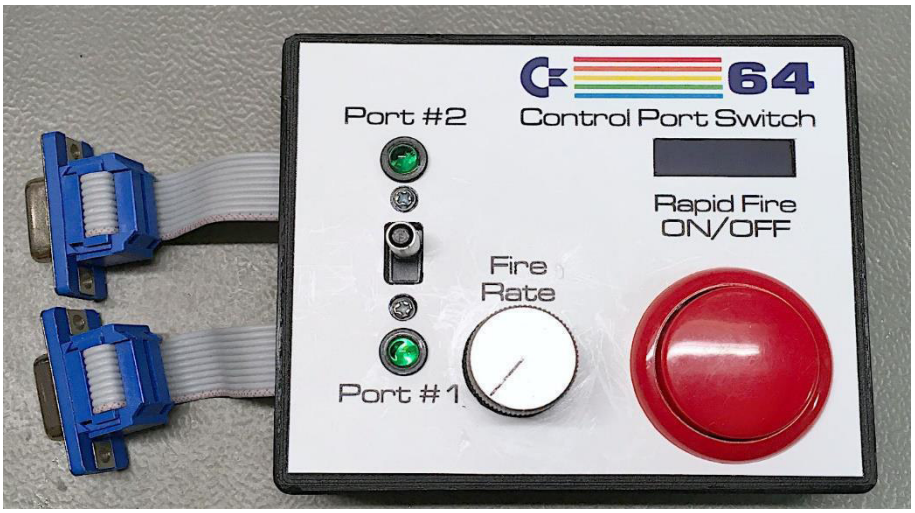
Project Documentation

C64 – Joystick Switch & Rapid-Fire

Project number: 119

Revision: 1

Date: 18.03.2020



C64 – Control Port Switch & Rapid-Fire Rev. 1

Module Description

Most C64 games require the joystick being connected to Control Port 2. Some games, especially those written in the early years of the C64, want the joystick on Control Port 1. To save the hassle of connecting the joystick back and forth, this joystick switch is does it on pressing a button. The selected port is displayed with an LED. The POTX and POTY signal for the paddles is switched as well.

Also, a rapid-fire function is implemented, which is synchronized to the fire button. That means, it starts firing immediately after the fire button was pressed (the maximum delay is 1 ms) at an adjustable frequency. This way, an optimized frequency can be set for every game individually.

The micro controller, which is used in this project is a Pro Micro. They are available for cheap on Ebay and from other online shops, they can be programmed with the free Arduino Software and only a Micro-USB cable is required for the in-system programming of this controller. A I²C connection allows to connect an OLED display to visualize the fire rate.

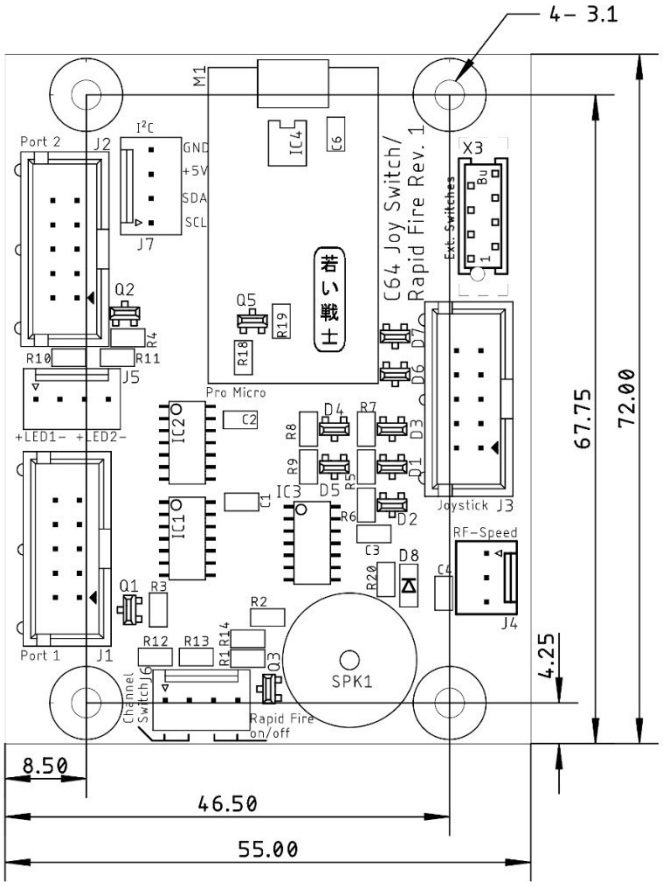


Figure 1: Dimensions of the PCB

A 3D printed case is provided with the project data. Alternatively it fist into the Reichelt *RND 455-00959*.

For future expansions, a serial (I²C) EEPROM (IC4) can be installed as a non-volatile memory. Also, the connector X3 is not required.

Programming the Pro Micro

The *.ino Sketch needs to be compiled and programmed into the Pro Micro module. This is fairly simple. Only a Micro USB cable is required. Make sure, that the cable is a full USB cable.

Required software:

- Arduino IDE
- Adafruit GFX Library (https://github.com/adafruit/Adafruit-GFX-Library)
- Adafruit SSD1306 Library (https://github.com/adafruit/Adafruit_SSD1306)
- The actual software (joysw_rf.ino)

The two libraries should be installed first. This is accomplished within the Arduino IDE: Tools → Manage Libraries. Search for the respective library and click Install (in case the library is not INSTALLED).

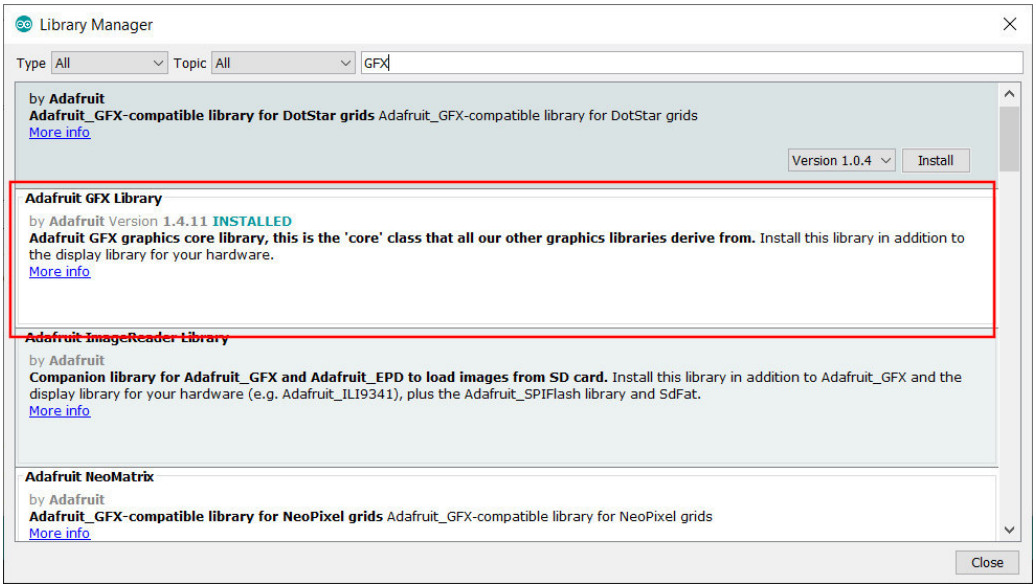


Figure 2: The Adafruit GFX Library in the Library Manager

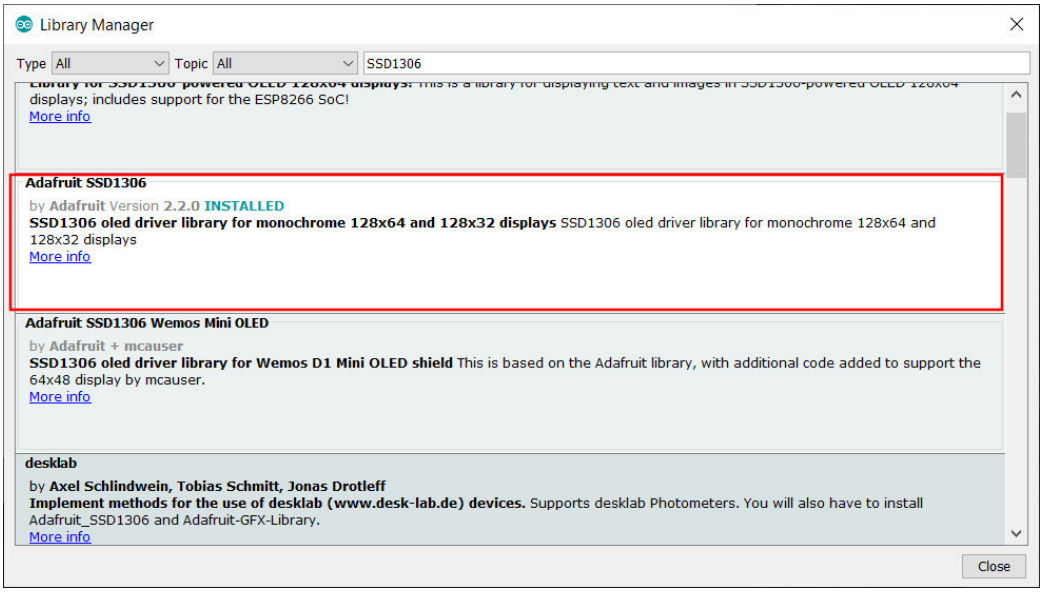


Figure 3: The Adafruit SSD1306 Library

Those libraries are required for the OLED display.

Next is selecting the type of Arduino. The Pro Micro is acting like a Leonardo. So in the Arduino IDE, you have to select Tools → Board → Arduino Leonardo.

Now make sure, that Pro Micro is connected to the PC via the USB cable (Micro USB). It does not need to be installed in the Control Port Switch. It is powered via USB.

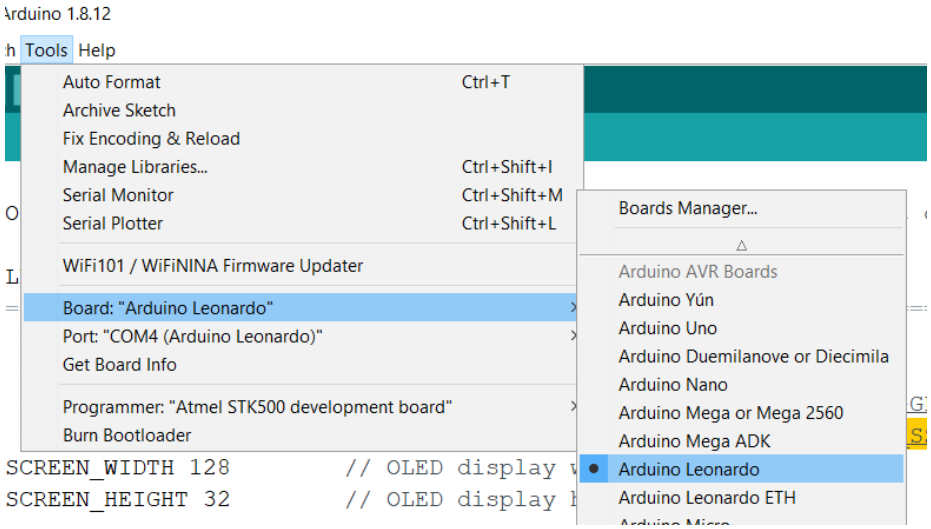


Figure 4: Setting up the board type (Leonardo)

After connecting the Pro Micro, the PC should report a new device is connected. The Pro Micro's programming interface acts as a serial interface (COM-Port). If not, there might be a problem with the drivers or the Pro Micro is broken.

