Larkin Power Components

PRODUCT INFORMATION

800-317-5526 January 2006

# Testing and Maintaining Power Semiconductors for System Reliability

Power Semiconductors are a family of devices used in all types of industries mainly for AC/DC conversion and motor speed control.

A variety of different packages and configurations are available, e.g stud mounted, press pack (hockey puck), single and dual thyristor/diode modules, and transistor modules.

When a Power Semiconductor fail, expensive loss of production is the immediate result.

In most cases, un-scheduled down-time, i.e. loss of production, due to faulty or marginal components, can be avoided by testing the Power Semiconductors regularly during scheduled outages or service days.

It is imperative that only instruments specifically designed for testing Power Semiconductors are used. Meggers and hi-potters should under no circumstances be used, since these kind of instruments can easily damage the components

Ohm meters are ONLY reliable to detect a short, since they do not have enough voltage to properly energize the silicon wafer in a Power Semiconductor

## MINIMIZING FAILURES IN POWER SEMICONDUCTORS

### TEST COMPONENTS BEFORE INSTALLATION

Make sure that the replacement component is functional, before being installed.

### CLEAN POWER SUPPLY

Try to keep the power supply as noise free as possible, i.e. free from transients (spikes), and harmonics. In some cases an isolation transformer is the only way to get a clean supply.

### KEEP COMPONENTS CLEAN

Dirt and moisture on the components could cause surface leakage.

### FOLLOW INSTALLATION SPECIFICATIONS

Make sure that press pack components are torqued in accordance to specifications.

### HANDLE COMPONENTS WITH CARE

Power Semiconductors may look rugged, but they could easily be mechanically damaged if dropped.

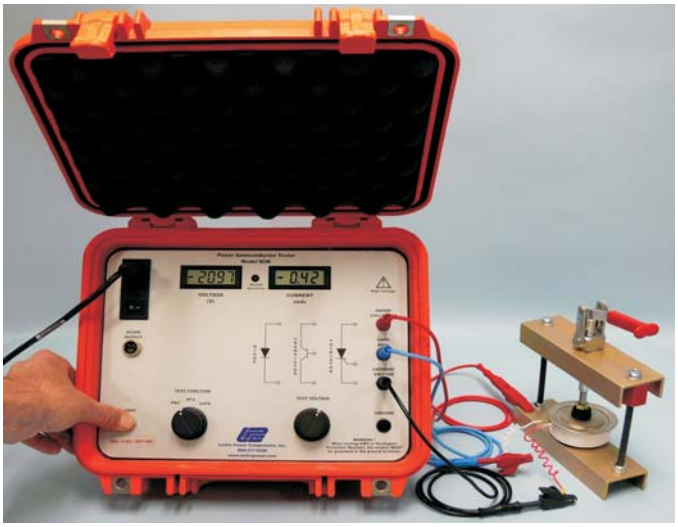


*Fig.1: Power Semiconductor Tester - Model M3K*

## WHY POWER SEMICONDUCTORS FAIL

A Power Semiconductor could fail, or degrade, for a number of different reasons, mechanical or electrical.

Some failures can easily be prevented with proper service, maintenance, and handling. Others are impossible to prevent, since they are inherent with the system where they are installed.

## COMMON REASONS FOR FAILURES

### ELECTRICAL

- Transients on the electrical power feed.
- Faulty, or wrong, replacement component installed.
- Surface leakage due to dirty components.
- Low resistance/short in device controlled by the component.

### MECHANICAL

- Mishandling of component.
- Shipping damage.
- Improper installation.

