computer corner

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MOST MICROCOMPUTERS MANIPULATE INFORMATION eight bits at a time. For example, the 8080A microprocessor can move the eight bits from internal register to internal register, from internal register to memory, and between the accumulator and an external I/O device. It can also perform arithmetic and logic operations, the former including add, subtract, and compare, and the latter including AND, OR, EXCLUSIVE-OR, and COMPLEMENT. In this column, logic operations will be explored.

The basic rules governing one-bit logic operations are truth tables. A truth table can be defined as a tabulation that shows the relation of all output logic levels of a digital circuit to all possible combinations of input logic levels in such a way as to characterize the circuit functions completely.[1] The truth tables for the AND, OR, EXCLUSIVE-OR, and COMPLEMENT operations are:

AND

B	A	Q
0	0	0
0	1	0
1	0	0
1	1	1

OR

B	A	Q
0	0	0
0	1	1
1	0	1
1	1	1

EXCLUSIVE-OR

B	A	Q
0	0	0
0	1	1
1	0	1
1	1	0

COMPLEMENT

A	Q
0	1
1	0

These truth tables are called *one-bit tables* because data words A and B each contain only a single bit.

In discussing logic instructions, it is useful to employ *Boolean symbols.* Such symbols originate from the subject of *Boolean algebra,* which is the mathematics of logic systems. Alphabetic symbols such as A, B, C, . . . , Q are used to represent logic variables and 1 and 0 to represent logic states. This particular form of mathematics was originated in England by George Boole in 1847. It did not become widely used until 1938, when Claude Shannon adapted it to analyze multi-contact networks for telephone networks.

What should be learned about Boolean algebra are the basic Boolean symbols that are used in Boolean algebra computations, and thus all digital logic. These symbols include the following:

- $+$ which means *logical addition* and is given the name OR
- $\cdot$ which means *logical multiplication* and is given the name AND
- $\oplus$ which is given the name *EXCLUSIVE-OR* or XOR
- $\bar{A}$ which means *negation* and is given the name NOT

The negation symbol is a solid bar over a logical variable such as A, B, . . . , Q. Thus, the Boolean statement for a two-input AND gate is $Q = A \cdot B$, or simply $Q = AB$, where the equality symbol means that the variables or groups of variables on either side of the "=" symbol are the same, i.e., both are in the same logic state. It is useful to summarize the symbol operations for the three gates that are being considered:

AND

$0 \cdot 0 = 0$
$0 \cdot 1 = 0$
$1 \cdot 0 = 0$
$1 \cdot 1 = 1$

OR

$0 + 0 = 0$
$0 + 1 = 1$
$1 + 0 = 1$
$1 + 1 = 1$

EXCLUSIVE-OR

$0 \oplus 0 = 0$
$0 \oplus 1 = 1$
$1 \oplus 0 = 1$
$1 \oplus 1 = 0$

COMPLEMENT

$\bar{0} = 1$
$\bar{1} = 0$

Multibit logic operations are treated as many one-bit logic operations. No new principles of logic are involved. The corresponding bits of one binary word logically operate on the corresponding bits of the second binary word to produce an overall multibit logic result. The length of the binary words can be any number of bits: two bits, eight bits, thirty-two bits, etc. Since the 8080A microprocessor performs multibit logic operations on eight-bit words (bytes), all of the examples will involve full bytes.

Consider the eight-bit logic variable, A. The individual bits in this variable are labeled as A7, A6, A5, A4, A3, A2, A1 and A0, with A0 being the least significant bit (the 2^0 bit) and A7 being the most significant bit (the 2^7 bit). Also consider the eight-bit logic variable, B, that has individual bits that are labeled as B7, B6, B5, B4, B3, B2, B1 and B0. The logic operation, $A \cdot B = Q$, means the following eight one-bit logic operations:

$A0 \cdot B0 = Q0$ $\quad$ $A4 \cdot B4 = Q4$
$A1 \cdot B1 = Q1$ $\quad$ $A5 \cdot B5 = Q5$
$A2 \cdot B2 = Q2$ $\quad$ $A6 \cdot B6 = Q6$
$A3 \cdot B3 = Q3$ $\quad$ $A7 \cdot B7 = Q7$

The result of the logic operation is the logic variable Q that has a least significant bit of Q0 and a most significant bit of Q7. In other words, *multibit logic operations are performed bit-by-bit via a series of one-bit logic operations.* It is easier to perform multibit logic operations if the multibit binary words are placed one under the other. Thus, if $A = 11011111_2$ and $B = 00100011_2$, then $A \cdot B$ is

$$\begin{array}{r} 11011111_2 \\ \cdot\ 00100011_2 \\ \hline 00000011_2 \end{array}$$

or $Q = 00000011_2$. In performing a logical AND, the relationships $0 \cdot 1 = 0$ and $1 \cdot 1 = 1$ were used in deriving the final result. (The subscript 2 reiterates the fact that a bit takes only two values.)

One of the more important uses for multibit logic operations is in situations in which the on-off state of external devices must be monitored. Consider the following system of eight devices:

Bit position	Device	Logic state information
Bit 0	pressure sensor	1 = pressure above setpoint 0 = pressure at or below setpoint
Bit 1	temperature sensor	1 = temperature above setpoint 0 = temperature at or below setpoint
Bit 2	velocity sensor	1 = velocity above setpoint 0 = velocity at or below setpoint
Bit 3	flow rate sensor	1 = flow rate above setpoint 0 = flow rate at or below setpoint
Bit 4	concentration sensor	1 = concentration above setpoint 0 = concentration at or below setpoint
Bit 5	Valve A	1 = valve A open 0 = valve A closed
Bit 6	Valve B	1 = valve B open 0 = valve B closed
Bit 7	Power	1 = power on 0 = power off

The group of eight bits is called the *status byte* for our system of eight devices. At any instant of time, the status byte will have a specific value. For example, the status byte 11100010_2 signifies that the pressure is at or below the setpoint, the temperature is above the setpoint, the velocity is at or below the setpoint, etc. There are 2^8 or 256 possible combinations.

The importance of logic instructions in a digital computer is that they permit the determination of the following characteristics about the external devices listed above:

- Which devices are on, open or above the setpoint?
- Which devices are off, closed, or at or below the setpoint?
- Since the last time we checked, which devices have gone from on to off, open to closed, or above the setpoint to at or below the setpoint?
- Since the last time we checked, which devices have gone from off to on, closed to open, or at or below the setpoint to above the setpoint?

In other words, using logical instructions, not only can the current state of the external devices be determined but also what changes have occurred since the last time that the devices were interrogated. Since it is not clear how this is done logically, a specific example based upon the eight devices described above should help.

Assume all eight devices have just been interrogated and the current status byte is found to be 11101010_2, where the least significant bit, bit 0, is on the far right. One second ago, the status byte was 11101001_2. What is the current state of each device, which devices have changed state during the last second, and in which direction? The steps to be employed to answer such questions are as follows:

STEP 1. Examine the current status byte. Determine the status of each external device from the logic state of its status bit.

The current status byte (CSB) is 11101010_2. From this value, it is concluded that the pressure, velocity and concentration sensors are all at or below their respective setpoints; the temperature and flow rate sensors are above their respective setpoints; and that valve A, valve B and power are all on.

STEP 2. Perform an EXCLUSIVE-OR operation between the prior status byte (PSB) and the current status byte (CSB). A logic 1 in the result indicates that the logic state of that device has changed.

The logic operation to be performed is

$$PSB \oplus CSB = Q1$$

where $PSB = 11101001_2$, $CSB = 11101010_2$ and Q1 is the result of the EXCLUSIVE-OR operation. Thus,

$$\begin{array}{rl} 11101001 & PSB \\ \oplus\ 11101010 & CSB \\ \hline 00000011 & Q1 \end{array}$$

and $Q1 = 00000011_2$. Only the pressure and temperature sensors have changed state.

