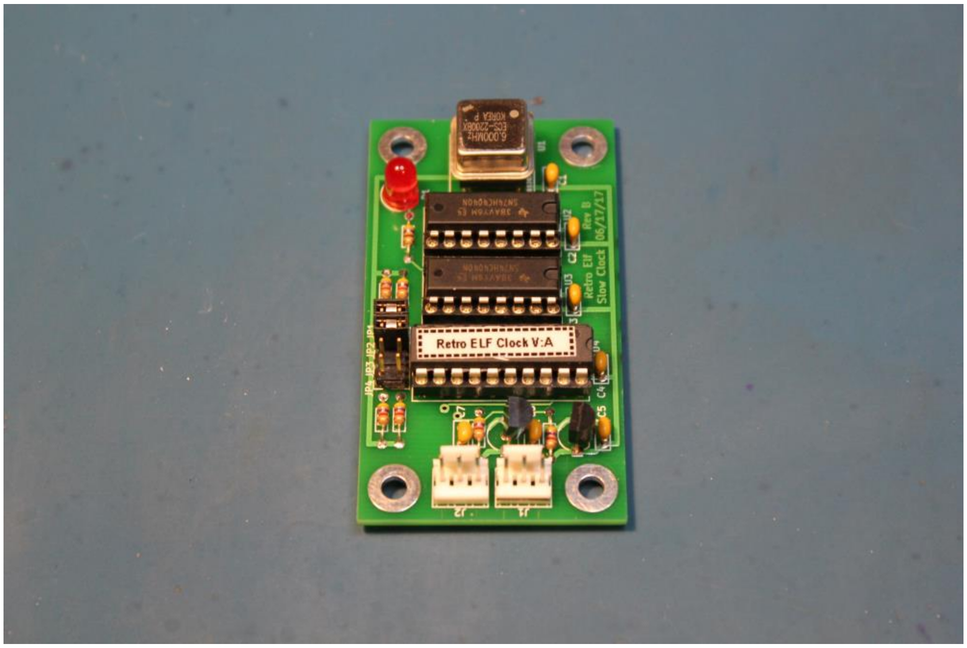


Retro Elf Plus – Slow Clock - Revision B

1 – About the slow clock board

One of the interesting features of the Retro Elf's CMOS construction, is the ability to adjust the clock speed at any time to any rate. The Slow Clock board takes advantage of this.

The slow clock is NOT a single step operation, where the 1802 clocks a full speed through fetch and execute and then waits at the end of the cycle for you to say another step please.

The slow clock allows you to see how the 1802 process code. You will discover that the address LEDs no only display the address of the next memory operation but also the 16-bit data being moved from internal registers. A decrement of an internal register will show up on the address LEDs during the execute phase and then return to the next memory location on the next fetch.

The resulting design uses a three-position toggle switch with the same look a feel as the toggle switches already in place on the front panel of the Retro Elf. In the up position, you get f ull clock speed normally 3Mhz. In the second, middle position, the system clock is divided down to ~183Hz. With the toggle set in the down position you get the lowest speed of ~3Hz.

Testing showed that the middle speed was just fast enough to push through code but still get some useful indications from the status LEDs. The slowest speed gave you the time to really watch each clock cycle happen.

2- Assembly

Warning: If you read nothing else on the assembly of this board, please read about the installation of both U5 and U6. Failure to do so will result in the destruction of both these parts at power up.

Before you begin, some helpful hints

Follow the instructions carefully and read the entire step before you perform the operation. Solder a part or group of parts only when you are instructed to do so.

Each circuit part in an electronic kit has its own component number (R2, C4, etc.). Use these numbers when you want to identify that same part in the various sections of the Manual. These numbers, which are especially useful if a part has to be replaced, appear:

- In the Parts List
- At the beginning of each step where a component is installed
- In the schematic

SAFETY WARNING: *Safety glasses are recommended. Avoid eye injury when you cut off excess lead lengths. Hold the leads so they cannot fly toward your eyes.*

Soldering

Soldering is one of the most important operations you will perform while assembling your ki t. A good solder connection will form an electrical connection between two parts, such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well -assembled kit from operating properly.

