

# **AMEL21 EXTRA HIGH VOLTAGE (EHV) TRANSMISSION**

## **UNIT-1 HVDC POWER FLOW**

- 1.1 Subscripts and symbols, Thyristor principle and control, Power conversion principle, Direct Voltage  $U_{d1}$  and  $U_{d2}$ , Power at Rectifier-end  $P_{d1}$ , Power at Inverter-end  $P_{d2}$ ,
- 1.2 Power loss in DC system, Power in middle of HVDC line, Power at sending end, Power at receiving end, General equations,
- 1.3 Solved Numerical examples on  $P_d$  and  $U_d$ , Summary and Questions.

## **UNIT-2 CONVERTER CONNECTIONS, RECTIFIER AND INVERTER WAVEFORMS**

- 2.1 Rectifier Bridge Connections and Waveforms on AC and DC side, Six Pulse Bridge (Graetz Bridge), 12-Pulse Bridge, Phase Control and Delay angle,
- 2.2 Effect of Phase control on DC Voltage, Valve Voltage, Inversion, Connections of Converter Bridge, Commutating Reactance, Angle of Overlap Extinction Angle,
- 2.3 Significance of Delay Angle and Extinction Angle, Control of DC Voltage, Configuration of Bipolar 2T HVDC System, Valves and Converters, Summary and Questions.

## **UNIT-3 REACTIVE POWER COMPENSATION IN HVDC SUBSTATIONS**

- 3.1 Reactive Power requirements of HVDC Converters, P.Q.S., Reactive Power  $Q$  required by converter, and HVDC Substation, Reactive power equations,
- 3.2 Effect of delay angle and Extinction angle, Short Circuit Ratio (SCR), Impedance of AC Network, Equivalent short circuit ratio, SCR in Planning of HVDC.
- 3.3 Transient Voltage Rise, Summary and Questions.

## **UNIT-4 MULTI-TERMINAL HVDC SYSTEMS**

- 4.1 Two pole HVDC with earth return, substation poles in different locations, MTDC System with series connected convertors, MTDC System with parallel connected convertors,
- 4.2 Control of Parallel connected HVDC System, Reversal of power in a terminal of HVDC System, Three TDC System with parallel tapping , Two pole reversal in 3 TDC System,
- 4.3 HVDC Breakers in MTDC System, Applications of MTDC Systems, Worlds First Commercial 3 TDC System, World's first 5 TDC System,

## **UNIT-5 INSULATION REQUIREMENT OF EHV-AC AND HVDC EQUIPMENT AND TRANSMISSION LINES**

- 5.1 Classification: Self restoring and Non-self-restoring insulation, Insulation Design Aspects, Stresses on Insulation , Tests, Causes of Flashover through Air and Gases,
- 5.2 Insulation withstand characteristics of Air Gaps, Leakage Distance or Creepage Distance of AC Insulators,
- 5.3 Leakage Distance or Creepage Distance of DC Insulators Line Insulator Design with respect to Creepage Distance, Voltage Grading Rings (Collector Rings) to reduce pollution,
- 5.4 Clearances (Insulation Distance) for AC and HVDC, Clearances in HVDC Substations, Choice of Clearance based on impulse withstand level, summary and questions.

## **UNIT-6 ENGINEERING ASPECTS OF EHV-AC TRANSMISSION AND TRANSMISSION PLANNING**

- 6.1 Electrical, Mechanical and Thermal Design Aspects, Engineering Aspects of EHV AC Transmission system, Transmission Planning and its co-relation with Generation Planning,
- 6.2 Distribution Planning, Why 400 kV AC was selected in India, Recent advances.

## **UNIT-7 ELECTROSTATIC FIELD AT GROUND LEVEL AND BIOLOGICAL EFFECTS (EHV-AC AND HVDC)**

- 7.1 Basic principles and terms in Electromagnetic Field theory, Significance of Electric Field Intensity (Negative of Potential Gradient) at ground level,
- 7.2 Electric field intensity of 3 phase AC line at ground level beneath the conductors and at the edge of Row, Charging of Objects, Vehicles and Human Body,
- 7.3 Biological effects on Human Beings, Shock Effects of Electric Field, Contact Currents, Limiting Values of 50 Hz Contact Currents, Summary and Questions.

## **UNIT-8 CORONA AND CORONA LOSSES (EHV-AC AND HVDC)**

- 8.1 Principle of Corona, Empirical Formulae for  $E_c$  and  $E_{cr}$ , Terms and Definitions, Corona of AC Overhead Lines, Factors affecting Corona,
- 8.2 Notations of terms in Derivations, Critical Surface Gradient, Peek's Law, Critical Disruptive Voltage and Critical Electric Stress for Visual Corona, Corona Phenomenon with HVDC,
- 8.3 Critical HVDC Voltage and Corona, Bipolar Corona Loss, Influence of Weather on DC Corona Loss, Summary and Questions.

## **UNIT-9 RADIO INTERFERENCE, TV INTERFERENCE AND AUDIBLE NOISE (EHV-AC & HVDC) RADIO INTERFERENCE**

- 9.1 Units of Measurement of RI, Generation of RI, propagation and Attenuation of RI, Attenuation of RI waves, Radio Interference Field Strength against Distance,
- 9.2 RI Design Criterion for EHV AC Line, Signal to Noise Ratio (SNR), Broadcast Signal Strength, RI Lateral Attenuation with Distance, RI at Edge of Row, Minimizing RI and TVI,
- 9.3 Bundled Conductor for reducing Corona and RI, Evaluation of RI by Comparison Method & Semi Analytical Method.
- 9.4 TV Interference : Comparison Formula for TVI Calculation of AC Lines RI and TVI Calculation of AC Lines RI and TVI in HVDC Overhead Lines, Elimination of DC Harmonics,
- 9.5 RI from Bipolar HVDC Line, Comparison of RI from HVDC line and EHV AC line TVI from HVDC Line.
- 9.6 Audible Noise : Terms and Definitions of Acoustics, Fundamentals of Sound, Measurement of AN and weighting curves, Attenuation of Sound Pressure Level,
- 9.7 Causes of AN in substation and Transmission Line, Transmission Line Design based on AN, Steps in Evaluating RN,

### **Reference Book:**

1. EHV AC , HVDC Transmission and Distribution Engineering, Publisher Katsons , Writer Sanjay K Sharma