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NASA TECH BRIEF

NASA Headquarters

Frequency Shifting With a Solid-State Switching Capacitor

The problem:

Frequency shifting is commonly used in electronic signal processing. It is applied in tuning, automatic frequency control, antenna element switching, phase shifting, etc. Unfortunately, circuits that are used for frequency shifting are costly, frequently unreliable, and complex.

The solution:

Frequency shifting can be accomplished economically and reliably with a simple circuit which uses a solid-state switching capacitor.

How it's done:

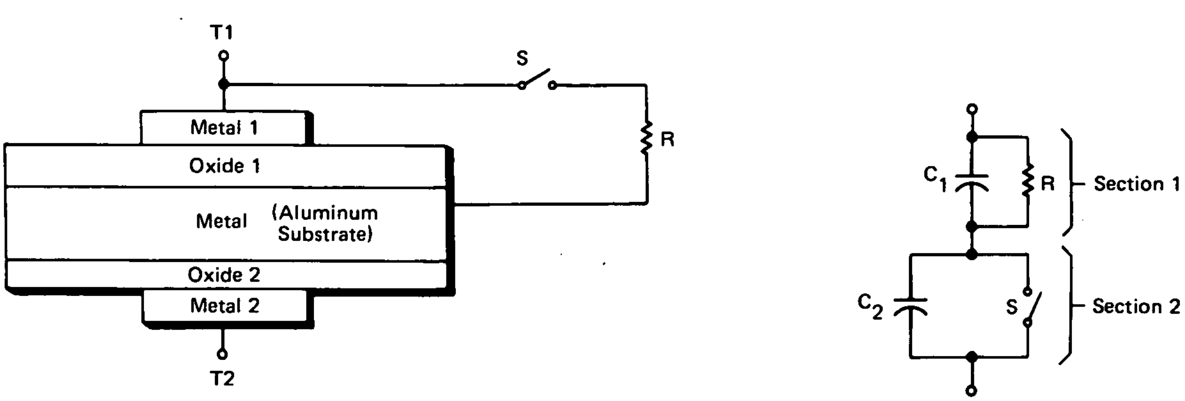
The circuit comprises a conventional resistor and a solid-state switching device which can be equivalent to two capacitors, depending on the switching state. As shown in Figure 1 (a), the device is a metal-oxide-metal-oxide-metal (MOMOM) structure which contains a 99.999% pure aluminum substrate with dielectric oxide layers on both sides. Each dielectric is deposited differently. The first one (oxide 1) is deposited in 3% reagent grade d-tartaric acid and 97% water with reagent grade NH_4OH added to produce solution of pH 5.5. The second dielectric (oxide 2) is grown in oxygen atmosphere at an elevated temperature to an approximate thickness of 50 angstroms. After oxide deposition, the substrate is placed in vacuum at 5×10^{-5} torr, and a series of counter electrodes are then deposited on each oxide.

Figure 1 (b) shows an equivalent circuit of the device which is represented by capacitors C_1 for oxide 1 and C_2 for the thin-film oxide 2. Fixed capacitance values of each capacitor are determined by

$$C = EA/D$$

where E is the dielectric constant of one oxide, A is the external electrode area of the respective capacitor, and D is its oxide thickness.

The circuit is controlled by bias voltage applied across the entire section. When the bias is at or above a fixed



(a) Circuit Using the Solid State Capacitor

(b) Equivalent Circuit

Figure 1

(continued overleaf)

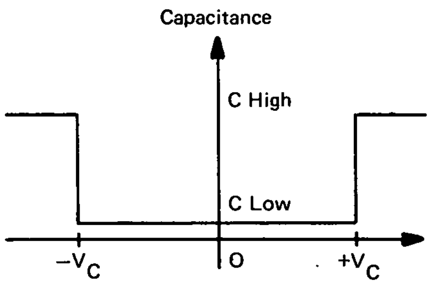


Figure 2

level V_c, the circuit acts as if the shunt switch on C_2 were closed. The capacitance of the circuit at this time is high and equal to C_1 (see Figure 2). When the bias voltage drops below V_c, the switch opens (by quantum mechanical tunneling) introducing series capacitor C_2 which reduces the total circuit capacitance.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
NASA Headquarters
Code KT
Washington, D. C. 20546
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Patent status:

NASA has decided not to apply for a patent.

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