Program Name : **Diploma in Medical Electronics**

Program Code : **MU**

Semester : **Fourth**

Course Title : **Microcontroller and Embedded System**

Course Code : **22434**

1. RATIONALE

In industry, microcontroller is heart of most of the domestic, industrial, consumable and other high end electronic products. Automation in every field is being used and microcontroller is inbuilt element of these embedded systems, requiring knowledge of microcontrollers is very vital. This course is intended to develop the skills to diagnose and rectify embedded system related problems in the industry.

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 biomedical instruments based on microcontroller and 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 microcontroller for various biomedical applications.
b. Use IDE to write embedded C programs for AT89C51 microcontroller.
c. Interface I/O devices with microcontroller.
d. Maintain various communication protocolsin medical systems.
e. Maintain embedded systems in biomedical applications.

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.

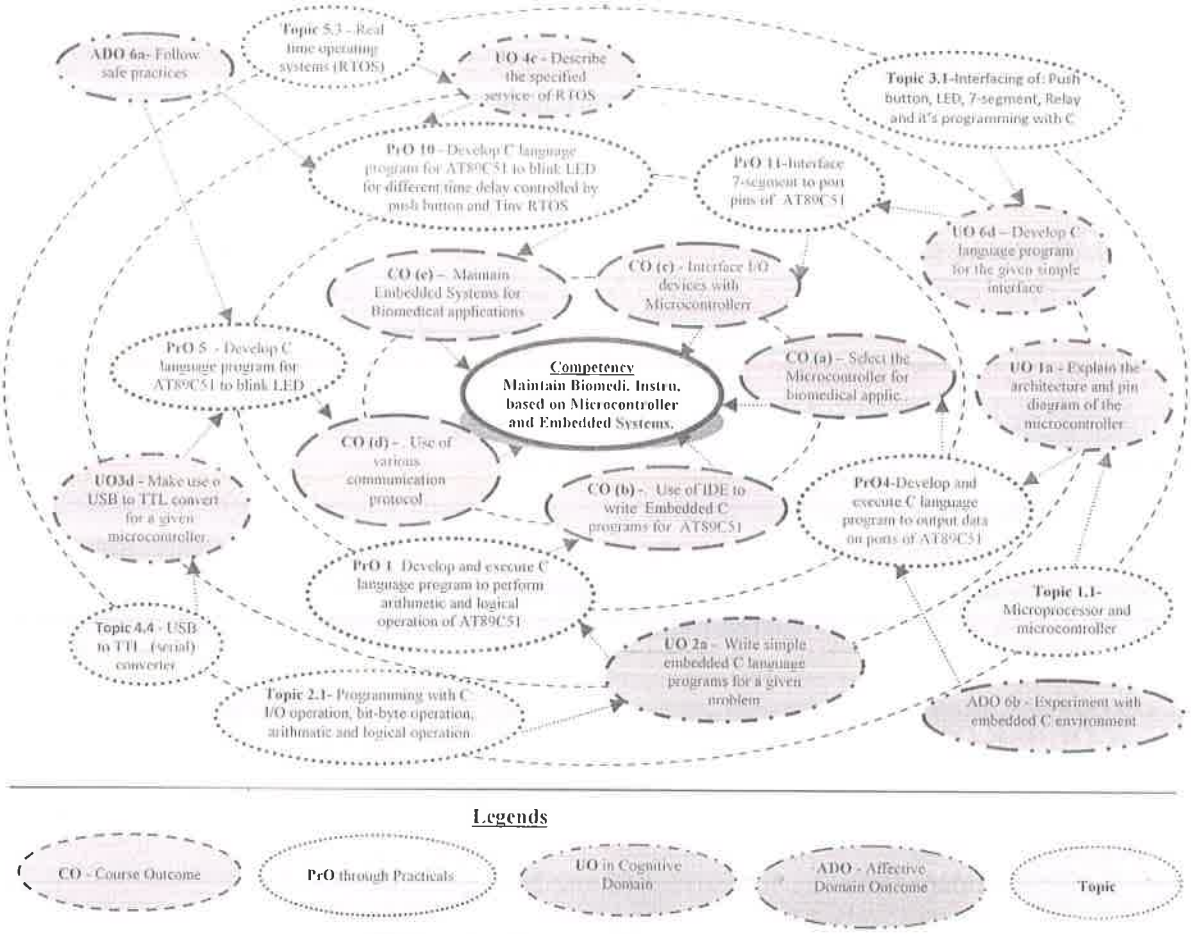

Figure 1 - Course Map

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.	Develop and execute assembly and C language program to output data on ports of AT89C51.	II	02*
2.	Develop and execute assembly and C language program to perform arithmetic and logical operations of AT89C51.	II	02
3.	Develop and execute time delay program for AT89C51 using assembly and C language.	II	02
4.	Develop and execute C language program to generate square wave on port pin of AT89C51.	II	02*
5.	Develop and execute C language program to send data serially on TXD line of AT89C51.	II	02
6.	Interface single digit 7-segment to port of AT89C51 and write C language program to display numbers.	III	02*
7.	Interface Relay to port pin of AT89C51 and write C language	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	program to turn ON the bulb through the relay.		
8.	Interface 4x4 matrix keyboard to AT89C51 and write C language program to scan the code of pressed key and display it on port.	III	02
9.	Interface 16x2 LCD with AT89C51and write C language program to display message.	III	02
10.	Interface ADC0808 with AT89C51 and write C language program to convert analog data to digital and display it on port.	III	02
