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Day 2

- **Key concepts of HVDC substation components**

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Technical Considerations

- **Bulk transmission of Power at voltages up to 800kV**
- **Back-to-back HVDC converters are used to connect two AC systems with different frequencies –two regions where AC is not synchronized**
- **Submarine Cable Transmission**
- **Transmission at reduced voltage**
- **Inherent Overload Capability**

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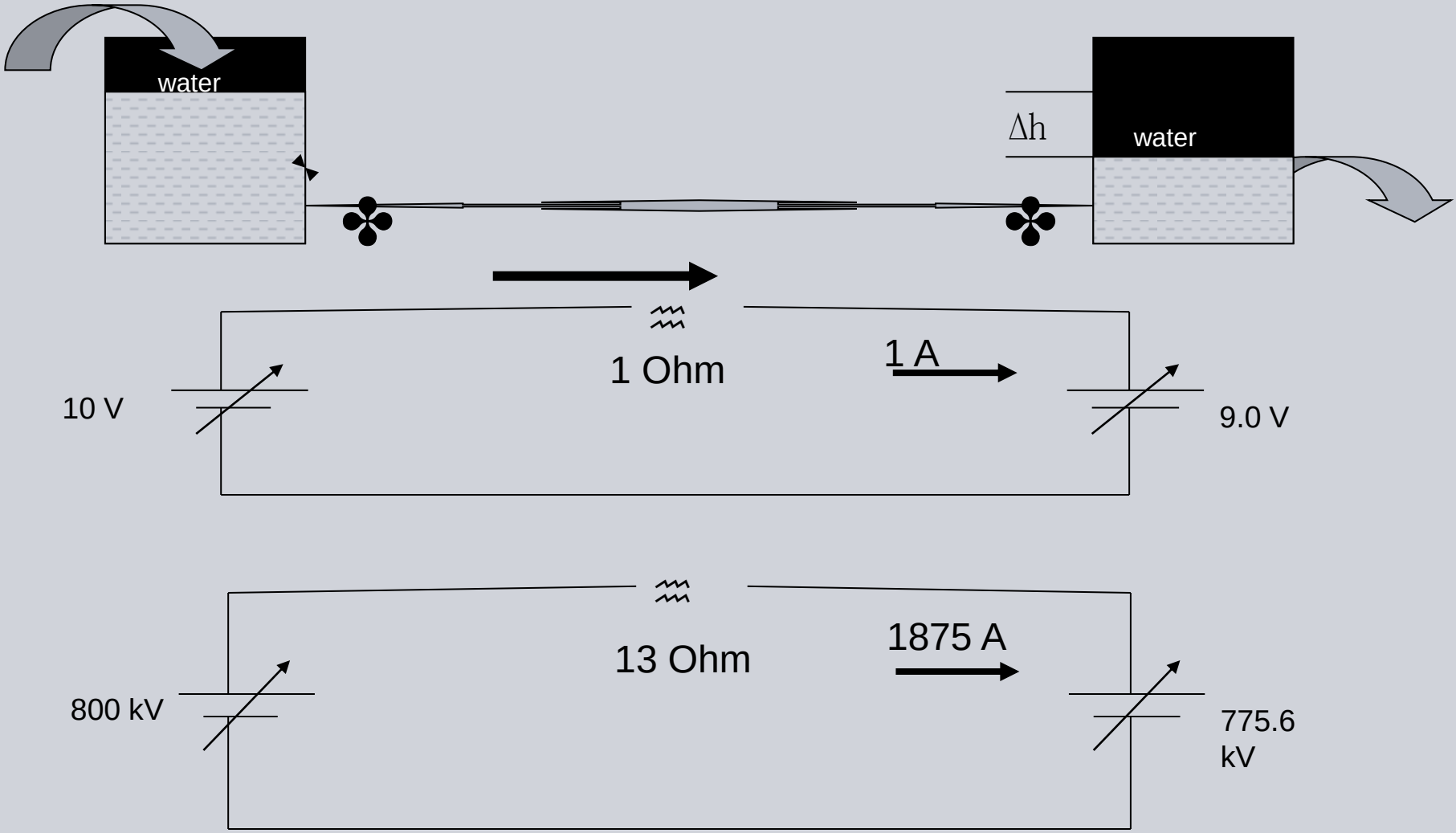
FUNDAMENTAL OF HVDC OPERATION



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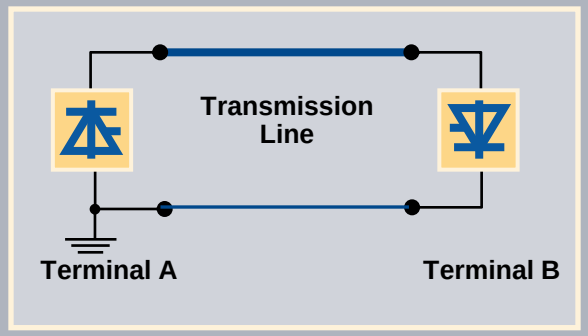
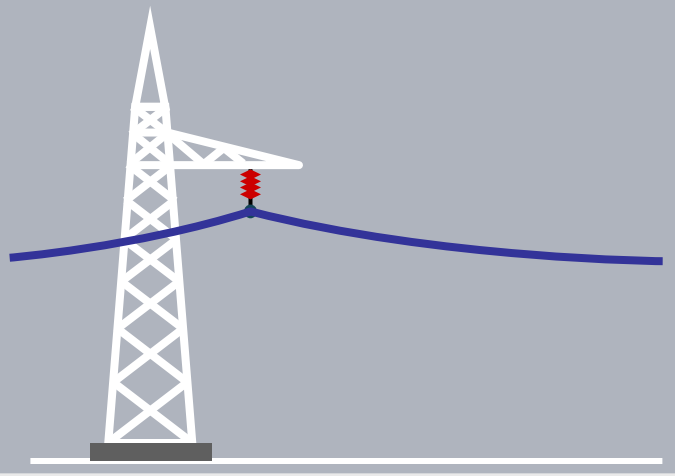
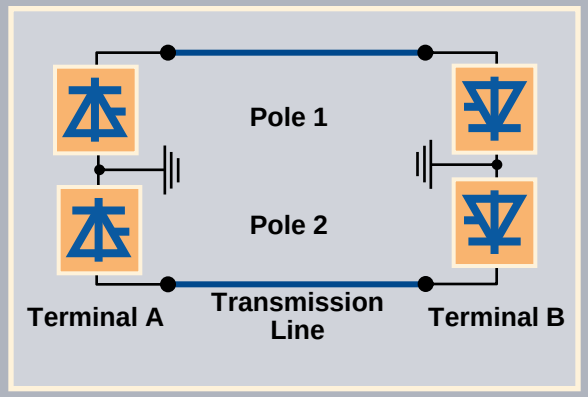
HVDC Long Distance Transmission Systems

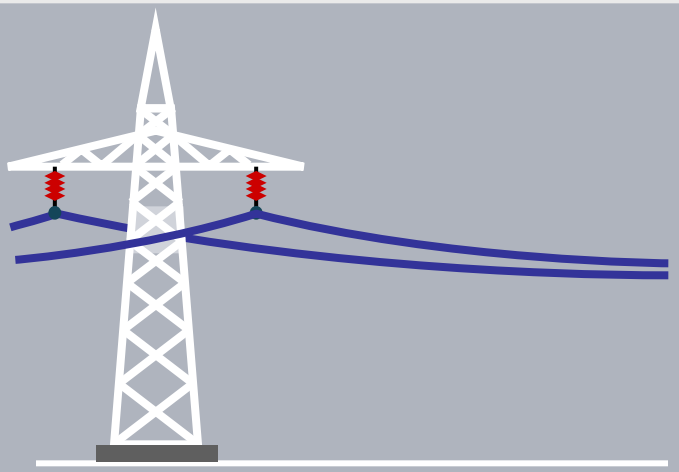
Monopolar





Bipolar





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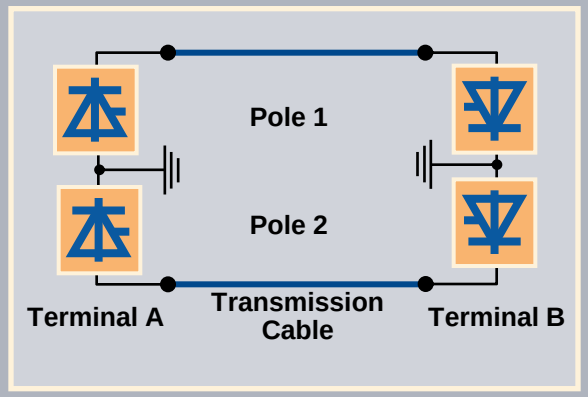
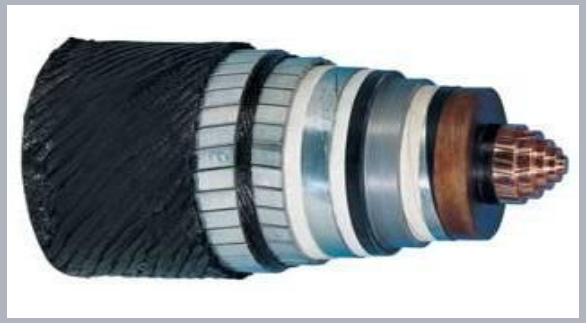
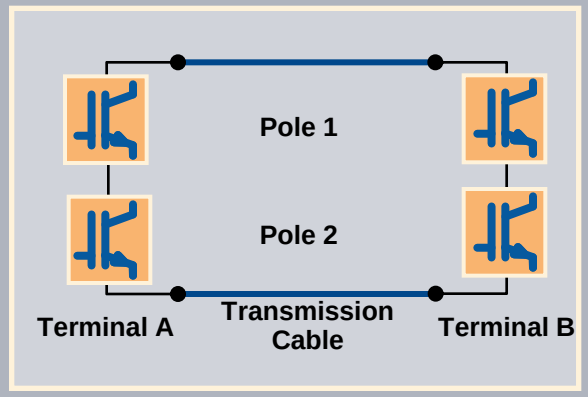
HVDC Cable Transmission Systems

HVDC Classic Bipole





HVDC PLUS Symmetrical Monopole



Cable Systems

- Submarine Cable Systems
- Land Cable Systems

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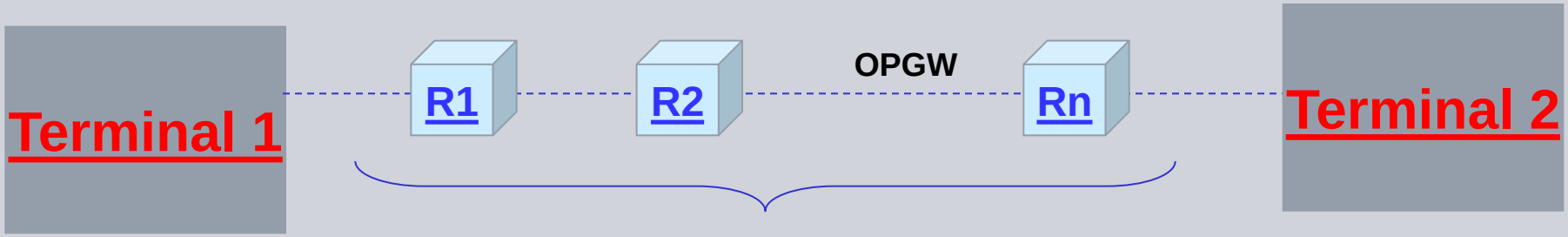
COMMUNICATION

