ZSCircuits Electronic Systems
ZS-1100-A
IOT Power meter: User Guide Ver 0.21

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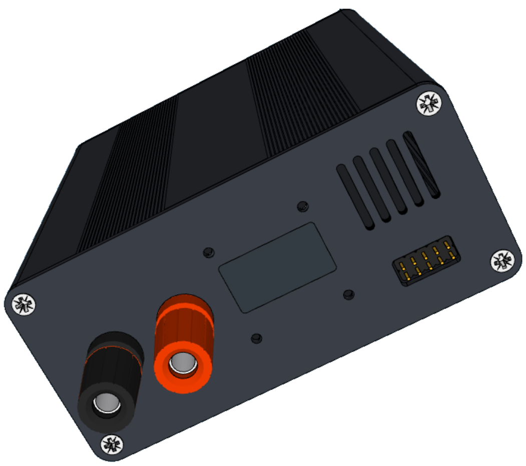


Contents

1. Welcome

Thank you for purchasing the ZS1100A, IOT Power Meter tool. This is an open hardware tool which is designed to measure the power consumption of IOT devices accurately. This user guide will help you to perform the accurate power measurements of IOT devices with minimal effort. The user guide refers to the Ver 2.7.x of the IOT Power Profiler software. For latest information and updated please visit the following links. https://github.com/zscircuits/zs1100a . It is recommended to view the product demo video for easy understanding. The videos can be viewed on our website www.zscircuits.in

2. Terms and Abbreviations

DUT	:	**D**evice **U**nder **T**est
IOT	:	**I**nternet **O**f **T**hings

3. PC Requirements

For using the IOT power profiler a computer with the following specifications are required.

Operating System	:	Windows 10
Processor	:	Intel Core i3 2.3 GHz or AMD Ryzen-3 2.1 GHz and above
RAM	:	2GB Free
Hard Disk space	:	20MB for installation, 10 GB for data. SSD drive preferred.
Display resolution:	:	1600x900 or higher. (1920x1080 recommended)
Connectivity	:	USB 2.0 port (Do not use USB hub or front panel ports on a desktop PC)

Note : The product is tested extensively on a PC with AMD Ryzen3 2200g @ 3.5GHz with 16GB DDR4 RAM and a 250GB SSD drive. It is also verified to work reliably on a laptop with Core i3 @ 2.1GHz with 8GB RAM and 160GB SSD drive. In case of battery powered laptop, set the power options for Best Performance to ensure that the CPU performs at its best rate.

4. Contents of the package

Sr No	Feature	Type	Qty	Notes
1	ZS-1100-A IOT Power meter	Hardware	1	
2	USB 2.0 cable Type-A to Type-B	Hardware	1	
3	Banana to Crocodile/Alligator clip wires	Hardware	2	RED, BLACK
4	Jumper Wires for Digital Data	Hardware	4	
5	USB Flash Drive	Hardware	1	Contains Software, Calibration Data, License key file Please keep this safe for future use
6	Quick Start Guide	Documentation	1	

5. Software Installation

Insert the USB drive provided with the kit into an USB slot on the PC. Go to the Setup Folder and Click on PowerProfilerSetupXXX.exe. Follow the instructions on the screen. On the first run, the GUI will prompt the user to insert the USB stick to copy the Key files stored on them. Please follow the instructions.

The files are installed to C:\Program Files (x86)\ZSCircuits\IOTPowerProfiler\

The data files are written to C:\Users\username\AppData\Roaming\ZSCircuits\IOTPowerProfiler\Data

Other folders created include

License File Directory : C:\Users\username\AppData\Roaming\ZSCircuits\IOTPowerProfiler\License

Data Model Directory : C:\Users\username\AppData\Roaming\ZSCircuits\IOTPowerProfiler\Models

Please keep the USB flash drive securely for future usage. An installation on a new PC requires this flash drive. Without the key files, the Power profiler tool will not work.

In case these files are accidentally deleted, please contact support@zscircuits.in with your product serial number. The serial number is printed at the bottom side of the ZS1100A tool, on the packaging box and on the Invoice. The GUI also displays the serial number on the bottom left side corner after a successful connection.

6. Basic measurement

6.1. Measurement setup

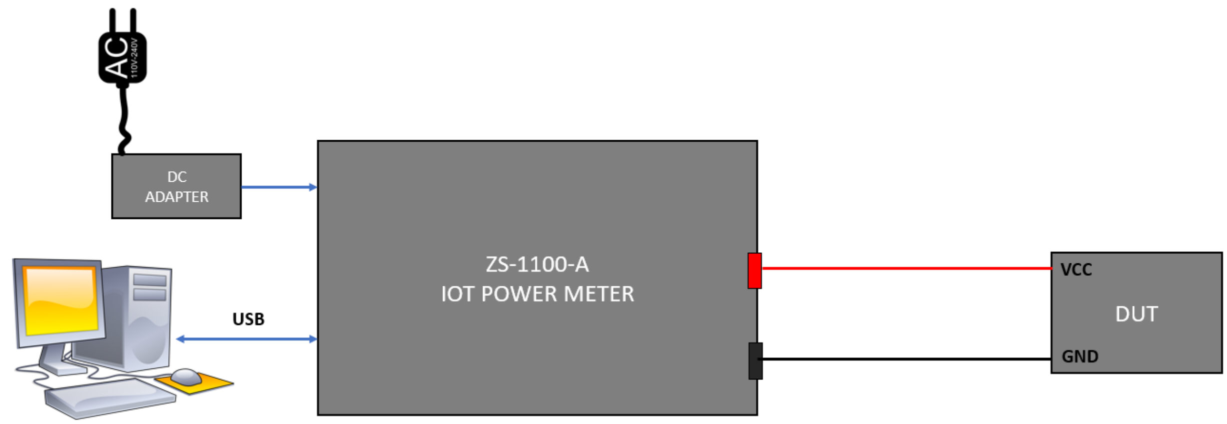
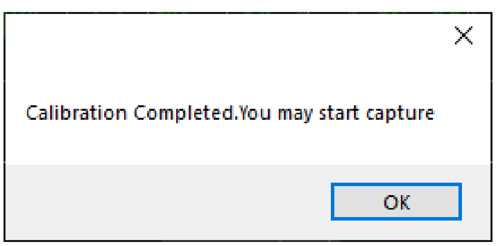


Figure 1 : Measurement setup

Just connect the DC Adapter and USB cable to the ZS1100A. Connect the load at the output terminals. Program the output voltage, current limit using the GUI and Start the measurements. The setup is very easy and hassle free.