Now, try to find the COM-Port number, that the Pro Micro is configured as:

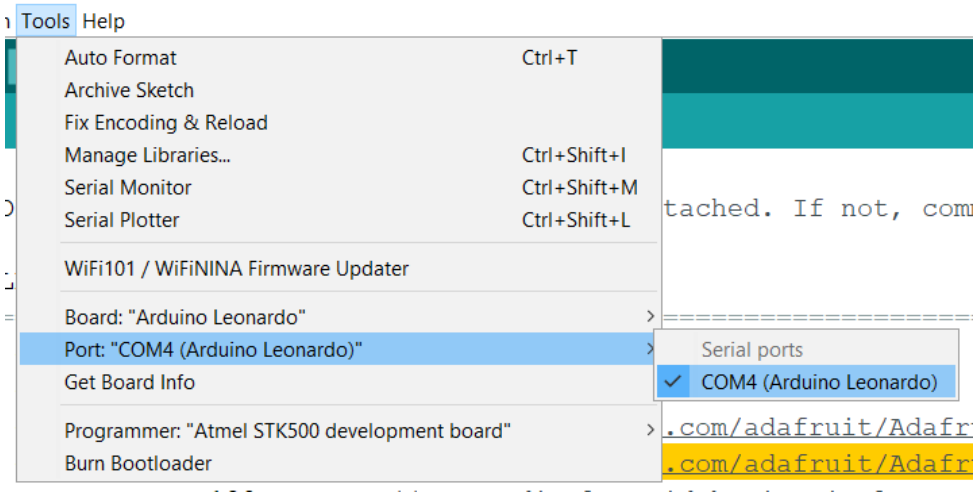


Figure 5: Selecting the COM-port

In Tools → Port, this COM-port should be visible. Select it. The COM-port is the serial channel, the Arduino IDE is communication through with the ATmega 32u4 micro controller on the module.

Now you can load the Sketch into the Arduino IDE (File → Open…). The Sketch is the source code of the program. It needs to be compiled (to create a machine program, which the processor understands). In the Arduino IDFE, it is very much simplified. You do not need to care for make-files etc. like in other development environments for micro controllers. If you are not into this topic, Arduino is for you.

You can even edit the source code. In case you do not want to connect a display (which is recommended), you can put // in front of the #define OLED directive. This makes a comment out of it, so it is not effective anymore. You will see a // comment at almost every line. Feel free to look though it, you might find it interesting. Programming is no witchcraft!

So, to compile and upload the sketch, click the right arrow icon at the top left of the Arduino IDE.

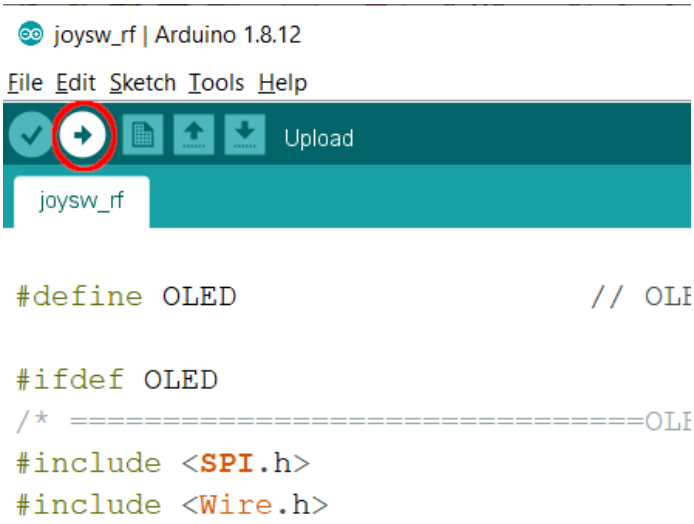


Figure 6: Compiling the Sketch and uploading (right arrow)

If all libraries are installed, the correct board type and COM-Port is selected and the Sketch is unmodified, the code should compile and upload without any error messages.

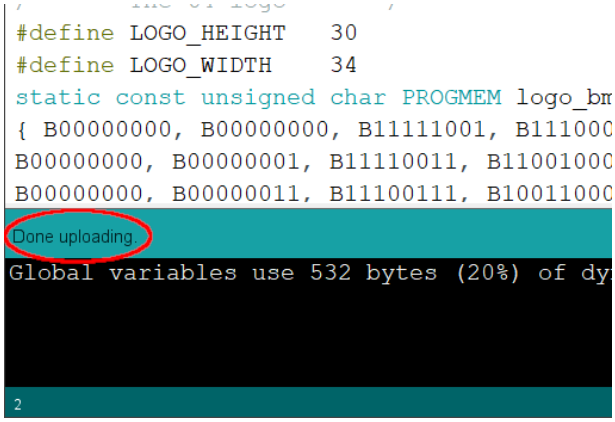


Figure 7: The Upload is done

So, look out for "Done uploading", like shown in Figure 7. If you don't see this message, you should read the error messages, which are displayed in the bottom of the window.

Wiring the Device

Crimping

Crimping is the preferred way of making cables, the connections are of a good quality (if the crimping carried out well). Unfortunately, it requires some dedicated tools. Fortunately, there are tools available for a fair price. Good results can be accomplished with the Engineer PA-20 and PA-09 tools. The IWISS IWS-2820 is a cheaper alternative, the results are acceptable.

Those tools are two pass tools. That means, the wire crimp and the isolation crimp have to be carried out in two consecutive passes. I prefer the "wire crimp first" method. There are plenty video

tutorials about crimping on Youtube. I also plan to write an essay about crimping on my website (http://tech.guitarsite.de). This is a future project.

Figure 8: My crimp tools (from left to right: IWS-2820, PA-09, PA-20)

After 25 years in industrial engineering, I prefer locking connectors. The widely popular DuPont connectors are also acceptable for hobby projects. They might need to be secured with a drop of silicon glue (hot glue might work, but is harder to separate, if required).

Direct soldering of the wires onto the board, is also a working method, if you don't have any crimp tools or don't want to invest in them. It is not really great and it is hard to separate the components of the built, if required.

Cables

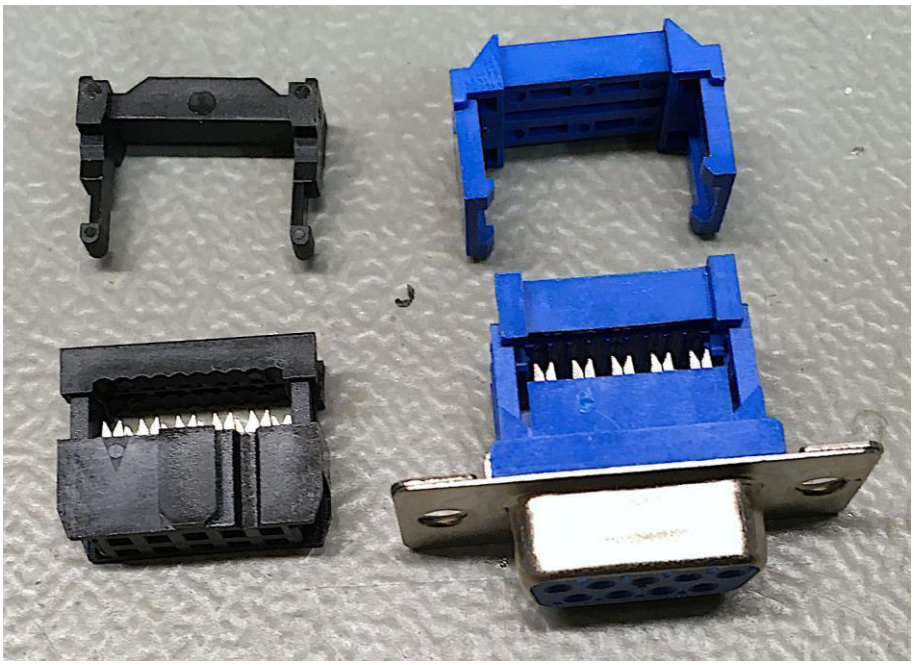


Figure 9: 2x5 and DSub IDC connectors and strain reliefs

There are three ribbon cables, two for the control ports, one for the joystick input. Both types of connectors are IDC (Insulation Displacement Connectors). This means, no soldering required, easy make. The little blades on each pin will penetrate the insulation of each wire of the ribbon cable and make a reliable contact with the conductors. It is a technology, which is established since the 1970s.

You don't even need a special tool for making the cables, just a (little) vice (Figure 10). There is a strain relief for both connectors, which is installed last. First, you cut the ribbon cable to length. Then insert the ribbon cable and align to the opposite side of the connector. Keep in mind, that installing the strain relief will cause a 180° turn (Figure 11). So, insert the cable from the opposite side that you finally want the cable to leave the connector. Pin 1 is marked. The wire 1 is also marked on a ribbon cable.

All D-Sub 9 connectors only have 9 pins, the IDC connectors have 2x5 (=10) pins. Thus the 10th wire has to be separated before the cable is inserted (Figure 12) in the D-Sub and finally clipped off.

