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BOARDMASTER 4000 SERIES

OPERATORS MANUAL

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BoardMaster 4000 DIAGNOSTIC SYSTEM - CONTENTS

SECTION 1

GETTING STARTED

1.1 introduction

Thank you for purchasing the BoardMaster 4000 Diagnostic System. We know that you will want to unpack and switch on straight away, but please try to resist the temptation until you have read this manual. Damage to the system and/or the board under test can be caused if the correct procedures are not followed.

There are two manuals supplied with the BoardMaster 4000 system - the OPERATORS MANUAL and PROGRAMMING MANUAL. The programming manual is used in the main for reference, and if like the majority of engineers you do not like reading manuals we suggest that you put it on one side for now and concentrate on this one, the OPERATORS MANUAL. BOTH manuals are intended to be read by engineers who are familiar with the concepts and principles of digital electronics, and in many places a highly technical description is necessary to fully explain the operating procedures.

The BoardMaster 4000 diagnostic system is a comprehensive diagnostic tool for PCB fault diagnosis and repair, both at post-assembly repair stations and in Service and Maintenance departments. Various techniques can be employed to track down faults, including continuity testing, voltage measurement, V-I testing, functional IC testing, short location - the BoardMaster 4000 will even help you to map out the circuit of a board. The results from a KNOWN GOOD BOARD can be stored on a 3.5 inch floppy disk to allow rapid comparison and detection of faults on a suspect board of the same type. A PC software package, MasterLink ML-40, is also available which allows the BoardMaster 4000 to be controlled from a PC via the serial interface.

MENU DRIVEN operation, context related HELP, AUTOMATIC CLIP POSITIONING and AUTOMATIC CIRCUIT COMPENSATION all contribute to outstanding ease of use, but don't let this fool you - you won't get the best out of the BoardMaster 4000 system until you have had some experience and have read and understood this manual.

WARNING - The outputs of the system will be damaged by application of voltages greater than 5.5 volts or less than 0 volts. A protection circuit detects voltages outside this range at the start of the test and isolates the outputs to prevent damage, but once the test has started this protection can no longer apply. It is your responsibility to ensure that no voltages outside the safe range can appear during the test. The system can also be damaged by powering the board under test from an external supply without linking its 0 volt terminal to the system 0 volt terminal on the front panel - this lack of reference can result in voltages outside the safe range appearing, even though the external supply may be a single 5 volt unit.

1.1.1 unpacking and installation

The input voltage for the BoardMaster 4000 is factory set to either 240V or 110V AC 50/60Hz - consult the rear panel label to ascertain the correct operating voltage for your system. Contact the supplier if you require the system to operate from any other voltages. The mains input is fused at 2A/4A respectively in the IEC connector in the rear panel, and to ensure continued protection this fuse rating should not be changed.

WARNING - This equipment should not be used without an adequate earth connection.

The BoardMaster 4000 system consists of the following components:-

Central diagnostic system
Integral Liquid Crystal Display
External ASCII keyboard
Standard test lead with 40 pin clip and ground clip installed
Split Lead including 2 x 20 way test clips
Combined bus disable output (BDO) and Short Locator lead
Red and Black power supply leads
Mains lead
Formatted disk
In addition, you may have purchased various accessories such as a printer, along with associated cables and connectors. We will now have a look at the system components and their uses.

1.1.2 central diagnostic system

The central diagnostic system is the heart of the BoardMaster 4000. It contains all the hardware required to provide a wide range of diagnostic facilities, including a floppy disk drive, integral back-lit liquid crystal display, video display interface and a 5V 5A power supply for the PCB under test.

1.1.3 video monitor

The video monitor provides an optional display of the results of all diagnostic operations. It has its own mains lead and plugs into the BoardMaster 4000 using a 9 pin D connector. The output specification falls within the standard PC MDA video timing tolerance, but to avoid potential problems we recommend that you only use the Philips monitor supplied by A B I. Note that the output will not drive colour or analogue VGA monitors. Please note that this video output facility is discontinued from December 1993.

EXTERNAL VIDEO CONNECTOR PIN OUT (WHERE FITTED)

PIN NUMBER	SIGNAL
1	Ground
2	Ground
3	Unconnected
4	Unconnected
5	Unconnected
6	Unconnected
7	TTL video
8	Horizontal sync
9	Vertical sync

1.1.4 LCD display

The liquid crystal display provides a display of the results of all diagnostic operations. Either a reflective or back-lit type may be fitted, and the DISPLAY option is provided on the CONFIGURE menu to select the type.

1.1.5 external keyboard

The external ASCII keyboard is only required for certain operations, mainly disk operations and programming. If you wish to use it, insert the DIN plug

on the end of the keyboard cable into the 3 pin Din socket at the rear of the BoardMaster 4000.

WARNING - The external keyboard supplied is a TTL level serial output type. Do not attempt to use any other type of keyboard, or damage may be caused to either the BoardMaster 4000 system and/or your keyboard.

1.1.6 test leads

The standard test lead is used for almost all in-circuit diagnostic functions. It is a dual 40 way ribbon cable with a 40 pin test clip and ground clip already installed into the black sockets. If the clip has been removed, you will find out how to reinstall it later. Plug the blue pair of sockets of the test lead into the connectors at the front of the system, noting that there are polarisation "bumps" to ensure correct insertion.

The split lead is required for the IC INTERCONNECTION TEST. However it may be used for any of the other tests provided you are testing or measuring no more than 20 channels at a time. Either of the clips on the split lead may be used for the IN CIRCUIT IC TEST but for the V-I TEST or SHORTS/OPENS/VOLTAGE TEST you must use the left hand clip (connected to the half of the lead with the red stripe).

1.1.7 test clips

20 pin and 40 pin test clips are supplied, to cover the majority of common IC dual-in-line packages. Please contact our Product Support Department for details of other sizes or test clips for surface mount ICs.

1.1.8 bus disable output (BDO) and short locator lead

The BDO/Short Locator lead is a seven way lead with 4 BDO signal clips (blue clips), 2 short locator probes (red and black) and a black ground clip. The 4 BDO clips can be configured to act in a variety of ways using the system CONFIGURE facility. These signals are used to selectively disable parts of the circuitry under test to ensure valid results, for example they may be used to disable a clock or reset a microprocessor. The red and black short locator probes are used to locate short circuits on a PCB. Plug the BDO/Short Locator lead into the 10 way connector at the front of the system, using the polarisation "bump" to ensure correct insertion.

1.1.9 power leads

The red and black power leads are for powering the board under test, and are inserted into the 4mm sockets at the front of the system. Eventually you will wish to make your own power leads to suit your particular boards, but keep them short to avoid voltage drop and noise problems. If you insert the leads at this stage, make sure that the free ends do not short out to each other!

1.1.10 printer

The printer can be bought separately and is used to record, for example, test results and program listings. It has its own mains lead, and connects to the system by a parallel lead to the connectors on the rear of the BoardMaster 4000 and the printer. Consult the printer manual for full details of printer installation and paper loading. A print-out of any screen display can be taken at any time by pressing the PRINT key. Note that some print operations make use of printer graphics facilities, and we therefore suggest that you use the recommended printer to avoid unpredictable results.

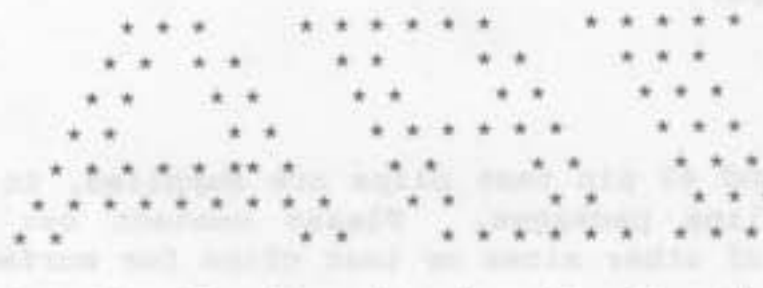
1.1.11 MasterLink ML-40 PC control software

The MasterLink ML-40 software is an optional PC based control package that allows the BoardMaster 4000 to be controlled from your PC, allowing you to make use of the data storage and graphics facilities on the PC. Operation is almost identical to stand-alone mode. Full details of the MasterLink package are given later in this manual.

1.2 system operation

1.2.1 switching on

To switch on, you will need the central system and the external video monitor if required. Plug the monitor into the mains and connect the 9 pin D connector to the video socket at the rear of the system). Ensure that the test cable, BDO/Short Locator cable and PSU leads are not connected to anything and that there is no IC in the ZIF socket. Then insert the mains lead into the rear connector and switch on. After allowing for the display to warm up, the initial screen should be as follows:-



```
E L E C T R O N I C S

B o a r d M a s t e r  4 0 0 0
D I A G N O S T I C  S Y S T E M

S O F T W A R E  V E R S I O N  N O :  B M / X . X X  C o p y r I g h t ( c ) 1 9 9 2
A . B . I .  E l e c t r o n I c s  L t d .
M a n u f a c t u r e d  b y  A  B  I  E l e c t r o n I c s  L t d ,  B a r n s l e y ,
S o u t h  Y o r k s h I r e ,  E n g l a n d

S E L F  T E S T  P A S S ,  P R E S S  E X E C U T E  T O  C O N T I N U E
```

The bottom line of the display will be flashing, and the software version number will be dependent on the date of purchase of the system. If your software version is over 6 months old, the message "Software update now available, contact your dealer" will appear (assuming the system time and date is correctly set), indicating that you can if you wish update your system. Contact Product Support if you wish to do so.

If the message, "SELF TEST FAIL -" flashes at the bottom of the screen along with a brief fault description, please contact our Product Support Department for advice, but first ensure that the test cable (if present), BDO/Short Locator cable and PSU leads are not connected to anything and that there is no IC in the ZIF socket.

To clear the initial display and prepare for use, press the EXECUTE key which is located at the top right hand corner of the keypad.

WARNING - Note that by pressing EXECUTE a sufficient number of times the screen can be cleared and the system can be used even if a diagnostic failure was detected, but in this case the operation of the system may be suspect, depending on the exact nature of the fault.

1.2.2 navigating the menu system

The BoardMaster 4000 main operating menu will now be displayed, as follows:-

```
TEST SEARCH COMPARE CONFIGURE PROGRAM UTILIT
IES


IN CIRCUIT IC TEST
OUT OF CIRCUIT IC TEST
V-I CURVE TEST
SHORTS/OPENS/VOLTAGE
IC INTERCONNECTION TEST
SHORT LOCATOR TEST
SYSTEM SELF TEST
```

The most important keys on the keypad are the four cursor keys at the lower right hand side, and the SELECT and EXECUTE keys at the top right. Most of the functions of the system are accessed using these keys, and a system of explanatory prompts on the bottom line of the display will guide you as you learn the system.

If you use the left and right cursor keys, you will see the range of system functions available on the main menu. The main functions are categorised into TEST, SEARCH, COMPARE, CONFIGURE, PROGRAM and UTILITIES, and an individual function can be selected from within each category using the up and down cursor keys. To activate a function, position the reverse video bar or cursor on the appropriate function and press the EXECUTE key. The screen display and the next action to be taken will depend on the function selected, but for now you can go back to the main menu by pressing the CANCEL key.

The BoardMaster 4000 has extensive on screen HELP facilities, which enable you to quickly learn about the operating features whilst using the system. Press the HELP key, whereupon a screen full of instructions will be displayed. This HELP facility is available at any time except during a test and in PROGRAM mode, and the instructions displayed depend on the context of the operation in progress when the HELP key is pressed. To return to normal system operation, press the HELP key a second time. Try to get into the habit of using the HELP key - in particular you will find the HELP feature of great value after a test in analysing the result.

When you have positioned the cursor bar on the desired function, a press of the EXECUTE key will activate the function and the screen display will change. The bottom line of the screen will indicate the choice of key depressions from then on. As an example, select IN CIRCUIT IC TEST and press EXECUTE. The screen display will be as follows:-


```
+-------------------------------------------------------------------+
| FUNCTION: IN CIRCUIT IC TEST          RESULT: UNDEFINED   SAVE:   NO |
| IC NUMBER:          MODE: SINGLE TEST  THRESHOLDS: DEFAULT TRACE: OFF |
+-------------------------------------------------------------------+
```

Enter the number 7400 on the keyboard or keypad and press EXECUTE or TEST. The display will show the result for the 7400 IC test in the form of a 14 pin IC pin-out diagram, and a TEST INFORMATION box which gives helpful information about the IC and the test result, as follows:-

```
+-------------------------------------------------------------------+
| FUNCTION: IN CIRCUIT IC TEST          RESULT:     FAIL    SAVE:   NO |
| IC NUMBER:7400    MODE: SINGLE TEST   THRESHOLDS: DEFAULT TRACE: OFF |
+-------------------------------------------------------------------+
+-------------------------------------------------------------------+
| 7400       QUAD 2 INPUT NAND GATE                                 |
| NO SUPPLY/GROUND                                                  |
|                                                                   |
|                                                                   |
|                                                    HH:MM:SS   DD/MM/YY |
+-------------------------------------------------------------------+
                          1  1A        VCC  14 NO VCC
                          2  1B         4B  13
                          3  1Y         4A  12
                          4  2A         4Y  11
                          5  2B         3B  10
                          6  2Y         3A  9
                          7  GND        3Y  8
     EXEC/TEST=test, 0-9 = new IC no, CANCEL = menu, SELECT = toggle info box
```

In this case the test failed because the test clip was not attached to an IC and no power supply could be detected. More information on the use of this test mode will be given later in this manual.

