

1. Overall Filter Scheme Configuration

Pole-1

- **Total filters: 7**
- **Eastern side:**
 - CWC23 – Double tuned
 - CWC24 – Double tuned
 - CWC25 – Single tuned
- **Southern side:**
 - CWC33 – Double tuned
 - CWC34 – Double tuned
 - CWC35 – Single tuned
 - CWC36 – Single tuned

Pole-2

- **Total filters: 8**
- **Configured as harmonic banks:**
 - HP12/24A and HP12/24B groups
 - Z1, Z2Z3, Z4Z5 sections
 - Z6 used as **shunt reactor branch**

2. Filter Types and Tuning Philosophy

Filter Types Used

- **Combined filters (C + D type)**
 - Rated: **106 Mvar @ 400 kV**
 - Functions: Reactive power + harmonic filtering
- **D-type (double damped) filters**
 - Tuned typically to **12th & 24th harmonics**
- **C-type filters**
 - Tuned to **3rd harmonic**
- **Single/Dual tuned filters**

- Used in Pole-1 configuration (site-specific tuning)
- **Shunt Reactors**
 - Rated: **80 Mvar @ 420 kV** (~72.5 Mvar @ 400 kV)

3. Arrangement and Configuration Philosophy

Typical Configuration per Side (East/South)

- **2 × Combined filters**
- **1 × D-type filter (minimum)**
- **Shunt reactors (Eastern side primarily)**

Key Design Rules

- At least **one combined filter must always remain energised**
- **D-type filters are added** based on:
 - Harmonic distortion limits
 - Reactive power demand
- Second combined filter:
 - Used mainly at **high load / high var conditions**
- Reactors:
 - Used to **absorb excess vars**, especially at light load

4. Harmonic Performance-Based Configuration

- Harmonic monitoring range: **11th to 50th order**
- Filters are switched to maintain:
 - Individual distortion limits
 - Total harmonic distortion
 - Telephone Influence Factor (TIF)

Control Rules

- If harmonic limits exceeded:
 - **Energise D-type filter first**
 - If not available → energise combined filter
- If harmonics are **very low (<50% threshold)**:

- Filters may be **de-energised**

Key Switching Criteria

Deadband

- Reactive power deadband: **<130 Mvar**
- Switching margin: **20 Mvar**
- Hysteresis: **~25 Mvar (5%)**

5. Protection Configuration (Filter-Related Only)

Pole-1 Protections

- Resistor overload (SAW)
- Resistor open circuit alarm
- IDMT overcurrent relay
- Instantaneous overcurrent
- Earth fault relay
- Breaker failure
- Capacitor unbalance (3 stages)

Pole-2 Protections

- Reactor/resistor thermal overload
- AC filter earth fault
- Breaker failure
- Capacitor unbalance protection
- Ferro-resonance detection
- Low-voltage capacitor protection
- Detuning supervision

6. Key Design Takeaways

- **Hybrid filter mix** (Combined + D-type + reactors) ensures:
 - Harmonic compliance
 - Reactive power flexibility

AC Filter Configuration Summary (VIZAG HVDC Station)

- **Dynamic Mvar capability** (voltage/frequency dependent)
- **Hierarchical switching logic:**
 1. Open-loop (power-based)
 2. Closed-loop (var + harmonic)
- **Robust stability features:**
 - IDMT delays
 - Hysteresis
 - Lockouts
- **Fast fault recovery:**
 - Sub-cycle to few-cycle response

Note: For further details Bidders are advised to visit VIZAG HVDC Station site.