Photovoltaic Maximum Power Point Tracking Design for Communities

Micheal Bardwell[1], Jason Wong[1], Steven Zhang[1], Petr Musilek[1]

BACKGROUND

Maximum power point tracking (MPPT) is a required area of study for optimizing cell to end-use photovoltaic (PV) efficiency (η_{PV}). Fig. 1 demonstrates how wide the solution space can be under partial shading conditions. In response, hybrid tracking algorithms have been designed to start/stop the search process effectively, with $\eta > 95\%$.

In the future, companies would be wise to combine these successful algorithms with an Internet of Things (IoT) platform, tapping into the growing IoT infrastructure. This can be applied in communities to improve system reliability through redundancy and provide information for the incoming wave of in-home digital services.

Common segments of MPPT algorithms are implemented and timed on multiple IoT devices, including the Beaglebone Green (BBG) and the ESP8266 Feather Huzzah (ESP). The results will be used to determine which segments largely contribute to capping the algorithm frequency, $F_{p,\ IoT}$.

A battery-charging, buck converter circuit has been designed in Simulink to demonstrate the relationship between $F_{p,\ IoT}$ and converter performance.

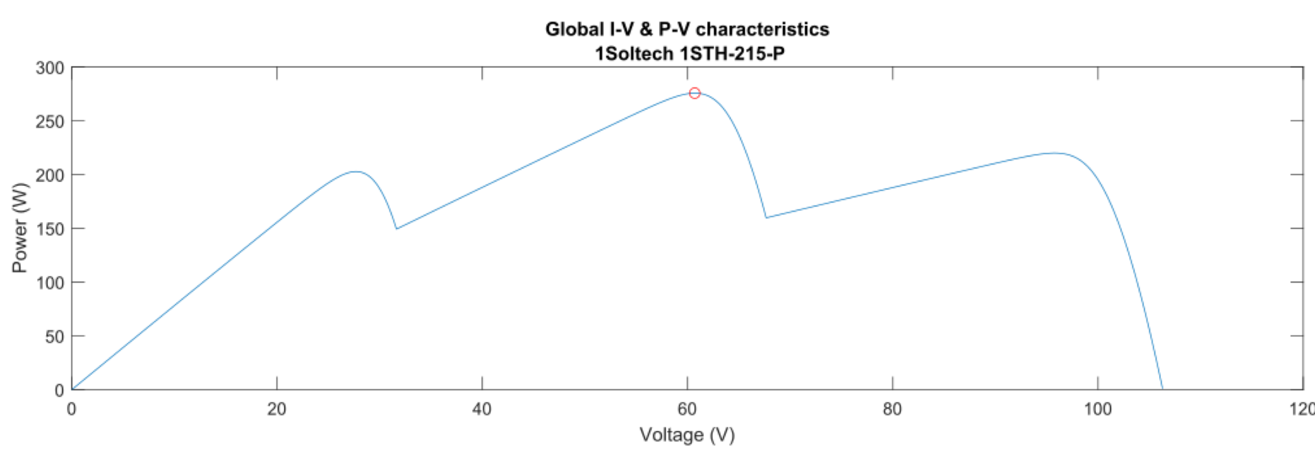

Figure 1. Three 1Soltech 1STH-215-P PV panels in series under partial shading conditions