The bottom line on the display shows the choice of key depressions, and for now press CANCEL twice to go back to the main operating menu. You can experiment if you so wish with other functions using the cursor keys and EXECUTE, remembering that the CANCEL key will eventually get you back to the main menu.

1.2.3 introduction to test functions

The first menu category consists of TEST functions, and within this category can be found the main fault diagnosis capabilities of the BoardMaster 4000. We will give a brief summary of each function here, but full details will be given later on in the manual.

The first TEST function is IN-CIRCUIT IC TESTING. This allows you to functionally test an IC on a PCB powered from a single 5V supply within the BoardMaster 4000. In addition to a functional test, the system will also perform a continuity test on each pin of the IC, measure the supply and ground voltages, and display the IC function and pin-out information. After the test a window will appear on the display containing an analysis of the result. The test programs are contained in an internal library which can be extended using the PROGRAM function if required. The test result for a known good board can be SAVED on a floppy disk for later comparison with another board of the same type.

The next function is OUT OF CIRCUIT IC TESTING. This performs broadly the same sequence of tests as above, but on an IC inserted into the 40 pin zero insertion force socket on the top panel of the system.

SHORTS/OPENS/VOLTAGE TESTING is used to perform a continuity check on each pin of an IC, even if the IC is not contained in the functional test library. In addition, the logic level at each pin and the DC voltage at each pin is displayed. The result can be SAVED for later comparison with another board.

V-I CURVE TESTING is a completely different test technique which can be used to identify faults on all types of components. A plot of voltage against current is displayed for each pin of the component under test, and the shape of the curve can, with experience, be used to detect faults such as leaky inputs/outputs which may or may not be detectable by a functional test. The BDO/Short Locator cable provides a convenient method of performing the test on discrete components using one or more of the BDO clips. V-I test results for a known good board can be SAVED on disk along with other types of test results for later comparison with a suspect board.

The IC INTERCONNECTION TEST feature requires the special cable with the two 20 pin clips at the end, and it allows you to map out the interconnections (connections between ICs and to each supply rail) on an unknown PCB. This facility is useful when no circuit diagrams are available, and it will enable you to rapidly identify the source of clock signals, for example, that must be disabled during a test. This test can be SAVED along with other results for comparison with another board - this provides a quick way of checking the electrical continuity of the interconnections on a suspect board.

The SHORT LOCATOR TEST enables you to find the exact physical position of a short circuit on the PCB under test, using a bar graph display and audible tone to indicate the relative resistance between the two short detector probes. You can also use the short locator for simple continuity testing.

The SELF TEST feature is self-explanatory - the system will perform a diagnostic check on all its systems in the same way as during a normal power up sequence, reporting any faults found on the screen. Pressing EXECUTE will then display the main operating menu again.

1.2.4 introduction to other functions

The second item on the main menu is the SEARCH category - this allows you to identify, in or out of circuit, an IC from the library, together with any equivalents. The LIBRARY REVIEW facility is also included in this category,

which allows you to look at and print a full list of all the ICs in the library.

The COMPARE function allows the various types of test results obtained from a suspect board to be compared with those obtained from a previously saved KNOWN GOOD BOARD. Most aspects of the result are compared, including voltages, pin connections, logic levels and V-I traces, and differences are easily identified, leading to extremely rapid fault diagnosis. In many repair situations the SAVE AND COMPARE facility will be the most common method of fault diagnosis.

The CONFIGURE function allows you to tailor the operation of the system to your needs - many of the BoardMaster 4000 operating parameters are stored in a battery backed memory and can be easily changed using the CONFIGURE feature. The screen display will show the type of parameters that can be changed - the cursor keys together with SELECT and EXECUTE are used to choose each value, although in some cases (TIME/DATE and SECURITY) literal text is required.

The PROGRAM category contains only one option - BASIC TEST PROGRAM. This facility allows you to write your own programs for ICs not in the library, or indeed (with suitable interfacing) for any digital subsystem that has up to 40 input/output pins. The language used is similar to BASIC, but with additional commands optimised for IC testing functions. Full details of the command structure, with sample programs and further background information, is contained in the programming manual. If you pressed EXECUTE to enter program mode, you can return to the main menu by typing QUIT followed by RETURN on the external keyboard.

Finally, the UTILITIES category provides several file/disk handling functions, together with a PCB file editor and programs for exchanging data between the system and another computer via the RS-232 interface. The on-screen prompting together with the HELP key make file handling operations self-explanatory.

1.3 preparation for in-circuit testing

WARNING - Now at last we are ready to test a real IC on a real board. Before doing this, a word of warning - occasionally an IC which is good can at first sight appear to the system to be faulty. There are many possible reasons for this, and many possible solutions, but we don't want to go into too many technical details just yet. Suffice to say that this will be covered in detail elsewhere in this manual.

Testing ICs in-circuit involves a certain amount of preparatory work, which we will now describe. Testing ICs out-of-circuit will be described later on.

The first step, and until you get the hang of it it may appear a little confusing, is to install the test clip of your choice to the end of the test cable. If you have just unpacked the system, the 40 pin test clip and the ground clip will be already installed. When testing an IC with 40 pins or fewer, the AUTOMATIC CLIP POSITIONING feature of the system will determine the position of the IC within the clip and test it accordingly. Should you wish to remove or change the clip, follow these instructions carefully.

1.3.1 installing the test clip

The test lead consists of two 40 way ribbon cables with blue 40 way connectors at one end and black ones at the other end. The test clip is inserted into these black connectors by following this sequence:-

1) Position the two black 40 way connectors so that they are back to back with the polarisation bumps away from each other.

2) Insert the test clip pins into the INNER rows of pins (ie. away from the polarisation bumps). Any position in these rows is acceptable, although in some cases you will find interpretation of results easier if the clip is inserted at the end with the red stripe on the ribbon cables.

3) The ground clip is inserted into the end pair of holes in the outer row of pins, although for convenience of handling you may wish to remove it since it is not required for many ICs.

The blue pair of connectors should be inserted into the sockets at the front of the BoardMaster 4000 system. The test cable is now ready for use.

1.3.2 preparing the board under test

From this point on, the exact sequence of operations depends on the type of board under test, so we can only give general instructions. However, there is a reasonably well defined sequence of steps which need to be taken for most boards prior to testing, and we will list those steps now.

1.3.3 cleaning the board

It will usually be advisable to clean the pins of the ICs on the board to ensure good contact with the test clip. This applies equally to old boards with oxidation and dirt on the pins, and to newly assembled boards with flux residue on the pins. Cleaning solvents to remove these materials are readily available.

1.3.4 disabling the clock

To avoid interference and invalid test results, any clocks or oscillators on the board should be stopped during the test to ensure that the signals on the board are static. Well designed boards have facilities for this to be done by jumpers, links etc., or it could be done by removing a crystal. Alternatively, one of the BDO signals could be used to stop the clock. No harm will come to the board or the system if the clock is not disabled, but the test results may be unreliable. If in doubt at this stage, ignore this requirement but bear it in mind after the test if "strange" results are obtained.

1.3.5 powering the board

The board to be tested should now be powered from the single 5V supply within the BoardMaster 4000, using the power supply leads provided, although for convenience you may wish to make up your own leads with the appropriate connectors for your type of board. If the board under test has a current consumption of greater than 5A, an external supply will be needed, but for now choose a board that can be easily powered from within the system to avoid unnecessary complications at this stage.

WARNING - It should be carefully noted that the supply to the board under test must ALWAYS be 5 volts, even with CMOS boards which operate from other voltages in normal use. Damage may be caused if this warning is ignored.

1.3.6 entry of IC type number

Now we are ready to test an IC on the board. Select IN CIRCUIT IC TEST from the main menu and press EXECUTE. Interpretation of the results is easier if you test a familiar IC whose pin connections you know. Enter the numeric part of the IC type number, missing out the prefixes and suffixes and the IC family

information. For example, both the SN74LS00N and N7400N ICs should be entered as simply 7400 on the keyboard or keypad. As you type in the IC number the message "IC NOT IN LIBRARY" will be displayed until the system recognises the number.

1.3.7 other in-circuit test parameters

You will have noticed that the menu for the IN CIRCUIT test function contains other parameters in addition to the IC number. You do not need to change any of these for now, but to satisfy your curiosity we will briefly explain them. They can be changed by moving the cursor to the appropriate position using the cursor control keys and using the SELECT key to select from a range of allowable values.

The meaning of the various options is as follows:-

MODE - either SINGLE TEST, LOOP TEST, PASS LOOP or FAIL LOOP. This parameter defines a single (one shot) test and three different types of test repeat functions, depending on the result of the test.

THRESHOLDS - either DEFAULT, USER or SWEPT. If USER is selected, a window appears on the screen prior to the test which allows you to choose the required values of logic thresholds, using the cursor keys and SELECT. If DEFAULT is selected the threshold values are fixed and no window will appear. If SWEPT is selected the system will automatically determine the tightest possible thresholds for the IC under test.

SAVE - either YES or NO. This is set to YES if you are building a PCB file on disk for use later with the COMPARE function.

TRACE - either ON or OFF. This is set to ON if you wish to view the test sequence on screen using the logic TRACE facility.

Ensure that the parameters are set as follows before continuing:-

```
+-------------------------------------------------------------------+
| MODE:   SINGLE TEST    THRESHOLDS: DEFAULT    SAVE: NO   TRACE: OFF  |
+-------------------------------------------------------------------+
```

1.3.8 attaching the test clip

Now we can attach the test clip to the IC. Any size clip can be used, provided that it completely covers the IC under test. Attach the clip to the chosen IC, ensuring that it is correctly seated on the pins. Due to the AUTOMATIC CLIP POSITIONING feature, there is no need to think about polarity or positioning other than to ensure that all pins are covered. You may find the clips a little awkward at first, particularly the 20 pin clip which requires considerable force to open it fully. Squeeze the body of the clip rather than the connectors - if you persevere you will find that there is a "knack" to it and it becomes easier once you know how.

1.3.9 testing the IC in-circuit

Now, at last, we can press the TEST or EXECUTE button on the keypad. The bottom line on the display should momentarily indicate "Test in progress, please wait ..." before the test result appears. If the flashing message "IC NOT IN LIBRARY OR ON DISK" appears, this means that the IC selected is not in the library and cannot for the time being be tested. The test result is in

the form of a IC pin-out diagram showing the conditions on the pins of the IC, together with the "PASS" or "FAIL" result. There will also be a TEST INFORMATION box containing information about the IC and the test that will be useful in analysing the test result. This box can be removed if required by pressing the SELECT key (for example, to see the entire result for an IC with 28 pins or more). There are many differing types of conditions that the result display will show, most of which are self-explanatory. We will describe them in detail later, but for now the best way to become familiar with the BoardMaster 4000 is to try testing several ICs and comparing the results with the circuit diagrams of the board, if available. Do not worry if at this stage you get a FAIL result for an IC which you know to be good - this may be caused by many factors which will be discussed later. You may see a flashing warning message at the beginning of a test, depending on the IC under test and the circuit conditions. Most of these can be ignored for now, but you will have to press the EXECUTE key to continue with the test (or CANCEL to abandon it) if any warning message appears. If you seem to get the message "NO VCC" continually, it may be that the test clip is not correctly inserted - so double check this before going any further.

1.3.10 printing the result and testing the next IC

After the test you will see on the bottom line of the screen the range of valid keys at this stage. If you want to test the same IC again, simply press the TEST key again. If you want to test another IC, key in the new number which will automatically clear the display. To remove the test information box press the SELECT key, and to go back to the IN CIRCUIT TEST menu press CANCEL.

Sometimes you may wish to take a hard copy of the test result on an external printer, and the PRINT key allows you to do this. Details of pin connections, baud rates etc are contained in a separate chapter later in this manual.

1.4 preparation for out-of-circuit testing

Out of circuit testing is a much simpler operation, but there are a few points to note before testing. All dual in line (DIL) ICs are tested in the 40 pin ZIF socket, with the IC positioned as far forwards (ie. towards you) as it will go in the socket. Make sure that the IC is fully home in the socket and making good contact before testing. Select OUT OF CIRCUIT IC TEST from the main menu, then continue as for IN-CIRCUIT TESTING. Note that there is no SAVE option when out of circuit testing.

WARNING - When the TEST or EXECUTE key is pressed, a 5V power supply will be applied to the appropriate pin of the IC under test depending on the type number of the IC. If the wrong type number is entered, this may result in this supply being applied to the wrong pin of the IC, which may cause damage. In addition, some ICs require other components to be added prior to the test. All relevant information will be displayed on the screen if this is the case.

When you have inserted the IC into the socket, press the TEST or EXECUTE key. The result displays are similar to that obtained for in-circuit testing, but there are some slight differences which will be explained later in this manual.

Note that after repeated out of circuit testing the internal contact pins of the ZIF socket can become contaminated by flux deposits and dust, causing intermittent faults to be indicated. The pins can be cleaned with a non-metallic brush slightly moistened with flux removing solvent or contact cleaner aerosol.

