Power Over Ethernet (PoE)

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February 10, 2018

Figure 1: **A jumble of PoE equipment**

Contents

1 What is Power over Ethernet?

Power allows a device to function, and this power can be delivered over the wires of a standard[1] ethernet cable. Power in these cases are categorized as low–meaning a maximum of 30 watts (W) per port. This is much lower than the typical power used in household wiring.

The low power aspect is useful, since it allows us to run "power" wiring, without having to worry about electrical standards and inspections, since we're only working with ethernet cabling.

A fairly good place to start learning about PoE is the PoE Wikipedia page.. It is much more in depth than I could ever be.

2 Device Types

There are a couple of common definitions for the types of devices used in PoE. First, there are devices that supply power named Power Sourcing Equipment (PSE). Second, there are the devices that consume the supplied power named powered devices (PD). A third hybrid-like device type are passive injectors.

2.1 Power Sourcing Equipment (PSE)

These devices are usually small to large multi-port ethernet switches. They are designed with large power supplies and send power directly out the ethernet ports. They are also referred to as endspan power sources, as shown in figure 2.

2.1.1 Power Budget

PSE devices typically have a power budget–a maximum amount of power that can be delivered over all ports. The consequences of exceeding the deliverable power are usually to cut power from a connected device according to port priority settings. Some devices may cut power to all connected devices if their power draw is exceeded. Check the specifications.

[1] Currently 'good enough' is Category 5e, with Category 6 and up available.

Figure 2: **An endspan PoE switch (TP-Link)**

For example, an eight port PSE device may guarantee power on ports 1-4, but only make a best effort on ports 5-8, dropping power on port 8, then 7 and so on. Of course, the power budget available increases with the price of the PSE device.

An eight port PSE with a budget of 80W will usually be less expensive than an eight port PSE designed to power 8 devices at 25 watts each (power budget of 200W).

2.2 Powered Devices (PD)

There are an almost unlimited number of devices that can be powered by PoE. Strictly speaking a powered device usually has builtin circuitry to extract the power directly from the ethernet cable.

Other devices can use a splitter which breaks out the data and power jacks into separate cables.

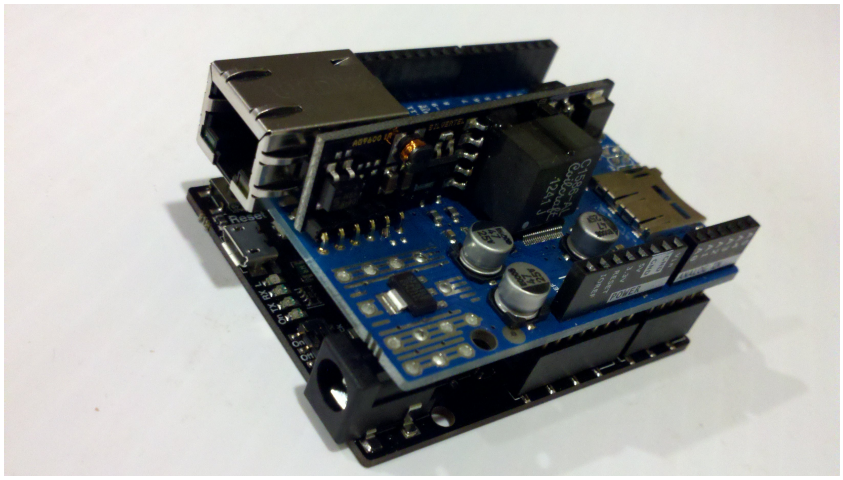

Figure 3: **An ethernet arduino with a builtin power extractor (across the top)**

