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TRIBOLOGY ISSUES IN THE OPERATION OF A MICROSWITCH – A TUTORIAL

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ABSTRACT

Microswitches have the potential to be used in numerous applications [1]. Microswitches are slower and currently less reliable than semiconductor switches. However they have the advantage of reduced power consumption, less insertion loss, and better isolation. The operation of a microswitch involves many interesting phenomena which will be reviewed.

In an electrostatically actuated switch a voltage difference is applied between the beam and the gate. The resulting electrostatic force pulls the beam toward the gate such that its tip contacts the drain and completes the circuit. However the momentum of the beam causes it to deflect further, even after the tip is in contact with the drain. This stored elastic energy can be sufficient to cause the tip to separate from the drain resulting in what is often referred to as "contact bounce" [2].

Contact bounce causes several problems. First the switch cannot be used until the bouncing has stopped, thus increasing the effective time-to-closure. Second the tip and drain are subjected to more mechanical open-close contacts than are intended. Third the impact force between the tip and drain can be several times greater than the force in the closed position. These last two phenomena can prematurely degrade the contact surfaces. Attempts have been made to tailor the actuation voltage in order to reduce both the impact force and contact bounce [3].

Switches can fail in either of two failure modes. In one mode the contact resistance decreases with cycling. This behavior, while seemingly not a problem, is symptomatic of the contact being cleaned due to repeated contacts (i.e. "contact scrub" as it is known in the industry). As the resistance decreases the force of adhesion increases between these clean metal-to-metal contacts, eventually causing the switch to stick shut when the restoring force in the beam is insufficient to pull the contacts apart [4]. Another failure mechanism is a steady increase in contact resistance until the point at which the switch is no longer useable. These failures are attributable to the growth of contamination in the form of a friction polymer on the contacting surfaces [5].

Another measure of switch performance is intermodulation distortion which quantifies the distortion of a pair of harmonic RF signals with nearly equal frequencies. The beating between two such components causes the power to vary relatively slowly, i.e. at the beat frequency. This beat frequency may be sufficiently close to the thermal response time of the switch leading to distortion and false signals in the frequency range of interest [6].

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