PVP 23

Code: 23EE4602C

III B.Tech - II Semester - Regular Examinations – APRIL 2026

HIGH VOLTAGE ENGINEERING
(ELECTRICAL & ELECTRONICS ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

		BL	CO
1.a)	State Paschen's Law.	L2	CO1
1.b)	Differentiate dielectric material and insulator.	L2	CO1
1.c)	Define intrinsic strength of a solid dielectric.	L2	CO1
1.d)	List out the different insulating materials used in electrical applications.	L2	CO5
1.e)	Define Voltage doubler circuit and mention its uses.	L2	CO2
1.f)	Give the specifications for standard impulse wave.	L2	CO2
1.g)	What are the limitations of van de graff generator?	L2	CO5
1.h)	What is Rogoswki Coil?	L3	CO3
1.i)	What are the uses of Generating Voltmeter?	L2	CO4
1.j)	What are the uses of sphere gap?	L3	CO5

PART – B

			BL	CO	Max. Marks
UNIT-I					
2	a)	Derive Townsend's first and second ionization co-efficient with clear explanation.	L3	CO1	5 M
	b)	A steady current of 600µA, flows through the plane electrodes separated by a distance of 0.5cm. When a voltage of 10KV is applied. Determine the Townsend's first ionization coefficient if a current of 60 µA flows when the distance of separation is reduced to 0.1cm and the field is kept constant.	L3	CO1	5 M
OR					
3	a)	Explain Collision process in gaseous dielectrics.	L3	CO1	5 M
	b)	Discuss breakdown mechanism in Vacuum dielectric.	L3	CO1	5 M
UNIT-II					
4	a)	What are the commercial liquid dielectrics, and how are they different from pure dielectrics?	L3	CO1	5 M
	b)	Explain any one theory of breakdown in commercial liquids.	L3	CO1	5 M
OR					

5	a)	Explain clearly breakdown due to internal charges in solid dielectrics.	L3	CO1	5 M
	b)	What is thermal breakdown in solid dielectrics, and how is it practically more significant than other mechanics?	L3	CO1	5 M
UNIT-III					
6	Explain any two methods for producing High DC voltages. Give their advantages and disadvantages.		L4	CO2	10 M
OR					
7	Explain the principle and operation of Resonant Transformers.		L4	CO2	10 M
UNIT-IV					
8	a)	Explain the construction and operation of a Marx Impulse Generator.	L4	CO3	5 M
	b)	A 12 stage Impulse Generator has 0.126µf condensers. The wave front and wave tail resistances connected are 800 ohms respectively. If the load condenser is 100pf, find the front and tail times of the impulse wave produced.	L4	CO3	5 M
OR					
9	Explain in detail about generation of High Impulse Currents.		L4	CO3	10 M

UNIT-V				
10	What is capacitance voltage transformer? Explain with phasor diagram how a tuned capacitance voltage transformer can be used for voltage measurement in power systems.	L4	CO4	10 M
OR				
11	Briefly discuss about oscilloscope for Impulse Voltage and current measurement.	L4	CO4	10 M

PRASAD V POTLURI SIDDHARTHA INSTITUTE OF TEHNOLOGY
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
III B. Tech - II Semester - Regular Examinations – April 2026

HIGH VOLTAGE ENGINEERING (23EE4602C)

Scheme of Evaluation

PART – A

1.	a) State Paschen's Law.	2M
	b) Differentiate dielectric material and insulator.	2M
	c) Define intrinsic strength of a solid dielectric.	2M
	d) Different insulating materials used in electrical applications.	2M
	e) Define voltage doubler circuit and mention its uses.	2M
	f) Specifications for standard impulse wave.	2M
	g) Limitations of Van de Graaff generator	2M
	h) Definition of Rogowski Coil	2M
	i) Uses of generating voltmeter	2M
	j) Uses of sphere gap	2M

PART – B

UNIT – I

2.	a) Townsend's first ionization coefficients	2.5M
	Townsend's second ionization coefficients	2.5M
	b) Problem Solution procedure	4M
	Answer	1M

OR

3.	a) Collision process in gaseous dielectrics	5M
	b) Breakdown mechanism in vacuum dielectric	5M

UNIT – II

4.	a) Commercial liquid dielectrics	2.5M
	Pure liquid dielectrics	2.5M
	b) Theory of breakdown in commercial liquids (One Theory)	5M

OR

5.	a) Breakdown due to internal charges in solid dielectrics	5M
6.	b) Thermal breakdown in solid dielectrics	5M

UNIT – III

6.	Two methods for producing high DC voltages.	5M+5M

OR

7.	Principle and operation of resonant transformers	5M
	Diagram of resonant transformers	5M

UNIT – IV

8.	a) Construction of a Marx impulse generator	2.5M
	Operation of a Marx impulse generator	2.5M
	b) Problem Solution procedure	4M
	Answer	1M

