Request for Proposals (RFP)

The 2017 International Future Energy Challenge (IFEC'17)

A student competition sponsored by the

The Institute of Electrical and Electronics Engineers (IEEE)

August 20th, 2016

Summary of Competition and Proposal Requirements

General Information

Competition Title: 2017 International Future Energy Challenge (IFEC) Student Competition

Topic: *High-Efficiency High-Density Isolated DC-DC Converter*

Period of Competition: July 25th, 2016 to July 25th, 2017

Challenge Program Awards: There will be a Grand Prize of $10,000 and three additional awards granted at $1,000, $3000 and $5,000 each.

Prize requirements: US$10,000 will be awarded as Grand Prize for highest score among entries in each topic area meeting all minimum requirements as confirmed through reports and hardware tests. The remaining prizes will be awarded to the teams who have scored the highest in categories such as Best Undergraduate Educational Impact, Best Innovative Design of Power Electronics Converters, etc.

Intellectual Property and Use of Prize Money:

The International Future Energy Challenge does not restrict the use or protection of inventions or other intellectual property produced by participating teams. There are no special licenses or rights required by the sponsors. However, the Final Test Events in July 2016 will include public disclosure of each team's technology. Teams interested in securing protection for their inventions should be aware of this date when making arrangements.

The prizes provided to schools are intended to benefit the team members and student team design project activities. There is a Letter of Support (Attachment II) required for submission with the proposal and it should outline the plans of the school in the event that a prize is received.

Outside Support:

Individual schools should solicit project funding from companies, foundations, utilities, manufacturers, government agencies, or other sources. There is no limitation for the sources of project funding.

Eligibility Information:

- **Eligible schools must:** have an accredited or similarly officially recognized engineering program (through the Accreditation Board for Engineering Technology (ABET) or equivalent); be a college or university with engineering curricula leading to a full first degree or higher; have the support of the school's administration; establish a team of student engineers with an identified faculty advisor; demonstrate the necessary faculty and financial support commitments; and demonstrate a strong commitment to undergraduate engineering education through their proposal.

- **University Eligibility Limit: Each university is limited to support only one team.**

To confirm eligibility, potential participating schools must submit a Letter of Support (Attachment II) together with a Preliminary Team Information Form (Attachment I) when they submit the proposal.

How to Participate: Participation is on a proposal basis. Those schools that are interested must submit a proposal before the proposal deadline. Proposals will be judged by a distinguished panel of volunteer experts from the IEEE and the industry. Schools with successful proposals will be notified two months after the proposal deadline. Student teams will then carry out the work and prepare hardware prototypes and reports. Deadline for the qualification reports are also listed in the attachment and will be posted on the IFEC website. The reports will be judged by a similar expert panel. The panel will select a group of teams as Finalists based on the qualifying reports. These teams are invited to present their progress to the panel at IEEE APEC conference on March 26-30, 2017, in Tampa, Florida, USA. Feedback will be given to the team to improve the system. The team will be invited to a competition event in July of 2017. A Final Report will be due at the competition event.

Judging Panels

Experts from IEEE Power Electronics Society (and others to be announced) and representatives from manufacturers, national labs, independent test labs, utilities, and R&D engineers.

Judging

Student team project results will be judged based on cost effectiveness, performance, quality of the prototype and other results, engineering reports, adherence to rules and deadlines, innovation,

future promise, and related criteria. Each aspect of judging will be scored according to a point list and test protocol.

Proposals

Proposals will be judged on the quality of plans, the likelihood that a team will be successful in meeting the International Future Energy Challenge objectives, technical and production feasibility and degree of innovation. Other key criteria are evidence of the school's commitment, capability, experience, and resources to implement their design over the one-year span of the competition. Commitment to excellence in undergraduate education is important, and acceptable proposals will involve undergraduate students as the primary team members. For each team, the **minimum** undergraduate student number is **three** to qualify for the competition. Interdisciplinary teams are encouraged. Graduate students are not excluded, but are limited to technical assistant role in the team. The upper limit of graduate student participants is **two** for each team.

