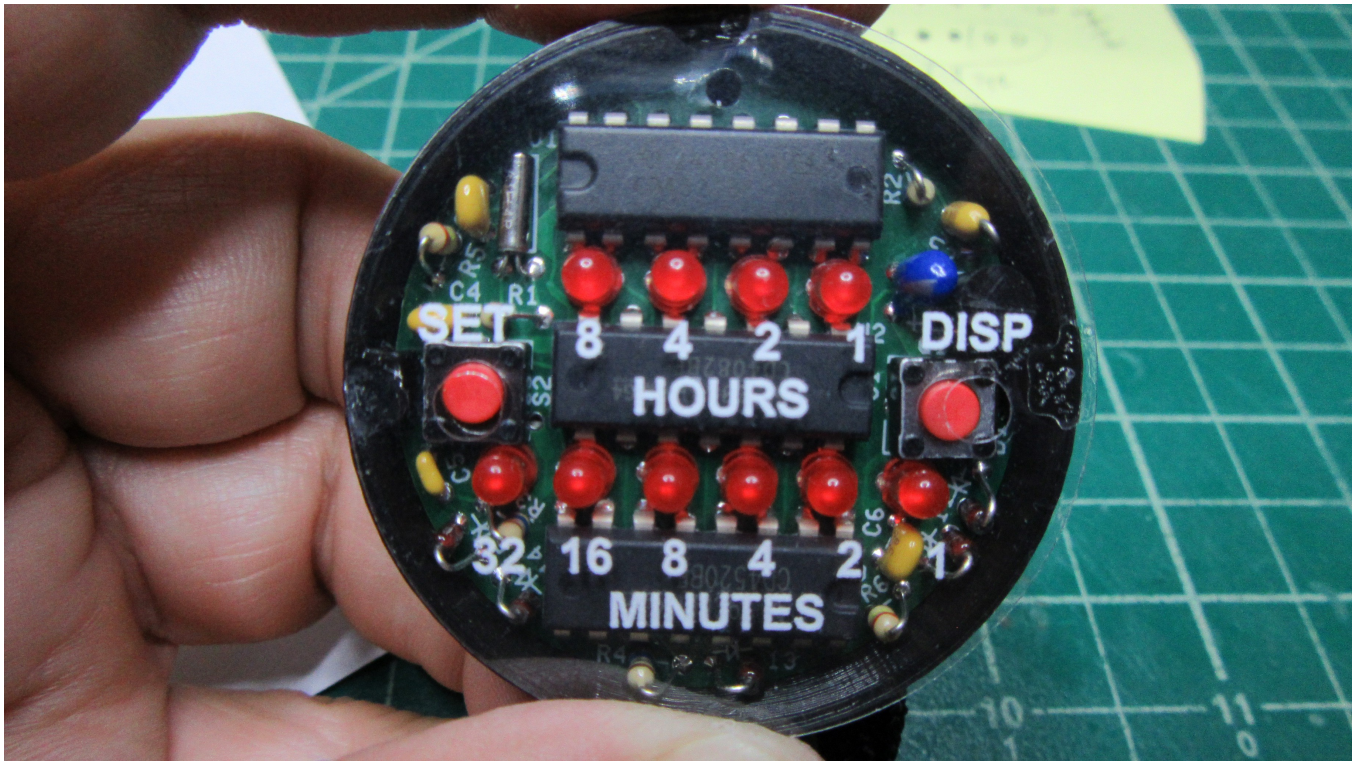
A Retro Binary Watch

for the Vintage Computer Festival Midwest

by Lee Hart and Paul Schmidt – 10 Sept 2025



What is it?

- A cool retro digital watch that displays the time in binary format
- Built entirely with generic 1970's vintage parts and technology
- Quartz crystal for highly accurate timekeeping
- Runs for a year or more on a standard coin cell
- Minimum size, cost, and parts count
- Maximum fun!

History:

The world's first electronic digital watch was the Hamilton Pulsar. It was introduced in 1970 for the astounding price of $2100 US dollars. As a “must have” fashion accessory, it was featured in Playboy magazine, and worn by James Bond in the movie “Live and Let Die”.

The first **affordable** digital watch was the Sinclair Black watch. It was introduced in 1975 for a mere £24.95 British pounds (or £17.95 in kit form). Typical of Sinclair products, it was brilliantly conceived, but horribly executed. Quality was low, battery life was short, and timing accuracy was poor.

