DERri
Distributed Energy Resources
Research Infrastructures

ANNEX 2: TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

Use-Project Acronym	**CoLeadSuCapa**
User-Project Title	**Common operation of Lead storage and Super capacitor in UPS systems**
Main-scientific field	UPS system
Specific-Discipline	Storage system with supercapacitor

Lead User of the Proposing Team:

Name	**Tzvetomir Rangelov Rangelov**
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Nationality	Bulgarian
Organization name, web site and address	CM – KONSULT LTD. , www.cm-konsult.com
Activity type and legal status* of Organization	Small or Medium size private enterprise
Position in Organization	Owner

* 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)

Additional Users in the Proposing Team:

Name	**Nikolay Rangelov Rangelov**
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Organization name, web site and address	CM – KONSULT LTD. , www.cm-konsult.com
Activity type and legal status* of Organization	Small or Medium size private enterprise
Position in Organization	Consultant

Name	**Nikolay Luboslavov Hinov**
Phone	+359 899 286 132
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Nationality	Bulgarian
Organization name, web site and address	TU-Sofia, www.tu-sofia.bg Bulgaria, Sofia, Kliment Ohridski str. 8
Activity type and legal status* of Organization	Higher Education Institution
Position in Organization	Assoc. Professor

Name	**George Vassilev Kraev**
Phone	+359 897 050 866
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Nationality	Bulgarian
Organization name, web site and address	TU-Sofia, www.tu-sofia.bg Bulgaria, Sofia, Kliment Ohridski str. 8
Activity type and legal status* of Organization	Higher Education Institution
Position in Organization	Assistant Professor

Name	**Dimitar Damianov Arnaudov**
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Nationality	Bulgarian
Organization name, web site and address	TU-Sofia, www.tu-sofia.bg Bulgaria, Sofia, Kliment Ohridski str. 8
Activity type and legal status* of Organization	Higher Education Institution
Position in Organization	Assoc. professor

* 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)
(Repeat for all Users)

Date of submission	30.06.2012
Re-submission	_____ NO _____
Proposed Host TA Facility	CEA INES PRISMES, TECHNALIA
Starting date (proposed)	

Summary of proposed research (about ½ page)
Prepare a ½ page summary describing the relevance and the scope of the proposed work, and the expected outcome(s)

This project is focused on the design and test of control logics for mutual work of lead-acid batteries with supercapacitors in UPS systems. To be precise, not all UPS systems, but only for double conversion or so called online UPS. Such type of UPS are used in “noisy” power environment (the utility power outages, sags or other anomalies are frequent) or when protection of sensitive IT equipment loads is required, or finally when operation from an extended-run backup generator is necessary. The main issue of double conversion UPS is the batteries. The operation mode involves short life of batteries. Below is shown the block diagram of online UPS. By inspection is obvious that batteries are operating during the entire work of UPS, unlike other UPS when batteries are needed only in special cases (power outage or sag). As a result lifetime of batteries is shortening.
One project task would be to add knowledge and experience for the optimal power and control infrastructure with variety of applications, loads, power consumption.
Focus of work will be energetic performance of converters used in the system, with main goal of optimal usage of supercapacitor (the most expensive device). Those types of systems are used for supplying sensitive consumers, thus it is very important to have low level of electromagnetic radiation and interference.
Studies are inherently interdisciplinary and results may be used in all systems with energy storage.

The successful realisation of the proposal will enable the researchers to raise their competence and allow for following research projects in Industrial Electronics.

State-of-the-Art (about 1 ½ page)

Describe in brief (in about 1½ pages) the current knowledge on the subject, citing recent relevant references. Identify any knowledge gaps and their relevance.

Regardless of improvement of energy systems unwanted power outages are unavoidable and in some cases inadmissible. The standard way of handling the issue is using UPS with built-in lead-acid battery, but in many ways this is not a solution, because the minimum response time of UPS of 0,1 s is unacceptably slow. In some industrial equipment the response time should be 1 ms or even 100 µs. Because of all this, in recent years have been developed UPS with supercapacitors or combined supercapacitor with battery. The main disadvantage of such UPS is its small protection time, but this is not a big disadvantage, because statistics shows for the last 20 years the power outages in 98% of cases are less than a second.

