CONTROL SYSTEMS LABORATORY (20A02502P)

PREPARED BY

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VEMU IT

CONTROL SYSTEMS LABORATORY

VEMU INSTITUTE OF TECHNOLOGY

DEPT.OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF THE INSTITUTE

- To be a premier institute for professional education producing dynamic and vibrant force of technocrats with competent skills, innovative ideas and leadership qualities to serve the society with ethical and benevolent approach.

MISSION OF THE INSTITUTE

- To create a learning environment with state-of-the art infrastructure, well equipped laboratories, research facilities and qualified senior faculty to impart high quality technical education.
- To facilitate the learners to foster innovative ideas, inculcatecompetent research and consultancy skills through Industry-Institute Interaction.
- To develop hard work, honesty, leadership qualitiesand sense of direction in rural youth by providing value based education.

VISION OF THE DEPARTMENT

- To produce professionally deft and intellectually adept Electrical and Electronics Engineers and equip them with the latest technological skills, research & consultancy competencies along with social responsibility, ethics, Lifelong Learning and leadership qualities.

MISSION OF THE DEPARTMENT

- To produce competent Electrical and Electronics Engineers with strong core knowledge, design experience & exposure to research by providing quality teaching and learning environment.
- To train the students in emerging technologies through state - of - the art laboratories and thus bridge the gap between Industry and academia.
- To inculcate learners with interpersonal skills, team work, social values, leadership qualities and professional ethics for a holistic engineering professional practice through value based education.

PROGRAM EDUCATIONAL OBJECTIVES(PEOs)

Programme Educational Objectives (PEOs) of B.Tech (Electrical and Electronics Engineering) **program are:**

Within few years of graduation, the graduates will

PEO 1: Provide sound foundation in mathematics, science and engineering fundamentals to analyze, formulate and solve complex engineering problems.

PEO 2: Have multi-disciplinary Knowledge and innovative skills to design and develop Electrical & Electronics products and allied systems.

PEO 3: Acquire the latest technological skills and motivation to pursue higher studies leading to research.

PEO 4: Possess good communication skills, team spirit, ethics, modern tools usage and the life-long learning needed for a successful professional career.

PROGRAM OUTCOMES (POs)

PO-1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO-2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO-6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO-7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO-11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO-12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

On completion of the B.Tech. (Electrical and Electronics Engineering) degree, the graduates will be able to

PSO-1:Higher Education: Apply the fundamental knowledge of Mathematics, Science, Electrical and Electronics Engineering to pursue higher education in the areas of Electrical Circuits, Electrical Machines, Electrical Drives, Power Electronics, Control Systems and Power Systems.

PSO-2:Employment: Get employed in Public/Private sectors by applying the knowledge in the domains of design and operation of Electronic Systems, Microprocessor based control systems, Power systems, Energy auditing etc.

COURSE OUTCOMES

CO	Description
C317.1	**Determination** of transfer functions of DC servo motors.
C317.2	**Design** controllers and compensators
C317.3	**Understanding** the characteristics of Controller and Servo motor.
C317.4	**Apply** the knowledge of location of poles and zeros in transient and steady state behaviour of second order systems.
C317.5	**Determine** the performance and time domain specifications of first and second order systems.

LIST OF EXPERIMENTS

1) Time Response of Second order system
2) Characteristics of Synchros
3) Programmable Logic Controller – Study and verification of truth tables of logic gates, simple Boolean expressions and application of speed control of motor.
4) Effect of feedback on DC servo motor
5) Transfer function of DC Machine
6) Effect of P, PD, PI, PID controller on a second order system
7) Lag and Lead compensation – Magnitude and phase plot
8) Temperature controller using PID
9) Characteristics of magnetic amplifiers
10) Characteristics of AC servo motor
11) Simulation of op-Amp based Integrator and Differentiator Circuits
12) Linear system analysis (Time domain analysis, Error analysis) using Soft Tools.
13) Stability analysis (Bode, Root locus, Nyquist) of Linear Time Invariant system using MATLAB
14) State space model for classical transfer function using Soft Tools – Verification.
15) P, PI and PID controller design for Temperature control using Soft Tools.

