Developments in the Angle-DC project: Project challenges, developments and findings to date

Andrew Moon, ScottishPower Energy Networks

The presentation introduces the issues encountered by an interconnected 33 kV AC network in North Wales, which faces increased power flows on and off the Isle of Anglesey, due to increasing levels of distributed energy resources. A solution, seeking to address these issues, is being trailed under the UK Network Innovation Competition framework. The Project, titled Angle-DC, aims to deploy Europe's 1st Medium Voltage DC interconnector using existing AC circuits. Project challenges, developments and findings during the 1st 2-years of the Project are presented, including: AC circuit conversion, MVDC converter technology and topology, control concepts, expected performance and challenges to-date.

SP ENERGY NETWORKS

Future Networks

Tuesday, 17 April 2018

ECPE Workshop

Developments in the Angle-DC project: Project challenges, developments and findings to date

Background

Background: Anglesey Electricity Networks

Background: Project Overview / Purpose

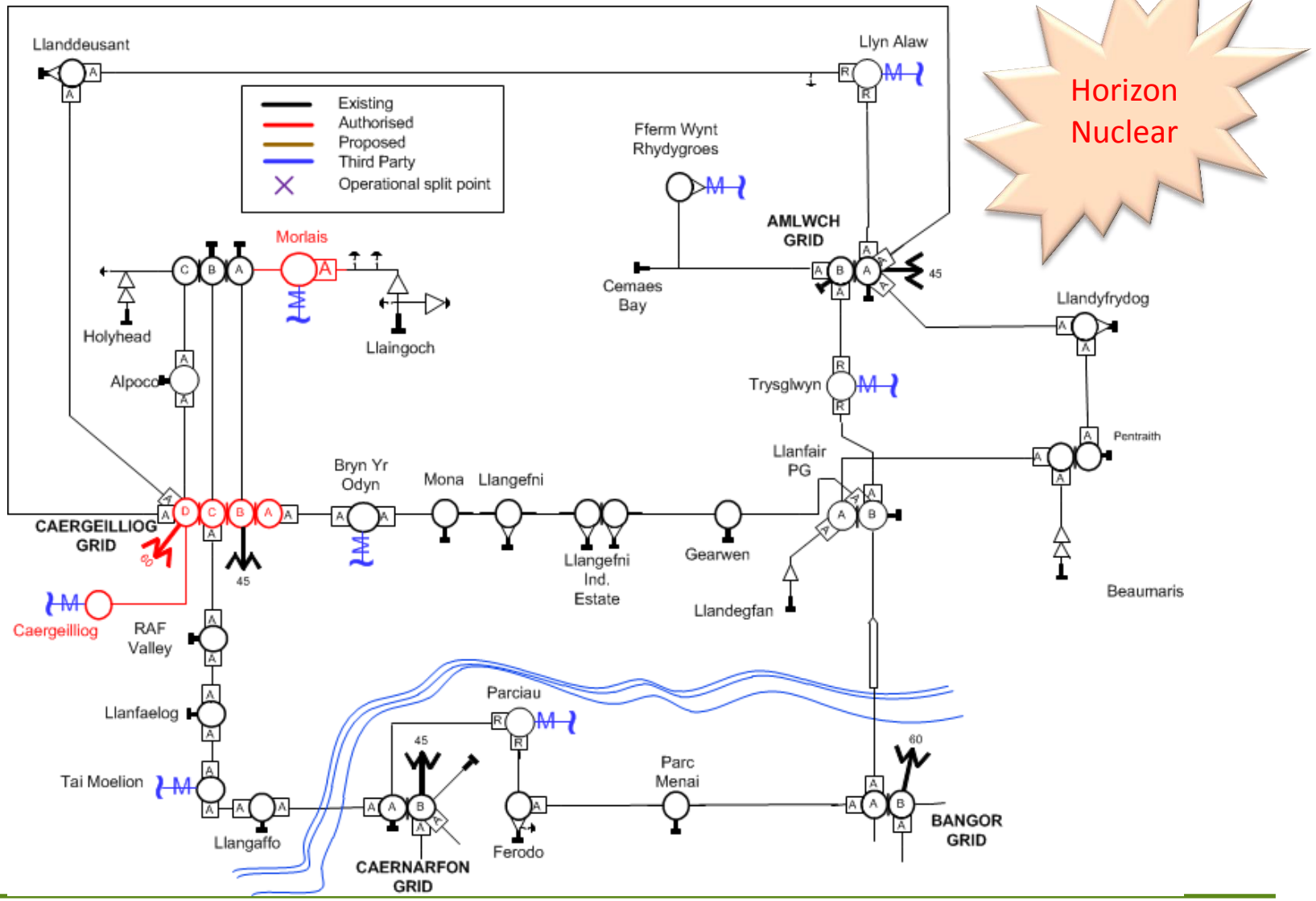
Existing Anglesey Island network:

- Bounded network with 400kV and 33kV connection to mainland North Wales.
- Network runs ‘solid’ (interconnected) at 33kV = Parallel with 400kV.
- High penetration of renewable generation.
- New nuclear station at top of Anglesey in the pipeline.
- Voltage issues near bottom end of island.

