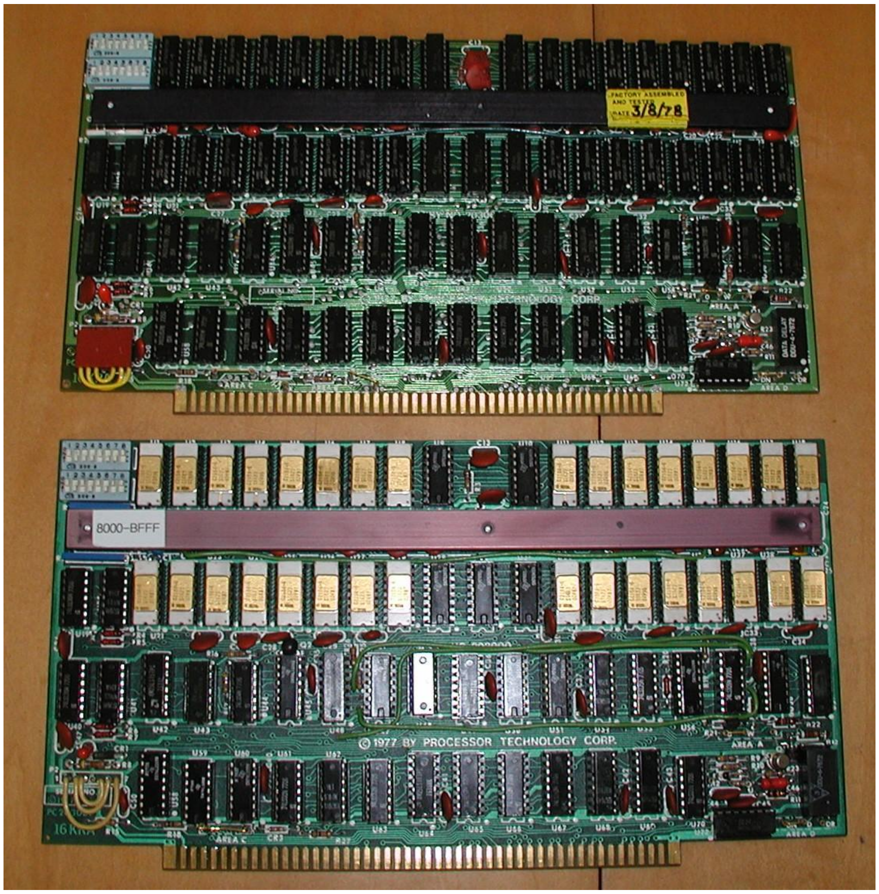
The SOL-20 Computer - Restoration & Repairs.

(H. Holden. Dec. 2018)

1) Processor Technology 16KRA memory cards & Delay Lines.

The Processor Technology (PT) 16KRA SRAM card is a very early example of an S-100 bus RAM card, typically used in computers such as the SOL-20. An example of two of these is shown below:

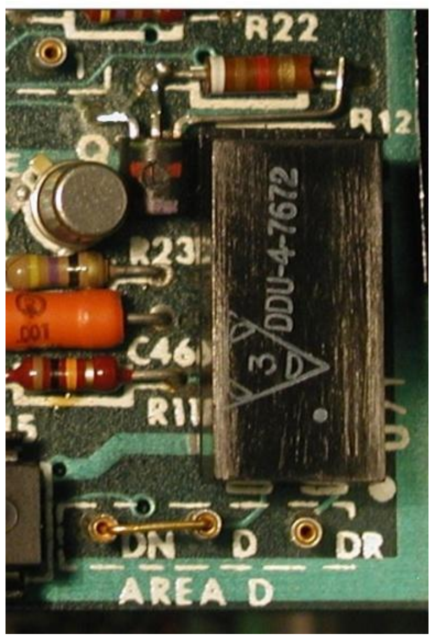


PT had the reputation for being one the first companies to design reliable memory cards. Early SRAM IC's were more difficult to use than later types, they required elaborate control circuitry. There are more timing and memory control circuits on the 16KRA cards, compared to later cards, such as those made by Seattle Computer Products. These later cards used far fewer control IC's in the memory management circuits.

The 16KRA boards are truly remarkable for the large number of IC's, about 71 IC's and two voltage regulators. (Of note: Atari's entire Arcade video game, PONG from 1972, contained about 66 TTL IC's)

To realize the design of their 16KRA card, PT deployed a digital delay module to help coordinate the activity of the card's "machine cycle". The module is located near one card corner:

DIGITAL DELAY UNIT ON PROCESSOR TECHNOLOGY's 16kRA RAM CARD.



The module sits in a standard DIL socket (but sometimes it is soldered to the pcb) and has the label DDU-4-7672 .The module is powered by +5V and has 4 outputs for a digital delay of 100nS, 150nS, 250nS and 350nS.

The module in one of my 16kRA ram cards spontaneously failed, deactivating the entire card. The question then became what to replace it with?

PT's description of the delay module:

The first thing I noticed was there were some mistakes in the 16KRA manual:

5.3.3 Cycles Processor Technology 16kRA Manual, page 5-4

The timing of all six cycles (Read, Write, Refresh, Unselected, Coincidence and Null) is identical. Each consists of a nominal 370 nsec active period and a nominal 150 nsec recovery period.

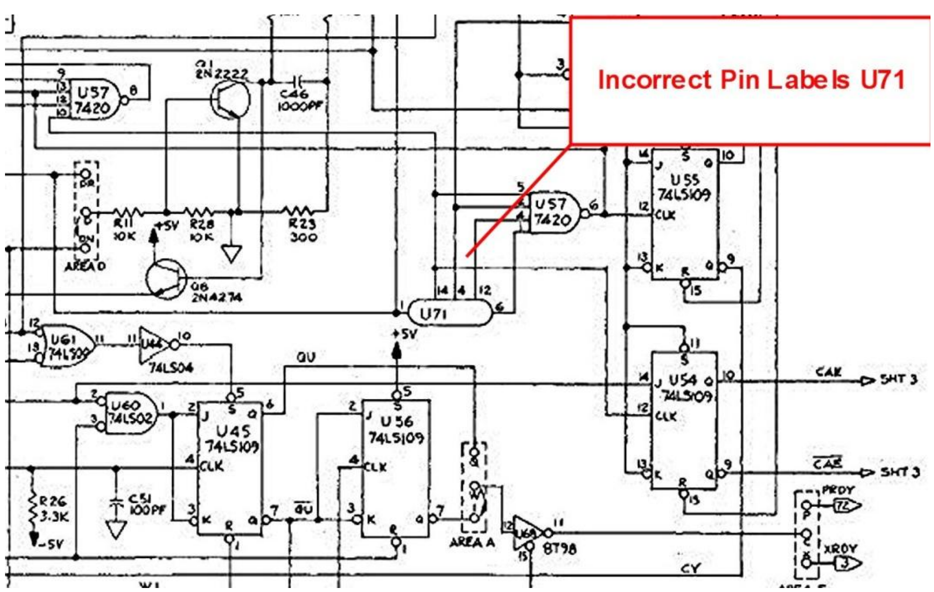
Either of two signals, MC or RC, can initiate a cycle. RC describes a refresh cycle and MC describes a read or write cycle. Misprints: Should be 100nS (pin 12) & 250nS (pin 10) . Pin 14 is +5V.

MC and RC are or'ed in U61, with the output on pin 8 being applied to U71. U71 is a delay line with outputs which reproduce MC+ RC delayed by 100 nsec (pin 14), 150 nsec (pin 4), 250 nsec (pin 12) and 350 nsec (pin 6). This is a passive delay line consisting of LC sections and TTL drivers built into the input and output lines.

These four delayed outputs are connected to a four-input nand gate (U57-6), the output of which is used to reset the binaries producing RC and MC. This reset will occur 350 nsec after the rise of RC or MC. RC+ MC will then fall, and 100 nsec later U57-6 will rise again, releasing the resets of RC and MC.

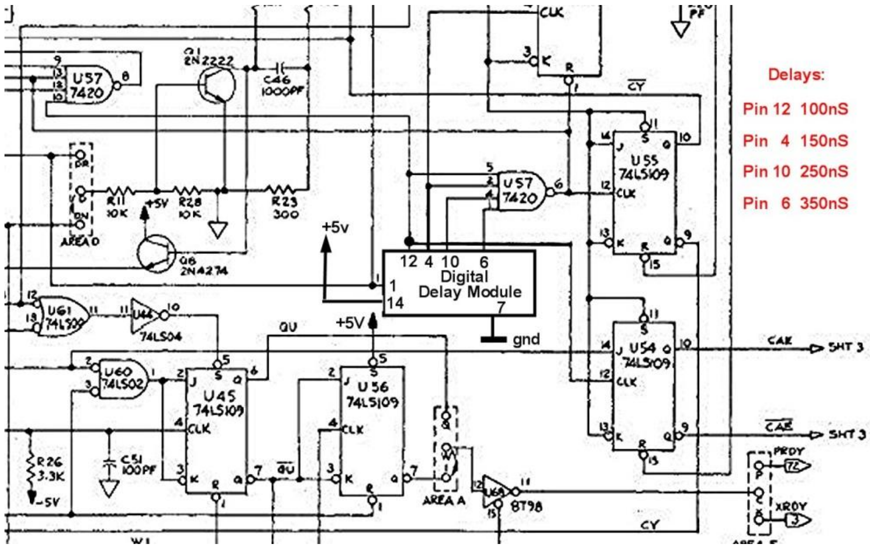
The above cycle contains passive delays totaling 450 usec, and propagation delays through logic stages totaling 50 nsec min., 70 nsec typical. RC or MC will be on for about 370 nsec and off for about 150 nsec, giving a cycle duration of about 520 nsec.

In addition the circuit diagram relating the module's (U71) wiring was incorrect:



There is another version of the above circuit too which shows the delay module as a 16 pin object which might explain the errors in the numbering not relating to a 14 pin version of the module. All the DDU-4 modules I have seen so far have been 14 pin.

Corrected 16KRA partial Schematic:



As explained by PT, the module is required to generate a 350nS long interval for a "machine cycle" to coordinate the activities of the memory.

