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Inside... HEX BUFFERS

Have you ever wished for a universal circuit that could do anything?

☐WE ALL KNOW THAT (UNFORTUNATELY) THERE'S NO SUCH thing as a "universal circuit" that will do whatever you want it to do. If there were such a device, getting an electronics engineering degree wouldn't take more than two weeks! But some integrated circuits are so applicable in so many different uses, that they come awfully close to universal. Such devices are the 4049 and 4050 CMOS chips.

You will often find the 4049 at work as a regular inverter in digital circuits. But its capabilities go beyond simple low-power inverter applications. It has the power capability to drive LED's, solid-state relays, sensitive electromechanical relays, two-TTL inputs, etc., so it is known as an inverting buffer and TTL driver. The 4050 is the same as the 4049, except that it is non-inverting.

Pin-out diagrams are given in Fig. 1. Note that the supply voltage is connected to pin 1 and that pin-outs are the same for the 4049 and 4050. Electrical characteristics are the same, too. At 5- volts DC, each of the six segments will source 2.5 mA and sink 6 mA (Fig. 2). Those values rise to 10 and 40 mA respectively at 15 volts. The sink connection will supply greater current for operating a relay, etc.

A 555 slow clock can be used to demonstrate the operation of the buffers (Fig. 3). Two LED's can serve as a load. A clock-output LED in connection with a bipolar transistor indicates the clock-output logic. One of the hex sections is source-loaded by an LED; the other, sink-loaded.

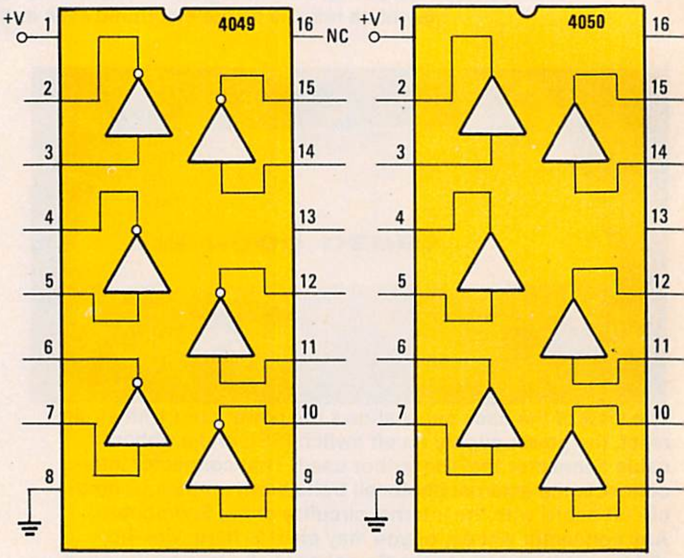

Fig. 1—Pinouts for the hex buffers are shown above. The 4049 is shown at the left, the 4050 on the right. Note that pinouts and electrical characteristics are the same for both the 4049 and 4050. The only difference is that the 4050 is non-inverting.

Make a Prototype

Build the circuit on a solderless circuit board and apply power. Note that the LED, which is sink-connected, will illuminate when the clock-output logic is 1. Since the 4049 is an inverter, the output at pin 2 will be logic 0 when the clock output is logic 1. The associated LED is connected to the supply voltage. Therefore, it will turn on, because pin 2 is at logic 0. Conversely the second output LED will turn on when the clock output is logic 0. In that case, pin 4 of the 4049 is at logic 1 and source current is present in the LED because of its connection to ground (logic 0). The sink-connected LED will glow brighter than the source-connected LED.

Remove the 4049 and substitute a 4050 in its place. No rewiring is required. The 4050 output is non-inverting. Consequently the source-connected LED will turn on when the clock logic is 1; the sink-connected LED when the clock-output logic is 0. You choose the 4049 or 4050 according to your circuit's needs.

