



# ● CDM Testing

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# **Recent Changes to CDM Test Standards**

# ESDA/JEDEC Standards Status

## CDM Device Testing ESDA (WG5.3.1)

- The ESDA released a version of the ANSI/ESDA-STM5.3.1 CDM standard, ESD S5.3.1-2009<sup>[1]</sup> which replaced ESDA-STM5.3.1-1999.
- Some highlights of the document changes:
  - Added a tester conceptual drawing
  - Included graphical and definitions for the Single and Dual discharge methods
  - Waveform verification equipment specifications were improved
    - 3GHz scope required for calibration
    - 1GHz scope can be used for verification
    - 18GHz for all cables and attenuators
  - Waveform verification modules can be either FR4 or RF35, however RF35 is recommended as this does not suffer from humidity and other issues that FR4 does
  - The verification module capacitance should be measured
    - Due to the restraints of previous versions, the specified size of the modules versus their required capacitance values do not correlate. Size of the modules may not adhere to the values in the standard.

# ESDA/JEDEC Standards Status

## CDM Device Testing JEDEC

- JEDEC released JESD22-C101E<sup>[2]</sup> in December 2009
  - Section 10.4 is the only section that changed in this new release of the standard.
  - This new release changes the number of pulses **from 3 pulses per polarity to at least 1 pulse per polarity** during device testing. The other change to this section highlighted the need to verify a discharge has occurred, since there will be only one pulse per polarity.
- JEDEC released JESD22-C101D in October 2008
  - Section 10.4 is the only section that changed in this new release of the standard.
  - This new change allows partitioning of the tests between multiple devices. Partitioning can provide additional information during the failure analysis, compared to stressing one device with both polarities or all pins on a single device.

# AEC (Automotive Electronics Council) Standard Status

## AEC CDM Device Testing

- AEC Q100-011-Rev-B <sup>[3]</sup> is the latest CDM document from the AEC
  - The last release of this document was in July of 2003 and remains at Rev B
- Document specifications
  - References ESDA and JEDEC CDM standards
  - Uses ESDA style targets (4pF/30pF)
  - Mentions that an insulator on the charge plate can be used, as long as it's less than 130 microns thick
  - Mentions both Direct and Field Induced Charging Methods
  - In Section 3.2 "Charging and Discharging methods" (see below) there is a glaring error in the document, as it states "direct contact discharge method is the only acceptable method to discharge a DUT"

In January of 2006, we contacted the lead standards person at AEC and he stated  
*"The CDM test required by the AEC should have referenced both discharge methods ... with a preference of the non-contact discharge method"*

3.2 There are two acceptable methods of charging a DUT: Direct Charging and Field-induced Charging. Either method may be used to perform CDM ESD testing and must be recorded. While several methods exist for discharging a DUT, the direct contact discharge method is the only acceptable method to discharge a DUT for this test method.

# AEC (Automotive Electronics Council) Standard Status

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## AEC CDM Device Testing

- AEC Q100-011-Rev-B is the latest CDM document from the AEC
  - Recently, the CDM committees contacted AEC to discuss their possible adoption of the ESDA/JEDEC standards
  - Rather than simply adopting the ESDA/JEDEC standards, AEC indicated they would update their standard with the information we provided regarding the incorrect discharge method in addition to some other recommendations from the committee
  - A new version of the standard is expected to be released shortly

# References

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- [1] ESD S5.3.1-2009 Electrostatic Discharge Sensitivity Testing - Charged Device Model (CDM) - Component Level
- [2] JEDEC JESD22-C101E "Field Induced Charged-Device Model Test Method for the Electrostatic Discharge Withstand Thresholds of Microelectronic Components"
- [3] AEC - Q100-011 Rev-B July 18, 2003, CHARGED DEVICE MODEL (CDM) ELECTROSTATIC DISCHARGE TEST



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# New Joint Standard Status

Agust 2010

# Joint ESDA/JEDEC Standards Status

## **Joint ESDA/JEDEC CDM Device Testing**

- A joint committee was formed in 2009, tasked with harmonizing and creating one standard, which would be recognized by both standard bodies. The joint committee is made up of members from both the ESDA and JEDEC work groups.
  - This new standard will combine aspects of both standards, encompassing improvements that have been made in both documents over recent years, while also reviewing required changes for today and tomorrow's test requirements.
- There are a number of issues confronting this combined work group:
  - The overall non-repeatability of the air discharge method
    - Waveform repeatability during testing
    - Waveform verification issues with the non-repeatability
    - Effects of the environment on the test results
- Based on a number of these issues, we've made the following recommendations
  - The spec should include a maximum humidity requirement
  - Vacuum or mechanical means for keeping the device pressed against the charge plate to eliminate air gaps, which reduce the capacitance and hence the I<sub>peak</sub> should be added to the spec

# Joint ESDA/JEDEC Standards Status

## Joint ESDA/JEDEC CDM Device Testing

- As you may know, there are a number of large differences between the ESDA and JEDEC standards. *(See a complete list of the differences on page 5)*
  - JEDEC specifies a 15mil insulator on the charge plate – ESDA does not
  - JEDEC verification modules are coins – ESDA uses FR4 with a gold pad as the “coin”
    - Capacitance values are also different
  - Waveform specifications are different, including the verification levels required
  - Waveform measurement techniques, such as the bandwidth used to calibrate and verify the waveforms is different – JEDEC states 1gig – ESDA specifies 3gig for calibration and 1gig for verification
- Because of these differences, creating a single document is showing to be more difficult to achieve than say for combining the HBM document!!

# Joint ESDA/JEDEC Standards Status

## Joint ESDA/JEDEC CDM Device Testing

- The committee has been working on a number of items to ensure the document encompasses the best of both documents, as well as some additional items that have been learned during this process
  - Bandwidth experiments are on going, to ensure the proper calibration levels are selected for the document. Different bandwidth scopes are being reviewed and internal and external bandwidth limiters are being reviewed
  - Waveform experiments have taken place, to make the proper selection of tester configuration, i.e. which charge plate setup and calibration modules to use. Presently leaning towards JEDEC setup.
  - Experiments are on going, to determine whether a change in the current measurement scheme (1 ohm) would improve the measurement repeatability. One idea is to change the resistance value to dampen the waveform and allow easier waveform verification.
- At the present time, the committee is writing a preliminary document but there are still a number of items that need to be ironed out before it can move forward.
- We estimate that a new document is still 1-2 years away.

# Joint ESDA/JEDEC Standards Status

Requirement	ESDA	JEDEC
Air Discharge	Yes	Yes
Insulator	Mylar <130 microns	FR4 / 0.381mm
Target – Small	FR4, 0.8mm, 4pF	Metal 0.889 in diameter, 1.27mm thick, 6.8pF
Target – Large	FR4, 0.8mm, 30pF	Metal 2.54 in diameter, 1.27mm thick, 55pF
Cal Levels	125, 250, 500, 1000, 1500, 2000V	Small, 500 and 1000V Large 200 and 500V
Current Probe	Inductive current or coaxial resistor(1Ω disk)	1Ω disk resistor
Scope Bandwidth	1GHz and <b>3.5GHz</b>	1GHz
	<i>Numbers are 3.5GHZ</i>	
500V requirements	4pF      30pF	6.8pF      55pF
Peak Current	7.5A    18A+/-20%	5.75A    11.5A+/-15%
Rise Time	< 200ps    < 250ps	< 400ps      --
Pulse Width (FWHH)	< 400ps    < 700ps	1ns +/-0.5      --
Undershoot	< 50% of Ip1	< 50% of Ip1
Overshoot	< 25% of Ip1	< 25% of Ip1
Zaps per polarity	3	At least 1

# References

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[1] White Paper 2: A Case for Lowering Component Level CDM ESD Specifications and Requirements, Industry Council on ESD Target Levels, Rev1  
March 2009

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# **Problems and Variables in CDM testing**

# Problems and Variables in CDM testing

CDM testing has always been a difficult test to perform, due to the air discharge portion of the test method. The original Socketed CDM Method tried to address these issues but introduced other tester influences.

