Dick Smith System 80

64K Memory Upgrade using 4164 DRAM

M.B. 7/2015

The System 80 comes with 16K of RAM as standard when manufactured. This is achieved by using 8x 4116 16K by 1-bit DRAM chips. Upgrades of up to 48K are traditionally possible by either installing an expansion unit, or by piggybacking additional 4116 IC's on top of the original 8 IC's and then modifying the address bus to suit. As I discovered 16K isn't much to play around with; so upgrading to 48K is desirable.

The main reasons I chose to convert my System 80 to 4164 64K DRAM are as follows. Firstly obtaining an expansion unit has become difficult due to the fact that most people have thrown them away; plus they were not all that common to begin with. I am still very much on the hunt for an expansion unit; however I really need the extra memory now. Secondly while piggybacking 4116 DRAM is possible it makes it very difficult to remove a single IC for testing purposes. In my experience one of the most common failures in vintage electronics is RAM and having to desolder stacks of 3 IC's is not appealing.

The following guide is based on my experience in converting my System 80 Mk II from 16K of 4116 DRAM to 64 of 4164 DRAM. **<u>A word of caution at this point</u>** – not all 4164 DRAM is suitable. Please read on for more information.

<u>As usual perform this modification at your own risk. I can't guarantee anything past the fact that I did it and it is working fine so far. Also take what I have written with a grain of salt. It's entirely possible that I made a mistake while typing this up; if it does not make sense then it's up to you to think about it.</u>

<u>This should be undertaken by people who have good skills in soldering and basic electronics (i.e. know how to use a multimeter and measure resistance).</u>

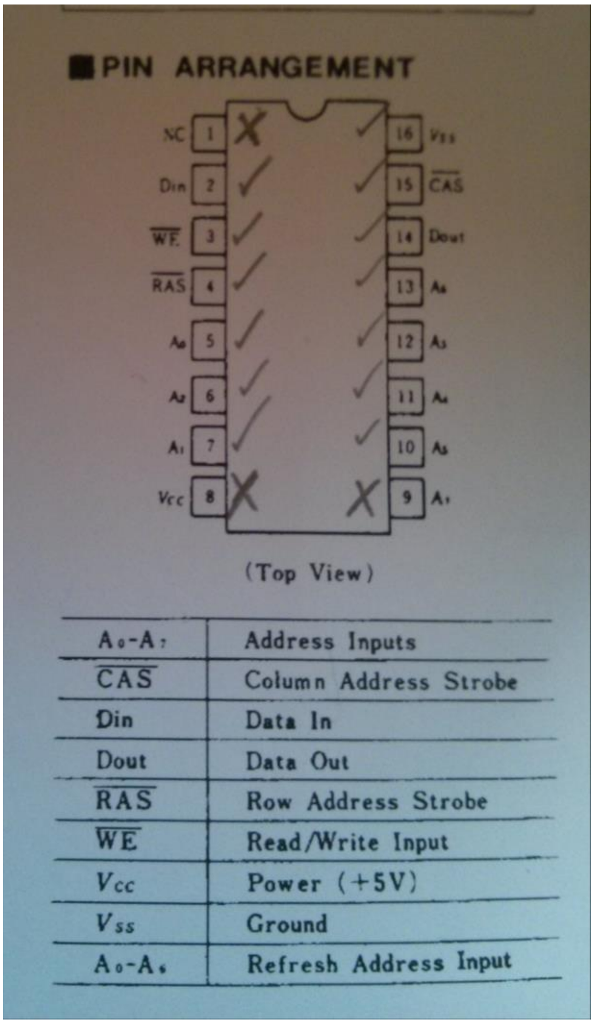
Acknowledgements:

In constructing this guide I used the 'John Gilbert & Company' System 80 64K upgrade instructions. These were meant to be used in conjunction with a kit they sold and used on their own they make limited sense. These are available from Terry Stewarts System 80 website (http://www.classic-computers.org.nz/system-80/index.htm). I also used some various bits of information on RAM upgrades, including a blog post, from Terry Stewart's website. Terry's website also provided me with some circuit diagrams from the System 80 technical manual which were used to confirm certain details. Finally attached to the 64K upgrade instructions was a hand drawn circuit diagram, source unknown.

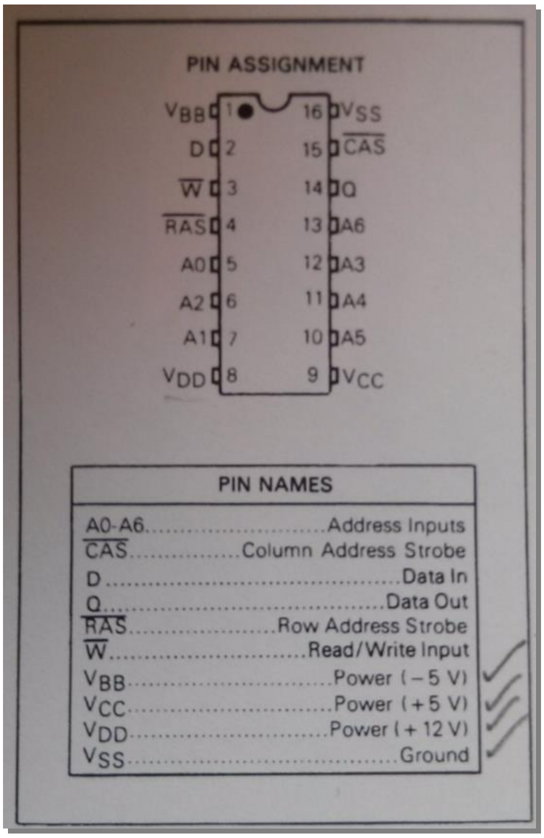
I highly recommend Terry's site as a reference for technical information.