A pulse timing diagram below (from PT's manual) shows how the reset pulse is produced at the start of the leading edge of the 350nS pulse and terminated by the trailing edge of the 100nS pulse. One interesting thing is that although the 150nS pulse has another application in triggering a flip flop, the 250nS pulse is actually redundant; the leading or trailing edge of it is not involved in the timing of any process, so it could in fact be eliminated from the design.

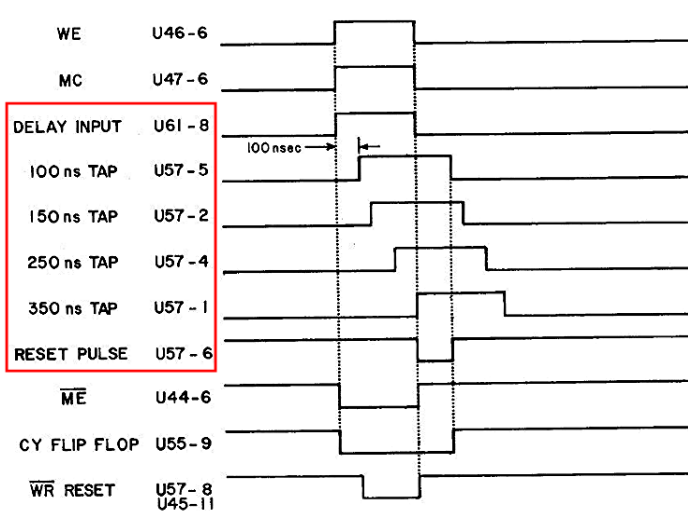
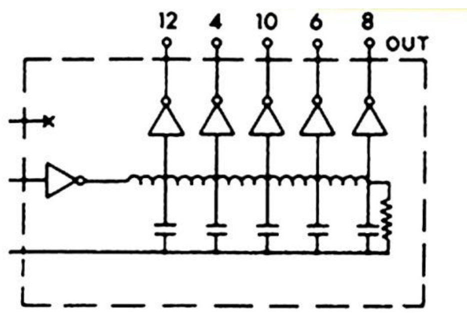


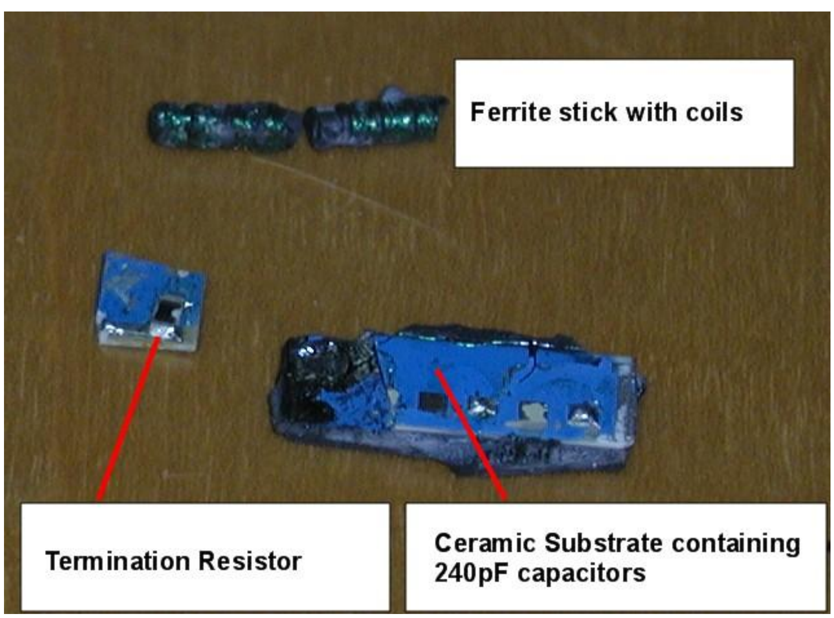
Figure 7-7 Cycle (CY) Timing

Investigating delay modules:

After some research I found that these modules typically contain a TTL IC and an L-C delay line. The delay line is terminated to prevent reflections arriving back at its input. The module itself is constructed from a TTL Hex inverter IC, placed in a small housing with a coil assembly and a capacitor array and potted in “rock solid black resin”. The following diagram shows the general arrangement:



I was not sure why the original module would have failed. So I opened it up and slowly removed as much of the hard resin as possible to see how it was constructed and why it might have failed. Fragments of the module are shown below:



The “Delay Line” was a hybrid/modular design and consisted of a ferrite stick, about 2mm to 2.5mm in diameter (broken in two in the photo) with small shoulders to separate about 7 groups of windings. Taps from the windings fed the approx 240pF capacitors and the IC input pins. The capacitors were formed on a single ceramic substrate. The surface mount line termination resistor had calibration cut in its surface.

In some places there were some soldering flux residues and some corrosion around the resistor. It appears that the line termination resistor or one of the coil wires may have become disconnected as the probable mechanism of failure. But I could not be certain. However, this is no reflection on the quality of the device, it is 40 years old.

The IC itself that was inside the module with the above components (a 74S04) after removal, tested normally and had not failed.

I thought it very unlikely I could get a replacement module as the delay arrangement of 100,150,250 and 350nS is not a standard part and Processor Technology would have acquired it by special order over 40 years ago. (How wrong that assumption turned out to be. See end of article, section 5).

Replacement Options – My first attempt at making a data delay module 1:

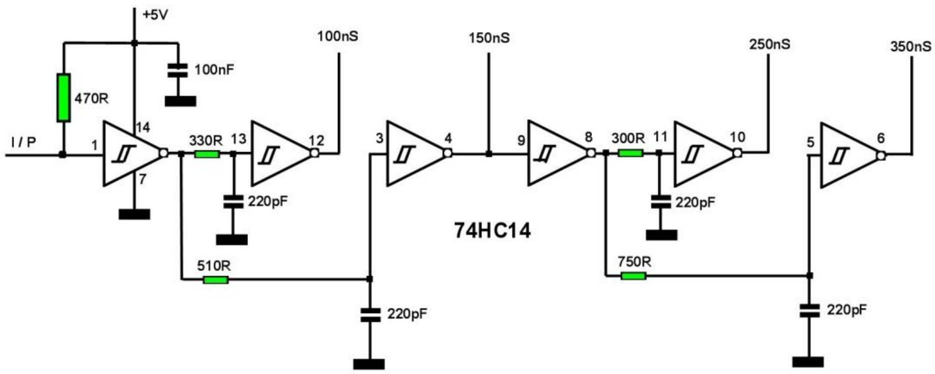
I was now stuck with a non working 16KRA memory card. I looked around at my stocks of parts in my workshop to see what I could cobble together to make a replacement “delay line”. I decided an R-C delay “should work” (but I was wrong).

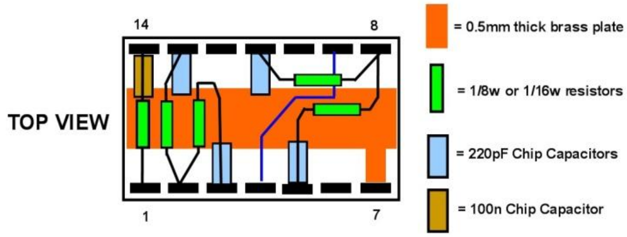
I investigated a number of Hex inverter IC’s I had in my stocks, to see which one might be best suit the task. I quickly found out that the `04 types (eg 7404, 74S04,74LS04, 74AS04, 74C04,74HC04,74HCT04 etc) are such that the ultimate analog signal gain through the inverter is such that if the input rate of change of voltage with time is slowed down too much, with an R-C network, the rate of change of the output becomes slow.

Going to a CMOS Schmitt Trigger inverter, initially, such as the HEF40106 didn’t work either because the propagation time through one gate was too long. The better suited IC for the task, turned out to be the 74HC14.

To create the delays the required resistors and surface mount chip capacitors were mounted on a 14 pin dual in line carrier and then this was placed on top of a 74HC14 IC. The circuit I used is shown below:

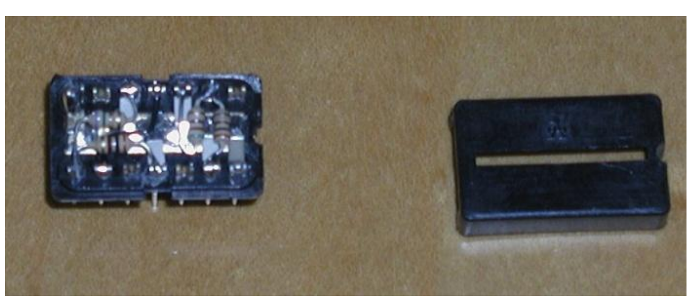
Experimental Delay Circuit :

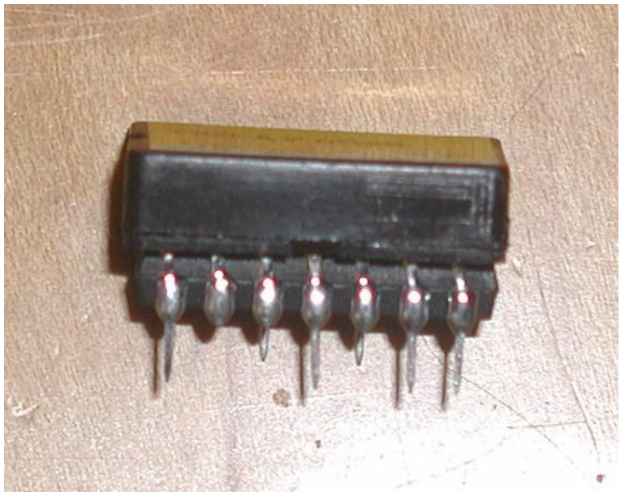




Firstly a strip of brass plate was placed in a groove between the pin rows on a carrier. This type of 14 pin fitting was intended to be a wire-able plug that would plug into a 14 pin DIL socket and has a dust cover or cap. In this case its pins were simply trimmed down and soldered to the IC's pins:

As noted the surface mount capacitors were soldered in first, then a small brass strip to complete the connection to pin 7 and the link wire between pins 4 and 9. Then the resistors were added and the dust cap fitted and the arrangement then soldered to the IC:





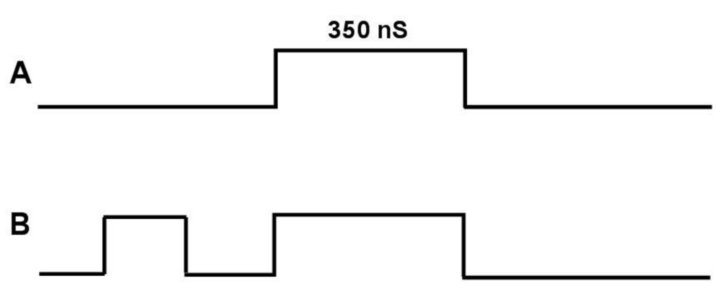
FIRST ATTEMPT AT A REPLACEMENT MODULE

The module performed flawlessly *on the signal generator and scope* and I was able to get the delays within about 5nS of the specified values using a well calibrated Tek 2465B scope. And it would have worked, if the waveforms were those specified in the Processor Technology drawing in the 16KRA manual….. but they are not !

