

FIST Programme

2009[195]

Technical Progress Report



(Sanction No. SR/FST/ETI-029/2009 Dated 17.11.2009
and subsequent order dated 15.2.2010)

Submitted to

Department of Science & Technology/
Govt. of India, New Delhi

Department of Applied Physics
(Electrical Engineering and Instrumentation Engineering)
University College of Technology, University of Calcutta
92, A. P. C. Road
Kolkata 700 009

Contents

Format 1	Page 3- 6
Format 2	Page 6-26
Annexure 1	Page 27-38
Annexure 2	Page 39-41

FORMAT - 1

DST – Fund for Improvement in S&T Infrastructure(FIST 2009[195])

Department of Applied Physics, University of Calcutta

Sanction No. SR/FST/ETI-029/2009 Dated 17.11.2009 and subsequent order dated 15.2.2010.

1.1 Brief Outline Department (not more than 5 lines)

The Department of Applied Physics, University of Calcutta , a forerunner in this country in the field of Technological Education and Research, has completed Eighty nine years of its existence in 2014. At present the Department, with a dedicated team of highly experienced and distinguished faculty is continuing the pursuit under the Faculty of Technology, University of Calcutta. It has been a continuous Endeavour of our department to adequately update the infrastructure in terms of sophisticated equipment, laboratory developments, diversification, library, workshop and other ancillary facilities to sustain the contemplated standards of education and research.

1.2 Teaching And Research Activities (not more than 5 lines)

At present, Applied Physics Department is comprised of Electrical Engineering and Instrumentation Engineering divisions meant for post graduate studies and innovative research activities in challenging and as well as in classical areas. It offers Post B.Sc(H) 3 year (6-semester) B. Tech. in Electrical Engineering and Instrumentation Engineering, 2 year (4-semester) M. Tech. in Electrical Engineering and Instrumentation & Control Engineering, 3 year (6-semester) part-time evening M. Tech. courses in Electrical Engineering (Electrical Power) and Instrumentation & Control engineering and Doctoral programs in the different areas of Electrical, Instrumentation and Control Engineering. With the untiring efforts of faculty members, at present, a number of government and industry funded projects are going on in the Department.

1.3 Facilities Created

[Brief about Facilities costing more than Rs 5 lakh in not more than 3 lines. Attach Photograph (6"x 4" size) of the Facilities created]

1.3.1 Biomedical Lab: Ethernet ready 16 Channel Data Acquisition and Analysis System, Noninvasive Blood Pressure System, ECG (Multilead ECG),

Heel/Toe strike and Blood Pressure, Pulse Plethysmography, . Heart Sound system, Wireless Remote monitoring module set. Make : Biopac System, U. S. A



1.3.2 Embedded System Lab : DSP Starter Kit : On-board TMS320F2812 DSP, 32-bit fix-point Flash DSP, Power supply and Motor control development Kit, Emulator, Emulator Pod, Evaluation module, Universal Programmer – type 2, Advanced FPGA Platform with SPARTAN3, FPGA Interfacing cards/ modules set for real world application & experiments.



1.3.3 Power System Lab:

i) Real time single phase HVDC transmission line simulator
Terminal Unit – 1 , Terminal Unit – 2 , Transmission line Unit-4. Load Unit



ii) NTPL Make Phantom load test set



iii) (a) Numerical Motor Protection Relay of Type – MiCOM P-220, Type no. P220C00 F11100

(b) Numerical Directional Feeder Management Relay of Type MiCOM P-141, Type no. P141311A1M0440J



1.3.4 Computer Networking Lab:

Router wireless 300 mbps d-link (qty. : 1 no.), access point 300 mbps d-link (qty. : 1 no.), IBM x 3100 m4 server (qty. : 1 no.), hp laserjet 2035 laser printer (qty. : 1 no.), i-ball 9" x 12" digital pen tablet (qty. : 1 no.), wireless lan card d-link (qty. : 16 no.), Computer (qty. : 17 no.)



1.4 Funding

<i>Budget Heads</i>	<i>Amount Sanctioned</i>	<i>Amount Received</i>
<i>a. Equipment</i>	<i>Rs. 42,00, 000/-</i>	<i>Rs. 42,00, 000/-</i>
<i>b. Infrastructure</i>	<i>Nil</i>	<i>Nil</i>
<i>c. Networking</i>	<i>Rs. 5,00,000/-</i>	<i>Rs. 5,00,000/- (carry forward unspent balance Rs. 4,05,725/- + sanctioned amount Rs. 94,275/-)</i>
<i>d. Maintenance</i>	<i>Rs. 5,00,000/-</i>	<i>Rs. 1,00,000/-</i>
<i>e. Total</i>	<i>Rs.52,00,000/-</i>	<i>Rs. 48,00, 000/-</i>

For further details contact:

Dr. J.N.Bera, Head
 Tel. No. 03323508386 Extn-476 (O),
 Fax no. 03323519755
 Email ID. jitendraber@rediffmail.com
 Department of Applied Physics,
 University College of Technology, University of Calcutta
 92, A.P.C.Road, Calcutta 700009

FORMAT – 2

Academic Report for utilization of FIST support

1. Name of Department and University

Department of Applied Physics

University College of Technology, University of Calcutta

2. Address for communication (Name and address of the Head of the Department with e-mail and telephone/fax numbers)

Dr. J.N. Bera

Head

Department of Applied Physics, University of Calcutta

92, Acharya Prafulla Chandra Road, Kolkata 700 009

Email: jitendraber@rediffmail.com

Dr. Madhuchhanda Mitra

Coordinator

FIST Programm-2009[195]

Department of Applied Physics, University of Calcutta

92, Acharya Prafulla Chandra Road, Kolkata 700 009

Email : madhuchhanda94@rediffmail.com, mmaphy@caluniv.ac.in

3. Date and ref. No. of DST Sanction letter of FIST Programm-2009[195] supported to Department of Applied Physics, University of Calcutta.

Sanction No. SR/FST/ETI-029/2009 Dated 17.11.2009 and subsequent order dated 15.2.2010 and dated 27.8.2012

4. Details of the Grants

<i>Budget Heads</i>	<i>Amount Sanctioned with Date</i>	<i>Amount Received with Date</i>
<i>a. Equipment</i>	<i>Rs. 42,00, 000/-</i>	<i>Rs. 42,00, 000/-</i>
<i>b. Infrastructure</i>	<i>Nil</i>	<i>Nil</i>
<i>c. Networking</i>	<i>Rs. 5,00,000/-</i>	<i>Rs. 5,00,000/- (carry forward unspent balance Rs. 4,05,725/- + sanctioned amount Rs. 94,275/-)</i>
<i>d. Maintenance</i>	<i>Rs. 5,00,000/-</i>	<i>Rs. 1,00,000/-</i>
<i>e. Total</i>	<i>Rs. 52,00,000/-</i>	<i>Rs. 48,00, 000/-</i>

5. Equipment ordered/purchased/installed:

Equipment Head			
<i>Name (with Model & Make)</i>	<i>Order Number and Date</i>	<i>Installation date</i>	<i>Cost in INR</i>
Biomedical Lab All instruments make : Biopac System, U. S. A 1. Ethernet ready 16 Channel Data Acquisition and Analysis System 2. <u>Noninvasive Blood Pressure System</u> 3. ECG (Multilead ECG) 4. Heel/Toe strike and Blood Pressure 5. Pulse Plethysmography 6. Heart Sound system 7. Wireless Remote monitoring module set	06/ORD/APH/FIST /2010-11 Date 31.1.2011 Purchased in FE through LC	25.7.2011	19,95,416.00 & Customs duty 1,04,735.00 Total 21,00,151.00
Embedded System Lab	01/ORD/APH/FIST /2010-11	18.3.11	9,88,000

The Detail items in the Lab: 1. DSP Starter Kit : On-board TMS320F2812 DSP, 32-bit fix-point Flash DSP, operating at 150MHz 2. Power supply for DSP and Motor control development Kit for DSP 3. Emulator, Emulator Pod for DSP 4. Evaluation module for DSP 5. Universal Programmer – type 2 6. Advanced FPGA Platform with SPARTAN3 7. FPGA Interfacing cards/ modules set for real world application & experiments	Date 5.1.2011		
Power System Lab			
1) Real time single phase HVDC transmission line simulator Make :M/S Electronica, Kolkata	02/ORD/APH/FIST /2010-11 Date 5.1.2011	31.3.11	4,17,604
2) Phantom load test set Input voltage-415V, 3-phase, 4-W, 50Hz Make : NTPL, Kolkata	03/ORD/APH/FIST /2010-11 Date 5.1.2011	9.5.2011	78,780
3A) Numerical Motor Protection Relay of Type – MiCOM P-220 3B) Numerical Directional Feeder Management Relay of Type MiCOM P-141 Make : of M/s AREVA T&D	04/ORD/APH/FIST /2010-11 Date 5.1.2011	3.5.2011	69,466 1,85,242 Total 2,54,708
4) PSCAD Software Educational version 10 user, Manitoba HVDC Research Centre, Canada through its Indian Agent.	05/ORD/APH/FIST /2010-11 Date 5.1.2011	5.4.2011	1,39,513
Total			39,78,756.00

Note : Payment of all orders are complete.

