Burn-in & Test Socket Workshop

March 2 - 5, 2003
Hilton Phoenix East / Mesa Hotel
Mesa, Arizona

Sponsored By The IEEE Computer Society
Test Technology Technical Council

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Burn-in & Test Socket Workshop

Technical Program

Session 2
Monday 3/03/03 10:30AM

Burn-in Tools And Test Equipment

"DUT Host: DUT-Level Burn-In System Diagnostic Tool"
Trent W. Johnson - Advanced Micro Devices

"Total Automation Of Burn-In Process Flow"
S. Kumaran - Trio-Tech International

"Qualification Of Test And Burn-In Sockets Using A Desk Top Test System"
Jeff Cymerys - Advanced Micro Devices
Ken Hallmen - Checksum, Inc.
Rafiq Hussain - Advanced Micro Devices

AMD

DUT-Host:
DUT-Level Burn-In System Diagnostic Tool

Trent W. Johnson
Advanced Micro Devices
March 3, 2003

BiTS
BURN-IN & TEST SOCKET WORKSHOP

Agenda

- The Hybrid Burn-In Platform
- Introduction to DUT-Host
- DUT-host Software structure
- Sample Screen Shots
- Summary of Lessons Learned

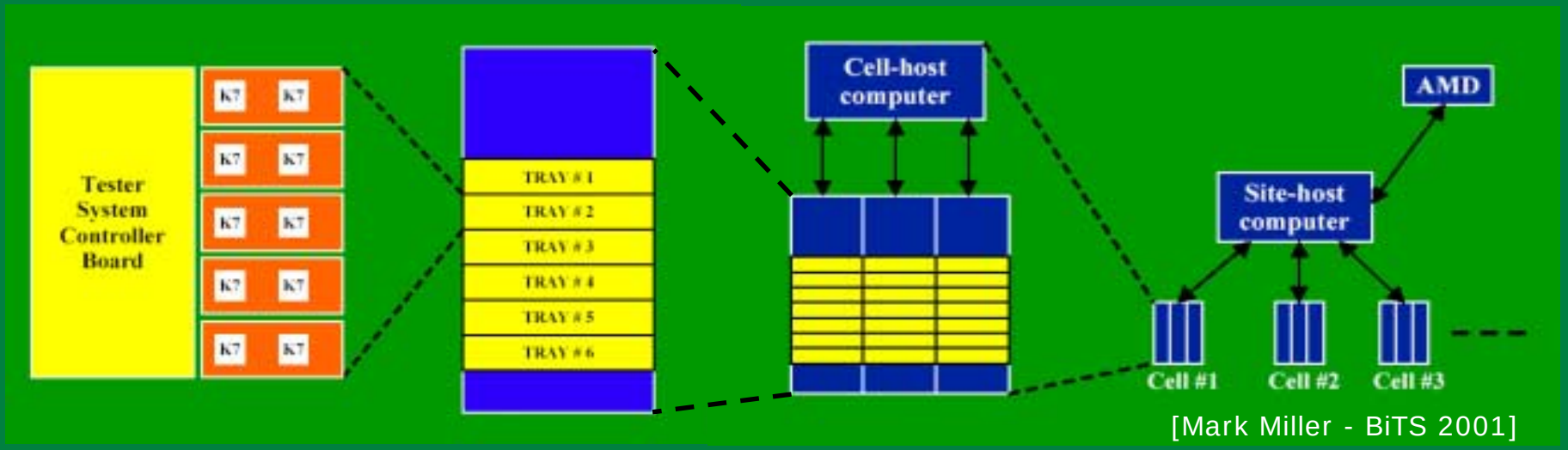
Hybrid Burn-In Overview

What Is "Hybrid Burn-in" ?

- New generation of burn-in technology at AMD that has evolved due to the unique requirements of the Athlon and Duron microprocessor product lines
  - More electrical features than "traditional" burn-in (minus ovens)
  - Individual DUT temperature, voltage, and frequency control
  - Able to execute X86 code and BIST code individually
  - Failed units can be shutdown individually to prevent damage
  - Real time individual data collection and communication to host
- "HBI" is actually a multiple position, independently programmed, low pin-count, *tester* that is able to economically run long test times (burn-in durations) at unique burn-in conditions

[Mark Miller - BiTS 2001]

Hybrid Burn-In Block Diagram



- 10 DUT positions controlled by one local microcontroller
- 18 Trays linked to the “Cell-host” via Ethernet
- Multiple Cell-hosts linked to the “Site-host” computer
- Production data accessed remotely from Site-Host

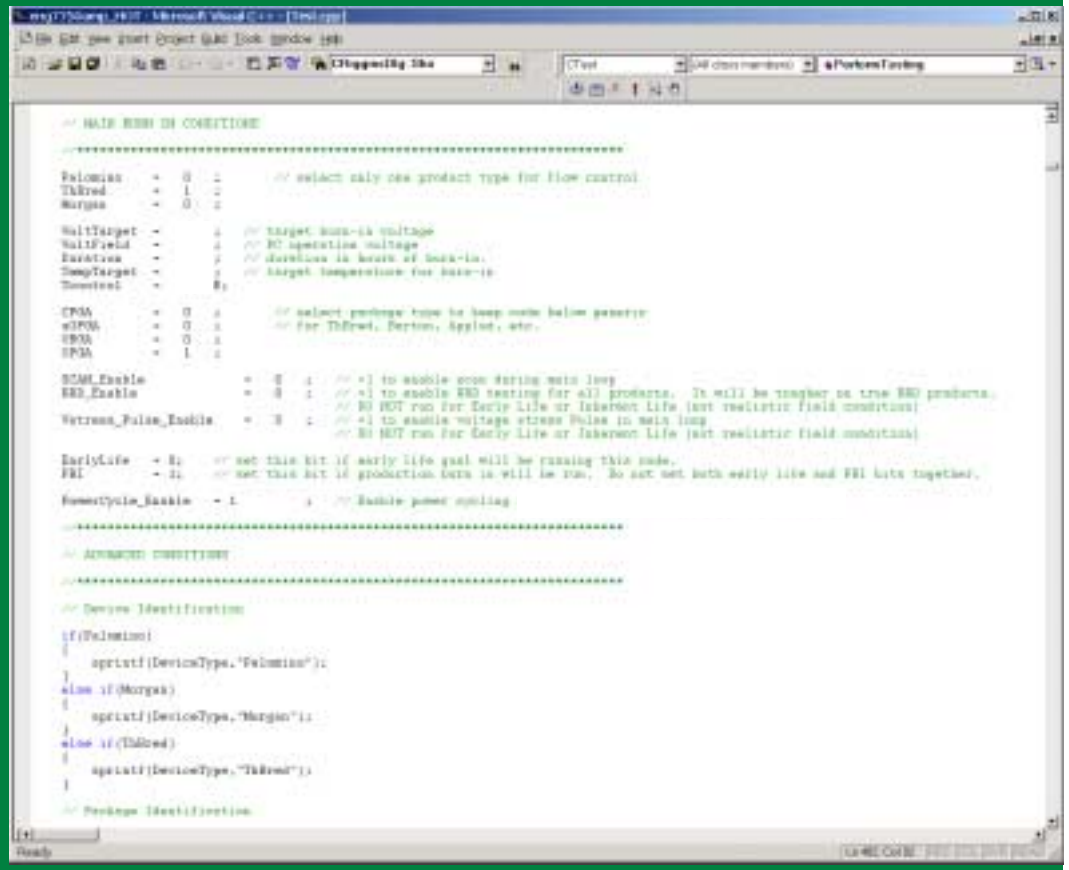
What is DUT-Host?

- DUT-Host is a tool developed by AMD to allow manual control over AMD's Hybrid Burn-In system.
- DUT-Host provides a unique test environment for a single DUT in Hybrid Burn-In.
- DUT-Host is simple enough to use that an expert is not required to operate it.
- One Cell-host computer controls several DUTs.

