Design and Verification of 12-bit SAR ADC with Non-Binary Multiple-LSB-Redundant and Non-Integer-and-Split-Capacitor DAC

Dharma Anargya Jowandy – Personal Project Proposal
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Project Background

This personal project was initiated as a result of participating in the Chipathon 2025 contest. The proposal for the analog track focuses on an 8-bit SAR ADC design. As a second-year undergraduate Electrical Engineering student from ITB, Indonesia, with no prior IC design experience, I was unable to continue because the demanding pace of the competition design stage was too fast. Nevertheless, I am eager to complete the design as a personal project on my own timeline. In carrying it out, I'm fortunate to be supervised by a senior who is now pursuing a master's degree at KAIST and has experience in the mixed-signal field

# Objectives

Proposed Design Specifications

Parameter	Value
Resolution (bit)	12
Technology (nm)	180
Supply Voltage (V)	5
Sampling Rate (MS/s)	1
DNL (LSB)	0,54
INL (LSB)	0,89
ENOB (Bit) @Nyquist	11,25
Power Cons. (µW)	44,78
Area (mm²)	0,367
Unit Cap. (fF)	20
Total Cap. (pF)	10,24
FoM (fJ/conv.-step)	18,39
FoM (dB)	169,99

- The main goal of this project is to design a 12-bit SAR ADC architecture, covering the ideal circuit simulation, transistor-level circuit implementation & simulation, and layout design.
- Design performance itself is taken from the work of Kuo et al. (2017) as a reference.
