# SAMSKRUTI COLLEGE OF ENGINEERING & TECHNOLOGY

## Department of Electrical and Electronics Engineering

## Hand Out

**Subject Name: HVDC TRANSMISSION**

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**Year and Sem, Department:** IV Year I Sem, EEE

## Unit-I (Important Points)

1. Converters: The AC to DC and DC to AC conversion are done by the converters. It includes transformers and valve bridges.
2. Smoothing Reactors: Each pole consist of smoothing reactors which are of inductors connected in series with the pole
3. The reactive power used by the converters could be more than 50% of the total transferred active power.
4. Mono Polar Links: Single conductor is required and water or ground act as the return path. If the earth resistivity is high, metallic return is used.
5. Homo Polar Links: It consists of more than two conductors which is having equal polarity generally negative. Ground is the return path.
6. Bipolar Links: Double converters of same voltage rating are used in each terminal. The converter junctions are grounded.
7. Application of HVDC Transmission:

   Undersea and underground cables
   AC network interconnections
   Interconnecting Asynchronous system
8. HVDC stands for high voltage direct current, a well-proven technology used to transmit electricity over long distances by overhead transmission lines or submarine cables

## Unit-I (2 Marks Questions)

1. What are the factors to be considered for planning HVDC transmission.
2. What are the limitations of EHVAC transmission?
3. What are the demerits of HVDC transmission system?
4. What are the applications of DC transmission system?
5. What is pulse number of a converter? What is its significance?
6. List the applications of DC transmission.
7. What is the need of static converter in HVDC systems and how is it configured?
8. Differentiate between 6-pulse and 12-pulse converters?

## Unit-I (10 Marks Questions)

1. List out Converter Station Equipment and describe about them in detail.
2. Explain Modern trends and planning of HVDC Transmission System.
3.Explain the Operation of 6- Pulse Converter with neat circuit diagram. Sketch the wave form and derive the Expression for output Voltage?
4.List out the factors that decide the converter configuration.
5. Make a comparison between HVAC and HVDC transmission. Also list the advantages of HVDC transmission.
6.Draw the schematic diagram and explain the operation of a twelve pulse converter.
7. Draw and explain the equivalent circuit for a 6-pulse converter.
8..Compare A.C. and D.C. transmission system based on economic aspects and technical performance and reliability.
9. With neat sketches explain the different kinds of D.C. links available and list out its merits and demerits.
10. Describe modern trends in DC transmission.
11 Draw the circuit diagram voltage and current waveform of a three-phase, 6-pulse uncontrolled bridge rectifier and derive the expression for (i) Average DC voltage and (ii) total VA rating of valves and transformer.
12. Explain the technological development of modern trends in dc transmission.
13. Explain the major components of HVDC transmission in converter station unit.
14. Compare AC & DC transmission systems and Explain the application of DC transmission systems.

15. Draw the schematic circuit diagram of a 6 pulse gratez circuit and explain its principle of operation.

## Unit-I (Fill in the blanks)

1.The characteristics of insulators vary with the type of **Voltage** applied

2. The Dielectric losses in case of power cables is also very **less** for DC transmission

3. The corona effects on DC conductors tend to be_**less**_significant than for AC.

4. The power transfer in AC lines is dependent on the angle difference between the **voltage** phasors at the two ends.

5.The voltage control in **AC Lines** is complicated by the line charging and inductive voltage drops.

6. The maintenance of constant voltages at the two ends requires **Reactive Power** control from inductive to capacitive as the line loading is increased.

7. In AC cable transmission, it is necessary to provide **shunt compensation** at regular inverters.

8. It is tobe noted that even while operating in the monopolar mode, the AC network feeding the DC converter station operates with balanced voltages and **Currents**

9. The difficulty of breaking DC currents which results in **High cost** of DC breakers.

10. The reliability of **DC** _transmission systems is quite good and comparable to that of AC systems.

## Unit-II (2 Marks Questions)

1.What do you understand from the term system hierarchy control?

2. Why is 'control' required in HVDC systems? Draw the converter control characteristics?

3.What do you understand by starting of D.C. link?

4. List various types of DC links.

5. Draw the converters control characteristics.

6. What is meant by firing angle control?

7.What are the limitations of EHVAC transmission?

8. Write short note on starting of DC link.

## Unit-II (10 Marks Questions)

1. Explain the converter control characteristics in HVDC system.

2. Explain the relative merits and demerits of constant current and constant voltage operation of an HVDC Link.

3. Explain the individual characteristics of a rectifier and an inverter with sketches.

4. Discuss in detail the principle of DC Link control.

5.Discuss equidistant pulse firing angle control scheme with its relative merits and demerits

6.A 6-pulse bridge connected inverter is fed from 238/110 kV transformer which is connected with 3-□, 238 kV, 50Hz supply. Calculate the direct voltage output when the commutation angle is 200 and delay angle α is i) 300 , ii) 900 and iii) 1500 . Comment on the results.