OR

9.	Explain in detail about generation of high impulse currents	5M
	Circuit diagram of generation of high impulse currents	5M

UNIT – V

10.	Capacitance voltage transformer operation	5M
	Circuit and phasor diagram of capacitance voltage transformer	5M

OR

11.	Discussion of oscilloscope for impulse voltage and current measurement	5M
	Diagram of oscilloscope	5M

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ANSWERS
PART – A

1.

a) Paschen's Law states that the breakdown voltage (Vb) of a gas depends on the product of pressure (p) and gap distance (d).

$$V_b = f(pd)$$

For a given gas, breakdown voltage first decreases with pd, reaches a minimum, and then increases.

b) Differentiate dielectric material and insulator

Dielectric Material	Insulator
Stores electrical energy	Prevents current flow
Used in capacitors	Used for isolation
Characterized by permittivity	Characterized by resistivity
Polarization is important	Insulation strength is important

c) Intrinsic strength is the maximum electric field a pure dielectric material can withstand without breakdown, under ideal conditions (no impurities or defects).

d) Different insulating materials used in electrical applications: Gaseous: Air, SF_6, Transformer oil, Paper, mica, glass, rubber, PVC, porcelain.

e) A voltage doubler is a rectifier circuit that converts AC to DC and produces output approximately twice the peak input voltage. Uses: High voltage power supplies, CRT circuits, X-ray equipment

f) Standard impulse wave is expressed as: 1.2/50 μs. Front time: 1.2 μs (time to reach peak) and Tail time: 50 μs (time to decay to 50% of peak).

g) Limitations of Van de Graaff generator: Low current output, Large size required for high voltage: Sensitive to humidity and dust and Mechanical losses and belt wear.

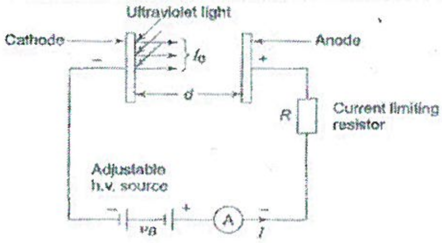
h) A Rogowski coil is a toroidal air-cored coil used to measure high-frequency or impulse currents, producing output proportional to the rate of change of current.

i) Uses of Generating Voltmeter: Measurement of high DC voltages, Calibration of high voltage instruments, Used in HV laboratories for non-contact measurement.

j) Uses of sphere gap: Measurement of peak high voltages, Calibration of voltmeters, Standard reference for high voltage testing.

2. a) Townsend's criteria of breakdown in gases

In a gaseous medium, a small number of free electrons are always present due to natural ionization caused by cosmic rays, ultraviolet radiation, or radioactive impurities. When an electric field is applied, these electrons are accelerated towards the anode. If the electric field strength is sufficiently high, the electrons acquire enough kinetic energy between collisions to ionize neutral gas molecules. This process is known as primary ionization and results in the production of additional electrons and positive ions. As the electrons move toward the anode, the number of charge carriers increases exponentially, forming what is known as an electron avalanche. The positive ions formed in this process drift slowly toward the cathode.



When a high electric field is applied across a gas, free electrons present in the gas are accelerated and produce primary ionization by collision with gas molecules. This results in an electron avalanche. The number of ionizing collisions per unit length is represented by the first Townsend ionization coefficient (α). The positive ions produced in the avalanche move towards the cathode and cause secondary ionization, releasing additional electrons from the cathode surface. This process is characterized by the second Townsend ionization coefficient (γ).

The current in the gas gap of distance d is given by:

$$I = \frac{I_0 e^{\alpha d}}{1 - \gamma\left(e^{\alpha d} - 1\right)}$$

For breakdown to occur, the discharge must be self-sustaining. This happens when:

$$\boxed{\gamma\left(e^{\alpha d} - 1\right) = 1}$$

Townsend's second ionization coefficient (γ) represents the secondary electron emission from the cathode, which is essential for sustaining a discharge in a gas. It is defined as the number of secondary electrons emitted from the cathode per incident positive ion (or photon/metastable particle) striking it. Physically, when the primary electrons (generated due to the first ionization coefficient, α) move toward the anode, they create positive ions. These positive ions drift back toward the cathode under the applied electric field and, upon impact, release additional electrons from the cathode surface. This process is quantified by γ. Mathematically, γ is expressed as:

$$\gamma = \frac{\text{number of secondary electrons emitted}}{\text{number of incident positive ions}}$$

$$I = \frac{I_0 e^{\alpha d}}{1-\gamma\left(e^{\alpha d}-1\right)}$$

$$\gamma\left(e^{\alpha d}-1\right)=1$$

Thus, γ plays a crucial role in maintaining continuous ionization by compensating for electron losses, making it fundamental to the initiation and sustenance of electrical breakdown in gaseous dielectrics.

