KOMPUTER KORNER

PETER RONY, DAVID LARSEN, and JOHN TITUS*

CONTAINED WITHIN THE 78-INSTRUCTION SET OF the 8080 microprocessor IC is the 16-bit OUT instruction. The OUT instruction comprises two successive 8-bit bytes, and can be written in binary notation as 11010011_2 $XXXXXXXX_2$. The OUT instruction can also be written in 8-bit octal code such as 323_8 YYY_8, or in 8-bit hexadecimal code, such as $D3_{16}$ ZZ_{16}. A discussion of how one converts 8-bit binary code into either octal or hexadecimal code can be found in Reference 1.

In the above notations, $XXXXXXXX_2$ represents an 8-bit byte that can range in value from 00000000_2 to 11111111_2; YYY_8 represents a three-digit octal code that can range from 000_8 to 377_8; and ZZ_{16} represents a two-digit hexadecimal code that can range from 00_{16} to FF_{16}. A quick calculation will demonstrate that 11111111_2, 377_8, and FF_{16} all represent the same 8-bit binary word.

* Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University, Blacksburg, Virginia. Mr. Titus is president of Tychon, Inc., Blacksburg, Virginia.

The choice of a coding system is up to you. Binary code is awkward to write and difficult to remember. Octal code is used in the popular Digital Equipment Corporation PDP 8 and PDP 11 minicomputer software and is easy to remember. Hexadecimal code is more natural for an 8-bit binary word and is popular among microprocessor manufacturers. Note well that the way you write the code on paper will not affect the way the microcomputer will execute a program. Both octal and hexadecimal code must be converted back to binary code that is stored in successive 8-bit memory locations. The code conversion can be done in several ways, by hand or by a computer program.

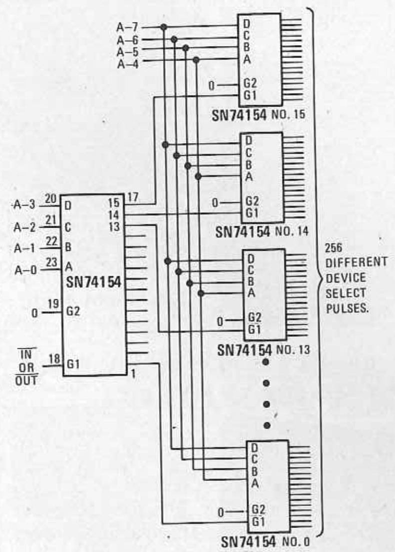

FIG. 1

The second 8-bit byte, $XXXXXXXX_2$, in the 16-bit OUT instruction is the *device code* for the output device. A total of 256_{10} different devices can be addressed with such a code. How this is done is shown in full detail in Fig. 1, a device decoding circuit of seventeen SN74154 IC's. Since this is a rather complicated circuit, let us first discuss the simpler decoding circuit of Fig. 2.

The SN74154 integrated circuit is a 4-line-to-16-line decoder that allows you to input any 4-bit binary word ranging from 0000_2 to 1111_2 and to select any single output among sixteen different output channels labeled 0 to 15_{10}. G1 and G2 are the *strobe* or *gating* inputs to this chip. When these inputs are both at logic 0, the SN74154 IC is *enabled* and the output channel that corresponds to the binary input at pins 20 to 23 is at logic 0. When either G1 or G2 is at logic 1, the SN74154 IC is *disabled*–inoperative–and all sixteen output channels are at logic 1 irrespective of the binary input at pins 20 to 23.

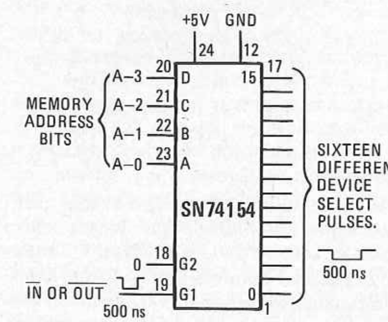

FIG. 2

The basic trick that the 8080 microcomputer employs is to *enable* the SN74154 chip for a very short period of time, 500 ns to be exact. This is done with the aid of a negative clock pulse at G1. This negative clock pulse, called $\overline{IN}$ or $\overline{OUT}$ in Reference 1 or $\overline{I/O\ R}$ or $\overline{I/O\ W}$ in the Intel Corporation literature[2], is generated by the microprocessor chip with the aid of some additional circuitry. $\overline{IN}$ and $\overline{I/O\ R}$ refer to the 16-bit IN instruction; $\overline{OUT}$ and $\overline{I/O\ W}$ refer to the 16-bit OUT instruction that we are discussing in this column. During this 500-ns period of time, the device code appears on the *memory address bus* and can be used as inputs to the SN74154 chip to select a desired output channel.

