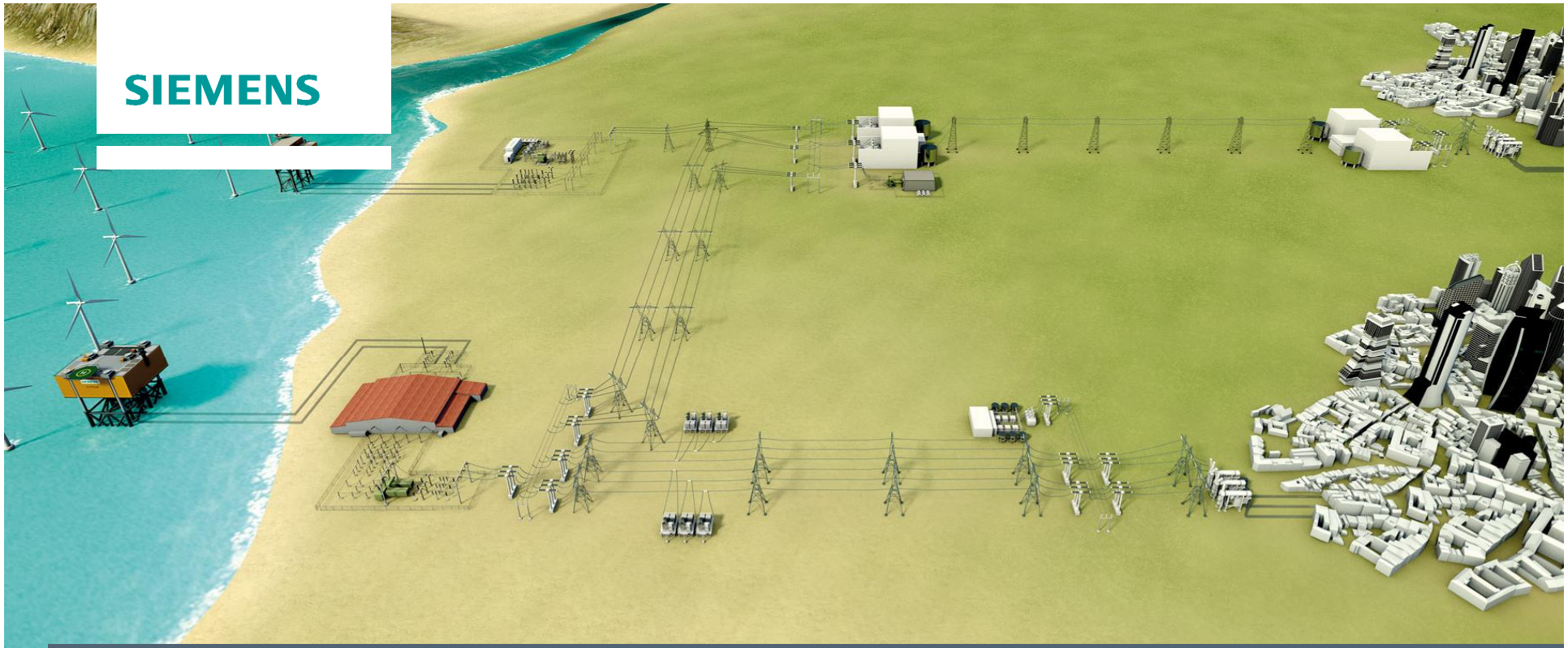


SIEMENS

RTDS European UGM 2016 in Glasgow, Scotland September 15th – 16th, 2016

Use of RTDS at Siemens AG HVDC/FACTS

M. Sezer / S. Endruschat

Agenda

Presentation will be split into two parts

- **VSC based SVC application**
  - **presented by Murat Sezer**
- **VSC based HVDC application**
  - **presented by Sibylle Endruschat**

Murat Sezer / EM TS LTS FACTS EN C&P-P
Sibylle Endruschat / EM TS LTS ENEC-HVDC SE RTS

