2021

Arab Academy for Science and technology

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[A PROPOSAL FOR AAST RESEARCH FUNDING]

"Research on Optimizing the Effect of Loads on Characteristics of Power Electronics Converters for Renewable Energy Applications"

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Proposal Application

Proposal Details

Title:

"Research on optimizing the effect of loads on characteristics of power electronics converters for renewable energy applications"

Keywords: Control Techniques Power Electronics, Renewable Energy, Simulations, Experimentation

Funding and Duration: 12 Months

Total cost: Estimated overall budget of the project: 70,000 EGP

Research Theme: Electrical and Control Engineering

Proposal Summary: English

The use of renewable energy resources instead of fossil fuels resources has increased exponentially in the last decade. Electricity generation from Photovoltaic and Wind farms does not cause pollution with possibly no noise emission. In addition, these renewable sources don't involve running fuel costs. This research project proposal presents a study of load effects (DC, AC, statics and dynamics) on characteristics of power electronics converters for renewable energy applications; in order to optimize the overall system performance. For example, in a stand-alone photovoltaic application, load characteristics impact the selection of converter and the implemented Maximum Power Point Tracking (MPPT) algorithm [1]. Also, within a stand-alone PV application, for a fixed load, the resistance seen by the PV panel can be adjusted by changing the DC/DC converter duty cycle [2]. Further illustrations of the PV system input resistance concept are discussed in [3]. The proposed study will involve comparison of each load effect on the renewable energy systems and the control algorithm. Case studies will be mainly a renewable source, power electronic convert and loads, and the evaluation criteria of each case study will be on power transfer level, system cost and size together with the overall system efficiency. The outcome of the project can be a standardised method of the selection and design of the suitable converter and control technique for a given load within renewable energy applications. Software simulation and experimental test rig will be utilised to conform the attained results.

Proposal Summary: Arabic

ملخص المشروع

نظرا لزيادة استخدام موارد الطاقة المتجددة بدلاً من موارد الوقود الأحفوري بشكل كبير في العقد الماضي. و كذلك الاعتماد علي توليد الكهرباء من محطات الطاقة الشمسية وطاقة الرياح فى مصر و الذى لا يسبب تلوثًا بيئيا. بالإضافة إلى ذلك،فانه لا تتضمن هذه المصادر المتجددة تكاليف تشغيل الوقود المستمرة.لذلك يقدم هذا المشروع البحثي مقترح لدراسة تأثيرات الحمل (احمال التيار الثابت ، احمال التيار المتغير ،الأحمال الديناميكية المتغيرة كالمحركات الحثية) على خصائص الدوائر الكهربية و المحولات الاكترونية المستخدمة في تطبيقات الطاقة المتجددة ؛ و ذلك بهدف تحسين أداء النظام بشكل عام. على سبيل المثال، في أحد التطبيقات الطاقة الشمسية الغير متصلة بالشبكة، تؤثر خصائص الحمل على اختيار الدائرة الكهربية وطرق التحكم بالتبعية [1]. أيضا ضمن تطبيق الطاقة الشمسية الغير متصلة بالشبكة، في حالة وجود حمل ثابت، يمكن ضبط المقاومة التي تراها لوحة الطاقة الشمسية عن طريق التحكم في طريقة عمل المفتاح الكهربي في دائرة تحويل الطاقة الكهربية الالكترونية [2]. دراسة مفهوم مقاومة مدخلات أنظمة الطاقة الشمسية يمكن توضيحة في مرجع [3]. ستشمل الدراسة مقارنة تأثير الأحمال المختلفة على أنظمة الطاقة المتجددة وطرق التحكم المنفذة. ستكون دراسات الحالة المقترحة بشكل أساسي عبارة عن مصدرًا متجددًا ودائرة تحويل الطاقة الكهربية الالكترونية والأحمال المختلفة، وستكون معايير التقييم لكل دراسة حالة على مستوى نقل الطاقة وتكلفة النظام وحجمه إلى جانب كفاءة النظام الإجمالية. يمكن أن تكون نتيجة المشروع طريقة معيارية لاختيار وتصميم الدائرة الكهربية المناسبة وتقنية التحكم لحمل معين ضمن تطبيقات الطاقة المتجددة بهدف تحسين اداء المنظومة بشكل عام. سيتم استخدام محاكاة استخدام برامج بالإضافة الي تجارب عملية لمطابقة النتائج المحققة.

Questions and Objectives

- **Questions**

  The main research questions are:

  - What are the effects of load on characteristics of power electronics converters in renewable energy applications?
  - How to optimize this effect to improve the performance of power electronics converters in renewable energy applications?
  - How can loads affect the implemented control techniques within different renewable energy applications?
  - What is the impact of such effects on the design of converter topologies in terms of component sizing?
  - What is the effect of load on maximum power point MPPT technique? Hence how more efficient methods can be suggested?