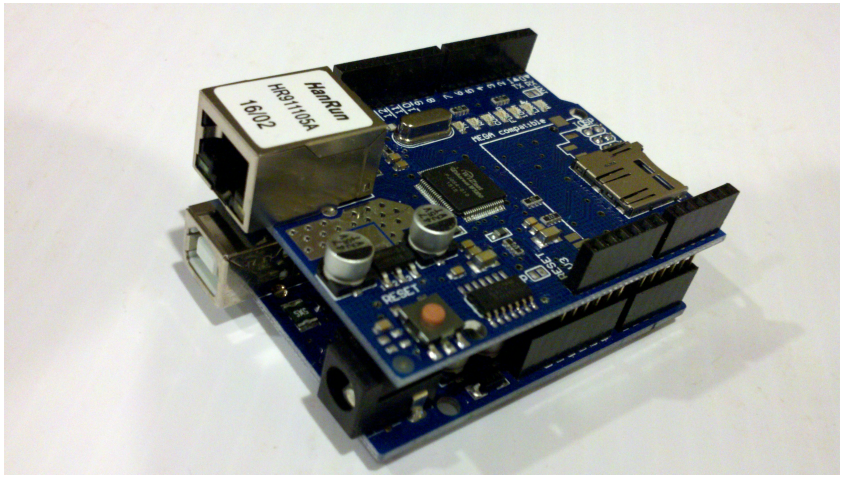

Figure 4: **An ethernet arduino that requires a splitter**

2.3 Passive Injectors / extractors

Other classes of powered devices require passive end-points to split power and data from the ethernet cable. These injectors and extractors are devices that allow non-PoE designed devices to otherwise use the power delivered along an ethernet cable.

Certain types of these injectors are called midspan sources and usually sit between a non-PoE switch and the powered devices. Here is an example:

Figure 5: **A midspan PoE injector**

2.4 Secret Handshake

Some people might get nervous about connecting a powered ethernet cable to a non-PoE device. This worry is unfounded because the standard calls for the PSE to detect a compliant device. This detection involves the PD providing a 25kohm resistance across the powered pairs. This will tell the PSE that it is capable of receiving power. Other parameters such as power required by the device are negotiated. The PSE then turns the power on. If the PSE doesn't receive this 'secret handshake', no power is delivered.

3 Anatomy of an Ethernet Cable

The category 5 cable article at Wikipedia has lots of interesting tidbits and details. The short version is that an ethernet cable has 8 wires total, grouped in pairs, so there are four pairs. The two wires in each pair are twisted around each other. This twisting reduces many bad electrical signalling effects and is useful, but it doesn't really affect power transmission.

Ethernet transmission speeds have grown over time, from 10 to 100 megabits per second (Mbps), and now are at gigabit per second (Gbps) speeds. This is only important to mention because, for speeds up to 10 to 100Mbps, only two of the four pairs of wires were used for data transmission, leaving the other two "unused". Power is sent over either the unused pairs or the data pairs, depending on the standard's alternatives A or B. We don't care about this.

Of course, gigabit systems now use all four pairs for data transmission, but clever electrical engineers devised ways to transfer power alongside the data.

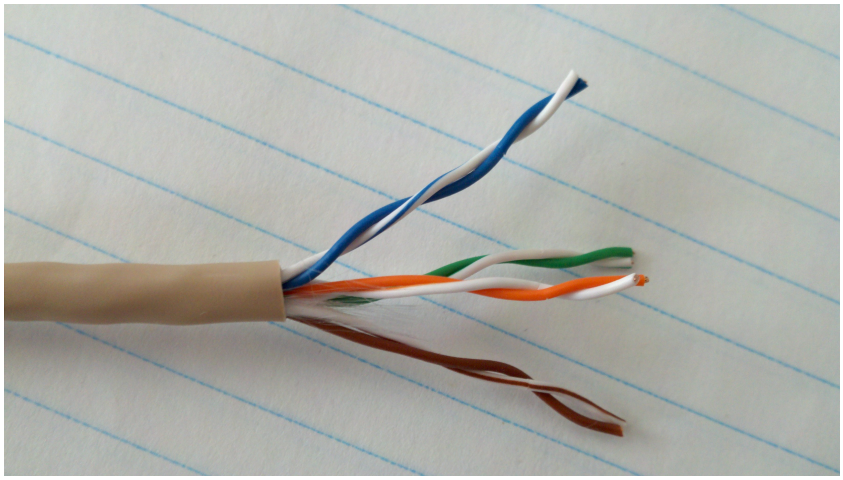

Figure 6: **The 4 sets of coloured, twisted pairs in an ethernet cable**

The twisted pairs are colour-coded, for ease of use. Bottom line–lots of wires, used for both data and power.

3.1 Connectors - RJ45

The TIA/EIA-568-B standard (Wikipedia) describes the methods for commercial building cabling as well as pin/pair assignments used in the 8 conductor ethernet cables.

Unfortunately, there are two slightly different schemes for pin/pair assignments, named A and B, because one scheme would have been too simple...

In any event, the colour schemes allow us to attach modular connectors to the ends of cables with a consistent pattern (just choose one of A or B and stick with it, don't mix A at one end of a cable with B at the other).

