Project 2 - Research

ELECENG 2EI4
Dr. Yaser Haddara

February 16th, 2025
Edison He (400449140)

As a future member of the engineering profession, the student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University and the Code of Conduct of the Professional Engineers of Ontario. Submitted by **[Edison He,hee6, 400449140]**

Introduction

Electrical switches are used in a multitude of practical applications. They range from simple applications such as lights to computers and microelectronics. The purpose of this research paper is to understand the ideal characteristics of a switch in comparison to a practical real life switch. Understanding the deviations from the ideal model of a switch is essential to engineering design to improve circuit reliability, performance, and ensure target requirements are met.

Ideal Switches Characteristics

There are four main ideal characteristics for an ideal switch. These characteristics include infinite resistance in the open stage, zero resistance in the closed state, instantaneous transition phase, and a bidirectional ability. If the switch is in the open position, it must have infinite resistance, or act like an open circuit. The switch must have zero current flow between both ends. On the other hand, if the switch is closed, it must display an unrestricted current flow. In other words, it must inhibit zero internal resistance. This ensures that there is zero voltage drop between the nodes. When in the transition phase between open to close or vice versa, the transition must happen instantaneously with no delay. Finally, the switch must be bidirectional. Its behavior is akin to an ideal wire in the sense that it can conduct current from both terminals[1].

In addition to the four main ideal characteristics, there are other characteristics that an ideal switch should exhibit. An ideal switch must not degrade or generate heat as a byproduct. The electrical elements in the switch must not degrade over time when used with any voltage or current level. It must also be able to handle both AC and DC states. Additionally, in both the open and closed states, the switch should not dissipate heat as a byproduct. This means there must be zero power dissipation in all states in any conditions[1].

Non-Ideal Characteristics

Similar to circuits in laboratory experiments, a real world switch has many deviations from the ideal switch. Like an ideal wire, a switch in the closed state has an internal resistance. This resistance has a snowball effect on the switches performance. The internal resistance results in a voltage drop across the switch and in turn, inhibits the flow of current. Even if the internal

resistance is minimal, in applications with large amperage result in a significant voltage drop. Additionally, the internal resistance dissipates power in the form of heat. Heat and mechanical wear from friction can degrade the electrical components overtime and can be worn down further in certain conditions, especially when operating past voltage and current thresholds. Finally, a practical switch does not have an instantaneous transition phase and can introduce electrical noise within the circuit[2].

Knowing the limitations of non-ideal switches is essential to circuit design. If a design engineer understands the limitations, they can work around or compensate for the faults. This can be done through quantification of the drops. Knowing the internal resistance or the voltage drop from the switch can be accounted for in the battery to achieve the target voltage and current values. Through Ohm's law the current leakage and power can be found through a measured voltage and resistance. The time of the transient state can be quantified or viewed as a graph to ensure vital operations do not occur in this period, especially important to face paced circuits[2].

References

[1] M. Razavi, Design of Integrated Circuits for Optical Communications. 2nd ed. New York, NY: McGraw-Hill Education, 2012.

[2] All About Engineering. 2019. What is an Ideal Switch & Characteristics of an Ideal Switch. Retrieved from https://allabouteng.com/characteristics-of-an-ideal-switch/