Agenda

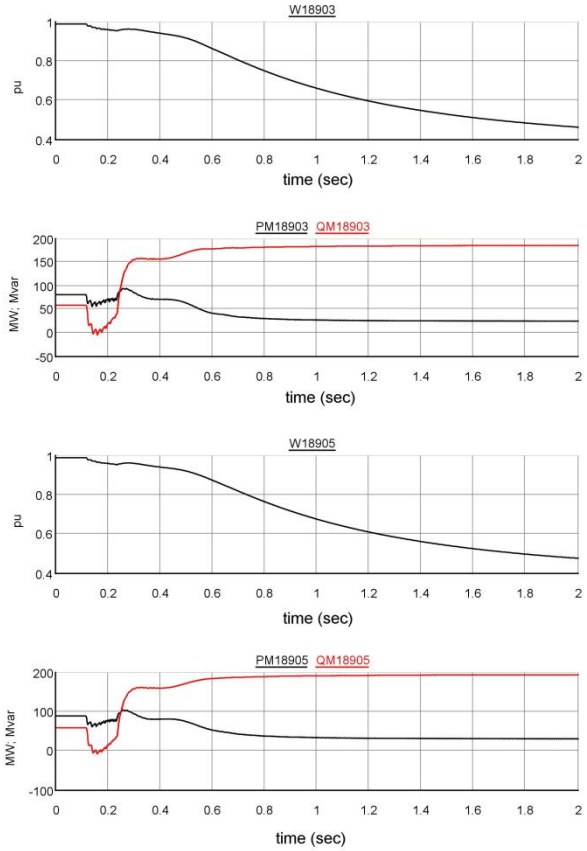
- Why VSC based SVCs in Middle East, SLD of some projects
- RTDS Overview Simulator, RTDS Software
- Dynamic Behavior of SVC Hybrid
- Simplified Converter representation
- Benchmark cases

Dynamic Model of Networks in Saudi Arabia

Middle East Network

- Summer Load / Peak Load is consisting Air conditions
- Air conditions are causing Motor Stalling Phenomena
- The Loads are simulated with Induction Machines in RTDS
- Every Mvar is needed during and after the fault case
- VSCs are favorable

Induction Motor stalls after Fault Case



- **Long 1-phase-to-earth, 2-phase-to-earth and 3-phase-to-earth faults causes Motor Stalling**
- **Up to 3 times more inductive reactive power is absorbed from the network**

Dynamic Difference Between Classic SVC and SVC PLUS

SVC Classic

$$Qsvc = \sqrt{3}\ x\ Vll\ x\ Isvc$$
$$Qsvc = 3\ x\ Vle\ x\ Isvc$$
$$Qsvc = 3\ x\ Vle\ x\ (\frac{Vle}{Zsvc})$$
$$Qsvc = Vll^2\ /\ Zsvc$$

