

PUBLIC

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Hitachi Energy HVDC C & P Factory System Test

Saudia Arabia – Egypt Project and RTDS Wind Turbine model Validation

Adnan Azmat – Senior Test Engineer – Tender and Conceptual Design – Control and Protection

2023-09-20

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 **Hitachi Energy**

Agenda

1. FST (Factory System Test)
2. Saudi-Egypt Multi-terminal HVDC
3. Generic Wind Farm model Validation

History

- Itaipu 6300 MW
- Analogue Simulator
- Regular use of Real-Time Digital simulation for C & P testing since 2004



Main data

Commissioning year:	1984 -1990
Configuration:	Bipole
Power rating:	6,300 MW
Direct voltage:	±600 kV
Application:	Connecting remote generation

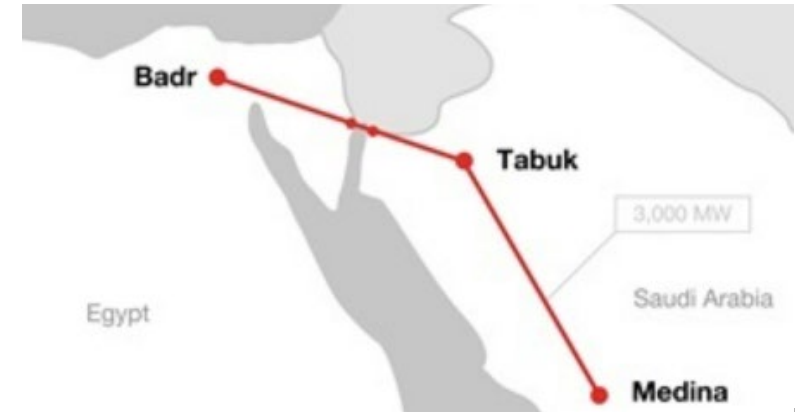
Some of our projects in FST



SwePol Upgrade



Gotland Upgrade



Saudi-Egypt Multiterminal



Project Lightning 480 cubicles



SunZia 140 cubicles



Higashi-Shimitzu 74 cubicles

Main Purpose

- Verify that the C & P equipment meets design specifications
- Verify the function and coordination of control and protection actions
- Performance analysis of C & P system with Real-time HIL system

Consequential Benefits

- Shorten time for commissioning and plant "burn-in"
- Identify and solve problems as early as possible in the process
- Minimize disturbances to the AC-system during commissioning

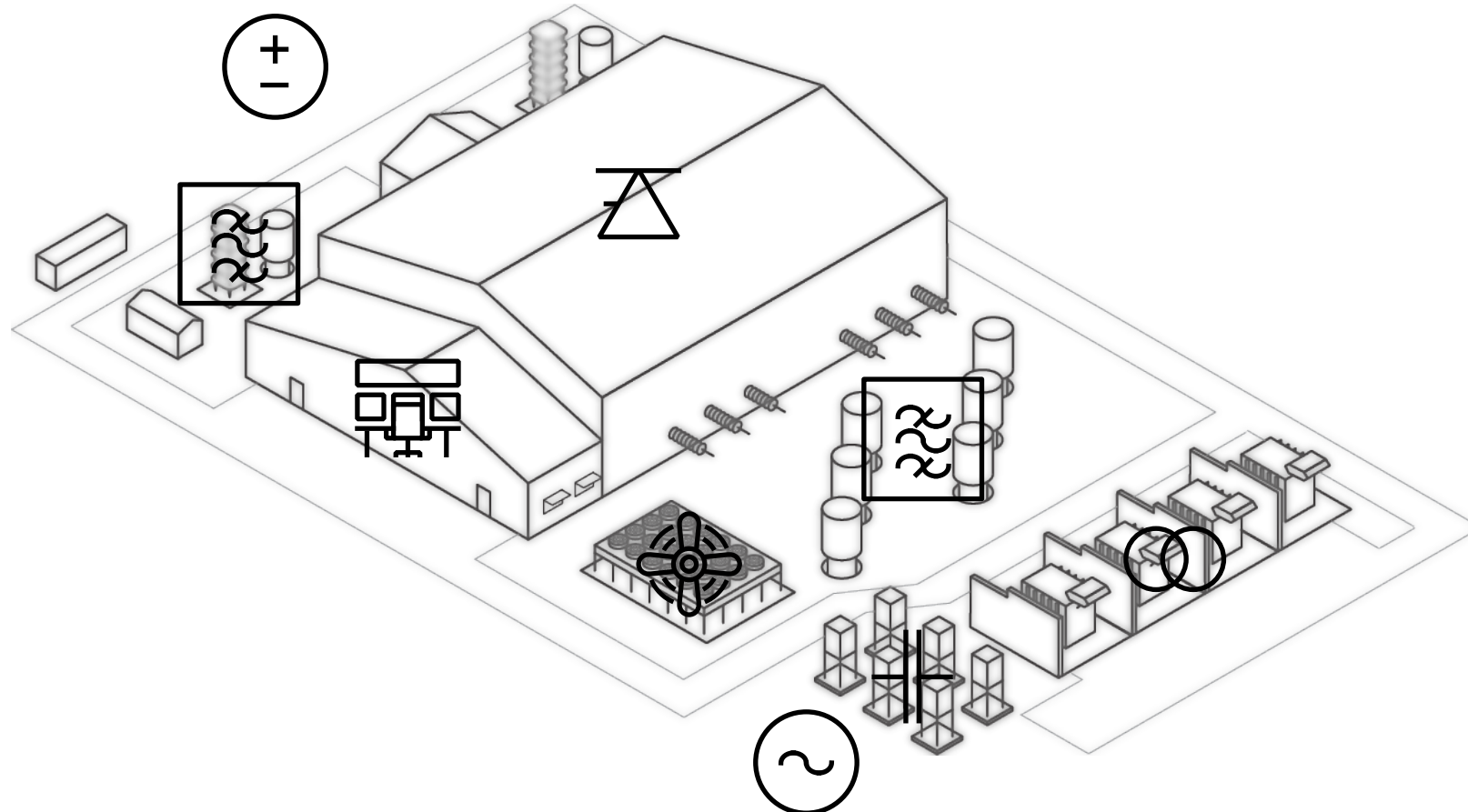
MACH control and protection system is assembled and connected to a real-time simulator

The set-up includes:

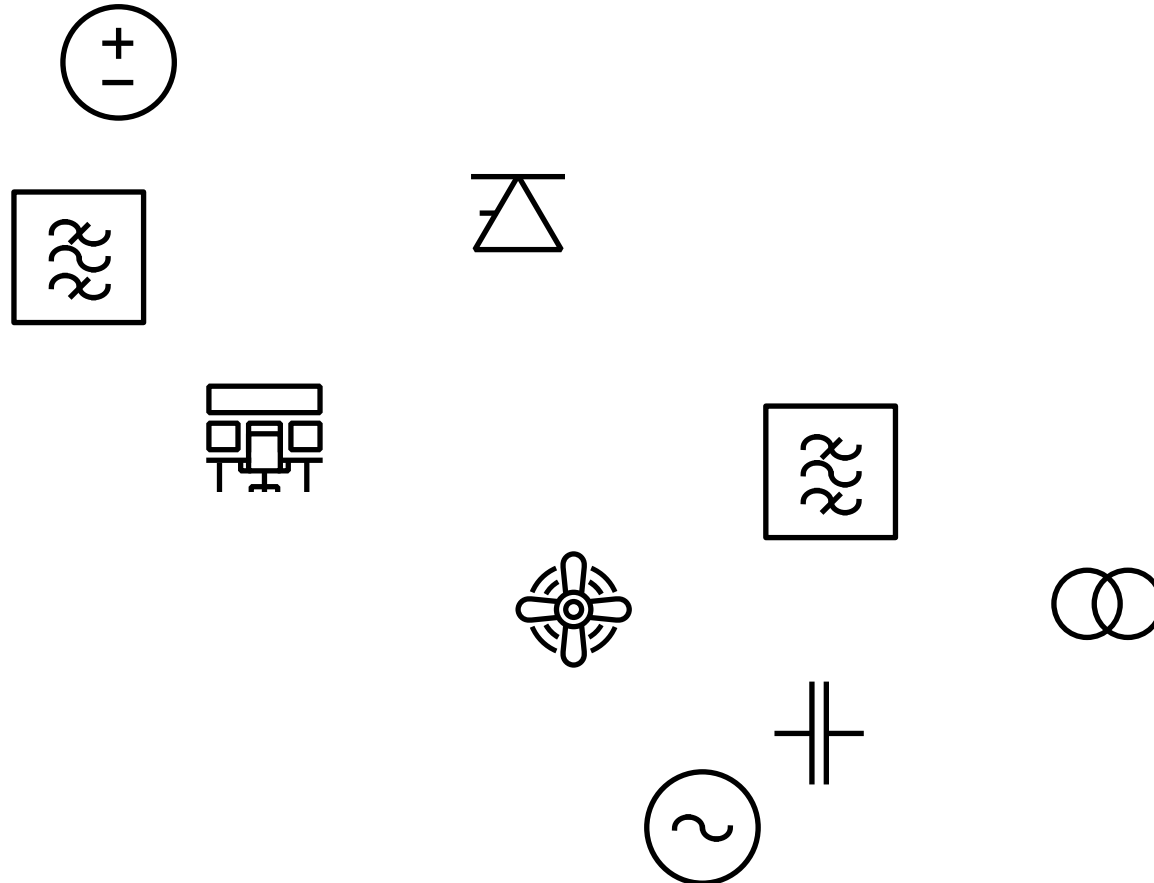
- Control and Protection systems
- Operator interface and interface to the customer SCADA.



