

**Program Name : Diploma in Instrumentation / Instrumentation and Control**  
**Program Code : IS / IC**  
**Semester : Sixth**  
**Course Title : Building Automation**  
**Course Code : 22649**

### 1. RATIONALE

Knowledge of building environments is fundamental requirement to the design, operation and maintenance of today's complex buildings. Building management system plays a vital role in automation of Commercial buildings, Government offices, Hospitals, Pharmaceutical industries, Hotel industries, Clubs, Casinos, Air Ports, etc. Instrumentation diploma engineers has major role in building automation hence knowledge of Building Management System is essential for instrumentation students. This course will help the students to understand the various aspects of different automation systems seen in well-structured buildings.

### 2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain instrumentation involved in Building Automation Systems.**

### 3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

- Select the relevant components for Building management systems (BMS).
- Maintain the various equipment/components of HVAC.
- Maintain the different Circuits/ components in BMS Subsystems.
- Maintain Direct Digital Controllers for controlling parameters in BMS.
- Use advanced features for effective facility control using BMS software.

### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
L	T	P		Theory								Practical					
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	

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

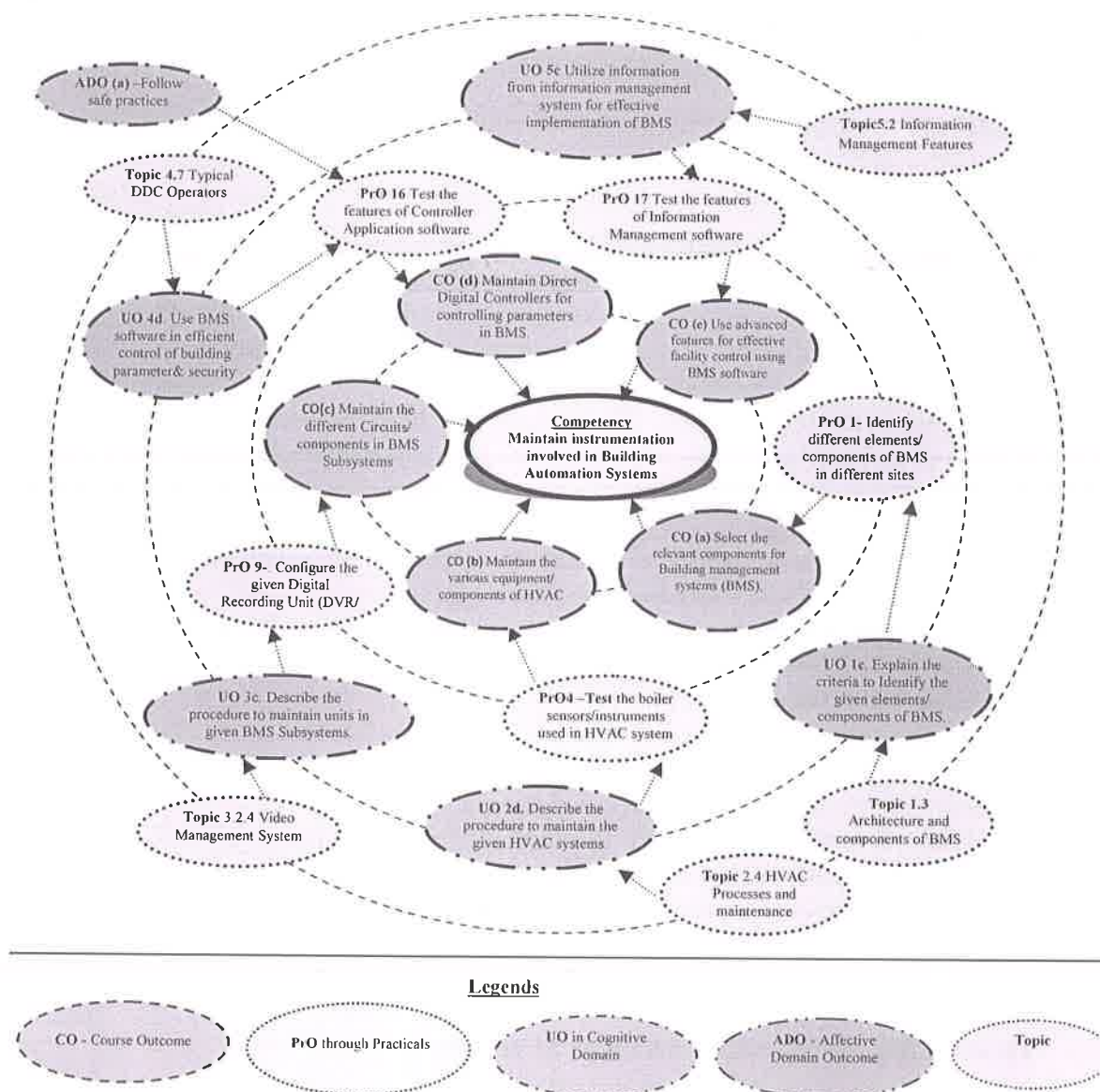
**Legends:** L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment

### 5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the



course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map..



