CORONA EFFECT

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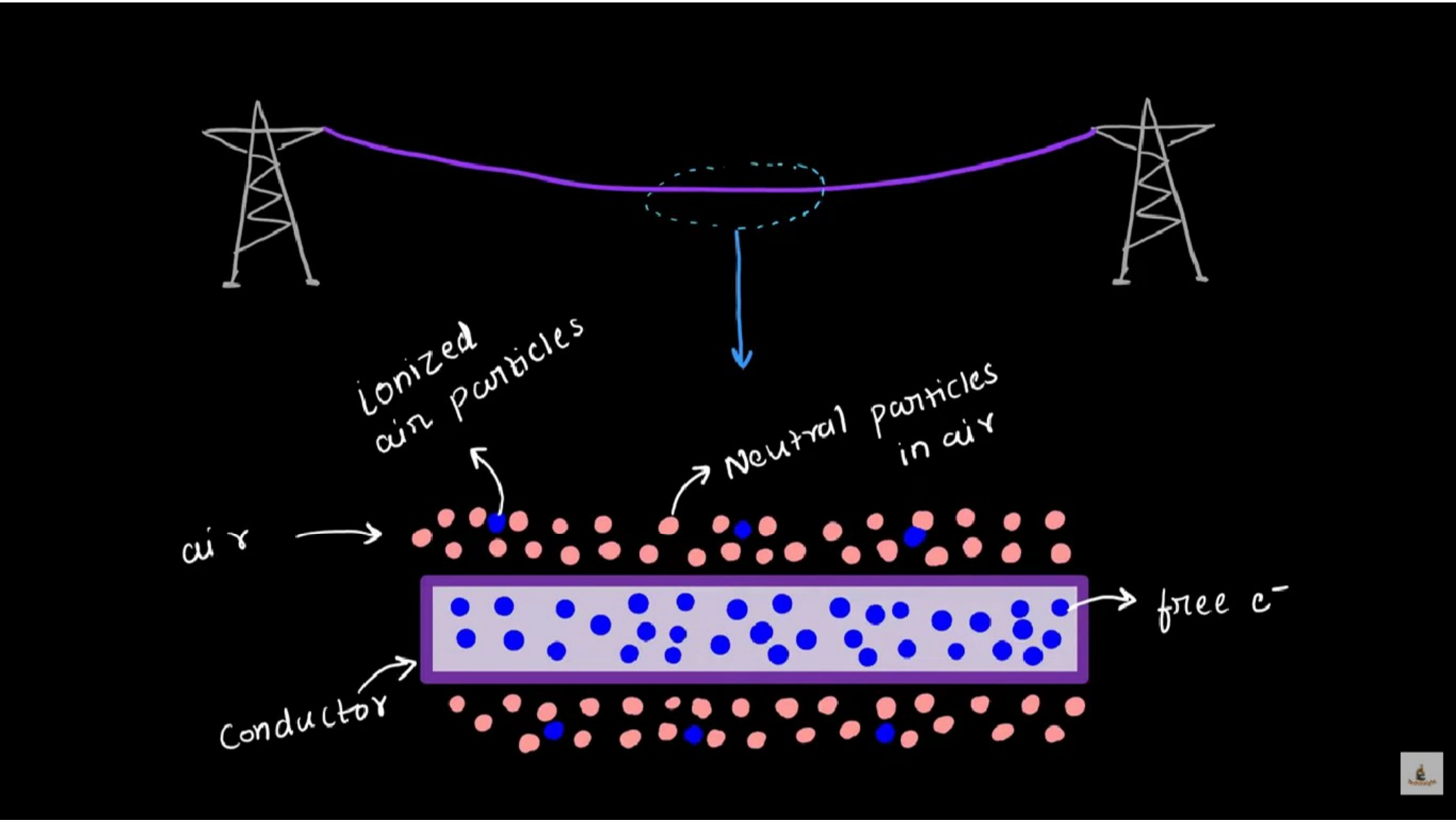
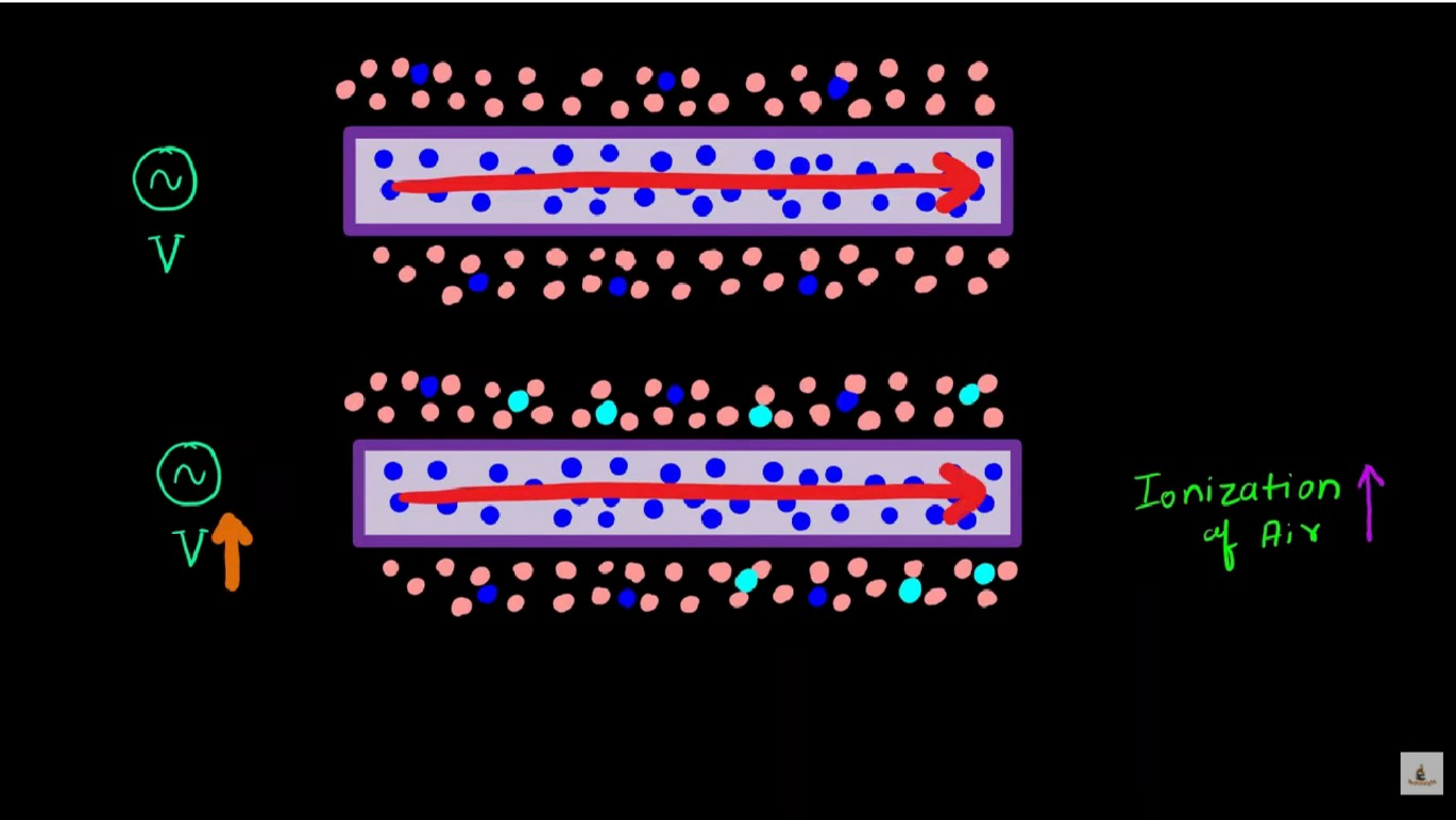
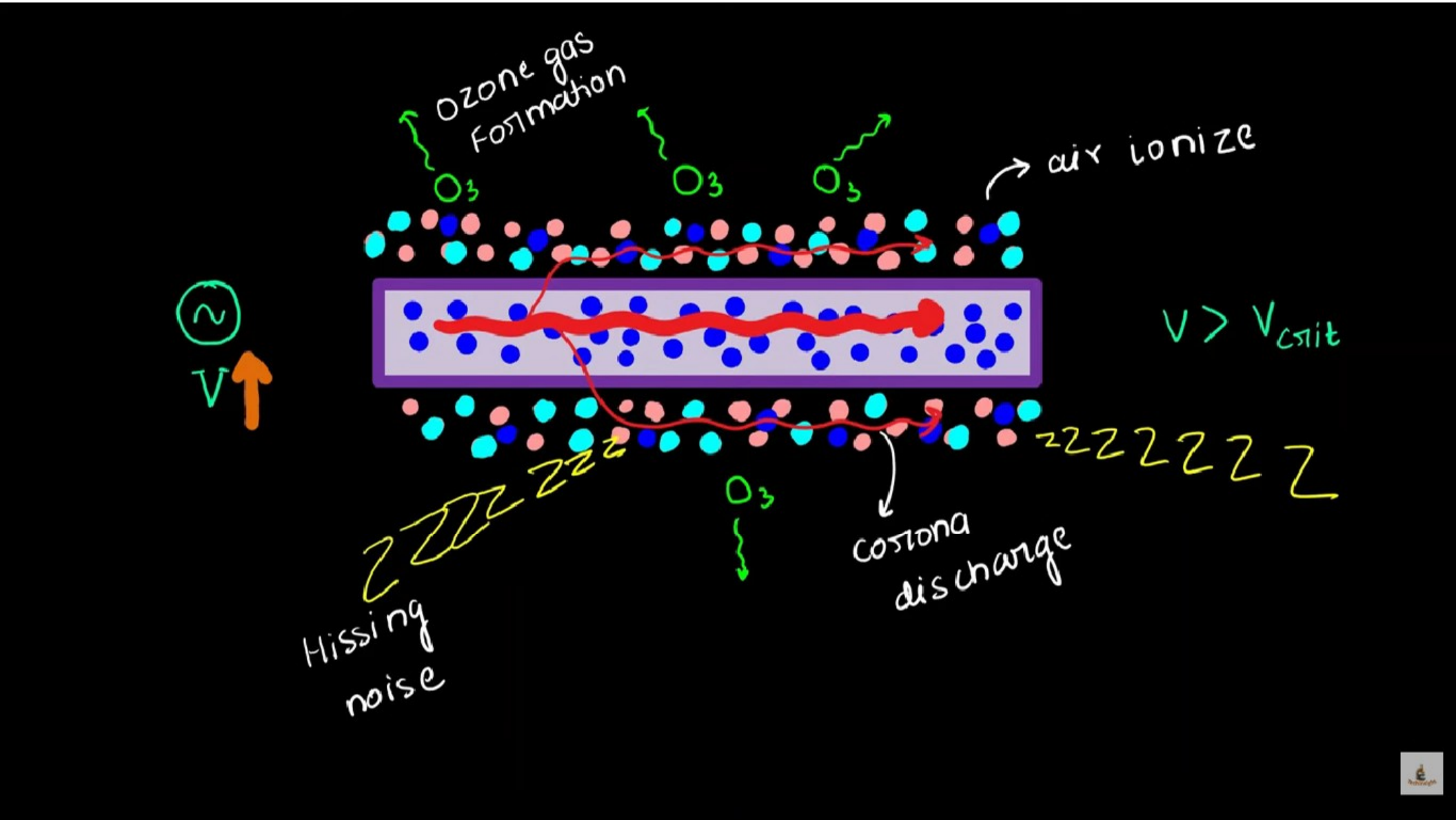
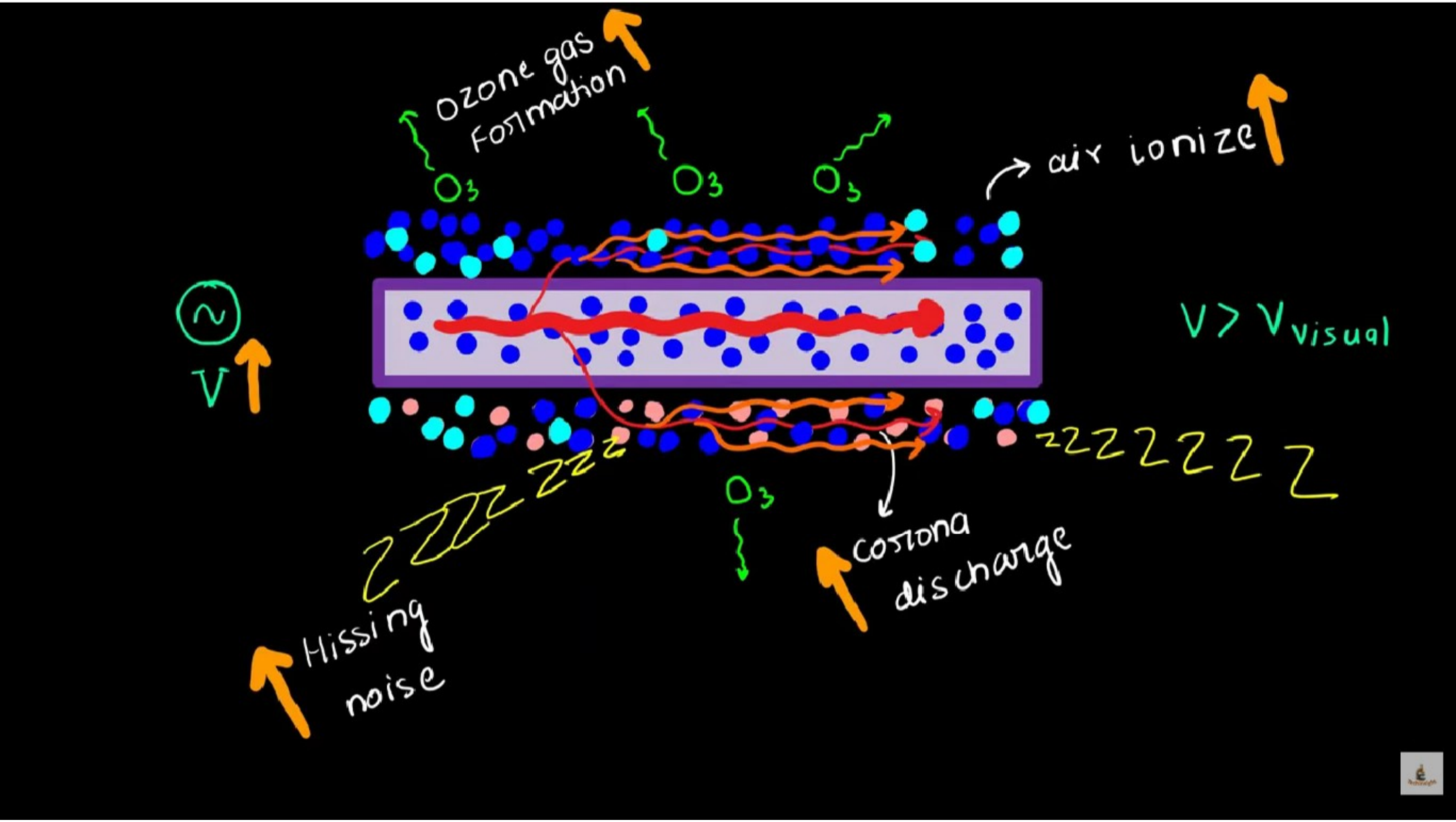
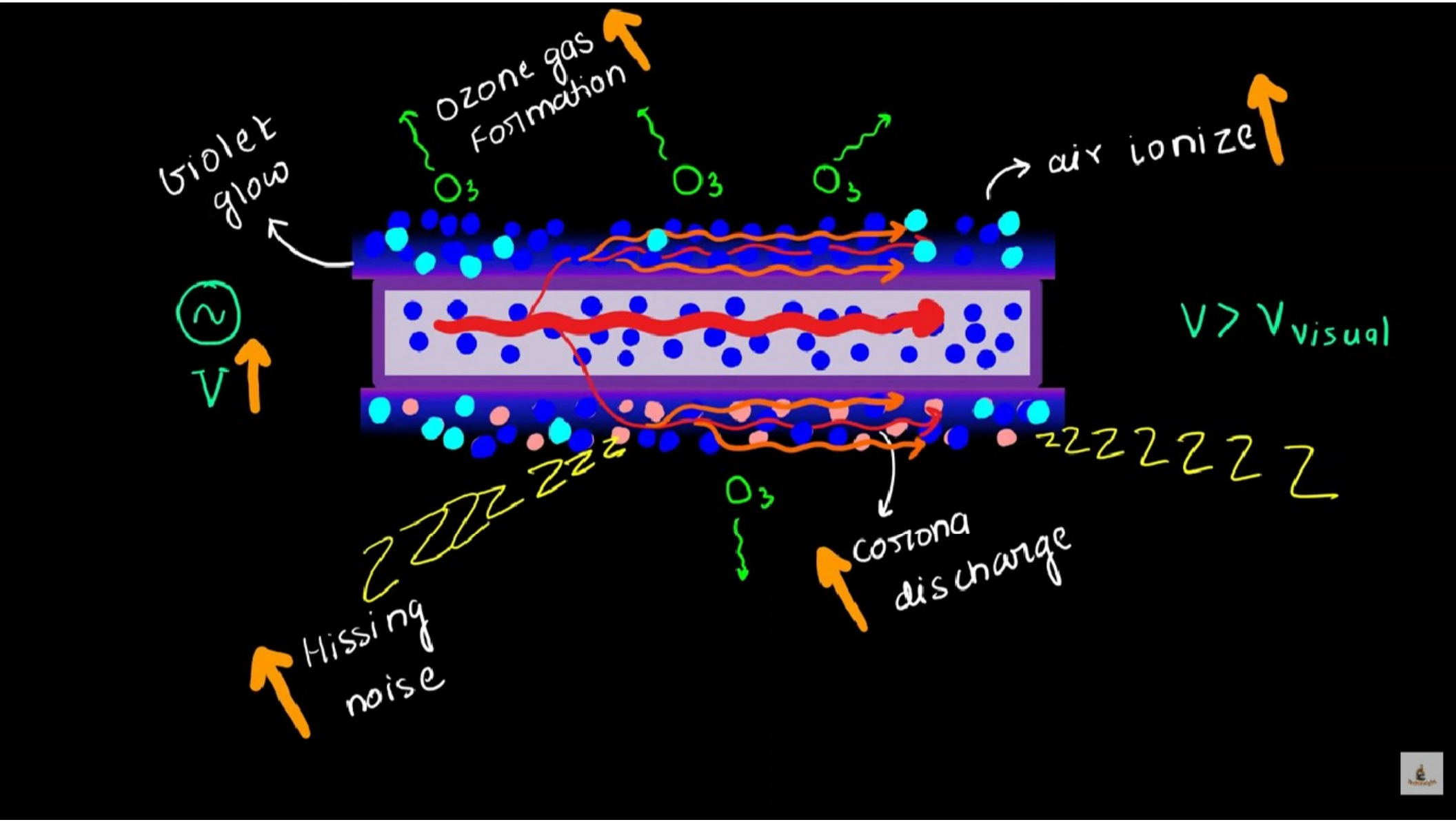
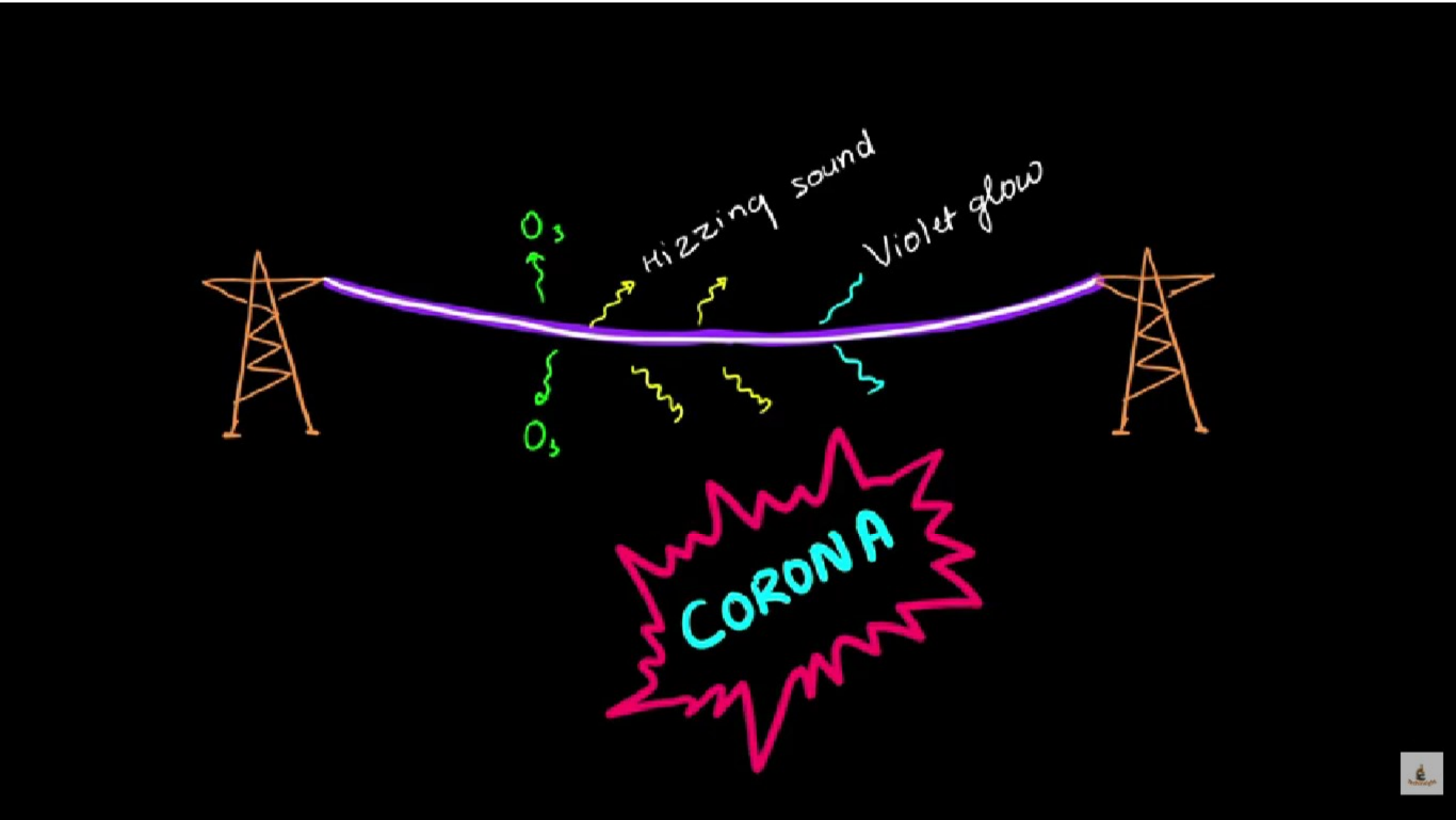

