ReA4091 SCSI Host Adapter

An interview with creators Chris Hooper & Stefan Reinauer

SCSI drives may be more expensive than their ATA siblings, yet their reliability and speed remain unmatched. This is reason enough why SCSI hard disks are still the backbone of many enterprise-level businesses (with the SAS standard having pushed the interface even further). Some readers may be unaware that their humble Amiga can also hugely benefit from the performance boost that SCSI delivers. So, no matter whether it's a floppy or CD drive, hard disk - or some crazy storage solution - chuck out those sluggish IDE and SATA devices right away *(Ed. - "Don't even hesitate!")*, and grab yourself an Amiga SCSI controller!

Most Amiga users aren't short on options when it comes to buying a used SCSI interface (something made by Squirrel for example), but for those with big box machines, old adapter cards are both rare and costly. That is, until now. Enter Chris Hooper and Stefan Reinauer, the team who have successfully cloned the best SCSI card to ever grace Zorro III

Chris Hooper, who is based in California.

Amiga 3000 and 4000 computers; the A4091. Let's ask them about their story, their motivation and how they managed to pull off such an ambitious project:

How did you get started with the Amiga?

Chris: I bought an A2000 and 1084S monitor in 1988. A friend had showed me his A500 the year prior, my first experience with a colour graphical environment. Around 1990 I bought a secondhand A1000, and I would use my Amigas with *ParNet* – one for development and the other for testing. In the subsequent years I purchased more Amigas than I'm willing to admit!

Stefan: My first Amiga was an A500 in 1987. My mom had brought it home from work on loan - after witnessing its graphics and sound I knew where my allowance would go for the next 100 years! Later, I upgraded to an A2000. When that machine disintegrated, I quickly copied a Kickstart image and the Workbench and Extras disks to PC floppies. This turned out to be lucky when I found the *Unusable Amiga Emulator*, to which I contributed a few features (Zorro, and serial/parallel port emulation). Photos taken in my dorm room at that time can still be seen on the *Amiga Forever* website: www.amigaforever.com/news-events/19970920-uae/

And you're both based in Silicon Valley?

Chris: Stefan and I have a similar background but we've never crossed paths professionally. We met through Paul Rezendez's Discord server (Acill

Classics). My job is in low level software for embedded systems and real-time operating systems. For the past 20 years, my experience was in enterprise storage systems.

Stefan: I am a firmware engineer and I enjoy low level software. In 2020 I was trying to learn how to solder, I found Paul's online soldering classes and Discord server. I remember my surprise finding out Chris was not only also in California, but lived minutes away. We started exchanging PCBs and electronic parts for our smaller projects.

Who came up with the idea of cloning the Commodore A4091 SCSI-2 controller?

Stefan: In 2021 I was lucky to buy a cheap A4091 (one of only two Zorro III SCSI controllers ever designed). Upon inspection, it turned out that all of the ICs were still available. Luckily, Dave Haynie, the original hardware designer, had released the logic equations for its GALs a few years earlier. This meant that this was the only Zorro III SCSI controller that could actually be reproduced.

Chris and I discussed the possibility of making a clone at AmiWest, and we received encouragement from people listening in on our conversation.

Did any issues arise once you started?

Chris: Dealing with early board instability was challenging. The instability was mostly due to compromises Commodore were forced to make when designing the

LEFT & ABOVE: Holding the right mouse button at power on provides a useful A4091 startup menu.

A4091, in order to reduce the number of components and cost. The biggest trade-off was relying on gate delays in some parts of the PAL (Programmable Array Logic) code for timing purposes. We didn't have any idea that certain assumptions were made regarding the relative speed of the PALs installed on the board. Since we were building new boards from NOS (New Old Stock), the parts we bought came from different production batches. We spent a good deal of time with prototypes, first to understand where the timing issues were and later stress testing against different system configurations. I built two utilities to help. One is *devtest* for stress tests and the other is the test option in the *A4091 Utility*. Over time, the *A4091 Utility* evolved to be able to test 53C710 device registers, data pins, address pins, interrupts, and even SCSI data and control pins. It's now our go-to for testing the A4091 hardware underneath the driver.