11.	Interface DAC0808 with AT89C51and write C language program to generate various waveform.	III	02
12.	Interface stepper motor with AT89C51 and write C language program to rotate it by different angles.	III	02
13.	Interface Push button and LED to port pins of Arduino board and write C language program to turn ON LED when Push button is pressed.	III	02
14.	Interface DC motor with Arduino board and write C language program to rotate it CW and CCW.	III	02
15.	Develop C language program for AT89C51 to blink LED and load it to microcontroller using CP2102.	IV	02*
16.	Develop C language program for AT89C51 to blink LED for different time delay controlled by push button and Tiny RTOS.	V	02*
	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 %
1	Write algorithm and draw flowchart	10
2	Use IDE tools for programming	40
3	Debug, test and execute the program	20
4	Observations and Interpretation	10
5	Answer to sample questions	10
6	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. Handle command prompt environment
b. Experiment with embedded C environment
c. Plan, construct, compile, debug and test embedded C program
d. Practice good housekeeping

e. Practice energy conservation
f. Demonstrate working as a leader/a team member
g. Maintain tools and equipment
h. 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	Hardware: Personal Computer Pentium 4, 2GHz onwards, I3-I5 preferable, RAM minimum 2 GB onwards	1 to 17
2	Operating system: Windows XP/ Windows 7/Linux onwards	1 to 17
3	Trainer kit for AT89C51 with onboard 16x2 LCD, 4x4 matrix keyboard, 7-segment display, ADC and DAC interface	1 to 13. 16, 17
4	Trainer kit for stepper motor	13
5	Trainer kit for DC motor	15
6	Keil/SPJ IDE	1 to 13, 16, 17
7	Proteus software	1 to 17
8	Hyperterminal	5.16
9	Device programmer for AT89C51	1 to 13, 16, 17
10	USB to TTL (serial) converter CP2102	16
11	Digital Multmeter	1 to 17
12	Digital storage oscilloscope 50MHz	4.8.12
13	Arduino board	14,15

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 Microcontroller MCS-51	1a. Explain with sketches the function of the given pin of AT89C51. 1b. Explain with sketches the function of the given interrupt of AT89C51. 1c. Describe with sketches Timer/Counter	1.1 Microprocessor and microcontroller 1.2 Features of MCS-51 microcontroller, it's architecture and pin diagram

