experiment · 5 Mansi Uniyal
19EE10039
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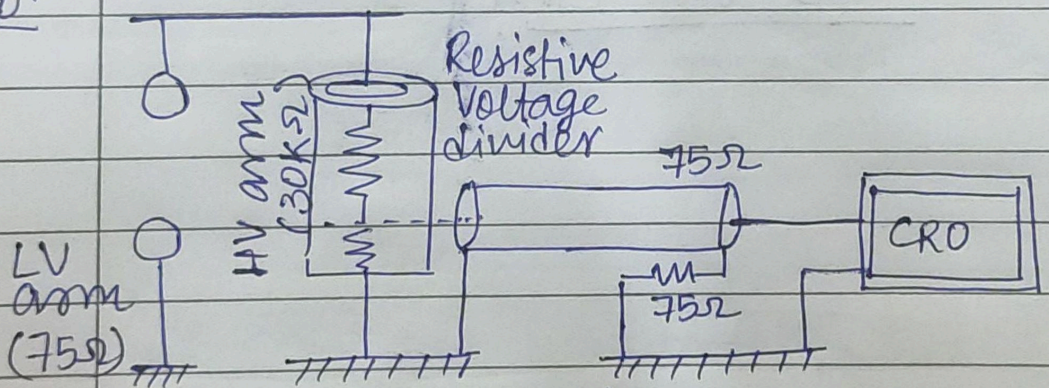
Study of Impulse Voltage Generator and Determination of Impulse Breakdown Voltage of Sphere gap.

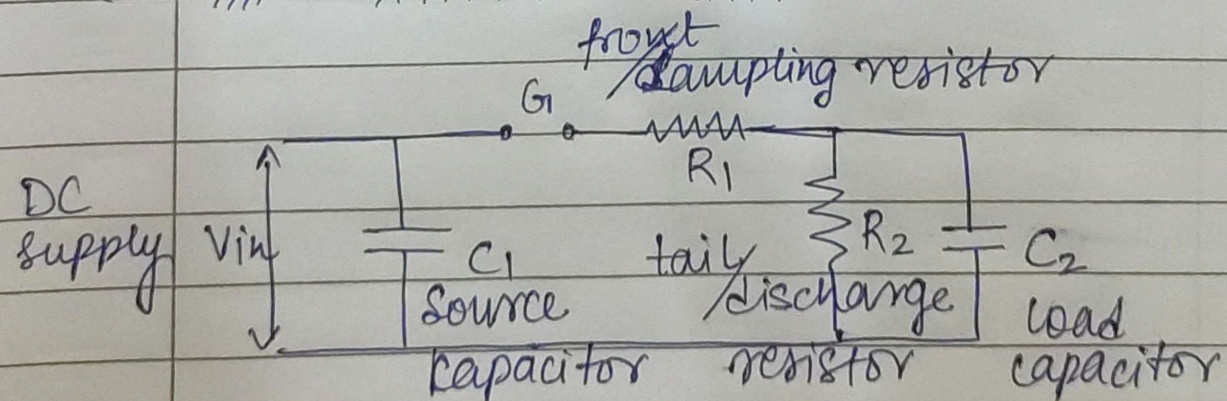
(Critical flashover voltage)

Objective:

1. Study of Impulse Voltage Generator.
2. Generation of standard Impulse voltage.
3. Determination of impulse breakdown voltage of sphere gap.

Experimental setup:





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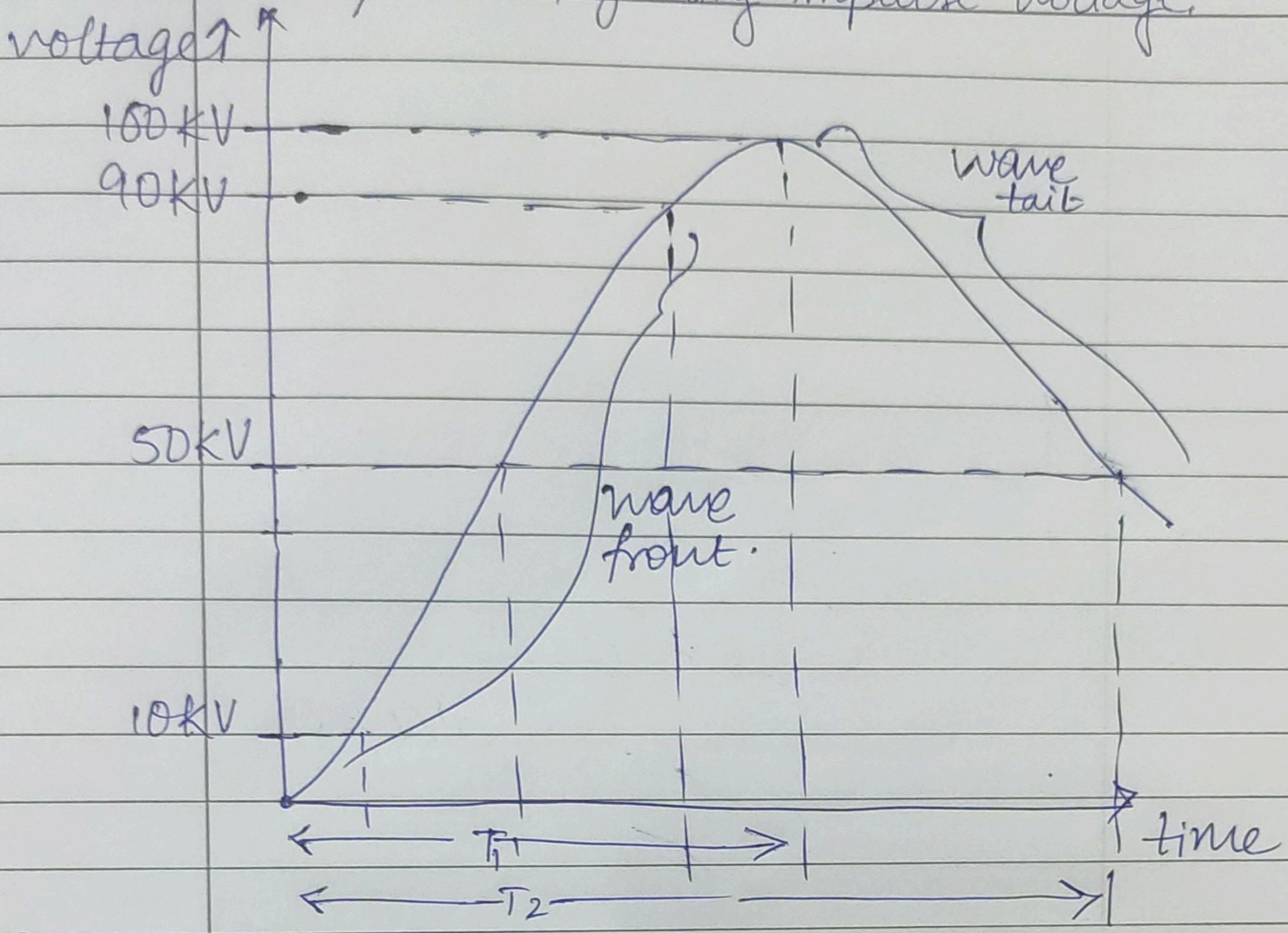
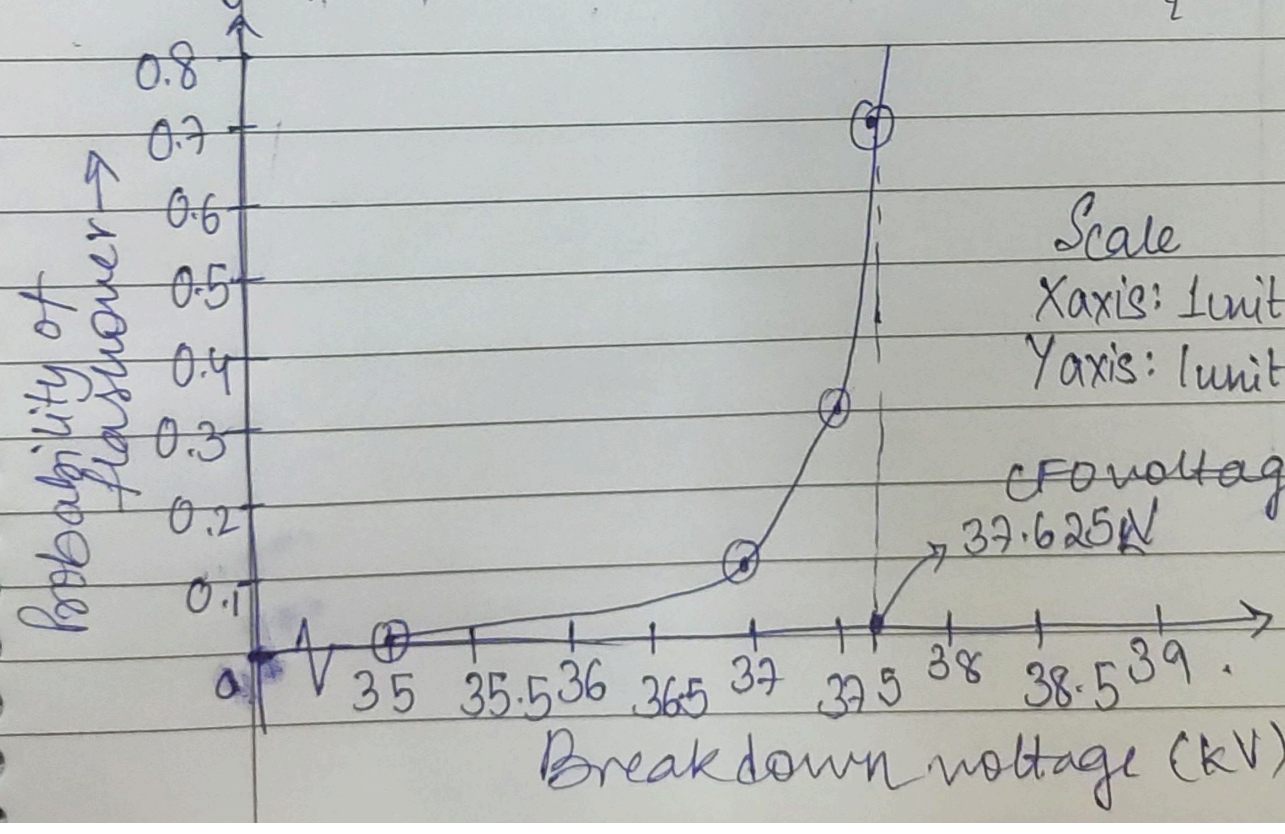
Standard 12/50 μs lightning impulse voltage.



