The 1802 Face Card

A TMSI **ElectroniKit** (tm) by Lee Hart
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If you have never built anything with a microcomputer, here's your chance. This project will show you just how simple a microcomputer can get. It may also be the silliest use for a microcomputer yet!

I designed the circuit way back in 1978. I used the classic RCA 1802 microprocessor to randomly blink a set of LEDs. When I built my Pocket Pixie, I realized that the LEDs in the 1802 circuit could also be arranged to make faces.The eyes roll left and right, and wink. The eyebrows raise and lower, and the mouth smiles, frowns, opens, and closes.

Parts List

Quantity		Identifier	Description
( )	3	C1, C2, C3	Capacitor, 0.1uF 50v ceramic
( )	1	D1	Diode, 1N4003 general purpose
( )	12	D2-D13	LED, green (for the eyebrows)
( )	10	D14-D23	LED, yellow (for the eyes)
( )	14	D24-D37	LED, red (for the mouth and nose)
( )	4	Q1-Q4	Transistor, 2N2222 NPN general purpose (marked 01-4)
( )	1	R1	Resistor, 1.5 meg 1/4w 5% (brown-green-green-gold)
( )	2	R2, R3	Resistor, 10 meg 1/4w 5% (brown-black-blue-gold)
( )	4	R4-R6, R10	Resistor, 150k 1/4w 5% (brown-green-yellow-gold)
( )	1	R8	Resistor, 220 ohm 1/4w 5% (red-red-brown-gold)
( )	2	R7, R9	Resistor, 330 ohm 1/4w 5% (orange-orange-brown-gold)
( )	1	U1	CDP1802 Microprocessor
( )	1	PCB	"Face Card" printed circuit board
( )	1	piece	insulated sleeving (for lead of R10)

Assembly

Assembly is straightforward. I like to put the lowest profile parts in first, and work my way up to the tallest ones last. This means putting the resistors in first, then diode D1, then the capacitors, LEDs, transistors, and finally the 1802.

( ) Resistors R1-R9 have colored rings to indicate their value. Use the parts list to identify each resistor, and install it in the right place on the board. Check the value with an ohmmeter if you're not sure.

( ) Diode D1 (1N4003) is polarity sensitive. The banded end must match the label on the board.

( ) Capacitors C1-C3 (0.1uF) are blue, and marked "104".

( ) LEDs: The flat side and shortest lead wire goes toward the **top** of the board. It's best to solder just **one** lead of each LED, then straighten them if necessary for better appearance, then solder the other lead.

( ) Transistors Q1-Q4 (2N2222): They are marked "01-4". Install so the flat side of the case matches the label on the board.

( ) Microprocessor U1 (CDP1802): Pin 1 goes in the lower left corner, so the writing is right side up. You can socket it, or solder it in directly. Socketing it lets you use the 1802 elsewhere, or use the Face Card as an 1802 "tester".

Power: I used a 4-cell AAA battery holder with switch from Radio Shack (#2700411) for power. Solder its + and - wire leads to the board at "B1" (red to +, black to -). I hot-glued the battery holder to the back, with its door to the rear.

The Rev.A board has one small error. The 1802 can accidentally fetch a HALT instruction (all zero's). This would cause it to STOP, and all action would cease. Therefore, you need to add resistor R10. It pulls at least one BUS0-7 pin high, making a HALT impossible. Here's how I do it:

( ) Look for two small holes for the new resistor (R10). One end is just left of the "R3" designator, and the other is just left of the "C3" designator. Install R10 in these holes.

( ) Solder the left wire of R10 (next to R4) to the pad of R4. This is VDD, the positive supply.

( ) Solder the right wire of R10 (next to C3) to **one** pin of the 1802 from 8 to 15. Any of these pins will do; it just changes the random sequence of LED blinking. Put a piece of insulated sleeving (supplied) on this lead so it won't short to anything.

Theory of Operation

How does it work? Transistor Q1, R1, and R4 are wired as an inverter. This inverter works with the 1802's internal inverter (between CLK and /XTAL) to form a very low frequency oscillator. The frequency is determined by the time constant of C1 and R2.

The LEDs are connected to the address, read/write, and state code lines. The program... well, there **IS** no program! The 1802 has no internal memory (no RAM and no ROM). The data bus is left floating, so it fetches random values, and executes them as if it is a "program". One of the data lines is pulled high with R10; this prevents the data bus from ever being 00, which is the HALT instruction.

The eyebrows are controlled by address lines MA0, MA1, MA2, and MA6. If MA0 is high and MA1 is low, LEDs D3 and D13 light and the outer ends of the eyebrows arch down. If MA0 and MA1 are in the opposite states, D2 and D12 light and the outer ends arch up. MA2 and MA6 work the same way for the inner ends of the eyebrows.