Ionized air particles
Neutral particles in air
air
free e⁻
Conductor


V
V
Ionization of Air


ozone gas
Formation
O_3
O_3
O_3
air ionize
V
$V > V_{critical}$
O_3
corona
discharge
Hissing
noise

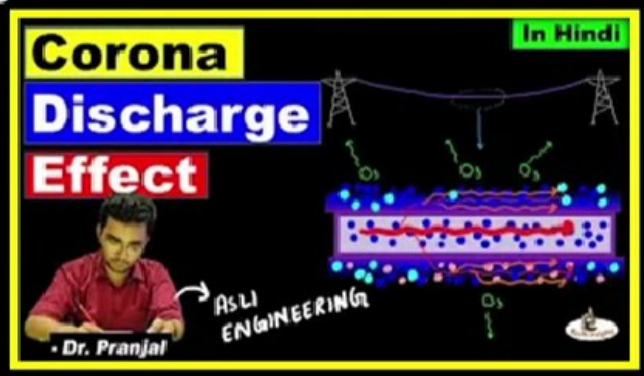

ozone gas Formation
O_3
O_3
O_3
air ionize
V
$V > V_{visual}$
zzzzzzz
zzz zzz
O_3
corona discharge
Hissing noise


Violet glow
Ozone gas Formation
O_3
O_3
O_3
air ionize
V
$V > V_{visual}$
O_3
Hissing noise
Corona discharge

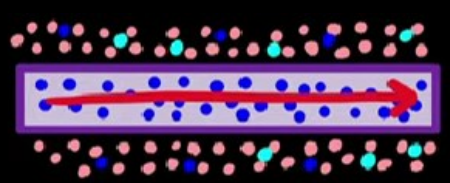

Hizzing sound
Violet glow
O_3
O_3
CORONA

What is corona ?

