**Al-Maqdisi Program
Design and Control of
Photovoltaic Systems**

Project title	Design and Control of Photovoltaic systems
Palestinian Team Leader	1st year : Mahmoud ISMAEL(PTU) 2nd year : Basim AL SAYED (PTU)
Palestinian Universities	**Palestine Technical University Tulkarm (PTU)** **Palestine Polytechnic University Hebron (PPU)**
French Team Leader	**Ghislain REMY (LGEP)**
French University / Laboratories	**Université Paris-Sud 11 / Laboratoire de Génie Electrique de Paris and IUT Cachan**
French Coordinator	**Jean DEPREZ (MedLink)**

FINAL REPORT (French team)

1- Remaining of the objectives

- To begin a research cooperation in the field of control command of renewable energies between the teams, "Conception Command Diagnostic" of the "**Laboratoire de Génie Electrique de Paris**" (**LGEP**), the **Palestine Technical University** (**PTU**) and the **Palestine Polytechnic University** (**PPU**).
- To develop a test Bench and to perform experimentation in the PTU and the PPU using an experimental platform dedicated to the identification and the control of a photovoltaic system.
- To design tools dedicated to the design of photovoltaic systems and its optimization in the LGEP.
- To develop, with the support of the IUT Cachan, of PCB cards and electronic boards (DSP, microcontroller or FPGA), able to process the control and the optimisation algorithms.
- To organize, along the project, some training workshops for the teachers, engineers and technicians in Palestinian Universities and Technical Colleges (reinforcement of the existing network in Electrical Engineering and Industrial Automation & Control)

2- Activities

Getting high system efficiency from a photovoltaic system whatever the environmental conditions needs the use of **Maximum Power Point Tracking** (**MPPT**) algorithms which consist to find the best way to benefit from the inherit panel characteristics.
The project had to define the best solution (hardware and software) regarding the **cost and efficiency constraints** for the application. All the activities have been conducted either in France or Palestine in order to design the hardware architecture (photovoltaic panels, static power converters, data acquisition interfaces) and the related hardware/software control architecture (digital processor).

Date-Place	Activity	Description	Participants
November 1-3, 2000 **PTU** **Tulkarm**	**1- First meeting of the steering committee** **2 missions** **FR -> PAL** Support: Al-Maqdisi MedLink PTU	- Remaining of the objectives of the program. - Administrative and Financial aspects. - Definition of the steps of the project, including bibliography, training, equipment specification and installation, simulation, experimentation, validation and optimization, valorisation of the results. - Identification of the tasks in PTU and PPU respectively. - Synthetic information of the state of the art concerning photovoltaic panels, control hardware and software and system optimisation. - Definition of date, objective and content of the next mission (Palestine to France) and listing of the tasks to be achieved before this mission.	Ghisl. REMY (LGEP/IUT), Jean DEPREZ (MedLink), Basim ALSAYID (PTU), Mahmoud ISMAIL (PTU), Samer ALSADI (PTU), Raed AMRO (PPU), Khaled TAMAIZI (PPU)
April 13, 2011	**2- Internet Conference** Support: LGEP	Revision of results of simulation of different components of the system ; suggestions ; general discussion	Mahmoud ISMAIL (PTU), Samer ALSADI (PTU), Moham. DRADI (PTU), Jaffar JALLAD(PTU), Anees A. SNEINEH(PTU), Sameer KHADER(PPU), Raed AMRO(PPU), Khaled TAMAIZI(PPU), Ghisl. REMY (LGEP,IUT)
June 20-24, 2011 **IUT** **Cachan**	**3- Workshop in France** **2 missions** **PAL -> FR** Support: Al-Maqdisi IUT Cachan	- Validation of simulation models - Explication on the sizing procedure of a PV installation - Lectures on programming an efficient MPPT on PSoc/microcontroller - Specification and ordering the hardware	Jaffar JALLAD(PTU), Mekawi HURIZ(PPU), Sengprasong PHRAKONKHAM (LGEP), Abdoulaye KEBE (LGEP), Ghisl. REMY (LGEP, IUT), J-Y LE CHENADEC (IUT), E. LABOURE (LGEP,IUT)
July 7-8, 2011 **LGEP**	**4- Workshop in France** **1 mission** **PA L-> FR** Support: MedLink LGEP	- Working on simulation models - Changes in PSoc programming - dSPACE experimentation	Khaled TMAIZI (PPU), Ghisl. REMY (LGEP, IUT), Jean DEPREZ (MedLink)
October 24-29, 2011 **PTU**	**5- Workshops in Palestine** **2 missions** **PAL -> FR** Support: Al-Maqdisi MedLink PTU PPU	**Workshop in PTU** - Installation of the test bench for identification of a PV panel. - Determination of I-V and P-V characteristics for various irradiation intensities - Characterization of temperature dependence of the PV open circuit voltage - Reminder on Buck-Boost DC/DC converter: general structure, equations - Structure proposed for the Buck-Boost converter of the PV system - Installation of 2 panels on the roof, I-V and P-V characteristics - Preliminary tests of the Buck-Boost DC/DC converter - Programming of the PSoC microcontroller - Association PSoC - Buck-Boost DC/DC converter	Basim ALSAYID (PTU), Moham. DRAHI (PTU), Khalid SHADEED (PTU), Anees A.SNEINEH (PTU), Jaffar JALLAD (PTU), Samer ALSADI (PTU), Abdel K. DAOUD (PTU), Nassim IGTEIT (PPU), Khaled TAMIZI (PPU), Mekawi IHRAIZ PPU), Ghisl. REMY (LGEP, IUT), Jean DEPREZ (MedLink)

