National Aeronautics and Space Administration

FY23 Topic Areas Research and Technology Development (TRTD)

Direct Energy Transfer Solar Array Architecture with Inherent Array Collapse Prevention

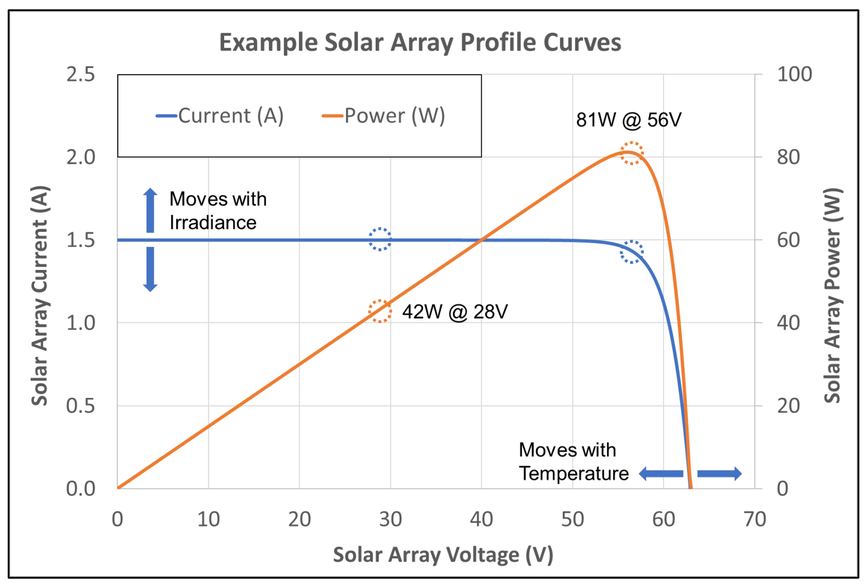
Principal Investigator: Christopher Stell (346); **Co-Investigator:** Andre Sukernik (346)

Intern Support: Sophia Du, Justin Lee

Strategic Focus Area: Power generation

BACKGROUND

Energy sources like Solar Arrays and RTGs have a characteristic Current – Voltage profile where there is nominally a single maximum power point.



Energy transfer to a battery can be increased by operating at this point. By slowly adjusting the duty cycle (**D**) of a power converter, the voltage of the source is adjusted without compromising the stability of the system

Buck Converter Transfer Function $V_{out} = D \cdot V_{in}$

$$V_{in} = \frac{V_{out}}{D}$$

Solar Array Voltage

Stiff Battery Voltage

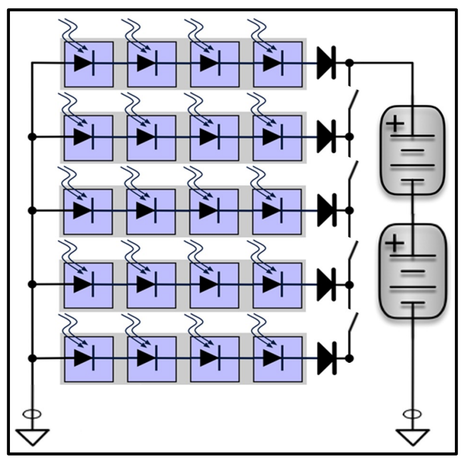
Control Input

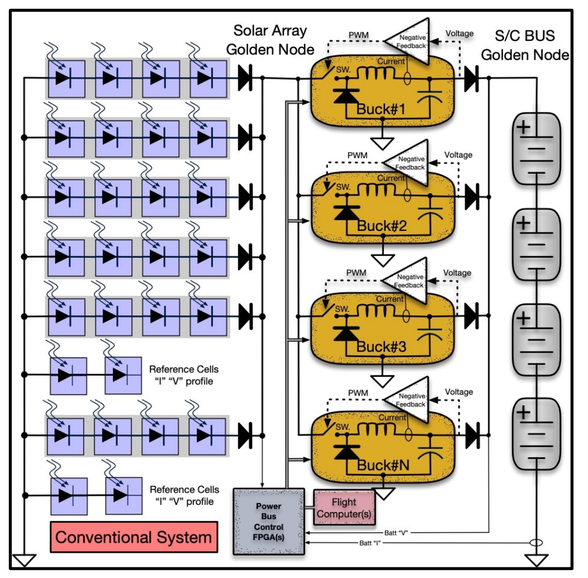
Controlled 'Output'

