INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

PROPOSAL FOR INTRODUCING A NEW SUBJECT

1. Name of the Department/Centre/School proposing to introduce the subject : AT

2. Name of the subject : EMBEDDED SENSING, ACTUATION AND INTERFACING SYSTEM

3. L-T-P and Credit loading of the subject : L-T-P : 4-0-0 Credit : 4

4. Status of the subject

   a) Specify the Session,Semester ,from which the subject is going to be offered : SPRING,2019-2020

   b) Level of the Subject : PG Level

   c) Name(s) of the Programme(s) in whose curricula this subject will be included : 1) ,PHD/MS LEVEL RS.
   2)1 st Year,EMBEDDED CONTROLS AND SOFTWARE PG.
   3)1 st Year,MICROELECTRONICS & V L S I DESIGN PG.
   4)1 st Year,VISUAL INFORMATION AND EMBEDDED SYSTEMS ENGG. PG.
   5)1 st Year,INSTRUMENTATION AND SIGNAL PROCESSING PG.
   6)1 st Year,WIRELESS COMMUNICATIONS AND NETWORKS PG.
   7)1 st Year,MECHANICAL SYSTEMS DESIGN PG

   d) Whether the subject will be offered as Compulsory or Elective : ELECTIVE

   e) The semester in which the subject will be offered. : SPRING

5. Prerequisite(s) for the subject, if any Please give the subject number and names) :

6. Objectives and contents

   a) Objectives : Sensors and actuators are the integral parts of an embedded system which finds versatile applications in automobile, aerospace, biomedical, consumer electronics, agriculture, environment and so on. Sensors and actuators connect the macroscopic analog world with the embedded controller through interfacing circuits. The interfacing system perform necessary operations on the real world signals to make them compatible with the associated parts of embedded system. Each type of sensors and actuators demands unique requirements while integrating with an embedded controller. Hence without adequate knowledge on various sensors, actuators and their interfaces with embedded controller, the concept of embedded control system remains incomplete. Although there are some courses related to embedded system, its programming and control aspects, the same with respect to smart sensing and actuation technology along with their advanced interfacing circuits in various applications are not available.
   This course is aimed at developing the practical technical skills among the students to integrate various sensing, actuation units and other required accessories with embedded controller and build a complete embedded system for intended applications. The course will enable the students to gather necessary concepts to develop and select suitable smart sensors, actuators, with associated knowledge of interface electronics and signal conditioning for cuttingedge applications. Micromachining technology for miniatuarization of smart devices along with CMOS integration will be also discussed. The cutting edge research topic on energy harvesting technology towards development of selfpowered wireless sensor network along with the security issues will be covered as well. Finally various case studies with recent application trends will be illustrated.

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b) Contents (in 100 to 150 words) :

1.Introduction: Overview of Embedded System, Architecture; Importance of advanced sensors, actuators and interfacing circuits: Applications. [2L]

2.Embedded Sensors and Actuators: Various types of sensors, actuators, their descriptions and applications: Thermal, Electrical, Magnetic, Mechanical, Optical, Chemical, Magnetoresistive, Hydraulic, Pneumatic etc. [4L]

3.Interfacing of Sensors and actuators to embedded controller: Signal conditioning circuit, loading effect, OpAmp based circuit implementation, ADC, DAC, environmental effects, Driver circuits and elements, Signal Processing: Sampling, Ztransform, Digital Filters. [5L]

4.Advanced Techniques for Direct Interfacing of Resistive Sensors to Embedded controller: Embedded Processor Based Excitation System; Direct interfacing Resistive Sensors and its array to Microcontrollers; Electrochemical Impedance Spectroscopy; Case study: Smart temperature sensor. [5L]

5. Advanced Interfacing Techniques for the Capacitive Sensors to Embedded controller: Microcontroller Compatible Oscillator Based Active Bridge Circuit for wide range measurement, Auto balancing bridge for Lossy Capacitive Sensor, Current Mode Circuit for Grounded Capacitive Sensors; CDC, Subnanometer range displacement sensing. [5L]

