ELECTRICAL ENGINEERING (PAPER-I)

Time Allowed : Three Hours  
Maximum Marks : 250

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections and printed both in HINDI and in ENGLISH.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Answers must be written in the medium authorized in the Admission Certificate which must be stated clearly on the cover of this Question-cum-Answer (QCA) Booklet in the space provided. No marks will be given for answers written in medium other than the authorized one.

Assume suitable data, if considered necessary, and indicate the same clearly.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Attempts of questions shall be counted in chronological order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.
1. (a) चित्र 1 में Δ-Υ प्रतिस्थापन का प्रयोग करते हुए, α तथा δ के मध्य प्रतिलोम ज्ञात कीजिए।

Using Δ-Υ substitution, determine the resistance between a and d, in Fig. 1.

(b) चित्र 2 में एक वर्ग तरंग का पराश 0 से π के बीच व्यक्त किया गया है, तथा तरंग π से 2π के बीच तथा f(t) = 0 के द्वारा। चर्याली के शैली में इसके पृष्ठभूमि पर ज्ञात कीजिए।

Figure 2 shows a square wave that is described through the range from 0 to π by \( f(t) = 2 \), and through the range from π to 2π by \( f(t) = 0 \). Find its Fourier components in the exponential series.

(c) किसी चालक को एक धातु प्लेट से पुनरात्मक संपर्कों द्वारा आवश्यक किया गया है, जिसे प्रयोक्त संपर्क के पराश एक स्फीर बोल्टर वाले स्थान से जोड़कर आवश्यक किया जाता है। यदि प्रत्येक संपर्क का पराश चालक का आवेश \( q \) है, तब दर्शाइए कि चालक में ज्ञात आवेश \( \frac{Q-q}{Q-q} \) है।

A conductor is charged by repeated contacts with a metal plate which, after each contact, is recharged to a quantity of charge \( Q \) by connecting it to a constant voltage source. If \( q \) is the charge of the conductor after the first operation, show that the ultimate charge on the conductor is \( \frac{Q-q}{Q-q} \).

(d) एक संक्षेपात्मक प्रवेशक (OP-AMP) का प्रयोग करके किसी प्रवेशक का अवलंब्रत्न कीजिए जिसकी लच्छी +5 हो। चयन कीजिए कि \( R_i = 10 \) kΩ.

Design an amplifier with a gain of +5 using one OP-AMP. Choose \( R_i = 10 \) kΩ.
(e) (i) Write the Maxwell’s equations including the continuity equation in vector form for time-varying fields in general medium naming each of them.

(ii) Define the following parameters for an OP-AMP:
- Input offset voltage
- Bias current
- Slew rate
- Output impedance
- CMRR

2. (a) Consider the unbalanced Wheatstone bridge shown in Fig. 3:

The internal resistance of the galvanometer is 1 ohm. Using Thevenin's theorem, determine the galvanometer current.

(b) Determine the current I in Fig. 4 using the ladder method.
In Fig. 5, capacitor $C_1$ is initially charged at 100 V and the other two capacitors are initially uncharged. The switch $S$ is closed at time $t = 0$. Find the current flowing through the resistor as a function of time.

$E_x = A \cos(\omega t + kz) \quad \quad E_y = 0$

$H_x = 0 \quad \quad H_y = B \cos(\omega t + kz)$

Plane monochromatic waves are propagated parallel to the z-axis in both positive and negative directions. At the origin, the field strengths are given by

$E_x = A \cos(\omega t + kz) \quad \quad E_y = 0$

$H_x = 0 \quad \quad H_y = B \cos(\omega t + kz)$

Calculate the mean intensity of the radiation in each of the two directions in terms of $A$, $B$ and the constants of the medium.

Show that the energy stored in a plane electromagnetic wave is equally divided between the electric and magnetic fields.

A lossless transmission line with air dielectric is 12 m long. What is the line length in wavelengths and what is the value of the phase constant $\beta$ at 15 MHz?
4. (a) A single differential operational amplifier (OP-AMP) is to be used for a high-speed switching system. The op-amp is to be used at a switching rate of 20 dB, with \( \omega = 10000 \) rad/sec. Use a capacitance of 0.01 \( \mu F \) for a 0.1 Hz load.

Using an OP-AMP, design a lossy integrator whose peak gain is 20 dB and the gain is 3 dB down from its peak when \( \omega = 10000 \) rad/sec. Use a capacitance of 0.01 \( \mu F \).

(b) 8 V is to be regulated to 7805 IC. Design a voltage regulator using 7805 IC to get a voltage output of 8 V.

(c) A two-pole Butterworth filter is to be used for a 1 kHz cutoff frequency. Choose \( C = 0.1 \mu F \). The damping factor \( \alpha \) is given to be 1.414. Choose \( R_i \) as 10 k\( \Omega \).

5. (a) The maximum voltage range is 5V for TTL logic. Specify power supply voltage range, output logic 1 level voltage and output logic 0 level voltage for standard TTL gates.

(b) ‘Учебный элемент’ is used in various machines, such as mixers, grinders, and electric motors. Explain why this device is used in universal motor.

(c) DC-DC converters are used in various devices. Specify the type of transformer used in DC-DC converter and explain why iron core is not used in it.

(d) A superheterodyne receiver is to be used for a good selectivity. How is the selectivity achieved in a superheterodyne receiver?

(e) A 4x1 multiplexer is used for implementing a logic function. Draw a block diagram to implement logic \( F = A \cdot B \) using a 4x1 multiplexer.
6. (a) Determine the MSP form of the switching function

\[ F(uvwxyz) = \Sigma(0, 1, 4–6, 11, 14–17, 20–22, 30, 32, 33, 36, 37, 48, 49, 52, 53, 59, 63) \]

using 6-variable Karnaugh map.

(b) A sequential machine produces an output of 1 only when exactly two 0's arc followed by a 1 or exactly two 1's are followed by a 0. Determine the reduced state table of the machine.

(c) Assuming that logic 0 is available, show that the INCLUSION gate is a universal building block.

7. (a) A single-phase transformer of turns ratio 3 : 1 is connected to 110 V AC mains. It draws a primary current of 1 A at unity p.f. when delivering power to a load with an efficiency of 85%. If the no-load current of the transformer is 0.43 A, determine the p.f. at no load.

(b) Draw the circuit diagram of SCR-based control circuit for full-range speed control of a shunt DC motor using two SCRs to run from single-phase AC mains.

(c) In MOSFET, what is the effect of gate capacitance of MOSFET in driving circuit when it is used in high-frequency power switching applications like sine wave inverter or DC-DC converter?

8. (a) A certain FM signal is represented by \( V(t) = 10 \sin(10^8 t + 15 \sin 20000t) \) volts, where \( t \) is in seconds. Find the parameters of the FM wave.
(b) यह दर्शाए है कि वीनर-होफ (Wiener-Hopf) फिल्टर केवल तभी न्यायवादी होता है जब अन्तर्वेश एन० एन० भांग० (SNR) न्यून हो।

Show that the Wiener-Hopf filter is practical only when the input SNR is small.

(c) स्पष्ट कीजिए कि एफ० एम० (FM) अभिग्राही में स्केलेन से लिस्त अंतर्गत, एम० एम० (AM) की तुलना में अच्छा क्या होता है। अपने स्पष्टकार्य के लिए उपयुक्त आर्थिक बनाएँ।

Explain why signal to noise ratio is better in FM receiver as compared to AM. Draw suitable diagrams in support of your explanation.