When developing the open source driver, although I have experience with an Amiga filesystem handler (I'm the author of BFFS), I only had API experience with Amiga drivers. Luckily, there is a lot of good Amiga reference material. After getting a shell of the driver together, the core NetBSD driver code actually started working sooner than I expected. Whilst porting, I was overjoyed seeing the Amiga-side code for the NetBSD-style timeout callback mechanism working. This was one of the last pieces needed to make the driver able to tolerate failures from the device. It took weeks of development past that point to make the driver reliable. As I/O started working, this is where our *devtest* tool came in. I wanted to see how other Amiga drivers reacted to specific packets. More features were added to the *devtest* application, not only to verify that a4091.device correctly supported the expected trackdisk-compatible device packets, but also to force different kinds

of performance and timing stress on a4091.device.

Stefan: Modern components can behave slightly differently. New GALs (Gate Array Logic) have a so-called pin-keeper mechanism that is great to keep a design in a defined state instead of having all sorts of floating signals around. This means a design can't rely on floating signals and logic levels must be watched as the signals propagate across several GAL chips.

The A4091 was bleeding edge enough back in the 90s that it was relying on a lot of implicit assumptions that break if you try to build the same thing three decades on. The Amigas they go into have gotten older too, and particularly the A3000 is a rather temperamental creature. For me, not being familiar with the Zorro III protocol on the wire level made debugging hard.

The first boards we built took seven hours to complete and if a card didn't work, a further seven hours of debugging was not unheard of. Without our builder Kavanoz optimising manufacturing, we would definitely have given up on trying to supply A4091s to those interested.

Why did you create an Open Source ROM?

Chris: One of our concerns was support for hard drives greater than 4GB. By setting a *HDToolBox* tooltype and enabling SCSI Direct for the drive, one can work around Commodore's limited scsi.device by having the filesystem send SCSI commands directly to the drive. A user-friendly method for recent AmigaOS versions is for the device to support TD64 or NSD commands (which we included), increasing the 32-bit device address to a 64-bit address.

Another obstacle was the unknown legal status of Commodore's A4091 ROM. Trademarks on Commodore hardware have long since expired, but copyrights on software are still owned. Michael Battilana of Cloanto generously granted Stefan and I a quantity of licenses to distribute the Commodore ROM, but that didn't extend to everyone else who would like to build or expand upon the open hardware.

It would be nice for the community to have access to the driver source in the future to add enhancements, but it seems that the Commodore source can never be open like that. For those reasons, we decided to implement our own driver. Choosing to port the NetBSD driver as a starting point

Stefan Reinauer… he also lives in California!

was a natural choice, it is slightly less bloated than the Linux driver.

Stefan: Creating a new driver allowed us to make something comprehensible that can continue to be worked on. We had amazing people from the Amiga community like Toni Wilen, Matthew Harlum and Olaf Barthel helping.

A positive is that there is now a modern scsi.device driver available that should be fairly easy to port for other SCSI controllers and chips. If someone wanted to do a modern ROM, for say, an Amiga 2091, they'd be almost there already.

The ReA4091 works incredibly well, have you added any enhancements?

Chris: Our goal was staying faithful to the original Commodore design. To that end, we went so far as to duplicate quirks in PCB routing.

Other than the PCB colour, the ReA4091 was designed to be as similar as possible to the original A4091 "Rev B". That said, the latest boards being produced by Salih Albayrak (AKA Kavanoz) offer a few features not found on the original. The first is that our open source driver is now the only one shipped. The original Commodore driver, and its 4GB limitations no longer need to be licensed.

Another is that a PC floppy power connector and a fan connector have been added. Finally, a brilliant engineer in Germany, known online as Dorken, has patched the original Commodore PAL/GAL code to improve Zorro performance and system compatibility.
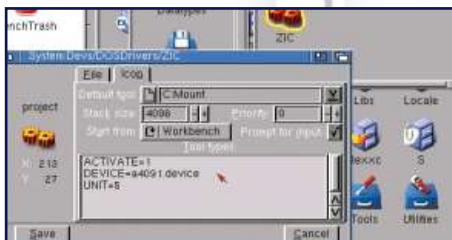
Stefan: While Chris did most of the hard pieces of porting the NetBSD driver for the 53c710 controller chip to AmigaOS, I spent time on a few fun features. The ▶
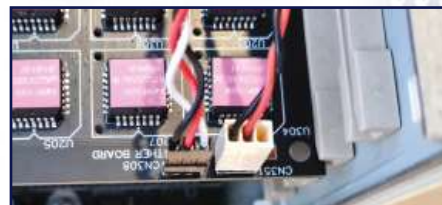
LEFT: DIP switches and external SCSI-2 connector. RIGHT: ReA4091 board fitted, note the connectors for the disk activity status LEDs on the Amiga's front panel.