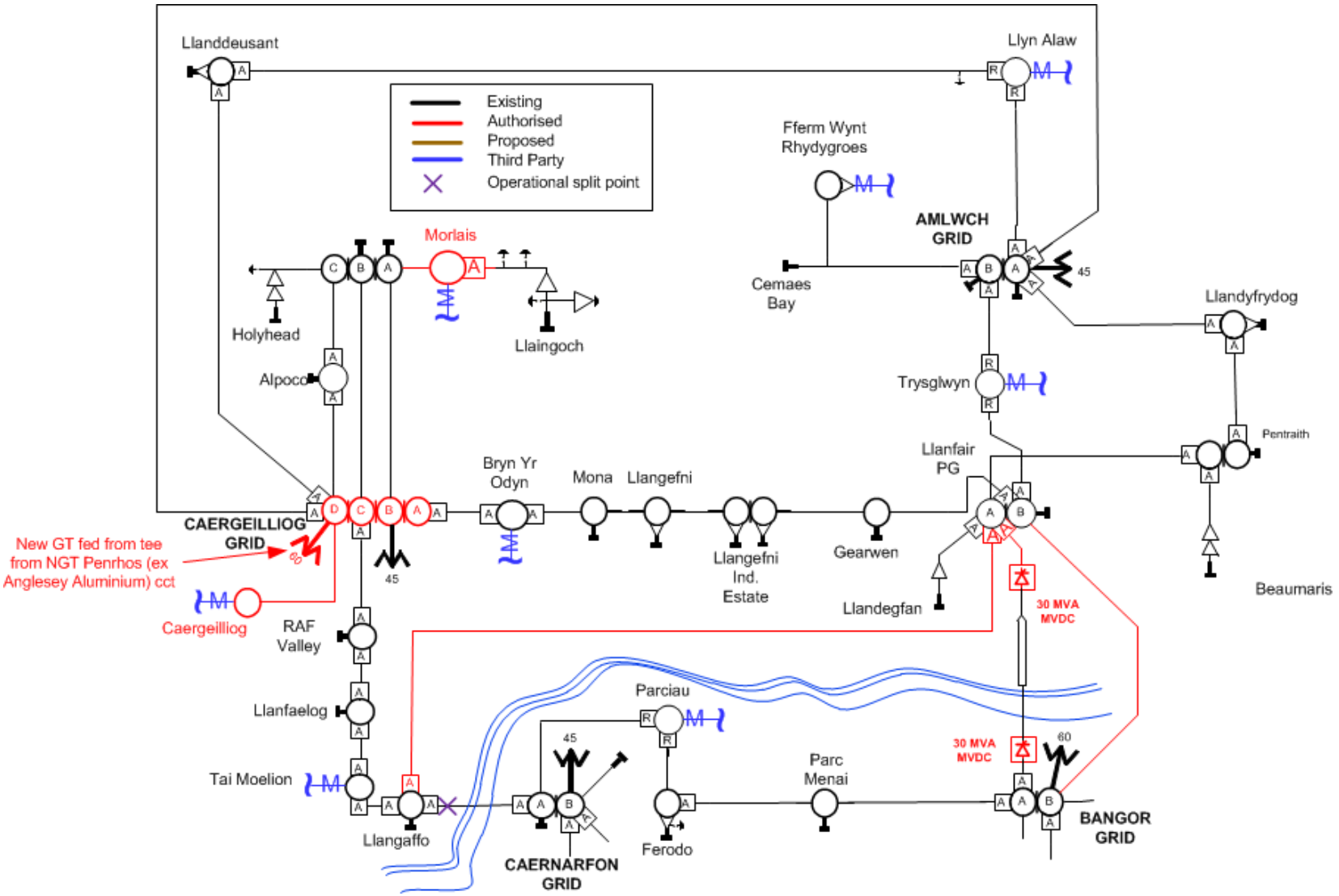
Angle DC project aims:

- Increase capacity of existing 33kVAC circuit (~25% uplift)
- Prevent 400kV parallel power flow.
- Provide voltage support (even if circuit unavailable in STATCOM mode).
- Experience deploying/using MVDC on existing circuits.

Background: 33kV Network Anglesey/North Wales (existing)



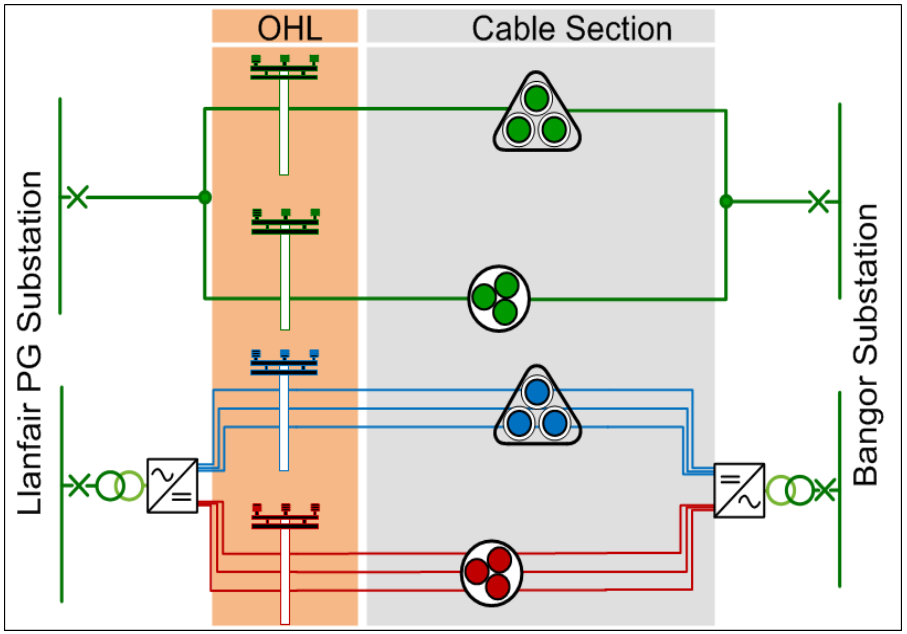
Background: 33kV Network Anglesey/North Wales (post Angle DC)



Background: Bangor Grid to Llanfair PG circuit

Background: Project Objectives

- To utilise an existing 33kVAC cable/OHL circuit for DC operation.
- To control real/reactive power flows, voltage and gain loading capacity in a network with high levels of embedded generation.
- To understand the challenges of deploying DC on existing AC circuits.
- To provide learning of how to install, operate and control a DC link.

