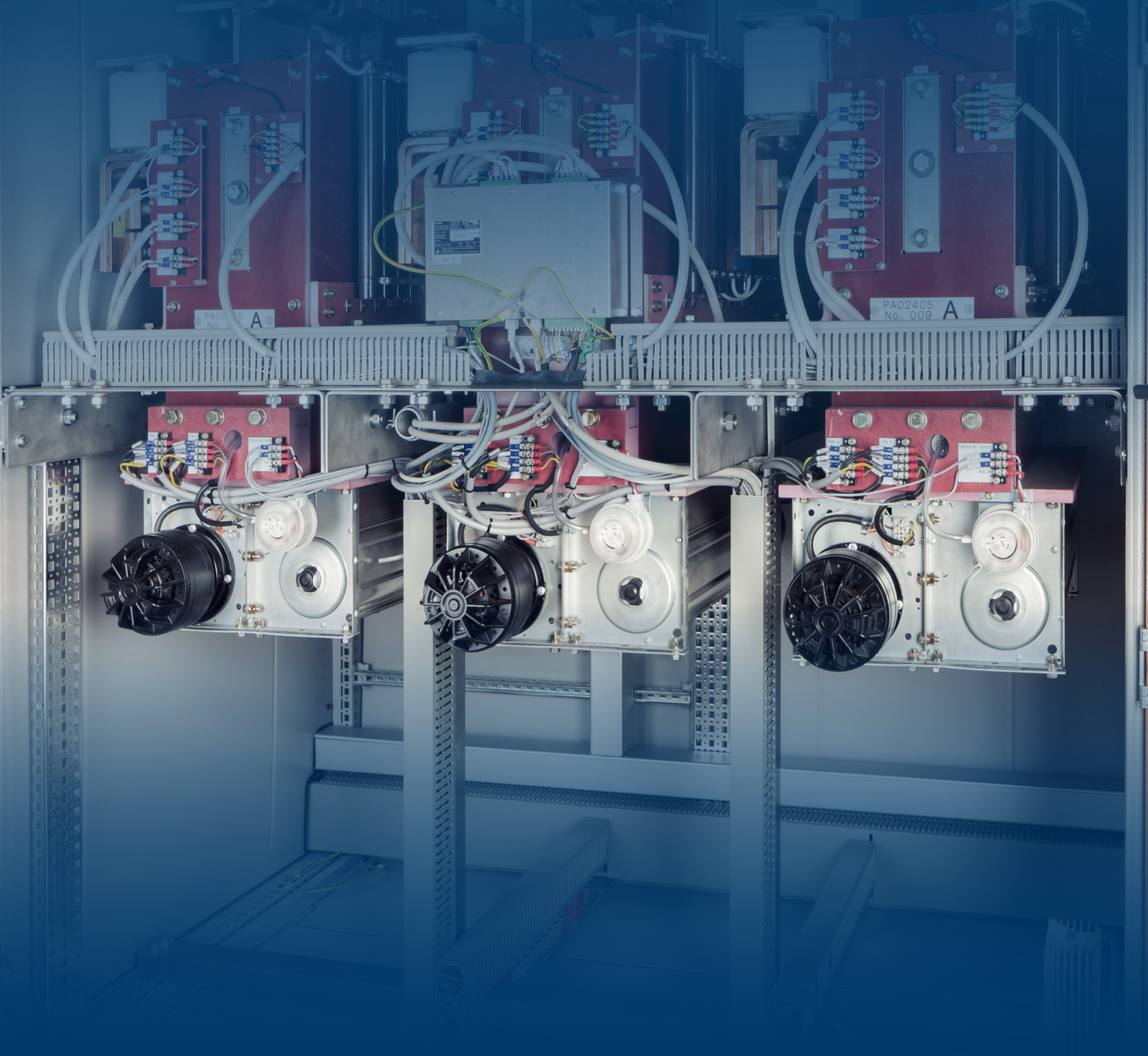




Power Assemblies Products & Applications



FIRSTLY

INTRODUCTION

TO DYNEX SEMICONDUCTOR

Dynex Semiconductor Ltd has a rich history in the design, development and production of High Power Semiconductor modules and Power Assemblies. Throughout the years, Dynex products have been applied in projects that vary from transportation, power grid, renewables, industrial, equipment and specialist applications.

The Power Semiconductor and Power Assemblies operation is located in Lincoln, England, manufacturing a range of high power IGBT modules, Bipolar capsule devices and power assemblies.

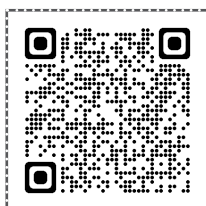
WHY CHOOSE DYNEX

FOR YOUR PROJECT?

- ✓ Over 60 years' experience in the design and build of power assemblies
- ✓ Design and manufacture products with high quality materials, following internal and external processes and standards
- ✓ Engineering experts who encompass a wealth of power electronic experience and industry knowledge
- ✓ Bespoke assemblies designed and manufactured in-house to meet specific customer requirements
- ✓ Customer support from all business areas
- ✓ In-house design capability
- ✓ ISO14001, ISO9001 and ISO50001 certified

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Scan this QR Code to visit Dynex website for further information about our Power Assemblies and for contact details

INTRODUCTION TO --- POWER ASSEMBLIES

Dynex provide power assemblies products for those customers that require more than the basic semiconductor components. We are able to design power assemblies with tailored semiconductors to meet customer specifications.

