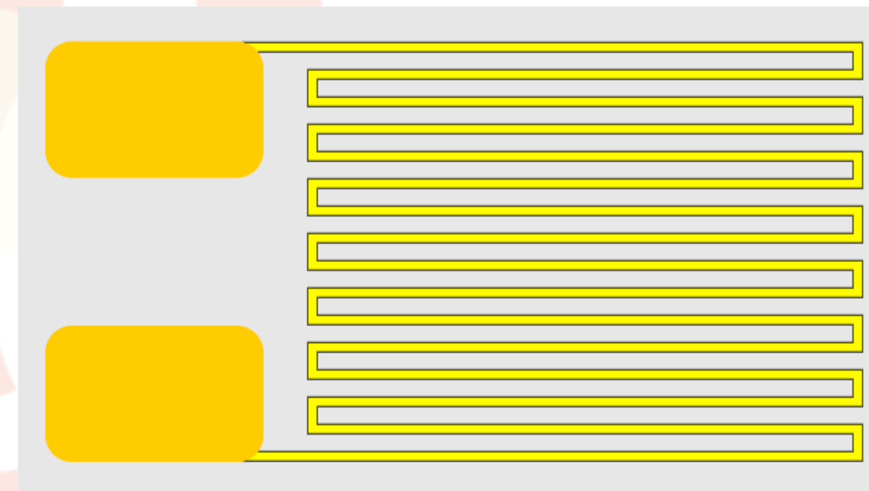
Stage 2 Mechatronics Lab

Strain Gauges



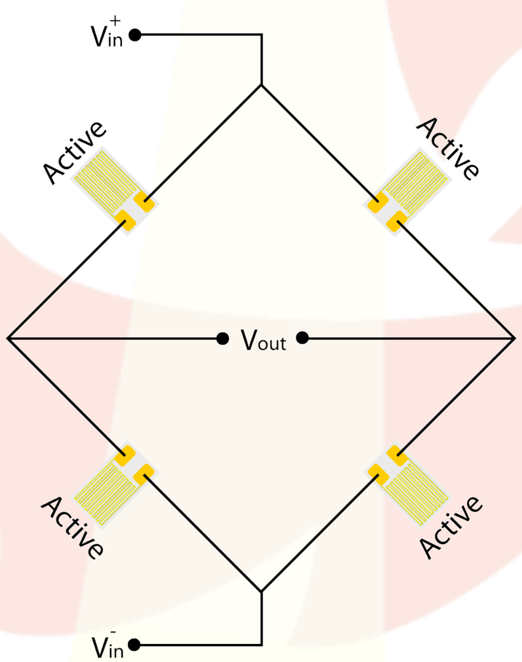
Strain gauges use wires or conducting foil which change resistance with length, and so by measuring the change in resistance the strain can be estimated.

The gauges are designed to be sensitive to strain changes in a particular direction. The gauge illustrated here would measure strain parallel to the *x*-axis.

The relationship between strain and resistance is:

$$\frac{\delta R}{R} = S\varepsilon$$

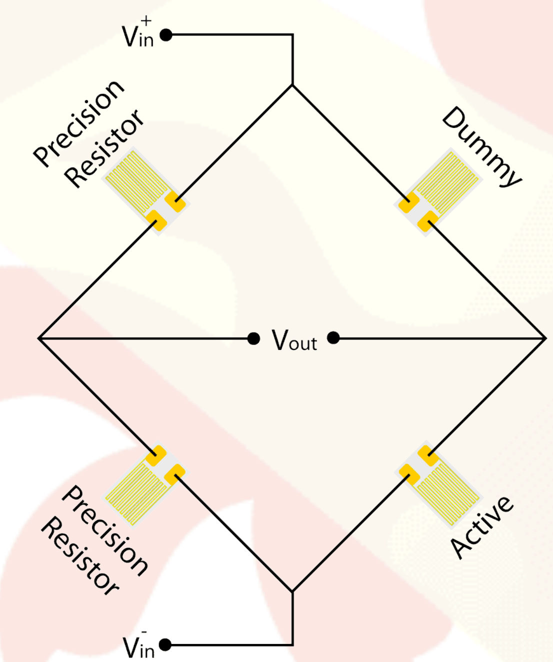
δR	Change in resistance
R	Resistance of unstrained gauge
S	Strain sensitivity factor, or 'gauge' factor
ε	Strain



Strain gauges are usually arranged in a Wheatstone Bridge to increase sensitivity.