The drive pulse to the input of the delay line has a short period where it is high then low again immediately before the 100nS long input pulse arrives. Due to this the charges on the delay capacitors in my circuit have not settled to a value close to 5V (from the output of the cmos gate driving them). Therefore the delays become shortened compared to the values attained where the input pulse has been low for a long period prior to the leading edge of the input pulse occurring.

On testing the first attempt module, it actually worked in one 16KRA card, but not in another, so this timing error was borderline & unsatisfactory. This is because the time delay is too dependent on the *initial conditions* (state of charge of the capacitors) in the R-C delay network.

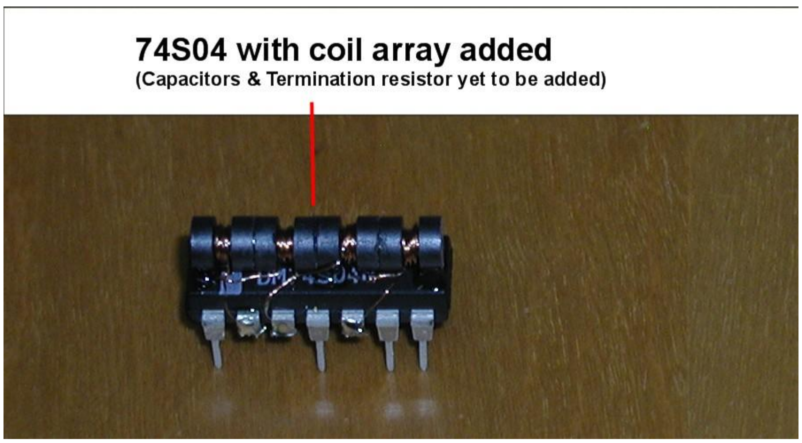
The diagram “A” below shows what PT suggested in their diagram, the waveform “B” is similar to what the actual module receives at pin 6:



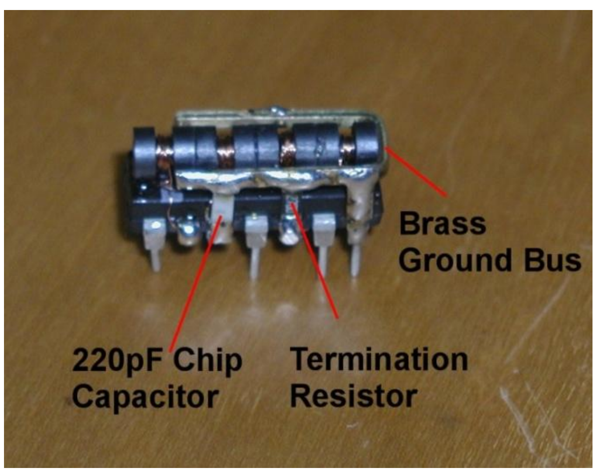
The implication of the above is that the R-C delay technique used to delay the input pulse cannot work reliably in PT’s circuit and explains why the first attempt module I designed failed to be satisfactory.

Module 2:

I also made an experimental L-C delay line with an inductor, capacitors and termination resistor & 74S04 IC to resemble the original method. The four ferrite sections were scavenged from transistor radio 455kHz IF transformers and glued together to make a ferrite stick:



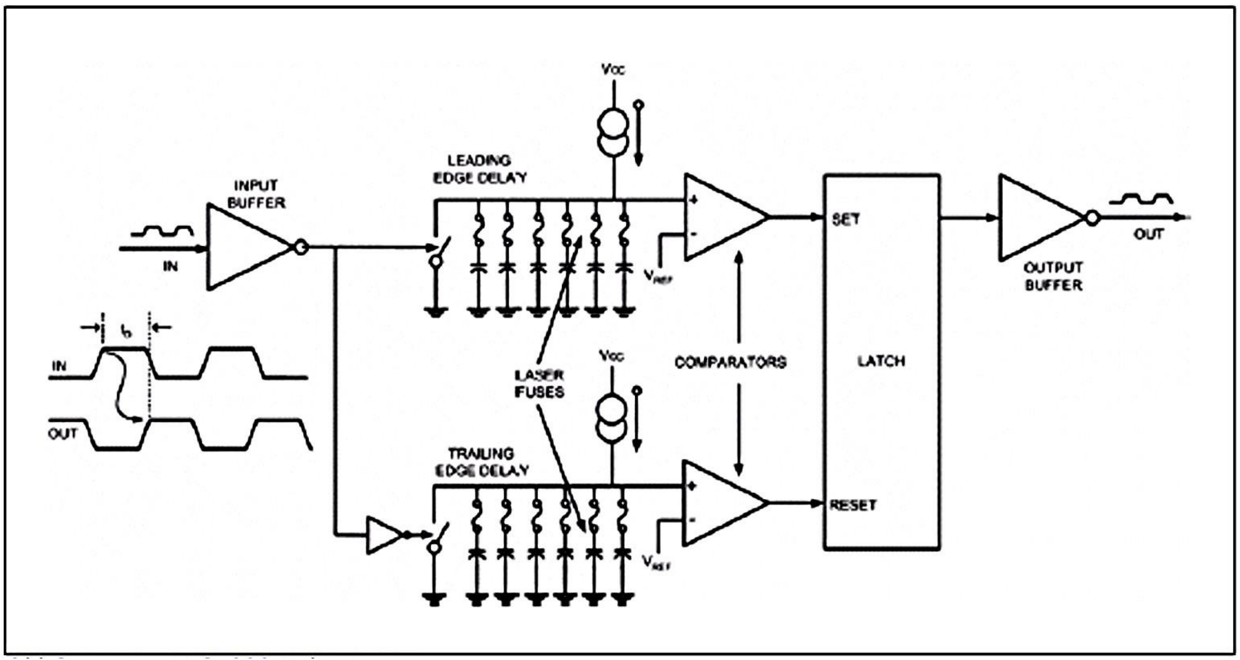
I used 220pF chip tuning capacitors added to this and a 200R chip termination resistor. It was very difficult to get the delays simultaneously correct and quite time consuming to make even one replacement module and I was not completely satisfied that it reached the performance of the original modules. After attempting this design, it gave me great respect and admiration for the designers of the original module.



Module 3:

After producing two failed modules I decided on a different approach.

By the early 1980's the modular or hybrid type of delay line that PT had used were in some cases being replaced by another design. In this type of design a constant current source charges a capacitor on the input of a comparator to create the delay that way. Also, the trailing edge of the pulse has its own delay circuit, so it can have an accurate delay too. The basic arrangement is shown below of the Dallas DS1000. The delay is factory calibrated with Laser fuses:

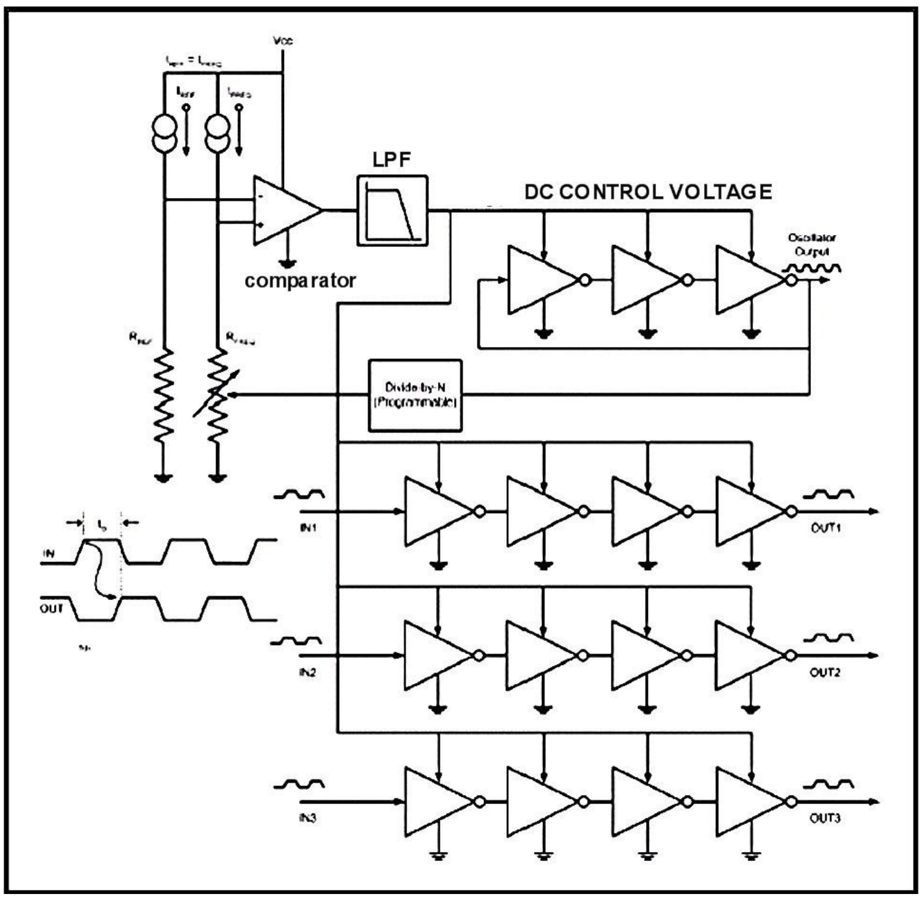


After the leading (or trailing) pulse edge the capacitors are charged enough after a delay, to exceed the comparator's reference and trigger the flip flop. The capacitors are discharged quickly and completely by the switches on the trailing edge, so the initial voltage conditions of the input signal prior to the rising edge, within reason, doesn't affect the time delay (unlike my R-C circuit). The state between the leading and trailing edge is "remembered" by the S-R flip flop to regenerate the delayed pulse where the leading and trailing edges are delayed by the same amount. A pretty hard to beat system, at least I would have thought.