1.5 getting started - summary

In this section you have learnt how to install and switch on the system, how to use the keypad and find your way around the menu system, and the basic steps to perform IN- and OUT-OF-CIRCUIT IC testing. Armed with this knowledge you can now go ahead and start diagnosing faults, but there are many more features of the BoardMaster 4000 system that you will need to use to gain the maximum benefit from the system. In particular, the remaining test functions (V-I CURVE testing, SHORTS/OPENS/VOLTAGE testing, IC INTERCONNECTION testing and SHORTS LOCATOR testing) together with the COMPARE operation, will be used very often to speed up the fault diagnosis process.

We will now describe the other features of the system in more detail.

SECTION 2

OPERATION GUIDE

2.1 test procedure for in-circuit testing

You will already have seen some typical result displays, but we will now consider in more detail the way the results are presented. The in-circuit test procedure can be broken down into well-defined stages, starting with the AUTOMATIC CLIP POSITIONING operation. In this section we will describe these stages and illustrate the types of messages that may be displayed at each stage. A full list of the messages is given after the stage by stage description which follows.

2.1.1 high voltage detection

All 40 I/O pins and the BDO signals are checked for voltages greater than 5.5 or less than -0.5 volts. An error display will result if a high/low voltage exists and the test will be abandoned.

2.1.2 automatic clip positioning

AUTOMATIC CLIP POSITIONING establishes the position of the IC within the test clip, so that the clip can be applied in any desired position. Also at this stage, the VCC and GROUND pins are checked for the correct voltages, and the test will be abandoned if either of these supply rails are missing. The result display at this stage will show one or more of the following messages:-

VCC: This means that the pin in question is connected to the 5V supply rail and is greater than 4.5 volts when under load.

GROUND: The pin in question is connected to the 0V supply rail and is less than 0.5 volts when under load.

NO VCC: The pin in question has no valid supply voltage present.

NO GROUND: The pin in question is not connected to ground.

2.1.3 short and link detection

The next step is to detect pins that are connected to either supply rail (SHORTS) or to each other (LINKS). This is necessary to identify faults such as solder bridges and etching faults. The short and link data will also be used by the AUTOMATIC CIRCUIT COMPENSATION software to ensure that the test sequence to be performed later is adjusted to allow for these connections. Note that a short on an output, however, will not be allowed for and will always cause a FAIL result. This can be identified since the message is then displayed in reverse video for emphasis. After this test the system may display one or more of the following messages:-

SHORT 0V: This means that the pin in question is connected to the 0V (ground) supply rail.

SHORT 5V: The pin in question is connected to the 5V supply rail.
LINK n: The pin in question is connected to all other pins with the same value of n, where n = A,B,C, etc..

2.1.4 floating and open circuit pin detection

Next, pins which are FLOATING (ie. inputs which are not being driven with a valid logic level) and pins which are OPEN CIRCUIT (ie. pins which are completely open-circuit) are detected. These two conditions overlap to a certain extent, particularly with CMOS ICs, and together they can identify faults such as broken tracks, dry joints and unsoldered pins. In addition, OPEN CIRCUIT is a common indicator of an incorrectly fitted test clip or dirty IC pins. Note that the indication by the system of SHORT, LINK, FLOATING or OPEN CIRCUIT is not necessarily a fault, but simply indicates the conditions existing at the pins in question. The following displays may result from this test:-

FLOATING: The pin in question presents a loading to the system consistent with that presented by a TTL input that is not connected, ie. not driven by another IC output.

OPEN CCT: The pin in question presents negligible loading to the system.

Note that this FLOATING/OPEN CIRCUIT pin check can be disabled if required by using the MISCELLANEOUS option of the CONFIGURE function to set FLOATING/OPEN CIRCUIT to OFF. In this case no check will be performed and no FLOATING/OPEN CIRCUIT pins will be displayed.

2.1.5 pre-test checks

The next step in the test is to identify any conditions which may interfere with the outcome of the test, so that the necessary action may be taken. The following checks are made:-

a) The IC inputs are checked for changing signals which mean that the board clock(s) must be disabled.

b) The ability of the system to correctly drive the input pins is checked.

c) In the case of tri-state ICs, the outputs must be FLOATING or OPEN CCT prior to the test, otherwise a bus conflict is indicated.

If one of these conditions occurs, one of the following messages, respectively, will be displayed in flashing text on the bottom line of the display:-

```
Input signal changing, EXECUTE = continue, CANCEL = stop

Backdrive error, EXECUTE = continue, CANCEL = stop

Output Conflict, EXECUTE = continue, CANCEL = stop
```

You now have the choice of abandoning the test by pressing CANCEL, or continuing it by pressing EXECUTE. If EXECUTE is pressed, do not be surprised if you get a FAIL result. It is usually necessary at this stage to consult the board circuit diagrams, if available, to find a way of eliminating the problem. Further details of the procedures for doing this are given in section 3. In addition to the flashing warning message, one of the following displays will also be shown on the IC pin-out diagram:-

SIGNAL: The pin in question is a changing signal which may interfere with the results of the test.

LOAD 0V: The pin in question presents an excessive load to the 0V rail, and as a result cannot be adequately driven high.

LOAD 5V: The pin presents an excessive load to the 5V rail, and as a result cannot be driven low.

CONFLICT: The output of this tri-state IC is not floating or high impedance when switched off and as a result a conflict between this pin and another output on the board is indicated.

2.1.6 functional test

Only now can the functional test of the IC begin. The system applies a pre-defined sequence of signals to the IC inputs, checking the output response at each stage. If the response is correct throughout the test sequence, the result is PASS, but if an error is found the result will be FAIL irrespective of the number of errors. The voltages on the output pins of the IC under test are compared with pre-defined LOW, HIGH and SWITCHING threshold values, which for TTL ICs are 0.5 volts, 2.4 volts and 1.2 volts respectively. The corresponding values for CMOS ICs are 0.5 volts, 4.0 volts and 2.5 volts respectively. Note that these voltages can be changed if required by selecting USER THRESHOLDS within the IN-CIRCUIT TEST option. A window appears on the screen prior to the start of the test which allows you to choose the required values of logic thresholds, using the cursor keys and SELECT. If DEFAULT is selected the threshold values are fixed and no window will appear. If you select SWEPT thresholds the test will be carried out with the thresholds set to extreme values, and repeated until there are no MID LEVEL outputs present. This is a convenient way of setting the USER thresholds to the tightest values for the particular IC under test.

A voltage below the SWITCHING threshold is regarded as a LOW logic level, and a voltage above the SWITCHING threshold is regarded as a HIGH logic level. A voltage between the LOW and SWITCHING threshold levels is regarded by the system as a MID LOW voltage, in addition to a HIGH or LOW when compared to the SWITCHING threshold. Similarly, a voltage between the SWITCHING and HIGH threshold levels is regarded as a MID HIGH voltage.

Press the EXECUTE key to carry out the test.

In the case of a FAIL result, the output(s) in question is/are identified by one of the following messages, which are displayed in reverse video for emphasis:-

LOW: The output in question was found to be low with respect to the SWITCHING threshold voltage at some point in the test sequence when it was expected to be high.

HIGH: The output in question was found to be high with respect to the SWITCHING threshold at some point when expected to be low.

MID LOW: The output in question was found to be in between the LOW and SWITCHING threshold voltages for the type of IC under test.

MID HIGH: The output in question was found to be in between the SWITCHING and HIGH threshold voltages for the type of IC under test.

2.1.7 analysing the test results

Because of the effects of interaction with other ICs on the board, there are several circumstances when a FAIL result could be indicated with a good IC. Fortunately, the system is designed to recognise most of these and warn you accordingly, although it cannot determine the solution to the problem. Many

such failures can be eliminated by using the BDO signals to control other parts of the circuitry on the board during the test, and full details of how this is done are given in section 3.

The TEST INFORMATION box may contain several points to note about the test just performed, and pressing the HELP key will give more detailed information about the test on screen. A list of these items and their meanings follows. In many cases a FAIL result for a known good IC will be explained by one or more of these points, but a more detailed discussion of some of them follows the list:-

HIGH VOLTAGE	- abandoned test because a high voltage was detected
TEST ABANDONED	- the test was abandoned by pressing the CANCEL key
PROGRAM ERROR	- there is an error in the TESTBASIC program
SELF TEST FAIL	- the last self test failed
USER THRESHOLDS	- user/swept logic threshold levels selected
NO HIGH V PIN DATA	- connections to high voltage pins not checked
NO POWER PIN CHECK	- power supply voltages have not been checked
INPUT MID LEVEL(S)	- mid level voltages were found on input(s)
NO SUPPLY/GROUND	- no valid supply and/or ground voltages were detected
GROUND CLIP NEEDED	- the ground clip may be required for this IC
OPEN COLLECTOR O/P	- OPEN COLLECTOR outputs which may be driven from another IC
TRI STATE O/P	- TRI STATE outputs which may be driven from another IC
OPEN EMITTER O/P	- OPEN EMITTER outputs which may be driven from another IC
OUTPUT SHORTED	- one or more output(s) shorted to either supply rail
OUTPUT CONFLICT	- TRI-STATE output(s) driven from another source
INPUT CLOCK SIGNAL	- there is a changing signal on one or more input(s)
BACK DRIVE ERROR	- cannot drive one or more input(s) with valid level
OPEN CIRCUIT PINS	- open circuit pins may indicate bad test clip contact
LINKS BETWEEN PINS	- IC has LINKS which may interfere with the test
UNDETECTED SIGNAL?	- IC may have a clock signal above about 4MHz

2.1.8 tri-state, open-collector and open-emitter outputs

Particular problems occur with these type of outputs, since they may be connected to other outputs which the system has no control over during the test. If these other outputs become active during the test, a conflict may occur preventing a valid test. In the case of tri-state ICs, the CONFLICT error will often indicate this but in any case one of the above warnings will be displayed as a reminder.

2.1.9 ground clip needed

Some ICs require the ground clip for a successful test. The reasons for this are highly technical and are explained in section 3 - for now ensure that the ground clip is used if a FAIL result is obtained and this warning is displayed in the TEST INFORMATION BOX.

The ground clip should be connected to a 0 volt point on the board under test as close as possible to the device under test.

2.1.10 self test fail

This warning is displayed for either PASS or FAIL results if the last diagnostic test failed for some reason, and is there to indicate that the result may be invalid due to a malfunctioning test system.

2.1.11 user thresholds

This warning is displayed for either PASS or FAIL results if you have selected different threshold levels to the DEFAULT levels, by selecting either USER or SWEPT thresholds. This may mean that a good IC fails because the levels you have chosen are beyond the IC specification, or conversely a bad IC may pass because the levels are too "slack".

2.1.12 summary of test results

The table below is a summary of all possible conditions that can be displayed on each pin of the IC in question:-

MESSAGE	MEANING
VCC	Supply voltage (>4.5V) on this pin
GROUND	Ground voltage (<0.5V) on this pin
NO VCC	No supply present
NO GND	No ground present
SHORT 0V	Pin connected to 0V or ground
SHORT 5V	Pin connected to 5V or supply
LINK n	Pin linked to others with LINK n
FLOATING	Pin loading as undriven TTL input
OPEN CCT	Pin loading negligible
SIGNAL	Changing signal at this pin
LOAD 0V	Heavy load to 0V (GROUND) preventing drive
LOAD 5V	Heavy load to 5V (VCC) preventing drive
CONFLICT	Conflict with other T/S output
LOW	Pin low when expected to be high
HIGH	Pin high when expected to be low
MID LOW	Pin between low and switching thresholds
MID HIGH	Pin between switching and high thresholds

2.2 test procedure for out-of-circuit testing

The out-of-circuit test procedure can be broken down into stages in a similar way to the in-circuit procedure, but there are several differences which we will discuss here.

2.2.1 power supply switching

The first step is to switch the 5V power supply to the correct pins of the IC under test. Remember that if you key in the wrong type number, power may well be applied to the wrong pins of the IC under test.

2.2.2 input load test

The next step is to check that the input current required by the IC under test is not excessive. As a result of this test, one of the following messages may be displayed:-

LOAD 0V: This means that the input high current was too high, due to an excessive load to the 0V supply.

LOAD 5V: This means that the input low current was too high, due to an excessive load to the 5V supply.

2.2.3 functional test

The functional test is identical to that used as the last stage in the in-circuit test, and the same logical fault indications (HIGH, LOW, MID LOW, MID HIGH) are used.

2.3 using the other test options

2.3.1 loop testing

There are many occasions when the ability to repeatedly test an IC is useful. Intermittent faults can be detected, and ICs which for various reasons will only pass occasionally can be tested.

WARNING - During any in-circuit test the IC under test needs to be isolated from the surrounding circuitry by a process called BACKDRIVING or NODE FORCING. Much has been said and written over the years about this technique, but for now suffice to say that you should be aware that prolonged backdriving will take place during the LOOP modes that we are about to describe. It is the user's responsibility to ensure that the ICs and other components on the board under test will not be affected by this, by reference to the IC data sheets.

The simplest loop function is LOOP TEST mode, which is activated by using the cursor keys and SELECT until the mode display indicates that LOOP TEST mode is selected. Entry of the IC type number and pressing the TEST or EXECUTE key in the usual way will then cause the test to be repeated indefinitely, irrespective of pass or fail, until the CANCEL key is pressed. The display is updated at the end of each test, so that any condition which changes during the LOOP is identified. If you start a test and then physically move the test clip, you will see how the varying conditions on the test clip pins are displayed.

