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# Expand Your KIM!

## *Part 4: a TTY substitute*

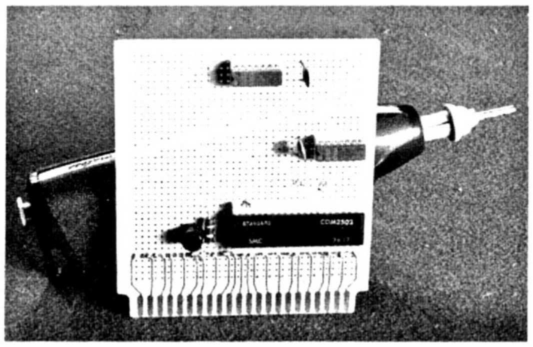
*Photo 1. This $10 circuit makes an SWTP keyboard and PR-40 printer act like a miniature Teletype.*

Even if you are not building the KIM-1 System described in the first three parts of this series, you may find this article interesting and useful.

The first section is devoted to converting the SWTP keyboard and PR-40 printer into a low-cost ($310) teletypewriter. The latter portion of the article describes a method for adding an external keyboard and display to KIM.

In the KIM-1 System, many useful subroutines, including I/O, are provided in ROM. These routines operate over the KIM 20 mA TTY interface lines. The cost of even a reconditioned TTY was prohibitive for me, and besides, the PR-40 printer was better suited to my requirement of portability.

To take full advantage of the ROM I/O routines, and to avoid using KIM's two non-dedicated I/O ports, I set out to construct a 20 mA serial interface for the PR-40 and the SWTP keyboard.

**Overview**

Since the interface would deal primarily with TTL signals on both ends, I eliminated the optical isolation often found on other interfaces. My baud-rate frequency would be far from critical, since KIM automatically adjusts its software timing to match the incoming signal. These considerations made possible a simple interface consisting of only three chips and one transistor.

The advantages of the KIM self-adjusting I/O routines are obvious, but, as it turns out, disadvantages are also present. The KIM-1 System utilizes a Dazzler for its video display (see last month's article), which puts the processor into a hold approximately 20 percent of the time so it may gain access to the bus for DMA. This delay creates the probability that the characters transferred during Dazzler operation will have faulty timing.

In addition, during observation of the above symptoms I found that the cable positions and mainframe wiring placement held potential noise problems from the Dazzler that could affect serial transfers. There are many methods of correcting either problem, but most corrections are more applicable to mass production where the designer will know the location of every wire and the length of each cable.

Not having this control over systems built by *Kilobaud* readers, I chose to shut off the Dazzler during all transfers of serial data, thus eliminating any possible timing or noise problems that might be introduced by the DMA operations.

Stopping the Dazzler naturally causes the video display to blank during data transfers; but since I'm transferring data at just over 5200 baud, the display only blanks for 2.1 ms, which is not noticeable.

This high data rate does provide a potential problem with the printer during carriage returns. The printer has a 40-character buffer memory and can accept data faster than any microprocessor can send it. However, during the carriage return (about one second), the inputs to the buffer are locked out, and any data transferred at that time is lost.

Most systems (including KIM) correct this problem by sending several nonfunctioning characters, such as nulls, after each carriage return, just to take up time. Although this works well for the standard TTY rate of 110 baud, it would take nearly 500 nulls for a one-second delay at 5200 baud.

I corrected this situation by putting the processor into a hold (thus stopping transfers) whenever a carriage return was in effect. Although I lose one second of processor time during carriage returns, I can load the buffer memory in only 85 ms as opposed to four seconds required at 110 baud. Obviously, I have increased my throughput time by as much as 500 percent with this method. One function of the interface is to convert the parallel data from the keyboard to compatible serial data for KIM. Compatible, in this case, means

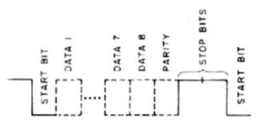

*Fig. 1. Timing detail for serial transfers.*

adding a start bit and two stop bits to each data word.

The serial data line normally remains at the high (logic 1) level, and a high-to-low transition (the start bit) is used to indicate the beginning of a new word of data. The high and low levels are often referred to, respectively, as marks and spaces.

