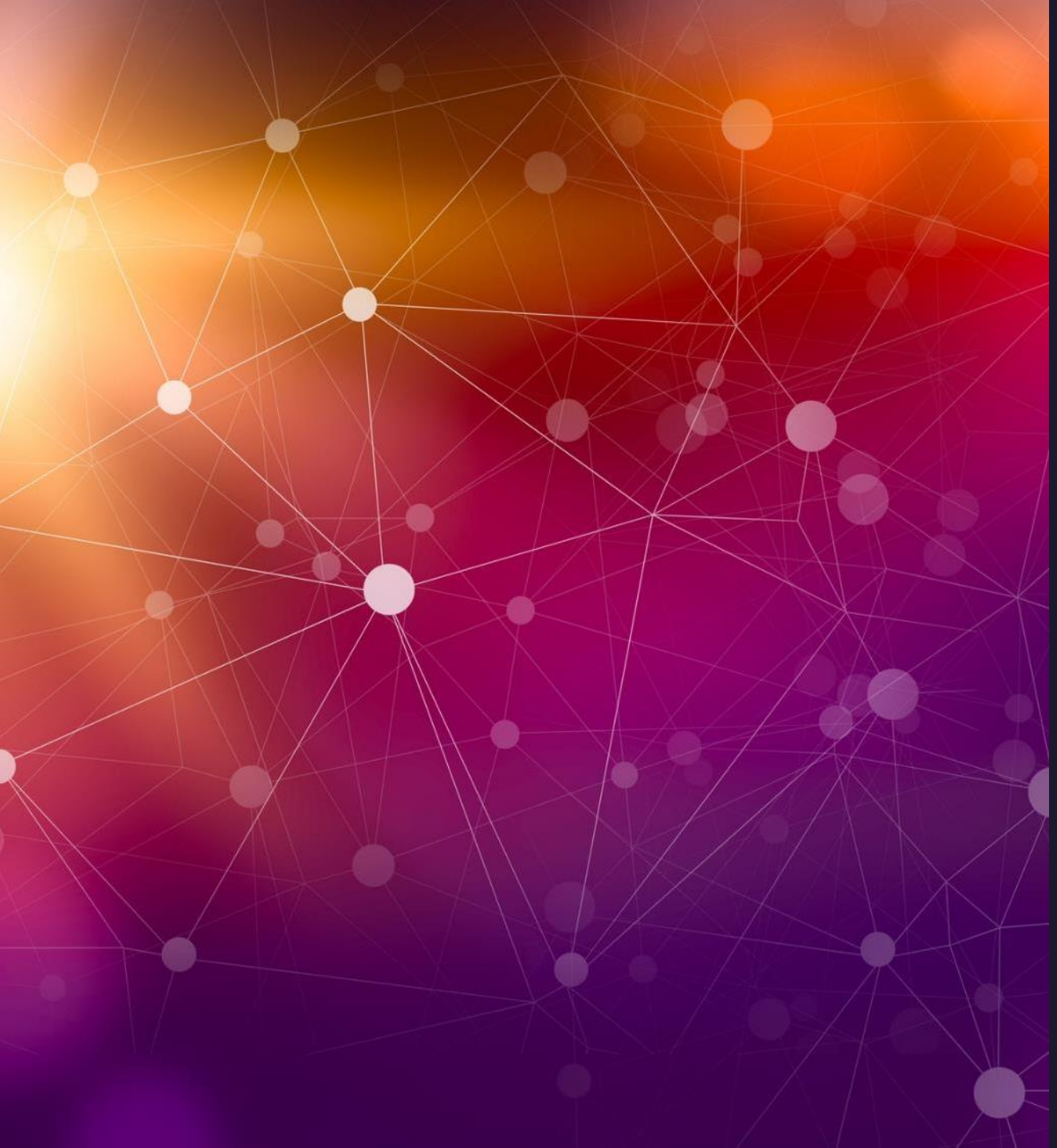


Electricity:

Care and Feeding of your Rig

Linwood Ferguson

TL;DR

Astro setups tend to be “fragile”. They are expected to track at sub arc second tolerances, image where data is less than 0.1% of the range of your camera, and do so while unattended. Murphy is always there to break something.

It is helpful if you don’t provide additional tools to Murphy.

This is about one aspect within your control, where you can remove one of Murphy’s tools.

Electricity!

Short version: Don’t be cheap, provide good power, your rig will be happier, keep Murphy at bay.

