

Centre for Interdisciplinary Program, IIT Hyderabad

Interdisciplinary Program: MTECH in Integrated Sensor Systems (ISS)

Background:

Since 2020, IIT Hyderabad has started an interdisciplinary MTech degree program in Integrated Sensor Systems (ISS). Candidates admitted into the program will require to do 52 credits which included 28 credits for course work and 24 credits for thesis work. The course work will provide all necessary basic and applied skills for design, fabrication and testing of integrated sensor system in all area of importance by using the concept of interdisciplinary science and technology. During the course work, candidates may take courses in Basic Concepts of Smart Materials and Devices, Physics of Low Dimensions Devices, Computational Modelling Techniques, Micro and Nanofabrication Technologies, Circuit and Packaging, Embedded Programming (Design and Lab), Intelligent Signal Processing using AI/IoT, and elective courses in other allied fields. Additionally, in thesis project, a candidate is required to design, analysis, fabricate, and characterize a device to achieve excellent thesis grade which will enable him/her to get confidence and skills in Integrated Sensor Systems. Most of the projects will be based on industry oriented problems. The program will help the candidates to get excellent industrial as well as academic career. The program also includes Industry lectures and a course in English communication. The overall program will develop manpower and technopreneurs in the area of sensors technology.

Duration: Two Years/Project Sponsored Three Years

Eligibility:

BE / B Tech or equivalent degree in any discipline with GATE paper in AE, BT, BM, CE, CH, EE, EC, IN, ME, MT, PH, XE OR MSc or equivalent degree in Electronics, Physics, Chemistry with GATE paper in CY, EC, IN, PH.

Selection Procedure:

The MHRD supported candidates will be selected based on **GATE Score**. Self-Sponsored and Industry sponsored candidates will be selected based on **written exam and/or interview**.

Departments: MAE, EE, PHY, CE, MS, BM

Laboratories:

1. Advanced Embedded Systems and Digital IC Design Lab, EE
2. Design of Analog RF Mixed Integrated Circuit Lab, EE
3. Nano-X Clearroom and Characterization Lab, EE
4. Nano Photonics Lab, EE
5. SenAct Lab, ME
6. Micro Mechanics Lab, ME
7. MEMS and Micro/Nanosystems Lab, PHY
8. Many other associated labs in CH, BM, EE, PHY, MS.

A) Name of faculties associated with the program:

1. Dr. Ashok Kumar Pandey, MAE, Program Co-ordinator
2. Dr. Prem Pal, PHY
3. Dr. Shiv Govind Singh, EE
4. Dr. Asudeb Dutta, EE
5. Dr. Viswanath Chinthapenta, MAE,
6. Dr. Surya Jammalamadaka, PHY
7. Dr. J Mohanty, PHY
8. Dr. Chandra Shekhar Sharma, CHE
9. Dr. Siva Vanjari, EE
10. Dr. K Nayak, EE
11. Dr. Amit Acharyya, EE
12. Dr. Naresh Kumar Emani, EE
13. Dr. Sushmee Badhulika, EE
14. Dr. Shishir Kumar, EE
15. Dr. Abhishek Kumar, EE
16. Dr. Arabinda Haldar , PHY
17. Dr. Chandrasekhar Murapaka, MSME
18. Dr. Ranjith Ramadurai, MSME
19. Dr. Bhabani Shankar Mallik, CHY
20. Dr. Saswata Bhattacharya, MSME
21. Dr. CH. Gajendranath Chaudhury, EE
22. Dr. Suhanya Duraiswamy, CHE
23. Dr. Rajalakshmi Pachamuthu, EE
24. Dr. Falguni Pati , BME
25. Dr. Jyotsnendu Giri, BME
26. Dr. Aravind Kumar Rengan, BME
27. Dr. Shourya Dutta Gupta , MSME
28. Dr. Suresh Kumar Garlapati, MSME

B) Name of Students registered in 2020

1. Mr. Rajan Kumar, 2 Year MTech
Project title: "Elimination of production cycle induced market inefficiencies with the help of sensor networks and Machine learning"
Guide Name: Dr. P. Rajalakshmi, EE.
2. Mr. Ashutosh Bilthara, 2 Year MTech
Project title: "Water pollution monitoring and remedy through Digital systems design using the IoT framework"
Guide Name: Dr. Amit Acharyya, EE
3. Mr. Dungaram D, 2 Year MTech

Project title: “Design, Fabrication, and Characterization of Uncooled Microbolometer for Thermal Imaging Applications”

