

Disk Imaging Techniques - using - ImageDisk & Catweasel

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Malcolm Macleod

malcolm@avitech.com.au

Topics:

1. Floppy disks – recording format
2. Introduction to ImageDisk and Catweasel
3. Other imaging techniques
4. Connecting vintage floppy drives to the PC
5. ImageDisk's "TestFDC" Utility
6. Suggested PC platform for IMD and CW
7. How to use Tim Mann's CW tools
8. Tips and Tricks

Disk Imaging – Why?

- To make real system and application disks for our vintage computers using disk images found online
- To archive and share our stash of vintage computer disks – before its too late!
- To accurately duplicate disks - including most “copy protected” disks
- To “format shift” – for example, we can replace an 8” drive with a 5.25” 1.2M drive or a (model-dependent) 3.5” 1.44M drive
- To move disks between simulators and real hardware

Applicability

- Discuss ways of reading and writing floppy disks created on systems based on the WD1771 family and its descendants (WD1771, WD179x, WD 279X) - eg:
 - Single-density disks loosely based on the “IBM 3740” (FM) format
 - Double-density disks loosely based on the “IBM System 34” (MFM) format
- Examples of systems that use these formats:
 - TRS-80 Models 1, 3 & 4 (and II?)
 - Many CP/M systems (eg Ferguson Big Board, ADC Super Six)
- Examples of systems that can't benefit from these techniques:
 - Apple II 5.25” (uses GCR)
 - Commodore 8-bit 5.25” (uses GCR)
- Main focus is 8” and 5.25” disks – both SD and DD

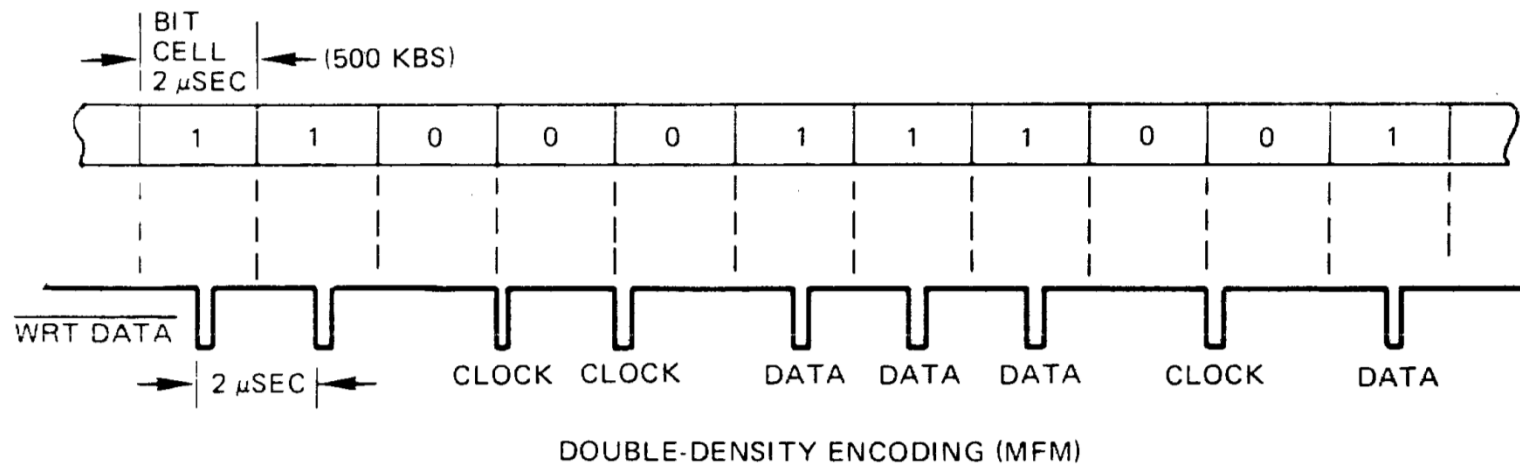
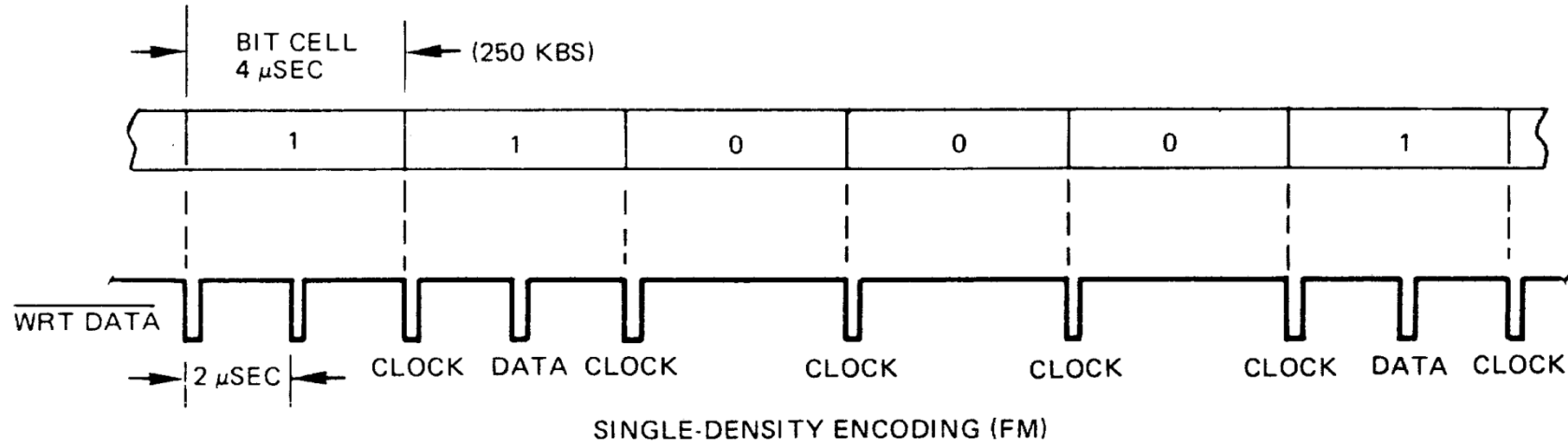
Floppy Disk Media Considerations

- A significant portion of older disks (perhaps 5 to 10%) are failing due to age and/or poor storage conditions
- Failure modes include:
 - Warped and physically damaged disks
 - Cloudy / mould affected
 - Oxide detachment on first read

SO:

- Test the drive before putting your irreplaceable disks in them
- Examine disks before and after read or write operations
- Assume the first read might be the only read
- Suspect the disk, before suspecting the drive