CONVENTIONAL SYSTEMS

String Switchers

String switchers are simple and Robust, but they operate in Direct Energy Transfer by directly connecting the Solar Array to the Battery, leaving power on the array





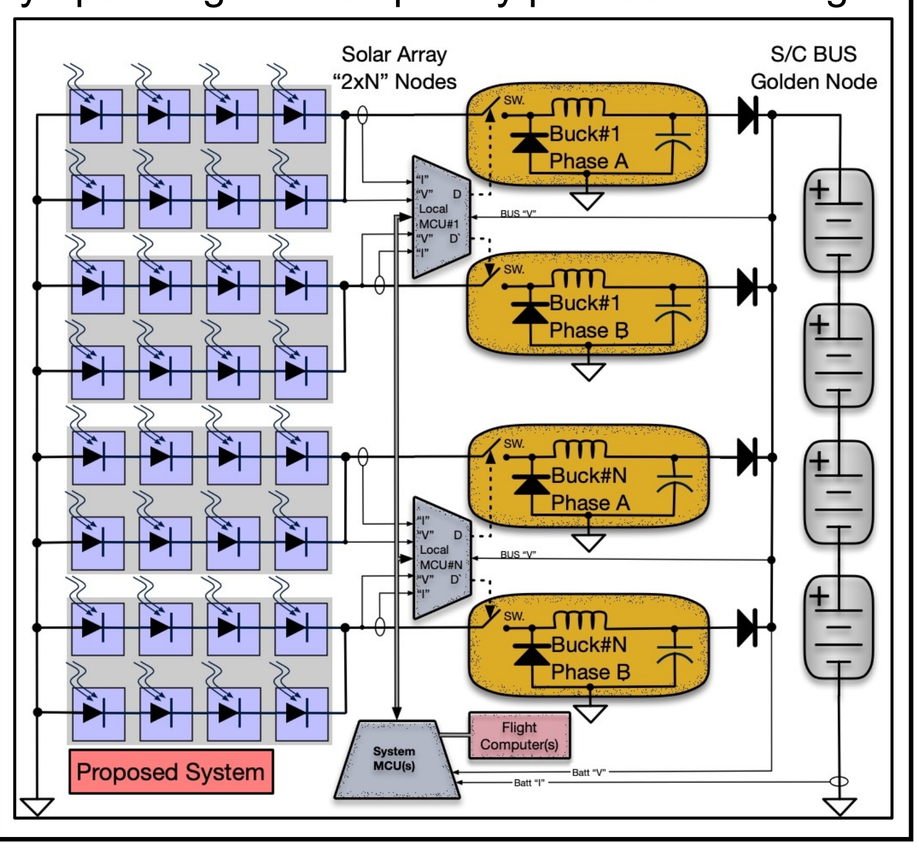
State of the Art

Uses switching converters with negative feedback, and can require large capacitive banks to mitigate stability concerns

