EIRGRID

eastwest interconnector

Benefits of Interconnection

- Security Of Supply
- Promote Competition in The Electricity Sector
- Accommodate Growth Of Renewable Energy
- Reduce Dependence on Imported Fuels
- Downward Pressure on Price
- Achievement of National and European Objectives

East West Interconnector Background

Key Strategic Project

- Priority Interconnector Project - DG TREN January 2007
- '..Critical National Strategic Importance..' – NDP 2007-2013

CER to arrange for design of competition for construction of a 500MW interconnector at earliest possible date *(*2012 or earlier)

Upon completion, I/C to be owned by EirGrid

Work on selection of sub sea route and sites and associated grid reinforcement to proceed in parallel with selection of developer process

Project Risk Register and Program

Top 3 Generic Risks to a large energy infrastructure project

1. Planning
2. Infrastructure Access
3. Procurement – lead times

Pick a route and begin route surveys?

Planning will take time?

2-3 years to build a HVDC scheme once we press the go button and design and route is finalised?

>2 year lead time for cable slots with manufacturers?

Procurement including competition design, specification ,evaluation and contract negotiations under the negotiated procedure of a complex scheme takes 2 years?

Project Scoping

Concept to Reality

- Need a well defined route to get comparative offerings and value
- Need Planning to secure Finance
- Need Grid Access to deliver benefits

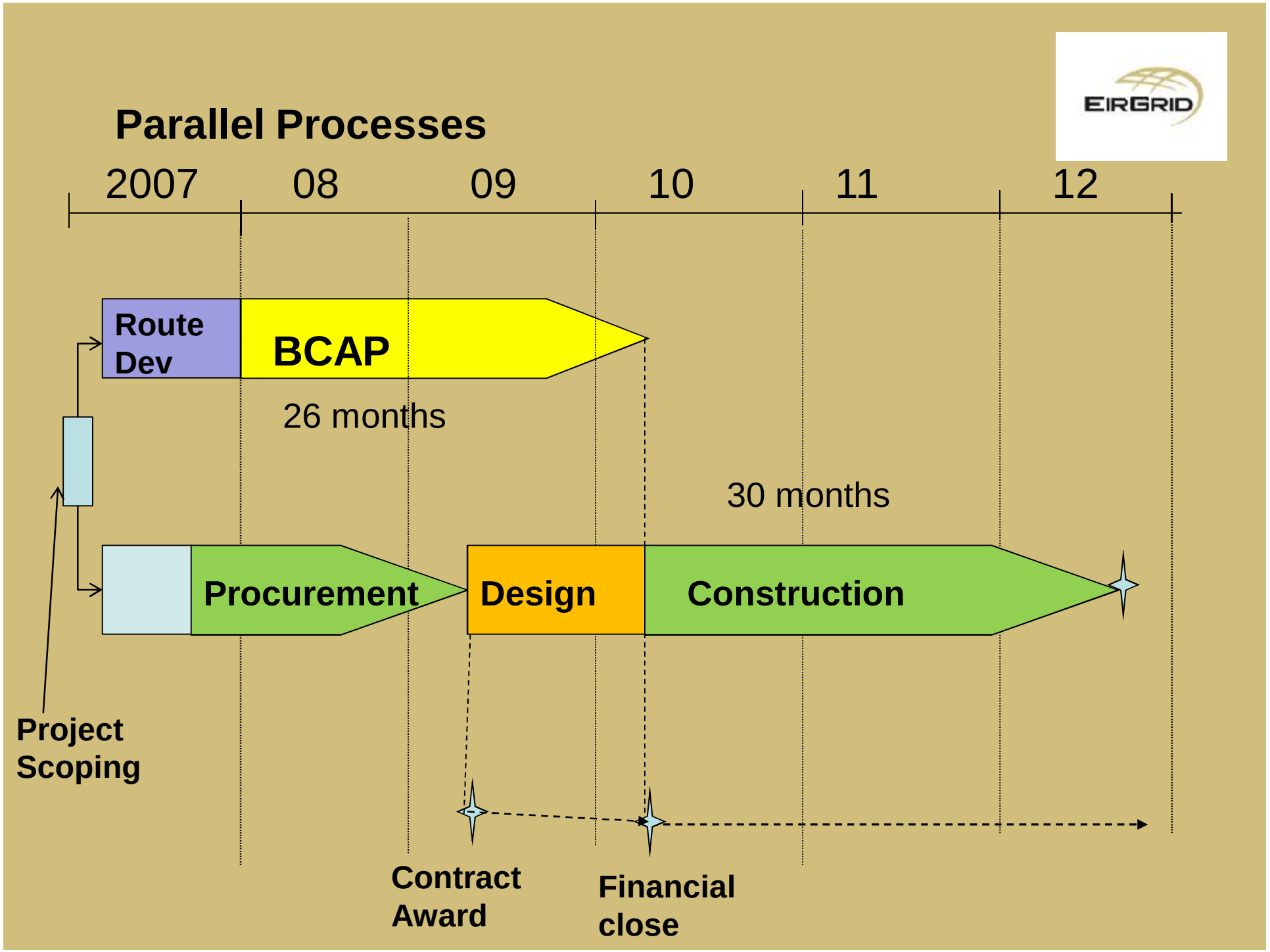
Competition in the HVDC market is limited with long lead times for equipment

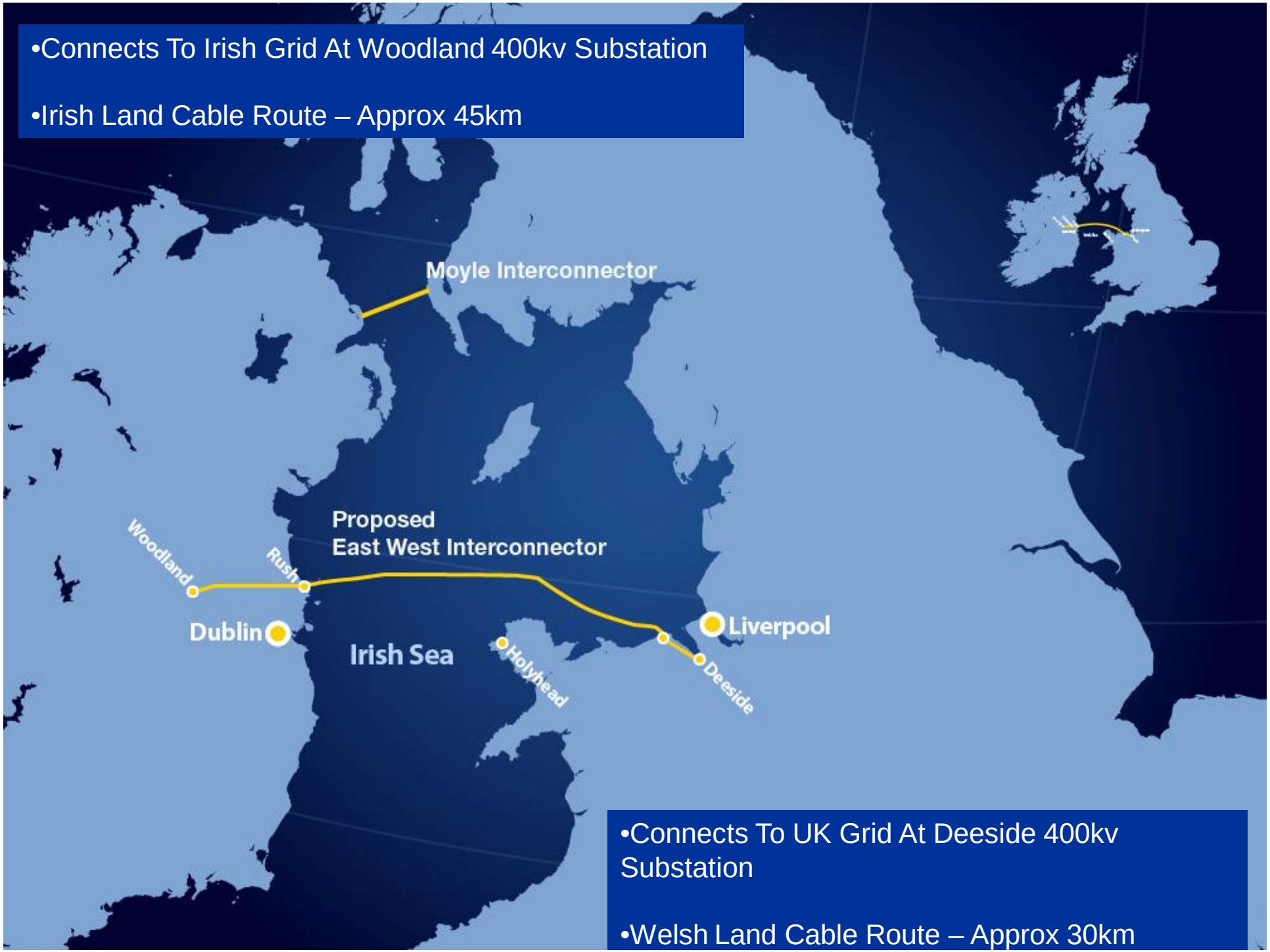
- Turnkey versus multi-contract
- Newer Technology versus more established Technology
- Lots approach to cables and converter stations

Can it be done for 2012? Yes, if we parallel*

- Ø Route development /selection with procurement
- Ø Planning with contract negotiations and design

