PROPOSAL DETAILS

(CRG/2019/001210)

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Technical Details :

Scheme :	Core Research Grant		
Research Area :	Civil Engineering (Engineering Sciences)		
Duration :	36 Months	**Contact No :**	+919434147950
Date of Birth :	11-Nov-1979		
Nationality :	INDIAN	**Total Cost (INR) :**	35,38,800

Is PI from National Laboratory/Research Institution ? No

Project Summary :

Mathematical theory for Oscillatory pumping tests will be developed for different conditions. A Laboratory scale confined/unconfined aquifer will be built in the in the laboratory of Hydraulic and Water Resources Engineering at the Department of Civil Engineering, IIT Kharagpur. The laboratory physical model will be built within a box. The aquifer built in this way will be provided with a testing well along with monitoring wells. Oscillatory pumping tests will be conducted in the testing well and data (i.e. pressure responses) regarding the test will be recorded in the monitoring wells. The noisy data will be smoothed. The smoothed data will be passed through a mathematical model to estimate aquifer parameters. A control system will be developed for Oscillatory pumping tests.

Objectives :

• Development of the theoretical and experimental framework for oscillatory pumping tests in laboratory scale sandbox model.
• Design of control system to implement the theoretical discharge and response mechanism for oscillatory pumping tests.
• Development of design procedure for oscillatory pumping tests.

Keywords :
Groundwater Modeling, Oscillatory pumping tests, Aquifer, Wells, Hydraulic conductivity

Expected Output and Outcome of the proposal :

The following are the expected output or outcome of the proposal I. Design procedure for oscillatory pumping tests under different conditions (e.g., delayed yield, aquifer setup, the penetration level of a well) II. Guideline for upscaling of the model test results. III. Control system for oscillatory pumping tests.

SNo.	CO-PI Details	
1		**Suman Maiti** sumanmaiti@gmail.com Assistant Professor(Department of Electrical Engineering) **Indian Institute of Technology Kharagpur** Kharagpur, WEST BENGAL, KHARAGPUR

Project Proposal

On

Design and Development of Oscillatory Aquifer Pumping Tests System at Laboratory scale with Implication to Field Scale

Submitted to

Science and Engineering Research Board (SERB)

Department of Science & Technology

GOVERNMENT OF INDIA

Principal Investigator

Dr. Anirban Dhar

Associate Professor

Department of Civil Engineering

Indian Institute of Technology Kharagpur

Co-Principal Investigator

Dr. Suman Maiti

Assistant Professor

Department of Electrical Engineering

Indian Institute of Technology Kharagpur

1. Origin of the Proposal

Aquifer characterization (i.e. Estimation of aquifer flow properties which include hydraulic conductivity (K), specific storage (S_s), specific yield (S_y) for unconfined aquifer and transmissivity (T), Storage coefficient (S) for confined aquifer) is generally done through two field experiments a) constant-rate pumping tests b) slug tests.

In constant-rate pumping test the testing well is pumped at a constant rate and drawdown is measured in one or more surrounding observation wells. Constant-rate pumping tests are of two types a) Steady state pumping test b) Unsteady state pumping test. Constant-rate pumping test possess many disadvantages:

i) In steady state pumping tests steady state flow condition can be reached after long pumping time.

ii) Hydraulic conductivity (K), among all other aquifer parameters, can be determined by steady state pumping tests.

iii) Generally the number of observation wells, required to conduct the steady and unsteady state pumping tests, are more to have the proper drawdown curve.

iv) The steady and unsteady state pumping tests are costly.

v) The risk of possible contaminated flow is very high.

Slug tests consist of an abrupt addition (extraction or displacement) of a known water volume in the well and the subsequent monitoring of changes in the water level (hydraulic head) as initial equilibrium conditions return. Although aquifer parameters estimated through slug test are more vulnerable to errors and uncertainty (Aristodemo et al. 2018).

Oscillatory pumping is used for aquifer characterization. In oscillatory pumping test aquifer hydraulic properties are estimated using sinusoidal pumping. During one cycle of sinusoidal pumping fluid is injected for first half a period and then extracted next half a period. The data regarding the hydraulic head are recorded in the monitoring wells. Oscillatory pumping tests have several the other advantages over traditional pumping tests (Cardiff et al. 2013; Cardiff et al. 2015) :

i) Oscillatory pumping tests require less time compare to other traditional pumping tests.

ii) The number of observation wells required in oscillatory pumping test is less compare to that of other pumping tests.

iii) Oscillatory pumping tests are more economical compare to the other traditional pumping tests.

iv) The risk of possible contaminated flow is very low.

(v) Oscillating signals of known frequency can be easily separated from noise and drift.

For these reasons Oscillatory pumping test has been chosen for aquifer characterization.

2. Review of status of Research and Development in the subject

2.1 International status

Unlike constant rate pumping test, in oscillatory pumping test aquifer hydraulic properties are estimated using sinusoidal pumping. During one cycle of sinusoidal pumping fluid is injected for first half a period and extracted next half a period.

Cooper et al. (1965) derived an analytical solution of sinusoidal pumping for confined aquifer for partially penetrating wells.

Black and Kipp (1981) derived an analytical solution for an aquifer borehole test for sinusoidal pumping in a confined non-leaky aquifer. Solutions are provided for both a point source (i.e., a well screened over a very small section relative to the entire thickness of an aquifer) and a line source (i.e., a well screened over the entire thickness of the aquifer). Complex exponential function was used to represent the sinusoidal pumping rate.

Rasmussen et al. (2003) derived analytical solutions of sinusoidal pumping for confined aquifer, leaky aquifer and partially penetrating conditions in confined aquifer. Using sinusoidal pumping and derived analytical solutions estimated aquifer parameters at the Savannah River site, South Carolina, USA.

Dagan and Rabinovich (2014) derived an analytical solution of the sinusoidal pumping by a partially penetrating well in a homogeneous and anisotropic unconfined aquifer.

Cardiff et al. (2013) used several sinusoidal signals of different frequencies as stimulation for oscillatory pumping test to estimate heterogeneity properties of aquifer (i.e., estimation of hydraulic conductivity K and Storage coefficient S).

Bakhos et al. (2014) have done denoising of oscillatory signals under various types of noise.

Cardiff and Barrash (2015) presented analytical methods for design and analysis of oscillatory pumping tests. The method was choosing testing frequencies and flow rates which maximize the signal amplitude with given design constraints.

Rabinovich et al. (2015) conducted in situ oscillatory pumping tests at the Boise Hydrogeophysical Research Site. They estimated aquifer properties (i.e., hydraulic conductivity K, specific storage S_s, specific yield S_y) using the analytical solution given by Dagan and Rabinovich (2014) and field data.

Zhou et al. (2016) performed the oscillatory pumping tests of several frequencies in laboratory scale sand box model. They used steady periodic ground water flow model and geostatistical inversion method to determine heterogeneous aquifer properties.

Marco et al. (2017) conducted in situ Oscillatory pumping test of a well field located at the campus of Science and Technology of the University of Parma (Northern Italy). They simplified the injection and extraction process using a square wave with constant flow rate. They used Ground water flow model developed by means of MODFLOW 2015 and Bayesian Geostatistical approach to estimate hydraulic conductivity K and Storage coefficient S of the field.

Aristodemo et al. (2018) conducted different slug tests in a laboratory model of confined aquifer at the University of Calabria. Noisy hydraulic head data was smoothed using Savitzky-Golay filter, Fourier Transform, and two types of Wavelet Transform Mexican hat and Morlet. The smoothed hydraulic heads were used to determine the hydraulic conductivity of the aquifer.

Fallico et al. (2018) presented a methodological approach to quantify the exponent of a power law to determine the spatial distribution of the hydraulic conductivity.

2.2 National Status

Till date no study is available for laboratory scale sand-box experiment and in situ test of Oscillatory pumping test problem.

2.3 Importance of the proposed project in the context of current status

Till date Indian standard regarding pumping test IS 14476 (parts 1 to 9) only address constant-rate pumping tests which have many limitations as stated before. In context of present scenario water scarcity is global problem. In this respect constant- rate pumping test consumes a large amount of ground water which reduces ground water table which has severe effects on environment.