- The overall non-repeatability of the air discharge method causes
  - Waveform repeatability during testing
  - Waveform verification issues due to the non-repeatability
  - Effects of the environment on the test results
- Issues in testing today's smaller pin pitch devices
  - As device pin pitch continues to decrease, achieving discharges from required pins is becoming more difficult if not impossible
    - Which pin is actually being discharged?
  - As the requirement to test package less devices increases, it is apparent that the air discharge method is not feasible
    - Smaller diameter or pointed pogo pin may be required, however these change the waveform performance



# Problems and Variables in CDM testing

With the release of the “Industry Council White Paper 2 Rev 1 March 2009<sup>[1]</sup>, which recommends lowering the Component Level CDM ESD Specifications and Requirements to 250V, from 500V and then to 125V in 2015, the above issues become harder to overcome with the present test methodologies.

- As the stress levels decrease, the effects of humidity play an even greater role in the peak current seen during the discharge
- As the device pin spacing continues to decrease and more package less devices require testing, air discharge won't be usable

**These issues have led us to the development of our patented CDM2 test methodology. See the Thermo Scientific CDM2 presentations for additional information!**

# References

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[1] White Paper 2: A Case for Lowering Component Level CDM ESD Specifications and Requirements, Industry Council on ESD Target Levels, Rev1  
March 2009

# Orion2 CDM Tester



# What is Orion2 CDM Tester?

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**Orion2 is a new CDM Tester that addresses today's CDM Testing Issues – repeatability and reproducibility**

- ✓ An existing Orion CDM Tester can be upgraded to an Orion2!

# Orion2 CDM Tester Features

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- **CDM2 Discharge Head Option** configurable within minutes.
- **Humidity Control** monitors, controls and reports humidity in the chamber and ensures humidity is below a settable threshold before a test is allowed to run (user selectable). Very important for repeatable FICDM air discharges.
- **Integrated Package Editor** allows the user to enter any custom DUT package in minutes for any size or any shape DUT including off-grid pin-outs.
- **Integrated Oscilloscope** Interface to automatically record and store discharge events to verify the event occurred and to gather valuable information from device waveforms. Only a single (1) stress pulse/pin would be required if stress current waveform validated for each discharge.

# Orion2 CDM Tester Features

- **Faster mechanism** (5X) for improved throughput.
- **Improved mechanical resolution** (125X from 1 mil to 0.008 mil =  $\pm 0.2$   $\mu$ m) for tiny DUTs. Orion2 has tested 0.4 mm pitch devices and 90  $\mu$ m die pad spacing. Mechanism repeatability better than 25  $\mu$ m.
- **Automatic alignment** to off-angle DUT placement. Just teach 2 opposite DUT pins and go.
- **Improved video resolution with zoom** (100X) *[Release date TBD]*
- **Faster Video** camera updates (2X) to ease mechanical teach operation.
- **Program different Voltage Stress levels** by pin group in same Test Plan.

# Orion2 CDM Tester Features

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- **Multiple languages** supported by User Interface (English, French, German, Italian, Japanese, Chinese, Korean, etc).
- **Configurable** between ESDA, AEC, JEDEC, JEITA and new Thermo Scientific CDM2 method within minutes for maximum CDM Tester versatility.
- **Upgradable** from existing Orion CDM Testers to an Orion2 to provide all of the features above.

# Orion2 CDM Tester



- Provides testing to all of today's Field Induced CDM standards
  - *Also provides a path for the future!*
- Enclosed interlocked test chamber allows control of the testing environment (humidity)
- Windows based software provides flexibility for test creation and waveform verification using our integrated scope interface
- Highly accurate mechanism makes testing of high density devices and even wafers possible



# Orion2 CDM Tester



- Dual High Resolution color cameras make device outline creation and alignment easy
- Large device test area allows testing of today's high pin count devices
- Vacuum and variable alignment plate allows testing of most devices without the need for special fixturing
- Discharge event detector helps ensure your testing is correct

# Orion2 CDM Tester

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- Meets all current versions of today's ESD specifications:
  - ESD Association S5.3.1-2009
  - JEDEC C101-E
  - AEC-Q100-011
  - JEITA- EIAJ ED-4701/001
    - Switching between configurations is quick and easy
- Also, ready for the next generation of CDM testing
  - CDM2 – *A new method for repeatable, controlled CDM testing*
    - *CDM2 is a new approach to CDM testing which eliminates FICDM testing issues such as air discharge and environmental impacts on waveform / testing integrity*

# Orion2 CDM Tester

- Transparent, antistatic, interlocked test area enclosure allows the test area to be flooded with nitrogen or dry air for improved test control
  - Optional environmental control takes this a step further by monitoring and controlling the test chamber humidity level
  - Testing can be automatically halted or prevented from starting should the chamber level move outside of user programmable levels
- Windows based software provides easy programming of device outlines and test plans:
  - A list of standard package outlines is provided, however user defined package outlines can be saved for future use as well
  - *A new device creation feature makes user defined and created device outline creation easy*

# Orion2 CDM Tester

- Windows based software provides easy programming of device outlines and test plans:
  - Test plan programming includes
    - Selection of test configuration type
      - (ESDA, JEDEC, AEC, JEITA, or CDM2)
    - Test voltage level on a per pin basis
      - +/- 25V to 2kV
    - Number of ESD pulses
    - Positive, negative or alternating polarity routines
    - Single polarity or dual polarity (JEDEC) discharge methods
    - Inclusion of discharge event detection
    - Selection of waveform capture routine, which provides scope control and capture of discharge waveforms into a selected directory. Waveform data can also be included in your reports.
    - Selection of optional humidity control

# Orion2 CDM Tester

- High Resolution dual cameras are displayed on the computer monitor for ease of use during outline creation
  - They can be left on during testing to visually verify pin alignment
- Mechanism provides high accuracy while also providing the testing speed you need
  - X , Y and Z axis 0.2  $\mu\text{m}$  resolution with <25  $\mu\text{m}$  repeatability
- Large test plate allows testing of large devices
  - 6.35 cm X 6.35 cm Test area
  - Minimum pitch <400 $\mu\text{m}$  with a 254 $\mu\text{m}$  pogo pin surface diameter
  - With CDM2 contact method, minimum pitch is <100 $\mu\text{m}$ , as a smaller pointed pogo can be used (not practical for FICDM)

# Orion2 CDM Tester

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- Testing is performed with the device dead-bug
  - The system uses user supplied vacuum and a variable alignment plate to locate the device during testing.
    - Vacuum ensures the correct “test setup” during testing
    - This arrangement eliminates the need for costly fixturing
- Discharge event detector is used to confirm pins have been stressed and to allow retesting of missed pins
  - Indicator flashes when event occurs
  - Software records whether a discharge has occurred, allowing the user to retest “missed” pins

