# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Diploma Engineering**

**Level: Diploma**

**Branch: Instrumentation and Control / Automation and Robotics**

**Subject Code : DI05000231**

**Subject Name : Virtual Instrumentation**

| | |
|---|---|
| **`w. e. f. Academic Year:** | 2026-27 |
| **Semester:** | 5th |
| **Category of the Course:** | MOPEC |

| | |
|---|---|
| **Prerequisite:** | To successfully engage with this course in Virtual Instrumentation, students are expected to possess a foundational understanding of Basic Electrical and Electronics Engineering, specifically the behavior of passive components and fundamental circuit laws. A primary prerequisite is a working knowledge of Transducers and Sensors, as students must understand how physical process variables are converted into the electrical signals that simulation software will eventually process. |
| **Rationale:** | This course offers a comprehensive introduction to the principles and applications of Virtual Instrumentation. Students will leverage software-defined measurement techniques to design, model, and analyze complex electronic circuits and control systems. By mastering industry-standard simulation tools, learners will bridge the gap between theoretical concepts and practical implementation, gaining the proficiency required to build and test advanced automation and electronic architectures in a virtual environment. |

**COURSE OUTCOME:**

After Completion of the Course, Student will able to:

| No | Course Outcomes | RBT Level |
|---|---|---|
| 1 | Define virtual instrumentation concepts | R U A |
| 2 | Compare traditional and virtual instrumentation | R U A |
| 3 | Describe data acquisition system for virtual instrumentation | U A |
| 4 | Simulate different electronic and control system using virtual instrumentation environment | U A |
| 5 | Apply Virtual Instrumentation techniques for Environment Sustainability | A |

**Revised Bloom's Taxonomy (RBT)*

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**TEACHING AND EXAMINATION SCHEME:**

| Teaching Scheme (in Hours) | | | Total Credits L+T+ (PR/2) | Assessment Pattern and Marks | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | Tutorial / Practical | | |
| L | T | PR | C | ESE(E) | PA(M) | PA(I) | ESE (V) | |
| 3 | 0 | 0 | 3 | 70 | 30 | 0 | 0 | 100 |

**COURSE CONTENT:**

| Unit | Topics and Sub-topics | No. Of Hrs. | % Weightage |
|---|---|---|---|
| **Unit-I Introduction to Virtual Instrumentation** | **1.1 Historical perspective of virtual instrumentation**<br>• Basics of Virtual instrumentation<br>• Role virtual instrumentation in real-time world<br>**1.2 Block diagram and Architecture of Virtual Instrumentation**<br>• Data flow techniques in virtual instrumentation<br>• Compare virtual instrumentation and traditional instrumentation<br>• Limitations of traditional instrumentation<br>**1.3 Application of virtual instrumentation in Industry**<br>**1.4 Hardware and Software in Virtual Instrumentation**<br>• Role of hardware in virtual instrumentation<br>• Role of software in virtual instrumentation<br>**1.5 Virtual Instrumentation for Test, Control and Design**<br>• Virtual instrumentation for Test<br>• Virtual instrumentation for Industrial I/O and Control<br>• Virtual instrumentation for Design | 17 | 20 % |
| **Unit-II Programming techniques in Virtual Instrumentation environment** | **2.1 Basics of Graphical User Programming (GUI)**<br>• Compare conventional programming and GUI based programming<br>• Prepare basic program in virtual instrumentation software<br>• Compare graphical programming and text based programming | 13 | 30 % |

| | | | |
|---|---|---|---|
| | • VI and Sub-VIs: Concepts of modular programming; creating, saving, and calling Sub-VIs within a main Virtual Instrument<br>**2.2 Structural Control and Execution Logic**<br>• Iterative Structures: Implementation of For Loops and While Loops for repetitive tasks.<br>• Decision Making: Using Case Structures for conditional logic and Sequence Structures for controlling execution flow.<br>• Mathematical Operations: Using Formula Nodes and MathScript for complex mathematical calculations within the graphical environment.<br>**2.3 Data Handling and Organization**<br>• Data Storage Entities: Difference between Arrays (homogeneous data) and Clusters (heterogeneous data).<br>• Variable Management: Proper use of Local Variables and Global Variables for data transfer between different parts of a program.<br>• Strings and File I/O: Techniques for handling text data and reading/writing measurement data to external files.<br>**2.4 Visualization and Signal Display**<br>• Basics of Charts: Real-time data plotting for continuous monitoring.<br>• Basics of Graphs: Plotting fixed arrays of data for post-acquisition analysis.<br>• Signal Generation: Programming techniques to generate standard waveforms like Square and Triangular waves<br>**2.5 Error Handling and troubleshooting** | | |
| **Unit III Elements Of Data Acquisition in virtual instrumentation environment** | **3.1 Introduction to Data acquisition system**<br>• Block diagram of DAQ System<br>**3.2 Selection criteria of hardware and software for data acquisition system**<br>**3.3 Basics of Analog to Digital Converter (ADC), Digital to Analog Converter (DAC), Digital Input Output (DIO)** | 8 | 20 % |