SVC PLUS

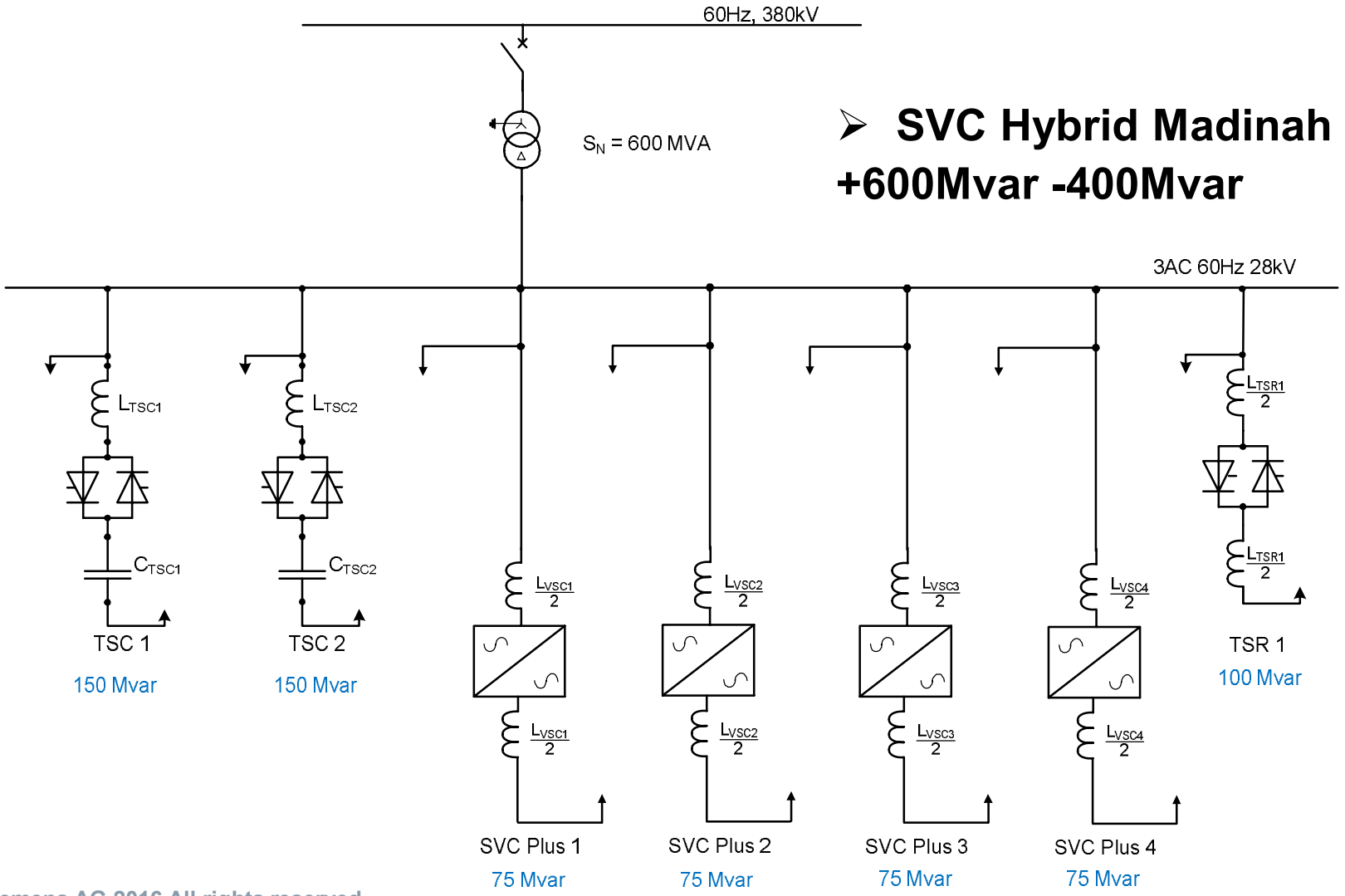
$$Qvsc = \sqrt{3}\ x\ Vll\ x\ Ivsc$$

Summary

$If\ the\ voltage\ drops\ to\ 50\%\ max.\ 25\%\ of\ nom.\ Qsvc\ is\ generated\ by\ classic\ SVC$

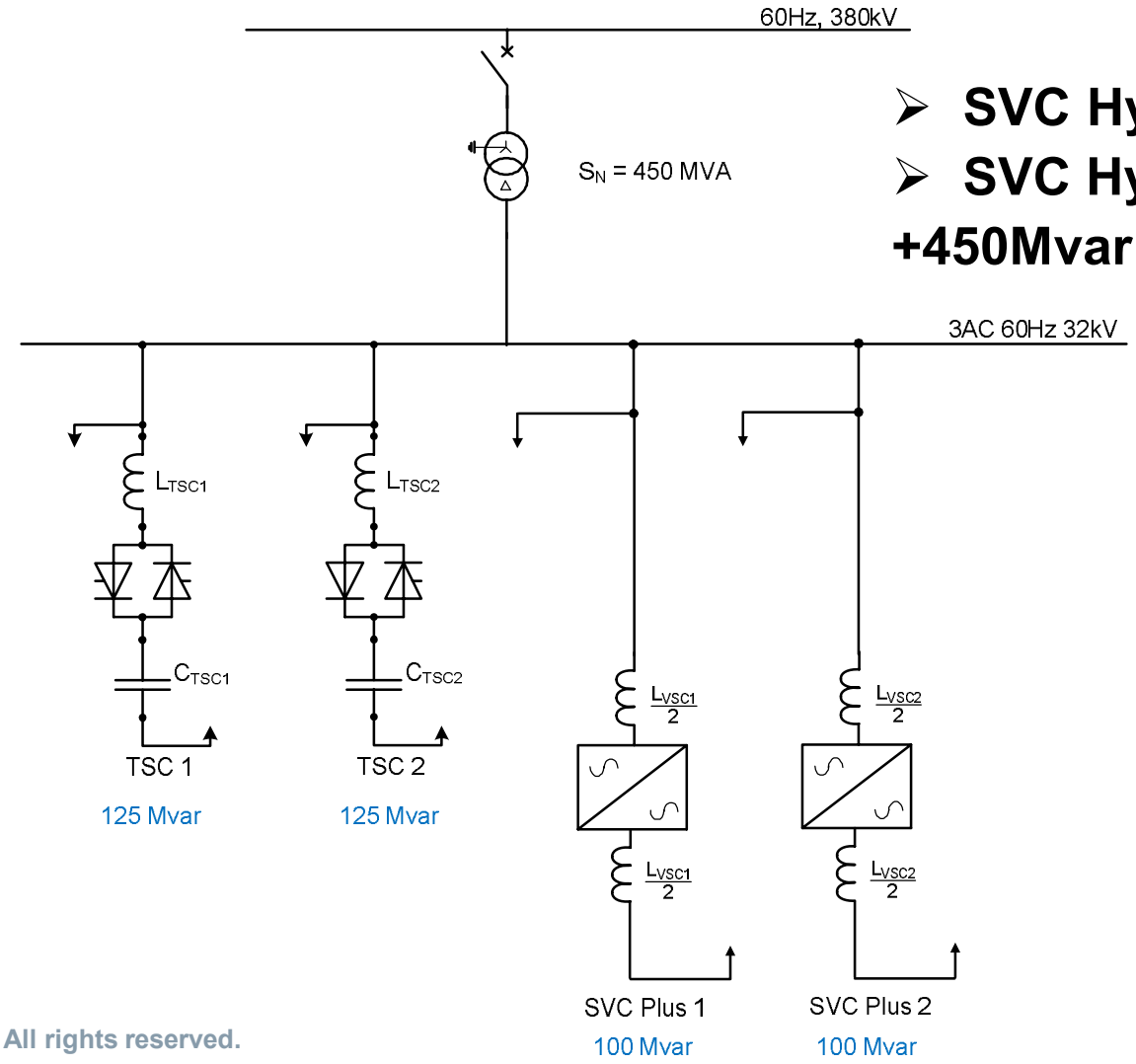
$If\ the\ voltage\ drops\ to\ 50\%\ max.\ 50\%\ nom.\ Qvsc\ is\ generated\ by\ SVC\ PLUS$

