UNINTERRUPTED POWER SUPPLY BATTERY LIFE CYCLE SYSTEM DEVELOPMENT

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Abstract. Today, during the information technology era, almost every device, like telecommunications centers, various database servers, scientific equipment and user workstations need to provide stable and uninterrupted access to electricity. Uninterruptible power supplies are used to ensure workstations whit electrical power in case of power failure. To enable such devices to operate over long periods of time and to manage them is needed for optimum results. Various uninterruptible power supply manufacturers also offer uninterruptible power supply monitoring solutions, but such solutions cannot be adapted to devices from other manufacturers that are not suitable for large organizations. And one of the investigated organizations is the Latvia University of Agriculture, which uses the equipment of several different manufacturers. Within the framework of the research, several different types of management systems were compared. More detailed look was taken at the possibilities of integrating these systems in the existing infrastructure of the Latvia University of Agriculture, installation and maintenance of these systems, as well as future development and expansion prospects and, of course, compression between the systems. The solutions offered on the current market are difficult to implement fully in the current system of the Latvia University of Agriculture, therefore, the study offers a new technological solution for monitoring, longevity extension and maintenance of various uninterruptible power supplies. The system has been approbated for the existing infrastructure of the Latvia University of Agriculture in order to install, maintain and further develop this system without any infrastructure reforms.

Keywords: uninterruptible power supply, power supply, UPS.

Introduction

An uninterruptible power supply (UPS) is a backup power source that activates, when the main source fails. Although complex, UPS has a very simple overall design. Every UPS has power inputs (for intake of commercial power during normal operation), power outputs (to connect protected equipment), and backup batteries (to prevent interruption of power to protected gear, when commercial power is lost). It also has a control system that quickly switches to backup battery power, when the main source of electricity goes down. The word "uninterruptible" means that the power supply will activate quickly enough to prevent the gear from ever losing power, when the main power source goes dark. This means that the UPS system must be capable of activating backup power within 25ms of power loss. UPS mostly uses lead-acid batteries [1; 2].

UPS systems have enabled improvement of the power source quality, providing clean and uninterruptible power to critical loads, such as industrial process controls, computers, medical equipment, data communication systems and protection against power supply disturbances or interruptions [3; 4].

After determining the battery voltage, it is possible to determine, when it needs to be changed after its load, since the battery capacity is determined by the battery's internal EDS and the impedance. By studying the situation at the Latvia University of Agriculture, it was found how to use UPS numbers and their models. Summarizing the information, it was found that most of the UPS existing in the LLU are devices that do not have specific management systems. Investigating the number of UPSs in the LLU, it was found that different UPS companies are being used. A summary diagram showing the percentage of UPS can be seen (see Fig.1). Bb breakdown of manufacturers, only 9 % are UPS devices with management capabilities or with the option to add management expansion cards to obtain such features.

The UPS power distribution shows that most are low power and medium power UPS that are used for switching cabinets and for employee protection (see Fig.2). The most powerful UPS, which is relatively smaller, is for server cabinets, switchgears of importance, as well as for various scientific devices.

The number of UPS for a single office is relatively high, but due to lack of management hardware or software, battery damage or depreciation is not detected in a timely manner. Which, in turn, prevents UPS from providing hardware for power failure or even damage the UPS.

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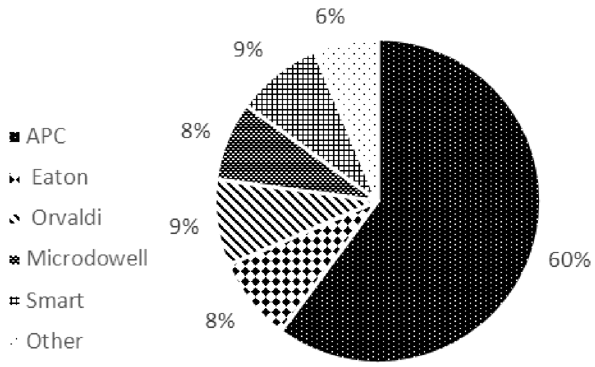

