Current measurement challenge of IOT devices

The Internet Of Things (IOT) is buzzword these days, with millions of developers involved in creating differentiated products. By various estimations the number of devices connected to the internet would exceed 20 Billion shortly. Most of these IOT devices are powered by small batteries and optimizing the battery life is one of the most critical design challenges in this area. For predicting the battery life, an accurate estimation of the current consumption of the IOT device is needed. This is quite a challenging measurement as explained below.

The Problem

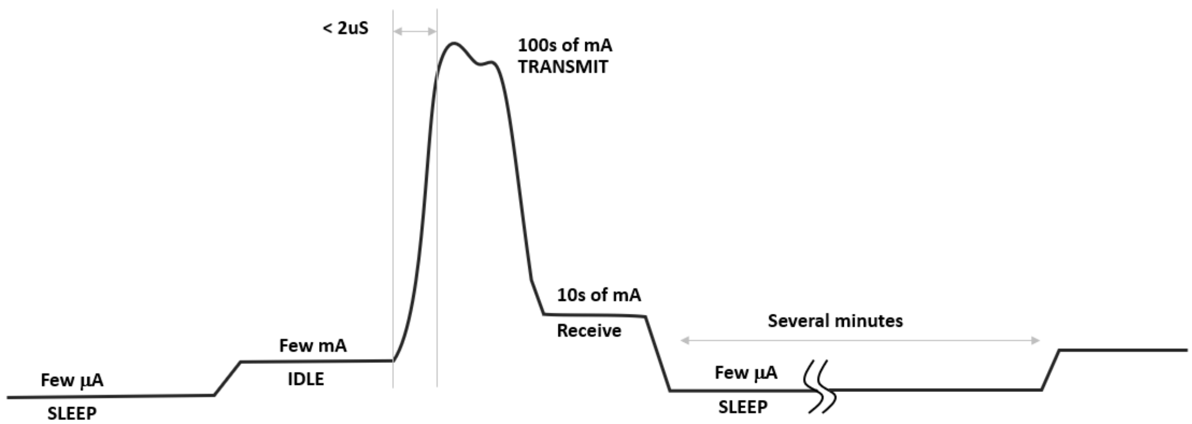

Figure 1 : Typical IOT device current

The current profile of a typical IOT device is shown in the above figure. The device would mostly be in the SLEEP state waiting for interrupt or monitoring some sensors. It would consume few µA from the battery in this state. It then wakes up into an IDLE state consuming few mA as it processes some data. It then transmits this data to the cloud, thereby drawing several 100 mA. The current changes from IDLE to ACTIVE in few micro seconds. It then receives some ACK from the cloud and then goes into SLEEP again. It would stay in this state for extended periods of time well into several minutes. It then repeats the cycle again. Thus the current signal has high dynamic range, requires high bandwidth for measurement and needs to be measured for several minutes, if not hours.

Multimeters cannot measure the currents which has very short pulses. These would get filtered out by the front-end filter. One could use a multimeter to measure the SLEEP currents, but in case of intermittent wake-up, the multimeter would not register any changes. The high resistance of the multimeter while measuring low currents, would cause the measured circuit to trip, during the high current spikes.

Alternate method is to use a series resistor with the load and measure the voltage across it using a oscilloscope. But this method suffers from dynamic range problem. Most oscilloscopes use an 8-bit or 10-bit digitizer, thereby limiting the dynamic range to well below 60dB, whereas the IOT current signal span well over 100dB dynamic range. So one is limited by measurement accuracy. In most cases the total capture length of the profile will be limited to few seconds or couple of minutes, due to memory depth limitations on oscilloscopes.

The Solution: ZS-2102-A IOT Power Profiler Tool

The ZS-2102-A is a tool which is custom designed to meet all the requirement of IOT current measurement. It has a high dynamic range, wide bandwidth and the required accuracy to measure the power consumption of IOT devices accurately.

Features of the tool

- Precision Analog design to achieve both dynamic range and bandwidth
- High Dynamic Range from uA to 1A in single range. No range switching
- High Bandwidth and excellent step response of < 2us
- Sampling rate of 1Msps for current.
- High Accuracy (1% +/-1uA)
- Resolution better than 100nA
- Low series voltage drop. (0.1 Ohm resistance across the range)
- 0 to 6V input voltage range.Voltage sampled every 20ms with 1% Accuracy
- 2 Quadrant operation (V+,I+) & (V+,I-)
- Supports negative current measurement to account for battery charging.
- Electromagnetically shielded for excellent noise reduction.
- 8 Bit Digital IO capture for synchronization.
- Real world battery models for accurate battery life estimation.
- Long continuous capture time (24 hrs capture tested)
- State of the art data compression saves disk space. (24hrs on 10GB)
- Free GUI with waveform analysis tools for Windows.
- Conforms to FCC, CE & RoHS standards

Measurement setup

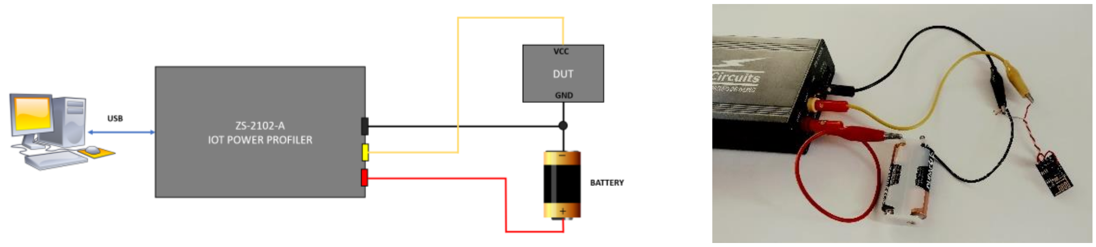

Figure 2: Measurement Setup

The device is very simple to setup and use. Just insert it like an ammeter in series with the load and connect the ground reference from the circuit. Plug it into the USB slot of a PC and the setup is ready to make measurements. As an example, we measure the current drawn by a popular WiFi module as it connects to an access point.