- **Highly reliable and effective telecommunication system should be available between the terminals.**
- **Telecommunication link can be either PLCC or OPGW.**
- **Optical Ground Wire (OPGW) can be installed on one of the peaks of the HVDC line.**



n : depends on the Mux power and distance between the HVDC terminals

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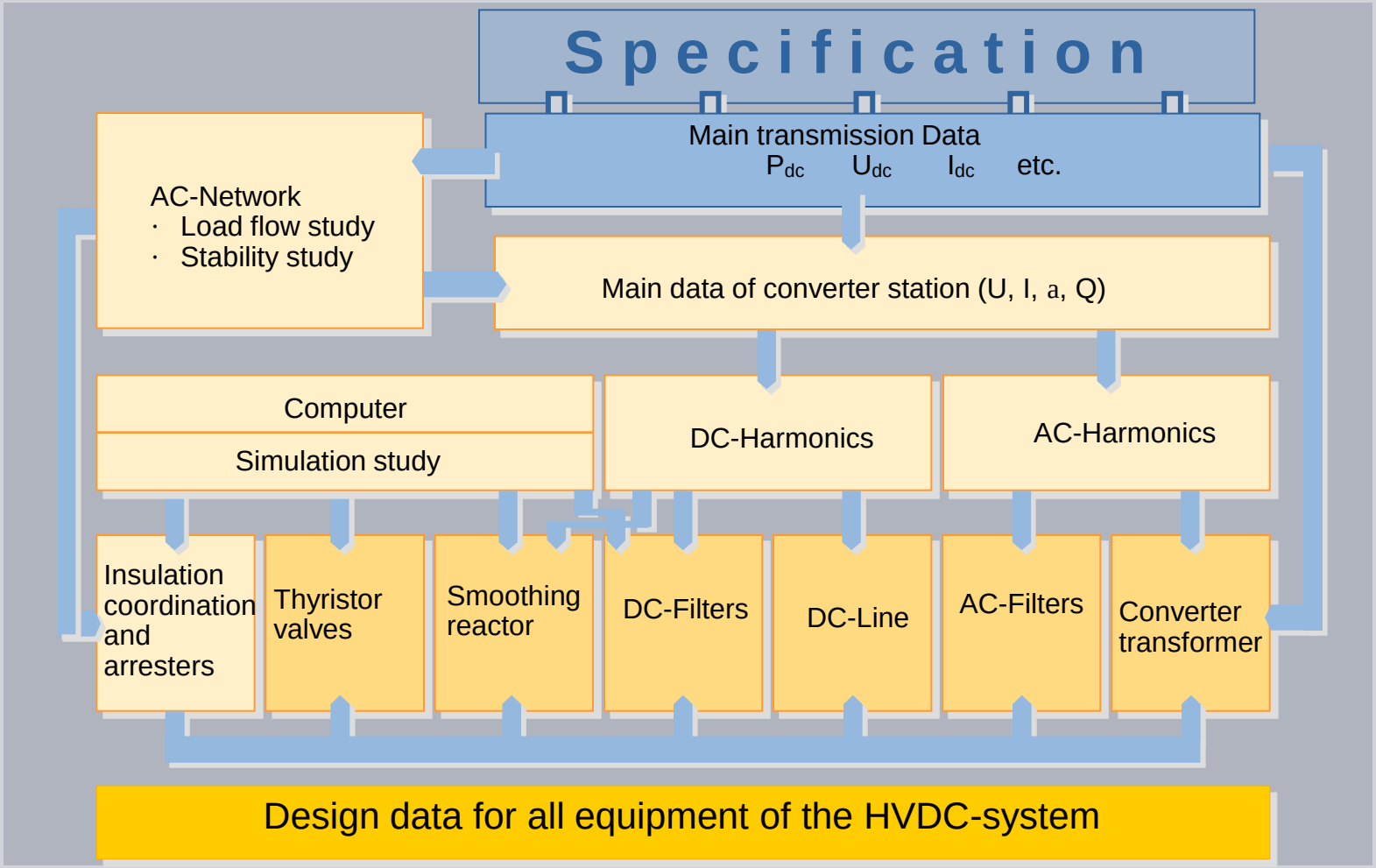
Basic Design Process



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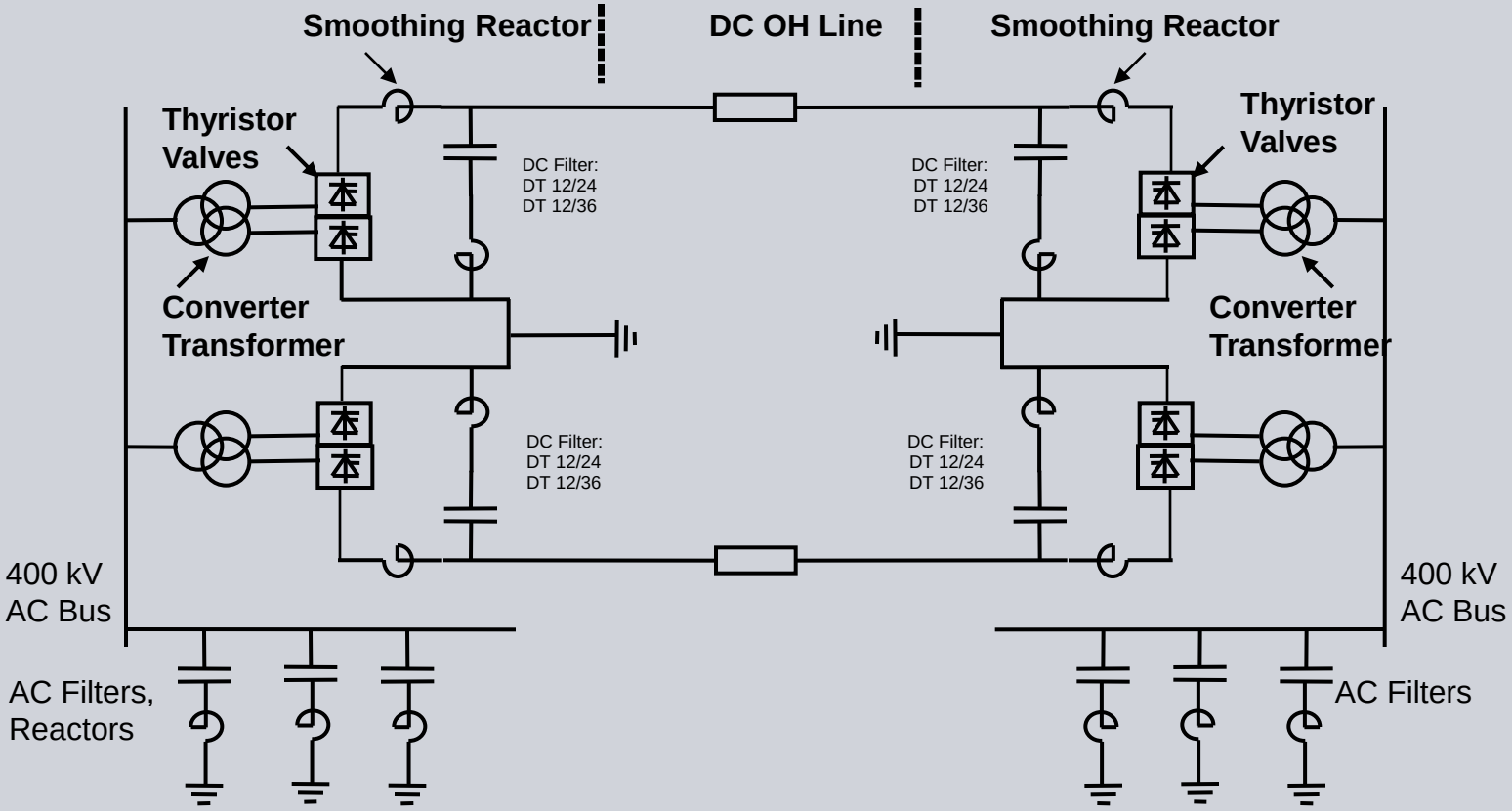
Basic HVDC Single Line Diagram



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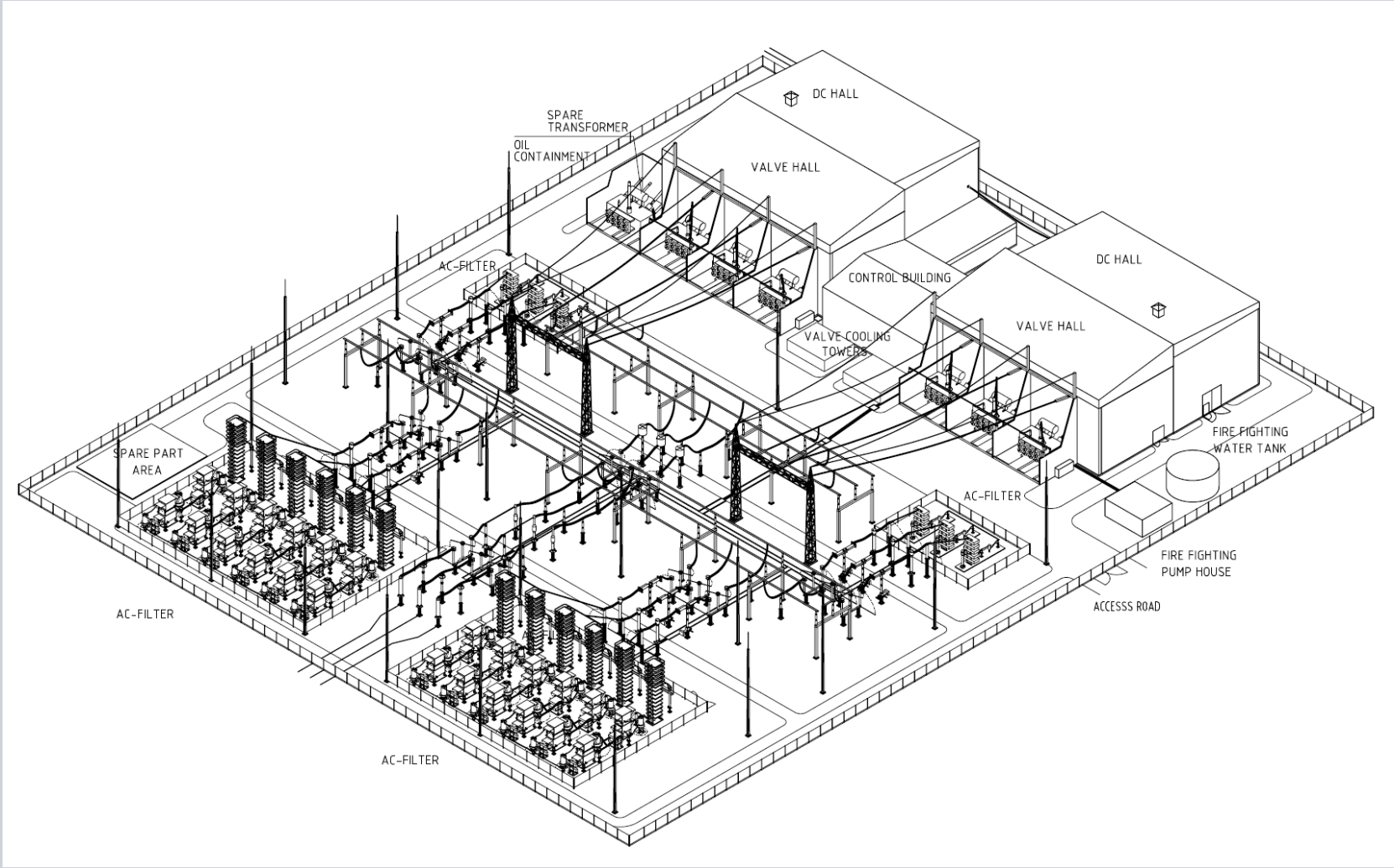
Isometric view – Conventional Bipolar HVDC



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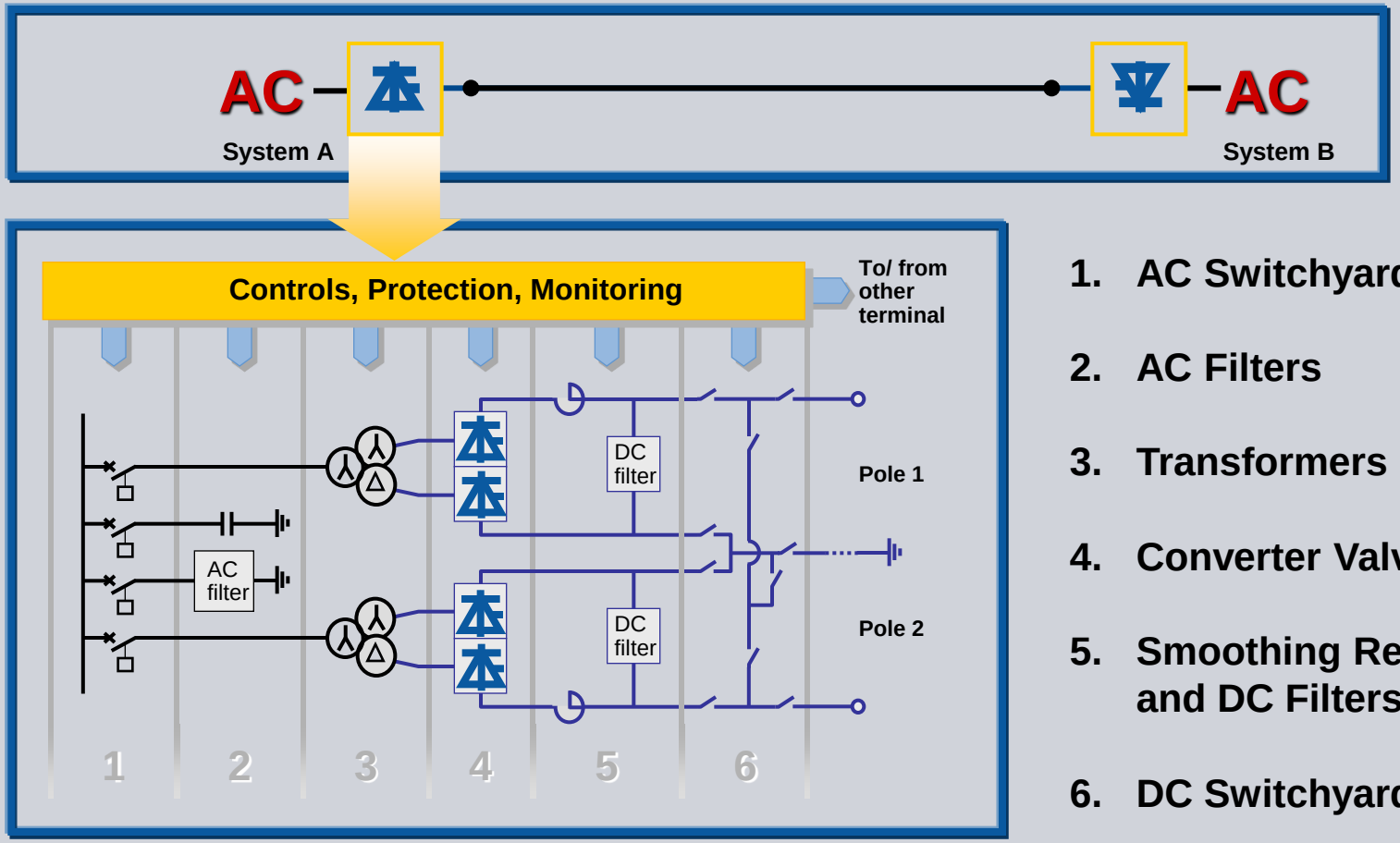
Key Components of HVDC
Bipolar HVDC Terminal



