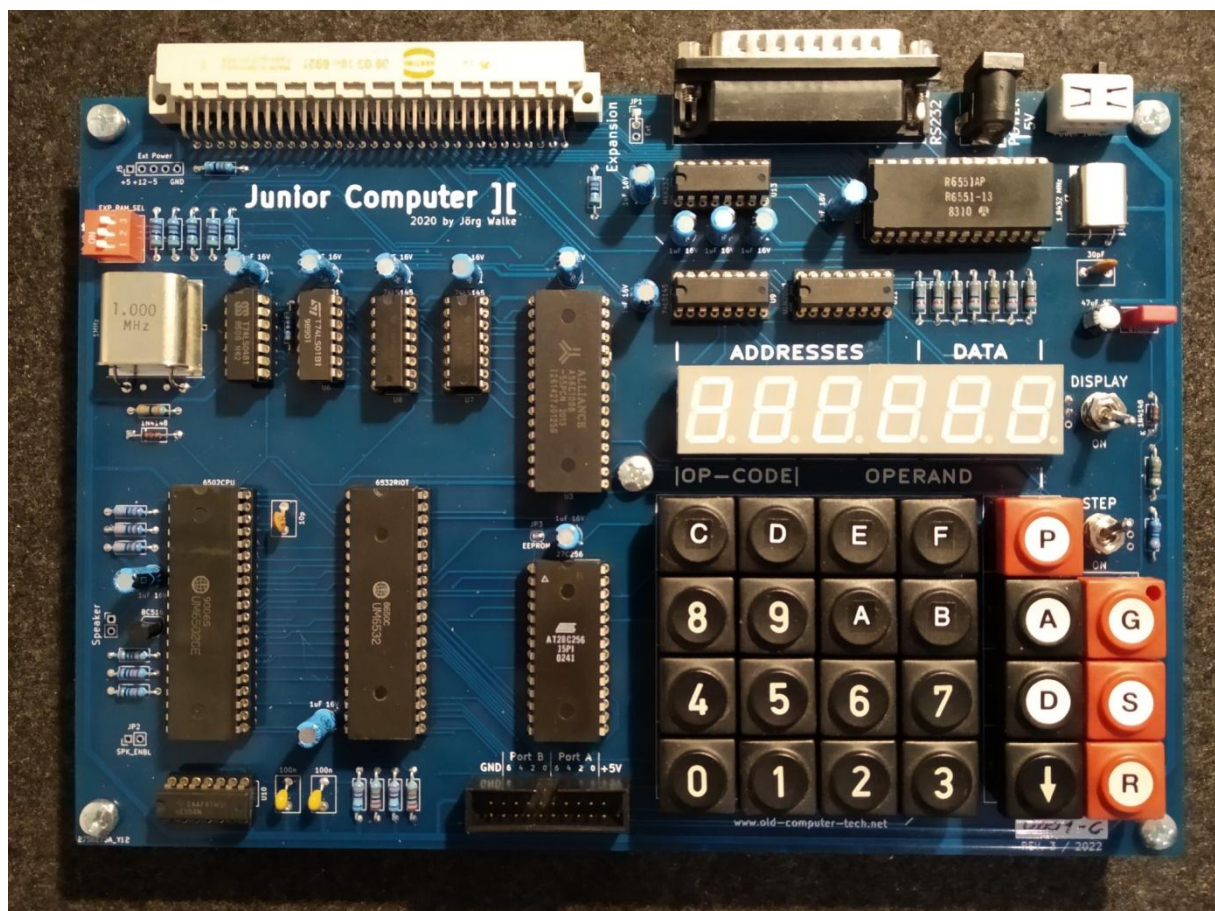


# *Junior Computer ][*

2020 by Jörg Walke



## Preface

In May 1980 the DIY project Junior Computer was presented in the Elektor electronics magazine (originally Elektuur).

The little single-board computer was equipped with 1 KB ROM, in which the monitor program is located, 1 KB RAM (plus 128 bytes of RAM located in the 6532 RIOT), which, according to the authors, was more than enough at the time.

