Powering throught micro USB

Since there are a lot of issiues with underpowered boards, this 'White Paper' should explain why it's recommendet to think about the powering situation of your board (especially if it's powered throught micro USB).

Basics:

It's all about Ohm's Law (eq. 1), your SBC needs a defined voltage (U) and current (I). So the only variable that we can influence is the resistance (R)!

$$U = R * I \ (eq. 1)$$

The micro USB cable which powers our board acts as resistor between the output of the power source and the input of our board. For the moment, let's assume our power source delivers a stable Voltage (what isn't true, depends on current needed) and our cable has fixed resistance (what's more or less correct). It's clear that the more current is needed, the more drops the voltage (fig. 1).

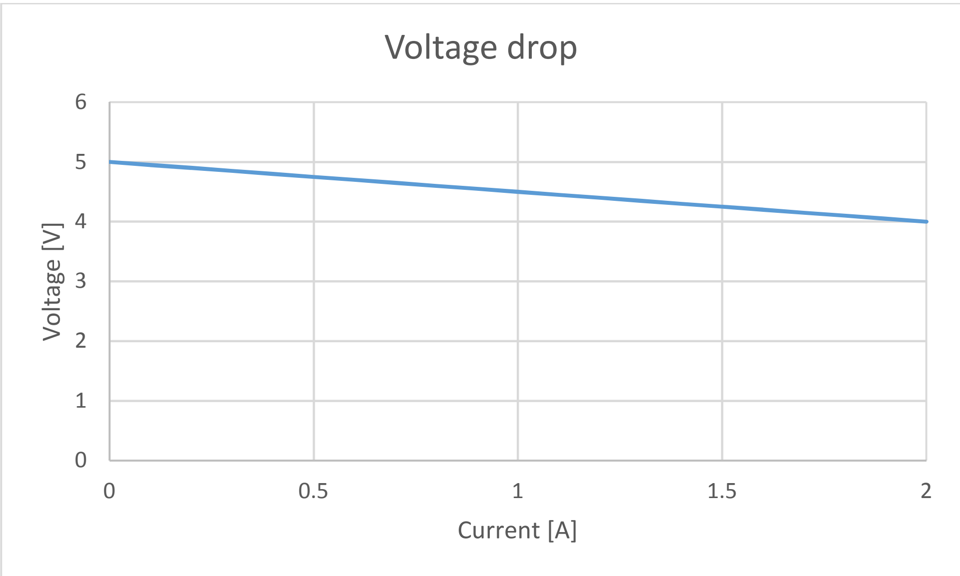

Figure 1: Voltage droping (cable ressistance was assumed to 0.5 Ohm)

Depending on your SBC, it's more or less tolerant to such a voltage drop. But the result is mostly the same → software instability.

How can we influence the resistance of our cable, this is simple → Use the thickest and shortest cable that you can find. The resistance of a round coper wire is defined by eq. 2.

$$R = \frac{\rho * L}{A} \qquad \begin{matrix} \rho: Resistivity \\ L: Lenght \\ A: Cross - sectional\ area \end{matrix} \qquad eq. 2$$

Cause ρ is a material constant, only length and thickness could be changed. The length can easily be checked. Whereas for the thickness you have to cut the cable and check it, or trust the vendor that he doesn't cheat you (the more copper inside a cable, the higher the production cost). The American wire gauge (AWG) classifys the thickness of your copper wires inside your cable. Its often written on your cable. Micro USB cables have mostly a AWG number between 30 (d=0.255mm) to 20 (d=0.812mm) for realy good ones.

Example:

If we assume that there’s no voltage drop from the connector (which is not true) and the power source has an output of 5.1 V @ 2.0 A and our SBC needs >4.8 V to run properly*. How long can a copper-cable with a defined diameter be before the SBC crashes?

*this numbers are chosen randomly, since I don’t have any validatet numbers when a specific board runs into instability.

Using eq. 2 for cables between EWG 20 and EWG 30 gives us the following results (fig. 2).

