Program Name : **Diploma in Industrial Electronics**

Program Code : **IE**

Semester : **Sixth**

Course Title : **Embedded System**

Course Code : **22532**

1. RATIONALE

In the rapidly growing digital world, role of embedded systems is increasingly vital in various domains such as industrial and home automation, entertainment systems, medical equipments and many more. The core of all such system is powered by electronic hardware and associated software. It is therefore evident to impart the knowledge of the related technology and hands on skills to develop and maintain electronics hardware based embedded systems.

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 Embedded 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:

a. Select the relevant microcontrollers for various industrial applications.
b. Use 'Embedded C' programming language to maintain embedded systems.
c. Interpret the communication standards of embedded systems.
d. Develop simple applications of embedded system.
e. Interpret features of Real Time Operating System.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		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.

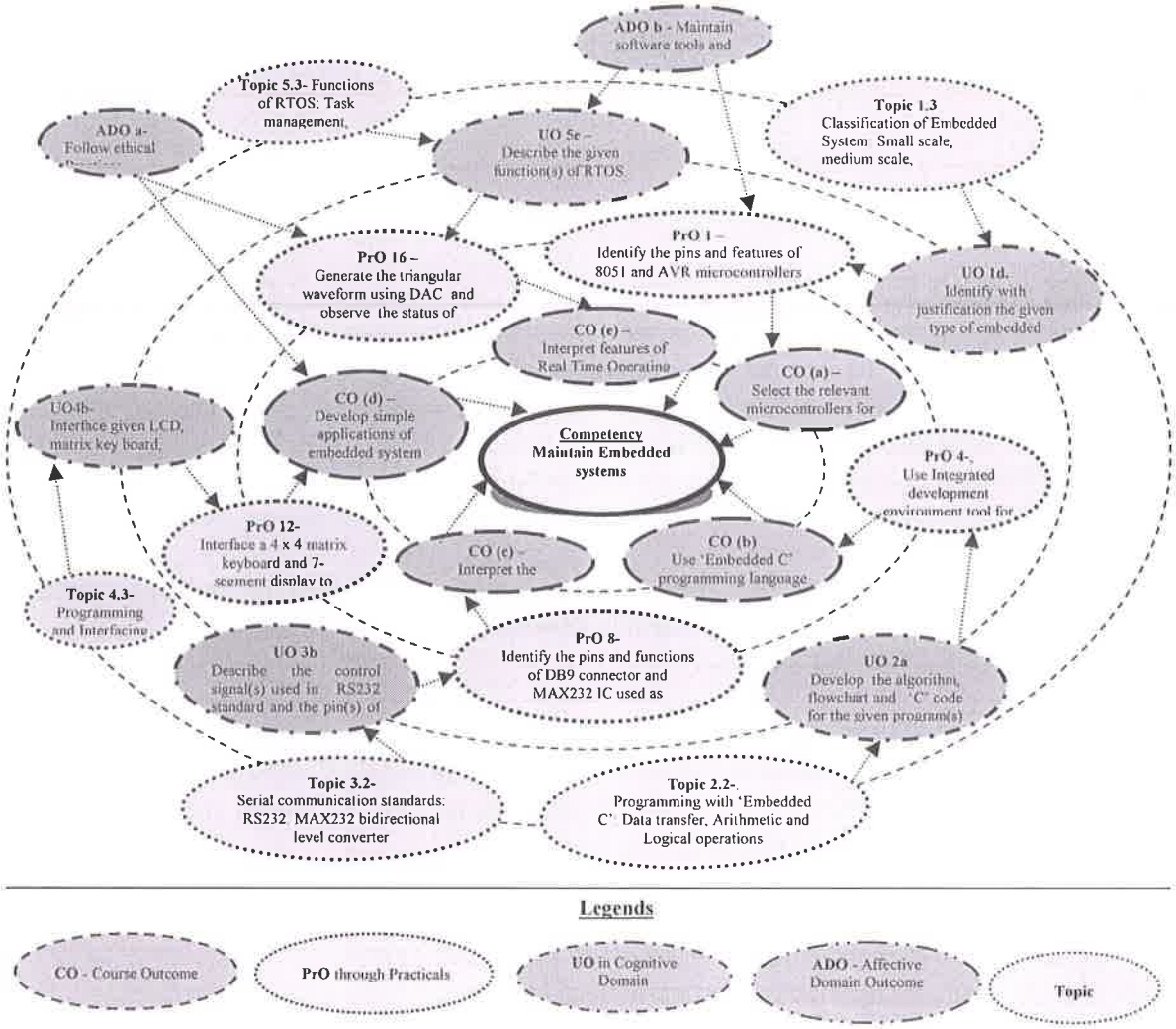

Figure 1 - Course Map

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 the pins and features of 8051 and AVR microcontrollers.	I	2*
2	Identify the pins and features of PIC and ARM microcontrollers.	I	2
3	Identify the family of the given microcontroller.	I	2
4	Use Integrated development environment tool for developing embedded system (Using MicroProC, Keil)	II	2*
5	Execute the C program to perform following arithmetic operations on 8-bit data:-addition, subtraction, multiplication and division for microcontroller	II	2*
6	Execute the C program to perform following arithmetic operations on 16-bit data:-addition, subtraction.	II	2
7	Execute the C program to perform transfer of data from source to destination internal data memory location	II	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Identify the pins and functions of DB9 connector and MAX232 IC used as bidirectional level converter used in RS232 interface.	III	2
9	Execute the C program to turn on LED with respect to Switches connected to port pins of 8051.	IV	2*
