Curve Tracing Systems

Robson Technologies, Inc.  
results through innovation
www.testfixtures.com
Models Available

- **MultiTrace**: The most flexible solution for devices up to 625 pins, capable of any of the applications described here. Comes with a PGA-625 fixture.

- **MegaTrace**: A larger version of the MultiTrace for devices up to 2160 pins. Available with 8 busses and 5 Amp drive options.

- **MultiTrace Century**: A lower pin count version of the MultiTrace but with all the power of the full size system. The Century is limited by fixturing to 100 pins.
Curve Tracing Defined

- Curve tracing is typically a series of current measurements while the voltage is varied over a range is plotted on a graph with Voltage on the X axis and Current on the Y axis.
- For failure analysis we often do this to multi-pinned devices with respect to some grounded pins or biased power pins.
- Curve tracing can find most forms of damage to pins on an IC.
- Often curve tracing is applied to 2 and 3 terminal devices to obtain their critical operating parameters such as with Transistors, SCRs and Diodes.
Terminology & Acronyms

- **SMU**: Source Measure Unit, Also known as a drive, these can source voltage or current and measure them at the same time.

- **FET**: Field Effect Transistor; A type of solid state switch that has no moving parts.

- **Bus**: A channel in the switch matrix that connects the drive to any one or more of the pins of the DUT

- **DUT**: Device Under Test

- **Fixture**: The hardware that the device adapter connects to

- **DUT Board**: An adapter in which the package DUT is placed which interfaces with the tester’s fixture.
MultiTrace Overview

- Basic Test system for most customers
- Available with 2, 4, or 6 switch Matrix Channels (Busses)
- 8 SMU supplies (4 and 6 bus systems)
  - 6@+/-15V, 1A
  - 2@ +/-100V, 100mA
- Relays and FET switches
- Available with 216 pins to 625 pins
- Expandable to 1296 pins with MegaTrace style test fixture (2 bus only).
MultiTrace Century Overview

- Small footprint test system for low pin count devices
- 2, 4, or 6 switch matrix channels
- Same configurations as MultiTrace
- 4 or 8 SMU supplies
- 96 or 100 pins
- Compatible with Yamaichi connector style fixtures like RTI 950 Series Fixtures and dedicated boards
MegaTrace Overview

- Largest test system for complex devices
- Up to 2160 pins and 8 switch matrix channels
- 5 Amp option for high current devices
- Reliable Pogo pin or Elastomer Fixture
- Fully integrated mobile tester platform
Curve Tracing
Test Coverage

- Curve Tracing will discover any parametric damage to the pins of any device of any technology.
- Any electrical damage to the pins on the device will be found.
- Find damage from ESD, EOS, mechanical opens and shorts.
- Electrical damage to the core of the device may be found as supply current anomalies. Many damaged pins also show up as high supply current.
- Some Functional-Only Failures in the core of the device are undetectable with curve tracing.
Standard Testing Methods

- **Unpowered Curve Tracing** – Curve traces each pin with respect to one or more of the other pins grounded.

- **Powered Curve Tracing** – Curve trace input, Output, I/O and Analog pins with respect to the biased Power pins.

- **Supply current (IDDQ)** – Power up a device with up to 3 power domains and measure the supply current. Freedom to alter the input pin states while making measurements.

Testing Options on MTForms Software
Curve Tracing Methods

• Hypothetical Model of a CMOS IC circuit
Curve Tracing Methods

• Hypothetical I/O Bond Pad structure
Unpowered Curve Tracing

- Equivalent to a detailed continuity test
- More than just opens and shorts
- Easiest test to configure
- Device function independent
- Least expensive entry with MultiTrace only requires 2 bus system
- Opens, shorts, gross leakage, damaged clamp diode are all easily found with unpowered curve tracing.
- Typical testing done with Analog curve tracer or manual switch boxes
Unpowered Curve Tracing

**Standard Testing Methods:**
- Unpowered
- Powered
- Supply Current

Unpowered curve trace of a device with curves from all pins displayed.
Unpowered Curve Tracing
Test Conditions

• All pins Grounded
  – Excellent place to start
  – An open is an open
• VDD or VSS only Grounded
  – Similar results to all pins but can have blind spots in test coverage
• Pin to Pin
  – Good for power pin groups
• Finding shorts
  – Ground the shorted pin and curve trace the others
Unpowered Curve Tracing
Test Coverage

• Opens
  – Usually indicates fused metallization, open bonds or assembly defects

