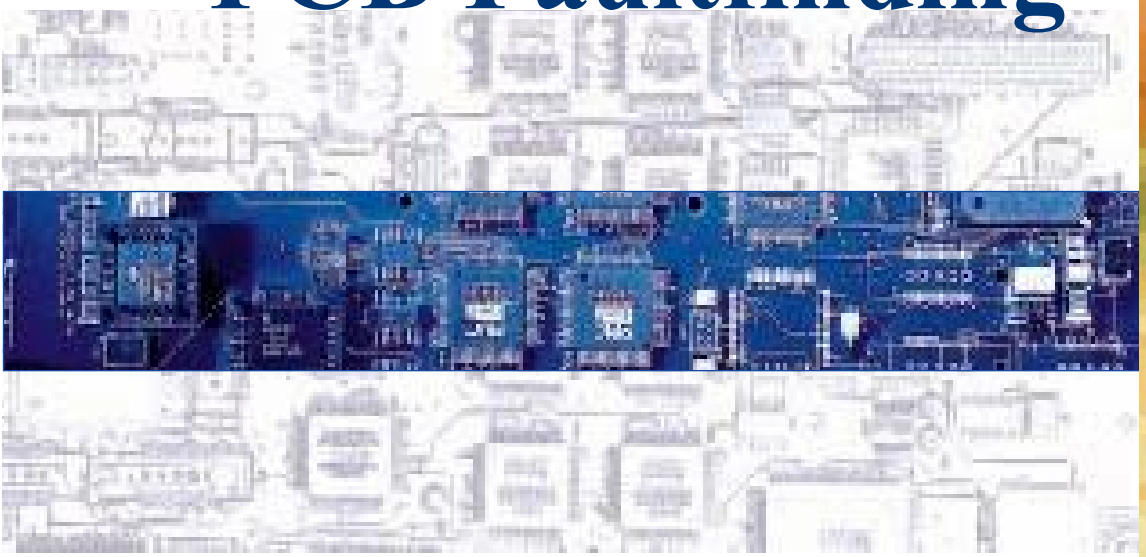
PCB Faultfinding



Manufacturing and
Service Solutions

Polar

www.polar.co.uk

Component Level Faultfinding

Whether you are involved in the manufacture or service of electronic PCBs, there will be faults that you need to locate to component level. Despite the major improvements in component quality and reliability, defects still occur. In practice, the advances in component technology often create special problems if you are involved in the test or repair of PCBs.

Shrinking geometries mean you may be handling components with lead pitches that are difficult to access manually. Modern PCBs are typically multilayer and have become too complex to faultfind using conventional methods.

Locating defective components is a challenge and whilst no solution is 100% effective, the instruments and systems described in this booklet are specifically designed to help you succeed.


PMC
ALTERA
PLX
PORT 3

Faultfinding in Manufacturing & Service

Surface Mount Technology
Modern PCBs are multilayer and contain SMT components with lead pitches of 0.5mm or below. In some cases the components are mounted on both sides of the board. Many of the ICs may be custom and it is not unusual for a PCB loaded with components to have a manufacturing cost in excess of US$2000.

There are specific issues when locating faults on this type of PCB :

- *Having to probe such physically small devices*
- *The technical challenges of faultfinding a highly complex system.*

Testing
Historically, many manufacturers have used in circuit ATE to test PCBs. Changes in technology and shorter production runs are reducing the cost effectiveness of in circuit ATE and there is a move towards using functional test. The cost of ATE fixtures and writing test programs is becoming difficult to justify and the close pitch of many SMT components does not allow test pins to be mounted next to each other.

Once a new board has been debugged, the manufacturing test yields should be high but there will still be a small percentage of PCBs that require component level fault location. Production areas have a post ATE or functional test debug area to identify the defective device.

Old Technology / New Technology
Departments involved in Service have to cater for a wide range of technologies, often spanning a 10 or 20 year period. Although a defective PCB may be of low value, when it is a key part of a larger system, its value becomes as great as the replacement cost of the whole system. Frequently replacement is not an option and repair is mandatory.

Traditional test instruments are ideal as measurement tools but are not designed to locate faults. The use of oscilloscopes and DVMs requires engineers with high skill levels and a working knowledge of the faulty circuit, both of which are often in short supply.

Pre-Production batches / Shorter Production Runs
The frequency of enhancements and changes to most designs results in shorter production runs for many Contract Equipment Manufacturers (CEMs). In addition, manufacturers require a cost effective testing solution for pre-production and prototype batches before the design is finalised and testing procedures have been developed.

