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BAHRAIN SOCIETY OF ENGINEERS

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A Journey with

Engineer Heyam Al-Maskati

Bahrain Society of Engineers is a professional institution with a large and pivotal role in the engineering work system in Bahrain, especially as it carries a professional legacy extending for more than five decades.

The bridge project linking Shaikh Isa bin Salman Causeway and Avenue 105 in Busaiteen... A cornerstone for enhancing traffic flow

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Message from the Editor-in-Chief



Professor
Isa Salman Qamber

The Bahrain Society of Engineers is always committed to highlighting developments and areas of progress in the Kingdom of Bahrain, as well as addressing topics and articles that contribute to the advancement of engineering education. As part of ongoing efforts to develop infrastructure and enhance the quality of projects, the Ministry of Works is working to develop the road network and improve traffic efficiency in ways that help save time and effort. The Ministry also places significant emphasis on construction engineering and management, recognizing it as a key professional field that contributes to the successful planning and execution of projects, while also promoting quality and safety standards throughout the various stages of work.

From an educational perspective, and in light of the rapid advancement of technology, artificial intelligence has become an important tool that can be utilized in education and engineering practice. However, excessive reliance on AI by students may affect the development of critical thinking, research, and analytical skills. Therefore, students should also place strong emphasis on developing fundamental skills such as writing, manual design, and independent thinking.

Achieving a balance between benefiting from technology and developing individual capabilities is an essential step toward preparing a generation capable of meeting the demands of the future with competence and responsibility.

Shaikh Isa bin Salman Causeway – Street 105 Flyover provides a vital connection between Manama and Muharraq, saving up to 20 minutes of commute time during peak hours, with a traffic flow reaching 4,000 vehicles per hour. The project was completed in just 7 months at a cost of 12.7 million Bahraini Dinars. This segment was featured as the mafeatured in this issue of ALMOHANDIS.

In this issue, we interview Engineer Heyam Al-Maskati, who pursued a degree in electrical engineering at the University of Bahrain, and underwent practical training at Batelco. Afterward, she went on to join the company for work. In the course of her employment at Batelco, she managed the projects of developing 2G, 3G, and 4G networks. In addition, she is involved with the Bahrain Society of Engineers as a board member and contributed through its committees.

Shaikh Isa Bin Salman Causeway – Avenue 105 Overpass provides connectivity between Manama and Muharraq, saving 20 minutes in travel time during peak hours, and has an hourly vehicle flow of 4,000 vehicles. The project was completed in only 7 months for a cost of BD12.7 million. This section was addressed as a profile in the present issue of Al Mohandis Magazine.

The present issue includes four articles: two in Arabic and two in English. It is important to note that students' use of AI could reduce their capacity for critical thinking and research skills and promote plagiarism and misinformation, particularly if foundational skills like manual writing and design have not yet been attained. In order to make sure that educational outcomes are accomplished, educational establishments need to control the use of AI by defining where it can be used and what percentage of it can be used. This is what the author Dr. Wael Abdel Hamid highlights this concern in his article.

In the article by the author Dr. Eng. Youssef Amin, he notes that a number of issues that affect engineering projects usually arise prior to execution due to poorly defined and inadequate understanding of concepts, hence the introduction of the (SMART++) approach towards understanding the external environment around the concept. This is to enable transformation from the abstract concept to a fully grown one that can be analyzed and executed as a project with focus on the importance of analysis, a case study on an educational platform, and reminding young engineers that not all ideas are good for projects and sometimes they need to be altered or delayed.

Engineer Abdulameer Almulla writes in his English article that improper arc welding practices - especially connecting the return lead far from the workpiece - can let high current flow through plant structures, causing dangerous heating, sparks, explosions, or corrosion. Safe welding requires short, close leads, inspected equipment, qualified/ trained welders, strict permit checks, fire precautions, and regular audits.

Building Engineering Management (BEM)" is a carefully balanced combination of engineering and management aspects in a business where there is the balance between scope, time, and cost, which is responsible for the processes of planning, procurement, resource management, risks, quality control, and contract administration. This is the concept that the engineer Shouq Ahmed Alkooheji elaborated on.

Five winning projects are summarized in the present issue. The Dilmun Civilization Museum architecture project in Bahrain will showcase ancient Dilmun heritage—especially Saar's sun god temple—through detailed halls, artifacts, archaeological finds, and multimedia displays. It aims to create an immersive, spiritual experience of Dilmun life linked to Gilgamesh's myth of immortality and hope, while also serving as a community and intellectual hub. The chemical project develops a PLC-based continuous control system using PROFINET, TIA Portal, PID tuning methods, and SCADA for monitoring and controlling water level and temperature processes. It also includes a 3D-designed PLC training board and a 13-experiment user manual, providing P&IC students with practical, hands-on experience before graduation. The civil engineering project addresses increasing traffic congestion and serviceability issues on Shaikh Salman Highway, particularly at the North Isa Town junction, which significantly affects travel time. It proposes designing a cost-effective interchange or bridge with three lanes and a 140 km/h design speed to accommodate current and future traffic demand. The winning electrical engineering project develops a field-current control system for a synchronous generator using a DSPACE MicroLabBox, two-level rectifier, and Voltage-Oriented Control to maintain constant terminal voltage under varying loads. The system dynamically adjusts the field current to improve voltage stability, power quality, generation efficiency, and demonstrate modern controller capabilities. The winning mechanical engineering project develops a theoretical and experimental Earth-Air Heat Exchanger (EAHE) model to predict air outlet temperature and cooling capacity using geothermal energy. Simulations and experiments in Bahrain assess its potential to reduce indoor temperatures and peak cooling loads, thereby lowering summer energy consumption.

Four projects in this issue of Al Mohandis Magazine highlight summaries of engineering students' graduation projects. The first graduate project develops a stationary bicycle system that converts human kinetic energy into electrical energy, stores it in batteries, and then converts it to 50 Hz AC power using a DC motor, converter, and H-bridge inverter. MATLAB/Simulink and Proteus simulations showed successful DC-to-AC conversion, demonstrating the system's potential for powering small electrical loads and promoting renewable energy use.

The second graduate project focuses on the topic of developing and simulating a Virtual Power Plant using Typhoon (HIL) to coordinate distributed energy resources, manage power flow, and simulate real-time energy market transactions. The results demonstrate effective system adaptation and market participation, with simulated daily income ranging from approximately BD 159 to BD 170, close to or exceeding the target.

The third graduate project covers an AI-based energy management system for residential PV-battery-grid systems to monitor demand, PV generation, battery state of charge, and grid usage while detecting abnormal conditions. The AI reduces unnecessary battery cycling and state of charge violations, provides alerts, extends battery life, and improves long-term performance with only a small increase in grid import.

The fourth project describes the analysis of a Voltage-Oriented Control (VOC) strategy for a three-phase grid-connected inverter, using PLL-based synchronization, dq control, PI controllers, and SPWM to convert the DC generator output into regulated AC power. MATLAB/ Simulink results demonstrate proper grid synchronization, balanced current injection, near-zero reactive power, effective active-power delivery, and reduced switching ripple through the LCL filter.

A Journey with an Engineer

Engineer Heyam Al-Maskati



Bahrain Society of Engineers gave me the opportunity to gain insight into diverse experiences, expertise, and specializations; the personal impact has been profound, particularly in enhancing my communication and teamwork skills.

In this issue of Al-Mohandis magazine, we host a prominent figure in the engineering field. Our guest is a member of the Bahrain Society of Engineers and has served on its board of directors for several terms. She progressed through the ranks of the engineering profession, specializing in electronics engineering, specifically communications systems. She enrolled at the University of Bahrain to study engineering, and during her studies, she joined Batelco to complete the mandatory practical training period for all engineering students. This marked the beginning of her distinguished and accomplished engineering career.

Interviewed and prepared for publication by: Mr. Husain Ismail

To begin, could you tell us about your upbringing and early beginnings, and your educational journey during your school years?

My earliest formal education began in the early 1970s at Fatima Al-Zahra Primary School in Manama. I then moved to the intermediate stage at Aysha Umm Al-Mu'minin School, where I was among the first cohort when the third intermediate grade was added to the compulsory stages. This change meant that students would complete 12 years of compulsory education instead of the previous 11 years.

I later attended Manama Secondary School for Girls. In the early 1980s, the scientific-tracks system was introduced, dividing both scientific and literary specializations into sub-specializations. I chose the scientific track, specifically the physics and mathematics branch, because I excelled in those subjects.

What led you to choose engineering as your field of university study?

Throughout my school years, I was academically outstanding, which motivated me to pursue engineering. Although the number of engineering scholarships allocated to girls was limited at the time, I was determined to study engineering and fulfill a dream I had always held.



His Excellency Shaikh Khalid bin Abdullah Al Khalifa, Deputy Prime Minister, honored Engineer Heyam Al-Masqati with the Woman Engineer Award in the Specialized Disciplines category. This took place during the Kingdom of Bahrain's celebrations of Bahraini Women's Day, which in 2017 was dedicated to honoring Bahraini women in the engineering field.

Where did you study engineering? And how did you begin working in the engineering sector?

I joined the University of Bahrain to study engineering. During my studies, I joined Batelco to complete the practical training period required of all engineering students, and that was where it all began.

What is your engineering specialization? And why did you choose this specialization specifically?

I later chose electronic engineering, specifically communication systems, which I preferred over the various other subjects in the specialization, especially after I worked on a small project during my practical training in satellite communications. At that time, I felt a great passion within me for communication systems.

We would like to learn about the most prominent milestones of your journey and contributions in the engineering field in the Kingdom of Bahrain, from the beginning until today. What are the most notable jobs and positions you have held during your professional career?

Immediately after graduation, I began my work search. Among the entities I applied to for employment were the then



At the earth station with H.H. Shaikh Ali bin Khalifa Al Khalifa, former Chairman of the Board of Directors of Batelco

Ministry of Electricity and Water and Batelco. Fortunately, I received two attractive offers from both: one in the control systems department at the Ministry of Electricity and Water, and the other at Batelco's satellite earth station in Abu Jarjur area, near Alba.

The choice was not easy, but I preferred the satellite earth station because of my passion for communications, and from there my professional journey began. I worked at the station as a trainee engineer. The beginnings were extremely difficult, not because of the nature of the work, but because I was the first female engineer in the history of the satellite station. The entire working team—technicians, engineers, and management—were men, and the presence of a woman among them created a barrier that some found difficult to cross or deal with. It was also difficult for me because it represented a different kind of challenge: I had to show excellence in my field more than my colleagues so that I would not be accused of negligence for no reason other than being a woman.

I accepted to work on a shift system, and I used to work late hours at night only to prove to everyone that I was capable of performing my duties to the fullest, leaving no room for discrimination between my male colleagues and me. Sometimes I had to leave my home and my young child, who was not yet one year old at the time, late at night when I was called in because of any technical fault in the department where I worked.

My diligence had a direct impact on my obtaining higher positions on the career ladder; I progressed rapidly through jobs until I obtained the position of head of section at the earth station. After nearly eight years of work, I decided to leave work temporarily to obtain a master's degree. I received the Chevening scholarship, which the British Council was offering at the time to distinguished employees in various government entities. My husband receiving the same scholarship in the same year was a great incentive to leave my job temporarily and go to Britain to study at the University of Nottingham.

At the university, I studied information technology, and my research topic was on artificial intelligence applications. I graduated with a master's degree and then returned to Bahrain and to work again in the mobile networks department at Batelco.

I progressed through positions at Batelco from manager to senior manager until I reached the level of executive director. I worked for nearly twenty years in the field of planning, development, operation, and maintenance of mobile networks in Bahrain. The development of the network from the second generation (2G) to the third generation (3G) and then the fourth generation (4G) was among the largest projects I supervised, with budgets allocated to them exceeding the equivalent of 20 million Bahraini dinars.

What are your most prominent participations in voluntary work, whether in the engineering sector or in social work in general?