• Shorts
  – Extreme form of leakage where resistance is so low that clamp diode $V_f$ is not reached before max test voltage

• Leakage
  – Linear leakage usually associated with metallization
  – Non-Linear leakage usually associated with Silicon damage
Unpowered Curve Tracing Model of CMOS Pin
**Powered Curve Tracing**

- Simultaneously shows Continuity, Pin Type, Leakage and Supply Current
- Characterizes Supply Current as a function of pin voltage, Output source/sink current, ESD clamp voltage, and most other parameters typically found in the DC specifications can be checked with Powered Curve Tracing.
- Minimal information required to configure. Pin groupings by function like VDD1, VDD2, GND, I/O, Input and Output are usually sufficient
- Test is typically done in a static state, Compatible with Preconditioning software when needed

**Standard Testing Methods:**

- Unpowered
- Powered
- Supply Current
**Powered Curve Tracing**

*Standard Testing Methods:*
- Unpowered
- Powered Supply Current

Powered Curve Trace showing a single pin I-V curve and two Supply current curves.

**Red** = Idd Curve 1
**Pink** = Idd Curve 2
**Blue** = I-V Standard
Powered Curve Tracing
Test Conditions

• Input pins
  – Best Practice is to tie to either $V_{IH}$ or $V_{IL}$ ($V_{DD}$ or GND)
  – All inputs low is a good place to start
  – Inputs such as to minimize IDD is also a good test condition for fault localization techniques
  – Floating Inputs often leads to elevated supply current particularly for CMOS devices
  – Pins with Pull-up or Pull-down can be left floating
  – Supply Current (IDD) will usually vary as pin is tested
  – Toggling or Vectoring inputs before curve tracing can precondition a device into a known state to cause a failure to emerge
Power Test Conditions

I/O Pins

- Can power up as input, output or tri-state depending on the actual device
- Tri-Stated I/O pin usually very similar to Input curve but typically does not cause changes in $I_{DD}$ while tested
- Changing the state of an I/O pin typically requires vectoring and clocking of the device
Powered Curve Tracing
Test Conditions

• Output Pins
  – Should be left floating except when actually tested

• Power pins
  – Biased to normal supply voltage as specified in DataSheet
  – While not actually curve traced, the supply current can be monitored and the changes of IDD while other pins are being curve traced can hold valuable diagnostic clues
Powered Curve Tracing
Test Coverage

• Power pins
  – Supply Current is Monitored while curve tracing other pin types. Shape of these curves is displayed superimposed on I, O and I/O curves.
  – IDDQ, Switching Transitions and Standby and other static state supply currents can be measured

• Input pins
  – Leakage, Clamp Diode Voltage
  – VIL, VIH, IIL, IIH by observing supply current switching transitions
  – Lone input pins have smaller supply current transitions than control or clock pins which toggle many nodes within the device
  – Pull-up or Pull-down Current
  – Parallel or series resistance
Powered Curve Tracing
Model of CMOS Pin
Powered Curve Tracing
Test Coverage

• I/O Pins
  – Similar to Inputs or Output when in corresponding state.
  – Supply current companion curve usually flat when in Tri-State

• Output Pins
  – VOL, VOH: at modest current load or no load you can confirm datasheet values
  – IOS: At higher current load you can characterize the total power of an output pin
  – Damage to parallel gate structures revealed as lower than normal IOS curves
  – State instability shown as spontaneous switching of logic levels
Powered Curve Tracing
Model of CMOS Pin

- Power Supply Voltage (Vdd)
- Voltage Levels (VOL, VOH)
- Current Levels (10mA, 110mV, 4.1V, 45mA, 35mA)
- Input/Output Levels (IOS, N-Channel, P-Channel)
Supply Current Testing

- Simple indication of supply current on 1, 2 or 3 $V_{DD}$ supplies.
- Static test conditions, simply list pins for $V_{IL}$ or $V_{IH}$
- Ramp VDD and Single Point Vdd modes of testing for flexibility

**Standard Testing Methods:**

- Unpowered
- Powered

**Supply Current**
Supply Current Testing

• Test conditions similar or the same as Powered Curve Tracing
• Good for focusing on just the supply current without extra information of per pin curve traces
• Toggle inputs and see supply current change
• Insights to failures in the Core of the device
• Ramping VDD slowly can show some aspects of ESD clamp circuitry
Fault Localization

