Continuing Education Programs in

Automation, Instrumentation and Control

OFFERED BY

Control Automation Reliability Instrumentation Measurement Optimization (CARIMO)

Control Automation Reliability Instrumentation Measurement Optimization (CARIMO) Cell

Systems and Control Engineering Group

Indian Institute of Technology Bombay

Program Objectives

The objective of this program is to cover key facets of industrial technology, related to Automation, Control, Measurement, and Instrumentation. The program modules cover in depth fundamentals and high end technology.

The program can be targeted towards a particular industry. Application specific training approach will be followed in order to maintain the orientation, while preserving the interest of the participants.

Program Features

- Industry specific modules
- Practical relevance to work
- Knowledge as well as skill based approaches
- Exposure to state of the art technology

Program is Beneficial for

- Managers
- Engineering and Design Personnel
- Technicians
- ITI and Maintenance people
- Consulting Engineers

Various modules of the course have been offered to participants from top industries such as Bharat Petroleum, BHEL, Century Rayon, Cipla, Hindustan Petroleum, Indian Aluminum, Indian Oil, IPCL, ISPAT Steel industries, Klocner & Windsor, L & T, Lupin, Lubrizol, Mazgaon Dock, National Fertilizer, , Nuclear Power Corporation, ONGC, Ranbaxy, Reliance Industries, Suzlon. More than 700 participants benefitted from the courses.

Faculty

The faculty consists of renowned experts from academia and industry:

Prof. Dr. P. S. V. Nataraj

Coordinator-in-Chief

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Prof. Ravindra D. Gudi

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Mr. Vilas S. Chitnis

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Prof. Dr. Ajay V. Deshmukh,

Program Coordinator

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Program Modules

The program is a generic offer, and specific contents shall be mutually worked out for a particular Industry.

PART A: Practical PID Control

TOPICS INCLUDE:

1. Fundamentals of Control
2. Selection and Tuning of PID Controllers
3. Limitations of Single Loop PID Control
4. Cascade, Feedforward, and Ratio Control
5. PID Tuning Techniques for Multivariable plants
6. PID Control – Experimental Case Studies

PART B: Advanced Control

TOPICS INCLUDE:

1. Model Identification using Pulse and PRBS Testing
2. Advanced Compensation Methods
3. Internal Model Control
4. Nonlinear Control
5. Inferential Estimation and Soft Sensing
6. Performance Assessment of Control Loops

PART C: Automation in Process Control

TOPICS INCLUDE:

1. Programmable Logic Controllers
2. Introduction to Distributed Control System (DCS)
3. Configuration Software as per IEC-61131-3 Standard.
4. SCADA
5. MMI / HMI Programming
6. Industrial Communications and Communication Protocols.

Part D: Instrumentation, Measurement, and Configuration

TOPICS INCLUDE:

1. Temperature Measurement
2. Pressure Measurement
3. Flow Measurement
4. Level Measurement
5. Control loops for Flows, Levels, Pressures, Temperatures
6. Control loops for Heat Exchangers
7. Control loops for Distillation Columns
8. Control loops for Pumps and Compressors

9.

DETAILED COURSE CONTENTS

Detailed Course Contents of Part A: Practical PID Control

Module 1A: Fundamentals of Feedback Control

- Introductory Application – heater process
- Degrees of freedom analysis of heater process
- Feedback control scheme – block diagram, loop elements: controller, valve, etc.
- Steady state analysis of the heater process
- Effect of proportional control, integral control, derivative action.
- Steady state analysis – analytical approach, numerical approach to analyze the heater process
- Dynamic responses of a typical closed loop system – under P control, under PI control
- Appendix: Derivation of the steady state linear model for the heater process

Module 2A: Selection and Tuning of PID Controllers

- Tuning of PID Controllers- introduction
- Performing experiments on plants
- Open loop step test –fitting first order plus dead-time models

- The Relay feedback test
- Selection table for PID control, for dead-time compensation, for feedforward control
- Tuning controllers based on open loop, closed loop and relay feedback tests
- Tuning controllers using integral performance criteria- revised Zeigler-Nichols tuning
- Digital PID controllers – position algorithm, velocity algorithm
- Application illustrating effects of P, I, and D control
- Different PID algorithms – Idealized, Weighted reference PID, Modified Derivative action
- Parameter Optimized PID controllers

Module 3A: Limitations of Single Loop PID Control

- Processes with unfavorable dynamics - introduction
- Processes with multicapacity – Application to jacketed kettle system
- Processes with fast disturbances
- Processes with variable characteristics – Application to exothermic reactors
- Processes that are highly nonlinear – Application to Neutralization system (pH) loops
- Processes that are multivariable: Application to distillation column with multiple loops

