SENSORS/TRANSDUCER INTERFACING

CONTENTS

INTRODUCTION

- To be useful, systems must interact with their environment.
- To do this they use sensors and actuators
- Sensors and actuators are examples of **transducers**

A transducer is a device that converts one physical quantity into another

  - examples include:
    - a mercury-in-glass thermometer (converts temperature into displacement of a column of mercury)
    - a microphone (converts sound into an electrical signal).
    - A flow meter

CONTD..

- Almost any physical property of a material that changes in response to some excitation can be used to produce a sensor
  - widely used sensors include those that are:
    - resistive
    - inductive
    - capacitive
    - piezoelectric
    - photoresistive
    - elastic
    - thermal.

CLASSIFICATION

- Primary Transducer Types
  - Resistive Sensors (Potentiometers & Strain Gauges)
  - Inductive Sensors
  - Capacitive Sensors
  - Piezoelectric Sensors
- Secondary Transducers
  - Wheatstone Bridge
  - Amplifiers
  - LVDT

SENSOR PERFORMANCE

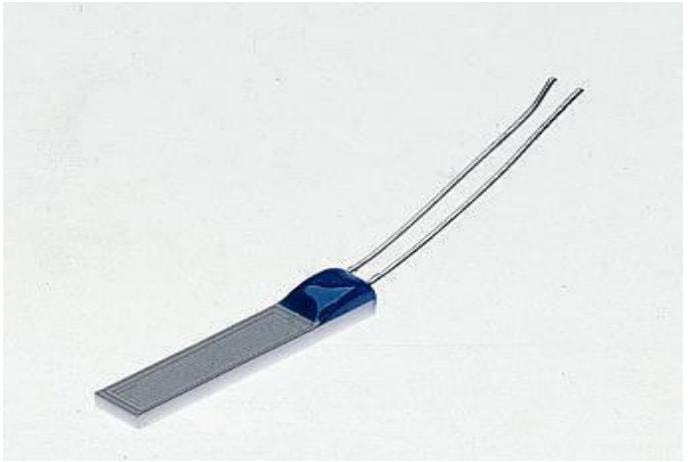
- **Range**
  - maximum and minimum values that can be measured
- **Resolution or discrimination**
  - smallest discernible change in the measured value
- **Error**
  - difference between the measured and actual values
    - random errors
    - systematic errors
- **Accuracy, inaccuracy, uncertainty**
  - accuracy is a measure of the maximum expected error

CONTD..

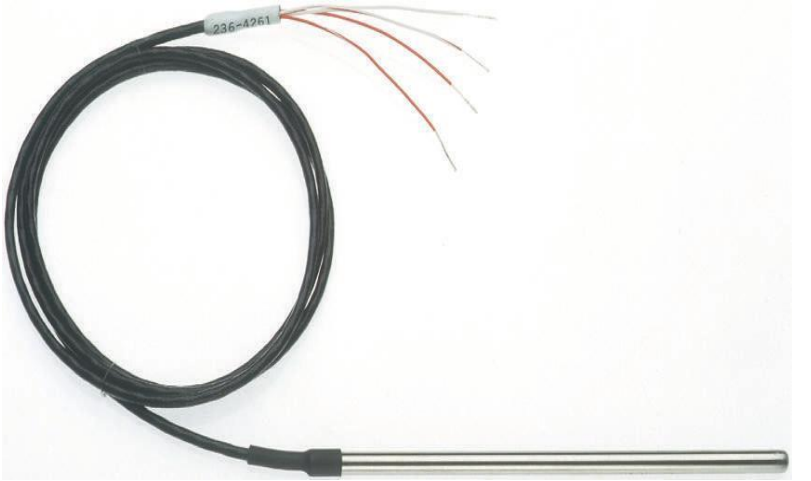
- **Linearity**
  - maximum deviation from a ‘straight-line’ response
  - normally expressed as a percentage of the full-scale value
- **Sensitivity**
  - a measure of the change produced at the output for a given change in the quantity being measured

TEMPERATURE SENSORS

- **Resistive thermometers**
  - typical devices use platinum wire (such a device is called a platinum resistance thermometers or PRT)
  - *linear* but has poor *sensitivity*