# Orion2 CDM Tester

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- Built in waveform monitor port
  - Used for system waveform verification
  - Monitor ESD pulse during actual testing

# Orion2 CDM Tester Options

## Waveform Configurations

- Each Includes the following
  - Pulse Head (Ground Plane)
  - Charge Plate
  - Verification Targets
- ESDA configuration
- JEDEC configuration
- AEC configuration
- JEITA configuration

## CDM2 (A new CDM test method)

- CDM2 configuration
  - Includes
    - Pulse Head
    - Verification Targets
    - High bandwidth coax cables

## Environmental Control

- ORI2 Environment
  - Includes
    - Humidity sensor
    - Nitrogen control valve
    - Environmental Control Software

## Calibration Accessories

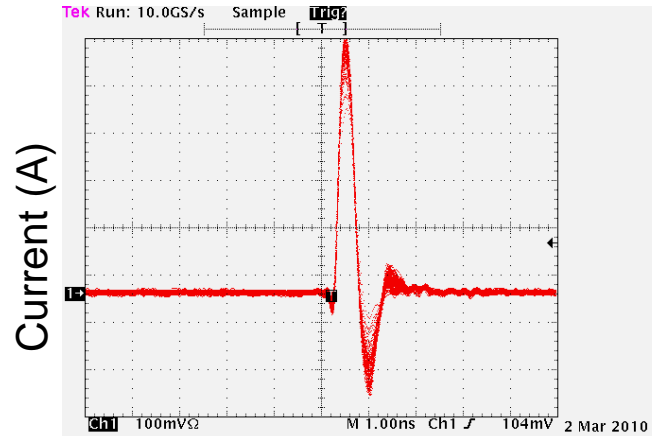
- CAL Group
  - Includes
    - High bandwidth coax cables
    - SMA / Coax adapter
    - Attenuators



