NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Remotely-Actuated Biomedical Switch

The problem:
To design an implantable electronic switch that consumes no power in the off condition and can be actuated by a single-frequency telemetry pulse to turn on or off implanted instrumentation.

The solution:
Switching circuits using transistors have the disadvantage that in their off position they require a quiescent-state bias current that imposes a constant drain on batteries. The unique electrical characteristics of the silicon controlled-rectifiers permitted the design of a switching circuit which in the off position imposes essentially zero drain on the supply batteries.

How it's done:
Figure 1 is a circuit diagram of the actuator for the remotely-actuated biomedical switch. The actuator generates a short burst of rf signal when the spring-loaded, momentary-contact switch shorts the capacitor through the inductance of the antenna. When returned to its normal position, the switch reconnects the battery and allows the capacitor charge to be established through the resistor. The operating distance of the actuator is determined by the voltage of the battery (i.e., the charge stored by the capacitor). Since the resonant frequency is determined by the value of the capacitor and the inductance of the antenna, the operating frequency can be readily adjusted to fall within the range of the antenna tank circuit of the implanted electronic switch.

Figure 2 is a circuit diagram for the remotely-actuated biomedical switch. When the electronic switch is initially in the de-energized condition, the base of Q1 is biased off through the ferrite antenna, L1, to its emitter; SCR1 and SCR2 are in the “off” condition and amplifier switches Q2, Q3, and Q4 are also biased in their off conditions. As a result, there are no current

This document was prepared under the sponsorship of the National Aeronautics and Space Administration. Neither the United States Government nor any person acting on behalf of the United States Government assumes any liability resulting from the use of the information contained in this document, or warrants that such use will be free from privately owned rights.
paths existing within the switch network. The biomedical instrument is inactive, and no battery power is dissipated.

When the actuator radiates a single damped-frequency impulse which is picked up by the ferrite antenna, L₁ (appropriately tuned by capacitor C₁), amplifier switch Q₁ turns on, allowing capacitors C₂ and C₃ to charge up to the battery's potential. The charging current through capacitor C₂ and gate of SCR₁ will trigger it on, which allows C₄ to charge to the battery potential. The initial current flow through SCR₁ anode is extremely large due to the unimpeded charging of capacitor C₄. When SCR₁ is turned on, Q₁ is activated and the biomedical instrument is thus supplied with voltage and current from the battery.

Simultaneous with the SCR₁ turn-on sequence, the charging current of capacitor C₅ is actuating the gate of SCR₂, allowing its cathode-to-anode circuit to conduct. Since the anode current is less than its minimum holding current, SCR₂ turns itself off, but the resulting current pulse through SCR₂ has developed a voltage across resistors R₄ and R₅, which turns on transistor switch Q₃ and actuates transistor switch Q₂. When transistor switch Q₂ momentarily saturates, it will short-circuit SCR₁ anode-to-cathode connections which, under low anode current conditions, would ordinarily turn SCR₁ off. However, SCR₁ remains in conduction because the time during which its anode-to-cathode connection is shorted is not long enough to sweep clean all the electrons within its anode-to-cathode semiconductor layers; this condition is the result of the high charging current for capacitor C₄ passing through SCR₁. Since SCR₁ remains in conduction, the biomedical instrument remains energized for an experiment.

The biomedical instrument can be de-energized on command by recycling the actuator. The ferrite antenna picks up the rf pulse from the actuator which saturates amplifier switch Q₁, charging capacitors C₂ and C₃ to the battery voltage. Since SCR₁ is already in conduction, its gate circuit is inactive and, therefore, the charging current through capacitor C₂ has no effect. However, the charging current through capacitor C₃ to the gates of SCR₂ will initiate a current impulse through its anode-to-cathode circuit momentarily saturating amplifier switches Q₃ and Q₂, thus short-circuiting the anode-to-cathode circuit of SCR₁. As a result, SCR₁ reverts to its nonconducting state because its anode current is now at a much lower value with capacitor C₄ fully charged. Consequently, all active semiconductor devices revert to their off conditions; the biomedical instrument is deactivated.

Notes:
1. The values of resistors R₇ and R₅ are selected so that the sum of the currents through them is somewhat greater than the holding current for SCR₁.
2. Transistor switch Q₄ has a small voltage drop across it when saturated; thus, the biomedical instrument is supplied with essentially the voltage of the battery pack, usually two 1.35-volt mercury cells. If the biomedical instrument package is connected between the positive terminal of the battery and point A (Q₄, R₇, and R₅ can be eliminated), it will be supplied a potential equal to the battery voltage minus the voltage drop across SCR₁ (usually about 0.7 volt). The load current of the biomedical instrument package must be greater than the holding current of SCR₁.
3. The sensitivity of the electronic switch to rf impulses from the actuator drops off as the third power of the distance. Additionally, the receiving circuit is quite insensitive, but this lack of sensitivity offers an advantage in that the system is not likely to be triggered by extraneous noise signals. Ideally, the actuator is used in close proximity to the implanted electronic switch; other forms of rf activation may provide actuation at long distances.
4. The actuator was designed by Mr. George R. Cook of the NASA Ames Research Center.
5. Documentation for this invention is available from:
   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10117

Patent status:
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Robert Dick Lee (ARC-10105)