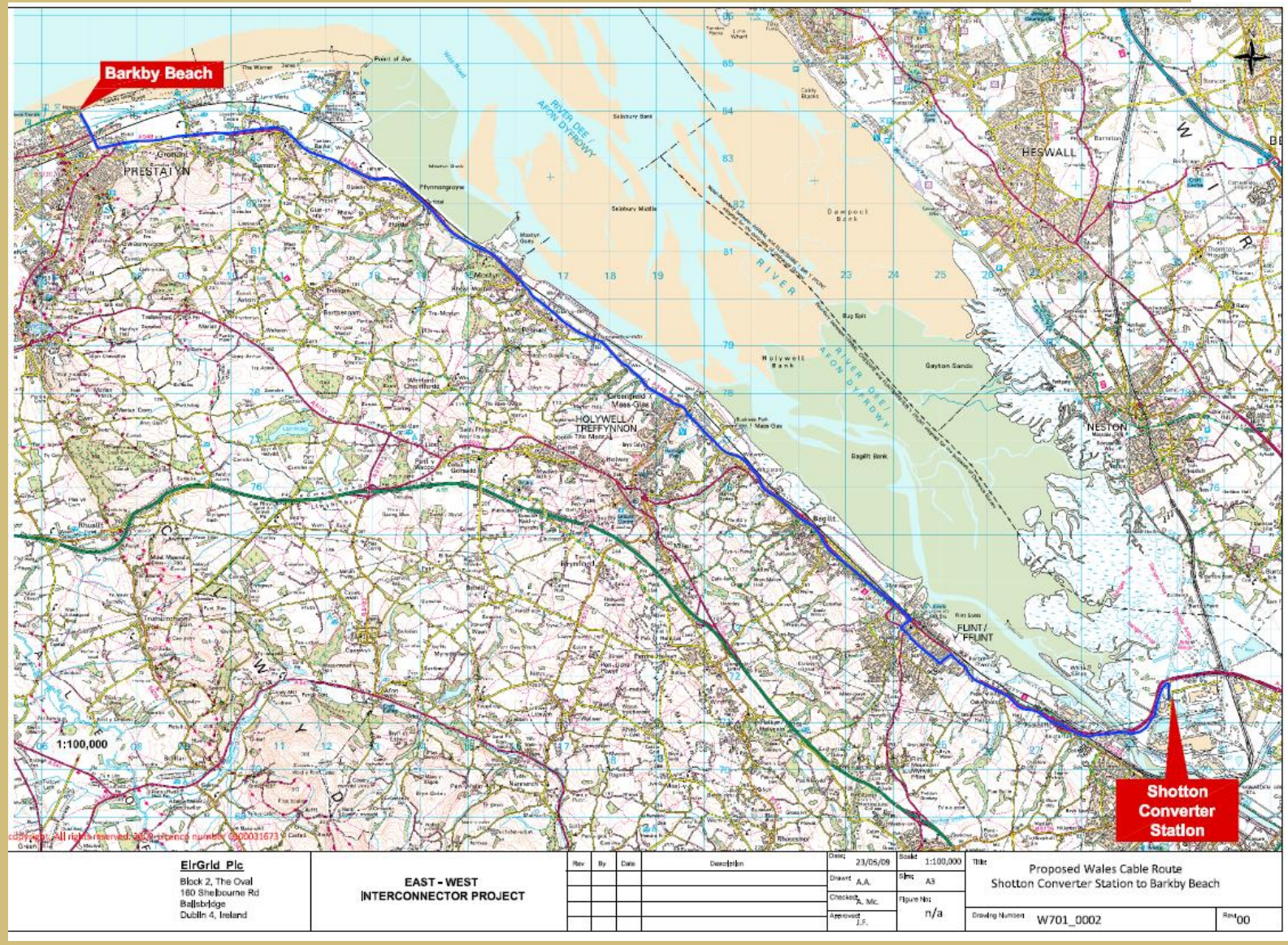
* subject to planning and procurement


Parallel Processes
2007
08
09
10
11
12
Route Dev
BCAP
26 months
30 months
Procurement
Design
Construction
Project Scoping
Contract Award
Financial close

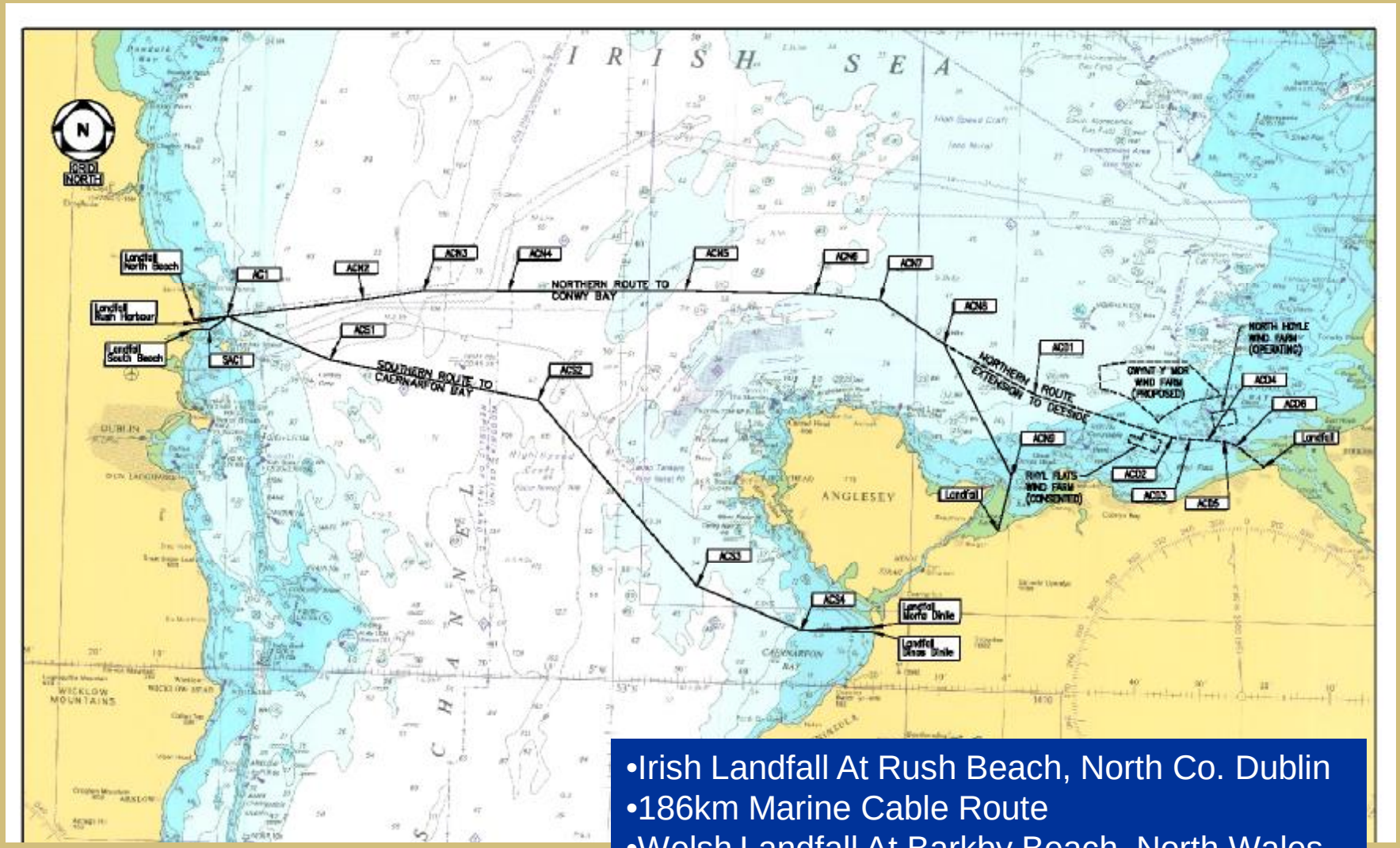

•Connects To Irish Grid At Woodland 400kv Substation
•Irish Land Cable Route – Approx 45km
Moyle Interconnector
Proposed
East West Interconnector
Woodland
Rush
Dublin
Irish Sea
Holyhead
Liverpool
Deeside
•Connects To UK Grid At Deeside 400kv Substation
•Welsh Land Cable Route – Approx 30km

Irish Land Route

Welsh Land Route

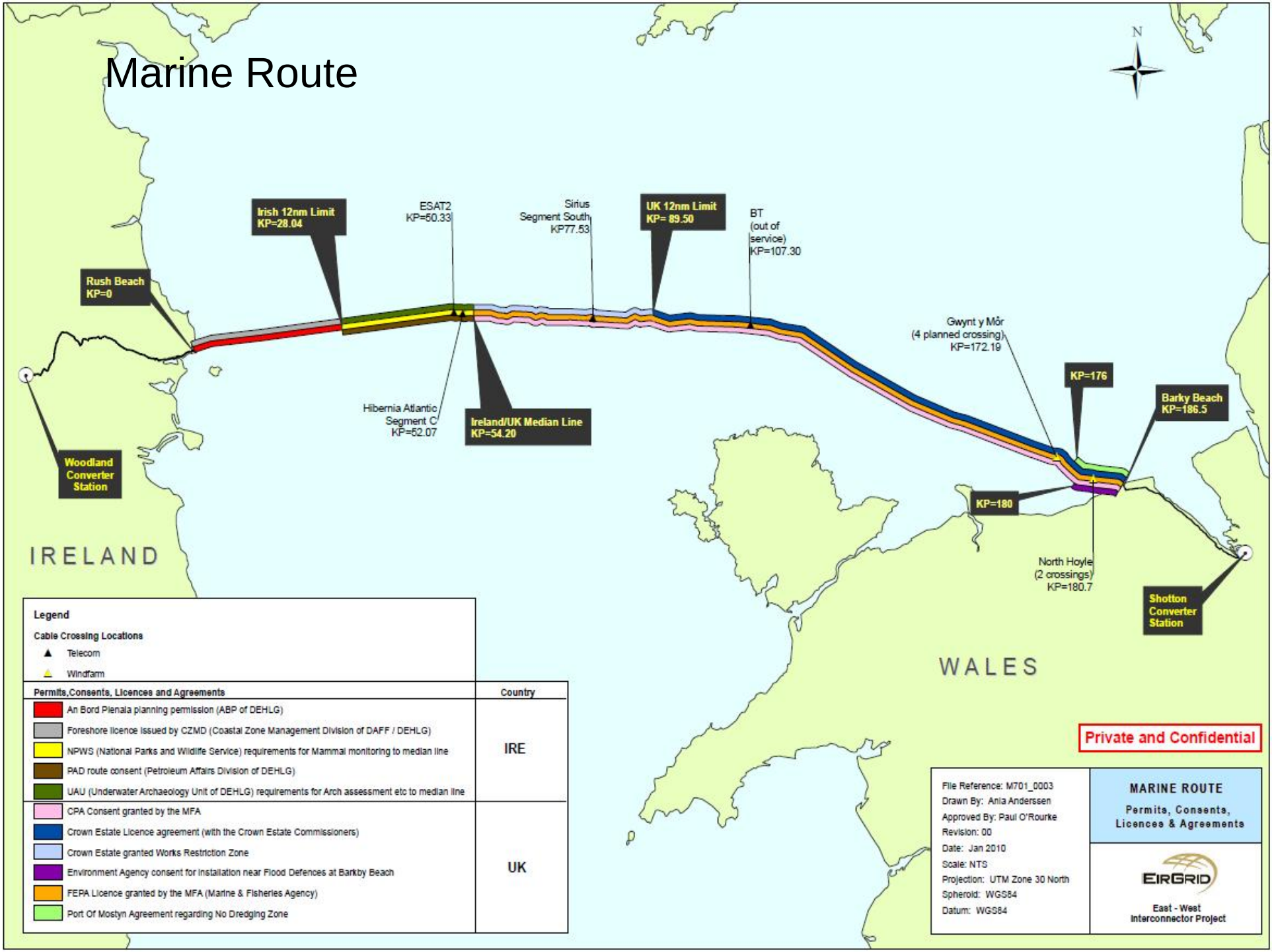


Marine Routing



- Irish Landfall At Rush Beach, North Co. Dublin
- 186km Marine Cable Route
- Welsh Landfall At Barkby Beach, North Wales

Marine Route



Marine Survey

FUGRO

OSAE

Recent Milestones

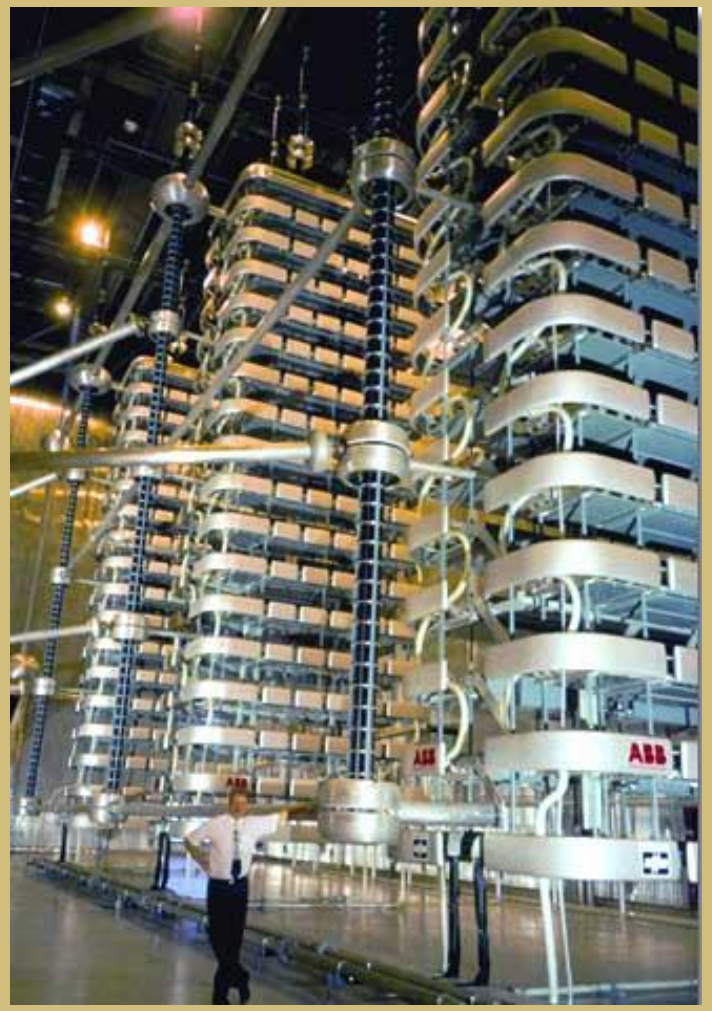
• Government Approval / Contract Award	March 2009
• Planning Permission in Britain	Sep 2009
• Planning Approval Granted in Ireland	Sep 2009
• European Investment Bank funding secured	Sep 2009
• Granted Foreshore Licence in Britain	Oct 2009
• Commencement of Works in Wales	Nov 2009
• EU Grant secured	March 2010
• Full Notice to Proceed	March 2010