It is easy to make a good solder connection if you follow a few simple rules:

- Use the right type of soldering iron. If available, a temperature controlled soldering iron is recommended. Otherwise us a 25 to 40-watt pencil soldering iron. In either case use a 1/8" or 3/16" chisel or pyramid tip for best results.
- Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned.
- Use only a high quality rosin-core, 62/36/2 silver-bearing solder with a 0.020 or 0.015 inch diameter.
- A good solder connection is made when you heat the component lead and the foil on the circuit board at the same time. This will allow the solder to flow evenly onto the lead and foil. The solder will then make a good electrical connection between the lead and the foil.

Board Assembly

Refer to the silk screen on the printed circuit board or the Board Layout in Appendix C for parts locations on the board.

Install the ten 1/8 watt resistors at the following locations.

( ) R1: 470 ohm, 1/8-watt, 5% (yellow-violet-brown)

( ) R2: 4.7K ohm, 1/8-watt, 5% (yellow-violet-red)

( ) R3: 4.7K ohm, 1/8-watt, 5% (yellow-violet-red)

( ) R4: 4.7K ohm, 1/8-watt, 5% (yellow-violet-red)

( ) R5: 4.7K ohm, 1/8-watt, 5% (yellow-violet-red)

( ) R6: 4.7K ohm, 1/8-watt, 5% (yellow-violet-red)

( ) R7: 4.7K ohm, 1/8-watt, 5% (yellow-violet-red)

( ) Solder the leads to the foil and cut off the excess lead lengths

Install the fourteen capacitors at the following locations.

( ) C1: 0.1uF ceramic

( ) C2: 0.1uF ceramic

( ) C3: 0.1uF ceramic

( ) C4: 0.1uF ceramic

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) C5: 0.1uF ceramic

( ) C6: 0.001uF ceramic

( ) C7: 0.001uF ceramic

( ) Solder the leads to the foil and cut off the excess lead lengths.

NOTE: *16-pin and 20-pin IC (integrated circuit) sockets are used in this kit. Make sure all pins are straight. Carefully insert the socket pins in to the circuit board holes. Make sure that the index notch on the IC socket is on the same end as pin one (a square pad indicates pin 1) of that IC's location. All sockets are placed on the compunet side and solder on the solder side of the board. Start by soldering only a single pin to the board. Verify that the socket is aligned and tight against the component side of the board. If not, carefully reheat the pin and reposition the IC socket as needed. Once the IC socket is correctly placed, solder the remaining pins.*

( ) U2: Install a 16-pin IC socket.

( ) U3: Install a 16-pin IC socket.

( ) U4: Install a 20-pin IC socket.

NOTE: *The oscillator module you will be installing in the next step is not listed in the BOM (Bill Of Materials). Assuming that the oscillator is installed on an IC socket, the goal is to recycle the currently installed oscillator in use on the CPU board. The following steps can only be performed if there is an IC socket under the ocsillator.*

CAUTION: *The oscillator module you will be installing in the next step is a CMOS device that can be damaged by static electricity. Use the following sequence when you install this oscillator integrated circuits.*

> *1. Pick up the CPU board with the oscillator mounted on it.*
>
> *2. Hold the CPU board in one hand and pull the oscillator from the pins and set the CPU board aside.*
>
> *3. Pick up the Slow Clock circuit board while you hold the oscillator.*
>
> *4. Carefully insert the oscillator in indicated holes. Make sure to install the oscillator in the correct orientation on the board. Carefully bend the leads just enough to hold the oscillator in place before you set the circuit board down in to your work surface for soldering.*
>
> *5. Verify that the oscillator is in the correct orientation and solder the four oscillator leads to the board and trim as needed.*

The oscillator is now protected by circuit board's sockets foil.

