Project Documentation

Commodore PET/CBM80xx/40xx Diagnostic Clip

Project number: 163

Revision: 2

Date: 01.01.2023

Commodore PET/CBM80xx/40xx Diagnostic Clip **Rev. 2**

Module Description

Table Of Contents

1. Introduction 1
2. Test procedure 2
   2.1. Brief discription 2
   2.2. Notes 3
3. Diagnostic Software 4
   3.1. 80 col CRTC 4
   3.2. 40 col CRTC 5
   3.3. 40 col non-CRTC 6
4. Complete Diagnostic Clip Set 7
5. Dimensions 8
6. Connectors and Jumpers 9
   6.1. J1 – Connector to test clip/6502 Ribbon Cable Adapter 9
   6.2. Jumpers & Switches 9
7. Resources 10
   7.1. Websites 10
   7.2. Commodore Training: 40xx/80xx Service Manual 10
      7.2.1. DIAGNOSTIC BOX DESCRIPTION 11
      7.2.2. Test description 11
8. Annotations 13
   8.1. 3D printed Case 13
   8.2. Ribbon Cable 13
9. Revision History 14
   9.1. Rev. 0 14
   9.2. Rev. 1 14
   9.3. Rev. 2 14

1. Introduction

The diagnostic clip is a diagnostic tool, which is originally issued by Commodore. It contains the diagnostic software, which has to fit to the board type, that is tested. For testing, it is connected to the 6502, switches off the ROMs on the mainboard and/or redirects the Kernal accesses to its built in EPROM.

The original hardware consists of:

- DIP40 test clip (3M is still producing this kind of clip – They are available from Mouser and Digikey: https://www.digikey.com/en/products/detail/3m/923743-40/12075, which is $94.07 in February 2023)
- the box with the EPROM/Test software)
- the keyboard feedback dongle
- user port feedback dongle

There is an extra box for each version of the software.

The goal of this development is to eliminate the need for an expensive DIP40 test clip and to merge the different box designs to one PCB. Further, shorting A13 and A14 to GND should be prevented.

The result is a 4 PCB solution:

- the clip box with a ribbon cable
- a ribbon cable adapter for the 6502
- a keyboard feed back
- a user port feed back

The EPROM in the clip box is fully connected to the 6502 μprocessor address and data bus. When connected (and configured properly), the test software is run after powering up the machine. The two main types of mainboards require different methods of making the test software appear in the system.

- CRTC machines, like the 8032, have a $\overline{\text{NOROM}}$ signal, which can switch off all ROMs on the mainboard (except the character set) and the test software resides at $Fxxx instead of the Kernal. It comes with its own RESET vector @ $FFFC/D (it points to $F000, the start of the test software)
- Non CRTC machines, like the PET2001 or CBM30xx: the Kernal access is redirected to the option ROM address space $9xxx. This happens by (brutally) shorting the address signals A13 and A14 to GND – $F/1111_{BIN}$ becomes a $9/1001_{BIN}$. The test software starts at $9800, the redirected reset vector is now at $9FFC/D and it points to $9800

Note: CRTC means "**C**athode **R**ay **T**ube **C**ontroller. The first PETs had a video circuit, solely consisting of TTL ICs and the Character ROM. This includes the first "dynamic PETs", like the CBM 30xx. The later machines had a controller chip (6545) as the heart of the video circuit. It can be configured for 40 column and 80 column machines and is a bit more flexible. The CBM 80xx and most CBM 40xx are CRTC machines.

2. Test procedure

2.1. Brief discription

The diagnostic hardware (clip/ribbon cable adapter, clip box, keyboard and user port dongles have to be connected before power up.

After power up, the diagnostic software is started. It consists or the first basic tests, which make sure, that the basic system is working:

- Printing the character set on the screen
- Testing the "TV RAM" (screen memory)
- Testing the Zero Page
- Testing the stack
- Copying the actual test software into the RAM, starting at $0200. Jumping to that software
- Waiting for the clip to be removed

NOTE: A switch installed on JP5 allows to switch off $\overline{\text{NOROM}}$, which is logically removing the clip EPROM from the system. As a non-CRTC machine the CBM3016 was tested.

The copied test software first waits for the clip to be removed by checking the (redirected) reset vector. If it does not point to $F000 or $9800 for a couple of seconds, it is assumed, that the clip is removed. Then testing is proceeded:

- Video Test
- Checksum Test (CRTC machines)
- Horizontal (video) Test
- Video RAM Test (CRTC machines)
- 32k RAM test
- ROM Test (shows checksum only)
- Refresh Test (dynamic RAM refresh)
- Keyboard Test
- 60Hz (non CRTC) or 50Hz (CRTC) IRQ (interrupt) test
- Timer 1 Test
- Timer 2 Test
- Cassette 1 Test
- Cassette 2 Test
- IEEE DIO Test
- IEEE Ctrl Test

This part of the test is cycling until the Reset switch is pressed or the computer is power down. The tests are described in chapter 7.2.2

2.2. Notes

The **user port** is used to monitor the video signals, SRQ and EOI from the IEEE Bus, the Tape write and read signals and the "Diagsens" and "Graphic" signal.

I would not consider this as a proper user port test.

The IEEE signals are fed back internally, there is no external feedback, so the driver chips are not tested.

The tape port TPWRITE signal on the user port us fed back to both TPREAD1 and TPREAD2. CASS SWITCH #1 and #2 are not tested, neither is CASS MOTOR #1 and #2.

The testing will stop on the first failed test.

3. Diagnostic Software

3.1. 80 col CRTC

The file name in the "Diagnostic Software" folder is "**80_col_diagnostic_v1.1.bin**". It is suitable for 80 col 80xx and 40xx machines (with the 12" monitor).

Figure 1: 80_col_diagnostic_v1.1.bin - first page

After removing the clip, respectively switching it to "remove", the test continues on the 2nd page.

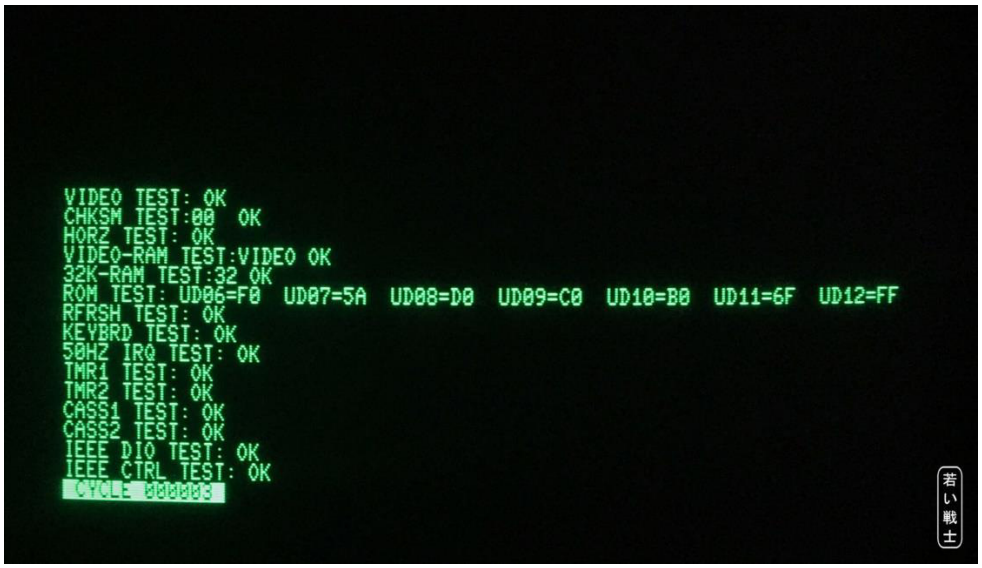


Figure 2: 80_col_diagnostic_v1.1.bin - second page

3.2. 40 col CRTC

Since no such a computer is available, just the opening page can be shown on a 40 col. screen. A further test on a non CRTC machine (CBM3016) fails. The test itself passes on the CBM8032, but the output screen is not properly aligned.

