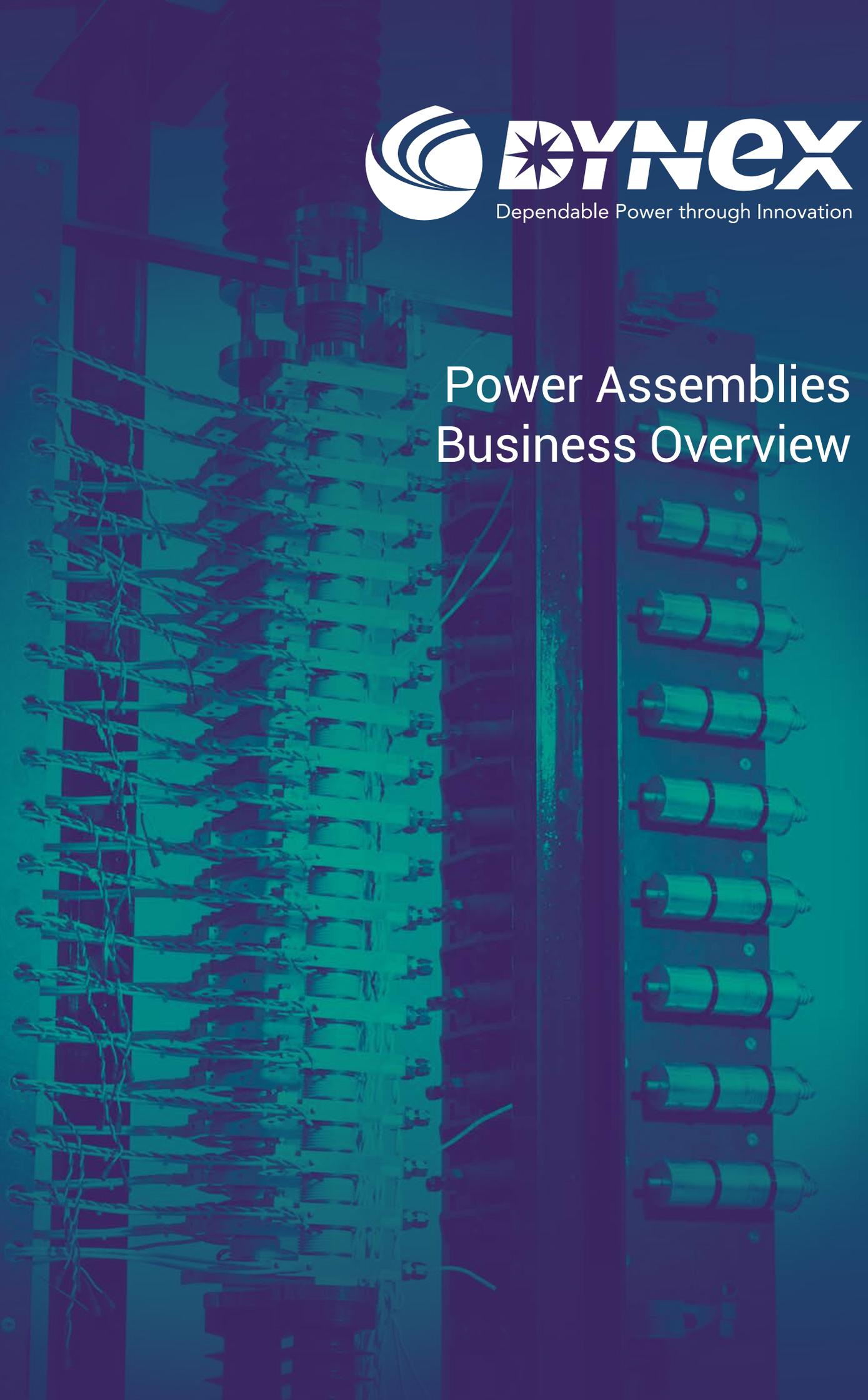




Power Assemblies Business Overview





Contents

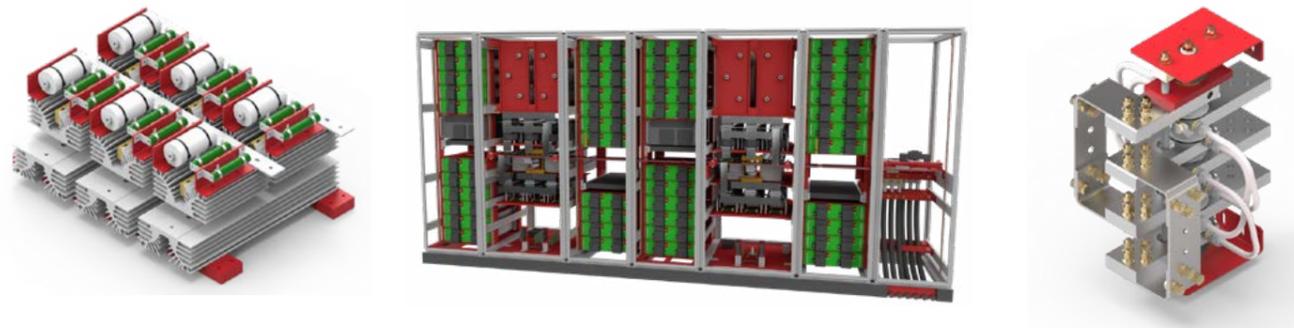
- Introduction to Power Assemblies 2
- Power Assembly Design Service 4-5
- Standard Power Assemblies 6
- Power Assembly Components 7
- Pulsed Power Assemblies and Systems 8
- On-site Power Testing Facility 9
- Power Electronics Laboratory 9
- Contract Assembly Services 10
- Traction Assembly Refurbishment 11
- Power Semiconductor Testers 12-13
- Power Supplies and Energy Delivery Systems 14-15
- About Dynex Semiconductor Ltd 16

Introduction to Power Assemblies

Dynex Semiconductor Ltd. has been manufacturing semiconductors in Lincoln, UK for more than 50 years. The Power Assemblies team evolved to provide a support service for those customers requiring more than the basic semiconductors components.

Specialising in the design of assemblies such as rectifiers and converters, Dynex has a mature supply chain for all components of power assemblies including electrical components such as resistors and capacitors for snubber networks and control circuits such as gate drives. Mechanical elements such as heatsinks, both natural air and water cooled and other mechanical elements such as clamps and busbars.

The team utilises the skills of our power electronics, mechanical and electrical engineering experts and has direct access to the company's wider application, test and product design groups to bring the very best technology to our products.



Power Semiconductor Testers, Power Supplies and Energy Delivery Systems

As well as serving the traditional power assemblies areas, we have developed a team of expertise in the development of bespoke equipment. With our range of production and reliability testers for high power semiconductors such as IGBTs and also having developed bespoke equipment for the testing of fuse equipment and high power resistors.

Most recently Dynex has begun working in the area of very high energy delivery systems, in the form of various power supplies, providing pulses up to 40kA in output current. These systems have leveraged learning and development in very fast response and critical safety control systems.



Power Assembly Design Service

The power assemblies design team have vast experience of working with our customers to create customised power assemblies to meet their exact requirements.

Dynex are able to provide a "fast prototype" service for most power conversion applications, turning our customers ideas into reality.

