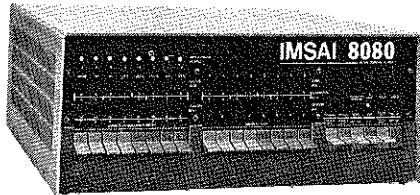


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CIRCLE 40 ON FREE INFORMATION CARD

KOMPUTER KORNER

PAUL E. FIELD, DAVID G. LARSEN,
PETER R. RONY, and JONATHAN A.
TITUS*

THIS MONTH, WE RETURN TO THE SUBJECT OF the substitution of software for hardware, *i.e.*, the substitution of machine-level routines and subroutines for specific digital hardware devices that store, manipulate, transmit, or receive digital information. The hardware device that we will discuss is the universal asynchronous receiver/transmitter, or UART—a 40-pin integrated circuit that contains an independent 8-bit asynchronous receiver and an independent 8-bit asynchronous transmitter. Data rates range from DC to 60,000 bits per second. The receiver and transmitter sections of the IC can be programmed for 5, 6, 7, or 8 data bits; 1 or 2 stop bits; even or odd parity; and parity or no parity. The IC contains a variety of flags.

An interface circuit for a simplified *software* UART is shown in Fig. 1. Owing to the nature of the specific application that the circuit was designed for, there was no need for special flag-bits or error checking. Thus, the interface circuit consists of a single three-state input buffer gate (SN74126), a single output data-latch (SN7474), two input device-select pulses, and one output device-

select pulse. With appropriate modifications of the device select pulses, this circuit can be used with almost any microprocessor IC. In our case, an 8080A-based microcomputer

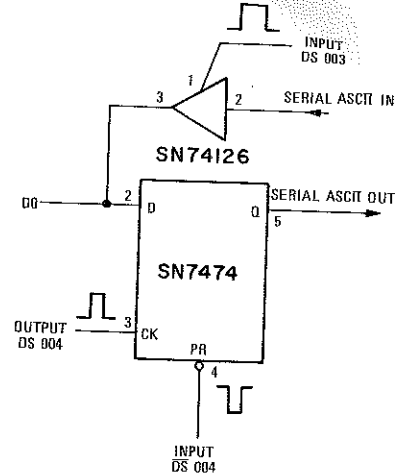


FIG. 1

TABLE 1—MICROCOMPUTER SUBROUTINE that demonstrates the asynchronous serial transmission of an eleven-bit ASCII word at a teletype speed of 110 Baud.

| LO memory address | Instruction byte | Mnemonic | Description |
|-------------------|------------------|----------|---|
| • | • | • | • |
| • | • | • | • |
| • | • | • | • |
| • | • | • | • |
| • | • | • | • |
| 144 | 056 | MVI L | Accumulator contains 8-bit ASCII word. Bit 8 is the parity bit that can be set for even or odd parity, or no parity. |
| 145 | 013 | 013 | Set ASCII word bit counter to 013 |
| 146 | 267 | ORA A | Set carry bit to logic 0 |
| 147 | 027 | RAL | Rotate carry bit to DO in accumulator |
| 150 | 323 | OUT | Output carry bit to SN7474 latch |
| 151 | 004 | 004 | |
| 152 | 315 | CALL | Call 9.09 ms time-delay subroutine |
| 153 | 'B2' | 'B2' | LO address byte of time-delay subroutine |
| 154 | 'B3' | 'B3' | HI address byte of time-delay subroutine |
| 155 | 037 | RAR | Rotate bit in ASCII word to DO in accumulator |
| 156 | 067 | STC | Set carry bit to logic 1 |
| 157 | 323 | OUT | Output bit to SN7474 latch |
| 160 | 004 | 004 | |
| 161 | 055 | DCR L | Decrement bit counter by 1 |
| 162 | 302 | JNZ | If bit counter has a value of zero, ignore this instruction. If all of the bits in the 11-bit ASCII word have not yet been transmitted, jump to address LO = 152 above. |
| 163 | 152 | 152 | LO address byte |
| 164 | 'B3' | 'B3' | HI address byte |
| • | • | • | • |
| • | • | • | • |
| • | • | • | • |
| • | • | • | • |
| • | • | • | • |

