

HITACHI

Pushing the Limits of Offshore AC Power Transmission with FACTS Technology

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2026 MADRID USER'S GROUP MEETING
MADRID, SPAIN



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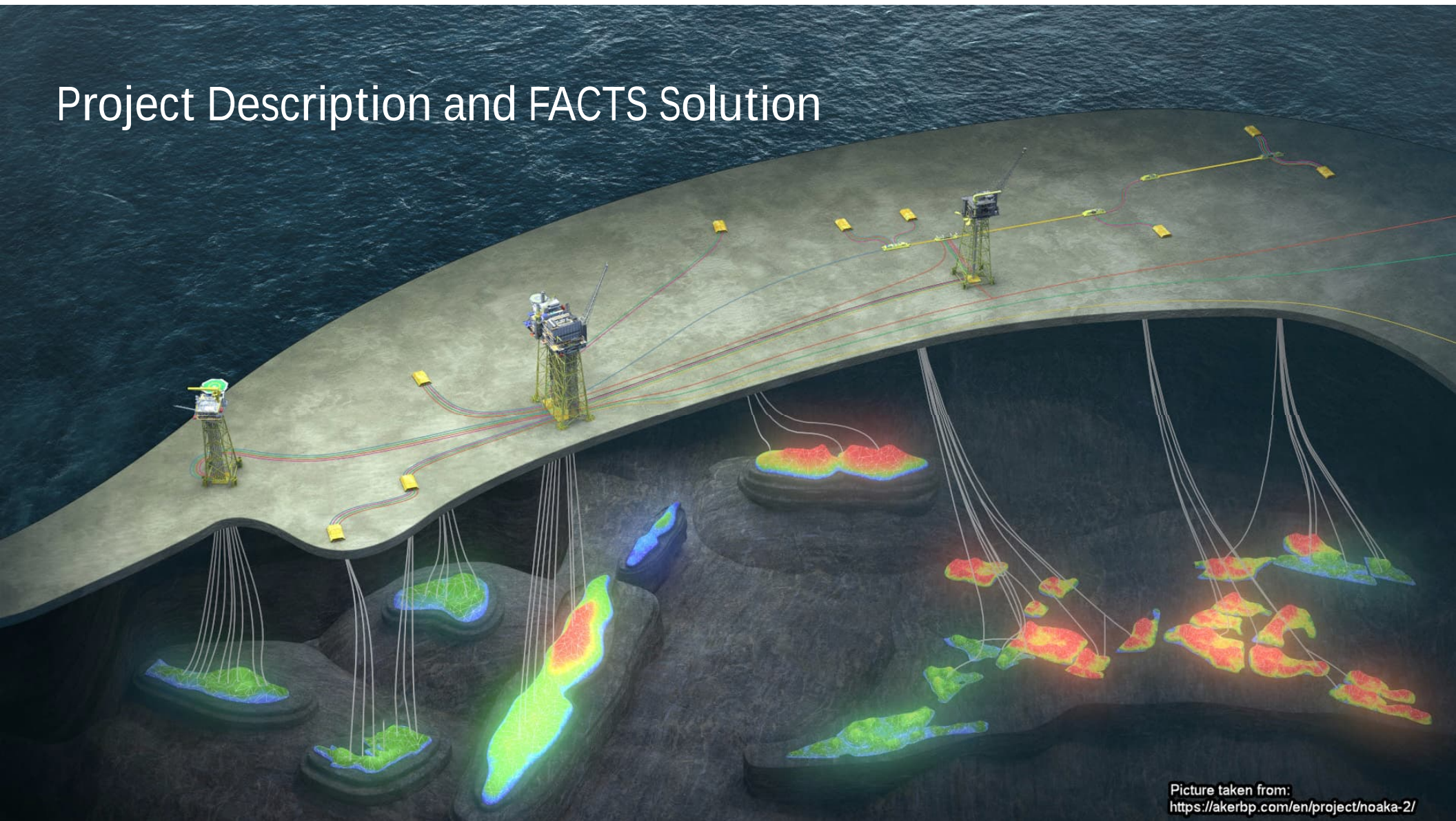
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Project Description and FACTS Solution