- *Traditional test methods are suited to medium/high volume batches and are not cost effective for many of today's applications*

How do you find faults?
As boards have become increasingly complex, full in circuit test of large custom devices has become less effective. Polar uses a simple technique comparing Nodal Impedances of a good board against a board under test. This is effective on typical faults found in manufacturing and service ranging from:

- *DTL (Diode Transistor Logic) control PCBs manufactured over 25 years ago.*

to:

- *Leading edge technology such as GSM base station, multilayer SMT assemblies.*

Companies throughout the world are using Nodal Impedance comparison and its strengths include:

- *Suitable for all types of technology*
- *The circuit under test is unpowered*
- *Ideal for use with Flying Probe Test Systems (i.e. fixtureless test method)*
- *No traditional ATE programming required*

Flying Probe Test Systems
Flying probers allow you to test (faultfind) on PCBs without having to construct a "bed of nails" fixture. They store the physical position of all the PCB components and can automatically probe every connection, comparing the result against a known good result. Their benefits include:

- *No test fixtures required*
- *Can probe SMT devices*
- *Fast set up (can read component positions from CAD data)*
- *Effective on short production runs and pre-production batches*
- *Suitable for post functional ATE debug*

Short Circuits
Shorts are a common problem and easy to diagnose, however their physical position can be very difficult to locate, especially when the short involves a plane on a multilayer PCB. Operators can spend hours trying to identify the cause of the fault as it can arise from either a defective component (e.g. a shorted SMD capacitor) or a physical short on the PCB (e.g. a solder bridge). Experience shows that over 90% of shorts are located on the outside of the PCB, even if they involve an inner layer plane. Many PCBs have been scrapped as "unable to repair" because of an inner layer short when the short was physically present on the outer surface of the PCB.

New techniques have been developed to locate the position of shorts on multilayer PCBs resulting in:

- *Less scrap*
- *Faster repair*
- *Higher quality because of less rework*

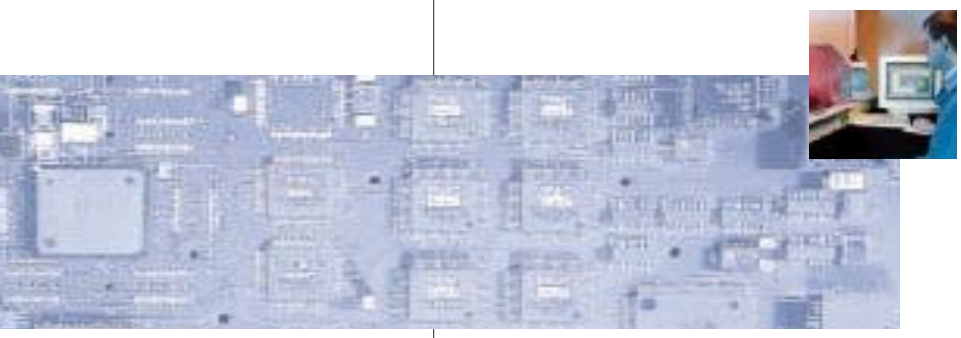
Flying Probe Test System

Robotic Prober Tests PCBs to Component level

Testing PCBs containing SMD devices
The pin spacing of SMDs (surface mount devices) is continually shrinking and this creates many difficulties when trying to test and faultfind PCBs. Some of the leads on ICs are so closely spaced that it is difficult for you to see them with the naked eye. In addition, frequent design changes to PCBs make it difficult for manufacturers to justify the costs or time required for dedicated ATE fixtures.

The Polar Flying Probe Robotic Test System offers you a solution by automatically probing the nodes of a PCB including each of the legs or PCB pads of fine pitch devices. You do not need a dedicated test fixture since the FT100 stores the position of each point to be probed. You simply use the FT100 to automatically probe and learn the response of a golden (good) PCB. Batches of the same type of PCB can then be automatically probed and the FT100 will identify any differences.

If the layout of a PCB changes, there is no fixture to modify as the FT100 software adapts to the new layout (you can also keep the original layout stored for future use).



High Speed Probing, Pinpoint Accuracy and large Z axis travel
The FT100 will test your PCBs quickly (typically 5 tests per second) and accurately (down to devices with 0.4mm lead pitch). Detailed attention to mechanical design includes a highly rigid frame, combined with independent X and Y movements driven by leadscrews.

The FT100's precision engineering ensures long term accuracy with high resolution and repeatability.

The long Z-axis travel of 100mm allows you to test PCBs that contain tall components. The system automatically detects the height of the PCB before commencing the test to ensure correct Z-axis travel and a reliable connection during test.

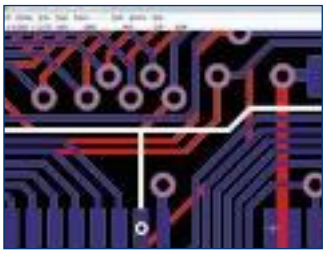
Learning the position of components
The FT100 software contains a library that makes it easy for you to learn the position of components. Using the joystick and camera you can learn the exact position of several pins on a device and the software will automatically interpolate and calculate the position of the other pins.