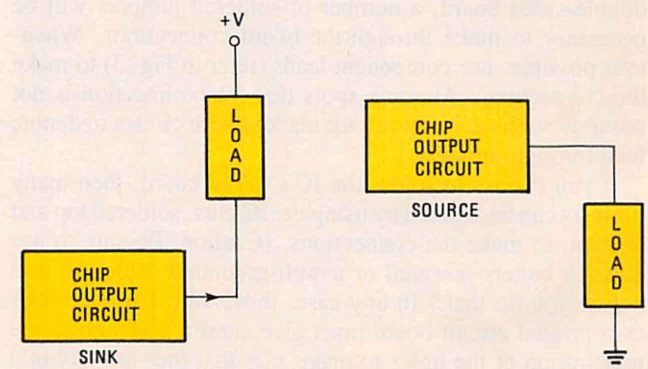

Fig. 2—Sinking and sourcing a load are demonstrated in the block diagrams above. With a 5-volt DC supply, each segment will source 2.5 mA and sink 6 mA. As shown, one segment is source-loaded by an LED, the other is sink-loaded.

Return the 4049 to the circuit. Connect a sensitive electromechanical relay to the outputs of three paralleled sections of the 4049 as shown in Fig. 4. The 6-volt relay with a relay coil resistance of 500 ohms will be satisfactory. The Radio Shack 275-004 can be used. Required relay current is 12 mA. Three paralleled sections will have a sink-current capability greater than that value, so the relay current can be supplied easily. The relay coil is sink-connected because of its tie-in to the plus supply voltage.

Wire and operate the circuit. Observe that the relay is energized when the clock-output logic is 1. If you would prefer relay energization to match a clock-output logic of 0, you can use the 4050 instead of the 4049. As the relay contacts are SPDT, the contact wiring can be such that the LED will turn on or turn off with the relay energized. The contacts of the relay are capable of handling 1A at 125VAC.

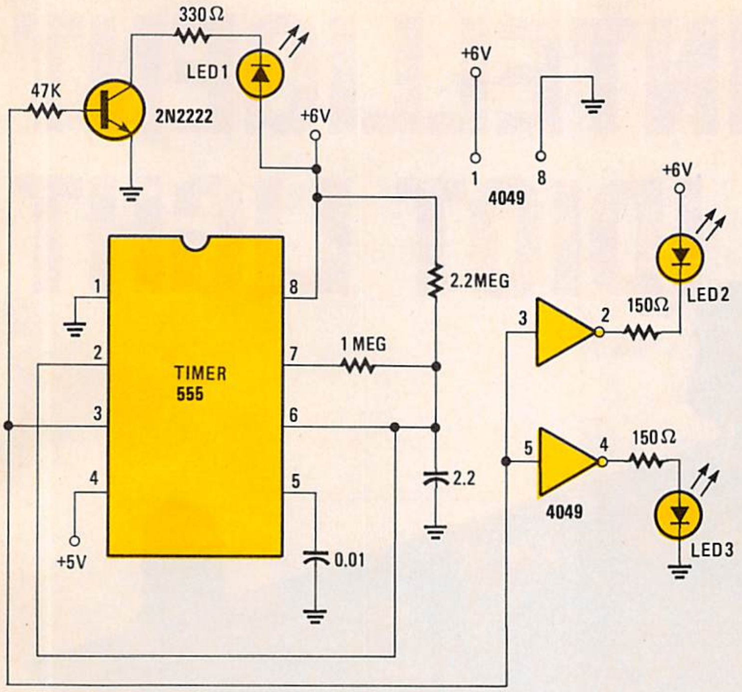

Fig. 3—Slow clock circuit above, shows method of operation of the buffers. Loads are represented by light-emitting diodes. In the schematic diagram shown, one segment is sink-loaded by LED2, the other is source-loaded through LED3. Timer 555 with bipolar transistor indicates clock output logic through output LED1.

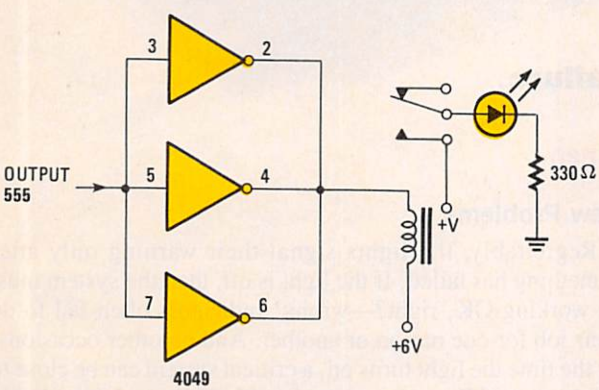

Fig. 4—Circuit shows how to use a clock timer with three segments of the 4049 to control a sensitive electro-mechanical relay. The relay is energized when clock output is at logic 1. You could change that simply by switching to a 4050, but since the relay is a SPDT type, you can accomplish the same thing by simply connecting it to the other relay contact.

