Politecnico di Torino
III Facoltà di Ingegneria

Energy management of IoT application
Report laboratory session 3

Master degree in Computer Engineering

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Contents

CHAPTER 1

Introduction

The aim of the third laboratory session is to simulate an IoT device implemented in Matlab/Simulink, where we analyze the power perspective of the system.

The activity is divided in three main parts described in this report:

- Model and simulate the behavior of a Photo-voltaic cell.
- Model and simulate a DC-DC converter and a battery.
- Load the entire module and scheduling and simulate behavior of the system.

The creation of the model is performed using Simulink environment. In order to stress the battery a pack of 4 sensors has been created. The whole power demand is handled by a DC bus, which interfaces the loads with power supply. At the end, in order to improve the battery system, a photovoltaic cell has been connected and interfaced with the system. The overall structure of the system is showed below.

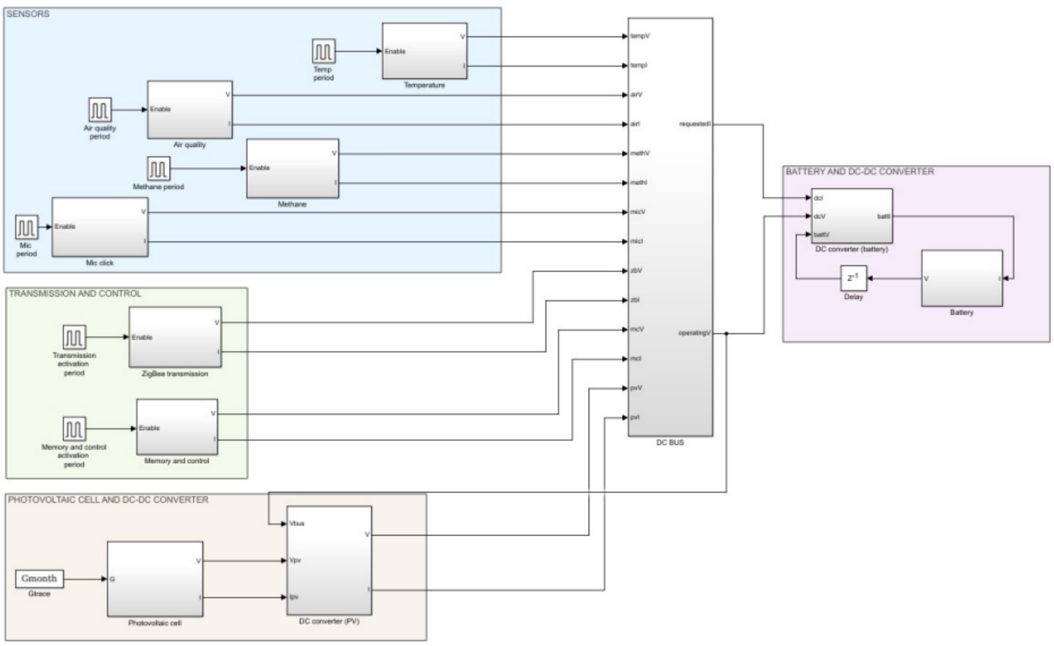

Figure 1.1: System implementation

CHAPTER 2

Modules description

2.1 Model of the photovoltaic module

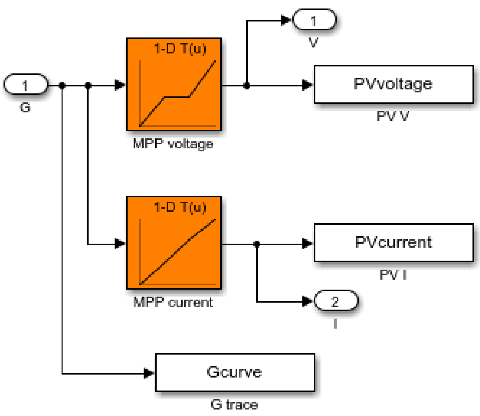

Figure 2.1: PVcell

The Scheme of the Photovoltaic cell (Fiure 2.1) is composed by two elements: One is the Photovoltaic cell itself and a DC-DC converter that is used to extract and operate at maximum power point `MPP`.

From the data sheet, depending on the irradiance, the different MPP have been extraced. The MPP values are showed in the table below.

Irradiance [W/m²]	V_{MPP} [V]	I_{MPP} [A]
250	3.0139	0.0127
500	3.1317	0.0263
750	3.1317	0.0417
1000	3.2796	0.0551

Figure 2.2: PVcell MPP

These values are insterted in the Look up tables in simulink in order to characterize the component.