In recent years the study of supercapacitors and their application are very intensive. Today we know that supercapacitors have extended lifetime, especially in comparison with batteries. They could be charged or discharged rapidly. Supercapacitors are used as power buffers because of their high power density and instant reaction.

In the literature the mutual operation between supercapacitors and batteries is described especially for the renewable energy sources. We lack of data for researches conducted for the usage of supercapacitors in UPS.

References

List relevant References

[1] Linzen D., Buller S., Karden E. & De Doncker R.W. (2005) “Analysis and Evaluation of Charge-Balancing Circuits on Performance, Reliability, and Lifetime of Supercapacitor Systems” *In: IEEE Transactions on Industry Applications* 41(5), 1135-1141

[2] Lai J.-S. Levy S. & Rose F. (1992) “High energy density double-layer capacitors for energy storage applications”, *In: Aerospace and Electronic Systems Magazine, IEEE* , vol.7, no.4, pp.14-19, Apr 1992

[3] Maxwell Technologies. (2008) *Maxwell Technologies BCAP3000 Ultracapacitors.* [online] Avaliable from http://www.maxwell.com/ultracapacitors/products/large-cell/bcap3000.asp [Accessed 14 May 2008]

[4] Andersson T. & Groot J. (2003) *Alternative Energy Storage System for Hybrid Electric Vehicles.* M.Sc thesis, Chalmers University of Technology

[5] Andersson B. & Johansson P. (2008) *Comparison of Simulation Programs for Supercapacitor Modeling*. M.Sc thesis, Chalmers University of Technology

[6] *TECHNOLOGIES FOR ELECTRICAL POWER CONVERSION, EFFICIENCY, AND*

DISTRIBUTION: METHODS AND PROCESSES MIHAIL HRISTOV ANTCHEV

[7] Pasquier A.D., Plitz I., Menocal S. & Amatucci G. (2002) "A comparative study of Li-ion
battery, supercapacitor and nonaqueous asymmetric hybrid devices for automotive applications"*Journal of Power Sources* 115(2003) 171-178

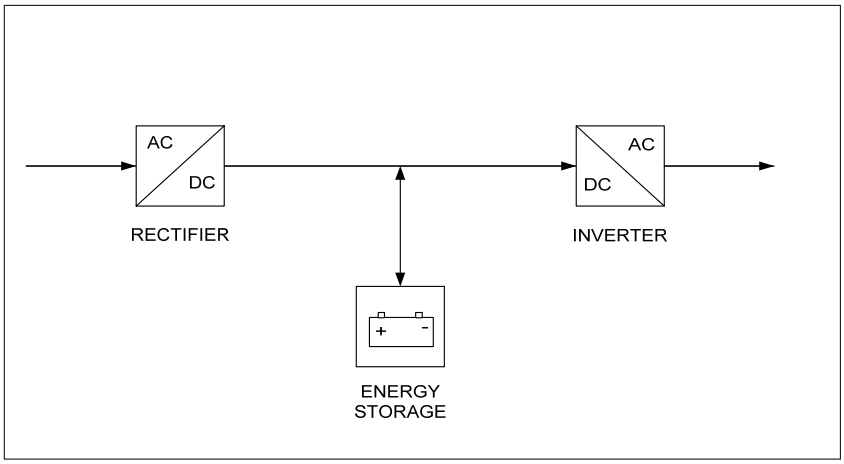
[8]http://www.maxwell.com/products/ultracapacitors/docs/20090316_instruction_manual.pdf#search="integration kit"

[9] Virtanen , A. , H. Tuusa , Power compesators for high power fluctuating loads with a supercapacitor bank energy storage , 2nd IEEE International Conference on Power and Energy , PECon , 2008