( ) U1: Install the crystal oscillator module taken from the CPU board.

( ) J1: 3-pin header. Match the silk screen.

( ) J2: 3-pin header. Match the silk screen.

( ) JP1: 2-pin jumper header. Match the silk screen or board layout and solder.

( ) JP2: 2-pin jumper header. Match the silk screen or board layout and solder.

( ) JP3: 2-pin jumper header. Match the silk screen or board layout and solder.

( ) JP4: 2-pin jumper header. Match the silk screen or board layout and solder.

NOTE: *When Installing the LED, position the flat side as shown to match the outline on the board. Note that the short LED lead is in the square hole on the board. Hold the LED tight to the board and solder the leads to the foil and cut off the excess lead lengths.*

( ) D1: Install a Red LED.

NOTE: *The next part installed is a DS1233. This integrated circuit is packaged in a TO-92 style case and look like a transistor.*

CAUTION: If the DS1233 is installed backwards, it will be destroyed on powerup.

Due to a silk screening error in the Revision B board's, both U5 and U6 are drawn rotated 180 degrees on the boards silk screen!

When installing the DS1233, make sure to rotate the 3-pin package so the flat side of the part is rotated 180 degrees form the outline on the board's silk

screen. I.E the flat side of U5 and U6 should be facing in the direction of components R7 and C7.

( ) U5: Rotate the DS1233 180 degrees to the silk screen on the board. Insert each of the 3-pin in to their respective holes and carefully push the part to about 0.1 inches above the board. Bend the leads slightly on the back to hold the part in place. Check that all looks good and solder.

( ) U6: Like above, rotate and install the second DS1233.

NOTE: *In the following steps, install ICs in the designated sockets. Be careful to match the pin 1 end of each integrated circuits to the index mark on the socket. Before you apply downward pressure to an integrated circuit, make sure each integrated circuits pin is centered in its proper socket h ole. Handle integrated circuits with care, as their pins bend very easily.*

CAUTION: *The integrated circuits that you will install are CMOS or MOS devices that can be damaged by static electricity. Use the following sequence when you install the integrated circuits.*

1. *Pick up the conductive foam block with the desired integrated circuits mounted on it.*
2. *Hold the IC in one hand and pull the conductive foam pad from the pins.*
3. *Pick up the circuit board while you hold the integrated circuits.*
4. *Carefully insert the IC in its socket before you set the circuit board down in to your work surface.*

The IC is now protected by circuit board's sockets and foil.

NOTE: *DIP = Dual Inline Package.*

( ) U2: 74HC4040 - 16-pin DIP

( ) U3: 74HC4040 - 16-pin DIP

( ) U4: Pre-programmed GAL 16V8 labeled "Retro ELF Clock V:B" - , 20-pin DIP

Testing

( ) Now is the time to take a last look over the finished assembly once more looking for any issues like bent pins under ICs, unsoldered connections, cold solder joints or parts in wrong locations.

( ) Carefully check for any solder bridges between pins and foil pads. If a solder bridge has occurred, hold the circuit board solder side down and hold the soldering iron tip between the two points that are bridged. The solder will flow down the soldering iron tip.

( ) Set an ohm meter to read the lowest resistance setting and measure across pins 1 and 3 on 3-pin connector J2. If the resistance reading close to zero (less than 50 ohms) then some form of electrical short may exists. Carefully inspect the board assembly for solder bridges or parts installed backwards or at incorrect locations. Correct and issues found and re perform this test.

( ) Reverse the meter leads on J2 and re-read the resistance. Like before, if the reading is close to zero then some form of electrical short exists. Carefully inspect the board assembly for solder bridges or parts installed backwards or at incorrect locations. Correct and issues found and re perform thi s test.

This completes the assembly of the Retro Elf Slow Clock Board.