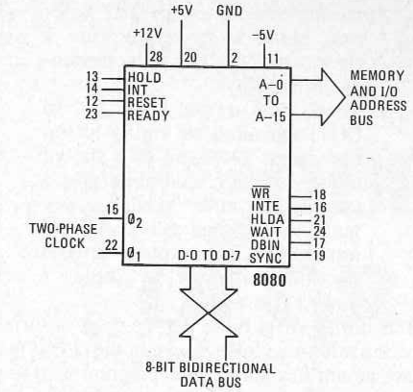

FIG. 3

The memory address bus is a group of 16 output pins on the 40-pin 8080 integrated circuit chip (Fig. 3). A *bus* can be defined as:

bus—A path over which digital information is transferred from any of several sources to any of several destinations. Only one transfer of information can take place at any one time. While such transfer is taking place, all other sources that are tied to the bus must be disabled.

The important point here is that two types of information can appear on the 16-bit memory address bus; either the 16-bit memory address for a memory location addressed by the 8080 microprocessor chip, or the 8-bit device code in the second 8-bit byte of an IN or OUT microprocessor instruction, but not both at the same time. The IN or OUT microprocessor instruction requires 5 μs for execution, and the device code appears only during the last 1.5 μs of this time. When the device code appears on the memory address bus, the bus is subdivided into two 8-bit bytes, each byte containing the address code. Thus, you have your choice of bits A-0 through A-7 or A-8 through A-15 for the device code.

This 8-bit device code is connected directly to one or a group of SN74L154 IC's, as is shown in Figs. 1 and 2. In Fig. 2, only four of the eight bits are used, whereas in Fig. 1, all

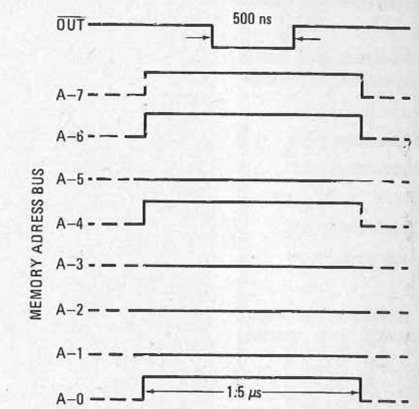

FIG. 4

eight bits are decoded into 256_{10} different output or input device-select pulses. Each output device is addressed uniquely by the $\overline{OUT}$ function pulse and a corresponding 8-bit device code. The same is true for each input device, only the $\overline{IN}$ function pulse is employed instead of the $\overline{OUT}$ function pulse at the gating input G1 to the SN74154 IC. Each device select pulse lasts for only 500 ns, the time that the SN74154 IC is gated.

Figure 4 is a set of timing diagrams that summarizes the external consequences of the 16-bit OUT instruction:

1. An 8-bit device code appears on the memory address bus, in this case the code for device 11010001_2 or 321_8, for a period of 1.5 μs.
2. During this 1.5 μs, an OUT function pulse is generated for a period of 500 ns as a device-select pulse.
3. These nine output lines (A-0 to $\overline{OUT}$) are used as inputs to the seventeen SN74154 IC's shown in Fig. 1. This circuit generates a 500-ns negative device-select pulse for device 321_8. All the remaining 255_{10} outputs from the decoders remain at logic 1 during this time.

