CASE STUDY

GE
Power Conversion

Type 23 Frigates
Duke Class

The Type 23 frigates are designed as Anti submarine Warfare ships for the Royal Navy. A combined Diesel Electric and Gas Turbine (CODLAG) propulsion plant operating in direct drive electric propulsion mode ensures a low noise signature at low speeds while higher speeds are achieved via the gas turbines running through reduction gearboxes. A further feature of this configuration is the significant fuel saving that is achieved when operating in diesel electric mode. This design was developed during the 1980s prior to the advent of AC variable drive systems.

The Type 23 Duke Class of Frigates for the Royal Navy were designed with a radical propulsion system for the purposes of providing low noise signature propulsion at slow speeds.

At the time of system design there were few options available. The specification required the use of fixed pitch propellers which, in turn, necessitated the use of a variable speed propulsion solution. Submarines were the source of much experience with low noise propulsion systems; invariably these used DC propulsion motors.

The range of high power AC motors which are available for ship designers in the present era were simply not available when the Type 23 frigate design was being evolved. There were significant limitations when using DC motors: commutation limited their output power at propeller shaft speed thus preventing the implementation of a full electric propulsion system.

A hybrid electrical/mechanical propulsion system was designed. This employed a low power DC propulsion motor, supplied via the ship's diesel generators, for slow speed quiet operations. This was complemented by gas turbines, driving through a reduction gearbox, for higher speed operations. This system is known as CODLAG or Combined Diesel Electric and Gas Turbines.

In order to further minimize mechanical noise during quiet operations, the propulsion motor is positioned on the propeller shaft aft of the gearbox. The rotor is supported by the gearbox bearing and a shaft bearing.

The gearbox is clutched out when operating in quiet diesel electric mode and is clutched in for gas turbine operation when higher speeds are required. Maximum power is achieved by adding the DC motor in tandem with the gas turbine.

The gearbox is of the non-reversing type so all reversing, including crash stops, is achieved through the diesel electric drive system.

Prior to the development of the CODLAG design quiet electric drives employed DC propulsion motors supplied by pure DC from either batteries of from DC generators. Since the Type 23 generators were to be used for propulsion and for ship's services they had to be AC running at constant frequency. Therefore the design incorporates a thyristor converter which rectifies the AC to a variable voltage DC to supply the motor at varying voltages (equating to varying speeds). A thyristor converter works by 'chopping' the alternating current and produces direct current with a 'ripple' on the output which appears as vibration in the motor. A key responsibility for GE's Power Conversion business during system design was that of designing a converter which would attenuate this ripple to levels comparable to those associated with DC generators.

The thyristor converters are based on a 6 pulse system which creates unwanted harmonic currents on the distribution switchboard. The switchboard is rated at 600 V which is matched to the design of the propulsion motor. Previous RN ships achieve high quality power supplies by employing individual generating sets for individual loads. In order to provide a more conventional high quality 440 V power supply whilst simultaneously mitigating the harmonic effects, a motor generator set is employed to isolate the 600 V system from the 440 V ship's systems.

The propulsion motor itself is designed based on principles applicable to those of submarine motors, including the skewing of rotor slots.

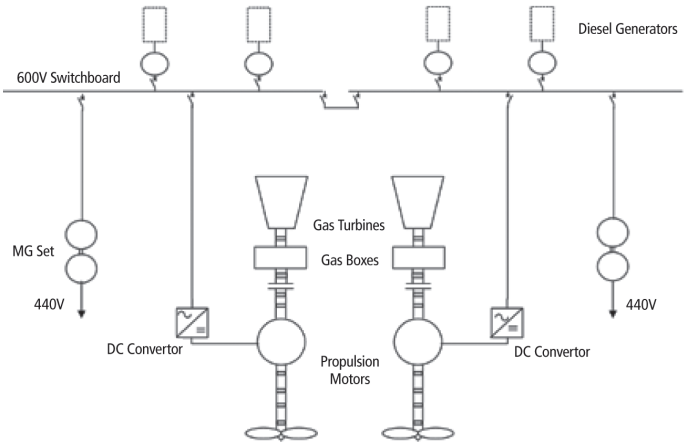
Power Conversion was appointed a 600 V system design authority and as supplier of the electric propulsion system and motor generator sets. Power Conversion was responsible for specifying parameters for the generator sets, the switchboards and for the protection system which integrates the propulsion and power systems.

imagination at work

The system has proved to be extremely successful and reliable, at time of writing the system had clocked up in excess of 2.5 million nautical miles without serious breakdown or failure. The noise signature has met all requirements and expectations.

As a byproduct of this innovative design, the system has shown itself to be extremely fuel efficient when operating in diesel electric mode and has been instrumental in the selection of diesel electric propulsion systems for subsequent classes of ship for the Royal Navy.

Of the 16 ships built, 13 remain in service with the Royal Navy while 3 have been sold to the Chilean Navy.



Key Facts	
OPERATOR	Royal Navy
SHIPYARD	Yarrow Shipbuilders Swan Hunter
IN SERVICE	1990-2002
No. Ships in Class	16
LENGTH	133 metres
DISPLACEMENT	4200 tonnes

CODLAG Power & Propulsion
2 x 1.5 MW DC Propulsion Motors
2 x DC Propulsion Converters
2 x 1200 kVA Motor Generator Sets

Name	In Service Date
Norfolk*	1990
Argyll	1991
Lancaster	1992
Marlborough*	1991
Iron Duke	1993
Monmouth	1993
Montrose	1994
Westminster	1994
Northumberland	1994
Richmond	1995
Somerset	1996
Grafton*	1997
Sutherland	1997
Kent	2000
Portland	2001
St Albans	2002

* Sold to Chile (now renamed):
Almirante Cochrane
Almirante Condell
Almirante Lynch

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