Guide Name: Prof. Shiv Govind Singh, EE

4. Mr. Shashi Preetham R, 2 Year MTech
Project title: “Multiple sensor fusion using kalman filtering”
Guide Name: Dr. Ketan Detroja., EE
5. Mr. Vipul Prakash, 2 Year MTech
Project title: “Video Stabilization for Real-time 360 degrees see-through awareness”
Guide Name: Dr. Amit Acharyya, EE
6. Ms. Sudarshan Yadao, 2 Year MTech
Project title: “Real time structural health monitoring system design using Acoustic emission sensor”
Guide Name: Dr. Amit Acharyya, EE
7. Ms. Haimanti De, 2 Year MTech
Project title: “Real time video acquisition, stitching and systems design for 360 degree see through awareness”
Guide Name: Dr. Amit Acharyya, EE
8. Ms. Debalina Bhattacharyya, 2 Year MTech
Project title: “Nanogenerators”
Guide Name: Dr. Sushmee Badhulika, EE
9. Mr. Tushar Deshpande, 2 Year MTech
Project title: “Application of AI and ML in predicting heart attacks”
Guide Name: Prof. Shiv Govind Singh, EE
10. Mr. Supravat Debnath, 3 Year MTech(RA)
Project title: Electric Circuit Design
Guide Name: Dr. Asudeb Dutta, EE

2 Yrs. MTECH (ISS-Integrated Sensor Systems)

Total Credit: 52 (28 Theory + 24 Thesis)

Course Code	Semester 1	
IS5010	Smart Material and Transducers	2
IS5013	Fabrication Technology and Characterization	3
IS5020	Physics of low dimensional systems and quantum devices	3
IS5030	Computational modelling techniques	2
ISXXXX	Elective –I (Fundamental/Generic)	2 (or 3)*
IS5050	Industry Lecture Series	1
	Total	13

	Semester 2	
IS5023	Circuits and Packaging	3
ISXXXX	Elective – II	Each 2 (or 3)*
ISXXXX	Elective – III	
ISXXXX	Elective – IV	
IS5033	Embedded Programming	3
IS5040	Intelligent Signal Processing using AI/IoT	2
LA5180	English Communication Skills: Advanced	1
	Total	15

*** Total elective credits (I+II+III+IV) should not exceed 8.**

	Semester 3	
IS5015	Thesis stage -1	12

	Semester 4	
IS5025	Thesis stage -2	12

3 Yrs MTECH (ISS-Integrated Sensor Systems) - Interdisciplinary Department

Total Credit: 52 (28 Theory + 24 Thesis)

Course Code	Semester 1	
IS5010	Smart Material and Transducers	2
IS5013	Fabrication Technology and Characterization (Theory+Lab)	3
IS5020	Physics of low dimensional systems and quantum devices	3
IS5030	Computational modelling techniques	2
ISXXXX	Elective –I (Fundamental/Generic)	2 (or 3)*
IS5050	Industry Lecture Series	1
	Total	13

	Semester 2	
IS5023	Circuits and Packaging	3
ISXXXX	Elective – II	Each 2 (or 3)*
ISXXXX	Elective – III	
ISXXXX	Elective – IV	
IS5033	Embedded Programming (Design+ Lab)	3
IS5040	Intelligent Signal Processing using AI/IoT	2
LAXXXX	English Communication	1

	Total	15
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* Total elective credits (I+II+III+IV) should not exceed 8.

	Semester 3	
IS5035	Thesis stage -1	Variable**

	Semester 4	
IS5045	Thesis stage -2	Variable**

	Semester 5	
IS5055	Thesis stage -3	Variable**

	Semester 6	
IS5065	Thesis stage -4	Variable**

**Total thesis credit = 24 and the distribution per semester to be decided by Guide.

Guidelines for Guide and Elective Selection

- 1) Guide selection at the end of 1st Semester.
- 2) For project sponsored student, guide to be assigned at the start of first semester
Elective I should be taken in consultation with MTech Convener or PI.
- 3) Electives II, III, and/or IV should be taken in consultation with the guide or PI.
- 4) Electives I, II, III, and/or IV can be selected from the other departments mentioned previously or any other courses only with the approval of Guide/PI/MTech Convener.
- 5) Total elective grades (I+II+III+IV) should not exceed 8 credits.
- 6) Course and thesis credits allocation per semester to be decided with the approval of Guide/PI's for 3 Year MTech.
- 7) Emphasis can be given on development of sensors or actuators for the thesis work. However, guides/PIs are free to allot the topic of thesis relevant to Integrated Sensors System.