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	mode for specific application of the given microcontroller. 1d. Describe the use of the given serial communication mode for data transfer in the given situation. 1e. Select microcontroller for specified application wih justification. 1f. Compare the features of the given two types of microcontrollers from the MCS-51 family. 1g. Describe with sketches the procedure to troubleshoot the given type of microcontroller.	1.3 Interrupt structure, timer/counters and it's modes, modes of serial communication and related SFRs 1.4 Selection factors of microcontroller 1.5 Derivatives of MCS-51: 8031,8032,8051,8052,8751, 8752 and AT89C51
Unit-II Programming AT89C51 microcontroller with Embedded C	2a. Describe with sketches the functions of the given IDE tool. 2b. Explain with sketches the embedded software development cycle of the given IDE tool. 2c. Compare features of the assembly and C language on the basis of specified parameters. 2d. Write simple Embedded C language programs for the given problem. 2e. Use assembly instructions in C program for specific time delay for the given microcontroller.	2.1 Integrated Development Environment (IDE) for developing program, IDE tools: Editor, assembler, compiler, debugger and linker 2.2 Assembly language versus embedded C 2.3 Programming with C: I/O operation, bit-byte operation, arithmatic and logical operation, timer/counter operation, time delay routine, serial communication 2.4 Assembly instructions for time delay in C
Unit– III I/O Interfacing application with AT89C51 and Aurdino board	3a. Develop C language program for the given simple interface. 3b. Develop the logic to locate a specified key which is pressed on the 4x4 matrix keyboard interfaced to the given type of microcontroller. 3c. Write commands to initialize 16x2 LCD interfaced to the given microcontroller in the given situation. 3d. Develop the logic to convert 8-bit data using ADC0808/9 interfaced to the given microcontroller in the given situation. 3e. Develop the C language program to generate the given waveform by interfacing DAC0808 with the given microcontroller in the given situation. 3f. Develop the logic to rotate the given	3.1 Interfacing of: Push button, LED, 7-segment, Relay and it's programming with C 3.2 Interfacing of 4x4 matrix keyboard (no program) 3.3 Interfacing of 16x2 LCD (only initialization commands and logic, no program) 3.4 Interfacing of ADC0808/9 (only interfacing diagram, no program) 3.5 Interfacing DAC0808 and write C program to generate square, triangular and sawtooth waveform 3.6 Interfacing of stepper motor with AT89C51

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	motor for the specified criteria interfaced to the microcontroller. 3g. Explain with sketches the procedure of interfacing the given device with aurdino board.	3.7 Arduino board: pinout diagram, function of pins, interfacing with LED and DC motor
Unit– IV Communication Protocols	4a. Compare the given parameters of the specified communication modes. 4b. Explain with sketches the working of the given serial protocol. 4c. Explain with sketches the working of the given wireless communication protocol. 4d. Explain with sketches of how to use the USB to serial converter for the given microcontroller. 4e. Describe the procedure to troubleshoot the given type of communication protocol	4.1 Serial and parallel communication, synchronous and asynchronous communication 4.2 Serial communication protocol: I2C, USB, serial peripheral interface (SPI) 4.3 Wireless communication protocol:IrDA, Bluetooth 4.4 USB to TTL (serial) converter CP2102
Unit –V Embedded System Design	5a. Classify embedded system on the basis of given parameters. 5b. Describe the characteristics of the embedded system for the given application. 5c. Compare features of the OS and RTOS on the basis of the given parameters. 5d. Describe with sketches the specified service of RTOS. 5e. Troubleshoot the specified problems in intertask communication with justification.	5.1 Embedded System: Introduction, classification, application, advantages and disadvantages 5.2 Characteristics of embedded systems 5.3 Real time operating systems (RTOS): Comparison of normal OS and RTOS, need of RTOS in embedded system, multitasking, inter task communication

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' 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	Microcontroller MCS-51	12	04	06	06	16
II	Programming AT89C51 microcontroller with embedded C	14	02	06	08	16
III	I/O Interfacing application with AT89C51 and Aurdino board	10	02	06	08	16
IV	Communication protocols	06	02	04	04	10
V	Embedded system design	06	04	04	04	12

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
Total		48	14	26	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. Use various microcontrollers and IDEs to develop small scale embedded system.
b. Conduct Library / Internet survey of Microcontrollers and I/O devices.
c. Prepare power point presentation on microcontroller based system.
d. Develop a small report on "Applications of Microcontrollers for health, safety, environment and society'

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. Use PPT to explain the communication protocols.
f. Guide student(s) for using data sheets.
g. Guide student(s) in undertaking interesting micro-projects. For some groups of bright students, microprojects using other microcontrollers like PIC16F877 and AVR can also be given.