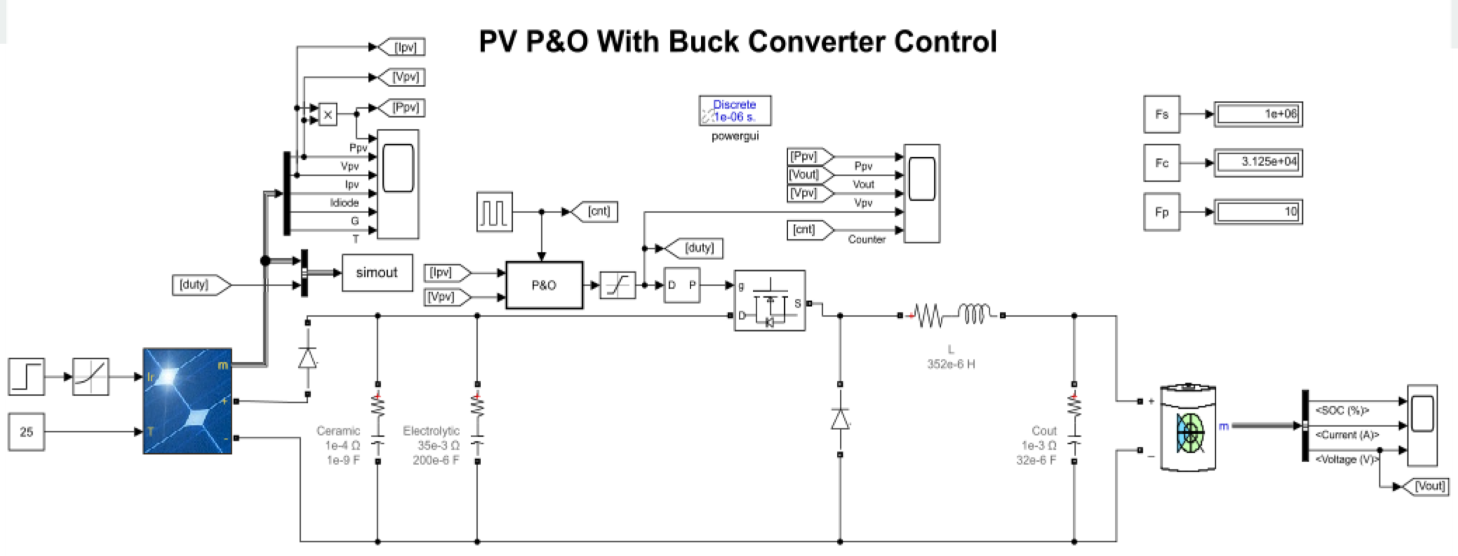

Figure 2. PV powered battery-charging circuit with MPPT control

RESULTS

In Fig. 5, the timing result from the segmented MPPT code is displayed and $F_{p,IoT,\ max}$ = 72.6 Hz for the BBG and 50 Hz for the ESP. This is in contrast to the maximum allowable algorithm frequency as per converter performance of $F_{p,converter,max}$= 54 kHz.

This discrepancy in frequency demonstrates the suboptimality of this IoT strategy. The time required for the API call creates a frequency threshold that lowers η.

Fig 3. displays the voltage settling time of the converter when perturbed. The signal converges demonstrating system stability. In Fig. 4, the MPPT algorithm responds in ideal fashion to a step change in irradiance.

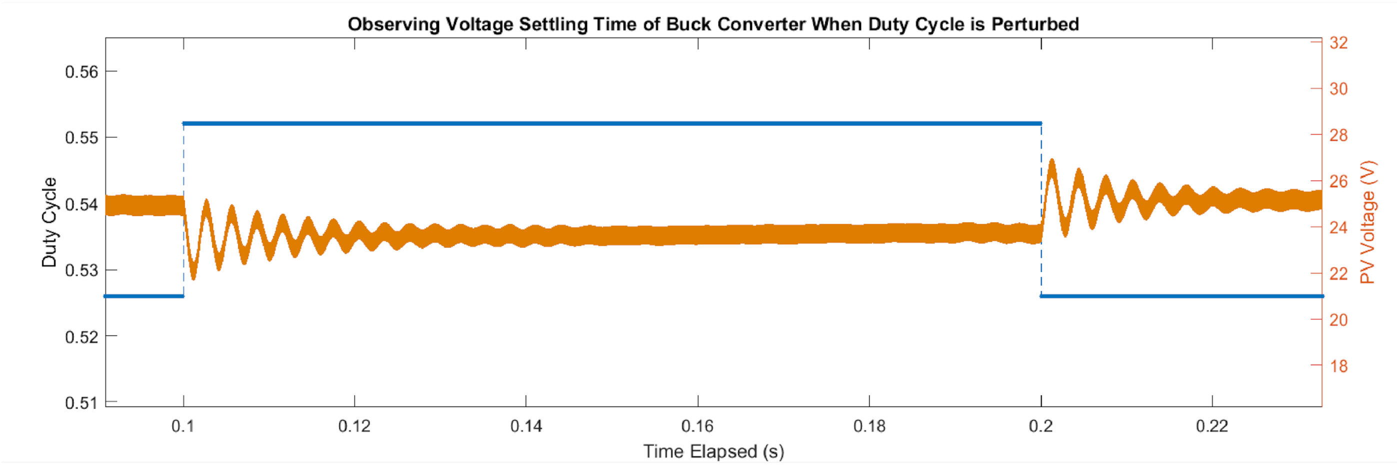

Figure 3. Settling time of converter in Fig. 2 with *x = 0.026*

	API (ms)	Sense (μs)	Alg. (μs)	PWM (μs)
BBG P&O Py	13.2	546	15.7	22.8
BBG IncCond Py	13.2	546	13.8	22.8
ESP P&O C	19.9	82.2	1.75	5.27
ESP IncCond C	19.9	82.2	6.48	5.27