Detailed Description of proposed project : Objectives – Expected Outcome – Fundamental Scientific and Technical value and interest (2-3 pages)

Provide a detailed description of the objectives of the proposed activity, the way these objectives will be fulfilled through the proposed work, as well as indications on the expected outcome and the fundamental scientific and technical value and interest of the proposal. Specify the type of TA infrastructure (distributed generation simulator; domotic house; etc.) and the test setup. With the understanding that these aspects will be discussed with the TA infrastructure after approval of the proposal and specified in the Agreement to be signed between the TA infrastructure and the User team, indicate the number of tests to be carried out and their sequence, the response quantities to be measured through the instrumentation, etc. Describe any special requirements for equipment, standards, safety measures, etc. Point out any shortcomings, uncertainties and risks for the fulfillment of the project objectives, as well as the means to mitigate relevant risks.

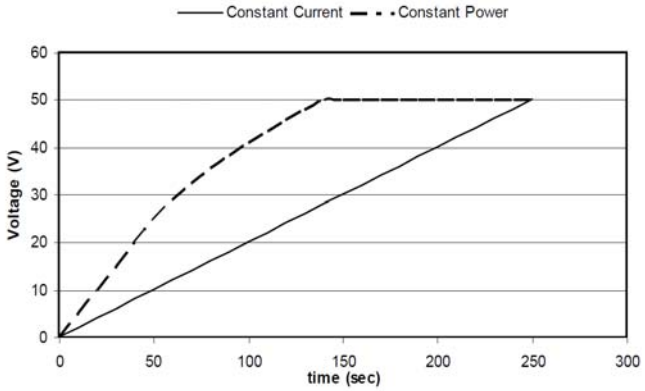
Main goal of the proposal is conducting in depth scientific and applicable studies of UPS, using common operation of lead-acid batteries and supercapacitors. The following block diagram clarifies the operation of double conversion or online UPS. From there it is obvious that the energy storage block is continuously used.

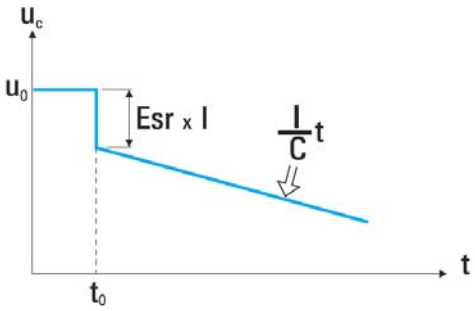


The supercapacitors usage in UPS will handle following issues:

1. Lead-acid batteries will be used only after >5 minutes of power outage, which is going to extend their lifetime.

2. The charging time of a supercapacitor is multiple time less compared to lead-acid batteries, the time to put system in operation will be shortened after unbinding power outage. (In the Figure below are shown charge/discharge waveforms of a supercapacitors).
3. Reducing usage of lead-acid batteries will have a positive impact on the environment.





For the successful realisation of planned studies the following activities will be performed:

1. Research of existing and market supply of supercapacitors;
2. Revision and codification of main parameters of the supercapacitors, their equivalent circuits, cell balancing methods, datasheets;
3. Studying of charging circuits for supercapacitors. Application description in hybrid systems with renewable energy sources and other storage devices;
4. Revision of existing circuit of electronic energy converters and patterns for supercapacitor discharging;
5. Revision of existing circuit of electronic energy converters supplied by lead-acid batteries and supercapacitors;
6. Choice of specific power circuits for conducting researches;
7. Conducting simulations of converters;
8. Conducting experiments of electronic converters;
9. Analysis and summary of obtained results. Publishing the results.

Originality and Innovation of proposed research – Broader Impact (1-2 pages)

Demonstrate the originality and innovation of the proposed work and the impact the expected results will have on current and future research or practice, public safety, European standardization, competitiveness, integration and cohesion and on sustainable growth.

Originality and innovation of the proposed work are described in the section State of the Art.

Expected results:

The obtained results could be multiply in other fields where energy storage is used:

- electric transport;
- power supply for electronic devices
- autonomous power supply in distant areas;
- in systems for renewable electric energy.

