Demo Abstract: ATON, A battery-less power supply with dynamic duty cycle for wireless sensor networks

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Abstract—. **In this demo, we introduce ATON, a battery-less power management system particularly suitable for wireless sensor networks to be deployed outdoors. The main physical elements of ATON are a set of small-sized solar cells for energy harvesting and an ultracapacitor for power storage. The power consumption is managed by adapting the duty cycle of the radio to the charge/discharge cycle of the ultracapacitor. The main aim of the demo is to show the feasibility of ensuring the long-lasting operation of a low-power sensor node, such as the Telosb, by properly adapting the duty cycle of the radio of the wireless node to the charge/discharge cycles of the ultracapacitor.**

Index Terms— **power management, sensor networks supercapacitors, energy harvesting.**

I. Introduction

Power management is nowadays one of the main challenges in the deployment of wireless sensor networks. Even though several projects have put forward novel energy harvesting technologies and alternative energy storage devices [1][2][3], the development of a solution ensuring the long-lasting operation of sensor nodes requires smart management strategies. In this demo, we introduce ATON, a battery-less power supply with dynamic duty cycle for wireless sensor networks.

II. ATON

A new battery-less system supply based on harvesting techniques has been designed for low power wireless sensor networks. The proposed system is made up of: 1) a set of low-power solar cells connected in series forming a photovoltaic panel of 60x40mm with an optimum voltage work of 3.3V and 24mA of current; 2) a supercapacitor or high density capacitor as energy storage; 3) a power control unit responsible of properly coupling the supercapacitor voltage to the sensor node electrical characteristics; and 4) a filter stage connected to Telosb mote to avoid electromagnetic interferences and possible noise produced by the power unit.

Figure 1 shows the diagram of the electronic components of ATON. The power control unit, with the filter stage, is responsible for supplying the energy that the sensor node will consume. The sensor node continuously monitors the stored energy in the supercapacitor. This information is used for adapting the duty cycle of the radio system.

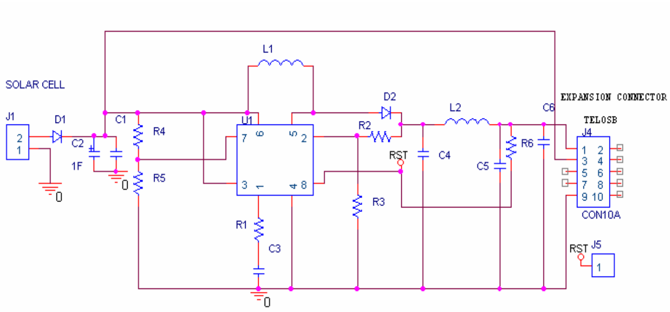

Figure 1. Circuit diagram of ATON

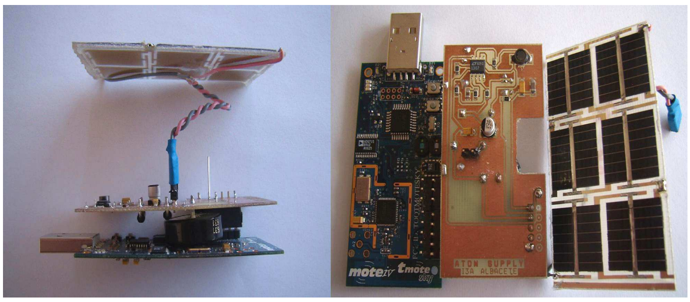

Figure. 2. Telosb mote with ATON

The novel advantage of this system is the fact that it has no batteries. In this way, we avoid the problem of battery replacement which in many instances may be prohibitive [4].

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III. DEMO CONFIGURATION

A. Testbed setup

The testbed setup will consist of two Telosb motes. The first mote will act as data sink and it will be further connected to a laptop computer which will act as server for data capture and visualization. The second Telosb which will be powered up by ATON with a 1-F supercapacitor, will be periodically reporting via the wireless channel the charge of the capacitor as well as the power consumption due to the node activity, mainly due to the radio system. In order to charge the supercapacitor, a lamp will be used as light source. As already stated, the data being captured will be sent to the laptop for storage and data visualization. The packet length of the data being transmitted is 12 bytes long. Figure 3 depicts the graphical user interface of the application enabling the visualization of the supercapacitor status, i.e., load.