This device-select pulse can be used to turn on the solid-state relay shown in the circuit in last month's column. The program that is analogous to one given previously, is simply:

Memory address	Octal instruction	Description
0	323	Send device-select pulse to device given by the following 8-bit device code
1	321	Device code for clear input to SN7474 flip-flop
2	166	Halt the microcomputer

Summary

We have discussed the interfacing technique called *accumulator I/O*, which is also known as *isolated I/0* in the Intel Corporation literature.[2] A much more exciting interfacing technique is *memory I/O*, which is also known as *memory mapped I/O*,[2] in which an I/O device appears to the microcomputer CPU as a simple memory location. Without question, memory I/O will be the most popular interfacing technique among all the different microprocessor families. One important advantage of this technique is the considerable number of IC's that have already been designed for memory I/O applications. Included among such chips are the 8255 programmable peripheral interface, the 8251 universal synchronous/asynchronous receiver/transmitter (USART), the MC6820 peripheral interface adapter, and the XC6850 asynchronous communications interface adapter. We shall discuss this alternative I/O technique in a future column. **R-E**

References:

1. *Bugbook III. Microcomputer Interfacing Experiments Using the Mark 80 Microcomputer, an 8080 System,* E&L Instruments, Inc., Derby, CT, 1975.
2. *Intel 8080 Microcomputer Systems User's Manual,* Intel Corporation, Santa Clara, CA, 1975.

Japan moves toward fiber optics for national two-way cable TV system

An experimental interactive (two-way) CATV network that could eventually provide every household in Japan with services ranging from request entertainment to police and fire protection began test operation on November 15.

The field trial is taking place in Higashi Ikoma, a model city near Osaka. The Higashi Ikoma optical video information system gives the project its name, HI-OVIS. The field trial will supply information that can be used to extend the system to the entire country.

The project was begun in 1972. At that time, no problems were seen in the way of an interactive system using a variety of computer-controlled communications units, but during development the limitations of a coaxial-cable system emerged. The bulk, cost and relatively narrow transmission area per cross-section of cable were obstructions to the geographical scope, multichannel requirements and future flexibility of the net.

The possibilities of optical lines, at that time thought to be ten years from practical use, were considered, and the services of Arthur D. Little, a research organization that was independently exploring the near-term future of optical technology, were engaged. The American-based organization reported that optical-fiber technology had not only progressed far enough to be utilized, but was ideally suited to the combination of analog and digital signals and varying bandwidths of the communications media in the HI-OVIS project.

Besides the usual television screen, the home-centered system will have a keyboard that may be used for a number of purposes. These will include request TV programs; request data (supplied in still-picture form and providing various types of specialized information, including news); facsimile; computer-assisted instruction, for both children and adults; cashless transactions, such as payment of utility bills; TV shopping and reservations.

TV retransmission and independent broadcasts will be available. These would include re-runs of current CATV programs, plus such special items as stock market broadcasts, not included in the regular CATV programs. In addition, FM broadcast and request FM transmissions can be supplied.

The system will include a protection service. Detectors will be installed in each home to detect intrusions, heat, smoke, etc., and respond to the appropriate agency.

After the Higashi Ikoma field trial the Japanese government plans to extend the system to the series of small cities—of no more than 100,000 residents—being established around crowded population centers, such as the Tokyo-Osaka corridor. The new system will play an important part in this "String of Pearls" concept by linking the cities with mainstream programming, while also serving communal and regional needs. The "wired cities" will give people a wider and more comfortable choice of homesites without cultural isolation.

Metric system being accepted by 67 percent of manufacturers

A gradual switch toward the metric system for dimension of products is taking place in electronic manufacturing, reports the Distributor Products Division of the Electronic Industries Association (DPD,EIA). Out of 106 manufacturers replying to a recent EIA survey, more than half had established a formal policy for conversion, and some 67 percent are now making some items to metric dimensions.

There are some obstacles in the way of speedy conversion, most notable of them being cost and psychological difficulties. One manufacturer reported that he was making items to metric measurements "when he had to," and another reported converting English measurements to metric. But at least one is using metric measurements as fundamental and converting to English for domestic buyers. (That way the queer fractions appear in the inch and foot, rather than the meter and centimeter measurements.)

The electronics technicians who will work with the new dimensions, and who already find it easier to say "100 K" than "100 thousand" will probably have no difficulties.