DC-DC converters, Power Injection and pixels

There is a lot of talk about power injections and the use of DC-DC converters and how to figure them out. I will try to explain as best I can for those that are interested.

I am going to use generic examples and hope I touch on most people's questions.

First let's look at the pixels and figure out what we are trying to do.   If you are using something like WS2812 pixel "strips" you will most likely experience a two volt drop or more from the feeder end to the output end (5m length). This voltage drop can cause the blended colors of your LEDs to not match from one end to the other. A single color like Red or Green or Blue would be fine because it draws less current then multiple colors and therefore would cause less of a voltage drop. Mixed colors, like white (RGB full on) can vary from a Cool White at the feeder end to almost yellow at the opposite end.   For some, this really doesn't bother them. To those of us that really are in tune with the color and even color matching, it is a very big deal.

This voltage drop is due to the resistance of the PCB traces or "lands" and the amount of current the LED circuits draw. Voltage drop is calculated as E=I x R or Voltage (E)   current (I)   resistance (R)

To combat the color temperature difference many of us "inject power" either at both ends or in the middle. Assuming you have waterproof strips, injecting in the middle is somewhat of a pain. Therefore injection power at the ends is the easiest approach.   With Pixels string, injecting in the middle can be easier than with strips, but I still prefer injecting at both ends of a long string.

With that said...........

DC-DC converters:

What: They are like transformers for DC but they will regulate the output to a specific value. Most will take in a wide range of voltages and give you a specific output voltage that is regulated.   ie... 9-30vdc input   5vdc output

When: Use them when you want to distribute DC power over longer distances or when multiple regulated voltage points are desired and normal voltage drop over wire can be an issue. Also use when you want to run lower voltage props from a higher available voltage supply. ie.. I have 12v or 24v supplies and want to run 5v pixels.

Why: Using a main supply with a higher voltage to feed the converters can be advantageous because the current required at the higher voltage is less than the output current of the converter. This allows smaller wire to be use on the input side and the voltage drop is far less significant over distances.   They also lend themselves to good regulation at the point where you need a constant voltage. All this with current limiting to protect the downstream wiring.

Calculations:** {assume 24v primary (main power supply) & 5v Secondary (out of the converter)}

Determine the power you need for your application, (round numbers). For example, a 5m strip of 5vdc pixels can use about 36 watts. (36 watts is according the manufacturer spec). That means it draws about 7.2 amps of current at full white.

So 7.2 amps x 5volts = 36watts of power required. {P=I x E} P=Power I=Current E=Voltage

> ***NOTE:*** *If you must calculate your own power because you either don't have the factory specs or you have cut the strips shorter, you can use a rule of thumb as follows. Each color of LED chip draws about 0.02 amps. So that means an RGB cluster would be about 0.060 amps. (again, round numbers and may not be accurate but it is a good place to start).*
> *You may also substitute 12v for 5v if you have 12v pixels and do the math that way.*

To calculate the primary side at 24v..... 36watts/24volts=1.5amps.
This means that if you use a 24vdc supply to feed the converter you should expect to draw about 1.5amps from that 24v supply to run the pixel strip at full white (7.2 amps) assuming no losses in the converter and no losses from the resistance of the strip's PCB. The wire size required to run to the converter is much smaller than what would be required if you use a 5vdc supply. As a matter of fact, you can run about six full RGB strips from a single 24vdc 240watt power supply including a safety margin and not exceed the maximum draw of 10 amps.

Let's assume you are running those six strips and they are end to end on the eves of your house. If you want a good white capability from those strips, you would need to inject power at both ends of the strip. In my opinion, the best way to run power injection to those strips would be to use that same 24vdc supply with a #14 wire pair along the entire length of the eves. Then install a DC-DC converter at the beginning of the first strip and in between each subsequent strip, feeding power both directions. That means the 2nd converter would feed back to the end of the 1st strip and the beginning of the 2nd strip and so on down the line. When you get to the end of the sixth strip your converter would feed only that end. You would most likely not run into any issues with the converters trying to regulate against each other because there is enough resistance in the PCB of the strips to allow for an equalizing voltage drop. (I have not done this personally but it designs out on paper just fine)

Another scenario would be distributing power over various locations in your display. You could put converters where ever you needed them to be to maintain a constant 5vdc at the pixels and feed them from one or more 24v supplies that could be mounted in a single location. The voltage drop would be pretty insignificant going to the converters since most will operate from about 9-30vdc input and still regulate the output. The 24v wire size would be far smaller than if you tried to run 5v and mitigate the voltage drop with larger wire size.

Converters can have almost any output voltage. You need to buy for your application. They can even be adjustable if you bought the adjustable converters. They are small, and inexpensive. With the growing usage of the 5v pixel, I think you will see more and more converters being used to maintain good regulation without buying a lot of individual power supplies.

**These are all round number calculations and do not take into account conversion efficiencies, PCB and wire voltage drops other than in general. As a "rule of thumb" I would add a 10-15% minimum safety margin for power supplies and converters.

Addendum: 9-15-14

Be very careful with wire size for the primary DC buss. Do not undersize the DC wiring. As you get longer wire and more load farther away from the supply, the converters will see a lower input voltage. With that lower input voltage comes a higher current draw from the converters.. This in turn will cause more voltage drop on the Buss wiring and that in turn will cause more current draw from the converters, and so on, until it reaches a point where the converters will draw large amounts of input current and drag the buss voltage down to the point where the last converter is not regulating.

My test example was with six pixel mini trees using 50 each WS2811 pixels per tree fed from a 5v converter on each tree. The main 24vdc supply draw was about 4.4 amp with all on white. Cable was equal to 20 gauge wire. (White 4 core Chinese cables). The voltage at the input of the sixth tree was approx 16vdc. When I added a seventh tree, the current draw from the 24vdc supply shot up to 7.7 amps and the output voltage from the sixth tree was about 7.4vdc. The wire dropped far too much voltage for the application. Also, had this not just been a test, there is a chance that the wire could have heated up over the long term since I did not fuse it for the test.