Fig. 1. **UPS summary at Latvia University of Life Sciences and Technologies**

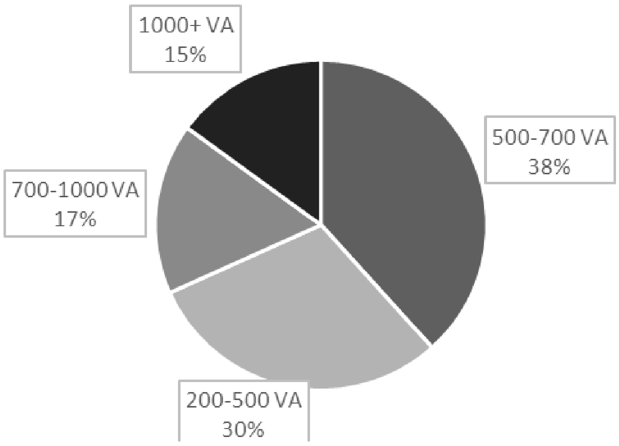

Fig. 2. **UPS breakdown by power at Latvia University of Life Sciences and Technologies**

Various manufacturers use different UPS management protocols, but standard protocols, such as SNMP and SEC, are not implemented on all UPS devices or use different commands and functions. This is intended to make the UPS equipment of different manufacturers not compatible with the management systems of other manufacturers. Simple Network Management Protocol (SNMP), an application layer protocol, facilitates the exchange of management information among network devices, such as nodes and routers. It comprises part of the TCP/IP suite. System administrators can remotely manage network performance, find and solve network problems and plan for network growth by using SNMP. The SEC protocol can be used to connect suitably enabled UPS's manufacturers. This is a serial protocol using RS232. The protocol is nodeless, so only one UPS can be connected to the port of the gateway [5;6].

Materials and methods

For the experiment ACS758 Hall-Effect-Based Linear Current Sensor for UPS battery current measuring was used, initially for voltage measuring we used a voltage divider for stepping down higher voltages to lower levels, Arduino ADC and formulas in software were used so that Arduino UNO can collect data and send to software for processing. But after inconsistent data we changed Arduino PCB to Graphtec logger GL220 for more consistent data recovery. The whole conceptualized system can (see Fig.3) note that UPS inner workings may vary from developer to developer.

The purpose of the experiment is to find out how different condition batteries behave in different situations like when they are charged, discharged or when charging. Also, to determine when you need to change the battery to a new one according to the battery's electrical nature. Is there a difference between the various UPS manufacturer devices and if it can be detected by studying battery behaviour. In order to figure out these things we need three different manufacturer UPS devices with the same or similar power and three 7Ah 12Vbatteries, which are in different states.