*Figure 2: Typical Power Semiconductor Components*

## Identifying Different Types Of Power Semiconductors

| Type of Power Semiconductor | | Function | Types |
|---|---|---|---|
| **Thyristor (SCR)** |  | Acts like a switch. The gate turns on the SCR. Removing the voltage across anode and cathode turns the device off. | Phase Control and Inverter Grade. |
| **Diode** |  | Current flows in one direction only. Can be either forward or reversed biased. Arrow on on diode indicates current flow direction. | Standard and Fast Recovery. |
| **GTO** |  | Gate Turn Off Thyristor. Similar to a SCR but the can be turned of by applying voltage. | Anode Short and Symmetrical. |
| **Power Module** |  | Diode/Diode, Thyristor/Thyristor and Diode/Thyristor types. | Phase Control and Inverter Grade.<br>Standard and Fast Recovery. |
| **AC/DC Bridge** |  | Diode, Thyristor and types. | Single & 3-phase |
| **Transistor Module** |  | Darlington Transistors | Single & Dual |
| **IGBT Module** |  | Insulated Gate Bipolar Transistors | |

### Mounting Puck Devices to Heat Sinks

The following instruction is essential for maintaining low, stable thermal and electrical resistance associated between puck devices and heat sink surfaces.

1. ***Inspection of mating surfaces***
   Check each mating surface for nicks, scratches and surface finish.
2. ***Surface De-oxidisation and Cleaning***
   Although plated surfaces are recommended for aluminum and copper heat sinks, bare surfaces may be used if careful attention to cleaning and treating is assured. Plated surfaces should be lightly sanded with 600 grit paper, then oil or compound applied as recommended. Un-plated aluminum surfaces should be vigorously braided with a fine wire brush or 3M "Scotch Brite" coated with Alcoa EJC #2 compound. The EJC #2 should be removed and the recommended compound applied.
3. ***Final Surface Cleaning***
   Apply silicone oil or a **very** thin layer of grease or compound as indicated below. Rotate the puck to properly distribute the applied agent. Limit maximum joint temperature to: 95C using EJC #2, and 150C using SF1154, DC550 or G322L
4. ***Mounting***
   Center the puck in the heat sink using the roll pins in each heat sink as a guide.
5. ***Applied Mounting Force***
   The spring clamping hardware usually has a gauge indicating when the correct pressure is applied. There are a variety of clamping devices on the market, each with a slightly different method of indicating the correct pressure. Consult with your Basler representative for recommendations or more detailed instructions.

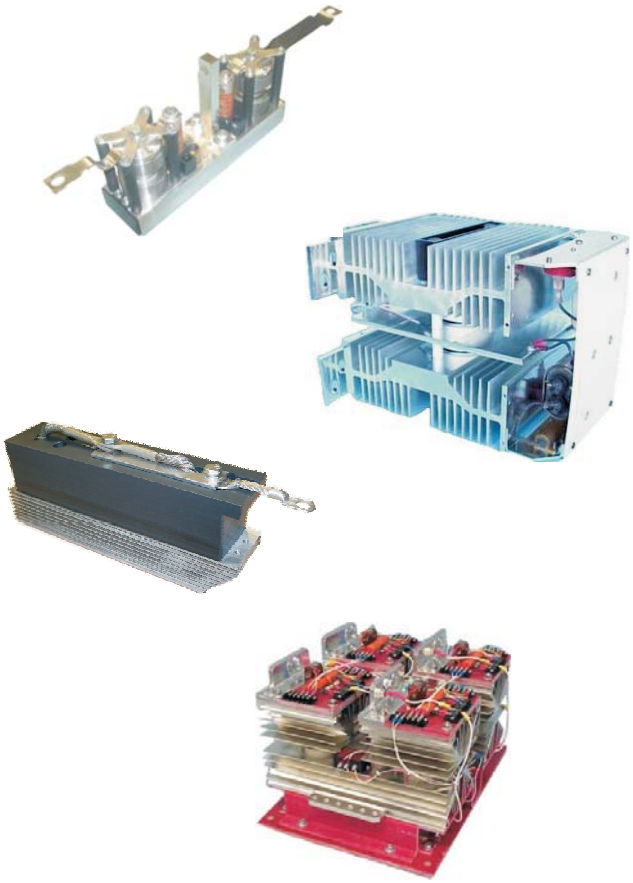


*Fig 4: Examples of Heat Sink Assemblies*

# Testing Methods for Power Semiconductors

There are a variety of testing methods used in the industry for testing power semiconductors, ranging from a simple ohmmeter to sophisticated laboratory equipment. Whichever method is used, it is important to understand its limitations and potential to damage the component.

