Electrical Power Systems

By

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كلية الهندسة بشبرا

FACULTY OF ENGINEERING AT SHOUBRA


Lecture (3)

Course Code: EPE 215

Study Hours: 2 Lect. + 2 Tut + 2 Lab

Assessment:

Final Exam: 90 marks (50%) .

Year Work & Quizzes & Midterm: 60 marks (33.33%).

Oral & Practical: 30 marks (16.67%)

Textbook:

1- M. S. Naidu, High Voltage Engineering, 2009.

2- B. L. Theraja, A textbook of electrical and technology in S. I. System of units, Vol. III

3- Hadi Saadat, Power System Analysis

Syllabus

1. Introduction.
2. AC and DC Transmission Systems.
3. AC and DC Distribution Systems.
4. Substations and circuit breakers.
5. Interconnections of power systems.
6. Electrical and Mechanical Design of Transmission Lines.
7. Insulators and Voltage Distribution.
8. Underground Cable Systems.
9. Overvoltage in Electrical Power Systems.
10. Protection of individuals, equipment and power system installations.
11. Protective devices and insulation co-ordination.

Transients and dynamics of over voltages in high-voltage systems

LIGHTNING

* Causes of over voltage
* Lightning phenomenon
* Charge formation of Lightning
* Rate of Charging of thunder cloud
* Mechanism of Lightning strokes
* Characteristics of Lightning strokes
* Factors contributing to good line design
* Protection afforded by ground wires.
* Tower footing resistance
* Interaction between lightning and power system
* Mathematical model of Lightning

Causes of Lightning

*Lightning phenomenon

- peak discharge in which charge accumulated in the cloud into neighboring cloud or to the ground

* Electrode separation – cloud to cloud or cloud to ground is about 10 km or more

