Analysis and Design of Temperature Independent Methodologies for Advanced CMOS Circuits

Student's Name	**T. A. Shamjad**	**VLSI (PT-2010)**
Academic Supervisor(s)	P. Chandramohan	
Industrial Supervisor(s)	Mohasin Uddin Khan, ARM Embedded Technologies Pvt. Ltd., Bengaluru	

T. A. Shamjad
shamjad.ta@gmail.com
Ph. No: 0 99024 72400

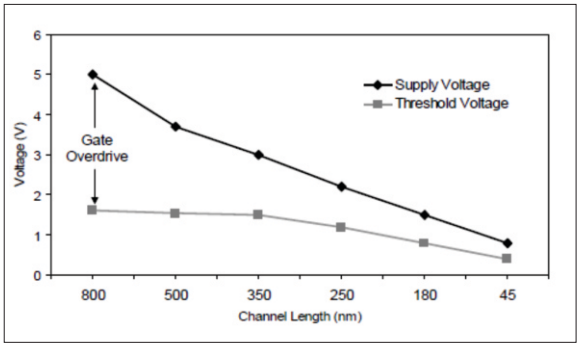
Keywords: Temperature Inversion, Ring Oscillator, Delay Characteristics, Current Source

Abstract:

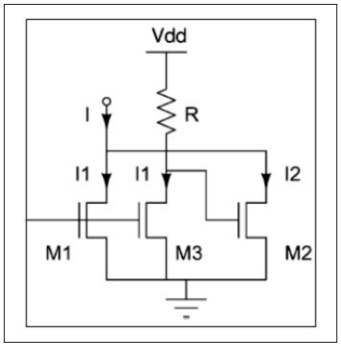
The delay characteristics of CMOS circuits vary widely with temperature. The important parameters that are influenced by the variations in temperature are threshold voltage, mobility and saturation velocity. The project aims at analysing the temperature dependent phenomena in advanced CMOS technology nodes. The scope of this project includes analysis of "temperature inversion" phenomenon as seen in advanced technology nodes and design of a temperature insensitive ring oscillator circuit using an addition based current source.

The temperature inversion effects in MOS designs are analysed. The transfer curves for multi voltage devices such as LVT, HVT and RVT were plotted for different technology nodes like 65 nm, 32 nm and 28 nm. These graphs were used in the study and analysis of Zero Temperature Coefficient (ZTC) points in each technology. A ring oscillator has been designed with 11 inverter stages and the effect of temperature variation is analysed. The design was modified to include addition based current source header and footer blocks to produce constant current source for the ring oscillator. The circuit was designed using 28 nm HVT devices and simulated using HSPICE. The simulation was performed at -4° C and 125° C conditions using device models for SS process corner at VMIN condition and the variation in delay has been recorded.

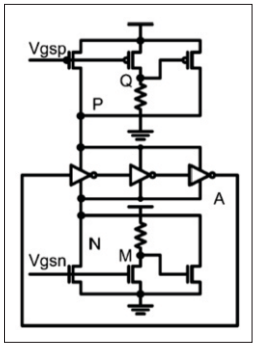
The results showed that HVT devices are more prone to temperature inversion. The temperature inversion phenomenon is more pronounced at lower technology nodes. In the lower technology nodes, it is observed that the devices tend to become faster at higher temperatures and slower at lower temperatures, contrary to what is seen at older technology nodes like 180 nm. It was seen that the ring oscillator circuit with addition based current source was showing only a variation of 4% when temperature was varied from -4° C to 125° C as opposed to the normal ring oscillator circuit which showed around 38% variation. The modified circuit does not show inversion.



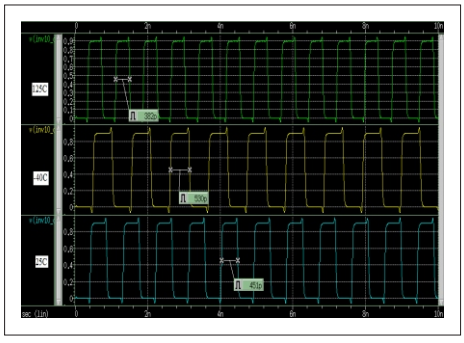
The scaling of the supply and threshold voltages



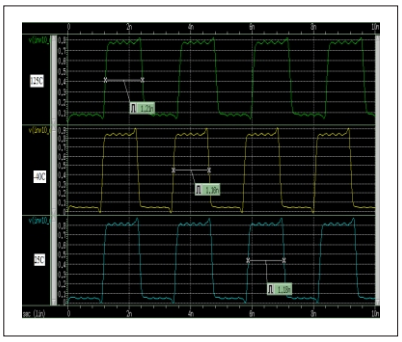
Addition based current generator



Addition based ring oscillator



Simulation result of normal ring oscillator



Simulation result of addition based ring oscillator