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DESIGN AND DEVELOPMENT OF A SCALABLE, MODULAR AND EFFICIENT MAXIMUM POWER POINT TRACKING STAGE FOR A CUBESAT EPS

Abstract

This paper presents a design of a modular, scalable, and efficient maximum power point tracking stage that can be used in 2U to 36U form-factor missions and be easily adaptable for customer power and hardware requirements. The selection process as well as the verification of the system hardware and software designs are presented.

Power point tracking algorithms are systematically reviewed and compared; on this basis the Modified Perturb & Observe algorithm is selected for implementation. Simulink and Python simulations show that this algorithm can reliably acquire a global maximum power point within 6 seconds under static, dynamic, and partial shading conditions while being agnostic of the size and electrical characteristics of a solar array that is being used.

Hardware for the proposed system is designed using commercial off-the-shelf components that can withstand the environmental conditions in low Earth orbit. A single power point tracker, based on a DC/DC converter, is capable of handling solar arrays with open-circuit voltages up to 60 V, corresponding to a string array of up to 22 cells. A control scheme via input regulation is proposed, allowing both input regulation and precise external operating point control by the power point tracking algorithm. This control system is analysed, verified, and tuned for stability and a low bandwidth of 2.2 kHz to reduce noise. The DC/DC converter design is simulated in LTSpice to show its feasibility; a settling time of 4 milliseconds is demonstrated for the proposed DC/DC converter, which is suitable for the proposed MPPT algorithm.

Using the unregulated DC/DC converter output the ability of the system to determine the power demand of the satellite and share the load between paralleled power point trackers is shown. Through this mechanism, it is possible to scale the system to process up to 100 W of input power. Redundancy mechanisms to eliminate single points of failure are also evaluated.

The combination of hardware and software forms the complete power point tracking stage, which is the outcome of this work.