Modelling and simulation of datalogging embedded module with solar panel supply and NiMH battery energy storage

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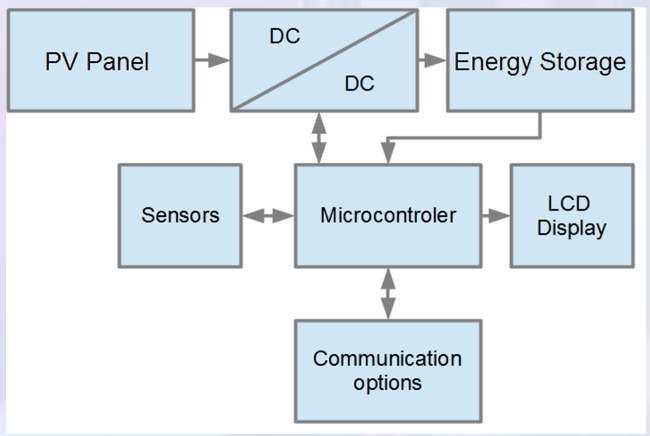
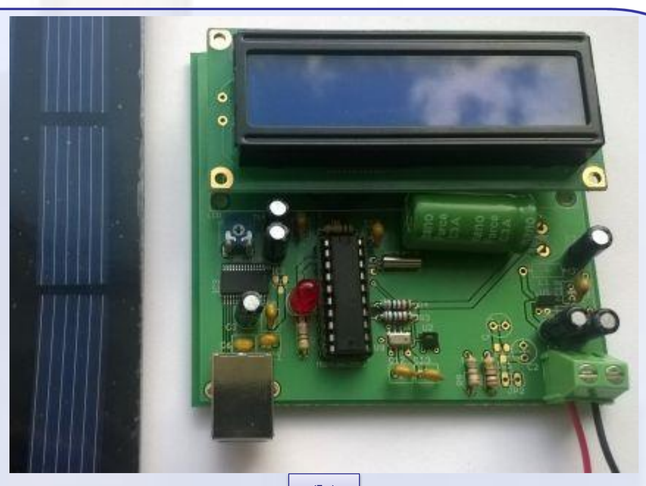
INTRODUCTION

The paper focuses on modelling and simulation of energy consumption of an autonomous embedded system with a solar cell as energy source and NiMH battery as energy storage during night. Key aspects in the design and implementation of the proposed system are presented. Simple models for energy consumption/generation for solar cell, NiMH battery charging and discharging, microcontroller and its peripherals are elaborated, tested and coupled together for complete system simulations that allow system configuration and optimization.

The module is based on a high performance microcontroller with integrated communication capabilities that handles the power management for all other peripherals (sensors, display or communication devices) and stores the measured data in a flash memory that can be read over USB interface



(a)

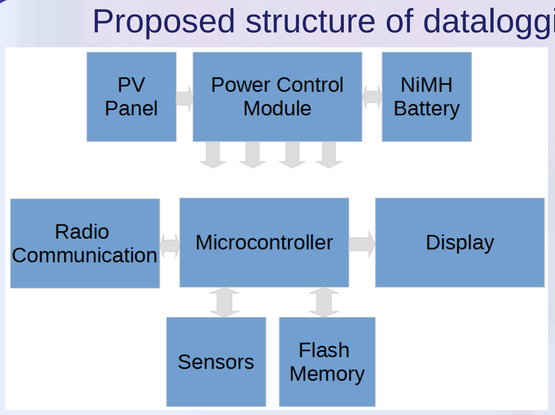


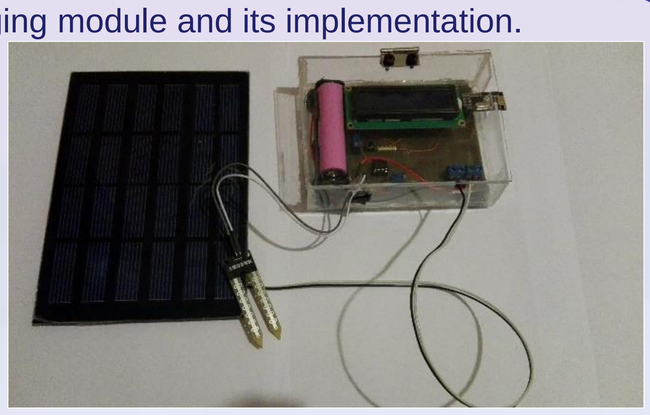
(b)

Structure of a microcontroller-based datalogger module with solar panel supply and energy storage (a) and its implementation with 10Farad supercapacitor as energy storage (b).

THE STRUCTURE OF DATALOGGING MODULE

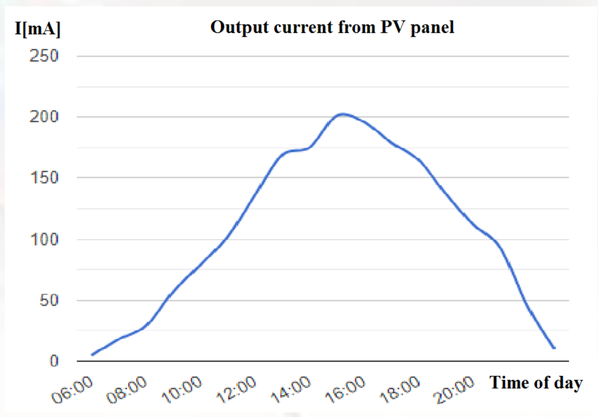
Proposed structure of datalogging module and its implementation.