Figure 3: 40_col_diagnostic_v2.0.bin - first page

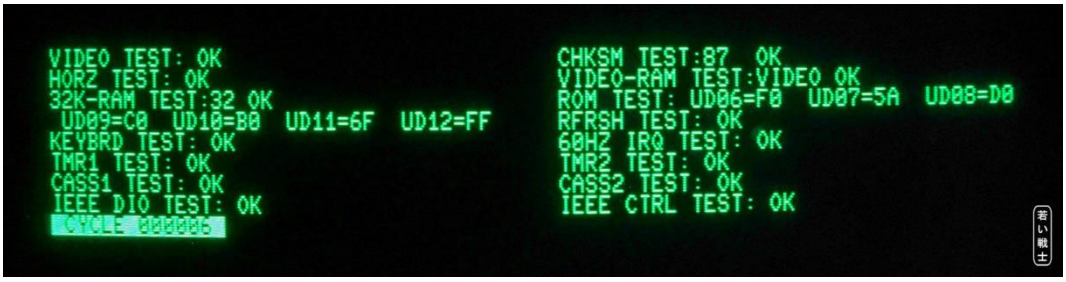


Figure 4: 40_col_diagnostic_v2.0.bin - second page (on an 80 col machine)

3.3. 40 col non-CRTC

This test should work with all 40 column non-CRTC machines. The 2nd page is scrolling, so an upper and lower half of the looping test is shown.

Figure 5: 901447-30_diagnostic_320350g_$9000.bin - first page

Figure 6: 901447-30_diagnostic_320350g_$9000.bin - 2nd page (upper half)

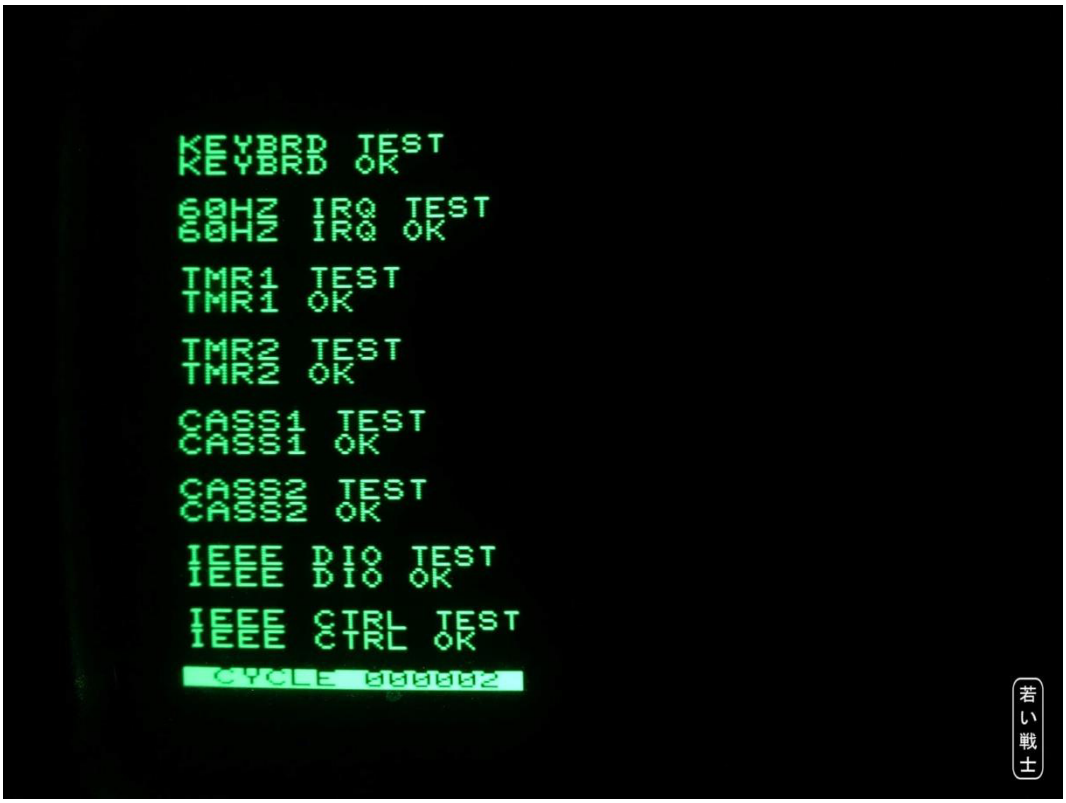


Figure 7: 901447-30_diagnostic_320350g_$9000.bin - 2nd page (lower half)

4. Complete Diagnostic Clip Set

In Figure 8 all required PXCBs are shown. The short 40 pin ribbon cable is missing.

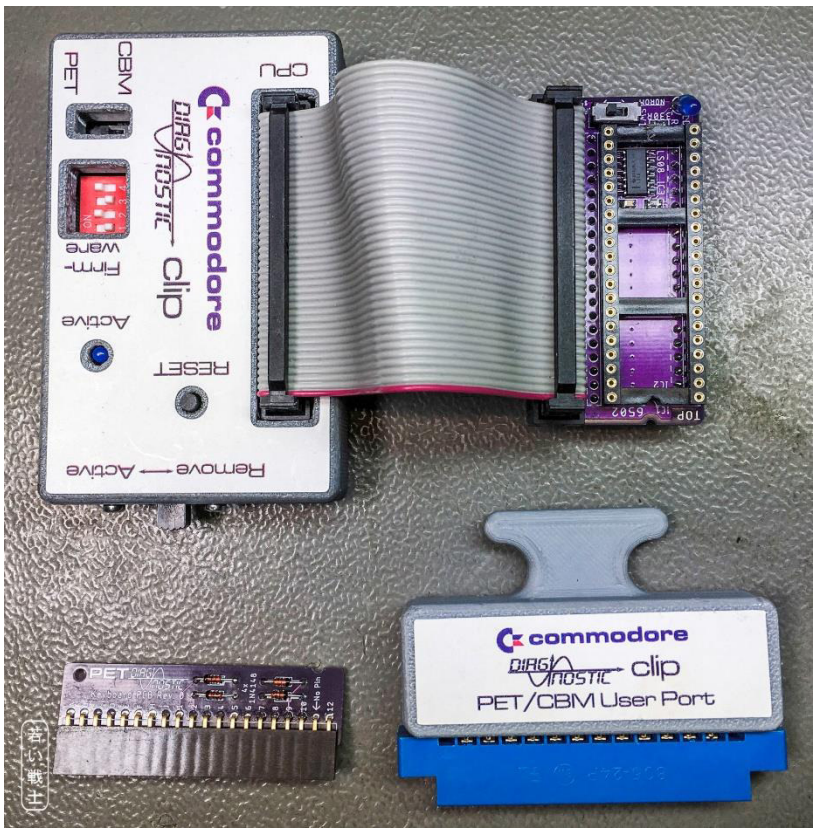


Figure 8: Diagnostic PCBs assembled

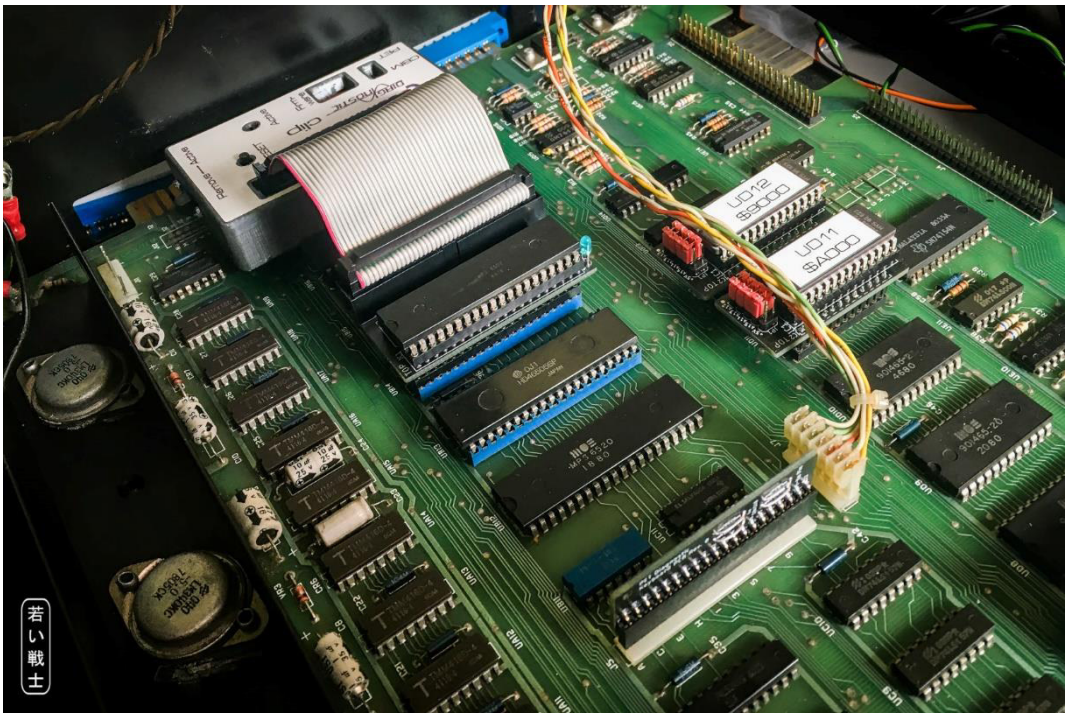


Figure 9: Diagnostic clip connected to the 6502 ribbon cable adapter (in the CBM8032)