2.3.2 pass loop testing

This mode will again repeatedly execute the test, but only if the test result was PASS. Conditions which have no bearing on the test result, for example a pin that is FLOATING occasionally, will not cause the loop to stop, but conditions that cause a test fail such as LOW, HIGH or MID LEVEL errors at the outputs will cause the loop to stop.

2.3.3 fail loop testing

The FAIL LOOP mode is probably the most useful, since it can often be used to overcome the problems of dirty IC pins and tri-state output conflicts. This time the test will be repeated until the result is PASS, with the display being updated after each test as before. In the case of an IC with dirty pins, for example, the clip can be applied to the IC and the test started. The clip can then be manually adjusted, or given an extra "squeeze", until the IC passes the test.

2.3.4 using different threshold voltages

The THRESHOLDS option can be set to either DEFAULT, USER or SWEPT. DEFAULT uses fixed values of threshold voltages for both TTL and CMOS ICs. USER uses values which can be changed either by using the CONFIGURE function or from within the IN CIRCUIT/OUT OF CIRCUIT test functions in the TEST menu. SWEPT causes the test to be repeated with gradually changing thresholds until no MID LEVEL outputs are present, resulting in the tightest thresholds at which the

IC under test will pass being stored in the USER thresholds. Both USER and SWEPT are useful if you want to test an IC beyond the normal specification, or when testing semi-digital ICs with different output levels.

2.3.5 using the save option

Setting the SAVE option to YES allows you to store the test result on a disk and build up a file for later comparison with another board. Full details of how to do this will be given in a chapter by itself later on. Note that this facility is only available for IN CIRCUIT mode.

2.3.6 using the logic trace facility

The LOGIC TRACE feature allows the logic signals present on the pins of the IC under test to be recorded in memory during the test, and subsequently they can be displayed in timing diagram form in a similar way to a logic analyser. This facility is useful in detailed failure analysis, where the exact point in the test sequence where a FAIL occurred can be determined, and also when debugging programs you are writing yourself.

To use the TRACE, select TRACE: ON using the cursor keys and SELECT before executing the test by pressing TEST or EXECUTE in the normal way.

After the test, pressing EXECUTE will cause the PAGE 1 SETUP SCREEN to appear. Down the left hand side of the display will be the pin names of the IC under test in numerical order. You can display them as they are, or you can change the order to any sequence you wish using the cursor control keys in conjunction with SELECT. Note that the ******* symbol indicates that this line on the display will be blank. If the IC has more than 20 pins, the upper pins will be displayed on page 2. When you are happy with the page 1 setup screen, press EXECUTE to display the PAGE 2 SETUP SCREEN. Select the display pins required (if any) on page 2, then press EXECUTE again to display the actual trace data.

The timing diagram will now appear, together with a menu at the top of the screen. If the trace data is too wide to fit the screen, a SCROLL message will appear and the cursor keys can be used to scroll the display window left and right by either one character or one page. Other options are:- to abandon the trace display and go back to normal system operation press CANCEL, and to go back to the SETUP SCREEN press EXECUTE. The SELECT key can be used in the case of an IC with more than 20 pins to display page 2 trace data.

Logic levels are indicated in timing diagram form on the display, with faulty levels indicated by a "thickened" trace. MID LOW and MID HIGH conditions are both indicated by the letter M. This information indicates where in the test sequence the system identified a fault condition.

2.4 V-I characteristic curve testing

The V-I CHARACTERISTIC CURVE TEST is a completely different way of identifying defects on a PCB, which can be applied to all types of discrete components as well as digital and analogue ICs. The principle of the test is that a varying voltage is applied to each pin of the component under test from a current limited source, and the direction and magnitude of current flow is measured. A graph of voltage against current is then plotted, and the shape of this graph can be used, with experience, to detect all manner of fault conditions. The curve for a known good component can be stored within a PCB SAVE/COMPARE file on disk and used as a reference for comparison with the curve for a suspect component.

A pure resistor will give a straight line sloping graph, since the current through it is directly proportional to the voltage applied. The angle of the line is an indication of the value of resistance - a vertical line is a direct short, whilst a horizontal line is an open circuit. Other components give different shaped curves, and a typical pin of an IC in a circuit may have quite a complex impedance present which results in a particular shape of curve.

The range of voltages over which the test is performed is selectable using the CONFIGURE function. The V-I LOW LIMIT parameter can be either 0, -2, -4, -6, -8 or -10 volts, and the V-I HIGH LIMIT parameter can be either 2, 4, 6, 8 or 10 volts. The curve will always be plotted to fit the entire screen, so selecting a narrower range than the default of -10 to +10 volts will perform a higher resolution test. The output current is limited to +/- 1mA, so it is unlikely that damage may occur to a component, but if in doubt you should select the low limit and high limit values to a safe range for the type of component under test.

2.4.1 executing a V-I curve test

The V-I curve test is executed by selecting V-I CURVE TEST from the main menu and pressing EXECUTE. The parameters now required are the number of channels and the SAVE option, chosen using the SELECT key. Note that the BDO selection is available, which allows the 4 blue BDO clips to be used when testing discrete components. The SAVE option is set to YES if you are incorporating V-I tests into a PCB file for later comparison using the COMPARE function, but at this stage we suggest you leave it at NO. Unfortunately, the AUTOMATIC CLIP POSITIONING feature is of no use during a V-I test, since the system has no knowledge of the component under test, so with these tests you must make sure that the test clip is inserted at the "top" end of the connectors, that is the end with the red stripe on the test cable. A warning message appears on the screen to remind you of this.

Pressing the TEST or EXECUTE key will cause the V-I PARAMETERS CONFIGURE window to appear. This allows you to choose the limit values and compare voltage tolerance. The compare voltage tolerance is used during V-I comparison operations to evaluate the degree of similarity of the two curves.

Pressing TEST/EXECUTE will then execute the test. After the test, the display will show the curve for pin 1. You can now use the SELECT key followed by EXECUTE to choose another pin to view, or you can save the curve on disk for later comparison using the COMPARE function is SAVE was previously set to YES.

2.5 shorts/opens/voltage testing

2.5.1 power up testing

With some ICs a functional test is not possible - the IC may not be in the library, it may be a custom IC, ROM or PAL. It may even not be an IC at all, but a component such as a resistor pack or a DIL relay - in all these cases the BoardMaster 4000 can still help you to locate faults, even though it cannot test the IC directly without programming. The fault detection capability is restricted in these cases to MANUFACTURING DEFECTS TESTING, which is test jargon for faults such as solder bridges, dry joints and so on.

WARNING - If the board under test has any EEPROM or non-volatile RAM devices, the contents of these could possibly be changed by signals applied during this test. To avoid this, remove the ICs before continuing, or use one of the BDO leads to disable it during the test.

The SHORTS/OPENS/VOLTAGE test function allows you to identify circuit conditions such as SHORTS, LINKS and FLOATING pins, the quiescent logic levels at all the pins, and finally the DC voltage at each pin is measured. To execute one of these tests, use the SELECT key to choose the number of channels (pins) of the component under test and press TEST or EXECUTE in the usual way. You will see the usual IC display on the screen, but no PASS or FAIL result.

Unfortunately the AUTOMATIC CLIP POSITIONING feature is of no use here since the system has no knowledge of the component under test, so with these tests you must make sure that the test clip is inserted at the "top" end of the connectors, that is the end with the red stripe on the test cable. A warning message will appear on the screen to remind you of this.

Two of the usual test options are still available to you, but there are no PASS LOOP or FAIL LOOP modes available since there is no result for these tests. The SAVE option is available however. You will find these tests very useful as a means of finding assembly and mechanical defects, particularly when used with the SAVE and COMPARE facility. Most engineers recognise that a MID LEVEL voltage is a tell tale clue to a problem in most digital circuitry, and using one of the SHORTS/OPENS/VOLTAGE tests will often identify this even with ICs not in the library.

2.5.2 power down testing

WARNING - ICs with anti-static protection diodes often specify that these diodes should not be forward biased, that is input signals should not be applied with no supply voltage present. This is particularly true of CMOS, so power down testing should be avoided with CMOS ICs.

The SHORTS/OPENS/VOLTAGE tests outlined above can be performed on, for example, a 40 pin microprocessor, and the address, data and control buses can be quickly checked for shorts. If the board is newly assembled, it can be checked with only the ground supply lead connected, to avoid powering up a board with a potentially damaging short on an output from the microprocessor. Since the types of condition detected by this test are "hard" faults, no power is required to detect them, and when used in conjunction with the SAVE AND COMPARE facility this method of testing is quicker than visual inspection for finding assembly defects.

Note that for convenience the SHORTS/OPENS/VOLTAGE tests can be executed directly from the IN CIRCUIT TEST menu by simply typing in the number of pins (08, 14, 40 etc), to avoid unnecessary menu switching once you are familiar with the system.

2.6 IC interconnection test

The IC INTERCONNECTION TEST feature allows you to identify the interconnections between ICs on a board. This information is useful, particularly if you do not have access to circuit diagrams, when deciding where to attach BDO signals to disable parts of the circuitry on the board. It is also of general value in a repair environment when inadequate circuit documentation is available.

To carry out this function the split cable is required, which has two 20 pin clips at the end to allow you to clip on to two ICs at once.

If you select IC INTERCONNECTION TEST from the main menu, you will see that there are two options to choose, MODE and SAVE. By using the SELECT key you can choose between SINGLE TEST of LOOP TEST. Use the cursor key to move to the SAVE option and select YES or NO.

Pressing the EXECUTE key will carry out the test, and the result display is in the form of two 20 pin IC diagrams side by side, with only LINKS and SHORTS shown to simplify the display. AUTOMATIC CLIP POSITIONING is of course not functional, so that the clips must both be applied in a known position to simplify interpretation of the results.

Note that for convenience of operation once you have grown accustomed to using the system, the IC INTERCONNECTION TEST can be executed from the IN CIRCUIT TEST menu by entering the type number 2020.

2.7 short locator test

WARNING - Before using the short locator, ensure that the PCB under test has no power applied. Remove any batteries and discharge any large capacitors prior to using the short locator.

The SHORT LOCATOR feature uses the red and black probes on the BDO/Short Locator lead to enable you to find the exact location of a short on the PCB under repair, using a low resistance measuring technique. If you select SHORT LOCATOR and press EXECUTE, you will see three options to choose before carrying out the test, namely RANGE, BLEEPER and AUTO ZERO. The meaning of these options is as follows:-

SCALE - You can select one of three ranges, to cater for a wider range of resistances than a single range would allow. If the "short" you are locating has a relatively high resistance the bar graph may go off scale, in which case you can select a less sensitive scale to bring the bar graph back onto the display.

BLEEPER - You can select one of three operating modes for the bleeper. In the RESISTANCE mode, the bleeper will sound intermittently in the presence of a short, at a rate which gets faster as the resistance of the "short" gets lower. This allows you to track down the short without having to look up at the display. In the CONTINUITY mode, the bleeper will sound continuously when there is a short between the probes, allowing you to perform a "buzzing out" operation. In the OFF mode, the bleeper is disabled and the bar graph display alone is used to indicate the resistance of the "short".

AUTO ZERO - This is carried out at the start of the SHORT LOCATOR operation to compensate for the resistance of the test leads. Always set this option to YES when starting to use the SHORT LOCATOR.

Having selected the desired options, pressing EXECUTE will start the SHORT LOCATOR operation. If AUTO ZERO is set to YES, you will be prompted to short the probes together and press any key to continue. The system will not let you continue until it detects a reasonably low resistance "short" between the two probes, although you can return to the menu by pressing CANCEL. Once you have set the zero, the display will show the relative resistance between the probes in the form of a bar graph, and the bleeper will sound (in the RESISTANCE mode) at a rate depending on the value of the resistance. Note that the numeric indication on the screen bears no relationship to the actual ohmic value of the resistance - it is simply for comparison purposes. You can now use the probes to track down the short on the board under test, listening for the fastest rate of bleeping and/or looking for the lowest display on the bar graph. To stop the SHORT LOCATOR test and return to the menu, press CANCEL.

2.8 self test diagnostic

The system hardware self test executes automatically on switch on but can also be executed on command, along with several other self test functions, by selecting the SELF-TEST mode from the main menu and pressing EXECUTE. A SELF

TEST FUNCTION window will appear and you can choose any of the following functions using the SELECT KEY. The chosen function is executed by pressing the EXECUTE key:-

HARDWARE: The power up hardware diagnostic sequence will now take place, and if all is well the message "SELF TEST PASS, PRESS EXECUTE TO CONTINUE" will be displayed. Pressing EXECUTE will then return the system to the main menu and you can resume operation. Make sure that the test clip is not attached to an IC, that there is no IC in the ZIF socket and that the BDO/Short Locator cable is not connected during the hardware self test.

If a fault is found during this test, the message will be of the form "SELF TEST FAIL..., with an additional message describing the nature of the fault. Depending on the type of problem the system may well be still usable, so please contact our Product Support Department for advice.

PRINTER: This test will continuously send the entire ASCII character set to the printer and RS232 interfaces.

DISK VERIFY: This test will verify (non-destructively) that the disk in the drive can be read with no errors.

OUTPUT DRIVE: This test will check that all 40 test channels, BDO/Short Locator channels and all 40 ZIF channels are functional.

