Circuits and component for A to D conversion

To create an A to D converter, we need a device that can compare two voltages and give a "1" or "0" logic decision on if the voltage is above or below a reference voltage. This component is called a comparator. Its symbol is shown below. This symbol is also the same as that for a operational amplifier (OPAMP). These two parts are very similar in behavior and function, but are optimized for different applications



schematic symbol for a comparator or an OPAMP

An OPAMP is a infinite gain differential amplifier that has an output that is linear. In other words the output is able to take on values from its negative to its positive supply voltage. A comparator has an output that is either a digital "1" or a "0" depending on the relative input voltages. The differential nature of these two parts means that the amplification or comparison takes place between the voltages at the "+" and "-" inputs and not against ground or some fixed reference.

A comparator is a special case of a OPAMP. The '-' terminal is normally considered the reference terminal, just like our volt meter. It operates by asserting a "1" at its output if the voltage at the "+" terminal is higher than the voltage than the "-" terminal. Otherwise, the output voltage is zero. Commonly available comparators can easily sense a 1mV difference between input terminals and give a result in < 10ns. Many comparators can also make 50 million comparisons per second.

Using this new component how can we implement a A to D converter? Imagine if we could produce a set of voltages as reference inputs to multiple comparators that could tell us if we are above or below the different decision points. We could create the reference voltages using voltage dividers, or even better one big voltage divider with multiple "taps" where we get the decision voltages. See the schematic below.



The resistor network creates the reference voltages required by using only 2 different values of resistor. Their absolute values are not critical as long as R is one-half of 2R.

The voltage at the bottom tap follows the voltage divider equation we studied before.



The reference input to each comparator is connected to one of the voltage reference taps. The output of each comparator indicates if the input signal exceeds that reference input.

The output of each comparator would correspond to a yes or no decision as to if the input signal exceeded the decision points. These digital outputs can be applied to a simple logic network that will encode the seven inputs to three outputs. With the decision points we have, there are only eight possible sets of output codes for the seven comparators, so mapping them to three digital bits is possible.