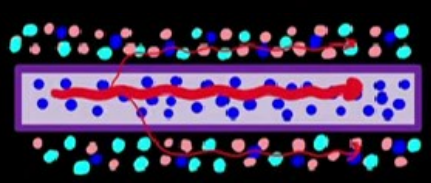
" The phenomenon of ionization of air causing Hissing noise, violet glow and formation of ozone gas in an overhead transmission line is known as CORONA "



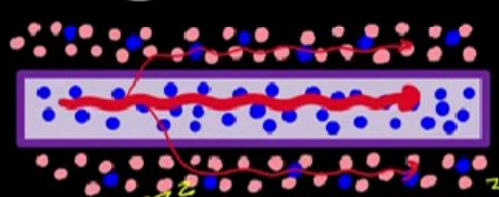
activates above 33kV



Air Ionization

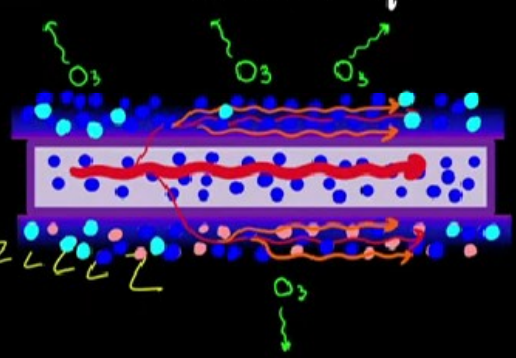


Corona discharge



Hissing Noise

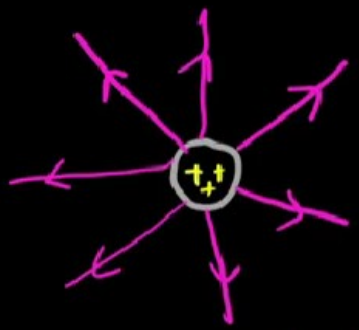
Violet glow



Ozone gas formation

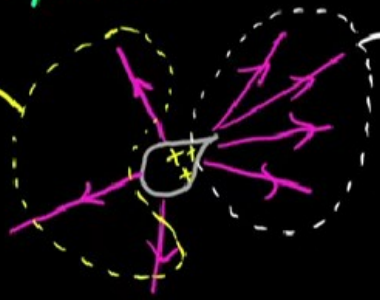
Important Terms

* Potential Goradient at conductor surface (g) ⟶ Signify the strength of Electric field intensity



Loco potential gradient

High Potential gradient



UNIT → volt/m

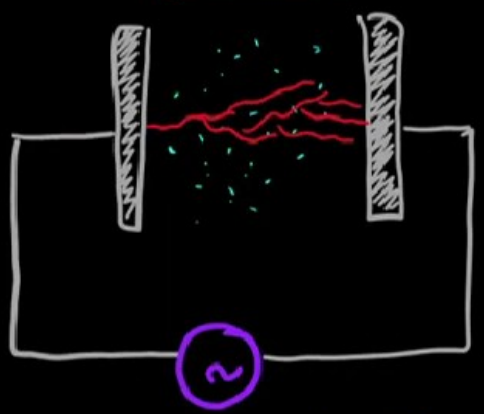
* Breakdocon strength

The potential gradient at which Insulator looses its insulation property and becomes conductor

UNIT = V/m

$g_s \geq g_o$

V/m ≥ Breakdown strength of air



Air Breakdown and becomes conducting

NOTE:- Air act as insulator Till $g_s < g_o$

Less chances of Breakdown

more chances of Breakdown

Low Potential gradient

High Potential gradient

Need Corona Protection

eg. Corona Ring

Critical disruptive Voltage (V_c)

Minm phase – neutral voltage at which corona occurs

$V_s \rightarrow V_c$

$g \geq g_0$

Potential gradient at conductor surface (g) $= \frac{V_c}{r \cdot \ln \frac{d}{r}}$ volt/cm

$g_0 = \frac{V_c}{r \cdot \ln \frac{d}{r}}$

For corona

g_0 = Breakdown strength of air

25°C, 76 cm of Hg pressure

g_0 = 30 kV/cm (max)

21.2 kV/cm (RMS)

$$V_c = g_0 \cdot r \cdot \ln \frac{d}{r}$$

conductor smoothness

air density → δ

m

↳ 1 (for polished conductor)

↳ 0.98 to 0.92 (for dirty conductor)

↳ 0.87 to 0.8 (for stranded conductors)

$$V_c = m g r \delta \ln \frac{d}{r}$$

$$\delta = \frac{3.29\,b}{273 + t}$$

b → barometric pressure of b cm mercury

t → t° C temperature

Visual Critical Voltage (V_v)

$$V_v > V_c$$

"The minimum phase-neutral voltage at which corona glow appears all along the conductor"

$$V_v = m_v g_0 \gamma \delta \left(1 + \frac{0.3}{\sqrt{\delta r}}\right) \ln \frac{d}{r} \quad \text{kV/ph}$$

$m_v \rightarrow$ 1 (for polished conductor)

$\hookrightarrow$ 0.7 to 0.8 (for rough conductors)

FACTORS AFFECTING CORONA

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1

$V_c = m g_0 \delta r \ln \frac{d}{r}$

$V < V_c$

sharp point → initiate corona at low voltage

smooth surface

Corona initiate at higher voltage

$V \geq V_c$

Tower

corona ring

Jumper wire

① Effect of sharp points

sharp point → initiate corona at low voltage

$V < V_c$

smooth surface

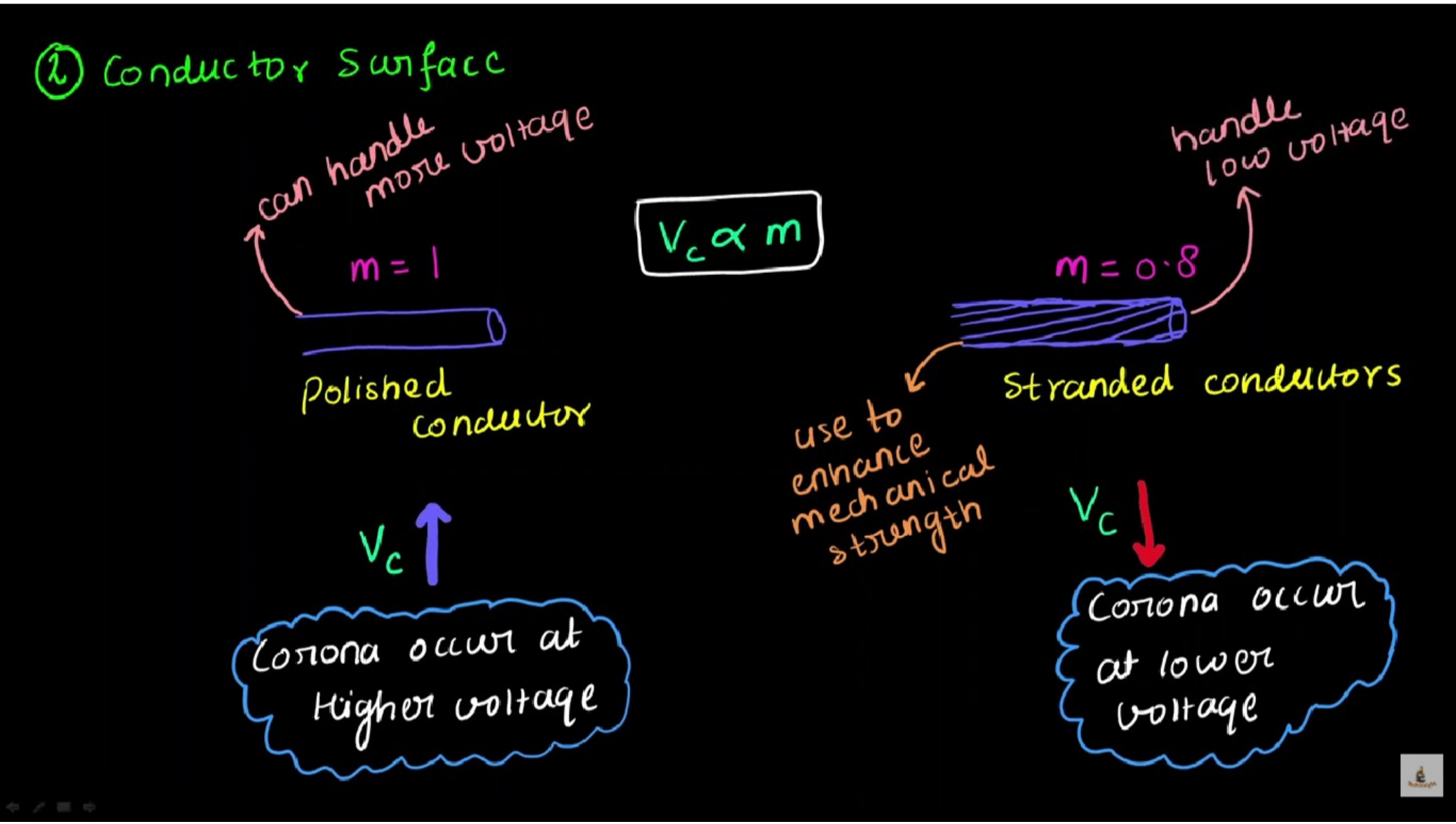
Corona initiate at higher voltage

$V \geq V_c$

Tower

Jumper wire

② Conductor Surface



③ Air density factor δ

$$\delta = \frac{3.29\,b}{273 + t}$$

$V_c \propto \delta$

Air density (δ) ↓ → V_c ↓

V_c ↓ → corona occurs at lower voltages

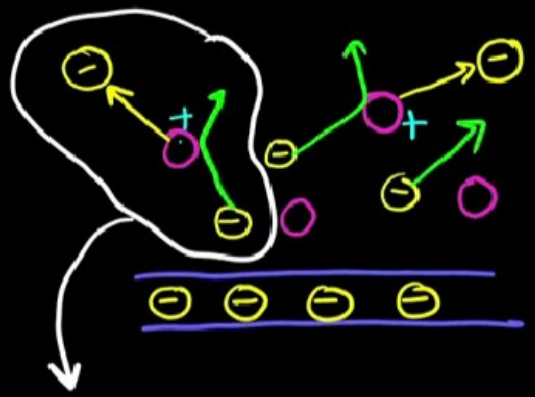
Air density (δ) ↓ → atmospheric Pressure