5. Dimensions

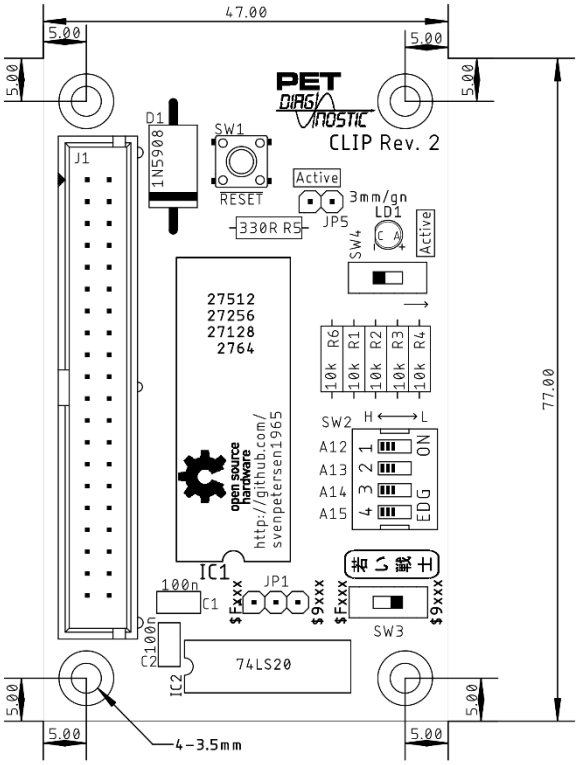


Figure 10: Dimensions of the Diagnostic Clip PCB Rev. 0

6. Connectors and Jumpers

6.1. J1 – Connector to test clip/6502 Ribbon Cable Adapter

A 2x20 box connector, 2.54mm pitch

Signal	Pin	Pin	Signal
GND (6502, Pin 1)	1	2	$\overline{\text{RES}}$
RDY	3	4	PHI2
PHI	5	6	S.O.
$\overline{\text{IRQ}}$	7	8	PHI0
$\overline{\text{NOROM}}$	9	10	n.c. (6502, Pin 36)
$\overline{\text{NMI}}$	11	12	n.c. (6502, Pin 35)
SYNC	13	14	R/$\overline{\text{W}}$
5V	15	16	DB0
AB0	17	18	DB1
AB1	19	20	DB2
AB2	21	22	DB3
AB3	23	24	DB4
AB4	25	26	DB5
AB5	27	28	DB6
AB6	29	30	DB7
AB7	31	32	AB15
AB8	33	34	AB14
AB9	35	36	AB13
AB10	37	38	AB12
AB11	39	40	GND (6502, Pin 21)

6.2. Jumpers & Switches

6.2.1. JP5/SW4 – Switch for "Active ↔ Remove"

The "Jumper" is not actually placed, but an external slide switch (at least SPST) is connected via short cables. ON means "active", OFF means "remove". Internally the mini slide Switch SW4 can be installed instead of JP5, which is not the recommended solution.

6.2.2. JP6/SW3 – AB13 & AB14

This selects the CRTC/non CRTC mode

Signal	Pin	Pin	Signal
n.c.	1	2	AS14
AB13	3	4	AB14
GND	5	6	GND

CRTC machines, like the 80xx or most 40xx: Jumper 1 – 3 & 2 – 4.

Non-CRTC machines, like the PET20xx or CBM 30xx: Jumper 3 – 5 & 4 – 6.

Internally the mini slide Switch SW3 can be installed instead of JP6, which is **the recommended solution**.

6.2.3. SW2 – The DIP Switch

The DIP-Switch serves for selecting the test software (one of 16 possible) from the EPROM (27C512) that can be run on the clip. The size of the test software is 4kByte, while the size of the EPROM is 64kByte. If it is desired to have a smaller EPROM, the highest (not required) address bits have to be HIGH and the DIP-switch can be smaller.

EPROM	SW	Address Bits	DIP-Switch
27C256	8x4k	A15 open/HIGH	position 1-3
27C128	4x4k	A15&A14 open/HIGH	position 1-2
27C64	2x4k	A15&A14&A13 open/HIGH	position 1

The OFF position of a switch means HIGH, the ON Position means LOW.

4	3	2	1	A15..12	4k Slot	EPROM Offset
on	on	on	on	0000	0	$0000
on	on	on	off	0001	1	$1000
on	on	off	on	0010	2	$2000
on	on	off	off	0011	3	$3000
on	off	on	on	0100	4	$4000
on	off	on	off	0101	5	$5000
on	off	off	on	0110	6	$6000
on	off	off	off	0111	7	$7000
off	on	on	on	1000	8	$8000
off	on	on	off	1001	9	$9000
off	on	off	on	1010	10	$A000
off	on	off	off	1011	11	$B000
off	off	on	on	1100	12	$C000
off	off	on	off	1101	13	$D000
off	off	off	on	1110	14	$E000
off	off	off	off	1111	15	$F000

7. Resources

7.1. Websites

The information for creating this project, like the schematics of the original diagnostic clips and some test software was retrieved from André Fachat's website:

- http://www.6502.org/users/andre/petindex/diag/index.html

Further test software and the connections of the keyboard and user port feedback was retrieved from Bo Zimmerman's website:

- http://www.zimmers.net/anonftp/pub/cbm/firmware/computers/pet/other/index.html
- http://www.zimmers.net/anonftp/pub/cbm/schematics/computers/pet/diagnostics.txt

7.2. Commodore Training: 40xx/80xx Service Manual

Some further descriptions can be found in the (German) "Commodore Training_40xx_80xx_Service Manual" on Carsten's great retro-commodore.eu website .

Page 33ff:

7.2.1. DIAGNOSTIC BOX DESCRIPTION

"*DIAGNOSTIC-BOX BESCHREIBUNG*

Die Diagnostic-Box ist ein Testgerät, mit dem die wichtigsten Komponenten auf der Logic-Platine der Zentraleinheiten getestet und ein hoher Prozentsatz der Fehler gefunden werden kann.

Die Tastatur selbst und das Video-Board wird nicht überprüft. Für jede Zentraleinheit gibt es eine spezielle Diagnostic-Box.

Anschluß und Starten des Testprogramms:

Zur Diagnostic-Box gehören zwei Diagnostic-Stecker, einer für den User-Port und einer für die Tastatur. An der Box befindet sich ein 40-poliges Flachbandkabel mit einem IC-Clip.

Dieser Clip wird auf den Prozessor gesteckt und die beiden Diagnostic-Stecker kommen an die entsprechenden Positionen

Wenn die rote LED leuchtet, kann das Diagnose-Programm durch drücken der roten Taste (Reset) gestartet werden.

Auf dem Bildschirm wird nun angezeigt welcher Test gerade läuft, ob er fehlerfrei durchläuft, oder was für Fehler erkannt wurden. Wird ein Fehler erkannt, stoppt das Testprogramm. Treten keine Fehler auf, werden die Tests laufend wiederholt."

Translated to English:

"DIAGNOSTIC BOX DESCRIPTION

The Diagnostic-Box is a test device with which the most important components on the logic board of the central units are tested and a high percentage of errors can be found.

The keyboard itself and the video board are not checked. There is a special diagnostic box for each computer.

Connection and start of the test program:

The Diagnostic Box includes two diagnostic plugs, one for the User port and one for the keyboard. There is a 40-pin ribbon cable with an IC clip attached to the box.

This clip is put on the processor and the two diagnostic plugs are connected to the appropriate positions/connectors.

