Savitribai Phule Pune University
(Formerly University of Pune)

Department of Technology
Board of StudiesElectronics and Electrical Technology (EE)

STRUCTURE OF ONE YEAR FULL TIME POST GRADUATE DIPLOMA IN Industry4.0 BasedMechatronics and Robotics(PGD-MR)

Each Trimester is of 15 weeks followed by examination in subsequent week.

Trimester 1

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	PGMR101	Concepts in Digital Technology Engineering	3	1		4
2	PGMR102	Control Technology Engineering	3	1		4
3	PGMR103	Industrial Drives and Controls for Automation	3	1		4
4	PGMR104	Sensors and Signal Conditioning	3	1		4
		Total Credits				**16**

Trimester 2

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	PGMR201	Industry 4.0 Cloud Platform	3	1		4
2	PGMR202	Industrial Robotics Automation Lab	3	1		4
3	PGMR203	Industrial Automation and Mechatronics Lab			6	3
4	PGMR204	Industrial Robotics Automation Lab			6	3
		Total Credits				**14**

Trimester 3

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	PGMR301	Industry Internship				10
		Total				**10**
		Total Course Credits				**40**

1. CONCEPTS IN DIGITAL TECHNOLOGY ENGINEERING

To understand the basics and working principles of electronic components and theirapplications. This course is intended for learning the Fundamentals, properties and applications of Digital technology with, digital circuits, test and measuring instruments.

OBJECTIVES:

- To present the Digital fundamentals, Boolean algebra and its applications in digital systems
- To familiarize with the design of various combinational digital circuits using logic gates
- To introduce the analysis and design procedures for synchronous and asynchronous sequential circuits
- To explain the various semiconductor memories and related technology
- To introduce the electronic circuits involved in the making of logic gates

UNIT I -DIGITAL FUNDAMENTALS

Number Systems – Decimal, Binary, Octal, Hexadecimal, 1‘s and 2‘s complements, Codes – Binary, BCD, Excess 3, Gray, Alphanumeric codes, Boolean theorems, Logic gates, Universal gates, Sum of products and product of sums, Minterms and Maxterms, Karnaugh map Minimization and Quine-McCluskey method of minimization.

UNIT II- COMBINATIONAL CIRCUIT DESIGN

Design of Half and Full Adders, Half and Full Subtractors, Binary Parallel Adder – Carry look ahead Adder,

BCD Adder, Multiplexer, Demultiplexer, Magnitude Comparator, Decoder, Encoder, Priority Encoder.

UNIT III -SYNCHRONOUS SEQUENTIAL CIRCUITS

Flip flops – SR, JK, T, D, Master/Slave FF – operation and excitation tables, Triggering of FF, Analysis and

design of clocked sequential circuits – Design – Moore/Mealy models, state minimization, state assignment, circuit implementation – Design of Counters- Ripple Counters, Ring Counters, Shift registers, Universal Shift Register.

UNIT IV -ASYNCHRONOUS SEQUENTIAL CIRCUITS

Stable and Unstable states, output specifications, cycles and races, state reduction, race free assignments, Hazards, Essential Hazards, Pulse mode sequential circuits, Design of Hazard free circuits.

UNIT V MEMORY DEVICES AND DIGITAL INTEGRATED CIRCUITS

Basic memory structure – ROM -PROM – EPROM – EEPROM –EAPROM, RAM – Static and dynamic RAM – Programmable Logic Devices – Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA) – Implementation of combinational logic circuits using PLA, PAL.

Digital integrated circuits: Logic levels, propagation delay, power dissipation, fan-out and fan-in, noise

margin, logic families and their characteristics-RTL, TTL, ECL, CMOS

OUTCOMES:

At the end of the course:

- Use digital electronics in the present contemporary world
- Design various combinational digital circuits using logic gates
- Do the analysis and design procedures for synchronous and asynchronous sequential circuits
- Use the semiconductor memories and related technology
- Use electronic circuits involved in the design of logic gates

TOTAL: 45 Hrs

REFERENCES:

1. Mill Man and Halkias ":Electron devices and circuits" McGraw-Hill2004.
2. Jocob Mill Man, Micro electronics Digital and Analog circuits & Systems – McGraw-Hill2004.
3. Ray & Chaudary, Linear Integrated Circuits, New Age2006.
4. Malvino & Leach, Digital Principals & application, TMH2002.
5. Helfrick A.D and Cooper .W. D. " Modern Electronic Instrumentation and Measurements Techniques" Printice Hall2008.