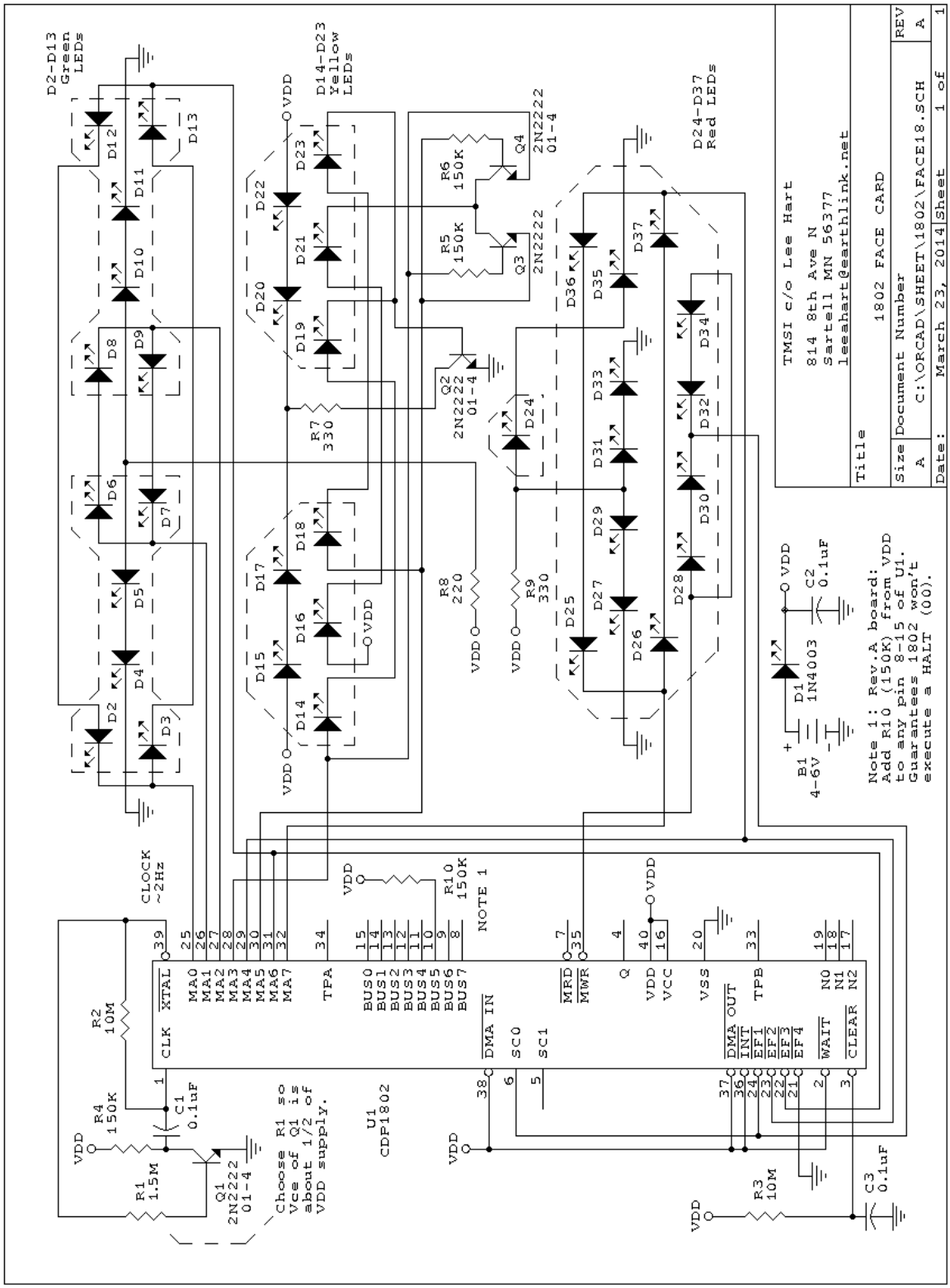
The eyes are controlled by two address lines, MA3 and MA5. Q2, Q3, and Q4 decode the four states of these lines to make the eyes look left, look right, look ahead, and blink. If MA3 is high, the left LEDs (D14 and D19) light. If MA5 is high, the right LEDs (D18 and D23) light. If either MA3 or MA5 is high, these LEDs also provide the base current to turn on Q2, which lights the top LEDs of the eyes (D15, D17, D20, and D22). If MA3 and MA5 are in opposite states (one high, the other low) then either Q3 or Q4 turns on, to light the center LEDs (D16 and D21).

Resistors R7, R8, and R9 set the LED brightness. The values are chosen so the brightness of the LEDs forming the eyebrows, eyes, and mouth is about the same. I normally supply green LEDs for the eyebrows, yellow for the eyes, and red for the mouth. If you use different colors or types of LEDs, you may want to alter these resistor values.

D1 is an "idiot" diode, to prevent damage in case the power is accidentally connected backwards. C2 is a power supply bypass capacitor. C3 and R3 are for power-on-reset, so it starts from a known state when power is first applied. Reset isn't strictly necessary in this application, but it is provided anyway (just in case).

Notes

The LED patterns are completely random, and depend on whether the BUS0-BUS7 data lines "float" high or low. These will change just by handling the board, as your skin resistance adds random resistors. It may seem to get "locked in" to a particular pattern for a while (such as never smiling, or the eyes always off). But it will indeed "cheer up" at some point. If you want to experiment, try connecting R10 to other BUS0-BUS7 pins to force different lines high. Let me know if you find something interesting!



Facecard schematic - face18.bmp