2. b) Numerical Solution

Initial current I_1=600 μA

New current I_2=60 μA

Initial gap d_1=0.5 cm

New gap d_2=0.1 cm

Electric field is constant

For primary ionization (neglecting γ for this case): $I = I_0 e^{\alpha d}$

So for two cases: $I_1 = I_0 e^{\alpha d_1}, \quad I_2 = I_0 e^{\alpha d_2}$

$$\frac{I_1}{I_2} = \frac{e^{\alpha d_1}}{e^{\alpha d_2}} = e^{\alpha(d_1-d_2)} = \frac{600}{60} = e^{\alpha(0.5-0.1)}$$

$$10 = e^{0.4\alpha}$$

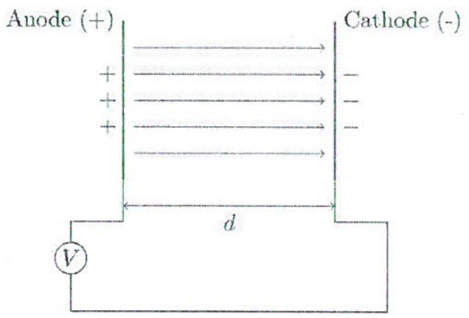
$$\ln 10 = 0.4\alpha$$

$$\alpha = 5.7565 cm^{-1}$$

$$\alpha \approx 5.76 cm^{-1}$$

3. a) Collision Process in Gaseous Dielectrics

In gaseous dielectrics, the collision process is fundamental to electrical conduction and breakdown. When an electric field is applied across two electrodes, free electrons present in the gas accelerate toward the anode and gain kinetic energy. As they travel, they collide with neutral gas molecules, leading to different types of interactions. At low energies, elastic collisions occur in which only the direction of the electron changes without loss of energy. At higher energies, inelastic collisions take place, where part of the electron's energy is transferred to the gas molecule, resulting in excitation or ionization. During ionizing collisions, if the electron energy exceeds the ionization potential, additional charge carriers are produced according to



$$e^- + A \rightarrow 2e^- + A^+$$

$$e^- + A \rightarrow e^- + A^*$$

$$n = n_0 e^{\alpha x}$$

where α is Townsend's first ionization coefficient. The cumulative effect of these collisions determines whether the gas remains insulating or undergoes electrical breakdown. Thus, the collision process—governed by ionization, excitation, and attachment mechanisms—plays a crucial role in the behavior of gaseous dielectrics under high electric fields.

3 b) Breakdown Mechanism in Vacuum

Breakdown in vacuum differs significantly from gaseous breakdown because of the absence of gas molecules, meaning ionization by collision does not occur. Instead, the mechanism is primarily governed by electron emission from electrode surfaces, especially from the cathode. When a very high electric field is applied across a vacuum gap, electrons are emitted due to field emission (cold emission) from microscopic irregularities (micro-protrusions) on the cathode surface. This process is described by the Fowler–Nordheim equation:

$$J = AE^2 \exp\left(-\frac{B}{E}\right)$$

Thus, vacuum breakdown is essentially a surface phenomenon, initiated by field emission, followed by thermal effects and plasma formation, rather than bulk ionization as in gases.

4. a) Difference in Commercial Liquids and Pure Dielectrics

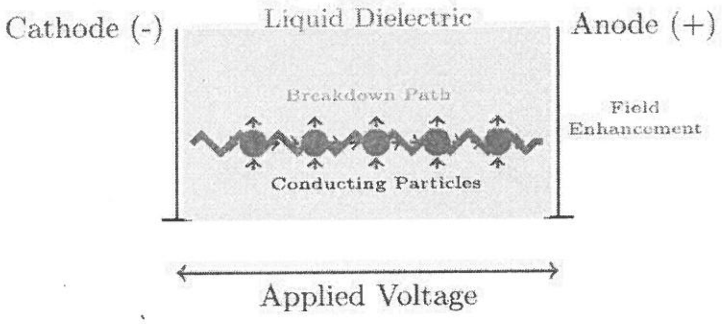
Commercial liquid dielectrics are insulating liquids used in practical electrical equipment, but unlike pure liquids, they contain impurities such as moisture, dissolved gases, and suspended particles, which significantly influence their electrical behavior. According to the textbook, liquids in their pure state have very high dielectric strength, but in practice, commercial liquids behave differently due to contamination effects.

Aspect	Pure Dielectrics	Commercial Dielectrics
Purity	Completely pure	Contains impurities
Breakdown	Intrinsic (molecular)	Due to impurities
Dielectric strength	Very high	Lower
Mechanism	Electron ionization	Particle/moisture effects
Practical use	Laboratory only	Industrial applications

4. b) Breakdown in Commercial Liquid Dielectrics

Breakdown in commercial liquid dielectrics is mainly governed by impurities rather than intrinsic properties. According to standard theory, several mechanisms have been proposed to explain breakdown in such liquids, including (i) Suspended Particle Theory, (ii) Cavitation or Bubble Theory, (iii) Stressed Oil Volume Theory, and (iv) Thermal Breakdown Theory. In practical insulating liquids like transformer oil, impurities such as moisture, solid particles, and dissolved gases play a dominant role in initiating breakdown.