DESIGN CAPABILITIES

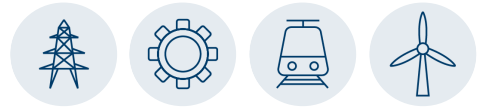
- ✓ Team of experienced experts in Device Physics, Electrical, Electronic and Mechanical Engineering
- ✓ In-depth knowledge of wear out mechanisms to design Power Assemblies for a range of applications
- ✓ Ability to tailor device performance and packaging to suit the needs of the application
- ✓ Electrical circuit, mechanical stress and CFD simulation expertise

MANUFACTURING AND DESIGN

- ✓ Experienced team of engineers trained in high voltage wiring, crimping and clamping
- ✓ Full traceability of materials and operatives
- ✓ In-house machining capability
- ✓ Testing facilities to screen out early life failures on full range of products
- ✓ Process traceability with barcode scanning of sub components and data verification
- ✓ ESD clean room assembly facility and environment with semi-automated mount down and assembly equipment
- ✓ Ability to adapt to work on lower quantity products as well as larger production runs

POWER ASSEMBLIES APPLICATIONS





GRID LINKED POWER EQUIPMENT

Custom assemblies, modular power stack, sub-contract assemblies, power factor correction and test equipment

- ✓ High power rectifier systems for demanding applications
- ✓ Tailored design with redundancy and maintainability built in
- ✓ Assembly design to withstand corrosive environment
- ✓ Designed with complimentary crowbars and anti-spike filters
- ✓ Proven design with >100,000 operation high humidity environment

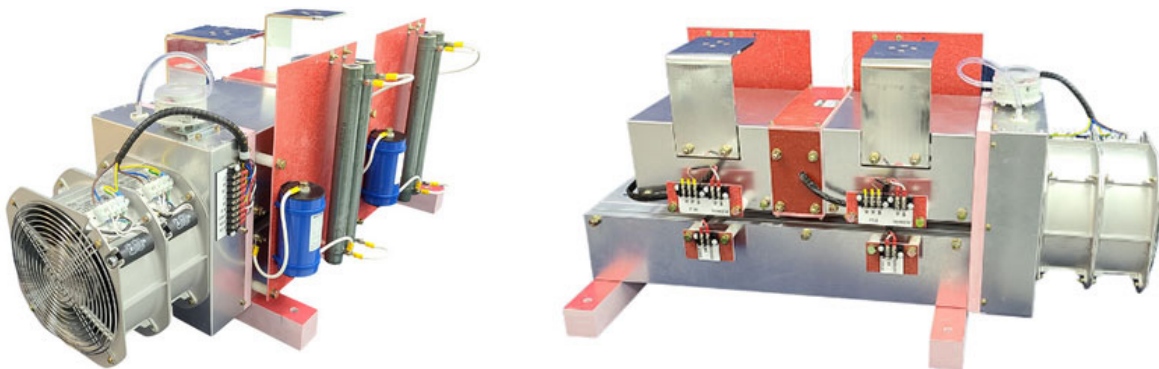
Our Grid-Linked Power solutions seamlessly connect to existing power grids, creating a symbiotic relationship between traditional and renewable energy sources. This integration allows for optimal energy distribution, minimizing wastage and maximizing efficiency.

Using our Grid-Linked Power Converter Systems, you can harness the full potential of renewable energy, such as solar, hydro and wind. These systems convert variable renewable power into stable and reliable electricity, ensuring a constant and uninterrupted energy supply. This allows you to reduce your carbon footprint and contribute to a sustainable future.

We provide systems with varying levels of integration depending on our partners preference, from fully cabinetised systems utilising our control platform regulated via ethernet, down to simple semiconductor clamped assemblies with heatsink mounting.

High power air-cooled controlled rectifier assemblies such as DSS3200BM-B6C-930 are manufactured from Thyristors with optimised losses for grid linked rectifier applications, that provide a highly controllable supply for the switching devices.

AIR COOLED POWER ASSEMBLIES





FUSION ENERGY APPLICATIONS

High DC, HV and Pulsed Power Solutions

Dynex have provided converter designs to support Fusion Energy research efforts around the globe.

Our vertically integrated supply chain enables us to understand our semiconductors and their performance, as well as tailor our devices to the specific requirements of the application. This is especially relevant for Fusion research, where often the best possible device is not available on the market. We work collaboratively with our partners to optimise our devices to suit their application requirements and support their research.

Dynex Power Assemblies Department can assist the design of the whole mechanical arrangement for these converters, providing an electrical, mechanical and thermal design service.

Our Power Assemblies design service includes considerations for:

- ✓ High voltage series devices switching on synchronously
- ✓ High di/dt operation at large pulse currents
- ✓ Management of high electric fields
- ✓ Gate drive isolation to earth potential
- ✓ Long term isolation integrity and partial discharge

Tokamak designs use strong electromagnets to contain fusion plasma in a stable torus shape. The electromagnets are controlled using powerful, fast switching power electronics to control the electric field and stabilise the plasma.

IGBT's provide the ideal semiconductor to perform this function, with the latest IGBT range of 1700V 1400A half bridge modules offering efficient, high speed switching. These are typically fed from controlled rectifiers, providing a stable DC rail to supply the field coils.

Other designs require high pulse power devices, that can deliver extraordinarily large currents over a short period of time. Our long history of providing pulse power devices places us in an excellent position to offer wide diameter, fast turn on Thyristors that can meet these challenging requirements, whilst providing a highly reliable platform. For example, devices such as the PT85 Pulse Power Thyristors were designed for laboratory experiments, and are now being used to support Fusion Energy research efforts globally.



FUSION ENERGY APPLICATION EXAMPLE

Tokamak Energy provided with a Merging Compression Power Supply

Merging compression is an efficient and robust method for plasma start-up which can achieve both high plasma current and high temperatures at fusion relevant densities. It involves the formation of plasma around two in-vessel poloidal field coils followed by a magnetic reconnection event after which the plasma can be compressed.

The power supply consisted of:

- ✓ Current 50kA / Volts 11kVDC link capacitor
- ✓ Fibre optically controlled high voltage Thyristor Stack Assembly
- ✓ Capacitor bank 30mF/11kV
- ✓ Mechanically changeable flywheel diode with series resistance for resonance damping





HYDROGEN

Power converter technology is ideally suited for power supplies needed for hydrogen electrolysis applications

Dynex is uniquely able to design power converters with its own tailored semiconductors, as well as benefiting from expert knowledge of wear out mechanisms and capability outside of the common operation.

