

Implementing Multi-Voltage Level Power Supplies Using Off the Shelf Components

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Abstract

This paper discusses how to use several off the shelf components to create multiple line voltages that can be used to power several components for system integration. This is useful when designing for a large system where several off the shelf components will be used. An example design is given to explain how this would work.

Keywords: Power, Supply, integration, safety

Introduction

When creating systems that integrate multiple off the self components it is often necessary to provide different line voltages to them. These voltages may need to be both positive and negative in order to support a range of devices that require different voltage levels. It also has to be easy for users of the combined power supply to attach/detach their devices. There also has to be a level of safety both to the user and the components used.

Background

The simplest way to obtain a large range of voltage levels is to purchase several off the shelf low cost power supplies. These power supplies can then be quickly and for low cost be integrated together. By using off the shelf power supplies the cost of the final product can be reduced.

Issues

One of the major issues that needs to be addressed when looking at these types of system is safety. Of highest importance is the safety of the people around the power supplies and the safety of the power supplies and the other components are a secondary. Power supplies that can be tied together in the way that we will be discussing often have exposed power terminals and require 120 V AC in order to run. Because of this if the supplies are not enclosed in some way there will be a lot of opportunities for bridging and electrical shock. The easiest way to resolve this problem is to place the parts inside a case which will make it harder for electrical shock to occur. This also has an added bonus in that the parts used inside the case can be mounted to the sides and provide a more polished look. In addition to this, any parts that are exposed and should be heat shrink wrapped if possible which will reduce the chance of accidental bridging and arcing. By adding a fuse to the hot line coming into the power supplies the chance of electrical overload can be reduced.

Of secondary importance is to allow for the power supplies to be easily replaced. This might be because the voltages that have been selected are incorrect or the unit has become unusable. This

can be accomplished by making sure all wires that connect to the power supplies are not permanent either using a terminal block or lugs instead of directly wiring. This way the power supply box becomes more modular and can also easily allow for swapping in more or different connectors.

Example

The following is an example of how to create a power supply that contains five distinct voltage levels (+24, -6, +15, -12, +6), be fused and have a master switch to turn all the power supplies on and off at the same time. In order to create this device the following items are needed:

1. 24 V DC power supply
2. 6 V DC power supply
3. 15 V DC power supply
4. 12 V DC power supply
5. 6 V DC power supply
6. Switch capable of 120 V AC (this example will include a switch with an indicator lamp)
7. 2 A slow blow fuse

AC Wiring

Hooking up all the power supplies turns out to be the hardest part of this project. The thing to keep in mind is that the power going to each of the power supplies needs to be the same so all the power supplies can be attached in parallel. By attaching them in parallel the voltage drop across one power supply won't affect any of the other power supplies. This also makes it easy to make these connections because each power supply can chain off the supply closest to it.

Before the power can be applied to the power supplies it needs to be run through the fuse and the switch. The fuse needs to come before the power supplies because if the fuse is after the power supplies the current spike would hit the supplies first causing them to potentially fail or become damaged. The fuse itself needs to be picked based on the maximum current rating on the components that are being used in the main product. In order to select the fuse rating the lowest maximum current rating for all components should be used. That way the weakest component is safe from overload.

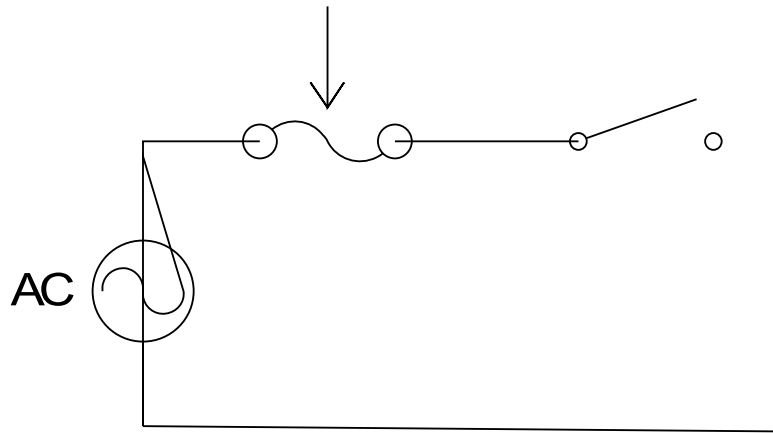


Figure 1 Basic AC Wiring For Example

One indicator that can help with safety is if the switch used to turn the power supplies on and off can have a lamp set up to indicate it's status. That way the users will know if power supply is safe. This can easily be done by purchasing a switch that contains an integrated lamp that operates on 120 V AC. This improves the cleanliness of overall wiring and also reduces the number of holes that need to be cut into the side of the case. The switch has three different leads on it which can be used in two different modes. If the only the switch is to be used as a switch for the hot line from the 120 V AC source will be wired to the number one lead and it's output will come out lead number two. In order to use the included lamp, terminal number three must be attached to the cold line from the 120 V AC in addition to the same configuration from the just switch mode. If the first terminal and the second terminal are swapped then the lamp will not turn off. If this does occur the two lines should just need to be switched.

