Project Documentation

Commodore VIC-20: Hyper Expander

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Revision: 2

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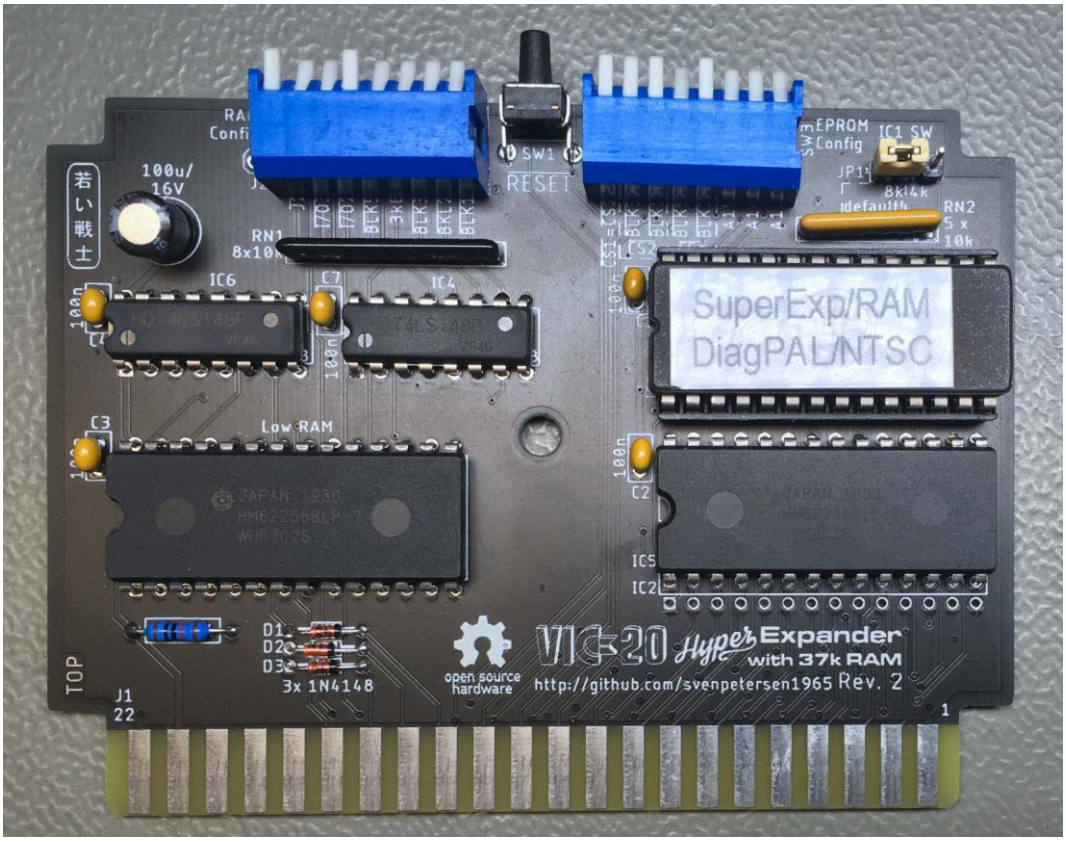

Commodore VIC-20: Hyper Expander Rev. 2

Module Description

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Introduction

The Hyper Expander is a cartridge for the Commodore VIC-20, which provides up to 16kB EPROM and up to 37kB RAM. It is a super-set of the original Commodore VIC-1211A Super Expander, which provides only 3k of RAM.

The Hyper Expander can hold up to two 27C512 EPROMs, the 8k memory bank of both EPROMs (A13...A15) can be selected for both EPROMs. The same selection applies to both of them. Each EPROM (IC1 and IC2) can be configured to two chip selects (one each). That is $\overline{\text{BLK2}}$ or $\overline{\text{BLK5}}$ for IC1 and $\overline{\text{BLK1}}$ or $\overline{\text{BLK3}}$ for IC2 or in case SW3, switch 8 (CS1 = CS2) is selected, all four chip selects can be assigned to one EPROM (one at a time!).

The RAM consists of two 32kB 62256 type static RAMs. The memory is divided into four banks each. Two 74LS148 decode the active chip selects to one of each memory bank. The used chip selects can be configured with SW2.

Configuration

Note

The chip selects of the EPROM and the RAM can be concurrent. The same chip select must not be used for RAM and EPROM at the same time.

DIP-Switches

There are two DIP Switches, which are used to configure the cartridge. The footprints of the DIP-switches are versatile and offer several ways for a fix or variable configuration:

1. A fix configuration via solder bridges
2. Jumpers
3. Horizontal DIP-switches
4. Vertical DIP-switches with 2.54mm (0.1″) row distance
5. Vertical (piano style) DIP-switches with 7.62mm (0.3″) row distance

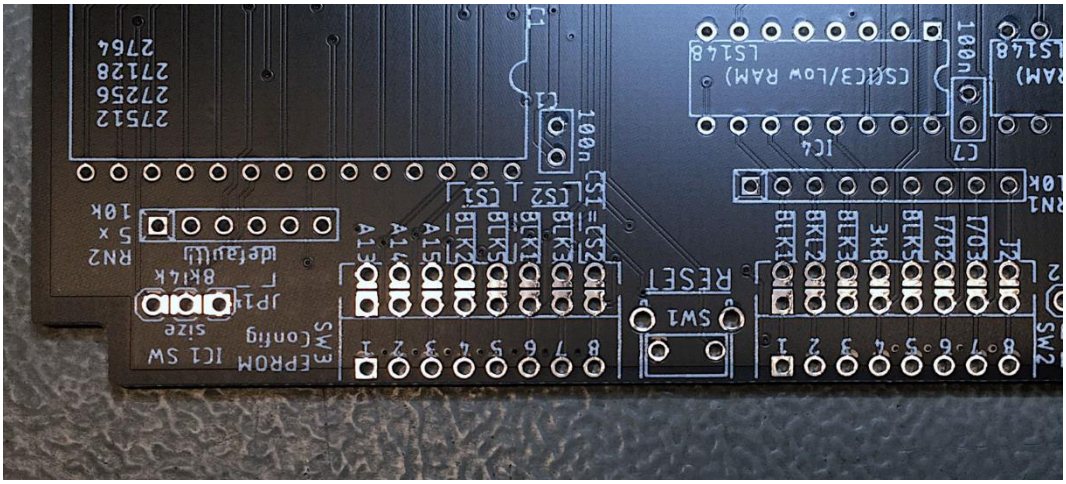


Figure 1: The footprint of the configuration DIP-switches allows a fix configuration with solder bridges

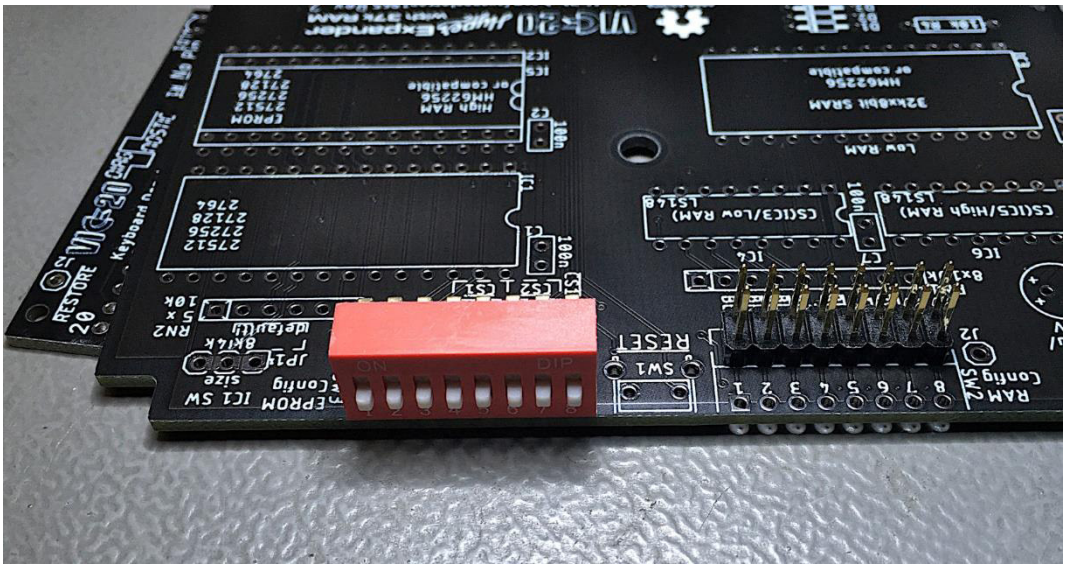


Figure 2: Vertical DIP-switch (row distance 2.54mm) or configuration with jumpers