Additional Experiments

1) Simulation of DC & AC Circuits using PSPICE
2) Simulation of Mesh Analysis using PSPICE

WHAT IS SERVO MOTOR?

- A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.
- Servomotors are not a specific class of motor although the term *servomotor* is often used to refer to a motor suitable for use in a closed-loop control system.
- Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

MECHANISM

- As the name suggests, a servomotor is a servomechanism. More specifically, it is a closed-loop servomechanism that uses position feedback to control its motion and final position.
- The input to its control is some signal, either analogue or digital, representing the position commanded for the output shaft.

- The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured.
- The measured position of the output is compared to the command position, the external input to the controller.
- If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position.
- As the positions approach, the error signal reduces to zero and the motor stops.

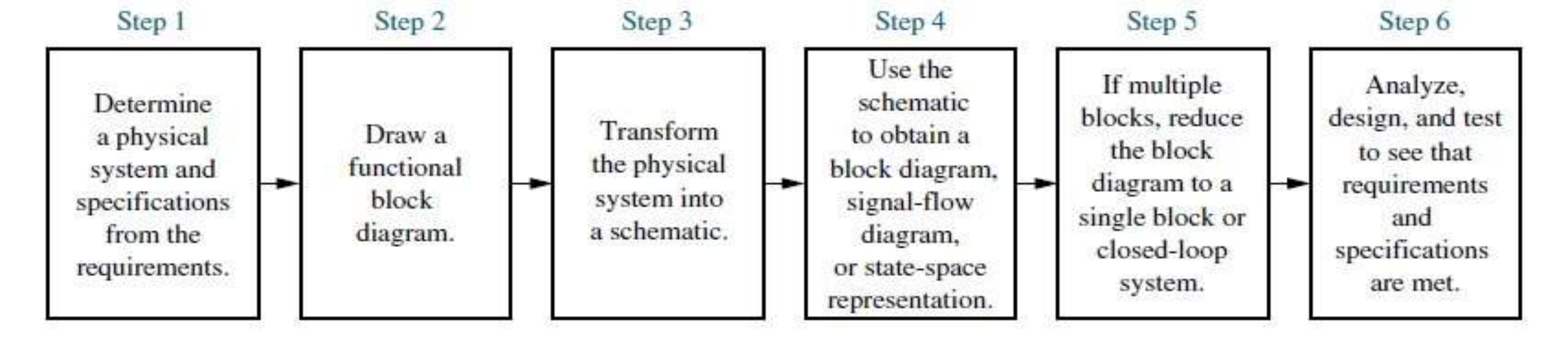
- The very simplest servomotors use position-only sensing via a potentiometer and bang-bang control of their motor; the motor always rotates at full speed (or is stopped). This type of servomotor is not widely used in industrial motion control, but it forms the basis of the simple and cheap servos used for radio-controlled models.
- More sophisticated servomotors measure both the position and also the speed of the output shaft. They may also control the speed of their motor, rather than always running at full speed. Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.

APPLICATIONS

- Machine Tool (Metal Cutting)
- Machine Tool (Metal forming)
- Antenna Positioning
- Packaging
- Woodworking
- Textiles
- Printing

