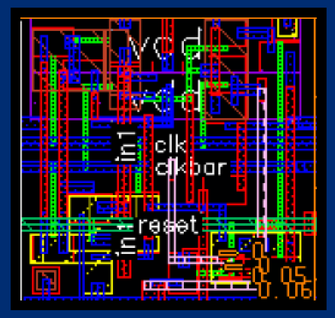


Low-Area CMOS Keyword Spotter

CMOS keyword spotting system for wake-word detection with layout-area-conscious design

Joseph Gregory, Gwenyth Tran, and Taiyo Tagami
EN.520.216.01.SP26, Introduction to VLSI - Dr. Ralph E. Cummings
Whiting School of Engineering, Johns Hopkins Univeristy

JOHNS HOPKINS
WHITING SCHOOL of ENGINEERING

I THE CHALLENGE

Always-On Voice Detection at Low Power

Voice assistants can be activated even when the device appears idle. Continuous speech processing would be too power-intensive, so systems may rely on a low-power CMOS-based keyword spotter to detect trigger phrases efficiently. It must be compactand energy-efficient to fit and perform well in the device.

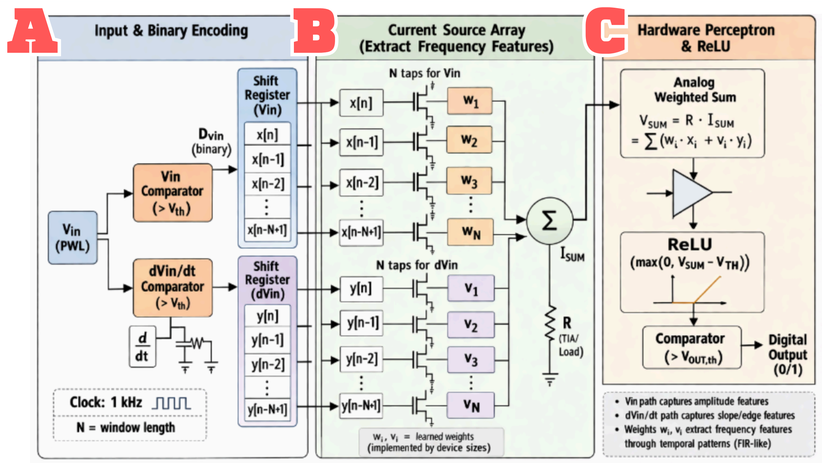
II OBJECTIVES

Design CMOS-based keyword spotter architecture

→

power efficiency and speed

III METHODS



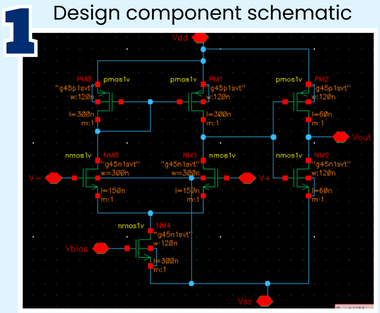
Keyword spotter design process. Adapted from Prof. Ralph E. Cummings, EN.520.216.01.SP26, 2026

COMPONENT DESIGN PROCESS

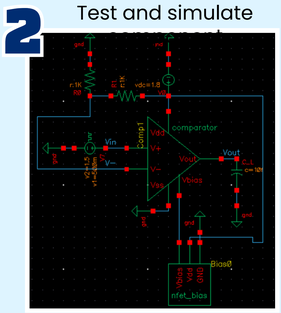
*Diagrams below are for the comparator.

2D CAD Software: Cadence Virtuoso

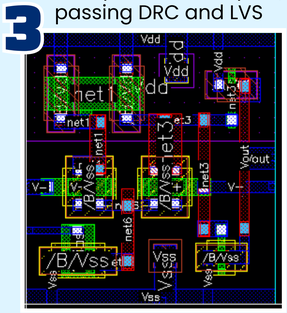
1 Design component schematic



2 Test and simulate



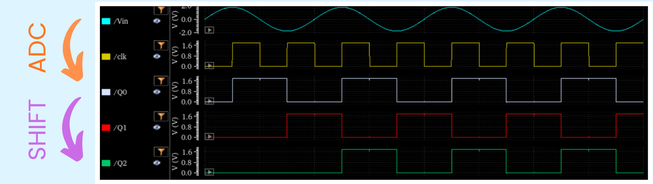
3 Complete small layout, passing DRC and LVS

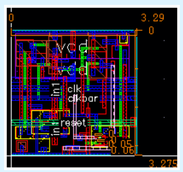


IV RESULTS

A Input & Binary Encoding (ADC + Registers)

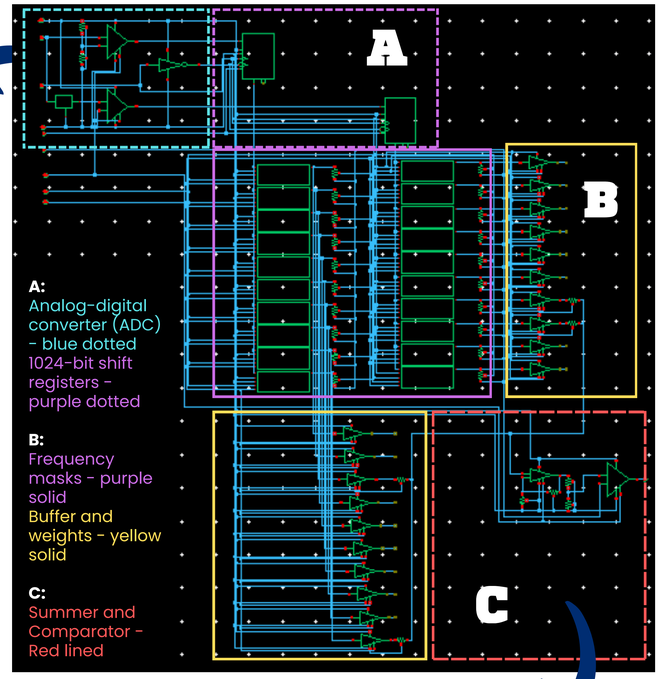
- High-pass filter designed with **pseudo resistor** differentiates input signal
- Comparators digitize raw signal in a process called analog-digital conversion (ADC) using thresholds: $v > \frac{V_{DD}}{2}$, $\frac{\partial v}{\partial t} > 0$
- Signals pass through and are stored in 1024-bit shift registers for ~1 second





Layout areas:

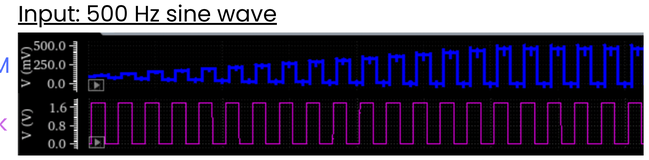
- Comparator: 2.305 x 2.520 μm²
- D Flip-Flop: 3.290 x 3.275 μm²
  - Aggregated for shift register
- High-pass: 7.670 x 1.405 μm²



B Current Source Array (Frequency Masks)

- Frequency masks detect given frequencies
- **Op-Amp buffer** designed to separate masks and weight blocks

Input: 500 Hz sine wave



Voltage reaches max as matching signal shifts in →

C Perceptron and Output

- Implemented summer amplifier to sum weights
- Flagged wake-word detection using comparator

V CONCLUSION

- A wake-word detector was successfully created in Cadence
- Experimented and researched designs that maintain compact layout area
- Layout was created for designed components