An Integrated High Efficiency Ultra-low Power DC/AC Inverter for Liquid Crystal Driving in Electro-optic Diffractive Lenses

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Abstract

- An integrated high efficiency, ultra-low power liquid crystal driver for electro-optic diffractive lenses[1] is presented in this poster. The proposed LC driver provides an adjustable 3V to 15V RMS square wave output voltage to drive a liquid crystal in the electro-optic lens, which can be modeled as a 5nF capacitive load. This application is powered by a 3V lithium button cell or energy harvest devices.
- Implemented in a 0.25µm 5V VGS, 12-45V VDS BCD technology, the proposed LC driver achieves peak power efficiency of 98%. The transaction time of LC driver output from high to low is 48us, which is 219 times faster than that when auto-sink scheme is disabled.

Objective

- Maintain high power efficiency over the entire output voltage and load current range.
- Compact system profile and low EMI noise.
- Ultra-low power consumption control circuitry and fast response time.

Methods

- A reconfigurable hysteretic 2×/3×/4×/5× switched capacitor charge pump is developed for DC-DC conversion to enhance the power efficiency over a wide input-output voltage range.
- An improved full bridge driving scheme is developed to reduce the DC/AC inversion power loss.
- An auto-sink scheme is developed to speed up output transaction from high to low in different output modes.

