

THE CMOS UP OR DOWN COUNT, 12-24HR DIGITAL CLOCK WITH 1/10 SEC READOUT, COUNT DOWN FROM 99hrs:59min:59sec:0.9sec TO ZERO & LATCH WITH AM & PM INDICATORS IN 12HR MODE. Dr H. Holden. 2015.

Introduction:

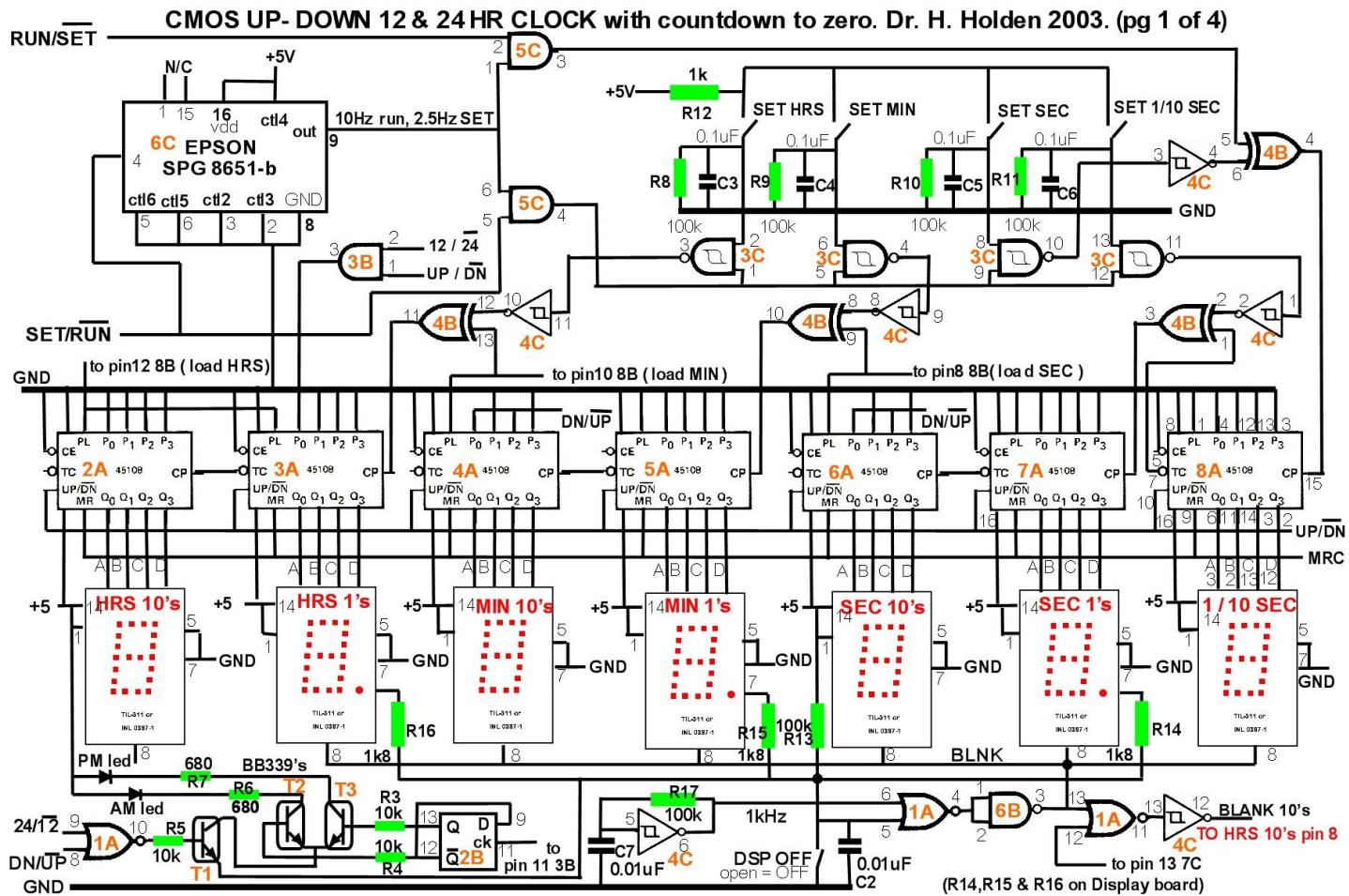
It is practically a right of passage that every Electronics Engineer or Physics enthusiast will at some stage in their life build an electronic clock. Perhaps it is the fascination with the arrow of time itself that drives this interest since time remains somewhat enigmatic. Or the Question posed: Why can one not change the past? The answer given in the second Time Machine movie by the public library's compendium of all human knowledge: Because one cannot travel into the past. This statement remains true currently. Fortunately for the time traveller in this fictional story it was not correct. On a more practical note our entire human civilization is now structured and coordinated around clocks and time measurement.

