DYNAMIC POSITIONING CONFERENCE
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ENVIRONMENT/TESTING

"Fault Ride-Through" Testing of a LV Power Solution, BlueDrive PlusC

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Fault Ride Through Testing of LV Power Solution BlueDrivePlusC

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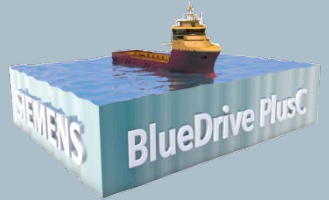

BlueDrive PlusC
Main building blocks of the LV power solution

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DC power distribution system

DP operation with a closed bus tie (ILC breaker)

Variable speed generators

Integrated rectifiers

Integrated frequency converters

Integrated Ship-net supplies (clean power network)

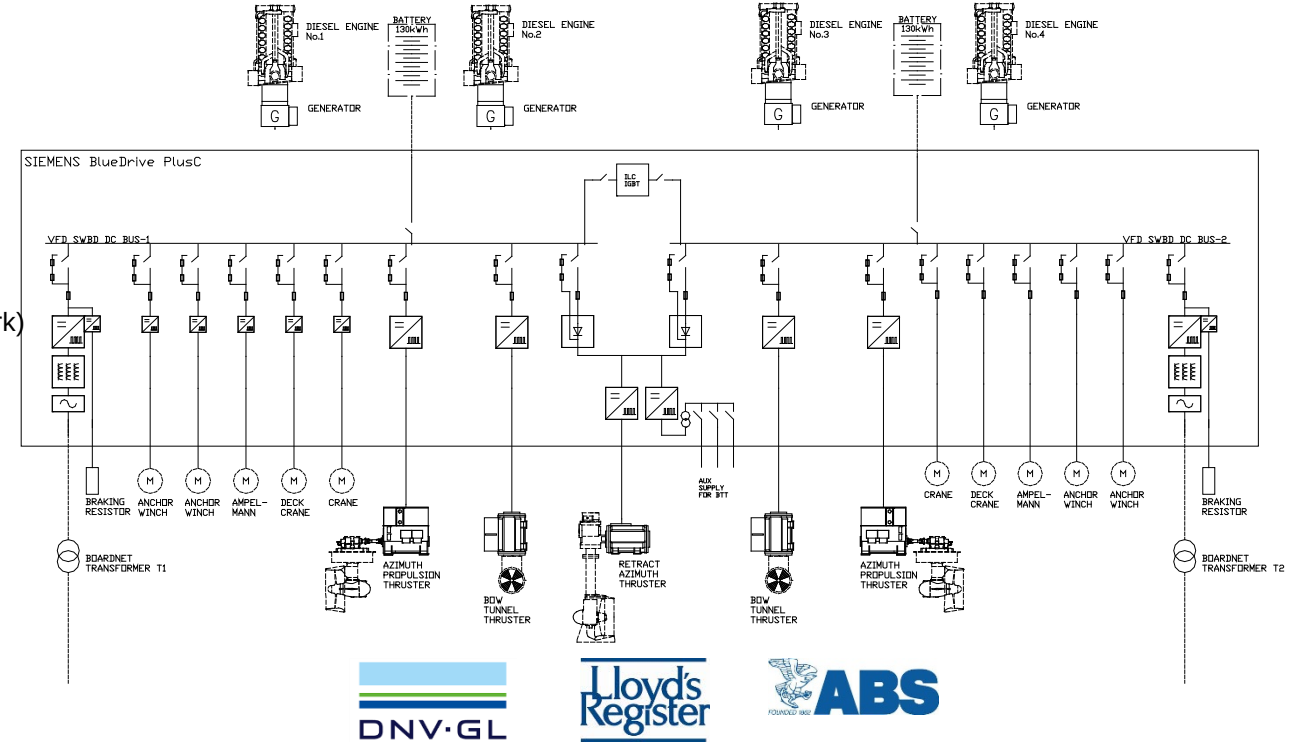
Integrated auxiliary VFD or DC feeds

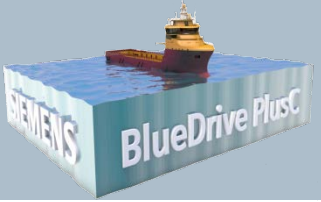
Dual Thruster feed

Optional energy storage solutions
(battery or super caps)

