Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ/IS/IC**

Semester : **Fifth**

Course Title : **Embedded Systems (Elective for IS/IC)**

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 basic applications using embedded systems.
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.

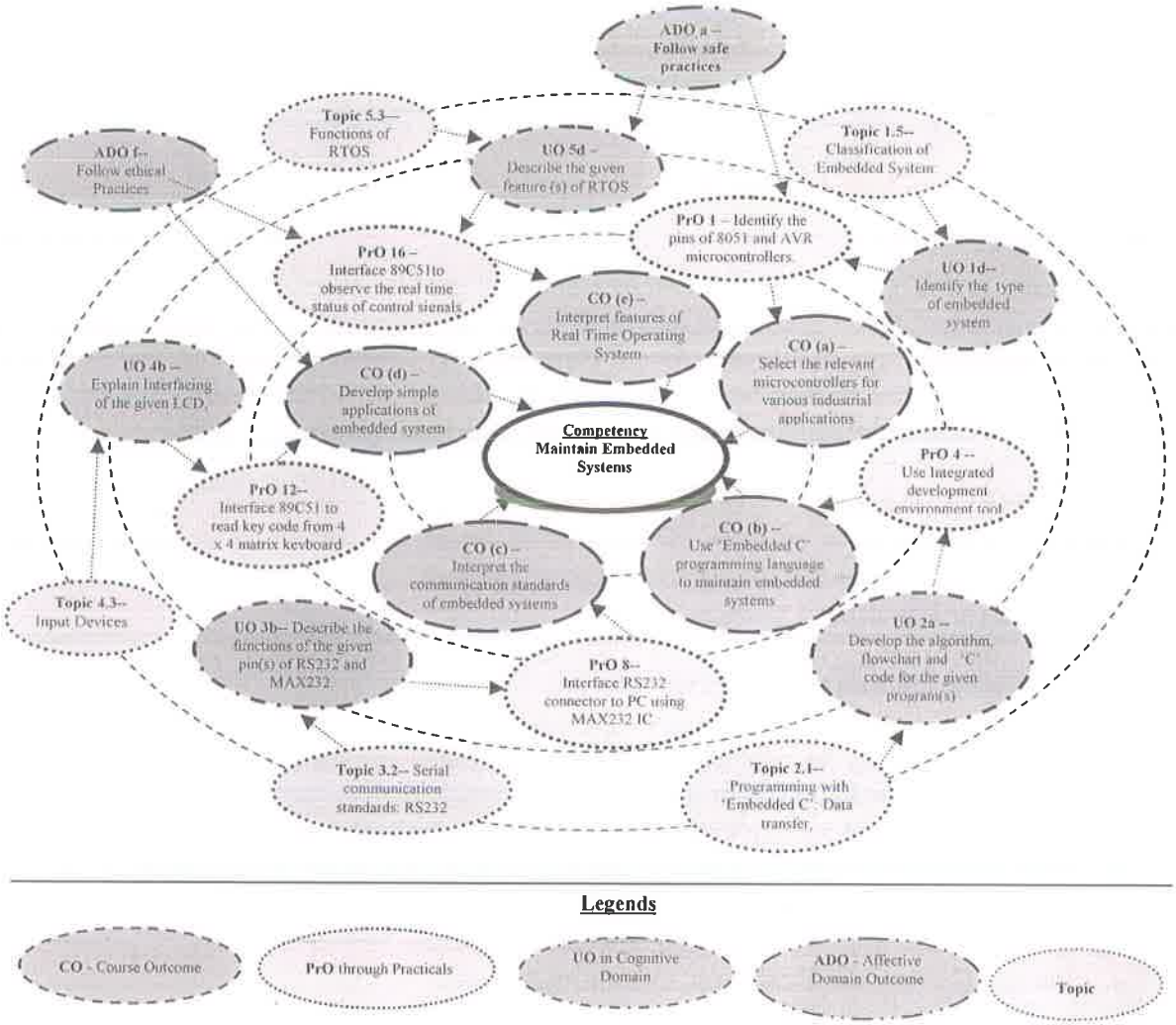

Figure 1 - Course Map

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:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the pins of 8051 and AVR microcontrollers.	I	2*
2	Identify the pins and features of PIC microcontrollers.	I	2
3	Identify the features of ARM microcontroller on the basis of IC number.	I	2
4	Use Integrated development environment tool for developing embedded 'C' programs (Using MicroProC/ Keil).	II	2*
5	Execute the 'C' program to perform following arithmetic operations on 8-bit data: addition, subtraction, multiplication and division.	II	2*
6	Develop and Test the 'C' program to perform following arithmetic operations on 16-bit data: addition, subtraction.	II	2

