DENIS FERRANTI GROUP

ELECTRIC MACHINES,
POWER AND CONTROL SYSTEMS

AEROSPACE
INTRODUCTION

DENIS FERRANTI GROUP

Denis Ferranti is a world leader in safe, high performance machines and power systems for innovative electric and more electric aircraft applications, providing mechanical and electrical power.

Denis Ferranti technology covers requirements such as gas turbine hybridisation, propulsion, back-up propulsion for helicopters and high power, high voltage generation systems for aerospace applications.

Our extensive intellectual library and specialism in electric aircraft systems reduces risk and leadtime when developing new technology.
The technical challenges associated with hybridization and propulsion in aeronautical applications are significant.

The main technical challenges include safety, certification, performance, mass and cost. At Denis Ferranti Group we provide solutions to these challenges through our extensive, application specific, intellectual property library.

**WHAT CAN WE DO FOR YOU?**

We offer a design and build to specification capability along with a range of background IP.

Delivering the optimum technical solution for your electrical machine and power system requirement, in the shortest timescale, at the best value with a clear route to certification.

**OUR TECHNOLOGY COVERS:**

- Machines and converters for provision of electrical and mechanical power
- Powers up to 300 kW with a roadmap to 1 MW
- Speed ranges from 500 rpm to 30,000 rpm
- Voltages from 28V to 700V and beyond
- Architectures include simple, multiplex
- Permanent magnet and induction machines
- Unique intellectual property mitigating fire
- ARINC and CAN for communications
- Typical applications include electrical power generation and motor functions in continuous operation, transient power burst and propulsion
PERMANENT MAGNET TECHNOLOGY FOR AEROSPACE
DEMONSTRATING EXPERTISE AND CAPABILITY

Denis Ferranti Group has developed high power motor and converter technology for aeronautical applications.

KEY MARKET REQUIREMENTS:

- High availability
- Mitigations to fire
- High power up to 180 kW
- High efficiency > 90%
- Low mass < 28kg

To answer the requirement we developed an integrated machine and converter.

CONVERTER:
- Multiplex converter in line with ARP 4754 and ARP 4761
- 450V DC
- Fire and short circuit protection
- Health monitoring
- Bespoke control system using FOC, field weakening and 3rd harmonic injection algorithms
- CAN and ARINC compatible
- Mass of 18 kg

ELECTRIC MACHINE:
- Innovative permanent magnet electric machine
- High speed
- Multiple barrier insulation systems
- Mass of 10.6 kg

The technology is under development for permit to fly and serial application.

The programme followed a typical aerospace development route and was subsequently tested on Denis Ferranti’s site and at the customer’s facilities. The technology is currently being positioned for serial application.
Denis Ferranti Group is developing HVDC generators in the frame of clean sky 2.

**Requirement:**
- Nominal power 90kW
- Voltage +/-270VDC with a midpoint
- Nominal speed 25,000 rpm
- Transients
- Continuous
- Efficiency > 95 percent
- Forced air and liquid cooling
- Operation from -45°C to 280°C
- High availability
- No fire or motor burst
- Least mass
- No ITAR restrictions

Denis Ferranti Group is currently developing a bespoke system solution in accordance with DAL A for complex hardware and software.

**Converter:**
- Multiplex bespoke converter
- Multiple barrier insulation systems protecting helicopter chassis and 28V network
- Barriers to burst
- CAN and ARINC compatible
- Independent controller for health monitoring of voltage, current and temperature
- Short circuit protection
- Environmental capability in accordance with platform vibration and DO160
- A bespoke control system covering the motor and generate functions
- Graphical user interface for software
- High availability and fire criteria further developed for certification
- Liquid cooling system

**Electric Machine:**
- Permanent magnet electric machine with optimised geometry, slot fill and materials (patent applied for fail-safe capability)
- Multiple barrier insulation system
- Burst containment
- High speed bearings
- Air and liquid cooling
- Flexible shaft
- Shear section
- Clutch
- High temperature components
- Optimised for increased slot fill and low ac losses
- Low mass
- High availability and fire criteria further developed for certification
Denis Ferranti Group has developed high-power induction motor/generators of the order of 150 kW.

**REQUIREMENT:**
- High power ~ 150 kW
- High efficiency
- High availability
- No fire or motor burst
- Least mass
- No ITAR restrictions

To answer this requirement Denis Ferranti Group developed a bespoke high-speed induction machine.