The way an electronic clock could be built is only limited by human imagination. The options include all manner of display types including LED, LCD, Nixie Tube, Cathode Ray Tube or any type of visible display including a pseudo analogue display with hands. The display format has been done in the past in interesting ways such as Binary or Roman numerals for creative effect. The electronics could be as varied and as simple TTL or CMOS logic circuit or a programmed PIC microcontroller. The time-base could be as simple as using the mains power frequency as a reference, or a divided down crystal reference as is customary in most electronic clocks, or a Cesium or Rubidium atomic reference or even synchronizing the clock to a GPS reference signal.



This article shows the design of a compact multi-function clock based on 4000 series CMOS logic IC's and a beautiful type of LED display, the INL-0397-1 made by Innocor. This display is the CMOS high efficiency equivalent of the famous TIL-311 made by Texas Instruments. The clock is built into a high quality OKW housing and powered by 4 rechargeable AA cells and/or a 6V DC mains plug-pack.

The clock has very low power consumption. The circuit draws only about 14mA with the displays disabled. When the displays are running they are strobed with a 50% duty cycle from a 1kHz square wave oscillator as shown below. The current consumption is only about 45mA under these conditions with the display lit up. The efficient Innocor displays are very bright. The schematics are shown below in 4 pages:



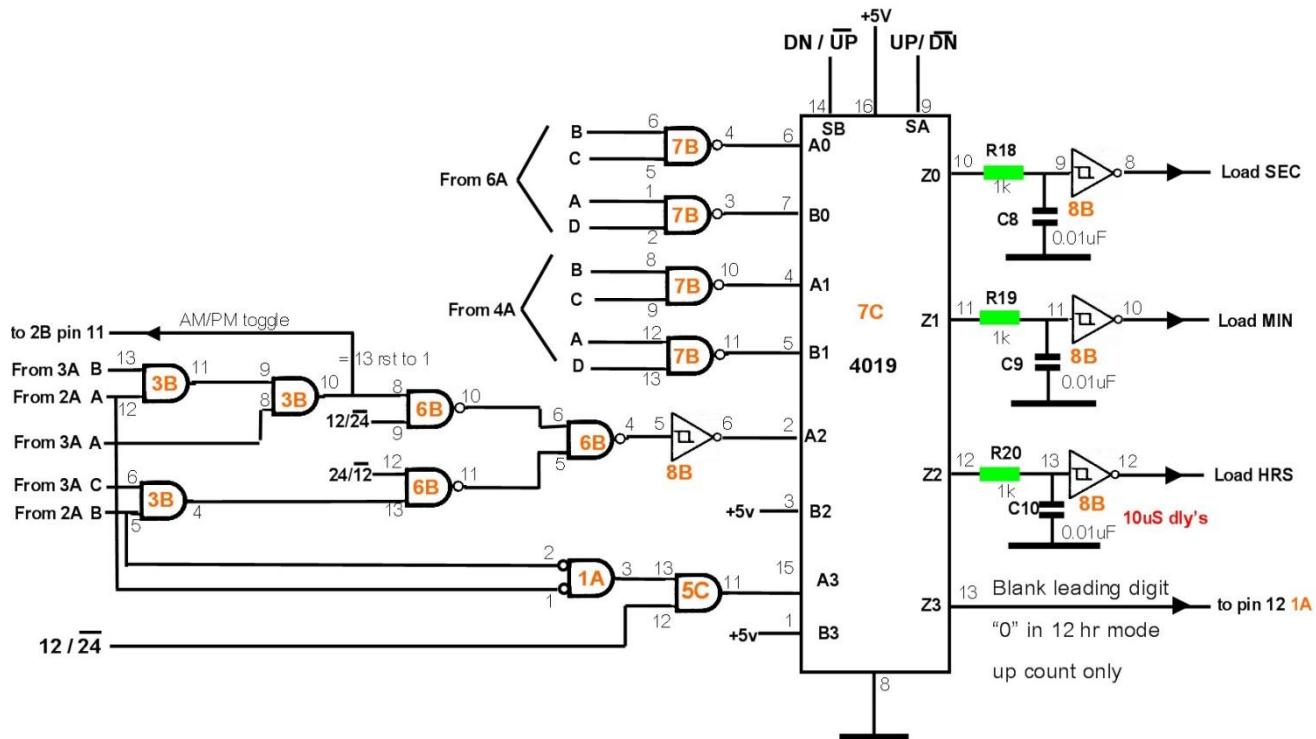
In order that the 1/10 second, seconds, minutes and hours can be individually set, XOR gates are used to mix the individual clock set signals from the set buttons into the appropriate 4510

