Episode Book

EPISODE #5734

USB Amps: What Actually Happens When You Plug In

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SYNOPSIS

Daniel wrote in with a drawer full of five-volt gadgets, dubious adapters, and one big question: does the plug have to match the device's expected amperage? The answer flips the instinct most of us have. Current isn't pushed into a device — it's pulled by the device, which means an over-spec charger is harmless and an under-spec one is where things actually go wrong. Along the way: why a 1996 connector with a 4.5-watt spec ceiling pushes 30 watts in the wild, how the Battery Charging 1.2 handshake works (it's just shorting two data pins), why a Nexus 7 once starved itself on a 2.1-amp port, and why Type A's dumb always-on five volts is exactly why cheap gadgets still cling to it.

TRANSCRIPT



Corn

...and the thing about the drawer is that you never actually audit it. You just keep adding to it.



Herman

Everyone has that drawer. Mine has a charger from a phone I don't own anymore.



Corn

Which phone?



Herman

I don't remember. That's the point of the drawer.



Corn

Herman, we should probably get to the actual prompt, since Daniel went to the trouble of writing it down rather than just thinking it loudly at us.



Herman

Right, yes. Sorry.



Corn

So Daniel's written in with a whole cluster of questions, and they're good ones. He points out that an enormous number of devices run on five volts over USB, and that Type A is a legacy connector, but it's the power input for countless appliances, so we're going to be figuring out how to connect these things for a good while yet. Then he names the problem: when you go looking for ways to plug them in, you fall into a world of dubious adapters that were mostly built for charging phones. Some of them promise to power four Type A sockets off a single plug head, which he says always struck him as a bad idea. And



Corn (continued)

then the big one, the amperage question. He says he'd always assumed a five volt device could negotiate its draw, and that any decently engineered USB plug would accommodate the modest currents these devices pull. But then you see adapters rated five volts one amp, five volts half an amp, and up from there. So is it essential to pair the plug to the current the device expects, or is that conservative marketing in large part?



Herman

Four separate things in there. And the fourth one has a real answer.



Corn

Let's start with why we're even having this conversation in the first place, because Type A is a 1996 connector.



Herman

Nineteen ninety-six, and the official spec tops it out at four and a half watts. Meanwhile some Type A ports in the wild deliver thirty watts.



Corn

How does a connector with a four and a half watt ceiling end up pushing thirty?



Herman

Because the spec is the floor of what everyone agrees to, not the ceiling of what the hardware can do. Vendors shipped fast charging schemes on top of Type A years ago. Qualcomm's whole Quick Charge line ran over Type A. So the connector's official limit and the connector's real-world limit have been two different numbers for a long time.



Corn

So the two questions we're actually answering today are, one, how does power negotiation and current draw actually work, and two, when you buy one of these adapters, what actually matters.



Herman

And the arc I'd want to run is mechanism first, then the multi-port problem, then the safety landscape.



Corn

Mechanism first, because everything else follows from it. And there's a fresh angle here I want to flag up top, which is that Type A's dumb, always-on five volts is not a defect. It's exactly the reason cheap devices cling to it.



Herman

That's the through line. Let's start with the mess before there were rules.



Corn

How bad was it?



Herman

Under USB 2.0, in the year two thousand, a device could draw a hundred milliamps by default. It could negotiate up to five hundred milliamps, and that was the maximum. But a suspended bus limited draw to two and a half milliamps.



Corn

Two and a half.



Herman

Two and a half milliamps. So if you plugged in a device with a completely dead battery, and the bus went to suspend, the device could only reliably pull two and a half milliamps.



Corn

Which is essentially nothing.



Herman

It's essentially nothing. Charging in that era was a crapshoot.



Corn

That's a great phrase.



Herman

It's Analog Devices' phrase, I'll be honest.



Corn

Still good.



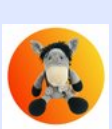
Herman

So the industry wrote a rulebook. Battery Charging specification one point two, released in twenty ten, and it defined three kinds of port.



Corn

Name them.



Herman

Standard Downstream Port. Dedicated Charging Port. Charging Downstream Port.



Corn

And the difference is?



Herman

An SDP is what you get on a laptop. Two and a half milliamps suspended, a hundred milliamps connected, five hundred milliamps once configured. A DCP is a charger with no data lines at all. D plus and D minus are shorted together, and it can supply beyond one and a half amps. A CDP is the best of both. Data plus up to one and a half amps.



Corn

So a device has to figure out which one it's plugged into.



Herman

Yes. And for a DCP, the detection is beautifully primitive. The device drives D plus high and measures D minus. Then it swaps. If the port shorts them, both readings come back the same, and the device concludes, I'm on a dedicated charger, I can pull real current.