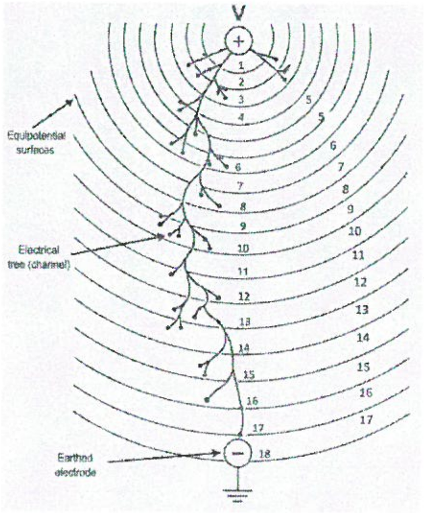
Suspended Particle Theory: It states that when an electric field is applied, suspended particles become polarized and experience a force proportional to the field intensity, given by $F \propto r^3 E^2$



where r is the particle radius and E is the electric field. Due to this force, particles move and align themselves along the field direction, forming chain-like structures between the electrodes. These chains gradually develop into a conducting bridge, which reduces the insulation strength and finally results in breakdown. The process is progressive: polarization → movement → alignment → bridge formation → breakdown. This theory explains why the dielectric strength of commercial liquids is highly sensitive to contamination and why purification (filtration and dehydration) significantly improves performance.

5. a) Breakdown due to internal charges in solid dielectrics.

Breakdown in solid dielectrics due to internal charges is mainly attributed to the accumulation of space charges within the dielectric material, which distort the applied electric field and lead to failure. In practical solid insulating materials, impurities, voids, and imperfections trap charges when an electric field is applied. These trapped charges, known as space charges, may be electrons or ions injected from electrodes or generated internally. According to the standard explanation, once charges accumulate inside the dielectric, they produce an internal electric field, which either adds to or opposes the applied field.



5. b) Thermal breakdown in solid dielectrics

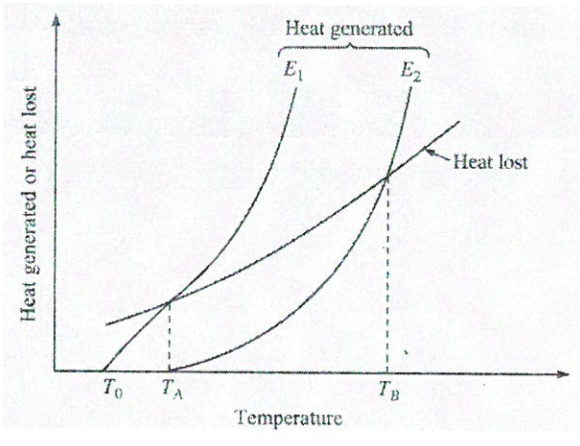
Thermal breakdown in solid dielectrics occurs due to excessive heat generation inside the material when an electric field is applied. In general, the breakdown voltage of a solid dielectric increases with thickness only up to a limit. Beyond this, the heat generated due to current flow dominates and determines conduction. When an electric field is applied, a small conduction current flows, causing heating and rise in temperature. The heat generated is transferred to the surroundings by conduction and radiation, and equilibrium is reached when heat generated equals heat dissipated.

Under DC stress, the heat generated is given by:

$$W_{dc} = E^2 \sigma \ \text{W/cm}^3$$

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

$$W_T = C_v \frac{dT}{dt} + \text{div}(K \,\text{grad}\, T)$$

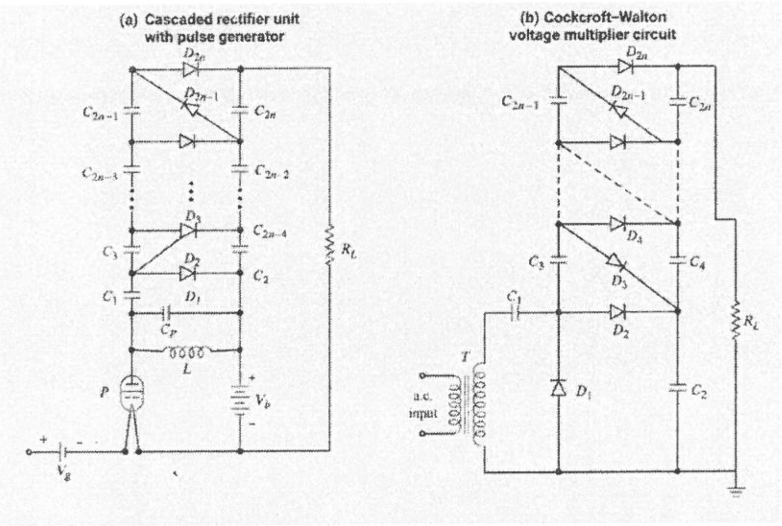


Thermal breakdown is more important practically because it occurs under normal operating conditions over time and depends on heat dissipation capability, unlike intrinsic breakdown which requires very high fields. It is the most common failure mechanism in thick insulation, cables, and transformers.

