Member Initiated Projects Round #3 Topic:
PowerAmerica's Module Challenge

The PowerAmerica Member Initiated Projects (MIP) program is a valuable benefit of the Institute that is focused on critical needs of the WBG community. The specific purpose of establishing MIPs is to provide a mechanism for Institute members to collectively identify the priority projects that are needed to advance WBG commercialization and to direct resources to address those challenges. As the name implies, these projects are funded by member dues and other revenue generating activities the Institute may perform (without DOE funds).

This request for proposals is issued as a result of action taken by the PowerAmerica Member Advisory Committee (MAC) on August 4, 2020. Details are provided below.

MIP Round #3 Objective

The objective is to produce generic demonstration modules, either SiC or GaN, with performance characteristics well beyond current, commercially available module parameters that are designed to provide maximum benefit from SiC and GaN technology and solve several technical problems simultaneously that limit module performance that have been identified by PowerAmerica members as part of developing and implementing PowerAmerica's Technology Roadmap. See Appendix A for more details. Demonstration of the superior performance of the modules is expected in one or more applications including but not limited to energy storage, electric motors, specific power conversion applications, medical equipment and other applications according to defined testing and reliability protocols.

Two distinct module challenges are proposed: High power and low power. It is not the purpose to create designs that would compete with members' products. Instead, the project would provide PowerAmerica members access to new design ideas, demonstration hardware and related IP generated by the project through addressing various technology issues.

<u>Project Requirements: High Power Module</u>

Power: (> 1000 kW) with a goal of 1000 A. Proposals will be scored in part according to how close to the goal the proposal aims to achieve using realistic methods. In meeting this goal, proposals can be:

Single phase with a goal of 1000A (rms); DC current goal 1600A
Double phase with a goal of 500A (rms)/phase; DC current goal 900A
Three-phase with a goal of 350A (rms)/phase; DC current goal 560A

Components: Must use commercially available SiC and/or GaN devices and peripheral components, no new devices designs are being sought. It is assumed, for purposes of this

project, that commercially available SiC devices do not exceed 1700V or 50A at case temperature >= 90C.

Module Size: Not to exceed 100 cm^3

Inductance < 1 nH

Ambient temperature: Operational within a range of -60C to >=90C case temperature with a goal of at least 600,000 lifetime temperature cycles before failure. The project need not perform lifetime tests to demonstrate the goal but should explain how this goal is considered in the design.

Project Requirements: Low Power Module

Power: < 10 kW with a minimum of 20A

Components: Must use commercially available SiC and/or GaN devices, 600V minimum and peripheral components; no new device designs are being sought.

Module Size: Not to exceed a footprint of 2 x 3 cm^2

Ambient temperature: Operational within a range of -60C to >=90C case temperature

Frequency: 600 kHz minimum with a goal of 1000 kHz. Proposals will be scored in part according to how close to the goal the proposal aims to achieve using realistic methods.

Reviewing Proposals for Either High or Low Power Module Design and Demonstration

In addressing the project requirements noted above, proposers should consider ways to best harness the unique attributes of SiC and GaN. This will be considered in scoring proposals. Consideration should be given to addressing specific issues applicable to module design and performance described in the document "2020 PowerAmerica Priorities from the Technology Roadmap," which is Appendix A to this document. Noteworthy items in Appendix A that are desirable to include in proposals are:

a. Design and selection of parts and materials to minimize manufacturing costs
b. Inclusion of novel heat management and cooling techniques including consideration of two-sided cooling (top and bottom of wide bandgap device)
c. Application of novel circuit designs including paralleling multiple devices, die attachment, interconnect, attachment and termination schemes to reduce parasitic inductance, hence EMI, (new wire bonding, double side mounting, lead attachment alternatives, etc.)
d. Integration of magnetics and capacitance, etc. using novel designs and techniques
e. Inclusion of integrated "intelligent" gate drivers

MIP Round #3 Proposal Process

Proposals can be offered for either the high power or low power module challenge, but not both, and must address the specifications and information provided in the MIP Round #3 Objective section above. PowerAmerica members (industry, university, and labs) are encouraged to participate on at least one team. Industry and university members can participate on more than one team, but each team must have it least one university and one industry member. The quality and makeup of the team and the role of each team member described in the proposal is a consideration in scoring proposals. It is encouraged that each team have a lead university and lead principal investigator who is responsible for the project.