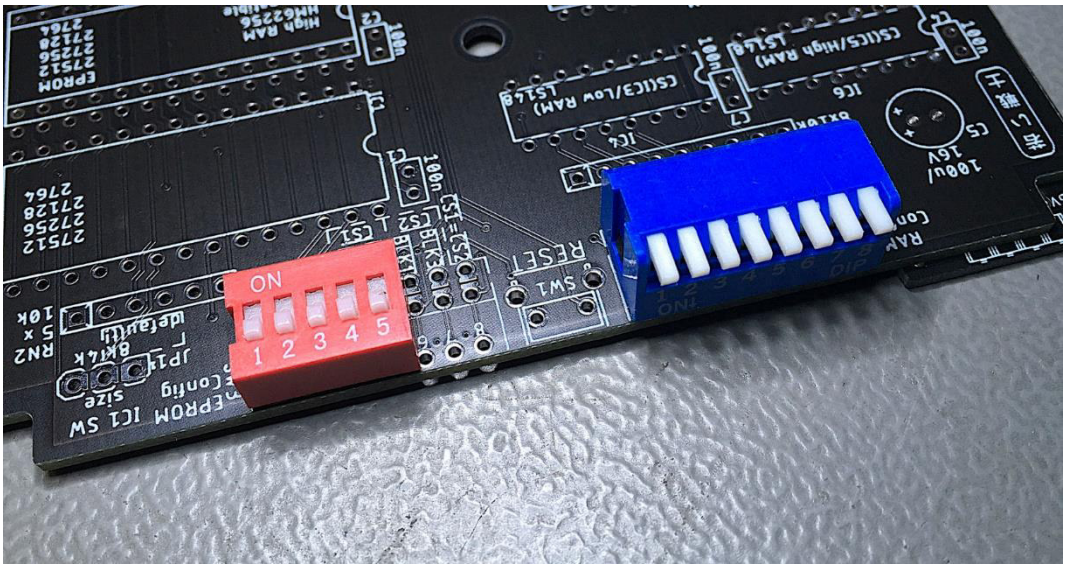


Figure 3: A horizontal or a piano style DIP-switch

SW3 – EPROM configuration

The DIP switches do not need to be 8 switches wide, in case just one EPROM is used (refer to Figure 3). In this case, only a 5 switches wide model is sufficient. For a mere EPROM cartridge, it would be a good idea to program software that uses the same chip select ($\overline{BLK*}$) *(or the same two chip selects for a 16k cartridge) and configure those with solder bridges. This way, the cartridge cannot be misconfigured.*

Switch	Function	VIC-20 Address	Note
SW3-1	EPROM Bank Select A13		Selects 8k Bank
SW3-2	EPROM Bank Select A14		Selects 8k Bank
SW3-3	EPROM Bank Select A15		Selects 8k Bank
SW3-4	IC1 chip select $\overline{BLK2}$	$4000 - $5FFF	
SW3-5	IC1 chip select $\overline{BLK5}$	$A000 - $BFFF	
SW3-6	IC2 chip select $\overline{BLK1}$	$2000 - $3FFF	
SW3-7	IC2 chip select $\overline{BLK3}$	$6000 - $7FFF	
SW3-8	$\overline{CS1}$ = $\overline{CS2}$		All $\overline{BLK*}$ effect both ICs

Table 1: EPROM configuration

In case all four of the previous chip selects should be configured to address one of the EPROMs, switch 8 (" $\overline{CS1}$ = $\overline{CS2}$ ") could be closed. In this case, both chip selects are tied together. **It is only allowed to activate one chip select!** This configuration is desired, in case both RAMs are placed and EPROM software residing at $2000 or $6000 is contained in IC1.

The mapping of the chip selects $\overline{BLK*}$ to the ICs are inherited from the original Super Expander. They support the known 16kB cartridge configurations. Hence, they are not in an ascending sequence on the DIP switch.

In case an EPROM should be deactivated, it is only required to switch the respective switch "off". The chip select then is HIGH (inactive) due to pull-up resistors.

SW3 - Memory Bank Select (EPROM)

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 DIP Switch SW3 (switch 1/2/3). This appears in/is mapped to the VIC-20 memory at the address determined by the chip select $\overline{BLK*}$ (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

SW3-3 A15	SW3-2 A14	SW3-1 A13	Address Bits A15	A14	A13	EPROM Address (Offset)
ON	ON	ON	L	L	L	0x0000 – 0x1FFF
ON	ON	OFF	L	L	H	0x2000 – 0x3FFF
ON	OFF	ON	L	H	L	0x4000 – 0x5FFF
ON	OFF	OFF	L	H	H	0x6000 – 0x7FFF
OFF	ON	ON	H	L	L	0x8000 – 0x9FFF
OFF	ON	OFF	H	L	H	0xA000 – 0xBFFF
OFF	OFF	ON	H	H	L	0xC000 – 0xDFFF
OFF	OFF	OFF	H	H	H	0xE000 – 0xFFFF

Table 2: 8k cartridges memory banks

A switch that is ON corresponds to a SET jumper, in case the cartridge is configured with jumpers instead of DIP-Switches.

For EPROMs smaller than a 27C512, the highest address pins have to be HIGH (see Table 7). To prevent these pins to accidentally be switched to LOW, the corresponding DIP-Switch pins could be clipped off.

IC1 Software Size - JP1

The software size of IC1 can be set to 4kB. In this case, only the first 4kB of an 8kB EPROM bank is active. This may be desired, if the hyper expander (EPROM) should be combined with cartridges, that use the second 4k memory of an 8k bank, like some machine language monitor or serial cartridges do. Of course, this only works with a software, that only requires 4k, like the Super Expander software.

The address range of the EPROMs (as seen by the CPU) with JP1 set to “4k”

Chip Select	VIC-20 Address
$\overline{BLK2}$	$4000 - $4FFF
$\overline{BLK5}$	$A000 - $AFFF
$\overline{BLK1}$	$2000 - $2FFF
$\overline{BLK3}$	$6000 - $6FFF

Table 3: Address ranges with SW size (JP1) set to "4k"

The default software size is 8k. If it is desired to combine two cartridge software (like Super Expander and the VIC-MON machine language monitor, it is recommended to burn those two bin files in the same 8k block at the proper position.

SW2 – RAM Configuration

SW2 activates the chip select signals, that are then decoded and address the respective RAM bank of IC3.

Switch	Jumper	Chip Select	Addresses
SW2-1	1-16	$\overline{\text{BLK1}}$	$2000 - $3FFF
SW2-2	2-15	$\overline{\text{BLK2}}$	$4000 - $5FFF
SW2-3	3-14	$\overline{\text{BLK3}}$	$6000 - $7FFF
SW2-4	4-13	$\overline{\text{CS3K}}$	*$0400 - $0FFF*
SW2-5	5-12	$\overline{\text{BLK5}}$	$A000 - $BFFF
SW2-6	6-11	$\overline{\text{I/O2}}$	$9800 - $9BFF
SW2-7	7-10	$\overline{\text{I/O3}}$	$9C00 - $9FFF
SW2-8	8-9	$\overline{\text{J2}}$	*Unused (experimental)*

Table 4: Settings SW2

BYTES FREE

Be aware, that not all RAM configurations will lead to a more BASIC memory (the BYTES FREE) on switch on. The BASIC memory has to be **coherent**.

The memory map (screen RAM, BASIC RAM) of the VIC-20 depends on the memory expansion. It will be different for internal RAM and 3k Expansion.

