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<td>An overview of the Power Assemblies and Complete Solutions group.</td>
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</table>
IGBT Test Equipment Overview

The high power semiconductor test equipment, group at Dynex Semiconductor have been producing Semiconductor test equipment for 30 years for their Thyristor, GTO and Diode products and have now developed test equipment to enable full parametric testing on all IGBT modules in the Dynex range which are specifically arranged to test IGBT module configurations up to 6.5kV across the full range of currents.

Dynamic and Static Test Equipment has been developed to test IGBT Modules and Substrates which conform to standard IEC 60747-9. These systems are semi automated with fully protected data recording software which allows for complete traceability to individual module serial numbers.

These systems are designed to support continuous testing as part of a production line, however there are many features which enable them to be customized to suit more specific testing.

Engineering Intervention is made very easy with quick access to the test programme parameters.

Parasitic inductances are minimized at the DUT interfaces to achieve 20nH on small devices, and the test heads can be heated or cooled. There are available options for Pressure contact IGBT and IGCT devices and these systems can be configured for SiC device testing.

Reliability assessment equipment, by its very nature, must itself prove to be reliable. Dynex have a number of years of experience in producing successful Thermal cycling test equipment with Active and Passive versions, where the Active cycler can provide Power cycling and IOT operations switching currents up to 3,000A for assessing IGBT long term reliability simulating operational conditions.

Dynex also provides a range of stand alone equipment for all other aspects of reliability assessment for semiconductor devices including high temperature blocking test equipment for assessing module collector and gate reliability.
The IGBT Dynamic Test Equipment can test IGBTs in the form of modules, or screening as substrates and provides engineering flexibility for changing test circuits and conditions for assessing the DUT (Device Under Test).

The equipment has a maximum capability of voltage up to 5kV and current up to 8,000A and a short circuit current of 18,000A. The DUT can be mounted upon a hot plate to be heated up to 175°C. The equipment has the option of having up to 6 different IGBT Gate Drives installed which are selected by the control software.

The system can be configured to apply multiple firing events to simulate “chopper” mode operation. A wide range of circuit inductances can be selected with 16 available pre-sets ranging from 0µH to 1,250µH. More inductance can be added at the customer’s request.

The equipment is fully computer controlled and features a LabView based user interface with a touch screen for direct control. It can be network ready for offline tasks such as reviewing test results or for preparation of test programs.

**System Configuration**

<table>
<thead>
<tr>
<th>Dynamic Test Voltage (Vcc)</th>
<th>100 - 5,000V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector Current</td>
<td>50 - 8,000A</td>
</tr>
<tr>
<td>Short Circuit Current</td>
<td>Maximum Current 18,000A</td>
</tr>
<tr>
<td>Single Pulse Testing</td>
<td>Automatically acquire waveform and calculate parameters of the Turn off event.</td>
</tr>
<tr>
<td>Double Pulse Testing</td>
<td>Automatically acquire waveform and calculate parameters of the Turn off and Turn on events.</td>
</tr>
<tr>
<td>FRD Testing</td>
<td>Automatically acquire waveform and calculate all test results related to the FRD by using voltage and current transducers.</td>
</tr>
<tr>
<td>Internal Stray Inductance</td>
<td>This will be &lt; 150nH [Excluding Device] and will be fixed.</td>
</tr>
<tr>
<td>Gate Clamping</td>
<td>This will be done via a local PCB on the test fixture.</td>
</tr>
<tr>
<td>Collector Clamping</td>
<td>This will be done via a local PCB on the test fixture.</td>
</tr>
<tr>
<td>Gate Resistor</td>
<td>An automatically selectable resistor will be available for the Dynex supplied gate driver with 32 $R_{ON}$ and $R_{OFF}$ values. The gate resistor selection for non Dynex gate drivers will be selected manually.</td>
</tr>
<tr>
<td>Gate Capacitor</td>
<td>This will be done via a local PCB on the test fixture.</td>
</tr>
<tr>
<td>Gate Driver Interface</td>
<td>The test system will feature its own gate driver board but will allow for up to 5 additional drivers to be installed, these can be selected automatically.</td>
</tr>
<tr>
<td>Mains Supply</td>
<td>240V, 16A, Single Phase @ 50Hz</td>
</tr>
<tr>
<td>Dimensions</td>
<td>1600 x 1000 x 2200 (W x D x H in cm)</td>
</tr>
</tbody>
</table>
Programmable Parameters
The parameters are programmable from the LabView test interface, for setting up different pulse conditions for the dynamic test waveform and measurements.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value/Range</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_C^{1st}$</td>
<td>First Pulse Switching Current</td>
<td>up to 8,000A</td>
<td></td>
</tr>
<tr>
<td>$I_C^{2nd}$</td>
<td>Second Pulse Switching Current</td>
<td>up to 8,000A</td>
<td></td>
</tr>
<tr>
<td>$V_{CC}$</td>
<td>Switching Voltage</td>
<td>100 to 5,000V</td>
<td></td>
</tr>
</tbody>
</table>