**Figure 1 - Course Map**

## 6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify different elements/ components of BMS in different sites. Part-I	I	2*
2	Identify different elements/ components of BMS in different sites. Part-II	I	2*
3	Test the chiller sensors/instruments used in HVAC system.	II	2*
4	Test the boiler sensors/instruments used in HVAC system.	II	2*
5	Dismantle, test and assemble the sensors used in AHU.	II	2*
6	Dismantle, test and assemble the sensors used in unitary system.	II	2*
7	Test the given Fire detector for Building safety & security.	III	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Test the given Smoke detector for Building safety & security.	III	2*
9	Configure the given CCTV camera (non IP / IP based) using relevant software available with your laboratory.	III	2*
10	Configure the given Digital Recording Unit (DVR/ NVR) available with your laboratory.	III	2*
11	Troubleshoot the faults in the given CCTV system.	III	2*
12	Test the features of the given RFID based access control system.	III	2*
13	Install a single door access control system for the given application.	III	2*
14	Troubleshoot the faults in the given access control system.	III	2
15	Test the features of Controller Operating software.	IV	2*
16	Test the features of Controller Application software.	IV	2
17	Test the features of Information Management software.	V	2
<b>Total</b>			<b>34</b>

### Note

- A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicious mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '\*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.
- The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental setup.	20
2	Setting and operation.	20
3	Safety measures.	10
4	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	Submission of report in time.	10
<b>Total</b>		<b>100</b>

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Work as a leader/a team member.
- Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1<sup>st</sup> year
- 'Organisation Level' in 2<sup>nd</sup> year





- 'Characterisation Level' in 3<sup>rd</sup> year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO.S. No.
1	Fire detector, smoke detector	1,6,7
2	RFID Detector System	1,12,13
3	Proximity sensors	1,3,4,5,6
4	Face and Voice detection system	2
5	Biometric system	2
6	PLC, DCS set up: with atleast 16 Input/ 16 output module	2
7	SCADA software:	2
8	HVAC set up	1,2,3,4,5
9	RTD, T/C, Thermistors, humidity sensor	1,3,4,5
10	CCTV Cameras: IP based/ non IP/ PTZ 2 MP, IR cameras, 20-30 meter distance	2,9,11
11	CCTV DVR/ NVR: 4/8/16 channel, Up to 2 SATA hard disks can be connectivity, 4TB SATA hard disk, local redundant recording, playback with all features like zoom, forward/ reverse, export video on USB etc.	2,10,11
12	Switch: 4/8/16 10/100/1000 Mbps Gigabit Ports, PPPoE/ simple, IEEE 802.1X port-based	2,11
13	Computers: with i3 6 <sup>th</sup> gen. processor, 500 Gb HDD, 4GB RAM, Windows 7	2,15,16, 17
14	IBMS Software	2,15,16, 17

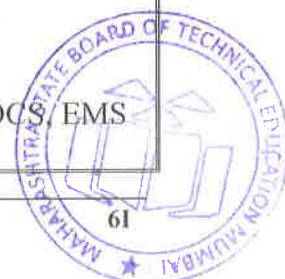
## 8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
<b>Unit-I. Building Management System</b>	1a. Describe the functions of the given BMS components. 1b. Explain with sketches the design considerations of BMS for the given application. 1c. Explain the criteria to Identify the given elements/ components of BMS. 1d. Prepare the Specifications of the BMS for the given requirements.	1.1 Concept of Building Management System (BMS) and its components such as Access control, CCTV, fire/ smoke detection and control, lighting control etc. 1.2 Requirements and design considerations and its effect on functional efficiency of building automation system, 1.3 Architecture and components of BMS. 1.4 Applications
<b>Unit-II. HVAC system</b>	2a. Describe science of HVAC system for the given application. 2b. Explain processes involved in HVAC system by	2.1 HVAC, Basic Processes (Heating, Cooling etc). 2.2 Basic Science: Air Properties, Psychrometric Chart, Heat Transfer mechanisms, Examples.