PPU		**Workshop in PPU** - Installation of the test bench for identification of a PV panel. - Determination of I-V and P-V characteristics for various irradiation intensities - Cartography of the spotlight irradiation - Installation and test of the system : PV panel/ Buck-Boost /Load controlled by PSoC - Test of 2 panels outside, I-V and P-V characteristics under sun irradiation - Connecting a battery to the system controlled by PSoC	Moham. DRAHI (PTU), Jaffar JALLAD (PTU), Nassim IGTEIT (PPU), Khaled TAMIZI (PPU), Mekawi IHRAIZ PPU), Ghisl. REMY (LGEP, IUT), Jean DEPREZ (MedLink)
February 12-17, 2012 **LGEP**	**6- Workshop in France** **2 missions** **PAL -> FR** Support: Al-Maqdisi LGEP	- Information on the installation of the PV panels in PPU - Analysis a data (temperature, irradiance) collected in Hebron - Research Seminar "Optimisation in Energy Distribution" (LGEP/SUPELEC) - Calculation and sizing of the components for the buck-boost converter - Simulation of the converter using Matlab and Simplorer. - Specification of components (data sheets and providers catalogues) - Physical implementation of the Buck Boost converter. - Choice of the voltage and current sensors and MOSFET's driver. - PCB design. Demonstration on the PCB machine. - Simulation with the PV wiring inductance and the protection capacitance - PCB design of the power part. - Test measurements on IR2117 +IRF640N - Estimation on the losses and efficiency - PCB design of the Command & Regulation part	Jaffar JALLAD(PTU), Mekawi HURIZ(PPU), Ghisl. REMY (LGEP, IUT), J-Y LE CHENADEC (IUT), E. LABOURE (LGEP,IUT), Jean DEPREZ (MedLink)
June 22-29, 2012 **PPU**	**7- Workshops in Palestine** **3 missions** **PAL -> FR** Support: Al-Maqdisi MedLink PPU	- Installation of the software Altium - Test of the PCB machine - Training workshop. Session 1: Altium Designer introduction - Training workshop. Session 2: Introduction to Schematic capture: Buck converter. - Simulation of the Buck converter - Simulation of Boost and Boost+Buck converters - Training workshop. Session 3: Altium schematic capture: Buck converter (end) - Training workshop. Session 4: Introduction to PCB editor. - Measurement of the maximum current as a function of the width of the track - Training workshop. Session 5: libraries of components - Training workshop. Session 6_1: Place - Routing - Training workshop. Session 6_2: Using the LPKF Machine - Training workshop. Session 6_3 and 7: PCB of the Buck converter	Mahmoud ISMAIL (PTU), Moham. DRAHI (PTU), Jaffar JALLAD (PTU), Mekawi IHRAIZ (PPU), Wadah SULTAN (PPU), Zaher SAAFIN (PPU), Sami ALSALAMEN (PPU) Ghisl. REMY (LGEP,IUT) Marc ARDILLIER (IUT) Jean DEPREZ (MedLink)