The table below shows the various options available, and their ability to confirming the true voltage capability and leakage current of a power semiconductor. The table does not include the laboratory equipment used by power semiconductor manufacturer, since this type of test systems cannot be used for field service due to size and cost.

| Type of Test | Benefits | Limitations and Precautions |
|---|---|---|
| Resistance (Ohmmeter) | Detects shorted device | Alarming and misleading resistance values for devices which are not shorted. Does not have the capability to apply high voltage |
| Resistance (Megger) | Applies reasonable voltage level. May force marginal device to short. | Alarming or misleading resistance values for devices which may be acceptable. Can damage device due to very “choppy” wave form. |
| AC Voltage Withstand (Hi-pot testing) | Can determine if device can reach rated voltage | Does not provide indication of leakage. Can easily damage device. Risk for personnel injury. |
| AC Voltage Withstand (Curve tracer) | Leakage measurements within 80-90% of nameplate | Does not provide indication of leakage, Can easily damage device if not properly operated. |
| DC Voltage | Applies adequate voltage level. | Misleading test results for larger power semiconductors. Too low current. |

## Best Solution

| | | |
|---|---|---|
| **AC Voltage according to EIA RS-397 Standard (M3K, M5K testers)** | **Permits application of rated voltage and displays leakage current. Visual indication of gate triggering.** | **Only portable unit testing according to JEDEC standard. Voltages up to 3400V (M5K 5500V). Gate trigger indication. Scope (X-Y) output.** |

## Caution!

Testing methods for Power Semiconductors are outlined in the EIA Standard RS-397 for Thyristors and Diodes.

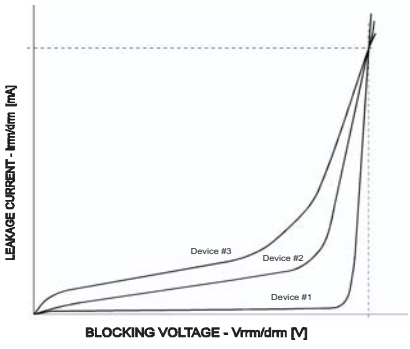
One of the most important conditions for these tests are that the rated voltage **MUST** never be exceeded.

An ideal component can have voltage applied until the device reaches avalanche voltage. In practice, many devices have soft breakdown, "punch through" or surface breakdown before the rated leakage current is reached.

For these devices, exceeding the rated voltage established by the manufacturer may result in instant failure or in down grading of the blocking characteristics.

### *Voltage/Current Characteristics*

When testing Power Semiconductors it is important to understand that the E/I curve, as shown in Figure 3, will not be the same for different types of devices.




A device could have a sharp knee, like Device #1, or a soft knee as Device #3.

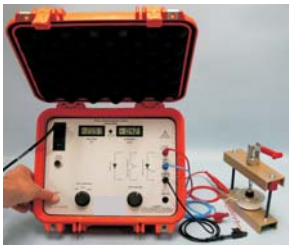
It is therefore very important to use a test instrument that can supply adequate voltage and current, (According to the EIA Standard RS-397 ), so that the E/I curve can be tracked from 0 to the rated voltage.

### *BASIC RULES FOR TESTING POWER SEMICONDUCTORS*

- Use a tester that conforms to the EIA RS-397 standards
- DON'T use an OHMMETER, other than for identifying shorted devices.
- DON'T use a HI POT tester
- NEVER exceed the manufacturers blocking voltage rating!
- NEVER exceed the manufacturers leakage current rating!
- If the maximum leakage current is reached before the rated blocking voltage, STOP!
- If the rated blocking voltage is reached before the rated leakage current, STOP!
- If possible, observe the Voltage/Current characteristics (E/I curve) of the device on an X-Y oscilloscope.