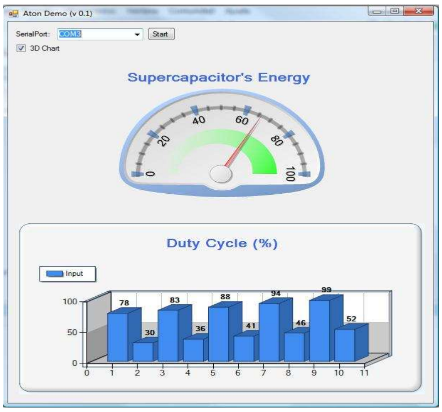

Figure. 3. ATON Software Interface

B. Trials

The Telosb mote powered by ATON sends a status data packet to the data sink according to the duty cycle, calculated proportionally to the supercapacitor´s stored energy level. Initially the supercapacitor is fully charged. To be able to show the prototype operation within a short time frame, the demo trial, we initially establish a 1 second-long cycle. The radio is turned on for 30 *ms* corresponding to the RX-TX mode. During this ON period, and according to the mote specs, the mote will draw a current of 21.8mA. During the OFF period, 970 *ms* long, the radio will be turned off. In this way, the mote remains in a standby mode consuming only 5.1µA during this OFF period [5]. The power control consumption (50µA) is also reported for each period.

In the top gauge meter of the application, refer to Figure 3, the energy level of the supercapacitor will be refreshed for every message received by the mote acting as base station. In the lower part, the duty cycle is traced on a packet per packet basis. A digital oscilloscope is used for monitoring the output voltage of the system and the frequency response.

While the supercapacitor is fully charged, it keeps sending a packet per second. As the load of the supercapacitor changes, the duty cycle will be varied accordingly allowing the supercapacitor to recharge. Figure 4 depicts a one-minute long snapshot of the operation of ATON. A seen from the figure, as the load stored by the capacitor decreases, the duty cycle of the radio system is decreased. This is to say, the time between the ON periods of the radio system is increased. As the energy stored by the capacitor increases, the duty cycle of the mote is increased. Figure 5 shows a 30-minute long snapshot of the operation of ATON. It is clear that the system will be able to operate for long periods of time. In fact, our lab tests have shown that the supercapacitor discharge time can last as long as 15*min* while powering up a Telosb mote operating with a duty cycle characterized by an ON/OFF ratio of 30*ms* to 970*ms*.

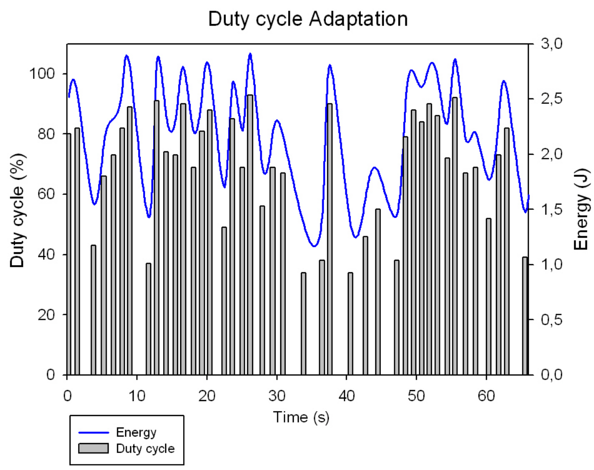

Figure 4. Duty cycle adaptation in Telosb node (1 min. snapshot)

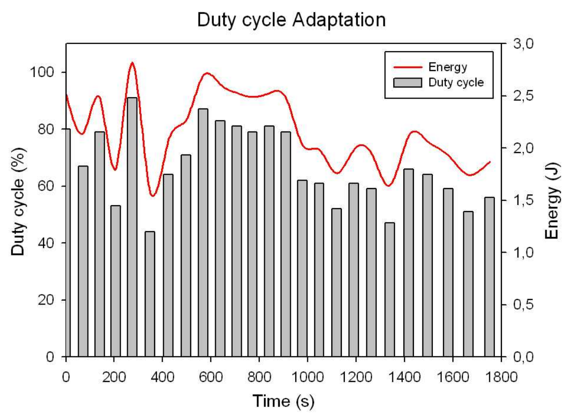

Figure 5. Duty cycle adaptation in Telosb node (30 min. snapshot)

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