The company CM-Consult works in the field of Information and Communication Technologies. The research and related results are very important for the company. CM-Consult works with closely with the Technical University of Sofia.

Proposed Host TA Infrastructure/Installation – Justification (about one page)
Specify the type of TA infrastructure (e.g. distributed generation simulator; domotic house; etc.) and if possible which one of the 13 TA Infrastructures in DERri may better serve the scope of the proposed research. Justifications should be provided on the grounds of the test set-up, testing method, equipment, past experience in relevant subject, etc. State whether the TA User team intends to deliver to the premises of the TA Infrastructure parts or components to be tested at the TA User's expense and responsibility, or to cover the whole or part of the construction/adaptation cost of the specimens to be tested.

Required scientific structure:

1. Adequate PCs for working with the latest simulating software for Power Electronics (PSIM, MatLab, PSpice, LabView)
2. Software for studying and simulating of power electronic circuits
3. Special research equipment with PC connection enabled:
    a. Digital multimeters
    b. Digital oscilloscopes
    c. Power supply units
    d. Sensors, etc.
4. Possible risk in project implementation is the lack of researchers' experience in operation with supercapacitors. Special attention of charging / discharging processes of the supercapacitors. The mitigation of those negatives is using external experts in the field.

According to information available on the project infrastructure we consider appropriate the following: infrastructures :**CEA INES PRISMES or TECHNALIA**

Synergy with ongoing research (about ½ page)
Provide information on any concurrent research project with the same or similar subject with the one proposed. Describe the synergy (if any) that will be sought between the existing and the proposed project.

1.DERlab Network of Excellence (NoE) of DER Laboratories and Pre-Standardization

2. W-Charge -Kabelloses Laden von Elektrofahrzeugen

1.Sol-ion -Erneuerbare Energie Systeme mit Lithium-Ionen-Energiespeichersystemen für

die Anwendung im häuslichen Bereich und für kleine Gewerbebetriebe

4.STROPA -Stromparkplätze für Elektrofahrzeuge – Konzepte, Prüfstand und Pilot-Anlage

Dissemination – Exploitation of results (about ½ page)
Describe the means through which the results to be obtained from the proposed project will be diffused and made broadly known.

Participation in national and international scientific conferences. Publishing in national scientific magazines.

Time schedule (about ½ page)
Provide an indicative time-schedule for the proposed work and a target starting date.

Activity/Month	***0***	***1***	***2***	***3***	***4***
State of the art	Done				
Agreement on tasks with partners		1 week			
Design of model		1 week			
Practical cooperation				1 week	1 week

Practical experimentation in the frame of 2 week 8 days starting in September 2012

Description of the proposing team (as long as needed)
Give a short description of each member (organization and persons) of the proposing team including publications, experience in test campaigns and role in the proposed project.

Team Members

1. **Nikolay Rangelov Rangelov**- CM – KONSULT LTD , Ph.D student, TU-Sofia- part time, 4 publications in the fields of power electronics and electrical appliance
2. **George Vassilev Kraev - Assistant**. Professor, TU-Sofia, over 10 publications in the field of electrical appliance
3. **Dimitar Damianov Arnaudov** – Assoc. Professor, TU-Sofia, over 90 publications in the field of electrical appliance
4. **Nikolay Luboslavov Hinov** – Assoc. Professor, TU-Sofia, over 100 publications in the field of electrical appliance

The proposing team is made up of:
• Nikolay Luboslavov Hinov (assoc. Professor, TU- Sofia)
• Dimitar Damyanov Arnaudov (assoc. Professor, TU- Sofia)
• George Kraev (Researcher, TU-Sofia)
• Nikolay Rangelov Rangelov (Ph.D. Student, TU-Sofia)

Nikolai Hinov
MSc and PhD in Power Electronics in the Technical University of Sofia (TUC), Bulgaria. Teaches in TUC since 1999 in different subjects: Special Power Supplies, Industrial

Electronics, Industrial electronic circuits and devices. Associate Professor in Industrial Electronics since 2006. Has 4 patents (2 Bulgarian and 2 European). Member of the board of the Union of Electronics, Electricity and Communications. Author of more than 100 publications in magazines and conferences, 3 textbooks. Tutor of 2 PhD students and more than 40 graduate students. Research interests: electronic converters, power electronic devices, analysis and modelling of inverters and DC converters, monitoring and control of electro-thermal energy systems.

