

## 64K (62K) 88-16MCS Mod with 88-PMC 2K PROM Board

One of the most reliable memory configurations using MITS hardware for the Altair is using three or four of the MITS 16K static RAM boards (88-16MCS). Four 16K boards provides 64K of RAM, but that leaves no room for a PROM board to make booting from disk or cassette/paper tape reasonable. However, using three 16K boards provides just 48K of RAM.

With the 88-PMC PROM board addressed in the upper 2K of memory space, the remaining 62K of memory space can be allocated to RAM with three 16K RAM boards, one 8K RAM board, one 4K RAM board, plus two 1K RAM boards. However, this is not a very convenient or power efficient solution.

Notes from MITS employee Steve Shepard document a mod to the MITS 16K RAM board that disables the upper 2K when used in conjunction with the MITS 88-PMC PROM board. This simple solution allows four 16K RAM boards to provide a full 62K of RAM along with the 2K PROM board.

The mod leverages the fact that the 88-PMC PROM board asserts the bus signal “Protect Status” (PS) whenever it is addressed. PS was intended to indicate that the currently addressed RAM location was protected due to a previous front-panel protect operation by the operator. This feature, however, was only implemented in the earliest RAM boards from MITS and was not present in the 88-16MCS RAM board.

A 16K RAM board with this mod still functions normally when not used with an 88-PMC PROM board, or when not addressed in the upper 16K of memory space. However, only one 16K RAM board in a system should have this mod since multiple boards with this mod may source too much current into the PS driver on the 88-PMC.

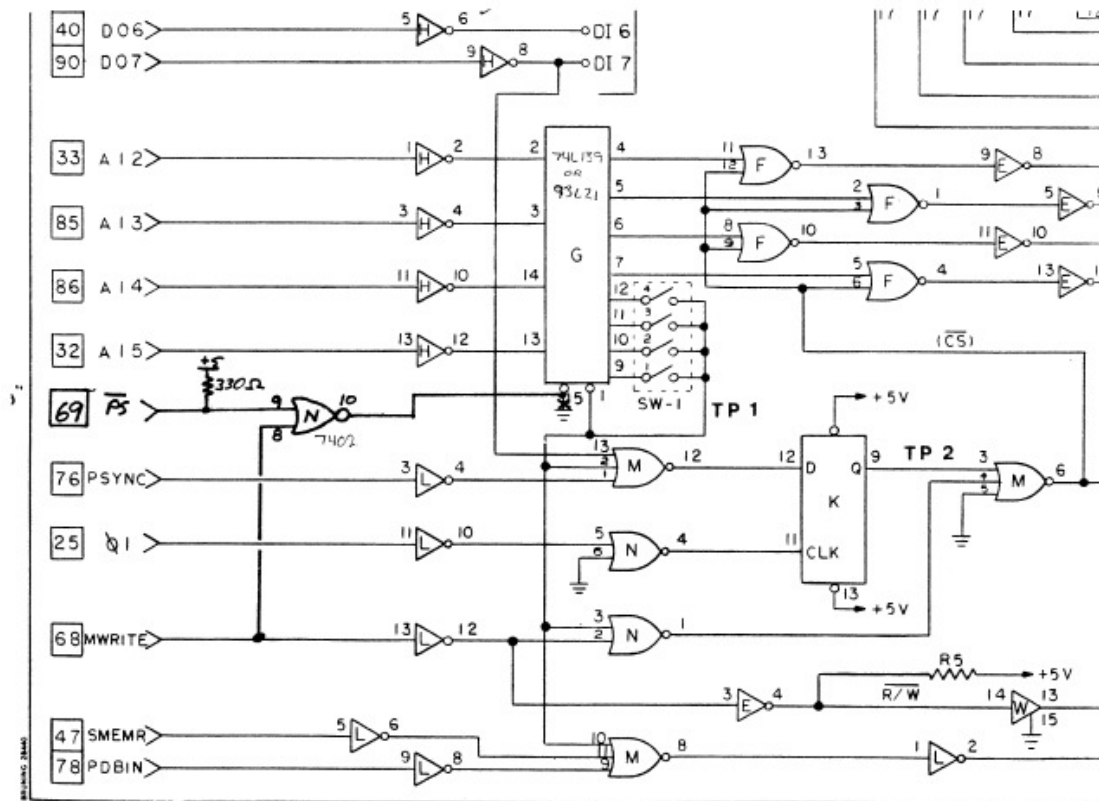
Steve’s notes regarding the mod are shown below. When PS is asserted (active low) by the PROM board, the address decoder on the 16K RAM board is disabled if it is not a memory write cycle. This prevents the RAM board from responding when the CPU is reading from the PROM board. The mod as shown is “write through” in that writes to the top 2K of address space still go to RAM even though the PROM board is addressed. This doesn’t seem to be a necessary feature since those locations in RAM can never be read, so when I implemented the mod, I simply tied both inputs of the NOR gate to the PS signal.

