DERri
Distributed Energy Resources
Research Infrastructures

TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

User-Project Acronym	Mavisis
User-Project Title	MODGES Module Efficiency
Main-scientific field	Power Electronics
Specific-Discipline	PV Inverter

Lead User of the Proposing Team:

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Activity type and legal status* of Organization	(3)
Position in Organization	Research Director

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

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Position in Organization	R&D Manager

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Date of submission	31 January 2012
Re-submission	YES_____ NO___X___
Proposed Host TA Facility	AIT
Starting date (proposed)	14 May 2012

Summary of proposed research

Mavisis Technology is a renewable energy power electronics company, founded in 2006 by the most award winning power electronics experts in Turkey. Since its foundation Mavisis has been the R&D partner of well-known companies internationally in power electronics, electrical safety/ protection, remote monitoring and renewable energy. Mavisis has also academic collaborations with TÜBİTAK (The Scientific and Technological Research Council of Turkey) and İTÜ Energy Institute.

Mavisis has developed renewable energy inverters under the brand name Mavi-Solar that fit perfectly for both domestic and utility scale power ratings changing from kWs to MWs. Mavisis products have been awarded several times by TÜBİTAK, TTGV (Technology Development Foundation of Turkey) and TÜSİAD (Turkish Industrialists' and Businessmen's Association).

MODGES POWER STATION is an innovative modular PV inverter system concept developed by Mavisis, and consists of 16 36 kW 3-phase modules each having 3 MPPT inputs. Modules are being switched in or out as the input power requires.

The PV simulator we are using is a constant supply that we can only test the conversion efficiency at a specified power. We need to compare the performances of two different MPPT algorithms we developed but Mavisis has no access to a PV simulator mimicking partial shading effects at required power range. We seek to have the opportunity of accessing to an infrastructure enables us to test our algorithms under fluctuating irradiation conditions and document the measured MPPT efficiencies of the algorithms.

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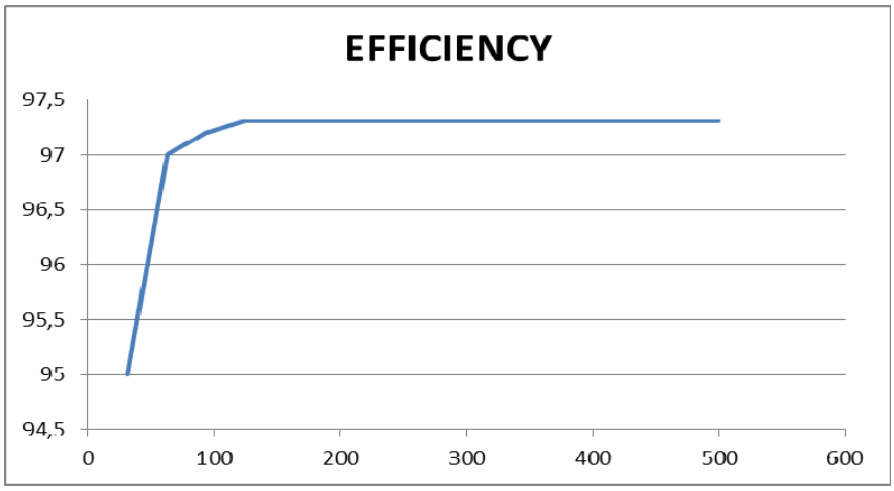
State-of-the-Art (about 1 ½ page)

MPPT measurements of the PV inverters dictated in the EN 50530, approved by CENELEC in 2010, are standard procedure now.

We have our MODGES 36 kW inverters tested in our own premises with three 900 V/25 A power supplies which enable us to measure only conversion efficiency of a single MPPT input at a time.

Since the controller unit ensures each module to be run at least 50% of its full load, all inputs are considered to be operating at a high (97%) conversion efficiency point rather than the lower part of the efficiency curve.