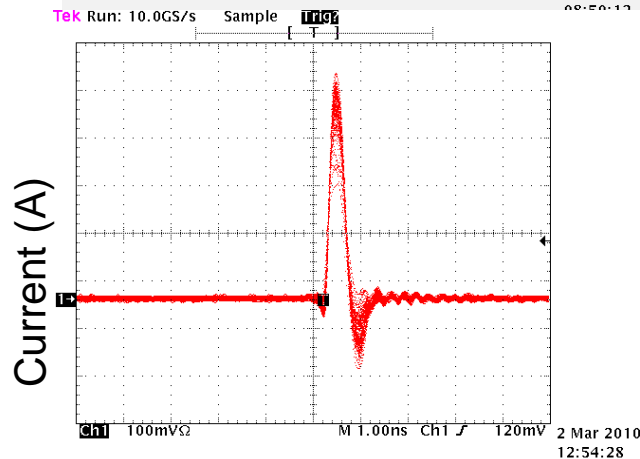
# Orion2 Humidity Control

100 3GHz FICDM waveforms at 500V on ESDA 4 pF target

10% RH

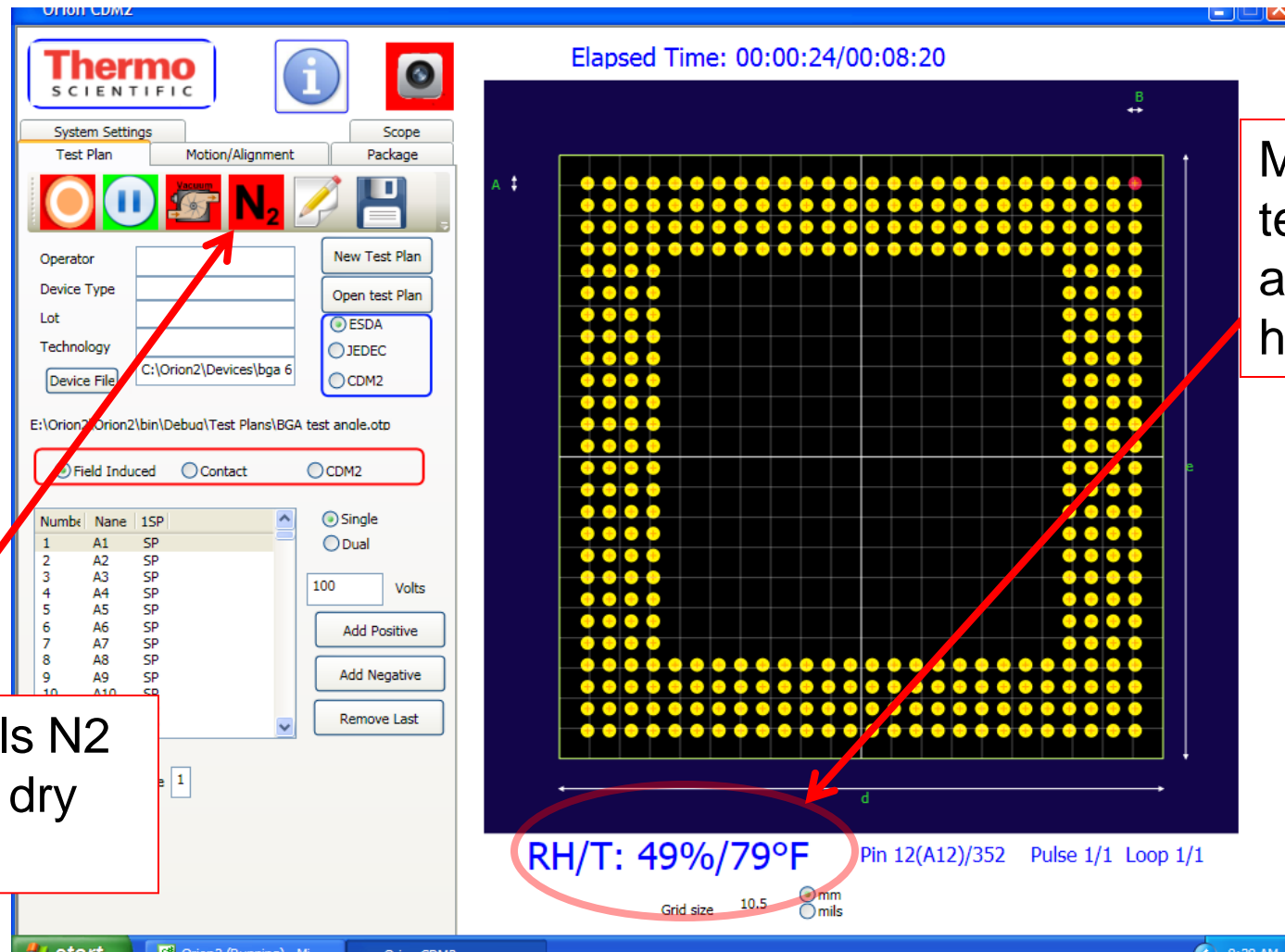


60% RH



**Why control Humidity? FICDM  $I_{pk}$  drops 20% with rising humidity, especially at the lower voltage levels**

# Orion2 Humidity Control User Interface



Monitors  
temperature  
and relative  
humidity

Controls N2  
flow or dry  
air

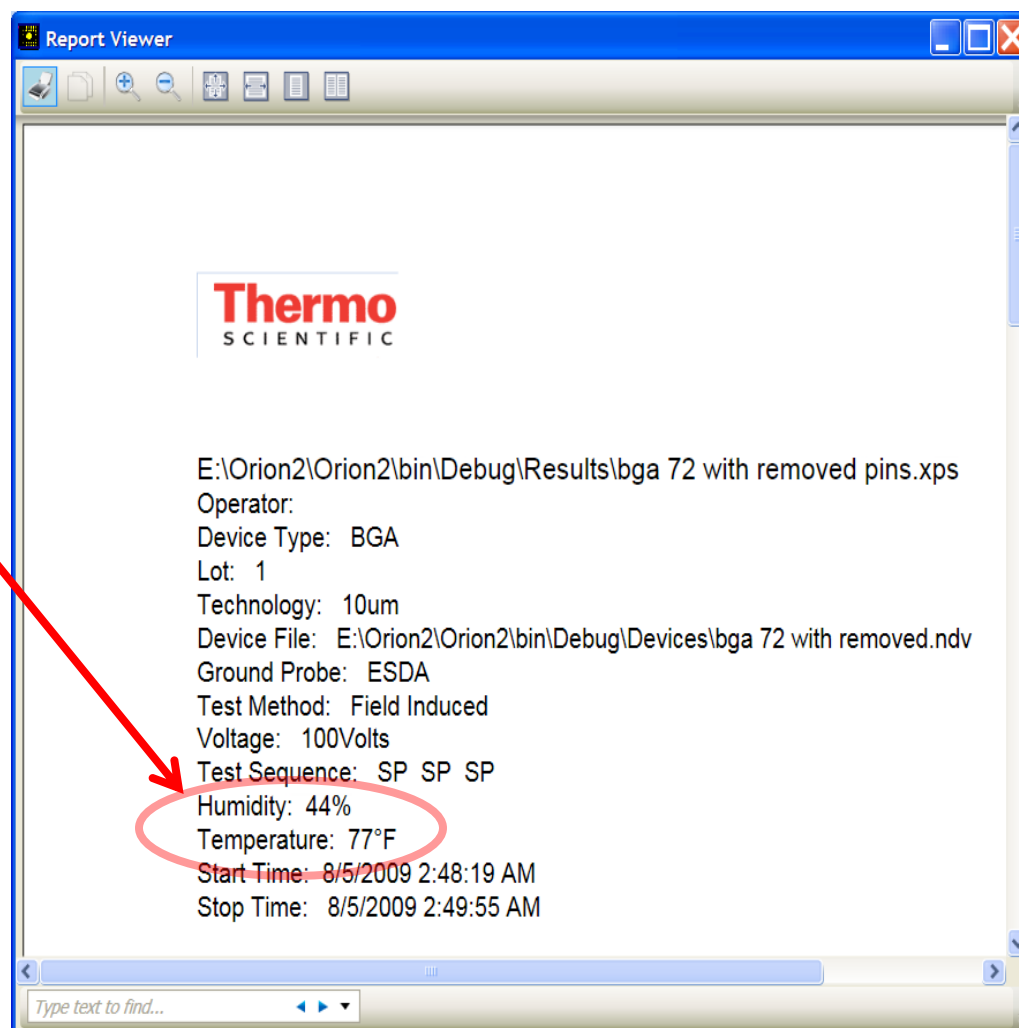
RH/T: 49%/79°F

Pin 12(A12)/352 Pulse 1/1 Loop 1/1

Grid size 10.5 mils

# Orion2 Humidity Control Report Sample

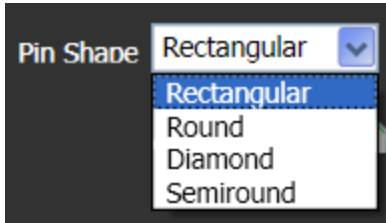
**Report Includes RH  
and Temperature**