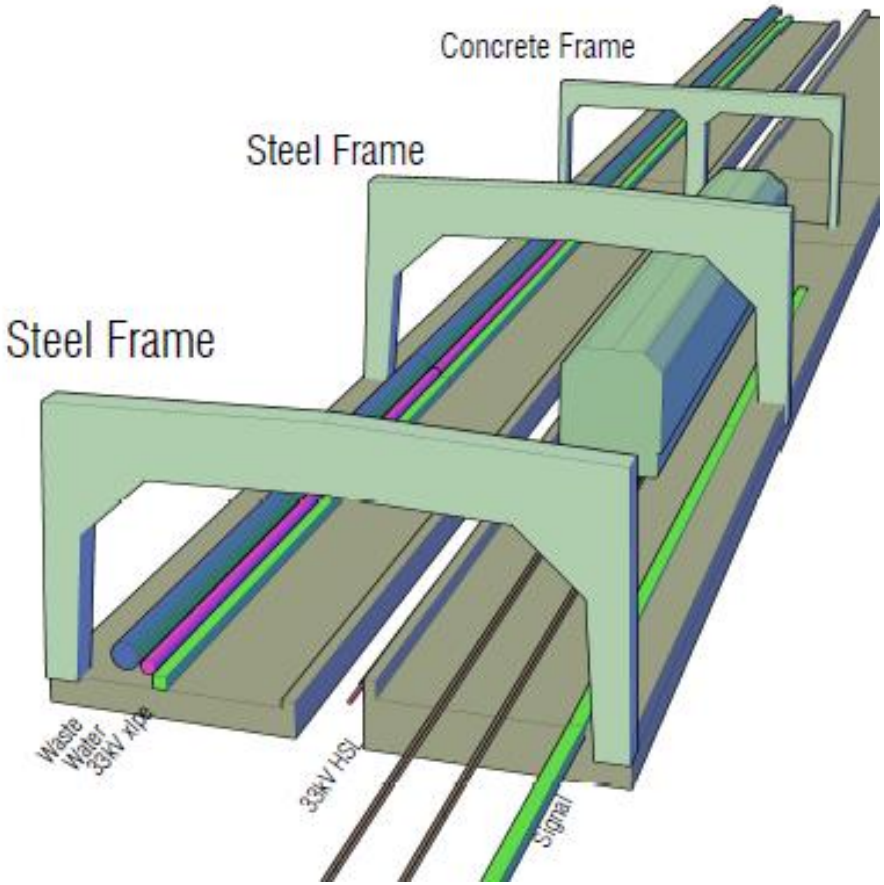


Existing 2 x paralleled 33kV circuits between Llanfair PG to Bangor AC (in green)

For MVDC operation, AC-DC converters to be installed at both sub-stations, via inverter transformers using each circuit as a positive (blue) and negative (red) pole

Challenges

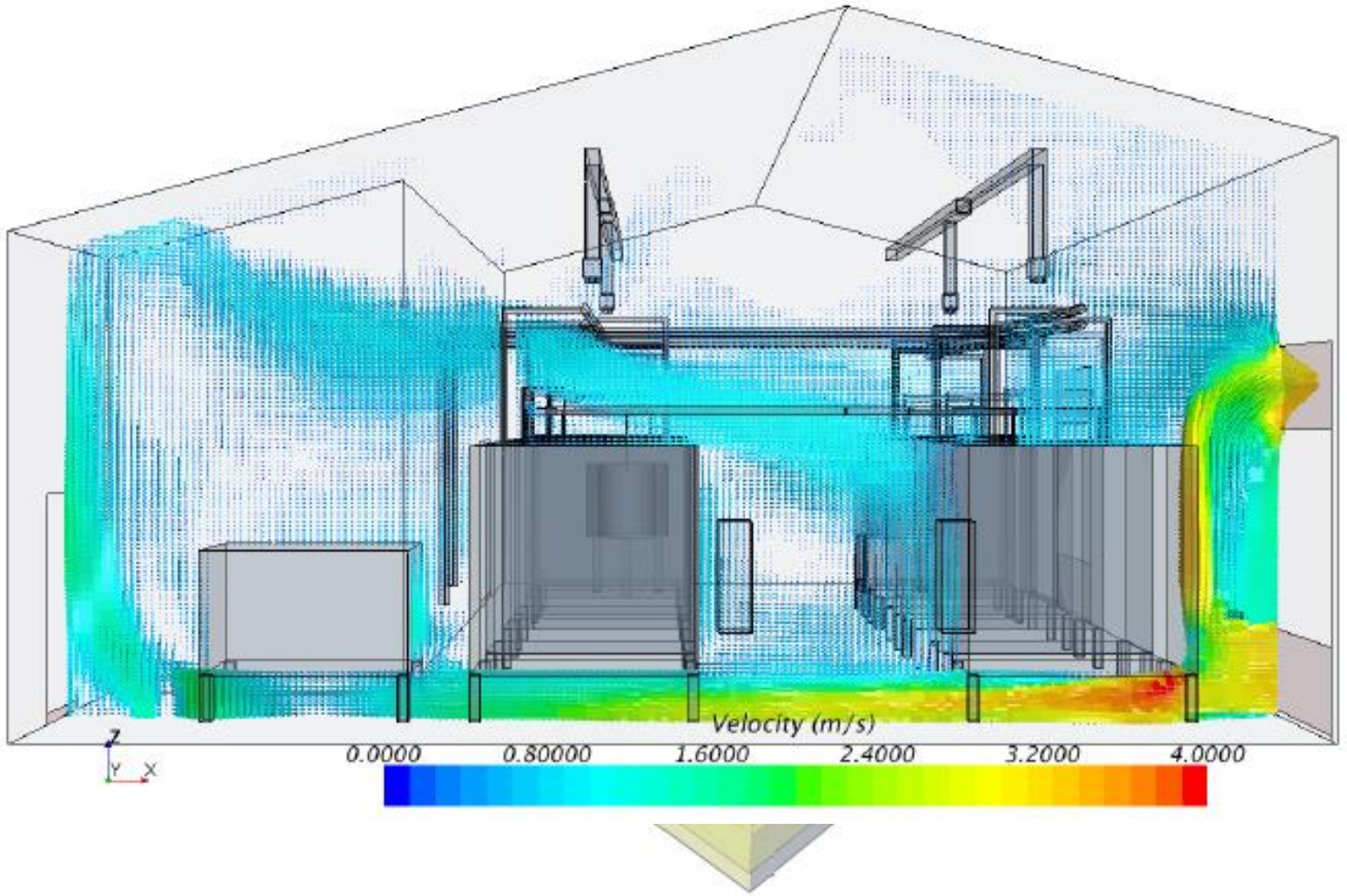
Challenges: CSM REA - DC Cable Sections on Britannia Bridge



