THE BBC MICROCOMPUTER

IEEE488 INTERFACE USER GUIDE
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IEEE488 INTERFACE USER GUIDE

Designed, developed and manufactured in the United Kingdom by Acorn Computers Ltd and Intelligent Interfaces Ltd

written by
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Intelligent Interfaces Ltd
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WARNING: THIS APPLIANCE MUST BE EARTHED

IMPORTANT: The wires in the mains lead for this appliance are coloured in accordance with the following code:

- GREEN AND YELLOW: EARTH
- BLUE: NEUTRAL
- BROWN: LIVE

If the socket outlet available is not suitable for the plug supplied, the plug should be cut off and an appropriate plug fitted and wired as described. The plug which is cut off must be disposed of as it would be a potential shock hazard if it were to be plugged in with the cut off end of the mains lead exposed. The moulded plug must be used with the fuse and fuse carrier firmly in place. The fuse carrier is of the same basic colour* as the coloured insert in the base of the plug. Different manufacturers’ plugs and fuse carriers are not interchangeable. In the event of loss of the fuse carrier, the moulded plug MUST NOT be used. Either replace the moulded plug with another conventional plug wired as described, or obtain a replacement fuse carrier from an authorised BBC Microcomputer/IEEE488 dealer. In the event of the fuse blowing it must be replaced, after clearing any faults, with a 3 Ampere fuse that is ASTA approved to BS1362.

As the colours of the wires may not correspond with the coloured markings identifying the terminals in your plug, proceed as follows:

The wire which is coloured green and yellow must be connected to the terminal in the plug which is marked by the letter E, or by the safety symbol -!- or coloured green, or green and yellow.

The wire which is coloured blue must be connected to the terminal which is marked with the letter N, or coloured black.

The wire which is coloured brown must be connected to the terminal which is marked with the letter L, or coloured red.

* Not necessarily the same shade of that colour.
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INTRODUCTION

Before using your IEEE488 interface check that you have received the following items in addition to this User Guide

- IEEE488 Interface
- IEEFS EPROM
- Guarantee Card
- Delta Ribbon Cable (for connecting one IEEE488 device to the computer)

If any item is missing, contact the dealer who supplied the IEEE488 interface quoting the order number given to you when you placed your order.

It is strongly recommended that the IEEFS EPROM be fitted by a dealer. However, fitting instructions are included in Appendix 5, and information on the use of the terminating resistors in the IEEE488 Interface are contained in Appendix 6.

Connecting the Interface to the Computer

1. Turn off the power to the computer and the interface.

2. Plug the 34-way IDC socket on the end of the ribbon cable into the IMHZ Bus header on the underside of the computer. Ensure that pin 1 of the socket is aligned with pin 1 of the header. The small indents on the socket should face the printed panel.

3. Turn on the power to the interface and computer.

The IEEE488 Standard

The IEEE488 interface is a general purpose system for exchanging digital data bit parallel byte serial form between a number of devices in a local area. The original concept was developed by Hewlett Packard who called it the HP-IB Hewlett Packard Interface Bus. The IEEE (Institute of Electrical and Electronics Engineers) first produced a standard in 1975, IEEE Std 488-1975. This was
revised in 1978 as IEEE Std 488-1978. The interface is identical to that described in the IEC (International Electrotechnical Commission) Publication 625-1, apart from the mechanical connection system. The IEEE standard specifies a 24 pin Microribbon connector whereas the IEC Publication specifies a 25 pin D-type connector as used for the EIA R5232-C data communication interface.

The IEEE499 interface makes use of two types of messages:

i) interface messages (commands) used to manage the interface

ii) device dependent messages (data)

A device can have the ability to send data (act as a talker), receive data (act as a listener), or do both (act as a talker-listener), or manage the system (act as a controller).

This User Guide does not attempt to reproduce the IEEE standard or explain every aspect of it. The interested user is referred to Ref 1. However, this User Guide provides all the information required to use the BBC Microcomputer and IEEE488 Interface with any other IEEE488 device.

Information covered and where to find it in this User Guide

Chapter 1 tells you how to connect the BBC Microcomputer’s IEEE488 Interface to other IEEE488 devices and communicate with them. Chapter 2 expands on this and covers the exchange of binary coded data. Some IEEE488 devices have the ability to provide information on what state they are in, and ways of obtaining this information are discussed in Chapter 3. Chapter 4 contains details of commands which can be used to change the state of IEEE488 devices. The computer can pass control of the IEEE488 interface to another device and Chapter 5 tells how this is done. Chapter 6 is useful for reference as it provides a glossary of IEEE488 commands in alphabetical order. Information on using the interface in Assembler programs is contained in Chapter 7. Finally, Chapter 8 gives some details of the hardware used in the interface.

Throughout this User Guide examples are given in BASIC. However, the interface can be used with any language running on the computer which permits the use of a filing system. IEEEFS commands are given in full, and in upper case. However, abbreviations and any mix of lower and upper case may be used. See Appendix 1 for minimum abbreviations.
1 GETTING GOING - Simple data transfer

Before connecting devices to the computer turn off the power to both interface and computer.

The interface can be connected to up to 14 other devices using IEEE488 standard cable assemblies. These have a plug and socket at each end, permitting star or linear interconnection of devices. The connectors are provided with two securing screws which allow them to be stacked on the socket of each device. The IEEE socket is normally found on the rear of a device. The IEEE488 standard permits individual cable lengths of up to 4 metres and a total cable length in a system of 2 metres per device or 20 metres whichever is the shorter. Cables can be obtained from the manufacturers of devices.

When all devices have been connected to the interface, turn on the power in the following sequence:

1 devices
2 interface
3 computer

The IEEE Filing System (IEEEFS)

The IEEE488 interface of the BBC Microcomputer appears to the user as an additional filing system. It gives the computer the ability to act as a controller-talker or controller-listener with the ability to pass control and request it back through the use of IEEEFS commands. These commands enable the full use of an IEEE488 system without detailed knowledge of the operation of the interface.

The IEEEFS is selected by the command

*IEEE

To reselect another filing system use the appropriate command

*DISK
*TAPE etc
Note When used with BASIC the IEEEFS does not respond to

*CAT
CHAIN
EOF#
EXT#
LOAD
PTR#
SAVE

Communication between a language and the interface is via two channels
The first is the 'COMMAND' channel used for transmitting IEEEFS commands and
receiving information on the state of the interface. The second is the 'DATA' channel used
for reading and writing data to other IEEE488 devices.

After the first use of *IEEE the COMMAND and DATA channels must be opened.

Example

10 *IEEE
20 cmd%=OPENIN("COMMAND")
30 data%=OPENIN("DATA")

If required these channels can be closed in the following way

1010 CLOSE#data%
1020 CLOSE#cmd%

Each device in an IEEE488 system must have a unique address. Some devices have only
one address (a primary address) whilst others have extended addressing (primary and
secondary addresses). Primary and secondary addresses may be in the range 0 to 30.
Secondary addresses are often used to select different functions within the same device
e.g. an analogue to digital converter with a number of inputs may have the input selected by
the secondary address. Most devices are delivered with factory set primary and secondary
addresses. These can be found in the manufacturer's manual. If more than one device in a
system has the same address, these can be changed by following the manufacturer's
instructions. Usually this involves changing switch settings on the rear of the device.
The OPENIN and OPENOUT functions are used to pass the primary and secondary, if specified, addresses of a device to the IEEFS via a 'device' channel. Up to 14 channels may be open at one time.

**Example**

A digital voltmeter has a primary address of 4 and no secondary address.

```plaintext
100 dvm%=OPENIN("4")
```

A sixteen input analogue to digital converter has a primary address of 5 and a secondary address of 11 indicating the input to be converted.

```plaintext
150 adc%=OPENIN("5,11")
```

If no channel is available a zero is returned.

All channels remain open, even if other filing systems are selected, until specifically closed while the IEEFS is active.

A 'device' channel may be closed using the CLOSE# statement.

**Example**

```plaintext
1110 CLOSE#dvm%
```

The CLOSE#0 statement closes all 'device' channels but not the COMMAND and DATA channels which must be closed individually.

As only 14 'device' channels may be open at one time, it is recommended that channels are closed when no longer required or at the end of a program.

The BBC Microcomputer must also have a unique device address. This is specified using the BBC DEVICE NO command and can be any number in the range 0 to 30 not already assigned to a device in the system.

**Example**

To specify the primary address of the computer to 7

```plaintext
40 PRINT#cmd%,"BBC DEVICE NO",7
```
The CLEAR command is now used to initialise the system.

**Example**

50 PRINT#cmd%,”CLEAR”

The REMOTE ENABLE command is used to Prepare devices for remote operation eg under computer control

**Example**

60 PRINT#cmd%,”REMOTE ENABLE”

**Data strings of up to 255 characters**

When strings of ASCII coded data are sent to or received from a device delimiting characters are used. Consult the manufacturer's manual for each device to find out the delimiting characters for that device. The computer defaults to the delimiting character Line Feed (LF, ASCII code 10). If a device requires different delimiting characters these may be specified using the END OF STRING command.

