# Department of Electrical Engineering

**Ph.D. Admissions 2021-22 (Spring Semester)**

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Abstracts of Research Topics and Projects

Detailed descriptions of TA and Sponsored Project Positions

This document lists the research topics available for TA positions (who will receive government scholarship) as well as sponsored project positions under the RA/TAP category. For explanation of different categories, please check here.

If you get selected under Institute TA (called TA from here on), then you have full flexibility of choosing your PhD supervisor and your PhD area of research at a later time. If you get selected under RA/TAP (meaning, a sponsored project position), then the project investigator(s) (PI) is your supervisor and the PhD area is aligned with the sponsored project.

If you are selected as Institute-TA, then all EE faculty members, including the PIs of the sponsored projects, are available for you to choose as your guide. The choice of research topic and guide for institute TAs is done later, typically within one year of taking admission, based on mutual consent between the student and the guide. On the other hand, a student taking admission under a particular RA/TAP project can not change the topic or guide later. If you are interested in TA, you still need to choose it as a preference (first, intermediate or last). Please read the project abstracts in detail while filling the RA/TAP choices. It is not possible for PhD students to change their project or guide once admission is given against a particular RA/TAP position. Please consider these aspects while filling your preferences in the form. Once submitted, these preferences can not be changed. Also note that the number of institute TA positions or seats is, usually, not correlated to the number of topics listed in the same category (but is limited by the MHRD funds) while the number of RA/TAP positions correlate well with the number of topics listed in the same category.
List of TA topics: EE1

(Communications and Signal Processing)

In addition to the specific projects listed in this section, the following faculty members are willing to take PhD students on topics to be decided by mutual consultation in the broad research areas mentioned against their names:

<table>
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<tr>
<th>Faculty</th>
<th>Research Areas</th>
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</thead>
<tbody>
<tr>
<td>Subhasis Chaudhuri</td>
<td>Machine Learning in Computer Vision (upto 2 students)</td>
</tr>
<tr>
<td>Bikash Kumar Dey</td>
<td>Information theory, Error correcting codes, Network codes, Distributed coded computing, Secret sharing</td>
</tr>
<tr>
<td>Shalabh Gupta</td>
<td>High-Speed Optical Communications, Radar Systems and Signal Processing in these systems.</td>
</tr>
<tr>
<td>Gaurav S. Kasbekar</td>
<td>Wireless Networks, Communication Networks, Network Security</td>
</tr>
<tr>
<td>D Manjunath</td>
<td>Social Network analysis and opinion dynamics, Multi arm bandits, Learning algorithms</td>
</tr>
<tr>
<td>Jayakrishnan Nair</td>
<td>Demand response in smart power grids, Internet economics, Queueing systems</td>
</tr>
<tr>
<td>Harish Pillai</td>
<td>Coding theory, Information theory</td>
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<tr>
<td>Sibi Raj B Pillai</td>
<td>Biological Information Transfer, Epigenetic Communication, Network Information Theory, Wireless communication, Deep learning decoders</td>
</tr>
<tr>
<td>Nikhil Karamchandani</td>
<td>Online Learning and Statistical Inference, Codes for distributed caching and computing, Networks and Information Theory</td>
</tr>
<tr>
<td>Deepak Jain</td>
<td>Optical Fiber Communications, Novel Light sources such as lasers and supercontinuum sources, Non-linear Fiber Optics, Space Photonics for communication, and Quantum Photonics</td>
</tr>
</tbody>
</table>

Topic #1

Faculty Name: Subhasis Chaudhuri

Title of Project: **Solving classical computer vision problems through machine learning**

Specialization: Communications and Signal Processing; Control and Computing

Description: Various image processing problems like edge detection, depth recovery, blind deblurring, etc. are currently being investigated as machine/deep learning problems, and very
often, they offer much improved results. In this project we would like to investigate the applicability of ML in such image processing problems. The project will require a good depth of understanding of the following topics - linear algebra, optimization theory, probability and random processes and programming skills.

Topic #2
Faculty Name: Bikash Kumar Dey
Title of Project: **Coding for fault tolerant computing**
Specialization: Communications and Signal Processing
Description: Suppose a large computation is to be performed with the help of many available computers. The server can distribute the work among these "worker" computers. The worker computers can send the results of their computations to the server, which can then combine them to compute the final result. However, some worker computers may not return their results or return wrong results if they are either running very slow due to other jobs or due to faults. Can we design schemes such that the server may recover the correct result in spite of a few slow or faulty workers. The approach will use principles and techniques of error correcting codes.

Topic #3
Faculty Name: Bikash Kumar Dey
Title of Project: **To share or not to share secrets**
Specialization: Communications and Signal Processing
Description: In the classical sharing framework, a secret message is encoded into many shares. These shares are then distributed among some parties. If the shares of sufficient number of parties are combined, then it is possible to discover the secret. Now, what if some of the parties provide wrong share? Can the encoding guard against such cheating parties? The techniques from coding theory and information theory will be used to study such problems.

Topic #4
Faculty Name: Gaurav S. Kasbekar
Title of Project: **Enabling Millimeter Wave (mmWave) Communications for 5G Cellular Networks**
Specialization: Communications and Signal Processing

Description: While low frequency bands are crowded, a huge amount of free bandwidth is available in the mmWave bands (30 GHz to 300 GHz), and it is expected that these bands will be an important part of the emerging 5G cellular networks. However, there are fundamental differences between mmWave bands and low frequency bands: e.g., mmWave communications suffer from high propagation losses and are sensitive to blockage by objects in the environment. Also, usually highly directional communication is used on mmWave bands. Some challenges that need to be addressed in order to enable mmWave communications for 5G cellular networks are as follows: schemes must be designed for optimally assigning mobile users to base stations, interference management and achieving spatial reuse; also, blockages must be effectively dealt with. The objective of this project is to design algorithms for enabling mmWave communications and to evaluate their performance via mathematical analysis and simulations.

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**Topic #5**

Faculty Name: Gaurav S. Kasbekar

Title of Project: Applications of Game Theory to Wireless Networks

Specialization: Communications and Signal Processing

Description: Several tasks in a wireless network can be effectively performed if different users cooperate with each other. For example, data can be rapidly transferred from a base station to a user with poor coverage if another user acts as a relay. However, typically users are selfish and try to maximize their own utilities instead of seeking to achieve a socially beneficial outcome. E.g., a user may refuse to act as a relay since relaying consumes battery energy. An objective of this project is to understand the behaviour that can be expected from selfish users in a wireless network, and to design mechanisms to achieve socially beneficial outcomes despite the presence of selfish users, using tools from game theory and mechanism design. Another objective is to use game theoretic formulations to design distributed algorithms for wireless networks. A combination of mathematical analysis and simulations will be used in the project.

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**Topic #6**

Faculty Name: Nikhil Karamchandani

Title of Project: Large-scale Inference and Network Analytics

Specialization: Communications and Signal Processing; Control and Computing
Description: There are several applications where one would be interested in estimating underlying system parameters, by observing and analysing large quantities of possibly noisy data. For example, consider inferring the ranking of players in an online gaming system from the results of head-to-head matches, or the detection of communities in a social network from pairwise node interactions, or finding the source of a rumour propagating along the edges of a graph. This project will focus on creating statistical models for such applications, analysing them, and proposing efficient algorithms, using techniques from probability and graph theory amongst others. Links to some of our previous work in this direction are given below and are also available at https://sites.google.com/site/nikhilkaram/home/publications

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**Topic #7**

Faculty Name: Jayanta Mukherjee

Title of Project: **Antenna, filters and other passive microwave design**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems

Description: We work in the field of passive microwave component design. This is especially critical nowadays where the frequency of operation is scaling up and newer standards like 5G have arrived. The focus is on novel antennas, filters and other microwave components like mode converters, diplexers, power dividers, couplers etc. Some of the specific topics of interest are:

1. Advanced metamaterial based antenna design
2. mm wave antenna design
3. Phase array antenna design

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**Topic #8**

Faculty Name: Jayanta Mukherjee

Title of Project: **RF Front end design**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems

Description: 1. Advanced topologies in LNA, Mixer and PLL design in CMOS
2. Advanced topologies in LNA, RF switch in GaN

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**Topic #9**

Faculty Name: Preeti Rao

Title of Project: **Music information retrieval**

Specialization: Communications and Signal Processing; Electronic Systems

Description: The ready availability of vast audio archives of music across genres opens up the need for powerful tools for search and navigation. Signal processing offers the possibility of generating a variety of computational encodings of music that facilitate search and navigation. The same computational tools can serve the needs of musicological research from audio archives as well as provide for powerful pedagogical aids. Our work is specifically directed towards investigating signal processing and machine learning methods for vocal and instrumental music applications.

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**Topic #10**

Faculty Name: Siddharth Tallur

Title of Project: **Embedded systems for non-invasive structural health and condition monitoring applications**

Specialization: Communications and Signal Processing; Electronic Systems

Description: We are looking to complement our team of passionate and dedicated students working on sensor design for structural health monitoring and condition monitoring applications. Currently our focus is on sensor design optimization, for which we use bench-top test setups, suitable for laboratory experiments, but not for field testing. Problems encountered in the field are of a very different from the ones that manifest in lab, and as such it is important for any project to rapidly progress towards field testing with large number of prototypes to uncover and then solve such issues. We are looking for candidates with good experience and interest in embedded system design and digital signal processing to develop hardware and algorithms for such systems. We are currently focused on corrosion monitoring inside reinforced concrete structures, and vibration based condition monitoring of machinery. Interested students are encouraged to engage us in a discussion to explore other applications.

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**Topic #11**

Faculty Name: Saravanan Vijayakumaran

Title of Project: **Privacy in Cryptocurrencies**
Specialization: Communications and Signal Processing

Description: Ensuring privacy in public blockchains is a challenging problem. Existing privacy-preserving techniques use zero knowledge proofs, ring signatures, and other cryptographic primitives. Our goal is to improve upon existing techniques or use them for new applications. This is a theoretical topic requiring familiarity with abstract algebra and cryptography.