The most prominent participation in voluntary work is my joining the Bahrain Society of Engineers. I also joined for a specific period the "Shamsaha" program dedicated to protecting women from violence.

Your professional career leads us to talk about your relationship with the Bahrain Society of Engineers. How did your relationship with the Society begin, and when did you join its membership?

My relationship with the Society of Engineers began a while after graduation, specifically in 1993, out of a desire to belong to a diverse professional community that contributes to refining my technical and personal skills. Batelco at the time also encouraged its engineers to join various local and international professional and specialized bodies (such as Bahrain Society of Engineers).

What has membership in the Bahrain Society of Engineers added to you professionally and personally?

Professionally, the Society has added a great deal to me, as it gave me the opportunity to learn about the experiences



With Engineer Badriya Al-Marzouq
At the 2017 Women Engineers Day celebration

and expertise of engineers from various specializations and to expand my professional network. Personally, the impact was deeper: participating in the Society's activities helped me strengthen my communication, teamwork, and relationship-building skills, and increased my self-confidence and my ability to participate, put forward ideas, and interact with others. In general, I see the Society of Engineers experience as not limited to developing my professional side, but also contributing to developing my personality, broadening my horizons, and strengthening my sense of belonging to the engineering community, and contributing to serving the profession and society.

How do you view the role and performance of the Bahrain Society of Engineers as a specialized professional society serving the engineering sector and engineers in the Kingdom?

Bahrain Society of Engineers is a professional institution with a large and pivotal role in the engineering work system



Being honored by the General Manager of the Networks Unit at Batelco

in Bahrain, especially as it carries a professional legacy extending for more than five decades. I believe the Society has played a tangible role in bringing together engineers from various specializations, providing platforms for training, development, and exchange of expertise, and working with relevant government bodies to regulate the practice of the profession. It is credited with laying the first seeds for the engineering profession practice office. We also should not overlook the Society's role in providing various engineering expertise to support development projects in the Kingdom by joining various government committees and making every effort to provide the specialized technical support needed to set plans and technical specifications for various sectors.

At the same time, I believe the next stage requires us to move from preserving achievements to expanding the Society's impact further, especially in the fields of digital transformation, artificial intelligence, sustainability, and modern engineering technologies, and in qualifying Bahraini engineers to compete locally, regionally, and internationally.

Therefore, my assessment of the Society is that it possesses a strong history, experience, and professional base, and I see the real challenge as not only continuing what it offers, but in its ability to invest these elements to create a greater and more sustainable impact on the future of the engineering profession and the Bahraini engineer.

For me, the Society is not only an entity that provides services to engineers, but a professional platform that should have an influential voice in developing the profession, an effective partner in development, and a space that brings together engineering expertise and transforms it into added value for society and the national economy.

You are considered one of the prominent members of the Bahrain Society of Engineers. What are the most notable works and achievements in which you participated through membership in committees or



At one of the events at Batelco

boards of directors, and which contributed to shaping your experience within the Society?

I was an active member of the Society from the beginning of my joining until I decided in 2004 to run for the Board of Directors elections for the first time, and I was fortunate to win one of the Board seats. Engineer Mohammed Khalil Al-Sayed was the elected president at that time.

Through my presence on the boards of directors in different terms, I participated in many committees, such as the Media Committee, where I took on the task of publishing the Engineer magazine, the Members and Profession Affairs Committee, the Secretariat, and the Financial Secretariat. I also participated in the organizing committees for a number of conferences and events. Currently, I chair the Communications, Informatics, and Space Committee of the Federation of Arab Engineers. I can say that my experience within the Society was not formed through one specific participation, but was shaped by my experience over the years and various experiences.

How do you assess the role of the engineering sector in supporting the developmental and urban renaissance in the Kingdom of Bahrain?

The engineering sector has a pivotal role in supporting the development renaissance in Bahrain, as engineers represent the link between development plans and their transformation into projects, infrastructure, and tangible services. Among the most prominent aspects of this role is infrastructure development, where engineers contribute to planning and implementing electricity, telecommunications, roads, bridges, sanitation, and water networks in a way that supports population and economic growth. Engineers also contribute to improving the quality of life through various engineering projects that raise the efficiency of public services and facilities. Engineers also play a fundamental



Master's Graduation Ceremony – University of Nottingham 1999

role in supporting the national economy through engineering projects operating in various sectors, such as industry, energy, and construction, which help create various job opportunities and stimulate related economic activities.

Away from engineering work, what hobbies and interests do you like and practice, whether in the past or at present?

Among my most important hobbies are reading, traveling, gardening, walking daily, and yoga.

Is there a piece of wisdom or a principle that you believe in and follow in your professional or personal life? And why?

My personal conviction, stemming from my practical experience, is that hard and persistent work must have a positive impact and return. Perhaps the impact is sometimes delayed, but it must eventually become evident later.

In light of your long experience in the engineering sector, did your specialization and professional career influence your children's educational or career directions?

Although my husband and I are both engineers, my two children did not wish to study engineering. My son specialized in economics, while my daughter studied speech and hearing therapy.

What are the most prominent awards or honors you have received during your professional career?

The most prominent honor was being recognized by Her Highness Princess Shaikha Sabika bint Ibrahim Al Khalifa on Women Engineers Day in 2017 in the category of pioneering female engineers in specialized fields. I also received the Batelco Chief Executive Officer Award for distinguished employees, which aims to ensure the continuity of Key Staff under the company's umbrella for no less than three consecutive years. There were also other honors, but not of the same importance.

What are the most prominent works or projects that you consider milestones and outstanding achievements in your professional career?

Among the most prominent projects that represent a milestone in my professional career is the project to transform



University of Nottingham 1999

the mobile phone network from the second generation (2G) to the third generation (3G) in 2004, where I supervised the project and worked with an integrated technical team of technicians and engineers to ensure work progressed without affecting network efficiency and within a tight timeframe. After that, in 2013, I worked on the project to upgrade the network from the third generation (3G) to the fourth generation (4G), and it was the largest project at the time, with a budget estimated in the millions of dinars. I also worked on many other projects related to mobile telecommunications infrastructure, such as expansion projects and value-added services projects. My work was not limited only to project management, but also to radio network planning, operations and maintenance, and strategic network planning.

During your long career in the engineering sector and your work with many figures and talents, is there a figure you consider a role model or source of inspiration for you in the field? And why?

There are many male and female colleagues from whom I learned a great deal, and to whom I owe much. I believe that a person learns from everyone they encounter in life, perhaps only to varying degrees. However, there are two people to whom I owe a debt of gratitude, as they provided me with a great deal of support and confidence throughout my professional career: the honorable Mrs. Mariam Janahi, then General Manager of Human Resources at Batelco, and Mr. Ibrahim Zainal, Chief Technical Officer.

There is no doubt that your professional career is full of situations and experiences that have left their mark on your professional and human personality. Would you share with the readers of Al-Mohandis magazine a situation or experience that is still stuck in your memory?

I have faced many situations and experiences. Perhaps one of the most difficult has been dealing with technical faults that cause outages for network users. These moments usually force us to work under time pressure and the threat



At a conference

of financial losses that can result from interrupting customer services. I remember one rare occasion when we had to work continuously for 24 hours to restore service after a technical fault caused by the introduction of modern equipment intended to improve efficiency. I learned a great deal from this experience, most importantly the need to remain composed so I could analyze problems scientifically and logically - and so I would not negatively affect the team around me.

Finally, what message would you like to direct to young engineers and to students who are about to study and specialize in engineering?

Finally, I would like to say to all young engineers that engineering is a beautiful profession. It gives an overwhelming feeling of self-satisfaction, especially when a person succeeds in finding solutions to problems that may sometimes be difficult. Believe in your abilities, continue learning, and master what you do.

I would also like to address a special message to young female engineers: do not be afraid of beginnings or of mistakes. You may face stages in your journey where you feel the path is difficult, and that you must always make an extra effort compared with your male colleagues, but always remember that your place in this field is deserved.

I also invite all male and female engineers to join the Society's membership, because this has a direct impact on their professional development. The value of an engineer is not measured only by their knowledge, but by what they offer to their professional surroundings and the impact they leave in the lives of others.



At one of the conferences at Batelco



During a business meeting in Stockholm with the management team at the Swedish company Ericsson



The bridge linking Shaikh Isa bin Salman Causeway and Avenue 105 in Busaiteen... a cornerstone for enhancing traffic flow

Introduction:

The bridge project linking the Shaikh Isa bin Salman Causeway and Avenue 105 is one of the key strategic projects, aimed at enhancing traffic flow and developing the infrastructure between the Muharraq and Capital governorates.

The project involves the construction of a flyover to connect traffic coming from Manama via Shaikh Isa bin Salman Causeway to the Muharraq Ring Road via Avenue 105 in Busaiteen, in addition to facilitating traffic towards Muharraq City. This contributes to improving traffic flow between the two areas and alleviating congestion at the intersection of Shaikh Isa bin Salman Bridge with Al-Ghous Street.

This project represents a distinguished model in planning and execution, having achieved a qualitative leap in traffic flow efficiency by reducing travel time between Manama and Muharraq by 20 minutes during peak hours, backed by the bridge's traffic-handling capacity of up to 4,000 vehicles per hour.

1. Scope of Work

The project includes the implementation of a range of works, most notably the construction of a flyover with two lanes in each direction on Shaikh Isa bin Salman Causeway, connecting it to Avenue 105, with the aim of improving traffic flow between it and Muharraq Ring Road and the surrounding areas such as Busaiteen and Saya. The following figure shows the project map.

2. Timeline and Cost

The project was fully completed on a design-and-build basis. It was executed by Nass Contracting Company, under the supervision of the consultant AECOM Middle East. The total project cost amounts to approximately 12.7 million Bahraini dinars, funded by the Government of the Kingdom of Bahrain.

This massive work was accomplished within a record period of only 7 months, covering design and construction concurrently until opening, while maintaining the highest standards of occupational safety, with over 680,000 work hours logged without any injuries. This success is attributed to effective project management through early coordination with all relevant stakeholders, alongside advanced risk management that helped drive the execution and rapid



H. E. Eng. Ibrahim Al Hawaj, Minister of Works opened traffic on the bridge linking Shaikh Isa bin Salman Causeway to Avenue 105 in Busaiteen

opening, ensuring the project is delivered in its fullest form and with added value.

3. Main Challenges

The project faced several challenges during the design and construction phases, the most prominent of which were the following:

1. Committing to the timeframe set by His Royal Highness the Crown Prince and Prime Minister, may God protect and preserve him, which did not exceed 7 months, to ensure the bridge opened before December 31, 2025.

2. The concurrence of design and construction, as the contract was on a Design and Build basis.

3. The project required backfilling a portion of the sea adjacent to Shaikh Isa bin Salman Bridge and commencing construction immediately without waiting for soil settlement, resorting to alternative solutions.

4. The presence of multiple underground utilities and the need for rapid and effective coordination.

5. The requirements of the General Directorate of Traffic to maintain the number of lanes on Shaikh Isa bin Salman Causeway, given that it is a main artery in the Kingdom of Bahrain's road network.

6. The procurement of certain specialized materials, such as bridge bearings and expansion joints, within a very limited timeframe.

The project's scope of work included the following quantities

- 14 Thousands square meters of **Asphalt**
- 1.3 KM of stormwater **Drainage network**
- 8 Thousands cubic meters of **Concrete**
- 1.2 KM of **Irrigation network**
- 58 Deep **foundations** (piles)
- 158.7 Thousands cubic meters of **Fill materials**
- 790 Meters of MSE **Retaining wall**
- 12.5 Thousands metric tons of **Rock**



Plan of the bridge project connecting Shaikh Isa bin Salman Bridge and Avenue 105

4. Environmental Impact and Sustainability of the Project

The project adopts a clear vision to enhance environmental sustainability and reduce its carbon footprint as a core component of its development framework. The tangible reduction in travel time by 20 minutes during peak hours contributes to decreasing vehicle idling and congestion, which directly leads to lower carbon emissions and harmful greenhouse gas emissions in the surrounding area. Furthermore, the project has created extensive afforestation areas within the same region, equipped with an irrigation network, in addition to establishing a stormwater drainage system to limit water accumulation and drain it sustainably for reuse.