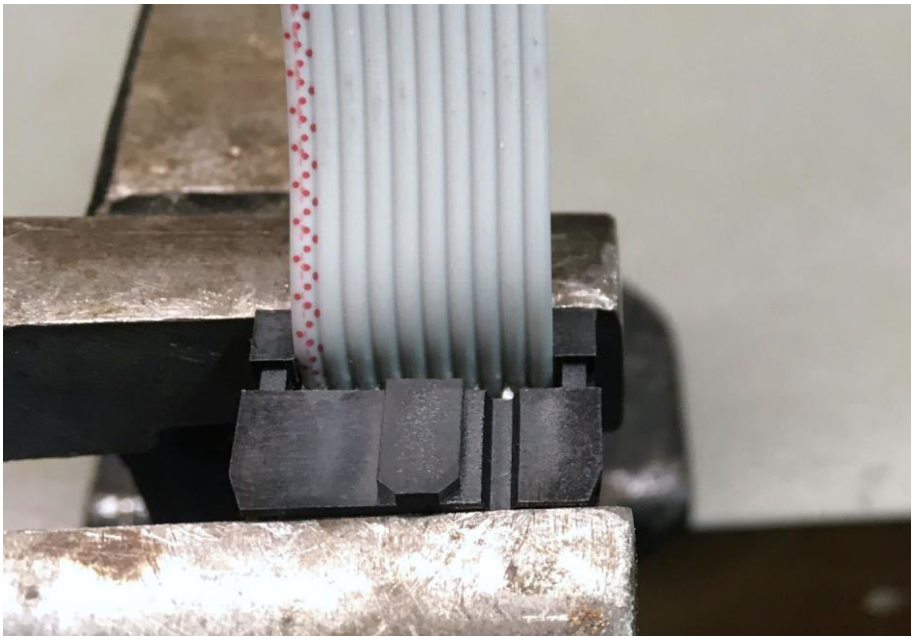


Figure 10: IDC connector before being compressed in a vice

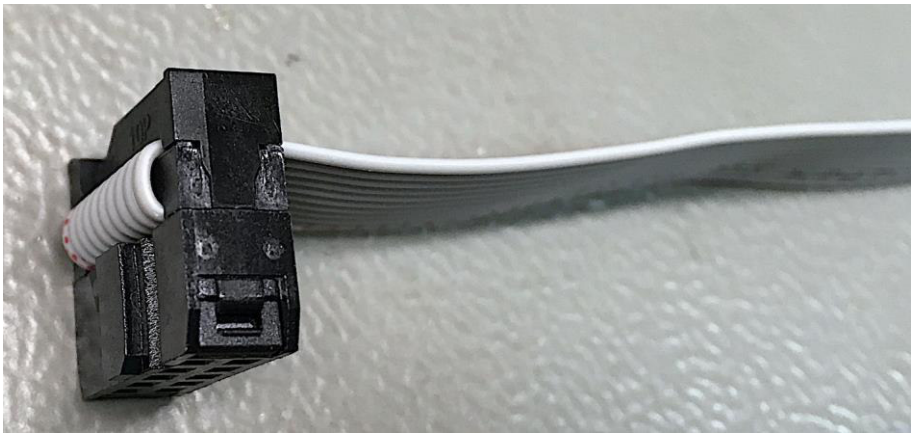


Figure 11: Side view after installing the strain relief

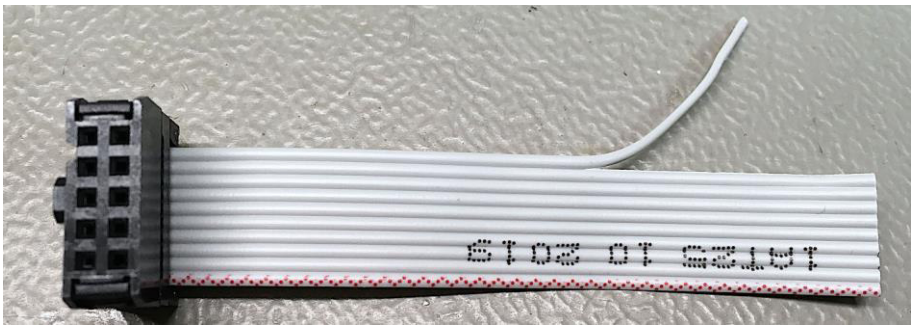


Figure 12: Separated 10th wire of the ribbon cable

Keep in mind, that pin 1 is in a deferent position on male and female D-Sub connectors. On a female connector, the pin numbers are usually shown on the contact face.

The required ribbon cables look like this:

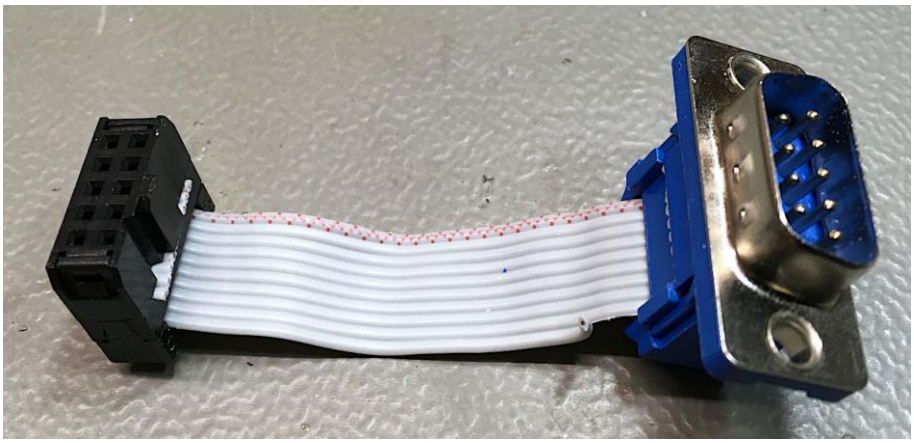


Figure 13: Joystick Input cable: Male D-Sub, 8cm ribbon cable

Figure 14: The output cables: female D-Sub, 8cm ribbon cable

Please note the different orientation of the coding notch in Figure 13 and Figure 14. Also, the marked wires (1) of the ribbon cables are on opposite sides. The cable shown in Figure 14 is required twice.

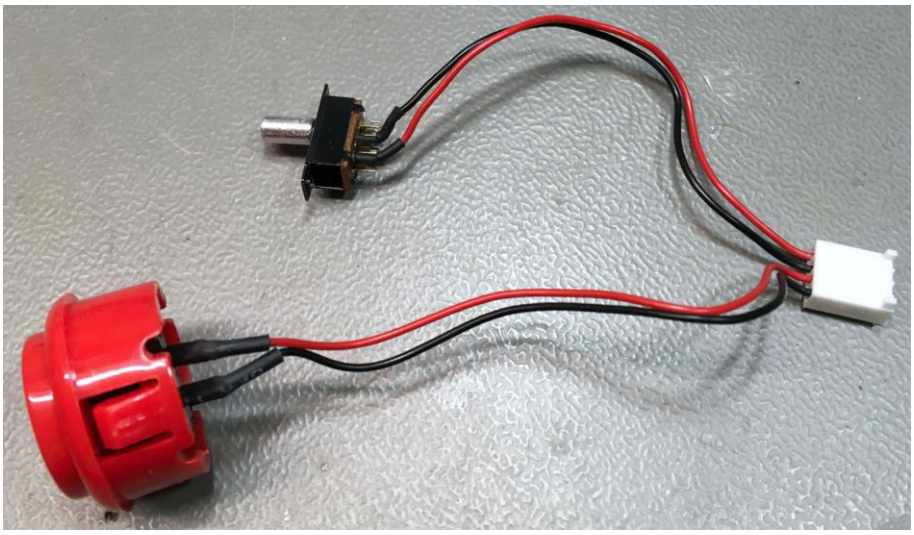


Figure 15: The cable with the rapid-fire button and the channel select switch

The rapid-fire button is sold as "30mm arcade button" on ebay or AliExpress. The switch is a panel mount slide switch, the screw holes (M2) pitch is 19mm. The cable length is 12cm for both switches.

It is advised to use shrinkable sleeve the shown connector is a Molex 22-01-2041 crimp housing (refer to the /Switches). The crimp dies used for the crimp terminal (also for DuPont crimp terminals) are 1.6mm for the wire crimp and 1.9mm for the insulation crimp.

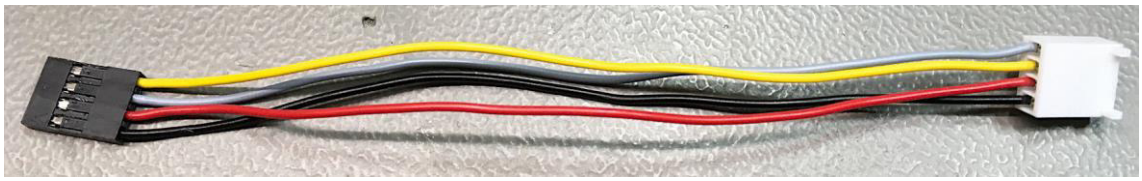


Figure 16: The display cable

DuPont	Signal	Color	Molex
Pin 1	GND	Black	Pin 4
Pin 2	+5V	Red	Pin 3
Pin 4	SDA	Yellow	Pin 2
Pin 3	SCL (also "SCK")	Grey	Pin 1

Figure 17: 0.91" OLED display

The display is a 0.91" OLED with I²C bus and an SSD1306 controller. The measures of the display PCB are 38mm x 12mm.

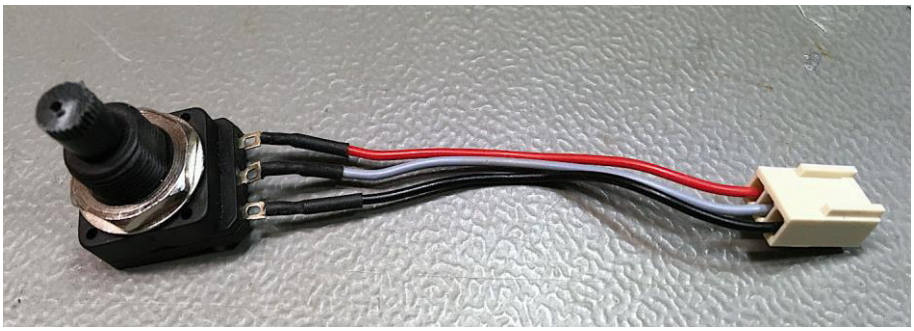


Figure 18: Potentiometer cable

The crimp housing is a Molex 22-01-2031. For the connection, please refer to chapter Pinouts/Fire-Rate Potentiometer.Length 6.5cm.

Pot	Signal	Color	Molex
Clockwise	+5V	Black	Pin 1
Tap	RF-Speed	Red	Pin 2
Counter Clockwise	GND	Yellow	Pin 3

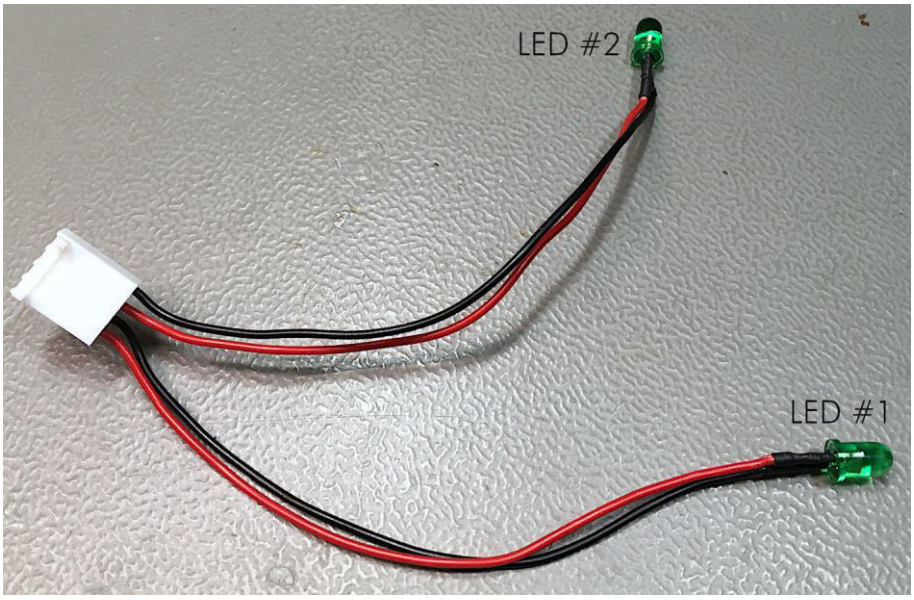


Figure 19: LED cable

Again, there is a Molex 22-01-2041 crimp housing (refer to Chapter Pinouts/LEDs). Note: The LEDs have a polarity. The anode (+) and the cathode (-) must not be confused. The cathode is marked with the flat side. Also, the cathode pin is shorter. It is advised to use shrinkable sleeves for the solder joints. Length: 8cm.