Load Inductance
Load Inductor
20µH, 50µH, 100µH, 200µH, 500µH, 1,000µH, 2,000µH
The test pulse is determined by software according to the current and inductance

Tests and Measurements
The following table shows the standard test types for the Dynamic Tester showing the measured parameters and test condition ranges.

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Measured Parameters</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Pulse 1st turn Off</td>
<td>$t_{d_{off}}, t_{f_{off}}, t_{z}, E_{off}, V_{CE MAX}, V_{CE}, dV_{CE}/dt, dI_{C}/dt$</td>
<td>$V_{CC}^{:} 100 - 5,000V$</td>
</tr>
<tr>
<td>$I_C$</td>
<td>$I_C^{2nd}$</td>
<td>Second Pulse Switching Current</td>
</tr>
<tr>
<td>$V_{CC}$</td>
<td>Switching Voltage</td>
<td>100 to 5,000V</td>
</tr>
<tr>
<td>Load Inductance</td>
<td>Load Inductor</td>
<td>20µH, 50µH, 100µH, 200µH, 500µH, 1,000µH, 2,000µH</td>
</tr>
<tr>
<td>FWD Recovery</td>
<td>$I_{RM}, T_{RR}, Q_{RR}, E_{REC}, V_{RM}, dI_{RF}/dt, dI_{RR}/dt, P_{frd MAX}$</td>
<td>$V_{CE}^{:} 100 - 2,000V$</td>
</tr>
<tr>
<td>Single Pulse turn Off</td>
<td>$t_{d_{off}}, t_{f_{off}}, t_{z}, E_{off}, V_{CE MAX}, V_{CE}, dV_{CE}/dt, dI_{C}/dt$</td>
<td>$V_{CC}^{:} 100 - 5,000V$</td>
</tr>
<tr>
<td>Short Circuit Type 1 and 2</td>
<td>$V_{CE MAX}, V_{CE MAX}, I_{C MAX}, I_{C MAX}, V_{CE MAX}, dI_{C}/dt, dI_{C}/dt, dV_{CE}/dt, dI_{C}/dt$</td>
<td>$V_{CE}^{:} 100 - 5,000V$</td>
</tr>
<tr>
<td>$Q_0$ Test</td>
<td>$V_{CC}^{:} 100 - 5,000V$</td>
<td></td>
</tr>
</tbody>
</table>

For further information and datasheets visit www.dynexsemi.com
Dynamic Test Waveforms
These test waveforms represent various switching events of the Dynamic Test Equipment.

Single Pulse

Double Pulse with Reverse Current

Turn On Event

Turn Off Event

Reverse Recovery

Short Circuit Withstand
IGBT Dynamic Test Equipment
IGBT Static Test Equipment has the capability of testing IGBTs as modules or as substrates and provide engineering flexibility for changing test circuits and conditions for assessing the DUT (Device Under Test).

The equipment has a maximum capability of voltage up to 7.5kV and current up to 6,000A. The equipment provides static testing to determine Leakage current characterisation and breakdown, threshold and saturation voltages.

The equipment is fully computer controlled and features a LabView based user interface with a touch screen for direct control. It can be network ready for offline tasks such as reviewing test results or for preparation of test programs.