Picture taken from:
<https://akerbp.com/en/project/noaka-2/>

Project Description and FACTS Solution

FACTS and Passive Compensation



Point of Connection

420 kV grid connection

Onshore lines: ~11 km

Ground cables: 3 km
Overhead line: 8 km

PFS cable: ~255 km

Fjord cable: 66 km
Offshore cable: 162 km
Infield cable: 27 km

Offshore 2

Offshore 1

Station 2 - Compensation station

Station for compensation, telecom
and connection to fiber net

Offshore 2 Offshore 1

J-tubes

Cable trench

Cable trench

Cable trench

Station 2 - Compensation Station:

- 1 STATCOM +/-150 Mvar
- 1 TCSC 86 Mvar
- 2 Fixed Shunt Reactors 120 Mvar
- 1 Variable Shunt Reactor 45-130 Mvar

Station 1 - Transformer Station:

- 2 Transformers, 180 MVA 400/125kV
- 145kV GIS

PoC Station:

- 420 kV busbar

Project Description and FACTS Solution

FACTS and Passive Compensation

STACOM

- Dynamically control the voltage at Offshore 1 platform
- Grid-forming control
- Wye-connected converter and transformer.

Thyristor Controlled Series Capacitor

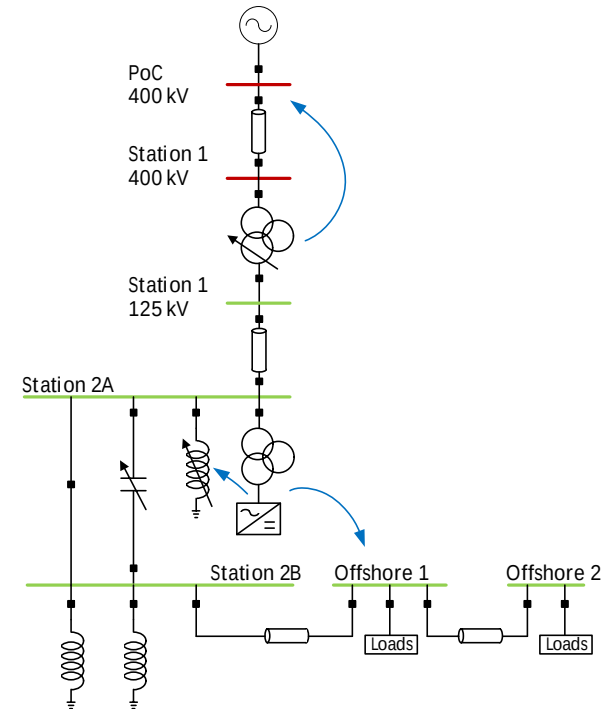
- Increase the transfer of active power
- Mitigate any possible resonance in the subsynchronous range
- Inherently reduce the voltage variation under sudden load changes