When the red LED lights up, the diagnostic program can be started by pressing the red button (Reset). The screen now shows which test is currently running and whether it is passed or failed, or what kind of errors were detected. If an error is detected, the test program stops. if there are no fails, the tests are repeated continuously."

[...]

7.2.2. Test description

"*Testbeschreibung*

Nach Betätigung der Reset-Taste wird der CRT-Controller initialisiert und der CBM-Zeichensatz in den oberen Teil des Bildschirms geschrieben womit festgestellt wird ob es überhaupt möglich ist Daten auf den Bildschirm zu schreiben.

Nun wird Zero-Page und Stack getestet. Treten hier Fehler auf wird entweder ein RAM als defekt angezeigt oder eine Adressleitung.

Eine genaue Erkennung des Fehlers ist aber in manchen Fällen nicht möglich, sodaß zum Teil unrichtige Fehlermeldungen ausgegeben werden. Um den Fehler zu lokalisieren kann man die CAS-Leitungen an den RAMs vertauschen und den Test neu starten. Wird wieder eine Fehlermeldung ausgegeben, so liegt der Fehler wahrscheinlich nicht an den RAM', sondern an der Ansteuerung (Adressleitungen, Refresh, RAS, CAS, RAM R/W, MUX A).

Ist Zero-Page und Stack in Ordnung wird ein Testprogramm in den RAM-Bereich geschrieben und die Aufforderung REMOVE CLIP erscheint auf dem Bildschirm.

Wird nun die Diagnostic-Box vom Prozessor entfernt, werden von dem in der Zero-Page befindlichen Testprogramm die weiteren Teile des Systems getestet. Die ausgegebenen Fehlermeldungen sind im Allgemeinen zuverlässig."

English:

"Test description

After pressing the reset button, the CRT controller is initialized and the CBM character set is displayed on the upper part of the screen, which determines whether it is even possible to write data on the screen.

Now the zero-page and stack are tested. If errors occur here, either a RAM is displayed as defective or an address line

In some cases, however, an exact detection of the error is not possible, so that in some cases incorrect error messages are output. To localize the error, you can swap the CAS lines on the RAM's and restart the test. If an error message is output again, the error is probably not due to the RAM, but to the control (address lines, refresh, RAS, CAS, RAM R/W, MUX A).

If the zero page and stack are OK, a test program is written to the RAM area and the REMOVE CLIP request appears the screen.

If the diagnostic box is now removed from the processor, the other parts of the system are tested by the test program in the zero page. The error messages issued are generally reliable."

CHKSM TEST:	*Um zu überprüfen, ob das Testprogramm richtig in die Zero-Page geladen wurde, wird eine Prüfsumme gebildet die 00 ergeben muß.*
VIDEO RAM TEST:	*Es werden in jede Bildschirmadresse Daten geschrieben wieder gelesen und verglichen*
32K RAM TEST:	*Es wird der gesamte RAM-Speicher außer Zero-Page und Stack getestet*
ROM TEST:	*Es werden Prüfsummen von jedem ROM gebildet (siehe Liste der Prüfsummen)*
RFRSH TEST:	*Es werden Daten in die RAMs geschrieben, eine Zeit lang gewartet und die Daten wieder ausgelesen. So wird überprüft, ob der Refresh in Ordnung ist.*
KEYBOARD TEST:	*Es wird die Funktion des Decoders und des PIA überprüft*
50 HZ IRQ TEST:	*Es wird getestet, ob von dem Signal Vert Drive über den PIA Interrupts erzeugt werden.*
TMR1/2 TEST:	*Es werden die beiden TIMER des VIA getestet*
CASS1/2 TEST:	*Es werden die beiden Cassetten-Ports getestet Beim Lesen werden Interrupts erzeugt (VIA, PIA)*
IEEE Tests:	*Es werden Daten und Steuersignale getestet. Die IEEE-Buffer werden mitgetestet*

English:

CHKSM TEST:	In order to check whether the test program has been loaded correctly into the zero page, a checksum is formed which must result 00.
VIDEO RAM TEST:	Data is written to each screen address, read back and compared
32K RAM TEST:	The entire RAM memory except for the zero page and stack is tested
ROM TEST:	Checksums are generated from each ROM (see list of checksums)
RFRSH TEST:	Data is written to the RAMs, waited for a while and the data is read out again. This checks whether the refresh is OK
KEYBOARD TEST:	The function of the decoder and the PIA is checked
50 HZ IRQ TEST:	It is tested whether interrupts are generated by the signal Vert Drive via the PIA
TMR1 / 2 TEST:	The two TIMERS of the VIA are tested
CASS1 / 2 TEST:	The two cassette ports are tested When reading, interrupts are generated (VIA, PIA)
IEEE Tests:	Data and control signals are tested. The IEEE buffers are also tested

8. Annotations

8.1. 3D printed Case

The case of Rev. 0 is not suitable for any later version of the PCB than Rev.0. The PCBs rev. 1 and 2 require the case revision 1.

For the switch, two M2x5 screws are required. For the case, four C2.9 x 9.5 (DIN7981) self-tapping plastic screws are recommended.

8.2. Ribbon Cable

The ribbon cable is used to connect the Diagnostic Clip (Box) to the 6502 Ribbon Cable Adapter. Since it directly connects to the address and data bus of the 6502, this ribbon cable should not be too long. 10cm -15cm are tested and acceptable.

The strain reliefs should be installed properly, because it is expected to be connected and disconnected several times.

Figure 11: Ribbon cable

Building the ribbon cable is fairly simple. The ribbon cable itself is cut to length, both ends should be cut off perpendicular to the cable. The red wire marks pin one.

- Insert the cable into the IDC receptacle, be aware of the orientation (Figure 11, rec circles)
- Slightly squeeze the connector (to hold the ribbon cable)
- check, if the wires are placed exactly over the blades of the connector
- squeeze the connector with a vice (or a special IDC tool)
- bend the ribbon cable over the top of the connector and install the strain relief (Figure 11, top right).

Note: IDC means "Insulation-Displacement Connector". When the crimping is carried out properly, the wires cold-weld to the blades, resulting in a gas tight connection. Refer to http://tech.guitarsite.de/cable_making.html#Ribbon%20Cables

9. Revision History

9.1. Rev. 0

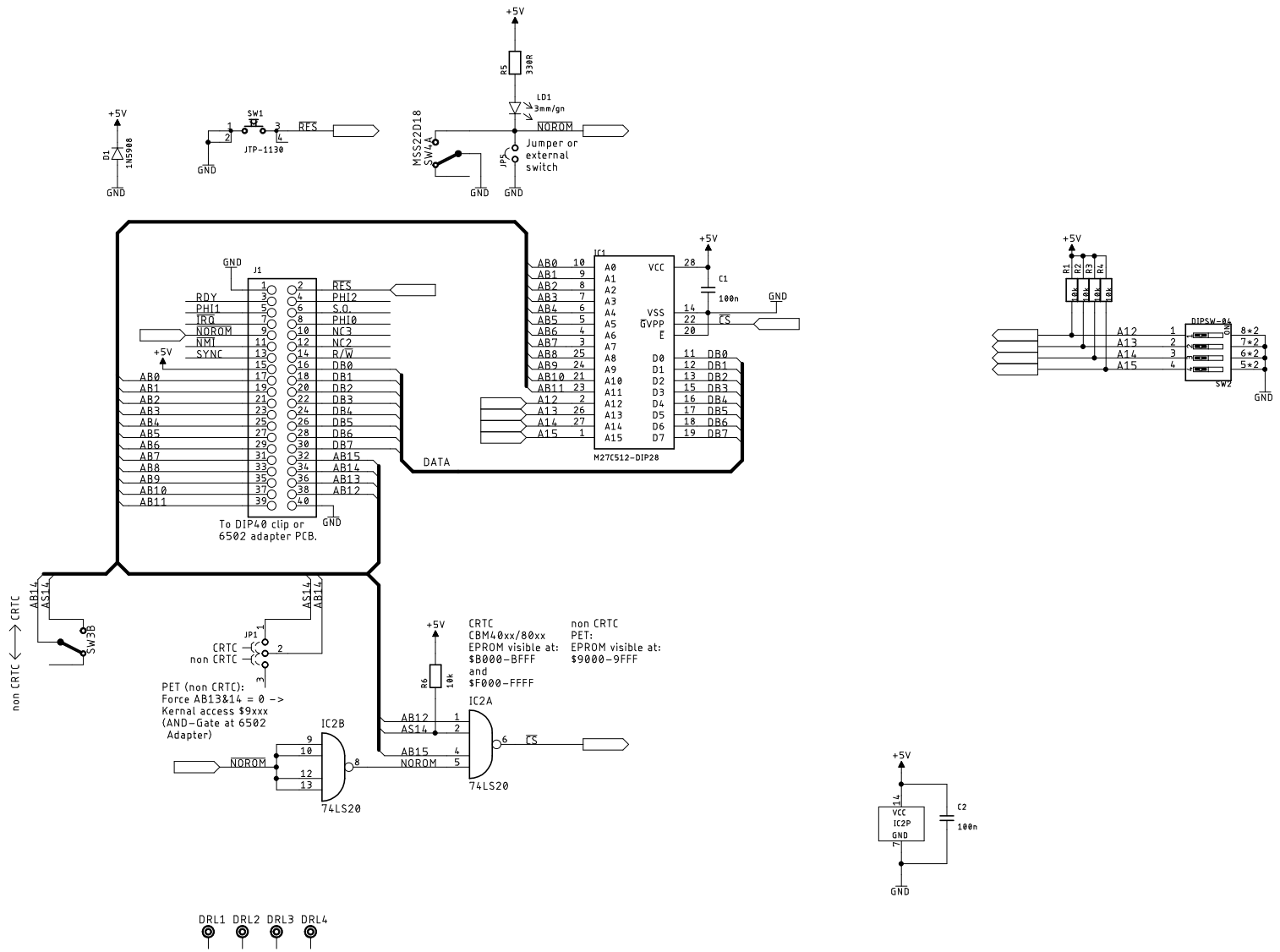
- Prototype tested successfully with an 8032. Need for improvement.

