



Insulation coordination for UHVDC 800 kV



abb.com/hvdc



Presentation items

- Operating experience
- Principles
- Smoothing reactor
- Insulation levels for different components
- Staging

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Insulation coordination. Experience from operation.

- Creepage flashovers -- Accurate creepage distance
-- Accurate insulator design
- Flashover because of uneven wetting
-- Attention to physical layout
- Overvoltages -- Excellent experience, no flashovers
(Overdesign)
- Cost of withstand for Lightning Impulse and Switching Impulse is “small” (exception: Thyristor valve) at 500 kv rating (creepage was dimensioning)
- At 800 kV the Lightning Impulse and Switching Impulse will influence size, weight and cost of equipment



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Insulation coordination - principles

- Limitation of switching surges is essential
- Highly efficient arresters
- Installation of additional arresters on 800 kV dc bus and converter bus between transformer and valve
- Arresters installed very close to object (no distance effects)
- Subdivision of smoothing reactor – 50 % on 800 kV, 50 % on neutral bus
- Insulation margins

	Oil insulation	Air insulation	Single Valve
Lightning impulse	20 %	20 %	10 %
Switching impulse	15 %	15 %	10 %

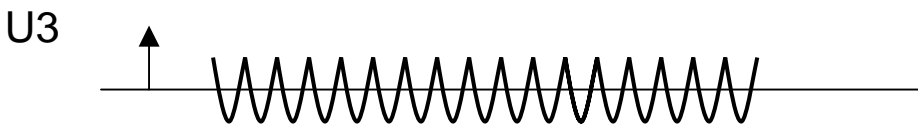
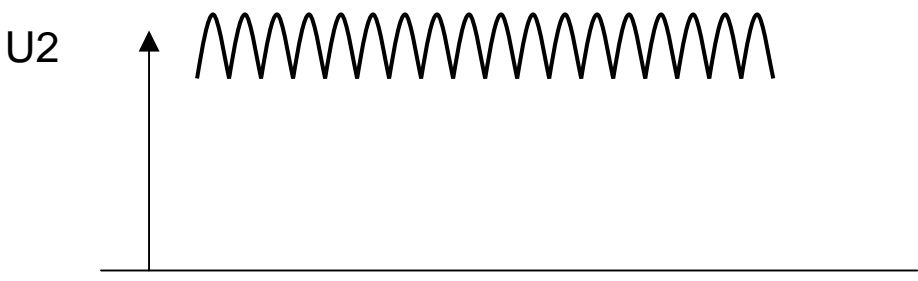
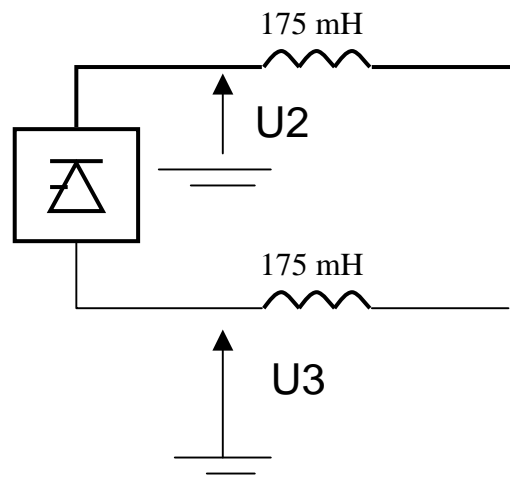
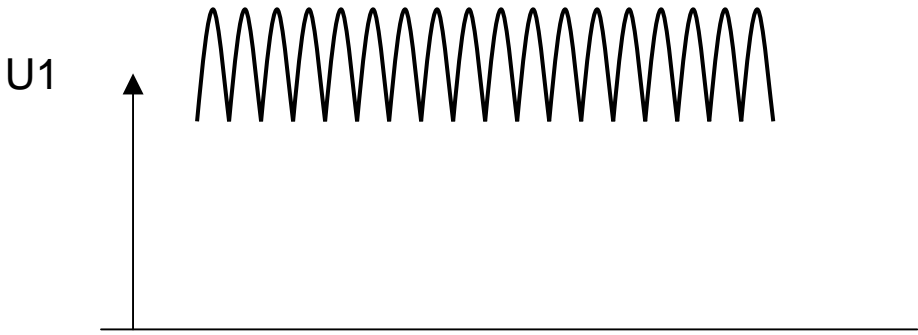
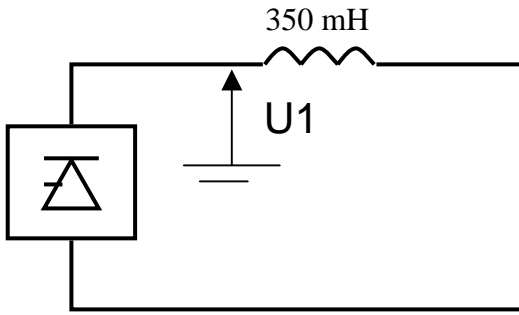
- Margin of insulation is sufficient – standard levels not applicable



