PhD RESEARCH PROGRAMME- SYLLABII FOR ENTRANCE TEST
ELECTRONICS AND COMMUNICATION ENGINEERING

NETWORKS
Network graphs: matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis. Network theorems: superposition, Thevenin and Norton's maximum power transfer, Wye-Delta transformation. Steady state sinusoidal analysis using phasors. Linear constant coefficient differential equations; time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits. 2-port network parameters: driving pointand transfer functions. State equations for networks.

ELECTRONIC DEVICES
Energy bands in silicon, intrinsic and extrinsic silicon. Carrier transport in silicon: diffusion current, drift current, mobility, and resistivity. Generation and recombination of carriers. p-n junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, p-I-n and avalanche photo diode, Basics of LASERs. Device technology: integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography, n-tub, p-tub and twin-tub CMOS process.

ANALOG CIRCUITS
Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and analog CMOS. Simple diode circuits, clipping, clamping, rectifier, Biasing and bias stability of transistor and FET amplifiers. Amplifiers: single-and multi-stage, differential and operational, feedback, and power. Frequency response of amplifiers. Simple op-amp circuits. Filters. Sinusoidal oscillators; criterion for oscillation; single-transistor and op-amp configurations. Function generators and wave-shaping circuits, 555 Timers. Power supplies.

DIGITAL CIRCUITS
Boolean algebra, minimization of Boolean functions; logic gates; digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinatorial circuits: arithmetic circuits, code converters, multiplexers, decoders, PROMs and PLAs. Sequential circuits: latches and flip-flops, counters and shift-registers. Sample and hold circuits, ADCs, DACs. Semiconductor memories. Microprocessor (8085): architecture, programming, memory and I/O interfacing.

SIGNALS AND SYSTEMS
Definitions and properties of Laplace transform, continuous-time and discrete-time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, z-transform. Sampling theorem. Linear Time-Invariant (LTI) Systems: definitions and properties; causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay. Signal transmission through LTI systems.

CONTROL SYSTEMS
Basic control system components; block diagrammatic description, reduction of block diagrams. Open loop and closed loop (feedback) systems and stability analysis of these systems. Signal flow graphs and their use in determining transfer functions of systems; transient and steady state analysis of LTI control systems and frequency response. Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion, Bode and Nyquist plots. Control system compensators: elements of lead and lag compensation, elements of Proportional-Integral-Derivative (PID) control. State variable representation and solution of state equation of LTI control systems.

COMMUNICATIONS
Random signals and noise: probability, random variables, probability density function, autocorrelation, power spectral density. Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, superheterodyne receivers; elements of hardware, realizations of analog communication systems; signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions. Fundamentals of information theory and channel capacity theorem. Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers, bandwidth consideration and probability of error calculations for these schemes. Basics of TDMA, FDMA and CDMA and GSM.

OK 24/5/2022 (BOS chairperson) ECE/EGI

PHD ENTRANCE EXAMINATION
ELECTRONICS & COMMUNICATION ENGINEERING

MODEL QUESTION PAPER

Time : 2 hrs | ALL QUESTIONS CARRY EQUAL MARKS | Max. Marks: 100

01. A region of negative differential resistance is observed in the current voltage characteristics of a silicon PN junction if

(a) both the P-region and the N-region are heavily doped
(b) the N-region is heavily doped compared to the P-region
(c) the P-region is heavily doped compared to the N-region
(d) an intrinsic silicon region is inserted between the P-region and the N-region

02. Consider a four bit D to A converter. The analog value corresponding to digital signals of values 0000 and 0001 are 0 V and 0.0625 V respectively. The analog value (in Volts) corresponding to the digital signal 1111 is ________.

03. Negative feedback in a closed loop control system DOES NOT
(a) reduce the overall gain
(b) reduce bandwidth
(c) improve disturbance rejection
(d) reduce sensitivity to parameter variation

04. A MOSFET in saturation has a drain current of 1 mA for V_{DS} =0.5V. If the channel length modulation coefficient is 0.05 V^{-1}, the output resistance (in kΩ) of the MOSFET is _____

05.The transmitted signal in a GSM system is of 200 kHz bandwidth and 8 users share a common bandwidth using TDMA. If at a given time 12 users are talking in a cell, the total bandwidth of the signal received by the base station of the cell will be at least (in kHz) _______.

06 The impulse response of an LTI system can be obtained by
(a) differentiating the unit ramp response
(b) differentiating the unit step response
(c) integrating the unit ramp response
(d) integrating the unit step response

ELECTROMAGNETICS

Elements of vector calculus: divergence and curl; Gauss' and Stokes' theorems, Maxwell's equations: differential and integral forms. Wave equation, Poynting vector. Plane waves: propagation through various media; reflection and refraction; phase and group velocity; skin depth. Transmission lines: characteristic impedance; impedance transformation; Smith chart; impedance matching; S parameters, pulse excitation. Waveguides: modes in rectangular waveguides; boundary conditions; cut-off frequencies; dispersion relations. Basics of propagation in dielectric waveguide and optical fibers. Basics of Antennas: Dipole antennas; radiation pattern; antenna gain.

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ELECTRONICS AND INSTRUMENTATION ENGINEERING

ELECTRIC CIRCUITS

Voltage and current sources: independent, dependent, ideal and practical; v-i relationships of resistor, inductor, mutual inductor and capacitor; transient analysis of RLC circuits with dc excitation. Kirchoff's laws, mesh and nodal analysis, superposition, Thevenin, Norton, maximum power transfer and reciprocity theorems. Peak-, average- and rms values of ac quantities; apparent-, active- and reactive powers; phasor analysis, impedance and admittance; series and parallel resonance, locus diagrams, realization of basic filters withR, L and C elements. One-port and two-port networks, driving point impedance and admittance, open-, and short circuit parameters.