At the 40th anniversary of the computer, I decided to design a version with all features I wanted for the junior back in the 80s. The result is the Junior Computer ][ described here. It has 8KB ROM and a maximum of 128KB RAM. A additional serial RS232 interface and a simple sound output (as described in Junior Computer Book 2, from page 41) are also added. A 5V plug-in power supply with 2A should be sufficient. If external hardware needs to be supplied with voltage via the expansion connector, 3 Amps is recommended.

In order to be able to address the additional memory, the originally address decoding had to be extended. This is designed in such a way that the compatibility of the computer with the original Junior is preserved. An adaptation of the original monitor ROM to match the new memory location was not necessary.

Like its ancestor, the Junior Computer ][ can be expanded with external hardware via a 64-pin connection. The pin assignment of the bus was largely retained.

In the new version, the 16 available port lines of the 6532 are available via 20-pin connector instead of a 31-pin connector.

The circuit changes mentioned here were made exclusively by me and expressly without the prior consent of the publisher Elektor, which is hopefully forgivable after 40 years. Of course, all rights to the original circuit design remain to Elektor and the authors.

Circuit diagrams, Gerber files, ROM images and other documents of the Junior Computer ][ (including this description) can be downloaded from <https://old-computer-tech.net/downloads/>.

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The original issue article, as well as the books published for the Junior Computer (volumes 1 to 4), can be downloaded from the excellent website <http://retro.hansotten.nl/6502-sbc/elektuur-junior/> created by Hans Otten. Here you can also find other interesting details, programs and suggestions for the computer.

Jörg Walke , Esslingen March 20, 2022

Part	Count	Value	Description
C1	1	10pF	Ceramic capacitor
C2-C10, C14, C16-C19	14	1µF 16V	Electrolytic capacitor
C11, C12	2	100nF	Ceramic capacitor
C13	1	47µF 6V	Electrolytic capacitor
C15	1	30pF (or 27pF or 33pF)	Ceramic capacitor
D1, D2	2	1N4148	Universal diode
Di1-Di6	6	LTS-457A	7 segment LED display 1 digit, red, common cathode, digit height 13,2 mm
or			
Di1-Di6	2	LTC5336WS-02	7 segment LED display LITEON 3 digits, red, common cathode, digit height 13,2 mm e.g. at POLLIN Electronic
R1-R3	3	3,3 K Ohm	Metal layer resistor 0,6W, 1%
R4	1	330 K Ohm	Metal layer resistor 0,6W, 1%
R5, R29 R12-R18	9	4,7 K Ohm	Metal layer resistor 0,6W, 1%
R6	1	330 Ohm	Metal layer resistor 0,6W, 1%
R7, R9	2	2,2 K Ohm	Metal layer resistor 0,6W, 1%
R8, R10	2	68 K Ohm	Metal layer resistor 0,6W, 1%
R11	1	820K	Metal layer resistor 0,6W, 1%
R19-R25	7	82 Ohm	Metal layer resistor 0,6W, 1%
R26, R27	2	10 K Ohm	Metal layer resistor 0,6W, 1%
R28	1	100 Ohm	Metal layer resistor 0,6W, 1%
U1	1	R 6502	CPU (DO NOT USE A 65C02)
U2	1	27C64, 27C128 or 27C256 or AT28C64 or AT28C256	EPROM 8Kx8, 16Kx8 (only 8K usable) EPROM 32Kx8 (only 8K usable) EEPROM 8Kx8 (solder bridge JP3 open) EEPROM 32Kx8
U3	1	W24512A or 626128	SRAM 64Kx8 SRAM 128Kx8
U4	1	UM 6532	RIOT (RAM, Input/Output, Timer)
U5	1	74LS04	INVERTER
U6	1	74LS01	NAND O.C.
U7-U9	3	74LS145	BCD Decoder O.C.
U10	1	LM556	Timer
U11	1	ULN2003	Power driver
U12	1	R 6551-AP	ACIA (Asynchronous Communication Interface Adapter)
U13	1	MAX232	RS232 level shifter
X-Tal 1	1	1 MHz	Crystal, HC-33 or HC-43/U
X-Tal 2	1	1,8432 MHz	Crystal, HC-43/U
Q1	1	BC516	Darlington Transistor
LS1	1	Loudspeaker 8 Ohm	
J1	1	DIN41612 Male 3 rows, 2x32 pin	Connector R - 64-pin, pitch 2,5 mm, THTR
J2	1	D-SUB ST25-EU Male	D-SUB connector, 25-pin, angled

