VOLTAGE DROP: How To Calculate Voltage Drop For Long Paired Wire Runs

A primary concern when installing lengths of wire is voltage drop. The amount of voltage lost between the originating power supply and the device being powered can be significant.Improper selection of wire gauge can lead to an unacceptable voltage drop at load end. The following chart is designed to help calculate voltage drop per 100 feet of paired wire as a function of wire gauge and load current.
By matching load current (in AMPs) across the top of the chart with wire gauge (AWG) down the left side of the chart, one can determine voltage drop per 100 feet of paired wire run.

NOTE: A paired wire run represents the feed and return line to the load. Therefore, a 500 foot wire pair is equivalent to 1000 feet of total wire.

EXAMPLE ONE:
Given a load current of 1 AMP, and using 18 AWG wire, how
much voltage drop can we expect at the load end for a 350 foot run of paired wire?
Using the chart, we match the row for 18 AWG and the column for 1 AMP and determine that voltage drop per 100 feet is 1.27 Volts. By dividing the paired wire length by 100, we get the factor by which we need to multiply voltage drop per 100 feet to determine total voltage drop. Therefore, 350 feet divided by 100 equals 3.5. Multiply 3.5 by 1.27 volts drop per 100 feet to get your total voltage drop. Thus the total voltage drop is 3.5 times 1.27, or 4.445 voltage drop for 350 feet.

$$\frac{350}{100} \times 1.27 = 4.45 \text{ Volts}$$

EXAMPLE TWO:
Given a camera load of 2 AMPs, that is 400 feet from the power source, which wire gauge should be selected to keep voltage drop at the camera to less than 3 volts?
To use the chart, we need to determine what the maximum voltage drop per 100 feet is. We calculate that 100 feet is 1/4 of
400 feet, thus the voltage drop allowed for 100 feet is 1/4 times 3 volts (which is the equivalent of 0.75 volts per 100 feet):

voltage drop per 100 feet = 3/4 = .75 volts per 100 feet.

So, knowing that we can not allow anything greater than a voltage drop of .75 volts per 100 feet, we can now look at the chart and select the wire gauges that will give us lower voltage drops per 100 feet at a 2 AMP load current. In this case, wire gauges of 10 (.40 V), 11 (.50 V), and 12 AWG (.64) will all suffice, with 13 AWG (.80) being a possibility.

Thus, in order to keep voltage drop at the camera to less than 3 volts given a camera load of 2 AMPs and a 400 foot paired wire run, we need to use a wire gauge in the range of 10-13 AWG.

VOLTAGE DROP PER 100 FT RUN OF PAIRED WIRE

GAUGE (AWG)	5 AMPS - Load Current	1 AMP - Load Current	2 AMPS - Load Current	4 AMPS - Load Current	10 AMPS - Load Current
10	0.10	0.20	0.40	0.80	2.00
11	0.13	0.25	0.50	1.01	2.52
12	0.16	0.32	0.64	1.27	3.18
13	0.20	0.40	0.80	1.60	4.00
14	0.25	0.50	1.01	2.02	5.04
15	0.32	0.64	1.27	2.54	6.35
16	0.40	0.80	1.60	3.20	8.00
17	0.50	1.01	2.02	4.03	10.08
18	0.64	1.27	2.54	5.08	12.71
19	0.80	1.60	3.20	6.40	16.01
20	1.01	2.02	4.03	8.07	20.17
21	1.27	2.54	5.08	10.17	25.42
22	1.60	3.20	6.40	12.81	32.02

FORMULA METHODS:
These handy equations can be used to determine voltage drop per 100 feet or wire gauge as an alternative to the chart, even for values that are not on the chart. To arrive at total voltage drop, always divide paired wire run length by 100, and then multiply that number by voltage drop per 100 Feet:

1. To determine voltage drop per 100 feet given load current and wire gauge:

where V_D = Voltage drop per 100 feet (Volts)

   I_L = Current load (AMPs)

   AWG = Wire gauge

$$V_D = .2 * I_L * 1.26^{(AWG-10)}$$

2. To determine wire gauge necessary given paired wire length, load current, and desired voltage drop:

$$AWG = 10 \, Log \left(\frac{V_D}{I_L}\right) + 17$$

With these useful tools, voltage drop problems can be avoided before installation, saving time, money and ensuring a correctly working   system.