6. Details of Infrastructure developed: NA

7. Details of Networking:

<i>Name (with Model & Make)</i>	<i>Order Number and Date</i>	<i>Installation date</i>	<i>Cost in INR</i>
ROUTER WIRELESS 300 MBPS D-LINK (Qty. : 1 No.) ACCESS POINT 300 MBPS D-LINK (Qty. : 1 No.) IBM X 3100 M4 SERVER – INTEL XION 3.1 GHZ, 500 GB SATA HDD, 4 GB DDR 3 RAM, DVD R/W, 18.5" LCD MONITOR SAMSUNG. (Qty. : 1 No.) HP LASERJET 2035 LASER PRINTER (Qty. : 1 No.) I-BALL 9" X 12" DIGITAL PEN TABLET (Qty. : 1 No.) WIRELESS LAN CARD D-LINK (Qty. : 16 No.) INTEL CORE i3 2120 PROCESSOR, INTEL DH61WW MOTHER BOARD, 4 GB DDR 3 RAM, 500 GB HDD SEAGATE, LG DVD WRITER, LOGITECH OPTICAL MOUSE, LOGITECH KEY BOARD, 18.5" LED MONITOR SAMSUNG, I-BALL CABINET WITH SMPS. (Qty. : 17 No.)	01/ORD/APH/FIST /2013-14 Date 19.04.2013	24.05.2013	4,99,101.75

Note : Payment of order is complete.

(Specify if the Internet facility is available to UG/PG/research students)

Computer networking Laboratory is equipped with 16 computers and a server. All the computers have wireless LAN card. Internet facility is provided to the

computers using wireless router and access point through wireless LAN. The Calcutta University internet line is the input to the router. So Internet facility is available to all UG/PG/research students working in the laboratory.

Moreover, a client server based intranet facility is also created in which useful software, study materials and biomedical databases are stored in the server and accessed from any terminals in the network for research and other academic purposes.

8. Utilization of the facilities created under FIST support:

- a. For teaching: list the Classroom use of equipment and new experiments introduced, if any.
- b. For research: Identify the research programs, including names of groups or individual faculty members, who are using the major equipment (> 5 lakhs) acquired with the FIST support

In the FIST program, our objective is

A) to develop two new Laboratories.

A1. Biomedical signal acquisition and processing Lab

A2. DSP and FPGA based embedded system Lab

B) Upgradation of Power System Lab

New Laboratories:

A1. Biomedical signal acquisition and processing Lab:

Faculty involved:

1. Dr. Madhuchhanda Mitra, Associate Professor
2. Mr. Rajarshi Gupta , Assistant Professor
3. Dr. Saurabh Pal , Assistant Professor
4. Professor S.C.Bera, Professor

Scholars involved:

1. Dr. Sucharita Mitra, Department of Electronics, Netaji Nagar Day College (affiliated to University of Calcutta)
2. Ms. Jaita Dutta, Dept. of Applied Electronics and Instrumentation Engineering, Guru Nanak Institute of Technology (Registered)
3. Harekrishna Chattopadhyay, Department of Electronics and Communication Engineering, Camellia Institute of Technology (Registered)

4. Saurav Mukhopadhyay , Guest faculty and registered Research Scholar, Department of Applied Physics, University of Calcutta (Registered, thesis ready to submit)
5. Swati Banerjee , Guest faculty and registered Research Scholar, Department of Applied Physics, University of Calcutta (Registered, thesis ready to submit)
6. Debolina Sadhukhan, DST Inspire Fellow, Department of Applied Physics, University of Calcutta (enrolled)
7. Samik Chakraborty, Assistant Professor, Department of Applied Electronics and Instrumentation Engg., Heritage Institute of Technology (enrolled)
8. Uday Maji Assistant Professor, Department of Applied Electronics and Instrumentation Engg., Haldia Institute of Technology, (enrolled)
9. Abhilash Sengupta (enrolled)
10. Souvik Das, Assistant Professor, Department of Biomedical Engineering, JIS College of Engineering, Kalyani, Nadia (enrolled)

Usage of the Laboratory

(a) For Teaching

- i) We develop Biomedical signal acquisition and processing Lab for B.Tech and M.Tech courses in Instrumentation Engineering.
- ii) We have also long term plan to start a new M.Tech course in Bio-Medical Instrumentation.
- iii) We are trying to organize Short Term Courses in the relevant areas.

Proposed List of Experiments for B.Tech and M.Tech:

Experiment 1. Design of Biopotential Amplifiers

Bio-potential signals are very weak signals. Even the strongest ECG signal has a magnitude of less than 10 mV. Furthermore, ECG signals have very low drive, i.e. source has a very high output impedance. Therefore, an ECG amplifier is usually required to have the following properties:

1. Capability to sense low amplitude signals in the range of 0.1 - 10 mV,
2. Very high input impedance, usually more than 5 Mega-Ohms,
3. Very low input leakage current, 1 micro-Amps or below,
4. Flat frequency response of 0.1 - 100 Hz,
5. A high common mode rejection ratio (CMMR).

Experiment 2. Design of isolator

To design the isolator for bio-signal first convert the signal from Analog to digital. Then isolate the signal bit by bit. Finally convert the signal in analog form using ADC. Compare the final output with input.

Experiment 3. Acquisition of ECG from lead 2 using BioPack system

1. Connect ECG electrodes in Lead 2 configuration.
2. Make a recording of a screen of 5 to 10 complete cardiac cycles in Biopack system
3. Increase your heart activity (how would you do this?)
4. Repeat step 2.
5. Make a third recording while you are moving your arms.
6. Transfer your data to a file.

Plot the recorded ECG waveforms, label P, QRS and T waves. Fill the table below for both ECG recordings:

P-P interval (milli-seconds)	
P-QRS interval (milli-seconds)	
Deduced AV delay (milli-seconds)	
QRS-T interval (milli-seconds)	
QRS-QRS interval (milli-seconds)	
Heart Rate (beats/minute)	
Length of cardiac cycle (milli-seconds)	
Estimated duration of systole (milli-seconds)	
Estimated duration of diastole (milli-seconds)	

Experiment 4. Proof of Einthoven's law

Take the ECG record from Lead I, II and III. Add the ECG of Lead I and III bit by bit. Compare the result with the data of Lead II.

Experiment 5. Determine the systolic, diastolic, mean blood pressure, and heart rate using Noninvasive Blood Pressure System

Experiment 6. Experiment on acquisition of PPG using BioPack system

Experiment 7. Acquisition of ECG from bipolar leads using data acquisition system developed in our laboratory

We have used the Laboratory for M.Tech Projects. List of completed and ongoing projects are