2. CONTROL TECHNOLOGY ENGINEERING

To understand the programming interfacing and applications of various microcontrollers and programmable logiccontroller. This course is intended for learning the Introduction and Architecture of Microcontroller, Fundamentals of Assembly language Programming, Programming of Microcontroller and Interfacing of Microcontroller. This course is also gives the ideas of Fundamentals. Architecture and Operations of programmable logic controller, Problem solving using logic ladder diagrams and communication inPLCs.

OBJECTIVES:

- To present the IOT compatible Microcontroller technology, Redberry PI, Android Board and its applications
- To familiarize with the design of various applications using Open souse platform.
- To present the IOT compatible Industrial Automation Hardware Platform, Siemens, Mitsuhashi, Allen and its applications
- To familiarize with the design of various applications using Industrial Hardware.
- To introduce the programming concept with ladder and SCADA development tools.

INTRODUCTION TO MICRO CONTROLLER:

Microprocessors and Microcontrollers – CISC and RISC - Fundamentals of Assembly language Programming – Instruction to Assembler – C Programming for Microcontrollers – Compiler and IDE – Introduction to Embedded systems - Architecture 8051 family - PIC 18FXXX – family – Memory organization.

PROGRAMMING OF RESBERRY PIMICROCONTROLLER: Instruction set – Addressing modes – I/O Programming-Timer/Counter - Interrupts – Serial communication of 8051.

PROGRAMMING OFANDROID PLATFORM . Instruction set – Addressing modes – I/O Programming-Timer/Counter - Interrupts – Serial communication, ECCP PWM programming of PIC18FXXX.

PERIPHERALINTERFACING : Interfacing of Relays, Memory, key board, Displays – Alphanumeric and Graphic, RTC, ADC and DAC, Stepper motors and DC Motors, I^2C, SPI with 8051 and PICfamily.

PLC PROGRAMMING : Fundamentals of programmable logic controller – Functions of PLCs – PLC operations – Evaluation of the modern PLC – Memory– Selection of PLC – Features of PLC – Architecture – Basics of PLC programming – Developing Fundamental wiring diagrams – Problem solving using logic ladder diagrams – communication in PLCs – Programming Timers – Programming counters – DataHandling.

COMMUNICATIONPROTOCOLS

NETWORK PROTOCOLS: LAN, WAN and MAN Networks – RS485, RS 422, LXI Protocols – Modbus – Field bus – Ethernet – CAN bus – SCADA and DCS.

DATA ACQUSITION SYSTEM: Continuous and Discrete signals – Sampling theorem – Quantization – Sampling and Hold – ADC – DAC – Resolution and Sampling Frequency – Multiplexing of input signals – Single ended and differential inputs – Sampling of Multi-channel analog signals – Concept of Universal DAQ card – Timer & Counter and analog output in Universal DAQ card.

PROGRAMMINGTECHNIQUES

Algorithm – Flowchart – Variables & Constants – Expressions – Data types – Input output operations. Conditional Statements – Looping – Sub-programs/Functions – Arrays, Structures and Classes – Inheritance – Polymorphism – Debugging.

GRAPHICAL PROGRAMMING

GUI – Graphical Programming – Data Flow techniques – Processing Data in GP – Loops and Structures – Event based & Schedule based operations – Global and Local Variables – File I/O operations – Parallel processing of data – Virtual Instrument and control – VISA & SCPI

OUTCOMES:

At the end of the course:

- Use IOT Hardware Tools in the present contemporary world
- Design various applications using IOT Hardware Tools.
- Use open platform for IOT technology
- Do the interface with ladder and Scada software integration.
- Development Vacuous applications using IOT Hardware Technology.

TOTAL: 45 Hrs

REFERENCES

1. Muhammad Ali Mazidi and Janice GillispicMazdi, “The 8051 Microcontroller and Embedded Systems” Pearson Education, Inc2006.
2. John B. Peatman, PIC programing, McGraw Hill International, USA,2005.
3. John B. Peatman, Design with Micro controllers, McGraw Hill International, USA,2005.
4. Kenneth J. Aylala, “The 8051 Micro controller, the Architecture and Programming applications”:2003..
5. James W. Stewart, “The 8051 Micro controller hardware, software and interfaciung, regents Prentice Hall,2003.
6. Frank D. Petro Zella, “Programmable logic controller” McGraw – Hill Publications,1998
7. Mill Man and Halkias “:Electron devices and circuits” McGraw-Hill2004.
8. Jocob Mill Man, Micro electronics Digital and Analog circuits & Systems – McGraw-Hill2004.
9. Ray & Chaudary, Linear Integrated Circuits, New Age2006.

