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Repair: Apple Macintosh PowerBook 100 "Gotta re-cap 'em all!"

Posted on September 24, 2016 by lui_gough

In the last part of this little project, I managed to refurbish the two PowerBook 100 power supplies to a working condition. The next step is to refurbish the main unit itself. Even though I was equipped with the service manual, I was a little hesitant owing to the possibility of breaking something which could be hard to source, or making it worse than it already is. Nothing ventured, nothing gained, I suppose.

I'm aware that others have done the same to their PowerBook 100s and seen positive impacts. It's hardly surprising when you consider its age. Some were even nice enough to draw out capacitor maps for the boards. Even though I've seen them, I decided to "go it alone" and instead base my repair on my own teardown and analysis.

This post will seem a little "jumpy" as both teardown and repair are interspersed, but I feel that's probably the best way to present it.

Required Material and Methodology

I suppose if you've never done any soldering or re-capping of electronics, it's probably not a good idea to start with a piece of equipment that you value. That being said, from my experience working with the PowerBook 100, it definitely rates a moderate-to-hard difficulty compared with some other work I've done.

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In order to get the job done, the tools you should have include:

- A set of Phillips head screwdrivers of various sizes for laptop disassembly.
- A fine-tipped soldering iron, preferably of the temperature regulated sort.
- Some solder, 60/40 tin-lead type works well.
- High quality desoldering braid – I personally use Chemtools branded wick, but formerly used Goot which varies a little in quality. Good wick really makes the job easier, bad wick can leave you very frustrated.
- Desoldering bulb (or solder sucker) – the bulb type seems to be more useful as you can "blow" the holes open or "suck" them clean, whereas the pen type is really "one shot" with one hand and hardly easy to get into position.
- Hot air gun (preferable, but not essential) for removing the SMD components with more ease.
- Foil (I didn't have this, but I probably should have) to mask sensitive portions of the board during hot air rework.
- Tweezers to grab a hold of the SMD components as you're heating them with the hot air gun, and to position replacement components.
- Cotton tips for use in cleaning the board and getting into the crevices.
- High purity isopropyl alcohol (e.g. methylated spirits) for cleaning residue from old leaky capacitors.
- Hobby knife for "picking out" all the disintegrated rubber feet in the laptop.
- Side cutters for trimming component legs after they've been mounted.

Other things you will obviously need include the replacement capacitors themselves, some time and patience to work on the boards, steady hands, decently good eyesight, and preferably a good workspace including an ESD workbench (which I don't have, but with appropriate precautions, you can get away without it). Some other people like to have a thin stainless steel needle for clearing out holes, although I've never had one or used it before. Having storage for screws and small components removed from the machine is also a good idea, and pen-and-paper in case you need to draw a quick sketch or a camera to take photos of how things were originally arranged.

In my case, I decided that I didn't want to open up the laptop again *for a while* so I opted to replace the capacitors (where possible) with more durable tantalum capacitors which will not leak. These capacitors are typically a little more expensive. Even though it's likely the original capacitors were over-rated in terms of voltage, I've decided to match the voltage rating like-for-like, and also match the type (SMD vs through-hole radial where possible to avoid straining surface mount pads). This required me actually tearing down the laptop first, assaying all the capacitors and then finding a "compatible" replacement. Unfortunately mechanical fit is hard to verify beforehand, especially when changing capacitor type, so in some cases you might have to be creative.

In hindsight, it may have been more appropriate for someone with a single iron and a basic hot air gun with no SMD experience to have gone with all-through-hole components for a neater look, however, the SMD components function as expected despite the slightly less elegant skewed mounting.

I obtained all components from element14, a major electronic components distributor just down the road. Unfortunately, the range of locally stocked components were, at times, limited, thus I had to choose slightly more expensive alternatives. All in all, the

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cost of the capacitors came out to be about AU$60 in total, as tantalums are a bit on the pricey side. It is thanks to them that I could even obtain some of the SMD variety, which aren't easily obtainable elsewhere without a minimum order quantity, longer delays or higher prices.

Re-Capping Technique

Even though I've replaced capacitors in many devices thanks to the "capacitor plague", I've never really ever written about the technique, which I think, deserves some mention. I've developed the technique out of experience and "feel" for it, and it helps to minimise any risk of damaging the board. It might seem like a trivial thing to "desolder" something and replace it with something else, but it's actually more difficult than it seems. Part of the reason is that the boards are often produced for automated manufacturing and have pads and component placement which are not optimized for hand soldering or rework. These boards can have multiple layers with plated-through-hole vias which can be damaged if not desoldered with care, and traces can easily overheat and delaminate, or be damaged by applying too much force.

The most basic sort are the through-hole capacitors, which are mounted in holes that go through the board. This sort is quite common, especially for larger electrolytic capacitors. A naive approach may be to wick away the solder using braid or a solder sucker and then just yank the component out. **However, this approach rarely works** for a number of reasons – often the solder pads and holes are just barely larger than the component, so effective removal of all solder is unlikely. Yanking the component out while solder remains partially in place risks pulling off pads and plated-through holes and damaging traces making it impossible to repair. Further to this, if the board is manufactured with lead-free solder, or the solder has oxidised a bit, it will be very difficult to wick the solder away **at all**.

My approach is to use a moderate iron temperature about 325-360 degrees and first **add solder to the joints**, making sure to alloy the whole mass of solder. In the case of reworking lead-free with leaded, this will contaminate the solder a bit but also slowly bring down the melting point due to incorporation of more lead. In the case of lead-free, I might choose to wick away the excess solder and add more fresh 60/40 to make the joint more "workable". My goal is to make the joints somewhat "bulbous" in shape, as the **excess solder** also helps with thermal mass, in keeping the joint fluid when heated.

Next, I heat up one of the legs and wait until it becomes fluid. With my other hand, I then gently rock the capacitor slightly away from the melted leg so that it levers out slightly. There's no need to go overboard, as you will stress the other joint if you do so.

I then alternate and heat the other joint, and rock the capacitor in the opposite direction. This may gain enough leverage that this leg is now freed from the board. I then return to the original leg, and repeat until the capacitor is entirely free from the board. The heat isn't removed at all during the rocking process, otherwise the solder may set and "grab" onto a trace and pull it through.

Then, **I clean the holes** by using good quality desoldering braid which should wick up the solder and leave the holes somewhat clean. If this is not the case, because there's some "tough" solder left somewhere, I heat up the whole joint until the solder is fluid and

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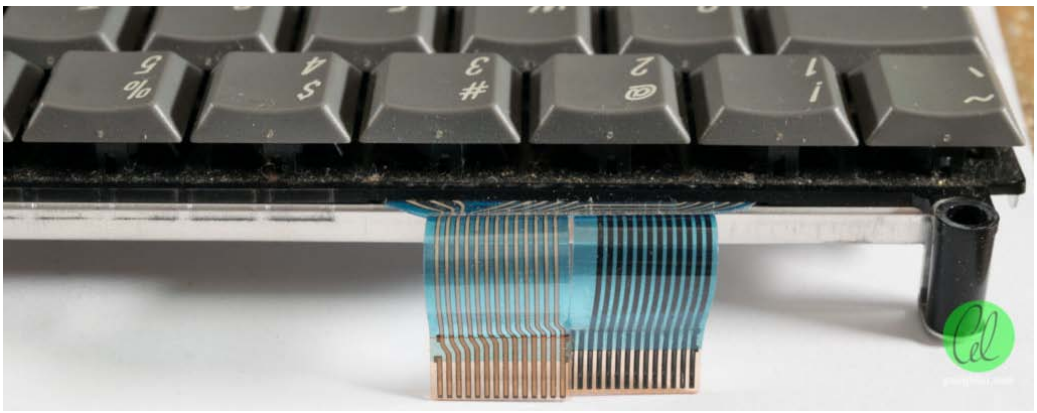
use a desoldering bulb to blow the hole clean. Others have had success using stainless steel needles, and other implements.

