LPCXpresso IDE Power Measurement Guide

Rev. 8.1 — 3 June, 2016

3 June, 2016

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1. Power Measurement Overview

The Power measurement tool enables the measurement of power usage on the LPCXpresso boards that incorporate the power measurement circuit – for example the LPCXpresso 54102 board. The power measurement tool is composed of three parts:

1. An LPCXpresso board featuring the power measurement circuit

2. The Power measurement firmware

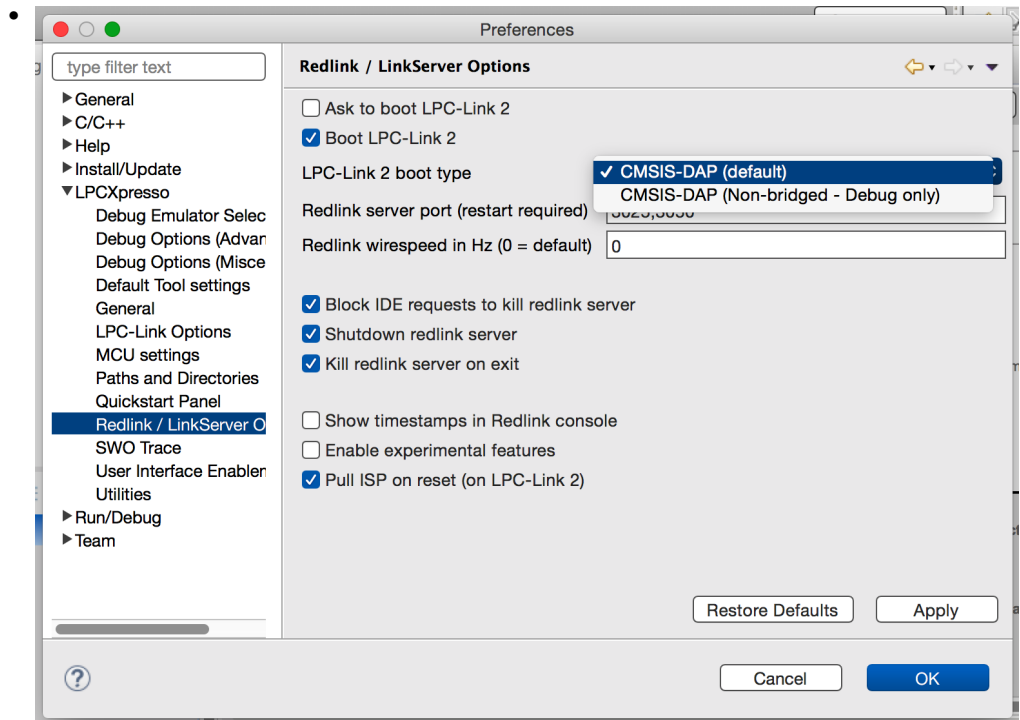3. LPCXpresso Power Measurement plug-in (part of LPCXpresso IDE 7.7.2 and above)

Note For Windows systems we require that Windows 7 and Internet Explorer 9 or higher needs to be installed. We recommend that you install the most recent version of Internet Explorer available for your Windows OS.

The tool can capture a burst of detailed high resolution power usage data or continuously measure average power data. It can capture a burst of samples at up to 200ksps of either the target current usage, the target supply voltage or the shield current. This information is displayed in a graph and can be exported for further analysis. The average values of the collected data can also be displayed.
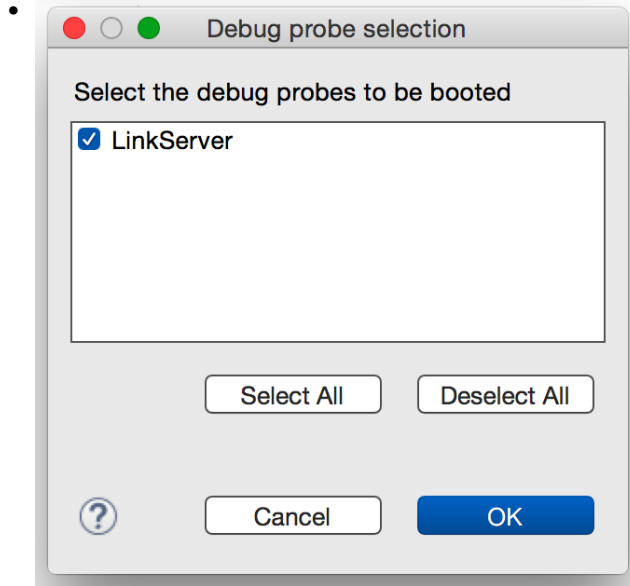
2. Quick Start