On the other hand oscillatory pumping test do not consumes any ground water. Hence there is no risk of lowering ground water table. Only Cardiff and Barrash (2015) presented an analytical method for design and analysis of oscillatory pumping tests. But still there is neither any standard design procedure nor any standard instrument or controlling systems is available for oscillatory pumping tests.

Dagan and Rabinovich (2014) derived an analytical solution of the sinusoidal pumping of a partially penetrating well in a homogeneous and anisotropic unconfined aquifer. But delayed gravity response, which is an important phenomenon for flow to a well in an unconfined aquifer in pumping test, was not considered. Till today analytical solution of the sinusoidal pumping for fully penetrating well has not been derived.

2.4 If the project is location specific, basis for selection of location be highlighted:

A laboratory scale experimental set-up of confined/unconfined aquifer will be built in the in the laboratory of Hydraulic and Water Resources Engineering at the Department of Civil Engineering, IIT Kharagpur. It is laboratory experiment of oscillatory pumping tests. For conducting the experiment, it requires electricity, water supply facilities, small electrical gadgets, spare parts for experimental set-up, maintenance and repairs facilities, maintaining the temperature so that all controlling systems work properly along with other laboratory facilities. For all these reason the laboratory of Hydraulic and Water Resources Engineering at the Department of Civil Engineering, IIT Kharagpur has been chosen.

3. Work Plan

3.1 Methodology

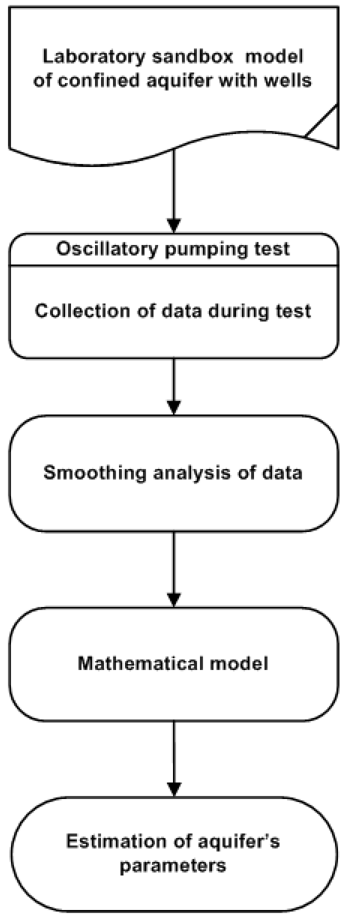

Figure 1: Schematic presentation of aquifer Characterization of laboratory sand box model

Laboratory Sand Box Model of Conned Aquifer with Wells:

Laboratory Sand Box Model of confined aquifer will be constructed as per Laboratory scale Sand Box Model of confined aquifer of slag test given in Aristodemo et al. (2018). The laboratory physical model will be built within a box made with Plexiglas with a square bottom of side of 2 m with a height of 1 m. The water will flow into the box through connections with two external loading reservoir placed on the opposite sides of the box (only one external loading reservoir shown in Figure 2). Along the entire perimeter of the box, at a distance of 5 cm from the vertical walls, a fine wire mesh will be fixed.

A geo-textile will be used covering entire the wire mesh which will prevent the porous material from passing through the wire mesh. The wells will be made of smooth PVC pipes (Polyvinyl Chloride) with a length of 1 m and diameter of 2.8 cm. The wells will be perforated along the thickness of the confined aquifer and appropriately covered with geo-textile to prevent soil particles from entering. The centrally placed well (well no. 1 in Figure 3) will be testing well. The observation wells (well no. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 in Figure 3) are placed at a radial distance either 0.4 m or 0.8 m from the testing well. Starting from the bottom of the box, a layer of porous material, with a thickness equal to 0.25m, will be placed to form the confined aquifer on which the experimental tests will be conducted. Top of the confined aquifer will be provided with plexiglas pertaining as top impervious layer and sandy material will be placed above this impervious layer pertaining as unconfined aquifer. Submersible pressure transducers will be placed at the end of each well. A pumping unit, which consists of a BLDC motor, a reversible pump, C2000 DSP controller, PC, Raspberry-Pi based Display system, IGBT based converter system with protection, is connected with the central testing well.

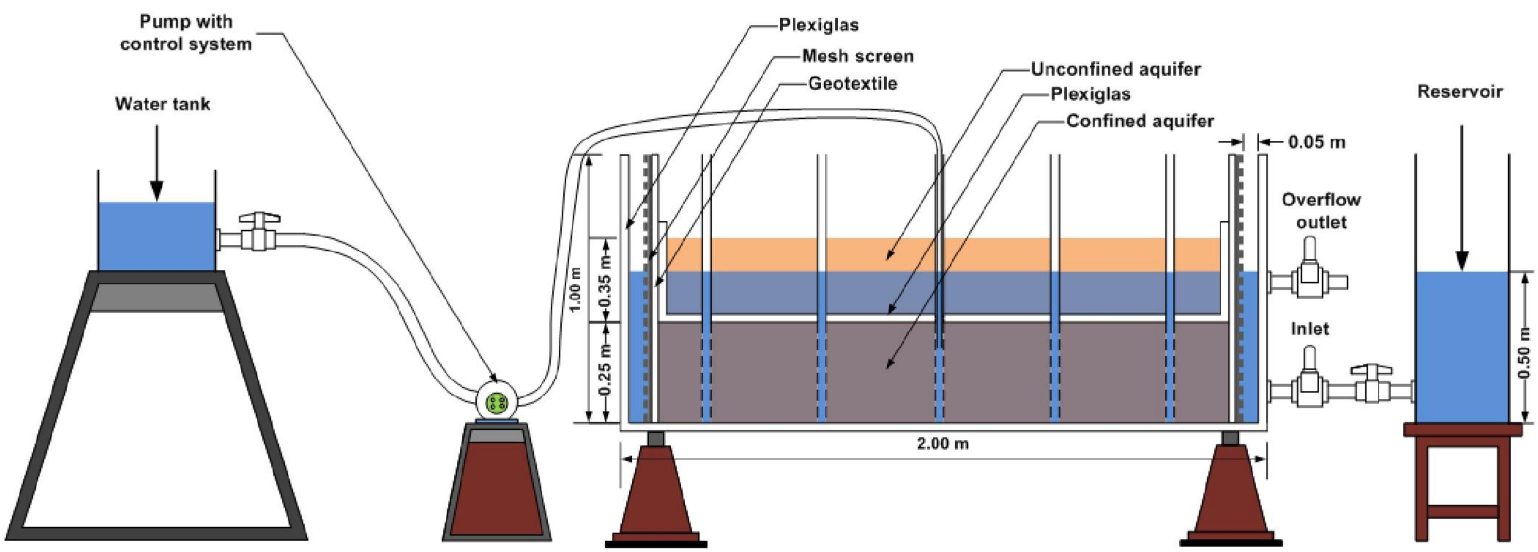

Figure 2: Laboratory Sand-box setup of confined aquifer

Oscillatory Pumping Test and Collection of Data:

Oscillatory pumping will be conducted in the testing well and data regarding pressure responses will be collected during the test using pressure transducer, located at the bottom of each monitoring well.

Smoothing Analysis of Data:

The noisy data will be smoothed using Fourier transform (Bakhos et al., 2014).

Mathematical Model and Estimation of Aquifer Parameters:

Mathematical model consists of MODFLOW and Geostatistical model. The smoothed data will be feed in this mathematical model to get tomography of aquifer parameters.