• A Curve tracer can be used to aide in localizing the defect in a failed device
• First the device is characterized in a non destructive manner
• Next the device is decapped to gain access to the die and view the surface with a Microscope
• A cabled test fixture is usually required so the decapped device can be positioned under a microscope or in a light tight enclosure
• Popular localization methods Include but are not limited to
  – EMMI- Photon Emission Microscopy (Visible and Topside IR)
  – Liquid Crystal Hot Spot Detection
  – Backside Infrared Emission Microscopy
  – Voltage Contrast
Fault Localization
Test Coverage

• Very useful for finding the location of Leakage type failures caused by EOS or ESD
• Useful in finding high supply current mode failures in the core of the device
• Not useful in finding Opens failures
• Less useful in finding low resistance short failures because little heat or photons are created without using excessive current
Fault Localization Methodology

• The same method used to characterize a leakage failure can be used to stimulate the leakage during fault localization methods

• Generally reduce sweep voltage range so as not to excite the clamp diode structures and create false hotspots

• Avoid sweeping through switching transition range of inputs to avoid false hotspots

• Constant Voltage good for EMMI

• Repetitive Sweeping good for Liquid Crystal

• Voltage range, sweep speed and pulsing modes can be used to fine tune stimulus to the leakage defect
Customized Test Methods

- Measure any DC parameter within the +/-15V, 1A range with 8 sources.
- Input-Output Transfer Functions
- Transistor Family of Curves
- Op Amp gain characterization
- Measure Hysteresis of an input pin
- Characterize ground current $V_{SS}$
Customized Test Methods

- Input – Output Transfer function and Transistor Family of Curves
Device Fixturing

- Adapters are available for any footprint but lead time needs to be accounted for when preparing for new devices. 4-8 weeks is typical.
- The Remote Test Head option allows you to place the device under a microscope for fault localization techniques like emission microscopy (EMMI).
- Compatibility Adapters can be made to convert any other adapter footprint to be compatible with the MultiTrace. For example; IDC and RTI fixture cards.
Available Interface Fixtures

Interface fixtures provide a standard way of connecting to the tester.

- AutoTrace Card Edge
- AutoTrace Pogo Pin 96pin Interface
- MultiTrace PGA-625
- MegaTrace Elastomer Fixture
- MegaTrace OctaPogo Fixture
- Custom Fixtures
DUT Boards

DUT Boards connect to the tester interface and provide a way for SMT and Thru-Hole devices to make contact.

- PGA/DIP base Adapters
- Pogo Pin Adapters
- OctaPogo Adapter
Device Sockets

RTI can manufacture or source sockets for any type of device or small module.

- Test/Burn In style sockets
- Pogo Pin Sockets
- Sockets for small modules
- Heated and Cooled sockets
- Active DUT boards
- BGA, CSP, SOIC, QFN, and any other device
The 950-096 series offers a complete family of sockets and test fixtures for topside and back-side test of low pin count devices including micro-probing, backside emission, and heated sockets for temperature testing and liquid crystal testing. A complete unit consists of a universal fixture base (a), a universal mini card and socket (b), a dedicated FA or Eng socket lid (c), and a fixture base clip on or screw down lid (d). The 950-096 fixtures use a 100-pin Yamaichi connector to interface to RTI's switch / break-out boxes, RTI's and third party curve trace systems, functional test systems, and other common FA test equipment. An optional bottom-side connector can be added to allow the test fixtures to plug into dedicated fixtures mounted on probe stations and other test equipment. (see 900-384 fixtures) Custom fixtures are also available for other connector and cable systems.
950-096 Heated mini cards and socket lids have a built-in copper heating element and temperature-sensing device (RTD or Thermistor). A RTI temperature controller is required for the operation of heated equipment (See S6-02). A heated fixture base is required for heated mini cards. Heated mini cards rely on the fixture base to power and monitor temperature. Heated lids connect directly to the temperature controller and do not require a heated fixture base. Due to its unique design, a standard fixture base cannot be upgraded later to a heated fixture base. Available sockets for heated applications include the standard 900-1133 and 900-1141 series.
RTI’s universal sockets are a cost effective solution when tests need to be performed on multiple package sizes within the same ball pitch. Available pitches range 0.4mm through 1.27mm.

The first step is to determine which socket is needed, based on the DUT’s pitch and maximum array size. Keep in mind that multiple DUTs of smaller arrays with the same pitch can be used in the same socket base. A one time purchase of a universal socket is made after choosing the appropriate series. Universal, clip-on, adjustable lids specific to socket series are also available. All that is left to purchase is a low cost alignment plate and corresponding open top lid specific to each package size that will be tested. A new universal socket will have to be purchased only when the need to test a new package of a different pitch arises.