North Ocean 102 Cable Laying Vessel
ABB HVC Karlskrona

Road works in Wales

Facts & Figures

- 500MW Continuous Rated Power
- Overload Capacity Up To 550MW
- DC Cable Voltage ±200kV
- Reactive Power Capability
- Total Estimated Losses At Rated Power – 30MW
- Completion Date Q3 2012



EWIC – Technical Presentation

- LCC and VSC Converters
- ABB VSC Projects
- VSC Main Circuit Plant
- EWIC Converter Station Layout
- EWIC Bridge Operation
- EWIC Control Interface
- Questions

ABB HVDC Light© - Features

- Inherent Capability To Operate In A Weak Or Dead AC Network
  - Has Black Start Capability
  - Block load pick-up, frequency droop (VSC is the swing bus)
- Can Control Active and Reactive Power Flows Fast and Independently
- Can Be Operated As Static VAr Compensators
- Less Shunt Capacitance Required For Filtering
- Very Reliable With Redundancy Provided For All Parts
- Will Be Operated Remotely From National Control Centre (NCC) In Dublin

Other HVDC Light© Interconnectors

- ABB has Significant Operational Experience with HVDC Light

Project	Country	In Service (Year)	Power (MW)	DC Voltage (kV)	Distance (km)	Connection
HÄLLSJÖN	Sweden	1997	3	+/- 10	10	Over head
GOTLAND	Sweden	1999	50	+/- 80	70	Cable
DIRECTLINK	Australia	2000	180 (3 x 60)	+/- 80	65	Cable
TJÆREBORG	Denmark	2000	7.2	+/- 9	4.4	Cable
EAGLE PASS	USA	2000	36	+/- 15.9	0	Back to Back
CROSS SOUND	USA	2002	330	+/- 150	40	Cable
MURRAYLINK	Australia	2002	220	+/- 150	180	Cable
TROLL A	Norway	2005	82 (2 x 41)	+/- 60	67	Cable
ESTLINK	Estonia to Finland	2006	350	+/- 150	105	Cable
VALHALL	Norway	2010	78	150	292	Cable
NORD E.ON 1	Germany	2009	400	+/- 150	203	Cable
CAPRIVI LINK	Namibia	2010	300	350	970	Over head
EWIC	Ireland to UK	2012	500	+/- 200	260	Cable

HVDC - LCC “Classic” and VSC “Light ©”

Capability	LCC	VSC
Bulk Power Transmission	Up to 3000 MW	Up to 500 MW (present)
Black start	No	Yes
Weak networks	No	Yes
Dynamic reactive control	No	Yes
Reactive damping	No	Yes
Power reversal (time)	Limited	Fast
Dynamic power control (including run-back)	Yes	Yes
Real-power damping	Yes	Yes
Frequency response	Yes	Yes
Harmonic filters required	Yes	Yes (less)
Losses	Yes (less)	Yes

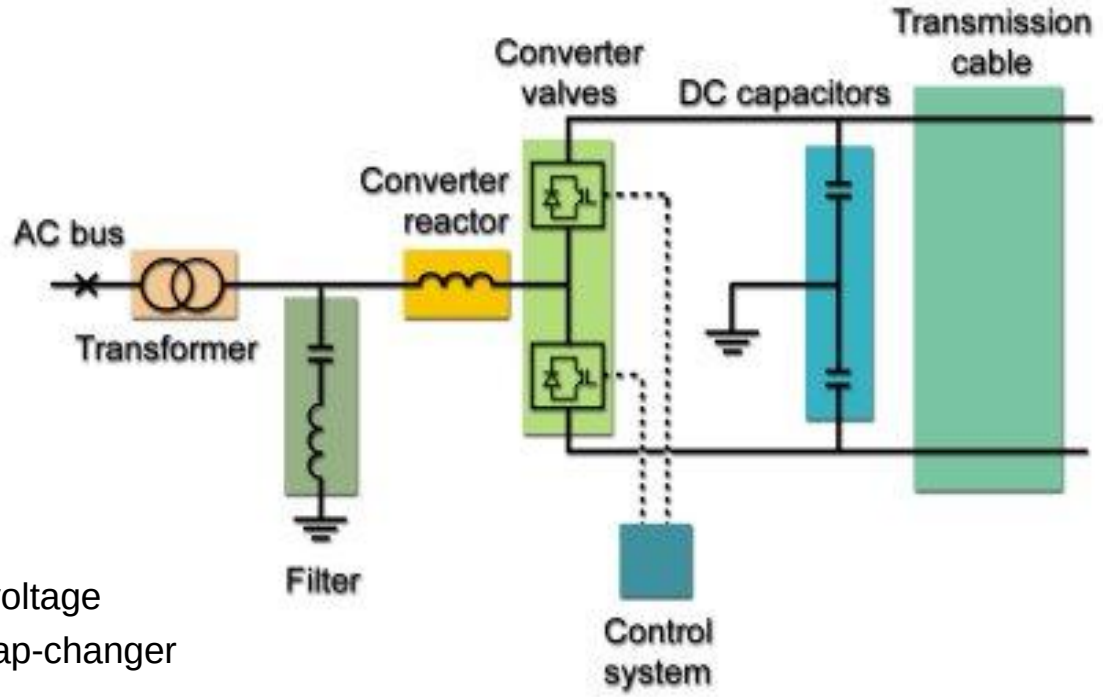
ABB HVDC Light© - Converter Components

– Bridge
- IGBT with anti-parallel diode
- Optical triggered IGBT's
- 2, 3 and Multi Level Bridges

– Phase Reactor
- Energy Storage, LP Filter

– Filters
- Shunt higher harmonics

– Transformer
- Match system voltage to filter bus voltage
- Extend reactive power range with tap-changer
- EWIC: 400kV/260kV



Voltage Source Converter Technology

- LCC Utilise Thyristors
- VSC Utilise Solid State Devices – IGBTs (Insulated Gate Bipolar Transistors)
  - Low Voltage Drop
  - Rated For High Currents
  - Robust under short circuits
- Not reliant on line or external circuit to force commutation
- Means VSC can be used to supply dead or weak networks
- Can Achieve Full Power Reversal Almost Instantly

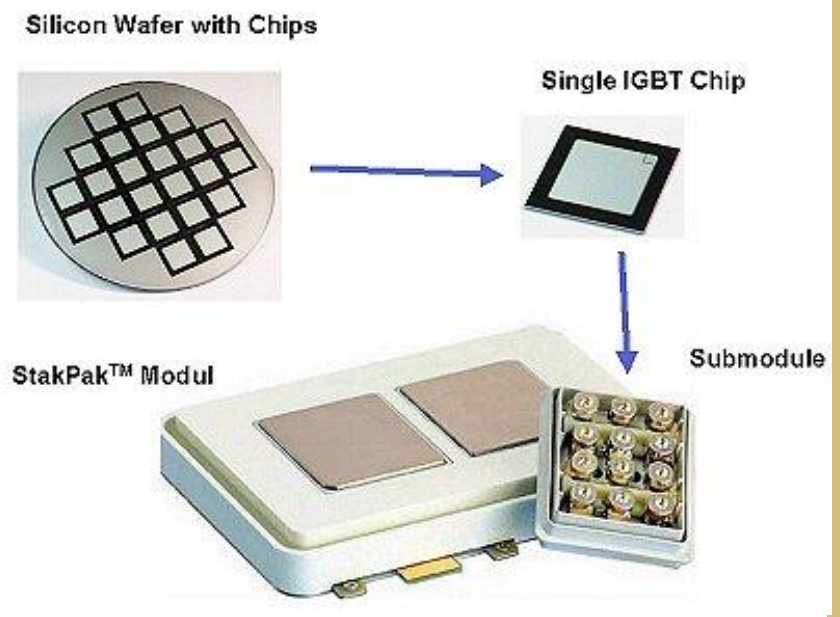
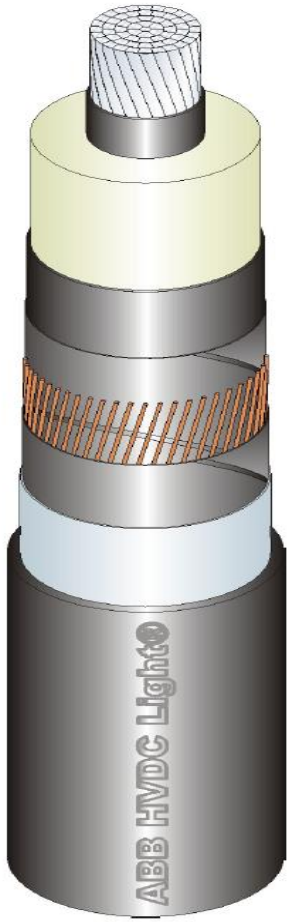
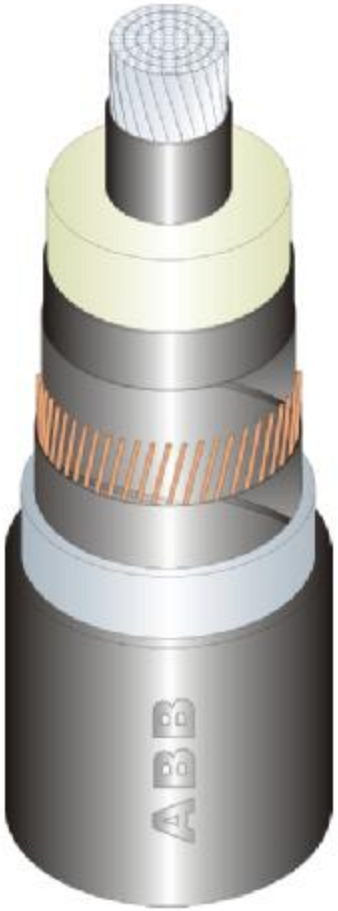