Single Line Diagram Madinah East



- **SVC Hybrid Madinah East +600Mvar -400Mvar**

Single Line Diagram Hail & Al-Jouf



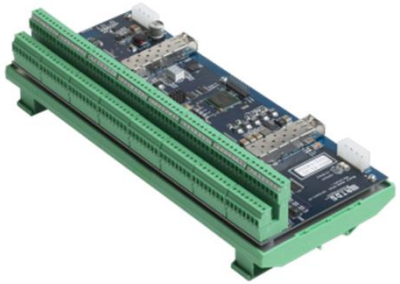
- **SVC Hybrid Hail**
- **SVC Hybrid Al-Jouf**

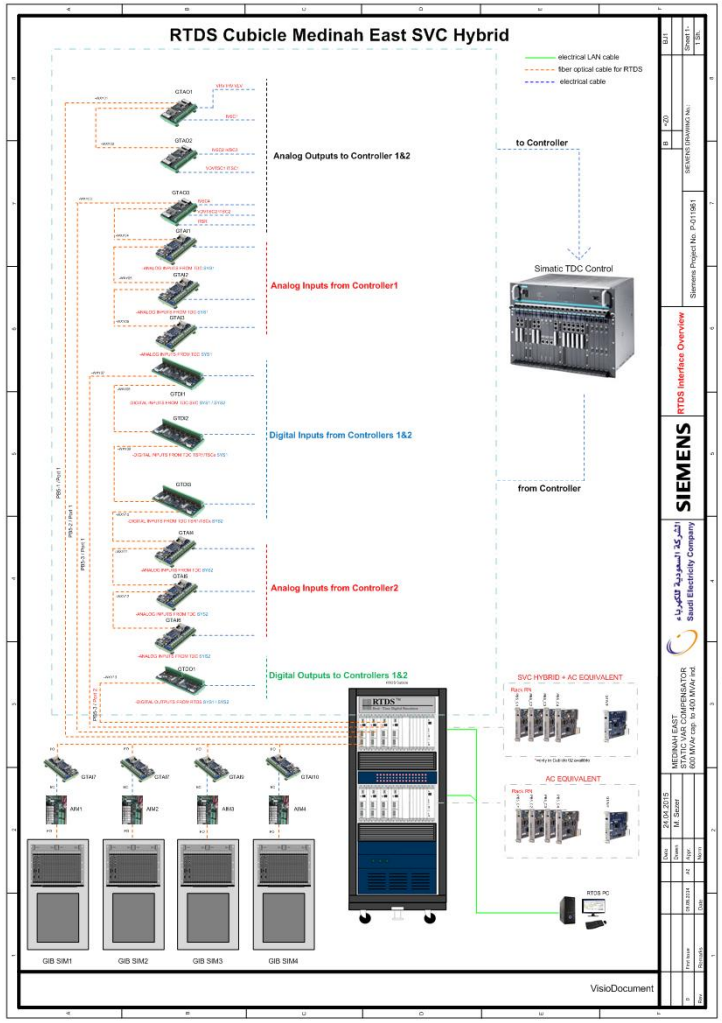
+450Mvar -150Mvar

RTDS Simulator Overview Madinah East

3xGTAOs

3xGTDIs

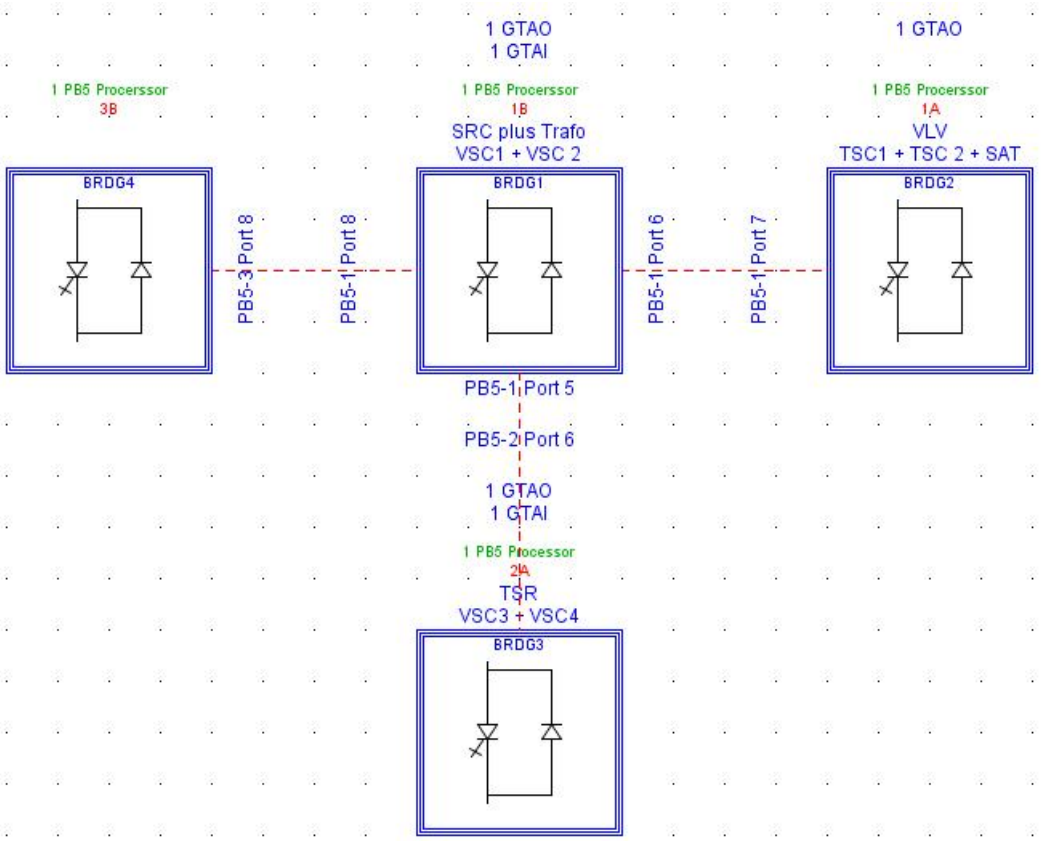




10xGTAIs