In this quick start guide you'll learn how to collect current measurements from the LPC54102 using the bridged version of the CMSIS-DAP bridge probe firmware.
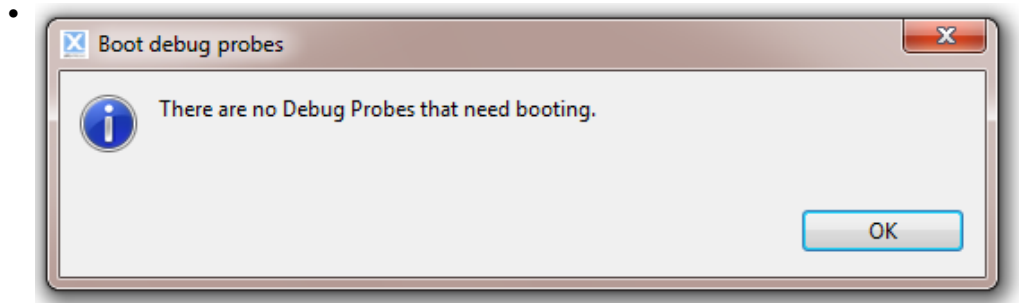
1. On the LPCXpresso 54102 (LQFP) board make sure that the jumper JP5 (DFULink) beside the Link USB socket is closed. This jumper puts the Link into DFU mode and allows the Power measurement firmware to be downloaded.

2. Connect the Link USB socket on the board to your computer.

3. In LPCXpresso, switch to the **Power Measurement** view by either:

    • typing "power " in the Quick Access search box and selecting **Power Measurement Tool** or

    • using the menus: Window->Show view -> other -> Power Measurement -> Power Measurement View)

4. Configure LPCXpresso to use the CMSIS-DAP power probe:

    • Open the preferences page from the main menu bar

        • Windows and Linux: Window -> Preferences

        • Mac: LPCxpresso -> Preferences

    • Locate the Redlink / LinkServer Options page by expanding the LPCXpresso item.

    • Select "CMSIS-DAP (Default)" from the LPC-Link 2 boot type options.

    •

5. Download the firmware to the probe by pressing the **Boot Debug Probe** button

    • If there is a probe in DFU mode the following dialog box will appear.

-

    - check the box next to **CMSIS-DAP** and press **OK**

- If the probe is not connected or the probe is not in DFU mode you will see this dialog after the previous step:

    -

    - Double check that the board is connected using the USB socket labeled **Link** (not Target) and that the jumper JP5 is closed, then power cycle the board and retry.

    - **Note:** the firmware must be re-downloaded every time the probe is power cycled. This will be done automatically if you are using debugging with the LPCXpresso IDE

6. The firmware:

    -
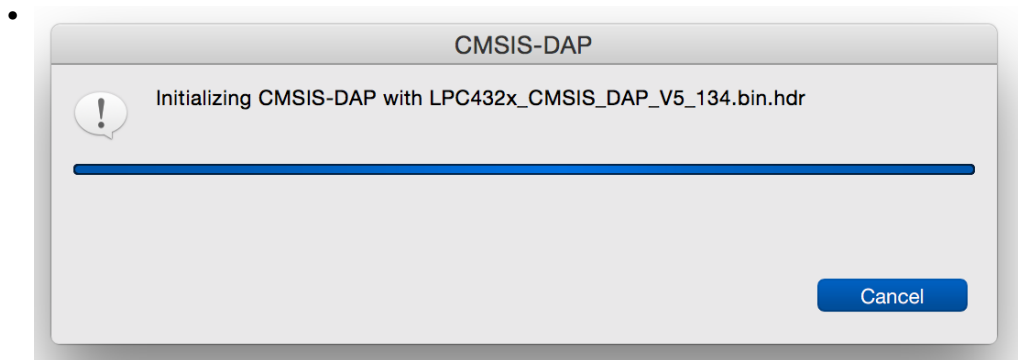
7. Once the firmware is downloaded you can download your code to the target if it is not already in flash.