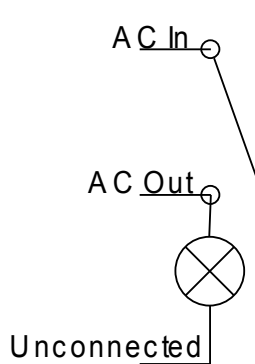


Figure 2 Switch Only Mode

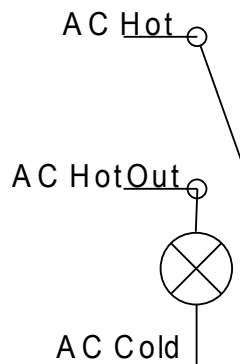


Figure 3 Switch With Lamp

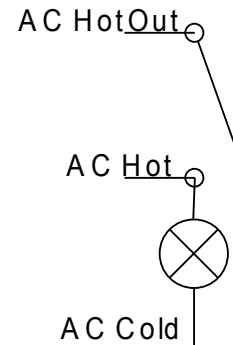


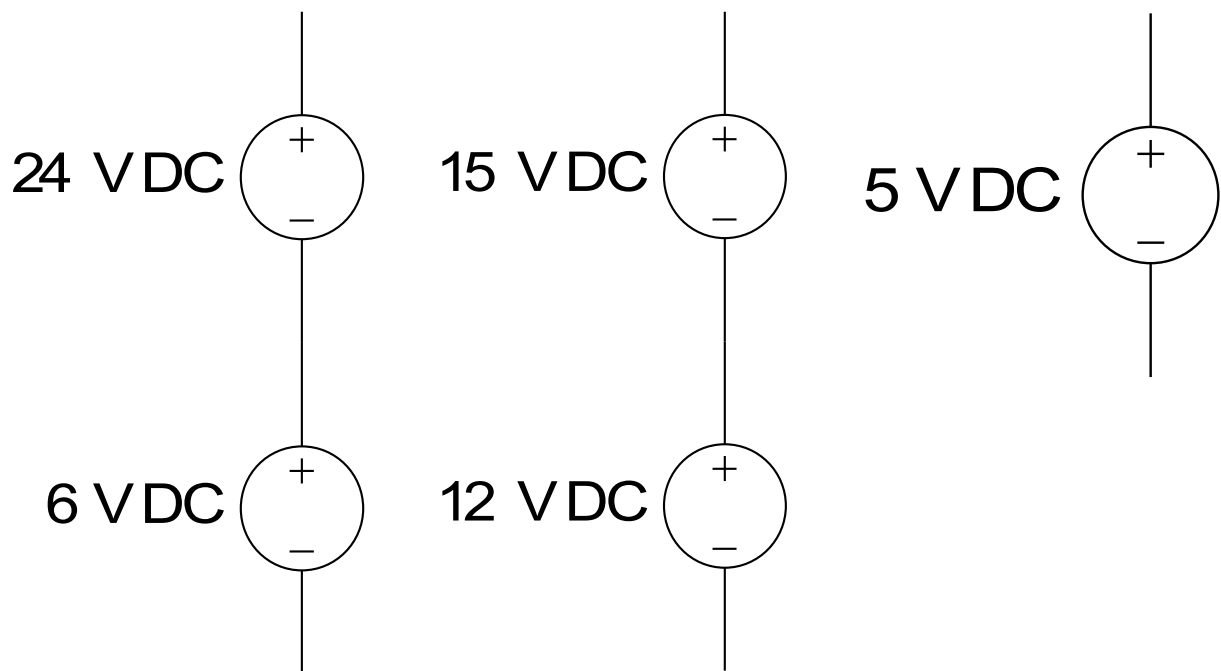
Figure 4 Switch with lamp always on

How to Obtain Negative Voltages

A problem that can be encountered when integrating different parts is that some of the input ranges may not be within the range of the output that should be going into it. A quick and low cost way to fix this problem is to run the signal through an Operation Amplifier (Op-Amp) which can then bring the values into range. One of the properties of an Op-Amp is that it needs both a positive and a negative voltage level in order to work correctly. A quick way to generate negative voltages is due to the way the power supplies are hooked up.

By attaching the positive terminal of one power supply with the negative of another and defining that as the ground this is automatically done. This also allows for three other voltages levels depending on how the wires are attached.

In our example the following connections will be made:



The Importance of Colored Wiring

An important thing to keep in mind while you're building these types of system is to use different colored wires to distinguish the different voltage levels. This can both ease the constructing of the system and make it harder to damage equipment by hooking the wrong level to it because you can tell exactly what type and level of voltage is being run through the wire. It also makes the system look nicer if there is a predetermined wire path that keeps wires in specific sections of the box that they should be.

In our example the following wiring colors were picked. For the AC hot line red was used and for AC cold black was used. This quickly distinguished them from the DC line voltages. For the DC wires darker colors indicated negative voltages and brighter colors were used for positive voltages this added an additional level of distinction. The following chart summarizes what

colors were used.

Color	Voltage
Red	120 V AC Hot
Black	120 V AC Cold
Green	DC GND
Yellow	+24 V DC
Gray	-6 V DC
Blue	+15 V DC
Brown	-12 V DC
White	+5 V DC

Conclusion

A power supply can easily be created with multiple voltage levels for use in system integration. By using off the shelf pieces and keeping basic electrical safety in mind the system can be both cost and time effective and safe. This allows for rapid development of the system without spending massive amounts of time building and testing a custom solution.