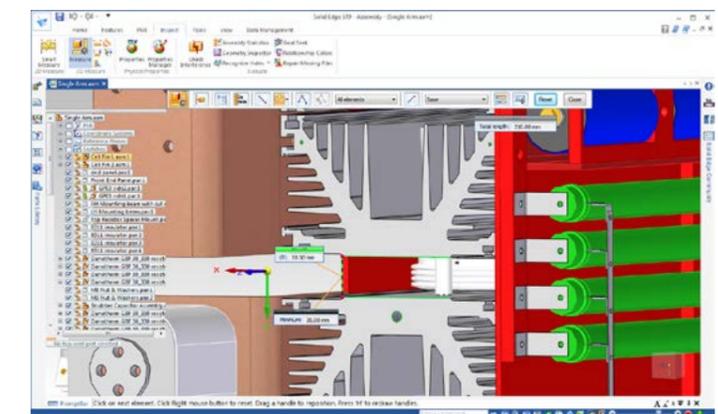
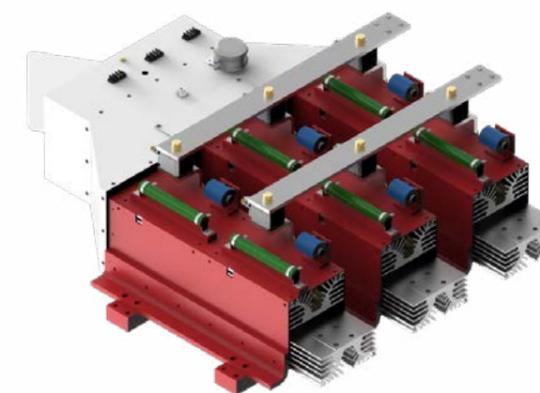
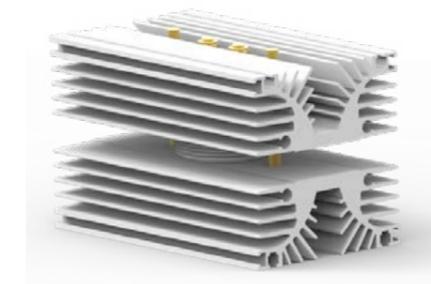
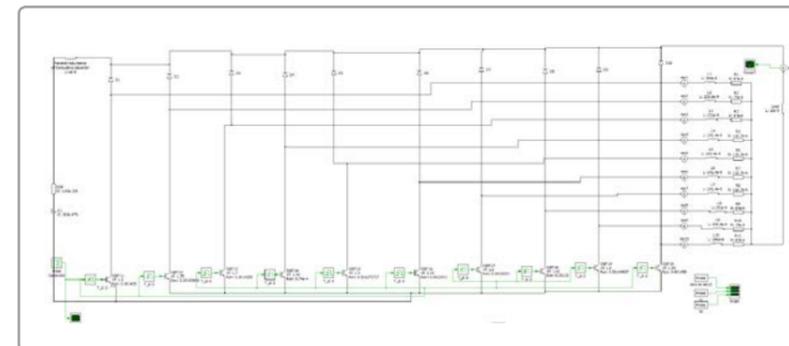
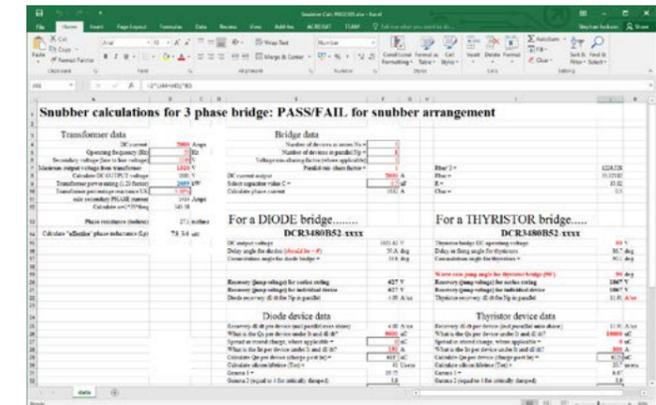
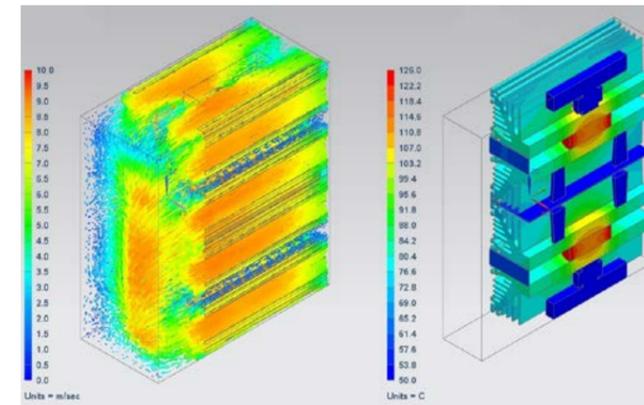
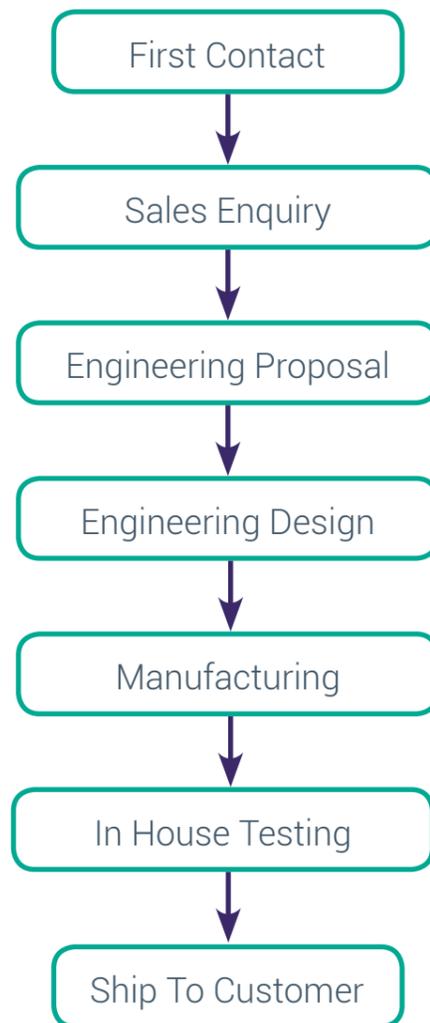
It all begins at the enquiry phase where our customers interact with our applications support team. This is where we collect the appropriate information to build up a requirement for the work.