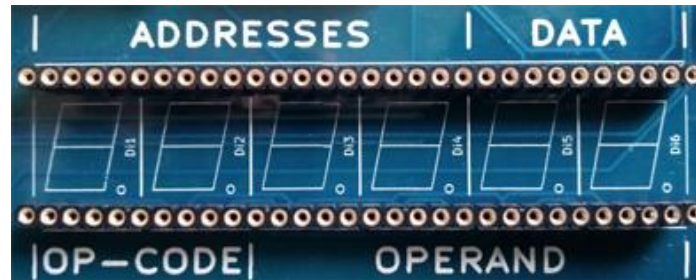
J3	1	low voltage socket for power supply 5V DC, 2A center positiv !!!	horizontal, 6.3mm outer diameter, 2.5mm pin diameter
J4	1	Pin Header 2x10 pin	Box connector 20-pol, pitch 2,5 mm
JP1	1	Pin Header 1x3	External Control Enable
JP2	1	Pin Header 1x2	Speaker Enable
JP3	1		EEPROM select
JP4	1	Pin Header 1x2 with Jumper	ALT_ROM_SEL
SW26	1	Slide switch POWER ON	E.g. APEM 1xOn-On or 2xOn-On pitch 2,54 mm or 5,08 mm
SW1	1	Push Button Marquard 6425.0101 Keycap 826.000.071	E.g. Conrad Labeling RST (Reset), Sticker
SW2	1	Push Button Marquard 6425.0101 Keycap 826.000.071	E.g. Conrad Labeling STP (Stop), Sticker
SW3	1	Push Button Marquard 6425.0101 Keycap 826.010.011	E.g. Conrad Labeling 0, e.g. Conrad
SW4	1	Push Button Marquard 6425.0101 Keycap 826.001.011	E.g. Conrad Labeling 1, e.g. Conrad
SW5	1	Push Button Marquard 6425.0101 Keycap 826.002.011	E.g. Conrad Labeling 2, e.g. Conrad
SW6	1	Push Button Marquard 6425.0101 Keycap 826.003.011	E.g. Conrad Labeling 3, e.g. Conrad
SW7	1	Push Button Marquard 6425.0101 Keycap 826.004.011	E.g. Conrad Labeling 4, e.g. Conrad
SW8	1	Push Button Marquard 6425.0101 Keycap 826.005.011	E.g. Conrad Labeling 5, e.g. Conrad
SW9	1	Push Button Marquard 6425.0101 Keycap 826.006.011	E.g. Conrad Labeling 6, e.g. Conrad
SW10	1	Push Button Marquard 6425.0101 Keycap 826.007.011	E.g. Conrad Labeling 7, e.g. Conrad
SW11	1	Push Button Marquard 6425.0101 Keycap 826.008.011	E.g. Conrad Labeling 8, e.g. Conrad
SW12	1	Push Button Marquard 6425.0101 Keycap 826.009.011	E.g. Conrad Labeling 9, e.g. Conrad
SW13	1	Push Button Marquard 6425.0101 Keycap 826.051.011	E.g. Conrad Labeling A, possibly Sticker
SW14	1	Push Button Marquard 6425.0101	E.g. Conrad