Water cooling systems

Approved design by:





”Fault ride through test”
The test object and state of operation

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The ”fault ride through test” was performed on a
Platform Support Vessel

Vessel Configuration

The vessel has two power sections connected together two parallel connected bus-ties of the type: Siemens ILC, 2000A DC

Connected to Port side:

Two generator incomers
Main Propulsion thruster port
Bow tunnel thruster No 1
FiFi Pump No 1
Liquid Mud Pump No 1
Shipnet supply

Connected to Stbd side:

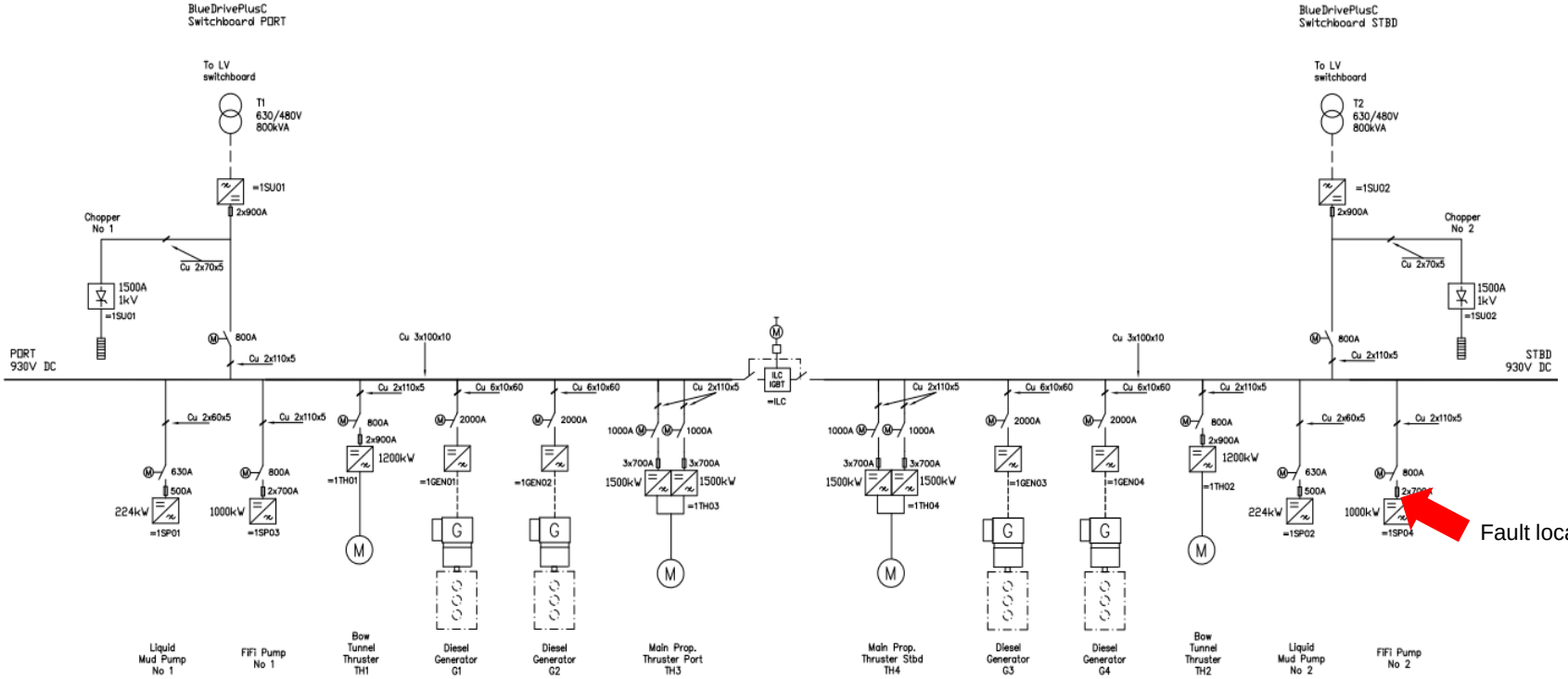
Two generator incomers,
Main Propulsion thruster port
Bow tunnel thruster No 2
FiFi Pump No 2
Liquid Mud Pump No 2
Shipnet supply

