

# Amrita Vishwa Vidyapeetham

Bengaluru Campus, (ASE and ASC)

## Research Newsletter

*Research at a glance:*

- | No. of Funded Projects: 17
- | No. of On-going Projects: 15
- | No. of Completed Projects: 02

• No. of Funding Agencies: 12  
• Total funds granted 5+ Crores

Outstanding Researcher  
Awards: 02

- | 1) Dr. Anand R., Department of EEE, ASE, Bengaluru
- | 2) Dr. Deepa K., Department of EEE, ASE, Bengaluru





# Funded projects

## Single Sided Matrix Converter fed Brushless DC Motor for Energy Conservation.

PI: Dr. Anand R., Department of EEE, ASE, Bengaluru

Co-PI: Dr. J. Ramprabhakar, Department of EEE, ASE, Bengaluru

**Project funding agency:** Defense Research and Development Organization - Aeronautics Research and Development Board (DRDO - ARDB)

**Amount:** Rs. 23.25 Lakhs

**Status:** In-progress.

### Objective:

A three-phase BLDC motor driven by a single sided matrix converter (SSMC) with hysteresis band control has been opted for its high reliability, fault tolerance, and compact structure. A new technique is contrived and proposed to drive the BLDC motor fed by matrix converter to accomplish desired speed-torque character-

istics meeting the load requirements. The use of Single Sided Matrix converter with BLDC motor is used to achieve operation without any complex control circuitry.

Details of approach intended to be adopted in the execution of the Project:

a) A three phase BLDC motor driven by a single sided matrix converter (SSMC) with hysteresis band control has been opted.

b) The use of an SSMC with a BLDC motor is novel and is used to achieve operation without a microprocessor.

c) A simple hysteresis current control strategy is implemented to control motor torque.

d) The multiphase SSMC provides high reliability and fault tolerance with the penalty of more power devices. This approach is highly suitable for pumps, compressors and propulsion applications.

## A Micro-Grid Test-bed Laboratory – with a view: Transition towards Smart-Grid Knowledge Centre

PI: Dr. Anand R., Department of EEE, ASE, Bengaluru

**Project funding agency:** Vision Group of Science and Technology (Scheme - K-FIST L1)

**Amount:** Rs. 20 Lakhs **Status:** In-progress.

### Objective:

A Smart Grid is a form of electricity network utilizing digital technology. Smart Grid delivers electricity from suppliers to consumers using two-way digital communications to control appliances at consumer level. This saves energy, reduces costs and increases reliability and transparency.

In existing (centralized) power

grid, the basic principle of transferring energy from power plant to a large number of users cannot often meet the increase in demand. To resolve this problem, the trend is to seamlessly integrate the sources of renewable energy, and allow distributed power generation. This necessitates a scalable grid structure connecting distributed sources of energy supply and consumers, and offers better disruption resilience.

However, there are a number of open research problems in designing practical Smart Grid. The main difference between a traditional grid and a smart grid is that the latter relies more on communication between consumers, sup-

pliers, smart devices and applications. The power networks and information networks shall be integrated into Smart Grid network for bidirectional data flow, control flow and energy flows. Other open research problems include: price driven real-time demand response; disruption resilience with self-healing; management of intermittent power supplies; dynamic pricing; reduction in energy loss; and scheduling of power consumption to constrain peak load.

To investigate various other research problems and enable the development, analysis, evaluation of efficacious algorithm and protocol as a solutions to these



problems, it is essential to build the Smart Grid Lab test-bed. State-of-the-art Smart Grid design needs innovation in a number of dimensions: distributed and dynamic network with two-way information and energy transmission, seamless integration of renewable energy sources, management of intermittent power supplies, real-time demand re-

sponse, and energy pricing strategy. To realize these, the research work is aimed for designing a wireless Smart Grid test-bed to help the Smart Grid research community analyze and evaluate their designs. Through this it is possible to contrive novel protocols in the lab environment and hence it is possible to get equipped with real time problems and their remedies

in lab environment. The set up can be extended to render training young technologists, researchers from various institutions across India through Faculty Development Schemes. Such thought process could stimulate research community in-house and other reputed institutions to be encouraged and involve the development of smart grid in our nation.

## Implementation of Dynamic light scattering (DLS) technique using Ocular fluorometer: a noninvasive method to quantify intraocular inflammation