6.2. Calibration

- Before starting any measurement, it is required to calibrate the equipment with the applied voltage. For calibration perform the following steps.
- Arrange the setup as shown in Figure 1 & Start the GUI Software on the PC
- Click on the **CONNECT** button. Wait for the prescribed time for the equipment to warm up. Typically 2 minutes.
- Click on the **CALIBRATE** button. Follow the instructions on the screen.
- Wait for about 10 seconds for the calibration procedure to end. This is indicated with a pop-up window as below



At this point the system has finished calibration and is ready for measurement.

6.3. Basic measurement

- Calibrate the equipment as in the procedure listed in the above section
- Connect the DUT at the output terminals.
- Click on START to start the measurement. Create a new session or use an old session.
- The current meter and the pilot graph will indicate the current measurement on the run.

- When the required data is captured (At least 16 seconds minimum needed), click on STOP button.
- The measurement is now completed, and a popup message will indicate this.
- The total length of the measured data is also indicated by the RECORD LENGTH in seconds.
- The session can be loaded from the “Sessions Manager” window by selecting that session name and clicking on Load Session.
- The chart in the now shows the measured data.
- A Zoomed in version of the chart is displayed in the middle graph. The zoom factor of the middle chart can be set by scrolling the mouse wheel over the chart.
- Using the Estimation menu, the battery life of the product can be estimated from the captured waveforms.
- The correct battery type may be chosen from the tool for accurate analysis.

7. Graphical User Interface (GUI)

The ZS1100A requires a GUI which is provided as part of the kit. The users may also download the same on our website at www.zscircuits.in or at github location https://github.com/zscircuits/zs1100a . The GUI is intuitive and easy to use which features many advanced features.

Figure 2 : GUI ver 2.6.x

The first step is to connect the device to the PC using the USB cable and clicking on the CONNECT button. 

On a successful connection, the CONNECT button turns to GREEN colour and the status shows CONNECTED. The product’s serial number is displayed at the bottom left corner of the screen. After a connection is established, the OLED indicator on the screen displays the product number followed by the measured voltage and current. Note that the current measurement is updated only during a capture.

7.1. Control Panel

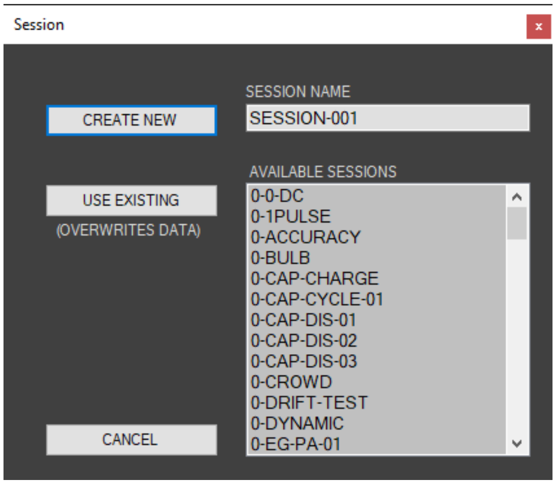
On a successful connection, a control panel pops up on the screen. This panel is used to set the various parameters of the ZS1100A including the output voltage, current limit and output resistance. The same control panel is used to start and stop the capture of the current waveform.

At any time, the control panel can be invoked by clicking on the  icon

There are three dials on the control panel, indicating the current, voltage and the temperature inside the power meter. The current dial is updated only when the acquisition is under progress. The voltage dial indicates the measured voltage at the front panel jacks. The temperature sensor measures the internal temperature of the board and is used for calibration and thermal protection.

The acquisition group is used to control the calibration and the acquisition process. Before starting any measurement, it is recommended to initiate a calibration process by clicking on the CALIBRATE button. The tool initiates a calibration sequence which lasts about 10 seconds. Before the calibration it is recommended to set the desired output voltage and wait for about a minute to let the tool stabilize. This yields the best performance.

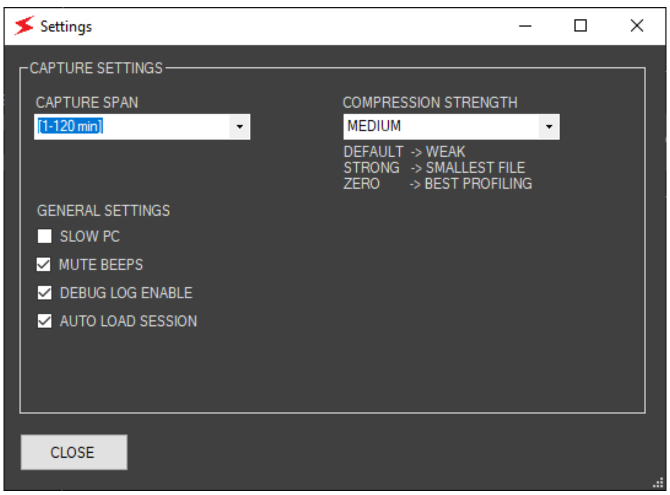
When the GUI is in IDLE state, the START button can be clicked to start the capture of the current waveform. A session window pops up, which is used to name the session to be captured. Users can either chose a new session or use an existing session which gets overwritten with new data.



