# Multiphase Synchronous Generators for DC Aircraft Power Systems

## Overview

Multiphase machines offer a number of benefits toward the aerospace sector, particularly when considering DC power distribution systems. The high number of phases allows for the possibility for a reduction in DC voltage ripple magnitude. This offers the potential to remove the filter capacitance necessary when rectifying AC to DC for a three-phase system. These capacitors are an expensive, sizeable and hazardous component in aerospace applications.

## System Application

The current power distribution system found on the Boeing 787 Dreamliner, which utilises the Rolls-Royce Trent 1000 gas turbine engine, is a variable frequency AC network. The variation in frequency over the flight cycle poses problems with loads that are directly connected to the distribution network.


*Figure 1: Boeing 787 Dreamliner*

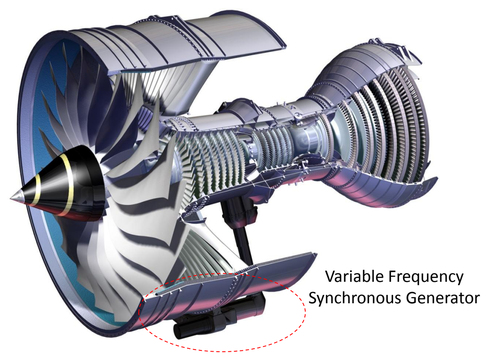


*Figure 2: Rolls-Royce Trent 1000*

Flight control surfaces such as ailerons, found on the Boeing 787 Dreamliner, require power electronic conversion at present. This could be eliminated by using a DC power network. Uncontrolled rectification provides DC output with less complexity and at low cost. However, the currents drawn from the generator can induce saturation and increase stator losses. Introducing control of switching will allow for an increase in generator performance.

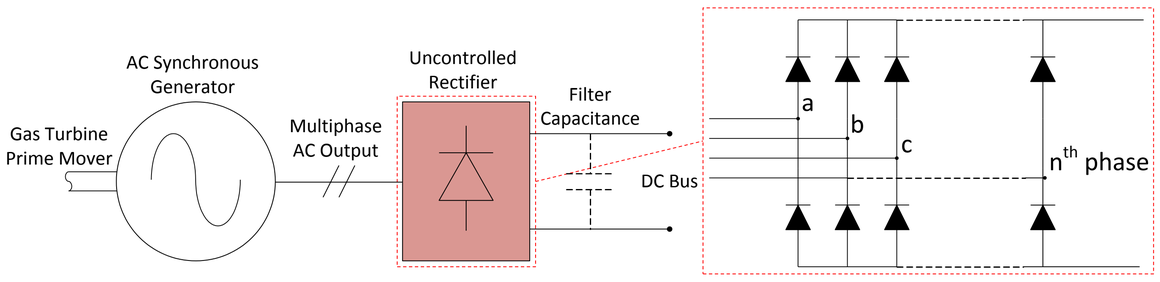


*Figure 3: Uncontrolled Rectifier System*

## Electric Machine Performance

The compromise between generator performance and DC power quality is of significant interest. Star (Y) connected machines offer greater fault tolerance but draw higher peak currents as phase number increases. Delta (Δ) connected machines draw a more uniform current but offer a severely reduced fault tolerance. DC ripple voltage reduction remains consistent.