		- PCB for the prototype of the Buck converter board - Etching the prototype, solving the problems - Determination of the test protocol for the Buck converter - Soldering of the converter - Test of the board: fixing soldering problems - Modification (hardware) of the board to solve error in conception - Results on PV panels characterization - Design of a Basic Buck converter - Test of the converter - Proposal for the following	
September 2012 to April, 2013 *IUT Cachan*	**8- Training project** **2 IUT students (4 hours*28 weeks)** Support: Al-Maqdisi IUT	- Specification, buying and characterisation of PV panels analog to those installed in PPU and PTU - Determination of the structure of didactic equipment for a photovoltaic lab. (bust converter + buck converter) - Design and simulation of a bust converter - PCB, soldering, test of the bust converter - Association PV panel, converter, and 48V DC rail - PSoC control with MPPT algorithm of the system	J-Y. LECHENADEC (IUT) Jean DEPREZ (MedLink) 2 students of IUT

The reports of all missions are available on http://AssociationMedLink.com
The technical reports of the activities have been sent to the French Consulate after each mission.

3- Results

3.1- Photovoltaic panels
Two identical photovoltaic basic equipments have been bought in PTU and PPU. Each consists on 2 polycrystalline Cell photovoltaic panels (PVP) Photowatt PW 1250 and 1 lead acid battery LFP1265(12V65Ah).
- The protocol for test and characterization under various irradiation conditions has been established.
- Experimental setup allowing the test of the PVP under artificial light in the lab have been specified and experimented
- Mechanical systems allowing mounting the PVP on the roof of the building, with suitable orientation, have been designed and equipped with the electrical connections allowing remote voltage and current measurements.
- The typical characteristic for sun irradiation around 550 W/m2 has been deduced from numerous experimental data and validated by comparison between simulation and experimental results.
- For further optimisation and transient analysis of the system, solar radiation and temperature have been collected in Tulkarm within two time scales: duration 5 days sampling period 1 sec; duration 35 mn, sampling period 10 ms.

3.2- Power electronics
Two DC/DC converters structures have been designed and simulated using Matlab/Simulink and Simplorer simulation software.
The [buck-boost] structure is the more attractive in term of component cost and efficiency. It uses a single chopper for voltage matching between the PVP and the battery, even at low irradiance of the PVP. A basic prototype, using non-optimized spare parts from IUT Cachan

(DC Chopper, Inductance, Diode, Current Sensor) has been successfully tested in PTU with resistive load but some difficulties have been encountered (instability) when repeating the experiment in PPU with the battery as load.

The [boost-buck] structure is easier to design but needs two choppers with an intermediary high DC voltage rail between the PVP and the battery. It is also easier to build and test step after step. That's why we have chosen this structure for developing a PCB prototype.

This prototype was the result of the training workshop during activity 7 in PPU. Unfortunately, for technical reasons and errors in the design the test of the prototype was unsuccessful.

On the other hand, the prototype of boost converter developed in activity 8 was successively tested.

3.3- Control

IUT Cachan has provided for the project 2 microcontroller PSoC kits (Cypress CY8C29466-24PXI PDIP). A basic training session has been done in order to give to the Palestinian team the capability to program and interface the microcontroller.

Programs for open loop control of the system and basic MPPT algorithms have been tested.

We have encountered a lot of problems concerning the analog interfacing (current sensors, differential voltage measurement) which have not be solved at the end activity 7. They have been solved in activity 8.

3.4- Diffusion of data

Detailed technical reports have been written by the French team for all activities.

4 posters have been designed by the French Team, related to activities 1 and 5.

The project did not reach a scientific level allowing publication or communication. It has been suggested the participation of the Palestinian team to local conferences.

4- Conclusion and recommendations

In the field of Electrical Engineering, there is no real research team in Palestine. The French team accepted to enter in the project because it was based on the active participation of 2 Palestinian colleagues identified in PPU and PTU. They were supposed, by their competence and dynamism, to catalyse the emergence of a working group. One of them, Mahmoud ISMAIL, from PTU, who was the Palestinian coordinator of the project and holder of a Master in Renewable Energy, left Palestine after the first semester to benefit of a PhD scholarship in Malaysia. The other was Khaled TMAIZY, mecatronic lab supervisor, the best trainee we had during several technical training workshops in Palestine. He spent 6 weeks in IUT Cachan in 2009. He is very efficient and familiar with our way of working. Due to the interference of the Board of Trustees of PPU in the decisions of the steering committee of the project, he was isolated from the project. The heavy hierarchy which reigns in the Palestinian universities is not favourable with the emergence of young competences…

From the 8th month, two participants from PTU (Jaffar JALLAD and Mohammad DRAHI) and one participant of PPU (Mekawi IRHAIZ) follow all the activities of the project. Some others participants made, occasionally, non-constructive specific appearances. Because of their low scientific and technical levels, and of their incapacity to enter in a production phase, we didn't overpass with them the phase of training. At the end, we are not even sure that they understood the methodological aspect of research.