CAD import
In addition there is optional software that you can use to directly import CAD (Computer Aided Design) data using industry standard FABmaster* software. If you have access to the CAD data for your PCBs, this option will directly import details of all the components and their position on the PCB and considerably reduces the programming time.
**FABmaster supports over 40 CAD systems, full details are on their web site www.fabmaster.com*

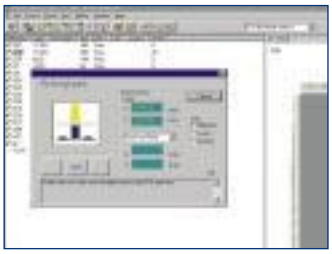
FT100 used with Functional Test Systems
Manufacturers are increasingly using functional test instead of in circuit ATE achieving high first time pass rates once the manufacturing process is established. The FT100 flying probe test system is ideal for component level fault location on the small number of defective PCBs. After the PCB is repaired, it is put back through the functional test to confirm the repair.

Two Position Camera
The FT100 has a camera that automatically adjusts its position depending on whether you are testing a PCB or learning the position of components. During a test, you can see the test pin making contact with the PCB or component. During set up and learning, the camera is used to align the PCB with a crosshair. The camera moves automatically between its two positions unlike many systems that require the operator to make a manual adjustment.

Are there limitations?
Nodal Impedance comparison is not suitable for finding internal functional faults such as wrongly programmed ICs and is not a substitute for functional test.

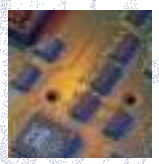


Polar Fabmaster provides FT100 CAD import facilities for over 40 popular CAD formats



Simple commands allow you to fly safely over tall components

The FT100 uses impedance comparison techniques to help you faultfind complex pcbs.



Flying Probe Test System

Safety
The FT100 complies with the latest safety regulations and is CE compliant. It has a safety hood and is fitted with safety switches that automatically stop all movement if the cover is lifted during a test.

Ease of Use
You can learn how to use the operating software in a few hours, as it is simple but highly effective. The FT100 system is based on the well established PFL software used by many hundreds of companies throughout the world and runs under Windows 95, Windows 98 or Windows NT.

Should I consider a Flying Test System?
You can use the table below to see whether a Flying Prober will be of benefit:

	Your Existing Test Method			Should I use FT100?
PCB Volume	In circuit	Functional	Scope, DMM	
Prototype / Pre Production	No	No	Yes	Yes
Low	No	Yes	No	Yes
Medium	No	Yes	Yes	Yes
High	Yes	No	Yes	Maybe
High	Yes	Yes	Yes	No
High	No	Yes	Yes	Yes

Benefits
The FT100 flying probe test system offers you the following:

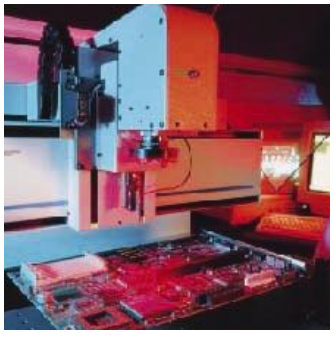
- ❑ *No fixtures or ATE programming*
- ❑ *Minimum delay before testing new designs*
- ❑ *Suitable for short production runs and designs that change frequently*
- ❑ *Effective for pre-production batches*
- ❑ *Successful in post functional test repair station*
- ❑ *Successful fault location in both manufacturing and service environments*