TABLE II
TIMING DATA FOR SEGMENTED MPPT PROCESSES ON MULTIPLE IOT PLATFORMS WITH ARM-BASED PROCESSORS: ESP8266 AND BEAGLEBONE GREEN

	$T_{p,min}$ (ms)	$F_{p,max}$ (Hz)
BBG P&O Py	13.8	72.6
BBG IncCond Py	13.8	72.6
ESP P&O C	20.0	50.0
ESP IncCond C	20.0	50.0

TABLE III
CALCULATED MINIMUM TP FOR MULTIPLE IOT PLATFORMS WITH ARM-BASED PROCESSORS

Figure 5. Timing results from segmented MPPT algorithms

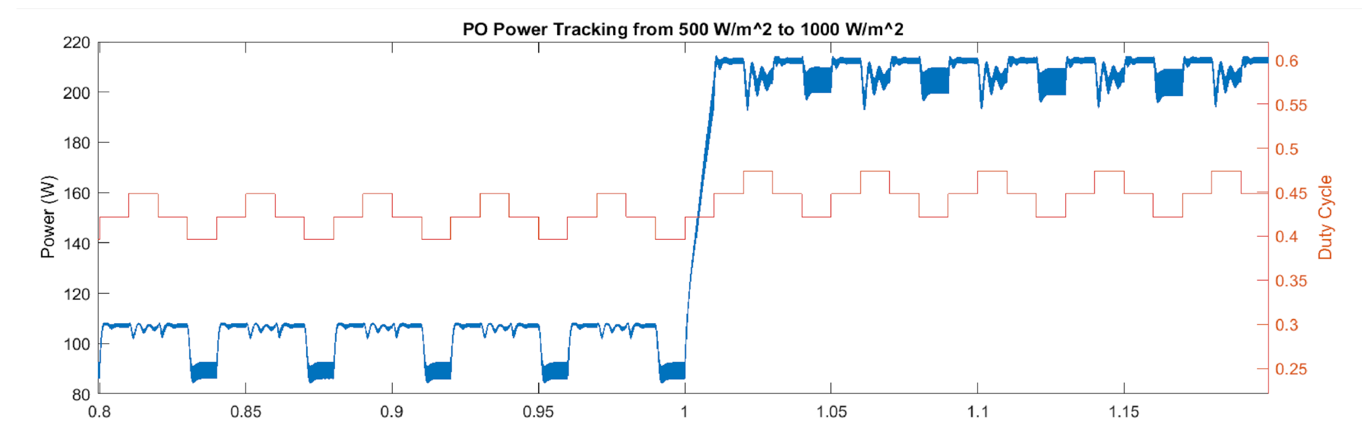

Figure 4. Duty cycle perturbation in response to an irradiance step change

FUTURE DIRECTIONS

Many considerations can be made to further develop IoT-based MPPT. 1) To increase tracking algorithm bandwidth, API cloud server calls can be replaced with rooftop to rooftop connection, reducing the signal time from sensor to algorithm implementation. 2) Most converters have non-linear transfer functions and require PI control to implement consistently sized perturbations; this adds another dimension to be considered in setting the algorithm frequency.

A physical system is under development and algorithms with high tracking factors and low computational requirements such as the Beta method [2], will be trialed first. Practically, more algorithms, especially of the iterative calculation variety will be written and timed.

ACKNOWLDEGEMENTS

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References:

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[2] M. A. G. de Brito, L. Galotto, L. P. Sampaio, G. d. A. e Melo, and C. A. Canesin, “Evaluation of the main mppt techniques for photovoltaic applications,” IEEE Transactions on Industrial Electronics, vol. 60, no. 3, pp. 1156–1167, Mar. 2013.

FES PROJECT OVERVIEW

Project T06-P02

Modern energy systems provide plethora of data (including data on generation, loads, weather and market conditions) that can be harnessed for the design, monitoring, and control of electric power grids. Under the smart grid framework, this data and information is gathered and processed using information and communication technologies (ICT) and can be used to enhance the reliability, efficiency, flexibility, and resilience of power systems. In future energy systems, an additional degree of complexity will be brought by mass introduction of renewable energy sources (RES) and storage devices. This integrated research program will address the major challenges expected within the future grids through data-driven methods, and develop principles for building grids capable of adaptation to changes not yet anticipated in the future.

[1]Department of Electrical and Computer Engineering, University of Alberta

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