Variable Shunt Reactor

- Unload the STACOM
- Control the exchange of reactive power at Samnanger

Fixed Shunt Reactor

- Absorb reactive power from the cable



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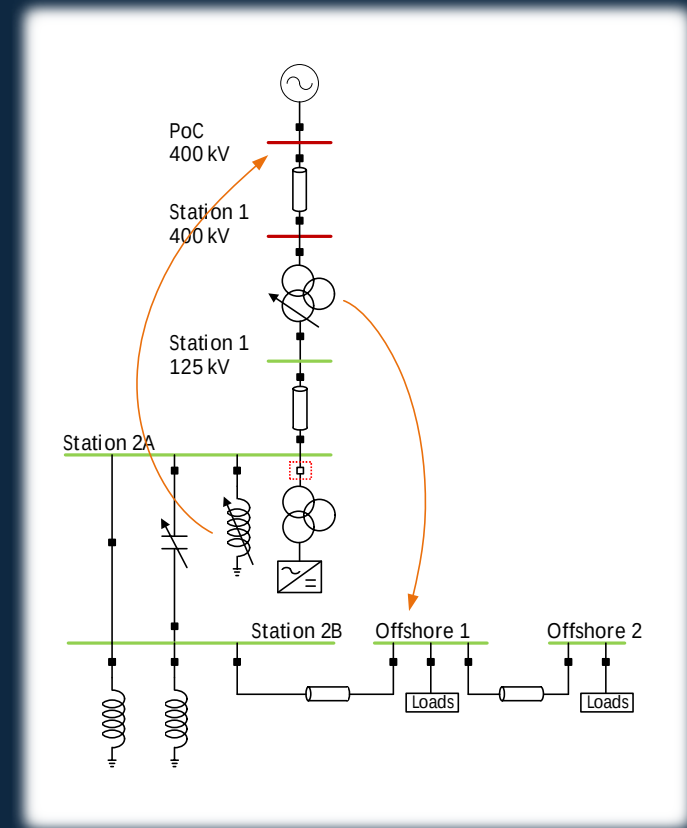
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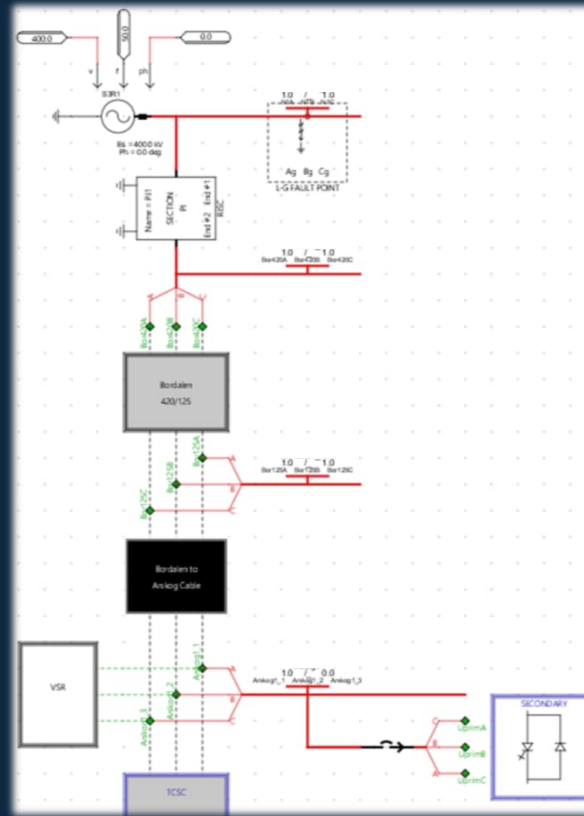
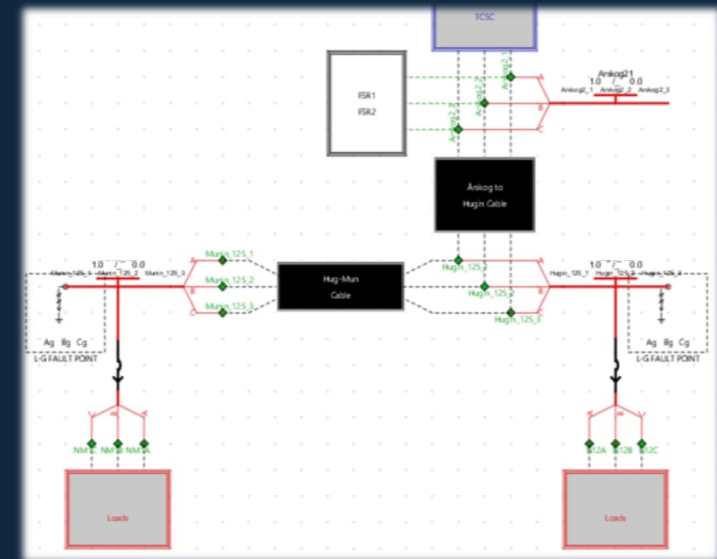


RSCAD Model

Model converted from PSCAD

Hardware:

- Novacor 1.0
- Cores: 9
- GTAO: 4
- GTDI: 1
- GTDO: 1
- GTFPGA: 1



PSCAD to RSCAD Conversion – Cable Models

01

Challenge with the Automatic conversion

- PSCAD network converted to RSCAD
- 2.5–3 kHz oscillations appeared after STATCOM start-up
- Oscillations increased with a larger main timestep; a smaller timestep was limited by computational/overflow constraints

02

Investigation into oscillations

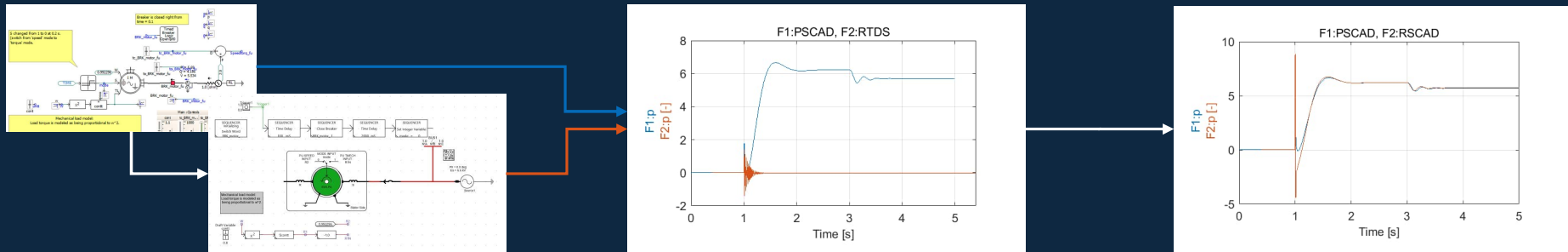
- Simplified/full-model and timestep comparisons used to isolate the problem
- Breakpoint analysis traced the instability toward the frequency-dependent cable representation, rather than the STATCOM alone

03

RTDS collaboration & resolution

- RTDS reproduced the cable-model issue
- Numerical limitations in the RSCAD frequency-dependent cable representation and curve fitting.
- Adjusting the curve-fitting setup and pipe representation resolved the observed instability

RSCAD Model PSCAD to RSCAD Conversion - Motors



Dynamic Performance Study Challenges

Power from Shores Energization Sequence

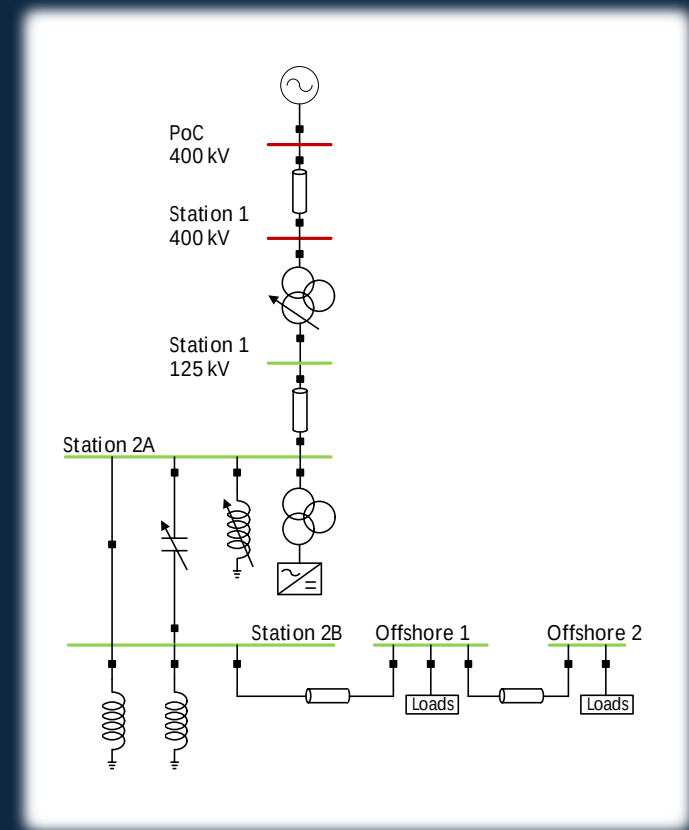
- Find appropriate voltage level
- Find the correct sequence to energize passive compensation, FACTS, and cables.

