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**B.E./B.TECH. DEGREE EXAMINATIONS, MARCH 2024**

**Second Semester**

**23EE281-BASIC ELECTRICAL & ELECTRONICS ENGINEERING**

**(Reg 2023)**

**(B.E-Aeronautical, Aerospace, Automobile, Computer Science, Computer Science (CS), Mechanical Engineering, B.Tech- Information Technology, Artificial Intelligence & Data Science)**

**Continuous Assessment – I**

**Time: 9.00 to 10.40 am Maximum: 50 Marks Date: 14.03.2024**

**Answer ALL Questions**

**PART – A (5 x 2 = 10 Marks)**

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| **1.** | **State Kirchhoff’s current and voltage law. (2M)**  KCL (Kirchhoff’s Current Law) states that the algebraic sum of currents entering a node (or a closed boundary) is zero. (or)The sum of the currents entering a node is equal to the sum of the currents leaving the node.  KVL (Kirchhoff’s Voltage Law) states that the algebraic sum of all voltages around a closed path (or loop) is zero. (or) Sum of voltage drop = Sum of voltage rise. |
| **2.** | **Using Kirchhoff’s voltage law, write the mesh equation for the following circuit:** |
| **3.** | **Explain why transformers are rated in KVA? (2M)**  The losses that occur in transformers are independent of power factor, which is why they are rated in kVA. The apparent power unit is kVA. Reactive and actual power are combined in it. Transformers are made without taking into account the associated load. |
| **4.** | **Define Back EMF and write the formula. (2M)**  The back EMF of a DC motor is a voltage that is generated by the motor's movement and is opposite in polarity to the applied voltage. The back EMF is directly proportional to the speed of the motor and is given by the following formula: Back EMF = K \* ω |
| **5.** | **List the applications of various types of DC motor. (2M)**  **Shunt motor:**  This motor has a constant speed and is used in applications where a constant speed is required, such as in lathes, drill machines, fans, and blowers.  **Series motor:**  This motor has a high starting torque and is used in applications where a high starting torque is required, such as in electric traction, cranes, and hoists.  **Compound motor:**  This motor is a combination of the shunt and series motors, and it has the characteristics of both motors. It is used in applications where both a high starting torque and a constant speed are required, such as in rolling mills and elevators. |