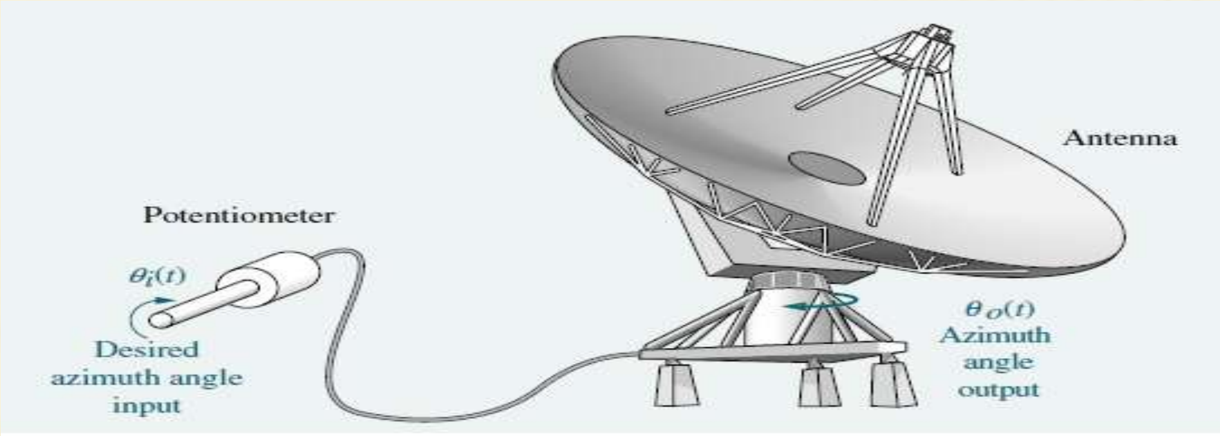
CONTROL SYSTEM DESIGN PROCESS

- An orderly sequence for the design of feedback control systems that will be followed.