# How to Choose the Correct Battery Size For Your Application

Figuring out the size of a battery necessary to support the load discharge current for a specific amount of time can be tricky. Batteries are rated at maximum efficiency over a 20 hour discharge period. Therefore, a 20 AMP-Hour battery will provide 1 AMP over a 20 hour period. However, calculating the discharge time for other discharge currents is not as easy as division or multiplication. A 20 AMP-Hour battery that supplies 1 AMP for 20 hours will not provide 2 AMPs for 10 hours, but rather, 1.8 AMPs for 10 hours, which is equivalent to 18 AMP-Hour. Thus, we provide the chart below to facilitate calculations to determine the correct battery size for chosen discharge currents and discharge times.

In order to use the chart, simply match the load discharge current requirement (in AMPs) along the bottom of the chart with the desired discharge time (in Hours) on the left. At the intersection of the two lines, find the diagonal line immediately above that point, which then represents the minimum battery rating needed (in Ampere-Hours).

EXAMPLE:
Requirement: you need 4 hours of backup for a 2 amp load. Using the chart, simply find the intersection of the 2 AMP vertical line and the 4 hour horizontal line. Then, find the closest diagonal line that is above this intersection. Follow that diagonal line up to determine the minimum battery size that is required. In this case, a 12 AH battery (see blue circle).

DISCHARGE TIME AS A FUNCTION OF DISCHARGE CURRENT

BATTERY SIZE (IN AMPERE-HOUR RATINGS)

4.0   7.0   12 17   33   40   80

DISCHARGE TIME (HOURS)

DISCHARGE CURRENT (AMPS)
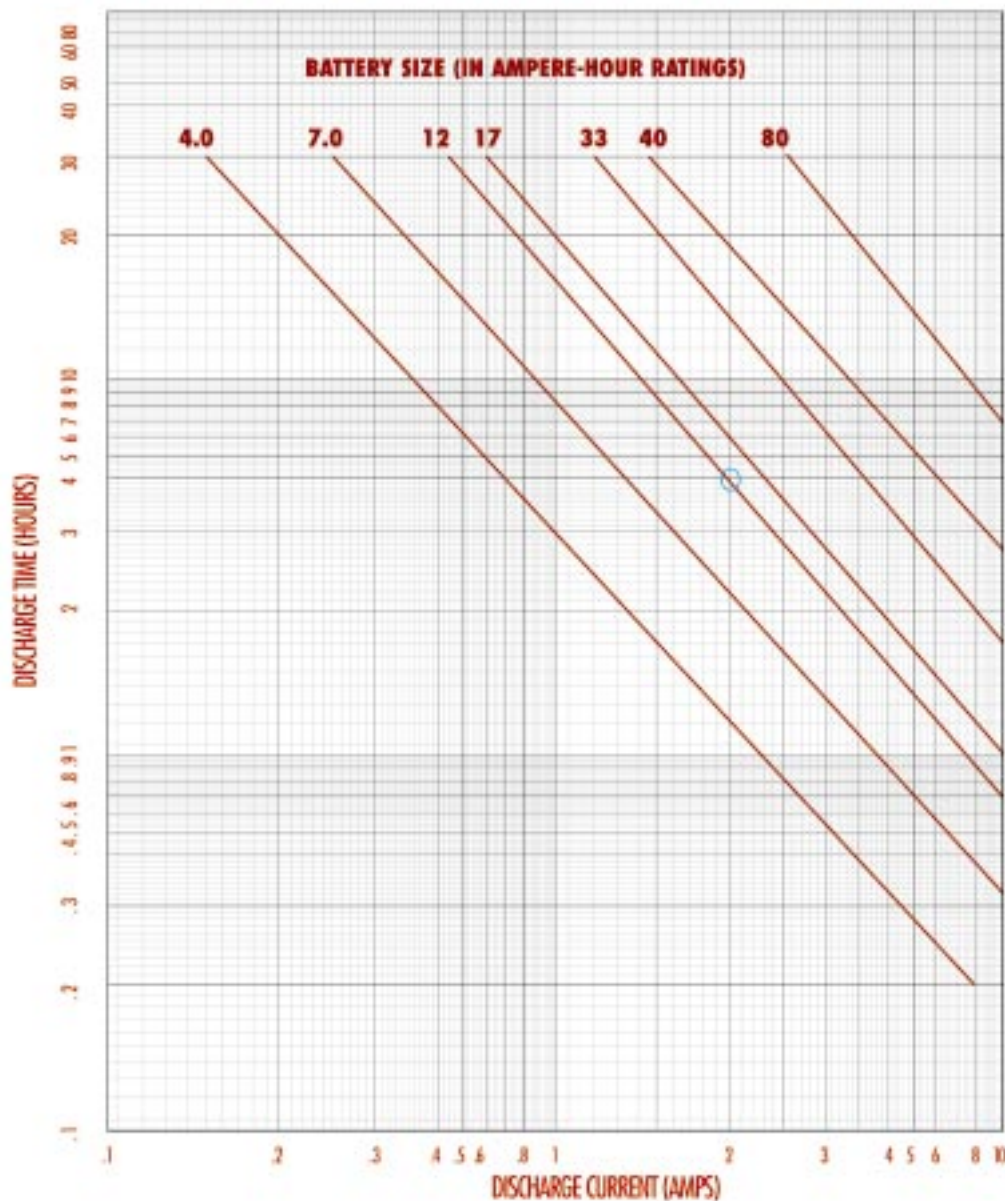
PTCs (a.k.a. Circuit Breakers) vs. Fuses

