The LM 339

A Great Comparator

Four independent comparator circuits on one chip can be used in a variety of analog and digital applications

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THE KEY WORD to describe the 339 quad comparator is *versatility*. This device can interface a slow-moving analog signal to almost any logic family, will drive a LED, detect high- and/or low-voltage limits and can be used as a monostable oscillator.

What makes the 339 so versatile? Consider its power requirements as an example. The chip will work from a single dc source between 2 and 32 volts, or a split power supply from ±1 to ±18 volts. Current drain is a meager 0.8 mA, independent of supply voltage.

The common-mode range includes ground, even when operated from a single supply. With a typical input bias current of 25-nanoamperes, a 3-nanoampere offset and a 3-mV input offset voltage, the input can "look" at almost any source impedance without loading.

The 339 output stage is an npn transistor having an uncommitted collector so that an external pullup resistor can be used with a supply voltage different than that used by the remainder of the device. You can even hard-wire the outputs in an OR configuration. The transistor output stage will sink up to 20 mA, but you may have to live with a high saturation voltage (with 4 mA it is 250 mV). The output is compatible with TTL (fan-out of 2), DTL, ECL, MOS and CMOS.

The 339 chip contains four identical comparators, and is available from many parts suppliers at prices as low as $1 each.

Device Operation. The pinout for the 339 is shown in Fig. 1A. The numbers across each row indicate the noninverting and inverting inputs with the associated outputs for each of the four comparators in the chip.

A basic comparator is shown in Fig. 1B. Here, the input signal V_{IN} is compared with a fixed reference V_{REF}. Whenever the input signal exceeds the reference level by just a couple of millivolts, the output (V_O) goes high. This action is illustrated by the associated waveforms.

Unfortunately, such a basic circuit can oscillate during the transition period, and although this might present a problem with slow analog signals, it would cause no trouble for the fast transition times associated with digital signals. This can be averted by using a small amount of positive feedback as shown in Fig. 1C. The feedback not only speeds up the transition, but adds a little hysteresis. Feedback resistor R_F is typically a high value, 10 megohms for example.

While hysteresis can eliminate the transient oscillation, it can also be put to work in a useful manner such as "cleaning up" input waveforms, acting like a

Schmitt trigger. However, most Schmitt triggers lack adjustability, and further along in this article, we will illustrate a 339 Schmitt trigger that does not have this problem.

Analog-to-Digital Interface. The input for a frequency counter is a good example of an analog-to-digital interface (not to be confused with an A/D converter as used in computers).

The input of a frequency counter must be capable of accepting a wide variety of signals, slow or fast, and provide a signal compatible with the digital counter circuits that follow. Also, since the input levels can span a broad range of levels, sensitivity adjustments are required. Then there must be a "threshold" established either to reject noise, or possibly to match a digital source. Such a circuit is shown in Fig. 2A.

Sine-wave performance (10 kHz) is shown in Fig. 2B with a 3-volt rms input and Fig. 2C with 1-volt rms input. This circuit has been used with excellent results to 1 MHz.

CMOS to TTL Translation. The circuit shown in Fig. 2A is also useful for translating various logic families. For this application, two series-connected 1N914 diodes may be substituted for the 2000-ohm potentiometer. This estab-
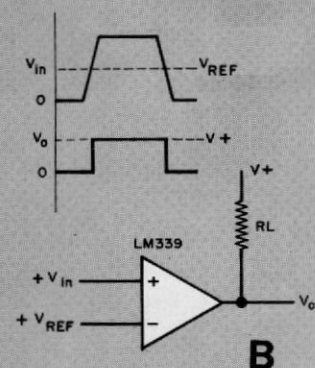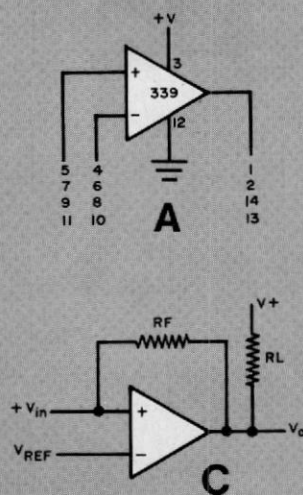
Fig. 1. Pinout of the LM339 (A). Comparator with basic waveforms (B). Comparator with feedback resistor for faster switching action (C).

