Dr. A.P.J. Abdul Kalam Technical University, Uttar Pradesh, Lucknow

SYLLABUS

FOR

M.TECH. (Automation and Robotics)

[Effective from the Session:2016-17]
### SEMESTER-I

<table>
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<tr>
<th>S.No</th>
<th>Subject Code</th>
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**Departmental Elective-1:**
- MTAR 011: Introduction to Mechanical Engineering
- MTAR 012: Introduction to Electronics & Electrical Engineering

**Departmental Elective-2:**
- MTAR 021: Sensors Application in Manufacturing
- MTAR 022: Microprocessor & Microcontroller
- MTAR 023: Mechatronics
- MTME 011: CAD/CAM

### SEMESTER-II

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**Departmental Elective– III:**
- MTAR 031: Virtual Instrumentation
- MTAR 032: Artificial Intelligence & Expert System in Automation
- MTAR 033: Robotics & Control
- MTAR 034: Simulation, Modeling & Analysis

**Departmental Elective-IV:**
- MTAR 041: Pneumatic & Hydraulic Control
- MTAR 042: Process Control & Automation
- MTAR 043: Design of Mechanisms and Manipulators
- MTME 041: Optimization Techniques & Design of Experiments

**Departmental Elective-V:**
- MTAR 051: Numerical Methods & Computer Programming
- MTME 051: Flexible Manufacturing Systems
- MTME 052: Machine Vision
- MTME 053: Additive Manufacturing & Tooling

### SEMESTER - III

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**Note:** The Dissertation Work for M.Tech consists of Dissertation Work – I and Dissertation Work–II. Students are required to undertake research work related to latest developments in the field of Automation & Robotics with multidisciplinary background and innovative concept. For students desirous of seeking career in industry, may take up industry sponsored projects or application oriented project i.e developing a complex application which does not already exit, or by enhancing some existing application or method to improve its functionality, performance for immediate use of industry, as equivalent to the theoretical research work towards M.Tech dissertation.
MTAR-101  INDUSTRIAL AUTOMATION 3 Credits


PLC: Introduction, Micro PLC, Programming a PLC, Logic Functions, Input & Output Modules, PLC Processors, PLC Instructions, Documenting a PLC System, Timer & Counter Instructions, Comparison & Data Handling Instructions, Sequencing Instructions, Mask Data Representation, Typical PLC Programming Exercises for Industrial Applications.

Text Books / References:
2. “Computer Based Industrial Control” – Krishna Kant, EEE-PHI


Text Books / References:

MTAR-011 INTRODUCTION TO MECHANICAL ENGINEERING  3Credits


Theory and principles of design of couplings, clutches, brakes, belt and chain drives, spur, helical, bevel and worm gear drives. Lubrication Systems.


Text Books / References:

Basic Electronics-Diode, Transistor Biasing and Introduction to experimental mode of transistor (Low frequency and high frequency analysis), Operation amplifiers-Application of operational amplifier characteristics and equivalent circuits, Power amplifier: Class A, Class B, Class C, Class AB efficiency calculation and heat sinks, Feedback amplifiers-Advantages, disadvantages, Classification (positive and negative feedback), V & I feedback.

Oscillators-PC phase shift, LC Wein bridge & crystal, Digital- Number system, Boolean algebra, Gates, K-map, sequential circuits, Brief introduction of-Transformer, motors AC/DC, Solid state devices- SCR, IGBT, Converters & Invertors, Variable speed drives (AC & DC), Transducers.

Books:
1. Integrated Electronics MillmanHalkias Tata McGraw-Hill
3. Operational Amplifier-Linear Integrated Circuits Gayakwad Prentice Hall India
4. Power Electronics Mohammad H. Rasid Prentice Hall India
5. Electrical and Electronics Measurement &
   Instrumentation A.K. Sawhney DhanpatRai& Sons
M.TECH – AUTOMATION& ROBOTICS

Departmental Elective- II

MTAR - 021 SENSORS APPLICATIONS IN MANUFACTURING 3 Credits

Unit I


Unit II

Sensors and their applications: Inductive, capacitive, magnetic, various types of photo sensors, detection methods, through-beam detection, reflex detection & proximity detection, ultrasonic and microwave sensors. Applications and understanding of the above sensors.

Unit III

Advanced Sensor Technologies: Laser production, characteristics of lasers, types of laser sensors, bar code sensors, benefits of bar coding, transponder, RFID (Radio Frequency Identification), electromagnetic identifier, optical encoders, color sensors, sensing principles, color theory, unit color measurement, colour comparator, color sensing algorithm, fuzzy logic color sensor. Fuzzy logic for opt-electronic colour sensor in manufacturing.