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**Topic #12**

Faculty Name: Rajesh Zele

Title of Project: **Super High Speed DAC (Digital to Analog) Converter Design for HDTV/Cable/Satellite Communication System Applications**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems; Electronic Systems

Description: As everything including RF/Analog and Digital Systems are getting integrated on a SOC (System-On-Chip), there is a strong desire to convert real-world analog (RF) signals to digital using high sampling rate and do the signal processing in the digital domain as early as possible. Similarly, there is a need to convert the digital data to analog at a very high sample rate before transmitting over the air/cable using power amplifiers. High performance Digital to Analog Converters play a critical role in the overall product development.

The student will be involved in the system implementation along with developing various circuit techniques in the design of super high-speed Digital to Analog Converters with very good linearity. This project will provide high performance Integrated Circuits and System design experience culminating in sending out their chip for fabrication in 28nm CMOS technology. Student will also get good experience in testing their chips.

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**Topic #13**

Faculty Name: Rajesh Zele

Title of Project: **Ultra-Low power Ultra-miniaturized Radio for Wireless Body Area Sensor Network (WBAN) using ISM Bands**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems; Electronic Systems

Description: Increasing demand for higher data rate communication has led to opening up 57-64 GHz unlicensed spectrum in many countries. Due to high path loss, the 60 GHz signal has very
short range (few meters). Short range facilitates low interference from other 60GHz radios, enabling the WPAN (Wireless Personal Area Network) applications. Due to very high frequency of operation, the antenna size is small leading to an ultra-miniature form factor - a requirement for Wireless Body Area Networks.

Traditionally millimetre wave devices have been implemented in III-V semiconductor technologies such as GaAs or InP. Today’s nm CMOS technologies can provide sufficient high frequency performance to implement 60 GHz radios. CMOS technology offers an easy path to efficiently integrate digital baseband enabling single chip solution. Our goal in this project proposal is to implement a fully integrated 60 GHz wireless transceiver using standard CMOS technology by providing new design techniques to overcome the challenges. PhD candidate will be involved in communication system design, 28 nm CMOS chip design/layout and testing.

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**Topic #14**

Faculty Name: Prof. Shalabh Gupta

Title of Project: **Signal Processing Techniques in CMOS and Silicon Photonic Integrated Circuits for High-Speed Optical Fiber Interconnects.**

Specialization: Communications and Signal Processing; Electronic Systems; Solid State Devices

Description: The project aims to develop signal processing techniques for very high data rate short reach optical interconnects. The project also aims at developing state-of-the-art high-speed CMOS integrated circuits and silicon photonic integrated circuits for such interconnects. Prior knowledge of optical communications (or fiber optics) is not required. Interested candidates should interested either in communications signal processing or in CMOS IC design/silicon photonic IC design (along with interest in working with the high-end equipment available in the lab).

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**Topic #15**

Faculty Name: Deepak Jain

Title of Project: **Next-generation fiber lasers emitting around two-micron wavelengths**

Specialization: Communications and Signal Processing

Description: Two-micron wavelength lasers have tremendous applications in different sectors such as polymer welding, silicon processing, medical surgeries, defence weapons, free-space communications, and gas sensors. The current state-of-the-art fiber lasers at two-micron wavelength suffer from two stringent trade-offs between laser efficiency and good beam quality,
and between output power level and good beam quality. The project will target novel specialty optical fibers to break this trade-off.

This project will demonstrate highly efficient fiber lasers emitting around two-micron wavelength with good-beam quality in close collaboration with the industry. The project will establish the proposed two-micron wavelength lasers in the Indian and international industries, especially for the upcoming fourth-generation industrial revolution.

Interested candidates are encouraged to contact the PI for further discussions.

Topic #16

Faculty Name: Deepak Jain

Title of Project: Mid-infrared Optical Fiber and Light Source Technology based on Germania glass

Specialization: Communications and Signal Processing

Description: Silica-glass-based optical fibers have proved their tremendous importance in the last few decades for different applications such as data communications (Internet), medical diagnostics & treatments, high power fiber lasers, and sensing. However, properties of Silica-glass limit the operational wavelength regions and functionality of fiber, such as higher losses at longer wavelengths (>2 µm). The Germania (GeO2)-glass based fiber is an attractive option for exploiting the 2 to 3 μm wavelength range thanks to low losses in the region due to the shift of the intrinsic IR absorption and the impurity of the Ge–OH absorption bands to longer wavelength.

This project aims to establish Germania-glass-based optical fiber technology in two-to-three-micron wavelength region by developing novel beam delivery fibers, couplers, light sources, and amplifiers in this wavelength region.

Interested candidates are encouraged to contact the PI for further discussions.

Topic #17

Faculty Name: Deepak Jain

Title of Project: Can Lasers be used for clearing-off space debris?

Specialization: Communications and Signal Processing
Description: There are nearly 2000 live satellites in space but more than 3000 failed ones! As per NASA’s OPD office, there are more than 23,000 pieces of debris, each larger than 10 cm are revolving around the earth. Several companies intend to launch multiple mega-constellations constituted of hundreds or even thousands of satellites planned for low Earth orbit to deliver wide-coverage internet services. These plans have the potential to create millions of space debris.

Space debris is a serious threat to satellites, international space stations, and ground-based astronomy experiments. At the moment, there is no solution to this problem. A mission “ClearSpace-1” led by Swiss start-up “Clear Space” will be the first space mission to remove an item of debris from orbit, planned for launch in 2025. This mission aims to use robots to remove the debris.

Earlier, a laser-based approach has been proposed to clear off the debris, however, there is no comprehensive scientific model for the same. This project will develop a comprehensive model for the laser-based Orbital Debris Removal System (LODR).

Interested candidates are encouraged to contact the PI for further discussions.

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**Topic #18**

Faculty Name: Satish Mulleti

Title of Project: **Super Sampling of Correlated Signals**

Specialization: Communications and Signal Processing

Description: Digital signal processing (DSP) is one of the prominent areas in engineering. The goal is to process data in the digital domain where design and implementation are considerably simplified compared to analog processing. To digitally process analog signals they must be sampled with an analog-to-digital converter (ADC) which converts the signal to a sequence of numbers. The samples are then processed to extract the required information. Consequently, the theory and practice of sampling are at the heart of DSP: Any technology advance in sampling theory has a huge impact on a myriad of applications. Typically, signals are sampled at the Nyquist rate by assuming that the signals are bandlimited. In practice, signals might have additional structures that can be leveraged to reduce the sampling rate and overall cost of the analog system. In this project, the goal is to explore the correlation among the multi-sensor system and reduce the sampling rate.
Topic #19

Faculty Name: Satish Mulleti

Title of Project: Model-Based Machine Learning for Signal Processing

Specialization: Communications and Signal Processing

Description: The past decade has witnessed a revolution in the deep learning (DL) approaches due to the availability of large-scale training data and accessibility to powerful computational resources. The development of efficient training algorithms and effective network architectures resulted in the exceptional success of DL methods in applications such as computer vision, pattern recognition speech recognition, language processing, etc. In the signal processing domain, learning-based data-driven algorithms provide an interesting alternative to traditional model-based signal processing methods. A majority of the DL approaches are purely data-driven and employ general network architectures towards learning classification and regression mappings. It is difficult to interpret the results of the intermediate layers and the impact of the individual parameters. In the areas of autonomous vehicles and clinical research, it is crucial to understand the role of each layer and the parameters which help in determining the limitations and robustness of the systems. To address the lack of interpretability of the DL networks, recently, network architectures that are inspired by model-based methods with iterative algorithms are proposed. The technique is called unrolling or unfolding where each layer of the network represents one iteration of the network. Concatenating these layers forms a deep neural network that overcomes the lack of interpretability in conventional neural networks.

Unrolling methods are successfully applied to problems such as compressive sensing, deconvolution and image processing, etc. Further to extend the application of the unrolling method, in this project we would like to develop unrolling methods for jointly designing sampling patterns and recovery methods, particularly, for compressive blind-deconvolution and sparse sensor networks. Both these research topics are relevant to the automotive application and as mentioned it is desirable to develop interpretable networks for a better understanding of the system and analysis of risk minimization.
List of TA topics: EE2
(Control and Computing)

In addition to the specific projects listed in this section, the following faculty members are willing to take PhD students on topics to be decided by mutual consultation in the broad research areas mentioned against their names:

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<td>Machine Learning in Computer Vision (upto 2 students)</td>
</tr>
<tr>
<td>Bikash Kumar Dey</td>
<td>Distributed coded computing, Error correcting codes</td>
</tr>
<tr>
<td>S V Kulkarni</td>
<td>Computational Electromagnetics</td>
</tr>
<tr>
<td>D Manjunath</td>
<td>Social Network analysis and opinion dynamics,</td>
</tr>
<tr>
<td>Dwaipayan Mukherjee</td>
<td>Topics related to, but not limited to, fault detection in and monitoring of networked dynamic systems, formation control, Robust consensus in multi-agent systems, and other similar topics based on mutual consultation.</td>
</tr>
<tr>
<td>Debasattam Pal</td>
<td>Switched Singular Systems, Data-driven Robust Control, Numerical Issues in Singular Optimal Control, Algebraic Analysis of Distributed Parameter Systems</td>
</tr>
<tr>
<td>Harish Pillai</td>
<td>Any area of control theory, Numerical Linear Algebra, Finite Fields Applications</td>
</tr>
</tbody>
</table>

Topic #1

Faculty Name: Madhu N Belur

Title of Project: Elimination of impulses using feedback control

Specialization: Control and Computing

Description: Feedback control is the standard and robust way to achieve various control objectives like stabilization, pole-placement. Elimination of impulsive behavior has been important and feedback control has received less attention as a control technique. This Ph.D. topic aims to work in the theoretical, algorithmic and numerical aspects that arise during impulse elimination controller design.
Topic #2

Faculty Name: Madhu N Belur

Title of Project: **Congestion control using feedback in railway networks**

Specialization: Control and Computing

Description: Congestion control is important in many applications where we have buffer and we can choose one out of many scheduling policies. Internet congestion control has TCP/IP and router packet drop strategies as an example. Highway traffic dynamic re-routing also uses feedback control to dynamically divert traffic through alternate routes when congestion is detected along one route. Feedback control helps in having better capacity utilization while reducing congestion. In the context of railway networks, congestion control tends to be more centralized since the units to be dispatched are not small packets, nor small vehicles, but are large and long vehicles. Use of feedback control can help in railway networks too: but more intricate analysis and optimization is needed before deployment. This PhD topic pursues feedback based congestion control policies for railway networks.