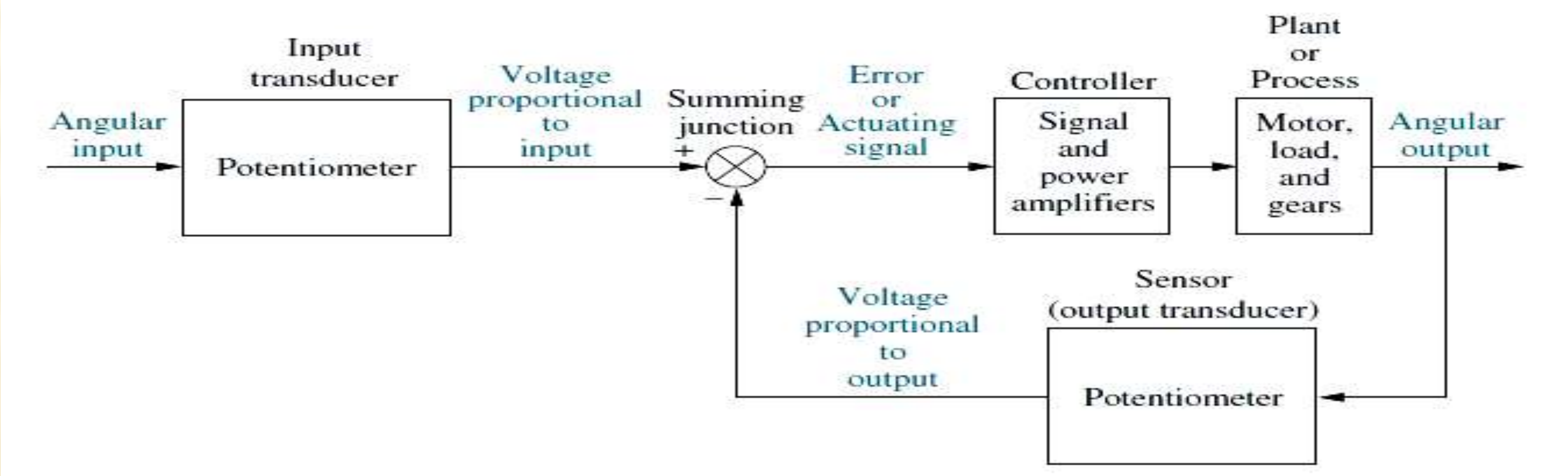


The control system design process

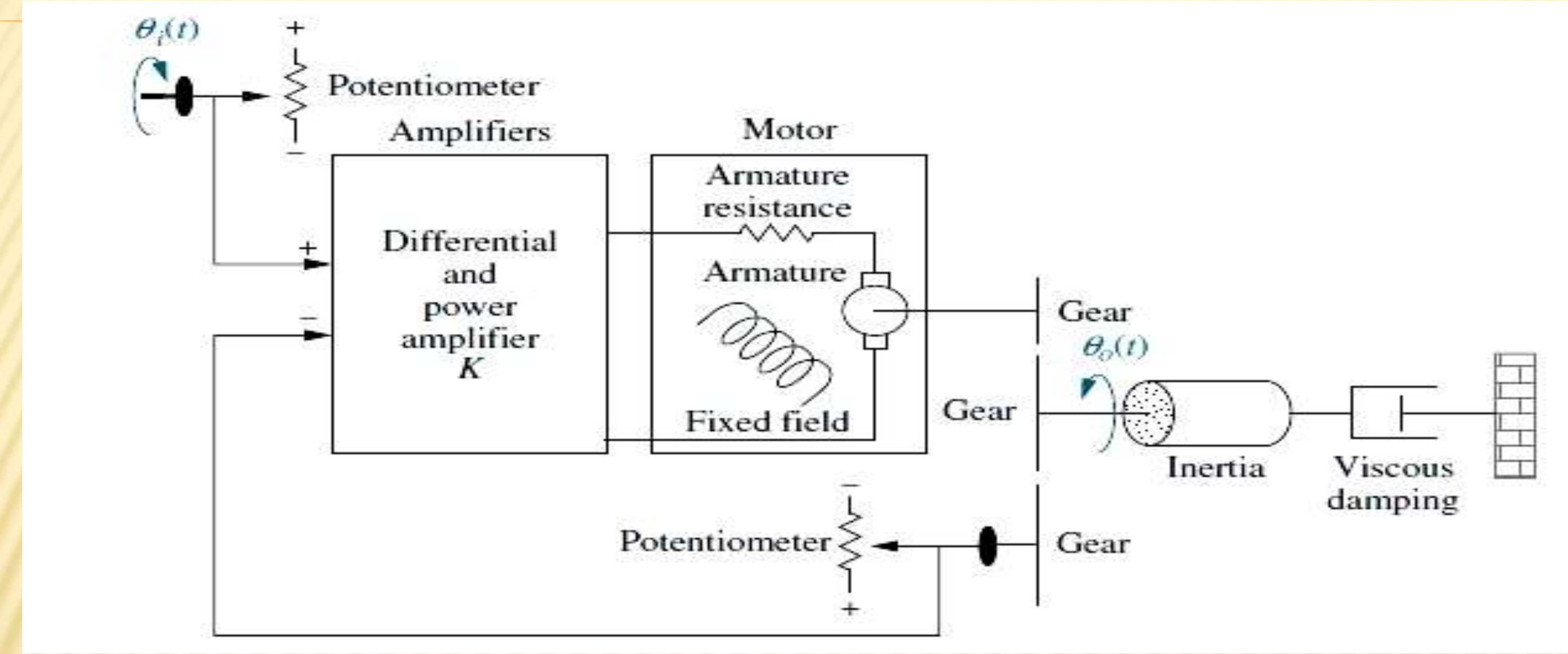
Step 1: Transform Requirements Into a Physical System