During the second year of the project, we focussed only on the implementation a basic didactic system. During the activities, we tried to introduce the basis of experiment planning and measurement protocol, which seems to be unknown by the Palestinian colleagues.

We didn't notice, between the missions in Palestine or France, any production due to initiative of the Palestinian team. No exchange of information. No questions… We are afraid that, in the Palestinian side, it would not appear any following of this work…

In IUT Cachan, we estimate that some information and technical experience have been collected during the project. In order to benefit from this, we decided to finalize the project with IUT students. Two of them, supervised by Jean-Yves LECHENADEC have realized a part of the system during their 3rd and 4th semesters training projects. Two other will continue next academic year. We expect to obtain a didactic platform and we propose to duplicate it in PPU and PTU labs.

In general conclusion, this tentative in research cooperation leads us to think that we didn't well estimate, at the time of the writing of the project proposal, the capability – and may be the will – of the Palestinian partners to mobilize experimented researchers able to enter in the processes that are involved in experimental research by research teams. We are now sensitized on this point, and we think, and hope, having also sensitized our Palestinian colleagues.

Paris, May 29th, 2013

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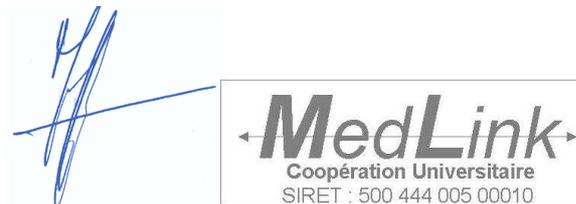
Jean DEPREZ,
President of MedLink

Ghislain REMY
French Team Leader

Joint Appendix : Financial report

Appendix: FINANCIAL REPORT (French Team)

The global analysis of the resources and expensive is given in the following table.

RESOURCES		
	French Consulate	MedLink, IUT
CNOUS - payment 1	6080	
CNOUS - payment 2	1720	
IUT Cachan		506,66
MedLink		1603,1
Total	7800	2109,76

EXPENSIVE							
		Support : French Consulate				Support : MedLink, IUT		
Activity		Flight Tickets	Perdiem, food, hotel, passeport	Equipment(IUT,LGEP)	Taxes, Bank charges	Flight Tickets	Equipement (PPU,PTU)	Taxes, Bank charges
1	Mission France Palestine 1 - 4 / 11 / 2010	572,00	67,70			572,00		
3	Mission Palestine France 20 - 24 / 06 / 2011		992,36				250,00	
4	Mission Palestine France 7-9 / 07 / 2011					540,00		
5	Mission France Palestine 23 - 29 / 10 / 2011	1 835,58			40,82	405,10		
6	Mission Palestine France 12 - 17 / 02 / 2012		1 093,28					
7	Mission France Palestine 22 - 29 / 06 / 2012	1 696,05	317,00	381,77	117,86		256,66	86,00
8	Design of a Didactic Platform in IUT			485,58				
Total		4 103,63	2 470,34	867,35	158,68	1 517,10	506,66	86,00
General Total		7 600,00				2 109,76		

In addition to the main resource from the French Consulate, incomes from IUT Cachan and MedLink have allowed extending the mobility activities and providing some small equipment to the Palestinian laboratories.

The detailed account table is given in annex.

A provision of 2500 € is reserved by MedLing, allowing the following of the program in IUT and the duplication of the resulting didactic platform in PPU and PTU.