9.2. Rev. 1

- DIP switch SW2 is 4 position now (no more "active")
- Slide switch SW3 is new (CRTC ↔ non CRTC)
- Slide switch SW4 is new (active ↔ remove)

9.3. Rev. 2

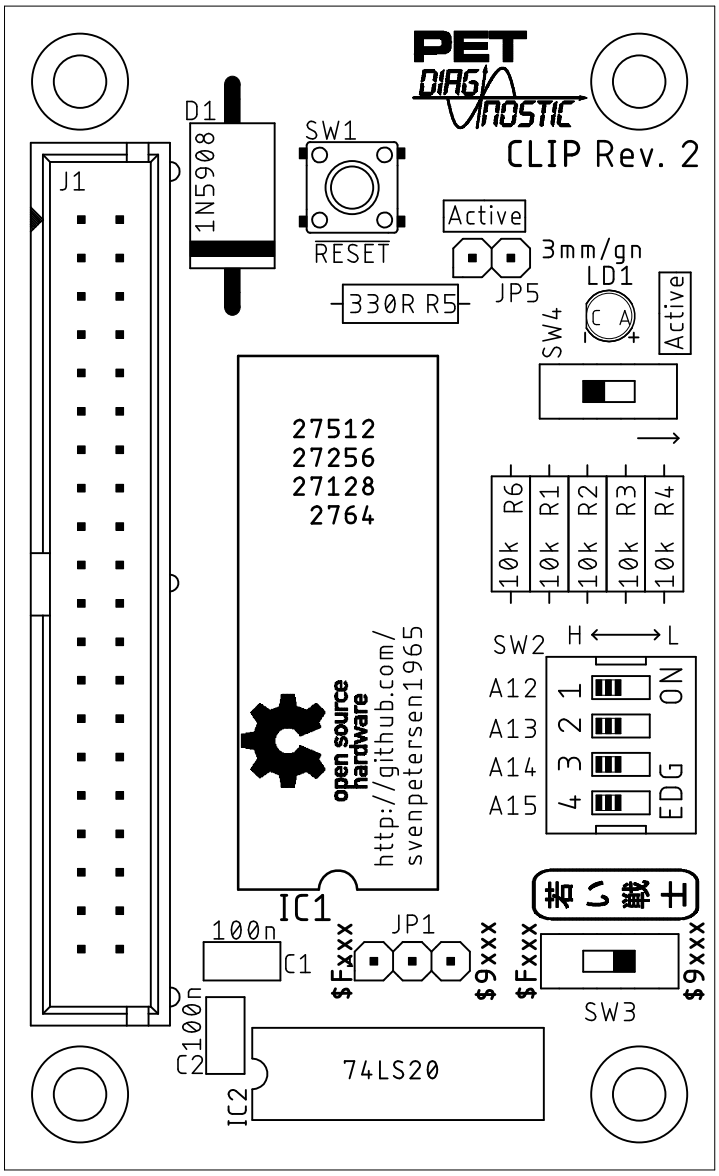
- Support of the AND-gates on the ribbon cable adapter to set A13 and A14 low (for non CRTC mainboards).
- SW3 different circuit
- JP6 1x3 pin, different circuit
- Requires 6502 ribbon cable adapter Rev. 1 or later
- No more 3M DIP40 clip possible for non CRTC machines, since no grounding of A13 and A14



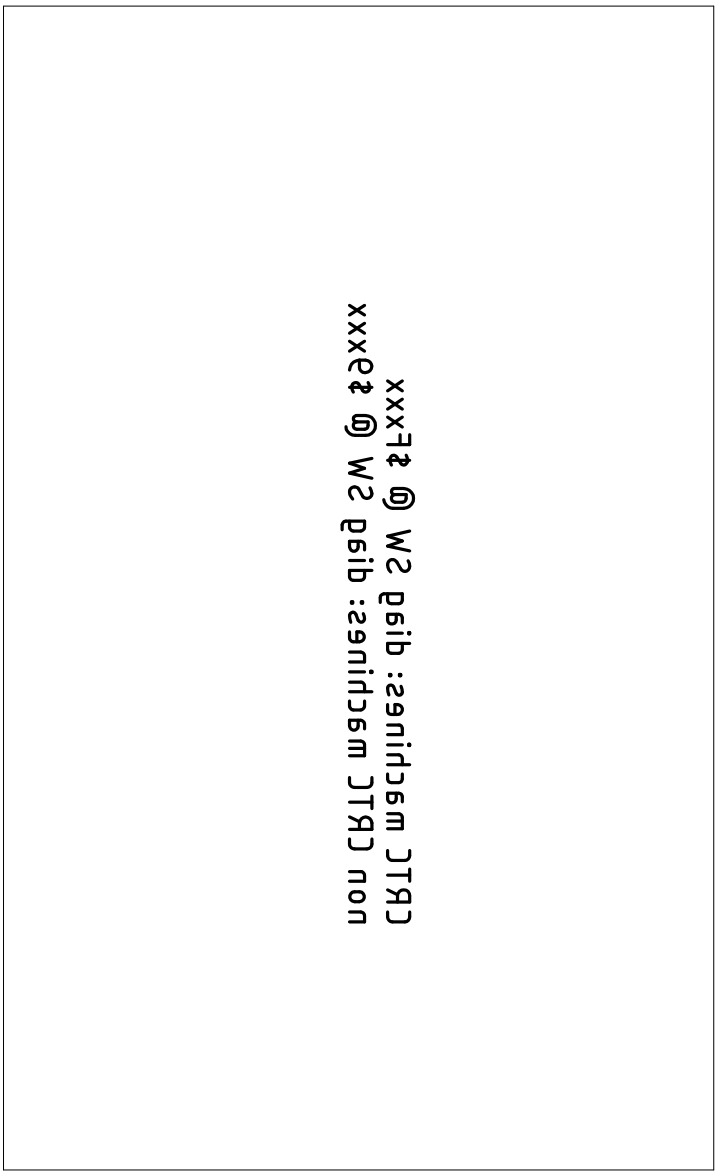
Title:	Commodore PET/CBM40xx/80XX Diagnostic Clip	Doc.-No.:	163-1-01-02
		Draft.:	Sven Petersen
Date:	25.02.2023 14:45	Rev.: 2	Page 1/1
File:	PET_Diag_Clip		
	http://github.com/svenpetersen1965		A3