Electives:

I. List of electives under different baskets

Course Code	First Semester Electives: Electives I	
BM4190	Biofabrication	2
MS5010	Properties of Materials	3
CY7230	Nanochemistry and Applications	3
PB5220	Advanced Fabronics	2
MS5030	Materials Synthesis and Characterization	3
EE 5181	Semiconductor Devices Modeling	3
EE6410	Biomedical IC Design	3
EE5183	Analog IC Design	3

Course Code	2 nd Semester Electives II + III + IV	
PH6168	Spintronics	2
EE6151	Topics in Nanophotonics	2
EE6320	Wireless sensor network	3
EE6160	Mesoscopic Carrier Transport	2
EE6151	Topics in Nanophotonics	2
EE5137	Mixed Signal Circuit Design	2
EE5192	Integrated Circuits for Wireless Communication	3
EE6120	Nanoelectronics: Principles and Devices	3
EE5186	Digital IC design Theory	2
EE5187	Digital IC Design Lab	1
CH5390	Microfluidic Platform for Cell Culture & Diagnostics (3D Printer)	1
EE5188	Analog IC Design Lab	1
EE 6180	Semiconductor Heterojunction Devices Physics	3
EE 6170	Mesoscopic Device Electronics	3
CC 5130	Atmospheric Electricity	2

II. Complete Lists of Electives:

With the permission of Guide/MTech co-ordinator, a student can select alternate elective from the below mentioned list or any other suitable course from other department.

Course Code	Courses from other departments	Credits
BM4190	Biofabrication	2
BM6110	Nano medicine	2
PB5220	Advanced Fabronics	2
CH5390	Microfluidic Platform for Cell Culture & Diagnostics	1
CH5290	Introduction to Microfluidics and Micro reactors	2
CY7040	Organic Electronics and Photonics	3
CY7230	Nanochemistry and Applications	3
CY5230	Statistical Thermodynamics and Surface Science	3
CY5220	Solid State Chemistry	3
EE6150	Nanophotonics and Metamaterials	3
EE5611	Machine Learning Applications for Wireless Communications	2
EE5607	ML – Hardware Implementation	1
EE5167	Embedded System Hardware and Design	2
EE5147	Digital IC Design	2
EE5148	Digital IC Design Lab	1
EE5127	Analog IC Design	2
EE5128	Analog IC Design Lab	1
EE5158	Advanced Digital IC Design	2
EE5159	Microfabrication and Device Simulation Laboratory	2
EE5110	Semiconductor Device Modeling	3
EE6120	Nanoelectronics: Principles and Devices	3
EE6160	Mesoscopic Carrier Transport	2
EE6410	Biomedical IC Design	3
EE7110	More Than Moore Electronics	3
ME5010	Mathematical Methods for Engineers	3
ME5130	Finite Element Method	3
ME5080	Scaling Laws and Multi-scale Manufacturing	1.5

MS5010	Properties of Materials	3
MS5030	Materials Synthesis and Characterization	3
MS5080	Thin Films Technology	3
MS5140	Introduction to Computational Methods in Materials Science	3
MS5270	2d Materials: Synthesis, Characterization and Applications	3
PH6168	Spintronics	2
PH6448	Microfabrication Techniques	2
PH7013	Advanced Optical Instrumentation	3
CS6510	Applied Machine Learning	3

IS5010: Smart Material and Transducers (Credit 2)

Instructors: Naresh K. Emani, Sushmee Badhulika, Ranjith Ramadurai, Ashok Kumar Pandey, Siva Vanjari

Si photodetectors, III-V group semiconductors (Epitaxy, DBG & Quantum well and dot), Nanophotonics (Optimum drop of metal, localized surface plasmon resonance sensing), Metamaterials (Introduction to energy ϵ and μ , -ve refractive index), Different types of sensors and their sensing mechanisms (Temperature sensors, Metal oxide sensors, Potentiometric sensors, Chemical sensors), Introduction to smart systems and their applications. Introduction to Smart materials, Equilibrium properties of the systems, Ferroelectricity, Piezoelectricity. Scaling Laws, Overview of MEMS design and fabrication issues, Modelling of mechanical deflection, frequency, electrostatic forces, Electromechanical effects and fluid flow in MEMS and its effect. Performance analysis of a MEMS gyroscope device. Electrochemical Biosensors

References:

1. K.Uchino "Advanced Piezoelectric materials science and technology" Woodhead publishing
2. J.F. Nye "Physical properties of Crystals, Oxford Science publishers
3. S. D. Senturia, "Microsystem Design", Springer, NewYork, USA.
4. Alberto Corigliano, Raffaele Ardito, Claudia Comi, Attilio Frangi, Aldo Ghisi, Stefano Mariani "Mechanics of Microsystems", John Wiley & Sons, 20-Nov-2017.
5. Harmeet Bhugra, Gianluca Piazza, "Piezoelectric MEMS Resonators", Springer, 09-Jan-2017.

