DAC Architectures (Nyquist Rate)

Types

- Voltage Scaling
  - Resistor String DACs (string DACs)
  - Interpolating
- Current Steering
  - Binarily Weighted Resistors
  - R-2R Ladders
  - Current Source Steering
    - Thermometer Coded
    - Binary Weighted
    - Segmented
- Charge Redistribution
  - Switched Capacitor
- Serial
  - Algorithmic
  - Cyclic or Re-circulating
  - Pipelined
- Integrating
- Resistor Switching
- MDACs (multiplying DACs)
Switch Implementation Issues

Review from last lecture.

- n-channel
- p-channel
- T-gate
Current Steering DACs

InherentlyInsensitive to Nonlinearities in Switches and Resistors
Smaller ON resistance and less phase-shift from clock edges
Current Steering DACs

- T-gate
- Compensation
- \( R \)
- \( S_1 \)
- \( I_1 \)
- \( V_{\text{REF}} \)
- \( R_F \)
- \( n \)
- \( R_{\text{Sn}} \)
- \( I_{\text{IN}} \)
- \( V_{\text{OUT}} \)
- \( I_T \)
- \( I_{\text{SUM}} \)
- \( d_k \)
- \( \beta \)
- \( \sum \)

- Review from last lecture...
Current Steering DACs

Binary-Weighted Resistor Arrays
Current Steering DACs

Binary-Weighted Resistor Arrays

Actual layout of resistors is very important
Current Steering DACs

Segmented Resistor Arrays
Current Steering DACs

R-2R Resistor Arrays
Current Steering DACs

R-2R Resistor Arrays

V_{REF}

R
2R
b_1

R
2R
b_2

R
2R
b_3

R
2R
b_4

R

R_F

V_{OUT}

R-2R Resistor Arrays
Another R-2R DAC
Another R-2R DAC

![Diagram of an R-2R DAC with labeled components: $b_4, b_3, b_2, b_1$ and input currents $I$ connected to ground $V_{SS}$, and output voltage $V_{OUT}$ with feedback resistor $R_F$.]
Another R-2R DAC
Current Steering DAC

\[ I_{OUT} = kI \]
Current Steering DAC

\[ I_{OUT} = kI \]
Current Steering DAC

![Diagram of Current Steering DAC]

- $X_{MSB}$
- $V_{XX}$
- $X_{LSB}$
- $n_1$
- $n_2$
- $R_F$
- $V_{OUT}$
- $I_{OUT}$

Block Diagram:
1. Binary to Thermometer
2. Thermometer Coded Array
3. Binary Coded Array
4. Operational Amplifier
5. Output $V_{OUT}$
Current Steering DAC
Current Steering DAC

\[ \text{IOUT} = kI \]
Current Steering DAC

- Binary to Analog Decoder (all ON)
- I_{OUT} = kI

- Cascode Current Source (Mirror)
- Differential Amplifier (Analog)
Current Steering DAC

\[ \text{Current DAC Diagram} \]
Current Steering DAC

\[ I_{d1}, I_{d2}, \ldots, I_{dN-1}, V_{OUT} \]

\[ V_{XX}, V_{YY}, V_{SS} \]

\[ k \]

\[ I_{OUT} = kI \]

\[ R_f, V_{OUT} \]

\[ d_k, C_{P1}, C_{P2} \]

\[ V_{1}, V_{2}, I_{D1}, I_{D2} \]

\[ I_T, V_d, \sqrt{2} V_{EB}, -\sqrt{2} V_{EB} \]
End of Lecture 36