decade counters. The XOR system has the advantage of being able to clock the counters regardless of the logic state of the previous counter normally driving the clock input.

Also in the Set mode, the time-base reference, derived from an Epson SPG8651B is set to 2.5Hz to speed up the setting process. The time set push buttons are de-bounced by the RC network and the Schmitt trigger Nand gates 3C.

The display's leading zero in the hours column is blanked in the 12 hour mode count up direction only to give the normal display appearance of a 12 Hr clock. When in set mode, the up/down switch can also be used so the time setting function is bidirectional which is another unique feature.

CMOS UP/DOWN 12/24 HR CLOCK SEQUENCE ENCODER. pg 2 of 4. Dr H. Holden.



Since the clock can count either upwards in 12 or 24Hr time and count downwards from a maximum of 99:59:59.9 (Format = HRS:MIN:SEC.(1/10)SEC) then different gating is required to control the decade counters in the up & down modes. This is executed with the gate array

shown above with the help of a 4019 Multiplexer IC controlled by the up-down mode switch. Also in count down mode the total hours count down was not limited to 24 Hrs, it can be up to 99 Hrs.

When the counter outputs are detected corresponding to the correct count in the up or down mode, the new value which follows is parallel loaded into the 4150 counter using the parallel load facility. For example with the pair of minutes (or seconds display) counting up to 59 is followed by 00 because the state 60 is detected by the gating and 0 is parallel loaded into the 4510 tens of minutes counter 4A and at the same time 5A returns to zero as it is a decade counter overflow.

In count down mode 00 is followed by 59 because the state 09 is detected by the gating.

For the hours in the 12Hr count up mode 12:59:59.9 is followed by X1:00:00.0 (X = blanked digit) because 13 Hrs is detected and the leading zero blanked.