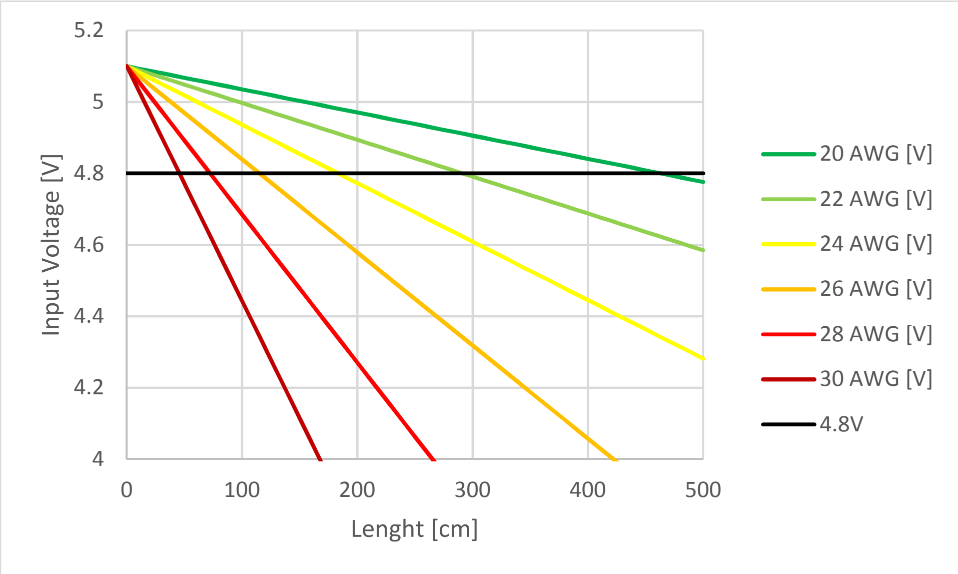

Figure 2: Voltage drop of a copper cable at various thiknesses

If we only had a voltage drop due to the cable length (no resistance from the USB connectors nor inside the SBC) we could have cable lenghts between 40cm (AWG30) up to 4.8m (AWG 20). But that’s not the reallity! To illustrate this, some measurements on a real issue were done.

Case Study:

Three different USB-Chargers and four different micro USB cables were used to charge a ‘xtorm’ powerbank (from the powerbank spec, it should be possible to charge it with 2.0A @5V). This powerbank has to possibilities for charging. With the ‘onboard’ USB-cable or with a micro-USB input. With a ‘Keweisi’ USB-Powermeter on one side and a multimeter on the other side current, and voltage drop during charging was measured (Illustration 1).

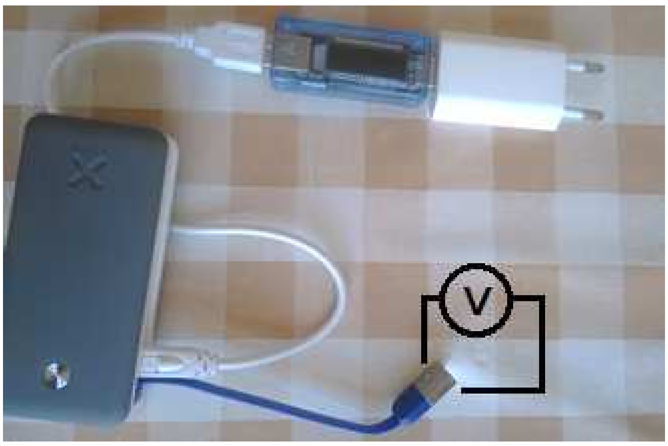

Illustration 1: Setup vor measurement

FYI: These measurements weren't made under laboratory conditions nor with high precision equipment. All chargers are listed in Table 1.

Table 1: Specification of the tested chargers

Model:	Claimed Specification:	V out without load:
Noname phonecarger from Aliexpress	2A @5V	5.28V
iPhone 5	1A @5V	5.19V
TrekStore	2A @5V	5.36V

Table 2 displays the tested micro-USB cables, they came mostly from buyed usb devices and were not especially buyed to power a SBC!

Table 2: Tested micro USB cables

No.	Source	Length [cm]	AWG
1	External USB HD	30	-
2	TrekStore x86 7’’ tablet	80	-
3	Arduino clone	100	30
4	Mobilephone charger cable	65	28

Results:

After all this theory, lets have a look how much the voltage drops at delivered current. All resulsts are sumarized in Fig. 3.