**Example**

To set delimiting characters to carriage return, line feed

80 PRINT#cmd%,”END OF STRING”,CHR$(13)+CHR$(10)

The computer will then send these characters and expect to receive them after each data string until they are respecified.

**Data Output**

Channels must be opened to the devices concerned as previously described.

Before data can be sent to the devices, they must be listened, using the LISTEN command.

**Example**

160 voltmeter%=OPENIN(“9,3”)
180 PRINT#cmd%,”LISTEN”,voltmeter%,printer%,”EXECUTE”
The EXECUTE command must follow the last device to be listened.

Data can then be sent to the devices through the DATA channel using the PRINT# statement.

**Example**

190 PRINT#data%,”RI”

would set the range of the voltmeter and print RI on the IEEE printer. When output has been completed, the devices can be unlistened.

**Example**

340 PRINT#cmd%,”UNLISTEN”

**Data Input**

Channels must be opened to the devices concerned as previously described.

Before a device can send data it must be talked using the TALK command.

**Example**

210 counter%=OPENIN(“6”)
220 PRINT#cmd%,”TALK”,counter%

Note If there is already an active talker it will automatically be untalked.

Data is then received from the device via the DATA channel using the INPUT# statement. All active listeners will receive the data sent.

**Example**

230 INPUT#data%,count$

When input has been completed the device can be untalked.

**Example**

580 PRINT#cmd%,”UNTALK”
Checking the State of the Interface

The IEEEFS maintains a status word. This is available to the user through the STATUS command. The meaning of each bit of the status word is detailed in Chapter 6 under STATUS.

When ASCII coded data is being handled there are three status bits of interest.

bit 4 if set indicates the input sequence was terminated because over 255 characters were received before the delimiting characters

bit 6 if set indicates the END message was received from a device with the last character

bit 7 if set indicates an incomplete source handshake. This is most likely to occur during a TALK or LISTEN sequence if no devices are connected to the interface

Example

1030 PRINT#cmd%,”STATUS”
1040 INPUT#cmd%,state%
1050 IF (state% AND 64) = 64 THEN PRINT”END received” ELSE PRINT”NO END received”

An Example of Data Input and Output

It is required to take three readings in the range 0 to 5v from a digital voltmeter with a primary address of 9 and print them on the computer’s screen. The voltmeter sends the readings in the format +/- N.NNN CR LF

10 *IEEE
20 cmd%=OPENIN(“COMMAND”) 
30 data%=OPENIN(“DATA”) 
40 PRINT#cmd%,”BBC DEVICE NO”,0
50 PRINT#cmd%,”CLEAR” 
60 PRINT#cmd%,”REMOTE ENABLE”
70 PRINT#cmd%,”END OF STRING”,CHR$(13)+ CHR$(10):REM sets delimiting characters to CR LF
80 voltmeter%=OPENIN(“9”)
90 PRINTYkcmd%,”UNLISTEN”
Note In the above example the voltmeter had the same talk and listen addresses. This is usually, but not always, the case.

Detailed information on each command can be found in Chapter 6, and minimum abbreviations are in Appendix 1.
2 MORE ON DATA TRANSFER

Binary Coded Data

Sometimes it is necessary to send and receive more than 255 characters at a time without delimiting characters, so the PRINT# and INPUT# statements cannot be used.

Devices such as spectrum analysers, digital storage oscilloscopes and other microprocessor based devices with their own internal memory send and receive long fixed length sequences of binary coded data. The last byte is normally accompanied by the END end remote message. Data of this type can be sent and received using the WRITE BINARY and READ BINARY commands, together with the BPUT# and BGET# statements.

Example
To send 1024 data bytes held in an array to the memory of a spectrum analyser, primary address 11.

870 analyser%=OPENIN("11")
880 PRINT#cmd%,”LISTEN”,analyser%,”EXECUTE”
890 PRINT#data%,”WTM”,4000,1024” :REM prepare analyser to receive data and store it in memory starting at location &4000
900 PRINT#cmd%,”WRITE BINARY”,1024 :REM send the next 1024 bytes and accompany the last byte with the END message
910 FOR I%=1 TO 1024
920 BPUT#data%,wave%(I%) :REM output byte
930 NEXT I%
940 PRINT#cmd%,”UNLISTEN”
950 CLOSE#analyser%

Example
To receive 512 data bytes from the memory of a digital storage oscilloscope, primary address 15, and store them in an array.

670 scope%=OPENIN(”15”)
680 PRINT#cmd%,”LISTEN”,scope%,”EXECUTE”
The TRANSFER Command

If it is required to exchange ASCII or binary coded data between devices without storing it in the memory of the computer, the TRANSFER command can be used. Two options are available.

a) TRANSFER with a count

Example
To print ten successive readings from a digital voltmeter, primary address 3, on an IEEE488 printer, primary address 9. The voltmeter sends the readings in the format +/-NNN CR LF ie 8 bytes per reading giving a count of 80 bytes.

Sample code:
```plaintext
540 printer%=OPENIN("9")
550 voltmeter%=OPENIN("3")
560 PRINT#cmd%,"LISTEN",printer%,"EXECUTE"
570 PRINT#cmd%,"TALK",voltmeter%
580 PRINT#cmd%,"TRANSFER",80
590 PRINT#cmd%,"UNTALK"
600 PRINT#cmd%,"UNLISTEN"
610 CLOSE#voltmeter%
620 CLOSE#printer%
```
b) TRANSFER without a count

This can only be used when the END message is sent with the last data byte to be exchanged. It has the advantage of leaving the computer free to continue with other asks.

Example
To send a wave form stored in the memory of a fast data capture unit, primary address 5, to the memory of a spectrum analyser, primary address 8, for analysis.

460 analyser%=OPENIN(“8”)
470 captureunit%=OPENIN(“5”)
480 PRINT#cmd%,“LISTEN”,captureunit%,“EXECUTE”
490 PRINT#data%,“OUT”,3000.1024” :REM prepare capture unit to output data
500 PRINT#cmd%,“UNLISTEN”
510 PRINT#cmd%,“LISTEN”,analyser%,“EXECUTE”
520 PRINT#data%,“WTM”,2000,1024” :REM prepare analyser in input data
530 PRINT#cmd%,“TALK”,captureunit%
540 PRINT#cmd%,“TRANSFER”,0 :REM transfer with no count

REM computer continuing with other tasks

910 REPEAT :REM read the status word until the END message is received
920 PRINT#cmd%,“STATUS” :REM causing the transfer in progress flag to be reset
930 INPUT#cmd%,state%
940 UNTIL (state% AND 8) = 8
3 HOW TO FIND OUT WHAT A DEVICE IS DOING

Serial Poll

If a device requires action from the computer, for example in order to rectify some error condition, it requests this by sending the SRQ (service request) message. When this happens bit 5 of the status word is set.

The SERIAL POLL command is used to determine which device has requested service. Each device with a serial poll capability must be polled. Consult the manufacturer's manual for each device to find out how many bytes it returns. Most devices return a single byte. Bit 6 of the first byte returned conveys the RQS (request service) message. If set, this indicates that the device was requesting service. The remaining bits of the first byte and ensuing bytes, if any, indicate the reason that service was requested. The meaning of this information can be found in the manufacturer's manual, and the appropriate action should be taken.

Example

270 PRINT#cmd%,"STATUS" 280 INPUT#cmd%,state%
290 IF (state% AND 32) = 32 THEN GOTO 5000

5000 counter%=OPENIN(“6’”)  
5010 signalgenerator%=OPENIN(“13”)
5020 PRINT#cmd%,"SERIAL POLL",counter%,1 :REM 1 byte expected
5030 INPUT#cmd%,counterstatus$
5040 IF ASC(counterstatus$) AND 64) = 64 THEN PROCservicecounter
5050 PRINT#cmd%,"SERIAL POLL",signalgenerator%,1
5060 INPUT#cmd%,signalgeneratorstatus$
5070 IF (ASC(signalgeneratorstatus$)AND64)= 64 THEN PROCservicesignalgenerator

Because each device must be polled separately, a serial poll is time consuming.
Parallel Poll

This is a rapid way of finding out whether one or more devices require action by the computer. However the computer must be committed to carrying out a parallel poll periodically.

The PARALLEL POLL REQUEST command returns a single parallel poll response byte, each bit of which is assigned to a device or devices and, if set, indicates that the device requires action by the computer.

Devices with a parallel poll capability are assigned a bit in the parallel poll response byte using the PARALLEL POLL ENABLE command. This command uses an integer, the least significant 3 bits of which specify the associated bit of the parallel poll response byte as follows:

<table>
<thead>
<tr>
<th>b2</th>
<th>b1</th>
<th>b0</th>
<th>parallel poll response byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0 0 0 0 0 0 0 0 0 0 1 0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0 0 1 0 0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0 0 0 0 0 0 1 0 0 0 0 0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0 0 0 0 1 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0 0 1 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0 1 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

Bit 3 of the integer specifies the 'sense' of the response. Refer to the manufacturer's manual to decide on its setting.

During a parallel poll request each enabled device compares its individual status with the value of the sense bit it received when it was enabled. If the comparison succeeds, the bit assigned to that device is set in the parallel poll response byte.

