Joulemeter

USER MANUAL

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Joulemeter webpage: http://research.microsoft.com/joulemeter/

Joulemeter Version 1.1

Microsoft® Research

Contents

Introduction

Joulemeter is a software tool to view the power consumption of your computer. Power data is shown for the computer as a whole as well as the key hardware components. Power data changes due to a specific application can be tracked. The data can also be stored periodically to a file if desired. Figure 1 shows a screenshot of the power metering interface exposed by Joulemeter.

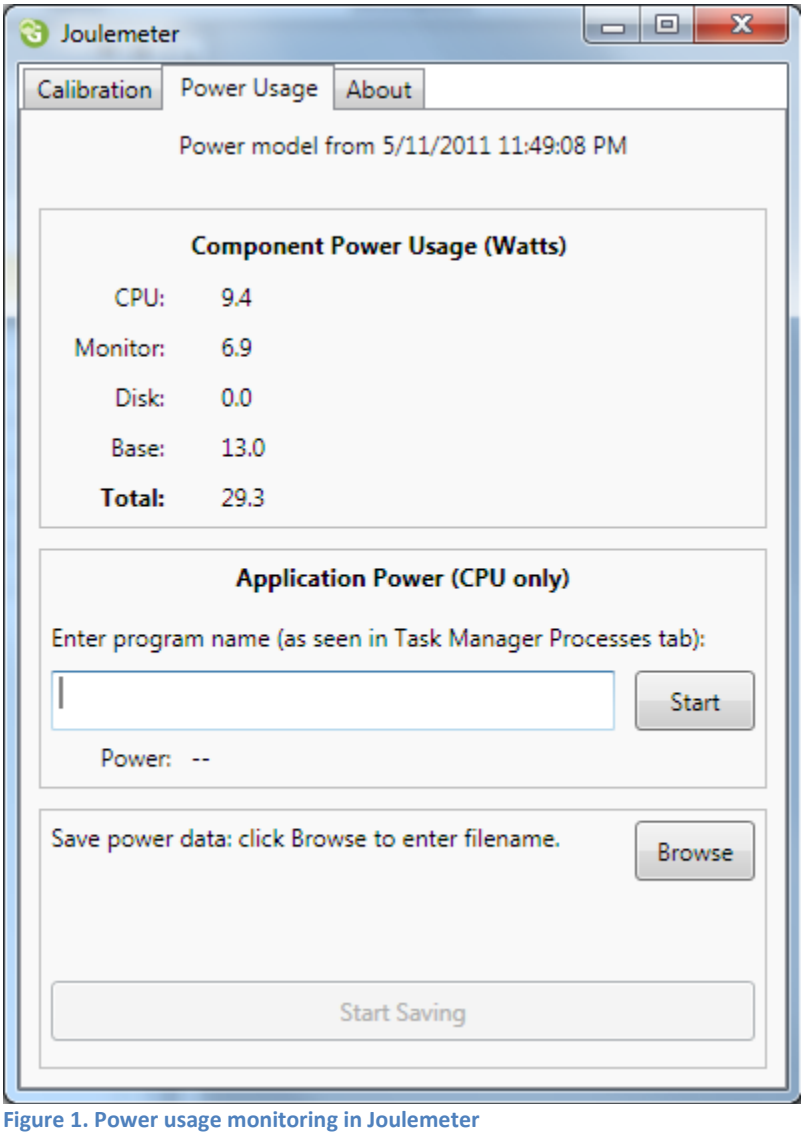

Figure 1. Power usage monitoring in Joulemeter

Joulemeter estimates the power usage through a power model that relates the computer resource usage and hardware power state (processor utilization, processor frequency, screen brightness, monitor on/off state, disk utilization) to power drawn. This relationship, known as a power model, is learned using a process called calibration.

System Requirements

Joulemeter has only been tested to run on **Windows 7**. It will also run on Windows Server 2008 R2 if the Hyper-V role is disabled.

On laptops calibration can be performed without any external power meter. For desktops, a WattsUP PRO power meter (available from WattsUpMeters.com) is required. If such a meter is not available, approximate power data can be monitored.