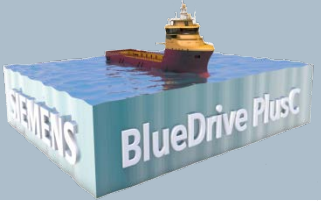
Operation at the time of test:

The vessel was operating in DP2 mode with closed bus.

Fault location
The fault was injected at the STB FIFi pump No2, the fault was created by connecting a Siemens 3WL breaker in short circuit between + /- after the fuse of the FiFi pump inverter.
The breaker was closed remotely

BlueDrive PlusC
The tested power system





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The vessel operation pre fault

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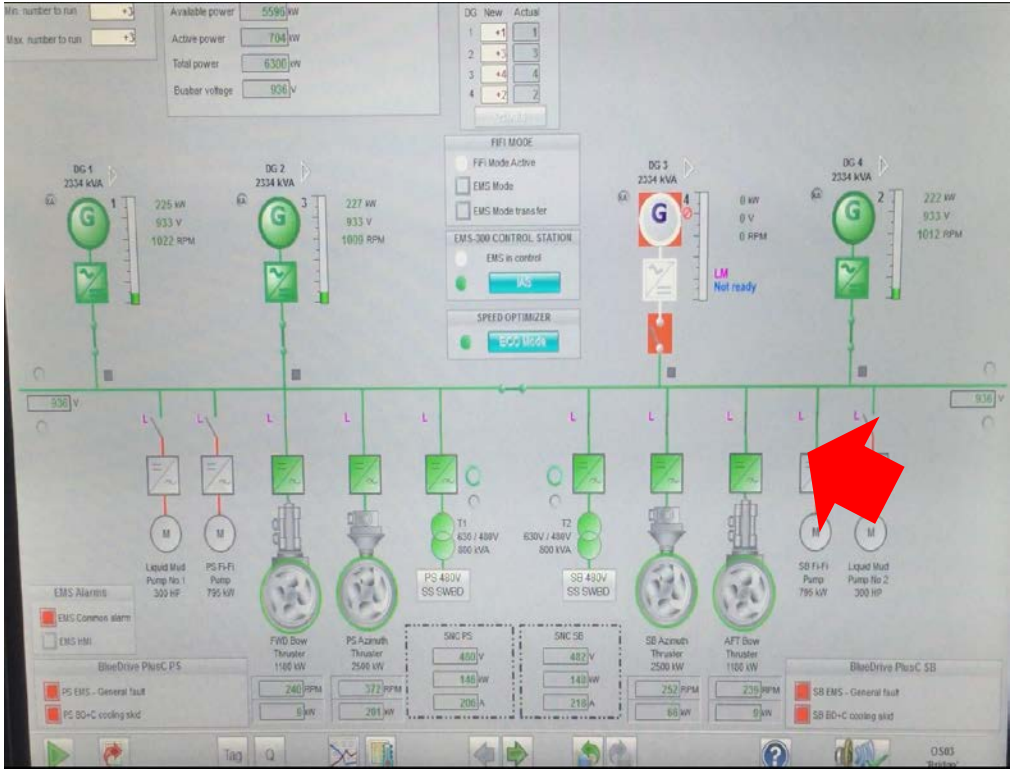
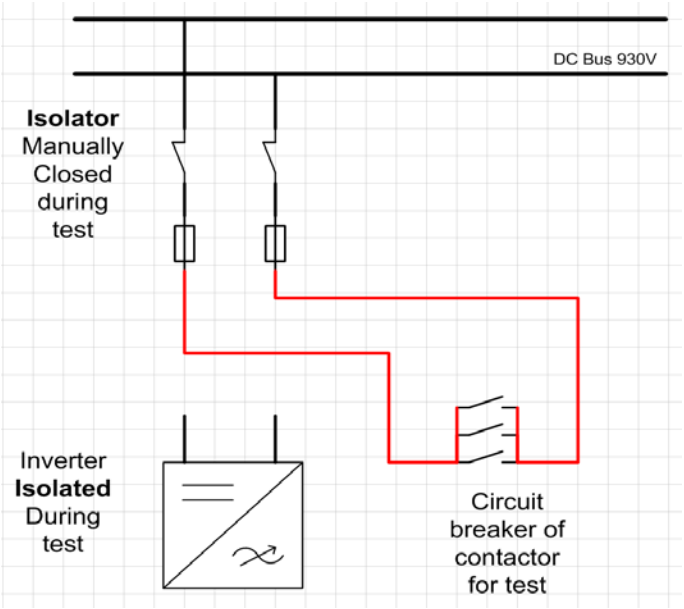
- The vessel was in DP2 operation with closed bus-tie.
- Two generators were connected on the opposite side and one generator on the side where the fault was introduced. The total system load was approx 700kW (13% of max load) for each generator.
- Diesel generators were operated in ECO-mode -> variable frequency mode with reduced speed of approx 1010 RPM at the time of the test
- All inverters connected and both main propulsion were loaded to approx 150kW
- ILC/ bus-tie breakers was closed (two ILC's in parallel)
- Both Shipnet Supplies were connected, each with a load of 150kW, bus-tie on the 480V AC switchboard was closed