A typical PRT element



A sheathed PRT

THERMISTORS

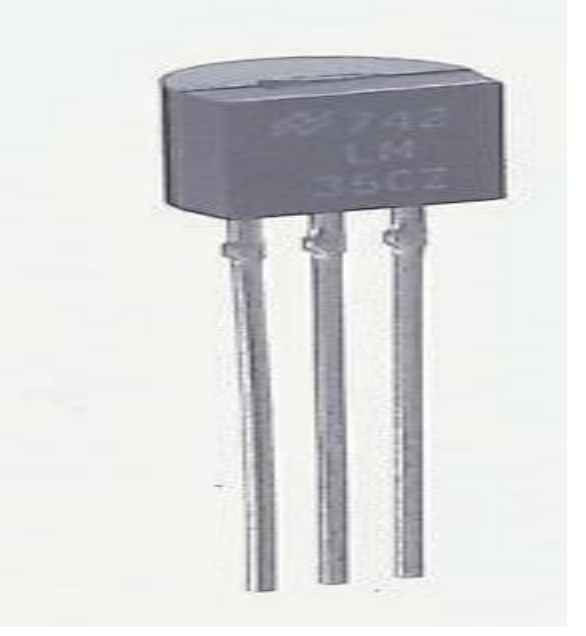
- use materials with a high thermal coefficient of resistance
- *sensitive* but highly *non-linear*

A typical disc thermistor

A threaded thermistor

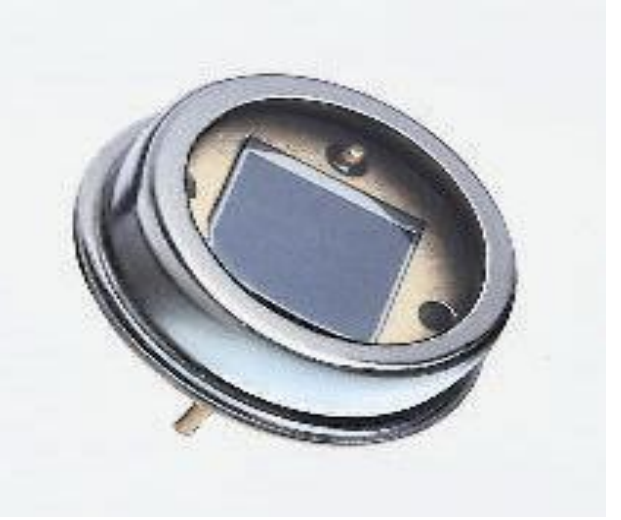
PN JUNCTIONS

- a semiconductor device with the properties of a diode
- *inexpensive*, *linear* and *easy to use*
- *limited temperature range* (perhaps -50°C to 150 °C) due to nature of semiconductor material