This works well in my experience where the naive approach never really works except for single-sided boards such as power supplies with large holes and simple layout. SMD capacitors are a little trickier, but with a single iron, you can do the same thing just **noting not to rock the capacitor too hard otherwise you might tear off the pad**. The safer way is to use a hot air gun and heat up the whole vicinity until the solder begins to show signs of change and then gently pick the components off with a tweezer while the board is still hot. It's probably a good idea to mask sensitive areas of the board which you're not reworking using foil to prevent them from being thermally stressed.

For soldering the through hole capacitors, there's nothing to it really – insert the components in the right orientation, check for clearances, bend legs, solder as normal. For the SMD capacitors, it's tricky to do it properly at home – I've decided just to "bodge" it by first reflowing a small amount of solder onto each pad on the board, tacking down one end of the capacitor with the soldering iron while being held with tweezers, then soldering the other end, and finally returning to the first side and touching up the joint there. It's not a good look – but I suppose you could go over it with a hot air gun to straighten it out. To do it properly probably entails brushing with solder paste and hitting it with the hot air gun – but the pads were probably not optimized for the replacement SMD capacitors so the results may be a little underwhelming.

Teardown and Repair



For the PowerBook 100, I followed the service manual almost completely when it came to disassembly. To remove the rubber feet, I used the knife to "stab" and "lever" out the gooey mess as much as possible. The top screen assembly came apart from the laptop after undoing three screws, and the keyboard was next to be removed. The keyboard has two flex connectors – probably one for rows and another for columns or something like that, which contrasts with modern keyboards that have a single connector.

The next thing to come off was the palm-rest which revealed the hard drive and trackball assemblies.

Service/NOAA, USA)

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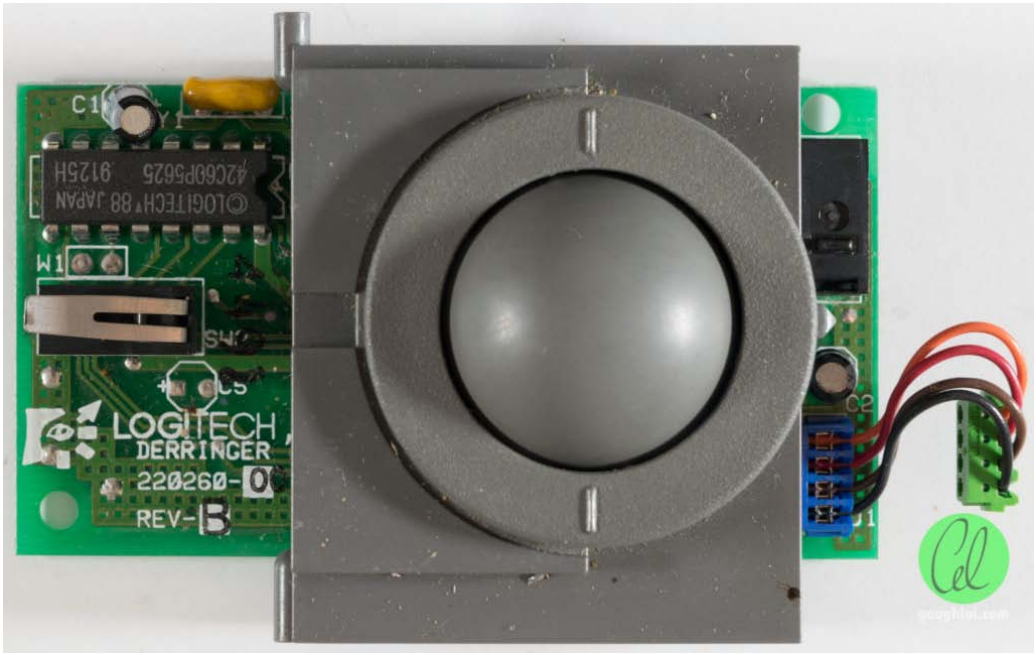
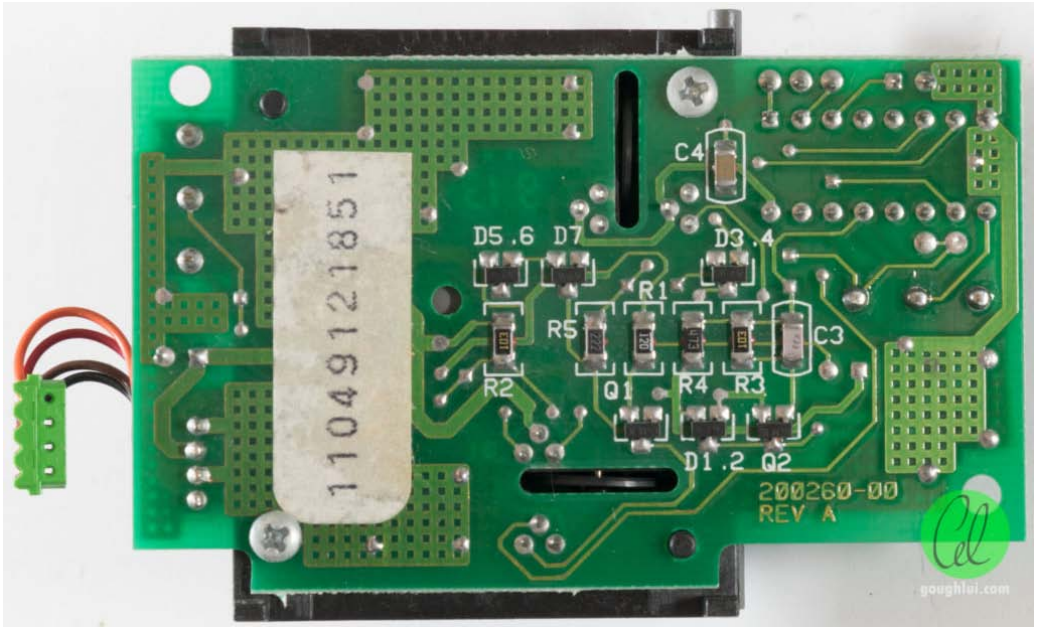


One of the biggest surprises to me was that the trackball was a **Logitech** product. I didn't expect that. **Because I wasn't paying attention, I didn't even notice C1 or C2** and so I forgot to order replacement capacitors for this entirely. Whoops. I noted down the value of C1 (0.22uF/50V), but not C2 ... sometimes these things are a little tricky.



I suppose element14 is probably not going to be happy with me ordering one or two capacitors to fix this one up. Oh well. Anyhow, it turns out that the hard drive was a Quantum Godrive 120Mb SCSI drive, with a relatively thick form factor.