Topic #3

Faculty Name: Subhasis Chaudhuri

Title of Project: **Solving classical computer vision problems through machine learning**

Specialization: Communications and Signal Processing; Control and Computing

Description: Various image processing problems like edge detection, depth recovery, blind deblurring, etc are currently being investigated as machine/deep learning problems, and very often, they offer much improved results. In this project we would like to investigate the applicability of ML in such image processing problems. The project will require a good depth of understanding of the following topics - linear algebra, optimization theory, probability and random processes and programming skills.

Topic #4

Faculty Name: Narendra Shiradkar

Title of Project: **Fundamental thermodynamics of batteries and power management**

Specialization: Communications and Signal Processing; Control and Computing
Description: We live in a world on the cusp of an electric vehicles revolution, as well as a renewable energy revolution, with integrated intelligent power systems spanning single devices to entire grids. In this scenario, several groups are developing algorithms that allow exploiting even greater efficiencies out of such systems. We ask the question: what are the fundamental limits of such attempts? Are there fundamental laws of batteries? Is there an inevitable energy cost to uncertainty in power supply, and can it be quantified? Our approach is based on theoretical ideas that provide a dictionary between information theory and thermodynamics, and allow us to think of power management systems in analogy with multilevel memory caching systems.

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**Topic #5**

Faculty Name: Nikhil Karamchandani

Title of Project: **Large-scale Inference and Network Analytics**

Specialization: Communications and Signal Processing; Control and Computing

Description: There are several applications where one would be interested in estimating underlying system parameters, by observing and analysing large quantities of possibly noisy data. For example, consider inferring the ranking of players in an online gaming system from the results of head-to-head matches, or the detection of communities in a social network from pairwise node interactions, or finding the source of a rumour propagating along the edges of a graph. This project will focus on creating statistical models for such applications, analysing them, and proposing efficient algorithms, using techniques from probability and graph theory amongst others. Links to some of our previous work in this direction are given below and are also available at https://sites.google.com/site/nikhilkaram/home/publications .

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**Topic #6**

Faculty Name: Debasattam Pal

Title of Project: **Stability and stabilization of distributed parameter systems**

Specialization: Control and Computing

Description: This topic is theoretical. Algebraic analysis of PDEs is expected to play a central role in the study. There is ample scope of extending/generalizing various system theoretic ideas pertaining to lumped parameter systems to the case of distributed parameter systems.

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**Topic #7**

Faculty Name: Debasattam Pal
Title of Project: *Study and resolution of singularities in theory of dissipativity*

Specialization: Control and Computing

Description: Dissipativity theory plays a crucial role in several control problems. The theory is well-understood, however, under some regularity assumptions. The project is aimed at studying the issues when these regularity assumptions are relaxed.

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**Topic #8**

Faculty Name: Debasattam Pal

Title of Project: *Analysis of switched systems via non-commutative algebra*

Specialization: Control and Computing

Description:

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**Topic #9**

Faculty Name: Siddharth Tallur

Title of Project: *Synchronization methods for chaotic oscillators and their applications*

Specialization: Control and Computing; Electronic Systems

Description: Chaotic oscillators can enable several applications in cryptography. Such applications require synchronization of a network of such oscillators. We have recently obtained interesting results applying LQR control theory to design linear partial state feedback controller to synchronize electronic oscillator circuits. The thesis will involve extending these ideas to explore systems with richer dynamics for a variety of applications.
List of TA topics: EE3

(Power Electronics and Power Systems)

In addition to the specific projects listed in this section, the following faculty members are willing to take PhD students on topics to be decided by mutual consultation in the broad research areas mentioned against their names:

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<tbody>
<tr>
<td>Kishore Chatterjee</td>
<td>Power evacuation from solar photovoltaic systems, Chargers for Electric vehicles</td>
</tr>
<tr>
<td>S V Kulkarni</td>
<td>Power Transformers: Analysis and Diagnostics, Electromagnetic and coupled field computations in electrical equipment, Modeling of hysteresis, High voltage engineering/ insulation diagnostics</td>
</tr>
</tbody>
</table>

**Topic #1**

Faculty Name: Anshuman Shukla

**Title of Project:** Development of Smart Inverters using Wide-Bandgap Devices

**Specialization:** Power Electronics and Power Systems

**Description:** The goal of this project is to develop the next generation of smart inverters using Wide-Bandgap Devices (Silicon Carbide and Gallium Nitride devices) for the renewable energy, electric vehicle and energy storage applications. They will be more efficient, modular, cost-effective, fault-tolerant, compact and able to self-diagnose and self-repair. Moreover, they will be specifically adapted for the harsh environments.

**Topic #2**

Faculty Name: Anshuman Shukla

**Title of Project:** Integration of Renewable Energy Resources in Microgrid Systems using Power Electronic Transformer

**Specialization:** Power Electronics and Power Systems
Description: The aim of this project to develop a Microgrid system enabled by Power Electronic Transformer (PET). In a traditional ac microgrid system, a transformer is used to interconnect the ac main grid and the distribution system. However, additional inverters are needed to connect PV and the other dc type renewable energy sources to the ac main grid. Similarly, the dc loads need an addition power electronic converter to generate dc voltage, while the ac loads can be connected directly with the ac main grid. The same requirement of additional power electronic converters is also true for dc microgrid systems for the respective ac/dc sources and loads. A PET is a three port power converter that includes an ac to dc conversion stage, a high frequency dc to dc conversion stage and a dc to ac conversion stage. Therefore, in a PET enabled microgrid system, the number of converters can be reduced and additional control flexibility can be introduced. This project will focus on the most effective control schemes and the most optimal PET topologies for microgrid systems.

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**Topic #3**

Faculty Name: Anshuman Shukla

Title of Project: **Fast Chargers for Electric Vehicles**

Specialization: Power Electronics and Power Systems

Description: The aim is to design and develop a fast charging station prototype. It is expected to be best in class in terms of technical features, charging speed, affordability, efficiency and compactness.

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**Topic #4**

Faculty Name: Anshuman Shukla

Title of Project: **Design, Control and Implementation of Modular Multilevel Power Electronic Converters**

Specialization: Power Electronics and Power Systems

Description: In this project, the most suitable converter and submodule configurations for the modular multilevel converter for different applications will be identified and characterized. The corresponding modulation and control schemes will be developed and verified using both simulation and experimental studies.
**Topic #5**

Faculty Name: Vivek Agarwal

Title of Project: **Ultra-compact power inverter configurations using Wide-Bandgap devices (SiC and GaN) and multilevel concept**

Specialization: Power Electronics and Power Systems

Description: Using wide-band gap devices like SiC and GaN it is possible to operate at very high switching frequency, yet with low losses. Having multiple levels in the output voltage helps in reducing the common mode and differential mode filter size. The objective of this project is to realize a compact power inverter using both these concepts. Investigations on advanced voltage balancing schemes, PWM strategies and optimized inverter configuration would be needed for this project. The system could be designed for any application of the candidate’s choice (grid connected renewable energy system, power quality compensation, railway traction etc.).

**Topic #6**

Faculty Name: Vivek Agarwal

Title of Project: **Pole-phase modulated motor drives for gear-less EV applications**

Specialization: Power Electronics and Power Systems

Description: The objective of this project is to emulate a mechanical gear by modulating the number of poles and the number of phases of a motor. This can result in high efficiency and compactness for EV applications as the mechanical gear may be eliminated or reduced in size. In a conventional motor, the number of phases and poles is fixed. For this project the candidate needs to design or arrange a special motor where the number of poles and phases can be electronically altered as per the requirements. Investigations into advanced power inverter topologies and special control schemes would also be needed in this work. It is possible to suitably modify the scope of the work as per the interest and inclination of the candidate.

**Topic #7**

Faculty Name: Vivek Agarwal

Title of Project: **Wireless charging of electric vehicles and machine learning based charge scheduling and traffic prediction**

Specialization: Power Electronics and Power Systems
Description: The objective of this project is to design and develop a power converter system for charging of EV battery wirelessly. The charging may take place while the EV is running or in stand-still. While the EV is running the charging process is referred to as the dynamic charging which is more challenging than the EV charging at standstill. In this project investigations on improving the magnetic coupling, resonant converter topologies and advanced PWM control schemes would be needed. The scope of the work may be expanded by including machine learning based charge scheduling and/or traffic conditions. It is possible to suitably modify the scope of the work as per the interest and inclination of the candidate to include integrated charging plus motor driving solution, or anything else.

Topic #8

Faculty Name: Vivek Agarwal

Title of Project: **Efficiency optimization in elevator drives including machine learning based commuter pattern prediction**

Specialization: Power Electronics and Power Systems

Description: The objective of this project is optimize the energy consumption of elevator drives. This may be done by using permanent magnet synchronous motor as the drive motor and optimizing the ride profile of the elevator. Hence investigations of advanced drive control schemes and trajectory optimization techniques are needed for this project. Further, machine learning may provide an energy optimum solution by predicting the commuters ride pattern. It is possible to suitably modify the scope of the work as per the interest and inclination of the candidate.

