The CED Micro1401-3 Owners Handbook

Table of contents

Typographic conventions The following conventions apply to the text in this manual:

- Ordinary text is in Times New Roman.
- Titles of chapters, other manuals and other publications are in *italics*.
- Labels and identifiers appearing on the equipment described in this manual are in Arial.
- Menu items, buttons, and other contents of computer displays are in *Arial italics*.
- Names of files, drives, paths and directories are in `Courier New`.
- Signal names are in Times New Roman, SMALL CAPS.

Use of symbols Where applied, the following symbols have the meanings below:

This symbol declares that the equipment passes the relevant clauses of EU directives on safety and EMC emissions; see the certificate reproduced on page 41.

Observe precautions against electrostatic discharge.

The CED Micro1401-3 is lead-free and conforms to the EU RoHS directive.

The CED Micro1401-3 is subject to the EU WEEE regulations and may be returned to CED for recycling.

Attention, consult accompanying documents.

The DC symbol indicates that the Micro3 chassis is powered from a DC-only supply.

The earth symbol indicates a metallic contact at mains earth potential.

Micro1401-3 v earlier Micros

The Micro1401-3 is an updated and enhanced version of the previous Micro1401 mk II. Improvements include:

- Updated computational core, running at 90 MHz
- Internal memory increased to 4 Mbyte SDRAM
- 16-bit DACs replace 12-bit DACs
- Analogue supply rails raised from ±12 V to ±15 V, to give improved performance in ±10 V range
- Voltage range on ADC and DACs selected by the user
- Extended synchronization options
- DC power switch relocated to front panel

In this manual 'Micro3' is frequently used as an abbreviation for 'Micro1401-3'. '1401' by itself is used generically, to mean any member of the CED Micro1401 or Power1401 families.

Potential for Radio/Television Interference *(USA only)*

The Micro1401-3 generates and uses radio frequency energy and may cause interference to radio and television reception. Your Micro3 complies with the Specification in Subpart J of Part 15 of the Federal Communications rules for a Class A computing device. These specifications provide reasonable protection against such interference in a residential installation. However there is no guarantee that interference will not occur in a particular installation. If the Micro3 does cause interference to radio or television reception, which can be determined by turning the Micro3 mains supply off and on, you can try to eliminate the interference problem by doing one or more of the following:

- Re-orient the receiving antenna
- Re-orient the position of the Micro3 with respect to the receiver
- Move the Micro3 away from the receiver
- Plug the Micro3 into a different outlet so that the Micro3 and the receiver are on different branch circuits

If necessary, consult CED or an experienced radio/television technician for additional suggestions. You may find the booklet, prepared by the Federal Communications Commission, helpful: *How to Identify and Resolve Radio/TV Interference Problems*. The booklet is available from the US Government Printing Office, Washington DC 20402, Stock no. 004-000-00345-4.

To comply with FCC rules, Part 15 B Class A Computing device, use only shielded interface cables.

Life support **CED products are not authorized for use as critical components in life support systems without the express written approval of the chairman of the board of directors of CED.**

Life support systems in this context are systems which support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided, can be reasonably expected to result in a significant injury to the user. A critical component in this context is any component of a life support system whose failure to perform can reasonably be expected to cause the failure of the life support system, or to affect its safety or effectiveness.

Fast installation guide

Step1 Install the software first: either your CED application or the CED 1401 installation CD

- CED's software is supported under Windows 98 SE, Windows Me, Windows NT 2000, Windows XP, Vista, and Windows 7

Step 2 Set up your hardware for USB interface:

- Power-up the computer and the Micro3
- Connect the USB cable
- USB hardware is recognized and the correct driver is located automatically

Step 3 Check the installation

- Run TRY1401, set tests *All On*, select *Run Once*
- Test should take ~20 seconds and give no errors

Step 4 Your Micro3 is now ready for use

Introduction This manual will guide you through the initial check and installation of your Micro3. It introduces you to the external inputs and outputs. It also describes maintenance and diagnostic procedures. This manual does not cover Micro3 programming, nor the use of application programs with the Micro3.

Checklist The installation kit for your Micro3 comprises:

- A Micro3, with optional rack-mount kit
- A power brick with attached DC supply cable
- A power brick mains cable, suitable for your country
- A USB data cable to connect Micro3 and computer
- An installation disk to allow you to install and check out your Micro3
- This owners manual

The power brick The power brick will run with no adjustment on any mains voltage from 100 V to 240 V, 47 Hz - 63 Hz, consuming a maximum of 15 Watts. It has no switch, being controlled by plugging in and switching on at the mains socket.

The Micro3 front-panel push-switch actuates an internal relay that switches DC power to the rest of the circuitry. For complete electrical isolation, mains power must be disconnected from the power brick.
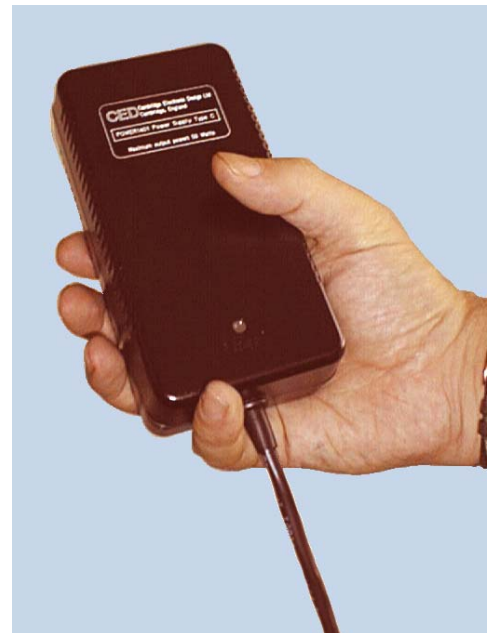
The power brick:
PowerSolve PSE60-312 shown

Confidence check Your Micro3 was soak-tested at CED before shipping. To pass the test, a Micro3 must not generate a single error in at least 96 hours of testing. The next procedure checks that the Micro3 hardware is in the same state as it left the factory.

Ensure that the front-panel DC power switch, marked ⏻, is off (with the button protruding from the panel). Plug the power-brick output cable into the DC Power In socket, but do not connect the data cable. Check that the Mode selector is in position 1. Switch the Micro3 on. The switch button should light red for a few seconds while the yellow LEDs flicker. The button should then turn blue and glow steadily. If this is not the case, turn to *Trouble shooting* on page 35.

Installing the Micro3 Once the Micro3 has passed the confidence check, you should turn to the section that deals with installation for your computer and interface. The remainder of this section deals with general topics. The section starting on page 12 describes the signal inputs and outputs. Following sections deal with expansion options, maintenance and troubleshooting.

Storage and operating environment For a Micro3 the storage and operating temperature must stay within −5° to +50° Celsius, in conditions of non-condensing humidity. Humidity should not exceed 95% saturation. The Micro3 is suitable for continuous operation. The Micro3 is not protected against ingress of water or dust. There are no hazardous voltages inside the Micro3. The Micro3 complies with relevant EU and USA requirements for electromagnetic interference. The Micro3 is subject to the EU WEEE regulations and may be returned to CED Ltd for recycling.

At some point you will choose a permanent position for your Micro3. It is happy in the same sort of environment as suits the host computer. The Micro3 normally stands on its base, but it will work on its side or upside down, if required.

Application software The Micro3 requires application software to run it. Most customers will run CED application programs such as *Signal* or *Spike2*, or products supplied by third parties. Alternatively, you may wish to write your own programs, with the help of the *1401 Language support for MS-DOS and Windows* library and your own computer programming manuals.

Operating platforms We support the 1401 family (including the Micro3) under Windows 98 SE, Windows Me, Windows NT 2000, Windows XP and XP64, Vista and Vista64, and Windows 7.

Installing CED application software CED application software such as *Spike2* or *Signal* is installed separately from a CD-ROM. Typically this will autorun; if it does not, run *setup.exe*. The installation program loads the Micro3 drivers at the same time. The installation guide with the software will give more detailed instructions.

Information on application programs Technical information required to use CED application programs is contained in the software manuals. Technical histories of some of our programs, upgrade information, and in many cases downloadable files, may be found on the CED Web site: www.ced.co.uk.

Information for programmers The 1401 language support kit, for users who wish to program their Micro3 from their host computer, includes the *1401 family programming manual* for detailed descriptions of the 1401 standard command library.

Circuit diagrams Circuit diagrams for the Micro1401-3 can be made available for a fee. Purchasers must sign a non-disclosure agreement.

Overview This section provides an overview on installing a Micro3 on a PC.

To install the Micro3 you will need:

- a Micro3, power brick and mains cable
- a USB cable
- the CED application software disk

The section that follows deals with installing the USB interface. The instructions take you through the software part (installing the Micro3 device driver and utility programs) and the hardware part (making the physical connection between the Micro3 and your computer.

Windows variants PC operating systems are treated as two groups:

- Windows 98 SE and Windows Me
- Windows NT 2000, Windows XP, Vista, and Windows 7

The groups are covered in that order.

Test and diagnostic utilities The *CED 1401 installation* disk includes test and diagnostic programs. They are of great use if something goes wrong, but not essential for normal operation. They are automatically installed at the same time as the device drivers. See page 9 onwards for details of these utilities.

The USB driver You must be running Windows 98 (Second Edition), Windows Me, Windows NT 2000, Windows XP, Vista or Windows 7 in order to use the USB interface. USB is not supported under Windows 95, Windows NT 4, Windows 3.x, or DOS. We describe installation under Windows 98/Windows Me first, then Windows NT 2000, Windows XP, Vista, and Windows 7.