Air density (δ) ↓ → Temperature

Rain, storm, snow season → δ ↓ → Corona start at lower voltage

Air Density ↓

e^- have sufficient space to attain high K.E

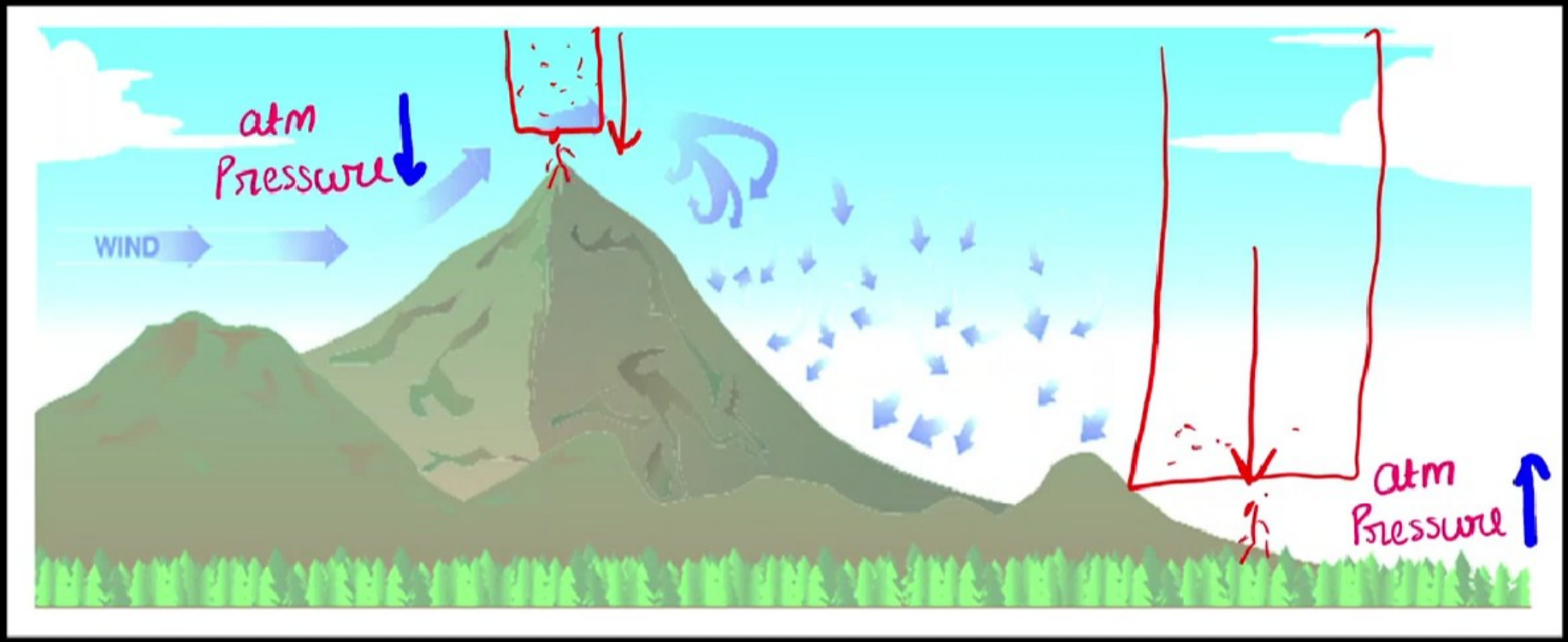


e^- must have sufficient K.E to ionize neutral atom

Air ionization

Corona discharge

4



4

5

conductor

water droplets act as sharp edges

Trigger corona discharge at lower voltages

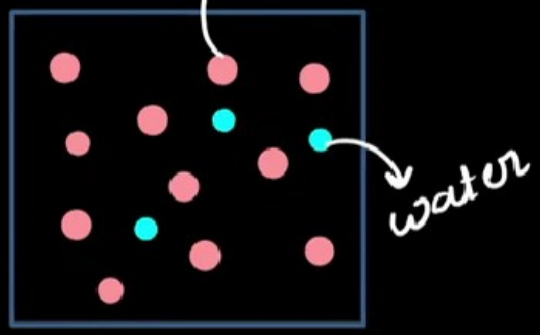
snow

conductor

act as sharp edges

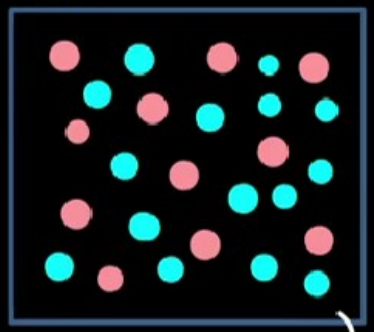
Trigger corona discharge at lower voltages

6



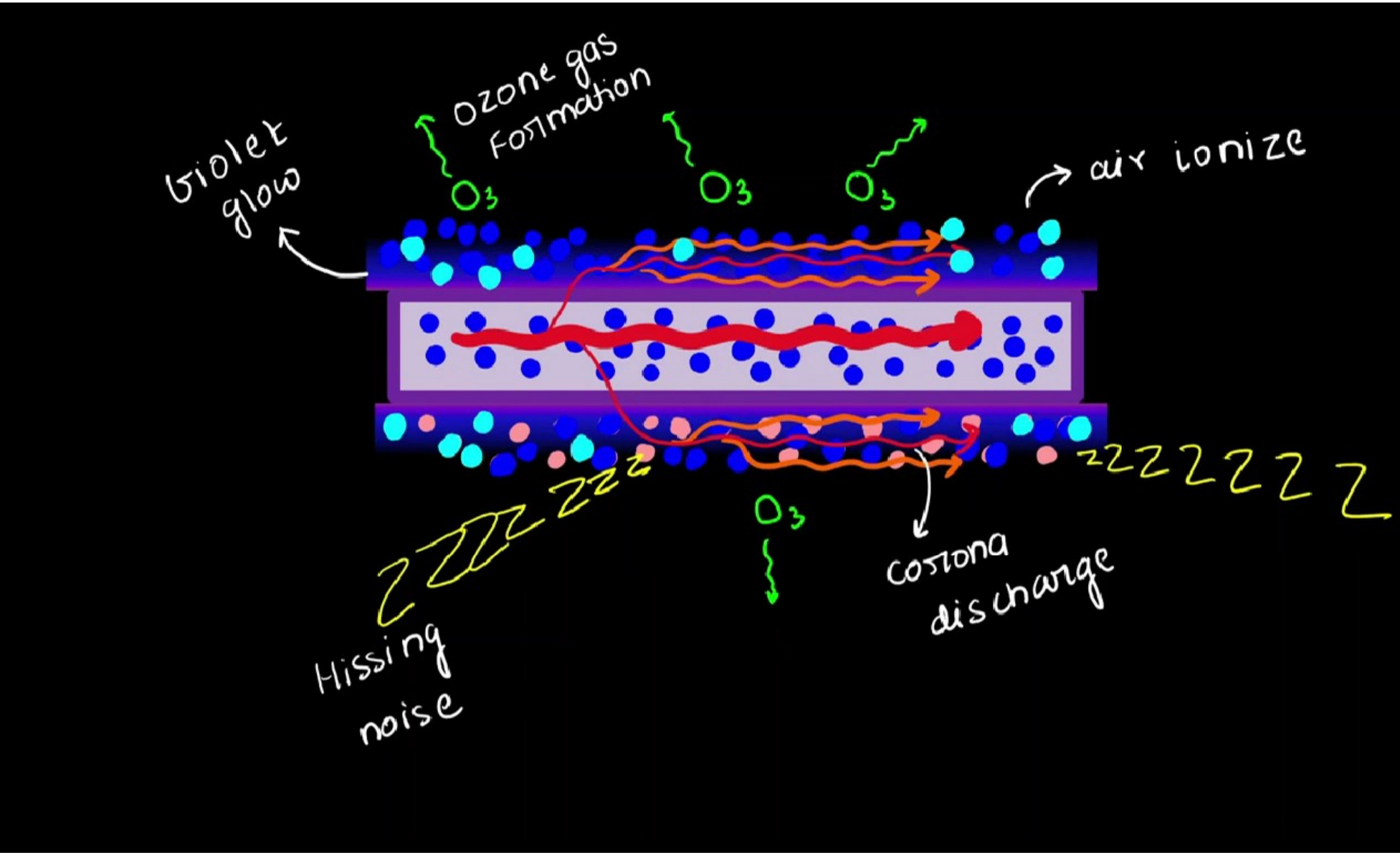
Dry air

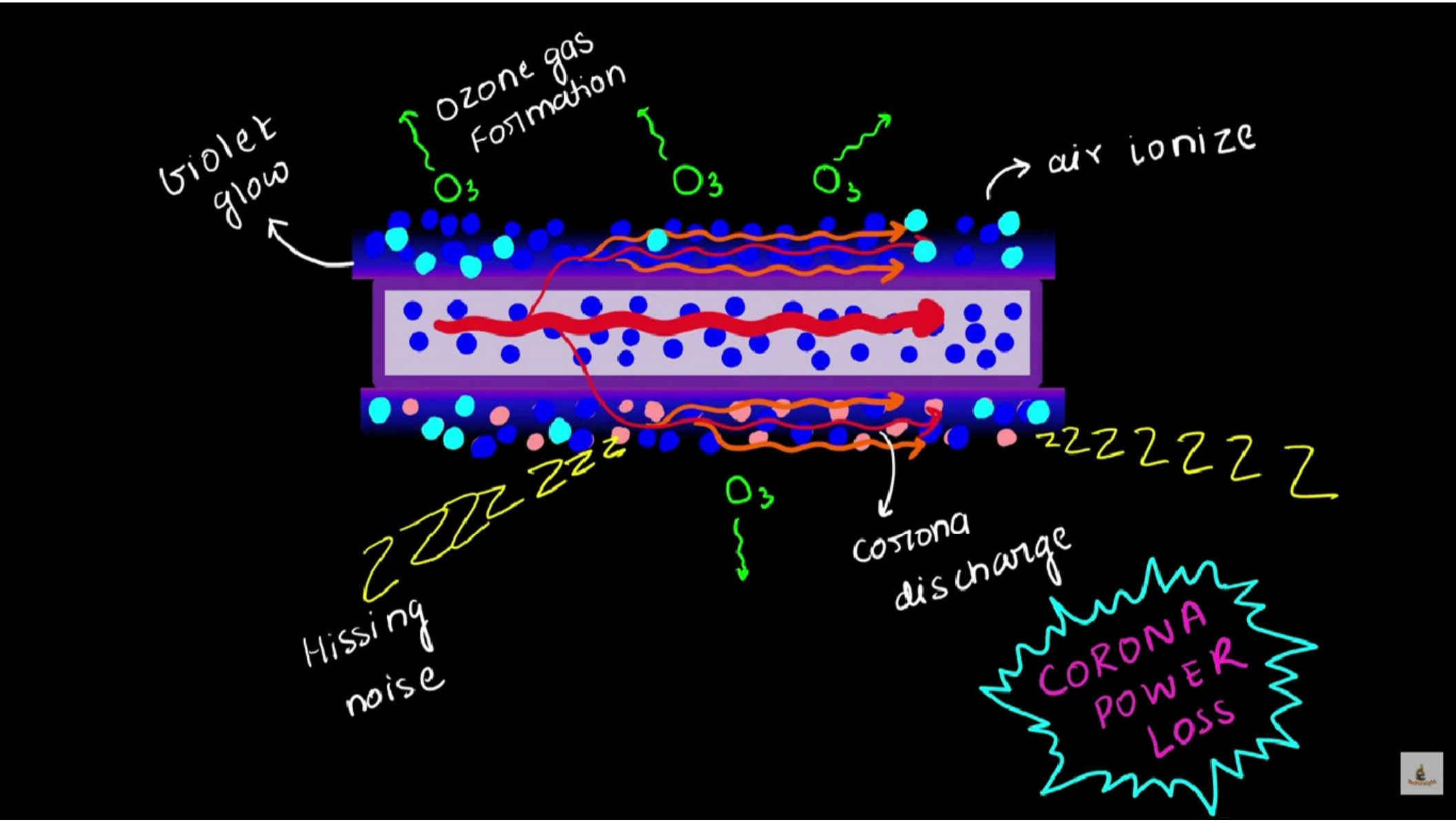
High dielectric strength



Large water content

Low dielectric strength → Corona start at low voltages.


violet glow
ozone gas formation
O_3
O_3
O_3
air ionize
zzzzzzz
zzz zzz
O_3
hissing noise
corona discharge


violet glow
ozone gas formation
O_3
O_3
O_3
air ionize
zzzzzzz
zzz zzz
O_3
corona discharge
Hissing noise
CORONA POWER LOSS