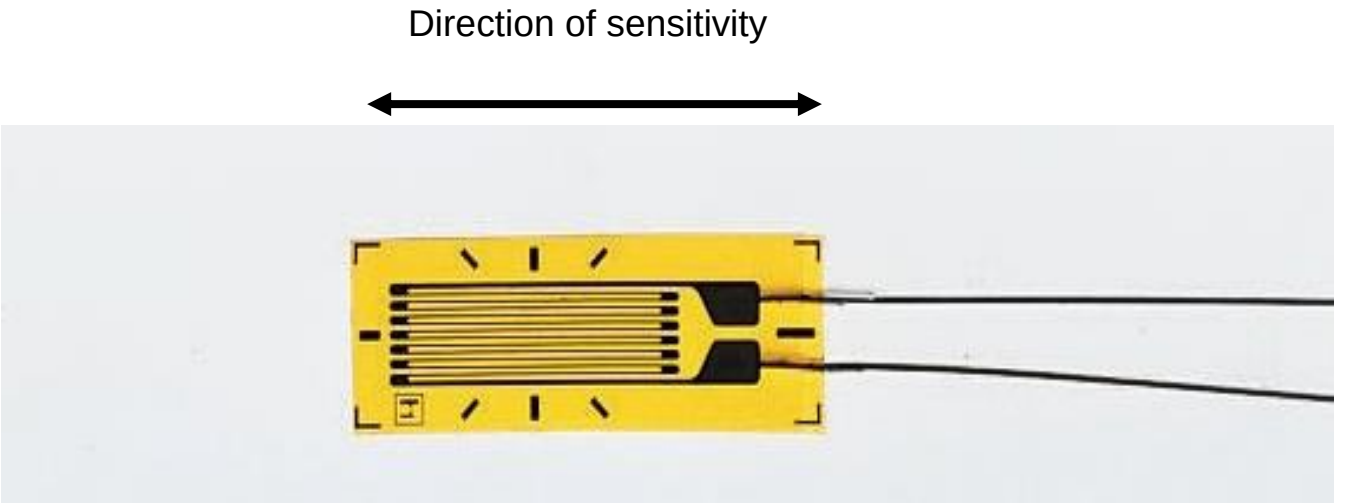
LIGHT SENSORS

- **Photovoltaic**
  - light falling on a *pn*-junction can be used to generate electricity from light energy (as in a solar cell)
  - small devices used as sensors are called **photodiodes**
  - fast acting, but the voltage produced is *not* linearly related to light intensity



FORCE SENSORS

- **Strain gauge**
  - stretching in one direction increases the resistance of the device, while stretching in the other direction has little effect
  - can be bonded to a surface to measure strain
  - used within load cells and pressure sensors



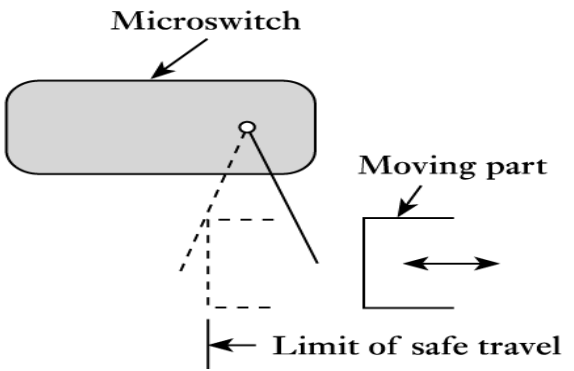
DISPLACEMENT SENSORS

- **Potentiometers**
  - resistive potentiometers are one of the most widely used forms of position sensor
  - can be angular or linear
  - consists of a length of resistive material with a sliding contact onto the resistive track
  - when used as a position transducer a potential is placed across the two end terminals, the voltage on the sliding contact is then proportional to its position
  - an inexpensive and easy to use sensor

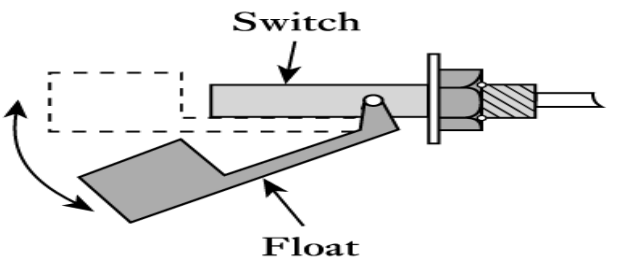
SWITCHES

simplest form of *digital* displacement sensor

- many forms: lever or push-rod operated microswitches; float switches; pressure switches; etc.



