Chap 13 (D/A & A/D Conversions)

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Using Resistor Networks for D/A Conversion

When all high, $V_{OUT} = 15V$
Using Resistor Networks for D/A Conversion

If all switches were high!
Using Resistor Networks for D/A Conversion

If all switches were low!

15V

- $R_1 = 8K\Omega$
- $R_2 = 4K\Omega$
- $R_3 = 2K\Omega$
- $R_4 = 1K\Omega$

$V_{OUT} = 0\%$
Using Resistor Networks for D/A Conversion

We obtain 15V at the output because all of the resistors are in parallel with each other.

All high = parallel circuit
All low = parallel circuit
Any combination in between = series-parallel circuit
Using Resistor Networks for D/A Conversion

\[ 1010_2 = 10_{10} = 10V \]
Series-Parallel Circuit Equivalent for the previous slide example

\( V_{\text{OUT}} = 10V \)

\[
\begin{align*}
R_2,4 &= 0.8\, \text{K}\Omega \\
R_{1,3} &= 1.6\, \text{K}\Omega \\
R_T &= 2.4\, \text{K}\Omega \\
R_4 &= 1\, \text{K}\Omega \\
R_2 &= 4\, \text{K}\Omega \\
R_3 &= 2\, \text{K}\Omega \\
R_1 &= 8\, \text{K}\Omega \\
\end{align*}
\]

\[.66 \times 15V = 10V \]

\[10V = 1010_2\]
Using Resistor Networks for D/A Conversion

\[ +15V \]

\[ V_{OUT} \]

\[ 0010_2 = 2_{10} = 2V \]

\[ R_1 = 8\,\text{K}\Omega \]
\[ R_2 = 4\,\text{K}\Omega \]
\[ R_3 = 2\,\text{K}\Omega \]
\[ R_4 = 1\,\text{K}\Omega \]

Red = e- flow path

MSB
\[ 2^3 = 0 \]

LSB
\[ 2^0 = 0 \]

\[ 2^2 = 0 \]
\[ 2^1 = 1 \]
Series-Parallel Circuit Equivalent for the previous slide example

\( V_{\text{OUT}} = 2V \)

\( R_1 = 8K\Omega \)
\( R_2 = 4K\Omega \)
\( R_3 = 2K\Omega \)
\( R_4 = 1K\Omega \)

\( R_2 = 4000\Omega \)
\( R_{1,3,4} = 615\Omega \)
\( R_T = 4615\Omega \)

\( .1333 \times 15V = 2V \)
\( 2V = 0010_2 \)
Using Resistor Networks for D/A Conversion

• Now --- just replace the switches with gate logic and 😊

Thus D/A Conversion………………
A/D Conversions (Using an OpAmp)

• Using an LM324 Quad OpAmp IC as a Comparator

https://www.youtube.com/watch?v=y0Q0ERSP24A
A/D Conversions
(OpAmps vs. Comparators)

- “So the op-amp looks like the perfect device to use as a comparator. But why then do there exist special-purpose comparator devices?
- Looked at from the outside, op-amps and comparators appear indistinguishable. Besides power connections, they both have “+” and “−” inputs and a single output.
- Taking a look at the internal circuit diagram, again the two devices appear broadly very similar (although a comparator device with an open-collector or open-drain output does look more obviously different from an op-amp).
- The big difference, which is not apparent without looking at the circuit more closely, is that the output stages of operational amplifiers are designed for linear operation…”

  - Propagation times are better with Comparators
  - Rail to Rail Voltage is possible with Comparators

LM324 vs. LM339

LM324 OpAmp

LM339 Comparator
A/D Conversions (Comparators)

• The goal here is to get a binary number from an analog value input.
• We use comparators (LM 339 ICs) to accomplish this.
• Figure 13-10
  • Each Comparator has a different voltage value placed on the – input due to the voltage divider (1-7V)
  • As $V_{IN}$ increases, more comparators are triggered on as the + inputs will become > the – inputs.
  • The Comparator’s outputs are then routed through logic and then decoded to obtain a binary number between $000_2$ and $111_2$.

https://www.youtube.com/watch?v=_2sFiEXRga4