



## ZX81 ULA Replacement

The ZX81 ULA replacement is a plug in pin compatible clone of the original ZX81 ULA with a bit of an extra boost.

### Installing the ULA

The replacement ula includes circuitry to directly drive the composite video input of your monitor or TV, therefore you are required to make a small modification.

Method 1. modify the modulator (easily reversible). This method requires disconnecting 1 end of a resistor and disconnecting the input wire to the modulator. (images are from a Issue 1 UK board)  
Step 1, lift the lid from your modulator and identify the resistor circled in red below, you should unsolder this resistor from the output pin of the modulator, as shown on the right.



up out of the way.

Step 2. disconnect the modulator input wire. And bend

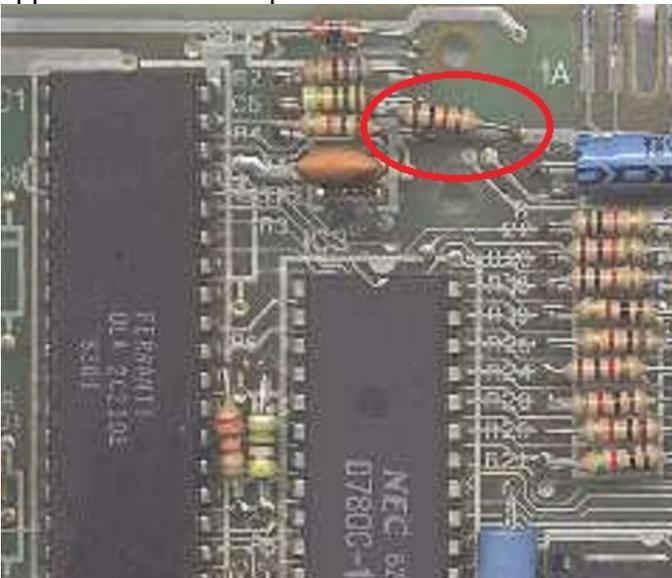


Step 3. Connect a new wire. Solder a short piece of wire to the modulator output pin, then feed wire through plastic insulator on side of modulator and finally connect wire to the pad where you disconnected the modulator input in step 1.