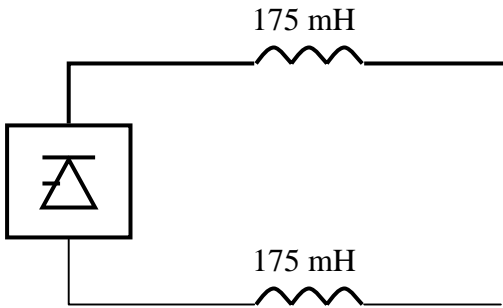
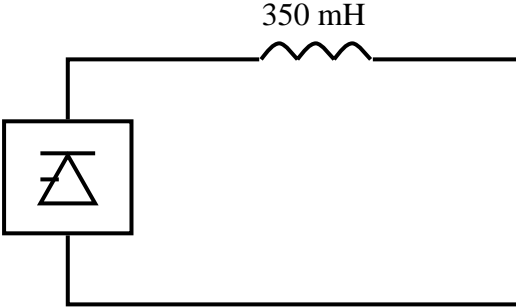
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- **Smoothing reactor**
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Air insulated smoothing reactor



Air insulated smoothing reactor



Smoothing reactor is located on neutral bus at Skagerrak, CU and Inga-Shaba +/-500 kV project



Air core smoothing reactors in ABB projects

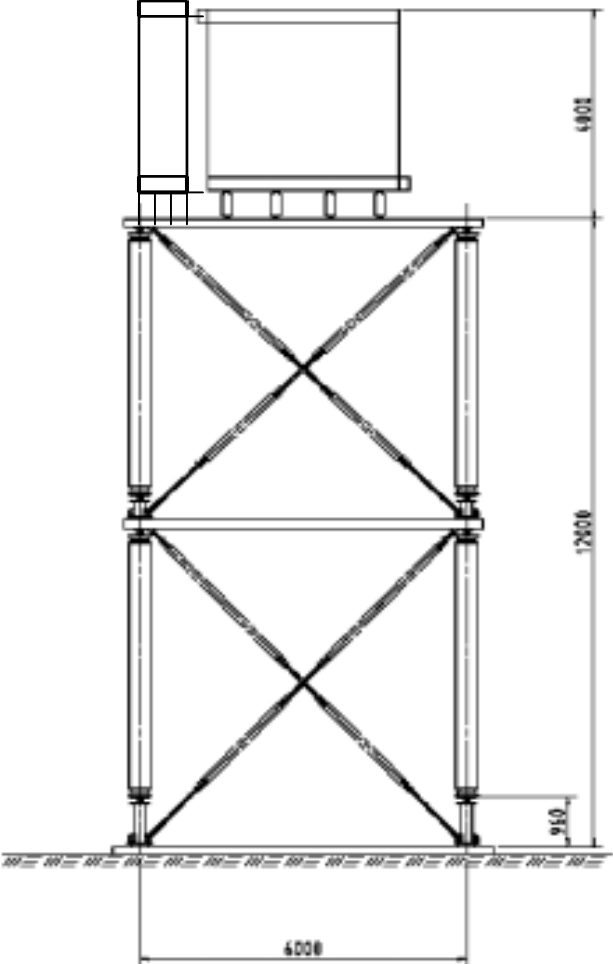


Power Systems DC - 10 -

	kV	A	mH
Rihand-Delhi	500	1500	180
HQ-NEH	500	2250	2x150
Sylmar	500	3100	2x150
Vizag	BtB	3900	2 x 30
UHVDC	800	3750	4x90
Dimensions	Weight ton	Height m	Diameter m
Sylmar	43	4.0	4.2
UHVDC	40	4.0	4.0



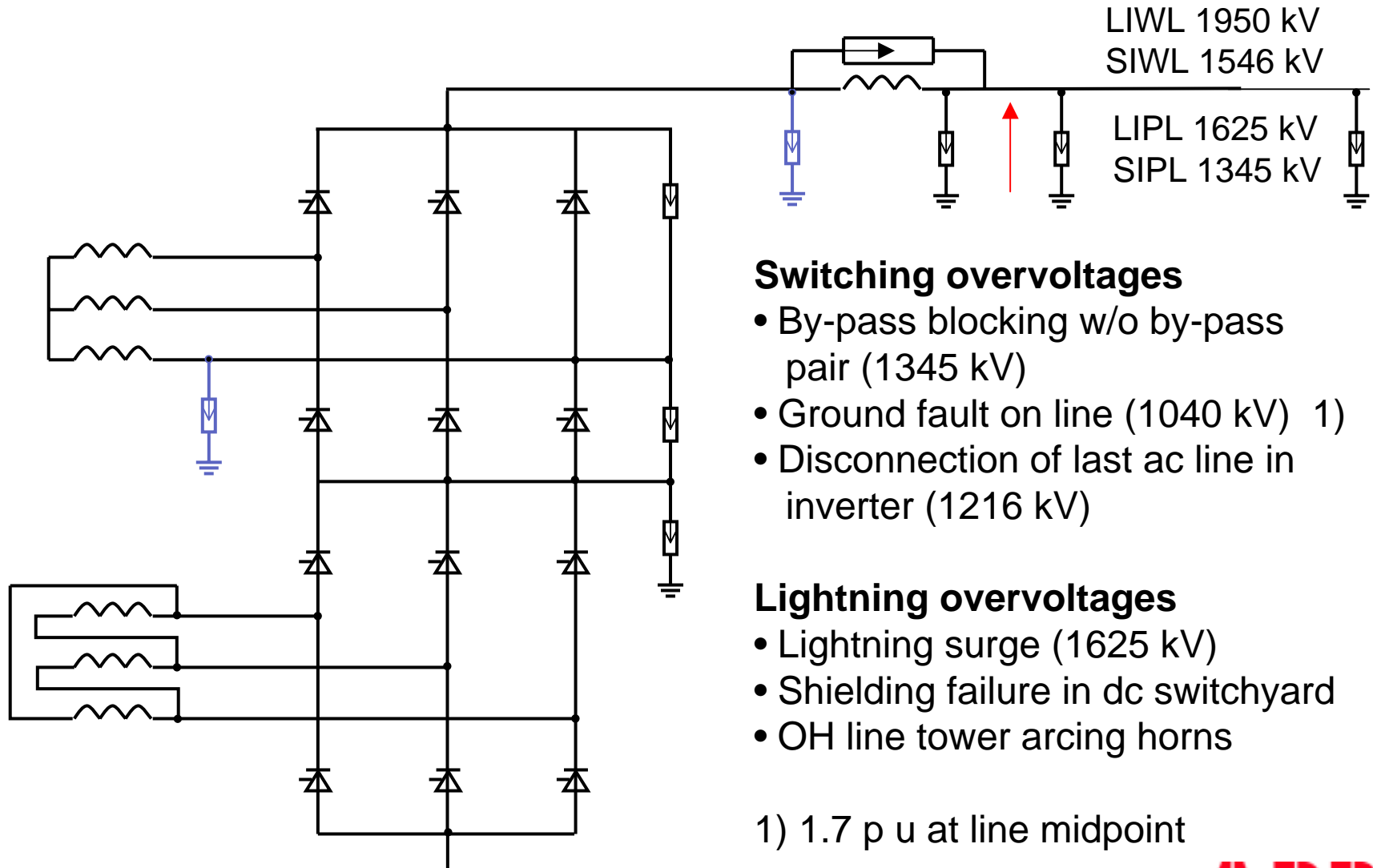
Platform for smoothing reactor and arrester