RAM Configuration	BYTES FREE
$\overline{\text{CS3K}}$	6655
$\overline{\text{BLK1}}$	11775
$\overline{\text{CS3K}}$ and $\overline{\text{BLK1}}$	11775
$\overline{\text{BLK1}}$ and $\overline{\text{BLK2}}$	19967
$\overline{\text{BLK1}}$, $\overline{\text{BLK2}}$ and $\overline{\textit{BLK3}}$	28159
$\overline{\text{BLK1}}$, $\overline{\text{BLK2}}$, $\overline{\textit{BLK3}}$, $\overline{\text{CS3K}}$ *and* $\overline{\textit{BLK5}}$	*28159*
$\overline{\text{CS3K}}$, $\overline{\text{BLK2}}$, $\overline{\text{BLK3}}$	6655

Table 5: Reported BASIC RAM

RAM that is not visible as BASIC RAM can of course still be accessed. In case $\overline{\text{BLK1}}$ is selected, the lowest 3k are not visible as BASIC RAM. In case a memory gap is configured (like $\overline{\text{BLK2}}$ and $\overline{\textit{BLK3}}$ *are configured, but* $\overline{\text{BLK1}}$ is missing, the BASIC RAM consists of the internal RAM and the 3k RAM expansion.

The **Super Expander** Software (in ROM) requires 136 bytes of RAM. In case this software is activated (it is associated to $\overline{\text{BLK5}}$) the BASIC memory will be reduced by this number of bytes.

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 6.

The effect of the settings and the recommended configurations are shown in Table 7.

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 6: 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 7: 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 8: EEPROM pin compatibility

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

Table 9: Settings per EEPROM type

Dimensions

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

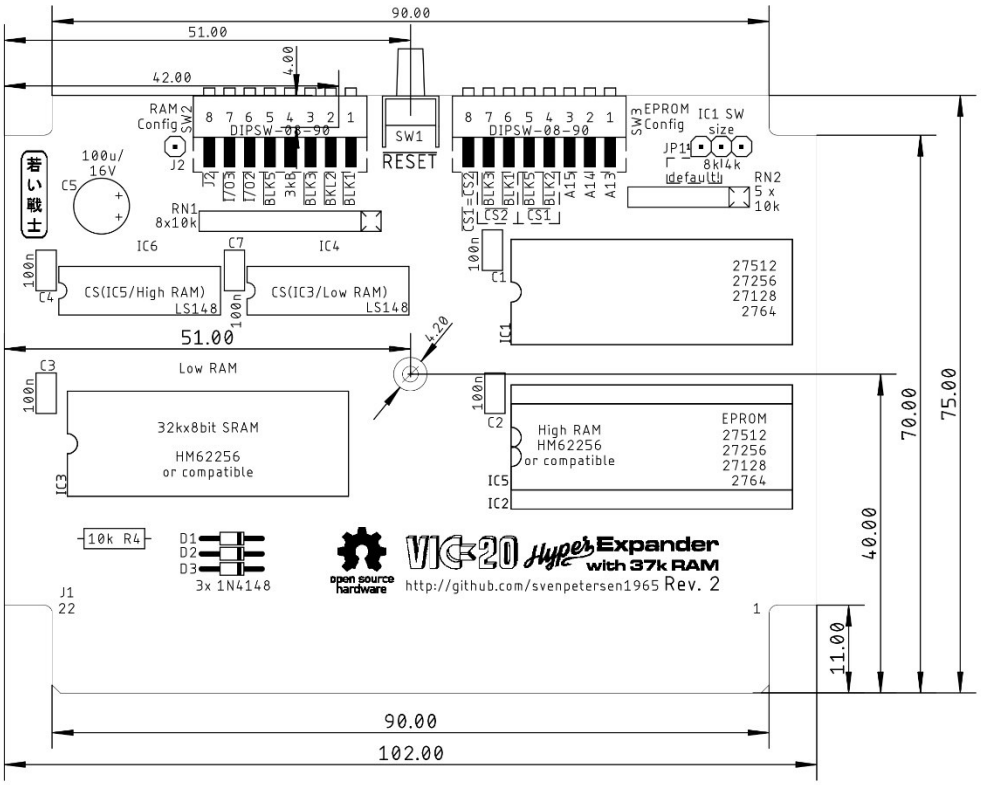


Figure 4: Dimensions of the Hyper Expander

The PCB fits the original Super Expander cartridge case, another VIC-20 cartridge case from Commodore or the 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.

Assembly and BOM

The High RAM (IC5) cannot be installed together with the 2nd EPROM (IC2).

Full RAM Build

Do not place: JP2, IC2

No RAM, just EPROM

Do not place: IC3, C3, IC4, C4, IC5, IC6, C6, RN1, D1-3, R4, SW2

Revision History

Rev. 0

- Prototype: Fully functional.

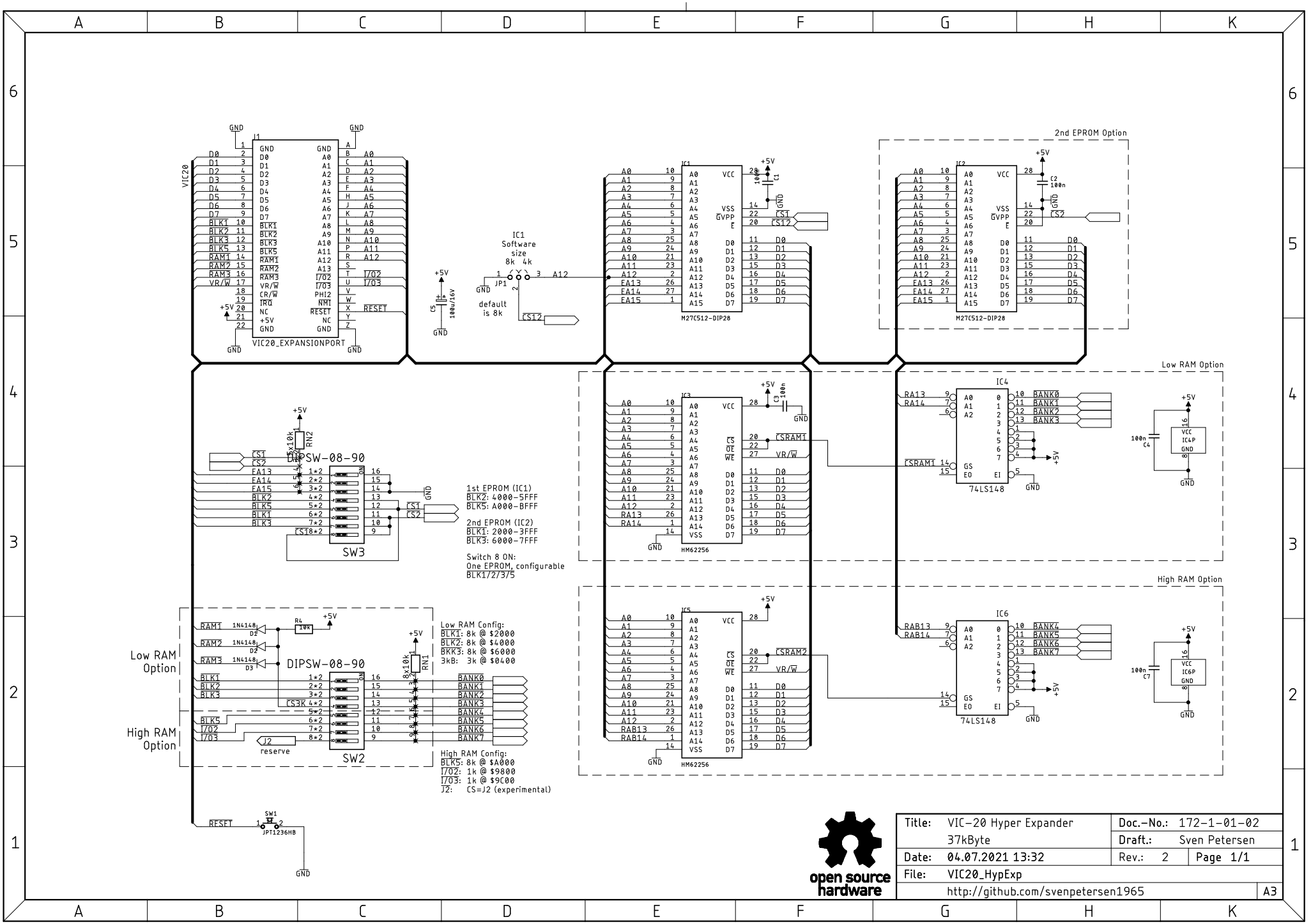
Rev. 1

- Second optional RAM (IC5, "High RAM") to provide the maximum possible RAM

- All jumpers moved to the front edge, so they can be accessed while the cartridge is installed
- Optional vertical RESET switch
- Resistor networks for many pull ups reduce the required space
- Pull ups for the EPROM chip selects

