Upgrading the Tektronix 2402/2402A

I have a couple of 2400-series Tektronix Digital Storage Oscilloscopes. These date from the late 80's to the early 90's range. I call them "Vintage", but others might disparagingly call them "antique". They work quite well, and it would cost quite a bit of money for a more modern version with the same or better analog specifications.

The Tektronix 2402 and its successor the 2402A were ahead of the curve in the PC revolution. They were add-on devices to interface to the Tektronix 2400-series digital storage oscilloscopes. They could be controlled (mostly) through menus displayed and selected on the oscilloscope itself. They are relatively rare as they were expensive additions to an already expensive oscilloscope. They were quite small compared to the PCs of the time.

The 2402 had an 80186 CPU, which was for the most part equivalent to the 8088 used on the IBM PC and XT computers of the time, except the 80186 has a 16-bit bus. Despite this, the 2402 series, in its stock form, only uses the 8-bit bus for its ISA riser backplane which held a National Instruments GPIB interface card. Also, the 2402 and 2402A had a video board only as an option. It seems, based on eBay sales, about 60% of them had an optional video board. The two video options were CGA and VGA. The CGA board supported standard CGA and an oddball "2XCGA" which I believe had double the vertical resolution of the standard CGA.

The 2402A was essentially the same as the 2402 except it had a 16MHz CMOS 20286 (with a header for a custom 20287 daughtercard). The CMOS type processor was used so it would run cooler and draw less power than the standard 80286.

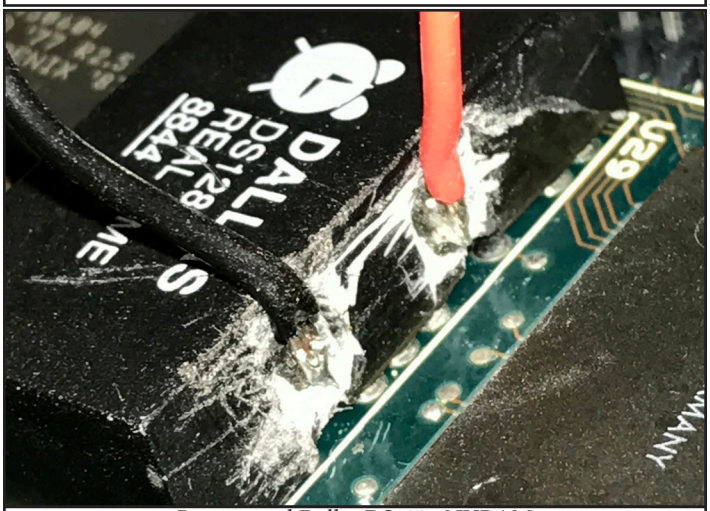
The 2402A had an optional SCSI hard disk, and no provision for an IDE hard disk. The 2402A motherboard had an IC socket which was optionally populated to provide the SCSI functions for the optional SCSI hard disk. One of the two floppy disk slots was occupied by the SCSI disk if it were supplied.

I bought a dual-floppy 2402A and got it functioning. THEN I remembered why I liked having a hard disk back when I had computers like this, and why I was so happy when the fast 486 and Pentium models came along.

It took a bit of effort to get the 2402A working. Fortunately, the power supply worked perfectly, but the

2402A mounted to Tektronix 2432

Ampro LittleBoard/286 showing the unused SCSI IC socket in the upper area to the right of center. Below this is the problematic Dallas battery-backed SRAM which stores the BIOS setup values. Note the slotted holes to each side of the midline which are the mounting points for the board.


