Inexpensive Optical Paper-Tape Reader

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1 microprocessor + 8K BASIC tape +4K Startrek tape +45 min=RUN

This was the terrible equation I had to contend with *every time* I wanted to play my favorite game program. It would take me 30 minutes to load the 8 K BASIC paper tape. But not any more!

The solution is a 400 character per second paper-tape reader that can interface to any 8-bit input port of almost any microprocessor. It uses only 2 integrated circuits and costs approximately $15.

I had always wanted something faster than my old reliable Teletype, but I never seemed to have the $40 to $100 that was needed to buy one of the many available kits. I also wondered why most of these kits required so many integrated circuits to accomplish the simple task of latching 8 bits of data. There are 7 bits (sometimes 8 bits) of parallel paper-tape data spaced at regular intervals, and a sprocket hole for strobing, included at no extra cost. Why not design a self-strobing, 8-bit data latch using an inexpensive large scale integration (LSI) transistor-transistor logic (TTL) integrated circuit, the INTEL 8212?

The Intel 8212 provides 8 bits of input, 8 bits of output, strobe, clear, and several device enable lines for about $5. All I needed to do was to optically sense the punched paper-tape holes and strobe them into the latch at every sprocket hole.

Although there are several ready-made, 8-level, paper-tape-reader photodiode assemblies available, I decided to construct my own reader assembly using individual phototransistors that I already possessed, the Motorola type MRD150, which are available at most wholesalers for approximately $1 each. Their miniature size is ideally suited to 0.1 inch (0.25 cm) spacing.

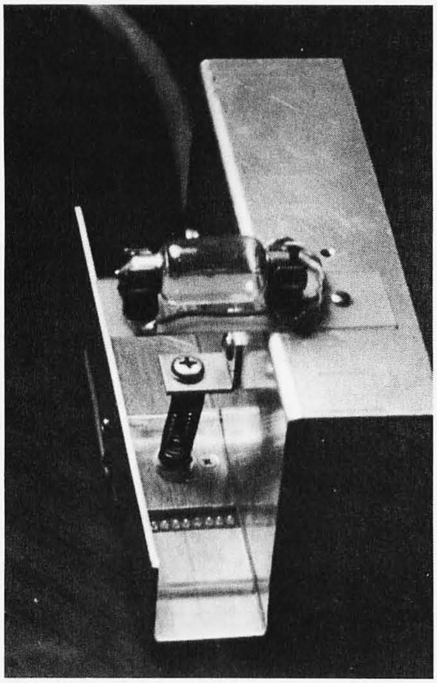

Photo 1: View of the paper-tape reader showing the light source and the light-detecting phototransistors. The spring and clamp device keeps the paper tape in place.

Using epoxy, I glued 9 of the phototransistors into a 0.5 by 1 inch (1.27 by 2.54 cm) piece of 0.100 inch (.025 cm) perforated board The photocell placed between positions 3 and 4 (as shown in figure 1) is physically reversed so that the active surface element of the cell is not in line with the other 8 cells. This out-of-line detector provides a physical delay of the sprocket-hole signal which will be signal-conditioned later.

This cell begins to detect light through the sprocket hole only after all other data holes are fully centered over their respective detectors. The strobe pulse is now positioned close to the center of the pulse from the data holes, as shown in the waveforms of figure 2.

In order to make the strobe pulse as insensitive as possible to the variation in tape speed caused by moving the tape by hand, the sprocket-hole detector is amplified by transistor Q1 and is threshold-detected by IC1a, a 7414 hex Schmitt trigger TTL gate (see figure 3, p. 121). The output of IC1a is then differentiated and level-shifted by the capacitor and resistor combination C1, R1, and R2 such that the output of IC1b is fast and clean even for very slow dark-to-light transitions through the sprocket hole.

The additional gate sections IC1c and IC1d provide buffered outputs of the signals STROBE and $\overline{\text{STROBE}}$, which will be used as sense input lines to the 8-bit interface port.

The last 2 sections of the Schmitt trigger are configured as a delayed power-up signal that holds the $\overline{\text{CLEAR}}$ input pin of the latch at ground until the power supply voltage has stabilized.

The $\overline{\text{DS1}}$ and MD pins of the 8212 are grounded and the DS2 pin is pinned to the supply voltage, thus placing the 8212 into the strobed latch mode of operation. In this way the 8 bits of data available to the input pins DI-0 thru DI-7 are latched through to the output pins DO-0 thru DO-7 by each positive pulse at the STROBE pin.

Since most paper-tape programs used with today's microprocessors use only 7 bits of the 8-bit ASCII code (bit 8 being vertical parity), it is convenient to use this 8th bit as the strobe sense line. When connecting the output pins of the latch to the processor input port, simply select strobe signal STROBE or $\overline{\text{STROBE}}$ and connect it to the pin corresponding to bit 8.