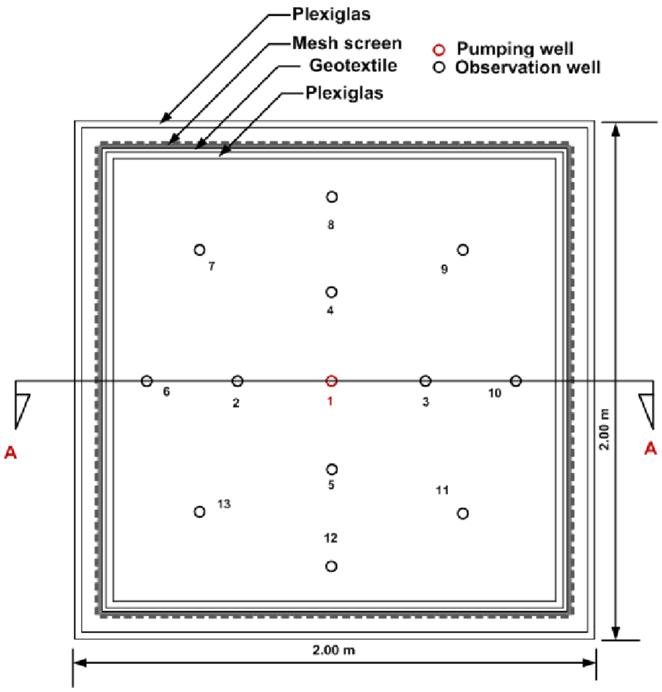

Figure 2: Plan view of the arrangement of the pumping and observation wells

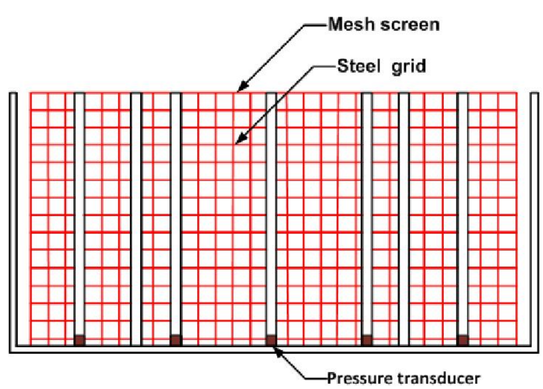

Figure 3: Section A-A without having geotextile on mesh screen

Ground Water Flow Equation for Unsteady Radial Flow for Oscillatory Pumping In Confined Aquifer

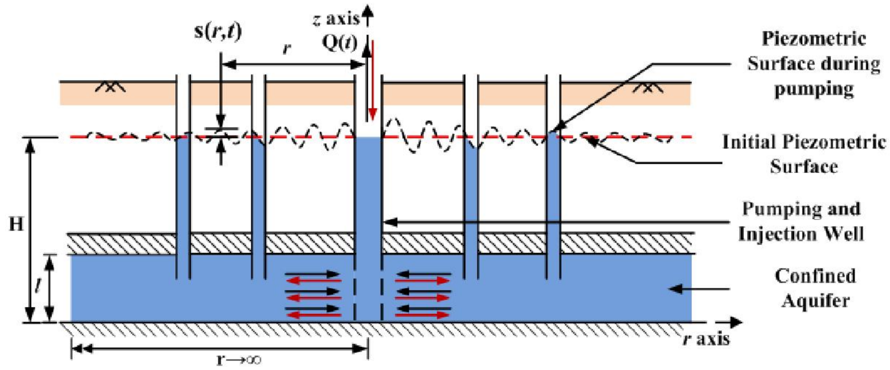

Figure 4: Oscillatory pumping test

Ground water flow equation for unsteady radial flow in confined aquifer is

$$\frac{\partial^2 s}{\partial r^2} + \frac{1}{r}\frac{\partial s}{\partial r} = \frac{S}{T}\frac{\partial s}{\partial t} \qquad \forall t = 0, r \in \Omega$$

Flow rate (Black and Kipp, 1981; Rasmussen et al., 2003)

$$Q(t) = Q_0 \exp(i\omega t)$$

Where $s = s(r,t)$ is drawdown. Q_0 is peak flow rate. s is specific storage. $T = Kl$ is transmissivity. H is initial uniform piezometric head.

Boundary Condition of Oscillatory Pumping Test in Confined Aquifer

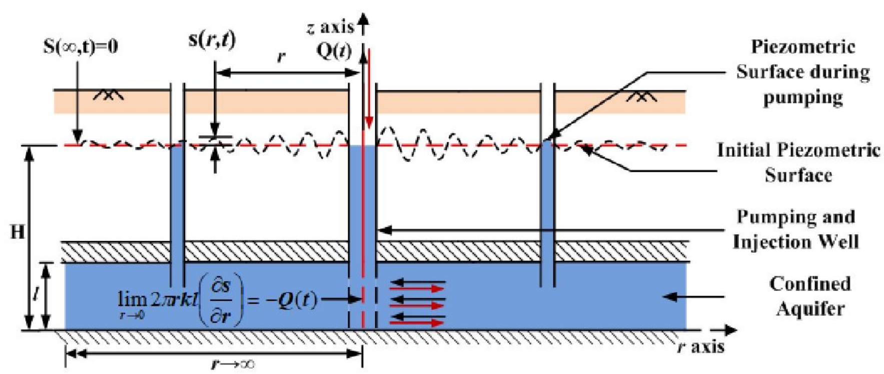

Figure 5: Boundary conditions of oscillatory pumping test in a confined aquifer

Initial condition (Black and Kipp, 1981; Rasmussen et al., 2003):

$$s(r,0) = 0 \qquad t = 0, \forall r \geq 0$$

Boundary conditions (Black and Kipp, 1981; Rasmussen et al., 2003):

Boundary conditions of drawdown at infinity:

$$s(\infty, t) = 0 \qquad \forall t = 0, r \to \infty$$

Boundary conditions at periodic line source:

$$\lim_{r\to 0} 2\pi r l \left(k \frac{\partial s}{\partial r}\right) = -Q_0 \exp\,(i\omega t) \qquad \forall t = 0, r \to 0$$

Solution of 2D Unsteady Radial Flow Equation for Oscillatory Pumping Tests

The steady periodic solution to the equations (Black and Kipp, 1981):

$$s(r,t) = \frac{Q_0}{2\pi T} K_0 \left[\left(\frac{r^2 S\omega i}{T}\right)^{\frac{1}{2}}\right] \exp\,(i\omega t)$$

$$s(r,t) = G(r,\omega) \exp\,(i\omega t)$$

Amplitude (Black and Kipp, 1981):

$$|G(r,\omega)| = \frac{Q_0}{2\pi T} N_0 \left[\left(\frac{r^2 S\omega i}{T}\right)^{\frac{1}{2}}\right]$$

Phase shift (Black and Kipp, 1981):

$$\emptyset = \emptyset_0 \left[\left(\frac{r^2 S\omega i}{T}\right)^{\frac{1}{2}}\right]$$

Where K_0 is the modified Bessel function of second kind. $\mathrm{G(r,\omega)}$ is complex frequency function. $|\mathrm{G(r,\omega)}|$ is amplitude of complex frequency function. N_0 is amplitude of Kelvin functions. $\emptyset_0$ is phase angle of the kelvin functions.

3.2 Time Schedule of activities giving milestones through BAR diagram

Milestones of activities	**First Year**				**Second Year**				**Third Year**			
Purchasing of Equipments												
Installation of laboratory scale experimental setup- Sand-box experimental setup												
Run Experiments: Conducting the oscillatory pumping test and experimental data collection												
Mathematical modeling and analysis												
Preparation and submission of reports and publication												

3.3 Suggested Plan of action for utilization of research outcome expected from the project

Laboratory scale experiments will be upscaled for field level experiments. A standard design method will be formulated for in-situ oscillatory pumping tests. Moreover, the developed control system can be suitably modified to perform field scale tests. In future the overall methodology will be useful for in-situ oscillatory pumping tests.

3.4 Environmental impact assessment and risk analysis

(i) Oscillatory pumping tests help to avoid risks associated with handling and treating significant amounts of contaminated water, relative to traditional pumping tests (Cardiff et al. 2015).

(ii) Oscillatory pumping tests of reasonable amplitudes do not cause significant contaminant plume movement, relative to traditional pumping tests, since the average flow velocity induced by such pumping is zero in all directions (Cardiff et al. 2015).