Installation

To install, obtain the latest installer linked from: http://research.microsoft.com/joulemeter/

Double-click the downloaded file to start the installation. Follow the installation wizard. Default settings in the installer work fine for most users.

The Joulemeter program will now be available through the Windows Start menu.

(If an older version of Joulemeter was installed before, it should be uninstalled before installing the new version.)

Using Joulemeter

When the program is started for the first time, it will open with the Calibration tab in view.

Note: If you had previously installed an older version of Joulemeter and a power model was acquired using calibration, Joulemeter may directly open in the Power Usage tab. You may manually switch to the Calibration tab in this case to perform calibration again. Otherwise, skip the calibration section below and proceed to the Power Usage section that follows.

The Calibration tab appears as shown in Figure 2.

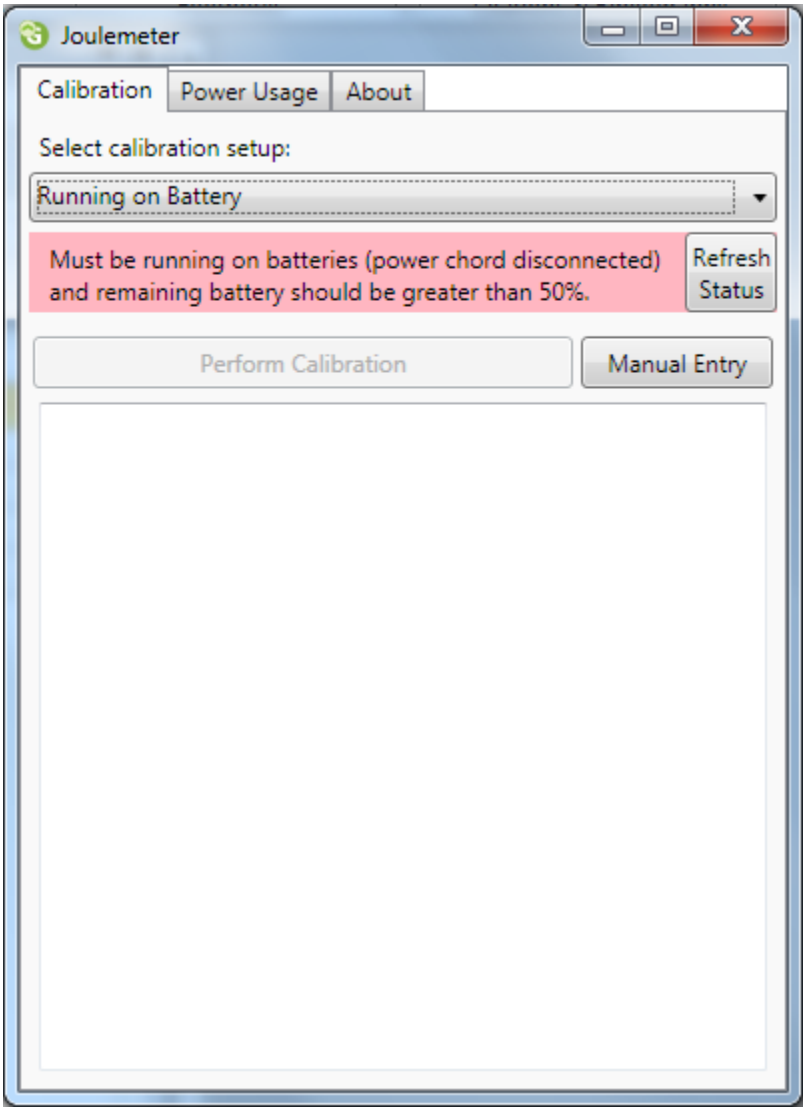

Figure 2. Calibration tab view

The detailed instructions to perform calibration are provided in the next section.

Calibration

Calibration is the process of acquiring a power model for your computer. Calibration is performed as follows:

Step 1: Setup

In the drop down menu shown below "Select Calibration setup:" choose one of the following setups:

Running on Battery: Use this option if you have a laptop computer. The battery must more than 50% charged. Disconnect the power chord so that the computer is using the battery.

