

Solar-powering your geek gear

Alternative and mobile energy for all your little toys

Michael “script” A.

25c3 - December 27th to 30th 2008

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

About me


- 23 years old
- Computer-Science student at the University of Kaiserslautern
- Always been fascinated by electronics

Licensing

This talk is licensed under the following creative commons license:
“Attribution-Noncommercial-No Derivative Works 2.0 Germany”
[CC2008].

Licensing

You are free:

-  **To Share.** - To copy, distribute and transmit the work

Licensing

You are free:

- **☞To Share.** - To copy, distribute and transmit the work

Under the following conditions:

- **📄Attribution.** You must attribute the work in the manner specified by the author or licensor (but not in any way that suggests that they endorse you or your use of the work).
- **🚫Noncommercial.** You may not use this work for commercial purposes.
- **⊘No Derivative Works.** You may not alter, transform, or build upon this work.

Disclaimer

This project involves ...

- High currents
- High voltages

Warning

- Use everything you learn here at your own risk!
- You could easily fry your laptop!
- There is absolutely no warranty!

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Why?

- Solar power is a cool thing
- No power sockets around
- Not (yet) to save money

How much?

- About 50 EUR (60 USD) / 10 Watts
- About 200 EUR for the foldable 40 Watts-Module I used
- Some more for a voltage regulator and the power meter

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

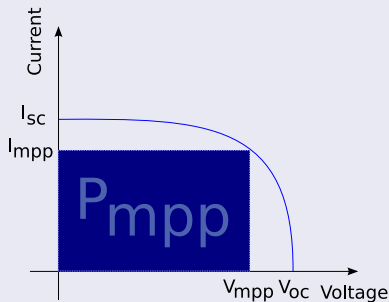
Understanding the Specs I

Modules are characterized by

- Short-Circuit-Current I_{sc}
- Open-Circuit-Voltage V_{oc}
- Maximum-Power-Point (MPP) (V_{mpp} , I_{mpp}).

Understanding the Specs II

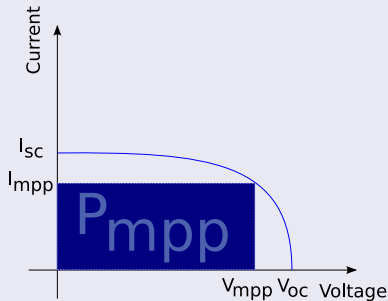
V-I-Curve (ideal)



Under testing-conditions ($1000\text{W}/\text{m}^2$, 25°C)

Understanding the Specs III

V-I-Curve (real)



Under more typical conditions ...

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Deciding what to power

Quite a lot of possibilities

- Laptop, PDA, phone
- Battery chargers
- Electrical fridge, inverter, ...

Deciding what to power

Quite a lot of possibilities

- Laptop, PDA, phone
- Battery chargers
- Electrical fridge, inverter, ...

Might it possibly work?

- Have a look at the ratings or the original power-supply
- Try to power it using an adjustable power-supply
- Decide whether you need a voltage regulator

Choosing the Solar Panel

Whatever you try to power ...

- 1 Do some tests using an adjustable power-supply
- 2 If it doesn't work, it probably won't using the solar panel either

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

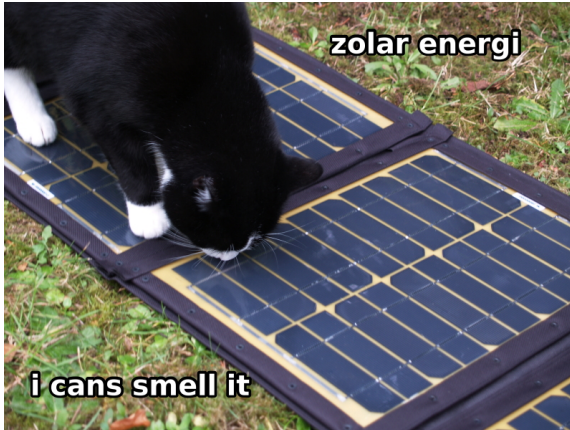
- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Folded