Presentation items

- Operating experience
- Principles
- Smoothing reactor
- Insulation levels for different components from a study using typical data
NB! Only the upper 12-pulse converter is shown
- Staging

800 kV DC bus outside smoothing reactor



Switching overvoltages

- By-pass blocking w/o by-pass pair (1345 kV)
- Ground fault on line (1040 kV) 1)
- Disconnection of last ac line in inverter (1216 kV)

Lightning overvoltages

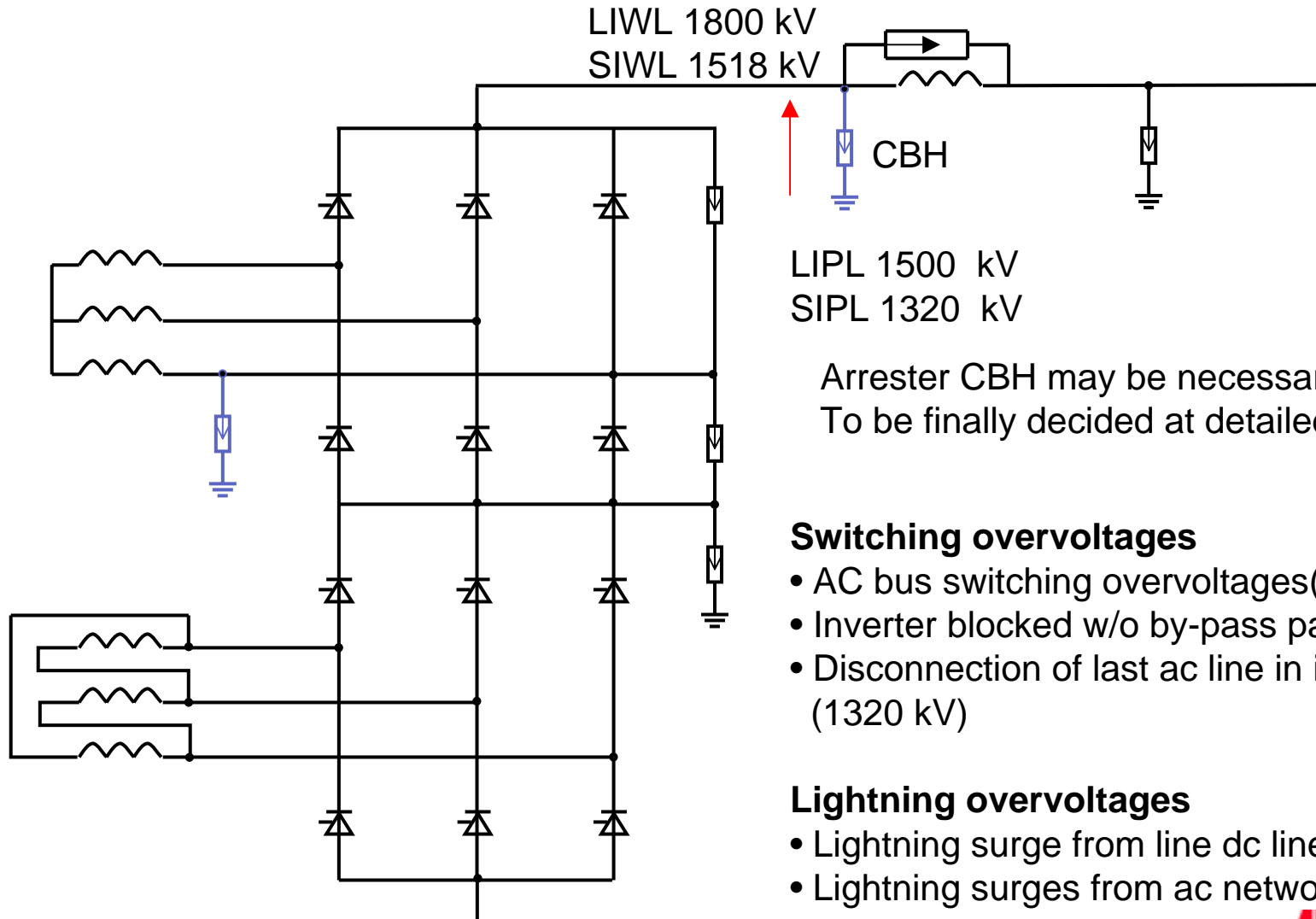
- Lightning surge (1625 kV)
- Shielding failure in dc switchyard
- OH line tower arcing horns

