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Technical Bulletin

Novanta

Power Wiring 101
Successfully Wiring DC Power to Novanta's Synrad Brand Lasers

Description:

All of Novanta's current Synrad brand laser models are powered by DC supply voltages. Some models take 30VDC (48 Series, v30), some take 48VDC (vi, ti, p Series, i401) and the f201 laser takes 96VDC. The specifications for the supply voltage tolerance range from +/- 0.5 VDC to +/- 2.0 VDC. The factory supplied power cables are designed to have a large enough wire gauge to ensure that the voltage drop through the wiring will be small enough to keep the laser supply voltage within tolerance when the laser runs at idle current or full current demand.

If you can reach the power supply with the factory power wiring, then connecting everything up is as simple as:

1. Connecting red to + and black to –.
2. Using care when applying torque to the power terminals on the laser and the power supply.
3. Providing adequate AC mains power and fusing to the supply (see the Power Supply data sheet for details).
4. Installing the supply in a suitable cabinet as required to protect it from damage and disturbance, and to protect the operators from accidentally touching the input and output connections.

Occasionally, our customers have found that the AC/DC supply must be located further away from the laser than allowed by the length of the factory supplied wires. This leads to the question "what is the best way to add power wiring to the laser?"

Resistance is futile!

To review some basic facts about standard copper wire using the American Wire Gauge (AWG) system:

1. Copper wire has resistance, specified in ohms per 1000 feet.
2. 10AWG wire has a resistance of 1.02 ohms per thousand feet. Since we will be dealing with small voltage drops through relatively short lengths of wire, we will use milliohms/foot (mΩ/ft).
3. The AWG specifications are logarithmic in nature so that:
    a. A change of 3AWG results in halving or doubling of the wire resistance - 7AWG wire resistance = 0.5 mΩ/ft, 13AWG wire resistance = 2 mΩ/ft.
    b. A change of 6AWG then increases or decreases resistance by a factor of 4.
    c. A change of 10AWG results in 10x or 1/10 of the resistance.

The following table provides wire resistance per foot and per meter of copper wire at 20°C:

American Wire Gauge (AWG)	**Cross Section Area** (mm^2)	**Milliohms** (Per Foot)	**Milliohms** (Per Meter)
0	53.4751	0.0983 mΩ	0.3224 mΩ
1	42.4077	0.1239 mΩ	0.4066 mΩ
2	33.6308	0.1563 mΩ	0.5127 mΩ
3	26.6705	0.197 mΩ	0.6464 mΩ
4	21.1506	0.2485 mΩ	0.8152 mΩ
5	16.7732	0.3133 mΩ	1.028 mΩ
6	13.3018	0.3951 mΩ	1.296 mΩ
7	10.5488	0.4982 mΩ	1.634 mΩ
8	8.3656	0.6282 mΩ	2.061 mΩ
9	6.6342	0.7921 mΩ	2.599 mΩ
10	5.2612	0.9988 mΩ	3.277 mΩ
11	4.1723	1.26 mΩ	4.132 mΩ
12	3.3088	1.588 mΩ	5.211 mΩ
13	2.624	2.003 mΩ	6.571 mΩ
14	2.0809	2.525 mΩ	8.285 mΩ
15	1.6502	3.184 mΩ	10.448 mΩ
16	1.3087	4.015 mΩ	13.174 mΩ
17	1.0378	5.063 mΩ	16.612 mΩ
18	0.823	6.385 mΩ	20.948 mΩ
19	0.6527	8.051 mΩ	26.415 mΩ

How to determine the wiring Voltage Drop?

Ohms law defines the voltage drop through a resistor (or a wire) as the resistance times the current:

$$V = I*R.$$

The key to properly wiring DC power to your laser is to keep the overall power path resistance low enough so that the total voltage loss through the wiring at full laser current is minimized. To find the maximum current draw and the required input voltage tolerance for your laser, refer to its Operator's Manual. You can download the manual from the appropriate product page on our website at https://novantaphotonics.com/.

A Case in Point:

The i401 laser draws 125A maximum current. To keep the voltage loss at less than 0.5V at the laser, the total wire resistance must be 0.5V = 125A * R, so that R = 0.5V/125A = 0.004ohms (4 mΩ).

For our standard 6ft power cables, the required wire gauge must be selected such that the total power circuit resistance is less than 4 mΩ. Remember that the total path length for 6-foot power cables is actually 12 feet – 6 feet for the positive power lead and 6 feet for the return power lead.

To find the proper wire size for this laser, divide the total maximum resistance by the overall path length: 4 mΩ / 12 feet = 0.33 mΩ/ft. This would specify that the power cables should be at least 5AWG. In truth, we use #1/0AWG cable (0.1 mΩ/ft) to further minimize heating in the wire and power fluctuations at the laser.

If you wanted to insert 40 feet of extra cable run between the power supply and the factory power leads, you would need to find wire with a total path resistance of R = 0.5V/125A = 0.004ohms (4 mΩ), as stated earlier. Resistance per foot would be 4 mΩ / 80 feet (40 feet for +, 40 feet for -, 80 feet total), or 0.05 mΩ /ft, which is the resistance of #4/0 AWG cable.

Will the cable be moving?

If the cable will be routed through a flexible cable carrier, remember to order high flex cable! Standard cable subject to continuous flexing will slowly start to suffer broken strands, effectively shrinking the cable AWG over time until the voltage fluctuations cause equipment faults or damage.

Common Questions:

Q: If I'm only going to run the laser at 10% duty cycle, can I use smaller wire?

A: Not a good idea, since our lasers are pulse width modulated:

- While the PWM pulse is in the on state, the laser draws FULL power.
- When the PWM pulse is in the off state, the laser draws idle power.

This results in the power supply current demand being very 'peaky'. Overall average current draw will be around 10 - 15% of maximum current draw, but designing the power wiring against this average current draw will result in large voltage swings at the laser power input that may not be long enough to trigger the laser's undervoltage fault but will have an adverse effect on the laser performance and may lead to premature problems in the laser electronics. In such cases, a simple DC Voltmeter might show the power supply voltage dropping from 48.0VDC to 47.5VDC, but an oscilloscope would show the voltage dropping by 5VDC or more on every 'on' PWM pulse.

Q: Should I just splice the wire onto the existing factory power cables?

A: A better idea is to provide a terminal strip within reach of the factory cables, then run your extra wiring to the terminal strip. This provides some advantages over splicing the wire:

a. If the size of the added wire differs greatly from the factory cable, splicing can be difficult.

b. If you need to send the laser in for service, it is much easier to disconnect.

Q: I need to run 80 feet of power wiring to the laser. Do I really need to spend that much money on these huge cables?

A: Yes, if you MUST locate the power supply that far from the laser. Alternately, if you can locate the power supply closer to the laser, you will NOT need to put so much money into huge copper cables:

a. There will be much less current required to run an AC/DC power supply from the AC mains. For very large supplies, three phase mains may be used, so that even a 12000W power supply (recommended for the p400 laser) is drawing a little over 30 A from the AC mains vs. the 170 A that would be required for the 48 VDC lines.

b. Modern Switch Mode Power Supplies (SMPS) have much more tolerance to voltage fluctuations than our lasers, because they have an internal regulator circuit generating a high voltage DC bus voltage that is then converted down to the DC output. The SMPS front end automatically varies its duty cycle to accommodate for input voltage fluctuations, so that most supplies are rated to run from 90 VAC (or lower) to 260 VAC (or higher).

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