If a device is no longer required to take part in a parallel poll, the PARALLEL POLL DISABLE command is used. The PARALLEL POLL UNCONFIGURE command renders all devices unable to take part in a parallel poll.
Example

640 siggen%=OPENIN(“5”)
650 counter%=OPENIN(“6”)
660 analyser%=OPENIN(“IO”)
670 PRINT#cmd%,”PARALLEL POLL UNCONFIGURE” :REM to ensure no other devices take part in parallel poll
680 PRINT#cmd%,”PARALLEL POLL ENABLE”,siggen%,8 :REM sense bit = 1 ppr bit 0
690 PRINT#cmd%,”PARALLEL POLL ENABLE”,counter%,9 :REM sense bit = 1 ppr bit 1
700 PRINT#cmd%,”PARALLEL POLL ENABLE”,analyser%,2 :REM sense bit = 0 ppr bit 2
710 PRINT#cmd%,”PARALLEL POLL REQUEST”
720 INPUT#cmd%,responsebyte%
730 IF (responsebyte% AND 1) = 1 THEN PROCservicesiggen
740 IF (responsebyte% AND 2) = 2 THEN PROCservicecounter
750 IF (responsebyte% AND 4) = 4 THEN PROCserviceanalyser

1020 PRINT#cmd%,”PARALLEL POLL DISABLE”,analyser%,”EXECUTE” :REM analyser no longer required to take part in parallel poll
4 OTHER COMMANDS

The Timeout Facility

The TIMEOUT ON command can be used to enable a 2.5 sec timeout. This is useful in preventing a program from 'hanging up' when a device fails to respond. Bit 0 in the status word is set if a timeout occurs during output and bit 1 is set if a timeout occurs during input. If timeouts are no longer required the TIMEOUT OFF command is used.

Timeouts are not part of the IEEE488 standard and so the IEEFS defaults to TIMEOUT OFF.

Example

500 PRINT#cmd%,"TIMEOUT ON"
510 adc%=OPENIN("17,3")
520 PRINT#cmd%,"TALK",adc%
530 INPUT#cmd%,reading$
540 PRINT#cmd%,"STATUS"
550 INPUT#cmd%,state%
560 IF(state% AND 2 = 2 THEN PROCtimeoutoninput

730 PRINT#cmd%,"TIMEOUT OFF"

Remote Local Operation

When a device is listened after a REMOTE ENABLE command control of the device passes from its front panel to the computer. The LOCAL LOCKOUT command prevents devices with this capability from inadvertently being returned to front panel control. If it is wished to return control to the front panel the GO TO LOCAL command is used. However, when the device is next listened, the front panel switches will again be locked out. To disable the locking out of the switches, the REMOTE DISABLE command should be used. This also has the effect of returning all devices to local control.
**Example**

110 PRINT#cmd%,"REMOTE ENABLE"
120 voltmeter%=OPENIN("21")
130 PRINT#cmd%,"LOCAL LOCKOUT"
140 PRINT#cmd%,"LISTEN",voltmeter%,"EXECUTE" :REM voltmeter under control with front panel switches ineffective
150 PRINT#data%,"R2" :REM set up voltmeter
160 PRINT#cmd%,"UNLISTEN"
170 PRINT#cmd%,”TALK”,voltmeter%
180 INPUT#data%,reading$
190 PRINT#cmd%,”UNTALK”
200 PRINT#cmd%,”GO TO LOCAL”,voltmeter%,”EXECUTE” :REM voltmeter under front panel control

460 PRINT#cmd%,”REMOTE DISABLE” :REM returns all devices to local control and disables front panel lockout
470 CLOSE#voltmeter%

**Initialising Devices**

A device may have been set up incorrectly or an error may have occurred. Some devices have the capability of being returned to a known condition. The **SELECTED DEVICE CLEAR** command may be used to return individual devices to a known state or the **DEVICE CLEAR** command to return all devices with the capability to a known state.

**Example**

410 voltmeter%=OPENIN("6")

530 PRINT#cmd%,”SELECTED DEVICE CLEAR”,voltmeter%,”EXECUTE” :REM return voltmeter to known condition
Triggering Simultaneous Operation of Devices

Sometimes, for example in test systems, it may be required to start a process and commence measurements at the same time. This can be achieved using the TRIGGER command which sends the GET (group execute trigger) message.

**Example**

```plaintext
660 signalgenerator%=OPENIN("IO")
670 recorder%=OPENIN("9")
930 PRINT#cmd%,"TRIGGER",signalgenerator%,recorder%,"EXECUTE" :REM start measurement process
```
5  PASSING CONTROL

The system controller is the device which can send the IFC (interface clear) and REN (remote enable) messages, and only one is allowed in a system. The IEEFS and the interface hardware is supplied configured so that the computer acts as system controller.

The controller in charge is the device which manages the system. This is not necessarily the system controller.

After the CLEAR command has been executed the computer is controller in charge. The TAKE CONTROL command can be used to pass management of the system to another device.

Example
To pass control to another computer with an IEEE488 interface, primary address 13

340 secondcontroller%=OPENIN("13")
350 PRINT#cmd%,'"TAKE CONTROL",secondcontroller%

After control has been passed to another device there are three ways in which the computer can regain management of the system.

i) When the current controller in charge addresses the computer and sends the TCT (take control) message.

ii) The REQUEST CONTROL command can be used to indicate to the current controller in charge that the BBC Microcomputer wishes to regain control of the system. It does this by sending the SRQ (service request) message and when polled by the current controller in charge during a serial poll sends the RQS message indicating it was requesting service together with a STB (status byte) of zero showing it wishes to regain control. There is no obligation on the current controller in charge to pass back control to the BBC Microcomputer. However, if it does, this occurs as described in the previous paragraph. To find out when the computer has regained control, bit 2 of the status word should be checked.
iii) through the use of the CLEAR command the BBC Microcomputer sends the IFC (interface clear) message. This instantly halts any current activity and returns the system to a known state. Data being transferred may be lost during this process. The computer is then controller in charge.

**Example**

100 PRINT#cmd%,"CLEAR"
6  THE IEEE FILING SYSTEM - A Summary

The IEEE488 Interface appears to the Operating System of the BBC Microcomputer as an additional filing system. It is selected by the command

*IEEE

The IEEFS and the interface hardware is supplied so that the computer is system controller. The computer can act as a controller-talker controller-listener with the ability to pass control to another device and request it back.

Channels

Communication between a language and the IEEFS is via two special channels. The first is a ‘COMMAND’ channel used for transmitting commands and receiving information on the state of the interface. The second is the ‘DATA’ channel used for reading and writing data.

Example

200 cmd%=OPENIN("COMMAND")
210 data%=OPENIN("DATA")

The IEEFS maintains a status word, accessible to the user, which enables recovery from bus communication errors. When a command is received from the language via the COMMAND channel the IEEFS interprets it and checks the status word. If it is satisfactory then the appropriate action is taken and, finally, the status word is updated.

The BBC DEVICE NO and CLEAR command should always follow the opening of the COMMAND and DATA channels.
Device Addresses

The OPENIN or OPENOUT functions are used to pass the primary and secondary, if specified, addresses of a device to the IEEEFS via a 'device' channel. Addresses must be in the range 0-30. Note that the primary address of the BBC Microcomputer is specified by the BBC DEVICE NO command.

Example
A voltmeter has a primary address of 4 and a secondary address of 2.

100 voltmeter%=OPENIN("4,2")

An analyser has a primary address of 11.

100 analyser%=OPENIN("11")

A 'device' channel may be closed using the CLOSE# statement.

Example

100 CLOSE#voltmeter%

100 CLOSE#0 closes all 'device' channels but not the 'COMMAND' and 'DATA' channels which must be individually closed

Device Dependent Remote Messages (Data)

Strings – Input

Strings of up to 255 characters can be input by the IEEEFS and passed to the language via the 'DATA' channel. The INPUT# statement is used. The IEEEFS expects to receive the end of string characters after each string input from device. However, if the END end remote message is received before the end of string characters this terminates the input sequence.
Remote Messages

ATN
true computer addresses itself as a listener
false DAB 1
false DAB 2
etc
false DAB n end of string
false EOS 1 and END characters
true computer unaddresses itself as a listener

Example

100 PRINT#cmd%,”END OF STRING”,CHR$(13)+CHR$(10)
110 PRINT#cmd%,”TALK”,analyser%
120 INPUT#data%,response$

Strings – Output

Strings of up to 255 characters passed to the IEEEFS via the 'DATA' channel can be output. The PRINT# statement is used. The IEEEFS sends the UNT untalk remote message before the string and the end of string characters after each string it outputs to a device. It sends the END end remote message with the last character.

Remote messages

ATN
true UNT computer addresses itself as a talker
false DAB 1
false DAB 2
etc
false DAB n end of string
false EOS 1 and END characters
true computer unaddresses itself as a talker

Example

100 PRINT#cmd%,”END OF STRING”,CHR$(13)+CHR$(10)
110 PRINT#cmd%,”LISTEN”,analyser%,”EXECUTE”
120 PRINT#data%,”AV4 RE”
Binary Coded Data

If this is to be handled, the READ BINARY and WRITE BINARY commands are used. Single data bytes are passed to and from the language via the 'DATA' channel. The BPUT# and BGET# statements are used. For further details see the READ BINARY and WRITE BINARY commands.
IEEEFS Commands

The following pages describe the IEEE commands under a number of headings.

