UNIT-III GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS

Generation of high DC, AC, impulse voltages and currents – Tripping and control of impulse generators.

1. **Give some uses of HVDC.**
   - Electron Microscopes
   - X-Ray units
   - Electrostatic precipitators
   - Particle Accelerators in nuclear physics

2. **What are the applications of impulse current wave forms of high magnitude?**
   - Testing of surge diverters
   - Testing of non-linear resistors
   - Electric arc studies
   - Studies of electric plasmas in high current discharges

3. **Explain the necessity for generating impulse currents and mention the features of impulse current generators**.

   Impulse current generation is required for,
   - Testing of surge diverters
   - Testing of non-linear resistors
   - Electric arc studies
   - Studies of electric plasmas in high current discharges

- For producing impulse currents of large value, a bank of capacitors connected in parallel are charged to a specified value and are discharged through a series *R-L* circuit.
- Waveshapes used in testing surge diverters are 4/10 and 8/20 μ s. The tolerances allowed on these times are ± 10% only.
- Rectangular waves of long duration are also used for testing. The rectangular waves generally have durations of the order of 0.5 to 5 ms, with rise and fall times of the waves being less than ±10% of their total duration.

4. **How are capacitances connected in an impulse current generator?**

   In high impulse current generation, a bank of capacitors connected in parallel are charged to a specified value and are discharged through a series *R-L* circuit.

5. **What are the types of wave form will be available in impulse current generator output?**
   1. Impulse current waves - 4/10 and 8/20 μ s; Tolerances are ± 10%.
   2. Rectangular waves - Durations of the order of 0.5 to 5 ms, with rise and fall times of the waves being less than ±10% of their total duration.

6. **Draw a circuit diagram of a simple voltage doubler.**

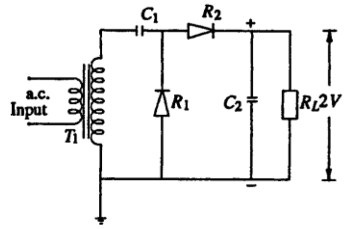


Fig.3.1. Voltage Doubler Circuit

7. **Write the expression to find the optimum number of stages and %ripple in a voltage multiplier circuit.**

$$n_{optimum} = \sqrt{\frac{V_{\max} fC}{I}}$$

8. What is tesla coil?

Tesla coil is the commonly used high frequency resonant transformer, which is a doubly tuned resonant circuit. The primary and the secondary are wound on an insulated former with no core (air-cored) and are immersed in oil.

9. Draw a simple tesla coil equivalent circuit for generation of high frequency AC high voltage.

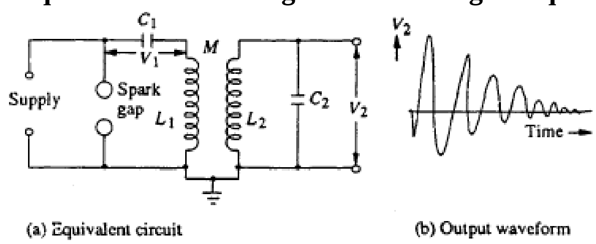


Fig.3.2. Tesla Coil & Output Waveform

10. What are the advantages of high frequency resonant transformer used in HVAC generation?

Advantages of these high frequency transformers are:

i. Absence of iron core saves in cost and size,
ii. Pure sine wave output,
iii. Slow build-up of voltage over a few cycles and hence no damage due to switching surges, and
iv. Uniform distribution of voltage across the winding coils due to subdivision of coil stack into a number of units.

11. Find the percentage ripple in the output voltage produced by an 8 stage Cockcroft-Walton multiplier circuit with a capacitance all equal to 0.05µF. The supply transformer secondary voltage is 125kV at a frequency of 150Hz and the load current is 5mA.

$$\text{Percentage Ripple} = \frac{\delta v \times 100}{2nV_{\max}}$$

$$\text{Ripple Voltage, } \delta v = \frac{I_1}{fC}\frac{n(n+1)}{2}$$

where, No.of Capacitances,n=2 X No.of Stages

$$n = 2 \times 8 = 16$$

$$Load\ Current, I_1 = 5 \times 10^{-3} A$$

$$\delta v = \frac{5 \times 10^{-3} \times 16 \times (16+1)}{150 \times 0.05 \times 10^{-6} \times 2} = 90.67kV$$

$$\%Ripple = \frac{90.67 \times 10^3 \times 100}{2 \times 16 \times 125 \times 10^3} = 2.2667\%$$

12. **A Cockcroft Walton type voltage multiplier has 8 stages with capacitances all equal to 0.05µF. The supply transformer secondary voltage is 125kv at a frequency of 150Hz and the load current is 5mA.Find the optimum number of stages for minimum voltage regulation**.