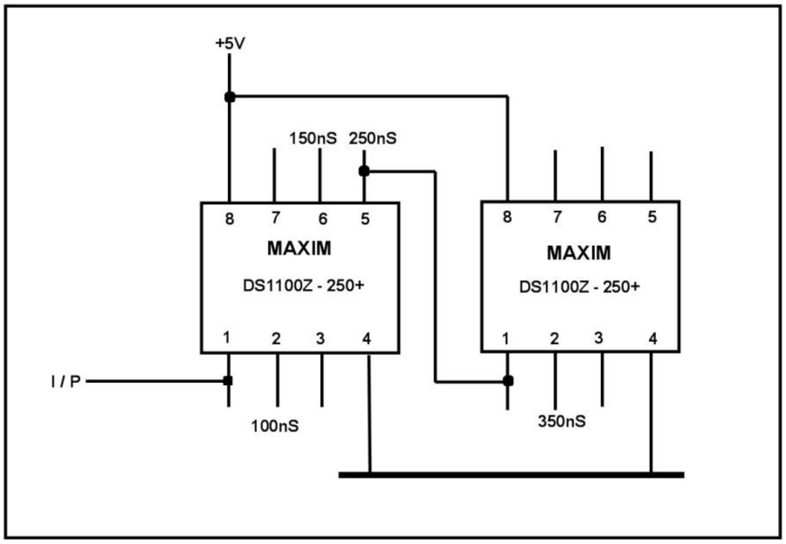
However, Maxim acquired Dallas and upgraded the design to a new operating principle seen in delay lines such as the DS1100. In these devices a method was created to make the delays independent of the individual gate delays and variation of those with respect to manufacturing process, temperature and *voltage* variations. The voltage (power supply voltage) variation is the important one because the propagation delay via a logic gate is affected by its power supply voltage. In the DS1000 silicon delay lines, if the power supply voltage varies, so does the delay to some extent.

In the DS1100 series devices, a group of inverter gates are wired up as an oscillator and the oscillator is locked in a feedback loop to a reference. If the gate's properties change with temperature or voltage the loop feedback voltage alters. This same voltage is used to power the gates in the delay system. Since all the gates in the circuit are on the same substrate, even though the delay gates themselves are effectively run open loop, the correction voltage corrects for their errors as well.

The diagram below shows the internal arrangement in the Maxim DS1100 series delay lines:



I decided on the DS1000Z – 250 or the DS1100Z – 250, which have a max delay of 250nS in five 50nS steps, so that two IC's in an SOIC package could be configured on a 14 pin adapter:



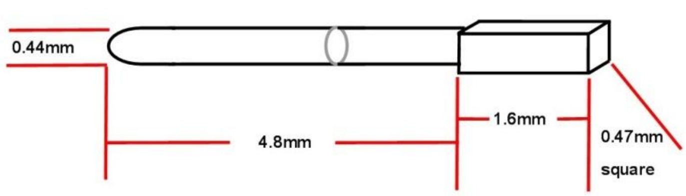
I designed a small adapter board. The pins that project from this board are unusual. They are Gold plated 0.44mm diameter pins (the part that passes into the 14 pin socket on the 16kRA pcb). At one end they have a square section and they press fit into 0.48mm internal diameter plated through holes. They were acquired from another type of pcb “adaptic”.

It is hard to find adapter pcb’s with pins the same width (about 0.45mm) as a standard DIL IC pin, usually they are larger ranging from 0.5mm to 0.6mm. Although the Winslow Adaptics company appear to have paid a lot of attention to the required pin diameters on their IC adapters. But there are many adapters on Ebay where the pins are too thick to use without damage to the IC sockets.

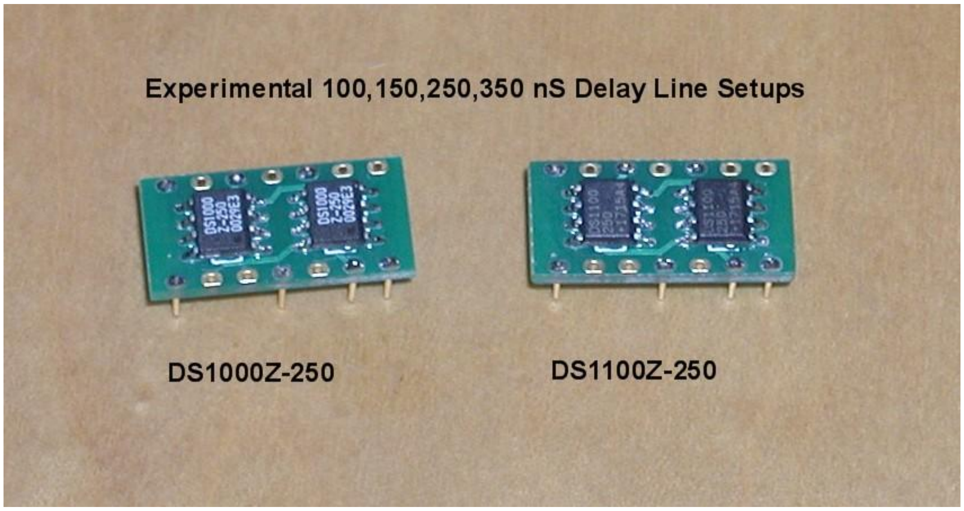
In the case of the IC sockets used by PT (on their Ram boards or the Sol-20 computer) or any IC sockets for that matter, oversize pins should never be pushed into them. This stretches the contacts and they lose spring force, especially if a standard pin size part is inserted later.

The gold pins used for this adapter have the following geometry:

Gold Plated Press pcb pins :



The photo below shows the completed adapter with the two SOIC packages fitted:



The only difference I could detect with the performance of the DS1000Z vs the DS1100Z is that the power supply voltage (+5V) affects the exact delays a little in the DS1000, but not the DS1100Z (for the reasons outlined above). Both of these restore the 16KRA card back to normal working order, unlike my first two failed attempts.

Once I had made the delay line on the custom adaptics and tested it, there was the issue of appearance. I wanted the module to look about the same as Data Delay Devices's original module. Therefore a housing or cover would be needed. I found that the housing on a 7 way black CTS DIP switch was about the same size. So I removed one from a switch, sealed the 7 rectangular holes with epoxy resin and painted the top. It was then glued over the adapter and labelled. I had specifically made the adapter pcb to be 9 x 19mm with this idea in mind. The photo below shows this:

Common 16KRA issues:

After repairing four of these 16KRA cards, there was a common theme; It is very unwise to plug in one of these 40 year old cards and just “expect it to work”.

It is even more unwise to start to initially chase a fault when it is found not to be working (often the case). This is because there are 71 IC’s on the 16KRA card and over **1000 IC pin and IC socket connections** just on the one card and only one connection has to be defective for the card to malfunction.

For example I spent four hours tracking down a fault cause by a resistance developed between the output of one IC pin driving the RAM banks, cause by corrosion between the pin of the IC and the socket it was plugged into.

Over the years (more than 40 years in this case) oxides and corrosion, microscopic and sometimes macroscopic, occurs between the dissimilar metal surfaces of the IC pins and the IC sockets. Some IC pins are silver plated (they gain a black corrosion and can also rust as they are steel, typical for TI brand IC’s). Other IC’s appear to have Nickel plated pins while others are Tin/Lead coated and have a surface obviously set up for soldering, not sockets, but were placed in sockets nonetheless.

In addition there are two types of IC socket design used on the various specimens of 16KRA cards. One type used extensively by PT are TI (Texas Instruments) types and they grip the IC pin on its narrow surface from side to side, where the pin is 0.45mm wide. The other common type of conventional socket, the spring pins grip the IC pins across their broader surface where the pin is 0.25mm thick.

While “exercising” the sockets by removing and re-inserting the IC’s can help, it is only a temporary fix. It is much better if all the IC’s are remove and each IC pin cleaned.

On observing the pins, a line of corrosion can be seen where the socket’s metalwork gripped the IC pin. This corroded zone must be cleaned away from every pin on every IC.

A gentle scrape from a small screwdriver blade works. The back rectangular edge (not the blade’s sharp edge) of a tool like a number 11 scalpel blade works too. The four surfaces on each IC pin should be cleaned until the oxides are removed and then the pins sprayed with contact cleaner and then lubricated with WD-40. This helps prevent future corrosion.

For the severely corroded and the oxidised silver plated TI IC’s, 2000 grade paper will clean up the IC pin’s surfaces, followed by cleaning with contact cleaner & lubrication.

For the sockets I initially cleaned them with contact cleaner and applied a small amount of WD-40 too, however I found, for the sockets, just applying a small amount of WD-40 is adequate. Inserting an IC with perfectly clean pins gains a good new connection, without having to apply the contact cleaner to the socket itself. With time the lower molecular weight hydrocarbons in WD-40 evaporate and leave a small amount of the higher MW oil behind for a longer period. It is a useful temporary lubricant to help reduce wear if IC's are plugged in and out in the medium term. If the socket is completely dry there is a lot more wear when the IC's are removed and re-inserted, which they may well have to be in a fault finding scenario.

If it is suspected that an IC socket is defective, a single pin can be removed from a modern low value DIL IC and used as a "mechanical test pin". If held in forceps it can be inserted to the socket pins one by one to feel the spring force from the socket. Make sure it is lubricated with a small amount of WD-40, or it will add wear to the socket. This way the individual socket pins can be checked.

Never insert anything other than an IC pin which is close to 0.45mm across and 0.25mm thick into any IC socket. Or the socket's metal arms will be stretched apart and lose spring force for a normal sized pin inserted later.

To clean every IC pin on every IC on the PT 16KRA card, lubricate and re-insert them takes about three to four hours. As noted I spent four hours chasing down one fault with the scope related to just one of the over 1000 connections. So it is by far and away better to make sure every IC pin is cleaned and has a proper connection prior to powering and testing the 16KRA card or attempting any fault finding at all. If this is not done first, you will be going around in circles because the faults caused by oxidised connections are often intermittent as well.