10	Execute the C program to display numbers 0 to 9 on 7-segment display with some delay.	IV	2
11	Interface 16 x 2 LCD to 8051. Execute embedded C language program to display string on it.	IV	2
12	Interface a 4 x 4 matrix keyboard and 7-segment display to 8051. Execute C language program to read and display key code on 7-segment display.	IV	2*
13	Interface 8 bit ADC to 8051. Execute C language program to read data of ADC and store the converted digital data in memory.	IV	2*
14	Interface 8 bit DAC to 8051. Execute C language program to generate square, sawtooth and triangular waveforms.	IV	2
15	Interface stepper motor to 8051. Execute C language program to rotate stepper motor with different speed in clockwise and counter clockwise direction.	IV	2*
16	Generate the triangular waveform using DAC and observe the status of control signals using IDE tool(MicroProC, Keil)	V	2*
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial 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.*

ii. *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 %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

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:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.

d. Demonstrate working as a leader/a team member.
e. Maintain software tools and equipment.
f. 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 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd 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. No.
1	Microcontroller kit (8051,AVR/PIC/ARM):-single board systems with minimum 8K RAM,ROM memory with battery back up,16X4, LCD display,7-segment Display, PC keyboard interfacing facility, 4X4 matrix keyboard, cross c-compiler, USB, interfacing facility with built in power supply.	All
2	Desktop PC with Integrated Development Environment (MicroPro C, Keil)	All
3	Stepper Motor, 50/100 RPM	15
4	CRO- Bandwidth AC 10Hz ~ 20MHz (-3dB). DC ~ 20MHz (-3dB), X10 Probe	13,14,
5	Keyboard 4X4 trainer board	12
6	7-segment LED Display:- 0.56 in 1-digit, common anode/common cathode	10,12
7	ADC (0808)trainer board	13
8	DAC (0808)trainer board	14
9	LCD trainer board	11
10	Add on cards for 8 Switches and 8 LED interface	9
11	Digital Multimeter	13,14, 15,16

