IARC Common Kill Switch

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Please note: This kill switch was originally desinged for smaller Mission 6 vehicles and may require modification to meet the larger current draw requirements of Mission 8 vehicles.

This design is representative of the minimum requirement to pass static judging but should be tailored to each team's specific design.

1 Introduction

The purpose of this project was to create a common kill switch device for use with small electric-powered air vehicles. This design provides a simple and effective means of killing power to the motors of a small air vehicle through the use of a separate radio control receiver. This design can be copied and built as-is, or used as a reference design for teams to implement into their own vehicle. This design is considered the standard design by which other kill-switch mechanisms will be judged.

2 Circuit Description

This were two goals for the design of this kill switch: 1) to use a minimum of components; 2) to not require a microcontroller or any software programming. To achieve these goals, the circuit was designed to be parasitic to the main motor power source. This circuit was designed with the following two assumptions: 1) the motors are powered from no more than a 3-cell series connected Li-Poly battery pack; 2) the main motors draw 35-amps continuous with peak pulses of 100-amps. This section will describe the operation of the circuit which is shown in Figure 1.

The kill switch is powered parasitically from the main motor power source via a 5-volt regulator, U1. The circuit draws approximately 15 mA of current. The LED, D1, is used to indicate that power is applied. The core of the kill switch is the PWM to TTL converter. The pulse into the converter is provided by a standard radio control receiver connected to P3. Power to the receiver is provided by the 5-volt regulator U1. The PWM to TTL converter is constructed from the dual-D flip-flop, U2A and U2B. The first flip-flop U2A is wired as a 1-shot timer with the delay time set from R2 and C4. The trigger is the rising edge of the PWM signal from the radio control receiver. Normally, the width of this pulse is between 1 mS and 2 mS with 1.5 mS center. Using R2 and C4 a time constant of 1.5 mS can be programmed.

On the rising edge of the pulse into U2A on pin-3, the timer is started. U2A output pin-1 charges C4 via R2. Once the voltage at U2A, pin-4, reaches threshold, U2A is reset. This causes the inverting output of U2A, pin-2, to go high. This low to high transition of pin-2 triggers the clock input, pin-11, of U2B. This trigger will latch the value of pin-9 into the output of U2B, pin-13. If the pulse width of the PWM signal is greater than the delay time, the output will be high, else low. There is some chatter possible around the set delay time due to the ramping of the voltage at pin-4. The LED, D2, allows for a visual indication of the current state of the PWM to TTL converter.

The output of U2B, pin-13 is used to turn on/off the three N-channel MOSFETs Q1, Q2, and Q3. These are wired in series to decrease the on resistance. It is noted that these MOSFETs control the low-side of the motor power. The input power from the battery is connected to P1 and the vehicle motors are connected to the switched output power at P2.

3 Construction

The circuit was implemented on a 2-layer PCB 1.725 inches by 0.810 inches. The total weight of the prototype without connecting wires was 4.5 grams. The bill of materials is shown in Table 1. All of the components are available from Digi-Key. Basic SMD soldering technique

