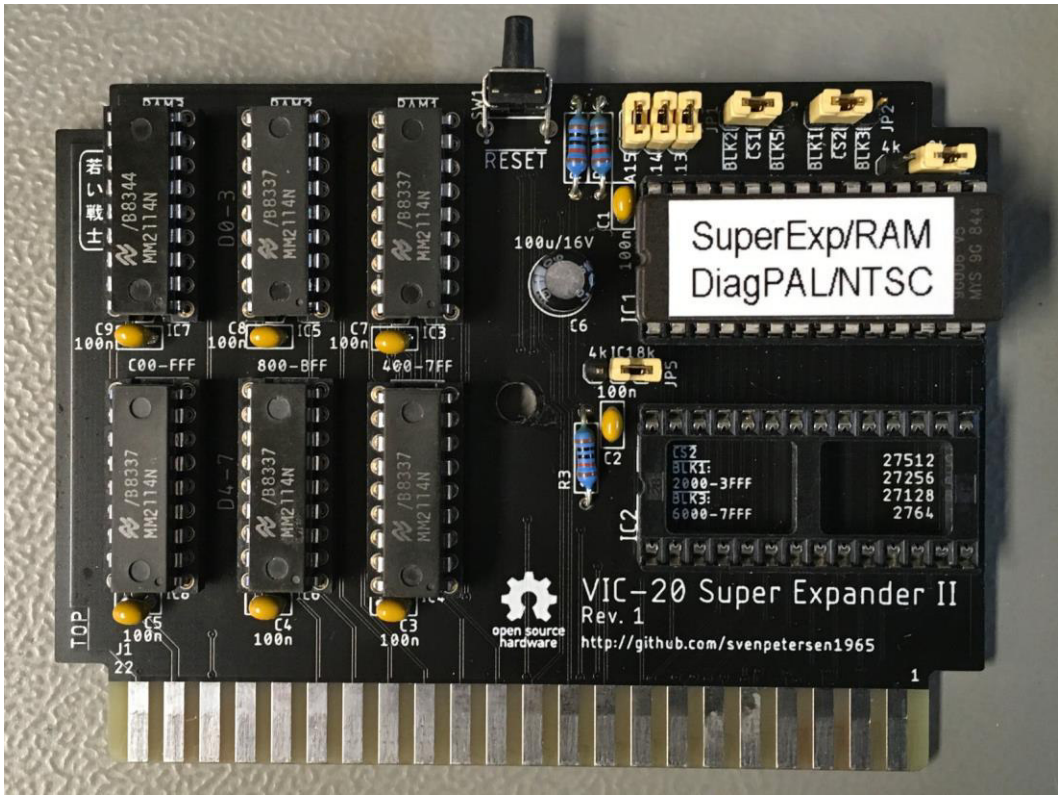
Project Documentation

Commodore VIC-20: Super Expander II

Project number: 157

Revision: 1

Date: 16.07.2021



Commodore VIC-20: Super Expander II Rev. 1

Module Description

General Description

The original Commodore VIC-1211A Super Expander is a Basic Extension, which contains high resolution graphics and sound commands and additional 3kB of RAM. It is a pretty versatile cartridge, which allows up to two 2364 ROMs, that can be configured to use either the 8k chip-selects /BLK2, /BLK5, /BLK1or /BLK3. The configuration is done with solder bridges.

Figure 1: The Commodore VIC-1211A Super Expander Cartridge

With less RAM (1k) and another software, the same PCB is used as a (Commodore) diagnostic cartridge for the VIC-20.

The disadvantage for own projects is the usage of 2364/2332 ROMs. Thus, the Super Expander II is a version of the original Super Expander cartridge that can fit up to two 27C512 EPROMs. The configuration is done with jumpers, which also work as solder bridges (no pin header required), in case the configuration is not desired to be changed.

Two of the chip-select signals apply to each EPROM. The 8k memory bank can be selected with three jumpers. The selection applies to both EPROMs.

The 2114 4x1k (static) RAMs are the same, like in the original Super Expander. They are still available from some retro computer stores for a comparatively good price and also from AliExpress (search term “upd2114”).

Configuration

Chip selects

EPROM	Jumper	Chip Select	VIC-20 Address
IC1	JP1	$\overline{\text{BLK2}}$	$4000 - $5FFF
		$\overline{\text{BLK5}}$	$A000 - $BFFF
IC2	JP2	$\overline{\text{BLK1}}$	$2000 - $3FFF
		$\overline{\text{BLK3}}$	$6000 - $7FFF

Table 1: Configurable Chip Selects

RAM Address

RAM	Chip Select	VIC-20 Address
IC3 (bit 0-3) IC4 (bit 4-7)	$\overline{\text{RAM1}}$	$0400 - $07FF
IC5 (bit 0-3) IC6 (bit 4-7)	$\overline{\text{RAM2}}$	$0800 - $0BFF
IC7 (bit 0-3) IC8 (bit 4-7)	$\overline{\text{RAM3}}$	$0C00 - $0FFF

Table 2: Mapping of the RAM ICs

Software Size

The original Super Expander used a 2332 ROM, which had a 2nd, low active chip select input, which disabled the ROM while A12 (connected to this 2nd input) was HIGH. This way, the Super Expander can be combined with cartridges, that use the $B000 - $BFFF address space, like the machine language monitor cartridge. The Super Expander II resembles this behavior by optionally setting the chip enable input of the EPROMs HIGH (with A12). This can be selected with JP4 (for IC1) or JP5 (for IC2) being set to "4k". **Default setting is "8k" (chip enable = LOW).**

The address range of the EPROMs (as seen by the CPU) with JP4 ond/or JP5 set to "4k"

EPROM	Jumper	Chip Select	VIC-20 Address
IC1	JP1	$\overline{\text{BLK2}}$	$4000 - $4FFF
		$\overline{\text{BLK5}}$	$A000 - $AFFF
IC2	JP2	$\overline{\text{BLK1}}$	$2000 - $2FFF
		$\overline{\text{BLK3}}$	$6000 - $6FFF

Memory Bank Select

There are two different types of addresses mentioned in this document:

- VIC-20 Address
- EPROM Offset Address

Both types must not be confused! The **EPROM Offset Address** is the address of the selected memory bank within (the program buffer of the EPROM). This is, where you load the different binary files to the EPROM buffer. One of those memory banks is selected with the Jumper JP3. This appears in/is mapped to the **VIC-20** memory at the **address** determined by the chip select $\overline{\text{BLK1/2/3/5}}$ (see Table 1).

