Smoothing Reactor and AC/DC Filter
DC Smoothing Reactors
Smoothing Reactor - Purpose

- Connected in series in each converter with each pole
- Decreases harmonic voltages and currents in the DC line
- Smooth the ripple in the DC current and prevents the current from becoming discontinuous at light loads
- Limits crest current \((\text{di/dt})\) in the Rectifier due to a short circuit on DC line
- Limits current in the bypass valve firing due to the discharge of the shunt capacitances of the dc line.
DC Smoothing Reactor ratings

• Two Smoothing Reactors per pole
• Inductance - 125mH
• Nominal DC Voltage – 500KV
• Max DC Voltage – 515KV
• BIL – 950/1425KV

(Typical Value for 2000 MW ± 500 KV Bipole HVDC Link)
DC Smoothing Reactor ratings

• Continuous current - 2000A
• Continuous Over load current - 2200A
• Type – Air Cored Dry type
• Forced Air cooling system
  automatically controlled on Amb. Temp & DC current
• Location : Outdoor
• Total mass – 30 Ton
• Temperature Class - F

(Typical Value for 2000 MW ± 500 KV Bipole HVDC Link)
HARMONIC FILTERS
HARMONIC FILTERS

- Conversion process generates – Harmonics
- AC side Harmonics- Current harmonics
  - Generated harmonics – (12n ± 1) harmonics
  - n = 1, 2, 3, ....
  - Predominant harmonics – 11, 13, 23, 25, 35, 37
  - Additionally 3rd harmonics
- DC side Harmonics- Voltage harmonics
  - Generated harmonics – (12n) harmonics
  - n = 1, 2, 3, ....
  - Predominant harmonics – 12, 24, 36
Disadvantages of Harmonics

- Over heating and extra losses in generators
- Over heating and extra losses in motors
- Instability in the converter control
- Interference with telecommunication systems
- Over voltages due to resonance
AC Filters – (For A TYPICAL 2500 MW,±500 KV Bipolar project)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter sub bank</td>
<td>DT 12/24</td>
<td>DT 3/36</td>
<td>Shunt C</td>
</tr>
<tr>
<td>Rating (3 ph., 400 kV)</td>
<td>MVAr 120</td>
<td>97</td>
<td>138</td>
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<tr>
<td>No.of 3 phase Banks</td>
<td>- 8</td>
<td>4</td>
<td>5</td>
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<tr>
<td>HV-Capacitor C1</td>
<td>μF 2.374</td>
<td>1.85</td>
<td>2.744</td>
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<tr>
<td>HV- Reactor L1</td>
<td>mH 16.208</td>
<td>5.444</td>
<td>1.602</td>
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<td>HV-Resistor R1</td>
<td>ohms 420</td>
<td>300</td>
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<td>LV-Capacitor C2</td>
<td>μF 4.503</td>
<td>3.759</td>
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<tr>
<td>LV- Reactor L2</td>
<td>mH 7.751</td>
<td>204.2</td>
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<tr>
<td>LV-Resistor R2</td>
<td>ohms -</td>
<td>1500</td>
<td>-</td>
</tr>
</tbody>
</table>
12/24 Double Tuned Filter – 120 MVAr

C1 = 2.374 µF
C2 = 4.503 µF
R1 = 420 Ω
L1 = 16.208 mH
L2 = 7.751 mH

Impedance Graph
12/24 Double Tuned Filter – Sectional view
3/36 Double Tuned Filter – 97 MVAr

C1 = 1.85 µF
L1 = 15.444 mH
R1 = 300 Ω
L2 = 204.2 mH
C = 23.759 µF
R2 = 1500 Ω

Impedance Graph
3/36 Double Tuned Filter – Sectional view

- Capacitor stack
- Resistor
- Reactor
- CT
- Reactor
- Reactor
- C = 23.759 µF
Shunt Capacitor – 138 MVAr

- No harmonic filtering
- Supplies MVAr to the grid
- Switched into the circuit for voltage control purpose
- Capacity – 138 MVAr

\[ C_1 = 2.744 \, \mu F \]
\[ L_1 = 1.602 \, mH \]
Shunt Capacitors-Voltage Improvement
DC Filter
DC Filter 12/24

C1 = 1800 nF
R1 = 400 Ω
L1 = 14.71 mH
L2 = 8.19 mH
C1 = 5700 nF
DC Filter 12/36

L1 = 7.21 mH
L2 = 12.68 mH
C1 = 1800 nF
C1 = 3300 nF
R1 = 400 Ω
THANK YOU