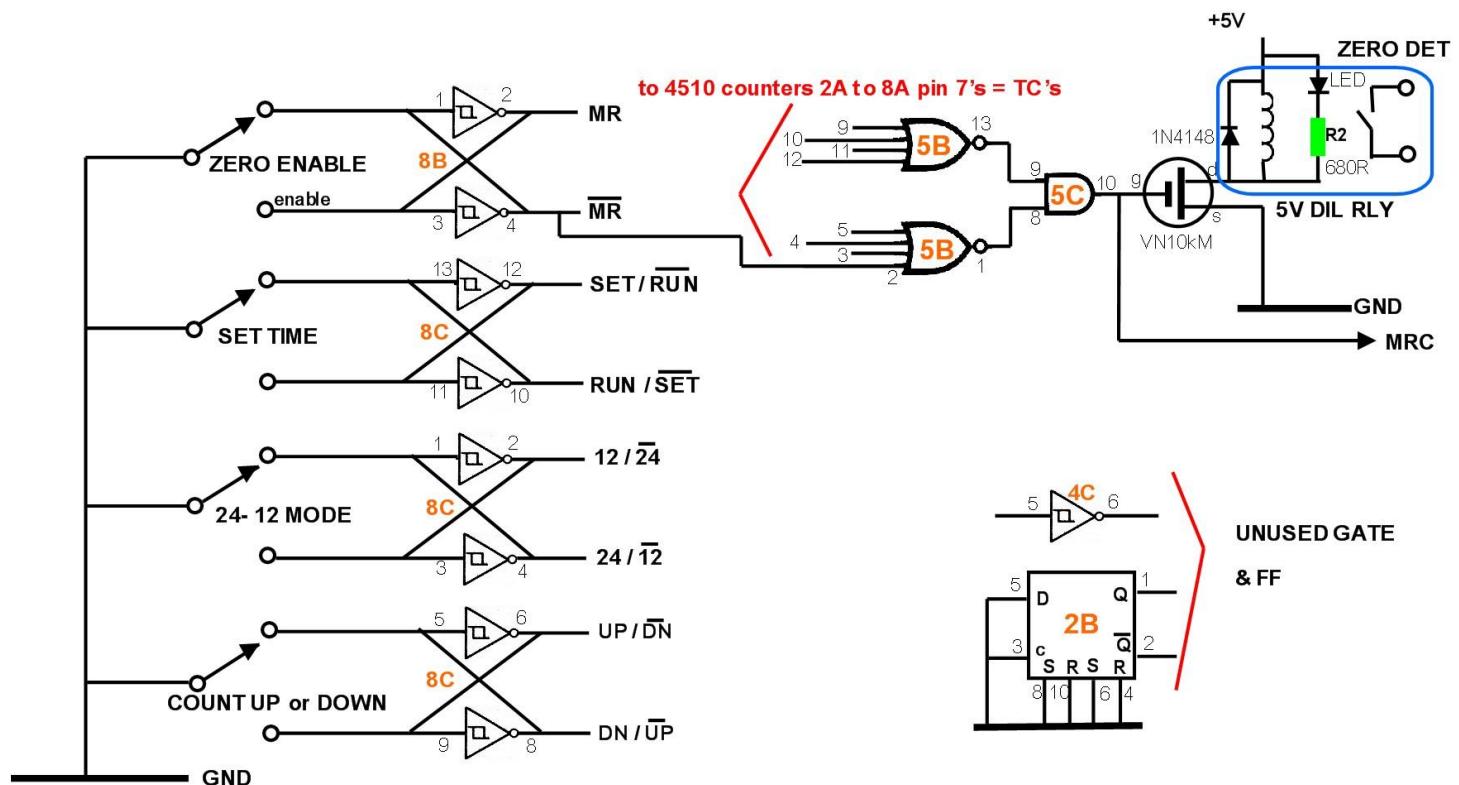
In the 24Hr count up mode after 23:59:59.9 the official (and displayed) time is 00:00:00.0 .This zero state is not detected by the count down zero detector IC 5B(even with the zero enable switch on) because the terminal count output (pin 7) of each 4510 counter IC in this condition is high, not low. So the 00:00:00.0 state is only detected when the clock is used as a count down timer.

A small delay of 10uS is added to the parallel load circuits to ensure the 4510 counters definitely reach a new stable state during the load process because after the load process the data that initiated the load process (on the counter outputs) vanishes. The AM and PM lights toggle at the count just after 12:59:59.9 only in the 12 HR mode and are off in the count down or 24Hr mode.

To ensure the mode control switches are effectively de-bounced, they are a changeover type configured with pairs of inverter gates. This method is by far and away the most effective method of contact de-bouncing as it is not frequency or time domain dependent to any extent (except for the short gate propagation delay) as an R-C network is and it is also superior to any software de-bouncing. However it does require a changeover switch to execute it. This de-bouncing is shown below:

CMOS UP/DOWN 12 / 24 HR CLOCK SWITCH DEBOUNCER & ZERO COUNTDOWN DETECTOR. pg 3 of 4.

Dr H. Holden.



When the clock is in the countdown timer mode (operating in 12 or 24 Hr mode) IC 5B detects when the count on all 4510's has reached zero (Zero detected = Zero Det.) and so pin 10 of 5C goes high. This deploys the master reset for all of the 4510 counters (MRC) and the display freezes on zero. The VN10kM Mosfet turns on the DIL relay and the relay contacts can be used to trigger an external event for any practical task such as a laboratory experiment.