		Keycap 826.052.011	Labeling B, possibly Sticker
SW15	1	Push Button Marquard 6425.0101 Keycap 826.053.011	E.g. Conrad Labeling C, possibly Sticker
SW16	1	Push Button Marquard 6425.0101 Keycap 826.054.011	E.g. Conrad Labeling D, possibly Sticker
SW17	1	Push Button Marquard 6425.0101 Keycap 826.055.011	E.g. Conrad Labeling E, possibly Sticker
SW18	1	Push Button Marquard 6425.0101 Keycap 826.056.011	E.g. Conrad Labeling F, possibly Sticker
SW19	1	Push Button Marquard 6425.0101 Keycap 826.000.011	E.g. Conrad Labeling AD (Address), Sticker
SW20	1	Push Button Marquard 6425.0101 Keycap 826.000.011	E.g. Conrad Labeling DA (Data), Sticker
SW21	1	Push Button Marquard 6425.0101 Keycap 826.017.011	E.g. Conrad Labeling +, possibly Sticker
SW22	1	Push Button Marquard 6425.0101 LED Optional Keycap 829.000.071-00 (with LED drilling)	e.g. Conrad Labeling GO, Sticker
SW23	1	Push Button Marquard 6425.0101 Keycap 826.000.071	e.g. Conrad Labeling PC, Sticker
SW24	1	Toggle switch 2 x ON-ON, 5mm screw	Labeling STEP
SW25	1	Toggle switch 1 x ON-ON, 5mm screw	Labeling DISPLAY
SW27	1	DIP-Switch	3xON
OPT1	2	Socket strip, 1x30, 2,54 mm	Socket for LED-Display
DIL1	3	DIL 14-pin	IC-Socket
DIL2	5	DIL 16-pin	IC-Socket
DIL-3	3 (2)	DIL 28-pin	IC-Socket
DIL-4	1	DIL 32-pin	IC-Socket instead of 1xDIL 28
DIL-5	2	DIL 40-pin	IC-Socket
Alt SW1- SW23	23	Omron B3S-1002P	Alternative input switches

## Assembly Instructions

### Display

In order to raise the 7-segment LED displays to the level of the keyboard and, of course, to make it easier to replace the modules, I recommend installing two 30-pin socket. To make soldering easier, the display modules should first be plugged into the sockets before they soldered in. **The solder pads 31 on the far right of the sockets are for +5V Display supply voltage. You can use it for own made plug-in PCBs such as Dot-Matrix LED Displays.**



Instead of the six 1-digit 7-segment displays, three 2-digit or two 3-digit displays with the same digit height and a common cathode can also be installed. However, the pin assignments should be compared with the specified modules.

### Keyboard

The standard Marquard button modules without a LED have a bulge in one corner and two pin bushings for an optional LED. These are suitable for the SW22's existing LED connections on the circuit board.

The cathode of the status LED for the STEP mode (button SW22, labeled GO), must be soldered to the square solder pad.



As an alternative keyboard assembly, SMD buttons with 4.5mm contact spacing can be soldered onto the existing pads.

## Other Stuff

- Jumper bridge JP1 is used to enable/disable the onboard address decoder. Pin 1 is marked with a square solder pad. In the EXT position (JP1 pin 2-3), the two 74LS145 address decoders can be enabled/disabled via the pin C-30 (EXT) of the expansion slot J1. If C-30 is high, the select signals K2-K7 (K7 is equal to ROM\_SEL), RAM\_SEL and the BANKx0\_SEL kept high by pull-up resistors. These signals can then be activated by external hardware via the expansion slot J1 on the respective pin.

**If no external control is required, JP1 must be bridged via pin 1 and 2, otherwise the computer will not start!**

As an alternative, a 4.7 KOhm resistor can be soldered between pin 1 and pin 2 of JP1. Also bridge pin 2 and pin 3 of JP1. This pulls an open EXT connection at J1 to low.

