Purpose:

Characterize power interruption ride-through duration; that is, how long does each component operate without power?

Motivation:

During 2017 competition season, FRC team #1018 encountered several occasions where the robot lost communications with the field. We probably weren’t alone! What might be different, is that we were told that our radio did not reset; our RoboRIO did. This effort was undertaken to define the ride-through duration for the RoboRIO, the Radio and the robot system.

Results:

We found:

Interruption of power to the RoboRio in excess of 6.3 msec (milli-second) results in a reboots of the RoboRio,

Interruption of power to the Open-Mesh radio in excess of 4 msec results in a reboot of the radio,

Interruption of power to the VRM in excess of 2 msec results in a reboot of the Open-Mesh radio, and

Interruption or power at the input of the main breaker in excess of 43.8 msec results in a reboot of the entire robot; RoboRio and radio included.

The most surprising results from this test are that the link from the PDP to the VRM, with the VRM providing power to the radio, appears to be more susceptible to power interruption than the radio is alone.

This work does not address the likelihood of power interruption; only the critical duration at which power interruption impacts upon operating the robot.

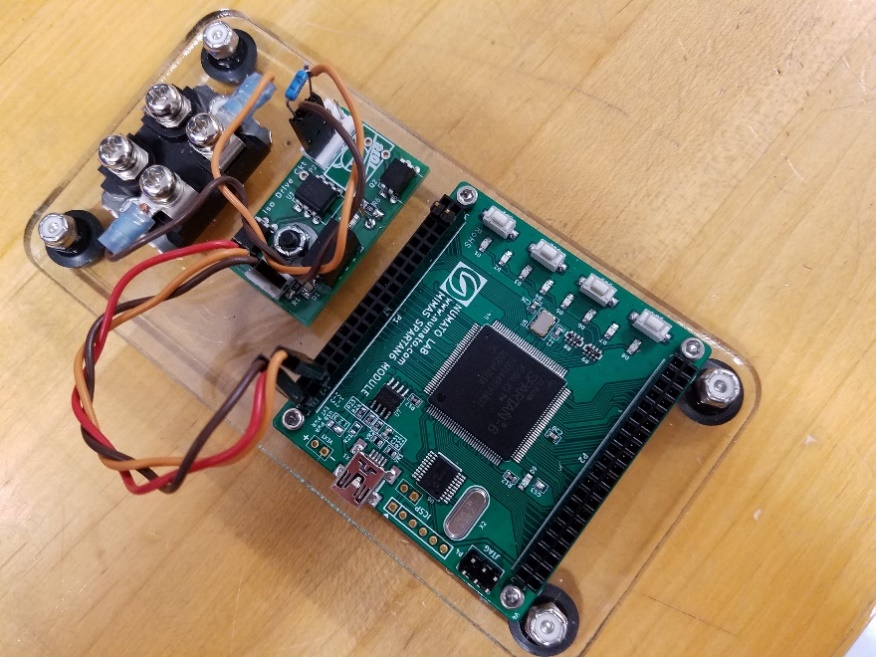
Method:

First, we used a MOSFET to interrupt the supply Voltage line to the Item tested, i.e. a high side switch.

Second, we used a flashlight switching circuit to operate the switch. This circuit was designed into a printed circuit board as a by-product of FIRST stronghold. The key item is that the circuit provides the isolation needed to operate the MOSFET as a high side switch.

Third, we used an FPGA board to generate the needed power interruption pulse. Once programmed, using VHDL, the board was capable of producing an arbitrary length pulse. The pulse is used to operate the switch.

All three of these components are shown in the following figure:



The FPGA board is a Numato Mimas, which provides a Xilinx XC6SLX9 with a 100 MHz. clock. Details on this product can be found at:

<https://numato.com/product/mimas-spartan-6-fpga-development-board>

The MOSFET is an IXYS N-Channel MOSFET IXFN360N10T. Details on this product can be found at:

<http://ixapps.ixys.com/DataSheet/DS100088(IXFN360N10T).pdf>

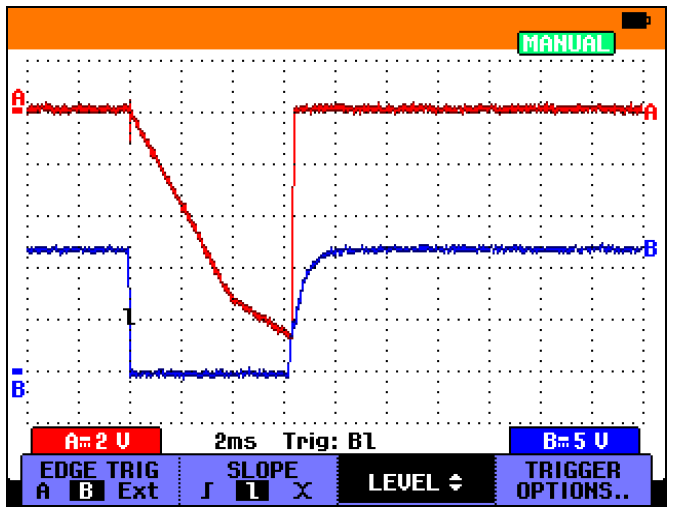
VHDL for the project will be posted to CD, as well.

Detailed results are provided on the following pages. Note that each plot may use a different timescale on the horizontal axis.

RoboRio testing

Several pulse durations were tested. We identified 6.2 msec as the duration at which a repeatable reset of the RoboRio occurred. We used a Fluke Scopemeter to record the switch Gate-Source and Drain-Source Voltages. These waveforms also document the time durations.