George Kraev
MSc in Power Electronics in TUC, Bulgaria. Assistant Professor in TUC. Author of more than 20 publications in magazines and conferences. Research interests: marketing and advertising, market research, electronic converters, power electronic devices.

Dimiter Arnaudov
MSc and PhD in Power Electronics in TUC, Bulgaria. Teaches in TUC since 2009 in Power Supplies. Associate Professor in Industrial Electronics since 2005. Has 2 patents (1 Bulgarian and 1 European). Member of the board of the Union of Electronics, Electricity and Communications. Author of more than 40 publications in magazines and conferences, 2 textbooks. Tutor of more than 30 graduate students. Research interests: electronic converters, power electronic devices, analysis and modelling of inverters and DC converters, UPS, security systems, measuring in telecommunication.

Nikolai Ranguelov
Projects:
Oct 2010 – Oct 2011: Building the infrastructure of control of measurement devices in Wine Cellar KEHLIBAR.
July 2011 – Building the infrastructure of control of measurement devices in Wine Cellar Domain Marash.
Education:
Jul 2011 – up today: TUS, Dept. of Power Electronics, PhD Student
Oct 2004 – Feb 2009: Student in Power Electronics, TUS (MSc)

Publications:

1. **Nikolai Hinov,** Dimitar Arnaudov, Nikola Gradinarov, George Kraev, Nikolay Rangelov, “Multiphase resonant inverters for supercapacitor charging”, Official Proceedings of The International exhibition and conference for power electronics, intelligent motion, renewable energy and energy management - PCIM Europe 2012, Nuremberg, Germany, 10 –12. 05.2012, pp.1078-1085.

2. D.ARNAUDOV, N. HINOV, N. GRADINAROV, G. KRAEV, N. RANGELOV, “ Multiphase converters for charging capacitors with large capacitance”, XVIIth International Symposium on Electrical Apparatus and Technologies – SIELA 2012, Бургас , България , 28 – 30 май 2012 г. Стр. 368 - 374

3. Gradinarov N., **Nikolai Hinov**, George Kraev, Dimitar Arnaudov, “New DC–DC converters circuits with better features and zero commutation of all devices” Official Proceedings of The International exhibition and conference for power electronics, intelligent motion, renewable energy and energy management - PCIM Europe 2010, Nuremberg, Germany, 05 –07.

05.2010, pp. 878-885.

4. Gradinarov N., **N. Hinov**, D. Arnaudov, "Analisys and Design of Resonant Inverters with Improved Output Characteristics, Working with zero-current switching", Proceedings PCIM'03, Power Conversion, Nuremberg, Germany, 20 –22. 05.2003, p.p. 423-427.

5. **Hinov, N.**, N. Gradinarov, D. Arnaudov, "Autonomous resonant inverters with voltage clamp in commutating capacitor" PATENT No 103942 / 02.12.1999, issued on 25.01.2002

6. **Hinov, N.**, N. Gradinarov, D. Arnaudov, "Autonomous resonant inverters for DC-DC converters with improved parameters" No. №104666, PATENT from 04.08.2000

7. **Kraev, George**, N. Hinov, N. Ranguelov, D. Arnaudov "Study of single transistor ZVS resonant DC converter", XI International Conference, Electronics 2012 – pp.168 – 175 , 14 – 15 June 2012

8. **Hinov, N.**, D. Arnaudov, George Kraev, Project No 102-205-3, Study and development of electronic converter for electric energy with improved characteristics and different type of load, Sofia, Bulgaria, 2010 – 2011