CSM—28/22

ELECTRICAL ENGINEERING

ଇଲେକ୍ଟ୍ରିକାଲ୍ ଇଞ୍ଜିନିୟରିଂ

PAPER—I

Time : 3 Hours

ସମୟ : ୩ ଘଣ୍ଟା

Full Marks : 250

ପୂର୍ଣ୍ଣ ସଂଖ୍ୟା : ୨୫୦

The figures in the right-hand margin indicate marks.

ପ୍ରଶ୍ନପତ୍ରର ଡ଼ାହାଣ ପଟେ ପ୍ରତ୍ୟେକ ପ୍ରଶ୍ନର ମାର୍କ ଦର୍ଶାଯାଇଛି ।

Candidates should attempt ***any*** **10** ***(ten)*** *questions of* **GROUP—A** *with word limit of 250 words and should attempt* ***any*** **5** ***(five)*** *questions from* **GROUP—B** *with word limit of 300 words.*

ପରୀକ୍ଷାର୍ଥୀମାନେ **GROUP—A** ରୁ ଯେକୌଣସି **୧୦**ଟି ପ୍ରଶ୍ନର ଉତ୍ତର ୨୫୦ ଶବ୍ଦ ମଧ୍ୟରେ ଏବଂ **GROUP—B** ରୁ ଯେକୌଣସି **୫**ଟି ପ୍ରଶ୍ନର ଉତ୍ତର ୩୦୦ ଶବ୍ଦ ମଧ୍ୟରେ ସୀମିତ ରଖିବେ ।

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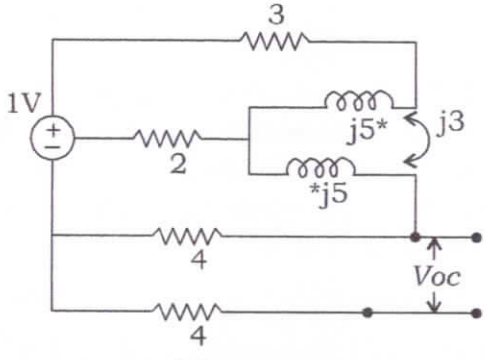
GROUP—A

1. *(i)* Find the Thevenin's equivalent circuit of the given figure. 7½

ପ୍ରଦତ୍ତ ଚିତ୍ରରେ Thevenin's equivalent circuit ନିରୂପଣ କର ।



(ii) A signal is represented by 7½

ଏକ signal ଉପସ୍ଥାପିତ ହୋଇଥାଏ

$$X(t) = \begin{cases} 1 & |t| < 1 \\ 1 & |t| > 1 \end{cases}$$

The Fourier transfer of the convolved signal

Convolved signal ର Fourier ସ୍ଥାନାନ୍ତର

$$Y(t) = X(2t) + X\left(t/2\right)$$

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2. *(i)* A series R–L–C circuit is observed at two frequencies. At $\omega_1 = 1\text{krad/s}$, we note that source voltage $V_1 = 100\angle 0^\circ$ V results in current $I_1 = 0 \cdot 03\angle 31^\circ$ A. At $\omega_2 = 2$ krad/s, the source voltage $V_2 = 100\angle 0^\circ$ V results in a current $I_2 = 2\angle 0^\circ$ A. Find out the value of R, L and C. 7½

ଦୁଇଟି frequencies R–L–C circuit ର ଏକ କ୍ରମ ପାଳନ କରାଯାଏ । $\omega_1 = 1\text{krad/s}$ ଆମେ ଦେଖୁ ଯେ ଉତ୍ସ $V_1 = 100\angle 0^\circ$ V ଫଳାଫଳ $I_1 = 0 \cdot 03\angle 31^\circ$ A । $\omega_2 = 2$ krad/s ରେ, ଉତ୍ସ voltage $V_2 = 100\angle 0^\circ$ V ସାମ୍ପ୍ରତିକ $I_2 = 2\angle 0^\circ$ A ରେ ଫଳାଫଳ କରେ । R, L ଏବଂ C ର ମୂଲ୍ୟ ବାହାର କର ।