STATCOM

- Time delay of the voltage measured at the platform.
- Backup voltage measurement.
- Determine the strategy for when to change the voltage reference.

TCSC and FSR Coordination

- Voltage rise at Station 2B if the cable to offshore is open



Dynamic Performance Study Challenges

Power from Shores Energization Sequence

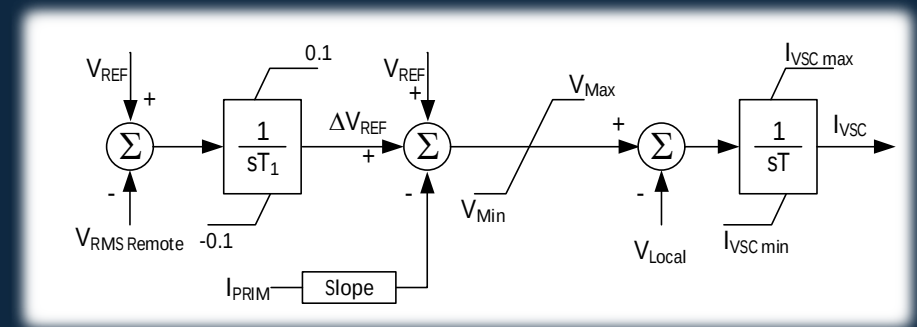
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TCSC and FSR Coordination

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Overvoltage Criteria

Location / Characteristic	Deviation	Duration
Platform voltage tolerance in steady state	+6% / -10%	Steady state
Platform max RMS voltage variation	+20%/ -15%	
Cable systems' max voltage variation	1.3 [pu]	2 s
125 kV Cables (Bør-Ark-Hug-Mun)	TOV limits: 286.2 k VRMS SFO limits: 330.4 kVp	300 s 20 μ s – 20 ms
Børdalen Transformer 125 kV Hugin A Transformer 125 kV VSR / FSR	TOV limits: 239 kV RMS SFO limits: 478 kVp	300 s 20 μ s – 20 ms
Munin Transformer 125 kV	TOV limits: 200 kV RMS SFO limits: 400.0 kVp	300 s 20 μ s – 20 ms

Dynamic Performance Study

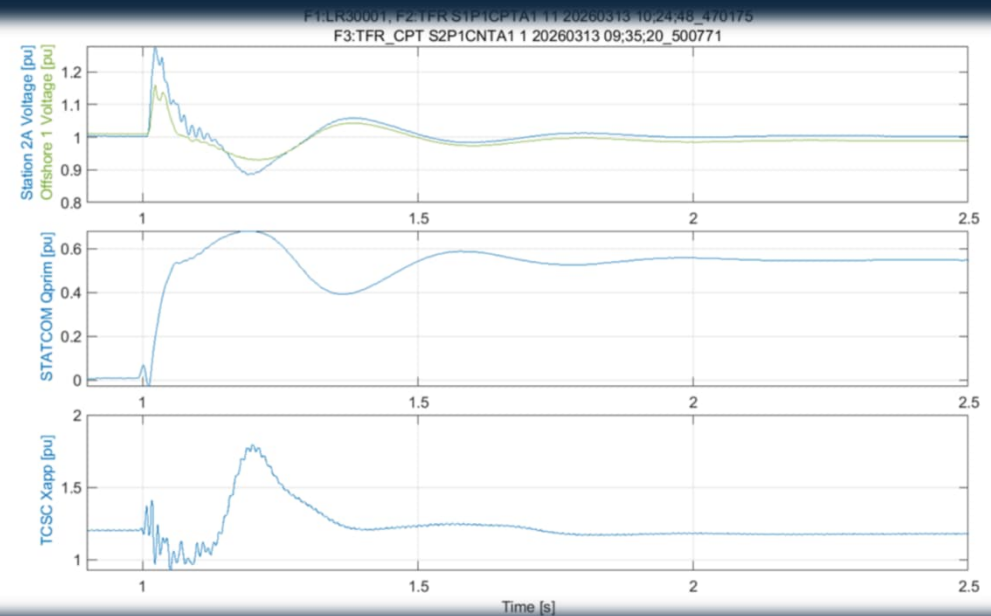
Load Rejection

N-1 Contingencies

- Find the maximum load that will keep the voltage at the platform within the allowed deviation
- Emergency shutdown load rejection