Corn

That's it? That's the whole handshake?



Herman

Electrically, that's it. A DCP is D plus and D minus shorted, with a maximum of two hundred ohms between them. That's the entire definition.



Corn

Which means a device that's built to look for that specific signature is looking for something very easy to fake.



Herman

And vendors did fake it. Apple's one amp and two point one amp chargers used resistor dividers on D plus and D minus instead of the BC one point two short, so the device would read a specific voltage and conclude, this is an Apple charger, I can pull two point one. Samsung did the same thing on Galaxy tablets for two amps.



Corn

So you had a spec, and then you had three or four proprietary dialects layered on top of the spec.



Herman

Which is why adapter emulators exist. Chips like the Maxim MAX fourteen six thirty and MAX fourteen six thirty-two sit in a charger and auto-detect what the device is asking for, then switch the resistor network to match. They speak every dialect.



Corn

So a modern multi-port adapter is basically a little translator.



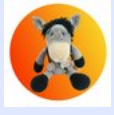
Herman

It's a translator that's guessing.



Corn

Right. Now the amperage question.



Herman

Here's the answer, and it's the load-bearing fact of the whole episode. The device controls the draw. Not the charger.



Corn

Say that again, because I think people have it backwards.



Herman

The device controls the draw. Anker puts it plainly. The device itself controls how much current it draws. If a gadget is capped at one amp, it will only draw one amp, even when plugged into a two amp charger. EcoFlow says the same thing. You can plug a device built for five volts one amp into a five volt two amp charger that supplies higher current, and the device only draws what it needs.



Corn

So the classic fear, that a bigger charger will force current into your device and fry it, is just wrong.



Herman

It's wrong. Current isn't pushed. It's pulled. The charger advertises what it's capable of, and the device takes what it wants.



Corn

Then why do we all have the instinct that it matters?



Herman

Because the reverse case is real. Ask Leo spells it out. The amperage provided must match or exceed what the device requires. Greater than the requirement, it works. Matching the requirement, it works. Less than what's needed, and the device may fail, may run or charge slowly, the supply itself may overheat, or the device may be damaged.



Corn

So under-spec is the dangerous direction.



Herman

Under-spec is the dangerous direction. Over-spec is fine. That's the whole asymmetry, and the instinct people have points the wrong way.



Corn

Here's the part I don't fully understand though. If the device controls the draw, how does it ever draw less than it could?



Herman

By failing to recognize the port.



Corn

Give me the example.



Herman

The Nexus 7. Plugged into a two point one amp port, and it drew five hundred milliamps.



Corn

It willingly starved itself.



Herman

It saw data pins where there shouldn't be data pins, assumed it was on a standard downstream port, and applied the five hundred milliamp USB spec limit. There was more current available and it refused to take it.



Corn

So the negotiation can fail in the safe direction too. The charger is generous and the device doesn't believe it.



Herman

And that's actually the more common failure for Daniel's odd gadgets. It's not that they pull too much. It's that they refuse to pull enough.



Corn

Which brings us to the Type A versus Type C thing, because this is where it gets interesting.



Herman

Type A always feeds five volts to a pin as soon as it has a power source.



Corn

Always. Unconditionally.



Herman

Unconditionally. A sink device doesn't need any special characteristics to receive power. It just touches the pin and there's five volts there. That's it. That's the entire protocol.



Corn

And Type C?



Herman

A Type C source sends nothing until the sink signals readiness. There are resistors involved. The device has to present the right resistance on the configuration channel before the charger will turn on the current at all.



Corn

Which is safer.



Herman

It's much safer.



Corn

And which is why a whole category of devices exists that will not charge from a Type C to Type C cable, but charge happily off a Type A port.



Herman

There was a first-hand account of exactly this in August, on XDA. Devices with Type C ports that flatly refuse a Type C charger and work instantly off a Type A.



Corn

So the device has a modern connector and the internals of a nineteen ninety-six gadget.



Herman

It has a Type C port that's only wired for the shape. Nobody implemented the signaling, so the charger does the correct thing, sends nothing, and the device sits there dead.



Corn

And Daniel's drawers full of these things. Which means Type A isn't just lingering out of nostalgia. It's lingering because it's the port that doesn't ask questions.



Herman

It's the port that works on the device that was built badly, which is a strange kind of resilience.



Corn

So amperage, the short answer. Matching plug to device is not essential in the direction people worry about. A two amp supply won't hurt your one amp device. A one amp supply will hurt your two amp device, or at least disappoint it.



Herman

That's the whole thing.



Corn

So where does the conservative marketing come in?



Herman

Ah. So Daniel framed it as, is the rating essential, or is it conservative marketing. And the honest answer is that the marketing is conservative about the device and generous about the charger.