Fro the DC-DC converter, it is characterized itself by the an efficiency curve given in the data-sheet and below the relative simulink schematich is reported:

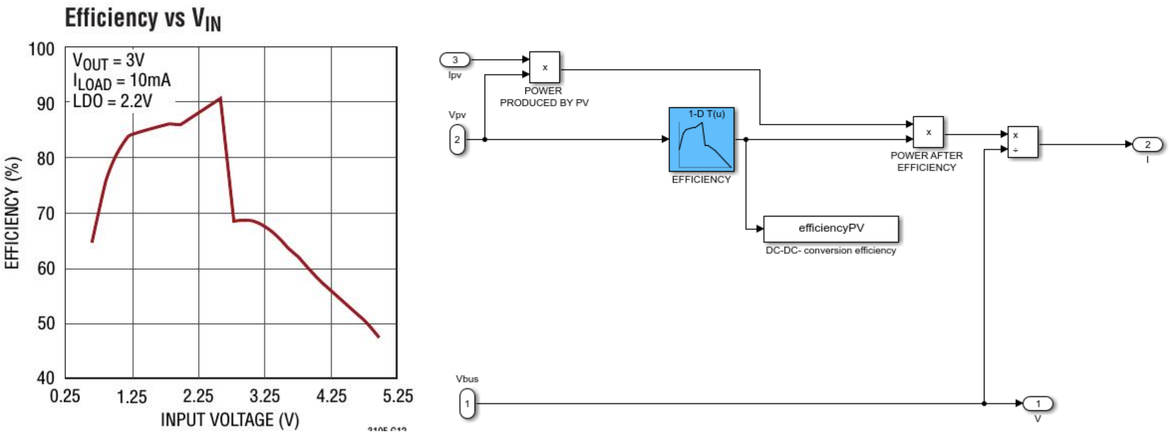

Figure 2.3: DC-DC converte for the PVcell

2.2 Model of the battery module

The model of the battery is composed by a DC-DC converter and an abstraction of a battery based to a specific model. The electrical model of the battery is represented by the circuit in Figure 2.4.

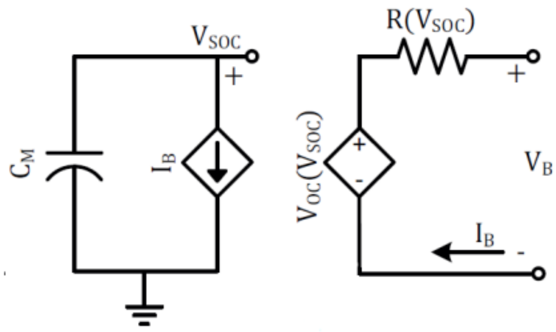

Figure 2.4: Battery circuit model

On the left we have a representation that shows `CM` as the available usable capacity, then the `Ib` discharge current and the SOC voltage `Vsoc`.

On the right the model that shows the internal resistance `Rsoc` that has a voltage drop across the resistance itself that simulate the voltage drop due to ohmic losses, then the discharge current `Ib` and the `VB` that is the voltage across the battery.

Also the DC-DC converter of the battery is characterized by an efficiency curve data is given by datasheet.

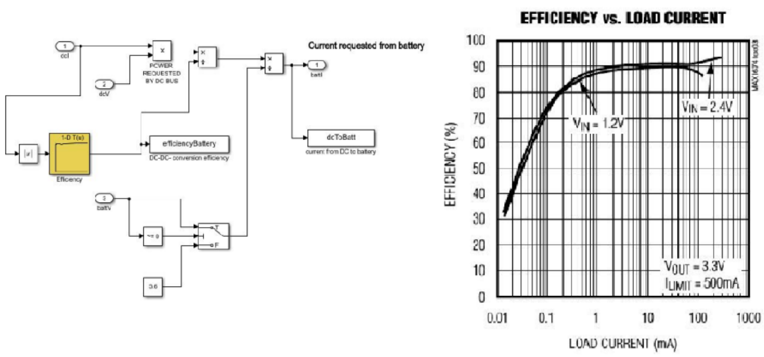

Figure 2.5: Battery circuit model

We need to find are the equations that regulates the resistance `R`, which models the voltage drop due to internal resistance, and the Open-Circuit Voltage. Both of them depends on the State of Charge, that can be found in the data-sheet of the battery.

$$Voc = V_{1C} + R * I_{1C}; \tag{2.1}$$

$$R = \frac{V_{2C} - V_{1C}}{I_{2C} - I_{1C}}; \tag{2.2}$$

These two variables are obtained observing the battery discharge characteristics given in the data-sheet and the curve 1C and 2C have been digitized.