- The focused design stage will be implemented using an open-source toolchain, such as gf180mcuD PDK, Ngspice, Magic, and Klayout.
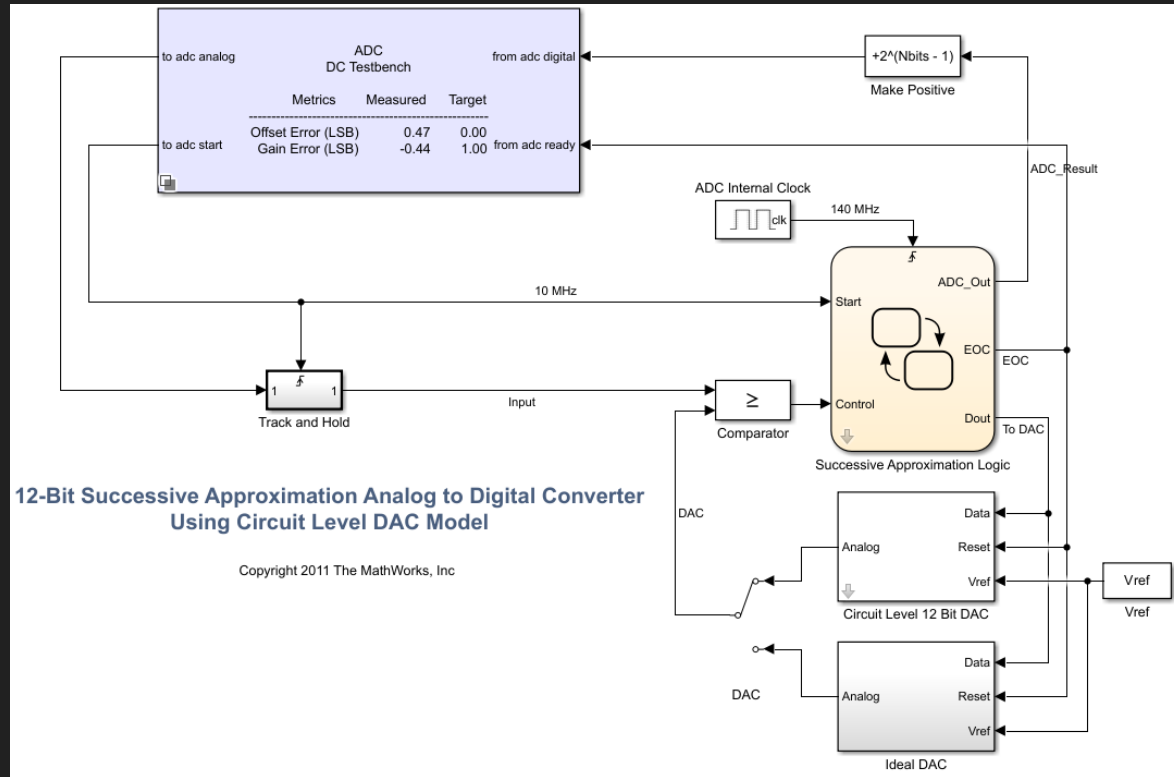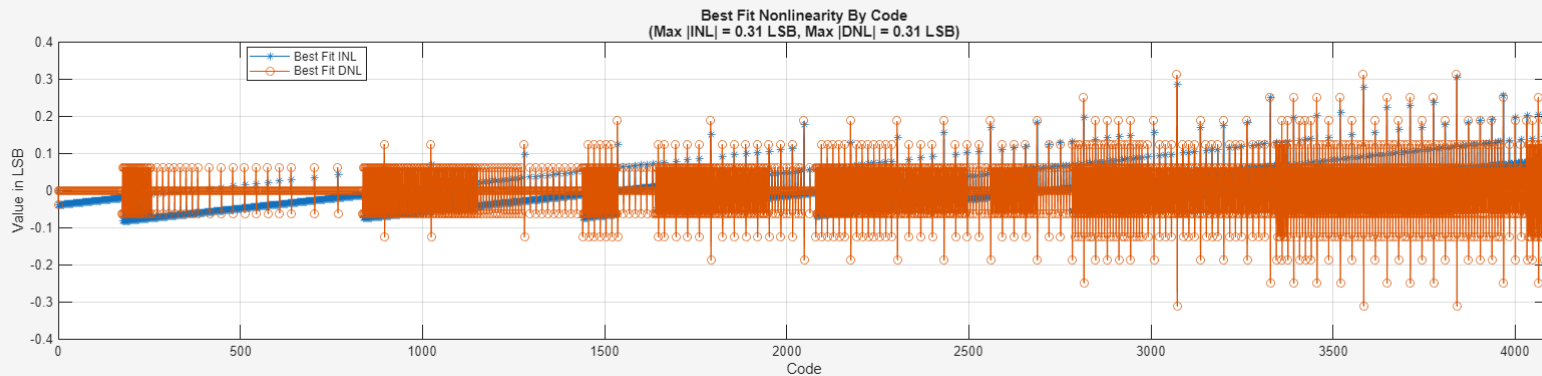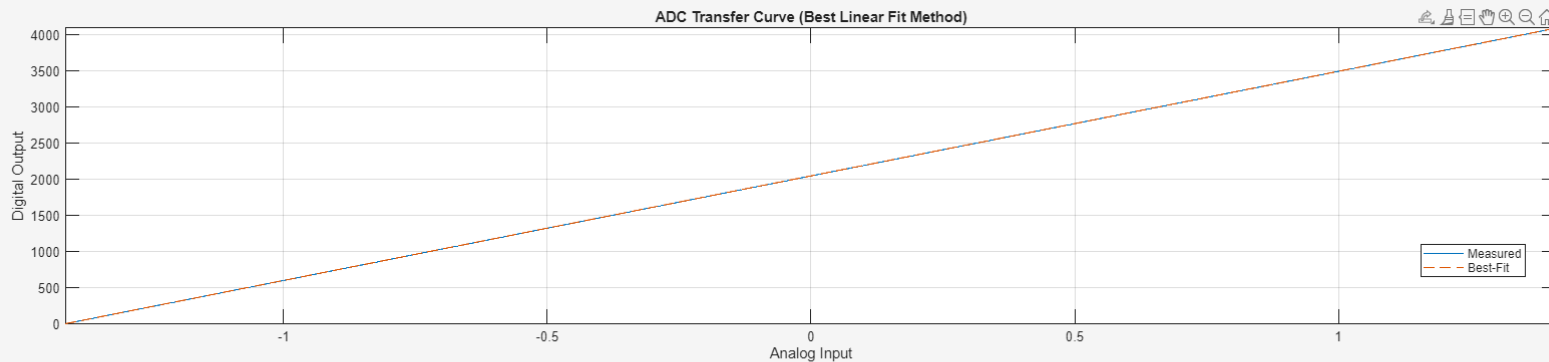
Block Diagram (Top Level)
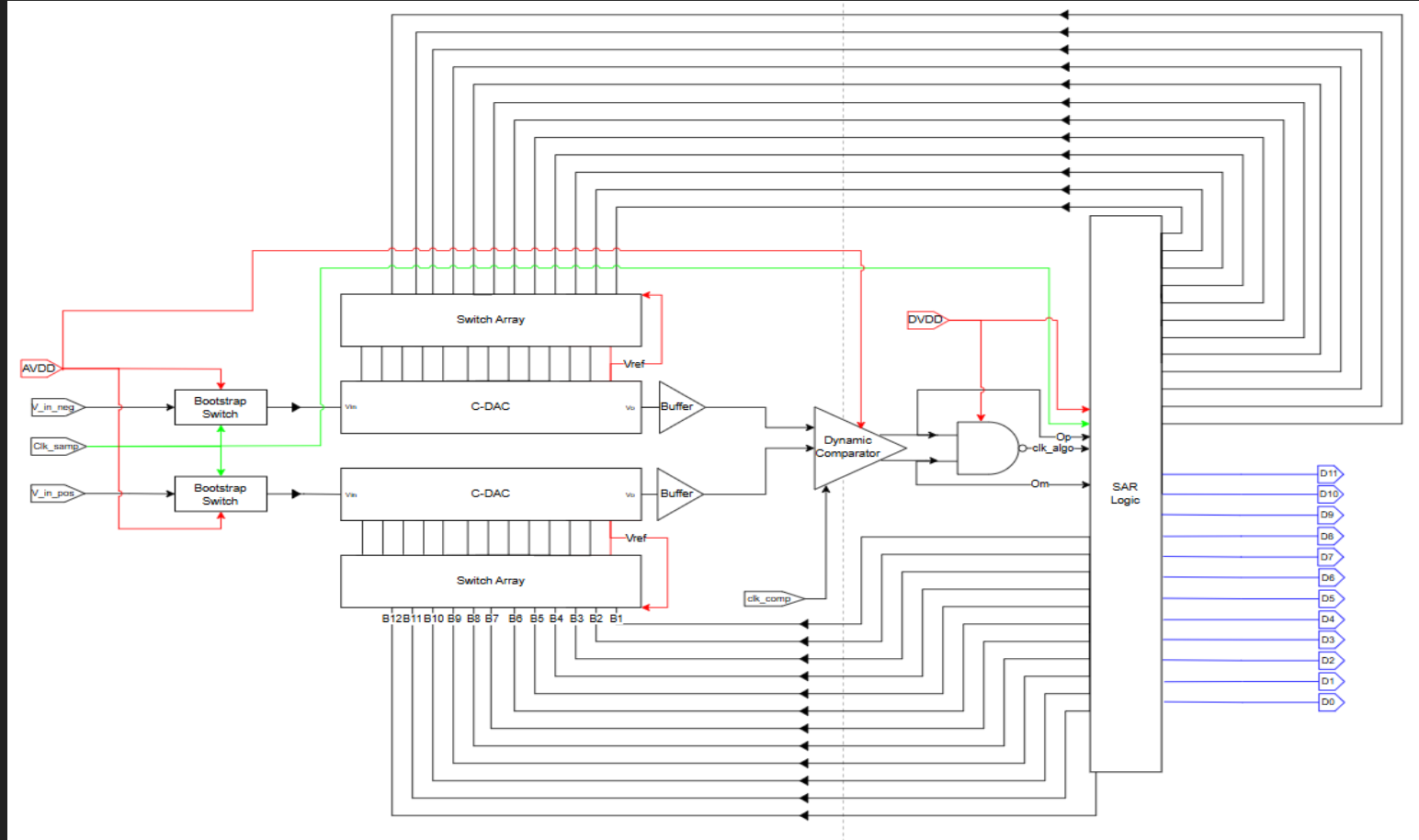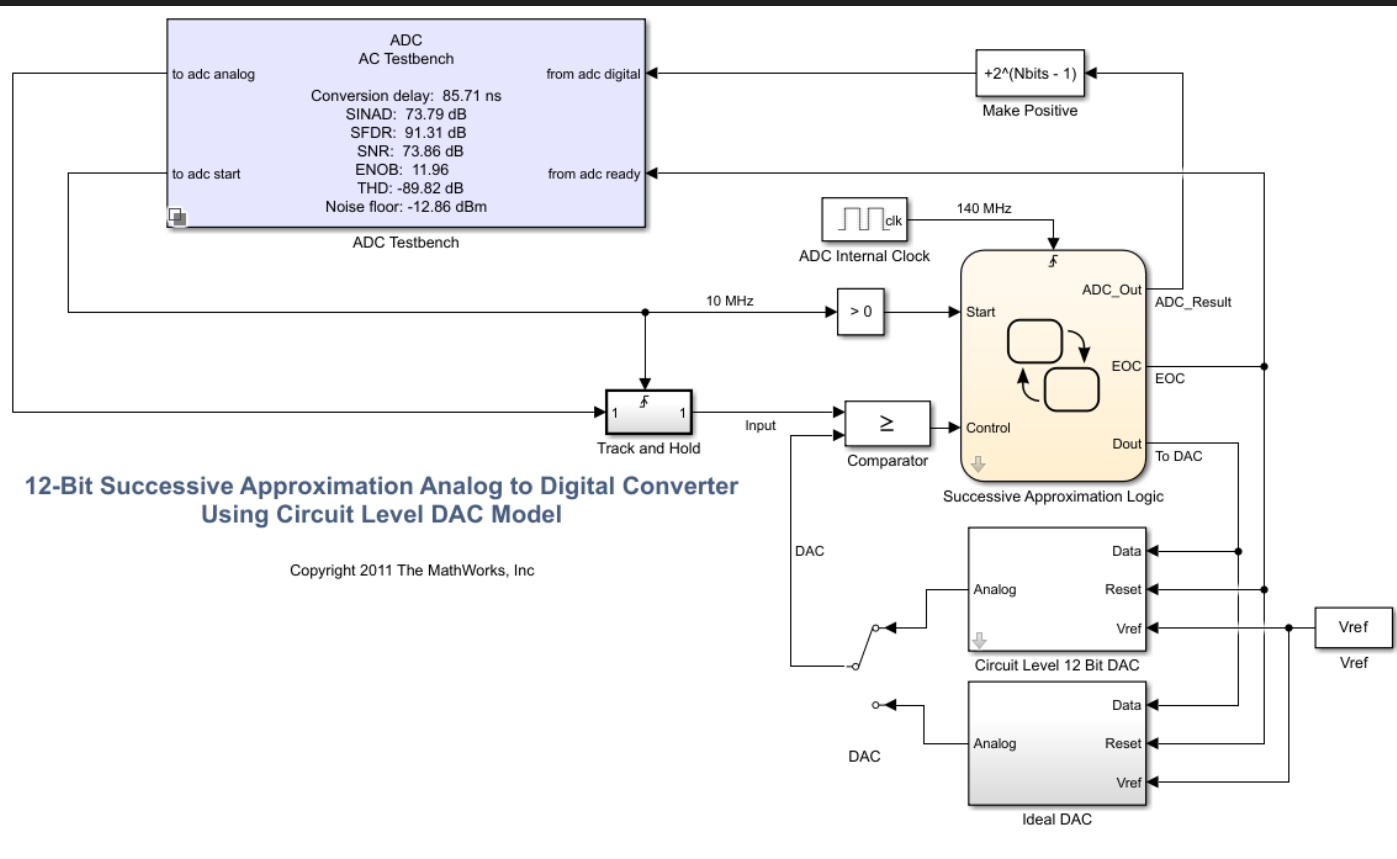
SAR ADC System-Level Model Setup
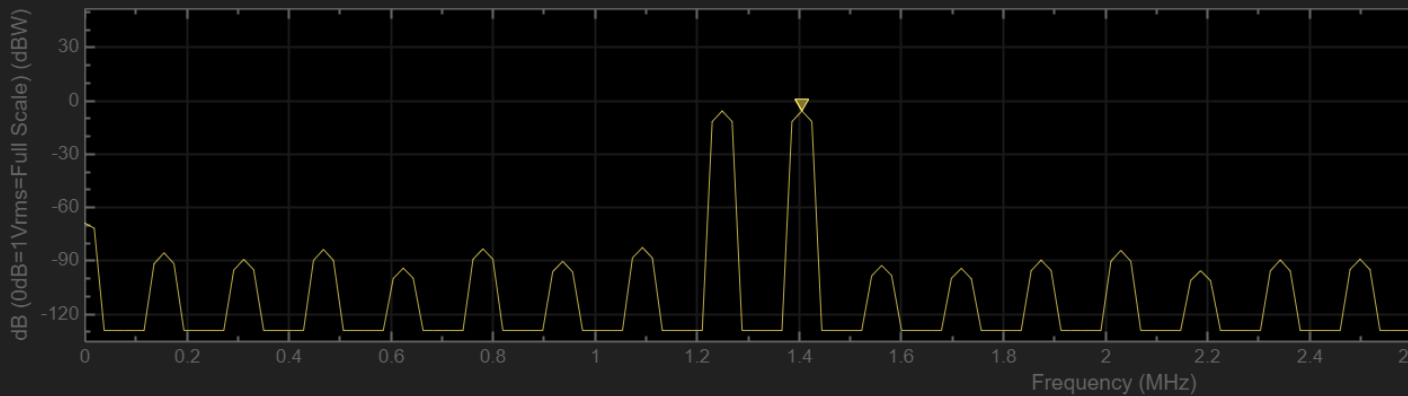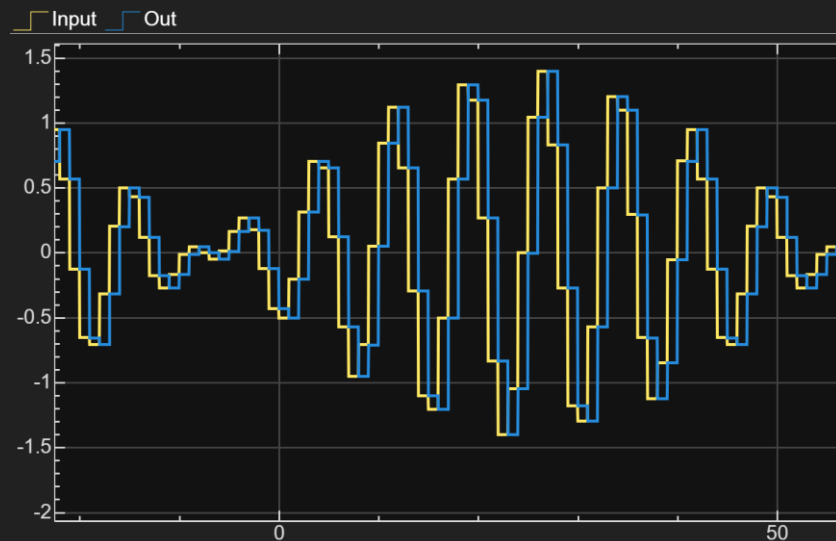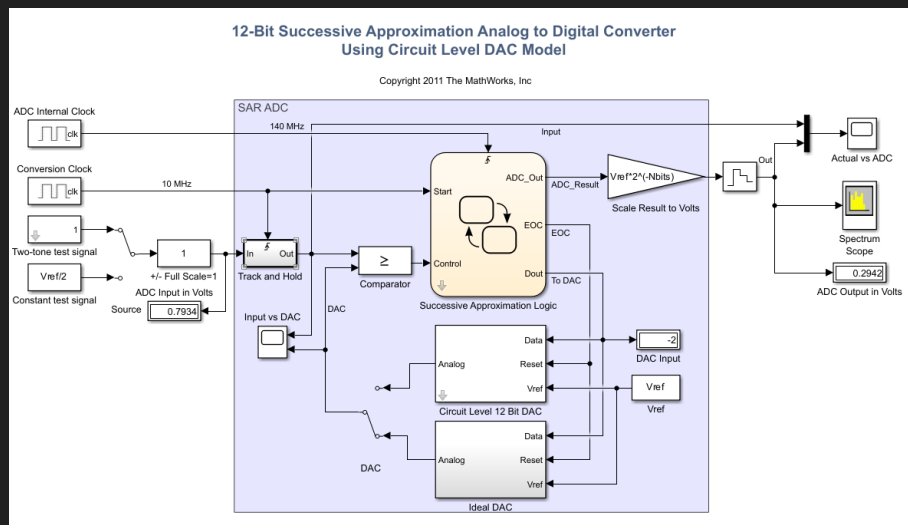
System-Level Model: SAR ADC DC Testbench