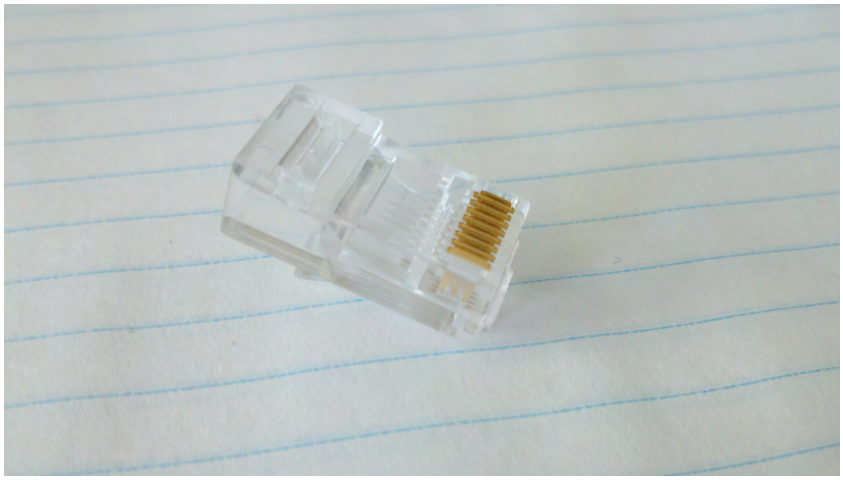

Figure 7: **An ethernet cable RJ45 jack**

These connectors are commonly known as RJ45 and are the standard for plugs and jacks.

4 Actual Standards

There are two that we care about, one updating and expanding the first:

1. IEEE 802.3af-2003
2. IEEE 802.3at-2009

They are incorporated into the larger standard: IEEE 802.3-2012, which is the main document/working group for all things ethernet. it can be found here: https://en.wikipedia.org/wiki/IEEE_802.3.

The important bits to remember are the 'af' or 'at' specifications for powered devices (PD) and power sourcing equipment (PSE).

4.1 The 'af' Standard - PoE

This was created to provide up to 15 W of DC power, but practically maxes out around 13W. The 'down-the-wire' voltage range and maximum current for this standard is 44-57V at 350mA.

Things that can run on this standard:

- Small network switches (<4 ports, usually)
- Raspberry Pis
- Arduinos (all sorts)
- Sensors
- Most single board computers (Odroid, Beaglebone, etc.)
- IP phones or ATA devices (VoIP)

Anything under 13 Watts, for example, 5V x 2Amps = 10W, perfect for an RPi3.

4.2 The 'at' Standard PoE+ (PoE Plus)

This was created to increase the maximum power up to about 30 W of DC power, but practically maxes out around 25W. The voltage range and maximum current for this standard is 50-57V at 600mA.

Things that can run on this standard:

- IP cameras (see figure 8)
- All of the above 'af' items
- Wireless Access Points

Figure 8: **An IP Camera that requires 'at' power (PoE+), with a builtin extractor and backup power cable**

Normally, the powered device will have internal circuitry to transform the voltage to its proper level, or an external adapter can split the power and data into two short cables with a power plug and an RJ45 connector.

5 Discussion

There are two things that an Internet of Things (IoT) device must have:

1. Power.
2. A way to communicate.

Power can be handled variously by:

- A device specific transformer using a wall plug (AC power);
- A battery or set of batteries;
- A solar power panel w/battery;
- A power over ethernet setup.

Communication can be fulfilled with:

- Wireless ethernet;
- Wired ethernet;
- Another radio based data exchange (nRF24L01 transceivers, Bluetooth) to a network attached controller;
- 2G/3G (and friends) cellular connections.

I'm sure there are others.

There are a number of ways to satisfy both of these requirements simultaneously. We'll look at pros and cons of these needs and their combinations.

5.1 Power - Pros and Cons

These pros and cons can help you decide what power source to use.

5.1.1 Batteries

Batteries are an option, but a painful one. The pros and cons are in table 1.

Table 1: Pros and Cons for Batteries

Pros	Cons
No wires!	Got to keep changing them
	Location may be difficult to access
	Expensive to replace over time
Can be rechargeable	Need at least two sets for recharging and running

Summary: batteries are very high maintenance.

5.1.2 Solar

Solar is a nice, renewable power source. It is usually out of scope for most use-cases regarding IoT devices. If you can manage to get it implemented, then it is a great option. Table 2 shows its pros and cons.

Table 2: Pros and Cons for Solar

Pros	Cons
Only a few wires depending on placement	Got to keep the sun shining
	Is there a place for them?
	Expensive to implement for higher wattage requirements
Can use rechargeable batteries	Rechargeable batteries still need replacing

Summary: weather bound and can be complicated.

5.1.3 AC Power

AC power is great and if you have it nearby, use it. Table 3 lists its pros and cons.