**Purpose**
A plain English description of what the command does.

**Example**
An example to illustrate the use of the command.

**Notes**
Lists restraints regarding type and range of variables.

**IEEE Status Required before Execution**
Lists the status flags checked by the IEEEFS before carrying out a command.

**IEEE Status after Execution**
Lists the status flags changed by the IEEEFS after successfully carrying out a command.

**Remote messages**
Shows the logical state of the ATN remote message and the other remote messages sent by the IEEEFS.

**Description**
A brief description of the command and its effect.

**Associated Commands**
Similar commands and those which are concerned with the IEEE488 function.
**BBC DEVICE NO**

**Purpose**
To specify the primary address of the computer.

**Example**
100 *IEEE
110 cmd%=OPENIN(“COMMAND”)
120 data%=OPENIN(“DATA”)
   etc
200 PRINT#cmd%,”BBC DEVICE NO”,6

**Notes**
Integer constants and variables in the range 0 - 30 may be used for the primary address.

**IEEE Status Required before Execution**
No requirement.

**IEEE Status after Execution**
The BBC DEVICE NO command executed flag is set.

**Remote Messages**
None

**Description**
The computer stores the primary address which is set by the CLEAR command. It requires a primary address so that, after control has been passed to another device using the TAKE CONTROL command, it may be addressed as a talker and control passed back to it. This normally follows a REQUEST CONTROL command.

**Associated Commands**
CLEAR
CLEAR

**Purpose**
To clear the interface.

**Example**
100 PRINT#cmd%,"BBC DEVICE NO",address%
110 PRINT#cmd%,"CLEAR"

**IEEE Status Required before Execution**
The BBC DEVICE NO command executed flag must be set.

**IEEE Status after Execution**
The timeout on output flag is reset
- timeout on input flag is reset
- computer is controller in charge flag is set
- TRANSFER in progress flag is reset
- string of more than 255 characters received flag is reset
- SRQ service request remote message received flag is reset
- END end remote message received flag is reset
- incomplete source handshake flag is reset
- binary coded data being handled flag is reset
- a device has been TALKed flag is reset
- a device has been LISTENed flag is reset
- CLEAR command executed flag is set
- input error flag is reset
- output error flag is reset
- conflict for control of interface flag is reset
- computer in process of becoming controller in charge flag is reset
- computer in process of acknowledging an unidentified command from another device flag is reset
- computer in process of entering the controller active state following a TRANSFER command flag is reset
- REN remote enable remote message being sent flag is reset
- non fatal error flag is reset

**Remote Messages**
- IFC
- IFC false
Description
The primary address of the computer, as specified by the BBC DEVICE NO command, is set before sending the IFC interface clear remote message. This places the interface in a known quiescent state. The computer exits the command as controller in charge.

Associated Commands
BBC DEVICE NO
DEVICE CLEAR

**Purpose**
To clear all devices

**Example**

100 PRINT#cmd%, "DEVICE CLEAR"

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another
device flag must be unset

**IEEE Status after Execution**
No change

**Remote Messages**
ATN
ture DCL

**Description**
After this command has been executed all devices with a device clear capability are initialised.

**Associated Commands**
SELECTED DEVICE CLEAR
END OF STRING

Purpose
To specify the characters delimiting device dependent messages.

Example
100 endchr$=CHR$(13)+CHR$(10)
110 PRINT#cmd%,”END OF STRING”,endchr$

Notes
String constants and variables of 1 or 2 characters may be used to specify the end of string characters. The default character is LF (line feed).

IEEE Status Required before Execution
No requirement

IEEE Status after Execution
No change

Remote Messages
None

Description
The computer stores the End of String characters and sends them after each string of data bytes it outputs and expects to receive them after each string of data bytes it inputs.
GO TO LOCAL

Purpose
To return the referenced devices to local control.

Example
100 voltmeter%=OPENIN("9")
110 plotter%=OPENIN("5")
120 PRINT#cmd%,"GO TO LOCAL",voltmeter%,plotter%,"EXECUTE"

Notes
The last channel must be followed by the 'EXECUTE' command.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another
device flag must be unset

IEEE Status after Execution
The device or devices have been LISTENed flag is reset.

Remote Messages
ATN
true UNIL
true MLA 1
true MSA 1 if specified
true MLA 2
true MSA 2 if specified
etc
true MLA n
ture MSA n if specified
ture GTL
ture UNL
Description
After this command has been executed, devices with a remote capability referenced by the previously OPENINed channels are returned to local control.

Associated Commands
REMOTE ENABLE
REMOTE DISABLE
LISTEN
LOCAL LOCKOUT
LISTEN

Purpose
To address the referenced devices as listeners.

Example
100 voltmeter%=OPENIN(“2,1”)
110 printer%=OPENIN(“5”)
120 PRINT#cmd%,”LISTEN”,voltmeter%,printer%,”EXECUTE”

Notes
Up to 14 devices may be LISTENed at any one time. The last channel must be followed by the ‘EXECUTE’ command.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
controller in process of acknowledging an unidentified command from another device flag must be unset

IEEE Status After Execution
The device or devices have been LISTENed flag is set.

Remote Messages
ATN
true MLA 1
true MSA 1 if specified
true MLA 2
true MSA 2 if specified
etc
true MLA n
true MSA n if specified

Description
The computer sends the MLA, my listen address, and MSA, my secondary address if specified, remote messages of the devices referenced by the previously OPENINed channels.

Associated Commands
UNLISTEN
LOCAL LOCKOUT

**Purpose**
To prevent conflict between the remote and local operation of all devices.

**Example**
100 PRINT#cmd%,”LOCAL LOCKOUT”

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another
device flag must be unset

**IEEE Status after Execution**
No change

Remote Messages
ATN
True   LL0

**Description**
After this command has been executed, devices with a local lockout capability may only be returned to local (front panel) from remote (interface) control by using the GO TO LOCAL command.

**Associated Commands**
REMOTE ENABLE
REMOTE DISABLE LISTEN
GO TO LOCAL
PARALLEL POLL DISABLE

**Purpose**
To disable the referenced devices so that they are unable to take part in a parallel poll

**Example**

```
100 analyser%=OPENIN(“11”)
110 voltmeter%=OPENIN(“6”)
120 PRINT#cmd%, “PARALLEL POLL DISABLE”, analyser%, voltmeter%, ”EXECUTE”
```

**Notes**
The last channel must be followed by the 'EXECUTE' command.

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another device flag must be unset

**IEEE Status after Execution**
The device or devices have been LISTENed flag is reset.

Remote Messages
ATN
true UNL
true MLA 1
true MSA 1 if specified
true MLA 2
true MSA 2 if specified
etc
true MLA n
true MSA n if specified
true PPC
true PPD
true UNL

**Associated Commands**
PARALLEL POLL ENABLE
PARALLEL POLL UNCONFIGURE
PARALLEL POLL REQUEST
**PARALLEL POLL ENABLE**

**Purpose**
To enable the referenced device to take part in a parallel poll.

**Example**

```
100 spectrumanalyser%=OPENIN("9")
110 PRINTVPcmd%,"PARALLEL POLL ENABLE",spectrumanalyser%,10
```

**Notes**
The parallel poll response remote message is specified by the least significant 4 bits of an integer constant or variable.
Bit 3 specifies the sense of the response and Bits 0-2 specify the response.

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another device flag must be unset

**IEEE Status after Execution**
The device or devices have been LISTENed flag is reset

**Remote Messages**

- ATN
- true UNL
- true MLA
- true MSA
- true PPC
- true PPE
- true UNL

**Associated Commands**

- PARALLEL POLL DISABLE
- PARALLEL POLL UNCONFIGURE
- PARALLEL POLL REQUEST
PARALLEL POLL REQUEST

Purpose
To conduct a parallel poll.

Example
100 PRINT#cmd%,”PARALLEL POLL REQUEST”
110 INPUT#cmd%,pollresponse%

Notes
The response may only be returned to the least significant byte of an integer variable via the command channel.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
CLEAR command executed flag must be set

IEEE Status after Execution
No change

Remote Messages
ATN  IDY
true  true  PPR

Description
If a TRANSFER is in progress then the computer waits until the current data byte has been transferred before conducting the PARALLEL POLL; it then restarts the transfer. In this way no data is lost.
If no TRANSFER is in progress the PARALLEL POLL is conducted immediately.

Associated Commands
PARALLEL POLL ENABLE
PARALLEL POLL DISABLE
PARALLEL POLL UNCONFIGURE
PARALLEL POLL UNCONFIGURE

**Purpose**
To render all devices unable to take part in a parallel poll.

**Example**

100 PRINT#cmd%,”PARALLEL POLL UNCONFIGURE”

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
computer in process of acknowledging an unidentified command from another device flag must be unset

**IEEE Status after Execution**
No change

**Remote Messages**
ATN
true PPU

**Associated Commands**
PARALLEL POLL ENABLE
PARALLEL POLL DISABLE
PARALLEL POLL REQUEST
READ BINARY

Purpose
To enable the input of a specified number of data bytes.