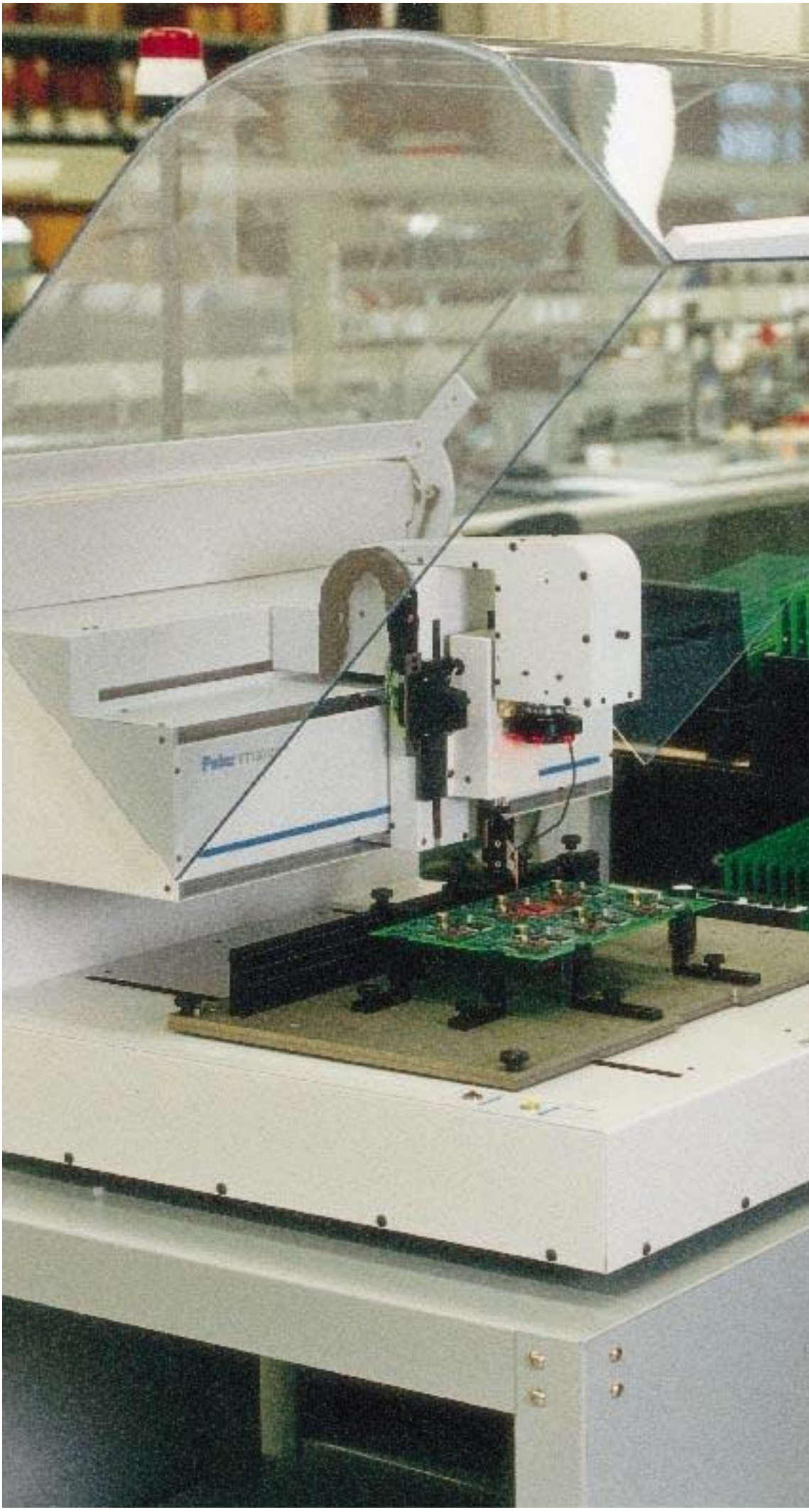
FT100 Specifications

	Metric	Imperial
Probing area (max.)	300x450mm	12”x18”
PCB size (max.)	330x630mm	13”x24.8”
Test speed (typical)	5 tests per second	5 tests per second
Component height (max.)	100mm	4”
Max. Z travel	100mm	4”
Accuracy	+/- 0.04mm over 300mm	+/-1.6 mil, 0.0016” over 12”
Repeatability (typical)	+/- 0.008mm	+/- 0.3 mil, 0.0003”
Resolution	0.016mm	0.6 mil, 0.0006”
Probe pressure	Less than 120gm	Less than 6oz
Dimensions	800x650x524mm	31.5”x25.6”x20.6”
Weight	90kg	200lbs

Camera	Auto positioning mono camera
Prober Interface	PC Custom Interface board supplied (full length, 122mm height inc. edge connector)
Controller	Pentium PC, running Windows 95, Windows 98 or Windows NT, 16Mb RAM, VGA monitor
Approvals	Conforms to applicable European Directives and is CE marked
Acquisition System	Polar PFL760 or PFL780, ordered separately
Standard Accessories	Supplied with external monitor and joystick plus all leads, cables and Operator Manual
Optional Accessories	FABmaster CAD import software, contact us Service Manual, part number MAN173
Nato Stock Number	6625 25 147 5816

Flying Probe Test System





“By introducing Polar Toneohm 950s into our production process, we are able to achieve maximum throughput of quality-approved boards in our repair facility. This has proved to be a sound economic investment for Motorola.”

Barry Hayes
Production Manager, Motorola, UK.

Toneohm 950 Locating PCB Shorts

Multilayer shorts made simple

Locating PCB shorts and bus faults with the Toneohm 950

Have you ever had to spend many hours trying to locate the position of a short on a PCB, or tried to identify which of 10 ICs on a bus is causing contention? Have you ever had to reject a valuable PCB loaded with components because of a short? If the answer is yes to either of these questions, the Toneohm 950 Shorts Locator can help you.

PCBs are becoming increasingly complex and valuable. It is quite common for a modern PCB plus components to have a value of over US$1000.
This makes it cost effective for you to invest a few minutes using the Toneohm 950 to locate the position of a short so that it can be repaired.

Unlike simple milliohm shorts testers, the Toneohm 950 can locate plane to plane shorts e.g. between Vcc and Ground. Even though the planes are internal, you will find that most shorts are on the outside of the PCB and can be repaired. The 950 is equally effective in locating trace to plane or trace to trace shorts.