”Fault ride through test”
The test setup with the fault simulator

The circuit breaker creating the short circuit



Simplified view of the fault circuit

Test monitored by two Current measurement with two oscilloscopes

”Fault ride through test”
The test setup with the fault simulator

Cables connected below fuses, motor module for FiFi pump disconnected

Current and voltage measurements over the ILC bus-tie breaker

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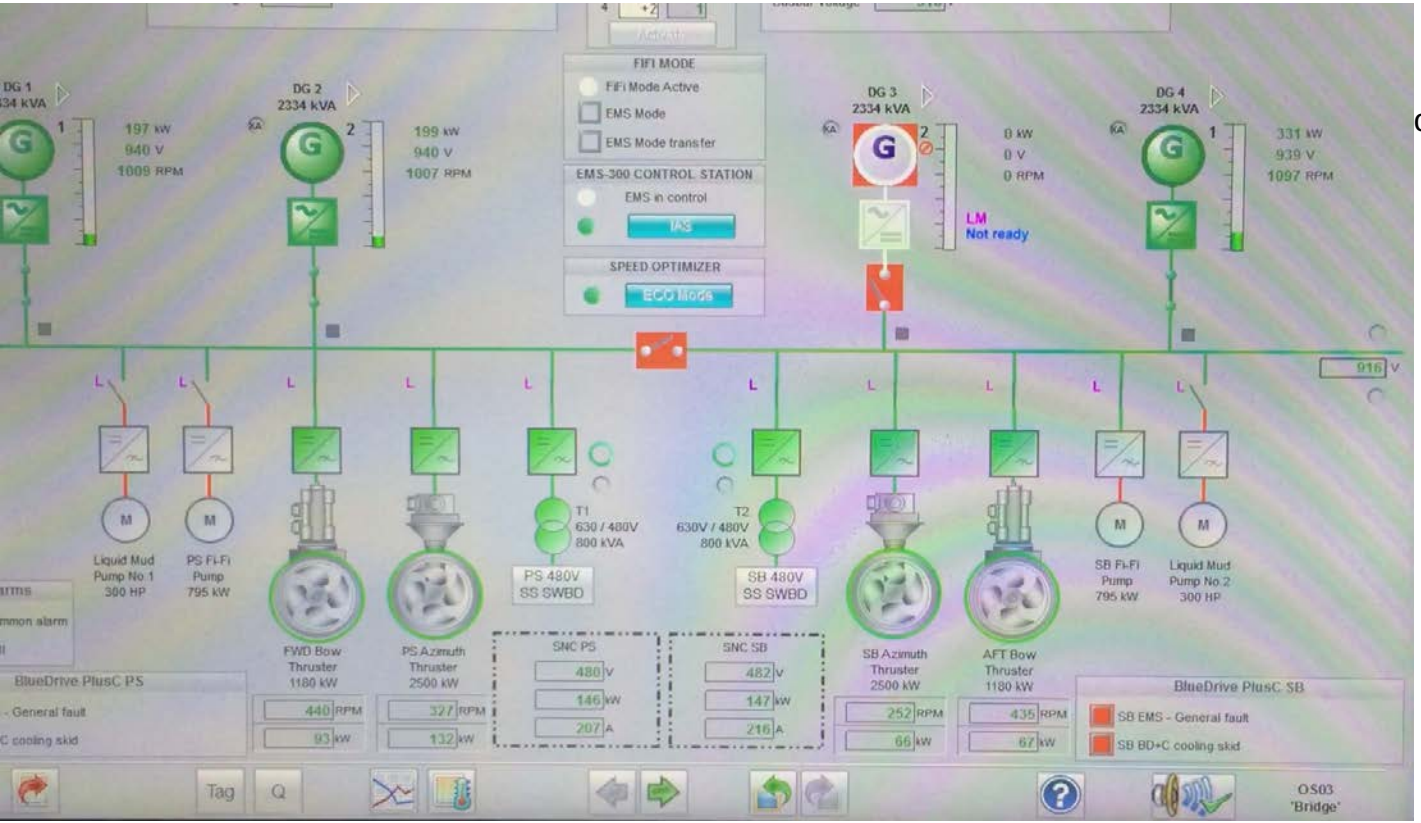
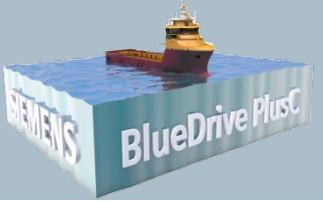
The vessel operation post fault



Two generators on one side and one on the other in operation during the test.

Result:
Tripped bus-tie and four fuses (2 per pole) blown in the cabinet with the fault.

The rest of the system was fully operational.