Floppy Disk Encoding Techniques



IBM 3740 Track Format – For SD (FM) 8” Floppy

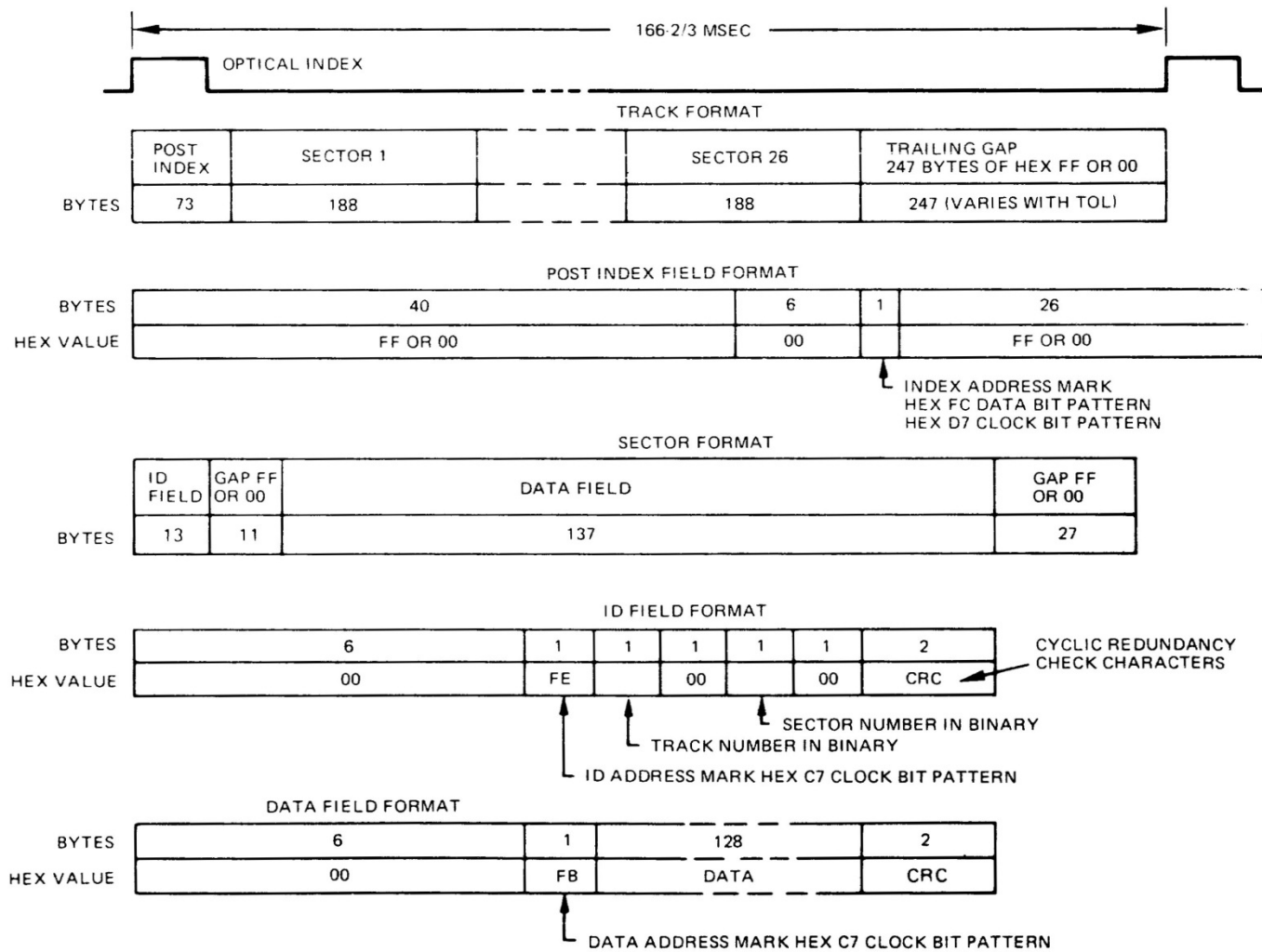
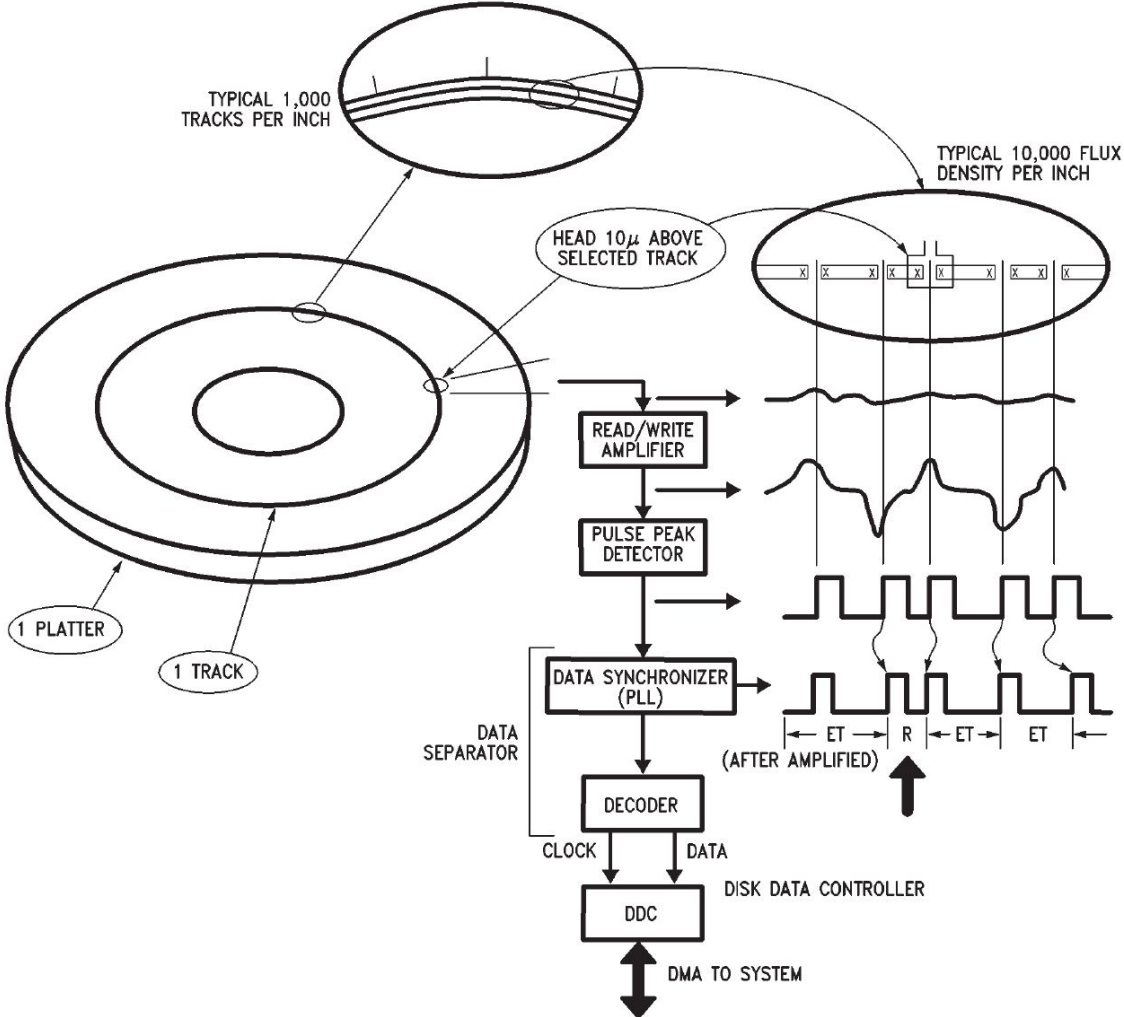


Figure 1-5. IBM 3740 Format

IBM 3740 Track Format – For SS, SD, 8-Inch Floppy



(a) Reading From Disk

TL/F/8663-12

ImageDisk

- Written by Dave Dunfield
- Uses the PC's own FDC [built-in or plug-in]
- MSDOS only
- Package includes:
 - TESTFDC.COM – Tests capabilities of FDC
 - IMD.COM – Read/Write disk images, format disks, exercise heads
 - IMDU.COM – Image manipulation (convert to binary or uncompressed files, etc)
 - IMDV – View content of IMD files
 - Utilities to convert DMK and TD0 images to IMD format
- Current Version: 1.18
- Source code available
- Website includes a large number of downloadable system disk images
- IMD file format is documented and available

ImageDisk – Main Screen



ImageDisk – Result of Reading a Disk

```
A: 500k DD      T76  H1                26x256  14  54
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
0.....1.....2.....3.....4.....5.....6.....7.....
Read into C:\IMD\cpm86pda.imd
CP/M-86 TM PROGRAM DEVELOPMENT AIDS
COPYRIGHT 1982 BY DIGITAL RESEARCH, INC.
DO NOT DUPLICATE
SERIAL NO: 082484012304AMATCH #15723
PART NO: 819-076002-0100  REV 04
(IMAGED ON 01.04.2014 USING TM848E DRIVE AND D7600 MOTHERBOARD)
 0/0: 500k SD - 26 sectors of 128 bytes - G1:7 G2:27
      : Deleted-Data
 0/1: 500k DD - 26 sectors of 256 bytes - G1:14 G2:54
      : Single-step
 1/0: 500k DD - 26 sectors of 256 bytes - G1:14 G2:54
4004 sectors (37 Compressed, 43 Deleted)
Read complete - press ENTER for main menu
```

ImageDisk - Limitations

Excellent highly useful suite of programs. Very well documented.

Limitations are:

1. IMD images not widely supported by simulators [???
2. Most PC motherboard FDC's don't support single-density (FM)
3. NEC765 derivatives suffer "blindness" after index pulse -> lost data
4. NEC765 derivatives can't read or write the "non standard" (F9 or FA) data address marks used by Model 1 TRSDOS
5. Will NOT work with USB floppy drives

Catweasel

- Is a floppy disk controller card [with other Amiga-related features]
- Designed by Individual Computers
- No longer available
- Some online shops show stock available – but are out of stock!
- PCI versions were MK 3 and MK 4
- Not subject to the limitations of NEC765-compatible FDC's
- Low-level drivers available for Linux and Windows. Not widely used
- Best high-level software (that I've used) is Tim Mann's "Catweasel Floppy Read/Write Tools". Current version is 4.4. Source code is included
- Tim Mann's tools store data in DMK format
- DMK format is documented and available
- See Wikipedia pages for more background info on Catweasel

Catweasel MK 3 PCI Card



Other Options for Disk Imaging

Techniques that capture raw flux transition data:

1. KryoFlux

<http://www.kryoflux.com/>

Standalone board with USB interface

Commercial product. Closed source [???]. Licence restrictions apply [??].

