DESIGN ERROR

In the September 1977 "Hobby Corner," Earl Savage makes the statement that since he has built all the circuits shown in the column and they worked, any problems a reader has cannot be traced to bad circuit designs. In making the statement, he neglects the device-to-device variability allowed by the spec sheets. In fact, the pulse switch shown in Fig. 6 contains a design error, as well as a typographical error.

The typographical error concerns the red LED. This LED is connected backwards. The more subtle error involves the green LED. This LED is designed to be on when the NAND gate has a high-state output. The TTL data sheets show that in the high state, an output is only required to source 10 × 40 μa = 0.4 mA of current. If the gate is putting out 2 volts, (the absolute minimum safe voltage for the high state) and the LED voltage drop is near maximum at 1.6 volts, the current required is still (2.0 − 1.6)/ 270 = 1.5 mA. Thus, the required current is almost four times what the spec sheets require the device to provide. The result is that perfectly good 7400 IC's will yield an output voltage below 2 volts, and this voltage may or may not be interpreted by another gate as a logic 1. In fact, the other NAND gate in the circuit may be affected this way since it is connected to the output.

The solution is quite simple. Connect the green LED to the output of the other NAND gate in the circuit in the same manner as the correct connection of the red LED. Although a TTL output only has to source 0.4 mA, it is required to be able to sink 16 mA.

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1. As soon as one says something won't go wrong, it does! Several sharp-eyed readers called attention to the reversed LED.

2. The hobbyist, technician or engineer who ignores possible device variability is asking for trouble, as was stated in the caution regarding component tolerance.

3. The matter of the design calling for a gate to source sufficient current for the LED is correct, up to a point. Much depends on whose specs you accept for your calculations. Published specs do not always agree for a given IC. However, the underlying point is that of the proper mix of theory and practice in circuit design (which was also behind my statement that all circuits had actually been constructed).

First, understand that I am not antagonistic toward theory; in fact, I use it to the limits of my knowledge. Yet, I am of a practical turn of mind, and you sent me to my books to double-check your specs, where I found two different specs for I_{OH} for 7400's, and then to my workbench. I had to find out if the circuits I had built, including one I have used for over two years, were only flukes.

I designed a circuit to check 7400 gates for both the ability to source sufficient LED current and at the same time produce highs and lows acceptable to other gates. In summary, each of the one hundred and thirty-six 7400 gates I had on hand demonstrated the capability of performing both functions. Not one failed in the test procedure which required some 140,000 state changes. *(As I write this, there are two 7400's in the test circuit that have been continuously operating for the last 42 hours—or over 60 million state changes for each gate!) A number of gates did have some current leakage through the red LED and in eight of these, the optical performance was marginal although usable (these two ceramic IC's were quite functional electronically—there was no observable distortion of the square-wave output pattern). Furthermore, the average source voltage (V_{OH}) was +3.34 VDC (per specs), and the average source current (I_{OH}) was 3.3 mA. Quite obviously, the latter is impossible according to the published specs! Why does it work? I don't know, unless the specs deliberately understate the capability of the upper transistor in the totem-pole output by a considerable factor.*

In any case, I do not believe that all these 7400's are similarly atypical, especially since my stock has been purchased at various times and from several suppliers. Therefore, based on my past experience and upon these tests, I feel justified in my design. This is another case in which theory and practice apparently do not agree and that further emphasizes that they must be judiciously mixed.

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