**PART – B (2 x 16 = 32 Marks) (1 x 8 = 8 Marks)**

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| **6. (a)** |  | Derive steady state analysis of RL Circuit. (16 M)  **The RL Series Circuit**    The above LR series circuit is connected across a constant voltage source, (the battery) and a switch. Assume that the switch, S is open until it is closed at a time t = 0, and then remains permanently closed producing a “step response” type voltage input. The current, i begins to flow through the circuit but does not rise rapidly to its maximum value of Imax as determined by the ratio of V / R (Ohms Law).  This limiting factor is due to the presence of the self induced emf within the inductor as a result of the growth of magnetic flux, (Lenz’s Law). After a time the voltage source neutralizes the effect of the self induced emf, the current flow becomes constant and the induced current and field are reduced to zero.  We can use Kirchhoff’s Voltage Law, (KVL) to define the individual voltage drops that exist around the circuit and then hopefully use it to give us an expression for the flow of current.  Kirchhoff’s voltage law (KVL) gives us:    The voltage drop across the resistor, R is I\*R (Ohms Law).    The voltage drop across the inductor, L is by now our familiar expression L(di/dt)    Then the final expression for the individual voltage drops around the LR series circuit can be given as:  lr series circuit voltage    We can see that the voltage drop across the resistor depends upon the current, i, while the voltage drop across the inductor depends upon the rate of change of the current, di/dt. When the current is equal to zero, ( i = 0 ) at time t = 0 the above expression, which is also a first order differential equation, can be rewritten to give the value of the current at any instant of time as: Expression for the Current in an LR Series Circuit current through lr series circuit   * Where: * V is in Volts * R is in Ohms * L is in Henries * t is in Seconds * e is the base of the Natural Logarithm = 2.71828   The **Time Constant**, ( τ ) of the LR series circuit is given as L/R and in which V/R represents the final steady state current value after five time constant values. Once the current reaches this maximum steady state value at 5τ, the inductance of the coil has reduced to zero acting more like a short circuit and effectively removing it from the circuit.  Therefore the current flowing through the coil is limited only by the resistive element in Ohms of the coils windings. A graphical representation of the current growth representing the voltage/time characteristics of the circuit can be presented as. Transient Characteristics Curves lr transient curves    Since the voltage drop across the resistor, VR is equal to I\*R (Ohms Law), it will have the same exponential growth and shape as the current. However, the voltage drop across the inductor, VL will have a value equal to:  Ve(-Rt/L). Then the voltage across the inductor, VL will have an initial value equal to the battery voltage at time t = 0 or when the switch is first closed and then decays exponentially to zero as represented in the above curves. |
| **(b)** |  | A 230V. 50Hz ac supply is applied to a coil of 0.06 H inductance and 2.5Ω resistance connected in series with a 6.8µF capacitor Estimate (i). Impedance (ii). Current (iii) phase angle (iv) power factor (v) power consumed. (16 M) |
| **7. (a)** | **(i)** | **Briefly explain the constructional parts of a DC generator. (8 M)**  A DC generator is an electrical machine whose main function is to convert mechanical energy into electricity. When the conductor slashes magnetic flux, an emf will be generated based on the electromagnetic induction principle of Faraday’s Laws. This electromotive force can cause a flow of current when the conductor circuit is closed.  **Parts of a DC Generator**  A DC generator can also be used as a DC motor without changing its construction. Therefore, a DC motor, otherwise a DC generator, can be generally called a DC machine. Below we have mentioned the essential parts of a DC Generator.    **Parts of a DC Generator**  Stator  The main function of the stator is to provide magnetic fields where the coil spins. A stator includes two magnets with opposite polarities facing each other. These magnets are located to fit in the region of the rotor.  Rotor  A rotor in a DC machine includes slotted iron laminations with slots that are stacked to shape a cylindrical armature core. The function of the lamination is to decrease the loss caused due to eddy current.  Armature Windings  Armature windings are in a closed circuit form and are connected in series to parallel to enhance the produced current sum.  Yoke  The external structure of the DC generator is known as Yoke. It is made of either cast iron or steel. It provides the necessary mechanical power for carrying the magnetic flux given through the poles.  Poles  The function of a pole is to hold the field windings. These windings are wound on poles and are either connected in series or parallel by the armature windings.  Pole Shoe  Pole shoe is mainly utilized for spreading the magnetic flux to prevent the field coil from falling.  Commutator  A commutator works like a rectifier that changes AC voltage to DC voltage within the armature winding. It is designed with a copper segment, and each copper segment is protected from the other with the help of mica sheets. It is located on the shaft of the machine.  Brushes  The electrical connections can be ensured between the commutator as well as the exterior load circuit with the help of brushes. |
|  | **(ii)** | **A 4 pole lap wound dc shunt generator rotates at the speed of 1500 rpm, has a flux of 0.4 mWb and the total number of conductors are 1000. Calculate the value of EMF generated. (8 M)** |
