

AMIWEST 2022 - 2022-10-18 - 24

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Updat Stefan Reinauer & Chris Hooper

established

ADVANCED SCSI II CONTROLLER BD.

A4091 REV B

### **THE TEAM**

Two firmware engineers meet in a Silicon Valley garage and start building hardware together





Stefan Reinauer Eng Manager, Google LLC

coresystems, coreboot, OpenBIOS, UAE



Chris Hooper Founder, DSSD

MX29F1615 Prog, BFFS, RGB2HDMI



# WHAT?

#### A brand new Zorro III SCSI Controller

- One of only two Zorro III SCSI controllers ever built
- Full-length Zorro-III DMA
- Fast SCSI-II (10MB/s)
- designed for the A4000, works in A3000
- Needs Buster 11 (minimum ;)
- NCR 53C710
- Autoboot ROM

## How it all began...

- Stefan learned soldering in 2020
- Chris and Stefan met on Acill's discord and found out they live 7 minutes apart.
- Stefan got an A4091 on eBay
- Pandemic made the card sit in Germany until August 2021

## How we got here

A short history of about everything that lead to this talk



#### Pick-up

Mom, do you have another suitcase?

#### First PCBs

We're done, right?

#### Collateral

There's more to the story

# But Why? It's 2022!

#### Because we can, and ...

- Classical Amiga hardware prices skyrocketed
- Inspired by folks like Paul Rezendes and John Hertell, and others!
- Dave Haynie Files!
- Create an accessible but compatible storage solution
- Open Source helps future generations learn about technology
- A tribute to the shoulders of the giants on which we stand today

### **End-to-End**



# Let's take some pics



### ... and how it continued



Mapping out all connections of all parts with a multimeter





# ... and how it continued





# **Making of the Schematics**

### Two revisions of the original board

- Revision A: Commodore, Inc.
   Has a few last minute fixes using bodge wires
- Revision B: DKB Software, Inc.
   Identical (?) but bodge wires routed on inner layers instead



# **Routing the board**

#### Oh wait!

This is a 4 layer board. How do we verify the buried traces?

# **Routing the board**



#### Goals

- close to the original
- Get it working
- Clear labeling, easy to build



# **Routing the board**



# Help from around the world

### Thank you

- Dave Haynie
- Szymon Gosk
- Tim Eire
- Michael Battilana
- Olaf Barthel
- Toni Wilen

### Brackets

U

#### **Custom Metal**

Zorro orientation matches
 ISA, not PCI

28 181268

• Acts as drive mount reinforcement

# **Brackets**





## **Brackets**

### More experiments

• Bending metal is .. hard.

 PLA / ABS looks nice, but is too flexible





### Artwork

#### A new challenge

• Way harder to come by than the board!

D ROM Blvd.

• Pictures courtesy BBOAH

**JKB 4409** 

SCSI II Hard Drive Controller

Stay on the Fast Track

• Which version do you like better?



## **The Manual**





### A thousand paper cuts...

- Original manual had 3 languages
- Pages were nearly translucent
- Cutting a booklet of 84 pages is tricky... for a firmware engineer



# The Box







### A new challenge

How big is this #\$%^& thing?







# Katsu's Foam Pit











# **Getting ready: Bringup**





# It works! \$%&\*#! It doesn't work

#### **First board assembly**

- First boot: Board shows up
- No boot, no cookie!
- Endless loop in DiagROM





# Getting serious: Logic Analyzer

#### Zorro III, meet Saleae Logic16

... why did the Amiga just stop talking?





# Assumptions

#### GALS

- Original A4091 uses -10 and -15 parts
- Original A4091 uses both PALCE and GAL parts
- ATF22V10 is a compatible replacement
- Faster chips never hurt

### **Ferrite Beads**

- A4000T design uses 600 Ohm beads in many places
- eBay beads are just as good as ones from Mouser
- How do we measure these things?

Assumptions are made and most assumptions are wrong.