System-Level Model: SAR ADC DC Testbench

System-Level Model: SAR ADC AC Testbench

Timeline

Month	Phase	Description
Sep-25	System & Behavioural Modelling	• 12-bit SAR ADC system level modelling • AC & DC testbench • Define the high-level architecture
Oct-25 & Nov-25	Capacitor DAC & Reference	• Define the capacitor array architecture • Design and add the reference buffer
Dec-25	Comparator & S/H Design	• Design the comparator • Design the sample-and-hold (S/H) circuit
Jan-26	Full ADC Integration	• Integrate the comparator, S/H, DAC, and reference buffer • Add the SAR logic & NAND Gate • Full performance simulations
Feb-26	Block-Level Layout Design	• Layout the comparator • Layout the DAC array • Layout the S/H circuit and reference buffer • Run Design Rule Check
Mar-26	Top-Level Layout Assembly	• Assemble all blocks at the top level • Optimize block placement for area efficiency

References

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- H.-L. Kuo, C.-W. Lu, and P. Chen, "An 18.39 fJ/Conversion-Step 1-MS/s 12-bit SAR ADC with Non-Binary Multiple-LSB-Redundant and Non-Integer-and-Split-Capacitor DAC," *IEEE Access*, vol. 9, pp. 5651-5669, 2021, doi: 10.1109/ACCESS.2020.3048979.