Sensors in Flexible Manufacturing Systems: Vision sensors, image transformations, robot visual sensing tasks, detecting partially visible objects, sensors in flexible manufacturing

Unit VI

Networking: Networking of sensors, control of manufacturing process, tracking - the meantime between operations interventions, tracking the yield and mean process time, detection of machining faults, diagnostic systems, resonance vibration analyzer, sensing motor current for signature analysis, temperature sensing.

Unit V

Sensors for Special Applications: A multi objective approach for selection of sensors in manufacturing, cryogenic manufacturing applications, semiconductor absorption sensors, semiconductor temperature detector using photoluminescence temperature detectors using point-contact, sensors in process manufacturing plants, measurement of high temperature, robot control through sensors, other sensors, collection and generation of process signals in decentralized manufacturing system.

References:
1. Sensor Technology Handbook by Jon S. Wilson
2. N.L.Buck&T.G.Buckwith, Mechanical measurement.
3. Sensors and Transducers by Ian Sinclair

Text Books:

8087 Numerical processor and its interfacing with 8086. Introduction to 8051 micro-controller family: Pin description of 8051 and its internal structure, connections of I/O ports and Memory organization Addressing mode. Instruction set & its format and simple programs. Atmel micro-controller 89C51 and 89C2051.

Introduction to 8096/8097 family and essential difference with 8051.

Applications of microprocessors and micro-controller

**Text Books / References:**

1. D V Hall, Microprocessor and It’s Applications, TMH.
2. B.B. Bray, The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium pro processor, architecture, programming and interfacing, PHI India.
4. James L. Antonakos, The Pentium Microprocessor, Pearson Education
Mathematical Elements, CAD, Solid modeling methods, Database structures for CAD, CSG formulation, B-rep and wire frame methods, Intersection surface generation methods, Boundary file generation methods, Feature based modeling systems, Surface modeling, B- splines, Coons and Bezier surfaces, NURBS and surface patches, fitting surfaces for arbitrary digested points, Offset surfaces, Fillet surfaces, Sewn surfaces.
Features recognition from the databases, IGES, STEP, PDES, and DXF data exchange formats, Graphic standards for CAD/CAM such as GKS, PHIGS and VDI.

Concurrent engineering integration of manufacturing principles and analytical principles in design, Manufacturing information generation from CAD data, Planar sectioning, Penalty functions, cavity milling, Optimization of cutter path, Effect of tool profile geometry, Methods for multi-axis machining, Methods for software design for CAD/CAM system, use of software libraries, Development of software package for a specific problem as part of course using software libraries.

Introduction to automation, CAM/CIM, Part programming, Interpolator & Control.

Books:

2. CAD/CAM Theory and Practice Ibrahim Zeid & R Sivasubramanian Tata McGraw-Hill
4. Computer Aided Engineering & Design Jim Browne New ATC International
5. The Engineering Database D.N. Chorafas and S.J. Legg Butterworths
7. CAD/CAM H P Groover and E W Zimmers Prentice Hall
Its elements – such as mechanics, electronics, microelectronics, power electronics and information technologies.

Mechanical elements with integrated electronics, suspension systems, vibration dampers, clutches, bearings – mechanical / magnetic, gears etc. Micro-motors dc-micro motors, PCB motors, disc motors, reluctance motors, PM motors(Materials, design &construction), Brushless motors, stepper motors, universal motors, aerial field motors, Induction motors and synchronous motors.

Applications to Tele-communication technology equipment, computer printers actuators consumer products such as cameras, camcorder, timers, clock, VCR, wipers, fax machines, recorders.

Text Books / References:
1. Bolten, “Mechatronics”
Unit I


Unit II

Industrials Drives: DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects, electric braking, rheostatic and regenerative braking principles in power converters.

Unit III

Motion laws for rotary and linear systems: converting rotary to linear system, concepts and principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches of Robots, Control loops using Current amplifier.

Unit IV

Introduction to Programmable Logic Controllers: Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing’s, types of variables, definition of firmware, software, programming software tool and interfacing with PC (RS232 & TCP-IP), methods of PLC programming (LD, ST, FBD & SFC), function blocks logical / mathematical operators & data types, array & data structure, PID, types of tasks and configuration, difference between relay logic and PLC, selection of PLC controller.