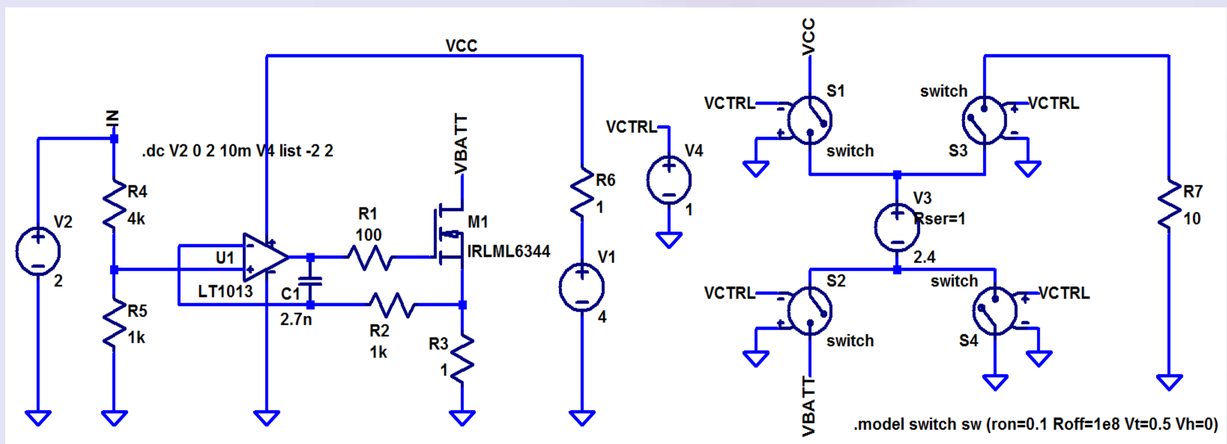
The proposed structure includes a 16 bit microcontroller, flash memory, communication module, LCD display, sensors and analog electronics that implements power control for charging the NiMH battery from solar panel and supplying the entire system.

The module uses a 2W rated solar panel with 6Volt open voltage and 333mA short circuit current. 2 standard NiMH cells with 800mAh capacity are used as energy storage and fast charged in 2 hours. An important test is related to the output current of the photovoltaic panel.

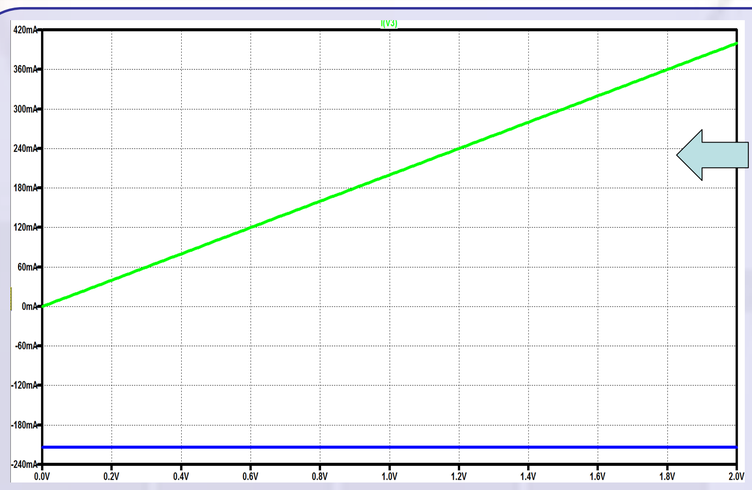


Several measurements were performed during many days in July and August in Bucharest, from 06:00 to 21:00, and the average values are presented

SPICE MODELING AND SIMULATION OF THE SYSTEM



Because NiMH batteries need constant-current charging, a constant-current source5] able to sink currents is required; the battery discharging process involves a simple resistive load.is shown above. The left side of the circuit implements a voltage controllable constant current source that sinks currents up to 400mA. This source can be voltage-controlled by a microcontroller or other embedded system. V3 voltage source models a NiMH rechargeable 2-cell battery pack that is charged in constant-current mode at a desired value according to voltage source V2 that models the output from controlling system. V1 voltage source and R6 model the solar energy source (solar panel + power management chip). A single-supply operational amplifier with input and output voltage range extending to ground is required in this application. NiMH battery discharging and switching from charging to supplying mode is modeled with 4 voltage controlled switches and R7 load resistance. When battery is in charging mode, S3 and S4 switches are off and S1 and S2 switches are on; they connect the battery to constant current circuit. When S3 and S4 switches are on, S1 and S2 are off and battery supplies the R7 load. Ltspice IV simulator was used.



Spice parametric simulation of charging and discharging currents.

3-day simulation of NiMH battery charging and discharging

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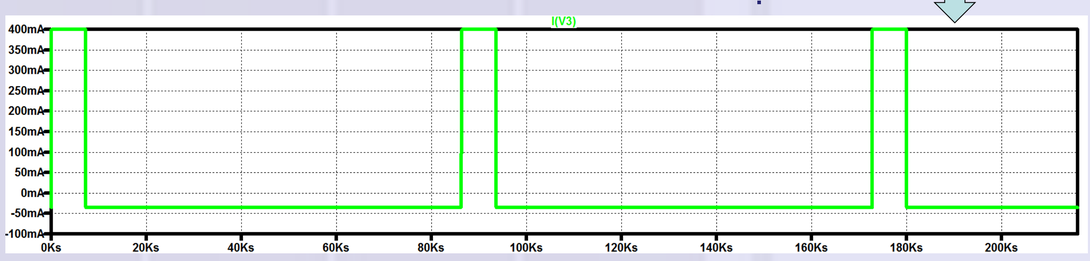

CONCLUSIONS

- ✓ Modern microcontrollers and sensors simplify the design of dataloggers for parameter monitoring and have low power consumption. Photovoltaic panels can supply such low power embedded systems but storage devices like rechargeable batteries or supercapacitors are required for night time, when photovoltaic panels supply no energy. Modelling and simulation tools are required for correct tuning of the system in order to have continuous (day and night) operation.