**System Configuration**

| Static Test Voltage | 100 - 7,500V |
| Collector Current | 50 - 6,000A |
| Leakage Testing | 7.5kV and 1µA to 200mA full scale, pulse width up to 200ms |
| Gate Leakage Testing | +/- 30V 10nA to 10mA full scale, resolution 1nA |
| Saturation Voltage Testing | 6,000A and 6 Voltage ranges from 100mV to 40V full scale |
| Kelvin Contact | R(C-Cs), R(G-Gs), R(E-Es) |
| Mains Supply | 240V, 16A, Single Phase @ 50Hz |
| Dimensions | 1600 x 800 x 1800 (W x D x H in cm) |

**Tests and Measurements**

Single-shot measuring techniques are used for all tests. The forcing parameters use 12 bit D-A converters and all the measurements are made using a +/- 13 bit A-D converter. This gives a resolution of 1 part in 8191, a good compromise between speed and accuracy.

**Measured Parameters**

Test Fixtures

Specific test fixtures can be designed to suit a range of module and substrate configurations. This can include custom modules which have specific busbar configurations.

The test fixtures can be easily and quickly swapped out and stored within the fixture drawer inside the equipment cabinet.

The IGBT Dynamic Test Equipment also makes use of these style test fixtures. Pressure contact IGBT, IGCT test presses are also available.

Typical Test Circuits

The below test circuits show some typical usage scenarios for the IGBT Static Test Equipment. The functions of the equipment are not limited to the below circuits.

Ices

```
HV Power Supply

Gate Circuits

DUT

Set Gate
Emmitter
Conditions

(Short Circuit
for Ices)

Sense [Kelvin]
Contacts Not
Used for Ices

Set Voltage

Current
Monitor
```

Iges

```
Voltage Source

DUT

Collector/Emitter
Conditions

(Short circuit for this test)

Set Voltage

Set
Polarity

Current
Monitor
```

Vf + Vce (sat)

```
Gate Source

DUT

(Not used when measuring diode)

Current Source

(Not used when measuring diode)

Voltage Monitor
```

For further information and datasheets visit www.dynexsemi.com
The purpose of the Active Power Cycling Test Equipment is to characterise the wear out lifetime of the wire bond contacts to the IGBT and FRD die based upon IEC 60647-9.

This is achieved by cycling them with a high power current source to produce heat followed by a cooling period, resulting in a typical 50°C junction temperature swing for a typical length of 1 Million cycles. As bond wires begin to lift or crack, the total Vce of the DUT may increase. This will be detected by the equipment and the test will be terminated after certain conditions are met.

The device chip temperature is determined by monitoring the Vce real time and looking up an equivalent temperature from a calibrated curve which is determined prior to the test. This is achieved using a hot plate oven heating the device to a range of known temperatures and reading the device Vce at a set calibrated current.

The number of cycles and min and max temperatures are logged for the entire test whereas Vce waveforms are recorded for up to 5 hours prior to test termination.

Rth evaluation can be accurately determined from the characteristic heating and cooling curves and this data can be presented for the particular DUT.

This is a sophisticated test system which utilizes the Vce measurement to determine junction temperature excursions, however the system can be configured to operate as a simple IOT tester with simple on – off times and forced DC current control.

System Configuration

**Main Power Supply**

Up to 1,800A Via 12 Pulse Bridge Supply

**Calibration Current Supply**

100mA Calibrated to determine Junction Temperature

**Tester Capacity**

1 IGBT Per Tester

**Mains Supply**

415V, 63A, Three Phase @ 50Hz

**Cabinet Dimensions**

600 x 900 x 1800 (W x D x H in cm)

**Chiller Dimensions**

600 x 800 x 800 (W x D x H in cm)
IGBT Active Power Cycling Tester

For further information and datasheets visit www.dynexsemi.com
Dynex have designed a simple 19” rack version of our usual multiple module cycler.

This is designed to be stand alone with its own local chiller for cooling the device under test after each heat cycle.

This has been designed to produce an accurate temperature cycling area on the mounting plate which will accommodate all sizes of IGBT modules as individual components, however it can be arranged to take multiple smaller components, by modifying the mounting arrangement on the plate.