5. National Cadres:

This project embodies an inspiring success story for national competencies, where Bahraini engineers—alongside the ministry, the contractor, the consultant, and other relevant project stakeholders—played a pivotal and effective role in transforming challenges into tangible achievements by concurrently leading the design and execution processes to complete and open the bridge within a record period of no more than 7 months.

This meticulous supervision and professional oversight by the national cadres on-site was reflected in the project's comprehensive completion to the highest quality within the required timeframe. The role also extended to encompass social responsibility and knowledge transfer; Bahraini engineers oversaw the activation of the project's role as a pioneering educational platform, which received over 40 male and female students from various local universities during multiple field visits. These visits successfully familiarized young talents up close with best field practices, directly contributing to the qualification and preparation of the next generation of young national energies to continue the march of sustainable infrastructure development in the Kingdom.



Aerial view of the bridge project connecting Shaikh Isa bin Salman Causeway and Avenue 105



Another aerial view of the bridge project connecting Shaikh Isa bin Salman Causeway and Avenue 105

The Sixth Bahrain Society of Engineers Award The winning projects - 2025

Introduction

The Bahrain Society of Engineers Award is an annual award aimed at motivating Bahraini engineers to innovate and excel in the engineering field, while recognizing their outstanding achievements and contributions to society and the nation. The award is divided into three main categories:

1. Lifetime Achievement in Engineering Award
2. Outstanding Engineer Award
3. Best Graduation Project Award

There are four main objectives of the award, summarized as follows:

1. Honoring Excellence:

Highlighting the remarkable achievements of Bahraini engineering professionals throughout their careers and their service to Bahrain's industrial community.

2.Supporting Innovation:

Encouraging creativity and innovation in the engineering field by promoting smart and sustainable solutions.

3. Inspiring Students:

Fostering a spirit of creativity and innovation among engineering college students and encouraging their outstanding graduation projects.

4. Enhancing Competitiveness:

Creating an environment of scientific and creative competition among engineers.

This issue highlights five award-winning projects.

1 Architecture

Student:
EBRAHIM JAMEEL

Dilmun Civilization Museum

Supervisor:
Dr. Wafa Al-Ghatam

Dilmun civilization museum in Bahrain is the project that will be an exciting opportunity to explore the ancient heritage related to Dilmun in Bahrain. In showing off the meaning and attraction of the Dilmun villages, especially noting the temple of the sun god in Saar.

One will take a stroll through an interesting museum with different exhibition halls that explain in detail all information about the Dilmun culture. The visitors will be able to delve deep into the details as well as complexities that characterize this civilization, unearth the history, art and even social aspects that surrounded it. Dedicated spaces will be created to exhibit artifacts, archaeological findings and multi-media installations aimed at the holistic understanding of Dilmun culture. Besides being a depository of intellectual resources, the museum will act as an arena of community activity.

Creating a spatial and emotional experience for the ruins of antiquities located on the site in a way that simulates the process of life in the Dilmun period, and ensuring the transmission of a spiritual experience that reflects the character of the Epic of Gilgamesh and the myth of the land of immortality and hope.



The Suggested Site Design for Dilmun Civilization Museum



Site Plan



MAQUETTE VIEW

2 Chemical Engineering

Students:
1. Mohamed Abdulhameed
2. Fatema Abdulhameed
3. Feras Saeed Alkhanaizi

DEVELOPMENT OF PLC-SCADA SYSTEM FOR MONITORING AND CONTROLLING PCT-9 AND PCT-13 ARMFIELD TRAINING CONTROL UNITS

Supervisor:
Dr. Noureddine Mansour
Co-supervisor:
Dr. Mohamed Bin Shams

The project involves panel construction to hold two PLCs connected by PROFINET. Calculation of transfer functions of actual processes, followed by the application and comparison of tuning methods such as ITAE and IMPC to control the process. TIA portal programming will be utilized, employing function blocks like PID, normalizing, and scaling. Additionally, SCADA is developed to control and monitor the water level of PCT-9 and the water temperature of PCT-13. Finally, 3D designing and constructing a PLC training board that simplifies the interaction with the PLC inputs and outputs and provides more control options. By that, the establishment of a continuous control system using a PLC panel for P&IC students, this comprehensive approach allows students to conduct experiments and gain hands-on experience in all the skills we acquired during this project, enables them to become familiar with these techniques before graduation. We prepared a user manual consisting of thirteen experiments teaching the students how to operate the project and gain the skills that we gained.



(Level Control Unit (PCT-9



Constructed panel with two Siemens S7-1212C PLCs

3

Civil Engineering

Students:
AQIB KHAN SAR ZAMIN
EMAN AMEER MOHAMED ABUROWAIS
SHAWQI ABBAS ALI AL-QATTAN

Design of Bridge at North Isa Town Junction

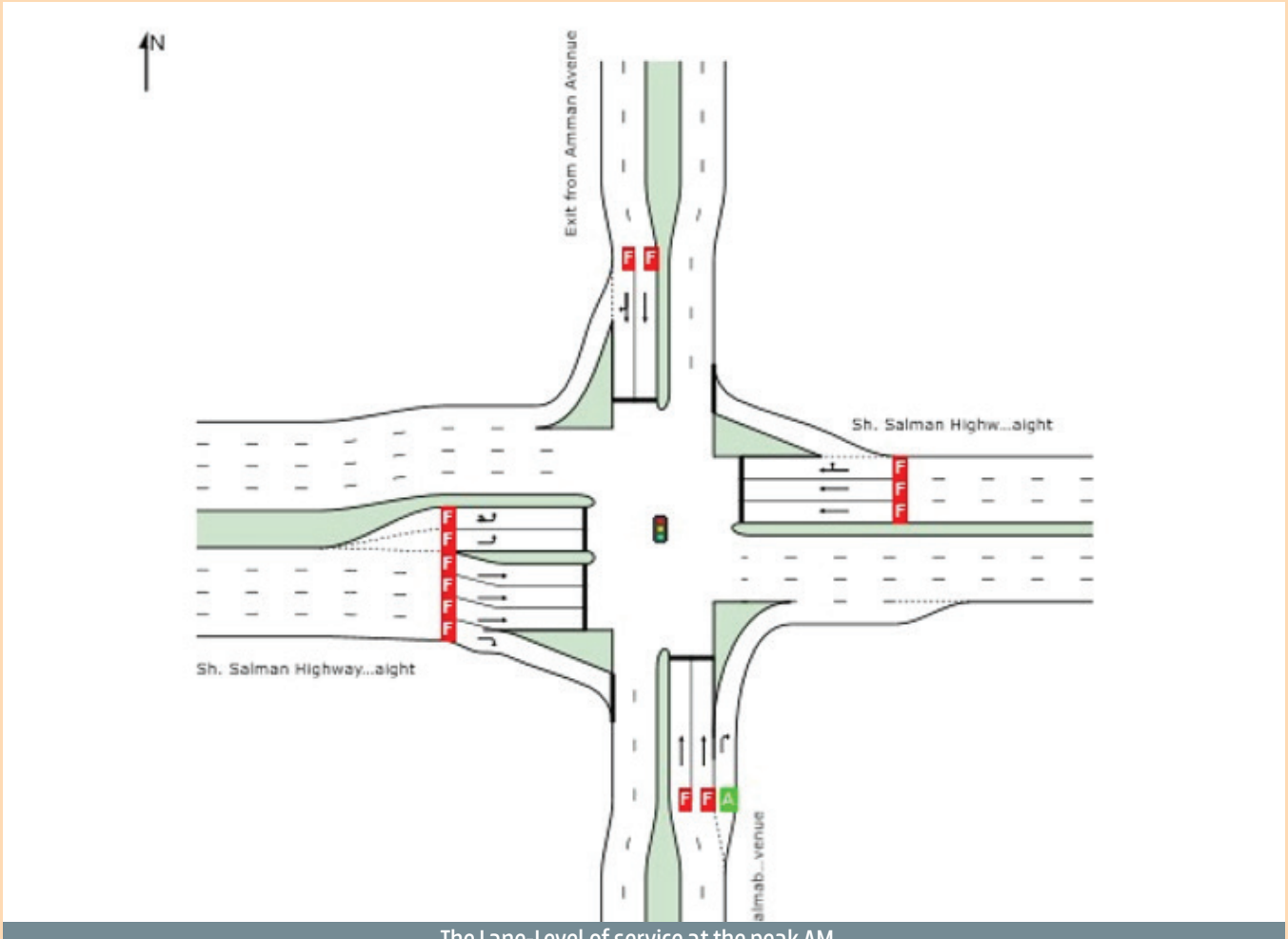
Supervisors:
Dr. UNEB GAZDER
Dr. YUSUF MOHAMED ALMALKI

A major part of 2030 Bahrain vision focuses on development of infrastructure, especially highways and roads, as it has direct effect on Bahrain economic development by connecting cities and societies with sevices. So, it is essential to have adequate serviceability, infrastructure, and geometric design. It is especially critical for highways like "Shaikh Salman" highway which serves and carries an average of 58,500 vehicles each day, and 2,400 vehicles an hour at peak times. As a result of the annual growth in volume of traffic, "Shaikh Salman highway" now faces many serviceability and utility issues, particularly with the current volume.

A significant increase in traffic volume at peak hours, especially at the "North Isa Town junction", affects the total travel time. The interchange control's inability to cope with this amount affects the total travel time. So, for that we will make an interchange called "North Isa Town interchange', or another cheap solution if possible. This interchange would be primarily beneficial to the people travelling from Manama towards Riffa & from Riffa to Manama as their destination. Therefore, our aim is to design a new interchange or bridge to satisfy the current traffic demand, using the standard engineering methods and techniques. It will primarily based upon 3 lanes with design speed of 140 Km/hr.



Project Location Point



The Lane-Level of service at the peak AM

4

Electronic Engineering

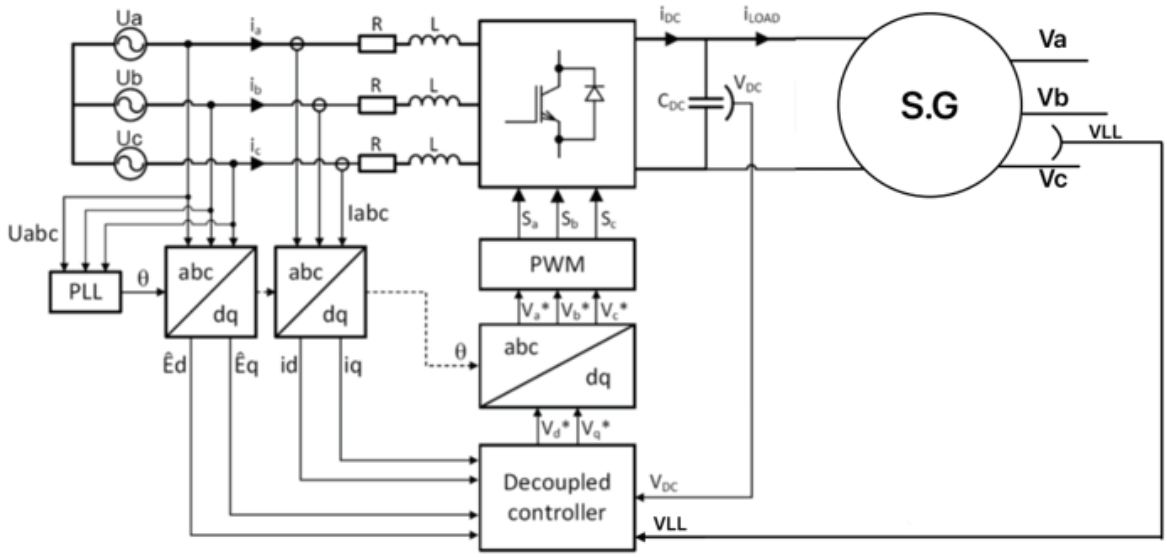
Students:
ALI JAAFAR ALI KHUDHAIR
HUSAIN HASAN AHMED
SAYED JAAFAR EBRAHIM NEMAA

