Bangladesh Electronics Olympiad 2015

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Topics of the Bangladesh Electronics Olympiad:

1. Digital Electronics
2. Analog Electronics
3. RF and Communication Electronics
4. Semiconductor Devices and Technology
5. Semiconductor Fabrication and Processing Technology
6. Integrated Circuit Design
7. Opto-Electronics and Photonic Devices
8. Micro- and Nano-Electronics
9. Biomedical Electronics
10. Electronic Instrumentation
11. Electronics in ICT and Digital Bangladesh

Syllabuses of the Topics of the Bangladesh Electronics Olympiad are given below:

1. **Digital Electronics and Microprocessors:** Introduction to number systems and codes. Basic logic functions, Boolean algebra, combinational logic design, minimization of combinational logic. Implementation of basic static logic gates in TTL, CMOS, BiCMOS and the other logic families and their comparison. DC characteristics, propagation delay, fan out, noise margin and power dissipation. Power optimization of basic gates and combinational logic circuits. Modular combinational circuit design: pass transistor, pass gates, multiplexer, de-multiplexer and their implementation in CMOS, decoder, encoder, comparators, binary arithmetic elements and ALU design. Programmable logic devices: logic arrays, field programmable logic arrays and programmable read only memory. Sequential circuits: different types of latches, flip-flops and their design using ASM approach, timing analysis and power optimization of sequential circuits. Modular sequential logic circuit design: shift registers, counters and their applications.
   Introduction to microprocessors. Intel 8086 microprocessor: Architecture, addressing modes, instruction sets, assembly language programming, system design and interrupt. Interfacing: programmable peripheral interface, programmable timer, serial communication interface, programmable interrupt controller, direct memory access, keyboard and display interface. Introduction to micro-controllers. Advanced microprocessor series.

   Referred Books:
   1. **Digital Logic and Computer Design**
      Morrice M. Mano
   2. **Digital Systems: Principles and Applications**
      Ronald J. Tocci
   3. **Microprocessors and Microcomputer-based System Design**
      Mohammad Rafiquzzaman
   4. **8086 Microprocessors and Interfacing**
      Douglas V. Hall

2. **Analog Electronics:** p-n junction formation, intrinsic and extrinsic semiconductors, operational principle of p-n junction diode, contact potential, current-voltage characteristics of a diode, simplified DC and AC diode models, dynamic resistance and capacitance. Diode circuits: half wave and full wave rectifiers, rectifiers with filter capacitor, clipping, clamping and voltage multiplier circuits; characteristics of a Zener diode, Zener diode in voltage regulator circuit.
   Bipolar Junction Transistor (BJT): construction, current components, characteristics and regions of operation, BJT as an amplifier and as a switch, biasing the BJT for discrete circuits, small signal equivalent circuit models. Single stage mid-band frequency BJT amplifier circuits: voltage and current gain, input and output impedance of a common base, common emitter and common collector amplifier circuits.
   Metal Oxide Semiconductor Field Effect Transistor (MOSFET) as circuit element: structure and physical operation of an enhancement MOSFET, threshold voltage, Body effect, current-voltage characteristics of an enhancement MOSFET, biasing discrete and integrated inverter.
   Frequency response of amplifiers: techniques of determining 3 dB frequencies and bandwidth of amplifier circuits. Operational amplifiers (Op-Amp): properties of ideal Op-Amps, non-inverting and inverting amplifiers, inverting integrators, differentiator, weighted summer and other applications of Op-Amp circuits, effects of finite open loop gain and bandwidth on circuit performance, logic signal operation of Op-Amp, DC imperfections. General purpose Op-Amp: DC analysis, small-signal analysis of different stages, gain and frequency response of 741 Op-Amp. Negative feedback: properties, basic topologies, feedback amplifiers with different topologies, stability, frequency compensation. Active filters: Different types of filters and specifications, transfer functions, realization of first and second order low, high and band-pass filters using Op-Amps. Signal generators: Basic principle of sinusoidal oscillation, Op-Amp RC oscillators, LC and crystal oscillators. Power Amplifiers: Classification of output stages, class A, B and AB output stages. Push-pull amplifier.