Topic #9

Faculty Name: Vivek Agarwal

Title of Project: **Modular multilevel converter (MMC) based ac to dc converter systems for EV charging infrastructure**

Specialization: Power Electronics and Power Systems

Description: Modular multilevel converter (MMC) is a proven technology for HVDC systems. This technology in conjunction with isolated DC-DC converter at submodule (SM) level could be equally pragmatic for a multi megawatts charging infrastructure for charging the EVs. Megawatt power level operation may be shown by using simulations while the hardware validation may be provided on a low power laboratory prototype that is already available in the lab. The objective of
this project is to design a new configuration of MMC and/or a novel SM topology with suitable control schemes for such a charging infrastructure for a reliable and efficient processing of power between grid and EVs. It is possible to suitably modify the scope of the work as per the interest and inclination of the candidate.

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**Topic #10**

Faculty Name: Vivek Agarwal

Title of Project: **Optimum sizing and energy management for hybrid energy storage systems using supercapacitors**

Specialization: Power Electronics and Power Systems

Description: Supercapacitors (SC) are being used along with batteries for satisfying transient power demands. Proper energy management and sizing of the SC is required for maximizing the life of the battery and minimizing the cost of system. The uncertainties in the energy demands needs to be considered for the design. Machine learning may be explore to predict the uncertainties in energy demands. It is possible to suitably modify the scope of the work as per the interest and inclination of the candidate.
List of TA topics: EE5

(Electronic Systems)

In addition to the specific projects listed in this section, the following faculty members are willing to take PhD students on topics to be decided by mutual consultation in the broad research areas mentioned against their names:

<table>
<thead>
<tr>
<th>Faculty</th>
<th>Research Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sibi Raj B Pillai</td>
<td>Biological Information Transfer, Deep learning decoders</td>
</tr>
<tr>
<td>Maryam Shojaei</td>
<td>Compact Sensor Systems for Healthcare Technologies, Agri-Tech systems, energy autonomous water quality monitoring systems, Instrumentation and Signal Conditioning for Emerging Applications with focus on IoT (IoE), MEMS based photo acoustic systems, Energy harvesting systems</td>
</tr>
</tbody>
</table>

Topic #1

Faculty Name: V R Rajbabu, P.C. Pandey

Title of Project: **Lip contour detection for estimation of mouth opening area for use in speech training aids**

Specialization: Communications and Signal Processing; Electronic Systems

Description: In speech training aids for providing visual feedback of the articulatory efforts, time-varying vocal tract shape during speech production is generally estimated by linear prediction (LP) analysis of the speech signal and assuming a constant area at the glottis end as a reference. Variation in the glottis-end area during speech production causes errors in the estimated vocal tract shape. The problem can be overcome by using area of the mouth opening as the reference. This area can be estimated by detecting the inner lip contour from the video recording of speaker's face during speech utterance. We have earlier developed a technique for detection of inner lip contour, based on color transformation and template matching. Building on this work, further research will involve developing a technique that is not affected by skin hue and presence of teeth and tongue, and implementation of the technique as part of a speech training aid.
Topic #2

Faculty Name: Preeti Rao

Title of Project: **Music information retrieval**

Specialization: Communications and Signal Processing; Electronic Systems

Description: The ready availability of vast audio archives of music across genres opens up the need for powerful tools for search and navigation. Signal processing offers the possibility of generating a variety of computational encodings of music that facilitate search and navigation. The same computational tools can serve the needs of musicological research from audio archives as well as provide for powerful pedagogical aids. Our work is specifically directed towards investigating signal processing and machine learning methods for vocal and instrumental music applications.

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Topic #3

Faculty Name: Maryam Shojaei

Title of Project: **Autonomous Wireless Sensor Network for Real-time Water Quality Monitoring**

Specialization: Electronic Systems

Description: Field oriented sensor system integration for wireless sensor networks and IoT applications is on demand. In this direction this project aims at a complete Indigenous and modular multi-parameter instrumentation and electronics for the sensor signal conditioning and networking for water quality monitoring in the selected waterways. The developed solution will be economical and low power so as to be scalable for different waterbodies.

The project will also bring several new interesting research and development aspects in the areas of the circuits and systems for this application and in the real field.

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Topic #4

Faculty Name: Siddharth Tallur

Title of Project: **Bulk acoustic wave (BAW) resonator based gyroscopes**

Specialization: Electronic Systems; Solid State Devices
Description: Nature of work: Experimental (control electronics design and characterization). BAW gyroscopes have been the hot topic in MEMS gyroscope research around the globe in the past decade (notable groups include Ayazi at Georgia Tech, Najafi at UMich, Kenny at Stanford, Shkel at UC Irvine), but only one unsuccessful attempt to commercialize the technology was made (by Qualtre Inc., now part of Panasonic Corp.) There are several technical challenges pertaining to resonator design and fabrication and control electronics, that remain open problems in this area. Many of the problems are limited by fabrication technology, which continues to improve with time, calling upon innovations at the electronic design level. This project will involve working on one of more of these aspects together with other students, in a group that is passionate about solving these issues. This project may involve collaboration with a research group in Taiwan and a commercial foundry for interested candidates.

---

**Topic #5**

Faculty Name: Siddharth Tallur

Title of Project: **Embedded systems for non-invasive structural health and condition monitoring applications**

Specialization: Communications and Signal Processing; Electronic Systems

Description: We are looking to complement our team of passionate and dedicated students working on sensor design for structural health monitoring and condition monitoring applications. Currently our focus is on sensor design optimization, for which we use bench-top test setups, suitable for laboratory experiments, but not for field testing. Problems encountered in the field are of a very different from the ones that manifest in lab, and as such it is important for any project to rapidly progress towards field testing with large number of prototypes to uncover and then solve such issues. We are looking for candidates with good experience and interest in embedded system design and digital signal processing to develop hardware and algorithms for such systems. We are currently focused on corrosion monitoring inside reinforced concrete structures, and vibration based condition monitoring of machinery. Interested students are encouraged to engage us in a discussion to explore other applications.

---

**Topic #6**

Faculty Name: Siddharth Tallur

Title of Project: **Synchronization methods for chaotic oscillators and their applications**

Specialization: Control and Computing; Electronic Systems
Description: Chaotic oscillators can enable several applications in cryptography. Such applications require synchronization of a network of such oscillators. We have recently obtained interesting results applying LQR control theory to design linear partial state feedback controller to synchronize electronic oscillator circuits. The thesis will involve extending these ideas to explore systems with richer dynamics for a variety of applications.

Topic #7

Faculty Name: Rajesh Zele

Title of Project: **Super High Speed DAC (Digital to Analog) Converter Design for HDTV/Cable/Satellite Communication System Applications**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems; Electronic Systems

Description: As everything including RF/Analog and Digital Systems are getting integrated on a SOC (System-On-Chip), there is a strong desire to convert real world analog (RF) signals to digital using high sampling rate and do the signal processing in the digital domain as early as possible. Similarly there is need to convert the digital data to analog at a very high sample rate before transmitting over the air/cable using power amplifiers. High performance Digital to Analog Converters play a critical role in the overall product development.

The student will be involved in the system implementation along with developing various circuit techniques in the design of super high speed Digital to Analog Converters with very good linearity. This project will provide high performance Integrated Circuits and System design experience culminating in sending out their chip for fabrication in 28nm CMOS technology. Student will also get good experience in testing their chips.

Topic #8

Faculty Name:

Title of Project: **Ultra-Low power Ultra-miniaturized Radio for Wireless Body Area Sensor Network (WBAN) using ISM Bands**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems; Electronic Systems

Description: Increasing demand for higher data rate communication has led to opening up 57-64 GHz unlicensed spectrum in many countries. Due to high path loss, the 60 GHz signal has very short range (few meters). Short range facilitates low interference from other 60 GHz radios,
enabling the WPAN (Wireless Personal Area Network) applications. Due to very high frequency of operation, the antenna size is small leading to an ultra-miniature form factor - a requirement for Wireless Body Area Networks.

Traditionally millimetre wave devices have been implemented in III-V semiconductor technologies such as GaAs or InP. Today’s nm CMOS technologies can provide sufficient high frequency performance to implement 60 GHz radios. CMOS technology offers an easy path to efficiently integrate digital baseband enabling single chip solution. Our goal in this project proposal is to implement a fully integrated 60 GHz wireless transceiver using standard CMOS technology by providing new design techniques to overcome the challenges. PhD candidate will be involved in communication system design, 28 nm CMOS chip design/layout and testing.

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**Topic #9**

Faculty Name: Prof. Shalabh Gupta

Title of Project: **Signal Processing Techniques in CMOS and Silicon Photonic Integrated Circuits for High-Speed Optical Fiber Interconnects.**

Specialization: Communications and Signal Processing; Electronic Systems; Solid State Devices

Description: The project aims to develop signal processing techniques for very high data rate short reach optical interconnects. The project also aims at developing state-of-the-art high-speed CMOS integrated circuits and silicon photonic integrated circuits for such interconnects. Prior knowledge of optical communications (or fiber optics) is not required. Interested candidates should interested either in communications signal processing or in CMOS IC design/silicon photonic IC design (along with interest in working with the high-end equipment available in the lab).

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**Topic #10**

Faculty Name: Rajesh Zele

Title of Project: **ADC design for Radar Applications**

Specialization: Electronic Systems, Integrated Circuits and Systems

Description: The current communications used in military RADAR applications use discrete-component-based data converters. The advanced military aircraft requires the power and area-efficient Nyquist rate ADCs with signal bandwidths in GHz range. The high-performance ADC
will also require the design of digital calibration and correction circuits to ensure high resolution for GHz range input signals.

The student will design with a top-down approach of system-level modeling, replacing the building blocks with actual circuits and verification of the design for added non-linearity. The student will get an opportunity to design and fabricate the chip in CMOS 28nm technology. The student will then design a test circuit board and test the ADC chip. The project will help student get expertise in both Analog and Digital Circuit design. Many opportunities for innovation at the circuit level as well architecture level.