Using the latest IGBT AFE (Active Front End) technology our supplies are optimised in terms of efficiency, size, power factor correction and harmonic distortion.

With a wealth of experience in designing power converters our team of application engineers are able to match and refine a power supply to meet the customers needs, whether that be DC ripple requirements, space limitations or differing incoming supply voltages.

All of our power supplies feature a Dynex designed controller that makes it easy to interface the electrolyser control system with our power supply. This gives constant status feedback to ensure the smooth and efficient running.

With the production of hydrogen, safety is paramount, this is why our power supplies feature an MCCB on the input side that has a trip that can be customer controlled to instantly cut power in the case of an emergency shutdown.

POWER SUPPLIES FOR HYDROGEN

- ✓ Active Front End IGBT rectifiers for high efficiency, unity power factor and low harmonic DC supply
- ✓ Turn key solution with built in MCCB, precharge and contractors
- ✓ Controlled over Profinet (other methods available)
- ✓ Voltage, current or power control
- ✓ Ripple to customer specifications
- ✓ Additional Buck converters to achieve output voltages <650V
- ✓ Customisation available
- ✓ Power rating from 100kW to 10MW and above
- ✓ Liquid cooling or forced air cooling
- ✓ Multiple outputs to provide power to numerous stacks





HYDROGEN

Power converter technology is ideally suited for power supplies needed for hydrogen electrolysis applications

THYRISTOR AND DIODE RECTIFIERS

- ✓ High power SCR and Diode rectifiers designed for Hydrogen Electrolysis
- ✓ High power rectifier systems for demanding applications
- ✓ Tailored design with redundancy and maintainability built in
- ✓ Assembly design to withstand corrosive environment
- ✓ Designed with complimentary crowbars and anti-spike filters
- ✓ Proven design with 15 years operation in high humidity and other harsh environments







STANDARD POWER ASSEMBLY PRODUCTS

Bipolar Assemblies, Pulse Power, IGCT, Soft Start, Locomotive Rectifier

Dynex Standard Assemblies offer:

- ✓ Selection of standardised outlines in proven natural convection, forced air - and water - cooled designs
- ✓ A range of standard clamps matched to our devices with options on mounting and isolation
- ✓ Options for Gate Drives for high isolation
- ✓ Snubbers designed to suit application

Dynex offer a range of industry standard power assembly products configured to suit application and specific performance requirements.

To maximise the semiconductor performance in an assembly, the type of heatsink, transient conditions, overloads, ambient temperature, surface finish (e.g. black anodised) and the method of cooling (air, liquid or phase change) needs to be considered. Our design engineers have a wealth of experience using 3D CAD and simulation software, with an increasing range of bipolar and IGBT power semiconductor devices and components available to ensure that standard power assemblies are optimised for customer applications.

Rectifiers

- ✓ Force Air-Cooled controlled rectifier assemblies
- ✓ Single phase controlled and uncontrolled rectifier
- ✓ 3-Phase and dual 3 phase rectifier assemblies
- ✓ 3-Phase (6 pulse) and dual 3 phase (12 pulse) controlled rectifier assemblies
- ✓ Options for resistance corrosive environments

AC Switches

- ✓ Force Air-Cooled and Water-Cooled assemblies

Gate Drives

- ✓ Force Air-Cooled and Water-Cooled assemblies



PULSED POWER ASSEMBLIES

Connection of energy, protecting a load, thyatron & ignitron replacement

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

The choice of the semiconductor device is critical for reliable operation.

Dynex offer a wide range of thyristor types, including those that have been specifically developed for high di/dt pulsed power applications. In addition to this, Dynex have many years experience in providing assemblies for custom pulsed power requirements.

Our pulsed power equipments are typically used for:

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



PULSED POWER ENERGY DELIVERY EQUIPMENT

Power supply converters to control the delivery of energy



Dynex have developed a number of complete power supply converter equipments which enable customers to control the delivery of energy using Thyristor, GTO and IGBT technology to provide the best solutions.

The power supplies utilise the latest energy storage techniques with batteries, ultracapacitors or conventional capacitors. The output of our supplies deliver controlled DC or AC pulses using H bridge topology with IGBT modules.

The range of power supplies offer voltages up to 30kV and currents up to 40,000A DC suitable for applications in high power protection circuit testing, lightning simulation, magnet control, UPS and sag protection.