Dynex can design the DUT plates to suit the particular components under test.

**System Configuration**

**Hot Plate / Cold plate Temperature Range**
20°C - 200°C

**Test Duration Range**
Up to 9,999 Hours

**Tester Capacity**
Defined by module size

**Mains Supply**
415V, 63A, Three Phase @ 50Hz

**Cabinet Dimensions**
600 x 900 x 1030 (W x D x H in cm)

**Hot plate / Cold Plate Dimensions**
Up to 300 x 500 (W x D in cm)
IGBT Passive Thermal Cycling Tester

For further information and datasheets visit www.dynexsemi.com
IGBT Vce Blocking Tester

The Vce blocking tester consists of a hot plate oven and test cabinet. The test cabinet houses 8 high voltage power supplies and a LabView based control system. The devices are tested under elevated temperatures using the hot plate oven at up to 200°C.

The hot plate oven is fully enclosed with an insulated split hinged lid which allows for easy access for mounting modules in the test positions. The oven also has safety interlocks and locking mechanisms to ensure user safety during testing.

The control software can set independent voltages to each of the 8 test positions and monitors leakage current, tripping at individually set alarm points. Tests can last up to 9,999 hours and all devices can be tested simultaneously.

The software samples voltage and current at each position and the data can be logged for investigation and analysis away from the test equipment.

For high voltage modules where the leakage current is high enough to add thermal load, Dynex have designed a “hot oil cooling” system which will control the local temperature up to 175°C and avoid thermal runaway.

IGBT Vce Blocking Test Principle

System Configuration

| Collector Voltage Supply | 0 - 8,500 V DC |
| Collector Current Supply | 0-500mA DC |
| Oven Temperature Range | 50°C - 200°C |
| Test Duration Range | Up to 9,999 Hours |
| Tester Capacity | Up to 8 Devices Simultaneously |
| Mains Supply | 415V, 63A, Three Phase @ 50Hz |
| Cabinet Dimensions | 600 x 900 x 1030 (W x D x H in cm) |
| Hotplate Oven Dimensions | 1200 x 900 x 1030 (W x D x H in cm) |
IGBT Vce Blocking Tester
Another recognized failure mechanism in IGBT technology is for the gate structure to become leaky with temperature and no longer support the gate voltage. The Vge Blocking tester provides a simple test in accordance to Dynex qualification standards whereby the gate terminal voltage is maintained and the leakage current is monitored over time to assess any changes.

The Vge Blocking Tester is now built into the hotplate oven with an insulated split hinged lid which allows easy access for the mounting of devices. Up to 8 devices are mounted inside the hot plate oven where the devices can be operated at elevated temperatures up to 200°C.

The equipment also uses LabView based control software allowing for real-time monitoring and statistics. Giving control of test durations and leakage current alarm points per device. Test records can also be saved for analysis offline.

**IGBT Vge Blocking Test Principle**

**System Configuration**

- **Gate Voltage Supply**: 0 - 60 V DC
- **Gate Current Supply**: 0-1mA DC
- **Oven Temperature Range**: 50°C - 200°C
- **Test Duration Range**: Up to 9,999 Hours
- **Tester Capacity**: Up to 8 Devices Simultaneously
- **Mains Supply**: 240V, 16A, Single Phase @ 50Hz
- **Dimensions**: 1200 x 900 x 1030 (W x D x H in cm)
IGBT Vge Blocking Tester
Additional Information

Press Pack Compatibility

The IGBT Dynamic and Static Test Equipment and Power Cycling Tester can be built with a press for testing of Press Pack IGBTs. The press will allow for testing both round and square devices, the maximum dimensions for these devices are; Round: Diameter 190mm x Height 400mm, Square: Length 240mm x Width 240mm x Height 40mm.

The IGBT Dynamic Test Equipment will have the capability to have 2 devices with the same dimensions clamped at the same time (DUT and Auxiliary).

Pressure: Range: 0-150kN, Resolution 0.1kN, Accuracy +/- 0.1kN
Temperature: Range: Ambient - 200°C, Resolution 0.1°C, Accuracy +/- 2%
Insulation: AC Peak Voltage 10kV
Roughness: Ra < 1µm
Flatness: < 0.015mm
Parallelism: < 0.02mm
Temperature Rise: The time from ambient to 150°C less than 30 minutes.