Both of these alternatives looked like unreasonable options; so I decided to build my own!

The Retro Binary Watch is born

Around 1980, I designed my own digital watch, using parts I could actually get, and through-hole technology so I could actually build it. I used standard 4000-series CMOS counter ICs, and red LEDs for the display (the only color available at the time). I chose to display the time in binary, which made the circuitry a lot simpler. It's not that much harder to read, and besides, it has a definite “geek” appeal. Four LEDs represent the hours (8-4-2-1), and six LEDs for the minutes (32-16-8-4-2-1).

It worked! But the LEDs of the time were too dim if I drove them directly with the counters. If I added drivers for adequate brightness, it doubled the IC count and battery life was short. So I put the project in a box and forgot about it.

This year I moved. In the process, I stumbled across my old project box, and decided to try it again with today's much-more efficient LEDs. They did the trick! Brightness was now good even without driver ICs, for excellent battery life. The Watch draws about 3 microamps for timekeeping, and about 3 milliamps when the display is active. That allows a coin cell to easily power it for a year even when the time is checked a dozen times a day.

Amazingly, the ICs I used are **still** inexpensive and readily available. I laid out a PC board that's watch-sized at about 1.5” in diameter. The assembled Watch is less than 1/4” thick (or about double that with a battery mounted).

For manual updates and more information, contact me at Lee Hart, 2521 19th St N, St. Cloud MN 56303, email <leeahart@earthlink.net>, or go to **http://www.sunrise-ev.com**

Parts List

QTY	ID#	Description	Source (-ND = digikey.com)
1	B1	CR2032 3v 225maH coin cell	P189-ND
1	B1a	battery holder for B1	2057-BH-49C-1-ND
1	C1	4.7uF 10v tantalum capacitor	445-8404-ND
1	C2	0.22uF 50v ceramic capacitor	445-5305-ND
3	C3,C4,C6	22pF 50v ceramic capacitor	BC1005CT-ND
1	C5	330pF 50v ceramic capacitor	BC1069TR-ND
10	D1-10	LED high-efficiency red, T1 size	2007-BL-B5131E-TRS18A-ND
5	D11-15	1N4148 signal diode	1N4148FS-ND
1	Q1	2N3906 PNP transistor	4878-2N3906CT-ND
4	R1-4	18 Meg resistor (brown-grey-blue-gold)	738-CF18JT18M0CT-ND
2	R5, R6	220K resistor (red-red-yellow-gold)	CF18JT220KCT-ND
2	S1, S2	tactile pushbutton switch, 2-wire	EG2512-ND
1	U1	CD4521 oscillator/24-bit binary counter	296-14158-5-ND
1	U2	CD4082 dual 4-in AND gate	296-2067-5-ND
1	U3	CD4520 dual 4-bit binary counter	296-2077-ND
1	Y1	32.768 KHz crystal (small silver tube)	2151-R26-32.768-12.5-ND
1	PCB	printed circuit board	Lee Hart leeahart@earthlink.net
1	overlay	clear overlay with labels for LEDs	also from me (Lee Hart)

Notes

IC sockets are not supplied with the kit. You can add your own sockets, but it will make it too thick to use as a Watch.

Rev.A – Original version. It only went to developers, and included an LED brightness regulator.
Rev.B – Version for VCF East. Says “Vintage Computer Federation” on the back. I removed the brightness regulator, and added diodes so pressing SET automatically enables DISPLAY. The PCBs never arrived in time for the show!
Rev.C – Version for VCFMW. Same as rev.B but says “VCF Midwest Edition” on the back.