- Albert Einstein

### Success!

### Time to collect hard disks

- Tested with 20+ hard drives
- External DVD, ACARD, Tape Drives
- SCSI I, II, III (w/ adapter)

Workbench Sc Workbench	reen 1	0   11   12
0 Horkb	ench 1% full, 1000.7MB free, 9.2MB in use	
Ra Wor Hork	befine a New Drive Type       FileNane:       Grive definitions       Manufacturers Nane:       Drive Nane:       Drive Revision:       Blocks per Track:       Blocks       Blocks per Track:       Blocks       Blocks per Track:       Blocks       Blocks	ead Configuration
		× ×



#### **Benchmarks**

- Right now: 5.1 MB/s with "drivespeed"
- Zorro III Burst not (currently?) supported

# **Boys and GALs**



### I'll be BACKKK....

### ... comes with a Terminator

• Dremel responsibly, my friends!





# The disk for your drives

### The most elusive part

Not strictly needed anymore but hey!





# Cables!



# **The factory**

A4091

### It's a silicon valley garage!

No, honey, it's only temporary, I promise!









# Software - 2nd.scsi.device

### What software is driving the A4091?

- Latest released version: 40.13
- 40.20 was spotted in the wild
- CosmosAmiga published a "patched 40.14"
- Drivers contain host portion in Assembler / C and controller portion requiring NCR script assembler that's virtually unobtainable
- No NSD, no TD64 (but 3.2.1 is tested to support large drives via SCSI-direct)
- A4000T shares almost the same driver (minus the Zorro III part and other minor changes)
- Newer versions unlikely w/ "the situation" of the Amiga community.

# Software - Script Compilers & NetBSD

### If it's not open source, it's a waste of time

- Chris Hooper started rewritten driver based on NetBSD code
- Modern driver design
- Uses open source NCR script compiler from NetBSD
- Max speed measured: over 7MB/s (to Zorro III RAM!)
- NSD + TD64 support!
- Pre-boot diag screen and optional CD-ROM booting

### Software - a small comparison

Ours 40.13 47.4

TD_GETGEOMETRY	Yes	Yes	Yes
TD_CHANGENUM	Yes	Yes	Yes
TD_CHANGESTATE	Yes	Yes	Yes
TD_PROTSTATUS	Yes	Yes	Yes
TD_GETDRIVETYPE	No	No	No
TD_GETNUMTRACKS	No	No	No
TD_RAWREAD	No	No	No
TD_RAWWRITE	No	No	No
SCSICMD Inquiry	Yes	Yes	Yes
SCSICMD TUR	Yes	Yes	Yes
NSCMD_DEVICEQUERY	Yes	No	Yes
CMD_READ	Yes	Yes	Yes
ETD_READ	Yes	No	No
TD_READ64	Yes	No	Yes
NSCMD_TD_READ64	Yes	No	Yes
NSCMD_ETD_READ64	Yes	No	No
TD_SEEK	Yes	Yes*1	Yes*1
ETD_SEEK	Yes	No	No
TD_SEEK64	Yes	No	Yes
NSCMD_TD_SEEK64	Yes	No	Yes
NSCMD_ETD_SEEK64	Yes	No	No
CMD_STOP	Yes	Yes	Yes
CMD_START	Yes	Yes	Yes
TD_EJECT	Yes	No	Yes*2
TD EJECT LOAD	Yes	No	Yes*2