IS5013: Fabrication Technology and Characterization (Credit 3)

Instructors: Prem Pal, Chandra Sekhar Sharma, Shiv Govind Singh

Fabrication methods for Microelectromechanical systems (MEMS): Microstereolithography, Lithography, Galvanofomung, Abfomung (LIGA), Micromachining, etc., Surface micromachining, Bulk micromachining, Dry bulk micromachining, Deep reactive Ion Etching (DRIE), Wet chemical-based micromachining. Thin film, 3-D ICs Fabrication, Modelling challenges, Material, Mechanical and Electrical characterization.

References

1. M. Gad-el-Hak, "The MEMS Handbook". 2nd edition. CRC Press.
2. M. Tilli. T. Motooka, V. M. Airaksinen, S. Franssila, M. P. Krockel, V. Lindroos, "Handbook of Silicon Based MEMS Materials and Technologies", William Andrew
3. P. Pal, and K. Sato, "Silicon wet bulk micromachining for MEMS". CRC Press.
4. M. Elwenspoek, H. Jansen, "Silicon Micromachining". Cambridge University Press, UK.
5. T. R. Hsu, "MEMS & Microsystems: Design and Manufacture", Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Marc Madou, "Fundamental of microfabrications: the science of miniaturization", 2nd Edition, CRC Press, New York.

IS5050: Industry Lecture Series (Credit 1)

Instructors: *Amit Acharya and Asudeb Dutta*

There will be 12 to 14 lecture series by different industry experts.

IS5020: Physics of Low Dimensional Devices and Quantum Devices (Credit 3)

Instructors: *Surya Jammalamadaka + Jyoti Mohanty*

Phonons and lattice dynamics, Free electron theory and Band theory of solids, Density of states, 1D, 2D and 3D, Effective mass tensors in low dimensions. Heterostructure concepts and low dimensional systems such as quantum wells, nanowires and quantum dots. Quantum physics applied to such systems. Optical properties of low dimensional systems (transition rules, polarization etc.). Transport properties of 2D and 1D systems. Quantized conductance with Landauer-formalism. Scattering phenomena in 1D. Devices based on quantum phenomena and Coulomb blockade. Magnetic nanowires, Domain wall motion devices, Magnetic nanoparticles and applications to data storage, the dielectric function and optical absorption. Excitons and plasmonics, Raman scattering and photoluminescence.

References

1. Davies, J H, "The Physics of Low-dimensional Semiconductors: An Introduction", Cambridge University Press 1997. ISBN: 052148491X
2. Kittel, Charles, "Introduction To Solid State Physics" 8Th Ed
3. Martin T. Dove, "Structure and dynamics", Oxford University press, 2002
4. John Singleton, "Band Theory and Electronic Properties of Solids", Oxford University press, 2001.
5. Stephen Blundell, "Magnetism in condensed matter", Oxford University press, 2001.
6. F.Iacomi, "Spectroscopia vibrațională a materialelor zeolitice," Ed. Stef, Iasi, 2007
7. L.David, C.Craciun, O.Cozar, V.Chis, Rezonanta "Electronica de Spin. Principii. Metode. Aplicații". Presa Universitară Clujeană, Cluj-Napoca, 2001
8. S. E. Lyshevski, "Nano and Molecular Electronics", CRC Press Taylor & Francis Group 2007

IS5030: Computational modelling techniques (Credit 2)

Instructors: *Saswata Bhattachaya, Bhabani S. Mallik, Vishwanath Chinthpenta*

Review of computational linear algebra, numerical methods for ordinary, partial differential equations and integration. Concepts of modeling across length and time scales. Theory of Atomistic simulations: Molecular Dynamics and Monte Carlo methods and their applications in materials modelling. Introduction to Finite Element Method in Multiphysics Modeling Multiphysics Simulations

References:

1. Richard Lesar, "Introduction to Computational Materials Science", Materials Research Society, Publisher: Cambridge English; First South Asian Edition edition (2016).
2. Daan Frenkel and Berend Smit, "Understanding Molecular Simulation: From Algorithms to Applications", 2nd Edition -, Academic Press.
3. J N Reddy, "An Introduction to the Finite Element Method", J N Reddy, McGraw Hill Education, July 2017.
4. Attilio Frangi, "Advances in Multiphysics Simulation and Experimental Testing of MEMS", World Scientific, 2008
5. John A. Pelesko, David H. Bernstein, "Modeling MEMS and NEMS", CRC Press, 25-Nov-2002.