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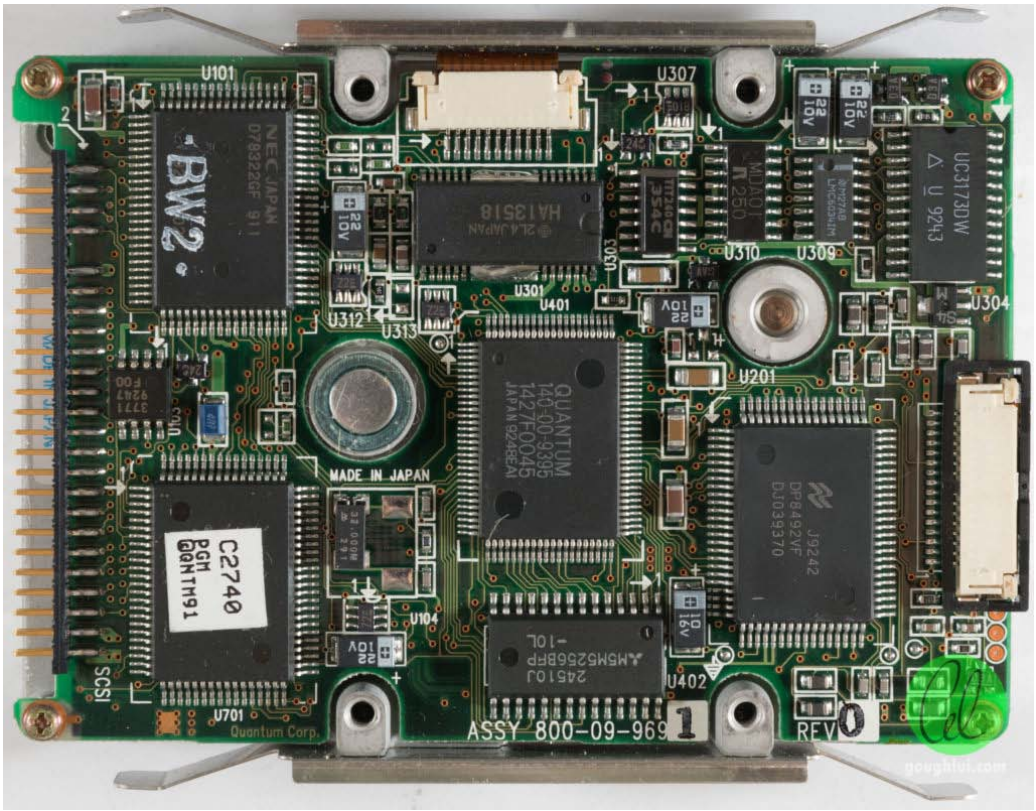
Sadly, these are known to be failure prone nowadays, because of their internal rubber parts which have also probably disintegrated into goo.



The underside has a few chips which take up the majority of the area of the board. No electrolytic caps that I can see, which is good.

Superdisk LS-120

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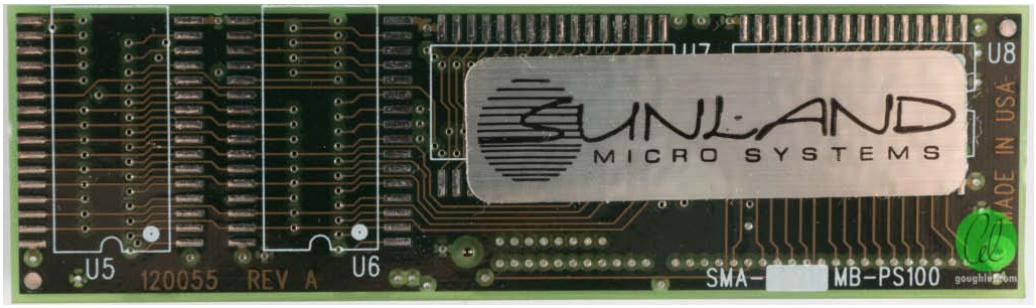
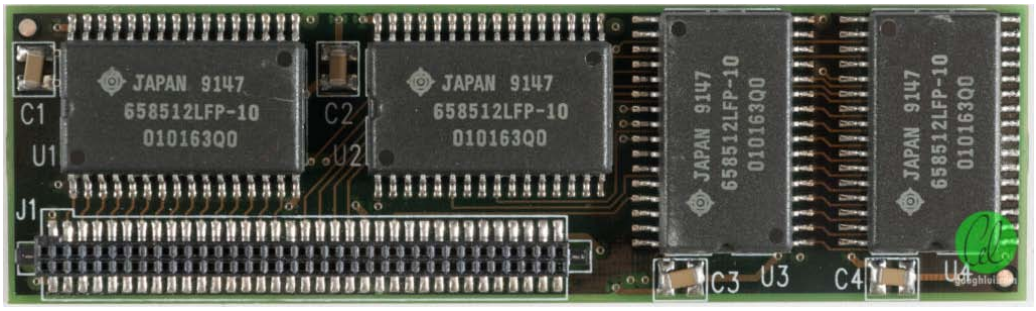
Of course, it has a 2.5″ SCSI interface which looks visually similar to what you might find on the back of a 2.5″ IDE drive. I've never handled a 2.5″ SCSI drive, so this was a first for me.



With these in hand, the next step was to take off the expansion RAM board. As it turns out, the expansion board was a third party board from a company called Sunland Microsystems. It had four unpopulated footprints on the top, which made me think whether it would be feasible to mount a few more pSRAM chips on the top and make it twice the capacity (4Mb rather than 2Mb expansion).

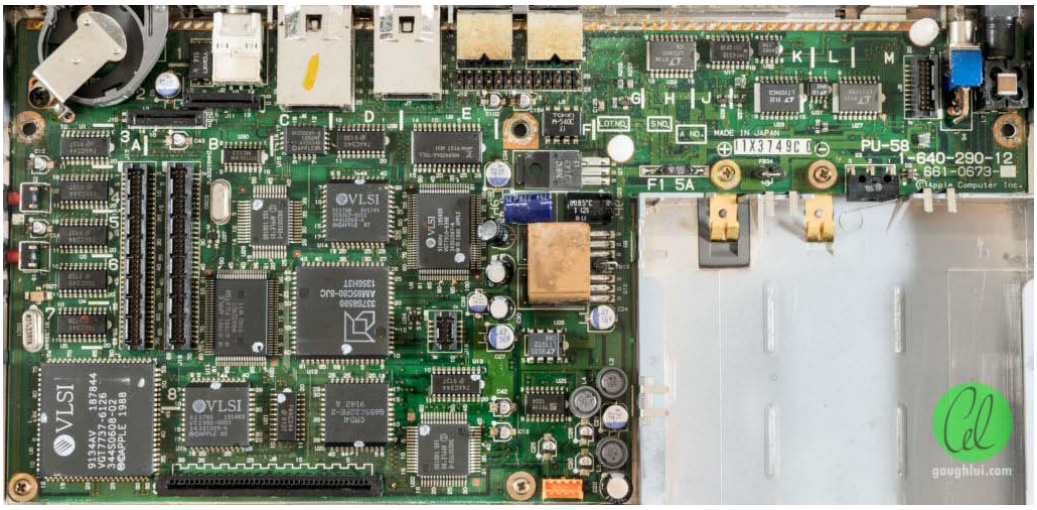


The pSRAM in question is a Hitachi 658512LFP-10. I managed to find some for sale online, but in a larger batch than I needed and at a price I'm not sure I could justify – after all, to do the modification could risk damaging the board as it stands, and I'm not entirely sure if it would work. The capacitors on the board look like they're not the right size for the footprint, hence their "crooked" orientation. No caps need replacing here, which is good.

The system daughterboard was next to come off, and this is basically the processor, ROM and RAM on a card.

This would turn out to be our first patient, as this has an SMD electrolytic capacitor near the small connector. The tantalum next to it doesn't necessarily need replacement.

The capacitor (C310) was replaced with an equivalent value SMD tantalum capacitor – noting that the band on tantalum capacitors faces the **positive**. The orientation is a bit crooked, but considering I'm doing it by hand with a single iron, I think it's okay.