	Juig	10.15	1/.1
TD_REMOVE	Yes	No	Yes
TD_ADDCHANGEINT	Yes	No	Yes
Eject REMOVE Int	Yes	No	No*1
Eject CHANGE Int	Yes	No	No*1
Load REMOVE Int	Yes	No	No*1
Load CHANGE Int	Yes	No	No*1
TD_REMCHANGEINT	Yes	No	Yes
TD_REMOVE delete	Yes	No	Yes
CMD_WRITE	Yes	Yes	Yes
ETD_WRITE	Yes	No	No
TD_WRITE64	Yes	No	Yes
NSCMD_TD_WRITE64	Yes	No	Yes
NSCMD_ETD_WRITE64	Yes	No	No
TD_FORMAT	Yes	No	Yes
ETD_FORMAT	Yes	No	No
TD_FORMAT64	Yes	No	Yes
NSCMD_TD_FORMAT64	Yes	No	Yes
NSCMD_ETD_FORMAT64	Yes	No	No
TD_MOTOR ON	Yes	No	NOP
TD_MOTOR OFF	Yes	No	NOP
	TD_REMOVE TD_ADDCHANGEINT Eject REMOVE Int Eject CHANGE Int Load REMOVE Int Load CHANGE Int TD_REMCHANGEINT TD_REMCHANGEINT TD_REMOVE delete CMD_WRITE ETD_WRITE TD_WRITE64 NSCMD_TD_WRITE64 NSCMD_TD_WRITE64 NSCMD_ETD_WRITE64 TD_FORMAT ETD_FORMAT TD_FORMAT64 NSCMD_TD_FORMAT64 NSCMD_ETD_FORMAT64 NSCMD_ETD_FORMAT64	TD_REMOVEYesTD_ADDCHANGEINTYesEject REMOVE IntYesEject CHANGE IntYesLoad REMOVE IntYesLoad CHANGE IntYesTD_REMCHANGEINTYesTD_REMOVE deleteYesCMD_WRITEYesTD_WRITE64YesNSCMD_TD_WRITE64YesTD_FORMATYesTD_FORMATYesTD_FORMATYesTD_MOTOR ONYesYES	TD_REMOVEYesNoTD_ADDCHANGEINTYesNoEject REMOVE INTYesNoEject CHANGE INTYesNoLoad REMOVE INTYesNoLoad CHANGE INTYesNoTD_REMCHANGEINTYesNoTD_REMOVE deleteYesNoCMD_WRITEYesNoCMD_WRITEYesNoNSCMD_TD_WRITE64YesNoNSCMD_ETD_WRITE64YesNoTD_FORMATYesNoTD_FORMATYesNoSCMD_TD_FORMAT64YesNoNSCMD_ETD_FORMAT64YesNoTD_MOTOR ONYesNoTD_MOTOR OFFYesNo

Oure

4013 474

Yes\*1 = with bug requiring io\_Length & buffer Yes\*2 = previous state not correctly reported No\*1 = interrupt did not trigger after load/eject command

# **Software - Challenges**

### This should really just work, why is it crashing?

- Amiga driver details are poorly documented at times
- Relied on anecdotes and tribal knowledge
- We even found a gcc bug (and bebbo fixed it!)
- -fbaserel -resident -m68020-60 are a mess
- RDB parsing is not part of the OS. Each driver has its own variant.
- Neither is loading hunks at boot time. We wrote our own LoadSeg. Or two.
- How to talk to a4091.device from within a4091.device...?

#### These are all identical...



#### ...or not



#### When you're placing 228 components



#### A mistake can happen





### Soldering: Pins can float or short







# **Rework and** Inspection Who needs solder? 0 Lots of beads

# Eye candy time...

#### **Boot Menu**

- Debugging options
- Probing for disks
- Show DIP switches

#### A4091 Diagnostics - DIP switches

Welcome to your Amiga 4091 Zorro-III SCSI-II Host Controller This project is brought to you by Chris Hooper and Stefan Reinauer

Off/On 8 🖂	SCSI LUNs Disabled
700	External Termination Off Synchronous SCSI Mode Short Spinup Mode
4	SCSI-2 Fast Bus Mode SCSI Address A2 = 1 Host ID: 7 SCSI Address A1 = 1
	SCSI Address A0 = 1 Back

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#### A4091 Early Startup Menu

#### Welcome to your Amiga 4091 Zorro-III SCSI-II Host Controller This project is brought to you by Chris Hooper and Stefan Reinauer



### The big question...

- Are there Easter eggs in Open Source drivers?
- Any other cool features?

### ... and new features, too

#### **CDROM BOOT**

• Currently needs "hack" with BootCDFileSystem

AmigaPE 1.0	
Welcome to the Amiga Preinstallation Environment	
К	
SysInfo   Workbench Work Hork Amiga0S3.2CD	
	 ▼

# Stop talking, where is it?



# What's next?



### Let's get this thing out there!

- Next step: Open Source schematics and gerbers
- Find someone to help us build a lot of these.
- We need a break (and build BFG9000s and A4000TXes like everybody else, for a change)