Defining Terms

Here is an analogy of terms with water instead of invisible electricity. If you understand electricity ignore these slides.

Voltage is like pressure: the deeper a tank the more pressure at the bottom, so these two tanks have the same pressure. Measured in volts. Voltage (pressure) can exist without any flow (current).

Resistance is like the size of the pipe, bigger pipe, less resistance. Resistance is measured in ohms (Ω, omega).

Current is like volume of water, how much comes out. It is measured in Amps. So consider at right you will get twice the water (current) from the left side than the right due to wider pipe (less resistance).

Power is how much work the result can do, think of it like cleaning away a pile of dirt. You can get similar results from a lot of water at low pressure, or a little water at high pressure. Both represent similar work. Expressed in watts.

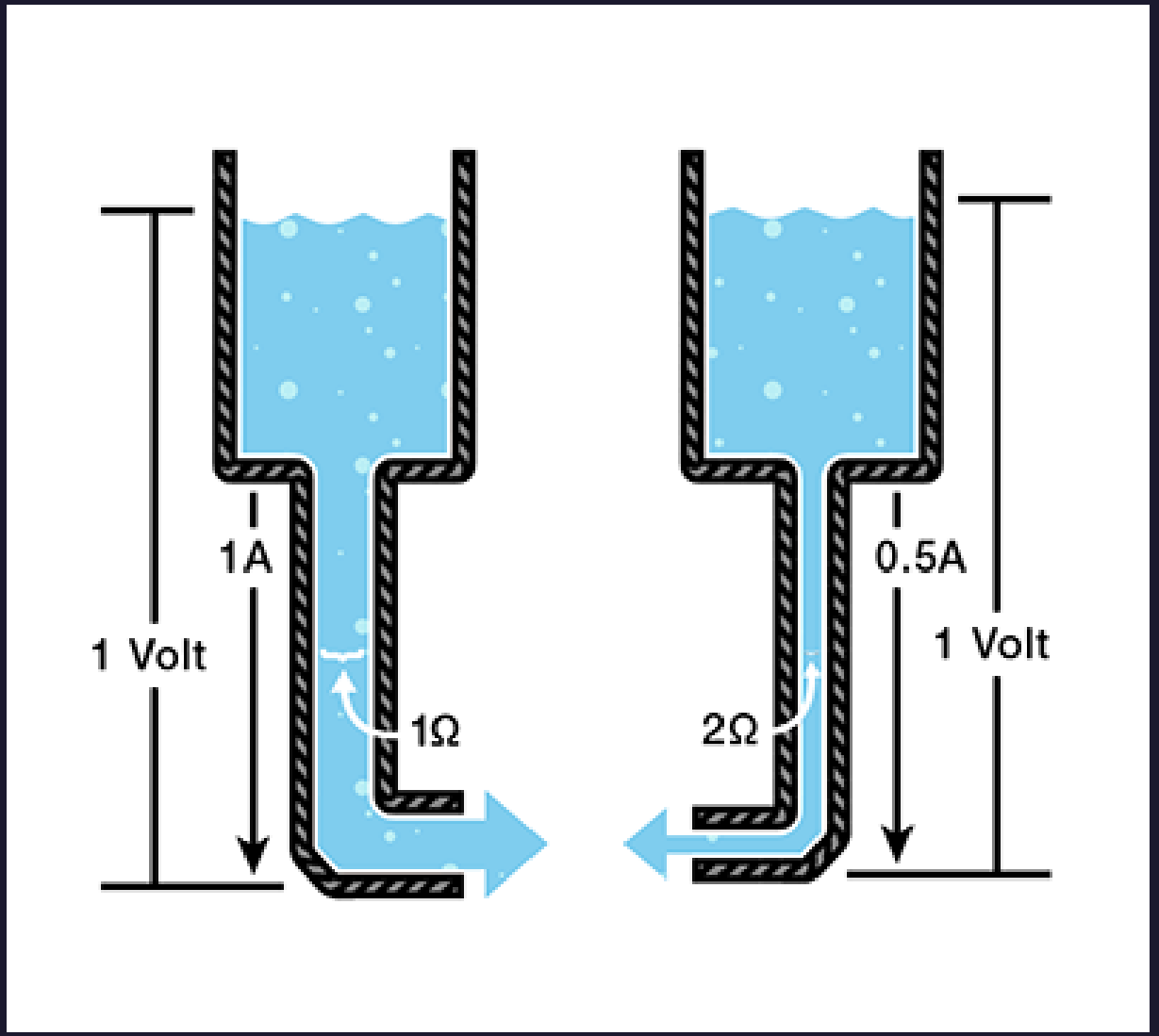
Energy is cumulative amount of power – how much power you had over time (doesn't have a great water analogy). Energy is what you pay for, or how long a battery lasts.