Probability Vs Breakdown voltage.



Compute probablity & draw 'Probablity vs breakdown voltage' curve.

W → withstand
f → flashover

Voltage level Stge(kV)	Pulse No. 1	2	3	4	5	6	7	8	9	10	Probablity of flashover
35	W	W	W	W	W	W	W	W	W	W	0.0
37	W	W	W	W	f	W	W	W	W	W	0.1
37.5	W	f	W	W	W	W	f	W	f	W	0.3
37.7	W	f	W	f	f	f	f	W	f	f	0.7

$$P_F = \frac{\text{no. of flashover at given voltage levels}}{\text{total no. of pulse no at given voltage level.}}$$

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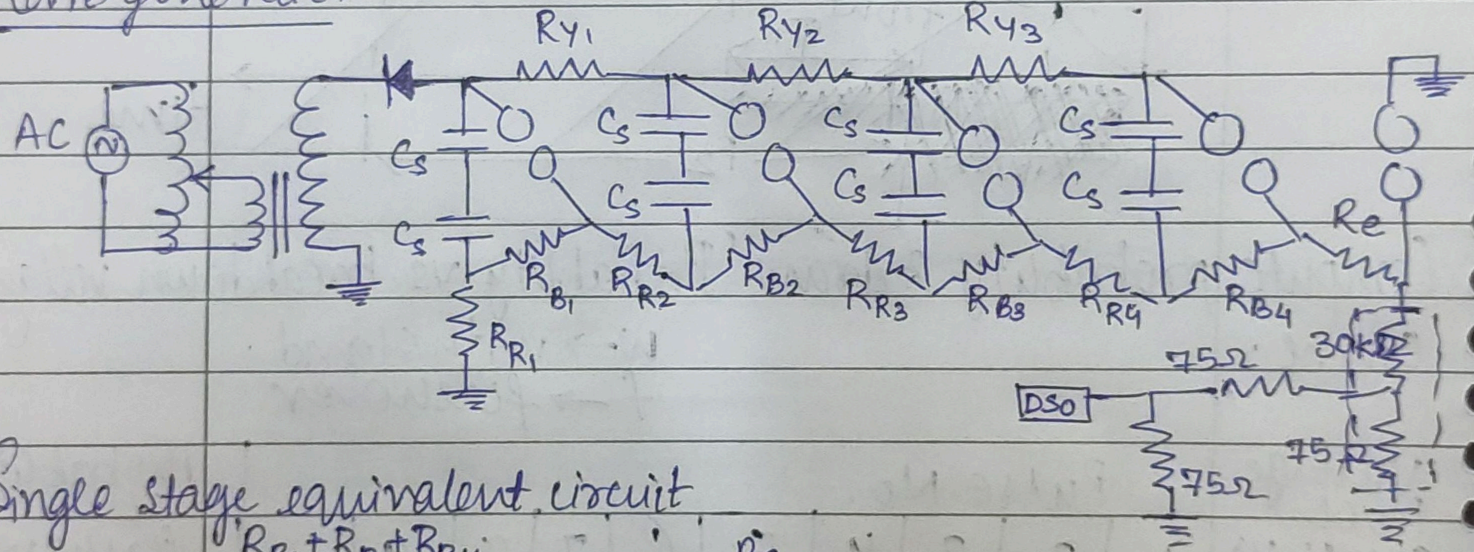
Determine CFO voltage for 70mm sphere gap at STP from experimental measured:

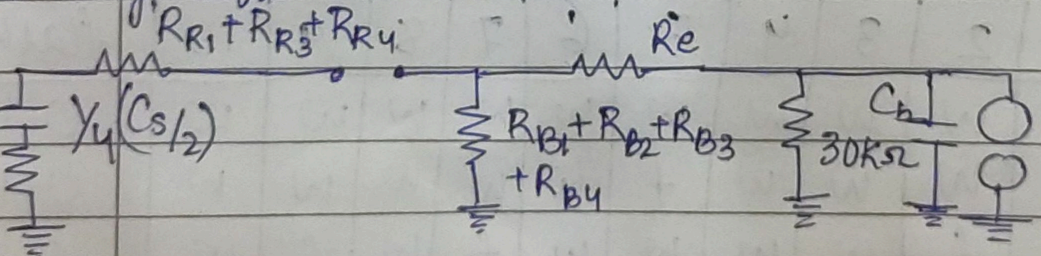
~~For~~

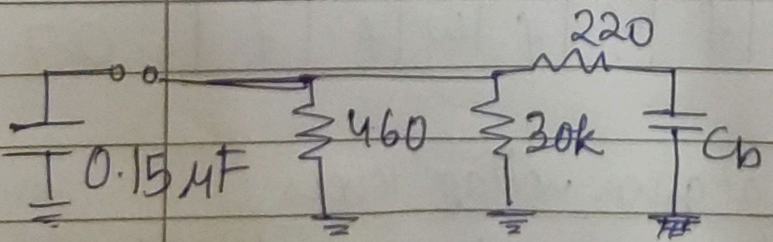
CFO voltage is cost voltage of standard impulse for which it exhibits 50% probability of failure. So, probability is 0.5. CFO voltage from graph is approximately 37.65 kV.

Draw single stage equivalent circuit for 4-stage Marx generator



Single stage equivalent circuit





replacing values and simplyfying

$C_b = \frac{0.405u}{220} = 1.8nF$

$R_1 = 220\Omega$; $R_3 = 460\Omega$; $\frac{1}{s} = R_3 C_1 = 69\ \mu F$

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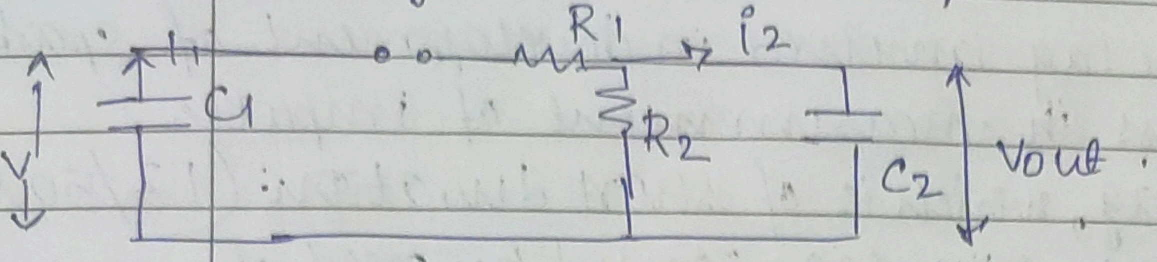
approximated expression for double exponential impulse voltage across load capacitor



