data acquisition

read …

Fraden Chapter 5,
Interface Electronic Circuits
for some additional details and an alternative perspective to mine

topics ...

- data acquisition
  - sensor-to-signal interface
    - *usually* means convert some interesting environmental parameter to a signal voltage
  - “signal conditioning”
  - convert analog signal to digital format (ADC)
  - communicate signal to computer

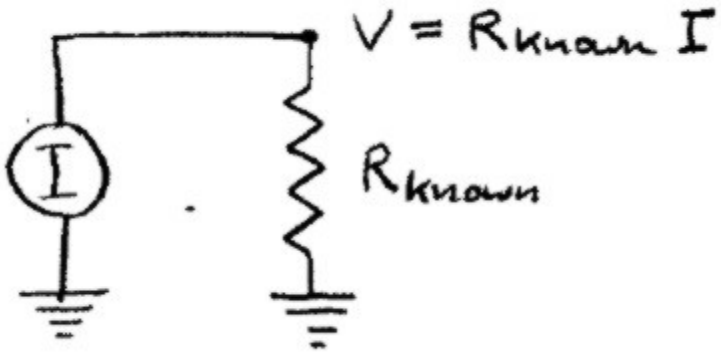
data acquisition (& control)

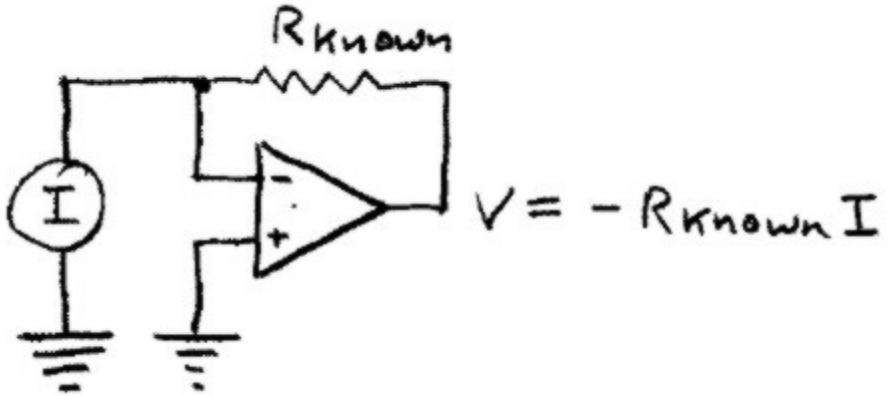
sensor-to-signal interface

- action of environment on sensor causes it to generate an electrical signal directly
  - voltage source (V)
  - current (I) or charge (Q) source
- action of environment on sensor changes an electrical parameter that we can measure
  - resistance changes: $V \sim I$
  - capacitance changes: $V \sim \int I\,dt$, $I \sim dV/dt$
  - inductance changes: $V \sim dI/dt$, $I \sim \int V\,dt$

example: current-to-voltage conversion

- simple: $I = V_{measured} / R_{known}$
- better: use an “op amp”





signal conditioning

- filter for expected frequency regime
- subtract DC offset (“zeroing”)
- amplify or attenuate signal (“scaling”)
- linearize relationship between measurand and observed electrical parameter
  - now *usually* done in software after ADC
- etc ...

example: AD594/595

thermocouples Table I should not be used in conjunction with European standard thermocouples. Instead the transfer function given previously and a DIN thermocouple table should be used. ANSI type K and DIN NiCr-Ni thermocouples are composed

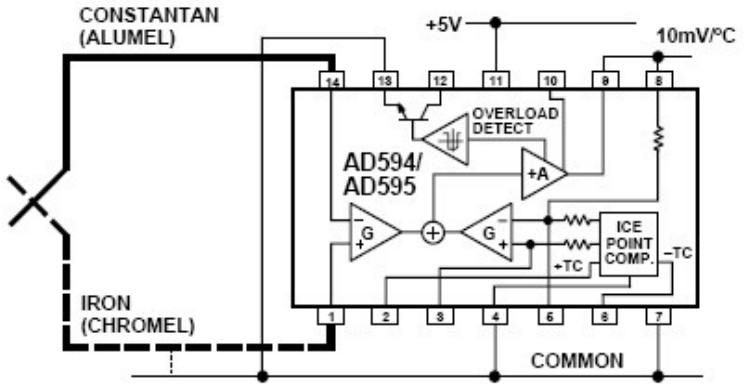


Figure 1. Basic Connection, Single Supply Operation

of identical alloys and exhibit similar behavior. The upper temperature limits in Table I are those recommended for type J and type K thermocouples by the majority of vendors.