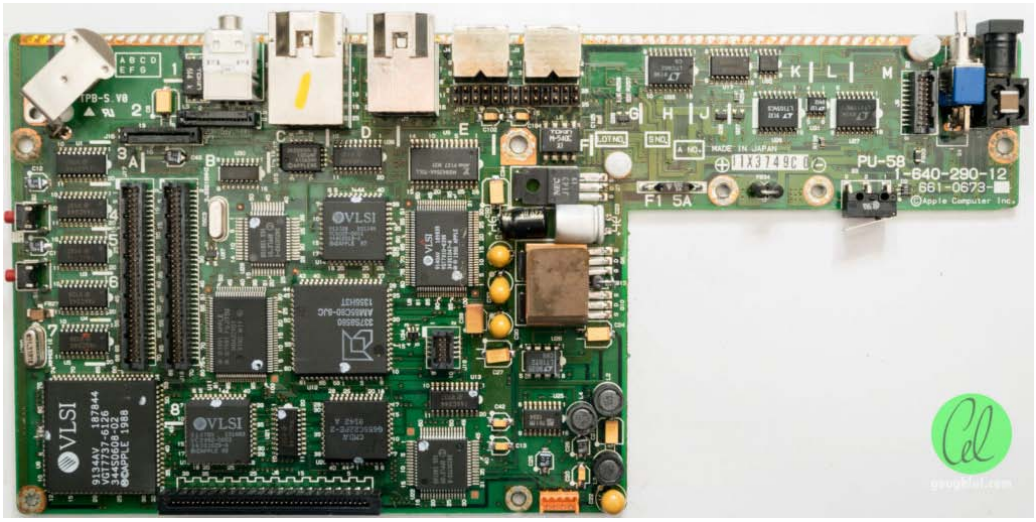


The next step is the main-board, which has a whole lot of capacitors that look like they need attention. The surface mount electrolytics show signs of distress, namely the solder joints around them look a little corroded, indicating that there is probably some leaking of electrolyte over time.

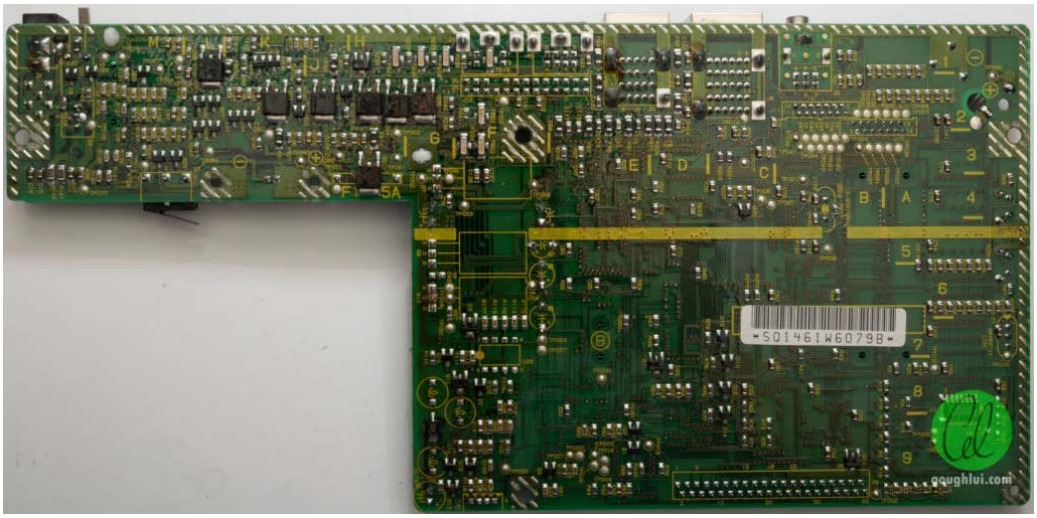
> **The best way to deal with the leaky electrolytics from my experience is simply to first scrub the area near the suspected leaking capacitors with a cotton tip soaked in high purity isopropyl alcohol.** If the tip turns brown, you know you've got an issue. It's good as it allows you to clean up some of the chemical residue which reduces the *awful smell* that comes out of heating up the residue during desoldering. A lot of the mess won't be accessible as it's underneath the capacitor, but once removed, you can then scrub the area **again** using a fresh cotton tip with isopropyl and that should bring the area back to cleanliness.

There's a good number of SMD and through-hole radial capacitors on this board, and the best way to get it done would be to go slow, and exercise caution and patience. The through-hole ones really caused trouble as the solder had somehow formed a "hardened" alloy which resisted melting and required me to up the iron temperature and suck the solder out as it wouldn't alloy nor wick out. At least I caused no damage there.

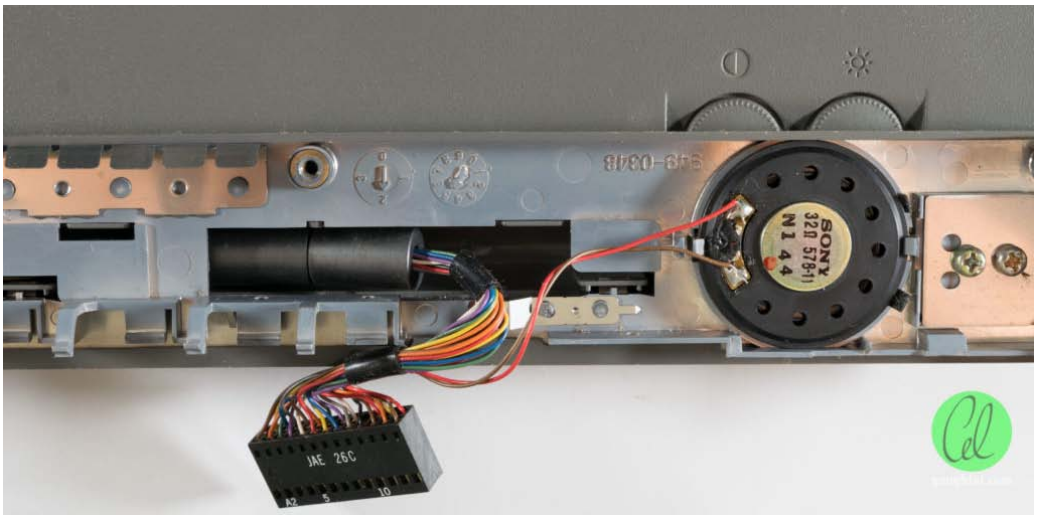
For the SMD chips, removing them one by one with an iron got tedious and risky in terms of tearing off a pad, so I used a hot air gun. The smell was **rancid** and ultimately, I didn't have any foil on hand and didn't mask anything so I melted the keyboard flex connectors slightly. That's a **lesson learnt** – connector plastic and hot air don't really mix. One of my tantalums was physically bigger than the footprint, so I applied solder, soldered one end and then "waved" the hot air over to get the other contact to solder. In the process, I "cooked" the outside of the capacitor ... oh well.



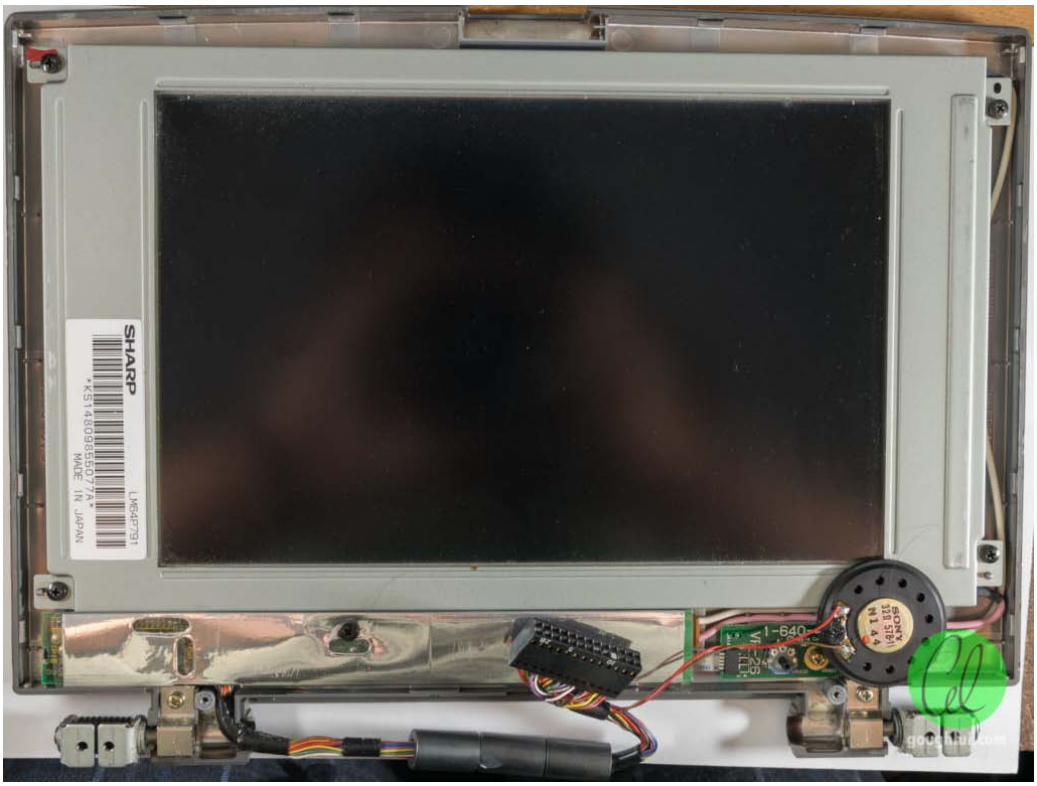
In the end, it's probably not my best work, but it's **my first attempt at SMD work** with a single iron. It's not ideal, but functionally, it should be **just fine**. The larger capacitors weren't available in tantalum, so I settled to go with one solid-electrolytic and a regular 105 degree rated electrolytic. It's a compromise I had to make.