(ii) A non-salient pole synchronous generator having synchronous reactance of 0·8 pu is supplying 1 pu power to a 0·9 power factor load at a terminal voltage of 1·1 pu. Neglecting the armature resistance, find the angle of the voltage behind the synchronous reactance with respect to the angle of the terminal voltage in degrees. 7½

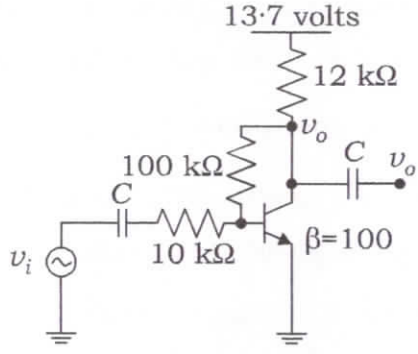
0·8 pu ର synchronous reactance ଥିବା ଏକ non-salient pole synchronous generator ର 1·1 pu ର terminal voltage ରେ 0·9 power factor load ପାଇଁ 1 pu ଯୋଗାଉଛି । Armature ପ୍ରତିରୋଧକୁ ଛାଡି, degree ରେ terminal voltage ର କୋଣ ସହିତ synchronous ପ୍ରତିକ୍ରିୟା ପଛରେ voltage କୋଣ ଖୋଜ ।

3. *(i)* A 220 V, 15 kW, 1000 r.p.m. shunt motor with armature resistance of 0·25 Ω, has a rated line current of 68 A and a rated field current of 2·2 A. What change in field required to obtain a speed of 1600 r.p.m. while drawing a line current of 52·8 A and a field current of 1·8 A. 7½

0·25 Ω ର armature resistance ସହିତ ଏକ 220 V, 15 kW, 1000 r.p.m. shunt motor ର 68 A ର rated line current ଏବଂ 2·2 A ର rated field current ରହିଛି । 52·8 A ର ଏକ line current ଏବଂ 1·8 A ର ଏକ field current ରେଖାଙ୍କନ କରିବା ବେଳେ 1600 r.p.m ର ଗତି ପାଇବା ପାଇଁ କ୍ଷେତ୍ରରେ କେଉଁ ପରିବର୍ତ୍ତନ ଆବଶ୍ୟକ ।

(ii) Find the voltage gain A_{Vs} of the given circuit. 7½

ପ୍ରଦତ୍ତ circuit ର voltage gain A_{Vs} ବାହାର କର ।



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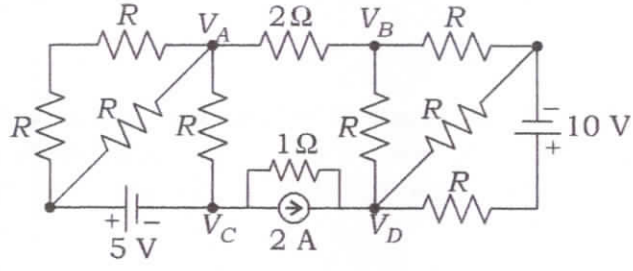
4. (i) If $V_A - V_B = 6V$, find $V_C - V_D$. 7½

ଯଦି $V_A - V_B = 6V$, $V_C - V_D$ _____? ବାହାର କର ।



(ii) A diode circuit feeds an ideal inductor. Given $V_s = 100\sin(\omega t)V$, where $\omega = 100\pi$ rad/s, L = 31·83 mH. The initial value of inductor current is zero. Switch S is closed at t = 2·5 ms. Find the peak value of inductor current i_L (in A) in the first cycle. 7½