Once the session is created, the tool starts to capture the data. The data is displayed on the control panel window in real time. Note that the current waveform and the current numbers show a moving averaged value and hence is highly filtered. The raw data gets written to a file which can be viewed at the end of the capture.

After at least 16 seconds, the STOP button can be pressed to stop the capture and display the data.

7.2. Measurement settings



Use the measurement window to set various parameters for capture. For e.g. if a long capture span (> 2 hours) is being performed, then the Capture Span parameter can be selected to a higher value. This optimizes the disk write interval to achieve better stability in long runs.

Users have the option to select the Compression strength, ranging from ZERO (No compression) to STRONG (Maximum compression). The GUI uses advanced compression algorithms to compress the incoming current, voltage and digital waveform in order to save the disk space. The current compression algorithm is highly optimized to preserve the peak value and average value across different compression strengths. A compression ratio of between 60x to 100x is achieved using the STRONG compression strength, for a typical IOT device current measurement.

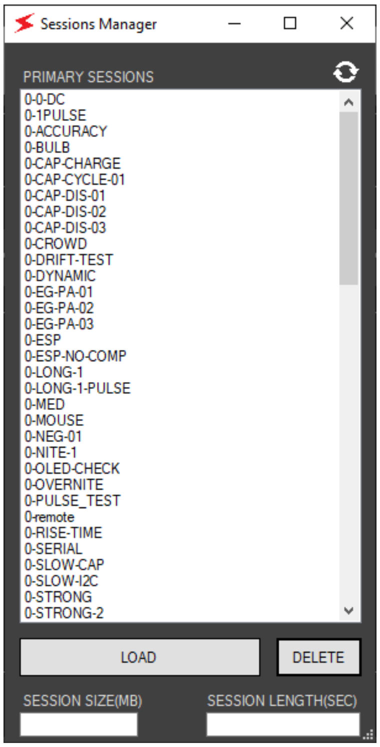
Note : For most accurate profiling of the current, ZERO compression strength is recommended. For most measurements, where a battery life estimation is required, WEAK compression strength is recommended. This is a compromise between disk space and fidelity of the current waveform.

There are few additional settings which can be used for debugging and other purpose. For e.g. if the PC used is very slow, then the SLOW PC option can be clicked. This reduces the amount of data displayed on the screen in real time and can reduce the CPU loading.

The DEBUG LOG enabling can help us with any issues like GUI crash or data corruption.

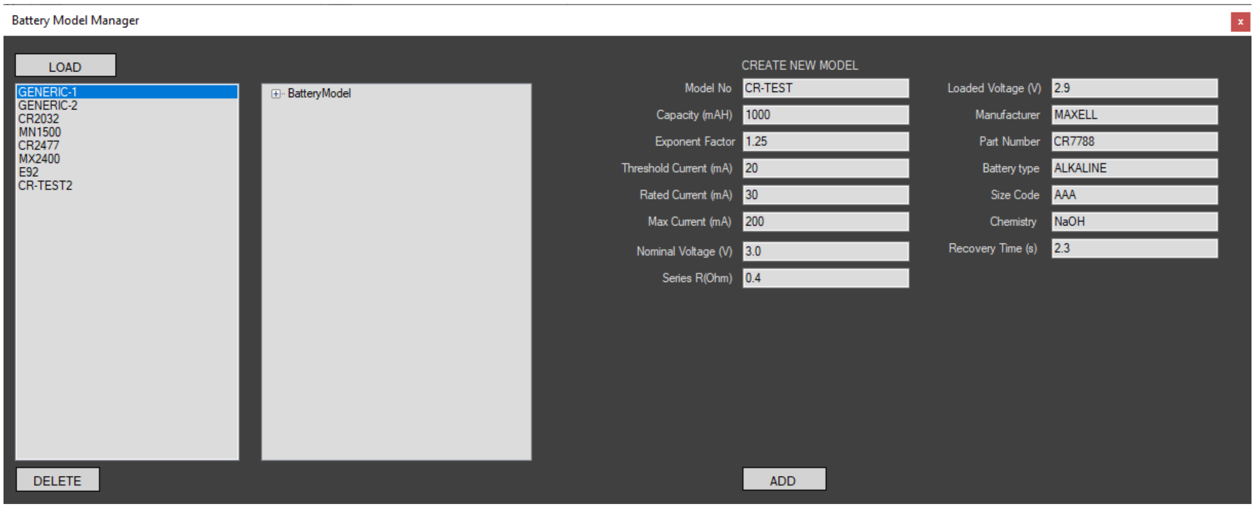
The AUTO LOAD SESSION checkbox is selected by default. At the end of the capture session, the captured data is automatically displayed on the screen, if this option is checked.

7.3. Session Manager



All the captured sessions are displayed on the session manager. The users could load the sessions using this window. The sessions can also be deleted from this window. Note that the deleted sessions cannot be recovered. In cases where the capture was stopped abruptly by closing the GUI or disconnecting the USB, the session gets locked and may not be displayed here. The lock could be removed by browsing to the Sessions Folder and removing the lock.bin file from the corresponding folder.

7.4. Battery models



The tool provides various popular battery models for use by the customers. One may also add additional models to the tool by using this window. All the parameters need to be entered in the right side panel and click on the ADD button. A new model based on those numbers are then added to the list, which can be used later for the battery life estimation.

Out of the various parameters, the following are of prime importance and is used in the battery life computation

a. Capacity (mAH) C
b. Exponent factor (k)
c. Threshold Current (I_{th})

Of these, the Exponent Factor and the Threshold Current needs a bit more explanation.