---

**Topic #11**

Faculty Name: Rajesh Zele

Title of Project: *Automated Design of Analog Circuits using Machine Learning Techniques*

Specialization: Electronic Systems, Integrated Circuits and Systems

Description: Analog circuits play an important role in processing real world signals and interfacing them with digital processing units. The design of analog circuits is challenging as the parameters of the analog circuits are interrelated and difficult to tune to achieve the desired performance, optimizing one parameter will result in the degradation of another. Designers are always trying to get an optimum trade-off between the performance metrics.

In this project, PhD students will learn methodology for analog circuit design. With help of Machine Learning techniques, they will be able to implement the design intelligence into any new circuit for any fabrication technology reducing chip design/verification cycle time.
List of TA topics: EE6
(Integrated Circuit and Systems)

In addition to the specific projects listed in this section, the following faculty members are willing to take PhD students on topics to be decided by mutual consultation in the broad research areas mentioned against their names:

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<thead>
<tr>
<th>Faculty</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Udayan Ganguly</td>
<td>Spiking Neural Network Devices and Circuit; Non-volatile Memory Devices e.g. Resistance RAM, Ferroelectric RAM, Flash; Transistor Design</td>
</tr>
<tr>
<td>Maryam Shojaei</td>
<td>Analog/Mixed-Signal CMOS IC Design for Impedance Spectroscopy ASICs, Data Converters for Emerging Applications, Energy efficient CMOS RF modules for the IoT within the 5G plans, Energy harvesting and CMOS power management for emerging applications</td>
</tr>
</tbody>
</table>

Topic #1

Faculty Name: Jayanta Mukherjee

Title of Project: **Antenna, filters and other passive microwave design**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems

Description: We work in the field of passive microwave component design. This is especially critical nowadays where the frequency of operation is scaling up and newer standards like 5G have arrived. The focus is on novel antennas, filters and other microwave components like mode converters, diplexers, power dividers, couplers etc. Some of the specific topics of interest are:

1. Advanced metamaterial based antenna design
2. mm wave antenna design
3. Phase array antenna design
**Topic #2**

Faculty Name: Jayanta Mukherjee

Title of Project: **RF Front end design**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems

Description: 1. Advanced topologies in LNA, Mixer and PLL design in CMOS

2. Advanced topologies in LNA, RF switch in GaN

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**Topic #3**

Faculty Name: M.B. Patil

Title of Project: **Automatic design and optimization of integrated analog circuits**

Specialization: Integrated Circuits and Systems

Joint Supervisor: Prof. Maryam Shojaei

Description: In analog circuit design, transistor sizes need to be chosen in order to meet certain specs. In general, this is a complex problem, requiring simulation and optimisation. In some cases, the specs can be combined in the form of a single objective function to be optimised; in others, the specs may need to be treated as multiple objectives. In this project, the student would be expected to learn about optimisation techniques, particularly evolutionary algorithms, and apply them to the domain of analog circuit design.

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**Topic #4**

Faculty Name: Maryam Shojaei

Title of Project: **Design, fabrication and integration of impedance spectroscopy ASIC**

Specialization: Integrated Circuits and Systems

Description: The purpose of this project is to make one (or two) customized CMOS impedance spectroscopy ASIC(s) for the selected agritech and biosensing applications.
**Topic #5**

Faculty Name: Maryam Shojaei  
Title of Project: **Energy efficient CMOS RF modules for the IoT within the 5G plans**  
Specialization: Integrated Circuits and Systems

Description: The IoT (IoE) is going to change life of many people in the near future. In this project we will design, fabricate and test various CMOS RF modules based on the recommendations and band allocations for IoT.

**Topic #6**

Faculty Name: Maryam Shojaei  
Title of Project: **Energy harvesting and CMOS power management ASIC for artificial smart skin**  
Specialization: Integrated Circuits and Systems

Description: Artificial smart skin is a growing area finding its applications in robotics and medical applications. This technology also brings new aspects of energy provision for the artificial skin. In this project we will work on the flexible layers of generators with a CMOS power management ASIC which will be designed, fabricated and integrated on the artificial skin.

**Topic #7**

Faculty Name: Maryam Shojaei  
Title of Project: **Novel energy efficient noise-tolerant analog and mixed-signal CMOS signal conditioning ASIC or sensing applications**  
Specialization: Integrated Circuits and Systems

Description: Various emerging sensing applications need energy efficient and noise-tolerant analog signal conditioning for the high performance, followed by novel hybrid low-energy high-resolution architectures for the analog to digital conversion (ADC). The purpose of this project is to extend such functionalities with high performance to the various domains of information for better tolerance to the internal and external noise as well as calibration for the selective analog to digital conversion.
**Topic #8**

Faculty Name: Rajesh Zele

Title of Project: **Super High Speed DAC (Digital to Analog) Converter Design for HDTV/Cable/Satellite Communication System Applications**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems; Electronic Systems

Description: As everything including RF/Analog and Digital Systems are getting integrated on a SOC (System-On-Chip), there is a strong desire to convert real world analog (RF) signals to digital using high sampling rate and do the signal processing in the digital domain as early as possible. Similarly there is need to convert the digital data to analog at a very high sample rate before transmitting over the air/cable using power amplifiers. High performance Digital to Analog Converters play a critical role in the overall product development.

The student will be involved in the system implementation along with developing various circuit techniques in the design of super high speed Digital to Analog Converters with very good linearity. This project will provide high performance Integrated Circuits and System design experience culminating in sending out their chip for fabrication in 28nm CMOS technology. Student will also get good experience in testing their chips.

**Topic #9**

Faculty Name: Rajesh Zele

Title of Project: **Ultra-Low power Ultra-miniaturized Radio for Wireless Body Area Sensor Network (WBAN) using ISM Bands**

Specialization: Communications and Signal Processing; Integrated Circuits and Systems; Electronic Systems

Description: Increasing demand for higher data rate communication has led to opening up 57-64 GHz unlicensed spectrum in many countries. Due to high path loss, the 60 GHz signal has very short range (few meters). Short range facilitates low interference from other 60GHz radios, enabling the WPAN (Wireless Personal Area Network) applications. Due to very high frequency of operation, the antenna size is small leading to an ultra-miniature form factor - a requirement for Wireless Body Area Networks.

Traditionally millimetre wave devices have been implemented in III-V semiconductor technologies such as GaAs or InP. Todayâ€™s nm CMOS technologies can provide sufficient high frequency performance to implement 60 GHz radios. CMOS technology offers an easy path
to efficiently integrate digital baseband enabling single chip solution. Our goal in this project proposal is to implement a fully integrated 60 GHz wireless transceiver using standard CMOS technology by providing new design techniques to overcome the challenges. PhD candidate will be involved in communication system design, 28 nm CMOS chip design/layout and testing.

---

**Topic #10**

Faculty Name: Rajesh Zele

Title of Project: **ADC design for Radar Applications**

Specialization: Electronic Systems, Integrated Circuits and Systems

Description: The current communications used in military RADAR applications use discrete-component-based data converters. The advanced military aircraft requires the power and area-efficient Nyquist rate ADCs with signal bandwidths in GHz range. The high-performance ADC will also require the design of digital calibration and correction circuits to ensure high resolution for GHz range input signals.

The student will design with a top-down approach of system-level modeling, replacing the building blocks with actual circuits and verification of the design for added non-linearity. The student will get an opportunity to design and fabricate the chip in CMOS 28nm technology. The student will then design a test circuit board and test the ADC chip. The project will help student get expertise in both Analog and Digital Circuit design. Many opportunities for innovation at the circuit level as well architecture level.

---

**Topic #11**

Faculty Name: Rajesh Zele

Title of Project: **Automated Design of Analog Circuits using Machine Learning Techniques**

Specialization: Electronic Systems, Integrated Circuits and Systems

Description: Analog circuits play an important role in processing real world signals and interfacing them with digital processing units. The design of analog circuits is challenging as the parameters of the analog circuits are interrelated and difficult to tune to achieve the desired performance, optimizing one parameter will result in the degradation of another. Designers are always trying to get an optimum trade-off between the performance metrics.
In this project, PhD students will learn methodology for analog circuit design. With help of Machine Learning techniques, they will be able to implement the design intelligence into any new circuit for any fabrication technology reducing chip design/verification cycle time.
List of TA topics: EE7 (Solid State Devices)

In addition to the specific projects listed in this section, the following faculty members are willing to take PhD students on topics to be decided by mutual consultation in the broad research areas mentioned against their names:

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<tr>
<td>Subhananda Chakrabarti</td>
<td>Compound (III-V and II-VI) semiconductor materials and devices</td>
</tr>
<tr>
<td>Udayan Ganguly</td>
<td>Spiking Neural Network Devices and Circuit; Circuits for Non-volatile Memory Devices e.g. Resistance RAM, Ferroelectric RAM, Flash; Variability resistant circuits</td>
</tr>
<tr>
<td>Shalabh Gupta</td>
<td>Ionizing radiation tolerant integrated circuits in CMOS technologies.</td>
</tr>
<tr>
<td>Souvik Mahapatra</td>
<td>Reliability of semiconductor devices</td>
</tr>
<tr>
<td>Dipankar Saha</td>
<td>Single photon sources using quantum dots for quantum communication.</td>
</tr>
<tr>
<td>Maryam Shojaei</td>
<td>Reliable and robust sensor and bio-sensor fabrication for agri-tech applications, MEMS based photo acoustic sensor fabrication and characterization, MEMS switch design and fabrication for energy-efficient integrated systems</td>
</tr>
<tr>
<td>Siddharth Tallur</td>
<td>GaN based MEMS (utilizing the rich properties of GaN viz. electro-optic coefficient, optical nonlinearity, piezoelectricity etc. for various resonator based sensing and timing applications)</td>
</tr>
<tr>
<td>Ashwin Tulapurkar</td>
<td>Spintronics, spin based devices and phenomena</td>
</tr>
</tbody>
</table>

Topic #1

Faculty Name: Prof. SP Duttagupta

Title of Project: **Rapid imaging and pattern recognition system for biomarker classification**

Specialization: Solid State Devices

Description: The objective is machine learning enhanced biomarker classification for sub-surface analysis of organic carbon in order to predict and estimate arsenic release pathways in groundwater. In parallel, biomarker classification will be useful for health-care applications such as analysis of dengue pathogenesis mechanism and serotype diagnosis to identify single or mixed infection at early stage of infection. The proposed system comprises of imaging, micro-fluidic and computational modules to enable high definition image capture, stabilization, analysis, and retrieval.
**Topic #2**

Faculty Name: Prof. SP Duttagupta

Title of Project: **Design and development of a compact Tera-Hertz spectroscopy set-up for biomarker discovery**

Specialization: Solid State Devices

Description: Terahertz (THz) radiation has many applications in condensed matter physics, medical diagnostics, high-bandwidth communication etc. In the electromagnetic spectrum, THz spans from 3mm to 30micron (wavelength). This radiation is capable of penetrating through opaque materials such as plastics, paper and textiles. Image resolution in the order of mm is possible. Unlike other imaging radiation like gamma rays, THz radiation does not exhibit an ionizing effect. Due to this reason these frequencies are considered to be biologically innocuous. However, at present Thz components (emitter, filter, mixer, detector) are difficult to source and require to be designed, fabricated and tested in-house. Accordingly we propose to develop a compact, cost-effective THz spectroscope which will be utilized for bio-marker imaging.