AA tested the ReA4091 with a Squirrel Hard Drive and Iomega ZIP. Once each driver's Information device flag was set to a4091.device, everything worked flawlessly.

two most visible ones are the A4091 Early Startup Menu (visible when holding the right mouse button during power on) and the feature which allows booting from CD-ROM with our new driver. Yes, you can install AmigaOS 3.2 directly from CD!

Testing must have been laborious?

Chris: Between the three of us, Stefan, Salih, and myself, we have an impressive amount of Amiga hardware and peripherals. But that's nothing compared to the number of configurations out there. We rely on feedback from end users to give us pointers on things we need to chase down. The unfortunate reality is that the A4091 is not going to work in every system. If you go back to early 90s Usenet posts, you'll discover that people had a variety of compatibility problems with the A4091 and other Zorro III cards. The fact is many Amigas shipped with the Buster-07 chip or earlier, which will never work with the A4091. Upgrading to Buster-11 is recommended, even though it does not resolve all Zorro issues.

Stefan: Chris and I had an A4000D, an A4000T and four different A3000Ds for testing. We encountered scenarios where each 3000D behaved differently from the other three. Oh, and I have way too many SCSI cables, terminators, peripherals and controllers in my garage now!

It took us three months to get the project off the ground and booting. And easily twice that went into debugging issues we found afterwards.

It's superb to see the project on GitHub...

Chris: This was always our intention. We believe in open hardware and software.

Stefan: An old platform like the Amiga is well suited for learning how computers function. It was in our interest to further this learning by making sure all of our work is accessible. But also to inspire others to do the same thing, or build on top of what we have created.

Are there any improvements you'd like to implement in the future?

Chris: I think we are close to the tapping out point on Zorro III performance. One that might be great is a cost-reduced version. There is a lot of empty real estate on the A4091 PCB, and a large metal

bracket to allow an internal drive to be mounted. These are costs which can be eliminated now most drives weigh just a few grams. We don't have any plans to implement such changes, but we are open to others creating derivative works.

Did Dave Haynie contribute to the project?

Chris: Other than the incredible job Dave Haynie did designing the original, his largest contribution was publishing source code for all the PALs. If he had not done that, the A4091 would have been frozen in time, like countless other amazing closed source products of the 80s and 90s.

How did you produce accurate packaging?

Chris: Most of the fine attention to user experience is Stefan's doing, including the packaging, manual, and floppy disk. I am responsible for the artwork - mostly done by rough capture from photos or scans, cleaned up using image editors.

Are you happy with the finished product?

Chris: I'm very happy how the A4091 turned out, but more grateful for the incredible partnership that Stefan and I had in building it.

I'm thankful for the development help from Kavanoz, LIV2 and Dorken, which made the difference between us sharing this with the entire Amiga community

instead of just a few friends. I'm looking forward to using the A4091 as a primary controller in my A4000.

Stefan: When I suggested to Chris that we start this project, I wasn't sure if we could even finish the PCB! Going from there to a boxed product resembling the 90s original is beyond what I thought we'd accomplish.

Thanks to Szymon Gosk for a fantastic job making the metal brackets, and to Toni Wilen for contributing a working mounter when I was still fighting loading file systems from RDB. Olaf Barthel also provided a lot of priceless knowledge and anecdotes.

Seeing interest from original Amiga developers like Dave Haynie and Dale Luck was a special reward. I keep a version of the board that was signed by Dave Haynie in my office.

Chris: Every time we've attended a Vintage Computer Festival or AmiWest, everyone we've met does something unique with their Amiga. This is what makes us so thrilled to be part of this community.

How can users order the ReA4091?

If you'd like to express your interest, visit www.scsi.me and click "I'm Interested" at the bottom. If you are skilled with soldering surface mount components and prefer to build your own board, see: www.github.com/A4091/

The ReA4091 handles both internal and external SCSI devices, a manual and utilities on floppy disk are included.