2. DiscFerret

<http://discferret.com/wiki/DiscFerret:FAQ>

Standalone board with USB interface

Open source hardware and software

Limited availability

3. DiskVaccum Project – on Papilio Pro FPGA Platform

Well documented project, CompuColor II focussed

<http://forum.gadgetfactory.net/index.php?/topic/1870-diskvaccum-project/>

4. Raspberry Pi Projects

See for example: <http://virtualfloppy.blogspot.ca> [TRS-80 / DMK focussed]

Other Options for Disk Imaging (cont)

PC-based software (mostly commercial or obsolete):

- OmniDisk / OmniFlop
- Teledisk, 22Disk, CopyQM, Anadisk

SAMdisk:

<http://simonowen.com/samdisk/>

Command-line program that reads/writes from the PC's (non-USB) floppy drive

Supports IMD, DMK, TD0 and many other formats

Can work with many formats including KryoFlux (RAW) and DiscFerret (DFI)

Windows 2000 or later

Or, if you don't mind doing things the hard way - write a program that runs on the vintage computer and which:

- Reads all bytes on the track (using the WD "read track" command)
- Dumps the data out to a PC in IMD or DMK format

Connecting a vintage 5.25" drive to PC FDC

PC FDC Connector (34-way box header)

Pin	Name	Dir	Description
2	/REDWC	Out	Density Select
8	/INDEX	In	Index
10	/MOTEA	Out	Motor Enable A
12	/DRVSB	Out	Drive Select B
14	/DRVSA	Out	Drive Select A
16	/MOTEB	Out	Motor Enable B
18	/DIR	Out	Direction
20	/STEP	Out	Step
22	/WDATA	Out	Write Data
24	/WGATE	Out	Write Enable
26	/TRK00	In	Track 0
28	/WPT	In	Write Protect
30	/RDATA	In	Read Data
32	/SIDE1	Out	Head Select
34	/DSKCHG	In	Disk Change/Ready

Remember:

1. Drive must be configured as DS1 (not DS0)
2. Keep it simple – one drive only
3. Terminating resistors must be fitted – all signals are open-collector
4. Connect drive to end of cable (connecting mid-cable may cause signal reflection problems)
5. Will be Drive A, if connected “after-the-twist”
6. Will be Drive B, if cable has no twists
7. PC expects pin 34 to be /DC (not /RDY)

If it's not working:

1. Use DSO to check signal levels
2. Can bridge connections on the spare IDC34
3. Go back to basics – try a 3.5" PC drive
4. Check drive's Hd-Ld, Drv-Slct & Motor jumpers

Connecting an 8" drive to PC FDC

Typical PC to 8" Drive Wiring

PC (34 Pin)	Name	Direction	8" (50 pin)
--	/TG43	--	2
8	/Index	In	20
10	/Motor On	Out	18
14	/Drv Slct 0	Out	26
18	/DIR	Out	34
20	/STEP	Out	36
22	/Write Data	Out	38
24	/Write Gate	Out	40
26	/Track 0	In	42
28	/Write Protect	In	44
30	/Read Data	In	46
32	/Select Side 1	Out	14
34	/DC or /Ready	In	12

Things to be aware of:

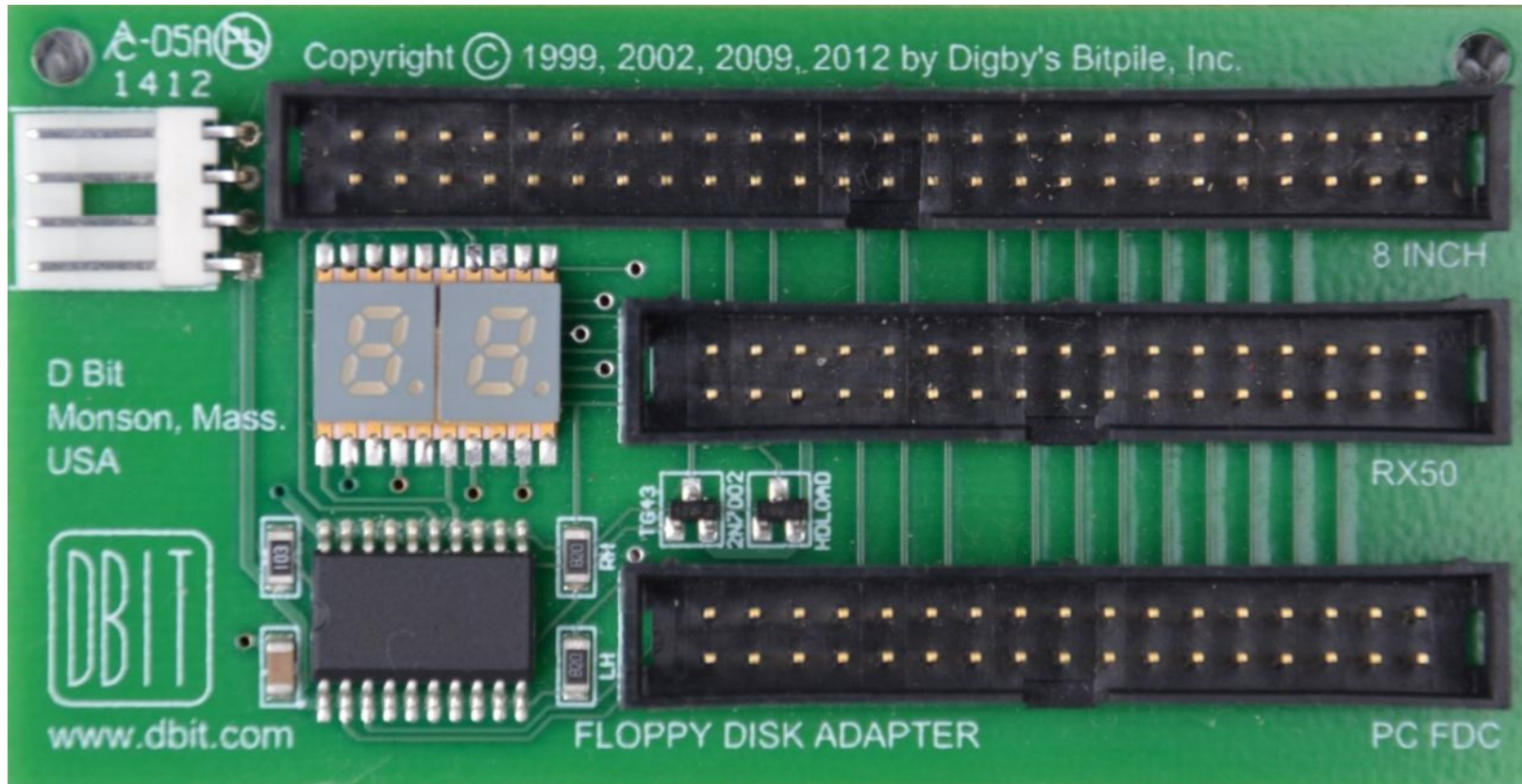
1. Configure floppy drive to respond to DS0
2. Check HL, Motor-On & Side-Select jumpers
3. Consider TG43 – Is it needed?
4. Terminating resistors must be fitted – all signals are open-collector
5. Connect drive to end of cable (connecting mid-cable may cause signal reflection problems)
6. PC will see the 8" drive as Drive A
7. Odd-numbered pins are GROUND
8. 8" drives need +24V and possibly 115 VAC

Wiring Options:

1. See detailed information on Dave Dunfield's website – including homebrew adapter
2. D-bit's FDADAP adapter - \$40 incl. postage

Using D-Bit's FDADAP Floppy Disk Adapter

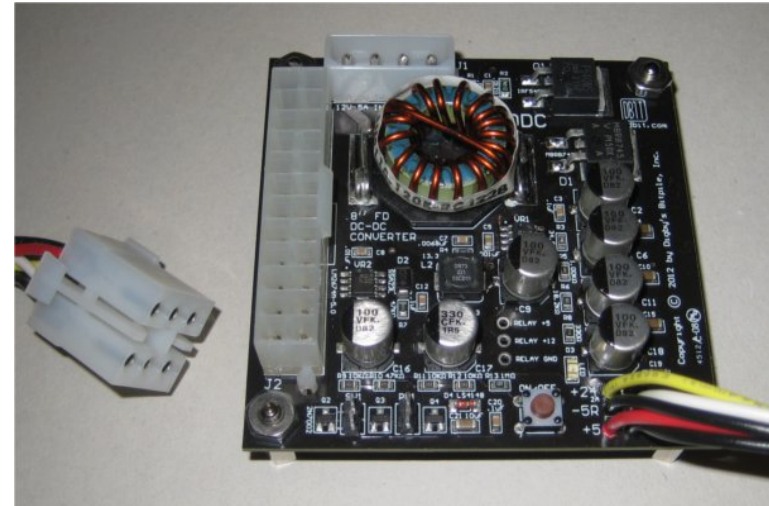
- Use 34-way “straight through” cable from PC FDC to FDADAP
- Use 50-way “straight through” cable from FDADAP to 8” Drive
- ImageDisk will see the drive as “Drive A”



Power Supply Options for +24 VDC for 8" Drives

1. D-Bit's FDDC

- <http://www.dbit.com/fddc.html>
- DC-DC Adapter
- Powered by IDE connector OR standalone ATX power supply
- \$80 including postage
- Not (yet) used by me



