Experimenter's Corner

By Forrest M. Mims

THE LM339 QUAD COMPARATOR

Multiple integrated circuitrs are a real boon to the electronics experimenter. They reduce a project's parts count, and are less expensive than the equivalent number of single-function IC's. Furthermore, they make the assembly of projects requiring several IC's of the same type much easier.

A particularly useful multiple circuit IC is the LM339 quad comparator. This versatile chip contains four independent voltage comparators which can be operated from a single-ended power supply. The pin diagram for this IC (Fig. 1) shows how each of the comparators is connected.

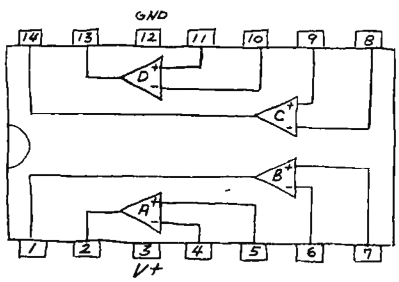


Fig. 1. Pin diagram of the LM339.

Before examining some practical applications for the LM339, let's briefly review comparator operation. As its name implies, a comparator literally compares two voltages. In a typical application, one voltage is supplied by a fixed reference and the other by a variable input signal. Whenever the signal voltage exceeds the reference voltage, the comparator switches on.

You can understand how a comparator works by thinking of it as an op amp without a feedback resistor, and therefore, having the highest possible gain. If you have used an op amp in this mode, you know that a relatively small input signal will cause the output to swing fully on. Actually, a comparator is merely a modified op amp, and you can often operate an op amp as a comparator.

VCO Circuits. National Semiconductor has published a number of circuit applications for the LM339 in application note AN-74 (R.T. Smathers, *et al.*, "LM139/LM239/LM339: A Quad of Independently Functioning Comparators," January 1973). One of the most interesting circuits is the voltage controlled oscillator (VCO) shown in slightly modified form in Fig. 2.

A VCO is an oscillator whose frequency is govemed by an input voltage. Two important applications for VCO's are phase locked loops and analog telemetry systems. In the latter role, the variable voltage from a sensor is used to control the frequency of a transmitted tone. Changes in the tone frequency can be analyzed with a decoder circuit to determine variations in the sensor voltage.

The VCO of Fig. 2 provides both square and triangle wave outputs. The input control voltage is provided by potentiometer *R1* which is connected as a voltage divider. But you can use any variable voltage source by removing *R1* from the circuit and applying the control voltage between the input of the VCO and pin 12 (ground) of the LM339.

Figure 3 is a graph I plotted for the circuit of Fig. 2. The graph shows the VCO frequency versus the input voltage. Note that the relationship between the two variables is nearly linear. The graph also illustrates the wide dynamic range of the circuit. With an input of 1 volt, the output frequency was 3447 Hz and the square waves at pin 1 were 150 μs wide. With an input of 20 volts, the frequency was 50,869 Hz and the square waves at pin 1 only about 10 μs wide.

With the values specified, the VCO will accept a minimum control voltage of about 40 millivolts, resulting in an output frequency of 8 Hz. You can increase *C1* to 1 μF for even lower frequencies.

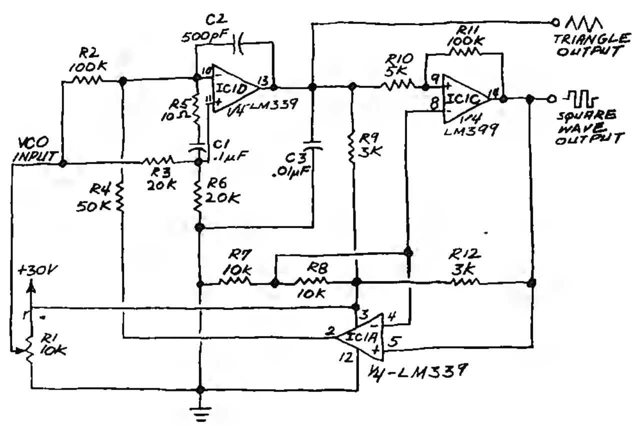
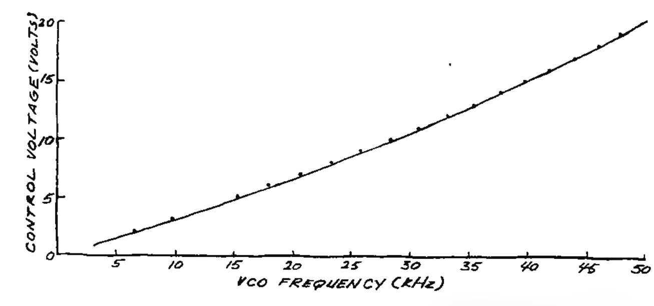


Fig. 2. Voltage-controlled oscillator using the LM339.

Fig. 3. Control voltage vs operating frequency of LM339 vco.