Maximum Voltage, V_{max}=125kV=125X10^3V

$$n_{optimum} = \sqrt{\frac{V_{\max} fC}{I}}$$
$$= \sqrt{\frac{125\times10^{3}\times150\times0.05\times10^{-5}}{5\times10^{-3}}}$$
$$= 13.693 \approx 14 \; Stages$$

13. **A tesla coil has a primary winding rated for 10kV with 2µF capacitance on primary side and 1nF capacitance on secondary side. If the energy efficiency is 5%. Calculate the output voltage**.

Output Voltage is given by,

$$V_2 = V_1\sqrt{\eta\frac{C_1}{C_2}}$$
$$V_2 = 10\times10^{3}\times\sqrt{\frac{5}{100}\times\frac{2\times10^{-6}}{1\times10^{-9}}} = 10\times10^{3}\times10$$
$$V_2 = 100kV$$

14. A 12 stage impulse generator has a 0.126µF capacitor. The wave front and wave tail resistances are 800ohms and 5000ohms respectively. If the load capacitor is 1000pF, find the front and tail times of the impulse wave produced.

Generator Capacitance, C_1=(0.126/12)=0.0105 µF

Load Capacitance, C_2=1000X10^{-12}F=0.001 µF

R_1=800Ω and R_2=5000Ω

Front Time, $t_1 = 3R_1C_e = 3R_1\left(\frac{C_1C_2}{C_1+C_2}\right)$

$$t_1 = 3\times800\times\left(\frac{0.0105\times10^{-6}\times0.001\times10^{-6}}{0.0105\times10^{-6}+0.001\times10^{-6}}\right) = 2.19\mu Sec$$

Tail Time, $t_2 = 0.7(R_1+R_2)(C_1+C_2)$

$$t_2 = 0.7(800+5000)(0.0105\times10^{-6}+0.001\times10^{-6})$$
$$t_2 = 46.69\mu Sec$$

15. What is voltage multiplier circuit?

- Multiplier circuit is a circuit to generate very high d.c voltages from single supply transformers by extending the simple voltage doubler circuits.
- This is simple and compact when the load current requirement is less than one milliampere, such as for cathode ray tubes, etc.

- Multiplier Circuits are designed to overcome the difficulties in higher voltage generation using cascaded voltage multiplier circuits which require too many supply and isolating transformers.

16. Distinguish between electromagnetic and electrostatic machines.

<u>Electromagnetic machines</u>: Current carrying conductors are moved in a magnetic field, so that the mechanical energy is converted into electrical energy.

<u>Electrostatic machines</u>: Charged bodies are moved in an electric field against an electrostatic field in order that mechanical energy is converted into electrical energy.

17. Name the circuits used to generate HVDC.

- High Voltage Half Wave and Full Wave rectifier

- Voltage Doubler and Cascaded Voltage Doubler
- Voltage Multiplier : Cockcroft Walton Multiplier
- Deltatron Circuit
- Electrostatic Machines: a.Van De Graff Generator, b.Electrostatic Generator

18. What are the advantages and disadvantages of Deltatron circuit?

- Can produce high voltages
- Gives high stability
- Small ripple factor
- Fast regulation

19. What are the limitations of Van de graff generator?

- Applicable only in low current applications
- Belt velocity is limited due to vibration
- Difficult to have an accurate grading of fields.
- Maintenance is required due to mechanically stressed parts.

20. What are the advantages and disadvantages of using cascaded transformer?

Advantages:

- Better cooling
- Easy to transport since the units are light and compact
- Construction is identical
- Three phase connection in delta or star is possible for three units
- Available for both indoor and outdoor applications

Disadvantage:

- Costly and requires more space for installation

21. What are impulse wave specifications?

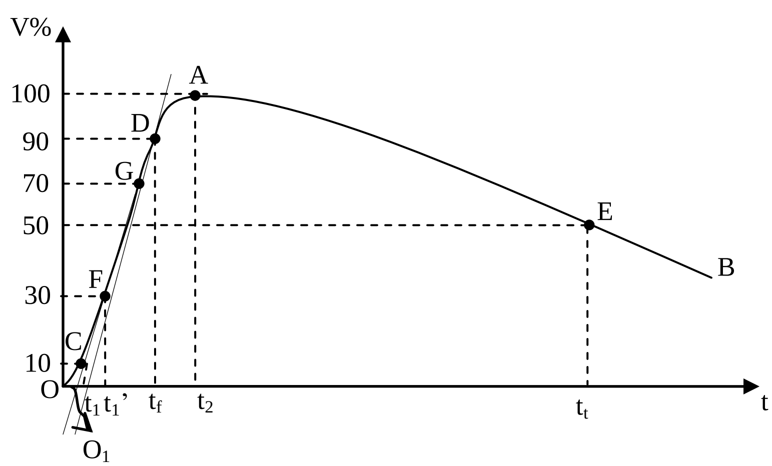


Fig.3.3. Impulse waveform and its definitions

t_f - Front Time (1.2µSec)

t_t – Tail Time (50 µSec)

22. What is the front and tail time of a standard impulse wave? What are the tolerances allowed as per the specifications?

i. **Front Time:** Time required for the wave to rise from 10% to 90% (or 0% to 100%) of the peak value at first instance.
Tolerance: ± 30%

ii. **Tail Time:** Time corresponding to 50% of the peak value during its tail.
Tolerance: ± 20%.