Resulting projected efficiency curve is shown below:



- Efficiency curve between 10% and 100% of input power is flat, due to disabled unnecessary power consuming inverter modules at partial powers.
- Recommended string design is as much serial connections as possible in order to decrease the amount of DC cables and DC cable losses. MODGES Inverter modules have higher efficiency at these real-life high voltages. On the other hand central and mini central inverters' real life efficiency is decreasing with increasing DC voltages

We need to document our prototype's MPPT efficiencies measured by an internationally accredited test laboratory and continue R&D as required.

References:

– TS EN 50530 "Overall efficiency of grid connected photovoltaic inverters", IEC/TSE, 2010.
– TS EN 61683 Photovoltaic systems – Power conditioners – Procedure for measuring efficiency, IEC, 1999.
– M. Valentini, A. Raducu, D. Sera, R. Teodoroscu, "PV inverter test setup for European efficiency, static and dynamic MPPT efficiency evaluation" Optimization of Electrical and Electronic Equipment, 2008. OPTIM 2008. 11th International Conference on, vol., no., pp.433-438, 22-24 May 2008
– R. Bründlinger et.al., "The New European Standard for Performance Characterization of PV Inverters" 24th European Photovoltaic Solar Energy Conference, Hamburg/ D, September 2009

Detailed Description of proposed project:

This research aims to see how different irradiation profiles can be handled by the MPPT algorithms we developed.

There are two different MPPT tracking algorithms we use in the inverter modules: The "Normal" algorithm assumes the weather is steady and part'al shadings on the PV array is neglectable; The "Shade Resistant" algorithm assumes that there is a high possibility of the photovoltaic array may be exposed to very rapidly changing variable irradiation conditions and partial shadings.

Objectives

In this project we want to see if the two algorithms perform as they required to. We want to evaluate the performances of tracking algorithms against varying irradiation simulations. Resulted tracking efficiency curves would allow us to determine the actual yield depending of which algorithm is used.

One another objective of this project is to exploit the result of a previous DERri research – ETAIzmir. In this research made through the DERri transnational access scheme, a weighted efficiency was suggested. We want to evaluate our prototype's efficiency within the framework of this research, as well as within the Eta Euro and Eta CEC weighting schemes.

Expected Outcome

Being have access to AIT PV Inverter Test Laboratory, we expect to have reliable and accredited performance report of our PV inverters with two different MPPT algorithms. Documenting those prototypes against EN 50530 would allow us to make amendments and further develop the tracking performance as necessary.

Fundamental Scientific and Technical value and interest

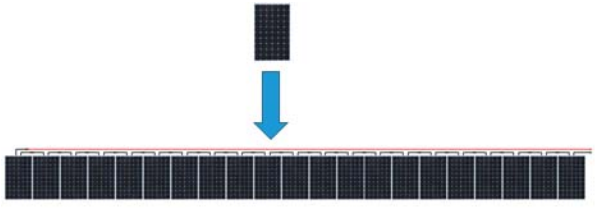
The proposed experiment of comparison and evaluation of MPPT algorithms would produce results that enable Mavisis to develop their innovative system further.

Based on the results that will be derived, other options of operations may be considered. We can envisage switching between the algorithms during the operation or running them in combination within the other modules in the whole system.

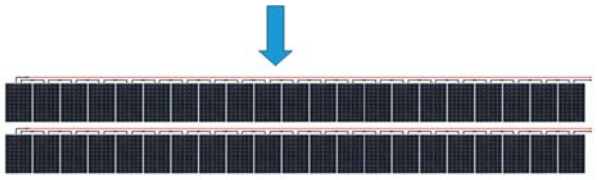
Originality and Innovation of proposed research – Broader Impact

MODGES POWER STATION; an innovative and cost effective photovoltaic inverter solution from 500 kW up to tens of MWs with increased modularity and excellent up-time. By using 36 kW modular 3-phase 3 MPPT input inverter modules it is possible to build MW size photovoltaic projects with following advantages:

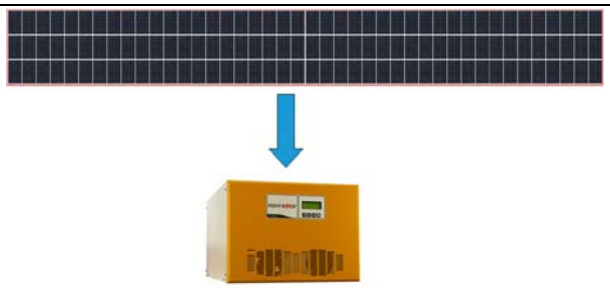
1. **Easy and efficient string design for increased throughput**
    a. Taking 220-270 Wp crystalline PV module types into consideration, it is possible to achieve 5 000-6 000 Wp string power, thanks to high inverter efficiency at higher DC Voltages.



A PV string can consist out of 20-22 series connected PV modules.



Each double string could be obtained without using any combiner box.



Three double strings could directly feed into three MPPT inputs of one MSXI-3336 inverter module. A 500kW MODGES POWER STATION consists of 16 MSXI-3336 modules and 48 MPPT inputs.

b. Each MPPT input of MAVISIS MSXI-3336 can have 10-12 kWp power. In the above motioned way, cabling costs can be reduced with 20% to 60%.
c. Another advantage of using separate inverter units rather than using central inverters is with the increased string DC voltage the DC cable losses are typically %36 lower.

High string voltage may lower the efficiency of central inverters. In MODGES POWER STATION, high voltage DC string design will have 1% to 2% higher efficiency in real operating conditions.

2. Each 500kW is composed of 48 MPPT inputs

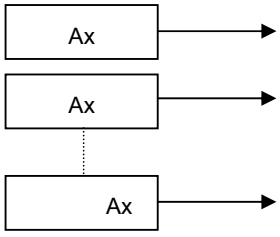
a. Shaded strings do not affect the overall performance.
b. PV module classification is not necessary in order to match the strings like in central inverters.
c. Thanks to 48 MPPT, system efficiency is less affected from tolerance mismatches, panel dirt-dust build-up, temperature and shadings.
d.

3. Modularity

a. 500 kW MODGES POWER STATION is composed of 16 MSXI-3336 modules. If a module failure occurs remaining modules continue to operate. Consequence is excellent redundancy.
b. MTTR (Mean time to recovery) of a 500 kW shelter is low and availability is very high.

Availability of typical central inverters is: A=0,97

Availability of a typical 500 kW MODGES POWER STATION is:



$A = (1- ((1- Ax)^{16})$
A = 0,9999999999999999.....

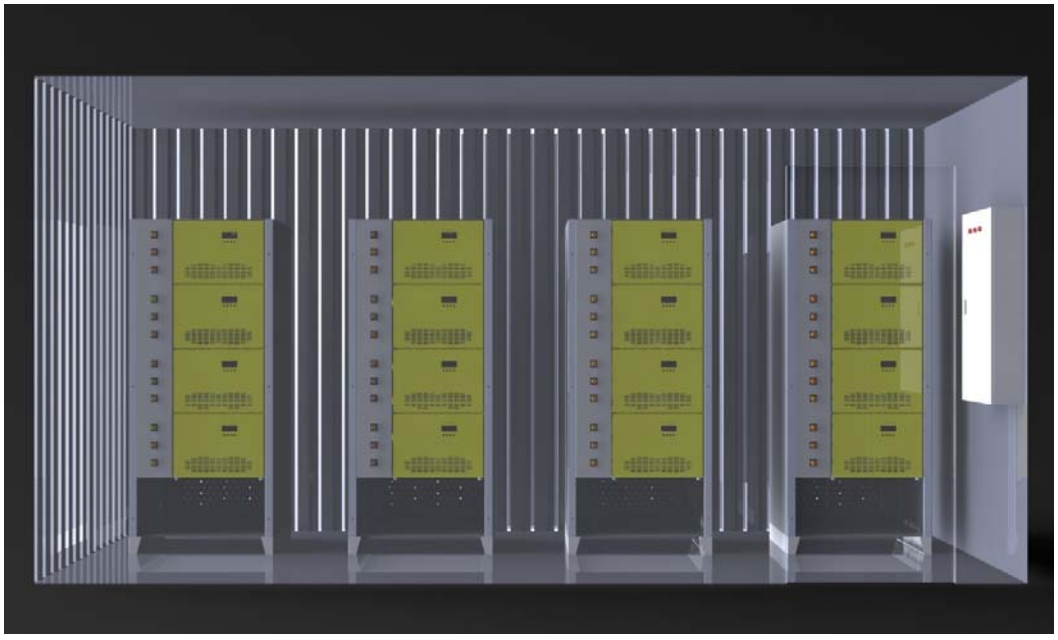
c. If an inverter module failure occurs there is no need to wait the technical staff. The failed inverter could be replaced with the spare inverter module in short time by a non-expert technician.
d. Preventive maintenance agreement is not an obligation, it is optional.
e. To replace the inverter modules no forklift or crane is necessary, the modules could be replaced by two people easily.