Driver installation Device drivers are supplied on CED applications disks and are loaded at the same time as the application. This is done before the hardware is connected. Drivers can also be found on the *CED 1401 installation* disk, and in CED software directories, e.g. `\Spike2\1401\Windrv`, if you have already installed application software.

Hardware installation Micro3s using the USB interface require a computer with a USB connector, but do not need an interface card. All you have to do is connect the USB cable between the computer and the Micro3.

USB hardware is designed for "hot plugging": with the software installed, and both computer and Micro3 switched on, the USB cable is inserted. This causes the computer to recognize the presence of a new USB device and look for its device driver.

Windows 98 SE, Windows Me The Micro3 should be plugged into a USB port while both machines are powered up. The USB hardware will detect the Micro3, and a message will briefly announce that Windows has detected a new USB device and is looking for its driver. Since this has been installed with the application, it will report that it has found the CED 1401 USB software, and disappear. With the USB driver installed, the Micro3 becomes recognized USB device, and a *1401 interface* icon will appear in the System Device Manager whenever the Micro3 is plugged in and powered up.

System Properties, Device Manager tab
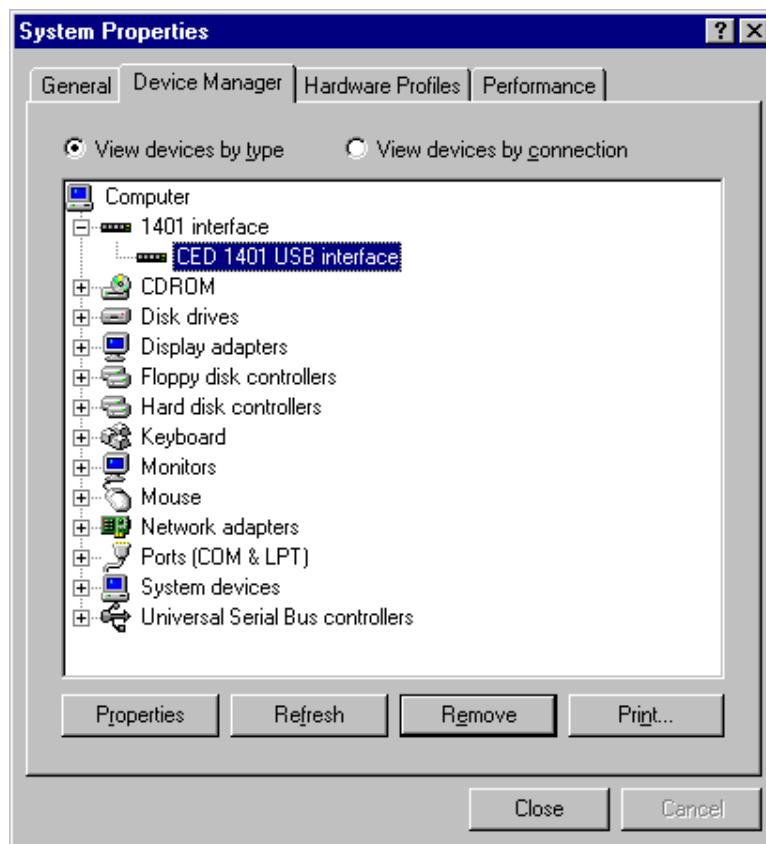
**Tabs in *Properties*** *General* provides overall device status, and allows for enabling/disabling the device. *Driver* lists device driver usage and version information. It has the *Change Driver* button, used to load device driver upgrades. *Resources* details interrupt, DMA and base address usage. From the *Settings* tab you can set the device number of the Micro3, if multiple Micro3s are connected. You can also reset the Micro3 here.

**Windows NT 2000, Windows XP, Vista, Windows 7**

The Micro3 should be plugged into the USB port while both machines are powered up. The USB hardware will detect the Micro3, and a message will briefly announce that Windows has detected a new USB device and is looking for its driver. Since this has been installed with the application, it will report that it has found the CED 1401 USB software, and disappear.

Device Manager, view devices by type
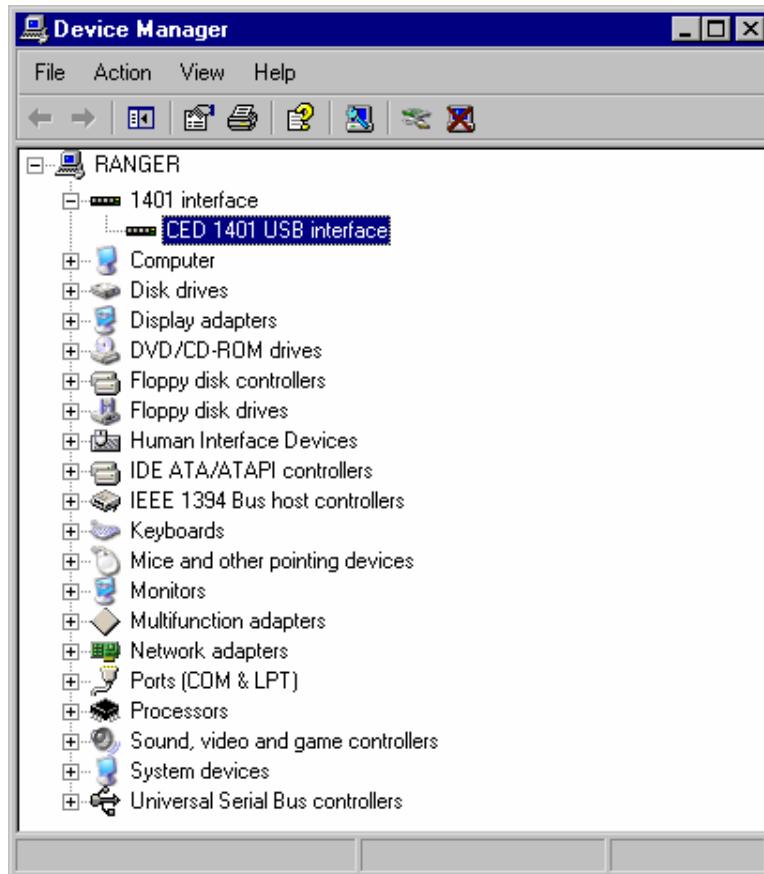
USB interface settings

With the driver installed, the Micro3 becomes a recognized USB device, and the *1401 interface* icon will appear in the Hardware Device Manager whenever the Micro3 is plugged in and powered up. To view the Micro3 USB settings, select

Start, *Control Panel*, *System*.

Double-click on *System*, select the *Hardware* tab and press the *Device manager* button to reveal the hardware devices tree. Click on the + of the *1401 interface* icon to display the *CED 1401 USB interface* icon. Among the tabs revealed when this is opened, the *General* tab provides overall device status, and allows for enabling/disabling the device. The *Settings* tab allows you to set the device number of the Micro3 if multiple Micro3s are connected.

Installing test & diagnostics

CED application disks include test utilities, that verify correct installation of your Micro3, assist in re-calibrating the analogue system, and diagnose hardware problems.

These utilities are installed automatically as a component of CED applications such as *Spike2* or *Signal*. For stand-alone users, they are installed as the Test1401 program group along with the 1401 commands by the *CED 1401 installation* disk.

TRY1401

These utilities are accessed through the *Try1401* icon. This may be found in any of the *Spike2*, *Signal*, or Test1401 program groups, which are accessed via *Start*, *Programs*. To run TRY1401, select
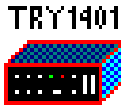
Start, Programs, Spike6, Try1401   or

Start, Programs, Signal4, Try1401   or

Start, Programs, Test1401, Try1401

as appropriate. If at a later date a *CED 1401 installation* disk is run, and it finds that it has drivers or utilities that are newer than those on your system, it will update them.

