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Explosive growth calls for more mixed-voltage analog integrated circuits

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The explosive growth of the consumer electronics market in the last two decades has led to a great demand of low-cost, high-performance integrated systems. The most effective way for cost minimization is by manufacturing the system chips in advanced nanoscale complementary metal oxide semiconductor (CMOS) technologies, given that most modern microsystems are dominated by digital circuits. Entered into the nanoscale CMOS regime, 90-, 65- or 45-nm processes are expected to deliver substantial improvements in speed and power reduction for digital circuits in comparison to the current sub-micron-scale technologies.

In contrast, the nanoscale CMOS process becomes an anathema in terms of analog and mixed-signal circuit performances. Threshold voltage scaling (Fig. 1)

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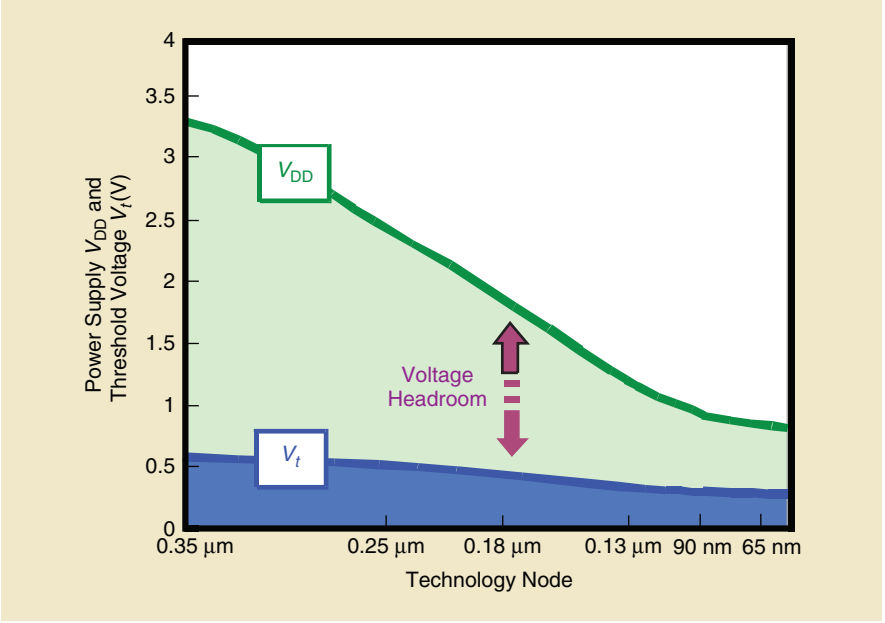

Fig. 1 Downscaling of power supply and transistor threshold voltage in CMOS technologies.

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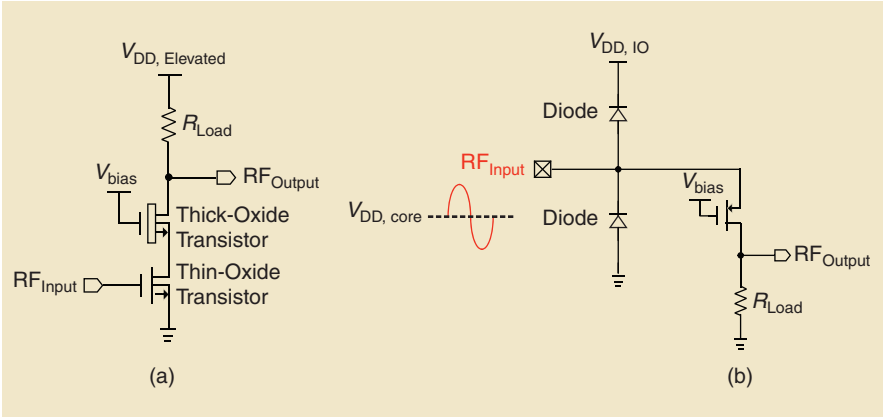

Fig. 2 RF Amplifier based on (a) a cascode structure with both thick- and thin-oxide transitors, and (b) an open-source-input ESD-protected structure using mixed power supply levels ($V_{DD,\ core}$ and $V_{DD,IO}$).

is not keeping pace with the reduction of the supply voltage that must scale down with the gate-oxide thickness accordingly. Fundamental circuits that were capable of processing large signal swing will not fully function when the voltage headroom is reduced to certain values lower than the sum of N-channel metal–oxide–semiconductor field-effect transistor (NMOS) and P-channel metal–oxide–semiconductor field-effect transistor (PMOS) threshold voltages. Examples include the floating switches and common-mode feedback circuits. Indirect implementation of them with auxiliary circuitry helps solve the problem at the expense of more power and silicon area.

Modern nanoscale technologies normally offer thin- and thick-oxide transistors. The former is intended for the core circuits that operate at a low-voltage supply (~1 V) because of reliability concerns [e.g., absolute maximum rating, negative bias temperature instability, hot carrier injection, time dependent dielectric breakdown, and electrostatic discharge (ESD)]. The latter features a thicker gate oxide but lower operating speed. It is intended for realizing input-output (I/O) interfaces and power management units because of its higher operating voltages (e.g., 1.8, 2.5 and 3.3 V).

As the technology continuously scales down, a concurrent use of dual-oxide transistors in the core circuits has a higher potential to maximize the performance with low power consumption. For instance, as shown in Fig. 2(a), thin-oxide transistors featuring a high intrinsic cut-off frequency can serve as the input device of radio-frequency (RF) circuits to maximize the input bandwidth, whereas a thick-oxide transistor can be used as the cascode device at the load, allowing the use of a high-voltage supply to maximize the output swing without the risk of transistor breakdown. Another example, as shown in Fig. 2(b), is a mix use of two power supply levels to maximize the input and output swings of RF circuits with ESD protection.

With such an idea, it is believed that many new opportunities will open up by using a mixed-voltage design methodology in analog integrated circuits and systems.

Read more about it

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About the author

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