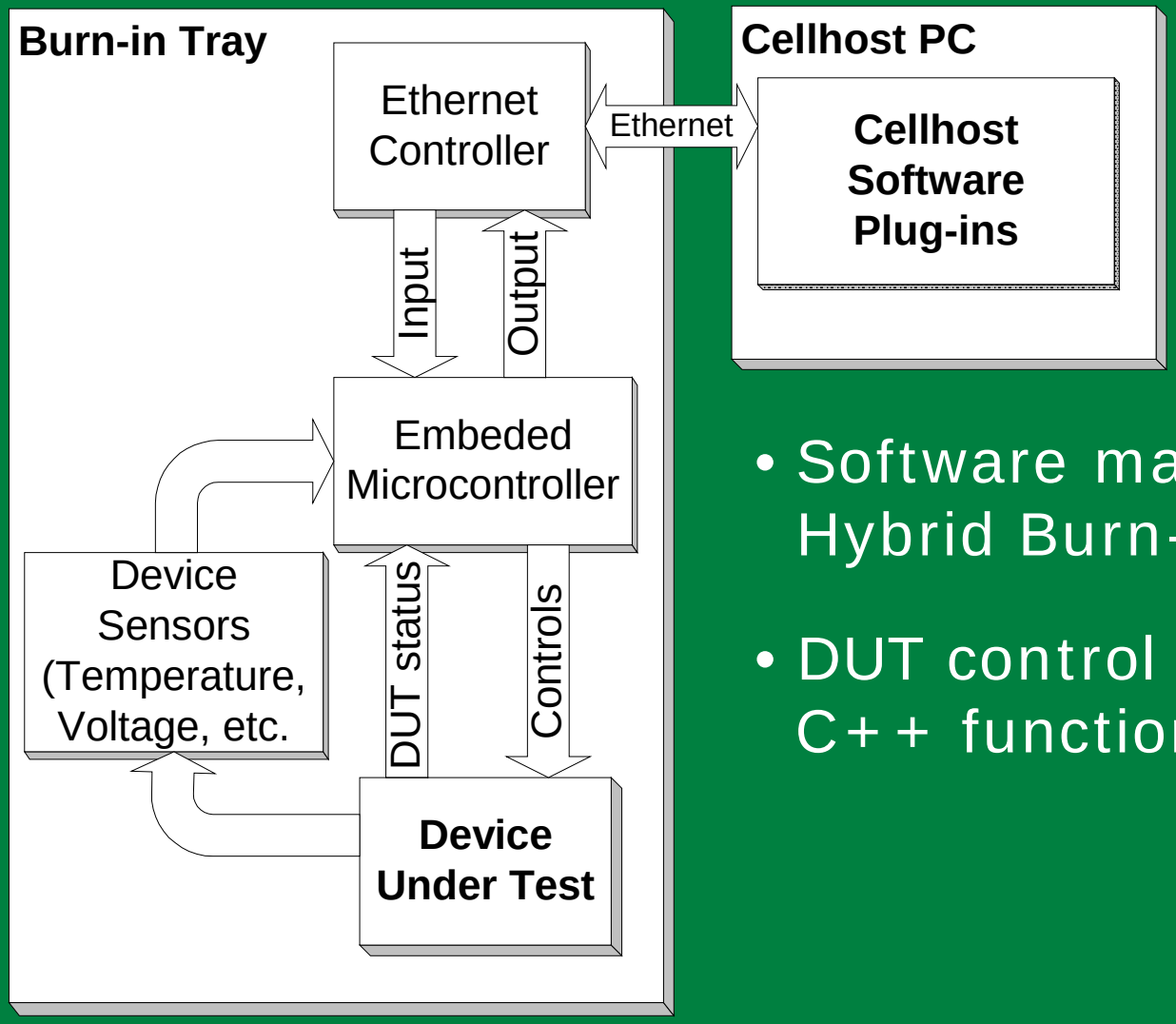
The old way of debugging

Tedious C++ code

- Recompilation at every change
- No real-time feedback
- Must be an “expert” to make sense of it all
- The person who knows it ends up doing it for everybody



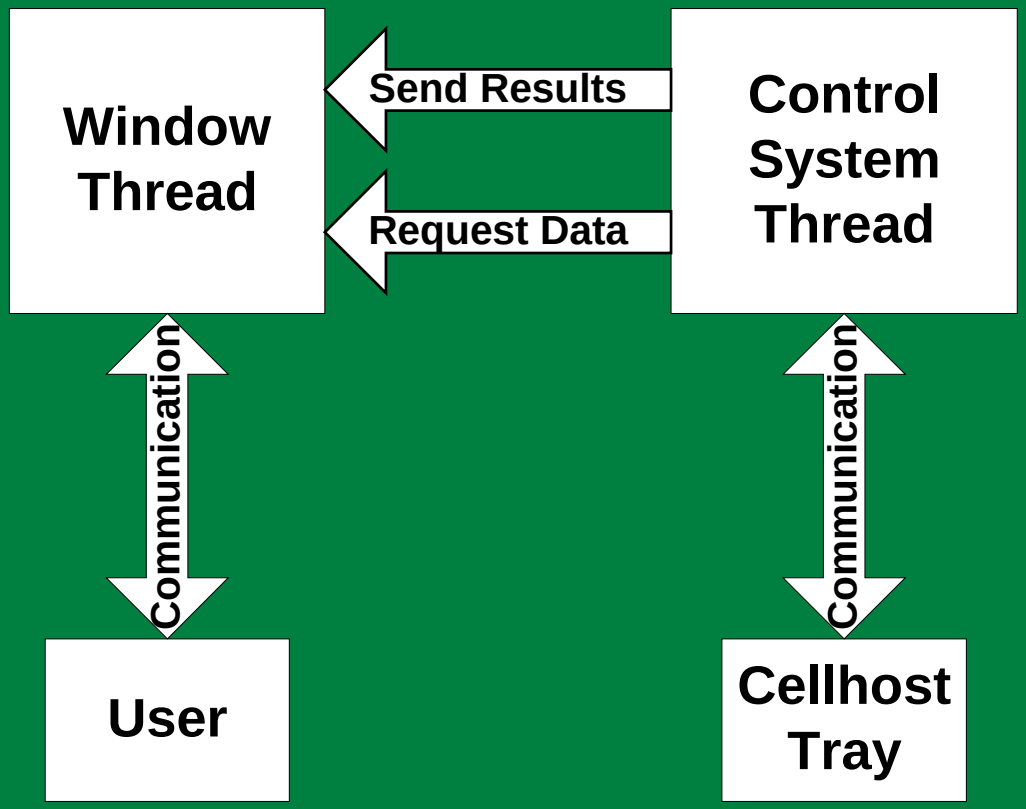
Programming Interface Diagram



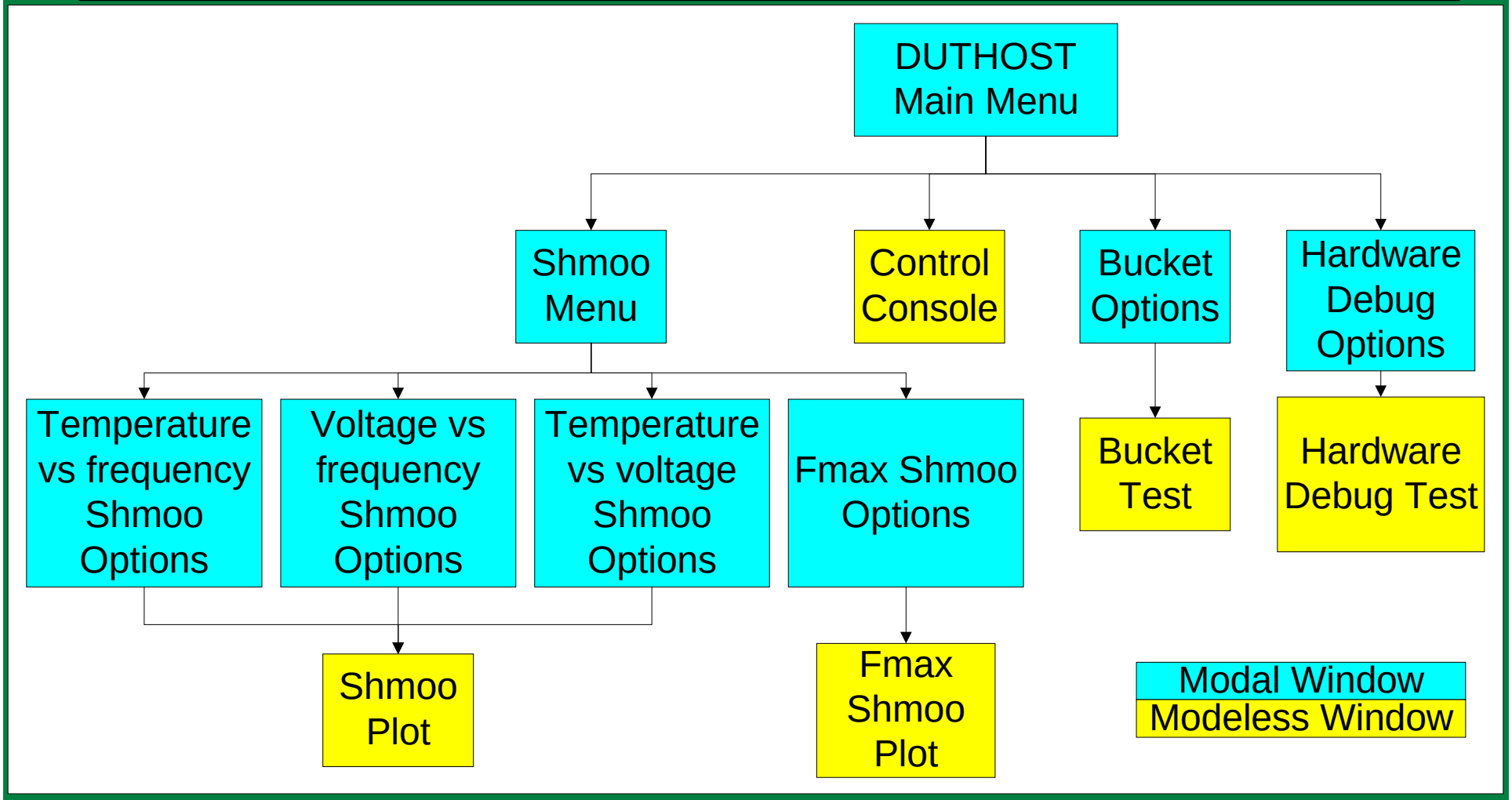
- Software may be added to Hybrid Burn-In as a plug-in
- DUT control via special C++ functions

Logic flow (function calling)

- Control System is in charge
- Windows© GUI takes all orders from the Control System thread
- DUT control efficiency is maintained in exchange for making the user wait a few more milli-seconds.