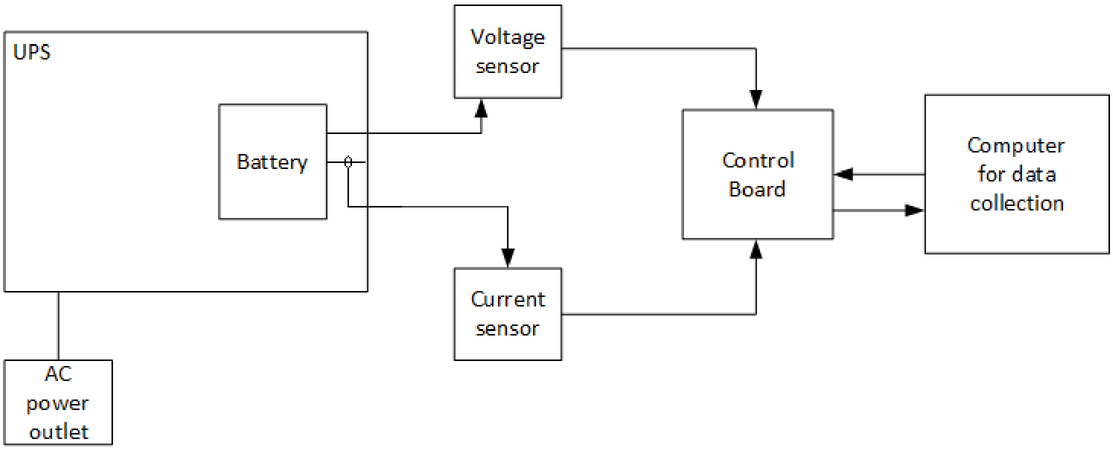

Fig. 3. **Conceptualized system**

The experiment will be performed, when the battery is fully discharging each of the 7 Ah 12 V batteries on each of the three 700W UPSs, measuring the voltage and current in the calculation of the power and then creating their curves with the same consumer connected. Measurements are performed once every second, the data are saved in a file and later processed. Example of one measurement (see Fig. 4). We want to repeat the experiment three times with each UPS and battery combination. And whit different loads to simulate different switch cabinets and different user stations. Prototype device was created based on the conceptualized system idea.

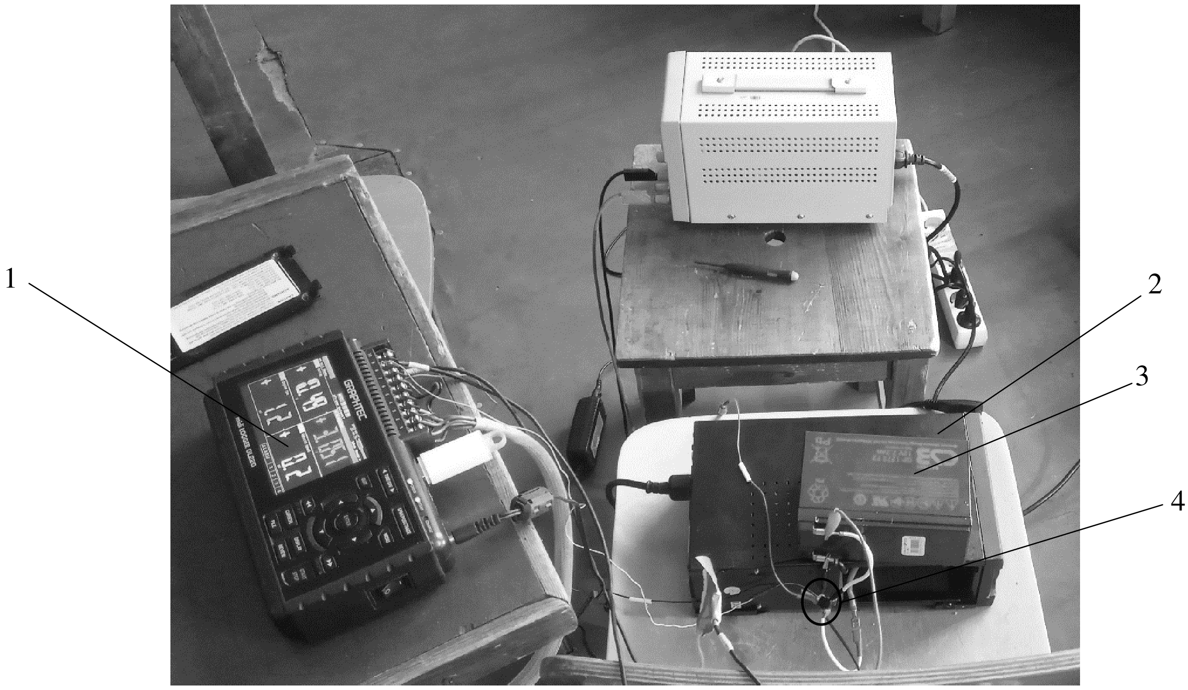

Fig. 4. **Experiment setup:** 1 – GL220 Logger; 2 – Test UPS device; 3 – UPS battery; 4 – ACS758 current sensor

An Analog to Digital Converter (ADC) is a very useful feature that converts an analogue voltage on a pin to a digital number. By converting from the analogue world to the digital world, we can begin to use electronics to interface the analogue world around us. ADCs can vary greatly between microcontrollers. The ADC on the Arduino is a 10-bit ADC, meaning it has the ability to detect 1,024 (210) discrete analogue levels. Some microcontrollers have 8-bit ADCs (28 = 256 discrete levels) and some have 16-bit ADCs (216 = 65,536 discrete levels) [7].