ଏକ diode circuit ଏକ ଆଦର୍ଶ inductor କୁ feed କରେ, $V_s = 100\sin(\omega t)V$ ଦିଆଯାଇଛି, ଯେଉଁଠାରେ $\omega = 100\pi$ rad/s ଏବଂ L = 31·83 mH । Inductor ର ପ୍ରାରମ୍ଭିକ ମୂଲ୍ୟ ଶୂନ । t = 2·5 ms ରେ ସ୍ୱିଚ୍ S ବନ୍ଦ ଅଛି । ପ୍ରଥମ ଚକ୍ରରେ i_L (A ରେ) inductor current ର ସର୍ବୋଚ୍ଚ ମୂଲ୍ୟ ବାହାର କର ।

5. (i) A 3-phase, 50 Hz, six-pole induction motor has a rotor resistance of 0·1 Ω and reactance of 0·92 Ω. Neglect the voltage drop in stator and assume that the rotor resistance is constant. Given that the full load slip is 3%, find the ratio of maximum torque to full load torque. 7½

ଗୋଟିଏ ଛଅ ପର୍ଯ୍ୟାୟ 50 Hz ଛଅ ପୋଲ induction motor ର rotor resistance of 0·1 Ω ଏବଂ reactance of 0·92 Ω । Stator ରେ voltage drop କୁ ବାଦଦେଇ ଅନୁମାନ କର ଯେ rotor resistance ସ୍ଥିର ଅଟେ । ପୂର୍ଣ୍ଣ load slip 3% ଅଟେ, ସର୍ବାଧିକ torque ର ଅନୁପାତକୁ full load torque ସହିତ ଖୋଜ ।

(ii) A perfectly conducting metal plate is placed in x-y plane in a right-handed coordinate system. A charge of $+32\pi\varepsilon_0\sqrt{2}$ coulombs is placed at coordinate (0, 0, 2). ε_0 is the permittivity of free space. Assume $\hat{i}, \hat{j}, \hat{k}$ to be unit vectors along x, y and z axes respectively. At the coordinate $\left(\sqrt{2}, \sqrt{2}, 0\right)$, what will be the electric field vector $\vec{E}$ (Newtons/Coulomb)? 7½

ଏକ ଉତ୍ତମ ଭାବେ ପରିଚାଳିତ ଧାତୁ ପ୍ଲେଟ ଏକ ଡାହାଣ ହାତର coordinate system ରେ x-y plane ରେ ରଖାଯାଇଛି । $+32\pi\varepsilon_0\sqrt{2}$ coulombs ର ଏକ charge coordinate (0, 0, 2) ରେ ରଖାଯାଇଛି । ε_0 ହେଉଛି free space ର permittivity । $\hat{i}, \hat{j}, \hat{k}$ କୁ ଯଥାକ୍ରମେ x, y ଏବଂ z axes ସହ vector ବୋଲି ମନେକର । coordinate $\left(\sqrt{2}, \sqrt{2}, 0\right)$ ରେ electric field vector $\vec{E}$ (Newtons/Coulomb) କ'ଣ ହେବ?

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6. (i) The average power of an omni-directional antenna varies as the magnitude of cos(θ) where θ is the azimuthal angle. Calculate the maximum Directive Gain of the antenna and the angles at which it occurs. 7½

ଏକ omni-directional antenna ର ହାରାହାରି ଶକ୍ତି magnitude of cos(θ) କାରଣରୁ ଭିନ୍ନ ହୋଇଥାଏ ଯେଉଁଠାରେ θ ହେଉଛି azimuthal angle । Antenna ସର୍ବାଧିକ Directive Gain ଏବଂ ଯେଉଁଠାରେ ଏହା ଘଟିଥାଏ ତାହା ଗଣନ କର ।

(ii) Explain the principle of operation and applications of loop antenna. 7½

ଲୁପ୍ ଆଣ୍ଟେନାର ପରିଚାଳନା ଏବଂ ପ୍ରୟୋଗ (operation ଏବଂ application) ର ନୀତିଗୁଡ଼ିକୁ ବ୍ୟାଖ୍ୟା କର ।

7. (i) Draw the circuit diagram of ring modulator and explain with its operation. 7½