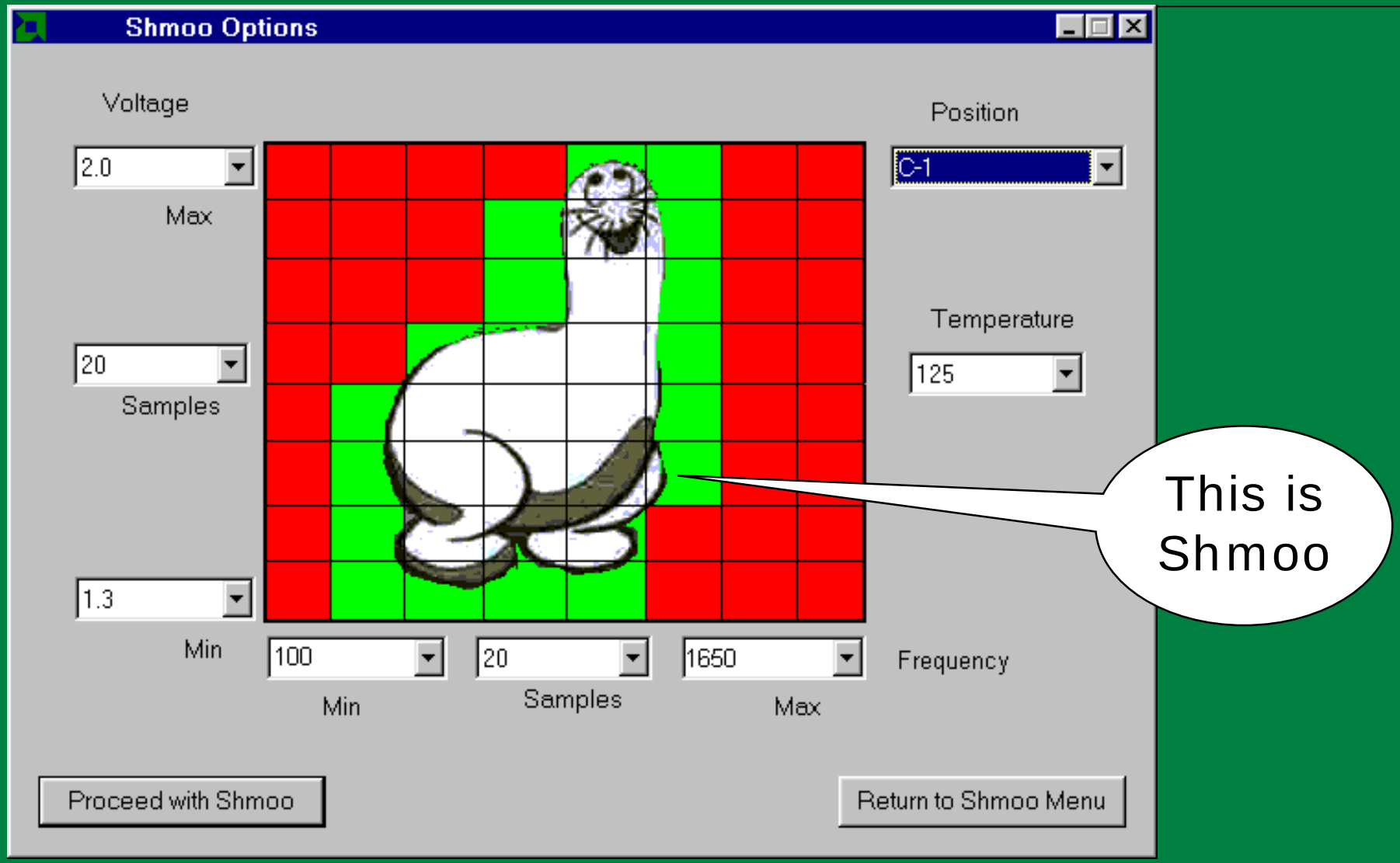
Menu Flow


DUTHOST Main Menu
Shmoo Menu
Control Console
Bucket Options
Hardware Debug Options
Temperature vs frequency Shmoo Options
Voltage vs frequency Shmoo Options
Temperature vs voltage Shmoo Options
Fmax Shmoo Options
Bucket Test
Hardware Debug Test
Shmoo Plot
Fmax Shmoo Plot
Modal Window
Modeless Window

Shmoo requirement

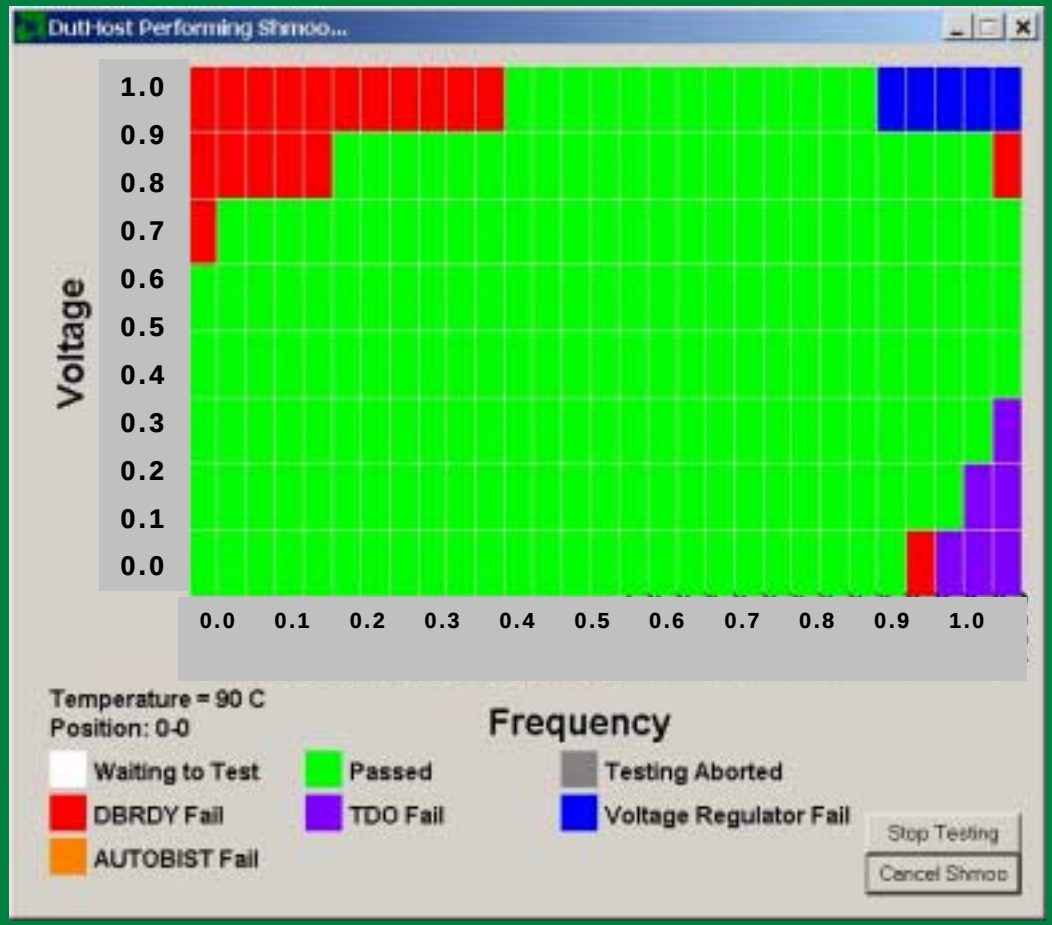
- VLSI testers have a great tool called “Shmoo” that plots pass/fail status over voltage and frequency.
- A common option on Shmoo is to show a legend of the failing tests
- Shmoo plots often show up speckled near failing boundaries. A manual re-test feature is necessary.
- What is a “Shmoo” anyway???

