# Educational Aspects of a Modular Power Management System

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***Abstract* — A redundant, modular, off-grid power supply unit is an often-used component in high reliability system. It makes it more fault tolerant and increase maintainability. With self-monitoring functions it can predict malfunctions and component lifetime. This system can also be used as a task for higher education projects. The students can expert their team working, problem solving, designing, building, testing skills with this kind of task.**

## I. Introduction

The ongoing research development project offers many opportunities for university education and training. Students can explore their own research and development topics. It is a good opportunity to learn individual, independent work. The next level, however, is the acquisition of creative, constructive activities in the team. As university professors, we have methodologically identified the following path for our students. The personalized, knit work has helped with the trainer, but it should be largely through a self-contained solution, for more dynamic and distributed, pro-active, flexible teamwork. It may also be possible for different grades or programs to work on a particular project. In the middle of the training, a scientific conference material can be used as a useful side-effect and even a thesis on well-documented developments can be created for graduate students. Of course, to achieve higher grades, these activities and documented materials can also help you gain access to the scientific degree. The implementation of a longer project solution into education and the use of modern technologies used will greatly contribute to the training of high-value graduate students. This also enhances the quality of training, improves satisfaction with industrial partners, as they are more willing to use fresh graduates with useful and up-to-date knowledge.

Each project can be implemented in a variety of courses that are taught and recorded. Measurements (test measurements) that can be connected to the developments in the measurement technology class can play an important role [1]. A project detail can also be used to form the electronics measurement labs [2]. It is a good opportunity to get to know the digital components of the electronics to be designed or being operated, i.e. to deepen the knowledge of digital electronics and to apply them in practice [3]. It is an excellent opportunity to learn the programming of digital circuits and microcontrollers [4]. Thinking in the system, you can learn how embedded systems work [5]. In addition to foundation objects, new professional differentiated courses can be launched in higher grades [6].

## II. In Practice

Let us look at how it is built, an R&D project is being built into our university level training.

Let us throw out a technological problem to solve. Define your needs. Give students the choice of the problems to be solved. If more than one group or course or course of study has the same function, introduce the "bidding" method. This basically means that for the given task the students are increasing the bar on the solution and make offers. The team that promises the highest quality, most useful solution will win the task. Of course, this can never mean that the solution cannot be further developed. A separate chapter should be devoted to the options for improvement.

Educational research projects can be co-operative, competitive or different. The solutions should aim to ensure that the problem solved is consistent with the problem that has been issued and has a well-defined output. So, it is important to define the tasks accurately, to develop a correct theoretical solution, to create a proper system plan, to perform preliminary simulations [7]. In case of wrong conclusions, step back into the planning in the right steps [8]. If the simulations are correct, they can only capture the students for circuit design and re-check the completed schematic plans with simulations. [9]

The next corner is also an important opportunity for further training. Real Circuit Designs (PCBs) must be

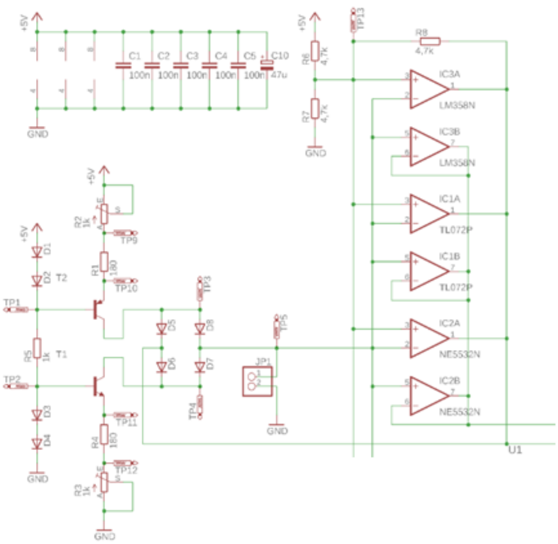


Figure 1. Schematic design example

made with the help of some authentic software (Fig. 1 and 2). [10] The modern equipment at our institute allows us to design printed circuit boards for 0-series equipment and to cut them off in an automated production line (Fig. 3 and 4). In a microcontroller environment, it is also possible to create firmware [11]. This requires proper hardware close and system knowledge [12]. The finished cards must also be measured by the students [13]. The measurements also can be automated (Fig. 5 and 6). [14]

Performing evaluations (evaluation) in one of the last steps and documenting the results. It is important to note that any development carried out in school conditions must not lead to the production of continuous and detailed work documentation, thus preparing our students for industrial work and approach. [15]