23. How is the wave front and wave tail times controlled in impulse generator circuits?

For a given impulse generator, the generator capacitance C_1 and load capacitance C_2 will be fixed depending on the design of the generator and the test object. Hence, the desired waveshape is obtained by controlling R_1 and R_2.

$$\text{Front Time, } t_1 = 3R_1C_e = 3R_1\left(\frac{C_1C_2}{C_1+C_2}\right)$$

$$\text{Tail Time, } t2 = 0.7(R_1+R_2)(C_1+C_2)$$

24. What is peak value?

The maximum positive deviation of the output with respect to its desired value is known as peak value.

25. Give four components of a multistage impulse generator.

1. D.C. Charging Set
2. Charging Resistors
3. Generator Capacitors and Spark Gaps
4. Wave-shaping Resistors and Capacitors

PART-B

1. Describe the cascaded transformer connection to generate high alternating voltages.

- For voltages higher than 400 KV, it is desired to cascade two or more transformers depending upon the voltage requirements.
- The transformers are usually identical, but transformers of different designs can also be used.
- With this, the weight of the whole unit is subdivided into single units and, therefore, transport and erection becomes easier.

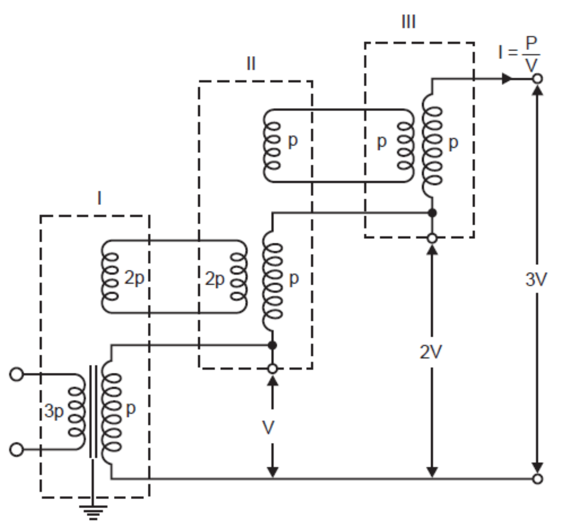
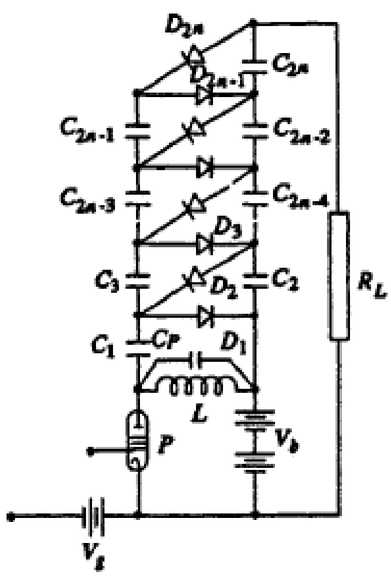


Figure 3.4. Basic 3 stage cascaded transformer

- Fig.1 shows a basic scheme for cascading three transformers. The primary of the first stage transformer is connected to a low voltage supply.A voltage is available across the secondary of this transformer.
- The tertiary winding (excitation winding) of first stage has the same number of turns as the primary winding, and feeds the primary of the second stage transformer.
- The potential of the tertiary is fixed to the potential V of the secondary winding as shown in Fig. 1.
- The secondary winding of the second stage transformer is connected in series with the secondary winding of the first stage transformer,so that a voltage of $2V$ is available between the ground and the terminal of secondary of the second stage transformer. Similarly, the stage-III transformer is connected in series with the second stage transformer. With this the output voltage between ground and the third stage transformer, secondary is $3V$.
- It is to be noted that the individual stages except the upper most must have three-winding transformers. The upper most, however, will be a two winding transformer.
- Fig. 1 shows metal tank construction of transformers and the secondary winding is not divided. Here the low voltage terminal of the secondary winding is connected to the tank.
- The tank of stage-I transformer is earthed. The tanks of stage-II and stage-III transformers have potentials of V and $2V$, respectively above earth and, therefore, these must be insulated from the earth with suitable solid insulation. Through H.T. bushings, the leads from the tertiary winding and the h.v. winding are brought out to be connected to the next stage transformer.