The team will prepare a proposal, which may include estimated costings and semiconductor device selection having completed the simulation work to make sure the proposal is feasible.

With the customer agreement, the design team then produce a full engineering design. With a 3D Model and if appropriate thermal, mechanical and electrical simulations are conducted to validate the design before continuing with manufacturing.

Our experienced team of assembly technicians and operators with the greatest care, once in house testing is completed to ensure proper operation, the product is shipped to the customer.

Customer feedback is encouraged at all stages to ensure that our design and any testing meets all of the customer requirements.



Many factors need to be taken into consideration to maximise semiconductor performance in an assembly. Typically these include; 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.

Dynex have a range of semiconductor device clamps and heatsink profiles for maintaining the thermal and electromechanical integrity of the components during operation. These can be used for Diodes, Thyristors, GTO's and IGBT products.

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 sided cooling, with high insulation versions available for high voltage assemblies.

Heatsinks

Dynex has access to a range of aluminium extrusions from independent manufacturers giving our design team the best options available. Water cooled heatsinks are available which are designed for use in high current, high power assemblies such as single, three of six phase bridges or AC Controllers.

Accessories

Dynex can also provide a wide range of accessories, such as gate firing boards, voltage divider networks, control signal optical combiner and splitter boards, ground level power supplies and high voltage isolated stack firing systems for multi level stacks (typically 10 levels).



Rectifiers

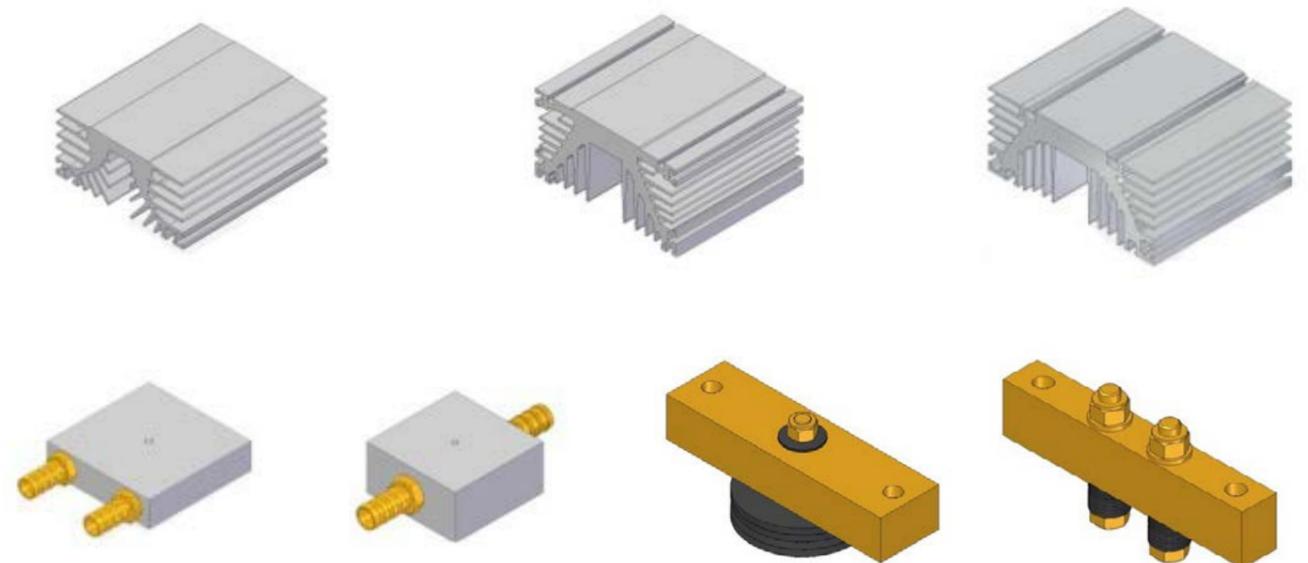
- Single phase controlled and uncontrolled rectifier assemblies
- 3-phase and dual 3-phase rectifier assemblies
- 3-phase (6 pulse) and dual 3-phase (12 pulse) controlled rectifier assemblies

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.

