

**Title:** Design of a Compact On-Chip Static IR Drop Detector System

**Author:** Sakshi Pandey

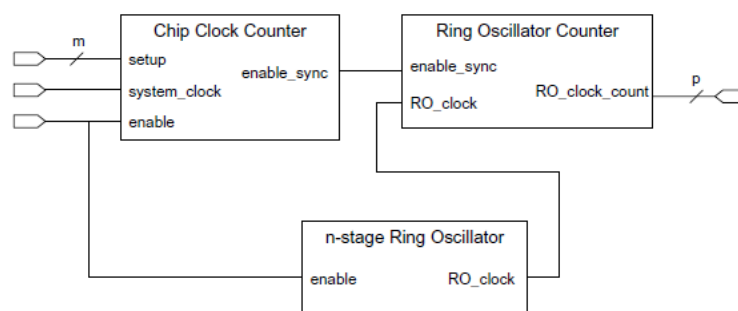
**College Name:** Dronacharya Group Of Institutions, Greater Noida

### **Description /Theory:**

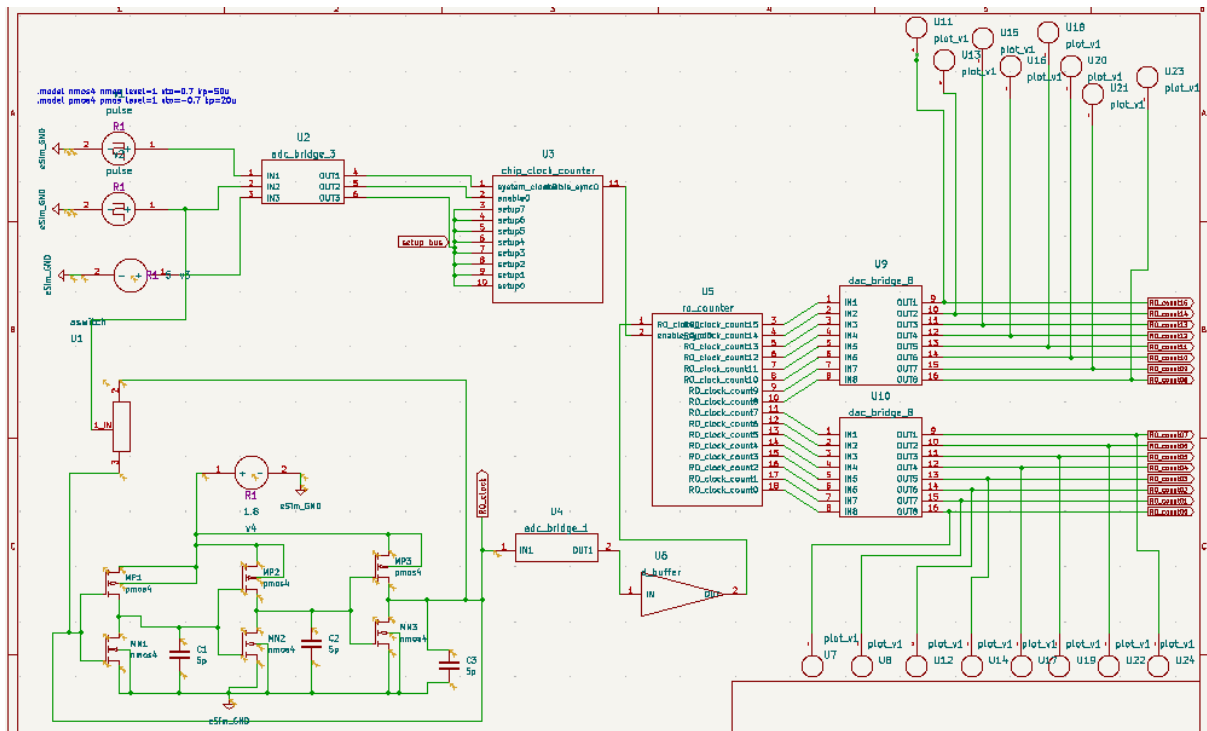
With continuous technology scaling, the reduction in supply voltage makes integrated circuits increasingly vulnerable to even small voltage drops across the power delivery network. Such **static IR drops** can degrade performance and compromise reliability. Accurate on-chip measurement of supply voltage noise is therefore essential for evaluating IR drop and enabling adaptive power management strategies. In this work, we present an **area-efficient static IR-drop detection and evaluation scheme** based on a ring oscillator. The proposed approach achieves reliable detection with minimal design overhead, while providing the capability to feed real-time information to power management units for voltage scaling and compensation.