CORONA LOSSES

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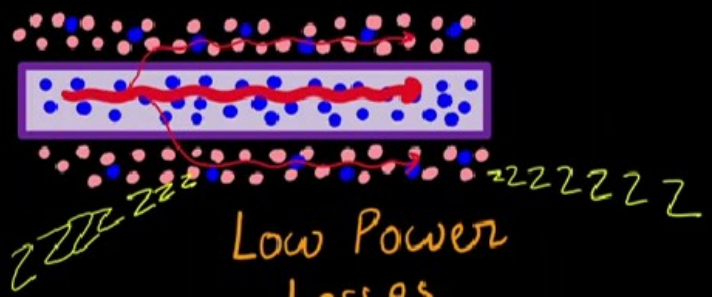
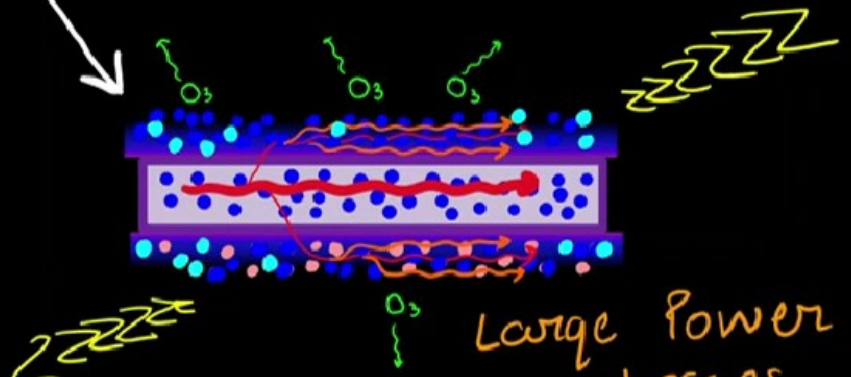
Corona Power Loss



Low Power Losses

$1.8 > \frac{V}{V_c}$

Peterson's formula



Large Power Losses

$1.8 < \frac{V}{V_c}$

Peek's formula

$V \rightarrow$ Supply phase voltage

$V_c \rightarrow$ Critical disruptive voltage

① Peek's formula

Peters

$$P_L = 242.2 \left[\frac{f+25}{\delta}\right]\sqrt{\frac{r}{d}}\,(V - V_c)^2 \times 10^{-5}$$

kW/km/phase

② Peterson's formula

$$P_L = 2.11\,\frac{f \cdot F \cdot V^2}{\left[\ln\left(\frac{d}{r}\right)\right]^2} \cdot 10^{-5}$$

kW/km/phase

$1.8 > \frac{V}{V_c}$

F → corona loss Function

F vary with $\frac{V}{V_c}$

V_c

V

V_{ph} / V_{d0}	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2
Factor(F)	0.012	0.018	0.05	0.08	0.30	1.0	3.5	6.0	8.0

Factors affecting corona Losses

$$P_L = 242.2 \left[\frac{f + 25}{\delta}\right] \sqrt{\frac{r}{d}} (V - V_c)^2 \times 10^{-5}$$

(1) Atmosphere

→ Rain

→ snowfall

→ wind

$(V - V_c)^2$ ↑ → V_c ↓ → P_L ↑

① Conductor size

↑ Radius → $\sqrt{\frac{r}{d}}$ ↑ → power → V_2

↑ Radius → $(V - V_c)$ ↓ → power → 2

P ↓

③ Surface conditions

↳ m ↓ ⟶ V_c ↓ ⟶ $(V - V_c)$ ↑ P_L ↑

④ Line voltage

↳ V ↑ ⟶ $(V - V_c)$ ↑ P_L ↑

① Conductor size

↑ Radius → $\sqrt{\frac{r}{d}}$ ↑ → power → V_2

↑ Radius → $(V - V_c)$ ↓ → power → 2

P ↓

③ Surface conditions

↳ m ↓ ⟶ V_c ↓ ⟶ $(V - V_c)$ ↑ P_L ↑

④ Line voltage

↳ V ↑ ⟶ $(V - V_c)$ ↑ P_L ↑

⑤ frequency

↳ $P_L \propto (f \uparrow + 25)$ $\quad P_L \uparrow$

↳ DC $\longrightarrow$ $P_L \propto (\cancel{f}^{\,0} + 25) \longrightarrow P_L \propto 25$

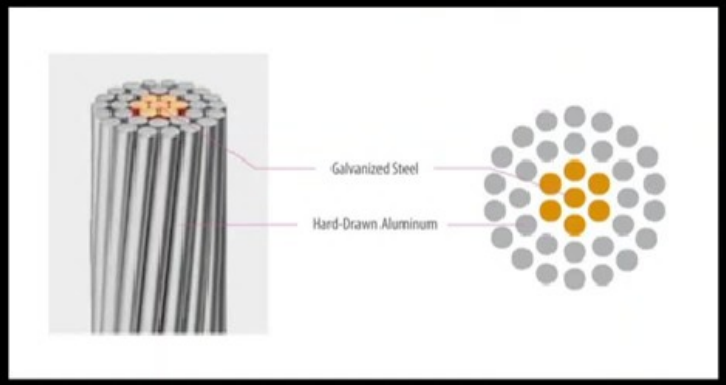
$\therefore$ $\boxed{P_{L_{AC}} > P_{L_{DC}}}$

⑥ Spacing blw conductors $\longrightarrow$ $V_C \uparrow \propto \ln \frac{d}{r} \uparrow$

↳ $P_L \propto \sqrt{\frac{r}{d}} \uparrow$ $\quad P \downarrow$

Methods of Reducing Corona Losses

(1) Increase size of conductor



↳ Aluminium Core Steel Reinforced (ACSR) conductors

$r \uparrow$

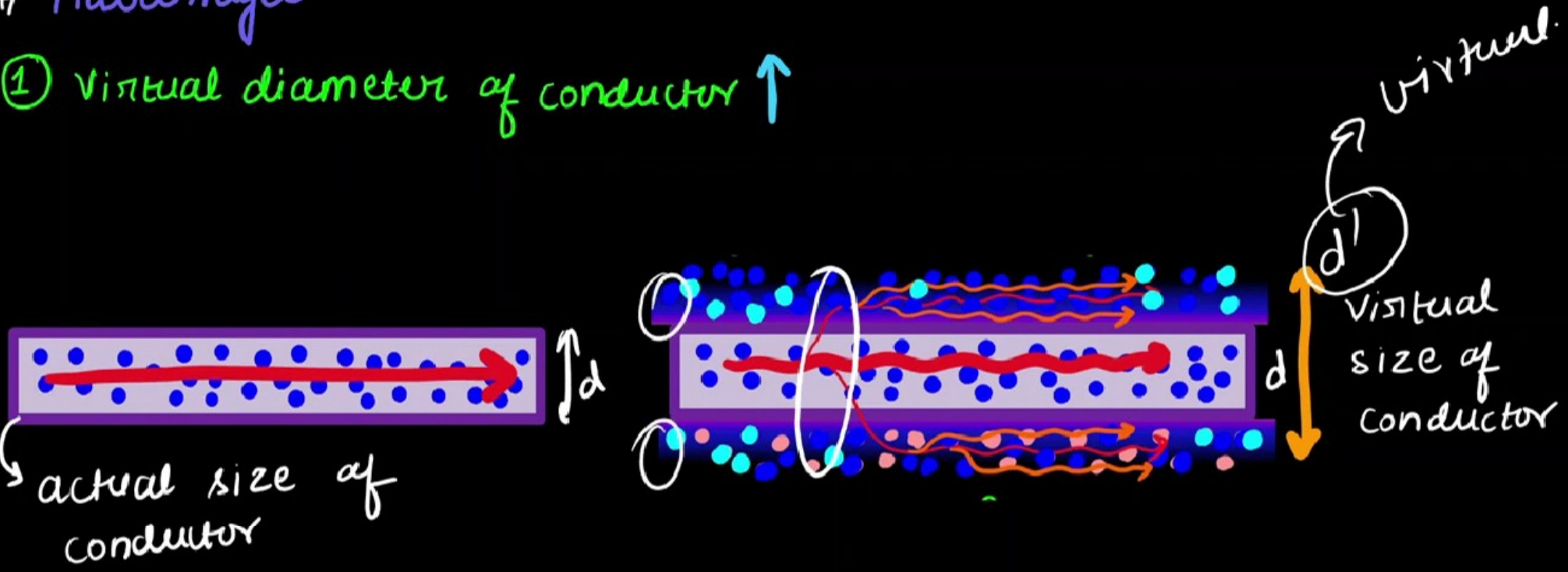
(2) Increase conductor spacing

↳ $d \uparrow$

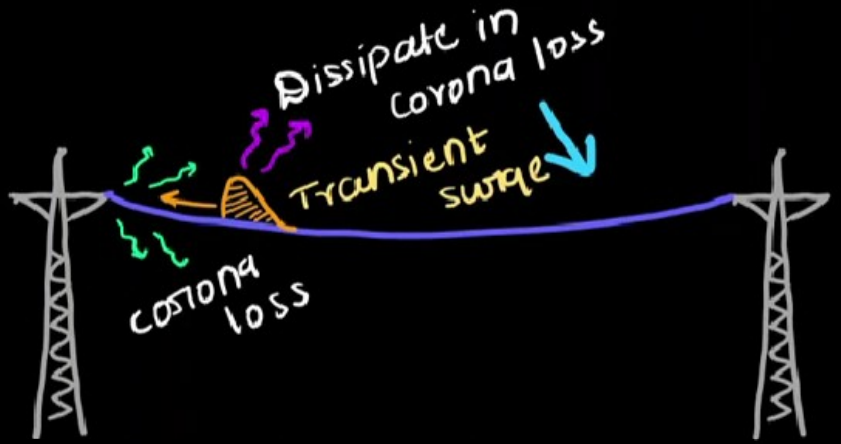
→ can't be increased too much otherwise cost of supporting structure increases.