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Introduction to Embedded systems.	1a. Describe the given component(s) of the given embedded system. 1b. Describe with sketches the architecture of given processor(s). 1c. Describe the given characteristics of the given embedded systems. 1d. Identify with justification the given type of embedded systems used for the given application. 1e. Select with justification the relevant microcontroller from the existing microcontroller families for the given application.	1.1 Block diagram of embedded system with hardware components. 1.2 Harvard and Von-Neumann architecture. RISC and CISC processors. 1.3 Characteristics of embedded system: Processor, power, memory, operating system, reliability, performance, power consumption, NRE cost, unit cost, size, flexibility, time-to-prototype, time-to-market, maintainability, correctness and safety. 1.4 Classification of Embedded System: Small scale, medium scale, sophisticated, stand-alone, reactive/real time (soft and hard real time) 1.5 Features of PIC,AVR and ARM microcontrollers with their applications.
Unit– II Programming using Embedded C	2a. Develop the algorithm, flowchart and 'C' code for the given program(s) used in data transfer, arithmetic /logical, Decision control and looping operations with the given microcontroller. 2b. Develop the algorithm, flowchart and 'C' code for the given program(s) used in timer/counter operations with microcontroller. 2c. Develop the algorithm, flowchart and 'C' code for the given program(s) used in serial communication with microcontroller. 2d. Develop the algorithm, flowchart and 'C' code for the given program(s) used in interrupt handling with microcontroller.	2.1 Programming with 'Embedded C': Data transfer, Arithmetic and Logical operations. Decision Control & Looping. 2.2 Timer/Counter programming with 'embedded C' for microcontroller. 2.3 Serial communication programming with 'embedded C 'for microcontroller 2.4 Interrupt control programming with 'embedded C' for microcontroller.
Unit-III Communication standards and protocols.	3a. Describe the mode(s) of communication 3b. Describe the control signal(s) used in RS232 standard and the pin(s) of MAX232 voltage level converter 3c. Describe the given communication	3.1 Modes of data communication: Simplex, Duplex, Half Duplex, Serial, Parallel, Synchronous and Asynchronous Communication 3.2 Serial communication standards:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	protocol(s) with relevant block schematic. 3d. Describe the given advanced serial communication interface(s)	RS232. MAX232 bidirectional level converter. 3.3 Communication protocols i. Serial Communication Protocol: I^2C, CAN, USB, Serial Peripheral Interface (SPI), Synchronous Serial Protocol (SSP). ii. Parallel Communication Protocol: PCI, PCI-X 3.4 Overview of advanced serial protocol: IrDA, Bluetooth, Zigbee.
Unit –IV Interfacing Input and Output devices	4a. Interface the given basic input/output device(s) with the given microcontroller and develop a simple embedded C program. 4b. Interface given LCD, matrix key board, multiplexed 7-Segment display with the given microcontroller and develop a simple embedded C program. 4c. Interface the given DC motor and stepper motor with the given microcontroller and develop a simple embedded C program. 4d. Interface the given ADC/DAC with the given microcontroller and develop a simple embedded C program.	4.1 Programming and Interfacing of switches, keys, pushbutton, sensors 4.2 Programming and Interfacing of LED, 7-Segment, Relays 4.3 Programming and Interfacing of Matrix keyboard, multiplex 7-Segment display, LCD. 4.4 Programming and Interfacing of stepper motor, DC motor 4.5 Programming and Interfacing of 8 bit ADC/DAC (0808/09)
Unit-V Real Time Operating Systems	5a. Describe general operating system and RTOS 5b. Describe the given characteristic(s) of RTOS. 5c. Describe the given function(s) of RTOS. 5d. Describe the given feature(s) of RTOS	5.1 Operating System: General and Real time operating system. 5.2 Characteristics of Real Time Operating System: Consistency, Reliability, scalability, Performance, Predictability. 5.3 Functions of RTOS: Task management, Scheduling, Resource allocation and interrupt handling 5.4 Features of RTOS: Watchdog timer, Semaphore, Deadlock