Sometimes precision resistors are used in place of strain gauges.

Since strain gauges can be sensitive to temperature, an unstressed 'dummy' strain gauge is often used as a reference.



Strain Gauges

Parallel circuit, so voltage drop across each branch is the same, i.e.:

$$\text{Total Voltage} = V_{in}^{+} - V_{in}^{-}$$

The total resistance in each arm is the same:

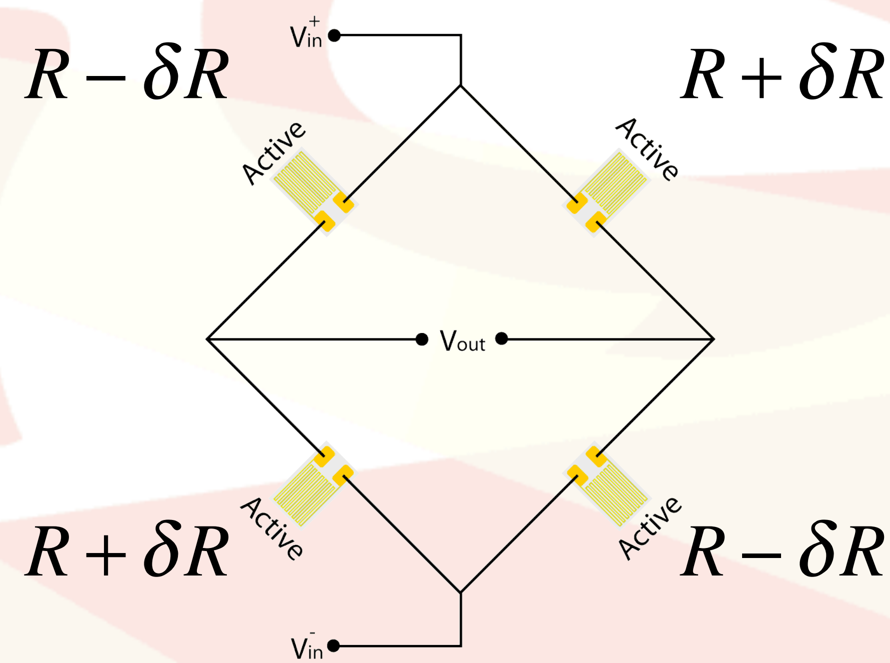
$$\text{Total Resistance} = (R + \delta R) + (R - \delta R) = 2R$$

So the current in each arm is:

$$\text{Current, } I = \frac{V_{in}^{+} - V_{in}^{-}}{2R}$$

The output voltage is the voltage difference:

$$V_{out} = \left(V_{in}^{+} - I(R - \delta R)\right) - \left(V_{in}^{+} - I(R + \delta R)\right)$$
$$= 2I\delta R$$
$$= \left(V_{in}^{+} - V_{in}^{-}\right)\frac{\delta R}{R}$$
$$= \left(V_{in}^{+} - V_{in}^{-}\right)S\varepsilon$$



Example: *A beam with two strain gauges on top, and two strain gauges underneath.*

δR Change in resistance
R Resistance of unstrained gauge
S Strain sensitivity factor, or 'gauge' factor
ε Strain

Strain Gauges

The output voltage can be +ve or -ve, depending on the strain:

$$V_{out} = \left(V_{in}^{+} - V_{in}^{-}\right) S\varepsilon$$

What do we do with it? Can we input it directly to a computer?