About TRY1401 TRY1401 is the principal user test program. It simulates a typical Micro3 application program and exercises the host computer and Micro3 in the same way.
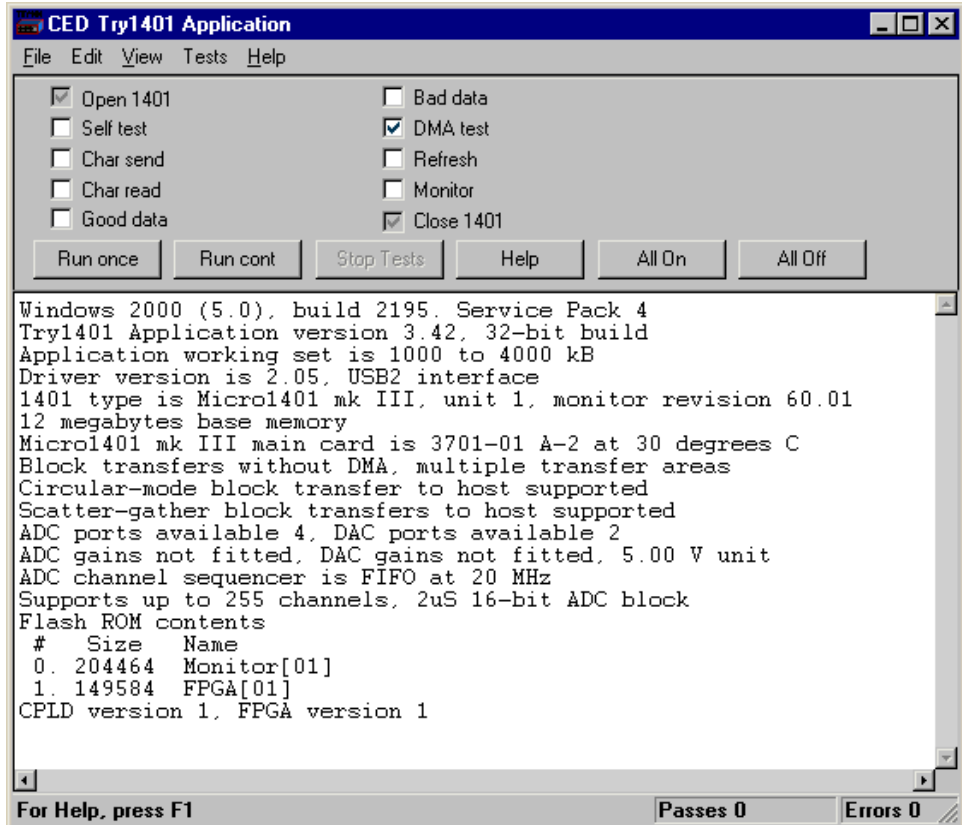
TRY1401 program screen

```
CED Try1401 Application                                    _ □ ×
File  Edit  View  Tests  Help

  ☑ Open 1401              ☐ Bad data
  ☐ Self test              ☑ DMA test
  ☐ Char send              ☐ Refresh
  ☐ Char read              ☐ Monitor
  ☐ Good data              ☑ Close 1401
  [ Run once ] [ Run cont ] [ Stop Tests ] [ Help ] [ All On ] [ All Off ]

Windows 2000 (5.0), build 2195. Service Pack 4
Try1401 Application version 3.42, 32-bit build
Application working set is 1000 to 4000 kB
Driver version is 2.05, USB2 interface
1401 type is Micro1401 mk III, unit 1, monitor revision 60.01
12 megabytes base memory
Micro1401 mk III main card is 3701-01 A-2 at 30 degrees C
Block transfers without DMA, multiple transfer areas
Circular-mode block transfer to host supported
Scatter-gather block transfers to host supported
ADC ports available 4, DAC ports available 2
ADC gains not fitted, DAC gains not fitted, 5.00 V unit
ADC channel sequencer is FIFO at 20 MHz
Supports up to 255 channels, 2uS 16-bit ADC block
Flash ROM contents
 #   Size   Name
 0. 204464  Monitor[01]
 1. 149584  FPGA[01]
CPLD version 1, FPGA version 1

For Help, press F1                          Passes 0      Errors 0
```

Running TRY1401 is self-explanatory. The check boxes allow different aspects of Micro3 function to be tested separately. *Self test* causes the internal self-test hardware to run. You should check this if the DC power switch remains flashing red after the Micro3 has been switched on. By clicking *Run cont*, the selected tests are run continuously, which can be useful for detecting intermittent faults.

1401 info… To access the summary of hardware and firmware information shown in the TRY1401 screen above, select

File, *1401 info…*

DAC & ADC Test
Event & Clock Test If you wish to re-calibrate the analogue hardware, or test the functions of the Clocks or Events, select

Tests, *ADC & DAC Test* or *Tests*, *Event & Clock Test.*

These are tests that the machine cannot do for itself since they require cables to be routed between various connectors, voltages set, etc. The tests are interactive. At each step the user is instructed what equipment is needed, what to do, and what results to expect. Some tests can be caried out solely by connecting cables and digital voltmeters to the Micro3; others require the box to be opened in order to adjust pots. See page 30 for how to take the lid off, and page 32 for the location of adjustable components. Analogue calibration is discused more fully on page 34.

ADC & DAC Test,
Ramp DAC test
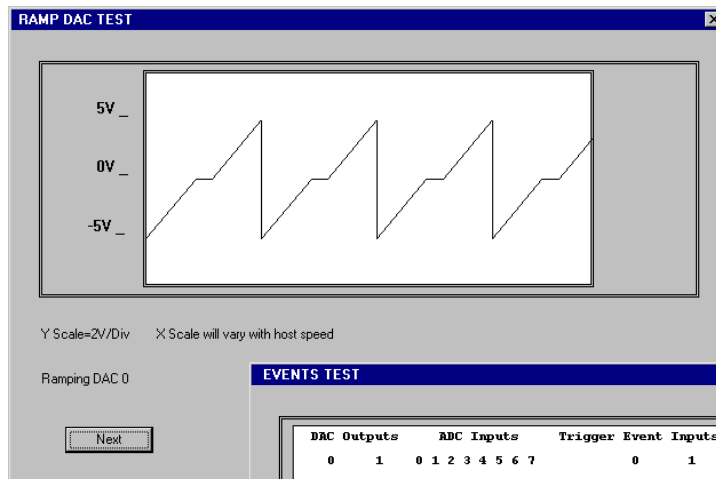
Clock & Event Test,
Events test ➢

Inputs and outputs

General These points relate to physical and electrical aspects of the Micro3 connectors, rather than to their electronic function.

Mains earth The outer sleeves of the front-panel BNCs, and the metal shells of the various rear-panel connectors, are robustly connected to the metalwork of the case, and, via the DC-inlet plug and the earth lead of the power brick, to mains earth. All signal returns are tied to mains earth on the Micro3 printed circuit board. Items of equipment connected to the Micro3 must not be regarded as isolated from mains earth, nor from each other.

Front panel LEDs All front-panel BNCs have adjacent yellow LEDs. These LEDs flash or blink to show appropriate activity, e.g. an ADC input LED lights when its channel is active; a DAC output LED flashes when its channel is updated; digital output LEDs will be lit when their bit is set. LEDs may light to prompt users to make connections. LEDs also flash in a characteristic manner on self test; see page 3.

DC switch LED The front-panel DC power switch first lights red to indicate self-test, then turns blue to indicate normal operation. It starts flashing red if a hardware error has been identified, or glows steadily red if an undiagnosable fault has been detected.

Socketed chips ICs connected directly to the outside world are susceptible to damage from electrostatic discharge or signal overload, though in practice this does not seem to happen very often. The ADC and DAC op-amps are fitted in sockets to allow you to replace them without recourse to unsoldering. See page 30 for opening the Micro3 and page 31 for their location and identification. All such chips are readily-available types; if ordering, specify device codes exactly as detailed to ensure lead-free, insertion-mount parts.

MOSFET protection Digital and event inputs are received by low-voltage chips that are only available in surface-mount style and so cannot be socketed. These chips are protected by MOSFET devices and are safe against moderate overloads of either polarity.

Connector diagrams On the following pages, all rear-panel connectors are drawn as the user sees them, i.e. viewed from the <u>outside</u>. This is also the view of their mating connectors as seen while wiring them up!

Waveform input Waveform input channels are buffered through unity-gain amplifiers. Signals are then steered into the ADC (Analogue to Digital Converter) via a multiplexer. The input sample-and-hold is part of the ADC chip. The ADC converts an input voltage to a 16-bit digital value in approximately 2 µs.

Waveform channels There are four waveform input channels on a standard Micro3, available through front-panel BNC connectors labelled ADC Inputs. The working input range of these channels is ±5 V (the default setting) or ±10 V. You can change the input range using the TRY1401 utility.

Trigger The front-panel input labelled Trigger can be set by software to be the external signal to start the ADC converting. The ADC external convert input is also permanently wired through pin 6 of the rear panel Events D-socket. Conversions are usually initiated by a high-to-low transition. External convert signals are used when the conversion time is determined by an external event, e.g. when synchronizing conversions to the phases of a rotating machine. When operating in internally-triggered mode the ADC typically samples at a fixed rate set by one of the clocks.

ADC LEDs The front-panel waveform input channels each have an associated yellow LED. They are controlled purely by software command and typically are turned on when the channel is in use.

Trigger LED The trigger-input LED flashes on detection of an active-edge transition at the Trigger input. The LED can be set by software to be either on or off during its quiescent state.

Technical details:
Analogue input

The input impedance of the waveform channels is typically 1 MOhm. The waveform inputs expect to be driven from a low-impedance source (100 Ohms or less); the output of most amplifiers is suitable. Waveform inputs are routed through common-mode ferrite chokes to prevent radiation of EMI. The maximum non-destructive input voltage range is ±15 V. If you do overdrive the inputs, it is possible to damage the input buffer amplifiers. The input amplifiers are lead-free, dual-in-line devices, part code OPA604AP. These chips are in sockets for easy replacement; see page 31.

Front-panel
Trigger input

The front-panel Trigger input has a normal working voltage range of 0 V to +5 V. There is MOSFET circuit protection allowing a safe input range of ±10 V, and a common-mode ferrite choke to prevent radiation of EMI. This input is held internally to +5 V by a 47 kOhm resistor and has input hysteresis: the low-going threshold voltage is set at 0·95 V and the high-going threshold at 1·2 V. Pulses driving the trigger input should be 1 μs or longer. To pull this input low, the driving device must be able to sink 100 μA.

Rear-panel ADC
external convert
input

The rear-panel ADC external-convert input is on pin 6 of the Events socket. It responds to TTL and switch closure signals, and has a normal working voltage of 0 V to +5 V. There is MOSFET circuit protection allowing a safe input range of ±10 V. This input is held internally at +5 V via a 10 kOhm resistor. Input pulses should not be narrower than 1 μs and must fall below 0·8 V for guaranteed recognition. Conversion is normally initiated on the high-to-low edge. Use of the other edge can be selected by an internal switch; see page 30.