SIGNALS AND SYSTEMS

Periodic, aperiodic and impulse signals; Laplace, Fourier and z-transforms; transfer function, frequency response of first and second order linear time invariant systems, impulse response of systems; convolution, correlation. Discrete time system: impulse response, frequency response, pulse transfer function; DFT and FFT; basics of IIR and FIR filters.

CONTROL SYSTEMS

Feedback principles, signal flow graphs, transient response, steady-state-errors, Bode plot, phase and gain margins, Routh and Nyquist criteria, root loci, design of lead, lag and lead-lag compensators, state-space representation of systems; time-delay systems; mechanical, hydraulic and pneumatic system components, synchro pair, servo and stepper motors, servo valves; on-off, P, P-I, P-I-D, cascade, feed forward, and ratio controllers.

ANALOG ELECTRONICS

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of operational amplifiers; applications of opamps: difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, precision rectifier, active filters and other circuits. Oscillators, signal generators, voltage controlled oscillators and phase locked loop.

DIGITAL ELECTRONICS

Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flipflops, shift registers, timers and counters; sample-and-hold circuit, multiplexer, analog-todigital (successive approximation, integrating, flash and sigma-delta) and digital-toanalog converters (weighted R, R-2R ladder and current steering logic). Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems, 8-bit microprocessor and microcontroller: applications, memory andinput-output interfacing; basics of data acquisition systems.

MEASUREMENTS

SI units, systematic and random errors in measurement, expression of uncertainty – accuracy and precision index, propagation of errors. PMMC, MI and dynamometer type instruments; dc potentiometer; bridges for measurement of R, L and C, Q-meter. Measurement of voltage, current and power in single and three phase circuits; ac and dc current probes; true rms meters, voltage and current scaling, instrument transformers, timer/counter, time, phase and frequency measurements, digital voltmeter, digital multimeter; oscilloscope, shielding and grounding.

(Dos) ECE/EEI

SENSORS AND INDUSTRIAL INSTRUMENTATION

Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (differential pressure, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement.

COMMUNICATION AND OPTICAL INSTRUMENTATION

Amplitude- and frequency modulation and demodulation; Shannon's sampling theorem, pulse code modulation; frequency and time division multiplexing, amplitude-, phase-, frequency-, pulse shift keying for digital modulation; optical sources and detectors: LED, laser, photo-diode, light dependent resistor and their characteristics; interferometer: applications in metrology; basics of fiber optic sensing.

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24/5/2022

(BoS chairperson)
ECE/EEI

PHD ENTRANCE EXAMINATION
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MODEL QUESTION PAPER

Time : 2 hrs | ALL QUESTIONS CARRY EQUAL MARKS | Max. Marks: 100

01. Liquid flow rate is measured using
(A) A Pirani gauge (B) a pyrometer
(C) An orifice plate (D) a Bourdon tube

02 An apparatus to capture ECG signals has a filter followed by a data acquisition system. The filter best suited for this application is
(A) low pass with cutoff frequency 200 Hz (B) high pass with cutoff frequency 200Hz
(C) band pass with lower and upper cutoff frequencies 100 Hz and 200Hz for its pass band
(D)band reject with lower and upper cutoff frequencies 1 Hz and 200Hz for its stop band

03 A mass-spring-damper system with force as input and displacement of the mass as output has a transfer function $G(s) = 1/(s^2+24s+900)$. A force input $F(t) = 10 \sin(70t)$ Newton is applied at time t = 0s. a beam from an option stroboscope is focused on the mass. In steady state, the strobe frequency in hertz at which the mass appears to be stationary is

(A) $5/\pi$ (B) $15/\pi$ (C) $35/\pi$ (D) $50/\pi$

04 The torque transmitted by a cylindrical shaft is to be measured by using two strain gauges. The angles for mounting the strain gauges relative to the axis of the shaft for maximum sensitivity are
(A) $\pm 45^\circ$ (B) $\pm 60^\circ$ (C) $\pm 90^\circ$ (D) $\pm 180^\circ$

05 A p–type semiconductor strain gauge has a nominal resistance of 1000 Ω and a gauge factor of +200 at 25°C. The resistance of the strain gauge in ohms when subjected to a strain of $+10^{-4}$ m/m at the same temperature is _______ Ω.

06 A power line is coupled capacitively through various parasitic capacitances to a shielded signal line as shown in the figure. The conductive shield is grounded solidly at one end. Assume that the length of the signal wire extending beyond the shield, and the shield resistance are negligible. The magnitude of the noise voltage coupled to the signal line is

(A) directly proportional to C_{1G} (B) inversely proportional to the power line frequency
(C) inversely proportional to C_{1S} (D) zero

07 The probability density function of a random variable X is $p_x(x) = e^{-x}$ for $x \geq 0$ and 0 otherwise. The expected value of the function $g_x(x) = e^{3x/4}$ is ________.

08 A signal is band-limited to 0 to 12 kHz. The signal spectrum is corrupted by additive noise which is band-limited to 10 to 12 kHz. Theoretically, the minimum rate in kilohertz at which the noisy signal must be sampled so that the UNCORRUPTED PART of the signal spectrum can be recovered, is ____ kHz.