Important math:

Voltage = Resistance x Current

Power = Voltage x Current

$$Energy = \int Power \circ dt$$



There's Always Math

Voltage = Resistance x Current

Power = Voltage x Current

$$Energy = \int Power \circ dt$$

For simple cases:

Energy = Voltage x Current x Time

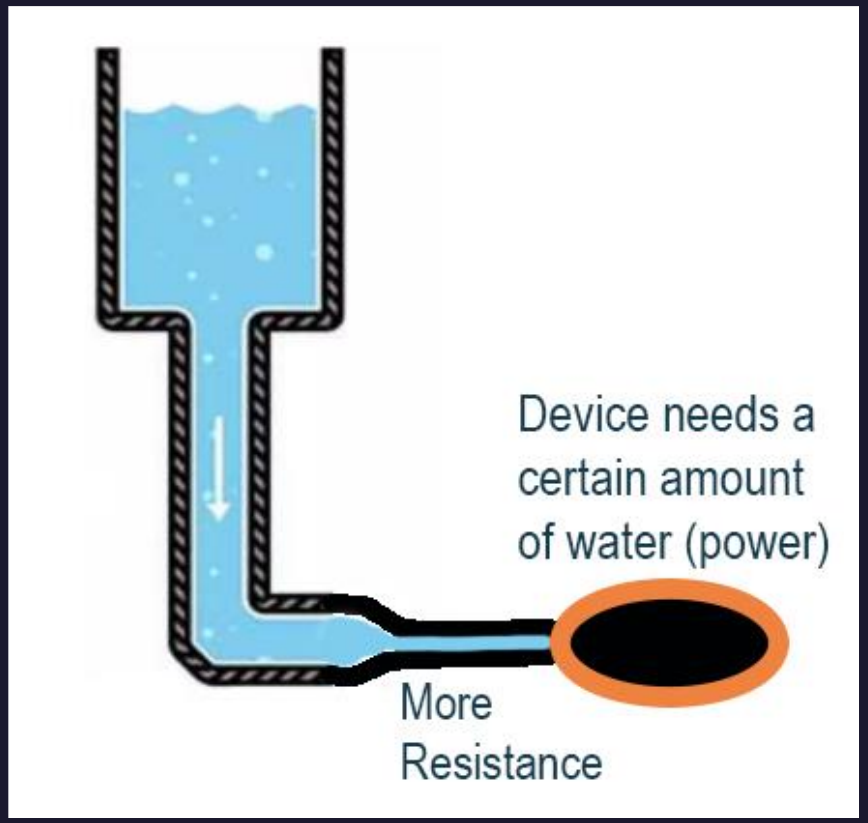
Example: Drawing 3 amps @ 12 v steadily for 8 hours

3 x 12 = 36 watts

3 x 8 = 24 amp hours

3 x 12 x 8 = 288 Watt Hours

Wire Resistance Starves Devices



The metaphor is breaking down a bit, but consider an astro device that needs a certain amount of power. Like a certain volume of water each minute.