1. AC Switchyard
2. AC Filters
3. Transformers
4. Converter Valves
5. Smoothing Reactors and DC Filters
6. DC Switchyard

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Main Equipments

- Thyristor Valves
- Valve Cooling
- Converter Transformer
- Smoothing Reactor
- DC Switches
- AC Filters
- DC Filters
- PLC Filter
- Ground Electrode
- Control and Protection

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Thyristor Valves

- **The rectification and inversion process is carried out by the Thyristor valves**

- **Housed inside the valve halls**

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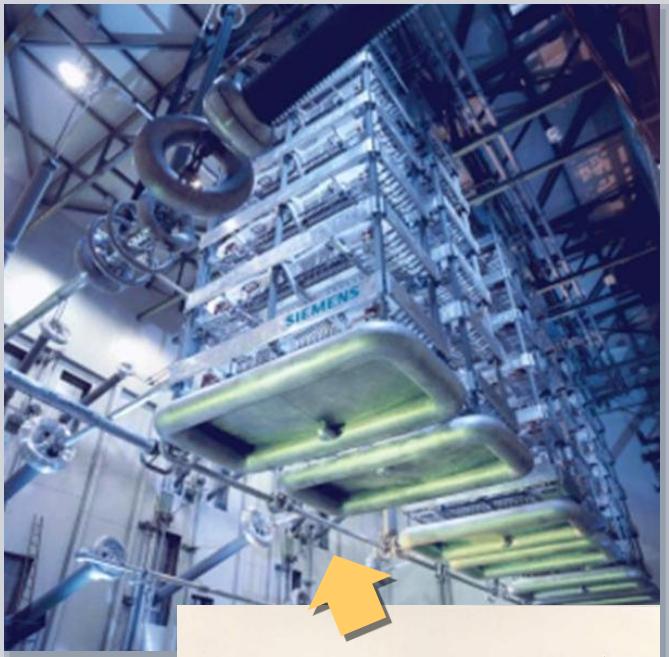
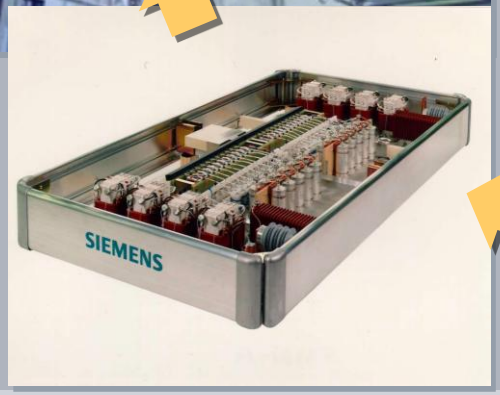
Thyristors





- Thyristor Technology with direct Light-Triggered Thyristors
- Rated Voltage up to 800 kV
- Rated Current more than 3,000 A
- Free from Oil and exclusive Use of Flame-retardant self-extinguishing Materials ⇨ Reduced Fire-Hazard
- Efficient and Corrosion-free Water Cooling
- Excellent Seismic Performance

Thyristor

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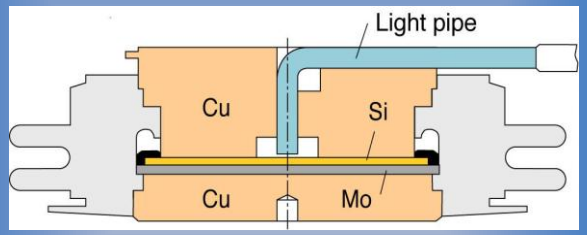
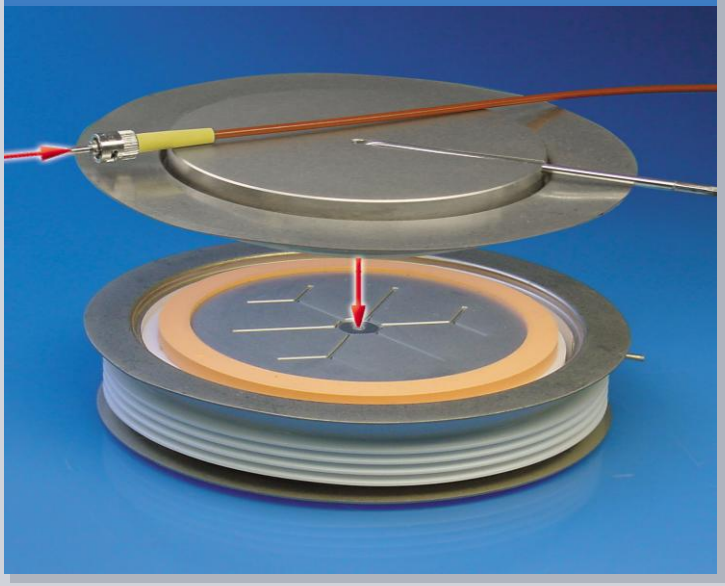
Direct Light Triggered Thyristor LTT





High Reliability

- 80 % less Electronic Components
- Direct Laser Light-triggered Thyristor
- Thyristor Blocking Voltage: 8 kV
- Thyristor Wafers:
  - 4" for currents up to 2,200 A
  - 5" for currents up to 3,700 A

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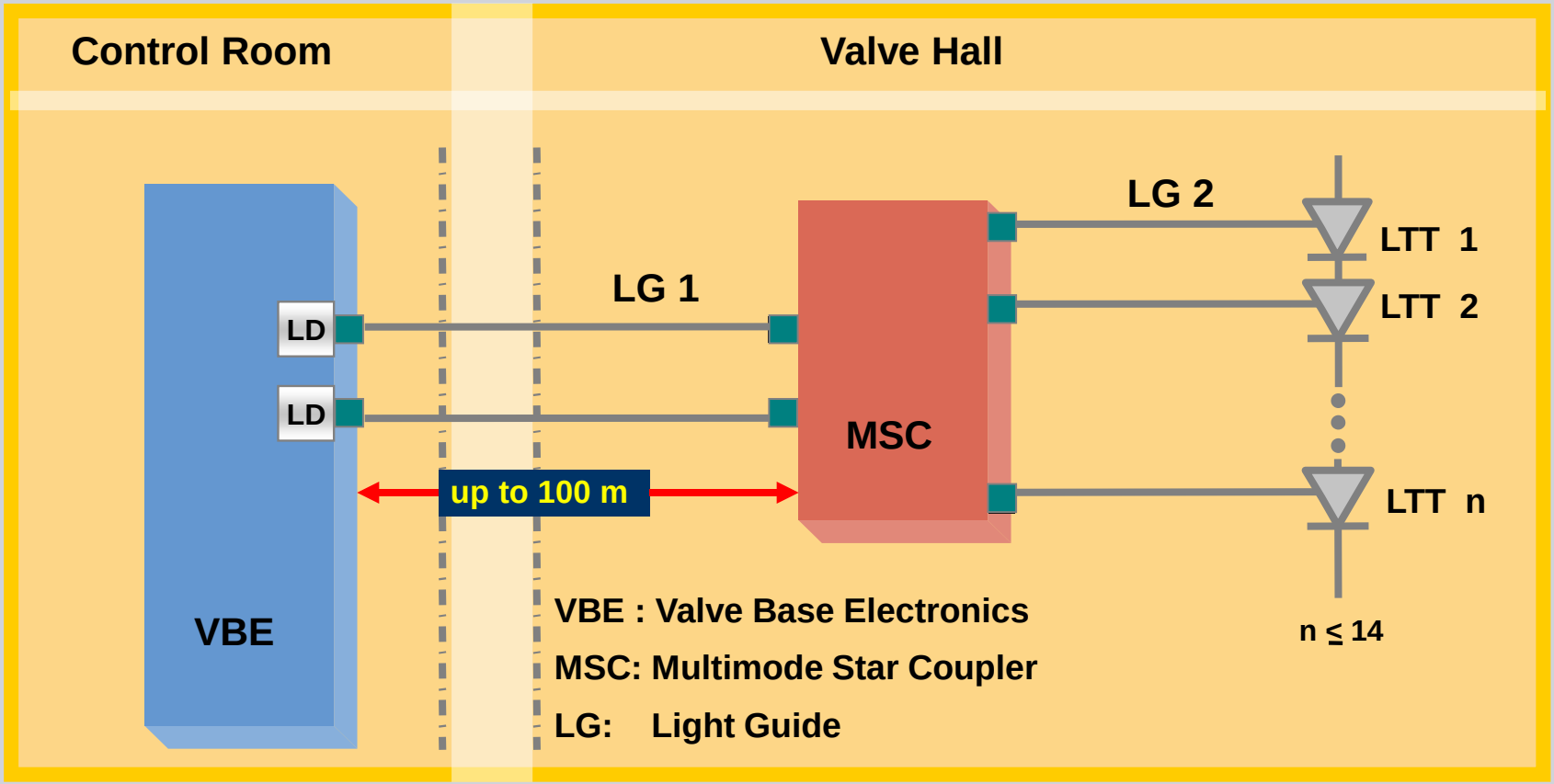
HVDC Station Design and Equipment: Thyristor Valves – Light Transmission from Ground to Thyristors



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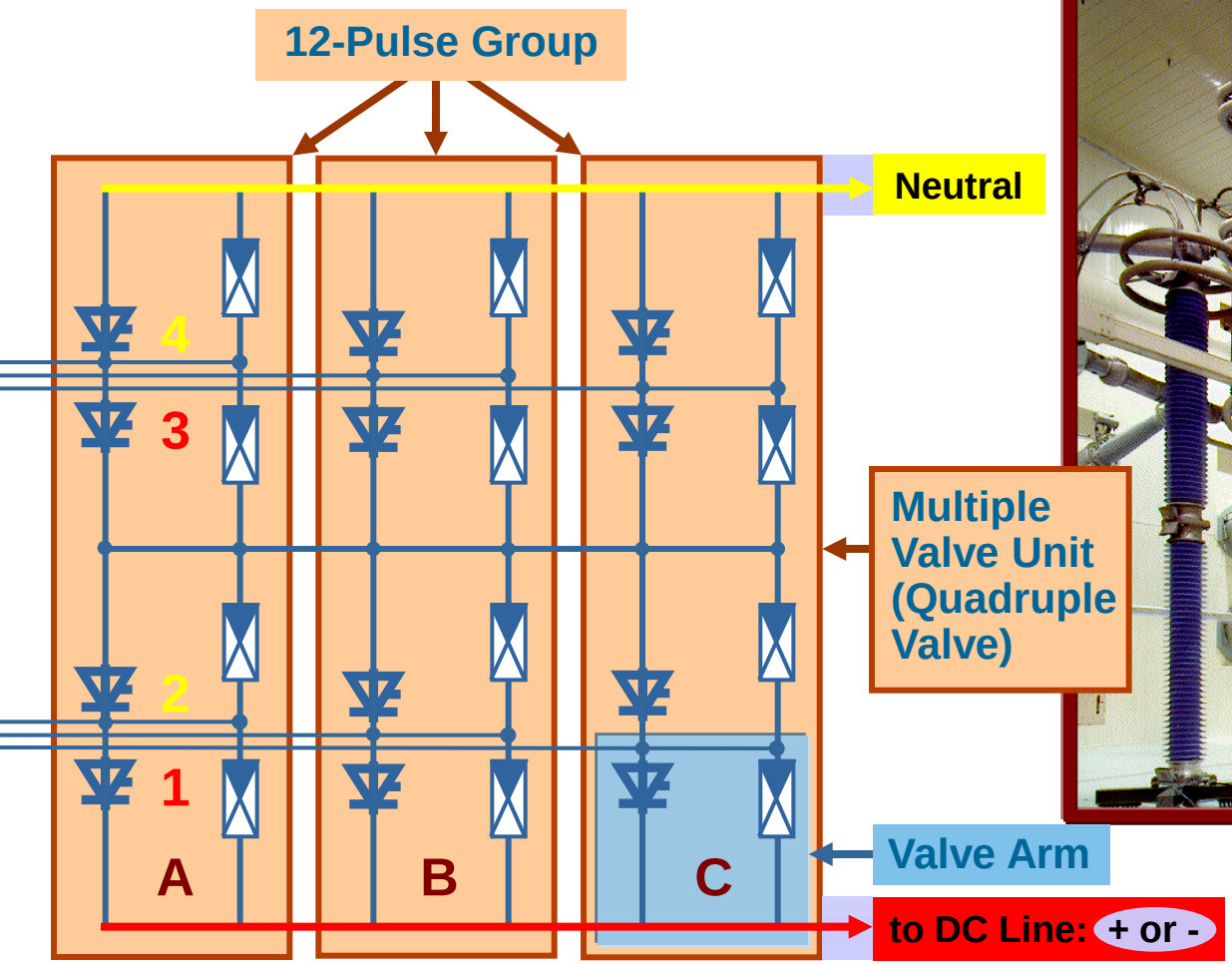
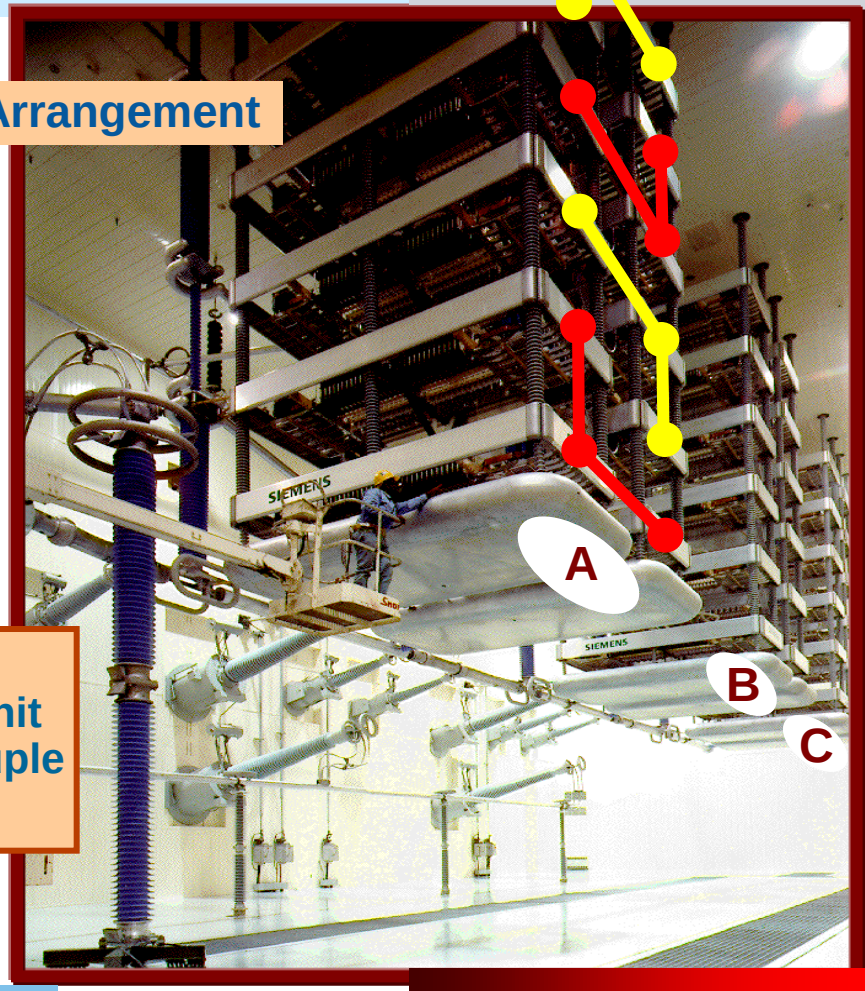
HVDC Thyristor Valves – Principle Circuit of a 12-Pulse Group