Module 4A: Cascade, Feedforward, and Ratio Control

- Multicapacity processes – difficulty of control

- Cascade control- Application to jacketed kettle system
- Best conditions for implementation of cascade control
- Multiloop control – Application to cascade control of steam flow to reboiler
- Application to cascade control of heater exchanger
- Elimination of reset windup in primary controller of cascade loops
- Tuning of cascade PID controllers
- Ratio Control
- Feedforward Control – Application to distillation columns
- Dynamic Feedforward Compensation
- Realization of Feedforward control – static with lead-lag compensation
- Feedforward combined with Feedback Control – An Effective control strategy
- Feedforward –Feedback strategy – Application to distillation column
- Feedforward - Cascade- strategy - Application to boiler control
- Feedforward - Cascade-Selective Control : with Application

Module 5A: PID Tuning techniques for Multivariable plants

- Multivariable control – introduction
- Decentralized control
- PID Tuning techniques for multivariable plants – sequential and simultaneous loop tuning, concept of detuning factor.

Module 6A: PID Control – Experimental Case Studies

- Case Study 1: Design of PI Controllers for induction motor, Design of PI Controllers for brushless DC motor. Three loop control strategy for currents and speed loops. Lecture includes video recording of actual experiments performed in our controls laboratory.
- Case Study 2: Design of advanced robust controllers for vibration damping in 2 DOF flexible link system. Two loop control. Lecture includes video recording of actual experiments performed in our mechatronics laboratory.
- Case Study 3: Design of PID controllers for industrial plant emulator using relay feedback method. Design of single loop PID based on relay feedback method. Design of multivariable PID based on relay feedback method. Experiments cover six different tuning rules: Zeigler-Nichols, Atkinson-Davey, McAvoy-Johnson, Luo et al., Tan et al., and Blickley. Comparison of single-loop PID performance versus multiloop PID performance - error and control effort. Lecture includes video recording of actual experiments performed in our controls laboratory.

Detailed Course Contents of part B: Advanced Control

TOPICS INCLUDE:

- Model Identification using Pulse and PRBS Testing
- Advanced Compensation Methods
- Internal Model Control
- Nonlinear Control
- Inferential Estimation and Soft Sensing
- Performance Assessment of Control Loops

(Details will be provided later).

Detailed Course Contents of part C: Automation in Process Control

Module 1C: Programmable Logic Controllers

- Automation: Basic Concepts and Need
- Types of Processes and Automation Strategies.
- Requirements of Batch and Sequential control.
- Design of Relay Logics with electrical accessories.
- Sequencing, Interlocking and latching concepts.
- PLC working along with Hardware details.
- Programming of PLC as per IEC61131-3.
- Ladder Diagram and Functional Block diagram programming.
- HMI Programming along with alarms and displays.

Module 2C: Introduction to DCS

- DCS Introduction, functions, advantages and limitations
- DCS components and architecture
- Specifications of DCS
- Engineering and design details
- SCADA-DCS Interface

Module 3C: Configuration software as per IEC-61131-3 standard

- Types of Editors used for configuration software
- Functionalities of the Important “Function Blocks”
- Ladder programming

Module 4C: SCADA (Supervisory Control & Data Acquisition System)

- SCADA features
- SCADA architecture
- Alarms
- Events
- Trends
- Graphic generation
- Report generation
- Communication protocols
- Interface with PLC and DCS

Module 5C: MMI / HMI programming

- Working principle & types of HMI
- WinCE based HMI

Module 6C: Industrial Communications

- Introduction to Industrial Networking
- Distributed I/O, device-level networks

- TCP/IP and industrial Ethernet Implementations
- Wireless on plant-floors

Detailed Course Contents of Part D: Instrumentation, Measurement, and Control Loop Configurations

Module 1D: Instrumentation and Measurement for Industrial Systems

- Temperature Measurement
  - Basics of Temperature measurement, Temperature Standards
  - Temperature measurement based on Gas, Liquid and solid expansion
  - Thermo resistive: RTD, Thermisters: Specifications, Basic Calculations, and Selection, Bridge Circuits, Two wire, three wire and four wire connections
  - Thermoelectric Temperature Measurement: Thermocouples Basics, Types
  - Noncontact type Temperature Measurement
  - Real applications of temperature measurement
- Pressure Measurement
  - Basics of pressure measurement,
  - Elastic elements like Bourdon tube, Diaphragm, Bellows
  - Resistive measurements: Strain gauges

    - Pressure transmitters
    - Real applications of pressure measurements
- Flow Measurement
    - Flow measurement basics
    - Obstruction type: Orifice, Venturi, flow Nozzles, Differential pressure measurement: DP Transmitter, Flow calculations and Signal Conditioning
    - Variable area type: Rotameter
    - Electromagnetic flow meter, Vortex flowmeter, Ultrasonic flowmeter,
    - Specifications, selection of flowmeter
    - Real applications of flow measurements
- Level Measurement
    - Basics of level measurement
    - Types of level gauges
    - Specifications of level gauges
    - Noncontact type level measurement
    - Level measurement for solids

