EE 435

Lecture 33

DAC Design
  • The String DAC
R-String DAC

Basic R-String DAC
Basic R-String DAC including Logic to Control Switches

Review from last lecture...
R-String DAC

- $V_{REF}$
- $X_{IN}$
- Decoder
  - $b_3 \overline{b}_3$
  - $b_2 \overline{b}_2$
  - $b_1 \overline{b}_1$
- Tree Decoder
  - $V_{OUT}$
Parasitic Capacitors in MOSFET
Operation Region Dependent and Fixed --Saturation

Overlap Capacitors: $C_{GDO}$, $C_{GSO}$
Junction Capacitors: $C_{BS1}$, $C_{BD1}$
Saturation Capacitors: $C_{GCH}$, $C_{BCH}$
Parasitic Capacitance Summary

<table>
<thead>
<tr>
<th></th>
<th>Cutoff</th>
<th>Ohmic</th>
<th>Saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{\text{GS}}$</td>
<td>$\text{CoxWL}_D$</td>
<td>$\text{CoxWL}<em>D + 0.5\text{C}</em>{\text{OXWL}}$</td>
<td>$\text{CoxWL}<em>D + (2/3)\text{C}</em>{\text{OXWL}}$</td>
</tr>
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<td>$C_{\text{GD}}$</td>
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<td>$\text{CoxWL}_D$</td>
</tr>
<tr>
<td>$C_{\text{BG}}$</td>
<td>$\text{CoxWL (or less)}$</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$C_{\text{BS}}$</td>
<td>$C_{\text{BOTAS}} + C_{\text{SWPS}}$</td>
<td>$C_{\text{BOTAS}} + C_{\text{SWPS}} + 0.5\text{WLC}_{\text{BOTCH}}$</td>
<td>$C_{\text{BOTAS}} + C_{\text{SWPS}} + (2/3)\text{WLC}_{\text{BOTCH}}$</td>
</tr>
<tr>
<td>$C_{\text{BD}}$</td>
<td>$C_{\text{BOTAD}} + C_{\text{SWPD}}$</td>
<td>$C_{\text{BOTAD}} + C_{\text{SWPD}} + 0.5\text{WLC}_{\text{BOTCH}}$</td>
<td>$C_{\text{BOTAD}} + C_{\text{SWPD}}$</td>
</tr>
</tbody>
</table>

Review from last lecture.
R-String DAC

Parasitic Capacitances in Tree Decoder
R-String DAC

Previous-Code Dependent Settling

Assume all C’s initially with 0V
Red denotes $V_3$, black denotes 0V, Purple some other voltage
R-String DAC

Transition from <010> to <101>

Example:
V3
V6

Previous-Code Dependent Settling

Assume all C’s initially with 0V
Red denotes V3, green denotes V6, black denotes 0V, Purple some other voltage
R-String DAC

Transition from \(<010>\) to \(<101>\)

White boxes show capacitors dependent upon previous code \(<010>\)

Assume all C’s initially with 0V

Red denotes \(V_3\), green denotes \(V_6\), black denotes 0V, Purple some other voltage
R-String DAC

Do the resistors that form part of PTL dissipate any substantial power?
No because only one will be conducting for any DAC output

Single transistor used at each marked intersection to for PTL AND gates
R-String DAC

\[ X_{\text{IN}} \]

\[ n = n_1:n_2 \]

\[ V_{\text{RFF}} \]

\[ V_{\text{OUT}} \]
Sometimes termed sub-divider, sub-range or dual-string DAC
R-String DAC

\[ X_{IN} \]

\[
\text{n} = n_1 : n_2
\]

\[ V_{RFF} \]

\[ V_{OUT} \]
R-String DAC

$X_{IN}$

$V_{RFF}$

$n = n_1:n_2$

$V_{OUT}$

Interpolator
R-String DAC

\[ X_{IN} \]

\[ n = n_1 : n_2 \]

\[ V_{RFF} \]

\[ I_{INT} \]

\[ V_{DD} \]

\[ I_{INT} \]

\[ V_{OUT} \]

Interpolator
End of Lecture 33