3– Theory of operation

Details on the revision-A Slow Clock module such as part locations, parts list and schematics, are located in appendix E.

The Slow Clock Board uses the same oscillator module as the one on the CPU board. Throughout this section a default oscillator frequency of 6MHz will be assumed for all calculations. Since the oscillator on the CPU board needs to be removed to allow the connection in of the Slow Clock board's interface cable. You should place the removed oscillator from the CPU board in to the U1 location on the Slow Clock board.

The 6MHz oscillator frequency is feed in to the clock input of a 74HC4040 (U2). The 74HC4040 is a 12-stage binary ripple counter that is used to divide the original clock by 212 or 4096 giving a ~15KHz (6,000,000HZ / 4096 = 1464.8Hz) output at pin 1.

The output on U2 pin 1 is then feed in to a second 74HC4040 (U3) for more dividing. The second stage of dividing is used to generate the final selection of frequencies to be used to feed the CPU board.

The following table details the four frequencies that are passed on the next stage in the circuit:

U3-74HC4040 output	Power	Divisor	Output Frequency
Pin 7 (Q2)	2^2	÷4	~366Hz
Pin 5 (Q4)	2^4	÷16	~92Hz
Pin 2 (Q6)	2^6	÷64	~23Hz
Pin 13 (Q8)	2^8	÷256	~5.6Hz

The Q10 - 2 10 output of U3 pin 14 is used to drive the LED at D1 through a 470-ohm current limiting resistor at R1. This status LED will blink at a rate of ~1.4Hz showing that the Slow Clock Board is running.

Two DS1233 (U5 and U6) and two 0.001uF capacitors (C6 and C7) are used to create two channels of switch debounce used by the incoming user switch singles from received via connector J1. The DS1233 is normally used as a power on reset controller for microprocessors but has a secondary function of de-bouncing a switch signal.

The 16V8 programmable logic device (U4) performs two functions. The first operation performed is creating two channels of input frequency selection. The resulting four frequency ranges from the second stage of the 74HC4040 (U3) are feed in to the 16V8 (U4) via the inputs C1 (U4 pin 2), C2 (U4 pin 3), C3 (U4 pin 4) and C4 (U4 pin 5). Two sets of two jumpers are used to select which of the four incoming frequencies will be used for the two-output channel at AOUT (U4 pin 17) and BOUT (U4 pin 18). Jumpers JP1 and JP2 are used to select frequencies for channel A while JP3 and JP4 are used to select for channel B. The following table shows the frequency selections possible:

Jumper	~5.7Hz (input C1)	~23Hz (input C2)	~93Hz (input C3)	~366Hz (input C4)
A0 or B0	In	Out	In	Out
A1 or B1	In	In	Out	Out

The second function in the 16v8 (U4) is the selection of which frequency is to be used. The selected frequency is based on the logical status of the two incoming signals from J1 pins 1 and 3. J1 is connected to the Front Panel's connector J2 via a three-wire interconnection cable assembly. The toggle switch is a

SPDT, ON-OFF-ON used to select which frequency is to be used. The three positions of the toggle switch select which of the three frequencies will be feed to the CPU board via J1 pin 2. In the up position, the resulting output at COUT will be at full clock speed of the oscillator at U1. In the second, middle position, channel B will be used routed to COUT and hence used for the CPU clock. With the toggle set in the down position you get the A channel selection.

Normally the middle setting would be a faster clock like 366Hz and the down position would be slower like 5.7Hz. If you wished, you could set the middle position to slow and the bottom to the faster speed. It is even possible to make both middle and bottom the same clock speed

J2 contains the COUT output from the 16V8 (U4 pin 19) to be used by the CPU board. In addition, the 5VDC power supply needed by the Slow Clock Assembly is also provided via J2. A short, three-wire, twisted cable assembly interconnects J2 on the Slow Clock Assembly to the IC socket at location U9 on the CPU board. Five 0.1uF capacitors (C1, C2, C3, C4 and C5) are connected across the 5V supple by each of the IC locations and are de-coupling capacitors.