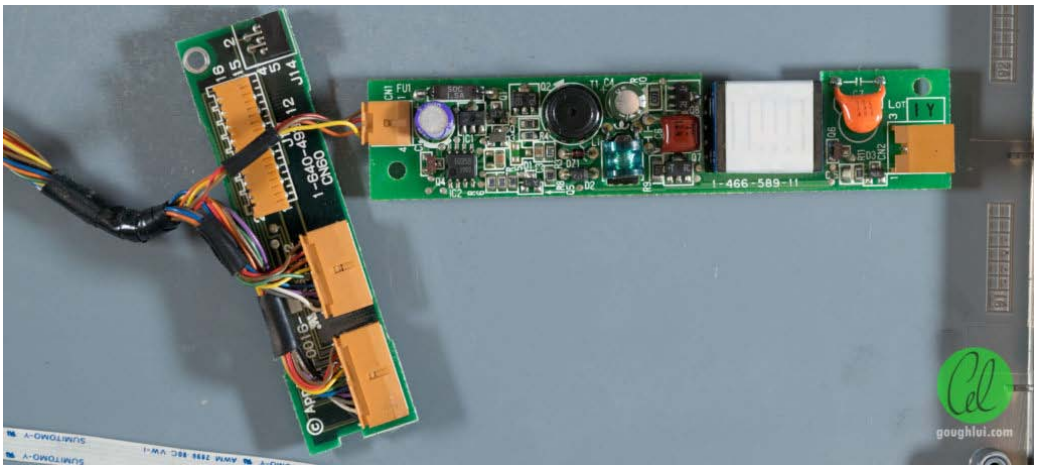
The underside of the board after it was repaired, and it looks mostly the same. The original factory seems to have left some sort of flux or coating on the rear which isn't really a nice conformal coating or anything, but it gives it an uneven glossy appearance.



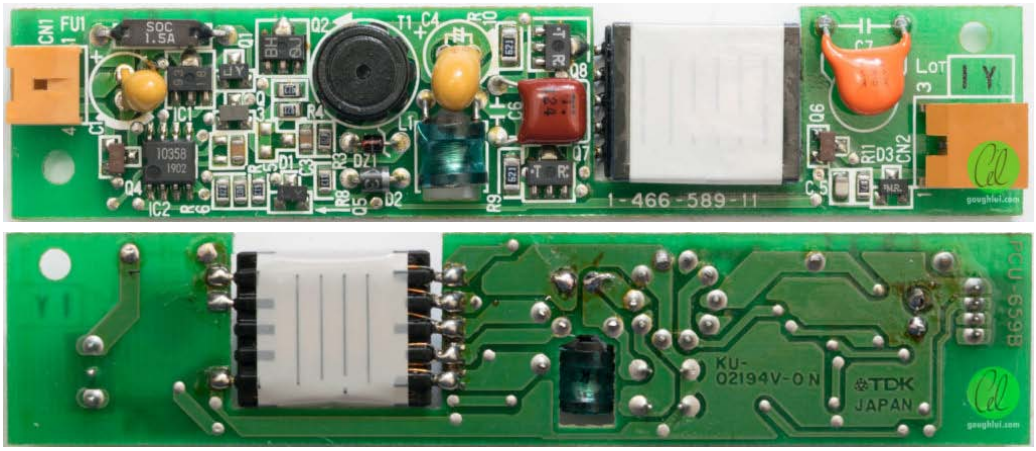
With that major piece out of the road, the next stop was the display – a known troublesome part in my case. To get to it involved removing the Sony speaker from the body, clutch plate, clutch covers, brightness and contrast knobs, more screws and screw covers etc.



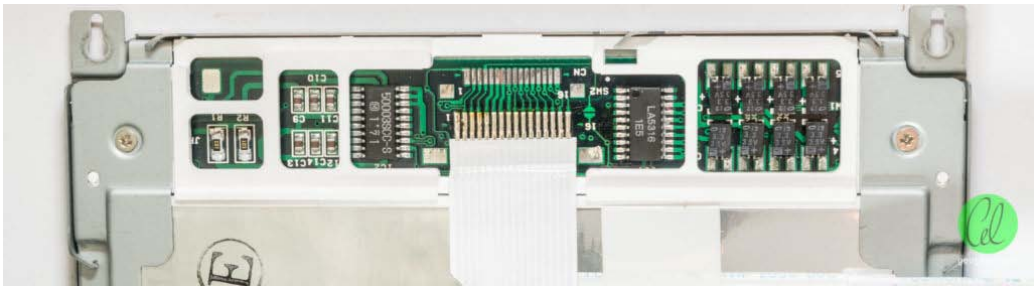
Inside, I found a Sharp LM64P791 LCD screen. There is a connector board and LCD backlight inverter underneath behind the shielding.



The backlight inverter had two electrolytic capacitors, which might need replacement. I decided to be safe and replace it anyway – although the replacement tantalums were a bit tall even when bent over, resulting in some stress on the board when reassembled.



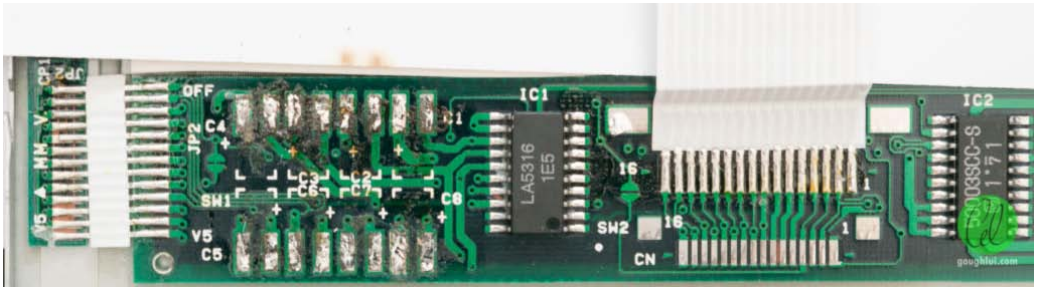
Then, thanks to an online tip-off by someone else with LCD trouble, I realized there were some sneaky electrolytic capacitors on the Tcon board itself. These were surface mount type with a very thin profile and connections on the same side.