Se No	Candidate Name	Year	Project/Seminar	Title of Thesis
1	Sangita Das Surja Sekhar Mandal Rohan Mandal	2011	project	Microcontroller based ECG Data Acquisition, compression & analysis of Electrocardiogram.
2	Monalisa Singha Roy Pritom Adhikary Nilkamal Sarkar Susmita Srimani	2011	project	Microcontroller based QRS detection technique for ECG signal.
3	Deboleena Sadhukhan	2012	M.Tech. Project	Noise reduction, feature extraction, analysis and compression of electrocardiography data
4	Tanusree Ghosh Sahas Dalui	2012	project	Denoising of an ECG signal using Discrete wavelet transform and QRS complex Detection.
5	Barnali Das Sreyasi Roy Sayanti Chattopadhyay	2012	project	Real time ECG QRS detection using standalone Embedded System.
6	Moumita Kundu Kabita Pandit Priyanka Bera	2013	Project	Noise cancellation from ECG signal and R peak detection using BIOPAC system and in MATLAB environment.
7	Priyanka Barat Moumita Mondal Saswata Mandal	2013	Project	Feature extraction from ECG signal and validation using BIOPAC software.
8	Samiran Das Palas Sardar Anupum Dutta	2013	Project	Development of ECG and PPG database using BIOPAC software and analysis of HRV.
9	Arijita Mondal Chandra Mukherjee Koushik Kumar Dandapat	2013	Project	Development of ECG and PPG database, de-noising and R peak detection from ECG signal and their validation using BIOPAC software.
10	Soumya Roy Soumen Hazra Abhirup Dey	2014	Project	Developing A Portable Short Range Ecg Monitoring System Using Ism Band Communication
11	Dhiman Das Rajanya Chakraborty Prabir Hazra	2014	Project	Acquisition And Analysis Of Electrocardiography (ECG) And Photoplethismography (PPG) Signal Using Biopack.
12	Rohit Mitra Avik Kundu	2014	Project	Development Of Low Cost Ecg Data Acquisition Module & Labview Based Heart Rate Monitor

(b) For Research

1. Present status of research of our group:

(i) Development of "Voltage- time data extraction package from strip chart record": Indian copyright; software; Registration no. : SW-3926/2008, dt 10.11.2008

(ii) Development of low cost Telemedicine system for Rural Health care

(iii) Development of ECG compression algorithms .

(iv) Feature extraction and classification of ECG

(a) Time Plane feature extraction of ECG wave

(b) Frequency plane feature extraction of ECG wave

(c) Joint time-frequency plane feature extraction of ECG wave

(d) ECG classifier design

The researches in these areas are substantiated by publications 12, 14, 15, 16, 17, 29, 30, 43, 44, 45, 55, 56, 57, 59, 60, 62, 63, 64, 65, 66, 67, 69, 74, 86, 93, 98, 99, 100 and 104 of **Annexure 1**.

Research areas explored using the Equipment procured from FIST

1. We have used the procured analysis software of BioPack for validation of different noise reduction and feature extraction algorithms developed by our group (M.Tech Project 6, 7).

2. We have generated 10 minute ECG and PPG database from our students, teachers and non-teaching staffs. From that database we generate the HRV (Heart Rate Variability) data of the subjects (M.Tech Project 8, 9, 11).

3. Developed ECG database will be used to validate different ECG classifiers developed by our group.

4. The heart rate variability (HRV) signal is indicative of autonomic regulation of the heart rate (HR). It could be used as a noninvasive marker in monitoring the physiological state of an individual. In our Biomedical Lab we record ECG and PPG simultaneously and generate HRV signal from both of the ECG and PPG signal. After the HRV signals are analysed, we try to develop a comparative study between four categories of control group, i) Normal male and Normal female of around same age, ii) Normal young male and normal old male, iii) Normal subject and MI subjects, iv) smoker and non smoker ((M.Tech Project 9).

5. We have planned to use the morphology of PPG to detect changes in posture. PPG signal may be used to detect the sleepiness of the object. We plan to apply PPG signal for detection of Stress level of a subject.

2. Future research plan utilizing the FIST equipment:

In the present project we wish to develop on line data acquisition system for biomedical signal and prepare a data fusion process for EGG, blood pressure and respiratory data for achieving improved clinical diagnosis. Data fusion refers to the synergic combination of information gathered by various sources and processed to gain a better understanding of the phenomenon under consideration.

From the blood pressure variation signal, it is possible to extract the information on respiratory and cardiac rhythm, as well as we can detect and differentiate a number of sleep disorders such as central or obstructive apneas. Information about the activity of the autonomic nervous system can be derived by analysis of key physiological signals, including ECG and blood pressure combined on a bit by bit basis. A drop in blood pressure combined with a rise in heart rate indicates that the heart is not pumping forcefully, and blood flow is impaired. The rise in heart rate occurs as the body attempts to increase blood flow.

Various civilization in the past have diagnosed diseases using arterial pulse from various locations on our body. In Ayurvedic literature more than 100 types of pulse disturbances are described. In traditional Chinese medicine, the fundamental concept of pulse feeling is the resonance of organs with the heart. With the help of Biopack data acquisition system we will capture the pulse. Pulse signals are expected to be analyzed in time and frequency domain and a neuro-fuzzy classifier will be developed to determine the condition of different organs from pulse analysis.

Placing Heel/Toe strike transducer in a shoe we will develop a system for Standing foot pressure image analysis. This analysis will help to detect levels of diabetic neuropathy, Gait, leprosy detection and different disease related to nervous system.

A2. DSP and FPGA based Embedded System Lab:

Faculty involved:

1. Dr. Jitendra Nath Bera, Associate Professor
2. Dr. Sumana Chowdhury, Assistant Professor

Usage of the Lab

(a) For Teaching

We develop DSP and FPGA based embedded system Lab for B.Tech and M.Tech courses in Instrumentation Engineering and in Electrical Engineering.

List of Experiments:

1. General feature study of DSP Starter kit
2. General feature study of FPGA Starter kit
3. Truth Table study for different logic gates
4. Development of programme for continuous loop operation for delay generation.
5. Development of programme for continuous data acquisition using ADC
6. Interfacing with PC through parallel port
7. Design of FPGA based 50 Hz notch filter
8. Design a FPGA based peak detector.
9. Development of FPGA based QRS detector
10. Experiment on FPGA based traffic light controller
11. DSP based DC Motor control

We have used the Laboratory for B.Tech and M.Tech Projects.

We are also planning to organize some Short Term Courses in the relevant areas utilising these facilities.

(b) For Research

DSP and FPGA based embedded system Lab is interdisciplinary in nature. We have used the laboratory equipments to develop different transmitting, monitoring and controlling unit which have used for smart energy meter and machine monitoring. The work is also going on in the area of DSP processor based modern controller design for speed and position control of Electrical motors. The same facility is also utilized to develop on line ECG signal processing system using FPGA technology [32].

(B) Upgradation of Power System Laboratories

Faculty involved:

1. Professor Samarjit Sengupta
2. Professor Anish Deb
3. Professor Gautam Sarkar
4. Mr. Priyaranjan Mondal

Scholars involved :

1. Dr. Surajit Chattopadhyay, Associate Professor, Electrical Engg. Dept., GKIT, Maldah
2. Dr. Arghya Sarkar, Professor, MCKV Institute of Engg, Kolkata
3. Dr. Sawan Sen, Assistant Professor, AOT, Kolkata, India
4. Mr. Ranjit Das, Director, Technical, SCP Ltd, Kolkata.
5. Mr. Jayanta Chattopadhyay, Territorial Manager (Eastern zone), APLAB India.
6. Ms. Debopama Kar Roy, Assistant Professor, MCKV Institute of Engg, Kolkata
7. Ms. Rumpa Saha, Assistant Professor, Narula Institute of, Kolkata

8. Ms. Jinia Datta,

Presently we have the **following laboratories related to Power System:**

Lab 1: Real Time Power System Laboratory

Lab 2: Power System Simulation Laboratory

Lab 3: RTDS (Real Time Digital Simulation) Laboratory

Lab 1: Real Time Power System Laboratory**(a) Equipment / systems available**

- 1) 400 KV 800 KM HVAC Three Bus Interconnected Transmission Line System having RLC load and series and shunt compensation facilities.
- 2) Induction type relays
- 3) Static relays
- 4) Motor Control Centre



Induction and static relays on panels

(b) Usage of the Lab through curriculum

The above are used by students of B. Tech. and M. Tech. in their practical classes and in B. Tech. and M. Tech Projects.

Lab 2: Power System Simulation Laboratory

(a) Simulation software available

ETAP software (old license version)

(b) Usage of the Lab through curriculum

The above are used by students of B. Tech. and M. Tech. in their practical classes and in B. Tech. and M. Tech Projects.

Lab 3: RTDS (Real Time Digital Simulation) Laboratory

(a) Equipment / systems available

RTDS unit with fourteen terminals and a server. RTDS is connected to the server through wire and the server is connected to the terminals through a wireless network.

(b) Usage of the Lab through curriculum

The above are used by students of M. Tech. in their practical classes and in B. Tech. and M. Tech Projects.

Equipment Procured under FIST-2009 for Power System Laboratory

- 1) Single phase HVDC Transmission Line Simulator
- 2) PSCAD software
- 3) Numerical Relays
- 4) Phantom Load Test Set

Utilisation of Equipment Procured under FIST-2009 for Power System Laboratory

(a) Utilization in Teaching

Single phase HVDC system has been installed in Lab 1: Real Time Power System Laboratory.