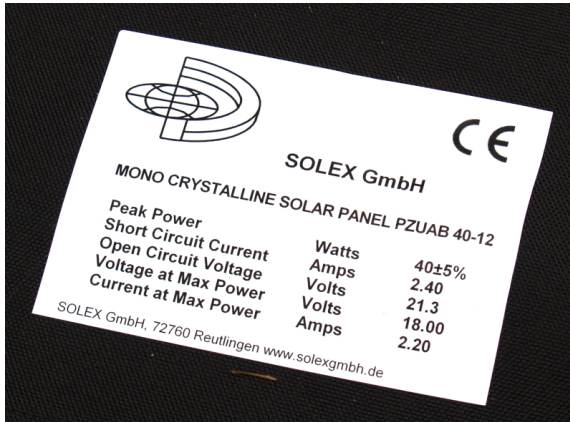


Unfolded





Specs



1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- **Connectors**
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Plug and Play I

Goals

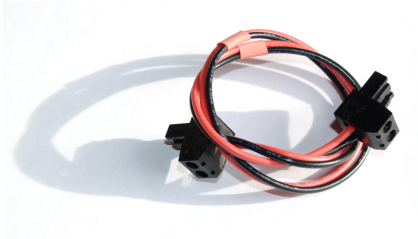
- Common connectors for all devices
- Safe connectors (no shorting and no reversal possible)
- Support for higher currents (up to 10A)

Plug and Play II

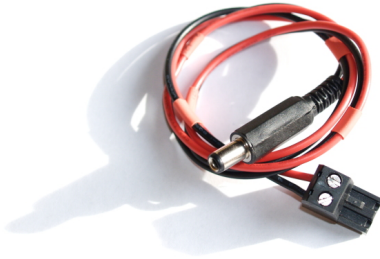
Solution

RIA Connect 230/249 Series^a

^aReichelt Part-No: AKL 249-02, AKL 230-02



Older ThinkPad Adapter



- Simple DC plug^a
- $\varnothing_i = 2.5\text{mm}$ (inner diameter)
- $\varnothing_o = 5.5\text{mm}$ (outer diameter)

^aReichelt Part-No: HS 25-9

Newer ThinkPad Adapter



- More complex plug
- Try to find it on eBay
- Cut it from a dead/cheap replacement power supply

Nokia Phones



- Two sizes (old and new phones)
- Cut it from a cheap replacement charger

12V Car-Equipment



- Inverters
- All kinds of chargers

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- **Universal Voltage Regulator**
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Why a Voltage Regulator?

- Output voltage of the solar panel depends a lot on the applied load
- We need to power a lot of different gadgets

USW-525

Based on LTC3780, a buck-boost-controller. Seamless switching between Step-Down (Buck) and Step-Up (Boost) modes.

Features

- Input-Voltage: 7-25V
- Output-Voltage: 4-25V
- Output-Current: up to 5A
- Efficiency: up to 97%



1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- **Buffering the Energy**
- Measuring Power and Energy

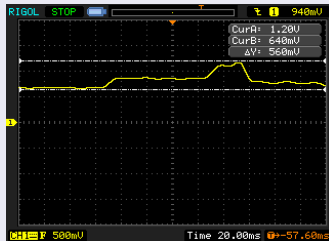
4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Why?

- Many devices have small peaks in their power consumption
- Devices might switch to battery power or reset

Example: Fluxbox switching desktops



- $1V \hat{=} 1A$ across a 1Ω -Shunt
- $\Delta I = 0.5A$
 $\Rightarrow \Delta P = 10W$

How?



High current warning

That capacitor can generate *extremely* high currents! Don't ever short it when charged and never try to charge it directly using a high-current source (e.g. a battery)!

Note

Use a blocking diode to protect your panel from reverse currents.

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- **Measuring Power and Energy**

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Motivation

Wouldn't it be nice to know ...

- How much power you're currently consuming?
- How much energy you have saved?

Motivation

Wouldn't it be nice to know ...

- How much power you're currently consuming?
- How much energy you have saved?