vout $= V_0(t) = \frac{1}{C}\int i_2\,dt$ → laplace domain

$$V_0(S) = \frac{I_2(S)}{C_2(S)}$$

$$I_1(S) = \frac{R_2}{R_2 + \frac{1}{C_2 S}} \times I_1(S)$$

$$I_1(S) = \frac{V}{S} + \frac{1}{1/C_1 S + R_1 + R_2 \| 1/C_2 S}$$

$$V_0(S) = \frac{V}{C_2 S} + \frac{R_2}{R_2 + 1/C_2 S} + \frac{1}{C_1 S + R_1 + \frac{R_2/C_2 S}{R_2 + 1/C_2 S}}$$

$$V_0(S) = \frac{V}{R_1 C_2}\left(\frac{1}{S^2 + \left(\frac{1}{C_1 R_1} + \frac{1}{C_2 R_2} + \frac{1}{C_2 R_1}\right)S + \frac{1}{C_1 C_2 R_1 R_2}}\right)$$

$$S^2 + \left(\frac{1}{C_1 R_1} + \frac{1}{C_2 R_2} + \frac{1}{C_2 R_1}\right)S + \frac{1}{C_1 C_2 R_1 R_2} = 0$$

∴ roots → $1/R_2 C_1$, → $1/R_1 C_2$

(1)

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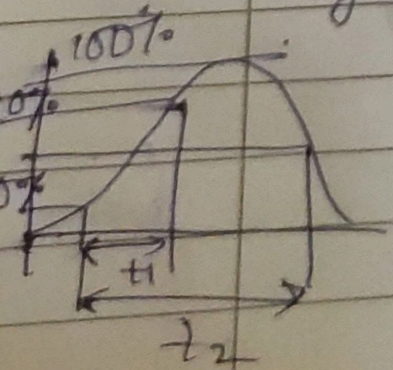
Why is impulse breakdown of sphere gap statistical?

Time lag involved in development of spark process in measurement of impulse voltage, which is of short duration: (1.2/50 μs)
Statistical timelage caused by need of electron to appear in gap during the appication of voltage.
Formative timelag, needed to develope once initiated.
So, depending on availability of injected electrons which is statistical.

(2)

How is wave shape of impulse voltage controlled?

By sllection of t_p and t_t (front and tail) time
While charging capacitor $R_{F1}, R_{F2}, R_{F3}, R_{F4}$ are in series, so they decide front time.
Choosing lower value of resistance, front time is less and rising wave will be quick. Same for $R_{B1}, R_{B2}, R_{B3}, R_{B4}$ contributing to falling wave, setting higher values make fall part smooth.



(3)

Why is capacitive storage not inductive storage for impulse voltage generator?

→ Impulse Generators: 1. Impulse current 2. Impulse voltage generator.

Capacitors store energy in large potential difference between plates of capacitor, while inductor stores energy in current.

High impulsive volt. are used to test strength of elective power equipment against ~~lightning~~ lightning and switching surges. High impulsed currents are needed not only for tests but also for several applications like plasma devices.

(4)

Describe an operator very peak of impulse voltage?

Peak decreases if increase in wave front resistance. But if value of wave tail resistance is increased, peak value of wave increases.

R_1 will primarily damp circuit & control front

R_2 will discharge capacitor & control wave tail.

(5)

Describe 50% flashover voltage and tell how it can be determined for test sample (insulator)?

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50%. flashover voltage is voltage which has probability of 50%. flashover when applied to test object. This is applied in impulse tests which has loss of insulation strength as temporary; determined using 'Probability of breakdown Vs applied voltage' plot. Regressive method can also be used to determine 50%. flashover voltage. Starting with low voltage pulses are applied & number of breakdown noted. Increasing voltage in 10%. steps., no. of breakdown are noted for 10 pulses. Until Breakdown:

$$P_{\text{Breakdown}} = \frac{\text{no. of breakdown}}{\text{no. of pulse applied.}}$$

Puting $P_{\text{breakdown}}$ VS voltage. and voltage at 50%. probability is 50%. flashover voltage