The ADC

The ADC is a successive-approximation converter with integral sample-and-hold. The input voltage is resolved into 65536 levels (16-bit precision); each step is approximately 150 μV (or 300 μV on ±10 V range).

Waveform output There are two waveform output channels on the Micro3, available through BNC connectors on the front panel labelled DAC Outputs (Digital to Analogue Converters).

The DAC waveform outputs produce voltages in the range ±5 V in steps of approximately 150 μV or ±10 V in steps of approximately 300 μV (16-bit precision). ±5 V is the default setting; you can select the output range using the TRY1401 utility.

Update modes The DACs can be set by program to update in response to an external signal, either the rear-panel Event Clock F input (see page 18), or the front-panel Trigger input, to synchronize the update rate to external equipment. Alternatively, they can be updated at a constant rate from one of the internal clocks; see page 16. When both channels of waveform are output, the Micro3 can be programmed to update the DACs simultaneously. The maximum update rate is in excess of 400 kHz.

DAC LEDs The front-panel waveform output channels each have an associated yellow LED. They are controlled purely by software command and typically turn on when their channel is in use.

Technical details The waveform outputs are designed for driving loads of 600 Ohms impedance or higher, and are short-circuit proof. For full accuracy, the load should not be less than 5 kOhms. There are common-mode ferrite chokes on the front-panel outputs to prevent radiation of EMI. The two output amplifiers are housed in a single lead-free, dual-in-line OPA2132PA. This chip is in a socket for easy replacement; see page 31.

Clocks The Micro3 has five clocks, used for timing and counting external pulses (Clock 0 and Clock 1), generating general purpose timing pulses (Clock 2), controlling waveform output (Clock 3 and Clock 4) and controlling the waveform input sampling rate (Clock 4). These clocks are managed automatically by the application software.

Trigger You may need to drive a clock from an experiment, e.g. to trigger sweeps of waveform sampling. The front-panel Trigger input will be routed by software to the correct clock, to set it running on your signal.

Clock output You may require the application to generate pulses to drive an experiment. The output of Clock 2 is available from the front-panel Clock BNC connector. Frequencies between 500 kHz and 3·55 nHz (one pulse in 8·9 years!) can be generated. The application manual describes this where it is relevant.

Clock inputs Where external signal pulses are to be timed or counted, the application program may use the front-panel Event 0 and Event 1 inputs. Pulses must be 1 μs or wider. If there are more than two such signals, the rear-panel Digital Inputs may be used; see page 22.

Frequency sources All clock frequencies are normally derived from an internal crystal oscillator. Users may sometimes need to take a timing source from outside the Micro3 instead. All the clocks can be driven from an external frequency source via the Clock F input, pin 7 on the rear-panel Events D-socket (see page 18.) When you need to synchronize two 1401 machines, use the synchronization port (see page 24.)

LEDs The trigger and event-input LEDs flash on detection of an active-edge transition. These LEDs can be on or off when quiescent, as set by software command, the latter to indicate that the input is armed and expects to be used. The clock output LED simply turns on whenever Clock 2 is enabled.

Technical details The normal working input range of Trigger, Event 0 and Event 1 is 0 V to +5 V. There is MOSFET circuit protection allowing a safe input range of ±10 V. These inputs are held internally to +5 V by 47 kOhm resistors and have input hysteresis: the low-going threshold voltage is set at 0·95 V and the high-going threshold at 1·2 V. To pull these inputs low, the driving device must be able to sink 100 μA. Pulses driving these front panel inputs must be 1 μs or longer.

Clock is an output, driven by an NC7SZ04MX5_NL single-gate, lead-free surface-mount device that can source or sink 8 mA. Note that, since this is an output device, it cannot have MOSFET protection. If it is damaged, its replacement will involve unsoldering and resoldering. Trigger, Event 0, Event 1 and Clock are routed through common-mode chokes to prevent radiation of EMI.

Event inputs More clock-related inputs, the Clock E series, are provided on the rear-panel Events D-socket. These inputs allow close control of the clocks for people writing their own software. Full details are given in the *1401 family programming manual*, and the *Micro1401-3 technical manual*. The front-panel BNCs Event 0 and Event 1 are often routed by software to the Clock E0 and E1 inputs.

Technical details Clock E and Clock F inputs respond to TTL or switch closure signals, and are held internally to +5 V by 10 kOhm resistors. To pull these inputs low, the driving device must be able to sink at least 500 μA; input pulses must fall below 0·8 V to guarantee recognition. Clock E pulses should not be narrower than 100 ns. Clock F frequency must not exceed 10 MHz; pulses should be wider than 50 ns. The working range of these inputs is 0 V to +5 V. There is MOSFET circuit protection allowing a safe input range of ±10 V.

The Event Out output is buffered by an NC7SZ04M5X_NL single-gate, lead-free, surface-mount device that can source or sink 24 mA. Note that, since this is an output device, it cannot have MOSFET protection. If it is damaged, its replacement will involve unsoldering and resoldering. This signal is normally isolated from the rear-panel socket, to help reduce EMI; a jumper must be inserted to make it available (see page 32.)

The sense of the Clock E and ADC external convert inputs may be inverted by a switch option (see page 30), but the inputs would all then be held active high if no input were connected.

Events socket
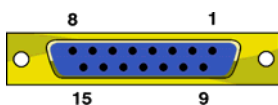
Pin	Function	Pin	Function
1	Clock E0 input	5	Clock E4 input
2	Clock E1 input	6	ADC external convert input
3	Clock E2 input	7	Clock F input for all clocks
4	Clock E3 input	8	Event Out output
9 - 15	Ground	Screen	Mains earth
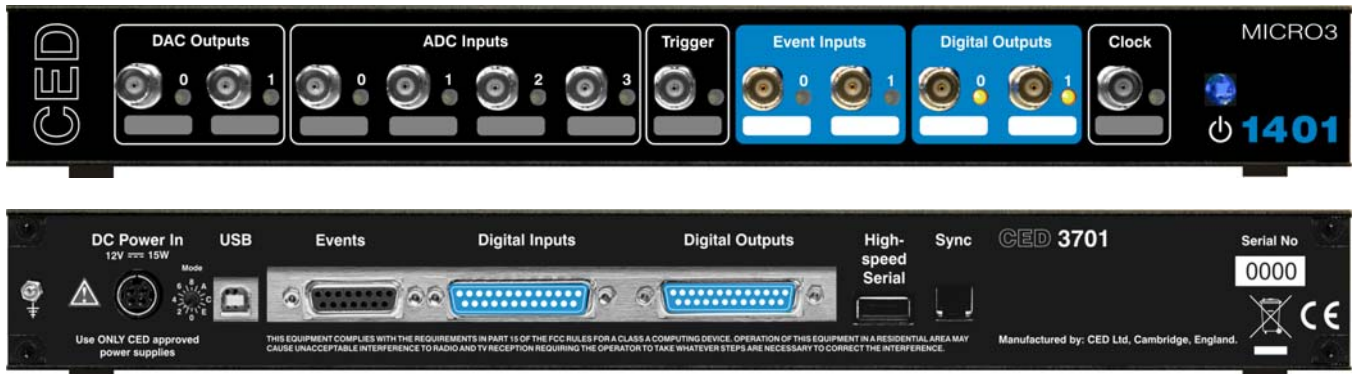
Digital input and output

The Micro3 has full 16-bit digital I/O available on rear-panel D-connectors marked Digital Inputs and Digital Outputs. Bits may be read or written singly, by low or high byte, or by the whole word. High-byte output bits 0 and 1 are also routed to the front-panel Digital Outputs, and, if enabled by software, high-byte inputs 0 and 1 are fed from the front-panel Event Inputs.

The input high byte can be programmed for detection and timing of change of state (i.e. any bit changing either way). Digital output can be gated with clock 2 so that it updates on clock 2 ticks. Digital output is normally permanently enabled, but either byte may be turned tristate-off by software. Grounding pin 11 of the output socket also turns both bytes tristate-off; they are enabled if pin 11 is high or disconnected.

Digital I/O LEDs

Front-panel event-input LEDs flash or blink on detection of active-edge transitions. The quiescent state is set by software command. Front-panel digital-output LEDs simply reflect the state of the bits, being lit whenever their bit is set (high).

Technical details Front-panel digital I/O is routed through common-mode ferrite chokes to prevent radiation of EMI. All digital inputs have MOSFET circuit protection. All outputs are buffered through SN74ACT373 or SN74ACT374 lead-free, surface-mount devices, which can source or sink 24 mA. Note that, since these are output devices, they cannot have MOSFET protection. If they are damaged, their replacement will involve unsoldering and resoldering.

Digital input requirements Unconnected digital inputs read 1, being pulled internally to +5 V by 4k7 (rear panel) or 47k (front panel). Input voltages of more than 2·0 V will always read as logic 1. To read as logic 0, the input must be pulled below 0·8 V, which for front-panel input takes 100 μA, for at least 1 μs; for rear-panel input it takes 1 mA, for least 100 ns.

5 volt output and circuit breaker There is a +5 V output available on pin 25 of both the digital input and output ports. This output is internally protected by a 200 mA circuit-breaker and is intended only to power one or two chips for interfacing purposes. The breaker is reset by removing power from the Micro3.

We have occasionally had problems with users who trip this protection very regularly. This is usually caused by a connector with a metal shroud being plugged into the digital input crookedly and the shroud touching pin 25, which causes overload. If you have this problem, the simple solution is to make this connection with Micro3 switched off, or to use a connector with a plastic shroud.