Below table shows the capacity of a battery model E92 with various current drawn. The rated capacity of the battery C = 1200mAH

Current Drawn(mA) Id	Avg Life (Hrs) L	Measured Capacity (mAH) C’	Weighted Current(mA) $W_d = C/L$
1	1200	1200	1
10	120	1200	10
25	45	1125	26.67
100	9	900	133.33
250	2.5	625	480.00

We observe that the total capacity of the battery drops after the current crosses a certain threshold. Beyond this current, the battery can no longer provide the rated 1200mAH or capacity. This is due to the capacity degradation at higher currents. This degradation is a function of the battery capacity, its peak current capability, size and other factors.

Using the data from the table, we try to fit an exponential model which relates the weighted current (W_m) to the actual current drawn.

The model is defined as below

$W_m = I_d$ for $I_d < I_{th}$

$W_m = I_{th} \times (I_d/I_{th})$^k

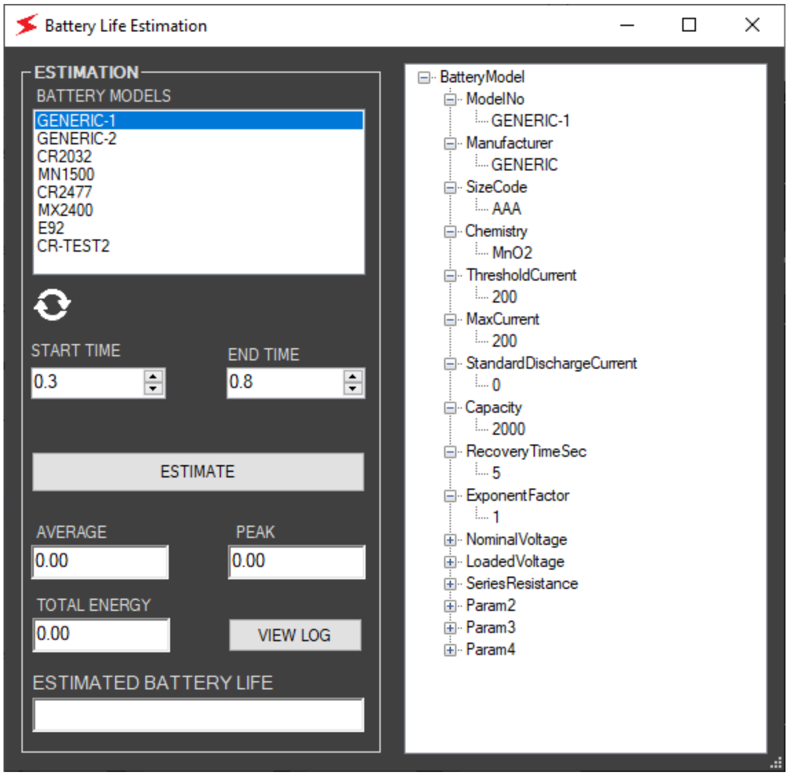
The model W_m is then compared to the W_d from the data and the best fit value of k and Ith is found out either graphically or by iterative solving or curve fitting.

For the E92 battery, the fitted curve is plotted along with the data from the manufacturer’s datasheet.

Here the value of k = 1.3 and I_{th} = 30mA

The IOT Power Profiler GUI estimates the battery life by using every point on the current curve and calculates the weighted current. This is used to estimate the capacity degradation from the rated capacity. Hence the IOT Power Profiler is able to compute the real-world average life numbers, which may be quite lower than what is estimated by using the average current and rated capacity alone.

7.5. Battery life estimation



Using this tool, the battery life of the product can be easily estimated from the current waveform captured. Just select the session from the session list, then choose the battery model for which the estimation needs to be performed.Then click on the ESTIMATE button. The average current, peak current, total energy and the estimated battery life is then displayed on the screen. Note that the calculation assumes that only one battery is used in the system. In case of series connection, there is no change in the battery life estimate as the voltage value is not used in the computation. In case of parallel connected cells, the battery life estimate displayed by the GUI needs to be doubled, to arrive at the actual numbers.

In the above window, the START TIME and END TIME indicate the start and end of the computation span.

