# Department of Electrical Engineering

# NIT Durgapur

## Structure and Syllabus for Question Paper in Written Test

## for Ph.D. Admission 2025-2026

## Structure

Candidates have to answer both PART A & PART B in the question paper. PART A will contain questions from syllabus given below as "Compulsory".

PART B will contain 4 sections on the specialization subjects: (i) Power Systems, (ii) Power Electronics and Machine Drives, (iii) Control System, (iv) Instrumentation. Candidates will choose only one out of these 4 sections. The syllabus given below as "Optional" pertains to PART B.

## Syllabus

### 1. Control Systems:

**Compulsory:** Introduction to control systems, Mathematical Models of Physical Systems, Representation of Control Components, Time domain analysis and design specification of linear systems: Concepts of Stability and Algebra Criterion, Root Locus Technique, Frequency Response Analysis and Stability Studies in Frequency Domain, Design and Compensation Technique, introduction to State Variable Approach

**Optional:** Design of control systems by classical methods, Sampled Data Control Systems, Non-linear control systems

### 2. Electrical Power Systems:

**Compulsory:** Distribution systems, electrical design of overhead lines, mechanical design of overhead lines, insulators, insulated cables, transmission and performance, corona, inductive interference; short circuit analysis, protective relays, protective relaying schemes - protection of feeders & transmission lines, transformers and alternators, circuit interruption devices.

**Optional:** Power flow studies, state estimation, economic operation of power systems, unit commitment, power systems stability studies, automatic generation control, power systems security, switching transients, protection against overvoltages, insulation coordination.

### 3. Electrical Machines:

**Compulsory:** Transformers, Armature windings, DC generator, DC motor, Three-phase Induction motor, Synchronous generator, Synchronous motor.

**Optional:** Different types of special electrical machine, parallel operation of alternators, Synchronous condenser, speed control if induction motors, effects of harmonics in transformers.

## 4. Electrical & Electronic Measurement

**Compulsory:** Measurement of current, voltage, power and energy in an electrical circuit, Theory and application of Instrument Transformers, Measurement of resistance, inductance, capacitance and frequency, Localization of cable faults, Theory and application of CRO, Introduction to digital instruments.

**Optional:** Instrumentation- Introduction to Sensors &Transducers, Strain Gauge, LVDT, Thermocouple, Thermistor, Pyrometer, Anemometer, Flow meter.

## 5. Power Electronics

**Compulsory:** Familiarization with semiconductor devices including Diode, Thyristor, BJT, MOSFET, IGBT, GTO, TRIAC, DIAC, Operation and analysis of: Uncontrolled Rectifier, Controlled Rectifier, DC-DC Converters, Inverters, Cycloconverters, AC voltage Regulators, Different switching topologies, Basic applications of PE Converters in Home appliances & Industry

**Optional:** Multilevel Inverters, Advanced Modulation Techniques, Resonant & Soft-switching Converters, Isolated DC-DC converters, and Control of Converters, Gate Driver and Protection circuits, Power System Applications, Industrial Applications, AC & DC drives.

## 6. Machine Drives:

**Compulsory:** Review of Electric Drive System, Dynamics of Electric Drive System, Open Loop Control of DC Machines, Induction Machines, Synchronous Machines, Industrial Applications of Drives

**Optional:** Vector Control of Induction Machine, DTC of Induction Machine, Vector Control of PMDC and BLDC machine, Sensorless Control.

## 7. Circuit Theory and Network Analysis & Synthesis

**Compulsory:** Network reduction: voltage and current division, source transformation – star delta conversion. Thevenin and Norton Theorems – Superposition Theorem – Maximum power transfer theorem – Reciprocity Theorem – Millman's theorem. A.C. circuits – Average and RMS value – Phasor Diagram – Power, Power Factor and Energy.- Analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced & unbalanced – phasor diagram of voltages and currents – power measurement in three phase circuits. Series and parallel resonance – their frequency response – Quality factor and Bandwidth – Self and mutual inductance – Coefficient of coupling – Tuned circuits – Single tuned circuits. Network solution methods: nodal, mesh analysis and different network theorems for ac circuits. Magnetically coupled circuits. Network topology. Time domain analysis of simple RLC circuits, Solution of network equation using Laplace transform. Frequency domain analysis of RLC circuits. 2-port network parameters: driving point and transfer functions. Passive filter as a two-port network. Fundamental of network synthesis.

**Optional:** Fourier series and transform. Synthesis of R-L-C function. Digital filter design techniques.

## 8. Microprocessor and Microcontrollers:

**Compulsory:** 8-bit microprocessor (8085): architecture, programming, memory and I/O interfacing; Data converters, ADCs and DACs, DMA, programmable peripheral interfaces; Semiconductor memories: ROM, SRAM, and DRAM; Interrupts

**Optional:** Microcontroller architectures, 8051, 8086, ARM, RISC, CISC, Pipelining, Real-Time Operating System, FPGA

## 9. High Voltage Engineering

**Compulsory:** Insulation as Gas, Liquid, Solid & Vacuum. Breakdown mechanism of Gases, Solids, Liquids, and Vacuum, Generation of High Voltage such as AC high voltage, DC High Voltage & Impulse High Voltage, Measurement of High Voltage. High Voltage Testing of High Voltage of Power Apparatus

**Optional:** Characteristics of Impulse Voltage, Insulation Coordination, Partial Discharge Testing. Dissolved Gas Analysis. Planning & Designing of High Voltage Laboratory. Automation of High Voltage Test Facilities.

## 10. Digital Signal Processing

**Optional:** Discrete time signals and systems, properties, convolution, analysis of discrete time systems in time-domain, Frequency domain representation of discrete time systems and signals, sampling theorem aliasing sampling of continuous time signals, Z- transforms, region of convergence, Z- transform theorems and properties, methods of Inverse Z- transforms, analysis of discrete time signals and systems in Z-domain, pole- zero plots, stability, Realization of FIR Systems and IIR systems.

## 11. Biomedical Signal and Image Processing

**Optional:** Introduction to Digital Signal Processing, Sampling and Reconstruction, Standard Discrete Time (DT) Signals, Concept of Digital Frequency, Signal Manipulations (shifting, reversal, scaling, addition, multiplication), Classification of Discrete-Time Signals, Classification of Discrete Systems, Fourier Transform, Fast Fourier Transform, Z Transform, Digital Filters, Digital Image Fundamentals, Digital Image Processing Systems, Sampling and Quantization, Representation of Digital Images, Image File Formats, Image Enhancement Techniques, Histogram Processing, Histogram equalization, Neighbourhood Processing, Spatial Filtering, Smoothing and Sharpening Filters, Median Filter. Basics of Biomedical and Medical Imaging Technology, Concept of 2D and 3D Images, Pixels and Voxels, Image Quality, Spatial Resolution, Temporal Resolution, Image Contrast, Biomedical Signals, Signal Acquisition and Image Formation, Introduction to XRay Radiograms, Fundamentals of X-Ray CT, MRI Images.

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