# *Typical Test Procedures for Power Semiconductors*

## PRESS PACK (Hockey Puck) SCRs (Thyristors)



Set the Voltage Control to the zero position (fully counter clockwise) before turning the unit on. Connect the Anode, Gate and Cathode leads to the device to be tested.

**DO NOT MIX UP THE ANODE AND CATHODE LEADS OR HIGH VOLTAGE WILL BE APPLIED TO THE GATE!**

Place the function switch in the PRV position and press the "TEST" button. Slowly increase the voltage while observing the Peak Voltage and Peak Leakage Current on the panel meters. In a properly functioning device, the rated voltage should be reached before the current starts to rise **rapidly**, (the "break-over point").

Place the function switch in the PFV position and repeat procedure described above.

Place the function switch in the GATE position and slowly raise the Voltage Control while observing the "TRIGGER INDICATION" light.
If the light does not turn on, the Gate on the SCR is faulty, and the device should be replaced.

## Transistor Modules (IGBTs and Darlingtons

Connect a test lead between the ground plate of the component and the GROUND terminal on the tester.
Connect a 100 kohm resitor between the BASE and EMITTER terminals on the tester.
**DO NOT MIX UP THE COLLECTOR AND EMITTER LEADS OR HIGH VOLTAGE WILL BE APPLIED TO THE BASE!**

Place the function switch in the PRV position and press the "TEST" button. Slowly increase the voltage while observing the Peak Voltage and Peak Leakage Current on the panel meters. In most transistor modules, the current will rise immediately due to the circuit design.

Place the function switch in the PFV position and press the "TEST" button. Slowly increase the voltage while observing the Peak Voltage and Peak Leakage Current on the panel meters. In a properly functioning device, the rated voltage should be reached before the current starts to rise rapidly, (the "break-over point").

Place the function switch in the BASE position and slowly increase the voltage while observing the "TRIGGER INDICATION" light.
If the light does not turn on, the Base is faulty, and the device should be replaced.
Note: Typical turn-on voltage is 5-6 V. The current is so low in transistor base circuit, that it will not show on the current meter.

## Rotating Rectifier Modules

Make sure the Voltage Control is at the zero position (fully counter clockwise) before turning the unit on. Connect the Anode and Cathode leads to the diode to be tested.

**NOTE** : Diodes only have to be tested in one direction. If the diode is forward biased (standard), the function switch should be in the PRV position. If the diode is reversed biased, the function switch should be in the PFV position

Place the function switch in the PRV (PFV) position and press the "TEST" button.
Slowly increase the voltage while observing the Peak Voltage and Peak Leakage Current on the panel meters.
In a properly functioning device, the rated voltage should be reached before the current starts to rise **rapidly**, (the "break-over point").

## Stud Mounted Diodes

Make sure the Voltage Control is at the zero position (fully counter clockwise) before turning the unit on. Connect the Anode and Cathode leads to the diode to be tested.

**NOTE** : Diodes only have to be tested in one direction. If the diode is forward biased (standard), the function switch should be in the PRV position. If the diode is reversed biased, the function switch should be in the PFV position

Place the function switch in the PRV (PFV) position and press the "TEST" button.
Slowly increase the voltage while observing the Peak Voltage and Peak Leakage Current on the panel meters.
In a properly functioning device, the rated voltage should be reached before the current starts to rise **rapidly**, (the "break-over point").

**Larkin Power Components, Inc.**
E. 9922 Montgomery, Suite #9, Spokane, WA 99206, USA
Ph. (509)891-5626, email: lpc@larkinpower.com
www.larkinpower.com