The software required to read in such data is shown in listing 1, where bit 8 is the STROBE sense line. When bit 8 goes through a low to high to low cycle, the data at the input port is valid.

If 8 bits of tape data are required, it is necessary to connect the strobe sense line to either another input port pin or to some other monitor line, such as an interrupt or serial input line, which can be tested under software control.

Mechanically, I used a piece of 0.100 inch (0.025 cm) aluminum sheet bent into a U-shape, with an inside, bottom width dimension of 1 inch (2.54 cm). I used a small piece of clear Plexiglas as a hold-down device for the tape as it passed over the reader photocells. Further improvements can be added, such as a motor-driven, pinch-roller pull-through, but I have had no problems when pulling the tape through by hand. As a matter of fact, I can stop pulling at any time, since the strobe pulse is speed insensitive. I plan to eventually add a hand crank and a take-up reel to avoid the great piles of tape that end up on the floor after loading some of my larger programs.

To generate the required illumination, I used an automotive lamp (type 211) mounted 3 inches (7.5 cm) above the photocells. Running the lamp on 5 V provides a good, uniform source of light, although it draws about 1 A of current.

This entire project took only 3 evenings to design and construct, and the $15 price tag was a bonus. If you are still limited to 10 characters per second with your Teletype reader, you should seriously consider this high-speed paper-tape reader. ■

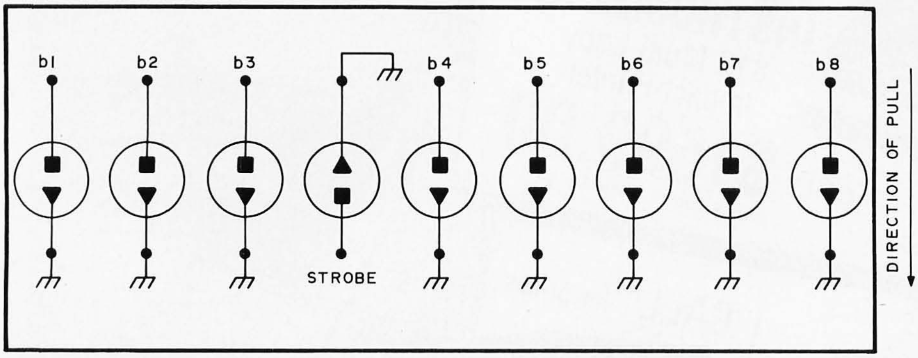

Figure 1: Phototransistors in the paper-tape reader. Note the placement of cell between bits 3 and 4. The active element is reversed in orientation.

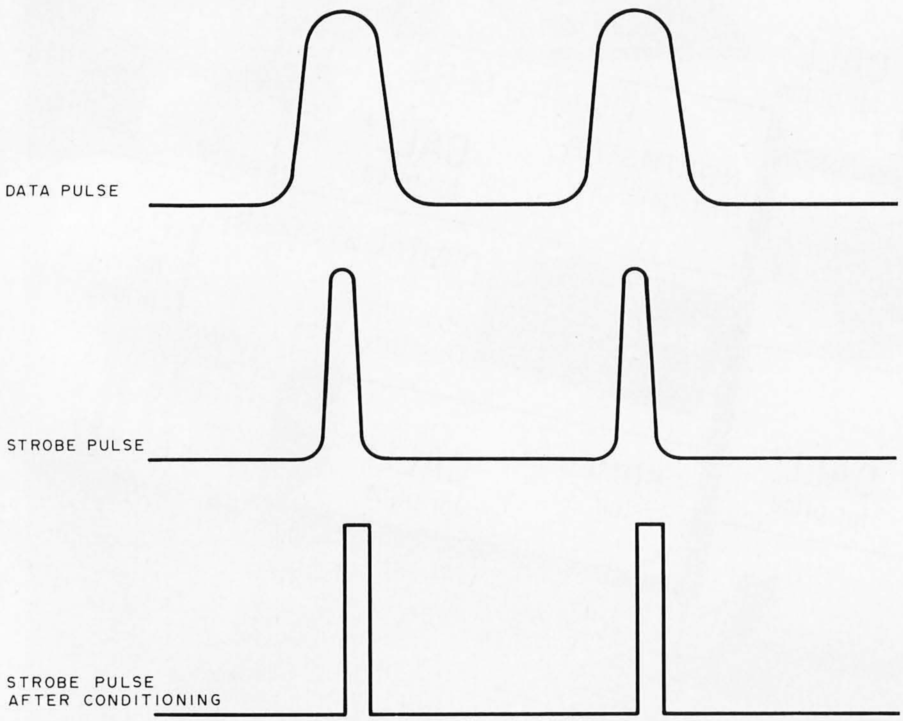

Figure 2: The strobe pulse is centered in the active signal from the data holes.