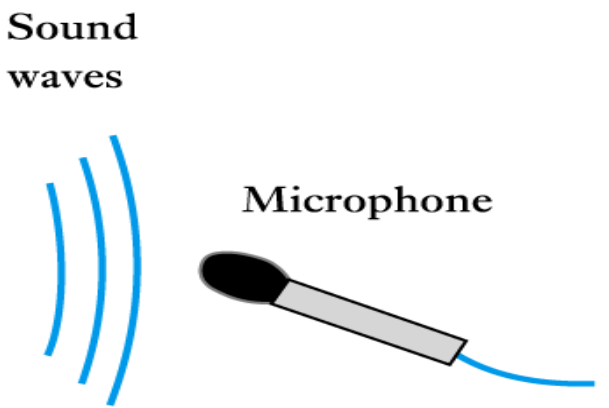
A limit switch

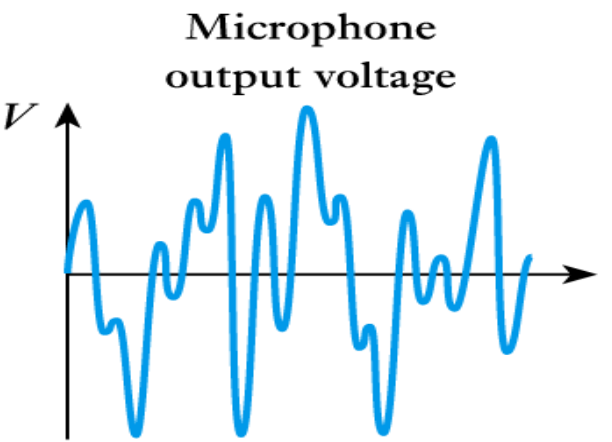


A float switch

SOUND SENSORS

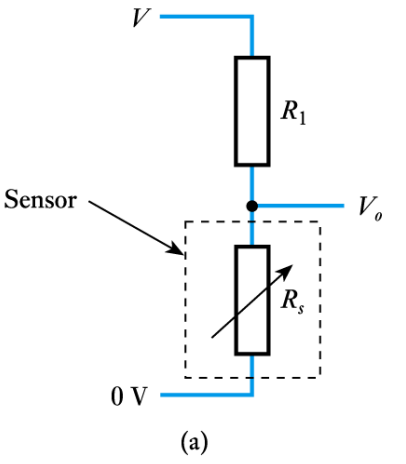
- **Microphones**
  - a number of forms are available
    - e.g. carbon (resistive), capacitive, piezoelectric and moving-coil microphones
    - moving-coil devices use a magnet and a coil attached to a diaphragm –





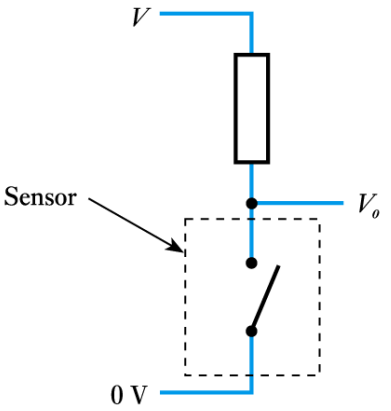
SENSOR INTERFACING

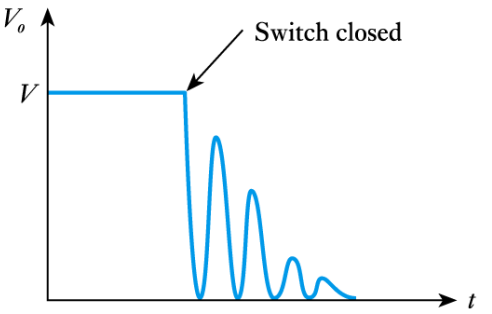
- **Resistive devices**
  - can be very simple
    - e.g. in a potentiometer, with a fixed voltage across the outer terminals, the voltage on the third is directly related to position
      - where the resistance of the device changes with the quantity being measured, this change can be converted into a voltage signal using a potential divider – as shown
      - the output of this arrangement is *not* linearly related to the change in resistance



SWITCHES

- **Switches**
  - switch interfacing is also simple
    - can use a single resistor as below to produce a voltage output
    - all mechanical switches suffer from **switch bounce**