HELP REVIEW: This test will display all the system HELP screens and IC NOTES in sequence, using the HELP key to move on to the next screen. The PRINT key can be used if desired to print out the HELP screens of your choice.

PIN DISPLAYS: This test will display a special 40 pin display containing all possible pin conditions.

2.9 using search and library review mode

The SEARCH mode is designed to allow the operator to identify an IC which is unmarked or unrecognisable, by monitoring the IC function and comparing it with the internal library of ICs. All ICs in the library which have the same function as the IC under test will be listed on the display. An additional facility in this category is LIBRARY REVIEW, which allows you to view on screen and print out all the ICs in the library or a subset of them.

2.9.1 using the search mode

WARNING - Before using the in circuit search on an unknown IC, you must take reasonable steps to ensure that the IC or others on the board will not be damaged by the backdriving that occurs during a prolonged search (some linear ICs are not as tolerant as digital ICs of backdriving - ensure that the IC is digital before proceeding). In addition, if the board under test has any EEPROM or non-volatile RAM devices, the contents of these could possibly be changed by signals applied during the search. To avoid this, remove the ICs before continuing or use a BDO lead to disable the IC during the search.

To perform a SEARCH, attach the clip to the IC or insert the IC in the ZIF socket and select either IN CIRCUIT SEARCH or OUT OF CIRCUIT SEARCH as appropriate using the cursor keys and EXECUTE.

You will now be prompted to select the number of pins of the IC under test. Use SELECT to choose the number of pins, then press the EXECUTE key to continue. As the search proceeds, the ICs which conform to the function of the IC under test will be listed on the screen. If the display box fills, you will be prompted to press any key to continue. If the IC cannot be

identified, the message IC NOT IDENTIFIED will be displayed. You will notice that with some ICs, several different numbers are displayed during the search. This can happen because of pin compatibility between ICs, and also because ICs with shorts or links can sometimes appear to the system to pass the truth tables of others. In addition, the system does not identify the differences between LS, S, HC and other variations of IC technology. Nevertheless, despite these limitations, you will find the search facility a useful diagnostic aid.

2.9.2 using the library review facility

The LIBRARY REVIEW feature produces a display in the same format as the SEARCH, but without carrying out any test functions. Select the LIBRARY REVIEW option from the SEARCH facility on the main menu. A window will appear on the screen which allows you to choose the size of the ICs under review and also gives you the option to print out the results. Use the cursor keys and SELECT to make your choice then press the EXECUTE key to continue. If PRINTER is set to ON the ICs under review will be printed, along with any special notes for the ICs. This is a convenient way of getting a hard copy of the entire library of the system.

2.10 the result save and compare function

Many of you will find the SAVE and COMPARE feature one of the most useful on the system. You can SAVE the test results and/or V-I curves for the ICs on a known good board on a disk file, allowing them to be subsequently used in COMPARE mode as a reference when testing a suspect board of the same type. All the conditions at the IC pins (eg. SHORTS, LINKS, FLOATING), the test result (PASS/FAIL), the test mode (NORMAL, LOOP, PASS LOOP or FAIL LOOP), BDO status, threshold levels, V-I parameters and up to 53 characters of text are stored, eliminating the need to consult diagrams during testing. Faults such as solder bridges, dry joints and broken tracks are rapidly identified and displayed as differences from the master result file, even though the IC under test may well still give a PASS result.

2.10.1 preparing the disk

The first step in using this facility is to generate the master file for a known good board. The disk supplied will already be formatted but for future disks you will need to format a disk on which to SAVE the results. Unfortunately, this means that we must here digress to tell you about disk formatting. As we are sure most of you will know, disk formatting involves writing information on a blank disk to enable the operating system to find its way around the disk to store and retrieve your files. The UTILITIES category on the main menu allows access to this and other disk operations which will be described fully later. For now, use the cursor keys to select FORMAT from the UTILITIES menu. The EXECUTE key will start the FORMAT operation. Insert a blank disk as prompted on the screen, and press EXECUTE again.

WARNING - The FORMAT operation completely wipes the disk, so that there is no possibility of recovering any files once the format is started.

If you are sure you wish to proceed, a second press of the EXECUTE key will format the disk. Now wait a while for the operation to finish, and we can then go back to the SAVE operation.

2.10.2 saving the master PCB file

A certain amount of forward planning is necessary when using the SAVE function. The COMPARE operation will go through the board in the same physical sequence as that used for the SAVE, although you can "jump around" if you wish. You will usually find it more convenient to follow the same

numerical sequence as the ICs on the board, so if you are doing this for the first time we suggest you start at IC 1. Select IN CIRCUIT IC TEST, SHORTS/OPENS/VOLTAGE TEST, V-I TEST or IC INTERCONNECTION TEST mode from the main menu, set SAVE = YES using the cursor keys and SELECT, attach the clip and test the IC in the usual way. At the end of the test you will be prompted to press EXECUTE to save the result, but before pressing EXECUTE have a look at the result. Remember that this result is to be used as a master for testing other boards, so ask yourself if it is a valid result. Was the test clip attached firmly? Were there any spurious results due to clocks running or bus contention? If you are happy, press the EXECUTE key.

2.10.3 entering the save parameters

The system will now ask you for the first of three parameters - the PCB FILE NAME. The PCB FILE NAME may already be there from a previous SAVE operation, and need not be entered again if it is correct. It is used to identify the board under test, and can be entirely numeric if you wish to eliminate the need to use the external keyboard. Enter the desired file name using either keyboard and press EXECUTE or RETURN. If you make a mistake the CANCEL key can be used to restart.

The next parameter is the IC REFERENCE. The initial value of this parameter depends on whether you are starting a new file or adding to an existing one. In the case of a new file the IC reference will default to 0001, although any alphanumeric value up to 4 characters can be entered using either keyboard. With an existing file the last IC in the file is extracted (and automatically incremented if it is entirely numeric) and used as a prompt, on the assumption that the current result is to be added to the end of the existing file. If this is correct, press EXECUTE to continue, but note that by changing the displayed value of the IC REFERENCE you can overwrite an existing result, for example when a board is modified (A much more sophisticated method of editing a PCB file is available using the EDIT utility).

Finally, the system prompts you for a USER PROMPT consisting of up to 53 characters of free form text which can be used to instruct the operator to attach BDO leads, ground clips etc. This text will be flashed on the screen prior to the test when using COMPARE mode. Enter a prompt if desired, using the CANCEL or DEL key if you make a mistake. Pressing EXECUTE will then complete the SAVE operation by writing the file on the disk.

2.10.4 saving the next result

The next IC on the board can then be tested, and the EXECUTE key pressed again. The same filename is automatically displayed, and if you simply wish to save the next IC in this file you only need to press the EXECUTE key. The IC REFERENCE will be automatically incremented by 1 if it is entirely numeric, and if this is correct you need not enter another one. You will see that testing the ICs in the correct numerical sequence reduces the number of keystrokes required.

2.10.5 using the result comparison facility

We now come to the COMPARE feature, which uses the results SAVED previously to rapidly test a suspect board.

Select the RESULT COMPARISON function from the main menu and press EXECUTE. The system now prompts you to enter the PCB FILE NAME for the board under test which you previously saved, along with the ENGINEER NAME and PRINTER LOG selection. The ENGINEER NAME is free format text, 20 characters maximum, which is printed on the COMPARE LOG if selected by setting PRINTER LOG to ON. Pressing the EXECUTE key after entering all the above causes the file to be

read from the disk, and the IC NUMBER and MODE displays on the screen will be changed to reflect the details stored in the file. If PRINTER LOG is ON, the title section of the printer log will be printed. The IC REFERENCE is also displayed on the screen to guide the operator around the board. Attach the test clip to the indicated IC, and press the TEST key, noting that there is no need to enter the IC type number (indeed, it is impossible to do so in COMPARE mode). The test will take place in the usual way, but if one of the LOOP modes was selected the comparison will not take place until the loop stops. For all tests except V-I tests, the actual results will be displayed and compared with the master results from the file, any differences being indicated by a star alongside the appropriate pin. The COMPARE display will change to COMPARE: GOOD or COMPARE: BAD to indicate the result of the comparison, and in the case of BAD the SELECT key can used to alternately select the actual and master results so that the differences can be seen. If PRINTER LOG is ON, a log entry for the test will be printed.

2.10.6 comparing V-I curves

If the test was a V-I test, no GOOD/BAD indication will be shown. At the top of the screen you will see the current PIN NO and DISPLAY option. The PIN NO can be changed by highlighting it and using SELECT in the usual way, the new curve(s) being displayed when EXECUTE is pressed. The DISPLAY setting can be set to either ACTUAL, to display the curve for the suspect component just tested, MASTER, to display the stored curve, or BOTH, to display them both for easier visual comparison. The default setting is BOTH, but it can be changed using the SELECT key. The comparison scores are displayed in a box on the left, one score for each pin. The score is a percentage measure of the degree of matching of the two curves for each pin. There can be no hard and fast rules about the degree of matching that is acceptable, and indeed the figures will vary depending on the setting of the V-I COMPARE TOLERANCE parameter using the CONFIGURE function. The default value for this parameter is 0.2V, but it can be set to any value in the range 0.1V to 1.0V. A difference in voltage for the two curves must be less than this value to give a good comparison, so a high value will give high percentage comparison results. Once you have arrived, by experience, at a suitable value, we suggest that you stick to it so that repeatable results are obtained and you get a "feel" for the outcome.

Do not however rely totally on the percentage scores when comparing curves - the visual representation is equally important, particularly for complex shapes which may "fool" the comparison algorithm. The score box can be removed, if required, by pressing EXECUTE to re-display the curve(s). Press CANCEL to return to the menu in readiness for comparing the next IC.

2.10.7 comparing the next IC

There are now several options - pressing TEST or EXECUTE will test and compare the same IC again, SELECT will display alternately the actual and master results, PRINT will print out the current result display (if printer log is on, the result print out will be inserted at this point in the log print out), and CANCEL will return you to the main menu. The usual action will however be to select the next IC to compare, using the cursor keys to move around within the file, either forwards or backwards, until the correct IC is selected. At the beginning or end of the file a message will be displayed to indicate that no further ICs are present.

2.10.8 "homing in" on the fault

You will soon realise that with most boards you may have some idea of the physical location of a fault, and to avoid unnecessary testing you can "home in" on the fault by entering the IC REFERENCE of the desired IC prior to

performing the test. This means you can compare any IC on the board, in any order, by simply entering the IC REFERENCE to load the master results from the file.

2.10.9 editing a PCB file

The EDIT option is one of the UTILITIES operations described later, but is included here because it is concerned with the SAVE and COMPARE operations. It allows you to change a result previously saved, and also to delete or insert results. In addition you can print a summary of the entire file on the printer.

To EDIT a file, select EDIT from the UTILITIES menu and press EXECUTE. Enter the PCB file name as prompted and select the desired EDIT function using SELECT followed by EXECUTE. You can select from one of five operations - EDIT RESULT, INSERT NEW RESULT, DELETE RESULT, RENAME RESULT and PRINT FILE DETAILS. At the end of each operation you will be asked to confirm that you have made the correct changes before the edited file is written back to the disk. A brief summary of each function is as follows:-

EDIT - change any of the details of the chosen result using a full screen editor. Note that for a V-I test only the text can be changed.

INSERT - insert a blank result in the PCB file BEFORE the chosen result, with a new IC reference. Note that the blank result must be edited before it can be used.

DELETE - delete the chosen result from the PCB file.

PRINT - print a summary of all the results in the file on the printer.

RENAME - change the IC reference of the chosen result.

2.11 the version 1.XX V-I compare function

Previous versions of the BoardMaster 4000 software used a different method of saving V-I files, using individual files of type VIT for each component. Now that you have version 2 software, you can still use your old VIT files for comparison by setting the V-I VERSION option to 1 using the CONFIGURE facility. The system will then operate exactly as before. The following notes on version 1.XX V-I comparison are included here but will not be needed if you intend to use version 2 all the time.

2.11.1 loading the version 1 V-I file and comparing

Select the COMPARE option from the main menu using the cursor keys and press EXECUTE. The system will then ask you to choose either RESULTS or V-I CURVES for the comparison operation. Use SELECT to choose V-I CURVES and press EXECUTE. The system will then prompt you for the V-I FILE NAME, and you should enter the 8 character name of the VIT file which you have previously saved. Pressing the EXECUTE key will load the file and prepare the system for performing the V-I curve test and comparison. Notice that the number of channels (and also the low and high voltage limits, although this is not apparent on the screen yet) is automatically extracted from the file.

When the file is loaded, press EXECUTE to perform the V-I curve test on the suspect component. The resultant display will consist of both ACTUAL (ie. the outcome of this test) and MASTER (ie. the stored data) curves for pin 1 of the component under test superimposed on one another, although if there is a close match they may not be distinguishable from each other. Also present will be a

box containing the "comparison score" in percentage form for each pin of the component under test.

2.11.2 comparing again

To perform the same test and comparison again, press CANCEL to go back to the comparison menu, followed by EXECUTE to compare the result again. To go back to the main menu, press CANCEL twice. The V-I file remains in memory until you go back to the main menu, so that you can continue the comparison on different boards if required.