The benefits of using the Toneohm 950 are:

- *Reduced costs resulting from fewer reject PCBs from shorts*
- *Higher quality because of less rework when locating a short*
- *Improved efficiency because of faster location of shorts*
- *Component level bus fault location*

How are shorts located?

The Toneohm uses a range of techniques allowing a non-technical operator to locate most shorts. VPS (Vector Plane Stimulus), a technique invented by Polar, allows you to locate plane to plane or trace to plane shorts. You attach stimulus leads from the 950 to a shorted plane at or near the corners of the PCB and a reference probe to the other shorted plane or trace.

You then use a roving probe to touch any connection on the stimulated plane and follow the arrows on the front of the 950. Three or four movements of the probe are usually sufficient to bring you to the region of the short.

Trace to trace shorts are located using a pair of probes that are moved along the shorted tracks until you find the lowest display reading (or hear the highest pitch tone from the instrument).

Two other techniques, non-contact current trace and microvolts drop are included. These locate bus faults and low resistance shorts on power supply traces.

Toneohm 950 Specifications

Ease of use
The Toneohm produces an audio tone whose frequency increases as you approach the fault. This allows you to concentrate on the PCB rather than having to look at the readings on the display.

Toneohms
Toneohms have become synonymous with shorts location and Polar invented the first Toneohm in 1974. There are now over 10000 in use throughout the world and the 950 is the latest instrument designed to address multilayer PCBs loaded with SMT and / or conventional through hole components.

TRACK RESISTANCE	Ranges	Ω, 200mΩ, 200Ω, 20kΩ
	Accuracy	6% 200mΩ, 4% in 200Ω, 5% in 2Ω and 20kΩ
	Ω range	High sensitivity uncalibrated, approximately 40mΩ full scale
	Probe voltage	60mV maximum
	Probe protection	±30V
	Indication	Tone and meter on all ranges
TRACK CURRENT	Ranges	200mA, 2A, Trace
	Accuracy	200mA, 2A ±15%
		Reading proportional to current when UNCALIBRATED illuminates.
	Trace	Reading proportional to detected magnetic field strength.
		Capable of detecting current flow with 200Ω across DRIVE SOURCE
	Probe voltage	600mV maximum in 200mA, 2A
	Probe protection	±30V
	Indication	Tone and meter on all ranges
TRACK VOLTAGE	Ranges	2mV, 20mV, 20V
	Accuracy	±4% ±15µV
	Input resistance	120Ω in 2mV, 20mV
		1MΩ in 20V
	Probe protection	±30V
	Indication	Tone and meter on all ranges
PLANE SHORTS	Indication	Tone, digital display and LED fault direction arrows
	Sensitivity	Adjustable to compensate for differing plane resistance
DRIVE SOURCE	Output voltage	0 to 550mV, adjustable
		AC in TRACE, DC in all other modes
		Protected to ±30V
PLANE STIMULUS	Output voltage	550mV maximum
POWER REQUIREMENTS		230V±10% or 115±10% @ 50/60Hz. 25VA
ACCESSORIES (STANDARD)		Detachable needle probes
		Detachable current trace/drive source probe
		Detachable plane probe
		Four detachable colour-keyed plane stimulus leads
		Lightweight headphones
		Operators manual
		All probes stored under hinged cover
APPROVALS		Conforms to applicable European Directives and is CE marked
NATO STOCK NUMBER		Contact Polar Instruments

PFL Fault Locating Instruments and Accessories

Successful Board Repair to Component level

Successful PCB Faultfinding

PFL Fault Locators offer a semi automatic alternative to the FT100 for debugging boards in manufacturing. In addition, service centres find the functional test feature gives added fault coverage in a repair environment, especially when the PCB under test contains a high proportion of 74xx or 4000 Series devices.

Test Methods

The primary method of fault location is Nodal Impedance Test. An AC voltage stimulus is applied to an unpowered PCB and the response is automatically compared with that stored from a known good PCB. Every node on a PCB has a unique signature that is learned and stored in the PC. By comparing the signatures from a defective PCB with those from the known good PCB, the differences will highlight the likely cause of failure. The PFL has a carefully selected range of voltages and frequencies to perform an effective nodal test on most analog, digital and discrete components.

Three terminal devices (e.g. Opto isolators, triacs, SCRs, transistors) are tested using the PFL's Pulser output.

The PFL780 also includes digital in circuit functional test (ICT) where the digital IC inputs are driven using a truth table stored within the PFL library. The outputs from the digital IC are compared to the stored model and advanced simulation software automatically adjusts the stimulus to compensate for IC connectivity. The digital output from a known good board is also learned and stored within the PC for comparison with a board under test.

Since the PCB is only powered by the PFL during a functional test, an IC can have both an ASA test and ICT test automatically run from the same test program.

