Project Introduction

SET Group will design, build and demonstrate a Gallium Nitride (GaN) based High Power High Frequency Wide Range LLC Resonant Converter capable of handling high power and high frequency operation. The GaN LLC Converter will operate at 1 MHz with an input voltage of 80V - 300V and output of 300V - 2kV, capable of handling up to 1 kW. The GaN LLC Converter will have an approximate size of 4in x 2in x 0.5in. Current technology utilizes silicon-based solutions for power conversion and distribution. GaN can fundamentally perform well beyond current silicon based hardware. GaN has direct benefits such as higher power density, reduced footprint, increased power capacity, and improved power efficiency. Increasing frequency of operation results in smaller components but it also creates a challenge for thermal management and magnetic component design. The proposed work will include a matrix transformer which offers: low profile, high power density, robust and flexible for shock and vibration handling, and superior electrical characteristics. In addition, the wide range capability will be handled thanks to the LLC topology which offers: wide input range, ZVS operation, low turn-off current. Finally, the GaN-LLC Converter will make use of additive manufacturing for its thermal management. The marriage of GaN, LLC, matrix transformer design, and additive manufacturing results in a design that is smaller, more efficient and more cost-effective than Si-based products. SET Group will design the GaN-LLC Converter to be used in PPUs, but the outcome of this work will help as a platform for other power conversion products utilizing GaN technology to be developed.

Anticipated Benefits

The greatest advantage of the technology proposed by SET Group is its ability to be used across a wide range of applications. An immediate application of our technology is for NASA's Solar Electric Propulsion systems. The PPUs in their system convert the 300V solar array output to the 700V - 2000V input level of an electric thruster. The proposed Wide Range GaN LLC Power Converter is a great candidate for that mission. In addition, the proposed work will serve as a platform to demonstrate GaN-based power conversion technology as a viable and better alternative than the current Si-based power conversion products. SET Group's goal is to develop other units using the same technology, and thanks to its wide voltage capability, it can be retrofitted for various applications with different voltage and power requirements without major redesign efforts.

Demand for broadband internet access in remote areas, airplanes and higher data capability (i.e. 4K TV, 360o video, etc), have pushed satellite manufacturers to provide more powerful RF transponders. These transponders require higher power, increasing satellite size and launching costs, which
results in more expensive satellite services for end consumers. SET Group's proposed GaN-LLC can provide satellite manufacturers a competitive edge by increasing power capabilities while reducing size, weight, and cost. In recent years, GEO satellite service providers, such as DirecTV, have been requesting more powerful satellites to handle the wider bandwidth needed to keep up with the data demand (DirecTV now offers 4K video). To meet broadband internet demand, companies have turned to LEO satellites, which due to their closer proximity to Earth, have a lower delay of signal (latency) over a GEO satellite. This is important for broadband internet given it is a two-way communication. OneWeb, a satellite manufacturer startup, will provide developing countries affordable access to internet by deploying a large constellation of LEO satellites (750 satellites) by 2020. SpaceX has also announced their own 4000 LEO satellite constellation. These satellites are small, thus reducing launching costs. A GaN-based EPS and PPU fits the equivalent capabilities of a much larger satellite into a much smaller and cost-effective one.

**Primary U.S. Work Locations and Key Partners**

<table>
<thead>
<tr>
<th>Organizations Performing Work</th>
<th>Role</th>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>✪ Glenn Research Center (GRC)</td>
<td>Lead Organization</td>
<td>NASA Center</td>
<td>Cleveland, OH</td>
</tr>
</tbody>
</table>

**Organizational Responsibility**

**Responsible Mission Directorate:**
Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**
Glenn Research Center (GRC)

**Responsible Program:**
SBIR/STTR

**Project Management**

**Program Director:**
Jennifer L Gustetic

**Program Manager:**
Carlos Torrez

**Principal Investigator:**
Raul Chinga Alvarado

**Technology Maturity (TRL)**

- Start: 1
- Current: 1
- Estimated End: 3

For more information and an accessible alternative, please visit: [https://techport.nasa.gov/view/93499](https://techport.nasa.gov/view/93499)
Primary U.S. Work Locations
Pennsylvania

Images

Briefing Chart Image
GaN-based High Power High Frequency Wide Range LLC Resonant Converter, Phase I
Briefing Chart Image
(https://techport.nasa.gov/image/30417)

Technology Areas
Primary:
- TX03 Aerospace Power and Energy Storage
  - TX03.3 Power Management and Distribution
    - TX03.3.3 Electrical Power Conversion and Regulation

Target Destinations
Mars, Others Inside the Solar System