

Solar-recharged UPS as a low cost AC power supply for Electronics and Environmental Education

J. Diz-Bugarín¹, M. Rodríguez-Paz²

¹ IES Escolas Proval, Avda Portugal 171, E36350 Nigrán (Spain)

² IES Tomiño, Solleiro s/n, E36740 Tomiño (Spain)

javier.diz@edu.xunta.es, montserpaz@edu.xunta.es

Abstract. *This article describes the transformation of an Uninterruptible Power Supply (UPS), commonly used as power backup for desktop computers, into a solar rechargeable portable mains supply. Almost any commercially available UPS can be used and the conversion can be made without having detailed knowledge about electronic circuits inside. A few external elements must be added: solar panel, charge regulator (commercial or self-made), a protection diode, cables and connectors. The system has many applications as a solar educational kit, as a small power source for car or camping, or for lighting and powering small isolated buildings.*

Keywords. Solar Power Supply, Electronics, Environmental education.

1. Introduction

Uninterruptible Power Supplies (UPS) are a simple and inexpensive protection against mains failures for computers and many other electronic systems. These devices contain almost all the elements required (battery, charger and inverter) to make a portable mains supply that can be recharged by many sources like solar photovoltaic energy, wind energy or hydro-electric power. If any of these sources is not available, the internal battery could be removed and recharged from a car battery or an ordinary ac socket.

Some external elements must be added, like a solar photovoltaic panel, a charge regulator and protection elements. The battery capacity can be increased adding a second element connected in parallel.

This article describes all the changes that must be made and elements that have to be added.

Fig. 1 shows the system with external elements, cables and AC socket ready to use.



Figure 1. Complete solar kit with panel and AC socket

This system was projected to light an old flour mill that will be prepared to host an educational exhibition about traditional uses of renewable energies. Fig. 2 shows the mill and surroundings with water channel. In this application the system could be recharged by solar or hydraulic energy.



Figure 2. Mill and water channel

2. UPS description

A common UPS (Fig. 3) contains the following elements:

- 1) Power supply and battery charger that are connected to external ac mains and keep the 12V battery completely charged.
- 2) Battery (Figs. 4 and 5) of lead-acid type, 12V and 7-12 Ah. A capacity of 7Ah (84Wh) provides about 20 minutes of use of a 200W computer, but at least 8 hours of light with a 10W lamp.
- 3) Power inverter that receives 12V DC from the battery and provides an output of 230V AC. A typical UPS can deliver a power of 300-1000VA.

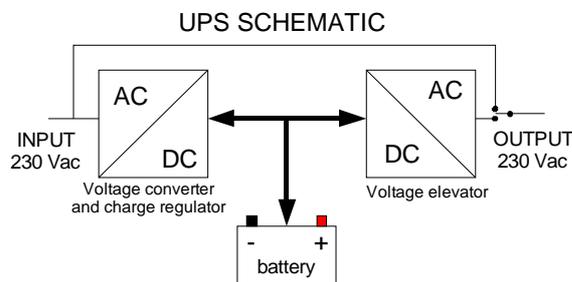


Figure 3. UPS internal schematic

These devices are typically connected to the mains all the time, in this situation battery is always fully charged. When there is a mains failure UPS inverter delivers power drawn from the battery to the external load.

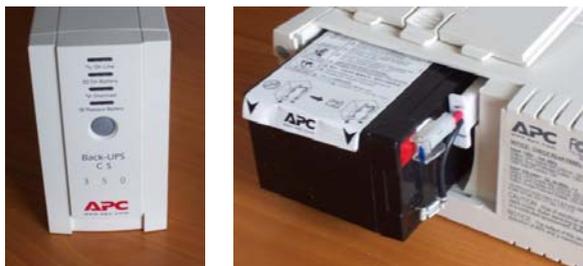


Figure 4. UPS and battery housing



Figure 5. Lead-acid battery

In this application UPS is simply disconnected from the mains, and will continue generating power until battery is empty. If the battery can be recharged without reconnecting it to the mains the UPS turns into an independent power source that can be used anywhere.

3. UPS modifications

The following changes have been applied to allow solar recharging, as can be seen in schematic (Fig. 6):

- An external connector must be installed and connected to the battery to allow access and recharging (Fig 7 and 8).
- A solar panel and external regulator must be connected directly to the battery. The solar panel should provide enough energy to recharge the battery (see solar energy calculations section). The regulator can be a commercial type or a self-made one (see next section).
- A protection diode must be inserted between the battery and external regulator. This diode allows simultaneous working of external and internal recharging and avoids discharge of the battery through the solar panel.

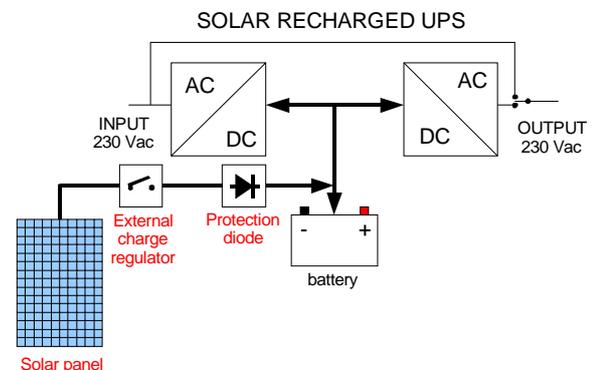


Figure 6. UPS modifications to allow solar recharging (external elements in red)

4. External regulator

UPS's have an internal charge regulator to avoid damage to battery. This regulator could be incorporated into the solar recharging system, but unfortunately manufacturers [3] do not provide enough information about internal circuits, so this option must be discarded. For this application a specific regulator was developed based in an integrated circuit of common use in electronics, the voltage regulator LM317 [2]. The circuit is adjusted to obtain an

output of 14,5V. Fig. 9 shows the schematic of this circuit, that can easily be assembled by electronics students in a typical school workshop. Fig. 10 shows a prototype of regulator inside an outdoor box.