Shmoo Condition Selection



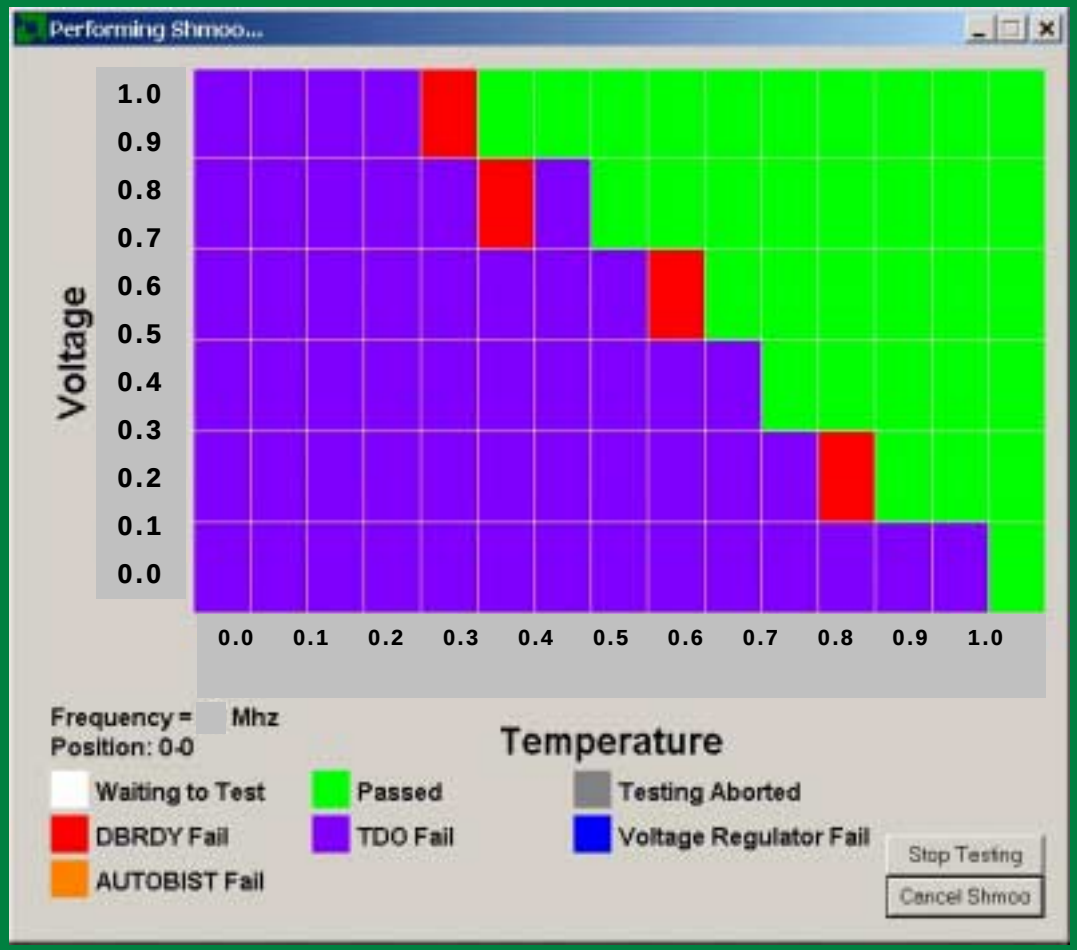
Voltage vs. Frequency Shmoo

- Fewer fail modes makes the output simple
- Double-click for re-test
- Failing boundaries are automatically tested twice.



Temperature as a shmoo axis

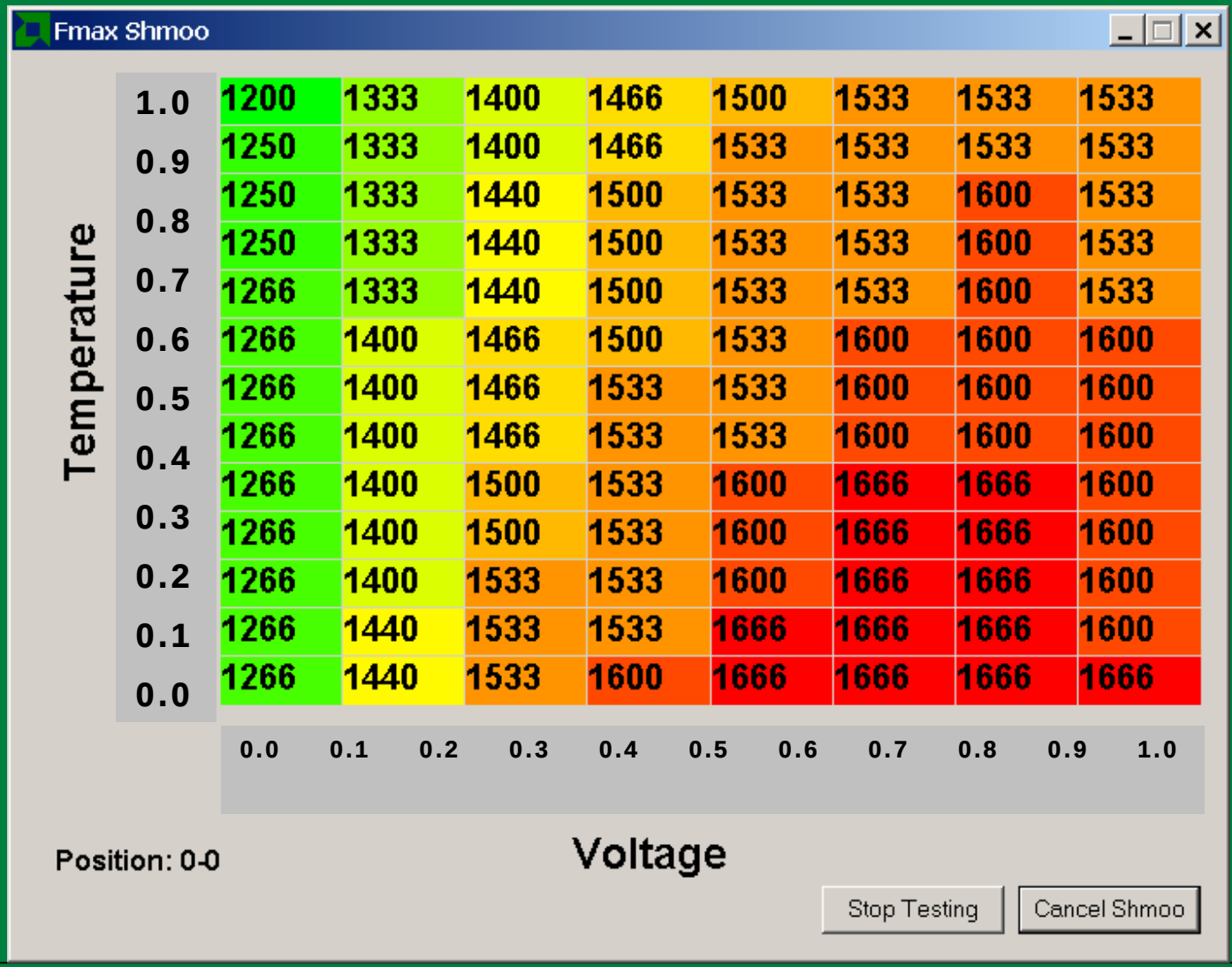
- Plot is NOT available with conventional VLSI testers
- Can seek out temperature dependent problems.