The same applies to the IC & sockets on the entire SOL-20 motherboard, of which there are over 1500 IC pins to attend to and nearly 400 on the keyboard as a rough estimate. There is no substitute for patience with this task. Therefore, to ensure good connections with three 16KRA cards, the Sol-20 Motherboard and also a disk controller card, roughly 5000 IC pins require cleaning.

Other issues on the 16KRA cards:

1) The heat sink for the 12V and 5V regulators on the card is a black anodized aluminium bar that runs the length of the card. Often the screws which retain it are loose and there is a poor thermal contact between the regulator's TO-220 metal tab and the heat sink. This bar is better initially removed and any old heat conducting compound cleaned away, fresh compound applied and re-tightened.

It appears for the 7805 and 7812 regulators, running them very hot over their lifetime results in a progressive drop in output voltage. If the output voltage has dropped below specification, it would pay to replace the regulator.

2) Unfortunately, the CTS brand DIP switches (now over 40 years old) which select the memory address are not sealed to the ingress of dust and atmospheric contaminants.

Dust and oxidation or a film builds up on the internal contacts over time, and the switch can be open circuit, even in the closed position. One of my 16KRA Ram cards failed for this reason and a page of memory dropped out. Also, I could not transfer any files to the Sol with a setting other than 300 baud. This also was due to open circuit DIP switches. It appears that if a switch has been in the open position for many years, when it closes again the contact is poor. These switches operate at low voltages and very low currents and the switches are not electrically self cleaning either.

The internal contacts inside these switches are not a sliding type, they are a touching type and there are no significant abrasive forces to clean the surface oxides away, so exercise does not help them. There is a plastic arm that runs across the contact surfaces to separate them, but it is not hard enough to break through the surface layer. Also, spraying switch cleaner into the switch does not help greatly either.

Each switch should be checked for continuity and if it fails has to be replaced. After disassembling the switches and seeing the corrosion in them and finding the surfaces to be a poor conductor, I decided to replace all of the old DIP switches on every 16KRA card and on the SOL-20 motherboard too.

Unsoldering DIP switches:

I will mention these tips for those less familiar with unsoldering techniques by many technicians are well versed with this problem.

This describes the task with a hand held (not automated) solder sucker.

The soldering iron ideally is temperature controlled and quite hot. Ideally test the tip temperature with a temperature probe, it should be around 320 deg C. Initially some fresh solder is applied to the pin & pad. This helps it to flow better. The join is then heated for about two to three seconds and the solder sucker nozzle quickly applied over it and deployed.

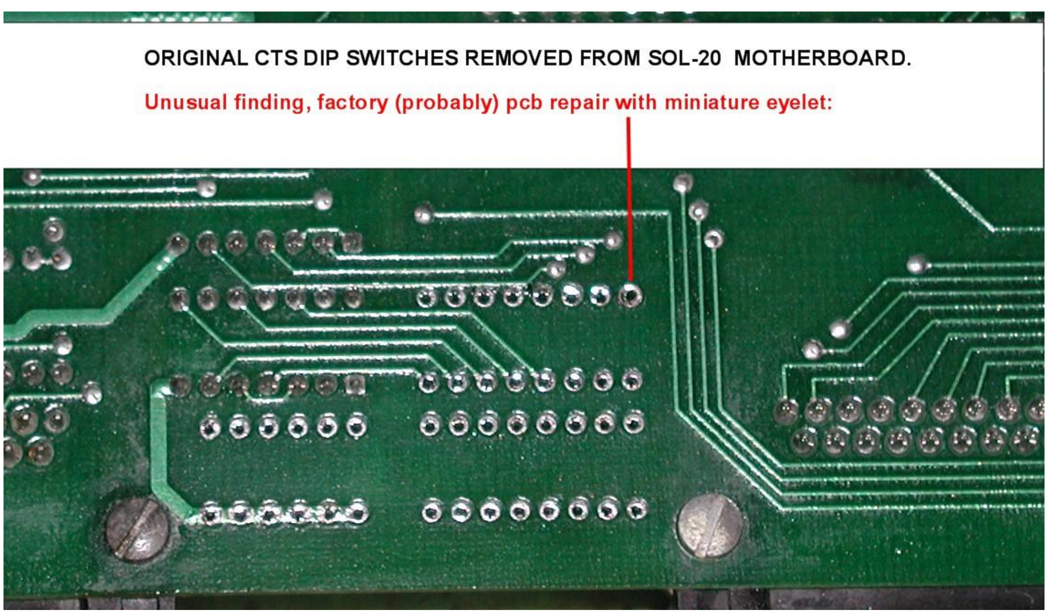
If the solder was adequately melted right through the hole and around the pin and there has not been too much delay before the sucker is applied allowing the solder to start to solidify, then the hole should appear clear after the sucker deploys.

However, usually the pin from the switch (or a soldered IC) lies down one side of the plated through hole and remains stuck to the side wall off the hole. The pin is then pushed sideways to free it so it is loose in the hole. Often a small click is heard when this is done.

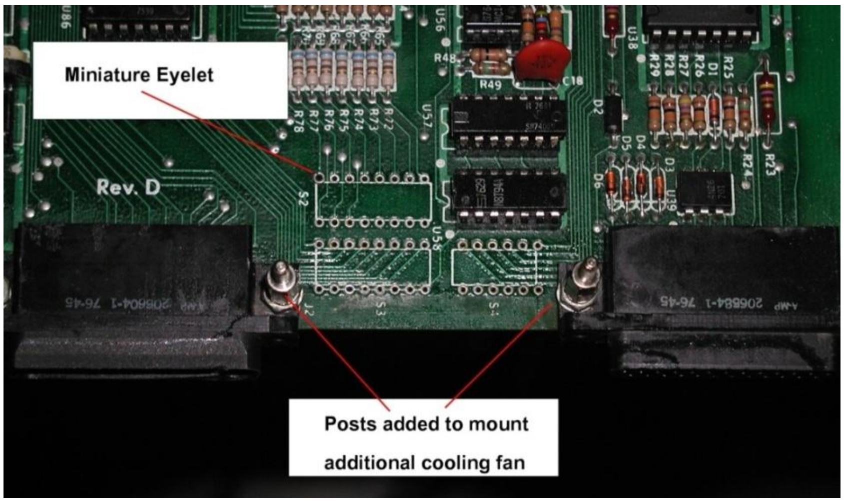
Do not move on to the next pin for de-soldering until the one you are working on is definitely free in the hole. Once it is free, cut off the part of the pin that projects from the pcb with flush cutters. This allows better access for the nozzle of the solder sucker on the next pin.

When all pins are de-soldered and perfectly free in the holes, the switch assembly should lift easily off the pcb. If it doesn't check again that all pins are free. If they are not the pcb pads and or plated through holes can get damaged when attempting to remove the switch (or IC or IC socket). If a pin does not clear, re-apply fresh solder and re-apply the sucker. Regularly clean the sucker which helps its efficiency at the task.

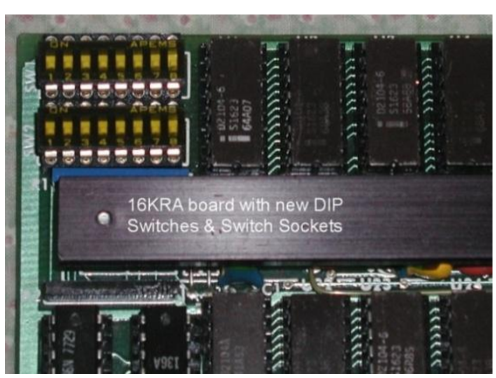
After the switches are removed, clean the pcb with circuit board cleaner and cue tips (cotton buds on a stick). Inspect the PCB, pads and plated through holes very carefully to ensure there is no pad, hole or track damage. The photo below shows the areas on the SOL-20 main board where the DIP switches were removed. I found there was a factory pcb repair. One of the pads/plated through holes had been professionally repaired with a miniature eyelet.

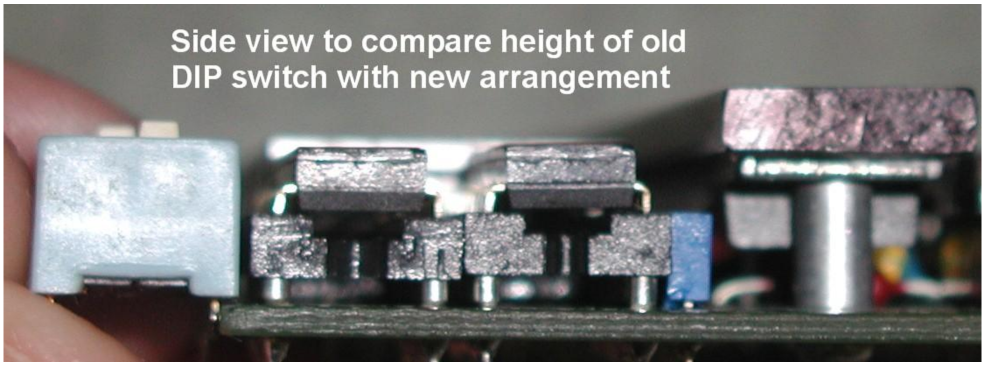


The top pcb surface is shown below after removal of the CTS DIP switches. Of note, two small 4-40 hexagonal posts were added on top of the projecting parts of the screws that retain the serial and parallel connectors (see below). It is not necessary to remove the motherboard from the case to do this. These are used to mount an extra fan (see section 4 below).