open source hardware

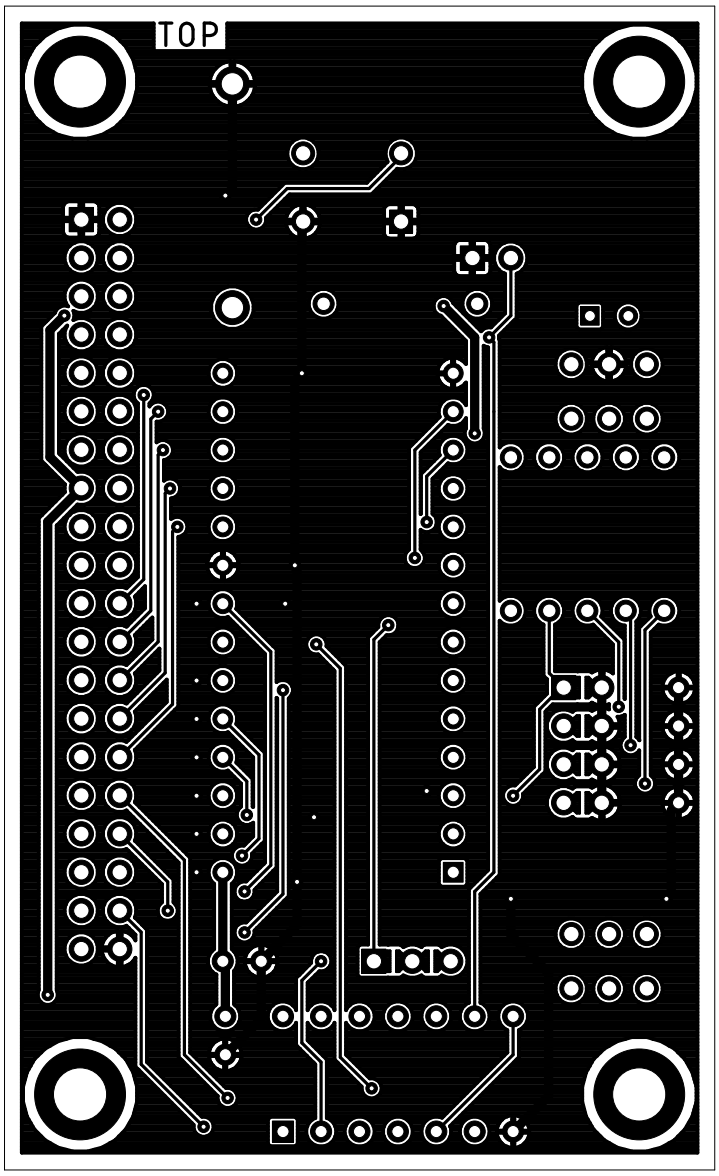
Sven Petersen 2023	Doc.-No.: 163-2-01-02	
	Cu: 35µm	Cu-Layers: 2
PET_Diag_Clip		
25.02.2023 14:45		Rev.: 2
placement component side		



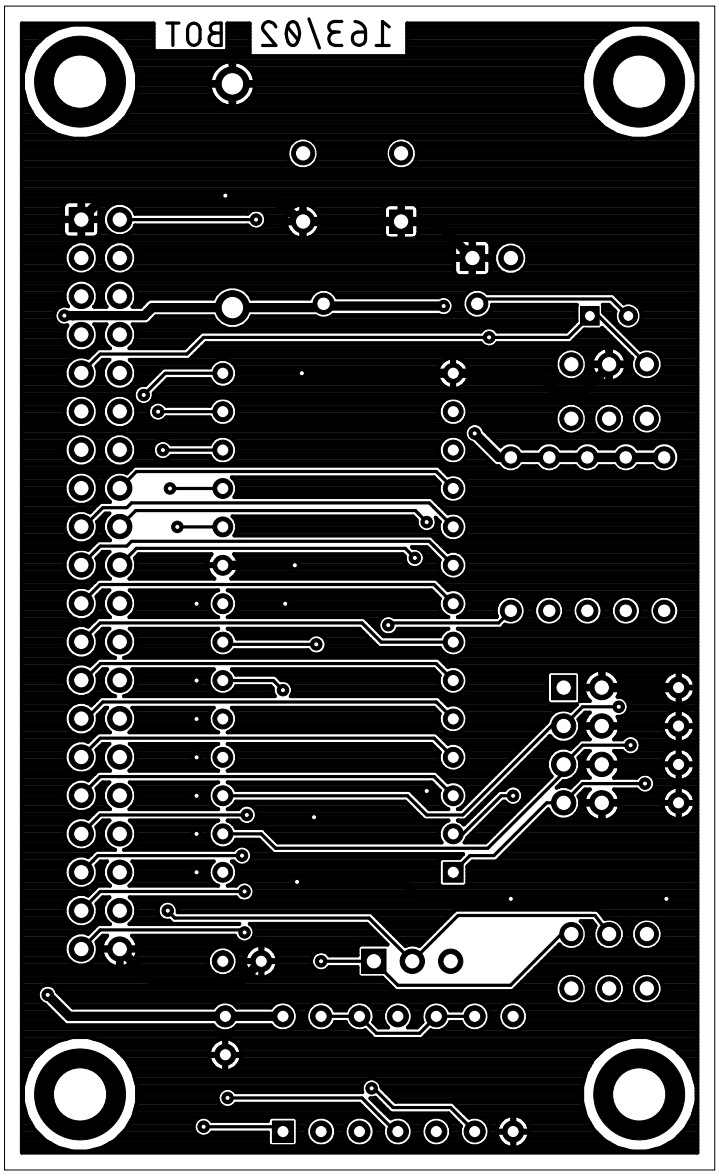
Sven Petersen 2023	Doc.-No.: 163-2-01-02	
	Cu: 35µm	Cu-Layers: 2
PET_Diag_Clip		
25.02.2023 14:47		Rev.: 2
placement solder side		



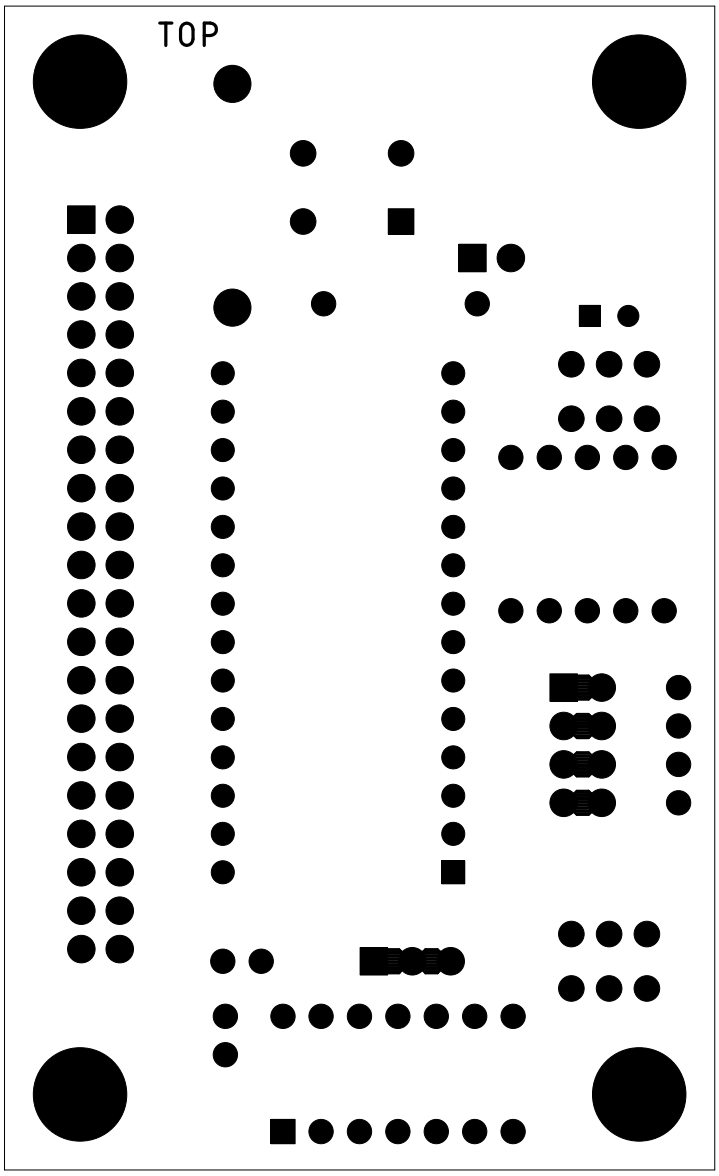
Sven Petersen 2023	Doc.-No.: 163-2-01-02	
	Cu: 35µm	Cu-Layers: 2
PET_Diag_Clip		
25.02.2023 14:47		Rev.: 2
top	[redacted]	