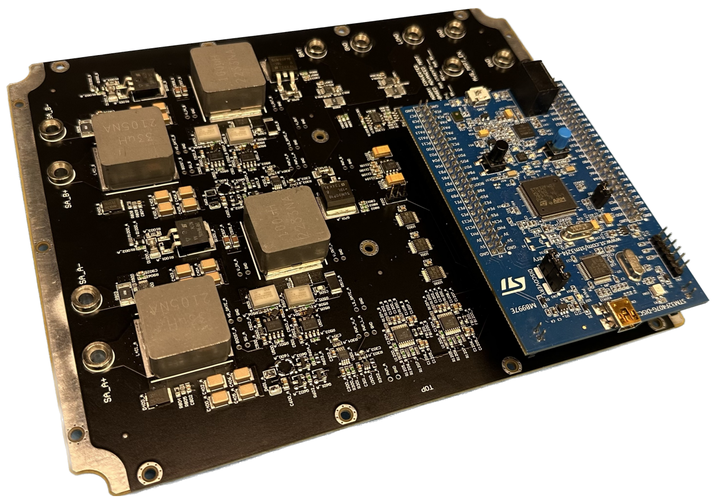
PROPOSED SYSTEM

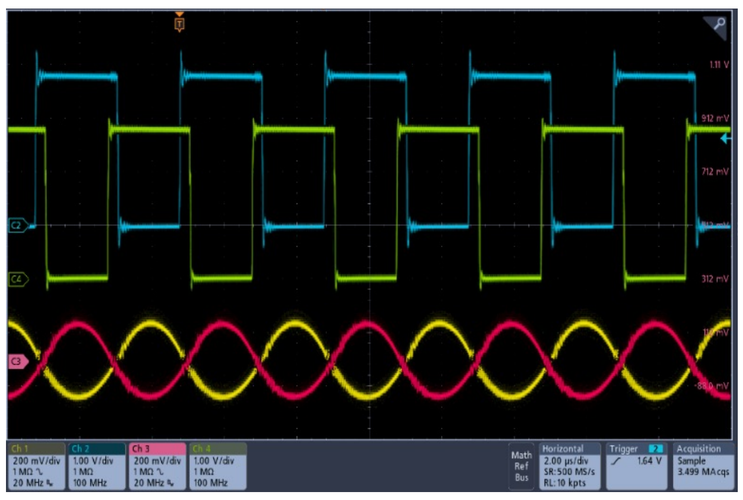
Key Technology Features

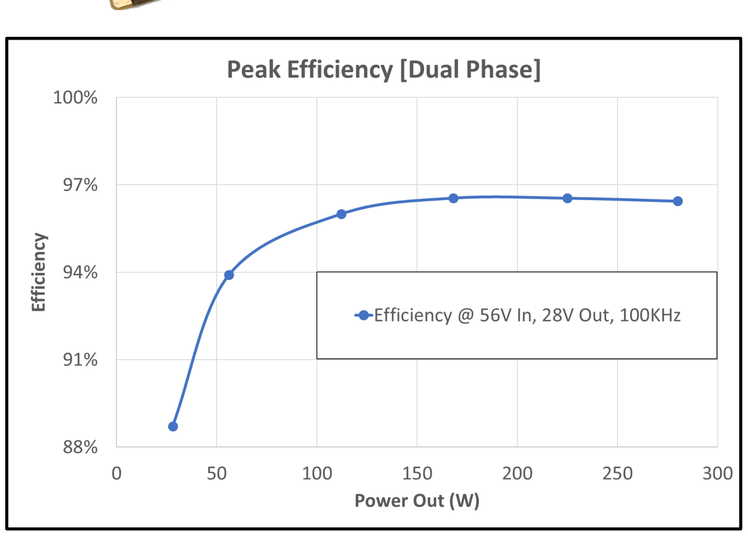
- Ensures stability by transferring energy from a source to a storage element via an effectively open loop switching regulator
- Converges to and operates at the Maximum Power Point of the energy source by using a simple perturb & observe algorithm running on an MCU
- Generates I-V profiles of the energy source without dedicated test cells
- Optimizes noise characteristics by operating with temporally phased switching
- Optimizes conversion efficiency by utilizing GaN switches and smart diode circuits