Assembly

The 3D printed housing consists of three parts and a label. Also, some screws are required.

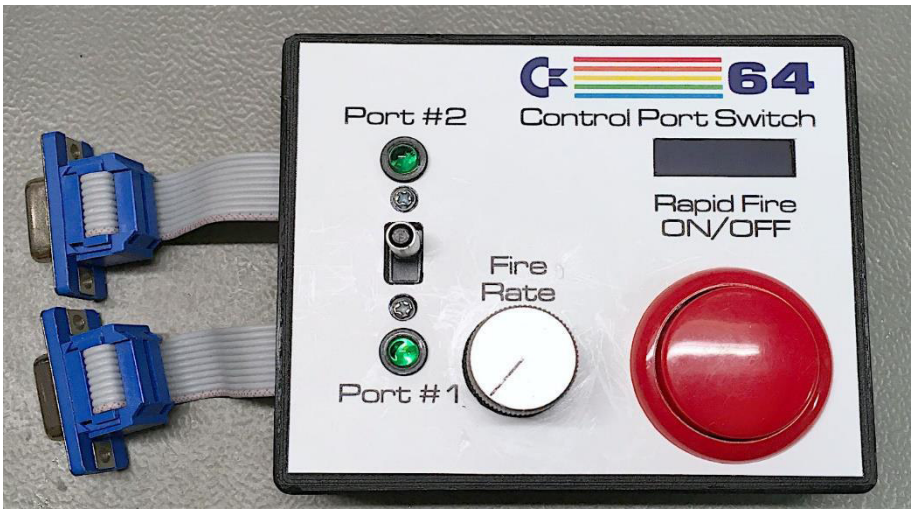


Figure 20: Top view of the completed Control Port Switch

The label is printed on a weatherproof outdoor sticker (I have used HERMA 9500) for laser printing (on my Samsung C1810W color laser printer). Other brands are also suitable. The foil sticks very well.

The top shell, bottom shell and display holder were printed with PLA filament.

Assembling the PCB is pretty straight forward. First populate the surface mount parts (SMD). The Pro Micro might require the pin headers being soldered. To get good and vertical connections, insert the pin headers into the socket strips into the PCB and solder the Pro Micro first. Then solder the socket strips in the PCB.

The through hole parts are soldered last.

Before mounting any parts in the top shell, the label should be installed.

Figure 21: The required screws

The following screws are required

- 2x M3x8 and M3 nuts for the D-Sub connector (Joystick input). Non-Metric screws are possible.
- 2x M2x6 for the slide switch
- 4x C2.2x4.5 for the display holder
- 4x C2.9x9.5 for the case

The tolerances of the display cutout and the display holder are +/-0.5mm, so such a display should fit in, although the tolerances might be high. Nevertheless, the display should be handles with care. The glass is thin and breaks easily. So, make sure, the display fits before you (carefully) tighten the screws (4x C2.2x4.5). Refer to Figure 22.

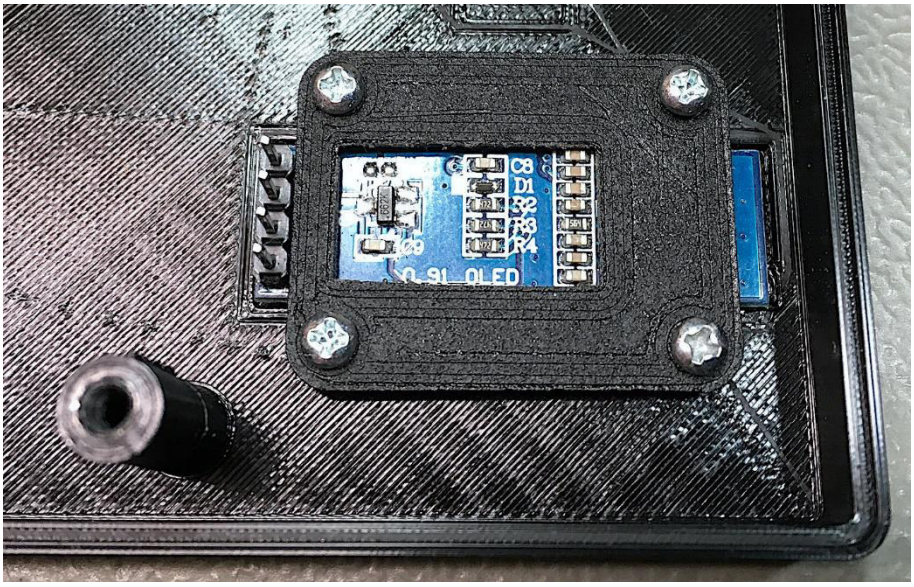


Figure 22: Mounted display

Mount the potentiometer. The pins should point inwards(Figure 23).

The cable with the arcade button can be mounted by inserting the slide switch through the hole. The arcade button snaps in place. There are different arcade buttons available, which might be slightly different. In case the arcade button sits lose, some hot glue can cure that. Do not apply the hot glues near the (open) sides, because it will block the button. Only apply it near the snap-in pins.

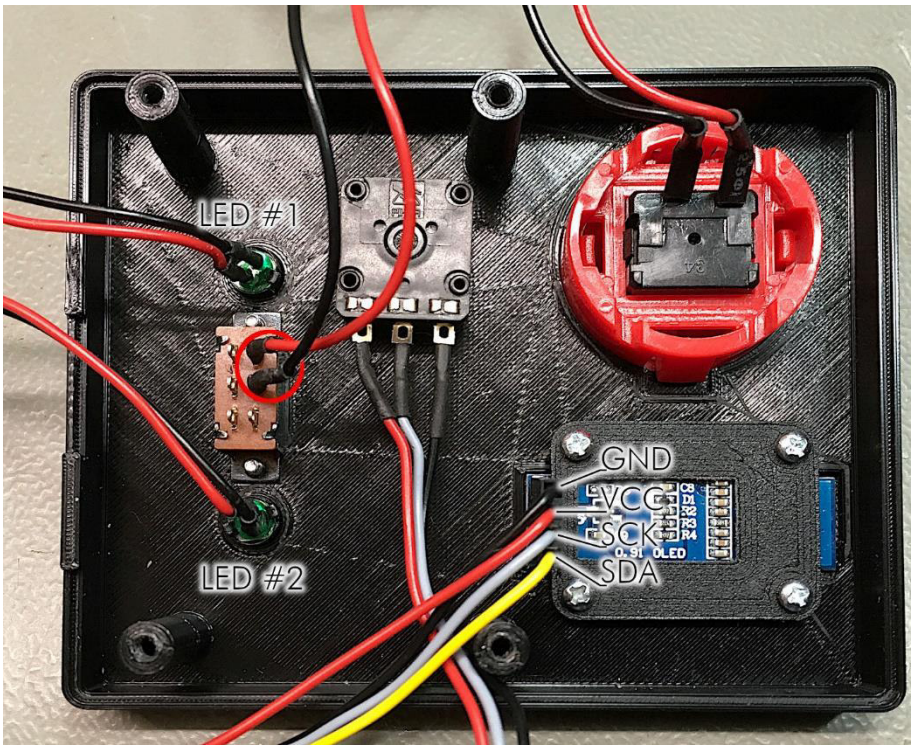


Figure 23: The completely assembled top shell

Fix the slide switch with two screws (M2x6). The two connected terminals of the slide switch should point to the side with the pot and the arcade button. Only this way, it will switch to Port #1 when slid downwards (red circle in Figure 23).

For the LEDs, snap in the LED holders and insert the LEDs. They could be confused, so make sure, that the LEDs are mounted in the place, they belong. Refer to Figure 19 and Figure 23.

Finally, mount the display cable. This can be oriented improperly. Refer to Figure 16 and Figure 23.

Assembling the bottom shell is not much work. The joystick input cable ("Male") is screwed to the bottom with two screws (M3x8 and M3 nuts). Refer to Figure 24.

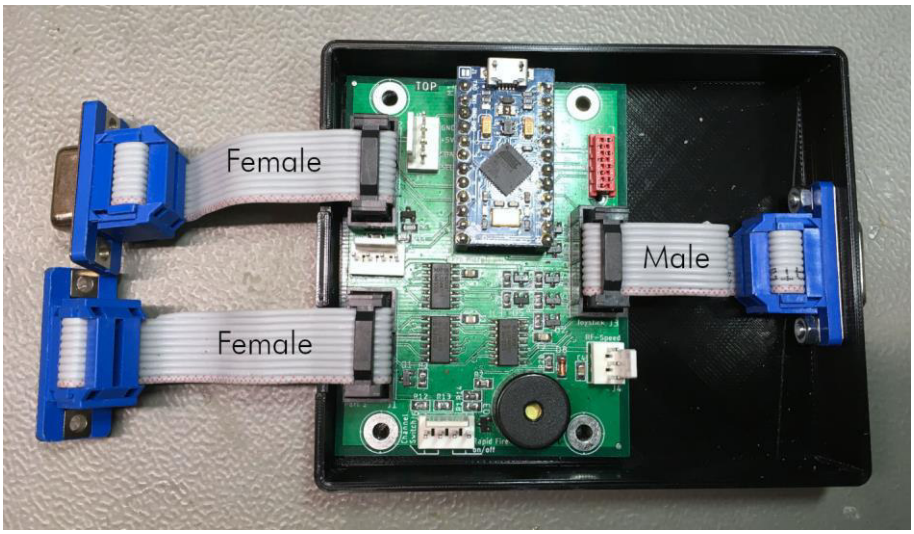


Figure 24: Assembled bottom shell

Put the PCB in place and connect the ribbon cables. The PCB is not yet held in place by screws.