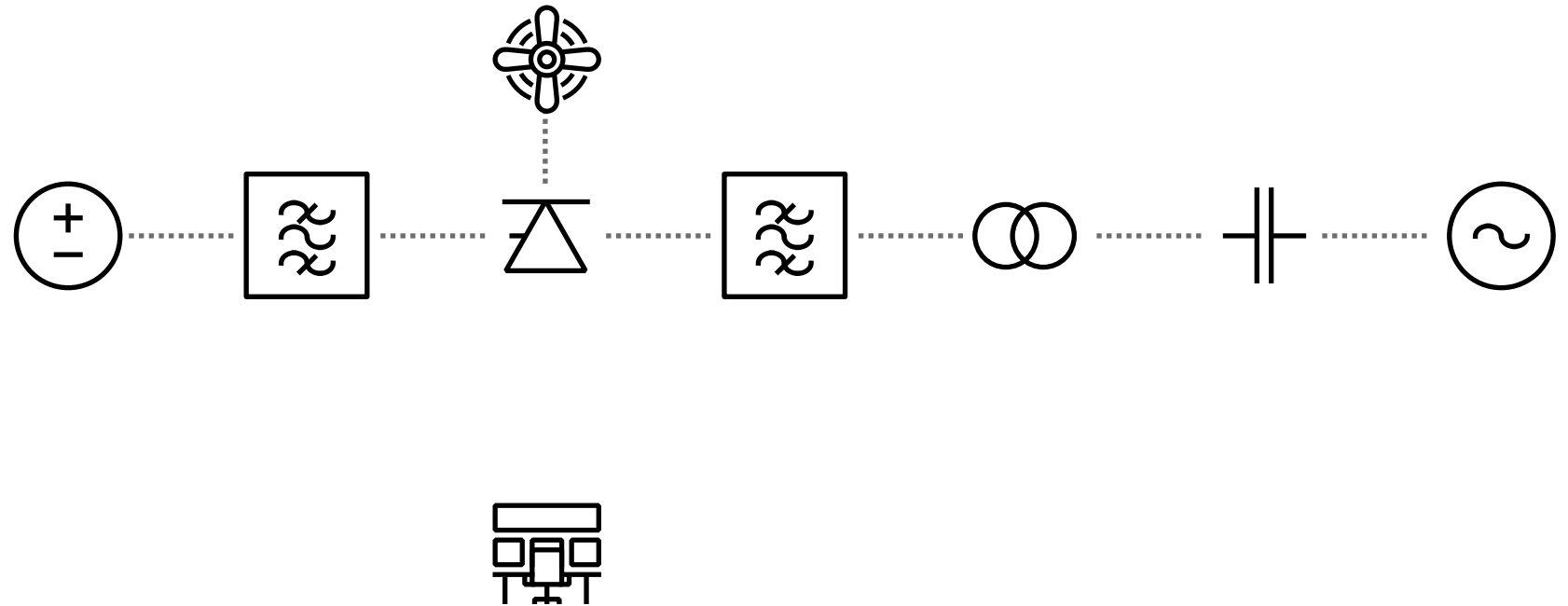
MACH™
Modular Advanced Control for HVDC



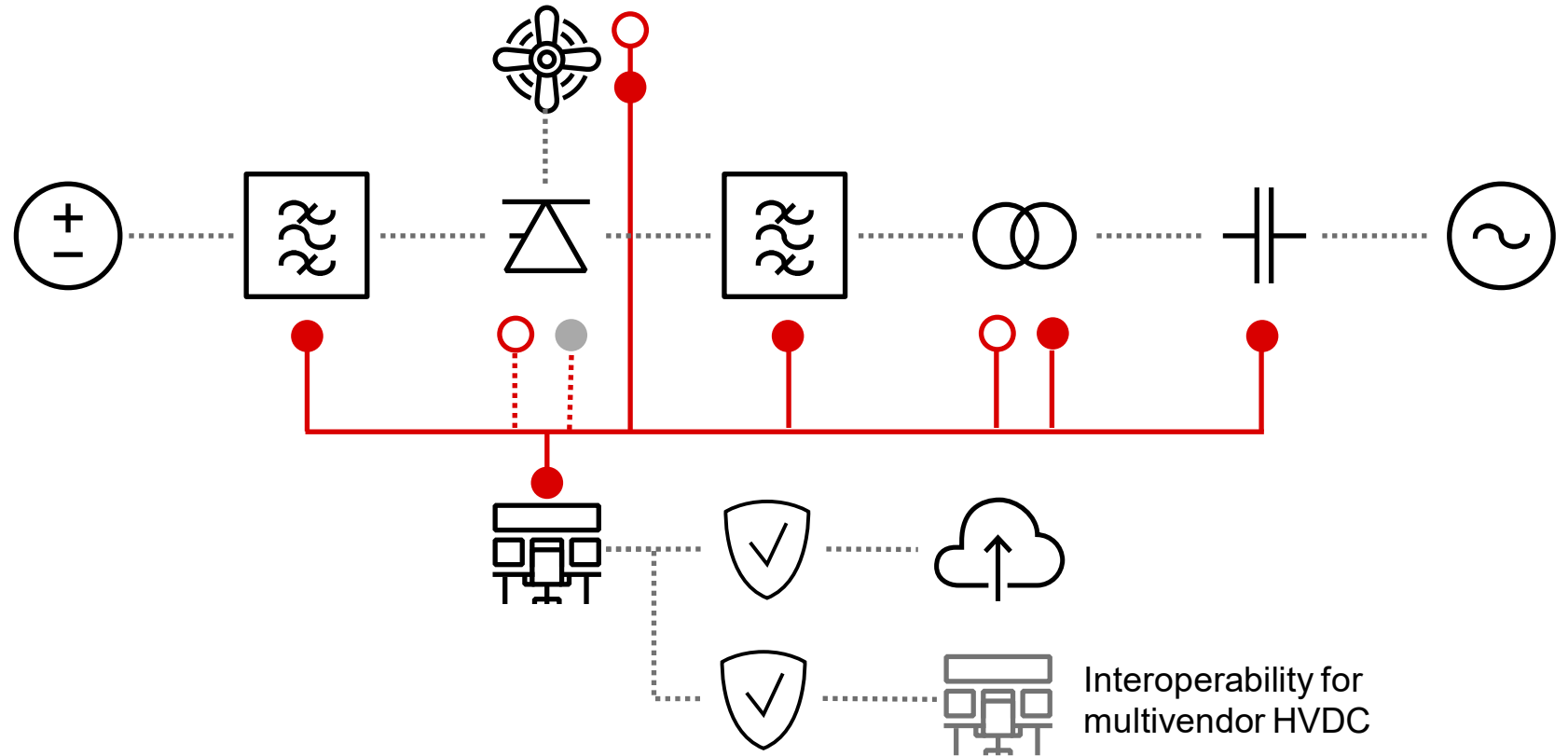
MACH™
Modular Advanced Control for HVDC



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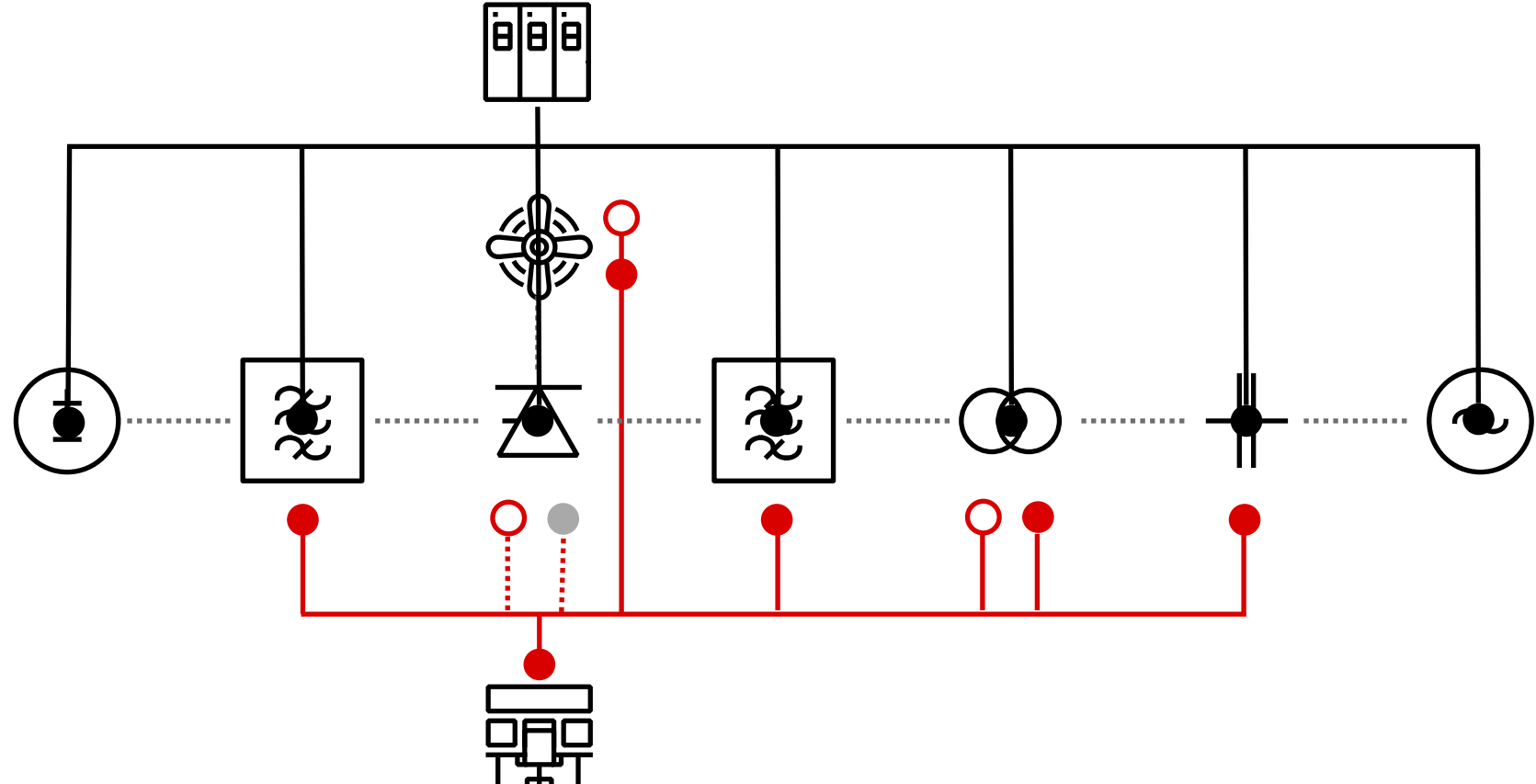
MACH™
Modular Advanced Control for HVDC



- Valve point
- Control point
- Measurement point
- I/O communication
- Valve communication