10. Malvino & Leach, Digital Principals & application, TMH2002.
11. Helfrick A.D and Cooper .W. D. " Modern Electronic Instrumentation and Measurements Techniques" Printice Hall2008.
12. Muhammad Ali Mazidi and Janice GillispicMazdi, "The 8051 Microcontroller and Embedded Systems" Pearson Education, Inc2006.
13. Wayne Wolf, Computers as Components – Principles of Embedded Computing System Design, Morgan Kaufmann Publishers2009.
14. Ball S.R., Embedded microprocessor Systems – Real World Design, Prentice Hall,2006
15. C.M. Krishna, Kang G. Shin, Real Time systems, McGraw Hill2009
16. Frank Vahid and Tony Givagis , Embedded SystemDesign
17. Tim Wilmshurst, An Introduction to the design of small – scale EmbeddedSystems.
18. Morris Mano M., Computer System Architecture, Prentice Hall of India, Third Edition,2002.
19. John P. Hayes, Computer Architecture and Organization, McGraw Hill International, Third Edition, 1998.
20. William Stallings, "Computer Organization and Architecture", VI Edition, Prentice Hall of India, 2003.
21. Krishna Kant , 'Computer based Industrial Control', Prentice Hall of India,1997.
22. Gary Johnson, 'LabVIEW Graphical Programming', II Ed. , McGraw Hill,1997.
23. Sanjeev Gupta, 'Virtual Instrumentation using Labview' Tata McGraw Hill,2004.
24. Jovitha Jeome 'Virtual Instrumentation using Lab View' PH1 Learning Pvt Ltd,2009.

3. INDUSTRIAL DRIVES AND CONTROLS FOR AUTOMATION

To impart knowledge in the area of hydraulic, pneumatic electric actuators and theircontrol. To make the students to learn the basic concepts of ac DRIVES, dc DRIVES, Linear and Rotary actuators, hydraulic, pneumatics and electric drives and their controlling elements in the area of Mechatronics systems. To train the students in designing the hydraulic and pneumatic circuits using ladder diagram. And designing control circuits for electricdrives.

OBJECTIVES:

- To understand the Pneumatic and Hydraulic technology.
- To understand the AC VFD drive and its application in the Industry.
- To understand the AC Servo drive and its application in the Industry.
- To familiarize with the design of various applications using IOT Hardware platform.
- To present the IOT compatible Industrial Automation Hardware Platform, Siemens, Mitsuhashi, Allen and its applications
- To familiarize with the design of various applications using Industrial Hardware.
- To introduce the programming concept with ladder and SCADA development tools.

FLUID POWER SYSTEM GENERATION AND ACTUATORS Need for automation, Classification of drives-hydraulic, pneumatic and electric –comparison – ISO symbols for their elements , Selection Criteria. Generating Elements-- Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification -Drive characteristics – Utilizing Elements-- Linear actuator – Types, mounting details, cushioning – power packs –accumulators

CONTROL ANDREGULATION ELEMENTS : Control and regulation Elements—Direction, flow and pressure control valves--Methods of actuation, types, sizing of ports. spool valves-operating characteristics-electro hydraulic servo valves-Different types-characteristics and performance.

CIRCUIT DESIGN FOR HYDRAULIC AND PNEUMATICS : Typical Design methods – sequencing circuits design - combinational logic circuit.design--cascade method - -Karnaugh map method--Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters,

Programmable logic control of Hydraulics Pneumatics circuits, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits.

ELECTRICALACTUATORS . D.C Motor--Working principle ,classification, characteristics, Merits and Demerits, Applications- AC Motor-- Working principle, Types, Speed torque characteristics, Merits and demerits, Applications Stepper motor- principle ,classification, construction. Piezo electric actuators – Linear actuators - Hybrid actuators – Applications.

ELECTRICAL DRIVE CIRCUITS DC Motors - Speed ,direction and position control using H-bridge under PWM mode**.** Control of AC motor drives – Need for V/ F drives – Energy saving AC drives. – Stepper Motor – Drive circuits for speed and position control, BLDC motor – Controller – Switched reluctance motor .