3-Dimensional failure plot

- We have control over Temperature, Voltage, and Frequency of the DUT
- Need a way of combining all 3 axes into a chart while retaining readability
- Solution: Use more color and data labels

3-Dimensional F-Max Shmoo



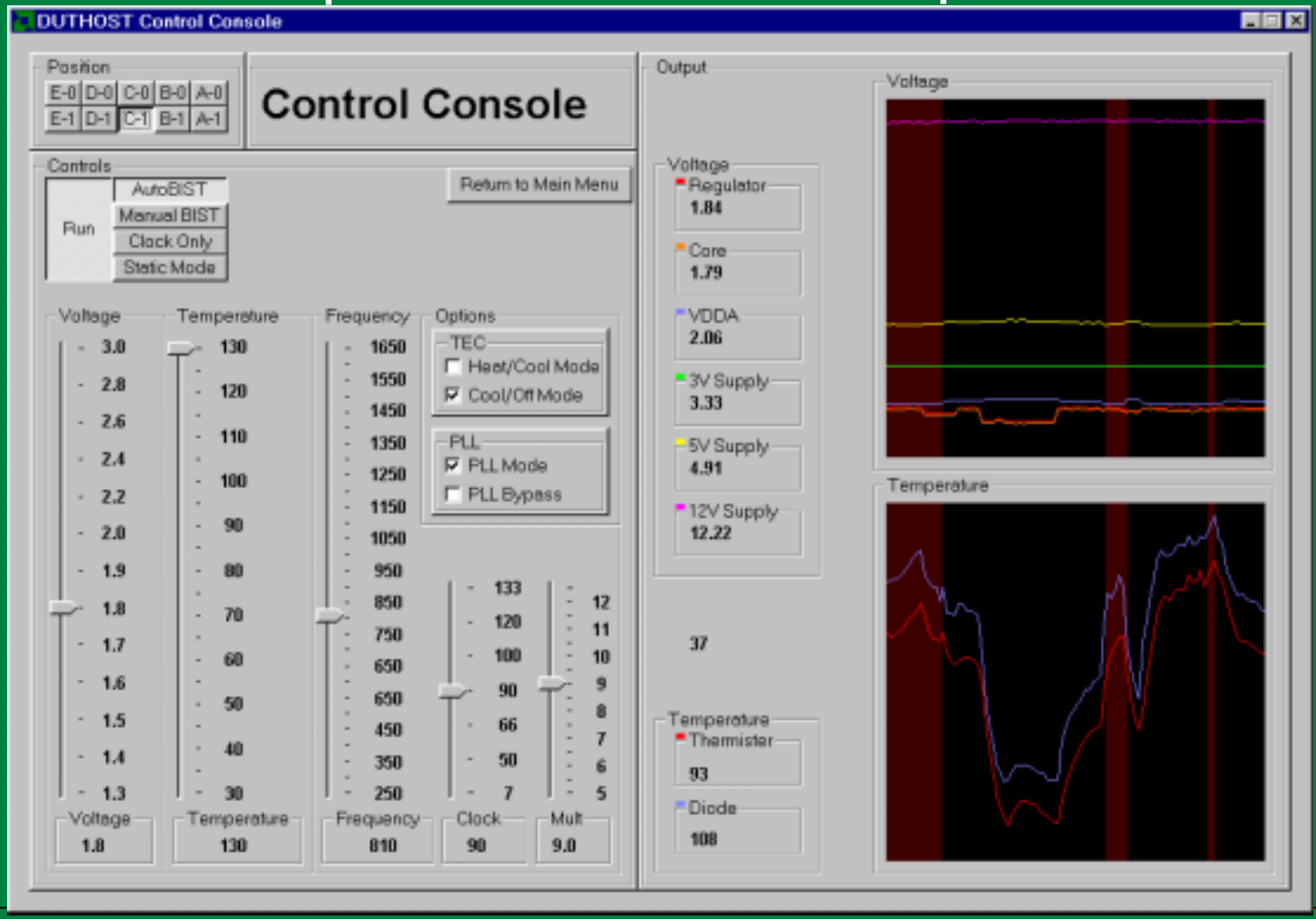
More Ways of Displaying Data

- For many custom experiments, Shmoo is not adequate
- Need a way to convert ALL HBI features into tunable knobs
- Need to see and log every possible traceable result
- Need to operate any or all DUTs at the same time
- Need it all in one dialog

Control Console

Inputs

Outputs



DUT-Host vs. VLSI Tester

DUT-Host on HBI

- Hundreds of dollars per position
- Basic JTAG Interface
- Simple to use
- Temperature control integrated
- Basic set of debug tools
- Inexpensive Signal drivers cannot operate very fast
- Slow test time

VLSI Tester

- Millions of dollars per position
- Hundreds of data channels
- High skill level required to use
- Temperature control is external
- Extensive set of debug tools
- Signal drivers can run at high speeds
- Fast test time

Lessons Learned

- DUT-Host has proved to be a useful tool for the following:
  - First Silicon check-out
  - Silicon Debug
  - Hardware diagnostics
  - Hardware development tool
  - Thermal cycling experiments
- DUT-Host still requires extra “hacking” to support device-specific test parameters.
- No matter how hard we try, we still need VLSI testers

Conclusion

- DUT-Host allows the potential of Hybrid Burn-in to be realized.
- No special training required to use DUT-Host.
- DUT-Host is a cost-effective alternative to a VLSI Tester for basic testing tasks.
- Burn-in Software Development is becoming an important task as we move to more complex burn-in systems.
- Testability: You get what you pay for.

Acknowlegements

Special thanks to Mark Miller for the use of presentation slides to describe Hybrid Burn-in in this presentation.

Hybrid Burn-In is the successful result of the combined efforts from numerous engineers at AMD.

TRIO-TECH INTERNATIONAL

2003 Burn-In & Test Socket Workshop

Total Automation of Burn-In Process Flow

S Kumaran (Engineering Manager)

BiTS
BURN-IN & TEST SOCKET WORKSHOP

We are certified QS9000

Outline

- ✓ Objective
- ✓ System Overview
- ✓ Advantages
- ✓ Specifications

5) Automated Burn-In Process Flow

- ✓ Electrical Test Module (Bench Check Station)
- ✓ Lot Summary Report / database
- ✓ Upgrading, Cost & Quality Comparison
- ✓ Summary
- ✓ Video

1) Objective

To Innovate the automation of all Burn-In Processes, to raise yield and increase productivity.

Following were automated to achieve the objective:-

- **Dry cleaning of BIB**
- **Loading of empty Burn-In-Board (BIB) from trolley**
- **Loading devices into BIB**
- **100% Bench Test of loaded BIB**
- **Transfer of BIB onto Oven trolley**
- **Loading of BIB into Oven for Burn-In**
- **Unloading BIB from oven and unloading devices**

2) System Overview

- **Burn-In Board Dry Cleaner**
  The Module was developed to clean Burn-In Board in Trolley

2) System Overview (Cont')

b) Loader/Unloader module was developed to:

- **Automatically load devices onto BIB**
- **Perform 100% device Testing at Board Check**
- **Loading BIB back onto Oven trolley**

2) System Overview (Cont')

c) Auto-BIB sloter into oven chamber & oven Trolley

This module was developed to automate loading and unloading of BIB in oven. Trolley lock onto oven for automatic loading and unloading of Burn-In Board from Oven.

Trolley locked on Oven

3) Advantages

- Reduces the operating cost
- Increases device yield
- Minimise human error (eg. Bent leads)
- Maintaining lead integrity
- Perform precise and high-speed transfer of IC packages
- Dry cleaning minimises dust particle on device
- Pleasant working environment

Advantages (Cont’)

- **User friendly buttons on both PC and machine**
- **Technicians easily trained to operate machine**
- **Software can be accessed/viewed/controlled from a remote PC**
- **Easy maintenance, with manual in help menu**

4) Specifications

- Handles Package Type:- All open top packages including PGA, BGA, QFP, TQFP,TSOP, SOP, SSOP &PLCC
- Resistance Check (0 ohms to 20 Mohm)
- Electrical Check: Signal Integrity Test (Max. 64 signal simultaneously)
- Results stored in database
- Automatic print-out of test result
- Throughput, 2200 UPH for 144pin QFP device, 2 head

5) Automated Burn-In Process Flow

Empty BIB Dry Clean Machine

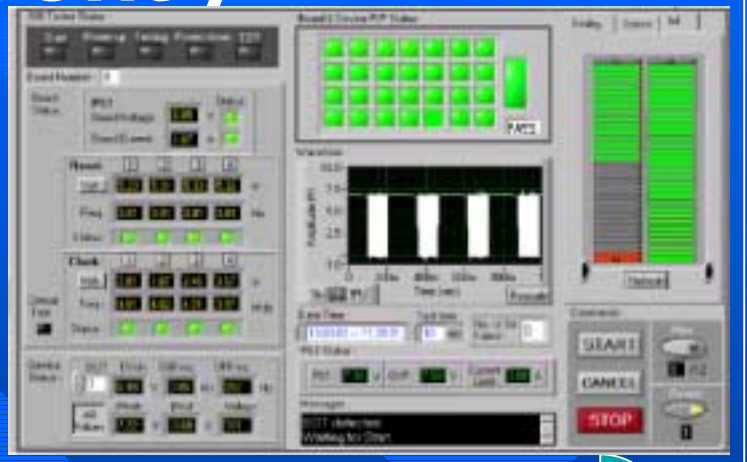
Empty BIB is loaded into PnP Machine

Device loading from tray to BIB

Loaded BIB is transported to 100% Board Check Station (BCS) module

Automated Burn-In Process Flow (Cont')

Position for 100% Electrical Board Check, with test pins automatically Brought down to BIB.



Automatic 100% Bench Check Result display.

