MINIMIZING AGING EFFECTS IN HIGH VOLTAGE SUPPLY DETECTION CIRCUITS

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Key words: CMOS structure, ageing effects, supply voltage detection circuit

Introduction. In modern integrated circuits, the length of the transistor channel continues to shrink to 3 nm and downward. Such changes allow the chips to be more functional due to the increase in the number of transistors in the same area. Reducing the size of transistors causes problems with the production of thick oxide transistors for com-panies producing and purchasing ICs. The absence of thick oxide transistors, in turn, causes many problems for the functionally and reliably operating circuits, which are reflected in the high-voltage detection circuit. At the beginning of the operation of the ICs, the supply voltages are established after a certain period of time. According to the power sequence, the low supply voltage is established at the beginning, after which the high supply voltage is asserted. It is very important to have a circuit in the IC that allows to detect the assertion of high supply voltage with the help of low supply voltage. (Fig. 1) shows the classic scheme of high supply voltage detection. The input to the circuit shown in the figure is connected to the high supply voltage which rises from 0 level to VDDH level over time. It is generally accepted that a high supply voltage is established when the voltage level is above 0.7 × VDDH. Problems with the undesirable effect of aging arise here because the values of the gate-bulk and gate-source voltages of the M1 transistor exceed the allowable threshold. The application of such voltages on device terminals results in degradation of linear and saturation mode currents which shows that some of the charge carriers have smashed into the oxide layer and a prolonged operation at this state will cause the oxide layer to break which in turn will cause a functional failure and unreliable operation conditions.

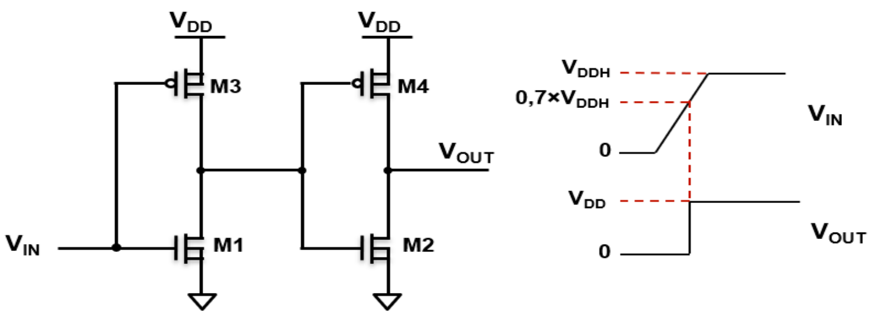

Figure 1. Power supply detection circuit using CMOS structure

The problem and proposed solution. The proposed scheme is based on the classic high-voltage voltage detection circuit with one transistor difference shown in Figure 2.

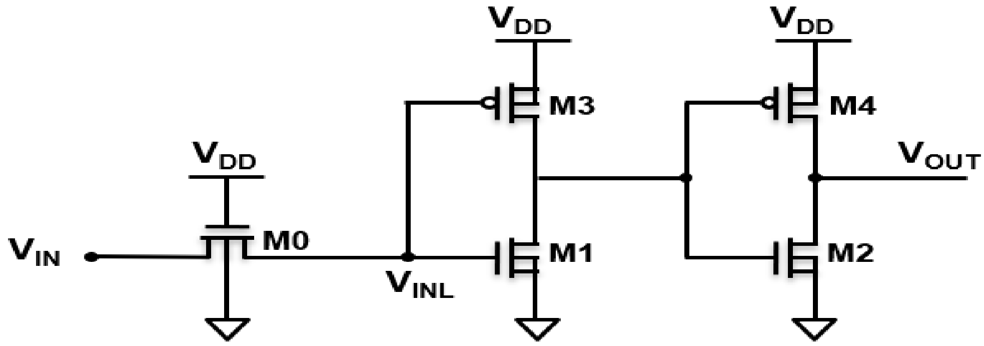

Figure 2. Proposed power detection circuit

In the proposed circuit the added device has its gate always connected to a low supply voltage (V_{DD}), as a result of which as the V_{IN} voltage increases, the V_{INL} voltage also increases. The value of V_{INL} voltage can be increased up to V_{DD}-V_{TH} where V_{TH} voltage is the threshold voltage of transistor M0. The largest value of the difference between the output voltages of transistor M0 is equal to V_{DDH}- (V_{DD}-V_{TH}), which helps to avoid the unwanted effect of aging. As a result, the use of transistor M0 helps to reduce the gate-bulk voltage of transistor M1, which ensures reliable and uninterrupted operation of the aforementioned circuit.

Economic significance. More than ten production masks are used for the production of modern integrated circuits. Most masks are used to create metal layers to provide connections between the layers. In the process of photolithography, different masks are needed to create the gates of different transistors. Each of these masks can cost up to several million dollars, significantly increasing production costs. As technological processses are declining in size, the required metal layers are increasing, it is necessary to reduce the variety of types of transistors used in the IC and to use the same type of transistors in different parts of the circuit. For this purpose, MOS transistors with thick oxide gate have been removed in many small technological processes, and standard thin oxide transistors are used even in analog blocks. Thick oxide transistors are more resistant to the effects of aging due to the high supply voltages at the input/output junctions. In the absence of these transistors, it is necessary to obtain solutions where thin oxide transistors will perform uninterrupted work for as many years as possible.