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Develop and Test the 'C' program to perform data transfer from source to destination (Use internal data memory locations).	II	2*
8	Interface RS232 connector to PC using MAX232 IC.	III	2
9	Develop and test the 'C' program to turn on LED (S) with key (S) press.	IV	2*
10	Interface 89C51/AVR microcontroller and write the 'C' program to display numbers from 0 to 9 on 7-segment display with specified delay.	IV	2
11	Interface 89C51/AVR microcontroller and write C program to display string on given 16 x 2 LCD.	IV	2*
12	Interface 89C51/AVR microcontroller and write 'C' language program to read key code from 4 x 4 matrix keyboard and LCD display .	IV	2*
13	Interface 89C51/AVR microcontroller and write C program to convert analog signal into digital form using given 8 bit ADC and store the converted digital data in memory.	IV	2*
14	Interface 89C51 and write C program to generate square and sawtooth waveforms using given 8 bit DAC.	IV	2*
15	Interface 89C51 /AVR microcontroller and write C program to rotate stepper motor with different speeds in clockwise and counter clockwise direction.	IV	2*
16	Interface 89C51 and write C program to observe the real time status of the triangular waveform generated using DAC (Use 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:

Sr. 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. Work as a leader/a team member.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisitions of the ADOs take 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.

Sr. 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	Arduino Board with AVR microcontroller	All
3	Desktop PC with Integrated Development Environment (MicroPro C/ Keil / Proteus).	All
4	Stepper Motor- 50/100 RPM (or any relevant).	15
5	CRO- Bandwidth AC 10Hz ~ 20MHz (-3dB). DC ~ 20MHz (-3dB), X10 Probe.	13,14,
6	ADC (0808) trainer board.	13
7	DAC (0808) trainer board.	14
8	Add on cards.	9
9	Digital Multimeter : 3 1/2 digit display, 9999 counts digital multimeter measures: V_{ac}, V_{dc} (1000V max) , A_{dc}, A_{ac} (10 amp max) , Resistance (0 - 100 MΩ) , Capacitance and Temperature measurement	13,14, 15,16

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
Unit– I Introduction to Embedded systems	1a. Describe the given component (s) of the given embedded system. 1b. Describe with the help of block diagram, the architecture of the given processor. 1c. Describe the given characteristic (s) of the specified embedded systems. 1d. Identify with justification the 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 Features of 89C51, PIC, AVR and ARM microcontrollers with their applications 1.4 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 1.5 Classification of embedded system: small scale, medium scale, sophisticated, stand-alone, reactive/real time (soft and hard real time).
Unit– II Programming using Embedded C	2a. Develop the algorithm, flowchart and 'C' program (s) for the given microcontroller to perform the given operation. (data transfer, arithmetic /logical, decision control and looping operations). 2b. Develop the algorithm, flowchart and 'C' code for the given delay using timer/counter with microcontroller. 2c. Develop the algorithm, flowchart and 'C' code for the given data transfer through serial communication port. 2d. Develop the algorithm, flowchart and 'C' code to control the given interrupt.	2.1 Programming with 'Embedded C': arithmetic and logical operations. data transfer with memory and port, decision control & looping 2.2 Timer/Counter program using 'embedded C' for given microcontroller 2.3 Serial communication program using 'embedded C' for given microcontroller 2.4 Interrupt control program with 'embedded C' for given microcontroller
Unit-III Communication standards and protocols.	3a. Describe the given mode (s) of communication. 3b. Describe the functions of the given pin(s) of RS232 and MAX232 with suitable sketch. 3c. Describe the given communication protocol (s) with relevant sketch. 3d. Describe the given advanced serial communication interface.	3.1 Modes of data communication: serial parallel, synchronous and synchronous communication 3.2 Serial communication standards: RS232 3.3 MAX232 as a bidirectional level converter 3.4 Communication protocols i. Serial communication protocols: I^2C, CAN, USB, serial peripheral