**Topic #3**

Faculty Name: Swaroop Ganguly

Title of Project: **Quantum electronic nose sensors**

Specialization: Solid State Devices

Description: Natural olfaction (sense of smell) is more sensitive and powerful than the artificial (electronic) nose sensors available today. The goal here is the development of biomimetic electronic nose sensors which will rival biological olfaction. One thrust involves biophysical models, and device design inspired by those. The work involves theory and computation. Background and/or strong interest in quantum mechanics, and solid-state device physics is required. Some knowledge of graph theory and interest in biophysics would also be useful. The second thrust is experimental, involving device fabrication, and characterization. For this, interest in semiconductor devices, and background in circuits, instrumentation and measurements would be useful.

**Topic #4**

Faculty Name: Anil Kottantharayil
Title of Project: **Spacial mapping of losses in solar cells and modules using advanced characterization techniques**

Specialization: Solid State Devices

Description: The work would involve the development of appropriate models and tools for the analysis of the characteristics of solar cells (current - voltage, quantum efficiency, luminescence images, infrared thermography images, ...) and evaluate the losses in solar cells. The student is expected to measure the characteristics and also develop the theoretical framework and analysis.

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**Topic #5**

Faculty Name: Apurba Laha

Title of Project: **Design, grow and fabricate III-Nitride based Ultraviolet Nano LED**

Specialization: Solid State Devices

Description: Disinfection of water by ultraviolet light (UV-C) exposure is the most effective and non-invasive mean of water purification. However, the currently available UV light sources are large, expensive and require large power to run. Due to these constraints, the UV sources are centrally located as disinfection hubs and therefore, leaving more than one third of the world population without a viable UV disinfection solution. Apart from water purification UV lights are also used for air purification, surface disinfection, free-space non-line-of-sight covert communication, epoxy curing, counterfeit detection, light therapy and fluorescence identification of biological/chemical agents. The first part of this project is grow AlGaN nanowires designed for UV light emission by state of the art Molecular Beam Epitaxy technique. Second part primarily involves fabrication of the LED using these nanowires.

---

**Topic #6**

Faculty Name: Saurabh Lodha

Title of Project: **2D Materials for Neuromorphic Computing**

Specialization: Solid State Devices

Description: The past decade has seen explosive growth in 2D materials such as graphene as well as synaptic/neuronal devices for artificial intelligence and neuromorphic computing. This project will explore experimental and analytical approaches towards harnessing unique electronic, optical and mechanical properties of 2D materials for building neuromorphic devices. It will target flexible and smart sensing and computing applications.
This work will leverage significant experimental and computational expertise in our research group on electronic and optoelectronic devices. Please visit http://www.ee.iitb.ac.in/~slodha/ for more details.

---

**Topic #7**

Faculty Name: Saurabh Lodha

Title of Project: **Gallium oxide devices for next generation power electronics**

Specialization: Solid State Devices

Description: Large band gap and ease of growth of gallium oxide has led to a new wave in wide bandgap power devices and electronics. At the same time, many fundamental challenges in gallium oxide processing and device fabrication offer an opportunity to explore new device physics and engineer high impact solutions. This project will explore the fabrication of normally off high power gallium oxide transistors for power switching applications. It will involve experimental device fabrication, characterisation and TCAD simulations.

In collaboration with Ohio State University (OSU) we have established basic process flows and demonstrated early successes in gallium oxide device fabrication. Please visit http://www.ee.iitb.ac.in/~slodha/ for more details.

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**Topic #8**

Faculty Name: Souvik Mahapatra

Title of Project: **Reliability of advanced CMOS logic and memory devices**

Specialization: Solid State Devices

Description: Experimental + Physics-model development / Simulation, Work with leading industries to incorporate models in practice.

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**Topic #9**

Faculty Name: Bhaskaran Muralidharan

Title of Project: **Topological Electronics**

Specialization: Solid State Devices
Description: Modern nanoelectronic device design for the upcoming “Beyond Moore” era calls for radical and innovative ideas at the device engineering level that feature the interplay of spin and charge while simultaneously exploiting the exciting day-to-day development in material structures. During the past decade or so, the search for “topological phases” in materials has gained a significant ground and is a topic of intense and active worldwide pursuit. These phases feature electronic states that are “topologically stable” and hence “disciplined” despite the presence of the agents such as defects and impurities that normally result in power dissipation in logic and memory devices and qubit decoherence in quantum computing. The aim of this work is to develop an atomistic computational platform to facilitate a comprehensive exploration of material hetero-structures and interfaces from a nanoelectronic device design perspective in order to realize “topotronic” devices and engineer such topological transitions for ultra-low-power logic and spin based quantum computing.

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**Topic #10**

Faculty Name: Bhaskaran Muralidharan

Title of Project: Quantum information processing with hybrid systems

Specialization: Solid State Devices

Description: Quantum technologies including quantum computing and information processing will form a very important aspect of the next generation technology. In this project we aim at the realization of quantum information processing using hybrid systems. Research on quantum hybrid systems strives to combine the benefits of different quantum objects into a new entity that is more useful than each of the systems by itself. That includes properties like storage of quantum states, ability to sense very small forces, fast gate times in quantum computational application and many more.

In our project we will take up the modeling and simulation aspect of some of the current hybrid system and focus on how to achieve information manipulation and distant information transfer using quantum dot spin qubits.

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**Topic #11**

Faculty Name: Bhaskaran Muralidharan

Title of Project: Nanomagnetics and spintronics

Specialization: Solid State Devices
Description: Magnetic RAM (MRAM) is a state-of-the-art non-volatile memory technology based on the electron spin that caters to low-power dissipation, non-volatility and stability. The aim of this project is to set up an advanced device simulation platform for some of the industry level devices that are currently under production. This is typically what is known in the industry as spin-transfer torque MRAM (STT-MRAM). Along with device models, we also expect to advance modular spintronics via circuit theory such that integrated functionalities may be realized.

**Topic #12**

Faculty Name: Bhaskaran Muralidharan

Title of Project: **Fast gate pulse designs in nanowire networks for realizing topological qubit logic**

Specialization: Solid State Devices

Description: The field of topological quantum information is expected to overcome the obstacles of traditional quantum computing. An important engineering aspect of the same is the hardware realisation using nanowire networks. This project deals with the simulation aspects of designing effective nanowire networks that can perform topological quantum computing logic gates.

**Topic #13**

Faculty Name: Pradeep R. Nair

Title of Project: **High efficiency low cost Solar cells**

Specialization: Solid State Devices

Description: Novel Photovoltaic concepts like organic-inorganic metal halide perovskites and Silicon based heterojunction solar cells have emerged as low cost and high efficiency alternatives to c-Si technology. However, given the promises, several important system level concerns needs to be addressed for this emerging technology to become a mature technology with issues ranging from the fundamental operating mechanism of the device, performance optimization pathways, and degradation mechanisms which contribute to device failure. Here, we aim to address these system level concerns through predictive modeling with detailed numerical simulations. Close collaboration with other experimental groups could be a key feature of this research. Related information can be found at [https://www.ee.iitb.ac.in/wiki/faculty/prnair](https://www.ee.iitb.ac.in/wiki/faculty/prnair)
**Topic #14**

Faculty Name: Dipankar Saha

Title of Project: *Few Electron and Photon Quantum Devices*

Specialization: Solid State Devices

Description: The work will involve quantum devices involving electrons and photons for improved performance in future applications. The work involve a balance of both experimental and theoretical works. The student should be hardworking and willing to learn new things.

**Topic #15**

Faculty Name: Dipankar Saha

Title of Project: *GaN based nanowire transistors*

Specialization: Solid State Devices

Description: This work will involve various properties of Gallium Nitride based nanowire transistors. Some of the properties include quantum transport, quantum capacitance, and sub-band resolved phenomena.

**Topic #16**

Faculty Name: Kasturi Saha

Title of Project: *Precision magnetic field sensing using wide-field microscopy with wide-bandgap semiconductors*

Specialization: Solid State Devices

Description: Tremendous research activity worldwide is focused to develop "engineered quantum systems" for precision magnetic field sensing. In our group, we use wide-bandgap semiconductors such as diamond and SiC with atomic defects that work as ultra-precise sensors for magnetic field. In this project, we will use an ensemble of such sensors to build a wide-field microscope for magnetic field sensing of 2D-magnetic thin films and superconductors. The project will involve simulations, setting up experimental setups, fabrication of microcoils for RF and MW, optical characterization and experimentation, analysis and comparison with theoretical models.
Topic #17

Faculty Name: Kasturi Saha

Title of Project: **Optical and spin properties of color defects coupled to photonic devices for quantum computation**

Specialization: Solid State Devices

Description: Atomic defects in wide bandgap semiconductors such as SiC, and diamond have shown great promise as solid state qubits for quantum computing. We wish to investigate the optical properties and spin coherence properties of such defects with applications to quantum computation and communication. The project will involve simulation and design using Comsol, Lumerical. Fabrication in the IITBNF and characterization using home built microscopy setup.