Challenges: MVDC Convertor Building Design Specification

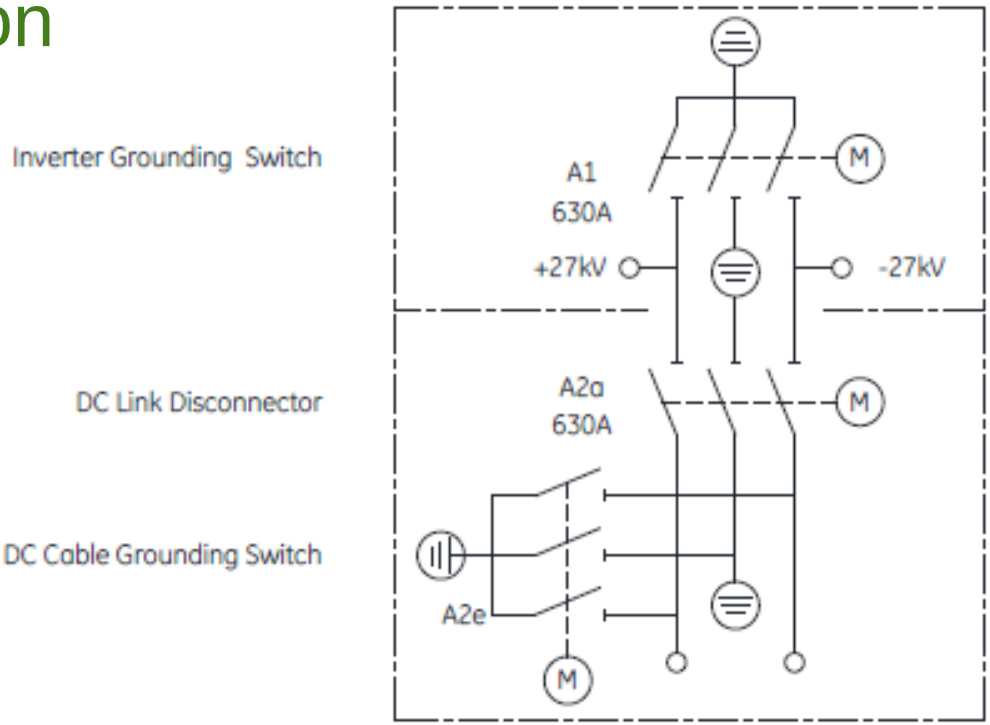
DC

Cc

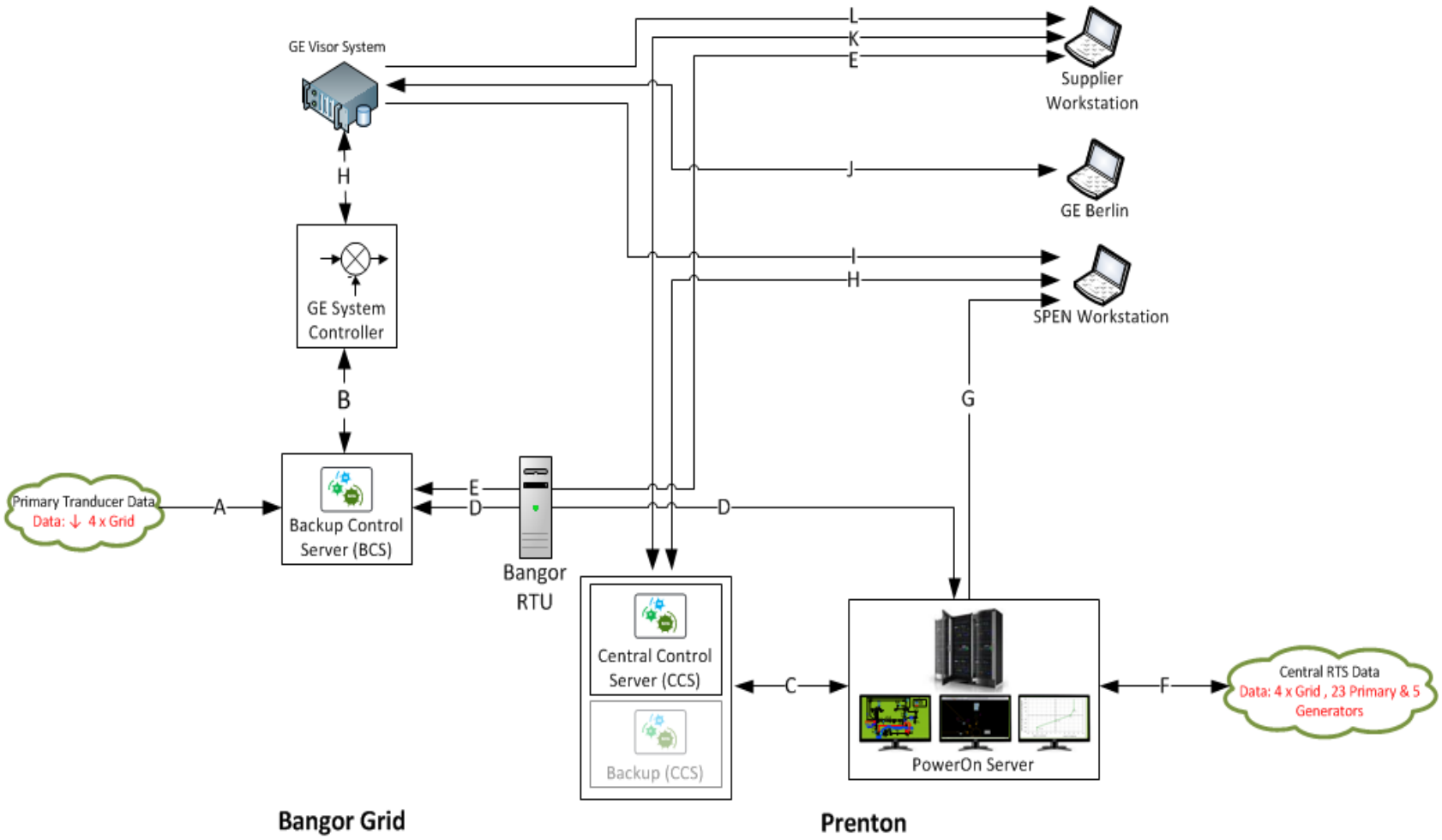


Challenges: DC Switchgear

- AC disconnectors used in DC application
- Switchgear never used before as a DC switch
- Used to earth station and DC link
- Used for maintenance and STATCOM operation
- Remote operation



Challenges: Network Control System