STATCOM	TCSC	Initial Load	After Load Rej.	Offshore 1 Voltage [pu]
ON	ON	100%	4%	x.xx
ON	BYP	100%	4%	x.xx
OFF	ON	100%	4%	x.xx
OFF	ON	38%	4%	x.xx

STATCOM and TCSC ON

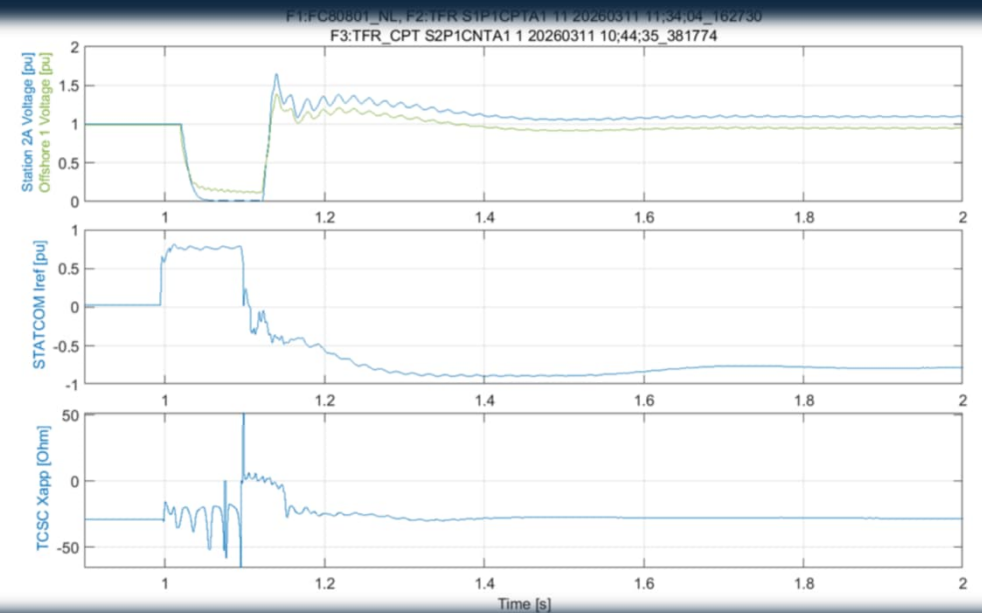


Dynamic Performance Study Fault Case

Three phase to ground fault

- Emergency Shutdown Conditions

Fault Location	Load	Circuit Breaker Open	Offshore 1 Voltage [pu]
Station 2A	100%	VSR	X.XX
	4%		X.XX
Station 2B	100%	FSR1	X.XX
	4%		X.XX