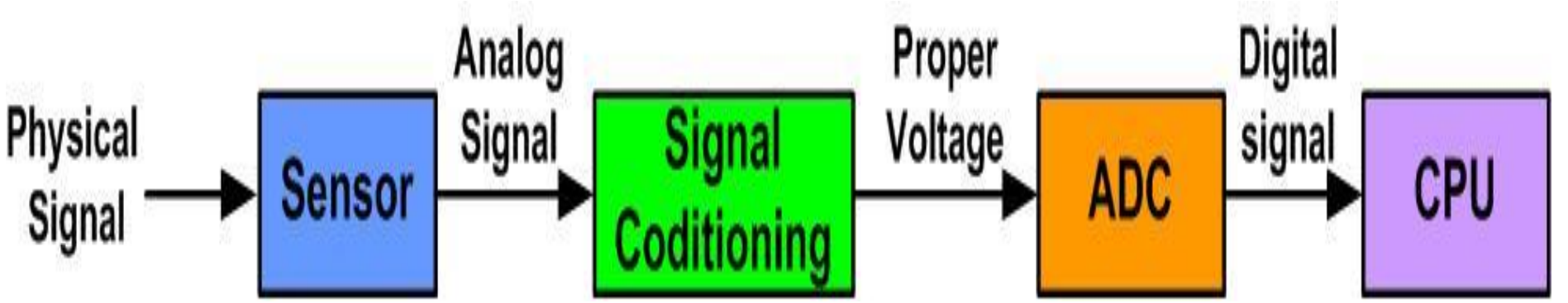


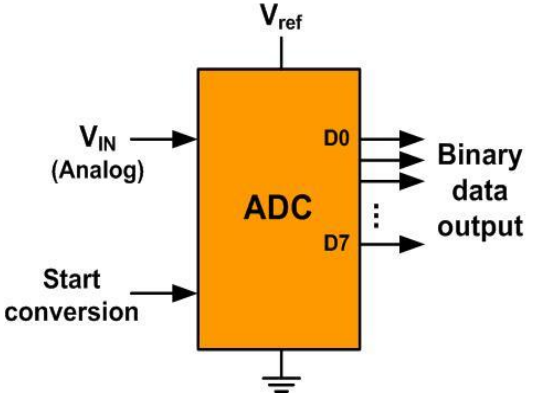


CAPACITIVE AND INDUCTIVE SENSORS

- sensors that change their capacitance or inductance in response to external influences normally require the use of alternating current (AC) circuitry
- such circuits need not be complicated