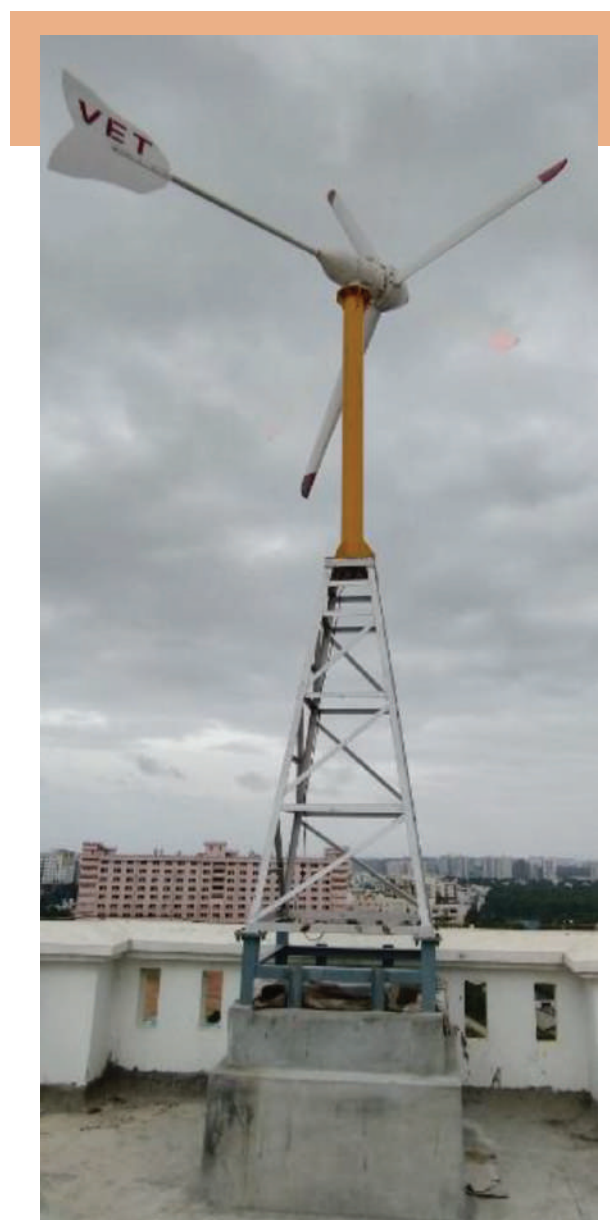
PI: Dr. Surekha P., Department of EEE, ASE, Bengaluru  
Co-PI: Dr. Abhilash Ravikumar, Department of ECE, ASE, Bengaluru

**Project funding agency:** Vision Group of Science and Technology, (K-FIST L1) Amount: Rs. 15 Lakhs

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**Status:** In-progress.

In a normal eye, the anterior chamber (space between the cornea and the lens) of the eye is filled with a transparent water-like fluid known as aqueous humor. Due to break down of the Blood Aqueous Barrier (BAB) causes leakage of inflammatory cells and proteins from the posterior chamber to the anterior chamber of the eye along with the flow of aqueous humor. When visible light is incident on these inflammatory cells scatters light (aqueous flare) due to the Tindall effect. The measured intensity of the scatter as a continuous index of the flare is graded based on the Standard Uveitis Nomenclature (SUN) scoring system. According to SUN classification, the aqueous flare is graded 0 in the absence of any notable flare, 1+ for faint flare, 2+ for moderate flare (iris and lens details clear), 3+ for marked flare (iris and lens details are hazy), and 4+ for intense flare (fibrin in the aqueous humor). This scoring system is frequently employed in the clinical management of uveitis. But the SUN scoring system is subjective and leads to interobserver variability. The custom-built Ocular fluorometer measurement has revealed fine scaling of the aqueous flare in a preliminary set of experiments of measuring the intraocular inflammation. The unique aspect of the instrument is that it is equipped with the lock-in amplifier and confocal optics. Lock-in amplifier is a signal conditioning device that can detect the weak signals in a noisy background. Thus, its inclusion rejects the contribution of ambient light and electronic noise. This can improve the precision, sensitivity, and



1 kW Horizontal Axis Wind turbine

dynamic range of the instrument. With confocal optics, the light scatter measurements can be made precisely from a focal point in the anterior chamber of the eye, without being confounded by light scatter from the cornea, iris, and lens. In this project, our goal is to quantify the intraocular inflammation (or aqueous flare) automatically by employing the DLS technique. DLS technique can quantify the morphological changes by measuring temporal changes in and around the random positions of molecules as

they undergo Brownian motion on a time scale of  $\geq 1 \mu\text{s}$ . The same technology can be applied to examine the molecular structures of the eye segments (of the cornea, the aqueous humor, and the lens) under physiological and pathological conditions. Specifically, by implementing the DLS technique using Ocular fluorometer the aqueous flare (Uveitis) can be graded by measuring the light scatter as indicative of the density of the particles under pathological conditions.

## Adsorption of magnetic metal complexes on 2-D magnetic substrates

PI: Dr. Abhilash Ravikumar, Department of ECE, ASE, Bengaluru  
Project funding agency: HPC-Europa3 Trans-National Access Program

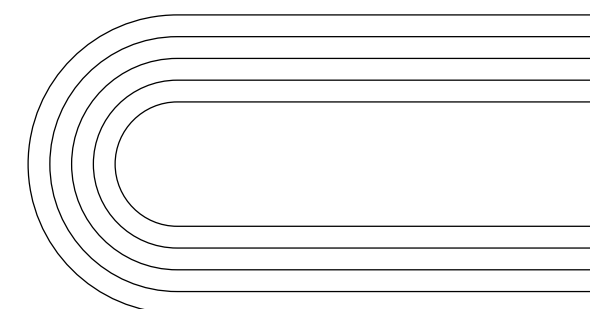
**Amount:** Rs. 6 Lakhs

**Status:** In-progress.

Magnetism in two dimensions has been a fulcrum for many theoretical [1, 2, 3], experimental and technological studies [4, 5] in the recent past. This is due to the degree of control offered by 2-D heterostructures enabling engineered levels of strain, surface chemistry, opto-electronic manipulation and detection of spin [6, 7, 8, 9]. In this regard the first two 2-D ferromagnetic crystals reported were Cr<sub>2</sub>Ge<sub>2</sub>Te<sub>6</sub> [10] and CrI<sub>3</sub> [11] which were discovered in 2017. Cr<sub>2</sub>Ge<sub>2</sub>Te<sub>6</sub> is a Heisenberg ferromagnet where the magnetic moments are oriented in all directions and has a very small magnetic anisotropy. CrI<sub>3</sub> on the other hand is an Ising A type antiferromagnet where the magnetic moments are oriented perpendicular to the 2-D plane [12]. With spin fluctuations significantly enhanced due to the crystal topology, these materials open new avenues to study low dimension magnetism. In these last two years alone, apart from these two materials, several other magnetic 2-D crystals have been discovered such as : FePS<sub>3</sub> [13], VSe<sub>2</sub> [14] and MnSe<sub>2</sub> [15]. In this study we consider 2-D magnetic CrI<sub>3</sub> adsorbed on graphene (ferromagnetic metallic heterostructure) and MoS<sub>2</sub> (ferromagnetic semi-conducting heterostructure) as substrates.