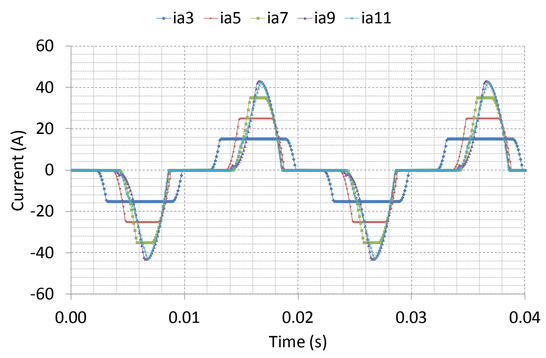


*Figure 4: Generator Star Current*

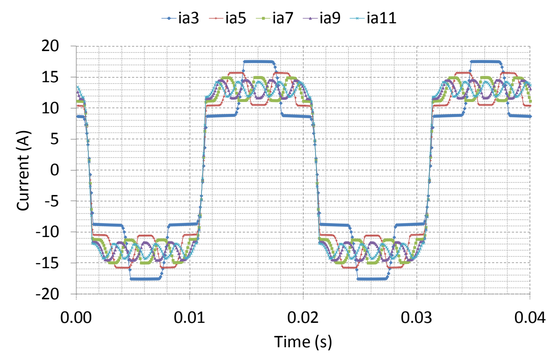


*Figure 5: Generator Delta Current*

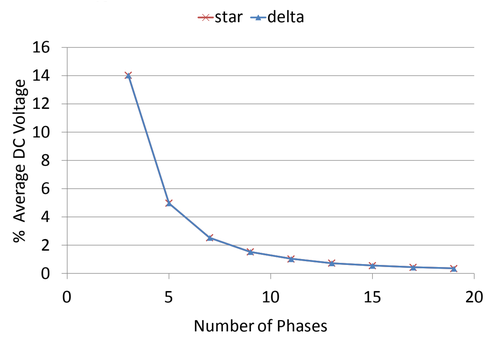


*Figure 6: DC Output Ripple Voltage*

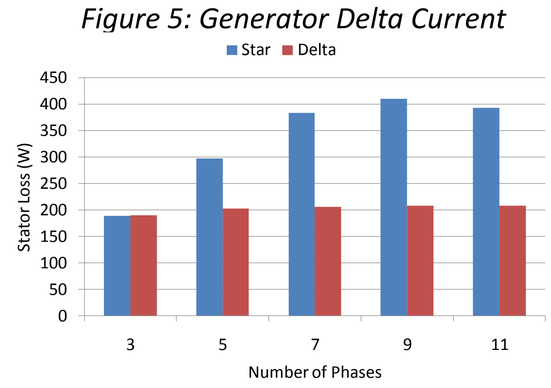


*Figure 7: Stator Losses*

## Future Work

Future work to be carried out:

- Design and construction of a IGBT rectifier
- Characterisation of multiphase machine upon receipt
- Integration of a full system multiphase test rig

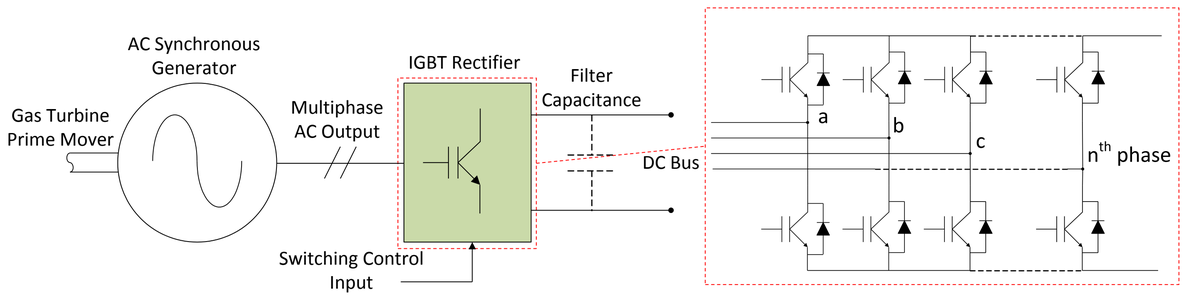


*Figure 8: IGBT Controlled Rectifier System*

## Electric Machine Design

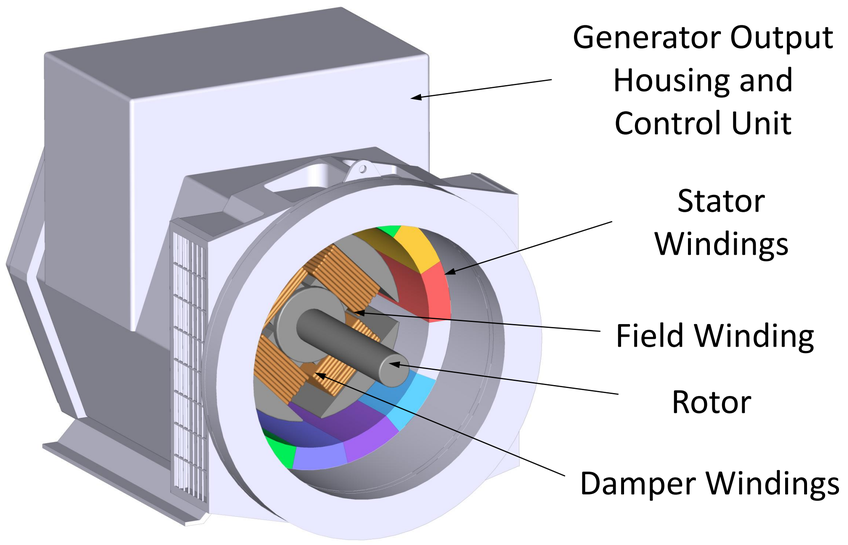


*Figure 9: Test Rig Multiphase Synchronous Generator*

Mathematical modelling can accurately simulate machine dynamics, however, when considering electric machine design, it is important to understand the internal performance of the generator.

Finite element modelling gives a mathematical solution of internal distribution of magnetic quantities such as flux density. These can be analysed to allow the machine to be designed so that, when moving toward a multiphase machine, harmonic loss components are not introduced into the generator air-gap.

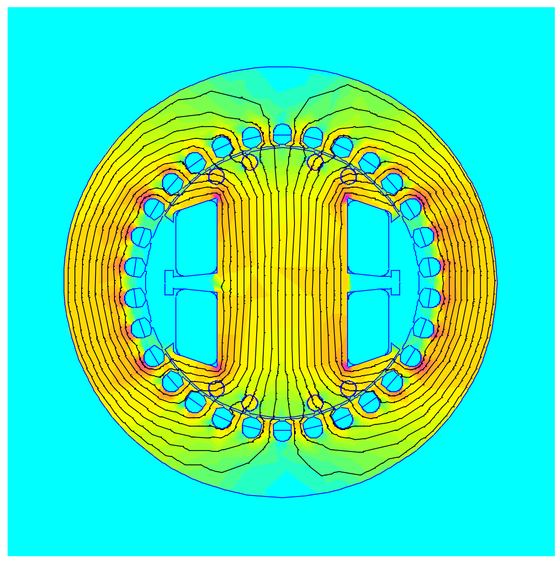

*Figure 10: Finite Element Flux Density Solution*

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