We have to get an input that has 5V for the high reference and 0V for the low reference level. Then, as we sample it discretely at points in time, we get a large range of numbers to work with and can therefore detect spikes and other sorts of changes in the waveform.

To condition a circuit is to range it, isolate it, buffer it, etc.

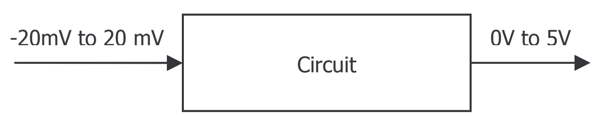
Heart rate signals, however, for example, do not fit in this range of 0V to 5V. If we're lucky, they might range between -10mV and 5mV. Every sample on the HC11 would yield the same number, thus rendering our ADC conversion useless.

Linear Ranging

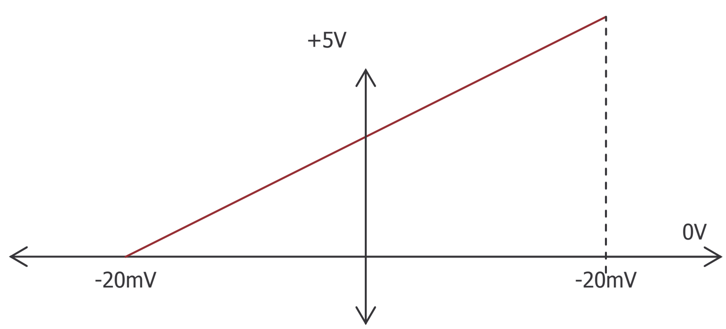
We want the signal to have the same shape but be several times larger so that we get a unique and different set of numbers when we sample it.

The basic behavior:

Taking a small signal, ranging it linearly so it sits between Vref low and Vref high.



A linear transformation is easily done graphically.



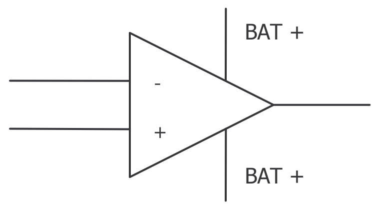
$$V_O = m \cdot V_{IN} + V_{OFFSET}$$
$$m = \frac{\Delta y}{\Delta x} = \frac{\Delta V_{OUT}}{\Delta V_{IN}} = \frac{5V - 0V}{20mV - -20mV} = \frac{5V}{40mV} = 125$$
$$b = V_{OUT} - mV_{IN} = 5 - 125(20mV) = 2.5V$$
$$V_O = 125V_{IN} + 2.5V$$

In circuit theory, multiplication is called amplification or gain.

m (slope) = A_V = Gain

If $A_V > 1$: Amplify
If $A_V < 1$: Attenuation
If $A_V = 1$: Buffer

The Op Amp (Operational Amplifier)



No current can flow into the terminals.

The - terminal is the inverting terminal.
The + terminal is the non-inverting terminal.

$V_+ = V_-$ because of a large resistance between the two terminals.
$I_+ = I_- = 0A$

Op Amps were originally used to perform operations such as addition and subtractions. It was one of the first chips ever created. The 741 op amp IC is universal. It is one of the most used chips in the world and performs quite well throughout the audio frequency range of 20Hz to 20KHz.

Kirchhoff's Current Law
The sum of currents into a node is the sum of currents out of a node.

$\sum I_{IN} = \sum I_{OUT}$

Ohm's Law
$V_R = I_R \cdot R$

The key to remember: Ohm's law is defined by the voltage difference. Entry energy – exit energy, divided by resistance.

Characteristic Equation of the Amplifier
Describes how energy is transformed.

$$V_0 = \frac{-R_2}{R_1} \cdot V_{IN}$$

$$A_V = -\frac{R_2}{R_1}$$

From the inverting amplifier, we can build all other amplifying circuits of interest to us in this class.