Step 2: Draw a Functional Block Diagram



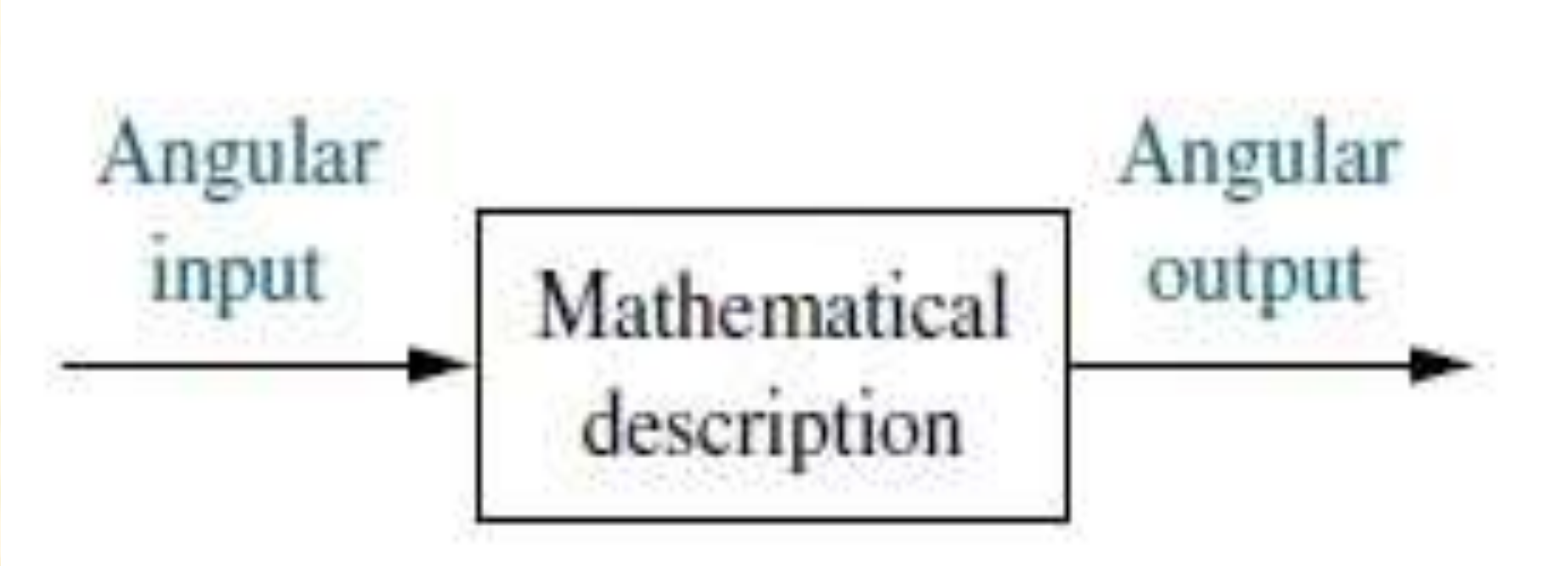
Step 3: Create a Schematic



Step 4: Develop a Mathematical Model (Block Diagram)

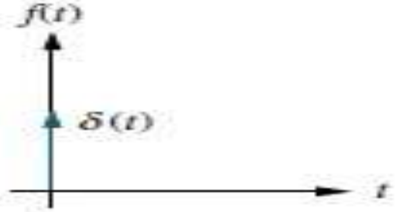
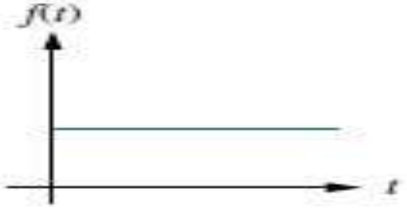
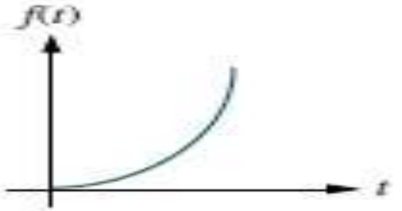
$$\frac{d^m c(t)}{dt^n} + d_{n-1}\frac{d^{m-1} c(t)}{dt^{n-1}} + \cdots + d_0 c(t) = b_m \frac{d^m r(t)}{dt^m} + b_{m-1}\frac{d^{m-1} r(t)}{dt^{m-1}} + \cdots + b_0 r(t)$$

