Driving Halogen Lamps

Abstract: This application note looks at the suitability of the Ultimod wide trim powerMods for applications driving Halogen lamps.

An incandescent lamp generates light by heating a tungsten wire or filament until it glows (at around 2,500 ºC) by passing an electric current through it. A halogen lamp is basically a modified version of an incandescent lamp. The difference is that the bulb of a halogen lamp has a small amount of a halogen gas added. The presence of this halogen in the bulb produces a chemical reaction (known as the halogen cycle) that redeposists tungsten evaporated by heating back onto the filament. In a standard incandescent the constant evaporation leads to the eventual failure of the lamp as the filament progressively thins and breaks or "burns out". Since in a halogen lamp the tungsten is redeposited back on the filament its lifetime is extended, and it also be heated to a higher temperature (in the region of 3,000 ºC), which increases its efficiency.

The high operational temperature of the filament results in a challenge for a constant voltage power supplies like the Ultimod due to the different resistance of the tungsten filament at room temperature and its resistance at 3,000 ºC.

For example, take a 24 V, 240 W halogen lamp. If the bulb consumes 240 W at 24 V, the resistance of the lamp while on must be about 2.4 Ω and will draw around 10 A. However, at startup the filament is at room temperature (which we will assume for now to be 25 ºC). The temperature coefficient of tungsten is 4.5 x 10^{-3} / ºC. This means that at room temperature, the resistance will only be 180 mΩ. This would draw 133 A from a constant voltage of 24 V. This would require a lot of Ultimod modules!

Of course, this is just a transient condition, and as the filament heats up the resistance will rise to the normal operating resistance of 2.4 Ω. This transient is known as inrush current and the power supply will have to be able handle this condition.

If we size our power supply for normal operating conditions (i.e. 2.4 Ω), we could use a single Xg4 powerMod (24 V, 10 A). But what happens at startup at room temperature when the filament is only 180 mΩ and tries to draw 133 A? The answer is that the powerMod will go into a protective current limit. The characteristics of this current limit are shown in Figure 1 below.

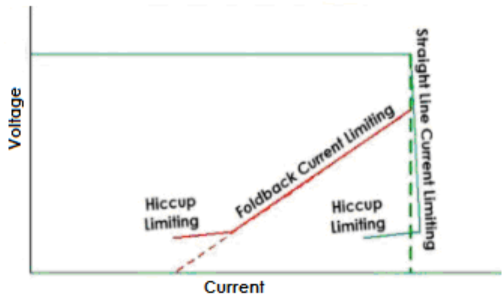

Figure 1 Current Limit Characteristics

You can see from Figure 1 that when we increase the load (by reducing the loads resistance) and the current increases above the set current limit of the modules we enter a mode of operation known as straight line current limiting where the current is held constant and the voltage is reduced. For an Xg4 powerMod this will occur somewhere between 10.5 and 12.8 A.

If the load is increased further, the voltage will continue to reduce until we reach a short circuit protection point. The powerMod then enters a mode of operation known as hiccup limiting where the module turns on and off until the short circuit condition is removed. For the Xg4 modules this occurs between 5.4 and 7.4 V. But even at 5.4 V the 180 mΩ will try to draw 30 A (three times the current limit of 10 A). This means that at startup the Xg4 will hiccup, and we will see the halogen lamp flash on and off. This startup undesirable profile as can be seen in Figure 2 below.

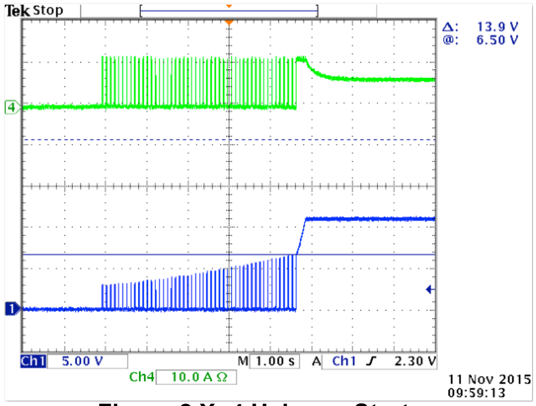

Figure 2 Xg4 Halogen Startup

The green trace in Figure 2 is output current, while the blue trace is output voltage. You can easily see the hiccupping during startup (where the current is clamped and voltage of each hiccup rises as the temperature of the filament slowly increases). When the filament temperature and resistance is high enough the hiccupping stops. The voltage then rises while the Xg4 maintains its maximum output current. As the filament heats up to its normal operating temperature the voltage reaches 24 V and the current drops down to its normal operating level. It take about 5 seconds in all for this to occur.

So, how do we avoid this unwanted hiccupping during initial power on? The answer is to use Advanced Energy wide trim powerModus. In this application we would be looking to use XgP modules. XgP modules are designed to operate over a wider voltage range than the Xg4 (1 – 58 V for the Xg4 vs 8 – 30 V for the XgP). This means that XgP hiccup limiting does not occur until the output voltage has been reduced to 0.9 V. At 0.9 V output the cold filament will draw only 5 A, meaning the lamp can startup without hiccuping at turn on. Figure 3 shows how voltage rises and the current is held constant as the filament temperature increases.

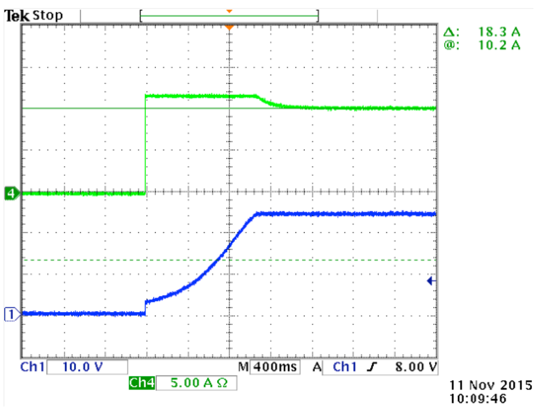

Figure 3 XgP Halogen Startup

The halogen lamp can now be powered with a single module without hiccuping, and reaches its operating temperature in about 1.2 seconds.

About Advanced Energy

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AE's power solutions enable customer innovation in complex semiconductor and industrial thin film plasma manufacturing processes, demanding high and low voltage applications, and temperature-critical thermal processes.

With deep applications know-how and responsive service and support across the globe, AE builds collaborative partnerships to meet rapid technological developments, propel growth for its customers and power the future of technology.

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