Voltage Regulation for Synchronous Generator Through PWM-Rectifier Supplying Rotor Side

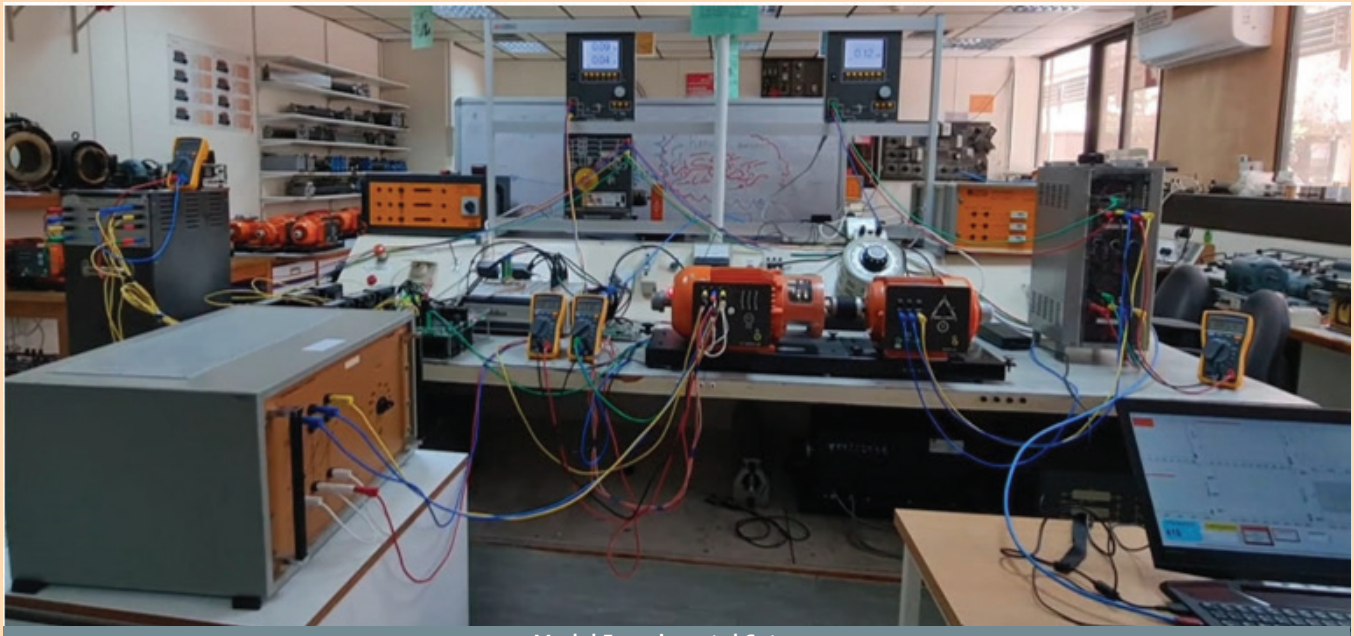
Supervisor:
DR. MOHAMED AMINE FNAIECH

In this project, we focus on field current control within a synchronous generator. Our objective is to maintain a steady terminal voltage despite varying loads. Our setup includes the synchronous generator, a DSPACE MicroLabBox, and a two-level rectifier. We have used Voltage-Oriented Control technique to control the rectifier output voltage. We have developed a control loop to measure the terminal voltage of the synchronous generator and adjust the DC voltage supplied to the field winding. This control loop ensures control of the output voltage of the generator and maintains a constant voltage even if the load varies. By dynamically adjusting the field current, we ensure consistent voltage levels.

This stability improves power generation efficiency and showcases modern microcontroller capabilities. In addition, the stability of power generation systems is paramount. Uncontrolled voltage fluctuations can lead to equipment damage, power quality issues, and inefficient energy consumption. By developing a robust control system for field current in synchronous generators, we address these challenges. Our project aims to showcase the capabilities of modern controllers while ensuring consistent voltage levels, ultimately improving power generation stability and efficiency.



Voltage Regulation Control System block diagram



Model Experimental Setup

5

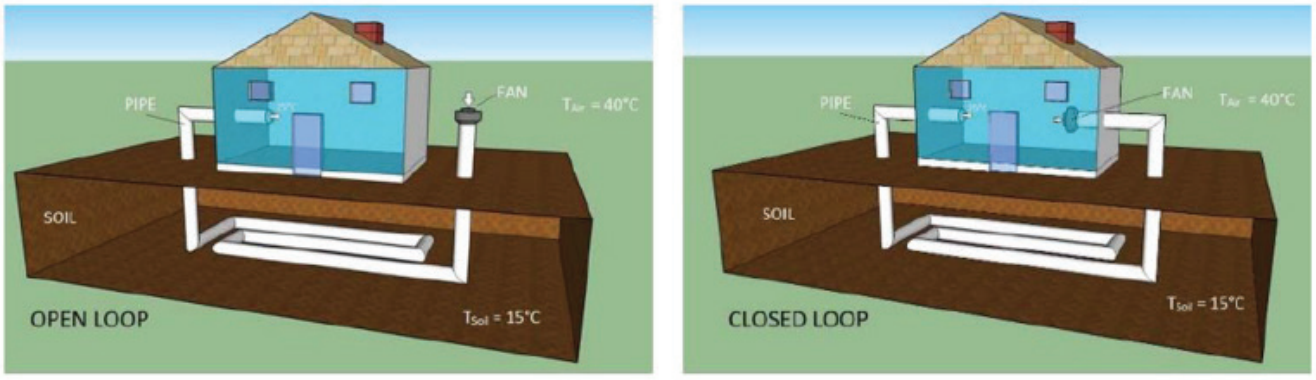
Mechanical Engineering

Students:
Aymen Saleh Abdul-Rasool
Sayed Murtadha Shehab Alawi
Bayan Ahmed Al-Halwaki

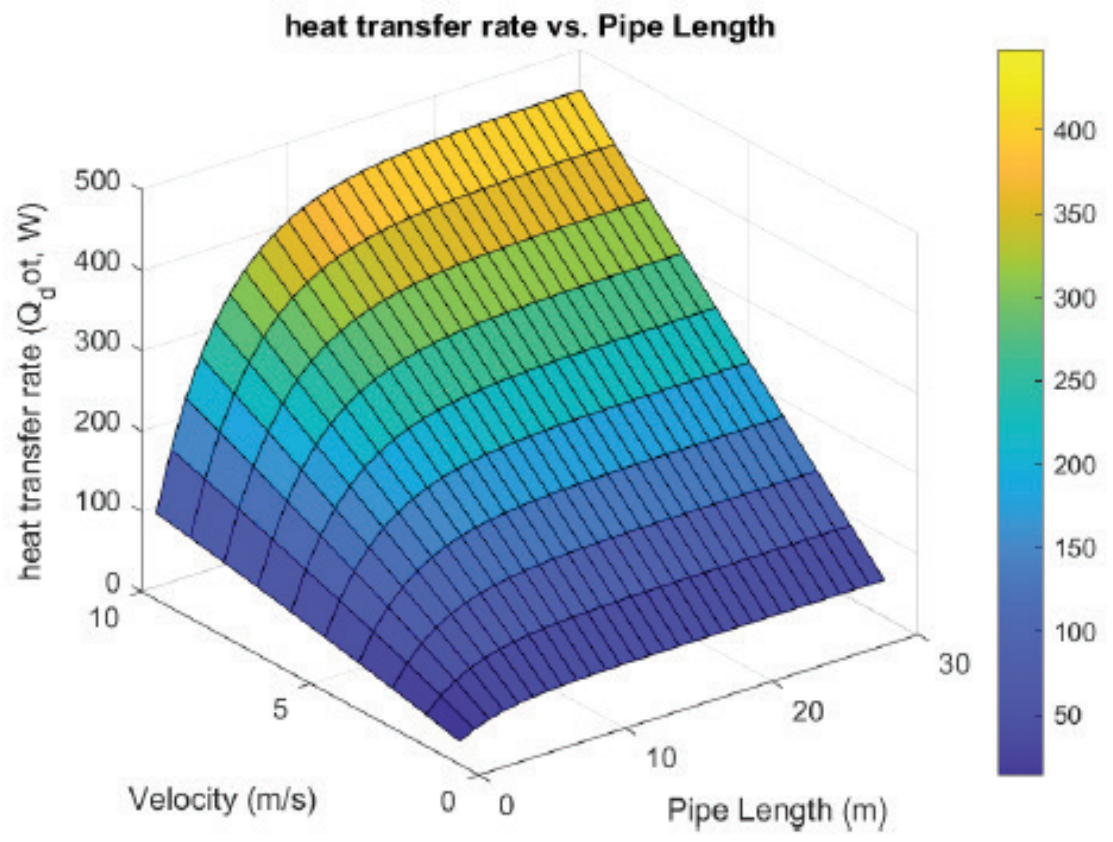
Geothermal Heating and Cooling System

Supervisor:
Dr. Mahir Mahmood

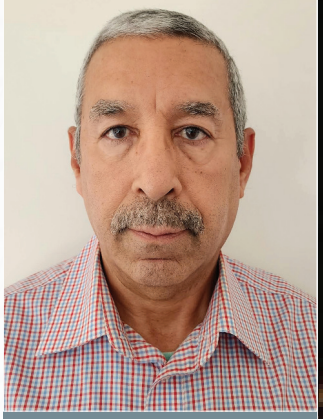
In response to rising energy costs and environmental concerns, A theoretical and experimental model for an earth-air heat exchanger (EAHE) has been created to forecast the exit air temperature and cooling capacity of these systems. Earth-Air Heat Exchangers (EAHXs) are being increasingly used in ventilation and air conditioning systems to harness geothermal energy. These systems consist of pipes that allow air to flow through them, facilitated by a fan. The earth's large energy potential can be used as a heat source in winter and a heat sink in summer due to the temperature difference between the surface and the ground. EAHXs can provide heating in winter and cooling in summer, making them suitable for various types of buildings. The simulations revealed that the EAHE could decrease the peak cooling load and lower the indoor temperature during the hottest hours of summer (mid-July), the simulation depending on the temperature will be constant after a certain depth. The EAHE demonstrates the potential to cut down the cooling energy demand in a standard house during the height of the summer season. The experiment aims to perform an experimental performance analysis of an EAHX system in Buri, Bahrain, in May. A sub-soil temperature model, specifically tailored for Bahrain conditions, is introduced and its results are compared with data from different sites.



Earth-air heat exchanger types during summer
a) Open-loop system
b) Closed-loop system reprinted with permission of Elsevier



Relationship between heat transfer rate, pipe length, and velocity



Engineer:
Abdulameer Almulla
Bahrain Society of Engineers



Improper Welding Practices
A Recipe for Disaster

Safety in refineries, petrochemical plants, and industry in general is of paramount importance. Operators take extreme measures to ensure safety of personnel and equipment is not compromised.
Electrical energy storage devices (those that contain batteries) are designed and controlled to prevent inadvertent generation of sparks or to induce excessive heat in hazardous areas. The aim is to ensure no tool or equipment used in process areas is capable of generating a spark. Yet, major heat or spark generating sources such as Arc Welding machines are not given the same attention.

As a matter of fact, most industrial organisations (Refineries, Petrochemical plants, Gas Plants, Power Generation & Water Desalination Plants) have very well established Permit To Work (PTW) procedures that control all hot works including Arc Welding. It is however the improper use of such equipment that jeopardizes safety and rarely gets noticed.

