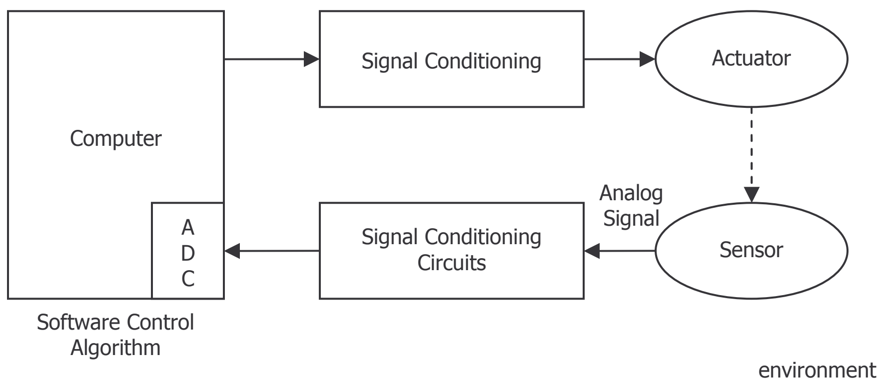
Today

1. Analog-to-digital conversion
2. Signal conditioning for ADC

Analog-to-Digital Conversion

Key Principle

We have sensors that produce voltage wave forms that we are going to condition and bring into something like the HC11.

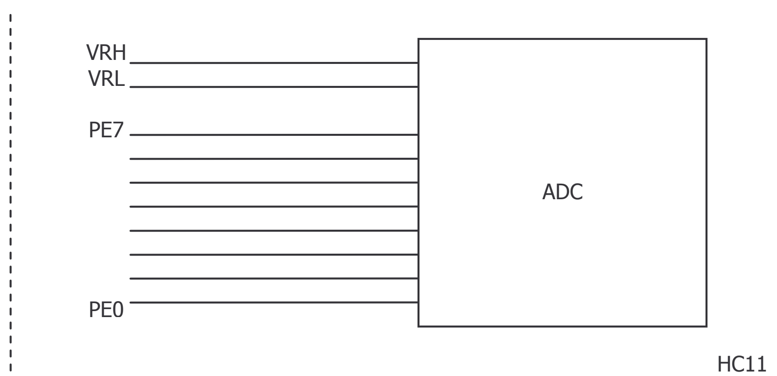


The MC68HC11 ADC

8-bit output numbers: 0x00 to 0xff (unsigned)

It has eight independent input channels, AD7:AD0. They share the port E pins on the microcontroller.

Therefore, the port E pins have some limitations on how much current can flow into the port E pins. This will be discussed later.



Traditionally, VRH and VRL are connected to +5V and ground.

$$\Delta V = \frac{V_{ref_h} - V_{ref_l}}{2^i}$$

where i = number of output bits

As the number of ADC conversion bits go up, the cost goes up. 16-bit ADCs are more expensive than 8-bit ADCs. Therefore, 8-bit ADCs have a good price point for smaller 8-bit microcontrollers and still provide reasonable performance.

Under the HC11 configuration:

$$\Delta V = \frac{5V - 0V}{2^8}$$
$$\Delta V = 19.6mV$$

This is often rounded to 20mV because it is easier to use in mathematical calculations on paper.

Ex: What would the HC11 ADC give for a value of 3.25V?

$$3.25V \cdot \frac{1\ count}{19.6mV} \approx 3.25V \cdot \frac{1\ count}{20mV} = 162.5 = 162$$

Programming the ADC on the HC11

The ADC is not interrupt capable and therefore does not have interrupt registers or need interrupt service routines. It must be read using polled behavior.

OPTION Register
ADPU – ADC power-up bit

ADCTL Register

7	6	5	4	3	2	1	0
CCF	-	SCAN	MULT	CD	CC	CB	CA

Examples
Suppose you want to sample PE4 1 time.

```
LDAA    #%00000100
STAA    ADCTL
```

PE 4 continuously

```
LDAA    #%00100100
STAA    ADCTL
```

One time sample of channel set PE3, PE2, PE1, PE0

```
LDAA    #%00010100
STAA    ADCTL
```

Classic Wait Loop

```
ADCWAIT         TST     ADCTL
                BPL     ADCWAIT
```

Signal Conditioning for ADC

We have to shift and scale any waveform so that it sits between VRL and VRH before it can be read by the ADC.