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It's time for another shutoff update. I've just returned from a trip to the American Physical Society March Meeting in Pittsburgh, PA, and while nobody there reported any new results on shutoff technology, I did get a chance to see Alex Prokofiev's new electronic shutoff close-up when I stopped by Philadelphia on my way to the conference. In short, I was very impressed with this little device. It's not just the device itself that impressed me, actually, but also the feat of home electronics engineering that Alex has pulled off with his creation. Not only did he design the conceptual underpinnings of the device and the circuits to implement it, but he has even taken to printing his own custom circuit boards to keep the device as small and light as possible.

The shutoff consists of 3 parts: an RF signal generator mounted in the handle, a circuit board with RF receiver and processing circuitry, and a valve to stop the fuel when the flyaway condition is detected. He also has a switch mounted on the handle that is used to "arm" the shutoff, and can be used to trip the shutoff for tests. Two batteries are needed, one in the handle, and one on the model. Encouragingly, even at this early stage of development the parts mounted on the model only weigh in at a few grams and contribute negligible additional drag.

The transmitter generates a high frequency signal, with its amplitude modulated at a much lower frequency. The frequency of the slow modulation amounts to the ID tag for the shutoff. The shutoff remains open while the low frequency signal is present, and shuts off once it does not detect anything at this frequency. This amplitude modulation (AM) technique is much more robust against noise and interference than techniques based on frequency modulation (FM). In particular, there is no problem if two pilots use this system simultaneously. During a line twist, both pilot IDs will be received by both shutoffs. This does not create any problem, however, because each shutoff only looks for its own ID: as long the receiver gets a signal at its own ID frequency it will remain open irrespective of the presence of the other pilot's ID. Even if both pilots use the same ID frequency there is no problem with interference. This realization is probably the key idea that will pave the way for the success of this design relative to other possible implementations.

The signal is transmitted through the lines to the model, and then picked up by the receiver board. At the moment, the receiver board is housed in a notch cut out of the foam in the leading edge. Finding a more secure/permanent mounting solution is a direction of current active research. Inside the model, there is a wire connected to the leadouts that brings the signal through a small hole in the leading edge to the notch where the receiver board lives. Somewhat surprisingly, Alex found that it is not necessary to solder any extra wires to the lines themselves: the contact between the metal loops on the handle, the leadout connectors, and the lines are sufficiently good under tension (flying conditions) that no further action needs to be taken.

Currently the signal is sent only through the down line, but it looks like during "full-control" inside loops where the model hangs on the up-line, the down line can become slack and lead to a loss of signal. The fix that Alex is using right now is to include a delay in the system so that the device will not shut-down until the pilot ID signal is absent for 2-3 seconds. The next version will send the signal through both lines so that as long as either one has a connection the receiver will get a positive signal. This will allow the delay time to be reduced, thus speeding up the action of the device in a real flyaway situation.

The valve that finally controls the flow of fuel is operated by a piece of "muscle-wire." This is a small piece of shape-memory alloy that contracts when heated. By passing a high current through the wire, it can be quickly heated to induce the shrinkage which closes the valve. This heating stage is where the battery gets used up. With the current battery, there is enough energy stored for about 10-12 shut-downs on a single charge. A convenient LED indicator flashes when the power gets low. To improve the longevity, Alex is considering switching to a higher capacity battery. Additionally, he is also working on schemes to improve the efficiency of the heating process which will allow a single charge to go a longer way.

All-in-all, I find these results to be very promising. What Alex has now is a working prototype system that in principle could be used as-is, but will become even better as further (already planned) improvements are made. The main problem now seems to be the cost and effort associated with building these devices. If, once the design is settled, we can find a way to put them into semi-mass production, perhaps the cost will come down and make the system widely accessible.