Topic #18

Faculty Name: Prof Maryam Shojaei

Title of Project: **Design and development of MEMS based photoacoustic sensor & system for the environmental monitoring**

Specialization: Solid State Devices

Description: The objective of this project is to design, fabricate and characterize sensitive MEMS photoacoustic gas detectors for photoacoustic spectroscopy (PAS) aimed for the environmental monitoring applications.

Topic #19

Faculty Name: Siddharth Tallur

Title of Project: **Bulk acoustic wave (BAW) resonator based gyroscopes**

Specialization: Electronic Systems; Solid State Devices

Description: Nature of work: Experimental (control electronics design and characterization). BAW gyroscopes have been the hot topic in MEMS gyroscope research around the globe in the past decade (notable groups include Ayazi at Georgia Tech, Najafi at UMich, Kenny at Stanford, Shkel at UC Irvine), but only one unsuccessful attempt to commercialize the technology was made (by Qualtre Inc., now part of Panasonic Corp.) There are several technical challenges pertaining to resonator design and fabrication and control electronics, that remain open problems.
in this area. Many of the problems are limited by fabrication technology, which continues to improve with time, calling upon innovations at the electronic design level. This project will involve working on one of more of these aspects together with other students, in a group that is passionate about solving these issues. This project may involve collaboration with a research group in Taiwan and a commercial foundry for interested candidates.

**Topic #20**

Faculty Name: Prof. Shalabh Gupta

Title of Project: **Signal Processing Techniques in CMOS and Silicon Photonic Integrated Circuits for High-Speed Optical Fiber Interconnects.**

Specialization: Communications and Signal Processing; Electronic Systems; Solid State Devices

Description: The project aims to develop signal processing techniques for very high data rate short reach optical interconnects. The project also aims at developing state-of-the-art high-speed CMOS integrated circuits and silicon photonic integrated circuits for such interconnects. Prior knowledge of optical communications (or fiber optics) is not required. Interested candidates should interested either in communications signal processing or in CMOS IC design/silicon photonic IC design (along with interest in working with the high-end equipment available in the lab).

**Topic #21**

Faculty Name: Prof. Bhaskaran Muralidharan

Title of Project: **Machine learning based nanodevice simulation**

Specialization: Solid State Devices

Description: Development of machine learning based models for 2D devices based on quantum transport models toward target functionalities that include emerging areas such as spintronics, neuromorphic computing and quantum technologies.

**Topic #22**

Faculty Name: Prof. Swaroop Ganguly

Title of Project: **Semiconductor Modeling: Materials to Devices to Circuits**
Specialization: Solid State Devices

Description: This involves connecting materials modeling to device performance, and modeling of devices to study their circuit level impact. There are two specific problems of interest at this time. The first relates to modeling of Gallium Nitride (GaN) devices for RF power applications such as radar and communications. This is in close partnership with the device fabrication effort in Prof. Dipankar Saha's group, and is expected to be in collaboration with a space agency. The second relates to wide bandgap semiconductor, e.g. Silicon Carbide (SiC), based devices for power switching applications such as in electric vehicles and renewables. This is expected to be in collaboration with a major US university program in this area.

Topic #23

Faculty Name: Prof. Swaroop Ganguly

Title of Project: Bio-inspired Devices: Digital Olfaction

Specialization: Solid State Devices

Description: The goal here is the development of paradigm-changing bio-inspired artificial olfactory sensing systems that will enable 'digital olfaction', i.e. reception, transmission and reproduction of olfactory (smell) signals, similar to what is done for audio and video signals today. The first thrust here involves biophysical models of olfaction, and device design inspired by those. The work involves theory and computation. Some background and/or interest in quantum mechanics and solid-state/semiconductor physics would be useful. Some knowledge of graph theory and interest in biophysics might also be useful. The second thrust is experimental, involving device fabrication and characterization, as well as the development of sensing circuitry. For this, interest in semiconductor devices and circuits, and background in instrumentation and measurements would be useful.
List of RA Topics

Project Investigator: Prof. Anshuman Shukla

Title of the project: **Smart Multi-Port Fault-Tolerant High Efficiency Converter for Microgrids**

Desired specialization: EE 3 (Power Electronics & Power Systems)

*Abstract of the project:*

The proposed power electronic converter system will consist of a multi-port configuration with a central high frequency transformer (HFT). Two of the ports will be utilized for local source (PV) and load and one port for the battery storage system. It will be designed for 5 kVA power rating. Also, the grid-interfacing feature will be incorporated, which will provide control and stability in case of the transitions from grid connected to islanded modes. The low cost but highly efficient converter configurations for all interfacing converter configurations will be used. These converters will operate at high efficiency making the HFT and overall system of as high-power density as possible. Thus, making it suitable to relocate the system as well as reduce the space requirements required for the application. Using this planned technology development, it will be possible to achieve high utilization of the renewable sources with enhanced higher reliability.

Project Investigator: Prof. Jayanta Mukherjee

Title of the project: **Novel Power Amplifier topologies for 5G/6G wireless networks**

Desired specialization: EE 6 (Integrated Circuit & Systems), EE 1 (Communication & Signal Processing)

*Abstract of the project:*

The continuous growth in demand for high-speed wireless connectivity is one of the main driving forces for 5G standardization. At the forefront of these innovations is massive Multiple-Input Multiple-Output (mMIMO), or the outfitting of a base station with hundreds to thousands of antenna elements, each with its own respective transmit/receive signal chain, to maximize spectral efficiency.

In recent years mMIMO is leveraging active antenna system (AAS) supporting optimal integration of antenna/radio. In this case, for a typical base station infrastructure application the effective isotropic radiated power (EIRP) of >320W has to be transmitted at the Antenna requiring 32 transmitters with each PA chain operating at 10-14W ave output RF power. Furthermore, currently the OEMs are highly interested in developing RFPAs and front-end modules at 2.6GHz, 3.5GHz and 4.9GHz band. However, due to bandwidth advantage there are efforts to already extend the operating frequency beyond 5GHz.

Under these circumstances, Power Amplifier (PA) design is becoming increasingly difficult with the ever 3GPP specifications.

The use of GaN HEMT technology has already permeated the wireless industry for large, macro-cell high power amplifiers (HPA) and is well positioned to overtake the popularized Si-based LDMOS PA that was previously leveraged. GaN transistors are capable of this all within a smaller package and at higher frequencies (DC-40 GHz) as manufacturing techniques advance with large wafer diameters and increasingly smaller gate-lengths (e.g., 0.25μm, 0.15μm)
fabrication processes. GaN-on-SiC, in particular, has the capability of achieving a higher efficiency at high frequencies, over a wide bandwidth.

The goal of this joint research proposal with Renesas Electronics is to develop a high performance 5GHz Front-end Module solution operating at 5W-10W average output power using GaN-on-SiC technology as the active device. The research will also include investigation of various transmitter chain topologies and final-stage PA architecture in a highly integrated environment to achieve industry leading RF performance.

This is a PM Phd fellowship position with industry participation. After admission the student will have to follow the procedures given in the following webpage

https://www.primeministerfellowshipscheme.in/

Project Investigator: Prof. Kasturi Saha

Title of the project: Ultra-sensitive magnetic field measurements with color defects in diamond

Desired specialization: EE 7 (Solid State Devices)

Abstract of the project:

Tremendous research activity worldwide is focused to develop “engineered quantum systems” for precision magnetic field sensing. In our group, we use wide-bandgap semiconductors such as diamond with atomic defects that work as ultra-precise sensors for magnetic field. In this project, we will use an ensemble of such sensors to build a wide-field microscope for magnetic field sensing of 2D-magnetic thin films. Projects will involve simulations, setting up experimental setups, fabrication of microcoils for RF and MW, optical characterization and experimentation, analysis and comparison with theoretical models.

Project Investigator: Prof. Dipankar Saha

Title of the project: Photo-acoustic Imaging for Detecting Subsurface Features

Desired specialization: EE 7 (Solid State Devices)

Abstract of the project:

A laser is used to excite a system. Heat is generated from the excitation. It triggers a transient thermoelastic expansion leading to ultrasonic wave generation. This effect is detected by another laser and/or ultrasonic transducer. Photoacoustic imaging is a useful non-invasive technique for sub-surface detection of targets, biomedical imaging, and identifying structural defects. The work will involve design and developing the system for this imaging technique. The student should be keen to learn, committed, and hardworking. No prior knowledge is mandatory.