POWER FACTOR CORRECTION

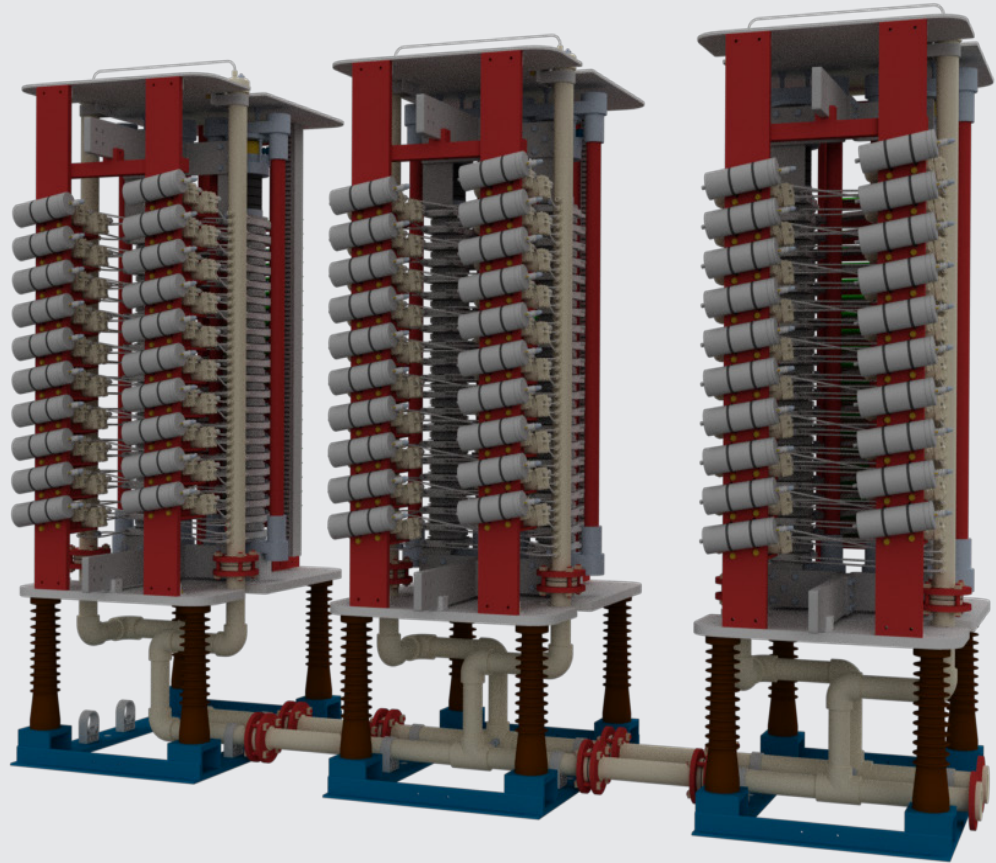
SVC TCR Valve power assemblies and STATCOM



Operation at
35kV



Range
extends up
to 360MVar



Thyristor Controlled Reactors (TCRs) are primarily used in combination with Fixed or Mechanically Switched Capacitors (FC or MSC) to provide Static VAR Compensation (SVC). This enables improved 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 complete range of water-cooled SVC valve assemblies, which utilise the latest i^2 thyristor technology for optimum efficiency and can be used in both single phase and three phase applications. These are primarily designed for operation at 35kV, with the range extending up to 360MVar. We have a growing number of reference projects currently in operation for the entire range.

The Dynex range of TCRs have been designed with optimum performance. All 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.

These switches are directly connected to the high voltage grid with Dynex designs completing tracking and flashing requirements. All valve assemblies are tested and verified at the Dynex facility.



RAIL REFURBISHMENT

Mid-life upgrades for traction power and control electronic equipment

With a typical lifespan of 40 years, the rolling stock industry are facing an increasing demand for mid-life upgrades for dated traction power and control electronic equipment.

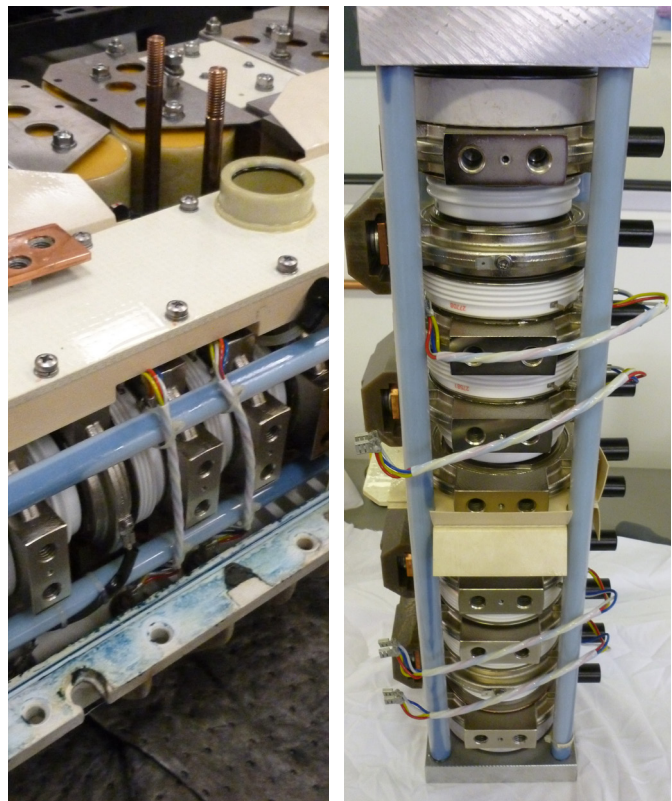
Dynex has a 40 year history of providing power electronics to the traction industry, many of which are still operational today. Using our proprietary knowledge of the wear out mechanisms associated with the power semiconductors and clamp assemblies provided, Dynex can offer an assessment of the likely health of semiconductors in application, as well as providing a feasibility report on the current availability of equivalent parts for replacement or spare stock.

Dynex offer the following capabilities to support this:

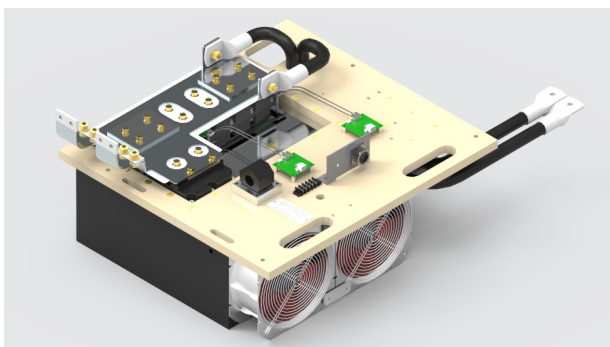
- ✓ Re-traction of propulsion systems (e.g. GTO to IGBT)
- ✓ Converter mid-life upgrade/overhaul
- ✓ Reliability improvements
- ✓ Replacement semiconductor devices

Mid-life upgrades offer a number of benefits including:

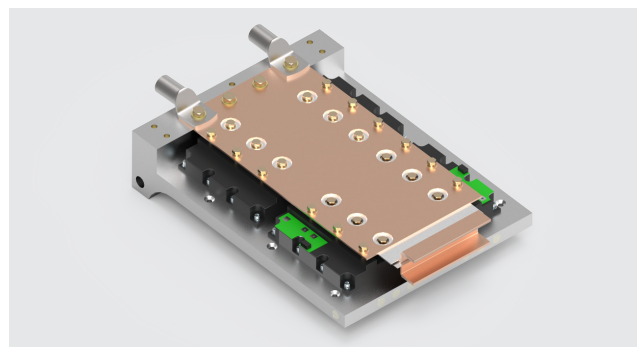
- ✓ Improved reliability and maintainability resulting in reduced life cycle cost
- ✓ Availability through lower downtime and higher reliability
- ✓ Obsolescence management - full collaborative agreement with Dynex insures long-term UK support for spares and maintenance.