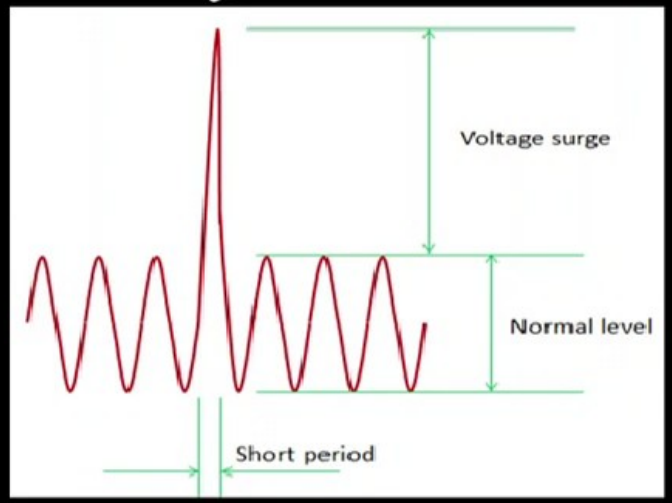
Advantages

① Virtual diameter of conductor ↑



(2) Effect of Transient Surges ↓

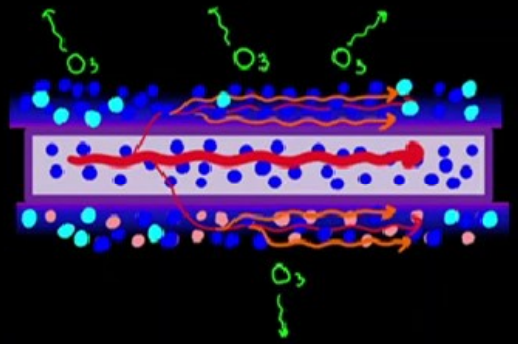




Disadvantages

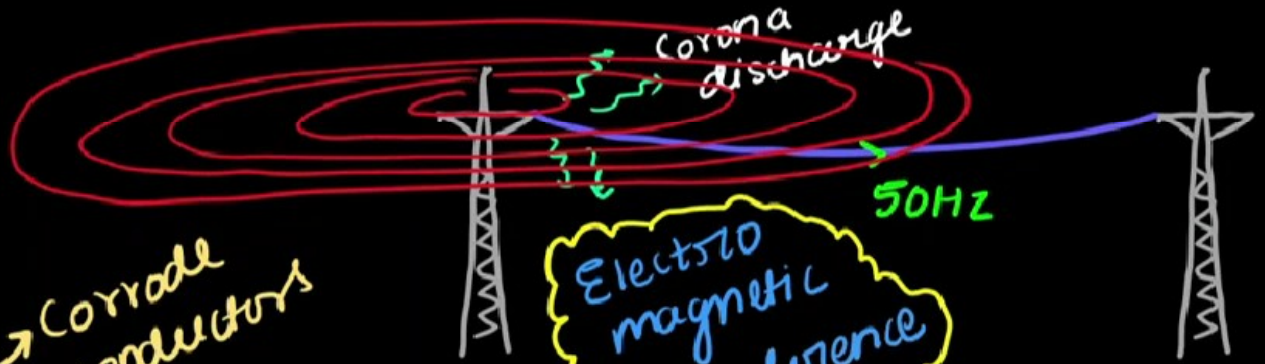
① Loss of Energy

② Ozone formation



Ozone gas formation → Corrode conductors

③ Interference



Electro magnetic Interference

CORONA CAMERA

CORONA DETECTION

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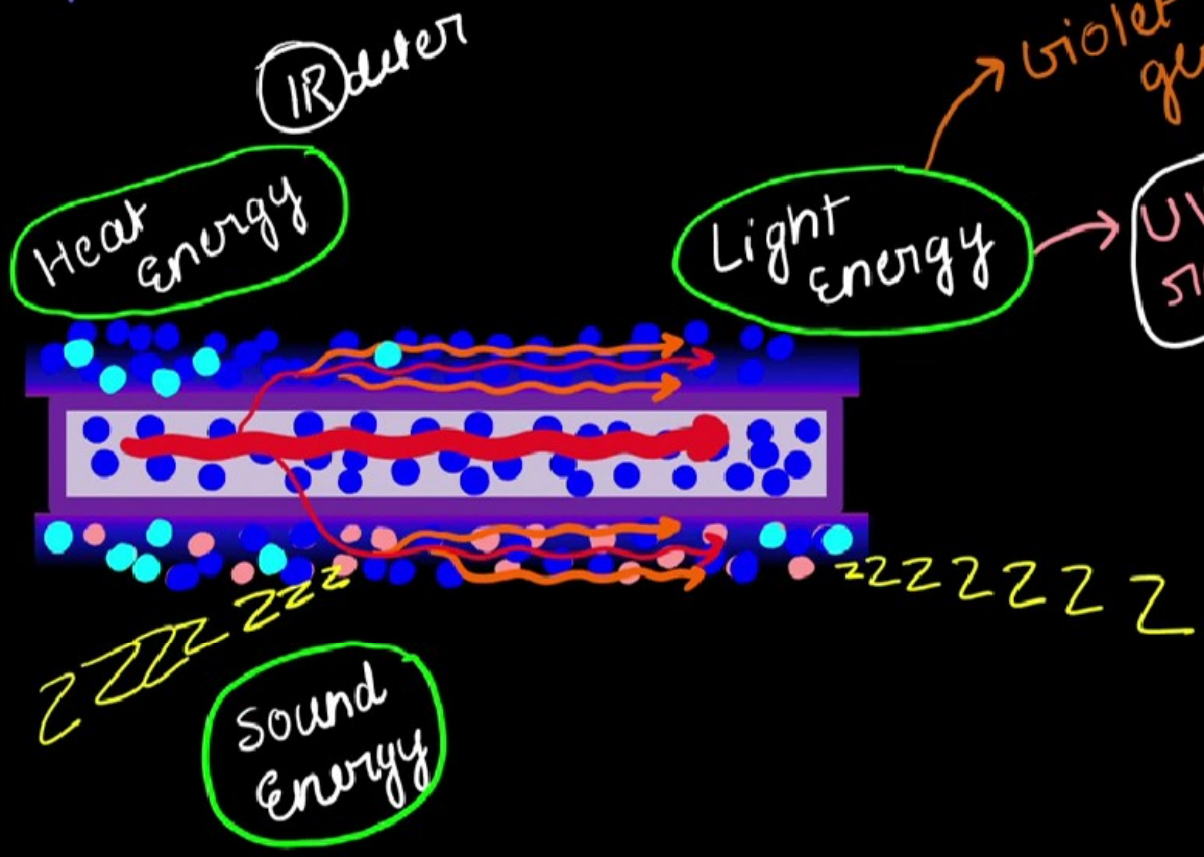
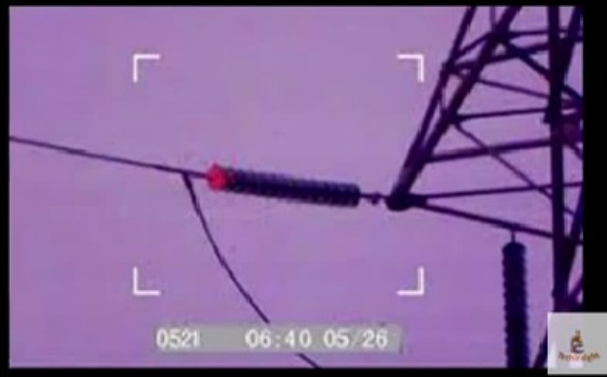
Corona Spectrum




Canon
EOS
5D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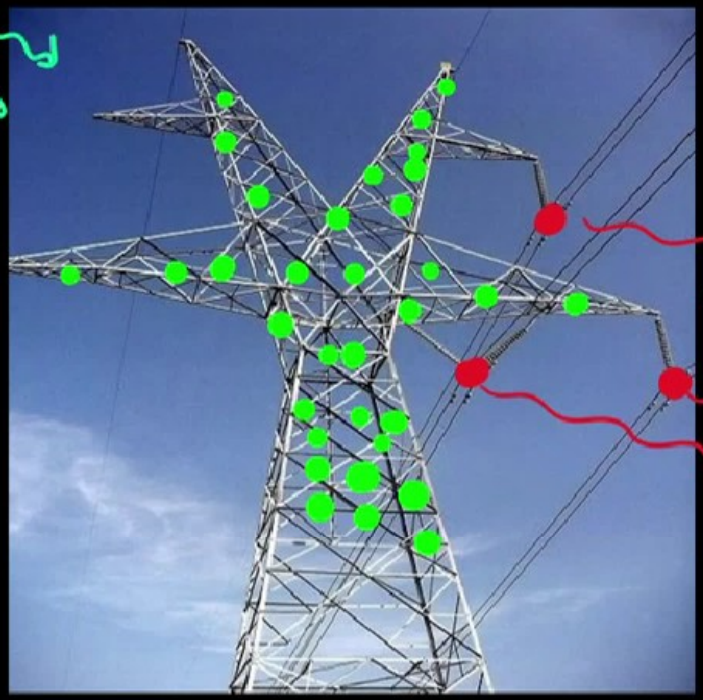
#Issue



FALSE INFORMATION

UV Radiation

λ = 100nm to 400nm

SUN

UV A

UV B

UV C

315-400 nm

280-315 nm

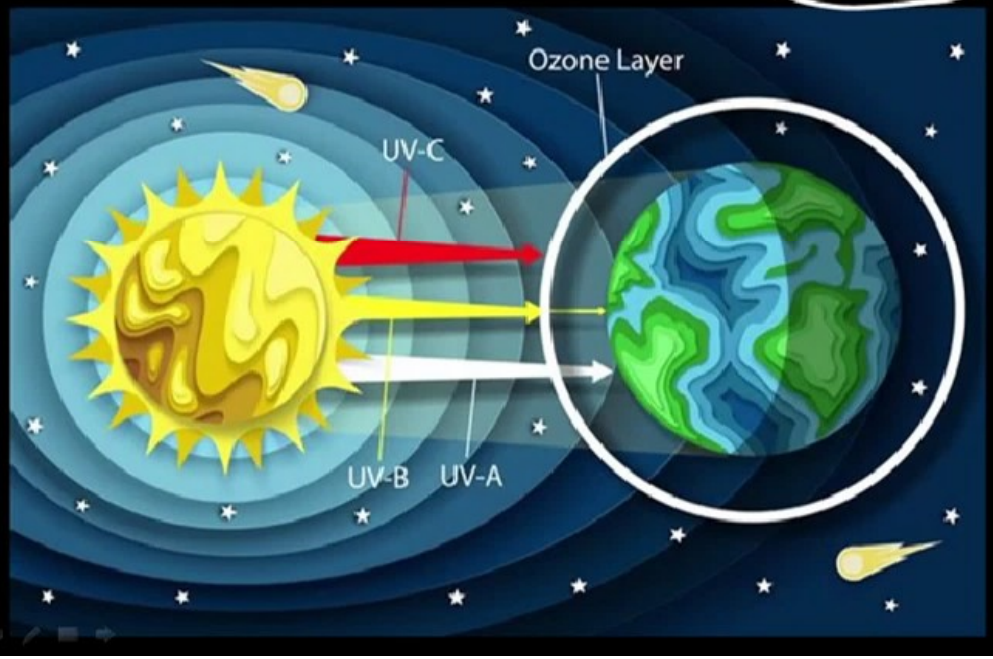
100-280 nm

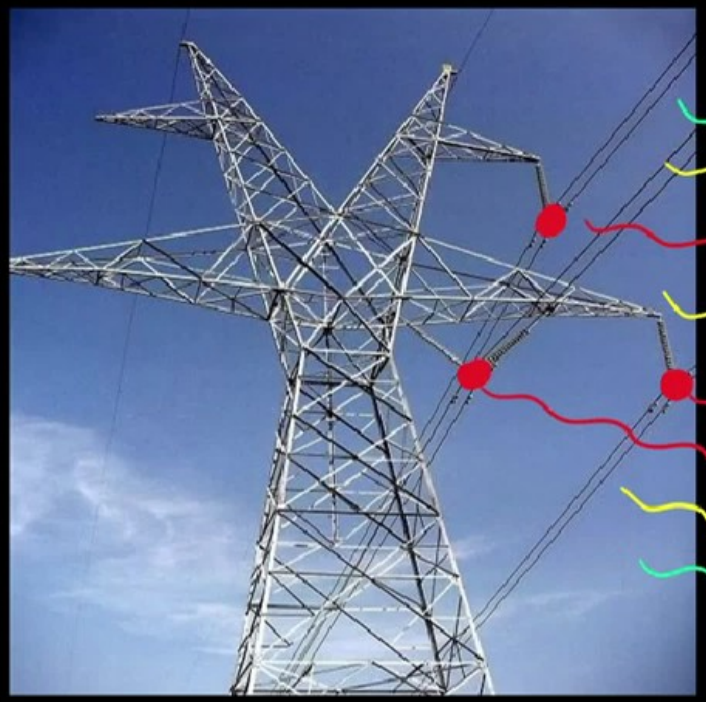
Corona

100-280 nm

Solar Blind Region

solar interference





UV_A UV_B UV_C UV_B UV_C UV_C UV_B UV_A

Filter

(Below 280 nm)

pass

UV_C

CORONA RING

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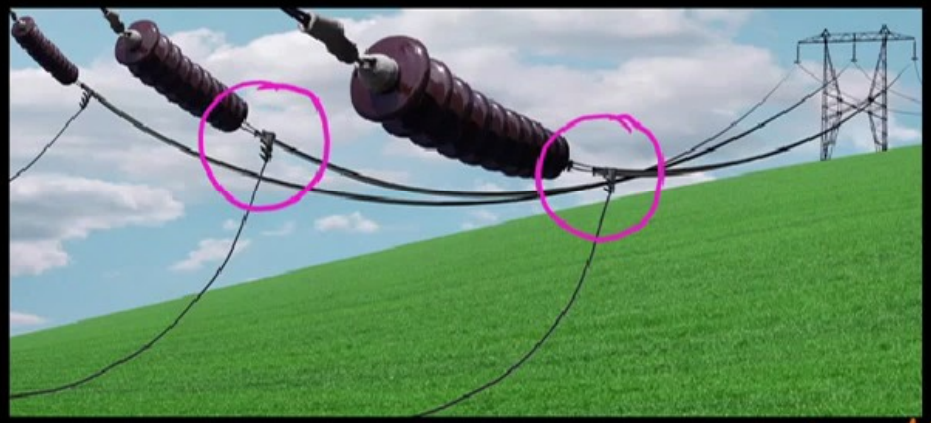
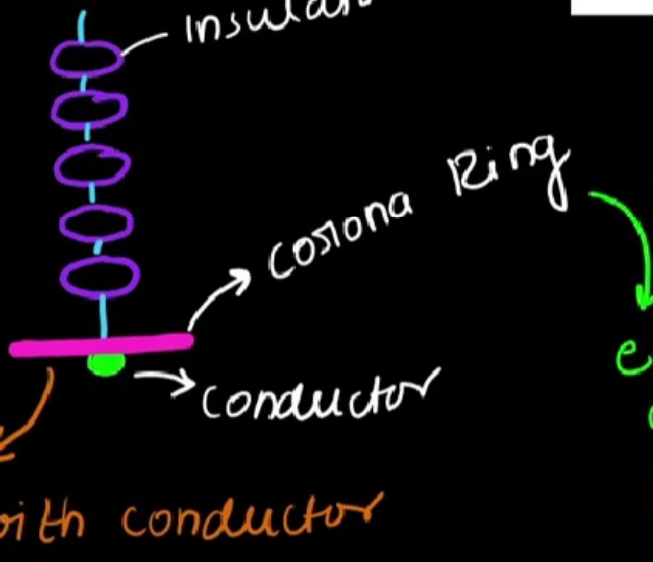
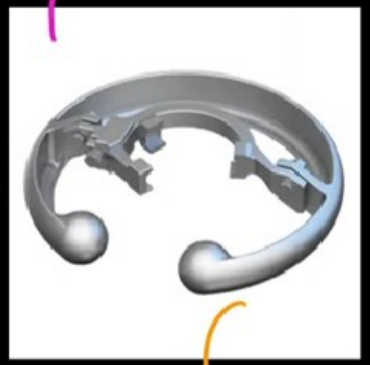
What is Corona Ring ?