Each project proposal is required to have two steps. The first step, lasting no longer than 60 days after project start, will be considered a "paper project" with a deliverable consisting of detailed drawings, diagrams, schematics, etc. describing the module hardware that will be produced during in the remainder of the project and the steps that will be taken to produce the hardware. There will be a brief pause in project activity after 60 days during which the "paper project" deliverables are reviewed by a PowerAmerica member working group. The working group will recommend to the Membership Advisory Committee those projects that should continue to be funded to develop the module hardware based on the designs that are considered most likely to succeed and have the greatest benefit for PowerAmerica members. Proposers are encouraged to review previous and current module-related projects funded by PowerAmerica so as to not propose work that has already been performed or objectives that have already been met. PowerAmerica staff can provide this information upon request.

Proposals must be made according to Appendix B to this document, including a Statement of Project Objectives (SOPO) and budget to produce module hardware that meets either the high power or low power module challenge. The budget should indicate funding required from PowerAmerica, not to exceed $200,000, plus a cost match. Included in the budget should be funding not to exceed $20,000 for the "paper project" for the first 60 days. The SOPO should also include a pro forma spec sheet indicating the target parameters of the project's result, test and reliability conditions, description of one or more system applications in which the module will be demonstrated, the entity(s) involved in the demonstration, and reference relevant industry standards to which the module will conform as appropriate (e.g. auto, JEDEC).

The deadline for proposals is Tuesday, October 13, 2020 at 11:59 p.m. EDT. Proposals received after this date will not be considered. Proposals must be submitted to the NC State/PowerAmerica InfoReady portal here: https://ncsu.infoready4.com/. **Proposals will be reviewed and scored by a member working group consisting of members not participating on any proposal. The working group will recommend proposals to the Membership Advisory Committee for funding with the goal of having projects under contract and started by the end of 2020. Questions about any aspect of this solicitation should be directed to the section of PowerAmerica website set up for questions at:** https://poweramericainstitute.org/member-initiated-projects/

Appendix A

Approved at the May 14, 2020 MAC Meeting

2020 PowerAmerica Priorities from the Technology Roadmap

Break-out sessions took place at the February 2020 PowerAmerica annual meeting in which participants gathered in discussion groups to identify technology priorities from the PowerAmerica Technology Roadmap for use in defining topics for Member-Initiated Projects (MIPs). Such projects are intended to advance SiC and GaN technology and applications, be pre-competitive in nature and benefit the membership as broadly as possible, with members retaining rights to the resulting intellectual property as defined in the Bylaws. As a starting point for break-out group discussions, "areas of interest" were derived from the latest Technology Roadmap and provided to each group. Numerous suggestions were made to identify the best ways to accelerate the adoption of SiC and GaN technology. The executive summary below outlines topics of greatest interest to PowerAmerica members for use in developing the next round of MIPs. A more detailed appendix reflecting the breakout group discussions is available separately.

EXECUTIVE SUMMARY

Device and Module Packaging

- Die interconnect, attach and termination schemes to reduce parasitic inductance, hence EMI, (new wire bonding, double side mounting, lead attachment alternatives, etc.)
- Power Modules with integrated gate drives, sensor circuitry and high frequency filtering
- Power module optimization for high voltage, high frequency, high altitude operation
- New concepts for device cooling, heat spreading, and low thermal resistance
- Packaging techniques for reliable operation at extreme temperatures/pressures (e.g. -55C to 250C), specific to SiC and GaN applications

Device and Module Reliability and Ruggedness

- Reliability improvement to meet standards of automotive/aerospace systems
- Module designs that address EMI, inductance, heat management, magnetics, capacitance issues
- Model and develop modules for different converter topologies
- Establish reference module designs that address magnetics, capacitance, device and external temperature limits. Consideration should be given to half-bridge, 6-pack, low inductance (5 nH) and establishing standard voltage.
- Medium voltage project to optimize: isolation, immunity, dV/dt/EMI gate drivers, creepage, and integration of passives, capacitors, and magnetics.

- Optimize paralleling multiple devices for high power module inverters and converters

Device Design and Gate-drivers

- Compact monolithic/integrated smart gate drivers with device health monitoring capability
- Definition of realizable roadmap for on-resistance, device capacitance and current rating for MV SiC MOSFETS.
- Improve Rds-on of low voltage devices; gate oxide interface for higher mobility
- GaN gate drivers for multiple paralleled devices with fast short-circuit response times

System Demonstrations and Integration Innovations for WBG Technology

- Fast chargers for phone/laptop adapters and power supply designs with ease of control - GaN
- SiC-based designs for energy storage, power conversion and management for medical equipment (MRI, X-ray)
- Reliability of WBG power electronic systems
- System demonstration in electric motors; new ways to drive motors for that fully harness the advantages of SiC and GaN technology – Example, power electronics built into generator/motor chassis
- High Power AC/DC with PFC implementations above 10kW
- SiC-based power converter addressing reduction of EMI, EMI issues, failure modes, and mitigation
- System levels cost considerations (high cost of devices modules vs. system savings and benefits)
- Open demonstration of new GaN performance capabilities and novel applications
- Mission profile standardization (GaN): develop a template and/or standardized set of mission profiles for key applications such as adapters, data centers, AC:DC