BlueDrive PlusC
Test result curves

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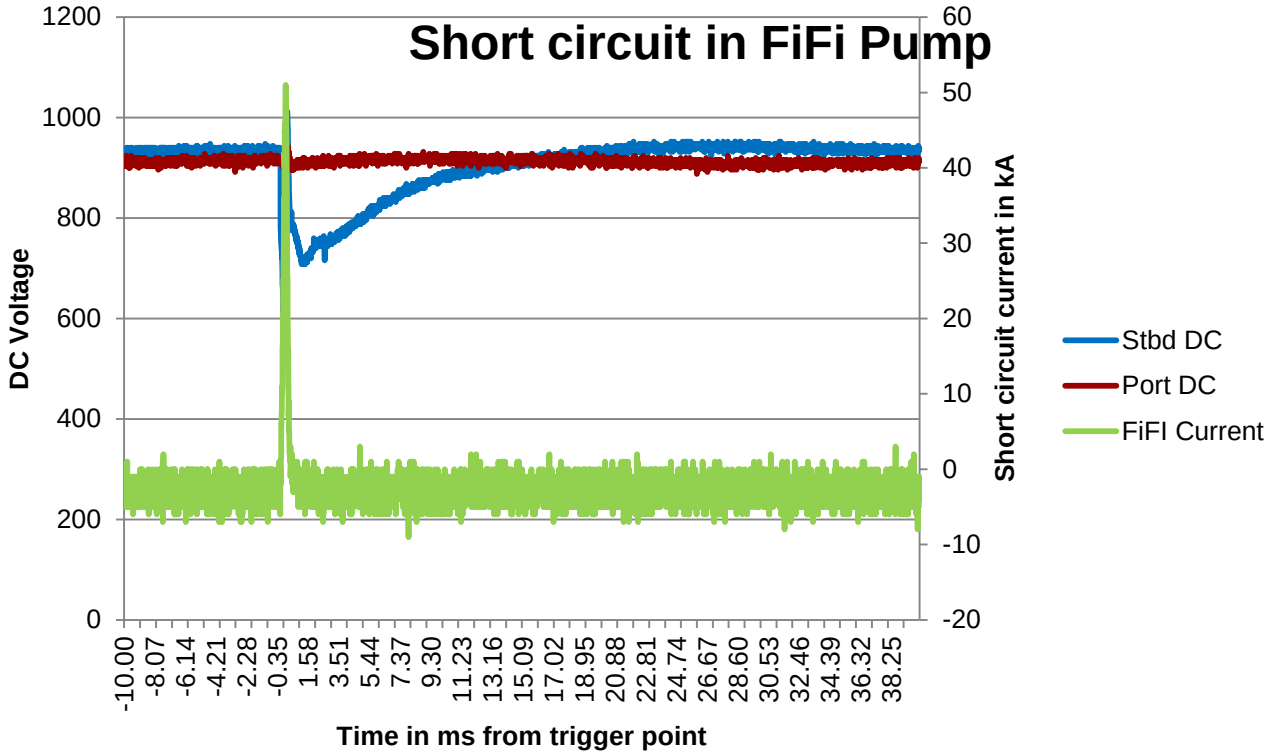

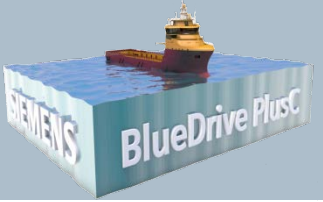

BlueDrive PlusC