OUTCOMES:
At the end of the course:

- Study Pneumatic Technology and its use in the Industry.
- Study Hydraulic Technology and its use in the Industry.
- Study VFD Drive and its use in the Industry.
- Study AC Servo Drive Technology and its use in the Industry.
- Design various applications using IOT Hardware Tools.
- Use open platform for IOT technology
- Do the interface with ladder and Scada software integration.
- Development Vacuous applications using IOT Hardware Technology.

TOTAL: 45 Hrs

REFERENCES:

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall,2006
2. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London,1979
3. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill,1978.
4. W.Bolton, Mechatronics, Electronic control systems in Mechanical and ElectricalEngineering Pearson Education,2003.
5. Gopal K.Dubey, Fundamentals of electrical drives. Narosa Pubilcations,2001

4. SENSORS AND SIGNAL CONDITIONING

To impart knowledge on various types of sensors and transducers for Automation in Mechatronics Engineering.

OBJECTIVES:

- To study basic concepts of various sensors andtransducers with I/O Link connectivity.
- To develop knowledge in selection of suitable sensor for mechatronics systems.
- To design suitable signal conditioning circuits for mechatronicssystems.
- To Study I/O Link with Sensors.

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types

MOTION, PROXIMITY AND RANGING SENSORS : Motion Sensors – Brush Encoders, Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn , Accelerometer.,– GPS, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor(LIDAR).

FORCE,MAGNETIC ANDHEADINGSENSORS Strain Gage, Load CellMagnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.

OPTICAL, PRESSURE ANDTEMPERATURE SENSORS . Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric, Temperature – IC, Thermistor, RTD, Thermocouple,

SIGNALCONDITIONING : Need for Signal Conditioning – DC and AC Signal conditioning – Filter and Isolation Circuits – Operational Amplifier Specifications, Characteristics and Circuits – Voltage and Current Amplifiers – Transmitting Circuits – Fundamentals of Data Acquisition System.

OUTCOMES:
At the end of the course:

- User of IO -Link in the Industrial Applications.
- IO Link sensors compatibility with Hardware.
- Use of Link in IOT technology.
- IO link and PLC integration.
- SCADA development and integration with IOT Hardware.

TOTAL: 45 Hrs

REFERENCES:

1. PatranabisD.,Sensor and Actuators, Prentice Hall of India (Pvt) Ltd.2005.
2. Ernest O. Doeblin, Measurement system, Application and design, , Tata McGraw Hill Publishing Company Ltd., Fiftieth Edition,2004
3. Bradley D.A., and Dawson, Burd and Loader, Mechatronics, Thomson Press India Ltd.,2004
4. RenganathanS.,Transducer Engineering, Allied Publishers (P) Ltd.,2003.
5. Bolton W., Mechatronics, Thomson Press,2003.

5. INDUSTRY 4.0 CLOUD PLATFROM

To impart knowledge on Industry Standard Industry 4.0 Cloud

OBJECTIVES:

- Understand IOT technology and its use in the Industry.
- Various development tools in the IOT software Platform.
- Integration between Hardware and Software for IOT technology.
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DEVELOPMENT ENVIRONMENT PLATFORM : Web Serve, Internate Connections, Data Import, Developer Plan, access to your account, small Cloud Foundry development space and Developer Plan – Tools ,Developer Cockpit for application registration and defining rolls and scope of applications,Usage Transparency for visualization of platform uses like outbound traffic API transactions,User Management should provide interface define rolls and scope of users kike talent admin and standard users,Asset Manager for user-friendly interface for onbaording of field assets. Developer

Cockpit : Use Developer Cockpit to Assign a new application to your own developer tenant. Manage versions of your application. A User can perform an update of an application. For detailed information for individual process/steps documentation should be available on internate or service provided platform., Usage Transparency and Management . Usage Transparency provides information regarding your resource consumption e.g. API calls,Number of Users,Inbound and outbound traffic .User Management allows managing User rights,

permissions and subtenants. For every User, an individual login is required. A third party User which you permit to test the application for such third parties' end use shall not be granted with administration rights, except for administration rights that are offered by the user management of a subtenant. .

