The **tristate driver**, shown in Figure 4.8, can be used dynamically control signals within the computer. It is called tristate because there are three possible outputs: high, low, and HiZ. The tristate driver is an essential component from which computers are built. To activate the driver, we make its gate (*G**) low. When the driver is active, its output (*Y*) equals its input (*A*). To deactivate the driver, we make its *G** high. When the driver is not active, its output *Y* floats independent of *A*. We will also see this floating state with the open collector logic, and it is also called HiZ or high impedance. The HiZ output means the output is neither driven high nor low. The operation of a tristate driver is defined in Table 4.4. The 74HC244 is an 8-bit tristate driver, such that all 8 bits are active or not active controlled by a single gate. The 74HC374 8-bit D flip-flop includes tristate drivers on its outputs. Normally, we can't connect two digital outputs together. The tristate driver provides a way to connect multiple outputs to the same signal, as long as at most one of the gates is active at a time.

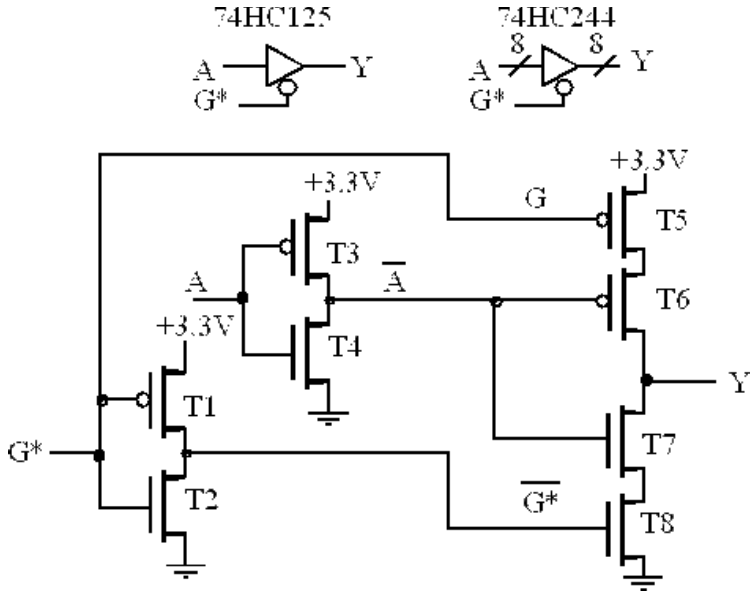


*Figure 4.8. A 1-bit tristate driver and an 8-bit tristate driver (if G* is low, then Y equals A, if G* is high, then Y is HiZ). The signal G* is negative logic.*

Table 4.4 describes how the tristate driver in Figure 4.8 works. Transistors T1 and T2 create the logical complement of *G**. Similarly, transistors T3 and T4 create the complement of *A*. An input of *G**=0 causes the driver to be active. In this case, both T5 and T8 will be on. With T5 and T8 on, the circuit behaves like a cascade of two NOT gates, so the output *Y* equals the input *A*. However, if the input *G**=1, both T5 and T8 will be off. Since T5 is in series with the +3.3V, and T8 in series with the ground, the output *Y* will be neither high nor low. I.e., it will float.

| A | G* | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Y |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | on | off | on | off | on | off | on | on | 0 |
| 1 | 0 | on | off | off | on | on | on | off | on | 1 |
| 0 | 1 | off | on | on | off | off | off | on | off | HiZ |
| 1 | 1 | off | on | off | on | off | on | off | off | HiZ |

Table 4.4. Tristate driver operation. HiZ is the floating state, such that the output is not high or low.

The output of an open collector gate, drawn with the '×', has two states low (0V) and HiZ (floating) as shown in Figure 4.9. Consider the operation of the transistor-level circuit for the 74HC05. If *A* is high (+3.3V), the transistor is active, and the output is low (0V). If *A* is low (0V), the transistor is off, and the output is neither high nor low. In general, we can use an **open collector NOT** gate to switch current on and off to a device, such as a relay, an LED, a solenoid, or a small motor. The 74HC05, the 74LS05, the 7405, and the 7406 are all open collector NOT gates. 74HC04 is high-speed CMOS and can only sink up to 4 mA when its output is low. Since the 7405 and 7406 are transistor-transistor-logic (TTL) they can sink more current. In particular, the 7405 has a maximum output low current ($I_{OL}$) of 16 mA, whereas the 7406 has a maximum $I_{OL}$ of 40 mA.

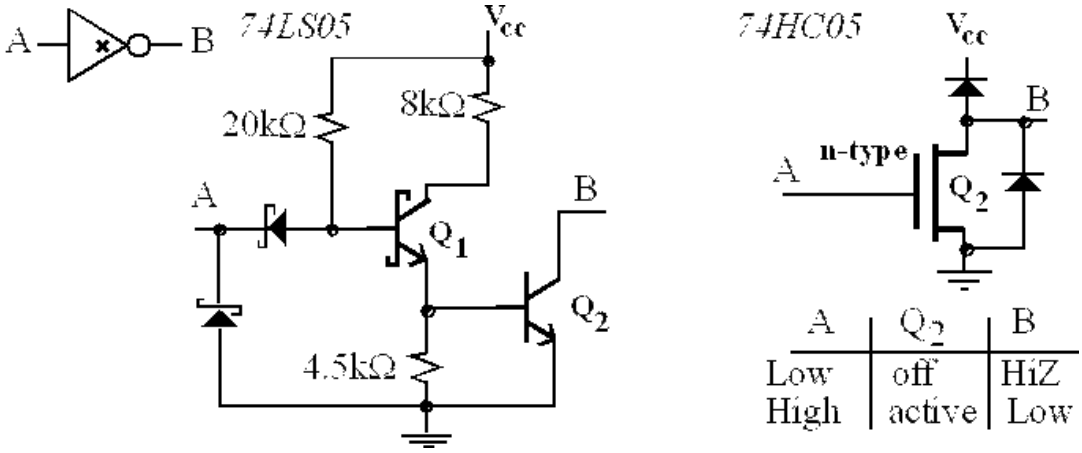


*Figure 4.9. Two transistor implementations of an open collector NOT gate.*


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