2. ***With neat sketch explain the working principle of a cockroft-Walton voltage multiplier circuits***



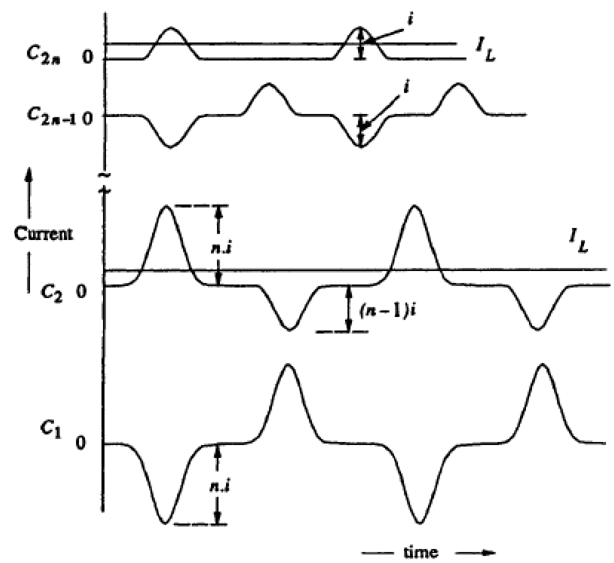


Fig.3.6. Output of Cockroft-Walton Circuit

Fig.3.5. Cockroft-Walton Circuit

The first stage, i.e. D1, D2, C1, C2, and the transformer T are identical as in the voltage doublet shown in Fig.a. For higher output voltage of 4.6,... 2n of the input voltage V9 the circuit is repeated with cascade or series connection. Thus, the condenser C4 is charged to 4Vmax and C2n to 2nVmax above the earth potential. But the volt across any individual condenser or rectifier is only 2Vmax.

3. ***Describe with neat diagram the principle of operation, advantages, limitations and applications of vande-graff generator.***

Charge is sprayed on to an insulating moving belt from corona points at a potential of 10 to 100 kV above earth and is removed and collected from the belt connected to the inside of an insulated metal electrode through which the belt moves.

The belt is driven by an electric motor at a speed of 1000 to 2000 metres per minute. The potential of the high voltage electrode above the earth at any instant is $V = Q/C$ where Q *is* the charge stored and C is the capacitance of the high voltage electrode to earth. The potential of the high voltage electrode rises at a rate.

The charging of the belt is done by the lower spray points which are sharp needles and connected to a d.c. source of about 10 to 100 kV, so that the corona is maintained between the moving belt and the needles.

The charging of the belt is done by the lower spray points which are sharp needles and connected to a d.c. source of about 10 to 100 kV, so that the corona is maintained between the moving belt and the needles. The charge from the corona points is collected by the collecting needles from the belt and is transferred on to the high voltage electrode as the belt enters into the high voltage electrode. The belt returns with the charge dropped, and fresh charge is sprayed on to it as it passes through the lower corona point.

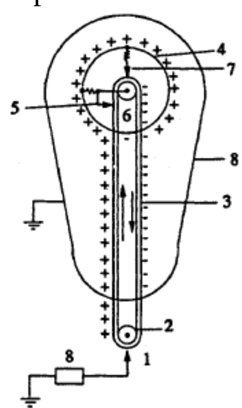


Fig.3.7. Van De Graff Generator

Limitations:

- Low current output
- Limitations on belt velocity due to vibration
- It is difficult to have an accurate grading of electric fields
- Maintenance necessary due to mechanically stressed parts.

Advantages:

- Very high DC voltages can be generated
- Ripple free output
- Precision and flexibility of control
- Stability of voltage can be acheived with suitable stabilizing devices

4. ***Give the Marx circuit arrangement for multistage impulse generator. How is the basic arrangement modified to accommodate the wave time control resistances?***