Following are pictures of the 88-16MCS board I modified. I installed the 330 ohm pull-up resistor in some unused SIP pads that included +5v on pin 1. To make it easier to cut the ground trace that runs to pin 15 of IC-G, I removed the bypass capacitor between IC-F and IC-G. The pictures are before re-installing the bypass capacitor.

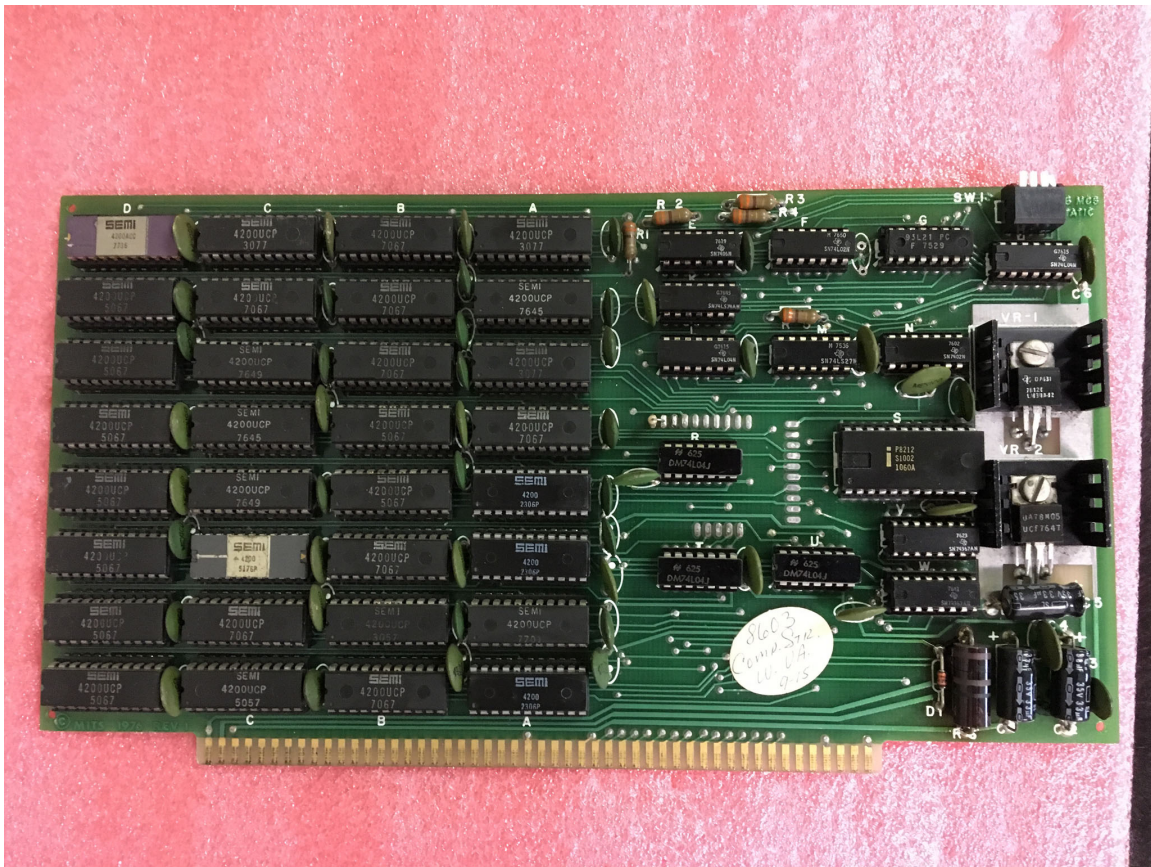
16 MCS MOD For 64K (62K) Operation with 2K Prom Board