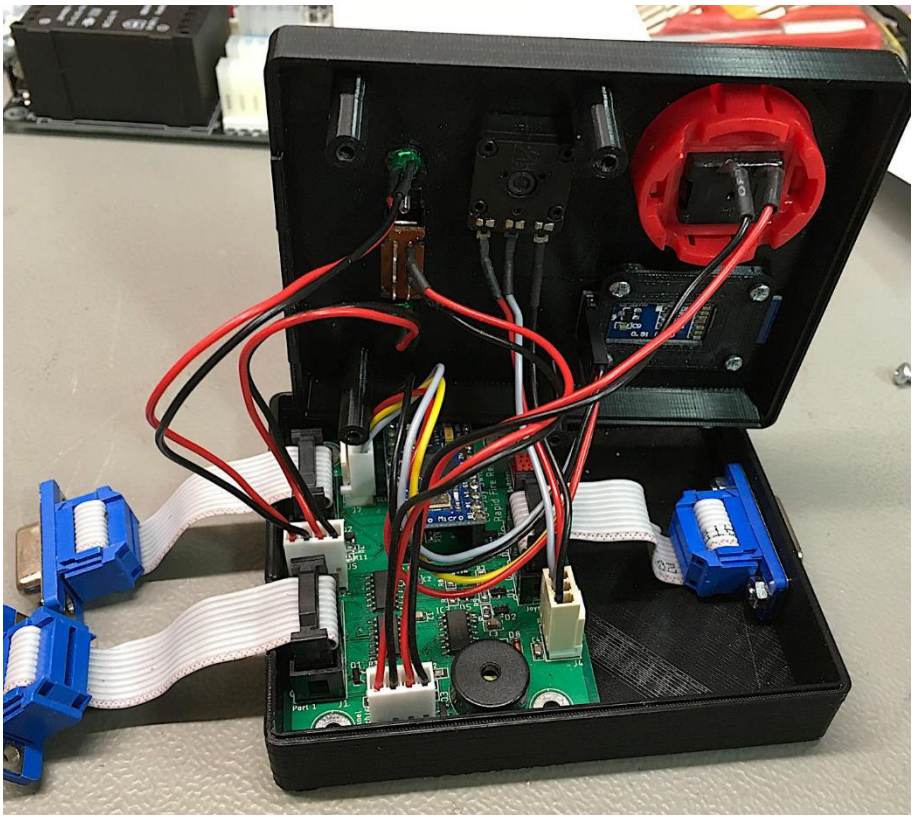


Figure 25: Connecting top shell and bottom shell

The cables from the top shell are now connected to the PCB. The space in the case is restricted and it might take some fiddling to close the case. Without cables being in the way.

Finally, the case is closed with the C2.9x9.5 screws. These screws are passing the mounting holes in the PCB and are screwed into the top shell mounting posts.

Figure 26: Finished Control Port Switch (side view)

Test of the Control Port Switch

For testing, I have used the Joytester II, which can be found on csdb.dk.

Connect the Control Port Switch to the C64, then switch on the computer. The Control Port Switch will issue a beep (1/4 second). The display should first show the 64 logo, then a link to my website (sorry for advertising).

The port selector switch selects one port and the corresponding LED should light up. Sliding the switch to the opposite side should select the other port.

Pushing the arcade button should switch on the rapid-fire. This is displayed on the OLED display. The LED of the selected Port should blink while rapid-fire is on. The blink rate resembles the fire rate. Turn the pot CCW and the fire rate gets less (150 r/min is the minimum in the present software), turning the pot clockwise should increase the fire rate (1500 r/min is the maximum in the present software).

Now load the software and connect the joystick. The joystick should be active on the selected port. All four directions and the fire button should be tested for both ports. They should show some activity on the selected port only.

Trouble Shooting

Make sure, that the cables are connected properly and that the single wires are not confused.

In case the device is dead (no sound, no light, no display), make sure, the Pro Micro is programmed.

Check the orientation of the ICs on the board, check the soldering.

Pinouts

Control Ports

J1 (Port 1) & J2 (Port 2) – 2x5 pin header (box connector) for a ribbon cable which connects via a D-SUB 9 (female) to the control port.

Pin	D-SUB	Signal	Pin	D-SUB	Signal
1	1	JOY0 (up)	2	6	FIRE
3	2	JOY1 (down)	4	7	+5V
5	3	JOY2 (left)	6	8	GND
7	4	JOY3 (right)	8	9	POTX
9	5	POTY	10	-	n.c.

Joystick Port

J3 – 2x5 pin header (box connector) for a ribbon cable which connects via a D-SUB 9 (male) to the control port.

Pin	D-SUB	Signal	Pin	D-SUB	Signal
1	1	JOY0 (up)	2	6	FIRE
3	2	JOY1 (down)	4	7	+5V
5	3	JOY2 (left)	6	8	GND
7	4	JOY3 (right)	8	9	POTX
9	5	POTY	10	-	n.c.

Fire-Rate Potentiometer

J4 – 3p. Molex 22-27-2031 (2,54mm pitch pin header, friction lock). Mating crimp housing 22-01-2031. Crimp terminal: 2478-TL/0850-0106.

Alternatively, a 2.54mm pitch standard pin header and a Dupont crimp housing and terminals can be used or the potentiometer is wired and soldered in without any connectors.

Pin	Signal	Note
1	+5V	Clockwise
2	RFSPEED	Tap
3	GND	Counterclockwise

Switches

J6 – 4p. Molex 22-27-2041 (2,54mm pitch pin header, friction lock). Mating crimp housing 22-01-2041. Crimp terminal: 2478-TL/0850-0106.

Alternatively, a 2.54mm pitch standard pin header and a DuPont crimp housing and terminals can be used or the switches are wired and soldered in without any connectors.

Pin	Signal	Note
1	/SWITCH	Switch for channel switching
2	GND	The other connection for this switch
3	/RF_ON	Switch for rapid-fire
4	GND	The other connection for this switch

LEDs

J5 – 4p. Molex 22-27-2041 (2,54mm pitch pin header, friction lock). Mating crimp housing 22-01-2041. Crimp terminal: 2478-TL/0850-0106.

Alternatively, a 2.54mm pitch standard pin header and a Dupont crimp housing and terminals can be used or the LEDs are wired and soldered in without any connectors.

Pin	Signal	Note
1	+5V	Anode of LED for Port 1 active
2	/LED1	Cathode LED1, 330Ω resistor on PCB
3	+5V	Anode of LED for Port 2 active
4	/LED2	Cathode LED2, 330Ω resistor on PCB

I²C-Bus

J7 – 4p. Molex 22-27-2041 (2,54mm pitch pin header, friction lock). Mating crimp housing 22-01-2041. Crimp terminal: 2478-TL/0850-0106.

The I²C bus provides a display connection. The total power consumption of the board, the display and the joystick should not exceed 100mA.

Pin	Signal	Note
1	SCL	I²C Clock
2	SDA	I²C Data
3	+5V	Supply voltage (I < 100mA)
4	GND	Ground

External Switches

X3 – MPE Garry 369-1-008 (MicroMatch 8p., female, THT).

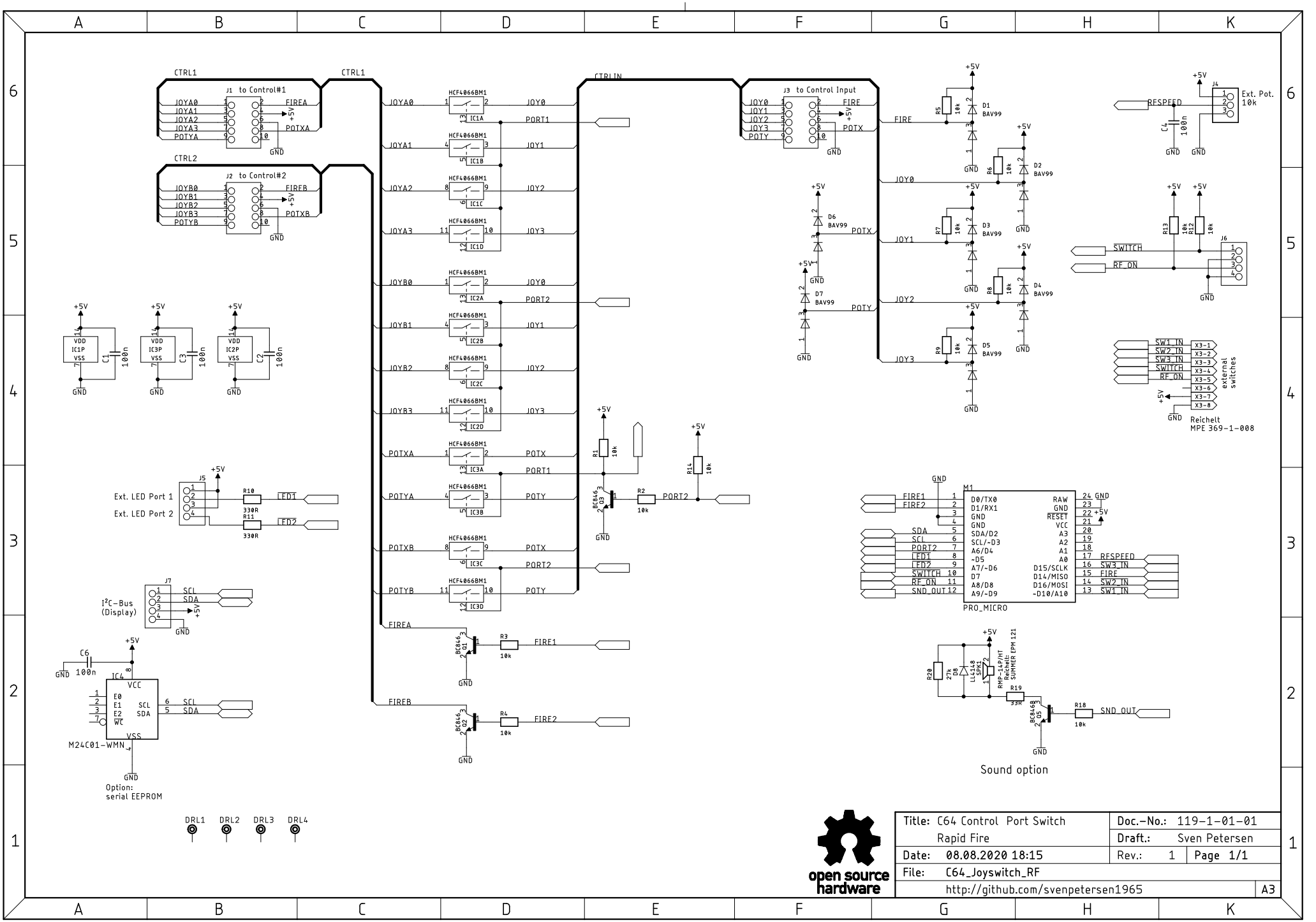
This is an optional connector to operate this module with an external switch board (Project No. 112) or rotary encoder board (Project No. 118) from the Pi1541 Project. Both boards are suitable for +5V supply, except the LEDs, which then should remain not assembled.

