A discussion paper about why a cheap carbon battery is best to power your fuzz face pedal.
• In most applications it is convenient to think of a 9V battery as a perfect voltage source. You connect it to the pedal and it provides current until “goes flat”.
• For many pedal applications this is “close enough” to reality.
• What’s actually happening is far more complex....
• How we usually think of a battery:
• Something closer to what’s actually going on (Thevenin based model):
• This is only an approximation of what’s really going on in the battery’s chemical reaction, but it is close enough to be a useful model.

• Let’s ignore the “self-discharge resistance”… it has much less effect than the others on tone.
• Every battery will have a different **Series resistance**, **Transient resistance**, and **Transient capacitance**.

• More importantly, these characteristics are dependent on how “full” the battery is and they will change over time.

• Broadly speaking, a carbon battery will have higher **Series resistance**, **Transient resistance**, and **Transient capacitance** than an alkaline battery. I’ll come back to that…
• Let’s see what connecting the battery to a pedal does.

• Ignore the Transient resistance for a moment and imagine you have a pedal connected with a steady current draw of 10mA.

• 10mA at 9V gives an effective “resistance” of the pedal power circuit of $9/0.01$ or 900 Ohms ($\Omega$).
• This works out just fine if the battery is full.
• By definition, the battery being “full” means that the **Series resistance** is very low – usually in the order of a few Ohms.

• Let’s say the **Series resistance** is 5Ω. 10mA going through 5Ω will cause a voltage drop inside the battery of 5x0.01 or 0.05V. Leaving the pedal powered with 8.95V. All good.
As the battery discharges, the **Series resistance** goes up – in fact, this is the electrical definition of a battery discharging... it’s not that the voltage goes away, it’s that the **Series resistance** gets so large the battery can’t do anything useful.

Imagine the **Series resistance** is now up to 500Ω instead of 5Ω. Everything changes. The 9V is now going across a total of 900+500Ω. Giving a current through the pedal of 9/1400 or 6.4mA. This gives 0.0064x900 or about 5.8V to the pedal. Ouch. Flat battery!
• Now, this isn’t all completely accurate from an engineering viewpoint. The pedal doesn’t stay at 900 Ohms as the voltage drops and the **Series resistance** isn’t strictly linear, but it is close enough to illustrate a point.

• The point is this – the battery **Series resistance** will mess with voltage provided to the pedal, and the bigger the **Series resistance** the larger the effect.

• If you add the effects of the **Transient resistance**, and **Transient capacitance** the overall effect is even larger.

• Let’s talk about **Transient resistance**, and **Transient capacitance** for a moment. These are a measure of how much “inertia” the battery has to changing load. The smaller they are, the less effect there is on the voltage that ends up on the battery terminals.
• To summarize:
  – Higher **Series resistance**, **Transient resistance**, and **Transient capacitance** will have a greater effect on the battery terminal voltage.
  – Lower **Series resistance**, **Transient resistance**, and **Transient capacitance** will have a smaller effect on the battery terminal voltage.

• Now, messing with the battery terminal voltage… messes with your tone. Higher **Series resistance**, **Transient resistance**, and **Transient capacitance** is a bit like putting a “dynamic starve” control on the pedal.

• This is bad for many types of pedal. You wouldn’t want it for your delay pedal, for example.

• BUT. The tone of your fuzzface actually relies on it. Let me state that again. **For a fuzzface to sound like a fuzzface, the pedal needs a power source that has high Series resistance, Transient resistance, and Transient capacitance.**
• For a fuzzface to sound like a fuzzface, the pedal needs a power source that has high **Series resistance**, **Transient resistance**, and **Transient capacitance**.

• You are probably one step ahead of me by now and have worked out that cheap carbon batteries have high **Series resistance**, **Transient resistance**, and **Transient capacitance**. So the pedal sounds like it should if you use one.

• It’s no coincidence that when the circuit for the pedal was developed cheap carbon batteries were the only thing available…

• Alkaline batteries have very low **Series resistance**, **Transient resistance**, and **Transient capacitance** (bad, for a fuzzface). Regulated power supplies are even lower (worse, for a fuzzface).

• Can you hear the difference? ABSOLUTELY.