- 1) Cut land going from Pin 15 of ICG (U3) to ground.
- 2) Jumper from pin 69 of buss ( $\overline{PS}$ ) to pin 9 of ICN (U8)
- 3) Jumper from pin 8 of ICN (U8) to Pin 13 of ICL (U6)
- 4) Jumper from pin 10 of ICN (U8) to pin 15 of ICG (U3)
- 5) Jumper from  $V_{CC}$  (+5V) to 330 ohm resistor and from opposite side of the 330 ohm resistor to pin 9 of ICN (U8) (PREVIOUSLY INSTALLED SCHEMATIC IS ALREADY INCORRECT)

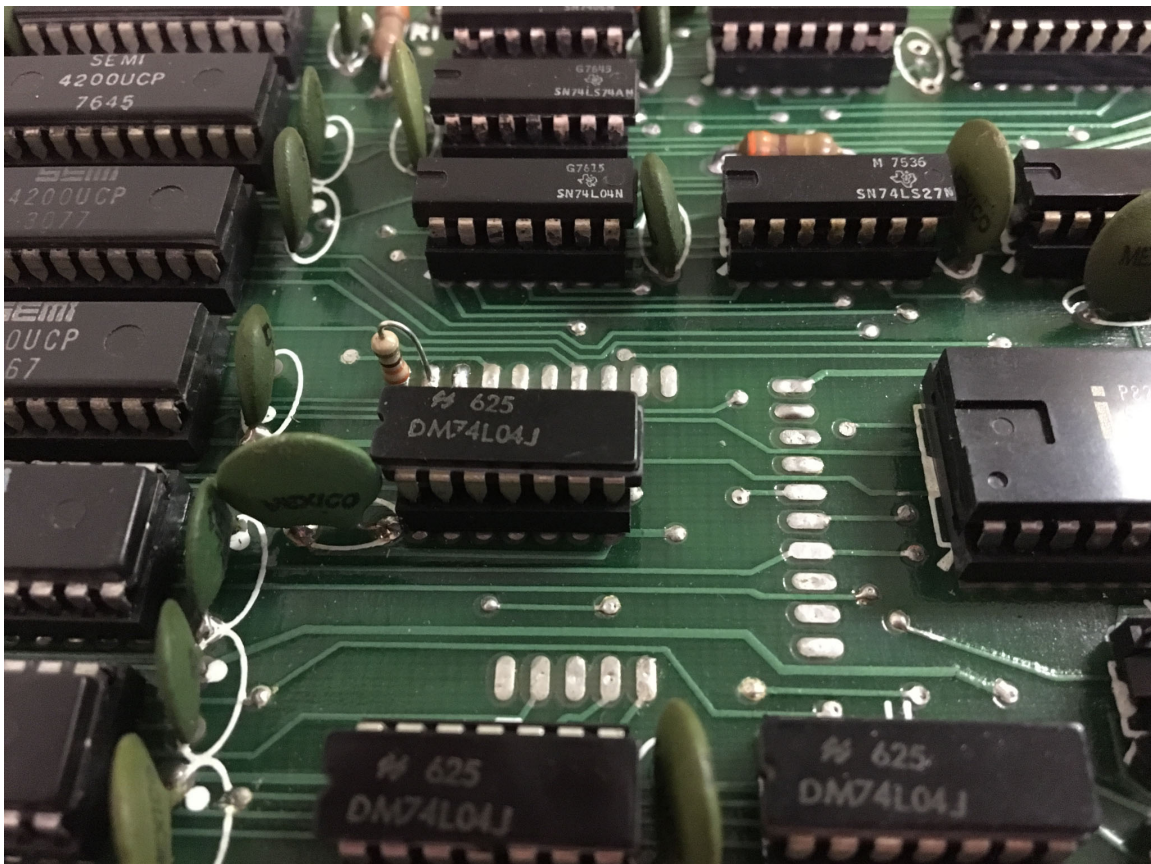
SHEPARD



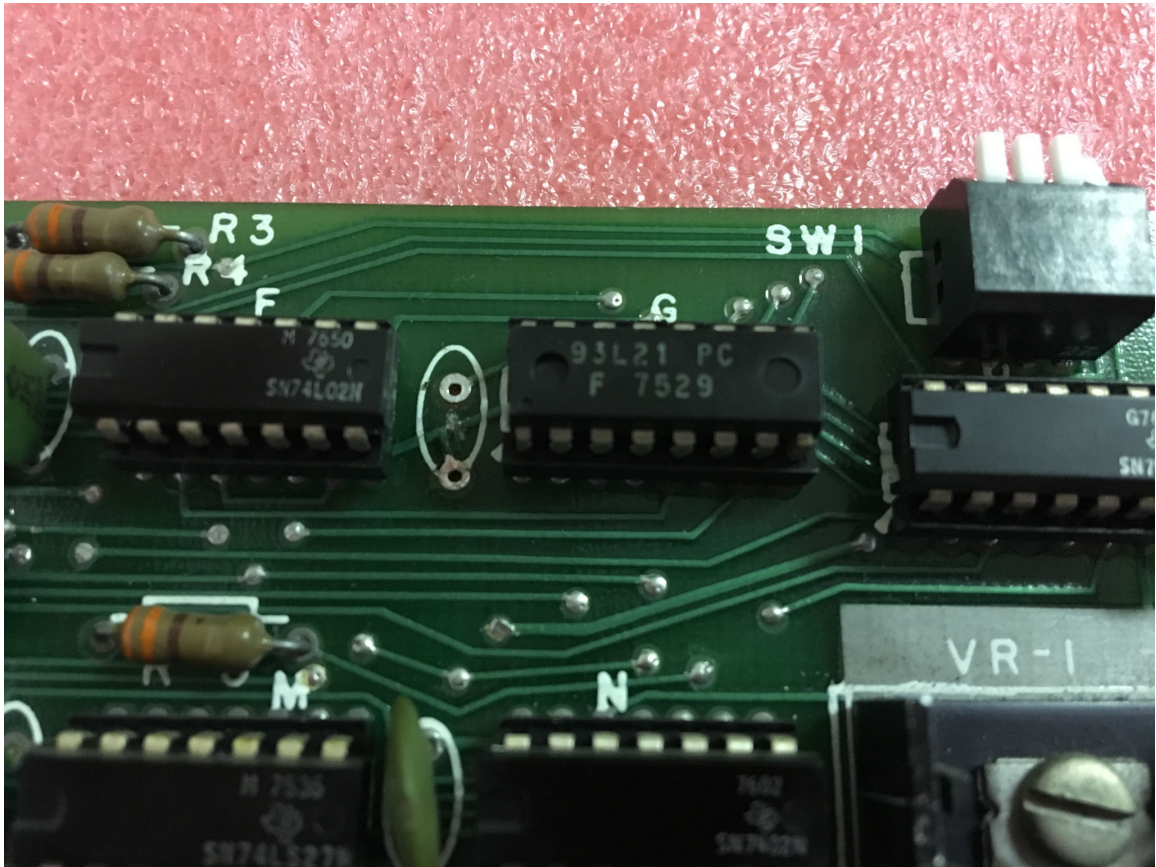
Steve Shepard's Mod Notes



