ABSTRACT

Nowadays, the power management unit (PMU) plays an essential role in electronic and communication devices and their reliability. More challenges for the power management industries are proposed from the increasing of low-voltage portable devices and growing requirements of complex functionalities. One of the limitations on the overall performance and the lifetime of these battery-powered devices is the limited capacity of the finite power source. The process of collecting and converting minute amount of unharnessed energy from surrounding environment into usable electrical energy is called energy harvesting. There are plenty of ambient energy sources ranging from the most common sources such as heat, solar energy, and mechanical vibrations to new-developed sources like microwave, bioenergy, etc. As energy harvesting raises the possibility of self-powered devices, which are truly autonomous, efficient energy harvesting circuit design has become increasingly important and has gained immense popularity.

Scavenging energy from solar is a good solution to address the increase of power consumption in electronic devices. Modern circuits and systems require multiple voltage supplies to provide different functionalities. For example, 2.2-3V supplies power RF and antenna circuit, while analog circuit and digital circuit operate using different voltage supplies ranging from 0.7V to 1.8V. Using multiple voltage supplies can improve the overall performance while reducing the power consumption of the devices.

In this research, an energy harvesting system is proposed to extract photovoltaic (PV) energy and deliver energy to application of Internet of Things (IOT). The main part of the system consists of a single-inductor H-bridge configuration DC-DC converter connecting with two inputs and two outputs. It regulates a constant 1V output voltage for several applications such as sensor and signal transmitters. The surplus energy is stored in a rechargeable battery. The

battery also serves as a secondary input source. The most critical issue in energy harvesting applications is maximum power extracting. In order to maximize power extraction under all conditions, a digital-controlled feed-forward maximum power point tracking (MPPT) system is implemented. An input approximation method is proposed to quickly predict the change in input power and shift the PV system to the maximum power point (MPP). Pulse-width modulation (PWM) and pulse-frequency modulation (PFM) are then used to regulate the output voltage at the MPP.

The PV system is designed using 0.18um technologies. The controller is mainly designed using digital circuit to enhance stability, reliability, and controllability. The system is able to extract energy from a single solar cell and deliver to multiple outputs loads. The proposed system achieves above 60% of conversion efficiency with a peak efficiency of 84.1% while driving 1uA to 1mW load current.