Digital I/O handshake protocol Digital data transfer between the Micro3 and external equipment can optionally be synchronized by pairs of handshake signals. There are separate pairs for each byte. The polarities of all signals can be independently set by software. The example that follows is typical.
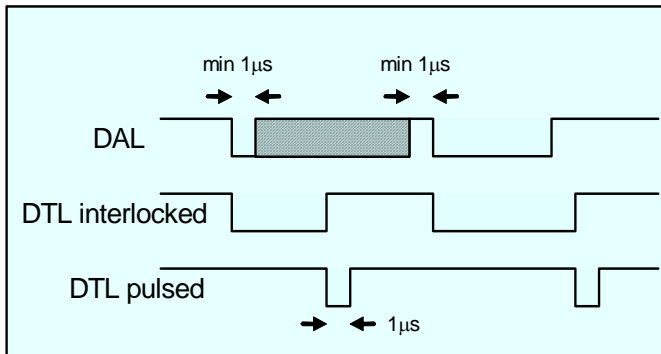

When presenting data, an external device sends a pulse at least 1 µs wide to the DAL (data available 0-7) input. When the Micro3 reads the data the DTL (data transmitted 0-7) output line pulses for 1 µs if in pulsed mode. If in interlocked mode, DTL is set by the Micro3 read and cleared by the next DAL.
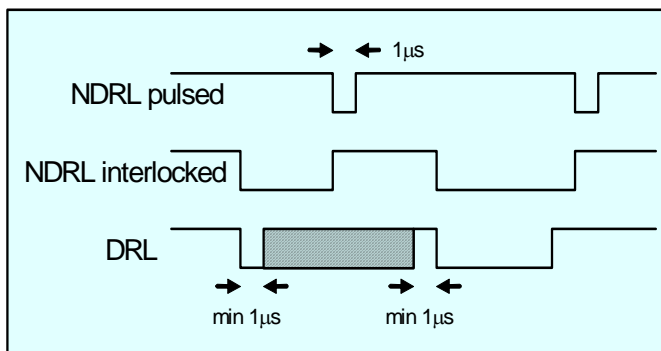
When Micro3 writes data to the digital output, the NDRL (new data ready 0-7) output pulses for 1 µs if in pulsed mode. If in interlocked mode NDRL is set by the data write and cleared by the answering DRL (data read 0-7) pulse, which must be at least 1 µs wide, from the external device.

Digital I/O connectors

Digital input plug
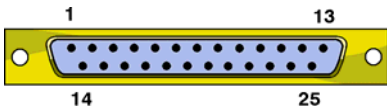
Digital output socket
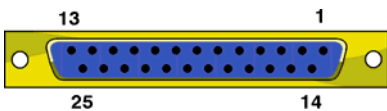
Pin	Output socket		Pin	Input plug	
1	High byte out 7	Word out 15	1	High byte in 7	Word in 15
14	6	14	14	6	14
2	5	13	2	5	13
15	4	12	15	4	12
3	3	11	3	3	11
16	2	10	16	2	10
4	1	9	4	1	9
17	0	8	17	0	8
5	Low byte out 7	Word out 7	5	Low byte in 7	Word in 7
18	6	6	18	6	6
6	5	5	6	5	5
19	4	4	19	4	4
7	3	3	7	3	3
20	2	2	20	2	2
8	1	1	8	1	1
21	0	0	21	0	0
9	DRH Data received 8-15 i/p		9	DTH Data transmitted 8-15 o/p	
22	User i/p (buffered, reserved)		22	Not connected	
10	User o/p (buffered, reserved)		10	Not connected	
23	NDRL New data ready 0-7 o/p		23	DAL Data available 0-7 i/p	
11	Output enable i/p		11	Not connected	
24	DRL Data received 0-7 i/p		24	DTL Data transmitted 0-7 o/p	
12	NDRH New data ready 8-15 o/p		12	DAH Data available 8-15 i/p	
25	+5V (200mA maximum)		25	+5V (200mA maximum)	
13	GND		13	GND	
Shell	Mains earth		Shell	Mains earth	

USB port The USB port is for use with the USB protocol. Data transfer rates are less than 1 MByte/sec for USB 1; for USB2, rates are up to 7·8 MByte/sec for transfers to the Micro3 and up to 14·5 MByte/sec for transfers from the Micro3.

USB socket The USB port is a style B socket on the rear panel. USB_DATA+ and USB_DATA- transmit the serial data as a differential pair. USB_GND is conn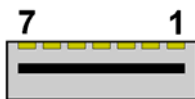ected to system ground via a choke. USB_+5 V is used as a cable sense input, also via a choke; +5 V applied to this pin indicates that the USB cable is inserted. The Micro3 is specified to meet European and US EMC regulations only if used with braid-screened cables supplied by CED.
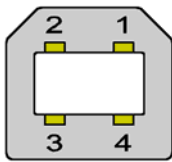
Pin	Function
1	USB_+5v (cable detect)
2	USB_DATA+
3	USB_DATA-
4	USB_GND (to system ground)
Shell	Mains earth to cable screen

High-speed Serial Link The High-speed Serial Link provides an alternative means for communicating with the host computer. A PCI interface card, the CED 1401-80 is required, and a PCI bus slot on the host motherboard. At present this port is used for test purposes only.

High-speed Serial Link socket

The High-speed Serial Link connects to the Micro1401-3 via a socket in the rear panel. One differential pair transmits data in each direction. Pre-formed, shielded cable must be used in order to meet European and US EMC regulations.

Pin	Function
1	Ground
2	RX+
3	RX-
4	Ground
5	TX-
6	TX+
7	Ground
Shell	Mains earth to cable screen

Synchronization port

The synchronization port enables two or more 1401s (Power or Micro in any mix, so long as they have synchronization ports) to be synchronized, so that there is absolutely no drift in timing between units.

Synch socket

The Synch socket is an RJ21 connector with six pins loaded. A screened cable is daisy-chained from unit to unit, and the "master" end of the cable determines which unit provides the clock frequency. Up to three 1401s may be slaved to the master. The units need to be in close physical proximity, side by side or stacked. If more than four 1401s need to be synchronized, the user should consider the CED 3301 external synchronization unit.
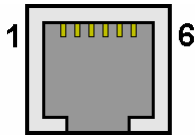
Pin	Function
1	MHZ_TR$_x$−
2	MHZ20_IN−
3	MHZ20_IN+
4	MHZ20_OUT−
5	MHZ20_OUT+
6	MHZ_TR$_x$+
Screen	Mains earth

Owing to the depth of the rear panel metalwork, removal of the synch cable requires the use of a jeweller's screwdriver (or similar tool) to access the RJ21 release lever.

DC power inlet

The power brick is a switch-mode regulator that provides a nominal 12V DC. This is regulated internally to generate the required voltage rails. The regulator will accept voltages in the range +9 V to +18 V, so the Micro3 will run off a car battery.

An internal relay controlled by the front-panel pushbutton switches both +12 V and 0 V. When inserting the DC supply plug, initial contact is made by mains earth when the sleeve engages the DC inlet screen. Mains earth also makes contact via a pin at the same time as the +12 V and 0 V pins.
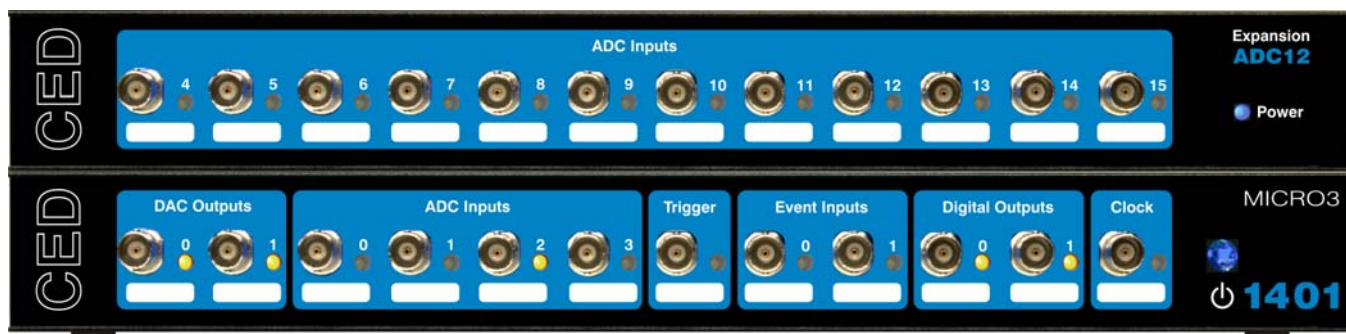
DC power socket
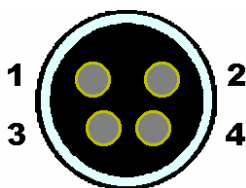
Pin	Function
1	+12 V
2	0 V
3	SPARE
4	Mains earth
Shell	Mains earth to cable screen

The unexpanded Micro3 will consume approximately 0·8 A at 12 V. This can rise to up to 1·3 A if the Micro3 is fitted with top-boxes.

The ADC12 top-box: 12 waveform inputs The four waveform input channels may be expanded by adding the ADC12, an expansion card with twelve extra channels, which become ADC channels 4-15. A second expansion unit may be added, to provide channels 16-27. Once the Micro3 is told about the extra channels by the installation program, the new ones may be freely used just like the basic set. Attempts to read unimplemented channels either cause the software to report errors, or the ADC is mapped onto an internal ground point, depending on the program.