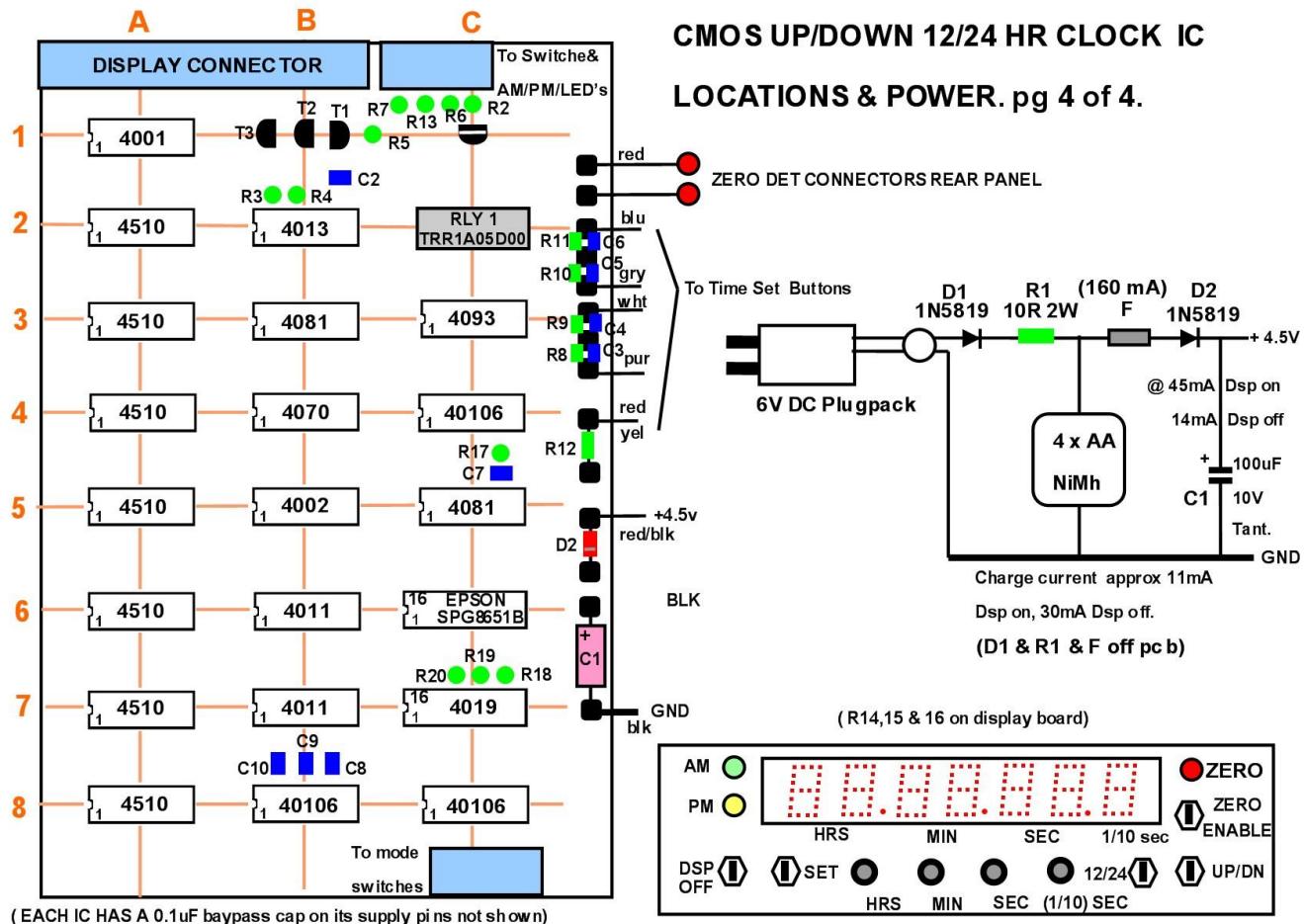
If the “zero enable switch” is not in the enabled position, the countdown simply passes by 00:00:00.0 and goes to 99:59:59.9 and keeps counting downwards again.

Using the Set controls the clock can be programmed to count down from any time below the 99:59:59.9 value to zero. However with the display enabled(lit) and the clock running on batteries alone, then the expected battery life with the clock's 45mA current drain is limited to