JP3			Address Bits			EPROM Address
A15	A14	A35	A15	A14	A13	(Offset)
SET	SET	SET	L	L	L	0x0000 – 0x1FFF
SET	SET	OPEN	L	L	H	0x2000 – 0x3FFF
SET	OPEN	SET	L	H	L	0x4000 – 0x5FFF
SET	OPEN	OPEN	L	H	H	0x6000 – 0x7FFF
OPEN	SET	SET	H	L	L	0x8000 – 0x9FFF
OPEN	SET	OPEN	H	L	H	0xA000 – 0xBFFF
OPEN	OPEN	SET	H	H	L	0xC000 – 0xDFFF
OPEN	OPEN	OPEN	H	H	H	0xE000 – 0xFFFF

Table 3: 8k cartridges memory banks

EPROMs

Four different types/sizes of EPROMs can be used with the Super Expander II, not all settings make sense with them. Their pin out is shown in Table 4.

The effect of the settings and the recommended configurations are shown in Table 5.

						27C64					
						27C128					
						27C256					
						27C512					
						SOCKET					
Vpp	Vpp	Vpp	A15	1	A15	VCC	28	VCC	VCC	VCC	VCC
A12	A12	A12	A12	2	A12	A14	27	A14	A14	/PGM	/PGM
A7	A7	A7	A7	3	A7	A13	26	A13	A13	A13	n.c.
A6	A6	A6	A6	4	A6	A8	25	A8	A8	A8	A8
A5	A5	A5	A5	5	A5	A9	24	A9	A9	A9	A9
A4	A4	A4	A4	6	A4	A11	23	A11	A11	A11	A11
A3	A3	A3	A3	7	A3	/OE	22	/G/Vpp	/G	/G	/G
A2	A2	A2	A2	8	A2	A10	21	A10	A10	A10	A10
A1	A1	A1	A1	9	A1	GND	20	/E	/E	/E	/E
A0	A0	A0	A0	10	A0	D7	19	D7	D7	D7	D7
D0	D0	D0	D0	11	D0	D6	18	D6	D6	D6	D6
D1	D1	D1	D1	12	D1	D5	17	D5	D5	D5	D5
D2	D2	D2	D2	13	D2	D4	16	D4	D4	D4	D4
GND	GND	GND	GND	14	GND	D3	15	D3	D3	D3	D3

Table 4: EPROM pin compatibility

EPROM	Size	A15	A14	A13
27C512	64kx8	yes	yes	yes
27C256	32kx8	HIGH	yes	yes
27C128	16kx8	HIGH	HIGH	yes
27C64	8kx8	HIGH	HIGH	HIGH

Table 5: Settings per EPROM type

In case Vpp is located at a dedicated pin (pin 1), A15 has no effect anymore. A HIGH level is recommended (switch is off). The /PGM Pin should be set HIGH. The n.c. (not connected) pin should be HIGH (with pull-up resistor) or open.

Using parallel EEPROMs

There are ***parallel*** EPROMs, which fit into the EPROM sockets. They do not require erasing with a UV eraser, like EPROMs, but the price is higher.

Since they can be written, which is controlled by the $\overline{WE}$ signal, but the Super Expander II cartridge is lacking of this functionality, this signal has to be HIGH (inactive). The 28C256 has the A14 signal connected to Pin 1, which is A15 of the EEPROM socket. This is no problem, but it has to be kept in mind, that the jumper for A15 has effect on the bank select A14 of the EPROM.

			28C64				
			28C256				
			SOCKET				
n.c.	A14	1	A15	VCC	28	VCC	VCC
A12	A12	2	A12	A14	27	/WE	/WE
A7	A7	3	A7	A13	26	A13	n.c
A6	A6	4	A6	A8	25	A8	A8
A5	A5	5	A5	A9	24	A9	A9
A4	A4	6	A4	A11	23	A11	A11
A3	A3	7	A3	/OE	22	/G/Vpp	/OE
A2	A2	8	A2	A10	21	A10	A10
A1	A1	9	A1	GND	20	/E	/CE
A0	A0	10	A0	D7	19	D7	D7
D0	D0	11	D0	D6	18	D6	D6
D1	D1	12	D1	D5	17	D5	D5
D2	D2	13	D2	D4	16	D4	D4
GND	GND	14	GND	D3	15	D3	D3

Table 6: EEPROM pin compatibility

EEPROM	Size	A15	A14	A13
28C256	32kx8	=A14	OPEN	yes
28C64	8kx8	OPEN	OPEN	OPEN

Table 7: Settings per EEPROM type

Dimensions

The dimensions of the Super Expander II are identical to those of the original super Expander PCB.

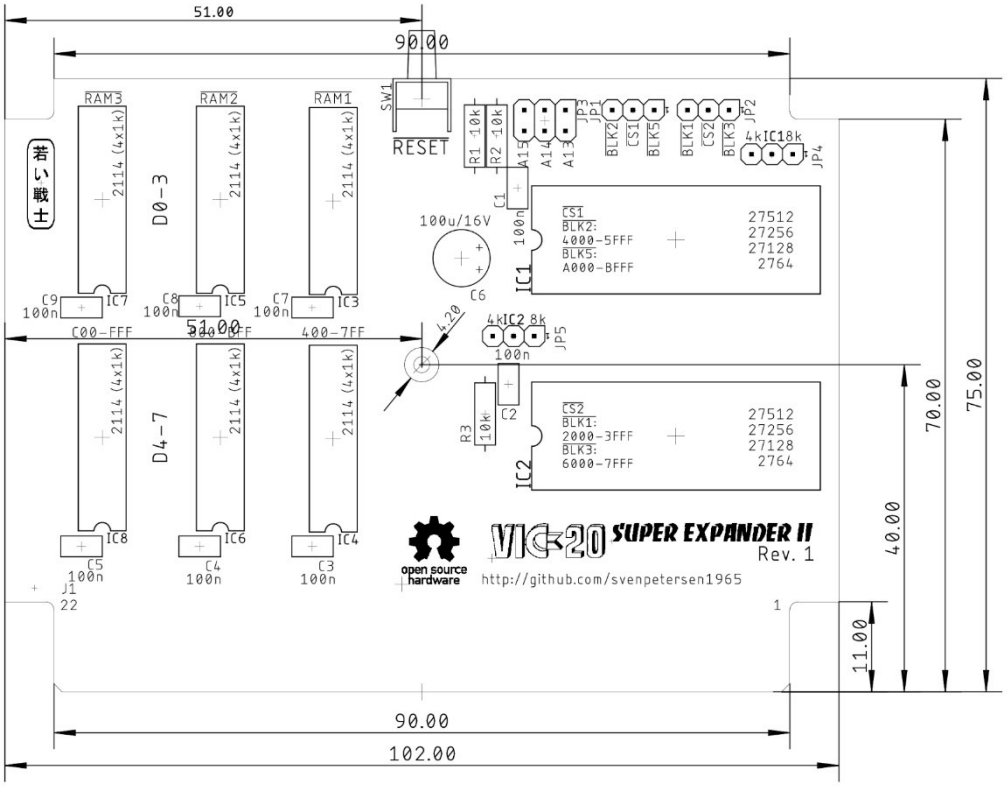


Figure 2: Dimensions of the Super Expander II

The PCB fits the original super Expander cartridge case, another VIC-20 cartridge case from Commodore or the [tfw8bit.com](tfw8bit.com) cartridge case.