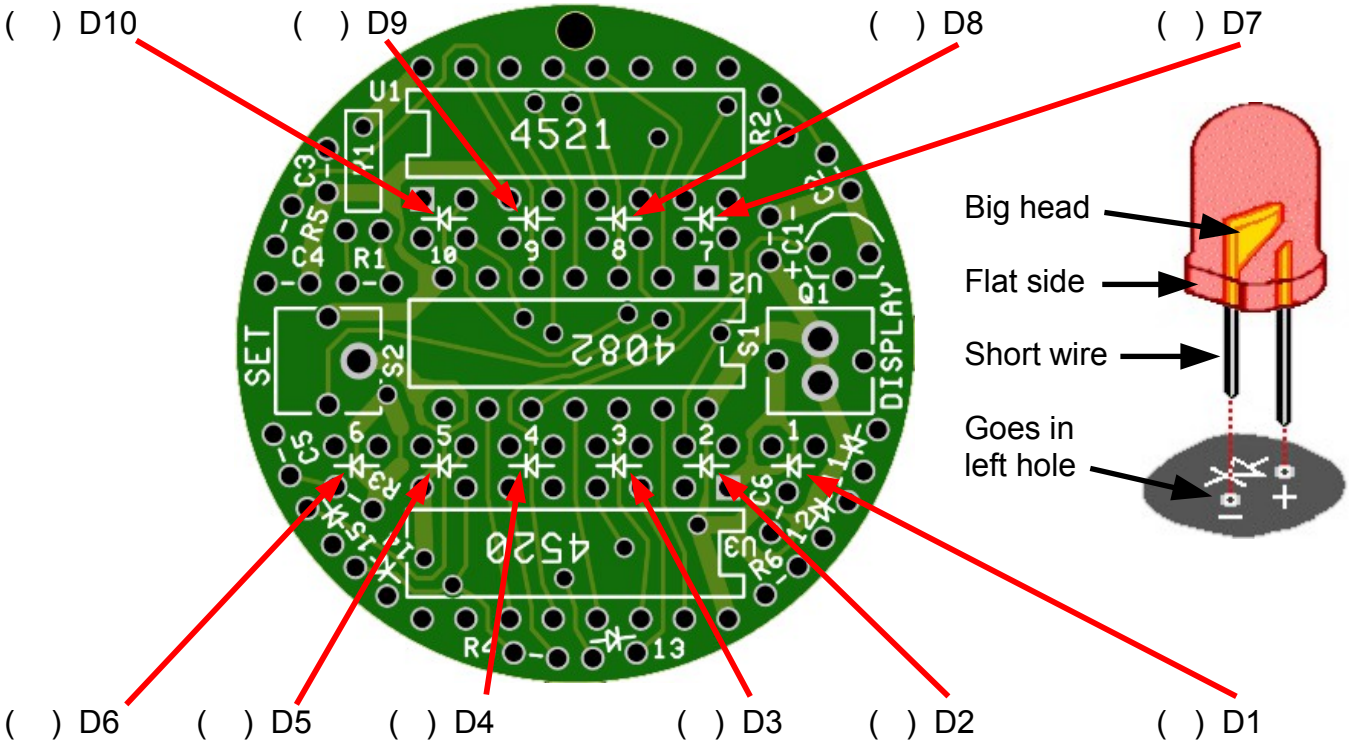
Assembly

Check the parts list to be sure you have all the parts. Everything mounts on the top (printed) side of the board (except the battery holder, which goes on the bottom). Mark each box (■) as you install each part.

Height is important! Press each part tight against the board, solder it, and cut off the excess lead length as short as possible.

D1-D11: Mount the LEDs **first**. They are the tallest parts, so everything else will be installed so its height is equal to or less than the LEDs.

LEDs are **polarized**, and must be installed with their + and – leads in the right holes. The short wire of the LED is the cathode (negative) end (also marked by the flat side, and big head visible inside the LED package). It goes in the **LEFT** hole at each location. Solder **one** lead of each LED, flip the board over, and be sure they are all neatly aligned and tight against the board. Adjust or re-solder them as needed. Then solder the remaining lead.



Install the ICs next. The ICs come with their pins bent slightly outward. To fix this, stand the IC on its side on the table, and tip it slightly inward so the rows of pins are parallel and will fit into the holes on the board.

ICs are **polarized**. The pin 1 end has a notch. Install them to match the notch shown on the PC board. This means the part number on U1 will be right side up, while the part numbers for U2 and U3 will be upside down.

( ) U1: CD4521BE
Pin 1 on left (←)

( ) U2: CD4082BE
Pin 1 on right (→)

( ) U3: CD4520BE
Pin 1 on right (→)

( ) Y1: Crystal. Lay it flat against the board.

Resistors: Bend the wire at one end tight against the body so they stand on end.