The PTC, or Positive Temperature Coefficient Resistor, acts as a type of circuit breaker. In general, the resistance increases dramatically as the PTC threshold temperature is exceeded due to the load current passing through it. This presents a high resistance, which in effect opens a circuit, protecting the device in question in the event of an over current condition. This is a misunderstood and widely misused component, and this application note should help clarify the most appropriate applications for the PTC. Basically, the PTC is well suited for battery protection, but its slow and inaccurate response could jeopardize delicate electronic equipment.

A PTC is appropriate for battery protection, since most battery shorts are heavy shorts thus quickly tripping the PTC. Even if they are not a heavy short, the battery is a rugged device that can tolerate high current for substantial times until the PTC trips.

Although we offer both PTCs and Fuses in our ALTV248 series of camera power supplies, we believe that for the above reasons that the slow acting and inaccurate trip threshold PTC does not protect the cameras as reliably as the fast acting fuse. It is better to make a service call to replace a fuse than a camera that was falsely protected. Since PTCs need to cool down to reset, it will most probably require a service call to release the short and reset the power supply anyway. However, for camera housing blowers and heaters a PTC will do just fine, since these devices better tolerate overload conditions.

For DC power supplies, Altronix designs include electronically resetable current limiting, which are superior to fuses or PTCs, and employ the PTC for battery, motor or heater protection.

PTC PROS:
It can be reused. It will reset itself after the device cools down and the short is released.

PTC CONS:
It is not an accurate device. A 1 AMP rated PTC might never blow at 2 AMPs, and might take greater than 30 seconds to blow at 5 AMPs, thus offering no protection to the device. Once it does blow, it might require shutting off the power supply to reset it, so as to allow cool down of the PTC. In essence, it could require a service call to reset the power supply. In addition, PTCs are very temperature sensitive. They will trip at lower current ratings as the ambient temperature goes up, and higher than specified current ratings as the ambient temperature goes down. These PTC ratings can vary by +/- 50 percent over manufacturers specified temperature range.

FUSE PROS:
It is faster acting and far more accurate than a PTC. For example, 1 AMP fuse will blow at 1.25-1.5 AMPs, in about 1 second.

FUSE CONS:
They are designed for one time use and must be replaced when they blow.

Remember that it is easier to replace a fuse than an expensive camera.

Power Demands of a System

When installing any new fire, security, CCTV or access control system, one of the first and most important considerations is power demand. Knowing this allows efficient and cost-effective matching of power supply to the system requirements. The same is true when a new device is added to an existing system. Will the system's power supply be able to handle the additional power requirements? The following equation is a helpful tool to determine what the total power demand of a system will be:

<div align="center">Power (in Watts) = Current (in Amps) x Voltage (in Volts)</div>

VA is power in watts described for AC systems. 100 VA equals 100 Watts.

To determine the power requirements for a system, add the total AMPs required by each device in the installation and multiply by the Voltage — the result is how many Watts, or VA are needed to run the system.

EXAMPLES:
1. Given a relay coil with a resistance of 300 Ohms and an Activation Voltage of 12 Volts, how much current is needed? Divide 12 Volts by 300 Ohms. This equals .04 AMPs, or 40 milliamps.
NOTE: 1000 milliamps equals 1 AMP.

2. Given a device that draws a 350 milliamp current at 12 volts, what is the power requirement of the system? Multiply .35 AMPs by 12 to get 4.2 Watts.

3. Given a 24 VDC system with 5 devices that draw 100 Milliamps each, and one device that draws 1 AMP, what is the total power demand of the system? In this case, five devices at .1 AMPs each (100 milliamps) plus one device at 1 AMP equals .1+.1+.1+.1+.1 + 1.0, which is equal to 1.5 AMPs. Multiplied by 24 Volts, the total power demand of the system is 36 VA, or 36 Watts.