Pin	Signal	Note
1	/SW1_IN	Select
2	/SW2_IN	Up
3	/SW3_IN	Down
4	/SWITCH	Channel Switching
5	/RF_ON	Rapid-fire on/off
6	-	Not connected
7	+5V	Power supply for external switches
8	GND	Ground

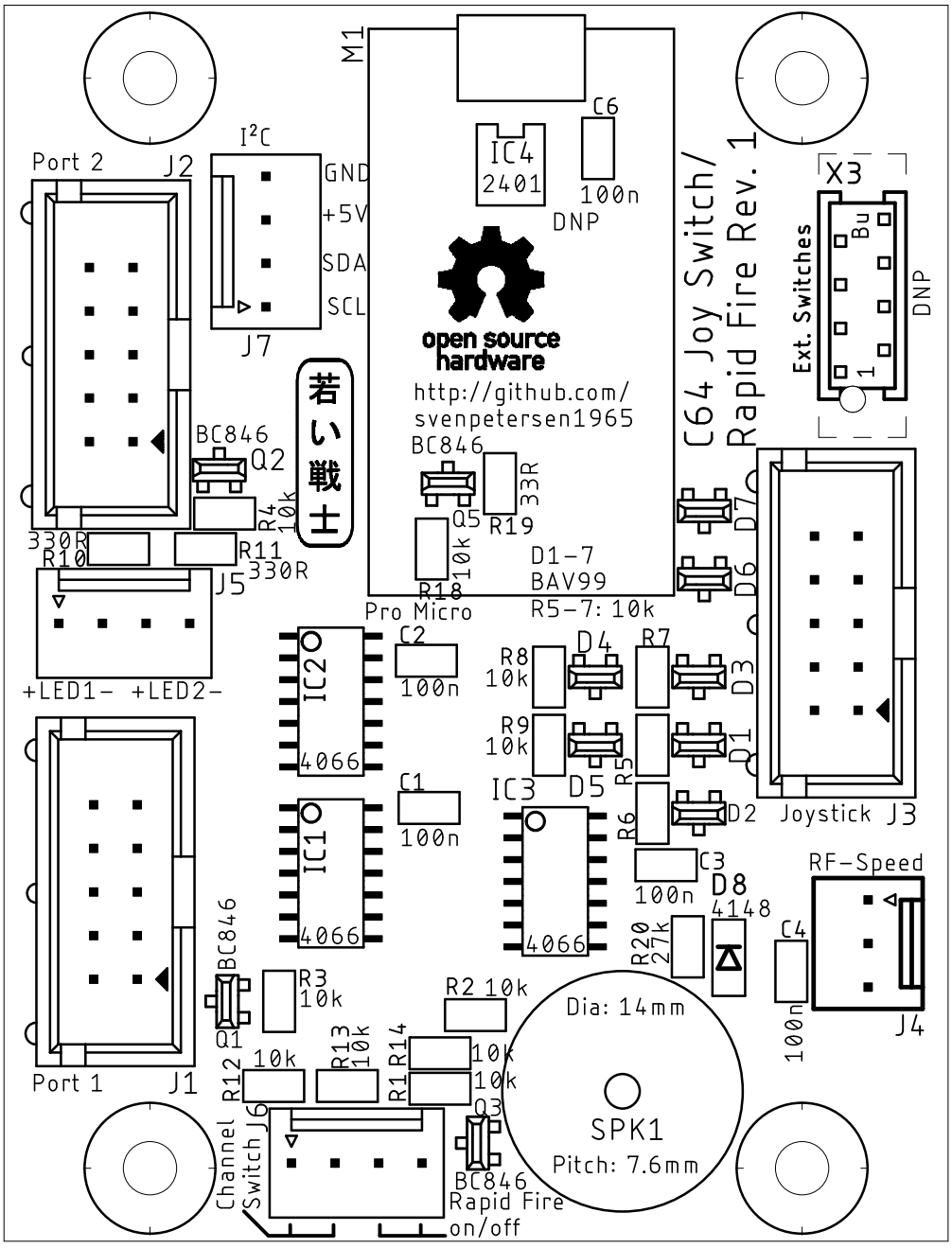
Links

- My github: https://github.com/svenpetersen1965
- My website: http://tech.guitarsite.de/
- Arduino IDE: https://www.arduino.cc/en/Main/Software
- The test software: https://csdb.dk/release/?id=170175
- A source of the OLED display: AliExpress: 1pcs 0.91 inch OLED module 0.91" white/blue OLED 128X32 OLED LCD LED Display Module 0.91" IIC Communicate
- A source of the arcade button: AliExpress: 10 pcs Arcade 30mm Round Button Copy SANWA OBSF-30
- A source of the Pro Micro: AliExpress: TZT Pro Micro ATmega32U4 5V 16MHz Replace ATmega328 For Arduino Pro Mini With 2 Row Pin Header For Leonardo Mini Usb Interface

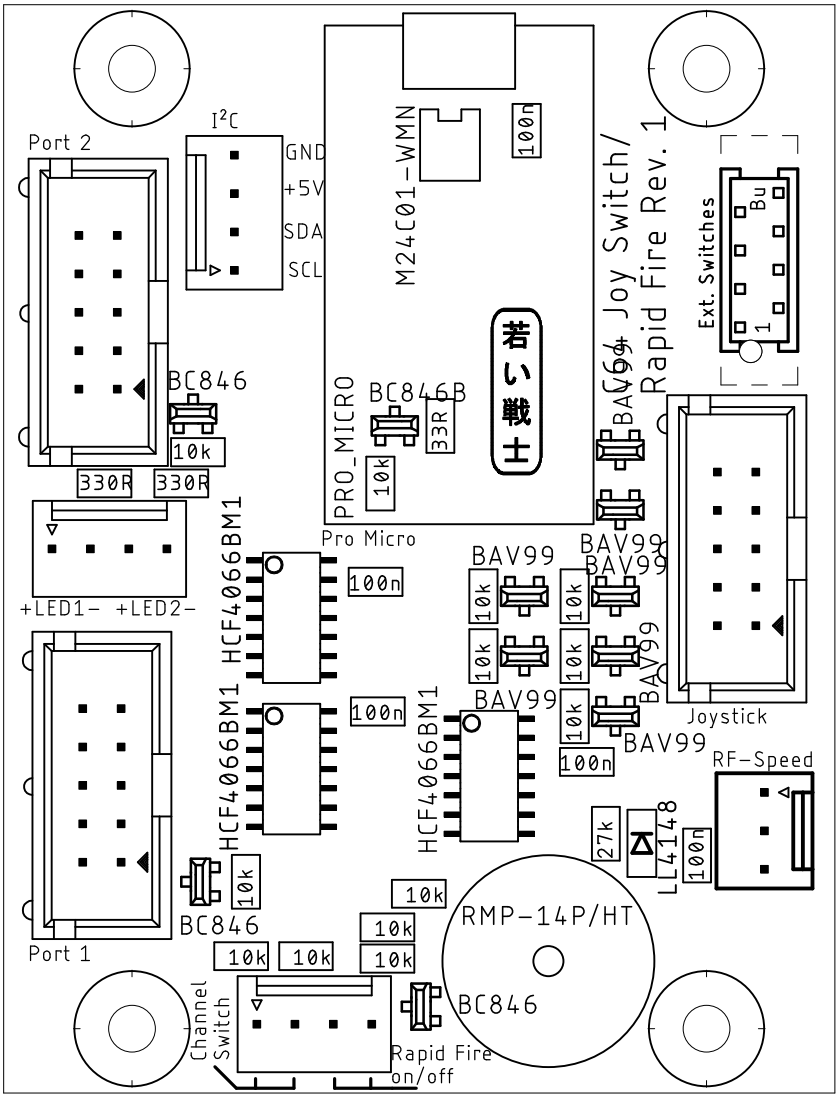
Note: The sources are one of plenty.


CTRL1
J1 to Control#1
JOYA0
JOYA1
JOYA2
JOYA3
POTYA
FIREA
POTXA
GND
CTRL2
J2 to Control#2
JOYB0
JOYB1
JOYB2
JOYB3
POTYB
FIREB
POTXB
CTRLIN
HCF4066BM1
IC1A
IC1B
IC1C
IC1D
IC2A
IC2B
IC2C
IC2D
IC3A
IC3B
IC3C
IC3D
PORT1
PORT2
J3 to Control Input
JOY0
JOY1
JOY2
JOY3
POTX
POTY
FIRE
D1 BAV99
D2 BAV99
D3 BAV99
D4 BAV99
D5 BAV99
D6 BAV99
D7 BAV99
R5 10k
R6 10k
R7 10k
R8 10k
R9 10k
+5V
J4
Ext. Pot. 10k
RESPEED
C4 100n
R13 10k
R12 10k
J6
SWITCH
RF_ON
SW1_IN
SW2_IN
SW3_IN
X3-1
X3-2
X3-3
X3-4
X3-5
X3-6
X3-7
X3-8
external switches
Reichelt MPE 369-1-008
C1 100n
C2 100n
C3 100n
VDD
VSS
IC1P
IC2P
IC3P
J5
Ext. LED Port 1
Ext. LED Port 2
LED1
LED2
R10 330R
R11 330R
R1 10k
R2 10k
R14 10k
BC846
Q3
J7
I²C-Bus (Display)
SCL
SDA
C6 100n
IC4
M24C01-WMN
E0
E1
E2
WC
VCC
VSS
Option: serial EEPROM
R3 10k
R4 10k
FIRE1
FIRE2
M1
PRO_MICRO
D0/TX0
D1/RX1
RAW
RESET
VCC
A3
A2
A1
A0
D15/SCLK
D14/MISO
D16/MOSI
-D10/A10
SCL/-D3
A6/D4
-D5
A7/-D6
D7
A8/D8
A9/-D9
SND_OUT
R20 27k
D8 LL4148
SPKR1
RMP-14P/HT Reichelt SUMMER EPM 121
R19 33R
R18 10k
Sound option
DRL1
DRL2
DRL3
DRL4
open source hardware
Title: C64 Control Port Switch
Rapid Fire
Doc.-No.: 119-1-01-01
Draft.: Sven Petersen
Date: 08.08.2020 18:15
Rev.: 1
Page 1/1
File: C64_Joyswitch_RF
http://github.com/svenpetersen1965
A3

Sven Petersen 2019	Doc.-No.: 119-2-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_Joyswitch_RF		
08.08.2020 18:39		Rev.: 1
placement component side		



Sven Petersen 2019	Doc.-No.: 119-2-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_Joyswitch_RF		
18.03.2020 21:20		Rev.: 1
placement component side		