Other

- Accelerate JEDEC standardization applicable to WBG devices
- Exploit RF community lessons for power electronics
- Get industry involved with realistic business cases; get more vendors to provide solutions for WBG
- Customer and workforce education: best design practices, tutorials/short-courses on WBG EMI, inductance/parasitics, gate drive and circuit design
- High frequency components transformers/circuit breakers/fuses investigate need for development and supply chain issues
- Development of high RPM motors that can leverage the improved performance of SiC MOSFETs ; engage industrial partners to bring more of them to market
- Bring SiC into additional markets
- Shipboard demonstrations at 3.3kV at 400-500A

Appendix B

Member Initiated Project Round #3 Requirements

Project Proposals

a. Projects should be pre-competitive in nature, the results of which should benefit members broadly. Project output, results and IP will be shared with all members.
b. Projects can be up to 12 months in length.
c. Cost match is encouraged but not required, but cost match is considered when scoring proposals. The Round #2 MIP projects funded by PowerAmerica have cost matching of approximately 30 percent on average. Equipment cannot be used in calculating the cost match.
d. Projects can be proposed and carried out by teams consisting of PowerAmerica members in good standing (e.g. current on member dues payments), and prospective members. Past members and those not current on dues are required to become current on dues in order to participate on a proposing team.
e. Although pre-competitive in nature, it is expected the project will contribute to the PA mission of realizing manufacturing jobs creation and energy savings through accelerated large-scale adoption of WBG semiconductor devices in power electronics systems, consistent with PowerAmerica's SiC or GaN technology roadmaps.
f. Team collaboration between members is required, either formally with compensation or as informal advisors on the project. All participants, formal or informal, must be named in the proposal. All proposals must include at least one PowerAmerica university and industry member on the team with the aim of increasing the likelihood of commercial relevance and rapid commercialization of the project's results. Team members can be added after the project begins.
g. No MIP funds can be provided to or used by non-members (except for materials, supplies, justified contracted services, etc.)
h. The award of an MIP will not affect any member's project activity or funding on a previously funded, on-going project.
i. All proposers must certify as part of their proposal that they have read and understand the provisions of PowerAmerica's Bylaws (revised April 23, 2019) that apply to MIP, including the intellectual property provisions of the Bylaws. In addition, any background intellectual property that may be used in the project, including in the project proposal, must be identified and described in the proposal. Since PowerAmerica members expect to have unencumbered use of the results of the project and designs submitted with the proposal, any restrictions on the use of background technology or other restrictions that may apply to the proposal or use of the results of the project must be fully disclosed. This includes

but is not limited to the use of technical data and patented technology. Such restrictions are likely to result in a lower score on the proposal or disqualification of the proposal.

j. No member organization serving as a lead on a proposal may offer more than one proposal for MIP Round #3.

Proposal Review Process

1. A MIP Working Group of the Member Advisory Committee (MAC) will review, score, and recommend projects to the MAC for the MAC's vote on the projects that will be funded.
2. PowerAmerica will post announcements related to MIP project solicitation, selection and funding through its website.
3. Expertise from outside the MIP Working Group may be employed as needed as part of the review.
4. Criteria that will be used in evaluating and scoring proposals are:

    a. Significance: The extent to which the project, if successfully carried out, will make an important and/or original contribution in a one or more ways that accelerate the adoption of SiC or GaN devices and SiC- or GaN-based products and technology in the marketplace consistent with the module challenge objectives. The project should be pre-competitive in nature but advance the state of the art and broadly benefit the membership and a range of applications. Incremental advances are not of interest. The number, qualifications and role(s) of team members participating on the project, paid or unpaid, to help guide the project to increase the likelihood of project success and rapid commercialization of the results will be taken into account, especially team members who may be eventual manufacturers or customers of the project's results. (35% weight)

    b. Approach: The extent to which the concept, design, methods, analyses, and technologies are properly developed, well-integrated, and appropriate to the aims of the project, and result in an outcome that meet the stated objectives. Evidence of scalability and potential manufacturing will also be considered. Any limitations on the use of background technology required to implement the project's results by PowerAmerica members will be taken into account, and if onerous, may disqualify the proposal. (35% weight)

    c. Feasibility: The likelihood that the proposed work can be accomplished within the proposed budget and within a one year timeframe by the investigators and technical staff, given their expertise, past performance and results specific to the technology that is the focus of the project, available resources, institutional/organizational commitment, and (if appropriate) access to technologies. The amount of cost match will be taken into account and the quality of any prior performance on a PowerAmerica project. (20% weight)

d. Time to implementation: The speed with which the project output can be put into commercial practice. (10% weight)