MICROCONTROLLER INTERFACING TO SENSOR VIA ADC

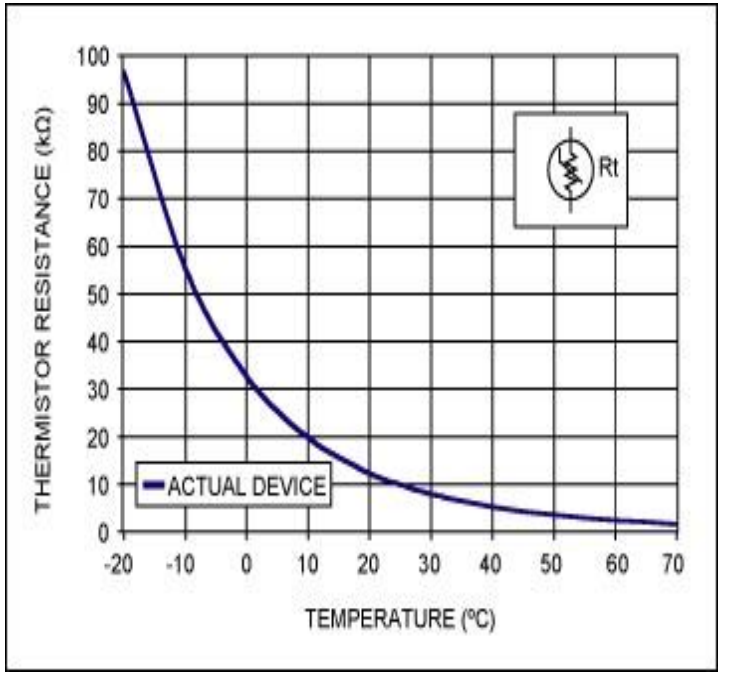


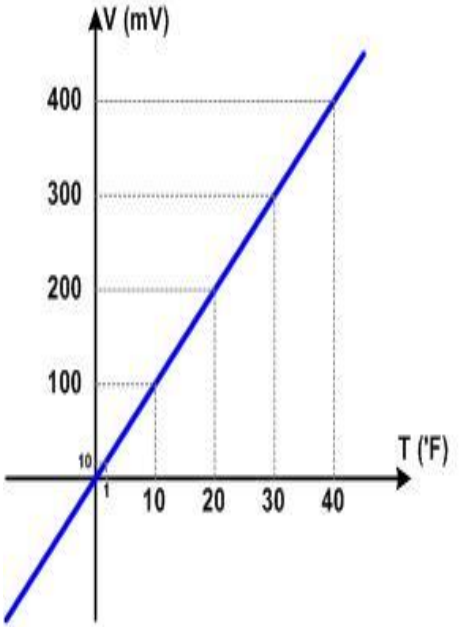


An 8-bit ADC Block Diagram

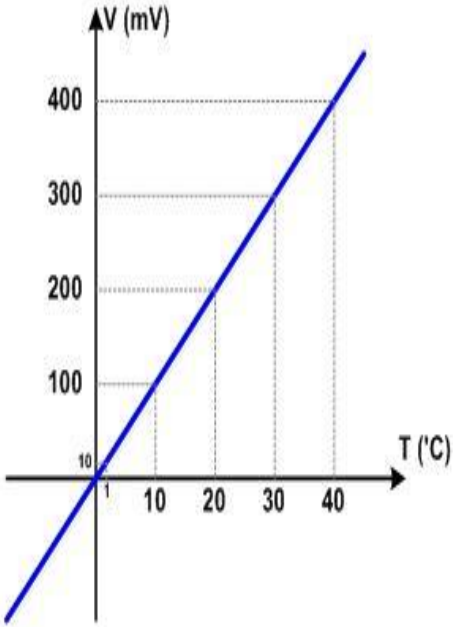
THERMISTOR

LM34 and LM35



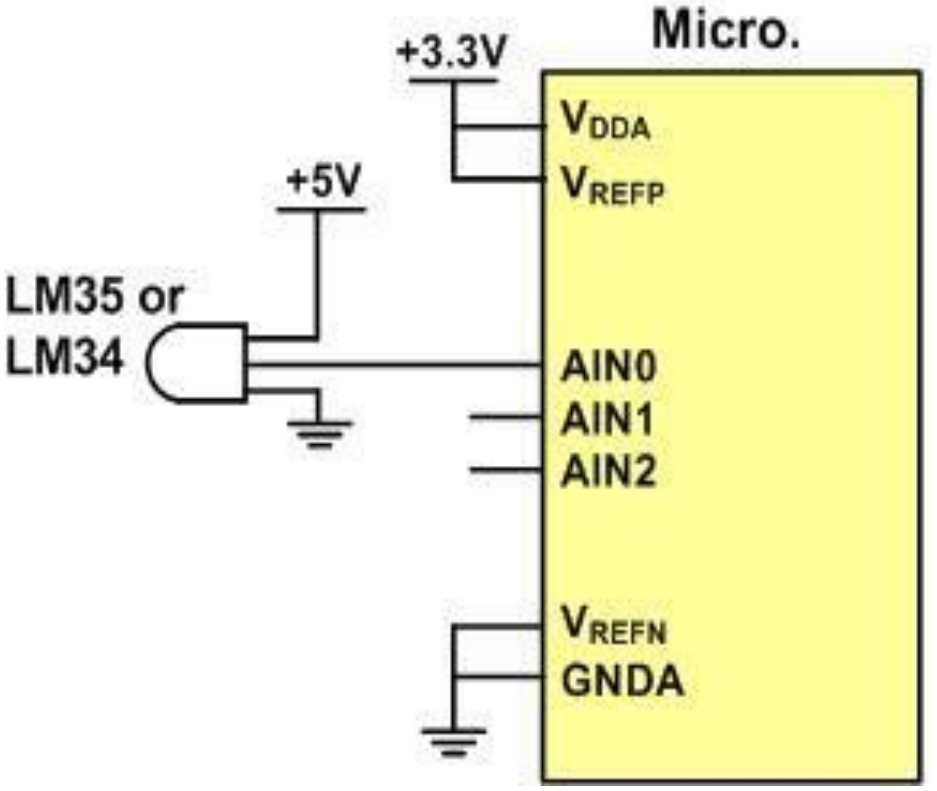


(a) LM34



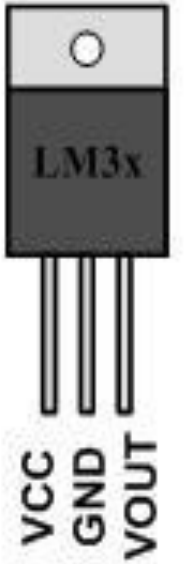
(b) LM35

LM34/35 CONNECTION TO MICROCONTROLLER AND ITS PIN CONFIGURATION



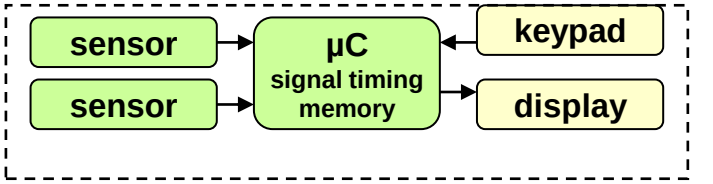
Bottom view
TO92 Package

Top view
TO220 Package



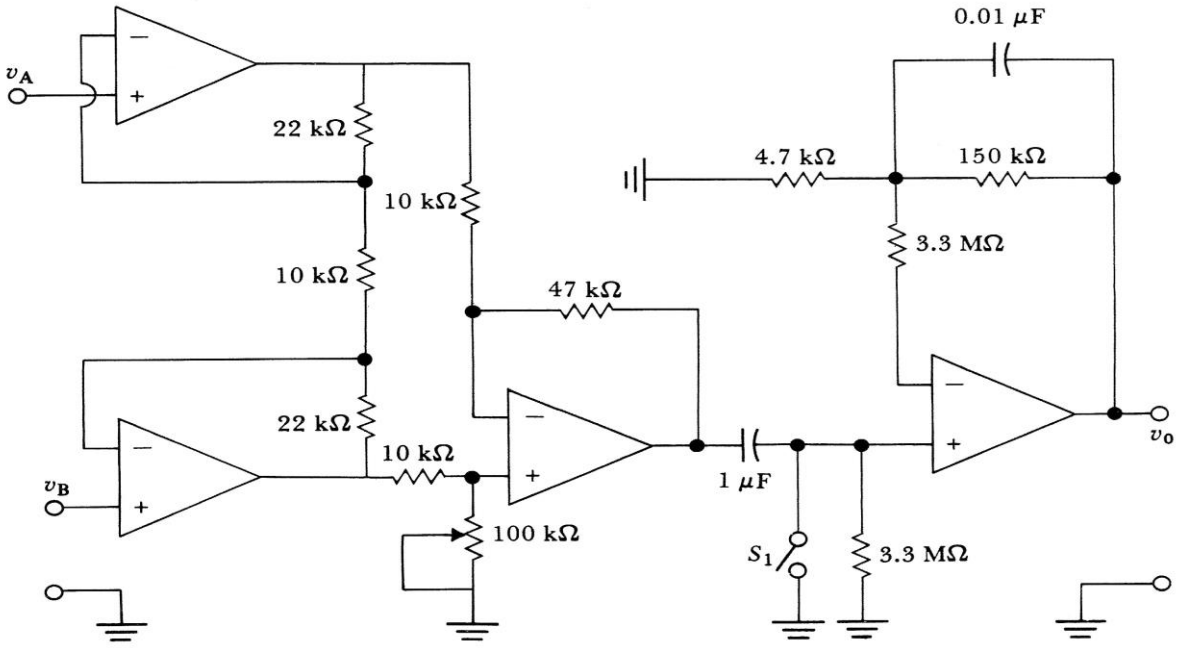
Connecting Sensors to Microcontrollers

- Analog
  - many microcontrollers have a built-in A/D
    - 8-bit to 12-bit common
    - many have multi-channel A/D inputs



- Digital
  - serial I/O
    - use serial I/O port, store in memory to analyze
    - synchronous (with clock)
      - must match byte format, stop/start bits, parity check, etc.
    - asynchronous (no clock): more common for comm. than data
      - must match baud rate and bit width, transmission protocol, etc.
  - frequency encoded
    - use timing port, measure pulse width or pulse frequency

INSTRUMENTATION AMPLIFIER WITH FILTER



instrumentation amplifier *Filter* *non-inverting amp*

Thanks