Valve Tower Arrangement



Example 500 kV

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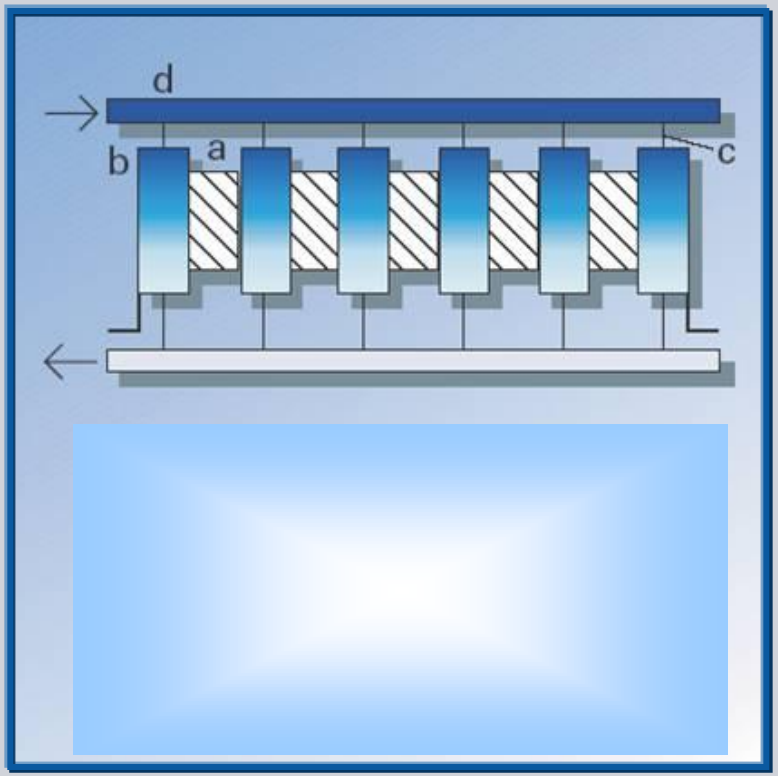
Parallel Water Cooling

The Siemens employs **Parallel-Water Cooling** which has been in Operation for more than 30 Years



- It provides all thyristors with the same cooling water temperature
- Electrolytic currents are minimized by the use of grading electrodes
- Careful choice of materials allows operation without de-oxygenizing equipment
- None of these systems had corrosion problems

a Thyristor
b Heat Sink
c Piping
d Manifold

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Thyristor Valves in Pre Fabricated Building

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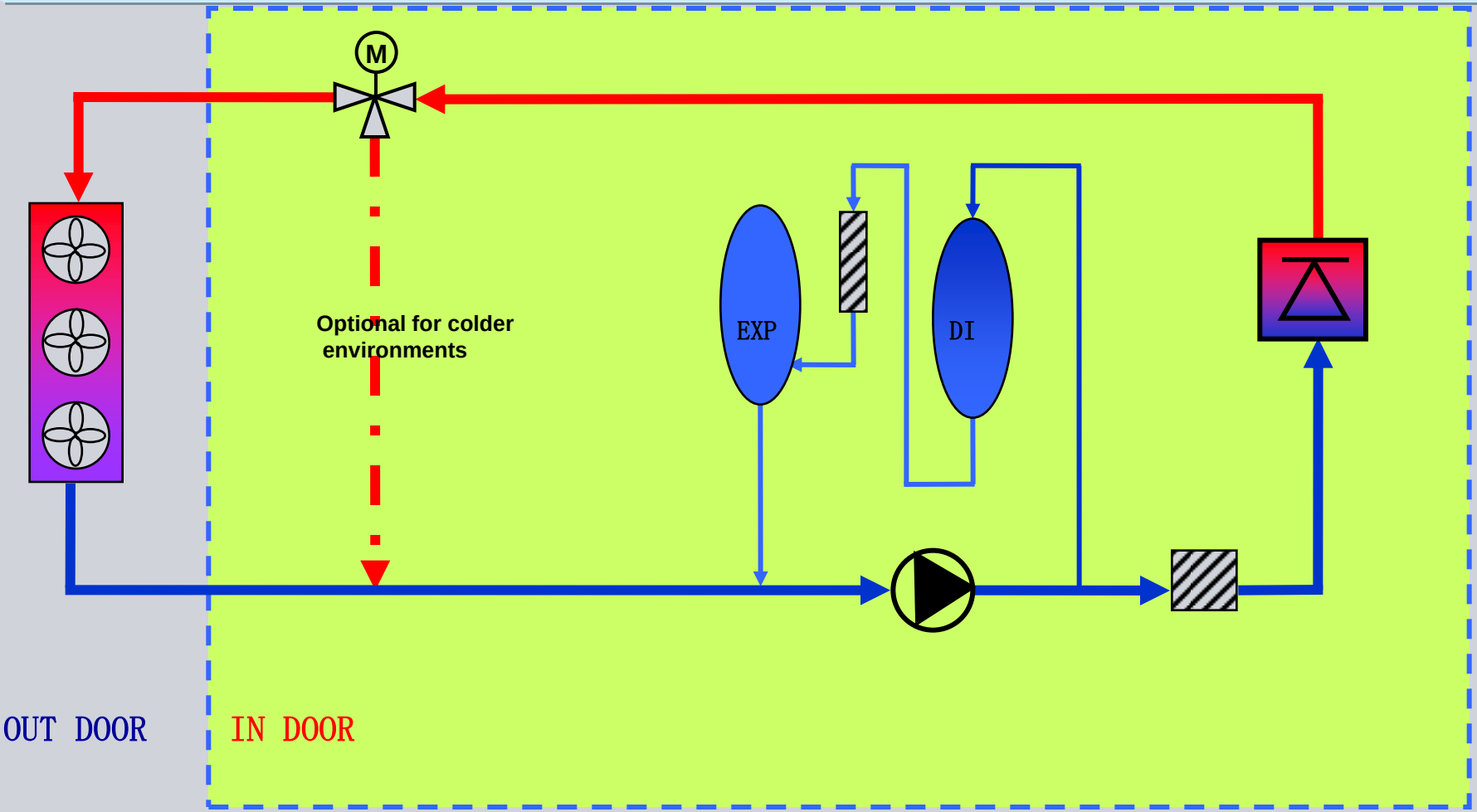
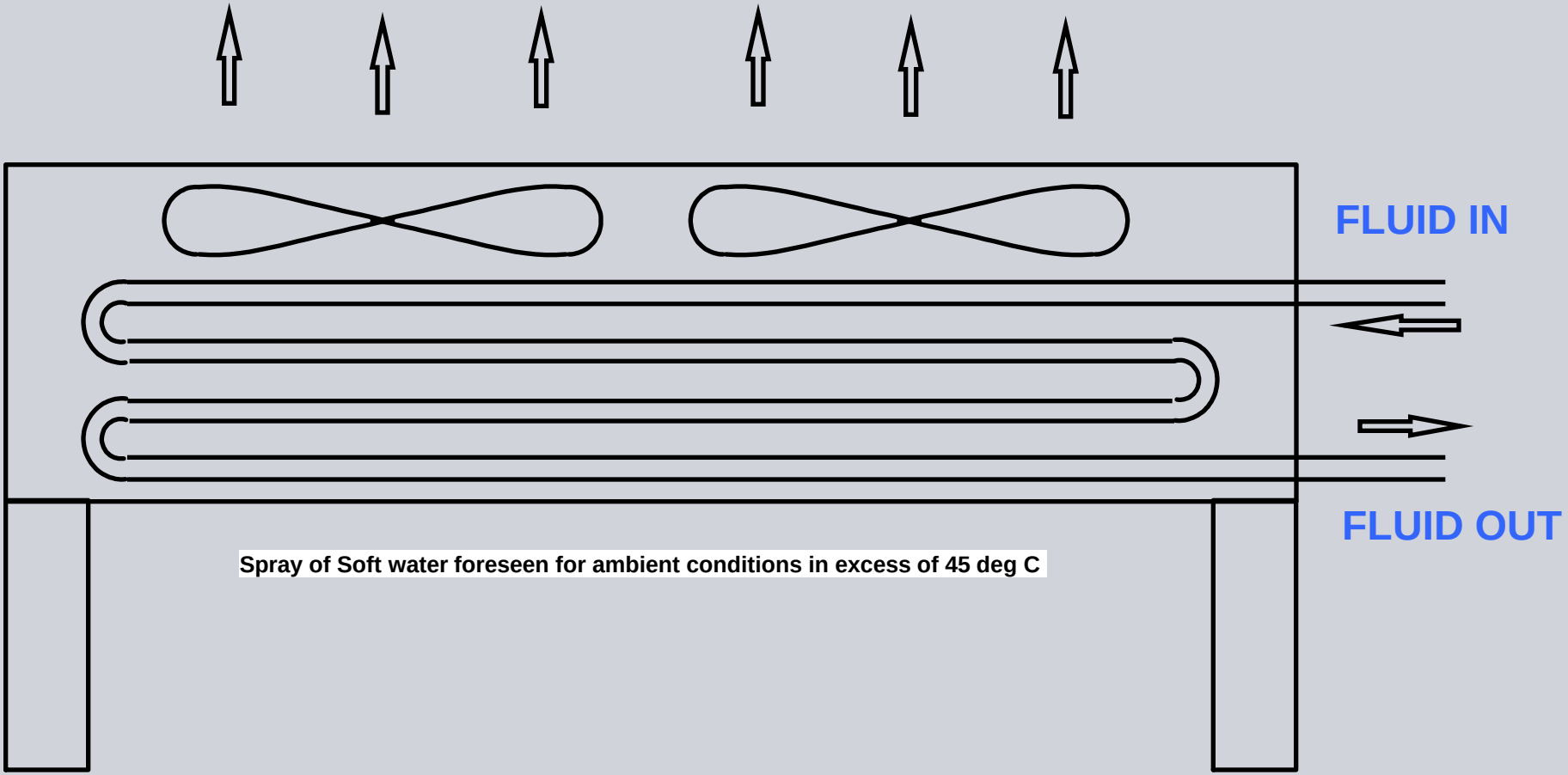
Simplified Cooling Circuit