Corn

Unpack that.



Herman

The ratings you see printed on a charger are almost never about protecting your device. Your device protects itself. They're about what the charger can actually deliver, and that number is the one that's usually optimistic.



Corn

Let's do the four-port thing, because Daniel's instinct there was right and I want to know if it was right for the right reason.



Herman

His instinct is right, but the reason is subtler than too much current.



Corn

Start with the mechanism.



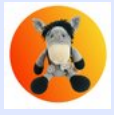
Herman

A multi-port charger has one fixed total wattage budget. One budget. It gets split among all the ports. As you add devices, the per-port share drops.



Corn

And there are two ways to split it.



Herman

Two schemes. Static split, where each port gets a fixed wattage. Predictable, but wasteful, because headroom on an unused port can't help the device next to it. And smart or dynamic sharing, which reallocates in real time, but is still capped by the total.



Corn

So the total is the wall no matter how clever the sharing is.



Herman

The total is the wall. You can't share your way past physics.



Corn

Give me the concrete case, because this is the one that proves it.



Herman

Tripp Lite U two eight zero, the four-UK. Rated five volts, six amps, thirty watts total. Advertised as five volts, two point four amps per port.



Corn

Two point four per port. Four ports.



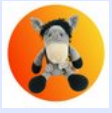
Herman

Read the spec sheet. It delivers five volts at one point five amps per port simultaneously when at maximum capacity.



Corn

So two point four becomes one point five the moment you use what you bought it for.



Herman

The two point four is only achievable when the other three ports are idle. It's true, technically. It's just not true in the configuration you bought it for.



Corn

That is the marketing gap in one product.



Herman

And it's not Tripp Lite being shady particularly. This is standard practice across the category. Look at the others. StarTech's four-port travel charger is thirty-four watts, six point eight amps total. Leviton's four-port wall outlet is four point two amps, twenty-five watts total, and it has a smart chip that recognizes each device's requirement.



Corn

So Leviton's honest about the total and lets the chip sort it out.



Herman

Leviton's number is the real number. Twenty-five watts spread across four ports. Nothing in the copy pretends otherwise.



Corn

So for Daniel's four-port skepticism, the risk isn't that four devices pull too much.



Herman

Right, because the devices control their own draw. That's the irony. He was worried about the wrong direction too, the same way everyone is.



Corn

So what actually goes wrong?



Herman

The adapter quietly gives each device less than it wants. And most devices won't complain. They'll just charge slowly, or behave erratically, or heat up, or reboot intermittently. You'll blame the device. It was the adapter.



Corn

A slow charge and a broken device look the same from the outside.



Herman

They look identical from the outside. That's why this is so hard to diagnose.



Corn

Alright. So a well-built multiport unit is fine, and a no-name one is the hazard. That brings us to safety, and I want the tells.



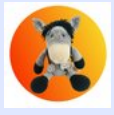
Herman

Hackaday did a teardown of cheap USB supplies, and the findings are the ones you'd want people to know. One unit had no fuse and no protective tape. Another had about a millimeter of creep distance between the AC and DC sides.



Corn

A millimeter. That's the gap between mains voltage and the thing you touch.



Herman

That's the gap. The USB port was soldered by only its four pins, nothing else holding it. There was a capacitor with long uncovered leads sitting dangerously close to the USB shell.



Corn

And the good one?



Herman

The good unit had two PCBs for isolation, protective tape, an injection-molded barrier separating the sides. Output of four point nine volts, quote, with nary a ripple.



Corn

Four point nine versus what the bad one put out.



Herman

The bad one measured five point three four volts under load, which is outside the five point two five USB limit, with a five point five volt peak at four kilohertz. It wasn't a charger. It was a noise generator with a plug on it.



Corn

So my markers to check. Isolation distance first.



Herman

Isolation distance. UL requires a few millimeters between the AC and DC sides, and that's not a formality. It's the thing standing between your hand and the mains.



Corn

Then?



Herman

A thermal cut-off, or a resettable fuse. Secure connectors. And a verifiable label.



Herman

It's doing all the work. The CE mark is the classic example. CE can mean Conformité Européenne, the actual European declaration. Or it can mean China Export, which is the same two letters in a slightly different spacing, and it means nothing at all. And a UL logo with a number you can check is worth more than either, because you can go and check it.



Corn

Unless the number was copied off somebody else's product.



Herman

Which happens constantly.



Corn

Give me the counterfeit figure.



Herman

A twenty sixteen report found more than ninety percent of, quote, genuine Apple chargers and cables sold on Amazon were fake.



Corn

Ninety percent.



Herman

And the comment threads around this made a point that I think is the most useful thing in the whole safety conversation, which is that Amazon commingles inventory. You cannot avoid it by buying from a particular store.



