MAKERERE UNIVERSITY

COLLEGE OF ENGINEERING, DESIGN, ART AND TECHNOLOGY

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

BSC. ELECTRICAL ENGINEERING

POWER SYSTEM'S ASSIGNMENT 3

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1. **Advantages and disadvantages of HVDC transmission**

   Advantages

   - HVDC transmission allows for a higher current carrying capacity due to reduced dielectric losses.
   - HVDC transmission has minimal power losses due to joule heating since it has no reactive components.
   - HVDC has reduced average operational costs per MW of power being transferred
   - HVDC allows for voltage regulation since there are no inductive components

   Disadvantages.

   - Uneconomical for low power supply over short distances i.e. high cost inverting and converting equipments are required.
   - Reactive power requirement and complexity of controls.
   - Identification of a fault is difficult since most DC lines are installed underground.
   - Use of forced communication.
   - HVDC transmission line is not suitable for a multi-terminal network.
   - Inability to use transformers to alter voltages.
   - Generation of harmonics.
   - Application of digital electronics and fibre optics in the control of converters.

2. **Applications of DC transmission**.

   - Long distance bulk power transmission.
   - Stabilization of power flows in integrated power system.

3. **Factors considered for planning HVDC transmission.**

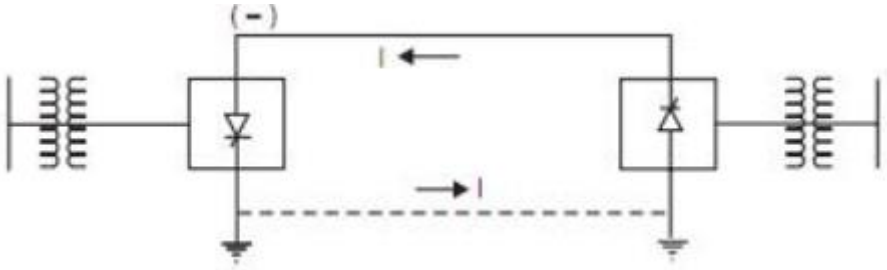
   - Cost. Minimum cost is always selected among various alternatives.
   - Reliability
   - Technical performance.

4. **HVDC Projects in the World**.

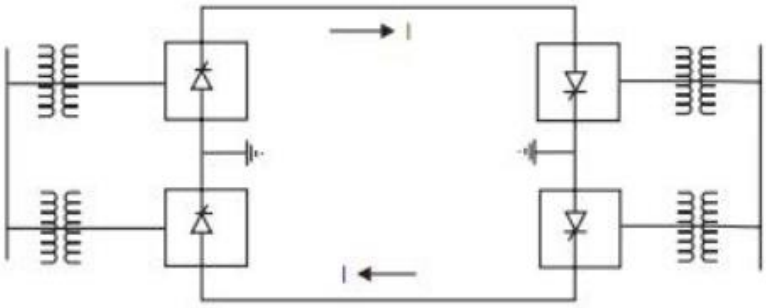
Project	Year of Commissioning	Power rating (MW)	Rated voltage (kV)
Nemo link (Belgium)	2019	1000	400
Cometa (Spain)	2011	400	250
Ethiopia Kenya HVDC interconnector	2019	2000	500
Baltic cable (Germany)	1994	600	400
Rihand-Delhi (India)	1990	1500	500
Western Alberta Transmission Line (Canada)	2015	1000	500
Plains & Eastern Clean Line (USA)	2018	4000	600
Maritime Link (Canada)	2017	500	200
Xingu-Estreito (Brazil)	2017	4000	800
Rio Madeira (Brazil)	2013	7100	600

5. Types of DC links in HVDC Transmission.

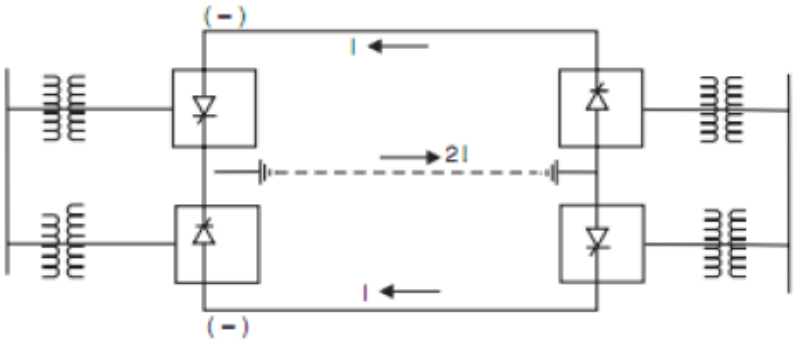
- Monopolar Link - Has a single conductor with the ground used as a return path.



- Bipolar Link – Has two conductors, one being positive and the other negative with respect to the ground. Converters are placed at both ends in series, and their midpoints earthed.



- Homo-polar Link – Two conductors of same polarity usually negative are used with poles connected in parallel to reduce insulation costs.



6. Use of transformer tap changer at inverter side of HVDC system;

- At the inverter side of an HVDC system, an AC voltage is produced by the inverter and a transformer is used to change the AC voltage levels by either stepping up or stepping down. The transformers have tap changers which regulate their output voltage by changing the number of turns in a particular winding, and therefore affecting the turns ratio. This alters the output voltage since it varies with turns ratio.

7. Operation of DC breakers in HVDC.

- DC breakers are used to interrupt high voltage currents in a power network. Unlike AC breakers, a current zero crossing must be developed to interrupt current flow in case of a fault. Two types of HVDC circuit breakers exist ; **Electromechanical** and Solid state.
  In electromechanical breakers, current zero is created by superimposing an inverse input current by discharging a capacitor through an inductor.
  Solid state circuit breakers interrupt current faster and they are based on Integrated Gate Commutated Thyristors (IGCT). The IGCT turns itself off when current flows inorder to interrupt.

8. Why is 3-phase bridge connection used invariably in converter and inverter circuits in HVDC systems.

Normally 3-phase bridge rectifiers are utilized in high voltage direct current converter due to the fact that they have the highest possible transformer utilization for the 3-phase system and the ripples in the output voltage is more smaller as compared to the other configurations hence the filter circuit usually required is equally small.

9. Explain the selection of converters for HVDC system

- Power Factor: The AC power supplied to the converter is usually given by; $P_{AC} = \sqrt{3}E_{LL}I_1 \cos\phi$ where $\cos\phi$ is the power factor and thus the DC power must match with the AC power ignoring the losses in the converter.
- Valve Voltage Rating: Usually the valve voltage rating is specified in terms of peak inverse voltage the converters can withstand and the valve utilization is the ratio of peak inverse voltage to average dc voltage.
- Firing angle delay (α): Delay angle is the time needed for firing the pulses in a converter for its conduction and is generally expressed in electrical degrees. Therefore it is the time between zero crossing of commutation voltage and starting point of forward current conduction. The mean value of DC voltage can be minimized by reducing the conduction duration that can be achieved by delaying the pulses that is to say, by increasing the delay angle can reduce the DC voltage and the power transmission from one valve to another valve can also be minimized.