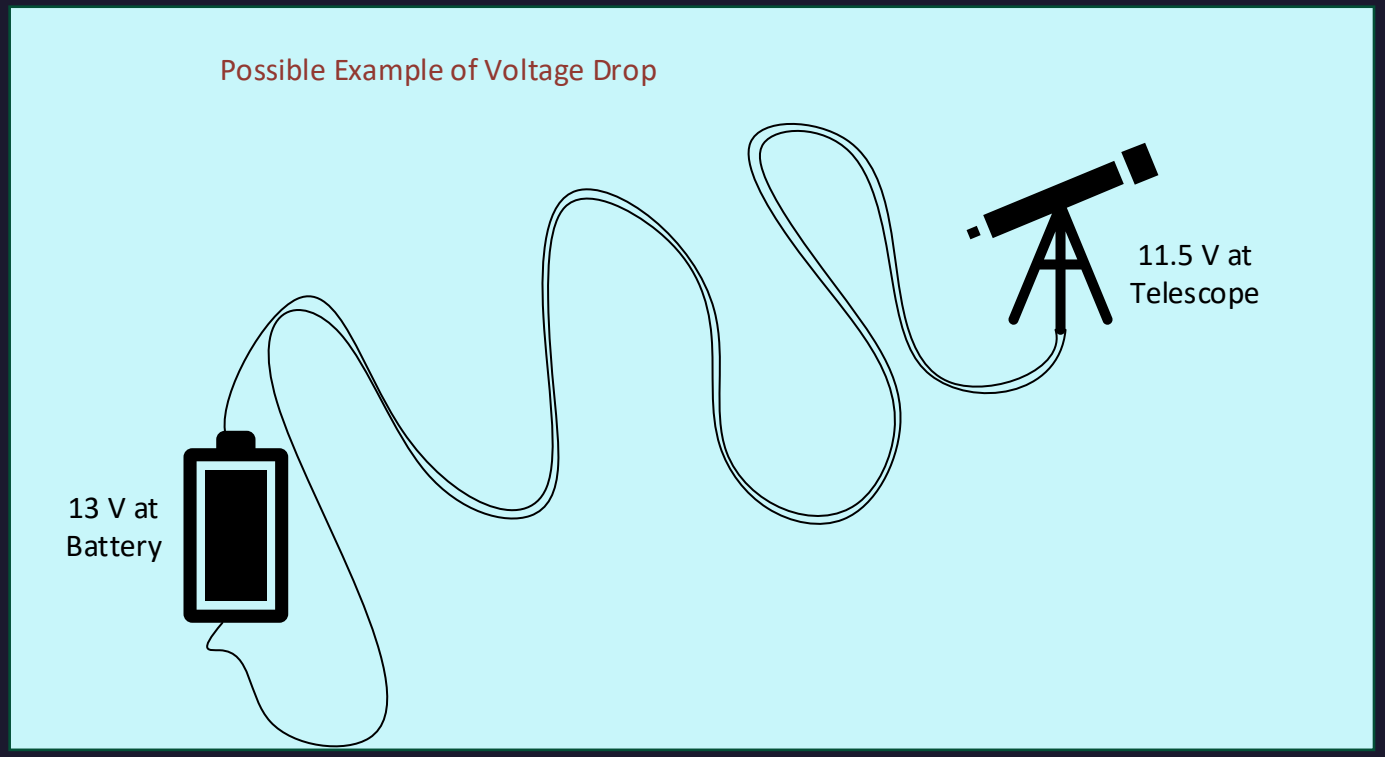
Now imagine your wire (pipe) is thin (high resistance). To get the same volume in a minute you need more pressure (higher voltage).

But you have a fixed voltage (pressure) supply, so your device (if this was water) gets starved for power.

Unlike for water, in the electrical world, the device just draws more and more current over that thin wire to make up, at lower voltage

This is Voltage Drop

For electricity, a device pulls more and more current (for fixed supply voltage) until it gets enough power. The effective voltage at the device goes down by the product of resistance (set by the wire length and size) and current drawn.



With smaller wire, the effective voltage goes down, and the current has to go up for the same power.

Higher current has the potential to damage (heat is from current not voltage).

Lower voltage can mean the device just not working reliably.

This is "Voltage Drop," and can be a significant problem in astro gear.

Important Concepts w/o the Math:

- Voltage Drop is bad if too large (hold that thought)
- Voltage Drop is worse with small wires

  Example: 18 AWG has about 3 times the resistance of 14 AWG.
- Voltage Drop is worse with small connectors
- Voltage Drop is worse with long wires (double length = twice resistance)
- Voltage Drop is worse with aluminum wire (about 50% more)

  (A lot of wire sold on amazon as copper is copper clad aluminum which is really aluminum not copper)
- Voltage drop is worse with more load

  Example: if your dew heaters come on higher as the night goes on, your drop will get worse.

And knowing that, do you make things worse?

The Mythology of 12v Systems

1. Myth: "Most astro gear works off of 12 volts"
2. The term "12 volt" is a classification, not a specification.
    - It comes from ages-old car batteries
    - Car batteries, when charged, are closer to 13 volts, specifically around 12.6-12.9 volts.
    - When being charged (almost 100% of the time while driving) they are around 13.8 volts.
    - They are nearing exhaustion when they fall to 12.0 volts.
3. Almost everything that is "12 volt" is really designed to work with car battery voltages.
    1. They are quite happy at higher voltages, up to 13.9v or so at least, often higher.
    2. They are often quite UNHAPPY at voltages below 12.0v
    3. Unhappy astro gear makes Murphy happy. A happy Murphy is a bad thing.
4. Remember voltage drop? If you want to stay in the "happy" range you need either less drop, higher starting voltage, or both.

