Introduction to Analog Interfacing

• Most embedded systems include components that measure and/or control real-world parameters.
• These include position, speed, temperature, etc.
• Usually exist in a continuous, or analog, form.
• Often need to amplify, filter, and convert these signals to digital form.
• This chapter develops analog circuit building blocks for data acquisition and control systems.

Resistors

(See Table 11.1)

Capacitors

(See Table 11.2)
DC Supply Filters and Bypass Capacitors

(See Figures 11.1 and 11.2)

Transistor Models

(See Figures 11.3, 11.4, and 11.5)

Ideal Op Amps

(See Figure 11.6)

1. Voltage ranges are bounded by the supply voltages.
2. Input currents are zero.
3. Negative feedback drives $V_z$ to equal $V_y$.
4. Positive feedback or no feedback drives $V_{out}$ to equal $-V_s$ or $+V_s$.

Input Impedance

(See Figures 11.7 and 11.8, and Table 11.4)
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Output Impedance

(See Figure 11.9)

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Offset Voltage and Current

(See Figure 11.10 and Table 11.5)

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Eliminating Offset Voltage and Current

(See Figure 11.11)

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Bias Current

(See Figures 11.12 and 11.13, and Table 11.6)
Noise Voltage and Current
(See Figure 11.14 and Table 11.7)

Affect of Load on Frequency Response
(See Figure 11.17)

Frequency Response
(See Figures 11.15 and 11.16, and Table 11.8)

Step Response
(See Figure 11.18)
Types of Op Amps

(See Table 11.9)

Saturation Properties

(See Figures 11.19 and 11.20)

A Voltage Comparator

(See Figure 11.21)

Simple Rules for Linear Op Amp Circuits

- Choose quality components.
- Negative feedback required to create linear mode circuit.

(See Figure 11.22)

- Assume no current flows into the op amp inputs
- Assume negative feedback equalizes input voltages.
- Choose resistor values in the 1kΩ to 1MΩ range.
- BW depends on the gain and the op amp performance.
Simple Rules for Linear Op Amp Circuits (cont)

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- Equalize the effective resistance to ground at the two op amp input terminals.
- Input impedance is input voltage / input current.

(See Figures 11.23 and 11.24)

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Simple Rules for Linear Op Amp Circuits (cont)

- Match input impedances to improve common-mode rejection ratio (CMRR).

(See Figures 11.25 and 11.26)

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Inverting Amplifier

(See Figures 11.27 and 11.28)

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Determining Short-Circuit Current

(See Figure 11.29)
Noninverting Amplifier
(See Figures 11.30 and 11.31)

Buffer Amplifier or Voltage Follower
(See Figures 11.33 and 11.34)

Determining Short-Circuit Current
(See Figure 11.32)

Inverting Adder Amplifier
(See Figure 11.35)
Differential Analog Amplifier

(See Figure 11.36)

Multiple-Stage Amplifier

\[ f_T = \frac{1}{\sqrt{(\frac{1}{f_1})^2 + (\frac{1}{f_2})^2 + \cdots + (\frac{1}{f_N})^2}} \]

(See Figure 11.39)

Instrumentation Amplifier

(See Figures 11.37 and 11.38)

Offset Adding Op Amp Circuit

(See Figures 11.40 and 11.41)
High-Gain Op Amp Circuit (See Figures 11.42 and 11.43)

Current-to-Voltage Circuit (See Figure 11.44)

Voltage-to-Current Circuit (See Figure 11.45)

Integrator Circuit (See Figure 11.46)
Derivative Circuit

(See Figure 11.47)

Voltage Comparators with Hysteresis

(See Figures 11.48 and 11.49)

Voltage Comparators with Hysteresis (cont)

(See Figures 11.50 and 11.51)