TEXAS INSTRUMENTS - ADS1211P. - 24BIT ADC, 1211, DIP24

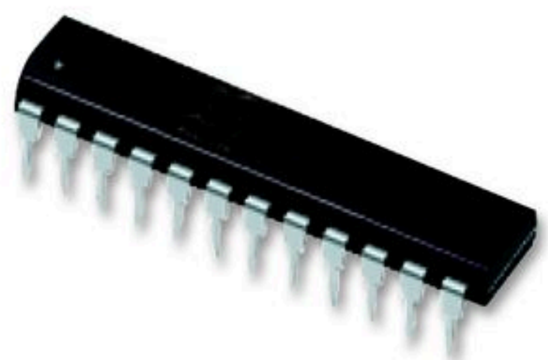


Image is for illustrative purposes only. Please refer to product description

Manufacturer: TEXAS INSTRUMENTS

Order Code: 1219430

Manufacturer Part No: ADS1211P.

RoHS : ● **Yes**

Description

- 24BIT ADC, 1211, DIP24
- Resolution (Bits):24bit
- Sample Rate:16kSPS
- Input Type:Differential
- Interface Type:Serial, 2 Wire
- Supply Current:3.5mA
- IC Case Style:DIP
- No. of Pins:24
- Operating Temperature Range:-40°C to +85°C
- SVHC:No SVHC (18-Jun-2010)
- Case Style:DIP
- A/D / D/A Features:CMOS, Internal Reference, Latches, Serial O/P
- Base Number:1211
- Conversion Time:1.2ms
- IC Generic Number:1211
- Linearity Error:0.003%
- Linearity Error ADC / DAC +:1LSB
- Linearity Error ADC / DAC -:1LSB
- Logic Function Number:1211
- Max Operating Temperature:85°C
- Max Power Dissipation Ptot:60mW
- Max Supply Voltage:5.25V
- Min Supply Voltage:4.75V
- Min Temperature Operating:-40°C
- No. of Bits:24
- No. of Channels:8
- Sampling Rate:16kSPS
- Termination Type:Through Hole

Price

Qty	List Price
1 - 9	£21.90
10 - 99	£17.41
100+	£15.47

Build your own circuit!

4/8 channels, one thousand samples (i.e., measurements) per second, 20-bit accuracy.

Of course, you need to do a lot more than just connect the ADC chip...

Or you could get the professionals to do the electronics. Take a look at this:

5

NI WLS-9237

Wireless Strain/Load/Torque Input: 4-Ch, 24-Bit, 50 kS/s/ch

Features | Specifications | Data Sheet

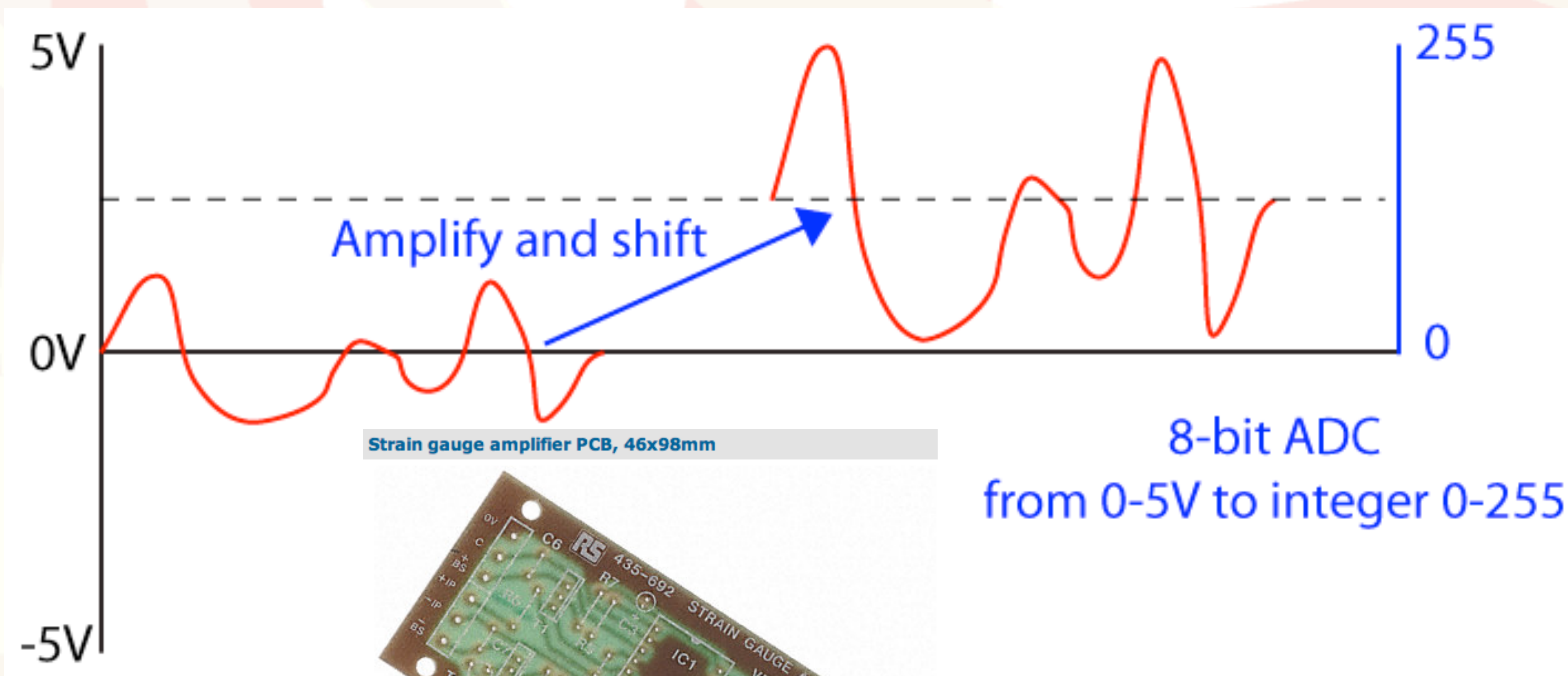
£ 1,249

(and you'll need a LabView license).

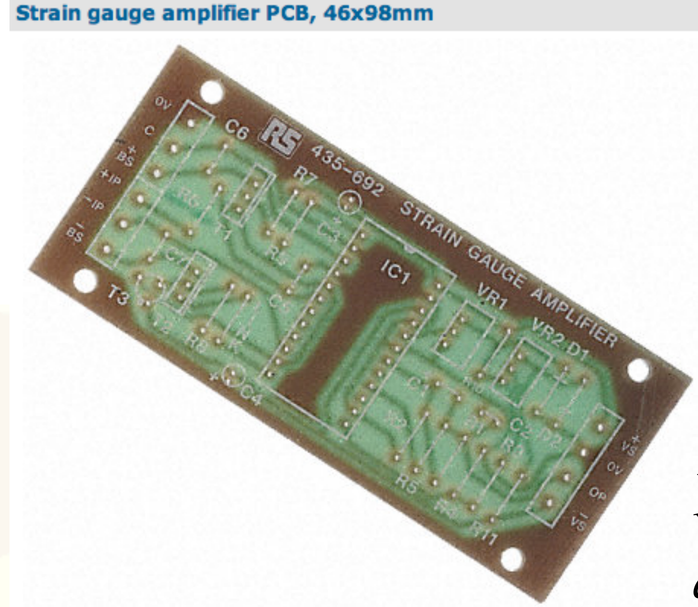
Analog Digital Converter (ADC)

An ADC takes a voltage input in a specified voltage range and converts it to a number in a corresponding range.

In general, digital electronic circuits don't look closely at the voltage, e.g., if the voltage is above 1V then the voltage is high and had digital value '1' (on); otherwise the voltage is low, with digital value '0' (off). This is like an ADC with 1-bit accuracy.