WattsUp PRO (Monitor(s) not on WattsUp): Use this option for desktop computers if you have plugged in only the computer into the WattsUp. See section on setting up a WattsUp for more information on how to connect the WattsUp meter.

WattsUp PRO (Laptop or Monitor(s) also on WattsUp): Use this option if you are using a WattsUp meter with a laptop computer, or for a desktop computer when the monitors and the desktop are plugged into a power strip that is in turn plugged into a WattsUp. See section on setting up a WattsUp for more information on how to connect the WattsUp meter.

When you select the correct setup, the text below the drop down menu will change to "Ready to perform calibration." If you selected the correct option but the required conditions were not met (such as the power chord was not disconnected when Running on battery was selected), you may fix the required condition (such as plug out the power chord) and click the Refresh Status button. Once the "Ready to perform calibration" message shows up, the computer is ready for calibration.

If none of the calibration setup options apply to your computer (for instance, if the computer is a desktop and a WattsUp PRO meter is not available), see the section on "Manual Entry."

Step 2: Calibrate

To the extent possible close all other programs before running calibration. Disconnect any USB disks or external storage drives before calibration.

Click the "Perform Calibration" button. Be prepared to not use the computer for several minutes.

During calibration, the Joulemeter program will exercise various resources (CPU, disk, monitor) on the laptop and learn their power usage characteristics. Do not plug-in or plug-out any USB devices during calibration. Do **not force the monitor to turn on** or manually change brightness when the screen turns off or dims out during the calibration process.

Once calibration is over, the "Power Usage" tab will become active and the power usage data can be seen as explained further in the Power Usage section.

Setting up a WattsUP

WattsUp PRO power meters are available from WattsUpMeters.com. Note that WattsUp PRO ES will also work but the other models will not as they do not have a USB connection.

To connect the meter, perform the following steps:

1. Shutdown the computer.
2. Plug in the power cable of the computer into the WattsUp power outlet. Alternatively, you may plug in the computer and its monitors into a power strip and plug in that power strip into the power outlet on the WattsUp meter. Make sure nothing else is plugged into the power strip. In this alternate setup, the power model for the monitor can also be learned (ie, power usage of the monitors will be also be shown in the Power Usage tab).
3. Plug in the WattsUp meter into a power outlet.
4. Turn on your computer.
5. Plug in the USB cable from the WattsUp meter into your computer. In most cases it will automatically install the WattsUp drivers. On Windows 7 64 bit systems, drivers may have to be manually downloaded from the manufacturer website at https://www.wattsupmeters.com/secure/support.php. If the correct drivers are not installed, Joulemeter ill not be able to detect the WattsUp PRO meter.

The WattsUp PRO meter can be disconnected after the calibration is completed. From now on, Joulemeter will use the power model acquired during calibration to compute power usage. External power meters are no longer needed.

Manual Entry

If the above methods are not feasible for your computer, the power model cannot be automatically learned. A manual estimate of certain power numbers may be entered to view power usage data.

On the Calibration tab, click the button labeled “Manual Entry.” It will show a dialog similar to Figure 3.