Item 1 – Background

Firstly it is very important to understand why each modification to the System 80 is necessary. The best way to do this is to start with the 4116 and 4164 datasheets. In particular it is good to look at the pinout diagrams side by side:



4164 Pinout



4116 Pinout

Firstly note that the 4164 DRAM only requires +5V and GND for operation. The 4116 being of slightly older technology requires -5V, +5V, +12V and GND for operation. As you can see from the diagrams most of the pins correspond between the two IC's. The exceptions are:

Pin Number	4164 Pin function	4116 Pin Function
1	Not Connected**	-5V Power
8	+5V Power	+12V Power
9	Address Line 7	+5V Power

** Note that even a not connected pin should never exceed design tolerances for a given device. In the case of the 4164 it should never be less than 0V (i.e. GND) or > +5V

As seen in the table if you installed a 4164 IC into the System 80 without modification it would result in either damage to the IC or the System 80 itself.

Furthermore the 4164 has an additional address pin, A7. Modifications must be made to the addressing circuitry of the system 80 to utilise this pin and hence allow access to the full 48K (or 64K if you feeling like remapping memory and running CP/M!)

All of the modifications beyond this point are to address these pin incompatibilities and provide proper address logic to the new 4164 IC's.

Item 2 – Preparation

I would suggest at this point if you do not understand a step in this guide I would suggest you either ask a question on Terry's forums, or get a friend who can help you.

As for materials/equipment you will need:

- Soldering Iron and Solder
- Thin hook up wire. I use thin solid core copper wire as it's easy to work with.
- Desoldering braid (or desoldering station)
- Multimeter capable of measuring Ohms
- Phillips head screwdriver
- CPU board diagram from Terry's site: http://www.classic-computers.org.nz/system-80/manuals_tm3_drawing%204.1_cpu%20board.jpg
- 3x 1N4148 small signal diodes
- 2.2Kohm resistor (1/4 watt)
- 8x 4164 DRAM IC's** See comment!!

** You need to select a type 4164 DRAM that is labelled as either '128 cycle', '7-bit refresh compatible' or '4116 refresh compatible'. This attribute is most easily determined by examining the datasheet of the particular 4164. I chose Hitachi HM4864P-2 DRAM as I had some in my spares box. A great resource for 4164 datasheets is http://www.minuszerodegrees.net/memory/4164.htm **256 cycle or 8-bit refresh RAM is NOT SUITABLE.**

Item 3 – Getting started

At this point I will assume that you know how to take the lid off your System 80. If not have a look at the resources on Terry's site.

- Turn off you System 80 and disconnect it from the powerpoint.
- Remove the top cover
- Remove the interface cable to the keyboard (gently!)
- Remove the keyboard (a few screws)
- Remove the interface cables to the interface board (gently!)
- Remove the power cable from the CPU board
- Unscrew the CPU board (the one on the left as viewed from the front) from the case (3 screws) and place the case aside.

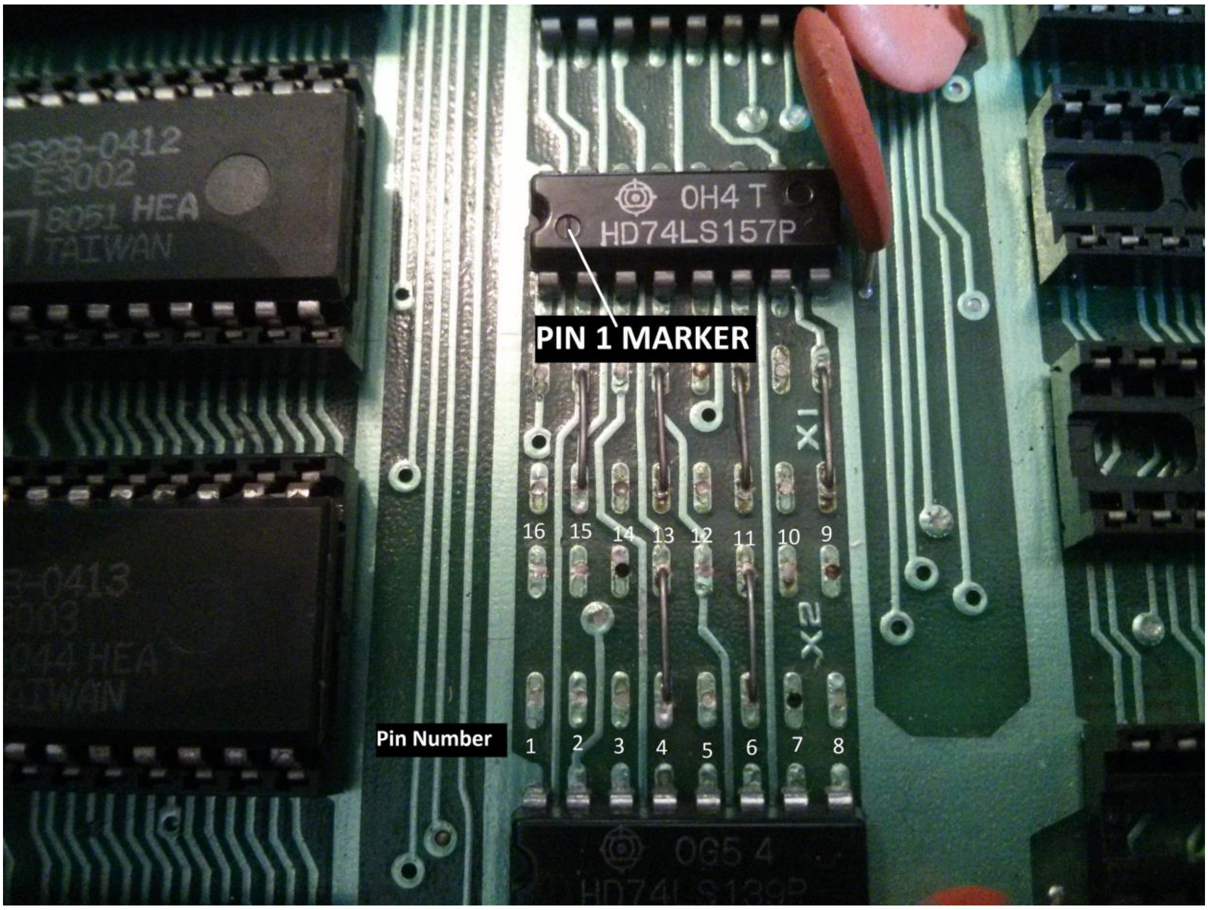
At this point you should have you CPU board on the bench ready for action. Get your CPU board diagram handy and then:

- **Remove the 8 4116 DRAM IC's** from Z27-Z34. Place them in a nice antistatic bag just in case you decide to use them again someday.