Corn

Meaning the seller is irrelevant.



Herman

The seller is irrelevant, because your order is filled from a shared bin where the real and the fake are mixed together.



Corn

That's grim.



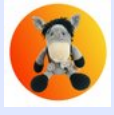
Herman

It is. And a commenter made the other point worth keeping, which is about the economics of it. For every customer that complains and asks for a refund, there might be three or more who don't bother. Some of these counterfeit products have legitimate safety concerns, including chargers with poor AC to DC electrical isolation.



Corn

So the market doesn't correct because the failures are silent.



Herman

Because the failures are silent, mostly. And when they aren't silent, they're catastrophic enough that you'd have heard about it, which makes them rare enough to ignore. It's a bad feedback loop.



Corn

One more thing for the file, a wearable device that shipped with a note saying, use only a one amp charger.



Herman

Which is wrong. That's not how USB charging works. The device controls its draw. So the note is either a misunderstanding by whoever wrote it, or it's a cover for a device that was designed badly enough that it does over-draw.



Corn

And there's no fresh investigation into counterfeit charger safety that we could find. The strongest evidence is that twenty sixteen teardown and the twenty sixteen counterfeit report.



Herman

So treat the safety angle as well established, but dated. The physics didn't change. The paperwork is older than we'd like.



Corn

Daniel's conservative marketing question, answered properly: it's conservative about your device's needs and generous about the charger's capability.



Herman

The charger overstates what it will give you per port when you load it up.



Corn

The device understates what it will take.



Hilbert

Anyway, mine was four point seven.



Corn

Four point seven what?



Hilbert

Volts. The moment I put a second device on it, it sagged from five point one to four point seven. That's below the four point seven five the spec requires, and you can watch it happen with a meter.



Herman

Wait, so a supplier sold you...



Hilbert

Four-port adapters. He said two point four amps per port, all day long. I tested one with a load, plugged in the second device, and watched it drop to four point seven. They're in a box. I kept the lot and I kept the receipt, because I couldn't decide what to do with either.



Corn

You tested it with a load?



Hilbert

I had a dummy load and a meter. I know what a supply is supposed to do under load. Two point four per port all day long, he said. It gave one point four on the second port and the voltage slid.



Herman

The number on the box is a claim about the first thing you plug in and nothing else.



Hilbert

That's right. But here's what I'd correct you on. You've spent the hour telling people the device controls its own draw. That's true. But you're framing the four-port problem as though the danger is the four devices pulling too much.



Corn

You don't think it is.



Hilbert

It isn't. The devices will take what they take. The problem is the adapter quietly handing each one less than it needs, and most devices won't say a word. They'll just charge slow, or behave strangely, and the owner blames the gadget.



Herman

The four point seven is the tell though. That's a device being starved of voltage and acting possessed.



Hilbert

Jittery touchscreen, reboots, a battery that never quite fills. I've had all three of those off one of these.



Corn

The Hackaday teardown found a bad unit running five point three four, outside the upper limit. Yours failed the other way, below the lower limit.



Hilbert

A supply can be wrong in both directions. Above the limit it cooks things. Below the limit it just starves them quietly, and that's the one people live with for a year.



Herman

Behaving possessed. Yeah, that's exactly what it looks like.



Hilbert

The two point four was on the box. The one point four was what it did. Same brick, ten minutes apart.



Corn

The question isn't just whether it's safe. It's whether it's honest.



Hilbert

That'll do.



Corn

The closing thought, and I want to build this on what Hilbert just said, because I think the honest-versus-safe distinction is the actual takeaway. If the device controls its own draw, then why do so many devices still ship with a note telling you to use only a one amp charger?



Herman

Three possibilities. A real design problem, a liability dodge dressed up as a spec, or somebody who never read BC one point two.



Corn

The second question. If Type A's always-on five volts is a feature, not a bug, what happens when the industry finally moves to Type C?



Herman

The cheap devices get left behind, or they get a resistor and a capacitor and they adapt. My read is they adapt slowly, because the incentive is that Type A costs pennies to make, and pennies are the whole reason any of these gadgets exist.



Corn

Type A sticks around because it's cheap and because cheap devices rely on its dumb behavior.



Herman

The risk was never the connector. The connector is a piece of shaped metal. The risk is the adapter, and the marketing that overstates what the adapter will actually give you.



Corn

It's a piece of shaped metal that doesn't ask questions. Which is the highest compliment you can give a piece of shaped metal.



Herman

That's going in the show notes.



Corn

Thanks as always to our producer, Hilbert Flumingtop. This has been My Weird Prompts. If you liked this one, subscribe and leave us a review, it helps. I'm Corn.



Herman

I'm Herman Poppleberry. We'll be back soon.