Rev. 2

- A completely new layout
- DIP-Switch option for the jumpers
- All four $\overline{BLK*}$ *can be configured to one EPROM (by setting* $\overline{CS1} = \overline{CS2}$)
- The 4k Software size option for EPROM IC1



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		Draft.:	Sven Petersen
Date:	04.07.2021 13:32	Rev.: 2	Page 1/1
File:	VIC20_HypExp		
	http://github.com/svenpetersen1965		A3

Sven Petersen 2021	Doc.-No.: 172-2-01-02	
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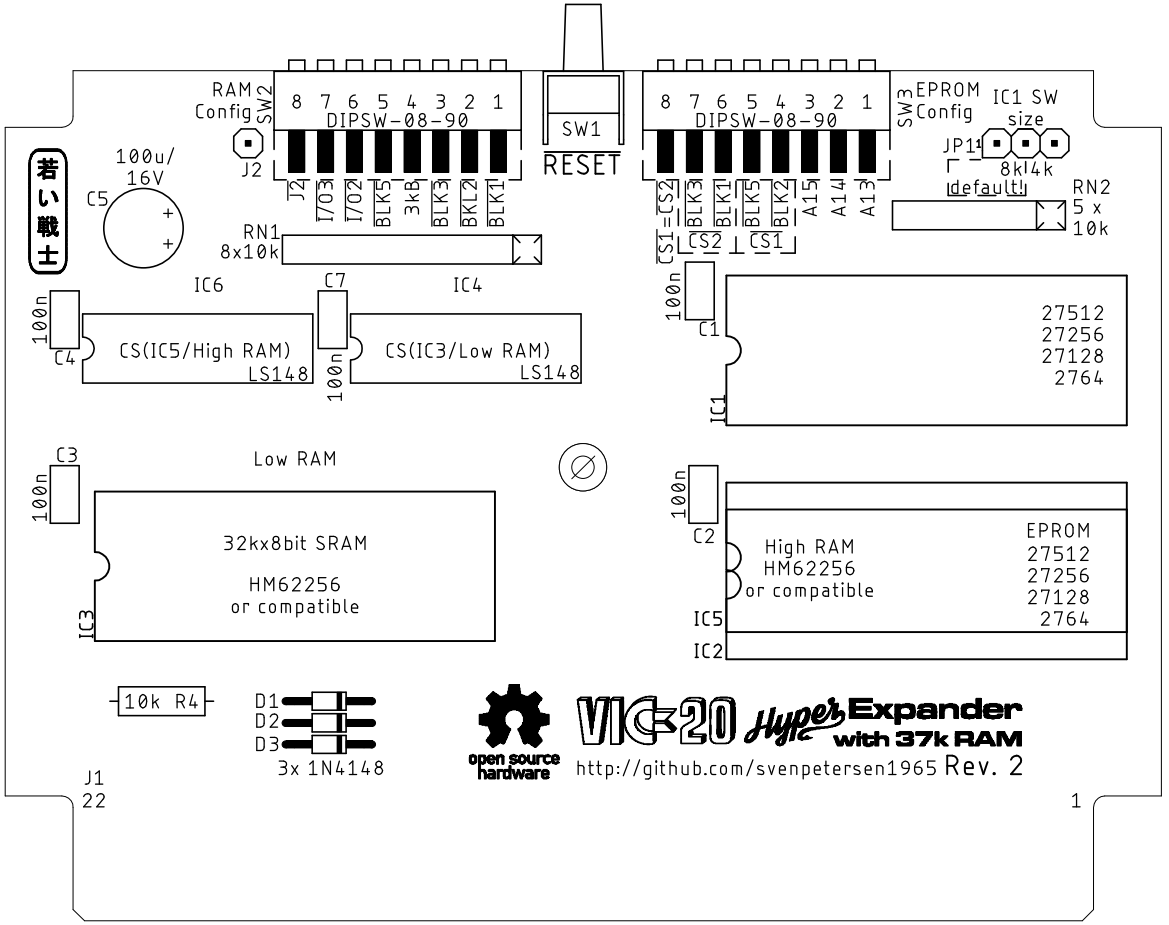
placement component side		



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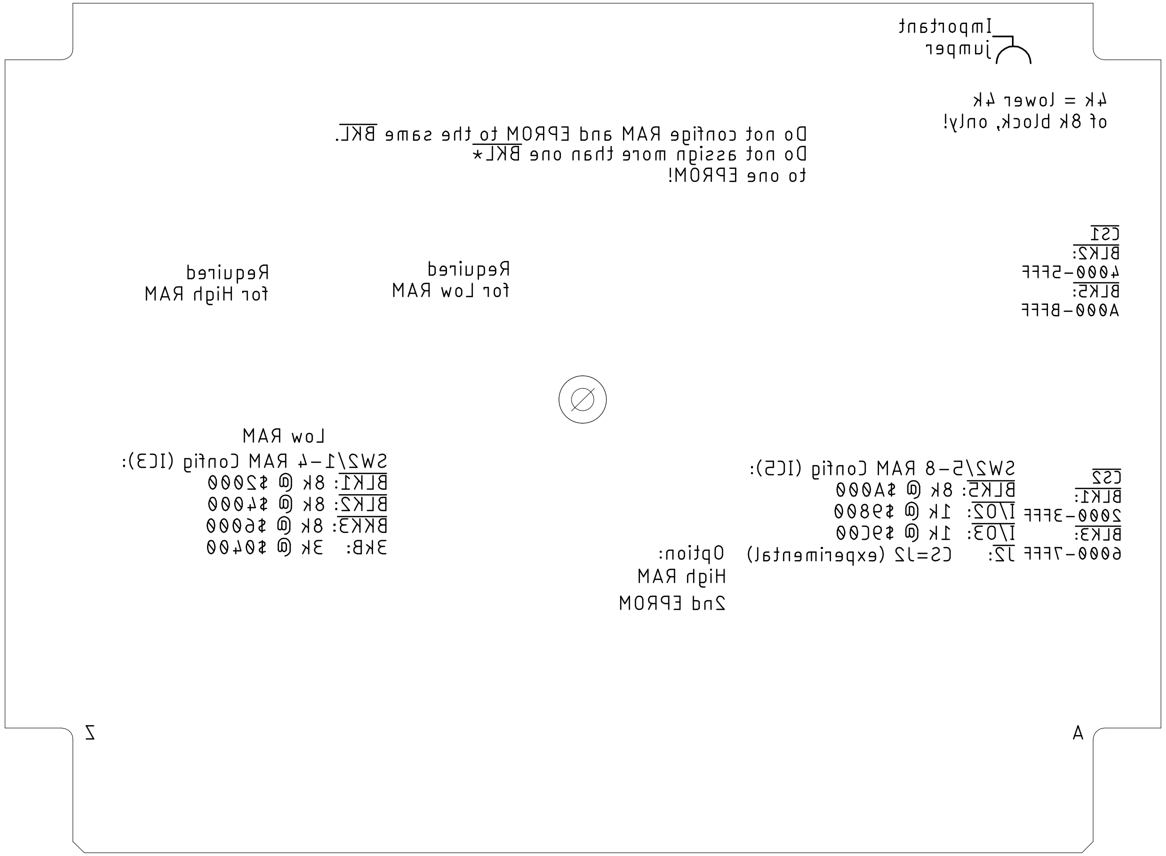