Example

90 DIM reading%(5"
100 recoder%=OPENIN("5"
110 PRINT#cmd%,"TALK",recorder%
120 PRINT#cmd%,"READ BINARY",512
130 FORI%=OT0511
140 reading%(i%)=BGET#data%
150 NEXT
160 CLOSE#recorder%

Notes
Integer constants and variables in the range 1 to &7FFFFFF may be used for the number
of data bytes.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
a device has been TALKed flag must be set
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another
device flag must be unset

IEEE Status after Execution
The binary coded data being handled flag is set.

Remote Messages
ATN false DAB 1 data bytes received
false DAB 2 etc
false DAB n and END the END remote message is not required
true
**Description**
This command enables the input of long, in excess of 255 data bytes, binary coded device dependent remote messages. The computer flags binary coded data being handled in the IEEE status word and addresses itself as a listener. A single data byte is input in response to each BGET#. When the specified number of data bytes have been input, the computer resets the flag in the IEEE status word and unaddresses itself as a listener. If the END end remote message is received during a READ BINARY command, this is flagged in the IEEE status word. However, it does not terminate the input.

**Associated Commands**
TALK
UNTALK
REMOTE DISABLE

**Purpose**
To return all devices to local control.

**Example**
100 PRINT#cmd%, “REMOTE DISABLE”

**IEEE Status Required before Execution**
The CLEAR command executed flag must be set.

**IEEE Status after Execution**
The REN remote enable remote message being sent flag is reset.

**Remote Messages**
REN false

**Description**
After this command has been executed all devices with a remote local capability are returned to local control, including those put in the local lockout state by a previous LOCAL LOCKOUT command.

**Associated Commands**
REMOTE ENABLE
LISTEN
LOCAL LOCKOUT
GO TO LOCAL
REMOTE ENABLE

Purpose
To enable the remote operation of devices.

Example

100 PRINT#cmd%, "REMOTE ENABLE"

IEEE Status Required before Execution
The CLEAR command executed flag must be set.

IEEE Status after Execution
The REN remote enable message being sent flag is set.

Remote Messages
REN

Description
After this command has been executed, the computer can change devices from local (front panel) control to remote (Interface) control using the LISTEN command.

Associated Commands
REMOTE DISABLE LISTEN
LOCAL LOCKOUT
GO TO LOCAL
REQUEST CONTROL

**Purpose**
To request that control be transferred back to the computer.

**Example**

100 PRINT#cmd%, "REQUEST CONTROL"

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
CLEAR command executed flag must be set
computer in process of becoming controller in charge flag must be unset

**IEEE Status after Execution**
No change

**Remote Messages**

<table>
<thead>
<tr>
<th>ATN</th>
<th>sent by current controller in charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRQ</td>
<td>when polled by controller in charge</td>
</tr>
<tr>
<td>STB, RQS and SRQ false</td>
<td></td>
</tr>
<tr>
<td>ATN</td>
<td>sent by computer</td>
</tr>
<tr>
<td>true</td>
<td>after TCT received from current controller in charge</td>
</tr>
</tbody>
</table>

**Description**
The computer sends the SRQ service request remote message and then exits the command. When the controller in charge conducts a serial poll the STB status byte and RQS request service remote messages are sent. The seven bits of the STB remote message are all 0. If the controller in charge sends the TCT, take control, remote message the computer becomes controller in charge and sets the appropriate flag in the IEEE status word.

**Associated Commands**
TAKE CONTROL
CLEAR
SELECTED DEVICE CLEAR

Purpose
To clear the referenced devices.

Example

100 plotter%=OPENIN(“7”)  
110 counter%=OPENIN(“3”)  
120 PRINT#cmd%,”SELECTED DEVICE CLEAR”,plotter%,counter%,”EXECUTE”

Notes
The last channel must be followed by the 'EXECUTE' command.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another
device flag must be unset

IEEE Status after Execution
The device or devices have been LISTENed flag is reset.

Remote Messages
ATN
true UNL
true MLA 1
true MSA 1 if specified
true MLA 2
true MSA 2 if specified
e tc
true MLA n
true MSA n if specified
true SDC
true UNL

Description
After this command has been executed the devices with the device clear capability
referenced by the previously OPENINed channels are initialised.

Associated Commands
DEVICE CLEAR
SERIAL POLL

Purpose
To conduct a serial poll of the referenced device.

Example

100 logicanalyser%=OPENIN("?")
110 PRINT$#cmd%,"SERIAL POLL",logicanalyser%,1
120 INPUT$#cmd%,statusmessage$

Notes
Integer constants and variables in the range 1 to 255 may be used for the number of status bytes sent by the device to be polled. The status bytes may only be returned to a string variable via the command channel.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
controller in process of acknowledging an unidentified command from another device flag must be unset

IEEE Status after Execution
If the RQS, request service, remote message is received, the SRQ, service request, remote message received flag is reset
The device has been TALKed flag is reset
The device or devices have been LISTENed flag is reset

Remote Messages
ATN
true UNL
true SPE
true MTA
true MSA if specified
false STB 1 and RQS?
false STB 2 etc
false STB n
true SPD
true UNT
**Description**  
Following the receipt of an SRQ, service request, remote message the SERIAL Poll command should be used to determine which device requires service.

**Associated Commands**  
STATUS
STATUS

Purpose
To return information on the current state of the interface.

Example
100 PRINT cmd%, "STATUS"
120 INPUT cmd%, state%

Notes
The status may only be returned to an integer variable via the command channel.

IEEE Status Required before Execution
No requirement

IEEE Status after Execution
No change

Remote Messages
None

Description
The individual bits of the status word indicate the following
<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>timeout on output</td>
</tr>
<tr>
<td>1</td>
<td>timeout on input</td>
</tr>
<tr>
<td>2</td>
<td>computer is controller in charge</td>
</tr>
<tr>
<td>3</td>
<td>TRANSFER in progress</td>
</tr>
<tr>
<td>4</td>
<td>string of more than 255 characters received</td>
</tr>
<tr>
<td>5</td>
<td>SRQ service request remote message received</td>
</tr>
<tr>
<td>6</td>
<td>END end remote message received</td>
</tr>
<tr>
<td>7</td>
<td>Incomplete source handshake</td>
</tr>
<tr>
<td>8</td>
<td>binary coded data being handled</td>
</tr>
<tr>
<td>9</td>
<td>TIMEOUT ON</td>
</tr>
<tr>
<td>10</td>
<td>“COMMAND” file open</td>
</tr>
<tr>
<td>11</td>
<td>“DATA” file open</td>
</tr>
<tr>
<td>12</td>
<td>a device has been TALKed</td>
</tr>
<tr>
<td>13</td>
<td>a device or devices have been LISTENed</td>
</tr>
<tr>
<td>14</td>
<td>BBC DEVICE NO executed</td>
</tr>
<tr>
<td>15</td>
<td>CLEAR executed</td>
</tr>
<tr>
<td>16</td>
<td>input error</td>
</tr>
<tr>
<td>17</td>
<td>output error</td>
</tr>
<tr>
<td>18</td>
<td>conflict for control of interface</td>
</tr>
<tr>
<td>19</td>
<td>computer in process of becoming controller in charge</td>
</tr>
<tr>
<td>20</td>
<td>computer in process of acknowledging an unidentified command from another device</td>
</tr>
<tr>
<td>21</td>
<td>computer in process of entering the controller active state following a TRANSFER command</td>
</tr>
<tr>
<td>22</td>
<td>unused</td>
</tr>
<tr>
<td>23</td>
<td>REN remote enable remote message being sent</td>
</tr>
<tr>
<td>24</td>
<td>unused</td>
</tr>
<tr>
<td>25</td>
<td>unused</td>
</tr>
<tr>
<td>26</td>
<td>unused</td>
</tr>
<tr>
<td>27</td>
<td>unused</td>
</tr>
<tr>
<td>28</td>
<td>unused</td>
</tr>
<tr>
<td>29</td>
<td>unused</td>
</tr>
<tr>
<td>30</td>
<td>unused</td>
</tr>
<tr>
<td>31</td>
<td>non fatal error</td>
</tr>
</tbody>
</table>
TAKE CONTROL

Purpose
To pass control to another device.

Example

100  secondcontroller%=OPENIN("2")
110  PRINT#cmd%,"TAKE CONTROL",secondcontroller%

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another
device flag must be unset

IEEE Status after Execution
The computer is controller in charge flag is reset
device or devices have been LISTENed flag is reset
device has been TALKed flag is reset

Remote Messages
ATN
true UNL
true MTA
true MSA if specified
true TCT
false

Description
After this command has been executed the computer may regain control of the
interface through REQUEST CONTROL or CLEAR commands.

Associated Commands
REQUEST CONTROL
CLEAR
T A L K

Purpose
To address the referenced device as a talker.

Example
100 digitalvoltmeter%=OPENIN(“2,1”)
110 PRINT#cmd%,”TALK”,digitalvoltmeter%

Notes
Only one device may be TALKed at any one time.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
controller in process of acknowledging an unidentified command from another
device flag must be unset

IEEE Status after Execution
The device has been TALKed flag is set.

