

# 3-phase synchronous AC machines

Can be operated as both motors or generators

Most common application across all power ranges from a few kW upwards is as AC grid connected AC generators (usually 50 or 60Hz)

Sometimes used as constant speed motors in MW range, but rarely used as motors in low to medium power applications (inverter controlled induction machines and permanent magnet machines usually being preferred)

As generators, normally driven by a prime-mover with precise speed control:

- Steam turbines: up to 1000MVA+
- Diesel generator sets: ~10kW up to many MW
- Geared gas-turbine up to 50MW

For 50Hz AC:

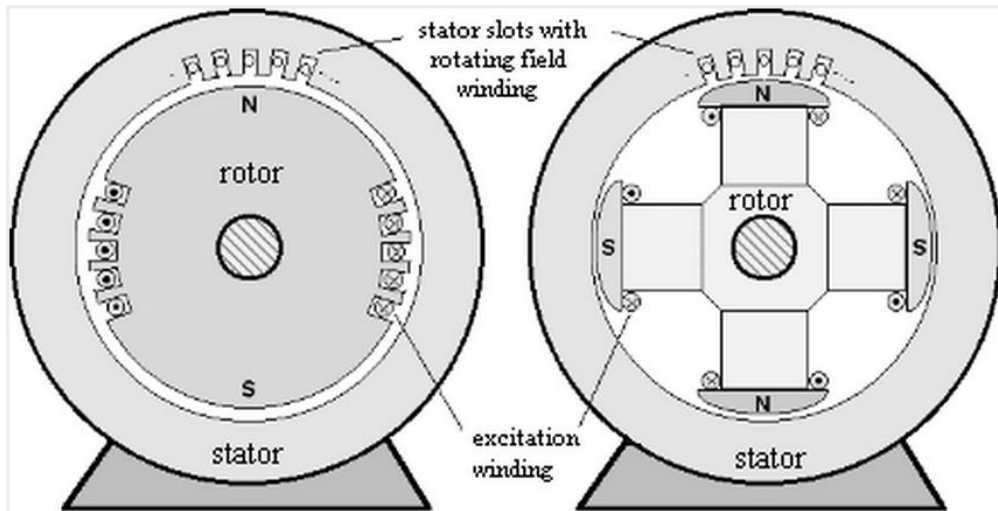
3000rpm for 2 pole machine

1500rpm for 4 pole

1000rpm for 6 pole etc

# Basic features of a synchronous machine

- Multi-phase (usually 3) winding on the stator which is designed to produce a sinusoidal output voltage
- DC winding on the rotor – referred to as the field winding
- Rotor can be salient or non-salient



Non-salient rotor

Salient rotor

only a few stator slot shown to aid clarity – in practice, slots extend around full periphery of stator



# 3-phase multi-MW AC grid connected generators

Steam turbine drive large generators  
(now up to 1500MW) – but many in UK  
660MW



660MW unit at Drax Power Station  
(2-pole, 3000rpm for 50Hz)

Hydro-electric AC generators (operate at  
much lower speeds several 10s to low  
hundreds and hence have many more  
poles to produce 50/60Hz)



# Medium sized AC generators for

Same basic principles and features

Typical ranges 600kVA – 20MVA

Driven by diesel engines, geared gas-turbines, gas engines, small steam turbines



Oil & Gas



Cogeneration/  
CHP Plant



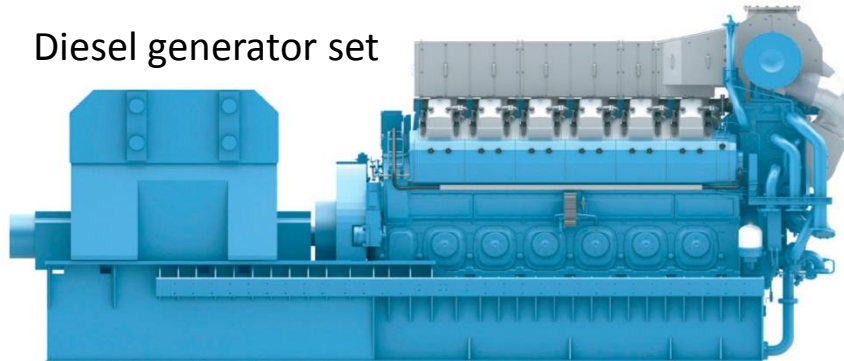
Marine/Tidal



Power Plant

**Source: Cummins Generator Technologies**

Diesel generator set



**Source: Rolls-Royce**



# Aerospace synchronous generators

- Older aircraft have fixed 400Hz output from variable speed input (take-off shaft from engine via a constant speed hydraulic mechanism).
- Hydraulic constant speed mechanism is inefficient and requires frequent maintenance.



Typical constant speed mechanism

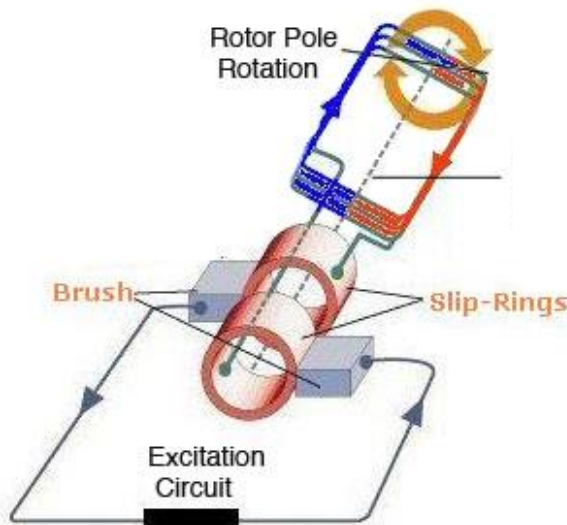
- Newer aircraft (1990s onwards) have variable frequency AC (VFAC) network in which the generator output frequency is allowed to vary between 360 and 800Hz over the engine operating range. Directly driven from gearbox. Ratings up to 250kVA on Boeing 787.
- Further information at:  
[http://www.boeing.com/commercial/aeromagazine/articles/2012\\_q3/2/](http://www.boeing.com/commercial/aeromagazine/articles/2012_q3/2/)



# Exciter

Provides a means of controlling the magnitude of the DC current in the rotating field winding, i.e. controlling the excitation

Can be realised through slip rings or brushless exciter



Typical rotating elements of brushless exciter