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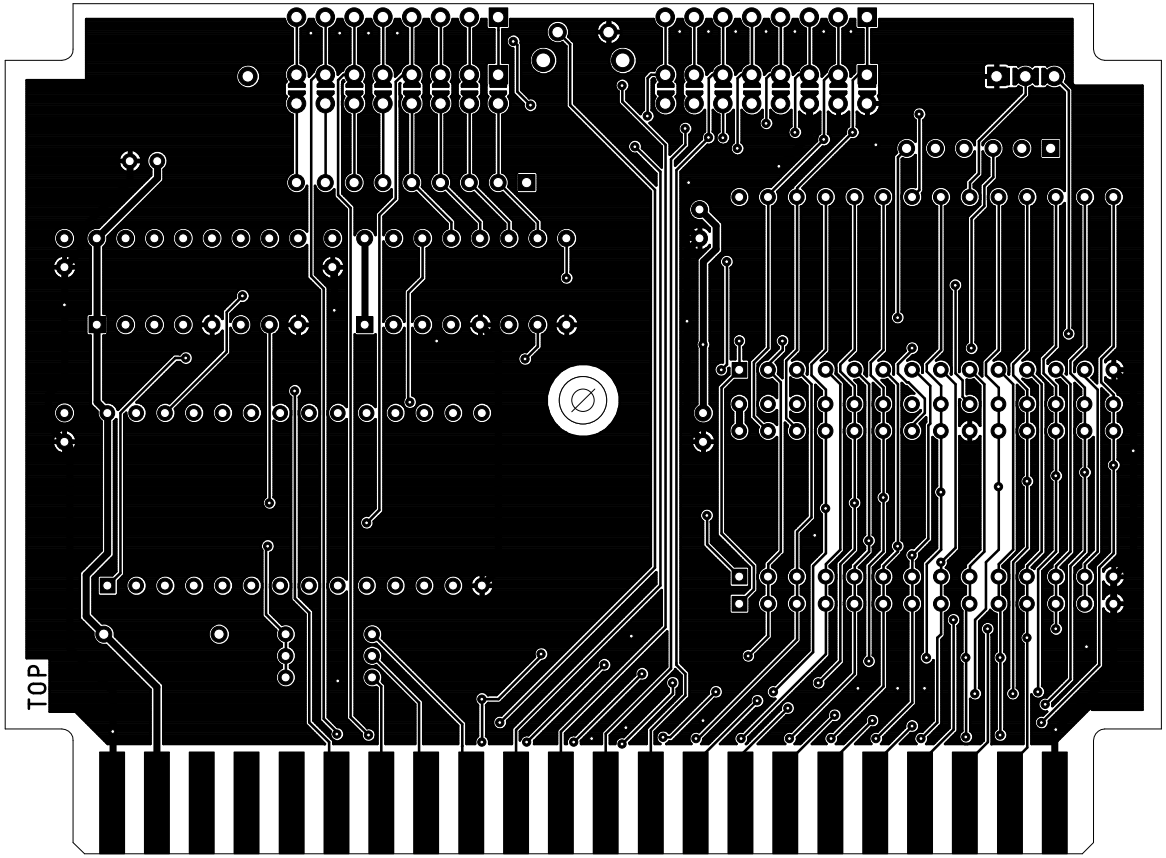

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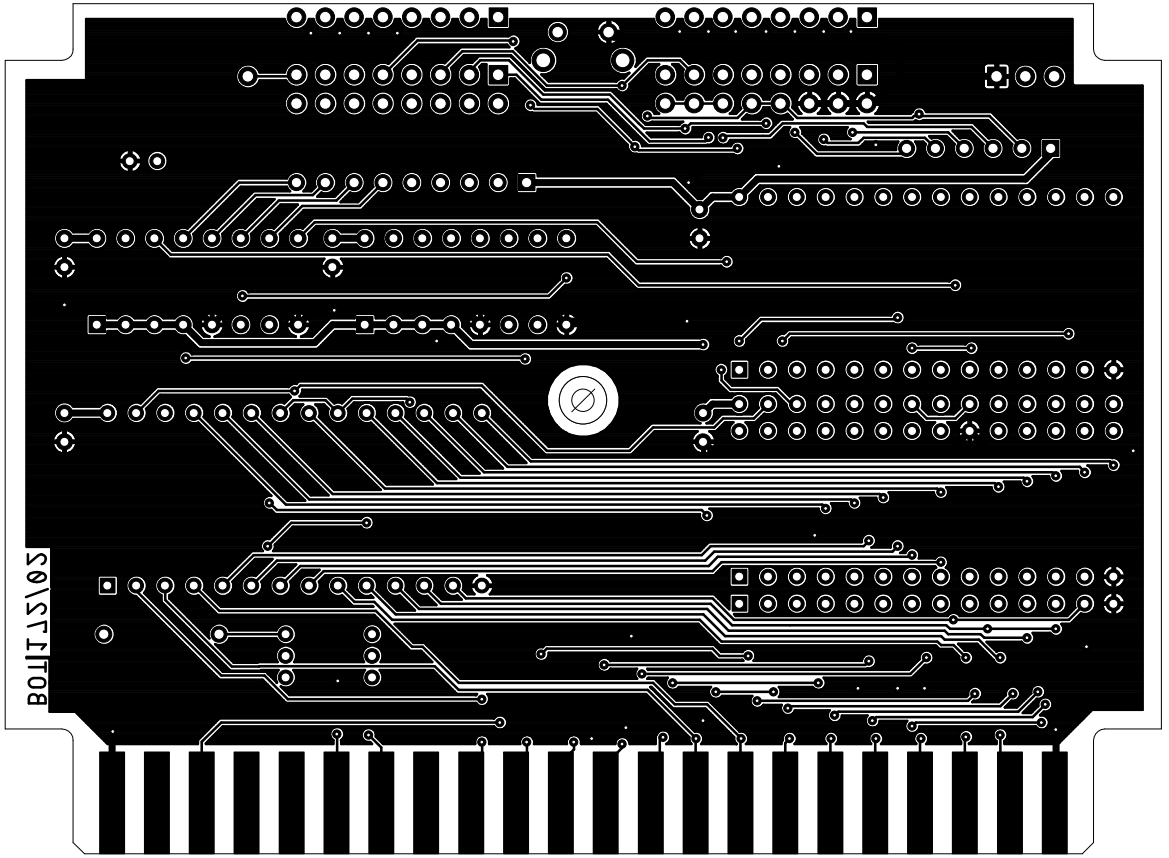

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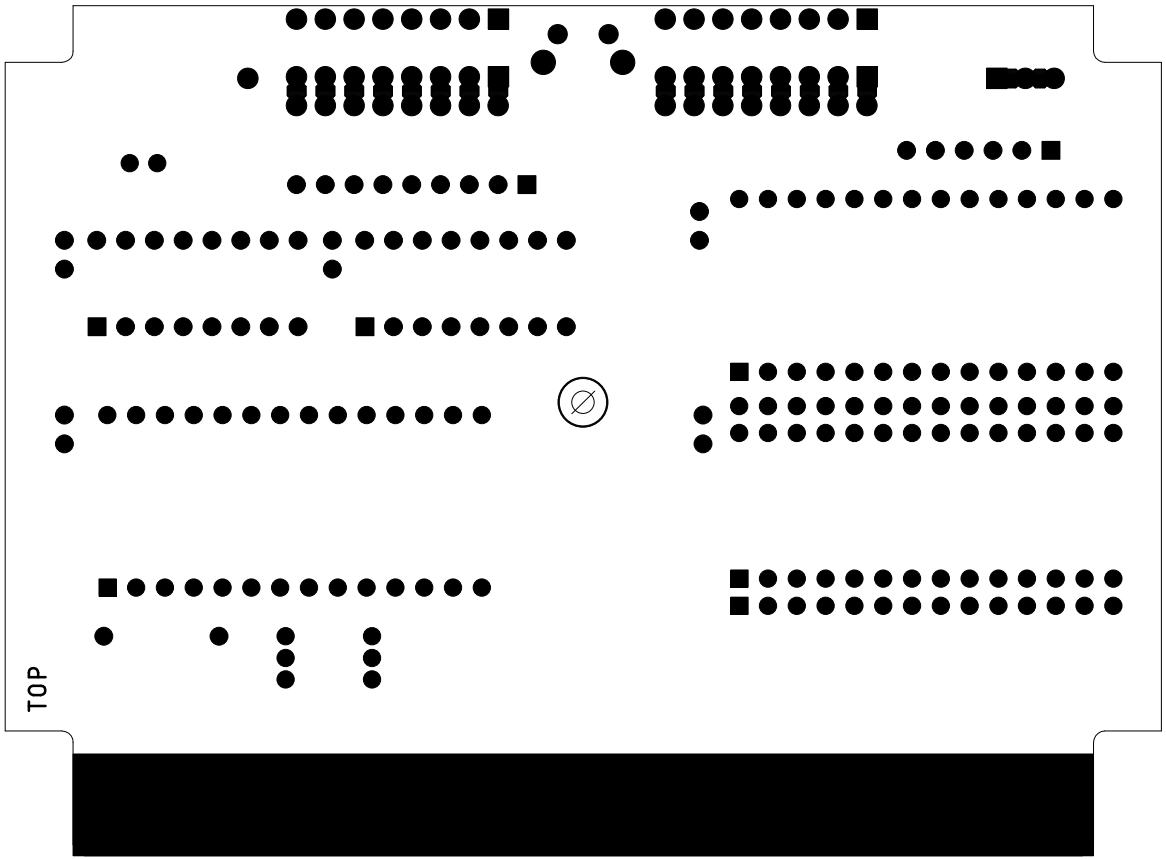