Welding Text books usually allocate a section on welding safety. Unfortunately, this section invariably covers the use of Personal Protective Equipment (PPE), shielding to protect coworkers and bystanders from radiation and methods of containment of flying sparks. Little if any, attention is given to the importance of making proper sound electrical connections. It is assumed that "welders know all safety measures related to their work".

This article briefly describes the Arc Welding process, highlights a common unsafe highly dangerous welding practice and presents a methodology that further enhances safety and contributes towards safer welding practices in industry.

Arc Welding Basics:

Manual Metal Arc Welding works on the principle of passing (relatively) high current from an Alternating Current (AC) or Direct Current (DC) source to the work piece. The arc is struck by touching the work piece with the tip of the electrode and then withdrawing it slightly to a distance of about 4-7 mm. The electrode tip gets heated up and surrounded by an electron cloud. These electrons are then accelerated and the air gap is ionized. i.e the arc is established. The resulting heat energy produces temperatures in the range of 5000 to 7000 oC (9000 to 12600 oF) sufficient to melt most metals.

For safety reasons, the maximum open circuit voltage is restricted to 120 volts. The voltage is directly related to the length of the arc and the current is related to the amount of the heat input. In both AC and DC Arc welding, the electrical circuit between the electrode and return leg must be kept as short as possible to prevent impeding the flow of current.

Connections: Why Do They Matter?

Welders like everybody else, would like to do their jobs in a practical manner and as quick as possible. As a result, they usually connect the negative or return lead to the first metallic structure of the plant nearest to the welding set. The Positive or Electrode lead is then taken to the welding location which may very well be 10-20 meters away from the point where the negative lead is connected. Welding starts thereafter.

What many welders do not appreciate is that tens of Amps of electrical current flow in the steel structure to return back to the machine through the negative lead. This current assumes the least (electrical) resistance path and thus not necessarily the shortest physical distance. In complex plant structures such as refineries, Petrochemical plants, Gas Plants, Power generation and desalination plants; the exact return path cannot be anticipated and thus could easily run into hazardous areas or close to ignition sources.

If for whatever reason, the best least resistance path has a high resistance spot or discontinuity somewhere along it, this spot will heat up. In the case of discontinuity, current would try to jump the discontinuity causing sparking. The amount of heating is proportional to the current flowing and contact area. Sparking on the other hand, is proportional to the welding voltage and geometry of the discontinuity. In Petrochemical Plants, Refineries and other industries, highly flammable gases may be present in process and production areas. If this heating or sparking takes place in these areas, there could be a great risk of explosion and possible catastrophe.

An incident that the author has witnessed in a Water Desalination plant resulted in damage to outer insulation of cables on a cable tray that coincidentally passed through a hot spot caused by such unsafe practice. Luckily, no fire took place but some of the cables had to be replaced.

Furthermore, DC welding current flowing in this manner can cause corrosion if it happens to flow in underground structures such as Gas lines.

It is imperative therefore to ensure that both welding leads are connected as close as possible to the work piece to prevent current flowing in the metallic structure of the plant.

A System Approach

To alleviate this malpractice, or any other for that matter, requires a good system to be in place. Such a system shall look much further than the practice itself.

The author, as a minimum, recommends the following:

i. Ensure all welding machines are fitted with two equal lengths of cables of the correct size.

ii. The welding machines and cables shall be inspected and tagged suitable for use by Electrical Maintenance periodically; say 3-6 months based on how frequent the equipment is used.

iii. Welder Qualification: ensures that competent welders carry out jobs they are qualified for only.

iv. Education and Training: All Welders to understand the whole welding process, appreciate the consequence of this malpractice and fully comprehend other safety requirements.

v. A permit to work procedure ensures hot work is carried out only in safe areas and after carrying out a gas test. However, the Permit Issuer must physically check that the negative lead is connected as close as possible to the welding spot before allowing work to proceed. This may seem as an overkill but the consequences if an explosion happen is far worse.

vi. A quality management system document "Standard Operating Procedure" shall detail the correct practice so that welders and their Supervisors can refer to at any time.

vii. A safety induction film that includes amongst other things, safe welding practices is shown to all contractors workforce before assuming any work in the plant. A written test conducted afterward reflects the level of comprehending the materials covered in the film.

viii. Special attention must be given to contractors carrying out welding jobs and equipment brought from outside. Many organisations focus on training their own welders but tend to be lenient with outsiders. A valid certificate is required to show that Contractors' welders are qualified to do the specific job. Welding machines sourced from outside must be inspected by Electrical Maintenance before work starts. A resident supervisor must also be made responsible for the work as he appreciates the consequences much better.

ix. A Portable Fire Extinguisher must be made available close to the welding spot. Welders must be competent to use the extinguisher if required.

x. Regular audits by Safety Personnel for all welding works in the plant to verify compliance.

Conclusion:

Safety in industry has no doubt improved dramatically. Yet every year we hear about major accidents all over the world; the latest was in Ras Laffan Gas Plant in Qatar where several people have unfortunately lost their lives and many injured.

In many cases, the circumstances and evidence leading to these incidents are destroyed by the intense explosions or fires that follow.

This article reaffirms the need to pay attention to details. When it comes to safety, welders must be educated and qualified to perform quality jobs safely. Procedures are essential to provide reference for new as well as experienced personnel. To close the loop, auditing is required to detect safety breaches. A holistic approach is essential to ensure that the issue is addressed from all aspects.

Articles



Engineer: Shouq Ahmed Alkooheji

Bahrain Society of Engineers



Building Engineering Management
A Strategic Approach

Introduction

In the minds of people, the idea of building something is quite simple. An architect designs the structure, and then a contractor puts it together. However, the process of constructing anything in today's world is infinitely more complicated. Modern construction requires performing thousands of coordinated activities, the services of hundreds of specialists, investing millions of dollars, and overcoming many challenges in terms of regulation, finance, logistics, and many other areas. Amid all this chaos, the practice that ensures perfect synchronization of all efforts to create a building is called Building Engineering Management.

Building Engineering Management (BEM) is more than just another technical area – it is a strategic and managerial field of expertise that combines elements of engineering with elements of business management in order to transform a mere idea into a fully functional and safe construction project..

Construction Engineering Management (CEM)

The Construction Engineering Management (CEM) is a specific professional field that uses techniques from science and engineering to supervise and control the construction process throughout its full cycle from conception to completion. Four benefits of construction engineering management are summarized as follows:

- Increased project success and delivery rates
- Enhanced safety standards and practices
- Improved client satisfaction and engagement
- More efficient and effective resource utilization

One of the important types of management is the construction engineering management. This importance might be summarized in the following points:

i. Enhanced operational efficiency
ii. Improved quality and performance
iii. Stronger cost control
iv. Effective risk management
v. Enhanced collaboration and teamwork

The roles of construction engineering managers are summarized in Figure (1).

The Core Pillars of the Discipline

Building Engineering Management is based on three basic elements: Scope, Time, and Cost, which are often called the "Iron Triangle." The core responsibility of the manager lies in finding an equilibrium between all these three competing factors. A variation in any of them necessarily impacts the others. An increase in scope requires additional time or more money, an attempt to cut down time costs will negatively impact scope

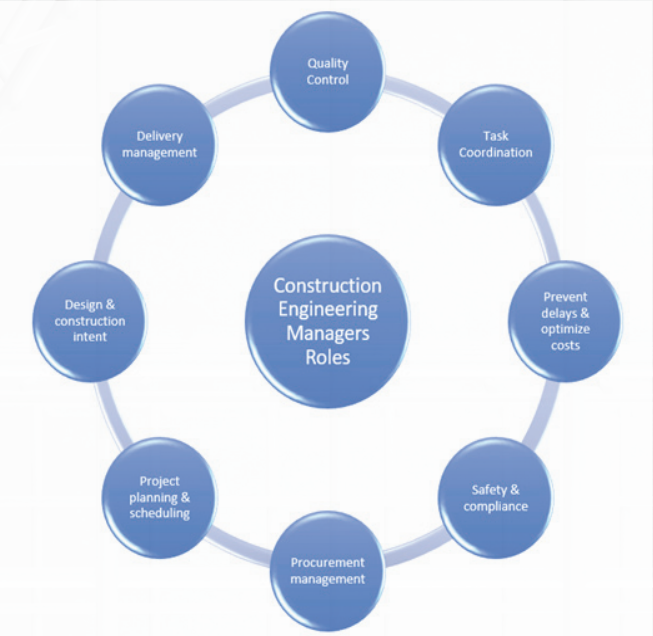


Figure (1): Roles of Construction Engineering Managers

or quality, and a reduction in cost will make scope and time management difficult.

In reality, the contemporary Building Engineering Management involves much more:

Firstly, planning and design management. Even before any construction can take place, the BEM professional takes an active role in the planning and designing phase of the project. They work with architects and engineers to ensure that the design of the building not only looks good but is also practical and affordable to build. Procurement management also comes under the purview of the BEM professional, which includes finding the right contractors and subcontractors and negotiating contracts. Secondly, resource and logistics management. A construction site is an unpredictable place to be in. Effective BEM ensures the coordination and management of the resources in the construction project. This includes workforce management, delivery of materials on time, in proper quantity, and utilization of machinery and equipment used for the construction project. Thirdly, risk management. Every project has risks associated with it. These risks may include natural disasters, problems with the supply chain, errors in design and other such factors. The main responsibility of a BEM professional here would be to manage and mitigate these risks. Fourthly, quality assurance and control. Buildings should be safe, robust, and suitable for the intended use. Quality control measures are stringent measures put in place by the Building Engineering Manager. It means making sure all the works from the construction of foundations up to the interior finish comply with designs and industry standards. Fifthly, financial and contractual management: He/she is the custodian of the projects' financial resources. That means making budgets, controlling expenditures, paying bills, and monitoring cash flows. Good understanding of contract laws and administration are important for the manager.

The Human Element, Leadership and Communication

Technical skill may not be negotiable, but the best Building Engineering Managers are those who excel in "soft skills." The managers act as leaders and communicators, and diplomats. They have to inspire a workforce that consists of different specialists ranging from architects and engineers to tradespeople and office workers. They serve as the focal point of the client and give them progress reports. They have to be good in negotiation, conflict management, and creating an environment conducive to collective problem solving. Poor communication is one of the most frequent reasons behind the failure of a project, and hence, communication is perhaps their most crucial task.

The Evolving Landscape: Technology and Sustainability

The world of Building Engineering Management is undergoing a radical change in its nature due to advances in technology and increasing awareness of people around the world.

• Technology: Technology is changing the industry in many ways through innovations such as Building Information Modeling (BIM). BIM is a tool which helps create the virtual replica of the building project allowing everyone involved in the process to see it in 3D, check clashes, and collaborate. There are also other technological advances that are used now including project management software, drone surveys, and IoT sensors to monitor the performance of buildings.

• Sustainability: Sustainable building is no longer an optional choice for those who are involved in the construction industry. Building Engineering Managers have taken up the leading roles in this movement and are responsible for using green techniques to minimize the carbon footprint of the buildings, such as use of sustainable materials, energy optimization, waste management, etc.

Conclusion

The profession of Building Engineering Management is the hidden force behind any successful building. This challenging, multi-faceted profession requires an unusual combination of various competencies and abilities. With projects becoming more complicated and there being a growing demand for sustainable infrastructure in the modern world, the significance of the Building Engineering Manager will keep on rising. They are the practical visionaries, the leaders who make the blueprint of what could be into reality. The Building Engineering Manager is not only building buildings; he builds value and certainty.