The organo-metallic complexes chosen for this study are magnetic metal-phthalocyanine (MPc) families due to their potential relevance in the field of single molecule electronics and spintronics. The electronic and magnetic properties of these molecules can be controlled by the core metal atom and therefore provide a platform of several interesting and technologically relevant applications[17]. For example, it has been shown that ferromagnet/molecule interface provides a spin-dependent hybridization which can be used to tailor spintronic device properties such as inversion and enhancement of interfacial spin[16]. Other relevant applications include magnetic softening, hardening, pinning and control over the Curie temperature modulation. The magnetic coupling of MPc with ferromagnetic metals and spin transport through these molecules have been studied previously[17,18].

Therefore in this project we propose to study the electronic, magnetic and core-level spectra of technologically relevant magnetic organo-metal complexes (MPc) adsorbed on 2-D ferromagnetic heterostructures from first principle calculations. examine the molecular structures of the eye segments (of the cornea, the aqueous humor, and the lens) under physiological and pathological conditions. Specifically, by implementing the DLS technique using Ocular fluorometer the aqueous flare (Uveitis) can be graded by measuring the light scatter as indicative of the density of the particles under pathological conditions.



## Design novel 2-D magnetic storage devices using CrI3 based van der Waals heterostructures.

PI: Dr. Abhilash Ravikumar, Department of ECE, ASE, Bengaluru

**Project funding agency:** Start-up Research Grant – SERB

**Amount:** Rs. 30,21,700.

**Status:** Completed.

In this study we propose to design magnetic storage devices using the van der Waals heterostructure interfaces formed by 2D ferromagnetic crystal (CrI3) adsorbed on topological insulators. In this regard, we consider three interesting topological insulators: Transition metal dichalcogenides (Eg.

MoS2), Bismuth Chalcogenides (Eg. Bi2Se3) and hBN sandwiched WTe2. MoS2 and Bi2Se3 show a large spin orbit coupling, a non-trivial semiconducting bandgap and behave as topological insulators. The final system considered is hBN sandwiched WTe2 which is a 2D topological crystal that displays exotic spin torque and gate tunable superconductivity.

We plan to perform ab initio quantum transport calculations based on density functional theory and nonequilibrium Green's function

approaches to examine the spin dependent electronic and magnetic properties of these systems. We also plan to study the current voltage characteristics and the transmission properties of these systems in the presence of external voltage biases.

We believe the construction of these realistic models would give us a fundamental understanding of the exotic interfacial properties of the system and enable us to predict and design novel 2D magnetic storage devices.

## Finite Element Methods in Haemodynamic Applications

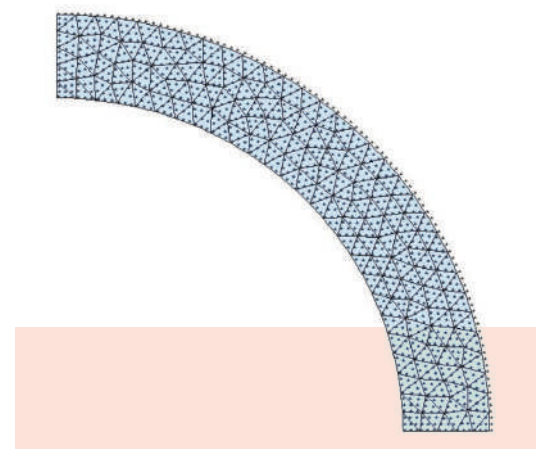


Fig.: Discretization of Blood Flow channel.

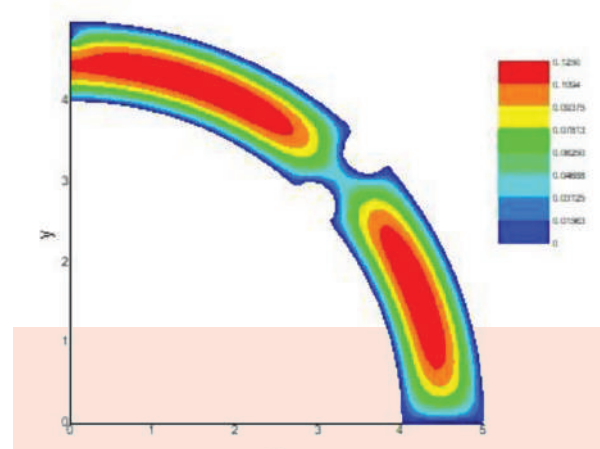


Fig. : Plot of numerical solution for Blood Flow channel.