*This article is reprinted courtesy American Laboratories. Dr. Field and Mr. Larsen, Department of Chemistry, and Dr. Rony, Department of Chemical Engineering, are with the Virginia Polytechnic Institute & State University. Mr. Titus is president of Tycho, Inc. Dr. Field is guest author of this month's column.

operating at 750 kHz was used. This generates and detects, asynchronous serial ASCH-coded 5-volt TTL data. For teletype operation, additional hardware is required to convert the 5-volt logic levels to 20 mA current-loop operation.

continued on page 24

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KOMPUTER KORNER continued from page 22

Transmit subroutine

The transmit subroutine, shown in Table 1, for the software UART occupies twenty to twenty-five successive program steps in memory once the appropriate PUSH, POP, and RET instructions have been included. Also required is a 9.09 ms time-delay subroutine that corresponds to an asynchronous serial ASCII data transmission rate of 110 Baud, i.e., teletype speed. The program in Table 1 can be described as follows:

Register L is used as the bit counter for the 11-bit ASCII word, and is set initially to octal 013. The seven data-bits plus the parity bit, which is Bit 8, are assumed to be present in the accumulator. At the LO memory address 146, the accumulator is OR'ed to itself to clear the carry bit (shown on the far left in Fig. 2.) In Fig. 2, the least significant data bit

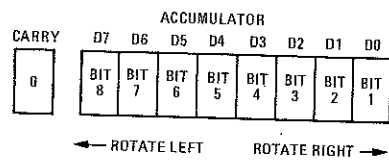
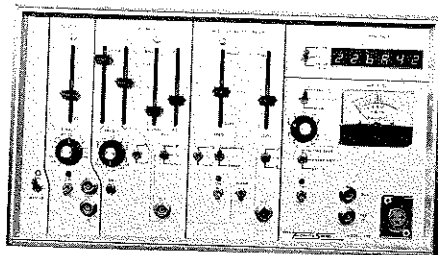


FIG. 2

is Bit 1. At address LO = 147, a RAL instruction is performed to rotate the start bit to bit position D0 in the accumulator. Fig. 3 should provide you with assistance in understanding the four different rotate instructions



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in the 8080A microprocessor instruction set. At address LO = 150, the start bit is output to the SN7474 data latch. The program then goes into a 9.09 ms time-delay subroutine, after which Bit 1 is rotated into

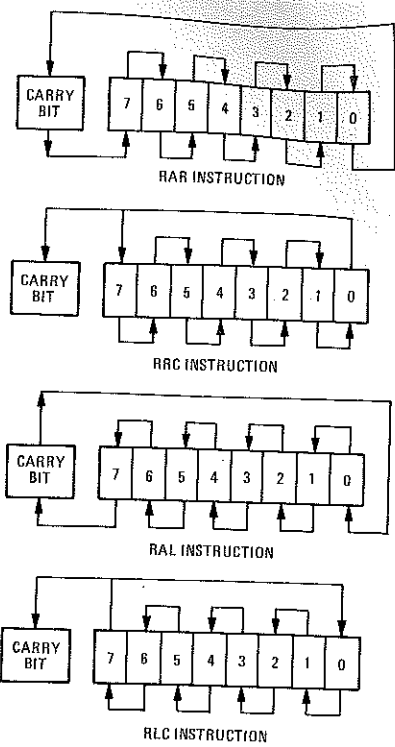


FIG. 3

the D0 accumulator position and the carry bit is set to logic 1. Bit 1 is fed to the SN7474 latch, the ASCII word bit counter in register L is decremented and program control is returned to the time-delay subroutine that is called at address LO = 152. The loop from LO = 152 to LO = 164 is executed a total of eleven times, after which register L becomes zero and the JNZ instruction at address LO = 162 is ignored.