2.12 using the configure function

The CONFIGURE function allows you to set up numerous system operating parameters. To activate system configuration mode, select the CONFIGURE category from the main menu and use the cursor keys to select the group of parameters to change. Pressing EXECUTE will cause the current value of the selected parameters to be displayed and you can then use the cursor keys and SELECT to change them as you wish. There are two types of parameters, although this is not always apparent on the screen. The most common type is a selectable non-text parameter, such as the BAUD RATE, where the SELECT key is used to select from a range of options. This approach ensures that invalid values cannot be entered. The other type of entry is a text entry, such as the PASSWORD, which is entered using any alphanumeric characters from either keyboard. The time and date entries are treated as text.

Pressing EXECUTE after changing the parameters will return you to the main menu and store the new parameters.

2.12.1 changing logic thresholds

The threshold levels used by the system when testing ICs can be changed, if required for a particular application. Using the THRESHOLDS parameter you can select the threshold voltages that are used and cursor control keys. Ensure that the values you select make sense - for example the TTL LOW threshold voltage must be lower than the TTL HIGH threshold voltage, and the TTL SWITCHING threshold must be in between. If an incorrect set of voltages is chosen, the error message "INVALID THRESHOLD COMBINATION" will be displayed, and you must correct the error before continuing. The default levels are shown on screen for reference purposes only - they cannot be changed.

2.12.2 changing RS-232 parameters

The RS-232 parameters (BAUD RATE, PARITY, STOP BITS, PROTOCOL and TERMINATOR) are all selectable from a range of options. For further information on the RS-232 interface, including details of pin connections, cables etc., see section 3.

2.12.3 changing display options

The BoardMaster 4000 system is supplied with either a reflective or back-lit LCD display. The operating parameters for each type of display are slightly different and the LCD TYPE option is provided to allow you to select the type of display you are using. Your system will have been set up with the correct type on delivery, but if for any reason this setting is lost you will need to use this facility to ensure that the correct display is obtained. The INVERSE option allows you to invert the video on the display, according to your personal preference.

2.12.4 changing BDO configuration

The blue BDO clips have colour coded leads, and each can be configured to act in three ways (see section 3). Each BDO colour is individually programmable on screen with the SELECT key.

2.12.5 changing V-I parameters

The V-I characteristic curve test voltage scans between the V-I LOW LIMIT and the V-I HIGH LIMIT, and these limits can be changed to alter the resolution of the test. The tolerance value is used by the V-I compare function to alter the accuracy with which the system compares two V-I traces.

2.12.6 changing the time and date

The system has a real time clock which displays the time and date in certain operating modes. The CONFIGURE function allows you to reset the time and date as required, by typing the new time and date in as text. The time will be set when you move the cursor forwards onto the DATE entry, or when you terminate the entire CONFIGURE option with EXECUTE. It is also possible to select between European and USA format by moving to the date format using the cursor keys and selecting the required option.

2.12.7 changing the security parameters

If you try to change the SECURITY values, you will notice that the system asks for a password before allowing access. The default password on systems shipped from the factory is 00000000, which you will need to enter to get past this stage in the procedure.

The password can be any combination of up to 8 alphanumeric characters, entered from either keyboard. You may wish to use a numeric only password to eliminate the need to use the external keyboard in future, but on the other hand the necessity to use the external keyboard may well be an advantage if extra security is required. As this is a text entry the CANCEL key can be used to clear an incorrect entry once entry has started. The password will be displayed on the screen when it is being changed, but at no other time will you be able to see it. If you do not require password protection, set the password to all blanks (use the CANCEL key) and the system will than ignore it until you reset it to something else. The password can only be changed if the current password is known to the user.

The system ACCESS LEVEL controls the access to any function which involves disk writing or programming. In OPERATOR mode all these functions are barred to avoid unauthorised modifications or deletion of your files, whilst in PROGRAMMER mode all functions are available. If the password is forgotten, contact our Product Support Department for advice.

2.12.8 changing miscellaneous parameters

The following parameters can be changed using the cursor keys and SELECT in the MISCELLANEOUS option of the CONFIGURE function:-

FLOATING/OPEN CIRCUIT - On some boards, the conditions FLOATING and OPEN CIRCUIT overlap to a certain extent, causing errors in COMPARE mode. This parameter allows you to define whether the two conditions are to be treated as the SAME or DIFFERENT. Alternatively the FLOATING/OPEN CIRCUIT function may be set to OFF, in which case no check will be performed and no FLOATING/OPEN CIRCUIT pins will be displayed.

POWER SUPPLY TO PCB UNDER TEST - The 5V 5A supply to the board under test is switched on prior to a test and then off again, reducing the average power dissipation and also ensuring better compare results by re-initialising the board each time a test is performed. The power supply can be switched on continuously, if required, by setting EXTERNAL PSU to CONTINUOUS. The power supply will now remain on, but will switch off after 4 minutes if no tests are performed.

COMPARE VOLTAGE TOLERANCE - When a SHORTS/OPENS/VOLTAGE is compared with a master result in COMPARE mode, the voltages at each pin are compared using a tolerance that can be set in the range 0.1 to 1.0 volts. A difference between master and actual voltages will only be flagged as an error if it exceeds this programmable tolerance.

BLEEPER - An audible warning sounds when a test FAILS, or when a bad comparison occurs in compare mode. If this annoys you, you can disable the warning with this parameter.

LANGUAGE - The default language is ENGLISH, but this can be changed if required to either FRENCH, GERMAN, ITALIAN or SPANISH. All menus, help text, error messages and IC notes are then displayed in the appropriate language.

V-I VERSION - This can be set to 1 if you wish to compare V-I curves using version 1 (VIT) files. It should normally be left at 2. Note that if you attempt to SAVE a V-I test, or COMPARE a version 2 format V-I test, this parameter will be automatically set to 2 by the system.

MASTERLINK - This is set to OFF for normal operation, but should be set to ON to configure the system in remote mode for use with the MasterLink ML-40 PC control software package (see later). Ensure that you have set the baud rate and other serial parameters prior to invoking MasterLink mode. Note that in order to run MasterLink your system must have been fitted with a different decoder PAL internally which is supplied with the MasterLink ML-40 update package. An error message will be displayed if you attempt to configure the system in MasterLink mode without fitting this new PAL.

2.12.9 configuration parameter storage

The CONFIGURATION PARAMETERS are stored in a battery backed memory. The battery has a life measured in years, but nevertheless will eventually become discharged and will require replacement. When this happens, a warning message "LOW BATTERY" will be displayed each time the system is switched on, but the parameters will still be intact at this stage. The system can continue to be used, but eventually the parameters will be lost. If this happens the warning message on switch on will be "SYSTEM RESET TO DEFAULT PARAMETERS", indicating that the previous parameters were lost and the system has reverted to the default values, which can be checked by viewing them on the screen. The system can still be used, but the parameters required for your application will have to be re-entered after each switch on. For battery replacement, contact our Product Support Department for advice.

2.13 using the utilities

So far, if you're following this manual from the beginning, you have seen a glimpse of the UTILITIES when formatting disks. We will now discuss the remaining functions which are file COPYING, DELETION, RENAMING, UPLOADING, DOWNLOADING, DIRECTORY viewing and PCB file EDITING. Most of these operations are menu driven and simple to operate provided you follow the instructions on the screen. Before describing the various functions, we ought to tell you something about the file handling system.

2.13.1 file names and types

Filenames on the BoardMaster 4000 can have from one to eight alphanumeric characters (no spaces allowed), but if required they can be entirely numeric to ensure that files can still be accessed without using the external keyboard.

There are two types of file - PCB files, which contain the SAVED results for use by the COMPARE mode and BASIC files, which contain your programs. However, if you have disks on which V-I curves were saved using version 1.XX software, you will also see these VIT files.

A three character string (PCB, BAS or VIT) is used to identify the different file types, but this can be changed from the internal keypad using SELECT without using the external keyboard.

2.13.2 the disks

The disks are housed in a robust cover to prevent ingress of dust, but care should be taken to store them away from extremes of temperature. In particular, they should be stored well clear of sources of magnetism to prevent corruption of stored data. There is a write protect tab in one corner, which is supplied in the write enabled position, but it can be moved to protect your files from accidental deletion.

WARNING - It is important to note that the disk operating system is not compatible with you know who, or anyone else for that matter, so you can only read and write the disks on the system itself.

2.13.3 directory viewing

The directory is an area on the disk which is used to keep track of the physical position of files on the disk, and includes details such as the size of the files and the time/date when they were last changed. Displaying the directory provides a convenient means of checking which files you have on your disks and finding out the available disk space. Select the DIRECTORY function from the main menu using the cursor control keys and press EXECUTE. The system will now read the directory information from the disk and display a table of filenames, file types, creation or updating time and date and their respective sizes. If the display fills the screen, it will pause until you press a key to display subsequent screens, and at the end of the display the remaining space on the disk, in K bytes, will be shown. Any key will then return you to normal system operation.

2.13.4 file copying

To take a copy of a file onto another disk file with a different name, select the COPY function from the main menu using the cursor keys and SELECT and press the EXECUTE key. The system will then ask you whether you wish to copy a single file or the entire disk. To copy a single file, select FILE COPY and press EXECUTE. The system will then prompt you for the source and destination file names together with the file type. Enter both filenames using the cursor control keys to move the reverse video cursor to the required entry. The file types are selected using SELECT or the space bar, thus avoiding the need to use the external keyboard if the filename is numeric only. As before, you can clear an incorrect entry using the CANCEL key. When you are happy with the data entered, press the EXECUTE key, and the system will perform the copy operation.

2.13.5 disk to disk copying

If you wish to duplicate an entire disk, select the COPY function and choose DISK COPY. Press EXECUTE to start the disk duplicate operation and then follow the disk swapping prompts on the screen, inserting a previously formatted blank disk to receive the data. It is a good idea to set the write protect tab on the original disk to the protected position, to prevent loss of data if a mix up occurs with the disks during the copy. Note that once started, the DISK COPY operation must be allowed to complete - if for any reason the operation is not completed the new disk will not contain all the files and will cause unpredictable results if you attempt to use it. In this situation you should repeat the entire process to be sure of taking a valid copy.

If you wish to copy a single file from one disk to another, start the FILE COPY operation in the usual way but enter the same file name in response to the DESTINATION FILE prompt. The system will then prompt you to change disks accordingly - make sure that you keep track of which disk is which, particularly if you are copying a large number of files! Again, it may be advisable to set the write protect tab on the disk you are copying from, so that if a mix up does occur nothing will be lost.

2.13.6 file deletion

If you wish to delete a file, select the DELETE function and press EXECUTE. Follow the prompts on the screen, and enter the name of the file to delete, using either keyboard. Select the type using SELECT, and press EXECUTE to complete the delete operation, but before doing so double check that the entered file name and type are correct.

2.13.7 file renaming

If you wish to change the name of an existing file, you can use the RENAME facility. Again, follow the screen prompts to enter both the old and new filenames, and press EXECUTE to complete the operation.

2.13.8 disk formatting

Disk formatting was described earlier in the SAVE AND COMPARE section, so please refer back for details. During the FORMAT operation, the system displays each track number in hexadecimal, before performing a VERIFY test to check for physical damage to the disk media. The verify test will read each track on the disk, pausing if an error is found. Pressing any key will cause the test to continue until all tracks have been verified. Any disk that causes an error message to occur should be regarded with suspicion and should not be used.

2.13.9 uploading a PCB file

The UPLOAD facility allows you to send a PCB file from the BoardMaster 4000 to a remote computer via the RS232 interface. PCB files of up to 32k in length can be sent to and from industry standard personal computers (PC's) without any special software using the DOS COPY command, but larger files will require a more sophisticated communications programme running on the PC to handle the data. Note that you cannot UPLOAD a PCB file containing V-I tests.

To send a PCB file to a remote computer, select the UPLOAD function and press EXECUTE. Enter the name of the file you wish to send - this file should already be present on the disk on your system. Ensure that the RS232

parameters have been set to match those used on the remote computer and the correct cable has been installed.

The remote computer should now be configured to receive the data - as an example, to UPLOAD a file called TEST.PCB on a DOS based system to drive C: the command would be:-

```
COPY COM1 C:TEST.PCB /A
```

followed by the RETURN or ENTER key on the PC.

Pressing the EXECUTE key on the diagnostic system will then send the PCB file to the PC. For best results ensure that the baud rate used is 4800 or less. The file is sent in ASCII in blocks of 64 characters followed by a CR,LF, but it is in a coded form which is not immediately intelligible. On some computer systems the serial input hardware/software may append characters to the beginning of the file - these should be removed with an ASCII editor before sending the file back to the BoardMaster 4000.

2.13.10 downloading a PCB file

Using the same example as above, to load the file TEST.PCB from a PC to the BoardMaster 4000 select the DOWNLOAD function and enter the filename (TEST). Pressing the EXECUTE key will cause the system to wait until data is received on the RS232 interface, and the message "WAITING FOR DATA ..." will be displayed. Then, at the PC end, the command:-

```
COPY C:TEST.PCB COM1 /B
```

will cause the file to be sent to the system. The message will change to "DOWNLOADING FILE ..." to indicate this. Again, do not use a baud rate higher than 4800 baud for best results. If the file you are downloading is too large, an error message will be displayed. You can abandon the download at any time by pressing ESCAPE on the external keyboard.