6.Miniatuarized sensors, actuators and interface: Requirement of miniatuarization, Technology used, Various types of miniaturized sensors and actuators, Working Principle, design, CMOS compatible miniatuarization process, SystemonChip integration, Sensor Fusion, Applications. [5L]

7.Energy Harvesting to develop SelfPowered Embedded Wireless Sensors Network: Energy harvesting techniques: Vibration: Piezoelectric, Electromagnetic, Electrostatic; Solar, Photoelectric, Pyroelectric, RF; Interfacing circuits; Sensors and Actuators in Wireless networks, Energy Management; Recent trends towards development of selfpowered embedded system. [7L]

8.Security aspects of cyber physical sensor system: System concepts and applications, Various attacks on sensor systems and their remedies. [3L]

9.Embedded Sensors, actuators and interfacing in Automotives: Smart remote pressure and temperature sensor in vehicle tires, rotation speed of engine, Integrated Hall Sensors, Accelerometers, Gyroscopes, Actuators in Steering wheel, seat positioning. [3L]

10.Embedded Biomedical Sensors, Actuators and their Interfacing: Wearable/implantable Integrated Biomedical Sensors; LabonPill, Smart Home for ElderPeople based on Wireless Sensors, Automatic Drug delivery system. [3L]

11.Case studies: Interfacing Techniques for Olfactory and Taste Sensors: Electronic Nose and Tongue; Structural health monitoring in Aerospace applications; Agriculture: Automatic Fruit Sorting and grading, Microbiological Food Spoilage Screening detection. Tutorials and assignments on design of signal conditioning circuit, interfacing circuits, and complete embedded system for various applications. [6L]

(Please attach the detailed lecture-wise breakup and/or list of experiments)

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7. Names of the faculty members of the Department/Centre/School who have the necessary expertise and will be willing to teach the subject (minimum two faculty members should be willing to teach the subject).

8. Do the contents of the subject have an overlap with any other subject offered in the Institute? If yes, please give details as follows. : Y

   a) The number and the name of the existing subject : 1)ADVANCED SENSING TECHNIQUES.
   2)PROGRAMMABLE AND EMBEDDED SYSTEM.
   3)MEMS & BIOSENSORS (EE60101,EE60098,MM61509)

   b) Approximate percentage of overlap : 10

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c) Reason for offering the new subject in spite of the overlap : The proposed course focuses on detail aspects of various advanced sensors, actuators and their interfacing techniques with the embedded controller which is a vital part of embedded control system. It also includes the cutting edge research topic on miniatuarized devices, energy harvesting technology towards development of selfpowered wireless sensor network along with the security issues The existing courses does not cover the above area completely and thus they have minimum overlap with the proposed course. The detailed comments comparing each existing courses and their syllabus with the proposed course are mentioned below.

EE60101: Advanced Sensing Technique

Syllabus:
Introduction, Features of Advanced sensing techniques. Introduction of advanced sensing materials, Properties. Design and modeling issue. Introduction of different mathematical tools, Optimization techniques used in sensor design. Numerical design such as FEM, FDM, etc. Study of Tomography, Introduction to MEMS sensor. Fabrication, Physical sensors: Hall Effect sensors, Eddy current sensors, Accelerometers. Humidity and moisture sensor, Proximity detectors, Microfluidic sensors, Chemical sensor. Potentiometric sensors, amperometric sensors. Introduction to concept of Lab on chips. The role of PCA, LDA, Neural network in designing sensor array. Case study of a gas sensing platform, liquid sensing.

Comments:
The above course mainly focuses on some advanced sensing techniques, sensor material properties, numerical modelling and design aspects of some sensors along with an overview of microsensors. It does not include the various aspects of interfacing the sensors and actuators in embedded platform in modern applications. Thus it has minimum overlap with the proposed course.