Solid-State Relay Operation

An opto solid-state relay can be driven from the output of a hex buffer. Such a relay consists of an input infrared diode that is light-coupled to a photosensitive output circuit and amplifier. The light protons follow a confined light path to the output circuit, and provide a high order of isolation between input and output. Output can be operated from a separate source of supply voltage that needs no connection to the input circuit. That method is ideal when you wish to interface digital circuits with a variety of electrical and electronics devices that are to be controlled.

One such device is the GE H11G1 or H11G3 6-pin, mini-DIP chip (Fig. 5). The IR diode is connected to pins 1 and 2. The infrared light activates a phototransistor and output transistor connected as a Darlington pair. The circuit or device

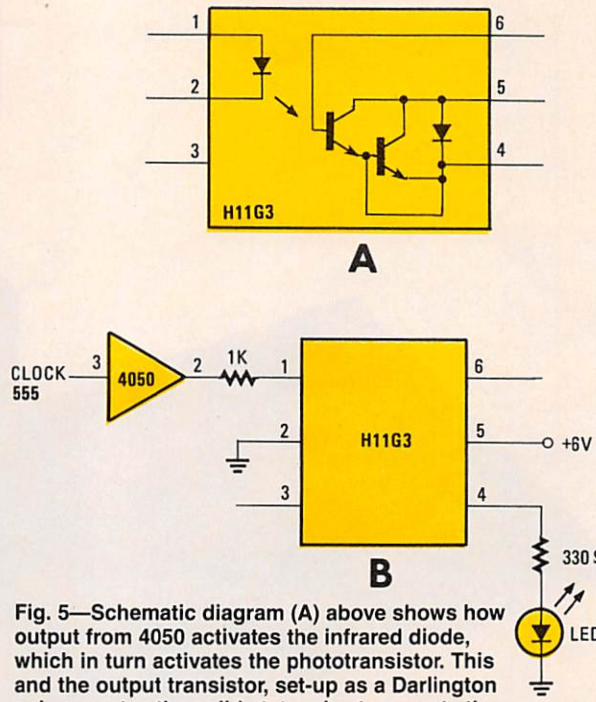

Fig. 5—Schematic diagram (A) above shows how output from 4050 activates the infrared diode, which in turn activates the phototransistor. This and the output transistor, set-up as a Darlington pair, operates the solid state relay to operate the load represented by LED1, which is source-connected.

that is to be controlled is connected between pins 5 and 4. Typical output current-capability is 40-50 mA.

More Circuits

Figure 5-b shows how the solid-state relay (SSR) can be connected to the clock and hex buffer circuit. The input-current requirement for the IR diode is so low that it can be driven from the output of a single buffer in series with a 1K resistor. Absolute maximum current for the diode is 60 mA. Be careful not to short it across the supply voltage. It will activate with less than 5 mA.

Place your circuit in operation. When the input clock is at logic 1, the LED will come on. If your project requires output when the input logic is 0, use a 4049 instead of the 4050. Don't forget that a major advantage of the SSR plan is that the supply voltage associated with pins 4 and 5 can be completely isolated from the digital system that supplies drive to the IR diode. That supply voltage can be as high as 55 volts for the G3 and 100 volts for the G1.

One application for the SSR circuit is to provide drive for a large electromechanical relay. The circuit of Fig. 6 shows the arrangement for driving a mini-DIP relay with output contacts that are rated for 3A at 125VAC. The relay used in the circuit was a Radio Shack 276-246, 5-volt DC SPDT printed-circuit relay. A coil current of 72 mA is required.

The circuit is given in Fig. 6. The pin 4 output of the SSR connects to one side of the relay coil, while the other side goes to ground. The arm of the PC relay connects to the supply voltage by way of a 330-ohm resistor. The normally closed and normally opened contacts of the relay are connected to indicating LED's.