2.13.11 converting a DIT-24XP PCB file

Version 2.02 and above of the BoardMaster 4000 software includes the facility for converting DIT-24XP PCB files to BoardMaster 4000 format, to enable customers upgrading to the BoardMaster 4000 to make use of their existing DIT-24XP files. This section explains how to carry out the conversion.

The DIT-24XP files are copied to a BoardMaster 4000 disk during the conversion process. The disk must have been previously formatted on a BoardMaster 4000 system.

Set the write protect tab on the DIT-24XP disk and insert it into the BoardMaster 4000 disk drive and display the directory using the DIRECTORY option on the UTILITIES menu. You may wish to print this out using the PRINT key to allow you to keep track of the conversion operation. Now select the COPY FILE option from the utilities menu and press EXECUTE. Enter the name (ie. the SOURCE FILE) of the first PCB file you wish to convert, and enter the identical name for the second file (DESTINATION FILE). Ensure that the file type shown is PCB. Press EXECUTE to start the COPY operation.

The system will now remind you that this is a disk to disk copy operation, which you should confirm by pressing EXECUTE again. The DIT-24XP file will now be loaded into memory, after which the system will prompt you to insert the BoardMaster 4000 (DESTINATION) disk. Remove the DIT-24XP disk, insert the BoardMaster 4000 disk and press EXECUTE. The system will now ask you to confirm that you wish to convert the file - if everything is in order up to this point press EXECUTE to carry out the conversion.

The conversion will now take place and the converted file will be written to the BoardMaster 4000 disk with the same filename. The system will now prompt you to insert the original (DIT-24XP) disk. That completes the conversion process for the first file - simply repeat the process for all the files you wish to convert.

TESTBASIC files (type BAS) can also be copied across using the same process, but there is no conversion required since the format is the same. Note however that programmes containing PEEK and POKE commands will not function on the BoardMaster 4000 due to hardware differences.

The DIT-24XP and BoardMaster 4000 PCB files have a different format - in particular the BoardMaster 4000 files contain further information over and above that contained in DIT-24XP files, which means that the conversion software must make certain compromises in operation. The following notes explain this in more detail:-

a) The DIT-24XP system MID LEVEL pin condition is converted into the BoardMaster 4000 MID LOW condition. If a MID HIGH condition is required, this must be added using the EDIT facility or by re-testing the IC and overwriting.

b) The BDO states in the BoardMaster 4000 are programmable, and the settings are stored in the PCB file so they can be reproduced during the COMPARE operation. During the conversion they are set to the default values of LOW LOW HIGH HIGH. If other settings are needed they must be changed using EDIT mode.

c) The threshold voltages in the BoardMaster 4000 are stored in the PCB file and used when comparing. During the conversion they are set to the TTL default values (0.5V, 1.2V and 2.4V). If other settings are required they must be changed using EDIT mode.

d) The BoardMaster 4000 allows 53 characters of text to be entered for each result, whereas the DIT-24XP allows only 32. The extra characters are blanked after conversion, but can be added to using EDIT mode.

e) When saving a SHORTS/OPENS/VOLTAGE test, the BoardMaster 4000 stores the voltages measured on each pin in the PCB file. The conversion cannot predict what these voltages should be so they are not filled in during the conversion process. This will cause COMPARE errors when using the converted file. The only way to insert the correct voltages is to re-test the relevant IC and SAVE it, overwriting the converted IC.

g) The DIT-24XP Logic Test (25 test etc) has no equivalent on the BoardMaster 4000, so it is converted to a SHORTS/OPENS/VOLTAGE test with the same number of pins.

2.13.12 editing a PCB file

PCB file EDITING was described earlier in the SAVE AND COMPARE section, so please refer there for further details.

2.13.13 disk errors

During disk operations various error messages may appear on the screen. These can be divided into two types - software errors which are caused by unavoidable factors such as full disks or non-existent files, and hardware problems, usually caused by damaged or worn disk media.

2.13.14 disk software errors

The following error messages may occur as a result of a system error:-

DIRECTORY FULL: There is no space in the disk directory for file information. The disk is effectively full

NO DATA SPACE: There is no more space on the disk

FILE ALREADY EXISTS: The file you have attempted to copy to or rename to already exists on the disk

FILE DOES NOT EXIST: The file you have attempted to copy from or rename from does not exist

WRITE PROTECTED: An attempt was made to write or format a disk with the write protect tab set.

2.13.15 disk hardware errors

The following error messages may occur as a result of disk hardware problems:-

DRIVE NOT READY: The disk drive is not ready for operation, usually due to a missing disk.

DATA CRC ERROR: An error occurred during a disk operation, usually caused by a worn, damaged or defective disk.

SECTOR NOT FOUND: The disk system could not find the required data on the disk, again usually due to a defective disk.

UNFORMATTED DISK: The disk in use has not been formatted, but this message can also be caused by a defective disk.

SECTION 3

MORE ADVANCED TOPICS

3.1 failure analysis

So far we have covered all of the basic operating functions of the BoardMaster 4000 system, with the exception of programming which is covered in the PROGRAMMING MANUAL. However, you will not get the best from the system until you gain some experience of fault diagnosis, and this section is our attempt to pass on some of the experience that our engineers and our customers have gained over the years.

When you have tested an IC and are looking at the result on the screen, you have completed the easy part of the test operation. Now comes the hard part, which is to interpret the results and locate the fault. There are many ways in which the BoardMaster 4000 can help you to locate faults. The first is the obvious one - the result says FAIL, you change the IC, and the board works. But of course it is not always that simple.

3.1.1 why good ICs sometimes fail

Before we go on, a gentle reminder. You will remember that we said right at the beginning during the preparation for testing section that often ICs will give a FAIL result even when they are good - the reasons for this are many and varied, and part of the learning curve associated with using the BoardMaster 4000 is to recognise the signs of this and, most importantly, to identify the ways and means of eliminating the problems. Most of these problems will be identified by points in the TEST INFORMATION BOX after the test, and by the HELP messages that you can display on the screen in the event of a FAIL result. This section will attempt to identify these test problems, and describe the typical solutions, although the rules of thumb given will need to be modified to suit your particular application. Using the IC INTERCONNECTION TEST in conjunction with the split test cable is a useful way of checking out the interconnections between ICs on the board if you do not possess circuit diagrams, and can often help you to identify BDO attachment points, for example. Pressing the HELP key after every test will give a summary of those conditions that are detectable by the system itself. The following are the most common reasons for an invalid FAIL indication:-

3.1.2 dirty pins

Poor contact between the test clip and the IC under test due to dirt, corrosion or flux residue is a common cause of failures. The usual indication of dirty pins is of course OPEN CIRCUIT, and if this is present on the display the result must be treated with a certain amount of suspicion, unless the IC is a tri-state or open-collector type. The solution to this is to make sure that the IC and the test clip are clean and making good contact with each other.

3.1.3 input clock signals

An input signal that is changing from high to low causes large transient voltage spikes as the output current changes from a high value to almost zero and back again. This causes the IC under test to malfunction as it responds to these noise spikes. The system is capable of detecting changing signals at IC inputs, but the speed of the input voltage measuring circuitry is such that this detection is erratic above 4MHz. Above this, no warning message will be

displayed but the test result will almost certainly be FAIL. If you get into the habit of disabling all clocks on the board before testing, you will avoid this problem. One of the BDO signals can often be used to disable clocks, depending on the design of the board under test.

3.1.4 tri-state and open-collector contention

Together these two problems will account for many of your test problems. In order to correctly test an IC that has its output(s) connected to other IC output(s), you must ensure that the outputs of the other IC(s) remain in the high impedance state during the test. The exact method of achieving this depends on the particular board under test, but usually involve locating a signal or signals, for example a microprocessor RESET input, that cause tri-state bus lines to go to their high impedance state. A memory array, as another example, may have several ICs on a common bus, with each IC being enabled from the output of some form of address decoding circuit. If you can find a point on the input side of the decoding circuit that acts as a global enable signal, you may be able to temporarily disable the entire memory array and proceed with the test. Again, one or more of the BDO signals will be useful here. With many microprocessor boards, removing the microprocessor from its socket can often disable the clocks and leave the bus free from conflicts at the same time.

In the case of TRI STATE contention, the system will often identify the problem for you and indicate an output CONFLICT.

3.1.5 backdriving noise

Depending on the type of ICs on the board under test, the current required to adequately "backdrive" the outputs connected to the inputs of the IC under test can be quite high, up to 180 mA or so. Transient voltage spikes often result when rapid switching of current from zero to this high value occurs, for example when a HIGH pulse is applied to an input that is being driven LOW. The IC under test may well respond to these "spikes" and depending on the type of IC may appear to fail the test. A good example of this is a digital counter which may count twice or more on each clock edge. The worst case situation for this fault is a high current output IC such as a 74S or 74F type with a steady state LOW output that must be driven HIGH. Note that it is not the IC under test that is the source of the noise, but the IC being backdriven.

The solution to this is usually to use the ground clip to provide a low impedance return path for the high backdrive current. In nearly all cases this will cure the problem, but if it persists one of the BDO signals may be used to make sure that the offending output is in the HIGH state prior to the test. The system is aware of those ICs which are likely to suffer from this problem, these being mainly sequential ICs such as flip-flops, counters and registers, and will inform you of this after the test in the test information box.

3.1.6 invalid input signals

If the input of the IC under test is not fed with a valid LOW or HIGH level, it may not respond correctly. One possible cause of this is the inability of the system to backdrive excessive loads, such as high current outputs of non-TTL or CMOS ICs (the 555 timer is notorious for this, with its 200mA or so of output current). Occasionally, designers may connect two or more gates in parallel to obtain higher output drive, and this causes the same problem. Fortunately, one of the PRE-TEST checks outlined earlier usually spots this, indicating a LOAD 0V or LOAD 5V in addition to a "BACKDRIVE ERROR" warning. Occasionally, though, a marginal condition may occur, particularly when

combined with backdriving noise mentioned previously, that causes an apparently inexplicable failure with a known good IC. Using a BDO signal to put the offending output into the "weakest" state is one possible solution.

3.1.7 unrecognisable connections

The AUTOMATIC CIRCUIT COMPENSATION software does a very good job at understanding some of the more imaginative ways in which an IC may be connected, but our engineers will be the first to admit that they probably haven't thought of everything. It may be that an IC on the board under test is connected in a way that the software does not recognise, and as a result the test fails. We've seen plenty of strange things in our time, including flip-flops used as inverters, counters used simply as latches, and a variety of oscillator circuits. If this happens, the clue will often be given by the pattern of LINKS and/or SHORTS shown on the display. The solution is twofold - the easiest way is to send a printout of the configuration to our Product Support Department, but another way is to write a program yourself to test the IC within its intended function in your circuit.

3.2 finding manufacturing defects

The BoardMaster 4000 is capable of finding all manner of defects on boards in addition to faulty ICs, due to the variety of tests it performs on the IC. Most of these are due to MANUFACTURING DEFECTS, and are indicated by the effect they have on the conditions found at the pins of the IC under test. The following is an attempt to quantify the types of fault that can cause the various conditions on the result display, but don't forget that these indications are usually not faults at all, but simply normal circuit conditions. Remember that if the IC you wish to test is not in the library, the SHORTS/OPENS/VOLTAGE test can still be used to identify manufacturing defects.

3.2.1 short 0V, short 5V, link

These indications can be caused by faults such as a solder bridge, a PCB etching defect, an uncropped lead shorting to another, a fault in a component such as a resistor or capacitor or, less commonly, an internal IC fault. Such a fault on an output will usually be accompanied by a logical error message (HIGH or LOW) and a FAIL result, but an input fault will often be mistakenly interpreted by the AUTOMATIC CIRCUIT COMPENSATION software as a valid connection, giving a PASS result unless the connection is totally illogical. This is the reason why interpretation of the test results requires some thought. The physical position of the short can be found using the SHORT LOCATOR function.

3.2.2 floating, open circuit

FLOATING can be caused by broken or cracked PCB tracks, open circuit connectors, dry joints, unsoldered pins, badly plated via holes, internal IC faults, and we've all seen the IC in a socket with a pin bent under. With CMOS or MOS ICs, the system cannot make the distinction between FLOATING and OPEN CIRCUIT and they both then have the same possible meanings. Unlike SHORTS and LINKS, these conditions have no effect on the result of the test.

3.2.3 mid level low and high

These conditions are unusual, because they could be caused by a faulty IC or by a mechanical defect as for SHORTS and LINKS. A solder bridge, for example, from an output of the IC under test to another IC output may well result in a MID LEVEL appearing if the two outputs attempt to go to opposite levels. The

test result will always be FAIL, but it may be an external fault that is causing the apparent malfunction. Some detective work is required here to find the cause of the problem. If you are testing the entire board, the best policy is to come back to this IC later, because the actual fault causing the MID LEVEL may well turn up in a more readily detectable form somewhere else.

The BoardMaster 4000 will also detect a MID LEVEL LOW or HIGH at an input of the IC under test. This will not cause the test to fail in itself, since when the system takes over the driving of the input during the test the correct levels will be applied. However, the presence of an INPUT MID LEVEL may indicate a fault such as an overloaded driving output or an input requiring excessive input current. In many cases the condition may be quite normal, for example in oscillator circuits. The display of this condition should be investigated in case a fault condition exists.