The ADC inputs are of identical design to the ones on the main unit, with an input range of ±5 V (optionally ±10 V), and a maximum non-destructive input range of ±15 V. All signals pass through common-mode ferrite chokes to reduce radiation of EMI. Each waveform input has a yellow LED that functions in identical manner to those on the motherboard. The expansion card makes internal connections to the Micro3 motherboard and is housed in the same metal can. This card, designated the 3001-03, requires the Micro3 expanded mechanics (can and case) and it is usually more convenient to send an unexpanded unit back to CED for upgrading than for the end-user to install it.
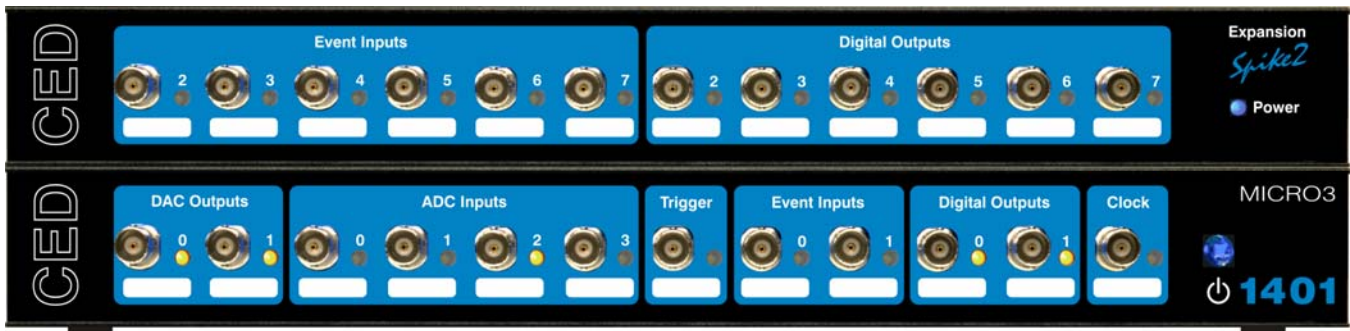
The *Spike2* top-box: digital BNC connections

In some circumstances, such as in many *Spike2* applications, the digital inputs and outputs are heavily used for signals. It is convenient to have more of these connectors available on the front panel as BNCs. The *Spike2* expansion card provides six event inputs mapped onto bits 2-7 of the digital input high-byte. Additionally, bits 2-7 of the digital output high-byte are brought out onto six front-panel BNCs.

The safe working voltage range of the digital inputs is ±10 V, and they present an impedance of 47 kOhm, as with the front-panel Event and Trigger inputs. They have input hysteresis: the low-going threshold voltage is set at 0·95 V and the high-going threshold at 1·2 V. The yellow LEDs by each BNC behave in identical manner to the front-panel event inputs and digital outputs. All signals pass through common-mode ferrite chokes to reduce radiation of EMI. The expansion card makes internal connections to the Micro3 motherboard and is housed in the same metal can. This card, designated the 3001-09, requires the Micro3 expanded mechanics (can and case) and it is usually more convenient to send an unexpanded unit back to CED for upgrading than for the end-user to install it.

The Event Expander: 12 event inputs

The Micro3 provides two front-panel inputs, Event 0 and Event 1, that are optimized for counting and timing pulses. There is MOSFET circuit protection allowing a safe input range of ±10 V. Signals are then conditioned by comparators and Schmitt triggers, so that sharp, unambiguous event pulses can be derived even from slow signals.

CED 2501-12, the Event Expander, provides event input on twelve BNCs labelled in hexadecimal from 00 to 0B, which are conditioned similarly to Event 0 and 1. They are processed quite differently, however: the Event Expander operates in conjunction with *Spike2* software. An event on any input generates an 8-bit encoded output that is routed to the Micro3 rear-panel Digital Input, and recorded on a *Spike2* digital marker channel. Minimum time resolution between two events is about 1 μs; each event code takes about 10 μs to transmit. Inputs can be individually set to respond to positive-going or negative-going signals by means of switches accessible from the rear panel. A yellow LED next to each input will flash to indicate the detection of an event.

Event codes are transmitted to the Micro3 via an external ribbon-cable from a rear-panel D-plug labelled To 1401 Dig In. There is a second D-plug, Dig In Expansion, allowing for the daisy-chaining of additional Event Expander units. The event BNCs on the second unit are labelled 0C to 17, and so on. Up to thirteen units may be daisy-chained, in which case the highest input would be 9B (i.e. 155). The second digital input can also be used to accommodate ordinary digital input signals, so long as they are held tri-state off whenever the Event Expander is in use.

The Event Expander is supplied in a single-height unit uniform with the Micro3, with its own power supply.
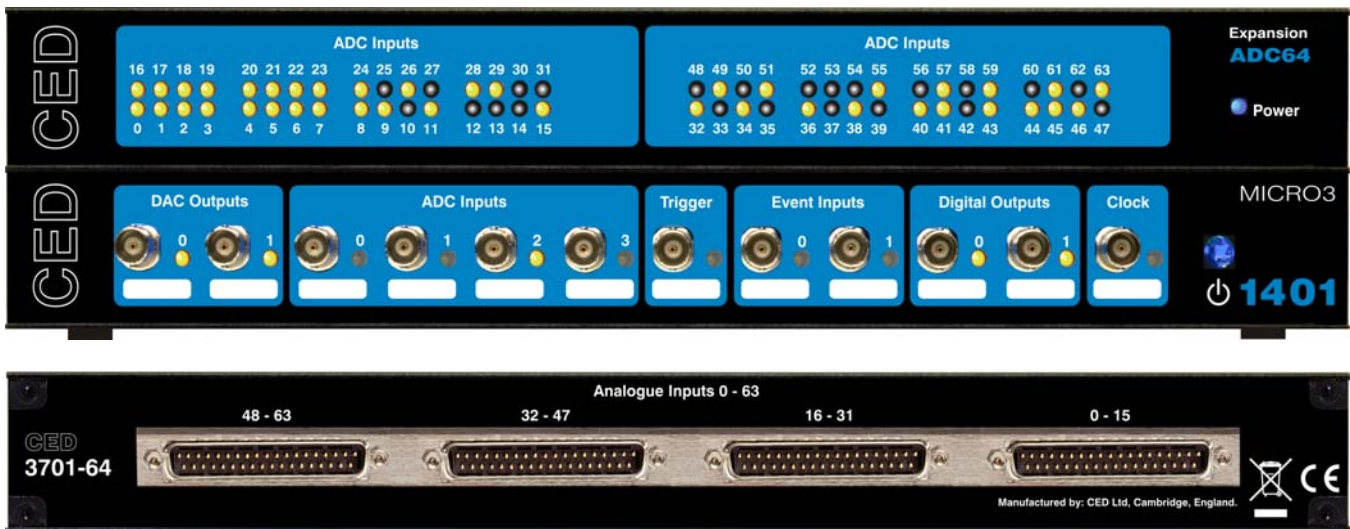
The 64-channel card: 64 differential inputs

The ADC64 provides sixty-four channels of waveform input on one card, for users requiring many inputs. A Micro3 can accommodate two such cards, allowing 128 channels of waveform input to be sampled on one machine. (The base-unit ADC channels cannot be used at the same time as the ADC64.)

The ADC64 uses instrumentation amplifiers, so the input is intrinsically differential; however, by grounding the inverting inputs, they can be operated in single-ended mode. Channel gains are set during manufacture, by gain-defining resistor, typically to between unity and ×10. The voltage input range is the same as is set for the original ADC inputs. Note that, because these channels are multiplexed and routed to the ADC on the motherboard, the maximum waveform conversion rate will be a little slower than in an unexpanded unit, on account of the extra capacitance; a full sweep of sixty-four channels will take on the order of 160 μs.

Input is by way of four 37-way D-type sockets mounted on the back panel. The front panel accommodates sixty-four LEDs that indicate the channels in use. The maximum non-destructive input range is ±15 V. All signals pass through ferrite chokes to reduce radiation of EMI. The expansion card makes internal connections to the Micro3 motherboard and is housed in the same metal can. This card, designated the 3701-64, requires the Micro3 expanded mechanics (can and case) and it is usually more convenient to send an unexpanded unit back to CED for upgrading than for the end-user to install it.