Simulation results. The proposed circuit is designed using "SAED 14nm" technology [3] and "Custom compiler" software [4]. The modeling was performed using the HSPICE tool [5]. Low supply voltage (VDD) is 0.75 V, High supply voltage (VDDH) is 1.1 V. Figure 3. shows the output signal of the designed circuit.

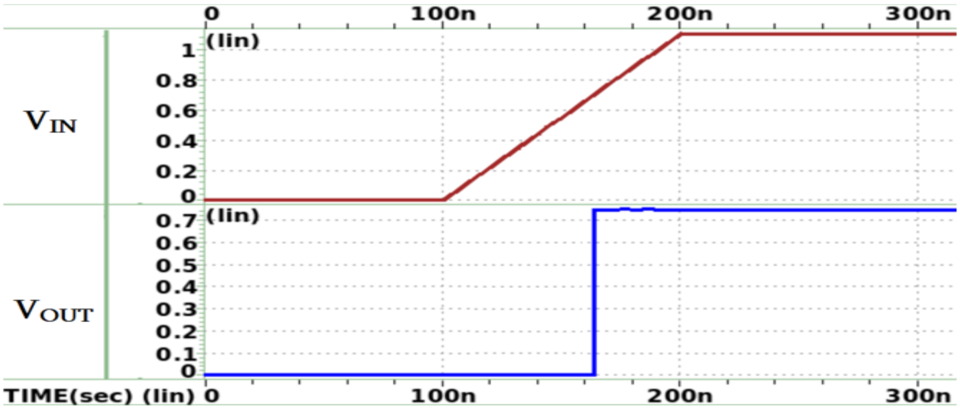

Figure 3. Input/output voltages of the proposed circuit during a transient simulation

Figure 4 shows the degradation of currents flowing in the saturation mode of transistors in the circuit without an ageing compensating transistor expressed in percentages.

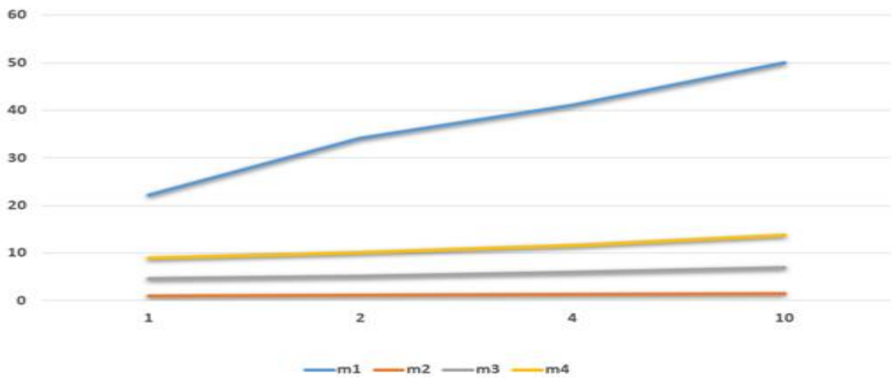

Figure 4. Percentage of current degradation vs Years of usage

Figure 5 shows the degradation of currents flowing in the saturation mode of transistors in the circuit with an ageing compensation transistor.

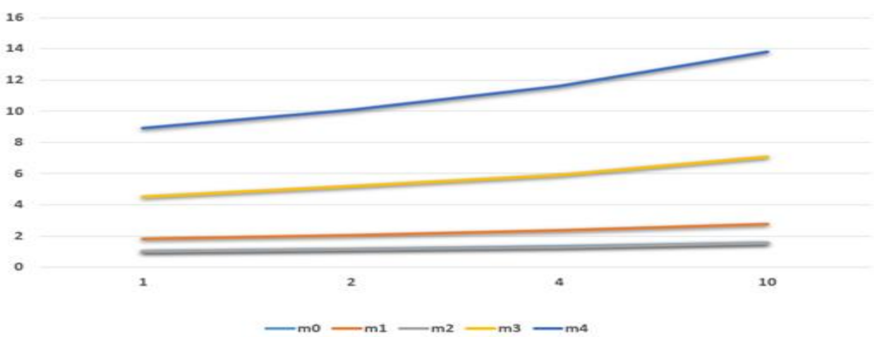

Figure 5. Percentage of current degradation vs Years of usage

Conclusion. A high voltage detection circuit without thick oxide transistors has been designed for the 14-nanometer SAED technological process. A method for reducing the effects of ageing in the circuit has been proposed, which has reduced the maximum degradation current of the degraded transistor from 50% to 14% in the high-voltage detection circuit. The obtained degradation corresponds to the requirements of modern integrated circuits. Such a result was obtained by increasing the number of transistors in the circuit, which in turn implies an increase in surface area. The solution does not cause additional complications at the schematic design stage.

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Minimizing ageing effects in high voltage supply detection circuits

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The ageing effects and their impacts in modern SoC circuits linked with continual shrinkage of technological processes and unavailability of thick oxide transistors were studied. These effects are more widespread in analog and mixed signal circuits located at input/output nodes of the system. Studied high supply voltage detection circuits showed that in order to have a long-lasting stable performance a solution is required to minimize the effect of overvoltage on thin oxide devices. A solution is proposed which provides protection to the power detection circuit from high voltage supply stress and greatly reduces the ageing effect thus maintaining the longevity of reliable operation.