- The loudspeaker amplifier can be activated with JP2. The speaker output can then be addressed as described in the Elektor Junior Computer Book 2, page 41.
- The three DIP switches (EX\_RAM\_SEL) can be used to page in 8KB of RAM to the specified memory area (\$80 = \$8000-\$9FFF, \$A0 = \$A000-BFFF, \$C0 = \$C000-\$EFFF).
- When using memory larger than 64KB, bank switching can be implemented via the expansion bus pin C-6 (/128K\_SEL).
- The lower two kilobytes of RAM of the Junior Computer ][ are selected via the interconnected pins 1 and 2 of the BCD decoder U8 (74LS145). By connecting the (U8) IC pins 3 to 5 (or the corresponding K2 to K4 lines on the bus) with the IC pins 1 and 2 (/RAM\_SEL on the bus), a maximum of three additional kilobytes of RAM can be added to the lower memory address location, if required. However, these 1-kilobyte address areas are then no longer available for any I/O expansions.
- JP3 (EEPROM) must be left open if you want to use a 64KB EEPROM, else it must be closed with a solder blob. Please note the [overview table for the assignment of the Junior Computer \]\[ ROM socket](#).
- On Pin header J5 (Ext Power) the Junior Computer ][ can be connected with the supply voltages of +5V, +12V and -5V via an external power pack. Additional +12V and -5V are then available on the expansion bus for old expansion cards.
- If you want to supply your Junior Computer with a single +5V power supply via the power jack, it's possible to generate the +12V and -5V voltages via DC-DC converters out of the +5V on J5. The two generated voltages can then fed back to the respective pins on J5.
- The power supply connection on J3 does not have any polarity protection by a diode. Since the output voltage of a modern 5V switching power supply is almost exactly 5V, the voltage drop across a protective diode would usually be too high to safely operate the circuit. It is therefore very important to ensure that the connector of the power-pack is center positive, i.e. the inner pole is +5V. The following symbol should be found on the power supply unit.



**If the power supply is connected incorrectly, the components of the Junior Computer ][ can be destroyed.**



- The two toggle switches SW24 (STEP) and SW25 (DISPLAY) must be connected from the downside of the board as follows.



On the left the switch for DISPLAY On/Off, right STEP On/Off

- The on/off switch SW26 can be used with one or two poles either with a pitch of 2.54mm or 5.08mm.
- All component values are printed on the circuit board. A resistance value of 3k3 means 3.3KOhm, 82 means 82 Ohm.
- The plus pole of electrolytic capacitors is marked with a small + sign.
- The cathode of the diodes D1 and D2 are marked with a thicker bar in the component symbol on the circuit board.
- If the 7-segment displays are too bright or too dark, the 82 ohm series resistors R19-R25 can be varied from 68 ohms (brighter) to 120 ohms (darker).

You can use 8, 16 or 32KB (E)EPROMs on the board. However, the Junior Computer's 1-kilobyte monitor program must be located in the upper 1024 bytes of the ROM. With an 8KB EPROM it should be located on address 1C00H to 1FFFH, with 16KB from 3C00H to 3FFFH and with 32KB from 7C00H to 7FFFH. The ROM images available on my side already contain the original Junior Monitor including my Extended Monitor starting from address F800H.

The revision 3.1B board contains an additional jumper (JP4) ALT\_ROM\_SEL, with which address line A14 can be toggled on 32KB ROMs. This means that you can use two different ROM versions.

Board revision 3b and newer, only supports 32-pin SRAMs (64KB or 128KB) with an additional CS2. This is connected to the processor clock Phi2 in order to guarantee correct memory timing with 6502 processors in CMOS design.

For older Revision 3 boards, the **RAM patch** must be carried out. Revision 2 boards can only be used with 1MHz 6502 NMOS processors, otherwise unexpected memory problems may occur.



## Assignment of the Junior Computer ][ ROM socket

27C256	27C128	27C64	28C256	28C64		Dual-In-Line-Package		28C64	28C256	27C64	27C128	27C256
VPP	VPP	VPP	A14	RDY	1		28	VCC	VCC	VCC	VCC	VCC
A12	A12	A12	A12	A12	2		27	WE_	WE_	PGM_	PGM_	A14
A7	A7	A7	A7	A7	3		26	NC	A13	NC	A13	A13
A6	A6	A6	A6	A6	4		25	A8	A8	A8	A8	A8
A5	A5	A5	A5	A5	5		24	A9	A9	A9	A9	A9
A4	A4	A4	A4	A4	6		23	A11	A11	A11	A11	A11
A3	A3	A3	A3	A3	7		22	OE_	OE_	OE_	OE_	OE_
A2	A2	A2	A2	A2	8		21	A10	A10	A10	A10	A10
A1	A1	A1	A1	A1	9		20	CE_	CE_	CE_	CE_	CE_/PGM
A0	A0	A0	A0	A0	10		19	I/O7	I/O7	O7	O7	O7
O0	O0	O0	I/O0	I/O0	11		18	I/O6	I/O6	O6	O6	O6
O1	O1	O1	I/O1	I/O1	12		17	I/O5	I/O5	O5	O5	O5
O2	O2	O2	I/O2	I/O2	13		16	I/O4	I/O4	O4	O4	O4
GND	GND	GND	GND	GND	14		15	I/O3	I/O3	O3	O3	O3

