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Introduction to Capacitor Charging Power Supplies

Capacitor Charging Methods and Formulas

Lumina Power capacitor charging power supplies are specifically designed as current sources for use in pulsed power applications. The most commonly used methods of charging capacitors in pulsed applications are full discharge and partial discharge. Full discharge, as the name implies, allows the capacitor to be discharged to zero every shot. The power supply is then enabled, the capacitor is charged to the set voltage and the discharge cycle is repeated. The high voltage switch is usually an SCR or in higher voltage applications a Thyratron is used. Partial discharge methods take advantage of semiconductor switches to turn on and off the discharge from the capacitor to the load allowing the designer to vary the pulse width along with the energy delivered. The specified capacitor is usually large enough so that only a small percentage of the energy is taken from it each shot hence the name “partial discharge”. In both cases standard formulas can be used to size the power supply and calculate the charge time.

The simplest way to estimate the amount of energy needed for an application is to use the formulas:

energy/pulse (joules) =0.5 x C x V^2
charge rate =energy/pulse x rep-rate

Where
C is the capacitor in farads
V is the charge voltage required
Rep-rate in hertz

Example: A 75uF capacitor is charged to 1500V at a rate of 20 Hz.

charge rate= 0.5 x 1500 x 1500 x 75uf x 20Hz = 1687.5 j/sec.

This formula does not allow for any dead time (settling time) which is usually required in most systems so in most low rep rate applications selecting a slightly larger supply is the best choice. In this case a 2000J/s power supply-would be a good model to specify. (Note1)

In the case of a partial discharge application the length of time the capacitor is allowed to discharge determines the amount of energy needed to recharge the cap to the set voltage. Pulse widths can vary from several hundred microseconds to tens of milliseconds with a corresponding droop in voltage. In general calculating the recharge energy can be done using the formula

$$E = 0.5x\ C_{load} \times (V_m^2 - V_d^2)$$

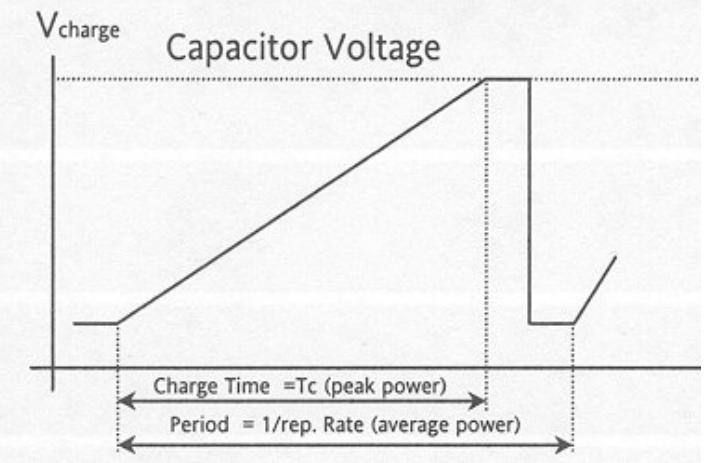
Where
V_m is the maximum voltage
V_d is the lowest droop voltage

(For assistance in designing partial discharge systems and selecting a power supply consult Customer Service at 978-241-8260.)

Using Power Ratings

A capacitor charging power supply has two power ratings expressed in joules per second (J/s), peak power and the average power. The peak power rating is used when calculating the charge time

and the average power is used to determine the maximum repetition rate. Figure 1 illustrates the difference between Average and peak power.



Calculating Charge Time (T_C)

Using the peak power rating of the power supply, charge time can be calculated using the following equation.

$$T_C = \frac{0.5 \times C_{load} \times V_{charge} \times V_{rated}}{P_{peak}}$$

Where:
T_C is the charge time (seconds).
P_{peak} is the unit peak power (J/s).
C_{load} is the load capacitance (farads)
V_{charge} is the required charge voltage
V_{rated} is the rated power supply voltage

To ensure the most available power for the application it is usually best to select a power supply with the same rated output voltage as your load requirement.

Example: A power supply is rated at 1500V out, 2200J/s peak. What is the time required to charge a 50uF cap to 1000 volts?

$$T_C = \frac{0.5 \times 50^{-6} \times 1000 \times 1500}{2200} = 17ms.$$

Calculating peak power ratings

By simply rearranging this formula the required peak power rating of the power supply can be calculated:

$$P_{peak} = \frac{0.5 \times C_{load} \times V_{charge} \times V_{rated}}{T_C}$$

Cap Charger Output Current

Current measurements are typically not published in our specifications but can be used to calculate charge times. Capacitor Chargers have traditionally had fixed output currents that can be calculated using the following formula:

$$I_{out} = \frac{2 \times P_{peak}}{V_{rated}} \quad \text{(note 1)}$$

Example: A power supply has a peak charge rate of 2200 J/s. The current for a 1000V(rated) power supply is:

$$I_{out} = \frac{2 \times 2200}{1000} = 4.4 \text{ amps}$$

Using the same parameters the charge time can be calculated using the formula:

$$T_C = \frac{C_{load} \times V_{charge}}{I_{out}}$$

Note:
1. Contact us for higher rep rate and settling time details.

2 Current formulas assume constant current from 0 volts to the required voltage. All of our Capacitor Charging Power supplies offer excellent pulse to pulse repeatability.

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