ABB HVDC Light© - Examples of Cables

DC sea cable

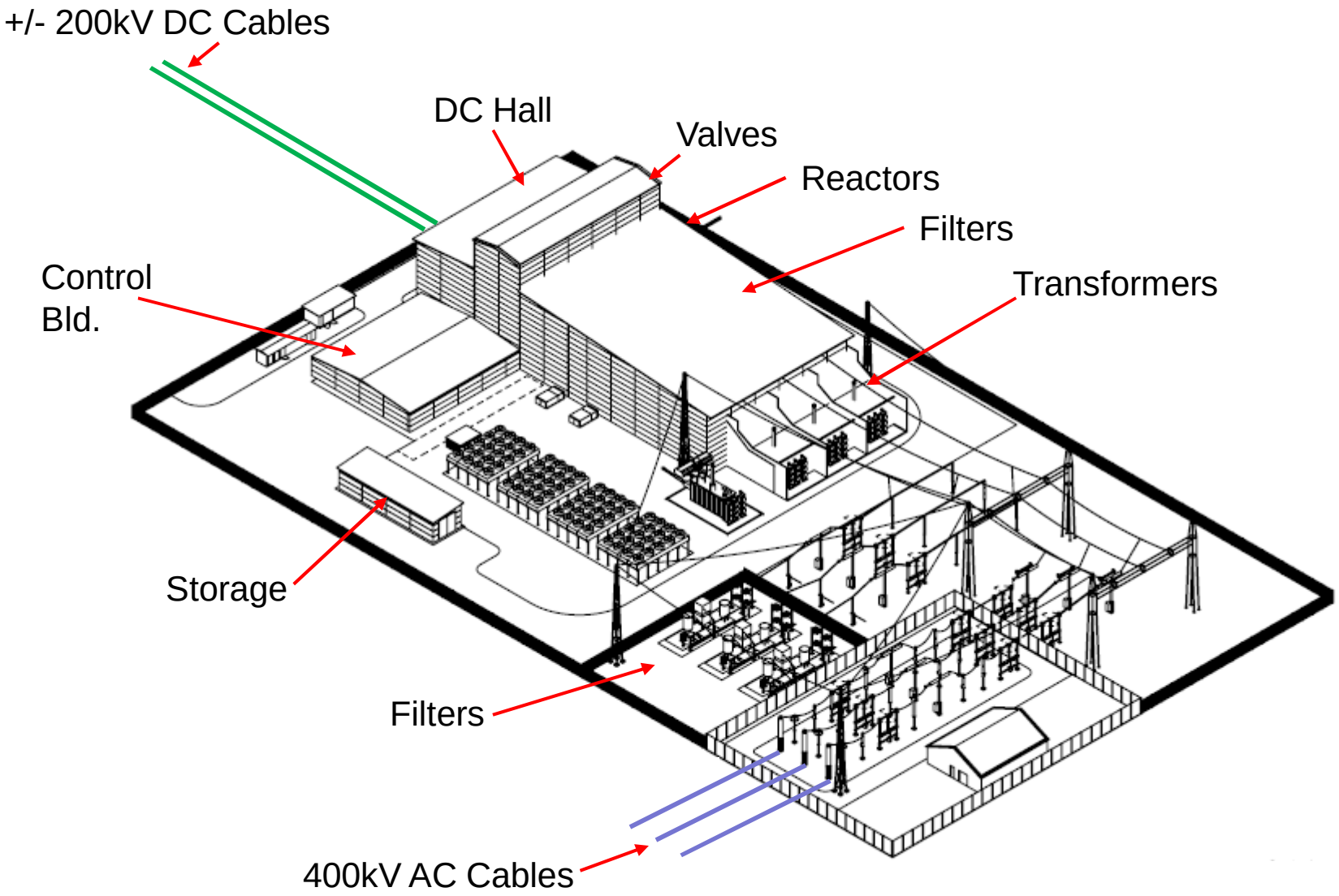


DC land cable



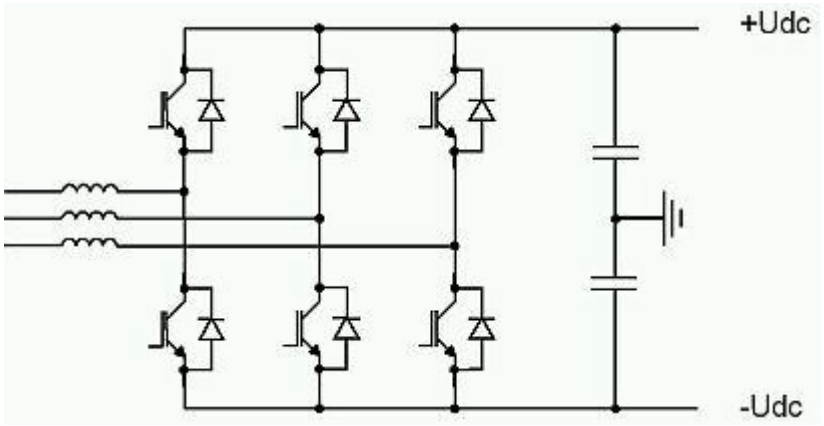
AC 400kV cable

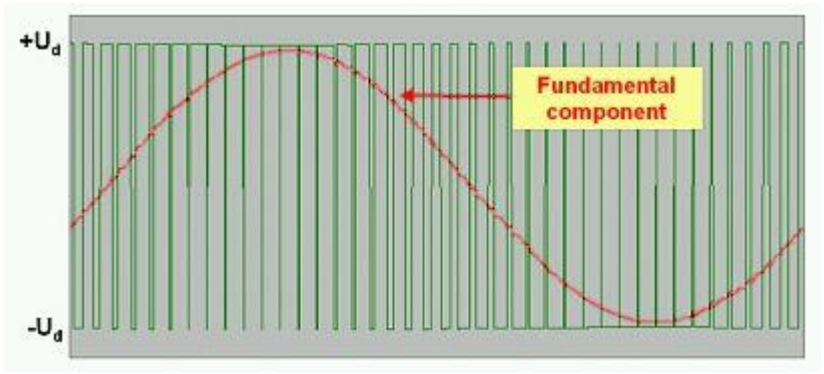
ABB HVDC Light© - EWIC General Layout



VSC Converter Technology

- **Voltage Source Converter:**
- Diagram shows a 2-level Pulse Width Modulation (PWM) bridge
- Fundamental frequency formed by filtering high frequency PWM voltage
- With PWM, it is possible to control both active & reactive power independently
- With OPWM, reduce losses, eliminate low-order harmonics



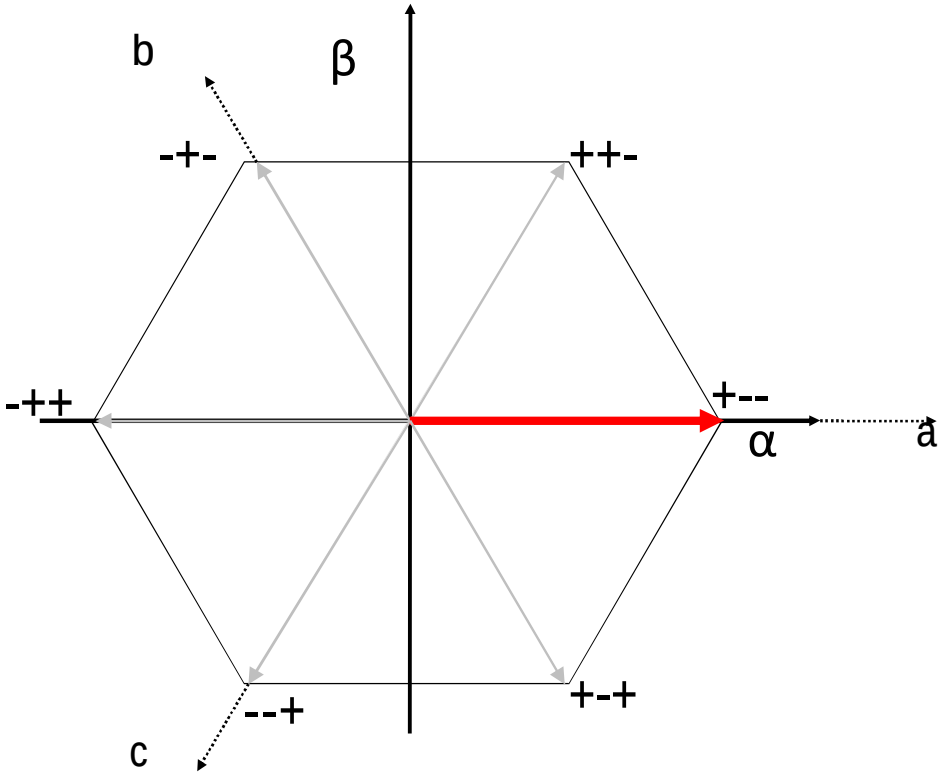


converter

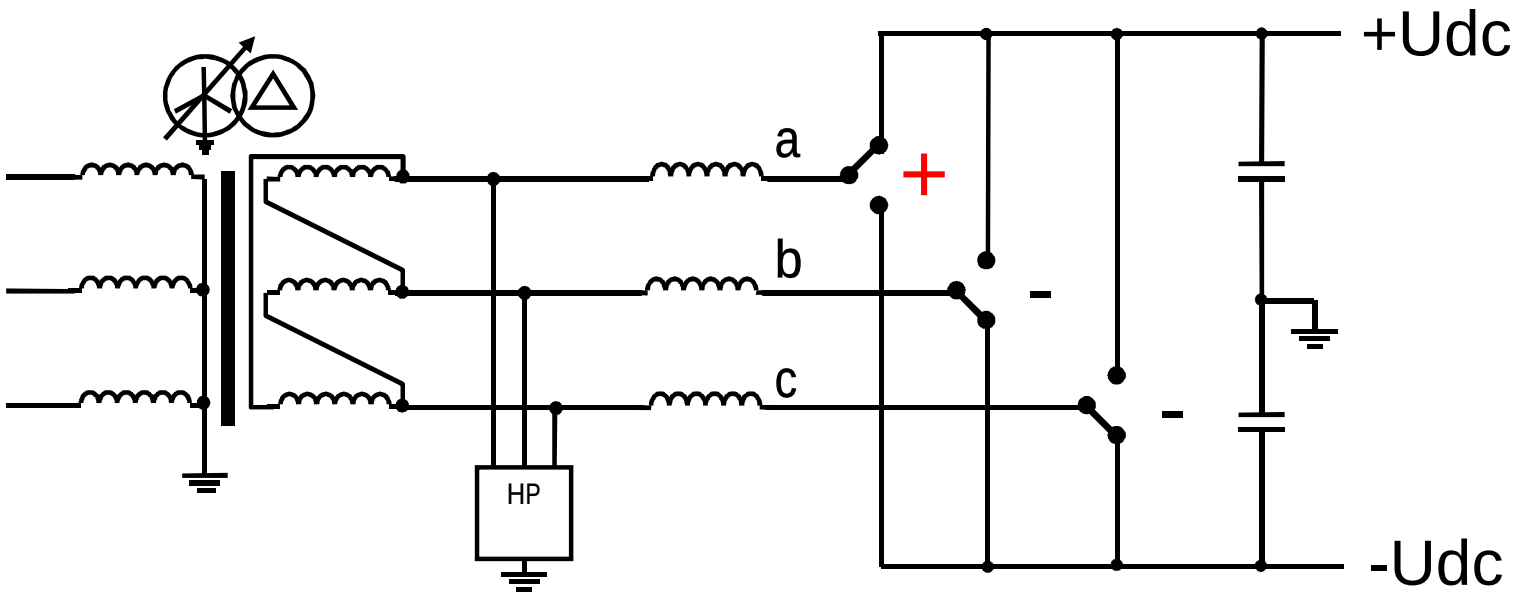
VSC – Voltage Representation

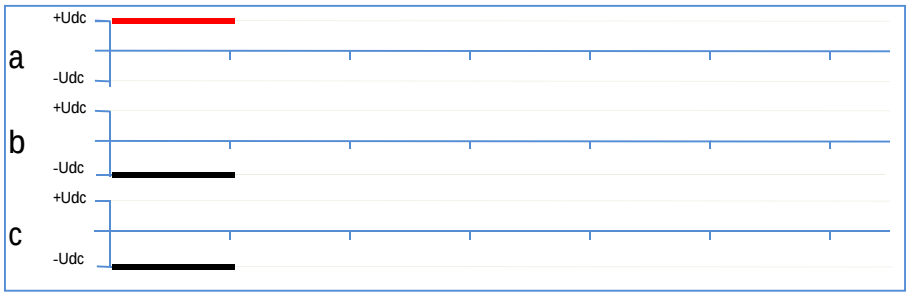
Vector representation:

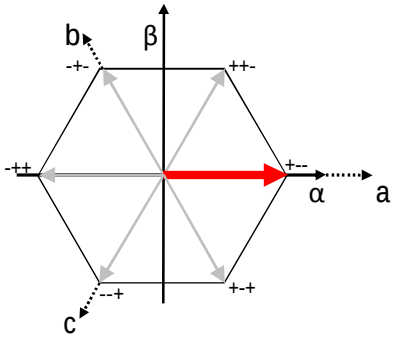
- Relates switch positions to phase potentials
- Relates phase potentials to zero-sequence free phase voltage
- Relates DC side current and voltage to AC side phase voltages
- For 3-phase 2-level bridge 8 realisable switch positions, 6 used for generating phase voltages



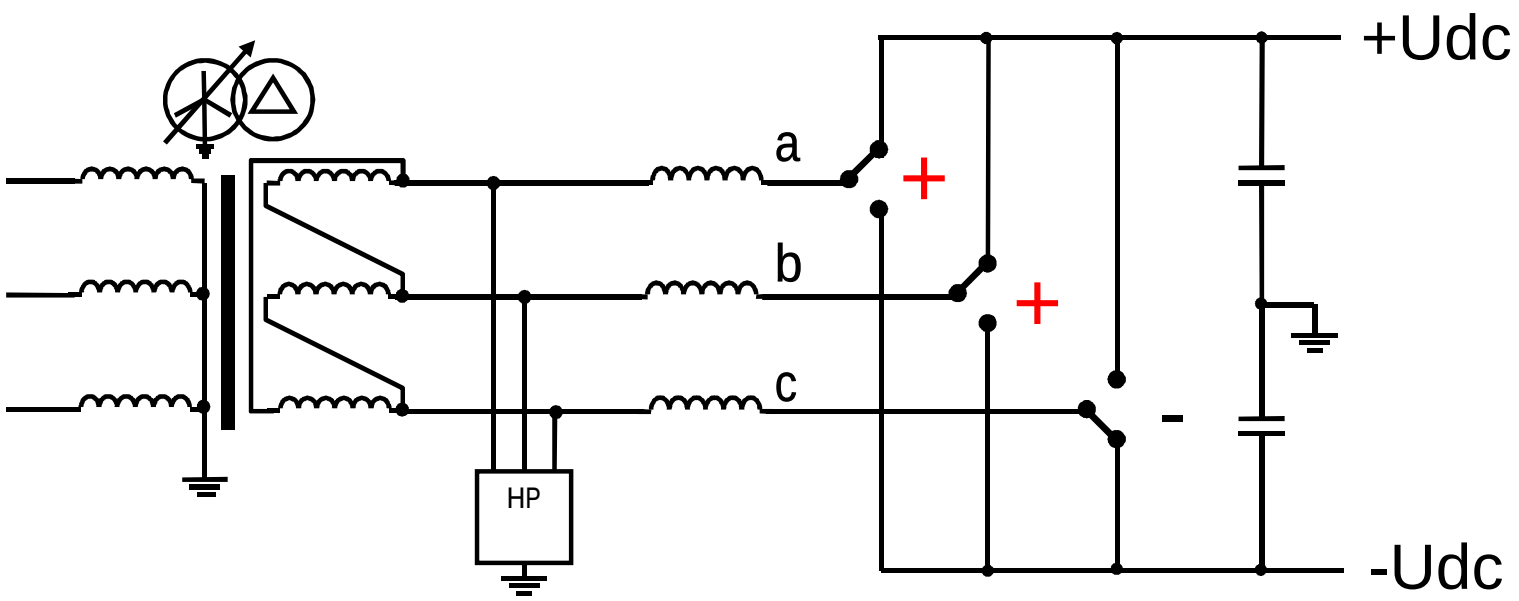
VSC - PWM Switching Sequences 1

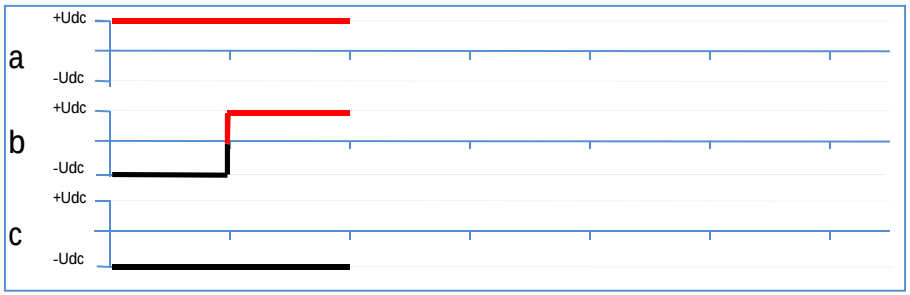


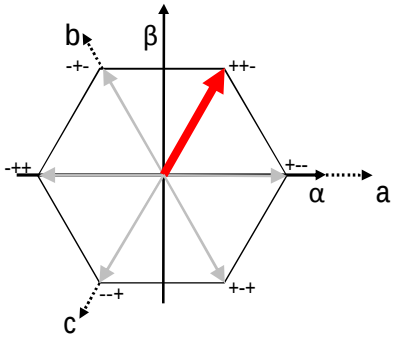




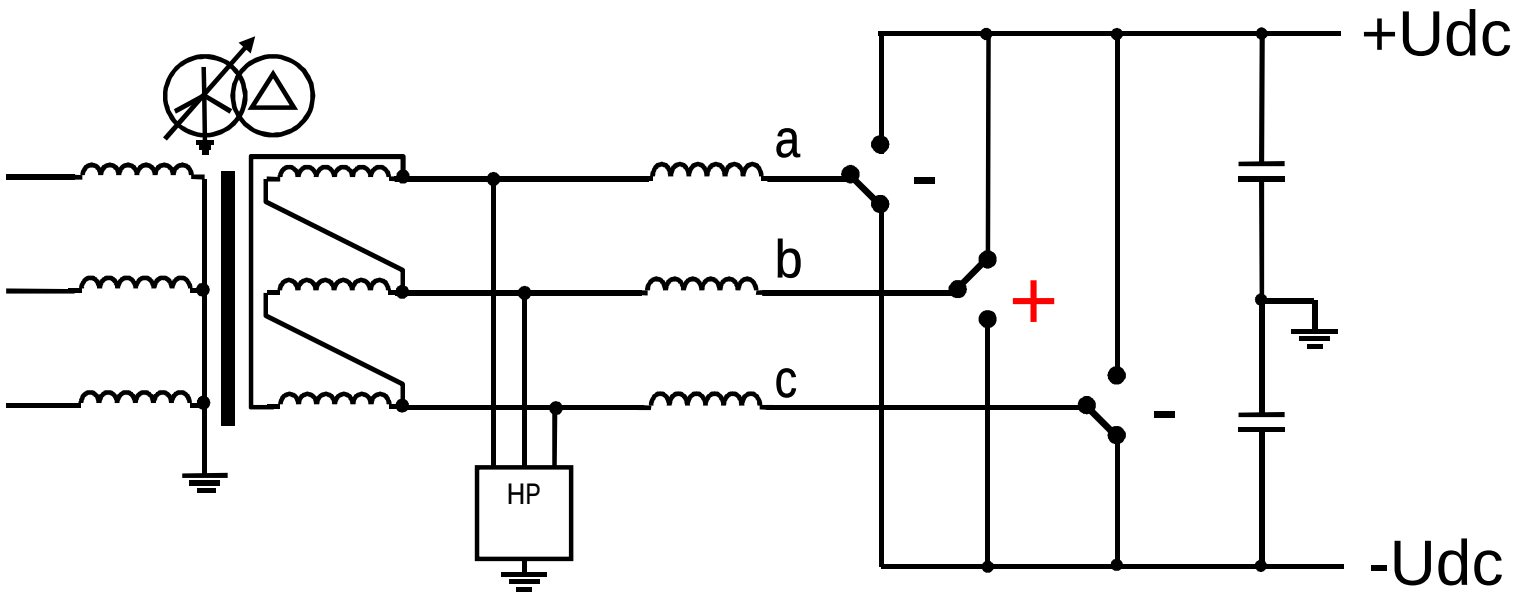
VSC - PWM Switching Sequences 2