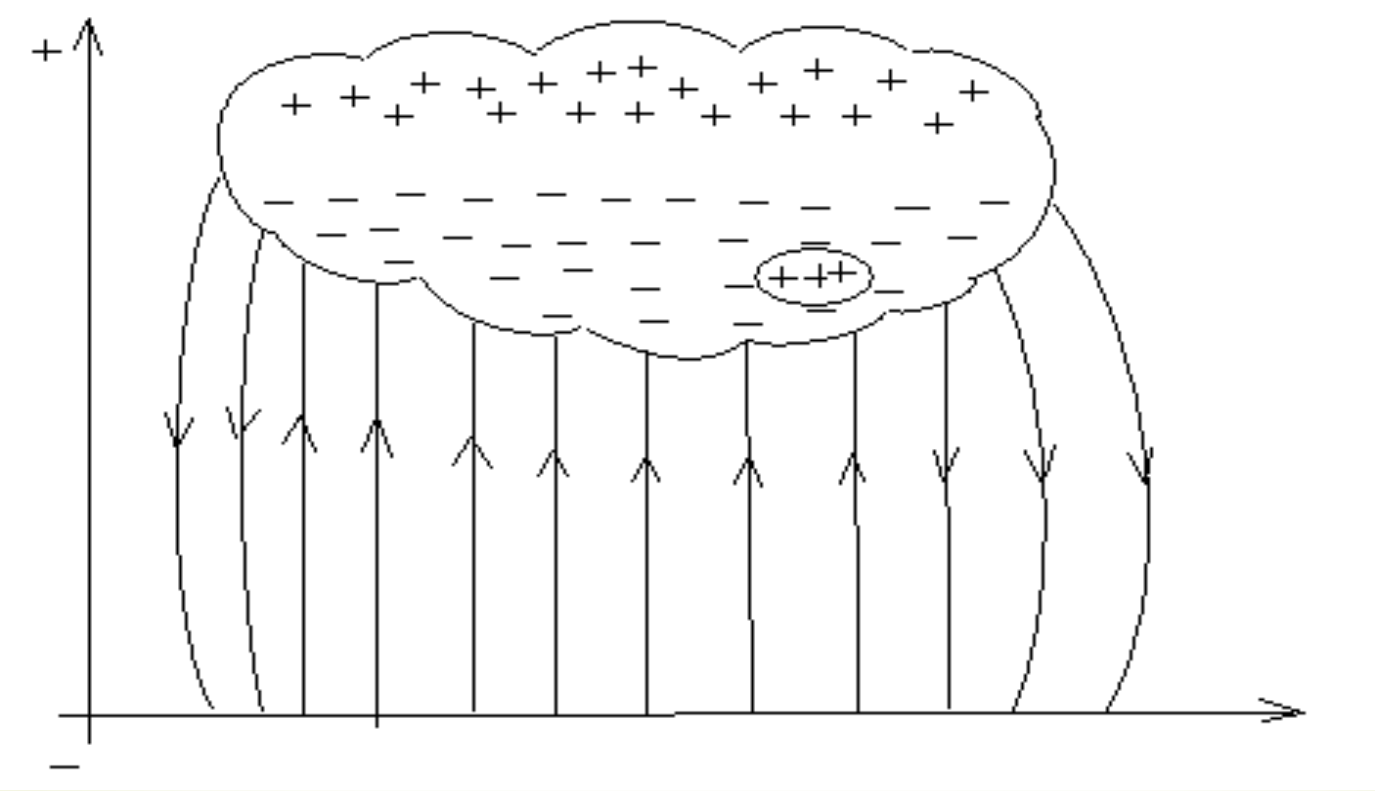
CHARGE FORMATION OF CLOUD

* Positive and negative charges become separated by heavy air current with ice crystals in the upper part and rain in the lower region.
* Charge separation depends on height of cloud (200 – 10,000m).
* Charge centers at a distance about 300 – 2km

CHARGE FORMATION OF CLOUD

* Charge inside the cloud – 1 to 100 C
* Cloud potential – 10^7 to 10^8 V
* Gradient within a cloud – 100 V/cm
* Gradient at initial discharge point – 10kV/cm
* Energy at discharge – 250 kWhr