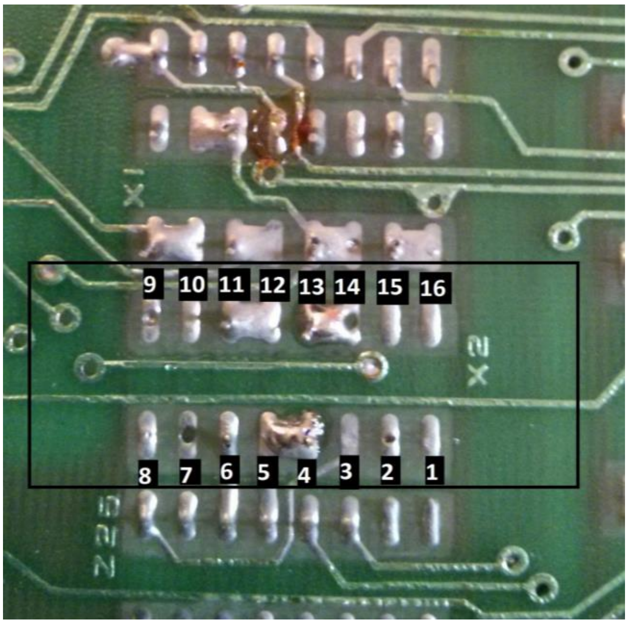
Item 4 – Modifications to the System 80 Board

I cannot stress enough that you check and recheck the following instructions. What confuses most people is the translation from 'component side' or the top of the board to the 'solder side' or bottom of the board. When we are talking PIN numbers they are REVERSED on the solder side. Take your time and work out the translation in your own head before starting.

Consider the following example for X2. See picture below.



Here we see X2. X2 is a bit unique as it does not have an IC installed. Pin numbers on the COMPONENT side start from the TOP LEFT corner **<u>of the component</u>**. Note the PIN marker dimple example above. NOW since X2 is **<u>effectively rotated 90 degrees</u>** pin 1 is actually on the bottom right as illustrated above. When you flip the board over to the solder side the pin numbers are transposed. See the same component (X2) from the solder side below.



<u>Make sure you understand this translation before continuing</u>. It is **<u>very easy</u>** to make a mistake here.

Step 1 – Remove the jumper wire between **Pin 6** and **Pin 11** of X2. It helps to reflow a little fresh solder into the joints before using the braid to absorb it.

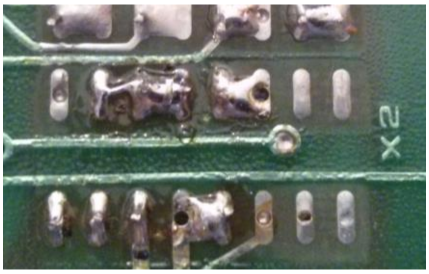
Step 2 – Clean any solder which may be obscuring the holes for **Pin 6, 7, 8, 10, 11, 12** of X2

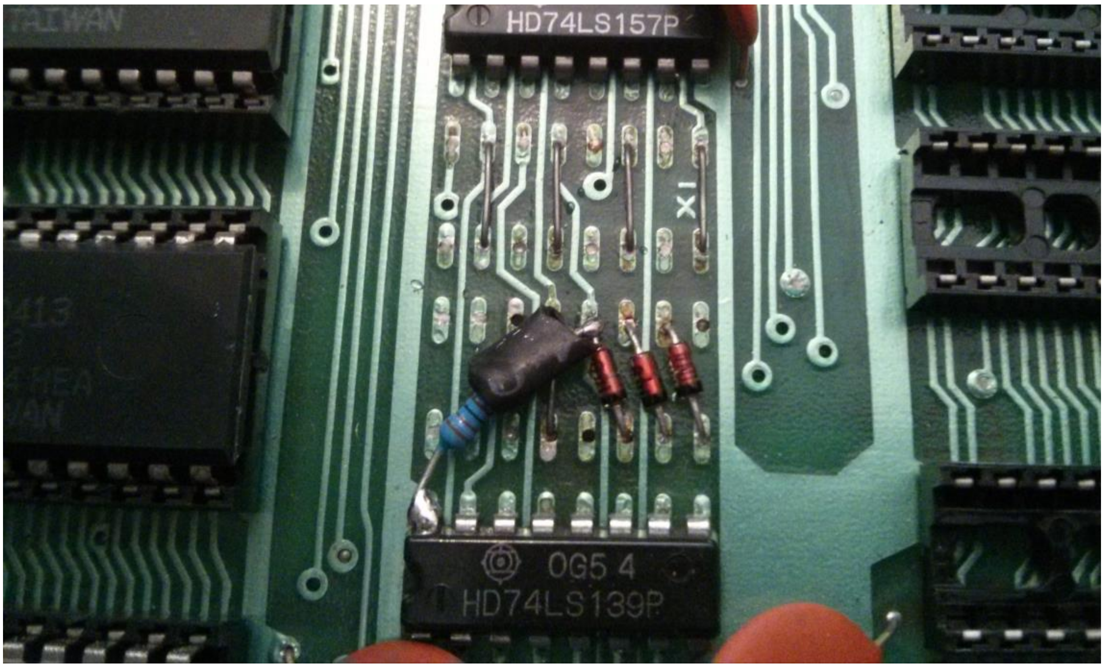
Step 3 – Install a 1N4148 diode between **pin 6** (cathode – black stripe) and **pin 12** (anode – no stripe) of X2 . Repeat installation of another diode between **pin 7** (cathode – black stripe) and **pin 11**. Finally repeat once more between **pin 8** (cathode – black stripe) and **pin 10**.