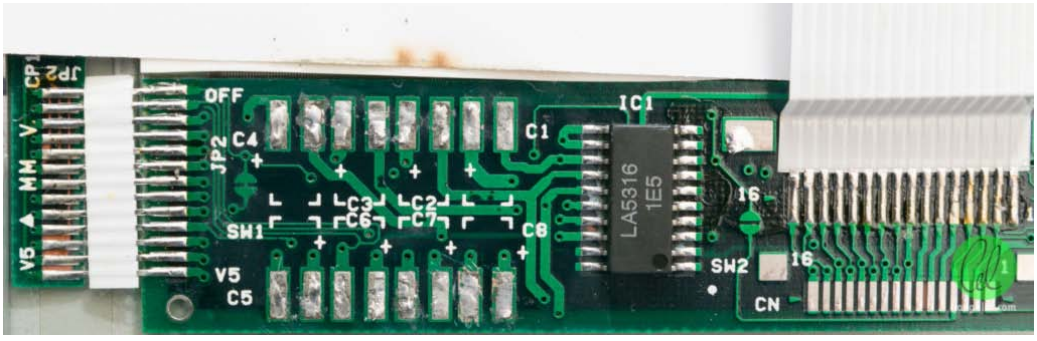
The units had frosty joints, a sure sign of bad capacitors. To get to it involved undoing four screws, bending out the retainer tabs, taking out the side metal strips, then removing the backlight assembly entirely, exposing the LCD screen itself.

We can see the flat-panel chip-on-flex drivers top and bottom. The flexible flat cable was very carefully threaded out from the frame – it's not on a connector on the PCB side which makes it both fragile and annoying.

To work with the board and screen in such close proximity is dangerous, so it's advisable to have some paper to cover the LCD during work, so that it doesn't become the victim of solder/flux splashes and scratches when repositioning. Due to the close spacing, desoldering was a bit of a challenge. Desoldering the capacitors shows you just how bad residue can be.

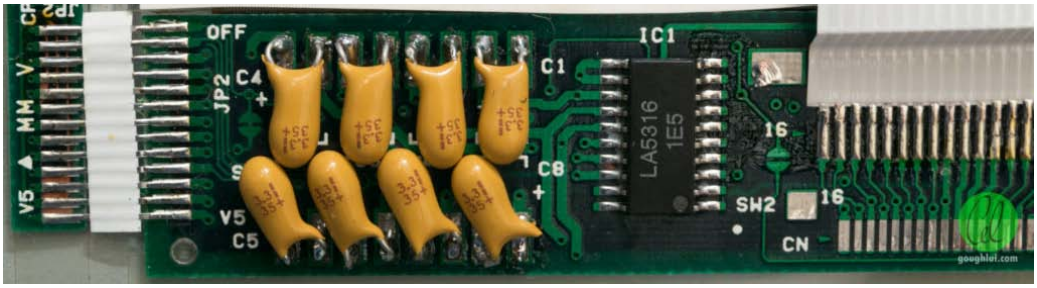


It's smelly, it's affecting the solder by causing some oxidation, it's sticky and it's a mess.



A good scrub with isopropyl alcohol and a cotton tip later and it's practically good as

new. Because the capacitors were not available, I substituted tantalum radial lead type capacitors, and with some creative lead cutting and bending, the best fit looked like this:



Unfortunately, when reassembling, I found a slight interference between C5 and the plastic frame, so a little bit of a snip was needed.

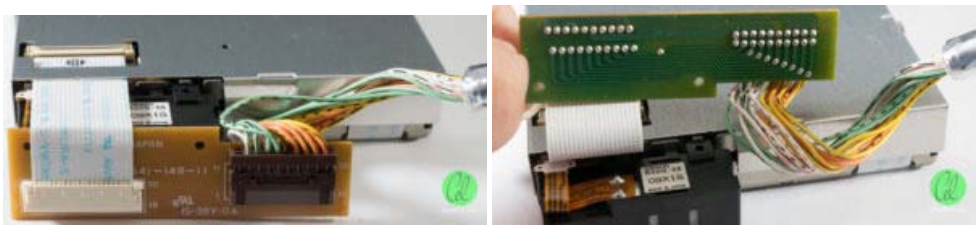
It was no big deal, because the main criterion is that they have the same vertical profile so they can fit into the casing. That was easily satisfied.

Now that all the internal bits have been attended to, it's also worth attending to the floppy drive, just in case there's something that needs to be serviced there. I didn't have any teardown instructions, but I seemed to have worked it out. If you unclip the front

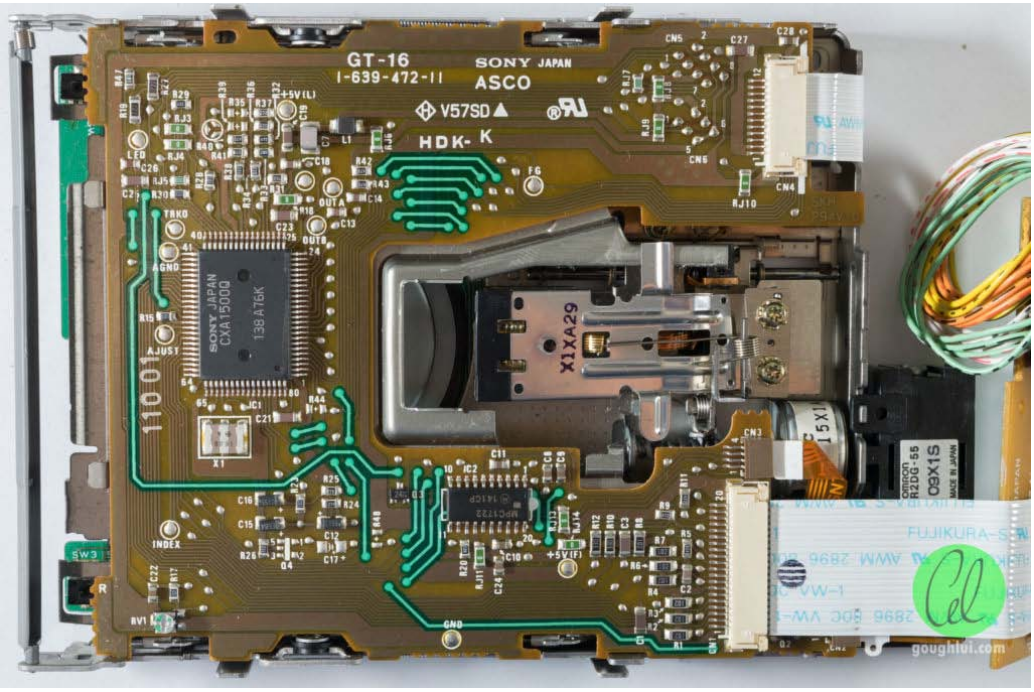
swivel cover, you can remove two plastic rings which allows you to slide the two parts of the case apart. That's literally it.

In this case, I opened the drive upside down, and the Sony model number is in clear view.

Right side up, the drive is covered by a shield, so nothing to see there.



The rear board is nothing but a passive wiring adapter that goes from the FFC to the external cable with a plug, so allowing the cable to be replaced if damaged.



Taking a peek under the shell shows a clean drive, with a PCB on the top and no obvious signs of electrolytic capacitors. There's one adjustment potentiometer in the bottom left which *might* be for drive speed? Who knows. I'm not touching it ... until I have to.

Now that **basically the whole ensemble has been torn apart** and everything has been re-capped **with the exception of the trackball PCB**, I have to reassemble everything and see if it still works.