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	<p>preparing Psychometric Chart in the given application.</p> <p>2c. Calculate properties of air using Psychometric Chart for given application</p> <p>2d. Describe the procedure to maintain the given HVAC systems.</p>	<p>2.3 Human Comfort: Human comfort zones, Effect of Heat, Humidity, and Heat loss.</p> <p>2.4 Processes and maintenance: Heating Process &amp; Applications (e.g. Boiler, Heater (no constructional details)), Cooling Process &amp; Applications (e.g. Chiller (no constructional details)), Humidifying process and applications (e.g. Air Washers, Vaporizing humidifier), Ventilation Process &amp; Applications (i.e. Central Fan System, AHU, Exhaust Fans),</p> <p>2.5 Unitary Systems (VAV, FCU etc).</p>
<b>Unit-III. BMS Subsystems</b>	<p>3a. Explain with sketches the concepts of the given BMS Subsystems.</p> <p>3b. Describe the procedure to test components/ elements and their functions in the given BMS Subsystems.</p> <p>3c. Describe the procedure to maintain the given units in specified BMS Subsystems.</p> <p>3d. Describe the procedure to Test the sensors/circuits used in given BMS Subsystems</p> <p>3e. Suggest the relevant CCTV, FAS, ACS components for specified end users.</p>	<p>3.1 <b>Fire Alarm Systems</b></p> <p>a) Basic of FAS systems</p> <p>b) FAS Architecture, Principles of Operation.</p> <p>c) FAS Components: Different fire sensors, smoke detectors, Fire Alarm Control Panel, Annunciator panel, Suppression systems</p> <p>d) Applications</p> <p>3.2 <b>CCTV Systems</b></p> <p>a) Basic of CCTV systems.</p> <p>b) System Architecture of CCTV Systems</p> <p>c) Concepts Camera Connectivity,</p> <p>d) Video Management System: DVR, DVM, NVR</p> <p>e) Applications</p> <p>3.3 <b>Access Control Systems</b></p> <p>a) Basic Concept.</p> <p>b) Component of Access Control Systems</p> <p>c) Access Control System Devices –Its features and Working principles</p> <p>d) Benefits of Access Control Systems</p>
<b>Unit-IV. Direct Digital Controller</b>	<p>4a. Suggest the controller for the given BMS application.</p> <p>4b. Describe with sketches the procedure to use microprocessors in automation of complex buildings.</p> <p>4c. Differentiate given controllers at various levels in BMS</p> <p>4d. Describe with sketches the procedure Use BMS</p>	<p>4.1 Role of BMS Automation software</p> <p>4.2 Evolution of DDC</p> <p>4.3 Block diagram of DDC</p> <p>4.4 Controller configuration</p> <p>4.5 Types of Controller</p> <p>a) Zone Level</p> <p>b) System Level</p> <p>c) Operation Level</p> <p>d) Management Level</p> <p>4.6 Controller Software</p> <p>a) Operating Software</p> <p>b) Application software- DDCS, EMS</p> <p>4.7 Typical DDC Operators</p>



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	software in efficient control of building parameters and security.	
<b>Unit-V. Advance Technology for effective facility Control</b>	5a. Explain with sketches the optimal features of BMS software for the given building. 5b. Explain with sketches Information Management Features in BMS software 5c. Describe the procedure to Utilize information from information management system for effective implementation of BMS. 5d. Prepare the documents for information management system.	5.1 Features for optimal Control: Optimal START / Optimal STOP, Optimal Run time, Load Rolling, Demand limiting, Economizer switchover, Night purge, After hour, Supply air reset ( Chilled water or Hot Water), Condenser water reset, chiller Sequencing. 5.2 Information Management Features: a) Summaries b) Password c) Alarm Report d) Time Scheduling e) Trending f) Totalization g) Graphics

*Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Building Management System	06	04	02	--	06
II	HVAC System	12	04	04	08	16
III	BMS Subsystems	10	04	08	12	24
IV	Direct Digital Controller	10	04	04	04	12
V	Advance Technology for effective facility Control	10	04	04	04	12
<b>Total</b>		<b>48</b>	<b>20</b>	<b>22</b>	<b>28</b>	<b>70</b>

**Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)

**Note:** This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary 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) Prepare design considerations and its effect on functional efficiency of BMS for the given premises.
- b) Prepare the diagrams for duct system used in the HVAC system for the given building.
- c) Prepare the specifications for boilers, chillers and humidifiers used for given industry/building.
- d) Identify various components of AHU used in various applications.
- e) Identify various components unitary systems used in various applications.
- f) Prepare the specifications for fire detectors.
- g) Prepare the specifications for smoke detectors.
- h) Prepare the diagrams of fire Alarm Control Panels, annunciator panels.
- i) Prepare the specifications for CCTV system.
- j) Prepare the specifications for the given access control system.
- k) Prepare specification of controllers used in various BMS systems.
- l) Prepare specification of controllers software used in various BMS systems.
- m) Prepare a layout of BMS control room for various applications using internet/YouTube.
- n) Make a survey and prepare a report on optimal Control features used in various buildings (e.g. malls, hotels, hospitals, cold storage etc).