Module 2D: Unit Operations and Control Loop Configurations in Industries

- Control loops for Heat Exchangers
    - Basics of heat transfer process by conduction,

    - Typical Heat exchanger equipment, Parallel flow, Counter flow and Cross flow type, Shell and Tube type heat exchangers, Plate Type Heat Exchangers,
    - Heat Transfer Coefficient, LMTD, Capacity and Effectiveness of heat exchangers,
- Distillation Columns
    - Basics of Distillation process, Flash Distillation of binary mixtures, Distillation with reflux, Stripping and rectification, Batch and Continuous Distillation, Example of Crude oil distillation
    - Vapor and Liquid dynamics, Material and Energy balances, Steady state behavior,
    - Control of Distillation Process: Reflux control, Control of Overheads and Bottoms, Multivariable and Cascade and Feed forward control loops for Distillation Column Control.
- Control loops for Pumps and Compressors
    - Pumps:
        - Basic Hydraulics, Types of Pumps, Specifications, Selection criteria,
        - Terminology: Head, Suction lift and capitation, NPSH,
        - Construction and Operation of Different Types of Pumps: Centrifugal, Reciprocating and Rotary pumps, Single Stage and Multistage pumps,
        - Pump performance, power requirements, efficiency
        - Pump Characteristics, Pump control requirement

- Compressors:
  - Basic thermodynamics of Air and Gas Compression, Types of compressors: Reciprocating, Screw Compressors, Centrifugal compressors, Construction, Operation and maintenance, Characteristics of Compressor: Specifications, and Selection of compressors, Comparison of air compressors.
  - Control System for Compressors: Control Requirement, Anti-Surge Computerized Control, Capacity control, Noise and Sound reduction in compressors

Eligibility

Engineering graduates

Diploma Engineers with some field experience

Science postgraduates working in industry

Certificate

A participant completing the program shall be eligible for a participation certificate issued by IIT Bombay.

For specially designed courses, a participant completing the program successfully shall be eligible for a ‘successful completion’ certificate issued by IIT Bombay.

Terms and Conditions

If the program is to be conducted on company premises, the concerned industry shall provide the classroom, LCD projector, required number of copies of the course materials, and computers. In addition, the concerned industry shall provide for travel, stay, and local hospitality of the course faculty and associates. On the other hand, if the program conducted on IITB campus, the lodging and boarding charges for the participants and expenditure towards sponsored participants shall be taken care of by the concerned industry.

Contact

For further details regarding the course, please contact

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Faculty Profiles

Prof. Paluri S. V. Nataraj is currently the Chairman and Professor of Systems and Control Engg Group at IIT Bombay. He obtained his Ph.D. from IIT Madras in process dynamics and control in 1987. He then worked in the CAD center at IIT Bombay, India for about one and half years before joining the faculty of the Systems and Control Engineering Group at IIT Bombay in 1988.

His current research interests are in the areas of Chemical Process Control, Optimization, Robust Stability and Control, Nonlinear System Analysis and Control, and Reliable Computing. He has guided more than 100 Masters and doctoral students in these areas, and published more than 100 papers in leading international journals and conferences. He is an editor of two international journals - International Journal of Automation and Control (Inderscience), and Opsearch (Springer).

He was invited as a “very high quality professor” by Spain in 2004-2005, and gave numerous invited talks in North and South America, Europe, and Africa in areas such as optimization, reliable computing, and control. Some of his papers received the best paper award at international conferences. In particular, his paper received the NASA / US Navy commendation and memento for the “Best Applied Research paper” at the International Symposium on Air Breathing Engines (ISOABE), Cleveland, Ohio, in 2003.

Prof. Nataraj was the chairman or co-chairman of several international conferences sponsored by IEEE and other societies. He also chaired and co-chaired several sessions in various international conferences in India and abroad.

Prof. Nataraj has given many control related courses to various industries and organizations, such as BHEL, L &T, ONGC, Reliance, Nuclear Power Corporation, and Defense Research organizations. He worked on several projects for the Aerospace, Nuclear, Defense organizations, and Chemical industries. He also worked on the Technology development mission project "Integrated Design and Competitive Manufacturing (IDCM)", for the Indian planning commission.

Prof. Ravindra Gudi is currently Professor in the Department of Chemical Engineering at IIT Bombay. His main research interests are in the areas of Optimization, Process Control, Fault Detection and Diagnosis, and System Identification.

Mr. Vilas Shripad Chitnis is currently the Vice-President and CEO of Control & Solutions (India) Pvt Ltd (CSIL). Mr. Chitnis has more than 25 years of experience in the field of instrumentation and process control. He holds a BE in instrumentation from Pune University.