The Wi-Fi module is programmed with a firmware to periodically wakes-up, connect to an access point and then go to the sleep state for 50 seconds. Then it wakes-up on an internal timer interrupt.

The GUI screenshot is shown above. The tool can collect the data from the DUT continuously for multiple hours. This is very useful for debugging intermitted current spikes. With the current and voltage data measured, the GUI can accurately estimate the battery life using the real world battery models. The battery model actually takes into account, the capacity degradation due to peak currents, the battery recovery time, total capacity etc.

Measurement results

Shown below is the in-rush current drawn into he module as it is connected to the power. This is the input capacitor charging from the supply. Note the narrow current spike. The spike rises from few µA to almost 1A in few micro seconds.

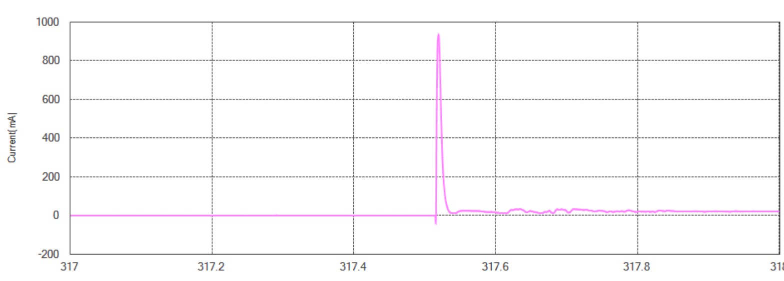

Figure 3: In-rush current into the module on power-up

The module then performs a calibration of the internal power amplifier where it is taken across different power levels and frequencies. The current profile measured clearly shows this pattern. This profile can be used to estimate the bulk capacitor value.

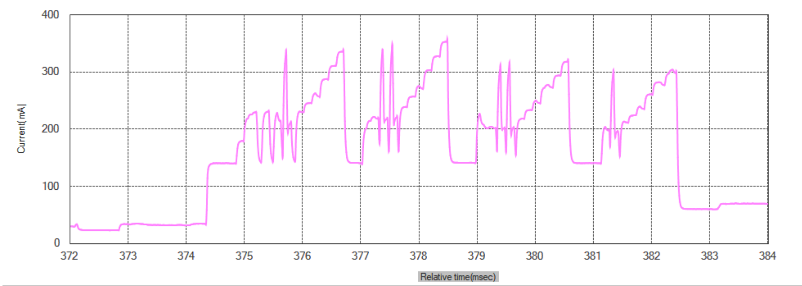

Figure 4 : Current drawn by the module during calibration.

Then some transmit pulses are measured, which are mostly rectangular pulses with sharp rise times. These pulses rise from few mA to 350mA in couple of micro seconds. Again the ZS-2102-A is able to catch up with these pulses and record them in real time.

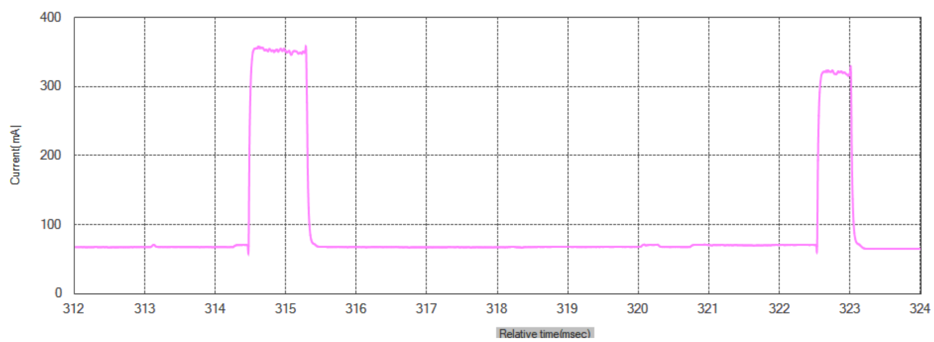

Figure 5 : Current pulses corresponding to transmission.

In addition, the tool also captures digital IO signals which provides a mean to synchronize external events with the current profile. This is very useful for differential power analysis in crypto hardware.

With the accurate power profile information in-hand, it is very easy to estimate the average battery life. It also helps to estimate the size of the bulk de-coupling capacitors as these are often arrived at by guess work. The peak current information can be used in a simulation setting to simulate the capacitor value for the system.

Summary

The ZS-2102-A is a tool which is customized to measure the power consumption of IOT devices. It is accurate, fast and has a wide dynamic range which is a key requirement of measuring the current of IOT devices. The ZS-2102-A can be very handy for a system designer to optimize his hardware. It is very useful for a firmware developer in understanding the impact of the firmware on the total battery life. An application developer can use this tool to optimize the application to prolong the battery life thereby enhancing the user experience. This tool is an absolute must-have for any IOT developer.

For more details on the tool visit www.anglercircuits.com

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