Circuits and Systems Design Automation of Analog VLSI

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Process-Voltage-Temperature

- Process variation (P)
- Supply voltage (V)
- Operating Temperature (T)

Three important factors contributed to performance variation.

Process-Voltage-Temperature

- Process variation (P)
  - Process variation accounts for deviations in the semiconductor fabrication process.
    - Usually process variation is treated as a percentage variation in the performance calculation.
    - Variation distribution will be provided by manufacture company.

Process-Voltage-Temperature

- Variations in the process parameters can be impurity concentration densities, oxide thicknesses and diffusion depths.
  - This introduces variations in the sheet resistance and transistor parameters such as threshold voltage.
- Dimension variations of the devices, are mainly resulted from the limited resolution of the photolithographic process.
  - This causes (W/L) variations in MOS transistors.

Process-Voltage-Temperature

- Supply Voltage Variation (V)
  - The design's supply voltage can vary from the established ideal value in real operation.
    - Often a complex calculation (using a shift in threshold voltages) is employed.
    - A simple linear scaling factor is also used for logic-level performance calculations.

Process-Voltage-Temperature

- Supply Voltage Variation (V)
  - Performance of a transistor depends on the power supply. For instance, the delay of a cell is dependent on the saturation current. In this way, the power supply inflects the propagation delay of a cell.

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- Supply Voltage Variation (V)
  - Throughout a chip, the power supply is not constant and hence the propagation delay varies in a chip.
    - The voltage drop is due to nonzero resistance in the supply wires.
    - The self-inductance of a supply line contributes also to a voltage drop.

Process-Voltage-Temperature

- Operating Temperature Variation (T)
  - Temperature variation is unavoidable in the everyday operation of a design.
    - Effects on performance caused by temperature fluctuations are most often handled as linear scaling effects, but some submicron silicon processes require nonlinear calculations.
    - When a chip is operating, the temperature can vary throughout the chip. This is due to the power dissipation in the MOS-transistors. The power consumption is mainly due to switching, short-circuit and leakage power consumption.

Process-Voltage-Temperature

- Process variation corners
  - A conventional name for process corner uses two-letter designators, where the first letter refers to the N-channel MOSFET (NMOS) corner, and the second letter refers to the P channel (PMOS) corner.
  - There are five possible corners:
    - typical-typical (TT) (not really a corner of an n vs. p mobility graph, but called a corner, anyway), fast-fast (FF), slow-slow (SS), fast-slow (FS), and slow-fast (SF). The first three corners (TT, FF, SS) are called even corners, because both types of devices are affected evenly, and generally do not adversely affect the logical correctness of the circuit.

Process-Voltage-Temperature

- Process variation corners
  - The first three corners (TT, FF, SS) are called even corners, because both types of devices are affected evenly, and generally do not adversely affect the logical correctness of the circuit.
  - The last two corners (FS, SF) are called "skewed" corners, and are cause for concern. This is because one type of FET will switch much faster than the other, and this form of imbalanced switching can cause one edge of the output to have much less slew than the other edge.

Process-Voltage-Temperature

- References

Weste, Neil H.E. and Harris, David (2005). *CMOS VLSI Design: A Circuits and Systems Perspective, 3rd Ed.,*. Addison-Wesley, pp.231-235.

http://en.wikipedia.org/wiki/Process_corners

http://asic-soc.blogspot.com/2008/03/process-variations-and-static-timing.html