7.Explain the starting and stopping of DC link

8.The AC side line voltage of a 3-PHASE bridge type inverter is 160kV with an extinction angle of 200 and an overlap angle of 200. Calculate the DC voltage. What should be the new extinction angle if the DC voltage at inverter and drop to 175 kV with the overlap angle and the AC line voltage remaining unaltered?

9. Explain in detail the equidistant pulse control (EPC) scheme for HVDC. Also list the merits and drawbacks of EPC scheme.

10.Discuss different types of converters used in HVDC stations.

11. Explain the extinction angle control of HVDC converters.

12. Describe firing angle control in HVDC converters.

13.Explain with the help of control characteristics how the constant current control and constant extinction angle are used to maintain the constant power flow in the HVDC link?

14. Discuss the mechanism involved in starting of DC link.

15.Describe in detail about current control scheme used in HVDC converters.

## Unit-II (Fill in the blanks)

1. Usually a STATCOM is installed to support electricity networks that have a poor _____ and often poor _____. There are however, other uses, the most common use is for voltage stability.
2. A STATCOM is a voltage source converter (VSC)-based device, with the voltage source behind a reactor. The voltage source is created from a_____ and therefore a STATCOM has very little active power capability.
3. STATCOMs active power capability can be increased if a suitable _____is connected across the DC capacitor.
4. The reactive power at the terminals of the STATCOM depends on the _____of the voltage source.
5. If the terminal voltage of the VSC is higher than the AC voltage at the point of connection, the STATCOM generates_____.

6. when the amplitude of the voltage source is lower than the AC voltage, it _____reactive power.
7. The response time of a STATCOM is shorter than that of an SVC, mainly due to the _____provided by the IGBTs of the voltage source converter.
8. The STATCOM also provides better reactive power support at _____than an SVC, since the reactive power from a STATCOM decreases linearly with the AC voltage.
9. HVDC has operational drawbacks that can limit its application. It requires a relatively _____on both sides of the HVDC link; it creates harmonic distortion on the AC systems
10. HVDC has limited control of the reactive power interchange with the AC system; and it needs a_____.
11. In a typical HVDC application operating at 200 to 400 kV DC, there would be several hundred sub-modules in series, and the voltage waveform would be suffi ciently sinusoidal to avoid the need for any additional harmonic filtering on the_____.

**Answers:**

1. reactive , voltage regulation
2. DCcapacitor
3. energy storage device
4. amplitude
5. reactive current
6. absorbs
7. afast switching times
8. low AC voltages
9. strong AC system
10. lot of space
11. AC side

## Unit-III (2 Marks Questions)

1.What do you understand by power flow study.
2. What are the major types of AC_DC interactions.
3. write the controller equations.
4. Discuss the various assumptions which are made while deriving the equations of AC-DC converter.
5. Why reverse power flow is needed in HVDC system?
6. Write a short notes on DC load flow solution.
7. Why do we need good simulation tool for HVDC simulation.
8. Discuss the various tools which can be used for the simulation of a dynamic system.
9. Discuss about sequential method the solution of AC-DC load flow.

## Unit-III (10 Marks Questions)

1.Explain in detail, with DC link modeling and control equations, the simultaneous method of AC/DC power flow

2. Draw the flowchart for sequential method of AC load flows

3 .Explain the conventional control strategy employed in HVDC System

4. Derive and explain the solution of AC/DC load flow problem using simultaneous method

5. Classify the solution methodology for AC-DC load flow and explain
6. Give out the differences between simultaneous and sequential methods of power flow.
7. Classify the solution methodology for AC-DC load flows and explain

## Unit-III (Fill in the blanks)

1. _____provide specialist solutions and services for Corporate Users. We understand that Corporate IT departments face a wide variety of challenges and tight timescales.
2. _____are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily.
3. Most DC to DC converters also regulate the_____. Some exceptions include high-efficiency LED power sources, which are a kind of DC to DC converter that regulates the current through the LEDs, and simple charge pumps which double or triple the output voltage.
4. Linear regulators can only output at _____from the input.
5. The inefficiency wastes energy and requires higher-rated and consequently _____and larger components.
6. The heat dissipated by _____supplies is a problem in itself and it must be removed from the circuitry to prevent unacceptable temperature rises.
7. Linear regulators are _____if the current is low, the power dissipated being small, although it may still be a large fraction of the total power consumed.
8. Linear regulators are inexpensive, reliable if _____are used and much simpler than switching regulators.
9. Electronic switch-mode _____convert one DC voltage level to another, by storing the input energy temporarily and then releasing that energy to the output at a different voltage.
10. The storage may be in either magnetic field storage components (inductors, transformers) or electric field storage components (capacitors). This conversion method is more power efficient (often 75% to 98%) than _____(which dissipates unwanted power as heat).

**Answers:**

1.DC Networks
2.DC to DC converters
3.output voltage
4.lower voltages
5.more expensive
6.high-power
7.practical
8.good heat sinks
9.DC to DC converters
10.linear voltage regulation

## Unit-IV (10 Marks Questions)

1.Broadly classify the HVDC faults and explain all possible converter faultswith their causes and effects on its operation

2. Describe about protection against over currents

3.Explain briefly about the surge arresters

4.Explain corona effects on DC lines?

