KOMPUTER KORNER

How to interface the microcomputer with input/output devices.

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THE VARIOUS DATA PATHS IN A MICROCOMPUTER consists of the data input, data output, external device addressing, in and out function pulses, and interrupt signals. These are the vital lines of communication between the microcomputer and the "outside world", for example, those signal lines that are necessary to interface the microprocessing unit (MPU) to the input/output or I/O devices that you would like to control.

What is an I/O device?

Some useful definitions include the following:

input/output—General term for the equipment used to communicate with a computer and the data involved in the communication.[1]

I/O—Abbreviation for input-output.[2]

I/O device—Input/output device. Any digital device, including a single integrated-circuit, that transmits data to or receives data or strobe pulses from a computer. The in and out functions are always referenced to the computer.[3]

The traditional view of an I/O device is that it is somewhat large or complex. Card readers, magnetic tape units, cathode-ray tube displays and teletypes certainly fit such a description. However, a single integrated circuit such as a latch, shift register, counter or small memory can also be considered to be an I/O device to a computer.

Another important point is that several device-select pulses may be required to interface a single I/O device. For example, a 74198 shift register has a pair of control inputs that determine whether the register shifts left, shifts right, or parallel-loads 8-bits of data. This IC also has a clock input and a clear input. Thus a single 74198, when serving as an output device, may require up to four device-select lines from the microcomputer. Therefore, the fact that we can generate 256 different input and 256 different output device-select pulses does not necessarily mean that we can address 512 different "devices." A more reasonable number is of the order of 50 to 100 different devices.

Device-select pulses are inexpensive and easy to implement. We encourage you to use them as often as possible as you attempt to substitute computer software for integrated circuit hardware. We shall repeat this theme often: software vs. hardware. There exists a tradeoff between the two, but your main objective in using microcomputers will usually be to substitute software for hardware. When you do so, the only penalty that you may pay is time—it takes time to execute computer instructions. If you can accept the delays inherent in computer programs, then you can vastly simplify the circuitry required to accomplish a specific interfacing task.

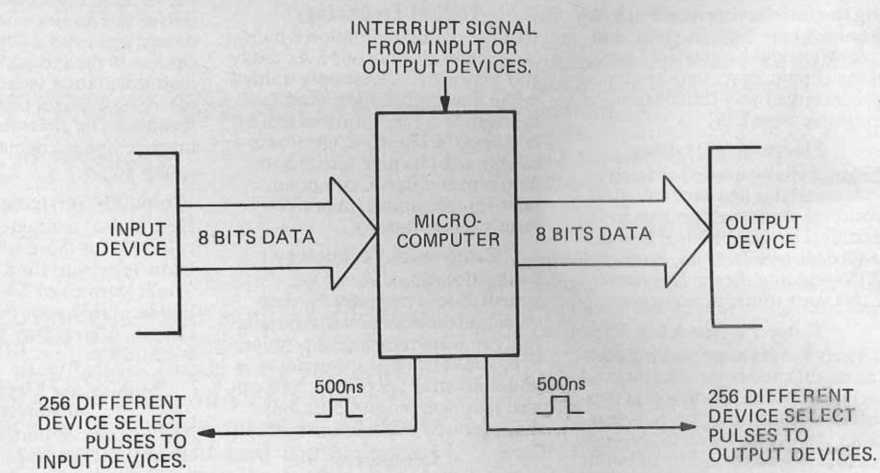

FIG. 1

Interfacing

Interfacing can be defined as the joining of members of a group (such as people, instruments, etc.) in such a way that they are able to function in a compatible and coordinated fashion. By "compatible and coordinated fashion," we usually mean synchronized. Some important definitions include the following:

synchronous—In step or in phase, as applied to two devices or machines. A term applied to a computer where a sequence of operations is controlled by equally spaced clock signals or pulses.[2]

synchronous computer—A digital computer that has all ordinary operations controlled by equally spaced signals from a master clock.[2]

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synchronous operation—Operation of a system under the control of clock pulses.[3]
synchronization pulses—Pulses that are originated by the transmitting equipment and introduced into the receiving equipment to keep the equipment at both locations operating in step.[2]
computer interfacing—The synchronization of digital data transmission between a computer and one or more external input/output devices.[3]