For this test, we interrupted the supply power from the Power Distribution Panel (PDP) to the RoboRio. The return line was wired directly and was not interrupted.



There are two waveforms recorded via a Fluke Scopemeter, blue and red.

The blue trace is the Gate to Source Voltage on the MOSFET. When held low, the switch is open; when released the gate charges and the switch turns on. The board, used to operate the MOSFET, was configured to clamp the gate to the drain when on (low Voltage condition on the blue trace) and release when off. When the clamp was released, the gate of the MOSFET was left to recharge through a current limiting resistor. This results in the charging RC waveform seen during the turn-on duration.

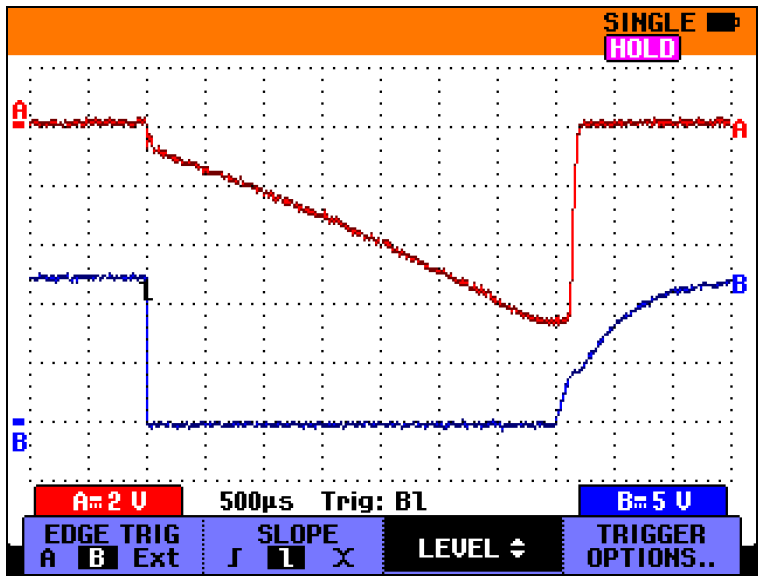
Note that the time durations reported reflect the duration where the switch is clamped off, and do not include the duration necessary to recharge the MOSFET gate and turn the switch on. From the testing performed, this appears to be on the order of 100 uSec (micro-Second).

The red trace is the drain to source Voltage; this is the Voltage across the switch. The input Voltage (source) doesn’t change. The output Voltage from the switch is the drain side of the MOSFET; this side of the switch is connected to the load device. When the switch turns off, the device under test continues to operate. As the device operates the input Voltage to the device is depleted and the Voltage across the switch increases.

Open-Mesh Radio testing

Several pulse durations were tested. We identified 3.5 msec as the duration at which a repeatable reset of the Open-Mesh Radio occurred. We used a Fluke Scopemeter to record the switch Gate-Source and Drain-Source Voltages. These waveforms also document the time durations.

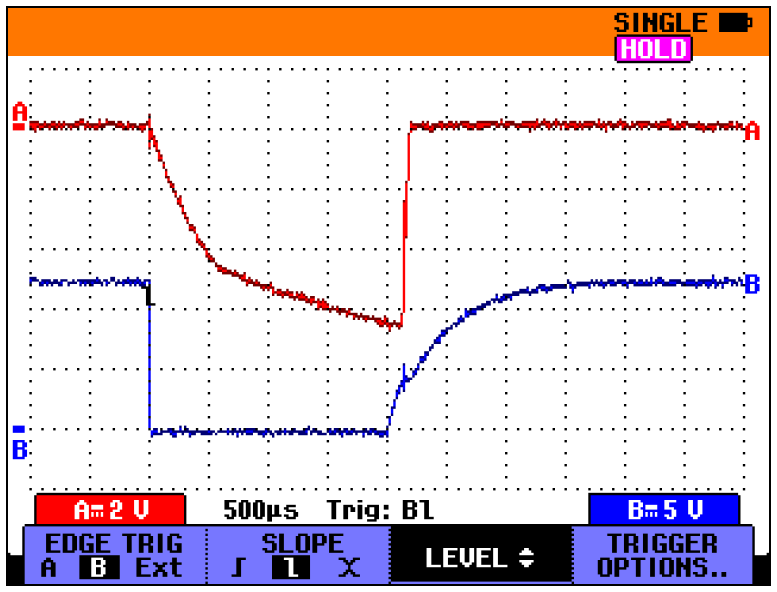
For this test, we interrupted the supply power from the Voltage Regulator Module (VRM) to the Open-Mesh Radio. The return line was wired directly and was not interrupted.



Voltage Regulator Module (VRM) testing

Several pulse durations were tested. We identified 2 msec as the duration at which a repeatable reset of the Open-Mesh Radio occurred in response to power interruption to the VRM. We used a Fluke Scopemeter to record the switch Gate-Source and Drain-Source Voltages. These waveforms also document the time durations.

For this test, we interrupted the supply power from the PDP to the VRM. The return line was wired directly and was not interrupted.



Robot main power testing

Several pulse durations were tested. We identified 40 msec as the duration at which a repeatable brown-out of the RoboRio occured. Further testing identified 43.8 msec as the duration at which a reboot of the entire robot occurred. We were not able to identify a duration that would result in either the radio or the RoboRio rebooting. We used a Fluke Scopemeter to record the switch Gate-Source and Drain-Source Voltages. These waveforms also document the time durations.

For this test, we interrupted the supply power from the battery to the main breaker. The return line was wired directly and was not interrupted.