Remote Messages
ATN
true MTA
true MSA if specified

Description
The computer sends the MTA, my talk address, and, if specified, the MSA, my secondary
address, remote messages of the device referenced by the previously OPENINed channel.

Associated Commands
UNTALK
TIMEOUT OFF

**Purpose**
To disable timeouts.

**Example**

100 PRIN#cmd%,”TIMEOUT OFF”

**Notes**
Timeouts are not a part of the IEEE488 standard. TIMEOUT OFF is the default IEEE status.

**IEEE Status Required before Execution**
No requirement.

**IEEE Status after Execution**
The TIMEOUT ON flag is reset.

**Remote Messages**
None

**Description**
With TIMEOUT OFF, if a device fails to respond during a source or acceptor handshake, then the ESC key must be pressed to exit from a command.

**Associated Commands**
TIMEOUT ON
TIMEOUT ON

Purpose
To enable timeouts.

Example
100 PRINT #cmd%,”TIMEOUT ON”

Notes
Timeouts are not a part of the IEEE488 standard. TIMEOUT OFF is the default IEEE status.

IEEE Status Required before Execution
No requirement.

IEEE Status after Execution
The TIMEOUT ON flag is set.

Remote Messages
None

Description
After this command has been executed and a device fails to respond in 2.55 seconds during a source or acceptor handshake then the appropriate timeout error is flagged in the IEEE status word.

Associated Commands
TIMEOUT OFF
TRANSFER

Purpose
To initiate the transfer of data bytes between an active talker and all active listeners.

Example (a)
100 printer%=OPENIN("4,2")
110 counter%=OPENIN("9")
120 PRINT#cmd%,"LISTEN",printer%,"EXECUTE"
130 PRINT#cmd%,"TALK",counter%
140 PRINT#cmd%,"TRANSFER",1024
150 PRINT#cmd%,"UNTALK"
160 PRINT#cmd%,"UNLISTEN"

Example (b)
100 printer%=OPENIN("4,2")
110 counter%=OPENIN("9")
120 PRINT#cmd%,"LISTEN",printer%,"EXECUTE"
130 PRINT#cmd%,"TALK",counter%
140 PRINT#cmd%,"TRANSFER",0
150
190 REPEAT
200 PRINT#cmd%,"STATUS"
210 INPUT#cmd%,status488%
220 UNTIL (status488% AND 8) = 8

Notes
Integer constants and variables in the range to \&7FFFFFFF may be used for the number of data bytes to be transferred.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
a device has been TALKed flag must be set
a device or devices have been LISTENed flag must be set
conflict for control of interface flag must be unset
controller in process of acknowledging an unidentified command from another
device flag must be unset

IEEE Status after Execution
When the number of data bytes is specified as 1 to 134217727, example (a), the END end remote message received flag is set if this occurs during the TRANSFER. When the number of data bytes is specified as 0, example (b). the TRANSFER in progress flag remains set until the END end remote message is received, it is then reset. Note that the END end remote message received flag is not set.

Remote Messages
ATN
false DAB 1 data bytes disregarded by computer
false DAB 2
etc
false DAB n and END the END remote message is not required if the number of data bytes is not 0
ture

Description
The TRANSFER command can be used in two ways:

Example (a)
The computer initiates the TRANSFER and after the talker has sent the specified number of data bytes exits the command.

Example (b)
The computer initiates the TRANSFER and exits the command. When the talker sends the END end remote message with the last data byte transferred, the computer resets the TRANSFER in progress flag in the IEEE status word. Thus, the computer can undertake other tasks while the TRANSFER is in progress and detect its completion by reading the IEEE status word.

Associated Commands
TALK
UNTALK
LISTEN
UNLISTEN
TRIGGER

**Purpose**
To initiate simultaneous operation of the referenced devices.

**Example**
```plaintext
100 generator%=OPENIN(“9”)
110 voltmeter%=OPENIN(“14”)
120 PRINT#cmd%,”TRIGGER”,generator%,voltmeter%,”EXECUTE”
```

**Notes**
The last channel must be followed by the 'EXECUTE' command.

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging an unidentified command from another
device flag must be unset

**IEEE Status after Execution**
The device or devices have been LISTENed flag is reset.

Remote Messages
ATN
true UNL
true MLA 1
true MSA 1 if specified
true MLA 2
true MSA 2 If specified
etc
true MLA n
true MSA n if specified
true GET
true UNL

**Description**
This command causes all devices with the device trigger capability referenced by the
previously OPENINed channels to start some basic operation.

**Associated Commands**
None
UNLISTEN

**Purpose**
To unaddress all active listeners.

**Example**
100 PRINT#cmd%,”UNLISTEN”

**IEEE Status Required before Execution**
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
controller in process of acknowledging an unidentified command from another
device flag must be unset

**IEEE Status after Execution**
The device or devices have been LISTENed flag is reset.

**Remote Messages**
ATN
true UNL

**Description**
The computer sends the UNL unlisten remote message to all active listeners.

**Associated Commands**
LISTEN
UNTALK

Purpose
To unaddress an active talker.

Example
100 PRINT#cmd%"UNTALK"

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
controller in process of acknowledging an unidentified command from another device flag must be unset

IEEE Status after Execution
The device has been TALKed flag is reset.

Remote Messages
ATN
true UNT

Description
The computer sends the UNT untalk remote message to the active talker.

Associated Commands
TALK
WRITE BINARY

Purpose
To enable the output of a specified number of data bytes.

Example
100 analyser%=OPENIN("11")
110 PRINT#cmd%="LISTEN",analyser%,"EXECUTE"
120 PRINT#cmd%,"WRITE BINARY",1024
130 FOR 1%=1 TO 1024
140 BPUT#data%,waveform%(1%)
150 NEXT
160 CLOSE#analyser%

Notes
Integer constants and variables in the range 1 to &7FFFFFFF may be used for the number of data bytes.

IEEE Status Required before Execution
The computer is controller in charge flag must be set
TRANSFER in progress flag must be unset
a device or devices have been LISTENed flag must be set
CLEAR command executed flag must be set
conflict for control of interface flag must be unset
computer in process of acknowledging unidentified command from another device flag must be unset

IEEE Status after Execution
The binary coded data being handled flag is set

Remote Messages
ATN
true UNT
false DAB 1 data bytes sent
false DAB 2 etc
false DAB n and END
true
**Description**
This command enables the output of long, over 255 data bytes, binary coded device dependent messages. The computer flags binary coded data is being handled in the IEEE status word and after sending the UNT untalk remote message addresses itself as a talker. A single data byte is output in response to each BPUT#. The END end remote message is sent with the last data byte. When the specified number of data bytes have been output the computer resets the flag in the IEEE status word and unaddresses itself as a talker.

**Associated Commands**
LISTEN
UNLISTEN
Read Chapter 43 of the BBC Microcomputer User Guide before writing assembler programs that use the IEEE488 interface. General information on using a filing system in assembler is presented there. This chapter gives details of the relevant operating system calls when using the IEEEFS.

OSFIND &FFCE Open or close a channel
OSGBPBP &FFD1 Not supported by IEEEFS
OSBPUT &FFD4 Send a single byte to channel from A
OSBGET &FFD7 Receive a single byte from channel in A
OSARGS &FFDA Not fully supported by IEEEFS
OSFILE &FFDD Not supported by IEEEFS
OSWORD &FFF1 Perform IEEE commands using parameter block to pass parameters
OSCLI &FFF7 Interpret IEEEFS command line

Throughout this section the term file is used to maintain compatibility with Chapter 43 of the BBC Microcomputer User Guide. However, it should be noted that IEEEFS 'files' are not true files in that they have no storage capability and serve only to pass information to the IEEEFS.

**OSFIND**

Opens a file for reading and writing. The routine is entered at &FFCE which indirects through &21C. The value in A determines the type of operation.

A=&00 causes a file or files to be closed
A<>&00 causes a file to be opened

IF A<>0 then Y (high byte) and X (low byte) must contain the address of a location in memory which contains the file name terminated with CR (MD).
On exit A will contain the channel number allocated to the file for all future operations. If A = 0 then the IEEEFS was unable to open the file.

If A=0 then a file, or all files will be closed depending on the value of Y. Y=0 will close all files, otherwise the file whose channel number is in Y will be closed.

On exit C, N, V and Z are undefined and D=O. The interrupt state is preserved.
OSBPUT

This call is used to send data. It write (puts) a byte in A to the file previously opened using OSFIND. The routine is entered at &FFD4 which indirects through &218. On entry Y contains the channel number allocated by OSFIND.

On exit A, X and Y are preserved, N, V and Z are undefined and 0=0. The interrupt state is preserved.

OSBGET

This call is used to receive data. It gets (reads) a byte from a file into A. The file must have been previously opened using OSFIND and the channel number allocated must be in V. The routine is entered at &FF07 which indirects through &216.

On exit C=0 indicates a valid character in A. X and Y are preserved, N V and Z are undefined and 0=0. The interrupt state is preserved.

OSARGS

This routine is entered at &FFDA and indirects through &214. The IEEFS only supports a call with A=&(0 and Y=&(0; this returns with A=U7 indicating that the IEEFS is in use.