4. String Level Control and Monitoring

a. String protection and string monitoring does not have extra costs. All these functions and costs are included in the inverters.
b. Each MPPT input current and voltage is monitored and logged separately. Thus string level faults; such as cable damage or lightning damages can be easily identified.

5. 500kW MODGES POWER STATION is composed of below listed components.

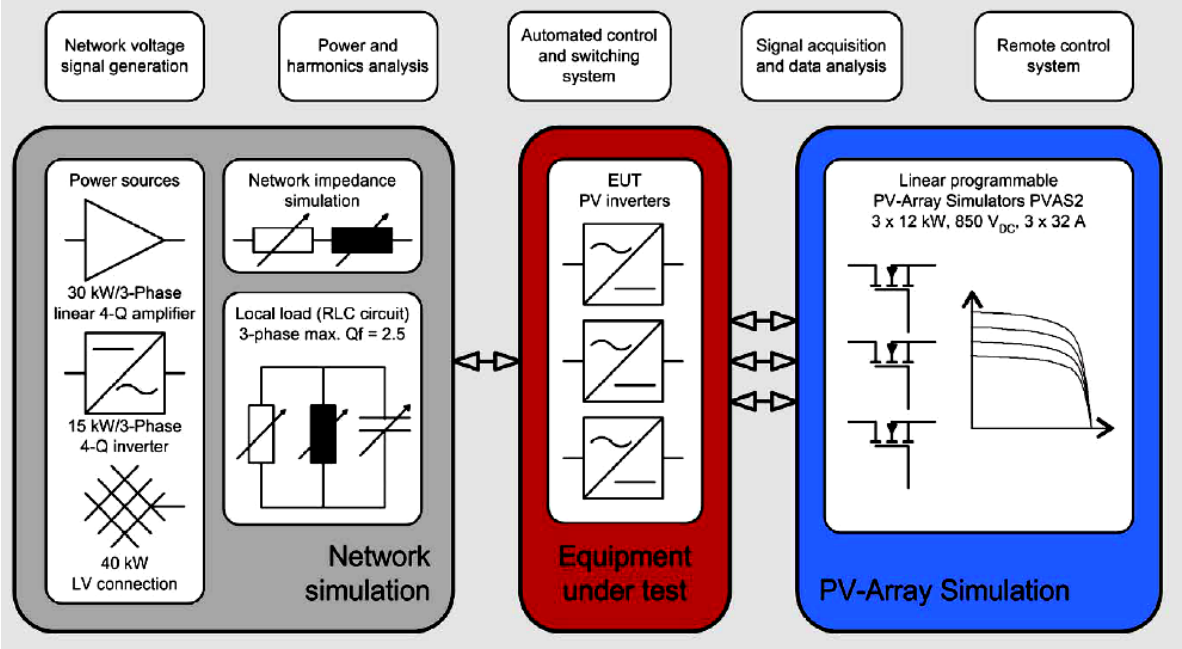
- 1x Shelter
- 4x 125kW Frames each of those holding 4 inverter modules.
- 16x MSXI-3336 Inverter Modules
- 1x MSXI-3336 Spare Inverter Module
- Cable pans and complete Shelter cabling
- Cabin Lights and air ventilation
- DC Disconnect Switches
- AC protection components and protection relays
- LV AC combiner box
- Data Logger



Proposed Host TA Infrastructure/Installation – Justification (about one page)

The proposed host is Austrian Institute of Technology – AIT. Preliminary correspondence was made with the institute and an initial settlement was made. AIT declared that they are interested with such an experimental proposal.