The impact on undergraduate education is a critical judging criterion. **Proposals are limited to 12 double-spaced pages total, including all diagrams, attachments, and appendixes.** Schools that are invited to participate in 2017 International Future Energy Challenge are expected to adhere to the basic plans described in their proposals. Approval of the competition organizers must be sought for significant changes in plans or engineering designs. **Only one proposal will be considered for each school. Proposals must be submitted electronically in PDF format.**

A. Proposal Objectives

Respondents should express their ideas and plans relevant to the competition topic area. The project should include the construction and operation of a complete hardware prototype. The proposal must address both technical and organizational issues for each phase of the prototype's development and testing. It must contain a realistic project budget, along with a plan to secure the necessary funding. The educational goals, including any course credit provided for work related to the 2017 International Future Energy Challenge, and how the project relates to other efforts within the school and at the regional or national level should be addressed. A Letter of Support from an official of the school confirming a commitment to participate in the competition, and stating the type(s) and level of support for the team's participation in the competition should be

attached, and is not counted toward the 12-page limit. Refer to the attachments at the end of this document for a sample.

B. Administrative Considerations and Limitations

This section describes the limitations placed on the proposal. Compliance is mandatory.

Language	Proposals must be written in English.
Length	Proposals are limited to 12 single-sided double-spaced pages of text, figures, and appendixes. The page size must be 8.5" x 11" or A4 and the font size must be no smaller than 10 point. Margins should be at least 25 mm. The Preliminary Team Information Form (Attachment I in this RFP), Support Letter (Attachment II in this RFP) from the school, government entities, or private sector organizations will not count in the proposal length.
Authors	Proposals are to be prepared by the student team in collaboration with the faculty advisors.
Signatures	Proposals must be signed by all authors of the proposal (or the student team leader) and the faculty advisor.
Letter of Support	Proposals must be accompanied by a letter of support from an appropriate Dean, Department Chair, or other authorized school official. The letter must confirm the school's commitment to participate. It must also state the type(s) and value of support from the institution. School support should match the value of cash and in-kind support from the team's principal sponsors. Additional letters of support from other team sponsors are optional. A sample letter is provided as Attachment II.
Preliminary Team Data	Submit one copy of the Preliminary Team Information Form (Attachment I) with the proposal, then an updated copy with the

progress reports to the address below. This form does not count in the 12-page limit.

Due Date

All proposals must be received by close of business on **October 14, 2016** for full consideration.

Proposal Submission

The electronic copy of the proposal in PDF format must be sent to the respect topic chairs via email, with a copy to the IFEC'17 chairman below:

General Chair:

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General Co-Chair:

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Topic Chair:

Qiang Li, Assistant Professor
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Information

The volunteer Organizing Committee for the 2017 International Future Energy Challenge maintains a web site at http://www.energychallenge.org/. The site will include the most

recent schedule and rule updates, frequency-asked questions, details about judging and scoring, and other team information. It should be checked regularly.

Time Schedule

Sept. 20, 2016	IFEC'17 Information Session at ECCE 2016
Oct. 14, 2016	Proposals Due
Dec. 16, 2016	Schools informed of acceptance into the competition
Mar. 20, 2017	Qualification reports due (Qualification reports must include preliminary experimental results. It is limited to 25 single-column pages total, including all diagrams, attachments, and appendixes).
Mar. 26-30, 2017	Workshop at APEC 2017, Tampa, Florida, USA. All accepted qualified teams must give an oral presentation.
April 10, 2017	Finalists notified (Selection is based upon likelihood of deliverable hardware, quality of design, and likelihood of success in meeting all the challenge objectives).
Jul. 14, 2017	Final reports due (Final reports are limited to 50 single-column pages total, including all diagrams, attachments, and appendixes)
Jul. 24-25, 2017	Final competition

2017 International Future Energy Challenge

Organizing Committee

General Chair: Prof. Yaow-Ming Chen, *National Taiwan Univ., Taiwan*

General Co-chair: Prof. Qing-Chang Zhong, *Illinois Inst. of Tech., USA*

Topic Chair: Prof. Qiang Li, *Virginia Tech, USA*

Webmaster: Prof. Jin Wang, *The Ohio State Univ., USA*

IEEE Inter-Society Associate: Donna Florek, *IEEE, USA*

Treasurer: Prof. Jin Wang, *The Ohio State Univ., USA*

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Competition Description

Scope: An international student competition for innovation, conservation, and effective use of electrical energy. The competition is open to college and university student teams from recognized engineering programs in any location. Participation is on a proposal basis.