CHARGE FORMATION OF CLOUD



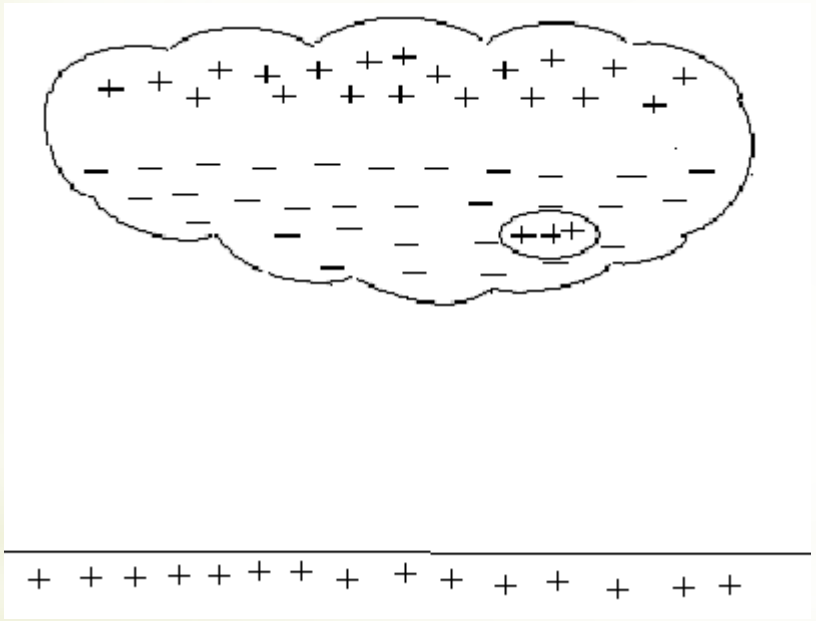
MECHANISM OF LIGHTNING FLASH

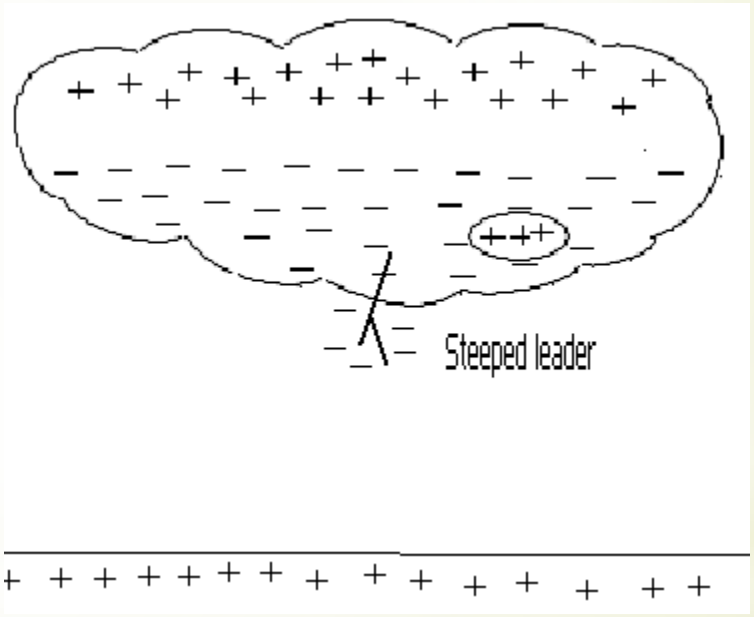
* Pilot streamer and Stepped leader

* Ground streamer and return stroke

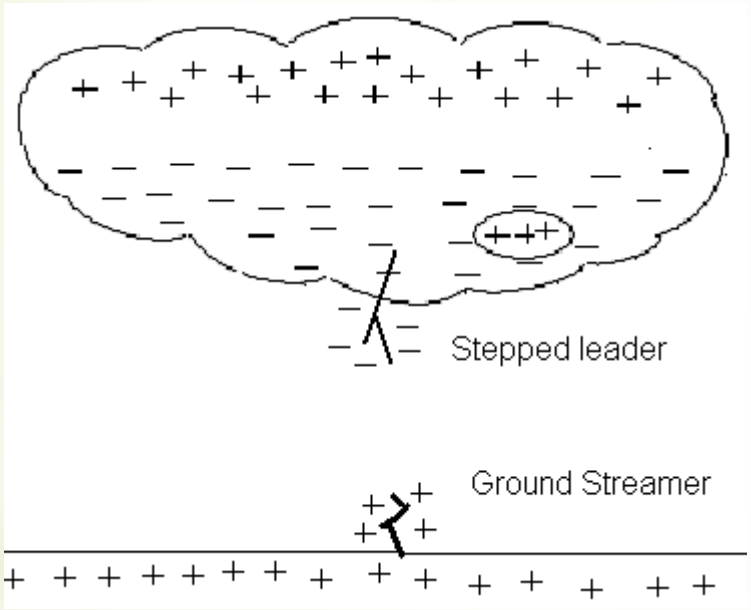
* Subsequent strokes

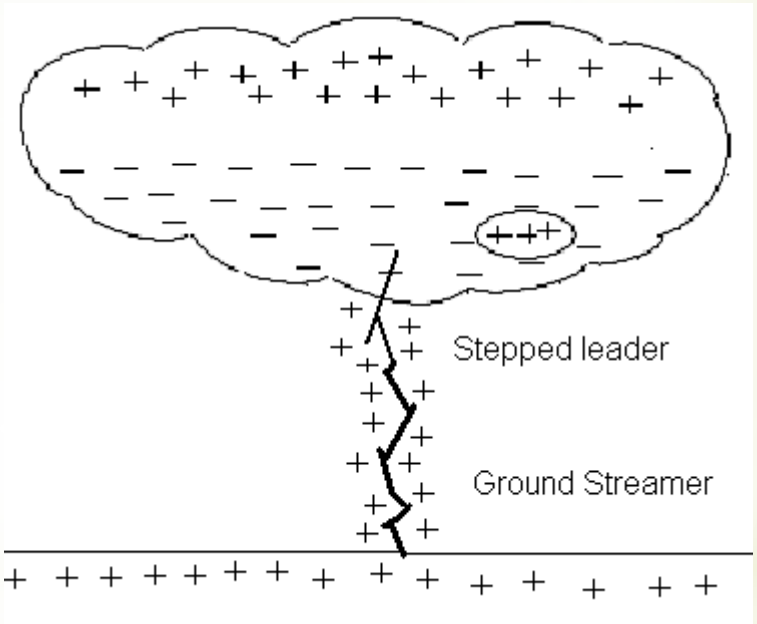
PILOT STREAMER AND STEPPED LEADER





GROUND STREAMER AND RETURN STROKE





CHARACTERISTICS OF LIGHTNING STROKES

* Current-time characteristics
* Time to peak or Rate of rise
* Probability distribution of current and time
* Wave shapes of lightning voltage and current

LIGHTNING CURRENT

* Short front time - 10µs
* Tail time – several ms.

RATE OF RISE

* 50% lightning stroke current – greater than 7.5kA/µs.
* 10% lightning strokes current – exceeds 25 kA/µs.
* Stroke current above half value – more than 30µs.

SURGE VOLTAGE

*Maximum surge voltage in transmission line – 5MV

*Most of the surge voltage is less than 1000 kV online.

*Front time – 2 to 10 μs

*Tail time – 20 to 100 μs

*Rate of rise of voltage – 1MV/ μs

LIGHTNING STROKES

* Direct stroke

  directly discharges on to transmission line or line wires

* Induced stroke

  cloud generates negative charge at its base, the earth object develop induced positive charge

OVER VOLTAGE DUE TO SWITCHING SURGES

INTRODUCTION

*In switching, the over voltage thus generated last for longer durations and therefore are severe and more dangerous to the system

*The switching over voltages depends on the normal voltage of the system and hence increase with increased system voltage

ORIGIN OF SWITCHING SURGES

* Making and breaking of electric circuits with switchgear may results in abnormal over voltages in power systems having large inductances and capacitances.