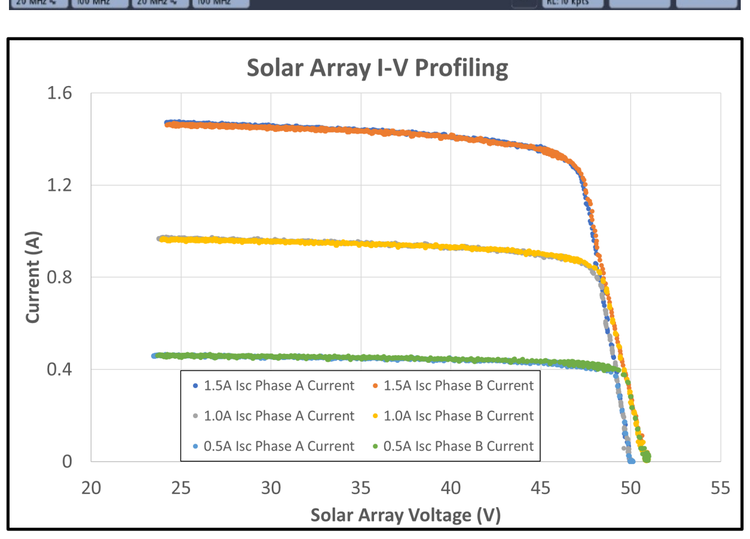


HARDWARE DEVELOPMENT





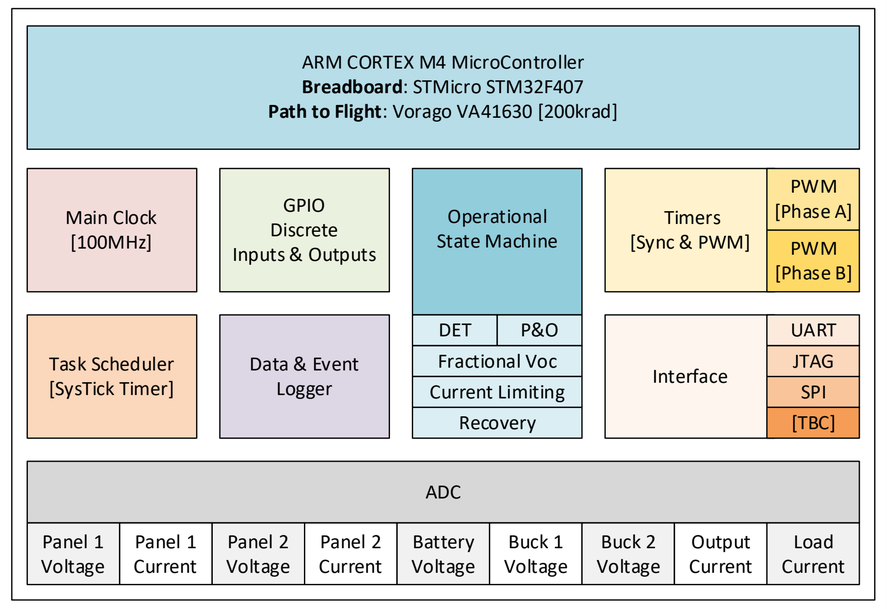




Clockwise from upper left: **(1)** PWA of a breadboard Bi-Phase Buck Converter implemented with GaN switches, with MCU daughter-card. **(2)** Oscilloscope view showing the duty cycle control variable and resulting voltage ripple with 180˚ phase separation. **(3)** Efficiency plot showing 96.5% peak power conversion efficiency. **(4)** MCU-generated direct I-V profile of the solar array simulator at 3 different irradiance levels

MCU DEVELOPMENT

A Time-Triggered Embedded System, written in C, showed 97-99% convergence to the MPP



National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
www.nasa.gov

Clearance Number: CL#00-0000
Poster Number: RPC#

Sponsor	Topical R&TD
PI	Chris Stell
Phone	805-990-0486
Email	christopher.b.stell@jpl.nasa.gov