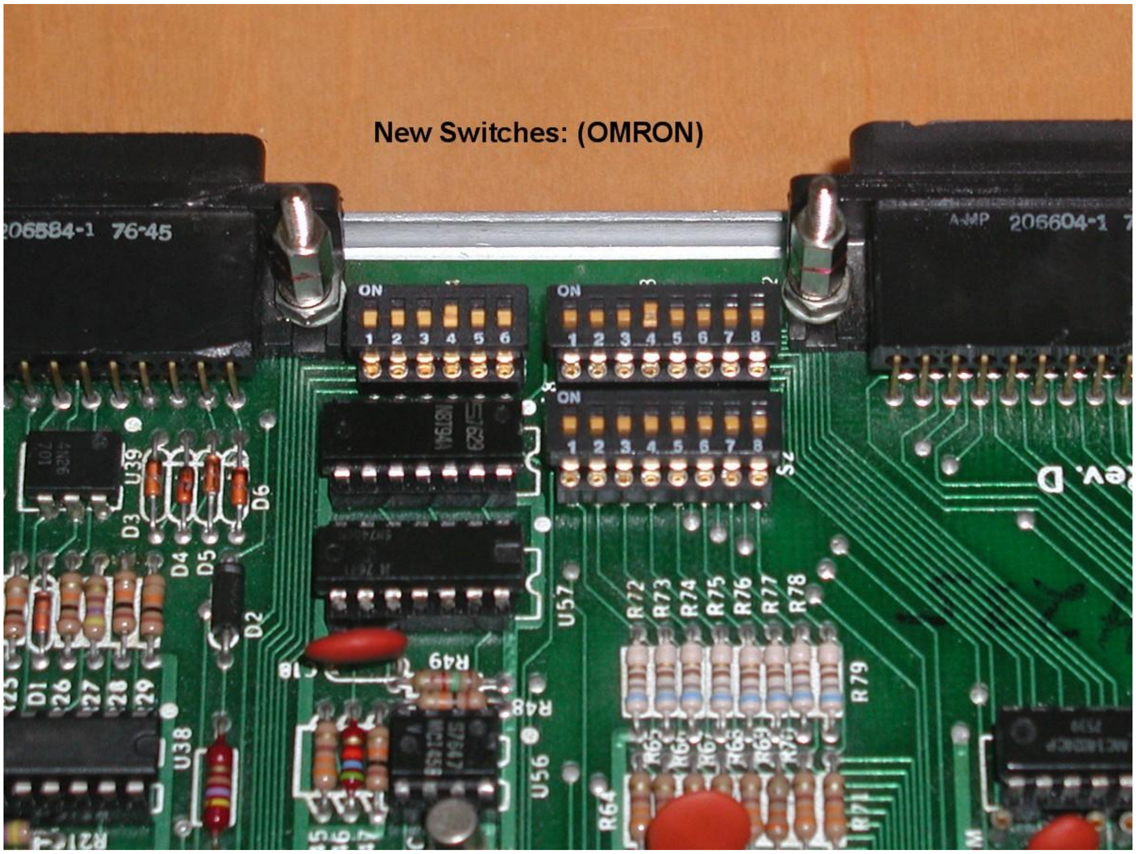
An excellent switch to replace the old DIP switches are a type that has been built into what amounts to a DIL IC housing. These have the same exterior geometry as a DIL IC and they plug into DIL IC sockets. Because they are low profile, the height of these switches and a standard machine pin IC socket are about the same size as the original CTS DIP switch assembly. These switches also have sliding contacts so they are a self cleaning design and using them with a socket means they are easily replaced. On top of this the switch pins are easy to get to from the top pcb surface with a meter to check the switch has continuity. While it is ok to de-solder a DIP switch once from a pcb, it could be harsh on the pcb to have to do it again. So fitting a quality DIP socket to the pcb, where the original DIP switches were, makes it unlikely it will ever have to be unsoldered again. The photo below shows replaced CTS DIP switches with these parts on a 16KRA board:





Good switches for the task are those by Omron or APEMS. The 8 way Omron switch is part number A6D-8103 and the 6 way version is A6D-6100.

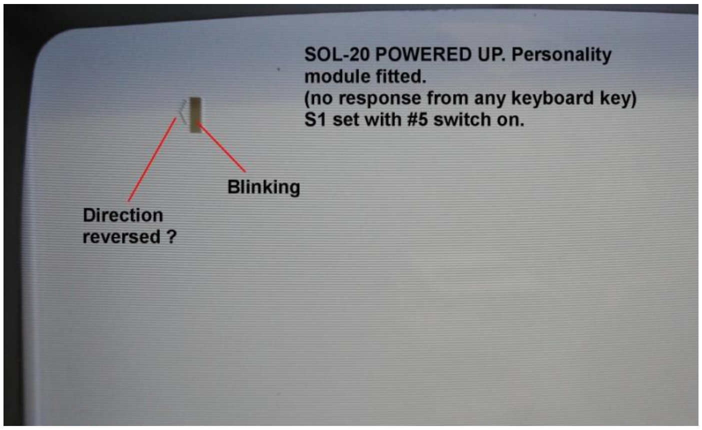
The photo below shows the new Omron switches (in sockets) fitted to the SOL-20 main board. The Omron switches are very good quality and also have gold plated pins. They cost more money than ordinary DIP switches, but the increase in reliability in my view pays for itself many times over. It doesn't pay to scrimp on a component which could result in hours of service down time, if it generates a fault, especially an intermittent fault.



2) Restoring the Sol-20 & the Keyboard:

The bulk of the work restoring my Sol-20 involved the cleaning and lubricating of every IC pin and IC socket. There were a number of faulty IC's. These were as follows. It may be unlikely the exact same faults would be present on other Sols but I will list them:

1) Failed Ram (U15) in the video ram bank. This caused some of the characters to be displayed incorrectly and the cursor arrow to appear reversed:



2) Failed line receiver IC; MC1489N (U38) on the serial port. This caused the incoming serial data to not make it to the UART IC and caused the inability to receive serial data. This is the second line receiver IC I have had fail in a vintage computer. The one in my IBM5155 also failed, see article:

http://worldphaco.com/uploads/LOST_IN_SPACE_REPAIR.pdf

I think this may happen because it is possible for a long RS-232 cable to develop a significant electrostatic charge, which can be coupled into the line receiver IC when the cable it plugged in, especially if the other end of it is not yet plugged into the another computer or RS232 device.

3) 8T97N IC (U77) in the CPU's clock buffer circuit unable to drive inputs on three 16KRA cards simultaneously, causing a power on lockup state. This can be solved by replacing the 8T97 with the 74LS367, or by replacing a link on each of the 16KRA cards with a resistor. This is the subject of a separate article:

http://worldphaco.com/uploads/SOL_Lock_Up_problem_3_x_16KRA_Ram_Cards..pdf

4) The keyboard required the usual replacements of the foam pads with the dielectric coated discs.

The original arrangement uses a 0.07mm thick dielectric (possibly mylar or polyester) on a foam disc with the conductive layer sandwiched in the middle of the dielectric, so about 0.035mm from the surface.

Experiments showed that the capacitance has to rise to about 10 to 15pF to produce a reliable negative going output pulse from the transistorized differentiator and threshold circuit, of about 800nS width. This sets the S-R flip flop U14 on a key-press.

Prior to getting the Sun 4 keyboard replacements pads, I had experimented with conductive rubber discs, which also work and running in a “DC coupled” mode the output pulses are 5uS long.

I bought some other capacitance pads to try which had a similar thickness dielectric, but the conductive coat was on one surface and therefore the capacitance didn’t rise high enough for reliable key detection as the dielectric layer was too thick.

After replacing all of the pads, the Sol keyboard appeared to work well on all keys.

However, every now and then it would stop and not respond to any keys. In seconds or minutes it would work again, Sometimes the problem disappeared for days. So I had my scope at the ready.

When the condition appeared, a quick test with the scope showed that there where no pulses coming via the keys from the key-scan circuit and that the key-scan pulses had vanished. The master clock U17 was still working. It turned out that U6 a Fairchild brand 7493 was faulty, with the A output intermittently disappearing, disabling the key-scan circuit. The IC was replaced. Intermittent IC’s are not very common and Fairchild 74 IC’s seldom do this sort of thing. Also, the intermittent failure of this IC, surprisingly, was not temperature sensitive. Heating or cooling the IC did not change the nature of the fault within it to any measurable degree.

5) The power supply required replacement of a 6-32 Nylon screw that fixes the 7912 regulator to the heat-sink with a metal screw and insulating washer, new mica washer and new thermal compound. The original 7912 was heat damaged, because with heat the nylon screw stretches and there is loss of a solid contact between the 7912 and the heat-sink. This nylon screw was a very bad idea.

The other power devices screwed to the metalwork also required re-fixing with new heat-sink compound.

Surprisingly, all of the electrolytic power supply capacitors tested normally for value, leakage and ESR so I kept them.

The mains power supply switch was replaced with a type that was an exact fit, Jaycar part SK- 0982.

The power supply was then checked by running it into a power resistor dummy load.

For cosmetic restoration, the timber side panels were gently rubbed down with 600 grade paper and re-spayed with satin wood varnish to restore the original appearance. They keys and paintwork was also cleaned to give the computer a new looking exterior finish.

3) SOL -20 Cooling Issues:

The Sol-20 was built with one cooling fan that blows air out of the case, from the power supply area. This creates a small negative pressure in the case (with the covers on) and air is drawn through the gaps around the keyboard and the rear below the case lid where the serial and parallel connectors are.

To have a lower profile computer, PT stacked the S-100 boards on top of each other horizontally. There is very little air flow between them and the boards in the middle of a stack get quite hot, especially from the heat dissipated by their 5V regulator IC's.

(note if the SOL-20 is run with the covers off, I would recommend covering the top of the psu area with a panel or a book and blowing a fan on the S-100 boards if there are more than two or three boards fitted)

The regulator dissipation depends on the line voltage and therefore the unregulated voltage set to the S-100 cards.

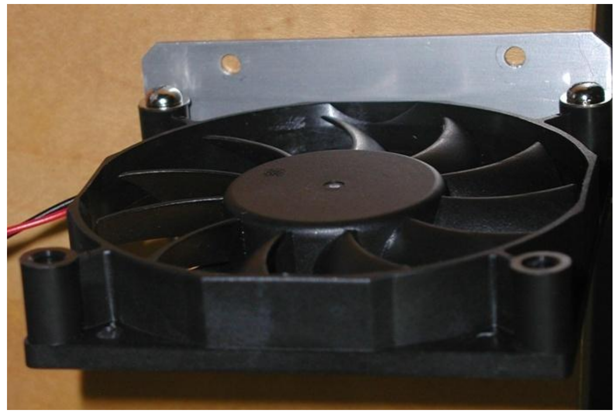
In my SOL, on a 117V line input voltage the unregulated voltages sent to the S-100 bus cards measures 10V and +/-18V. The 16KRA cards are rated for this. But the regulator dissipation is very high, especially for the 5V regulator IC's. With a line voltage of about 100-105V the situation is improved with a voltage of about 8V and +/-15.5V.