4. Expertise

4.1 Expertise available with the investigators in executing the project

Anirban Dhar (PI)

Dr. Dhar has more than 10 years of research experience and working in the areas of Groundwater Hydrology, Numerical Modeling. He has published 40+ research articles in SCI journals. He has developed number of numerical and analytical models to study the groundwater movement in porous media. Moreover, he has worked on experimental groundwater hydraulics. As a Co-consultant to the Tata Steel Limited, he has identified seepage sources From CRM Bara complex of Jamshedpur. Dr. Dhar has completed 2 sponsored research projects funded by SERB-DST and CWC. He has successfully completed more than 6 consultancy projects. Overall, Dr. Dhar has experience in conducting model tests and developing numerical or analytical models that has of specific interest to the present project.

Suman Maiti (Co-PI)

Dr. Suman Maiti, a Co-PI of this project has experience to work on Electric Machine Drives for more than ten years. He defended his PhD thesis on the speed estimation of induction machine drives and associated control issues. His research interests include High Performance Machine Drives and Power Electronics. His one of the research articles on this area has been selected for prize paper award by IEEE-IES in 2008.

Dr. Maiti is now actively engaged in the research on medium voltage induction machine drives using high power Converters. He is also engaged with an industry-institute project where research is involved on propulsion and energy management system for electric vehicles. He is also working on the development of new power electronic converter topologies for renewable energy integration along with energy storage support.

Dr. Maiti has experience of about five years to work in the R&D division of ABB Ltd. as an Associate scientist. During this period, he was engaged in the research activities related to high power converters (especially, the modular multilevel converters) and their grid integration. He was actively associated to some technology development projects in ABB, one of them is “Evaluation of converter topologies for HVDC and FACTS application including energy storage”. He owns some international patents, invention disclosers and technical reports on this area.

4.2 Summary of roles/responsibilities for all Investigators

S. No.	Name of the Investigators	Roles/Responsibilities
1	Anirban Dhar (PI)	Experimental and mathematical investigation of oscillatory pumping test models
2	Suman Maiti (Co-PI)	Design of control system as per requirement of the oscillatory pumping test

4.3 Key publications published by the Investigators pertaining to the theme of the proposal during the last 5 years

Anirban Dhar (PI)

Journals:

[1] Selva Balaji Munusamy, Anirban Dhar: *On Use of Expanding Parameters and Auxiliary Term in Homotopy Perturbation Method for Boussinesq Equation with Tidal Condition*. Environmental Modeling and Assessment 10/2018;, DOI:10.1007/s10666-018-9636-0

[2] Selva Balaji Munusamy, Anirban Dhar: *Analytical solution of groundwater waves in unconfined aquifers with sloping boundary*. Sadhana 07/2017;, DOI:10.1007/s12046-017-0695-8

[3] Selva Balaji Munusamy, Anirban Dhar: *Homotopy Perturbation Method-Based Analytical Solution for Tide-Induced Groundwater Fluctuations*. Ground Water 05/2016; 54(3), DOI:10.1111/gwat.12371

Suman Maiti (Co-PI)

Patent:

[4] A. Bharadwaj and S. Maiti, “Modular Multilevel STATCOM with Hybrid Energy Storage System”, Filed, Indian Patent, Appl.No:201931004757.

[5] A. Bharadwaj and S. Maiti, “Integration of Hybrid Energy Storage System using Modular Multilevel Converter for High Power Applications,” Filed (Ref : PCT/EP2015/057244)

[6] Suman Maiti *et. al*., “Voltage source converter and associated method”, Filed (Ref : PCT/EP2014/069532)

[7] Suman Maiti *et. al*., “Method and device for damping voltage harmonics in multilevel power converter,” Filed (Ref : PCT/EP2015/057244)

[8] Suman Maiti *et. al*., “Method and device for damping voltage harmonics in multilevel power converter,” Filed (Ref : PCT/EP2015/060873)

Journals:

[1] Umamaheswar Rao V., **Suman Maiti**, Chandan Chakraborty and Bikash Pal, “Series Voltage Regulator for DC Microgrid” *IEEE Transaction on Sustainable Energy*, 2017.

[2] Umamaheswar Rao V., **Suman Maiti**, Chandan Chakraborty, "Load Flow Control in DC microgrids," *IEEE Transaction on Smart Grids*, 2018.

[3] Tuhin S. Basu, Suman Maiti, "A Hybrid Modular Multilevel Converter for Solar Power Integration," IEEE IAS Magazine, In-press.

[4] Analysis and Control of Modular Multilevel Converter based E-STATCOM to integrate Large Wind Farms with the Grid," IET Generation Transmission Distribution, Accepted for publication.

[5] **Suman Maiti**, Vimlesh Verma, Chandan Chakraborty and Yoichi Hori, "An Adaptive Speed Sensorless Induction Motor Drive with Artificial Neural Network for Stability Enhancement" *IEEE Transaction on Industrial Informatics*, vol. 8, no. 4, pp 757-766, 2012.

[6] **Suman Maiti** , Chandan Chakraborty, Yoichi Hori and Minh-C Ta, "Model Reference Adaptive controller based rotor resistance and speed estimation techniques for vector controlled induction motor drives utilizing reactive power," *IEEE Trans on Industrial Electronics*, vol. 55, No. 2, pp. 594-601, Feb. 2008

[7] A. V. Ravi Teja, Chandan Chakraborty, **Suman Maiti** and Yoichi Hori, "A New Model Reference Adaptive Controller for Four Quadrant Vector Controlled Induction Motor Drives," *IEEE Trans on Industrial Electronics*, vol. 59, No. 10, pp. 3757-3767, Oct. 2012.

[8] Vimlesh Verma, Chandan Chakraborty, **Suman Maiti** and Yoichi Hori, "Speed sensorless vector controlled induction motor drive using single current sensor," *IEEE Transaction on Energy Conversion,* vol. 28, No. 4, pp. 938-950, Dec. 2013

[9] **Suman Maiti** and Chandan Chakraborty and Sabyasachi Sengupta, "Simulation Studies on MRAC-Based Speed Estimation Technique for the Vector Controlled Permanent Magnet Synchronous Motor Drive" *Elsevier Journal of Simulation Modeling Practice and Theory, Elsevier*, vol. 16, No. 4, pp. 585-596, 2009.

[10] **Suman maiti** and Chandan Chakraborty, "A New Instantaneous Reactive Power Based MRAS for Sensorless Induction Motor Drive", Elsevier Journal of *Simulation Modelling Practice and Theory, Elsevier*, vol. 18, pp. 1314–1326, 2010.

4.4 Bibliography

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Cardiff, M., Bakhos, T., Kitanidis, P. K., and Barrash, W. (2013). Aquifer heterogeneity characterization with oscillatory pumping: sensitivity analysis and imaging potential. Water Resources Research, 49(10):5395–5410.

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Dagan, G. and Rabinovich, A. (2014). Oscillatory pumping wells in phreatic, compressible, and homogeneous aquifers. Water Resources Research, 50(8):7058–7066.

Fallico, C., Ianchello, M., Bartolo, S. D., and Severino, G. (2018). Spatial dependence of the hydraulic conductivity in a well-type configuration at the mesoscale. Hydrological Processes, 32(4):590–595.

Marco, D., Andrea, Z., and Fausto, C. (2017). Oscillatory pumping test to estimate aquifer hydraulic parameters in a bayesian geostatistical framework. Mathematical Geosciences.

Rabinovich, A., Barrash, W., Cardiff, M., Hochstetler, D. L., Bakhos, T., Dagan, G., and Kitanidis, P. (2015). Frequency dependent hydraulic properties estimated from oscillatory pumping tests in an unconfined aquifer. Journal of Hydrology, 531:2–16.

Rasmussen, T. C., Haborak, K. G., and Young, M. H. (2003). Estimating aquifer hydraulic properties using sinusoidal pumping at the Savannah River site, South Carolina, USA. Hydrogeology Journal, 11(4):466–482.

Zhou, Y., David, L., Fausto, C., and Cardiff, M. (2016). Aquifer imaging with pressure waves—evaluation of low-impact characterization through sandbox experiments. Water Resources Research, 52:2141–2156.