DI: Deionising

EXP: Expansion Vessel

Air Blast Cooler



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Valve Hall-External View

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Talcher Kolar, India

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PEB Valve Hall

Converter Transformer

- Provide the AC voltage for the converter
- Subject to DC voltage and currents on the Valve side.
- Can be two winding or three winding depending on MVA rating and size …… unit weight of transportation is an important consideration
- Subject to special tests such as DC withstand, polarity reversal and heat run test with harmonic currents taken into account

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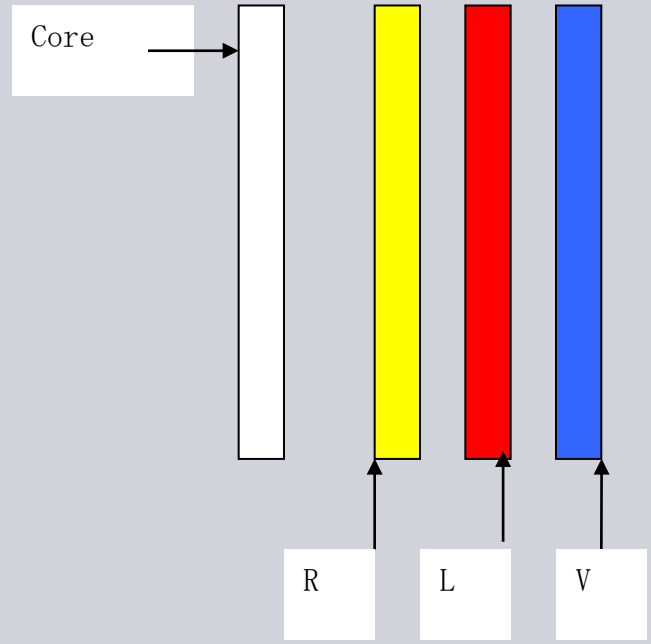
Winding Arrangement



R-Regulating Wdg

L- Line Wdg

V-Valve Wdg

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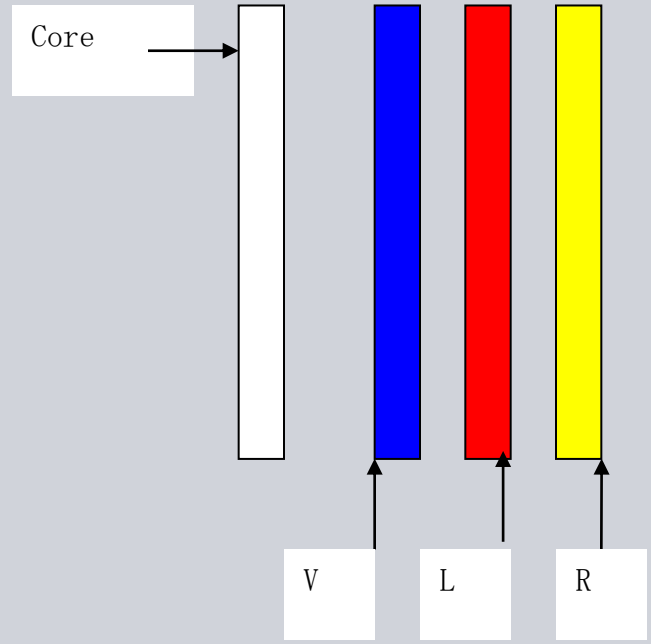
Winding arrangement



R-Regulating Wdg

L- Line Wdg

V-Valve Wdg

Converter Transformer

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Converter Transformer

Smoothing Reactor

- Removes ripples from DC voltage
- Limits rate of rise of current in case of DC line faults
- Limits higher order harmonics in DC line
- Limits possible resonance at fundamental and 2nd harmonic frequencies

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HVDC Smoothing Reactor

Oil immersed Design

270 mH

500 kV DC

3,000 A

Air-Core Design

150 mH

500 kV DC

1,800 A

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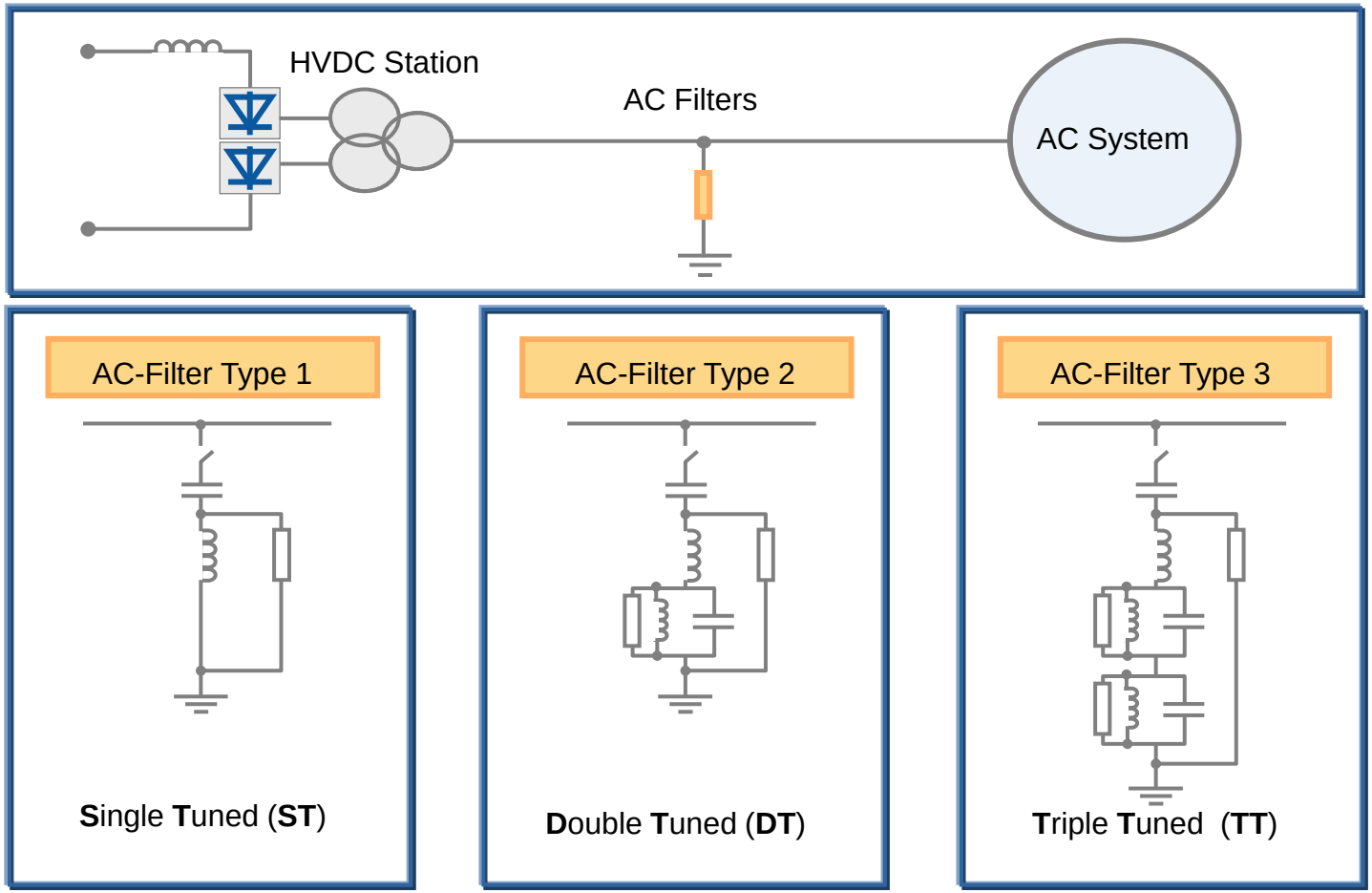
High Speed DC Switches

Switches to commutate direct current (MRTB, MRS, HSNBS, HSGS)

Metallic Return Transfer Breaker (MRTB) and Metallic Return Switch (MRS)

Use of standard SF_6 circuit breakers

HVDC Basic Design – Filter Configurations



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HVDC Basic Design: Examples of AC Filters

Shenzhen Converter Station (500 kV, 3000 MW) – HVDC LDT Guizhou-Guangdong II, China

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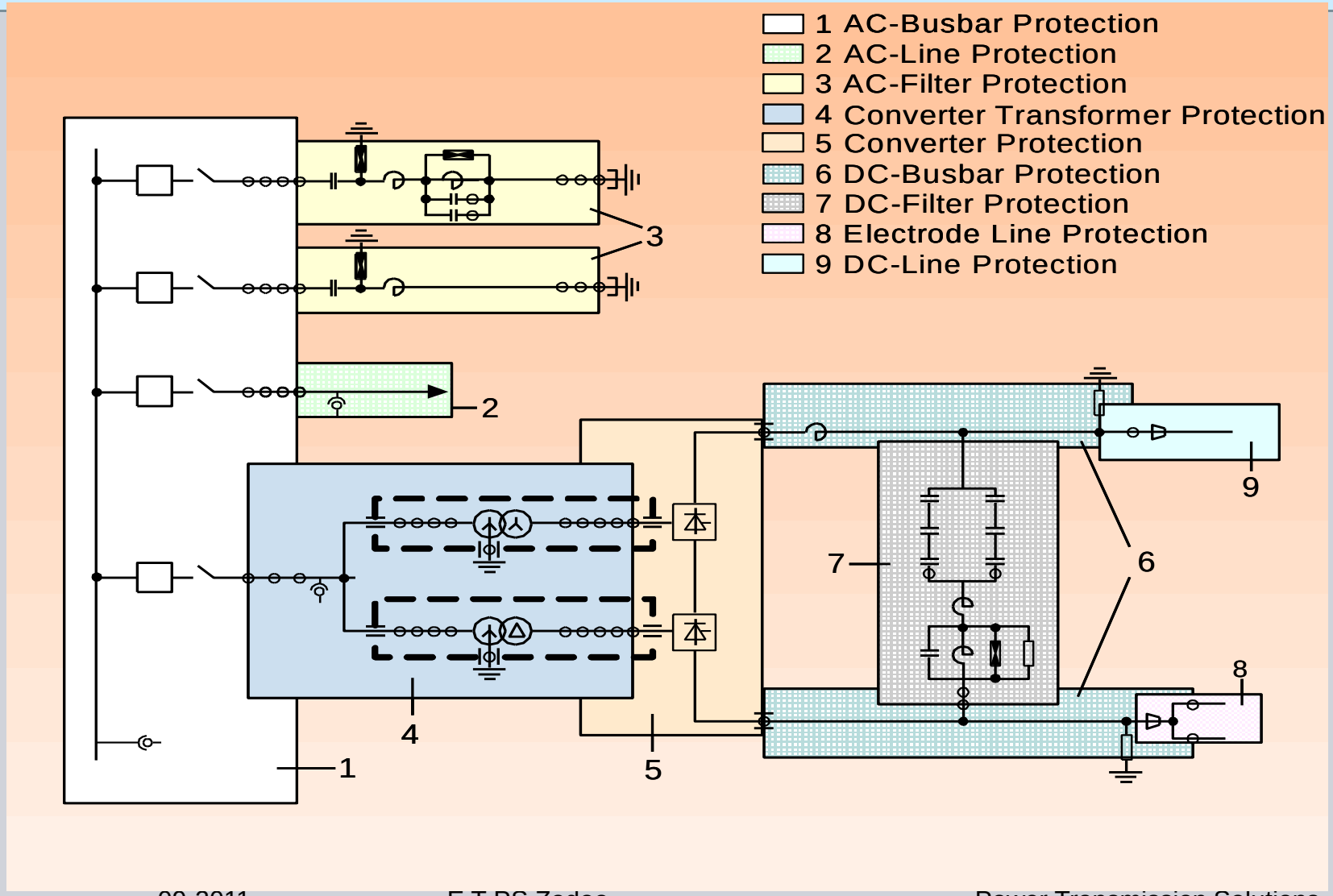
AC and DC Yard – The Protection Zones