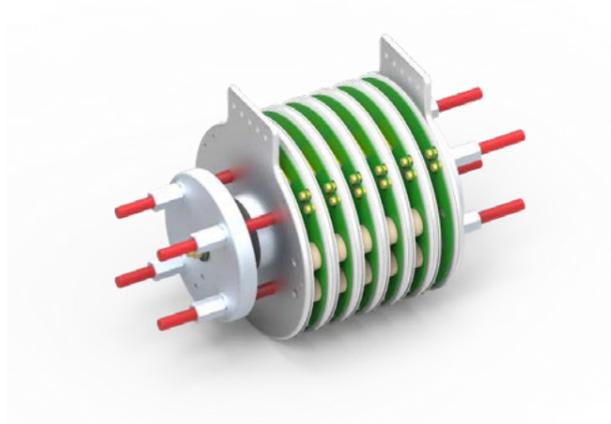


For many pulsed power applications, semiconductor switches can offer advantages over alternative switch technologies. These advantages include; increased number of operations and general reliability, improved waveform shaping and pulse control, increased repetition rate and higher current pulses.

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

Our pulsed power systems are typically used for:

- Connection of energy storage to low inductance loads
- Crowbars for by-passing / protecting a load
- General thyatron and ignitron replacement



In the table below are a few examples of our pulsed power systems with many years of successful operation in the field.

Application	Voltage	Peak Current	Waveform	di/dt	Frequency	Device Type
Plasma Initiation	9 kV DC	60 kA	2ms Half Sine	100 A/ μ s	Single Shot	DCR1673 Phase Control Thyristor
H2 Thyatron Replacement	17 kV DC	3.3 kA	2.5 μ s Trapezoidal	7500 A/ μ s	300 Hz	ACR300 Asymmetric Thyristor
Sterilisation	25 kV Forward 35 kV Reverse	4 kA	Damped Half Sine	1200 A/ μ s	30 Hz	PT60 Pulse Power Thyristor
Power Supply Crowbar	15 kV DC	4 kA	400 μ s Exponential Discharge	5000 A/ μ s	Single Shot	PT40 Pulse Power Thyristor
Laser Megajoule	26 kV DC	125 kA	Damped Half Sine	3200 A/ μ s	Single Shot	PT85 Pulse Power Thyristor

At Dynex we have many years experience of on-site power testing within our Power Assemblies group. Assembled products from our manufacturing team can be verified for standard end of line testing, e.g. isolation tests, partial discharge measurements and switching tests for example. Our team can also provide specialised tests on custom assemblies, such as high energy crowbars and controlled 3 phase rectifiers, testing up to 100kV and 4kA.



As part of our test facility we can perform pressure testing and thermal heat run tests using our localised liquid cooling plant for assemblies that use liquid flow rates up to 120 L/sec.

Power Electronics Laboratory

At Dynex, we have a very experienced cross functional team who work in our power electronics laboratory. Providing lab validation and qualification for the semiconductor and power assembly business.

This team has been responsible for device characterisation for the population of product data sheets and also for customer driven special applications. Non-standard production tests for our power semiconductors, e.g. avalanche pulse tests and turn on delay tests to customer conditions.

When our power assemblies team create new designs for our customers, we can validate the electrical circuits in our lab for expected behaviour. We can also investigate component suitability, for example most recently a comparison of life time of ultra capacitors from different manufacturers for use in our converter systems.

The laboratory itself has been developed over many years and now provides a unique environment where our engineers can create specialised test conditions very quickly for internal and external requirements. This facility is a very high value asset for our team and our customers.

Contract Assembly Services and Capabilities

The power assemblies team has developed vast experience in the assembly of products for our own designs and providing sub-contract assembly services for key customers, specialising in the field of high power semiconductor assemblies. We have lifting equipment which enables us to work with very large assemblies up to 2 tonnes in weight. We can handle many assembly types from higher volume smaller jobs to lower volume and more complex designs.

Key projects has seen the development of a range of assembly equipment driven by our internally developed process control software. The platform gives rich process instructions to operators whilst enforcing full process traceability with barcode scanning of sub-components with data verification.

The software also manipulates external tooling such as electronic assembly tools with position control systems to ensure proper mounting procedures are followed to the correct torque requirements and assembly sequence.

The platform is fast and flexible, which provides us with the capability to adapt our key equipment to assemble many different products and adapt as demands require.

