Home Power Monitor

Software and hardware design by Cliff Leitch

This device works in conjunction with electronic digital power meters to show how much power (in kilowatts, kW) the home is using at any particular time. It also shows the cumulative number of kilowatt-hours (kWh) used since being plugged in.

It uses an Atmel AVR ATtiny461 microcontroller.

Principle of Operation

Most of the newer electronic digital power meters have a light emitting diode (LED) built in that emits a flash of infrared light for each one watt-hour of electricity used. The LED is included in the meter for use with automatic calibration equipment, but it can also be used to monitor the rate of usage of electrical energy.

This Home Power Monitor uses an infrared phototransistor to detect the flashes of light from the meter and a microcontroller to compute the power (kW) and energy (kWh) used.

This Power Monitor only works with electronic power meters having the infrared LED. It is not compatible with older electro-mechanical power meters that have a spinning disk.

Cumulative energy usage in kWh is computed simply by counting the number of flashes and dividing by 1000.

Power in kW is computed by measuring the time, T (seconds), between flashes and computing power, in kW, from this formula:

$$\begin{aligned} P\ (\text{kW}) &= 3600\ (\text{seconds/hour})\ \times .001\ \text{kW/watt} / [\ T\ (\text{seconds / watt-hr})] \\ &= 3.6 / T\ \ (\text{kW}) \end{aligned}$$

Somewhere on the face of the power meter is a number, Kt, that specifies the number of watt-hours per flash. The software included with this project is designed for power meters having a Kt = 1.0, which includes most meters designed for residential use. If the Kt number is not 1.0, the software would have to be modified to multiply the number of kW by the actual Kt of the meter, and divide the number of kWh by the actual Kt of the meter.

Files Included in this Package

PowerMonitorSoftware.asm – Software for the ATtiny461 microcontroller in AVR Studio 4 assembly language.

PowerMonitorSoftware.hex – Software for the microcontroller in binary format, ready to program into the microcontroller’s flash memory.

Programming Notes:

- The **CKSEL3..1 Fuses** should be set to 110 to set External crystal oscillator 3.0 - 8.0 MHz.

- The **CKSEL0 Fuse** should be set to 1 and the **SUT1..0 Fuses** should be set to 11 for Crystal Oscillator, slowly rising power.
- The **CKDIV8 Fuse** should be left programmed to divide the 8 MHz crystal oscillator frequency by 8.
    - The clock frequency must be exactly 1 MHz or the power calculation will be incorrect.
    - The internal 8 MHz oscillator could be used instead of the crystal, but it could cause several percent error.
- The **RSTDISBL Fuse** must be programmed for the kWh function to work.
    - If RSTDISBL is not programmed, only the kW function will work and the other switch position will reset the microcontroller.
    - **CAUTION:** Programming the RSTDISBL fuse makes the microcontroller permanently inaccessible to ISP programmers like the AVRISP. Be sure the flash memory is programmed, the other fuses are programmed, and everything else is working correctly before programming this fuse.
    - An ISP programmer can program the RSTDISBL fuse but cannot unprogram it. A high voltage programmer is required to unprogram the fuse.

Bill of Materials.pdf – Bill of materials. All parts are available from Mouser Electronics and probably other places, too.

PowerMonitorLayout-Bottom (copper) Layer.pdf – PC Board layout. Both PCB's are single-sided.

PowerMonitorLayout-Silk screen layer.pdf – Silk screen layer showing parts placement on PCB's.

PowerMonitorLayout-ExpressPCB.pcb – PCB layout in ExpressPCB format

PowerMonitorSchematic.emf – Schematic diagram in Windows Metafile format
PowerMonitorSchematic.sch – Schematic diagram in ExpressPCB format

PowerMonitorFrontView.jpg, PowerMonitorInOperation.jpg, PowerMonitorRearView.jpg – Photos of the project. The Serpac enclosure comes with opaque plastic end panels. A clear end panel is available, but I bought a smoke-colored plastic clipboard at Office Depot and sawed out a piece to make an end panel. It looks sharper and more professional than the clear panel.

PowerMonitorSensor.jpg – Phototransistor as mounted on power meter. The phototransistor is mounted in a small hole drilled in a ½" PVC pipe plug and capped with a ½" PVC cap. It must be protected from direct sunlight.

The red arrow in the picture points to the infrared LED in the meter. Some meters have the LED on top instead. The green arrow points to the Kt rating. (See the comments in the Principles of Operation notes above.)

To position the phototransistor on the meter, first turn on an appliance that draws at least 1000 watts on a continuous basis (e.g., air conditioner, electric heater or hair dryer). Then, slide the phototransistor around on the face of the meter and mark the area where the right hand decimal point on the display flashes. (It flashes each time it detects a flash of light from the meter.) Then, mount the phototransistor assembly to the face of the meter, in the center of that area, with double-sided foam tape. (Be sure the tape does not cover the phototransistor.)

Alternatively, use an oscilloscope to detect the placement that gives the strongest signal.

A pulse of ≥ 1.3 volt at Pin 11 is required to trigger the microcontroller reliably. If the decimal point does not flash, it may be necessary to increase the value of R14. If the signal disappears in bright ambient sunlight, it may be necessary to decrease the value of R14 to a minimum of 180 ohms.