EE60098: Programmable and Embedded System

Syllabus:
Introduction to Embedded Systems; Embedded Systems Hardware: Processors Digital Signal Processors, Microcontrollers, Special Purpose Processors, I/O devices Analog I/O, Digital I/O, Bus I/O, Serial and Network I/O, Memory, Power and Display Devices Reconfigurable and Custom Logic Devices, System Hardware Design Case Study; Embedded Systems Software : Introduction to Operating Systems, Real Time Operating Systems, Device Drivers; Embedded Systems Application Design and Programming Environments : System Specification and Modelling, Programming, Simulation and Verification, Performance Analysis and Optimisation; Selected Application Case Studies from areas such as : Instrumentation and Signal Processing Systems, Control and Actuation Systems, Power Electronic Drive Systems etc; Embedded Systems Testing.
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Comments:
This course primarily deals with the details of microcontroller, its hardware description and software programming followed by some case studies. However the details of sensors, actuators and their interfacing aspects with embedded controller, energy harvesting to power the wireless sensor network along with security issues in various recent applications are not covered here. In the proposed course only the introduction module gives the overview of embedded system architectures. Hence, this course contains minimum similarity with the proposed course.

MM60059: MEMS & Biosensors

Syllabus:
Fundamental of MEMS: Introduction, MEMS materials, design, fabrication, Fundamental mechanical, electrical, biochemical and fluidic characteristics of the basic microstructures. BioMEMS: Fundamentals of micro and nano fabrication of biochips, bioimmobilization principles and procedures, onchip biochemical detection methods, introduction to micro/nano fluidics, basic components of labonachips and its integration. Biosensors and

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		Biochips: fundamentals of electrochemistry and electrochemical biosensors, microfluidic devices and systems, medical instrumentation and fundamental of bioelectronics. Comments: The main focus of this course is to cover various MEMS sensors, its technology along with their biomedical applications. However the details different sensors, actuators and its integration issues with embedded controller does not come under the scope of this course. The proposed course includes a small part to describe miniatuarized technologies for smart device aspects. Hence this course has minimum overlap with the proposed course.
9. Recommended Text Books	:	1. B. George, J. Roy, V. Jagadeesh Kumar, S. C. Mukhopadhyay, Ã¢ÂÂAdvanced Interfacing Techniques for SensorsÃ¢ÂÂ, 1st ed., Springer 2017 2. A. Mason, S. C. Mukhopadhyay, K Jayasundera, N, Bhattacharyya, Ã¢ÂÂSensing Technology: Current Status and Future TrendsÃ¢ÂÂ, 1st ed., Springer 2015 3. D. P. Agrawal, Ã¢ÂÂEmbedded Sensor SystemsÃ¢ÂÂ, 1st ed., Springer 2017 4. S. Nihtianov, A. Luque, Ã¢ÂÂSmart Sensors and MEMSÃ¢ÂÂ 1st ed., Elsevier, 2018 5. Nathan Ida, Ã¢ÂÂSensors, Actuators, and their InterfacesÃ¢ÂÂ, 1st ed. SciTech Publishing 2014.
10. Reference Books/Materials	:	1. Stuart R. Ball, Ã¢ÂÂAnalog Interfacing to Embedded Microprocessor SystemsÃ¢ÂÂ, Elsevier, 2004. 2. S. Zeadally and N. Jabeur, Ã¢ÂÂCyberPhysical System Design with Sensor Networking TechnologiesÃ¢ÂÂ, 1st ed., IET, 2016.
11 Names of the Departments/Centres/Schools/ Programmes whose students are expected to register for this subject	:	1)Advanced Technology Development Centre. 2)Electrical Engineering. 3)Electronics and Electrical Communication Engg.. 4)G.S Sanyal School of Telecommunication. 5)Mechanical Engineering

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