Connecting with Analog Devices

- Most real world information is analog.
- speed, weight, pressure, light intensity, and position measurements are all analog in nature.
- The following shows digital system with analog input and analog output.

• The analog input voltage could be produced by a transducer.
• A transducer is defined as a device that converts one form of energy to another.
  - for instance, a photocell could be used as an input transducer to give a voltage proportional to light intensity.
  - light energy is being converted into electrical energy by the photocell.
• Another transducers might include microphones, speakers, temperatures…
FIGURE 10.3 Output waveforms of D/A converter as inputs are provided by a binary counter.
15–5 INTEGRATED-CIRCUIT DIGITAL-TO-ANALOG CONVERTERS

One very popular and inexpensive 8-bit D/A converter (DAC) is the DAC0808 and its equivalent, the MC1408. A block diagram, pin configuration, and typical application are shown in Figure 15–8. The circuit in Figure 15–8c is set up to accept an 8-bit

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(a) Current switches

(b) Top view

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MSB

A_1 1 2 3 4 5 6 7 8 9 10 11 12

LSB

I_0

V_{ref} (+)

V_{ref} (-)

V_EE

V_{CC}

NC

Gnd

16 Compren.

15 V_{ref} (-)

14 V_{ref} (+)

13 V_{CC}

12 A_8 (LSB)

11 A_7

10 A_6

9 A_5

A_4 8

A_3 7

A_2 6

A_1 5

NPN current source pair

Reference current amplifier

R-2R ladder

Bias current

Top view

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<th>D1</th>
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**Figure 15-6** Analog output versus digital input for Figure 15-5.
• **RESOLUTION**
  • Resolution of D/A converter is defined as the smallest change that can occur in the analog output as a result of a change in the digital input.
  • \( \% \text{resolution} = \frac{\text{step-size}}{\text{full scale (FS)}} \times 100\% \)
  • reciprocal of the number of discrete steps in D/A output
  • for instance 4-bit D/A converter, has 15 discrete steps (number of step)
  • the resolution is \( \frac{1}{2^4 - 1} \times 100 = 6.67\% \)
  • general formula \( \text{resolution} = \frac{1}{2^n - 1} \times 100 \) where \( n \) is the number of bits.
  • and total number of steps is \( 2^n - 1 \)
• **EXAMPLE:**
  1. Determine the resolution of (a) an eight-bit and (b) a twelve-bit D/A converter in terms of percentage.
     a) \___________________\% \hspace{1cm} b)\___________________\%
  2. A 5-bit D/A converter produces \( V_{out}=0.2v \) for a digital input of 00001. Find the value of \( V_{out} \) for a 11111 input.
     \( V_{out} = \______________ \) V
• Example

3. A 10-bit D/A converter has a step-size of 10 mV. Determine the full scale (FS) output voltage and the percentage resolution.

\[ v_{\text{out (FS)}} = \text{___________ volt} \quad \% \text{ resolution} = \text{___________\%} \]
Figure 15–8  The MC1408 D/A converter: (a) block diagram; (b) pin configuration; (c) typical application.
Figure 15–9  Test circuit for a DAC application.
Figure 15–12  Counter-ramp A/D converter.
ADC804 IC Pin Layout
Fig. 13-18  Wiring diagram for a test circuit using the ADC0804 CMOS A/D converter IC.