8. Select the data source from the drop down box: the target's VDD or current, or the shield's current

   • Note that the only shields designed to work with the power measurement will work (currently only NXP's sensor shield Rev 3).

9. Choose a sample rate between 50ksps and 200ksps

10 Choose a collection period in seconds

11 Press **Start Capture**

The tool will capture a burst of samples and display them in a chart.

Once all the data is collected you can explore it by double clicking on the chart to show all the data and clicking and dragging to zoom into selected regions. For more information about using the graph see the Graph [8] and Toolbar [8] sections.

The data can be exported as a CSV file using the save data button

3. Power Measurement Firmware

3.1 Overview

The power measurement tool requires the latest version of the LPC-Link2 firmware to be installed on the probe. This firmware provides a data channel through which the power usage information is sent to be displayed in LPCXpresso.

The firmware is downloaded via the DFU mechanism. Since it resides in RAM you need to re-download it every time the board is power cycles. LPCXpresso will perform this step automatically, but first you need to choose the version of the probe to use.

The LPC-Link2 CMSIS-DAP firmware comes in two flavors: the "bridge probes" which support the Power and SWO data channels in addition to the trace channel and the "non-bridged" which only provides the trace channel. The non-bridged versions are provided for customers who experience USB bandwidth issues. If you are unable to debug your part with the bridged firmware try switching to the non-bridged firmware – you will not be able to use the power measurement tool, but should be able to do everything else.

3.1.1 Which firmware should I use?

There are two firmware choices:

1. CMSIS-DAP (Default)

2. CMSIS-DAP (Non-bridged – Debug only)

Choose the **CMSIS-DAP (Default)** option if you want to use the power measurement or SWO trace. If you debug in another tool chain, this option will allow LPCXpresso to capture the power data – even without a debug connection. Note that LPCXpresso does not need to be debugging the target to be able to use the power tool with this option. For example you could be tracking the power usage in LPCXpresso and debugging your code in Keil uVision using this firmware. It also includes the SWO functionality and the serial I/O bridge.

The **CMSIS-DAP (Non-bridged – Debug only)** option excludes the power tool, SWO trace and Serial I/O bridge extensions. This version uses less USB bandwidth and should be used if you experience USB issues. Power measurement and SWO trace will be unavailable.
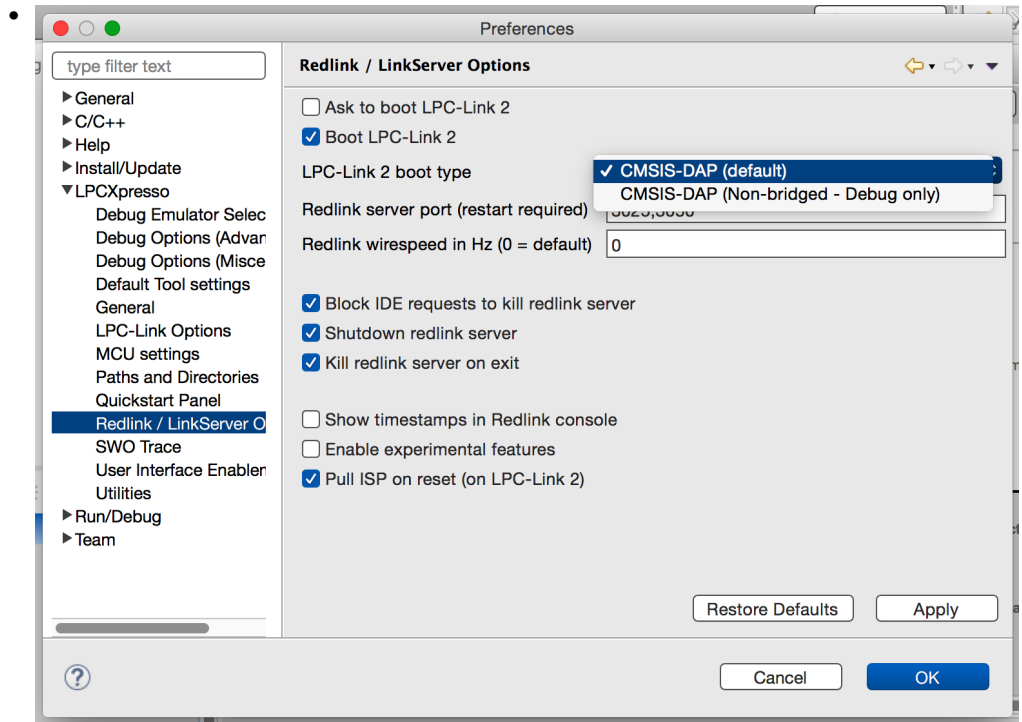
Note
Version 5.147 or later of the NXP CMSIS-DAP firmware is required to use the power measurement functionality.
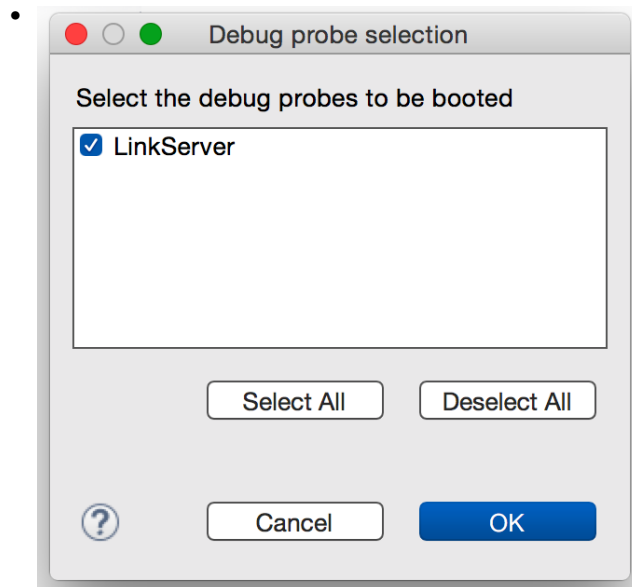
3.1.2 How to choose the firmware and download it