Ring modulator ର circuit diagram କୁ ଅଙ୍କନ କର ଏବଂ ଏହାର ପରିଚାଳନାକୁ ବ୍ୟାଖ୍ୟା କର ।

(ii) A normalised signal with 20 kHz bandwidth and 2 W power is transmitted via a channel with bandwidth of 100 kHz and loss of 50 dB by an FM modulator. Assume that the noise in the channel is additive and white with a power spectral density of $N_0/2 = 10^{-12}$ W/Hz. To get an SNR of 30 dB at the receiver output—

20 kHz bandwidth ଏବଂ 2 W power ସହିତ ଏକ normalised signal 100 kHz ର bandwidth ସହିତ ଏକ channel ମାଧ୍ୟମରେ ପ୍ରସାରିତ ହୁଏ ଏବଂ FM modulator ଦ୍ୱାରା 50 dB ନଷ୍ଟ ହୁଏ, ମନେକର ଯେ channel ରେ ଥିବା ଶବ୍ଦ $N_0/2 = 10^{-12}$ W/Hz ଶକ୍ତି spectral density ସହିତ additive ଏବଂ white । receiver output ରେ 30 dB ର SNR ପାଇବାକୁ :

(a) what is the corresponding modulation index;

ଅନୁରୂପ (corresponding modulation) index କ'ଣ?

(b) what is the minimum required transmitter power? 7½

ସର୍ବନିମ୍ନ ଆବଶ୍ୟକ transmitter ଶକ୍ତି କ'ଣ?

8. *(i)* A voltage commutated chopper feeds power to a battery-power electric car. The battery voltage is 80 V, starting current is 50 A and thyristor turn off time is 20 μsec. Calculate the values of the commutating capacitor C and the commutating inductor L. 7½

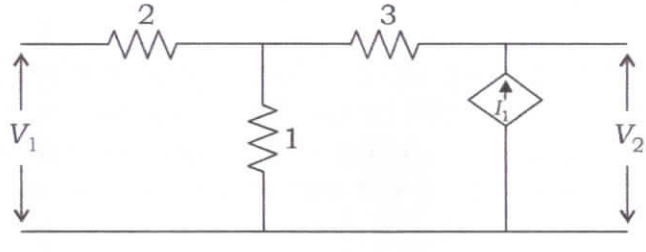
ଟୋଟିଏ voltage commutated chopper ଏକ battery-power electric car କୁ ଶକ୍ତି ଯୋଗାଏ । Battery voltage ହେଉଛି 80 V, ଆରମ୍ଭ current ହେଉଛି 50 A ଏବଂ ଏବଂ thyristor turn off time is 20 μsec. Commutating capacitor C ଏବଂ commutating inductor L ର ମୂଲ୍ୟ ନିର୍ଣ୍ଣୟ କର ।

(ii) An analog signal with bandwidth B = 6 kHz. $N = 2^m$ point DFT to compute the spectrum of the resolution less than or equal to 200 Hz. What is the minimum length of the analog signal recorded? 7½

Bandwidth B = 6 kHz ସହିତ ଏକ analog signal. 200 Hz ରୁ କମ୍ କିମ୍ବା ସମାନ resolution ର spectrum ଗଣନା କରିବାକୁ $N = 2^m$ point DFT. Record ହୋଇଥିବା analog signal ର ସର୍ବନିମ୍ନ ଲମ୍ବ କେତେ?