2. Mean Well NES-100-24

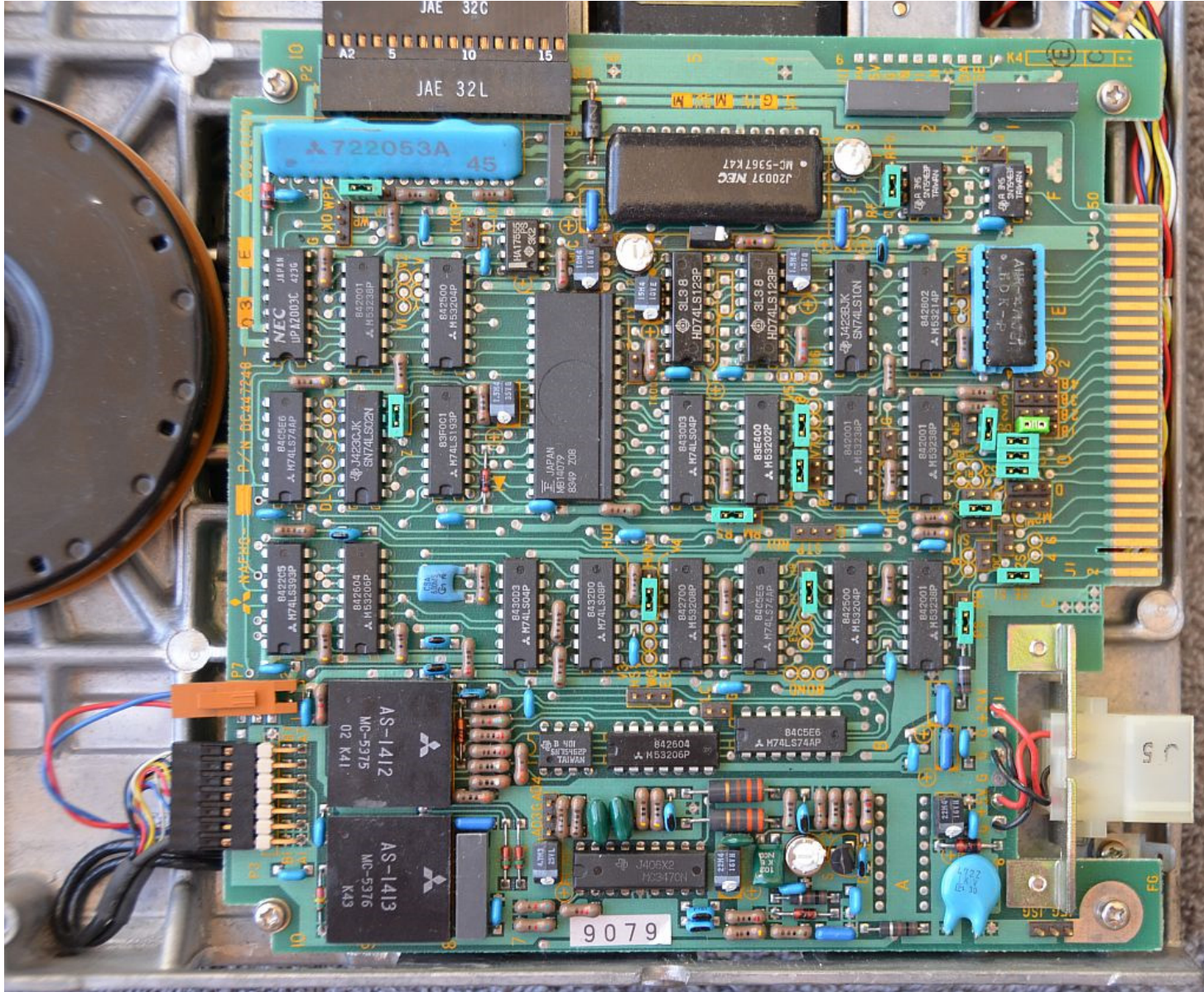
- +24 VDC 4.5A
- \$27 on eBay from China



Tandon TM848E - Jumper Settings



Mitsubishi M2896-63-02U - Jumper Settings



“Vintage” Floppy Formats

Drive Type	RPM	Flux Transition Rate	Data Rate	Typical Formatted Capacity (KB)
8" – 77 Trk, SS,SD	360	500	250	250 (26x128)
8" – 77 Trk, DS, DD	360	500	500	1232 (2x8x1024)
5.25" – 35 Trk, SS, SD	300	250	125	90 (10x256)
5.25" – 40 Trk, DS, DD	300	250	250	360 (2x18x256)
3.5" – 80 Trk, DS, DD	300	250	250	720 (2x18x256)

More Recent Floppy Formats

Drive Type	RPM	Flux Transition Rate	Data Rate	Typical Formatted Capacity (KB)
5.25 – 40 Trk, DS, DD <u>In a 1.2MB drive</u>	360	300	300	360 (2x18x256)
5.25 – 80 Trk, DS, HD	360	500	500	1200 (2x15x512)
3.5" – 80 Trk, DS, HD	300	500	500	1440 (2x18x512)

What FDC capabilities are required of the interface card for “vintage” formats?

Flux transition rate:

- 500 kpbs is required for 8” (SD or DD)
- 250 kpbs is required for 5.25 (SD or DD) standard drive
- 300 kpbs is required for 5.25 (SD or DD) in 5.25 HD drive

Able to encode

- SD (FM) – for SD disks
- DD (MFM) – for DD disks

How do I determine whether my PC’s FDC will work with ImageDisk:

Either:

- Consult the “Registry” listing on Dave Dunfield’s website (see Links section)
- Run Dave Dunfield’s “TESTFDC” program

Extract from Dave Dunfield's FDC Registry....

----- Mainboard / Controller Listings -----

S = Single Density	P = Passed
D = Double Density	F = Failed
X = Double Density / 128 byte sectors	N = Not tested

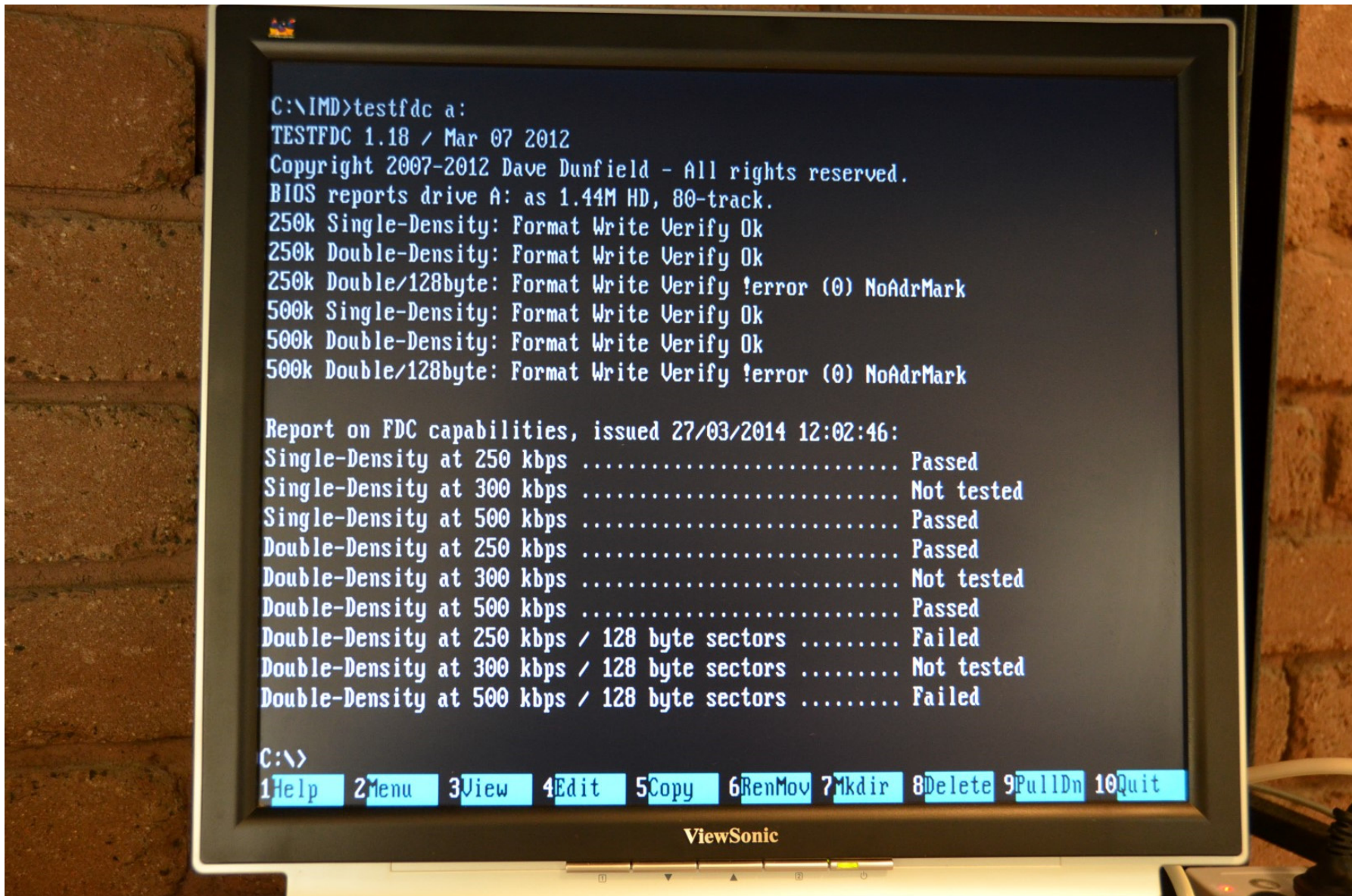
Manufacturer	Model	FDC chip	Class	Data rate		
				250 SDX	300 SDX	500 SDX
Abit	KT7A	?	Ath	PPF	PPF	PPF
Abit	TX-5IB2	M5135	P1	PPP	PPP	PPP
Abit	KV8PRO	W83627HF	Ath	PPF	PPF	PPF
Abit	KV80	W83627HF	Ath	PPF	PPF	PPF
Adaptec	AHA-1522A	DP8473AV	ISA	PPP	PPP	PPP
Adaptec	AHA-1542B	DP8473AC	ISA	PPP	NNN	NNN
Adaptec	AHA-1542CF	820778L	ISA	PPF	PPF	PPF
Aopen	AP5T	SMC FDC37C669	P1	PPF	FPF	PPF
Aopen	AP5VM	SMC FDC37C669	P1	PPF	FPF	PPF
Aopen	AX63PRO	W83977	P3	FPF	FPF	FPF
Aopen	AX6LC	W83977	P2	FPF	FPF	FPF
Aopen	MK33	?	Ath	PPF	PPF	PPF
ASrock	ALive-SATA2-GLAN	K8T890 CF	Ath64X2	PPF	PPF	PPF
Asus	A7V8X	?	Ath	FPF	FPF	FPF
Asus	P2BF Rev.1.0	W839771FAW	?	FPF	FPF	FPF
Asus	P3B-F	W83977EF	P3	FPF	FPF	FPF
Asus	P55TVP4	W83877F	P1	FPF	FPF	FPF