1. On the LPCXpresso board or LPC-Link2 make sure that the jumper beside the Link USB socket is closed. This jumper puts the Link into DFU mode and allows new firmware to be downloaded.

2. Connect the Link USB socket on the board to your computer.

3. Open the LPCXpresso preferences page from the main menu bar

   - Windows and Linux: Window -> Preferences
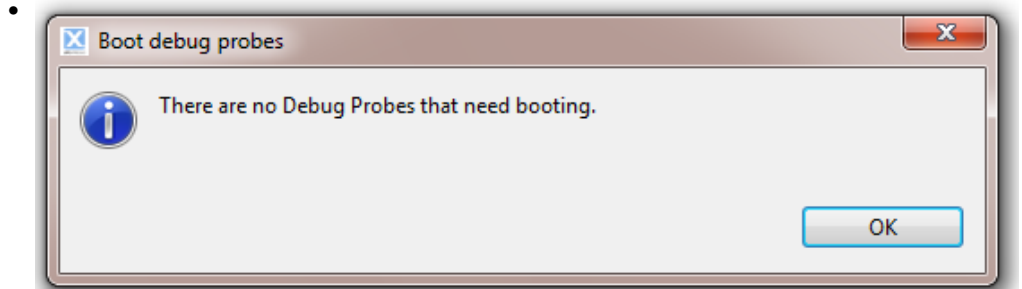
   - Mac: LPCxpresso -> Preferences

4. Locate the **Redlink / LinkServer Options** page by expanding the LPCXpresso item.

- Select "CMSIS-DAP (Default)" from the LPC-Link2 boot type options.

5. Download the firmware to the probe by pressing the **Boot Debug Probe** button 🦵

- If there is a probe in DFU mode the following dialog box will appear.

- check the box next to **CMSIS-DAP** and press **OK**

- If the probe is not connected or the probe is not in DFU mode you will see this dialog after the previous step:

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  - Double check that the board is connected using the USB socket labeled **Link** (not Target) and that the jumper JP5 is closed, then power cycle the board and retry.