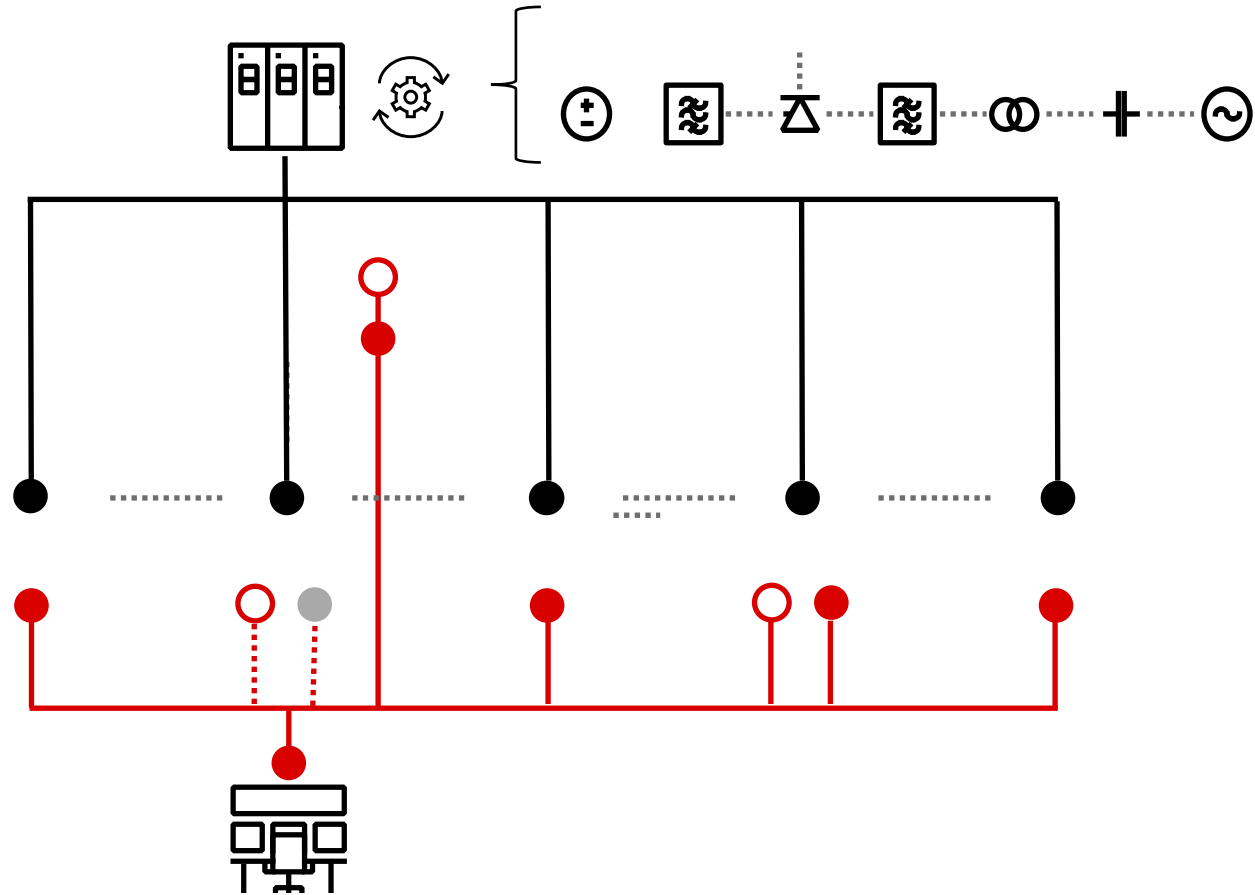
Interoperability for multivendor HVDC

MACH™
Modular Advanced Control for HVDC

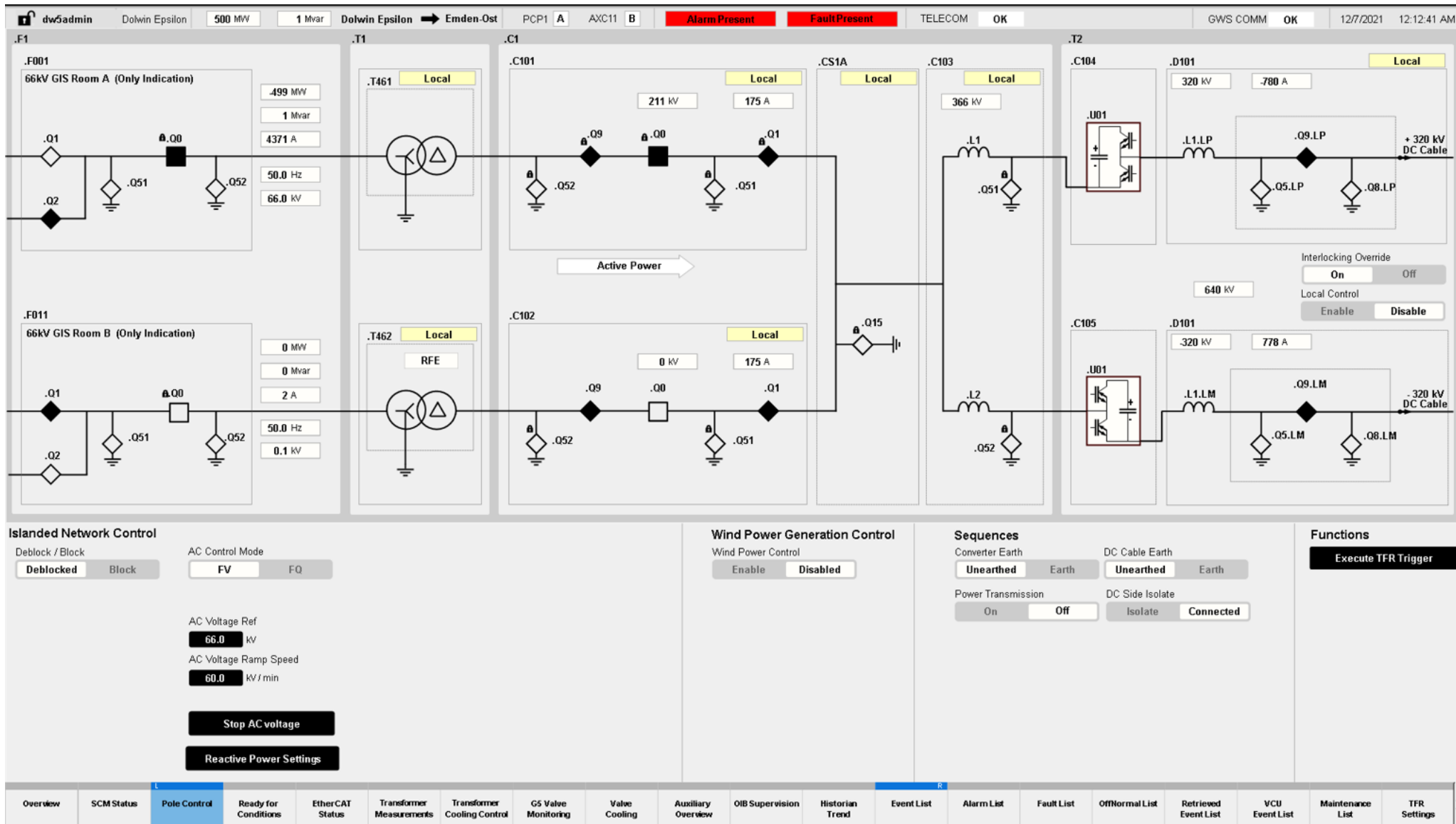


- Real-Time Digital Simulator
- Valve point
- Control point
- Measurement point
- I/O communication
- Valve communication

MACH™
Modular Advanced Control for HVDC



- Real-Time Digital Simulator
- Valve point
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- Valve communication



FST

Setup and Connection

Integration

Verification

Customer witnessing



Cubicle arrival



Code Freeze



Delivery

Integration and verification testing:

- Test instructions with defined steps and expected result
 - TFRs
 - Event lists
 - HMI screenshots for pre- and post conditions



Test Suites

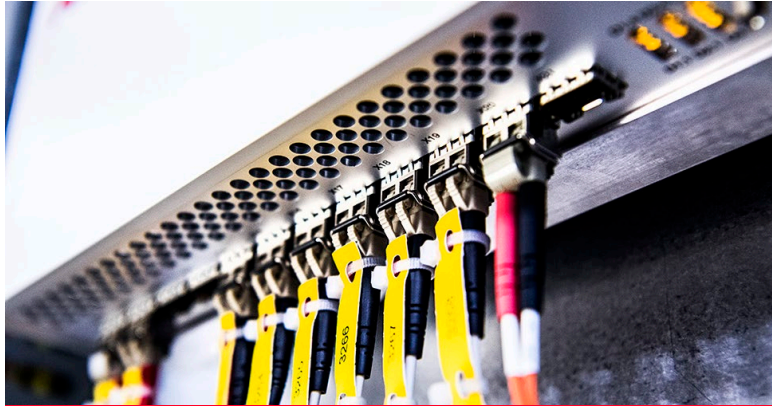
- Control
 - Damping Control (1)
 - Frequency Control (3)
 - Frequency Control al... ..
 - Emergency Power Con... (...)
 - AC Voltage Control (1)
 - Reactive Power Control (2)
 - DC Voltage Control (1)
 - Tap Changer Control (4)

Test Cases (5 items)

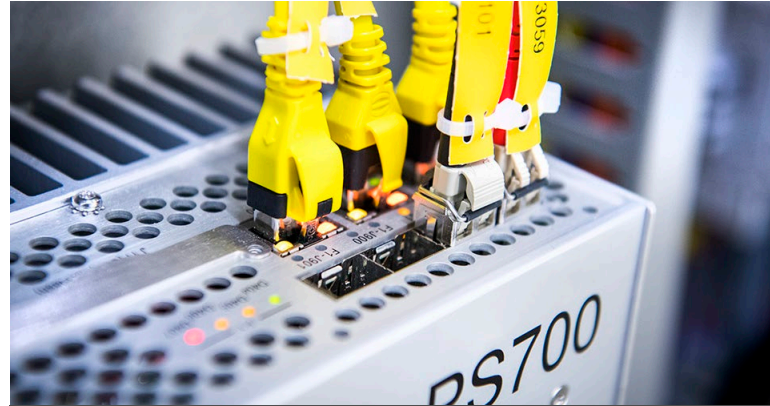
- Title
- Frequency control - Enabled in one converter with positive frequency deviation
- Frequency control - Enabled in one converter with negative frequency deviation
- Frequency control - Enabled in both converters
- Frequency control - During ramp of AREG
- Frequency control - Enabled in both converters MAX contribution used