Ease of use

The PFL is designed to be easy and effective for you to use. You store all the details for each PCB that you test in a unique Testfile. As well as storing the component details and signatures, you are also able to store a picture of the PCB and you can run the tests from the picture.

With the PCB picture displayed, you place the test clip or probe on the highlighted device and then press the foot pedal (or PC mouse) to run the test. A PASS is shown by a green outline around the device, a FAIL is shown by a red outline. The picture makes it very easy to locate components and show you where to place the clip or probe for the next test. The picture also shows the test status of all parts (pass, fail or not yet tested).

FAILed comparisons can result from:

- *Defective component*
- *Board under test switch settings*
- *Ageing components*
- *Different modification levels.*

The PFL is supplied with a foot pedal that lets you run tests without having to use the PC keyboard or mouse. This makes testing far easier as you can concentrate on the PCB and use your hands for holding the test probe or moving the test clip.

Connecting to Components
Whether you are finding faults on older technology PCBs that have DIL (dual in line) components or have leading edge technology with SMT, there are a range of clips and probes to suit your application. There are conventional IC test clips that cover DIL, PLCC and QFP outlines. Additionally you can use Polar SMD and IC probes to fit devices with lead pitches between 0.1" down to 0.4mm. A key feature of these probes is their flexibility as they can be used on ICs with any outline (unlike a conventional test clip that will only fit one outline).

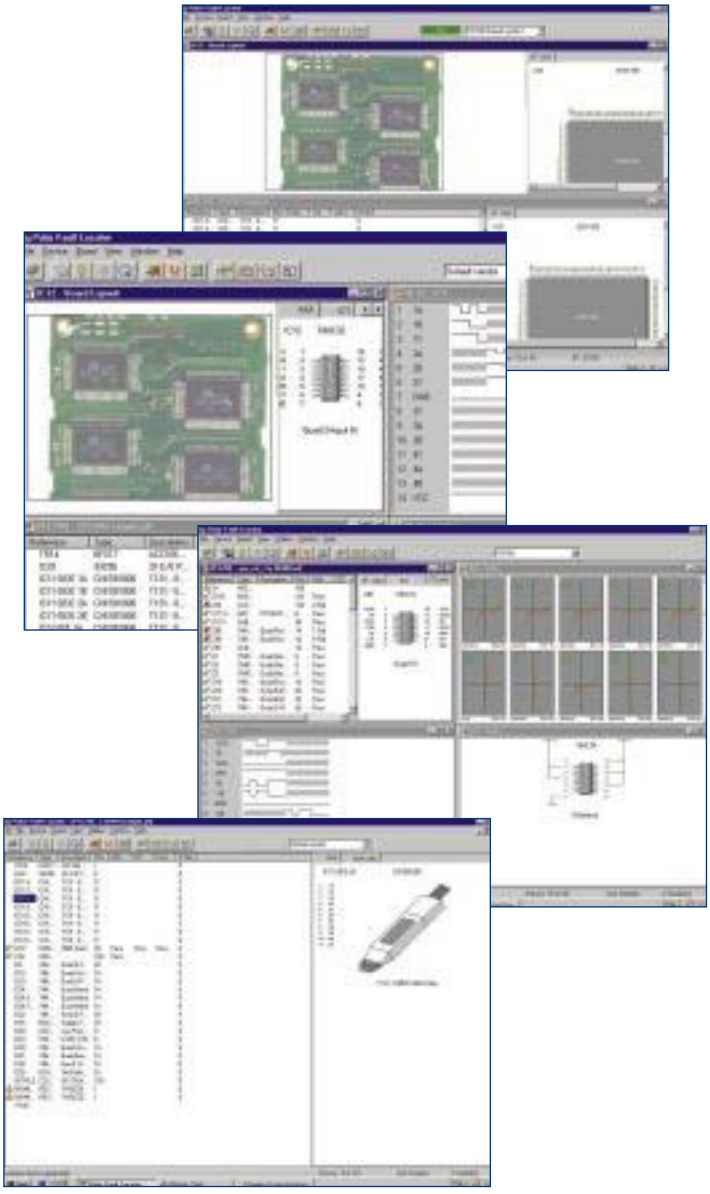
For boards with Conformal Coatings, see Polar Application Note AP116 on our web site **(www.polar.co.uk)**

For users who are regularly testing batches of the same board, a Flying Probe Test System that automatically probes all of the components will be ideal and is described earlier. A Prober is particularly effective for PCBs with a large number of SMDs and will make the test much faster than using manual clips and probes.

Benefits from using the PFL
No instrument will offer you a 100% solution but the PFL has been optimised to give you a cost-effective method of locating faults to component level.