Step 5: Reduce the Block Diagram



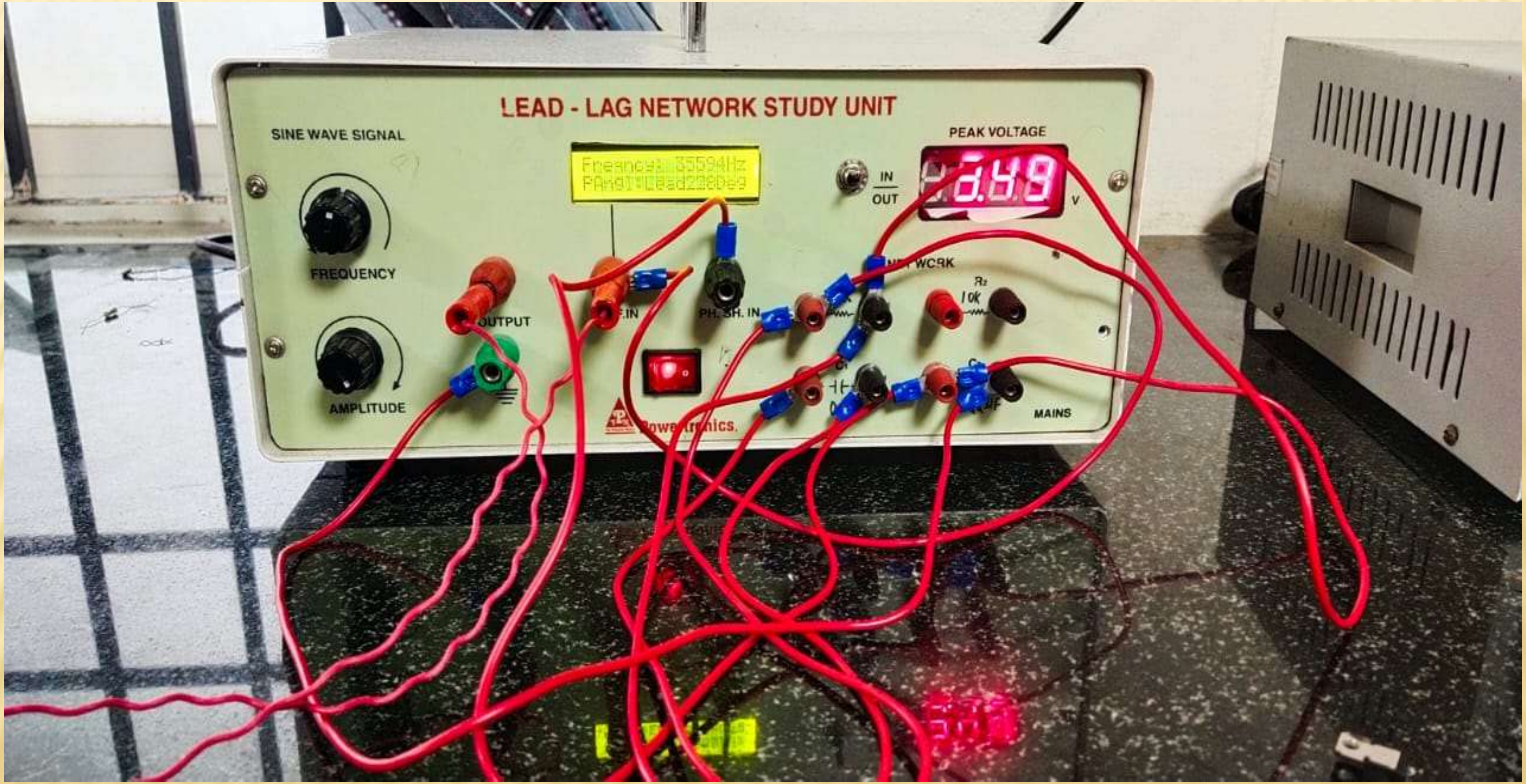
Step 6: Analyze and Design

The engineer usually selects standard test inputs to verify the design. These inputs are impulses, steps, ramps, parabolas, and sinusoids

Input	Function	Description	Sketch	Use
Impulse	$\delta(t)$	$\delta(t) = \infty$ for $0- < t < 0+$ $= 0$ elsewhere $\int_{0-}^{0+} \delta(t)dt = 1$		Transient response Modeling
Step	$u(t)$	$u(t) = 1$ for $t > 0$ $= 0$ for $t < 0$		Transient response Steady state error
Ramp	$tu(t)$	$tu(t) = t$ for $t \geq 0$ $= 0$ elsewhere		Steady state error
Parabola	$\frac{1}{2}t^2u(t)$	$\frac{1}{2}t^2u(t) = \frac{1}{2}t^2$ for $t \geq 0$ $= 0$ elsewhere		Steady state error
Sinusoid	$\sin \omega t$			Transient response Modeling Steady state error