The experiments presently carried out in this laboratory are:

400 KV AC TRANSMISSION LINES

1. To study the power flow characteristics with different line lengths of a 400 KV HVAC Transmission line.
2. To study the voltage profile variation with different loadings and with different line lengths of a 400 KV HVAC Transmission line.
3. To study the reactive power profile with different loadings and with different line lengths of a 400 KV HVAC Transmission line.

With the help of the procured Single phase HVDC Transmission Line Simulator, the following experiments are planned / executed in this laboratory:

1. Study on inverter and converter characteristics
2. Study of DC Transmission Line efficiency
3. Study of harmonic generation phenomena in HVDC lines.
4. Study of effects of harmonics on HVDC transmission system.

These experiments will be covered for B. Tech. and M. Tech students. Since the HVAC system is also available, a comparison of HVAC transmission and HVDC transmission can also be demonstrated.

PSCAD software has been installed in Lab 2: Power System Simulation Laboratory. In addition to the existing software, this software is being used by the B. Tech. and M. Tech students.

List of experiments done in the laboratory

1. Familiarization with PSCAD
2. Understanding of Reactive Power and Power Factor Correction in AC Circuits.
3. Transmission Line and Modeling
4. Studying the transient stability of a power system and comparing the same with results from ETAP.

Numerical Relays are installed in Lab 1: Real Time Power System Laboratory. Conventional relays are also kept in this laboratory. B. Tech. and M. Tech students use these relays also along with the other relays as part of their curriculum.

INDUCTION TYPE RELAYS

1. To study the characteristics of IDMT non-directional overcurrent relay
2. To study the characteristics of IDMT non-directional earthfault relay
3. To study the characteristics of IDMT directional overcurrent relay
4. To study the characteristics of IDMT directional earthfault relay
5. To study the characteristics of Reverse Power relay

STATIC RELAYS

6. To study the characteristics of undervoltage and overvoltage relay

NUMERICAL RELAYS

7. Understanding basic features of numerical relays and related software.
8. Understanding interfacing numerical relays with systems.
9. To study the characteristics of IDMT non-directional and directional overcurrent relay and earth fault relay using numerical relay

10. To study the characteristics of numerical motor protection relay

Phantom Load Test Set will also be kept in Lab 1: **Real Time Power System Laboratory**. This is utilized in practical classroom teaching of students for testing of energy meter and trivector meter.

(b) Utilisation in Research

Initially all these equipment are used by the B. Tech. and M. Tech students to carry out some practical experiments as mentioned above and their projects and theses. A list of some relevant B.Tech. and M. Tech. Projects are given below:

Sl. No.	M Tech Thesis	Year	Student names	Guide names
1.	Reactive Power Compensation in 9-bus System	2009	Debjani Bhattacharya Soujanya Sue Pranab Karmakar Suman Kumar Das	Dr. S Chowdhuri
2.	Transient stability Study of a Multibus Power network using ETAP	2010	Mohua Ghosh Indranil Das Kalyan Kar Sourav Kumar Samanta	Prof. S. Sengupta & Dr. S. Chowdhuri
3	Voltage Stability analysis using FACTS Devices, Emphasis on SVC	2010	Dola Chandra Suhas Deb Surojit Dutta Jagannath Roy	Dr. S Chowdhuri & G. Sarkar
4	Development of Fault Diagnostic Feature of Numerical Relay by Interfacing RTDS with Microcontroller based system	2010	Rajat Shubhra Pal, Kamala Kanti Duary, Somenath Hazra, Samistha Sinha, Madhuri Kanjilal	Dr. J. N. Bera
5	Measurement of Power Quality under non-sinusoidal conditions using Artificial Intelligence,	2010	Pampa Saha,	Prof. S. Sengupta
6	Development of Frequency Based Protection Scheme For Industrial Power System Using Transient Stability Study	2010	Kamala Kanta Duary, Madhuri Kanjilal, Rajat Shubhra Pal, Sarmistha Sinha, Somnath Hazra,	Prof. S. Sengupta
7	<u>Transient Stability Analysis of MultiBus Power System,</u>	2010	Mohua Ghosh, Shouvik Kr. Samanta, Kalyan Kar, Indranil	Prof. S. Sengupta

			Das,	
8	On line Analysis of the Effects of SVC and TCSC controllers on Voltage collapse point in Multibus System	2011	Suman Kr. Dey Pradumna Roy Sourav Basu Chandramouli Gupta	Dr. S Chowdhuri, G. Sarkar & Dr. J. N. Bera
9	Stability Analysis and Optimisation of a Captive Power Plant considering future load and Power Export Capability,	2011	Sudhansu Majumdar, Manirup Kundu, Poulomi Bhattacharyya,	Prof. S. Sengupta
10	Design and Analysis of Power System for a Co-Generation Plant and Stability studies during Power Export / Import in synchronism with Grid,	2011	Utpal Goswami, Sannitha Banerjee, Srimanta Banerjee, Nabanita Chakraborty,	Prof. S. Sengupta
11	Study of Power Network and Load pattern of Rashbehari Siksha Prangan and Design of a suitable power factor correction equipment,	2011	T. K. Khan, A. Middya, V. Mala, P. P. Das, S. Dalui,	Prof. S. Sengupta
1 2	Load Flow and Transient Stability Analysis of an IEEE-9 Bus system	2012	Dwaipayan Bhattacharjee, Anshuman Mukherjee, Arpana Saha, Animesh Ghosh,	Prof. S. Sengupta

Present Research in the Power System field

The present research areas in the power system fields carried out in the Department as evidenced by publications (Journal) and B. Tech. and M. Tech. Theses are as follows:

- i) Power system frequency estimation
- ii) Power system harmonics estimation
- iii) Power and energy measurement in nonsinusoidal environment
- iv) Load flow analysis
- v) Stability of large industrial systems
- vi) Power system communication
- vii) smart metering and smart grid

9. Details of full length research publications (in peer-reviewed journals) during the period under report: **Annexure 1**

10. Sponsored research projects in operation during the period under report (please provide name/s of PI/Co-PIs, title of the project, funding agency and total quantum of external support)

Name of the faculty	Sponsoring agency	Duration	Amount of grant	Title
Prof. S.Sengupta	UGC	1.4.2009-31.3.2014	66.9L + 20.0L	SAP DRS-1 Remote Communication System
Dr. J.N.Bera	Ministry of Power	2 years	25L	Development of Remote Energy metering system towards the estimation of zonal energy consumption with AMR

11. Utilization of Equipment from outside the Department: A number of scholars of the Department are from different educational institutions and industries. They are using these facilities for their research activities which are evidenced from the list of publications provided.

12. SELF-ASSESSMENT OF THE IMPACT OF FIST SUPPORT: Please specify if any of the following activity emerged/ improved as a consequence of the FIST support:

a. New class-room experiments at B.Sc./ M.Sc. or other levels

Proposed list of New class-room experiments is enclosed in Annexure 2

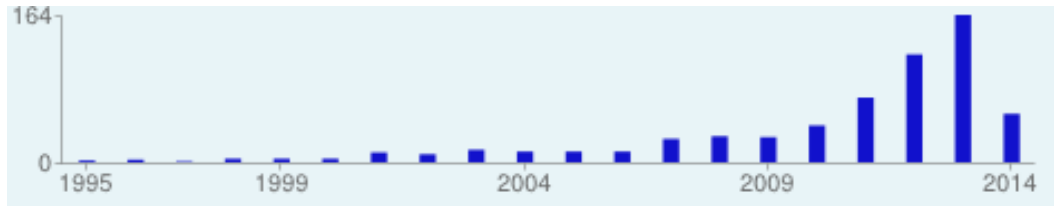
b. Success of students at national level tests (various PG/Ph.D. entrance tests and tests for JRF etc) NA

c. Any new research project that emerged on the basis of the FIST support

d. Did the newly created facility lead to betterment of quality of research publications

We hope that the newly created facility lead to betterment of quality of research publications.

Citation of the papers of Biomedical Group :



The picture is copied from Googles Scholar

- e. Any training program/ workshop organized by the department during the period of report, specially those involving the newly created facility) NA

13. Is any problem faced in utilization of the grant/facilities? No

A report highlighting the research activities of the department during the period under review may also be provided.