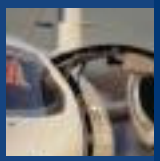
Specific benefits include:

- *Ease of use allowing users to have a wide range of skills*
- *Pictorial test method to guide the user*
- *Comprehensive ASA and ICT (where applicable) testing*
- *Suitable for all types of technology (Legacy systems to SMT)*
- *Proven results in both manufacturing and service applications*



PFL760 and PFL780 Specifications

		PFL 760	PFL 780
TESTS	Analog Signature Analysis (ASA, VI traces)	✓	✓
	In-Circuit Digital Functional Test (ICT)	N/A	✓
	Links	✓	✓
	Quicktest	✓	✓
	LIVE (Virtual Instrument)	✓	✓
CHANNELS	128	✓	✓
TEST RANGES	1V/500µA, 10V/5mA, 10V/150mA, 20V/1mA, 40V/1mA	✓	✓
	90Hz, 500Hz, 200Hz	✓	✓
	TTL, CMOS, user-programmable ICT levels	N/A	✓
PULSE GENERATOR	DC, 0 to ±5V variable, variable width, pulse modes for triacs & SCRs.	✓	✓
USER POWER SUPPLY	5V @ 5A (automatic control)	N/A	✓
GUARDS	4 logic high	N/A	✓
	4 logic low	N/A	✓
LOOP MODES	Loop Continuous	✓	✓
	Loop until PASS	✓	✓
	Loop until FAIL	✓	✓
LIBRARY	Extensive library supplied with instrument	✓	✓
	'Devlib' application supplied as standard, allows user to easily add new device details to library.	✓	✓
DATALOG	PASS/FAIL information stored for each device. Test list may be sorted against Datalog fail rate.	✓	✓
ICT TEST TIMES	Comply with International Defence Standard 00-53/1	N/A	✓
FOOT PEDAL OPERATION	Supplied as standard	✓	✓
PC REQUIREMENTS	Pentium running Windows95, Windows98 or WindowsNT, VGA monitor, RS232 port.	✓	✓
ACCESSORIES (STANDARD)	40-way DIL test clip with lead	✓	✓
	16-way DIL test clip with lead	✓	✓
	Hand-held probes	✓	✓
	Pulser leads	✓	✓
	ICT power leads	N/A	✓
	Foot pedal	✓	✓
	Operator manual	✓	✓
	Power cable	✓	✓
	RS232 cable	✓	✓
ACCESSORIES (OPTIONAL)	Software module for ICT library expansion (part ACC179)	N/A	✓
			✓
APPROVALS	Conforms to applicable European Directives and is CE marked.	✓	✓
NATO STOCK NUMBER	Contact Polar Instruments	✓	✓



Test Clip Packs

ACC139, 10 dual in line clips with leads
0.3" – 8 pin, 14 pin, 18 pin, 20 pin, 22 pin, 24 pin, 28 pin
0.6" – 22 pin, 24 pin, 28 pin

ACC140, 6 dual in line clips with leads
0.3" – 8 pin, 14 pin, 20 pin, 24 pin
0.6" – 24 pin, 28 pin

ACC160, 6 SO & SO(W) clips with leads
0.1" to 0.2" – 8 pin, 14 pin, 16 pin, 20 pin, 24 pin, 28 pin

ACC161, 7 PLCC clips with leads
20 pin, 28 pin, 32 pin, 44 pin, 52 pin, 68 pin, 84 pin

SMD and IC Probes

IC Pitch	IC width	Probe pin count	Probe pin format	Part number	ACC178 pack
Single-in-line					
0.4mm	-	32	single-in line	T141	✓
0.5mm	-	32	single-in line	T140	✓
0.65mm	-	32	single-in line	T137	✓
0.8mm	-	16	single-in line	T139	✓
1.0mm	-	14	single-in line	T136	✓
0.025in	-	32	single-in line	T138	✓
0.050mm	-	11	single-in line	T131	✓
0.1in	-	10	single-in line	T132	
0.1in	-	10	single-in line*	T132/N	
Dual-in-line					
0.1in	0.3in	16	dual-in line	T203	
0.4mm	-	20	dual-in line	T204	
Small outline					
0.05in	-	16	single-in line	T201	✓
0.1in	-	20	single-in line	T202	✓