SINGLE AND DUAL SUPPLY CONNECTIONS

The AD594/AD595 is a completely self-contained thermocouple conditioner. Using a single +5 V supply the interconnections shown in Figure 1 will provide a direct output from a type J thermocouple (AD594) or type K thermocouple (AD595) measuring from 0°C to +300°C.

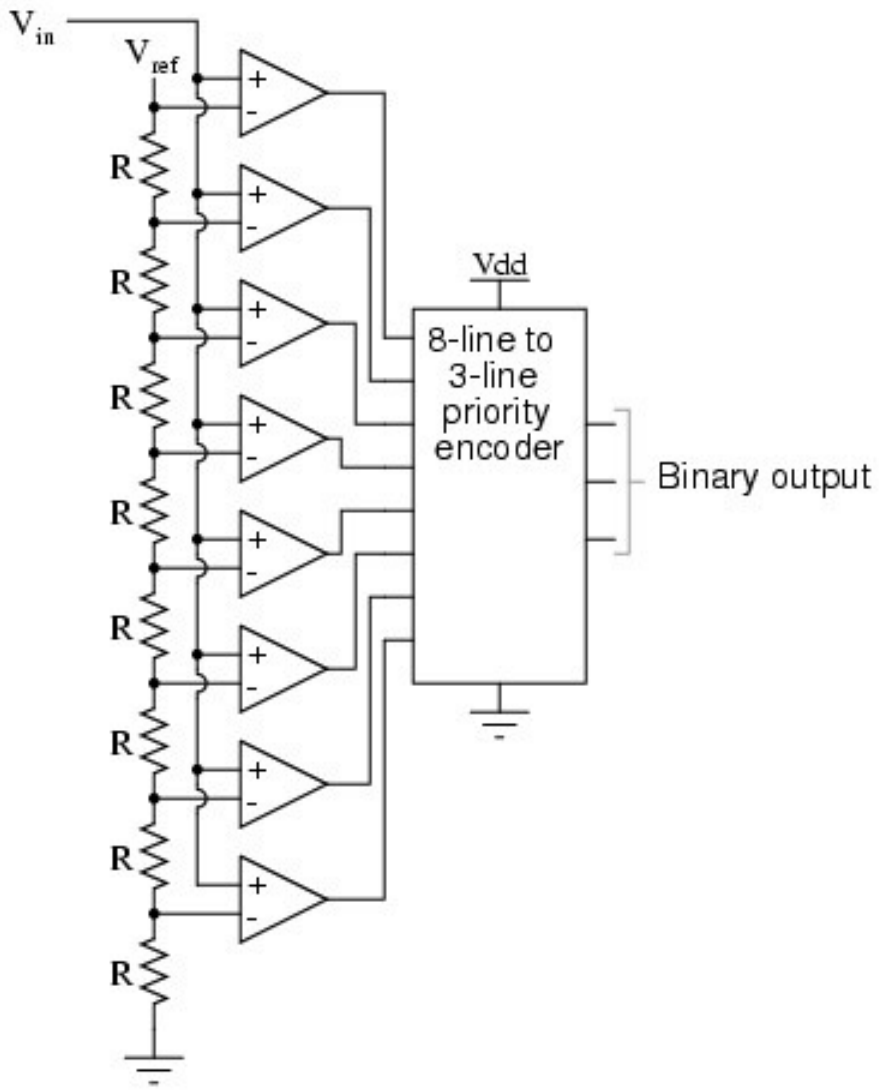
Any convenient supply voltage from +5 V to +30 V may be used, with self-heating errors being minimized at lower supply levels. In the single supply configuration the +5 V supply connects to Pin 11 with the V– connection at Pin 7 strapped to power and signal common at Pin 4. The thermocouple wire inputs connect to Pins 1 and 14 either directly from the measuring point or through intervening connections of similar thermocouple wire type. When the alarm output at Pin 13 is not used it should be connected to common or –V. The precalibrated feedback network at Pin 8 is tied to the output at Pin 9 to provide a 10 mV/°C nominal temperature transfer characteristic.