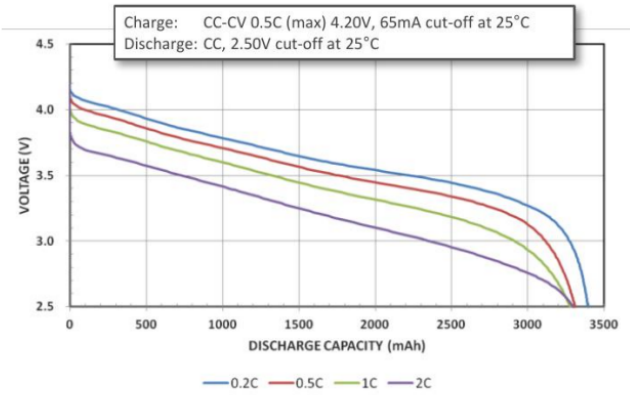

Figure 2.6: Battery discharge characteristic

Also with the tool curve fitting, the relative curves have been produced where R is putted in relation with the SOC:

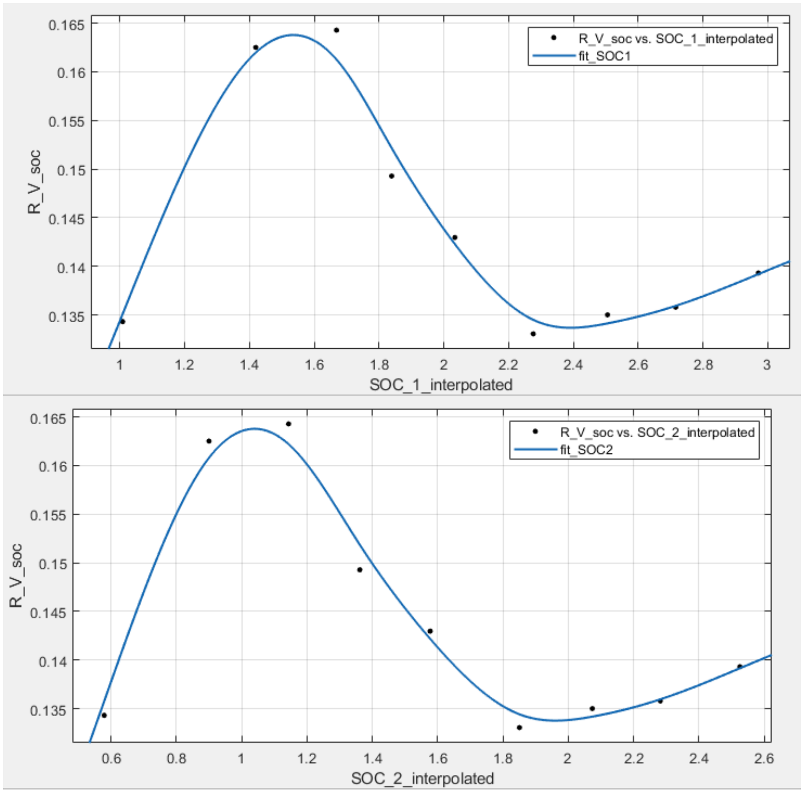

Figure 2.7: 1C and 2C curve fitting R vs SOC

CHAPTER 3

Simulation analysis

3.1 Parallel scheduling

Simulation to be done.

3.2 Sequential scheduling

Simulation to be done.

3.3 Improved solution

Simulation to be done.

CHAPTER 4

Conclusion and work unfinished

Unfortunately, Our team was not capable to simulate all the possibilities in this laboratory. We started having some problem with Simulink. The version seems to not be compatible with one version of Matlab installed in one of our laptop and so, we were limited on working concurrently. Due to personal problems and also to problems related to the exam session, we have reached the deadline with this work not completely done. We have appreciated the extra time given by the professor, indeed this have allowed us to improve the previous laboratory session work. We have understood theory behind this topic and ideas on how to improve the behavior of the system. We focused so, the most of our effort on understanding. In any case, we are delivering the work that was completed with files that demonstrate that we did it everything to initialize the system. In summary all the matlab scripts and data associated to the models.

In the in first part of the simulation, with the parallel configuration we could expect the results. Since the sensors are scheduled in parallel, we can expect a bigger total load current but for a short period of time. So the sensing part will have the heaviest impact over the other part i.e. Computing and transmitting. This means in other words that the most of the power will be consumed during the sensing part.

For the second part, where the sensor are scheduled serially, the system will be subjected to a lower load current distributed in a longer period of time. This will consume an amount of power that can be comparable to the computing and transmitting part. This will also depends on the period of time that is used.

In order to prove that we have understood the topic, we imagine also that a solution to improve the battery duration could be the one where we can increase the number of Photovoltaic cells or the number of batteries or both. In this way you can achieve greater recharge or greater overall capacity.

Of course we do not have simulations to prove this but, for what we have studied and understood during the course, the description given should give an idea of the behavior of the system overall.