GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2023)

Semester - VI

Course Title: Industrial Data Communication

(Course Code: 4361702)

Diploma programmer in which this course is offered	Semester in which offered
Instrumentation and Control	Sixth

1. **RATIONALE**

In the present industrial scenario the role of instrumentation is becoming more vital day by day specially in case of industrial automation. More advanced, precise and complex instrumentations are being employed in the industry. These advance instruments requires communication of data from equipment/machines to instruments and vice versa for process and quality control. Diploma engineers should therefore be able to identify, classify, troubleshoot and maintain the different industrial data communication systems employed for instrumentation. Therefore, this course has been designed so that students will be able to test, build, wire and troubleshoot the different types of industrial data communication circuits used for instrumentation and automation.

2. **COMPETENCY**

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

● **Install, maintain and troubleshoot various networks and protocols used for communication in instrumentation.**

3. **COURSE OUTCOMES (COs)**

The theory should be taught and practical should be performed in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

CO1	Identify network on the basis of various network parameters.
CO2	Identify OSI-ISO and TCP/IP network models.
CO3	Select guided and unguided medium for various types of data transmission.
CO4	Assign IP address to the network and network component as per the networks.
CO5	Install various types of network devices and other network hardware.
CO6	Troubleshoot problems in hardware/software employed in data communication.

4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.

5.   SUGGESTED PRACTICAL EXERCISES:

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	To study different types of transmission medias.	3	2Hrs
2	Prepare and Test Straight and Cross UTP Cable.	3	2Hrs
3	Prepare and Test Cross CAT5,CAT6 and RJ11Cable.	3	4Hrs
4	Configuring Computer modem.	1	2Hrs
5	Configuring Hub/Switch and Router.	3	2Hrs
6	Connect computer terminal in various physical topologies and test the data transfer.	1	4Hrs
7	Prepare detailed report of existing LAN in the Department/Institute	2	4Hrs
8	Configure static and dynamic IP addresses and Run basic utilities and network commands: ipconfig, ping, tracert,netstat, pathping ,route etc.	2	4Hrs
9	Configure file server and configure client to file server and use file services.	3	4Hrs
10	Set access rights and security permissions for user.	2,3	2Hrs
11	Setting up wireless network.	3	2Hrs
12	Connect multiple computers using wireless media.	2,3	2Hrs
13	Test the operational Fieldbus Network using Fieldbus tester	4	2Hrs
14	Select appropriate cable for FF and Profibus network	4	2Hrs
15	Connect multiple RTUs with ModBUS protocol.	5	2Hrs
16	Connect HART handheld communicator to HART network	5	2Hrs
17	Install and Configure HART point-to-point communication Network	5	2Hrs
18	ransmit 8 bit digital signal superimposed on 12mA analog signal using HART FSK technique	5	2Hrs

Note:

i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match theCOs. 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.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6.   MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Wires, tools and various connectors	2,3
2	Computer and modem.	4
3	Computer, Hub, switch and Router, RTUs, PLC or any other smart instrument used in Instrumentation.	5,6,7,8,9,10
4	Wireless router.	11,12

7.   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.

8.   UNDERPINNING THEORY:

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I **Local Area Network**	**1a**: Justify need of Computer Networks in automation. **1b**: Describe the functions of various components of Computer Networks. **1c**: Compare various computer network topologies. Based on Transmission, scale, and Architecture. **1d**: Classify computer networks-Based on Transmission, scale, and Architecture. **1e**: Differentiate LAN, WAN, MAN. **1f**: Describe configuration of LAN	1.1: Introduction to Computer Networks 1.2: Computer Networks in Instrumentation. 1.3: Components of Computer Networks: 1.3.1: hardware and software 1.3.2: Network topologies: Star, Ring, Bus, Mesh and Tree. 1.4: Network Classification Based on 1.4.1: Transmission Technologies: Point- to-point and Broadcast 1.4.2: Based on scale:

		LAN, WAN, MAN, VPN, Internet
	with example.	
	1g: State the applications service offered by WAN.	1.4.3: Based on Architecture: Peer to Peer, Client Server, advantages of Client Sever over Peer-to-Peer Model
	1h: Explain functions of VPN with example	
Unit – II **Network Devices and Communication Protocol**	**2a**: Justify the need of protocol. **2b**: Explain the need for layer modeling. **2c**: Describe the functions of each layer of OSI Reference model. **2d**: Describe the functions of each **2e**: Compare the major features of OSI and TCP/IP model. **2f**: Explain Format of IP v4 and IPv6 protocol. **2g**: Explain IP addressing scheme with examples. **2h**: Describe Domain Name system (DNS).	2.1: Basics of Protocol and its need 2.2: Brief functional description of each The OSI-ISO Reference Model layers with list of protocols 2.3: The TCP/IP Reference Model: Brief functional description of each of the Layer with list of protocols 2.3.1: IP layer Protocols: IPv4 and IPv6 frame Format (Limited to format only) 2.4: Internet addressing: Network addressing, Subnet and subnet masking, gateway addressing, broadcast addressing, dotted decimal notation, loopback addressing 2.5: Domain Name System (DNS): Introduction, IP address mapping.
Unit – III **Network Media and Hardware**	**3a**: Explain characteristics of guided and unguided transmission media. **3b**: Describe specifications of UTP and coaxial cable. **3c**: Describe specifications of Wired and Wireless. **3d**: Sketch constructional details of UTP and coaxial cable with labels. **3e**: List different types of connectors. **3f**: Describe different connectors with neat sketch. **3g**: List features of different network interface card. **3h**: Explain functions of following Network devices: Repeater, Hub, Bridge, Switch, Router, Gateway, Access point, Wireless Access points. **3i**: List features of different types of Servers.	3.1: Transmission Media: Unguided and Guided media, Wired and Wireless, UTP, Coaxial and Fiber optical cable 3.2: Types of Connectors: RJ-45, RJ-11, BNC, BNC Terminator, Fiber optic connectors:- Subscriber Channel(SC), Straight Tip(ST), Mechanical transfer– registered jack(MT-RJ) connectors 3.3: Network Interface Card (NIC), 3.4: ARCNET, 3.5: Ethernet. 3.6: Network connecting devices: Repeater, Hub, Bridge, Switch , Router, Gateway, Access point, Wireless Access points 3.7: Servers introduction : File, Print, Mail, Proxy, Web 3.8: Firewall (protection system)
Unit – IV **Basics of Fieldbus and ProfiBus**	**4a**: Discuss benefits of Foundation Fieldbus. **4b**: Sketch waveforms showing Manchester Bi-phase L encoding	4.1: Introduction to Foundation Fieldbus 4.1.1: Physical layer and wiring rules 4.1.2: Data Link layer

	scheme with four encoding states. **4c**: Sketch waveforms showing use of N+ and N– encoding states. **4d**: Draw OSI model of the FF protocol stack. **4e**: Explain data link layer of Foundation Fieldbus in brief. **4f**: Draw data link layer packet format for Foundation Fieldbus. **4g**: Describe application layer of Foundation Fieldbus in brief. **4h**: Draw the passage of information packets to the physical layer of Foundation Fieldbus. **4i**: List the important points to be considered while preparing termination for Foundation Fieldbus. **4j**: Draw and explain wiring configuration of Foundation Fieldbus system. **4k**: List the factors need to be known when troubleshooting the power system of an FF system. **4l**: Discuss the communication problems of Foundation Fieldbus. **4m**: State the parameters which can be checked by Foundation Fieldbus test equipment. **4n**: Describe the versions (ProfiBus DP, ProfiBus FMS and ProfiBusPA) of Profibus standard in brief. **4o**: Draw Profibus protocol stack **4p**: List the features of Physical layer of Profibus DP standard. **4q**: Draw and explain in brief about hybrid medium access control scheme of Profibus. **4r**: Differentiate between token passing and polling technique used in Profibus for medium access. **4s**: Describe token passing method of Profibus in brief.	4.1.3: Application layer 4.1.4: User layer 4.2: Wiring and installation practice with Fieldbus 4.2.1: Termination Preparation 4.2.2: Installation of the complete system 4.2.3: Troubleshooting of foundation field bus 4.2.4: Introduction to physical problem 4.2.5: Power problem 4.2.6: Communication problem 4.3: Test equipment for foundation field bus 4.4: Introduction to ProfiBus standard 4.4.1: ProfiBus protocol stack 4.4.2: Physical layer 4.4.3: Data Link layer 4.4.4: Application layer 4.5: Troubleshooting of Profibus. 4.6: Profibus cable and its types 4.6.1: Profibus to OFC Converter. 4.6.2: OFC to Profibus Converter.
Unit – V **HART and** **MODBUS**	**5a**: Write the salient feature of HART protocol which is generally not found in other protocol.	5.1: Concept of Highway Addressable Remote Transducer (HART) 5.2: HART and smart Instrumentation