PI: Dr. Kesavulu Naidu V., Department of Mathematics, ASE, Bengaluru

Co-PI: Dr. B. Venkatesh and Dr. K. Murali, Department of Mathematics, ASE, Bengaluru

**Project funding agency:** NBHM, Department of Atomic Energy(Government of India), Mumbai

**Amount:** Rs. 18,15,900.

**Status:** In-progress.

Finite Element Method (FEM) is one of the computational methodology developed to numerically approximate Partial Differential Equation (PDE). Most of real-life problems are modelled into PDEs, which

involve complex geometry and material constitution. The strategy of FEM is discretizing the complex geometry into simple elements called finite element. The same basis functions used to represent the geometry are then used to approximate the unknown solution of the PDEs. In the present case Lagrange Interpolations are used as basis functions, their mathematical properties lead to appreciable benefits for the numerical approximation of PDEs, especially for high order PDEs in the Galerkin weak formulation. The improvements in both accuracy and efficiency of FEM with curved sided triangular element compared to straight sided triangular element,

encourage the use of the present methodology. In fact, the simulation of blood flow in arteries requires the numerical approximation of Fluid-Structure Interaction (FSI) problems. In order to account for the deformability of the vessel, the Navier-Stokes equations representing the blood flows, are coupled with structural models describing the mechanical response of the arterial wall. However, the FSI models are complex from both the mathematical and the numerical points of view, leading to high computational costs during the simulations. With the aim of reducing the complexity of the problem and the computational costs of the simulations, reduced FSI models can be considered. FEM represent a powerful mean and recently became an effective tool to describe quantitatively and in an accurate manner some aspects of the physical system.

The problem concerning approximate solution of partial differential equations governing engineering problems over irregular curved boundaries are often found, using finite element analysis with triangular elements of straight sides (three straight sides) or curved sides (two straight sides and one curved side) in the framework of the weak Galerkin formulation method. As an alternative method, the present work proposes the use of efficient and powerful sub-parametric transformations (parabolic arcs) for higher

order curved triangular elements having two straight sides and one curved side. By using the iso-parametric

coordinate transformation these curved triangles in the global  $(x, y)$  coordinate system are mapped into a standard triangle:  $(\xi, \eta)/0 \leq \xi, \eta \leq 1, \xi + \eta \leq 1$  in the local coordinate system  $(\xi, \eta)$ . Under this transformation the curved boundaries of these triangular elements are implicitly replaced by a series of higher order arcs. The equations of these arcs involve parameters, which are the coordinates of points on the curved side. This work deduces relations for choosing the parameters in higher order arcs in such a way that each arc is always a parabola which passes through four points of the original curve. The derived higher order sub-parametric transformations for higher order triangular elements are effectively and efficiently used in solving Laplace, Poisson, Darcy-Brinkman-Forchheimer and Helmholtz equations related to various other applications.

The main aim of the present work is the development of a robust algorithm for finite element method solution of blood flow problems in arteries in biomedical sciences involving regular or irregular geometries with simple or complex boundary condition/s using higher order the sub parametric transformations.

## Measurement of light scatter in the anterior chamber of the eye for objective quantification of intraocular inflammation

PI: Dr. Surekha P., Department of EEE, ASE, Bengaluru

Co-PI: Dr. Abhilash Ravikumar, Department of ECE, ASE, Bengaluru

**Project funding agency:** Vision Group of Science and Technology, (K-FIST L1)

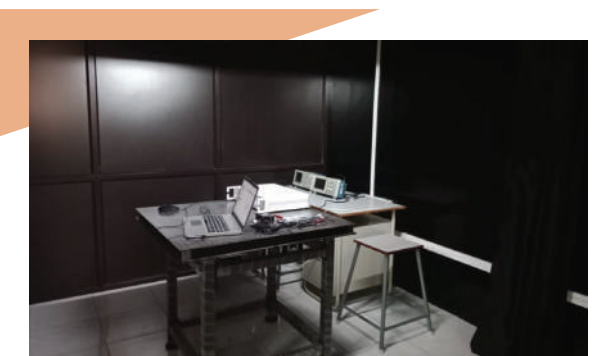
**Amount:** Rs. 15 Lakhs

**Status:** In-progress.

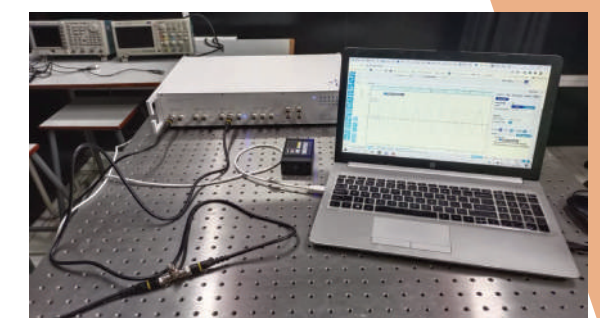
**Objective:**

- To adapt a custom-built Ocular fluorometer for the measurement of light scattering
- To calibrate the new instrument using standardized sources of different particle sizes
- To evaluate the DLS based Ocular fluorometer in uveitis patients
- To develop a mathematical model and synergize it with machine learning techniques to create a standardized grading system

A non-invasive ophthalmological device which can examine the severity of uveitis. The depth resolution (depth of scan) of the Ocular fluorometer is  $< 300 \mu\text{m}$ , whose value is well below that of anterior cham-



Dark room setup with the suspended table and experimental setup

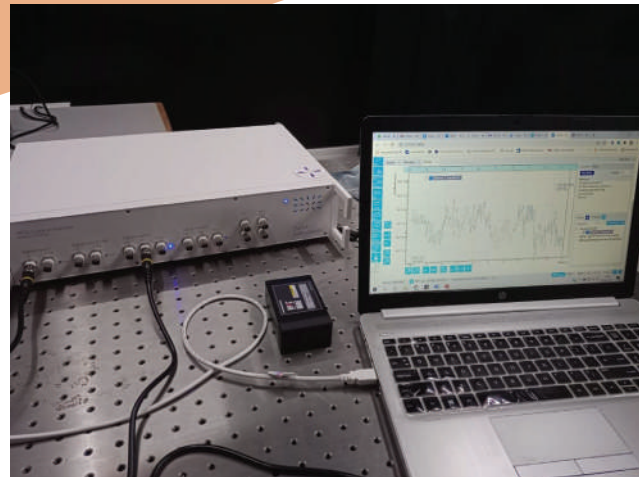


Signal generation and monitoring through the Digital Lock-in Amplifier



ber depth. Therefore, the intraocular inflammations in the case of cataract, post-cataract surgery, uveitis and diabetic multis can be detected with higher sen-

sitivity. As the device can be applied for diagnosing different layers of anterior chamber pathology; hence the application is cost-effective.