Unit V

Logic, instructions & Application of PLC: What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and
down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems, Types of visualization system, PC based Controller, Applications of HMI’s, and Interfacing of HMI with

Text Books:
2. Andrew Parr, Industrial drives, Butterworth – Heineamann
4. Programmable Logic Controllers by W.Bolton

References:
2. Instrumentation Engineers Hand Book - Process Control, Bela G Liptak, Chilton book company, Pennsylvania
5. Programmable Logic Controllers by Hugh Jack.


**OOP’s features for Automation:** Templates and Exceptions, C++ Input and output concepts, OOPS for Automation. Introduction to JAVA Features of JAVA, OOPS through JAVA.


Database Design: Relational Database, Logical Database Design, Data Base Models, DBMS Languages and Interfaces. Data Base Security and Authorization, Data Ware House.


**Operating System Structures:** Operating System Components and Services & brief discussion about protocols-FTP, TCP/IP & HTTP.

**Text Books / References:**
5. Object Oriented Programming with C++ - E. Balaguruswamy, TMH.
6. Object Oriented Programming with C++ - Robert Lafore, PHI
7. Operating Systems-A concept based approach”, D M Dhamdhere, TMH
8. Internet Working with TCP/IP – Douglas, PHI
9. Introduction to DBMS – Date C.J. Addison Wesley
UNIT- I  
**Virtual Instrumentation: An introduction**
Historical perspective, advantages, block diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems.

UNIT- II  
**VI programming techniques:**
VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O, Instrument Drivers, Publishing measurement data in the web.

UNIT- III  
**Data acquisition basics:**
Introduction to data acquisition on PC, Sampling fundamentals, Input/Output techniques and buses. ADC, DAC, Digital I/O, counters and timers, DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements.

UNIT- IV  
**VI Interface requirements:**
Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. Bus Interfaces: USB, PCMCIA, VXI, SCSI, PCI, PXI, Firewire. PXI system controllers, Ethernet control of PXI. Networking basics for office & Industrial applications, VISA and IVI.

UNIT- V  
**VI toolsets:**
Distributed I/O modules. Application of Virtual Instrumentation: Instrument Control, Development of process database management system, Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control.

**TEXTBOOKS**

**REFERENCES**
1. PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Kevin James, Newnes, 2000.
Expert system: Architecture, knowledge base, inference engine, expert system shell, applications. Fuzzy Logic: Fuzzy sets, membership functions, operation on fuzzy sets; fuzzy control system, Fuzzyfication, knowledge base, inference, defuzzification, application.

Neural Network: Neuron structure, classification, artificial neural network, back propagation training and algorithm, neuro-fuzzy controllers, applications.

Genetic algorithms: Concepts, encoding and selection methods, genetic operators (crossover and Mutation), applications.

Text Books / References:

1. Haykin “Neural Networks – A comprehensive Foundation” (Mc-millan)
2. J.M. Zureda “Introduction to artificial neural networks” (Jaico)
3. A Cichocki& R Unbehauen “Neural Networks for optimization and signal Processing” John Wiley
4. George J. Klin& Tina A Polgar “Fuzzy sets, uncertainty and Information”
5. BaertKosko “Neural network and fuzzy systems”
6. Peterson “Introduction to Artificial Intelligence and expert system (PHI)
7. Michell “Introduction to Genetic Algorithm” (PHI)
8. Vidyasagar M “Theory of learning and generalization” Springer
Introduction: Definition, Classification of Robots, Geometric classification and control classification.

Robot Elements: Drive systems, Control systems, sensors, End effectors, Gripper actuators and gripper design.

Robot Coordinate Systems and Manipulator Kinematics: Robot co-ordinate system representation, Transformation, Homogeneous transforms and its inverse, Relating the robot to its world.

Manipulators Kinematics, Parameters of links and joints, Kinematic chains, Dynamics of kinematic chains, Trajectory planning and control, Advanced techniques of kinematics and dynamics of mechanical systems, Parallel actuated and closed loop manipulators.

Robot Control: Fundamental principles, Classification, Position, path and speed control systems, adaptive control.

Robot Programming: Level of robot programming, Language based programming, task level programming, Robot programming synthesis, robot programming for foundry, press work and heat treatment, welding, machine tools, material handling, warehousing assembly, etc., automatic storage and retrieval system, Robot economics and safety, Robot integration with CAD/CAM/CIM, Collision free motion planning

Books:
   An Introduction to Robot Coiffet and Chirooza Kogan Page
2. Technology Robotics for YKoren McGraw Hill
   Engineers McGraw Hill
3. Robotics K.S. Fu, R.C. Gonzalez & CSG Lee International
   Robotics J.J. Craig Addison-Wesley
   Robots & Manufacturing
5. Automation Asfahl Wiley Eastern
Introduction: A review of basic probability and statistics, random variables and their properties, Estimation of means variances and correlation.