6. Two methods for producing high DC voltages.

a) Cockcroft–Walton - voltage multiplier circuits

The Cockcroft–Walton voltage multiplier circuit is a widely used method for generating high DC voltages from a low AC supply using a cascade arrangement of diodes and capacitors. It operates on the principle of charging capacitors during alternate half cycles of the input AC voltage and then stacking these voltages in series to obtain a multiplied output. During the positive half cycle, certain capacitors are charged to the peak value Vm, while in the negative half cycle, these charged capacitors act as sources and help charge other capacitors to higher voltages.


(a) Cascaded rectifier unit with pulse generator

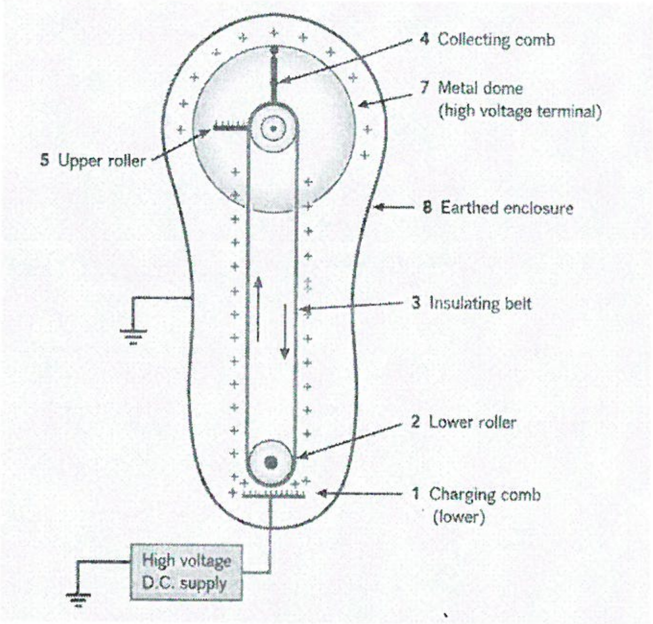
(b) Cockcroft-Walton voltage multiplier circuit

As the number of stages increases, the output voltage builds up approximately as Vout=2nVm, where n is the number of stages. In practice, the output voltage is less due to ripple and voltage drop caused by load current, frequency, and capacitance. This circuit is simple, economical, and capable of producing very high voltages, but it suffers from poor regulation and increased ripple, making it suitable mainly for low current high-voltage applications such as high-voltage testing, X-ray equipment, and electrostatic devices.

The Cockcroft–Walton circuit is a simple and effective method for generating high DC voltages using a cascade of diode-capacitor stages. However, its performance is limited by ripple and poor regulation, making it suitable mainly for low current high-voltage applications.

b) Van de Graaff Generator

The Van de Graaff generator is an electrostatic device used to produce very high DC voltages by continuous transport and accumulation of electric charge on a hollow metallic sphere. It consists of a moving insulating belt driven by a motor, two rollers, and metal combs for charge injection and collection. When the system operates, charges are sprayed onto the belt at the lower comb and carried upward to the top, where they are transferred to the metallic sphere. The charges accumulate on the outer surface of the sphere, causing the potential to rise to very high values. The output voltage is given by $V = \frac{Q}{C}$



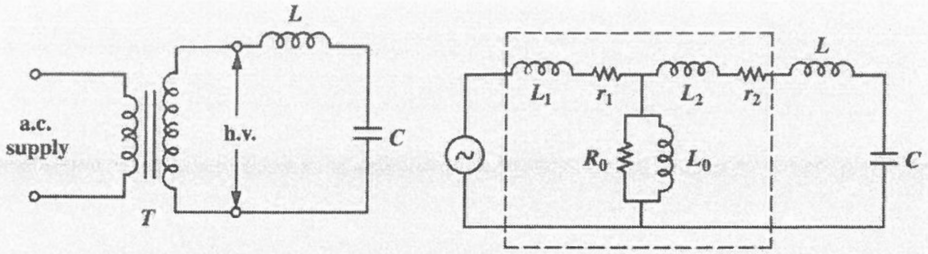
where Q is the charge stored and C is the capacitance of the sphere. Since the capacitance of an isolated sphere is small, even a small amount of charge produces a very high voltage. The generator provides a ripple-free DC output. The Van de Graaff generator is an effective method for producing very high, smooth DC voltages, but its practical use is limited by low current capacity and environmental sensitivity.