Paris, May 29th, 2013

Jean DEPREZ,   **Ghislain REMY**
President of MedLink   **French Team Leader**

Annex: Detailed account table

Al Maqdisi Program. MAE-CNOUS RESSOURCES

Mission / Date	Description	CREDIT	DEBIT	BALANCE	Flight Tickets	perdiem/taxi/food/accomodation	Equipment for IUT,LGEP	Equipment for PPU,PTU	Bank charges, change
1/10/10	Initial situation	0,00	0,00	0,00					
Mission France Palestine 1 - 4 / 11 / 2010	Flight Ticket Paris-Tel Aviv Ghislain REMY		572,00	-572,00	572,00	67,70			
	Advance to PTU perdiem Ghislain REMY and taxi		300,00	-872,00					
	Taxi CDG - Cachan		67,70	-939,70					
1/2/11	Bank transfer from CNOUS	6 080,00		5 140,30					
Mission Palestine France 20 - 24 / 06 / 2011	Perdiem Jafar, Mekawi		300,00	4 840,30		992,36			
	Metro/RER Jafar, Mekawi and escort		140,00	4 700,30					
	Meals Jafar, Mekawi		127,36	4 572,94					
	Hotel Jafar Mekawi		425,00	4 147,94					
4/8/11	Reimbursement from PTU	300,00		4 447,94					
Mission France Palestine 23 - 29 / 10 / 2011	Flight Ticket Paris-Tel Aviv Ghislain REMY		1 120,34	3 327,60	1 835,58	0,00			40,82
	Reimbursement MedLink (Flight ticket Paris-Tel-Aviv JD)	715,24		2 612,36					
	Advance to PTU perdiem Ghislain REMY and taxi		340,00	2 272,36					
10/11/11	Bank transfer from CNOUS	1 520,00		3 792,36					
23/12/11	Reimbursement from PTU / Bank fees	340,00	40,82	4 091,54					
Mission Palestine France 12 - 17 / 02 / 2012	Hotel Jafar Mekawi		500,00	3 591,54		1 093,28			
	Metro/RER Jafar, Mekawi		90,40	3 501,14					
	Meals Jafar, Mekawi		202,88	3 298,26					
	Perdiem Jafar, Mekawi		300,00	2 998,26					
Mission France Palestine 22 - 29 / 06 / 2012	Flight Ticket Paris-Tel Aviv G REMY/M ARDILLIER		1 130,70	1 867,56	1 696,05	317,00	381,77		117,86
	Reimbursement MedLink (Flight ticket Paris-Tel-Aviv JD)	565,35		1 302,21					
	Components DIGIKEY, BERNIER (+ UPS) for PPU, PTU		619,00	683,21					
	Components DIGIKEY, BERNIER (+ UPS) for IUT,LGEP		381,77	301,44					
	Perdiem Ghislain REMY, Marc ARDILLIER		360,00	-58,56					
	Taxi Ben-Gourion- Hebron-Jerusalem		134,00	-192,56					
	Hotel Jerusalem Ghislain REMY, Marc ARDILLIER		116,00	-308,56					
	Hotel Jerusalem Jean DEPREZ		45,00	-353,56					
	RER, Meals, Taxis, Diverses (GR,MA, JD)		272,00	-625,56					
	Reimbursement from PTU (cash 1534 USD), Change Fees	1 229,00	117,86	485,58					
19/9/12	PV Panel Helios Strategia SAS for IUT		370,76	114,82			370,76		
24/9/12	Components FARNELL for IUT		114,82	0,00			114,82		

Al Maqdisi Program. OTHER RESSOURCES

Mission / Date	Description	Source	CREDIT	DEBIT	BALANCE	Flight Tickets	perdiem/taxi/food/accomodation	Equipment for IUT,LGEP	Equipment for PPU,PTU	Bank charges, change
1/10/10	Initial situation		0,00	0,00	0,00					
Mission France Palestine 1 - 4 / 11 / 2010	Flight Ticket Paris-Tel Aviv Jean DEPREZ	MedLink		572,00	-572,00	572,00				
Mission Palestine France 20 - 24 / 06 / 2011	2 Kits microcontroller Psoc	IUT		250,00	-822,00				250,00	
Mission Palestine France 7-9 / 07 / 2011	Flight Ticket Amman-Paris Khaled TMAIZI	MedLink		540,00	-1 362,00	540,00				
Mission France Palestine 23 - 29 / 10 / 2011	Flight Ticket Paris-Tel Aviv Jean DEPREZ	MedLink		1 120,34	-2 482,34	405,10				
	Reimbursement	Al Maqdisi	715,24		-1 767,10					
Mission France Palestine 22 - 29 / 06 / 2012	Flight Ticket Paris-Tel Aviv Jean DEPREZ	MedLink		565,35	-2 332,45	0,00	86,00		256,66	
	Reimbursement	Al Maqdisi	565,35		-1 767,10					
	Second Passport Marc ARDILLIER	MedLink		86,00	-1 853,10					
	Components	IUT		256,66	-2 109,76					

All receipts (invoices, payment attestations…) are available on demand.