Fig. 3. Outputs of two separate 339 packages (four at top, four at bottom) show excellent matching.
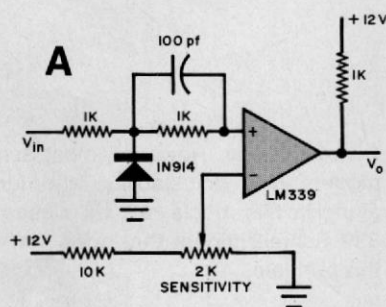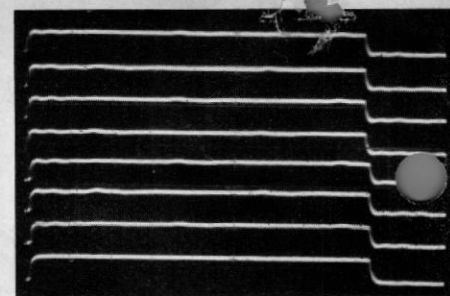

Fig. 2. Counter input circuit (A). Output with 10-kHz, 3-volt input (B) and 10-kHz, 1-volt (C). Outputs are upper traces, with 5 V/div. Sine waves are at 2 V/div.
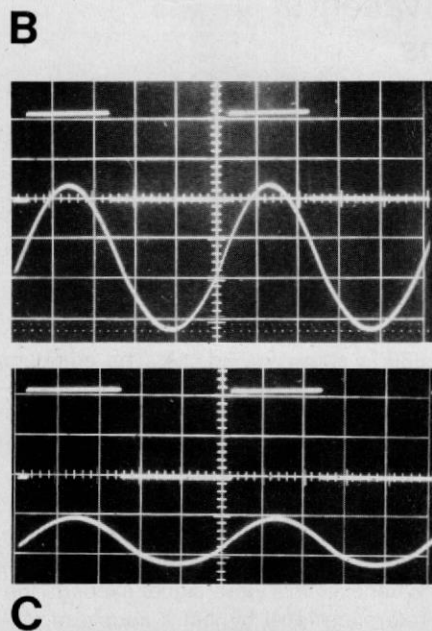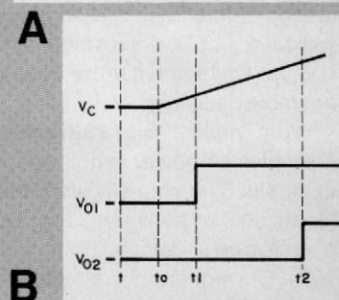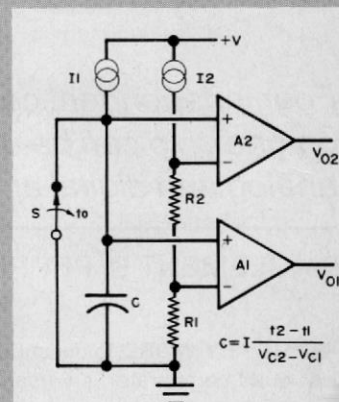

$$c = I \frac{t2 - t1}{V_{C2} - V_{C1}}$$

lishes a 1.4-volt reference compatible with both TTL and CMOS operating from a 5-volt supply. The 1000-ohm pullup resistor connected at the output has to be connected to the TTL 5-volt supply.

During the design of an 8-input oscilloscope circuit, the author connected eight such circuits, with all eight inputs connected to a source having a pulse 8-microseconds wide. The upper four traces of Fig. 3 came from one 339 package, while the lower four traces came from another 339 package. Actual time variations are about 200 nanoseconds. This illustrates the quality of diffusion techniques these days.

High and Low Limit Detection.
Two comparators working together sense the low and high limits in the simplified capacitance measuring scheme shown in Fig. 4A. The unknown capacitor (C) is charged from a constant-current source (I1). This results in a linear charging ramp whose slope is proportional to the capacitance (Fig. 4B). The limit voltages are 0.10 and 1.10 volts, so that the measurement becomes that of the time required to charge the capacitor to this higher voltage.

In the complete circuit (Fig. 4C), the addition of an exclusive-OR gate yields a pulse whose width is scaled to the val-

ue of the capacitor. Scope traces of a typical measurement are shown in Fig. 4D. The capacitance can be determined from the width of the pulse.

Earlier in this article, hysteresis was mentioned as one way to get high and low limit detection, such as used in a Schmitt trigger. The circuit shown in Fig. 5A uses a single comparator which does not have the precision of the dual comparator approach but is useful with looser tolerance circuits.