"A metal ring encircles the conductor or sharp points to eliminate corona discharge"



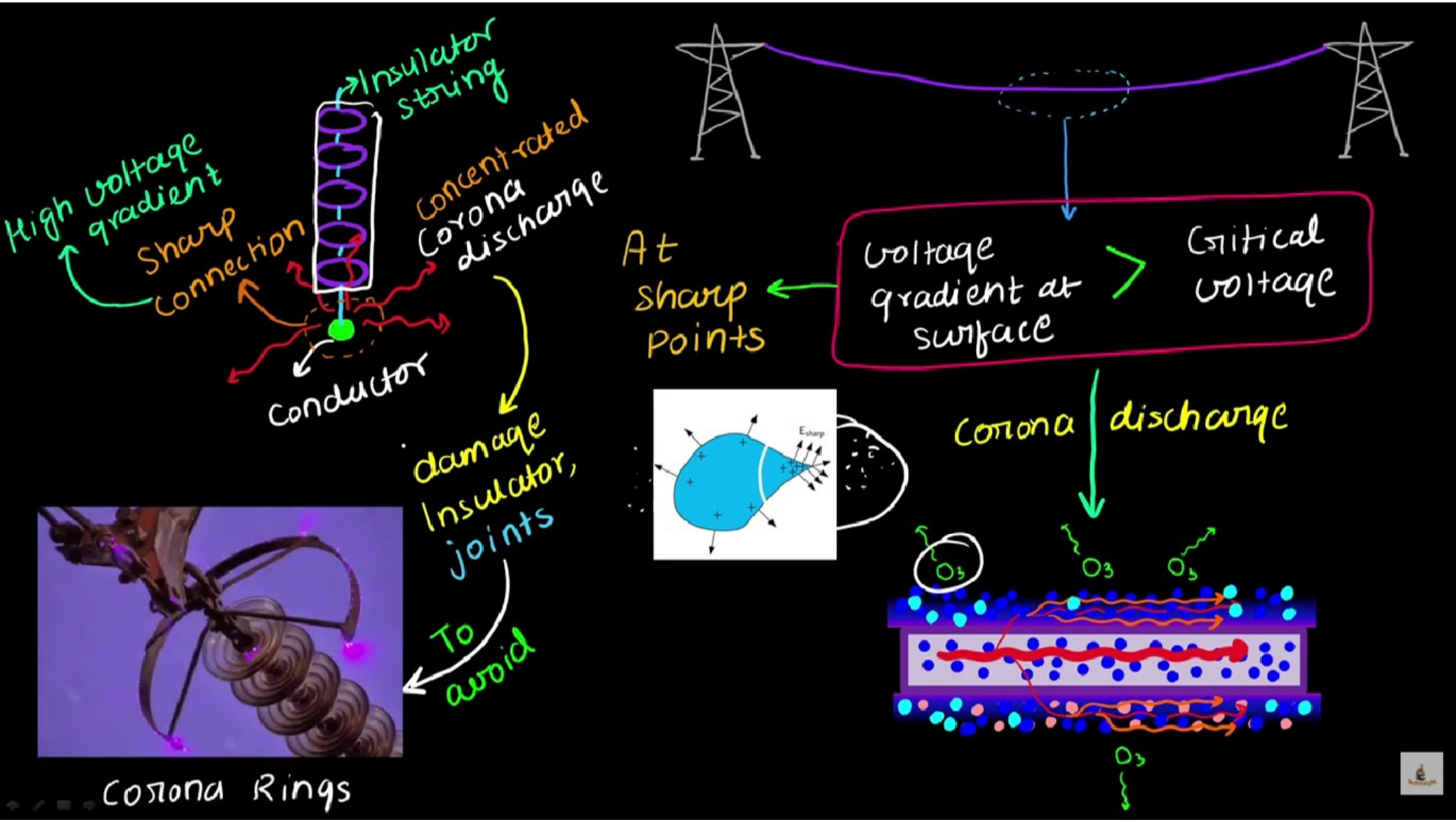


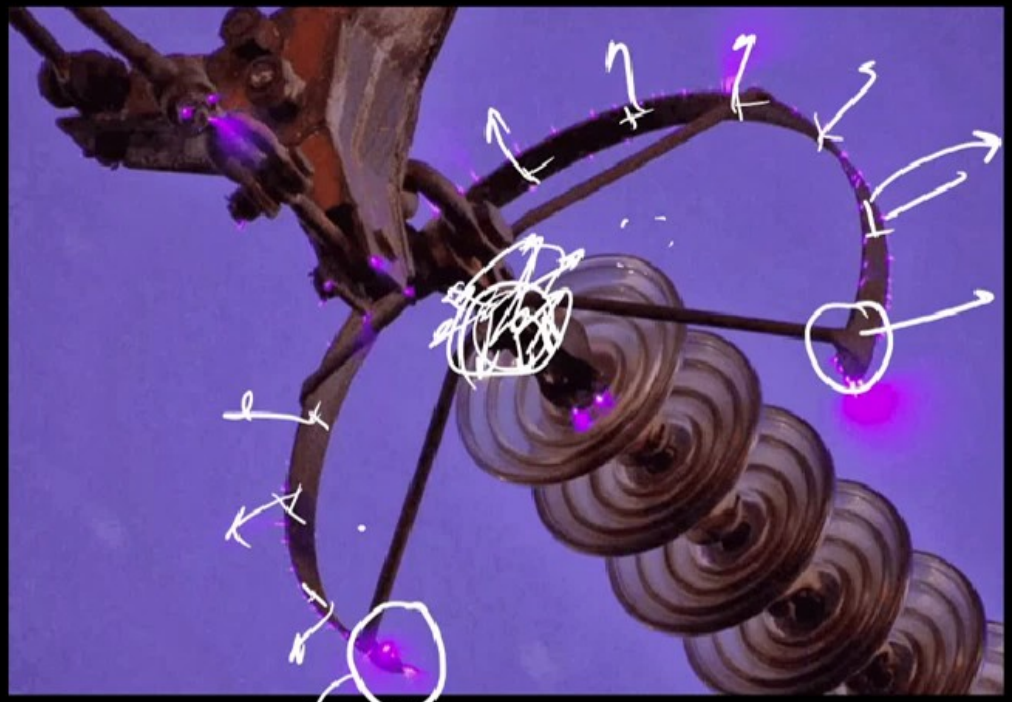
Toroidal shape



CORONA RING

Encircle only conductor


Insulator string
High voltage gradient
Sharp connection
Concentrated Corona discharge
Conductor
damage Insulator, joints
To avoid
Corona Rings
At sharp points
Voltage gradient at surface
> Critical voltage
Corona discharge
E_{sharp}
O_3
O_3
O_3
O_3



Ring increases the surface area near Insulator joints

→ Reduce voltage gradient

→ Limit corona discharge

Allow corona discharge at sharp ring edges

→ Preventing the sharp connecting points

Types

Closed corona Ring

MORE EFFECTIVE

Open corona ring

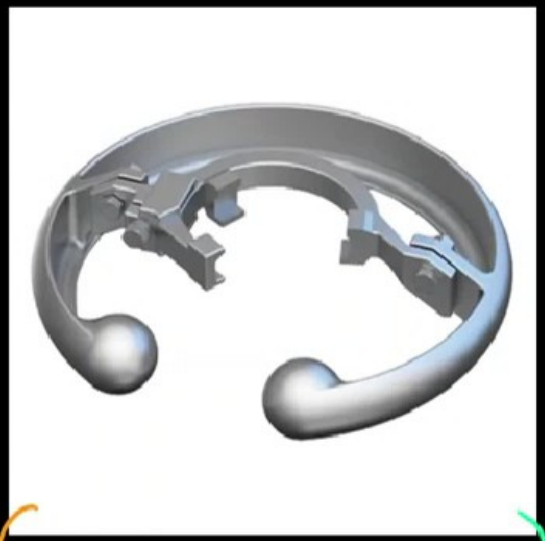
Both distribute electric field to reduce voltage stress

Prevent corona discharge

Discharge gap

allow discharging of high voltage

Protect Insulator



CORONA RING

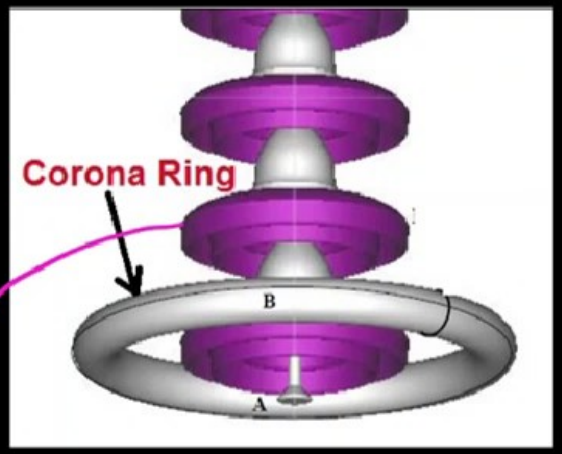
main aim is to supress corona discharge by distributing electric field