IS5023: Circuits and Packaging

(Credit 3)

Instructors: *Asudeb Dutta, Ch. Gajendranath Chaudhary, Ashutosh Kumar*

RLC circuits, Amplifier, OPAMP/OTA, Comparator, Data Converter, Clock generation. MOSFET Fundamentals, CMOS logic Circuits, Memory, RTL coding, Die-bonding, Chip Packaging, SiP/SoP

References

1. Behzad Razhavi, "Fundamentals of Microelectronics", Wiley 2013
2. Bob Dobkin, Jim Williams, "Analog Circuit Design: A Tutorial Guide to Applications and Solutions" Newnes; 1 edition (January 9, 2013)
3. William J. Greig, "Integrated Circuit Packaging, Assembly and Interconnections", Springer, Boston, MA, 2003
4. John P. Uyemura, "CMOS Logic Circuit Design", Kluwer Academic Publishers, New York, 2002.

IS5033: Embedded Programming (Credit 3)

Instructor: *Shishir Kumar*

Introduction to Embedded Systems, Architectures of embedded processors, Memory hierarchy and its management Basics of Microcontrollers –timers, interrupts, analogy to digital conversion, bootloaders Interaction with devices -buses, memory management, device drivers and wireless comm., Interfacing sensors, actuators and peripherals. Real-time principles - multi-tasking, scheduling, synchronization Building low-power high-performance systems – code profiling and optimization Architecture, Case Studies of Real time. Microcontrollers/Microprocessor: Arduino, Raspberry-pi, ARM, FPGA, ESP32, RL78etc)

References

1. Hennessy & Patterson "Computer architecture a quantitative approach", Morgan Kaufmann; 5 edition (25 October 2011).
2. Randal E. Bryant & David R. O'Hallaron "Computer Systems: A Programmer's Perspective" Pearson; 2 edition (4 February 2010).
3. <https://github.com/gadepall/IOT>
4. <https://github.com/gadepall/arm-embedded>
5. <https://github.com/gadepall/arduino>
6. <https://github.com/gadepall/FPGA>

IS5040: Intelligent Signal Processing using AI/IoT (Credit 2)

Instructor: *Amit Acharya, P. Raja lakshmi*

Algorithms, IC Design Perspective. Different types of signal processing techniques, Traditional Signal Processing algorithms vs. Practical Constraints; Need of an holistic view of Algorithm and VLSI Architecture, Hardware complexity analysis of resource constrained system; Computational Delay analysis of resource constrained system; Trade-off analysis : Arithmetic complexity vs Signal parameters; Wireless Sensor Networks, Network characteristics, Network Design and Challenges, Wireless Sensor Node Architecture and Design, Wireless Sensor Network Architecture, Data Aggregation, Sensor Data storage, Data Management and Processing, Time Synchronisation, Wireless Sensor and Actuator Networks, Network design, Control on Sensor Networks. Role of AI and ML in overall data aggregation, management and processing.

References:

1. Morris Mano "Digital Design-With an Introduction to the Verilog HDL", Pearson, Prentice Hall, New Jersey.
2. Hennessey and Patterson, Morgan Kaufmann "Computer Architecture Computer Architecture: A Quantitative Approach" 5 edition (September 30, 2011).

3. Israel Koren, A K Peters, "Computer Arithmetic Algorithms", CRC Press; 2 edition (November 30, 2001).
4. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic "Digital Integrated Circuits: A design perspective", Pearson Education India; Second edition (25 May 2016).
5. Hyeji Kim, Yihan Jiang, Ranvir Rana, Sreeram Kannan, Sewoong Oh, Pramod Viswanath. "Communication Algorithms via Deep Learning", <https://arxiv.org/abs/1805.09317>
6. Hyeji Kim, Yihan Jiang, Sreeram Kannan, Sewoong Oh, Pramod Viswanath, "Deepcode: Feedback Codes via Deep Learning". <https://arxiv.org/abs/1807.00801>
7. Timothy J. O'Shea, Jakob Hoydis, "An Introduction to Deep Learning for the Physical Layer", <https://arxiv.org/pdf/1702.00832.pdf>
8. Timothy J. O'Shea, Tugba Erpek, T. Charles Clancy, "Deep Learning Based MIMO Communications", <https://arxiv.org/pdf/1707.07980.pdf>
9. Fayçal Ait Aoudia, Jakob Hoydis, "End-to-End Learning of Communications Systems Without a Channel Model", <https://arxiv.org/pdf/1804.02276.pdf>