9. *(i)* Calculate the *ABCD* parameter of the following two-port network. 7½

ନିମ୍ନଲିଖିତ ଦୁଇଟି network ର *ABCD* parameter ଗଣନା କର ।



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(ii) In a battery powered dc drive scheme, a chopper controlled motor rated at 70 V, 250 A and 2000 r.p.m. is separately excited at a flux corresponding to its full rating. The current pulsation during acceleration is maintained between 180 A and 230 A. The motor resistance is 0·045 Ω, while the inductance is 7 mH. The battery resistance is 0·065 Ω. Neglecting semiconductor losses, determine the chopping frequency and the duty cycle ratio when the speed is 1000 r.p.m. 7½

ଏକ ବ୍ୟାଟେରୀ dc scheme ରେ 70 V, 250 A ଏବଂ 2000 r.p.m. rate ହୋଇଥିବା ଏକ chopper ନିୟନ୍ତ୍ରିତ motor ଏହାର full rating ସହିତ ଏକ flux ସହିତ ପୃଥକ ଭାବେ excited । Acceleration ସମୟରେ current pulsation 180 A ରୁ 230 A ମଧ୍ୟରେ ପରିଚାଳିତ । Motor resistance is 0·045 Ω ଥିବାବେଳେ inductance is 7 mH ଅଟେ । Battery resistance ହେଉଛି 0·065 Ω । ସେମିକଣ୍ଡକ୍ଟରର କ୍ଷତିକୁ ବାଦ ଦେଇ speed is 1000 r.p.m. ଥିବାବେଳେ, chopping frequency ଏବଂ duty cycle ratio ନିର୍ଣ୍ଣୟ କର ।

10. (i) In the parallel *R–L–C* circuit R = 8 kΩ, L = 0·2 mH and C = 8 μF. Calculate ω_0, Q and B. Find ω_1 and ω_2, power dissipated at ω_0, ω_1 and ω_2. 7½

ସମାନ୍ତରାଳ *R–L–C* circuit ରେ R = 8 kΩ, L = 0·2 mH ଏବଂ C = 8 μF । ω_0, Q ଏବଂ B କୁ ଗଣନ କର । ω_0, ω_1 ଏବଂ ω_2 ରେ ବିସ୍ତୃତ ω_1 ଏବଂ ω_2 ଶକ୍ତିକୁ ଖୋଜ ।

(ii) Design a band-pass filter to pass frequencies between 250 Hz and 3000 Hz and with K = 10. Take R = 20 kΩ. 7½

250 Hz ରୁ 3000 Hz ଏବଂ K = 10 ସହିତ frequencies pass କରିବା ପାଇଁ ଏକ band-pass filter ଡିଜାଇନ କର । R = 20 kΩ ଭାବେ ନିୟନ୍ତୁ ।

11. (i) Sketch and explain the open circuit and short circuit characteristics of a synchronous machine. 7½

ଏକ synchronous ମେସିନର open circuit ଏବଂ short circuit ବୈଶିଷ୍ଟ୍ୟଗୁଡ଼ିକ ଅଙ୍କନ କର ଏବଂ ବ୍ୟାଖ୍ୟା କର ।

(ii) An autotransformer has a primary winding with 200 turns and a secondary winding with 50 turns. Calculate the turns ratio (N_1 / N_2), voltage transformation ratio and the percentage impedance transformation, if the impedance on the secondary side is 8 ohms. 7½

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ଗୋଟିଏ autotransformer ରେ 200 turns ସହିତ ଏକ primary winding ଏବଂ 50 turns ସହିତ ଏକ secondary winding ଅଛି । ଅନୁପାତ (N_1/N_2), voltage transformation ratio ଏବଂ percentage impedance transformation କୁ truns ସହିତ ଗଣନା କର ଯଦି secondary side ରେ impedance 8 ohms ହୁଏ ।

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12. *(i)* Design a 2 decade BCD D/A converter. Write the characteristic of D/A converter. 7½

2 decade BCD D/A converter design ପ୍ରସ୍ତୁତ କର । D/A converter ର characteristic ଲେଖ ।

(ii) For a discrete-time system, the transfer function is given by 7½

ଏକ discrete-time system ପାଇଁ transfer function ଦିଆଯାଇଛି ।

$$H(z) = \frac{X(z)}{Y(z)} = \frac{z+1}{z^2 - 0{\cdot}9z + 0{\cdot}25z + 1}$$

(a) Determine the difference equation that represents the system.