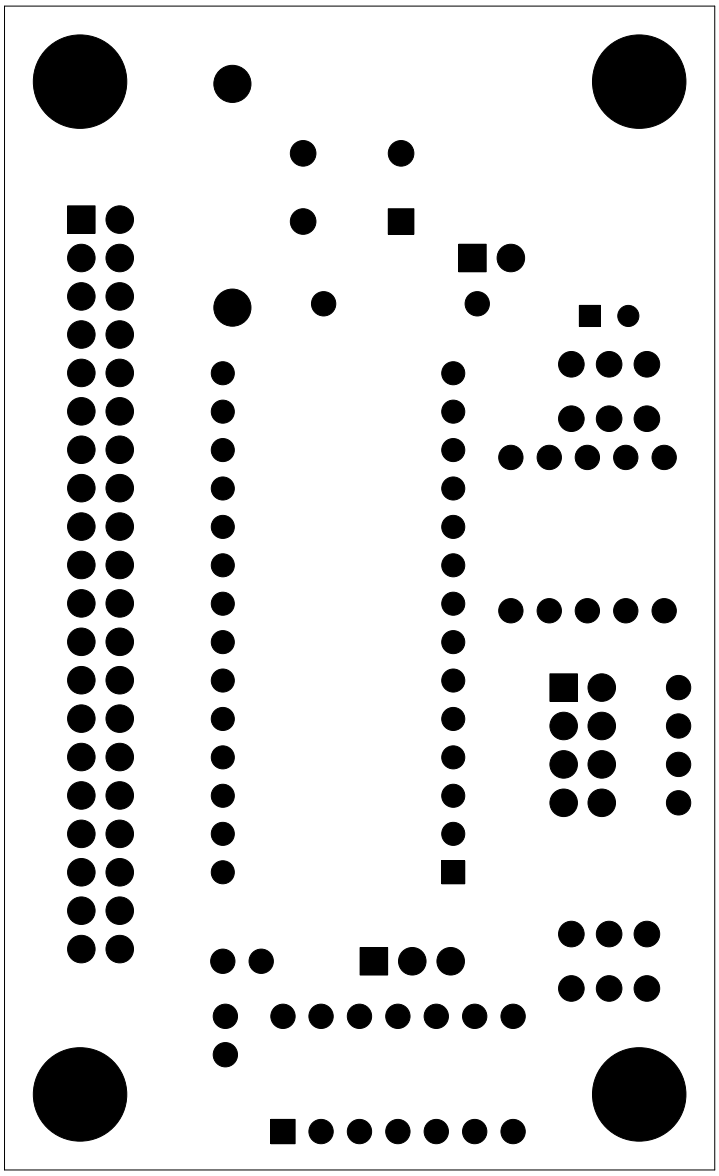
Sven Petersen 2023	Doc.-No.: 163-2-01-02	
	Cu: 35µm	Cu-Layers: 2
PET_Diag_Clip		
25.02.2023 14:47		Rev.: 2
bottom	[redacted]	



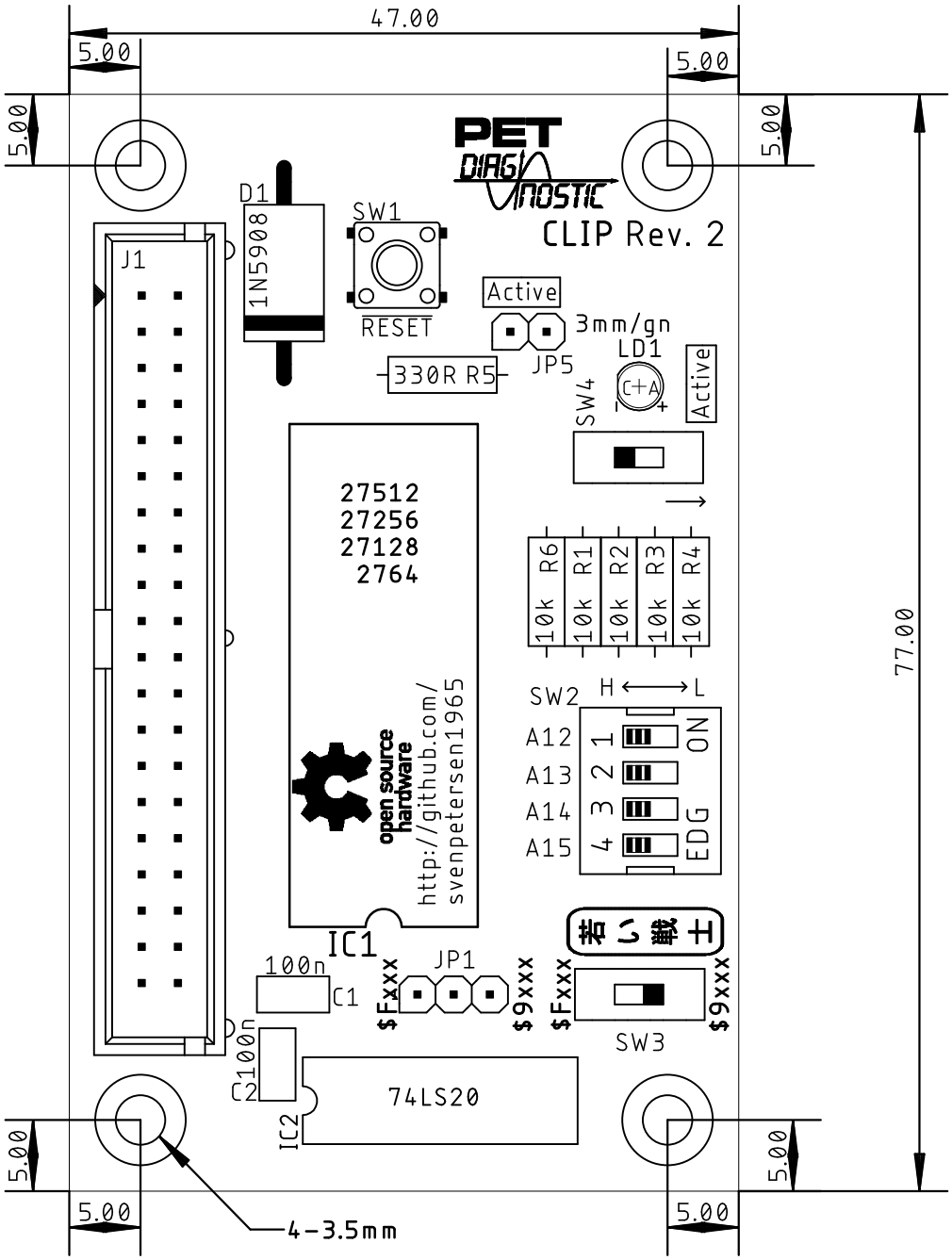
Sven Petersen 2023	Doc.-No.: 163-2-01-02	
	Cu: 35µm	Cu-Layers: 2
PET_Diag_Clip		
25.02.2023 14:47		Rev.: 2
stopmask component side		



Sven Petersen 2023	Doc.-No.: 163-2-01-02	
	Cu: 35µm	Cu-Layers: 2
PET_Diag_Clip		
25.02.2023 14:47		Rev.: 2
stopmask solder side		



Sven Petersen 2023	Doc.-No.: 163-2-01-02	
	Cu: 35µm	Cu-Layers: 2
PET_Diag_Clip		
25.02.2023 14:45		Rev.: 2
placement component side measures		



Commodore PET/CBM80xx/40xx Diagnostic Clip **Rev. 2**

Testing

Test Setup

The tests were conducted with the following setup:

- Diagnostic Clip Rev. 2
- 6502 Ribbon Cable Adapter Rev. 1
- Ribbon Cable (10 cm and 15 cm)
- User Port Dongle Rev. 0
- Keyboard Dongle Rev. 0
- Commodore CBM8032
- Commodore CBM3016

The CBM8032 was tested with the software "80_col_diagnostic_v1.1.bin"

The CBM3016 was tested with the software "901447-30_diagnostic_320350g_$9000.bin"

The software "40_col_diagnostic_v2.0.bin" was partly tested with the CBM3016 and with the CBM8032.