Using “TESTFDC” to determine FDC capabilities

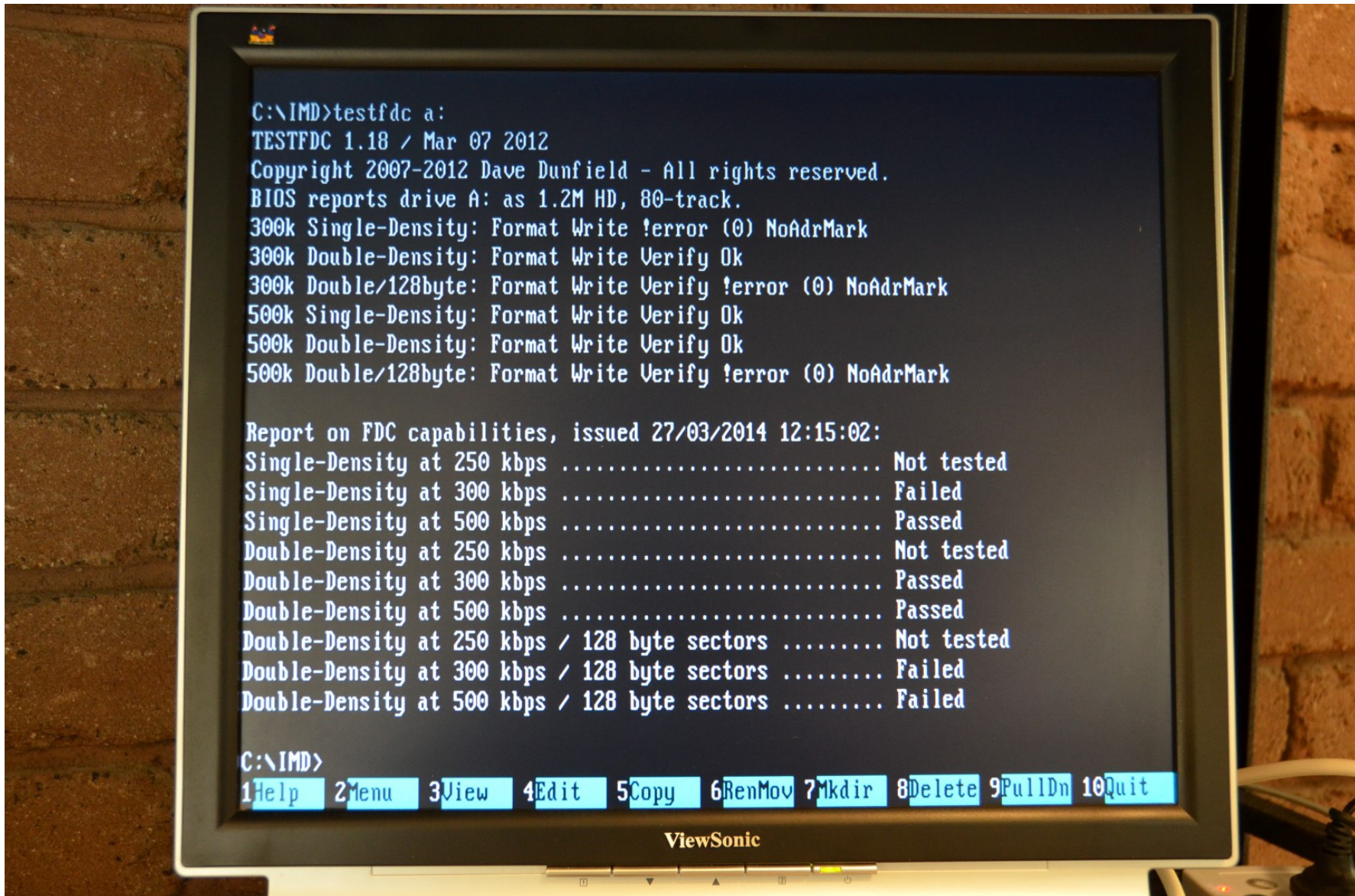
The testing process is as follows:

1. Connect a 250 kbps drive to your PC – eg:
 - a) 5.25” 360K drive (Teac FD-55Bx series)
 - b) 3.5” HD drive with 720K media
2. Change your PC’s BIOS settings to 5.25 360K, or 3.5” 1.44MB, as applicable
3. Boot MSDOS
4. Run FDCTEST
5. Examine results for 250 kbps test (it will skip 300 & 500 kbps tests)
6. Connect a 300/500 kbps drive to your PC – eg 5.25” 1.2M drive (Teac FD-55GFR series)
7. Change your PC’s BIOS settings to 5.25 1.2M
8. Boot MSDOS
9. Run FDCTEST
10. Insert DD and HD media when requested
11. Examine results for 300 & 500 kbps tests

TESTFDC – D7600 Motherboard with 3.5” HD Drive



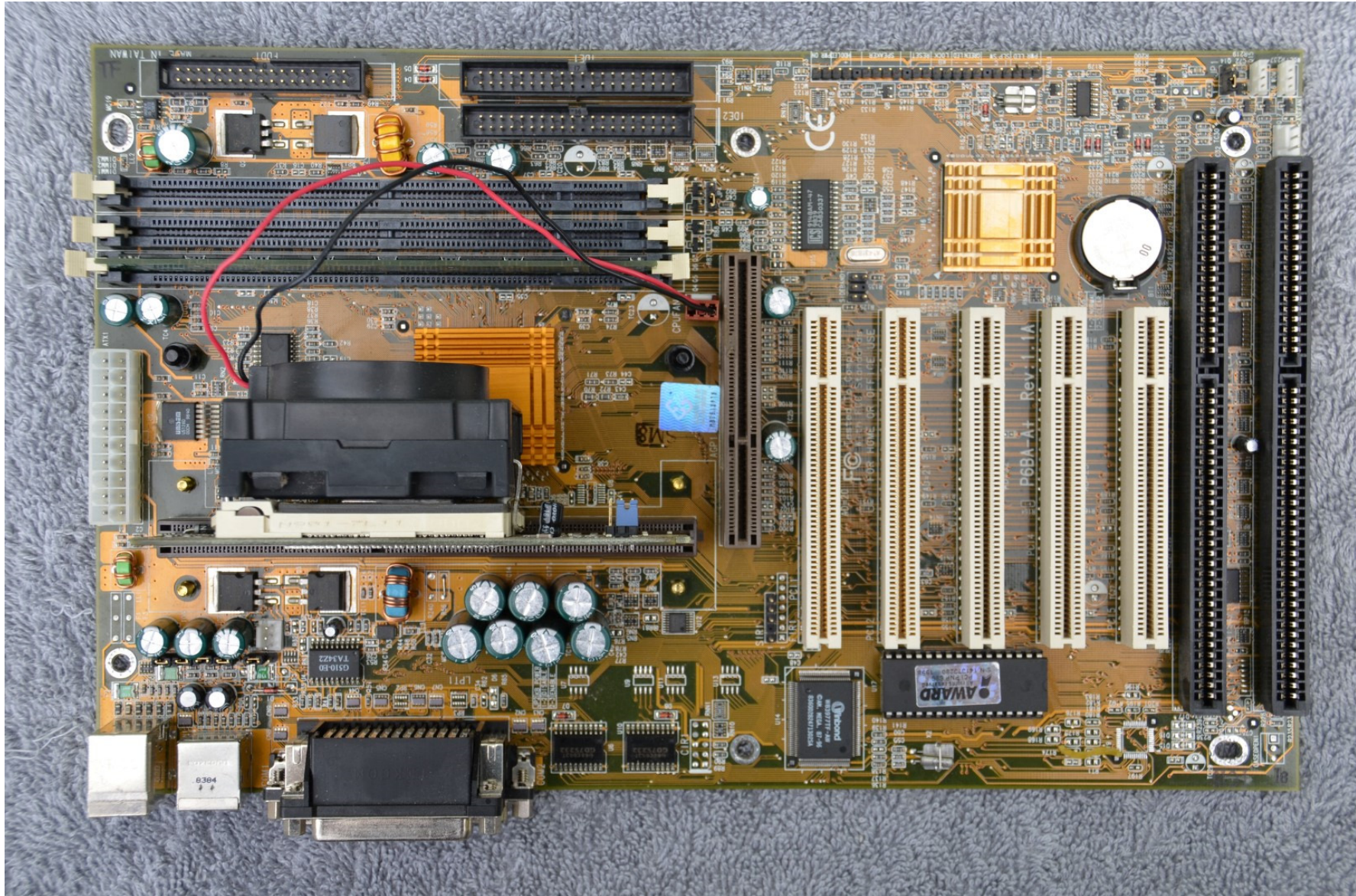
TESTFDC – D7600 Motherboard with 5.25” HD Drive