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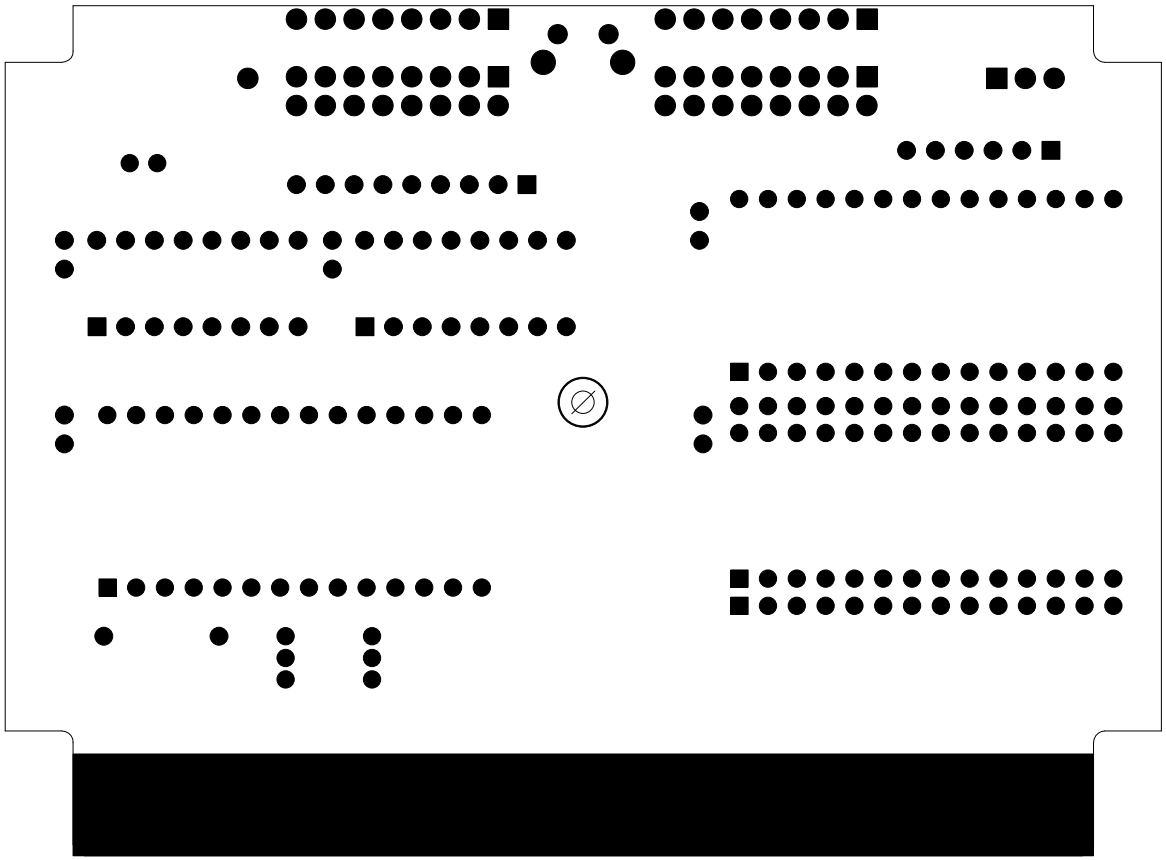

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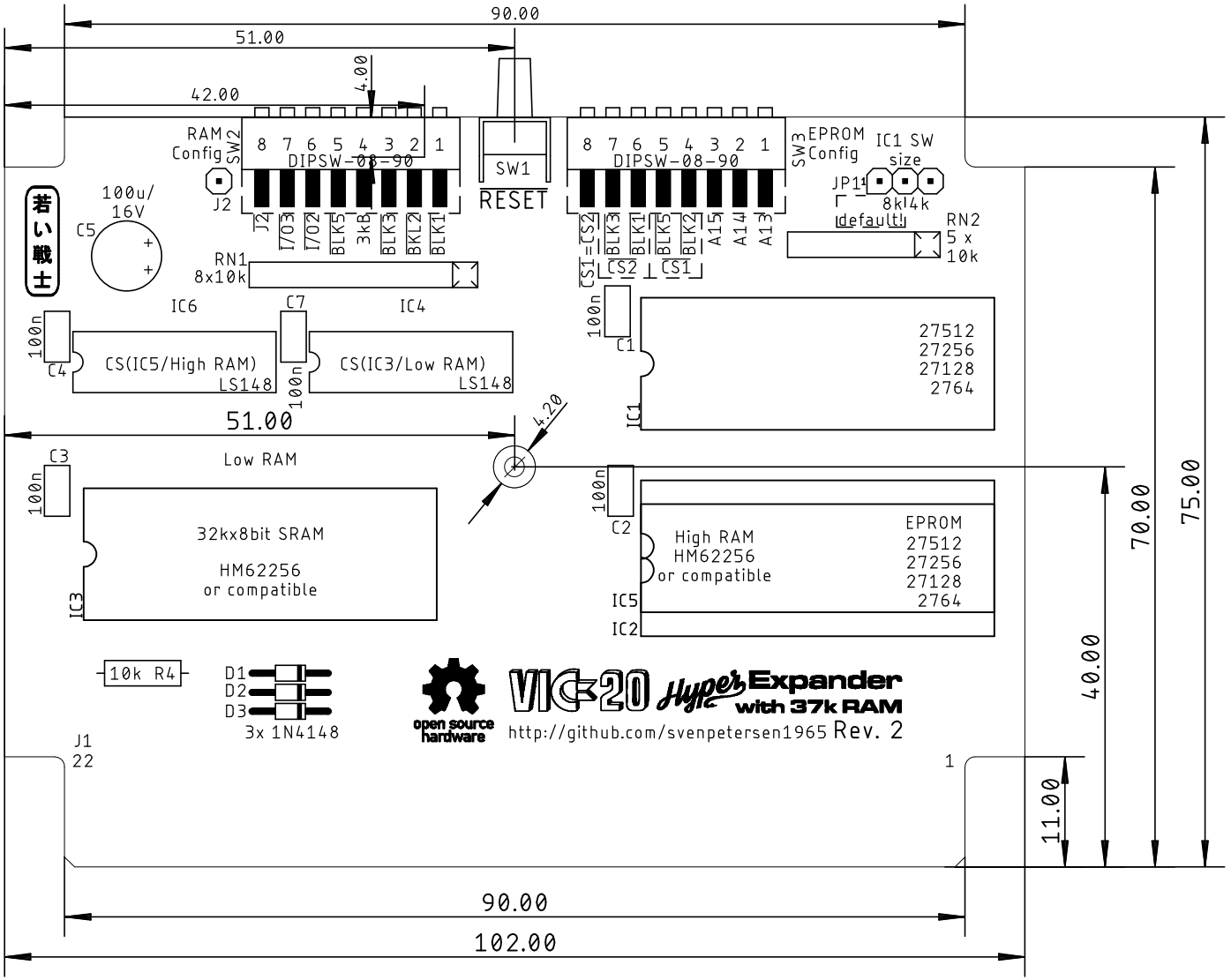

Commodore VIC-20: Hyper Expander Rev. 2

Functional Description

The EPROM part with IC1 and IC2 is pretty much a straight forward VIC-20 EPROM cartridge. The data bus (D0…D7) and the address bus (A0…A12) are connected to the EPROM. This allows to address 8k of memory. The address bit A13…A15 can be jumpered (SW3), which results in selectable 8k memory banks.