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UP:     IN   port#     ; READ INPUT PORT
        RAL            ; SHIFT 1 BIT LEFT
        JNC UP         ; JUMP TO UP IF CARRY BIT NOT SET
DOWN:   IN   port #    ; READ INPUT PORT AGAIN
        RAL            ; SHIFT 1 BIT LEFT
        JC   DOWN      ; JUMP TO DOWN IF CARRY BIT SET
READ:   IN   port#     ; READ INPUT PORT DATA BYTE
        RETURN         ; WITH 7 BITS OF DATA IN REG A
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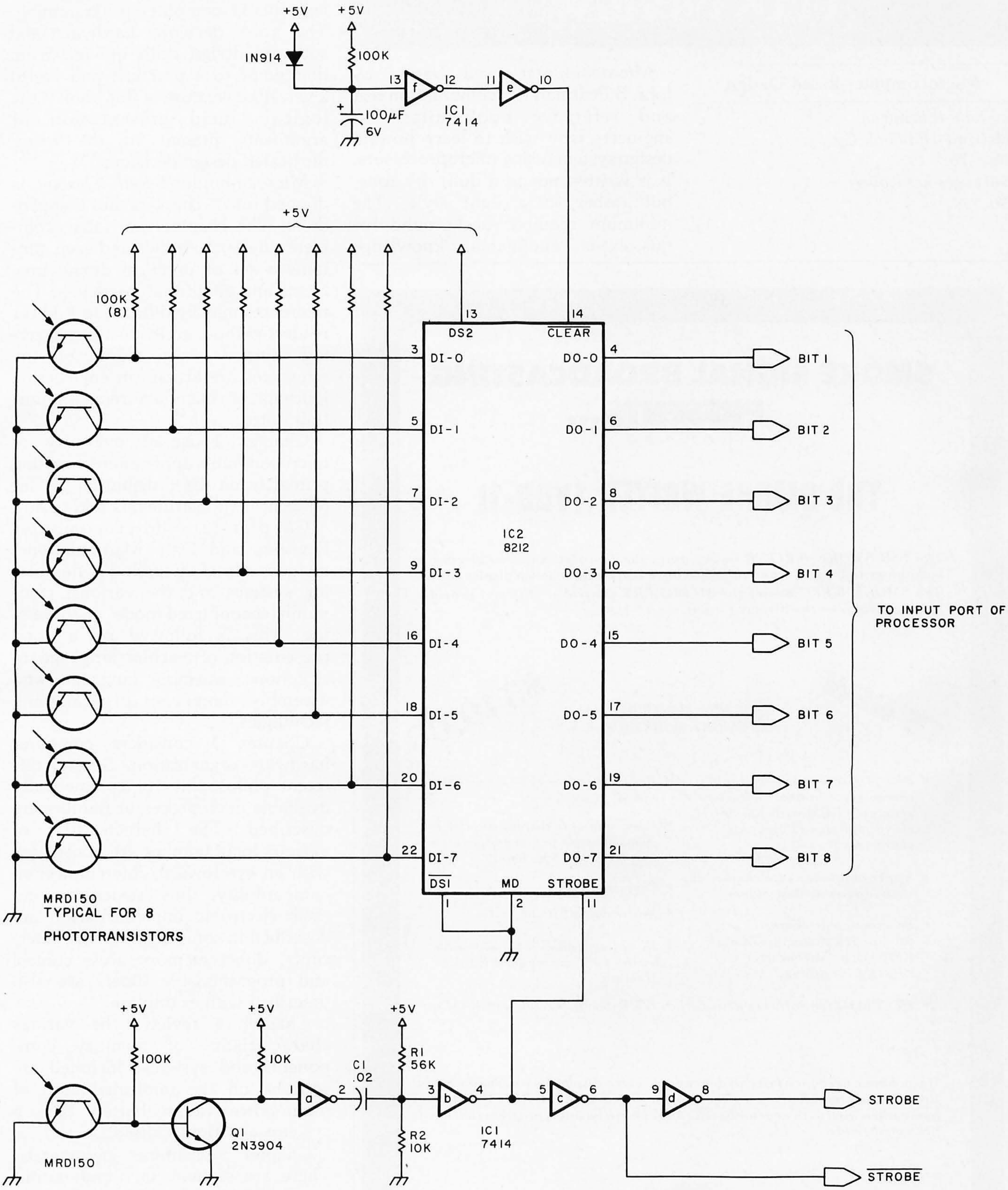
Listing 1: Simple 8080 assembly language program for inputting the data from the paper-tape reader.



IC	TYPE	+5V	GND
2	8212	24	12
1	7414	14	7

Figure 3: Schematic diagram of the paper-tape reader, which is capable of 400 characters per second.