Step 4 – Bridge **pin 10** and **11** of X2 by soldering a small bridge between them. A small offcut of component lead works well here.

Step 5 – Solder the 2.2Kohm resistor between **pin 12** of X2 to **pin 16** of Z25. Note Z25 is directly below X2 and pin 16 is connected to the +5V rail. I also put a little bit of heatshrink over the lead nearest to X2 as it may short on the jumper wire below it.

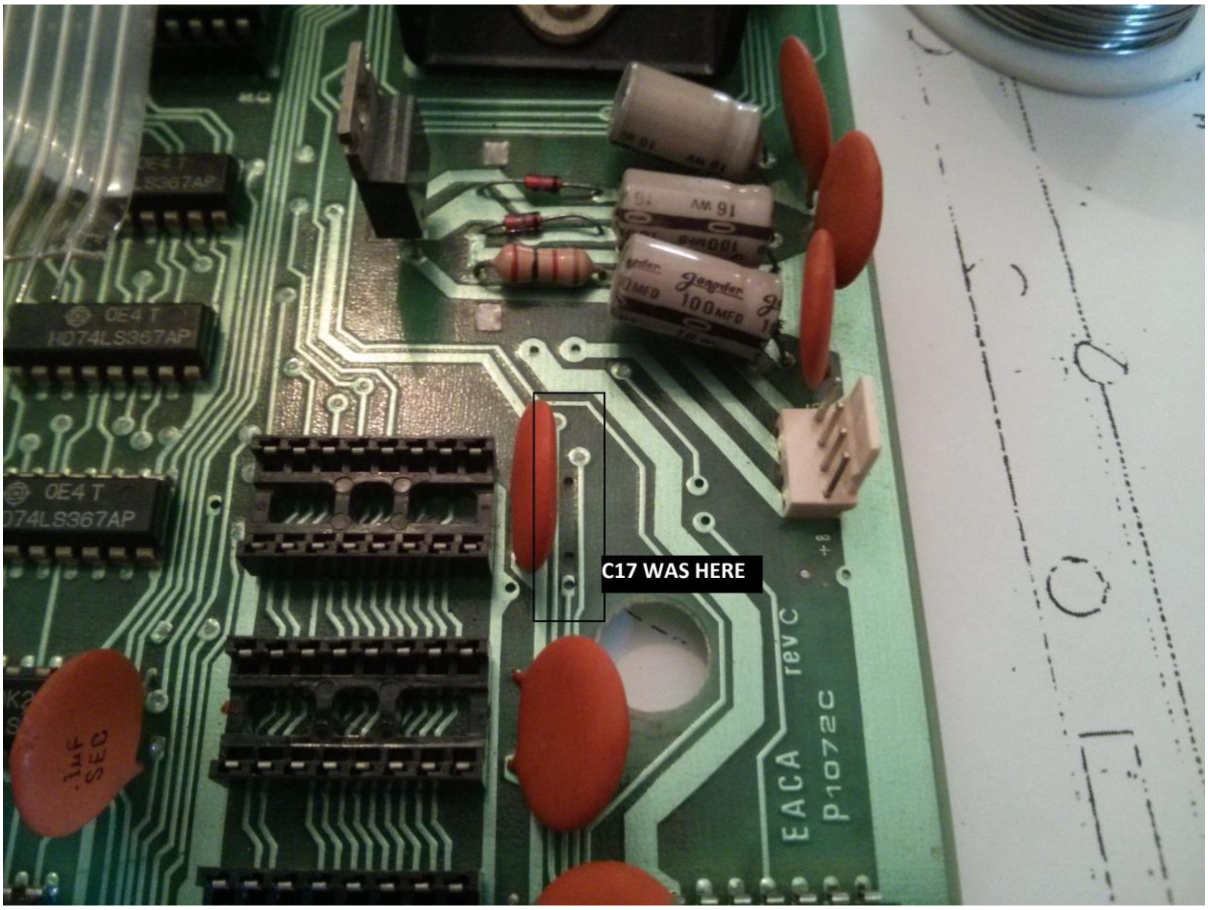
After all that you should have something that looks like this:





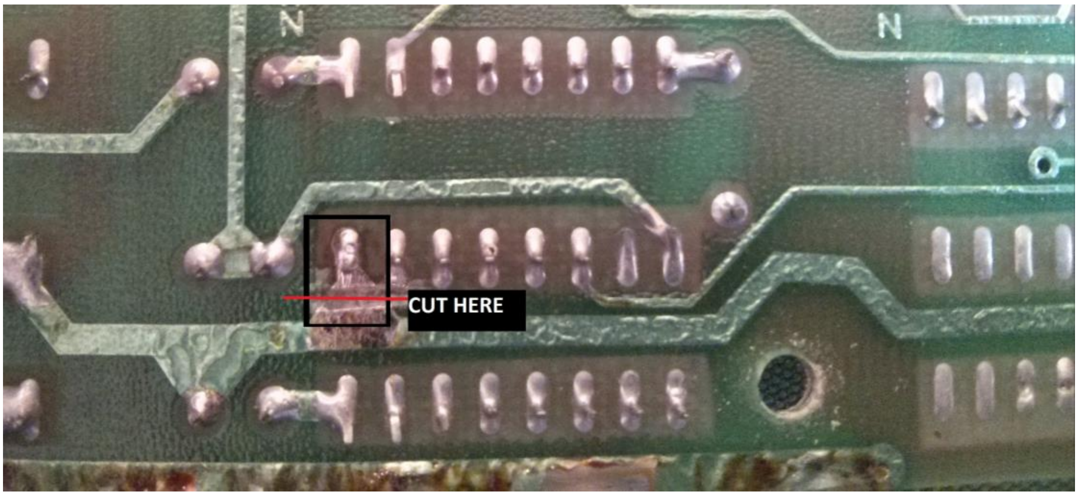
View from solder side (top image) and component side (bottom image).