5. List of Projects submitted/implemented by the Investigators

5.1 Details of Projects submitted to various funding agencies

Anirban Dhar (PI)

S. No.	Title	Cost in Lakh	Month of submission	Role as PI/Co- PI	Agency	Status
1	Integrated Water Resources Management Studies in respect of Subarnarekha River Basin under Development of Water Resources Information System Scheme	Rs. 1051.42 Lakhs	Jan 2019	Co-PI	Central Water Commission, INDIA	No Information Available

5.2 Details of Projects under implementation

Anirban Dhar (PI)

S. No.	Title	Cost in Lakh	Duration	Role as PI/Co-PI	Agency
1	Preparation of State-Specific Action Plan for Water Sector in West Bengal	Rs. 5000000.00	2017-2019	Co-PI	Department of Water Resources investigation and Development, Government of West Bengal

2	Morphological Studies of Rivers Mahanadi, Mahananda and Hooghly	Rs. 14646268.00	2016-2019	Co-PI	Central Water Commission, Morphology Directorate

Suman Maiti (Co-PI)

S. No.	Title	Cost in Lakh	Duration	Role as PI/Co-PI	Agency
1.	Modular Multilevel Converter-fed Medium Voltage Induction Motor Drives	45 Lacs	3 years	PI	DST
2.	Energy Storage Integration at High Power Level	65 Lacs	3 years	PI	DST

5.3 Details of Projects completed during the last 5 years

Anirban Dhar (PI)

S. No.	Title	Cost in Lakh	Duration	Role as PI/Co- PI	Agency
1	Physical And Mathematical Modeling Of Tidal Influence On Seawater Transport Through Porous Media Laboratory Scale With Implications To Field Scale	Rs. 2266000	2014-2017	PI	SERB-DST
2	Efficiency Study of Damodar Left Bank Irrigation System and Strategies for Integrated Command Area Water Management	Rs. 4696135	2012-2018	PI	MINISTRY OF WATER RESOURCES,NEW DELHI
3	STUDY OF WATER SEEPAGES FROM CRM BARA	Rs. 2760000	2016-2018	Co-PI	TATA Steel, Jamshedpur

Suman Maiti (Co-PI)

S. No.	Title	Cost in Lakh	Duration	Role as PI/Co-PI	Agency
1.	Solar power integration	28 Lacs	3 years	PI	IIT Kharagpur

	with the grid at high power level				
2.	Reliable and Efficient System for Community Energy Solution (RESCUES) (a collaborative project involving IIT Kharagpur, IIT Delhi, IIT Madras, VNIT Nagpur and DTU and three UK side institutions)	Rs.539 Lacs (for IIT Kharagpur)	3 years	Co-PI	DST (in collaboration with RC UK)

6. List of facilities being extended by parent institution for the project implementation

6.1 Infrastructural Facilities

Sr. No.	Infrastructural Facility	Yes/No/ Not required Full or sharing basis
1	Workshop Facility	Yes
2	Water & Electricity	Yes
3	Laboratory Space/ Furniture	Yes
4	Power Generator	Yes
5	AC Room or AC	Yes
6	Telecommunication including e-mail & fax	Yes
7	Transportation	Yes
8	Administrative/ Secretarial support	Yes
9	Information facilities like Internet/ Library	Yes
10	Computational facilities	Yes
11	Animal/ Glass House	Not required
12	Any other special facility being provided	Not required

6.2 Equipment available with the Institute/ Group/ Department/ Other Institutes for the project

Equipment available with	Generic Name of Equipment	Model, Make & year of purchase	Remarks including accessories available and current usage of equipment
PI & his group	Data Acquisition System with Pressure transducers	NI and Honeywell (2016)	Available for full time

7. Name and address of experts/ institution interested in the subject /outcome of the project

Water Investigation Departments of various states, CGWB and various research institutes will be benefited from the outcome of the project.

Budget Details

Institution wise Budget Breakup :

Budget Head	Indian Institute of Technology Kharagpur	Total
Manpower	11,64,000	**11,64,000**
Consumables	2,80,000	**2,80,000**
Travel	1,50,000	**1,50,000**
Equipment	12,05,000	**12,05,000**
Contingencies	1,50,000	**1,50,000**
Other cost	0	**0**
Overhead	5,89,800	**5,89,800**
Total	**35,38,800**	**35,38,800**

Institute Name : *Indian Institute of Technology Kharagpur*

Year Wise Budget Summary (Amount in INR) :

Budget Head	Year-1	Year-2	Year-3	Total
Manpower	3,72,000	3,72,000	4,20,000	**11,64,000**
Consumables	1,50,000	80,000	50,000	**2,80,000**
Travel	50,000	50,000	50,000	**1,50,000**
Equipments	12,05,000	0	0	**12,05,000**
Contingencies	50,000	50,000	50,000	**1,50,000**
Other cost	0	0	0	**0**
Overhead	3,65,400	1,10,400	1,14,000	**5,89,800**
Grand Total	**21,92,400**	**6,62,400**	**6,84,000**	**35,38,800**

Manpower Budget Detail(Amount in INR) :

Designation	Year-1	Year-2	Year-3	Total
JRF/SRF *JRF/SRF is required for performing experiments and analysis of data.*	3,72,000	3,72,000	4,20,000	**11,64,000**

Consumable Budget Detail (Amount in INR) :

Justification	Year-1	Year-2	Year-3	Total
The amount is requested for the purchase and transportation of the materials such as plexiglas, wire mesh, geo-textile, smooth PVC pipes for wells, pipes to facilitate water flow, porous material (i.e., sand, gravel), water tanks (i.e., reservoirs), supports for experimental set-up, supports for water tanks, supports for pumps, supports for control systems of pumps, different inlets and outlets needed to perform the experiments. Small electrical items required for experiments.	1,50,000	80,000	50,000	**2,80,000**

Travel Budget Detail (Amount in INR) :

Justification (Inland Travel)	Year-1	Year-2	Year-3	Total
This amount is necessary for attending project meetings, a few National and International (conducted in India) Conferences in the specified area.	50,000	50,000	50,000	**1,50,000**

Equipment Budget Detail (Amount in INR) :

Generic Name ,Model No. , (Make)/ Justification	Quantity	Spare time	Estimated Cost
Digital storage Oscilloscope (GENERIC) *To capture/store/analysis of data and waveforms during laboratory experiments*	1	30 %	**2,50,000**
PCB Fabrication (GENERIC) *For control system design*	1	30 %	**50,000**
Peristaltic Pump (GENERIC) *To supply water for inflow/outflow in the model*	2	30 %	**2,20,000**
C2000 DSP controller (GENERIC) *To implement control algorithms in real time platform*	1	30 %	**75,000**
Sensors (Voltage, Current & Speed) (GENERIC) *The sensors are required to measure voltage, current, and speed in the experimental prototype.*	1	30 %	**50,000**
IGBT based converter system with protection (GENERIC) *To control the BLDC motor according to the desired speed profile*	1	30 %	**1,00,000**
Reversible pump and BLDC Motor (GENERIC) *To facilitate controlled sinusoidal freshwater flux*	1	30 %	**1,50,000**
Personal Computer (GENERIC) *To perform computation, data analysis and to establish an interface with the DSP*	1	30 %	**60,000**
Pressure transducer (HONEYWELL) *To collect water pressure in the porous medium to determine water table*	2	30 %	**2,50,000**

Contingency Budget Detail (Amount in INR) :

Justification	Year-1	Year-2	Year-3	Total
Contingency will cover cost of repairs, information search and acquiring important literature, stationeries, secretarial expenses for publication and report preparation and unseen expenses.	50,000	50,000	50,000	**1,50,000**

Overhead Budget Detail (Amount in INR) :

Justification	Year-1	Year-2	Year-3	Total
20% as per institute guidelines	3,65,400	1,10,400	1,14,000	**5,89,800**

Other Budget Detail (Amount in INR) :

Description/Justification	Year-1	Year-2	Year-3	Total
NA NA	0	0	0	**0**

BIODATA

1. **Name and full correspondence address:**

Anirban Dhar

Associate Professor
Department of Civil Engineering
Indian Institute of Technology Kharagpur
Kharagpur-721302, WB, INDIA