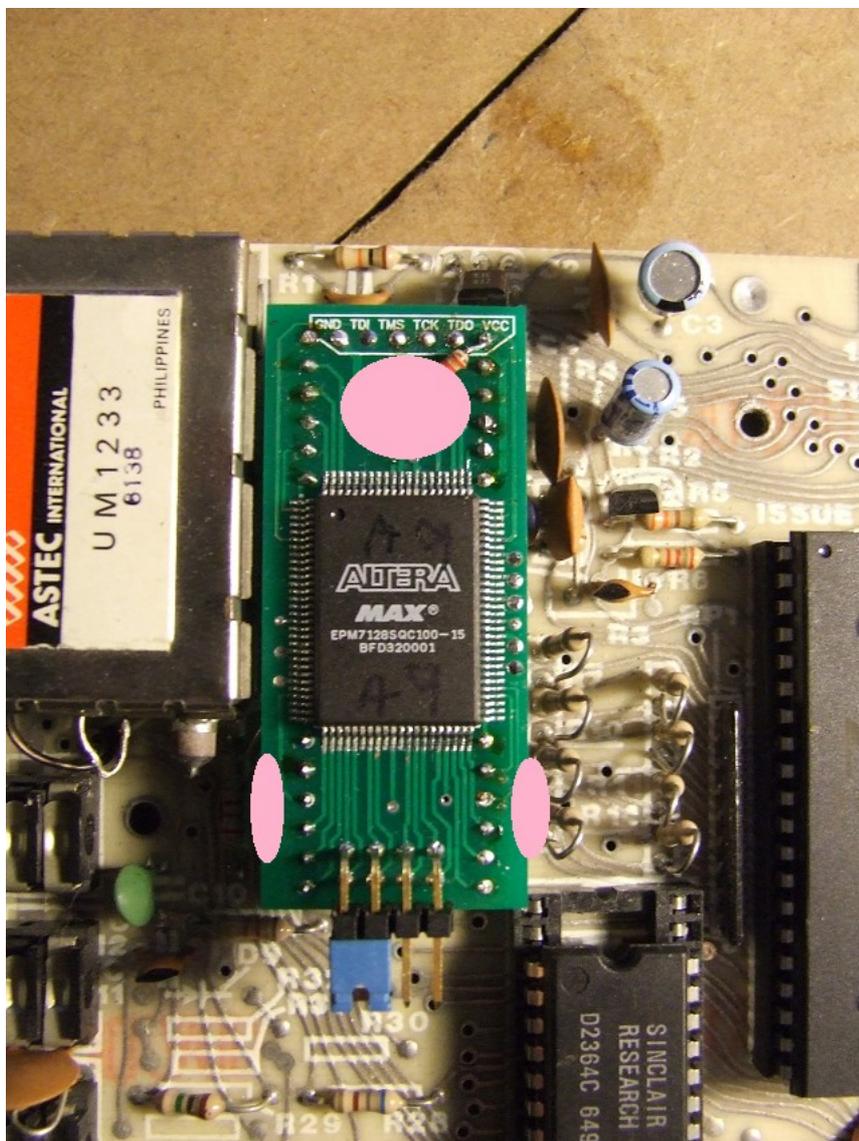


Method 2. connect a flying lead, instead of modifying the modulator a suitable lead can be connected directly to the ZX81, disconnect the modulator input wire, you should connect the GND (screen/shield) of your lead to a suitable gnd on the ZX81, probably the easiest point is the modulator casing itself. Then you should connect the video (signal) of your lead to the pad where you disconnected the modulator input from.

NOTE FOR ISSUE 3 BOARDS..... on most if not all issue 3 boards there appears to be an extra resistor in the oscillator circuit, why it is there I am unsure as I have tested original ULA's with and without it and they all seem to operate correctly. HOWEVER the replacement ULA requires this resistor to be removed. See below. Sometimes this resistor is on top of the other resistors and may appear in a different place to that shown below.