A ring oscillator-based IR drop detector is a fully digital circuit used to monitor static IR drop by observing changes in oscillator frequency, which is sensitive to supply voltage variations. The system comprises a chip clock counter (CCC), a ring oscillator made of NAND2 gates, and a ring oscillator counter (ROC). When enabled, the CCC defines a timing window during which the ring oscillator operates. The oscillator, influenced by local voltage, generates a clock signal whose rising edges are counted by the ROC. As IR drop increases, the oscillator frequency decreases, resulting in fewer counted edges. To isolate the effect of IR drop from process variations, the detector is first checked ideal conditions using simulations, and a correction factor (  $k$  ) is applied to compute the voltage drop ratio. This method allows for accurate detection without altering the original RTL design, and the detector can be synthesized, auto-placed, and routed as a hard macro. Once its operation is complete, it can be disabled entirely, ensuring no interference with the main circuit.

### **Circuit Diagram:**



**Figure : Ring Oscillator based IR drop Detector**



## Results:

Node	RMS Value
ro_clock	0.59736 Volts

Node	RMS Value
ro_count00	1.4266 Volts

Node	RMS Value
ro_count04	0.59736 Volts

Node	RMS Value
ro_count08	0.59736 Volts

Node	RMS Value
ro_count12	0.59736 Volts

Node	RMS Value
ro_count01	0.81025 Volts

Node	RMS Value
ro_count05	0.59736 Volts

Node	RMS Value
ro_count09	0.59736 Volts

Node	RMS Value
ro_count13	0.59736 Volts

Node	RMS Value
ro_count02	0.59736 Volts

Node	RMS Value
ro_count06	0.59736 Volts

Node	RMS Value
ro_count10	0.59736 Volts

Node	RMS Value
ro_count14	0.59736 Volts

Node	RMS Value
ro_count03	0.59736 Volts

Node	RMS Value
ro_count07	0.59736 Volts

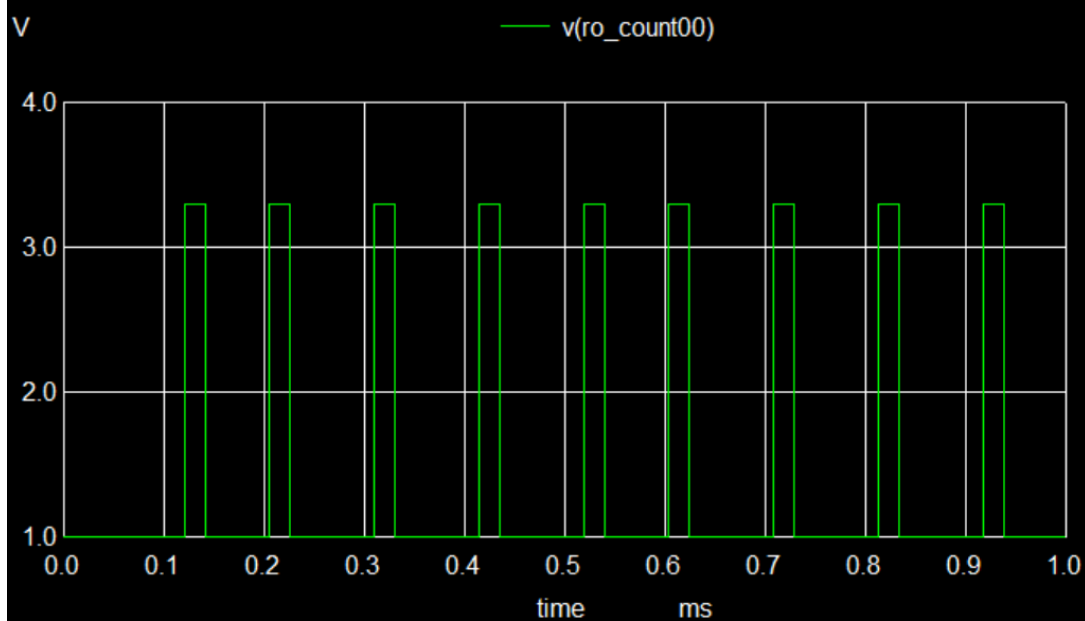
Node	RMS Value
ro_count11	0.59736 Volts

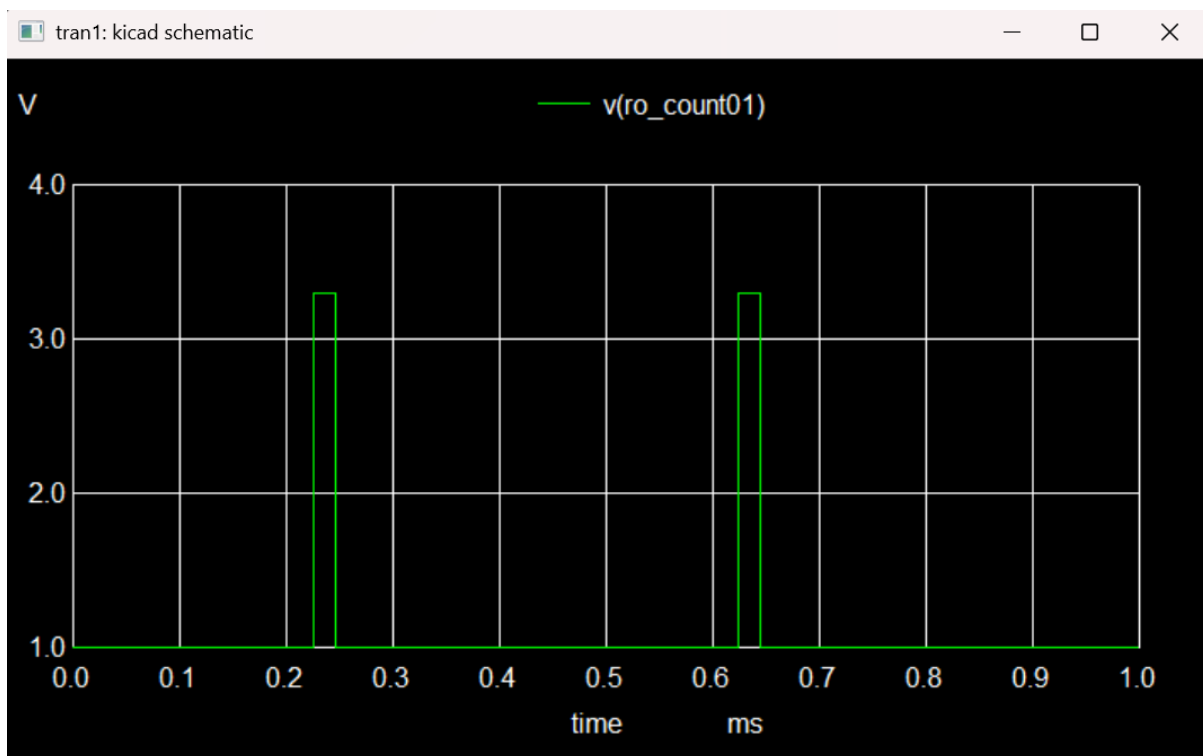
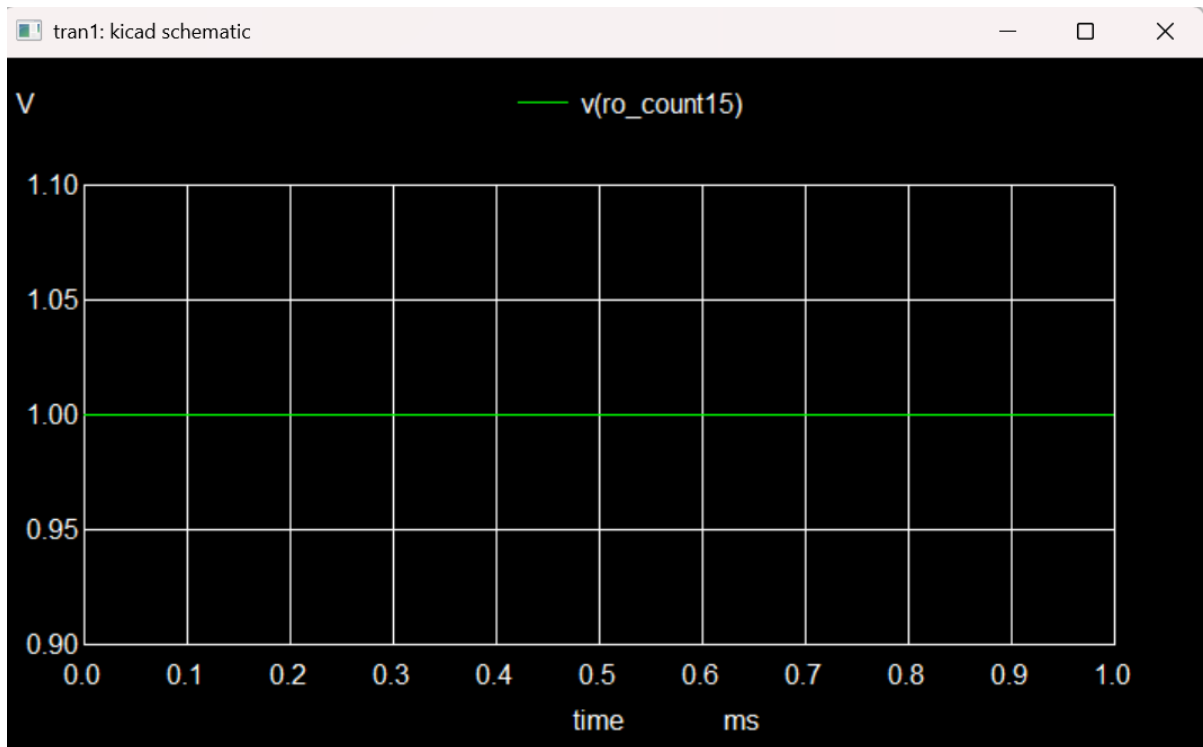
Node	RMS Value
ro_count15	0.59736 Volts