6. The firmware will then be downloaded

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![info icon] **Note**
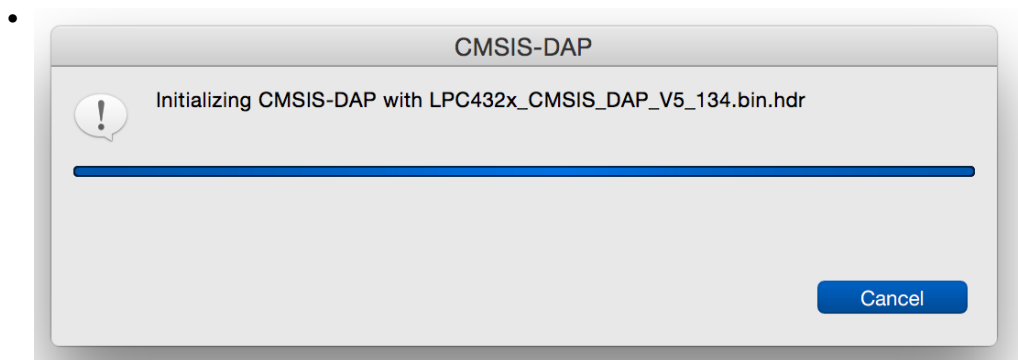
The firmware must be re-downloaded every time the probe is power cycled. This is done automatically if you are debugging with LPCXpresso IDE otherwise you need to use the **Boot Debug Probe** button ![icon] each time.

3.1.3 Troubleshooting

- **Time-out when downloading CMSIS-DAP probe on windows** - There is a conflict between the latest CMSIS-DAP probe drive and an older driver. To resolve, please see the FAQ 'LPC-Link2 fails to enumerate with CMSIS-DAP firmware':

  - https://community.nxp.com/message/630660

4. Power measurement tool view

Use the **Power measurement tool** view to collect and analyze bursts of high frequency samples. From this view you can choose and configure the measurement source; and then explore a graph of the collected data. See the "Average Power view"#AveragePowerView for continuous monitoring of the power usage.

4.1 Toolbar

This section contains a brief description of each button in the toolbar.

- ⊙ Starts collection of detailed data (using previous configuration if available)

- ⊙ Stops collection of data

- ⦀ Configures the board settings

- ⊗ Clears the captured data from memory, clearing the graph and average data

- ▦ Export the collected data to a CSV file

- ⊕ Zoom in on the center of the graph (also see zooming [8])

- ⊖ Zoom in out of the graph (also see zooming [8])

- ⊘ Reset the zoom level to show all data (also see zooming [8])

- ⌐ Set Y-axis to run from zero to maximum plotted value

- ⎧ Set Y-axis to run from minimum to maximum plotted value

- ⤸ Open the Average Power [11] view

- ⑦ Display about page and link to help

4.2 Graph

The collected data is displayed here.

4.2.1 Zooming

You can interact with the graph using the mouse by clicking and dragging on the graph:

- Zoom in on x-axis: click and drag horizontally to highlight the region to zoom into

- Zoom in on y-axis: click and drag vertically to highlight the region to zoom into

- Zoom out to see all data: double click in graph

- Pan left and right: hold down **shift** as you click and drag on the graph

Additionally, there are the zoom buttons in the toolbar [8]:

- x-axis zoom: ⊕ ⊖ ⊘

- y-axis zoom:

4.2.2 Axes

The y-axis can be configured to start from zero or from the minimum value in the visible data. Use these two buttons in the toolbar to switch between these modes:

The x-axis uses relative labeling – it always starts from zero no matter how far through your time series you are. Hover the mouse over a point to see the position of that point in the whole time series.

4.2.3 Point label

When the mouse cursor is in the graph a label appears in the top right corner indicating the time and value corresponding to the point at that position on the x-axis.

In order to show small differences in time throughout the collected data the time is represented as the sum of the time for the first point on the displayed x-axis plus the difference between that point and the highlighted point. Note the different units used for the two numbers.

4.3 Configuration

The configuration dialog box in the Power Measurement Tool allows you to set the measurement source, the sense resistors, the sample rate and the number of samples to capture.

4.3.1 Board hardware configuration

There are two different power measurement circuits supported by the tool: the version on the **LPCXpresso 54104** board and the later revision which was used on the other boards. The choose the circuit corresponding to the board that you are using.

Resistors: The values of the sense resistors across which the target and shield currents are measured can be adjusted here. They are initialize to match the LPC54102 board configuration. This setting allows the tool to be calibrated to adjust for the tolerance in those resistor values.

4.3.2 Capture details mode

There three options to configure for a capture.