*flux-piercing pins

Transistors
SOT23 transistor probe ACC166

Custom interface adaptors

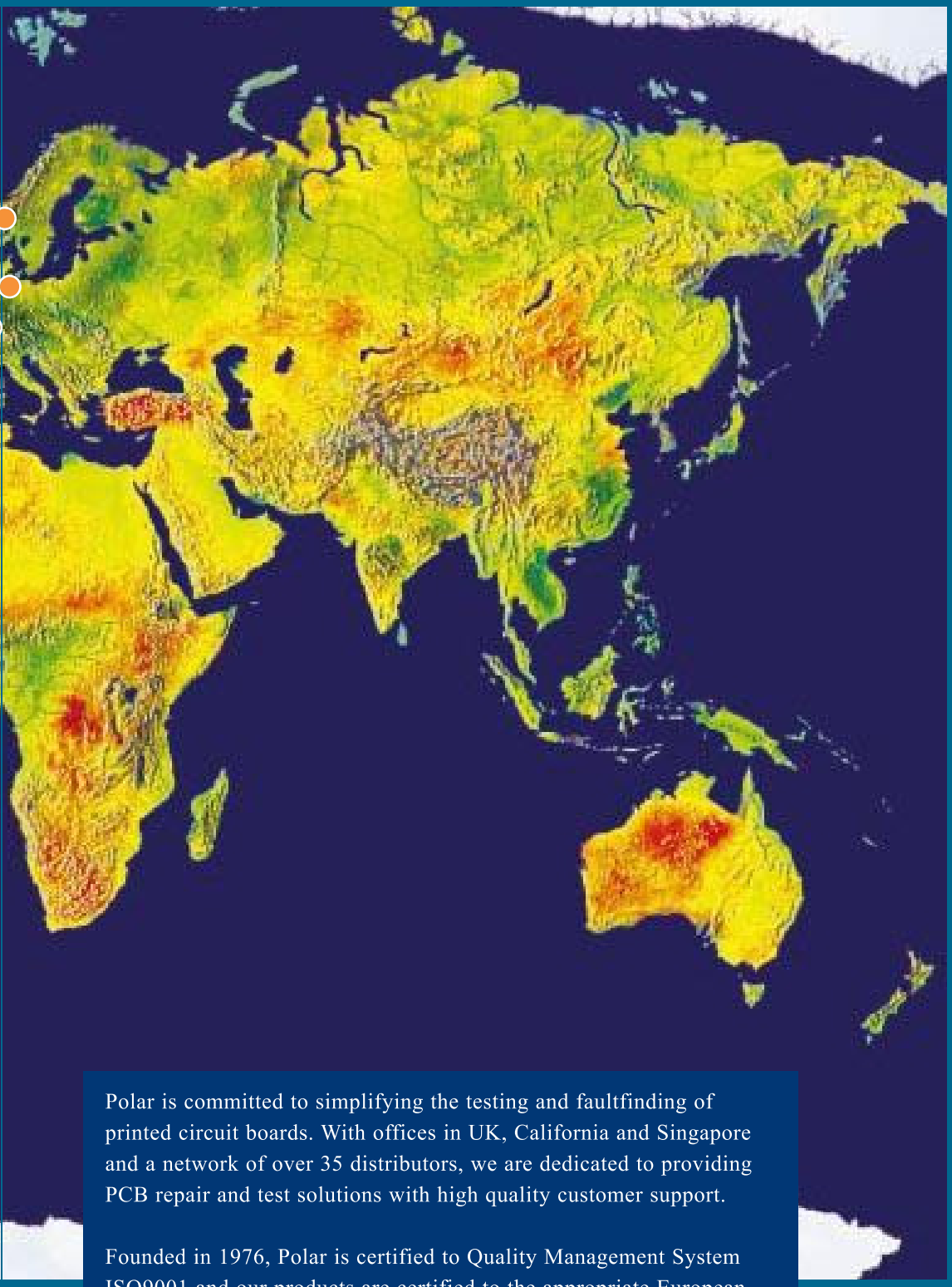
Description	Part number
Five 40-way connectors, enabling five test clips (or equivalent) to be connected to one 40-channel input of an instrument	ACC137
Single 40-way ZIF socket, connecting to one 40-channel input of an instrument	ACC145
Single PCB (210mm x 145mm) with a signal routing matrix, connecting to the two 64-channel inputs of an instrument	T41282
Single PCB (210 x 145mm) with a signal routing matrix and an edge connector for PC ISA cards.	T41283

Polar – a world leader
International companies using solutions from Polar include:

Europe
Alcatel, British Aerospace, Compaq, Daimler Benz, Ericsson, Marconi, IBM, Italtel, Olivetti, Philips, Renault, Siemens

Asia
Acer, Cathay Pacific, Hitachi, Hewlett Packard, Hyundai, LG Electronics, Motorola, NEC, Samsung, Sony

USA
AT&T, Celestica, DEC, Ford, Hewlett Packard, NorthWest Airlines, Tektronix, Texas Instruments, US Army



Polar is committed to simplifying the testing and faultfinding of printed circuit boards. With offices in UK, California and Singapore and a network of over 35 distributors, we are dedicated to providing PCB repair and test solutions with high quality customer support.

Founded in 1976, Polar is certified to Quality Management System ISO9001 and our products are certified to the appropriate European Directives (CE compliance). Polar has won several awards recognising the innovation and performance of our products and is a supplier to major international companies.

We would like to hear from you if you are involved in the testing or repair of PCBs. Please contact us or your local distributor. Alternatively you can look at our web site www.polar.co.uk where you will find the latest information, details of exhibitions where these products will be on show and a selection of Application Notes that support customer applications.

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