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



Dynex designed converter for Class 73 re-traction project



Concept converter design for GTO to IGBT conversion



CONTRACT ASSEMBLY & CAPABILITIES

Full process traceability with barcode scanning



+
High
Power
Expertise

Dynex cater for both higher volume less complex assemblies and lower volume more complex assemblies.

Process control software has been developed for key projects, the platform provides;

- ✓ Rich process instructions to operators
- ✓ Manipulation of external tooling such as electronic assembly tools
- ✓ Enforcement of full process traceability with barcode scanning of sub-components with data verification
- ✓ ESD clean room assembly facility and environment
- ✓ Mounting procedures followed to the torque requirements and assembly sequence.

CASE STUDY

Project Type

High voltage application, large assembly size (4m x 3m), liquid cooled with weight requiring mechanical handling over a 12 month period.

Prototype Evaluation

Provided full inspection and testing of the first customer build and able to fix all identified build defects and passed all testing at both room and elevated temperature / stress conditions.

Mechanical handling for manufacture and test

Completed the design and manufacture of mechanical handling requirements including the trolleys, which could be used for assembly and testing phases, supporting easy movement between different cells in the production cycles and transfer to packaging.

Build control & quality

Adhered to internal processes which enabled the customer to identify, qualify and manage sub-contract parts to the required standards. Full build control and test results storage with tractability of component serial numbers.

Manufacturing

Configured a dedicated cell based assembly area with required mechanical handling, fed from other cells preparing sub-assemblies, enabled quick transfer to the dedicated test area with controlled access.

BOM & Planning

Completed BOM sourcing with material & logistics handling for material in-flow and shipment of finished product.

Packaging for shipment

Prepared using nitrogen purging, packed for direct shipment to project site or storage facility.

Testing

Tests were completed by the engineers and technicians

- ✓ HV voltage testing
- ✓ Pressure testing
- ✓ Heat run testing

STANDARD RANGE OF CLAMPS

Range of standard clamps designed to accommodate press pack semiconductors with tie rod centres from 75mm to 210mm

Dynex engineers use disc springs to apply the clamping force over a wide temperature range.

The clamps incorporate pressure indicators to make installation simple and include a zinc plating with a yellow Passivated finish to offer enhanced corrosion protection.

If the clamp you require is not available in our standard range, our Dynex engineers can provide a solution to meet individual needs.

DC 75 Centre Bar Clamp



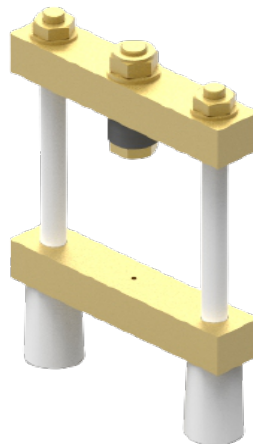
The DC75 has been designed to support the common semiconductor packages shown be:

Dynex Outline	Flange Diameter (mm)	Height (mm)
D	47	14.5
E	42	14.5
G	58	26.5
P	56	27
T	42	13.5

Features:

- ✓ DC clamp series with tie rod centres - 75mm
- ✓ Clamping forces available (kN) - 5, 11 and 15

DC 100 Centre Bar Clamp



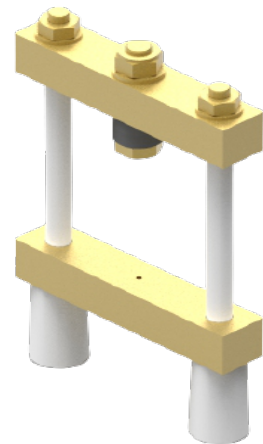
The DC100 has been designed to support the common semiconductor packages shown be:

Dynex Outline	Flange Diameter (mm)	Height (mm)
F	75	26.5
N	73	35.15

Features:

- ✓ DC clamp series with tie rod centres - 100mm
- ✓ Clamping forces available (kN) - 20 and 22

DC 145 Centre Bar Clamp



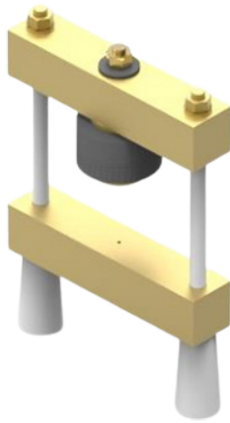
The DC145 has been designed to support the common semiconductor packages shown be:

Dynex Outline	Flange Diameter (mm)	Height (mm)
C	102	28
L	102	36
V	112	29
X	85	27
Y	120	36

Features:

- ✓ DC clamp series with tie rod centres - 145mm
- ✓ Clamping forces available (kN) - 20, 30, 35, 43 and 55

DC 178 Centre Bar Clamp | DC 178-2 Centre Bar Clamp | DC 210 Centre Bar Clamp

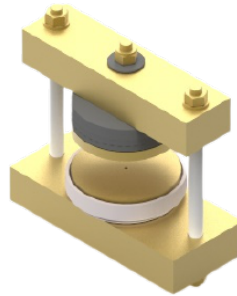


The DC178 has been designed to support the common semiconductor packages shown below:

Dynex Outline	Flange Diameter (mm)	Height (mm)
A	148	35
B	120	35.6
M	148	26.5
W	120	26.5

Features:

- ✓ DC clamp series with tie rod centres - 178mm
- ✓ Clamping forces available (kN) - 73 and 83.

