Power Systems Lab.

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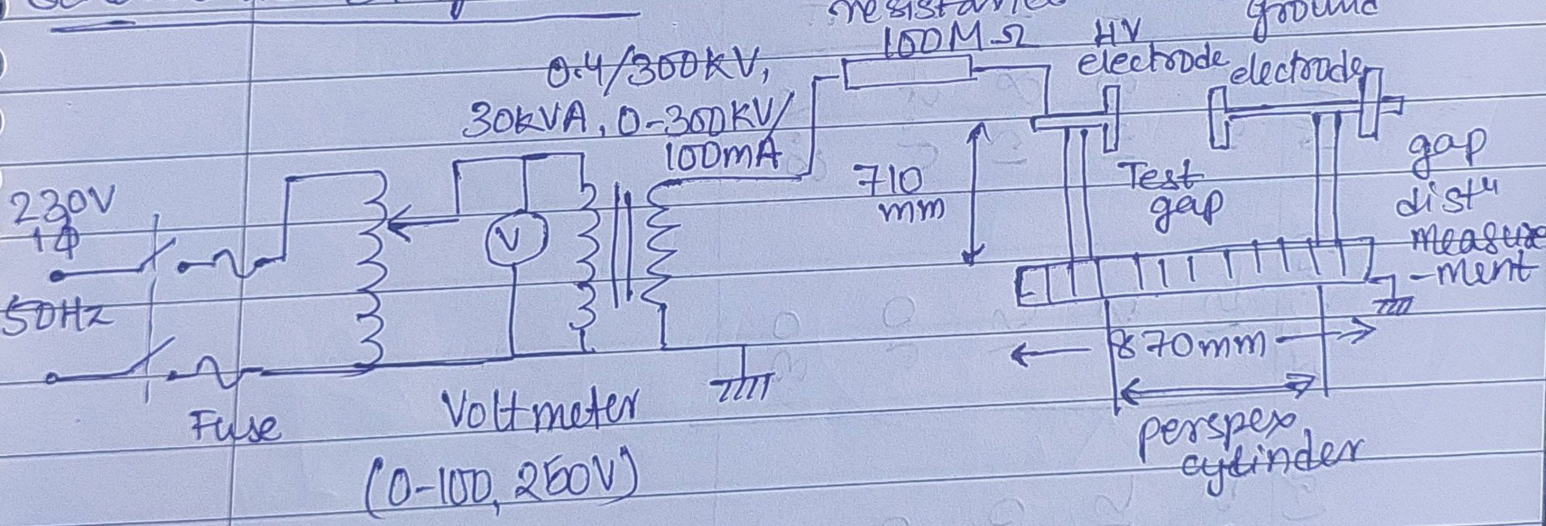
Study of Corona discharge and AC breakdown voltage for different electrode gap geometry.

Objectives:

1. Breakdown studies of uniform field and non-uniform field gaps under AC excitation
   a) Point-plane (non-uniform field gap)
   b) Sphere-Sphere (nearly uniform field gap).

2. Observation of Corona inception and corona extinction voltage.

Schematic Diagram:



Dry bulb temp = 33°C
Wet bulb temp = 30°C
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Observation:
atmospheric pressure = 755 mm Hg.

1. Point-Plane Electrode.

SL. No.	Gap distn (mm)	Corona Inception voltage (kV)	Visible corona inception voltage (kV)	Corona Extinction voltage (kV)	BDV (kV)
1	10	–	–	–	4
2	20	8	11	5	13
3	30	10	14	6	19
4	40	11	17	9	21
5	50	12	18	10	24.

2. Sphere-Sphere electrode.

SL. No.	Gap distn (mm)	Corona inception Voltage (kV)	Visible corona inception voltage (kV)	Corona extinction voltage (kV)	BDV (kV)
1	10	–	–	–	5
2	20	20	–	–	22
3	30	34	–	27	36
4	40	35	–	30	50
5	50	40	–	32	63

Calculations:

At NTP, $t_0 = 20°C$.

$P_0 = 760 mmHg$.

$$K_1 = \frac{P}{P_0}\left(\frac{273+t_0}{273+t}\right) = \frac{755}{760} \times \frac{293}{306} = \underline{0.9512}$$

air density correction factor $K_1 = 0.9512$.

relative humidity = 78%.

absolute humidity = $28\ g/m^3$.

'K' for AC voltage = 0.82

$$K^2 = \frac{1}{K^w} \quad \begin{cases} w=0 & \text{sphere - sphere} \\ w=1 & \text{point - plane electrode} \end{cases}$$

for point plane electrode

$$V_0 = \frac{V_{BD}}{K_1 K_2} = \frac{V_{BD} \times 0.82}{0.9512}$$

$$\boxed{V_0 = 0.8621\, V_{BD}}$$

for sphere - sphere electrode

$$V_0 = \frac{V_{BD}}{K_1 K_2} = \frac{V_{BD}}{0.9512}$$

$$\boxed{V_0 = 1.051\, V_{BD}}$$

Corrected Observation Table (corrected values of NTP).