7. Principle and operation of resonant transformers

A resonant transformer is used to generate high AC voltages based on the principle of series resonance in an RLC circuit. In this method, the inductance of the transformer (or an external reactor) and the capacitance of the test object are tuned such that the inductive reactance equals the capacitive reactance, i.e.,

$$X_L = X_C \text{ or } \omega L = \frac{1}{\omega C}, \quad \omega = \frac{1}{\sqrt{LC}}$$

$$V_C = QV$$



(a)

Transformer

T — Testing transformer
L — Choke
C — Capacitance of h.v. terminal and test object
L_0 — Magnetizing inductance

(b)

Equivalent circuit

L_1, L_2 — Leakage inductances of the transformer
r_1, r_2 — Resistances of the windings
R_0 — Resistance due to core loss

where Q is the quality factor of the circuit and V is the supply voltage. Thus, even with a low input voltage, very high voltages can be obtained due to voltage magnification. The inductance is adjusted to achieve resonance, and once the condition is satisfied, the circuit produces a high, nearly sinusoidal voltage suitable for insulation testing. This method is efficient, requires low input power, and is widely used in high-voltage laboratories for testing cables and capacitive equipment.

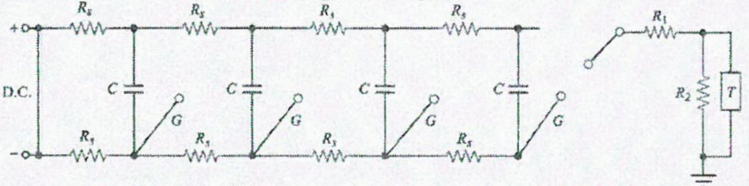
8. a) Construction and operation of a Marx impulse generator

A Marx impulse generator is used for producing high-voltage impulse waves by the principle of charging a number of capacitors in parallel and discharging them in series. The circuit consists of several stages, each having a capacitor, charging resistor, and spark gap. During the charging period, all capacitors are charged to a voltage V from a DC source through high-value resistors, while the spark gaps remain non-conducting. When the first spark gap is triggered, it causes a cascade breakdown of the remaining gaps, and all the capacitors are suddenly connected in series, producing a high output voltage given by

$$V_{out} = nV$$

where n is the number of stages. The generated impulse voltage is applied to the test object through wave-shaping resistors. The front resistor R_f controls the rise time, while the tail resistor R_t controls the fall time of the impulse wave. The impulse waveform is generally expressed as 1.2/50μs, where 1.2μs is the front time and 50μs is the tail time. Thus, the Marx generator converts low DC voltage into a very high impulse voltage suitable for testing insulation strength of high-voltage equipment.

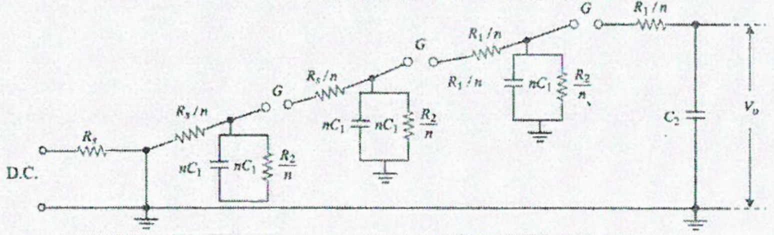
(a) Schematic diagram of Marx circuit arrangement for multistage impulse generator



C — Capacitance of the generator R_s — Charging resistors G — Spark gap

R_1, R_2 — Wave shaping resistors T — Test object

(b) Multistage impulse generator incorporating the series and wave tail resistances within the generator



R_s — Charging resistor per stage

C_1 — Capacitance of each stage capacitor

G — Spark gap

R_1 — Series (front) wave shaping resistor

R_2 — Wave tail resistor

C_2 — Load (test object) capacitance

V_o — Output impulse voltage

8. b) Numerical Solution

Given:

Number of stages n=12

Stage capacitance C=0.126μF

Front resistance R_1=800Ω

Tail resistance R_2=800Ω

Load capacitance C_L=100pF

Capacitors are connected in series during discharge

$$C_{eq} = \frac{C}{n} = \frac{0.126}{12} = 0.0105\mu F = 10.5nF$$

Effective Capacitance $C_L = 100pF \ll C_{eq}$

$$C_{eff} \approx C_L = 100pF$$

Front time is given by: $T_f \approx 3R_1C_{eff}$

$$T_f = 3\times 800\times 100\times 10^{-12}$$

$$T_f = 2.4\times 10^{-5}s = 24\mu s$$

Tail time is: $T_t \approx 0.7R_2(C_{eq}+C_L)$

$$T_t = 0.7\times 800\times (10.5\times 10^{-9} + 0.1\times 10^{-9})$$

$$T_t = 0.7\times 800\times 10.6\times 10^{-9}$$

$$T_t \approx 5.94\times 10^{-6}s = 5.94\mu s$$

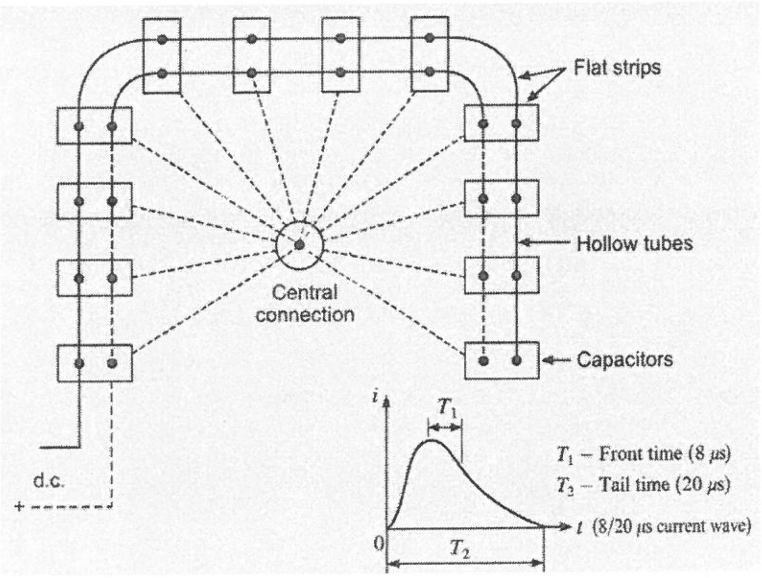
$T_f \approx 24\mu s$ and $T_t \approx 5.94\mu s$

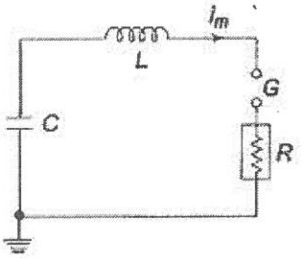
9. Generation of high impulse currents

High impulse currents are generated using low-voltage, high-capacitance capacitor banks discharged through a low-impedance circuit consisting of resistors and inductors. Unlike impulse voltage generators, impulse current generators are designed to produce very high currents (kA to MA range) at relatively low voltages. In this method, a number of capacitors are charged in parallel to a low DC voltage and then discharged through a test object via a suitable wave-shaping network. When the discharge switch (spark gap) is closed, a large current flows due to the low circuit impedance. The peak current is approximately given by

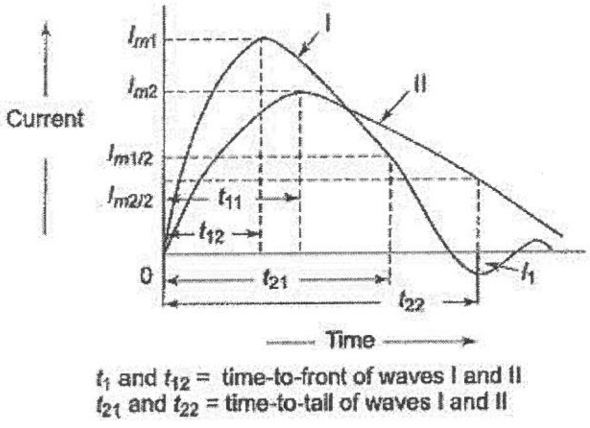
$$I_{max} = \frac{V}{Z}$$

where V is the charging voltage and Z is the circuit impedance.





(a) Basic circuit of an impulse current generator



t_1 and t_{12} = time-to-front of waves I and II
t_{21} and t_{22} = time-to-tail of waves I and II

I — damped oscillatory wave
II — overdamped wave
i_1 — overshoot

(b) Types of impulse current waveforms

The waveform of the impulse current is controlled by the resistance and inductance of the circuit, and is typically represented as 8/20 μs, where 8 μs is the front time and 20 μs is the tail time. The governing equation of the circuit is

$$L\frac{di}{dt}+Ri+\frac{1}{C}\int i\,dt=V$$

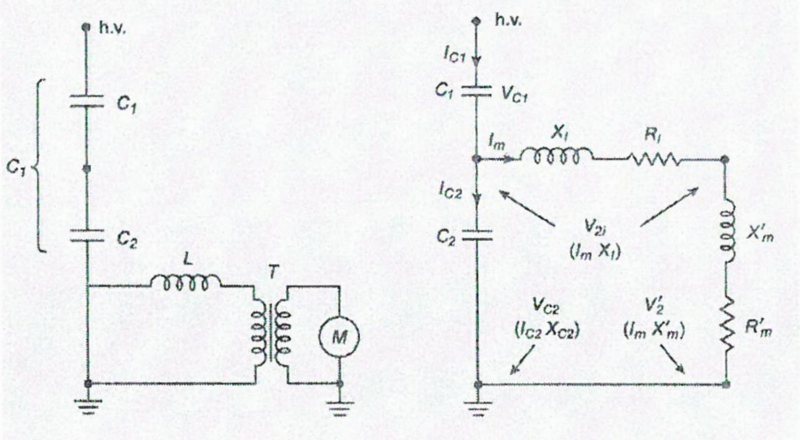
which represents an RLC discharge circuit. By properly selecting R, L, and C, the required impulse current waveform can be obtained. This method is widely used for testing lightning arresters, grounding systems, and protective devices, where high current capability is essential.