Now you have modified your ZX81 for composite video output it's time to install the ULA, it is designed to plug directly into the original ULA socket. You should ensure that you are inserting it in the correct orientation and that the pins are not misaligned, apply slow even pressure until your ULA is seated in the socket, **YOU SHOULD NOT PRESS DOWN ON THE CHIP !**, the easiest way is to use you thumb and forefinger on the edges at the bottom and the thumb or finger on the other hand flat at the top.



Do not alter the link settings at this time, they are set for ZX81 and enhancements disabled, we should first ensure that it operates correctly before considering wiring it up for enhanced operation.

At this point you should have a ZX81 that operates just like an original.

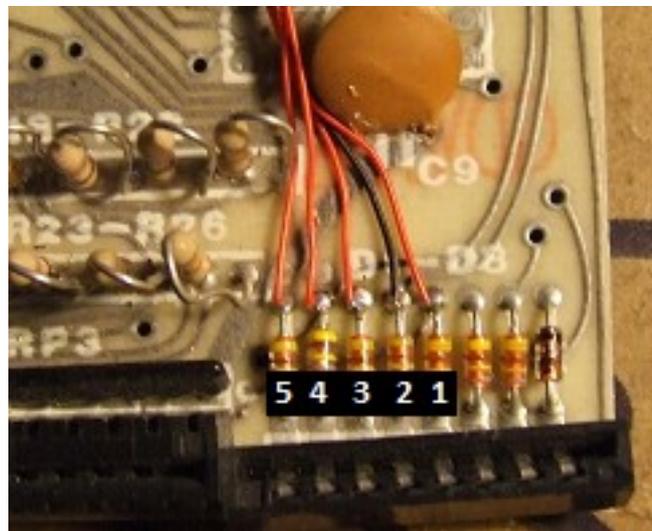
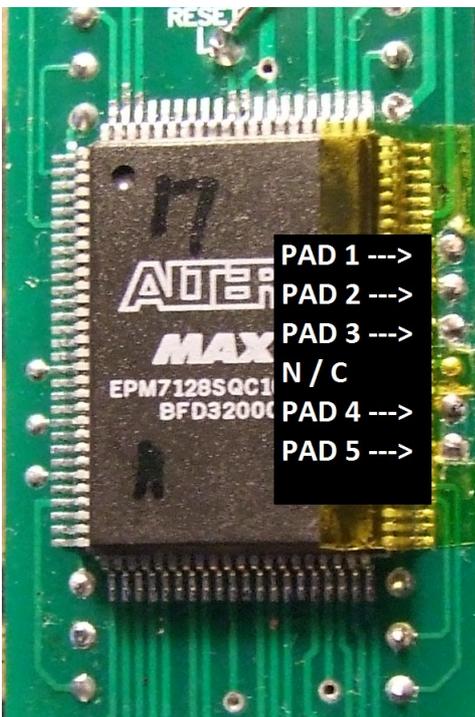
If you've got this far and it's all working lets wire it up for enhanced operation. In the event that it's not working please recheck that the ULA is seated correctly and that your video output is connected correctly also.