By using a wider ranging dual supply, as shown in Figure 2, the AD594/AD595 can be interfaced to thermocouples measuring both negative and extended positive temperatures.

analog-to-digital converter (ADC)

- many different principles
- often integrated with microcontrollers
  - in some types, e.g., “successive approximation”, the CPU to participates in the conversion
    - guess what the digital output should be
    - feed it to a digital-to-analog converter
    - compare analog input & output and iterate
- all involve trade-offs of speed (conversion time), resolution (number of bits), and cost
- “flash converter” is fastest, lowest resolution, highest cost: required for video digitization

flash converter (video applications)



Σ-Δ converter ("one-bit" audio)

ANALOG DEVICES

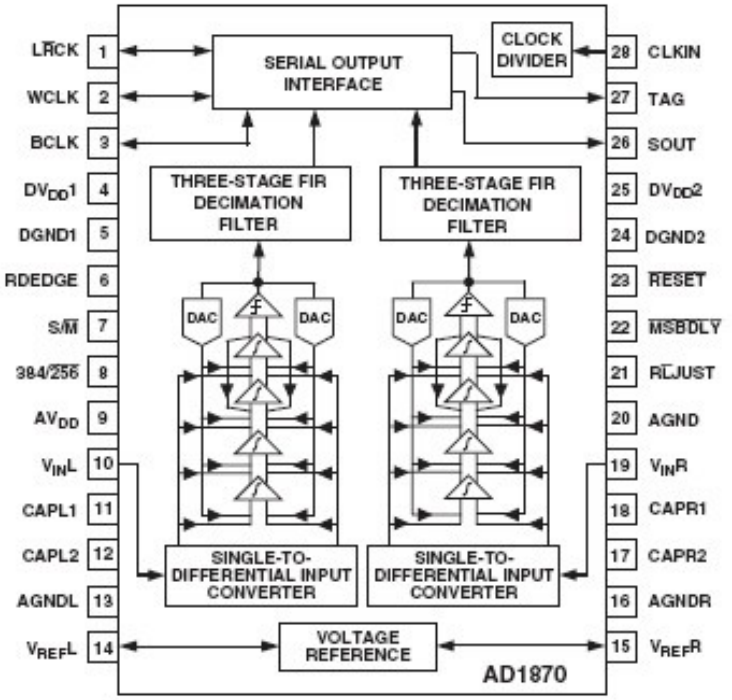
Single-Supply 16-Bit Σ-Δ Stereo ADC

AD1870*

FEATURES
Single 5 V Power Supply
Single-Ended Dual-Channel Analog Inputs
92 dB (Typ) Dynamic Range
90 dB (Typ) S/(THD + N)
0.006 dB Decimator Pass-Band Ripple
Fourth Order, 64× Oversampling Σ-Δ Modulator
Three-Stage, Linear-Phase Decimator
256 × f_S or 384 × f_S Input Clock
Less than 100 μW (Typ) Power-Down Mode
Input Overrange Indication
On-Chip Voltage Reference
Flexible Serial Output Interface
28-Lead SOIC Package

APPLICATIONS
Consumer Digital Audio Receivers
Digital Audio Recorders, Including Portables
CD-R, DCC, MD, and DAT
Multimedia and Consumer Electronics Equipment
Sampling Music Synthesizers