| | | | |
|---|---|---|---|
| | • Describe Basics of ADC, DAC, DIO<br>**3.4 Basics of Counters and timers**<br>• Function and application of Counters and timers<br>**3.5 Timing, Interrupts; RS232C/ RS485**<br>• Describe concept RS232/ RS485 module<br>**3.6 Signal Processing in DAQ**<br>• Signal processing in a DAQ system<br>• Define analog signal.<br>• Define digital signal.<br>• Define sampling<br>• Define quantization<br>• Define sampling rate.<br>• Explain signal conditioning | | |
| **Unit IV Operating System And Hardware Overview** | **4.1 PC architecture, current trends, operating system requirements,**<br>• PC based instrumentation,<br>• Interface requirement for virtual instrumentation<br>**4.2 Basics of analog and digital interfaces**<br>• Need for analog-to-digital and digital-to-analog conversion<br>• Working principles of ADC and DAC<br>• Definition and characteristics of analog signals<br>• Definition and characteristics of digital signals<br>• Timing concepts (clock, synchronization)<br>**4.3 Compare PC based and PXI based system** | 4 | 20 % |
| **Unit – V Virtual Instrumentation for Environment Sustainability** | **5.1 Introduction to Environmental Sustainability**<br>• Definition of environmental sustainability<br>• Importance of environmental protection<br>• Role of technology in sustainable development<br>**5.2 Role of Virtual Instrumentation in environmental Monitoring**<br>• Advantages of VI in environmental monitoring<br>• Energy monitoring and management using virtual instrumentation<br>**5.3 Role of VI in Robotics**<br>Basics of robotics control system using Virtual Instrumentation | 3 | 10 % |
| | **Total** | **45 Hrs** | **100%** |

**SUGGESTED PRACTICAL EXERCISES:**

The following practical outcomes (PrOs) that are the sub-components of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO. These PrOs need to be attained at least at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

| Sr. No. | Practical Outcomes (PrOs) | Approx. Hrs. Required |
|---|---|---|
| 1 | Study of Virtual Instrumentation based Simulator environment (Front Panel, Block Diagram, Tools Palette, Controls Palette). | 04 |
| 2 | Create a simple Virtual Instrument (VI) to perform basic arithmetic operations. | 02 |
| 3 | Implementation of numeric controls and indicators in Virtual Instrumentation based Simulator. | 04 |
| 4 | Implementation of string and Boolean controls in Virtual Instrumentation based Simulator. | 04 |
| 5 | Study and implementation of loops (For Loop and While Loop) in Virtual Instrumentation based Simulator. | 04 |
| 6 | Implementation of Case Structure in Virtual Instrumentation based Simulator. | 02 |
| 7 | Implementation of Sequence Structure in Virtual Instrumentation based Simulator. | 04 |
| 8 | Development of SubVI (Modular Programming) in Virtual Instrumentation based Simulator. | 04 |
| 9 | Implementation of array operations and waveform graphs. | 04 |
| 10 | Implementation of cluster and bundle functions. | 02 |
| 11 | Generation of basic signals (sine, square, triangle) using Virtual Instrumentation based Simulator. | 02 |
| 12 | Implementation of signal display using waveform chart and graph. | 02 |
| 13 | Study of signal filtering techniques in Virtual Instrumentation based Simulator. | 04 |
| 14 | Development of data logging system using file I/O functions. | 04 |
| 15 | Study of DAQ hardware interfacing with Virtual Instrumentation based Simulator. | 04 |
| 16 | Measurement of temperature using sensor and DAQ system. | 04 |
| 17 | Measurement of voltage signal using DAQ device. | 04 |

| Sr. No. | Practical Outcomes (PrOs) | Approx. Hrs. Required |
|---|---|---|
| 18 | Development of virtual oscilloscope using Virtual Instrumentation based Simulator. | 04 |
| 19 | Development of air pollution monitoring system using sensors. | 04 |
| 20 | Design of smart energy monitoring system using virtual instrumentation. | 04 |
| 21 | Design Control system in LabVIEW. | 04 |
| 22 | Design basic image acquisition system | 04 |
| 23 | Design basic signal processing circuits in simulator | 04 |

***Note***

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

| Sr. No. | Sample Performance Indicators for the PrOs | Weightage in % |
|---|---|---|
| 1 | Prepare experimental setup | 20 |
| 1 | Operate the equipment setup or circuit | 25 |
| 2 | Follow safe practices measures | 25 |
| 3 | Record observations correctly | 25 |
| 4 | Interpret the result and conclude | 25 |
| **Total** | | **100** |

**MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED:**

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure conduction of practical in all institutions across the state in proper way so that the desired skills are developed in students.