With the diversification of courses of instruction, the fields of research activities have also been widened to cover larger areas of technological aspects. The major areas of present research can be put under the following headings.

- ♣ Biomedical signal analysis in time and frequency plane and rule base knowledge generation.
- ♣ Development of smart sensor based telemedicine system for rural health care.
- ♣ Biomedical data compression.
- ♣ Application of piecewise constant orthogonal functions (PCOF) for control system analysis and identification.
- ♣ Microprocessor and microcontroller based performance analysis of longitudinal power system.
- ♣ Power system control, protection and stability using microprocessor / microcontroller.
- ♣ Integrated operation of power system.
- ♣ Basic transducer development.
- ♣ Fuzzy and neuro-fuzzy based real time controller design and intelligent control.
- ♣ Condition based predictive monitoring of fault for the rotating machines from the synergic combination of system signatures.

♣ Development Of Smart Wireless Energy Meter

♣ Wireless communication and embedded system.

Signature :
Programme Coordinator

Signature :
Head of the Department

Signature:
Registrar of the
University

Annexure 1

List of publication records (Year wise) in peer-reviewed journals

Year 2010

1. Dilip Dey, P. B. Dutttagupta, S. Sengupta "On-line Condition Monitoring of Induction Motor through WPD Technique" International Journal of Applied Engineering Research (IJAER). ISSN 0973-4562 Volume 5 Number 3, pp. 449-464, March 2010.
2. Sawan Sen, P. Roy, S. Sengupta and A. Chakrabarti "Genetic Algorithm based Generation Cost Constrained Re-dispatching Schedule in Deregulated Power Market" International Journal of Electrical Engineering, 2010.
3. S.K. Ahamed, S. Karmakar, M. Mitra & S. Sengupta, "Diagnosis of Induction Motor Faults due to Broken Rotor bar and Rotor Mass Unbalance through Discrete Wavelet Transform of Starting Current at No-Load" Journal of Electrical System, Vol Volume 6, Issue 3, (September 2010).
4. Arghya Sarkar, and S. Sengupta, "Second degree digital differentiator based power system frequency estimation under non-sinusoidal conditions," IET Science Measurement and Technology, vol. 4, no. 3, pp. 105–114, May 2010.
5. S. Chattopadhyay, M. Mitra, S. Sengupta, "Harmonic Power in Clarke Domain" IE (I), Journal – EL, Volume 91, December 2010, Pp. 1-6.
6. Microprocessor based identification of SISO sampled-data systems using a set of sample-and-hold function and Dirac delta functions; Anindita Sengupta, Anish Deb and K. L. Naidu Journal of the Institution of Engineers (India)-EL; vol. 91, pp. 49-54, September 2010.
7. S.C. Bera, R. Sarkar and N. Mandal "Study of the Effect of Excitation Frequency on the Performance of Electrode Polarization Impedance Type Flow Transducer for a Conducting Liquid" IEEE Transaction on Instrumentation and Measurement, Vol 59, No. 12, pp3289-95, December, 2010.

8. S. Chattyopadhyay and S.C. Bera, "Modification of Maxwell Wein Bridge for Accurate Measurement of Process Variable by an Inductive Transducer" IEEE Transactions on Instrumentation and Measurement, vol 69, No.9, pp2445-49, Sept. 2010.
9. S.C. Bera, and B. Chakraborty " A Mathematical Verification on a Developed Model of ECG Wave" Int. J. Biomedical Engineering and Technology, Vol. 4, No. 4, pp 315-27, 2010.
10. S.C. Bera, and R. Sarkar, "Fourier Analysis of Normal ECG Signal to Find its Maximum Harmonic Content by Signal Reconstruction" Sensors & Transducers journal (ISSN1726-5479), Vol.123, Issue 12, , pp.106-117, December 2010.
11. S.C. Bera, and D. N. Kole "A Modified Technique of Active Power Measurement for Industrial Frequency Applications' Sensors & Transducers Journal, (ISSN1726-5479), Vol. 119, Issue 8, pp. 82-90, August 2010.
12. R. Gupta, J.N. Bera, M. Mitra, "Development of an embedded system and MATLAB-based GUI for online acquisition and analysis of ECG Signal", Measurement 43 (2010) pp 1119–1126 (Elsevier Science Publication).
13. S.K. Ahamed, S. Karmakar , M.Mitra &S. Sengupta, "Diagnosis of Induction Motor Faults due to Broken Rotor bar and Rotor Mass Unbalance through Discrete Wavelet Transform of Starting Current at No-Load" Journal of Electrical System, Vol Volume 6, Issue 3, (September 2010).
14. R.Gupta, J.N.Bera, M.Mitra, "Remote ECG acquisition: Towards Distributed Healthcare", Accepted in International Journal of Recent Trends in Engineering (Academy Publishers, Finland), Vol. 4, No. 1, November 2010, pp. 24-28, [ISSN 2158-5563].
15. S. Banerjee, M. Mitra, "ECG Signal Denoising and QRS Complex Detection by Wavelet Transform Based Thresholding", Sensors & Transducers Journal, Vol. 119, Issue 8, August 2010, pp. 207-214.
16. S. Pal, M. Mitra, "Detection of Premature Ventricular Contraction Beats using ANN", International Journal of Recent Trends in Engineering [ISSN 1797-9617], Volume 3 No. 4, Pg. 1-3, May 2010
17. S.Pal, M. Mitra , "Detection of ECG characteristic points using Multiresolution Wavelet Analysis based Selective Coefficient Method", Measurement 43 (2010), pp 255–261. (Elsevier Science Publication).

18. P. Roy, Sawan Sen, S. Sengupta and A. Chakrabarti "Genetic Algorithm based Transmission Loss Optimization and Generator Re-dispatching Schedule for Congestion management under Deregulated Environment" Expert System with Application- Elsevier, 2010.

Year 2011

19. Arghya Sarkar, S. Roy Choudhury, S. Sengupta , "A self-synchronized ADALINE network for on-line tracking of power system harmonics ", Measurement, Vol. 44, No. 4, pp. 784-790, May 2011.
20. Arghya Sarkara, and S. Sengupta, " Bandpass Second Dgree Digital – Integrator Based Power System Frequency Estimation under non-sinusoidal conditions". IEEE Trans. On Instrumentation and Measurement, Volume: 60, Issue:3 pp. 846 – 853, March 2011.
21. S.C. Bera, N. Mandal and R. Sarkar, "Study of a Pressure Transmitter Using an Improved Inductance- Bridge Network and Bourdon Tube as Transducer," IEEE Transaction on Instrumentation and Measurement , Vol 60, No. 4, pp 1453-60, April 2011.
22. S. Chakraborty and S.C. Bera, "Study of Magneto-Optic Element as Displacement Sensor" Measurement, Elsevier Science, U.K., vol. 44, Issue. 9, pp. 1747-1752, November 2011.
23. S.C. Bera, N. Mandal and R. Sarkar, "A Novel Technique of Using a Thyristor Driven Pump as The Final Control Element and Flow Indicator of a Flow Control Loop" J. of ISA Transactions", Elsevier Science.,vol.50, Issue 4, pp. 496-503, July 2011.
24. S. Chakraborty, S.C. Bera, and A.K. Chkraborty "Simulation of a Polarization Pupil Filter Using Magneto-Optic Lense Under Elliptically Polarized Illumination" Optic, Elsevier Science.122, pp549-552. 2011.
25. S.C. Bera, and M. Bhowmick " Study of a Modified Displacement Transducer of a Piston in a Power Cylinder" Sensors & Transducers Journal, Vol. 128, Issue 5, pp. 81-88, May 2011.
26. M. Bhowmick and S.C. Bera, "Design of a DCS Based Model for Continuous Leakage Monitoring System of Rotary Air Preheater of a Thermal Power Plant" Sensors&Transducers journal (ISSN 1726-5479), Vol.124, Issue 1, January 2011, pp.83-100.
27. S. Chakraborty and S.C. Bera, "Over Current detection by Optical null