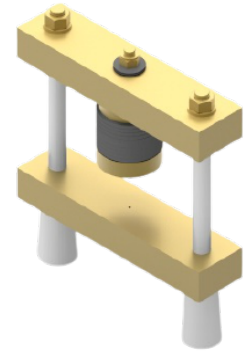


The DC178-2 has been designed to support the common semiconductor packages shown below:

Dynex Outline	Flange Diameter (mm)	Height (mm)
A	148	35
B	120	35.6
M	148	26.5
W	120	26.5

Features:

- ✓ DC clamp series with tie rod centres - 178mm
- ✓ Clamping forces available (kN) - 73 and 83.



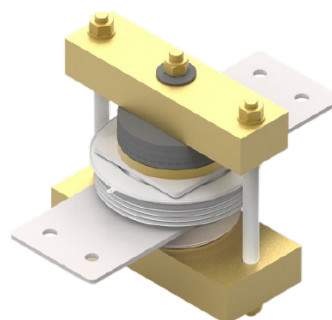
The DC210 has been designed to support the common semiconductor packages shown below:

Dynex Outline	Flange Diameter (mm)	Height (mm)
A	150	35
H	172	35
M	150	26.5

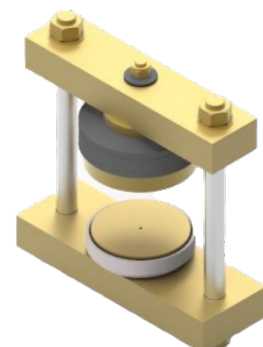
Features:

- ✓ DC clamp series with tie rod centres - 178mm
- ✓ Clamping forces available (kN) - 83, 120 and 138.

DC 178-2 Centre Bar Clamp with Device



DC 210-2 Centre Bar Clamp





In-house
Manufacturing
Support
Capabilities

DESIGN

3D Modelling, thermal, mechanical and electrical simulation

The power technologies design team have vast experience of working alongside customers to create bespoke power assemblies to meet their exact requirements.

Dynex are able to provide a "fast prototype" service for most power conversion applications for the purpose of approving production by Dynex.

During the enquiry phase, the applications support team interact with customers to understand their specification and requirements.

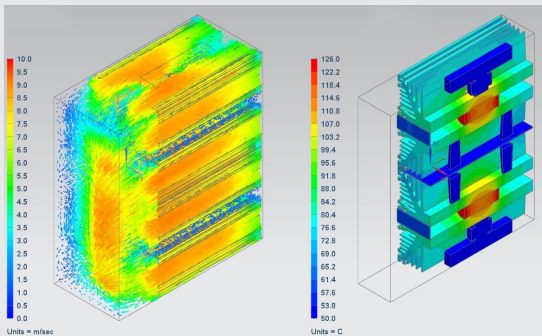
Following a comprehensive simulation analysis to ensure feasibility of the project, a proposal

is prepared to include estimated costings and semiconductor device selection.

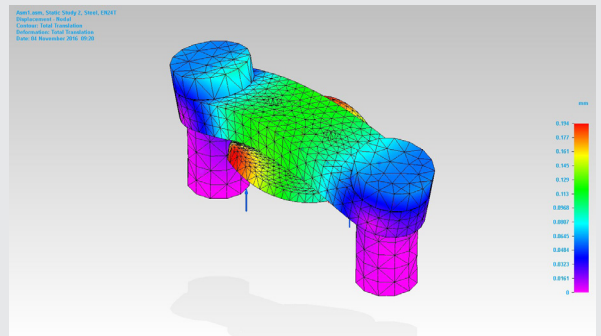
In collaboration with the customer, the team produce a full engineering design with 3D modelling and if required, thermal, mechanical and electrical simulations to validate the design prior to manufacturing by Dynex.

During each stage of the design, customer feedback is encouraged to ensure the design and testing meets their requirements.

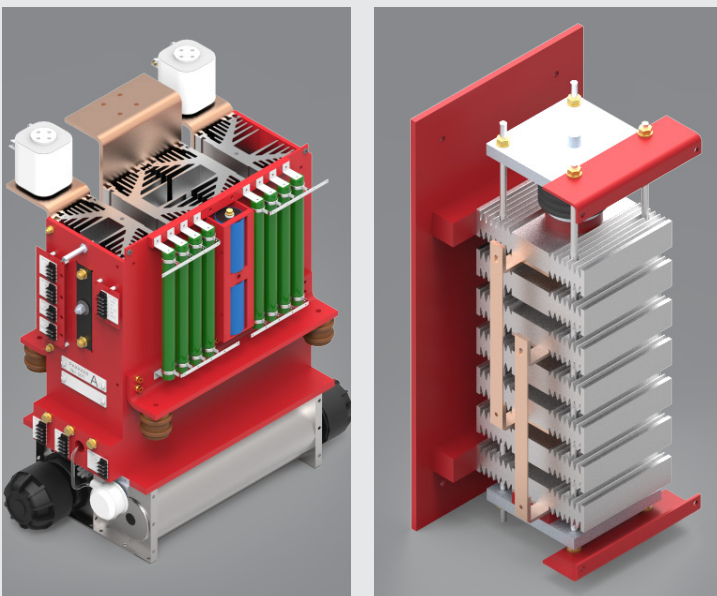
The design team use the following software to generate custom and standard power assemblies:



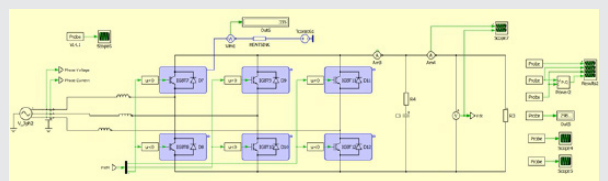
COMPUTATIONAL FLUID DYNAMICS - SIMULATION OF FLUID FLOW AND HEAT TRANSFER



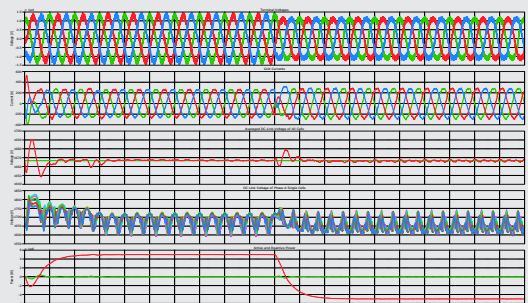
FINITE ELEMENT ANALYSIS - SIMULATION OF STRESS AND DISPLACEMENT



SOLID EDGE RENDERING - 3D SOLID MODELLING



PLECS SCHEMATIC - MODELLING AND SIMULATION OF COMPLETE POWER ELECTRONIC SYSTEM



PLECS WAVEFORM

ON-SITE POWER TESTING FACILITY



Testing up to 100kV



Testing up to 4kA



Liquid flow rates up to 120 L/min



Assemblies up to 2 tonnes in weight

Dynex provide on-site power testing for the power assemblies it manufactures. Assembled products can be verified for standard end of line testing for example, isolation tests, partial discharge measurements and switching. The team 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 the test facility we are able to perform pressure and thermal heat run tests using our localised liquid cooling plant for assemblies that use liquid flow rates up to 120 L/min.



POWER ELECTRONICS LABORATORY



The experienced multi disciplinary team based in the power electronics laboratory provide lab validation and qualification capabilities for the semiconductor and power assembly business.

During the initial design stages, the power assemblies team validate the electrical circuits for expected behaviour. Component suitability

investigation is undertaken to compare the life span of ultra capacitors from different manufacturers for use in Dynex power assemblies.