Two stop bits (marks) follow the actual data. It should be noted that all words contain the same number of data bits, and the stop bits are *not* used to indicate the end of a word. The stop bits have two functions. First, if either of the stop bits happens to be a zero, a framing error (timing) is probably indicated. Second, if the data words are following each other without an elapsed time between them, the mark condition of the stop bits assures that the negative edge of the start bit will be properly recognized. If this is not clear, imagine two words without stop bits in which the last bit of word one was a space. Obviously, if a mark-to-space transition is to be recognized, the line must return to the mark condition before the second word. Fig. 1 shows the timing for the serial data.

The second function of the interface is exactly opposite of the parallel-to-serial conversion just described. It is to convert the serial data (coming from KIM) to the parallel data required by the printer, and the generation of a strobe to initiate the actual parallel transfer.

Generally, the above functions could be implemented with shift registers under proper control. Fortunately, the shift registers and the control circuitry are available in a single chip called a universal asynchronous receiver transmitter (UART).

I chose a 2502 UART because of its low cost, but most any will do if you study its data sheets and utilize it properly. Table 1 lists the pin usages for the 2502. Just remember that the UART is simply doing serial-to-parallel and parallel-to-serial conversions.

Fig. 2 is a page from my notebook showing the schematic of the interface, component placement and pinout designations. The circuit is built on a 44-pin board (see Photo 1).

## How It Works

The operation of the interface is simple: The 7492 is used as a divide-by-12 counter to lower the frequency applied to the UART.

The serial data coming from KIM is from an open collector NAND gate. When a logic 1 is being output to the printer, this gate has a low output, thus sinking the 20 mA signal provided by the printer return. I shorted the gate output and the return together (pins 6 and 8 on the interface card) causing the gate to act as standard TTL, except that the signal is inverted. I used gate A1 (see schematic) to invert this signal so the UART was receiving the correct information.

The UART converts the serial data from A1 to parallel and sends it to the printer under control of the high-level strobe (UART pin 19). Gate A2 converts this signal to the low-level strobe required by the printer.

The keyboard inputs its parallel data by pulsing the UART pin 23. The serial output is used to control the conduction of transistor $Q_1$, which can be almost any NPN transistor. The transistor simply makes and breaks the 20 mA input loop on KIM.

Gate A3 inverts the low-level KIM reset to a high-level pulse for the UART.

Gate A4 is used as a buffer (pin 2 of the interface card is shorted to ground when the Dazzler power switch is off). Since pin 2 connects to the S-100 clear, *either* the Dazzler power switch or the depression of a key will cause the Dazzler to halt the DMA operations, thus preventing possible noise and timing problems as described earlier. Naturally, since the Dazzler is turned off when a key is pressed, it must be turned back on when the character

| Pin | Function |
|---|---|
| 1 | 5 volt supply. |
| 2 | -12 volt supply. |
| 3 | Ground. |
| 4 | Grounded to keep parallel outputs enabled. |
| 5-12 | Parallel outputs. |
| 13 | High-level output indicates parity error (not used). |
| 14 | High-level output indicates framing error (not used). |
| 15 | High-level output indicates parallel outputs are not taken before new character is received (not used). |
| 16 | Grounded to enable outputs of pins 13, 14, 15, 19 and 22. |
| 17 | Clock input (output baud rate is 1/16 of this frequency). |
| 18 | Low-level input resets pin 19 to a low level. |
| 19 | High-level output indicates the parallel outputs are valid. |
| 20 | Serial input. |
| 21 | High-level pulse causes Master Reset. |
| 22 | High level indicates parallel input buffer empty ( not used). |
| 23 | Low-level pulse enters parallel data. |
| 24 | High-level output between serial transmissions (not used). |
| 25 | Serial output. |
| 26-33 | Parallel inputs. |
| 34 | High level enables pins 35, 36, 37, 38 and 39. |
| 35 | High level eliminates parity. |
| 36 | High level sets two stop bits. |
| 37-38 | High levels indicate eight-bit character. |
| 39 | Indicates even or odd parity (not used). |
| 40 | Clock input (must be 16 times baud rate). |