Students Projects

Students:
Ahmed Zakariya
Mohammed Jameel
S. Mohammed Aqeel

Supervisor:
Dr. Ebrahim Abdulrahman Hassan
Co-supervisor (s):
Dr. Maamar Taleb

University of Bahrain
Department of Electrical & Electronics Engineering



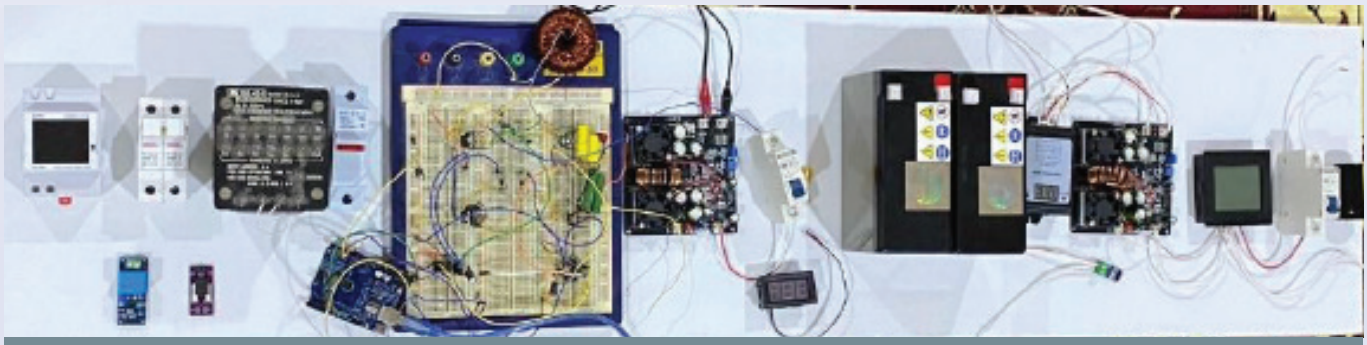
Energy Recovery Using h-Bridge Inverter

In recent years, the demand for alternative and renewable energy sources has increased due to the continuous growth in energy consumption and the environmental impact of conventional power generation methods. So, this project focuses recover the kinetic energy produced by human and converting it into usable electrical energy through a stationary bicycle system. The main idea of the project is based on using a DC motor as a generator connected to a bicycle mechanism, where the generated electrical power is stored in a battery and later be inverted dc/ac by a built h-bridge inverter then connected to a grid or a load.

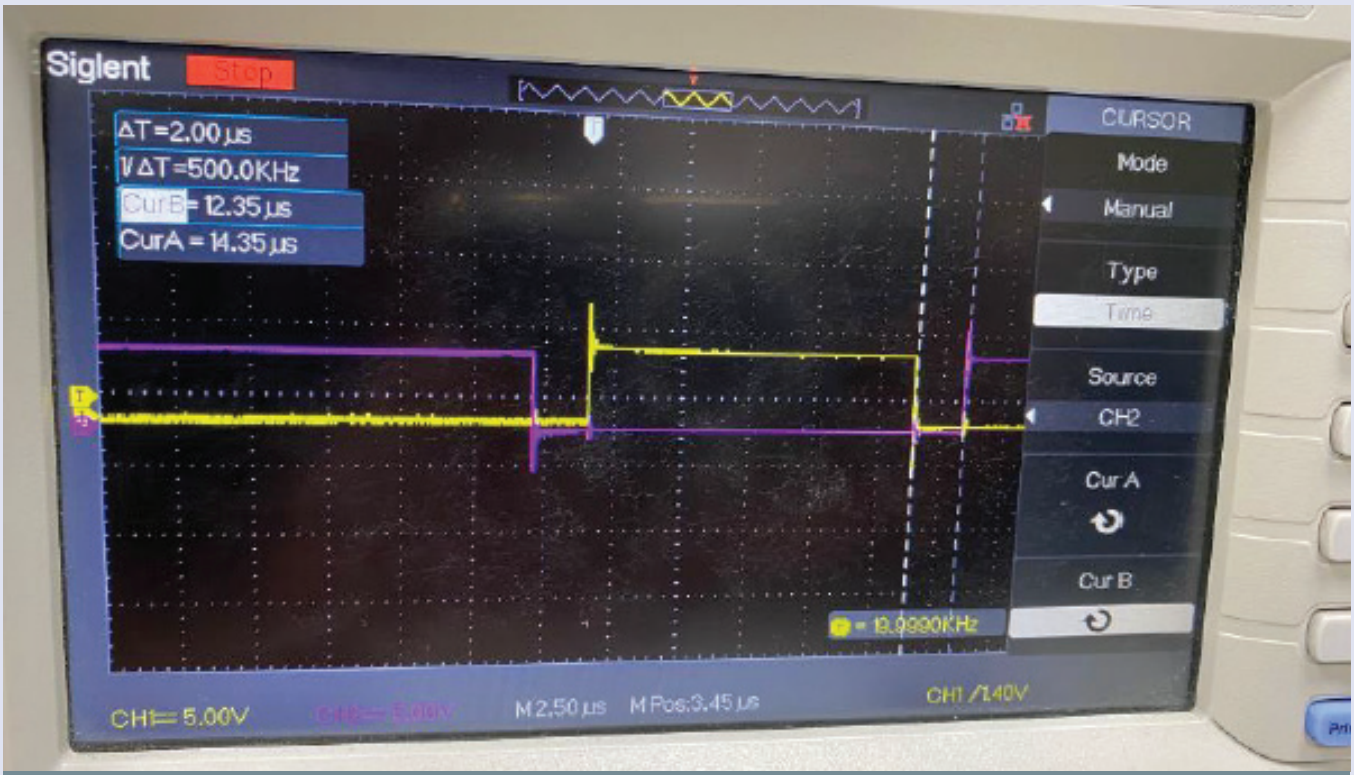
The proposed system includes many components bicycle connected to the shaft of a dc motor, then this energy stored on acid batteries, also we use buck-boost converter to regulate the DC voltage, and a full-bridge inverter built by MOSFEs and controlled by an Arduino UNO to convert the DC power into AC output. MOSFET driver circuits based on (IR2110 and IR2101 ICs) were used to drive the inverter switches, also an LC filter and transformer were added to filter and improve the output waveform (sine wave) and increase the voltage level. The inverter was designed to generate a 50 Hz AC signal suitable for powering small electrical loads.

To find how well the system works we did some tests using MATLAB/Simulink and Proteus software. The results we got were good the inverter worked fine. It was able to change the power from DC to AC. Due to the exceptional circumstances the region experienced, the components arrived late, affecting the project's continuation. We are now working to restore the power supply to the grid or utilize it for loads.

The project shows how important it is to use energy in the things we build today. The system performance of the kinetic energy project is very important, to us. We want to make sure that the kinetic energy system works well.



System wiring design



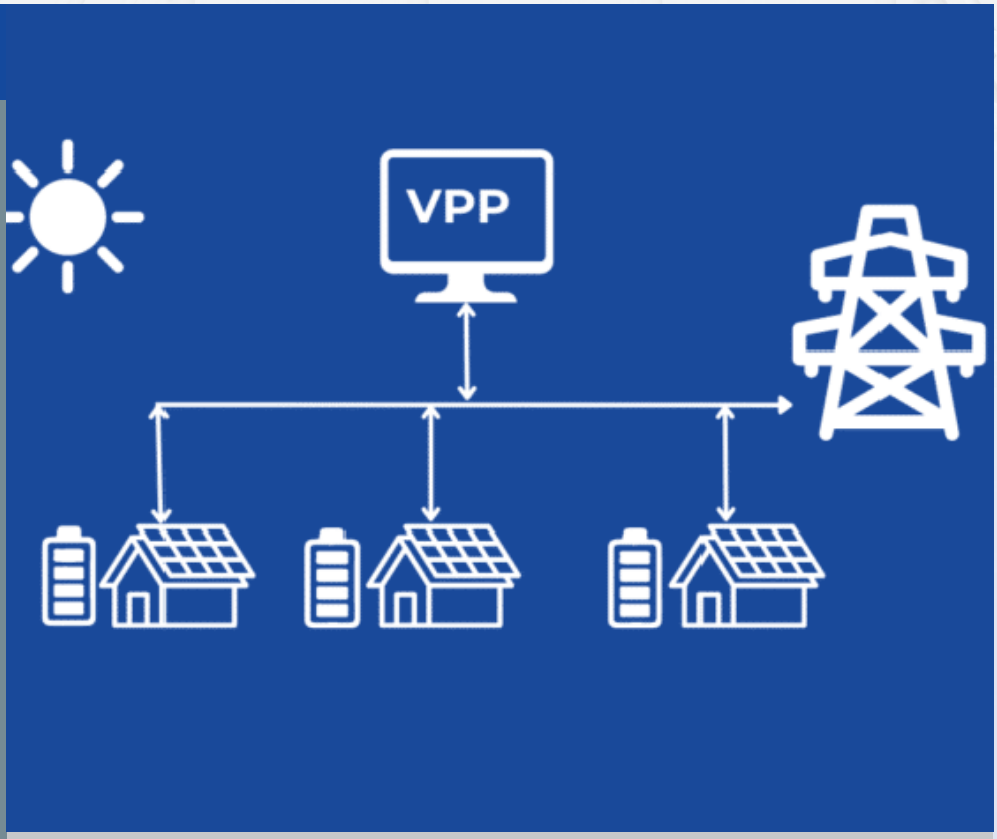
Dead time measurement — second cursor view confirming 2.00 s

Students Projects

Students:
Sayed Mohammed Kadhem
Sayed Ali Nasser
Mohammed Sameer Fayez

Supervisor:
Dr. Mohammed Majid M. Al-Khalidy

University of Bahrain
Department of Electrical & Electronics Engineering



Virtual Power Plant

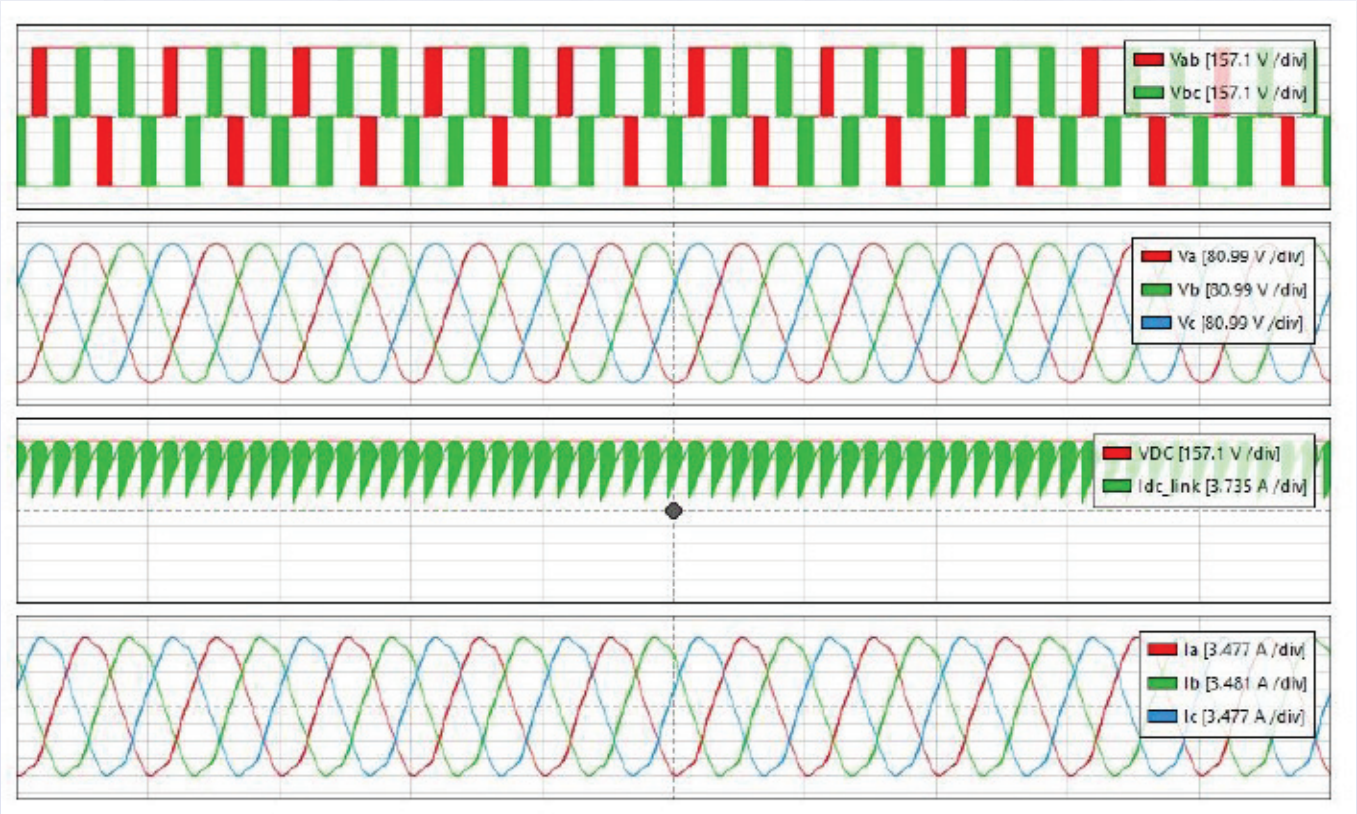
This project addresses several challenges associated with virtual power plants, we fix first the main problem which is the lack of co-ordination of the distributed energy resources (DERS) which is the VPP, then we go further in our project to solve the next real problems that comes from the VPP, like the challenge to attract and convince investors in a regulated energy market like Bahrain, and the challenge to control your VPP decisions to a point where you can benefit enough to invest in a similar project.