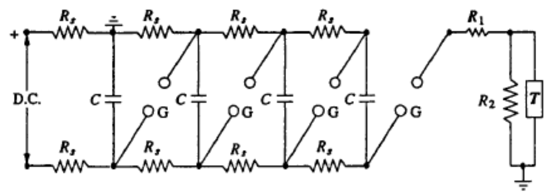


Fig.3.7.a. Marx Circuit

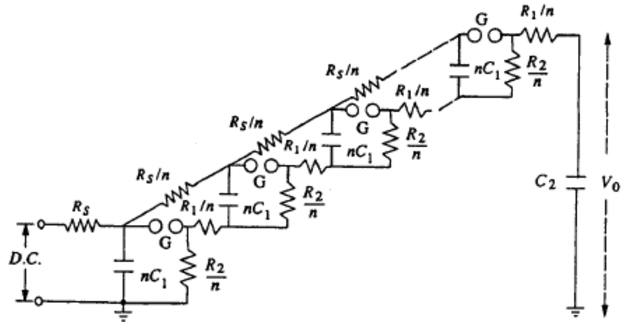


Fig.3.7.b. Modified Marx Circuit

- Beyond 200kV voltage, a single capacitor and its charging unit may be too costly, and the size becomes very large. The cost and size of the impulse generator increases at a rate of the square or cube of the voltage rating.
- Hence, for producing very high voltages, a bank of capacitors are charged in parallel and then discharged in series.
- The arrangement for charging the capacitors in parallel and then connecting them in series for discharging was originally proposed by Marx. Now-a-days modified Marx circuits are used for the multistage impulse generators.
- Usually the charging resistance R_S is chosen to limit the charging current to about 50 to 100 mA, and the generator capacitance *C* is chosen such that the product CR_S is about 10 s to 1 min.
- The gap spacing is chosen such that the breakdown voltage of the gap G is greater than the charging voltage *V*.
- Thus, all the capacitances are charged to the voltage *V* in about 1 minute. When the impulse generator is to be discharged, the gaps G are made to spark over simultaneously by some external means.
- Thus, all the capacitors *C* get connected in series and discharge into the load capacitance or the test object.
- The discharge time constant CR_1/n (for *n* stages) will be very very small (microseconds), compared to the charging time constant CR_5 which will be few seconds. Hence, no discharge takes place through the charging resistors R_S.
- In the Marx circuit is of Fig. a the impulse wave shaping circuit is connected externally to the capacitor unit In Fig.b, the modified Marx circuit is shown, wherein the resistances R_1 and R_2 are incorporated inside the unit.
- R_1 is divided into n parts equal toR_1/n and put in series with the gap G. R_2 is also divided into n parts and arranged across each capacitor unit after the gap G.
- This arrangement saves space, and also the cost is reduced. But, in case the waveshape is to be varied widely, the variation becomes difficult. The additional advantages gained by distributing R_1 and R_2 inside the unit are that the control resistors are smaller in size and the efficiency *(Vo/nV)* is high.
- Impulse generators are nominally rated by the total voltage (nominal), the number of stages, and the gross energy stored.

5. *What is tesla coil? How is damped high frequency oscillations obtained from a tesla coil*

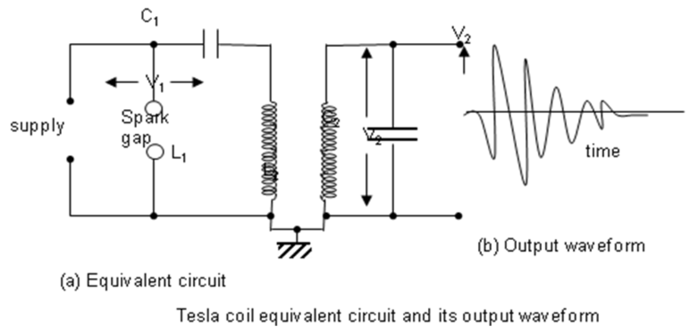


Fig.3.8. Tesla Coil

- Commonly used high frequency resonant transformer is the Tesla coil, which is a doubly tuned resonant circuit shown schematically in Fig. a.
- Primary voltage rating: 10 kV
- Secondary voltage rating: 500 to 1000 kV.
- Primary is fed form a.D.C. Or a.C. Supply through the condenser, C_1.
- Spark gap G connected across the primary is triggered at the desired voltage which induces a high self excitation in the secondary.
- Primary and Secondary windings are wound in air-cored former
- Windings are tuned to a frequency of 10 to 100kHz by means of the condensers C_1 and C_2.
- Output voltage, V_2 is a function of the parameters L_1, L_2, C_1, C_2, and the mutual inductances M.
- Resistance will be small and contribute only for damping of the oscillations
- Analysis of the output waveform can be done in a simple manner neglecting the winding resistance.
- Condenser C_1 be charged to a voltage V_1 when the spark gap is triggered
- Current i_1 flow through the primary windings L_1 and produce a current i_2 through L_2 and C_2 .
- The energy stored in the primary circuit in the capacitance C_1 is transferred to C_2 via the magnetic coupling.
- If W_1 is the energy stored in C_1 and W_2 is the energy transferred to C_2 and if efficiency of the transformer is , then

  $$W_1 = \frac{1}{2}\eta C_1 V_1^2 = \frac{1}{2} C_2 V_2^2$$

  $$i.e., V_2 = V_1 \sqrt{\eta \frac{C_1}{C_2}}$$

- Coefficient of Coupling, $K = \dfrac{M^2}{L_1 L_2}$
- If K is large, oscillation frequency is less