Step 6 – Remove capacitor **C17**. This capacitor is near Z27 (the first RAM socket). Consult the CPU board diagram and **<u>make sure you desolder the right one</u>**. Note that it is next to another capacitor that MUST remain. See picture below.

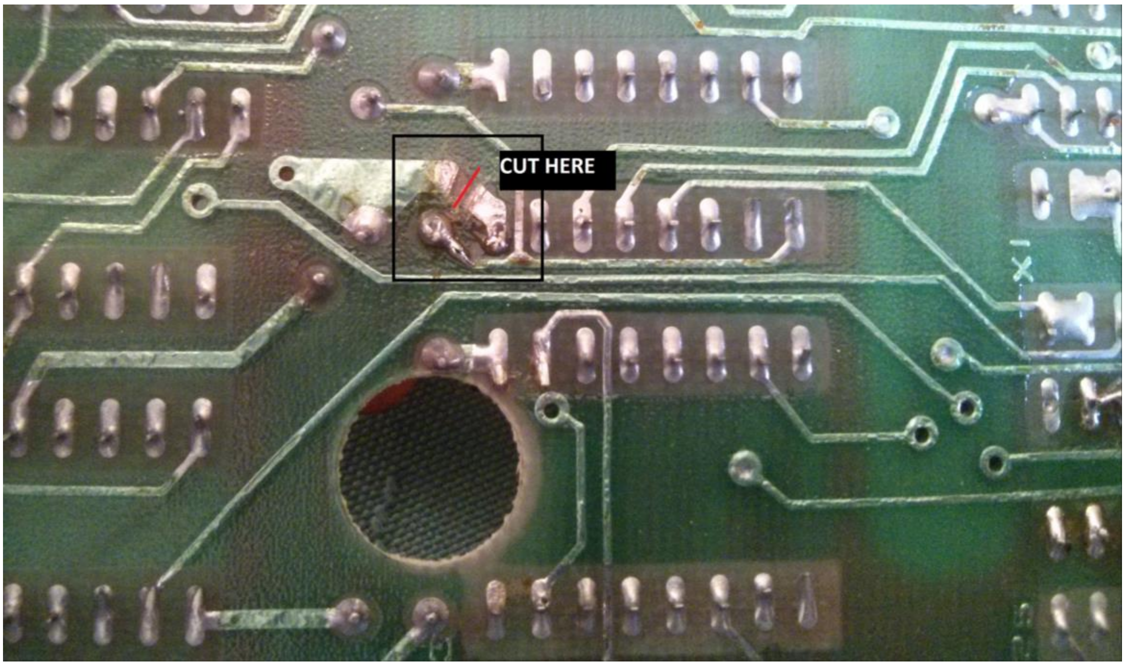


The reason for removing C17 is that it was a bypass capacitor between ground and the +5V rail. Since the +5V rail now corresponds to address pin A7 on the new 4164's it needs to be removed. If the capacitor was left on the board it would 'short' the pulses on pin A7 to ground.

Step 7 – Flip over the system board so that you are looking at the component side. The trace leading to pin 9 of Z34 and Z32 needs to be cut. This trace used to provide +5V to the 4114's. Since this pin will now be used as an address line it needs to be cut. See images below.