The VIC-20 cartridge cases are high enough to fits the Super Expander II PCB even with the ICs on sockets and vertical jumpers. This has been verified for the Super Expander case and the tfw8bit case. The tfw8bit case and the "other Commodore VIC-20" cases require two T-shaped board supports in the middle of the lower shell to be removed.

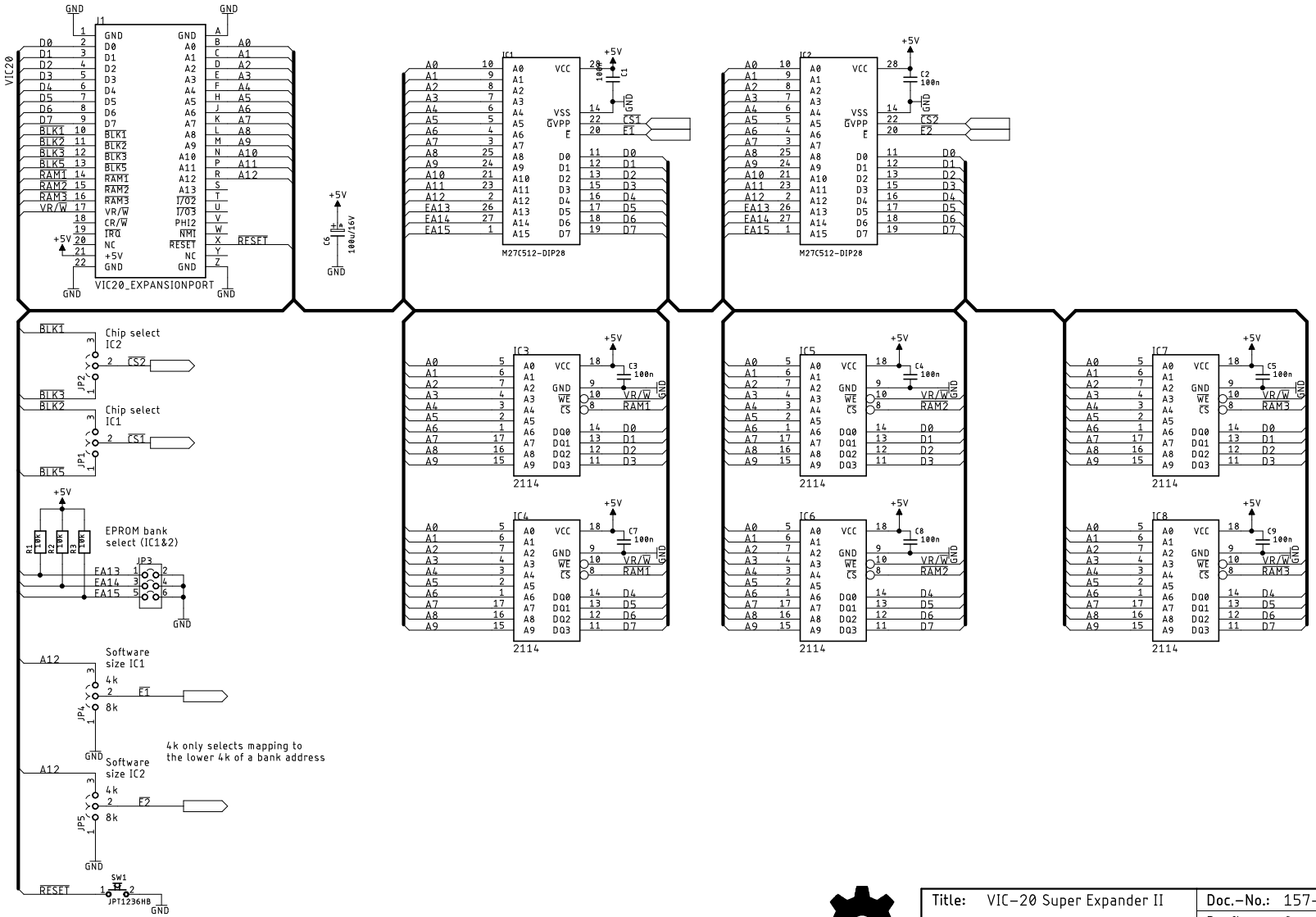
Revision History

Rev. 0

- Prototype: Fully functional.

Rev. 1

- 4k address decoding (lower 4k) enabled
- Type and location of reset switch changed
- Cool new logo



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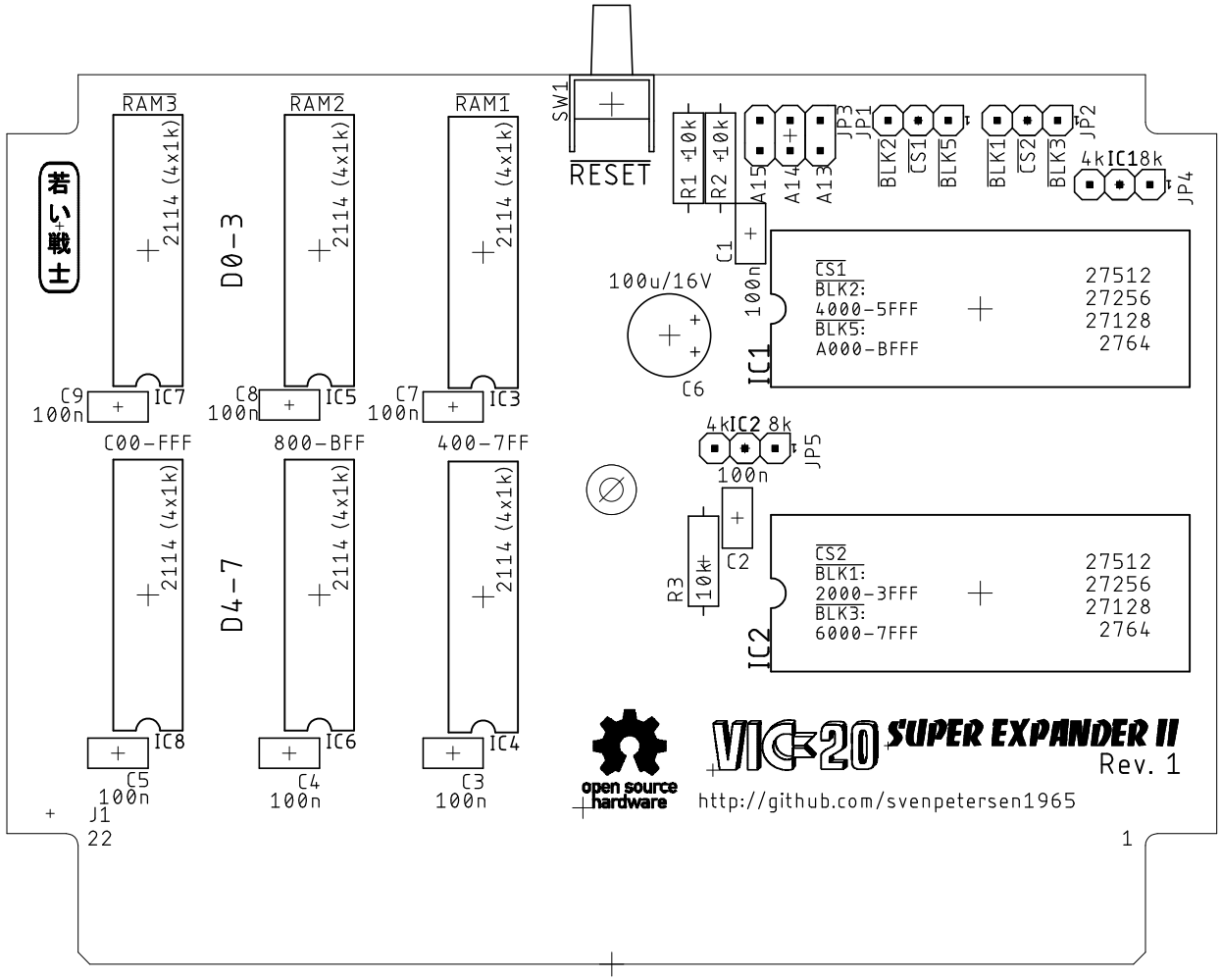
		Draft.:	Sven Petersen
Date:	09.07.2021 11:15	Rev.: 1	Page 1/1
File:	VIC20_SExpII		
	http://github.com/svenpetersen1965		A3