5. Once proposals are selected for an award, subsequent meetings may be organized with the member working group to shape and refine the project plans prior to project start and after the 60 day "paper project." The working group has the latitude to negotiate with the proposers to modify projects and budgets and negotiate the combination of similar proposals received from more than one entity.
6. PowerAmerica will issue the award to the project recipient(s).
7. Project reporting will be at the 60-day point and then quarterly, plus a final report, submitted to the full Member Advisory Committee.

Proposal Preparation -- General Provisions

- No proprietary information should be included in proposals.
- Documents must adhere to the following:
    - Page size – 8 1/2 x 11 inches
    - Margins – 1 inch
    - Spacing – single Font – Times New Roman 12 point

Proposal Format

A. Cover page (1 page)
- Project title and abstract
- Applicant organization
- Point of contact name and full contact information
- Team members (if applicable)
- Funds requested and cost match (encouraged, but not required) to be provided

B. Technical project description and Statement of Project Objectives (SOPO) (6 pages maximum)

- Describe the technical challenges addressed by the project, how the project is aligned with the module challenge topic, which items in Appendix A are addressed, and how PowerAmerica members will benefit from the results of the work.
- Describe the technical approach to be followed including but not limited to the deliverable for the initial 60- day "paper project" in terms of designs, drawings, schematics, etc. described as specifically as possible so as to give confidence that the technical targets can be met. Provide a justification for the technical approach. Describe the facilities and equipment to be used.

- Describe the current state of the art relevant to the work proposed, the proposer's previous, relevant work, its technology readiness level (TRL), and how the state of the art will be advanced and the expected TRL at project completion.
- Describe technical and other risks and describe risk mitigation approaches.
- Describe the primary tasks, milestones and deliverable(s) in SOPO format (attached) and how the deliverables advance PowerAmerica's objectives.

C. Identification and description of any background intellectual property that may be used in the project, and any restrictions on its use that may be encountered by PowerAmerica members in using the project's results. A certification is also required that the proposers have read and understand the provisions of PowerAmerica's Bylaws (revised April 23, 2019) that apply to Member Initiated Projects, including the intellectual property provisions of the Bylaws. (1/2 page)

D. Teaming arrangement, description of roles, and list of key personnel including any informal, uncompensated advisors (1/2 page)

E. Gantt chart or timeline showing monthly progress and quarterly milestones (1/2 page)

F. Budget estimate: See sample format given below; provide figures for each organization if more than one organization is participating and the cost match, if any, for each line item. (1 page)

Budget Sample Format

	PowerAmerica Funds	Applicant Cost Match
Personnel		
Equipment (>$5,000)		
Supplies & Materials		
Travel		
Indirect Costs		
Total		

Statement of Project Objectives (SOPO) Template

Your Project Title

Abstract:
One paragraph public abstract clearly stating the project *objectives* and expected *outcomes*.

Task Summary:
Narrative description of your technical approach, planned accomplishments, team member roles, notable equipment or supply issues, risks and plan for mitigation, etc. Include appropriate graphics, tables of engineering parameters, and other descriptive information as needed. Up to ½ page in length.

Subtask 1: Title of your first subtask

Subtask summary: Narrative description of your subtask. Up to ¼ page.

Milestone 1.1 Description of your measurable, quantifiable milestone with due date. (Month 3)

Milestone 1.2 Description of your measurable, quantifiable milestone with due date. (Month 6)

Subtask 2: Title of your second subtask

Subtask summary: Narrative description of your subtask. Up to ¼ page.

Milestone 2.1 Description of your measurable, quantifiable milestone with due date. (Month 9)

Milestone 2.2 Description of your measurable, quantifiable milestone with due date. (Month 12)

Create a Milestone Summary table and include all milestones described in the body of the SOPO.

Milestone Summary Table

Milestone No.	*Brief* Description	Verification Method	Month of Completion
X.XX.1.1	Lorem Ipsum		3
X.XX.1.2	Lorem Ipsum		6
X.X.X.2.1	Lorem Ipsum		9
X.X.X.2.2	Lorem Ipsum		12

Deliverables:
List all the project deliverables and when they will be provided.
1: Lorem Ipsum (Month X)
2: Lorem Ipsum (Month X)