| Sr. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1 | Computer with LabVIEW software | All |
| 2 | Computer with Matlab /Scilab software. | All |

| | | |
|---|---|---|
| 3 | Computer with Prosim/PSpice/Multisim software. | All |
| 4 | Circuit/Trainer board/ Demonstration modules of Thermocouples, RTDs, Thermistors | All |
| 5 | Temperature Switches, Optical Pyrometer, Radiation Pyrometer | All |
| 6 | Data Acquisition System | All |
| 7 | $CO_2$ Sensor Module (Carbon Dioxide Sensor) – Measures carbon dioxide concentration. | All |
| 8 | CO Sensor (Carbon Monoxide Sensor) – Detects toxic carbon monoxide gas. | All |
| 9 | PM2.5 / PM10 Sensor Module– Measures particulate matter (dust and smoke). | All |
| 10 | $SO_2$ Sensor Module(Sulfur Dioxide Sensor) – Detects sulfur dioxide pollution. | All |
| 11 | NOx Sensor Module (Nitrogen Oxides Sensor) – Measures nitrogen oxide gases. | All |

**AFFECTIVE DOMAIN OUTCOMES:**

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Work as a leader/a team member for assigned student activity.
b) Follow safety practices and procedure in Lab.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day-to-day observation

**SUGGESTED STUDENT ACTIVITIES:**

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Industrial visit for students. (Chemical industries, petroleum industries, production industries.) So that students can have exposure to the real industrial realm.
b) Department should arrange a workshop/seminar where students can have interaction with industry personnel.
c) Videos/Animation for different devices should be shown. Download videos of different industries from various YouTube channels like how it's made, how stuff works and show in class and discuss instrumentation used in that industry.
d) Model making.

**SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any):**

Following Sample strategies teacher can use to accelerate the attainment of the various outcomes in this course:

1. Use instrumentation trainer kits to demonstrate real-time measurement of pressure, temperature, flow, and level and to perform hands-on calibration using standard instruments.
2. Utilize industrial process simulation software such as MATLAB/Simulink, LabVIEW, Factory I/O, or SCADA simulators to visualize process behaviour and signal conditioning.
3. Demonstrate measurement principles using cutaway models and working models of various industrial instruments.
4. Use virtual labs and online platforms (NPTEL/AICTE) for performing simulated experiments related to process measurement.
5. Arrange field visits to process industries for exposure to real-time process parameters, control loops, and industrial instrumentation systems.
6. Implement case study–based learning focusing on transmitter faults, calibration issues, and troubleshooting scenarios from industries.
7. Apply problem-based learning (PBL) by assigning real-world measurement and instrumentation problems for student analysis.
8. Demonstrate standard calibration procedures, including zero, span, linearity, and hysteresis checks, using proper calibration documentation.
9. Use videos, animations, and AR/VR content to explain the working of pressure, temperature, flow, and level measurement devices.
10. Assign mini-projects and hands-on activities related to process parameter measurement, signal conditioning, and microcontroller/PLC interfacing.
11. Promote group activities and peer learning for calibration work, instrument connections, and laboratory data analysis.
12. Use standard industrial documentation such as P&ID diagrams, datasheets, instrument index, and loop diagrams during teaching and assignments.
13. Adopt flipped classroom techniques by providing pre-class learning materials and conducting in-class problem-solving discussions.

**SUGGESTED MICRO-PROJECTS:**

1. Temperature Monitoring System
2. Smart Air Pollution Monitoring System
3. Water Level Monitoring System
4. Digital Voltmeter using LabVIEW
5. Virtual Oscilloscope
6. Smart Energy Monitoring System
7. Soil Moisture Monitoring System
8. IoT Based Environmental Monitoring System

9. Data Logger System
10. Temperature Control System
11. Smart Greenhouse Monitoring System

**SUGGESTED LEARNING RESOURCES:**

| Sr. No. | Title of Book | Author | Publication with place, year and ISBN |
|---|---|---|---|
| 1 | Virtual Instrumentation Using LabVIEW | Jovitha Jerome | PHI Learning Pvt. Ltd., New Delhi |
| 2 | LabVIEW for Everyone: Graphical Programming Made Easy and Fun | Jeffrey Travis, Jim Kring | Prentice Hall, New Jersey, USA |
| 3 | Environmental Monitoring and Characterization | Janick Artiola, Ian L. Pepper, Mark Brusseau | Academic Press, Burlington, USA |

**SUGGESTED LEARNING WEBSITES:**

1. https://www.nptel.com
2. https://instrumentationtools.com
3. https://www.vlab.co.in/participating-institute-coe-pune
4. https://vlab.amrita.edu/?sub=1&brch=282&sim=1511&cnt=1
5. http://www.ni.com
6. https://www.engineeringtoolbox.com
7. https://www.omega.com/en-us/resources
8. https://www.emerson.com
9. https://www.keyence.com
10. https://www.yokogawa.com/library/resources/white-papers
11. https://ocw.mit.edu/
12. https://www.ptc.com/en/learning

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