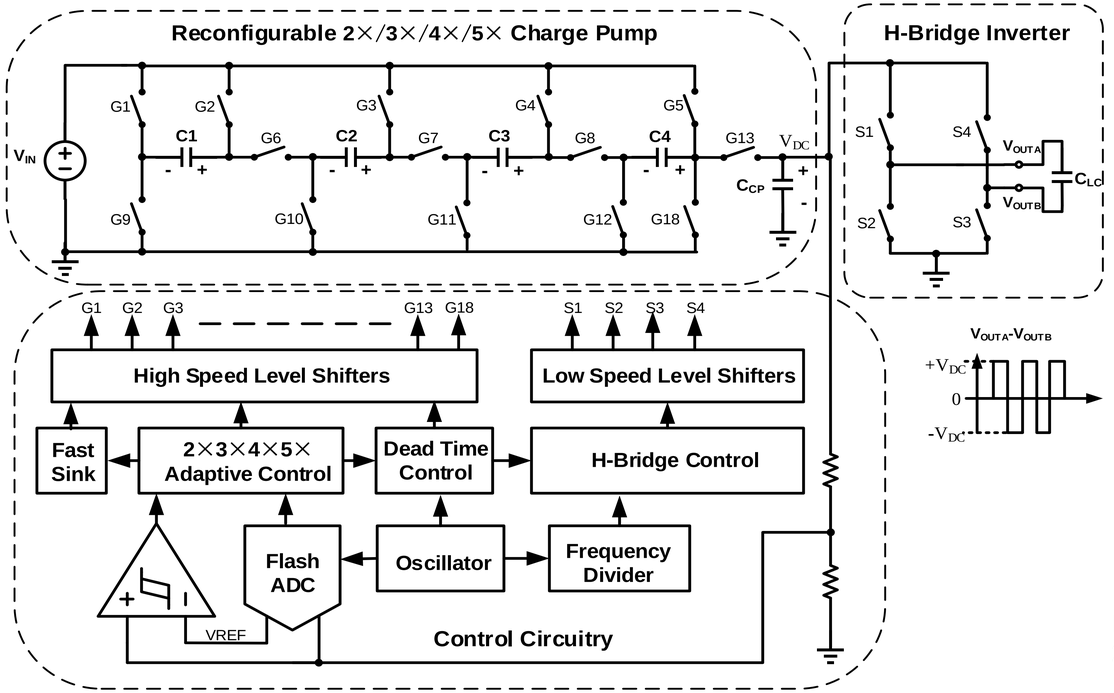

Figure1: Structure of the proposed LC driver

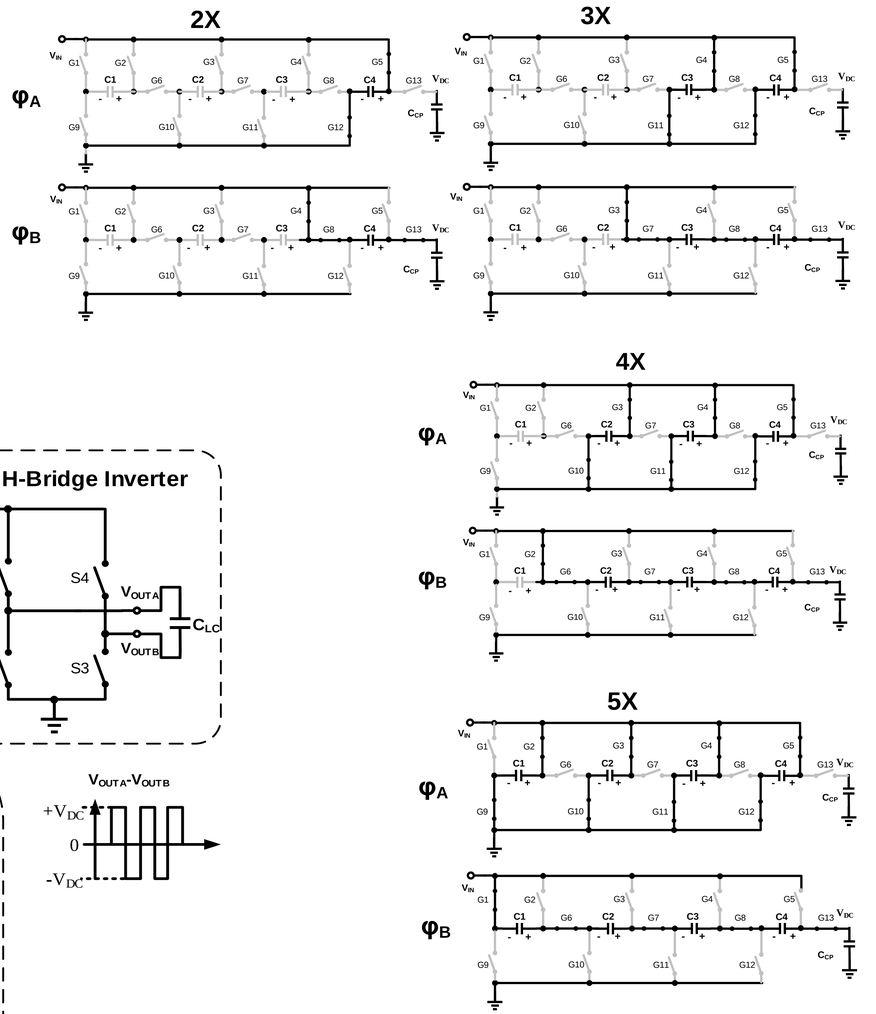

Figure 2: Operation of the proposed reconfigurable 2×/3×/4×/5× switched capacitor CP

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Implementation

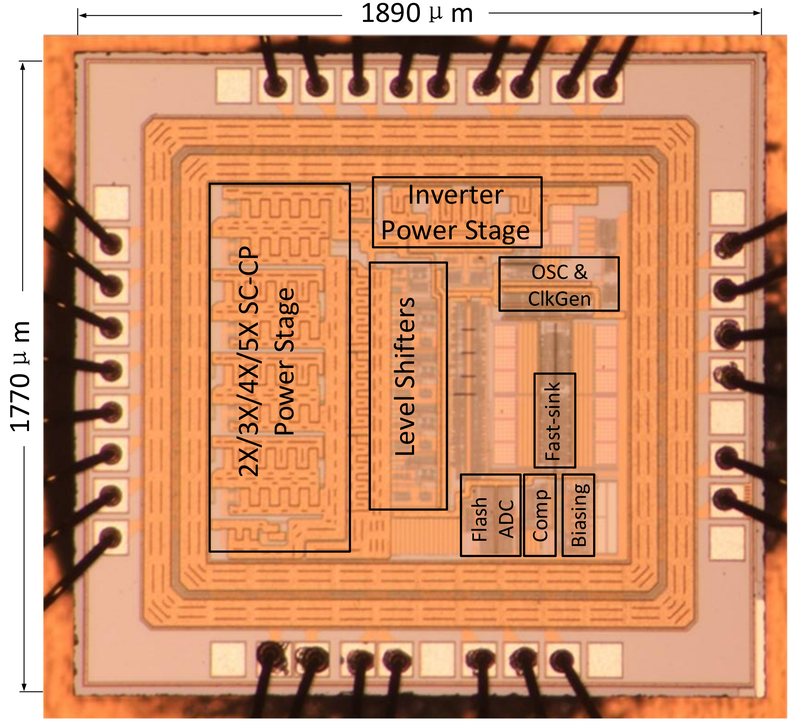

Figure 3: Chip microphotograph of the proposed LC driver

- Die area including all test pads is 3.3mm^2. All powertrain transistors and the control circuitry are integrated into this chip.
- The package of the LC driver is a 5mm × 5mm QFN. External components of the LC driver includes four 100nF external flying capacitors and one 1μF output capacitor.