4– Technical details

The slow clock uses two 3-pin connectors, J1 and J2, to interface with the Retro Elf system.

J1 carries the users desired clock speed selection from the front panel's "Speed" toggle switch. This three-position switch is used select slow, medium and full speed system clocking. When the toggle switch is in the down position, the SELECT A line (J1-1) is pulled to ground signaling the slow clock board to enter a slow clock mode.

Placing the toggle switch in the middle position, leaves both the SELECT A (J1-1) and SELECT B (J1-3) lines floating signaling the slow clock to enter medium clock mode.

Finally, placing the toggle switch in the up position, grounds the SELECT B line (J1-3) signaling the slow clock to enter the full speed clock mode.

Connection to the Retro Elf CPU board is made through a twisted, three-wire cable. At one end is a 4-pin IC header used to connect to the CPU's removed clock module location. The other end plugs in to connector J2 on the slow clock board. Pins 1 carries the power needed to run the slow clock while pin-2 carries the actual clock signal out form the slow clock board to the CPU board. Pin-3 is the common ground used for both power and clock ground return.

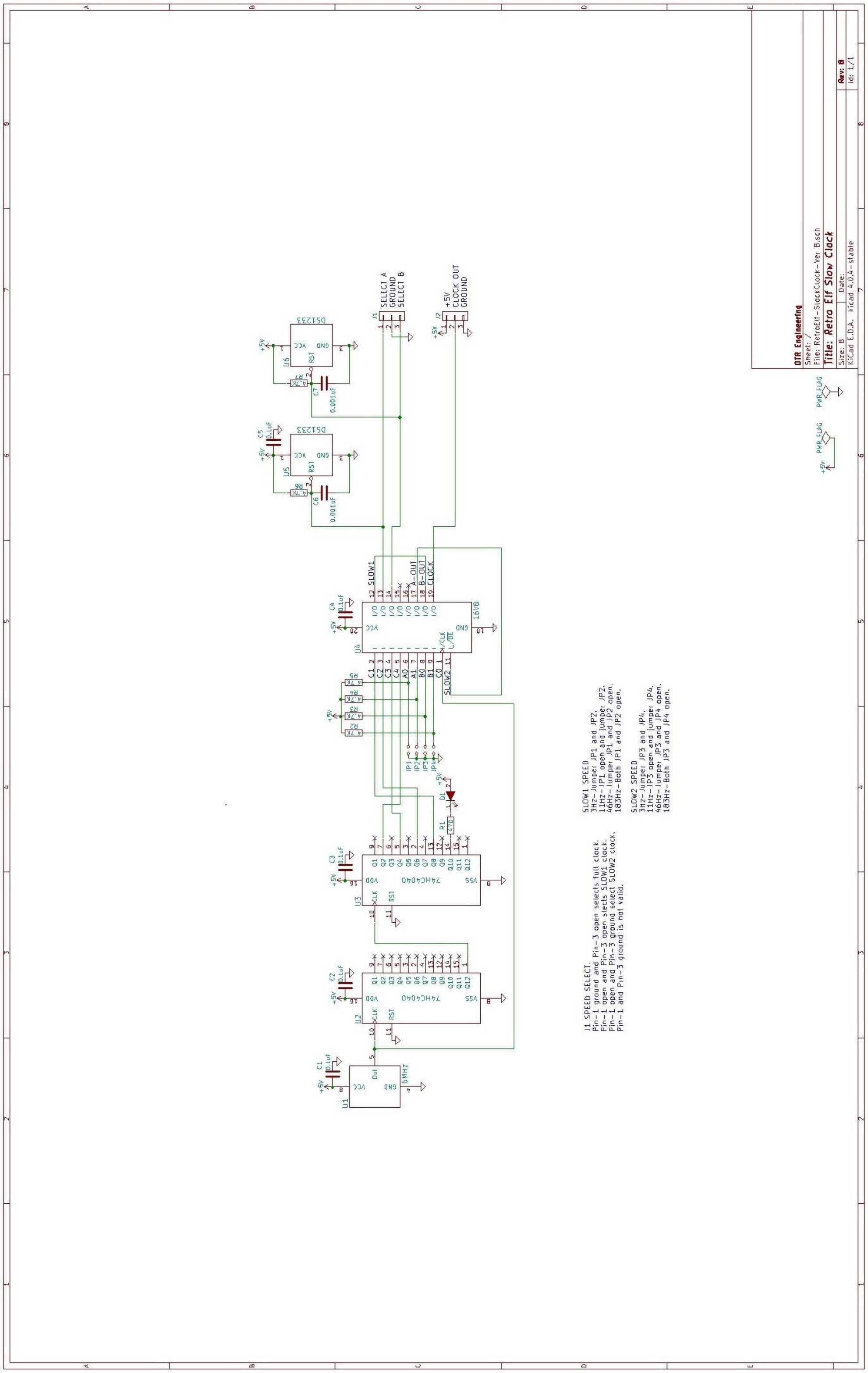
J1 – Slow clock selector switch

Pin	Type	Label	Description
1	Input	SELECT A	Clock speed selection input A.
2	Power	GROUND	Ground.
3	Input	SELECT B	Clock speed selection input B.