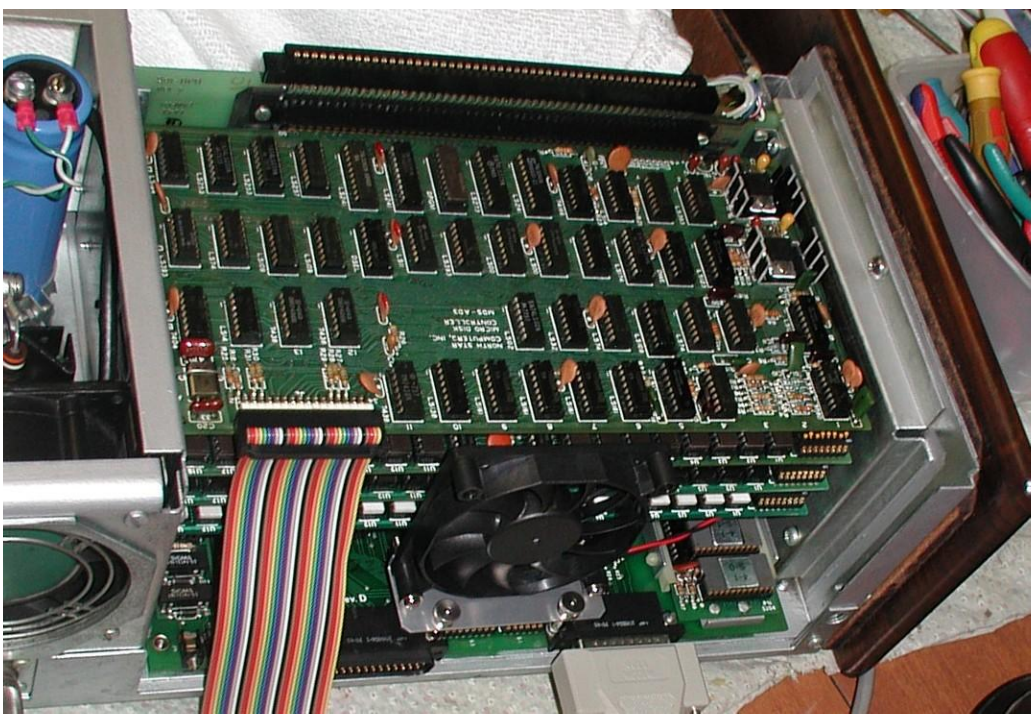
The input to a standard 7805 regulator needs to be at least 2.5V above its output voltage, equal to 7.5V or higher. The regulator heat dissipation is proportional to the current and the voltage drop across the regulator.

One easy way to mount an extra fan is to simply add two stand-off 4-40 posts to the tops of the screws that retain the series & parallel connectors. This way the SOL-20 computer is not modified in any way. I used a type with a projecting 4-40 stud so that I could fit two thumb nuts to retain the fan bracket.

It is not necessary to drill any holes in the SOL-20's top cover or anywhere else. (I have seen this done on some SOL-20's to increase the ventilation, but it is a shame to do this and damage the case or metalwork or paintwork). The addition of the fan, on its own, even with the top over on, still increases the convection through the unit and between the S-100 cards. The fan is orientated to blow air between the cards.

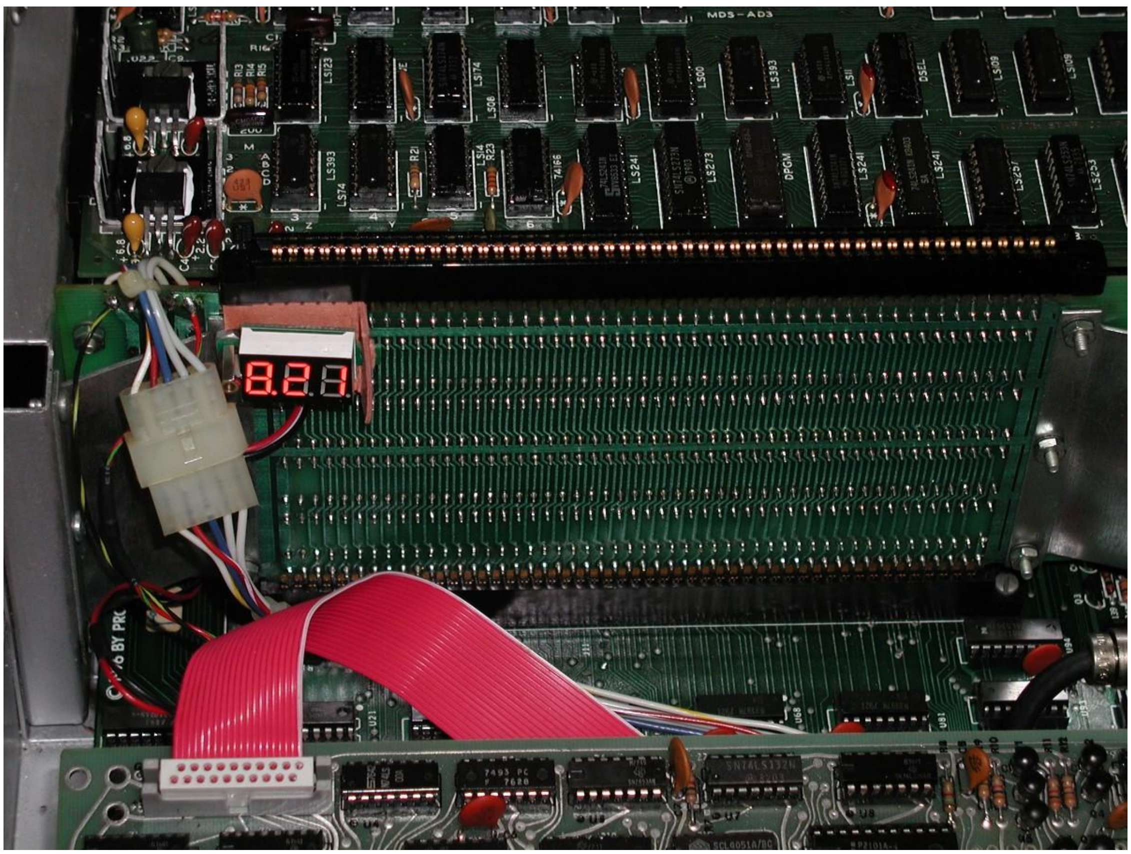
The photos below show the fan with a small right angle bracket added. The Micronel fan is a 12V 1.44W unit, 80 x 80 x 16mm type, RS part number 466-6820. I supplied it from the -16V supply to the S-100 bus and with a 1N4731 4.3V zener diode in series with it to reduce the voltage to around the 11 to 12V mark.





This way the fan is very quickly removed by undoing thumb nuts, to allow withdraw of the S-100 cards or reset the DIP switches. The other end of the fan wiring is on a 2 pin connector plug & socket so it is easy to remove.

Another thing I found it was useful to have a small volt meter added to monitor 8V DC bus voltages to the S-100 cards. This way I could vary the computer’s line voltage to a value that was sensible, so that the 8V supply voltage was around 7.5 to 8.5V and no higher. This helps limit the heat dissipation in the 7805 regulators on the S-100 boards. The meter was simply fitted onto a projecting screw thread, so no holes were drilled to fit it and it is easily removed.



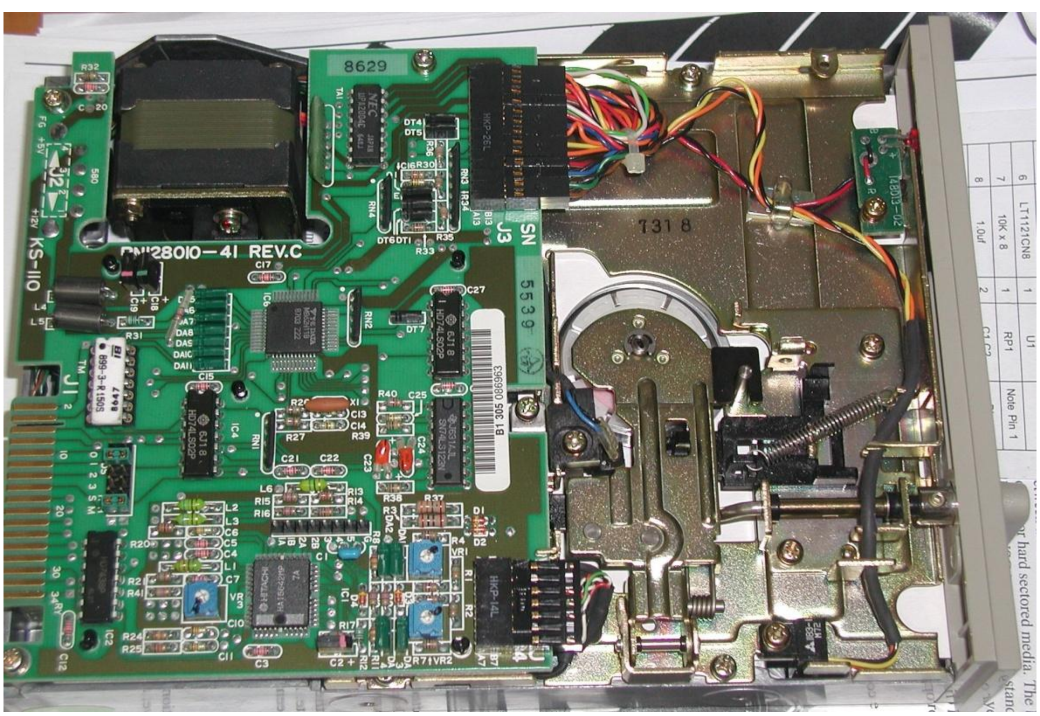
4) YD-580 disk drives for the Sol-20 and running CP/M.

One thing that concerned me was that if I acquired used disk drives, they could be faulty. Under normal circumstances this is not an issue *if they were in a previously working system,* they could be repaired.