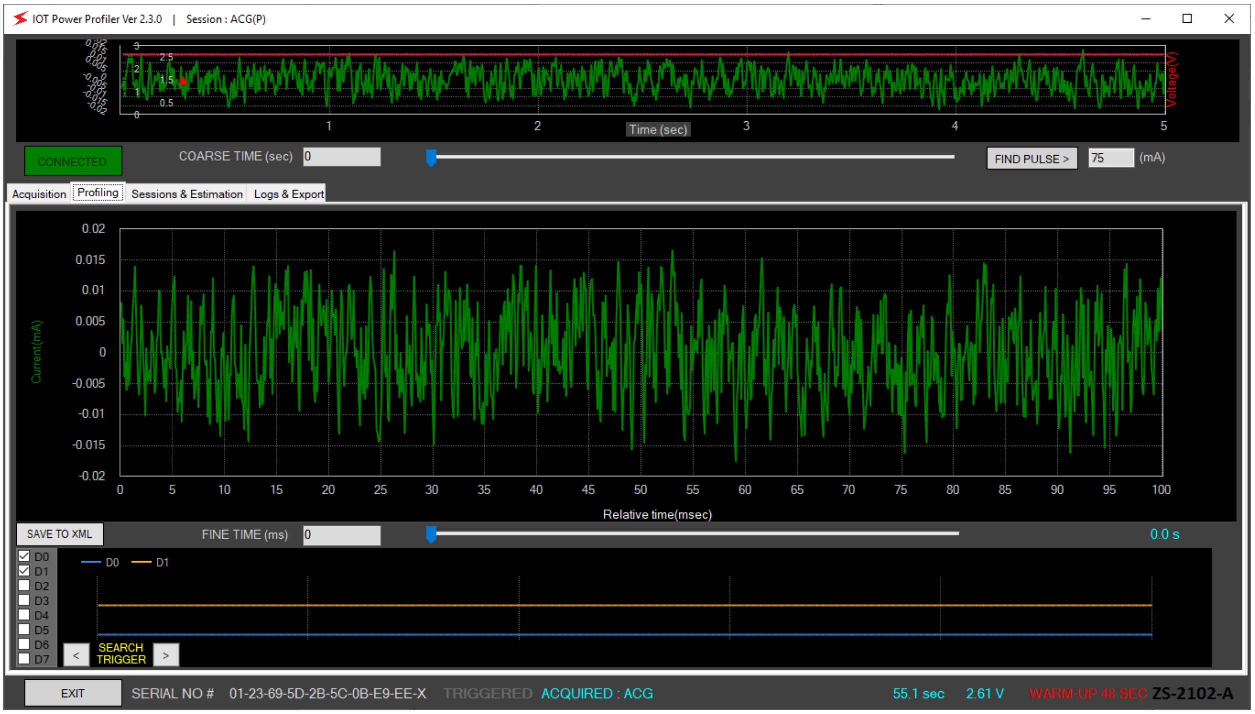
7.6. Profiling the data

This tab has all the functions needed for power profiling. After acquiring the waveform, the profiling tab is used to visualize the current, voltage and digital signals in sync with each other. There are several trigger search functions available. The Digital Trigger can be used to find out a toggle on the D0 line. The current trigger can be used to detect, when the current value breaches a certain threshold.

Zooming on the data

The graphs can be zoomed in and out using the mouse scroll wheel and can be moved in time using the slider bar.

By selecting the top chart with a span < 1 sec, the same area is displayed in the middle chart with the data zoomed in.



The middle graph shows a zoomed in version of the top chart. The middle chart shows only the current waveform. The area zoomed in is indicated by a shaded region on the top chart. The digital values are shown in the bottom chart. By hovering the mouse on the current waveform, a tool tip appears which indicates the current and the time. By selecting the top chart with a span of > 1sec, the average current and energy is displayed on a popup message. By using the coarse slider bar, the top chart can be moved in sync with the middle and the bottom charts. The fine slider bar moves only the middle and the bottom chart. Note that the charts always slide in sync with time.

Using the SEARCH TRIGGER buttons, the GUI can search for any transitions in the Digital IO signals. This can be used to sync the digital activity with the current and voltage waveforms.

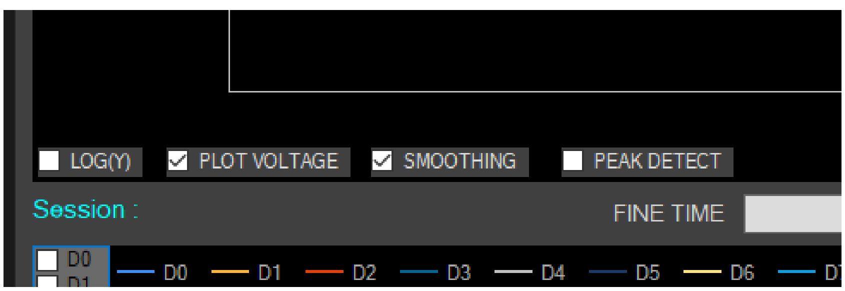


Figure 3 : GUI Ver 2.3.2

Log Scale

There is an option to plot the Y-axis in Log scale by checking the checkbox named “Log Y”. Note that the negative currents are truncated and may not be shown on the screen when the log scale is used.

Smoothing the output data

There is an option to filter the data (smoothing) by checking the SMOOTHING box.

Finding hidden peaks

In addition, a peak detection logic is added to the plotting. This is useful to plot narrow spikes in the data which may get filtered out with the smoothing operation.

7.7. Exporting data

The data captured from the tool is stored directly to a proprietary binary file. This file is directly read by the GUI to display the current profile using additional Metadata. Exporting of the data to the following formats is supported in GUI XML format

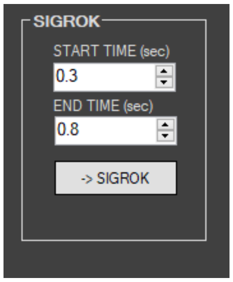
1. Sigrok format (To be displayed in PulseView, An open source signal Analysis software)

7.7.1. XML format

To export the data in an XML format, click on File->Export->XML. Then follow the instructions on the screen. Note that the XML format is an ascii file and takes large amount of space. Hence the export is limited to the data span shown by the middle chart only. A maximum length of 1sec of data can be exported to XML format

7.7.2. Sigrok Format

Sigrok™ is a popular tool used to connect to various instruments like logic analyzers and oscilloscopes. A graphical user interface Pulseview is available for Windows which works with Sigrok. The IOT Power Profiler GUI supports exporting the waveform file to Sigrok using the File->Export->Sigrok



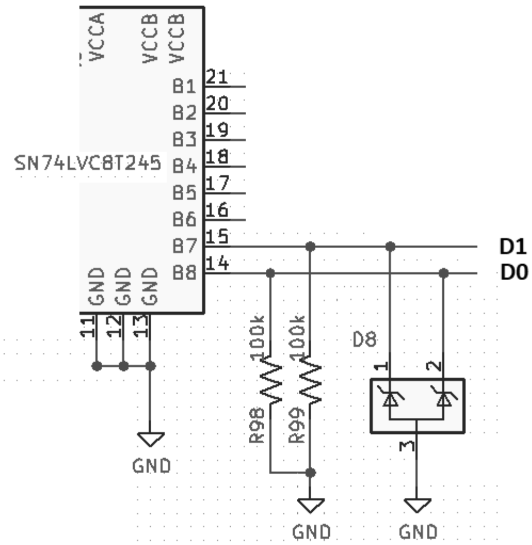
In order to save space on the disk, only the time span between the markers defined by START TIME and END TIME would be saved to the Sigrok file (.sr extension). This file can be directly opened in Pulseview. Using this tool, multiple protocol analyzers like I2C, SPI can be run on the digital IO captured by the ZS-1100-A. This is very handy while analyzing current waveform in sync with application software.