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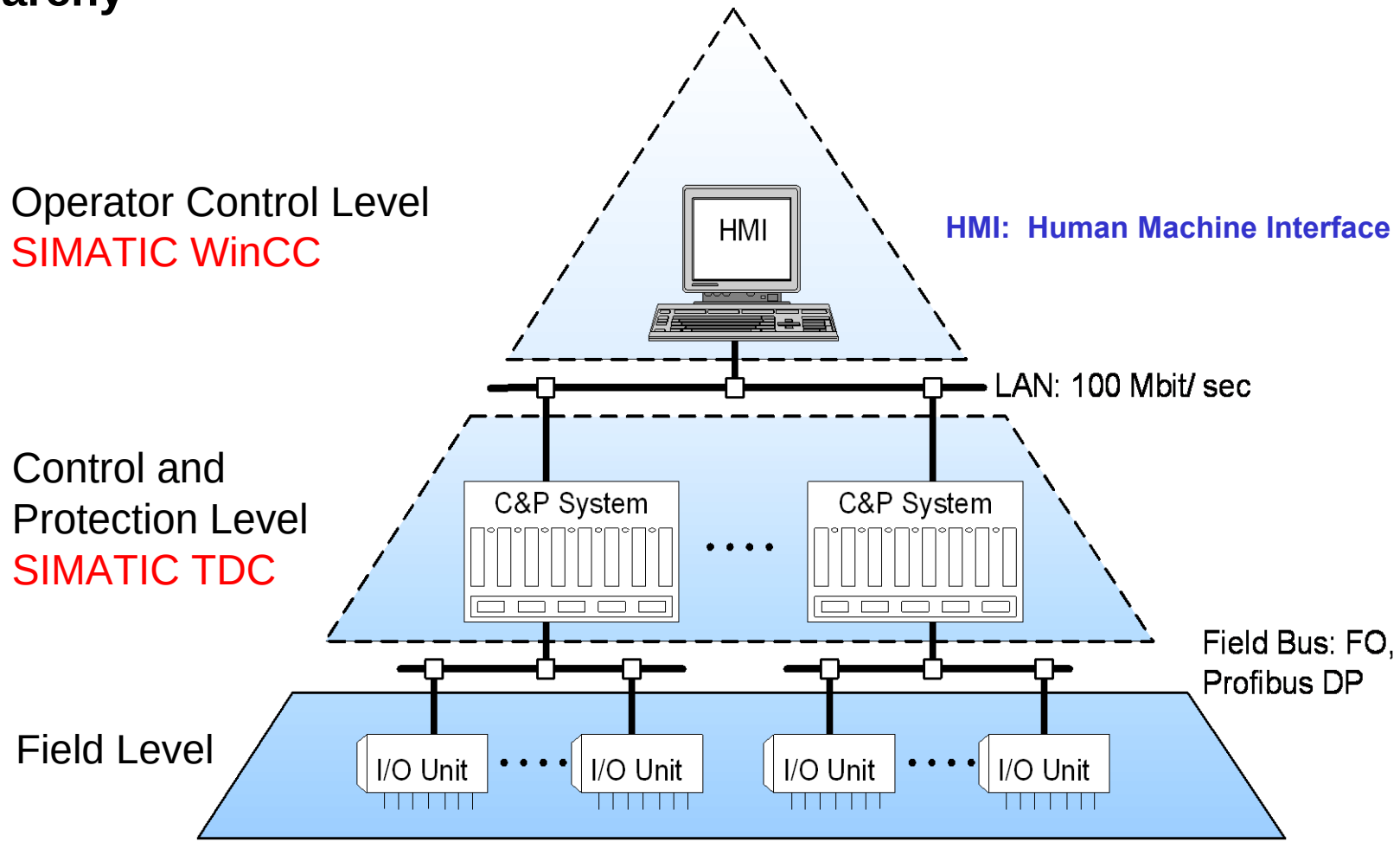
HVDC Control and Protection: Win-TDC * System Hierarchy



*** SIMATIC WinCC and SIMATIC TDC**

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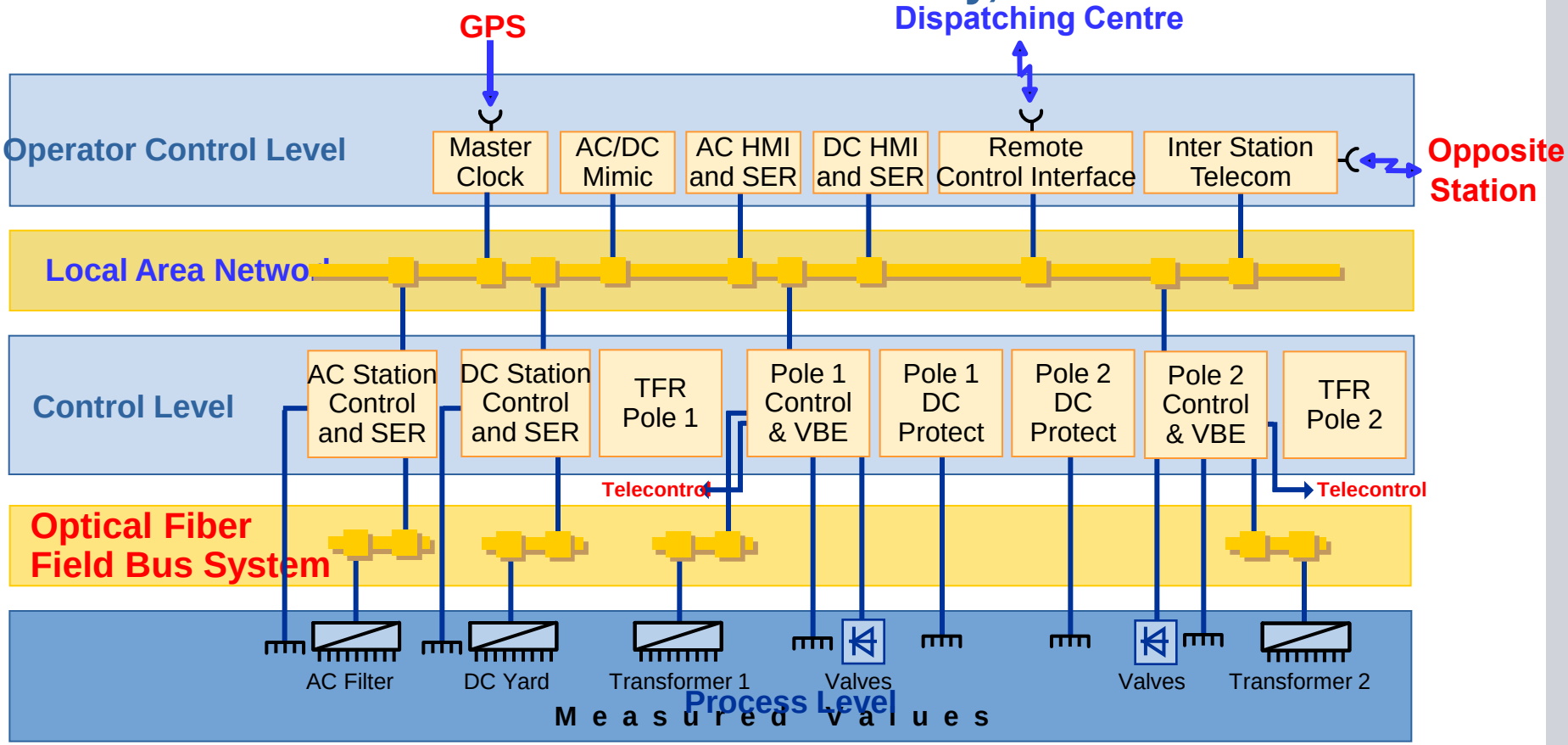
Decentralized Control and Protection System for Bipole Long-Distance Transmission

Control and Protection Hierarchy, one Station



Most of the Equipment is redundant (for Simplification not shown in the Figure)

SER: Sequence of Events Recording System TFR: Transient Fault Recording System

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Operator's AC and DC-Control Room: Example of TIAN GUANG HVDC Project

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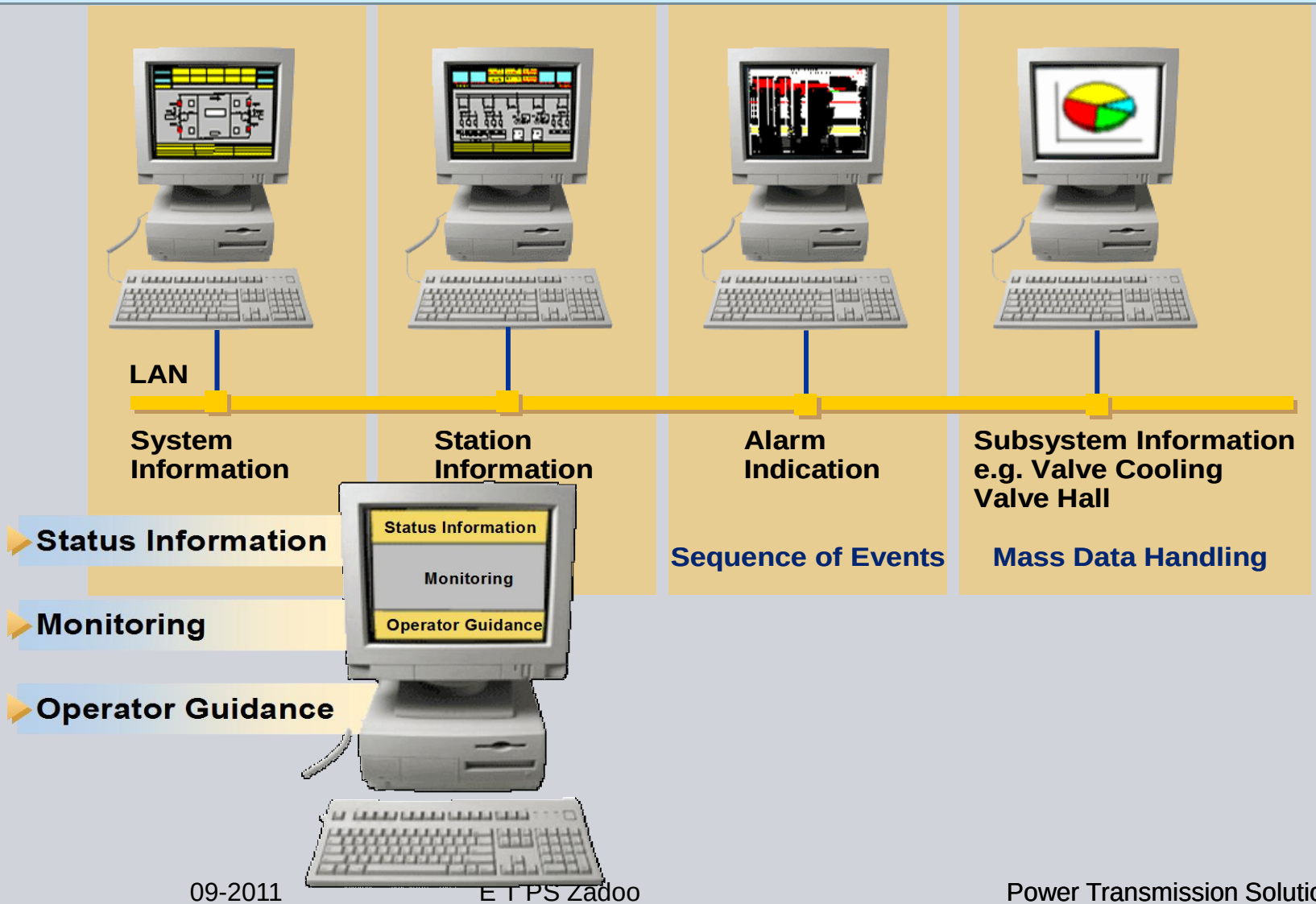
Operator's Control & Screen Layout: Configuration for Bipole Long-Distance Transmission



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SIMATIC WinCC and SIMATIC TDC

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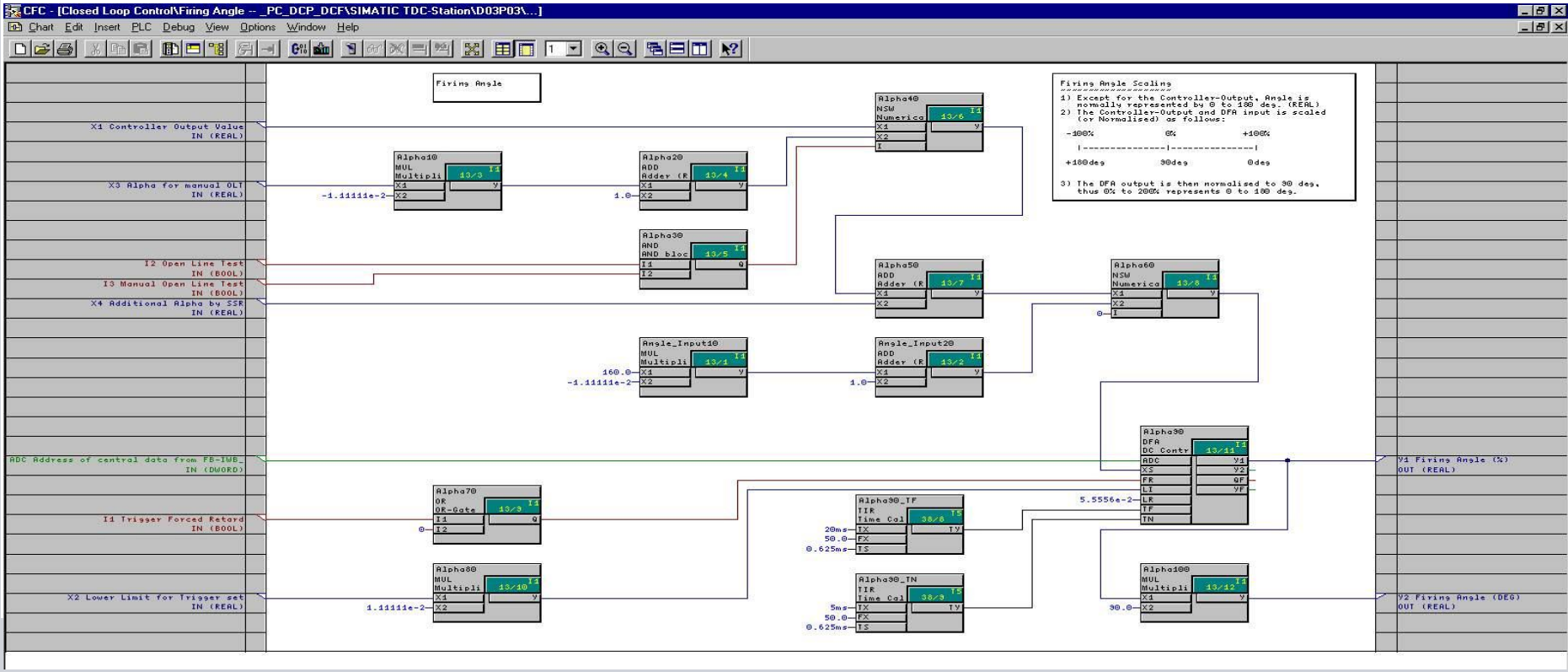
Win-TDC Control Software – Programming Language CFC (Continuous Function Chart)