**ELECTRIC MACHINE:**
- Induction machine
- Burst containment
- High speed
- High speed mixed flow fan for air cooling
- Flexible shaft
- High availability and fire criteria
Denis Ferranti Group has developed high-power starter / motor / generators for hybrid applications.

**REQUIREMENT:**

Nominal mechanical power 12kW to 50kW  
Voltage Low V, current > 1,000 amps  
Short bursts of operations  
Efficiency > 95 percent  
Forced air cooling  
No fire or motor burst  
Least mass

To answer this requirement Denis Ferranti Group developed a machine with the following features:

**ELECTRIC MACHINE:**

- Permanent magnet electric machine with optimised geometry, slot fill and materials  
- High temperature components  
- Optimised for increased slot fill and low ac losses  
- Mass of 8.7kg  
- High availability and fire criteria  

The programme followed a typical aerospace research development route and was subsequently tested on Denis Ferranti’s site and at the customer’s facilities on the intended gas turbine.

Denis Ferranti Group developed and manufactured the motors for the QinetiQ Zephyr Unmanned Aerial Vehicle (UAV).

The UK-built Zephyr is a solar powered aircraft that holds the world record for the longest official endurance record for an unrefuelled, unmanned aerial vehicle.

**UNMANNED AERIAL VEHICLE MAIN PROPULSION**

- Voltage 24v  
- Nominal speed 2000 rpm  
- Nominal power <0.5kW
DESIGN ORGANISATION

Denis Ferranti’s design organisation is structured around EASA part 21j, delivering to customer requirements in accordance with ARP 4574 and ARP4761.

With a proven track record in Aerospace innovation, we have access to a library of existing intellectual property which gives us the ability to develop and deliver solutions quickly and with greater value.

OUR DESIGN COMPETENCES COVER:

SAFETY AND RELIABILITY
SYSTEM ENGINEERING
CONTROL SYSTEM ENGINEERING
SOFTWARE
ELECTRONIC HARDWARE
ELECTRICAL POWER ENGINEERING
MACHINE DESIGN
MECHANICAL DESIGN
COOLING SYSTEMS

CERTIFICATION AND STANDARDS

We are familiar with working to the following airworthiness and certification requirements, standards and norms, including,

ARP4754 A, ARP4761, RTCA/DO-254, RTCA/DO-178C and RTCA/DO-160G.
In support of our technology, Denis Ferranti Group is a vertically-integrated manufacturing organisation in line with requirements of EASA Part 21, IPC3 and AS9100 Rev C.

The business incorporates all the skills, know-how and capital equipment required for mechanical / electronic manufacturing and testing of high power electrical machines and power systems.

With all the capability on one site Denis Ferranti can deliver against programmes in the shortest possible lead time without the frustrations of an extended external supply chain, from research project to serial manufacture.

**PRODUCTION ORGANISATION**

**VERTICALLY INTEGRATED PHILOSOPHY**

**ON-SITE MANUFACTURING OF ELECTRICAL POWER SYSTEMS**

**KEY FEATURES:**

- State-of-the-art facility and equipment
- Dek screen printers
- Mydata SMT
- 12 zone ovens for high thermal mass power boards
- Flow solder
- AOI and flying probe inspection
- Cable assembly and box build
- Function testing
- 24/7 operation
- AS9100 rev D
- IPC 3
VERTICALLY INTEGRATED PHILOSOPHY

ON SITE MANUFACTURING OF HIGH SPEED ELECTRICAL MACHINES

KEY FEATURES:

- Toyota Production System including pull system
- CAD/CAM
- Machining (milling, turning and grinding)
- Mechanical inspection including CMM
- NDT level 3
- Surface treatment
- Painting
- Assembly
- Balancing
- Verification and high-speed test

ON-SITE TESTING OF ELECTRICAL MACHINES AND POWER SYSTEMS

For most requirements, Denis Ferranti undertakes testing in-house, with access to high power, fire- and blast-proof laboratories, facilitating continuous high-speed and high-power tests.

OUR TEST CAPABILITY INCLUDES:

- High speed testing verifying delivery of electrical and mechanical power
- Endurance testing
- Mechanical testing
- Electronic hardware and function testing
- Software verification
- Environmental testing