

## One Cause Revealed for Loss of Control (LOC) Syndrome

I made up the LOC acronym for a syndrome I have seen flyers experience during several visits to the flying field. The symptoms come suddenly and without any notice. A helpless feeling pervades the body as the aircraft spirals out of control and smashes into the planet. The flyer looks dumbfounded and can not explain why the aircraft would not respond to transmitted commands. Was it caused by an anomaly in the ether or an aberrant vortex from Sedona? The servos seem to have LOCed up in awkward positions. Thankfully the planet once again survives the ordeal.

This happened to me once on an electric motor propelled airplane new to me. The servos locked to an extreme position and the result was that one fuselage became two short ones. I speculated that I had a receiver problem or a receiver power source problem since all controls seemed affected and I knew the transmitter to be good. I put the pieces on the bench, powered it up, and looked at the receiver's power supply voltage from the BEC (battery eliminator circuit frequently built into the ESC) with an oscilloscope. I sped up the electric motor, but saw remarkably small ripple on the battery and nothing bad coming out of the ESC's BEC. Then I started moving the control stick to cause servo activity since the servos are powered from the BEC. At first no problem, but then I rotated the right stick quickly in a circular movement and then they quickly LOCed up! On the oscilloscope I was able to see the 5V BEC output voltage rapidly glitch negative dropping about 1.5 volts. While the receiver might operate at 3.5VDC, strange things can happen when the drop occurs in a few hundred nano-seconds. The strange thing happened to be to lock the servos in extreme positions.

It just so happens that I have designed voltage regulators at the transistor level so this issue was right up my alley. The type of regulator used in the BEC was rated for enough DC current, but had trouble with the rapid transients. It was particularly sensitive because it was a very common low dropout regulator (LDO) which means that the 5V output is regulated until the input voltage from the battery drops to about 5.1V and then as the input falls the output follows about 0.1V lower. The tradeoff for this is that the LDO architecture has inherently high output impedance at higher frequencies (transistor collector or drain is the output), which means that when the load current changes rapidly from servo activity it can't regulate the voltage very well. The servos and motors we use generally produce higher frequency load currents because the currents supplied to them is usually switched on and off rapidly, at varying time intervals, to control their position or speed.

My solution was to bypass that LDO and use an old tried and true 3-terminal 5V/1.5A regulator integrated circuit, such as an LM340, that became available in the 1970s. It was novel at the time because it made power supply design simple as the 3 terminals are ground, voltage in and voltage out. It is not an LDO type so the input voltage needs to be at least 1.5V higher than the output voltage, but since I was using a 3S Lithium battery then no problem. Its architecture has inherently low output impedance at higher frequencies (transistor emitter or source is the output). I've never seen the problem since. At my last employer I worked on occasion with the designer of the LM340, now CTO, who originally developed the 3-terminal regulators and I know he is a capable person as he is now a billionaire... with a "B"! That boggles my mind.

In summary I suggest that anyone who has a BEC in their airplanes that powers servos and receiver to test their system on the ground by quickly moving all servos simultaneously with the joy sticks. This is an aggressive test that may indicate a problem that you wouldn't have in normal flying. You will have to interpret the results. If your airplane uses LiPo batteries then you likely have a BEC. If you shop for an ESC with a BEC I suggest you consider one that can handle several more servos than you need.

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