Important Formulae

Field Enhancement Factor

$$f = \frac{E_{\max}}{E_{\text{avg.}}}$$

Townsend current growth equation

$$I = I_0 \exp(\alpha d)$$

Current growth in presence of Secondary Processes

$$I = \frac{I_0 \exp(\alpha d)}{1 - \gamma\left[\exp(\alpha d) - 1\right]}$$

Breakdown conditions

$$\gamma \exp(\alpha d) = 1$$

$$\mathrm{pd}_{\min} = \frac{e}{A} \ln\left[1 + \frac{1}{\gamma}\right]$$

$$V_{\min} = \frac{eB}{A} \ln\left[1 + \frac{1}{\gamma}\right]$$

Voltage gradient to Corona inception for parallel wires

$$E_c = 20\, md\, [1 + .301/\sqrt{dr}\,]$$

Heat generated in a dielectric in ac field

$$W = \frac{E^2 f \varepsilon_r \tan\delta \times 10^{-12}}{1.8} \text{ Watts/cm}^3$$

Ripple in Voltage Multiplier Unit with 'n' capacitors included

$$\frac{I}{f_c} \frac{[n(n+1)]}{2} \qquad \text{(peak ripple)}$$

$$\frac{I}{f_c} \frac{[n(n+1)]}{4} \qquad \text{(average ripple)}$$

Voltage drop in n stage multiplier unit ($2n$ capacitors included)

$$\frac{I}{f_c}\ [2/3n^3 + n^2/2 - n/6]$$

Optimum number of stages = $\sqrt{V_{\max} f_c / I}$

Impulse Wave Shape (double exponential type)

$$V = V_0\ [\exp(-\alpha t) - \exp(-\beta t)]$$

Impulse Current Wave Shape (oscillatory)

$$I = I_m \exp(-\alpha t) \sin \omega t$$

Time to front for double exponential wave

$$T_1 = 3.0\ R_1\ C_1C_2/C_1 + C_2$$

Time to front for double exponential wave

$$T_2 = 0.7\ (R_1 + R_2)\ (C_1 + C_2)$$

Impulse Current Wave Shape (Oscillatory)

$$I_m = V/\omega L\ [\exp(\alpha f) \sin \omega t]$$

$$\alpha = R/2L,\ \omega = \sqrt{1/LC - R^2/4L^2}$$

T_1 rise time from Zero to max = $1/\omega \tan^{-1} \omega'/\alpha$

T_2 duration of one half cycle of oscillatory wave π/ω'

Current given by generating voltmeter = $i_{\text{rms}} = (V_{\text{m}}\omega)/\sqrt{2}$

Force on the plates of Electrostatic Voltmeter

$$F = \frac{1}{2}\ \varepsilon_0 A\ (V/S)^2\ Nw$$

Series capacitance required for compensation of ground Capacitance in voltage dividers

$$C_1' = nC_1\ [1 - C_g/6C_1]$$

Voltage ratio of capacitance divider with ground capacitance

$$= [1 + (C_2/C_1)\ (1 + C_g/6C_1))]$$

Skin depth for conductor at high frequencies

$$d = 1/\sqrt{\pi f \mu \sigma}$$

Bandwidth of a coaxial shunt

$$B = \frac{1.46\,\rho}{\mu\, d^2} \text{ and rise time } T = 0.237\ \mu d^2/\rho$$

For lossless Transmission line

for incident wave $e_1/i_1 = Z_1$

for reflected wave $e'_1/i'_1 = -Z_1$

for transmitted wave $e''_1/i''_1 = Z_2$

$$e'' = \gamma e, \quad i' = -\gamma i$$

$$e'' = (\gamma + 1)\, e, \quad I'' = (1 - \gamma)\, I \quad \gamma = \text{reflection coefficient}$$

High resistance measurement with dc Galvanometer

$$R = (V/R_s)\,(1/n)\,(1/D_s)$$

hv Schering bridge

Balance Condition $C_x = (R_3/R_4)\,(C_s)$

$$r_x = (C_3/C_s)\, R_1$$

$$\tan \delta_x = \omega\, C_x r_x = \omega\, C_3 R_3$$

Transformer ratio arm bridge

Balance Condition $C_x = (N_s/N_x)\, C_s$

$$R_x = (N_x/N_a)\, R_a$$

$$\tan \delta_x = (\omega\,(C_s R_a))\,(N_s/N_a)$$

Output Power Rating of Testing Transformers

$$P(\text{kVA}) = 2\pi f V^2 \times 10^{-9} \qquad [V \text{ in kV}, C \text{ in pF}]$$

Peak Output Voltage of Impulse Generator for Standard Impulse Voltage

$$V_s = n V_{\text{dc}}\,[0.95 - (C_L/C_L + C_g)]$$

Energy rating of Impulse Generator

$$W = \frac{1}{2}\, C_g\, V^2 \times 10^{-9} \text{ kJ} \qquad [V \text{ in kV}, C_g \text{ in pF}]$$

Minimum clearance required in HV Laboratories for safe operation

< 1.5 MV for ac and dc ratings

< 2.5 MV for Impulse ratings

ac	200 kV (rms)/m	Under standard atmospheric conditions
dc	275 kV (rms)/m	
Impulse	500 kV (peak)/m	