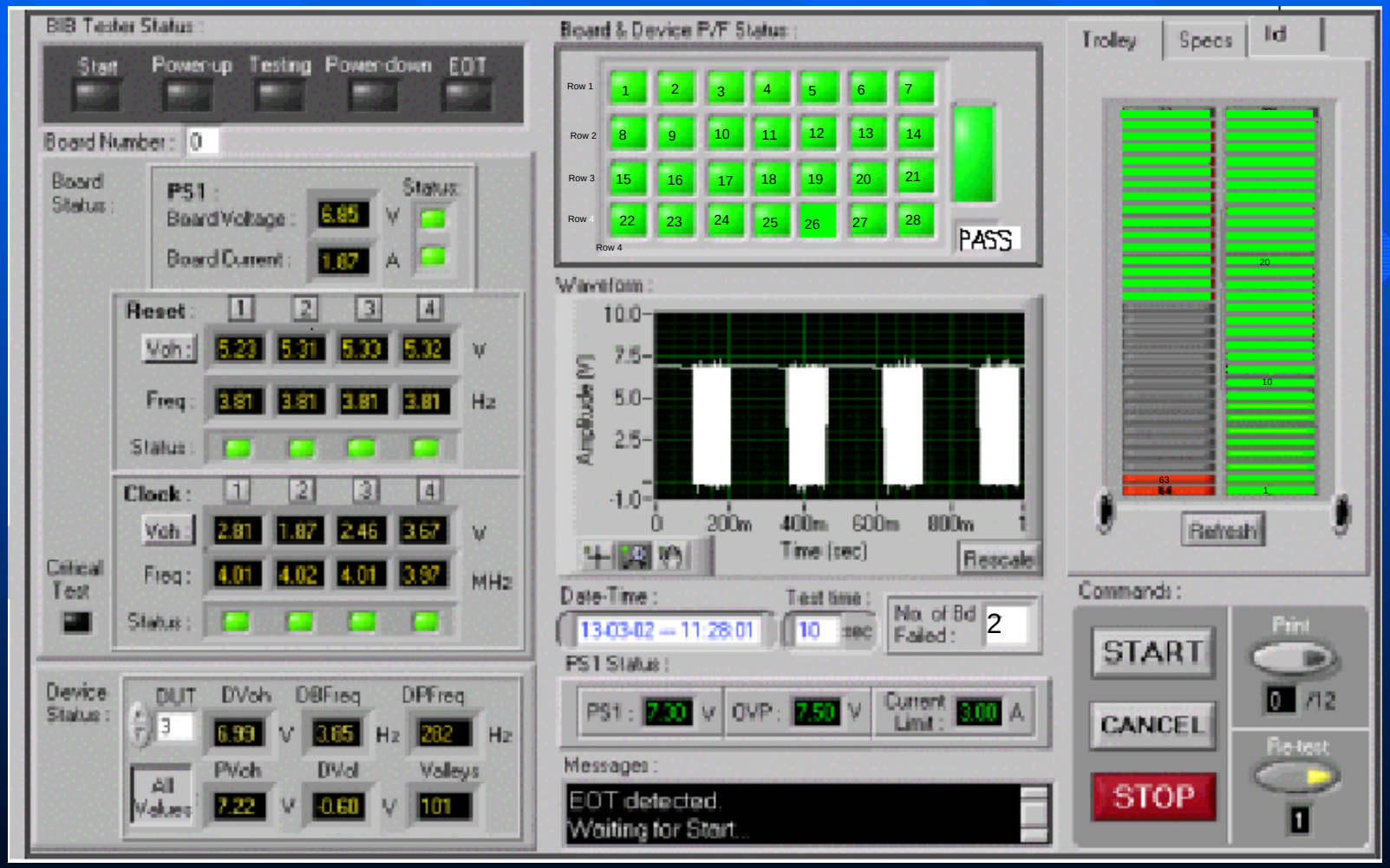
After signal test, loaded BIB will be transported back to the oven rack trolley

Trolley with BIB sloted automatically to Oven Chamber

6) Electrical Test Module Flow

- Burn-In Specification set-up
- BIB to Bench Check Station (BCS)
- Resistance check
- Voltage and Signal Sequence-up
- Voltage/Current check
- Signal frequency/Vol/Voh check
- DUT output signal check
- Print test result
- BIBs stored in Pass/Fail section of trolley

100% Bench Check Station Electrical Test Screen



7) Lot Summary Report/database

After testing of all BIBs from trolley:

- **Test results (Lot Summary) stored in database**
- **Automatic print-out of test results at End of Testing the full Trolley**
- **It is sorted out**
  - **by the date and time of Automatic Bench Test**
  - **by the lot number**
- **Test results can be retrieved anytime from database**

7) Lot Summary Report (Cont')

Example

PnP5 : LOT Summary
Lot id : TTS173856-1
Operator id : 5898

Time : 13-03-02 --- 11:28:01
BIB tested : 48
BIB failed : 2
% passed : 96

[BIB location] : Socket number with failed Device___, <BIB Voltage>

[64] : 23___, 26___, <7.01V>
[63] : 0___, <0.03V>

End

Check by : _____

Vcc Voltage

Slot #

0 indicate short or open cct bd

8) Upgrading, Cost & Quality Comparison

- IC Loaders upgradeable to include automated BIB 100% Bench check tester
- Oven upgradeable to include automated BIB loader/unloader
- Option to have BIB Cleaner incorporated
- IC loader/unloader, BCS, Stacker:- USD 240,000
- Auto BIB oven loader/unloader:- USD 35,000
- Automatic BIB Dry Cleaner:- USD 80,000
- Return on Investment:- 1.7 years

8) Upgrading Cost & Quality Comparison

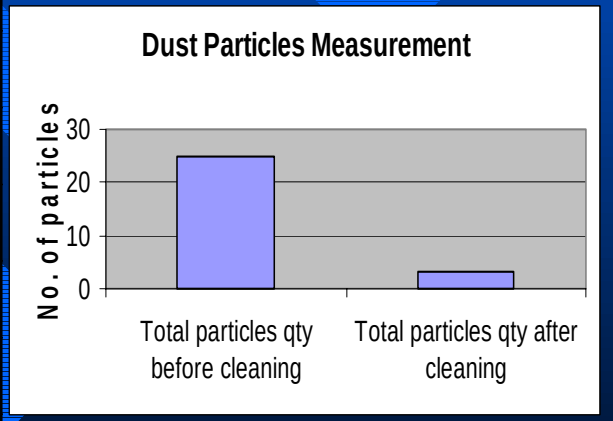
8b) Comparison Table

Manual Burn-In Process	Automated B/I Process
Bent leads due to human handling (80 ppm)	Minimize bent lead (20 ppm)
Handling Unit cost:- $0.0267	Handling Unit Cost:-$0.009
Throughput for 144lds QFP 510 device/per man hour	Throughput for 144lds QFP 2200 UPH
4 operators to achieve 2200 UPH	0.5 operator to achieve 2200 UPH.

8) Upgrading Cost & Quality Comparison

8c) Dry cleaner's yield before and after cleaning of BIB

BD S/N	Particle Before Cleaning (>100um)	Yield Before Cleaning	Particle After Cleaning (>100um)	Yield After Cleaning
312	3	91.40%	1	94.80%
161	2	92.50%	0	95.30%
784	1	96.40%	0	96.90%
041	2	95.30%	0	97.40%
001	2	96.90%	0	99.00%
082	4	95.10%	0	98.40%
806	3	95.40%	1	96.30%
738	2	95.10%	0	95.70%
648	2	94.40%	0	95.60%
038	4	93.40%	1	95.30%



B/I Yield improved to 96.5% from 94.5%

9) Summary

In conclusion, with our 100% automation of Burn-In Process flow

- **Improve throughput by 4 times**
- **Cost Reduction**
- **Better quality output (Minimize bent leads)**
- **Minimise device damage, reduce attrition rate**
- **Better yield with lesser manpower**
- **Automate electrical test, results recording & printing**
- **Improve working environment**

10) VIDEO

Dry Cleaner

PnP/ Tester

Auto-BIB Sloter
Into Oven Chamber

Qualification of Test and Burn-In Sockets Using a Desk Top Test System

2003 Burn-In and Test Socket Workshop

March 2 – 5, 2003

Ken Hallmen

Jeff Cymerys

Rafiq Hussain

Objective

- To qualify Open & Short performance of IC devices, test & burn-in Sockets

Plan of Record

- Test all contacts individually
- Socket lifetime
- Actuation force
- Contact resistance
- Real time testing
- User friendly desk top system

Agenda

- Why is real time testing important?
- Test System
  - Contact resistance testing
  - Digital IC package tests for opens & shorts
- Qualification of Test and Burn-In Sockets
- Post Assembly O/S testing of IC devices
- Conclusions