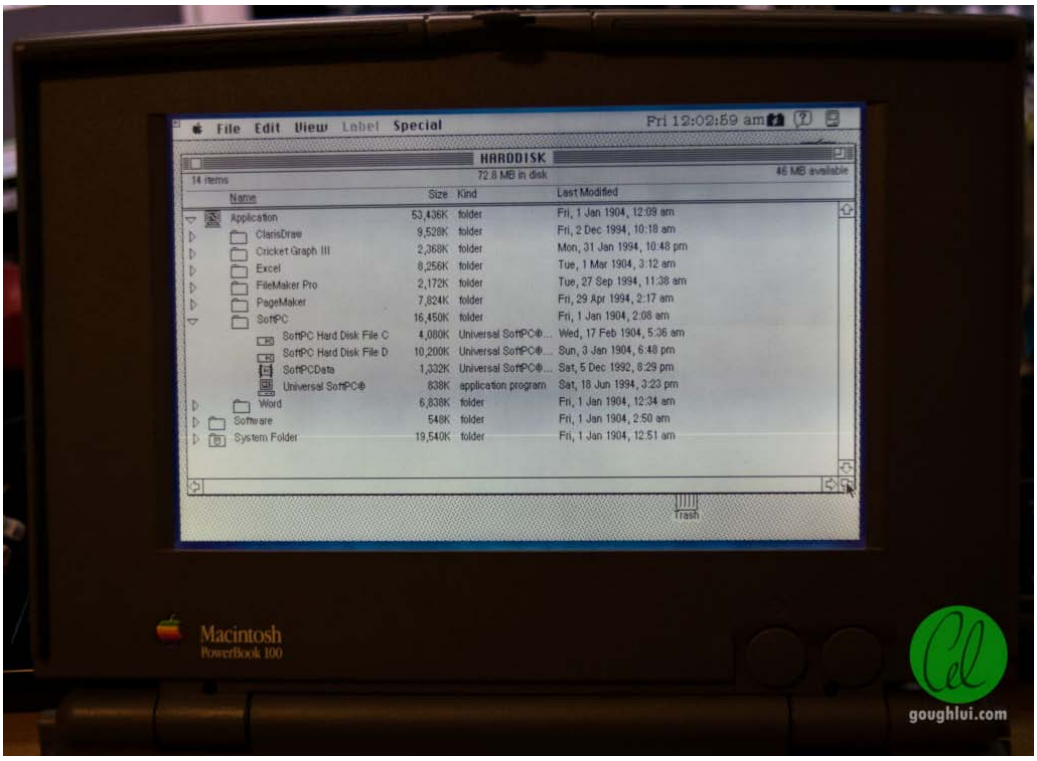
Result

Before I get to the result, I decided to save all the extracted capacitors and do a quick measurement of their status to see just how bad they were.

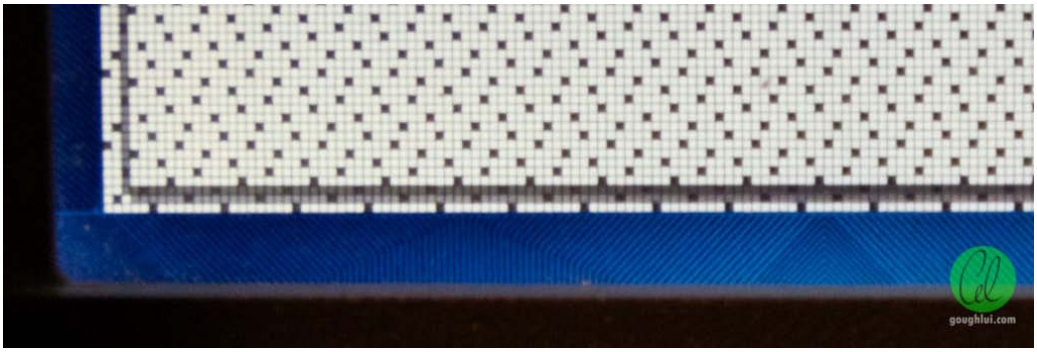
Location	Value		Original Capacitor					
	µF	V	Type	Cp (µF)	Cs (µF)	DF	ESR (Ω)	Error (%)
Mainboard (C26)	1	50	SMD Electrolytic	0.0001575	0.012246	8.52	OL	98.8
Mainboard (C25)	1	50	SMD Electrolytic	0.002348	0.02446	2.97	183450	97.6
Mainboard (C12)	1	50	SMD Electrolytic	0.006411	0.02047	1.46	107840	98.0
Mainboard (C11)	1	50	SMD Electrolytic	0.001186	0.0363	5.54	OL	96.4
Mainboard (C43)	1	50	SMD Electrolytic	0.0001779	0.00683	6.09	OL	99.3
Mainboard (C39)	4.7	50	SMD Electrolytic	4.793	4.801	0.033	11.232	2.1
Daughterboard (C310)	10	16	SMD Electrolytic	0.855	7.055	2.67	606.1	29.5
Mainboard (C102)	10	16	SMD Electrolytic	2.16	6.958	1.51	345.9	30.4
Mainboard (C104)	10	16	SMD Electrolytic	0.08162	0.7913	2.96	5941	92.1
Mainboard (C42)	10	16	SMD Electrolytic	0.02408	1.1918	6.96	8716	88.1
Mainboard (C13)	10	16	SMD Electrolytic	0.00012826	2.478	4.38	2845	75.2
Mainboard (C20)	10	16	SMD Electrolytic	0.007967	0.8976	10.5	17236	91.0
Mainboard (C34)	47	16	SMD Electrolytic	46.96	48.54	0.191	6.357	3.3
Mainboard (C24)	47	16	SMD Electrolytic	47.46	48.85	0.167	5.368	3.9
Mainboard (C27)	47	16	SMD Electrolytic	46.37	48.2	0.201	6.85	2.6
Mainboard (C21)	47	16	SMD Electrolytic	46.78	48.54	0.188	5.992	3.3
Mainboard (C6)	47	16	SMD Electrolytic	44.32	47.54	0.281	9.623	1.1
LCD Inverter Board (C1)	15	16	Sanyo OS CON Solid Electrolytic	16.245	16.303	0.028	2.763	8.7
LCD Inverter Board (C4)	47	16	SE18 Electrolytic	46.13	46.24	0.047	1.6126	1.6
Mainboard (C22)	47	35	Nichicon Electrolytic	44.1	44.33	0.045	1.6527	5.7
Mainboard (C38)	100	10	Nichicon N136 Electrolytic	85.66	86.48	0.095	1.7489	13.5
Mainboard (C37)	100	10	Nichicon N136 Electrolytic	86.36	87.12	0.097	1.7753	12.9
Mainboard (C30)	100	10	Nichicon N136 Electrolytic	87.56	88.41	0.095	1.7074	11.6
Mainboard (C32)	220	25	Nichicon VX Electrolytic	199.18	200.2	0.069	0.5519	9.0
Mainboard (C23)	330	16	Nippon Chemi-Con SME Electrolytic	280.5	284.7	0.12	0.6745	13.7
Sharp LCD Tcon (C1)	3.3	35	SMD Electrolytic	0.004179	0.286	7.59	44190	91.3
Sharp LCD Tcon (C2)	3.3	35	SMD Electrolytic	0.000862	0.08524	10	197050	97.4
Sharp LCD Tcon (C3)	3.3	35	SMD Electrolytic	0.006754	0.2785	6.14	38160	91.6
Sharp LCD Tcon (C4)	3.3	35	SMD Electrolytic	0.0011076	0.12262	10	144850	96.3
Sharp LCD Tcon (C5)	3.3	35	SMD Electrolytic	0.005645	0.3671	7.67	36820	88.9
Sharp LCD Tcon (C6)	3.3	35	SMD Electrolytic	0.007636	0.3995	7.01	26690	87.9
Sharp LCD Tcon (C7)	3.3	35	SMD Electrolytic	0.00924	0.09528	3.18	54690	97.1
Sharp LCD Tcon (C8)	3.3	35	SMD Electrolytic	0.002994	0.11548	5.92	74690	96.5
Trackball Board (C1)	0.22	50	Nichicon Electrolytic	?	?	?	?	?

Note that because the trackball board C1 wasn't replaced, we don't have any readings for it. Also, I didn't see C2 on that board when I made the table so it's missing. On the whole, the mainboard really only had two good capacitors of the lot – most of them were outright failures in both capacitance and dissipation factor (and thus, ESR). There was a bunch of Nichicon capacitors which had acceptable capacitance values but elevated ESRs which wouldn't have performed well. The logical surprise was that the LCD inverter board had both capacitors turn out good – the Sanyo OS CON solid electrolytic is probably no surprise as they're more durable than regular electrolytics, but the "SE18" was also good. The question is, for how long. All of the LCD capacitors were very very bad ...