This shows the trace being cut on Z34

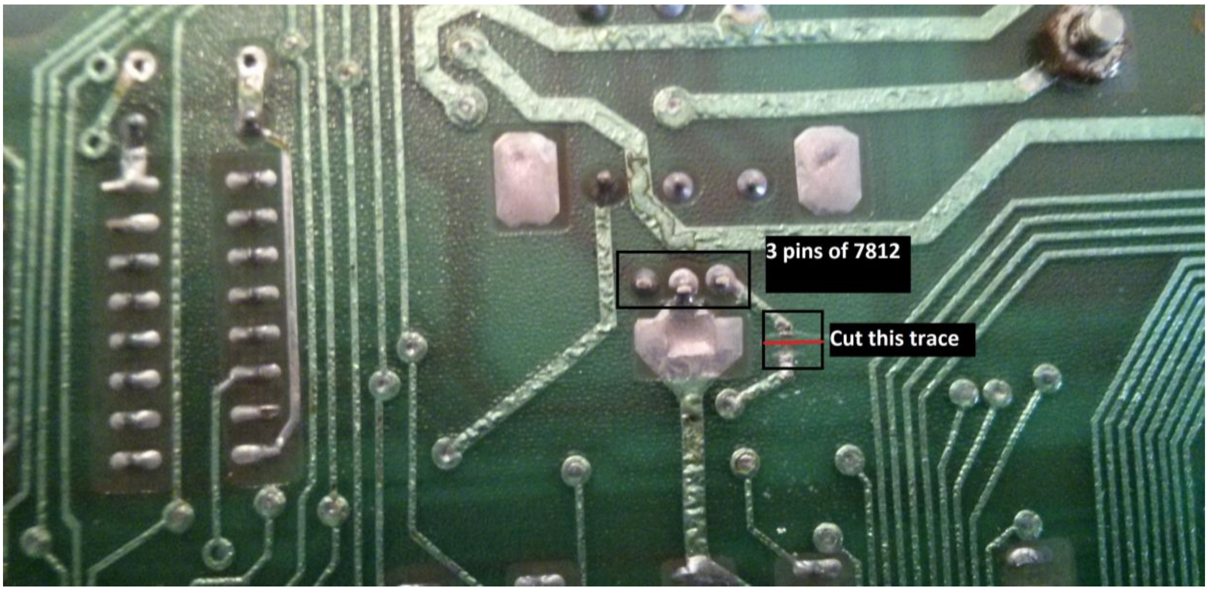


This shows the trace being cut on Z32

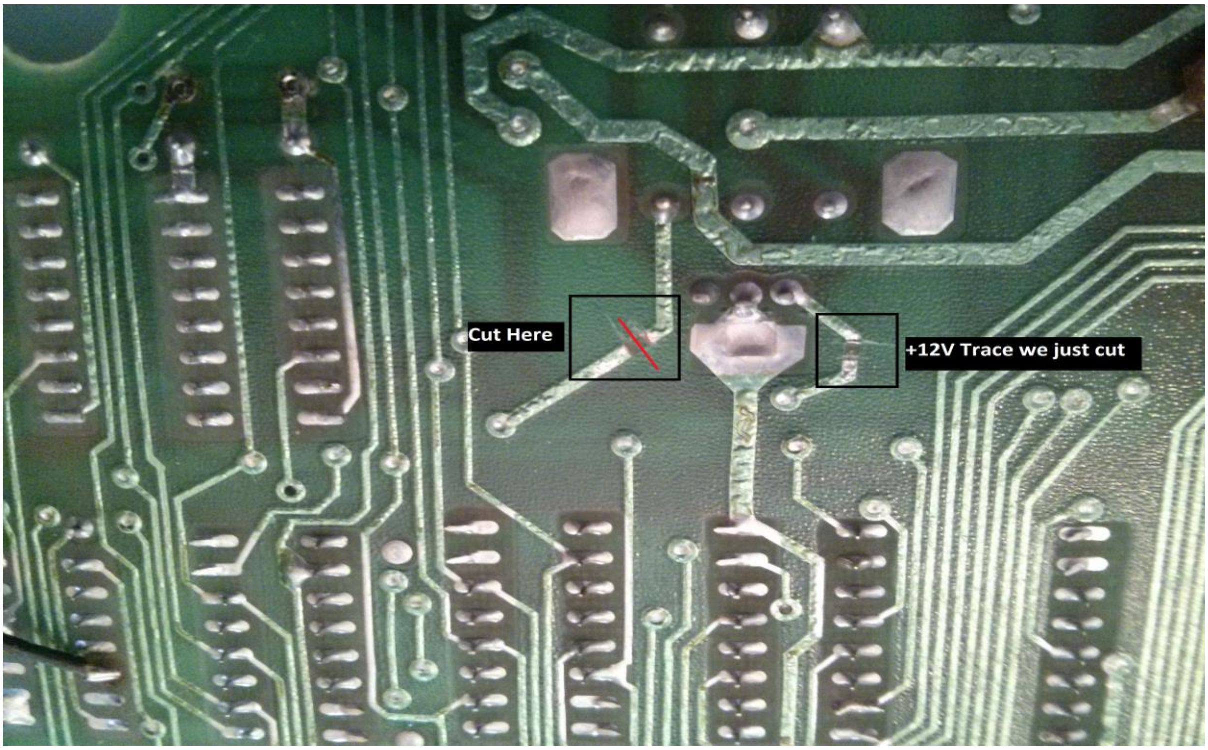
By cutting both of these traces the +5V line has now been disconnected from PIN 9 on all the RAM IC sockets.

Step 8 – Confirm that the 5V rail has been isolated by checking the continuity (resistance) between pin 9 on all RAM sockets to the +5V rail. The +5V rail is easily located as it is connected to pin 16 of Z25 (the one we just soldered a resistor to). Pin 9 to the +5V rail should have infinite resistance on every socket. If any continuity is found go back and check the cut tracks.

Step 9 – Locate the 7812 regulator using the CPU board diagram. On the solder side of the board, cut the trace from the 7812 regulator. By cutting this trace you are disconnecting pin 8 of the RAM sockets from the +12V rail. Easiest way to describe the location of the trace is using a picture:

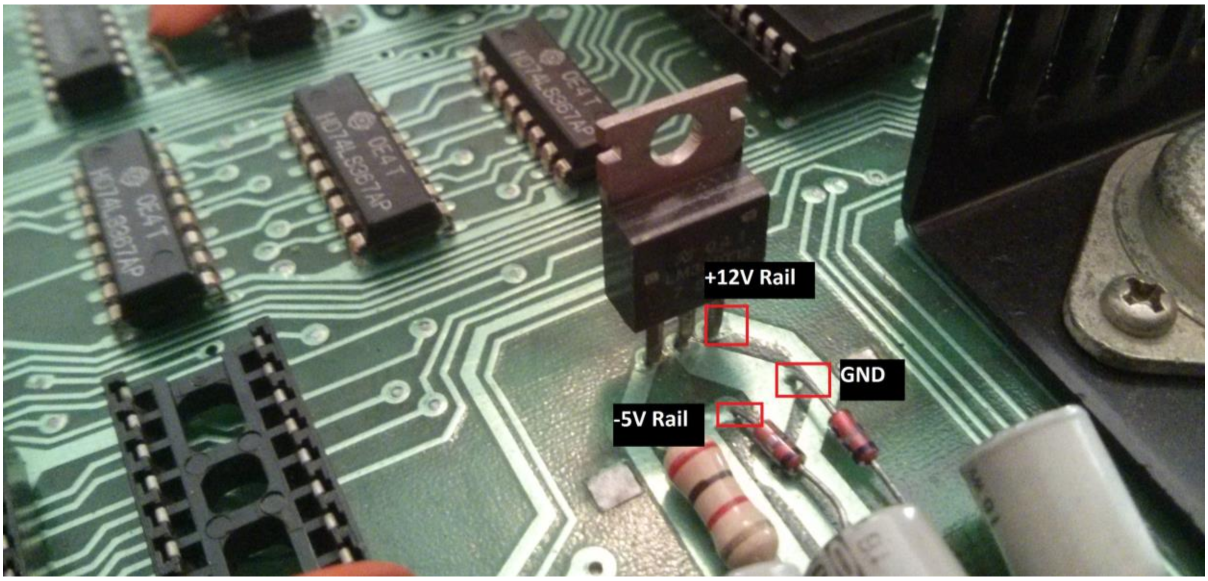


Step 10 – Cut the -5V rail near the D2 anode. This is the step where people usually go wrong. The trace IS on the solder side, not the component side. It swaps through from the top layer to the bottom layer using a via. If you cut the trace on the component side you WILL NOT isolate the -5V rail from the RAM sockets. You will only isolate the -5V rail from its smoothing capacitor. Picture of where to cut is below:



Step 11 – Check the +12V rail has been isolated from **PIN 8** of all the RAM sockets. Use your multimeter to check the resistance between the 12V rail (see image below) and PIN 8 of ALL RAM sockets. Resistance should be infinite; if not check cut trace.