Real Time Testing

- Validation is done in a lab environment
  - Real time evaluation
  - System time is not an issue
- Sockets can be modified and tested immediately
- Bench Top System can be used in place of production tester

Opens/Shorts Test System

- Off-the-shelf plus customized load boards
- Expandable up to 8,000 channels
- Modular PC-based cards
- Requires very little space
- Stand-alone and/or integrated with a handler
- Simple programs with auto-learn
- Automated and manual program generation
- Specific failure diagnostics

Electrical Capability

- Resistance
  - 0Ω to 19MΩ (minimum to maximum)
  - Constant voltage
  - Constant current
    - Current ranges from 0.1µA to 10mA using 200mV or 2V compliance
- Capacitance
  - 1pF to 20,000µF (minimum to maximum)
  - 100 Hz to 100 KHz
- Voltage measurement for load board analysis

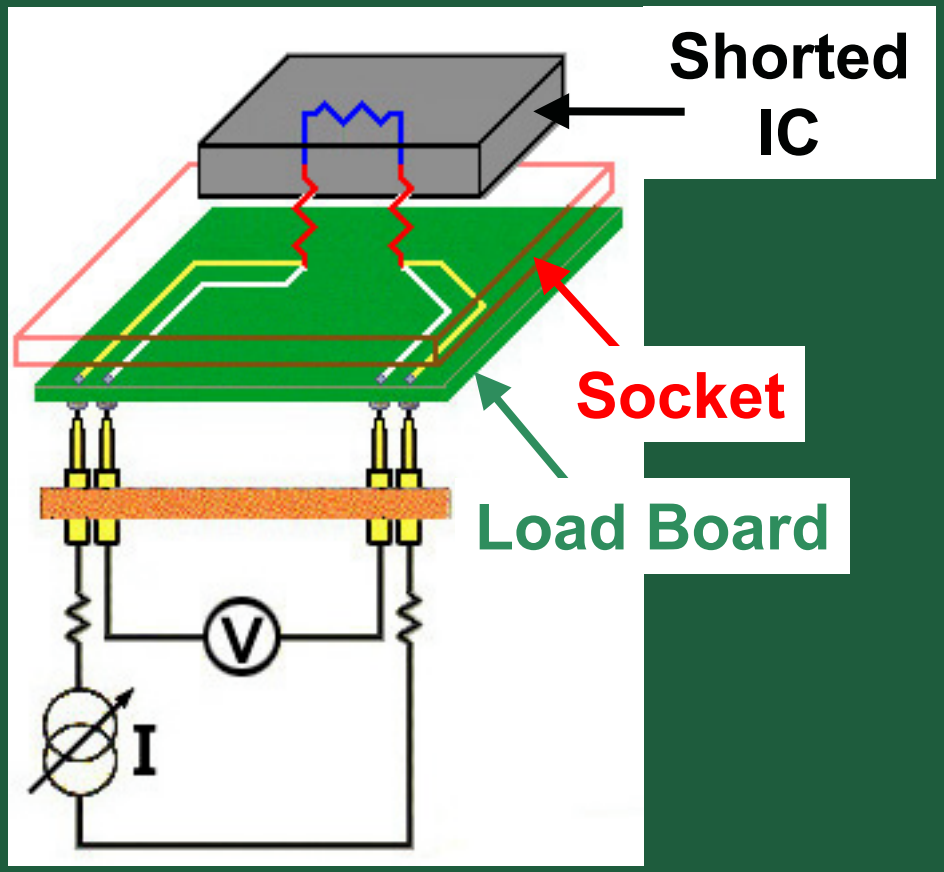
Contact Resistance Load Board

- Designed to isolate contact resistance
- Uses standard 4-wire Kelvin connections
- Measurement system zero offset compensation
- Milli-ohm resolution
- Milli-second measurements

4-Wire Kelvin Measurement

- Removes lead and trace resistance
- Requires proper physical layout for all traces
- Separate traces for current source
- Separate traces for voltage measurement

4-Wire Kelvin Connections



- 4-Wires connected to 4 separate test points
- Separate traces up to the socket
- Shorted IC test package

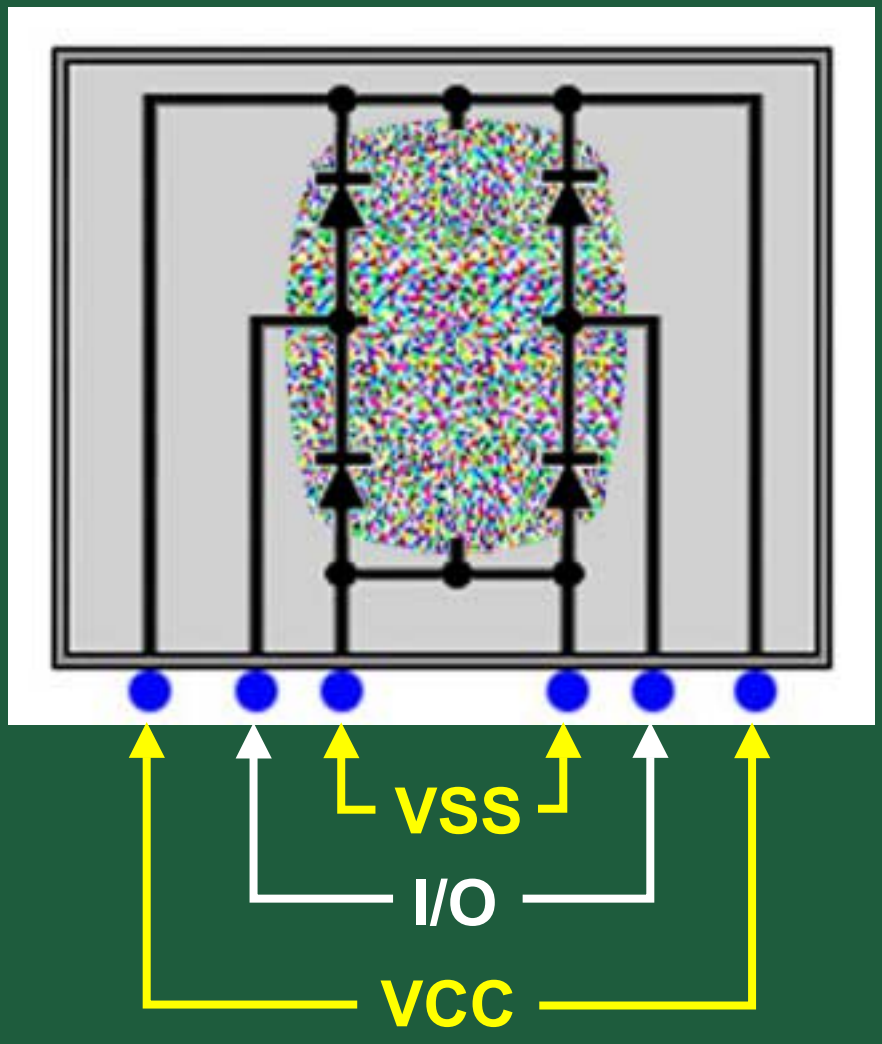
- Necessary for accurate, low-ohm measurements
- Up to 4,000 contacts using 4-wire connections

Digital IC Package Testing Load Board

- Contact resistance load board can be used
- Single connection to each lead is sufficient
- Verifies connectivity of I/O protection diodes

- Verifies common busses; e.g., VCC, VLDT, GND
- Milli-volt and milli-ohm resolution
- Milli-second measurements

IC Packaging Tests



- Tests connections from the BGA to die
- All common busses are checked for opens and shorts
- I/O protection diodes to busses verify I/O connections

Identification Recommendations

- Provide unique names for the test system I/O pins to identify failures quickly & accurately
  - Socket connection names, e.g. Pin 1, AE29
  - IC pin and signal names,
    e.g. Pin 1, AE29 MEMDATA[32]

- Socket connections names can be used for contact resistance tests
- IC pins and signal names can be used for IC packaging tests

Load Board Design Considerations

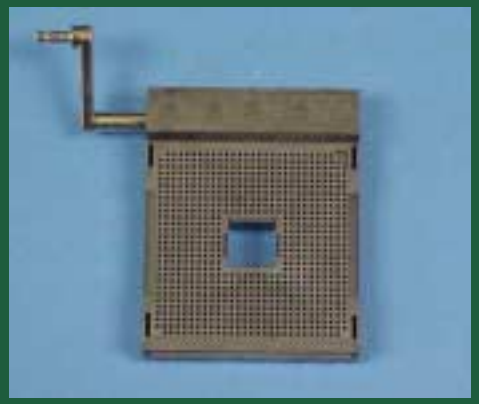
- Test system connections to the load board
  - Via cables to load board connectors
  - Via standardized interface from the tester to each load board
- Load board changeover efforts vary
- Can be configured with vacuum interface