### Using the solder bridge JP3 (EEPROM)

	Leave solder bridge JP3 open for 28C64 assembly
	Close solder bridge JP3 for 27C64/27C128/27C256/28C256 assembly

Document Version 0.1. Courtesy of Meinolf Schmid.

## Junior Computer ][ Print Monitor ROM 0.9 Usage

If no terminal is connected or detected, the behavior of the Junior Computer ][ is exactly like the original Junior Computer.

Connect a VT100 compatible terminal configured with 2400, 3600, 4800, 7200, 9600 or 19200 baud, 8 bits, no parity, 1 stop bit.

If the keyboard does not respond, select a higher baud rate (e.g. 2400 baud does not work with the ESP32 terminal).

Turn the Junior Computer ][ on.

With the latest ROM version and Rev. 3 boards with auto reset, the main screen appears immediately.

Without Auto Reset, press RST (Reset) button once.

### **For older ROM versions, or simply if you want to start the Print Monitor manually:**

Press the AD (address) button and enter the address F800 on the hex keyboard, then confirm with the GO button.

Input is not case sensitive, so typing 'M' or 'm' is the same.

Maximum input line length is 255 characters.

### **In Hex Monitor:**

On the prompt \*

- type (hex) address to show single data byte

\*E000

E000- 4C

- type start-address and end-address, divided by . (dot) to show data block

\*E000.E008

E000- 4C 05 E2 4C AD E3 4C 5D E0

- type address followed by : (colon) and then followed by (hex) data to enter one or more data bytes into memory

\*200: 4C 00 F8

0200- 03

- type address followed by G to run user program

\*200G

0200- 4C

- type Q (quit) to return to main Monitor.

- By entering M(onitor), the original Junior Computer Monitor program can be called.

More commands are described in the PrintMonitor documentation.

Since the print monitor is still under development, there are no fixed entry point addresses for helper routines. If available, I will post a list of such entry points.

## Bus Pin Assignment

a1 +5V	c1 +5V
a2 N.C.	c2 N.C.
a3 N.C.	c3 N.C.
a4 GND	c4 GND
a5 /RES	c5 RDY
a6 /128K_SEL	c6 /BANKC0_SEL
a7 D1	c7 D0
a8 D3	c8 D2
a9 D5	c9 D4
a10 D7	c10 D6
a11 /BANKA0_SEL	c11 /BANK80_SEL
a12 /IRQ	c12 /NMI
a13 N.C.	c13 N.C.
a14 K7	c14 S0
a15 K5	c15 K6
a16 -----	c16 (a16 connected with c16)
a17 K4	c17 +12V
a18 -5V	c18 K3
a19 A15	c19 A14
a20 A13	c20 A12
a21 A11	c21 A10
a22 A9	c22 A8
a23 A7	c23 A6
a24 A5	c24 A4
a25 A3	c25 A2
a26 A1	c26 A0
a27 PHI2	c27 N.C.
a28 N.C.	c28 K2
a29 /RAM_SEL	c29 R/W
a30 PHI1	c30 EXT
a31 RAM-R/W	c31 N.C.
a32 GND	c32 GND

## RS232 – SUB-D25 socket assignment

### Default RS232

Pin 2	TxD
Pin 3	RxD
Pin 4	RTS
Pin 5	CTS
Pin 7	GND

### Additional RS232 channel with extra assignments

Pin 9	+5V – supply voltage for ESP32 Terminal
Pin 10	+5V - supply voltage for ESP32 Terminal
Pin 11	+5V - supply voltage for ESP32 Terminal
Pin 14	TxD - TTL Level
Pin 16	RxD - TTL Level
Pin 25	GND – Ground for ESP32 Terminal and CTS Pulldown