1. Point-plane electrode. ($V_0 = 0.8621\ V_{BD}$)

Sl No	Gap distance (mm)	BDV observed (RMS) (kV)	Corrected BDV of NTP (RMS) (kV)	Corrected BDV of NTP (Peak) (kV)
1	10	4	3.4484	4.8768
2	20	13	11.2073	15.8495
3	30	19	16.3799	23.6031
4	40	21	18.1041	25.6031
5	50	24	20.6904	29.2606

2. Sphere-Sphere electrode ($V_0 = 1.051\ V_{BD}$).

Sl. No.	Gap distance (mm)	BDV (Rms) Observed (kV)	Corrected BDV of NTP (Rms) (kV)	Corrected BDV of NTP (Peak) (kV)
1	10	5	5.255	7.4317
2	20	22	23.122	32.699
3	30	36	37.836	53.508
4	40	50	52.55	74.3169
5	50	63	66.213	93.6313

Answer the followings:

Q1. Why no humidity correction factor for sphere gap?

Ans. From graphs, from the sphere-sphere electood gap distance v/s breakdown voltage. We observe that graph is linear. This is obvious for short ranges.
Here the effect of humidity is very less, around 0.3% change in breakdown voltage/1gm/cm3.

Variation of breakdown voltage is quite irregular in large gaps betn spheres and very high humid atmosphere. Spheres must have smooth surface and uniform curvatures.

No humidity correction factor is required since effect of moisture on smooth and polished surface is negligible under normal humidity conditions.
For this, we can rub the surface with abrasive paper to remove oil, dust & grease.

Q2. What is unique abt. high voltage testing transformer?

Ans High voltage transformers can be used to isolate equipment from high power circuits. Unique point about it is its current rating. Rated current is generally low. In case of fault, or any breakdown, the current values doesn't increase to a larger value. Hence current is always in bounds of human usage and is useful for transmission stepping. In experiment:—

Rated power = 30kVA

rated voltage = 300kV

rated current = $\frac{\text{Rated power}}{\text{rated voltage}} = \frac{30k\,VA}{300k\,V} = 0.1A$

Q3. Is corona useful at all?

Ans. Corona discharge is useful in some listed applications;

a) Radicals which represent one category of species activated by corona. They can themselves find some uses. Like: improving contribution by products ~~pair~~ of silent discharge.

b) Mobility of ions created by corona discharge used in gas diagnostics. Like: detect and measure gas containments

c) Used in manufacturing ozone photocopying air ions: EHD thrusters, Nitrogen laser and static charge radializer

d) Removal of ~~union~~ unwanted electric charges from surface of aircraft. Avoiding effect of uncontrolled electric discharge pulses.

Q4. Why corona inception voltage is not observed for small dist^n for electrode gaps?

Ans. Before visible corona discharge begins, corona inspection takes place with a hissing sound and voltage is knowns as corona inception voltage. Breakdown voltage of air = 30kV peak/cm.

Corona inception voltage = $21.2\, \delta\, m_o\, r \log_e(d/r)$ kV to neutral. If the distance (d) falls below radius (r) or radius of conductors, sufficiently small corona spreading ceases long before it bridge the conductors and stress is insufficient to ionize air and so there is no corona inception voltage observed.

Q5. Why is corona extinction voltage less than corona inception voltage?

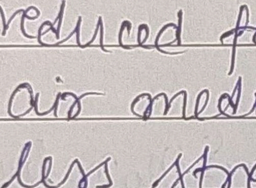
Ans. In real life, non uniform electric field exists. So increase in voltage leads to ionization of air surrounding the conductors. Before visible corona discharge begins, corona inception takes place with a hissing sound and voltage is 'corona inception voltage'.

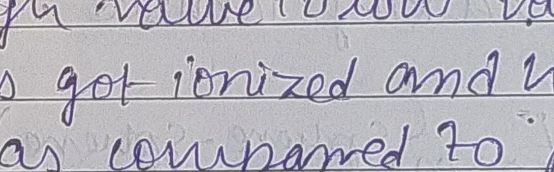
To make corona disappear, voltage is reduced from high value to low value as air medium has got ionized and has less strength as compared to pre-ionized state the voltage has to be lowered in inception voltage.

Hence corona extinction voltage is always lower than inception voltage.

Q6. Why BDV is more for sphere-sphere gap compared to point plane gap?

Ans.





Ans. For sphere-sphere gap, we have almost uniform field whereas in point-plane field is non-uniform.

Field intensity near point is more than intensity near plane. Whereas, intensity of field lines remain uniform and same in sphere-sphere.