For full enhanced operation we need to solder 6 small wires from the ULA to the circuit board of the ZX81, 1 wire is connected the the reset circuit and the other 5 are connected to the address bus. You will need some fine wire, Kynar wire wrapping wire or similar will do. The address bus connections are the same for Issue 1 and 3 boards. So I'll cover that first, because the enhanced

ULA uses a couple of POKES to control the various features we need to connect some additional address lines (A9 – A13) these are the small pads on the right hand side of the ULA

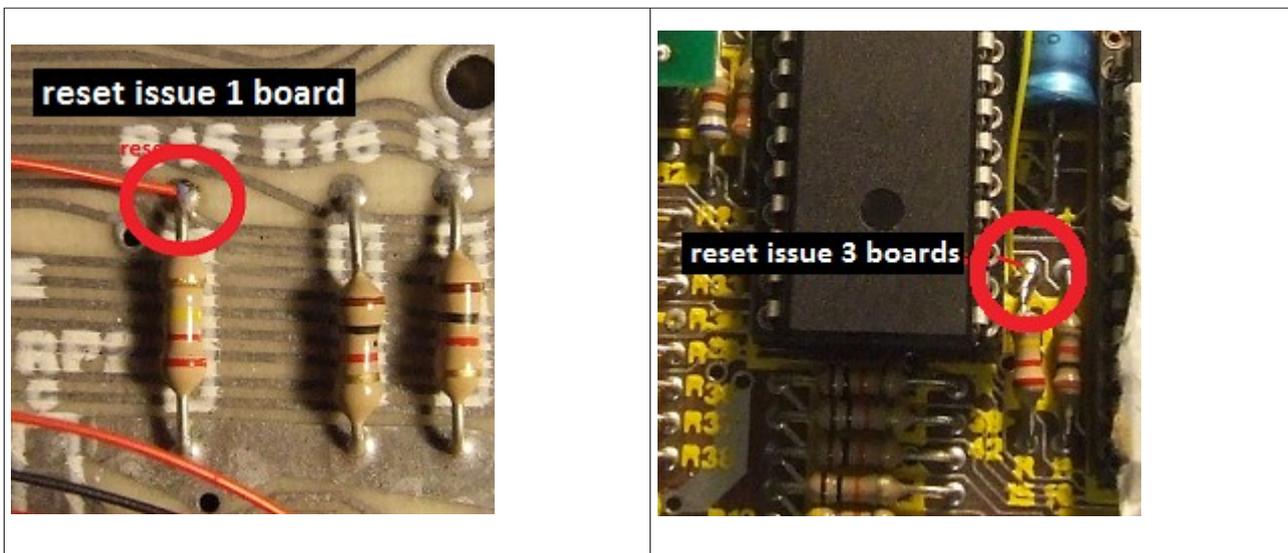
I suggest that you solder each wire to the ULA first as it;s easier to get them 'straight' if the other end is not connected first. The pads are quite small so a fine tipped soldering iron is best also great care should be taken not to short any of the pins on the chip, I have stuck a small piece of heat resistant Kapton tape over the pins on that side of the chip, it should protect against accidental solder splash but it will melt under sustained application of heat.

