ELECTRONIC SYSTEMS ENGINEERING

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

January–April Semester

E3 203 2:1 Design of Analog Electronics and Industrial Instrumentation-Naga Krishna V

1. Sensors and transducers• Active and passive transducers• Transducer characteristics: temperature, pressure,flow,magnetic field, light
2. Sensor and transducer interfacing circuits: amplifiers• Wheatstone bridge• Amplifier characteristics – noise, linearity, supply rejection, impedance, range• Current/voltage/charge sensing circuits Instrumentation, transimpedance amplifiers
3. Analog signal processing: filters• Filter characteristics – magnitude and phase, ripple, group delay• Linear filters – Butterworth, Chebyshev
4. Interfacing circuits: drivers• Load type considerations – resistive and capacitive• Large current drive
5. Interface to digital processors: Analog to Digital Circuits• ADC characteristics – Data rate, ENOB, SFDR, INL, DNL• ADC architectures and choices – Flash, SAR, D-S, Pipeline 6.PIDand Programmable Logic Controllers 7. Digital communication interface– USB, I2C, USART

Prerequisites: None

References: Dally, J.W., et al., Instrumentation for Engineering Measurements, John Wiley and Sons, 1984.

E3 204 3:0 Fundamentals of MOS Analog Integrated Circuits - Sanjiv Sambandan

Introduction to enhancement mode MOSFETs: MOS capacitor, CV characteristics,MOSFET – Device Physics of the MOSFET, Current voltage characteristics, Linear and saturation operation, MOSFET - Small Signal analysis techniques:transconductance, output impedance due to channel length modulation, small signal resistance, small signal circuit of MOSFETs, MOSFET as a Switch:Operation as a Switch, Switch-capacitor circuits- Dynamics, Time constants,Parasitics - clock feedthrough and charge injection, Charge sharing between capacitors Single Stage MOS Voltage Amplifiers: Voltage amplifiers: Single stage Topologies: Common source, common source with degeneration, common gate,common drain, cascode. CMOS technology and CMOS amplifiers, Small Signal, Low frequency analysis of MOS Single Stage voltage amplifiers, Small Signal, High frequency analysis of MOS Single Stage voltage amplifiers: Miller effect,transit frequency, dominant pole MOS Differential amplifiers: Concept and operation of Differential Amplifiers, Analysis of MOS differential amplifiers:Differential gain, Common mode gain, CMRR, Half circuit method Biasing Circuits: 2 MOSFET Current mirror, Impact of channel length modulation , Cascode current mirror, Self Biasing Circuits, Differential Amplifiers with Active Loads Frequency Response: Transfer function Poles, Zeros, Bode Plots,Stability of Systems, Frequency response of amplifiers, Miller Effect, Transit frequency of the MOSFET Noise: Noise in circuits: Characterization of Noise, Noise spectrum, Types of Noise: thermal noise, flicker noise, shot noise and their noise spectrum, Noise in RC circuits, Noise in MOSFETs: Corner frequency, analysis of noise in MOS voltage amplifiers, calculations of output and input referred noise in MOS circuits, Signal to noise ratio, Effective Noise Bandwidth Feedback: Concepts of Feedback, Analytical methods to calculate loop gain, closed loop gain, Feedback in circuits Operational Amplifiers: OPAMP architectures – Telescopic Cascode, Folded Cascode, Two Stage OPAMPs, Gain Boosted OPAMPS , Stability of OPAMPS - Dominant Pole Compensation, Miller Compensation, Power Supply Rejection Ratio, Slew Rate. System Design: Problem solving and Analysis at the System level – eg. Image sensors, displays,biomedical applications. New technologies: Thin film transistors and Vacuum transistors. Device level challenges and impact on circuit design. Approach to circuit design and impact on system performance.

Prerequisites: None

References: Design of CMOS Analog Integrated Circuits, B. Razavi, Mc Graw Hil~Analysis and Design of Integrated Circuits, Gray, Hurst, Lewis, Meyer~Research Papers IISc_SoI_JA_2025.

E3 231 2:1 Digital Systems Design with FPGAs - Debayan Das

Introduction to Digital design; Hierarchical design, controller (FSM), case study, FSM issues, timing issues, pipelining, resource sharing, metastability, synchronization, MTBF Analysis, setup/hold time of various types of flip-flops, synchronization between multiple clock domains, reset recovery, proper resets. Verilog: different models, simulation cycles, process, concurrent and sequential statements, loops, delay models, library, packages, functions, procedures, coding for synthesis, test bench. FPGA: logic block and routing architecture, design methodology, special resources, Artix - 7 architecture, programming FPGA, constraints, STA, timing closure, case study.