Once the Sigrok export is started, it is recommended not to use any other controls on the GUI till the export is finished. It is OK to Abort the export in between.

Note : Since Pulseview supports viewing of a voltage waveform only, the current data is also displayed as voltage. In this the scaling is 1V = 1A. The users need to interpret this as applicable.

7.8. Capturing digital data

The tool can capture any digital data connected to the 6-bit GPIO port on the front panel. The inputs are sampled at 1Msps and in sync with the current waveform. Note that the bits 3:0 has an internal pull-down resistor of 100K and the bits 5:4 has an internal pull-up resistor of 100K.



7.9. Synchronizing with external equipment

The ZS1100A outputs the 1MHz sampling clock on the front panel GPIO port. This can be used to synchronize any external circuits with the tool. Ensure that the external load on this connector do not exceed 1K Ohm || 30pF.

Note that the CLK is an output only port and no signal should be fed externally on this pin.

8. Advanced technical details

8.1. Inductive loads

Inductive loads can cause large voltage transients, when the current flowing through them is suddenly interrupted. The ZS1100A is protected against high voltage spikes. However it is recommended to not power highly inductive loads like DC motor using the ZS1100A. If used, it is recommended to DISABLE the outputs only when the current through the inductors have been reduced to zero.

8.2. Powered loads

Never connect an external power supply or battery to the output terminals of the ZS1100A. Doing so may cause high reverse currents to flow into the tool. Although the tool has internal reverse current protection, the transistors used for this purpose has limited power dissipation capability. Sustained reverse currents for long duration (several minutes) could cause irreversible damage to the tool.

8.3. Digital inputs

The digital inputs of the ZS1100A features a level shifter to accommodate any voltage level from 1.8V to 5V. The default port voltage is set internally to 3.3V. This can be forced to a different voltage by using external power applied to the VCC pin of the Digital IO port as explained below.

Note that the external power supply should be able to overcome the 33 Ohm resistor connected to the VccB of the level translator.

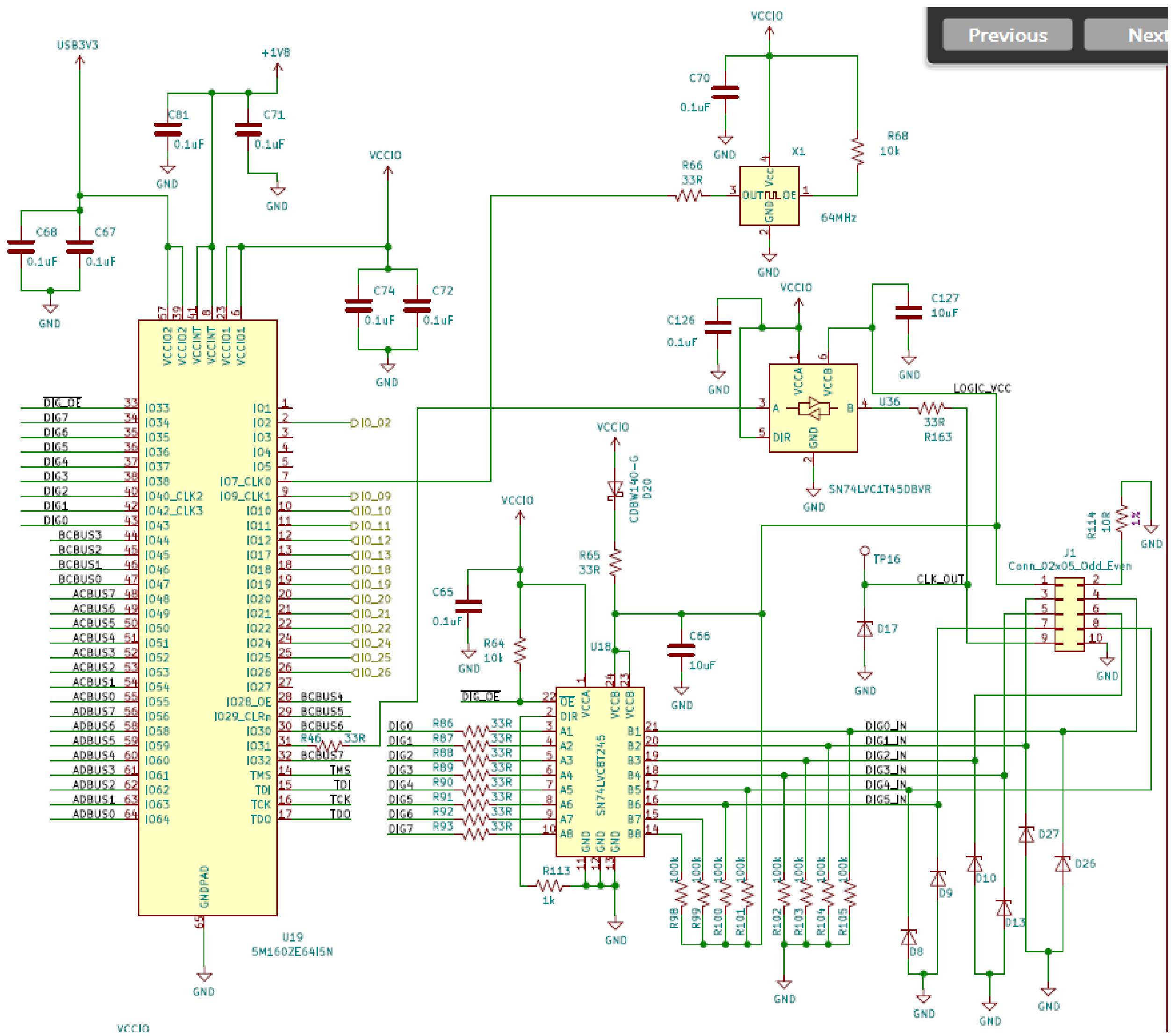


Figure 4 : Digital input circuit

The digital inputs D0 through D3 have a 100K ohm pull-down resistor connected at each pin to prevent them from floating. D4 and D5 have 100K pull-up resistors on them. Each Input pin also has ESD diodes to protect it from ESD strikes. The impact of the 100K pull-down/pull-up must be analyzed while connecting the digital signals. For e.g. an output drain signal with weak pull-up of 47K will not be able to drive this pin high and may cause a logic level contention. Similarly, leakage current can flow into these pull-down resistors from the DUT's IO pins if they are held at opposite levels. These facts should be considered while using these digital inputs.