J2 – Slow clock interface to CPU board.

Pin	Type	Label	Description
1	Power	+5V	Plus 5 volts DC to drive slow clock board.
2	Output	CLK OUT	Slow clock output used to drive the CPU's clock.
3	Power	GROUND	Power ground.

Appendix A - Slow clock schematic



Appendix B – Slow clock parts list

Location	Qty	Description	Vendor	Vendor PN	MFG	MFG PN
C1, C2, C3, C4, C5	5	Capacitor CER 0.1uF 50V 20% Radial	Digi-Key	399-4151-ND	Kemet	C315C104M5U5TA
C6, C7	2	Capacitor ceramic 1000pF 50V 20% Radial	Digi-Key	399-3770-ND	Kemet	C320C102M5R5TA
D1	1	1 ¾ Red LED	Digi-Key	754-1266-ND	Kingbright	WP7113LID
J1, J2	2	Connector header 3 position 0.1 pitch vertical tin	Digi-Key	WM4201-ND	Molex Inc	0022232031
JP1, JP2, JP3, JP4	4	JUMPER SKT BLACK	Digi-Key	952-2165-ND	Harwin Inc	M7567-46
JP1, JP2, JP3, JP4	4	2-Pin	Digi-Key		3M	
R1	1	Resistor 470 ohm 1/8-watt 5% CF axial	Digi-Key	CF18JT470RCT-ND	Stackpole	CF18JT470R
R2, R3, R4, R5, R6, R7	6	Resistor 4.7K ohm 1/8-watt 5% CF axial	Digi-Key	CF18JT4K70RCT-ND	Stackpole	CF18JT4K70
U4	1	Socket IC 20 Pin	Digi-Key	AE10015-ND	Assmann WSW	AR-20-HZL-TT
U2, U3	2	Socket IC 16 Pin	Digi-Key	AE10013-ND	Assmann WSW	AR16-HZL-TT
U4	1	GAL16V8 "Retro ELF Clock V:B"	Digi-Key	ATF16V8B-15PU-ND	Atmel	ATF16V8B-15PU
U2, U3	2	74HC4040	Digi-Key	296-8324-5-ND	Texas Instruments	SN74HC4040N
U5, U6	2	DS1233 - IC ECONORESET 5V 10% TO92-3	Digi-Key	DS1233-10+-ND	Maxim Intergraded	DS1233-10+

Appendix C – Slow clock parts locations