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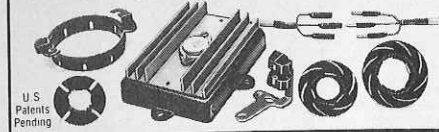
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CIRCLE 68 ON FREE INFORMATION CARD

KOMPUTER KORNEN

JOHN TITUS, DAVID LARSEN, and PETER RONY*

ONE OF THE MOST IMPORTANT PROGRAMMING characteristics possessed by any digital computer, including a microcomputer, is the ability to make a decision. For a typical microcomputer, we can define a *decision* as the process of determining further action based upon the logic state of a *flag*. A *flag* is a single flip-flop that can be either set or cleared in response to operations occurring within the microcomputer system. A change of state of the flag is usually an indication that either a particular operation has been completed or that a certain condition exists as a result of a microcomputer operation. Flags can be located either internal or external to the microprocessor chip; the ones that we shall discuss in this column are the internal flags that are set or cleared in response to specific types of microprocessor instructions such as arithmetic and logical instructions.

The flags that are located within the microprocessor chip are typically associated with the *arithmetic-logic unit (ALU)*, a region within the chip where all arithmetic and logical operations are performed. In the 8080 microprocessor chip, for example, there exists five flags that indicate the following conditions:

- zero flag*—If the result of an arithmetic or logical operation is zero, the zero flag is set to logic 1. If non-zero, the zero flag is reset to logic 0.
- sign flag*—If the result of an arithmetic or logical operation is negative, the sign flag is set to logic 1. If positive, the sign flag is reset to logic 0.
- parity flag*—If the result of an arithmetic or logical operation has even parity, the parity flag is set to logic 1. If odd parity, the parity flag is reset to logic 0.
- carry flag*—If the result of an arithmetic or rotate operation has a carry of the most significant bit of the 8-bit result, the carry flag is set to logic 1. If not, the carry flag is reset to logic 0 after all logical operations.
- auxiliary carry flag*—If the result of an arithmetic operation has a carry of bit-3 into bit-4 of the 8-bit result, the auxiliary carry flag is set to logic 1. If not, the auxiliary carry flag is reset to logic 0 after most logical operations.

* This article is reprinted courtesy American Laboratories. Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University. Mr. Titus is President, Tychon, Inc.

Since insufficient space is available in this column to discuss all of the above flags, we shall restrict our attention to the zero flag.

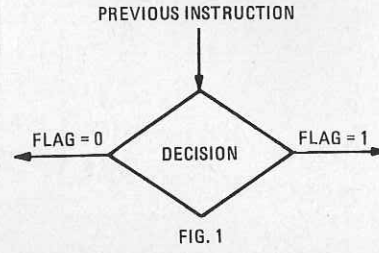
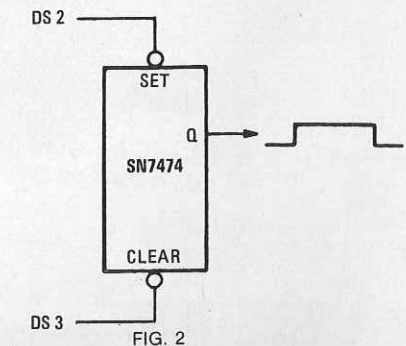


Figure 1 shows the traditional flowchart *decision symbol*. The next instruction that is executed depends upon the logic state of the flag that is associated with this specific decision. For example, consider the JNZ instruction, where JNZ means "Jump If Not Zero."

Instruction code	Mnemonic	Description
302	JNZ	If the zero flag is at logic 0, jump to the 16-bit memory address given in bytes <B2> and <B3> of this three-byte instruction. If the zero flag is at logic 1, ignore this instruction and proceed to the following instruction.
<B2>		
<B3>		

The statement, "Jump If Not Zero," refers to the 8-bit result of a preceding instruction, not the logic state of the zero flag. When this result is zero, the zero flag is set and program control passes to the next instruction.



The JNZ instruction is widely used in the creation of programmed *time-delay loops*, a *continued on page 24*

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example of which is provided in Table 1. In this program, both the address and instruction bytes are in octal code; it is assumed that the HI memory address byte is 000. The program first moves an 8-bit timing byte into register B. This byte, indicated by an asterisk (*) has any value between 000 and 377. The value of the byte will determine the duration of the time delay.

At LO memory address 002, a device-select pulse is generated to set the SN7474 flip-flop shown in Fig. 3. The contents of register B are then decreased by 1. The JNZ instruction immediately tests the logic state of the zero flag. If the contents of register B are not zero, the flag is at logic 0 and a jump occurs back to LO memory address 004. The DCR B and JNZ instructions are executed repeatedly until the contents of register B becomes zero, at which time the zero flag becomes logic 1. The JNZ instruction tests the flag for the last time and shifts program control to the OUT 3 instruction at LO memory address 010. This output instruction generates a device-select pulse that clears the SN7474 flip-flop. Once this has been done, the microcomputer comes to a halt.

