

    'Line 120 sets the CALL offset variable to zero. It is
     always zero throughout the use of the CALL with the IE-
     488. Line 130 declares A% as a dummy data variable and
     clears the error flag variable FLAG%. No data will be
     passed during SYSCON but the presence of a data
     variable is required as a "filler" in the CALL
     parameter list. Strictly neither line 120 or 130 are
     absolutely necessary as they may be declared by default
     in the CALL and BASIC will automatically initialize
     them to zero, being explicit is just good programming
     practice.

150 CALL IE488 (CMD$, A%, FLG%, BRD%)

    'Line 150 performs the initialization. The CALL

     parameters CMD$, A%, FLG%, BRD% must always appear in
     the CALL in the same order - think of it as COMMAND,
     DATA, ERRORS, ADDRESS. The pointers to the location of
     these variables will be passed on BASIC's stack  in the
     order they appear, hence the importance of keeping the
     order and number fixed (see CALL in the IBM BASIC
     Manual).

160 IF FLG%<>0 THEN PRINT "INSTALLATION ERROR" : END

    'This line is optional and just confirms that the
     initialization proceeded O.K. If the FLG% error
     variable returned anything other than zero, a mistake
     has been made.
```

Lines 100-150 will be required initialization in all your programs. From hereon, the programming depends on your application. For our example, we will first set the Keithley 175 into remote. This is a good way to check the buss is "alive" since most devices have some sort of remote indicator that will be activated on execution of the next CALL.

```
170 CMD$ = "REMOTE 12"

    'Our command is to put device #12 into remote mode.

180 BRD% = 0
    'Once initialized, the board address variable may be set
     to 0 or 1 depending on which board in a 2 board system
     that was being addressed or alternatively if we prefer
     the actual base address of the board (&H300 in this
     case). You may choose either option.

190 CALL IE488 (CMD$, A%, FLAG%, BRD%)
    'Remote indicator will now activate.
```

```
200 IFFLG%<>0 THEN PRINT "ERROR # ";HEX$(FLG%) :END
    'Again, optional check for errors.
```

Now we will read data from the DVM. The DVM outputs a data string of ASCII characters e.g. NDCV+0.1234E+0 meaning normal DC volts, +0.1234 exponent 10^0 i.e. 1. This is typical of many IEEE-488 instrument responses. To fetch this data we use the ENTER command. Conversely, if we wanted to write data to the instrument we would use the OUTPUT command.

The first step is to set up a data variable to receive this data. Since we are expecting an ASCII string, we choose a string variable with enough elements to contain the expected data.

```
210 DVMDT$ = SPACE$(25)
    'An empty (spaces) 25 character string.

220 CMD$ = "ENTER 12[$,0,18]"
    'Enter data from device 12. The image specifiers tell
     the IE-488 firmware that the data transfer will be to a
     string variable ($) and that 19 characters are to be
     transferred to elements 0 thru 18 of the string.

230 CALL IE488 (CMD$, DVMDT$, FLG%, BRD%)
    'Note that although we have used the mnemonic CMD$ as a
     name for our command string variable throughout our
     examples, you are free to choose any other string name
     e.g. MYOWNNM$ for command data as long as it is
     correctly referenced in the CALL parameter list.

240 IF FLG%<>0 THEN PRINT "ENTRY ERROR" : END
    'Checks for transfer errors - optional.
```

The data is now in DVMDT$. The numeric and range information can be sorted out using BASIC's string functions e.g. MID$, VAL etc. Alternatively, in a fixed format response application, the image specifier can select out the data of interest in the response string.

This exampleshows how in 15 lines of code, many lines of which are optional, the IE-488 board can be initialized and data returned. It also shows how the firmware interpreter minimizes user programming and keeps communication with the IEEE-488 buss down to memorizing a few "English like" commands, a feature that is unique to the MetraByte IE-488 interface.

Another helpful hint on using the IEEE488 bus with different instruments is to insure that each instruction has sufficient time to complete its requested command before issuing another.

REFERENCES ON THE IEEE-488 BUSS

The following literature on the IEEE-488 buss may be of interest:-

1. "IEEE Standard Digital Interface for Programmable Instrumentation". ANSI/IEEE Std. 488-1978. Published by the IEEE Inc., 345 East 47th. St.,New York, N.Y. 10017

2. "Hewlett-Packard Interface Bus User's Guide". Publication 9830A, 1974.

3. "HP-IB. Improving Measurements in Engineering and Manufacturing - A Collection of Useful Technical Information". Hewlett-Packard Publication #5952-0058.

4. "IEEE Standard 488 and Microprocessor Synergism". Loughry, D.C. and Allen, M.S. in Proceedings of the IEEE, Vol.66, No.2, February 1978, pp162-172.

5. "Standard Instrument Interface Simplifies System Design" Ricci, D.W. and Nelson, G.E.. Electronics, Nov. 14, 1974 pp95-106.