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Heading: An Event-Triggered Compensating Low Dropout Regulator with Cross-Loop Feedback Comparing Adaptive Oscillator

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Abstract

With the development of electric vehicles (EVs), many vehicle sensors are gradually being integrated into electric cars. To enable vehicles to perform functions more quickly, in the power management system, higher transient response and faster recovery times becomes an emphasis. This paper presents "An Event Driven Compensation Low Dropout Regulator with Adaptive Self Oscillating Cross-Feedback Comparator and Parallel Shift Register". To accelerate chasing time, an adaptive frequency oscillator and four parallel shift registers are designed, allowing the circuit to operate at double the actual frequency, substantial reducing chasing time, and achieving low power consumption once a steady state is reached. The oscillator in this work apart from conventional ones is that it is composed of two comparators. By providing cross-feedback to each other, it can generate two clocks with different phases but same frequency. This oscillator allows the circuit to switch frequencies between 200MHz, 100MHz, and 10MHz, without the need for capacitors can achieve a fast-chasing time of <100ns and a low power consumption of 29.63µA. In the transient compensation circuit can detect transient conditions at any time, and compensation power is added afterward. This enables the circuit to quickly restart and keeps the transient voltage variation below15%.

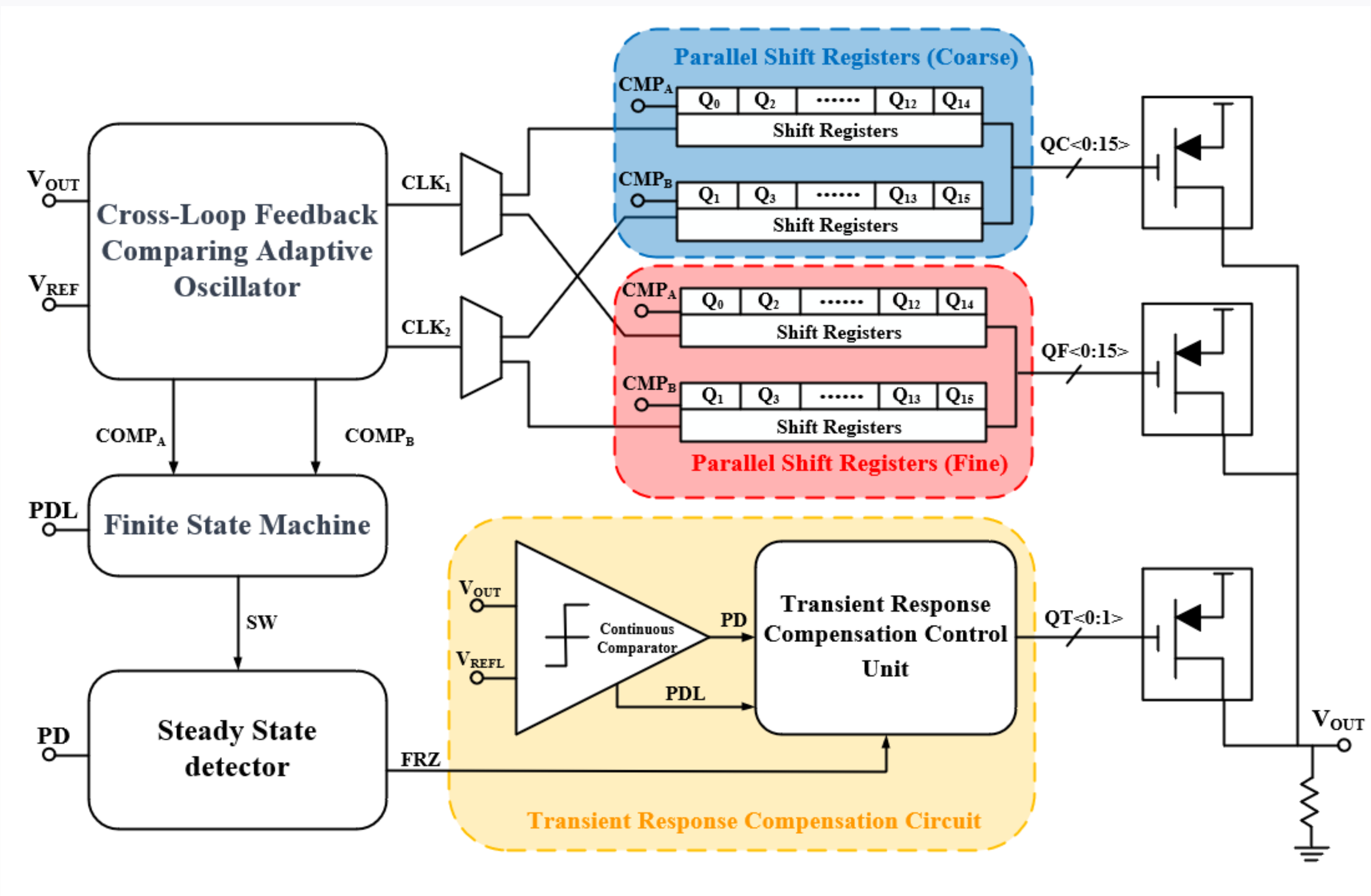
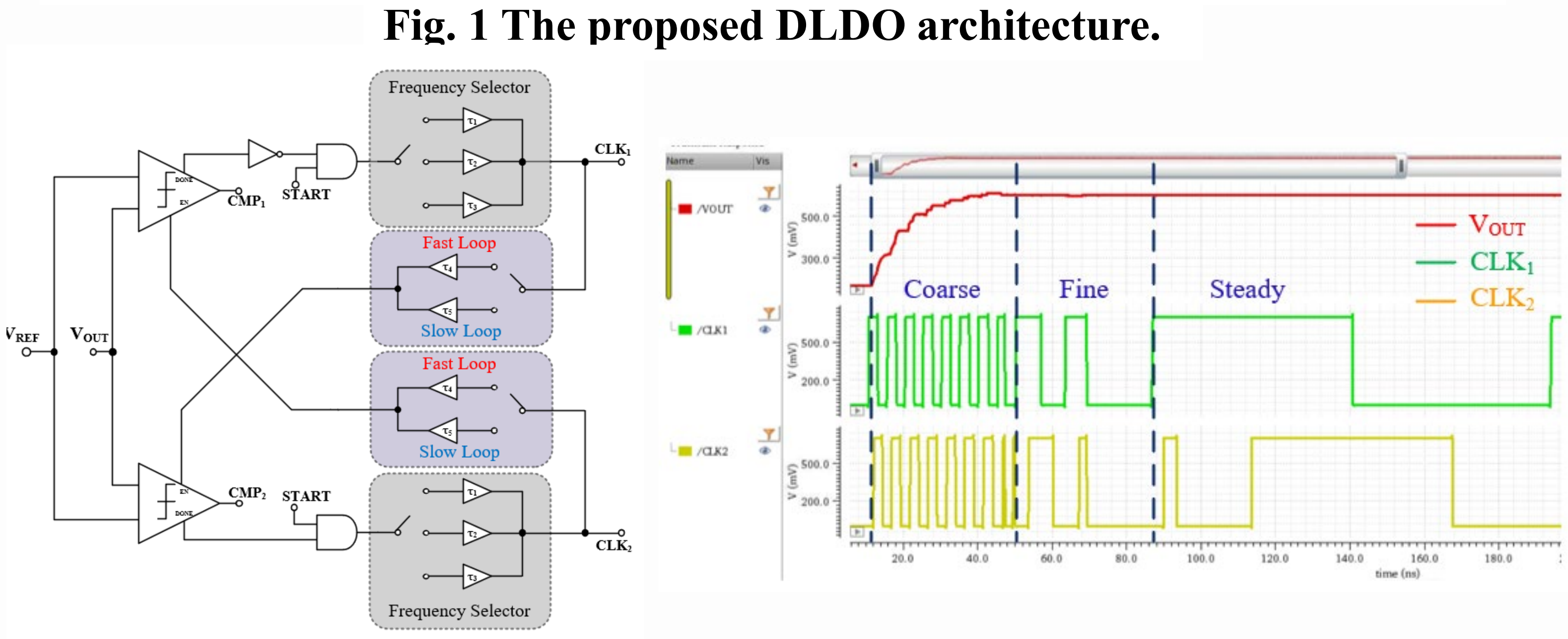


Fig. 1 The proposed DLDO architecture.



(a) (b)

Fig. 2 (a) Adaptive self oscillating cross-feedback comparator (b) The proposed LDO chasing diagram.