1) 1.7 p u at line midpoint

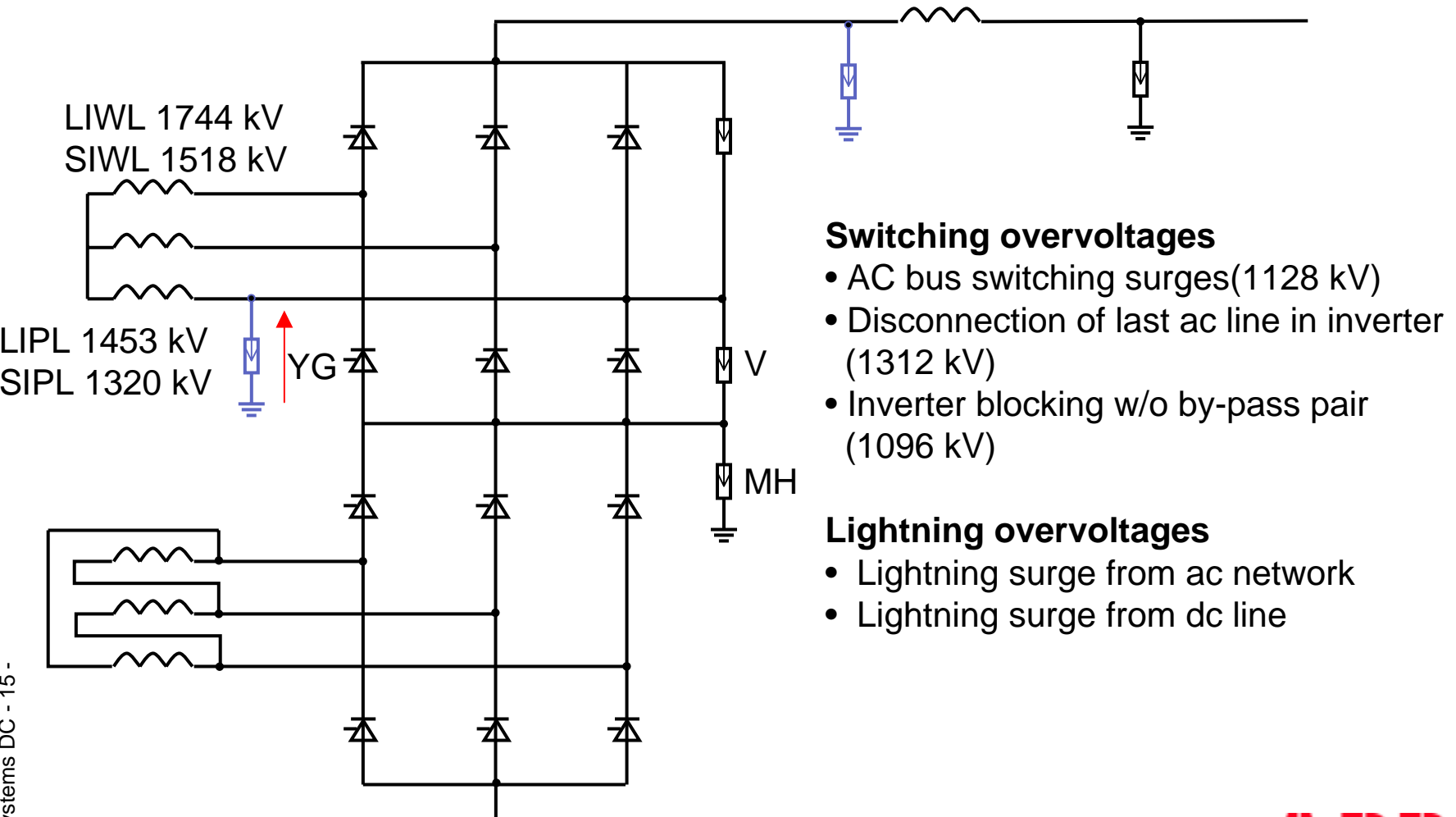
Two or three DC line arresters to cater for distance effects. All arresters are contributing to reduce switching surges