Physical Modelling: Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, advantages of simulation


System Dynamics: Growth and Decay models, Logistic curves, System dynamics diagrams.

Simulation of Manufacturing Systems: Simulation of waiting line systems, Job shop with material handling and Flexible manufacturing systems, Simulation software for manufacturing, Case studies.

Books:
4. Modelling and Analysis of Dynamic Systems  Charles M Close and Dean K. Frederick  Houghton Mifflin
5. Simulation of manufacturing  Allan Carrie             John Wiley & Sons
MTAR-041          PNEUMATIC AND HYDRAULIC CONTROL

3 Credits

Introduction to control system, Types of control system and their utility. Hydraulic power generation and transmission, valve control pressure flow relationship for hydraulic valves, valve configurations and constructions, steady state operating forces, transient forces and valve instability. Circuit design, Pneumatic valves, Hydraulic and pneumatic drives.


Physical concepts of pneumatics and electicals. Electropneumatic components operation and application interpretation of electric ladder diagram.

P.PI & PID – controllers & applications.

Text Books / References:

8. Hydraulic Control of Machine Tools by Khaimovich, Pergamon Press Ltd. 196
Process Modeling- Introduction to Process control and process instrumentation-Hierarchies in process control systems-Theoretical models-Transfer function-State space models-Time series models-Development of empirical models from process data-chemical reactor modeling-. Analysis using softwares

Feedback & Feedforward Control- Feedback controllers-PID design, tuning, trouble shooting-Cascade control- Selective control loops-Ratio control-Control system design based on Frequency response Analysis-Direct digital design-Feedforward and ratio control-State feedback control- LQR problem-Pole placement -Simulation using softwares-Control system instrumentation-Control valves- Codes and standards- Preparation of P&I Diagrams.

Advanced process control-Multi-loop and multivariable control-Process Interactions-Singular value analysis-tuning of multi loop PID control systems-decoupling control-strategies for reducing control loop interactions-Real-time optimization-Simulation using softwares

Model predictive control-Batch Process control-Plant-wide control & monitoring- Plant wide control design- Instrumentation for process monitoring-Statistical process control-Introduction to Fuzzy Logic in Process Control-Introduction to OPC-Introduction to environmental issues and sustainable development relating to process industries. Comparison of performance different types of control with examples on softwares

References

5. Macari Emir Joe and Michael F Saunders, Environmental Quality Innovative Technologies


DYNAMIC PROGRAMMING: Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.


STOCHASTIC PROGRAMMING: Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming.

REFERENCES:

1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan& Kumar/Springar
4. Operation Research/H.A. Taha/TMH
5. Optimization in operations research/R.L Rardin.
Mobility analysis, Degree of Freedom (DOF), Mixed Mobility, Total, Partial and Fractional DOF, Closed and Open Chain Systems, Application of D-H representation for 1) Kinematic parameter tables for standard robot structures like.

Link coordinate diagram and arm matrix of SCARA, Alpha-II, PUMA articulated robot, standard robot, polar frame, structure robot, Enter transform solution, Arm matrix of standard Robots, Polar frame, structure robots.

Structural Analysis and Synthesis of mechanisms, Alternative design solutions; Coding, evaluation and selection of optimum mechanism. Type synthesis, number synthesis and design of mechanisms. Indexes of merit; Graphical, Algebraic and Optimization techniques, Matrix methods of design and analysis; Design of function, Path and Motion Generators; Structural and Mechanical error; Design and Analysis using software like ADAMS.

Manipulators- Classifications, actuation and transmission systems; Coordinate Transformation – DH notations, Inverse and Forward kinematics, Manipulator dynamics from Lagrangian and Newtonian point of view.

Forces in Manipulator, manipulate Dynamics, selecting of robots for Robot Application Reliability of Robotic & Automation systems and their evaluation.

Text Books / References:
MTME 051  FLEXIBLE MANUFACTURING SYSTEM  3 Credits

**Introduction:** FMS definition and classification of manufacturing systems, automated production cycle, Need offlexibility, Concept of flexibility, Types of flexibilities and its measurement.