Test result curves

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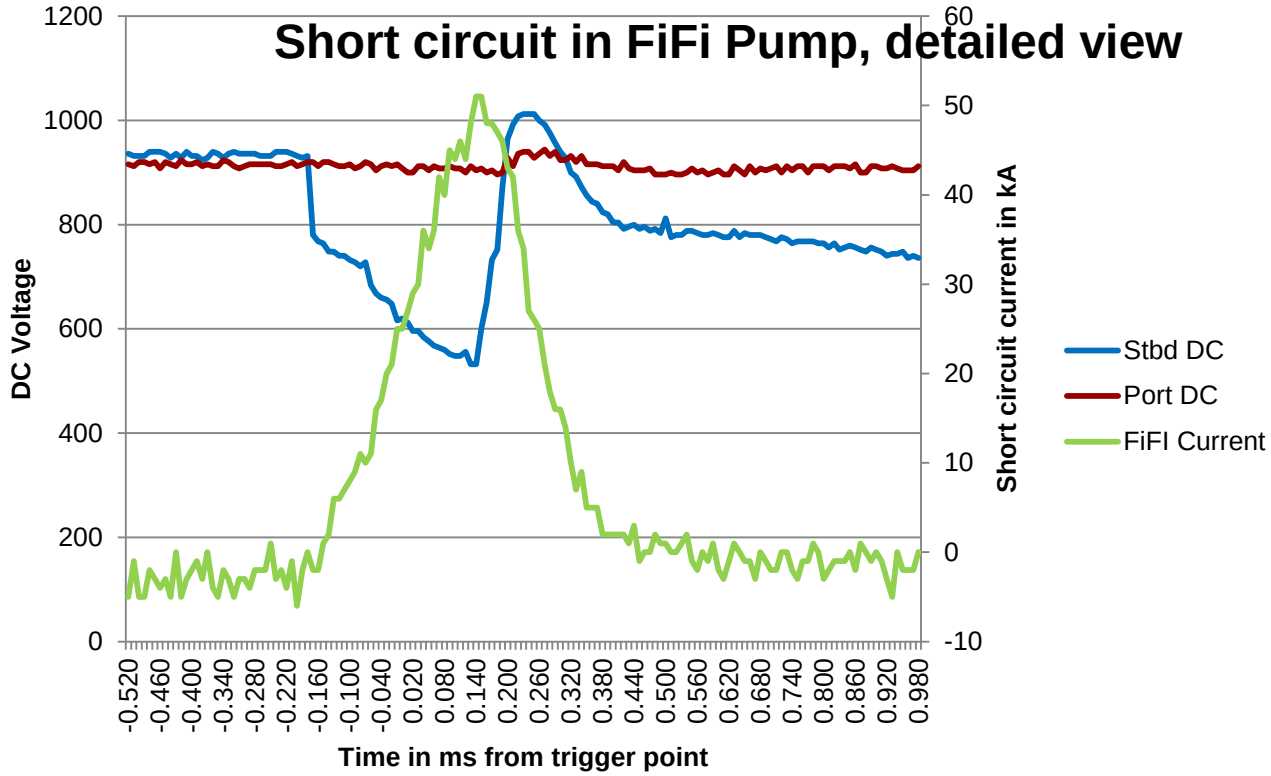
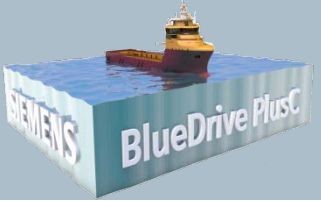
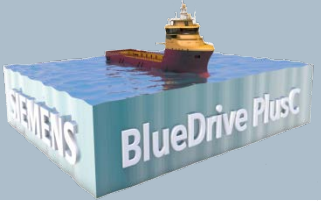