( ) R5: 220K
red-red-yellow

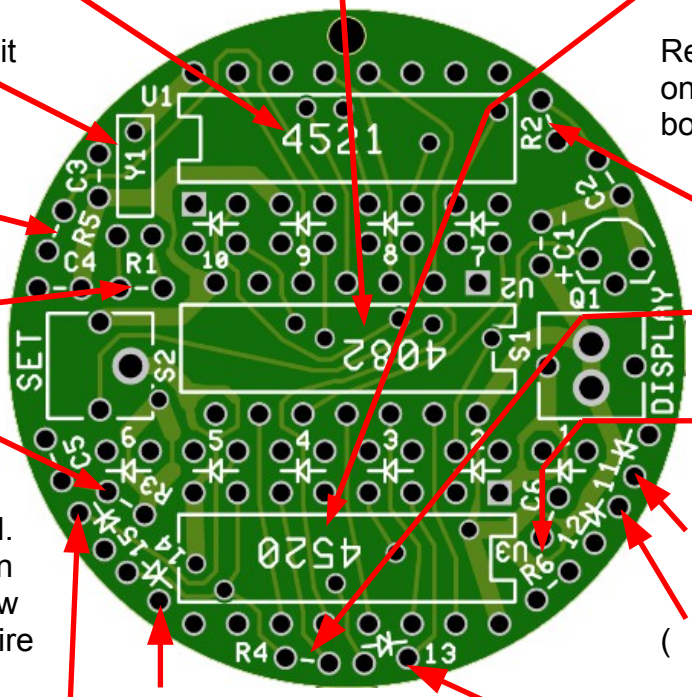
( ) R2: 18 Meg
brown-grey-blue

( ) R1: 18 Meg
brown-grey-blue

( ) R4: 18 Meg
brown-grey-blue

( ) R3: 18 Meg
brown-grey-blue

( ) R6: 220K
red-red-yellow



Diodes are **polarized**. The black ring goes in the hole that the arrow points to. Bend the wire at the other end tight against the body so it stands on end.

( ) D11: 1N4148. Black band in lower hole.

( ) D12: 1N4148. Black band in upper hole.

( ) D14: 1N4148. Black Band goes in right hole.

( ) D13: 1N4148. Black band goes in right hole.

( ) D15: 1N4148. Black band goes in left hole.

Install the capacitors next. Don't mix them up! There are tiny markings on them, but you may need a magnifying glass to read them. C1 is blue and **polarized**; it has a tiny "**+**" sign. C2 has its leads coming out the ends (like the resistors). The other capacitor's leads both come out the same end. C3, C4, and C6 are taped to a cardboard strip. C5 is loose, and **tiny**! Don't lose it!

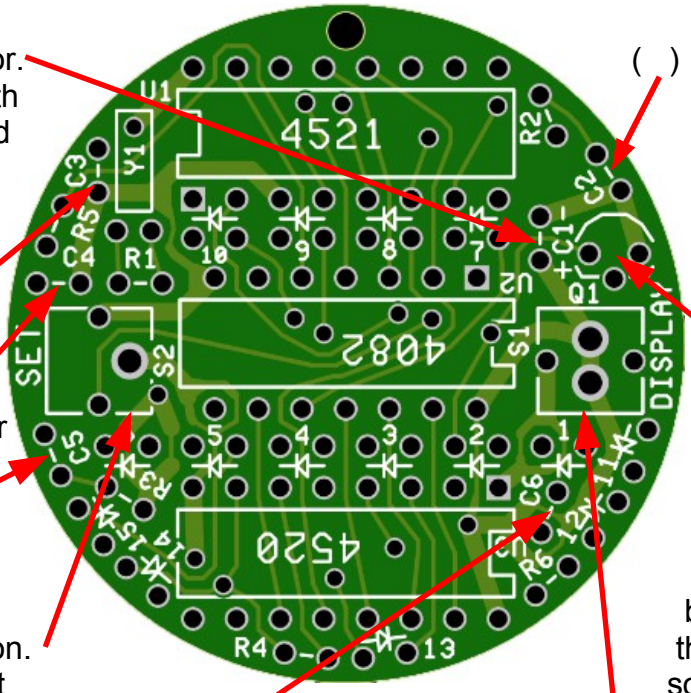
( ) C1: 22 uF capacitor. The longer wire with the silver stripe and "+" sign goes in the lower hole marked "+".

( ) C3: 22 pF cap marked BC 22J.

( ) C4: 22pF capacitor marked BC 22J.

( ) C5: 330pF marked 331.