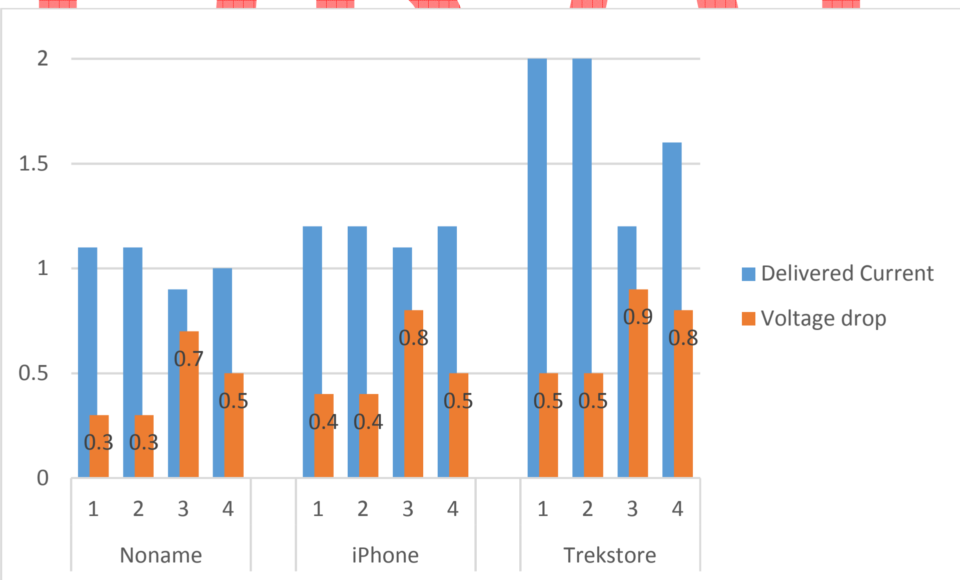

Figure 3: Voltage drop at delivered current of all chargers

Firstly, we see that the noname USB charger from aliexpress couldn’t deliver the claimed 2A, it seems like that it is more or less a 1A charger sold as 2A charger. The short USB-cable and the one deliverd to power a tablet (cable 1&2) performe well, with only a small voltage drop and the highest current. Even at arround 1A the thin cables (cable 3&4) have a realy hight voltage drop of around 0.5-0.7V! This is similar on the iPhone charger. If we go to high current, the situation becomes interesting. Even if the charger can deliver such a high current (cable 1&2), thin long cables (cable 3&4) can't deliver it and the voltage drops more than 0.8V! That’s definitely not a recommended setting for a SBC.

All these chargers are a little bit above the 5.0V at its output so no problem, right? 'If I use a short cable this small voltage-drop of around 0.3-0.5V wouldn't be a problem. That's not true! As soon as the charger must deliver higher current the voltage drops at its output (Fig 4).

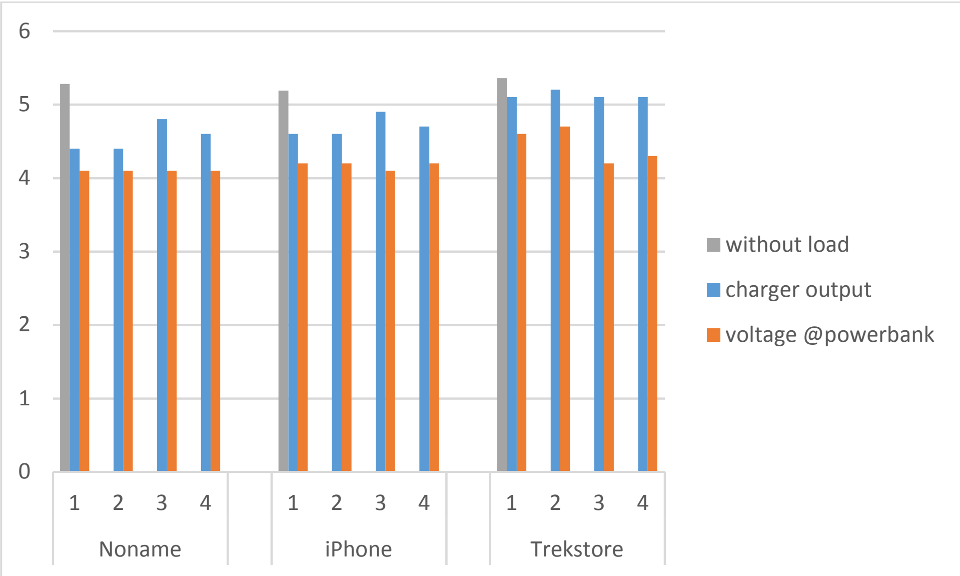

Figure 4: Voltage without load, with load and on output and @powerbank

Worst in class here to is also the noname cell phone charger. It delivers around 4.1V on the powerbank side. The iPhone charger doesn't perfome much better. Even the Trekstore charger, which is able to deliver 2.0A couldn't do this at 5V. With a short cable, it's around 4.6V. I wouldn't recommend one of these chargers to power a SBC with some peripherals attached to it.

Conclusion:

What's next? Should we never buy again a micro USB powered SBC? IMO no! A micro USB powered board is not a no go. But we should keep the powering situation in mind when we have such a device. Long thin cables are definitely not recommended for powering such a device. Even short cables with a bad power source will end in touble. It stands and falls with your setup (e. g. powerconsumption of your SBC, perepherials attachted to it) and the choosing of the right charger. For example, I use a charger (2A @5V) with a fix attached AWG 22 cable (Ill. 2). Doing the same test with it (current and voltage under load at its output could not been mesured since there is no USB for the powermeter) showed 4.84V on the output of the powerbank and 5.20V without load. Which is about 0.2V more than the Trekstore charger with the best cable attached to it. Spend a little bit more money on your powersource and you eliminate one of the possibilities to frustrate you!

Illustration 2: Recommended powersource