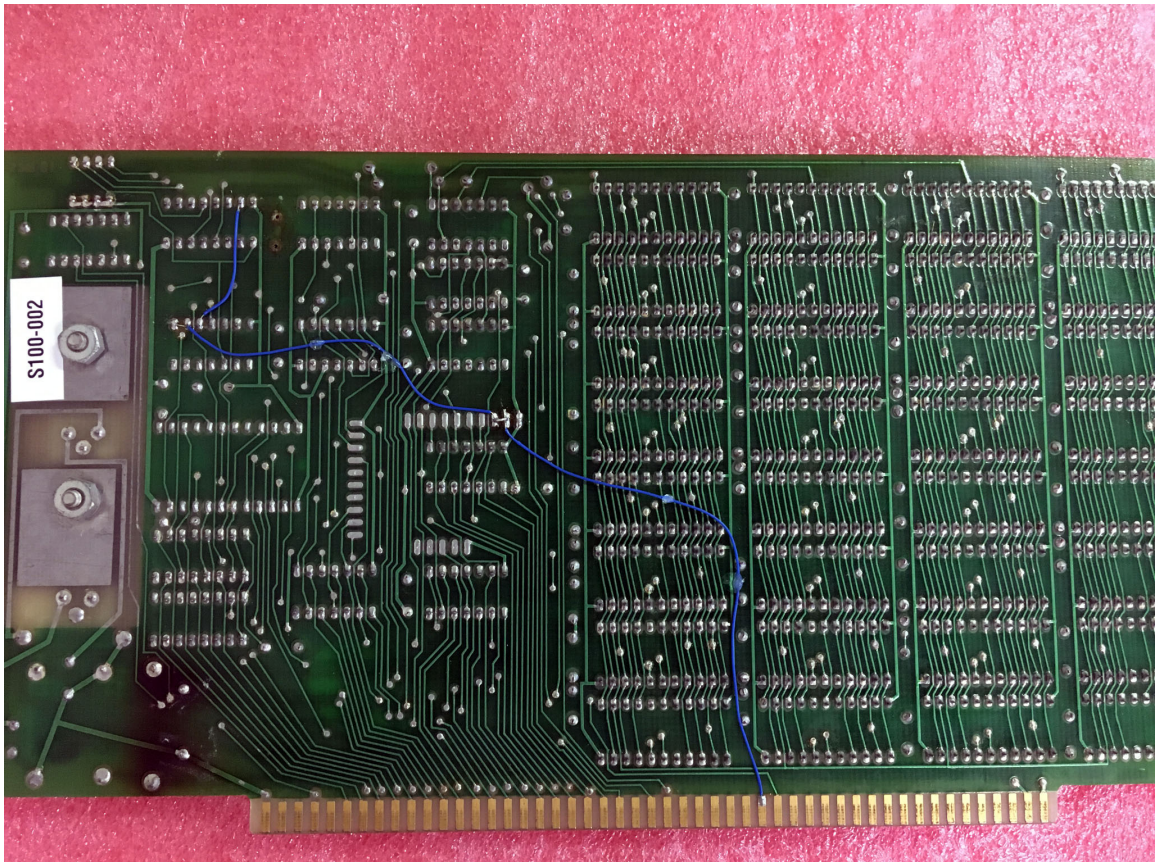
Front View of 16K RAM Board



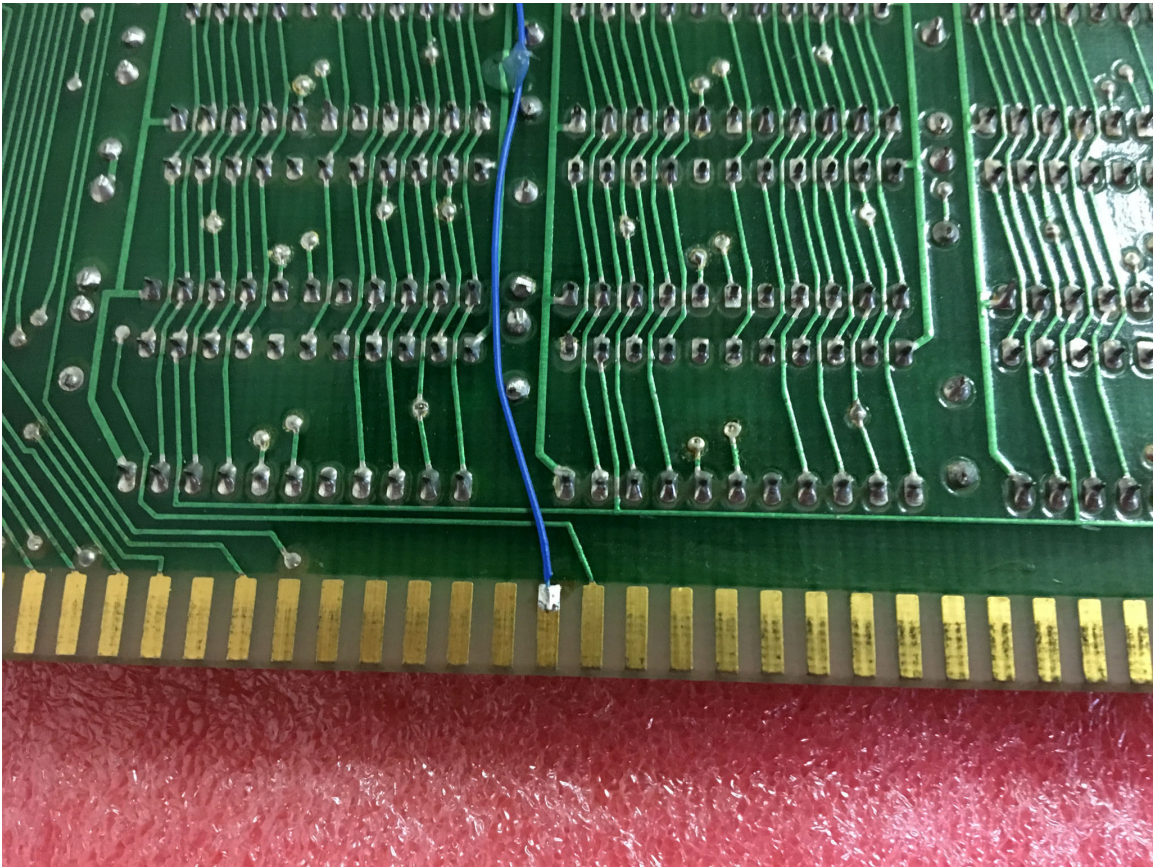
330 ohm Pull-Up in SIP Pads



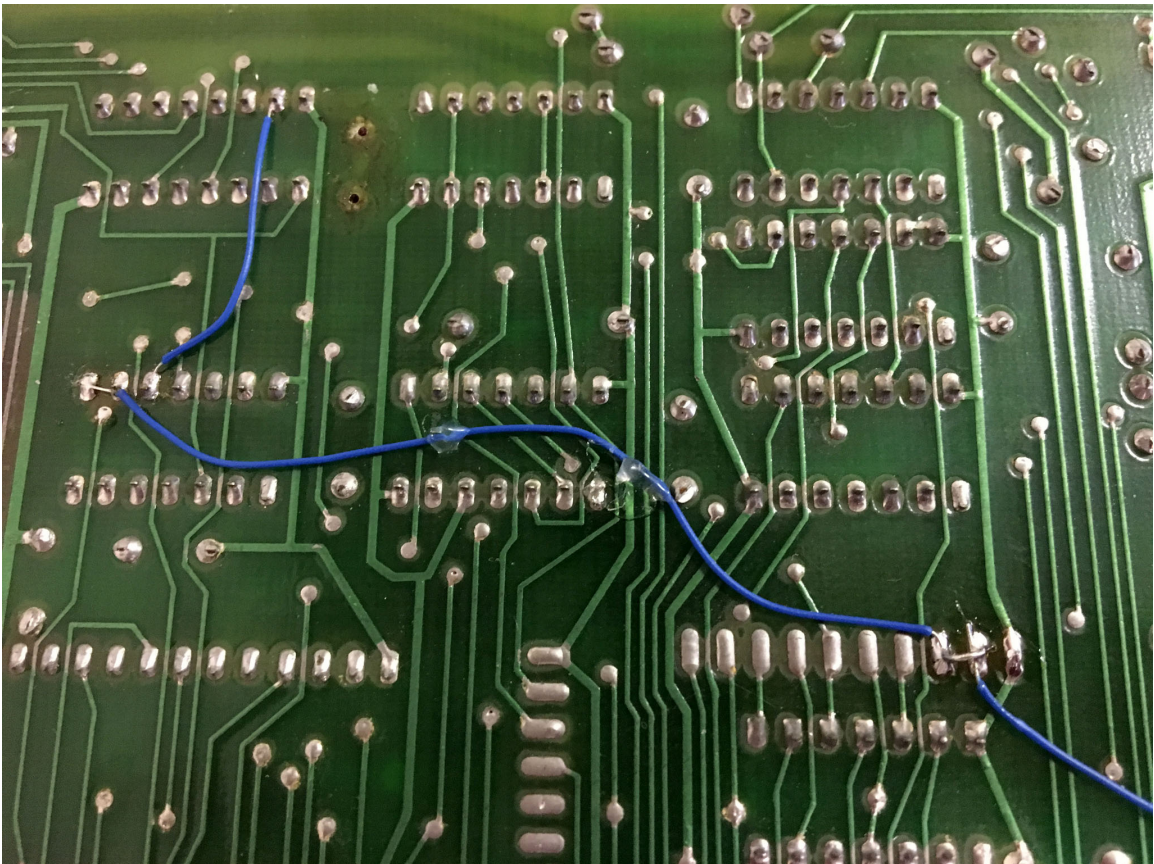
**Ground to Pin 15 IC-G Cut**



**Board View of Wire Mods**



**PS (pin 69) on Altair Bus**



**Close-up of Wire Mods**

Both Rev 0 and Rev 1 of the 88-PMC PROM board drive PS (Altair Bus pin 69) as shown in the schematic section below. Note, however, the most prevalent copy of the 88-PMC manual available on the internet does not show pin 69 being driven, even though it is.