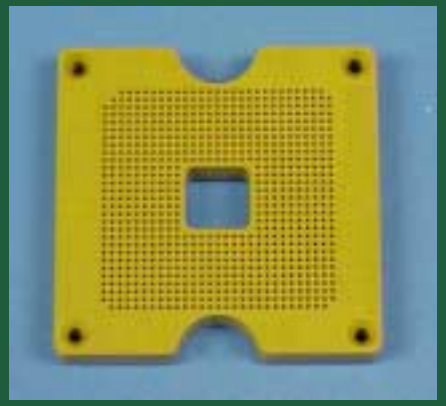
Test System with Load Board

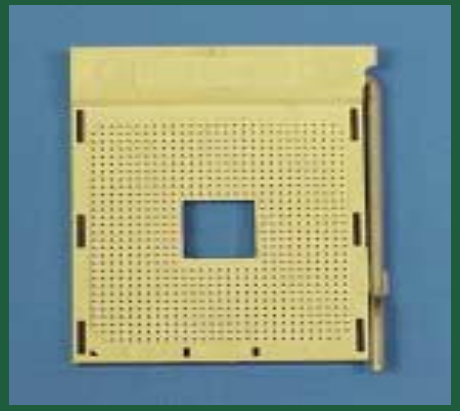
Standardized Load Board Interface

Load board on vacuum test head

Socket Qualification







Socket Continuity

From	To	Type	Title	Low Limit	Upper Limit	Value
A1	A2	Res	VDD Pin	0	5	3.25
R10	R7	Res	VDD Pin	0	5	5.2559 *
R7	Y14	Res	VDD Pin	0	5	O_Rng *
R10	N6	Res	VSS Pin	0	5	4.6959
R10	M26	Res	VSS Pin	0	5	5.3613 *
R10	J26	Res	VSS Pin	0	5	O_Rng *
Signal Pin	E12	Res	MEM CLK	100	733	505.64
Signal Pin	AG12	Res	MEMVREF	100	733	826.12 *
Signal Pin	H25	Res	LO CAD OUT	100	733	O_Rng *

- **Test each pin individually**
  - **Bus pins (VDD, VSS) tested for low resistance**
  - **I/O pins tested for connectivity (verify diode junction)**
- **Real time system response**

"*" signifies out of range failures

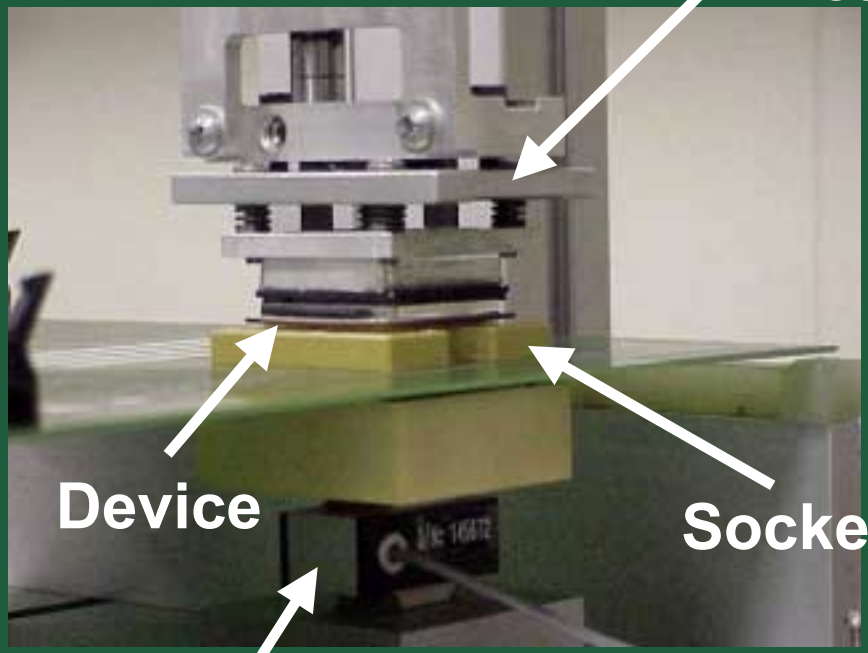
Pogo Pin Actuation Force

- Goal: To determine the ideal contact force
  - Force on package
  - Force on die

- Test Contactor or SLT (system-level test)
- Pneumatic actuator
- Force Measurement Unit
  - Load transducer

- Force vs. contact resistance

Force Measurement Unit



Force vs. Continuity (SLT)

Force (lbs)	Force (g/pin)	ERRORS	Pass/Fail
21.1	12.69	6	FAIL
22.2	13.36	18	FAIL
24.3	14.62	2	FAIL
26.4	15.88	1	PASS
26.5	15.94	0	PASS
27.4	16.48	0	PASS
28.5	17.15	0	PASS
28.7	17.27	0	PASS
29.5	17.75	0	PASS

- Identify the actuation force needed for all pins to make contact
- Goal: to achieve the lowest possible force!
- Consistency

Zero Failures!!

Pogo Pin Socket Lifetime (SLT)

- Insertion program
- Measurements at 25 k intervals
  - Goal is ~100 k insertions for SLT socket lifetime
  - 1 million insertions for test contactor
- Compare changes in contact resistance due to mechanical and thermal cycles
- Achieve mechanical lifetime of socket
  - Simulate production environment
- High frequency test – done separately

Mechanical Lifetime of socket

Vendor	Insertions	Rave (ohms)
Vendor A	Low	23.11
	25 k	23.27
	50 k	22.93
	75 k	22.68
Vendor B	Low	22.82
	40 k	22.04
	80 k	22.16
Vendor C	Low	23.37
	25 k	22.75
	50 k	22.70
	75 k	22.57
Vendor D	Low	22.02
	25 k	22.04
	50 k	22.25
	75 k	22.47

- Resistance values taken across a 20 ohm resistor in a package die

No increase in resistance

Slight Resistance increase

Bake and Contact Resistance (SLT)

RESISTANCE		
0 Hrs Bake	48 Hrs Bake @ 90° C	Change in milli-ohms
3.495	3.488	7
3.582	3.554	29
3.322	3.291	31
3.195	3.171	24
3.173	3.147	26
3.846	3.811	36
3.623	3.592	31
3.720	3.738	-18
3.185	3.151	35
2.357	2.334	23
2.065	2.040	25
3.982	4.031	-49
3.702	3.607	95
3.279	3.276	3

- Does the contact resistance change after baking the socket?
- 48 hours bake at 90^{o}C
- Repeatable for Burn-In socket evaluation
  - Higher temp
  - Longer burn-in cycles

Socket Type Comparison

System-Level Test vs. End User Socket

Package Pin	END USER	SLT 1	SLT 2	SLT 3
VDD ave (Ω)	1.823	2.973	3.046	3.138
VDDIO ave (Ω)	1.531	3.140	3.257	3.261
VLDT ave (Ω)	2.029	4.149	4.198	4.344
VTT ave (Ω)	2.624	2.927	2.989	3.358
VSS ave (Ω)	1.730	4.274	4.331	4.438

- Resistance values taken with a functional device loaded in socket

Socket Type Comparison

- End user (OEM)
- Burn-In
- SLT

- Can we bring all socket platforms to the same contact resistance standard?

Resistance ( )

END USER	BURN-IN	SLT
2.1692	2.4028	2.1529
2.1167	2.379	5.7962
1.8015	2.0459	2.2161
1.7888	2.0392	2.4381
1.8163	2.0369	2.372
1.8638	2.0796	2.8646
2.168	2.3766	2.8711
1.6496	1.9452	4.7262
1.6097	1.7743	3.0747
1.6481	1.8269	2.7709
1.8512	2.0444	3.0888
1.8249	2.1837	2.7112
2.1094	2.2739	3.6883
2.0587	2.2256	3.7532
1.6658	1.8267	3.4529
1.8736	1.9868	3.4928
1.934	2.0401	3.4596
1.8011	1.9287	3.4521
1.9489	2.0633	3.3499
1.2142	1.2738	3.2292

Post Assembly O/S Testing

- No need for a fully functional tester
  - Limited tester time
- Test All Device pins
  - Signal & Source
- C4 Bump continuity
- Die Attach
- Handler capability for volume testing
- Validated and correlated to a functional tester

Conclusions

- Lab environment test solutions provide flexibility and real time capability
- Testing all device pins allows us to isolate socket, board design or assembly related problems

- Socket qualification is more effective and thorough.
- Time cycle from engineering prototype to production is reduced

Conclusions Continued

- Compare socket performance across all platforms
- Build volume quantities of sockets based on the validation of a few.
- Target the ideal actuation force
  - Alleviate stress on package

- Transfer a “plug-and-play” socket from an engineering environment to the production floor

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Questions?