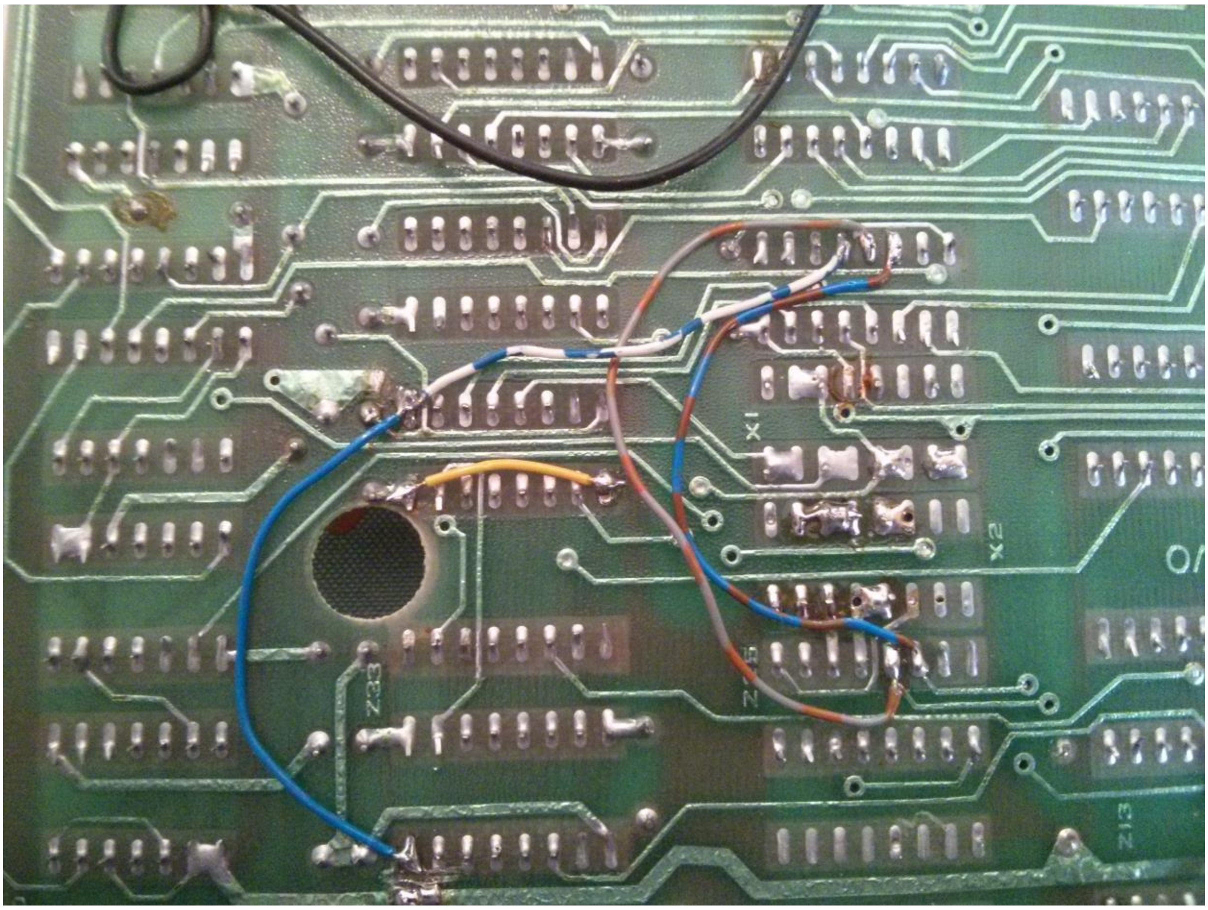
Step 12 – Similarly check the -5V rail has been isolated from PIN 1 of all the RAM sockets. The -5V rail can be accessed as shown in the image below. Resistance should be infinite; if not check cut trace.



Step 13 – This step involves connecting the address decoding logic together. Given that you should be quite well practiced on pin numbering I will summarise this and provide a 'final image' of what it should look like. You will need the insulated hook up wire for this step. Note all of this takes place on the solder side of the board and REMEMBER your pin numbering! Finally you will need to refer to your CPU board diagram to locate each component.