FUNCTIONAL BLOCK DIAGRAM

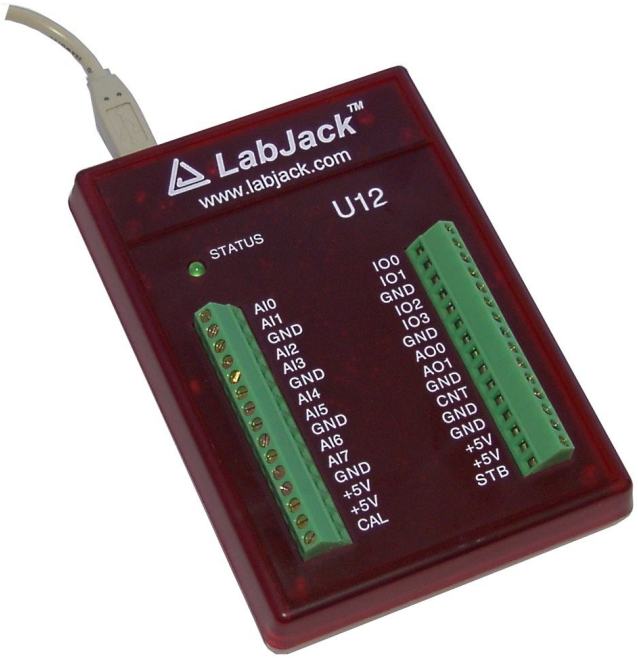


PRODUCT OVERVIEW
The AD1870 is a stereo, 16-bit oversampling ADC based on

communication with computer

- dedicated: DAQ/C (data acquisition & control) system with embedded processors
- tightly integrated: card resides in PC slot
  - a little less tight: bus extender “boxes”
- “box” connected to parallel/serial/USB port
  - or just a “dongle” plugged into the port
- IEEE-4888 instrumentation bus: parallel address, control, and data lines
- networked: instrument assigned IP address

example: USB DAQ/C for $129



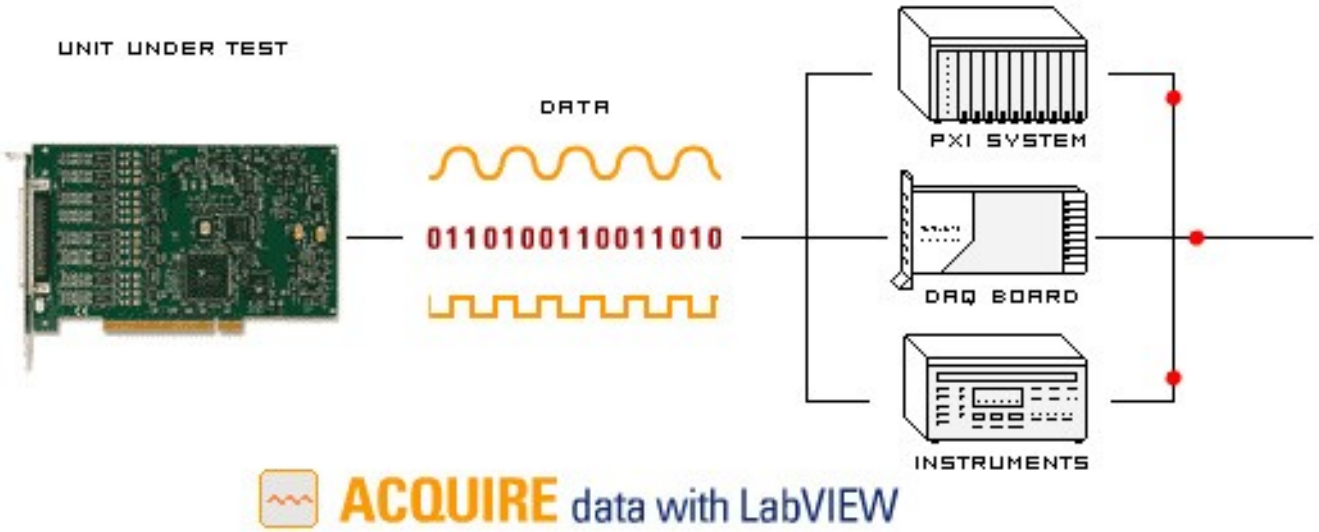
- 8 Single-Ended, 4 Differential 12-Bit Analog Inputs
- ±10 Volt Analog Input Range
- PGA with Gains of 1, 2, 4, 5, 8, 10, 16, or 20 V/V
- Up to 8 kSamples/Sec (Burst) or 1.2 kSamples/Second (Stream)
- Supports Software or Hardware Timed Acquisition
- 2 Analog Outputs
- 20 Digital I/O (Up to 50 Hz per I/O)
- 32-Bit Counter
- Watchdog Timer Function
- USB 2.0/1.1 Low Speed Interface (Data Rate Information)
- Connect Up to 80 LabJacks to One USB Host
- Complete Software Control, No Jumpers or Switches
- No Power Supply Needed
- Includes Licensed Copy of DAQFactory Express Software (Win2000/XP)
- Includes Sample Applications and Drivers
- Includes LabVIEW VIs
- Works with Windows 98SE, ME, 2000, or XP
- Includes Cable and Screwdriver
- Money Back Guarantee
- Approximately 4" x 6" x 1"
- Rated for Industrial Temperature Range
- OEM Board-Only Versions Available
- Complete specifications in Appendix A of User's Guide