Experimental setup with Digital Lock-in Amplifier and Silicon Photomultiplier



Wet chemical bench and space for experimenting on chemicals and biological sample

## Integration of AMoRA (Amrita Modular Robotic Arm) with RoboAnalyzer® for Effective Robotics Education

PI: Dr. Rajeevlochana Chittawadi-gi, Department of ME, ASE, Bengaluru

**Project funding agency:** SVR Infotech (Pune)

**Amount:** Rs. 8.437 Lakhs Status: In-progress.

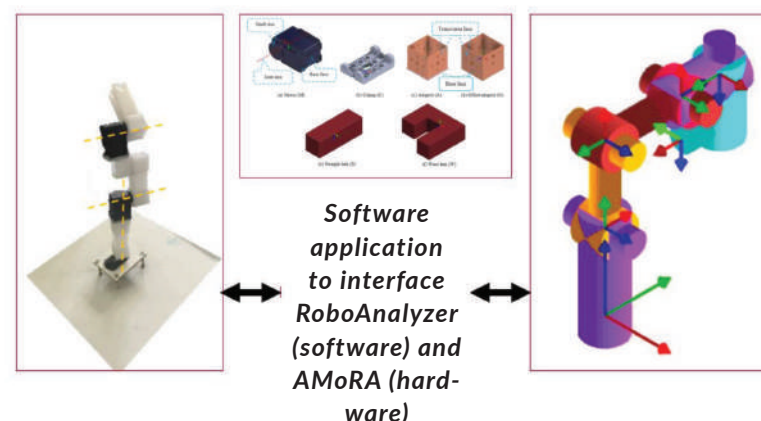
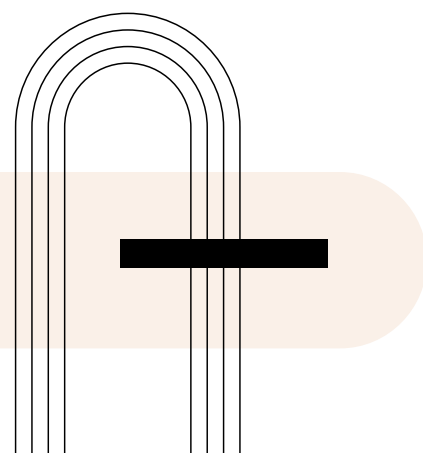
Kinematics taught in a typical Robotics course deals with the understanding of the architecture of serial chain robots or manipulators, also referred to as a robotic arm. The students study the relationship between the input and output motions of the robot. It is difficult to visualize and un-

derstand the motion without a physical prototype. A DIY (do-it-yourself) approach on building physical prototypes of robots using modular components can help in the effective learning of the concepts.

Amrita has conceptualized a novel design with modular components which can be connected to obtain various architectures of robotic arm, which is named AMoRA (Amrita Modular Robotic Arm). This acts as a DIY kit which can be used in teaching Denavit-Hartenberg (DH) parameters, taught in the robotics courses. Amrita has

already developed a Proof-of-Concept (POC) physical prototype using its resources, and as in the process of application of a patent for the same.

Through this project, SVR Infotech and Amrita can come together to integrate the physical prototype with RoboAnalyzer® software (a product developed at IIT Delhi and SVR Infotech being its commercialization partner). The duration of this project is one year. After the successful integration, the hardware (robot arm) shall be commercialized by SVR Infotech through a separate agreement.