The **data source** can be one of:

- Target Vdd

- Target Current

- Shield Current (requires the target shield to include current measurement hardware).

Sample Rate: The ADC reading the current can sample at rates of between 50 and 200 thousand samples per second (50ksps – 200ksps). The following sample rates can be selected (these are chosen to provide a whole number of microseconds between readings):

- 50ksps (20us period)

- 62.5ksps (16us period)

- 100ksps (10us period)

- 125ksps (8us period)

- 200ksps (5us period)

It is recommended to use lower sample rates to capture longer time periods.

Sample period defines the length of time to collect samples for in seconds.

Memory usage

A 60s capture at 200ksps collects 12 million samples, this takes up about 80MB of RAM. The longer the sample period, the more memory is required. The amount of memory allocated to a JAVA application is set when they start. When you start a capture this tool tries to preallocate the required amount of memory. If more memory is required than is available you will see an error message. Either reduce the sample period or increase the amount of memory allocated using the guide in the Appendix [15] .

The **Start Capture** button will apply the configuration and capture a burst of samples.

5. Average Power View

5.1 Overview

The Average Power View displays the average of the collected samples. It continuously switches between sampling from each available measurement source and displays an average for each. Compared with the detailed graphical view provided in the Power measurement tool [8], the Average Power view uses minimal resources on your host computer and the debug probe. Given the low overhead, the average power measurement and just be left running.

This view will also show the average of the chosen source when detailed data is being collected in the Power Measurement view.

It also shows the number of samples collected in the most recent collection and the number of breaks in the data.

The breaks occur when a packet of data is not collected from the probe before it gets overwritten. These can be reduced by increasing the amount of memory available or reducing the sample period.
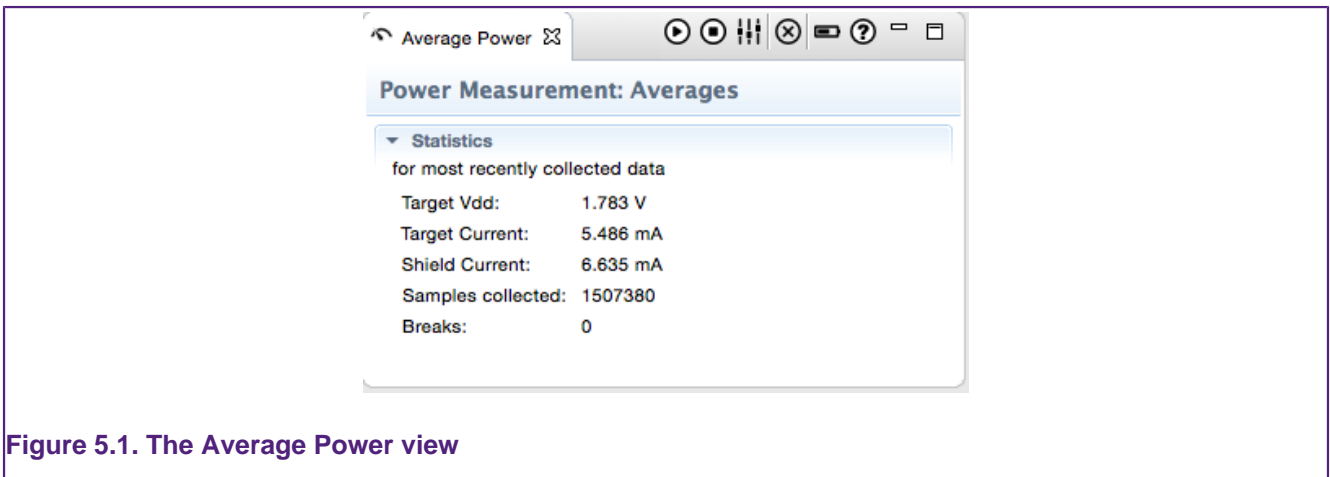

Figure 5.1. The Average Power view

5.2 Opening the Average Power View

Open the Average Power view by typing "Average Power" into the **Quick Access** search box in the top right of the IDE and selecting the **Average Power** view. You can also open it using the menus: Window -> Show View -> Other and then typing "power" in filter text box and finally selecting "Average Power".

It can also be opened by pressing the **Average Power** button in the Power Measurement graph tool.

5.3 Toolbar

This section contains a brief description of each button in the Average Power view's toolbar.