*Table 1. Pin functions for the 2502 UART.*

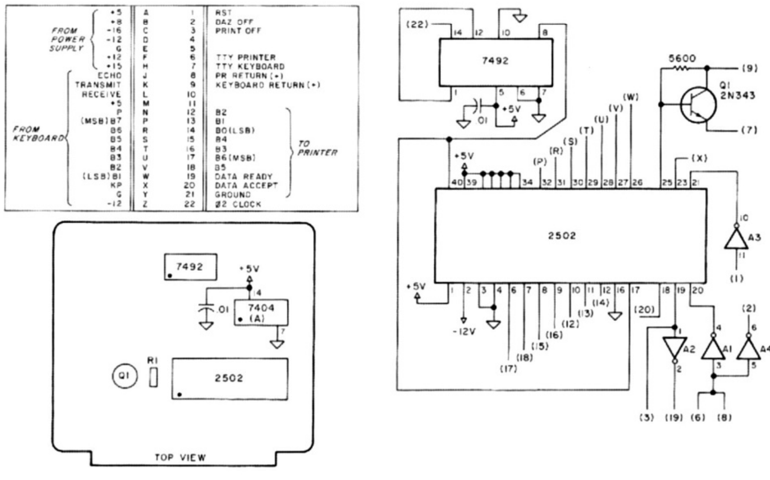

*Fig. 2. Interface schematic.*

has been transferred. The software example later in this article shows how this can be accomplished.

Note that when pin 3 of the interface card is shorted to ground by the Print power switch, transfers to the printer will be inhibited because the UART strobe signal is eliminated.

If you are constructing the KIM-1 System, do not pass lightly over these switch configurations since they provide useful functions that are not readily obvious.

Since the four TTY lines from KIM also connect to banana plugs on the backplane, an auxiliary TTY or video display may be easily connected to the system. The only requirement is that the

```
Address   Instruction     Label     Mnemonic          Comment
0300      D8              INIT      CLD               Select binary mode.
  01      A9  00                    LDA #$00
  03      85  00                    STA Color         Clear color.
  05      A9  10                    LDA #$10          Sets Dazzler to a
  07      8D  0F  80                STA DAZ1          32 x 32 color mode.
  0A      A9  90                    LDA #$90          Sets starting address
  0C      8D  0E  80                STA DAZ2          for display to page 20.
        ; Stores color in all of display area.
  0F      A2  FF          ALL       LDX #$FF          Initialize Index X.
  11      A5  00          ALL1      LDA Color         Get color.
  13      9D  00  20                STA(2000),x       Store according to x.
  16      8A                        TXA               Get index.
  17      F0  04                    BEQ INTEN         Branch if finished.
  19      CA                        DEX               Decrement x if not.
  1A      4C  11  03                JMP ALL1          Do it again.
  1D      20  7C  03      INTEN     JSR INPUT         Input from keyboard.
  20      CA  48                    CMP "H"           Is character an "H"
  22      F0  05                    BEQ HIGH          Branch if yes.
  24      A9  00                    LDA 00            Prepare for low intensity.
  26      4C  2B  03                JMP LOW           Go around high.
  29      A9  08          HIGH      LDA #$08          Set high intensity bit.
  2B      85  00          LOW       STA Color         Save intensity.
  2D      20  7C  03      SHADE     JSR INPUT         Get shade.
  30      29  07                    AND #$07          Change ASCII to binary.
  32      05  00                    OR Color          Combine shade and intensity.
  34      85  00                    STA Color         Save color (right byte)
  36      0A              ASL
  37      0A              ASL                         Form color in
  38      0A              ASL                         left byte.
  39      0A              ASL
  3A      05  00                    ORA Color         Combine left and right.
  3C      85  00                    STA Color         True full color.
  3E      9D  00  20      STORE     STA(2000),x       Puts color on display.
        ; Decodes next command.
  41      20  7C  03      DECODE    JSR INPUT         Get command.
  44      C9  4E                    CMP "N"           Is it an "N"
  46      D0  03                    BNE NEXTA         Branch if not
  48      4C  1C  03                JMP INTEN         Prepare for new color.
  4B      C9  41          NEXTA     CMP "A"           Is it an "A?"
  4D      D0  03                    BNE NEXTU         Branch if not.
  4F      4C  0F  03                JMP ALL           Jump if yes.
  52      C9  55          NEXTU     CMP U             Is it a "U?"
  54      D0  08                    BNE NEXTD         Branch if not.
  56      8A                        TXA               Prepare to change pointer.
        ; Move pointer vertically
  57      38                        SEC               Prepare to subtract.
  58      E9  10                    SBC #16           Subtract
  5A      AA                        TAX               Restore pointer.
  5B      4C  77  03                JMP CONTIN        Continue
  5E      C9  44          NEXTD     CMP "D"           Is it a "D?"
  60      D0  08                    BNE NEXTL         Branch if not.
  62      8A                        TXA               Prepare to change pointer.
  63      18                        CLC               Prepare to add.
  64      69  10                    ADC #16           ADD
  66      AA                        TAX               Restore pointer.
  67      4C  77  03                JMP CONTIN        Continue
  6A      C9  4C          NEXTL     CMP "L"           Is it an "L?"
  6C      D0  04                    BNE NEXTR         Branch if not.
  6E      CA                        DEX               Modify pointer.
  6F      4C  77  03                JMP CONTIN        Continue
  72      C9  52          NEXTR     CMP "R"           Is it an "R?"
  74      D0  01                    BNE CONTIN        Branch if not.
  76      E8                        INX               Modify pointer.
  77      A5  00          CONTIN    LDA Color         Get color.
  79      4C  3E  03                JMP STORE         Start over.
        ; Subroutine to get character and turn Dazzler back on
  7C      20  5A  1E      INPUT     JSR GETCHAR
  7F      85  01                    STA TEMP          Save accumulator.
  81      A9  90                    LDA #$90
                                                      Turns Dazzler on.
  83      8D  0E  80                STA DAZZ
  86      A5  01                    LDA TEMP          Restores accumulator.
  88      60                        RTS
```