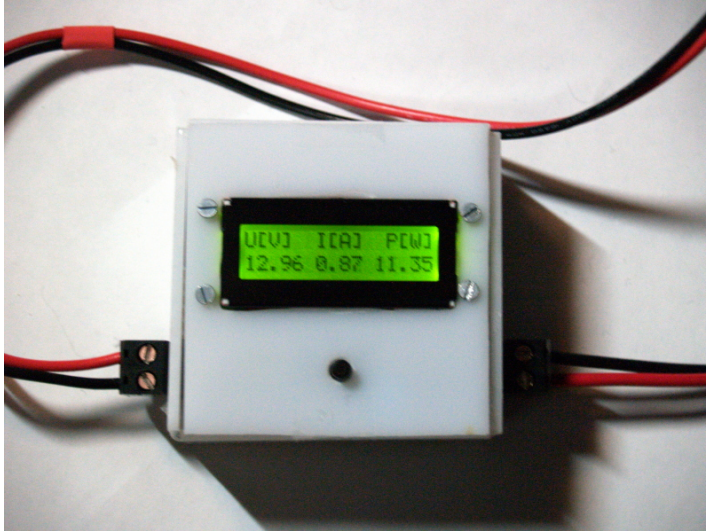
You can easily build a device to measure:

- Voltage range: 10V - 25V
- Current range: 0A - 2A
- Power range: 0W - 50W
- Energy range: 0Wh - several Wh

Software

- Measure voltage and current using the ADC
- Calculate power ($P = V \cdot I$)
- Calculate energy ($E = \int P dt$)
- Write energy to EEPROM and shut down when voltage becomes low

Pictures



1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Laptops in general

Well-suited for solar-power

- Built-in battery (no external battery necessary for cloudy sky)
- Power consumption around 10-30 Watts

Laptops in general

Well-suited for solar-power

- Built-in battery (no external battery necessary for cloudy sky)
- Power consumption around 10-30 Watts

But ...

- While operating and charging battery: a lot more power is required ...
- \Rightarrow We should prevent the battery from charging

Preventing the battery from charging

Possible solutions

- Use a full battery
- Use an old battery (they won't charge with high currents)
- Remove the battery (?)
- Try to use lower voltages so that no "AC" will be detected
- ThinkPad: use the `tp_smapi`-interface

Using tp_smapi

Example: Set start-threshold to 10%

```
echo 10 > /sys/devices/platform/smapi/ \
    BAT0/start_charge_thresh
```

Example: ThinkPad X300



1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Charging Nokia Phones

Problem

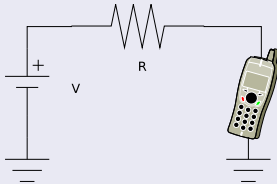
- Charging does not start if current is too high
- Original chargers have their current limited to ≈ 800 mA

Charging Nokia Phones

Problem

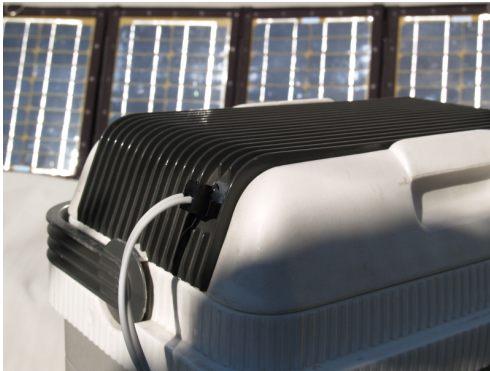
- Charging does not start if current is too high
- Original chargers have their current limited to ≈ 800 mA

Current-limited charging



- Older Nokia phones:
 $V = 5.7V, R \approx 5\Omega$
- Newer Nokia phones:
 $V = 5V, R \approx 5\Omega$

The Electrical Fridge



- Quite simple devices
- Most are around 40 Watts (at 12 Volts)
- I plug mine directly to the solar panel

1 Introduction

- About
- Motivation

2 Solar Panel

- Characteristics
- Deciding what to power
- Example: PZUAB-40

3 Accessories

- Connectors
- Universal Voltage Regulator
- Buffering the Energy
- Measuring Power and Energy

4 Applications

- Laptop
- Phone, Electrical Fridge
- Inverter and Anything else

Using an Inverter



- Spec says 10V - 15V, voltage regulator needed?
- Powers almost anything small (e.g. chargers)

Other low-voltage Devices



- Find a plug
- Adjust the voltage regulator
- Limit the current? (remember the Nokia example)
- Try it

References



Creative Commons

Attribution-Noncommercial-No Derivative Works 2.0 Germany

<http://creativecommons.org/licenses/by-nc-nd/2.0/de/deed.en>



ELV Elektronik AG

Universal-Step-up/Step-down- Spannungswandler USW 525

http://www.elv-downloads.de/service/manuals/USW525/66357_USW525_km.pdf



Michael Arndt

Power and Energy-meter

http://scriptkiller.de/en/a29/25c3/power_and_energy-meter/