The 6502 was inserted into the ribbon cable adapter, which then was installed in the CPU socket of the respective computer. The ribbon cable was connected to the ribbon cable adapter.

Later, the diagnostic box was connected to the ribbon cable, the keyboard and the user port dongle were connected to the respective connector of the main board. The IEEE-488 interface was open, the cassette port was not connected to a Datassette.

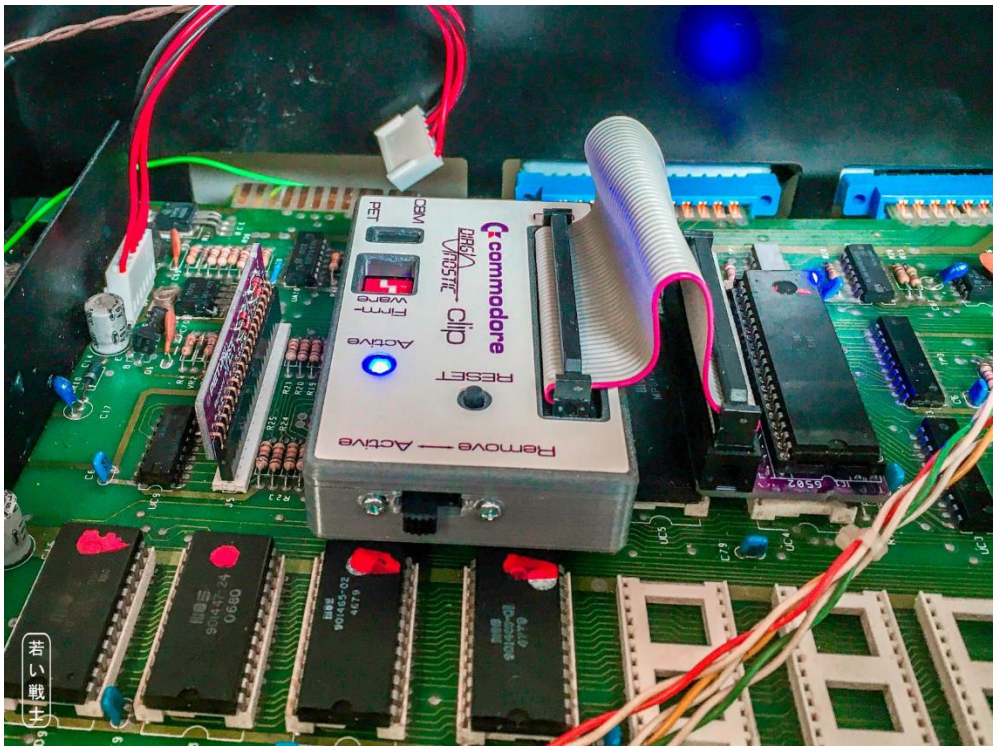


Figure 1: Testing the Diagnostic Clip in the CBM 3016

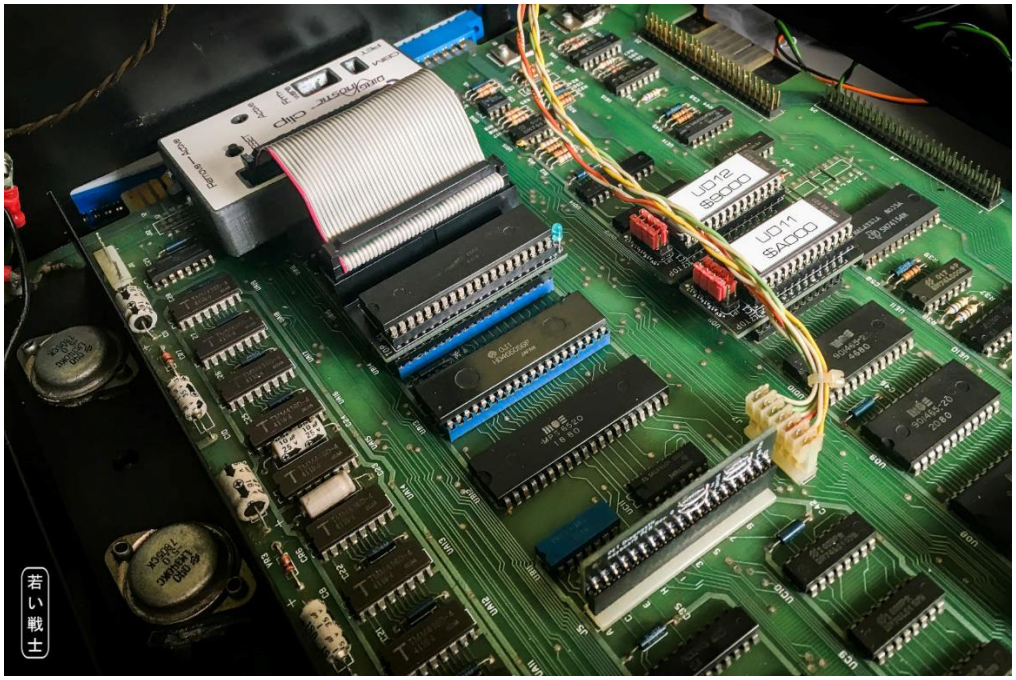


Figure 2: Test in CBM8032

Test Execution

Interference Test

First, the computer was started with the ribbon cable adapter with the ribbon cable only. The computer was operated over an hour. No crash was experienced. Next, the diagnostic box was connected to the said setup. The computer was used for several hours. No interference was found. **The computer operated properly**.

Diagnostic Test

The User Port and Keyboard Dongles were connected. The Diagnostic Clip was switched to “active”. The computer was switched on.

- The first page of the diagnostic was shown. All tests were performed properly (refer to module description)
- The switch was then toggled to “remove”.
- The actual diagnostic tests were repeatedly performed without error messages until the computer was switched off (refer to module description).

Test Result

The Diagnostic Clip, the adapter and the dongles are working properly.

Commodore PET Diagnostic: Diagnostic Clip Rev. 2
Bill of Material Rev. 2.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
1	1	163-2-01-02	2 Layer	PCB Rev. 2	2 layer, Cu 35µ, HASL, 77.0mm x 47.0mm, 1.6mm FR4
2	1	external DPDT switch wired up	1X02	JP5	Reichelt.de: T217 or AliExpress SS22F25-G7 + 6cm AWG24 cable
3	1	2x20 box header, 2.54mm pitch	2X20WV	J1	2x20, box pin header or standard pin header, e.g. reichelt.de WSL 40G
4	2	100n/50V	C-2,5	C1, C2	cer. cap, 2.5mm pitch
5	5	10k	R-10	R1, R2, R3, R4, R6	1/4W, 5%
6	1	1N5908	DO-201	D1	5V TVS diode. ST Micro. E.g. Reichelt: 1N 5908, tme.eu: 1N5908
7	1	330R	R-10	R5	1/4W, 5%
8	1	3mm/gn	3MM	LD1	standard LED 3mm/green + 5mm distance holder for 3mm LED
9	1	74LS20	DIL-14	IC2	e.G. RENESAS, e.G. Reichelt LS 20
10	1	DIPSW-04	DIPSW-04V-COMBI	SW2	Standard DIP-Switch with 4 switches (switch side facing up) The DIP-Switch can be replaced with a 2 switch DIP Switch and hardwire switch 3 and 4. Reichelt NT 04 or NT 02
11	1	mini slide switch, 2.54mm, DPDT, through hole	DPDT_9MM	SW3	Ali Express, ebay, Amazon, search term "MSS22D18"
12	1	mini slide switch, 2.54mm, DPDT, through hole	DPDT_9MM	SW4	do not place
13	1	JTP-1130	JTP-1130	SW1	standard TACT switch 6mm x 6mm, height = 13mm
14	1	JUMPER1x3	1X03	JP6	do not place
15	1	M27C512-DIP28	DIL28-6	IC1	M27C512 EPROM (or M27C256 or M27C128)
16	1	DIP 28 socket, low profile		(IC1)	e.g. Reichelt.de: GS 28P
17	1	2x20 pin IDC receptacle, pitch 2.54mm			e.g. Reichelt.de: PFL 40
18	15	cm ribbon cable, 40p, AWG28			e.g. Reichelt.de: AWG 28-40G 3M