Test waveforms used in control systems

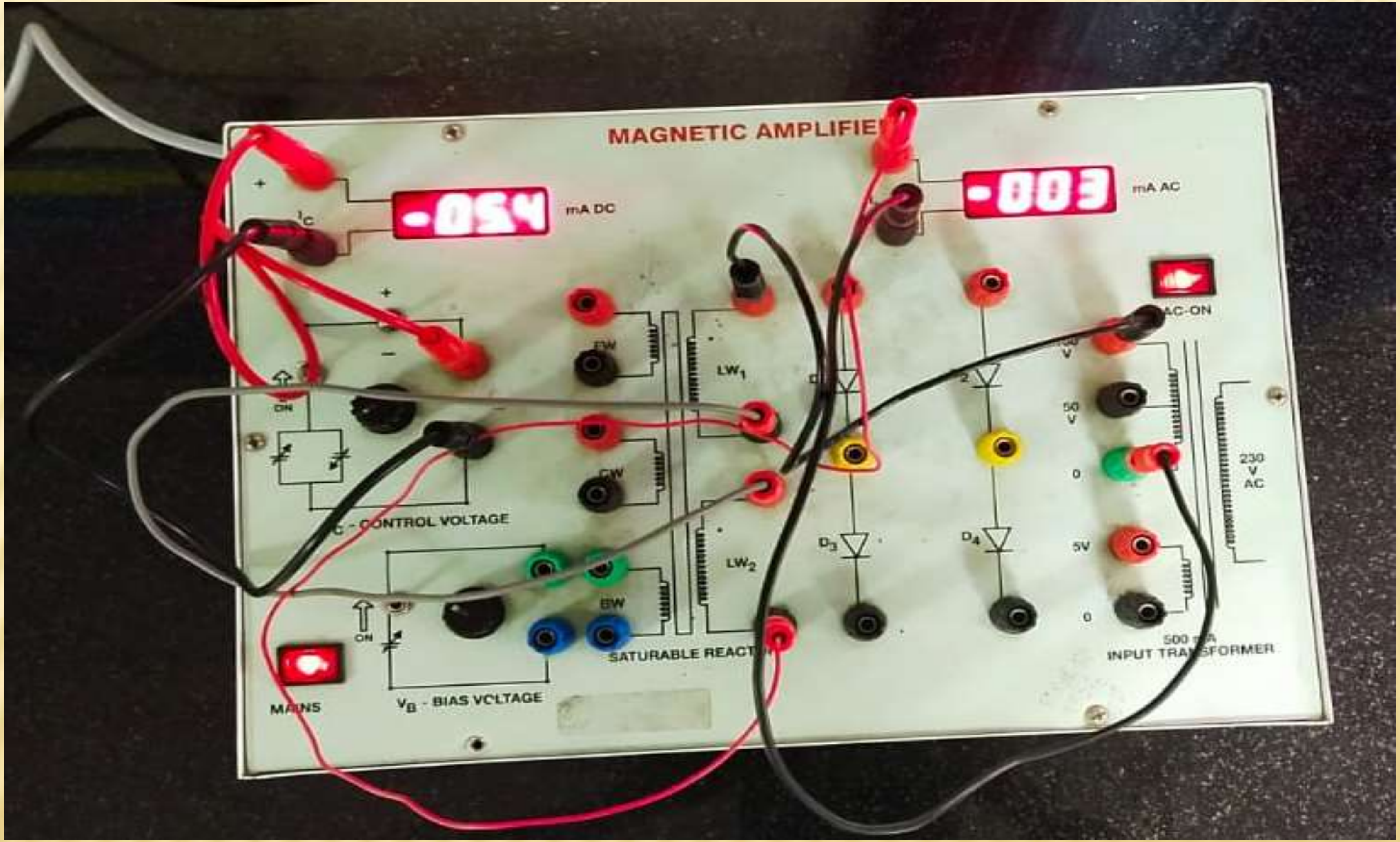
LAG AND LEAD COMPENSATION – MAGNITUDE AND PHASE PLOT



TEMPERATURE CONTROLLER USING PID

CHARACTERISTICS OF AC SERVO MOTOR

CHARACTERISTICS OF MAGNETIC AMPLIFIERS



EFFECT OF P, PD, PI, PID CONTROLLER ON A SECOND ORDER SYSTEM