Re-powered Dallas DS1287 NVRAM

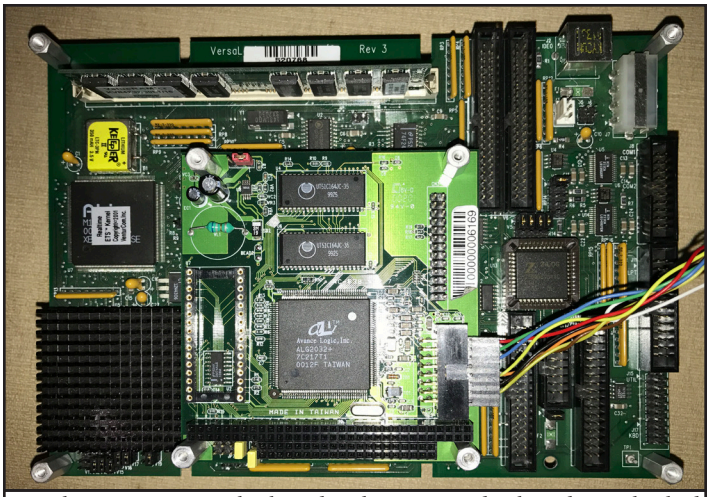
battery backup for the BIOS had failed. And the BIOS is poorly written so that even if you boot to the BIOS setup and enter all the correct values, it still fails to boot because it apparently checks the battery at boot up and assumes the BIOS is corrupted if the battery is bad.

I found a reference on-line showing how to re-power the Dallas NVRAM (with an integral, and non-replaceable, non-serviceable, battery). It involves carefully scraping away the plastic jacket and some potting material to get to the buried power leads inside. Then you can carefully solder some fine wires to these leads and add an external lithium ion battery. The repair applies external voltage to the dead batteries in the NVRAM, but this does not appear to be a problem.

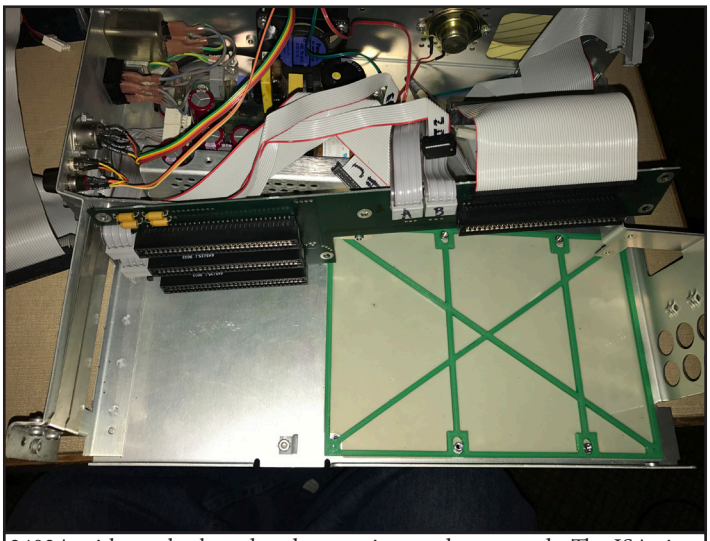
Once I got the NVRAM for the BIOS settings working, then I discovered that both the TEAC FD-235HF floppy disks had died. It is still fairly easy to get inexpensive 3.5" floppy drives, but many have mounting holes that do not precisely match the TEAC originals. And many of the FD-235HF drives do not have the same color of the faceplate (as seen in the photo of my 2402A). The faceplates can be interchanged if you have one with an exact matching faceplate. Later versions of the FD-235HF do not have a similar faceplate mounting arrangement.

After a short time, I decided to forego the original motherboard rather than try to find or make the 80287 daughtercard (I made the design, but never produced it, nor tried it, but the design can be found at OSH PARK). Nor did I want to find the SCSI disk drive IC for the motherboard and find a functional SCSI drive. Even if I had found a functional SCSI drive, it probably would be 44MB at the LARGEST!