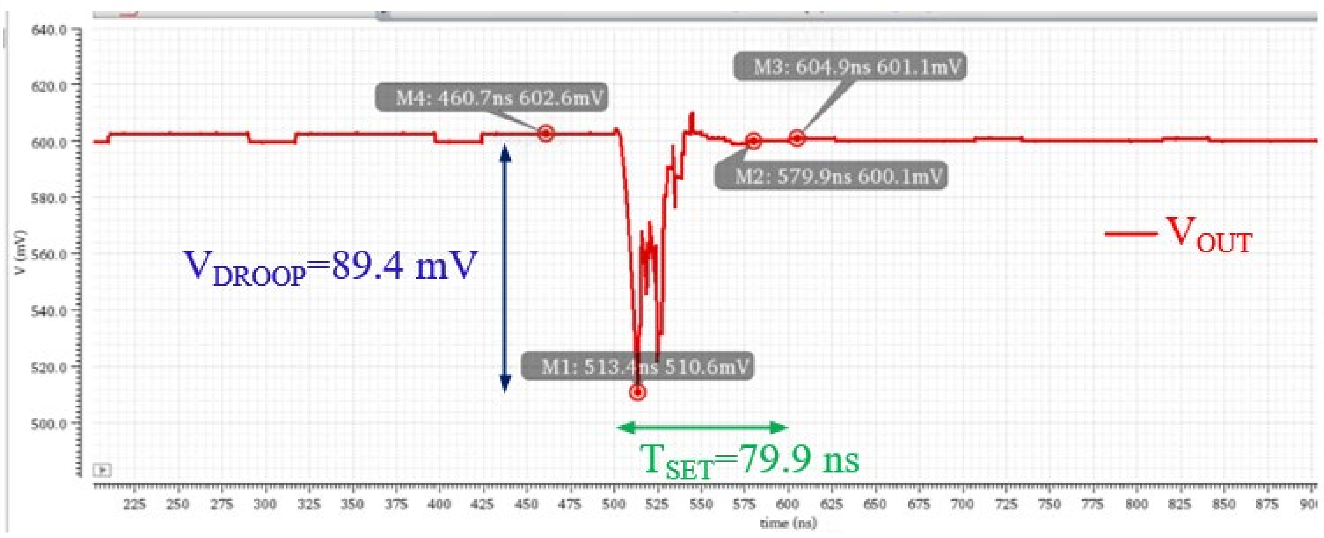


Fig. 3 The proposed LDO simulated transient response.

Fig.1 introduces An Event-Triggered Compensating Low Dropout Regulator with Cross-Loop Feedback Comparing Adaptive Oscillator architecture. The adaptive self oscillating cross-feedback comparator will be start-up by START signal and oscillating 200MHz for coarse loop to the fast chasing voltage, as shown in Fig. 2 (a). When achieving the target voltage (VREF), Finite state machine (FSM) will change the state from coarse to fine loop, and switch the clock from 200MHz to 100MHz to chase the voltage more accuracy. After the LDO output voltage (VOUT) lock to the VREF, the steady state detector will release a FRZ signal to chase the state mode from fine to steady loop, which also switch the frequency form 100MHz to 10MHz. In this state, the hole system will into the steady state and keep the voltage detecting by continuous comparator. When the under shoot happen, the continuous comparator will detect the transient and open the transient compensation loop to compensate the voltage which prevent the voltage droop to much. At the meanwhile, the continuous comparator also switches the state to the coarse loop for fast recovery time. The hole chasing diagram is shown in Fig. 2 (b).

Fig.3. shows the proposed LDO simulated transient response from 0.5mA to 3mA. When the under shoot happened, the continuous comparator work the transient compensation loop and restart the chasing work.

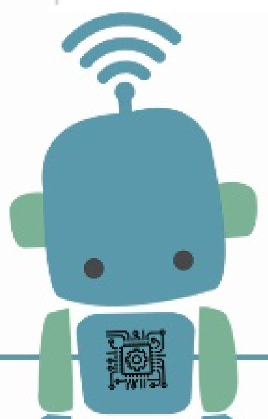
	This Work	[1]ISSCC'18	[2]TPE'22	[3]TCSII'20
Technology(nm)	90	65	65	180
V_{IN}(V)	0.7	0.5-0.9	0.9-1.2	0.8-1.1
V_{OUT}(V)	0.6	0.3-0.8	0.5-1.1	0.7-1.0
$I_{LOADMAX}$(mA)	3	3	19	170
IQ (uA)	29.63	48.4	131	500
△ILOAD (mA)	2.5	2.99	18.85	160
Edge time(ns)	15	0.2	5	*65
Settling time(ns)	79.9	*90	*80	80
C_{total}(pF)	3	365	200	390
△V_{OUT}(mV)	89.4	20.5	80	267
FOM_1 (fF)	3.48	403.74	101.09	325.41
$FOM_{1normalize}$ (fF)	2.51	403.74	101.09	117.51
FOM_2(ps)	0.98	40.51	5.92	2.14
$FOM_{2normalize}$ (ps)	0.71	40.51	5.92	0.77

Table. 1 Performance summary and comparison

SR=ΔI_{LOAD}/Edge Time

*Observed or estimated from the figures

$$FoM1=\frac{I_Q}{\Delta I_{LOAD}} * \frac{\Delta V_{OUT}}{V_{OUT}} * C_{OUT} \quad FoM2=I_Q*(\frac{C_L*\Delta V_{OUT}}{\Delta I_{LOAD}^2}+0.5/SR)$$



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