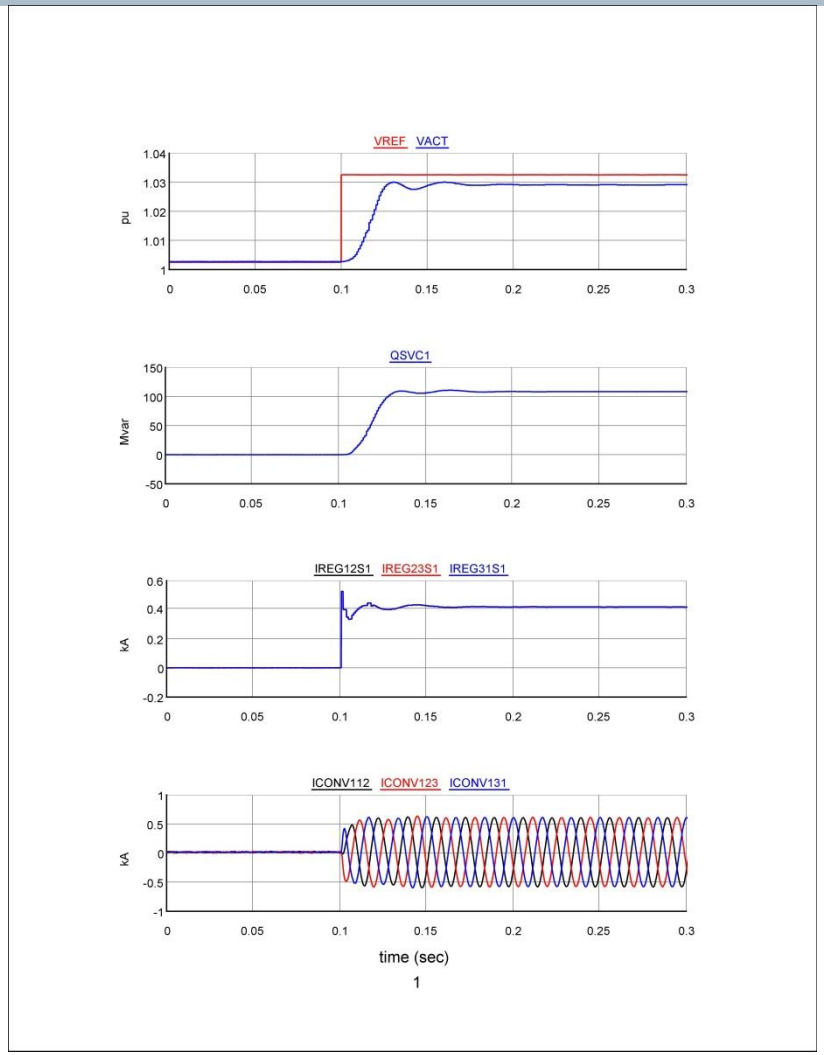
1xGTDO

RTDS Draft File of SVC Hybrid Madinah East



- The whole network is simulated in small time step. The aim is to reduce the risk of high frequency resonances inside network.
- Blue Boxes are connected with virtual short t-lines.
- In dynamic tests BRDG4 is replaced with AC-Equivalent. Interface transformer model must be used to combine AC-Network to SVC Hybrid.