Apply power. Note that when a logic 1 is supplied to the input of 4050 buffer, the normally open LED comes on because the relay is energized. When the input logic is 0, the normally closed LED turns on. Again, if you wish relay

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HEX BUFFERS

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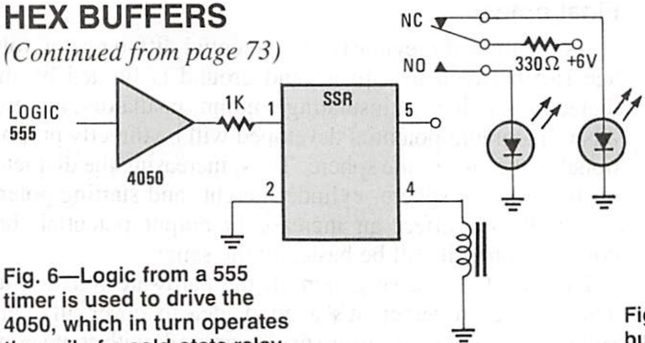

Fig. 6—Logic from a 555 timer is used to drive the 4050, which in turn operates the coil of a sold-state relay. The relay coil is source-connected, and the two LED's represent operating loads. Changing operating mode is as simple as switching from the 4050 to a 4049.

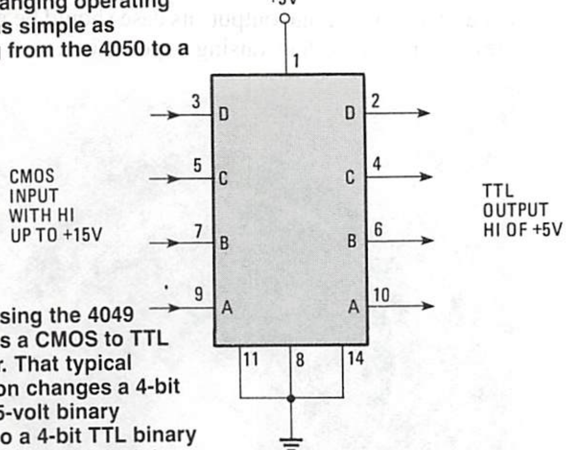

Fig. 7—Using the 4049 or 4050 as a CMOS to TTL converter. That typical application changes a 4-bit CMOS, 15-volt binary number to a 4-bit TTL binary number with a 5-volt high. Output drive is sufficient to supply two 4-bit TTL inputs.

energization when a logic 0 is applied to the input of the buffer, you need only substitute a 4049 in place of the 4050. The relay contacts are capable of switching three amperes, so it is capable of switching more than 350 watts assuming an AC source of 125 volts.

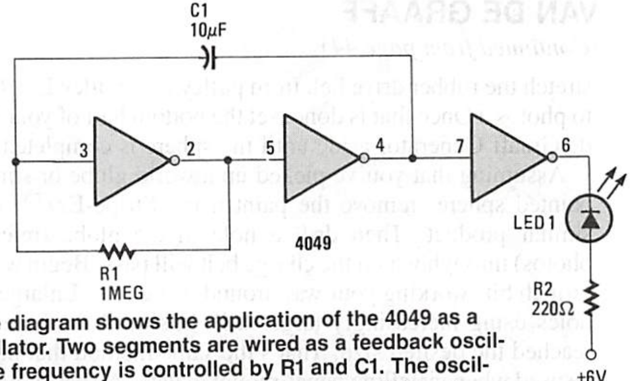

Fig. 8—The diagram shows the application of the 4049 as a buffer oscillator. Two segments are wired as a feedback oscillator whose frequency is controlled by R1 and C1. The oscillator is followed by an output stage and an LED indicator.

In the circuit of Fig. 7, a 4-bit CMOS 15-volt binary number is being changed over to a 4-bit TTL binary number with a high of 5 volts. The output drive is adequate for supplying this 4-bit TTL binary number to two 4-bit TTL inputs.

Buffer Oscillator

The inverting buffer can be connected into a general-purpose oscillator or clock generator delivering a good output for a variety of applications including the driving of two TTL inputs. In the arrangement of Fig. 8, two sections are connected as a feedback oscillator followed by an output section and an LED indicator.

Frequency of operation is set by the RC time constant and has an approximate value of:

$$f = 1 \div [2.2 \times R(\text{Megohms}) \times C(\mu F)]$$

For values shown frequency is:

$$f = 1 \div [2.2 \times 1 \times 10] = 0.045 \text{ Hz}$$

The 4050 and 4049 are a versatile pair of buffers. Keep them in mind in your project planning.

In summary, the hex buffer is attractive in many digital systems and interfacings. It is helpful to have two similar hex buffers that can be used in inverting or non-inverting applications. ■