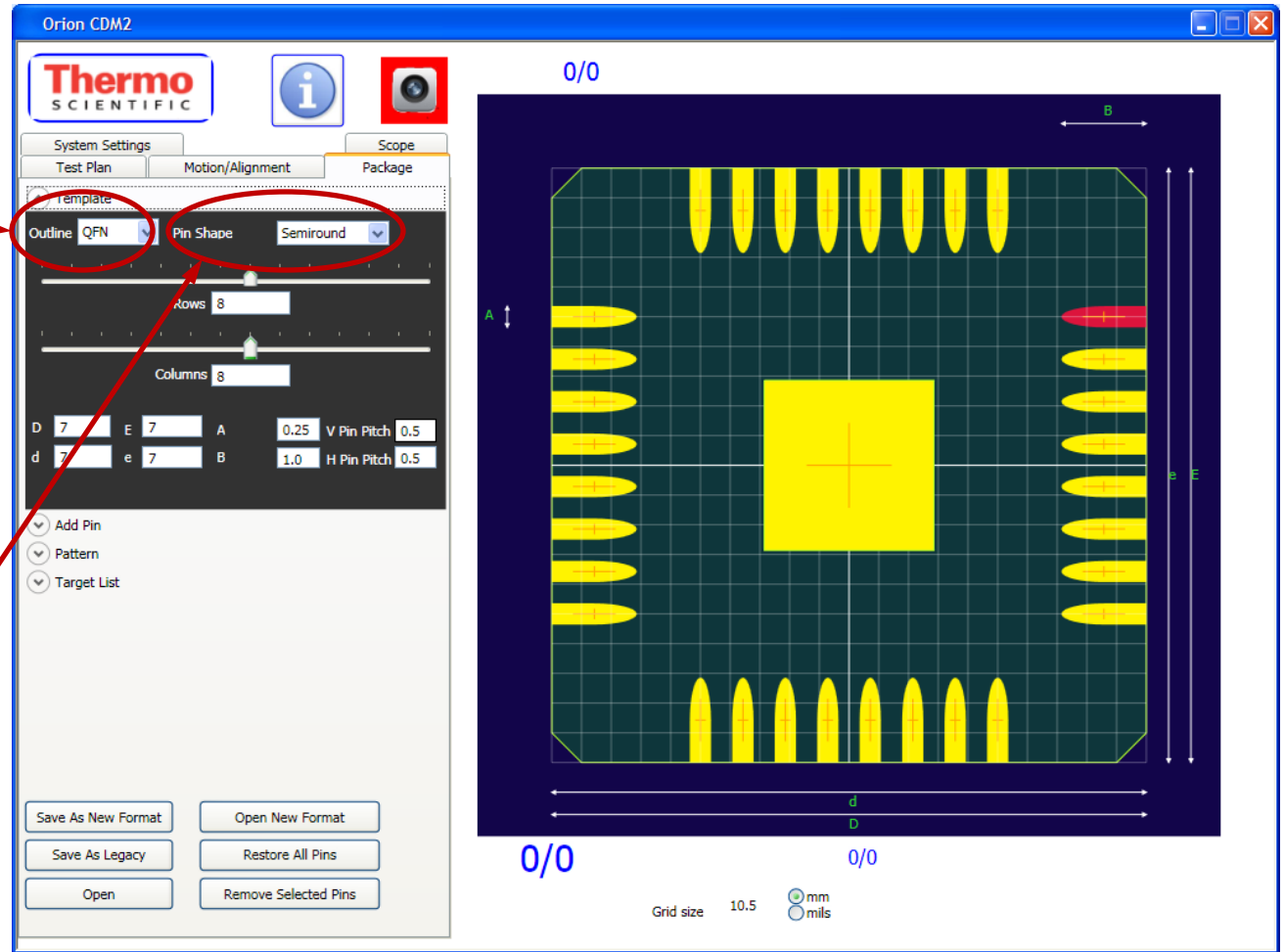
# Orion2 Package Editor User Interface



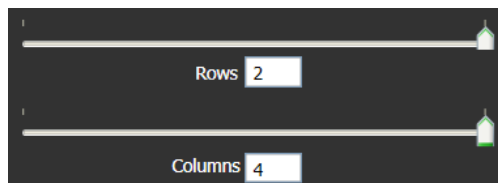
## Define package outline



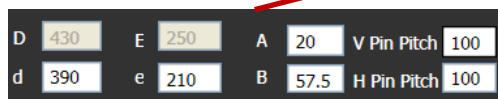
## Define pin shape



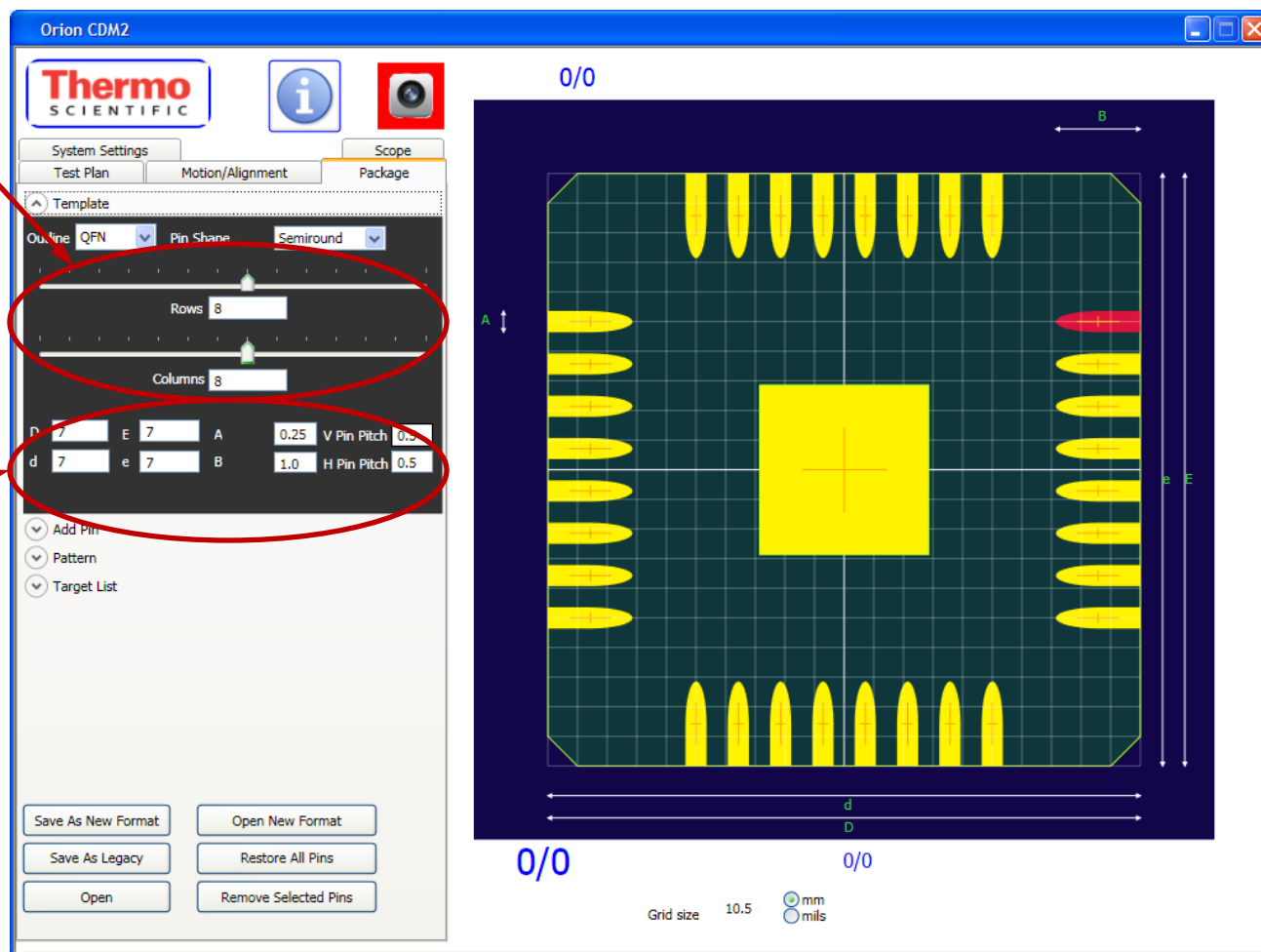