SVC Behaviour in FPT - Step Response of the VSC



- **Response Time**

tr = 23ms

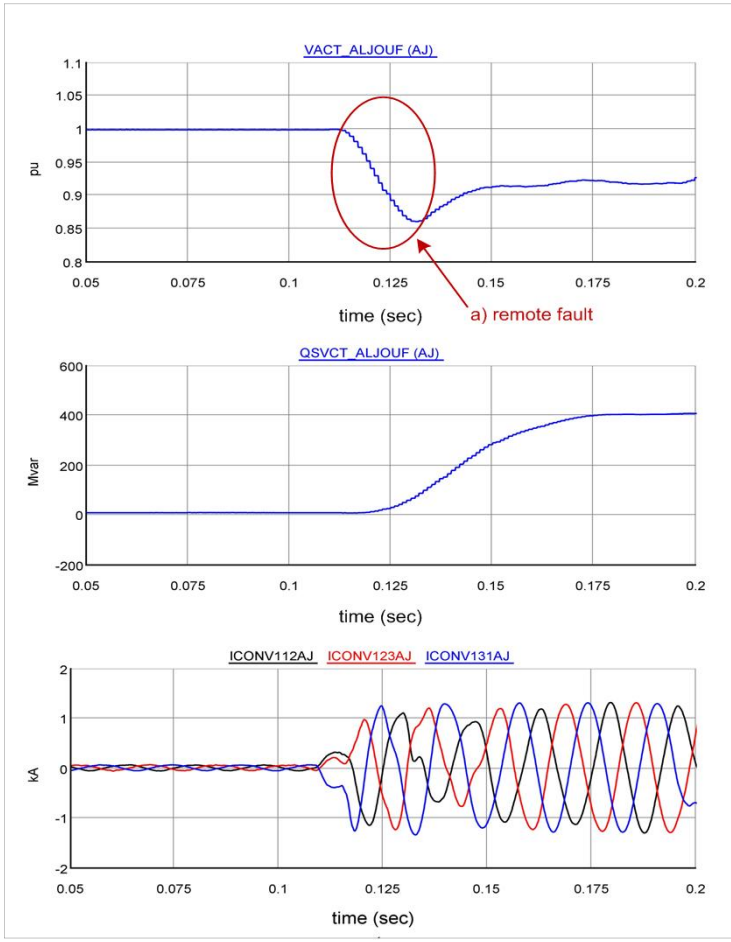
- **Settling Time**

ts = 45ms

- **Overshoot**

3.8%

SVC Behaviour in DPT - Remote Fault Case



- **NPS controller is active**
- **Fully capacitive reactive power injection during the fault case**

SIEMENS

Applications using RTDS at HVDC VSC technology (Siemens: HVDC PLUS)

- Replica with RTDS
- RTDS processor card usage
- What is Black Start?
- How Black Start is tested using RTDS?
- Onsite Test result