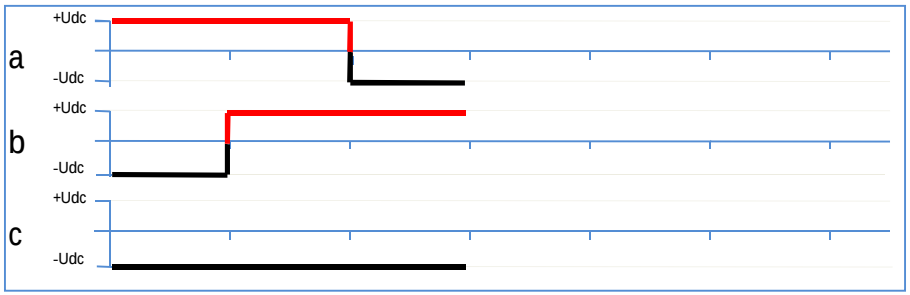


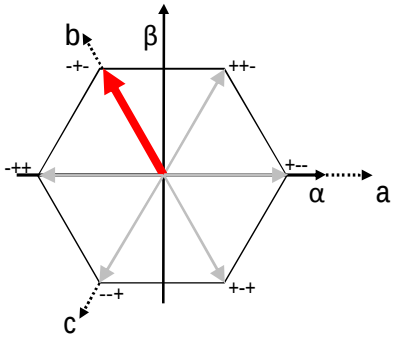




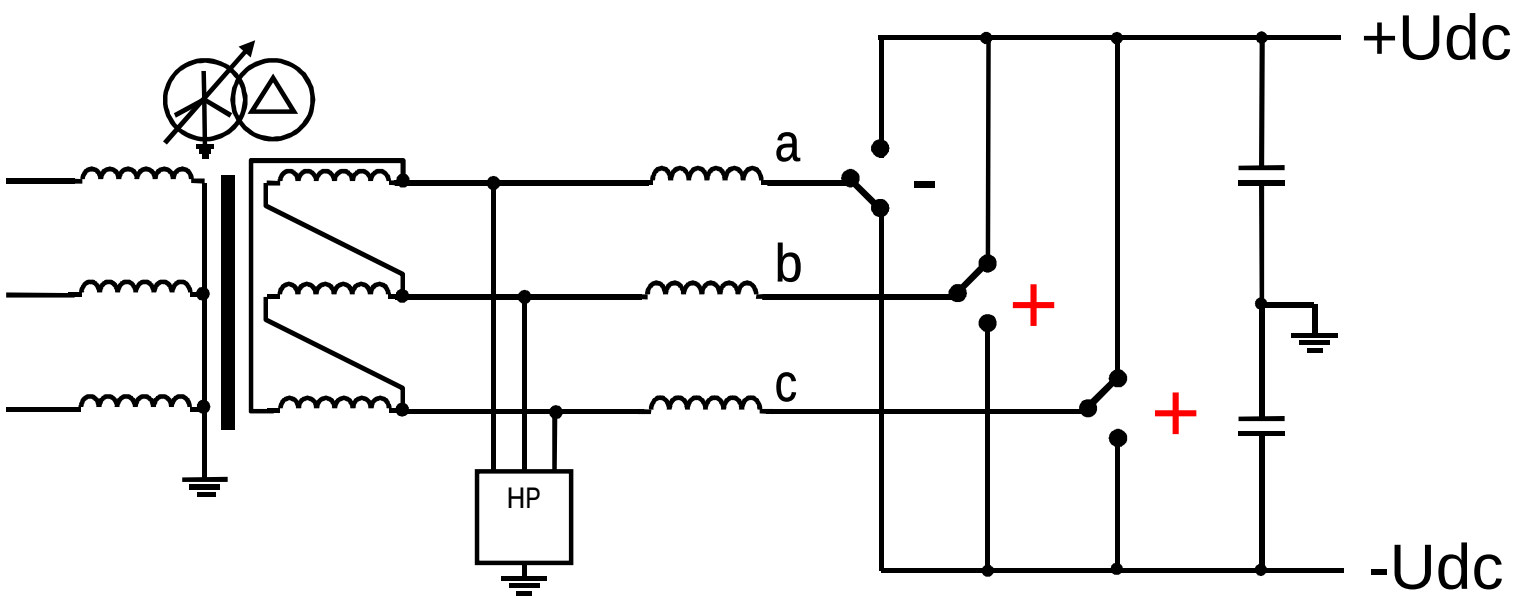
VSC - PWM Switching Sequences 3

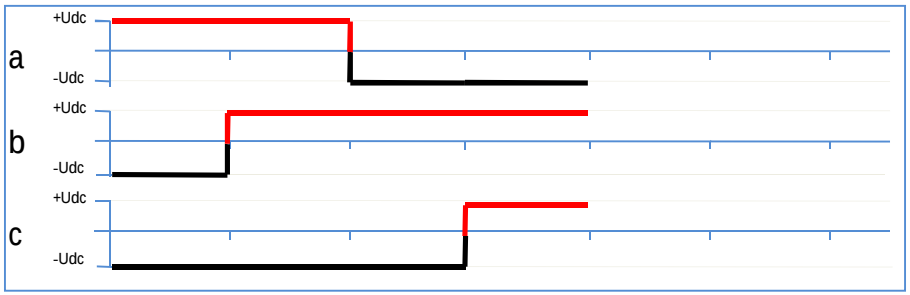


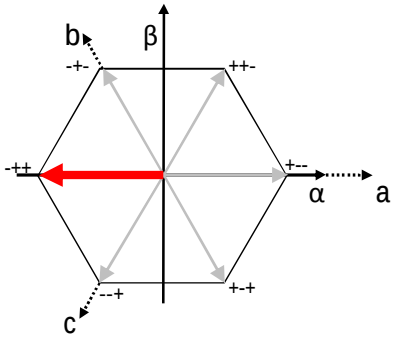




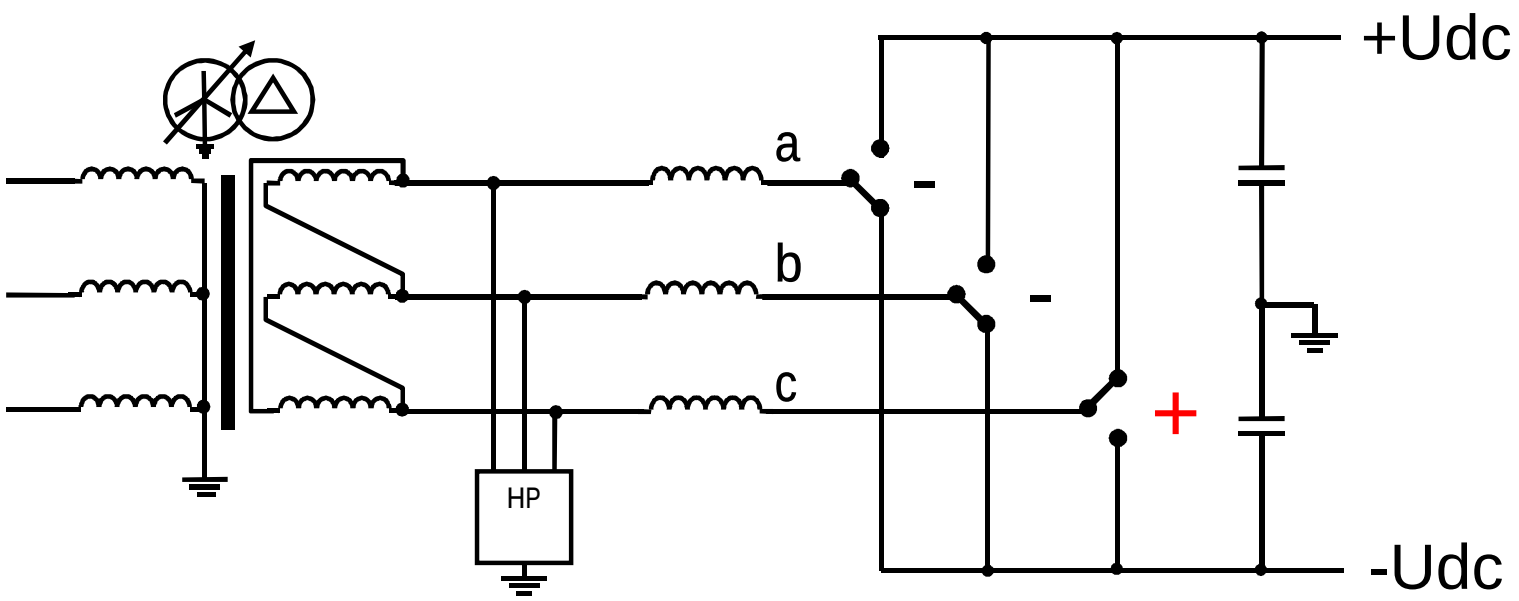
VSC - PWM Switching Sequences 4

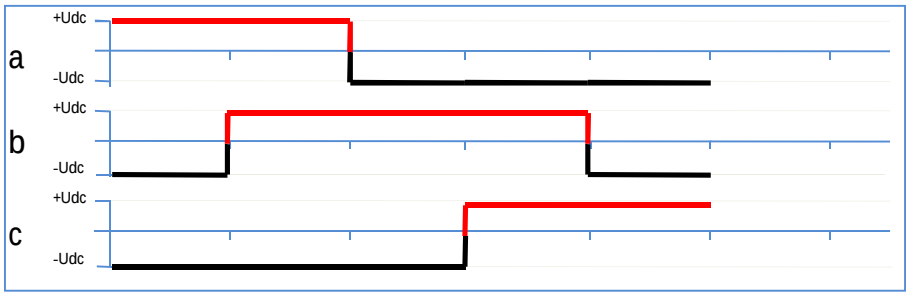


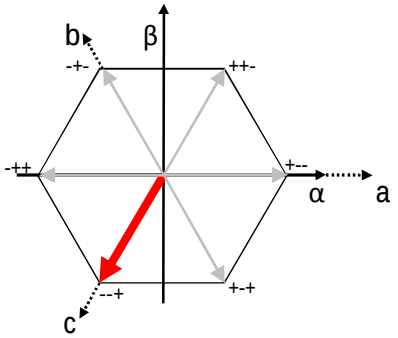




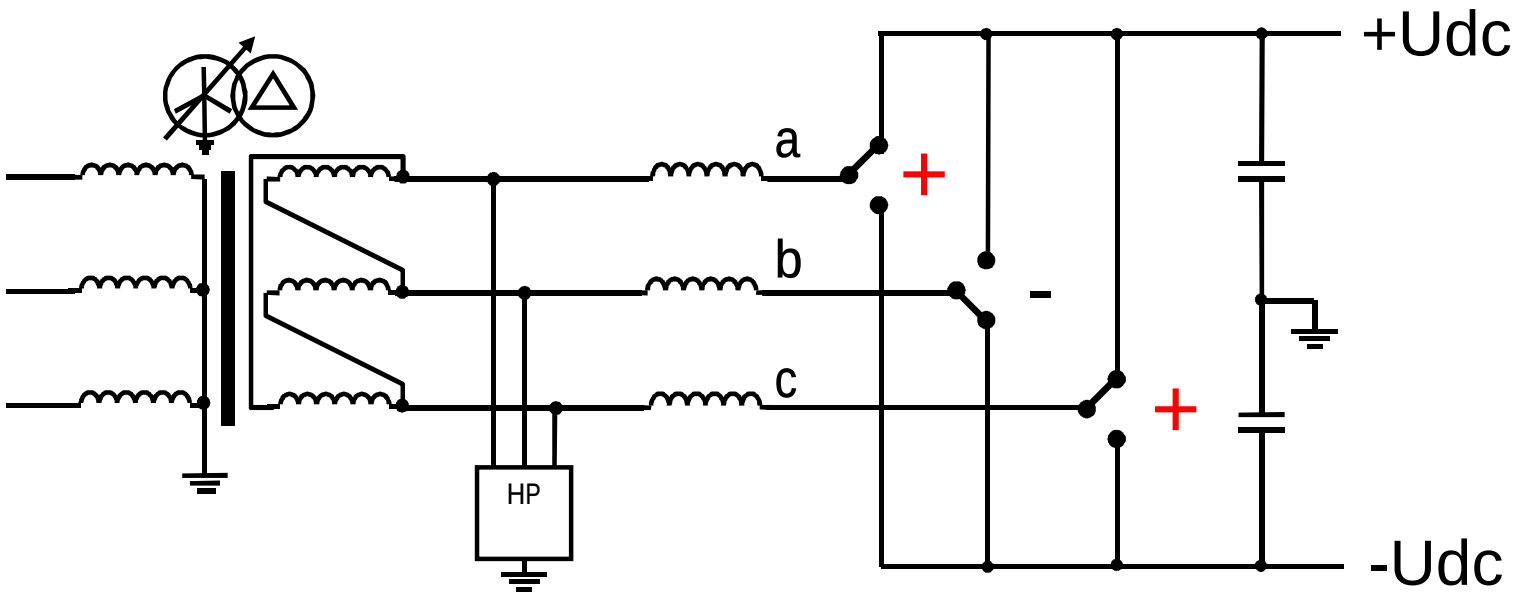
VSC - PWM Switching Sequences 5

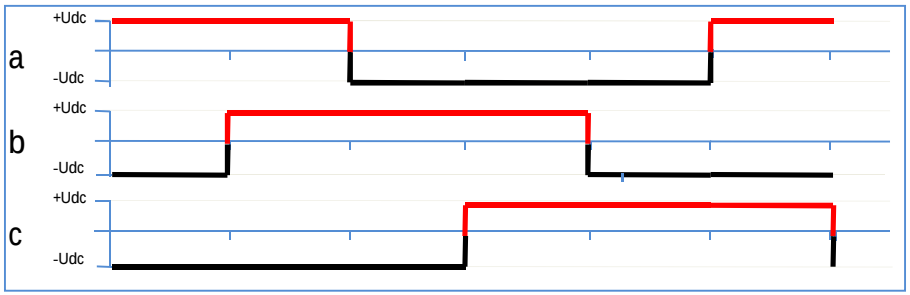