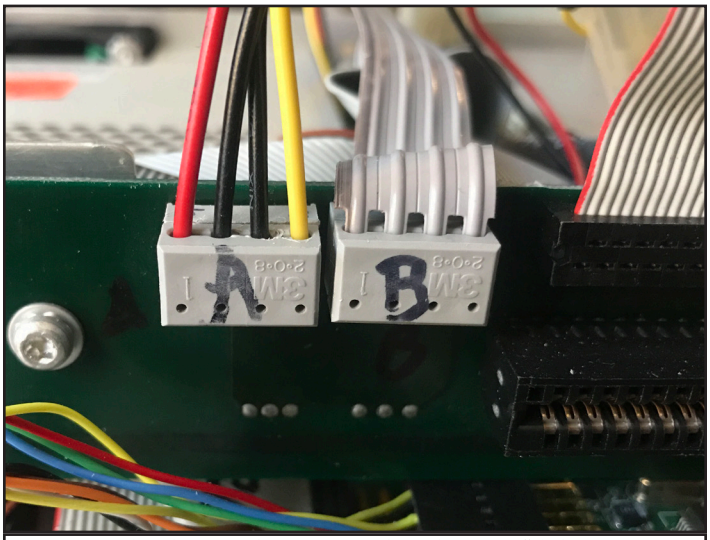
I thought it might be cheaper (and easier?) to find a newer motherboard. I wanted a 486, 586, or Pentium. What would Tektronix have done in their upgrade path, and what would they have called it? The "A" version was an 80286, upgraded from the non-A version with an 80186. The next in the line with a 386 name might have been the "B". The 486 could have been the "C", and the 586 (or maybe a Pentium) could have been the "D". Since this is effectively an "embedded" system, there would have been little reason to use a graphical user interface like Windows 95 or 98, although they are actually a DOS kernel at their core. So Tektronix would likely have stopped at DOS 6.x as the operating system. With a DOS system, and the needs for this application, there is no good reason to need anything faster than a Pentium CPU.



Versalogic VSBC-2 motherboard with PC/104 video board piggybacked on top. Note the female headers on the video board.



2402A with motherboard and expansion cards removed. The ISA riser board is free from its mounting. The green object is a template with mounting holes at the corners matching standard EBX mounts and also slotted holes closer to the center where the original Ampro motherboard was mounted. A replacement motherboard must match these slotted holes.



IDC power headers on the ISA riser board. Note "A" has new wires providing a longer length cable with a standard power coupler. This allows an additional splitter to provide power for the hard disk, floppy drive B, and the motherboard.

Tektronix would likely have maintained the outward appearance of the 2402/2402A machine. The footprint allows easy piggybacking of the 2402 to the oscilloscope to create a HEAVY, but convenient package as shown in the photos.

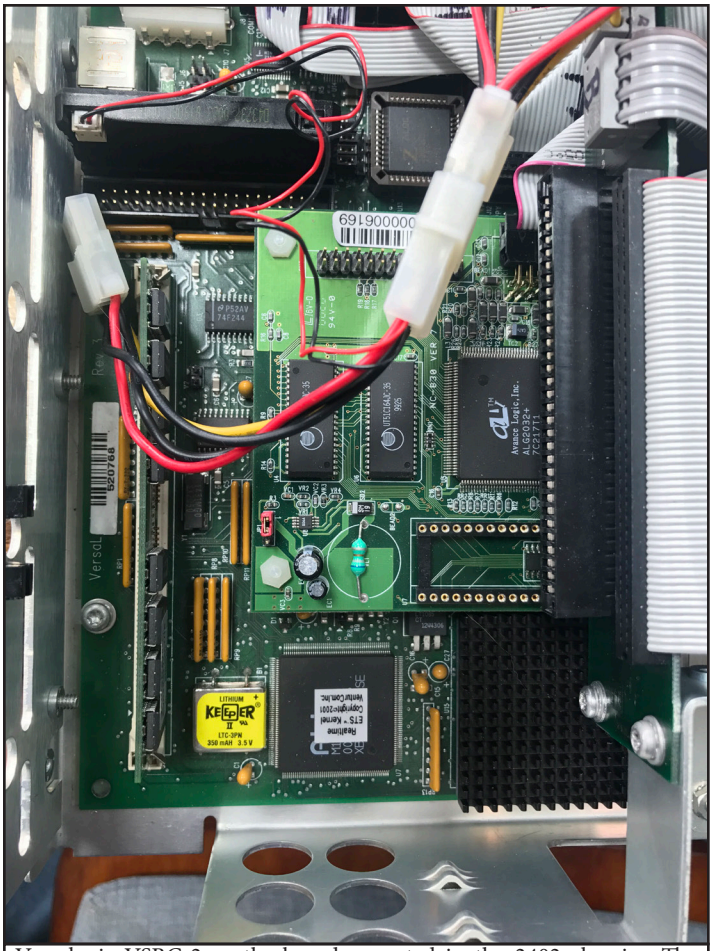
So, I decided to create a Tektronix 2402**D**! It would have a 586 or Pentium CPU and several gigs of RAM. There is no good reason to have a lot of extended/ expanded memory when you are running a limited set of DOS programs, but certainly more than 640K might be useful. I wanted an IDE hard disk. This probably does not need to be larger than 100MB, but anything that size or larger would be fine. Maybe a solid state IDE "hard disk" would be superior?
I wanted at least one 3.5" floppy. It would be great to have the option for a USB flash drive, but DOS does not play nicely with USB drives. It can be forced to work, sort-of. So maybe no USB. The 2402 provides connectors for two serial ports and one parallel port, so I wanted to be able to keep those. I also wanted VGA video hardware because monitors which support that standard are plentiful compared to EGA/CGA, although I did not anticipate needing anything other than a character-based display interface.