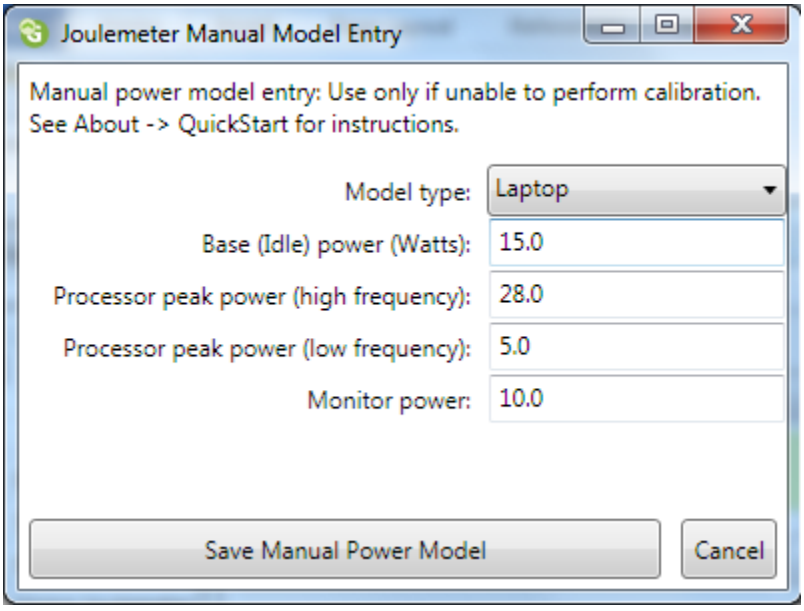

Figure 3. Manual entry dialog

In the drop down menu shown next to “Model Type” an option showing some type of computer will be shown. If you select the option that most closely represents your computer, suggested power numbers for that type of computers will be shown in the entries below. If a power model was previously learned, the power numbers extracted from that power model will be shown.

The numbers shown are explained below:

Base (Idle) Power: This represents the minimum power consumed by the computer when turned on. This is the power used when no programs are running, the monitor is set to its lowest brightness or turned off, and no background activity such as virus scanning is using the computer. If you have an estimate of your computer’s idle power, enter it here. Otherwise leave the default value.

Processor Peak Power (high frequency): This is the power consumed at 100% CPU utilization with the processor using its highest frequency. This power value may be available in your processor’s data sheet as the Thermal Design Power (TDP) value.

Processor Peak Power (low frequency): This is the power consumed at 100% CPU utilization with the processor using its lowest (P-state) frequency.

Monitor power: This is the power consumption of your monitor (available from the monitor user manual). If using more than one monitor, add up the power consumption of all monitors. This is the power used at highest brightness level for monitors that support multiple brightness levels.

Joulemeter will automatically set the other parameters of the power model such as disk power and power at processor frequencies between the highest and lowest.

Once you have entered appropriate values (or have decided to stay with the defaults), click the “Save Manual Power Model” button. This will save the power model. You may now switch to the Power Usage tab to view the power consumption based on the manually entered power model.

When you click the “Save Manual Power Model” button, any previously stored power model, such as learned via Calibration or previously entered manually, will be deleted and the new one will be saved. Thus, manual entry can be used to make adjustments to automatically learned models if needed.

Power Usage

The power usage tab shows the power use of the computer. There are three sections on this tab:

Component Power Usage (Watts)

This portion shows the total power use and also the break down among hardware components. If using a laptop, try changing the screen brightness and you will see that the monitor power number in the Joulemeter display changes. If you start playing a movie or open a website that has some movie playback, the power usage for the CPU will likely go up. If you start downloading a large file, disk power will go up.

Application Power (CPU only)

In addition to monitoring the computer's power use, Joulemeter also shows the power impact of a software program. To monitor any application:

1. Find the name of its executable file. One way to find the name of the executable is to start the Task manager (Press Ctrl-Alt-Del and select task manager), switch to the Processes tab within Task manager, and read off the name under the Image column. If you have developed the program that you wish to measure power for, you likely know the name of its .exe file. Alternatively, a web search may be used to find the names of the executables for popular programs.
2. Enter that name in the textbox shown in the Application Power (CPU only) portion of the Power usage tab. (If you wish to track the energy use of the Joulemeter program itself, the name of the executable to enter is Joulemeter.exe.)
3. Click Start. Within about a second, the power usage for that program will be displayed.
    a. If the application is not yet running, Joulemeter will wait for the application to start. Power data will be shown after the application is started.
    b. If more than one instance of the application are running (such as multiple Internet Explorer windows, each having the same executable name "iexplore.exe"), the power usage of all active instances will be added up. If however, additional instances are started after Joulemeter has already started displaying application power use, the new instances will not be added up.

Note that the power usage of applications shows *only the power consumed by the application on the CPU*. Joulemeter assumes that the monitor is anyway powered on and the monitor power is not attributed to this application alone. However, if the monitor is powered on only for this application, you may wish to add up the monitor power to the application power. Similarly, the base power of the computer may also be added to the application power if the computer has been turned on only to run that application.