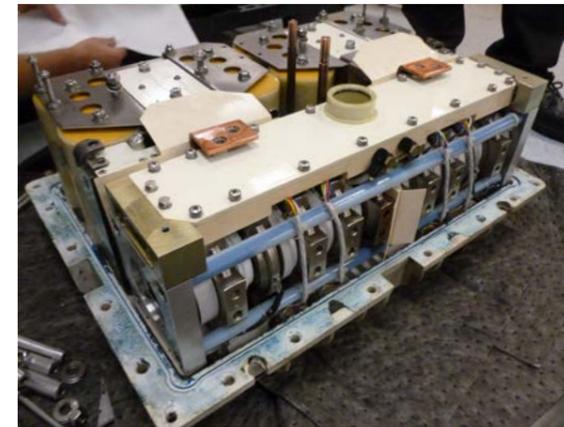


Contract Assembly Services and Capabilities

As part of our heritage, Dynex (MEDL, GEC) have worked with a number of railway drive and locomotive manufacturers and we are familiar with the requirements of the rail industry. We provide a service where we can strip, and improve the older sub-systems to provide regenerated parts which will ensure future performance is guaranteed.

As an original supplier into the UK traction market for power electronics devices, Dynex are now offering a service whereby we will renovate older systems that have been performing well in the field to prepare them for ongoing future operation.

We work with GTO and IGBT based systems, this work has included semiconductor device replacement as well as modifications which remove known failure mechanisms and improve the rail MTBF statistics significantly.



Disassembly and repairing of a GTO based assembly in an oil cooled converter system, these assemblies are also load tested at Lincoln.

Where appropriate, Dynex can also provide on-site load testing of refurbished assemblies to ensure full and correct functionality with full traceability to ensure the work is carried out to a high level of quality.



Power Semiconductor Testers

At Dynex we have an equipment build group who have been producing high power semiconductor test equipment for more than 30 years for our Thyristor, IGBT, GTO and Diode products.

As part of this work, we have developed test equipment to enable full parametric testing on all IGBT modules in the Dynex range which are specially arranged to test module configurations up to 6.5kV across the full range of current ratings.

The dynamic and static testers have been developed to test modules and substrates to conform to standard IEC 60747-9. These systems are semi-automated with fully protected data recording software which allows for complete traceability of testing to individual module serial numbers.

There is also a wide range of reliability testers equipment for determining the long term reliability of our modules. Reliability assessment equipment by their very nature must itself prove to be reliable. Dynex has had success in producing thermal cycling testers for both passive and active heating methods. The power cycling tester can switch currents up to 3,000A.

Some of our equipment has also been adapted to suit the needs of customers wishing to test their own custom modules, and also for new and emerging press pack technologies.

Our range of production and reliability test systems consists of, but is not limited to:

- IGBT Module Dynamic Tester
- IGBT Module Static Tester
- IGBT Module HTRB Tester
- Press-Pack IGBT HTRB Tester
- IGBT Module Power Cycling Tester
- Press-Pack IGBT Power Cycling Tester
- IGBT Module Passive Cycling Tester

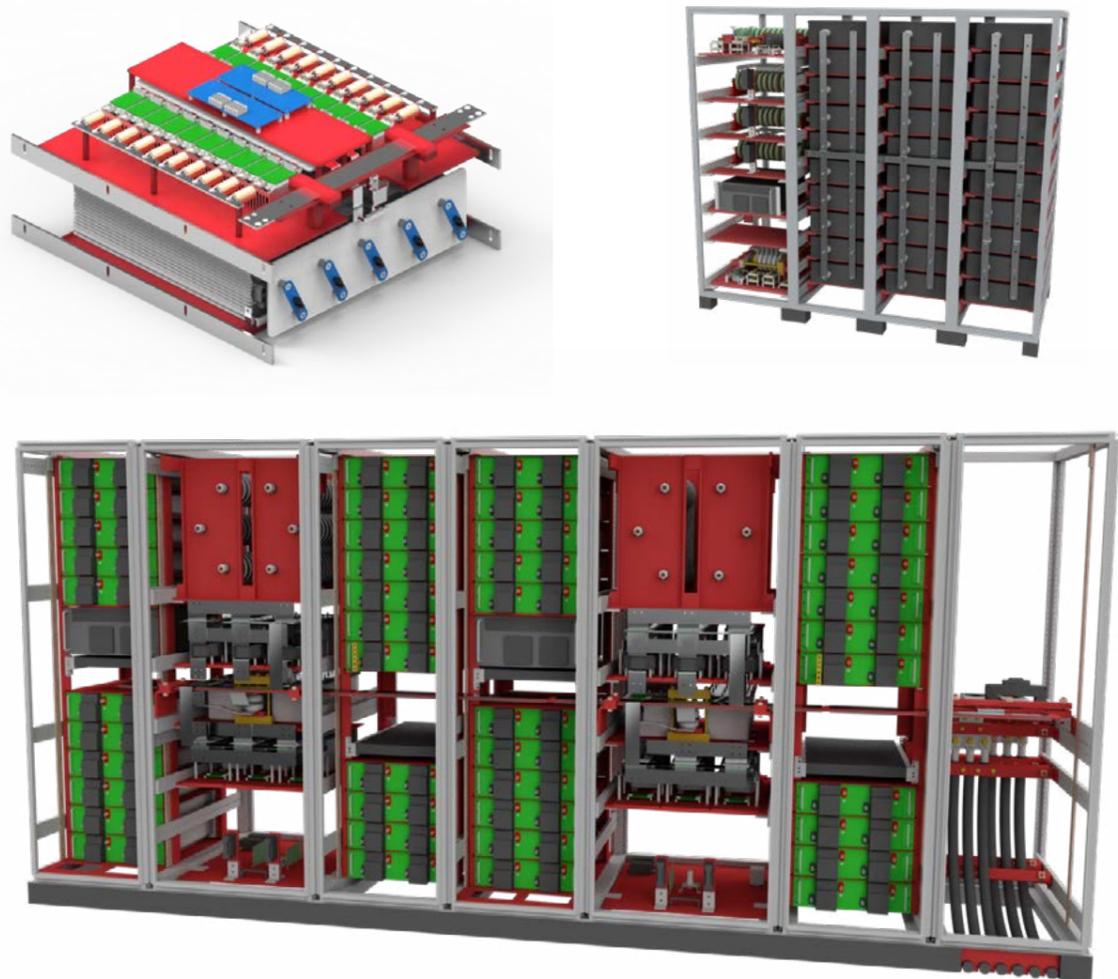
More information on our production and reliability test equipment can be found on our website.