Introduction: In 2001, the U.S. Department of Energy (DOE), in partnership with the National Association of State Energy Officials (NASEO), the Institute of Electrical and Electronics Engineers (IEEE), the Department of Defense (DOD), and other sponsors, organized the first Future Energy Challenge competition. The objective was to build prototype, low-cost inverters to support fuel cell power systems. This competition was originally open to schools in North America with accredited engineering programs. The 2001 Future Energy Challenge focused on the emerging field of distributed electricity generation systems, seeking to dramatically improve the design and reduce the cost of dc-ac inverters and interface systems for use in distributed generation systems. The objectives were to design elegant, manufacturable systems that would reduce the costs of commercial interface systems by at least 50% and, thereby, accelerate the deployment of distributed generation systems in homes and buildings. Final events were conducted at the National Energy Technology Laboratory (NETL) in Morgantown, WV, USA. Speakers from IEEE, DOE, and DOD introduced the competition and interacted with students during the event week. Hardware was tested with an experimental fuel cell at the NETL site. The 2001 Challenge was a success, and is now the first in a biannual series of energy-based student team design competitions.

To continue and expand the 2001 success, the 2003 International Future Energy Challenge (IFEC) was organized as a worldwide student competition. The 2003 IFEC had two topics, a revised topic on fuel cell power conditioning, and a topic for high-efficiency motor drive systems suitable for home appliances. Major sponsors included three IEEE societies, DOE, and DOD. Fuel cell inverter events were again held at NETL. Motor system events were held at Advanced Energy in Raleigh, NC, USA.

The 2005 IFEC had two topics. The inverter topic was revised to incorporate photovoltaic sources and grid interaction, while the motor topic was revised only slightly. Major sponsors included three

IEEE societies and DOD, with more modest sponsorship from DOE. Inverter events were held at the National Renewable Energy Laboratory (NREL) in Golden, CO, USA. Motor events were held at MPC Products in Skokie, IL, USA.

The 2007 IFEC had two topics. An integrated starter/alternator and a Universal battery charger system were chosen as the two topics. Major sponsors included IEEE Power Electronics society, and Power Supply Manufacturer Association (PSMA). The final competitions were held at MPC Products in Skokie, IL and Texas Instrument in Richardson, TX.

The 2009 IFEC, similar to the previous editions, had two topics. The Integrated Starter/Alternator-Motor Drive for Automotive Applications topic was repeated, a new topic, the Power Wind Turbine Energy Maximizer was included. Major sponsors included IEEE Power Electronics society, Industrial Electronics Society, MPC Products, Monash University, IEEE Power Electronics Society, IEEE Industrial Electronics Society, and Power Sources Manufacturers Association (PSMA). The final competitions were held at Illinois Institute of Technology in Chicago, IL, USA, and in Monash University, VIC, Australia.

The 2011 IFEC had two topics. Topic A focused on low cost lithium ion battery chargers. The final competition of Topic A was held at University of Michigan-Dearborn. And Virginia Tech University of USA won the Grand Prize and the Outstanding Performance Award. Topic B focused on Low Power Induction Motor Drive System Supplied from a Single Photovoltaic Panel for an Emergency Water Treatment Device Maximizer. The final competition of Topic B was held at Federal University of Maranhao, Brazil. Federal University of Maranhao won the Grand Prize and Outstanding Performance Award as well as the Best Technical Presentation Award. Sponsors of this year's competition include IEEE Power Electronics Society, IEEE Industrial Electronics Society, and Power Sources Manufacturers Association (PSMA).

