Comparators

A comparator as name implies, compares a signal voltage on one input of op-amp with known voltage called the reference voltage on the other input. In its simplest form , it is nothing more than an open loop op-amp, with two analog inputs and a digital output. The output may be +ve or –ve saturation voltage, depending on which input is larger.

An operational amplifier (op-amp) has a well balanced difference input and a very high gain. The parallels in the characteristics allow the op-amps to serve as comparators in some functions. A standard op-amp operating in open loop configuration (without negative feedback) can be used as a comparator. When the non-inverting input (V+) is at a higher voltage than the inverting input (V-), the high gain of the op-amp causes it to output the most positive voltage it can. When the non-inverting input (V+) drops below the inverting input (V-), the op-amp outputs the most negative voltage it can. Since the output voltage is limited by the supply voltage, for an op-amp that uses a balanced, split supply, (powered by $\pm V_S$) this action can be written:

$$V_{out} = A_o(V_1 - V_2)$$

In practice, using an operational amplifier as a comparator presents several disadvantages as compared to using a dedicated comparator:

1. Op-amps are designed to operate in the linear mode with negative feedback. Hence, an op-amp typically has a lengthy recovery time from saturation. Almost all op-amps have an internal compensation capacitor which imposes slew rate limitations for high frequency signals. Consequently an op-amp makes a sloppy comparator with propagation delays that can be as slow as tens of microseconds.
2. Since op-amps do not have any internal hysteresis an external hysteresis network is always necessary for slow moving input signals.
3. The quiescent current specification of an op-amp is valid only when the feedback is active. Some op-amps show an increased quiescent current when the inputs are not equal.

4. A comparator is designed to produce well limited output voltages that easily interface with digital logic. Compatibility with digital logic must be verified while using an op-amp as a comparator.

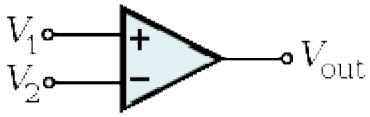

Figure 2.6

A dedicated voltage comparator will generally be faster than a general-purpose operational amplifier pressed into service as a comparator. A dedicated voltage comparator may also contain additional features such as an accurate, internal voltage reference, an adjustable hysteresis and a clock gated input.

A dedicated voltage comparator chip such as LM339 is designed to interface with a digital logic interface (to a TTL or a CMOS). The output is a binary state often used to interface real world signals to digital circuitry (see analog to digital converter). If there is a fixed voltage source from, for example, a DC adjustable device in the signal path, a comparator is just the equivalent of a cascade of amplifiers. When the voltages are nearly equal, the output voltage will not fall into one of the logic levels, thus analog signals will enter the digital domain with unpredictable results. To make this range as small as possible, the amplifier cascade is high gain. The circuit consists of mainly Bipolar transistors except perhaps in the beginning stage which will likely be field effect transistors. For very high frequencies, the input impedance of the stages is low. This reduces the saturation of the slow, large P-N junction bipolar transistors that would otherwise lead to long recovery times. Fast small Schottky diodes, like those found in binary logic designs, improve the performance significantly though the performance still lags that of circuits with amplifiers using analog signals. Slew rate has no meaning for these devices. For applications in flash ADCs the distributed signal across 8 ports matches the voltage and current gain after each amplifier, and resistors then behave as level-shifters.

The LM339 accomplishes this with an open collector output. When the inverting input is at a higher voltage than the non inverting input, the output of the comparator connects to the negative power supply. When the non inverting input is higher than the inverting input, the output is 'floating' (has a very high impedance to ground). With a pull-up resistor and a 0 to +5V power supply, the output takes on the voltages 0 or +5 and can interface with TTL logic:

Comparators are used in circuits such as digital interfacing, Schmitt triggers, voltage level detectors, and oscillators.

Comparator characteristics:

1. Speed of operation
2. Accuracy
3. Compatibility

Limitations of op-amp as comparators:

A general purpose op-amp such as 741 can be used in relatively less critical comparator applications in which speed and accuracy are not major factors.With +ve feedback the switching speed of op-amp comparator can be improved and false transition due to noise can be eliminated.