open source hardware

Sven Petersen 2021	Doc.-No.: 157-2-01-01	
	Cu: 35µm	Cu-Layers: 2
VIC20_SExpII		
09.07.2021 10:48		Rev.: 1
placement component side		



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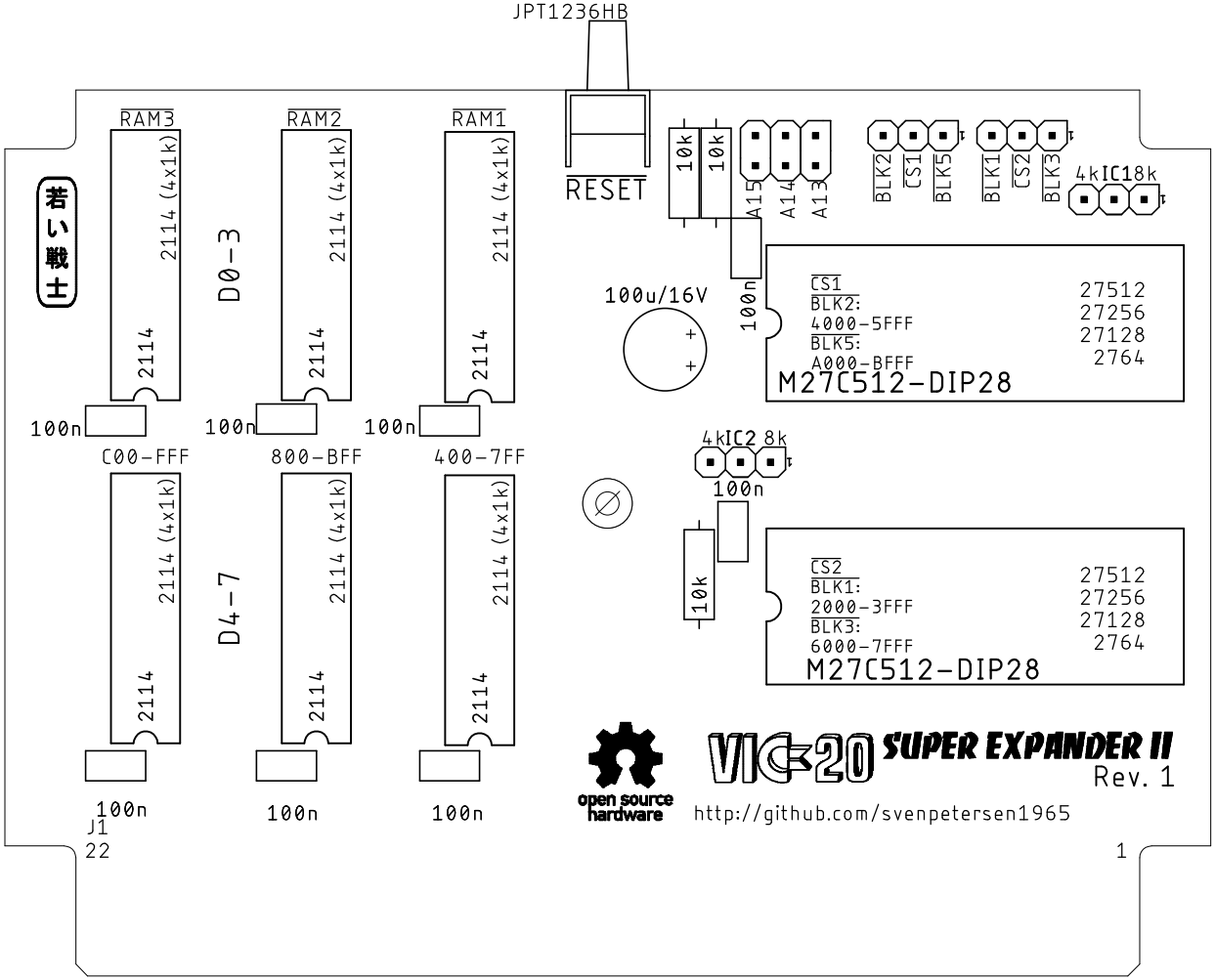