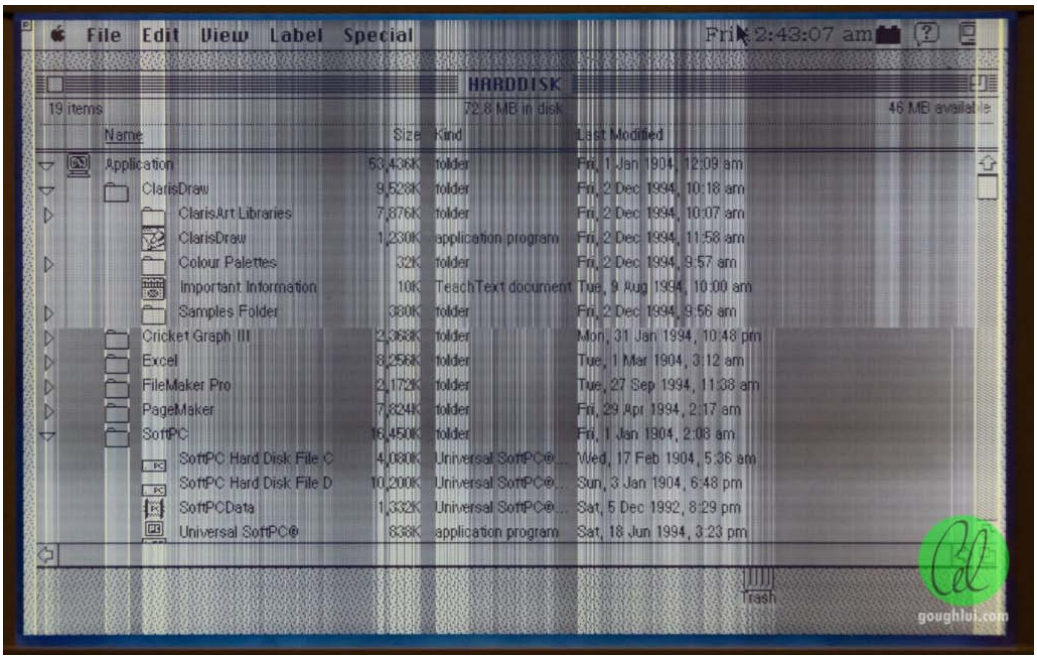
The leap of faith was to plug the unit into the refurbished power supplies and power it up. To my delight, the unit still works, even after the operation that took a whole afternoon and resulted in the loss of several rubber screw caps.



I also got a close look at the edge of the screen where the matrix lines were visible. It's a pretty nice pattern.



I decided to leave the unit to "soak" test and see whether it would be okay in the long run. The unit remained stable, but the problematic screen **returned**.



At this point, I was a bit annoyed and disappointed that my time investment didn't cure the machine entirely. The screen still exhibited column interference and occasional blanking of the bottom-third. I suspect this may be a problem with one of the chips on the flex cables to the array, as when the unit is cold, it is reliably clean and only plays up as it warms up.

Despite my disappointment, I was still **elated** that it was my first SMD re-cap, and despite my fear that my work would potentially damage the unit, it seems that I was successful this time around.

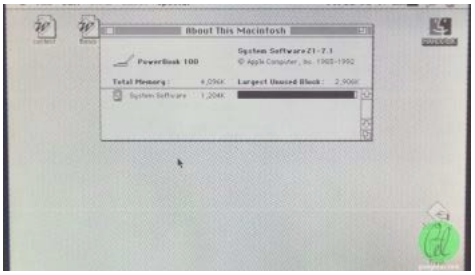
Conclusion

It took a lot of love, patience, time and energy to get this far. But now, at least, the power supply and the unit have been entirely re-capped (with the exception of the trackball PCB). At this stage, it's disappointing that the LCD wasn't completely happy, but the system did run reliably without a battery which was good and it managed a few hours sitting with a game on loop.

It was my first attempt at reworking SMD, just "going blind" as a hobbyist with no training and a cheap hot air gun. Of course, I melted parts of the keyboard flex sockets, and then I realized I should have shielded heat sensitive components. Oh well. Mistakes were made, but lessons were learnt. Hopefully, this information (along with tips and techniques) will be useful for others doing similar work.

I suspect I won't do anything to the machine for a while, as I wait for a CF Powermonster-II to arrive to replace the Quantum GoDrive. Then, I may redo the trackball PCB capacitors at the same time. Wish me luck!

Related



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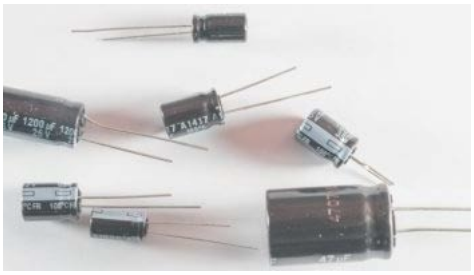
September 11, 2016
In "Computing"



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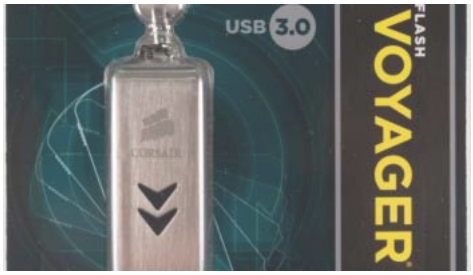

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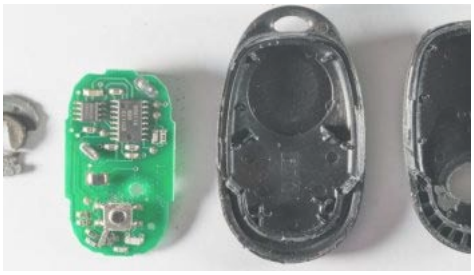

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About lui_gough
I'm a bit of a nut for electronics, computing, photography, radio, satellite and other technical hobbies. Click for more about me!
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2 Responses to *Repair: Apple Macintosh PowerBook 100 "Gotta re-cap 'em all!"*

Mark *says:*
September 26, 2016 at 8:09 am

A few things to be aware of:

Although tantalum caps don't usually have leakages issues, they do have a rather nasty age related failure mode... they like to go hard, 0 ohm short circuit. They can burn to a crisp (with a truly awesome smell), take out power supplies, or even explode. If you get one in backwards it's BANG! time. My company used to do all initial power-up testing of boards behind a plexiglass barrier. IBM required us to use three-leaded tantalum caps that could not be installed backwards. If you have worked on old Tektronix test equipment, you will be very aware of the not so subtle wonders of old dipped-tantalum capacitors.

Old flex cables have a nasty habit of having the traces delaminate from the substrate, particularly at the ends where the traces are not covered by plastic. Also, the traces become very brittle and crack at the slightest bend. I've fixed old flex cable ends by very carefully super-gluing the ends back down to the substrate using a drop of glue on the end of a needle.

Old floppy drives often have the head positioning lead screw lubricated with grease that turns into glue over time. The same applies to all sorts of old mechanical actuators. Grease/oil + time = glue.

I prefer to not bend through-hole leads when installing them. The bent over leads can be hard to desolder the next time you work on them. I install the component, flip the board over onto a folded towel or wadded up rag that holds the part against the board, solder one lead, flip the board over again to verify that the part is sitting flush, then solder the other lead.

Reply

lui_gough *says:*

September 26, 2016 at 9:06 am

Thanks for the information and hints – I have heard of the horrors of getting them in backwards with hot molten tantalum spewing from the package, but lets just say that regular aluminium electrolytic capacitors are much the same fun if one decides to put them in the wrong way, with the electrolyte quickly boiling and the can rupturing with a nice bang and smoke. Luckily for me, I've never had that happen to me. I can sort-of-appreciate the drastic safety measures – I wouldn't like to have small explosions with projectile hot-stuff thrown my way either.

– Gough

Reply

Error: Comment is Missing!