Although the details of computer interfacing vary with the type of computer employed, the general principles of interfacing apply to a wide variety of computers. Such principles include the following:

- The digital data transmitted between a computer and an I/O device are either individual clock pulses or else full data words.
- The computer and the I/O device are both clocked devices. At the very least, the I/O device has a single flip-flop that is set or reset by the computer. All data transmission operations are synchronized to the internal clock of the computer.
- The computer sends synchronization pulses, called device-select pulses, to the I/O device. These pulses are generated by the computer program and are usually quite short—for an 8080 microcomputer operating at 2 MHz, they last for only 500 ns. *The pulses synchronize and select at the same instant of time.*
- Individual device-select pulses are sent to individual input or output devices. This is called *external device addressing*. The pulses are used for latching data output and strobing data input.
- Computer program operation can be interrupted by the transmission of a clock pulse from an I/O device to a special input line to the computer. This is called *interrupt generation*. Upon being interrupted by an external I/O device, the computer goes to a computer subroutine that responds to, or *services*, the interrupt.
- Full data words can be output from, or input into, the accumulator register. For the 8080 microcomputer, a full data word contains 8 bits. Output data from the accumulator is available for only a very short period of time and usually must be latched. Input data into the accumulator is acquired over a very short period of time and usually must be strobed into the accumulator.

Interfacing basically consists of the synchronization of parallel input or output data via the use of the 512 device-select pulses. (See Fig. 1.) Hardware is required to tie the MPU to the external device and is just as important as the microcomputer software. We shall tackle both of these facets of microcomputer interfacing in detail in subsequent columns. **R-E**

References

1. *Microprogramming Handbook* (Santa Ana, CA: Microdata Corporation, 1971).
2. Rudolf F. Graf, *Modern Dictionary of Electronics*, Howard W. Sams and Company, Inc., Indianapolis, IN, 1972.
3. *Bugbook III* (Derby, CT: E & L Instruments, 1975).

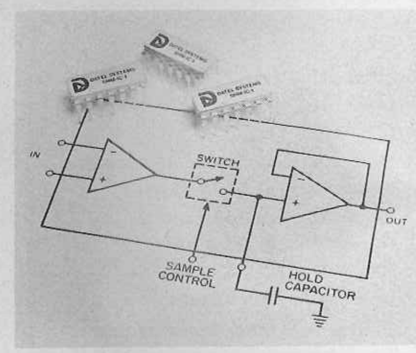
Solid-State News

National Semiconductor has submitted a 4K RAM memory that is different from the competition.

The MM5270 Tri-Share™ 4096 × 1 bit RAM is packaged in an 18 pin DIP in contrast to the industry standard 22 pin packages. Three functions share the use of a single lead—read/write, logical chip select and V_{cc}. One lead is also used for both data input and output.

The 18-pin packages can be squeezed in with a density nearly twice that possible with the 22-pin packages. National claims memory system costs are kept low because of the savings in PC cards, card frames, connectors and wiring. The cost of the memory package itself is lower. The access and cycle times are 200 ns and 400 ns, respectively.

RCA has also joined the NMOS memory field with the MW7001ID 1024 x 1 bit static RAM. The device is pin compatible with the AMS7001I and has a 60 ns maximum access-time and 180 ns maximum cycle-time. Also planned is a 4096 bit dynamic RAM.



DATEL SYSTEMS SHM-IC-1 high performance sample-and-hold.

Both the National and RCA chips are TTL compatible except for the chip select input.

The SHM-IC-1 from Datel Systems is a high performance sample-and-hold that uses only an external storage capacitor. Sample-and-hold systems are used in sampled data control systems, in the reconstruction of sampled waveforms and for data acquisition.

Acquisition time is 4μs with a .001 μF capacitor; the signal droop is 50 mV/s. The capacitor can be lowered to 100 pF for a faster 2 μs acquisition time, but droop also increases in the same ratio.

Three blocks make up the sample and hold. A high gain input differential amplifier, the electronic sampling switch, and an output buffer amplifier. The SHM-IC-1 sells for $29 in small quantities.