Fraunhofer EMFT

Miniaturized high-voltage piezoelectric actuator driver ASIC

Smartphone with integrated micropump.
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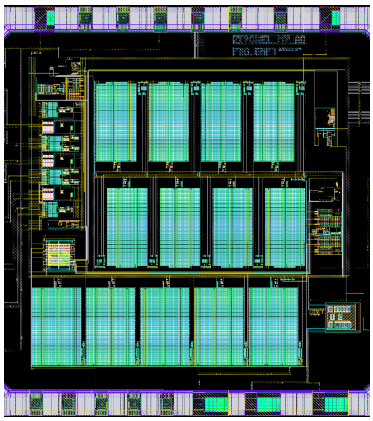
Applications

Mobile applications using MEMS components high voltage power supplies for the actuators are essential. However, designing an appropriate efficient driving system for portable applications comes with its challenges. These challenges include ensuring high efficiency,, minimizing solution size, and ensuring reliable operation.
Most compact energy sources suitable for portable applications, such as lithium batteries, typically have output voltages below 5V. However, piezoelectric MEMS actuators require higher voltages. This necessitates the use of voltage conversion circuits with step-up ratios above 20. While there are circuit topologies available with high step-up ratios, many of them are not easily miniaturized and may have poor efficiency at low output power levels.

To address these challenges, the Fraunhofer EMFT has developed a current-mode piezoelectric actuator driver IC. This IC offers a combination of power efficiency, miniaturization (QFN package), and smart driver control to compensate for actuator degradation. As a result, the IC promises enhanced actuation precision over long-term operation.

Possible applications are:

- Piezoelectric Sensors
- High-Precision Actuator Drives
- Ultrasonic Transducers
- Micropumps



Layout of the whole system.
The size of the testchip is 6.54mm².
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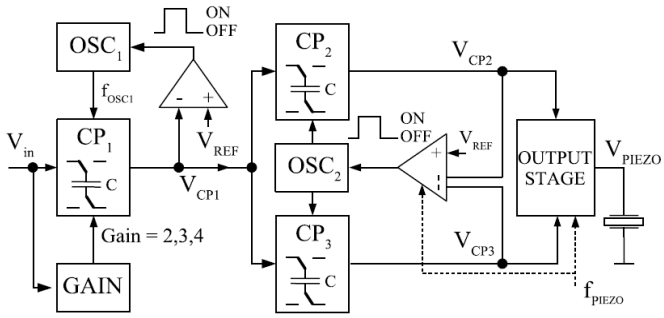
Technical innovation

Our innovative solution for capacitive high-voltage DC-DC converter is providing a bipolar output voltages of +60V and -20V for micropumps. It consists of a series of linear charge pumps utilizing a new innovative 2-switch bootstrapping technique. This cutting-edge approach ensures safe operating conditions for all switches involved and is focusing on the reliability of the circuit.



Micropump driver system. ©Fraunhofer EMFT/Bernd Müller

The high-voltage DC-DC converter efficiently steps up the input voltage to the desired high voltage level. In addition, our series of linear charge pumps offers a unique and effective method for generating high voltages. By utilizing the 2-switch bootstrapping technique, we achieve optimal performance and ensures safe operating conditions for all switches involved, enhancing the overall reliability and longevity of the system. With our solution, you can confidently achieve high voltages while maintaining the necessary safety measures.
It provides an outstanding cost-effective solution having several unique features:

- Single-ended high-voltage driving enables the use of MEMS (micro-electromechanical systems) micropumps in close-to-body applications, the silicon channel structure requires ground connection.
- Adjustable high voltage signal of positive and negative polarity to achieve fast and accurate pumping/mechanical displacement
- Programmable rising/ falling ramps allow accurate mechanical displacement control

Technical data

Engineering samples are fabricated and tested in a XFAB 180nm technology that can support voltage levels up to 200V. The device contains a flexible and fully integrated low power micropump driver using a new double bootstrapped switching scheme for the reliable operation of power switches in a high-gain Dickson charge pump with a four-phase clocking scheme. The new bootstrapped switching scheme allows a significant reduction of the number of switching stages for high voltage conversion ratios. The full system encompasses one variable gain low voltage charge pump, two high voltage Dickson charge pumps, two on-chip oscillators with 4-phase non-overlapping clock-signal generation, control loops and a high-voltage piezo driver stage. The circuit is providing bipolar driver signals between +60V and -20V at a switching frequency of 2 MHz. The circuit needs just three external capacitors for the first stage and two buffer capacitors for the high voltage rails. The device has a digital SPI interface for configuration and test purposes.

Fraunhofer EMFT offers a modular, fully flexible driver solution including various IPs that are adaptable to customer needs. The driver topology can support smart health applications with high precision requirements as good as mobile applications with low power/high efficiency requirements.

- Electrical characteristics

	Parameter	Test Conditions	Min	Typ.	Max	UNIT
T_a	Ambient Temperature		-40		125	C
V_{in}	Input Voltage		3		5.5	V
V_{out}	Output Voltage		-20		60	V
f_{piezo}	Control frequency	Cload = 2.7 nF	0		1000	Hz
R_{out}	Output Impedance	f_{piezo} = 2.2 MHz		20		kOhm

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