( ) S2: SET pushbutton. Hold it tight against the board, and solder it in place.



( ) C6: 22pF capacitor marked BC 22J.

( ) C2: 0.22uF capacitor marked K5U 224Z. Bend wire at one end tight against the body so it stands on end.

( ) Q1: Transistor, marked 2N3906. Bend the center wire sharply to the flat side, then at a right angle so the 3 leads fit into the holes. Press it tightly against the board so it is no higher than the LEDs. Then solder it in place.

( ) S1: DISPLAY pushbutton. Hold it tight against the board and solder in place.

Let's See It Work!

Now for the big moment. Let's test it before installing the battery holder, to be sure it works (and so you can correct any mistakes before they get covered up by the battery holder). Put the coin cell in the battery holder, with the side marked "+" on top so you can see it. Check the voltage with your multimeter – the single tab is "**–**" and the double tab is "**+**". You should have at least 3 volts.

If your battery is good, then connect it to the Watch with a pair of clip leads. "**+**" and "**–**" are marked on the bottom of the Watch board. Be sure to get the polarity right!

You should be rewarded with a (random) time display for about 4 seconds! The DISPLAY button displays the time. Each press shows the time for about 4 seconds. The SET button advances the time. Each press increments the time by 4 minutes (and display it for 4 seconds).

Note that due to the 18 megohm resistors used, fondling the Watch with your bare hands is likely to do odd things, as your finger's skin resistance causes random shorts. It won't hurt anything, but it will affect the time.

If all is well, it's time to clean up the bottom of the PC board. Cut all the leads as short as possible with "flush" diagonal cutters. Or, lay a piece of sandpaper on a flat surface, and slide the board back and forth to sand off any high spots.

When you're satisfied that it's flat enough, mount the battery holder to the BOTTOM of the board as follows:

( ) Remove the coin cell.

( ) Cut each of the three solder tabs of the battery holder to about half their length. Otherwise, they will hold the battery holder up above the board.

( ) Solder the tabs to the board from the bottom side.

( ) Install the coin cell. The clock should be running!

Step In Time

Setting the time is easy (though tedious). The SET button advances the time in 4-minute steps. Press it repeatedly until you get as close as possible to the correct time. The 1s and 2s of minutes can't be set; they just advance independently of the SET button.

How it Works

U1 contains the oscillator and a 24-bit binary counter. It divides the 32.768 KHz crystal frequency down to provide outputs every 16, 32, 64, and 128 seconds (Q20-23). The 64 and 128 second outputs directly drive the 1 and 2 minute LEDs. AND gate U2A detects when the Q20-23 count reaches 4 minutes (16+32+64+128=240 seconds), and resets U1 back to 0.

When U1 resets every 4 minutes, the falling edge on Q23 clocks U3A. Its outputs drive the 4, 8, 16, and 32 minute LEDs. Diodes D13, D14, D15, and resistor R4 form a Don Lancaster inspired AND gate to reset U3A back to 0 when it reaches 60 minutes (to count 0-59 minutes).

When U3A resets every hour, the falling edge on Q3 clocks U3B via R6. Its outputs drive the 1, 2, 4, and 8 hour LEDs. AND gate U2b detects when U3b's count reaches 13 (8+4+1=13 hours) to reset U3b back to 0. However, the hours should reset to 1 o'clock, not 0. So C6 couples the falling edge on U3b's reset pulse back to its EN clock input to immediately step it to 1 o'clock.