2022.03.07	09:56:26:7717	DWEPPCP1B1	AC Bus Circuit Breaker =F1.F001.Q0
2022.03.07	09:56:26:8377	DWEPPCP1B1	AC Bus Circuit Breaker =F1.F001.Q0
2022.03.07	09:56:28:9287	DWEPPCP1B1	AC Bus Circuit Breaker =F1.F011.Q0
2022.03.07	09:56:28:9947	DWEPPCP1B1	AC Bus Circuit Breaker =F1.F011.Q0
2022.03.07	09:56:30:8134	DWEPPCP1B2	Transient fault recorder (TFR)
2022.03.07	09:56:30:8136	DWEPPCP1A2	Transient fault recorder (TFR)
2022.03.07	09:56:30:8147	DWEPPCP1B1	Transient fault recorder (TFR)
2022.03.07	09:56:30:8155	DWEPPCP1A1	Transient fault recorder (TFR)
2022.03.07	09:56:30:8266	DWEPPCP1A2	Transformer Protections =T1.T461.T461
2022.03.07	09:56:30:8284	DWEPPCP1B2	Transformer Protections =T1.T461.T461
2022.03.07	09:56:30:8404	DWEPPCP1B2	Transformer Protections =T1.T461.T461
2022.03.07	09:56:30:8406	DWEPPCP1A2	Transformer Protections =T1.T461.T461
2022.03.07	09:56:32:9624	DWEPPCP1B2	Transformer Protections =T1.T462.T462
2022.03.07	09:56:32:9626	DWEPPCP1A2	Transformer Protections =T1.T462.T462

HVDC Control & Protection System



Dependable



Secure



Flexible



Optimized



Digital



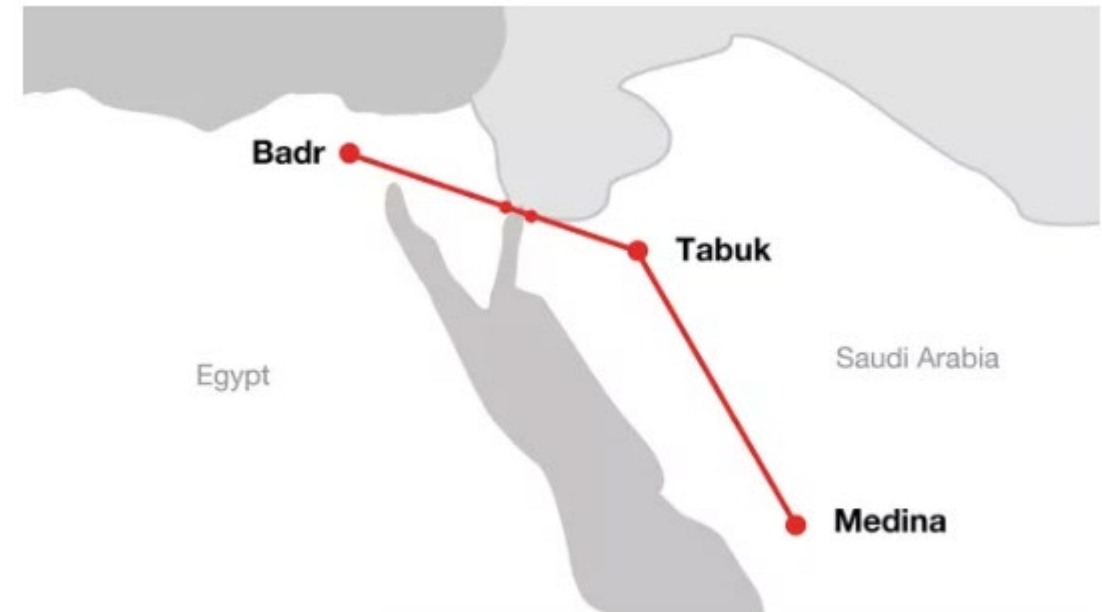
Upgradable

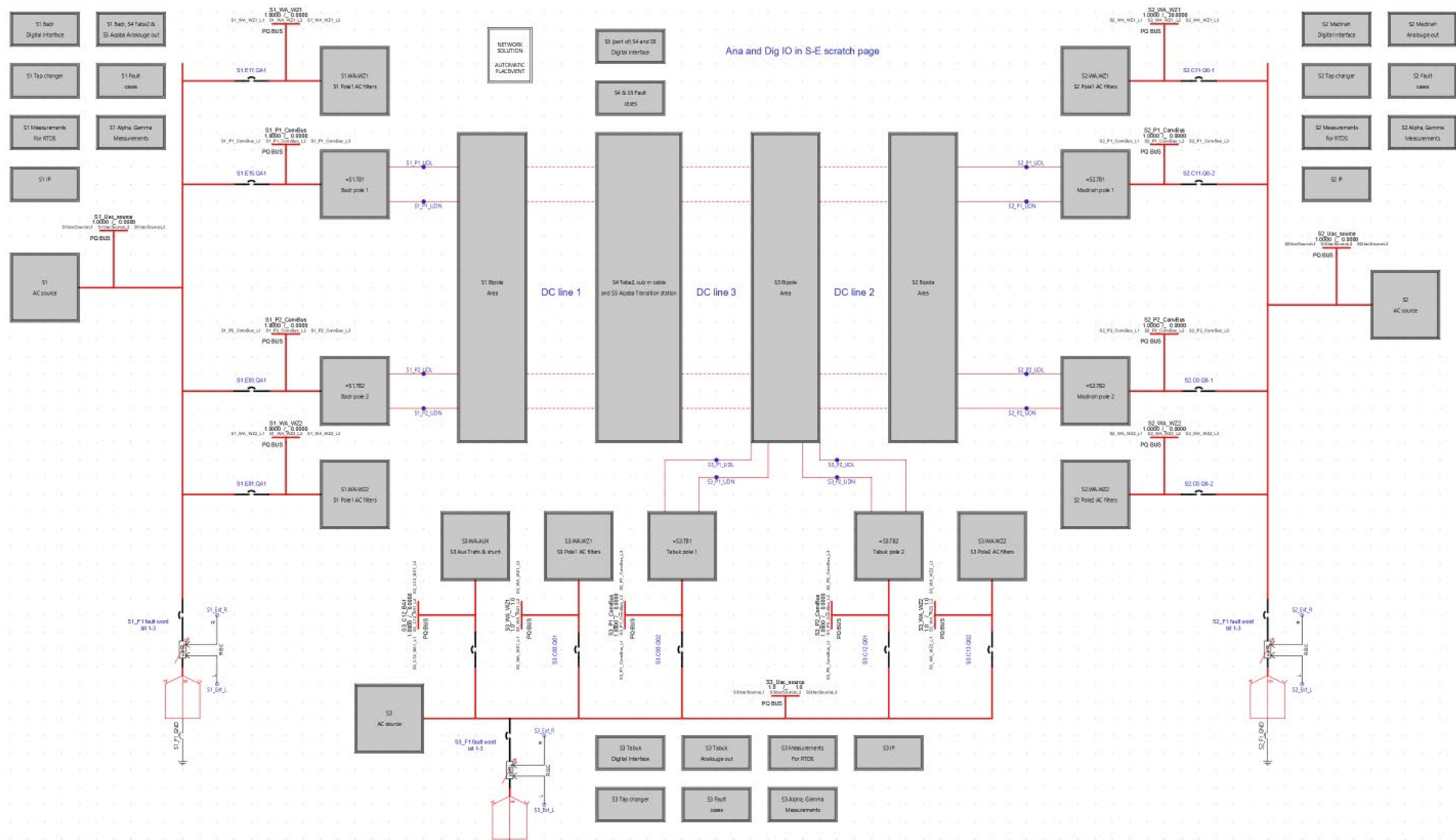
Agenda

1. FST (Factory System Test)
- 2. Saudi-Egypt Multi-terminal HVDC**
3. Generic Wind Farm model Validation



Main data	
Commissioning year:	2025
Configuration	Multi-terminal link
Power rating:	3,000 MW (multi-terminal) Madinah 2 *1500 MW (Saudi Arabia) Tabuk 2 *750 MW (Saudi Arabia) Badr 2 *1500 MW (Egypt)
AC voltage:	Madinah 380 kV (Saudi Arabia) Tabuk 380 kV (Saudi Arabia) Badr 500 kV (Egypt)
DC voltage:	±500 kV
Application:	Interconnecting grids