800 kV bus in valve hall



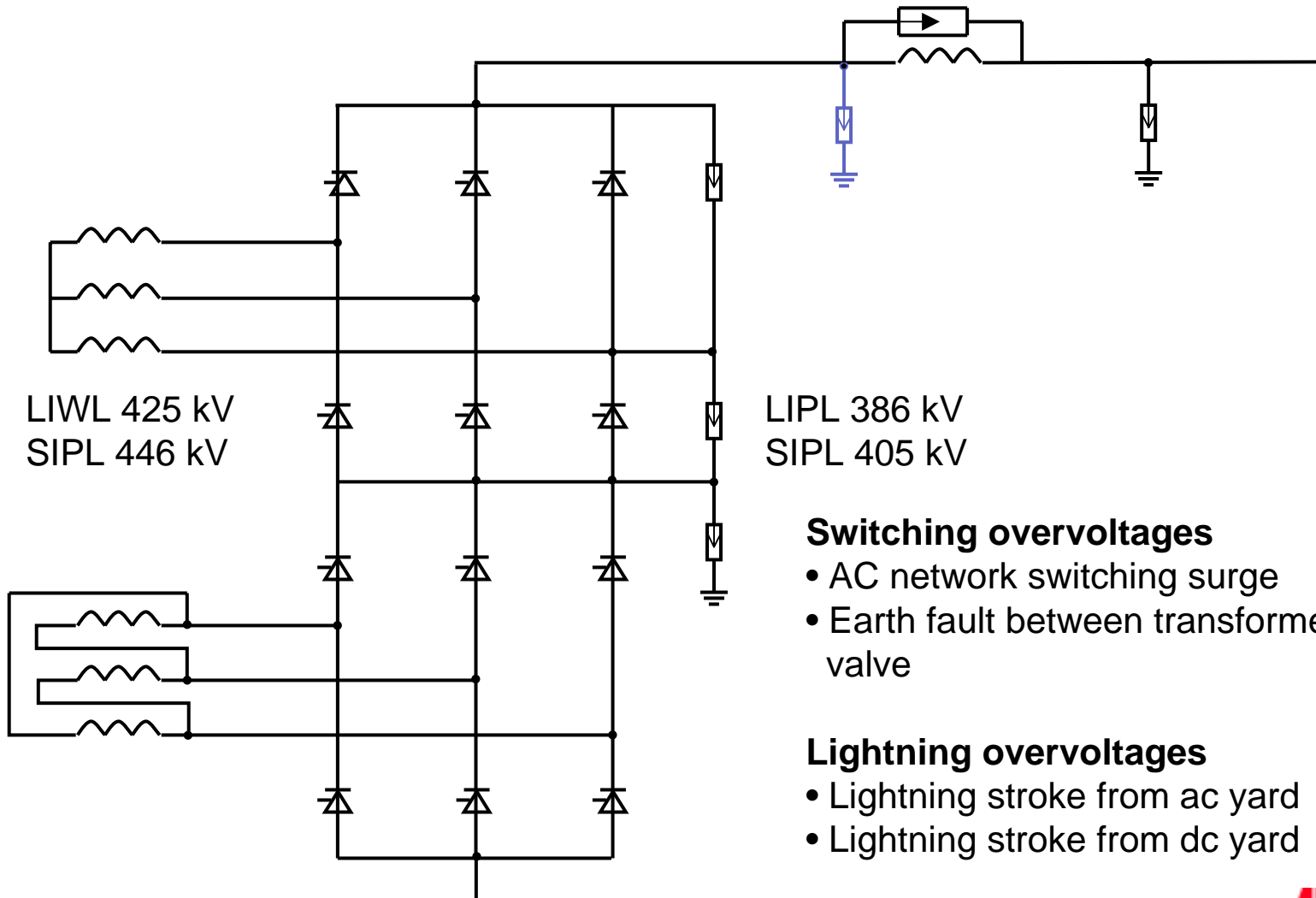
Y/Y connected transformer



The arrester YG will be installed if necessary to reduce switching overvoltages. Otherwise arresters MH+V protect phase-to-ground insulation