The 2013 IFEC Competition also had two topics. Topic A focused on highly efficient microinverter for photovoltaic panels. The final competition was held on July 18-19. National Taiwan University of Science and Technology won the Grand Prize and the Best Efficiency Award, Nanjing University of Aeronautics and Astronautics won the Best Engineering Achievement Award, University of Kassel of Germany won the IEEE IES Best Innovative Design of Power Electronic Converters Award, and Beijing Jiaotong University won the Best Presentation

Award. Topic B was focused on Low power off-line light-emitting diode (LED) driver with long lifetime. And the final competition was held at Zhejiang University on July 29-30. Zhejiang University won the Grand Prize and the Best Efficiency Award; National Cheng-Kung University won the Best Engineering Achievement Award; North China University of Technology won the Best Engineering Design Award. Sponsors of the 2013 IFEC competition include IEEE Power Electronics Society, IEEE Industrial Electronics Society, IEEE Industry Applications Society, IEEE Power and Energy Society and Power Sources Manufacturers Association (PSMA).

The 2015 competition addressed two topic areas: TOPIC A: High-efficiency Wireless Charging System for Electric Vehicles and Other Applications; and TOPIC B: Battery Energy Storage with an Inverter that Mimics Synchronous Generators.

In 2014, the IFEC steering committee proposed to the Power Electronics Society to make IFEC an annual event from 2016. A single technical topic will be addressed by each competition. The 2016 IFEC Competition topic is ultra-high power density AC-DC converter. The final competition was held on July 18-20 at National Taiwan University, Taiwan. Nanjing University of Aeronautics and Astronautics won the Grand Prize Award, National Cheng-Kung University won the Second Price Award, University of Belgrade won the Best Education Impact Award, National Taiwan University of Science and Technology won the Best Presentation Award, University of Illinois Urbana-Champaign won the Best Innovation Award, and University of Michigan-Dearborn won the The Best Report Award. Sponsors of the 2016 IFEC competition include IEEE Power Electronics Society, IEEE Industry Applications Society, IEEE Power and Energy Society and Power Sources Manufacturers Association (PSMA).

The detailed technical specification of the 2017 competition is listed in the following page.

Competition Topic

High-Efficiency High-Density Isolated DC-DC Converter

Background

The demands for isolated DC-DC converters are growing rapidly in recent years, including but not limited to computers, telecommunication, data centers, battery chargers, industrials, and aerospace applications. Collectively, these products consume more than 10% of the total electric power. One percent efficiency improvement in this industry sector represents tremendous energy saving. Moreover, with the increasing of cloud computing and big data, it is expected that data center alone will consume 10% of the total electricity by 2020.

Within the above mentioned industry sector, data center server power supplies are the most performance driven, energy and cost conscious. Within a data center, all major devices are powered from a 12V bus. This 12V bus architecture was developed in the early 90's, when the power consumption was minuscule in comparison with today's usage at 100A-200A levels per CPU. The i^2R related copper loss for 12V bus is excessive. To mitigate the copper loss in the power distribution, the International Electronics Manufacturing Initiative (iNEMI) recently undertook a project to develop a new industry standard for isolated DC/DC converters. This converter is used to step down 380V directly to 12V and placed directly on the motherboard. This architecture will eliminate the use of bulky cables and the losses associated with them. In order to place the high voltage DC-DC converter on the CPU board (mother board), this converter has to be very efficient and high-density to be compatible with core processors, memories, et al. Today, most 380V/12V isolated converter products are designed to operate at 50-100 kHz with a power density less than 7 W/cm^3 and they are too bulky to be placed directly on the motherboard. It is not easy to achieve this tall order with current design practice using silicon devices. However, wide bandgap (WBG) power devices, such as GaN devices make it possible to design isolated DC-DC converter with much higher switching frequency, which can help dramatically reduce converter size while still achieving high efficiency. The aforementioned iNEMI project indeed signifies a potential paradigm change in the design of isolated DC/DC converter for achieving high efficiency and high density at the same time.

The goal of IFEC 2017 is to develop a high-efficiency high-density isolated DC-DC converter.

Competition teams are encouraged to adopt WBG power devices in innovative circuit topologies to achieve higher efficiency and size reduction. Detailed specifications and requirements are listed in below.

Detailed Specifications and Requirements

- Input Voltage V_{in}: 360~400 Vdc
- Output Voltage V_{out}: 12 Vdc (V_{out} accuracy: ±0.1V)
- Output Voltage Steady State Ripple $V_{out,p-p}$: <100mV
- Output Power P_{out}: 750W (peak)
- Efficiency @ 380Vdc input:

  >91%@10%load, >97%@50%load, >96%@ full load
- Power Density: >15 W/cm^3 given an externally provided 200LFM air flow

  (Note: The converter can be built with open frame. The volume will be calculated as Volume=Length*Width*Height.)
- Temperature rising <40°C with 500W continuous power and 200LFM air flow @ 25°C Ambient Temperature.