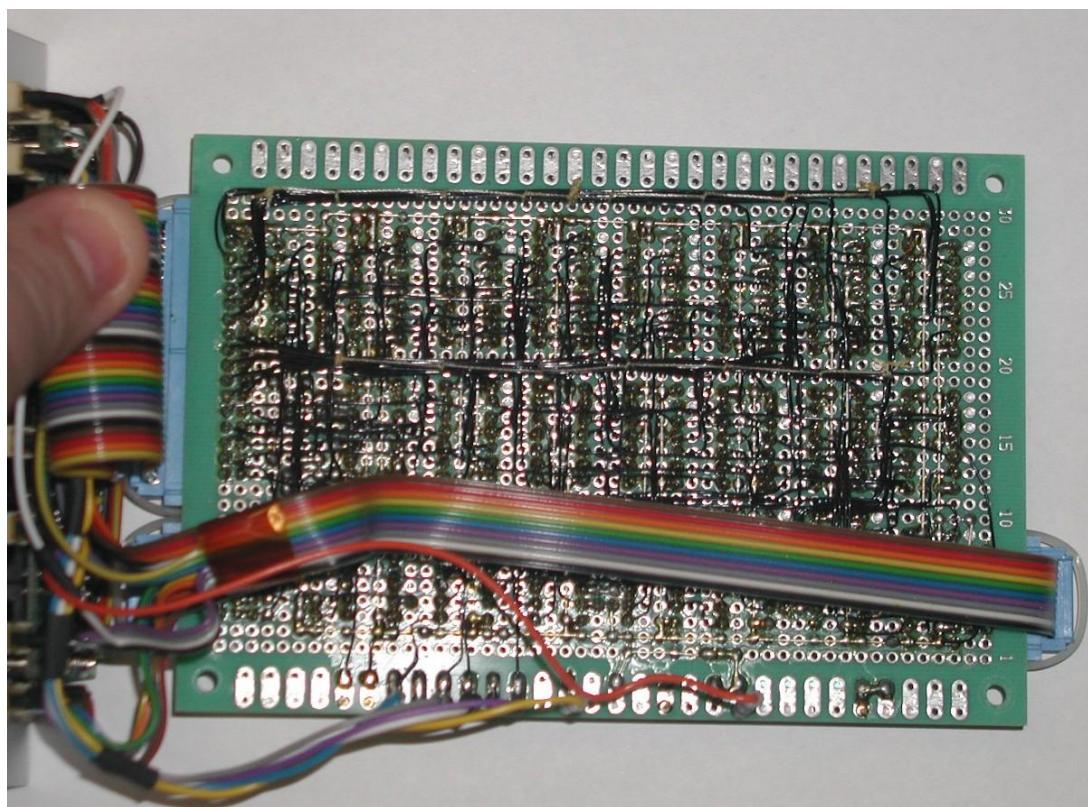
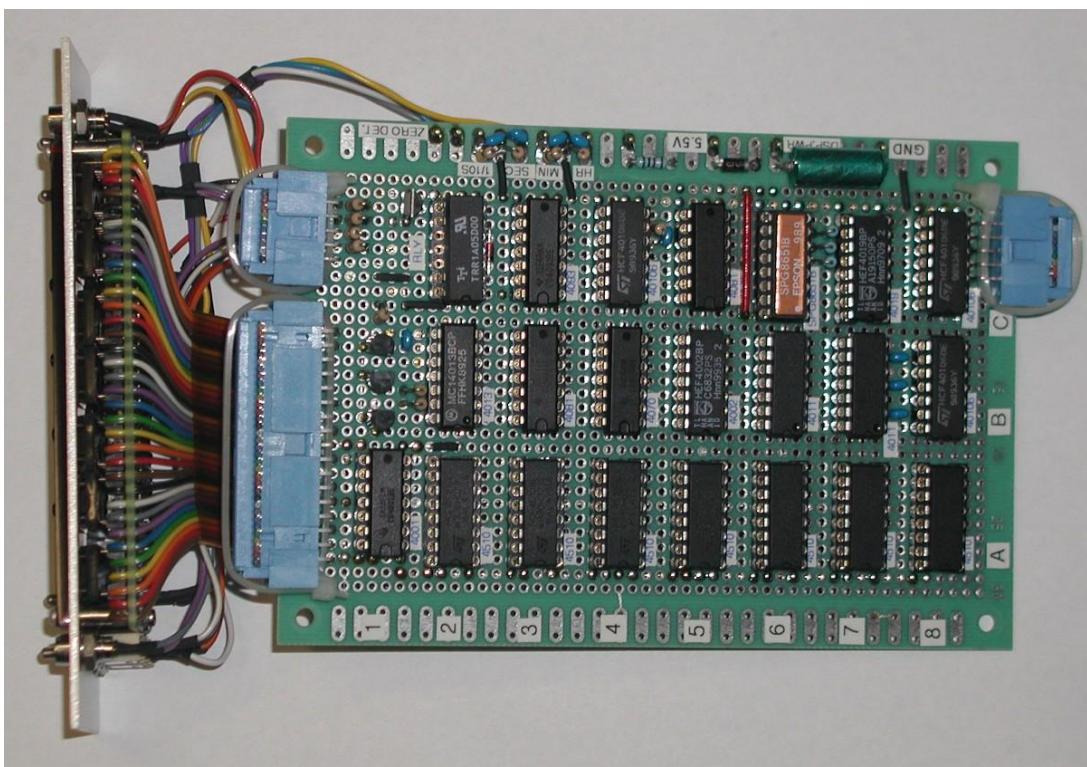
55 Hrs, but with the display turned off it is 178 Hrs as the current drain under that condition is only 14mA.