9. Improving measurement accuracy

9.1. Avoid long cables

Longer cables will have higher IR drops on them and will cause voltage drops. The longer cables can pick-up magnetic fields which will induce currents into the loop and cause noise. This can be minimized by using a twisted pair for the output connections.

9.2. Avoid strong magnetic fields

The IOT power meter is electro-magnetically shielded using a metal enclosure. This can suppress electric fields and electro-magnetic radiations. However strong magnetic fields can be problematic as the material is not magnetically shielded. Very strong, time varying magnetic fields can induce currents into the system, which can cause measurement errors. Hence it is recommended to keep the unit away from strong magnetic fields like induction motors, speakers, DC motors, high current bus bars etc. while in use.

9.3. Improving the calibration accuracy

The ZS1100A uses precision components which can be affected by large temperature changes. While this is taken care by the calibration, there are ways to improve this further. Some of the Opamps used on the board, take few minutes to stabilize their internal bias voltages. Hence it is recommended to start the calibration, a few minutes after the product is plugged into the USB port. This ensures that the entire board inside attains thermal and electrical equilibrium and yields the best performance.

Steps to perform calibration optimally

1. Set the desired output voltage, output resistance and current limit.
2. Turn ON the output (Enable the output)
3. Remove the load from the output Banana Jacks. Remove any cables, even if they are un-connected to the load.
4. Allow the unit to stabilize at this bias point for about 10 minutes.
5. At the end of 10 minutes, calibrate the ZS1100A.
6. Connect the load and start measurements.

How often should I calibrate the unit

1. Redo a calibration for any voltage change > 500mV from the previous calibration.
2. Redo the calibration for any USB disconnections and GUI re-connections.

9.4. Avoid temperature drift

The IOT Power meter uses precision components which can be affected by larger temperature changes. It is recommended to avoid temperature gradients while using the ZS1100A. For e.g. using it in direct sunlight can cause the unit to get heated up and cause measurement errors of few micro amps. Similarly using it near a fan, air blower, air conditioning duct or cooling fan of a desktop computer can cause thermal gradients. It is recommended to use it at a place where the thermal gradient or air flow is minimum.

9.5. Hand-held measurements

Quite often in the lab, quick connections are made by hands & measurements are performed. The human body is an excellent conductor and depending upon the humidity and the skin dryness, currents of several hundred micro amps can easily pass through it even with low voltages. Hence all measurements should be performed with proper electrical connections. Avoid touching any of the conductors during the measurements.

9.6. Avoid RF interference

Keep cellphones and wireless routers away from the ZS1100A when under use.

RF equipment like wireless transmitters including mobile phones, Wi-Fi routers can interference with current measurements if proper care is not ensured during measurements. In order to minimize the impact of RF interference, it is recommended to keep the wire lengths short and using a twisted pair cable for the load connections. In case, longer wires are needed, it is recommend to keep the lengths of the cables equal and keep them twisted to the highest degree possible. This ensures that the same amount of RF interference is picked up on the differential inputs and ensures better immunity to such pick-up.

While the ZS1100A is primarily intended to be used with wireless products, the same wireless transmissions can cause errors in the current measurement. It has been observed that keeping a mobile phone close (< 30cm) to the unit can cause noise spikes of about 0.1mA. While this may not be significant in average measurements, the impact can still be felt when analyzing power profiles. Hence it is recommended to keep mobile phones and Wi-Fi access points, which are not being measured, far away from the ZS1100A. The units under measure do not cause major problems as the transmit current will usually be in the tens of milli amps range and 0.1mA during that time would be not significant.

RF energy can also get rectified by the non-linear components (even order) on the board and can show up as DC offset at the output. This can cause measurement drift and offset which are difficult to filter out. Hence it is necessary to take precautions to avoid RF interference.

The design features common mode chokes (shown below), which reject RF interference which is picked up on both the output wires. However, differential signals picked up by the wires, can still cause issues, if the interference is strong enough.