So, in summary here are the specs of the system I was designing:

- 586/Pentium CPU on a motherboard to fit the 2402 chassis. (In a pinch a 486DX CPU would suffice)
- 1+ gig RAM
- 100+MB HDD, 1 or 2 3.5" FDD
- 2x serial ports (preferably 16550 type), 1x parallel port
- VGA display card

The original motherboard was an Ampro LittleBoard/286. Ampro was a significant innovator in small form factor computer boards. They developed the PC/104 standard and the EBX standard. But the 2402A PRECEEDED both these standards. The Ampro motherboard is ALMOST standard but not quite and this imposes some significant constraints on motherboard options. The differences between the 2402's motherboard and the EBX standard are small but important. The PC/104 and EBX standards were so important and useful that they make devices in these configurations to this day, mostly for industrial use!

First of all the LittleBoard/286 mounting points are not the same as the EBX standard. Some (one?) of the mounting EBX holes are in the right place, but most are not. Wouldn't it be nice to find a later motherboard which was compatible with these non-standard mounting



Versalogic VSBC-2 motherboard mounted in the 2402 chassis. The PC/104 video board is installed on the motherboard. Note the new power cable in the foreground.

holes? Without this, it would be necessary to add new mounts to the chassis with short stand-offs and grind away the originals (so the originals do not short out anything on the bottom of the new motherboard). Additionally, the EBX standard defined regions of the motherboard for types of functions such as RAM cards, headers, CPU, and PC/104 card mounting. The LittleBoard/286 is close to this standard but, again not quite. For instance, the EBX standard allows space for a tall CPU/fan. Tektronix made the space for the motherboard with only as much clearance as necessary in certain locations to match the height of the LittleBoard/286. They did not leave space for a "standard" EBX board, and no such standard existed at the time.
Another difference is the PC/104 connector. Ampro designed the PC-104 components to be stackable. For some reason the PC/104 header on the LittleBoard/286 is a left-right mirror image of the standard PC/104, so the PC/104 VGA video card is mounted upside-down on the motherboard. Not a problem, but the 2402A's ISA bus connector for the ISA bus riser (for the GPIB card and up to 2 more ISA cards) matches that mirrored layout. Any later EBX motherboard is

guaranteed not to have the proper configuration of the PC/104 connector, and a special adapter will be required to connect the ISA riser to a standard EBX motherboard.

I looked for a newer motherboard (486 or better) that was compatible with most of the mounting points of the LittleBoard/286. As far as I can tell Ampro, itself, did not make a later board that was backward compatible. But I did find the Versalogic VSBC-2. This does have some compatible mounting points as well as standard EBX mounting points. The PC/104 connector is standard, not the mirror image found on the Ampro board, as expected. The locations of the components and headers on the motherboard are nearly identical to the LittleBoard/286. It would seem that Versalogic was specifically planning on this board being a potential upgrade for equipment designed for the Ampro board.

I bought one of Versalogic VSBC-2 boards on eBay. They seem to come up fairly often and generally cost around $20-$30. Unfortunately, I paid more than that because someone else was interested in this board as well, and we had a slight bidding war. Just a week or 2 later another of these went unsold for less than I paid.