  The converter will also be tested in an environmental chamber with 500W continuous power and 200LFM air flow @55^{o}C for 10 minutes.

  (Note: Fan with 200LFM airflow will be provided during final test. The air flow direction will be horizontal.)
- Output voltage undershoot & overshoot both are smaller than 300mV with load transient between 20A and 40A @ di/dt=2A/μS

Final Competition Prototype Testing

The detailed test protocol will be presented to the teams prior to the competition. The final test will be carried out at Virginia Tech, USA.

Team Composition

For each team, the minimum undergraduate student number is **three** to qualify for the competition. Graduate students can only participate as technical assistants. Up to **two** graduate students are allowed per team.

Financial Support

Each team will receive travel support of $1000 for distance less than 5000 km and $2000 for distance of 5000 km and above.

ATTACHMENT I

2017 INTERNATIONAL FUTURE ENERGY CHALLENGE
PRELIMINARY TEAM INFORMATION FORM

Submit with Proposal

NAME OF UNIVERSITY:

CORRESPONDING ADDRESS (PLEASE INCLUDE NAME):

TELPHONE:
FAX:
EMAIL:

FACULTY ADVISOR(S):

Name	Department	E-Mail
_____	_____	_____
_____	_____	_____

PRELIMINARY TEAM MEMBERS:

Name	Major Field of Study	Degree and Expected Graduation Date
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

ATTACHMENT II

LETTER OF SUPPORT

Submit with Proposal

[The letter below is a typical sample and should not simply be copied. Please send a letter with similar content on your university letterhead.]

To:

Qiang Li, Assistant Professor
Center for Power Electronics Systems (CPES)
The Bradley Department of Electrical and Computer Engineering
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Blacksburg, VA 24061, U.S.A.
Tel: 1-(540)-231-6225, Fax: 1-(540)-231-6390
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Dear International Future Energy Challenge Coordinator,

Our university has organized a student team to participate in the 2017 International Future Energy Challenge. Our proposal is enclosed. A Preliminary Team Participation Form is attached, listing our contact person, the faculty advisor(s), and some of the students who plan to be involved. The team will keep an eye on the Energy Challenge web site for detailed rules and other information. We understand that we will be notified whether we have been accepted to participate by December 16, 2016. If we are accepted, we agree to have our student team perform the design tasks and prepare the reports and hardware prototypes required for the competition. Our school is prepared to support the team with the following resources:

- A final year project course, ***XXX***, has been authorized to provide engineering students across several disciplines with the opportunity to include this project in their curricula. Laboratory space has been arranged for this course.
- A faculty advisor, Prof. ***XXX***, has been identified, and has been formally assigned to teach the project course and to advise the student team as a portion of his/her regular duties.

- A graduate student assistant has been identified to help manage the student team and to supervise direct laboratory activity. This student is supported with a Teaching Assistantship, which represents a funding commitment of our university of approximately ***$X.***
- The student team will be provided with an appropriate level of technician and machine shop support to assist them with package preparation and assembly. This assistance represents a funding commitment of approximately ***$X***, and we consider this as a matching commitment for any in-kind support received from external sponsors.
- In addition, we will provide limited funds to help secure special parts and equipment, with a total commitment of up to ***$X.***
- The student team will be encouraged to secure outside sponsorship. Our university strongly supports all these efforts, and will match any outside cash support 1:1 up to an additional total of ***$X***.

In the event that our school receives prizes from the competition, we are committed to using approximately X% of this money for scholarships for the student team members. The remainder of the funds will be added to our Team Design Program fund, which supports this and similar projects through sponsorship matching, travel funds for participation in competition events, and other direct costs of large team design projects. In the event that our team creates new inventions in the topic area, our university also provides the possibility of assisting with organization of a start-up company.

We understand the importance of student team projects in the engineering curriculum and look forward to our participation in the 2017 International Future Energy Challenge.

Sincerely,

(Head of Department, Dean of Engineering or similar school official)