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Remotely-Actuated Biomedical Switch

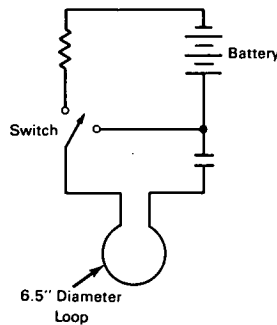


FIGURE 1

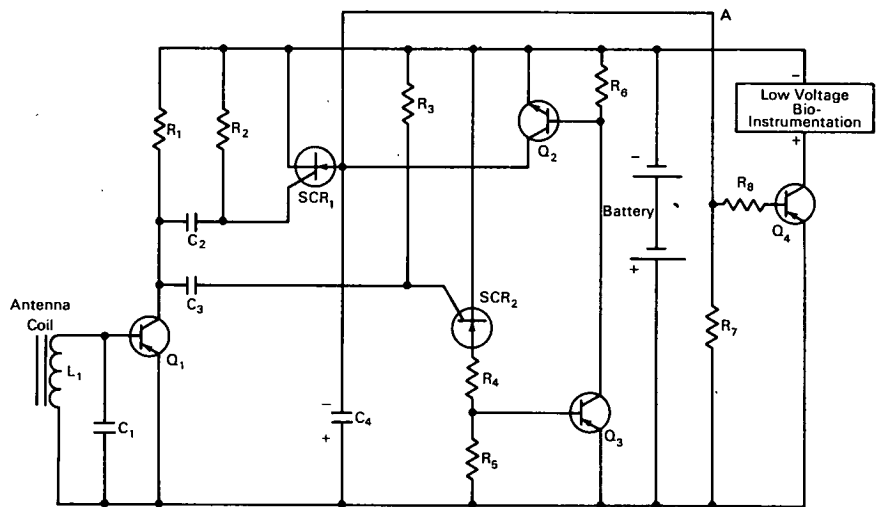


FIGURE 2

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 Q_1 is biased off through the ferrite antenna, L_1 , to its emitter; SCR_1 and SCR_2 are in the "off" condition and amplifier switches Q_2 , Q_3 , and Q_4 are also biased in their off conditions. As a result, there are no current

(continued overleaf)

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, L_1 (appropriately tuned by capacitor C_1), amplifier switch Q_1 turns on, allowing capacitors C_2 and C_3 to charge up to the battery's potential. The charging current through capacitor C_2 and gate of SCR_1 will trigger it on, which allows C_4 to charge to the battery potential. The initial current flow through SCR_1 anode is extremely large due to the unimpeded charging of capacitor C_4 . When SCR_1 is turned on, Q_4 is activated and the biomedical instrument is thus supplied with voltage and current from the battery.

Simultaneous with the SCR_1 turn-on sequence, the charging current of capacitor C_3 is actuating the gate of SCR_2 , allowing its cathode-to-anode circuit to conduct. Since the anode current is less than its minimum holding current, SCR_2 turns itself off, but the resulting current pulse through SCR_2 has developed a voltage across resistors R_4 and R_5 which turns on transistor switch Q_3 and actuates transistor switch Q_2 . When transistor switch Q_2 momentarily saturates, it will short-circuit SCR_1 anode-to-cathode connections which, under low anode current conditions, would ordinarily turn SCR_1 off. However, SCR_1 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 C_4 passing through SCR_1 . Since SCR_1 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 Q_1 , charging capacitors C_2 and C_3 to the battery voltage. Since SCR_1 is already in conduction, its gate circuit is inactive and, therefore, the charging current through capacitor C_2 has no effect. However, the charging current through capacitor C_3 to the gates of SCR_2 will initiate a current impulse through its anode-to-cathode circuit momentarily saturating amplifier switches Q_3 and Q_2 , thus short-circuiting the anode-to-cathode circuit of SCR_1 .

As a result, SCR_1 reverts to its nonconducting state because its anode current is now at a much lower value with capacitor C_4 fully charged. Consequently, all active semiconductor devices revert to their off conditions; the biomedical instrument is deactivated.

Notes:

1. The values of resistors R_7 and R_8 are selected so that the sum of the currents through them is somewhat greater than the holding current for SCR_1 .
2. Transistor switch Q_4 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 (Q_4 , R_7 , and R_8 can be eliminated), it will be supplied a potential equal to the battery voltage minus the voltage drop across SCR_1 (usually about 0.7 volt). The load current of the biomedical instrument package must be greater than the holding current of SCR_1 .
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. Antenna inductance L_1 is tuned by varying the number of turns on the ferrite cylinder core.
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.

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