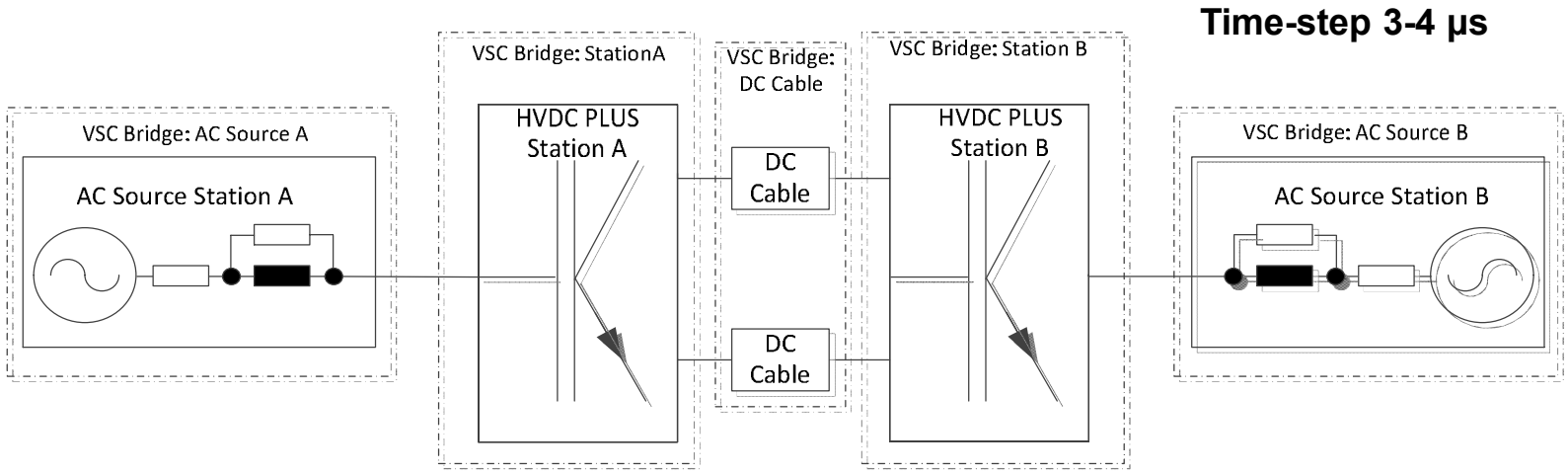
Replica

A Replica is a copy of the main project without redundancy
RTDS is used to simulate the onsite components

- Models used during FAT delivered
  - Running on two racks

- Costumer uses Replica mainly to
  - Investigate changes in their network
  - Train new operators

RTDS Simulator – Hardware configuration



- Converter Transformers with Tap Changer and Saturation
- DC Cable and DC-Cable Surge Arrestors
- Converter Phase Modules (Virtual)
- Star Point Reactors, Pre-insertion Resistors, Converter Reactors

RTDS Simulator – Hardware configuration

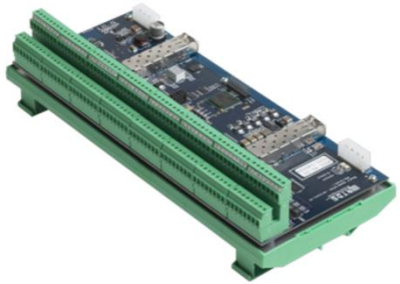
HVDC PLUS Technology requires small time step application

- Model is calculated within 3-4 µs
- Interfacing between PB5 processor cards is done with fiber optics
- Fiber optics going to the bottom are used for IO cards

RTDS Simulator – Hardware configuration

Interface to the Control and Protection Cubicle is done via

- GTAO (analogue output)
  - AC voltages and currents
  - DC voltages and currents
- GTDI (digital input)
  - Switching states
  - Tap changer position
- GTFPGA
  - Converter currents and voltages



New functionality tested using RTDS

- **New functionality within HVDC PLUS technology**
- **Developed at Siemens laboratories using RTDS**

- **What is Black Start**
  - Short explanation

- **How is it tested**
  - Test model presented

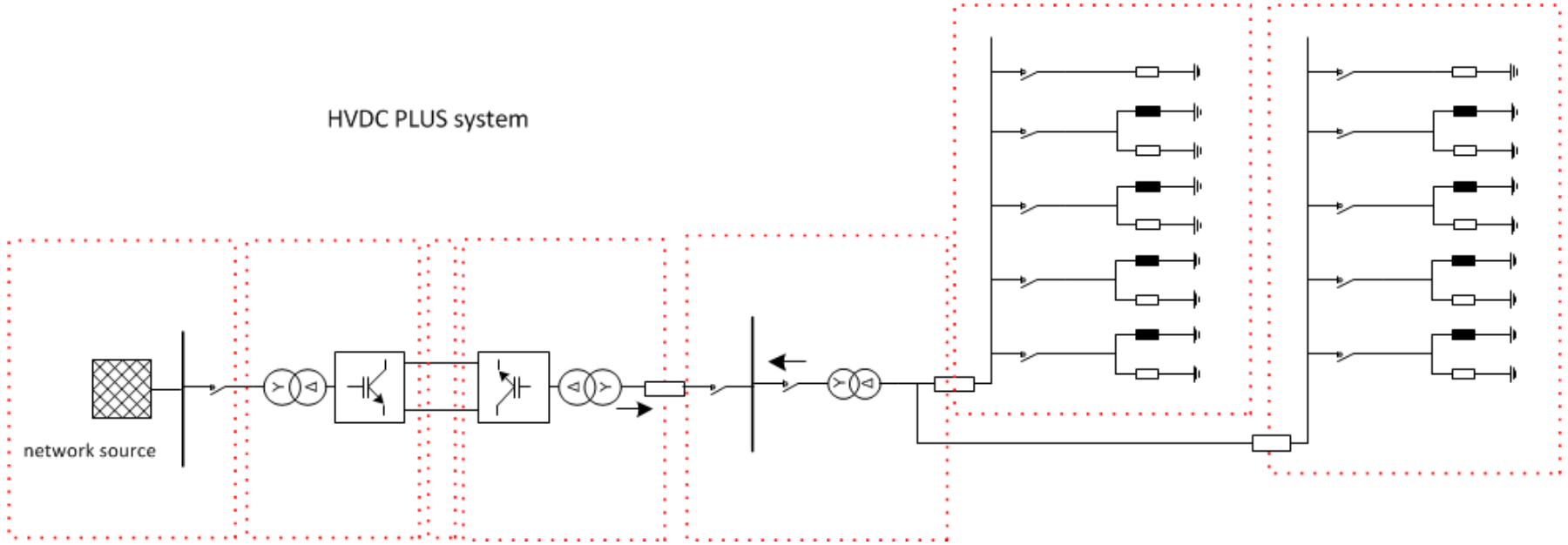
What is Black Start?