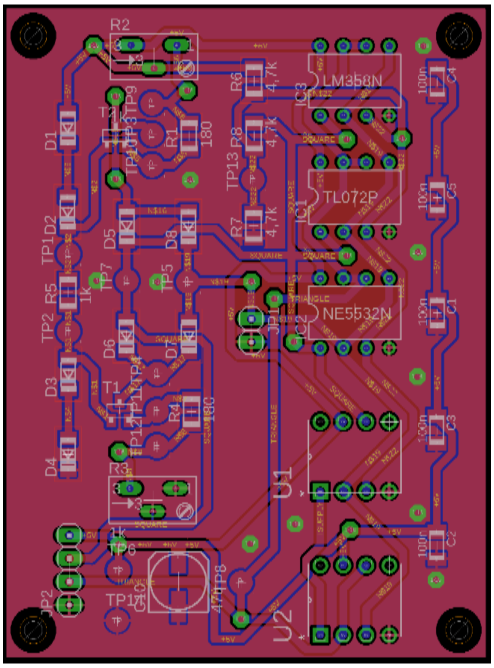


Figure 2. PCB design example

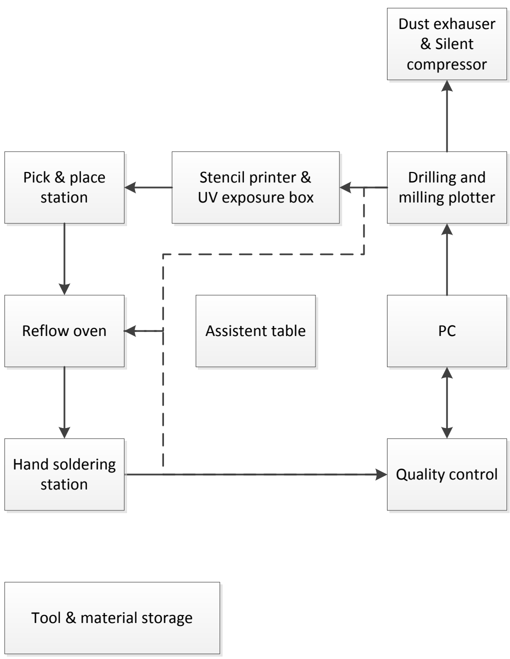


Figure 4. Prototype labor block diagram

## III. Realization

As an example project, the architecture of an off-grid redundant power supply system can be seen in Fig. 7.

The energy that feeds the system comes from the photovoltaic cells. The two redundant solar panel module can be compared to each other and can be selected one of them as an input of the next stage.

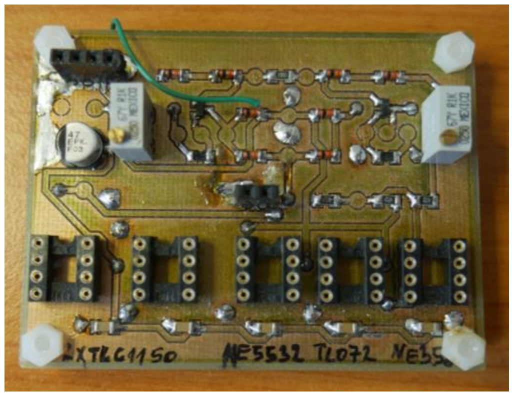

Figure 3. Milled and hand soldered PCB example

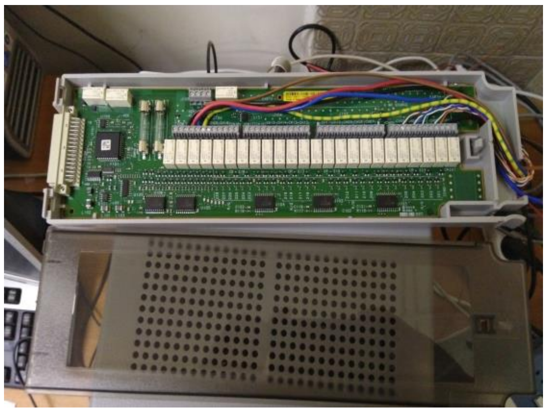

Figure 5. Digital multimeter multiplexer card

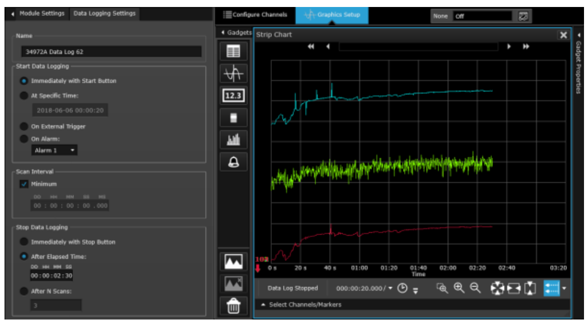

Figure 6. Automated measurement for validation purposes

The DC/DC converter module is also monitored (see Fig. 8) by the microcontroller unit (MCU). The input and output current and voltage are measured, and an efficiency is calculated. For further lifetime prediction the switching semiconductors (MOSFET's) drain-source voltage is measured, whet the element is open and under load. These modules will charge the accumulators and feed the system with stabilized DC voltage.