Developments

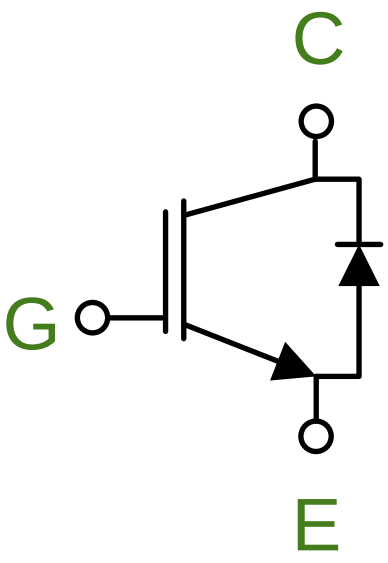
Developments to Date

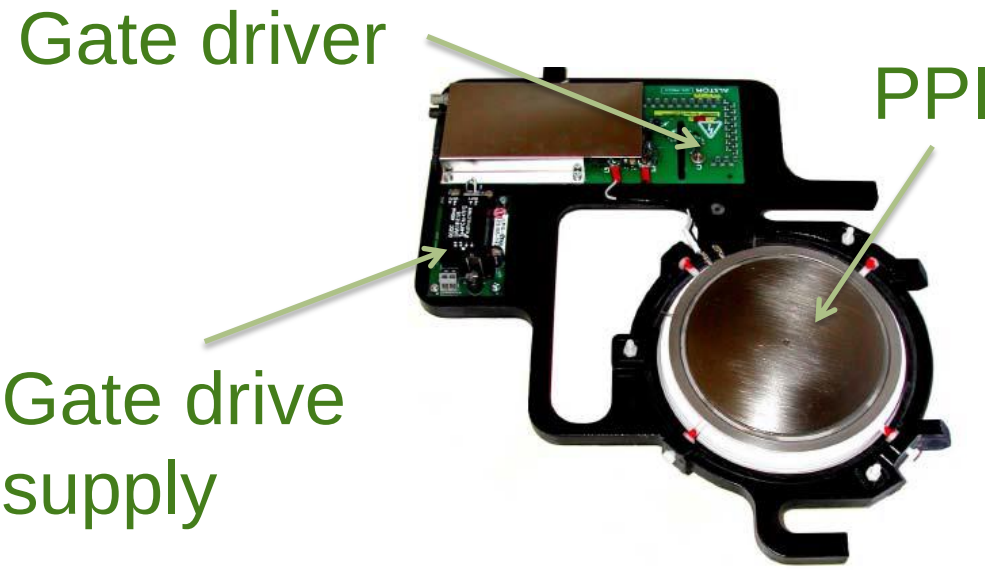
- CSM REA – Reference case with complete process documentation
- MVDC building template specification, design and modelling reports
- MVDC Converter technical specification
- Proof of concept for network optimisation with limited number of network measurement points