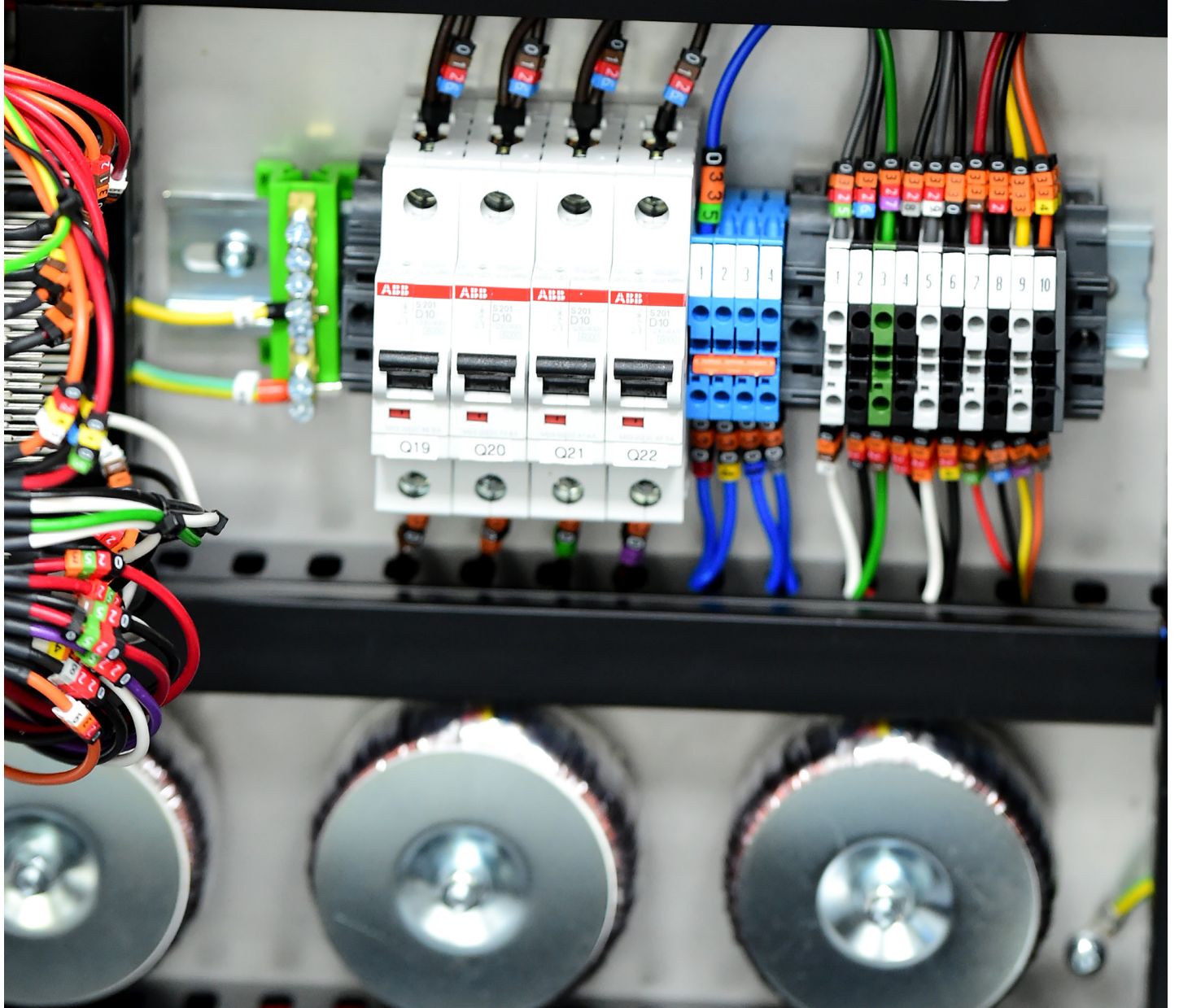
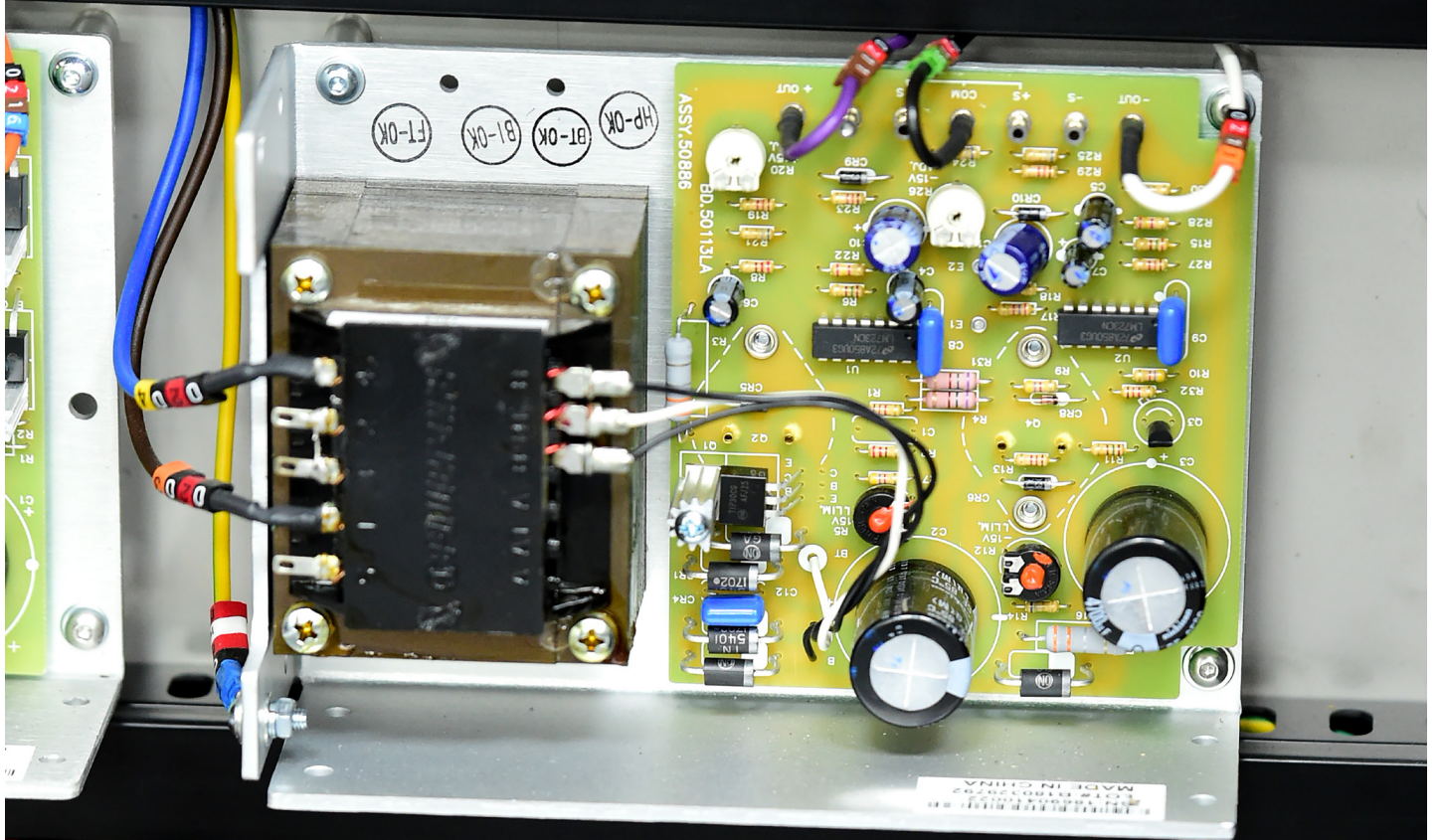
Our in-house laboratory is a high value asset for the engineering team and our customers, providing a unique environment to create specialised test conditions, in relation to power assemblies manufactured by Dynex.

MACHINE SHOP CAPABILITIES

We use conventional and CNC machines to cater to customer requirements and are able to work with a wide range of materials.

Dynex is an ISO 9001 certified company, and we ensure the quality of all product remains at the forefront of what we do.





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.

Warning Counterfeit Products:

There are counterfeit products on the semiconductor marketplace. Unfortunately, many of these products will have markings and labels that closely resemble those from Dynex's genuine products, making it

difficult to realise the difference. Dynex has extensive, proven controls to ensure its products are properly manufactured, tested, handled, and stored to prevent failures. Counterfeit products will not have been subjected to these processes. Therefore, Dynex does not warrant any parts purchased through unauthorised channels nor do we accept any liability for failure of counterfeit products.

Dynex's Advice to customer is as follows:-

Only purchase from Dynex directly or from one of Dynex's authorised distributors. Our Customer Services team can advise you whether a distributor is authorised via the details below.

Dynex products should not be purchased if the outer appearance differs from Dynex products you normally receive unless Dynex or a Dynex authorised distributor has provided you with a product change notification or can be seen on datasheets from the Dynex Website. We strongly advise against purchasing extraordinarily low priced Dynex products from unauthorised distributors. Dynex does not support the sale of Dynex products via online auction houses. We will be pleased to confirm the authenticity of the products. To do so please contact Dynex's Customer Services (see reverse for contact information) with the following information:

- ✓ Part number, quantity purchased, unit cost
- ✓ Name and contact name of the supplier with address, phone, and web/ e-mail addresses
- ✓ Digital photos of inner & outer label, inner & outer packaging, and front & back of product
- ✓ Copy of purchase order and invoice

This is intended to provide you with additional information on counterfeiting and steps that can be taken to better recognize counterfeit products.





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