Figure 7. External recharge connector

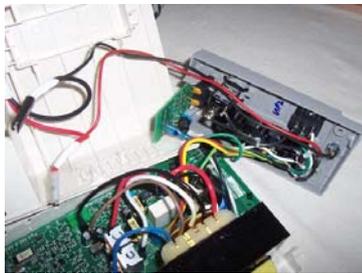


Figure 8. Detail of internal connections

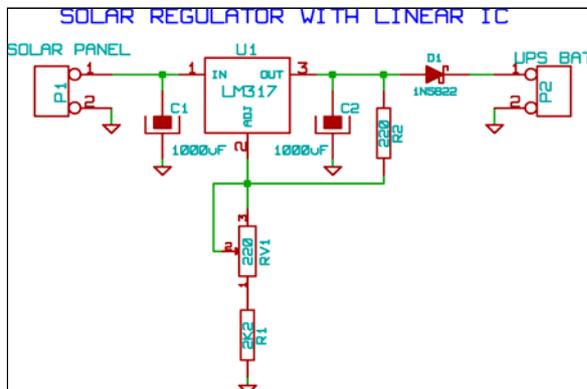


Figure 9. Charge regulator schematic

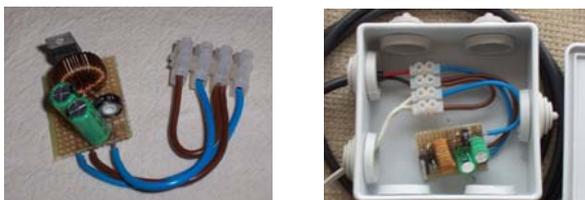


Figure 10. Charge regulator fully assembled

5. Final assembly

To make the final assembly of the system the

following steps must be followed:

1) Solar panel must be connected to the charge regulator input. It can be checked with a multimeter (under direct sunlight).

2) Regulator output must be connected to external battery connector in the UPS (see Fig. 9).

3) UPS output must be connected to an electric appliance (like a low consumption light). A mains socket (schuko or similar) can be mounted at the UPS output to allow different charges to be easily connected and disconnected.

If everything is right the power supply will start generating electric power. If there is enough solar energy to partially recharge the battery every day (see next section) the system will work indefinitely without any external contribution.

6. Solar Energy calculations

As an example of use of this system calculations will be made to light a small building (like a mill) with a few hours of use per week:

- lights: 1 low consumption bulb (18W)
- daily use: 2 hours maximum
- energy storage: battery 7Ah, 12V (84Wh)

The daily consumption will be 36Wh, that is lower than the battery capacity. A fully recharged 7Ah battery would provide at least 4h of light. A 12Ah battery would increase this time to 8h.

The amount of average solar energy available in Nigrán, Galicia (Spain) is about 3.9 KWh/m², with a minimum of 2 KWh/m² in winter and a maximum of 8 KWh/m² in summer [5]. Under this conditions a solar panel with a minimum power of 10Wp would provide the required average energy of 39Wh per day. It is recommended to use a higher power panel to ensure enough energy to recharge under most common weather conditions specially in winter. The performance of the system can be also affected by continued periods of rain and clouds, if needed an exact calculation of all this situations should be made.

The battery can also be changed to increase energy storage, or two batteries can be connected in parallel.

The above calculations can be applied to another small electric and electronic devices, many laptops have energy consumptions in the same range as this application.

The system has been successfully checked with a Kyocera KS10 solar panel [1] with the following characteristics:

- 10W peak power
- 21.5Voc (open circuit voltage)
- 0.62Asc (short circuit current)
- 16.9V at maximum power.

Another solar panel that is suitable for this application is Atersa A10-P [4], also with a power of 10W.

7. Other sources of energy

The external connector and charge regulator developed for this application allow the use of other sources of energy different from solar panels to recharge the battery. A simple cable should be connected between the selected generator and the UPS connector. Any generator with an output voltage of 12V DC or more can be used, for example:

- A car battery. The UPS should be connected to the lighter output of the car.
- A wind generator with an output of 12V.
- A small hydroelectric turbine.
- A combination of the above sources.

8. Applications

The system can be used wherever there is need for ac power with low consumption, like lighting in small isolated houses, camping, powering of small electronic devices like tv or radio transmitters, etc.

An important field of application is electronics students training, since these students can both make the system elements (like the regulator or connectors), and use them as a solar energy practice.

Students of other fields can also take advantage of this system due to its low cost, like in subjects related to environmental themes.

It can be used in exhibitions or science fairs about renewable energies, specially if other power sources are used for recharging instead of solar power (like a small wind generator, hydraulic generator, etc). As an example of this applications, the kit was shown at "Encuentro Solar 2007" meeting in Granada, Spain.

Another interesting application is as a backup power source for laptops when used outdoors. As an example, a 7Ah fully charged battery can provide 2 extra hours of use for a 40W computer. The new generation of Ultraportable Laptops like Asus EeePC or Acer Aspire One with consumptions of 10W or less is a good choice for this type of use.

9. Conclusions

- This article describes the transformation of an Uninterruptible Power Supply into a solar rechargeable portable mains supply.
- The transformation can be done without detailed knowledge of electronic circuits inside the UPS.
- A few external elements must be added: solar panel, charge regulator, a protection diode, cables and connectors.
- Another sources of energy can be used to recharge battery, like wind power or hydroelectric.
- The system has many applications as a solar educational kit, as a small power source for car or camping, or for lighting and powering small isolated buildings.
- It can also be useful as a backup source for new ultraportable laptops for outdoors use.

10. References

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