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Reduce cost, improve efficiency and reliability with a modular approach to laser power supplies

Typically, laser power supplies consist of an off-the-shelf power supply to provide the low voltage requirements of the system (such as displays, cooling/heating elements, and control and monitoring circuitry), as well as a costly, bespoke solution to power the laser. Whilst this approach works well due to the complex requirements of the laser, it is often expensive and inflexible, requiring different laser power supplies as the laser output varies from model to model.

There is a new type of modular power supply available that allow laser developers to use a common, off-the-shelf platform for the low-voltage supply and the laser supply, reducing total cost of ownership, improving ROI and offering outstanding flexibility and scalability.

Modular power supplies typically consist of a chassis that has a number of slots. With the Excelsys UltiMod range these chassis have either four or six slots. These slots can then be populated with power modules, which in the case of Excelsys are called powerMod, that offer different configurations in terms of output voltage, current and power. They also have versions capable of working in constant current mode, making them an excellent choice for complex laser power supplies.

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Constant current sources

Many lasers, particularly those based on solid-state technologies, require the laser power supply to provide a constant current, with the relevant compliance to drive the laser. In the case of the UltiMod series this is from 1V to 200V. A desirable feature is for the current to be adjustable and precisely controlled.

Modular power supplies like the UltiMod have an adjustable current limit function, I_{trim}, which allows precise control of the output current enabling the supply to act as a constant current source. Whilst this is great for continuous wave operation, there is also a requirement for pulsed applications where the constant current source is modulated at the appropriate frequency. This can be easily achieved with modern modular power supplies by using the logic level enable/disable feature which enables or disables the power supply output.

With standard powerMod units, the output current accuracy in this mode is around 9%; however, this can be customized to deliver a tolerance of <1%, allowing users to pulse a solid-state laser with a true constant current waveform.

The advantage of using modular power supplies is that the outputs from the power modules can be easily paralleled, ensuring a future-proof scalable architecture. For applications targeting the industrial market, the UltiMod range boasts compliance to UL/EN60950, and UL/EN60601-1 for medical applications.

Capacitor charging for IPL

Typical system architectures for IPL applications such as hair treatment, photo-rejuvenation, pigmentation and vascular treatments, involve charging a capacitor bank and then discharging this bank into the light source in order to get a high-energy pulse. Using an AC/DC converter to charge the capacitor bank would be the most efficient solution. However, the majority of AC/DC converters struggle, because when they are discharged, the capacitor appears as a short circuit and will normally trigger the AC/DC converters short-circuit protection systems. Historically this has precluded the use of off-the-shelf solutions and mandated the need for a complex specialist approach.

The UltiMod range,of powerMod's allows V_{trim} down to 1V. This unique, low-voltage trim range allows these powerMod modules to overcome the typical start-up problems associated with switching into a large value discharged capacitor.

By simply connecting these modules in series and/or parallel, the necessary current and voltage can be delivered to meet the charging profile required for the given application. The solution is scalable and existing applications being supported by the Excelsys range vary from 1V to 500V, charging capacitor banks up to 12F, although IPL typically will use sub-1F capacitor banks. For IPL, and other applications where medical certification is required, the UltiMod series are available with medical UL/EN60601-1 standards compliance.

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Easy configuration

When charging capacitor banks, the current required will depend on the size of the capacitor bank and the recharge time required, which in the case of laser applications will ultimately be directly related to the energy required and the pulse frequency of the system.

The rate at which a capacitor can be charged or discharged depends on the capacitance of the capacitor and the resistance of the circuit through which it is being charged or is discharging.

The critical formulae for capacitor charging are:

$$V = V_0[1-e^{-(t/RC)}]$$

$$E = \frac{1}{2}CV^2$$

$$I = C\frac{dv}{dt}$$

Excelsys has developed a simple configurator for their UltiMod series that easily defines a unique power supply solution for any given capacitor bank value and charging rate.. It is based on a simple algorithm linking the electrical properties and performance characteristics of the UltiMod solutions to the equation parameters above as they apply to a customer's system. This allows the software to instantly make a recommendation on a unique UltiMod product configuration to meet system needs.

System information

In order to fully define the requirements for charging capacitor banks the following information is a pre-requisite.

- How large is the capacitance?
- What is the operating voltage the capacitor must be charged to?
- Is there any additional loading?
- Is there a time limit that it must be charged within?
- How much does the voltage dip during discharge?
- What is the current drain during discharge?
- What is the energy requirement during discharge?
- How long does it need for recharge?
- Is there any additional load during recharge?