Strain gauge amplifier PCB, 46x98mm



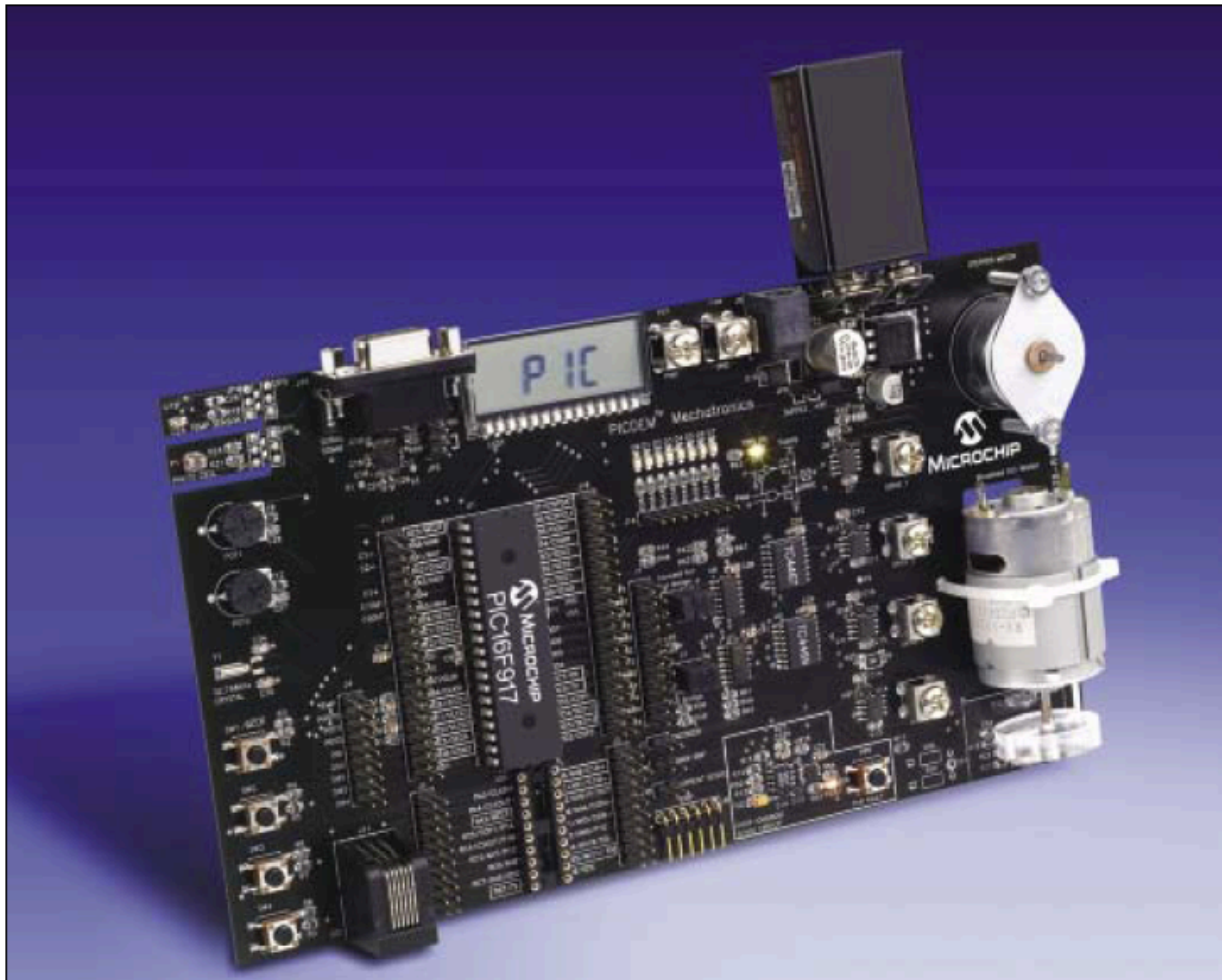
You may need to convert your signal to the correct voltage range. You can get specialised strain gauge amplifier circuit boards to help with this.

Analog Digital Converter (ADC)

So is this all about strain gauges?

No. It could be:

- accelerometers
- gyroscopes
- magnetometers
- potentiometers
- light sensors
- temperature sensors
- microphones



PICDEM Mechatronics Board

Pulse Width Modulation (PWM)

Okay, so the ADC converts a voltage into a number. Can we do it the other way round? Go from a number to a voltage?

Well, there is the Digital to Analog Convertor (DAC), but what exactly does this do?

In principle, instead of generating part of the (full) voltage all of the time, it has all of the (full) voltage part of the time...

For example, if voltage 'high' is 5V, then a 4V signal might be generated from a 1MHz (one million clock cycles per second) PWM by outputting voltage 'high' for 800 cycles out of every 1000.

This can then be smoothed out using a low-pass filter.