- **Main Objectives:**

  The main objectives of this research proposal are to:

- Perform mathematical analysis on the effect of different loads when connected to the renewable via the interface of power electronics converter.
- Better understanding of the load effect on overall performance of power electronics converters and associated control techniques such maximum power tracking with PV or wind applications.
- Implement a prototype setup for experimental study for different system topologies for practical validation
- Develop a standardised method of the selection and design of the suitable converter and control technique for a given load within renewable energy applications for enhanced overall system performance.

Research Design and Methods

The main research methods are as follows:

- Literate Review on similar research topics
- Mathematical analysis and analytical derivation of output impedance seen by the renewable energy source when connected to certain converter and load.
- This can then be verified using MATALB software in simulation including several methods of control techniques (such as maximum power point tracking) to evaluate the overall system performance and verify analytical derivation.
- Experimental validation on prototype system
- Provide final report with conclusions and recommendations for journal or conference publications.
- The adopted research techniques are relevant in Electrical Engineering field, where the first step involves mathematical analysis and then verify this analysis in a software package such as MATLAB software. Then the last step will include an experimental validation.
- The research techniques involve extremely minimum hazards. Besides, experimental work will involve the normal precautions taken in an power electronics laboratory, as the ratings of the experimental test rig will be scaled down as it is only needed as a proof of concept.

Anticipated Results and Evaluation Criteria

-The results are expected to be validated and analysed based on analytical and simulation analysis using computer software.

-Then experimental setup as a prototype will be investigated for practical result analysis and verification.

- The comparison between simulation and experimental results will be carried out for final conclusions and recommendations.

Expected Project Outcomes and Impact to AASTMT

I- Expected technical output and Impact:

- Providing a report including solid knowledge of the design of power electronics converters and associated control techniques within renewable energy applications for better research and consulting work.
- Introducing two different scientific papers for international publishing
- Introducing a prototype system that could be a part of undergraduate and postgraduate laboratorial facilities in AAST.
- Benefiting AAST and the academic community by disseminating findings of the project in renowned international journals or conferences to enhance the ranking of the AAST.
- The final outcomes and methods can be extended to cover the existence running on-grid PV station in AAST for possible performance enhancement.
- The possibility that one or two MSc/PhD students can join the project at certain point and thus the project can be part of the research work for of AAST MSc/PhD programs.

II- Financial feasibility & Socio-economic Impact:

This research project can help present standardised and optimized design of renewable energy integration systems in terms of the suitable converter and associated control techniques depending on load types. This can potentially benefit the market by bringing down the cost and maximizing the efficiency of renewable

energy systems; hence the market of renewable energy systems can convince and receive new residential/industrial customers.

III – Publication:

The expected publication outcome of this project is one or two original research papers to be published in related international journals or conferences.

Resources

- The resources currently available are mainly:
  - **The personnel:** the project includes two staff members of the Electrical And Control Engineering Department in AAST-Abu Qir Campus, namely ***Prof. Hamdy Ashour*** (AAST employer number ***2479***) and ***Dr. Osama Mohamed Hebala*** (AAST employer number ***5641***). Short bio are as follows:

    Prof. Hamdy Ahmed Abd El-Khalek Ashour is a Full Professor since 2009 in Arab Academy for Science & Technology, Department of Electrical and Control Engineering, Alexandria, Egypt. He has got B.Sc. from Alexandria University, Egypt, 1992. M.Sc. from Alexandria University, Egypt, 1996, Ph.D. from Heriot-Watt University, Edinburgh, United Kingdom, 1999. He has published two scientific books and more than 50 papers in different international journals and conferences. Main areas of interest are Electrical Machines, Variable Speed Drives, Power Electronics Applications, Industrial Automation Systems, Renewable Energy and Energy Management Systems.

    Dr. Osama Mohamed Hebala received the B.Sc. (Hons.) and M.Sc. degrees in Electrical and Control Engineering from Arab Academy for Science, Technology & Maritime Transport (AASTMT), Alexandria, Egypt, in 2011 and 2015, respectively. He received the Ph.D. degree in power electronics from Robert Gordon University, Aberdeen, UK, 2020. His research interests include DC-DC converters, power conversion systems, and power systems planning and optimization. Dr Osama has two Q1 journal publications out of his PhD, besides several other conference papers.

- **The Laboratory Space**: the research project will take advantage of the laboratories in Electric Engineering department in AAST-Abu Qir Campus as it can be easily fit in the power electronics lab of the department.

- **The resources that are planned to be obtained** in order to carry out the proposed research project are mainly the laboratory equipment needed for the building the experimental test rig. ***Examples of the equipment needed are:***
  - Small scale renewable energy off- grid setup with different associated components
  - Power electronics switches, transformers, controllers kit, inductors, capacitors, batteries and loads.
  - Needed measurements and data acquiring software and hardware facilities

Team Information

- Short bio of the two members participating in the project is shown in previous section (Resources/Personnel).
- Other details of participating members such as contact, principal investigator, etc are described in the research team information table shown below.