Analogue Interface

- 19 GTA0 V2
- 18 Current amplifiers

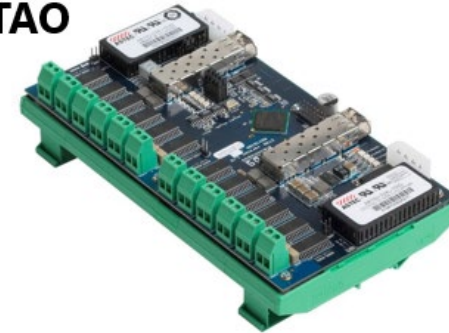
Digital Interface

- 7 GTDI V2
- 7 GTDO V2
- 145 Circuit Breakers
- 89 Relays representing ground switches

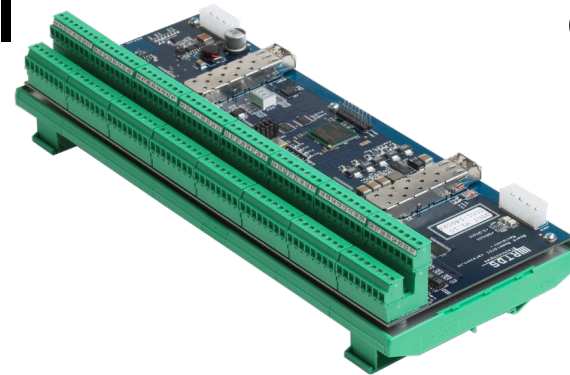
Real-time processing power

- 10 Cores (NOVACor)
- ~300 Power system nodes in Simulation

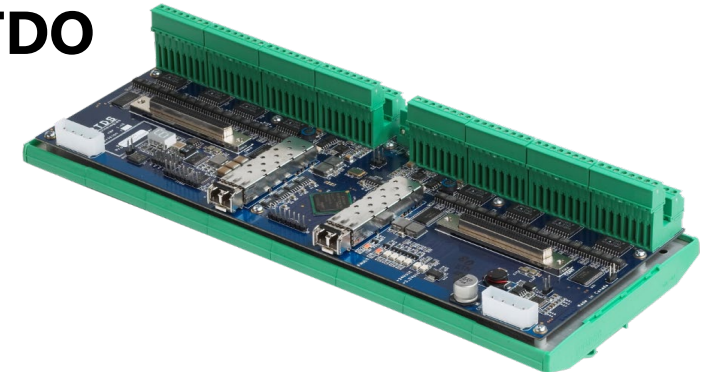
GTA0



GTDI



GTDO



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Case

- Offshore wind power integration to the network
- No available specific wind farm model for PSCAD/RSCAD from supplier
- Effect of connected wind farm on Control and Protection system for HVDC
- Fulfillment of the grid code by performing dynamic disturbances

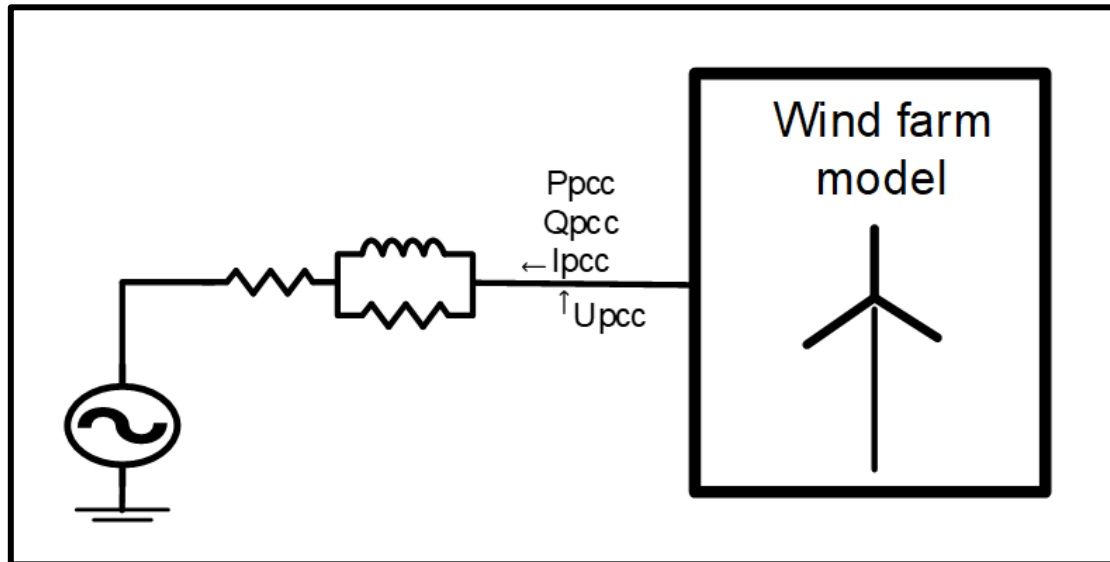
Simulation model

- Wind farm model connected to network equivalent represented by an infinite source
- Aim is to provide reasonable active and reactive power to point of common coupling

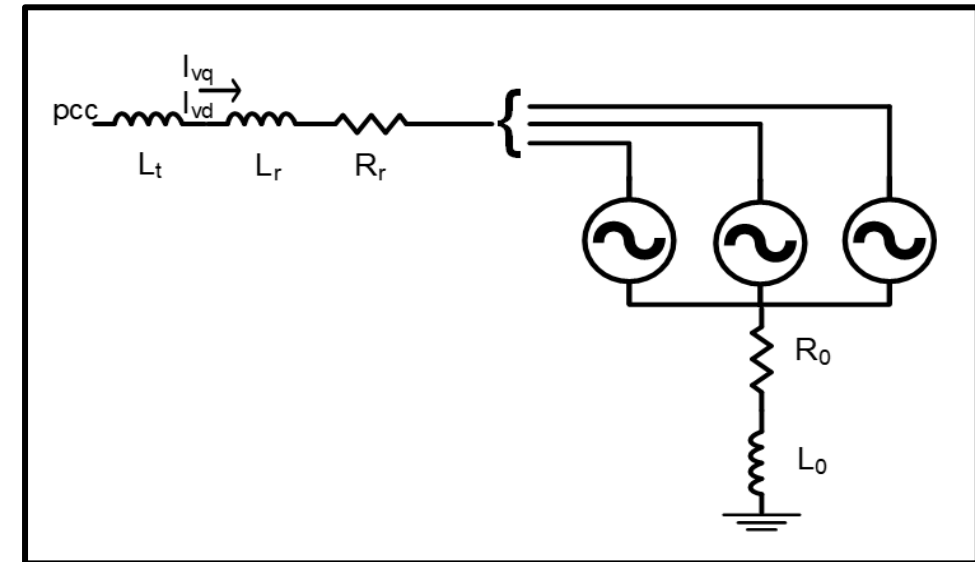
Wind farm model (Electrical main circuit)