## Motion Planning of an Industrial Robot to Perform Welding in a CAD Environment

PI: Dr. Rajeevlochana Chittawadi-gi, Department of ME, ASE, Bengaluru

**Project funding agency:** alfaTKG Technology India Services Pvt Ltd, Chennai

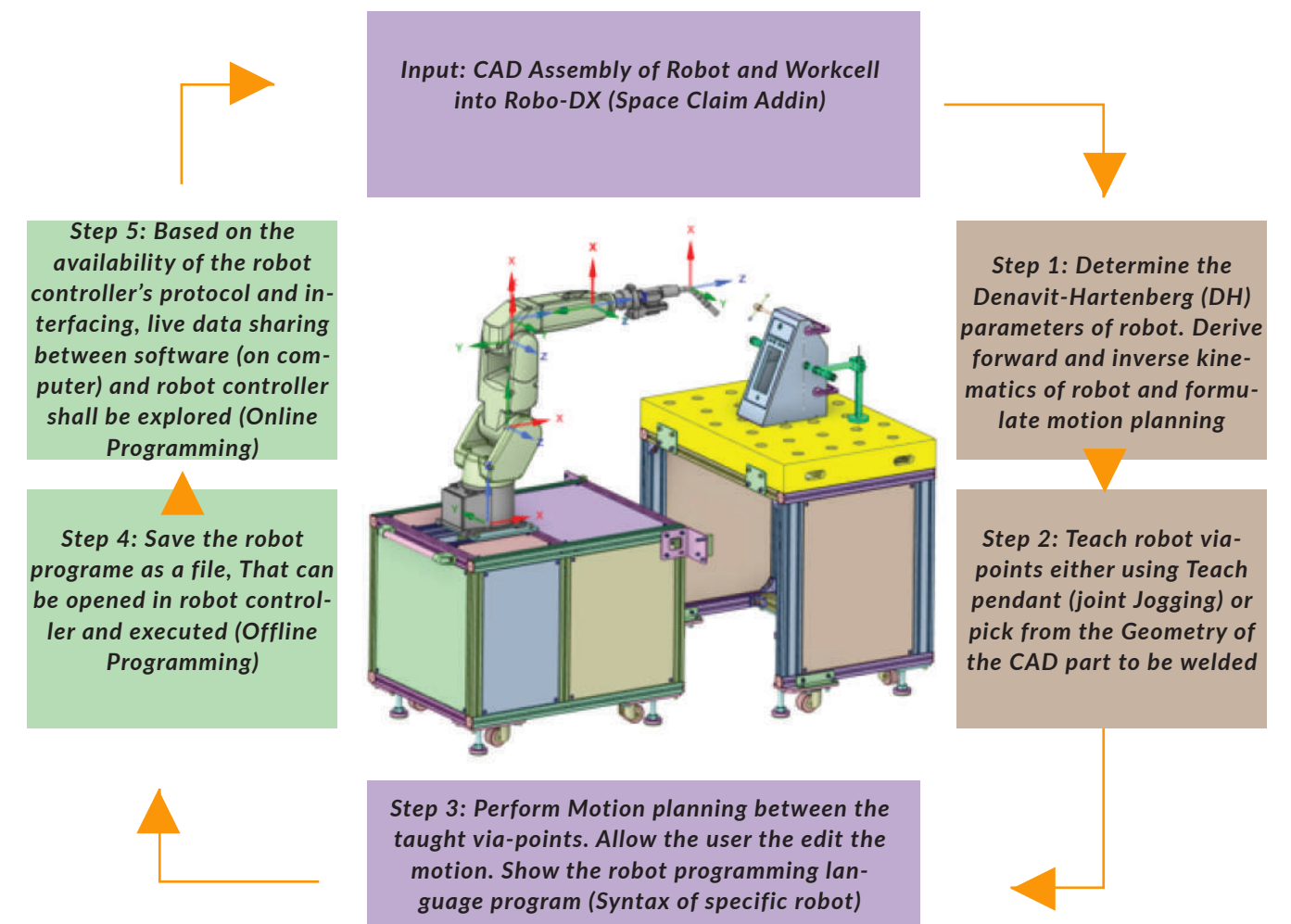
**Amount:** Rs. 9.4 Lakhs Status: In-progress.

Robot simulation in a virtual environment is one of the first step to perform offline programming of an industrial robot. The kinematic model of the manipulator should be known to perform the mapping of the joint motion to those of the end-effector or the TCP (Tool Center Point). The kinematic model is usually represented using the Denavit-Hartenberg (DH) parameters and then forward and inverse kinematics formulations are derived. In a motion planning module, the

desired motion of the end-effector frame is obtained using the inverse kinematics formulations at every intermediate point between the taught points. For a welding operation, the geometry of the curves or locations where weld has to be made is important and thereafter it is fed to the motion planning module. Hence, it is beneficial to develop a welding robotic simulator inside a full-fledged CAD software such as SpaceClaim where the geometry of the workpiece to be welded can be retrieved and used in the motion planning stage. Upon successful simulation, the joint trajectories can be exported or linked with the robot controller to perform the same action on an actual or physical robotic manipulator.

The Project Investigator (PI) has experience in developing addins (pl-

ugins/modules) in commercial CAD software such as Autodesk Inventor and SpaceClaim. The funding agency (alfaTKG) desires to develop a module in SpaceClaim which allows a robotic arm to be imported in a workcell with workpiece(s). The kinematic model (DH parameters) of the robot has to be determined using the methods proposed by the PI. The user would have an option to select curves/locations at which the robot has to perform welding and the CAD data shall then be fed to a motion planning library developed by the PI. Upon successful simulation, the joint trajectory can be exported or sent to a robot controller. Through this project, alfaTKG and Amrita can come together to develop expertise in robot simulation, particularly related to welding application.



## Amrita IKS centre of Vyākaraṇa, Darśana, and Āyurveda

PI: Dr. Rammanohar

Co-PI: Dr. Manish Walvekar, Department of Amritadarshanam, ASE, Bengaluru & Dr. Navin Bhatt

**Project funding agency:** AICTE

**Amount:** Rs. 39.4 Lakhs

**Status:** In-progress.

We are currently working on a project to publish a critical edition of the Aṣṭādhyāyī of Pāṇini, funded by the Indian Traditional Knowledge

Systems Division of the Ministry of Education (MoE) which is located in the AICTE (All India Council of Technical Education) Headquarters.

Studying and researching Indian Knowledge Systems is a significant focus of academic activities at Amrita Vishwa Vidyapeetham. We are committed to preserving and disseminating knowledge codified in the different knowledge systems of India. With this objective in mind, we wish to publish a critical edi-

tion of the essential text of Sanskrit grammar, the Aṣṭādhyāyī.