Project Investigator: Prof. Sandeep Anand

Title of the project: Wide Bandgap Based Solar Inverter

Desired specialization: EE 3 (Power Electronics & Power Systems)

Abstract of the project:

Power electronics converters play a very important role in renewable generation and EVs. The
ever-increasing demand for better efficiency, reliability, and compactness has made the requirement of innovation in the area of power electronics a need of the hour. The wide band gap (WBG) devices are a new disruptive technology which would drastically change the power electronic industry. Gallium Nitride (GaN) based power devices are now commercially available and offer better performance in terms of on-state resistance and gate capacitance. These advantages help in achieving high efficiency and power density in power converters. However, there are interesting research problems in designing and developing power electronic converters using these GaN devices. This project aims to carry out research in the area of GaN based power electronic converters. There are two open PhD positions in this project. This is a Department of Science and Technology (DST), Govt. of India, sponsored project. Following are some of the key phrases. If you find any one or more of the following interesting, then you must apply for this project:

- Wide bandgap Device based power converters
- Circuit topologies of transformer-less inverters
- Solar string inverter
- Modulation and control of solar inverters

Project Investigator: Prof. Sandeep Anand and Prof. Kishore Chatterjee

Title of the project: Electric Vehicles: Motors, Drives and Power Electronics

Desired specialization: EE 3 (Power Electronics & Power Systems)

Abstract of the project:

Reducing pollution, both as a national commitment towards public health, and a global commitment towards mitigating anthropogenic climate change, drives India’s muscular push towards Electric Vehicles. EVs is the stepping stone towards truly sustainable transportation solutions. Governments around the world have introduced policies which incentivized EVs to expedite its adoption rate. The electric drivetrain, consisting of electric motor, its controller and onboard charger are the key distinguishing elements of electric vehicles compared to their IC engine-based counterparts. Range anxiety and performance are some of the concerns among EV users. Hence, for a high performance and long range EV, a light weight, compact and energy efficient drivetrain is essential. This calls for active research for development of efficient and low-cost electric motor technologies. These attempts may include reduction in the magnet requirements or to go purely magnet-less to relieve the dependence on imports and support technological self-sufficiency of the country. For reduced maintenance cost, reliability analysis and lifetime estimation of drive train components is essential. The attempts to improve reliability may also involve replacement of failure prone components such as electrolytic capacitors with active power decoupling technique, achieving low volume and higher lifetime. To address the challenge of fast charging, high power EV chargers need to be developed. This invokes the need of high conversion efficiency, optimal thermal management and light weight. In addition, the volume of offboard EV chargers should also be reduced to make them suitable for installation in urban settings. Simultaneous achievement of high-power density and high conversion efficiency is a tedious task for power converter designers. However, use of wide bandgap devices is expected to simplify this task. Wide bandgap devices allow selection of higher switching frequency and hence, reduce the size of passive components required for power filtering. The advantages offered by wide band gap devices are so dramatic that these are expected to revolutionize the power electronics industry. It is a joint collaborative project between India and Europe, and would help you in getting much wider experience in the area of EV, along with expertise in one of the research topics. This project has multiple aspects and therefore we have 3 open PhD positions for the project. If you find any one or more of the following interesting, then you must apply for this project:

- Motor Design
- Motor Drive
- Onboard EV charger circuits
- EV fast chargers
- Reliability of power electronic circuits

Project Investigator: Prof. Deepak Jain

Title of the project: **Mid-infrared Single-Photon Sources for Quantum applications**

Desired specialization: EE 1 (Communication & Signal Processing)

*Abstract of the project:*

Single-photon sources are the essential sources to carry quantum information. Most of the single-photon sources (Atom/Ion Sources, Quantum Dots, and Diamond Colour Centres) are solid-state based, are not yet mature, and are highly sensitive to temperature and vibration perturbation. A fiber-coupled, single-photon source at different wavelengths can be of great importance for photonic quantum networks providing long-haul and ultra-secure data exchange. Other interesting applications include medical imaging at ultra-low light levels, quantum meteorology, quantum remote sensing, and quantum lidar. This project will develop fiberized heralded single-photon sources in the near and mid-infrared wavelength region. This proposal has great potential for enabling new domains of quantum technologies.

Project Investigator: Prof. Virendra Singh

Title of the project: **AI Powered Adaptive Cyber Defence Framework and Solution for National CII**

Desired specialization: EE 1 (Communication & Signal Processing), EE 2 (Control & Computing), EE 5 (Electronic Systems), EE 6 (Integrated Circuit & Systems)

*Abstract of the project:*

With sophisticated cyber attacks all over the world, it is clear that the attackers are well-funded through organized crimes, nation–support, etc. Thus, it has become important to address cyber threat intelligence to prevent some of the ulterior motives of the attackers to use attacks as weapons, in particular, when most of the public infrastructures are driven by sophisticated IT systems and further with the policy of building several smart-cities to address various societal issues. The latter naturally will lead to growth of Internet of Things (IoT), which in turn will increase the attack surface of the underlying infrastructure due to their vulnerabilities, malware susceptibility, and an emergence of denial-of-service (DoS) attacks will be acutely felt. Primary purpose is to build a scalable system with proactive sensing of cyber-physical systems using data from physical sensors and integrated from other relevant resources, combined via a broad based intrusion alert system and architecture, adaptable/tunable for a spectrum of applications like, attack predictions in the context of vulnerabilities, security alerts in IoT/SCADA, insider attack correlations etc. To realize properties of speed and accuracy using intelligence from a spectrum of resources, use cognitive security solutions using AI/Deep Learning Systems. This project also envisage the development of techniques of privacy-preserving merging/integrating different datasets and privacy preservation training.

Project Investigator: Prof. Siddharth Tallur

Title of the project: **Edge-AI for structural health monitoring**

Desired specialization: EE 1 (Communication & Signal Processing), EE 5 (Electronic Systems), EE 6 (Integrated Circuit & Systems)
Abstract of the project:

We are looking for a motivated and inquisitive PhD candidate to join our team for developing novel signal processing algorithms implemented in low-cost microcontroller and FPGA devices for smart structural health monitoring systems. This work will build on top of ongoing work in structural health monitoring in the group, for a variety of sensor systems - pulse eddy current, guided wave ultrasonics and vibration condition assessment. Interested students may get in touch with Prof. Tallur to discuss further. A strong background in machine learning is essential, and hands-on experience with embedded systems is highly desirable.

Project Investigator: Prof. Swaroop Ganguly
Title of the project: NNetRA
Desired specialization: EE 6 (Integrated Circuit & Systems), EE 7 (Solid State Devices)

Abstract of the project:

GaN Device Modeling: This project is about the modeling of Gallium Nitride based transistors and passives for RF applications, such as radar and communications - both terrestrial and space-based. You will be expected to learn and carry out model development and associated RF circuit design. This effort is complementary to, and collaborative with, the experimental GaN-based device fabrication effort led by Prof. Dipankar Saha. You would also work with engineers in space and other agencies who develop the aforesaid applications.

Project Investigator: Prof. Swaroop Ganguly
Title of the project: NNetRA
Desired specialization: EE 5 (Electronic Systems), EE 7 (Solid State Devices)

Abstract of the project:

Quantum Electronic Nose: This project is about developing the hardware, i.e. device and circuit, for a novel electronic nose sensor system based on inelastic electron tunneling (it has been conjectured that this could be mechanism for biological olfaction). You will be expected to carry out device design & fabrication and/or sensor circuitry design & development.

Project Investigator: Prof. Swaroop Ganguly
Title of the project: NNetRA
Desired specialization: EE 3 (Power Electronics & Power Systems), EE 7 (Solid State Devices)

Abstract of the project:

Design and Simulation of Silicon Carbide (SiC) Devices for EV/Renewable Applications: This project is about the design of robust SiC devices for power converters for EV and renewable applications. We are interested in simulating device behavior as well as its circuit/system level impact. This effort is a collaboration with Ohio State University.

Project Investigator: Prof. Bhaskaran Muralidharan
Title of the project: Machine learning driven 2D Nanoelectronics
Desired specialization: EE 7 (Solid State Devices)

Abstract of the project:

The project will feature machine learning driven quantum transport simulations on 2D devices, specially with respect to optimizing subthreshold logic. The project will also feature a device-circuit interface development that will feature 2D nano devices in modern neuromorphic circuit design.

Project Investigator: Prof. Anil Kottantharayil

Title of the project: Advanced silicon based solar cells

Desired specialization: EE 7 (Solid State Devices)

Abstract of the project:

Increasing the efficiency of solar to electricity energy conversion devices is of paramount interest for reducing carbon emissions related to energy production. India is also planning to get into solar manufacturing in a big way. The student would explore highly manufacturable silicon based solar cell technologies in this project.

Project Investigator: Prof. Udayan Ganguly

Title of the project: Spiking Neural Networks

Desired specialization: EE 1 (Communication & Signal Processing), EE 6 (Integrated Circuit & Systems)

Abstract of the project:

We are developing circuits and algorithms for spiking neural networks. We have developed the first 45nm RFSOI chip for Liquid State Machine. We also have access to LOIHI - Intel's digital SNN Chip.

3. Autoencoders: https://doi.org/10.1007/978-3-030-01418-6_26
4. Spiking Neuron based Classification https://doi.org/10.1109/TBCAS.2018.2831618

Project Investigator: Prof. Prasanna Chaporkar

Title of the project: Next Generation Wireless Research and Standardization on 5G and Beyond

Desired specialization: EE 1 (Communication & Signal Processing)

Abstract of the project:

The fifth generation (5G) technology is identified to have the potential to make a major societal transformation in India by enabling massive digital products and services across industrial, commercial, education, health care, environment, agricultural, financial, and social sectors. The proposed R&D project is envisaged to contribute to address two of the priorities viz. Technology and Manufacturing identified by the 5G HLF by conducting collaborative standards-based research by tapping the available resource pool spread across the country, and the research outcomes are taken to national and International standardization forums like 3GPP, ITU, and TSDSI for its adoption.
All the eight institutes agreed to submit the collaborative proposals contained herein to MEITY for funding to continue the 5G R&D activities in Next Generation Wireless Research and Standardization on 5G and Beyond project for a duration of four years with prime focus on standards-based research and participation in International standards along the recommendation of the task force setup by the steering committee constituted by the 5GHLF. The activities and outputs from this project will contribute to unlock the transformative power of digital communication networks to achieve the goal of GoI in enhancing the well-being of the people through digital empowerment as set out in the draft National Digital Communication Policy 2018 (NDCP 2018).

Given below are IIT Bombay deliverables:
- Use cases, Architecture and protocols for Frugal 5G Networks
- Architecture and protocols for wireless backhaul and Relay communication
- Algorithms for resource allocation and loss tolerance in multicast communication
- Algorithms for resource allocation in mmWave networks - Proposals for standardization to IEEE and 3GPP
- Prototypes and Simulators
- Training and workshops for industry/academic institutions