The key to the successful test

- Dynamic studies of the power solution was performed and supported the expected test result.
- Repetitive live short circuit tests performed in a safe test environment with equivalent equipment as installed on the vessel prior to SAT test.
- Competent, safety aware and positive experts preparing the test.
- Close cooperation with all involved parties such as vessel owner, vendors, and class authorities.



Revisiting the closed BT fundamentals after test

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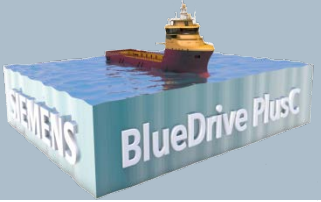
- ✓ Avoid failures
  - ➢ Low energy power system
  - ➢ Components can survive SC failures like generators, rectifiers and inverters (except internal fault)
  - ➢ Ultra fast failure disconnect between redundancy groups
- ✓ Autonomous system design – functional islands are not compromised with the new system
- ✓ In depth understanding of the power system behavior
  - ➢ Dynamic modeling, studies are still essential.
- ✓ Avoid transients not necessary
- ✓ Fast and selective disconnection if failure should happen
  - ➢ Trip of engines by excitation disconnect, only relevant during BB failures.
  - ➢ Ultra fast failure disconnect, fuses and bus-ties
- ✓ Back-up for hidden failures only necessary in bus-ties due to low energy in the system
- ✓ Extended test program including fault ride through tests done during SAT
- ✓ Fast black-out recovery due to no need for synchronizing and ACB connection



Conclusion of the test

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The LV closed tie solution tested has proven to be as good as an MV AC closed tie solution due to:

- ✓Fault ride through testing of the first LV power system is now successfully performed during a vessel SAT.
- ✓The ILC bus-ties separated the power sections by tripping the short circuit fault within 20 µs.
- ✓This ultra fast tripping ensures that the healthy section does hardly notice the fault.
- ✓Fast semiconductor fuses cleared the fault after 300 µs.
- ✓The section with the short circuit continued in operation.
- ✓Tear & wear of the rotating equipment and the electrical equipment are negligible.
- ✓This type of testing is shown not to be destructive in a BlueDrive PlusC LV power solution.

We are happy to answer your questions……