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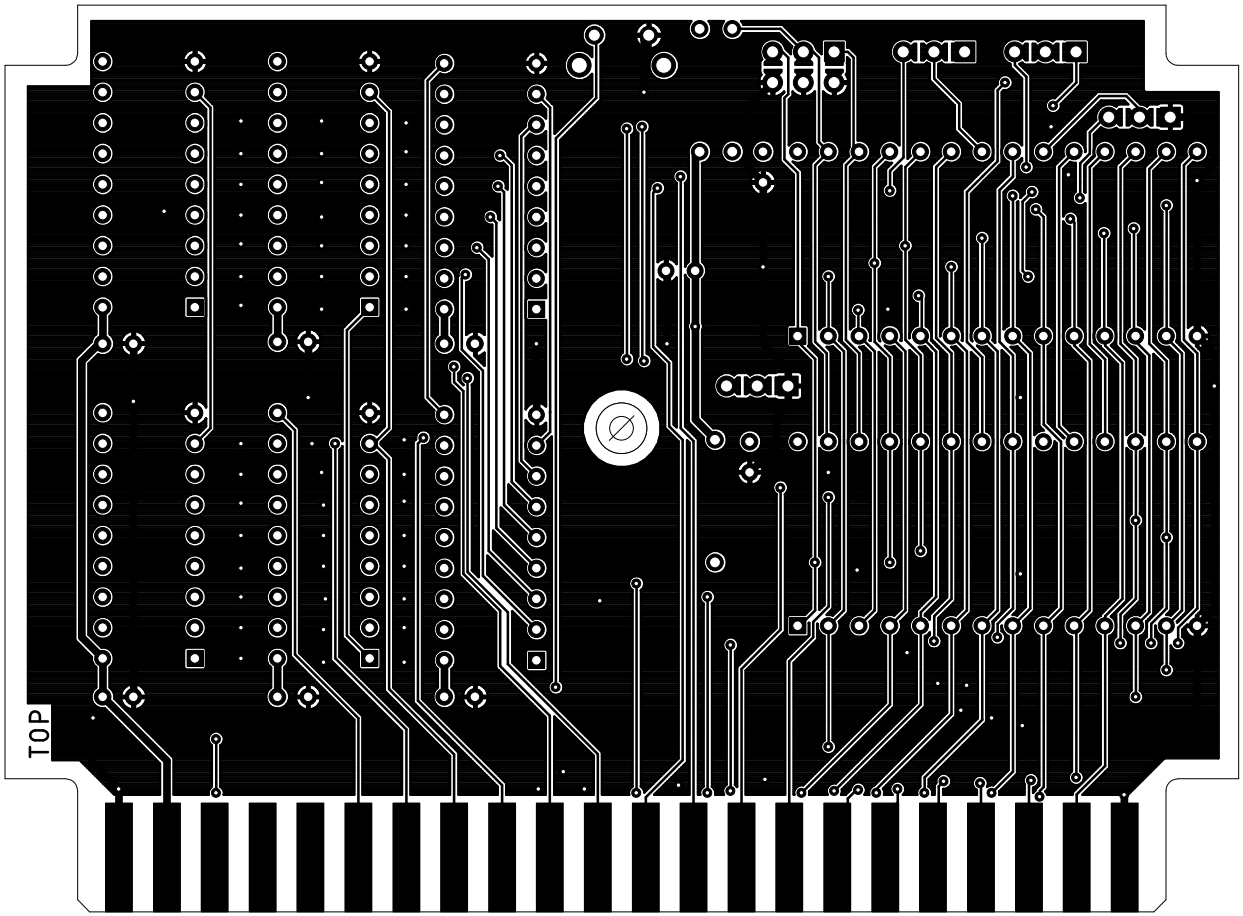

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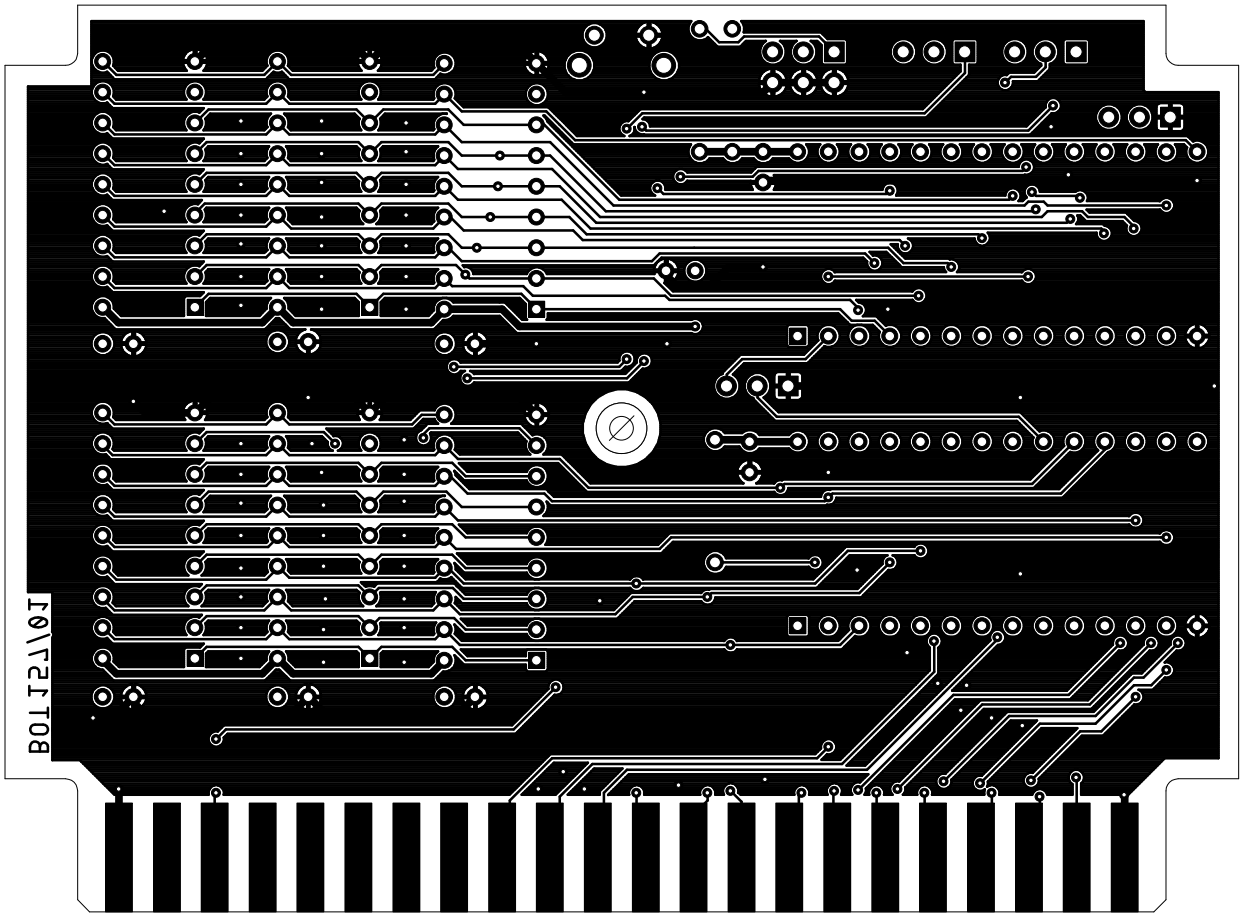