You will see there are 5 pads and 1 plated through hole, DO NOT connect anything to the plated hole. In the picture below I have number the pads 1 to 5, they should be connected 1 at a time to the TOP of the diodes near the 8way keyboard connector at the bottom right of your ZX81 board, following the images below, connect 5-5, 4-4, 3-3, 2-2, 1-1. the diode labelled 5 below does not have much 'clearance' to the adjacent track so care must be taken.



The Reset connection is different on issue 1 boards (left) and issue 3 boards (right)

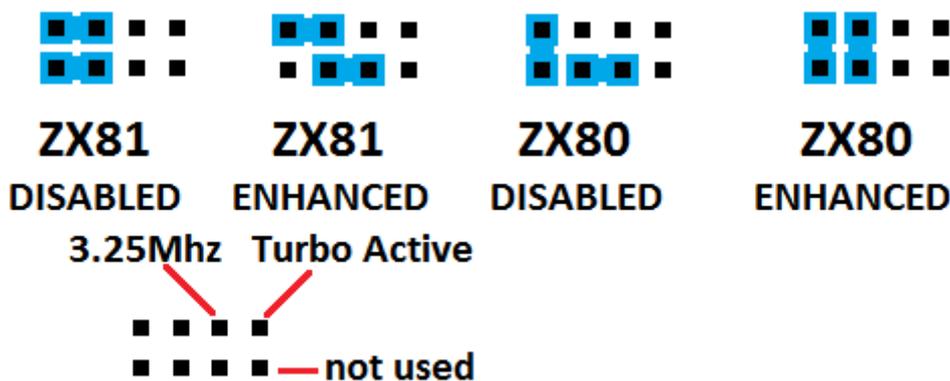
<p>Issue 1 boards connect to top of R15. (located just to the top right of the CPU)</p>	<p>Issue 3 boards connect to top of R15 (located to the immediate right of bottom right of CPU)</p>
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Once again check you have no shorts and everything is connected correctly, if everything went well your ZX81 should now power up normally.

Now its time to enable the Enhanced features :- ) shown below are the various link settings.

### Link settings



The ULA is supplied in the ZX81 disabled configuration and can be used as an ordinary ULA once the composite video output modification (above) has been completed. There are also 2 additional outputs ' 3.25Mhz ' is a clock output intended for users with a sound modules and ' Turbo Active ' intended for connection of and LED it is active high and you should always use a current limiting resistor 220 or 270 Ohms should be good for most standard LEDs.

Changed you links to ZX81 enhanced yet ? No? Well get to it, it's time to start playing with these enhancements.

Caution... TURBO should only be enabled if you have upgraded you CPU the standard 4Mhz version is unlikely to run for sustained periods if at all.

Controlling the enhancements is as easy as a POKE for ZX81 you have only to remember 2 numbers ' 101 ' and ' 1001 '

POKE 101,x is all you need to start, the value of x depends on what feature you want to turn on or off, here an understanding of the binary system helps as the various features are controlled by each 'bit' of the value.