So sphere-sphere gap is ionized for more BDV than other. HV end (point) has more field intensity and can be easily ionised.

$$\frac{E_{o,rms}\text{(sphere-sphere)}}{E'_{o,rms}\text{(point-plane)}} = \frac{21.2\,\delta\, m_o r_1 \log_e(d/r_1)}{21.2\,\delta\, m_o r_2 \log_e(d/r_2)}$$

as, $r_1 > r_2$.

BDV is more for sphere-sphere gap than point-plane gap.

Q. How BDV will vary for 30mm gap if point ~~plan~~ point electrode are used instead of point plane gap?

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Ans Inception of corona takes place when E_{rms} becomes just more than 21.2 kV/cm So in point point electrodes the effective radius decreases as compared to point plane electrodes. So breakdown voltage has to increase to cause the corona discharge. So as we see for point plane electrode gap BDV is 17.87kV after humidity correction.

So it will increase from that in point-point electrode.

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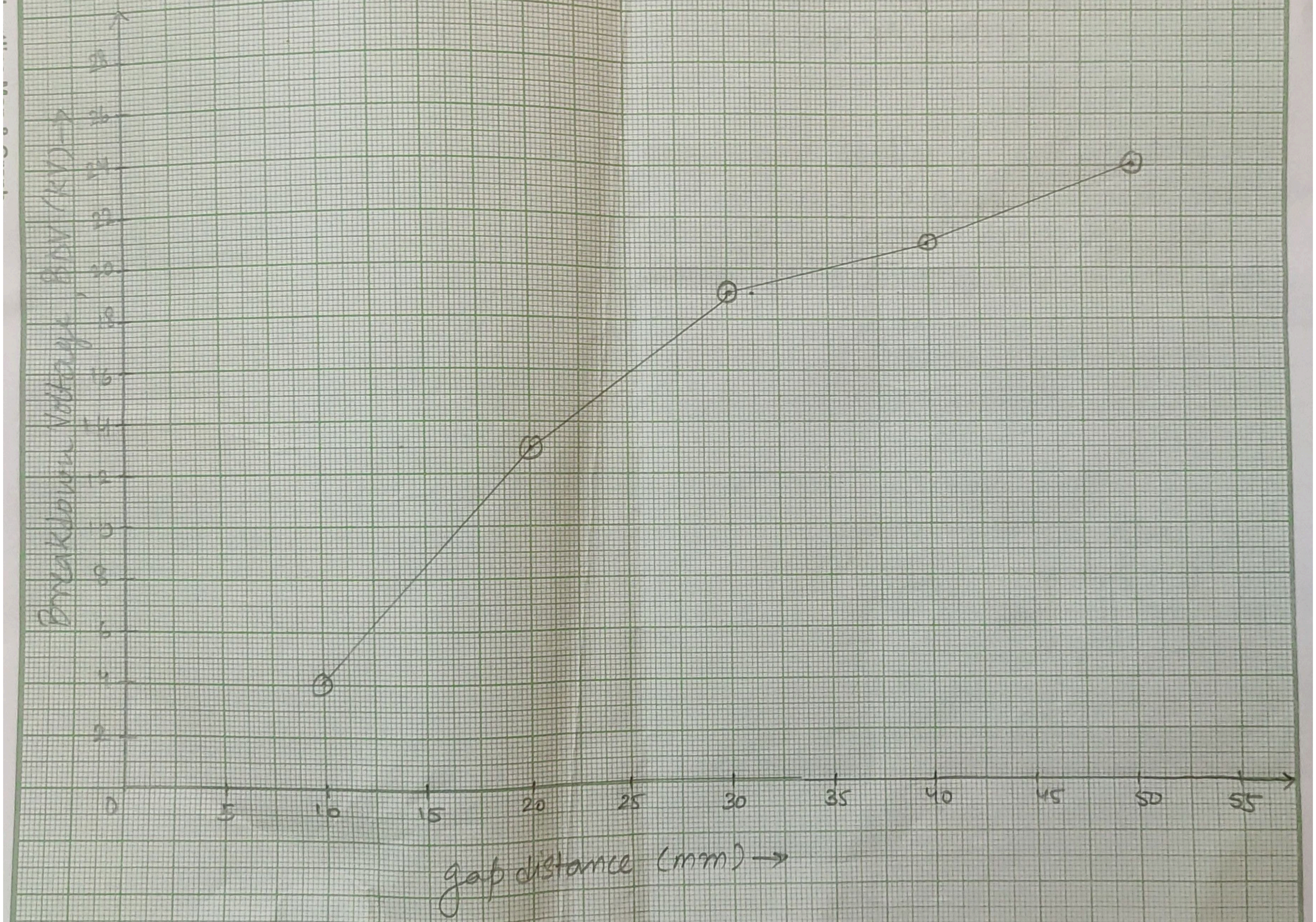
Point-plane electrode.

Scale:
X axis: 1 unit = 2.5 mm
Y axis: 1 unit = 2 kV.



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Sphere-Sphere electrode

Scale:

X axis: 1 unit: 2.5 mm

Y axis: 1 unit: 5 kV