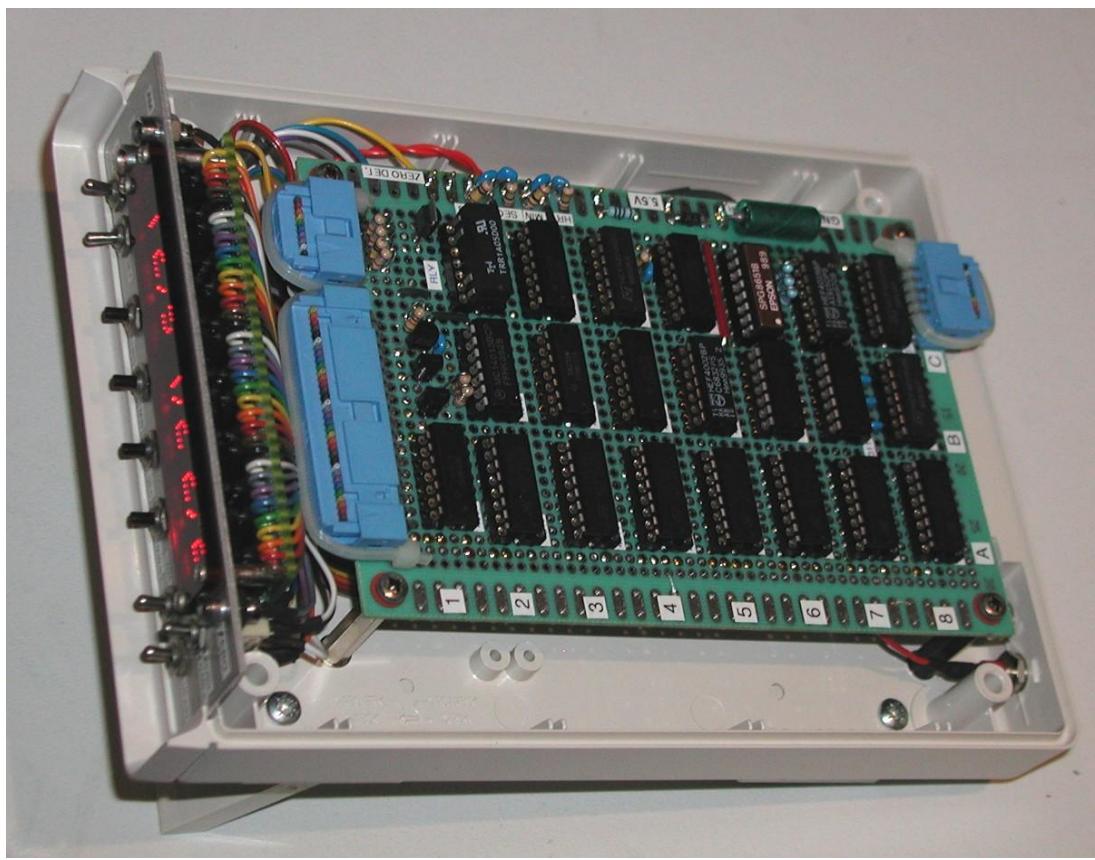
The clock runs from its internal 4 x 2500mAh internal batteries which receive a low charge when the clock is powered by its usual 6V DC plug pack:

The diagram above shows the basic component layout. The PCB was hand wired and connections soldered with over 400 connections. The wiring was laced together with silk thread in a loom like configuration on the rear of the PCB which is a Sunhayato product. Connectors and ribbon cable were used to keep the wiring between the front panel/switch/display to the main PCB tidy.



The photos below show the hand wired PCB:





The OKW housing has the 4 x AA battery holder integral to its design (not seen in the photo above) and is also fitted with tilt feet which are also an OKW product.