- Ideal voltage source controlled by phase, reactors and resistors
- Scalable components to adapt the test cases

Simulation model setup

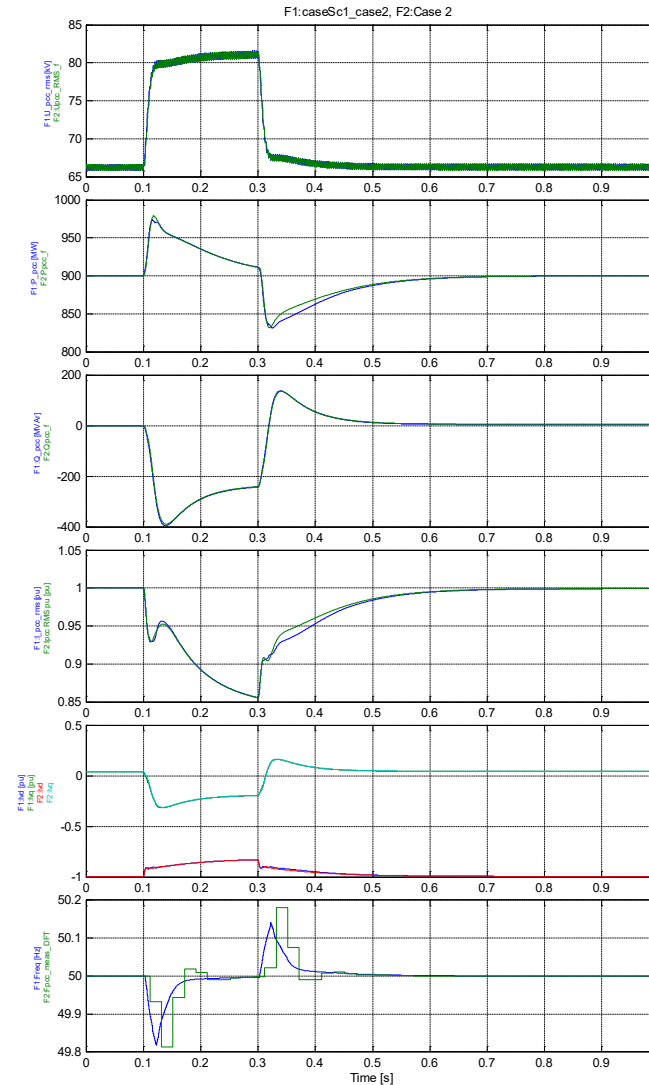


Wind farm model

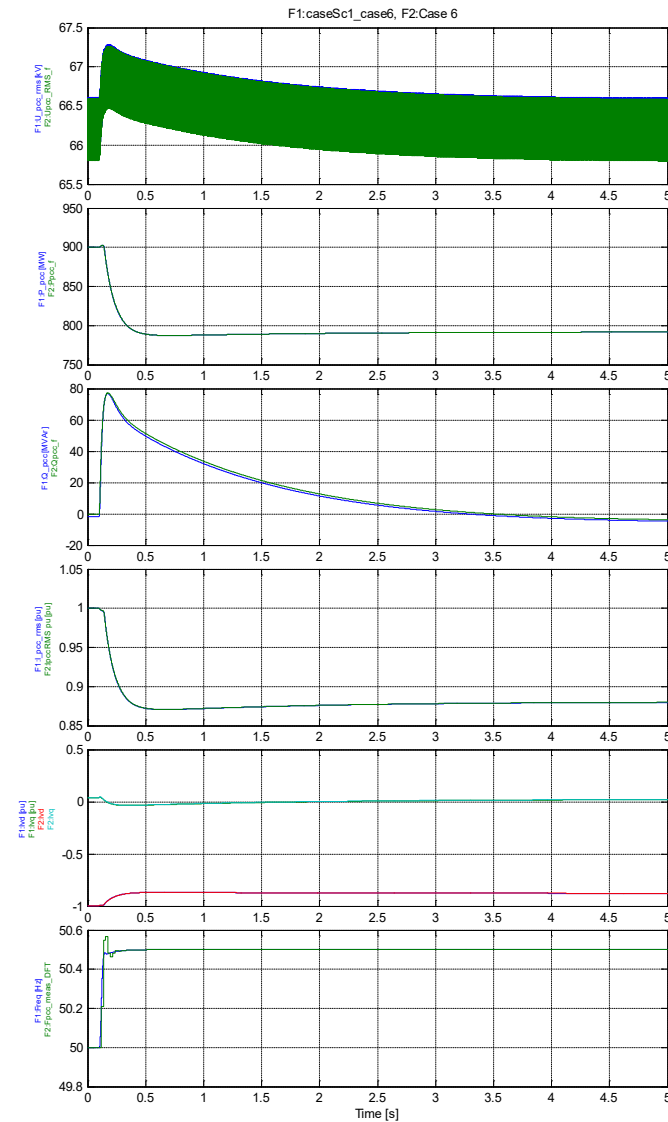


- AC Voltage step 1.25 p.u. for 200ms
- Frequency step 0.5 Hz
- Ramp frequency at rate 2 Hz/s
- Active power ramp down from nominal to 50% of nominal (EPC)
- 3PhG, 100 ms, 10% remaining voltage
- 1PhG, 100 ms, 50% remaining voltage