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Capacitor charging – a worked example

Here is a laser system example where a large capacitance is charged and then the capacitance is discharged across a laser diode.

System parameters are:

- Charged voltage of 58V
- Discharge of 90A for 70ms (through a constant current controller)
- 230ms to recharge back to 58V
- Start-up time of 3.2s or less
- 10% voltage drop from the 58V is considered permissible
- No additional load during charging cycles

A charge voltage of 58V would require an XgQ wide trim powerMod. The first step is to see how many powerMods are required in order to recharge the modules after discharge. 90A @ 58V represents a 5220W power draw from the capacitor by the diode during operation. Energy discharged is calculated as below.

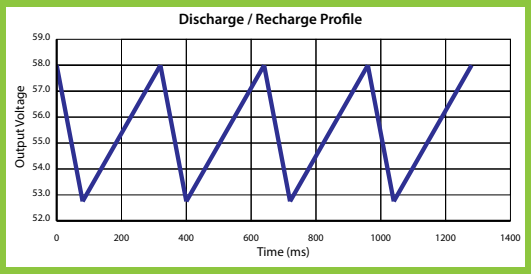
Given Load Power and Discharge Duration

Enter Load Power	5220 W
Enter Discharge Time	70 ms
Energy Discharged	365 J

Next we can select a capacitance to see how many modules are required. In this example, we will use 1F, but the exact value does not matter.

How Many Modules Needed to Charge?

Capacitance	1 F
Charged Voltage	58 V
Discharge Energy	365 J
Discharge Time	70 ms
Recharge Time	250 ms
Module	XgQ
Additional Load	0 A
Required Current	19.67 A
Modules Required	4
Voltage Dip	5.13 V

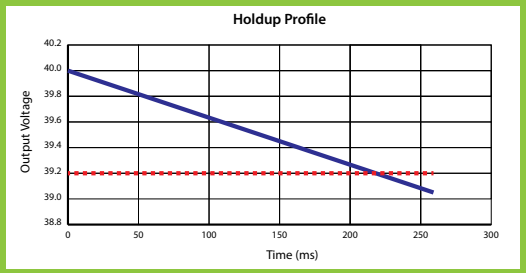


So, four XgQ powerMods are required.

Next we see the capacitance required for the 10% voltage drop using four modules.

Capacitance for Holdup (Module On)

Enter Voltage	58 V
Enter Load	90 A
Enter Permissable Drop	10 %
Which Module?	XgQ
Required Holdup Time	70 ms
How Many Modules	4
Required Capacitance	0.846 F



In this example, 846mF is required to ensure the 10% limit.

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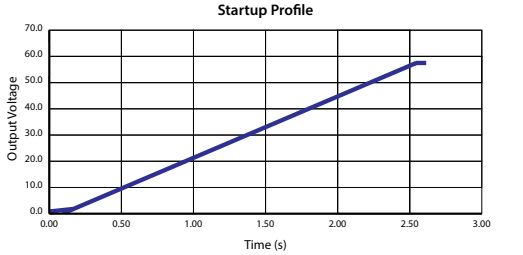
Next we validate startup and ensure time is within specification. Note that the start-up time can be reduced by adding powerMods in parallel.

Startup Profile

Charge Voltage	58 V
Capacitance	0.846 F
Module	XgQ
No of Modules	4
Additional Load	0 A
Startup time	2.6 seconds

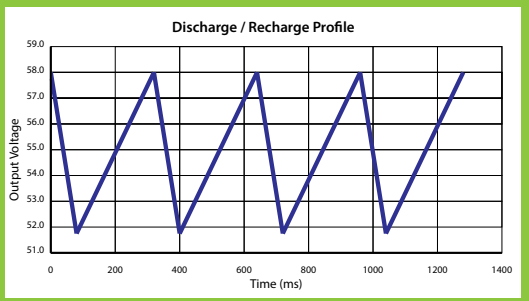


The capacitance is charged in 2.6 seconds, within specification.

The last step is to loop back to change the capacitance value in the charge/discharge sheet to show the actual charge/discharge profile.

How Many Modules Needed to Charge?