The VSBC-2 board is very nice. I was prepared for the possibility that the original lithium battery for the BIOS settings had failed, but it is still working! This battery is fairly easy to replace if you have some soldering skills. You can remove the Eagle Picher “Keeper II” 3.5 volt lithium battery and replace it with a similar 3.5 volt battery (which is still available), or with a 3 volt lithium ion coin cell. The half-volt voltage difference is not ideal but the price is great compared to the original type battery.

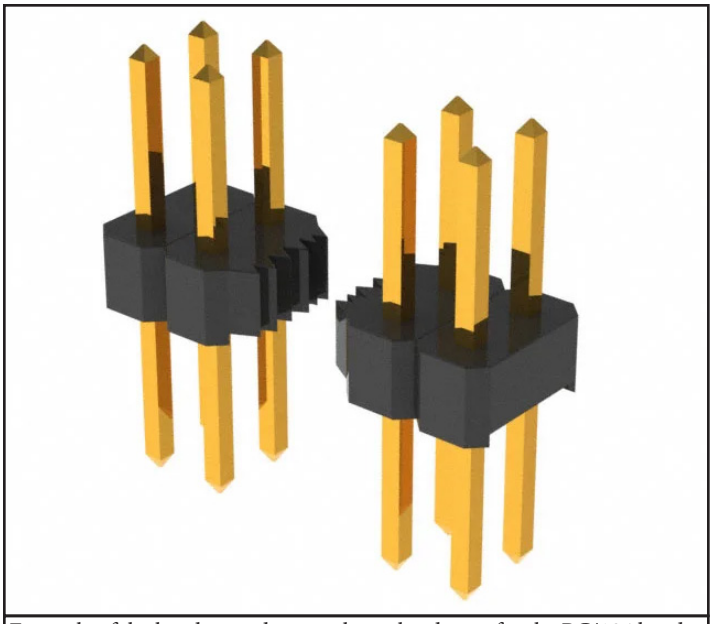
The VSBC-2 motherboard has an integrated IDE controller (no SCSI), and I used a 1 GB solid state IDE drive. It is about 1” tall and the length and width of the IDE header. It plugs directly into the 40 pin IDE header, and requires a separate 5 volt power supply connection. Anything more than 2GB is useless when running DOS. It only understands sizes up to approximately 2GB.

I mounted an PC/104 VGA board to the header on the motherboard. The card is stackable and has a feed-through connector to which the 64-pin cable from the ISA riser can connect. The connector has the standard arrangement of the pins, which is a left-right mirror of that used by the LittleBoard/286. I designed an adapter circuit board to take a standard PC/104 64 pin configuration and convert it to the left-right mirror image that the 2402/2402A ISA riser connector expects. This adapter is available on GITHUB and at OSH PARK. The adapter card has provision for two 64 pin (2x32)headers. One side uses a short ribbon cable to connect to the motherboard or video board header. The other header is where the ISA riser’s cable connects.

An alternative to usage of a PC/104 video board is to use an 8-bit VGA card. They are scarce but available, and maybe more common than the PC/104 video boards. Some of the ISA 16-bit cards are supposedly 8-bit compatible. In that case you leave the “AT bus” pins sitting free, not in any connector. I have NEVER used a VGA card in this manner, so I have no ability to confirm that it is feasible to use any 16-bit video card in an 8-bit connector. Nevertheless, some cards did say they were compatible with both 8-bit and 16-bit usage. Another advantage of using an ISA video card instead of a PC/104 card is that the ISA card will come with its own VGA connector. For the PC/104 card, you will likely have to fabricate your own VGA connector because they rarely are included in sales of used video cards. It is not easy to determine the correct video pinout of many old PC/104 video boards. For many, the documentation is long gone, and they usually pre-date the internet, so many have no availability of online references. An ISA VGA card could save a lot of effort!