16-channel waveform input connectors

Waveform input socket
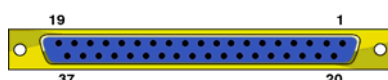
Pin	1st unit	0-15 / 4-19	16-31 / 20-35	32-47 / 36-51	48-63 / 52-67
	2nd unit	64-79 / 68-83	80-95 / 84-99	96-111 / 100-115	112-127 / 116-127*
1		A	A	A	A
2		Ch 0–	Ch 16–	Ch 32–	Ch 48–
3		Ch 1–	Ch 17–	Ch 33–	Ch 49–
4		Ch 2–	Ch 18–	Ch 34–	Ch 50–
5		Ch 3–	Ch 19–	Ch 35–	Ch 51–
6		Ch 4–	Ch 20–	Ch 36–	Ch 52–
7		Ch 5–	Ch 21–	Ch 37–	Ch 53–
8		Ch 6–	Ch 22–	Ch 38–	Ch 54–
9		Ch 7–	Ch 23–	Ch 39–	Ch 55–
10		Ch 8–	Ch 24–	Ch 40–	Ch 56–
11		Ch 9–	Ch 25–	Ch 41–	Ch 57–
12		Ch 10–	Ch 26–	Ch 42–	Ch 58–
13		Ch 11–	Ch 27–	Ch 43–	Ch 59–
14		Ch 12–	Ch 28–	Ch 44–	Ch 60–
15		Ch 13–	Ch 29–	Ch 45–	Ch 61–
16		Ch 14–	Ch 30–	Ch 47–	Ch 62–
17		Ch 15–	Ch 31–	Ch 47–	Ch 63–
18,19		A	A	A	A
20		Ch 0+	Ch 16+	Ch 32+	Ch 48+
21		Ch 1+	Ch 17+	Ch 33+	Ch 49+
22		Ch 2+	Ch 18+	Ch 34+	Ch 50+
23		Ch 3+	Ch 19+	Ch 35+	Ch 51+
24		Ch 4+	Ch 20+	Ch 36+	Ch 52+
25		Ch 5+	Ch 21+	Ch 37+	Ch 53+
26		Ch 6+	Ch 22+	Ch 38+	Ch 54+
27		Ch 7+	Ch 23+	Ch 39+	Ch 55+
28		Ch 8+	Ch 24+	Ch 40+	Ch 56+
29		Ch 9+	Ch 25+	Ch 41+	Ch 57+
30		Ch 10+	Ch 26+	Ch 42+	Ch 58+
31		Ch 11+	Ch 27+	Ch 43+	Ch 59+
32		Ch 12+	Ch 28+	Ch 44+	Ch 60+
33		Ch 13+	Ch 29+	Ch 45+	Ch 61+
34		Ch 14+	Ch 30+	Ch 47+	Ch 62+
35		Ch 15+	Ch 31+	Ch 47–	Ch 63+
36,37		A	A	A	A
Shell		Mains earth	Mains earth	Mains earth	Mains earth

A = analogue ground   * channel number cannot exceed 127

Maintenance operations

Introduction   The Micro3 requires very little maintenance. This section covers simple operations that may occasionally require opening the case, such as setting the internal options switch or replacing damaged I/O chips. There is also a discussion on updating the flash ROM and re-calibrating the analogue system.
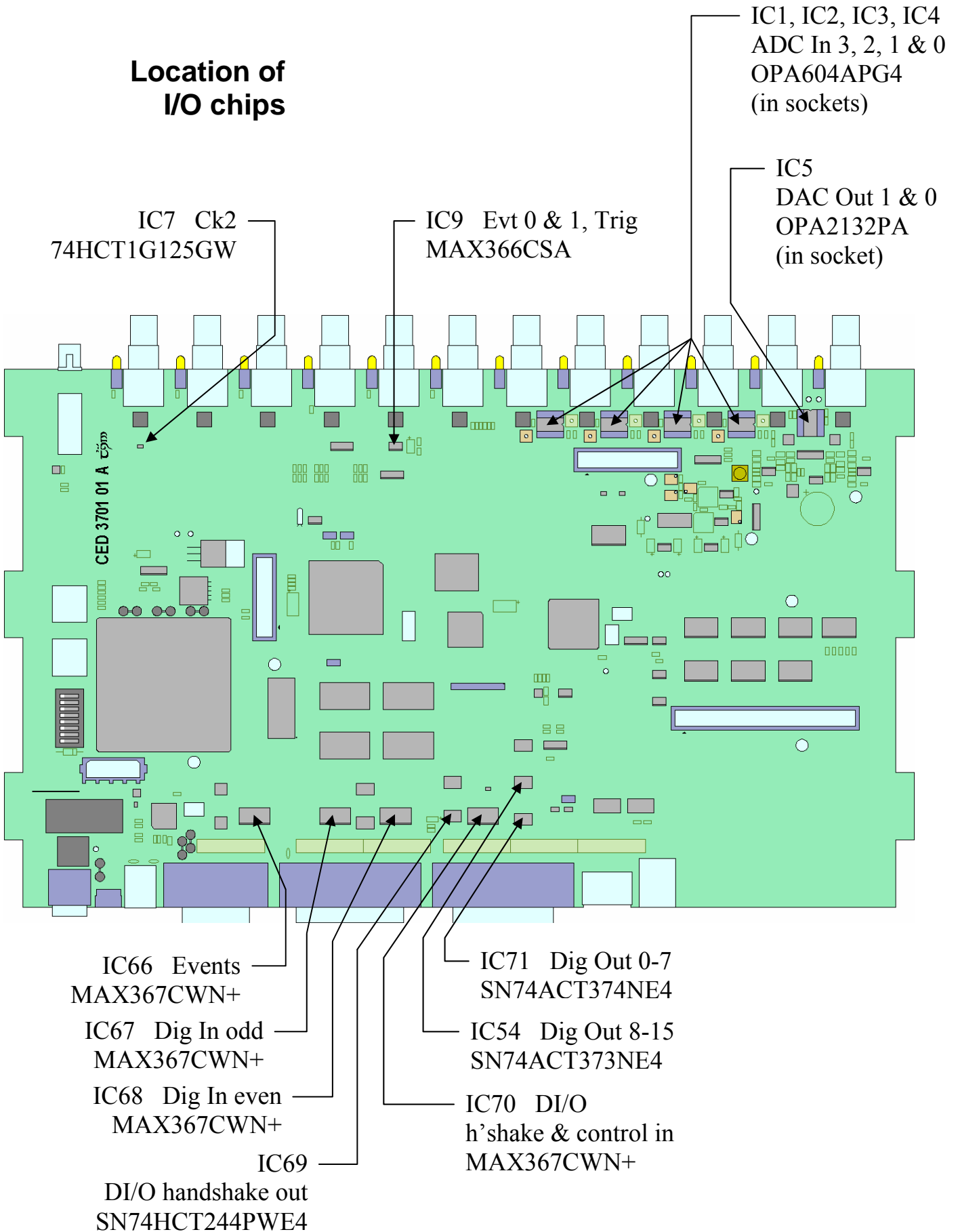
Taking the lid off   The Micro3 top cover is held in place by the back panel. To free the back panel, unscrew the four M3 screws at the corners with a 2 mm hex wrench. Swing the back panel away. There is no need to detach the green & yellow earth wire. Slide out the top cover. Be careful not to splay the sides; the case loses much of its rigidity once the back panel is off.

The inner can is now visible. Slide the can out to the rear, unplugging the green & yellow earth wire that plugs in a short distance along the side. Remove the lid by unscrewing the six small screws with a 1-pt Pozidriv screwdriver and gently pulling it up and off. Note the graphite-impregnated gasket strips: store them somewhere safe, since they are quite delicate. To close the Micro3, simply reverse this procedure.

Switch settings   This diagram shows the internal options switch settings on the Micro3. Logically, On counts as 0, Off as 1. Most options concern self-test and debug. Normally, all switches must be On, physically towards the edge of the PCB, as shown.

SW2 OPTIONS

8		1 = Loop mode on start
7		1 = Long mem test & test on each pass
6		1 = Special DigI/O & Event cables fitted
5		1 = No wait for host h'shake on power up
4		1 = Invert ADC ext conv & Event i/ps
3		1 = Tristate digital outputs
2		1 = Show serial line output during test
ON 1		1 = Continuous self-test

**Location of
I/O chips**

IC1, IC2, IC3, IC4
ADC In 3, 2, 1 & 0
OPA604APG4
(in sockets)

IC5
DAC Out 1 & 0
OPA2132PA
(in socket)

IC7   Ck2
74HCT1G125GW

IC9   Evt 0 & 1, Trig
MAX366CSA

CED 3701 01 A

IC66   Events
MAX367CWN+

IC67   Dig In odd
MAX367CWN+

IC68   Dig In even
MAX367CWN+

IC69
DI/O handshake out
SN74HCT244PWE4

IC71   Dig Out 0-7
SN74ACT374NE4

IC54   Dig Out 8-15
SN74ACT373NE4

IC70   DI/O
h'shake & control in
MAX367CWN+

Adjustable components & other features

UART2, debug (above)
UART1, boot (below)

Expansion power plug

ICE debug

Chan gain pots (if fitted) (3 left, 0 right)

Chan offset pots (3 left, 0 right)

VR12 10V gain trim

VR11 ADC offset

VR10 ADC gain

VR9 10V offset trim

CED 3701 01 A ©

Options switch Position 1 at bottom

DC power relay

Earth tag

Clock out link

Event & digital I/O breakout headers (if fitted)

Digital expansion header

Analogue expansion header

Flash ROM and the Micro3 Firmware

The Micro3 stores its firmware in non-volatile flash ROM, which is organized into 18 blocks. The primary boot loader, the power-on self-test (POST), and the monitor (the operating system) are stored in block 0; the FPGA configuration image is stored in block 1. The primary boot loader loads this firmware on power-up, so long as the rear-panel Mode switch is in position 1. Alternative boot loader, POST, monitor and FPGA firmware can be stored in blocks 2 and 3, and loaded by setting Mode to position 2.

