Empowering innovation in energy efficient marine solutions

Hybrid laboratory

Increased efficiency and reduced emissions are essential for the sustainable development of maritime industry. The experts at MARINTEK in Trondheim, Norway, have created an advanced laboratory to put the latest hybrid energy solutions through their paces.

The Hybrid laboratory at The Norwegian Marine Technology Research Institute (MARINTEK), part of SINTEF, Scandinavia's leading independent research organisation, has been created to support the study of energy efficient ship power- and propulsion systems. ABB's technology plays a pivotal role in the pioneering work undertaken here.

This case study details the equipment, structure and capabilities of the Trondheim-based laboratory.

Diesel engine – generator – rectifier

The lab has been constructed to house two sets of diesel engines, generators and rectifiers supplying a 540V DC bus. The diesel engines are four-stroke six cylinder units, of a different size, with a net engine prime power of 209kWb and 412kWb at 1500rpm. ABB has manufactured the generators, which have a rating of 230 and 400kVA at 1500rpm. One of the key benefits of the DC grid is that the engine/generator speed is not bound by electrical frequency; hence both generators are designed for variable speeds. The 450V AC output from the generators is rectified through two thyristor rectifiers, also supplied by ABB, which offer a controlled amplification of the voltage.

Drives line-up

The lab power system has two drive line-ups separated by a bus tie. The load consists of two 200kW squirrel cage ABB induction motors, featuring eddy current breaks. The breaks provide the motors with an adjustable load torque and can run pre-programmed load profiles to simulate ship propulsion. The motors are supplied by ACS800 multidrives. One of the advantages of a DC grid is that the drives do not need a rectifier. The diode supply unit (DSU) or inverter supply unit (ISU) used in conventional AC systems is replaced with a DC supply unit (DCSU).

The ABB-developed incomer module (input circuit, or IC) is part of the protection system of the onboard DC grid. The IC will be transparent most of the time, allowing power flow between the motor loads and energy storage systems at different line-ups.

Only in the case of a sudden drop in grid voltage will the IC block return currents from the drives to the generator side. This will ensure selectivity of the installed fuses, and quick recovery of the system after a fault.

Battery bank

The battery bank has a capacity of 159Ah and 55kWh at nominal voltage, with a peak charge/discharge current of 400/800A at nominal operating temperature. These batteries are considered to be high power and can discharge with a peak of 277kW at nominal voltage and temperature. High power batteries usually require more space and are heavier than high-energy batteries. The battery bank consists of two strings, each of which feature four sub-packs made up of 12 battery modules. A DC-DC converter, which allows bi-directional current flow, provides controlled charge/discharge of the batteries. The battery voltage can vary between 286-384V, with a nominal voltage of 346V.

Capacitor bank

The capacitor bank features 200 Maxwell super capacitors connected in series. Super capacitors have higher energy density than conventional capacitors, but can still deliver high currents at fast discharge rates. The capacitor bank has an energy capacity of 316Wh when discharging between 450V and 225V.

Control system

The laboratory control system includes a PEMS (Power and Energy Management System) that communicates with the GRCS (Generator and Rectifier Control System) and ESCS (Energy Storage Control System). The ESCS handles charging and discharge of the energy storage and contains different operational modes, such as Peak Shaving, Spinning Reserve, Enhanced Dynamic Performance, Enhanced Ride Through, Strategic Loading and Zero Emissions Operations. There is also a BMS (Battery Monitoring System) responsible for monitoring and protecting the batteries from operating outside their safe operating area.

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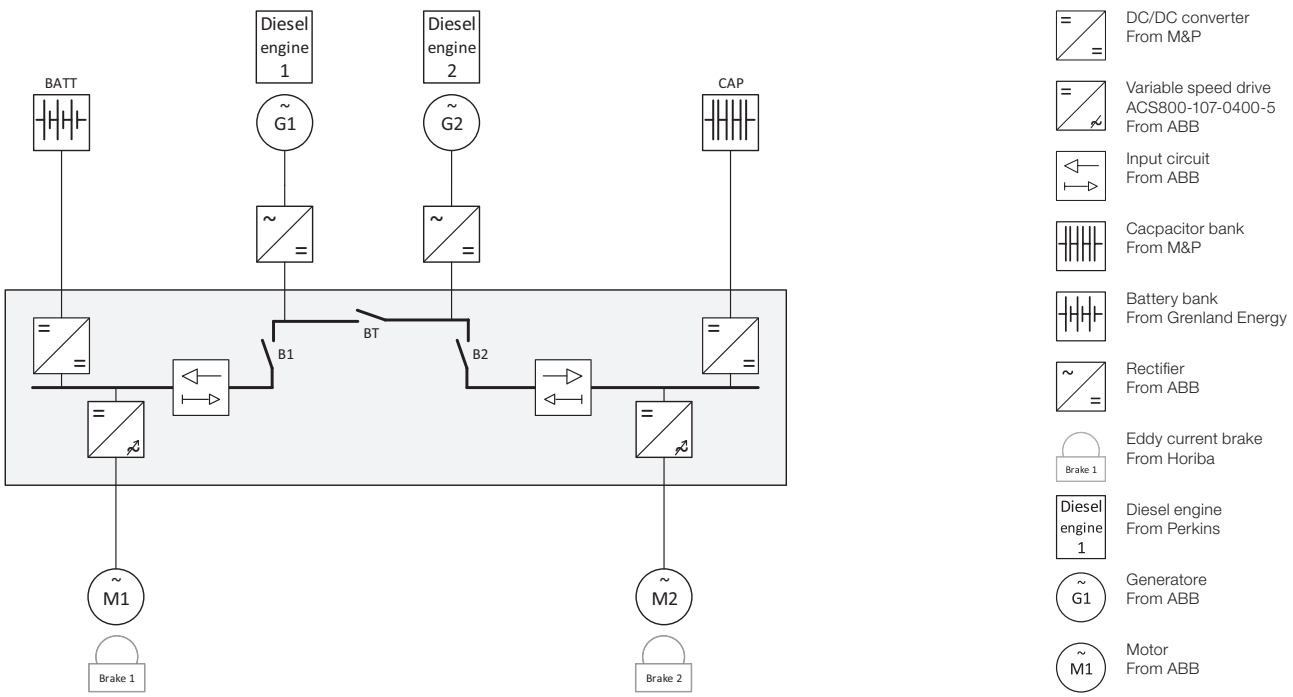

Single-line diagram for the hybrid lab