Make up of the MVDC converter

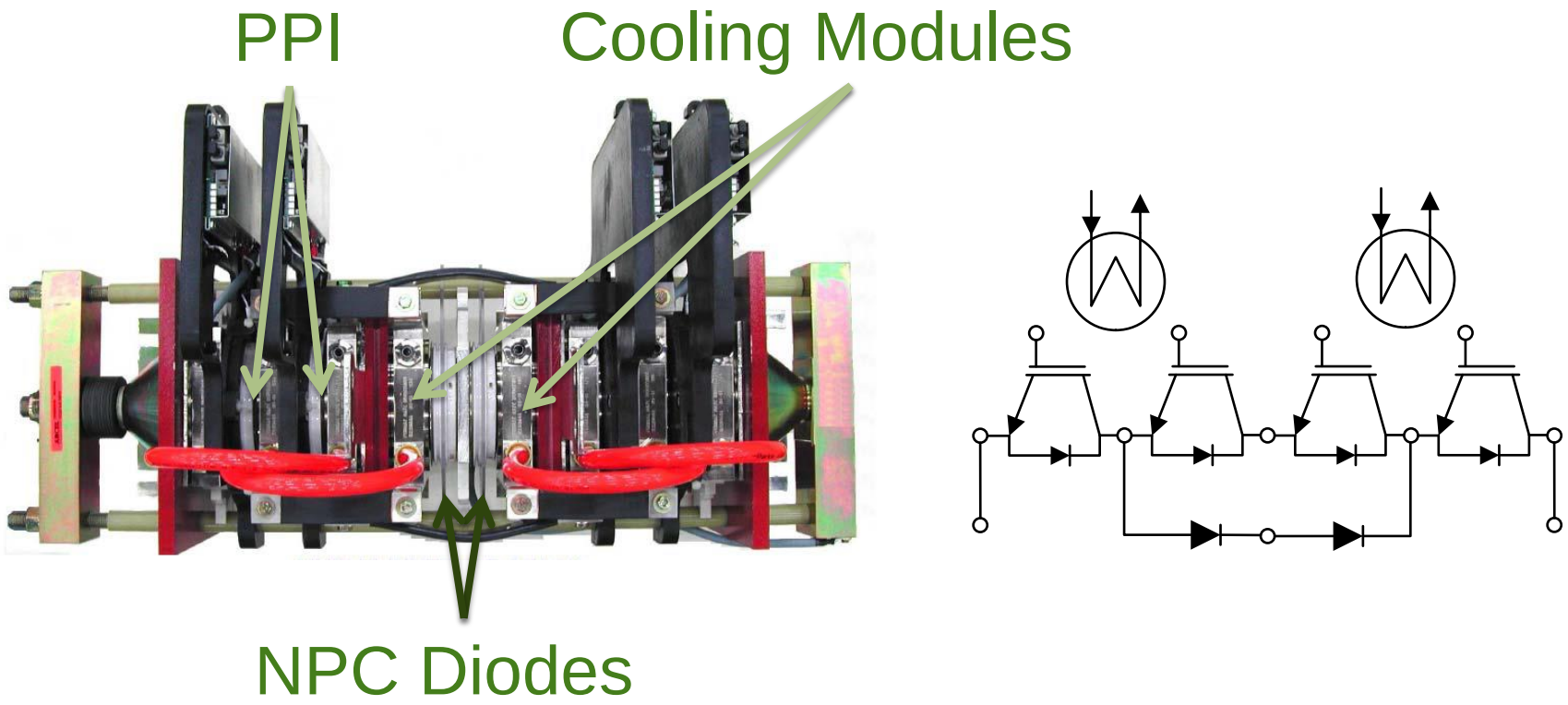
Make-up: AC/ DC Converter Switches

- GE Power Conversion traction supply solution
- MV7000 3-L NPC product line
- Uses press pack IGBT (PPI)
- MV7306 – Angle-DC Ratings: 2.1kV AC, 4.5 kV DC, 2.85 MVA



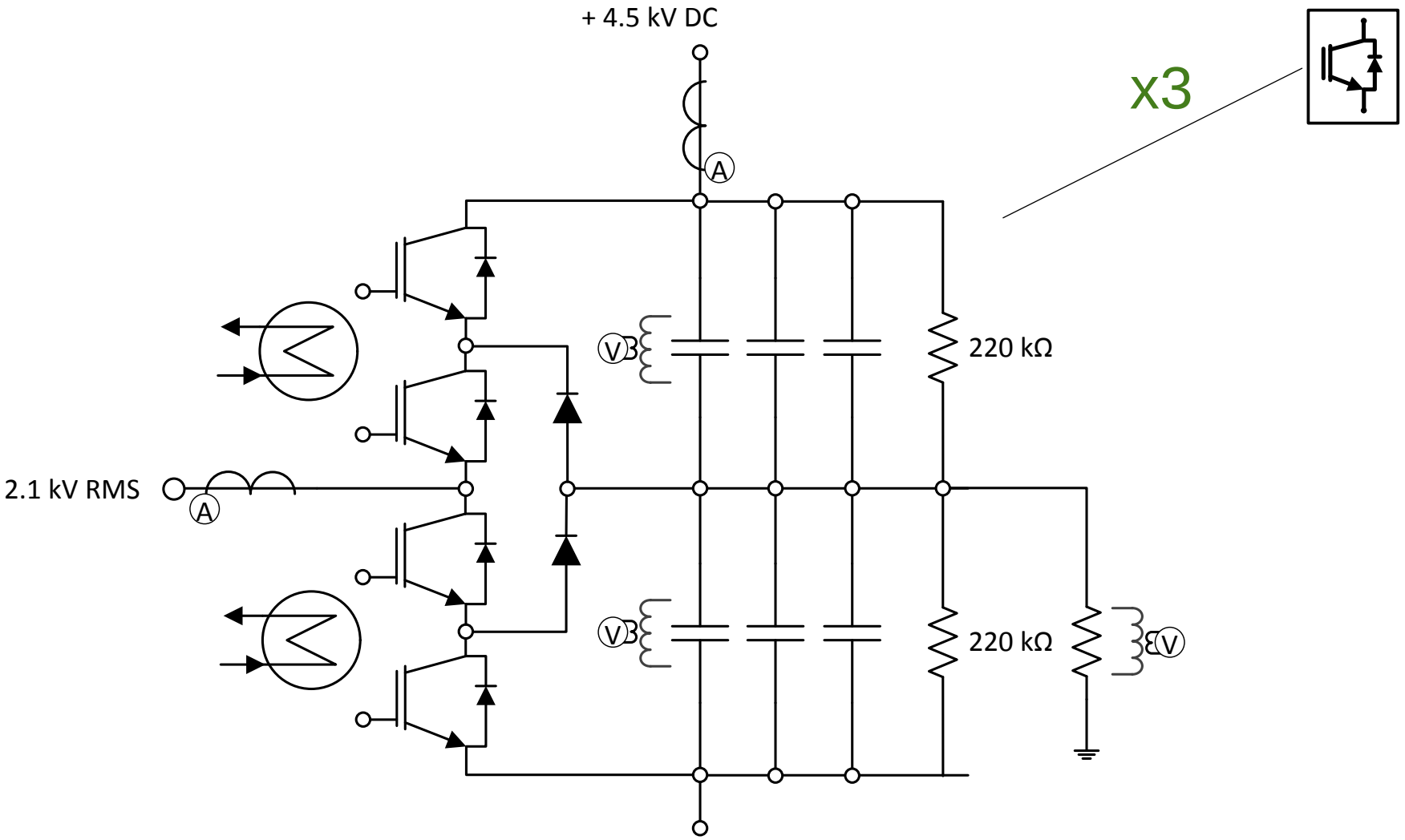


Make-up: AC/ DC Converter Stacks



- Stack assembly with 4 IGBTs and 2 clamping diodes
- PPIs are liquid cooled (50 ºC) with 70/30 water/glycol
- Single arm units coupled through LV delta winding