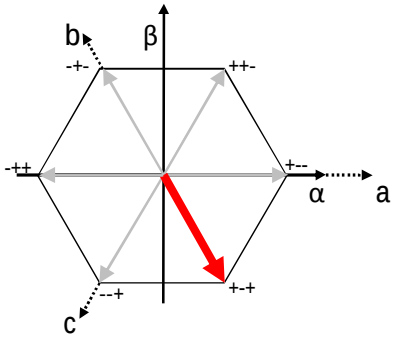




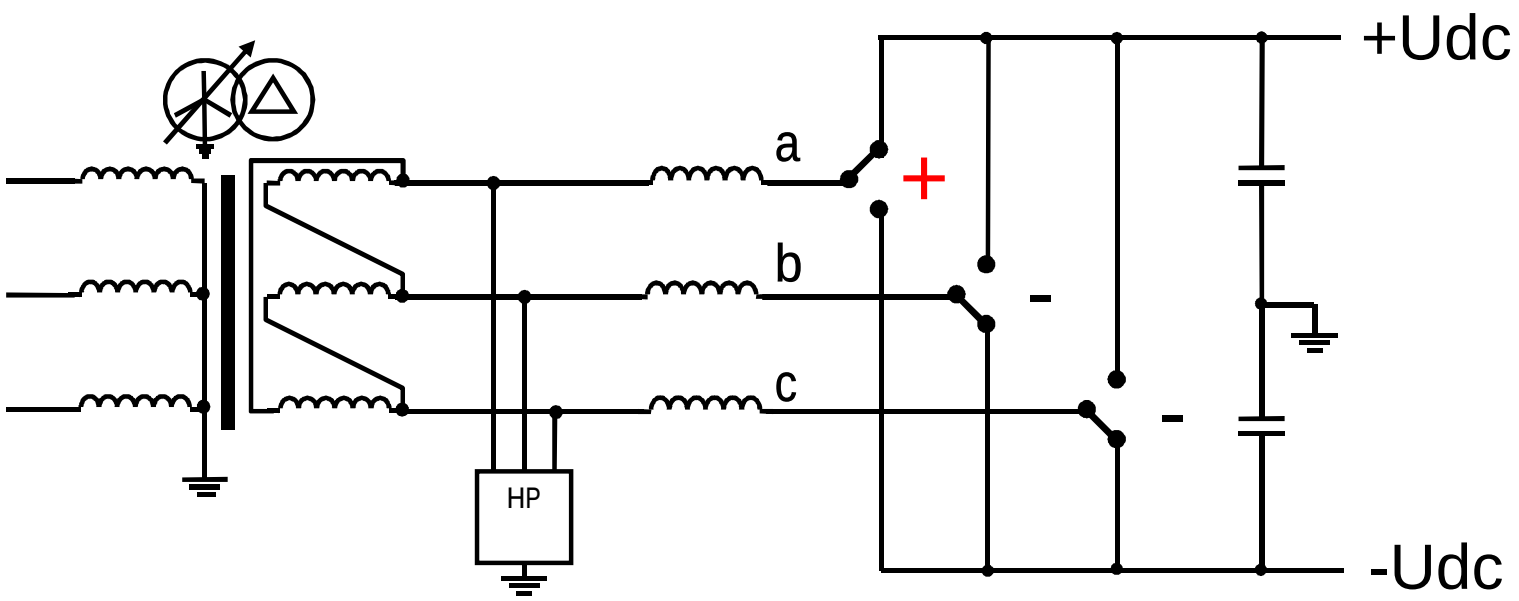
VSC - PWM Switching Sequences 6

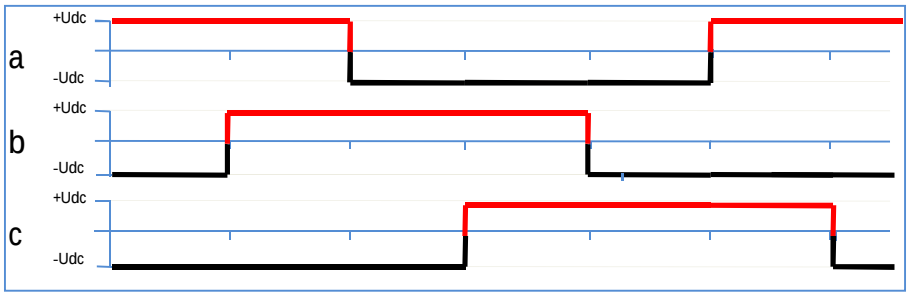


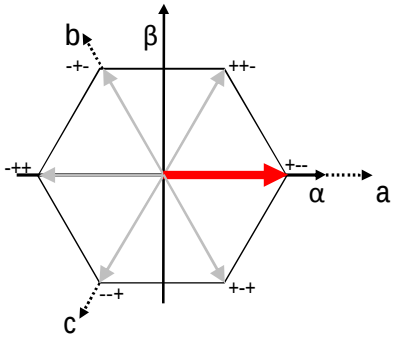




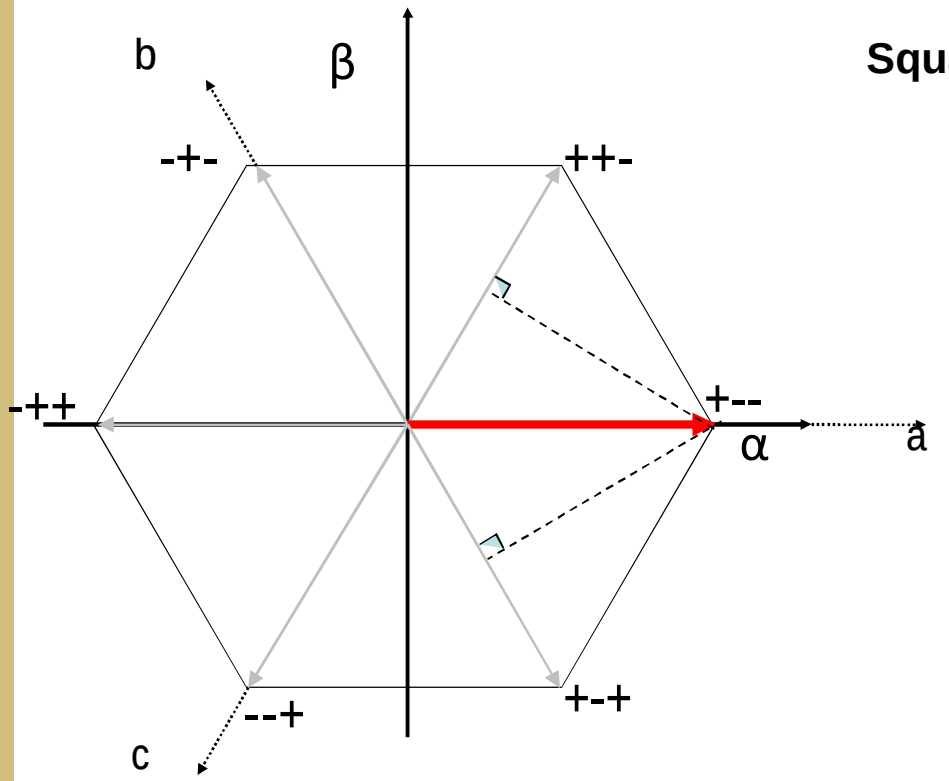
VSC - PWM Switching Sequences



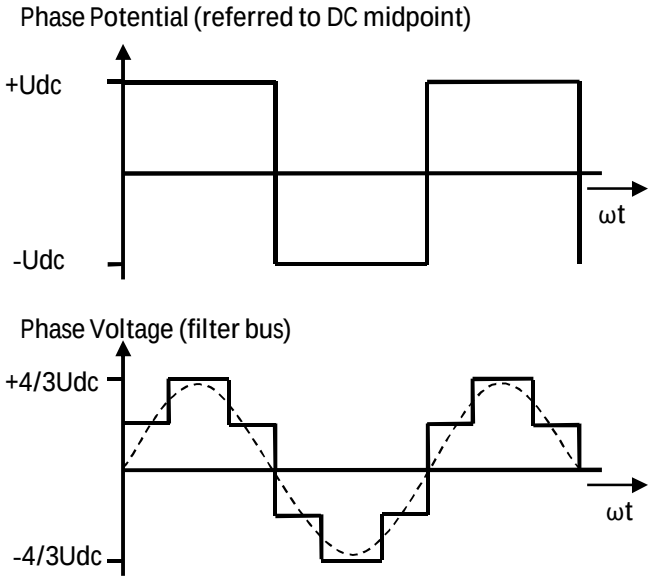




VSC – Harmonics

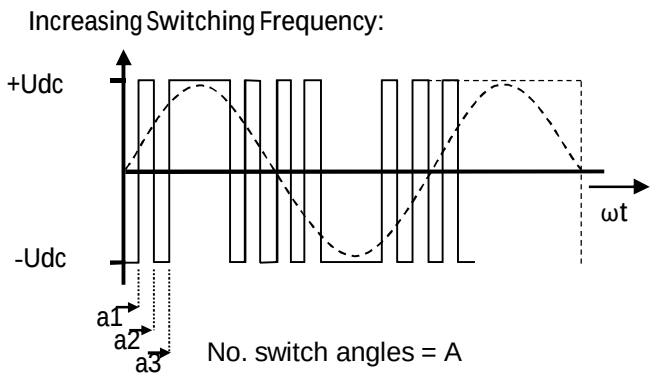


Square Wave Modulation:



By Fourier analysis:	
Positive Sequence	1, 7, 13, 19, 25, 31, 37.....
Negative Sequence	5, 11, 17, 23, 29, 35.....
Zero sequence	3, 9, 15, 21, 27, 33.....