A software UART transmit subroutine possesses a flexibility equivalent to the original 40-pin UART chip. With appropriate modifications to the program or the original accumulator data, you can transmit 5, 6, 7, or 8 data bits; 1 or 2 stop bits; even or odd parity; and parity or no parity. The time-delay subroutine can be modified so that you can transmit at data rates from 60 to 9600 Baud for a 750-kHz clock rate and higher for 2-MHz and 4-MHz clock rates.

The conversion from one data transmission rate to another is easily accomplished with the aid of appropriate software time-delay subroutines that replace R-C time-constant circuits. An additional advantage that is gained from the use of software is the potential to perform code conversions. For example, 5-level Baudot KSR machines are in widespread use and can still be obtained for under \$50. It is not too difficult to develop software that converts ASCII to Baudot and thus produce an inexpensive hard-copy terminal for the laboratory scientist, engineer, ham or computer buff.

Receive subroutine

The software UART receive subroutine requires 50 instructions and will not be repeated here. (Copies of the transmit and receive subroutines and a description of the

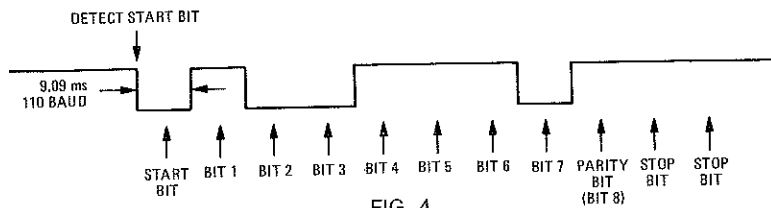


FIG. 4

smart data-entry station are available from Professor Paul Field, Department of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.) The basic programming concepts associated with the receive subroutine are shown in Fig. 4, which represents an 11-bit asynchronous serial ASCII word that is being detected by the 8080A-based microcomputer with the aid of the SN74126 three-state buffer gate shown in Fig. 1. The program repeatedly tests the serial ASCII input line for a logic 0 state. Once a logic 0 state is detected, which corresponds to a start bit, the program goes into a 4.54-ms wait loop. Upon leaving the wait loop, the program again inputs the logic 0 into bit position D0 in the accumulator, thus testing the validity of the start bit. The start bit is rotated to the carry bit and the program then enters a 9.09-ms wait loop, after which it inputs Bit 1 into position D0 in the accumulator. Register H is used as the SAVE register that stores the growing ASCII data word. The SAVE register is rotated one position, and the 9.09-ms wait loop is again entered, after which Bit 2 (a logic 0 in Fig. 4) is input into bit position D0 in the accumulator. The input of successive data and parity bits continues until the entire 8-bit data word is entered into the SAVE register. The two stop bits are also detected. With appropriate modifications, the program can detect parity or framing errors or an overrun condition. A data-ready flag signal can also be generated from software with the aid of a second SN7474 latch.

TIMESHARE

continued from page 67

able A and the second value to B. Line 20 assigns to variable C the value of the square root of the sum of the two entered values to the third power. Line 30 outputs the value of C to the terminal. Line 40 transfers execution back to line 10, and you're ready to execute the problem for two new values.

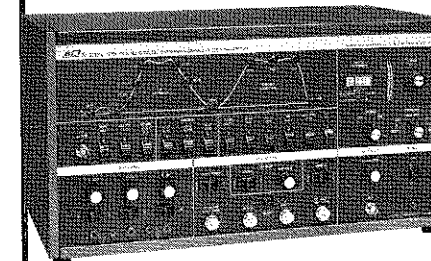
When you have all the results you require, you push the ESC key (escape) to stop the program, then sign off or enter a new program.

Notice the similarity between BASIC and English:

- INPUT—to input a value for a variable
- LET—to let a variable equal a value
- PRINT—to print the results at the terminal
- GOTO—to go to another part of the program.

This similarity exists throughout the BASIC language, which makes it ideal for people who are not computer programmers but need or desire to use a computer.

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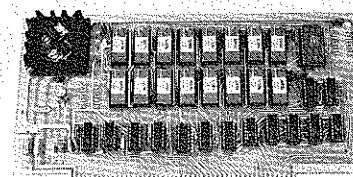
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