additonally supress corona discharge

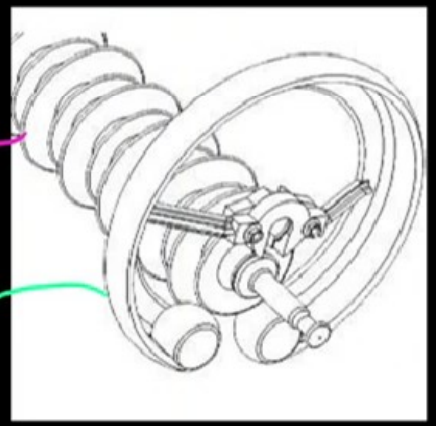
main aim to equalize potential gradient

GRADING RING

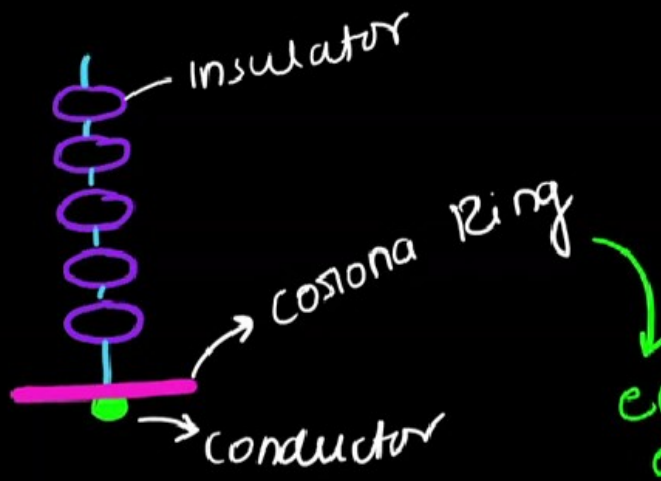
Fitting



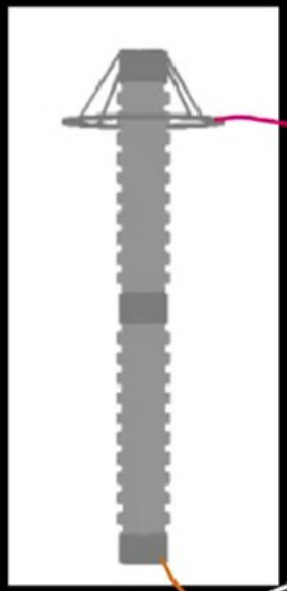
Insulator string



Corona Ring

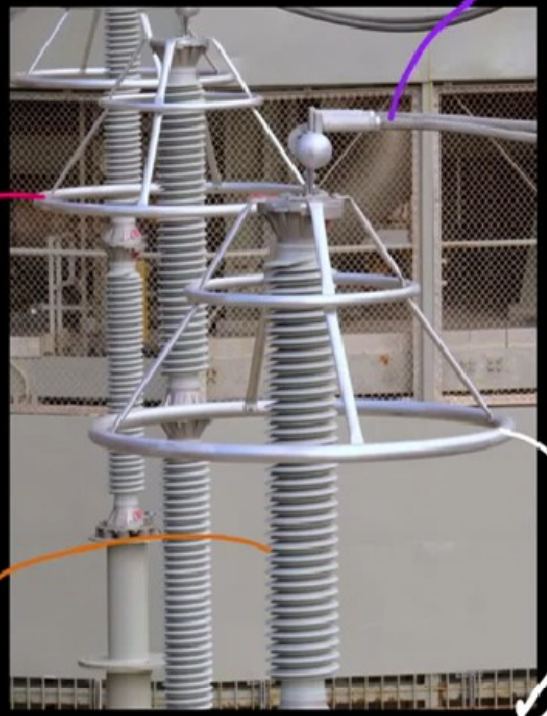


Encircle only Conductor



GRADING RING

Insulators



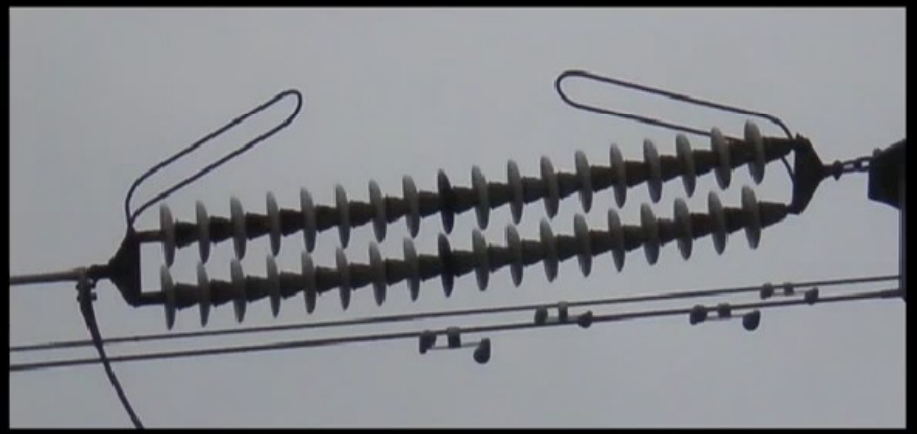
Conductors

Grading + corona

Grading Ring

encircle only Insulator

ARCING HORNS



ARCING HORNS

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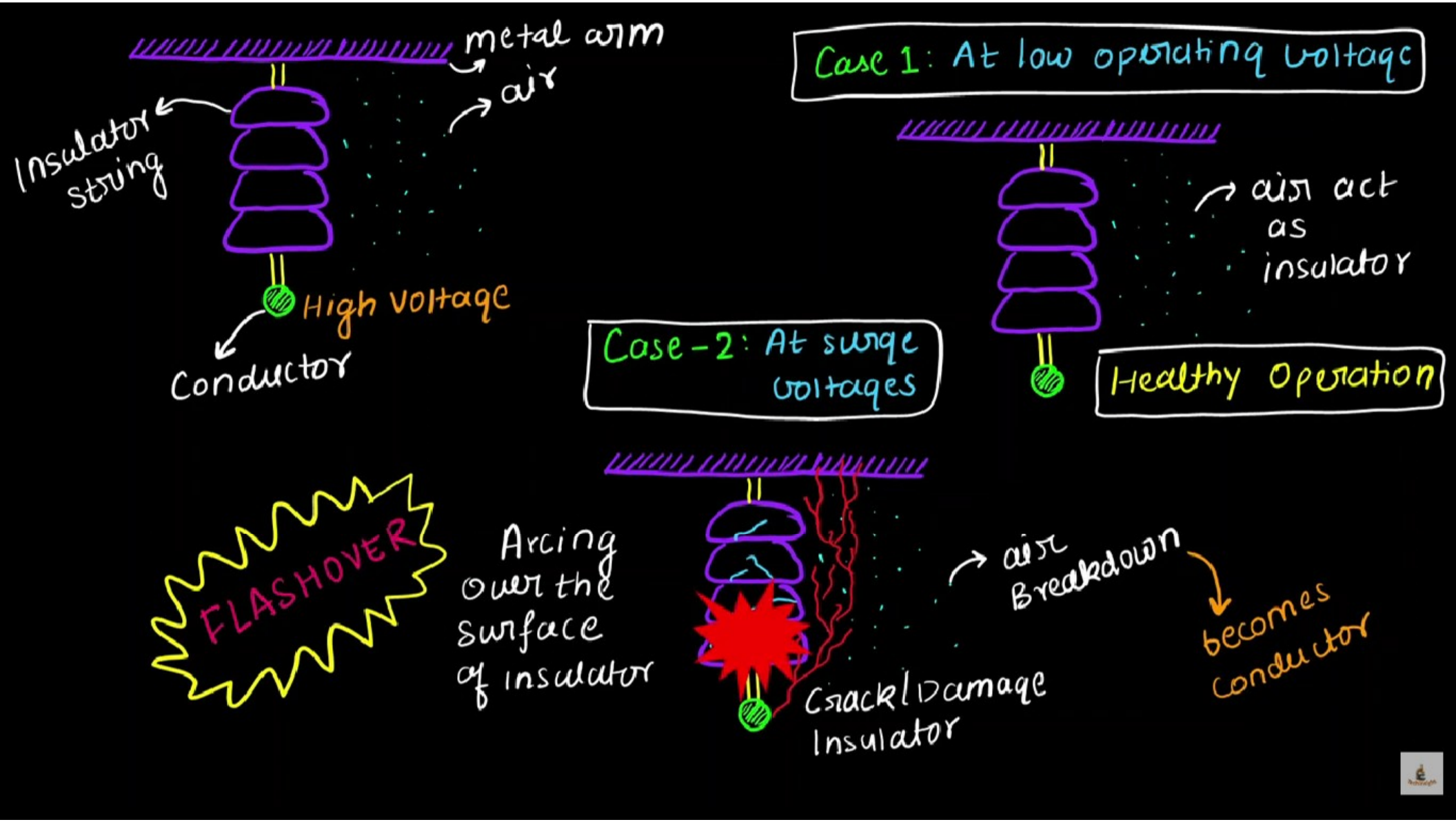
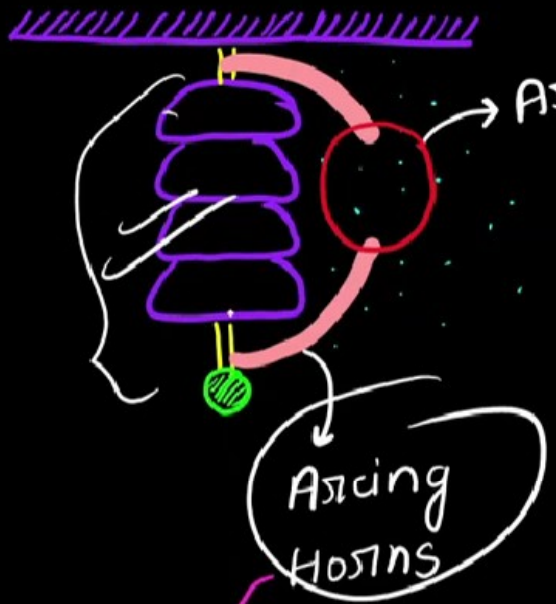
TechInsight


metal arm
air
Insulator string
High voltage
Conductor
Case 1: At low operating voltage
air act as insulator
Healthy Operation
Case-2: At surge voltages
FLASHOVER
Arcing over the surface of insulator
air Breakdown
becomes Conductor
Crack/Damage Insulator

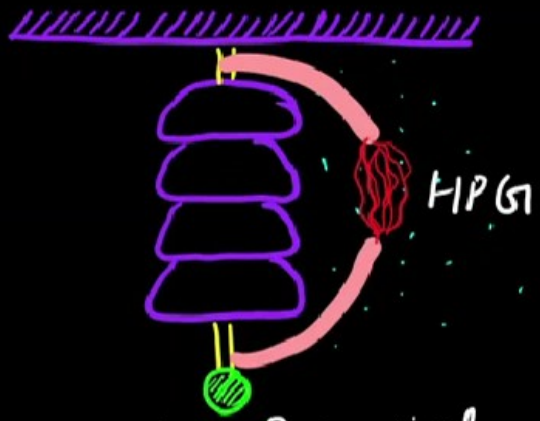
Arcing Horns operation

(1) Potential Gradient



Treated as Sacrificial equipment → cheaper → Easy to replace

Case-2: At surge voltages



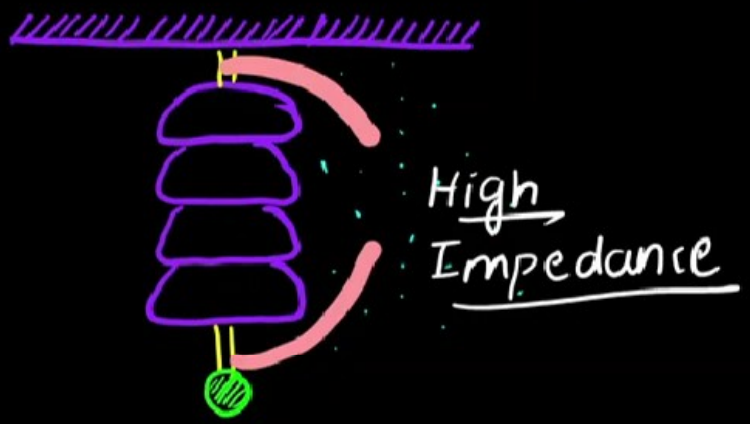
Arc develop across horns earlier than across insulator

↓

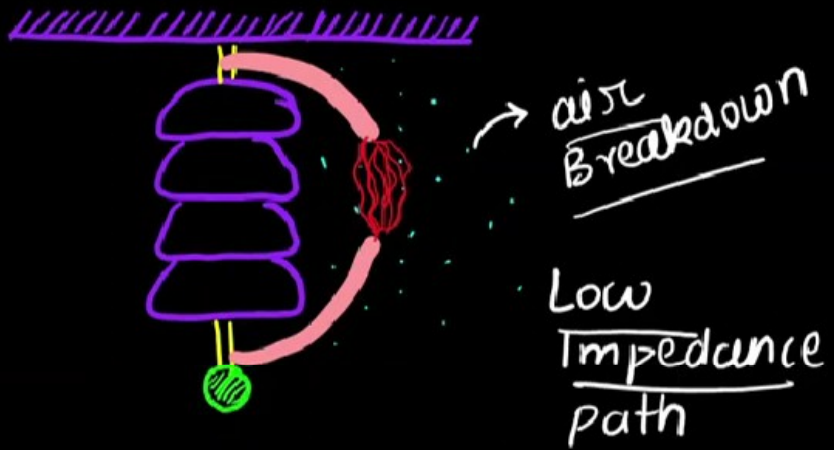
Divert the arc away from insulator and thus Protect it

② Variable Impedance

Case 1: At low operating voltage



Case-2: At surge voltages



* Non-Linear resistor have similar properties

→ can replace arcing horns