- Starts collection of average data.

- Stops collection of data.

- ▯▮▯ Configures the board settings

- ⊗ Clears the captured data from memory, clearing the graph and average data

- ▭ Open the Power measurement tool [8] graph view

- ⑦ Display about page and link to help

5.4 Configuration

The power measurement probe hardware comes and different configurations and can be reconfigured by end users. The Power tool in the LPCXpresso IDE need to be set up to match the board. This information is entered in the Configuration dialog box. This dialog box is opened the first time the **start button** is pressed and whenever the **Configuration** button is pressed (see figure Figure 5.2).
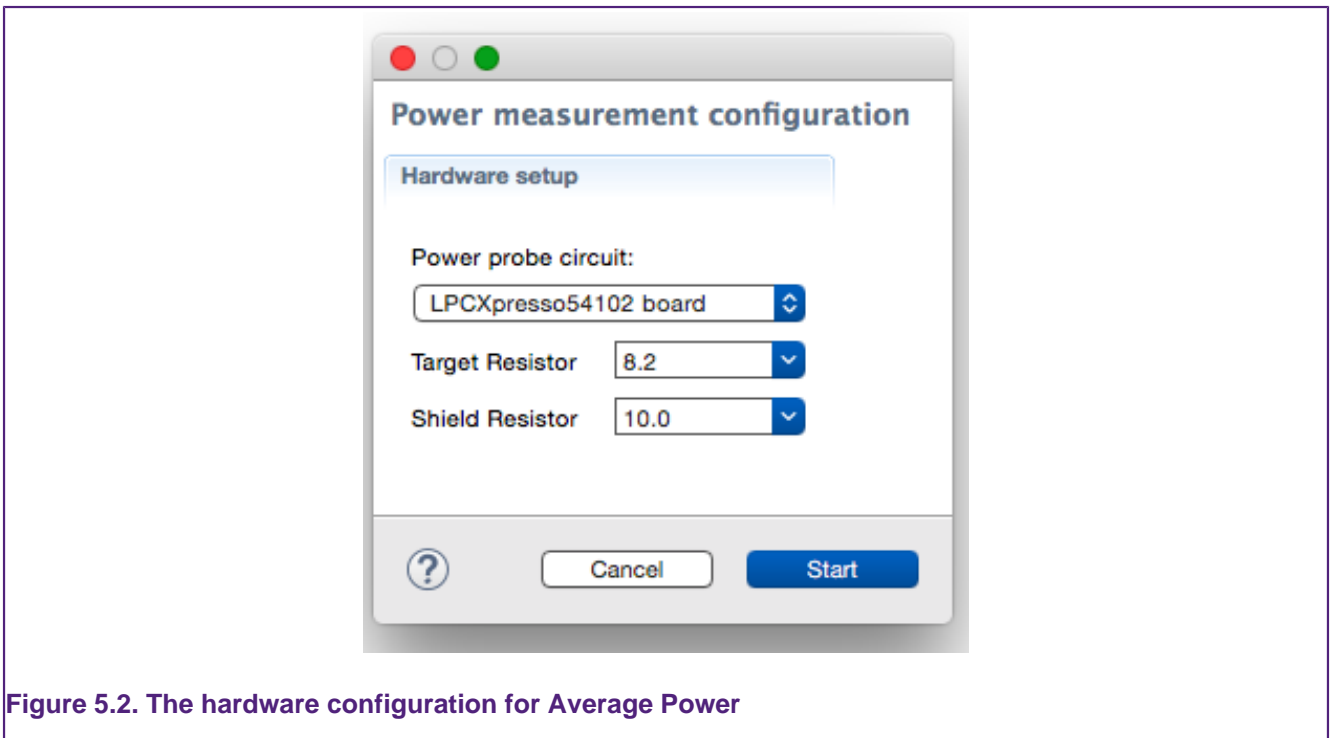
Figure 5.2. The hardware configuration for Average Power

5.4.1 Power probe circuit

There are two version of the circuit which are used on different LPCXpresso development boards. If you are using an LPCXpresso 54102 board choose "LPCXpresso54102" board, otherwise select "Other boards".

Note that users of the LPCXpresso 5411x boards should select "Other boards".