Save Power Data

Joulemeter also allows saving power use data to a file, as follows:

1. In the lower portion of the Power Usage tab, click the Browse button. A new dialog titled “File to save power data” opens. Browse to a folder of your choice and type a filename. Click the Save button in the dialog.
2. Click the Start Saving button. This will start saving power data to the file.
3. To stop data collection, click the Stop Saving button (same as the Start Saving button).

File format: The file is saved in comma separated values (CSV) format. This format may be easily opened in Microsoft Excel. Excel allows easy generation of graphs and visualizations of the saved power data. The saved file may also be opened in any text editor. The column headings indicate what data is represented in each column. The first column records the timestamp in milliseconds. Both component power data and application power data are included.

File Size: If recording power data for long durations, note that the power usage data file grows at approximately 150kB per hour of recording. An overnight recording would thus be less than 2MB of data.

Recommended Test Procedure for Application Power Testing: If you are developing your own application and wish to record its power usage in specific usage scenarios, the following procedure is recommended. It ensures that the entire run of the application is captured from start to end.

1. Start Joulemeter, enter the name of your executable in the application power textbox, and then click “Start Saving”. (Joulemeter will be waiting for application to start.)
2. Now start the test application (the one whose power is to be tracked). Joulemeter will start tracking it in about 1 second.
3. Run the usage scenario in the test app (manually or programmatically). This could involve the typical work that will be performed by that application.
4. Stop the test application.
5. Click “Stop Saving” in Joulemeter.

Energy Use: The total energy use for the entire run may be simply obtained by adding up the power values (shown in Watts) for the duration of interest. Since each value is the power use over one second, the sum is the energy use in Joules. Joules can be converted to other units such as Watts-hours or kW-hours using the following conversion factors:

Note that 1 kWh = 1000 Watts * 1 Hour = 1000 W * 3600 s = 3,600,000 Joules.

Thus, 1 Joule = 1/3,600,000 kWh.

FAQs

1. **Can I see the detailed power model generated by Joulemeter for my computer?**

   See the file PowerModel. XML saved in the program folder where you selected to install Joulemeter (typically C:\Program Files (x86)\Microsoft Research\Joulemeter\).

2. **I tried uninstalling the old version and then installed the new version. However, the new version still does not install and complains that any old version should be uninstalled first.**

   It is likely that the old version did not uninstall fully. In the control panel, under Uninstall programs list, right click the old version of Joulemeter and select Repair. After the repair finishes, again try uninstalling the old version. Now it should correctly uninstall. The new version may now be installed.

3. **Joulemeter seems to be showing bizarre power values. The power model looks grossly inaccurate.**

   It is likely that the mouse was touched during the calibration process. This would have caused the monitor to turn on when Joulemeter expected the monitor to be off. Perform the calibration step again. It is also possible that your computer has some non-standard hardware components that do not allow calibration to work correctly.

4. **What is new in version 1.1 compared to version 1.0 Alpha?**

   The key changes are:
   - Application energy metering feature is added
   - Save to file option is provided in the user interface
   - Manual editing of power model is supported
   - A single application is used for calibration and power usage monitoring (instead of a background service and a taskbar based application)
   - Several improvements have been made to the calibration process, making it more likely to succeed on a variety of machines
   - A new user interface is provided

5. **If a new version becomes available, will the Joulemeter program notify me?**

   No. Please check http://research.microsoft.com/joulemeter.

6. **The Power Usage tab does not show power usage even after performing calibration. Or, calibration fails to learn a power model.**

   Please copy the entire text shown in the textbox below the Perform Calibration button and send to the support forum shown in the Contact Us section.

Contact Us

Support for this software is available at the Joulemeter Forum. (URL: http://social.microsoft.com/Forums/en-US/joulemeter/threads)

For non-support questions such as commercial use, license/privacy issues, please email: jminfo@microsoft.com

For more information regarding the research related to Joulemeter please visit the project webpage: http://research.microsoft.com/joulemeter