# Orion2 Package Editor User Interface



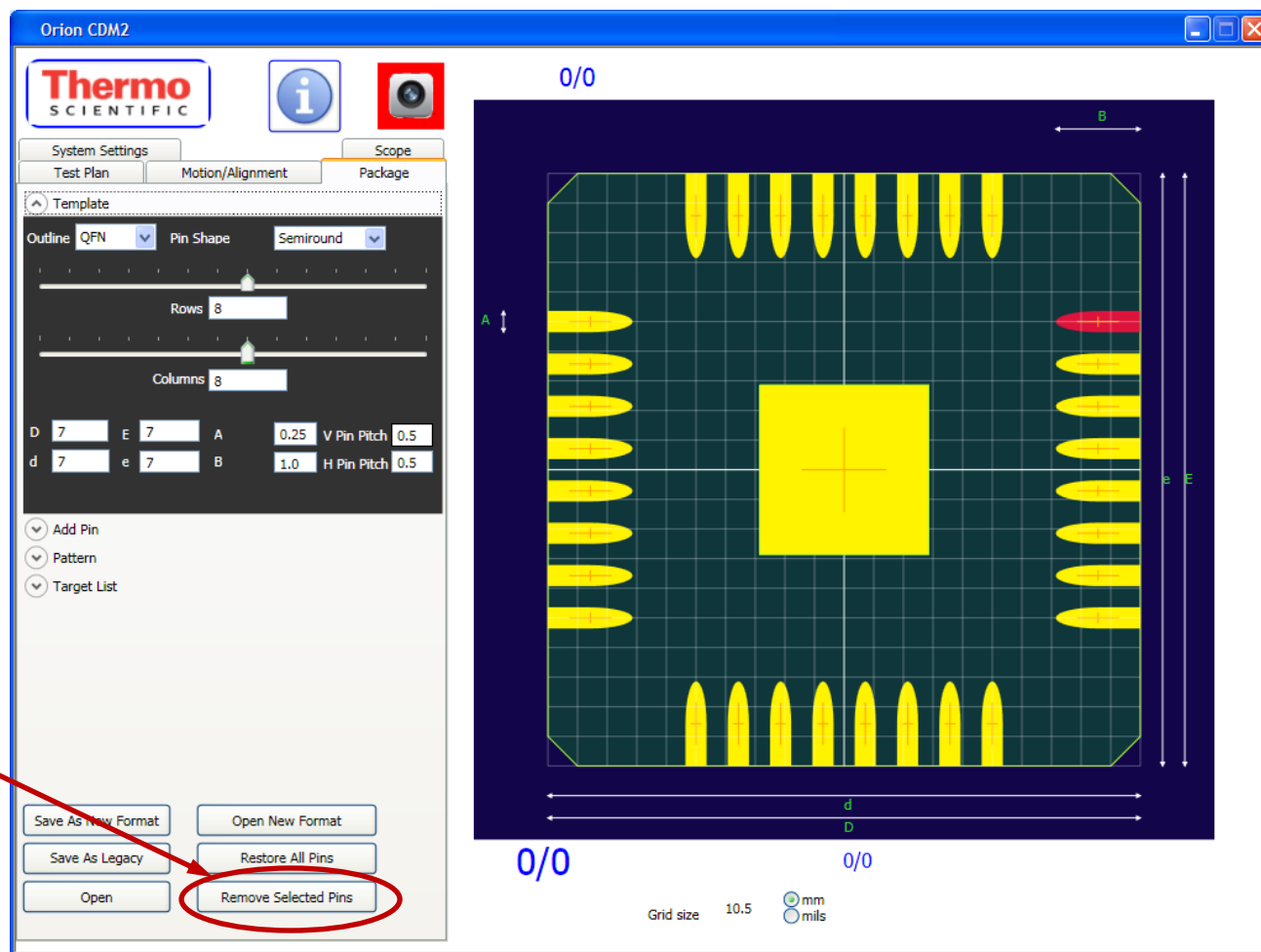
Define # of rows and columns by sliders



Define package dimensions

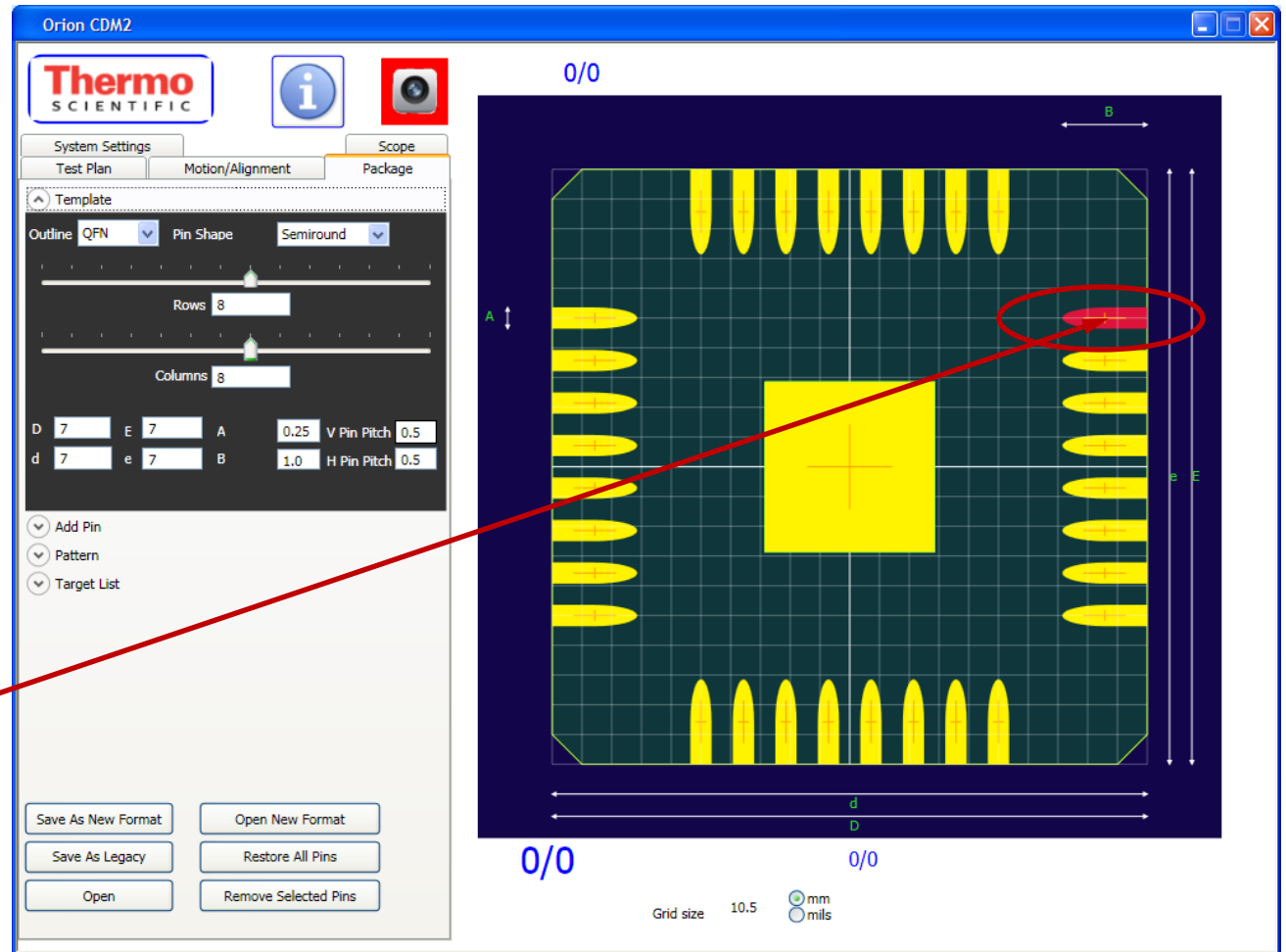


# Orion2 Package Editor User Interface



Select pins using mouse and click on "Remove Selected Pins"