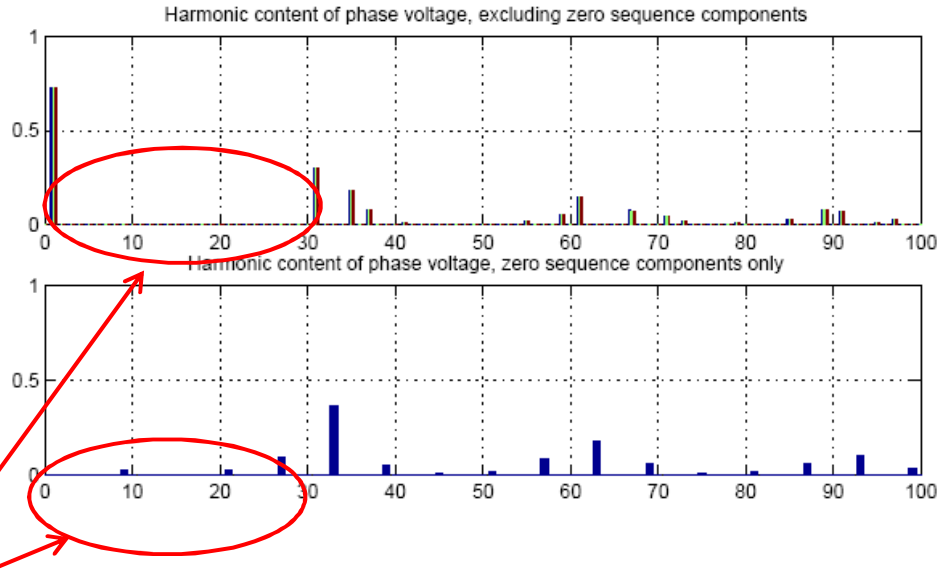
VSC - Harmonic Elimination with OPWM



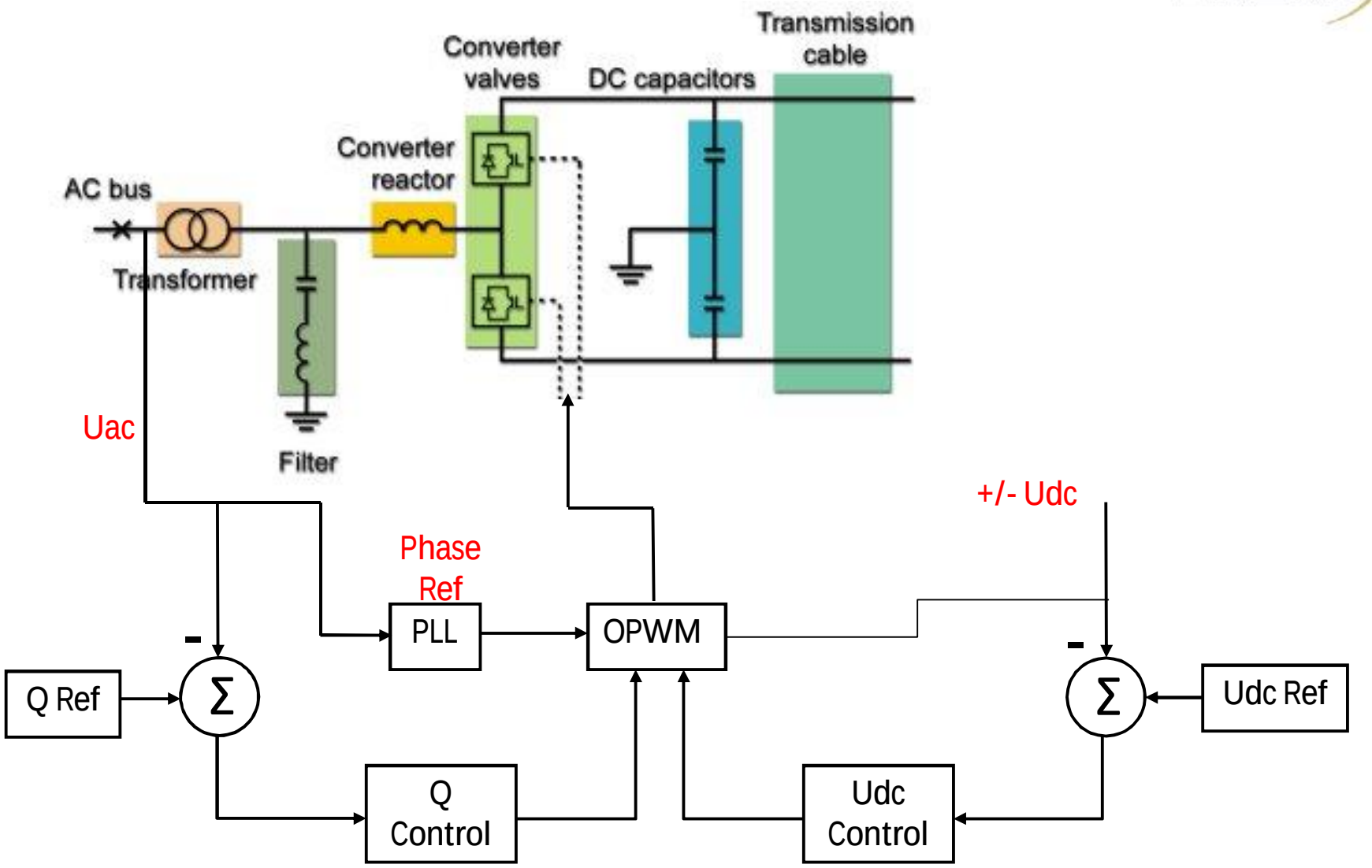
By increasing switching frequency:

- Increase degrees of freedom for harmonic elimination

- ¼ wavelength symmetric switching
- Eg. for 2-Level Bridge:
- A= 5 (eliminate up to 4 harmonics)
- Reduce need for filters, size of filters



VSC – Simplified Control Scheme



Converter – PQ Diagram (rated output)

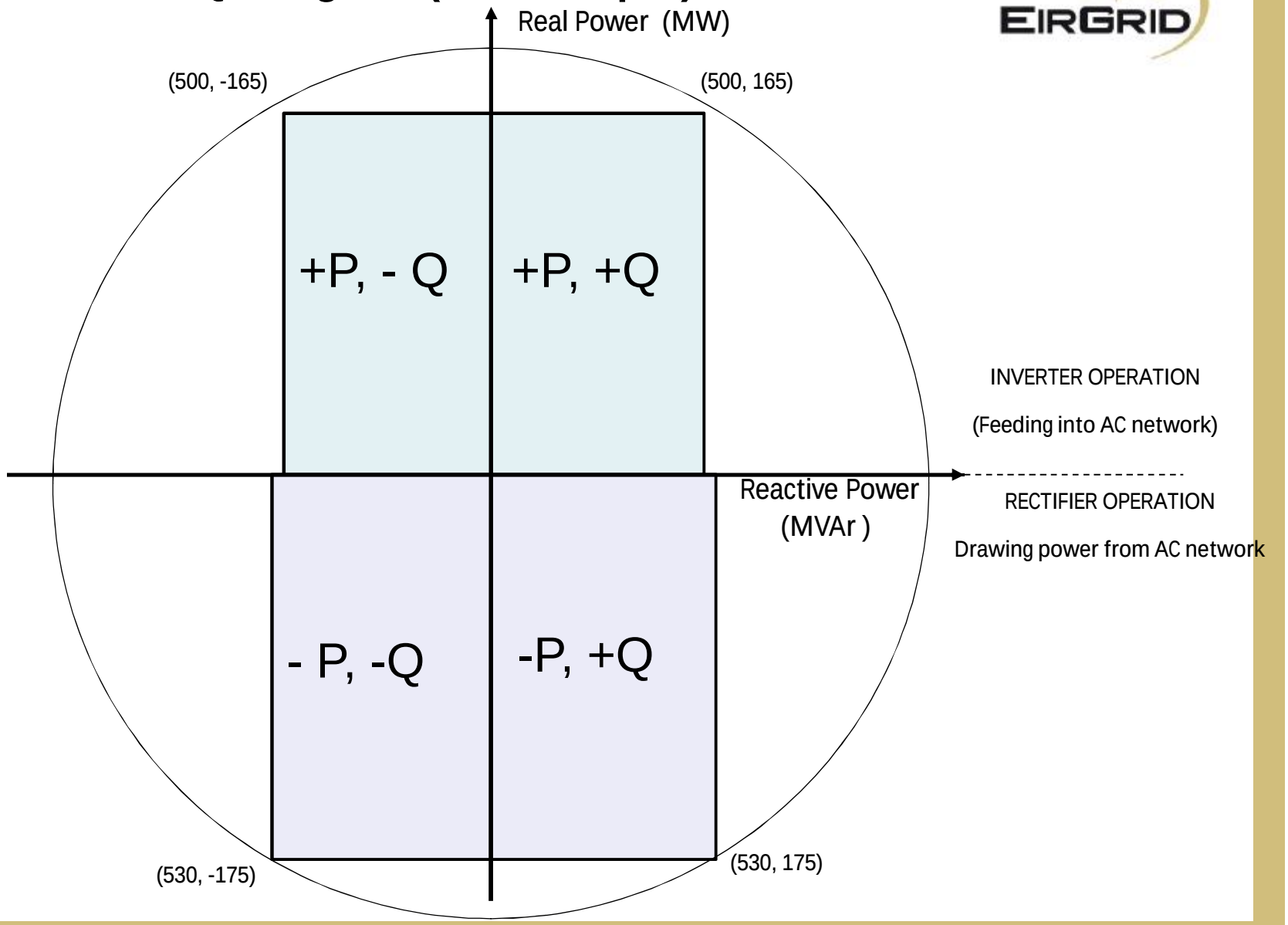
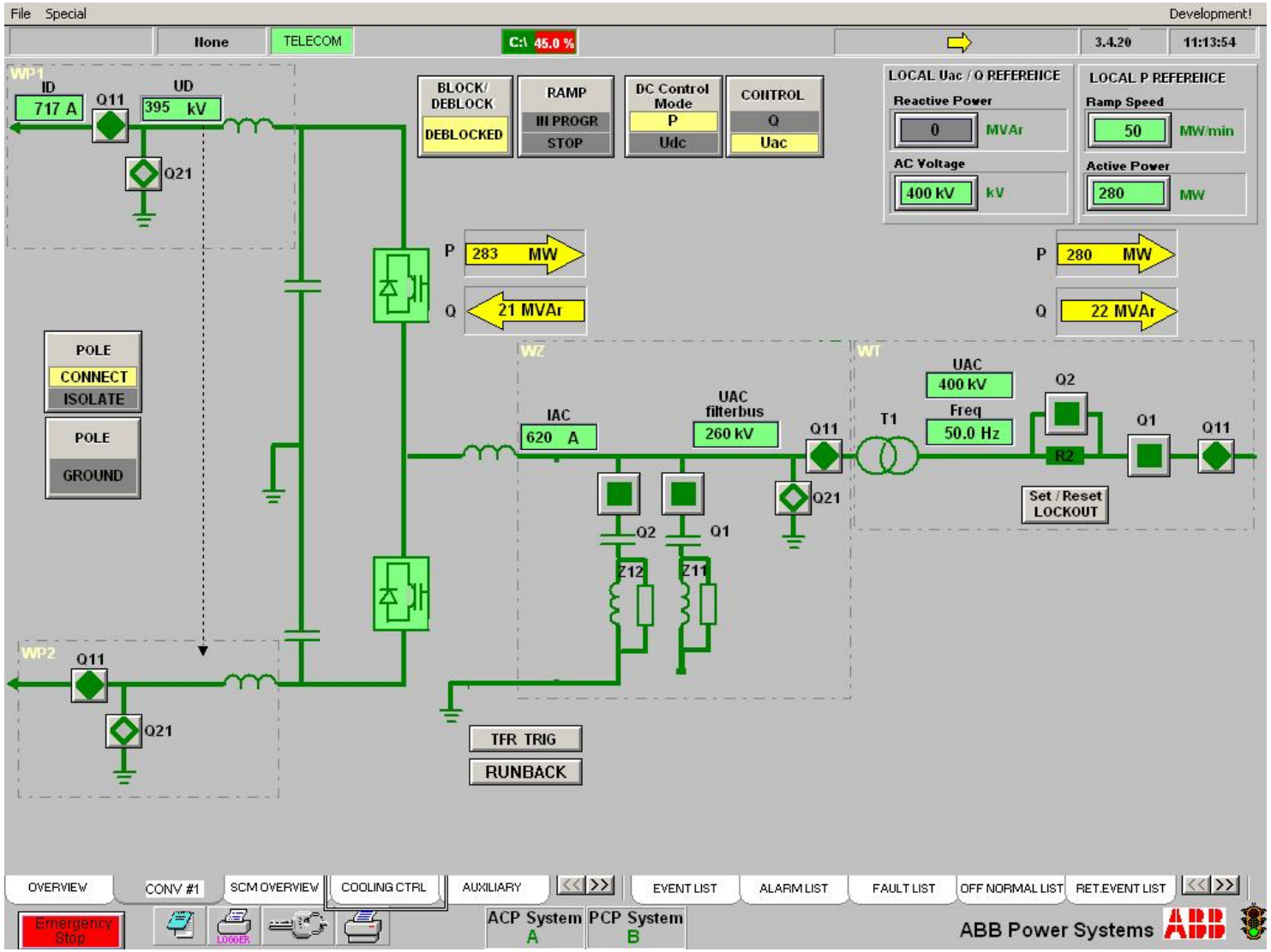


ABB HVDC Light© - Typical Operator Interface



Questions?

Further info:

EirGrid website: www.eirgrid.com
Project website: www.interconnector.ie
Planning websit www.eirgrideastwestinterconnector.ie
ABB HVDC: www.abb.com/hvdc