Sven Petersen 2021	Doc.-No.: 157-2-01-01	
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VIC20_SExpII		
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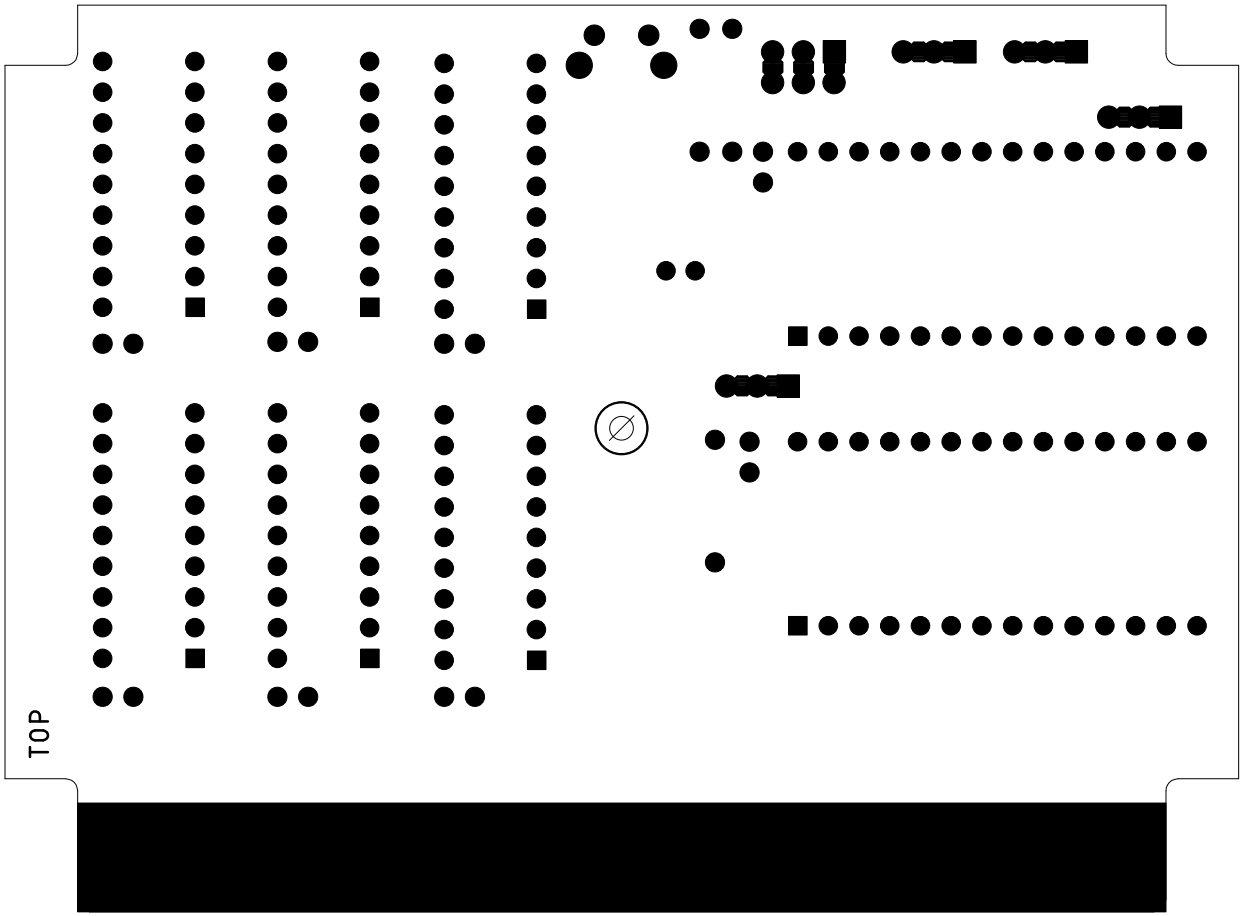
stopmask component side		



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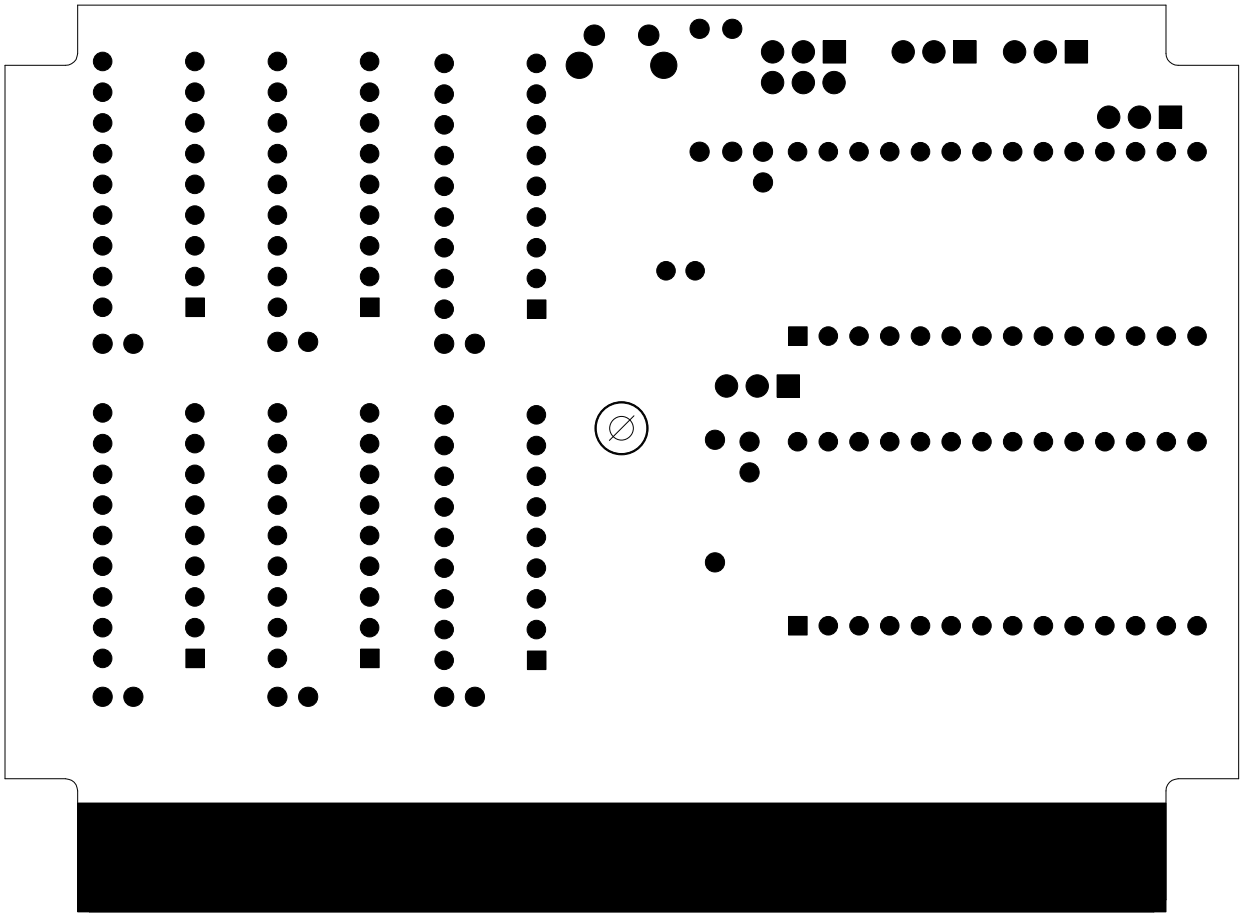