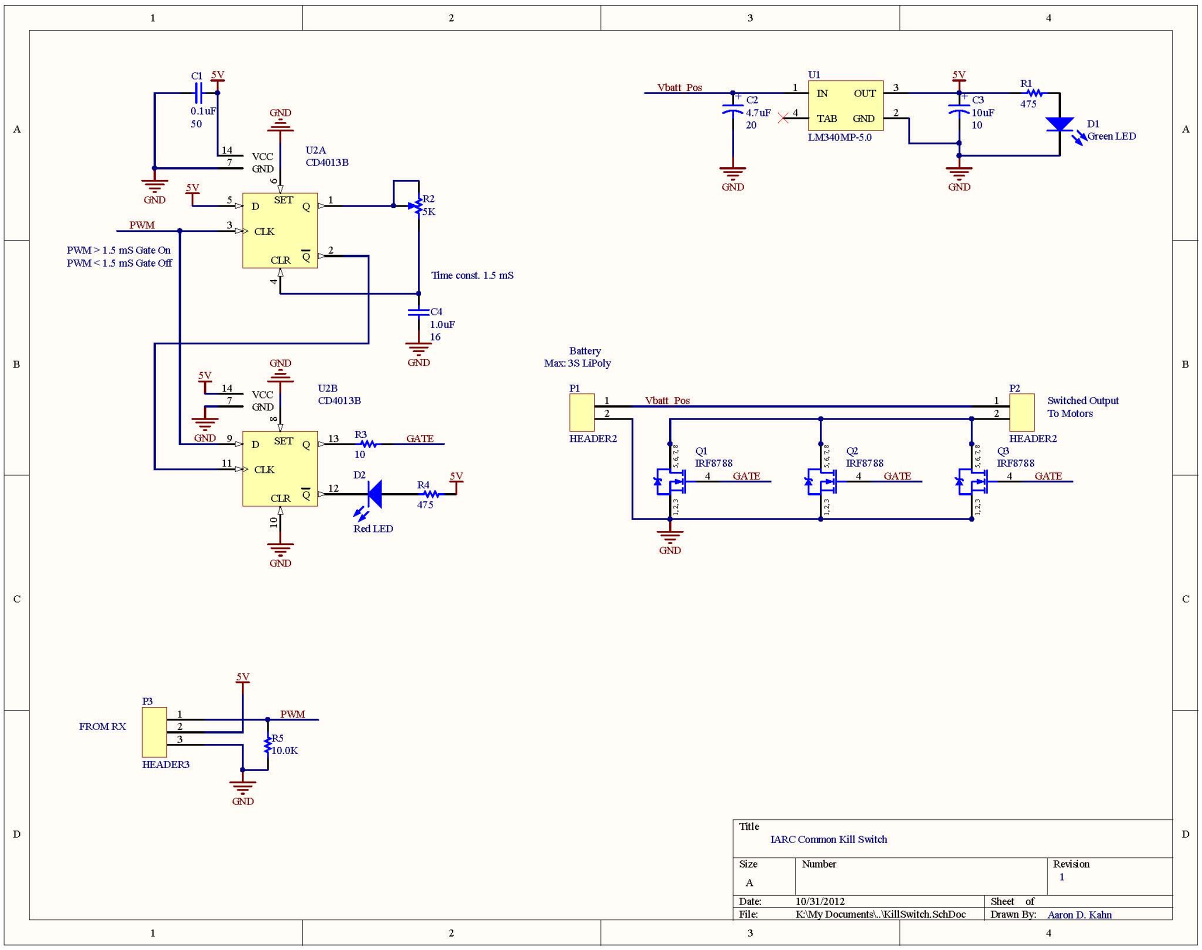

Figure 1: Schematic of kill switch.

Designator	Description	Value	Digi-Key Part	Qty
C1	Ceramic chip cap	0.1 uF	478-3352-1-ND	1
C2	Tantalum cap A-size	4.7 uF	478-1668-1-ND	1
C3	Tantalum cap A-size	10 uF	478-1654-1-ND	1
C4	Ceramic chip cap	1.0 uF	478-5034-1-ND	1
D1	Green 1206 LED		160-1169-1-ND	1
D2	Red 1206 LED		160-1167-1-ND	1
P3	0.1-in header		3M9448-ND	1
Q1,Q2,Q3	IRF8788 N-channel MOSFET		IRF8788TRPBFCT-ND	3
R1,R4	1/8W 1% 0805 Resistor	475 ohm	P475CCT-ND	2
R2	Bourns 3266 Vertical Pot	5K ohm	3266W-502LF-ND	1
R3	1/8W 1% 0805 Resistor	10 ohm	P10.0CCT-ND	1
R5	1/8W 1% 0805 Resistor	10.0K ohm	P10.0KCCT-ND	1
U1	LM340MP-5.0 5-volt regulator		LM340MP-5.0/NOPBCT-ND	1
U2	CD4013BM Dual-D Flip Flop		296-12972-5-ND	1

Table 1: Bill of Materials

was used to assemble the prototype. The author did not require a microscope for assembly. Point soldering was accomplished with a fine tip iron. Components U1, U2, Q1, Q2, and Q3 were installed first. The chip resistors, capacitors, and LEDs were installed next followed by the tantalum capacitors. The potentiometer and 3-pin header were installed last.