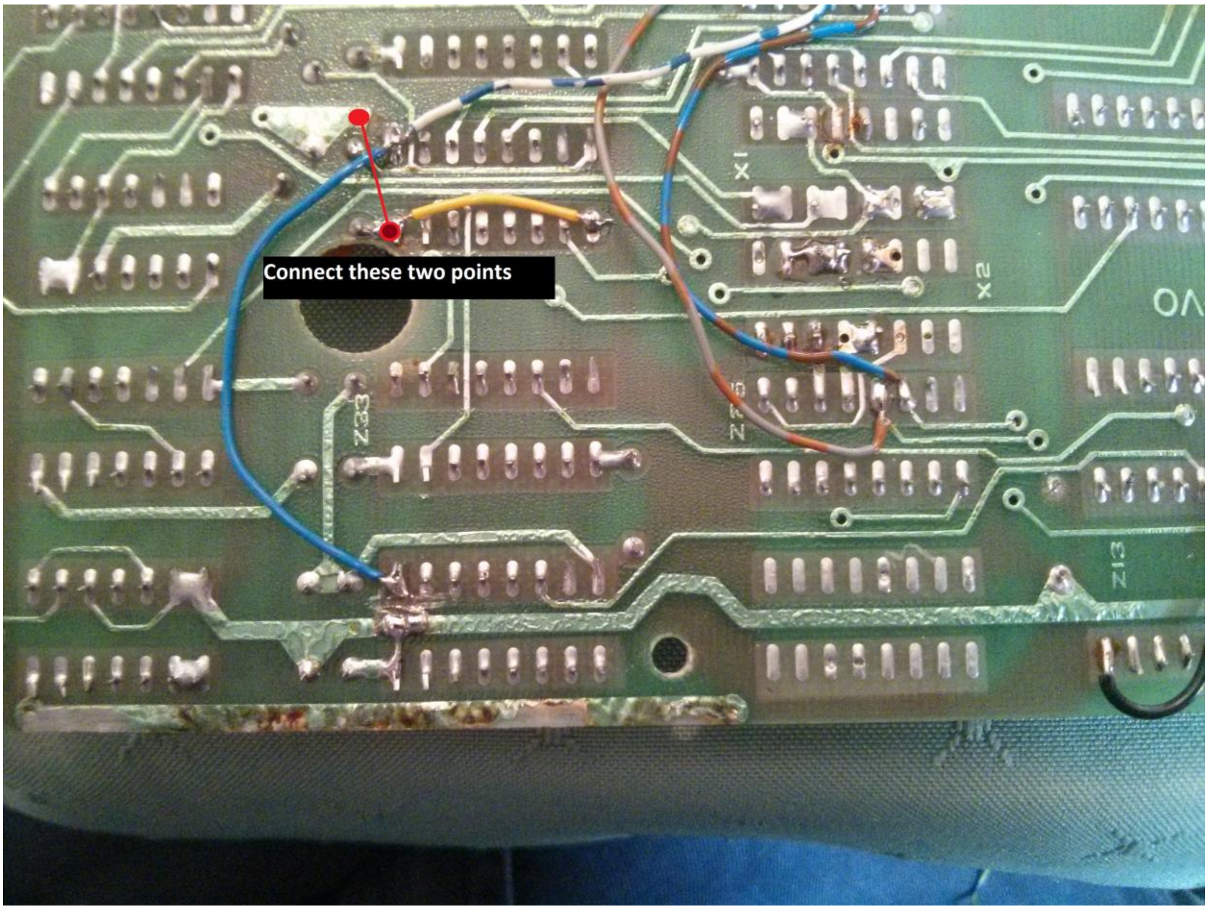
- Connect pin 14 of Z25 to pin 14 of Z24
- Connect pin 13 of Z25 to pin 13 of Z24
- Connect pin 12 of Z24 to pin 9 of Z32
- Connect pin 9 of Z32 to pin 9 of Z34
- Connect pin 1 of Z32 to pin 8 of Z32 (This ties the unused pin on the 4164 to +5V which is a fairly common design practice).

This should look like:

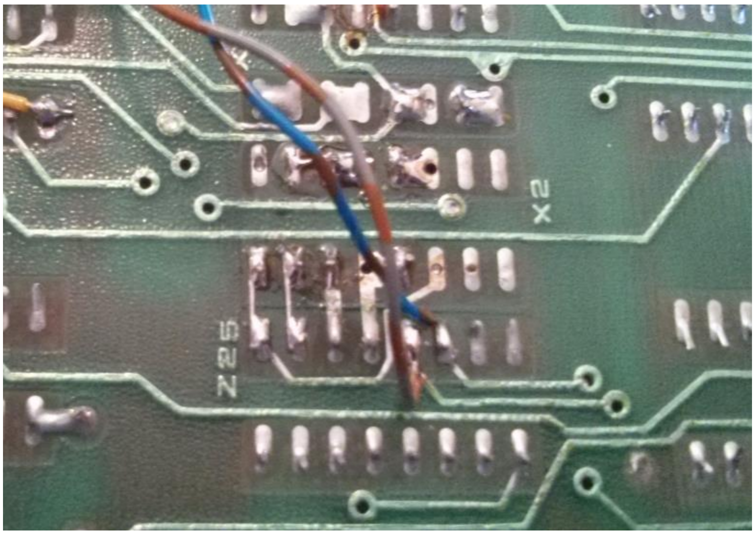


At this point make sure you have no shorts near your solder joints (multimeter). It is easy to inadvertently bridge tracks when soldering jumper wire. Check and re-check!

Step 14 – Reinstate the +5V rail to pin 8 of the RAM sockets. This is quite easy, just solder a wire from the cut track near pin 9 of Z32 to pin 8 of Z32. Sorry I missed getting a photo of this step, however here is a diagram of it:



Step 15 – Connect pin 7 of X2 to pin 10 of Z25. Also connect pin 8 of X2 to pin 9 of Z25. Here's a picture of it: (See left two sets of pins near the 'Z25' text).



Step 16 – Recheck everything. If you're unsure, recheck it until you are.

Step 17 – Check the resistance between the +5V rail and +12V rail. It should be fairly high. If it is close to zero ohms then you most likely created a short somewhere

Step 18 – Check the resistance between the +12V rail, +5V rail and GND respectively. As above each should yield a fairly high resistance. If it is close to zero then you have a short.

Step 19 – Check the resistance between the +12V rail, +5V rail and the -5V rail respectively. This should be a very very high resistance. If it's close to zero then you have a short.

Step 19a – Check the resistance between the +5V rail and pin 8 of all the RAM sockets. It should be ZERO OHMS.

Step 20 – Install 8x 4164 DRAMS into their sockets.

Step 21 – Reassemble and test!

Mine fired straight up to the READY? prompt. You can then enter into basic and type the command "PRINT MEM". It should return the number 48340.

I've done my best to ensure these instructions are all correct and double checked. If you find a mistake please let me know via PM at either the NZ classic computer forums (user 3PCEDEV) or the Vintage Computer Forums (user 3PCEDEV).

Good luck!