Asset Manager : Use Asset Manager to Onboard and off board agents to your Account, Configure assets. asset types,Cloud Foundry Org (CF Org):- CF Org is an environment to test and deploy applications , Visualization Applications,Launchpad,Application Interface facility,Identity management Service, Asset management service, Agent Management service,IOT Time series service,IOT time series aggregates service, Event analytic service etc.

Platform as –a Service: - Development platform should be open source platform as a service powered by cloud foundry for developing cross platform applications and lowering development efforts .

Software based Gateway : This software-based gateway platform like JAVA based Connectivity element for OPC UA server, Node-Red based connectivity element Hardware based Gateway : support of all IEC 61131-3 programming languages (LAD/FBD, STL, SCL, Graph and direct connectivity to cloud) and of high-level languages such as C++ enable efficient programming of the Advanced Controllers in the shared engineering framework TIA Portal,Web connectivity facility

OUTCOMES:

At the end of the course:

- Knowledge for IOT software development.
- Knowledge for IOT Hardware e development.
- IOT software compatibility with Hardware.
- Integration with Hardware.
- Communication techniques for IOT technology,
- Dash Board design and development.

TOTAL: 45 Hrs

REFERENCES:

1. www.3ds.com
2. www.sensital.com
3. www.ptc.com

6. INDUSTRIALROBOTICS

Types of Industrial Robots, definitions – classifications based on work envelope – Generations configurations and control loops, co-ordinate system – need for robot – basic parts and functions – specifications.

OBJECTIVES:

- Study Robotic technology with ABB and Motoman Brand.
- Study applications in the Industry for Pick and Place, and Manufacturing,

- Offline Robotic Software development and Integrating with Robot .
- application Various development tools in the IOT software Platform.
- Integration between Hardware and Software for IOT technology.

MECHANICAL DESIGN OFROBOTSYSTEM

Robot motion – Kinematics of Robot motion – Direct and Indirect kinematics Homogeneous transformations – linkages and joints – mechanism – method for location and orientation of objects – drive systems – end effectors – types, selection, classification and design of grippers – gripper force analysis.

SENSORS. Functions of Sensors – Position and proximity's sensing – tactile sensing – sensing joint forces – vision system – object recognition and image transformation – safety monitoring sensor systems – image analysis – application of image processing. .

ROBOT PROGRAMMING &AITECHNIQUES 8

Types of Programming – Teach pendant programming – Basic concepts in A1 techniques – Concept of knowledge representations – Expert system and its components.

ROBOTIC WORK CELLS AND APPLICATIONSOF ROBOTs. Robotic cell layouts – Inter locks – Application of robots in Manufacturing industries i.e Vision, Palletisation, Pick and Place,

OUTCOMES:

At the end of the course:

- Knowledge for Industrial Robot
- Knowledge for Robotic Programming.
- IOT software compatibility with Hardware.
- Integration with IOT Hardware development..
- Communication techniques for IOT technology,
- Dash Board design and development.

TOTAL: 45 Hrs

REFERENCES:

1. Groover.M.P. Industrial Robotics, technology, programming and application Mc-Graw Hill book and co. 2012
2. Fu.K.S , Gonzalac R.C ,Lee C.S.G, Robotics Control, sensing ,vision and intelligence, Mc- Graw Hill book co 2011.
3. Yoram Koren , Robotics, McGraw Hill2006
4. Janakiraman P.A. Robotics and Image Processing, Tata McGraw Hill,2002
5. Saeed B.Niku ,Introduction to Robotics , analyses , systems, applications, Prentice Hall Pvt Ltd. 2005

7. INDUSTRIAL AUTOMATION & MECHATRONICS LAB

LAB work :

- To study & Experimentation of Industrial Automation plant
- To study & Experimentation of PLC Programing & execution
- To study & Experimentation of PLC using HMI and SCADA

- To study & Experimentation Sensor interfacing
- To study & Experimentation Mindsphare interfacing
- Study of Pneumatic and Hydraulic Circuits.
- Study and exprementaion of Vertual Automation software
- To study and setup Advance Manufacutring Systems using various Sensors , Pneumatics Drives and PLC.

8. INDUSTRIAL ROBOTICS AUTOMATION LAB

LAB work :

- To study & Experimentation of Industrial Robot Automation plant
- To study & Experimentation for Pick and Place , Drawing and Vision Application
- To study & Experimentation of Palletisation using Robot
- To study & Experimentation using Robotic offline Simulation software