- method" Journal of Instrument Society of India, vol. 41, no. 1, pp.1-4, March, 2011.
28. S.C. Bera, and D.N. Koley, "A low cost infrared transmitter receiver based opto isolator circuit for analogue DC signal "Journal of Instrument Society of India, vol. 41, no. 1, pp.9- 12, March, 2011.
 29. H.K. Chatterjee, R. Gupta, M. Mitra, "A Statistical Approach for Determination of Time Plane Features from Digitized ECG", Computers in Biology and Medicine, 41 (2011), pp. 278–284 (Elsevier Science publication).
 30. S.K. Mukhopadhyay, S. Mitra, M. Mitra, "A Lossless ECG Data Compression Technique Using ASCII Character Encoding", Computers & Electrical Engineering, 37 (2011) 486–497, Volume 37 , Issue 4, July 2011, Elsevier Science publication.
 31. S.K. Ahamed, S. Karmakar , A.Sarkar, M.Mitra & S. Sengupta, " Diagnosis of Broken Rotor Bar Fault of Induction Motor through Envelope Analysis of Motor Startup Current using Hilbert and Wavelet Transform", Innovative Systems Design and Engineering , Vol 2, No 4, pp. 163-176, 2011.
 32. S Chattopadhyay M Mitra, and S Sengupta, "Part wise linear characteristics of FFT based spectrum of Current Transformer", International Journal on Modeling, Measurement and Control of General Physics and Electrical Applications, AMSE, Series -A, Vol. 84, Issue 1, 2011, pp 89-98.
 33. S. K. Sen, T. K. Pan and P Ghosal, An Improved Lead Wire Compensation Technique for Conventional Four Wire Resistance Temperature Detectors (RTDs), Jour. Measurement, Vol. 44, Issue 5, Pp. 842-846, June 2011. (Elsevier Science Publication).
 34. Abhisek Maiti, Sumana Chowdhuri, Jitendranath Bera, "Development of Microcontroller Based ISPWM Switching Technique for Single Phase Inverter", International Journal of Engineering Science and Technology (IJEST), ISSN : 0975-5462, Vol. 3 No. 6 June 2011 pp: 5298-5305.
 35. Jayanta Mukherjee, Sumana Chowdhuri, Samarjit Sengupta, "A novel Power Drive for minimization of Speed Oscillation in Switched Reluctance Motor irrespective of Input Utility Voltage and Frequency Fluctuations", IJEST, International Journal of Engineering Science and Technology (IJEST), ISSN:0975-5462, Vol 3, No.9, Sept 2011 , pp 6867-6875.
 36. R. Mudi and C. Dey, "Performance improvement of PI controllers through dynamic set-point weighting", ISA Transactions, Vol. 50, pp. 220-230, 2011.
 37. J. Datta (Das), S. Chowdhuri, J.N.Bera, G. Sarkar, "Remote monitoring of different electrical parameters of multi-machine system using PC",

Measurement, Elsevier Science Publication, Vol 45, September 2011, pp 118–125.

38. A. Maiti, S. Chowdhuri, J.N.Bera, "Development of Microcontroller Based ISPWM Switching Technique for Single Phase Inverter", International Journal of Engineering Science and Technology (IJEST), Vol. 3 No. 6, June 2011, pp 5298-5305.

Year 2012

39. Anish Deb, Gautam Sarkar, Priyaranjan Mandal , Amitava Biswas, Anindita Ganguly and Debasish Biswas; "Transfer Function Identification from Impulse Response via a New Set of Orthogonal Hybrid Functions (HF)"; Applied Mathematics & Computation, vol. 218, Issue 9, pp. 4760-4787, Jan, 2012.
40. Anish Deb, Gautam Sarkar, Anindita Ganguly and Amitava Biswas; "Approximation, Integration and Differentiation of Time Functions using a Set of Orthogonal Hybrid Functions (HF) and their Application to Solution of First Order Differential Equations; Applied Mathematics & Computation, vol. 218, Issue 9, pp. 4731-4759, Jan, 2012.
41. S.C. Bera, R. Sarkar and M. Bhowmick "Study of a Modified Differential Inductance Measurement Circuit as Position Transducer of a Power Cylinder" IEEE Transaction on Instrumentation and Measurement, 2011 vol.61, Issue. 2, pp. 530-538, February 2012.
42. S.C. Bera and R. Sarkar "An optoisolator based linearization technique of a typical thyristor driven pump" ISA Transactions, Elsevier Science., U.K. vol. 51, Issue.1, pp. 220-228 January 2012.
43. R. Gupta, J.N. Bera, M. Mitra , "A Bi-Phase Enabled Serial Acquisition System for Remote Processing of Digitized ECG" Computers & Electrical Engineering, 38 (2012), PP. 68-74 (Elsevier Science publication)
44. Saurabh Pal, Madhuchhanda Mitra, "Empirical Mode Decomposition based ECG enhancement and QRS Detection", Computers in Biology and Medicine, vol.42, issue 1, pp.83-92, January 2012, (ELSEVIER science publication).
45. S. Banerjee, R. Gupta, M. Mitra, "Delineation of ECG characteristic features using multiresolution wavelet analysis method", Measurement, 45 (2012), pp. 474–487 (Elsevier Science publication).

46. C. Dey, R. Mudi, and D. Simhachalam, "An auto-tuning PID controller for integrating plus dead-time processes", *Journal of Advanced Materials Research*, Vol. 403-408, pp. 4934-4943, 2012.
47. A. K. Pal, R. Mudi, and C. Dey, "Rule extraction through self-organizing map for a self-tuning fuzzy logic controller", *Journal of Advanced Materials Research*, Vol. 403-408, pp. 4957-4964, 2012.
48. S.C. Bera and S. Marick "Study of a Simple Linearization Technique of p-n Junction Type Anemometric Flow Sensor" *IEEE Transaction on Instrumentation and Measurement*, Vol 61, No.-9, pp2545-2552, September, 2012.
49. S.C. Bera and H. Mandal "A Modified Flow Measurement Technique Using a Novel Non Contract Capacitance Type Orifice Transducer" *IEEE Transaction on Instrumentation and Measurement*, Vol. 61, No.-9, pp2553-2559, September, 2012.
50. S.C. Bera, R. Sarkar and M. Bhowmick "Study of a Modified Differential Inductance Measurement Circuit as Position Transducer of a Power Cylinder" *IEEE Transaction on Instrumentation and Measurement*, Vol 61, Issue-2, pp530-538, February, 2012.
51. S.C. Bera and R. Sarkar "An optoisolator based linearization technique of a typical thyristor driven pump" *J. of ISA Transactions*, Elsevier Science., U.K , vol.51, Issue-1, pp 220-228, Jan, 2012.
52. C. Dey, R. Mudi, and D. Simhachalam, "An auto-tuning PID controller for integrating plus dead-time processes", *Journal of Advanced Materials Research*, Vols. 403-408, pp. 4934-4943, 2012.
53. A. Pal, R. Mudi, and C. Dey, "Rule Extraction through Self-Organizing Map for a self-tuning fuzzy logic controller," *Journal of Advanced Materials Research*, Vols. 403-408, pp. 4957-4964, 2012.
54. P. Pal, C. Dey, and R. Mudi, "Model based PID controller for integrating process with its real time implementation," *International Journal of Advancements in Electronics and Electrical Engineering*, Vol. 1, No. 2, pp. 139-144, 2012.
55. S. Pal, M. Mitra, "Detection of Cardiac Arrhythmic Beats by Logical Classifier using Binary Coding", *IET Science Measurement and Technology* ,6 (6) , pp. 449-455, 2012
56. S. K. Mukhopadhyay, M.Mitra, S.Mitra, "ECG Feature Extraction Using Differentiation, Hilbert Transform, Variable Threshold and Slope Reversal Approach", *Journal of Medical Engineering and Technology* 36 (7) , pp. 358-365, 2012.