Thyristor valve insulation



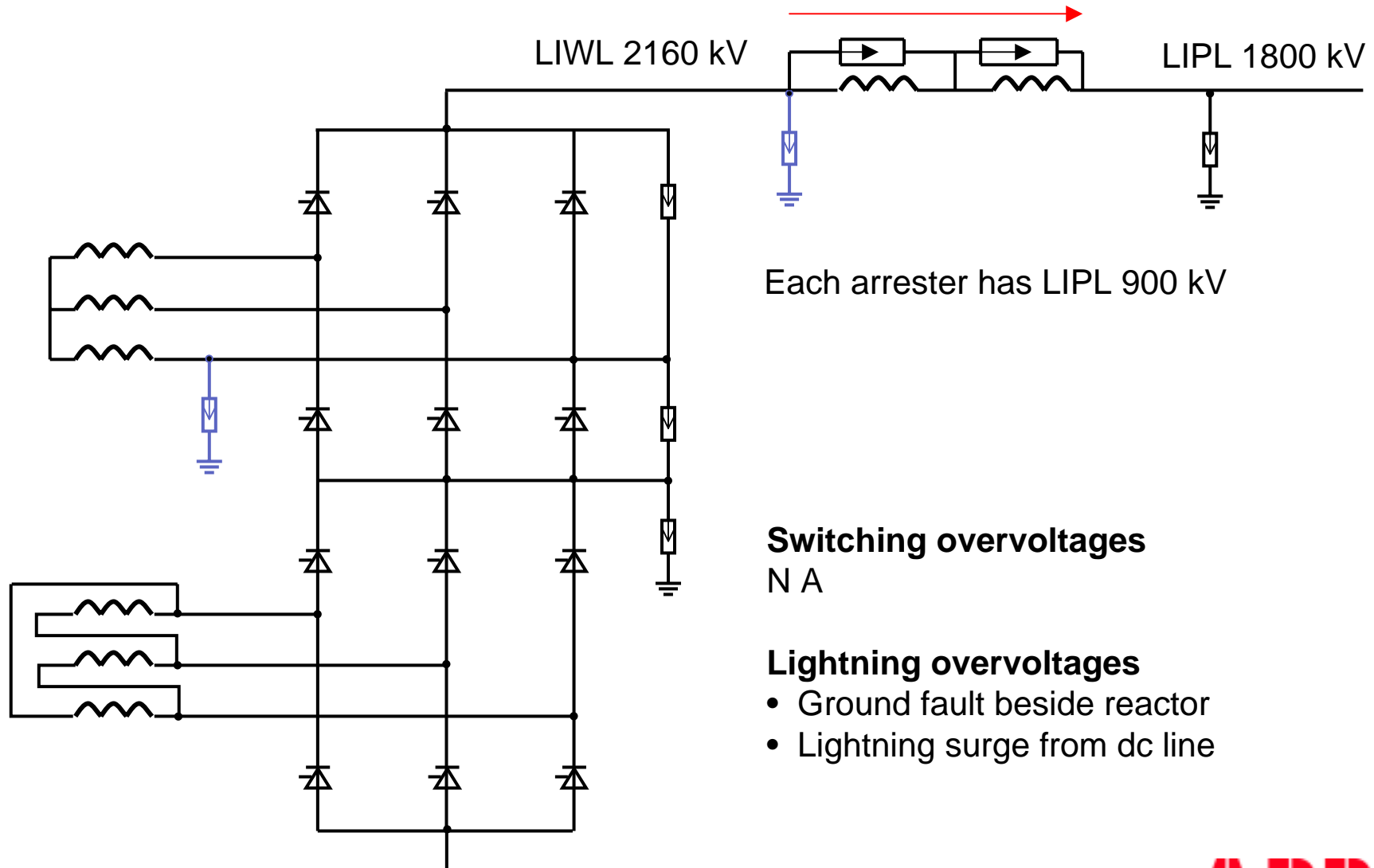
Switching overvoltages

- AC network switching surge
- Earth fault between transformer and valve

Lightning overvoltages

- Lightning stroke from ac yard
- Lightning stroke from dc yard

Smoothing reactor on 800 kV pole bus



Each arrester has LIPL 900 kV

Switching overvoltages

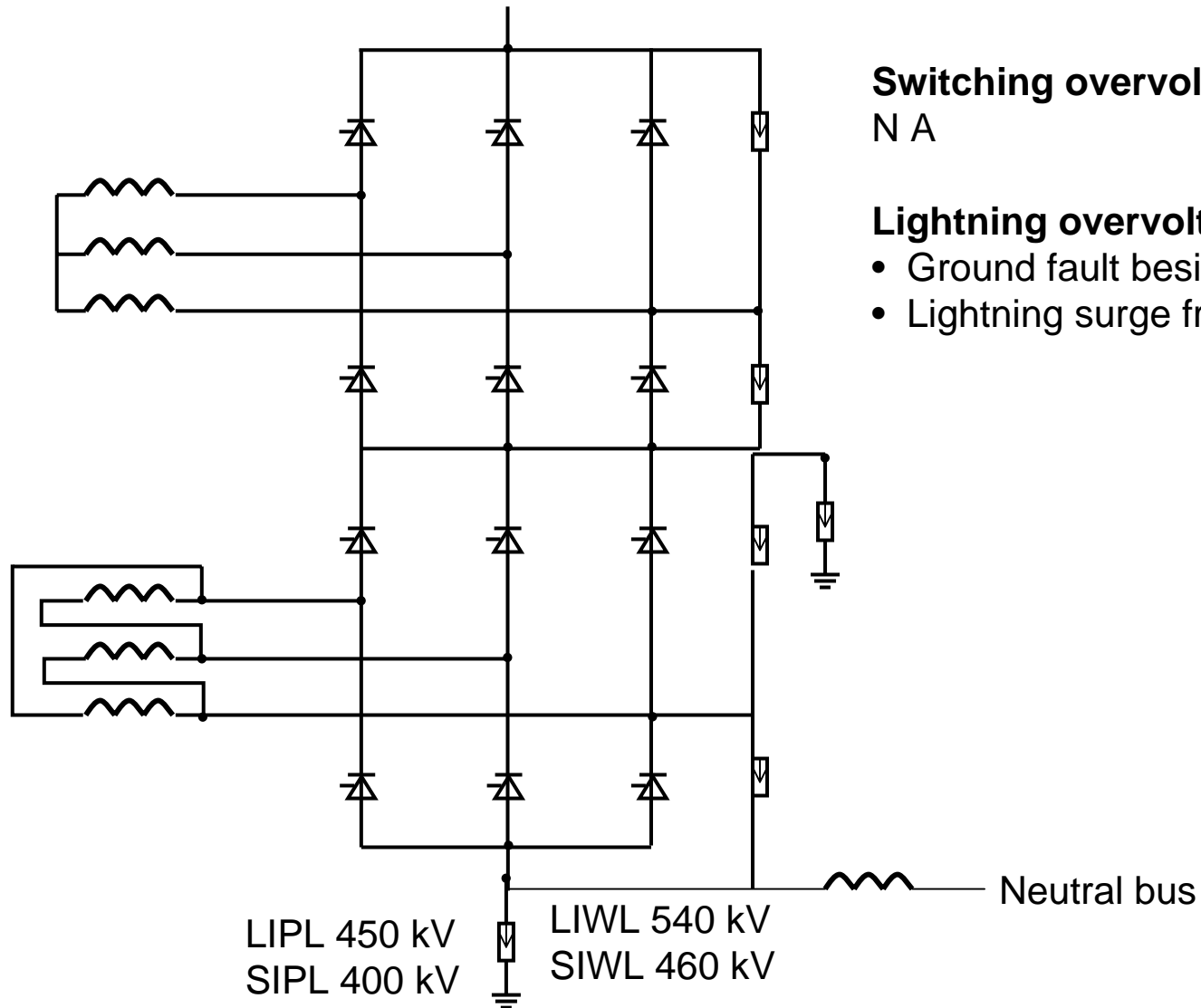
N A

Lightning overvoltages