10. Capacitance Voltage Transformer (CVT)

A Capacitance Voltage Transformer (CVT) is a device used to measure high AC voltages in power systems by using a capacitive voltage divider in combination with an electromagnetic transformer. It consists of two capacitors C_1 and C_2 connected in series across the high-voltage line, forming a voltage divider, and a tuning reactor (inductor L) connected with an intermediate transformer. The output is taken from the lower capacitor and fed to the transformer for measurement. The voltage division is given by:

$$V_2=V\cdot\frac{C_1}{C_1+C_2}.$$

To improve accuracy, the CVT is tuned to resonance by connecting an inductor such that: $X_L = X_C$ or $\omega L=\frac{1}{\omega C}$.



(a) Schematic representation

(b) Equivalent circuit

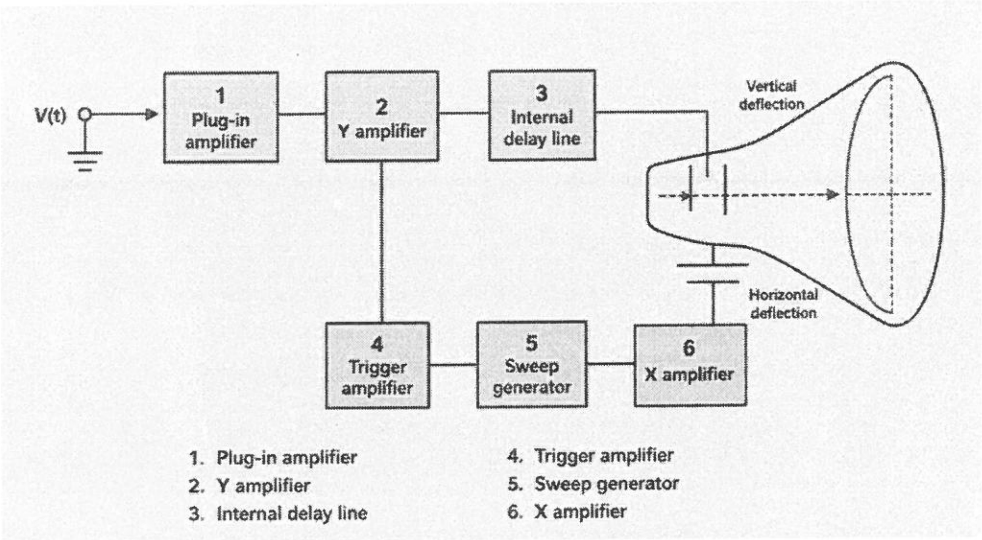
At this condition, the reactive components cancel, and the circuit behaves nearly resistive, minimizing phase error. In the phasor diagram, the capacitive currents lead the voltage by 90°, while the inductive current lags by 90°. When properly tuned, these effects cancel, resulting in the output voltage being in phase with the input voltage, ensuring accurate measurement.

Thus, a tuned CVT provides: Accurate voltage measurement, Reduced phase error, Improved regulation.

It is widely used in high-voltage transmission systems due to its economical design compared to electromagnetic transformers.

11. Oscilloscope for Impulse Voltage and Current Measurement

An oscilloscope, particularly a Cathode Ray Oscilloscope (CRO) or Digital Storage Oscilloscope (DSO), is widely used for measuring impulse voltages and currents in high-voltage laboratories. Since impulse voltages are of very short duration, they cannot be measured directly and are first reduced using a voltage divider (resistive or capacitive type). The reduced voltage is then applied to the vertical input of the oscilloscope, while the time base circuit provides horizontal deflection, enabling the waveform to be displayed.



For current measurement, a low-resistance non-inductive shunt or a current transformer is used to convert current into a proportional voltage signal, which is then fed to the oscilloscope. The oscilloscope thus displays the impulse waveform, from which important parameters such as peak value, front time, and tail time can be measured. Modern DSOs can store and analyze these waveforms accurately. Proper shielding, grounding, and matching of impedance are essential to avoid distortion. Thus, the oscilloscope is an essential instrument for accurate recording and analysis of impulse voltage and current waveforms in high-voltage testing.