



**Belias**  
Civil Service Academy

**SYLLABUS OF OPTIONAL  
SUBJECTS  
ELECTRICAL  
ENGINEERING  
(UPSC CS MAINS)**

# **ELECTRICAL ENGINEERING**

## **PAPER-I**

### **1. Circuits—Theory :**

Circuit components; network graphs; KCL, KVL; Circuit analysis methods : nodal analysis, mesh analysis; basic network theorems and applications; transient analysis : RL, RC and RLC circuits; sinusoidal steady state analysis; resonant circuits; coupled circuits; balanced 3-phase circuits. Two-port networks.

### **2. Signals and Systems :**

Representation of continuous-time and discrete-time signals and systems; LTI systems; convolution; impulse response; time-domain analysis of LTI systems based on convolution and differential/difference equations. Fourier transform, Laplace transform, Z-transform, Transfer function.

Sampling and recovery of signals DFT, FFT Processing of analog signals through discrete-time systems.

### **3. E.M. Theory :**

Maxwell's equations, wave propagation in bounded media. Boundary conditions, reflection and refraction of plane waves. Transmission lines : travelling and standing waves, impedance matching, Smith chart.

### **4. Analog Electronics :**

Characteristics and equivalent circuits (large and small-signal) of Diode, BJT, JFET and MOSFET.

Diode circuits : Clipping, clamping, rectifier. Biasing and bias stability. FET amplifiers. Current mirror;

Amplifiers : single and multi-stage, differential, operational feedback and power. Analysis of amplifiers; frequency-response of amplifiers. OPAMP circuits. Filters; sinusoidal oscillators : criterion for oscillation; single-transistor and OPAMP configurations. Function generators and wave-shaping circuits. Linear and switching power supplies.

### **5. Digital Electronics :**

Boolean algebra; minimisation of Boolean functions; logic gates; digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinational circuits : arithmetic circuits, code converters, multiplexers and decoders.

Sequential circuits: latches and flip-flops, counters and shift-registers. Comparators, timers, multivibrators. Sample and hold circuits, ADCs and DACs. Semiconductor memories. Logic implementation using programmable devices (ROM, PLA, FPGA).

### **6. Energy Conversion :**

Principles of electromechanical energy conversion : Torque and emf in rotating machines. DC machines : characteristics and performance analysis; starting and

speed control of motors. Transformers : principles of operation and analysis; regulation, efficiency; 3-phase transformers. 3-phase induction machines and synchronous machines : characteristics and performance analysis; speed control.

### **7. Power Electronics and Electric Drives :**

Semi-conductor power devices : diode, transistor, thyristor, triac, GTO and MOSFET-static characteristics and principles of operation; triggering circuits; phase control rectifiers; bridge converters : fully-controlled and half-controlled; principles of thyristor choppers and inverters; DC-DC converters; Switch mode inverter; basic concepts of speed control of dc and ac motor drives applications of variable-speed drives.

### **8. Analog Communication :**

Random variables : continuous, discrete; probability, probability functions. Statistical averages; probability models; Random signals and noise : white noise, noise equivalent bandwidth; signal transmission with noise; signal to noise ratio. Linear CW modulation : Amplitude modulation : DSB, DSBSC and SSB. Modulators and Demodulators; Phase and Frequency modulation : PM & FM signals; narrow band FM; generation & detection of FM and PM, Deemphasis, Preemphasis. CW modulation system: Superheterodyne receivers, AM receivers, communication receivers, FM receivers, phase locked loop, SSB receiver Signal to noise ratio calculation or AM and FM receivers.

**BeIAS**  
PAPER II  
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### **1. Control Systems :**

Elements of control systems; block-diagram representations; open-loop & closed-loop systems; principles and applications of feed-back. Control system components. LTI systems : time-domain and transform-domain analysis. Stability : Routh Hurwitz criterion, root-loci, Bode-plots and polar plots, Nyquist's criterion; Design of lead-lag compensators. Proportional, PI, PID controllers. State-variable representation and analysis of control systems.

### **2. Microprocessors and Microcomputers :**

PC organisation; CPU, instruction set, register set timing diagram, programming, interrupts, memory interfacing, I/O interfacing, programmable peripheral devices.

### **3. Measurement and Instrumentation :**

Error analysis; measurement of current voltage, power, energy, power-factor, resistance, inductance, capacitance and frequency; bridge measurements. Signal conditioning circuit; Electronic measuring instruments : multi-meter, CRO, digital voltmeter, frequency counter, Q-meter, spectrum-analyser, distortion-meter. Transducers: thermocouple, thermistor, LVDT, strain-gauge, piezo-electric crystal.

### **4. Power Systems: Analysis and Control :**

Steady-state performance of overhead transmission lines and cables; principles of active and reactive power transfer and distribution; per-unit quantities; bus admittance and impedance matrices; load flow; voltage control and power factor correction; economic operation; symmetrical components, analysis of symmetrical and unsymmetrical faults. Concepts of system stability : swing curves and equal area criterion. Static VAR system. Basic concepts of HVDC transmission.

### **5. Power System Protection :**

Principles of overcurrent, differential and distance protection. Concept of solid state relays. Circuit breakers. Computer aided protection : introduction; line, bus, generator, transformer protection; numeric relays and application of DSP to protection.

### **6. Digital Communication :**

Pulse code modulation (PCM), differential pulse code modulation (DPCM), delta modulation (DM), Digital modulation and demodulation schemes : amplitude, phase and frequency keying schemes (ASK, PSK, FSK). Error control coding : error detection and correction, linear block codes, convolution codes. Information measure and source coding. Data networks, 7-layer architecture.