The accumulators are also used as redundant elements. The measured flowing in and flowing out charge can be measured and an efficiency, inner resistance can be calculated, a lifetime can be predicted.

The test loads can be used for short time, periodic module measurements with constant load. The task of the switching and measuring matrices is to connect, cross connect the different modules. The capacitor module will feed the inner controlling microcontroller, the connected load and other optional modules, if the power flow is temporarily disconnected due to switching.

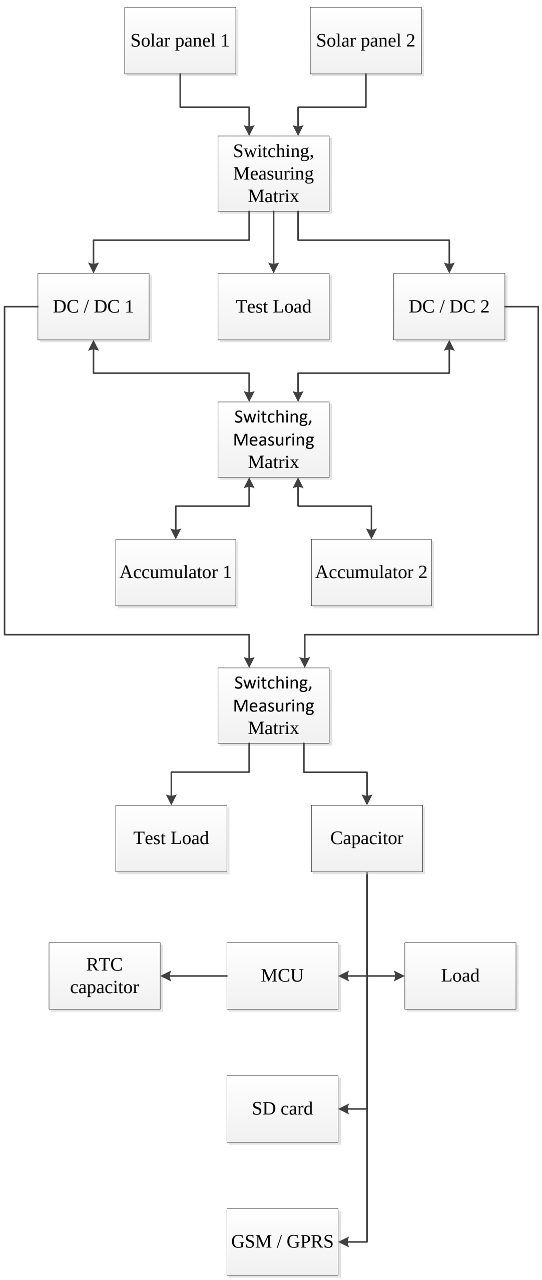


Figure 7. Redundant modular PSU structure

All these mentioned modules can be a development [16], construction [17], programming [18] and measurement tasks [19] for a whole semester. Students or student groups need to work together both in hardware and in firmware levels [20]. There are tasks to make a schedule, manage time, find the right solution, assign subtasks, find the connection interfaces and protocols between modules, and so on. [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31]

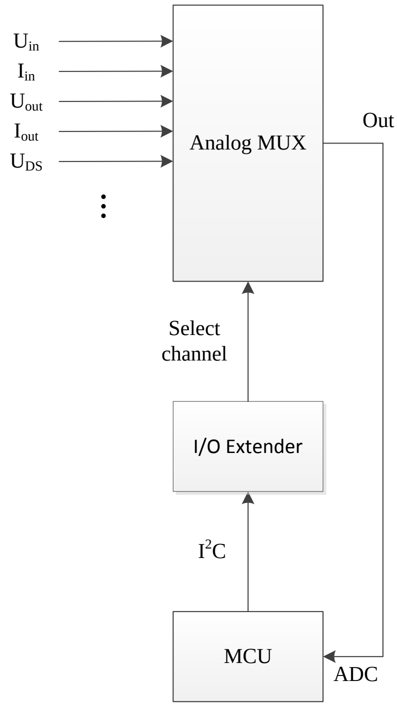


Figure 8. Module measuring architecture

## CONCLUSION

In this paper a useful real-life application about a modular redundant power supply unit has been presented. The cooperation between the modules is endured by a microcontroller based embedded system. It had been showed, how to implement the mentioned solution to educational environment. Students also can learn and practice a lot of important competences with this method.

The authors believe that the proposed solution can be useful for civilian and industrial applications, where reliability is hardly required, even if it is needs some extra hardware and software redundancy.

## ACKNOWLEDGMENT


We acknowledge the financial support of this work by the Hungarian State, the ITM, the NKFIH, and the Óbuda University under the UNKP 2019 project.


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