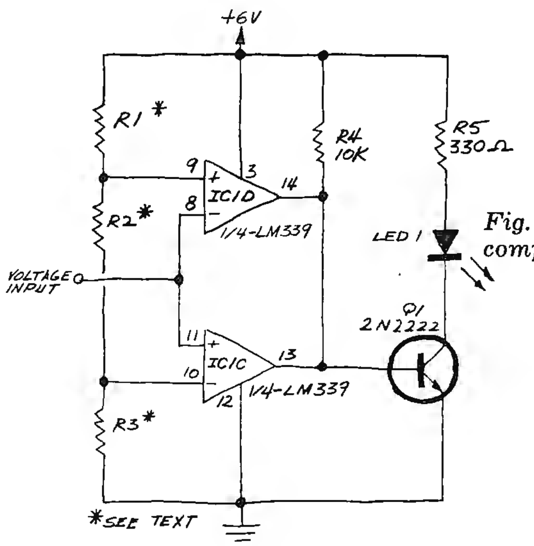


Fig. 4. LM339 Limit comparator.

Though all the results given here were made when a 30-volt power supply was used, the circuit will operate at much lower voltages.

Limit Comparators. Another interesting circuit is the limit comparator shown in Fig. 4. The circuit uses two of the comparators in the LM339, and its operation is straightforward. When both comparators are off, *Q1* is turned on by the base bias from *R4*. In turn, *Q1* activates *LED1*. If either comparator turns on, *Q1*'s base is shorted to ground, and the LED turns off.

This circuit has a variety of voltage sensing and indicator applications. The voltages at pins 9 and 10 of the LM339 determine if either comparator will be turned on. They are established by the resistance ratios in the voltage divider *R1 R2 R3*.

Resistors *R1* and *R3* determine the voltage levels at which the LED switches on and off. Because *R2* is connected between pins 9 and 10, reducing its resistance causes the switching voltages of the two comparators to approach one another. Increasing *R2*'s resistance causes the switching voltages of the comparators to diverge. Accordingly, the resistance of *R2* can be changed to adjust the input voltage range over which the LED stays on.

By using potentiometers for *R1*, *R2*, and *R3*, I was able to adjust the circuit so that the LED turns on when very small input voltages are applied. For example, when *R1* is about 500 ohms, *R2* is about 1200 ohms, and *R3* is about 1 megohm, the LED will begin to turn on when the input signal is only 4 millivolts! The LED will reach maximum brightness at 6 mV and turn off at 8 mV. When *R1* and *R3* are both about 15,000 ohms and *R2* is 25,000 ohms, the LED will turn on at an input signal of 1.5 volts and turn off when the input reaches 4.2 volts.

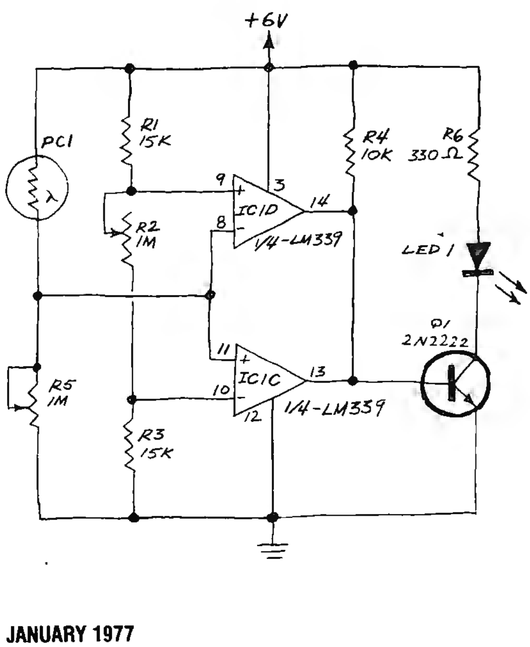


Fig. 5. Limit comparator operated as a programmable light meter

Be sure to experiment with the values of *R1*, *R2* and *R3*. Also, you might want to try replacing *Q1* with a PNP transistor (2N2907, 2N3906, etc.) to reverse the operation of the LED. A PNP transistor will cause the LED to be normally on and to turn off when a desired voltage appears at the input. If you try this substitution, reverse the emitter-collector connections for *Q1* shown in Fig. 4.

I mentioned earlier that the limit comparator of Fig. 4 has a variety of voltage sensing and indicator applications. Fig 5 shows one such application, a programmable light meter. The light sensor is a standard cadmium sulfide (CdS) photocell with a high dark resistance and a low light resistance.

Potentiometers *R2* and *R5* can be adjusted to cause the LED to glow only at a desired light level, or to glow when the light either exceeds or falls below a preset level. Incidentally, note that photocell *PC1* and *R5* of Fig. 5 are simply added to the circuit of Fig. 4. Since these two components form a voltage divider, you might want to try experimenting with their location in the circuit to reduce the component count. For example, try substituting *PC1* for *R1* and *R5* for *R3*. ◇