- Bit 0 (1's)
  - This is the LOCK FEATURES bit, once this bit is set no further changes can be made until a 'Reset' or 'power cycle' you should exercise caution when setting this bit.
- Bit 1 (2's)
  - setting this bit allows you to trigger Turbo mode when operating your ZX81 in 'FAST' bit 7 also needs to be set.
  - Within your program at some point after switching to 'FAST' you should execute a POKE 1001,x (the value of x is irrelevant, the act of trying to write a byte to location 1001 is sufficient)
- Bit 2 (4's)
  - setting this bit will cause the ULA to report an inverted version of the UK/US bit that is tested each time the display is updated, the upshot is that a 50Hz (UK) machine will now operate at 60Hz (US) and a 60Hz (US) machine will operate at 50Hz (UK), This bit is probably only useful for programmers wishing to ensure that their brand new red hot game functions correctly at both display frequencies.
- Bit 3 (8's)
  - This bit controls the ROMPATCH feature, When turbo is active it can be difficult to switch from 'FAST' to 'SLOW' this is because the ZX81's ROM is programmed to test for the presence of an NMI generator, it does this by attempting to turn on the generator and then waits a predetermined amount of time before testing if the NMI generator is active. But because the CPU is running at twice its normal speed this 'waiting time' is halved and is more often than not, no longer long enough. Rompatch counteracts this by patching byte 531 of the ROM so instead of the CPU seeing its normal value of 17, it is doubled and reports 34, thus restoring the 'normal waiting time'.
- Bit 4 (16's)
  - This bit controls the inverting of the video, when set it will invert the border and display area from the normal 'black on white' to 'white on black', you should use this in conjunction with Bit 5 for various combinations.
- Bit 5 (32's)
  - This bit controls the inverting of the border only, when set the border will invert from white to black. This bit should be used in conjunction with Bit 4 for various combinations.
- Bit 6 (64's)
  - M1NOT mod, When set this bit enables machine code routines to be run in memory spanning the 32-48K region, you should make sure that d-file does not encroach on this memory region as a 'Crash' is probably certain if it does. It is safer to ensure that RAMTOP is set to 32768 or lower before setting this bit.
- Bit 7 (128's)
  - this bit controls Turbo mode, when set turbo mode is active, this is an automatic Turbo mode so saving and loading will cancel turbo for the duration of the operation. If you wish to use Turbo mode in 'FAST' then you should also set Bit 1.

By poking various values of x you can turn on or off any or all of the features. So for example to invert the entire video and enable Turbo you would do POKE 101,144

You can also PEEK 101 and see what value is already stored.

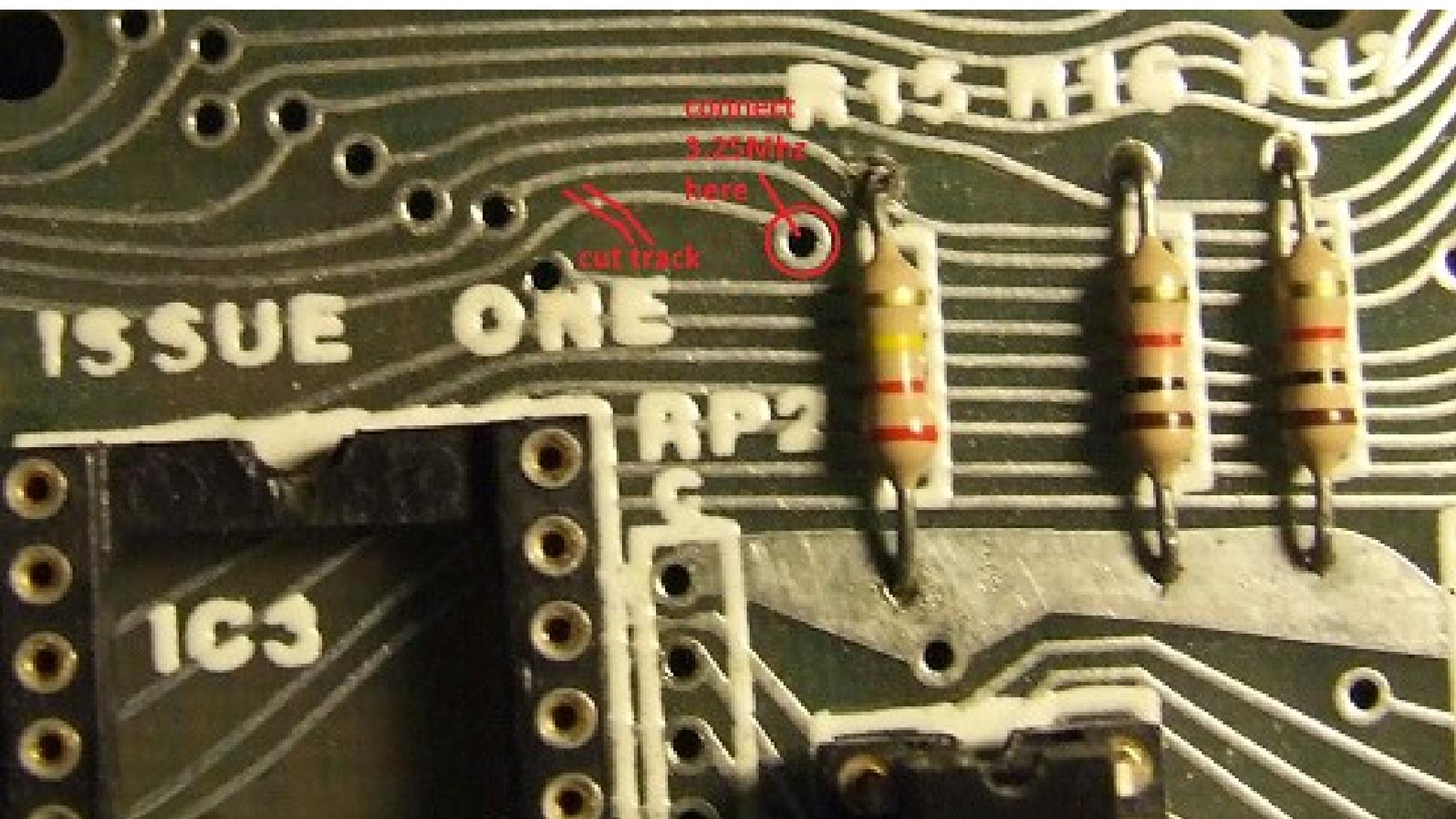
A CAUTIONARY NOTE ON USING TURBO MODE. There are several different ROMs fitted to the ZX81 during testing I have found that ROMs labelled " D2364C " appear to have too long an access time to operate in TURBO,. The MOTOROLA type ROMs labelled ' ZCM38818P ' work without problem. A replacement ROM with a quicker access time could be used.