   Referred Books:
   1. **Digital and Integrated Electronics**
      J. Millamnn
      R. Halkias

   2. **Microelectronic Circuits**
      Sedra and Smith

   3. **Op-amps and Linear Integrated Circuits**
      Ramakant A. Gayakwad

   4. **Operational Amplifiers and Linear Integrated Circuits**
      Coughlin and Driscoll

3. **RF and Communication Electronics:** Overview of communication systems: Basic principles, fundamental elements, system limitations, message source, bandwidth requirements, transmission media types, bandwidth and transmission capacity. Noise: Source, characteristics of various types of noise and signal to noise ratio. Information theory: Measure of information, source encoding, error free communication over a noisy channel, channel capacity of a continuous system and channel capacity of a discrete memory less system. Communication systems: Analog and digital. Continuous wave modulation: Transmission types- base-band transmission, carrier transmission; amplitude modulation- introduction, double side band, single side band, vestigial side band, quadrature; spectral analysis of each type, envelope and synchronous detection; angle modulation- instantaneous frequency, frequency modulation (FM) and phase modulation (PM), spectral analysis, demodulation

of FM and PM. Pulse modulation: Sampling- sampling theorem, Nyquist criterion, aliasing, instantaneous and natural sampling; pulse amplitude modulation- principle, bandwidth requirements; pulse code modulation (PCM)- quantization principle, quantization noise, non-uniform quantization, signal to quantization error ratio, differential PCM, demodulation of PCM; delta modulation (DM)- principle, adaptive DM; line coding- formats and bandwidths. Digital modulation: Amplitude-shift keying- principle, ON-OFF keying, bandwidth requirements, detection, noise performance; phase-shift keying (PSK)- principle, bandwidth requirements, detection, differential PSK, quadrature PSK, noise performance; frequency-shift keying (FSK)- principle, continuous and discontinuous phase FSK, minimum-shift keying, bandwidth requirements, detection of FSK. Multiplexing: Time-division multiplexing (TDM)- principle, receiver synchronization, frame synchronization, TDM of multiple bit rate systems; frequency-division multiplexing (FDM)- principle, de-multiplexing; wavelength-division multiplexing, multiple-access network- time-division multiple-access (TDMA), frequency-division multiple access (FDMA); code-division multiple-access (CDMA)- spread spectrum multiplexing, coding techniques and constraints of CDMA. Communication system design: design parameters, channel selection criteria and performance simulation.
Phase Locked Loop (PLL): Introduction, basic PLL and charge pumped PLL.

Referred Books:

1. **Communication Systems**
   Simon S. Haykin

2. **Electronic Communication Systems**
   Kenedy and Davis

3. **Satellite Communication Systems**
   B. G. Evans

4. **Wireless Communication Systems**
   X. Wang and H. V. Poor

5. **Optical Fiber Communications: Principles and Practices**
   John M Senior

6. **Optical Fiber Communications**
   Gerd Keiser

7. **Fiber Optical Communication**
   Govind P. Agrawal

4. **Semiconductor Devices and Technology:** Semiconductors in equilibrium: Energy bands, intrinsic and extrinsic semiconductors, Fermi levels, electron and hole concentrations, temperature dependence of carrier concentrations and invariance of Fermi level. Carrier transport processes and excess carriers: drift and diffusion, generation and recombination of excess carriers, built-in-field, Einstein relations, continuity and diffusion equations for holes and electrons and quasi-Fermi level. p-n junction: Basic structure, equilibrium conditions, contact potential, equilibrium Fermi level, space charge, non-equilibrium condition, forward and reverse bias, carrier injection, minority and majority carrier currents, transient and AC conditions, time variation of stored charge, reverse recovery transient and capacitance. Bipolar Junction Transistor: Basic principle of pnp and npn transistors, emitter efficiency, base transport factor and current gain, diffusion equation in the base, terminal currents, coupled-diode model and charge control analysis, Ebers-Moll equations and circuit

synthesis. Metal-semiconductor junction: Energy band diagram of metal semiconductor junctions, rectifying and ohmic contacts. MOS structure: MOS capacitor, energy band diagrams and flat band voltage, threshold voltage and control of threshold voltage, static C-V characteristics, qualitative theory of MOSFET operation, body effect and current-voltage relationship of a MOSFET. Junction Field-Effect-Transistor: Introduction, qualitative theory of operation, pinch-off voltage and current-voltage relationship.

Referred Books:

1. **Semiconductor Devices**
   Ben G. Streetman

2. **Physics of Semiconductor Devices**
   S. M. Sze

5. **Semiconductor Fabrication and Processing Technology:** Substrate materials: Crystal growth and wafer preparation, epitaxial growth technique, molecular beam epitaxy, chemical vapor phase epitaxy and chemical vapor deposition (CVD). Doping techniques: Diffusion and ion implantation. Growth and deposition of dielectric layers: Thermal oxidation, CVD, plasma CVD, sputtering and silicon-nitride growth. Etching: Wet chemical etching, silicon and GaAs etching, anisotropic etching, selective etching, dry physical etching, ion beam etching, sputtering etching and reactive ion etching. Cleaning: Surface cleaning, organic cleaning and RCA cleaning. Lithography: Photo-reactive materials, pattern generation, pattern transfer and metalization. Discrete device fabrication: Diode, transistor, resistor and capacitor. Integrated circuit fabrication: Isolation– p-n junction isolation, mesa isolation and oxide isolation. BJT based microcircuits, p-channel and n-channel MOSFETs, complimentary MOSFETs and silicon on insulator devices. Testing, bonding and packaging.