The range of test equipment may also be used to allow testing of other device types including MOSFET, and SiC modules providing baseplate compatibility.

Important Information

This publication is provided for information only and not for resale. The products and information in this publication are intended for use by appropriately trained technical personnel.

Due to the diversity of product applications, the information contained herein is provided as a general guide only and does not constitute any guarantee of suitability for use in a specific application. The user must evaluate the suitability of the product and the completeness of the product data for the application.

Although we have endeavoured to carefully compile the information in this publication it may contain inaccuracies or typographical errors. The information is provided without any warranty or guarantee of any kind.

The products are not intended for use in applications where a failure or malfunction may cause loss of life, injury or damage to property. The user must ensure that appropriate safety precautions are taken to prevent or mitigate the consequences of a product failure or malfunction.
Dynex Semiconductor is based in Lincoln in the United Kingdom supplying products and services specialising in the field of power semiconductor devices and bespoke high power semiconductor test equipment and high energy pulsed power supplies.

The Dynex power semiconductor business was originally established in Lincoln over 50 years ago when it was known as AEI Semiconductors Ltd. At that time, the business introduced some of the first silicon-based power semiconductor components in the world. Since then it acquired the power semiconductor interests, technologies and products from some major names such as GEC, SGS-Thomson, Alstom and Marconi Electronic Devices (MEDL). In 2008, 75% of shares of Dynex Power were acquired by Chinese manufacturer Zhuzhou CSR Times Electric Co., Ltd., a subsidiary of CRRC Corporation Limited.

As a long standing manufacturer of High Power semiconductor devices, Dynex have had to develop a number of complete suites of test equipment to be able to monitor the performance of the devices and also to prove the long term reliability of these devices.

The Dynex Equipment Group has designed a wide range of test systems for testing high power semiconductors. Having provided this type of equipment for internal use for 30 years, Dynex have developed a capability to provide customised test solutions for third party companies.

This capability has been developed to enable test systems to be offered for a wide variety of applications which are not always for semiconductor testing, these include; Fuse testing, lightning simulation, breaker testing, capacitor reliability, resistor thermal cycling, crowbar testing and many other high energy pulsed power applications in the high Megawatt region. Due to the nature of the bespoke pulse shape requirements, this has further developed our capability to supply High Energy Power Supplies (30kV, 40kA, short duration) to a growing number of customers.

Our Engineering team are able to review custom requirements for high voltage and high current testing and to design the hardware solution to meet these requirements.
About Power Assemblies Group

Power Assembly Products
In addition to the discrete product lines, Dynex offers a design, build and refurbishment service for power assemblies through our Power Electronic Assemblies group. This group provides support for customers requiring more than the basic semiconductor and utilises the skills of our power electronics, mechanical and electronic engineers. The team has direct access to the company’s application, test and product design personnel to produce the optimum solution for your requirements.

Power Assembly Products
Typical applications for Dynex power assemblies include:

- High power rectification
- Inverters
- Battery chargers
- Resistance welding switches
- GTO gate drive units
- Pulse power switches
- Soft starts
- Magnet supplies
- Variable speed drives
- Static compensation stacks

Dynex also has a range of air and liquid cooled heatsink and clamping systems.

Standard Assemblies
Many factors need to be taken into consideration to maximise semiconductor performance in an assembly. Typically these are; type of heatsink, transient conditions, overloads, ambient temperature, surface finish (e.g. black anodised) and the method of cooling on which the application relies (air, liquid or phase change). With a wealth of experience behind them and using 3D CAD and simulation software, our designers have a vast range of bipolar and IGBT power semiconductor devices and components available which will ensure that even standard power assemblies are optimised for customer applications.