Data values, which the prototype sends to software needs to be converted from ADC readings to Analog voltage measurements, which can be done with (1) formula.

$$\frac{ADC_{res}}{V_{sys}} = \frac{ADC_{read}}{V_m}, \quad (1)$$

where ADC_{res} – sensor Analog to Digital Converter resolution constant
V_{sys} – voltage that is used by sensor, it usually is 5 V, but it can be 3.3V
ADC_{read} – analog to Digital Converter readings form sensor
V_m – sensor measurements in volts

Formula (1) can be expended to express our needed values for further use in the software expended formula (2)

$$V_m = \frac{V_{sys} \cdot ADC_{read}}{ADC_{res}}, \quad (2)$$

Results and discussions

The developed system monitors the power consumed by the load and UPS. The implemented system is low cost, efficient and can be affordable by all the scales of industry. The developed system provides the parameters without any delay. This system can be modified and can be enhanced with slight modifications [8].

The experiment data (see Fig. 6) are not from all experiment and every measurement, but rather from one measurement set with one UPS device and three different batteries. Collected data can be divided in four parts showcased as examples (see Fig. 5).

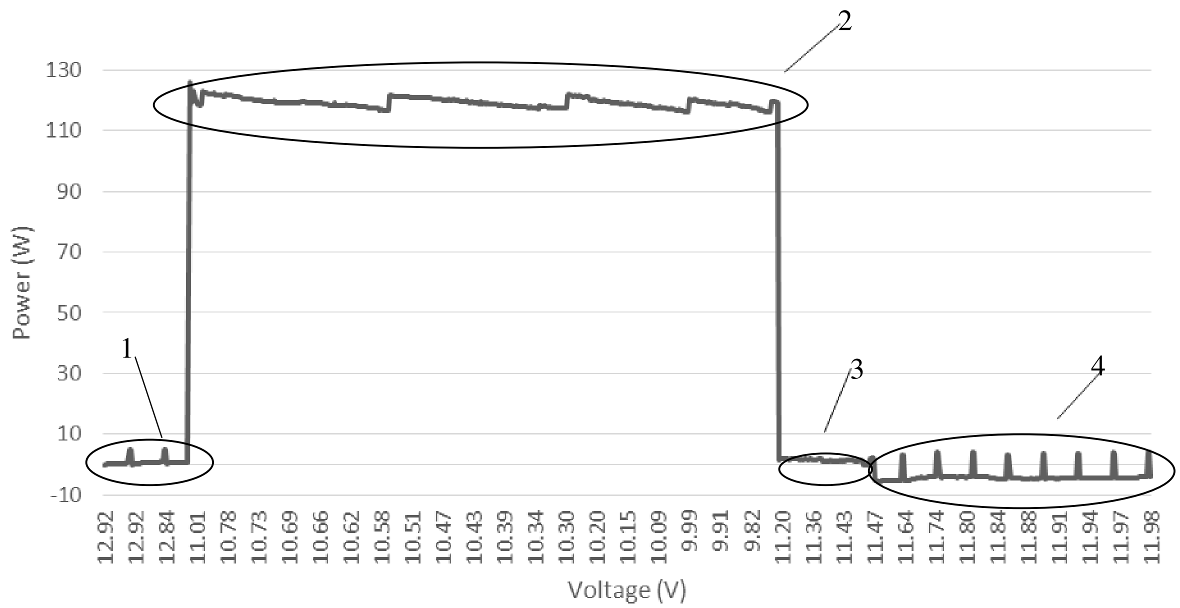

Fig. 5. **Measurement data explanations**

1. UPS is using outer power supply, can be noted at the star of measurements, when the UPS battery is fully charged and for the UPS device there is no need to draw energy form it.
2. Power supply is cut and UPS is using the battery as power source.
3. Battery is out of power and UPS has shut down.
4. Battery is charging.