On exit X and Y are preserved, C, N, V and Z are undefined and D=O. The interrupt state is preserved.

OSWORD

This routine is entered at &FFFI and indirects through &20C. IEEE commands are sent and information on the state of the interface received through the use of a single OSWORD call with A=&80. This fulfils the same function as the COMMAND channel. Y (high byte) and X (low byte) point to a parameter block. The structure of this is

- first byte: no of bytes in argument
- second byte: no of bytes in result
- third byte: command code
- subsequent bytes: as defined by the first three bytes
Details of each command are given in the table.

OSCLI

This call is used to select the IEEEFS by placing the address of the command line IEEE in V (high byte) and X (low byte) and calling &FFF7 which indirects through &2M. The command line should not start with an asterisk and must end with &OD. Any leading spaces will be stripped.

DATA

When data is sent using the OSBPUT and OSBGET calls, strings are transferred as type (&00) length and characters (in reverse order). When binary coded data is being handled it is sent and received a byte at a time.

Example

Typical sequence of operating system calls.

Select IEEEFS by calling OSCLI

Open COMMAND and DATA channels by using OSFIND

Execute IEEE commands eg CLEAR, REMOTE ENABLE etc by calling OSWORD

Open 'device' channels by calling OSFIND

Listen or talk devices by calling OSWORD

Send and receive data by calling OSBPUT and OSBGET Close channels by calling OSFIND
## Structure of OWORD Block

<table>
<thead>
<tr>
<th>Command</th>
<th>arg0</th>
<th>arg1</th>
<th>command</th>
<th>b0</th>
<th>b1</th>
<th>b2</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBC DEVICE NO</td>
<td>1</td>
<td>0</td>
<td>$40</td>
<td></td>
<td></td>
<td>dev no</td>
</tr>
<tr>
<td>CLEAR</td>
<td>0</td>
<td>0</td>
<td>$50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEVICE CLEAR</td>
<td>0</td>
<td>0</td>
<td>$62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>END OF STRING</td>
<td>1 or 2</td>
<td>0</td>
<td>$81</td>
<td></td>
<td></td>
<td>eos2 eos1</td>
</tr>
<tr>
<td>GO TO LOCAL</td>
<td>n</td>
<td>0</td>
<td>$22</td>
<td>chn</td>
<td>&quot;</td>
<td>ch2 ch1</td>
</tr>
<tr>
<td>LISTEN</td>
<td>n</td>
<td>0</td>
<td>$20</td>
<td>chn</td>
<td>&quot;</td>
<td>ch2 ch1</td>
</tr>
<tr>
<td>LOCAL LOCKOUT</td>
<td>0</td>
<td>0</td>
<td>$61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PARALLEL POLL DISABLE</td>
<td>n</td>
<td>0</td>
<td>$21</td>
<td>chn</td>
<td>&quot;</td>
<td>ch2 ch1</td>
</tr>
<tr>
<td>PARALLEL POLL ENABLE</td>
<td>2</td>
<td>0</td>
<td>$48</td>
<td>ch1</td>
<td>ppr</td>
<td></td>
</tr>
<tr>
<td>PARALLEL POLL REQUEST</td>
<td>0</td>
<td>1</td>
<td>$02</td>
<td>ppr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PARALLEL POLL UNCONFIGURE</td>
<td>0</td>
<td>0</td>
<td>$60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ BINARY</td>
<td>4</td>
<td>0</td>
<td>$14</td>
<td>cnt3</td>
<td>cnt2</td>
<td>cnt1 cnt0</td>
</tr>
<tr>
<td>REMOTE DISABLE</td>
<td>0</td>
<td>0</td>
<td>$71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REMOTE ENABLE</td>
<td>0</td>
<td>0</td>
<td>$70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQUEST CONTROL</td>
<td>0</td>
<td>0</td>
<td>$64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SELECTED DEVICE CLEAR</td>
<td>n</td>
<td>0</td>
<td>$24</td>
<td>chn</td>
<td>&quot;</td>
<td>ch2 ch1</td>
</tr>
<tr>
<td>SERIAL Poll</td>
<td>2</td>
<td>n</td>
<td>$44</td>
<td>ch1 pl1 cnt bn b1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS</td>
<td>0</td>
<td>4</td>
<td>$01</td>
<td>b3</td>
<td>b2</td>
<td>bi bo</td>
</tr>
<tr>
<td>TAKE CONTROL</td>
<td>1</td>
<td>0</td>
<td>$42</td>
<td>ch1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TALK</td>
<td>1</td>
<td>0</td>
<td>$41</td>
<td></td>
<td>ch1</td>
<td></td>
</tr>
<tr>
<td>TIMEOUT OFF</td>
<td>0</td>
<td>0</td>
<td>$52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMEOUT ON</td>
<td>0</td>
<td>0</td>
<td>$51</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRANSFER</td>
<td>4</td>
<td>0</td>
<td>$10</td>
<td>cnt3</td>
<td>cnt2</td>
<td>cnt1 cnt0</td>
</tr>
<tr>
<td>TRIGGER</td>
<td>n</td>
<td>0</td>
<td>$28</td>
<td>chn</td>
<td>&quot;</td>
<td>ch2 ch1</td>
</tr>
<tr>
<td>UNLISTEN</td>
<td>0</td>
<td>0</td>
<td>$54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNTALK</td>
<td>0</td>
<td>0</td>
<td>$58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRITE BINARY</td>
<td>4</td>
<td>0</td>
<td>$18</td>
<td>cnt3</td>
<td>cnt2</td>
<td>cnt1 cnt0</td>
</tr>
</tbody>
</table>
The interface uses the Texas Instruments TMS 9914A GPIB Adapter, together with the SN75160A and SN75162A octal GPIB transceivers. The TMS 9914A interfaces the computer via the IMHZ bus to the IEEE488 bus. It relieves the computer's processor of the task of handling IEEE488 protocol when commands and data are sent and received. The TMS 9914A generates interrupts and so the processor does not have to spend time polling it.

As supplied, the hardware is configured as system controller, Molex link SI on interface PCB in position A, and with the IEEE488 data bus to be driven by open collector outputs, Molex link 52 on interface PCB in position C.

A 5 MHz crystal provides a clock for timing.

The TMS 9914A is connected to the IMHZ bus in accordance with the guidelines given in Ref 2. The interface is supplied with four terminating resistor packs. They should be removed if the interface is not to be the last device on the IMHZ bus.

The read and write registers of the interface are located at addresses &FC20 to &FC27.

The user who wishes to program the TMS 9914A directly in order to configure the computer as a simple talker-listener should obtain Ref 3, and change the Molex link SI on the interface PCB from position A to position B.
### REFERENCES

| Ref 1 | IEEE Std 488-1978  
IEEE488 Standard Digital Interface for Programmable Instrumentation  
The Institute of Electrical and Electronic Engineers Inc 1978 |
|-------|---------------------------------------------------------------|
| Ref 2 | Application Note No 1  
BBC Microcomputer IMHZ Bus  
Acorn Computers Ltd 1982 |
| Ref 3 | TMS 9914 GPIB Adapter Data Manual  
Texas Instruments |
# APPENDIX 1

## IEEE Commands

<table>
<thead>
<tr>
<th>Command Description</th>
<th>Minimum Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBC DEVICE NO B.</td>
<td></td>
</tr>
<tr>
<td>CLEAR C.</td>
<td></td>
</tr>
<tr>
<td>DEVICE CLEAR D.</td>
<td></td>
</tr>
<tr>
<td>END OF STRING E.</td>
<td></td>
</tr>
<tr>
<td>EXECUTE E.</td>
<td></td>
</tr>
<tr>
<td>GO TO LOCAL G.</td>
<td></td>
</tr>
<tr>
<td>LISTEN L.</td>
<td></td>
</tr>
<tr>
<td>LOCAL LOCKOUT L0.</td>
<td></td>
</tr>
<tr>
<td>PARALLEL POLL DISABLE PARALLEL POLL D.</td>
<td></td>
</tr>
<tr>
<td>PARALLEL POLL ENABLE PARALLEL POLL E.</td>
<td></td>
</tr>
<tr>
<td>PARALLEL POLL REQUEST P.</td>
<td></td>
</tr>
<tr>
<td>PARALLEL POLL UNCONFIGURE PARALLEL POLL U.</td>
<td></td>
</tr>
<tr>
<td>READ BINARY R.</td>
<td></td>
</tr>
<tr>
<td>REMOTE DISABLE REMOTE D.</td>
<td></td>
</tr>
<tr>
<td>REMOTE ENABLE REM.</td>
<td></td>
</tr>
<tr>
<td>REQUEST CONTROL REQ.</td>
<td></td>
</tr>
<tr>
<td>SELECTED DEVICE CLEAR SEL.</td>
<td></td>
</tr>
<tr>
<td>SERIAL POLL SE.</td>
<td></td>
</tr>
<tr>
<td>STATUS S.</td>
<td></td>
</tr>
<tr>
<td>TAKE CONTROL TAK.</td>
<td></td>
</tr>
<tr>
<td>TALK T.</td>
<td></td>
</tr>
<tr>
<td>TIMEOUT OFF TIMEOUT OFF</td>
<td></td>
</tr>
<tr>
<td>TIME OUT ON TI.</td>
<td></td>
</tr>
<tr>
<td>TRANSFER TR.</td>
<td></td>
</tr>
<tr>
<td>TRIGGER TRI.</td>
<td></td>
</tr>
<tr>
<td>UNLISTEN UNI.</td>
<td></td>
</tr>
<tr>
<td>UNTALK U.</td>
<td></td>
</tr>
<tr>
<td>WRITE BINARY W.</td>
<td></td>
</tr>
</tbody>
</table>

Note - Standard IEEE488 mnemonics can be used as string variable names.