**FMS Equipment:** Why FMS, Factors responsible for the growth of FMS, FMS types and applications, Economic justification for FMS, Functional requirements for FMS equipments, FMS processing and QA equipment, e.g., turning and machining centers, Co-ordinate measuring machines, Cleaning and deburring machines, FMS system support equipment, Automated material handling and storage equipment, cutting tool and tool management, Work holding considerations, Fixture considerations in FMS environment.

**Group Technology:** GT concepts, Advantages of GT, Part family formation-coding and classification systems; Part-machine group analysis, Methods for cell formation, Use of different algorithms, mathematical programming and graph theoretic model approach for part grouping, Cellular Vs FMS production.

**FMS related problem and Solution Methodology:**
- FMS design problems: Part assignment, Machine selection, Storage system selection, Selection of pallets and fixtures, Selection of computer hardware and software, designing for layout integration of machine storage, Material handling System and computer system, Communication networks.
- FMS Implementation: Objectives, acceptance testing, Performance goals and expectation maintenance concerns.

**Books:**

1. Integrated Manufacturing  
   Groover  
   Englewood
2. Design and Operation of SMS  
   Rankey  
   IFS
3. Flexible Manufacturing System  
   Wernecks  
   Spring-Verlag
4. FMS in Practice  
   Bonetto  
   Northox Ford
5. Flexible Manufacturing Cells and systems  
   W.W. Luggen  
   Prentice Hall India
   Performance Modelling of Automated  
   Vishwanathan&Narhar
6. Manufacturing Systems  
   i  
   Prentice Hall India
MTME 052                                MACHINE VISION                                3 credits

Image capture and digitization; Image transforms; digital Fourier transform, fast Fourier transform, other transforms, convolution, correlation; image enhancement; spatial methods, frequency domain methods; image restoration;

Geometric transformation; image compression; error free and lossy compression; edge detection; hough transform, region based segmentation; image feature/region representation and descriptors; morphological operators;

Features based matching, Baye’s classification; Low level vision: Introduction to stereopsis, shape from shading, optical flow; Rule based picture segmentation. Tutorial exercises will emphasize development and evaluation of image algorithms.

Text Books / References:

Introduction: Historical developments, Fundamentals of RP Systems and its Classification, Rapid prototyping process chains, 3D modeling and mesh generation, Data conversion and transmission.

RP Systems: Liquid polymer based rapid prototyping systems, Teijin Seikis’ solid form and other similar commercial RP systems, Solid input materials based rapid prototyping systems, laminated object manufacturing (LOM) and fused deposition modelling systems etc., Power based rapid prototyping systems, selective Laser sintering, SoligenDiren’s shell production casting (DSPC), Fraunhofer’s multiphase jet solidification (MJS) and MIT’s 3D printing (3DP) etc.

RP Database: Rapid prototyping data formats, STL format, STL file problems, STL file repair, Network based operations, Digital inspection, Data warehousing and learning from process data.

RP Applications: Development of dies for moulding, RP applications in developing prototypes of products, application in medical fields, Development of bone replacements and tissues, etc., RP materials and their biological acceptability.

Books:

2. Rapid Prototyping: Principles And Applications, Kai Chua Chee, World Science
3. Rapid System Prototyping With Fpgas: Accelerating The Design Process, R C Cofer, Newnes
Unit I

**Introduction:** Working principle of synchronous, Asynchronous & stepper motors, Difference between I and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vector duty inducti Concepts of linear and frameless motors, Selection of feedback system, Duty cycle, , V/F control, Flu control.

Unit II

**Industrials Drives:** DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects, electric braking, rheostatic and regenerative braking principles in power converters.

Unit III

**Motion laws for rotary and linear systems:** converting rotary to linear system, concepts and principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches of Robots, Control loops using Current amplifier

Unit IV

**Introduction to Programmable Logic Controllers:** Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing’s, types of variables, definition of firmware, software, programming software tool and interfacing with PC (RS232 & TCP-IP), methods of PLC programming (LD, ST, FBD & SFC), function blocks logical / mathematical operators & data types, array & data structure, PID, types of tasks and configuration, difference between relay logic and PLC, selection of PLC controller

Unit V

**Logic, instructions & Application of PLC:** What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems, Types of visualization system, PC based Controller, Applications of HMI’s, and Interfacing of HMI with
Text Books:

2. Andrew Parr, Industrial drives, Butterworth – Heineamann
4. Programmable Logic Controllers by W.Bolton

References:

2. Instrumentation Engineers Hand Book - Process Control, Bela G Liptak, Chilton book company, Pennsylvania
5. Programmable Logic Controllers by Hugh Jack.