57. M.Mitra, J.N.Bera, R.Gupta, "Electrocardiogram compression technique for global system of mobile-based offline telecardiology application for rural clinics in India", IET Science, Measurement and Technology 6 (6) , pp. 412-419, 2012
58. S. K. Ahamed, A. Sarkar, M. Mitra, S. Sengupta "Detection of induction motor broken bar fault through envelope analysis using start-up Current" C3IT-2012 , ELSEVIER Procedia Technology 4, pp. 646-651, 2012.
59. S. K. Mukhopadhyay, M.Mitra, S.Mitra, "QRS Complex Identification Using Hilbert Transform, Variable Threshold and Slope Reversal Approach", International Journal of Biomedical Engineering and Technology (IJBET), (Inderscience Publication), pp-301-315, Vol. 9, No. 4, 2012, DOI: 10.1504/IJBET.2012.049215.
60. R.Gupta, J.N.Bera, M.Mitra, "An intelligent telecardiology system for offline wireless transmission and remote analysis of ECG", Journal of Medical Engineering & Technology (Informa Healthcare) 36 (7) , pp. 358-365, 2012
61. S. Chattopadhyay, S. Karmakar, M. Mitra, and S. Sengupta, "Assessment of crawling of an induction motor by stator current Concordia analysis", Electron. Lett, Volume 48, Issue 14, p.841–842 , 5 July 2012.
62. S. Pal, M. Mitra, "Increasing the accuracy of ECG based biometric analysis by data modelling", Measurement, 45 (7), 2012 , pp.1927-1932 (August 2012) (Elsevier Science publication)
63. R. Gupta, J.N. Bera, M. Mitra , "A Bi-Phase Enabled Serial Acquisition System for Remote Processing of Digitized ECG" Computers & Electrical Engineering, 38, PP. 68-74, (2012) (Elsevier Science publication)
64. Saurabh Pal, Madhuchhanda Mitra, "Empirical Mode Decomposition based ECG enhancement and QRS Detection", Computers in Biology and Medicine, vol.42, issue 1, pp.83-92, January 2012 (ELSEVIER science publication).
65. S. Banerjee, R. Gupta, M. Mitra, " Delineation of ECG characteristic features using multiresolution wavelet analysis method", Measurement, 45(3) , pp. 474–487, 2012 (Elsevier Science publication) .
66. S.K. Mukhopadhyay, S. Mitra, M. Mitra, "An ECG Signal Compression Technique Using ASCII Character Encoding" , Measurement, 45 (6), pp. 1651-1660 , 2012 (Elsevier Science publication).
67. D. Sadhukhan and M. Mitra, "R-peak detection algorithm for ECG using double difference and RR interval processing" C3IT-2012, ELSEVIER Procedia Technology 4, pp. 873-877 ,2012 .

68. S Chattopadhyay, S Karmakar, M Mitra, S Sengupta, "Symmetrical Components and Current Concordia based Assessment of Single Phasing of an Induction Motor by Feature Pattern Extraction Method and Radar Analysis", *International Journal of Electrical Power and Energy Systems* 37 (1) , pp. 43–49, 2012 (Elsevier Science publication).
69. H. K. Chatterjee, R. Gupta, and M. Mitra, "Real time P and T wave detection from ECG using FPGA" C3IT-2012 , *ELSEVIER Procedia Technology* 4, pp. 840-844 ,2012.
70. Debopama Kar Ray, Sudipa Deb, Tanusree Kumar, S. Sengupta "Diagnosis of Subsynchronous Interharmonic in Power System Signals under Non-sinusoidal Environment" *LCIT-National Journal of Engineering and Technology*, Vol. 1, 2012, Pp. 272-276.
71. S Chattopadhyay, S Karmakar, M Mitra, S Sengupta "Radar Analysis of Stator Current Concordia for Diagnosis of Unbalance in Mass and Cracks in rotor bar of an Squirrel Cage Induction Motor." *International Journal on Modeling, Measurement and Control of General Physics and Electrical Applications*, AMSE, Series -A, 2012.
72. S. K. Ahamed, A. Sarkar, M. Mitra, S. Sengupta "Identification of Mass-unbalance in Rotor of an Induction Motor through Envelope analysis of Motor starting current at no load", *Journal of Engineering Science and Technology Review* 5(1) (2012) 83-89.
73. Sawan Sen, S. Chanda, S. Sengupta, A. Chakrabarti, "Swarm Intelligence based Congestion Constrained Load Curtailment Strategy," accepted for publication in *ELECTRIKA - Journal of Electrical Engineering*, Malaysia, 2012.
74. "An online ECG QRS detection technique", R.Gupta, H.K.Chatterjee, M.Mitra, *International Journal of Recent Trends in Engineering & Technology*, Vol. 7, No.2, March 2012, pp. 1-5 [ISSN-2158-5563].
75. K. Das Sharma, A. Chatterjee and A. Rakshit "A Random Spatial lbest PSO Based Hybrid Strategy for Designing Adaptive Fuzzy Controllers for a Class of Nonlinear Systems" *IEEE Transactions on Instrumentation & Measurement*, vol-61, no.-6, pp-1605-1612, June, 2012.
76. K. Das Sharma, A. Chatterjee and A. Rakshit "A PSO-Lyapunov Hybrid Stable Adaptive Fuzzy Tracking Control Approach for Vision Based Robot Navigation" *IEEE Transactions on Instrumentation & Measurement*, vol-61, no.-7, pp-1908-1914, July, 2012.
77. K. Das Sharma, "A Systematic Design Methodology of PD Fuzzy Logic Controller Using Cellular Fuzzy Logic Concept", *International Journal of*

Automation and Control, Inderscience Pub., Vol. 6, Nos. 3/4, pp.231–245., 2012.

78. K. Das Sharma, "Group Improvisation Based HS Algorithm for Designing T-S Type Fuzzy Controllers for a Class of Non-Linear Systems," International Journal of Electrical, Electronics & Computer Engineering, (Special Edition for Best Papers of Michael Faraday IET India Summit-2012, MFIS-12), vol. 1, no. 2, pp-6-10, 2012.
79. Jinia Datta(Das), Soumyajit Datta, Sumana Chowdhuri and Jitendranath Bera, "Condition based reporting of multi-machine monitoring system using GSM", International Journal of Scientific and Research Publications, Volume 2, Issue 6, June 2012, pp 1-5.
80. Tista Banerjee, Sumana Chowdhuri, Gautam Sarkar, Jitendranath Bera, "Performance Comparison between GA and PSO for Optimization of PI and PID controller of Direct FOC Induction Motor Drive" International Journal of Scientific and Research Publications, Volume 2, Issue 7, July 2012, pp 1-5.
81. J.N.Bera, G. Sarkar, R. Rudra, "A Novel Sample Shifting Technique for Sinusoidal Steady State Solution of R-L-C Circuit", Journal of Electric Engineering, Volume 12, Issue 2, June 2012 pp. 217-225.
82. Gautam Sarkar, Suchismita Ghosh and Anish Deb, "On-line block pulse implementation of a sine wave using microprocessor", Measurement, vol. 45, Issue 6, pp. 1626-1632, July 2012.
83. Anish Deb, Anindita Ganguly , Gautam Sarkar and Amitava Biswas, "Function approximation, integration and numerical solution of third order linear differential equations using generalized one-shot integration operational matrices in orthogonal hybrid function (HF) domain", Applied Mathematics and Computation, vol. 219, Issue 4, pp. 1485-1514, November, 2012.
84. S.K. Ahamed, M. Mitra, S. Sengupta and A. Sarkar, "Identification of Mass-unbalance in Rotor of an Induction Motor through Envelope analysis of Motor starting current at no load", Journal of Engineering Science and Technology Review 5(1) (2012) 83-89.

Year 2013

85. S. Chattopadhyay, J. Sarkar and S. C. Bera, "A low cost design and development of a reluctance type pressure transducer" Measurement, Elsevier Science, Vol. 46 (2013), pp. 491-96.

86. S. K. Mukhopadhyay, M.Mitra, S.Mitra, "ECG Data Compression via ASCII Character Encoding and Feature Extraction Using Hilbert Transform based Approach", *Consumer Electronic Times*, (World Academic Publishing), Vol. 2 Issue 1, PP. 56-67, Jan. 2013.
87. K. Das Sharma, A. Chatterjee and A. Rakshit, "Harmony Search Based Hybrid Stable Adaptive Fuzzy Tracking Controllers For Vision Based Mobile Robot Navigation," *Machine Vision & Application*, Springer Pub., Accepted for publication, 2013.
88. Surajit Chattopadhyay, Aveek Chattopadhyaya, Samarjit Sengupta "Analysis of stator current of induction motor used in transport system at single phasing by measuring phase angle, symmetrical components, Skewness, Kurtosis and harmonic distortion in Park plane" *Journal of IET Electrical Systems in Transportation*, Sept. 2013, pp. 1–8, doi:10.1049/iet-est.2012.0048.
89. Aveek Chattopadhyaya, Harsha Banerjee, Surajit Chattopadhyay and Samarjit Sengupta "Assessment of CT Saturation Caused By Switching Transient", *International Journal of Electrical, Electronics and Computer Engineering* 2(2):57-61, 2013, Special Edition for Best Papers of Michael Faraday IET India Summit-2013, MFIS-13, ISSN No. (Online): 2277-2626.
90. D. Kar Ray, S. Chattopadhyay and S. Sengupta "Assessment of THD in Induction Motor due to Unbalanced", *International Journal of Electrical, Electronics and Computer Engineering* 2(2):46-50, 2013, Special Edition for Best Papers of Michael Faraday IET India Summit-2013, MFIS-13, ISSN No. (Online): 2277-2626.
91. Sananda Pal, A. Neogi, S. Biswas, M. Bandyopadhyay and S. Sengupta "Loss Minimization and Congestion Management of a Power Distribution Network through its Reconfiguration", *International Journal of Electrical, Electronics and Computer Engineering* 2(2):95-99, 2013, Special Edition for Best Papers of Michael Faraday IET India Summit-2013, MFIS-13, ISSN No. (Online): 2277-2626.
92. S.K. Ahamed, M. Mitra, S. Sengupta and A. Sarkar, "DSP Implementation of a Novel Envelope Analysis Approach for the Diagnosis of Broken Rotor Bar in Induction Motor", *Int. J. Modeling, Identification and Control*, Vol. 3, No. 3, 2013
93. H.K. Chatterjee, R. Gupta, M. Mitra, " An approach to determine amplitude features from ECG records", *International Jour of Biomedical Engineering and Technology (IJBET)*, ISSN online: 1752-6426, Vol. 12, No. 2, 2013, pp. 130-146.
94. K. Das Sharma "Stable Fuzzy Controller Design Employing Group Improvisation Based Harmony Search Algorithm," *International Journal of*