This project presents the development and simulation of a Virtual Power Plant (VPP) using Typhoon HIL to create a realistic model of a modern distributed power system. The simulation includes multiple distributed energy resources (DERs), inverter systems, and buck-boost converters connected to a standard 33-bus distribution network to study power flow, energy coordination, and system stability.

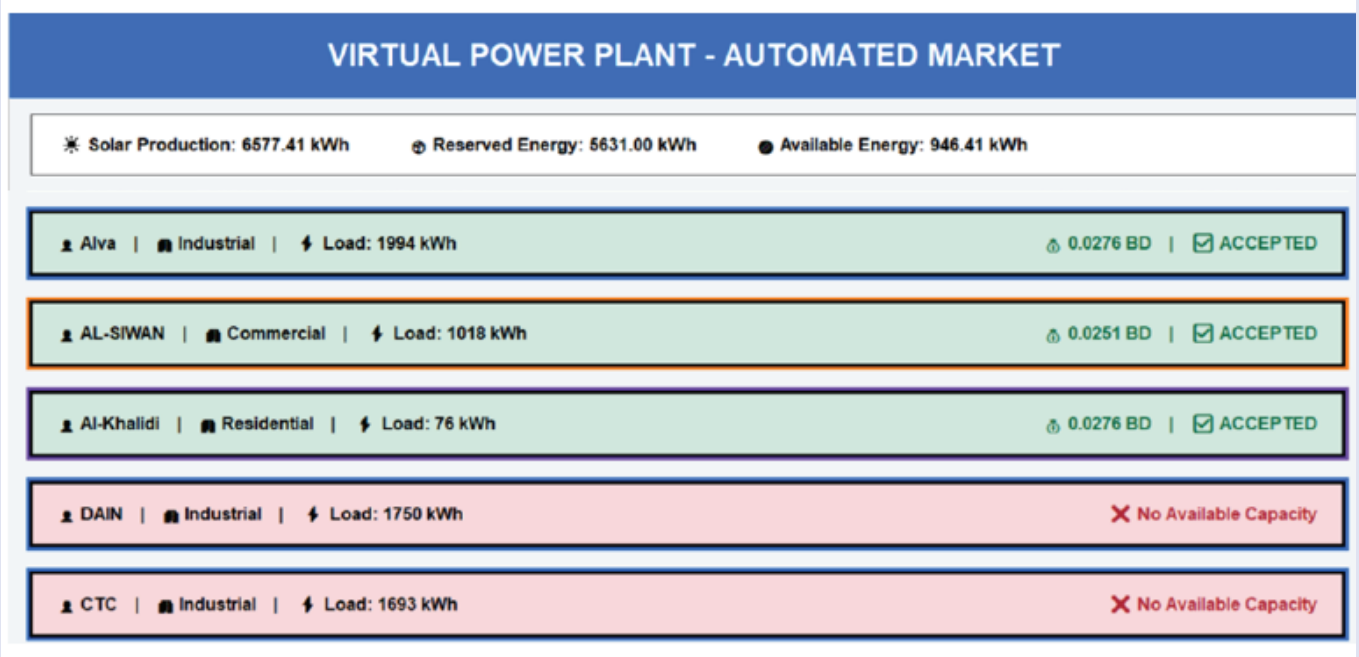
The developed system demonstrates how a VPP can coordinate distributed energy resources and balance energy demand and supply while minimizing operational complexity. The simulation includes dynamic market behavior through randomized power generation, pricing, and contract offers, allowing users to observe how energy transactions occur in real time. Multiple interface tabs were implemented to manage auctions, bids, and contracts in an interactive and user-friendly environment.

The project aims to provide a practical understanding of VPP operation, smart grid coordination, and energy market management through software simulation. In addition, the graphical interface improves visualization of market activities and participant interactions. The proposed simulation can serve as an educational and foundational platform for future development involving real-time power system tools, renewable energy integration, battery storage systems, and advanced market optimization techniques.

The results demonstrate the feasibility of using a software-based VPP model to simulate distributed energy coordination and market participation in a simplified smart grid environment. The total income for the best-case (169.774 BD) was above the daily target, and in the worst-case scenario the income (159.07 BD) was close to reaching the daily target. That indicates the ability of the controller to adapt to different scenarios and achieve relatively predictable income.



SCADA scope results



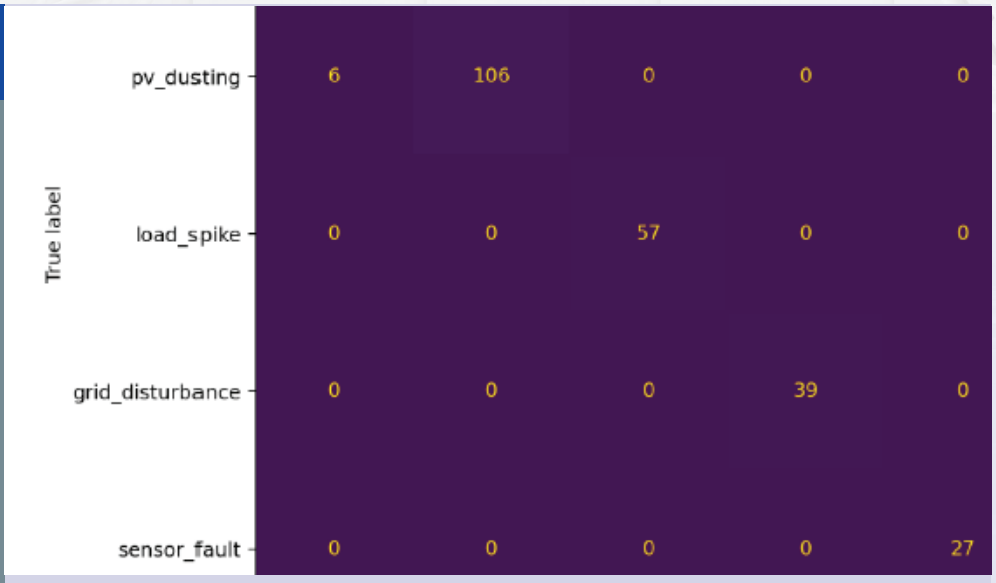
Tender tab work, with the outcomes registered

Students Projects

Students:
Ebrahim Ali Ebrahim
Qasim Hashim Alawi
Mohammed Mahdi Hameed

Supervisor:
Dr. S. Ali Al-Mosawi,
Associate Professor

University of Bahrain
Department of Electrical & Electronics Engineering



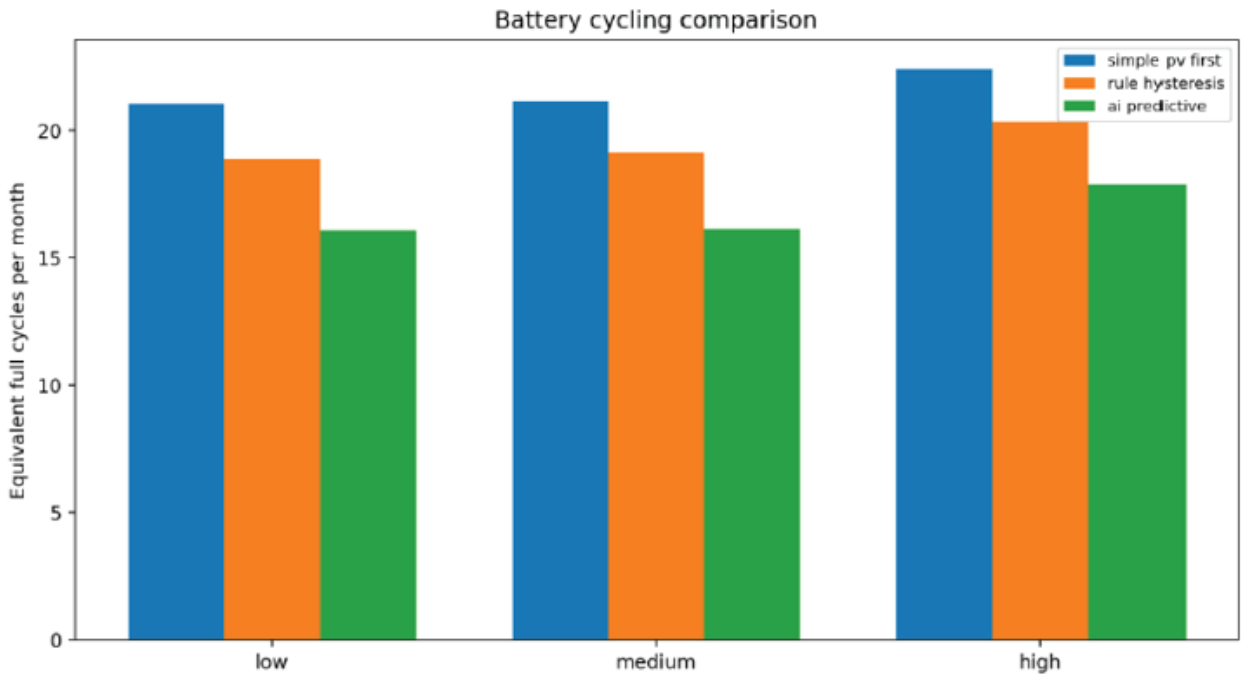
AI-Based Energy Management & Battery Life Extension in PV-Battery-Grid Systems

This project presents an AI-based smart energy management system for a residential PV-battery-grid system. The system uses Python-based training and simulation to monitor load demand, PV generation, battery state of charge, and grid usage.