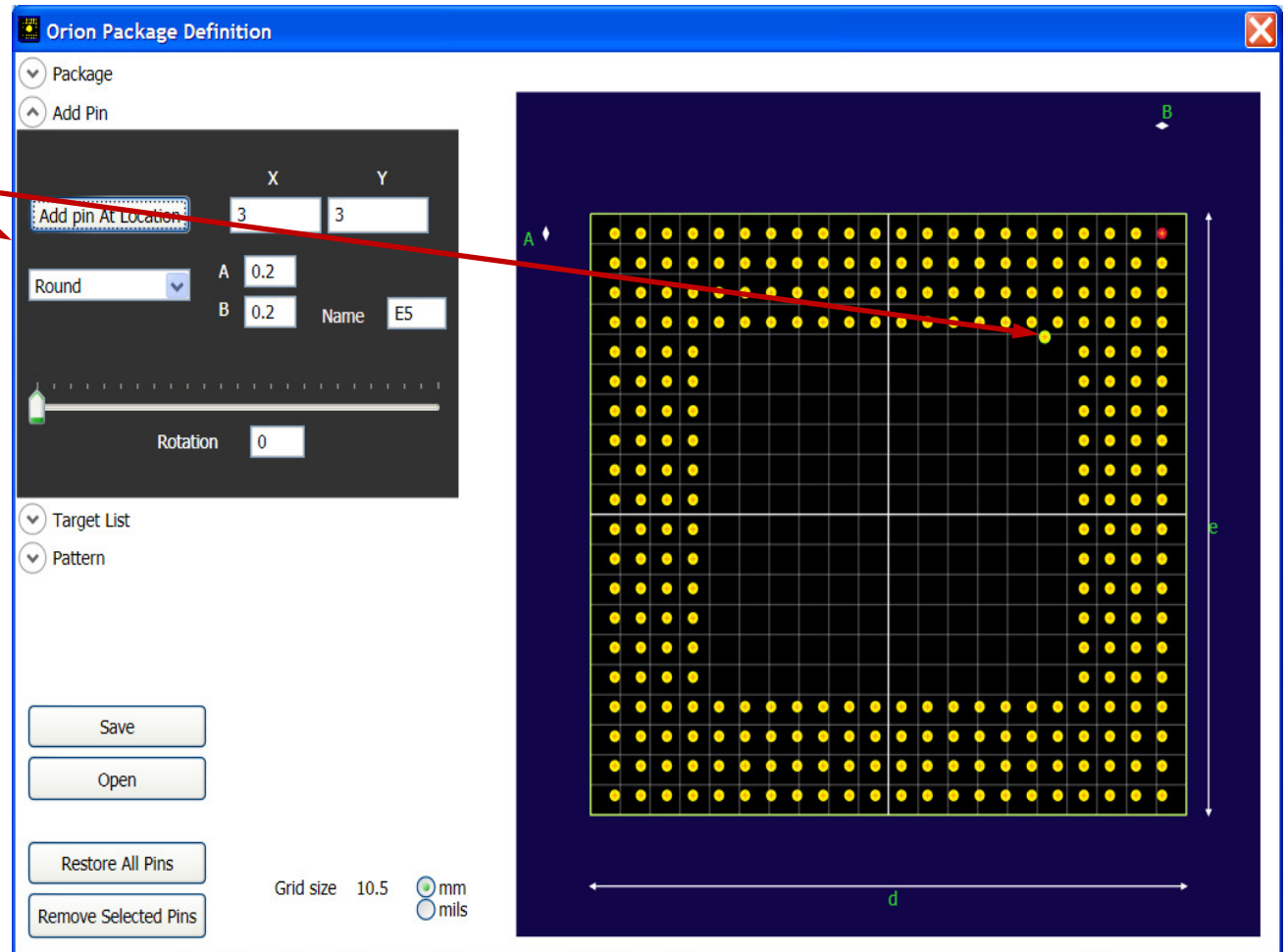
# Orion2 Package Editor User Interface



Orange cross lines  
indicate pogo touch  
point. User-editable

# Orion2 Package Editor User Interface

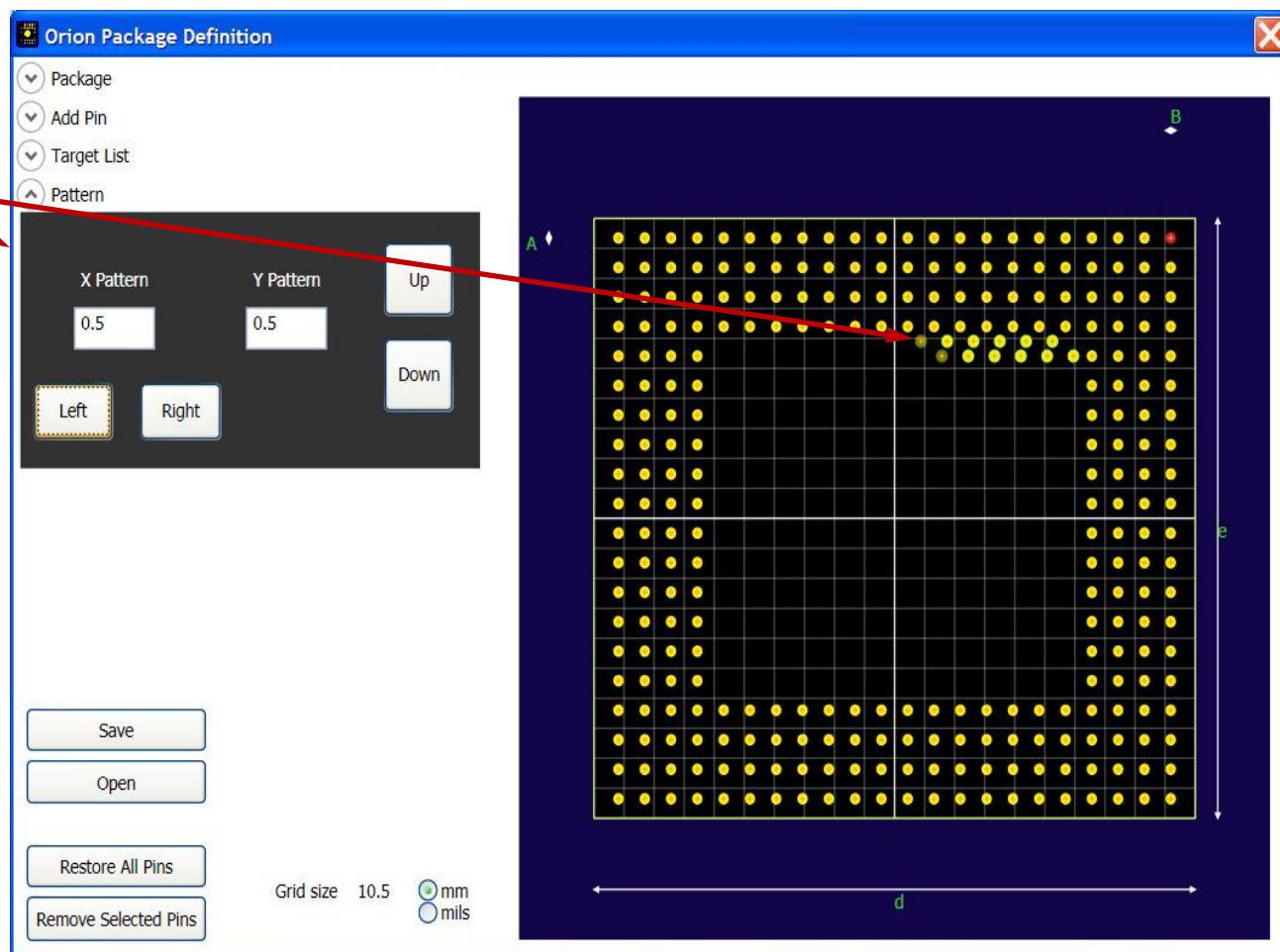
For off-grid pins,  
Use Add Pin  
dialogue box