4 Setup

Connect either the aileron or elevator channel of a radio control receiver to P3 and the main motor battery to P1 as shown in Figure 2. The LED, D1, should be glowing indicating power is applied. With the appropriate channel stick centered adjust the trim potentiometer, R2, until the LED D2 starts to chatter on and off. At this point the delay time is set to about 1.5 mS. Now, moving the appropriate stick from end to end, D2 should switch from steady on to steady off. This indicates proper operation. One can now reconnect P3 to the gear channel on the radio control receiver to control the kill switch. The LED D2 is used to visually check the status the switch. When D2 is glowing motor power at P2 should be applied, and can be confirmed with a volt meter. When D2 is off, the power is killed, and this too can be confirmed.

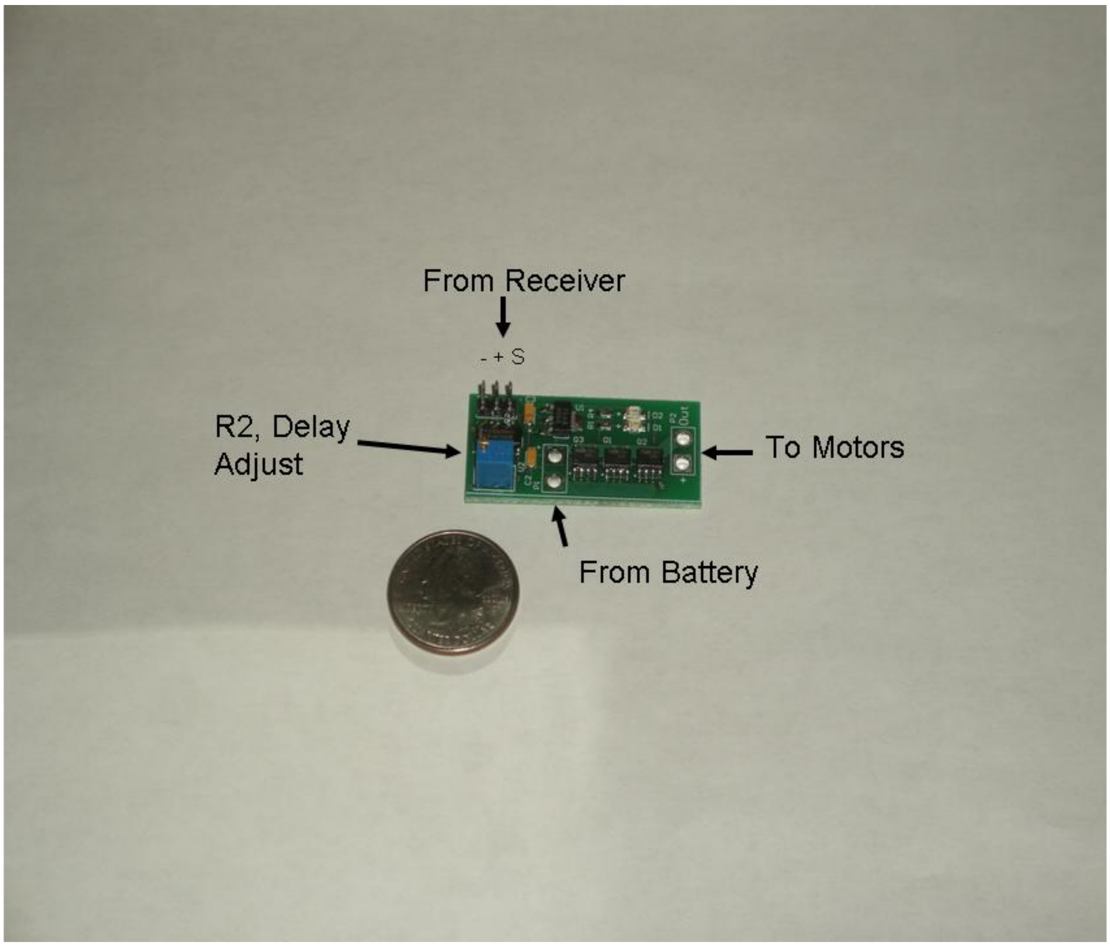

Figure 2: Connections to board