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## Electrical Engineering

### Topic: Power Electronics - Controlled Rectifiers

**Given Data:**

- Resistance, $R = 2$ ohms
- Inductance, $L = 75$ mH (0.075 H)
- DC Voltage Source, $V_{dc} = 48$ V
- Source Voltage, $V_{s} = 120$ V (RMS)
- Frequency, $f = 60$ Hz
- Delay Angle, $\alpha = 50^\circ$

#### (a) Expression for Load Current

##### Step 1: Convert RMS Voltage to Peak Voltage

$V_m = V_s \cdot \sqrt{2}$
$V_m = 120 \cdot \sqrt{2} \approx 169.71 \text{ V}$

*Explanation: The peak voltage $V_m$ is found by multiplying the RMS value by $\sqrt{2}$.*

##### Step 2: Calculate the Angular Frequency

$\omega = 2 \pi f$
$\omega = 2 \pi \cdot 60 = 120 \pi \text{ rad/s}$

*Explanation: The angular frequency is calculated by multiplying $2\pi$ by the frequency.*

##### Step 3: Derive the Differential Equation for Load Current

The controlled half-wave rectifier with a resistive (R), inductive (L), and DC voltage source (V_dc) is considered:
$V_m \sin(\omega t - \alpha) = L \frac{di(t)}{dt} + Ri(t) + V_{dc}$

*Explanation: This equation relates all voltage drops across the resistance, inductance, and DC source.*

##### Step 4: Solve the Differential Equation

Using the standard solution for first-order linear differential equations considering initial conditions and integrating factor:
$i(t) = \frac{V_m \sin(\omega t - \alpha) - V_{dc}}{R} + \left( i(0) - \frac{V_m \sin(\omega t - \alpha) - V_{dc}}{R} \right) e^{-\frac{R}{L}t}$

*Explanation: This represents the current in the RL circuit with time taking into account the voltage source drops along with resistor and inductor.*

#### (b) Power Absorbed by the DC Voltage Source

##### Step 5: Calculate Average Load Current (I_avg)

The load current over one cycle for a controlled rectifier with an inductor:
$I_{avg} = \frac{Vm \cos(\alpha) - V_{dc}}{R}$
Where,
$V_{m} \approx 169.71 \text{ V}$
$\alpha = 50^\circ$
$\cos(50^\circ) \approx 0.6428$
$I_{avg} = \frac{169.71 \cdot 0.6428 - 48}{2} \approx \frac{109.04 - 48}{2} \approx 30.52 \text{ A}$

*Explanation: This is the average current derived by considering the cosine of the delay angle and circuit parameters.*

##### Step 6: Calculate Power Absorbed by DC Voltage Source

$P_{dc} = V_{dc} \cdot I_{avg}$
$P_{dc} = 48 \cdot 30.52 \approx 1465 \text{ W}$

*Explanation: Power absorbed by the DC source is the product of its voltage and the average current.*

#### (c) Power Absorbed by Resistor

##### Step 7: Calculate the RMS Value of Load Current
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Given the half-wave rectifier:
$I_{RMS} = I_{avg} \sqrt{\frac{1}{2}}$
$I_{RMS} = 30.52 \cdot \sqrt{0.5} \approx 21.58 \text{ A}$

Explanation: The RMS value for half-wave rectified current is the factor by root half of average current.

Step 8: Calculate Power Absorbed by the Resistor

$P_{R} = I_{RMS}^2 \cdot R$
$P_{R} = (21.58)^2 \cdot 2 \approx 931 \text{ W}$

Explanation: Power absorbed by the resistor is calculated using the square of RMS current times the resistance.

Final Solution

- (a) The expression for load current:
  $i(t) = \frac{169.71 \sin(\omega t - 50^\circ) - 48}{2} + \left(i(0) - \frac{169.71 \sin(\omega t - 50^\circ) - 48}{2} \right) e^{-\frac{2}{0.075}t}$
- (b) Power absorbed by the DC voltage source:
  $P_{dc} \approx 1465 \text{ W}$
- (c) Power absorbed by the resistor:
  $P_{R} \approx 931 \text{ W}$

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