Research Team Information Table

Name of Res. Team Member in English	Name of Res. Team Member in Arabic	University / Institute In English	Position / Title	% of time spent on project	No. of months	Incentive per month (LE)	Number of other projects and their IDs	Total % of time spent on other projects	Contact No
Hamdy Ashour	حمدي عاشور	AASTMT (PI)	Full professor in Electrical and control Engineering department (AAST employer number ***2479***)	50%	12	500	none	50%	+20 100 820 2338
Osama Hebala	أسامة حبالة	AASTMT	Dr, lecturer in Electrical and control Engineering department AAST employer number ***5641***)	50%	12	500	none	50%	+20100 1635131

Plans for Disseminating Research Results / Sustainability of the action

-The obtain results will be included as a report in the AAST page site of each participant, and the final results will be published in international journals.

- A workshop and seminar for the department staff and students are proposed to be carried out for sharing the final research results and recommendations

Declaration of original submission and Other Grant(s)

Hamdy Ashour and Osama Hebala declare that their proposal did not and will not be submitted in whole or part for funding; twice within the same cycle, or to other funding programs within AASTMT, or other funding agencies during the evaluation period and in case of being funded.

Guided References

[1] Ahmed, Saidi & Cherif, Benoudjafer & Benachaiba, Chellali, *Renewable Energy for Smart and Sustainable Cities*- Pages 355-368 - Springer International Publishing, 2019, doi: 10.1007/978-3-030-04789-4.

[2] E. D. Aranda, J. A. Gomez Galan, M. S. de Cardona and J. M. Andujar Marquez, "Measuring the I-V curve of PV generators," in IEEE Industrial Electronics Magazine, vol. 3, no. 3, pp. 4-14, Sept. 2009, doi: 10.1109/MIE.2009.933882.

[3] V. V. R. Scarpa, S. Buso and G. Spiazzi, "Low-Complexity MPPT Technique Exploiting the PV Module MPP Locus Characterization," in IEEE Transactions on Industrial Electronics, vol. 56, no. 5, pp. 1531-1538, May 2009, doi: 10.1109/TIE.2008.2009618.

Acknowledgment Form:

By signing below, I acknowledge that I have read, understand and accept to comply with all the terms of the foregoing application, mentioned in AASTMT general conditions and guidelines for submitting a research proposal, including, but not limited to:

- The total number of the application pages should not exceed **30 pages** excluding a cover page, as well as all sections of the proposal (as mentioned in AASTMT General Conditions and Guidelines for Submitting Research Proposal).
- At any time, a contracted AASTMT project team member should only be participating in a maximum of one project.
- Allowable budget maximum limit should be strictly adhered to in the project proposal. In all cases, requested budget has to be justified in detail.
- AASTMT guidelines, IPR rules, code of ethics, etc. (www.aast.edu), should be read carefully and adhered to. These are integral parts of the contract.
- All proposals – in addition to PI and other data - must be uploaded to the AASTMT website by the designated deadline. Uploaded PI data should conform to the corresponding data in the application form.

Applications will not be considered eligible and will be discarded in the following cases:

- Proposals submitted by e-mail or sent as hard copies or uploaded to the AASTMT website after the deadline.
- Proposals not conforming to the designated format.
- Proposals whose uploaded PI data does not conform to PI data in the proposal file.
- Proposals in which the allowable budget maximum limit has been exceeded.
- Proposals in which maximum allowable contracted AASTMT project participation limit has been exceeded.
- Proposal letter does not include a scanned copy of the signed and stamped PI institution endorsement letter in case of team member work outside AASTMT.
- Proposal does not include a scanned copy of the signed acknowledgment form.

Date & Signature: ***Prof. Hmady Asour*** ***hamdy135@gmail.com*** ***23/1/2021***

Hamdy – 23/1/2021

Table of Eligible Cost

Eligible costs	Break downs		AASTMT support (L.E.)
(A) Staff Cost	PI		6000
	Name of each Team member		6000
	Technicians and/or Labor		2000
	Consultation fees		
	Total		
(B) Equipment	Equipment		24000
	Spare parts		2000
	Total Equipment		
(C) Expendable Supplies & Materials	Stationary		1000
	Miscellaneous Laboratory, Field supplies, Materials		2000
	Total expendable Supplies & Materials		
(D) Travel	Internal Transportation		1000
	Accommodation		2000
	Total travel		
	Services	Manufacture of specimens & prototypes	4000
		Acquiring access to specialized reference sources databases or computer software	4000
		Computer services	
	Report preparation		1000
	Publications & patent Costs		12000
	Workshops organization or Training		3000
	Others (explain)		
	Total other direct costs		
(G) Total Costs In Egyptian pounds			**70000**

Detailed Plan on Project's Activities (Gantt chart)

Activity Name	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Main 1: Literature survey.												
Main 2: Mathematical Modelling and Simulation Analysis.												
Sub 2.1: Effect of different loads (Resistive, Inductive, DC Motor.) on converters in case of different Renewable energy sources and **DC** coupling.												
Sub 2.2: Effect of different loads (Resistive, Inductive, AC Motor.) on converters in case of different Renewable energy sources and **AC** coupling.												
Main 3: Ordering Equipment.												
Main 4: Testing of equipment and Experimental Validation.												
Main 5: Disseminating findings of the project in Two International papers												
Main 5: Finalize and prepare final report.												