Is My Radio's Power Supply Adequate

David E. Buxton June 10, 2014

A couple of years ago I went through a full flying season of sparsely spaced radio/Vbar restarts. The heli would ignore me and go to zero collective for several seconds, perhaps a dozen times. Every single time my Trex-600 had been coasting along in level flight, never once during aggressive maneuvers. I was convinced that the BEC had plenty of excess DMM measured capacity, clearly not a brown out problem. Then in the fall the heli had just reached full head speed when it spontaneously lifted off and did a back flip, landing back on its skids, no damage. If the loop diameter had been several feet larger it could have killed me.

The first restart occurred in the spring, two or three weeks after replacing the tail servo. This article will help you understand what was going on with my heli. The servo's association became obvious much later when I learned that most digital servos use switched mode power.

There are two aspects of RC receiver input power that need to be working properly before you can be sure that your airplane or helicopter is safe to fly:

- Brownout avoidance power which can be measured with a DMM or LED monitoring device.
- Receiver power supply behaviors that can be seen on an oscilloscope with current and voltage probes (or use a peak min/max detecting DMM).

Brownout Avoidance

Power supply designers have devised several different ways to handle an overload. E.g. current limiting, shut down -> wait a bit -> try again, fuses. Or you can get smoke and fire if overloaded poorly designed protection circuits. We want to make sure that the power supply (e.g. voltage regulator, BEC, NiMH battery) has plenty of margin so the most aggressive flight conditions (e.g. pulling out of a power dive) do not come close to overload conditions.

Switched Mode Power

Switched mode power takes advantage of Ohm's law with regards to switches. E.g. MOS-FET switches exhibit very little leakage when open circuit and amazingly low voltage drop when closed circuit. Either voltage or current takes turns being very close to zero.

Switched mode power is high efficiency power and can offer a much taller input voltage range compared to analog (linear) power designs. The raw basics of switched mode power is illustrated below. It should be obvious why switched mode power is so noisy, especially if the capacitor is not large enough.

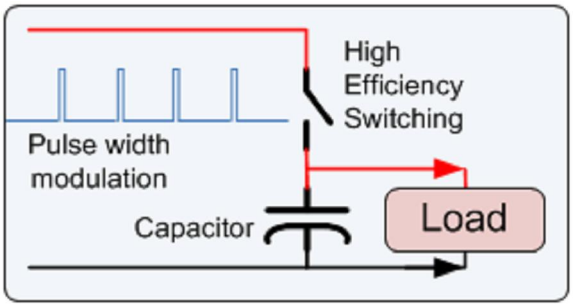

Figure 1: Switched Mode Power

Some examples of switched mode power:

- Electronic Speed Controllers (ESCs) convert DC to three phase AC.
- A steadily increasing percentage of Battery Eliminator Circuits (BECs) and voltage regulators use switched power.
- High speed, high torque aggressive digital servos use switched power.
- A few expensive servos use small ESCs to drive a 3-phase brushless motor.

Switched Mode Servos

Analog powered servo motors use an amplifier whose output voltage is proportional to the difference between servo position and target position.

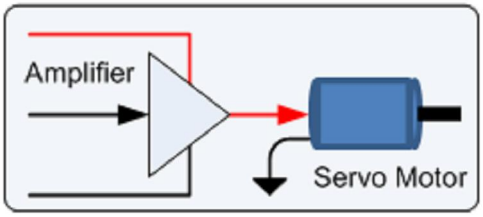

Figure 2: Analog Motor Drive

Switch mode servos use pulse width modulation (and or pulse rate) which is proportional to the difference between servo position and target position.

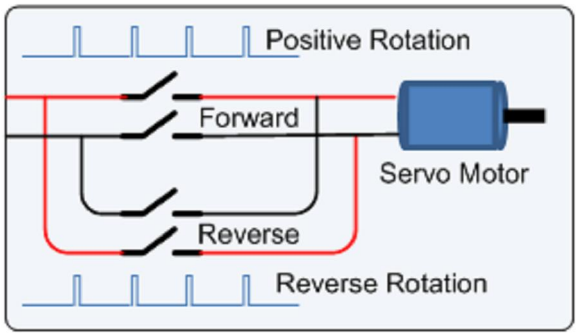

Figure 3: Switched Mode Motor Drive

Spin a motor and it becomes a generator. A motor at or near zero RPM offers very little resistance. The effective resistance is much higher when the generator effect kicks in as the motor spins. The result is that the tallest current pulses occur close to zero RPM.

For power supplies, there is some latency between detecting a voltage drop and responding to the pulsed need for more current. Switch power latency is significantly greater than for a linear supply (e.g. BEC). When the servo's pulse width is narrower than the BEC's latency then all of the pulse power must come from a capacitor. Without a large enough capacitance the voltage will fall too low and restart the radio.

A switched mode power supply intended for use with aggressive switched mode servos must use considerably more output capacitance than is needed for analog servos. Often enough we resort to a larger BEC, not because we need more amps but because the larger BEC has a larger output capacitor. Too many BEC manufacturers have been much too skimpy on output capacitance.

The idealized system solution would place capacitors inside (not practical) or near each digital servo. If you want the fastest hottest servos in town, then it is capacitance and not the BEC amps rating that will give your servos the biggest kick in town.

How about plugging in more capacitance?

> Caution: When a capacitor is charging it starts out looking like a short circuit. Some BECs cannot handle much additional capacitance. Check with the manufacturer if you plan to add a significant amount of capacitance. The safest solution is a BEC with plenty enough built in capacitance.

Not all digital servos are created equal. There really is no practical way to read the manufacturer's literature and specifications in order to determine if your heli or airplane is safe. A big amps power source is no guarantee. So what can be done to make sure your flying machine is safe?

VoltMagic

Some electronics technicians and engineers have access to equipment that can see the problems caused by switched mode servos. Hardly the expensive stuff with which to stock your field box. The only practical and economical solution that I know of is to use a VoltMagic which can be used on the bench or in the air. Right out of the packaging, plugged into an empty servo slot, it is capable of alerting you to inadequately filtered power reaching your receiver. There is a red LED that will continue to blink after sampling a voltage that dropped too low. A steady red means low battery and blinking indicates a transient low was detected.

The Smart-Fly system in my giant scale airplane separates receiver power from servo power. Do I need to test it with a VoltMagic?

> Some servos have embedded micro-controllers which are capable of restarts resulting in hesitation symptoms. Internal battery resistance, wiring, connectors, etc. can add up to too much resistance for those narrow high amp switching pulses.

Conclusions:

"The Perfect Storm" of risk for your receiver occurs with a switching BEC, aggressive digital servos, not enough capacitance and servos operating close to zero RPM. We cannot expect even high amperage BEC manufactures to provide enough capacitance for worst case digital servo scenarios. The most cost effective way to make sure your radio's power supply system is adequate is with a VoltMagic.