Power Supplies and Energy Delivery Systems

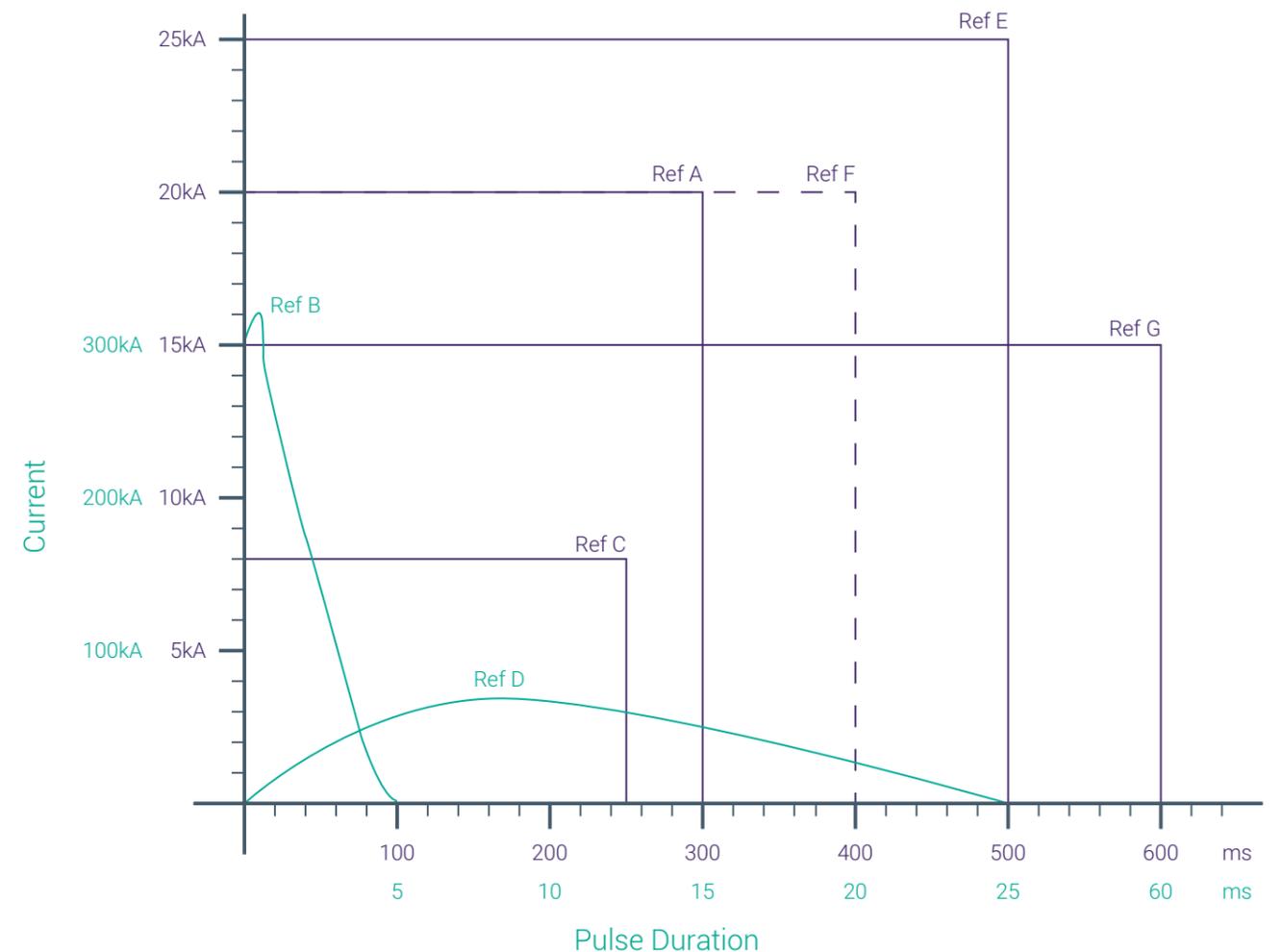
Dynex have been supplying semiconductor devices for a wide range of applications including the delivery of energy at extremely high currents for short durations. We have now developed a number of complete power supply converter systems which enable our customers to control the delivery of this energy using Thyristor, GTO and IGBT technology to provide the best solutions.

