وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا

Ain Shams University – Faculty of Engineering – ECE Dept. – Integrated Circuits Lab.
Dr. Hesham Omran

Analog IC Design
Design Challenge
Digitally Controlled Variable Gain Amplifier (VGA)

Intended Learning Objectives

In this design challenge you will:

- Learn how to select a proper circuit topology.
- Learn how to design an analog circuit on your own.
- Learn how to implement a digitally controlled analog circuit.
- Learn how variations affect the circuit.

Design Specs

It is required to design a digitally controlled variable gain amplifier with the following specifications.

Technology	65nm
Supply voltage	**1.2V**
Variations (Corners)	**For passive elements used in the design:** **Assume caps vary +/- 10%** **Assume resistors vary +/- 20%**
Reference signal	**Use a single ideal reference current source.** **Use ideal DC bias voltage if needed.**
Output type	**Single ended**
External load	**500 fF**
Feedback type	**Inverting - Capacitive (use 500fF unit capacitors ONLY)**
Digital control	**Single bit signal (D0)**
Closed loop gain	**D0 = 0: 6 dB** **D0 = 1: 12 dB**
Phase margin	**> 60°**
DC LG	**> 60 dB**
Closed loop BW	**> 10 MHz**
Output swing	**> 0.8 V pk-to-pk**
Power consumption	**Minimize**

Notes

- The PM, DC LG, and CL BW specs should be satisfied at all gain settings.
- Use an ideal feedback switch that is closed in DC and IC (initial condition) to set a correct DC bias point.

Deliverables

- From the closed loop specs, use hand analysis to find the worst-case open loop specs of the OTA (CLeff, DC Gain, UGF, PM).
- OTA topology selection and design steps (use ADT Cockpit **or** the Sizing Assistant).
- Schematics with device sizing.
- Schematics with DC OP and node voltages annotated.
- Simulations showing the amplifier closed loop specs (Closed loop gain and BW, DC LG, and PM) at the two different gain settings and across all required corners.
    - What is the worst-case corner?
    - Note: The PM is measured from the stb analysis (LG), not from the CL response!
- Closed loop transient simulations with sinusoidal input at 1 MHz at the nominal corner showing the maximum output swing at the two different gain settings.
    - Use the THD function in the calculator to calculate the distortion.
    - Is the THD the same for both gain settings? Why?

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