   Referred Books:

   1. **The Science and Engineering of Microelectronic Fabrication**
      Stephen A. Campbell

   2. **Microchip Fabrication: A Practical Guide to Semiconductor Processing**
      Peter Van Zant

   3. **Fundamentals of Semiconductor Processing Technology**
      Badih El-Kareh

6. **Integrated Circuit Design:** Review of FET amplifiers: Passive and active loads and frequency limitation. Current mirror: Basic, cascode and active current mirror. Differential Amplifier: introduction, large and small signal analysis, common mode analysis and differential amplifier with active load. Noise: introduction to noise, types, representation in circuits, noise in single stage and differential amplifiers and bandwidth. Band-gap references: supply voltage independent biasing, temperature independent biasing, proportional to absolute temperature current generation and constant transconductance biasing. Switch capacitor circuits: sampling switches, switched capacitor circuits including unity gain buffer, amplifier and integrator.
   VLSI technology: top down design approach, MOSFET scaling, SCE and RSCE, technology trends and design styles. CMOS circuit characteristics and performance estimation: resistance, capacitance, rise and fall times, delay, gate transistor sizing and power consumption. CMOS circuit and logic design: VLSI layout design rules and physical design of simple logic gates using PSPICE and Cadence. CMOS subsystem design: adders, multiplier and memory system, arithmetic logic unit. VLSI testing.

Referred Books:

1. **Analysis and Design of Analog Integrated Circuits**
   P.R. Gray, P.J. Hurst, S.H. Lewis and R.G. Meyer

2. **Design of Analog CMOS Integrated Circuits**
   B. Razavi

3. **Basic VLSI Design**
   Pucknell and Eshraghian

4. **Principles of CMOS VLSI Design – A Systems Perspective**
   Eshraghian and Weste

5. **VLSI Technology**
   S. M. Sze

7. **Opto-Electronics and Photonic Devices:** Optical properties in semiconductor: direct and indirect band-gap materials, radiative and non-radiative recombination, optical absorption, photo-generated excess carriers, minority carrier life time, luminescence and quantum efficiency in radiation. Properties of light: particle and wave nature of light, polarization, interference, diffraction and blackbody radiation.
   Light emitting diode (LED): principles, materials for visible and infrared LED, internal and external efficiency, loss mechanism, structure and coupling to optical fibers.
   Stimulated emission and light amplification: spontaneous and stimulated emission, Einstein relations, population inversion, absorption of radiation, optical feedback and threshold conditions. Semiconductor Lasers: Population inversion in degenerate semiconductors, laser cavity, operating wavelength, threshold current density, power output, hetero-junction lasers, optical and electrical confinement. Introduction to quantum well lasers.
   Photo-detectors: photoconductors, junction photo-detectors, pin detectors, avalanche photodiodes and phototransistors.
   Solar energy and spectrum. Silicon and Schottkey Solar Cells: construction, operation, I-V characteristics, energy band diagram, equivalent circuit, performance metrics.
   Modulation of light: phase and amplitude modulation, electro-optic effect, acousto-optic effect and magneto-optic devices. Introduction to integrated optics.

   Referred Books:

   1. **Opto-Electronics and Photonics: Principles and Practices**
      Safa O. Kasap

   2. **Opto-Electronics: An Inroduction**
      J. Wilson and J. F. B. Hawkes

8. **Micro- and Nano-Electronics:** Fundamentals of quantum mechanics: effective-mass equation, Schrodinger equation, matrix representation, Green's function. Fundamentals of non-equilibrium statistical mechanics: scattering and relaxation. Basic law of equilibrium and steady state condition. Restoration of equilibrium, phonon emission and absorption rates. Lifetime and momentum relaxation time.
   Carrier transport: 3D, 2D, 1D carriers, density of states, directed moments, quantized conductance, tunneling and transmission probabilities, introduction to transport in the collective picture, semi-

classical carrier transport, ballistic transport (classical and quantum). Basic principles of a few effective devices: resonant tunnel diode, super lattice, quantum wire and quantum dot.
The Ballistic MOSFET: the mean-free paths and L, ballistic I-V (T > 0 non-degenerate, T = 0 degenerate and T > 0), numerical simulation of the ballistic MOSFET. Scattering theory of the MOSFET: I-V in terms of the transmission coefficient, the transmission coefficient (low and high), the mean-free path for backscattering.
Beyond the silicon MOSFET (the Carbon Nano Tube FET): carbon nanotubes, band-structure basics, MIS electrostatics of carbon nanotube capacitors, theory of the ballistic CNTFET, CNTFETs vs. MOSFETs.