5. Describe about protection against over voltages

6. Discuss how protection of DC line difers from AC line protection

7.What are the basic principles of over current protection?

8. Give the effect of converter pulse number of harmonic generation. Explain what are characteristics and non- characteristic harmonics and their significance and effects on its operation

## Unit-IV (Fill in the blanks)

1. In an electric power system, _____ is a situation where a larger than intended electric current exists through a conductor, leading to excessive generation of heat, and the risk of fire or damage to equipment.
2. The main advantage of _____is that the main switches only withstand half of the input dc-link voltage, so lower voltage rating devices with better performance can be used
3. Three-level converters need to have _____--Vcin1 and Vcin2 and two clamping diodes to ensure proper operation and equal voltage sharing.
4. An HVDC converter station (or simply converter station) is a specialised type of substation which forms the terminal equipment for a high-voltage direct current (HVDC) transmission line. It converts direct current to _____.
5. Almost all converters used for HVDC are intrinsically able to operate with power conversion in either direction. Power conversion from AC to DC is known _____and conversion from DC to AC is known as *inversion*.
6. _____are used to eliminate high frequency interference. Such filters are required if the transmission line will usepower-line communication techniques for communication and control, or if the overhead line will run through populated areas.
7. The converter transformers step up the voltage of the AC supply network. Using a star-to-delta or "wye-delta" connection of the transformer windings, the converter can operate with _____for each cycle in the AC supply, which eliminates numerous harmonic current components.
8. Converter transformers operate with high flux Power Steps In the Four Steps of the Converter per cycle, and so produce more acoustic noise than normal_____.
9. When line commutated converters are used, the converter station will require between _____of its power rating as reactive power. This can be provided by

banks of switched capacitors or by synchronous condensers, or if a suitable power generating station is located close to the static inverter plant, the generators in the power station.

10. Voltage sourced converters can generate or absorb_____, and additional reactive power equipment is generally not needed.

**Answers:**

1. overcurrent or excess current
2. three-level dc–dc converters
3.balanced dc voltages
4.alternating current
5.as *rectification*
6.Special direct current filters
7.12ulses
8.three-phase power transformers
9.40% and 60%
10.reactive as well as real power

## Unit-V (2 Marks Questions)

1. What is the need of filters?
2. Write the Controller Equations.
3. Briefly discuss what the different harmonic instability problems are.
4. Define harmonics. List the causes for harmonics.
5. What are harmonics? What are their effects in power systems?

## Unit-V (10 Marks Questions)

1.Give the effect of converter pulse number of harmonic generation. Explain what are characteristics and non- characteristic harmonics and their significance and effects on its operation.

2. Write short notes on the following:(a)Telephone influence factor.(b) Harmonic distortion**.**

3. suggests some remedial measures.

4. What are non characteristic harmonics?

5.How do you estimate the harmonic order based upon pulse number of HVDC converter station? Give a detailed harmonic analysis of a 12-pulse converter for characteristic harmonics

6. What is the effect of increase in the pulse number beyond 12 on harmonics.

7. mention the configurations and impedance characteristics of various types filters.

8. what are the advantages of double tuned circuit.

9. Give design aspects of single tuned filter.

10. Explain in detail different strategies employed in HVDC system to mitigate the AC and DC side harmonics. Give their designing principles.

11. Explain the design of single tuned filter. How its cost optimized?

12. Discuss the following filters (a) Doubled Tuned filter (b) High pass C type filter .

# Unit-V (Fill in the blanks)

1. High harmonic generation describes the conversion of laser radiation from one fixed frequency to _____of that frequency.
2. To determine the electronic structure of the molecule, we need to fix their axes in space by _____alignment.
3. _____are caused by non-linear loads. When a non-linear load, such as a rectifier, is connected to the system, it draws a current that is not necessarily sinusoidal.
4. The current waveform can become quite complex, depending on the _____and its interaction with other components of the system.
5. A pure sinusoidal voltage is a conceptual quantity produced by an ideal AC generator built with finely distributed stator and _____that operate in a uniform magnetic field.
6. When a sinusoidal voltage is applied to a certain type of load, the current drawn by the load is determined by the voltage and impedance and follows the voltage waveform. These loads are referred to as _____.
7. Harmonics are caused by_____, that is loads that draw a nonsinusoidal current from a sinusoidal voltage source.
8. Some examples of _____producing loads are electric arc furnaces, static VAR compensators, inverters, DC converters, switch-mode power supplies, and AC or DC motor drives.
9. In the case of a motor drive, the AC current atthe input to the _____looks more like a square wave than a sinewave.
10. The rectifier can be thought of as a _____and produces roughly the same amount of harmonic current over a wide range of power system impedances.
11. The characteristic current harmonics that are produced by a rectifier are determined by the_____.

**Answers:**

1. **high harmonics**
2. **molecular**
3. **Current harmonics**
4. **type of load**
5. **field windings**
6. **linear loads**
7. **non-linear loads**
8. **harmonic**
9. **rectifier**
10. **harmonic current source**

**pulse number**