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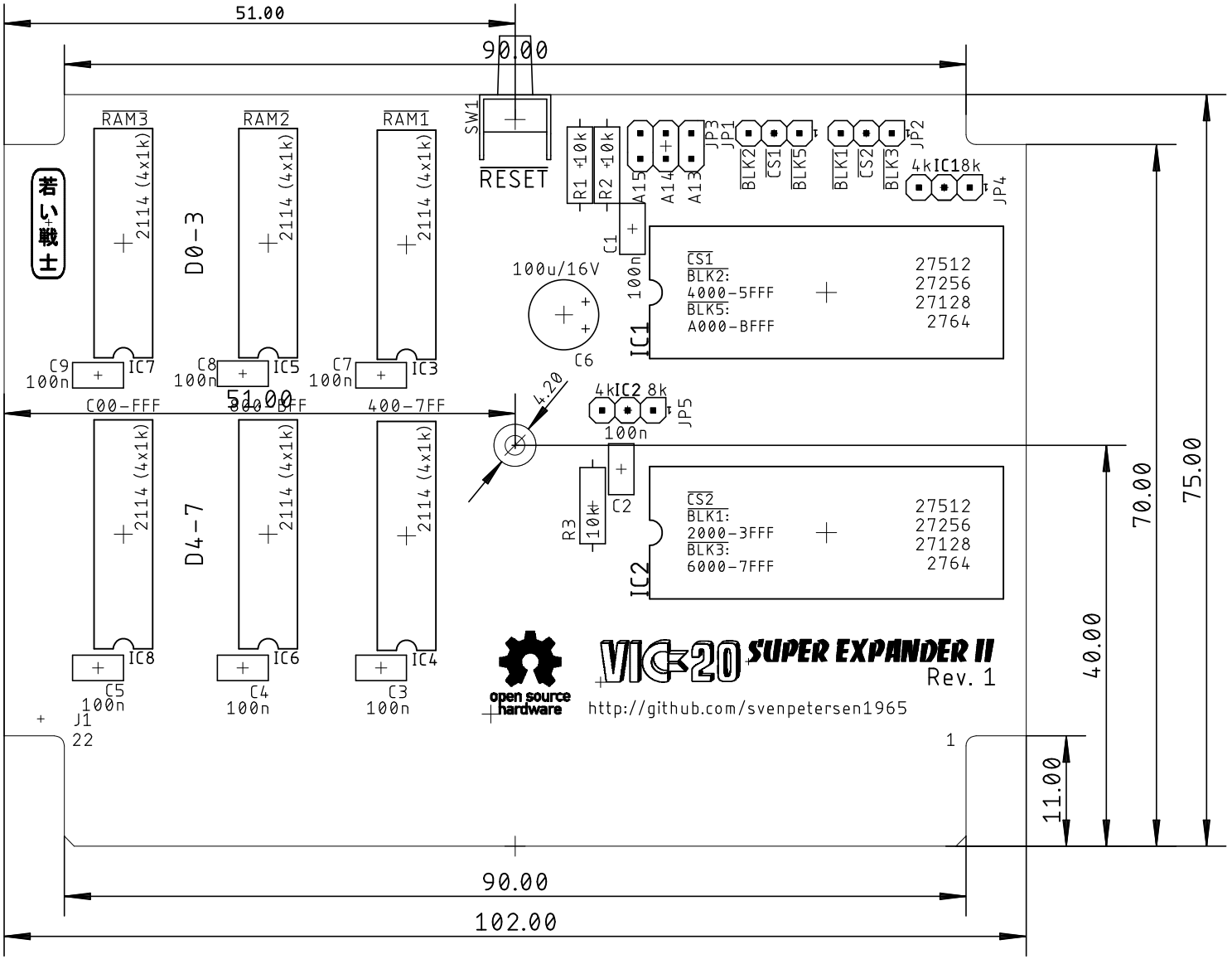
placement component side measures		



Commodore VIC-20: Super Expander II Rev. 1

Testing

Test Setup

The tests were conducted with a VickyTwenty (Reproduction of ASSY 250403 Rev. D) and a Super Expander II cartridge (Rev. 1) with 3k of RAM (6 pcs of National Semiconductor MM2114N) and up to two (ST) 27C512 EPROMs (120ns).

Figure 1: Test Setup

Test Execution

Super Expander Software

First, the original Super Expander Software from zimmers.net and the Commodore VICMON for $B000 were programed to an EPROM. These two programs fit into one 8k memory bank, since the Super Expander software is a 4k software. The EPROM was inserted the in IC1 socket and $\overline{\text{CS1}}$ (JP1) was set to $\overline{\text{BLK5}}$ ($A000-$BFFF). The software size of 8k (for IC1) was set on JP4.

The cartridge was inserted into the VickyTwenty and the computer was switched on. It booted normally and 6519 Bytes Free were reported. The Super Expander requires bytes in RAM, so this is correct.

The function keys produce some of the additional Super Expander instructions. A short program, which is using those instructions, was executed successfully.

- ✓ Function of RAM and EPROM IC1 with $\overline{\text{BLK5}}$ and the Super Expander Software verified.

SYS11*4096 (which is $B000) started the VICMON.

- ✓ Additional test.

The software size was configured to 4k (JP4). So, the VICMON was not visible anymore. The VIC-20 booted properly.

SYS11*4096 resulted in a software crash, which shows that the software size selection is working.

- ✓ Software size selection (4k/8k) for IC1 is working properly.

RESET Button

The RESET button (SW1) was pressed. The VIC-20 rebooted properly.

- ✓ RESET button verified

RAM Expansion Test software

The jumpers on JP3 were set to the 2nd 8k (A15..13: set/set/open), JP1 remained at $\overline{\text{BLK5}}$.

The software was executed properly. The 3k RAM expansion was found. Over 10,000 test cycles were carried out properly.