| **(b)** | **(i)** | **Explain the construction of various types of single phase transformer and working principle. And also derive the emf equation. (16 M)**  A transformer is a device used in the power transmission of electric energy. The transmission current is AC. It is commonly used to increase or decrease the supply voltage without a change in the frequency of AC between circuits. The transformer works on the basic principles of electromagnetic induction and mutual induction.  Transformer Types  Transformers are used in various fields like power generation grid, distribution sector, transmission and electric energy consumption. There are various types of transformers which are classified based on the following factors:   * Working voltage range * The medium used in the core * Winding arrangement * Installation location   Types of Transformer - different types of transformer - Circuit Globe  Based on Voltage Levels  Commonly used transformer types, depending on the voltage, are classified as follows:   * Step-up Transformer: They are used between the power generator and the power grid. The secondary output voltage is higher than the input voltage. * Step-down Transformer: These transformers are used to convert high-voltage primary supply to low-voltage secondary output.   Based on the Medium of Core Used  In a transformer, we will find different types of cores that are used.   * Air Core Transformer: The flux linkage between primary and secondary winding is through the air. The coil or windings wound on the non-magnetic strip. * Iron Core Transformer: Windings are wound on multiple iron plates stacked together, which provides a perfect linkage path to generate flux.   Based on the Winding Arrangement   * Autotransformer: It will have only one winding wound over a laminated core. The primary and secondary share the same coil. Auto means “self” in the Greek language.   Based on Install Location   * Power Transformer: It is used at power generation stations, as they are suitable for high voltage application * Distribution Transformer: It is mostly used at distribution lanes for domestic purposes. They are designed for carrying low voltages. It is very easy to install and characterised by low magnetic losses. * Measurement Transformers: They are mainly used for measuring voltage, current and power. * Protection Transformers: They are used for component protection purposes. In circuits, some components must be protected from voltage fluctuation, etc. Protection transformers ensure component protection.   Parts of a Single-phase Transformer  The major parts of a single-phase transformer consist of  1. Core  The core acts as a support to the winding in the transformer. It also provides a low reluctance path to the flow of magnetic flux. The winding is wound on the core, as shown in the picture. It is made up of a laminated soft iron core in order to reduce the losses in a transformer. The factors, such as operating voltage, current, power, etc., decide core composition. The core diameter is directly proportional to copper losses and inversely proportional to iron losses.  2. Windings  Windings are the set of copper wires wound over the transformer core. Copper wires are used due to the following:   * The high conductivity of copper minimises the loss in a transformer because when the conductivity increases, resistance to current flow decreases. * The high ductility of copper is the property of metals that allows it to be made into very thin wires.   There are mainly two types of windings: primary windings and secondary windings.   * Primary winding: The set of turns of windings to which the supply current is fed. * Secondary winding: The set of turns of winding from which output is taken.   The primary and secondary windings are insulated from each other using insulation coating agents.  3. Insulation Agents  Insulation is necessary for transformers to separate windings from each other and to avoid short circuits. This facilitates mutual induction. Insulation agents have an influence on the durability and stability of a transformer.  The following are used as insulation mediums in a transformer:   * + - * Insulating oil       * Insulating tape       * Insulating paper       * Wood-based lamination   Working Principle of a Transformer  Transformer Basics and Transformer Principles  The transformer works on the principle of Faraday’s Law of electromagnetic induction and mutual induction.  There are usually two coils – primary coil and secondary coil – on the transformer core. The core laminations are joined in the form of strips. The two coils have high mutual inductance. When an alternating current passes through the primary coil, it creates a varying magnetic flux. As per Faraday’s law of electromagnetic induction, this change in magnetic flux induces an EMF (electromotive force) in the secondary coil, which is linked to the core having a primary coil. This is mutual induction.  Overall, a transformer carries out the following operations:   * Transfer of electrical energy from one circuit to another * Transfer of electrical power through electromagnetic induction * Electric power transfer without any change in frequency * Two circuits are linked with mutual induction   The figure shows the formation of magnetic flux lines around a current-carrying wire. The normal of the plane containing the flux lines is parallel to the normal of a cross-section of a wire.  The figure shows the formation of varying magnetic flux lines around a wire wound. The interesting part is that the reverse is also true; when a magnetic flux line fluctuates around a piece of wire, a current will be induced in it. This was what Michael Faraday found in 1831, which is the fundamental working principle of electric generators, as well as transformers. Ideal Transformer  The ideal transformer has no losses. There is no magnetic leakage flux, ohmic resistance in its windings and no iron loss in the core.  EMF equation of single phase transformer.  N1 – Number of turns in the primary  N2 – Number of turns in the secondary  Φm – Maximum flux in the weber (Wb)  T – Time period. It is the time taken for 1 cycle.  EMF Equation of the Transformer- its Derivation - Circuit Globe  The flux formed is a sinusoidal wave. It rises to a maximum value of Φm and decreases to a negative maximum of Φm. So, flux reaches a maximum in one-quarter of a cycle. The time taken is equal to T/4.  Average rate of change of flux = Φm/(T/4) = 4fΦm  Where, f = frequency  T = 1/f  Induced EMF per turn = Rate of change of flux per turn  Form factor = RMS value / average value  RMS value = 1.11  (4fΦm) = 4.44 fΦm[form factor of a sine wave is 1.11]  RMS value of EMF induced in winding = RMS value of EMF per turn x No. of turns  **Primary Winding**  RMS value of induced EMF = E1 = 4.44 fΦm \* N1  **Secondary Winding**  RMS value of induced EMF = E2 = 4.44 fΦm \* N2  Rms value of induced emf  This is the EMF equation of the transformer.  For an ideal transformer at no load condition,  E1 = Supply voltage on the primary winding  E2 = Terminal voltage (theoretical or calculated) on the secondary winding Voltage Transformation Ratio  Voltage Transformation Ratio  K is called the voltage transformation ratio, which is a constant.  Case 1:If N2 > N1, K>1, it is called a step-up transformer.  Case 2: If N2< N1, K<1, it is called a step-down transformer. |

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| **8. (a)** | **(i)** | Identify the current through the 8 ohms resistor using mesh current analysis **(8 M)** |
| **(b)** | **(i)** | Estimate the value of current through the branch AB using mesh current analysis**(8 M)** |

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