**Example**
100 PFU$="PARALLEL POLL UNCONFIGURE"
110 PPE$="PARALLEL POLL ENABLE"
120 PPR$="PARALLEL POLL REQUEST"
130 PPD$="PARALLEL POLL DISABLE"

650 spectrumanalyser%=OPENIN("9")
660 PRINT#cmd%,PFU$
670 PRINT#cmd%,PPE$,spectrumanalyser%,10

940 PRINT#cmd%,PPR$
950 INPUT#cmd%,response%

990 PRINT#cmd%,PPD$,spectrumanalyser%,"EXECUTE"
APPENDIX 2

IEEEFS ERRORS

Error number
  &DC  syntax
  &88  out of range
  &DE  channel
  &8A  no device listened type mismatch
  &8B  no BBC DEVICE NO
  &8D  string too long
  &89  no device talked
  &8c  CLEAR not executed
  &FE  Bad command
# APPENDIX 3

## INTERFACE REMOTE MESSAGES

List of Messages Referenced in this Guide

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATN</td>
<td>attention</td>
</tr>
<tr>
<td>DAB</td>
<td>data byte</td>
</tr>
<tr>
<td>DCL</td>
<td>device clear</td>
</tr>
<tr>
<td>END</td>
<td>end</td>
</tr>
<tr>
<td>EOS</td>
<td>end of string</td>
</tr>
<tr>
<td>GET</td>
<td>group execute trigger</td>
</tr>
<tr>
<td>GTL</td>
<td>go to local</td>
</tr>
<tr>
<td>IDY</td>
<td>identify</td>
</tr>
<tr>
<td>IFC</td>
<td>interface clear</td>
</tr>
<tr>
<td>LLO</td>
<td>local lockout</td>
</tr>
<tr>
<td>MIA</td>
<td>my listen address</td>
</tr>
<tr>
<td>MTA</td>
<td>my talk address</td>
</tr>
<tr>
<td>MSA</td>
<td>my secondary address</td>
</tr>
<tr>
<td>PPC</td>
<td>parallel poll configure</td>
</tr>
<tr>
<td>PPE</td>
<td>parallel poll enable</td>
</tr>
<tr>
<td>PPD</td>
<td>parallel poll disable</td>
</tr>
<tr>
<td>PPR</td>
<td>parallel poll response</td>
</tr>
<tr>
<td>PPU</td>
<td>parallel poll unconfigure</td>
</tr>
<tr>
<td>REN</td>
<td>remote enable</td>
</tr>
<tr>
<td>RQS</td>
<td>request service</td>
</tr>
<tr>
<td>SDC</td>
<td>selected device clear</td>
</tr>
<tr>
<td>SPD</td>
<td>serial poll disable</td>
</tr>
<tr>
<td>SPE</td>
<td>serial poll enable</td>
</tr>
<tr>
<td>SRQ</td>
<td>service request</td>
</tr>
<tr>
<td>STB</td>
<td>status byte</td>
</tr>
<tr>
<td>TCT</td>
<td>take control</td>
</tr>
<tr>
<td>UNL</td>
<td>unlisten</td>
</tr>
<tr>
<td>UNT</td>
<td>untalk</td>
</tr>
</tbody>
</table>
APPNDIX 4

INTERFACE SPECIFICATION - note 1

SH  source handshake function
SH1 complete capability
AH acceptor handshake function
AH1 complete capability
T talker function - note 2
T5 complete capability
L listener function - note 2
L3 complete capability
SR service request
SR1 complete capability
RL remote local function
RL0 no capability
PP parallel poll function
PP0 no capability
DC device clear function
DC0 no capability
DT device trigger function
DT0 no capability
C control function
C1, C2, C3 complete capability
C4 and C5

Note 1 - This specification applies to the IEEEFS and interface hardware configured as system controller.

Note 2 - The interface only sends and receives data when the computer addresses itself to talk or listen, not when addressed by other devices.

Power supply 220-24OVAC 50-60Hz 3 watt
Manufactured in accordance with BS415/79 Class 1

Designed and manufactured to comply with Acorn Computers Ltd 1MHZ Bus Peripheral Specification.
APPENDIX 5

FITTING THE IEEEFS EPROM

CAUTION - STATIC SENSITIVE DEVICES
DO NOT HANDLE UNTIL YOU HAVE READ THESE INSTRUCTIONS

Please read these instructions carefully before attempting this conversion. If you are not completely confident of your ability to carry out this conversion yourself it will be in your own interests to take this unit to an authorised BBC Microcomputer dealer for him to carry out this upgrade.

1. Determine which operating system is fitted in your computer by typing *FX 0 and noting the version number displayed.

2. Switch off and disconnect the computer from the mains supply.

   WARNING
   DO NOT REMOVE THE LID OF THE COMPUTER WHILST IT IS CONNECTED TO THE MAINS

3. Unscrew the two large-headed screws on the rear panel of the computer and the two large-headed screws on the underside of the computer (near the front). Carefully remove the lid.

4. Unscrew the two (or three on some computers) bolts securing the keyboard assembly to the lower case and CAREFULLY unplug the 17-way ribbon cable connecting the keyboard assembly to the main Printed Circuit Board (PCB) by pulling the socket away from PLI3 on the main PCB.

5. Move the keyboard away from the main PCB until the loudspeaker plug is accessible. Unplug the loudspeaker by CAREFULLY removing the socket from PLI5. Place the keyboard assembly to one side on a flat surface.

6. If your computer contains an operating system of version 1.00 or later proceed to instruction 9.

7. The current Machine Operating System (MOS) is situated in the bottom right-hand corner of the main PCB in one of two formats as follows:

   a) One integrated circuit (IC) in socket 1C51 identified by the legend "Bo2.1 printed on top. If you have this format carefully remove the MOS IC from 1C51 using an IC extractor (a small screwdriver used with extreme care will do).
b) Four ICs in sockets IC52, IC88, IC100 and IC101 (these sockets are all next to each other despite the numbering) identified with the legends "C", "D", "E" and "F" respectively printed on the top. If this is the case the BASIC language IC (identifiable by the legend "BOI" printed on the top) and all four MOS ICs should be removed as described in 'a' above. Replace the BASIC IC in socket IC100 as described in '8'.

8 The new MOS is supplied in a single IC identified by the legend "B04" printed on the top. Insert the ROM carefully into the socket 1C51 ensuring that all the 'legs' locate properly into the holes and are not 'bent under' upon insertion. The IC should be orientated so that the semi-circular cutout in the top of the IC is at the top, i.e. away from the keyboard. Avoid touching the IC legs with your fingers wherever possible.

Now set the following links:
518 North
519 East
S20 North
521 Two off East/West
S22 North
S32 West
S33 West

N.B. North is the edge of the PCB nearest to the back of the case and South is the edge nearest to the keyboard. East and West follow logically from these.

9 Insert the IEEFS EPROM IC into any free socket (IC88, IC100 or IC101) as described in 8. If you have a disc filing system (DFS) ensure that the IEEFS EPROM is inserted to the right of the DFS IC.

10 Reassemble the BBC Microcomputer by reversing instructions 2 to 5.

11 To check that the IEEFS EPROM has been fitted correctly type

*HELP IEEE

The computer should display

IEEE Filing System <version number>
O.S. <version number>
If it does not disconnect the computer from the mains supply and ensure that all the instructions have been followed correctly. Reconnect to the supply and try again. If you still have problems contact an authorised dealer.
APPENDIX 6

REMOVAL OF TERMINATING RESISTOR PACKS

The interface is supplied with four terminating resistor packs. They should be removed following the instructions below if the interface is not to be the last device on the IMHZ bus.

1. Switch off the interface and disconnect it from the mains supply.
   WARNING - DO NOT REMOVE THE LID OF THE INTERFACE WHILST IT IS CONNECTED TO THE MAINS.

2. Disconnect the IMHZ Bus connecting cable from the computer or other 1MHz bus peripheral.

3. The two halves of the case may be separated by undoing three fixing screws two on the rear panel and one on the underside in the centre at the front. When reassembling push the two halves together whilst tightening the two rear fixing screws. Take care not to lose the two captive nuts for the rear fixing screws which are pushed onto the upper moulding.

4. The four resistor packs, R1, R2, R3 and R4, are located on the PCB towards the front of the case. Note the orientation of the resistor packs for future reference. Carefully remove them using an IC extractor (a small screwdriver used with extreme care will do) and store them safely so that they can be refitted in the future should the interface become the last peripheral on the IMHZ bus.

5. Reassemble by following steps 2 and 3 in the reverse order.
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