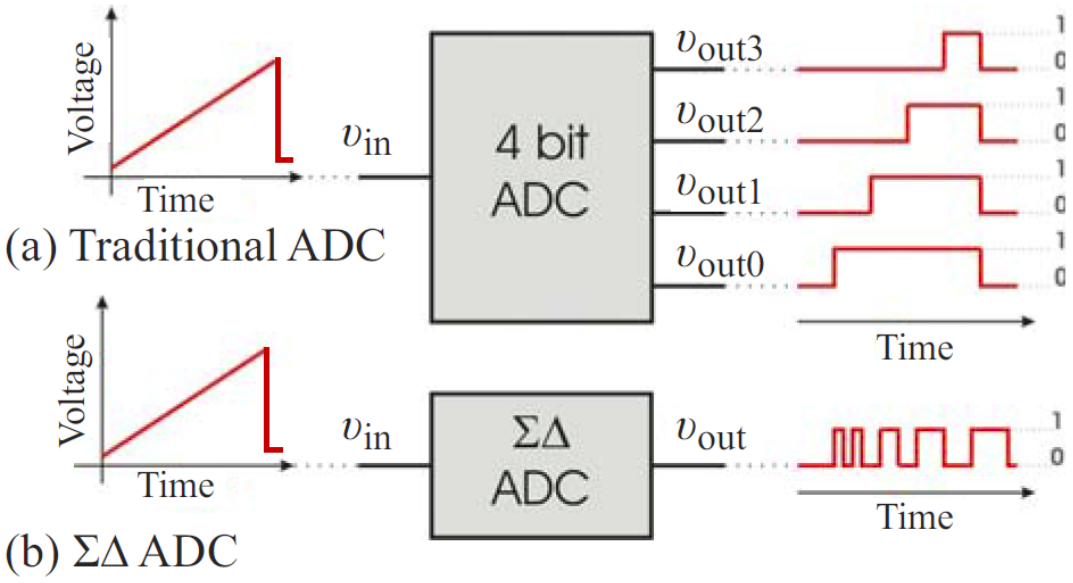
Analog to Digital Converters (ADC)

An analog-to-digital converter (ADC) is a circuit that transforms an analog input voltage into a digital value that represents the analog voltage's instantaneous magnitude (or amplitude).

There are many ways to convert an analog waveform into a digital representation. The classic ADC circuit takes a time-varying analog voltage, $v_{in}(t)$, and produces a corresponding time-varying digital output consisting of a number of bits ($V_{out}0$, $V_{out}1$, etc.). The top figure below shows the process schematically. Here, a linearly increasing voltage is fed into a 4-bit ADC; as the input voltage changes with time, the four digital output bits change their state (either "0" or "1"). All of the pulses have the same duration and can change states instantaneously. With 4 binary bits, we can construct 16 different values (i.e., 0000, 0001, . . . , 1111), so this 4-bit ADC converts any input voltage to one of 2^4 or, equivalently, 16 different digital values. Modern ADCs commonly have 12, 16 or even 24 output bits, giving them very high resolution (e.g., 2^{24} = 16,777,216 different values!). One usually trades off speed for resolution; the bits in a fast 12-bit ADC integrated circuit can change states once every 2 microseconds, which means that the ADC can measure the input voltage approximately 500,000 times per second.



Unlike conventional ADCs, the ΣΔ ADC (bottom figure) generates an output consisting of a single digital bit. The duration of the voltage pulse, however, depends on the value of the input voltage, thereby encoding the magnitude of the input voltage into the duration of a single pulse, instead of encoding it into the binary states of several pulses (bits) of equal duration. The ΣΔ modulator is particularly attractive for designing and building inexpensive ADC circuits because it can (a) be made using digital components, which are less expensive to build and easier to test than analog components, and (b) the digital components can be reprogrammed and modified by the user using firmware.