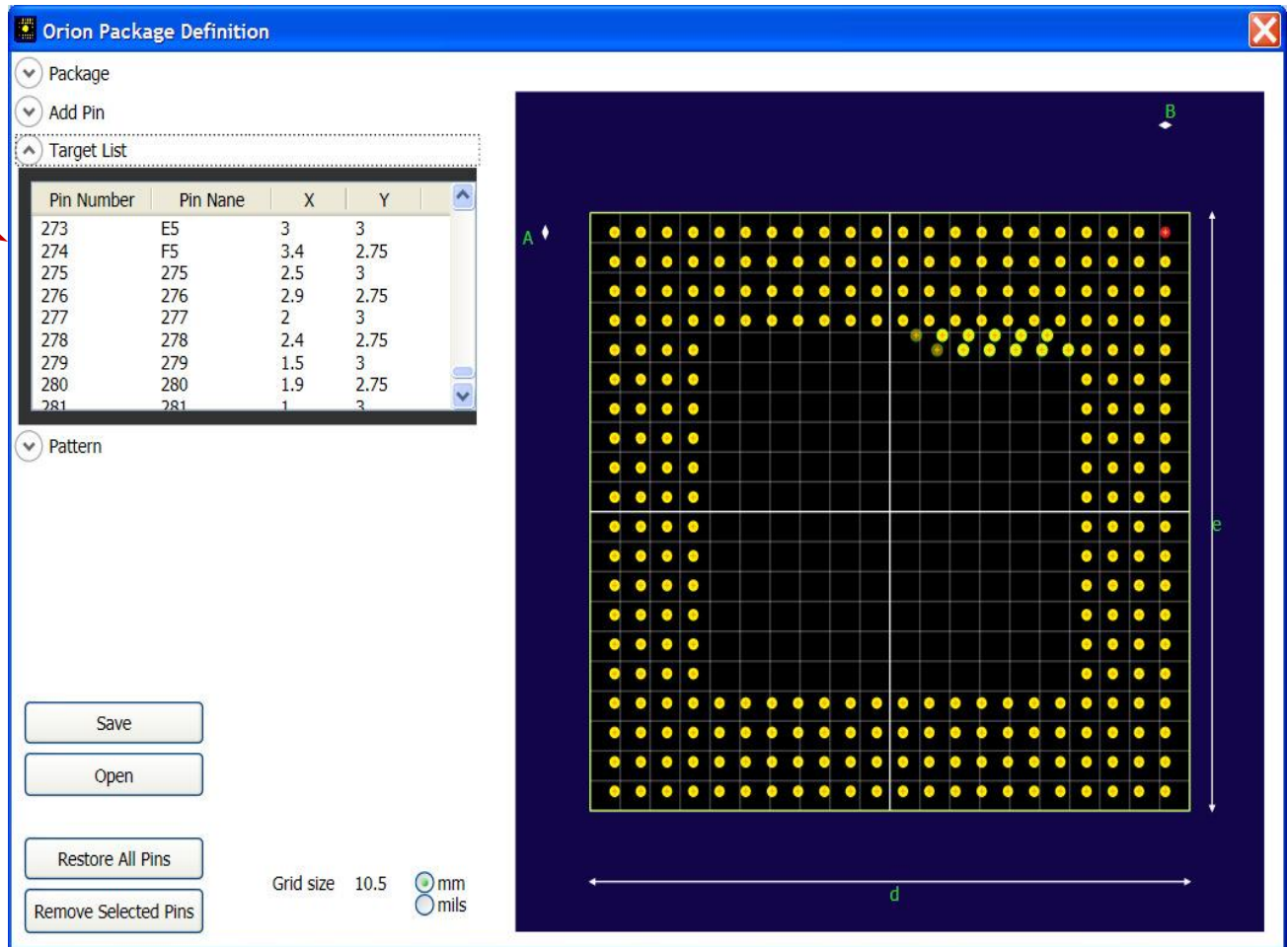
# Orion2 Package Editor User Interface

Continue to add pins individually or use the Pattern dialogue box



# Orion2 Package Editor User Interface

Click on Target List dialogue box to review the coordinates of each pin. This list can be exported and **imported**.



# Orion2 Integrated Scope Interface

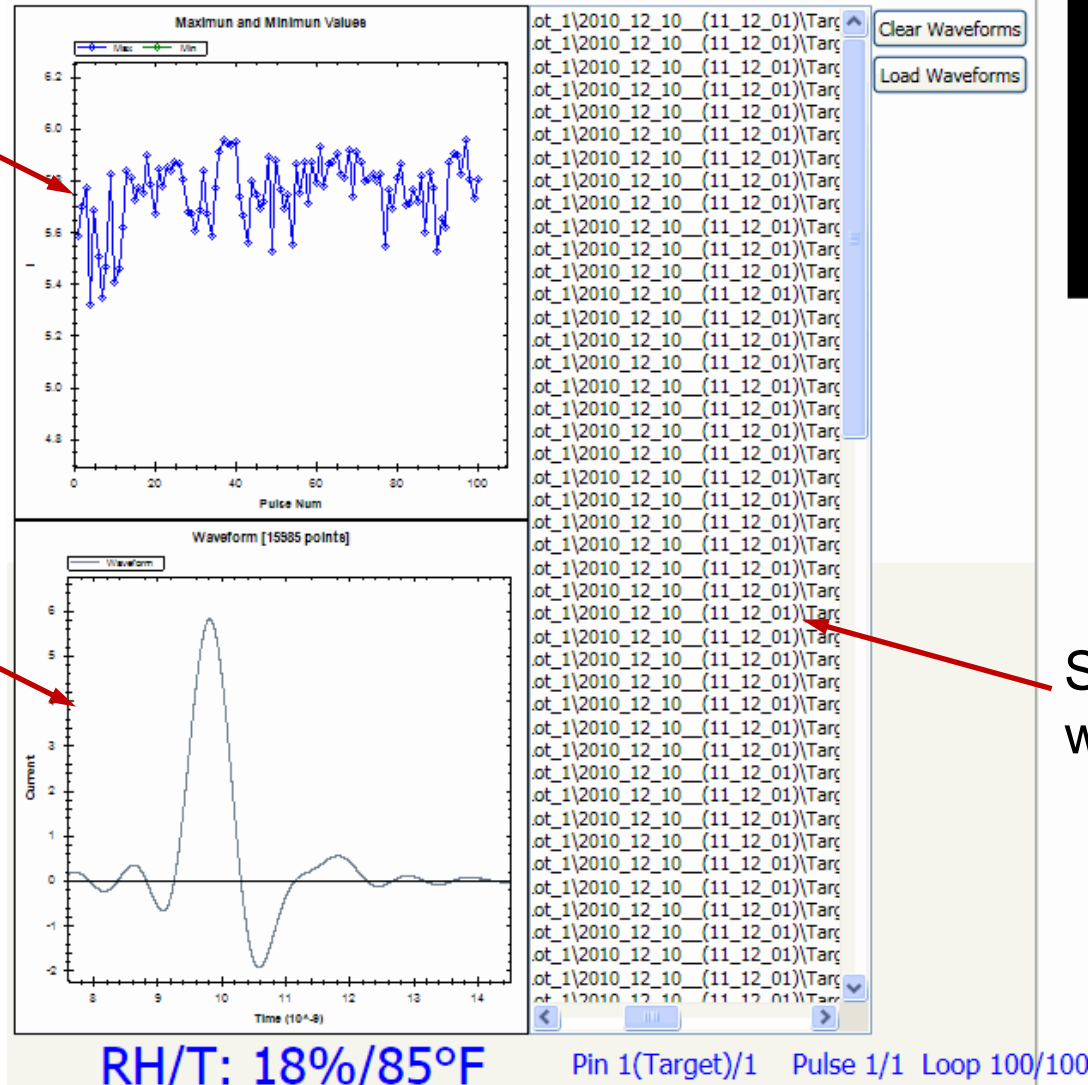
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- Can record each discharge waveform (user-selectable). The waveforms can be saved locally or to a network drive.
- Connect Oscilloscopes using GPIB, RS-232 or USB. Uses VISA (Virtual Instrument Standard Architecture) and IVI (Interchangeable Virtual Instrument) technology for instrument interfaces.
- We can easily connect to most of the Oscilloscopes in the market today.

# Orion2 Integrated Scope Interface

Records Ip1  
max and Ip2 min  
values for every  
discharge. Can  
zoom in and out.

Records every waveform. Can zoom in and out.



- Stores every waveform.

# CDM2 Discharge Head & Orion2 CDM Tester

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**An existing Orion CDM Tester can be upgraded to an Orion2 to provide all of the features above!**