- ✓ The bank selection on JP3 (001) works properly
- ✓ RAM works properly

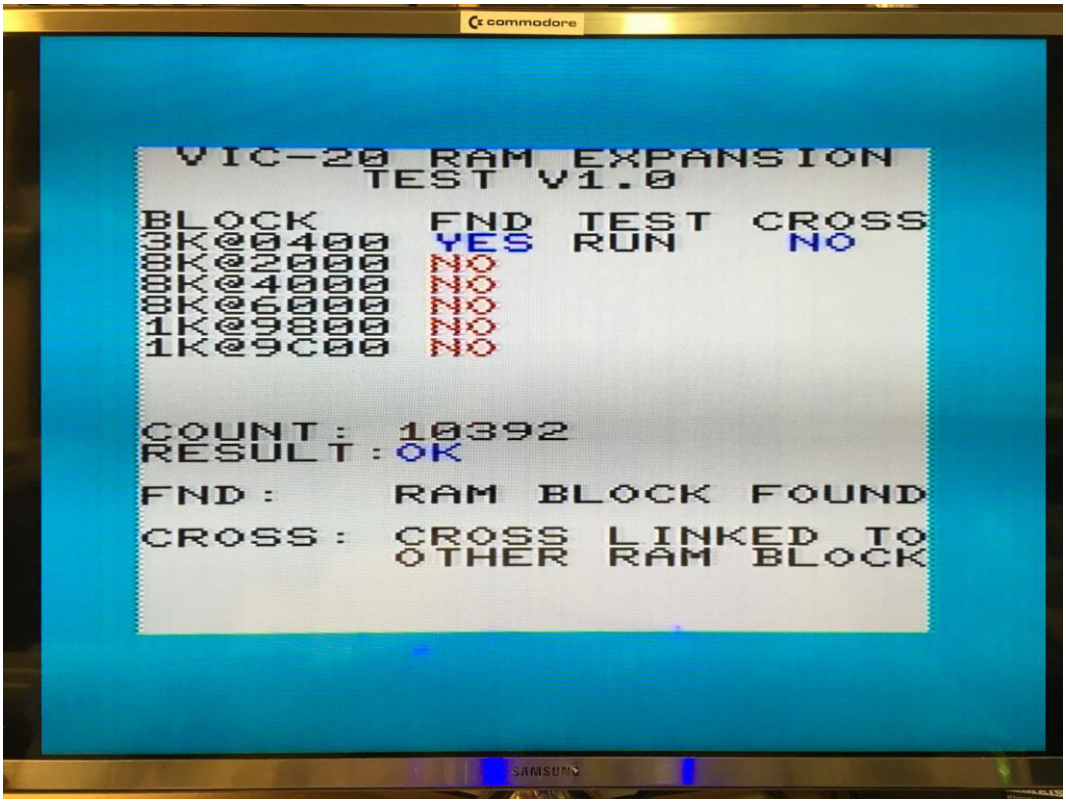


Figure 2: 3k RAM Expansion Test

VIC-20 Diagnostic Software

The software (PAL) also origins from zimmers.net. It was programmed into the 2nd 8k of the said EPROM, a different version of this software (NTSC) was programmed to the 3rd 8k.

The jumpers on JP3 were set to the 3rd 8k (A15..13: set/open/set), JP1 remained at $\overline{\text{BLK5}}$.

The diagnostics software started and executed properly (together with the VIC-20 diagnostics harness). For the 2nd version of the diagnostic software, JP3 was set to the 3rd 8k bank (A15..13: set/open/open). This software executed properly, too.

- ✓ **Bank select (000, 001, 010, 011) on JP3 verified**

Game Cartridge Donkey Kong

This game is a 16k game and requires both EPROMs.
The software for $A000 was programmed in a fresh EPROM, which was inserted into IC1. JP1 remained at $\overline{\text{BLK5}}$. The other part of the software, which is located at $2000 was programmed into another fresh EPROM, which was then inserted into the IC2 socket. JP2 was set to $\overline{\text{BLK1}}$. All jumpers on JP3 were set.

The software started properly and the game could be played.

- ✓ **EPROM IC2 with $\overline{\text{BLK1}}$ verified**

Game Cartridge AE

The software origins from zimmers.net. It consisted of two images, one for $A000 and one for $6000. The images were programmed into two EPROMs, the $A000 software was inserted into IC1, the $6000 software into IC2. Jumper JP1 was set to $\overline{\text{BLK5}}$, JP2 to $\overline{\text{BLK3}}$. The software started properly and the game could be played. The software size (JP4 and JP5) was set to 8k.

- ✓ **EPROM IC2 with $\overline{\text{BLK3}}$ verified**

VIC-MON (for $4000)

The source of this software is once again zimmers.net. It was programmed into the 5th 8k memory bank (@ buffer address $8000) of an EPROM. The EPROM was inserted into IC1 and JP1 was set to $\overline{\text{BLK2}}$.

SYS4x4096 started the software properly.

- ✓ **Bank select (100) on JP3 and $\overline{\text{BLK2}}$ (JP1) verified**

Installation in cartridge cases

The fully assembled Super Expander II PCB (all ICs on sockets and all vertical jumpers) was installed in the **original Commodore Super Expander cartridge case**- This could be accomplished without a problem.

The **original Commodore Game cartridge case** required removing some support structures for small PCBs, after that, it also fit.

The **tfw8bit.com VIC-20 cartridge case** fits after removing the support structures for the short PCBs.

- ✓ **Dimensions verified**

Conclusion

The Super Expander II Rev. 1 is fully functional

Commodore VIC-20: Super Expander II Rev. 1
Bill of Material Rev. 1.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
1	1	157-2-01-01	2 Layer	PCB Rev. 1	2 layer, Cu 35µ, HASL, 102.0mm x 75.0mm, 1.6mm FR4
	8	100n	C-2,5	C1, C2, C3, C4, C5, C7, C8, C9	Ceramic capacitor, pitch 2.5mm (25V or 50V)
	1	100u/16V	C07/2,5	C6	Electrolytic cap, pitch 2.5mm
	3	10k	R-10	R1, R2, R3	Metal fil resistor
	6	2114	DIL18	IC3, IC4, IC5, IC6, IC7, IC8	1k x 4 Static RAM. Type 2114. AliExpress search term "uPD2114". Or some retro computer stores like restore-store.de
	6	DIP18-Sockets		(IC3), (IC4), (IC5), (IC6), (IC7), (IC8)	optional
	4	1x3 pin header (2.54mm pitch)	COMBI-3P	JP1, JP2, JP4, JP5	standard pin header (option, can be configured with solder bridge)
	1	3X2 pin header (2.54mm pitch)	COMBI-3X2	JP3	standard pin header (option, can be configured with solder bridge)
	7	jumper 2.54mm		(JP1), (JP2), (JP3), (JP4), (JP5)	standard jumper. Refer to JP1-3
	1	JTP-1130	JTP-1130	SW1	6 x 6 mm tact switch (standard)
	1	M27C512-DIP28	DIL28-6	IC1	EPROM: 27C64, 27C128, 27C256 possible. Refere to document 157-6-02-**
	1	M27C512-DIP28	DIL28-6	IC2	option, not required for super expander
	2	DIP28-Sockets		(IC1), (IC2)	option, refer to IC1 and IC2