- Ground fault beside reactor
- Lightning surge from dc line



Smoothing reactor on neutral bus



Switching overvoltages

N A

Lightning overvoltages

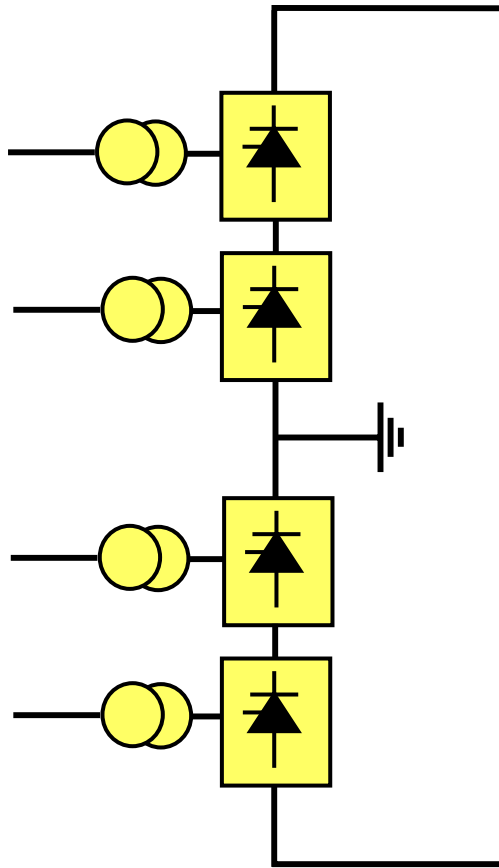
- Ground fault beside reactor
- Lightning surge from dc line



Presentation items

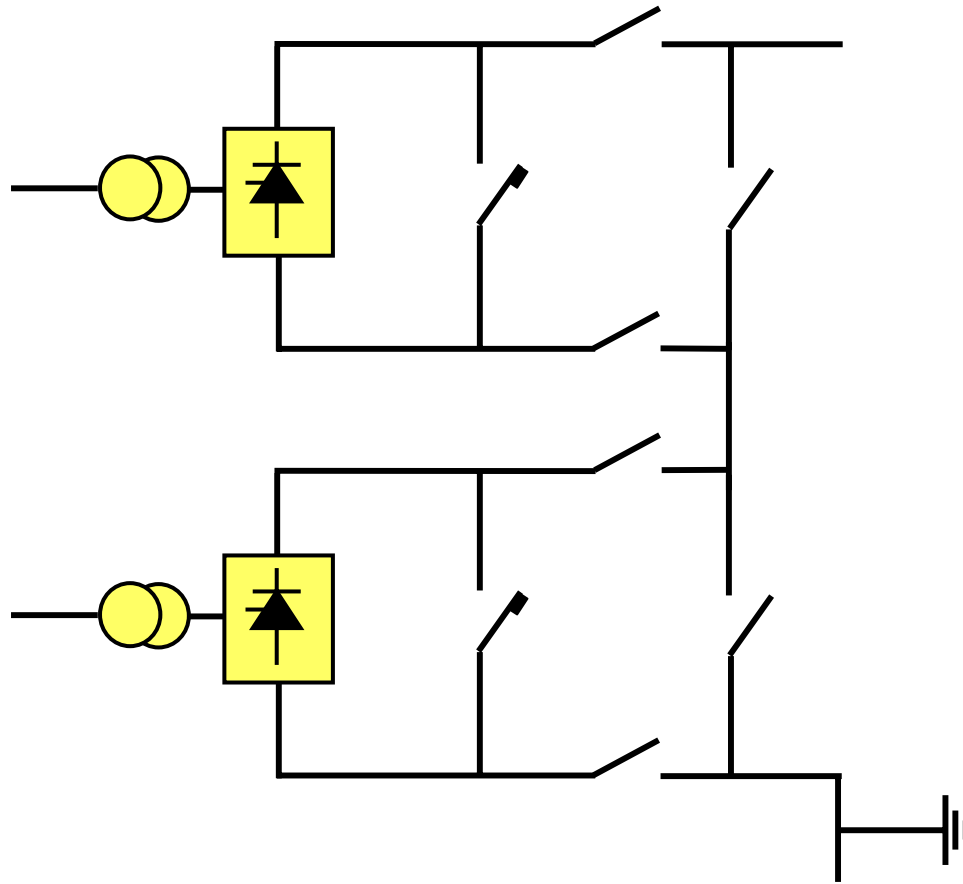
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UHVDC, 2 x 12-pulse converters/pole