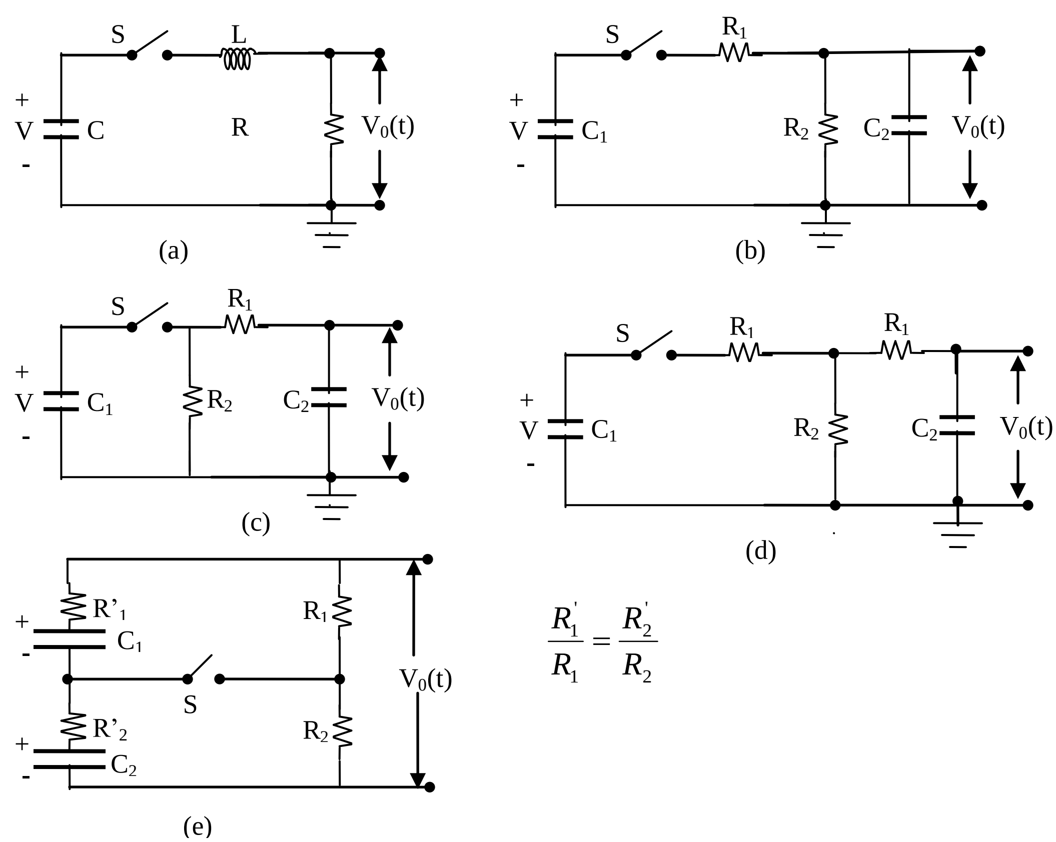
- For Large Values of the winding resistance and K, the waveform may become a unidirectional impulse.

6. ***Explain any one method of generating HVAC at power frequency and discuss its limitations (or) features.***

(Refer Q&A.Part-B.1)

7. ***Draw and explain the circuits for producing impulse waves.***

A double exponential waveform may be produced in the laboratory with a combination of a series R-L-C circuit under overdamped condition or by the combination of two R-C circuits. Different equivalent circuits that produce impulse waves are given in Figs. 3.9 a to e. Out of these circuits, the ones shown in Figs. 3.9 a to d are commonly used. Circuit shown in Fig. 3.9a is limited to model generators only, and commercial generators employ circuits shown in Figs. 3.9b to 3.9d.



$$\frac{R_1'}{R_1} = \frac{R_2'}{R_2}$$

Fig.3.9 Circuits for producing impulse waves

A capacitor C_1 or C previously charged to a particular d.c. voltage is suddenly discharged into the wave-shaping network $(LR, R_1, R_2 C_2 \text{or other combination})$ by closing the switch S. The discharge voltage $V_0(t)$ shown in Fig. 3.9 gives rise to the desired double exponential wave-shape.

Analysis of Impulse Generator Circuit Series R-L-C Type

Referring to Fig. 3.9 the current through the load resistance R is given by

$$V=\frac{1}{C}\int_0^t idt+Ri+L\frac{di}{dt} \qquad (6.16)$$

with initial condition at t=0 being i(0)=0 and the net charge in the circuit i=dq/dt=0. Writing the above equation as a Laplace transformer equation,

$$V/s=\left(\frac{1}{C_s}+R+L_s\right)I(s)$$

or,
$$I(s)=\frac{V}{L}\left[\frac{1}{s^2+\frac{R_s}{L}+\frac{1}{LC}}\right]$$

The voltage across the resistor R (Which is the output) is, $v_0(s)=I(s)R$, hence,

$$v_0(s)=V\frac{R}{L}\frac{1}{s^2+\frac{R_s}{L}+\frac{1}{LC}}$$

For an overdamkped condition, $R/2L \geq 1/\sqrt{LC}$

Hence, the roots of the equation $s^2+\frac{R_s}{L}+\frac{1}{LC}$ are $\alpha=s_1=-\frac{R}{2L}+\sqrt{\left(\frac{R}{2L}\right)^2-\frac{1}{LC}}$,

$$\beta=s_2=-\frac{R}{2L}-\sqrt{\left(\frac{R}{2L}\right)^2-\frac{1}{LC}}$$

The solution of the equation for $v_0(t)$ is, $v_0(t)=\frac{V\left(\frac{R}{2L}\right)}{\left[\frac{R^2}{4L^2}-\frac{1}{LC}\right]^{\frac{1}{2}}}\left[e^{-\alpha t}-e^{-\beta t}\right]=V_0\left[e^{-\alpha t}-e^{\beta t}\right]$