I also needed to provide a dedicated power cable for the motherboard. The original CMOS 286 board consumed so little power that Tektronix decided to power the motherboard “backward” through the ISA riser. The riser had two power cables coming in from the power supply, and two more power cables leading out to the floppy drives. The ribbon cable connecting to the motherboard supplied its power. Those ribbon cable conductors are quite small, and the 586 motherboard draws more power. I tested the capability of the motherboard to be powered without a dedicated power cable, and it DID seem to work fine. But I added an extra power cable for the motherboard (and the solid state hard disk via a splitter). To do this I removed the original heavy 4-conductor ribbon cable from the IDC connector on the ISA riser board. I then carefully and firmly fitted a standard cable to that IDC header on the riser. This is used to power floppy drive “B”, the motherboard, and the solid state hard disk. It has proven to work perfectly: no glitches.

There is a small added complication when connecting the custom 64-pin adapter board to the video board feed-through connector (or to the motherboard directly). if there is no PC/104 video board). Whereas



Example of the header used as a male-male adapter for the PC/104 header to allow a standard female-female ribbon cable to be connected. One possible item to be used is the Sullins PRPC032DABN-RC. This is a male header with the "mating" and "contact" both 0.230" length. Pin spacing is 0.1" and is a 2x32 configuration.

the original Ampro motherboard had a make header, the standard headers are 64 pin FEMALE. And most ribbon cables are female on both ends, so there is an incompatibility. It is possible to get a ribbon cable with one or more male ends, but they are relatively expensive compared to the standard female-female cable. So, it is cheaper to use a male-male adapter on the PC/104 header. And the cheapest way to do this is to use a 64-pin male header which has longer-than-usual pins that would normally get soldered to a circuit board. You need a 2x32 pin header with both sides ("mating" and "contact") being 0.230" length. An example of this is shown in the figure, and there is also a photo of the header with the adapter and the ribbon cable attached.

The installation of the Versalogic VSBC-2 motherboard required deletion of one screw used to hold the outer 2402 case to the chassis. At the far top left of the photo of the VSBC-2 here in this document, you can see a square silver component on the motherboard (a PS/2 keyboard connector), and just to the left of it is a threaded insert in the chassis. The screw that goes through that insert is long enough to hit the PS/2 connector. The screw needs to be shortened or eliminated. In my case I simply did not use the screw.

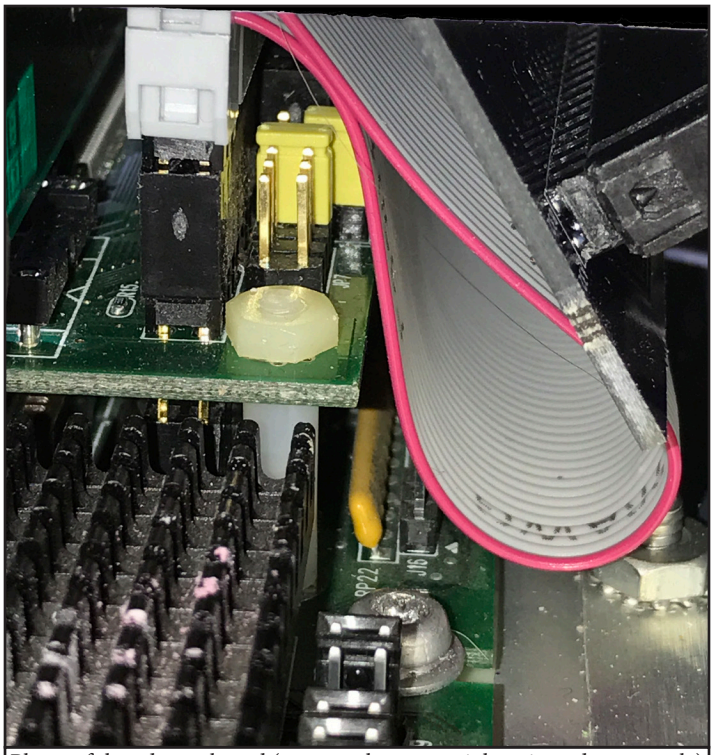


Photo of the adapter board (seen on the upper right oriented at an angle) to convert the signal orientation of the original ISA riser to standard. The white connector on the upper left has the male-male header adapter connecting to the video board's black female header below it.