A critical edition of the Aṣṭādhyāyī will be a valuable contribution to the scholar-community. A critical edition of this text will become an indispensable resource for every scholar worldwide working in Sanskrit grammar and allied subjects. Therefore, the need for a critical edition of Aṣṭādhyāyī is urgent and, indeed, necessary.

## A Study of Ophiolatry Manuscripts of India

PI: Dr. Tanashree Redij, Department of Amritadarshanam, ASE, Bengaluru Co-PI: Dr. Manish Walvekar, Department of Amritadarshanam, ASE, Bengaluru

**Project funding agency:** Central Sanskrit University

**Amount:** Rs. 6 Lakhs

**Status:** In-progress.

The inherent nature of snakes as well as the fear and wonder associated with them are largely responsible for the distinctive status of them in human life. Hence, the worship of snakes is a subject of the religious belief of common people without any particular religion or caste. As a result, ophiolatry or snake worship is a very com-

mon custom practised all over the world from the early period. Several rituals related to snakes mentioned in the Sūtra and Nibandha literature are still in practice (Härtel 666). The Nāgapañ camīvrata is one of such rituals mentioned in the Nibandha literature to be practiced in the honour of snakes. It is celebrated across the India on the fifth day of the bright half of the lunar month of Śrāvaṇa (July August). The Worship of snake-borrows or a serpent-deity made of clay, wood, metal, stone, or sometimes a picture of snake-deity is a core part of the ritual. Several puranic stories are associated with this ritual. Apart from the puranic stories, a set of

stories entitled Nāgapañ camīvrata (stories of Nāgapañ camīvrata) are very popular. It is very difficult to find out the origin of these stories since they were transmitted by oral tradition. Tradition of narrating the stories during the ritual was a core part of the ritual, but it is faded due to the impact of the modernization over a period of time. Moreover, the manuscripts of the Nāgapañ camīvrata entitled Nāgapañ camīvratakathā are housed at different libraries. The present project focuses on the study of Nāgapañ camīvratakathā manuscripts housed at different libraries.

## English to Sanskrit translation of M. Hiriyanna's book- Outlines of Indian Philosophy

PI: Dr. Manish Walvekar, Department of Amritadarshanam, ASE, Bengaluru

**Project funding agency:** Central Institute of Indian Languages. Ministry of Culture

**Amount:** Rs. 1,47,647.

**Status:** In-progress.

This project will bring out the authentic Sanskrit translation of M. Hiriyanna's book- Outlines of Indian Philosophy. This is under the initiative of the funding agency- National Translation Mission.

## ANN-based Microwave Sensor for Real-Time Monitoring of Cu(II), SO<sub>4</sub>(II-) and Cl(-) Ions in Plating Baths

PI: Dr. Murali Rangarajan, ASE, Coimbatore.

Co-PI: Dr. Dhanesh Kurup and Dr. Parul Mathur, Department of ECE, ASE, Bengaluru, Dr. Sasangan Ramathan, ASE, Coimbatore.

**Project funding agency:** LAM research

**Amount:** Rs. 42 Lakhs

**Status:** Completed, (Extension expected in 2024)

The primary objective of this proposal is to monitor, in real time, in a contact-free manner, changes in concentration of Cu<sup>2+</sup>, SO<sub>4</sub><sup>2-</sup> and Clin acidic copper plating baths used in electrochemical deposition (ECD) tools. This will be achieved using a novel microwave sensor whose performance is enhanced by artificial neural networks. Microwave-based

non-destructive techniques have the advantages such as non-contact nature, real time monitoring and high-resolution imaging capability. Techniques such as Inductively coupled plasma optical emission spectrometry (ICP-OES), inductively coupled plasma mass spectroscopy (ICP-MS), atomic absorption spectroscopy (AAS), and neutron activation analysis (NAA) are highly sensitive and versatile in terms of simultaneous determination of multiple elements in complex solutions but are unable to provide in situ, real-time, portable and low-cost monitoring in aqueous solutions. The chief advantages of microwave sensing are: (i) ability to detect metal ions and anions (through reflection), (ii) ability to develop portable, non-contact, robust, cost-effec-

tive, real-time device, (iii) ability to connect to controllers, IoT and wireless sensor networks. The feasibility of utilizing microwave sensors for real-time monitoring of metal ions in water has also been examined recently by many research groups. The uniqueness of our work is twofold: (i) mathematical model of sensor interaction with the material under test (MUT, i.e., all the constituents of the plating solution) and the contributions of its constituents to specific measured properties (ii) use of trained artificial neural networks (ANN) to map the measured properties back to the concentration of the constituents. This approach enables simultaneous detection of multiple ions in complex solutions such as electroplating baths.

## Behavioral Modeling and Digital Predistortion (DPD) of RF Power Amplifiers

PI: Dr. Dhanesh Kurup, Department of ECE, ASE, Bengaluru.

Co-PI: Dr. R. V. Sanjika Devi, and Dr. Chinthala Ramesh, Department of ECE, ASE, Bengaluru.

**Project funding agency:** ISRO

**Amount:** Rs. 44.5 Lakhs

**Status:** In-progress.

High power amplifiers (HPA) operating in non-linear region enables us to achieve higher power added

efficiency (PAE) in satellite communication systems. However, non-linear HPA introduces signal distortions leading to increased Bit Error Rate (BER) for bandwidth efficient modulation schemes such as higher order QAM. Proposed research of-

fers a solution to the above problems by aiming to:

- Develop efficient non-linear behavioral models of PA from CAD simulations such as ADS or measurements of the PA. The behavioral model can then be used for estimating BER in system level simulations which includes PA.