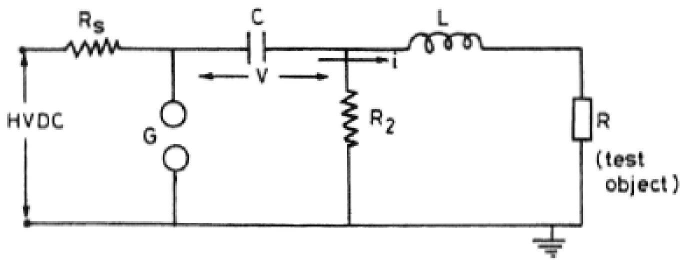
The sum of the roots $\left(\alpha+\beta=-\frac{R}{2L}\right)$ and the product of the roots are $\alpha\beta=-\frac{1}{LC}$

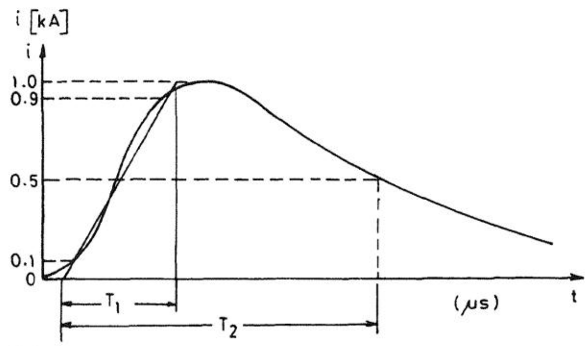
The wave front and the wave tail times are controlled by changing the values of R and L simultaneously with a given generator capacitance C; choosing a suitable value for L. β or the wave front time is determined and α or the wave tail time is controlled by the value of R in the circuit. The advantage of this circuit is its simplicity. But the waveshape control is not flexible and independent. Another disadvantage is that the basic circuit is altered when a test object which will be mainly capacitive in nature, is connected across the output. Hence, the waveshape gets changed with the change of test object.

8. How impulse currents are generated? Explain with the neat diagram.

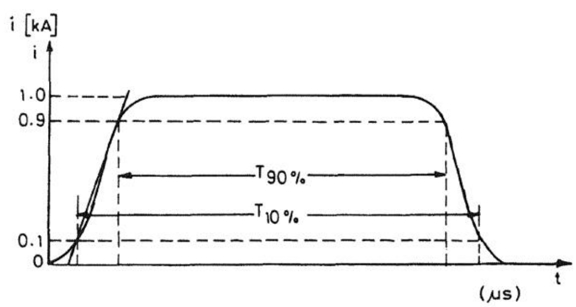
- Lightening discharges involve both high voltage impulses and high current impulses (≅100 kA peak) on transmission lines.

- Protective gear like surge diverters have to discharge the lightning currents without damage.
- Wave shapes used:
  - Double exponential and rectangular waves
- Applications:
  - Basic research on non-linear resistors
  - Electric arc studies
  - Studies relating to electric plasmas in high current discharges
- According to the IEC (1973), standard waves are T_1 =4/10 and T_2=8/20μS.





(a)



(b)

- Basic difference between this circuit and impulse voltage generators is that here the capacitances are much larger and the resistors are much smaller in magnitude.
- If the capacitor C is charged to a voltage V and discharged when the gap G is triggered, the current ‘i' can be shown to vary with time according to the relation,

$$i(t) = \frac{V}{\omega L} e^{-\alpha t} sin\omega i$$

Rectangular Current Pulses:

- The duration $T_{10\%} < 1.5T_{90\%}$*(as per IEC, 1970).*

- *The* rectangular current impulses are generated by discharging an artificial transmission line with lumped L, and C elements into the test object through a sphere gap.
- If the line is charged to a DC voltage *V and discharged through* the test object of resistance *R, the current pulse is given by* $I = V/(R + Z_0)$, where Z_o *is the surge impedance of the line.*
- *A pulse voltage of* $RV/(R + Z_o)$ is developed across the test object.
- The duration $T_{90\%}$ of the current wave is estimated as

$$T90\% \approx 2\frac{n-1}{n}\sqrt{\frac{L}{C}}$$ where *n is the number of L-C stages*

9. What are the components of multistage impulse generator? Explain.

DC Charging set:

- It should be capable of giving a variable d.C. voltage of either polarity to charge the generator capacitors to the required value.