Astro Gear Bricks are a Trap

- Most gear comes with their own power supply (individually).
- People tend to use these because “it came with it, so it must be good”.
- However:
  - These tend to be cheap, Chinese “bricks”
  - They often have long, thin wires (sometimes hidden in thick plastic sheaths)
- They often provide just a tiny bit more than 12.0 volts, usually 12.2-12.4
- Starting low means voltage drop hurts you sooner
- The point is not that they do not work, but they reduce the margin of error for other parts of your gear.

What Happens in the Dark....

- You start with a power supply that is just barely adequate.
- You add other devices onto it (think a camera with a USB hub powering your focuser or filter wheel, guide camera)
- You bought Amazon cables that are poor quality (e.g. aluminum).
- You have cheap barrel connectors with thin wires and high resistance connections
- You put extension wires that are long, thin, and coiled
- Now your voltage after voltage drop you are falling below 12.00 volts because you started at 12.20 (+/-)

But (you object)...

"The manufacturer wouldn't send me a bad power supply?"

Let's see – bad reducers, oil leaks, eyepieces that are junk, mounts that can't track without modification, software drivers that fail differently with each new update, mounts delivered with half the screws lose, screw holes that don't align without drilling, tiny-tiny Philips collimation screws that strip after the first use….

It is not necessarily that it is "bad". Each of these individually, in normal temperatures and plugged directly in, will probably work fine with each device. But not with other devices sharing power, in high or low temperatures, with added long, thin, coiled up wire….

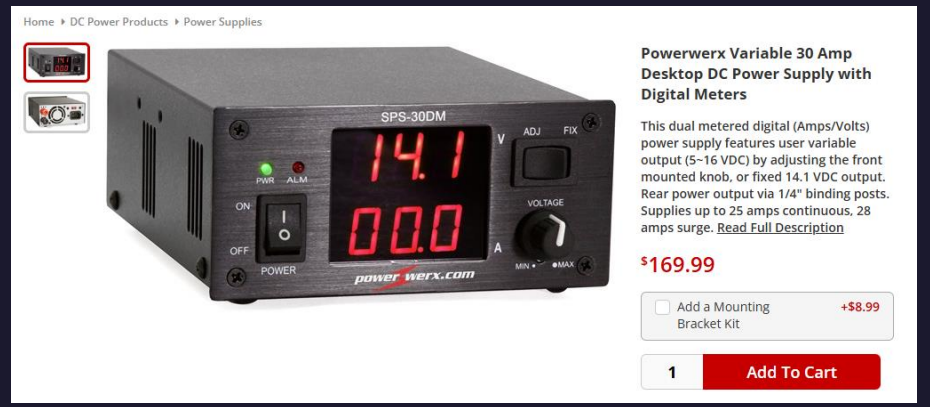
In most cases they send it so for really dumb users they have a known quantity to say "Are you using our power supply" when you make a support call, not because it is "good".

Imaging on the edge of failure ensures frustration.

OK, so what's the better answer? (Step 1)

For Local (110v available) Imaging:

- First, get a good quality regulated power supply, at the high end of battery range, like 3.8 volts (+/-); thus you start with some head-room after voltage drop. Ham Radio enthusiasts know all about good power supplies, trust them (avoid "linear" though).
- My favorites: One is variable voltage (if you are uncomfortable at 14.1v as too high) and has meters, the other is cheaper and uses power poles. Both are adequate for quite large rigs.



OK, so what's the better answer? (Step 1 Cont'd)

For Remote Imaging:

- A big LiFePO4 (Lithium Iron Phosphate, sometimes LFE) battery.
- 100ah likely plenty big for everything, 200ah even better and may do multiple nights.
- Flat discharge curve, at Florida temps is well above 12.5v up to 10% capacity +/-.
- Downsides:
  - Requires special charger
  - Cannot charge if battery temp below freezing (you CAN discharge, i.e. use, below freezing)
  - May not be able to parallel multiple batteries for more capacity (check specs)
- Note: If you set up for one AC power supply and distribution, it makes it trivial to swap that for a battery.

OK, so what's the better answer? (Step 1 Cont'd)

For Remote Imaging: How about a "generator", e.g. Jackery?