*Program listing.*

UART card be removed from the mainframe.

Since the SWTP keyboard does not have a rubout (DEL) key, one will have to be added. The rubout signal is used by KIM to measure the incoming baud rate.

The keyboard has an unused key in the bottom right-hand corner. If the two terminals of this key are connected to lines Y-10 and X-3 (refer to your keyboard schematic), it will become a rubout.

The instructions for the keyboard also indicate that a jumper be used to select uppercase or uppercase and lowercase letters. Auxiliary switch 1 on the KIM System front panel can be used for this so that either mode can be easily selected.

**Some Demo Software**

Fig. 3 is the flowchart of a simple program that will enable you to "draw" on the top half of your TV screen using the keyboard. The program is intended only to demonstrate some of the KIM-1 System peripherals. Study the flowchart and try to rewrite the program to utilize the entire screen.

To load the program, set auxiliary switch 3 low so that the hex keypad is operational. Once loaded, set the address to 0300 and set auxiliary switch 3 to the high position. This will cause KIM to enter the TTY mode. Set the Print power switch high so that the printer will be enabled. Press RST and Rubout. KIM should then respond on the printer with the letters KIM.

Set the Dazzler power switch high and type a capital G to begin execution of the program. Type H or L for high or low intensity and then a number between 0 and 7 to select the color. The screen should show that color in the upper left-hand corner. Typing U, D, L or R will move the color up, down, left or right, respectively, drawing a line as it moves.

Typing A colors *all* the screen to the present color and returns the present position to the lower right-hand corner.

Typing N prepares the program to accept a new intensity and color.

A thorough study of the program should help the reader to utilize the keyboard and the Dazzler with his own programs.

Note that if the Print power switch is turned off, everything still functions properly, and the hard-copy output is eliminated.

**External Display and Hex Keyboard**

The remainder of this article deals with adding an external display and hex keyboard to KIM. Many people may feel that since the ASCII keyboard also provides the ability to load hex numbers, this step would really not be necessary.

Remember, however, that the hex keyboard has several additional functions such as RST, NMI interrupt and single step. Also, I find it much easier to use than the ASCII keyboard if I'm entering only hex data. Finally, there are many games available that utilize the KIM keyboard and display.

When I first looked through the KIM manual, I was glad to see that MOS had made provisions for an external keyboard through the application connector.