When Turbo mode is active and your program switches to 'FAST' the CPU always runs at 3.25Mhz, to enable Turbo in FAST, when running in 'FAST' you need to also set bit 1 of the control byte. Then in your program where it switches into 'FAST' you should insert a line that performs POKE 1001,x to trigger Turbo in FAST, the value of x doesn't matter nor is it stored, merely the act of attempting to write to memory byte 1001 triggers Turbo in FAST. Each time the display becomes active Turbo in FAST will be cancelled and then if the program switches back to 'FAST' again you should re trigger the Turbo mode by executing another POKE 1001,x.

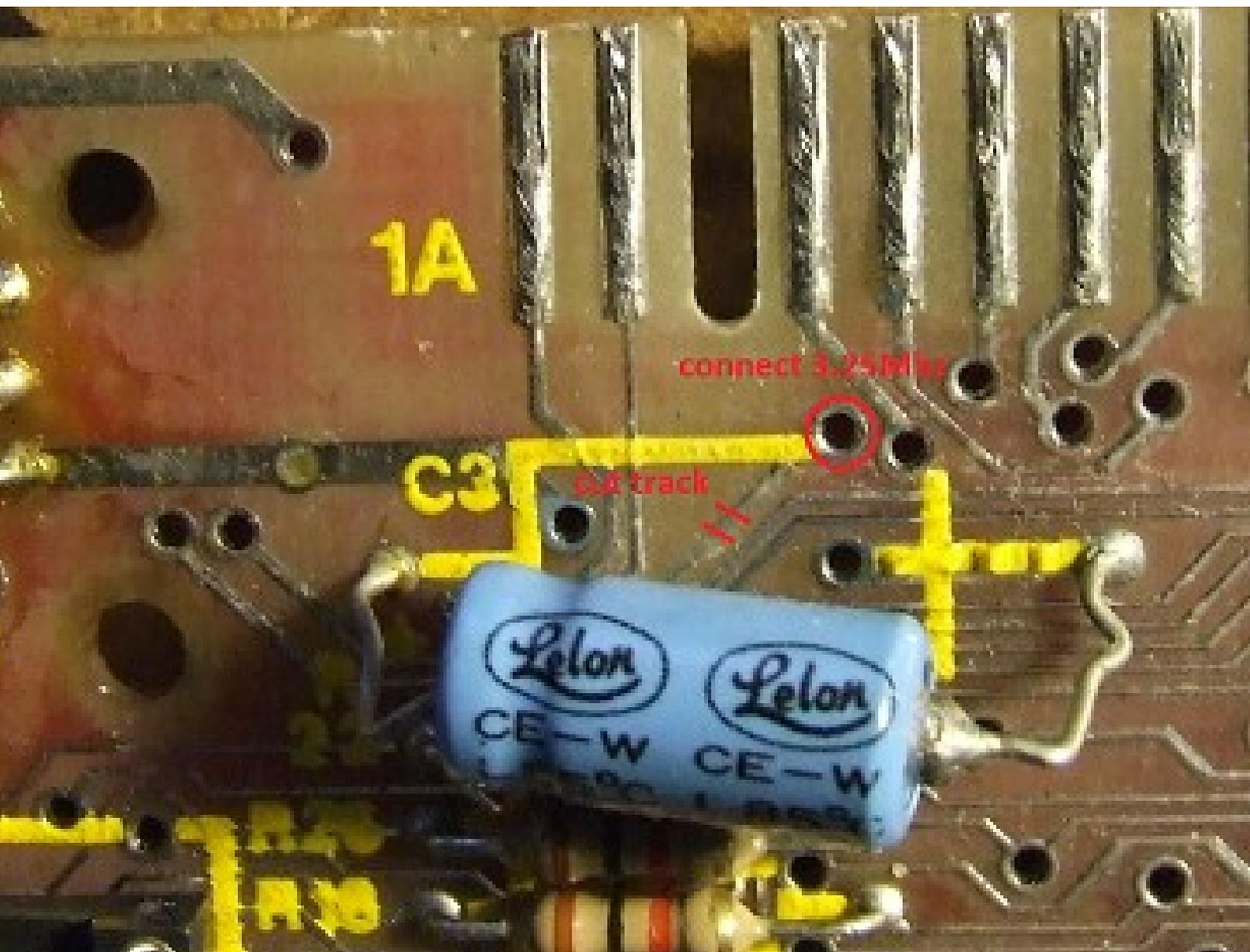
## USING SOUND MODULES

Zon-x and compatible sound modules mostly use the 3.25Mhz clock signal present at the ZX81's edge connector, however when operating in Turbo mode this signal switched between 3.25Mhz and 6.5Mhz and is not suitable for 'clocking' such sound modules. Therefore a dedicated 3.25Mhz Output is provided, please refer to the link setting above for it's location on the ULA. You can either modify your ZX81 board so that this constant 3.25Mhz signal is present at the edge connector OR if you prefer you could route it directly to your sound modules clock input, since each module differs I shall only show the modification to the ZX81 board.

You need to cut 1 track and then connect the plated through hole shown to the 3.25Mhz pin on the ULA with a suitable length of wire.  
Issue 1 ZX81.



Issue 3 ZX81



## ZX80 MODE.

You can also downgrade your ZX81 to behave like a ZX80, you will require a ZX80 ROM and suitable adapter to fit in place of the ZX81 ROM. The memory location you need to control the features with a POKE is 77 when in ZX80 mode, So for example POKE 77,128 will enable ZX80 turbo mode. You are also able to PEEK this location but bit 0 will always report as zero, but the settings may still be locked by setting bit 0. Bits 1 and 3 (trigger turbo in fast, Rompatch) have no effect when in ZX80 mode.

Turbo in ZX80 mode works differently from in ZX81 mode, most IO activity will temporarily turn off Turbo mode, as will the display loop when the ZX80 is waiting for user input.

## **Using Other ROMS**

if you wish to use other ZX81 hardware compatible roms (forth, aszmic, ect.) it is recommended to set the jumper links to ZX81 DISABLED. I have not tested any roms except ZX81 and ZX80 so cannot be 100% sure of correct operation.