In the experiments it can be noted that UPS batteries, which are older and more used, discharge much faster or do not supply enough power so that the load can be powered on. Our system usage will be in training the UPS battery by discharging it about thirty percent of its total capacity every day and then compare the trained battery with the battery that has been used normally.

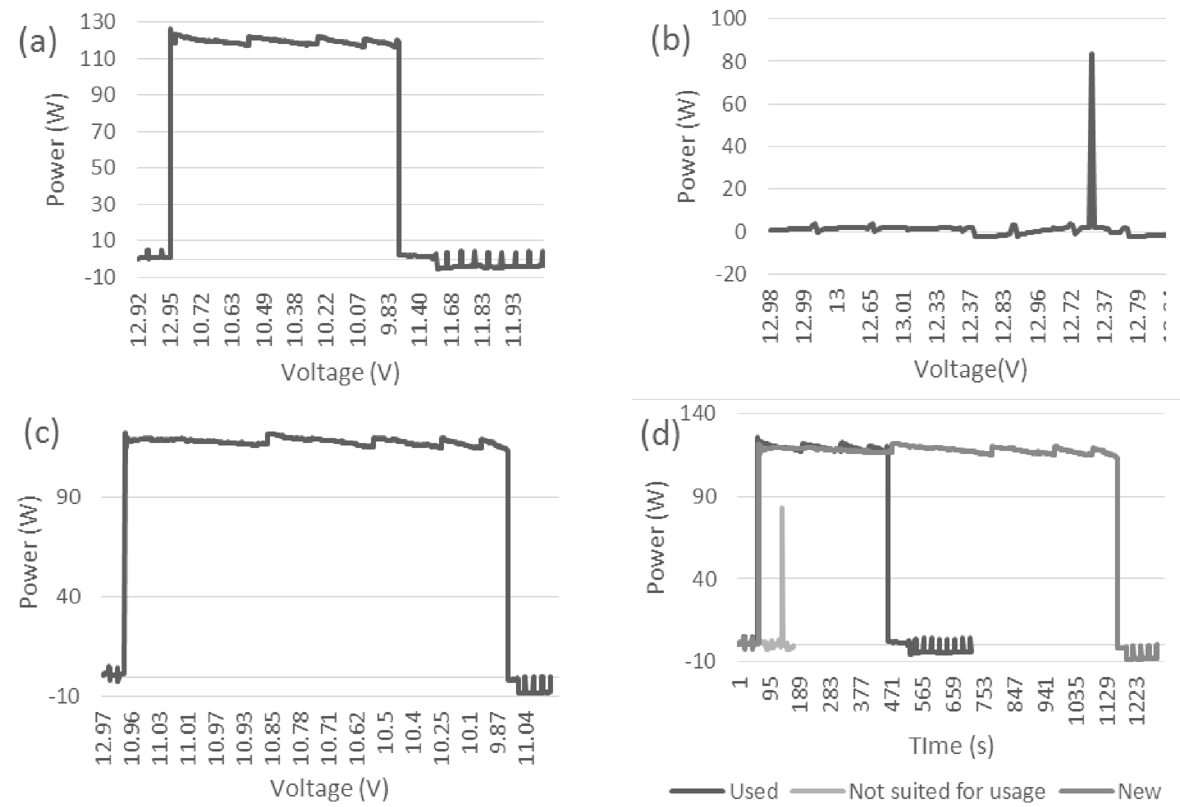

Fig. 6. **Measurements from used battery:** a – measurement with used battery; b – measurement with battery not suited for work; c – measurement with new battery; d – combined data

Conclusions

After testing the prototype, it was better suited for usage in switch cabinets and server cabinets rather than with a user computer. Using the offered prototype system, it is possible to conclude, when the UPS battery is under power drain, when it is charging or when the battery support is not necessary. Data that have been sent by the prototype system can be simply processed so that the system can work with different power UPS systems.

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