A little study will show, however, that a keyboard connected in that way will lack the three functions described above.

I decided to add three sockets to KIM and interface my external keyboard and display through them. The sockets were mounted by drilling holes with a #60 (no larger) drill bit for the pins. The wire was crimped around the solder tails of each pin. This connection, when

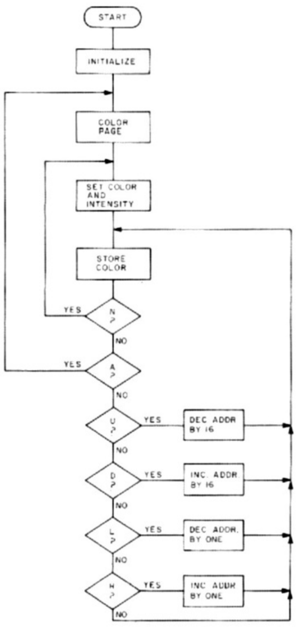

*Fig. 3. Program flowchart.*

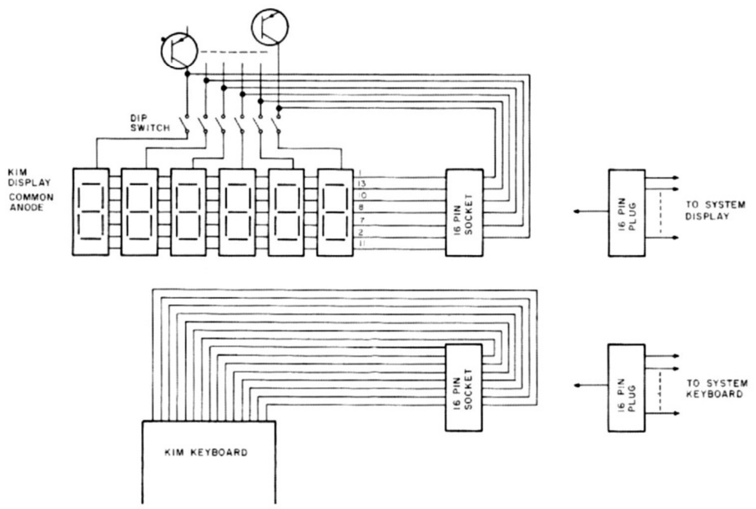

*Fig. 4. Keypad and external display schematic for KIM.*

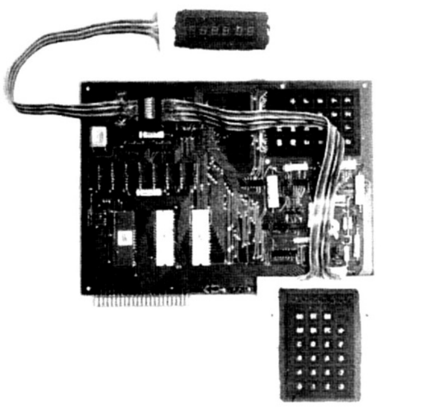
*Photo 2. External keypad and display attatched to KIM.*

soldered, holds the sockets tightly in place.

The keyboard is mounted on a printed circuit board to make the wiring and mounting easier. The cable wiring should simply connect the pins of one keyboard to the *same* pin on the other keyboard. A 16-pin DIP plug on one end of the cable allows the keyboard to be easily disconnected from KIM.

The display could be handled in the same way, but I chose to cut the foil lines on KIM that provided the multiplexed power lines to the LEDs so that only the external display is functional. A six-switch DIP is used to enable the on-board display if I should need it in the future. My external LEDs are mounted in wire-wrap sockets on Vector board. The board is painted black so that it is less noticeable when mounted. Fig. 4 is a schematic layout of the connections, and Photo 2 shows the modified KIM.

Most of your front panel is now operational; the next article on the external interface board will complete the system's hardware, bringing to life the sense switches, joysticks and D/A ports. ■

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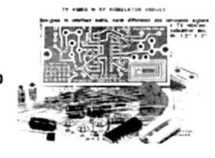

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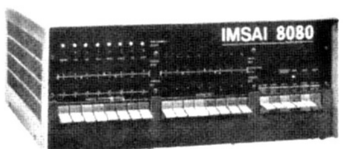

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