Rectifiers
Standard diode and thyristor rectifier combinations include:

- 3-phase and dual 3-phase diode rectifier assemblies
- 3-phase (6 pulse) and dual 3-phase (12 pulse) controlled assemblies

Inverters/Converters
- 3-phase thyristor inverter power units
- IGBT chopper H-bridge inverter modules
- IGBT full 3-phase inverters for motor control
- Frequency converters

Stack Assemblies
- Stick stacks for high voltage, high current applications
- MV soft starts
- Crowbars
- Thyristor/GTO assemblies with anti-parallel diode combinations
- Air cooled and water cooled stack assemblies

Pulsed Power Systems
For many pulsed power applications, semiconductor switches can offer advantages over alternative switch technologies. These advantages include:

- Increased number of operations and reliability
- Improved waveform shaping and pulse control
- Increased rep rate
- Higher current pulses

The choice of semiconductor device is critical for correct and reliable operation and Dynex have a wide range of thyristor types, including some which have been specifically developed for high d/dt pulsed power applications. In addition, Dynex have many years of experience in providing specific assemblies for custom Pulsed Power requirements. Typically used for:

1. Connection of energy storage to low inductance loads
2. Crowbars for by-passing / protecting a load
3. General thyatron and ignitron replacements
Contract Assembly Refurbishment and Customised Projects

The manufacturing facility has a proven capability for building and testing high power semiconductor assemblies. This capability is offered to third party customers looking for a ready built power assembly operation to provide part or complete solutions for this type of manufacturing. This service extends to refurbishment of these assemblies, where the units can be renovated with the latest technology components giving them extended operating life and renewed long term reliability.

SVC Valve Stacks

Thyristor Controlled Reactors (TCRs) are used, usually in combination with Fixed or Mechanically Switched Capacitors (IFC or MSC) to provide Static VAR Compensation. This helps improve the quality of the mains voltage supply by compensating for large loads with poor power factors. Typical example applications include flicker reductions and power factor compensation of Electric Arc Furnaces in steel mills. Dynex provide a range of water cooled TCR valves from 12MVar up to 100MVar. These can be used in both single phase and three phase applications. The Dynex range of TCRs has been designed with optimum performance and availability in mind. All the thyristor modules used in the TCR valves are matched to improve static and dynamic sharing whilst N+1 redundancy is included as standard to ensure consistent availability of supply, even in the harshest of operating conditions.

Heatsinks Clamps and Accessories

Device Clamps

A line of pre-loaded clamps is offered, up to 180kN for our 150mm disc devices. Bar clamps are suitable for single and double side cooling, with high insulation versions available for high voltage assemblies.

Heatsinks

Dynex has its own proprietary range of extruded aluminium heatsinks designed to optimise the performance of our semiconductors. Additionally, Dynex has access to a vast range of aluminium extrusions from independent manufacturers giving our design team the best options available. Water cooled heatsinks (coolers) are available and are compatible with devices up to 100mm silicon diameter. These are designed for use in high current, high power assemblies such as single, three or six phase bridges or AC controllers. Complete bridges of up to six devices may be constructed and two coolers per device may be used for double side cooling.

Accessories

Dynex can also provide a wide range of accessories, such as gate firing boards, voltage dividers, optical combiner and splitter boards, GLPS (Ground Level Power Supply) and high voltage isolated stack firing systems for multi level stacks (typically 10 levels).

High Power Test Equipment

The Dynex Equipment Group have designed a wide range of testers which can capture all of the electrical and timing measurements required to define the performance of high power semiconductor devices [Thyristors, Diodes, GTO’s and IGBT’s]. Having provided this type of equipment for internal use for 30 years, Dynex have developed a capability to provide cost effective customised test solutions for third party companies. This capability has been developed to enable test systems to be offered for a wide variety of applications which are not always for semiconductor testing. E.g. Fuse testing, lightning simulation, breaker testing, capacitor reliability, resistor thermal cycling, crowbar testing etc.

Our engineering team are able to review custom requirements for high voltage and high current testing and to design the hardware solution to meet these requirements. Amongst our existing designs we have produced the following systems in the field:-

- Passive thermal cycling equipment, power cycling equipment, dynamic IGBT testers, high voltage hot blocking equipment, low voltage hot test equipment, Qrr and Tq testing, multiple cycle surge testing, thyristor high power parametric test systems and high voltage leakage measurement systems.

For further information and datasheets visit www.dynexsemi.com