# Initial Transient Solution

Node	Voltage
net-_mp1-pad1_	1.8
net-_c1-pad1_	0.712263
net-_c2-pad1_	0.712263
net-_u2-pad1_	0
net-_u2-pad2_	0
net-_u2-pad3_	5
ro_clock	0.712263
ro_count07	1
ro_count06	1
ro_count05	1
ro_count04	1
ro_count03	1
ro_count02	1
ro_count01	1
ro_count00	1
ro_count15	1
ro_count14	1
ro_count13	1
ro_count12	1
ro_count11	1
ro_count10	1
ro_count09	1
ro_count08	1
v3#branch	0
vv2#branch	0
vv1#branch	0
v4#branch	-3.53689e-05
a4#branch_1_0	0
a4#branch_1_1	0

tran1: kicad schematic





The plots show the proper functioning of each block in the circuit. The counter output increases step by step with the system clock, while the ring oscillator generates continuous oscillations at higher frequency. The RO counter increments according to the oscillator clock and the two DAC outputs represent the lower and higher 8-bit values respectively. Overall, the plots confirm that the circuit works as expected.

#### References:

- An area efficient on-chip static IR drop detector/evaluator
- (<https://ieeexplore.ieee.org/abstract/document/5118186>)
- History Of IR detectors (<https://link.springer.com/article/10.2478/s11772-012-0037-7>)
- [https://www.itmconferences.org/articles/itmconf/pdf/2023/04/itmconf\\_I3cs2023\\_04001.pdf](https://www.itmconferences.org/articles/itmconf/pdf/2023/04/itmconf_I3cs2023_04001.pdf)