Solar Cell Tester Product Design Specification

Executive Summary

Solar system design requires finding solar cells which meet the system output power requirements. Cells are specified by their theoretical output power, but actual output varies widely. Device chemistry, manufacturing quality, and the brightness of available light all influence the final output.

Output power is obtained by multiplying the current (I) and voltage(V) produced by cells as the electrical load changes. Commercial measurement tools are targeted at large solar systems and cost several thousand dollars. Our system provides a reasonably priced alternative for making such measurements in low power hobbyist systems.

The solar cell tester plugs into a USB compatible computer or smartphone and measures the voltage and current a solar cell provides under the current lighting conditions. The I-V curve is displayed along with the true maximum output power of the cell. This information can be use for a variety of purposes, including:

- Comparing the maximum output power with the advertised value
- Identifying cell types based on characteristic I-V curves
- Checking if cells are suitable for a particular project

Brief Market Analysis

Given the emphasis on green energy today, we feel that there are a growing number of people who would like to experiment with solar technology. Commercially available solar test systems are designed for use by solar installers measuring hundred watt and larger systems, and therefore cost several thousand dollars. There does not appear to be a test device available on the market for small solar cells. Individuals interested in experimenting with small capacity solar arrays must construct their own measurement tools.

There are many DIY projects that a hobbyist can build, but it is difficult to find reliable information on complete designs, and it is time consuming to locate all the required hardware and software. We feel that an enthusiastic solar hobbyist would be willing to invest in a tool which easily and accurately measures solar cells in order to determine whether they are suitable for an intended project. The target price range for our solar cell test tool is $100 - $150, which is comparable to other hobby power items such as lithium battery packs and balance chargers.

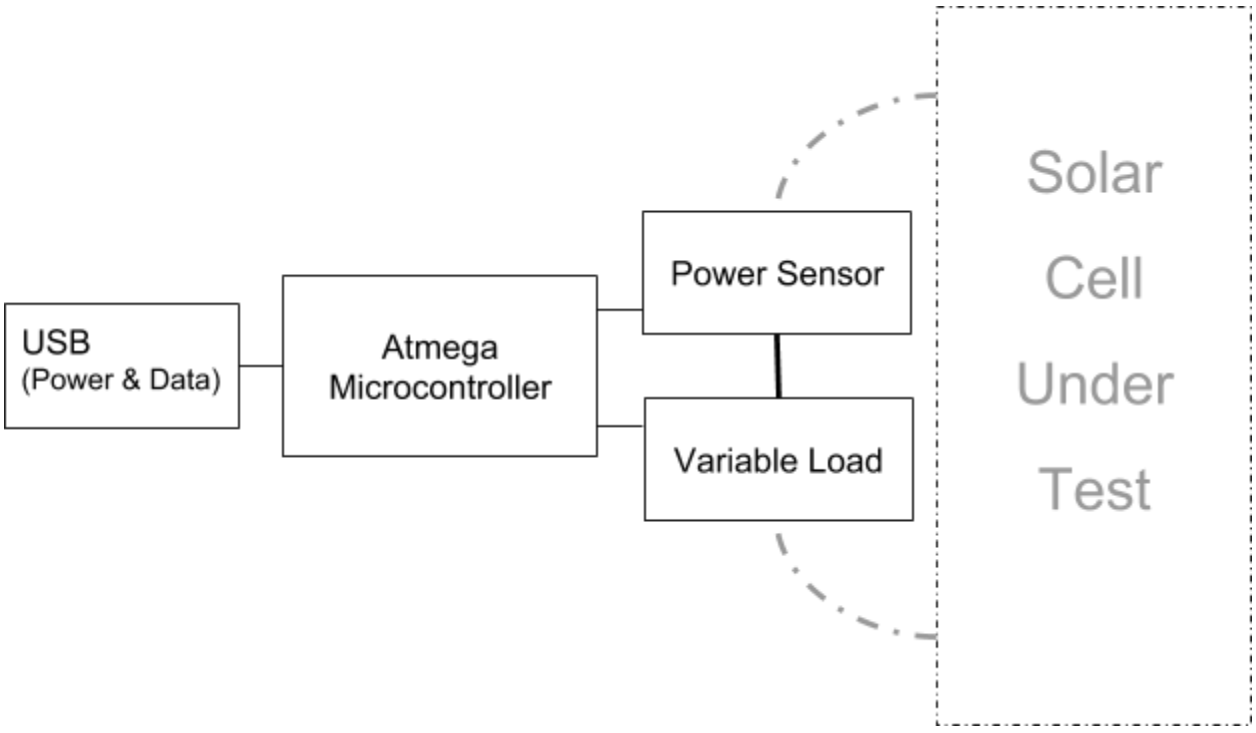
Requirements

The following criteria define the featureset for the final product:

- Must vary load on solar cell
- Must measure voltage across cell
- Must measure current through cell
- Must produce an I-V curve
- Must provide the sample data
- Must be powered by USB
- Must be able to dissipate load heat
- Must prevent overheating of load
- May support averaging voltage/current measurements

System Architecture

The system consists of a microcontroller, a power sensor, and a variable load. The microcontroller adjusts the load, demanding different amounts of power from the solar cell. The power sensor records the voltage across the solar cell and current through the cell. Graphing the resulting data produces the cell I-V curve. The maximum power point occurs where voltage multiplied by current is maximum. A block diagram of the system is shown below.



Design Specification

To enable rapid prototyping, our device is based on the circuit designs for the Arduino Micro and the Adafruit INA219 Current Sensor Breakout. A MOSFET with PWM switching provides the variable load, while the INA219 measures input voltage, and voltage drop across a shunt resistor. The INA219 communicates over I2C and supports computing current and power as well as multiple sample averaging.

Our design specifications are:

- Firmware development in the Arduino environment
- Enclosure has USB input and banana jacks for solar cell connection
- Powered by USB host
- Processor is a Microchip ATmega32U4
- Sensor is a Texas Instruments INA219 Current/Power Monitor
- Actuator is a FQP30N06L N-channel MOSFET