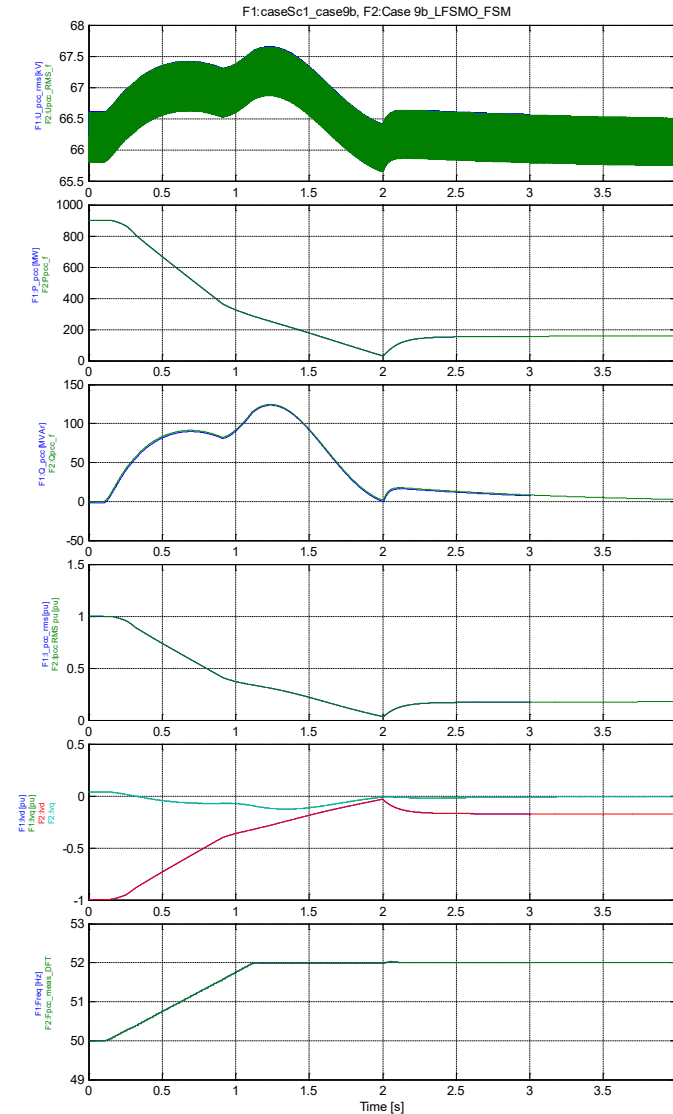
AC Voltage step 1.25 p.u. for 200ms



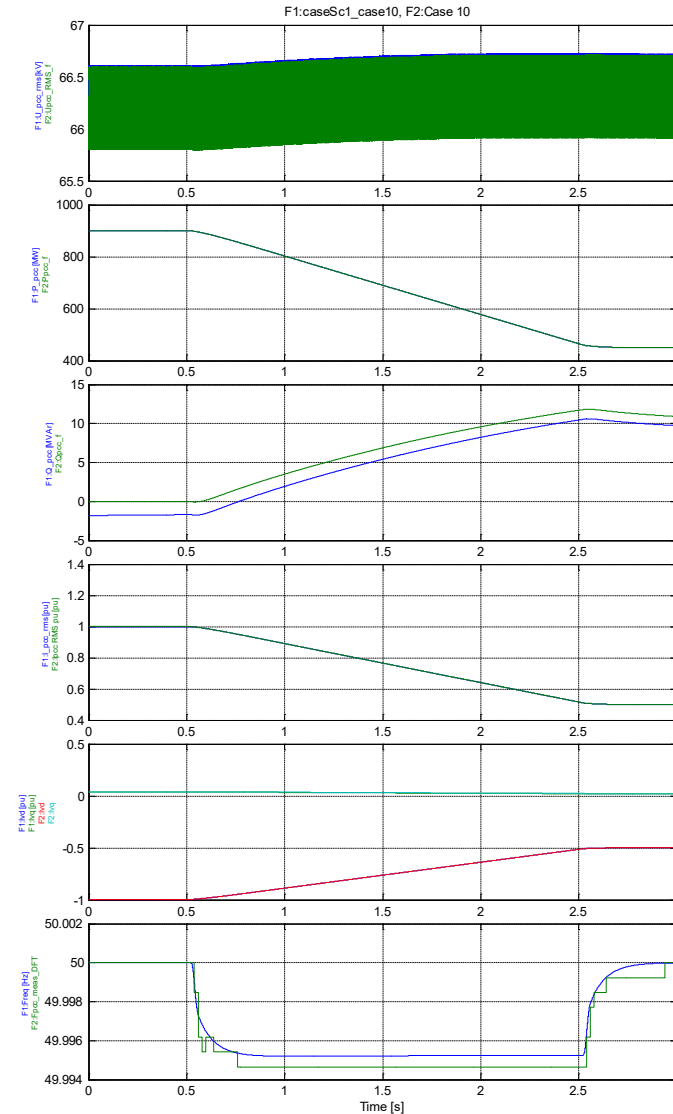
Frequency step 0.5 Hz



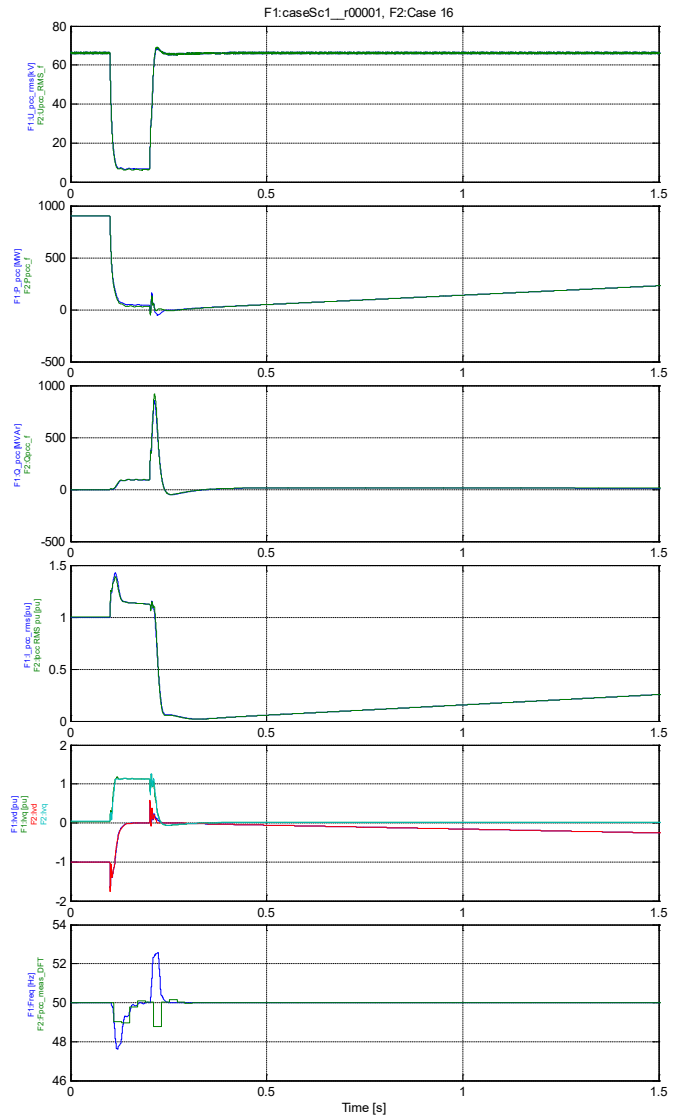
Ramp frequency at rate 2 Hz/s



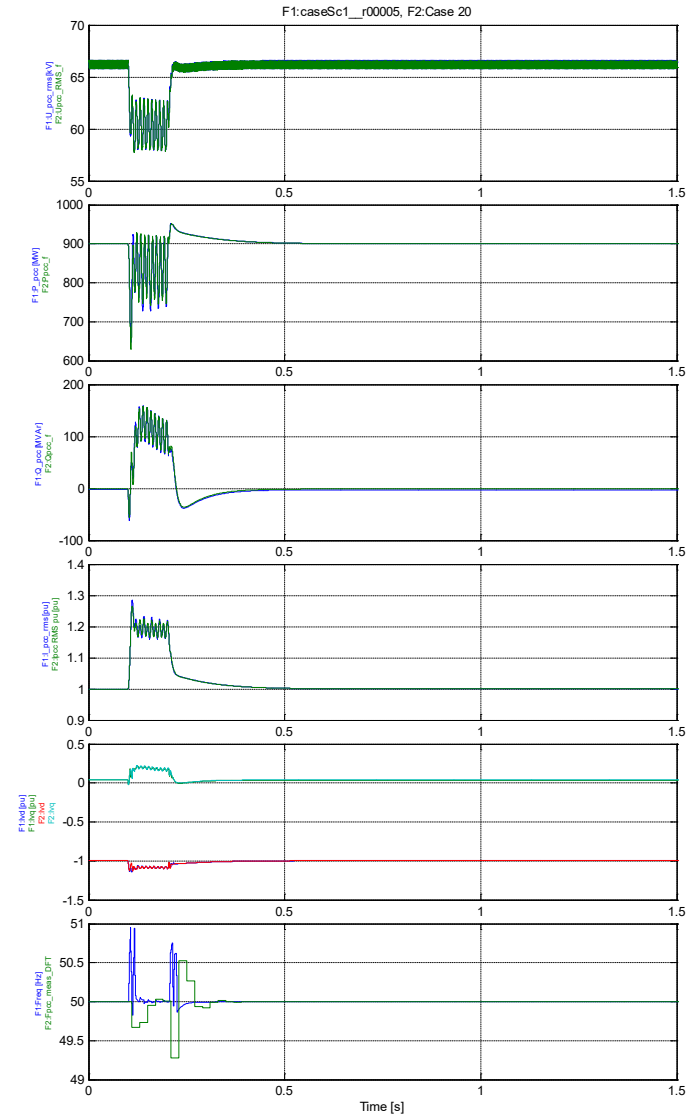
Active power ramp down from nominal to 50% of nominal (EPC)



3 Phase-Ground, 100 ms, 10% remaining voltage



1 Phase-Ground, 100 ms, 50% remaining voltage



Thank you!

Discussion!



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