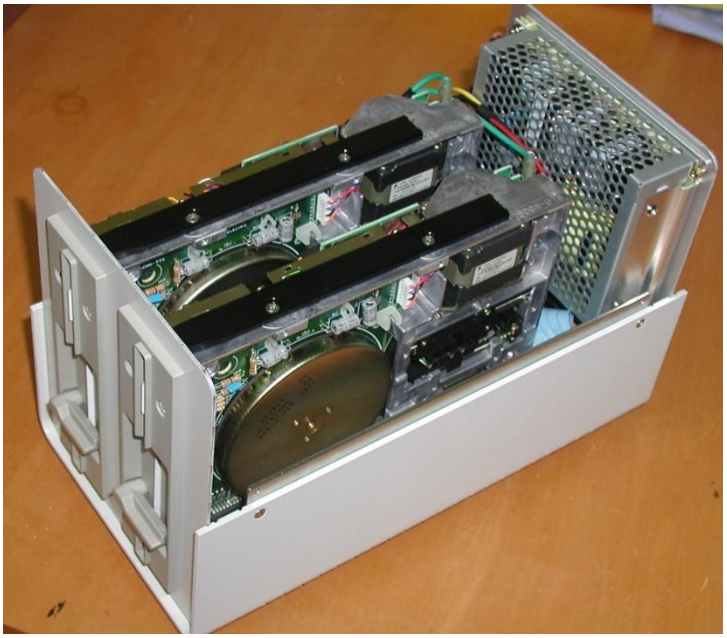
However, the system I was working with had never had a disk drive from new and I had acquired a North Star disk controller card in totally unknown condition. Also I had to mount the drives in an enclosure and add a virtual sector generator (VSG) to make it work with soft sectored media. So there were a large number of variables which could have stopped the initial system from working.

So I acquired two new old stock IBM YD-580 5.25” disk drive units, still sealed in their original boxes from 1984. (I would find out later that these drives were made to reject hard sectored media by disabling the index output pulses when a hard sector disk was encountered by them). The idea of the new drives being, that if the system didn’t work, I could concentrate on repairing the North Star card. Also I bought Mike Douglas’s “assembled & tested VSG” to be 100% certain that this part of the system would also be working. The North Star MDS-AD3 controller card was subjected to the same IC pin and socket cleaning protocol as described above for the 16KRA cards and the Sol-20 main board, before attempting to use it. The YD-580 drive was made in Japan, For IBM and appears to be excellent quality:

I



acquired a suitable enclosure and a power supply module from Jaycar and built these, with two YD-580 drives and the VSG into the enclosure with a fused mains/line IEC connector:



The enclosure had pre-punched ventilation holes in the bottom (or top). I set it up so they were on the bottom and added an array of 8 holes (4 on each side) near the top. This way the case gets some ventilation without too much dust entering the case.

The drive units, combined with the VSG have proven to be excellent with the North Star disk drive card running CP/M.

(I have yet to try the Sol-20 with the cassette tape interface which is the next Sol-20 project now the computer is stable & running with reliable memory).

5) Data Delay Devices, inc. – Product Support.

Who made the Original DDU-4 Module for PT's 16KRA card?

This module was made by Data Delay Devices, Inc. of Clifton New Jersey. They still manufacture a range of these devices and many other great products. However, in their stock range of the DDU-4, there is not a unit with a maximum delay of 350nS.

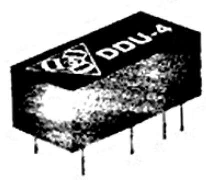
Digital Delay Units

SERIES: **DDU-4** — **1 to 5 Taps (14 pins DIP)**
T^2L Interfaced

data delay devices, inc.

Features:

- Completely interfaced for TTL and DTL application.
- No external components required.
- P. C. board space economy achieved.
- Low profile.
- Fits standard 14 pins DIP socket.



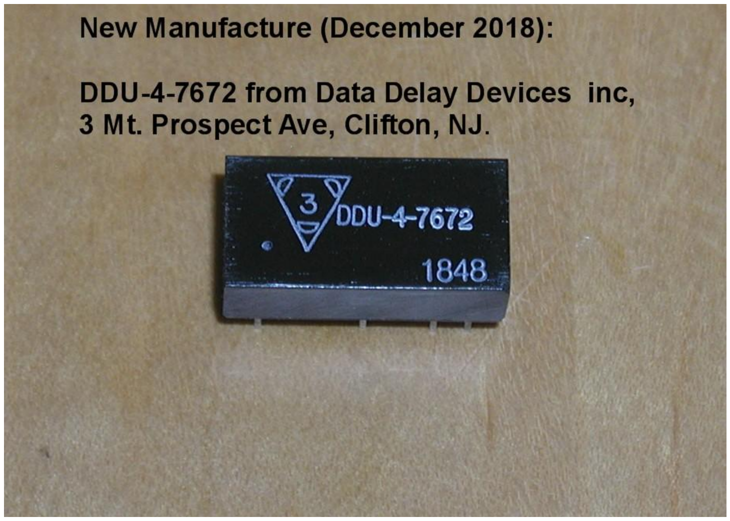
I contacted Data Delay Devices. The original DDU-4-7672 was a special order for Processor Technology. I think this would have been some time in1977. The 16KRA schematics I have seen are dated December 1977 as are the boards. The IC's on these boards have 1976 and 1977 date codes.

Paul Kuper of Data Delay Devices was very helpful and agreed to manufacture 5 modules.

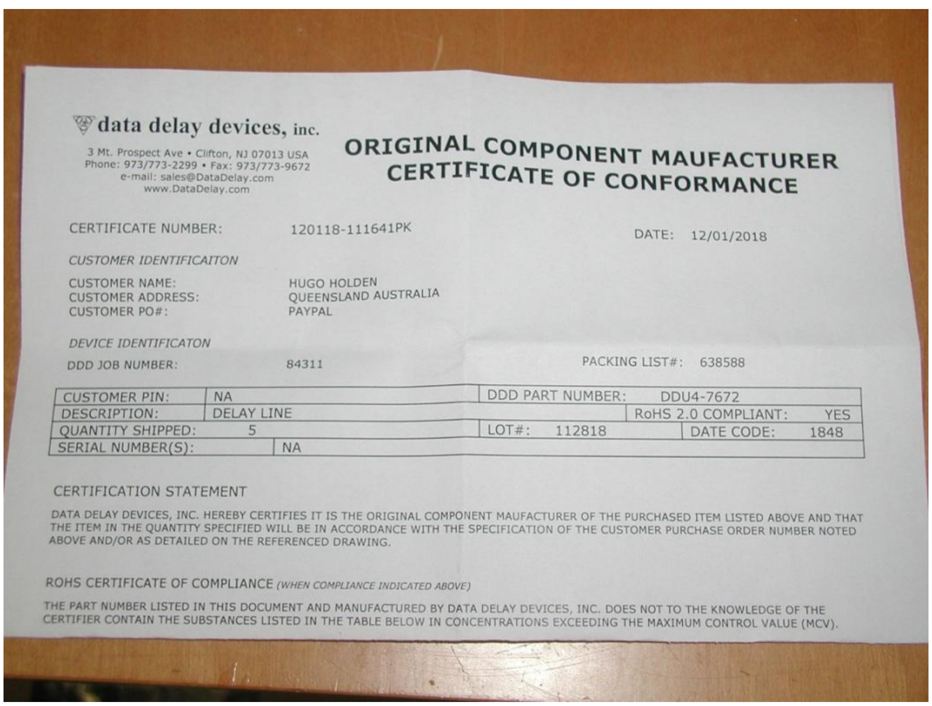
Imagine that, the same company, making the same module, spaced 41 years apart in time. The new DDU-4 modules arrived very promptly in one week from the order, even though 2 weeks delivery time was quoted. Also the devices are perfect, manufactured with military precision and with a conformance certificate and the price was very reasonable.

This has to be the best long term product support I have ever encountered. On this basis any company doing business with Data Delay Devices today could be 100% sure they are dealing with a very special company who totally back up their products.

A photo below shows the new DDU-4-7672 and the certificate they came with to prove that the above was not a figment of my imagination:



The certificate:



data delay devices, inc.

3 Mt. Prospect Ave • Clifton, NJ 07013 USA
Phone: 973/773-2299 • Fax: 973/773-9672
e-mail: sales@DataDelay.com
www.DataDelay.com

ORIGINAL COMPONENT MAUFACTURER
CERTIFICATE OF CONFORMANCE

CERTIFICATE NUMBER: 120118-111641PK

DATE: 12/01/2018

CUSTOMER IDENTIFICAITON

CUSTOMER NAME: HUGO HOLDEN
CUSTOMER ADDRESS: QUEENSLAND AUSTRALIA
CUSTOMER PO#: PAYPAL

DEVICE IDENTIFICATON

DDD JOB NUMBER: 84311

PACKING LIST#: 638588

CUSTOMER PIN: NA		DDD PART NUMBER: DDU4-7672	
DESCRIPTION: DELAY LINE			RoHS 2.0 COMPLIANT: YES
QUANTITY SHIPPED: 5		LOT#: 112818	DATE CODE: 1848
SERIAL NUMBER(S):	NA		

CERTIFICATION STATEMENT

DATA DELAY DEVICES, INC. HEREBY CERTIFIES IT IS THE ORIGINAL COMPONENT MAUFACTURER OF THE PURCHASED ITEM LISTED ABOVE AND THAT THE ITEM IN THE QUANTITY SPECIFIED WILL BE IN ACCORDANCE WITH THE SPECIFICATION OF THE CUSTOMER PURCHASE ORDER NUMBER NOTED ABOVE AND/OR AS DETAILED ON THE REFERENCED DRAWING.

ROHS CERTIFICATE OF COMPLIANCE *(WHEN COMPLIANCE INDICATED ABOVE)*

THE PART NUMBER LISTED IN THIS DOCUMENT AND MANUFACTURED BY DATA DELAY DEVICES, INC. DOES NOT TO THE KNOWLEDGE OF THE CERTIFIER CONTAIN THE SUBSTANCES LISTED IN THE TABLE BELOW IN CONCENTRATIONS EXCEEDING THE MAXIMUM CONTROL VALUE (MCV).

****