Table 3: Pros and Cons for AC Power

Pros	Cons
Plenty of Power!	Very expensive to install
Reliable	Permits and possible licensed electricians required
	Locations of plugs determine location of device.

Summary: use it if available.

5.1.4 PoE

Saving the best for last. PoE is very flexible and its pros and cons are in table 4.

Table 4: Pros and Cons for PoE

Pros	Cons
Single wire for data and power!	Requires installation
Low power, no permits required	Costs to install (but much cheaper than AC power)
Reliable	No support yet for higher wattage (>30 W) requirements
Can provide power to devices even without using the network	

Summary: easy installation (no regulations[2]), reliable, low maintenance.

[2]Not a guarantee, check your local codes, ordinances and laws

5.1.5 PoE Factoids

1. You can power a device that uses wireless technology for network communication, if it can be placed near an ethernet port. Only the power transmitting capabilities of PoE need to be used.
2. You can power any wired ethernet device that has low power requirements, whether it has builtin power extraction or you use an external extractor with power cable.
3. For an in-device rechargeable battery, for either a wired or wireless device, PoE can act as a power source for its charging port.

5.2 Communication Methods - Pros and Cons

These pros and cons can help you decide what communications methods to use. In some cases, you may be constrained to a specific method.

5.2.1 Wired

Table 5 shows some pros and cons concerning wired connections for communications.

Table 5: Pros and Cons for Wired Communications

Pros	Cons
Gigabit speeds	Requires installation
Extremely reliable	
Great for streaming video and gaming	
Can provide PoE	

5.2.2 Wireless - all forms

Wireless is quite convenient, but has pros and cons as shown in table 6.

Table 6: Pros and Cons for Wireless Communications

Pros	Cons
No wires needed	Except for power
Can be placed anywhere a signal is available	Interference likely since the frequencies are getting crowded
Good enough for modest network uses (email, sensors)	Can drop out and be unreliable
	Latency and retransmission issues are not great for streaming video and gaming
	Can get pricey if cellular options are used

6 When Buying Equipment

Some things to have on your checklist when buying PoE gear:

- Does the packaging or technical specification directly state 802.3af and/or 802.3at support. If it doesn't state one, it likely doesn't support it. The vendor claims must be specific.
- Know how much power your device needs–12W or less, you can use 'af' equipment, more power means you'll need 'at' support.
- The power over ethernet supply specifications must be able to handle your device–if you have at 'at' power rated device, you need and 'at' power rated PoE switch or injector.
- Buy quality PoE components, since your downstream devices will rely on them.

6.1 UPS Required

An uninterruptible power supply is a must have with any PoE system setup. It is generally wise to have a battery backup and power conditioner between main power and your PSE equipment. Brownouts, surges and sudden power loss can cause raspberry pi devices to corrupt their SD cards, for example.

A possible recommended setup is to run an MQTT network which can send a power

down signal when the UPS tells a monitoring system that power is out and the battery is low.

7 My Device List

- TP-Link TL-SG1008PE 8-Port Gigabit PoE Switch, 8 POE ports, IEEE 802.3at/af, Max Output 124W CDN$ 165.31 (Amazon.ca)
- ANVISION 2-Pack Active 12V PoE Splitter Adapter Injector, IEEE 802.3af Compliant 10/100Mbps, DC 12V Output for IP Camera Wireless AP Voip Phone AV-PS12*2 CDN$ 18.98 (Amazon.ca)
- ANVISION 2-Pack Active Gigabit PoE Splitter Adapter with Multi-Size Tips, 10/100/1000Mbps IEEE 802.3af Compliant Up to 100m (328 Feet), DC 5V/9V/12V Power Output for IP Camera Wirelss AP Voip Phone CDN$ 37.98 (Amazon.ca)
- 2 x 802.3af Poe Splitter for iPads and Tablets, Remote USB Power over Ethernet, Use with PoE Switches, 5 Volts 10 Watts Output Female USB WT-AF-USB CDN$ 29.95 (Amazon.ca)
- DLINK 8-port PoE managed switch, IEEE 802.3af/at with 64W power budget CDN$ 150 (Staples Victoria)
- StarTech POEINJ4G 4-Port Gigabit Midspan PoE+ Injector Wall-Mountable Power Over Ethernet CDN$ 163.05
- Hikvision DS-2CD2342WD-I 2.8mm HD 1080P IP Camera With Night Vision Up to 90ft, Super Wide 106 degree viewing angle, IP66 weather-proof protection, 3D Digital Noise Reduction CDN$ 179.00