Referred Books:

1. **Fundamentals of Quantum Mechanics: for Solid State Electronics and Optics**
   C. L. Tang

2. **Principles of Electronic Materials and Devices**
   Safa O. Kasap

9. **Biomedical Electronics:** Bioelectricity: genesis and characteristics. Measurement of bio-signals: transducers, amplifiers and filters. Electrocardiogram: electrocardiography, phono cardiograph, vector cardiograph, analysis and interpretation of cardiac signals, cardiac pacemakers and defibrillator. Blood pressure: electronic manometer, detector circuits and practical problems in pressure monitoring. Blood flow measurement: Plethymography and electromagnetic flow meter. X-ray. Electroencephalogram: analysis of EEG signals. Electromayogram (EMG). Tomograph: Positron emission tomography and computer tomography. Magnetic Resonance Imaging (MRI). Patient monitoring system, telemedicine and telemetry. Effect of electromagnetic fields on human body.

   Referred Books:

   1. **Introduction to Biomedical Equipment Technology**
      Joseph J. Carr and John M. Brown

   2. **Principles of Medical Electronics and Biomedical Instrumentation**
      C. Raja Rao and S. K. Guha

10. **Electronic Instrumentation:** Functional elements of a measurement system and classification of instruments. Measurement of electrical quantities: current and voltage, power and energy. Current and potential transformer. Transducers: mechanical, electrical and optical. Measurement of non-electrical quantities: Temperature, pressure, flow, level, strain, force and torque. Basic elements of DC and AC signal conditioning: instrumentation amplifier, noise and source of noise, noise elimination compensation, function generation and linearization, A/D and D/A converters, sample and hold circuits. Digital data transmission. Recording and display devices. Data acquisition system and microprocessor applications in instrumentation.

    Referred Books:

    1. **Electronic Instrumentation and Measurements**
       David A. Bell

    2. **Electronic Instrumentation**
       H. S. Kalsi

11. **Electronics in ICT and Digital Bangladesh:** Open topics from anywhere related to this theme. Few examples are given below:

Green use of computer: minimizing the electricity consumption of computers and their peripheral devices. Green disposal: re-purposing an existing computer or appropriately disposing of, or recycling, unwanted electronic equipment. Green design: designing energy-efficient computers, servers, storage devices, printers, projectors and other digital devices. Green manufacturing: minimizing waste during the manufacturing of computers and other subsystems to reduce the environmental impact of these activities.

Carbon footprint, service providers' battle to reduce carbon footprint as data centers expand, green data center; reduction of energy consumption with hot and cold aisles, optimization for best energy efficiency, MAID 2.0 and disk spin down for reducing energy costs. Designing, manufacturing, using, and disposing of computers, servers, and associated subsystems, such as, monitors, printers, storage devices, and networking and communications systems etc. Software and deployment optimization: algorithmic efficiency, resource allocation, virtualizing, terminal servers. Power Management: data center power, operating system support, power supply, storage and display etc.

Switching and multiplexing; ISO, TCP-IP and ATM reference models. Different Data Communication Services: Physical Layer- wired and wireless transmission media, Cellular Radio: Communication satellites; Data Link Layer: Elementary protocols, sliding window protocols. Error detection and correction, HDLC, DLL of internet, DLL of ATM; Multiple Access protocols, IEEE.802 Protocols for LANs and MANs, Switches, Hubs and Bridges; High speed LAN; Network layer: Routing, Congestion control, Internetworking, Network layer in internet: IP protocol, IP addresses, ARP; NI in ATM transport layer: transmission control protocol. UDP, ATM adaptation layer; Application layer: Network security; Email, domain name system; simple network management protocol; http and the World Wide Web.

Signal coding and compression: entropy coding, transform coding, vector quantization. Coding standards: H.26x, LPEG, MPEG. Wireless LANs and wireless multimedia. Entertainment networks: cable, satellite and terrestrial TV networks, ADSL and VDSL, high speed modems. Transport protocols: TCP, UDP, IP, Ipv4, Ipv6, FTP, RTP and RTCP, use of MPLS and WDMA. Multimedia synchronization, security, QoS and resource management. Internet telephony, teleconferencing and HDTV. E-governance and e-commerce, internet and mobile banking.

Referred Books:

1. **Green computing and green it best practices on regulations and industry initiatives, virtualization, power management, materials recycling and telecommuting**
   Jason Harris

2. **The Green Computing Book: Tackling Energy Efficiency at Large Scale**
   Wu-Chun Feng

3. **Green Computing with Emerging Memory**
   Kawahara, Takayuki, and Hiroyuki Mizuno

4. **Green Computing**
   Andy Hooper

5. **Multimedia Communications and Networking**
   Mario Marques da Silva

6. **Multimedia Communication Technology**
   Jens Ohm