Mr. Chitnis started his career as the Maintenance Manager in Rashtriya Chemical and Fertilizers (RCF) and commissioned several Distributed Control Systems while working through their Project Management Department. During his tenure in RCF, he was also associated with their training activities. He then moved to Emerson Process Control (Emerson is a Fortune 500 company) as the General Manager and head of the DCS and PLC divisions. He later became the Vice-President of Emerson Network Power.

While at Emerson, Mr. Chitnis started the Emerson Export Engineering Center in Pune for world wide placements. This center became very successful, and today generates large revenues for Emerson. He also successfully promoted the DCS business of Emerson (RS-3, Provox and Delta-V) in India with support from Singapore. He also implemented the business plan for Emerson Network power, and started a new manufacturing facility in Thane for UPS and Precision Air-conditioning. He successfully executed several turnkey projects on DCS and PLC, SCADA based projects for process industries, power distribution, terminal automation, pipeline SCADA, substation automation, and GSM based controls.

Through his present company CSIL, Mr. Chitnis has initiated several new activities through international collaborations in the field of Automation, Embedded Technology, Electrical Distribution Systems, Terminal Automation and Pipeline SCADA. CSIL is a well-known knowledge-based company in the field of automation of process Industries, providing consultancy and training for total automation, as well as cost effective solutions for integrated management for process control and project engineering.

Mr. Chitnis has also made significant contributions to training and education. He started the “Finishing School of Automation” with VIT Engineering college and DY Patil engineering college. The finishing school is basically for graduate students aspiring for jobs in multinational companies. During his tenure at RCF, he started a diploma college in Chemical,

Instrumentation, Electrical, and Mechanical Engineering. He developed computer based training (CBT) programs on Field Bus, PLC configuration, Microcontrollers, and SCADA.

He is a visiting faculty of College of Engg Pune, VIT Pune, DY Patil College of Engg Pune, IDEMI institute, IAEC, and a guest faculty of CARIMO Cell of IIT Bombay. He served as a member of the board of studies for Mumbai and Pune universities in the areas of instrumentation and control.

Mr. Chitnis has conducted more than fifty courses for various industries on Distributed Control Systems and PLCs, SCADA and its applications, Microprocessors and Microcontrollers, and instrumentation courses for measurement and control. Some of these industries are Indian Oil Corporation, Oil and Natural Gas Corporation, Lupin, Lubrizol, National Fertilizer, ISPAT Steel industries, Bharat Petroleum, Hindustan Petroleum, Cipla, Ranbaxy, Reliance Industries, Mazgaon Dock, Klocner & Windsor, Indian Aluminum company, and Century Rayon.

Mr. Chitnis is a senior member of ISA, and senior member of the Instrument Expert Club (IEC) Mumbai. He is also on the management committee of IEC.

Prof. Ajay V. Deshmukh is currently a Professor of Instrumentation and Control at the Cummins College of Engineering, Pune. Earlier, he was the Professor and head of the Department of Instrumentation Engineering at the Vishwakarma Institute of Technology, Pune. He has more than 18 years of teaching and research experience. He has authored a book “Microcontrollers: Theory and Applications”, McGraw-Hill (2005), that is being referred as a text in many universities in India and abroad. The book covers microcontrollers and their industry applications. He also recently published a research monograph “Functional MRI: Novel Transform Methods”, Narosa (2008). His current areas of interest are Instrumentation and Control, Measurements and Process Instrumentation, Signal Processing, Embedded systems, Microcontrollers, and Magnetic Resonance Imaging.

Prof. Deshmukh obtained his Ph.D. from IIT Bombay, India in 2006. As a part of his doctoral research, he worked on “Novel Transform methods in Magnetic Resonance Imaging”. He obtained his Master and Bachelor of Engineering degrees in Instrumentation Engineering from SGGSCE&T Nanded.

Prof. Deshmukh is a member of several societies: Indian Nuclear society of India (INS), National Magnetic Resonance Society of India (NMRS), Instrumentation Systems and Automation Society of India (ISA), Instruments Society of India (ISOI), Indian Society for Technical

Education (ISTE) and Biomedical Society of India (BMESI). He is currently the secretary of ISA, Pune section.

Prof. Deshmukh has conducted several training programs on instrumentation, measurement, and embedded systems to participants from various industries, such as Suzlon, L & T, IPCL, etc. The number of participants trained is more than 250. He has presented more than 25 special lectures at various institutes in India. As a part of Instrumentation Systems and Automation Society (ISA) Pune activities he has visited many industries in and around Pune along with groups of faculty members that includes Honeywell Automation India ltd, Forbes Matshall Pune, Virgo Engineers, Emerson etc.