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Effect of Energy Management Circuitry on Optimum Energy Harvesting Source Configuration for Small Form-Factor Autonomous Sensing Applications

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Abstract-- **The purpose of this paper is to investigate methods for improving power delivery from low-voltage, low-power energy harvesting sources, such as small form-factor dye-sensitised solar cells (DSSCs) as used in autonomous wireless sensing applications in buildings and homes. Energy harvesting powered wireless sensors enable existing and new structures to comply with Industry 4.0 and become smart buildings. Due to the size constraints of wireless sensor systems and the inherently low-power levels generated by energy harvesting sources, available power is limited and therefore the efficiency of power conversion and energy management circuitry connected between the source and output load has a significant impact on output power delivery. Most research to date focuses on improving the efficiency of individual components of such systems, without considering the impact of one stage on the others. In this paper, the potential of varying energy harvesting source configuration in combination with power converter operation to improve overall power delivery is investigated, where it is shown that by connecting sections of a DSSC in series rather than as a single cell, higher power conversion efficiency and therefore power delivery is achieved. Limitations to varying cell configurations and low-power DC-DC topologies are illustrated in order to demonstrate the scope of solutions available for small-sized, low-power, energy harvesting sources. It is shown that 8% improvement in overall power delivery is achieved for series vs. single cell connections within a fixed module area. This will translate into increased wireless sensor functionality and range, thereby furthering the development of the Industrial Internet of Things in buildings and homes.**

Index Terms— **Dye-sensitised solar cells (DSSC), energy harvesting, ultra-low power conversion, boost converter.**

1. INTRODUCTION

In partnership with the Industrial Internet of Things and Industry 4.0, wireless sensors provide an essential solution to the development of automated buildings and homes towards becoming autonomous and smart. In the case of smart homes, wireless sensors can be utilised for a wide range of applications aimed at improving occupant comfort such as remotely or autonomously operated temperature control, household appliances, security systems, etc., while also facilitating increased building energy efficiency [1]. Similarly, wireless sensors can be used in industrial building settings to enable autonomous control of important operating conditions such as temperature, CO_2 and humidity, or to optimise overall building efficiency. However, the main issue with wireless sensors in autonomous buildings and homes is the need for a separate and reliable power source for each of the individual sensors, where for example a machine diagnostic application may require up to 300 sensor nodes over an industrial production area of 25 m^2 [2]. Energy harvesting powered sensors have the ability to be fitted and operate autonomously in a wide range of locations without the need for access to mains power or battery maintenance, which means that autonomous building