2. **Email(s) and contact number(s):**

Mobile Phone: +91-9434147950
Phone: 03222-283432 | Fax: 03222-282254
email: anirban@civil.iitkgp.ac.in; anirban.dhar@gmail.com

3. **Institution:** Indian Institute of Technology Kharagpur

4. **Date of Birth:** 11th Nov 1979

5. **Gender (M/F/T):** M

6. **Category Gen/SC/ST/OBC:** Gen

7. **Whether differently abled (Yes/No):** No

8. **Academic Qualification (Undergraduate Onwards):**

	Degree	Year	Subject	University/Institution	% of marks
1.	B.E.	2002	Civil Engineering	University of North Bengal/ Jalpaiguri Government Engineering College	82.64 %
2.	M.Tech	2004	Civil Engineering	IIT Kanpur	8.73/10 (CPI)
3.	Ph.D.	2008	Civil Engineering	IIT Kanpur	10/10 (CPI)

9. **Ph.D thesis title, Guide's Name, Institute/Organization/University, Year of Award:**

Ph.D. Thesis Title: "Optimal Management and Monitoring of Coastal Aquifers and Other Contaminated Aquifers**"**
Guide's Name: Prof. Bithin Datta
Institute: IIT Kanpur
Year of Award: 2008

10. **Work experience (in chronological order):**

S.No.	Positions held	Name of the Institute	From	To	Pay Scale
1.	Visiting Scholar	James Cook University, AUSTRALIA	Jul 2008	Dec 2008	
2.	Assistant Professor	I.I.T. Kharagpur	Dec 2008	Jan 2018	
3.	Associate Professor	I.I.T. Kharagpur	Jan 2018	-	

11. **Professional Recognition/ Award/ Prize/ Certificate, Fellowship received by the applicant:**

S.No	Name of Award	Awarding Agency	Year
1.	Young Scientist Award	INC-International Association of Hydrogeologists	2014
2.	IEI Young Engineer Award	The Institution of Engineers (India)	2014
3.	Endeavour Research Fellowship	Australian Govt.	2008

12. **Publications** (List of papers published in SCI Journals, in year wise descending order).

S.No.	Author(s)	Title	Name of Journal	Volume	Page	Year
1	Munusamy, S. B., and Dhar, A.	On Use of Expanding Parameters and Auxiliary Term in Homotopy Perturbation Method for Boussinesq Equation with Tidal Condition	Environmental Modeling & Assessment	24(1)	109-120	2019
2	Sahoo, S., Sil, I.,Dhar, A., Debsarkar, A. Das, P. and Kar, A	Future Scenarios of Land-Use Suitability Modeling for Agricultural Sustainability in a River Basin	Journal of Cleaner Production	205	313-328	2018
3	Pahar, G., and Dhar, A.	On modeling of MPS-based multiphase fluid flow with low density ratios	International Journal for Numerical Methods in Fluids	87(10)	529-542	2018
4	Pahar, G., and Dhar, A.	On force consideration in coupled ISPH framework for sediment transport in presence of free-surface flow	Environmental Fluid Mechanics	18	555–579	2018
5	Sahoo, S., Dhar, A. Debsarkar, A. and Kar, A.	Impact of Water Demand on Hydrological Regime under Climate and LULC Change Scenarios	Environmental Earth Sciences	77(9)	341	2018
6	Sahoo, M., Dhar, A., Kasot, A., and Kar, A.	Space-Time Cokriging Approach for Groundwater-Level Prediction with Multiattribute Multiresolution Satellite Data	Journal of Hydrologic Engineering	23(7)	05018012	2018
7	Sahoo, M., Kasot, A., Dhar, A.,	On predictability of groundwater level in shallow wells	Water Resources Management	32(4)	1225-1244	2018

	and Kar, A.	using satellite observations				
8	Pahar, G., Dhar, A., and Islam, M. R. I.	Extending Incompressible SPH framework for simulation of axisymmetric free-surface flows	Engineering Analysis with Boundary Elements	84	35-41	2017
9	Biswas, P., Dhar, A., and Sen, D.	A Numerical Simulation Model for Conjunctive Water Use in Basin Irrigated Canal Command Areas	Water Resources Management	31(12)	3993-4005	2017
10	Sahoo, S., Munusamy, S.B., Dhar, A. Kar, A. and Ram, P	Appraising the Accuracy of Multi-Class Frequency Ratio and Weights of Evidence Method for Delineation of Regional Groundwater Potential Zones in Canal Command System	Water Resources Management	31	4399-4413	2017
11	Munusamy, S.B., Dhar, A.	Analytical Solution of Groundwater Waves in Unconfined Aquifers with Sloping Boundary	Sadhana	42(9)	1571-1578	2017
12	Pahar, G., Dhar, A.	On Modification of Pressure Gradient Operator in Integrated ISPH for Multifluid and Porous Media Flow with Free-surface	Engineering Analysis with Boundary Elements	80	38-48	2017
13	Pahar, G., Dhar, A.	Numerical Modelling of Free-surface Flow-Porous Media interaction using Divergence-free Moving Particle Semi-Implicit Method	Transport in Porous Media	118(2)	157-175	2017
14	Sahoo, M., Das, T., Kumari, K., Dhar, A.	Space-Time Forecasting of Groundwater Level using Hybrid Soft Computing Model	Hydrological Sciences Journal	62(4)	561-574	2017
15	Pahar, G., Dhar, A.	Coupled incompressible Smoothed Particle Hydrodynamics model for continuum-based modelling sediment transport	Advances in Water Resources	102	84-98	2017
16	Pahar, G., Dhar, A.	Robust boundary treatment for open-channel flows in divergence-free	Journal of Hydrology	546	464-475	2017

		incompressible SPH				
17	Pahar, G., Dhar, A.	Mixed Miscible-Immiscible Fluid Flow Modelling with Incompressible SPH Framework	Engineering Analysis with Boundary Elements	73	50-60	2016
18	Pahar, G., Dhar, A.	A Robust Volume Conservative Divergence-free ISPH Framework for Free-surface Flow Problems	Advances in Water Resources	96	423-437	2016
19	Mandal, U., Sahoo, S., Munusamy, S.B., Dhar, A., Panda, S.N., Kar, A., Mishra, P.K.	Delineation of Groundwater Potential Zones of Coastal Groundwater Basin Using Multi-Criteria Decision Making Technique	Water Resources Management	30 (12)	4293-4310	2016
20	Pahar, G., Dhar, A.	Modeling free-surface flow in porous media with modified incompressible SPH	Engineering Analysis with Boundary Elements	68	75-85	2016
21	Sahoo, S.,Dhar, A., Kar, A., Ram, P	Grey Analytic Hierarchy Process Applied to Effectiveness Evaluation for Groundwater Potential Zone Delineation	Geocarto International	32(11)	1188-1205	2016
22	Sahoo, S., Dhar, A., Kar, A., Chakraborty, D.	Index-based groundwater vulnerability mapping using quantitative parameters	Environmental Earth Sciences	75	522	2016
23	Sahoo, S., Dhar, A., Kar, A.	"Environmental vulnerability assessment using Grey Analytic Hierarchy Process based model	Environmental Impact Assessment Review	56	145-154	2016
24	Dhar, A., Sahoo, S., Sahoo, M.	Identification of Groundwater Potential Zones Considering Water Quality Aspect	Environmental Earth Sciences	74(7)	5663-5675	2015
25	Munusamy, S.B., Dhar, A.	Homotopy Perturbation Method-Based Analytical Solution for Tide-Induced Groundwater Fluctuations	Ground Water	54(3)	440-447	2015
26	Dhar, A., Sahoo, S., Mandal, U.,Dey, S., Bishi, N., Kar, A.	Hydro-Environmental Assessment of A Regional Ground Water Aquifer: Hirakud Command Area (India)	Environmental Earth Sciences	73(8)	4165-4178	2015
27	Dhar, A., Sahoo, S.,	Evaluation of Recharge and	Natural Resources	23(4)	409-422	2014