Prerequisites: None

References: Digital Design: Principles and Practices By J.F. Wakerly.

E3 257 2:1 Embedded System Design - Dagale Haresh Ramji

Development toolchain (Compiler, Linker and Debugger), ARM Cortex processor architecture, Memory subsystem, caching, interfacing and programming peripherals, GPIO, UART, I2C, SPI, interrupts and NVIC architecture, interrupt driven standalone system

Prerequisites: None

References: Definitive Guide

E3 263 2:1 Applied Security for Cyber-Physical Systems - Dagale Haresh, Joy Kuri

Introduction to security concepts - confidentiality, integrity, availability, authentication. Trusted computing base, classic attack methods - stack smashing, code-reuse. Basic mitigation techniques. Security challenges in enterprise networks – web-based attacks and phishing emails. Counter measures to protect email and web services firewalls, WAF, SEG, SPF, DMARC, DKIM, IDS. OT security – ICS networks, industrial networking protocols, security of OT devices – PLC, IED, and Engineering PC (Windows OS). APT attacks, case studies, domain specific security requirements. Security Framework: Purdue model, Cyber Kill Chain and MITRE ATT&CK. Machine learning algorithms and their use in CPS security: Naive Bayes, Multilayer perceptron, Random forest, J48, KNN, Decision Tree, KMeans, Logistic Regression. Lab Content: Static analysis, dynamic analysis, binary analysis. Network Tools – nmap, Kali Linux, MetaSploit. Classic network attacks – Denial of Service, port scanning, brute force attacks, Man In the Middle, MAC spoofing, IP spoofing. Web-based attacks – Cross Site Scripting (CSS), Cross site Forgery, code injection. Pen testing: Burp suite, OWASP. IDS: Snort and Suricata.

Prerequisites: E2-232 TCP/IP Networking

References: Security in Computing by Charles Pfleeger, Shari Pfleeger, Lizzie Coles-Kemp Addison-Wesley Professional; 6th edition (25 July 202 Computer Security: Art and Science Hardcover – 12 October 2018 by Matt Bishop (Author) Addison-Wesley; 2nd edition (12 October 2018)

E2 270 3:0 Quantum Information Theory - Shayan Garani Srinivasa

Overview of concepts from classical Shannon theory, noiseless quantum theory, noisy quantum theory and purified quantum theory, distance measures, quantum information and entropy, information of quantum channels, quantum typicality, packing lemma, covering lemma, Schumacher compression, entanglement concentration, noisy quantum Shannon theory, product measurements at the decoder, information-processing task, classical capacity theorem, superadditivity of Holevo information, entanglement-assisted classical communication

Prerequisites: some background or familiarity in classical information theory

References: • Mark M. Wilde, "Quantum Information Theory", Cambridge University Press • M. Hayashi "Quantum Information Theory: A Mathematical Foundation" Springer-Verlag • John Preskill Notes

E0 204 2:1 Neuromorphic Analog VLSI design - Chetan Singh Thakur

Topic Contents Computational Neuroscience Neuron/Synapse models, Auditory and Visual pathways, Olfaction pathway Neuromorphic Engineering Introduction MOS Transistor, Sub-threshold operation of MOS Analog Circuit Fundamentals DC Analysis, Freq response, Feedback system, Gm/Id Methodology Synaptic devices (Optional) Floating gate, Memristor Static circuits Transcondutance Amplifiers, Current Mirror, Differential Pair, Gain Stages DC Operation Current-mode circuits Translinear Principle, Floating-Gate MOS Circuits, Bump Circuit, Current Multipliers Signal-Aggregation Circuit Centroid Circuits, Resistive Networks, Diffusor Circuits, Winner-Take-All Circuits, Delay Lines Basic elements of Neuromorphic electronics Electronic models of neuron, synapse and dendrites Neuromorphic Systems Electronic Cochlea, Auditory Localization, Silicon Retinas, Voltage and Current Mode Neuron Models, Address Event Communication, Motor Pattern Generatio

Prerequisites: Analog Circuit Design

References: Peter Dayan and L. F. Abbott, Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, The MIT press, 2005. • Carver Mead, Analog VLSI Implementation of Neural Systems, Addison Wesley, 1989 • S.-C. Liu, J. Kramer, G. Indiveri, T. Delbrück, and R. Douglas, Analog VLSI: Circuits and Principles. Cambridge, MA: MIT Press, 2002. • Liu, S.-C., Delbrück, T.

E3 230 2:1 Essential Circuits for System Design - Umanand L

Prerequisites: None
References : None