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. **DC motor control using DTMF decoder and microcontroller:** Develop DC motor control system using CM8870 DTMF decoder IC and AT89C51. Write report on the same.
b. **LED control using DTMF decoder and microcontroller:** Develop LED ON/OFF control system using CM8870 DTMF decoder IC and **microcontroller**. Write report on the same.
c. **LED ON/OFF using Bluetooth and AT89C51:** Develop LED ON/OFF operation board using HC05 bluetooth device and AT89C51. Write report on the same.
d. **LED pattern generation using Arduino/Rasberry pi:** Generate LED pattern using Arduino board. Write report on the same.
e. **Heart beat Monitoring using Arduino/Rasberry pi:** Design heart beat monitoring system using Arduino board. Write report on the same.
f. **Distance measurement using Ultrasonic module and Arduino:** Design distance measurement unit using ultrasonic module and Arduino board. Write report on the same

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	The 8051 Microcontroller & Embedded Systems Using Assembly and C with CD	Ayla, Kenneth J.	Cengage Learning India Pvt. Ltd., New Delhi, 2010 ISBN: 978-8131511053
2	The 8051 microcontroller and embedded system using Assembly and C	Mazidi, Mohmad-ali; Mazidi, Janice-Gelispe;Mckinlay, Roline D.	Pearson India, New Delhi, 2008 ISBN: 9788131710265
3	Microcontroller theory and application	Deshmukh, Ajay	McGraw- Hill, New Delhi, 2011, ISBN: 9780070585959
4	Microcontrollers: Architecture, Programming, Interfacing and System Design	Kamal, Raj	Pearson Education India, New Delhi, 2011, ISBN: 9788131759905
5	Embedded System Design: A Unified Hardware/Software Introduction	Vahid, Frank; Givargis, Tony D.	Wiley, New Delhi, 2006 ISBN: 9780471386780
6	Embedded / Real-Time Systems: Concepts, Design and Programming -Black Book	Prasad, K.V.K.K.	Dreamtech Press, New Delhi, 2003, ISBN: 978-8177224610

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. freevideolectures.com/Course/3018/Microprocessors-and-Microcontrollers
b. nptel.ac.in/courses/Webcourse-contents/IIT.../microcontrollers
c. www.elprocus.com/basics-and-structure-of-embedded-c-program-with-examples-for-beginners/
d. www.scriptoriumdesigns.com/embedded/programming_basics.php
e. www.edgefx.in/steps-to-build-embedded-c-programming-tutorial/
f. www.eeherald.com/section/design-guide/esmod7.html
g. maxembedded.com/2013/09/serial-communication-introduction/
h. www.byteparadigm.com/applications/introduction-to-i2c-and-spi-protocols/
i. learn.sparkfun.com/tutorials/serial-peripheral-interface-spi
j. www.tutorialspoint.com/embedded_systems/es_overview.htm
k. nptel.ac.in/courses/108102045/1
l. www.sunrom.com/p/cp2102-usb-ttl-uart-module
m. www.youtube.com/watch?v=nlAweTBYISM
n. www.youtube.com/watch?v=RaOuzwQDHKg
o. www.circuitstoday.com/getting-started-with-keil-uvision
p. www.youtube.com/watch?v=Oy_cA1d6TqE
q. www.8051projects.net/wiki/Keil_Embedded_C_Tutorial#Introduction_to_Keil_C
r. www.arduino.cc/en/Tutorial/BuiltInExamples
s. www.arduino.cc/en/Guide/Introduction