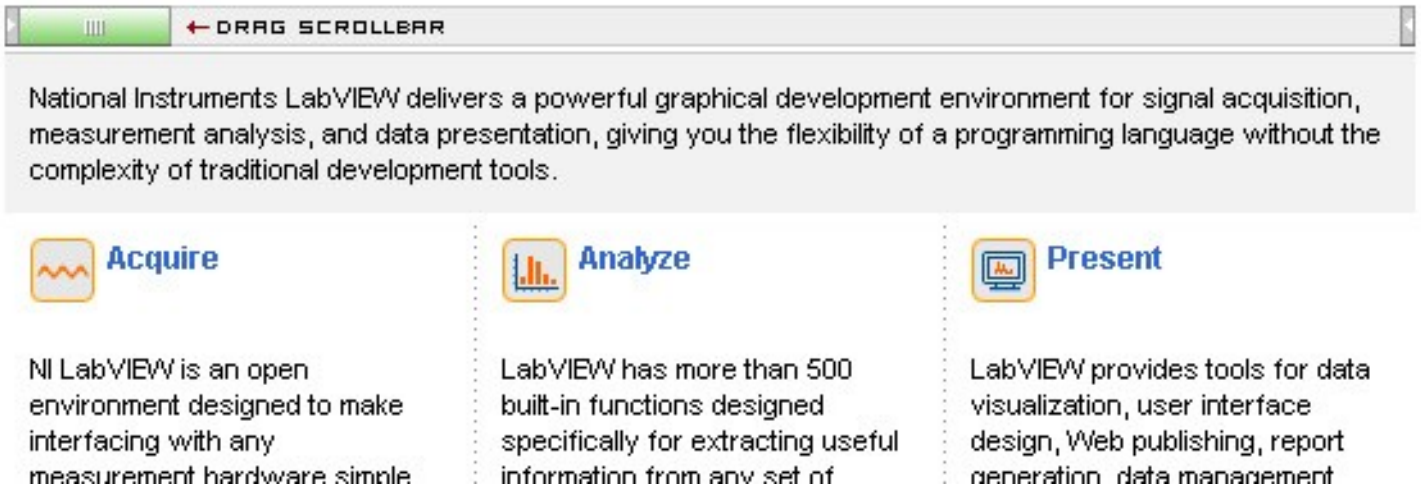
data acquisition

DAQ/C software

- low level:
  - software “pokes” setup into input registers
  - software “peeks” data stashed in output registers
- high level:
  - set-up and *acquire* data
  - set-up and provide system control signals
  - *analyze* data (Fourier transforms, statistics, etc)
  - interactive graphic visualization (“*presentation*”)
  - archiving data
  - formatting as required by target journal
  - etc

example: LabVIEW





assignment

(24) There are many articles on the statistics of the time differences between successive drops from a dripping faucet. Design a data acquisition & control system for this problem: identify suitable commercial hardware (and optionally software), and show the control program's logic. *Avoid hardware "overkill", i.e., features and ranges that you don't need, as these add expense and complexity.*

next topic … sensors!

- light sensors
- basic principles of image sensors