- One programming Language for all Control and Protection Functions
- Over 300 tested and well proven Standard Function Blocks
- Fully graphically configurable – easy for Engineering



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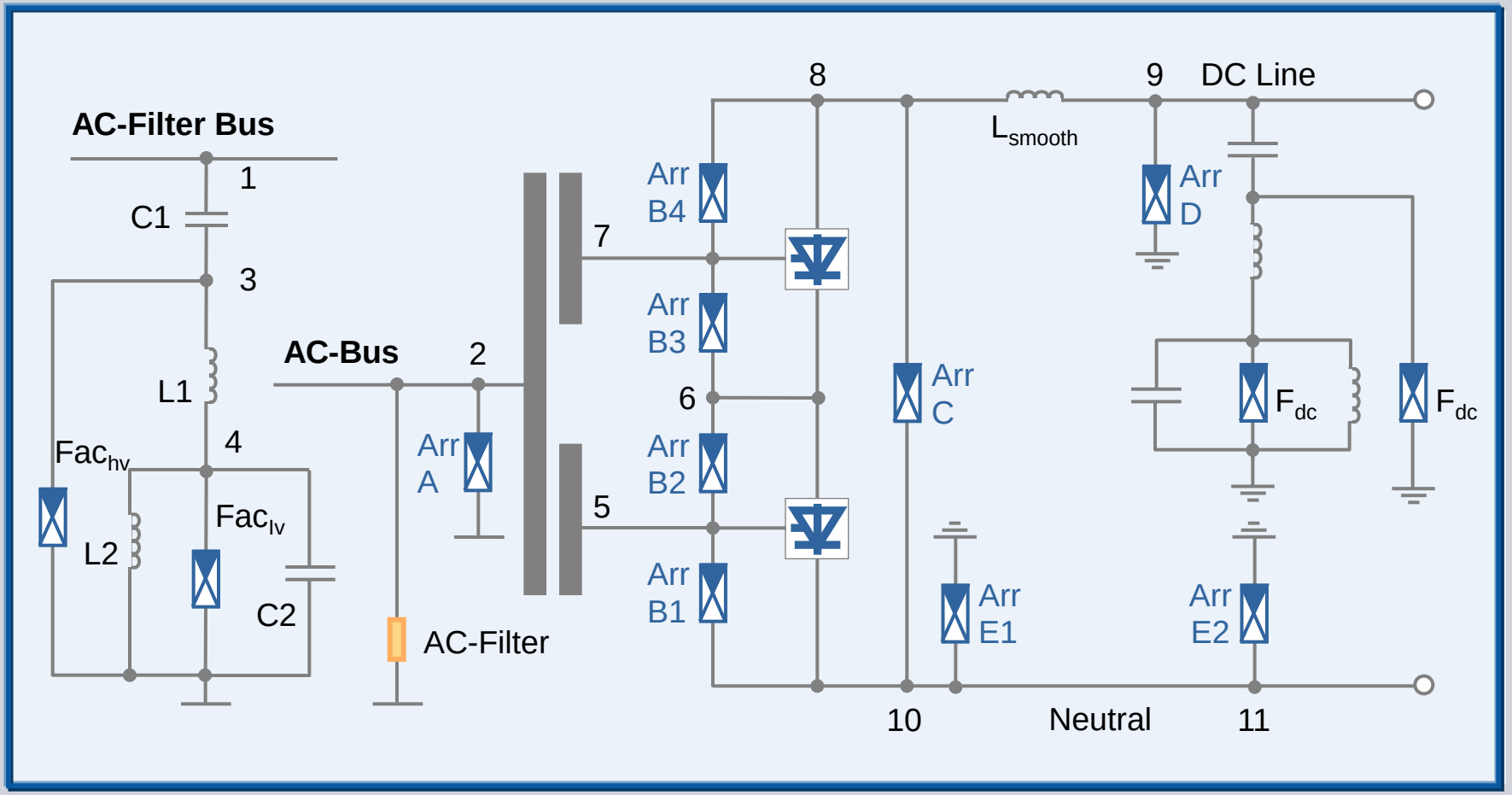
HVDC Basic Design: Arrester Arrangement



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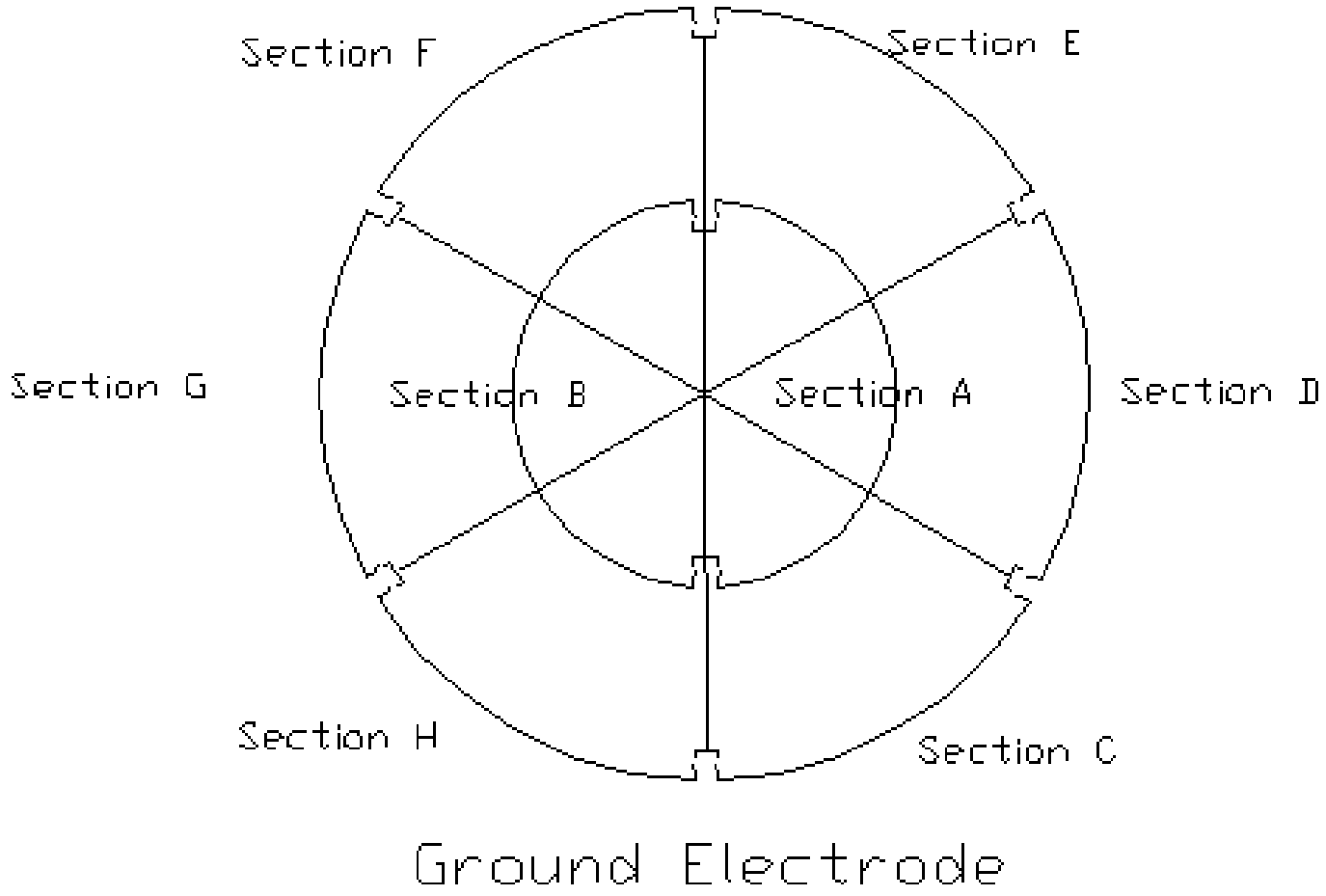
TYPICAL LAYOUT OF ELECTRODE STATION



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Ground Electrodes Effects

- Local Effects(Up to < 1 km)
- Safety of Humans and Animals
- High temperature rise of Ground and drying of soil.
- Remote Effects (may be up to 50 Km and beyond)
- Potential rise can cause DC current flow in transformer Neutrals
- Corrosion of buried metallic objects.

Design Requirements

Local Electrode parameters.

- Ground Electrode resistance ≤ 0.3 Ω
- Touch Voltage ≤ 40 Volts
- Step Voltage ≤ 6 Volts
- Current Density ≤ 0.5 A/m2
- Temperature on the surface of sub-electrode: ≤ 100 ˚ C.

Remote Effects.

The Ground potential rise and electric field shall decay fast and shall be negligible (few Volts) within 15-20 kms of electrode site.

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Auxiliary and Other Systems* - HVDC

- Auxiliary Power
- LT Power System
- DG Set
- DC Power/UPS
- Air Conditioning/Ventilation
- Fire Detection / Fighting
- Illumination
- PA System
- Valve Cooling System
- Oil Filtration System
- Service Water
- Telephone & PA System
- CCTVs, Maintenance equipment
- Tools and Tackles
- O&M Equipment

* Typical; subject to specification of individual contract9

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Auxiliary Power Sources

- Usually two 33kV/11kV sources
- DG Set connected on LT bus
- Voltage Variation: ±10%
- Frequency Variation: ±5%

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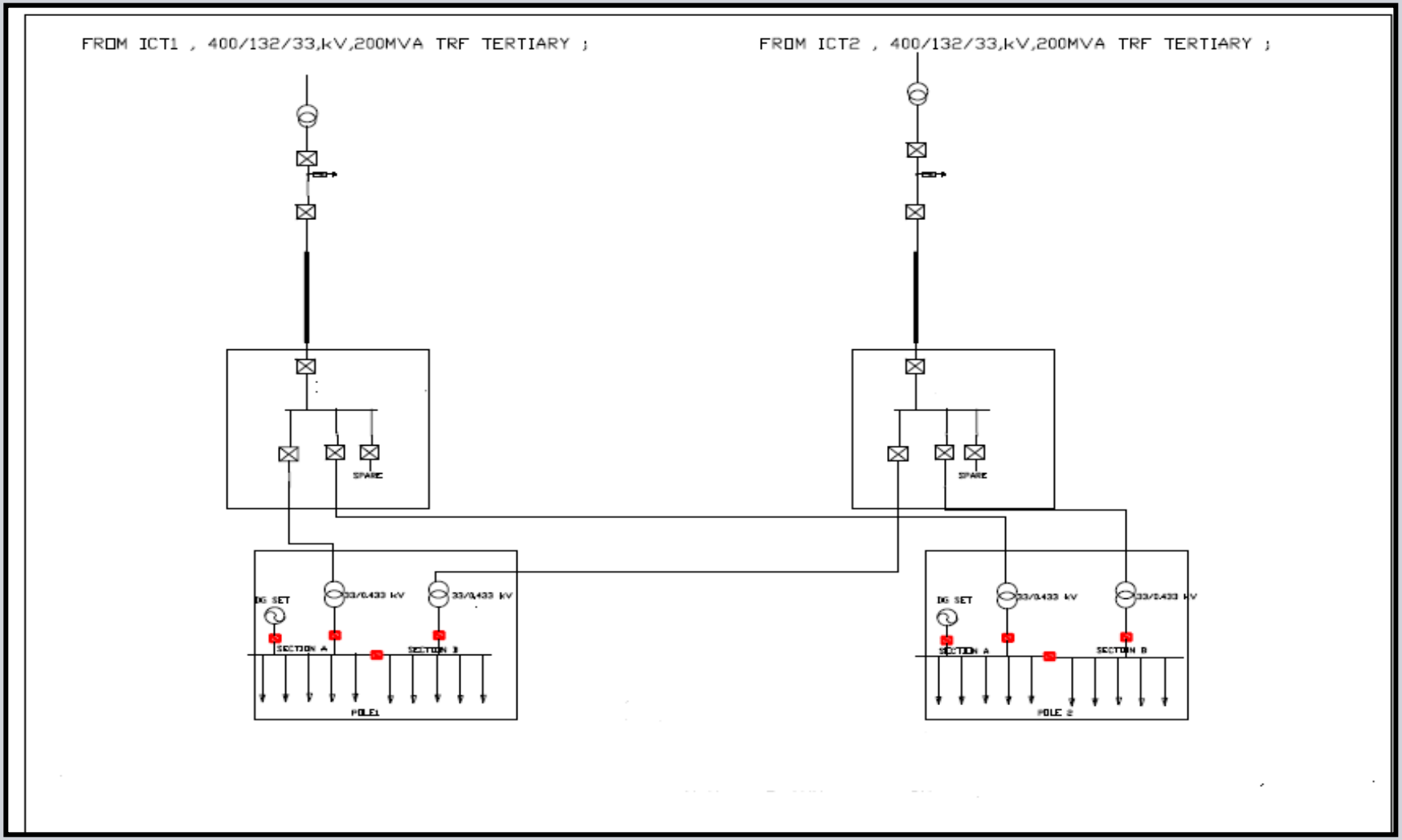
Typical Aux Power Scheme for HVDC Station