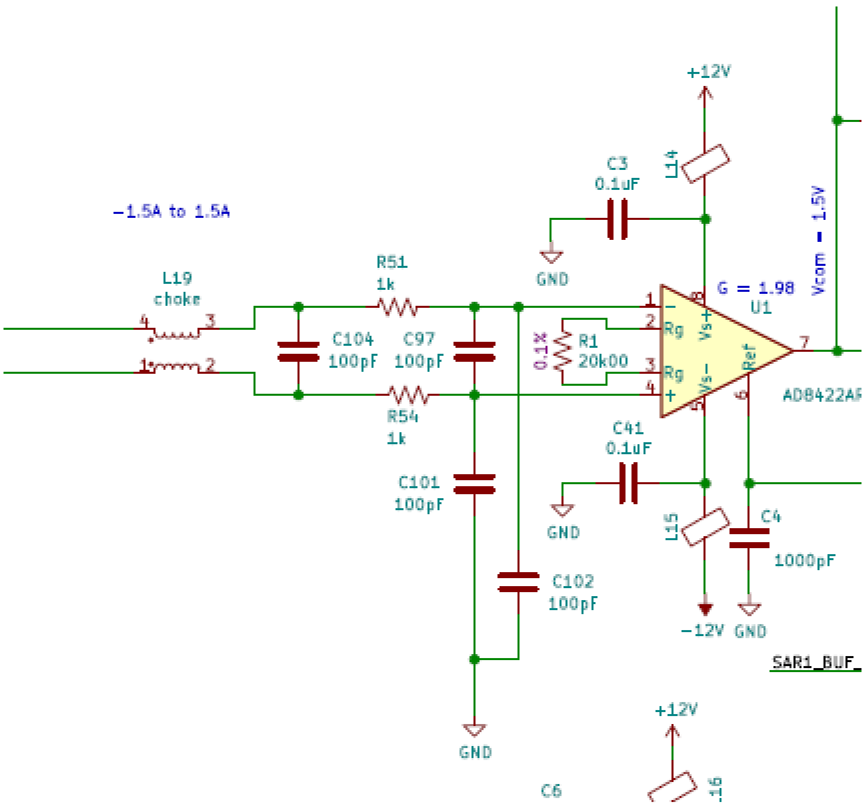


Figure 5 : Use of common mode choke on the signal path

9.7. Isolated measurements

The output terminals have very basic capacitive isolation from the ground. This may not be adequate for many applications. If a true isolated measurement is needed, then it is recommended to use a high speed USB isolator which can work at 480Mbps. We have verified the performance of the unit with the isolator made by Hifime. https://hifimediy.com/product/hifime-high-speed-usb-isolator/

An easier method to achieve isolation would be to use a laptop which is disconnected from the mains supply. This ensures that the ground loop is broken with the mains ground.

In addition, an isolated 15V DC power supply is also required to power the unit. The users may chose to disconnect the ground connection of the DC adapter provided with the kit in order to provide this isolation. However, this presents a risk of an electric shock, in case of a malfunction of the DC adapter.

10. Troubleshooting

Unstable connection or connection problems

1. Install the VC++ Redistributable package from Microsoft https://aka.ms/vs/16/release/VC_redist.x64.exe
2. Install the latest FTDI drivers from FTDI's website https://www.ftdichip.com/Drivers/D2XX.htm

GUI crashes during data collection

1. Check for the loading on the CPU.
2. Check for free disk space and available memory as per minimum requirements

Output voltage is lower than the set voltage

1. Check the output load current and current limit to ensure that the load is well below the current limit
2. Check the output resistance setting. The output will drop linearly with the output load with high resistance by a factor I x Ro

11. Frequently asked questions

Q1. Why is my measurement showing a lot of noise? For e.g. I am measuring a current of 10uA, but the chart shows that the samples are a low as -20uA. How is this possible?

Answer: Noise is inherent part of any electronic system. To get a fast rise time performance, the bandwidth of the system has been increased. The noise power is directly proportional to the bandwidth and hence we observe higher noise in the system. However, the noise will not impact the measurement adversely as the average value of the noise would tend to zero across enough samples.

Q2. Why do I observe some ringing and overshoot in the measured current?

Answer: The ringing observed is caused by the inductance of the wires. If this length can be reduced, the overshoot and ringing can also be minimized. The chart display on the GUI uses cubic spline interpolation to display data. In some cases, this can lead to overshoots which are not necessarily part of the measurement. However, the overshoot and undershoot is limited to 5% of the settled value.

Q4. Can I use any DC Adapter with the IOT Power meter?

Answer. NO.

All DC Adapters are not the same, even though they are of the same output voltage and current capacity. Some of the DC adapters tend to be noisy, and this can severely impact the current measurement. Hence it is recommended to use the same DC adapter which is supplied with the kit.

Q5. Is it necessary to perform the calibration before each measurement session?

Answer: The accuracy of the measurement is impacted by the ambient temperature and the output voltage set on the meter. Hence it is recommended to perform calibration with each session where the output voltage and temperature would have changed from the previous calibration. As a rule of thumb, it is recommended to perform calibration after each power-up of the unit, or the output voltage changes by 500mV. It is also recommended to wait for few minutes in CONNECTED mode, before performing the calibration. This is to ensure that the tool reaches electrical and thermal equilibrium.

12. Technical Specifications

Parameter	Specification	Notes
Output voltage range	0 to 6V	Programmable in 10mV steps
Output voltage accuracy	Error of 5mV max	Measured with 100mA load
Current Measurement range	-0.5A to 1.5A (Linear Range)	
Current measurement accuracy	1% of measured value +/- 0.2uA	After one time self calibration.
Current measurement resolution	< 0.1uA	
Max Output current	1A constant current	Vout = 5.0V
	3A with 10% Duty	Measured with 100ms pulse for every 1 second.
Load regulation	<1%	0 to 1.5A
Measurement bandwidth	300KHz	3dB bandwidth, Single pole RC filter.
Step Response	2µS	10% to 90% of full range.
Current Sampling rate	1MHz	
Sampling jitter	10ps	RMS jitter
Voltage sampling rate	Once in every 20ms	Set by the GUI
Digital Capture	6 bits at 1Msps	Bits D0 through DD3 have internal 100K pull down resistors Bits D4 & D5 have internal 100K pull-up resistors
Maximum capture length	Tested up to 24 hrs	Limited only by the free space on the HDD.
Error Rate	< 1E-12	Less than 1 error in 10^{12} samples. Or less than one sample error in 24 hours.
Export format	XML, Sigrok	
Operating environment	15C-40C < 90% RH	To be used indoors in a lab environment only
Power Consumption	< 1W	USB power < 1W for measurement unit. Load current is supplied by 15V DC Adaptor
Standard Conformance	CE, FCC, RoHS	

Note : Error rate does not include errors caused by external interference.

13. FCC Supplier Declaration of Conformance (SDoC)

These devices comply with Part 15 of the FCC Rules and Regulations for Information Technology Equipment. Operation is subject to the following two conditions:

(1) These devices may not cause harmful interference, and

(2) These devices must accept any interference received, including interference that may cause undesired operation.