Control, Automation and Systems (Springer Pub.), vol. 11, no. 5, pp.1046-1052, 2013.

95. Anish Deb, Suchismita Ghosh, Srimanti Roy Choudhury and Gautam Sarkar, "A new recursive method for the analysis of linear time invariant dynamic systems via double-term triangular functions (DTTF) in state space environment", *Journal of Control Theory and Applications*, vol. 11, No. 1, pp. 108-115, 2013.
96. Suchismita Ghosh, Anish Deb, Srimanti Roy Choudhury and Gautam Sarkar, "Modeling and analysis of singular systems via orthogonal triangular functions," *Journal of Control Theory and Applications*. vol. 11, no. 2, pp. 141-148, 2013.
97. Anindita Ganguly, Anish Deb and Gautam Sarkar Orthogonal hybrid functions (HF) for solving second order differential equations using one-shot integration operational matrices. *International Journal of Scientific Engineering and Technology (ISSN:2277- 1581)*, vol. 2, no. 3, pp. 171-185, April 2013.
98. S. K. Mukhopadhyay, S.Mitra, M.Mitra, M.Mitra, "ECG Signal Compression Using ASCII Character Encoding and Transmission via SMS", *Biomedical Signal Processing and Control* , 8 (2013) pp. 354– 363 (Elsevier Science Publication).
99. S. Banerjee, M. Mitra , " ECG beat classification based on Discrete wavelet transformation and nearest neighbour classifier", *TMET Journal of Medical Engineering and Technology* May 2013, Vol. 37, No. 4, pp. 264-272
100. S. K. Mukhopadhyay, S. Ghosh, S. Chakraborty M.Mitra and S.Mitra, "Lossless Electrocardiogram Compression Technique And Gsm Based Tele-Cardiology Application", *International Journal On Smart Sensing And Intelligent Systems* Vol. 6, No. 3, Pp. 888-909, June 2013

Year 2014

101. Syed Kamruddin Ahamed, Arghya Sarkar, Madhuchhanda Mitra and Samarjit Sengupta, "Induction Machine Stator Inter-Turn Short Circuit Fault Detection using Discrete Wavelet Transform, *Innovative Systems Design and Engineering*, Vol. 5, no.1, 2014, pp 75-82
102. K. Das Sharma, A. Chatterjee and A. Rakshit, "Harmony Search Based Hybrid Stable Adaptive Fuzzy Tracking Controllers For Vision Based Mobile Robot Navigation," *Machine Vision & Application*, Springer Pub., Vol. 25, Issue 2, pp 405-419, 2014.

103. C. Dey, R. Mudi, and D. Simhachalam, "A simple nonlinear PD controller for integrating processes", ISA Transactions, Vol. 53, No. 1, pp.162-172, 2014.
104. Swati Banerjee, M. Mitra, "Application of Cross Wavelet Transform for ECG pattern analysis and classification", IEEE Transactions on Instrumentation and Measurement Vol. . 63, NO. 2, February 2014 Page(s): 326 - 333, ISSN:0018-9456, Digital Object Identifier: 10.1109/TIM.2013.2279001

Annexure 2: List of Experiments

Biomedical signal acquisition and processing Lab:

Experiment 1. Design of Biopotential Amplifiers

Bio-potential signals are very weak signals. Even the strongest ECG signal has a magnitude of less than 10 mV. Furthermore, ECG signals have very low drive, i.e. source has a very high output impedance. Therefore, an ECG amplifier is usually required to have the following properties:

1. Capability to sense low amplitude signals in the range of 0.1 - 10 mV,
2. Very high input impedance, usually more than 5 Mega-Ohms,
3. Very low input leakage current, 1 micro-Amps or below,
4. Flat frequency response of 0.1 - 100 Hz,
5. A high common mode rejection ratio (CMMR).

Experiment 2. Design of isolator

To design the isolator for bio-signal first convert the signal from Analog to digital. Then isolate the signal bit by bit. Finally convert the signal in analog form using ADC. Compare the final output with input.

Experiment 3. Acquisition of ECG from lead 2 using BioPack system

1. Connect ECG electrodes in Lead 2 configuration.
2. Make a recording of a screen of 5 to 10 complete cardiac cycles in Biopack system
3. Increase your heart activity (how would you do this?)
4. Repeat step 2.
5. Make a third recording while you are moving your arms.
6. Transfer your data to a file.

Plot the recorded ECG waveforms, label P, QRS and T waves. Fill the table below for both ECG recordings:

P-P interval (milli-seconds)	
P-QRS interval (milli-seconds)	
Deduced AV delay (milli-seconds)	
QRS-T interval (milli-seconds)	
QRS-QRS interval (milli-seconds)	
Heart Rate (beats/minute)	
Length of cardiac cycle (milli-seconds)	
Estimated duration of systole (milli-seconds)	
Estimated duration of diastole (milli-seconds)	

Experiment 4. Proof of Einthoven's law

Take the ECG record from Lead I ,II and III. Add the ECG of Lead I and III bit by bit. Compare the result with the data of Lead II.

Experiment 5. Determine the systolic, diastolic, mean blood pressure, and heart rate using Noninvasive Blood Pressure System

Experiment 6. Experiment on acquisition of PPG using BioPack system

Experiment 7. Acquisition of ECG from bipolar leads using data acquisition system developed in our laboratory

DSP and FPGA based embedded system Lab:

1. General feature study of DSP Starter kit
2. General feature study of FPGA Starter kit
3. Truth Table study for different logic gates
4. Development of programme for continuous loop operation for delay generation.
5. Development of programme for continuous data acquisition using ADC
6. Interfacing with PC through parallel port
7. Design of FPGA based 50 Hz notch filter
8. Design a FPGA based peak detector.
9. Development of FPGA based QRS detector
10. Experiment on FPGA based traffic light controller

3. Power System Lab

Single phase HVDC system

1. Study on inverter and converter characteristics
2. Study of DC Transmission Line efficiency
3. Study of harmonic generation phenomena in HVDC lines.
4. Study of effects of harmonics on HVDC transmission system.

Since the HVAC system is also available, a comparison of HVAC transmission and HVDC transmission can also be demonstrated.

PSCAD software.

1. Familiarization with PSCAD
2. Understanding of Reactive Power and Power Factor Correction in AC Circuits.
3. Transmission Line and Modeling
4. Studying the transient stability of a power system and comparing the same with results from ETAP.

This software is also being used by the B. Tech. and M. Tech students for design and verification of all types of power system problems. Students are also using this software for their minor and major projects as evidenced above.

Numerical Relays

B. Tech. and M. Tech students will test these relays also along with the other relays as part of their curriculum.

The following are the experiments on numerical relays:

1. Understanding basic features of numerical relays and related software.
2. Understanding interfacing numerical relays with systems.
3. To study the characteristics of IDMT non-directional and directional overcurrent relay and earth fault relay using numerical relay
4. To study the characteristics of numerical motor protection relay

Phantom Load Test Set will also be kept in Lab 1: **Real Time Power System Laboratory**. This is utilized in practical classroom teaching of students for testing of energy meter and trivector meter.