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Valve Hall Ventilation Requirements*

- Inside DB temperature 50ºC±2ºC
- Inside R.H. 43% ±5%
- Clean room to ISO class 7 as per ISO 14644-1:1999
- Positive pressure – 3mm of water column
- Dedicated one running and one standby AHU
- Supply air through high efficiency filters to main desired clean room condition

*** Typical; subject to specification of individual contract9**

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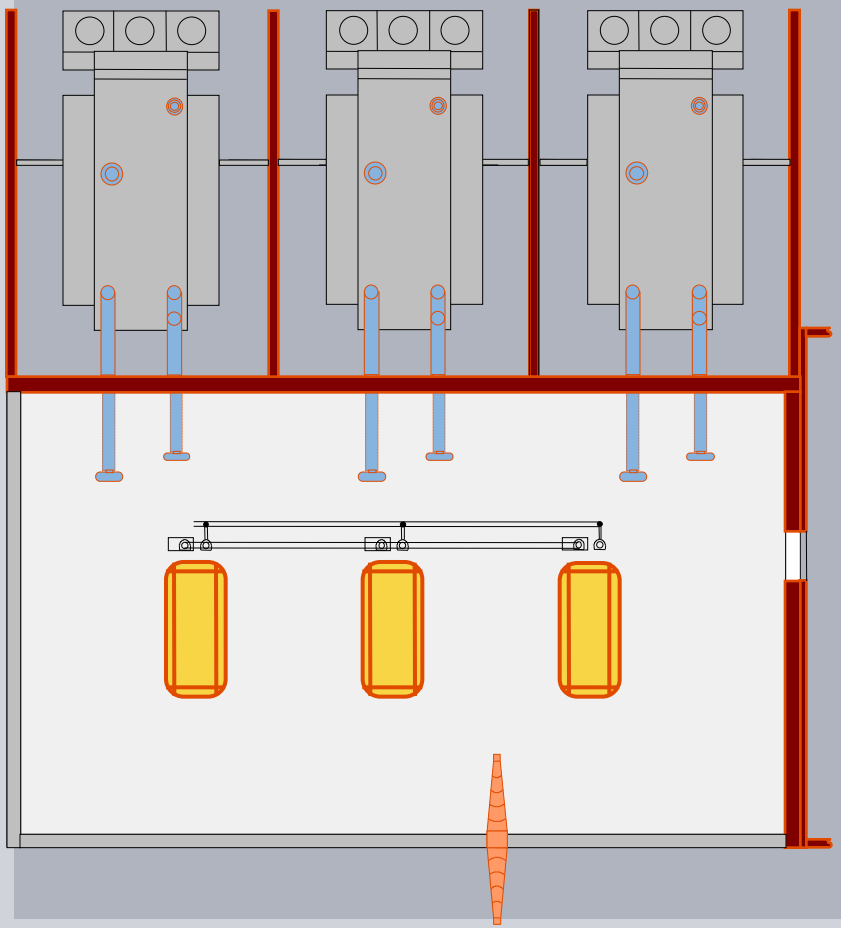
Fire Protection - Choice of Material



- Fire Protection Walls
- Dry Composite Transformer Wall Bushing
- Minimised Inflammable Materials
- Dry Composite Wall Bushing

* Typical; subject to specification of individual contract9

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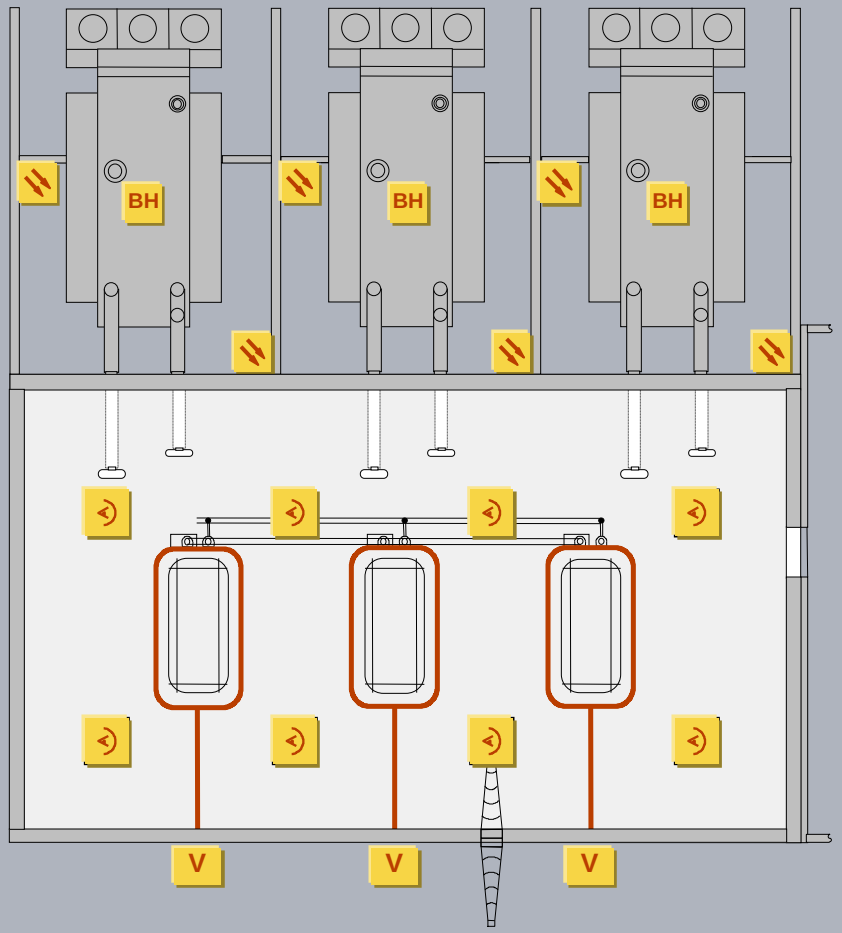
Fire Protection – Valve Hall & Transformers



- BH Buchholz Relays
- V VESDA* Detectors
- Air Sampling Tubes
- Ultra Violet Detectors
- Infra Red Sensors

* Very Early Warning Aspirating Smoke Detection

*** Typical; subject to specification of individual contract9**

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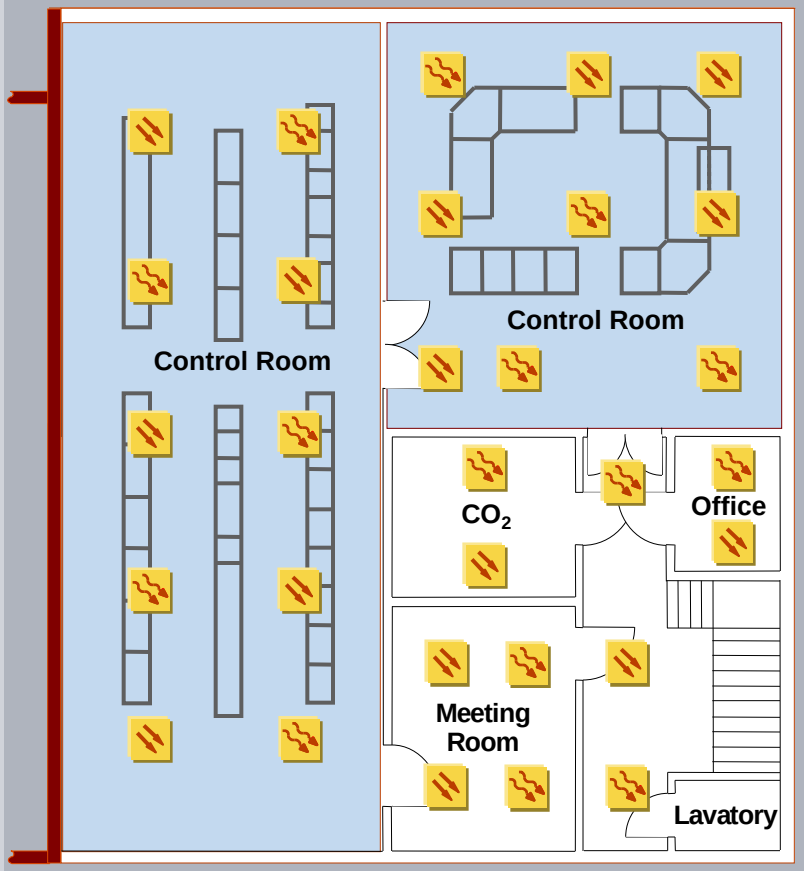
Fire Protection - Control Rooms



- Optical Smoke Detectors
- Ionisation Smoke Detectors
- Fire Protection Walls
- CO_2 Fire Fighting

* Typical; subject to specification of individual contract9

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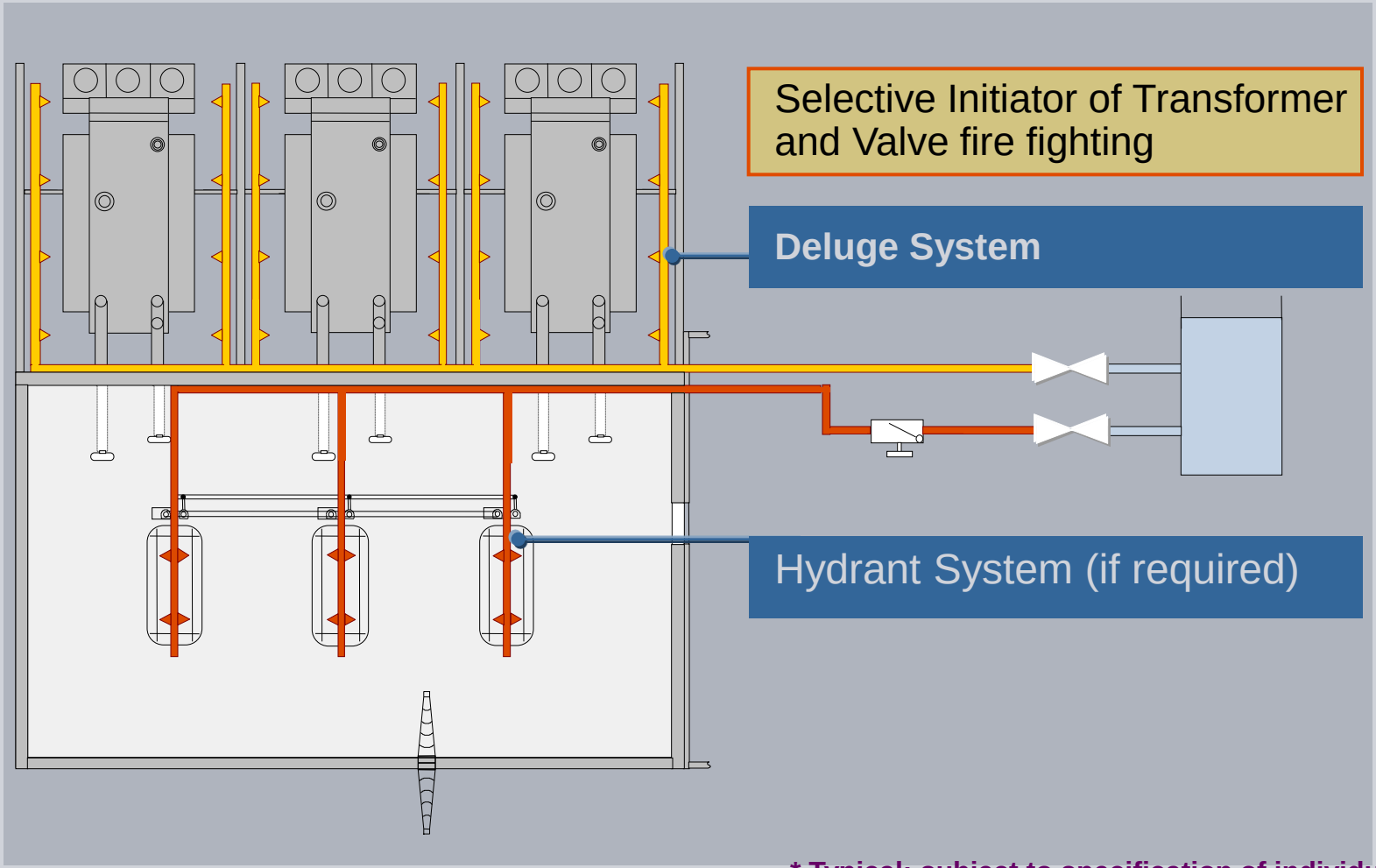
Fire Protection - Deluge System



* Typical; subject to specification of individual contract9

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Thank you for your attention please!