We have power supplies that utilise the latest energy storage techniques with batteries and ultra-capacitors as well as conventional capacitors, and the output of our supplies will deliver controlled DC pulses or AC pulses using H bridge topology with IGBT modules. Voltages up to 30kV and currents up to 40,000A DC have been generated by our range of power supplies for applications in high power protection circuit testing, tokamak fusion generator supplies, lightning simulation, magnet control, UPS and sag protection.



The following table and graph represent some of the projects that we have provided for our customers over the past 5 years.

Project	Peak Current	Supply Voltage	Pulse Duration	Energy	Delivery Type
Ref A	20 kA	1,200 V	300 ms	7.2 MJ	Controllable
Ref B	320 kA	2,000 V	2 ms	300 kJ	Exponential Discharge
Ref C	8 kA	2,000 V	250 ms	4.0 MJ	Controlled
Ref D	50 kA	11 kV	25 ms	1.8 MJ	Exponential Discharge
Ref E	±25 kA	500 V	500 ms	7.0 MJ	4 Quadrant Controlled
Ref F	±20 kA	600 V	500 ms	5.5 MJ	4 Quadrant Controlled
Ref G	±15 kA	900 V	600 ms	8.1 MJ	4 Quadrant Controlled



About Dynex Semiconductor Ltd.

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.

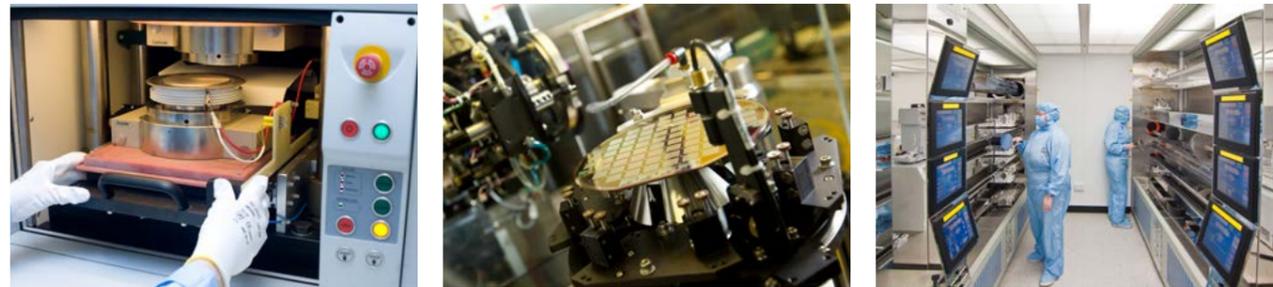
The Dynex power semiconductor business was originally established in Lincoln over 50 years ago when it was known as AEI Semiconductors Ltd. At that time, the business introduced some of the first silicon-based power semiconductor components in the world. Since then it acquired the power semiconductor 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 to 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.



IMPORTANT INFORMATION:

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. The user is responsible for product selection and ensuring all safety and any warning requirements are met. 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. This publication is an uncontrolled document and is subject to change without notice. When referring to it please ensure that it is the most up to date version and has not been superseded. The products are not intended for use in medical or other 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. All products and materials are sold and services provided subject to Dynex's conditions of sale, which are available on request. Any brand names and product names used in this publication are trademarks, registered trademarks or trade names of their respective owners.

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