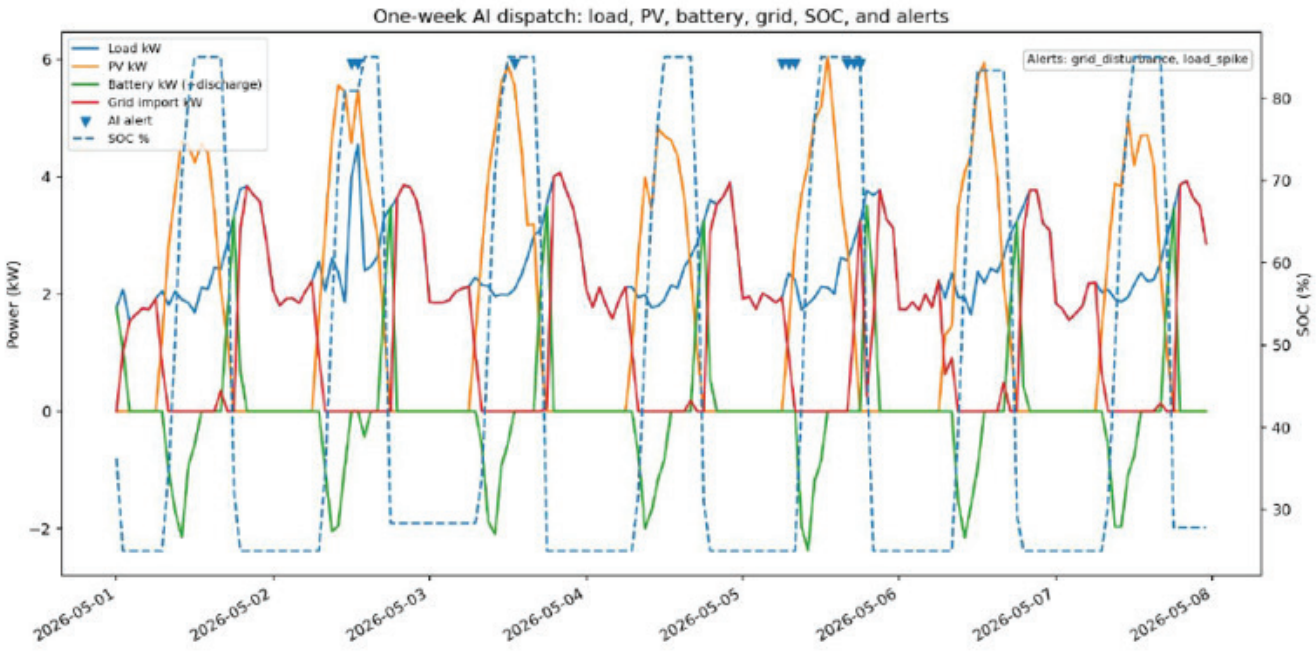
The AI controller predicts normal system behavior, detects abnormal conditions such as load spikes and PV dusting, and improves energy-flow decisions.

The main focus is reducing unnecessary battery charging and discharging to protect the battery and extend its lifetime.

Simulation results show that the AI-based controller can reduce battery cycling, limit SOC violations, provide user alerts, and improve long-term system performance with only a small increase in grid import.



Equivalent full-cycle comparison for the three PV-battery controllers



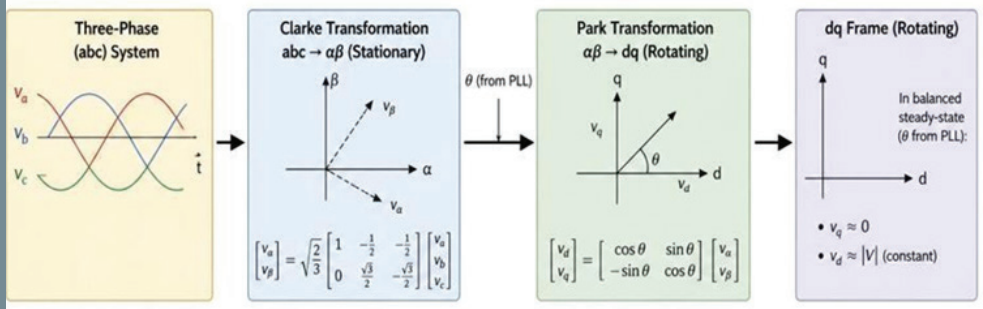
One-week AI dispatch timeline including load, PV, battery power, grid import, SOC, and AI alert markers

Students Projects

Students:
Mohamed Fawzi Alorayedh
Sayed Saeed Mohsin
Mohammed Abdulnabi Dawood

Supervisor:
Dr. Mohamed Amine Fnaiech, Assistant Professor

University of Bahrain
Department of Electrical & Electronics Engineering



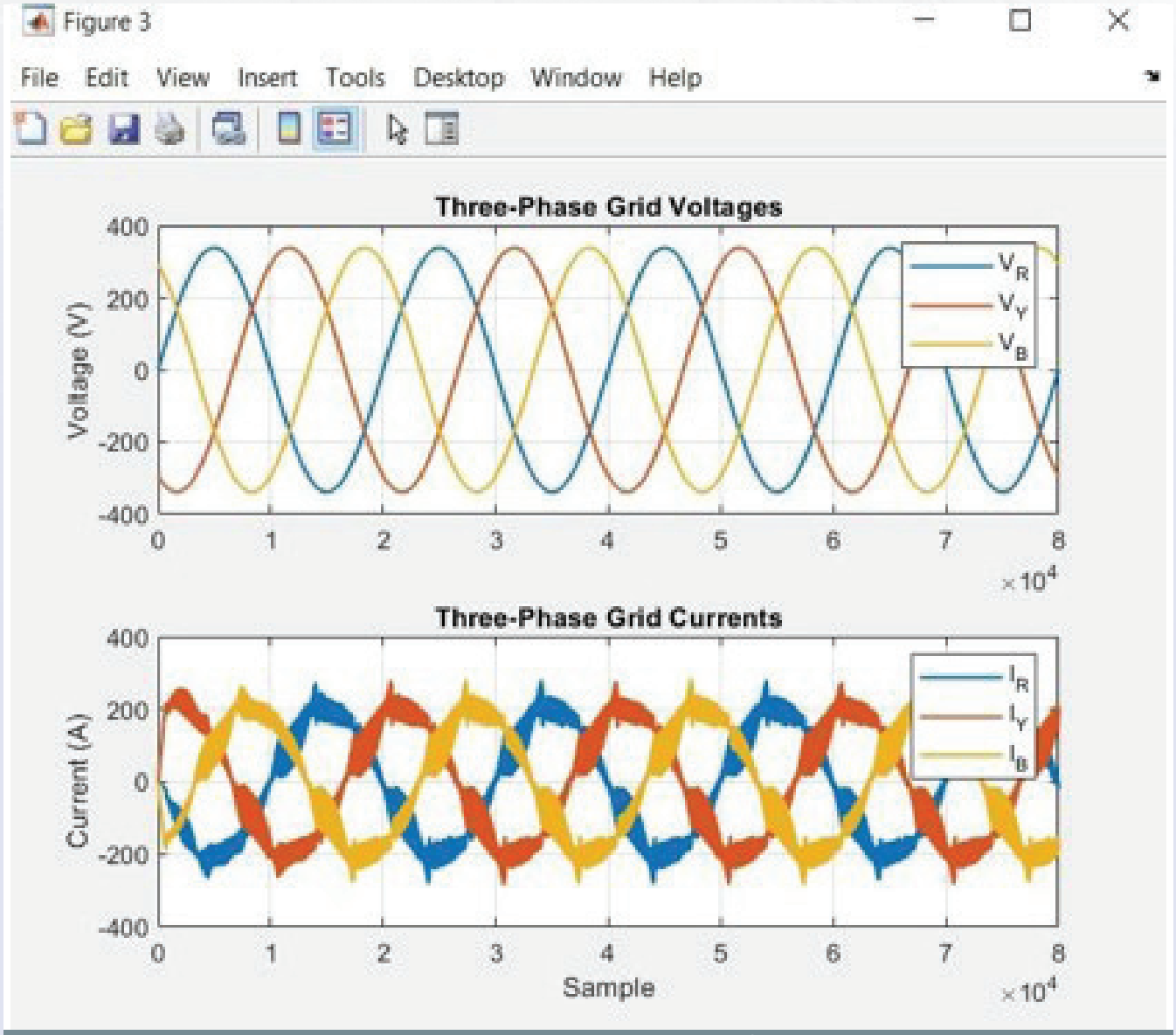
Voltage Oriented Control of a Three-Phase Grid-Connected Inverter for DC Generator

This work concentrates on the analysis of a Voltage-Oriented-Control strategy for a three-phase grid coupled inverter supplied by a DC generator. The purpose of the work is to show how the generator DC output can be converted into regulated AC power and be grid connected. The simulated system includes a DC generator, DC bus capacitor, two-level three-phase IGBT converter, LCL smoothing filter. Simulation was developed in MATLAB/Simulink to examine the behavior of both the power stage and controller during steady operating conditions.

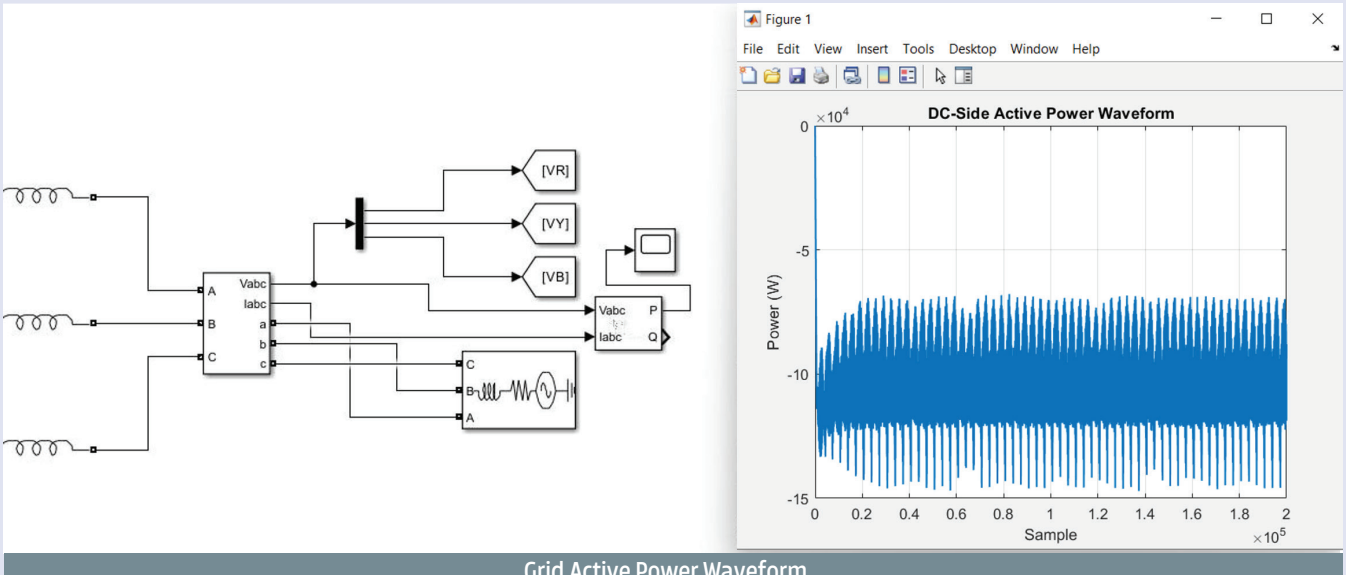
The control method used in this project depends on orienting the dq rotating frame to grid. PLL is implemented to obtain the grid angle, to be used in the abc-to-dq conversion process. By using this method, the measured three-phase quantities are converted into direct and quadrature axis components. This simplifies the control operation because the controller deals with almost constant values instead of sinusoidal waveforms. The direct-axis current controls active power flow, while the quadrature-axis current is maintained near zero to reduce reactive power. The PI controllers produce the required voltage references, and SPWM generates the six switching signals for the inverter IGBTs.

The simulation results show that the PLL achieved proper grid synchronization, as the quadrature-axis voltage was nearly zero and the direct-axis voltage matched the expected grid voltage level. The current results also show that the direct-axis current tracked the chosen negative reference, which represents power injection from the inverter to the grid. The quadrature-axis current remained near zero, which shows that reactive power exchange was minimized. The grid voltage and current results showed that the inverter produced balanced three-phase AC output and injected current into the grid. Some ripple appeared in the power and current responses because of the SPWM switching process, but the LCL filter reduced the ripple effect.

Overall, the results show that the VOC method can effectively control a DC-generator-fed three-phase grid-connected inverter. The system demonstrated correct synchronization and current regulation and delivery of active power.



Three-Phase Grid Current and voltage Waveforms



Grid Active Power Waveform



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