Life of a Power Supply: Effects of Temperature, Loading & Input Conditions

APPLICATION NOTE

The life of a power supply can be defined as the length of time a power supply can operate and continue to meet its specifications. Power supplies have limited life because they often use two types of components that have known and well documented wear out mechanisms. These components are aluminum electrolytic capacitors used for filtering/energy storage and fans for cooling. The rate at which these components wear out is dependent on the environmental and operating conditions of these components.

Aluminum Electrolytic capacitors slowly lose their electrolyte due to deterioration of the rubber seal and diffusion of the electrolyte. The loss of electrolyte causes a decrease in capacitance and an increase in ESR (Equivalent Series Resistance) resulting in a decrease of holdup time, an increase of output voltage ripple & noise and sometimes malfunction or no start conditions of the control circuits. The electrolyte loss depends on the temperature of the capacitor. Every 10°C reduction in temperature increases the life by a factor of two, according to the Arrhenius Law (see Figure 1). The graph shown is for 10,000 hour, 105°C rated aluminum electrolytic capacitors. 5000 hour, 125°C rated aluminum electrolytic capacitors are also available, but the chemistry of the electrolyte is different, so every 10°C reduction increases the life by a factor of only 1.7. However, capacitor manufacturers do put an upper limit of 15 years (130,000 hours) on the aluminum electrolytic capacitor's life.

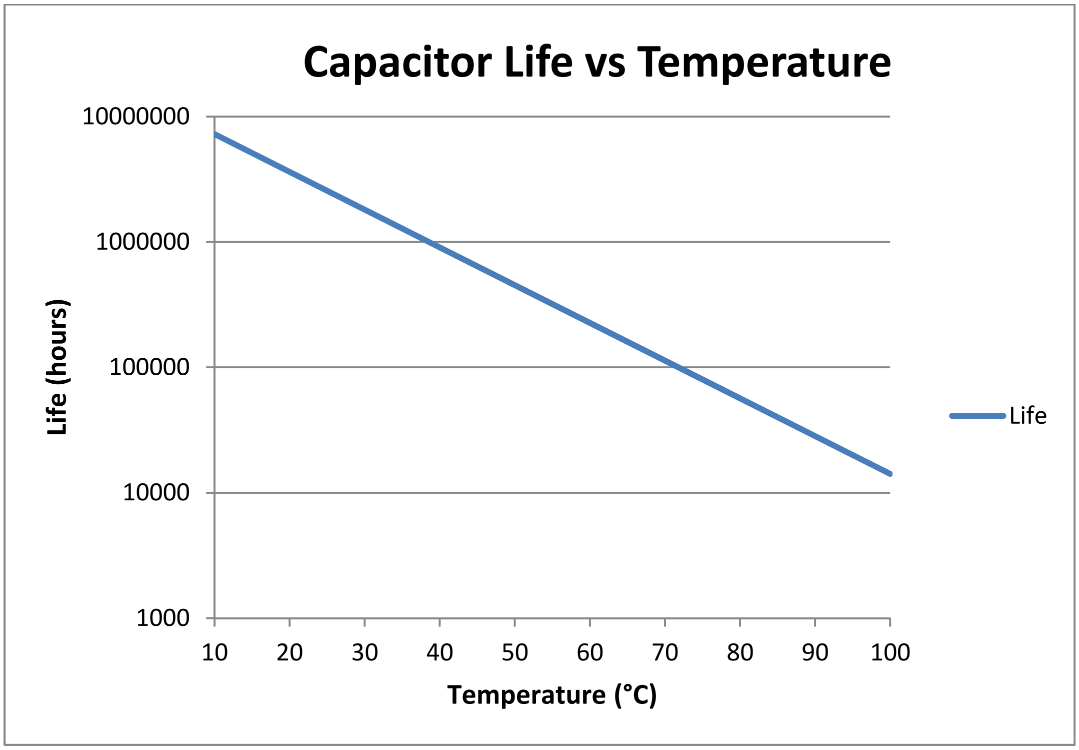

Figure 1

The temperature of the capacitor is the sum of the system's ambient operating conditions and the temperature rise of the power supply which raises the temperature near the capacitor's internal heating due to ripple current. The system's ambient operating conditions are application determined. The temperature rise of the power supply can be derived from the power supply's efficiency curve and the surface area of the power supply. The capacitor's rated ripple current is already factored into the capacitor's life specification so as long as the capacitor is operated at or lower than the rated ripple current, it can be ignored. The temperature rise of a typical 130W power supply that measures 5x3x1.5 inches with convection cooling is shown in Figure 2. Having some form of conduction cooling to a base plate or a fan to provide airflow can reduce the temperature rise of the power supply.

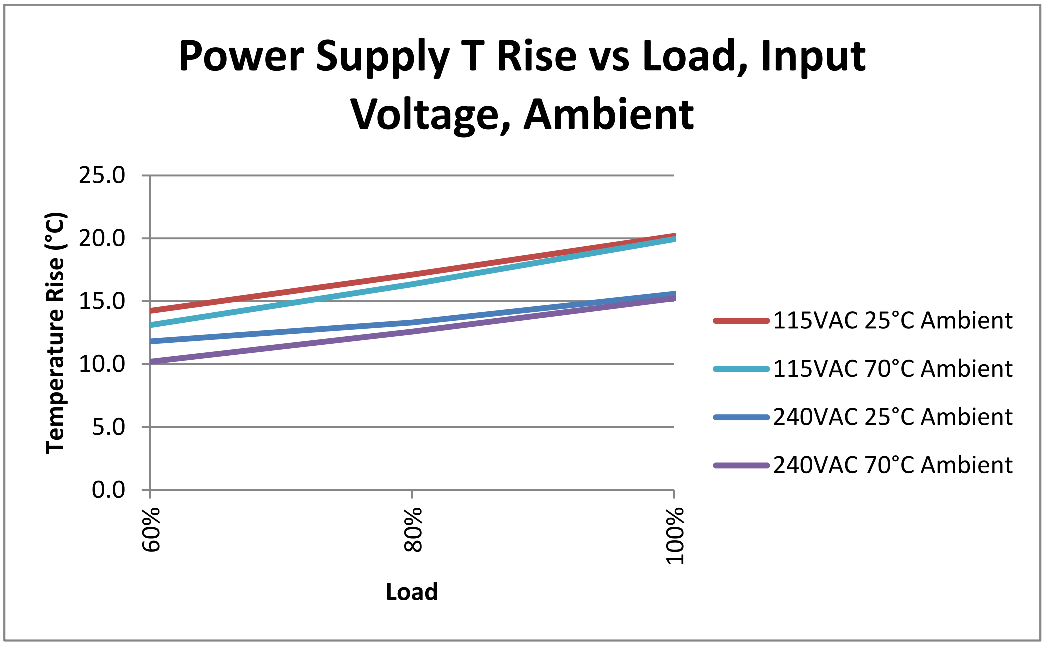

Figure 2

The life of a fan is often stated in terms of the L10 life expectancy. L10 specifically refers to the amount of time it takes for 10% of a group of fans to fail. The L10 life is often in the 60-80,000 hour range and is almost entirely based on the bearing system, the lubrication used and ambient temperature although the temperature effect is less pronounced than that of aluminum electrolytic capacitors. (see paper from NMB)

When the power supply uses 10,000 hour life rated 105°C capacitors, the capacitor life exceeds the life of any available fan, therefore eliminating the need for a fan.