Relay Documentation

If an error occurs in the code or the hardware, power must immediately be removed from the motors. Otherwise, the drone will become an unsafe projectile that can destroy itself or harm equipment or people in the lab. For this system, the “safe” condition is when the motors are physically disconnected from the power source. When any failure results in the safe condition, the operation is called “fail-safe”. Fail-safe operation is achieved through both code and hardware. This document focuses on the hardware.

The main hardware component for failsafe operation is the relay. Specifically, we use the 1 Channel 12V Relay Module based on the Songle SRD-12VDC-SL-C relay. A schematic is shown below. On side 1, there are three inputs: DC+ (battery power), DC- (ground), and IN (an analog input signal that acts as the trigger). On side 2, there are three outputs: NC (normally closed relay), COM (the communicated output signal), and NO (normally open relay). There are also three pins on the board: H, L, and an unlabeled pin between them I’ll call M. There is a cap to connect either H-M or L-M.

DC+ and DC- provide power to operator the relay. IN provides the trigger signal. When a relay output (either NC or NO) is “closed”, the COM value is passed to the output. We want to pass all the battery power, so we wire COM to the positive battery terminal, so COM=DC+. When a relay output is open, the ground value, DC-, is passed instead (really, the circuit is broken, but it helps me to think about passing ground). NC is normally closed, so without a signal from IN, COM will be passed. The opposite is true for NO. It is normally open, so without a signal from IN, ground will be passed. The “signal” is determined by H-M or L-M. If H-M is connected, then the signal is when IN is high. If L-M is connected, then the signal is when IN is low. This is summarized in the table below.

|  |  |  |
| --- | --- | --- |
|  | IN = Low | IN = High |
| L-M and NC | DC- | COM |
| L-M and NO | COM | DC- |
| H-M and NC | COM | DC- |
| H-M and NO | DC- | COM |

To ensure fail-safe operation, we need DC- to be passed to the output when

1. The RPI loses power.
2. The connection between RPI and relay is interrupted (aka loose wire).

Both of these conditions result in IN=Low, so in principle either L-M with NC or H-M with NO are valid choices. There are some esoteric reasons why one might be better than the other based on the actual physics of how the relays operate, but for our purposes either will do. We went with H-M and NO, which has worked well. The wiring can easily be flipped later if necessary.

Since we are using a high trigger, we want to ensure that the default value of the signal coming from the RPI is low. This is the case for all GPIO pins numbered >9. We currently have it connected to GPIO25.

Functioning correctly as of April 17, 2024

A diagram of a circuit

Description automatically generated

Since the relay works closely with the ESCs and operates similarly with respect to the RPI, it is initialized in the ESC function.