- **Good if you really must have 110v inverter, or want to solar charge**
- **Less efficient than a naked battery**
- **Much more expensive per amp hour to buy**
- **Many are not LiFePO4, but chemistry that will not last as long (though probably still more than adequate for astro use with Florida weather)**
- A "generator" 12v may be closer to 12.0v if it is regulated, be sure to check as you may be starting low

Clean up your wiring (Step 2)

Consider a wire distribution bus. I'm a fan of powerpoles, but there are many types. Put the bus on your pier/tripod, run one HEAVY wire from the power supply to the bus, and individual short (heavy-ish) wires to the devices they need to power. Get rid of the tangle of wires leading to your rig and on your rigs.

Clean up your wiring (Step 2 cont'd)

1. Learn to make wires, or buy custom lengths, so that you have minimal wire runs and avoid loops. You can also buy custom wire lengths (e.g. Powerwerx makes them).

2. Buy wire for power in large gauge. Wire gauge is bigger for smaller numbers. Examples:

   12-14 AWG for main power runs from PSU

   16-18 AWG for individual devices (18-20 is usually necessary for barrel connectors). Largest you can for cameras and high current devices.

   Avoid 20-22 AWG (and higher) where possible.

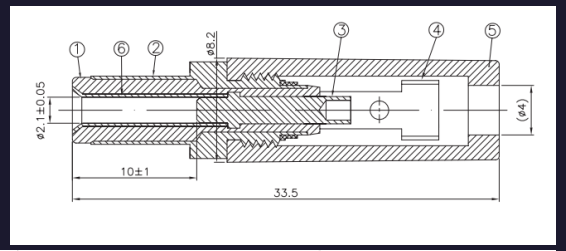
   Never use Aluminum (or Copper Clad Aluminum).

A Brief Comment on Loops

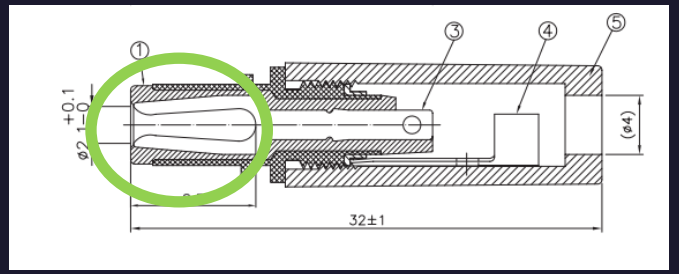
- It's tempting to coil wire up into loops to avoid risk of snags, and to avoid buying proper length wire.
- Loops of wire can create issues with induction; induction is a bit like resistance, but a bit different.
- In small amounts they are harmless, but **slightly** contribute to power and noise issues.
- But they are often a sign of too-long wires, and so big coils are a problem with length more than that they are coiled.

Quality Connectors (Step 3)

- Barrel connectors are a very bad design:
  - Mixing 2.1 and 2.5 connectors is easily done and results in very poor connection – Check!
    - Male 2.5 will fit into a Female 2.1 but work poorly – bad mistake to do this;
    - Male 2.1 will not fit at all on a 2.5 Female
  - All generally come from vendor with VERY small wire, 22 AWG is typical – get 16-18 AWG, making your own can be better
- Use only connectors with springs in male (plug) connector center to prevent loose connections.



Bad



Good

USB is the worst! (Step 4)

- USB Connections are responsible for more imaging failure than any other single item (in my opinion). Their voltage drop is more hidden but is the same problem.

1. Use something else if you can (ethernet for example)
2. Buy quality USB cables, as short as practical, as heavy as practical (small wires = higher resistance)
3. Coils are much worse on USB than power due to high frequency (data modulation) flow.
4. Never use active cables, extensions, or similar hacks to get more length – put the computer on the tripod, not on a desk nearby or worse in the house.
5. If you must use a hub, ALWAYS use a powered hub (separate 12v or 5v power).
6. If you have ongoing trouble, try USB 2 vs USB 3 cable (it is slower but much more forgiving)

[little realized fact – a USB 2 B connector fits in the larger USB 3 socket of different shape]

But my rig works perfectly now....

- (a) OK, do nothing and enjoy!
- (b) Are you sure? Have you had it outside lately? "Works perfectly" are two rarely said words.
- (c) If it works perfectly, forget everything I said. Until it doesn't.

- But on a more serious note:
  - These are recommendations to fix to reduce the likelihood of certain types of problems.
  - How well your rig works is an accumulation of probabilities, a hundred things can go right at night but one thing going wrong can shut you down. Being successful means pro-actively fixing things that might go wrong where you can, not so much fixing things that are acutely broken.
  - Only you can decide how important.

And finally:

- Better wiring, voltage and connectors will never hurt.

Thank you

Questions?