Make-up: AC/ DC Converter Modules

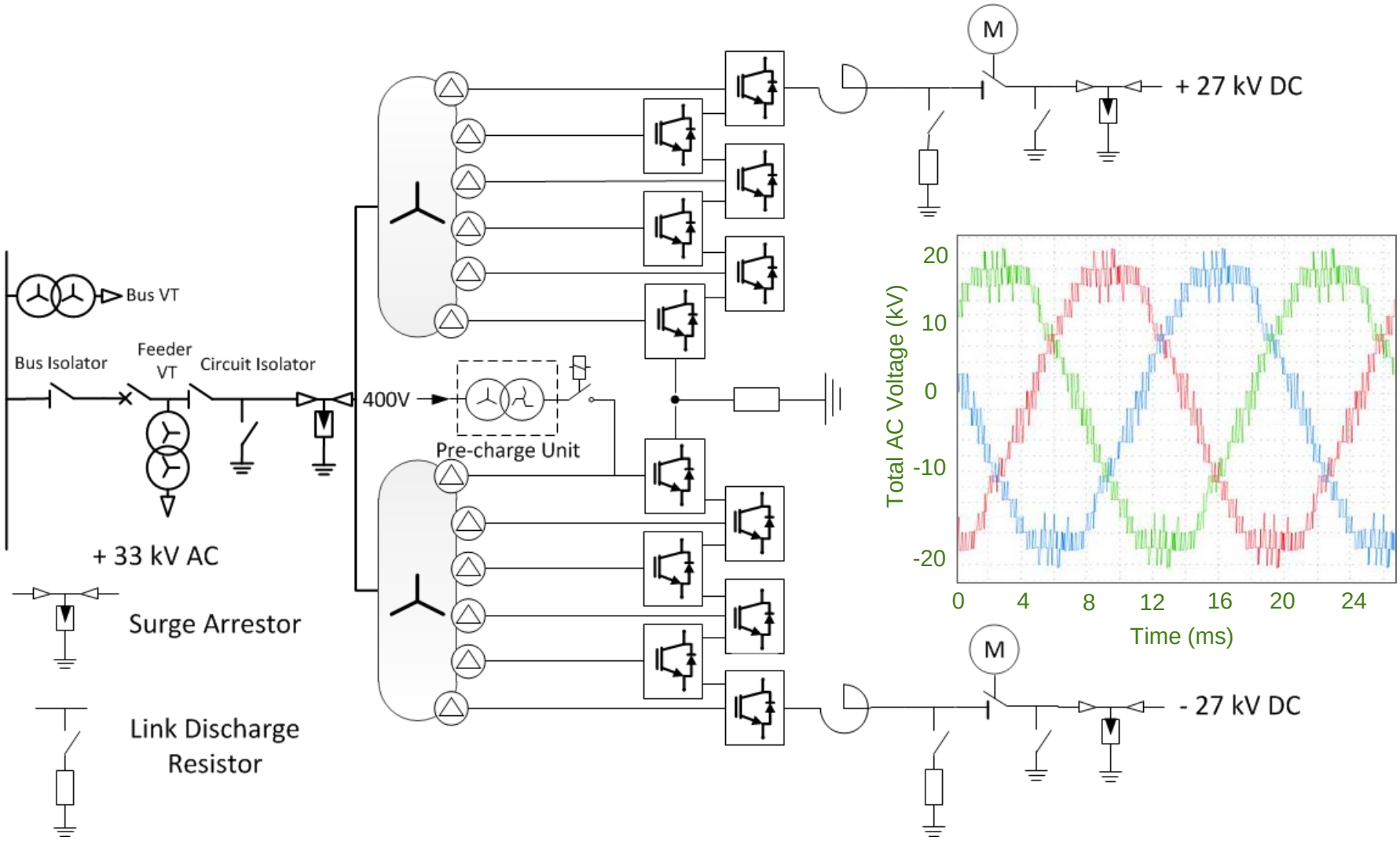


Make-up: AC/ DC Converter Modules

Capacitor banks

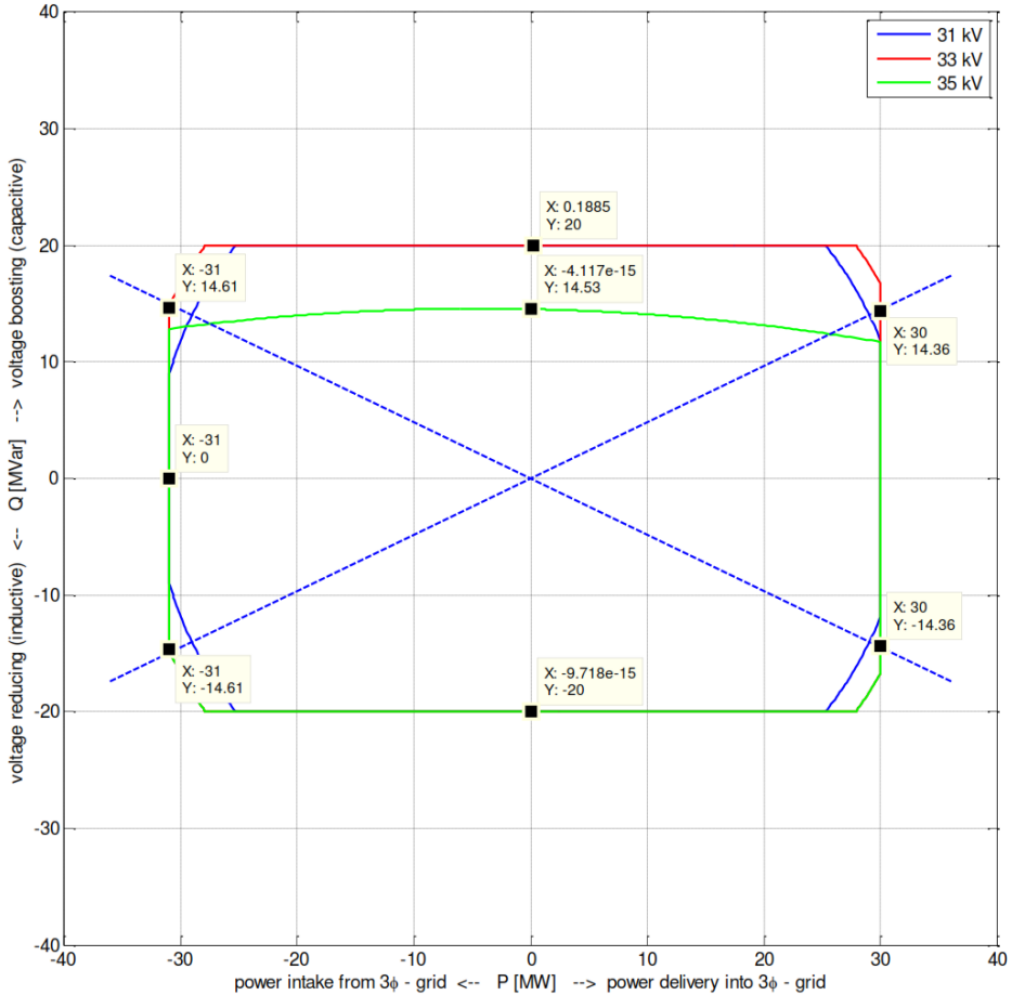
Single arm converter stack

Make-up: 35MVA AC/DC Converter - Single Line Diagram



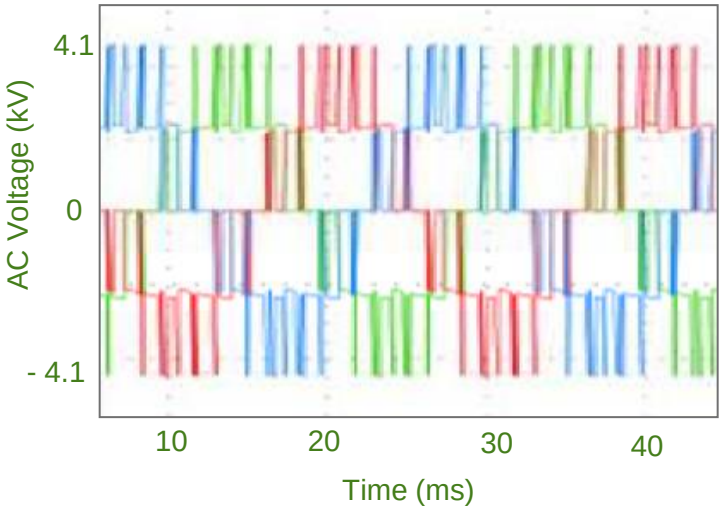
Control of the MVDC Converter

Power Flow Envelope and Steady State Operation

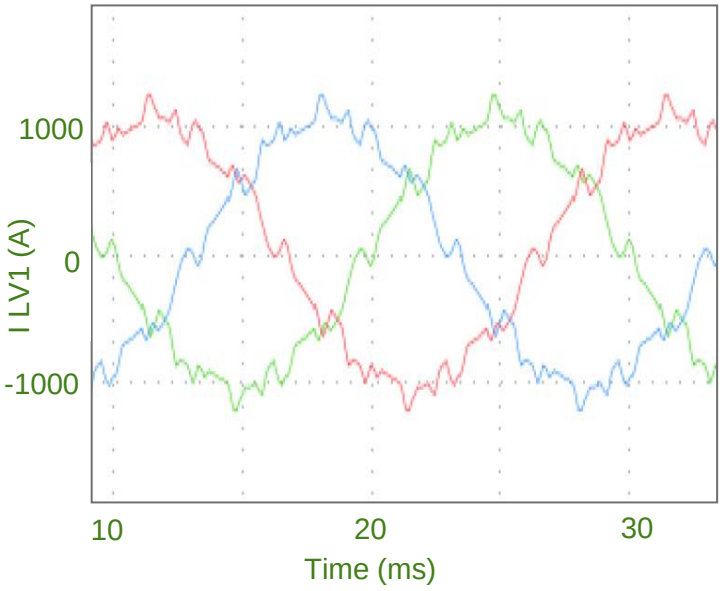


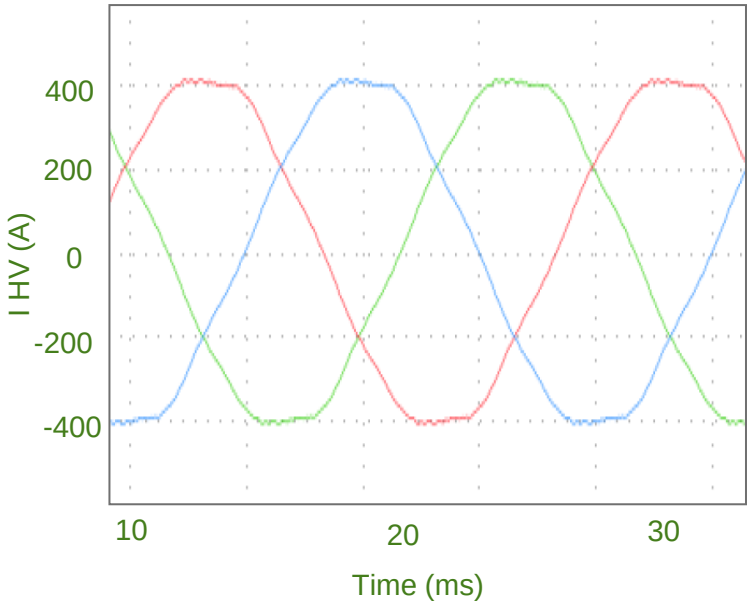
- Power throughput of the inverter is limited to the capability envelope.
- As with all VSC converters, +ve reactive power rating is lower than –ve.
- Project will utilise a maximum of ±15 MVAr
- Maximum real power transfer likely to be +20 MW.

AC/ DC Converter Switches



- PWM voltages of converters produced by 3LC PWM with carrier frequency of 1<kHz
- Switching harmonics are significantly cancelled in LV windings





Thank You

Email: kevin.smith@spenergynetworks.co.uk