The program shown in Table 1 generates a single output-pulse the duration of which can take any value between 0.0125 and 1.925 ms in steps of 0.0075 ms. The calculations associated with the conversion of clock cycles to pulse widths are discussed in the *Bugbook III. Microcomputer Interfacing Experiments Using the Mark 80 Microcomputer, an 8080*

TABLE 1—SIMPLE TIME-DELAY LOOP

LO memory address	Instruction byte	Mnemonic	Clock cycles	Description
000	006	MVI B	7	Move following timing byte into register B
001	*	—	—	Timing byte for register B
002	323	OUT 2	10	Generate device select pulse that sets the SN7474 flip-flop
003	002	—	—	Device code for set input to SN7474 flip-flop
004	005	DCR B	5	Decrement contents of register B by 1
005	302	JNZ	10	If zero flag is at logic 0, jump to the memory address given by the following two address bytes; otherwise, ignore this instruction
006	004	—	—	LO memory address byte
007	000	—	—	HI memory address byte
010	323	OUT 3	10	Generate device select pulse that clears the SN7474 flip-flop
011	003	—	—	Device code for clear input to SN7474 flip-flop
012	166	HLT	7	Halt the microcomputer

System (E&L Instruments, Inc., Derby, Conn., 1975). The number of clock cycles is a measure of the actual time that it takes the microcomputer to execute a single instruction or group of instructions. For a 2 MHz microcomputer, a single clock cycle has a duration of 500 ns.

The program in Table 1 and associated SN7474 flip-flop provide an example of what we mean by "the substitution of hardware by software," viz., a simple program and a single flip-flop replace a much more complicated

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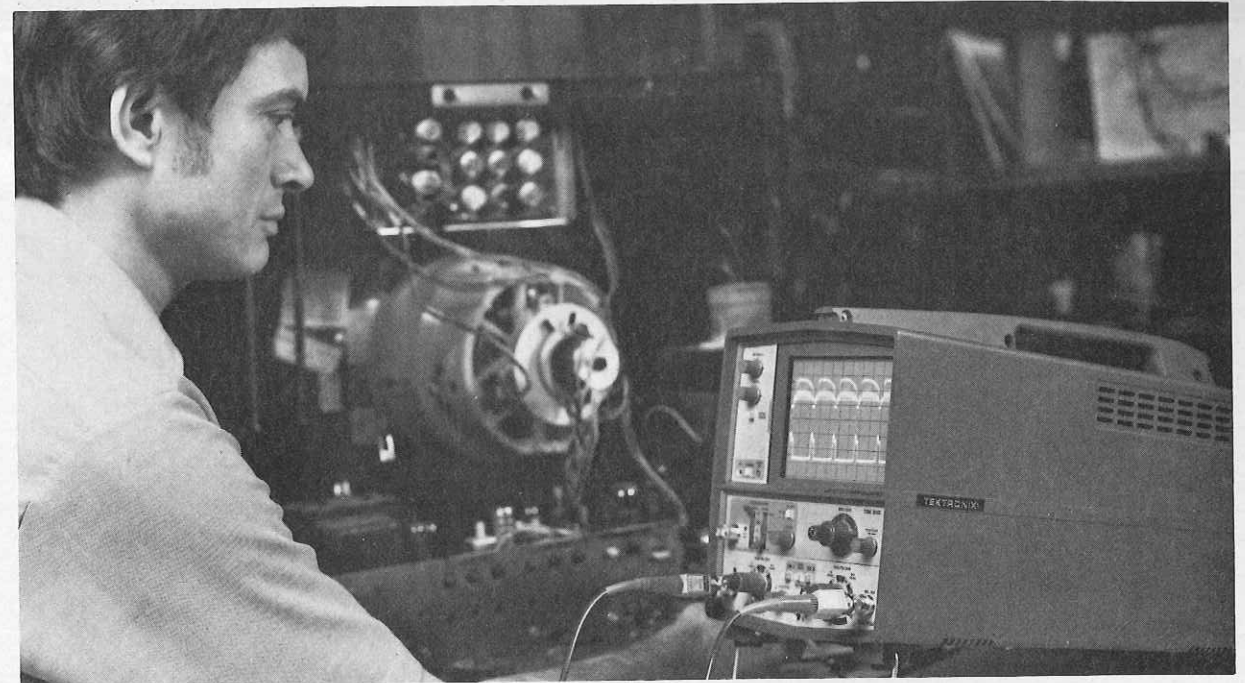
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