	5b: Discuss the features of HART for smart instrumentation.
	5c: Describe HART protocol in brief.
	5d: Draw and explain HART point-to-point communication.
	5e: Draw and explain HART multi-point communication.
	5f: State the uses of HART handheld communicator.
	5g: Sketch the connection diagram of HART handheld communicator
	5h: Show HART protocol implementation of OSI layer model.
	5i: Draw HART data link frame format.
	5j: List the benefits of HART. 5k: Describe the trouble shooting of HART network in brief.
	5k: State the limitations of Modbus network.
	5l: Draw and explain in brief about format of Modbus message frame.
		5.3: HART protocol
		     5.3.1:HART Physical layer
		     5.3.2: HART Data link layer
		5.4: HART benefits
		5.5: Troubleshooting of HART
		5.6: Overview of Modbus protocol
		5.7: Modbus protocol structure
		5.8: Function codes
		     5.8.1: Read coil or digital output Status (function code 01)
		     5.8.2: Read digital input status (function code 02)
		     5.8.3: Read holding registers (function code 03)

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN:

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Local Area Network	8	4	6	4	14
II	Network Devices and Communication Protocol	10	4	4	6	14
III	Network Media and Hardware	8	6	4	4	14
IV	Basics of Fieldbus and ProfiBus	8	4	4	6	14
V	HART and MODBUS	8	4	6	4	14
	Total	**42**	**22**	**24**	**24**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of theUOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. 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) Realize various topologies using computers and instruments.
   b) Give seminar on Internet and cyber security.
   c) Prepare a comparative Chart on various types of network.
   d) Give seminar wireless communication and its future scopes.

11.   SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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

   a) Inspire Student to read books on development and evolution networking, instruct them to take notes in form of summary
   b) Prepare a short note on applications of network security in industry.
   c) Guide students to make presentation on applications of HART Protocol.
   d) List out various models used in data communications along with their advantages and limitations.
   e) Guide students to make presentation on applications of Modbus Protocol.

12.   SUGGESTED MICRO PROJECT LIST:

NA

13.   SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Computer Networks	Tannebaum Andrews Wetherall David J.	Pearson, New Delhi, 5th Edition, 2011
2	Data and Computer Communication,	Stallings Williams	PHI Learning, New Delhi
3	Computer Networks	Trivedi Bhushan	Oxford University Press, New Delhi 2013
4	Data Communication and Networking,	Forouzen	Tata McGraw Hill, Education New Delhi (Latest edition)
5	Practical Industrial Data Networks: Design, Installation and Troubleshooting	Steve Mackay, Edwin Wright, Deon Reynders, John Park	Newnes An imprint of Elsevier
6	Data Communication Networks	Sharma Sanjay	S. K. Kataria and Sons, New Delhi (Latest edition)

14.   SOFTWARE/LEARNING WEBSITES:

   1.   www.nptel.iitm.ac.in.
   2.   www.isa.org
   3.   www.ieee.org
   4.   www.pacontrol.com
   5.   www.ourinstrumentation.com
   6.   www.profibus.com
   7.   http://www.siemens.com
   8.   http://sine.ni.com/nips/cds/view/p/lang/en/nid/208382
   9.   http://www.prosoft-technology.com/Products/Schneider-Electric-In-chassis/PROFIBUS-DP-Master-Network-Interface-Module-for-Quantum

10. www.rotork.com
11. www.ti.com
12. www.fieldbus.org/
13. xiii. www.automation.com/pdf_articles/fieldbus.pdf
14. xiv. https://www.buenoptic.net/fiber-optic-converter/profibus-fiber-optic-converter/item/25-profibus-to-fiber-optic-converter-profibus-olm.html
15. xv. https://cel-mar.pl/en/fibreoptic_profibus-rs485_7040bp.htm

15. PO-COMPETENCY-CO MAPPING:

Semester VI	Industrial Data Communication (Course Code:4361702)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experiment-ation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Install, maintain and troubleshoot various networks and protocols used for communication in instrumentation.						
Identify network on the basis of various network parameters.	3			3	1		3
Identify OSI-ISO and TCP/IP network models.	3			3	1		2
Select guided and unguided medium for various types of data transmission.	3		2		2	1	3
Assign IP address to the network and network component as per the networks.	2	2	1	2		1	3
Install various types of network devices and other network hardware.	2	3	1	2		1	3

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Member – Board of Studies (GTU), Electrical and Allied branches

Prof. Suresh Z. Shyara, IC Engineering, AVPTI, Rajkot

Prof. Mahesh J. Vadhavaniya, IC Engineering, Government Polytechnic, Palanpur

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Prof. Parth S. Thaker, IC Engineering, Government Polytechnic, Gandhinagar.

Prof. Jesika N. Kothari, IC Engineering, AVPTI, Rajkot.