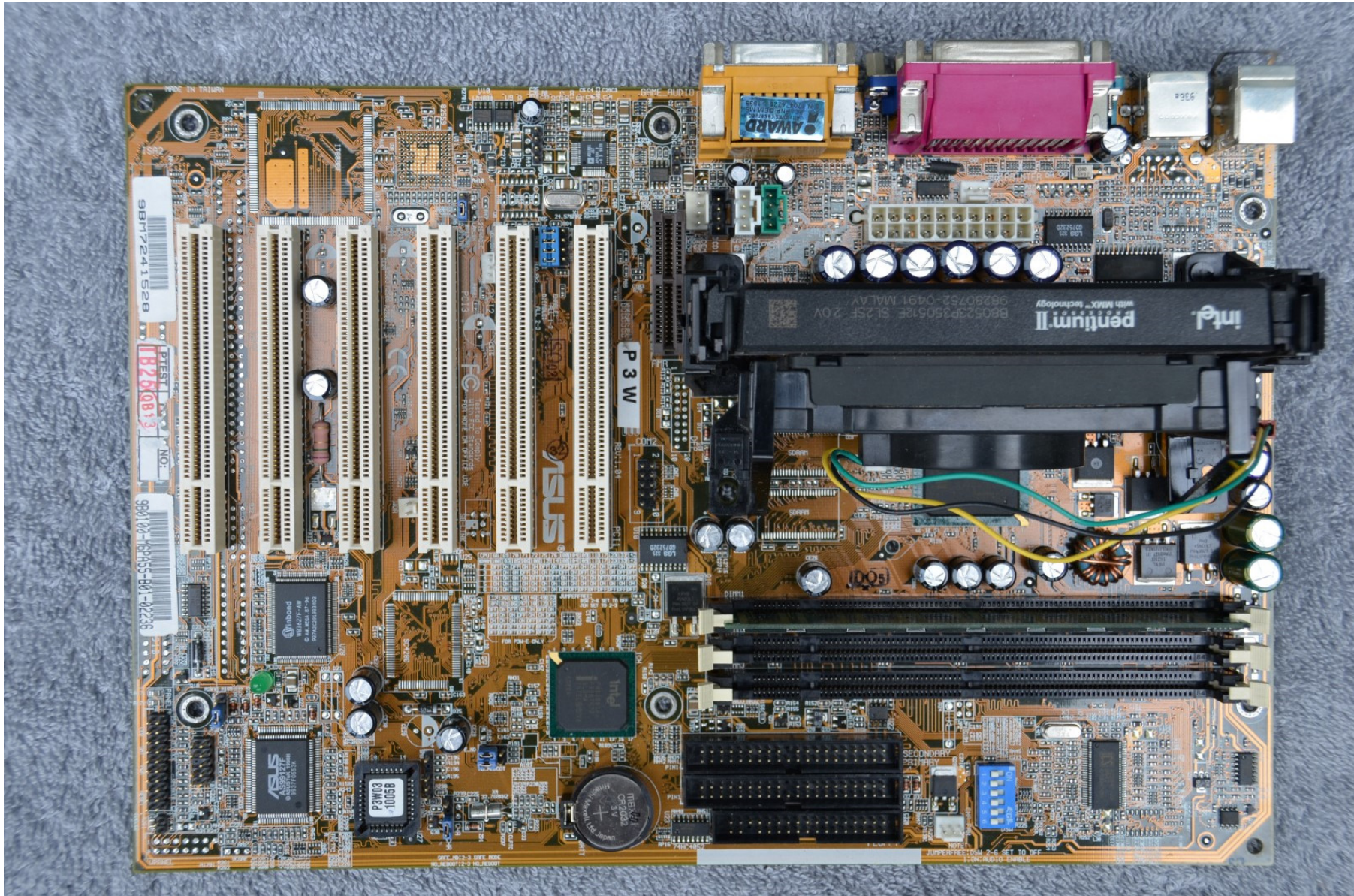
Boards Tested using TESTFDC:

1. ECS P6BA-A+
2. Asus P3W Motherboard
3. Generic Pentium 166 Desktop
4. HP Vectra D7600-6000 Motherboard
5. Dell GX280 Desktop (SFF & LFF)
6. HP Vectra VE Series 8 DT
7. Adaptec AHA-1522A SCSI/Floppy ISA Card

