EE 435

Lecture 37

DAC Design

R-2R DACs
Current Steering DACs
Charge Redistribution DACs
Current Steering DACs

R-2R Resistor Arrays

RREF

VOUT

R

b1

b2

b3

b4
Current Steering DACs

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

- Switch impedance does not affect accuracy!
- Requires two levels of matching
Another R-2R DAC
Current Steering DAC

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

$I_{OUT} = kI$

$V_{OUT}$

$R_F$
Current Steering DAC
Current Steering DAC
Current Steering DAC

\[ I_d1 \quad I_d2 \quad \ldots \quad I_dN-1 \]

\[ V_{OUT} \]

\[ V_{XX} \]

\[ V_{SS} \]

\[ I_{OUT} = kI \]

\[ R_f \]

\[ V_{OUT} \]
Current Steering DAC

\[ I_d1 \quad I_d2 \quad I_dN-1 \]

\[ V_{OUT} \]

\[ d_k \]

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

Cascode Current Source (Mirror)

Differential Amplifier (Analog)

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

![Diagram of a current steering DAC with components labeled for voltage sources $V_{XX}$ and $V_{YY}$, transistors $M_{1}$ to $M_{4}$, capacitors $C_{P1}$ and $C_{P2}$, and output current $I_{OUT}$=k$I$. The diagram also includes a binary to analog decoder and an op-amp configuration for signal amplification.]
Current Steering DAC with Supply Independent Biasing

If transistors on top row are all matched, \( I_X = V_{REF}/R \)

Thermometer coded structure (requires binary to thermometer decoder)

\[
I_A = \left( \frac{V_{REF}}{R} \right)^{N-1} \sum_{i=0}^{N-1} d_i
\]

Provides Differential Output Currents
Current Steering DAC with Supply Independent Biasing

If transistors on top row are all matched, $I_X = V_{REF}/R$

$$V_A = \left(-V_{REF} \frac{R_A}{R}\right) \sum_{i=0}^{N-1} d_i$$

Provides Differential Output Voltages
Current Current Steering DAC with Supply Independent Biasing

If transistors on top row are binary weighted

\[ I_A = \left( \frac{V_{REF}}{R} \right)^{n-1} \sum_{i=0}^{n-1} \frac{d_i}{2^{n-i}} \]

Provides Differential Output Currents