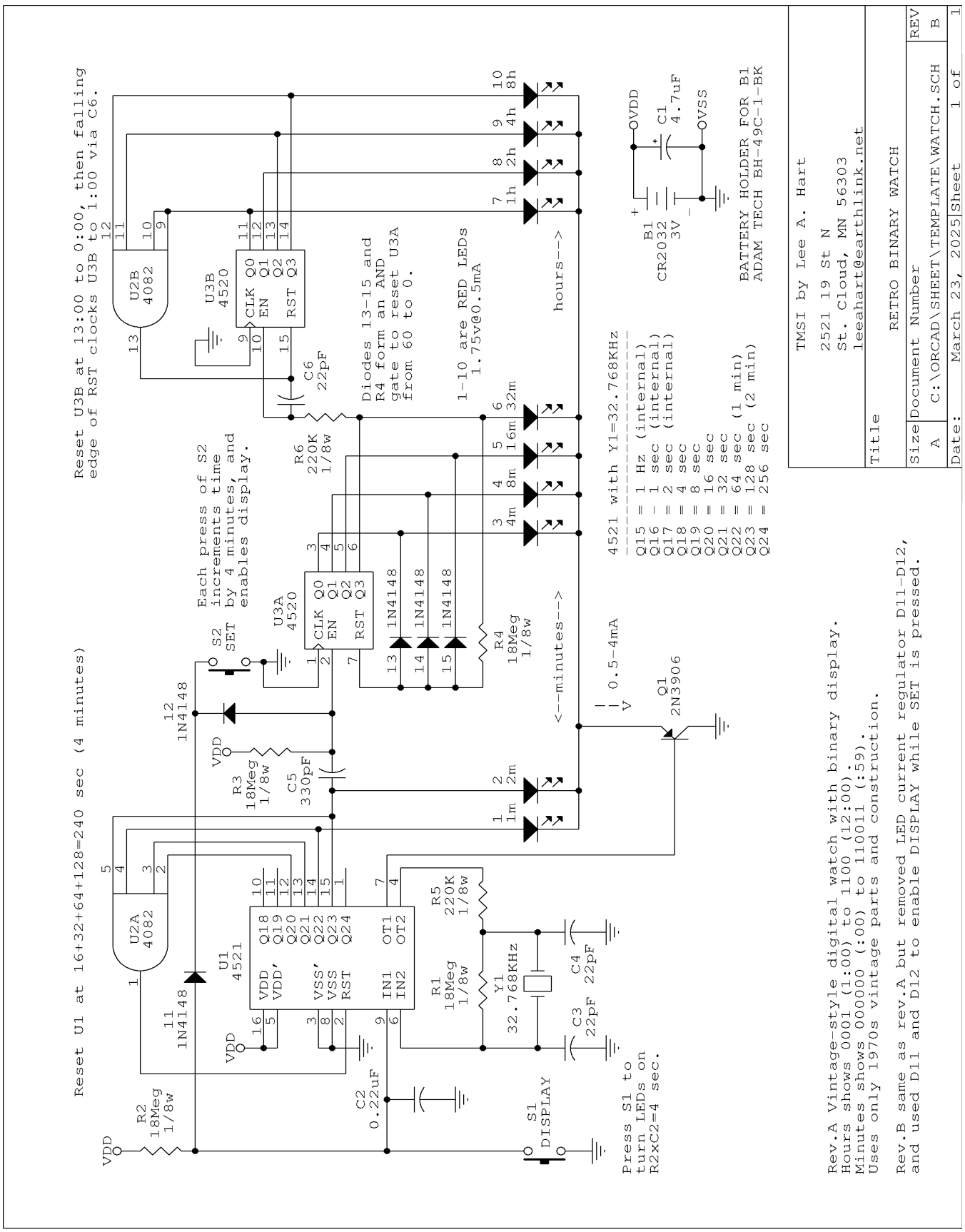
U1 also has a non-inverting buffer between IN1 and OT1. C2 and R2 pull IN1 low for 4 seconds when the DISPLAY button is pressed. The OT1 output turns on Q1 to enable the LEDs.

Packaging

I haven't worked out all the ways the Watch could be packaged. Options:

1. Simple: Put it in a clear polyethylene bag. You can view the LEDs and operate the buttons through the bag. The bag will insulate it, to keep your fingers from creating partial shorts or injecting 60 Hz hum into the counters to alter the time.
2. 3D print a case. Paul Schmidt has made a nice one, and has posted the DXF files on his server.
3. Find a suitable container. The lid of a Walgreens medium-size prescription pill bottle just happens to be the right diameter. The Watch is a tight fit in the orange bottle itself, and the lid is a loose fit; so either might make a neat and cheap case with some finagling.
4. The Watch is just about the right size for a standard size pocket watch case.
5. There is a hole at the top of the board to hang it from a lanyard or attach it to something.
6. Let me know if you come up with something!

Appendix A -- Watch Schematic



Rev.A Vintage-style digital watch with binary display.
Hours shows 0001 (1:00) to 1100 (12:00).
Minutes shows 000000 (:00) to 110011 (:59).
Uses only 1970s vintage parts and construction.

Rev.B same as rev.A but removed LED current regulator D11-D12, and used D11 and D12 to enable DISPLAY while SET is pressed.