STEP 3. Perform an AND operation between Q1 and the prior status byte (PSB). A logic 1 in the result indicates a device that has changed state from logic 1 to logic 0.

The logic operation to be performed is

$$PSB \cdot Q1 = Q2$$

where $PSB = 11101001_2$, $Q1 = 00000011_2$ and Q2 is the result of the AND operation. The following is obtained:

$$\begin{array}{rl} 11101001 & PSB \\ \cdot\ 00000011 & Q1 \\ \hline 00000001 & Q2 \end{array}$$

and thus can conclude that the pressure sensor has changed from being above the setpoint to now being at or below the setpoint (logic 1 to logic 0 transition).

STEP 4. Negate (or COMPLEMENT) Q2, then AND this complemented result with Q1. A logic 1 in the result indicates a device that has changed state from logic 0 to logic 1.

The logic operation that is now to be performed is

$$\overline{Q2} \cdot Q1 = Q3$$

Since Q2 is 00000001_2, the complemented value of Q2 must be 11111110. The result of the AND operation is obtained as follows,

$$\begin{array}{rl} 11111110 & \overline{Q2} \\ \cdot\ 00000011 & Q1 \\ \hline 00000010 & Q3 \end{array}$$

The result, $Q3 = 00000010_2$, leads to the *continued on page 89*

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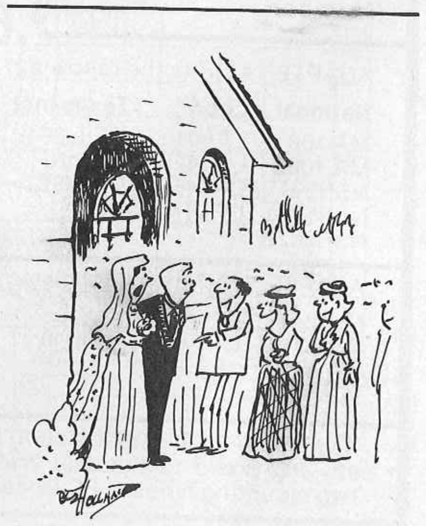
STEP BY STEP TROUBLESHOOTING
continued from page 86

new advances in transmission line use and construction. The Belden Corp., for instance, has recently developed an outstanding new CATV drop cable, the 9283, consisting of polyester film with aluminum foil bonded to the polyester core, and either a tinned copper or aluminum braid cover. Belden's tests (Fig. 4) show that with aluminum inner foil laminate plus 61 percent braid cover, there is 100-dB isolation from external interference. The cable, of course, is usable for home TV installations as well as CATV. There's a little cost differential, but the price spread between the *best* 300-ohm line and this cable isn't overwhelming either.

Figure 5 shows the attenuation characteristics (both the dB loss and percentage of signal remaining) for comparable 8228 cable (without the addition of extra braid), as compared with both unshielded and shielded 300-ohm standard TV transmission lines. Note that the 8228 cable is within approximately 1.5 dB of Belden's best unshielded—the 9085—over the entire frequency range. (Losses of the 9283 are almost identical with those of the 8228.) Then add 0.5 dB for each top (antenna) and bottom (receiver) matching transformer (balun), and you have a difference total of 2.5 dB. Will this do your metropolitan-suburban job of keeping interference to a minimum as well as passing excellent signals? Try it within 50 miles or less of the transmitter and you will be more than pleasantly surprised. Further, the total electromagnetic field will be contained in the coax; SWR will be low because of the matching transformers, and you'll have considerably better UHF and improved VHF reception as a result. **R-E**



"Uncle Bill, Mother, Sis! Let us have our honeymoon before Fred gets to your TV sets!"

