Design Project 2 – Ideal Switch Research

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Ideal Switch Properties

Operates for Any Input Voltage

The first key property of an ideal switch is that it should function regardless of the voltage applied across it. It should behave like a short circuit when closed and like an open circuit when open, regardless of whether the input voltage is positive or negative. However, this is not true for real switches because they have voltage constraints. Components such as MOSFETs and BJTs, often used as switches, have a maximum voltage rating, so any voltage exceeding this value could permanently damage the component and hinder it from functioning correctly. They also require a minimum voltage to turn on entirely, meaning they will likely not operate properly at a very low voltage. We are already limited to a maximum power supply of 5V for design project two. This means that the design will not function as a switch if the input voltage is outside our limited range. To measure/characterize this ideality, the voltage at which the switch fails could be measured or found in the switches data sheet. The minimum voltage at which the switch begins to conduct could be found by simple observation using an oscilloscope.

Zero Voltage Drop When Closed

The second key property of an ideal switch is that there's no voltage drop across a closed switch, meaning that the input voltage should be exactly equal to the output voltage. This is not true for real switches, as they have a small amount of resistance when closed, which is true for all electrical components, even wires. This leads to a small voltage drop across the closed switch, proportional to the current. Physical components cannot behave ideally, as when current flows through any component, small amounts of potential energy will be lost due to heat and other factors. This means real switches have a slightly lower output voltage than input voltage, which is important to consider when observing differences between theoretical calculations and physical results. To measure/characterize this ideality, a small current could be applied through the switch to measure the voltage drop across it, which could then be used to calculate its internal resistance.

Zero Current Flow / Infinite Resistance When Open

The third key property of an ideal switch is it should act as a perfect open circuit when the switch is open, meaning there is no current flowing through it due to its infinite resistance. This is not true for real switches, as they always have a small but nonzero amount of leakage current when off. This is especially true in semiconductor switches like MOSFETs. Real switches have a high, but not infinite, resistance. To measure this ideality, an ammeter could be used to measure current when the switch is in an open state. However, this will be difficult to measure as a precise ammeter is needed to gauge such a small current value. An ohm meter could also be used to measure the open switches' resistance.

No Power Dissipation in On or Off State

An ideal switch's fourth and final key property is that it does not dissipate any power, regardless of its state. When an ideal switch is on (closed), it should have zero resistance, meaning $P = I^2R = 0W$. When an ideal switch is off (open), it should have infinite resistance, meaning $P = \frac{V^2}{R} = 0W$. However, this is not true in real switches due to the reasons discussed in properties two and three. When a real switch is on, it dissipates a small amount of power as heat. When a real switch is off, it leaks a small amount of current which causes a small power dissipation. There is also power dissipated during the transition between on and off states. This ideality can be characterized by measuring current and voltage drop when in the switch is closed and by measuring the leakage current and applied voltage in the open state to calculate the power dissipated.