Capacitance	0.846 F
Charged Voltage	58 V
Discharge Energy	365 J
Discharge Time	70 ms
Recharge Time	250 ms
Module	XgQ
Additional Load	0 A
Required Current	19.67 A
Modules Required	4
Voltage Dip	6.118 V



So four XgQ modules will meet the desired charge and discharge profiles for this application. These will fit in a UX6 UltiMod chassis, giving a unique part number of UX6QQQQ00.

Other modules can then be added into the chassis to provide the low-voltage requirements for other parts of the system.

Scalable, flexible solutions for laser power supplies

Laser designers and manufacturers are increasingly turning to an off-the-shelf modular power supply approach as their power solution of choice. The unique user-configurability means that customers can effectively build their own custom power supply, in minutes, using standard building blocks.

Specification changes during the development phase of a project are easily handled simply by changing/adding/removing a powerMod in the lab without impacting on warranty or safety certifications. In addition, this allows laser system engineers to adopt a platform-driven product development/release philosophy, so using a scalable building-block solution like UltiMod can bring huge benefits.

A singular mechanical and EMC solution can act as the power-supply for low-, medium- and high-power laser products within a platform. Accessory products can easily be integrated into products within the platform at a later point in time. This saves significant design, test and certification time. For laser system designers this simplifies design and shortens the product-release cycle. The solutions meet all the critical safety standards – EN60950 for industrial applications and EN60601-1 3rd edition for medical applications. They offer the highest reliability by design with best-in-class efficiencies up to 92%. Additionally these platforms are field proven for almost 10 years, and offer a unique standard five-year warranty. Because this is all achieved with standard parts, very short lead times are possible with 24-hour turn around on sample quantities.

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Contact Acal BFi to revolutionise your next laser power supply

Over the past 10 years we have built up a fantastic understanding of laser systems. This knowledge, coupled with our breakthrough products, can add significant value to your next laser-system design.

Contact Acal BFi – we can specify your custom solution in minutes, and because our solutions are all based on standard products, sample quantities can ship in 24 hours and volume lead times of six weeks are typical.

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UltiMod powerPacs

	Model	Slots	Power	Medical Approval UL/EN60601-1 3rd edition	Industrial Approval UL/EN60950 2nd edition
UX	UX4	4	600W	Yes	Yes
	UX6	6	1200W	Yes	Yes

powerMods

Model	Vnom (V)	Set Point Adjust Range (V)	Dynamic Vtrim Range (V)	Imax (A)	Power (W)	Remote Sense	Power Good
XgA	12.0	10.8-15.6	-	12.5	150	-	-
XgB	24.0	19.2-26.4	-	8.3	200	-	-
XgC	36.0	28.8-39.6	-	5.6	200	-	-
XgD	48.0	38.5-50.4	-	4.2	200	-	-
XgE/Xg7	24.0	5.0-28.0	-	5.0	120	-	Yes
XgF/Xg8	24.0	5.0-28.0	-	3.0	72	-	Yes
	24.0	5.0-28.0	-	3.0	72	-	Yes
XgG	2.5	1.5-3.6	1.15-3.6	40.0	100	Yes	Yes
XgH	5.0	3.2-6.0	1.5-6.0	36.0	180	Yes	Yes
XgJ	12.0	6.0-15.0	4.0-15.0	18.3	220	Yes	Yes
XgK	24.0	12.0-30.0	8.0-30.0	9.2	220	Yes	Yes
XgL	48.0	28.0-58.0	8.0-58.0	5.0	240	Yes	Yes
Xg1	2.5	1.5-3.6	1.15-3.6	50.0	125	Yes	Yes
Xg2	5.0	3.2-6.0	1.5-6.0	40.0	200	Yes	Yes
Xg3	12.0	6.0-15.0	4.0-15.0	20.0	240	Yes	Yes
Xg4	24.0	12.0-30.0	8.0-30.0	10.0	240	Yes	Yes
Xg5	48.0	28.0-58.0	8.0-58.0	6.0	288	Yes	Yes

powerMods - wide trim series

MODEL	Vnom	Set Point Adjust Range (V)	Dynamic Vtrim Range (V)	Imax (A)	Power (W)	I Limit onset	Remote Sense	Power Good
XgM	5.0	3.2-6.0	1.0 to 6.0	40	200	49.	Yes	Yes
XgN	12.0	6.0-15.0	1.0 to 15.0	20	240	27.5	Yes	Yes
XgP	24.0	12.0-30.0	1.0 to 30.0	10	240	14.5	Yes	Yes
XgQ	48.0	24.0-58.0	1.0 to 58.0	6	288	7.4	Yes	Yes

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