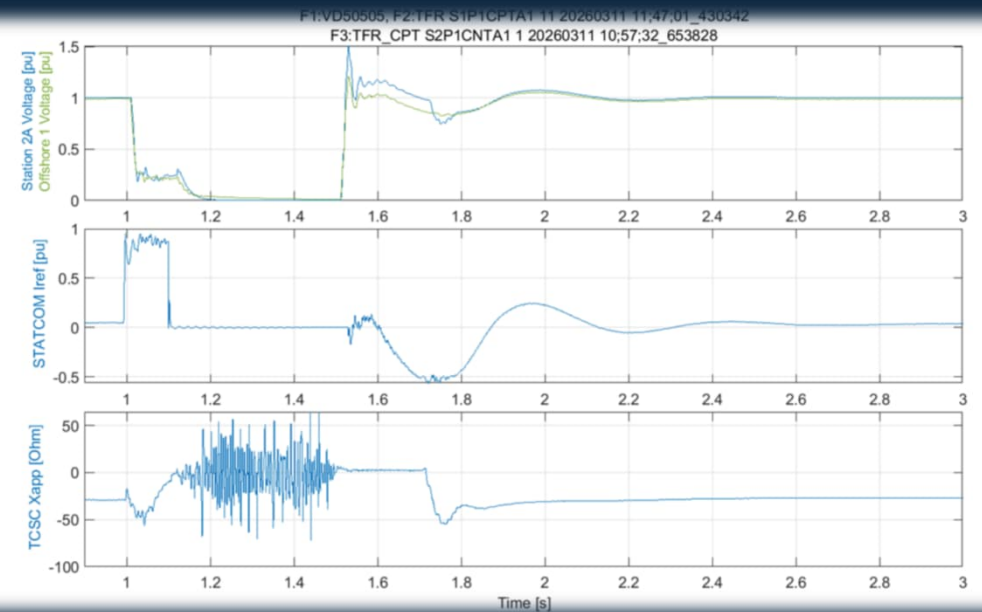
Dynamic Performance Study

Voltage Depression

Three phase to ground fault at PoC

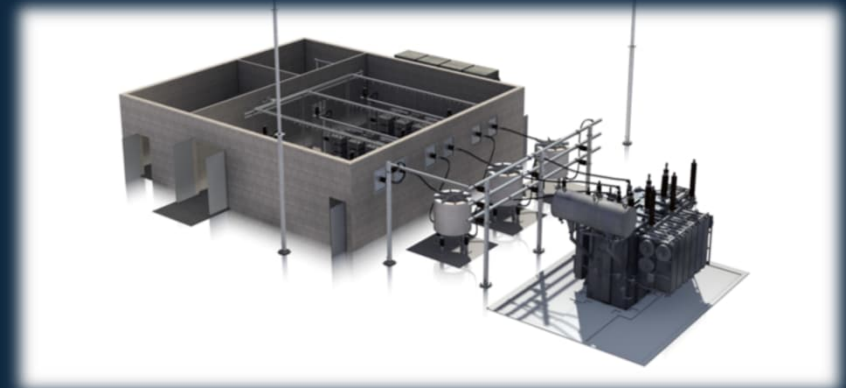
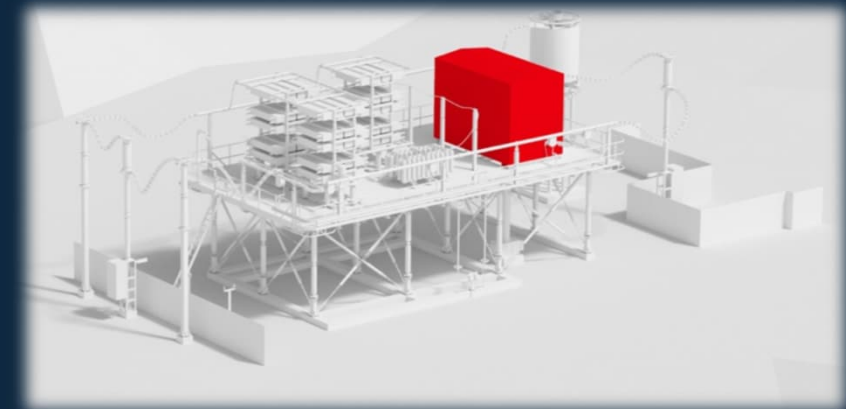
- Emergency Shutdown Conditions
- 500 ms fault duration

STATCOM	TCSC	Load	Offshore 1 Voltage [pu]
ON	ON	10%	x.xx
ON	BYP	100%	x.xx
ON	ON	4%	x.xx
OFF	ON	100%	x.xx



Conclusions

- The STATCOM and TCSC contribute to the stability and robustness of the system by supporting the voltage within their capabilities.
- The study results demonstrate a clear complementary effect between the STATCOM and TCSC. While each device provides an important contribution individually, their combined operation results in a more effective dynamic response.
- Voltage limits of Offshore 1 of 1.2 pu were exceeded during some fault recoveries. However, their durations were within the accepted limits.
- Control interactions between the TCSC and the STATCOM were not observed.



Questions and Discussions



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