* over voltages may go as high as 6 times the normal power frequency voltage.

ORIGIN OF SWITCHING SURGES

* In circuit breaking operation switching surges with a high rate of rise of voltage may cause repeated restriking of the arc between the contacts of a circuit breaker, thereby causing destruction of the circuit breaker contacts.
* Switching surges may include high natural frequencies of the system, a damped normal frequency voltage component, or restriking and recovery voltage of the system with successive reflected waves from terminations.

CHARACTERISTICS OF SWITCHING SURGES

* De-energizing of transmission lines, cables, shunt capacitor, banks, etc.
* Disconnection of unloaded transformers, reactors, etc.
* Energization or reclosing of lines and reactive loads.
* Sudden switching off of loads.
* Short circuit and fault clearances.
* Resonance phenomenon like ferro-resonance, arcing grounds, etc.

CONTROL OF OVERVOLTAGES DUE TO SWITCHING

* Energization of transmission lines in one or more steps by inserting resistances and withdrawing them afterwards.
* Phase controlled closing of circuit breakers.
* Drainage of trapped charges before reclosing
* Use of shunt reactors.
* Limiting switching surges by suitable surge diverters.

PROTECTION AGAINST OVERVOLTAGS

*Minimizing the lightning overvoltages are done by suitable line designs,

*Providing guard and ground wires,

*Using surge diverters.

PROTECTION AGAINST OVERVOLTAGS

* Shielding the overhead lines by using ground wires above the phase wires,
* Using ground rods and counter-poise wires,
* Including protective devices like explosion gaps, protector tubes on the lines, and surge diverters at the line terminations and substations

Thank You
For Your Attention

Mohamed Ahmed Ebrahim