Results

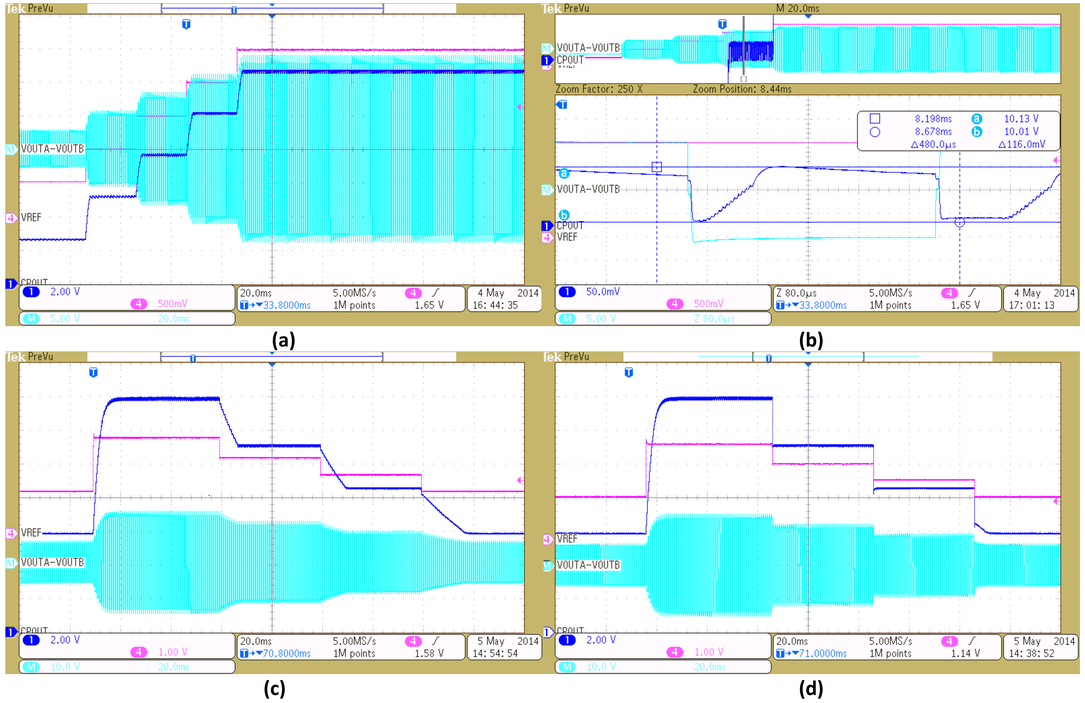

Figure 4: Measured output voltages of the proposed LC driver when (a) output step up 2x->3x->4x->5x; (b) measured output ripple; (c) output step down 5x->4x->3x->2x without fast-sink; (d) output step down 5x->4x->3x->2x with fast-sink;

- Figure 4 shows the output ripple is 116mV. The falling time from a higher output voltage to a lower output voltage is 10.5ms and 48μs without and with fast-sink enable, respectively.
- Figure 5 shows the measured power efficiency of the proposed LC driver. The measured peak efficiency is 98%.

- However, on the boundary of different VCRs, the switching frequency of CP increased significantly thus efficiency dips can be observed.

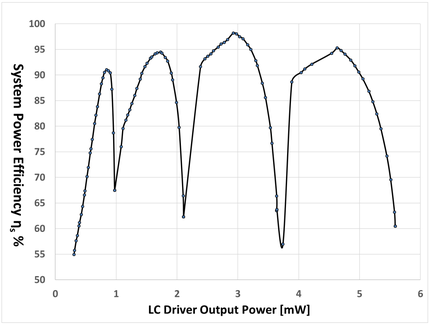

Figure 5: Measured power efficiencies

Conclusions

- The verified silicon results show the LC driver is suitable to be used in electro-optic lenses applications.

References

[1]Guoqiang Li et al., “High-efficiency switchable flat diffractive ophthalmic lens with three-layer electrode pattern and two-layer via structures,” Applied Physics Letters, vol. 90, 111005, March 2007.