	Dey, S., Sahoo, M.	Groundwater Dynamics of a Shallow Alluvial Aquifer in Central Ganga Basin, Kanpur (India)	Research			
28	Pahar, G., Dhar, A.	A Dry Zone-Wet Zone Based Modeling of Surface Water and Groundwater Interaction for Generalized Ground Profile	Journal of Hydrology	519	2215-2223	2014
29	Mandal, U., Dhar, A., Panda, S.N.	Integrated Land and Water Resources Management Framework for Hirakud Canal Subcommand (India) Using Gray Systems Analysis	Journal of Water Resources Planning and Management	139(6)	733-740	2012
30	Dhar, A., Patil, R.S	Multiobjective Design of Groundwater Monitoring Network Under Epistemic Uncertainty	Water Resources Management	26(7)	1809-1825	2012
31	Deb, K., Dhar, A.	Parameter Estimation for a System of Beams Resting on Stone Column-Reinforced Soft Soil	International Journal of Geomechanics	13(3)	222-233	2011
32	Datta, B.,Chakrabarty, D., Dhar, A.	Identification of unknown groundwater pollution sources using classical optimization with linked simulation	Journal of Hydro-environment Research	5(1)	25-36	2011
33	Dhar, A., Datta, B.	Logic-Based Design of Groundwater Monitoring Network for Redundancy Reduction	Journal of Water Resources Planning and Management	136(1)	88-94	2009
34	Dhar, A., Datta, B.	Saltwater Intrusion Management of Coastal Aquifers. II: Operation Uncertainty and Monitoring	Journal of Hydrologic Engineering	14(12)	1273-1282	2009
35	Dhar, A., Datta, B.	Saltwater Intrusion Management of Coastal Aquifers. I: Linked Simulation-Optimization	Journal of Hydrologic Engineering	14(12)	1263-1272	2009
36	Datta, B.,Vennalakanti, H., Dhar, A.	Modeling and Control of Saltwater Intrusion in a Coastal Aquifer of Andhra Pradesh, India	Journal of Hydroenvironment Research	3(3)	148-159	2009
37	Datta, B., Chakrabarty, D., Dhar,	Simultaneous identification of unknown	Journal of Hydrology	376	1-2-376	2009

	A.	groundwater pollution sources and estimation of aquifer parameters				
38	Dhar, A., Datta, B.	Global Optimal Design of Ground Water Monitoring Network Using Embedded Kriging	Ground Water	47(6)	806-815	2009
39	Datta, B., Chakrabarty, D., Dhar, A..	Optimal Dynamic Monitoring Network Design and Identification of Unknown Groundwater Pollution Sources	Water Resources Management	23(10)	2031-2049	2008
40	Dhar, A.., Datta, B.	Optimal operation of reservoirs for downstream water quality control using linked simulation optimization	Hydrological Processes	22(6)	842-853	2008
41	Dhar, A., Datta, B.	Multiobjective Design of Dynamic Monitoring Networks for Detection of Groundwater Pollution	Journal of Water Resources Planning and Management	133(4)	329-338	2007

13. **Detail of patents:** No Patents

14. **Books/Reports/Chapters/General articles etc.**:

S.No	Title	Author's Name	Publisher	Year of Publication
1	Density dependent flows, saltwater intrusion and management, In *Groundwater Quantity and Quality Management*, Edited by Mustafa M. Aral and Stewart W. Taylor	B. Datta and **A. Dhar**	ASCE, Environmental & Water Resources Institute	2011

15. **Any other Information (maximum 500 words):**

Served as:

- Member of Leadership Team of the IAHR (International Association for Hydro-Environment Engineering and Research) Groundwater Hydraulics and Management Committee (2017-2019).

- Member of Executive Council of Indian National Committee-International Association of Hydrogeologists (IAH) (2015-2016)

BIO-DATA

1. **Name and full correspondence address:** Dr. Suman Maiti
Assistant Professor
Department of Electrical Engineering
Indian Institute of Technology Kharagpur
Kharagpur - 721302
West Bengal

2. **Email(s) and contact number(s):** sumanmaiti@gmail.com
suman.maiti@ee.iitkgp.ernet.in
Mobile: +91 9734535243

3. **Institution:** Indian Institute of Technology Kharagpur

4. **Date of Birth:** 16/07/1979

5. **Gender (M/F/T):** M

6. **Category Gen/SC/ST/OBC:** Gen

7. **Whether differently abled (Yes/No):** No

8. **Academic Qualification (Undergraduate Onwards)**

Sl No.	Degree	Year	Subject	University	% of marks
1	Bachelor of Engineering	2002	Electrical Engineering	Jalpaiguri Govt. Enggineering College, Jalpaiguri	76.5
2	Master of Engineering	2004	Electrical Engineering (Control System Engineering)	Indian Institute of Engineering Science and Technology, Shibpur	79.8%
3	Ph.D.	2009	Electrical Engineering (Machine Drives and Power Electronics)	Indian Institute of Technology Kharagpur	NA

9. **Ph.D thesis title, Guide's Name, Institute/Organization/University, Year of Award.**

Ph.D thesis title	Guide's Name	Institute/ Organization/ University	Year of Award
Reactive Power Based Model Reference Adaptive System for Sensorless Indition Motor Drive	Prof. Chandan Chakraborty	Indian Institute of Technology Kharagpur	2009

10. Work experience (in chronological order)

Sl. No.	Position & Organization	Nature of Job	Period	Area of Work
1	Assistant Professor, IIT Kharagpur	Teaching and Research	2014(Nov.)- Till date	Machine Drives and Power Electronics
2	Associate Scientist, ABB Ltd.	R&D	2009-2014	HVDC & FACTS

11. Professional Recognition/ Award/ Prize/ Certificate, Fellowship received by the applicant

- **Best paper presentation** award in the 2nd National Power Electronics Conference, NPEC-2005.
- **Third Best Prize Paper** awarded by the IEEE-IES Electrical Machine Technical Committee, USA, 2009.

12. Publications (List of papers published in SCI Journals, in year wise descending order)

Sl. No.	Author(S)	Title	Name of Journal	Vol	Page	Year
1	V. Umamaheswararao, **S. Maiti, C. Chakraborty** and B. C. Pal	Series Voltage Regulator for Radial DC microgrid	IEEE Transactions on Sustainable Energy	**Early access**		**2018**
2	Vimlesh Verma, Chandan Chakraborty, **Suman Maiti** and Yoichi Hori	Speed sensorless vector controlled induction motor drive using single current sensor	*IEEE Transaction on Energy Conversion*	28	938-950	2013
3	**Suman Maiti**, Vimlesh Verma, Chandan Chakraborty and Yoichi Hori	An Adaptive Speed Sensorless Induction Motor Drive with Artificial Neural Network for Stability Enhancement	*IEEE Transaction on Industrial Informatics*	8	757-766	2012
4	A. V. Ravi Teja, Chandan Chakraborty, **Suman Maiti** and Yoichi Hori	A New Model Reference Adaptive Controller for Four Quadrant Vector Controlled Induction Motor Drives	*IEEE Trans on Industrial Electronics*	59	3757-3767	2012
5	**Suman maiti** and Chandan Chakraborty	A New Instantaneous Reactive Power Based MRAS for Sensorless Induction Motor Drive	Journal of *Simulation Modelling Practice and Theory, Elsevier*	18	1314–1326	2010
6	**Suman Maiti**, Vimlesh Verma, and Chandan Chakraborty	Sensorless Control of Grid-connected Doubly-fed Slip-Ring Induction Motor Drive	Journal of *Simulation Modelling Practice and Theory Elsevier*	18	984–997	2010