ECS P6BA-A+ Motherboard



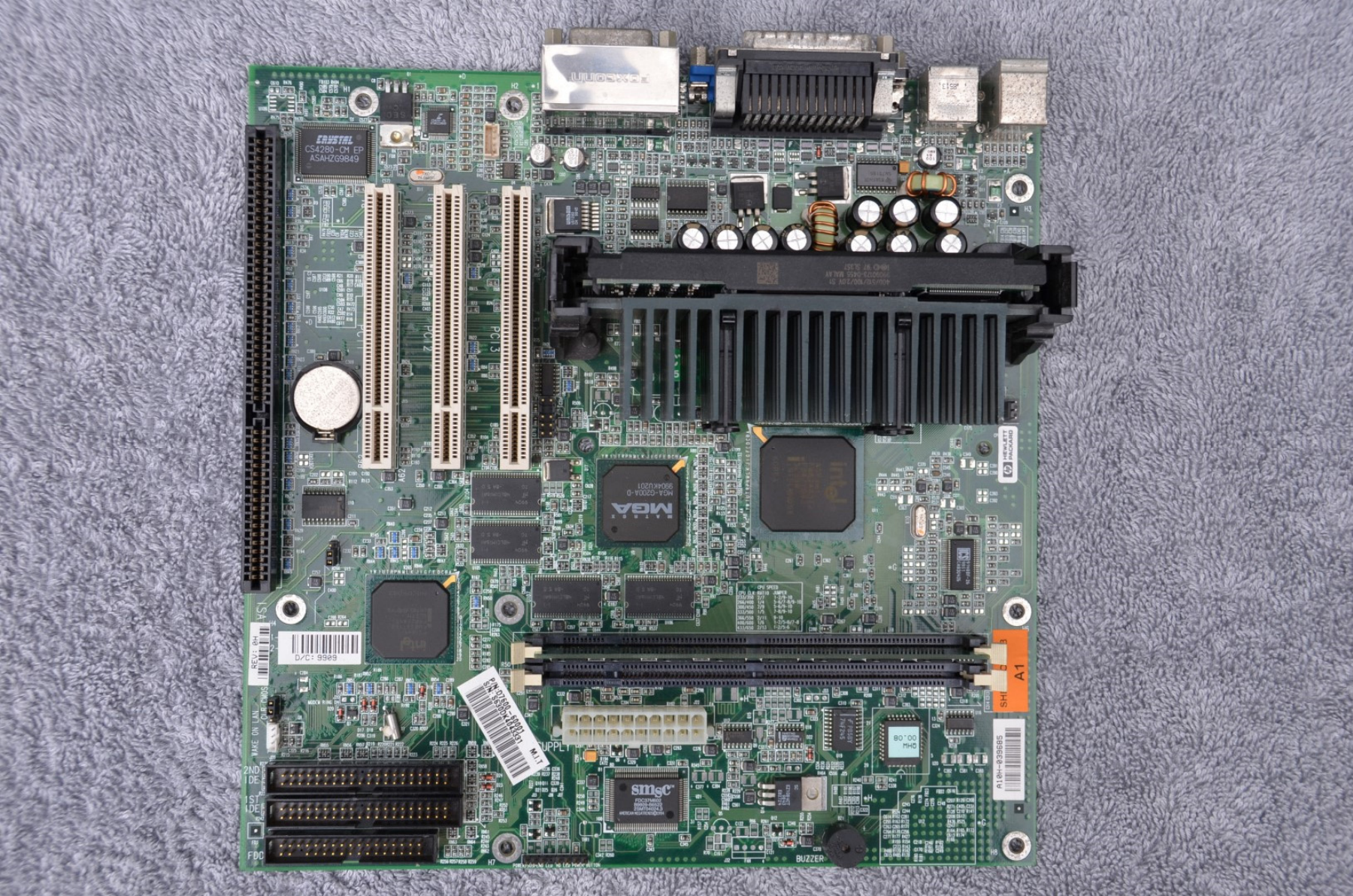
Asus P3W Motherboard



Generic Pentium 166 Desktop



HP VECTRA D7600-6000 Motherboard



Dell GX280 LFF Desktop



HP Vectra VE Series 8 DT



Adaptec AHA-1522A SCSI/Floppy ISA Card



TESTFDC Results

Computer / Controller	250 S D X	300 S D X	500 S D X
ECS P6BA-A+ Motherboard	F P F	F P F	F P F
Asus P3W Motherboard (Tested using 3.5" 1.44M drive only)	F P F	N N N	F P F
Generic Pentium 166 Desktop (Tested using 3.5" 1.44M drive only)	F P F	N N N	F P F
HP VECTRA D7600-6000 Motherboard	P P F	F P F	P P F
Dell GX280 "pizza box desktop" SFF & LFF (Tested using 3.5" 1.44M drive only)	P P F	N N N	P P F
HP Vectra VE Series 8 DT	P P P	P P P	P P P
Adaptec AHA-1522A SCSI/Floppy ISA Card	P P P	P P P	P P P

TESTFDC Results for AHA-1522A using 5.25" 360K drive

```
C:\>nc
The Norton Commander Version 5.5,
Copyright (C) 1986 - 1998 by Symantec Corporation.

C:\IMD>testfdc a:
TESTFDC 1.18 / Mar 07 2012
Copyright 2007-2012 Dave Dunfield - All rights reserved.
BIOS reports drive A: as 360K DD, 40-track.
250k Single-Density: Format Write Verify Ok
250k Double-Density: Format Write Verify Ok
250k Double/128byte: Format Write Verify Ok

Report on FDC capabilities, issued 17/03/2014 11:27:49:
Single-Density at 250 kbps ..... Passed
Single-Density at 300 kbps ..... Not tested
Single-Density at 500 kbps ..... Not tested
Double-Density at 250 kbps ..... Passed
Double-Density at 300 kbps ..... Not tested
Double-Density at 500 kbps ..... Not tested
Double-Density at 250 kbps / 128 byte sectors ..... Passed
Double-Density at 300 kbps / 128 byte sectors ..... Not tested
Double-Density at 500 kbps / 128 byte sectors ..... Not tested

C:\IMD>
1Help 2Menu 3View 4Edit 5Copy 6RenMov 7Mkdir 8Delete 9PullDn 10Quit
```

ViewSonic

TESTFDC Results for AHA-1522A using 5.25" 1.2M drive

```
C:\IMD>testfdc a:
TESTFDC 1.18 / Mar 07 2012
Copyright 2007-2012 Dave Dunfield - All rights reserved.
BIOS reports drive A: as 1.2M HD, 80-track.
300k Single-Density: Format Write Verify Ok
300k Double-Density: Format Write Verify Ok
300k Double/128byte: Format Write Verify Ok
500k Single-Density: Format Write Verify Ok
500k Double-Density: Format Write Verify Ok
500k Double/128byte: Format Write Verify Ok

Report on FDC capabilities, issued 17/03/2014 11:40:58:
Single-Density at 250 kbps ..... Not tested
Single-Density at 300 kbps ..... Passed
Single-Density at 500 kbps ..... Passed
Double-Density at 250 kbps ..... Not tested
Double-Density at 300 kbps ..... Passed
Double-Density at 500 kbps ..... Passed
Double-Density at 250 kbps / 128 byte sectors ..... Not tested
Double-Density at 300 kbps / 128 byte sectors ..... Passed
Double-Density at 500 kbps / 128 byte sectors ..... Passed

C:\IMD>
1Help 2Menu 3View 4Edit 5Copy 6RenMov 7Mkdir 8Delete 9PullDn 10Quit
```

ViewSonic

Suggested PC setup for IMD and CW

Hardware:

- Any mid to late 1990's PC motherboard
- ATX power supply
- PS2 keyboard
- VGA display
- IDE to CompactFlash card adapter
- 2G (or bigger) CF card
- D-Bit's FDADAP 8" adapter
- 34-way & 50-way floppy cables
- 24VDC power supply (for modern 8" drives)
- 3-wire RS232 null-modem cable
- Floppy power Y-adapters & converters
- 6" jumper wires (M-M) for bridging
- Lots of test disks (3.5, 5.25 & 8")
- Adaptec AHA-1522A SCSI/Floppy controller
- Catweasel MK 3 or MK 4 card

Software:

- MSDOS 6.22
- ImageDisk v. 1.18
- Tim Mann's CW tools v. 4.4
- Kermit / Qmodem

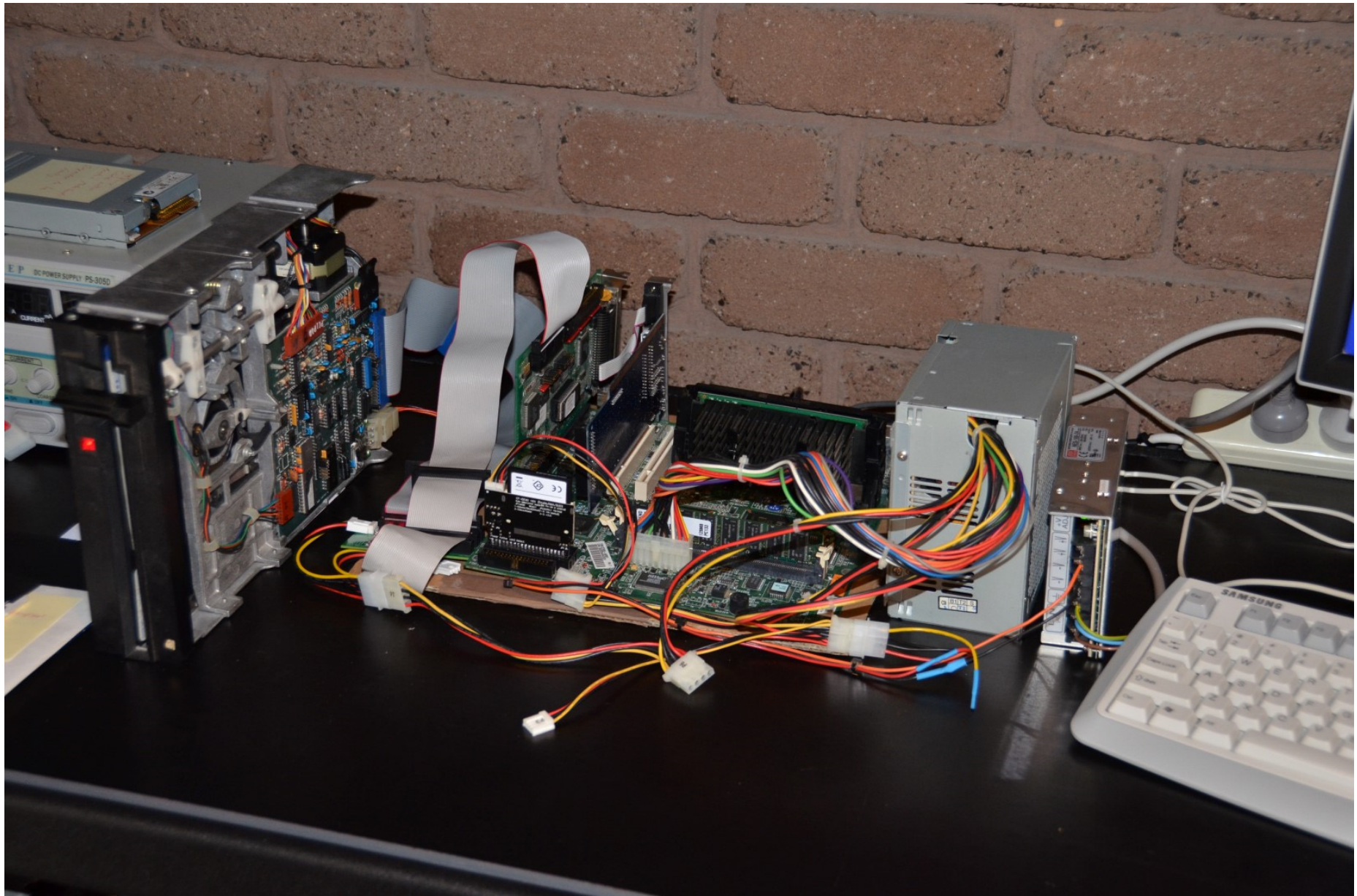
Drives:

- 3.5: Teac FD-235HG
- 5.25: Teac FD-55BV-06
- 8: Tandon TM848-2E or Mitsubishi M2896-63U

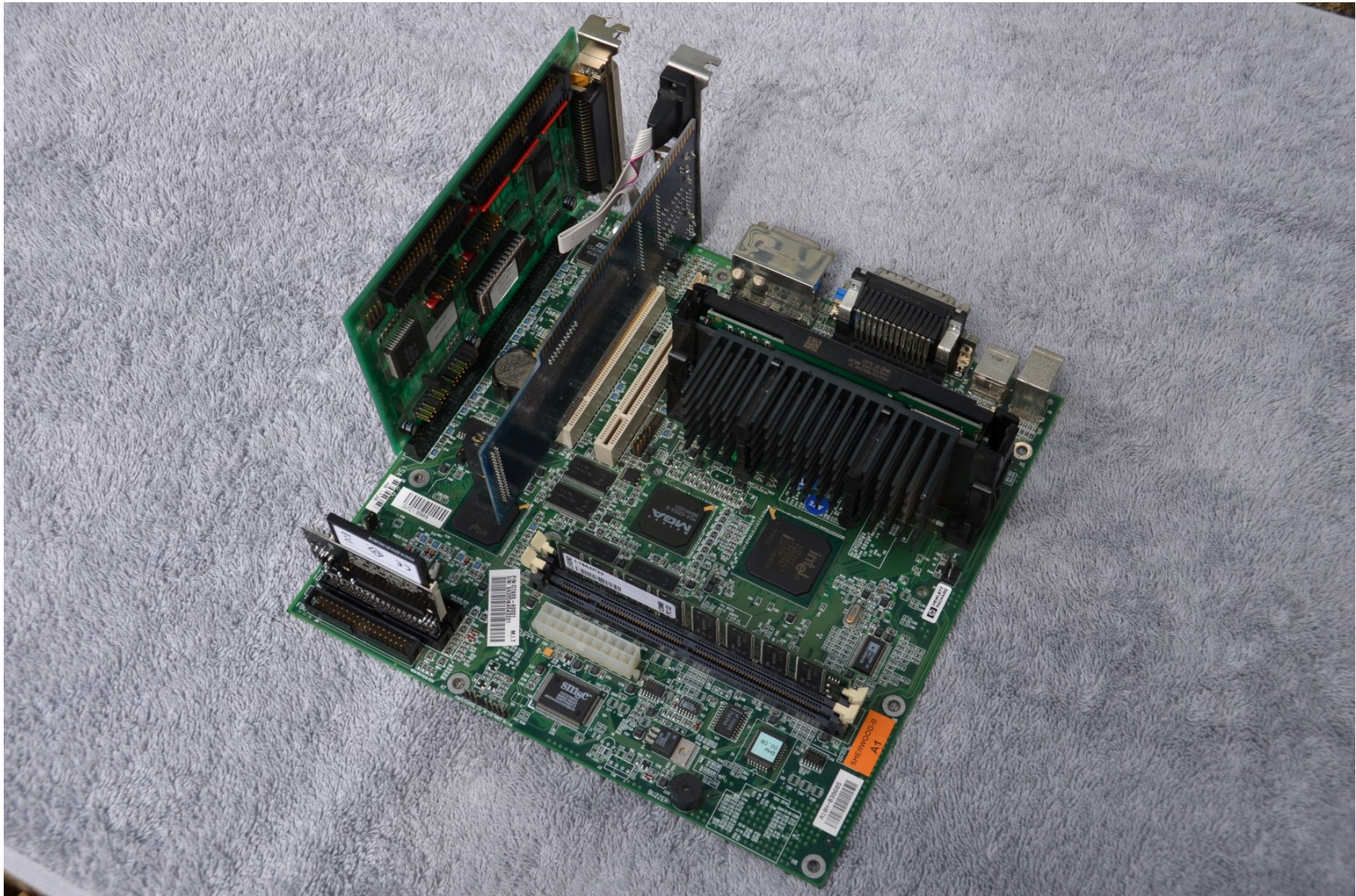
Test Equipment:

- Voltmeter or logic probe
- DSO

Disk Imaging Setup



Motherboard setup



Adaptec AHA-1522A SCSI Card with Floppy Interface

- Does SD, DD & DD/128 at 250, 300 and 500 kpbs
- No drivers required
- \$15 to \$50 on eBay

Caution: Only buy the “-1522A” version (“-1520A” uses same PCB but no FDC)



Setting up your AHA-1522A

- Check the AHA-1522A's jumpers are as per manufacturer's default settings
- Plug in the AHA-1522A card
- Configure your drive as Drive 1, as is standard practice with PCs (remember both A and B drives always get configured as Drive 1, not Drive 0 and Drive 1)
- Use the standard 34-way cable-with-twist to connect drive to AHA-1522A
- Your drive connects at far end of FDC cable (after the twist) – it will be Drive A
- Don't connect any other drives to the AHA-1522A or to the on-board FDC
- Check the terminating resistors are fitted to the drive
- Disable the on-board FDC (in PC's BIOS settings)
- Make sure the drive type (in BIOS settings) is appropriately set
- Boot MSDOS (might also work in Win 3.11 or Win 98 - untested)
- Run TESTFDC
- Examine results
- Repeat test using suitable drives for all required bit rates and densities
- No drivers required

CompactFlash Card & IDE Adapter

- Can be used in place of an IDE hard drive
- Attaches directly to the motherboard
- Allows easy means to transfer disk images files between imaging PC and your regular PC (via USB-CF adapter)



Using Tim Mann's Catweasel Tools

- Reading a 5.25" SD or DD disk:

```
cw2dmk -d1 -k2 [-s1] [-t35] -v42 filename.dmk
```

- Writing a 5.25" SD or DD disk:

```
dmk2cw -d1 -k2 filename.dmk
```

- Reading a 3.5" HD disk:

```
cw2dmk -d1 -k4 -v42 filename.dmk
```

- Writing a 3.5" HD disk:

```
dmk2cw -d1 -k4 filename.dmk
```

- Reading an 8" SD or DD disk:

```
cw2dmk -d1 -k3 [-s1] [-t77] -v42 filename.dmk
```

- Writing an 8" SD or DD disk:

```
dmk2cw -d1 -k3 filename.dmk
```

Remember: 5.25" drives connect "after-the-twist", 8" drives connect via straight-through cable when using FDADAP.

Some tips & tricks

1. If CF card won't boot after setting up MSDOS 6.22 from floppy, try "fdisk /mbr"
2. Sometimes 500 kpbs DD/128 checks using TESTFDC will fail on 3.5" 1.44M drives (ie 300 RPM), but work fine on 5.25" 1.2M drives (ie 360 RPM)
3. Neither is superior to the other – generally read errors on IMD also occur in CW, and vice versa. The exception is that IMD "unable to determine interleave" errors don't occur on CW.
4. DD/128 seems to be very rare (I've come across one DD/128 8" disk in a sample of about 100). So probably no need for this with IMD
5. Some 3.5" drives can be made to spin at 360 RPM in HD mode (rather than the normal speed of 300 RPM) by grounding Pin 2
6. If you have read errors – record this so you know whether the disk image is reliable.

Some tips & tricks (cont)

7. Consider scanning the disk label and other documentation (eg an directory listing) and storing this with the disk image
8. After writing a disk, read it back, to check for no errors

Resources & Links

- Siemens Floppy Disk Drive FDD 100-8 Technical Manual
www.bitsavers.org/pdf/siemens/FDD100-8_V1.pdf
- Herb Johnson's Tech information on floppy disks drives and media:
http://retrotechnology.com/herbs_stuff/drive.html
- Dave Dunfield's ImageDisk page
<http://www.classiccmp.org/dunfield/img/index.htm>
- D-Bit's FDADAP Floppy Disk Adapter:
<http://www.dbit.com/fdadap.html>
- Floppy Image – For reading and writing PC floppy images (IMG format):
<http://www.z80.eu/software/floppyimage/fi152.zip>
- AHA-1522A User's Guide (for jumper settings)
http://www.adaptec.com/en-us/support/eol/scsi_host_isa/aha-1522a/docs/aha1520a_ug_pdf.htm?nc=en-us/support/eol/scsi_host_isa/aha-1522a/docs/aha1520a_ug_pdf.htm
- DMK Format
<http://fjkraan.home.xs4all.nl/comp/trs80-4p/dmkeillimages/trstech.htm>
- Catweasel product page:
<http://www.jschoenfeld.com/home/indexe.htm>
- Tim Mann's Catweasel Floppy Read/Write Tools:
<http://www.tim-mann.org/catweasel.html>
<http://marc.info/?l=classiccmp&m=104957385022467&w=2>
- Catweasel Wikipedia pages:
http://en.wikipedia.org/wiki/Individual_Computers_Catweasel
<http://wiki.icomp.de/wiki/Catweasel>