The chip selects can be set for each EPROM differently (SW3). It is not every chip select possible to use with IC1 and IC2. Rev. 2 added the opportunity to set $\overline{CS1}$ = $\overline{CS2}$.

IC3 and IC5 are static RAMs (32kByte each). Again, the data bus (D0…D7) and the address bus (A0…A12) is connected to both ICs, which results in an 8k RAM bank size. These four RAM banks are selected with the signals RA13 and RA14 (IC3 = Low RAM)) and RAB13 and RAB14 (IC5 = High RAM)). Those additional address signals are generated by the 8 to 3 decoder IC4 and IC6 for the High RAM). If one of the chip selects gets LOW, the signal $\overline{CSRAM1}$ or $\overline{CSRAM2}$ gets LOW, too. This is forming the chip select signal of IC3/IC5.

The three chip select signals for the 3k RAM expansion are originally made for addressing 2114 1kx4 RAMs. Since the 4th RAM block is addressed with the 3k chip selects $\overline{RAM1..3}$, those need to be combined to a single chip select, which is accomplished with D1, D2 and D3 and the pull-up resistor R4. In case one of those signals is LOW, the combined $\overline{CS3K}$ is LOW as well.

The 2nd EPROM IC2 is optional and can only be installed, in case the High RAM IC5 is not installed. In this case, IC6 and JP4 are not required.

Commodore VIC-20: Hyper Expander Rev. 2

Testing

Test Setup

The tests were conducted with a VickyTwenty (a reproduction of the VIC-20 ASSY 250403) and two Hyper Expander cartridges Rev. 2. One was a RAM and 1 EPROM configuration with two HN61256BLP-7 RAM and up to two 27C512 EPROMs, the other was a 16k EPROM cartridge with two HN61256BLP-7 RAM.

Figure 1: Prototypes of Hyper Expander Rev. 2: 16kB EPROM (top), Full RAM and 8k EPROM (bottom)

Test Execution

Super Expander Software

First, the original Super Expander Software from zimmers.net and the VIC-MON 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 $\overline{\texttt{CS1}}$ was set to $\overline{\text{BLK5}}$ ($A000-$BFFF). The RAM was configured to 3k RAM expansion only (SW2: all off, except switch 4 on).

SW3-8 CS1=CS2	SW3-7 BLK3	SW3-6 BLK1	SW3-5 BLK5	SW3-4 BLK2	SW3-3 A15	SW3-2 A14	SW3-1 A13
off	off	off	on	off	on	on	on

The cartridge was inserted into the VIC-20 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.

Figure 2: Test with Super Expander Firmware and full RAM expansion

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 VIC-MON.

- ✓ **Additional test.**

The Super Expander Software was tested with all other RAM configurations, the VIC-20 always booted properly.

RESET Button

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

- ✓ **RESET button verified**

VIC-20 Diagnostic Software

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

The EPROM banks were set to the 2nd 8k SW3 switch 5 remained on ($\overline{\text{BLK5}}$).

SW3-8 CS1=CS2	SW3-7 BLK3	SW3-6 BLK1	SW3-5 BLK5	SW3-4 BLK2	SW3-3 A15	SW3-2 A14	SW3-1 A13
off	off	off	on	off	on	on	off

The RAM was configured to 3k Expansion only.

The diagnostics software started and executed properly (together with the VIC-20 diagnostics harness). For the 2nd version of the diagnostic software, SW3 was set to the 3rd 8k bank

SW3-8 CS1=CS2	SW3-7 BLK3	SW3-6 BLK1	SW3-5 BLK5	SW3-4 BLK2	SW3-3 A15	SW3-2 A14	SW3-1 A13
off	off	off	on	off	on	off	on

This software executed properly, too.

- ✓ **Bank select (000, 001, 010) on SW3 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. SW3 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.

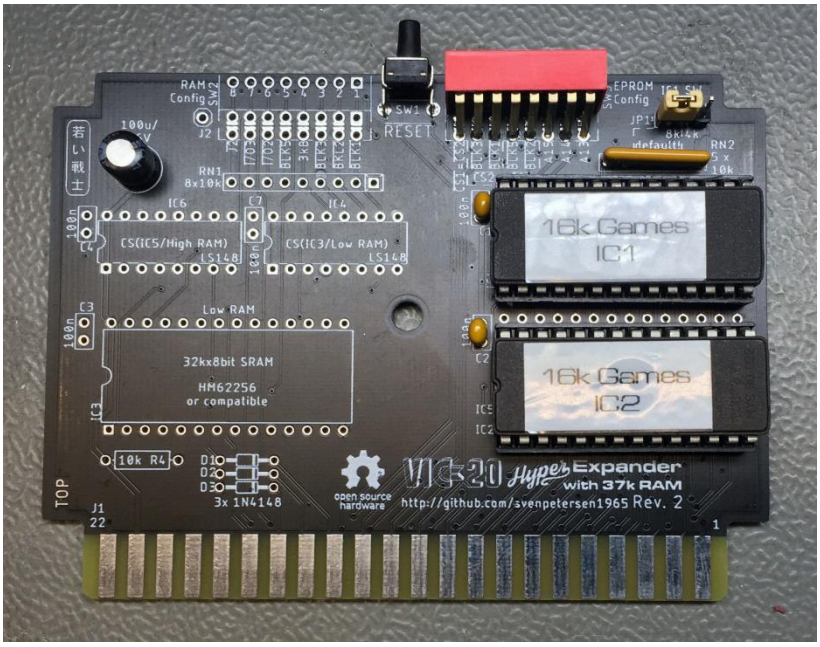

Figure 3: Configuration withn two EPROMs

SW3 was set to $\overline{\text{BLK1}}$ (SW3-1..8: on, on, on,off, on, on, off, off).

SW3-8 CS1=CS2	SW3-7 BLK3	SW3-6 BLK1	SW3-5 BLK5	SW3-4 BLK2	SW3-3 A15	SW3-2 A14	SW3-1 A13
off	off	on	on	off	on	on	on

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 $6000 software into IC2 (chip select **$\overline{\text{BLK3}}$**).

SW3-8 CS1=CS2	SW3-7 BLK3	SW3-6 BLK1	SW3-5 BLK5	SW3-4 BLK2	SW3-3 A15	SW3-2 A14	SW3-1 A13
off	on	off	on	off	off	on	on

The software started properly and the game could be played.

- ✓ **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 SW3 was set to $\overline{\text{BLK2}}$.

SW3-8 CS1=CS2	SW3-7 BLK3	SW3-6 BLK1	SW3-5 BLK5	SW3-4 BLK2	SW3-3 A15	SW3-2 A14	SW3-1 A13
off	off	off	off	on	off	on	on

SYS4*1024 started the software properly.

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

RAM Test

The RAM configuration was tested with the RAM Expansion Test Software Rev. 1.0 (https://github.com/svenpetersen1965/VIC-20-RAM-Expansion-Test-Software)

Figure 4: RAM Expansion Test running from EPROM

The version v1.0 of the RAM Test Software is capable of testing the RAM blocks attached to $\overline{\text{I/O2}}$ and $\overline{\text{I/O3}}$. This software tests every bit in a RAM block for LOW and for HIGH. Also address line conflicts and a cross talk to other RAM blocks are detected.

EPROM configuration:

SW3-8 CS1=CS2	SW3-7 BLK3	SW3-6 BLK1	SW3-5 BLK5	SW3-4 BLK2	SW3-3 A15	SW3-2 A14	SW3-1 A13
off	off	off	on	off	on	off	on

RAM configuration

SW2-8 $\overline{\text{J2}}$	SW2-7 $\overline{\text{I/O3}}$	SW2-6 $\overline{\text{I/O2}}$	SW2-5 $\overline{\text{BLK5}}$	SW2-4 $\overline{\text{CS3K}}$	SW2-3 $\overline{\text{BLK3}}$	SW2-2 $\overline{\text{BLK2}}$	SW2-1 $\overline{\text{BLK1}}$
off	on	on	off	on	on	on	on

In the first pass, the RAM Test was running from the on-board EPROM IC1, configured to $A000 with BLK5). The test was running several thousand times without reporting any problems.