5.4.2 Target resistor

Choose the resistance which matches the sense resistor on the LPXpresso board which has the target MCU on it. The standard options are provided in the drop-down list. If you have replaced the sense resistor with a different one you can directly type it into the box.

Note that all resistances must be entered in Ohms in decimal format.

5.4.3 Shield resistor

Choose the resistance which matches the sense resistor on the LPXpresso shield board. The standard options are provided in the drop-down list. If you have replaced the sense resistor with a different one, you can directly type it into the box.

Note that all resistances must be entered in Ohms in decimal format.

5.5 Usage

To collect average power information from all available measurement sources:

1. Open the Average power view

2. Ensure that your development board is connected

3. Ensure that the LPCXpresso CMSIS-DAP probe version 5.147 or later is booted. See Probe Firmware [5] for detailed instructions.

4. Press the Start button ▶

5. Configure the tool for your board and hit "Start" in the dialog box.

The view should start sequentially updating the average readings for each of the available sources. The samples collected box will start incrementing.

5.6 Sampling information

Each measurement source is sampled for approximately one second at a rate of 200ksps, before moving onto the next. A moving average of the data collected for each is kept, with a window size of 199626 samples (to match internal buffer boundaries). Since there are typically three measurement sources (target Vdd, target current and shield current) 2s of data out of 3s is missed from these averages. For more precise power usage the Power Measurement Tool graph view should be used.

The total number of samples collected from all sources is display in the "Samples Collected" row.

6. Precision and accuracy

The power measurement hardware uses an ADC with 12-bit precision. For the target's current this provides step sizes of 3.9uA, up to a maximum of 16mA. The sensor shield board has a step size of 3.2uA and a maximum current of 13.2mV. The target's Vdd has a step size of 806uV and a maximum of 3.3V.

The maximum measurable current depends on the sense resistor **Rs** (Ohms) and the target's voltage **VDD** (V). It can be calculated as: `I = (VDD - 0.1V) / (25 * Rs)`

Higher currents cannot be measured and will be recorded as the maximum, resulting in underestimation of the current usage. Change the sense resistor to a smaller resistance to increase the maximum measurable current.

Table 6.1. Maximum measurable currents

Sense Resistor (Ohms)	Vdd = 1.8V	Vdd = 3.3V
4.12	16.5mA	30.1mA
8.2	8.29mA	15.6mA
10	6.8mA	12.8mA

The power numbers can be expected to be accurate to within 2%. The major sources of error are the the gain amplifier (MAX9634TEUK+T) used by the Target current and the Shield current, and the tolerance of the sense resistors.

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7. Appendix

7.1 Increasing memory

The LPCXpresso IDE is a Java application. Low memory can result in gaps in your trace or prevent you from being able to capture as much data as you need to.

This appendix shows how to increase the amount of Java memory available for each error type.

7.1.1 The INI file

When the IDE starts, it loads Java configuration information from the ini file: `<install>/lpcxpresso/lpcxpresso.ini`

This file contains the parameter that control how the application uses memory.

```
-vmargs
-Xms128m
-Xmx512m
```

Description of the arguments:

- `-Xms128m` This defines the **initial** amount of heap space available to the Java runtime. This is dynamically allocated space and you should increase if you have a large number of files or projects in your workspace. The default is normally 128m; 256m would make it 256Mb.

- `-Xmx512m` This defines the **maximum** amount of Heap space available to Java. This value must be greater than or equal to the value used in `-Xms` .

7.1.2 Not enough memory to capture *n* samples

If you see an out of memory error when attempting to start a data capture try increasing the maximum heap size in the ini file. For example by changing `-Xmx512m` to `-Xmx768m` would increase the maximum heap size from 512mb to 768mb.

Restart the IDE for the changes to take effect.

7.1.3 Gaps in trace

Increasing the initial heap space can help to reduce the number of gaps in the trace. Try setting the `-Xms` parameter to be equal to the `-Xmx` value. The value for `-Xmx` must always be greater than or equal to the value for `-Xms`.

Restart the IDE for the changes to take effect.

7.1.4 Keeping track of memory usage

You may also wish to enable the workspace preference such that the Java heap status is displayed in the IDE status bar (bottom right of Window). To do this, select:

Window -> Preferences -> General -> Show heap status

A full discussion on the options available in the file can be found at http://wiki.eclipse.org/Eclipse.ini