***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	Introduction to Embedded systems	08	03	04	05	12
II	Programming using Embedded C	12	04	05	07	16
III	Communication standards and protocols	08	03	04	05	12
IV	Interfacing Input and Output devices	12	04	06	08	18
V	Real Time Operating Systems	08	03	04	05	12
	Total	**48**	**17**	**23**	**30**	**70**

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. Download the data sheets of all the components used in the practical.
b. Prepare a documentation of all the components and device along with their specifications
c. Deliver seminar on relevant topic.
d. Library / Web survey regarding different data books and manuals.
e. Prepare power point presentation on applications of microcontroller.
f. Undertake a market survey of different microcontrollers.
g. Follow the safety precautions.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various 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. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken 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. In special situations where 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 are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a chart of various features using data sheets of 8051,PIC,AVR,ARM microcontroller and its derivatives.
b. Prepare a chart of stepper motor to display its features and steps for its operations using data sheets.
c. Prepare a chart of various features and operations of temperature sensors using data sheets.
d. Prepare a chart of various types of ADC and DAC to display its features and pin functions using data sheets.
e. Prepare a chart of various types of LCDs to display its features, pin functions and steps of operations using data sheets.
f. Prepare a chart of various types of seven segment displays, keyboard to display its features and steps for its operations using data sheets.
g. Build a flashing display.
h. Build a rolling display
i. Build a buzzer system for rapid fire quiz competition.
j. Build a two digit counter.
k. Build a class period bell.
l. Build a temperature monitoring system.
m. Build a pollution monitoring system.
n. Build a humidity monitoring system.
o. Build automated door control system.
p. Build traffic light controller for specified delay.
q. Build a water level controller for given parameters.
r. Build a automated concert lighting.

Note: Use appropriate software for programming. Build the circuit on PCB.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	8051 Microcontroller Architecture Programming	Ayala, Kenneth	EEE/Prentice Hall of India, 2nd edition, New Delhi, 1 July 2004,

S. No.	Title of Book	Author	Publication
	and Application		ISBN-13: 978-1401861582
2	The 8051 Microcontroller and Embedded system	Mazidi, Mohmad Ali; Mazidi, Janice Gelispe; Mckinlay Roline D.	Pearson /Prentice Hall, , 2nd edition, Delhi,2008, ISBN 978-8177589030
3	Microcontroller Principle and Application	Pal, Ajit	Prentice Hall of India,New Delhi,2014, ISBN: 978-81-203-4392-4
4	Microcontroller Theory and Application	Ajay, Deshmukh	McGraw Hill Education, New Delhi, 2011, ISBN- 9780070585959
5	Microcontroller Architecture Programming, Interfacing and System Design	Raj ,Kamal	Pearson Education India, Delhi,2012, ISBN 13:9788131759905
6	The Embedded Software Primer	David E. Simon	Addison-Wesley ISBN 13: 9780201615692

14. SOFTWARE/LEARNING WEBSITES

a. www.keil.com
b. www.faqs.org/microcontroller
c. www.nptel.ac.in/courses/Webcourse-contents/IITKANPUR/microcontrollers/micro/ui/Course_home2_5.html
d. http://www.nptelvideos.in/2012/11/real-time-systems.html
e. https://www.youtube.com/watch?v=rpdygqOI9mM
f. www.intorobotics.com/8051-microcontroller-programming-tutorials- simulators-compilers-and-programmers/
g. www.electrofriends.com/articles/electronics/microcontroller-electronics-articles/8051-8951/80518951-microcontroller-instruction-set/
h. www.ikalogic.com/part-1-introduction-to-8051-microcontrollers
i. www.binaryupdates.com/switch-with-8051-microcontroller/
j. www.mikroe.com/chapters/view/64/chapter-1-introduction-to-microcontrollers/ www.8051projects.net/download-c4-8051-projects.html
k. https://www.elprocus.com/difference-between-avr-arm-8051-and-pic-microcontroller/