System କୁ ପ୍ରତିନିଧିତ୍ୱ କରୁଥିବା difference equation କୁ ନିର୍ଣ୍ଣୟ କର ।

(b) Find the impulse response $h[n]$ of the system.

System ର impulse response $h[n]$ ଖୋଜ ।

(c) Determine, if the system is stable.

System Stable ଅଛି କି ନାହିଁ ନିର୍ଦ୍ଧାରଣ କର ।

GROUP—B

13. *(i)* Derive the mathematical expression for energy stored in electric field. If $V = yx^2 + zx + xy$ V. Do the analysis of $\vec{E}$ at (2, 3, 7) and the electrostatic energy stored in a cube of side 4 m centered at origin. 10

ବୈଦ୍ୟୁତିକ କ୍ଷେତ୍ରରେ ଗଚ୍ଛିତ ଶକ୍ତି ପାଇଁ ଗାଣିତିକ ଅଭିବ୍ୟକ୍ତି ନିର୍ଣ୍ଣୟ କର । ଯଦି $V = yx^2 + zx + xy$ V । (2, 3, 7) ରେ $\vec{E}$ କୁ ଏବଂ origin ରେ କେନ୍ଦ୍ରିଭୂତ 4 m ପାର୍ଶ୍ୱର ଏକ cube ରେ ଗଚ୍ଛିତ electrostatic କୁ ବିଶ୍ଳେଷଣ କର ।

(ii) Draw the logic symbol of J-K flip-flop and explain the operation of it. Explain what is race around condition. 10

J-K flip-flop ର logic symbol ଅଙ୍କନ କର ଏବଂ ଏହାର କାର୍ଯ୍ୟକୁ ବ୍ୟାଖ୍ୟା କର । Race around condition କ'ଣ ବ୍ୟାଖ୍ୟା କର ।

14. *(i)* What is MOS logic? Explain. Using MOS logic, represent NOR and NAND gates. 10

MOS logic କ'ଣ ବ୍ୟାଖ୍ୟା କର । MOS logic କୁ ବ୍ୟବହାର କରି NOR ଏବଂ NAND କୁ ପ୍ରତିନିଧିତ୍ୱ କର ।

(ii) What is K-map? Write the advantages of K-map. Minimize the four-variable logic function using K-map

$$f(A,B,C,D) = \sum m(0, 1, 2, 3, 5, 7, 8, 9, 11, 14)$$ 10

K-map କ'ଣ? K-map ର ସୁବିଧାଗୁଡ଼ିକ କ'ଣ ଲେଖ । K-map ବ୍ୟବହାର କରି ଚାରୋଟି variable logic function minimize କର ।

15. *(i)* Design a capacitance multiplier circuit using Op-Amp, where output capacitance is 100 times that of input capacitance. 10

Op-Amp ବ୍ୟବହାର କରି ଏକ capacitance multiplier circuit ଡିଜାଇନ କର । ଯେଉଁଠାରେ output capacitance input capacitance ର 100 ଗୁଣ ଅଟେ ।

(ii) Explain the operation of Wien bridge oscillator. Design a Wien bridge oscillator circuit to oscillate at 100 kHz. What are Barkhausen criteria? 10

Wien bridge oscillator ର କାର୍ଯ୍ୟକୁ ବ୍ୟାଖ୍ୟା କର । 100 kHz ରେ oscillate ପାଇଁ ଏକ Wien bridge oscillator circuit design କର । Barkhausen criteria କ'ଣ?