Charging resistors:

- Non-inductive high value resistors of about 10 to 100 kΩ.
- Voltage Ratings: 50 and 100 kV.

Generator Capacitors and Spark Gaps:

- Spark Gap:
    i. Arranged vertically one over the other with all the spark gaps aligned
    ii. Spheres or hemispheres of 10 to 25 cm diameter.
- Capacitors:
    i. Designed for several charging and discharging operations.
    ii. Capacitors will be capable of giving 10 kA of current on dead short circuit.

Wave shaping resistors and capacitors:

- Should be capable of discharging impulse currents of 1000 A or more
- Designed for a maximum voltage of 50 to 100 kV
- load capacitor may be of compressed gas or oil filled with a capacitance of 1 to 10 μF
- In modern cases, resin cast resistors are used with voltage and energy ratings of 200 to 250 kV and 2.0 to 5.0 kWsec.
- The entire range of lightning and switching impulse voltages can be covered using these resistors either in series or in parallel combination

Triggering system:

- Consists of trigger spark gaps to cause spark breakdown of the gaps

Voltage dividers:

- Voltage dividers of either damped capacitor or resistor type and an oscilloscope with recording arrangement are provided for measurement of the voltages across the test object.

10. Explain the principle of generation of high frequency AC high voltages briefly.

(Refer Q&A.Part-B.5)

11. What is the principle of operation of resonant transformer? How it advantageous over cascaded transformers?

- In some case, the harmonics present in the test transformers are not desirable and it could not be given for the test circuits without filtering. On those case, an alternative method that is more economical and some times technically superior is offered by resonant circuits.
- The resonant transformer consists of air cored primary and secondary coils housed in a steel tank. The windings are cooled by the forced circulation of Freon gas at a pressure of 3 to 4 atmospheres. Freon(CCl_2F_2) has a very high dielectric strength which increases further at high pressures. Thus Freon acts as coolant as well as an insulating medium thus preventing corona.
- These transformer have been used for supply to X-ray machines, other radiological test apparatus and some electron accelerating devices.

Parallel resonance:

The addition of parallel reactors either in the primary low voltage circuit or the secondary high voltage circuit may or completely neutralize the capacitive load current, thus improving power factor. If motor-alternator is used as the supply source, the risk of self excitation of the alternator would thus be eliminated. Input power reductions of 10:1 are feasible, thus reducing drastically the cost of the regulator, reactors and filters.

Series Resonance:

An alternative system is series resonance circuit. By resonating the circuit through a series reactor L and a test frequency, harmonics are heavily attenuated. The shunt capacitance c usually represents the high voltage bushing and the test object. Fig 2 shows the equivalent circuit of the circuit transformer. Since $R_e >> \omega L_e$ and the voltage V_2 is almost in phase with V'_1. Thus, $V_2 = V_1' \dfrac{1}{1-\omega^2 L_e C}$.

As resonance approached, $V_2 >> V'_1$. Thus there is no fixed ratio of primary and secondary voltage. Therefor the secondary voltage itself should be measured accurately in the tests.

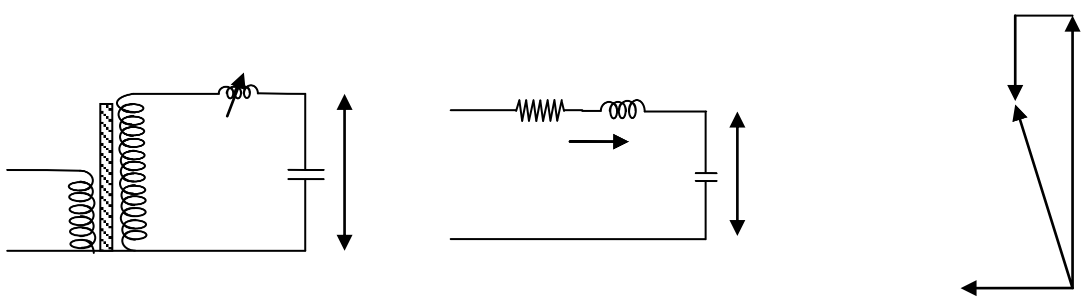


Figure 3. . (a). Simplified circuit of resonant transformer, (b). Equivalent Circuit & (c). Phasor Diagram

Advantages of Resonant Transformers:

1. Absence of iron core saves the space required for insulation from the core.
2. Due to the use of a tuned circuit, output waveform is almost sinusoidal. Also the oscillatory currents are usually very large as compared to the load currents; so the load neither distorts the waveform nor causes substantial voltage drops.
3. Voltage build up in output circuit is slow, so that surge voltages due to switching of input or load circuits will not present.
4. Careful design of coil stacks can give a fairly uniform voltage gradient.

The main disadvantage is that the additional variable reactors should withstand the full test voltage and full current rating.