AIT's infrastructure consisting of a 36 kW software controlled PV array simulator would be suitable for the performance evaluation of our prototype. Other necessities of a grid simulator, precision meters, power analyzer and statistical evaluation software are also available in AIT laboratories



Synergy with ongoing research

Mavisis, being an innovative R&D company, is in collaboration with respected universities in Turkey like İstanbul Technical University – İTÜ and Ege University and always take the chance to participate in academic researches.

Currently we are taking part in two R&D projects:

- Development of a Multifunctional (on/ off-grid) Inverter (<10 kW) with Kocaeli University
- Development of a remote monitoring system for PV inverters with İTÜ

Results of this transnational access through DERri would greatly contribute in the endeavors made in other researches.

Dissemination – Exploitation of results

Mavisis is a member of Turkish Photovoltaic Technology Platform – UFTP, the largest PV network in Turkey, with a variety of enabling and powerful members like governmental institutions, local authorities, universities, transmission/ distribution companies, commerce/ trade unions. Our transnational access and its results would enable us to report our product through this network.

The MPPT efficiency and their evaluation under ETAIzmir will be used in a doctorate study and be published as a part of the thesis.

Time schedule (about ½ page)

We envisage a 3-week study in AIT premises with a week of laboratory access:

Week 1: Orientation and preparation of the experiment procedures.
Week 2: Testing of the two algorithms within a 10 – 100% power range under various irradiation profiles
Week 3: EN 50530 test of the prototype(s)

Description of the proposing team

The lead user of the proposing team is Fatih Kavaslar. He is an experienced and science award-winning researcher focusing especially on renewable energy power electronics R&D. Mavisis Technology Ltd. which he is a founder and shareholder is the first company to manufacture wind inverter in Turkey. Company is known for their thin film PV inverters and grid power quality enhancing inverter designs.

Fatih Kavaslar graduated from İTÜ Electronic and Communication Faculty and received MSc. degree at the same.

Kavaslar worked for Siemens, Siemens-Nixdorf, SBS and Inform as R&D Engineer and R&D Director. His R&D projects 7 times awarded by TESİD, TUBİTAK, TTGV TÜSİAD for being innovative, creative. He is still working for the company Mavisis Teknoloji as a Director.

He is member of GENSED, UFTP, TSE PV Mirror Commitee.

The additional user is, Ilker Ongun M.Sc., Ege University Ege Higher Vocational School Electronics Technology, Chief of Department.

Ilker Ongun is also coordinator of Turkish Photovoltaic Technology Platform – UFTP, Education and Standards Workgroup.

Ilker Ongun is the vice president of PV Mirror Technical Committee of Turkish Standards Institution – MTC116 and has been commissioned for translating some PV standards into Turkish for his credited performance in the UFTP. These standards are:

- TSE CLC/TS 61836: Solar photovoltaic energy systems – Terms, definitions and symbols (published)
- TS EN 50530: Overall efficiency of grid connected photovoltaic inverters (in process)
- TS EN 50524: Data sheet and name plate for photovoltaic inverters (in process)
- TS EN 61683: Photovoltaic systems – Power conditioners- Procedure for measuring efficiency (IEC 61683:1999) (in process)
- TS HD 60364-7-712: Electrical installations of buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems (in process)

The second additional user is, Soner Sensoy M.Sc., graduated from ODTÜ Electrical Engineering Faculty.

Sensoy worked for Inform , Arçelik & Mavisis as an R&D Engineer and R&D Director. His R&D projects 2 times awarded by TESİD, TUBİTAK, TTGV TÜSİAD for being innovative, creative. He is still working for the company Mavisis Teknoloji as R&D Manager.