16. *(i)* Design the ladder network terminated with a 1 Ω resistor that has the normalised transfer function. 10

ଏକ 1 Ω resistor ସହିତ ସମାପ୍ତ ହୋଇଥିବା ladder network କୁ ଡିଜାଇନ କର ଯେଉଁଥିରେ normalised transfer function ରହିଛି ।

$$H(s) = \frac{1}{s^3 + 2s^2 + 2s + 1}$$

(ii) A 230 V, 1500 r.p.m., 20 A separately excited dc motor is fed from 3-phase full converter. Motor armature resistance is 0·6 Ω. Full converter is connected to 400 V, 50 Hz source through a delta-star transformer. Motor terminal voltage is rated when converter angle is zero. 10

A 230 V, 1500 r.p.m., 20 A ଏକ ପୃଥକ ଭାବେ excited dc motor କୁ 3 ପର୍ଯ୍ୟାୟବିଶିଷ୍ଟ full converter କୁ ଶକ୍ତି ଯୋଗାଇ ଦିଆଯାଏ, Motor armature resistance ହେଉଛି 0·6 Ω । Full converter ଏକ delta-star transformer ମାଧ୍ୟମରେ 400 V, 50 Hz source ସହ ସଂଯୁକ୍ତ । Converter angle zero ହେଲେ, motor terminal voltage ମୂଲ୍ୟାୟନ କର ।

Candidate must not write on this margin.

(a) Calculate the transformer phase turns ratio from primary to secondary.

Transformer phase turns ratio କୁ ପ୍ରାଥମିକରୁ secondary କୁ ଗଣନ କର ।

(b) Calculate the firing angle delay of the converter when the motor is running at 1000 r.p.m. at rated torque.

Rated torque ରେ 1000 r.p.m. ରେ motor ଚାଲୁଥିବାବେଳେ converter firing angle ବିଳମ୍ବକୁ ଗଣନା କର ।

Candidate must not write on this margin.

17. (i) A 280 V, two-pole, 60 Hz Y-connected wound-rotor induction motor is rated at 15 hp. Its equivalent circuit components are :
$R_1 = 0{\cdot}3\ \Omega$, $R_2 = 0{\cdot}15\ \Omega$, $X_m = 16\ \Omega$,
$X_1 = 0{\cdot}51\ \Omega$, $X_2 = 0{\cdot}42\ \Omega$, $P_{\text{mech}} = 260$ W, $P = 160$ W, slip = 0·05.
Find the line current, the stator copper loss, the load torque, the overall efficiency of the motor, the rotor copper loss, motor speed in r.p.m. 10

ଏକ 280 V, ଦୁଇଟି pole, 60 Hz Y-ସଂଯୁକ୍ତ wound-rotor induction motor କୁ 15 hp ରେ rate କହାଯାଇଛି । ଏହାର ସମାନ circuit ଉପାଦାନଗୁଡ଼ିକ ହେଉଛି :
$R_1 = 0{\cdot}3\ \Omega$, $R_2 = 0{\cdot}15\ \Omega$, $X_m = 16\ \Omega$,
$X_1 = 0{\cdot}51\ \Omega$, $X_2 = 0{\cdot}42\ \Omega$, $P_{\text{mech}} = 260$ W, $P = 160$ W, slip = 0·05.
Current line, stator copper loss, load torque, motor ର overall efficiency, rotor copper loss, r.p.m. ରେ motor speed କୁ ଖୋଜ ।

(ii) At what distance is the radiation component of magnetic field twice the inductance component? At what distance is it 100 times? 10

ଚୁମ୍ବକୀୟ କ୍ଷେତ୍ରର ବିକିରଣ ଉପାଦାନ କେତେ ଦୂରତାରେ inductance ର ଦୁଇଗୁଣ? କେଉଁ ଦୂରତାରେ ଏହା 100 ଥର?

18. (i) Discuss about spherical waves and biconical antenna. 10

Spherical waves ଏବଂ biconical antenna ବିଷୟରେ ଆଲୋଚନା କର ।

(ii) Discuss the coherent detection of DSB-SC modulated wave with a block diagram of detector and explain. 10

Detector ଏକ block diagram ସହିତ DSB-SC modulated ତରଙ୍ଗର ସମନ୍ୱିତ ଚିହ୍ନଟ ବିଷୟରେ ଆଲୋଚନା କର ଏବଂ ବ୍ୟାଖ୍ୟା କର ।

★★★