Sven Petersen 2019	Doc.-No.: 119-2-01-01	
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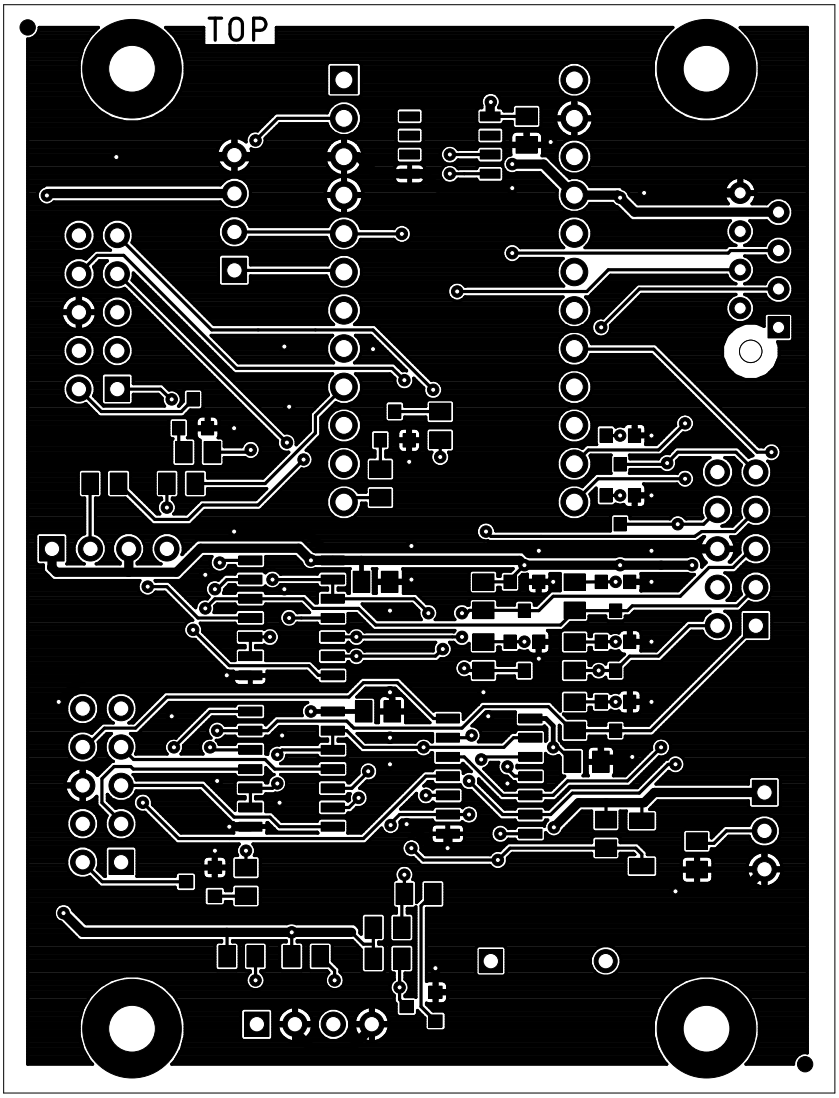
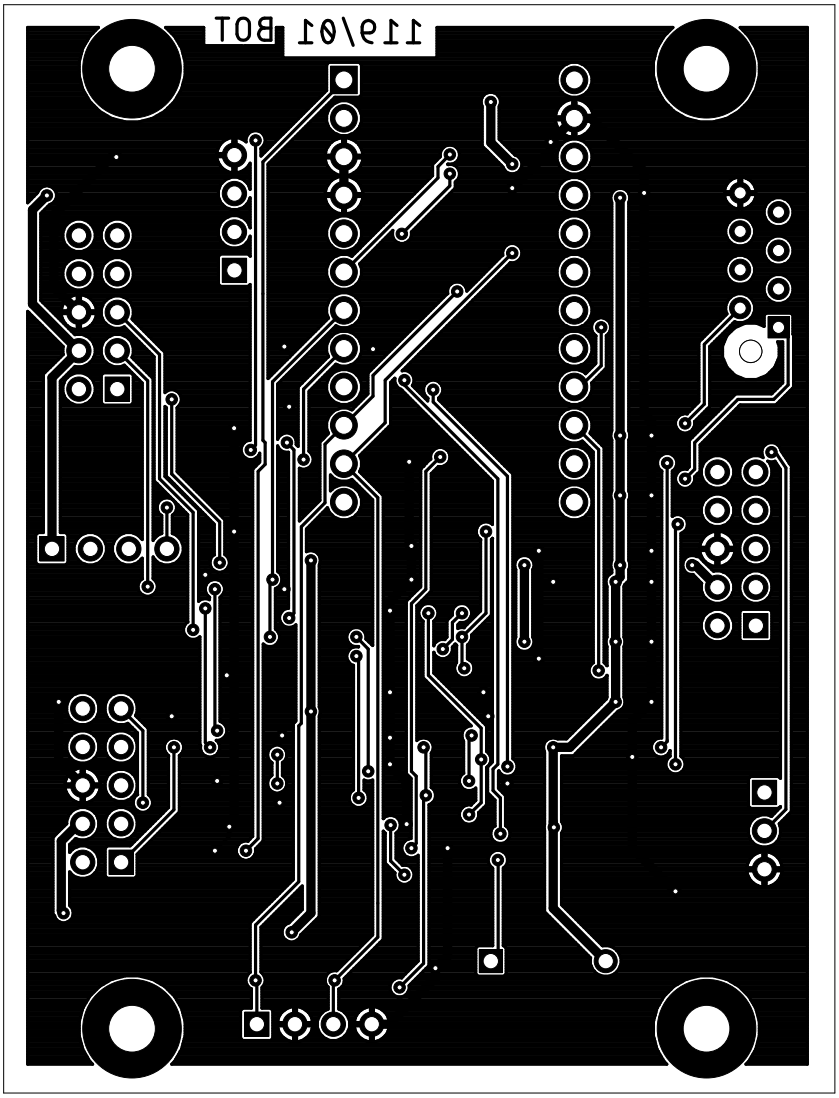
C64_Joyswitch_RF		
18.03.2020 21:20		Rev.: 1
top		



Sven Petersen 2019	Doc.-No.: 119-2-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_Joyswitch_RF		
18.03.2020 21:20		Rev.: 1
bottom		



Sven Petersen 2019	Doc.-No.: 119-2-01-01	
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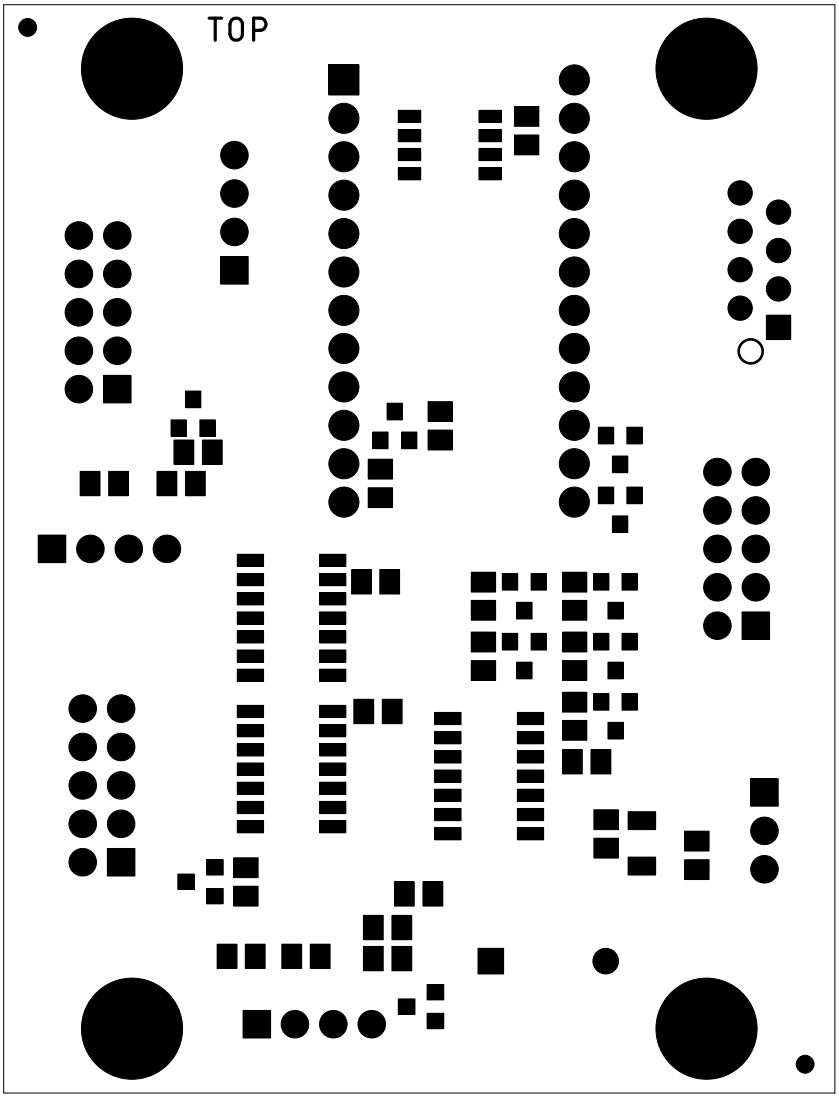
C64_Joyswitch_RF		
18.03.2020 21:20		Rev.: 1
stopmask component side		