To test the 7th RAM bank configured at $A000, the EPROM was removed and the RAM @$A000 was activated. This test configuration did not report any problems, either.

SW2-8 J2	SW2-7 I/O3	SW2-6 I/O2	SW2-5 BLK5	SW2-4 CS3K	SW2-3 BLK3	SW2-2 BLK2	SW2-1 BLK1
off	on	on	on	on	on	on	on

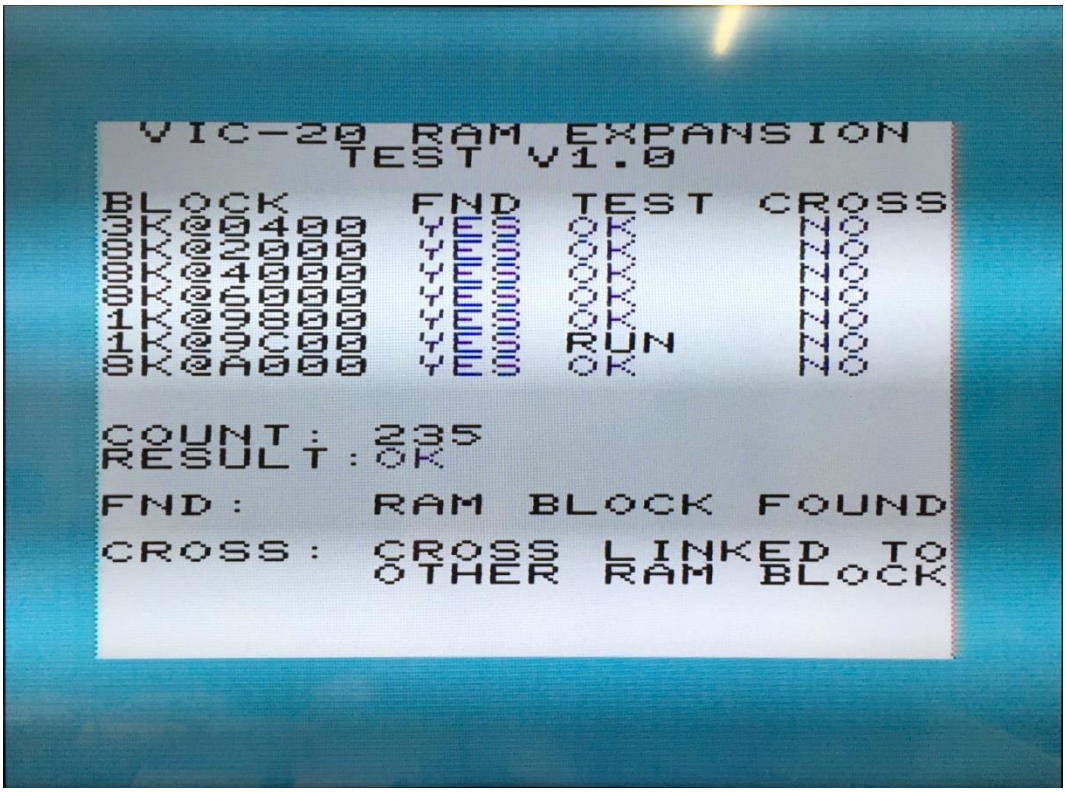

Figure 5: RAM Expansion Test running from a disk image

The game DOOM for VIC-20 requires 35k of RAM. It was played with all RAM activated and the EPROM deactivated.

Figure 6: DOOM running on the VIC-20 with the Hyper Expander configured to maximum RAM

- ✓ RAM function verified

Installation in cartridge cases

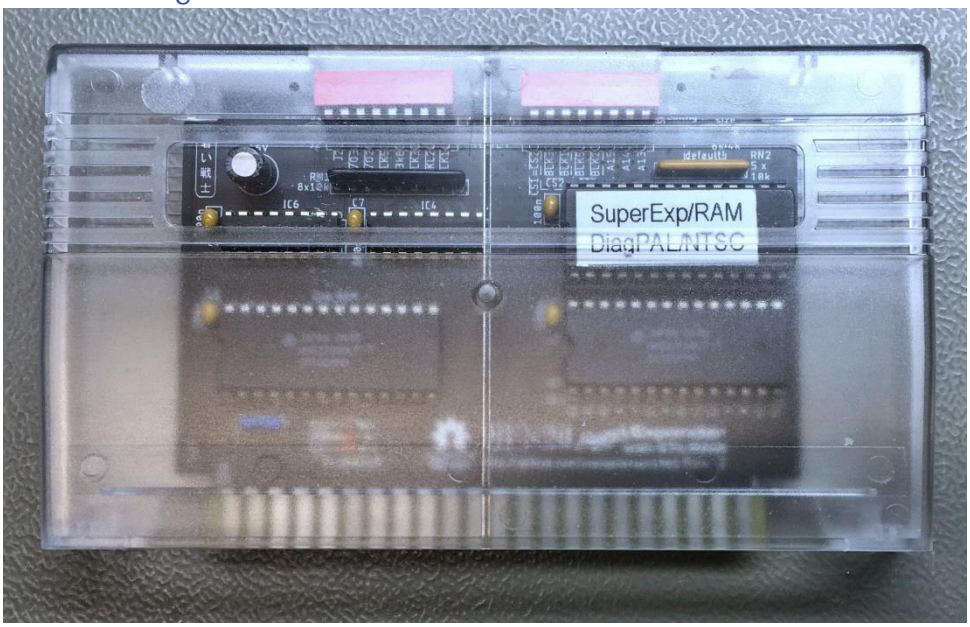

Figure 7: Installation in a tfw8bit case

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

In case the RESET switch is desired, the cases require a modification (5mm hole in the back)

- ✓ Dimensions verified

Conclusion

The Hyper Expander Rev. 2 is fully functional

Commodore VIC-20: Hyper Expander Rev. 2
Bill of Material Rev. 2.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
1	1	172-2-01-02	2 Layer	PCB Rev. 2	2 layer, Cu 35µ, HASL, 102.0mm x 75.0mm, 1.6mm FR4
2	5	100n	C-2,5	C1, C2, C3, C4, C7	Ceramic capacitor, pitch 2.5mm (25V or 50V)
3	1	100u/16V	C07/2,5	C5	Electrolytic cap, pitch 2.5mm, Ø 7mm
4	1	10k	R-10	R4	Metal film resistor, 10% or better
5	3	1N4148	DO-35	D1, D2, D3	Diode
6	2	74LS148	DIL-16	IC4, IC6	TI or other
7	2	DIP-Switch 8, vertical	DIP8	SW2, SW3	Vertical DIP-switches are recommended, horizontal are possible, jumper or solder bridges are an option
8	1	1x2 pin header (2.54mm pitch)	COMBI-1X2	JP1	standard pin header (option, can be configured with solder bridge)
9	2	HM62256	DIL28-6	IC3, IC5	Hitachi SRAM, 32k or compatible. E.G. AliExpress https://www.aliexpress.com/item/4001203718996.html?spm=a2g0s.9042311.0.0.22cb4c4dLFzppg, or Reichelt 62256-80
10	1	JPT1236HB	JTP_1236HB	SW1	Namae Electronics, e.g. Reichelt TASTER 3305B, tme.eu: TACTA-68N-F
11	1	M27C512-DIP28	DIL28-6	IC1	EPROM: 27C64, 27C128, 27C256 possible. Refere to document 172-6-01-**
12	1	M27C512-DIP28	DIL28-6	IC2	option, not required for super expander, do not populate for full RAM
13	3	DIP28-Sockets		(IC1), (IC2), (IC3 or IC5)	option, refer to IC1, IC2 and IC3
14	1	pinheader 1 pin	1X01	J2	do not populate
15	1	5x10k	RN-6	RN2	resistor network, 5 resistors, 6 pins
16	1	8x10k	RN-9	RN1	resistor network, 8 resistors, 9 pins

Please refer to the Module Description to determin the BOM required for your application