- Apply behavioral models for designing Digital Pre-Distortion (DPD). DPD enables us to reduce signal distortions and thereby reduce BER. For implementing DPD, we propose to use Field Programmable Gate Array (FPGA) based digital hardware prior to the PA. The behavioral modeling technique and experimental knowledge gained in the area of DPD will be shared with ISRO and fine-tuned to specifications of ISRO for on-going and future satellite communication systems.



### PC with CAD tool and software for signal processing

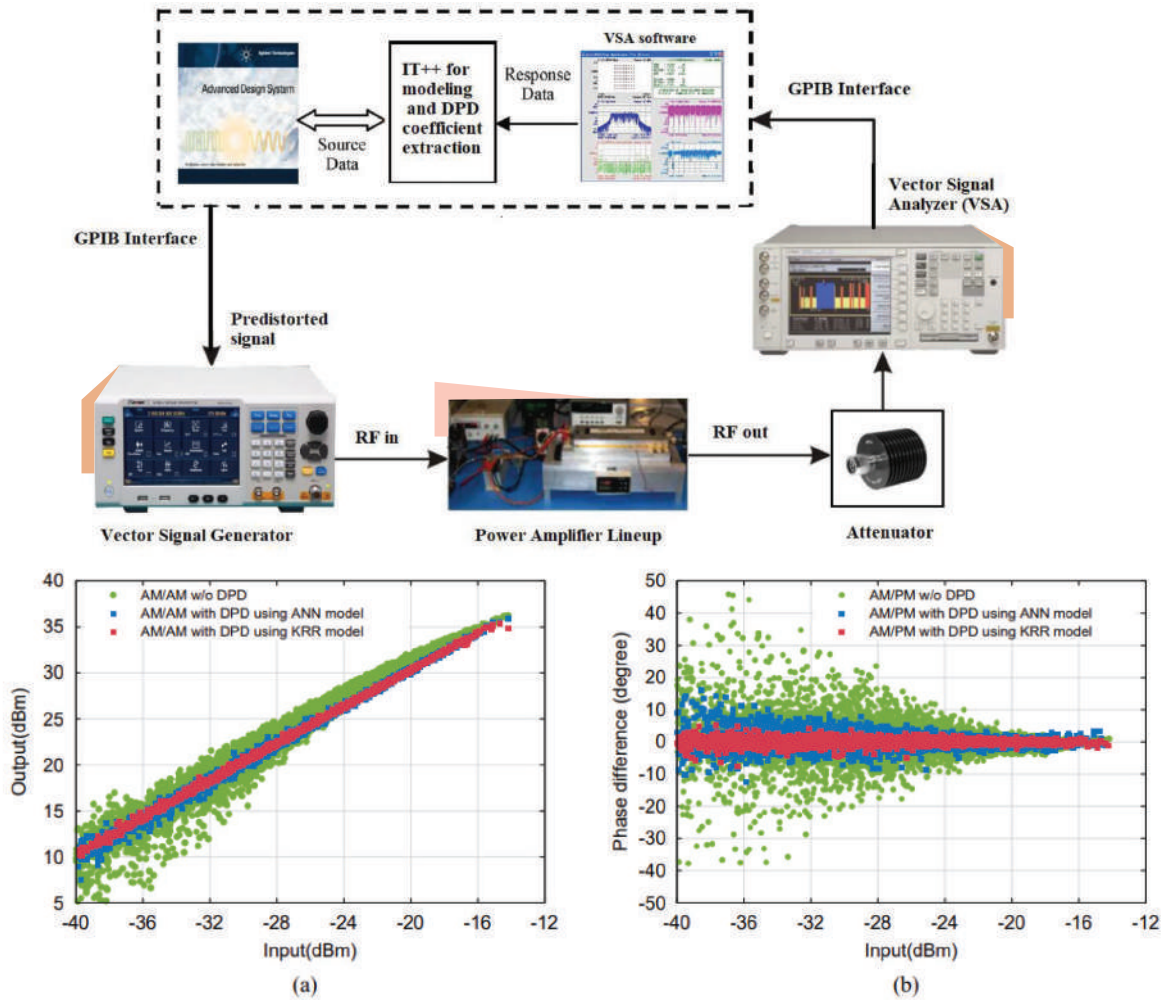


Figure: Linearization of the Gain and Phase Characteristics of the HPA after the application of Digital Pre-Distortion (DPD) Technique.

## Development of Portable Radar Cross-section Measurement System for Ships

PI: Dr. Dhanesh Kurup, Department of ECE, ASE, Bengaluru.

**Project funding agency:** Defense Innovation Organization, Ministry of Defense, Govt. of India.

**Amount:** Rs. 1.6 Cr

**Status:** In-progress.

This project aims to develop a Drone based Radar Cross-Section (RCS) measurement equipment with minimal dependency of imported sub-system components. First of its kind in India, the equipment once developed will provide Indian Navy a hardware system

to evaluate stealth capability of ships and various platforms located in ocean. The equipment will be low cost, portable and have minimal external power requirement for operation.

Amrita Vishwa Vidyapeetham is contributing to the initial prototype design through exhaustive survey of scientific literature in the field, especially statistical clutter modeling, system simulation, design and optimization.

The outcomes of the project will not only provide redundancy to

any existing RCS measurement system but also obviate the dependency on foreign OEMs for maintenance and training. In addition the project enables building manpower and expertise in the niche technology.

### GUI based Design Tool of the System

Design knowhow of the system will enable Amrita to undertake design of Drone based Radar Technology to locate fishing vessels lost in Sea, as well as trapped humans and live-stocks during natural calamities.