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

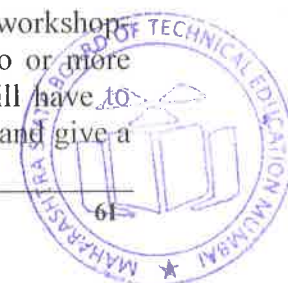
These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- b) '**L**' in item No. 4 does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
- c) About **15-20% of the topics/sub-topics** which is relatively simpler or descriptive in nature is to be given to the students for **self-directed learning** and assess the development of the COs through classroom presentations (see implementation guideline for details).
- d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- e) Video programs/YouTube may be used to teach various topics and sub topics.
- f) Demonstrate students thoroughly before they start doing the practice.
- g) Encourage students to refer different book and websites to have deeper understanding of the subject.
- h) Observe continuously and monitor the performance of students in Lab.
- i) Encourage students to use front/rear panel control of electronic instruments.
- j) Encourage students to visit nearby big facilities/complex buildings or manufacturing industries.
- k) Instruct students to safety concern of handling electronic instruments and also to avoid any damage to the electronic instruments.

## 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a group of students that needs to be assigned to him/her in the beginning of the semester. The project undertaken is to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. The groups have to be formed for micro-projects; the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a





seminar presentation of it before submission. The total duration of the micro-project should not be less than **16 (sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

- a) Draw architecture of HVAC system, BMS system.
- b) Built/construct a model for boiler used in HVAC.
- c) Built/construct a model for chillers used in HVAC.
- d) Built/construct a model for humidifier used in HVAC.
- e) Built/construct a model for cooling tower used in HVAC.
- f) Build a circuit for fire detector
- g) Build a circuit for smoke detector
- h) Build a circuit for fire and smoke alarm system.
- i) Setup a single camera CCTV system.
- j) Setup a single door access control system.
- k) Design a flowchart for various parameter control strategies for a specific application.

### 13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Smart Buildings	Jim Sinopoli	Butterworth-Heinemann imprint of Elsevier, 2 <sup>nd</sup> edition, 2010. ISBN- 9780978614409
2	Building Environment: HVAC Systems	Alan J. Zajac	Johnson Controls, Inc. ISBN- 9780766821002
3	Understanding Building Automation system	Reinhold A. Carlson, Robert A. Di Giandomenico	R.S. Means Company, Inc. (1991) First Edition ISBN- 9780876292112
4	Intelligent Building System	Albert Ting-Pat So, WaiLok Chan	Kluwer Academic, publisher, 3rd ed., 2012. ISBN- 9783319684611
5	Design of Special Hazards and Fire Alarm Systems	Robert Gagnon	Thomson Delmar Learning; New Delhi, 2007 ISBN-9781418039509
6	HVAC Controls and Systems	Levenhagen, John I. Spethmann, Donald H.	McGraw-Hill Publication, New Delhi, ISBN- 9780071786577
7	Process Control-Instrument Engineers Handbook	Bela G. Liptak	Chilton book co. New York, 2010, ISBN- 9781483145020

### 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

- a) Energy Management System :  
[www.nptel.ac.in/courses/108106022/LECTURE%201.pdf](http://www.nptel.ac.in/courses/108106022/LECTURE%201.pdf):
- b) Building Management System:  
[www.melbourne.vic.gov.au/SiteCollectionDocuments/bms-the-basics-explained.pdf](http://www.melbourne.vic.gov.au/SiteCollectionDocuments/bms-the-basics-explained.pdf):
- c) HVAC: [www.pdfs.semanticscholar.org/presentation/11c9/9a40a4ff55687ada3b9a2a3a9f25b04b9631.pdf](http://www.pdfs.semanticscholar.org/presentation/11c9/9a40a4ff55687ada3b9a2a3a9f25b04b9631.pdf):
- d) HVAC, BAS basics, DDC, controller softwares :  
<https://customer.honeywell.com/resources/techlit/TechLitDocuments/77-0000s/77-E1100.pdf>





- e) Building Automation basics, CCTV, Access control, security systems:<http://advancedcontrolcorp.com/blog/2015/05/what-is-a-building-automation-system>
- f) BAS: <https://www.printfriendly.com/p/g/FrX73d>
- g) BMS software: <http://faculty.kfupm.edu.sa/ARE/amhammad/ARE-457-course-web/Building-Management-System.pdf>
- h) BMS software:<https://www.environment.gov.au/system/files/energy/files/bms-guide.pdf>