- The complete network is blacked out
- The HVDC Plus converter is able to energize the converter (on the blacked out side) from the DC side
- Final step is to synchronize back to the grid

- Recently a project in the US was upgraded to this functionality
- The tests were done at Siemens laboratories
- During commissioning repeated onsite

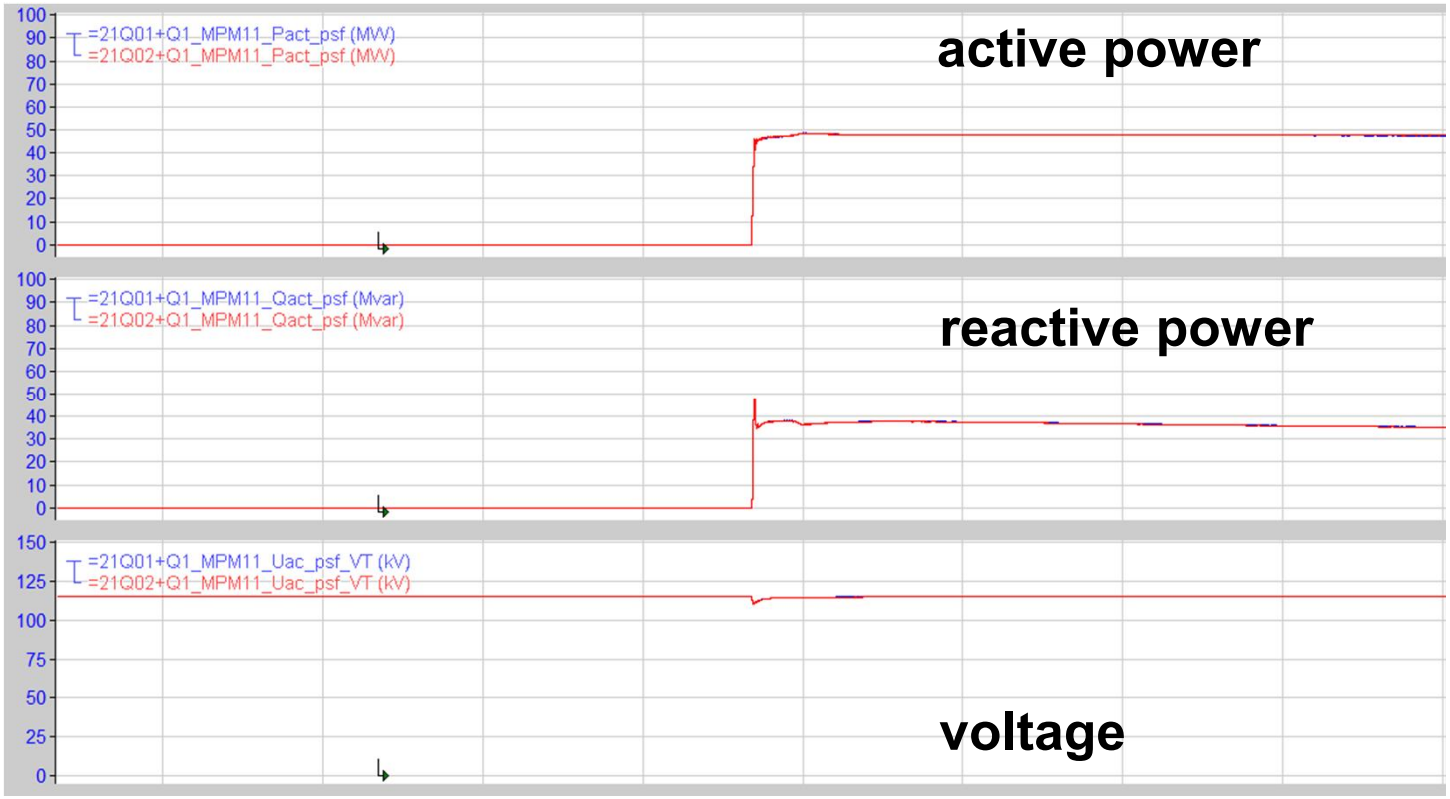
Black Start Testing

Test scenario



Test Results from Black Start Testing

Onsite Test



Thank You for Your Attention

Questions?

Murat Sezer / EM TS LTS FACTS EN C&P-P
Sibylle Endruschat / EM TS LTS ENEC-HVDC SE RTS