Memory block update report
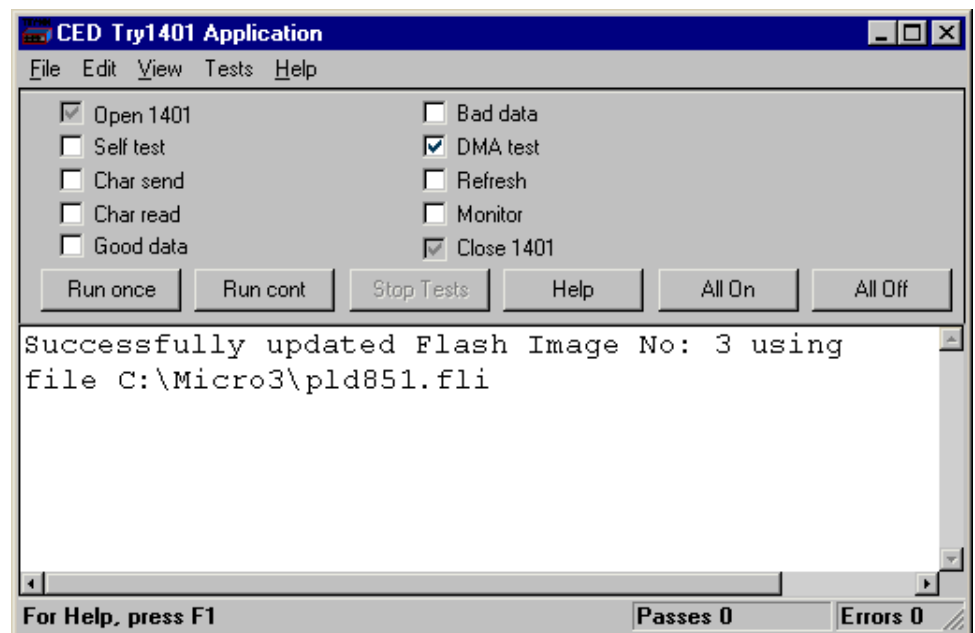
Upgrading firmware with TRY1401

You can upgrade the firmware by writing new files into flash ROM with the TRY1401 utility. You will need valid flash image files with .fli extensions, typically downloaded from CED's website, www.ced.co.uk. Further information comes with the download; it is important to read this before upgrading.

Open TRY1401 (see page 10); from the *File* menu select *Update Flash*. The new firmware does not overwrite the old, so the original set is still there in case of disaster, e.g. power failure during the few seconds taken to write the file. The contents of the flash ROM can be viewed in TRY1401, via *File, 1401 info…*

To use the new firmware, set Mode to 2 and switch the DC power off and on again.

Analogue calibration

ADC & DAC Test, a calibration utility found in the *Tests* menu of TRY1401, is used to calibrate the ADC inputs. This involves opening the Micro3, since the ADC trimming controls are manually-adjusted potentiometers (see page 30 on taking the lid off.) Before we ship your unit, we run this program and set the waveform system to an accuracy of approximately 0·5 mV, or three least significant bits (LSBs). On a ±5 V range, one 16-bit LSB corresponds to only 150 µV, which is of the same magnitude as the drift caused by the normal ageing of components. Therefore, if accurate voltage measurement is important to you, we suggest that you calibrate your Micro3 ADC against a known standard as part of your experimental protocols, and check the absolute accuracy once every six months. We find that most units drift by less than 32 LSBs (0·05%) over this period.

Equipment required

To make use of this program you will need a 1·4 mm flat-bladed jeweller's screwdriver, a few BNC-to-BNC cables and a BNC tee-junction, and an accurate digital voltmeter (DVM) with a resolution of 10 µV on the ±5 V range. It is most important that you allow the Micro3 to warm up with power on for at least 30 minutes before you start the calibration, to allow the system to reach thermal equilibrium.

Caveat

It has to be said that calibration is a complex, demanding and tedious job. You may well prefer to return your Micro3 to CED for calibration. See page 36 for advice on sending it back.

Running ADC & DAC Test

ADC & DAC Test is an option inside the Tests menu of TRY1401. See page 9 for ways of entering this program. *ADC & DAC Test* is a sequence of dialogue boxes. Each box lists the equipment required and the instructions for that stage of the calibration. The aim of the task is to calibrate the DACs against the DVM, then calibrate the ADC against the DVM using voltages generated by DAC0.

Electrostatic precautions

When working inside the Micro3 take precautions against static electricity. The case is connected to mains earth via the power cable; earth yourself to the case, preferably via a wrist strap.

Trouble shooting

Overview The Micro3 has comprehensive built-in self-test capabilities which are backed up by a range of test and diagnostic programs to pin-point problems. If you suspect there is a hardware fault, you should follow the procedures below to obtain as much information as you can about the problem, then call the CED Hardware Help Desk for advice. In the Micro1401-3, op-amps that connect to the outside world via the ADC or DAC channels are socketed for easy replacement; see the diagram on page 31. Often this means the Micro3 need not be returned to CED.

Stand-alone test The simplest test of a Micro3, which eliminates the possibility of a host computer or cable fault confusing the situation, is to disconnect the Micro3 from the host at the Micro3 end of the cable, remove all signal connections and then power-up the Micro3. If all is well, the DC switch LED should turn on red. The BNC LEDs will flash in a characteristic pattern. The DC switch LED should then turn blue and remain so. If the Micro1401-3 behaves like this, yet exhibits a fault in operation, it is likely that the fault lies in the interface cable, in the host computer hardware or in the host computer software.

Running TRY1401 If the DC switch LED begins to flash red, the internal Micro3 power-up self-test has detected a problem. It is likely that TRY1401 will be able to provide details of the problem. You will need to connect your Micro3 to the host computer before running the test. Open TRY1401 by selecting

Start, Programs, Spike6, Try1401   or

Start, Programs, Signal4, Try1401   or

Start, Programs, Test1401, Try1401.

Check the *Self test* box, then click on *Run once*. If no errors are detected it may be worth running continuous self-test (*Run cont*) to pick up any intermittent fault. Inform CED of any reported errors: *File, Send Email…* will create a new email with the report as an attachment (you can also copy and paste.) Our hardware help address is `hardhelp@ced.co.uk`.

If the DC switch LED remains steadily red after power-up, TRY1401 may not be able to help. You should contact CED for advice.

Calling the CED Help Desk If you cannot beat your Micro3 problems yourself, do call our Help Desk. Please email if possible; our email address is:

> `info@ced.co.uk`

Otherwise, our phone and fax numbers are at the front of this manual. If your email has attached files, please ensure that they are less than 1MByte (zipped). To save yourself time, and improve the efficiency of the process:

- Please make a note of the serial number of your Micro3, printed on the back, in the form M 4xxx.

- If the problem is with a program, please make a note of the version number, announced on entry, or in *Help, About…*.

- Make a note of your computer's CPU type and speed, and how much memory you have, (e.g. Intel® Pentium® 4, 3·0 GHz, 1 GByte).

- It is often useful for users to have run TRY1401, so that we know about the hardware state.

Sending it back If you need to send the Micro3 back to CED:

- You must first get a return authorization from CED.

- We advise you to dispatch the machine to us CIF. CED is not responsible for the safety of the equipment until it is inside our premises.

- If you are dispatching from outside the EU, it is essential to call us for advice on the documentation necessary to get your machine through Customs. If you do not provide the correct documentation, it may be subject to additional taxes or duties, be turned back, or even impounded.

- Include a paper description of the problem with the equipment.

- Make sure the packaging is adequate to avoid damage in transit. The original carton is ideal for this.

Index

User notes

Specification

Waveform inputs	Input impedance	1	MegOhm
	Active working range	±5, ±10	Volts
	Safe voltage range	±15	Volts
	Maximum conversion rate	500	kiloHertz
	Resolution	16	bits
	Crosstalk & noise	±3	LSBs up to 200kHz/chan
Waveform outputs	Active working range	±5, ±10	Volts
	Safe drive capability	600	Ohms
	Full accuracy drive	5	kilOhms
	Maximum update rate	400	kiloHertz
	Resolution	16	bits
Clocks	Accuracy & drift, 0-70°C	50	parts per million
Front-panel digital inputs	Input impedance	47	kilOhms to +5V
	Safe voltage range	±10	Volts
	Shortest pulse-width	1	microsecond
	Low voltage	0·8	Volts
	Low current	100	microAmps
Rear-panel digital and event inputs	Input impedance	10	kilOhms to +5V
	Safe voltage range	±10	Volts
	Shortest pulse-width	100	nanoseconds
	Low voltage	0·8	Volts
	Low current	500	microAmps
Digital outputs	Drive capability	±20	milliAmps
Mains Supply	Voltage range	100 to 250	Volts
	Frequency range	50 to 60	Hertz
	Current	0.7	Amps
Case size & weight	Micro3	44 × 217 × 366	millimetres
		2·9	kilograms
	Power brick	42 × 78 × 128	millimetres
		0·45	kilograms
Environment	Temperature range	−5 to +50	°Celsius
	Maximum humidity	95%	Non-condensing

CE
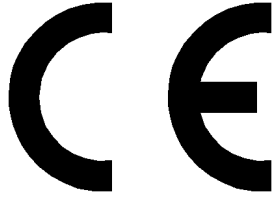
EC Declaration of Conformity

This is to certify that the:

CED Micro1401-3

Manufactured by:

Cambridge Electronic Design Limited
Science Park, Milton Road, Cambridge CB4 0FE, UK
Tel +44 (0)1223 420186

Conforms with the protection requirements of Council Directive 2004/108/EC,
relating to Electromagnetic Compatibility,
by the application of the following harmonized EMC standard:

EN61326-1 (1997) Class B with Amendment 1 (1998)
Amendment 2 (2001)
Amendment 3 (2003) -   COMPLIES

FCC CFR47 (2006) Part 15 Subpart B Class A -   COMPLIES

Signature   *Peter Rice*   Peter Rice
Technical Director

Date   07 May 2009