3.3 use of the BDO signals

Mention has been made of the BUS DISABLE OUTPUT (BDO) signals in various places in the manual, and we will now describe in detail how they can be used to overcome some of the problems with testing certain types of ICs. There are four BDO signals available, each of which has a blue clip and a colour coded lead. They are individually programmable with three different functions using the CONFIGURE function. The output current specifications are identical to the test clip outputs, so that they can be used to "backdrive" nodes on the board under test. There is also a further output with a black clip which is permanently connected to ground and should not be used to disable outputs.

The available functions are as follows:-

LOW = output will go low for the duration of the test.
HIGH = output will go high for the duration of the test.
OFF = output will remain off for the duration of the test.

The various uses of the BDO output signals can be summarised as follows:-

1) To disable tri-state outputs connected on a common bus to prevent contention with the outputs of the IC under test.

2) To disable clock signals to prevent interference with the test.

3) To disable open-collector outputs connected in a wired-OR configuration with the outputs of the IC under test.

4) To initialise a board to a known state to ensure that the ICs are tested under the same conditions, particularly using the COMPARE mode.

5) To reduce the effect of "backdriving" noise by forcing backdriven outputs to the high state.

3.3.1 connection of BDO signals

The exact point at which the BDO signals should be connected is usually determined by reference to the circuit diagrams, if available, or simply by intuition and physical examination of the board.

WARNING - It is important to ensure that the BDO signals are not connected via tracks on the board to the IC under test, otherwise the system will be in a position of backdriving its own outputs!

Some common connection points for the BDO signals are as follows:-

1) The RESET, HOLD or DMA REQUEST input of a microprocessor, if present. This will cause the output address, data and control lines of the microprocessor to go into a high impedance condition, enabling easier testing of, for example, memory ICs on the same bus lines.

2) The clock enable input or to some point in an oscillator circuit to disable the clock. If possible, this should be arranged so that the clock line stays in the high state since with TTL this is the "weakest" state from a backdriving point of view.

3) A global enable signal in an address decoding circuit. This can often be arranged to force all "chip select" signals in the system to an inactive state, again to ease the testing of other ICs on the same bus.

3.4 connecting your printer or computer

3.4.1 the parallel interface

The connector is a 36 way female, with the following pin connections:-

PIN	SIGNAL	DIRECTION	FUNCTION
1	STROBE	out	Active low strobe pulse
2	DATA BIT 0	out	Data to printer
3	DATA BIT 1	out	Data to printer
4	DATA BIT 2	out	Data to printer
5	DATA BIT 3	out	Data to printer
6	DATA BIT 4	out	Data to printer
7	DATA BIT 5	out	Data to printer
8	DATA BIT 6	out	Data to printer
9	DATA BIT 7	out	Data to printer
10	not used		
11	BUSY	in	Active high busy status
19-27	GROUND (0V)		
28	not used		
29	GROUND (0V)		

All remaining pins on the printer connector are unconnected.

If you have purchased the recommended printer from us as part of the system, you will already have the appropriate cable. If however you are using another type of parallel printer, you will almost certainly still be able to use the standard cable, but you should refer to the printer manual to confirm this. Note that V-I curves and logic traces use printer graphics and may not print correctly if you do not use the recommended printer.

Full details of installation of the tractor unit, paper loading, setting of character fonts and default switch settings are given in the printer manual itself. If your printer has an automatic line feed after carriage return feature, this should be switched off to prevent double spaced printouts.

3.4.2 the serial interface

The serial interface can be used to send data to a printer, but it is normally connected to a remote computer to allow downloading of result displays or for using the system in MasterLink mode. The inputs and outputs are on a 25 way D type socket on the rear panel, and standard RS-232 logic levels are used, ie. HIGH = +3 TO +12 volts and LOW = 0 to -12 volts. The system will respond to TTL logic levels on its inputs, but the outputs will always be at RS-232 levels. The operating parameters such as BAUD RATE, PARITY, STOP BITS, PROTOCOL and TERMINATOR are set using the system CONFIGURATION procedure.

For connecting to a serial printer, the TERMINATOR option should be set to NONE using the CONFIGURE function, but when sending data to a PC the TERMINATOR should be set to EOF. This causes an end of file character (1A hex) to be appended to the end of the data following any print operation. The PC uses this character to detect the end of the data transmission process, after which the data is stored on a disk file. Any BoardMaster 4000 print operation can send its output to a PC in this way, including screen dumping, compare log printing, PCB file printing, BASIC LPRINT and LLIST commands, and library review printing. Note that the files resulting from screen display of V-I curves and logic traces will have printer graphics control codes embedded in them.

The pin connections on the 25 way connector are as follows:-

PIN	SIGNAL	DIRECTION	FUNCTION
2	TRANSMIT DATA	out	Serial data output
3	RECEIVE DATA	in	Serial data input
4	REQUEST TO SEND	out	High = ready for RX
5	CLEAR TO SEND	in	High = ready for TX
6	DATA SET READY	in	Not used but reserved
7	GROUND (0V)		

All remaining pins on this connector are not connected.

For connecting the system to a PC, the cable should be as follows (note that a different cable is used for MasterLink, see next section):-

BoardMaster 4000 PIN	SIGNAL	Connect to	PC COM1 port PIN	SIGNAL
2	TRANSMIT DATA		2	RECEIVE DATA
3	RECEIVE DATA		3	TRANSMIT DATA
4	REQUEST TO SEND		8	CLEAR TO SEND
5	CLEAR TO SEND		4 and 6	DTR and DSR
7	GROUND (0V)		5	GROUND (0V)

3.4.3 RS-232 handshaking

In the simplest application only pins 2 and 7 need be used. This allows data to be transmitted, but there is no means of "handshaking" to control data transmission. You may be able to avoid the need for this by selecting a low baud rate, but in many applications some form of handshaking PROTOCOL will be required. There are two types of PROTOCOL that can be performed on the system, and the choice is made during the system CONFIGURATION procedure.

3.4.4 hardware handshake protocol

The first type of handshake is the hardware type, which uses the CLEAR TO SEND (CTS) signal on pin 6. This pin must be high to enable the system to transmit data, and transmission will stop if it is pulled low. If your printer or computer has a hardware handshake, there will be a signal on its RS-232 connector that can be connected to CTS on pin 6 to achieve the required handshake. Refer to the printer or computer manual to identify the signal.

3.4.5 software handshake (X-ON/X-OFF)

This protocol uses pin numbers 2,3 and 7, but ignores pin 6 which can be left open. When the printer wishes to receive data, it sends a X-ON code (11H) to the system. The system then starts sending characters, checking all the time for an X-OFF (13H) character being received from the printer. If such a character is received, transmission will stop until the next X-ON character is received. Selection of this protocol must be made with reference to your printer manual.

3.5 using the MasterLink PC control software

The MasterLink ML-40 package allows you to control the BoardMaster 4000 Diagnostic system from your PC, providing enhanced display facilities and greater storage capacity than the stand-alone system. Your BoardMaster 4000 can operate in either stand-alone or MasterLink mode, enabling you to make use of all your existing files and data. Note that your system must be fitted with a different decoder PAL in order to run the MasterLink software. The PAL and full fitting instructions are contained in the optional MasterLink ML-40 update package.

3.5.1 installation

The MasterLink ML-40 package consists of the following components:-

Operating software on 1 1.2Mb 5.25" floppy disk
Operating software on 1 720k 3.5" floppy disk
Serial cable for connection to PC
New decoder PAL

The minimum system configuration required to run MasterLink is IBM PC or true compatible running DOS 3.3 or higher, with 640k RAM and at least 500k of hard disk space. The majority of the functions do not require graphics capability, but to display V-I traces Hercules, EGA or VGA graphics facilities are required. Driver programs are included on the installation disks.

Before using the MasterLink software it must be installed on your hard disk on your PC. Switch on your PC and insert the MasterLink disk into your floppy drive. Log into the destination drive and directory where you want the MasterLink directory to be created, then log into the floppy disk drive where you have inserted the MasterLink disk. Type INSTALL followed by the destination drive, for example INSTALL C (The usual colon (:) is not needed) followed by ENTER. The sub-directory MLINK40 will then be created on the chosen drive and the files on the disk will be copied into it. The installation procedure is now complete.

You should now add the MLINK40 sub-directory to the PATH to enable the system to find the MasterLink files. After installing the software, connect the BoardMaster 4000 to your PC using the serial cable supplied, and the system is now ready for use.

Before using the BoardMaster 4000 in MasterLink mode, a different decoder PAL must be fitted. If you have purchased the MasterLink ML-40 software at the time of purchasing your BoardMaster system, this will have already been fitted, but if you are upgrading the PAL must be fitted according to the instructions included in the update package. An error message will be displayed if you attempt to use MasterLink mode with the wrong decoder PAL.

3.5.2 switching on

Switch on your PC and log in to the directory where you installed the MasterLink files. Load and run the MasterLink software by typing ML4000 at the DOS prompt. The opening menu will now be displayed on your PC screen. Now switch on the BoardMaster 4000 system and wait for the initial self test to complete. The next step is to set the baud rates on both the BoardMaster 4000 and the PC to the same values, using the CONFIGURE menu option at each end of the link. We suggest that you use 19200 baud to avoid undue transmission delays in operation.

The BoardMaster 4000 is now in stand-alone mode, and can be used in the normal way, but to select MasterLink mode choose the MISCELLANEOUS option on the CONFIGURE menu on the BoardMaster 4000 system. Using the cursor keys and SELECT (on the BoardMaster 4000 system) set MASTERLINK to ON, and press EXECUTE. The BoardMaster 4000 is now in MasterLink mode. To return to stand-alone mode, press CANCEL on the BoardMaster 4000 keypad.

3.5.3 operational differences

For full details of system operation, please refer to the previous sections of this manual. The way in which the various functions operate is almost identical to the BoardMaster 4000 operating in stand-alone mode, the only differences being the keys used. The following table outlines the keys used in MasterLink mode and their equivalents in stand-alone mode:-

BoardMaster key	MasterLink key	Function
SELECT	SPACE bar	Choose desired option
TEST	ENTER	Execute test function
EXECUTE	ENTER	Execute or accept selection
PRINT	F2	Print screen on printer
HELP	F1	Display context related HELP
CANCEL	ESCAPE	Abandon function
CANCEL	END	Stop LOOP test

Note that the F2 key can be used at any time to print the screen - the normal PC PRINT SCREEN key is disabled while in MasterLink mode.

If you are already familiar with using the BoardMaster 4000 in stand-alone mode, you will find it easy to switch to these new keys when in MasterLink mode. If you are using the system for the first time, you may find it easier to use the system in stand-alone mode until you gain experience. Remember that the prompt line at the bottom of the screen is there to help you. The remainder of this section outlines the differences between stand-alone and MasterLink operation.

3.5.4 executing a V-I curve test

To execute a V-I curve test your PC must have either Hercules, EGA or VGA graphics facilities. MasterLink supports the following graphics cards:-

Graphics Card	Resolution	Colours	Pages
HERCULES MONO	720 x 348	2	2
EGA MONO	640 x 350	16	2
EGA COLOUR	640 x 350	16	2
VGA COLOUR	640 x 350	16	2

To display V-I curves, you must have one of these cards installed in your PC. The graphics driver file(s) HERC.BGI and EGAVGA.BGI must be present in the

MLINK40 sub-directory. If you do not have any of these facilities you will still be able to use the system, but V-I testing can only be performed in stand-alone mode. When you select a V-I curve test you will notice the screen display change slightly as the system switches into graphics mode. If you want to print the results of a V-I test, you must set the PRINTER option (on the CONFIGURE menu) to EPSON since graphics are required to print V-I curves.

3.5.5 short locator test

The only difference between the MasterLink version of the SHORT LOCATOR TEST and the stand-alone version is that the audible tone works in a different way. In MasterLink mode, the pitch of the tone varies with the resistance, rather than the variable intermittent tone used in stand-alone mode.

3.5.6 self test diagnostic

You cannot perform a SELF TEST directly in MasterLink mode, but you can use the SELF TEST STATUS option to ascertain the result of the last test performed.

3.5.7 the result save function

The SAVE operation works in the same way as in stand alone mode, except that the PCB file created is stored on your hard disk and not on the BoardMaster 4000 system. The storage format is different and the files and disks are not interchangeable between the BoardMaster 4000 and the PC.

3.5.8 using the result comparison facility

The COMPARE facility works in an almost identical manner, but there are some slight differences in the way the information is presented which are self explanatory. When comparing V-I tests on a colour display, the actual and master curves are shown in different colours to aid analysis.

3.5.9 using the utilities

The system utilities are similar to those available in stand-alone mode, but of course they relate to files stored on the PC disk. There are two new utilities, CHANGE DIRECTORY and RUN DOS COMMAND, both of which are self-explanatory. Note that MasterLink occupies a large portion of memory, so that the RUN DOS COMMAND option will only work with relatively small programs.

3.5.10 using program mode

Test programs can be written in the same way as in stand-alone mode, but the storage format is different and they cannot be transferred to the BoardMaster 4000 system. In addition, it is not possible to execute a test program directly from the test menu, only from with the BASIC interpreter.

3.5.11 system error messages

GRAPHICS ERROR MESSAGES:-

GRAPHICS ERROR - DRIVER FILE NOT FOUND(HERC/EGAVGA.BGI)

MASTERLINK could not load the graphics display driver. Check that the MLINK40 sub-directory has been added to your PATH.