HOBBY CORNER
continued from page 73

You will notice that nothing has been said about a circuit being bad in the first place. That's because everything you see in this column has been checked out and built at least on a breadboard. *Any exceptions will be clearly marked "UNTESTED."*

Iron temperature control

Do you have a light dimmer or motor speed control on your workbench? Of course, it's handy for slowing down the drill or grinder when working in soft materials such as plastic. But at our workbench the soldering iron is usually connected to it.

Just having one all-purpose soldering iron instead of two or three for various uses can cause trouble with many solid-state circuits because excess heat can quickly ruin a part or even a circuit board. However, you can keep your iron at just the right temperature with a dimmer/speed control.

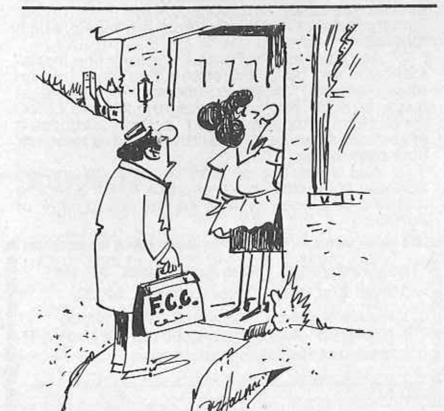
The control shown in Fig. 5 can be assembled quickly and easily. Be sure to provide a good heat sink for the triac. Although the 6-amp unit specified can readily handle any normal electronics iron, you might want to use the control with something heavier.

Once you use the dimmer/speed control with your iron you'll find you destroy fewer parts and boards and your iron and tip will last longer.

New CB guide

For beginning CB'ers, Radio Shack has published a second edition of *All About CB Two-Way Radio* (RS #68-1046). This updated nontechnical guide covers such topics as how CB got started, types of radios and antennas, how to set up fixed and mobile stations, FCC rules and regulations and plenty of ideas on using CB. **R-E**

Please remember that we want to hear from you—your needs, suggestions, ideas and circuits. Drop us a note. *73, Doc*



"Hey, Ed. He says he's your Uncle Charlie about a 10-30."

TESTING CB RADIOS
continued from page 53

completely during a noise pulse become apparent by their vastly improved performance over simple noise clippers.

22. Audio Output Power. At the level at which the audio output contains 10% distortion or full volume, whichever is greater, we will measure the AC voltage across the speaker terminals and, using the speaker's characteristic impedance, calculate the audio power in watts.

23. Public Address Output Power. We measure the power in watts directly into 8 ohms at the P.A. jack.

24. Power Drain. Measured in 6 watts at nominal line voltage in receive mode with audio squelched off.

The tests **Radio-Electronics** will use as a part of our CB Equipment Reports are conducted by an independent testing laboratory using the highest quality test equipment. We will from time to time add new tests if they are needed to rate as yet unknown features and delete those tests that do not seem important any longer. We will test at least two transceivers each month and may review an important new accessory occasionally if it requires a technical critique that fits our format. The actual tests will be performed on equipment supplied to us by the respective manufacturer and it is expected that they will be representative of the models in production. **R-E**

COMPUTER CORNER
continued from page 79

conclusion that the temperature sensor has changed from at or below the setpoint to above the setpoint (logic 0 to logic 1 transition).

The reason that such a series of logical operations is performed is to determine what type of corrective actions to apply to the system if it is not operating properly. If the temperature is below its setpoint, a heater may have to be turned on. If the concentration of a reactant is too high, valve B may have to be turned off to temporarily halt the flow of reactant into the system. If the pressure is above the setpoint, an emergency condition may exist and the power may have to be turned off for the entire system. With a properly interfaced microcomputer, all such decisions are easily and quickly made under software control and the necessary corrective actions initiated. However, electrical and electromechanical devices typically have response times that are much longer than the decision times for a microcomputer. These response times must be taken into account in software design, and are important considerations in the field of digital controls. A discussion of response times is beyond the current scope of this column. **R-E**

REFERENCES:

1. GRAF, R. F., *Modern Dictionary of Electronics,* Howard W. Sams & Co., Indianapolis, 1972.