Although the circuit appears tricky is easy to understand. First, you have to know the desired upper and lower switching voltages. Then, select a zener
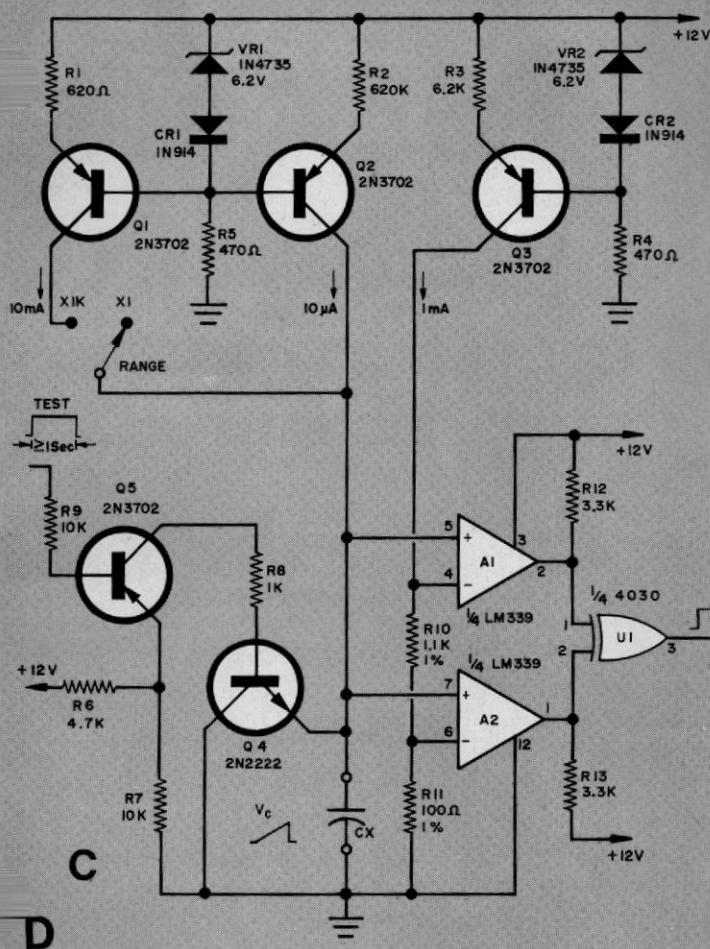
Fig. 5. High/low limit detector (A). Waveforms (B) show switching action.

R1 5.1K
1/4 LM339
R4 1.2K
+12V
ANALOG INPUT
R2 2K
VR1 5.8V
R3 3.3 K
Yo

A

B

Fig. 4. Basic capacitance measuring circuit (A) and timing diagrams (B). Complete circuit (C) and output for 4.7 µF (D).

R1 620Ω
VR1 1N4735 6.2V
CR1 1N914
R2 620K
R3 6.2K
VR2 1N4735 6.2V
CR2 1N914
+12V
Q1 2N3702
Q2 2N3702
Q3 2N3702
R5 470Ω
R4 470Ω
10mA X1K X1
RANGE
10µA 1mA
TEST ≥15ec
Q5 2N3702
R9 10K
R8 1K
R12 3.3K
+12V
A1 1/4 LM339
R10 1.1K 1%
1/4 LM339
U1 1/4 4030
A2
+12V
R6 4.7K
Q4 2N2222
R7 10K
Vc
Cx
R11 100Ω 1%
R13 3.3K
+12V

C

D

Fig. 6. Monostable circuit (A). In (B) 1710-Hz input is at top, output below (5 V/div).

6.8M
1K
+12V
t0
100pF
1M
1N914
LM339
to t1
1M
1N914
Cf
1M
1N914
Cf=100pF t1=290µs
1000pF 2800µs
.01µF 27ms
.1µF 200ms

A

B

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diode that falls midway between these voltages. Part of the problem comes when trying to get a zener diode of the correct value since zeners come in specific voltages. Therefore, pick the closest value. Select $R1$ for 5 to 10 mA of zener current.

When the 339 output is low, some of the current through $R1$ flows through $R2$ and $R3$ into the output. We can safely assume that none flows into the noninverting (+) input. Pin 5 of the 339 will now be lower than the zener.

With the 339 output high, current flows through $R4$, $R3$ and $R2$ into the zener diode.

Although we will not go into a detailed circuit analysis, the "trick" here is to select the resistor values. In the circuit shown in Fig. 5A, the switching points are 7.7 and 4.0 volts. Build the circuit and vary the resistor values to get a feel for circuit operation. A typical waveform is shown in Fig. 5B.

Monostable. The circuit for a 339 monostable is shown in Fig. 6A, with an output waveform shown in Fig. 6B.

The inverting (−) input of the comparator is biased about 1.25 volts positive by the 6.8-megohm and 1-megohm voltage divider.
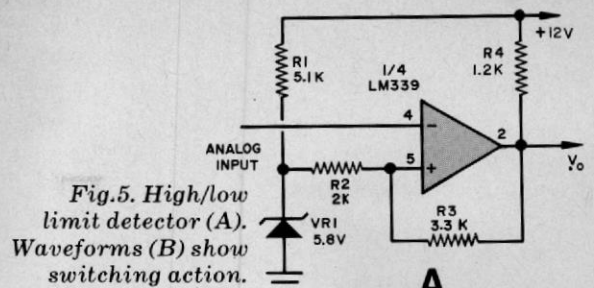
Triggering occurs on a negative-going input which forces the inverting input below ground. The 1N914 diode limits this to one diode drop. The resulting positive-going output is fed back to the noninverting (+) input, and the timing is determined by the discharge time of the feedback capacitor C_F and the 1-megohm resistor. This time is proportional to the capacitance value for the ranges shown in Fig. 6A.

Although this circuit may require some "tweaking" to achieve specific monostable action, it is useful to know about if you have an unused comparator in your design and require a monostable. ◇