Useful Equations

The equations presented below are just a small selection taken from our detailed collection of high voltage Application Notes. The latest versions of these Application Notes can be downloaded from the TDK product center at https://product.tdk.com/en/power/ale. Currently available titles are;

APP Note 500: Calculating Capacitor Charge Time
APP Note 502: Calculating AC Line Currents
APP Note 505: Charging units as Continuous Output DC Supplies
APP Note 507: Charging Large Load Capacitors
APP Note 509: What is Regulation and Repeatability?
APP Note 513: Power Factor Correction
APP Note 517: Protection Against Voltage Reversal

1. Calculating Capacitor Charge Time

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

T_c - *time to charge load*
C_{load} - *load capacitance in Farads*
V_{rated} - *power supply rated output voltage in volts*
V_{charge} - *capacitor charge voltage in volts*
P_{peak} - *power supply peak charge rate in Joules per second*

2. Average Power Rating Required

$$P_{av} = 0.5 \times C_{load} \times V_{rated} \times V_{charge} \times R$$

P_{av} - *average power in watts*
C_{load} - *load capacitance in Farads*
V_{rated} - *power supply rated output voltage in volts*
V_{charge} - *capacitor charge voltage in volts*
R - *discharge repetition rate in Hz*

3. AC line current draw

$$I_{1\varnothing} = \frac{P_{av}}{V_L \times PF \times Eff} \qquad I_{3\varnothing} = \frac{P_{av}}{\sqrt{3} \times V_L \times PF \times Eff}$$

$I_{1\varnothing}$ - *single phase RMS line current*
$I_{3\varnothing}$ - *three phase RMS line current per phase*
P_{av} - *average output power in watts*
V_L - *AC line voltage in volts*
PF - *Power Factor (see product data)*
Eff - *Efficiency (see product data)*

4. Pulse to Pulse Repeatability

$$\delta V = \frac{1}{2 \times F_{switch} \times T_c}$$

δV - *pulse to pulse repeatability (percentage)*
T_c - *time to charge load*
F_{switch} - *switching frequency of supply*
~ 40kHz for 500A, 102A, 152A, 202A, and LC1202
~ 30kHz for 402, 802, 203, and 303

5. Continuous DC Operation

$$Ripple = \frac{I_{load}}{2 \times F_{switch} \times C_f}$$

Ripple - *output voltage peak to peak ripple*
I_{load} - *current drawn by the load circuit*
C_f - *external filter capacitance across supply output*
F_{switch} - *switching frequency of supply*
~ 40kHz for 500A, 102A, 152A, 202A, and LC1202
~ 30kHz for 402, 802, 203, and 303

6. Voltage Reversal Protection

Voltage reversal following load capacitor discharge can potentially damage the power supply. Any reverse current must be limited by a series resistor, or by a clamp diode and resistors to prevent the possibility of damage to the output diodes inside the supply. The degree of protection required is a function of reverse voltage, duration of reversal, and repetition rate of reversal. If the reverse current is greater than the rated current of the supply then a protection diode should be used.

Refer to our online Application Note 517 for details, and guidance in determining the protection component ratings.

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