Unit	Unit Outcomes (UOs) (In cognitive domain)	Topics and Sub-topics
		interface (SPI), synchronous serial protocol (SSP) ii. Parallel communication protocols: PCI, PCI-X 3.5 Features of advanced serial protocol: IrDA, bluetooth, zigbee
Unit –IV Interfacing Input and Output devices	4a. Explain the steps for interfacing of the given basic input/output device (s) to the given microcontroller with embedded 'C' 'program. 4b. Explain the steps for interfacing of the given LCD, matrix key board, multiplexed 7-segment display, sensor to the given microcontroller with embedded 'C' program. 4c. Explain interfacing of DC motor to the given microcontroller to rotate in the given direction using embedded 'C'program. 4d. Explain the steps for interfacing of given stepper motor with the microcontroller to rotate in given direction, angle of rotation, with half step/full step with embedded 'C'program. 4e. Explain interfacing steps of the given ADC/DAC to convert data with the given microcontroller with embedded C program.	4.1 Interface the various input, output and special devices to the microcontroller 89C51/AVR 4.2 Output Devices : LED, LCD, relays, 7-segment displays, multiplex 7-Segment display 4.3 Input Devices : key, matrix keyboard 4.4 Motor : stepper motor, DC motor 4.5 ADC/DAC: 8 bit ADC/DAC (0808/09) 4.6 Sensor :Temperature sensor (LM35)
Unit-V Real Time Operating Systems	5a. Describe the given functions of the specified operating system with suitable sketch. 5b. Compare the given characteristics of RTOS and General OS. 5c. Explain deadlock condition in RTOS with suitable sketch. 5d. Explain the given features of RTOS with suitable sketch.	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: i. Task management: inter task communication and multitasking ii. Scheduling: scheduling algorithms. iii. Resource allocation and interrupt handling 5.4 Features of RTOS: watchdog timer, semaphore 5.5 Deadlock: i. Reason of occurrence ii. Handling of deadlock: detection, prevention, ignoring

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	04	04	04	12
II	Programming using embedded 'C'	12	02	06	08	16
III	Communication standards and protocols	08	02	04	06	12
IV	Interfacing input and output devices	12	04	06	08	18
V	Real Time Operating Systems	08	02	04	06	12
Total		**48**	**14**	**24**	**32**	**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 devices 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.

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 is 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 various features and operations of temperature sensors, devices using data sheets.
c. Prepare a chart of various types of LCDs to display its features, pin functions and steps of operations using data sheets.
d. Interface potentiometer with development board (Arduino) and write a program to generate LED pattern on it.
e. Programming of an Arduino (Arduino ISP) Interfacing Motor through L293D Driver with Arduino
f. Interfacing Accelerometer with Arduino Interfacing of Relay Driver ULN2803 with Arduino
g. Build a flashing display to flash advertisement of Mobile shop.
h. Build a system to display department name using rolling display.
i. Build a buzzer system for rapid fire quiz competition.
j. Build a two digit counter.
k. Build a class period bell as per the given time table which includes 7 teaching periods and lunch hour.
l. Build a temperature monitoring system to maintain temperature in given range.
m. Build a pollution monitoring system to observe the level of CO_2.
n. Build automated door control system to open and close the door.
o. Build traffic light controller for traffic signals as per specified delay.
p. Build a water level controller for given water levels.

Note: Use appropriate software for programming. Build the circuit on PCB or use development board such as Arduino.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	8051 Microcontroller Architecture, Programming and Application	Ayala, Kenneth	Cenage learning, 3rd edition, New Delhi,2007, ISBN: 978-8131502006
2	The 8051 Microcontroller and Embedded system	Mazidi, Mohmad Ali; Janice, Gelispe and Mckinlay, Roline D.	Pearson, 2nd edition, Delhi, 2008, ISBN: 9788177589030
3	Microcontroller Principle and Application	Pal, Ajit	PHI, New Delhi,2014, ISBN: 9788120343924
4	Microcontroller Theory and Application	Deshmukh, Ajay	McGraw Hill Education, New Delhi, 2011, ISBN: 9780070585959
5	Microcontroller Architecture Programming, Interfacing and System Design	Rajkamal	Pearson Education India, Delhi, 2012, ISBN: 9788131759905
6	The Embedded Software Primer	David E. Simon	Addison-Wesley,Delhi ISBN: 9780201615692

14. SOFTWARE/LEARNING WEBSITES

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


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