7	**Suman Maiti** and Chandan Chakraborty	An alternative adaptation mechanism for sensorless induction motor drive	Journal of *Electric power Components and Systems, Taylor and Francis*	vol. 38	710–736	2010
8	**Suman Maiti** and Chandan Chakraborty and Sabyasachi Sengupta	Simulation Studies on MRAC-Based Speed Estimation Technique for the Vector Controlled Permanent Magnet Synchronous Motor Drive	*Journal of Simulation Modeling Practice and Theory, Elsevier*	16	585-596	2009
9	Chandan Chakraborty and **Suman Maiti**	Performance of a Reactive Power Based Adaptive Estimation of Inverse Rotor Time Constant for Vector Controlled Induction Motor Drives	*International Journal of Automation and Control, Indurscience Publisher*	3	41-55	2009
10	**Suman Maiti** and Chandan Chakraborty	An adaptive stator resistance estimation technique for sensorless permanent magnet synchronous motor drive	*International Journal of Automation and Control, Inderscience Publisher*	3	189-201	2009
11	**Suman Maiti** , Chandan Chakraborty, Yoichi Hori and Minh-C Ta	Model Reference Adaptive controller based rotor resistance and speed estimation techniques for vector controlled induction motor drives utilizing reactive power	*IEEE Trans on Industrial Electronics*	55	594-601	2008

Under review:

1. T. S. Basu, **S. Maiti**, “A Hybrid Modular Multilevel Converter for Solar Power Integration,” IEEE Trans. on Industry Applications (major revision – under review).
2. Akhil C., **S. Maiti**, “Tapping power from HVDC grid using modular multilevel current source converter,” IEEE Trans. on Power Delivery (under review).

13. Detail of patents

Sl. No.	Patent Title	Name of Applicant(s)	Patent No.	Award Date	Agency/Country	Status
1	Voltage source converter and associated method	Sasitharan S, **Suman Maiti**	PCT/EP2014/069532	--	ABB Ltd./ International	Filed
2	Method and device for damping voltage harmonics in multilevel power converter	Aravind M. V., J-P. Hasler, **Suman Maiti**	PCT/EP2015/057244	--	ABB Ltd./ International	Filed
3	Method and device for damping voltage harmonics in multilevel power converter	Aravind M. V., J-P. Hasler, **Suman Maiti**	PCT/EP2015/057244	--	ABB Ltd./ International	Filed

14. Books/Reports/Chapters/General articles etc.

Sl. No.	Title	Author’s Name	Publisher	Year of Publication

15. Any other Information (maximum 500 words)

Dr. Suman Maiti has experience of five years to work in the R&D division of ABB Ltd. as an Associate scientist. During this period, he was engaged in the research activities related to high power converters (especially, the modular multilevel converters) and their grid integration. He was actively associated to some technology development projects in ABB, one of them is “Evaluation of converter topologies for HVDC and FACTS application including energy storage”. He owns some international patents, invention disclosers and technical reports on this area. He has experience to work on the topological variation, control, PWM methods, loss reduction, cooling issues and foot-print of modular multilevel converters. He visited few research laboratories (e.g. SECRC, Vasteras, Sweden and power electronics laboratory of KTH University, Stockholm) and plants (one LCC based HVDC station in Sweden) where high power converters were installed.

Certificate from the Investigator

Project Title: **Design and Development of Oscillatory Aquifer Pumping Test System at Laboratory Scale with Implications to Field Scale**

It is certified that

1. The same project proposal has not been submitted elsewhere for financial support.
2. We/I undertake that spare time on equipment procured in the project will be made available to other users.
3. We/I agree to submit a certificate from Institutional Biosafety Committee, if the project involves the utilization of genetically engineered organisms.
4. We/I also declare that while conducting experiments, the Biosafety Guidelines of Department of Biotechnology, Department of Health Research, GOI would be followed in toto.
5. We/I agree to submit ethical clearance certificate from the concerned ethical committee, if the project involves field trails/experiments/exchange of specimens, human & animal materials etc.
6. The research work proposed in the scheme/project does not in any way duplicate the work already done or being carried out elsewhere on the subject.
7. We/I agree to abide by the terms and conditions of SERB grant.

Name and signature of Principal Investigator: ANIRBAN DHAR
Date: 3/6/2019
Place: Kharagpur

Suman Maiti
03/05/2019

Name and signature of Co-PI (s) (if any): SUMAN MAITI
Date:
Place: Kharagpur

भारतीय प्रौद्योगिकी संस्थान
खड़गपुर : ७२१ ३०२, भारत

INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR - 721 302, INDIA

No. : IIT/SRIC/Acting DEAN/2019
June 04, 2019

Endorsement from the Head of the Institution

This is to certify that:

1. The Institute welcomes participation of **Dr. Anirban Dhar,** Associate Professor, Department of Civil Engineering, of this Institute as the Principal Investigator and Dr. Suman Maiti, Department of Electrical Engineering as the Co-Principal Investigator, for the project titled **"Design and development of oscillatory aquifer pumping tests system at laboratory scale with implication to field scale"** and that in the unforeseen event of discontinuance by the Principal Investigator, the Co-Investigator will assume the responsibility of the fruitful completion of the project with due information to SERB.
2. The date of project starts from the date on which the Institute receives the grant from SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi.
3. The investigator will be governed by the rules and regulations of Institute and will be under administrative control of the Institute for the duration of the project.
4. The grant-in-aid by the SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi will be used to meet the expenditure on the project and for the period for which the project has been sanctioned as mentioned in the sanction order.
5. No administrative or other liability will be attached to SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi at the end of the project.
6. The Institute will provide basic infrastructure and other required facilities to the investigator for undertaking the research project.
7. The Institute will take into its books all assets created in the above project and its disposal would be at the discretion of SCIENCE & ENGINEERING RESEARCH BOARD (SERB), New Delhi.
8. The Institute assumes to undertake the financial and other management responsibilities of the project.

STripathy

(Prof. Subhasish Tripathy)
Dean, SRIC (Acting)

संकायध्यक्ष / Dean
अनुदानित शोध एवं ... सहकारिता
Sponsored Research & ... Consultancy
भा.प्रौ.सं. खड़गपुर- 721302 / I.I.T. Kharagpur- 721302

FORM NO. E – 5 APPENDIX –VIII

ELECTRONICS CLEARING SERVICE (CREDIT CLEARING)
(MONDEL MANDATE FORM)
(INVESTOR/ CUSTOMER'S OPTION TO RECEIVE PAYMENT THROUGH CREDIT CLEARING MECHANISM)
(Scheme name and the periodicity of payment)

1.	INVESTOR/CUSTOMER'S NAME	:	SPONSORED RESEARCH & INDUSTRIAL CONSULTANCY INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR KHARAGPUR, PIN 721 302, WEST BENGAL Ph. No. 03222 282190, e-mail : sumit@adm.iitkgp.ernet.in; aosr@adm.iitkgp.ernet.in
	Category of Institution	:	GOVERNMENT AIDED
	Tan No.	:	CALI01878 C
	Pan No.	:	AAAJI0323G

2. **PARTICULARS OF BANK ACCOUNT**

(a)	Bank's Name	:	SYNDICATE BANK
(b)	Branch Name	:	SRIC-IIT, Kharagpur Branch, Kharagpur – 721 302, West Bengal
(c)	9-digit Code Number of the Bank Appearing on the MICR Cheque Issued by the Bank	:	000025000
(d)	Account Type (SB/Current Account of Cash/Credit with Code 10/11)	:	Savings Bank Account
(e)	Account Number (as appearing On the Cheque Book)	:	**95562200010394** **(IIT MHRD A/C–SB)**
(f)	IFSC Code No. of the Bank	:	**SYNB0009556**
(g)	Branch MICR No.	:	721025103

I hereby declare that the particulars given above are correct and complete. If the transaction is delayed or not effected at all for reasons of incomplete or incorrect information, I would not hold the user Institution responsible. I have read the option invitation letter and agree to discharge the responsibility expected of me as a participant under the scheme.

Signature, Name and Official Stamp of the Registrar/Senior Accounts Officer of the Institute/Customer

सुमित कुमार बिश्वास
Sumit Kumar Biswas
उप कुलसचिव/Deputy Registrar
अनुदानित शोध एवं औधोगिक सलाहकारिता
Sponsored Research & Industrial Consultancy
भा.प्रौ.सं. खड़गपुर-721302/IIT Kharagpur-721302