A Low-Power Compact HV TX/RX Switch Composed of Three HV-MOS Transistors for Ultrasound Imaging Front-End ASICs

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SUMMARY

This paper presents a compact and low-power high-voltage (HV) transmit/receive (TX/RX) switch for ultrasound imaging front-end (FE) application-specific integrated circuits (ASICs). The proposed design is derived from a previously reported architecture and introduces several optimizations to improve power efficiency and silicon area. The switch is composed of only three HV MOS transistors to isolate low-voltage (LV) receiver circuits from bipolar excitation pulses up to 200 V_{pp} while operating from a 3.3-V supply. To improve efficiency, the HV devices in the replica bias branch are replaced with LV transistors, the gate–source resistor is increased to reduce the bias current while maintaining the required gate drive voltage, and the conventional constant bias current is replaced with a pulsed current driver that charges the gate capacitance only during the TX-to-RX transition. Implemented in a 160-nm BCD-SOI technology, the proposed switch achieves an off-isolation of −42 dB at 3 MHz with an on-resistance of 190 Ω. Compared with the previous architecture, the design reduces power consumption from 660 μW to 66 μW and decreases the silicon area by approximately 25%.

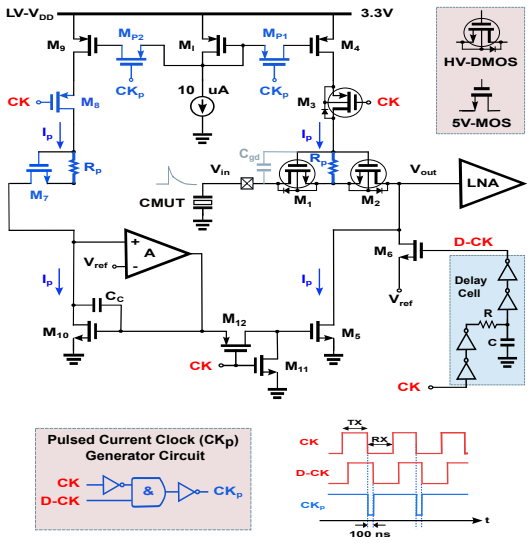

Fig. 1. Proposed HV TX/RX switch with its driver circuit.

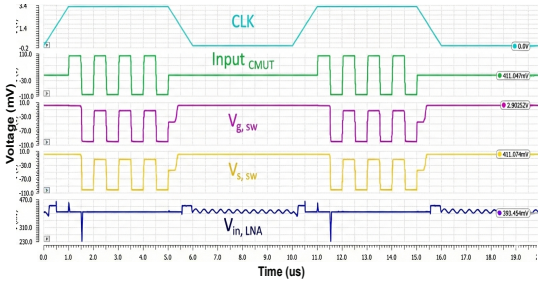

Fig. 2. Simulated waveforms of the proposed TX/RX switch.

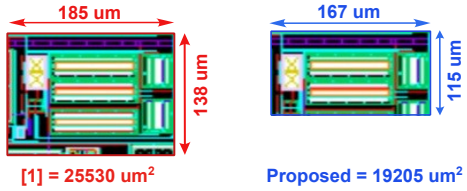

Fig. 3. Layout comparison between the previous work [1] (red) and the proposed design (blue).

TABLE I
COMPARISON WITH OTHER WORKS

Ref.@Year	[2]@2016	[3]@2018	[1]@2024	This Work
Technology	350-nm CMOS	350-nm CMOS	160-nm BCD-SOI	160-nm BCD-SOI
SW Supply	120-V	40-V	3.3-V	3.3-V
Number of HV MOSs	9	> 5	5	3
Static Power	N.A.	N.A.	660-µW	66-µW
Ron	700-Ω	180-Ω	190-Ω	190-Ω
Off-Isolation	−34 dB @10 MHz	−35 dB @10 MHz	−42 dB @3 MHz	−42 dB @3 MHz
Area	26 000-µm^2	48 320-µm^2	25 530-µm^2	19 205-µm^2

REFERENCES

[1] A. Amini, E. Moisello, P. Malcovati, and E. Bonizzoni, "A High-Voltage TX/RX Switch with 3.3-V Supply for Ultrasound Imaging Front-End ASICs," in *Proc. IEEE Int. Conf. Electronics, Circuits and Systems (ICECS)*, Nancy, France, 2024, pp. 1–4.

[2] D. Osipov et al., "Current driver with read-out HV protection for neural stimulation," *IEEE Nordic Circuits Syst. Conf. (NORCAS)*, 2016, pp. 1–4.

[3] H. Jung et al., "CMOS High-Voltage Analog 1–64 Multiplexer/ Demultiplexer for Integrated Ultrasound Guided Breast Needle Biopsy," *IEEE Trans. Ultrasonic, Ferroelectrics, and Frequency Control*, vol. 65, no. 8, pp. 1334-1345, Aug. 2018.