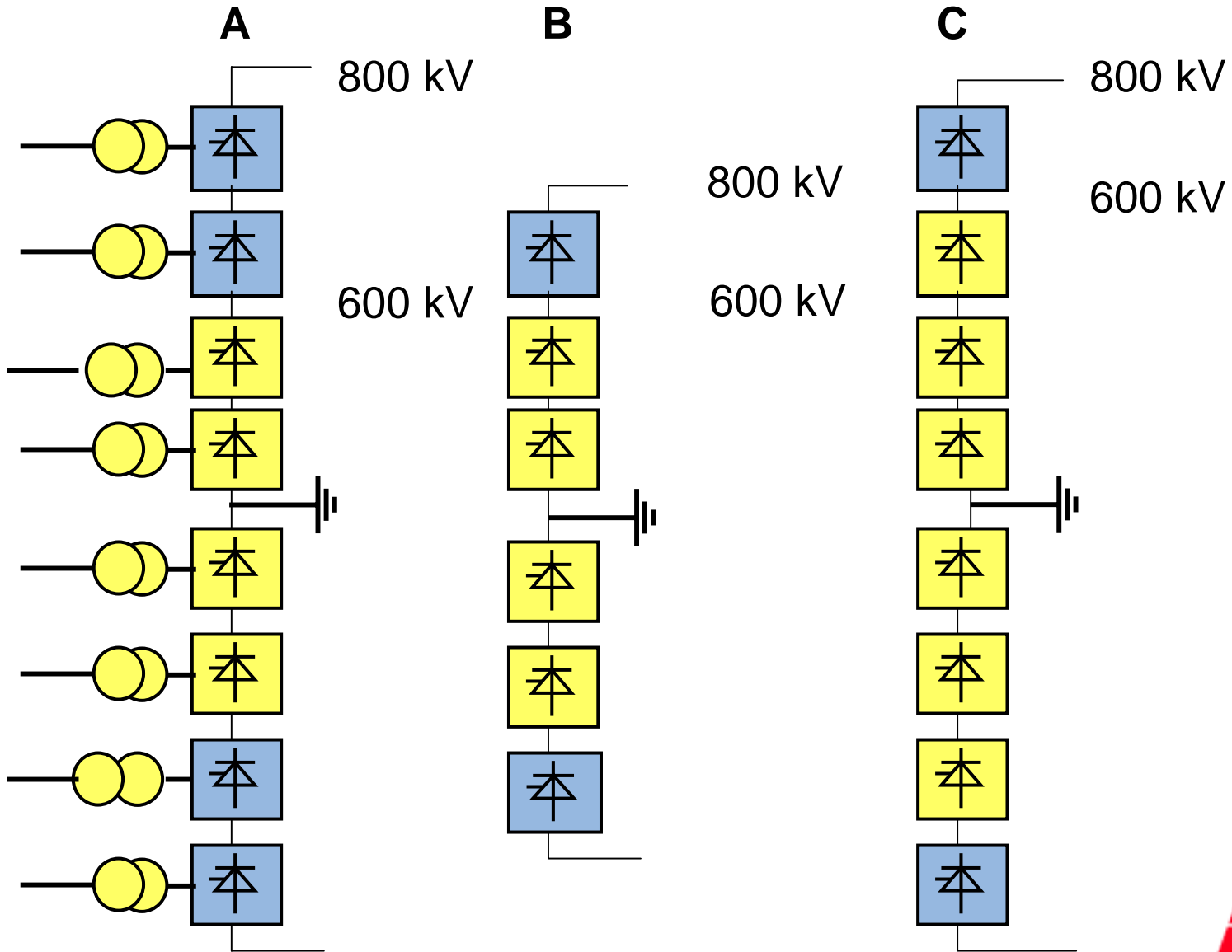
- 2 x 12 pulse groups/pole
- Max power 6200 MW at 800 kV DC
- Transformer data (6200 MW)
 - No 24 units
 - 1Ø2W 310 MVA
 - Weight 310 tons
 - LxWxH 8 x 4 x 5 meter
- Installed at Itaipu, in operation for 20 years

2 x 12 pulse groups/pole, switching arrangements



- Maximum flexibility & availability
- High speed by-pass switch
- Operational experience from Itaipu
- Operation at reduced voltage
 - 70 %
 - 35 %

UHVDC, stagewise extension



Converter configurations, 6000 MW, +/-800 kV, 3750 A

First stage		Second stage		Transformer	Cost
Connection	Voltage kV	Connection	Voltage kV	MVA/MVA 1st / 2nd	%
1x12pulse	400	1x12pulse	800	300/300	100
1x12pulse	500	1x12pulse	800	375/225	100
1x12pulse	600	1x12pulse	800	450/150	100
1x12pulse	600	1x6pulse	800	450/300	97
1x6pulse	600	1x6pulse	800	300/300	101



A B B