Sven Petersen 2019	Doc.-No.: 119-2-01-01	
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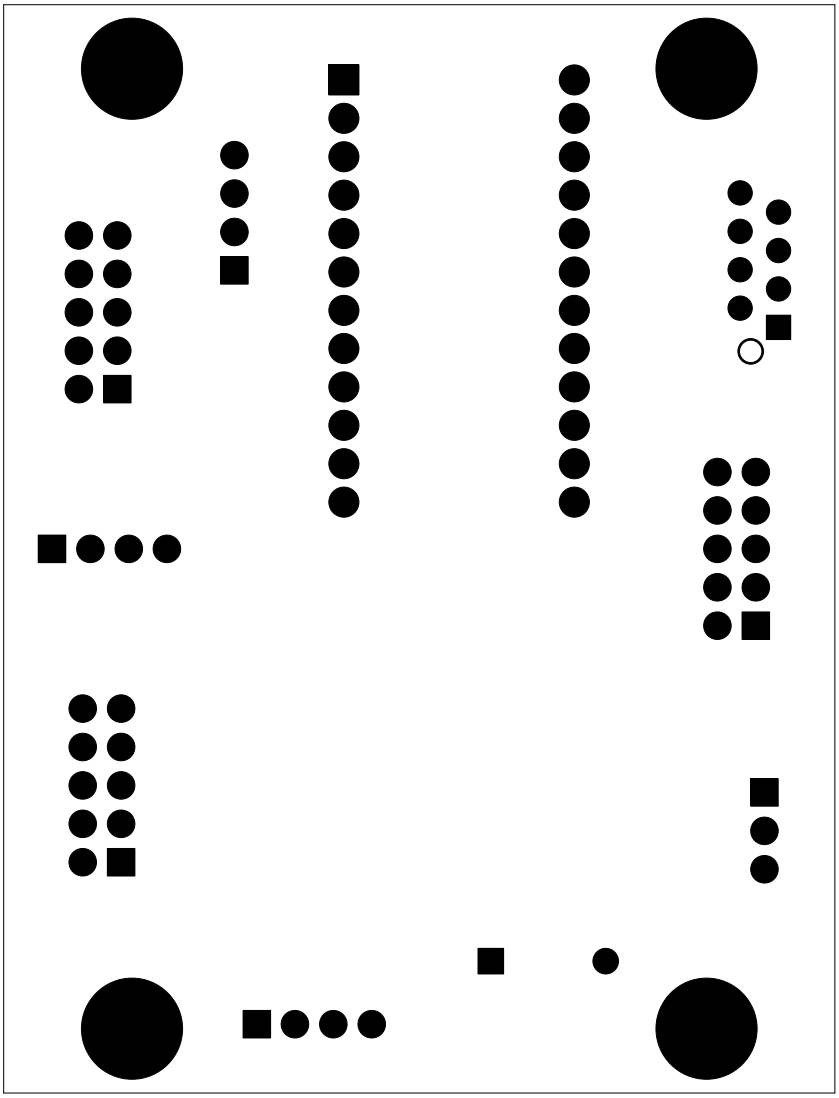
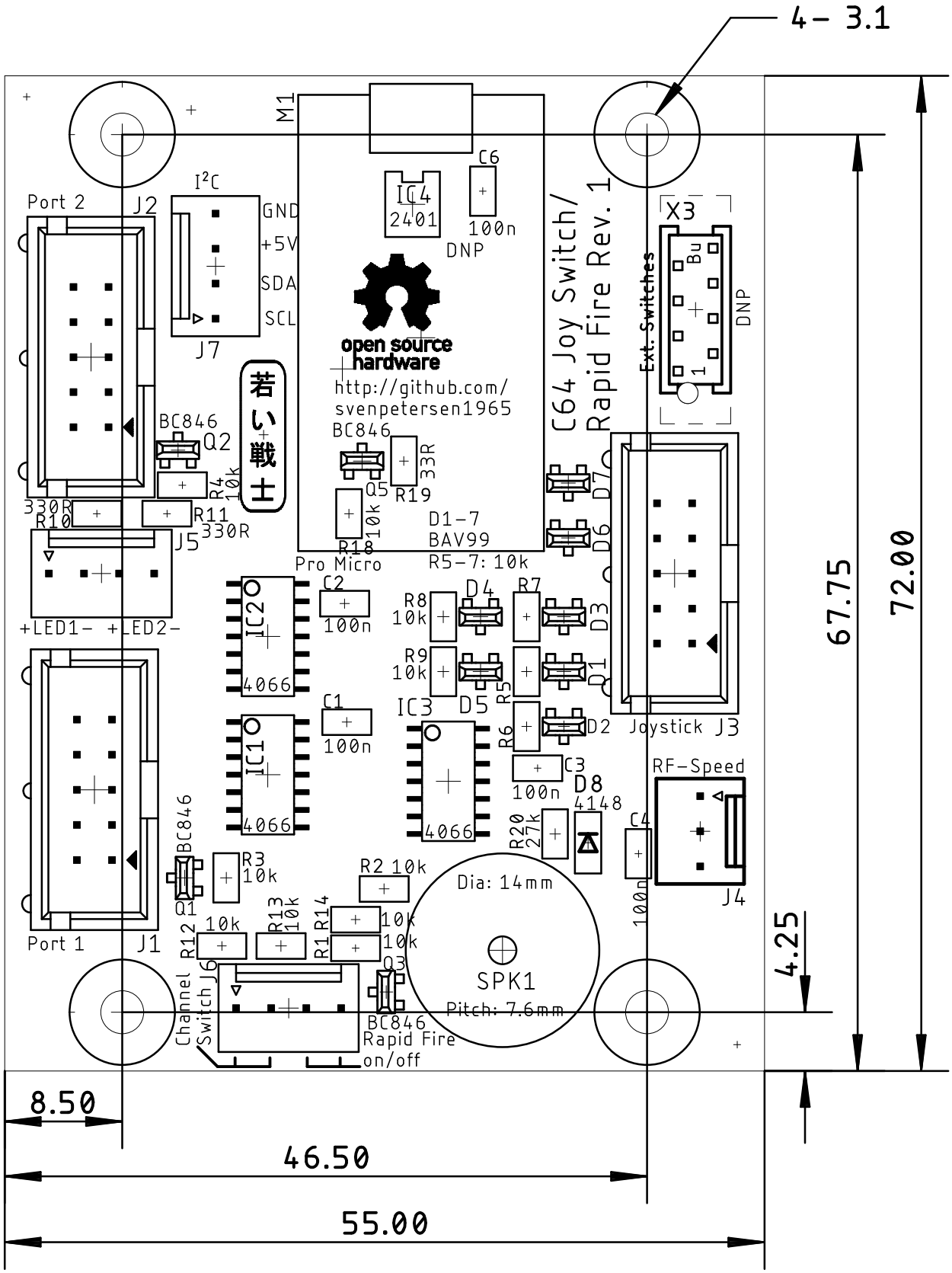
C64_Joyswitch_RF		
18.03.2020 21:20		Rev.: 1
stopmask solder side		



Sven Petersen 2019	Doc.-No.: 119-2-01-01	
	Cu: 35µm	Cu-Layers: 2
C64_Joyswitch_RF		
08.08.2020 18:39		Rev.: 1
placement component side measures		



C64 – Control Port Switch & Rapid-Fire Rev. 1

Functional Description

J1 connects top Control Port 1, J2 to Control Port 2. The switching functionality to the four direction channels (JOY0…3) of the joystick is realized in IC1 and IC2. A HIGH level on signal PORT1 switches on the analog switches of IC1 to the active state, while IC2 is switched off. The joystick signals are available on J1 (JOYA0…3).

A HIGH level on signal PORT2 switches IC1 off (PORT1 is the inverted PORT2), while IC2 is switched on. JOY0…3 are now present on JOYB0…3 (J2, Port 2).

The analog signals POTX and POTY are switched with the analog switch IC2. Q3 and R1 invert the signal PORT2. A HIGH level on the resulting Signal PORT1 is switching POTX to POTXA and POTY to POTYA on control port 1.

A HIGH level on PORT2 switches POTX to POTXB and POTY to POTYB (control port 2).

Both Fire signals (FIREA and FIREB) are generated by the micro controller module M1, a Pro Micro. Q1 and Q2 serve as switches. HIGH pulses on the signals FIRE1 and FIRE2 respectively issue LOW pulses on FIREA and FIREB respectively. LOW means, that the fire is active.

/LED1 and /LED2 should indicate the active control port. /SWITCH and /RF_ON are active LOW signals from external switches, the purpose is switching between channels and switching on/off the rapid-fire function.

The FIRE signal is issued by the connected joystick. It is active LOW. The controller is supervising this signal and issuing the HIGH level or pulses on FIRE1 or FIRE, depending on the rapid-fire option is switched off or on and the port, which is selected.

The signal RFSPEED is a voltage level depending on the position of the connected “Speed” potentiometer. The controller is converting it to digital internally.

J7 carries the I^2C bus signals of the controller and supply voltage (+5V) and ground. The purpose is connecting an I^2C bus LCD or OLED display. This can serve to indicate the state and rapid-fire rate.

The twin diodes D1…D7 serve as a basic protection of the joystick input. The digital joystick inputs are connected to 10k pull-up resistors.

IC4 is not necessarily populated. It is an EEPROM and can be used to store parameters that should be non-volatile. It is only required, if the scrip for the Pro Micro supports this feature.

The circuitry around Q5 is driving a piezo buzzer. It is an option and only required, in case the firmware (script) for the Pro Micro supports this feature.

C64 Control Port Switch Rev. 1
Bill of Material Rev. 1.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
1	1	119-2-01-01	2 Layer	PCB Rev. 1	2 layer, Cu 35µ, HASL, 72.0mm x 55.0mm, 1.6mm FR4
2	3	2x5 box connector	2X05WV	J1, J2, J3	e.g. Reichelt WSL 10G
3	3	10p IDC receptacle, 2,54mm		(J1), (J2), (J3), (J4)	e.g. Reichelt RND 205-00682
4	2	9p D-SUB (female), IDC		(J1), (J2)	e.g. Reichelt D-SUB BU 09FB
5	1	9p D-SUB (male), IDC		(J3)	e.g. Reichelt D-SUB ST 09FB
6	1	6410/22-27-2031	6410-3P	J4	Molex KK Pin header, 3p., 2.54mm, e.g. Reichelt MOLEX 22272031
7	1	22-01-2031		(J4)	Molex Crimp Housing
8	1	Potentiometer, 10k, linear, 6mm axis		(J4)	e.g. Reichelt PIH PC16IP061033
9	1	knob for rotary axis 6 mm		(J4)	e.g. Reichelt KNOPF 10-150B
10	3	6410/22-27-2041	6410-4P	J5, J6, J7	Molex KK Pin header, 4p., 2.54mm, e.g. Reichelt MOLEX 22272041
11	3	22-01-2041		(J5), (J6), (J7)	Molex Crimp Housing
12	15	2759-TL/0850-0114		(J4-J7)	Molex Crimp Terminal (order more than required)
13	2	3mm/green		(J5)	LED, e.g. Reichelt LED 3MM GN
14	1	30 mm arcade button		(J6)	From AliExpress, see module description
15	1	miniature slide switch		(J6)	hole pitch: 19mm
16	1	OLED 0.91", I²C, SSD1306		(J7)	OLED Display, see documentation
17	1	DuPont Crimp Housing 1x4		(OLED Display)	AliExpress, ebay, other webshops
18	4	DuPont Crimp Terminals		(OLED Display)	AliExpress, ebay, other webshops
19	5	100n	805	C1, C2, C3, C4, C6	0805 SMD ceramic capacitor, 25V or better
20	13	10k	805	R1, R2, R3, R4, R5, R6, R7, R8, R9, R12, R13, R14, R18	0805 SMD chip resistor, 5% or better
21	1	27k	805	R20	0805 SMD chip resistor, 5% or better
22	2	330R	805	R10, R11	0805 SMD chip resistor, 5% or better

C64 Control Port Switch Rev. 1
Bill of Material Rev. 1.0

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
23	1	33R	805	R19	0805 SMD chip resistor, 5% or better
24	1	369-1-008	MICMA08B	X3	do not place: MPE, Socket MicroMatch 1.27 mm, 2X04, straight, e.g. Reichelt MPE 369-1-008
25	7	BAV99	SOT23	D1, D2, D3, D4, D5, D6, D7	Twin diode, SMD SOT23
26	4	BC846B	SOT23	Q1, Q2, Q3, Q5	NPN transistor, SMD SOT23. Alternative: BC847B, BC848B,
27	3	HCF4066BM1	SO-14	IC1, IC2, IC3	4066B SMD, e.g. ST-Micro or NXP, Reichelt SMD 4066
28	1	LL4148	SOD80C	D8	SMD Diode
29	1	M24C01-WMN	SO-08	IC4	do not place
30	1	PRO_MICRO	PRO_MICRO	M1	Micro controller module, ebay or other online shops
31	2		1x12	(M1)	12 way socket strip (pitch: 2.54mm), e.g. Reichelt MPE 115-1-012
32	1	RMP-14P/HT	RMP-14P/HT	SPK1	KM, e.g. Reichelt SUMMER EPM 121
33	1	3D printed case			in the project files. Alternative: Plastic case Reichelt RND 455-00959
34	2	LED mounting clip 5mm			e.g. Reichelt MONTAGERING 5MM
35	60cm	Wire, AWG24/0.25mm², red			for wiring
36	60cm	Wire, AWG24/0.25mm², black			for wiring
37	9cm	Wire, AWG24/0.25mm², grey			for wiring
38	9cm	Wire, AWG24/0.25mm², yellow			for wiring
39	11cm	shrinkable sleve			for LEDs and switches
40	25cm	Ribbon Cable, AWG28, 10p			For joystick and control port connections