Project Documentation

Pi1541 – Rotary Encoder Board

Project number: 118

Revision: 0

Date: 17.03.2019

Pi1541 – Rotary Encoder Board Rev. 0

Module Description

The Rotary Encoder Board is intended to work with the Pi1541-HAT (Project 111) instead of the Pi1541-Switch Board (Project 112). Instead of the switches SW1 (Enter/Escape), SW2 (down) and SW3 (up) on the board mentioned above, a rotary encoder is used, which issues pulses (active low) to SW2 and SW3 depending on the direction in which it is turned. Pushing the axis of the rotary encoder will switch the SW1 signal.

The duration of the up or down pulses is determined by R/C combination and can be adapted to the requirements of the software. This way, no adaptation is requited of the Pi1541 software running on the Raspberry Pi to operate the rotary encoder.

The distances of the mounting holes, the LEDs and the switches remain the same like on the Pi1541-Switch board. The rotary encoder axis does not fit into the 8.6mm grid of the switches on the Pi1541-Switch board.

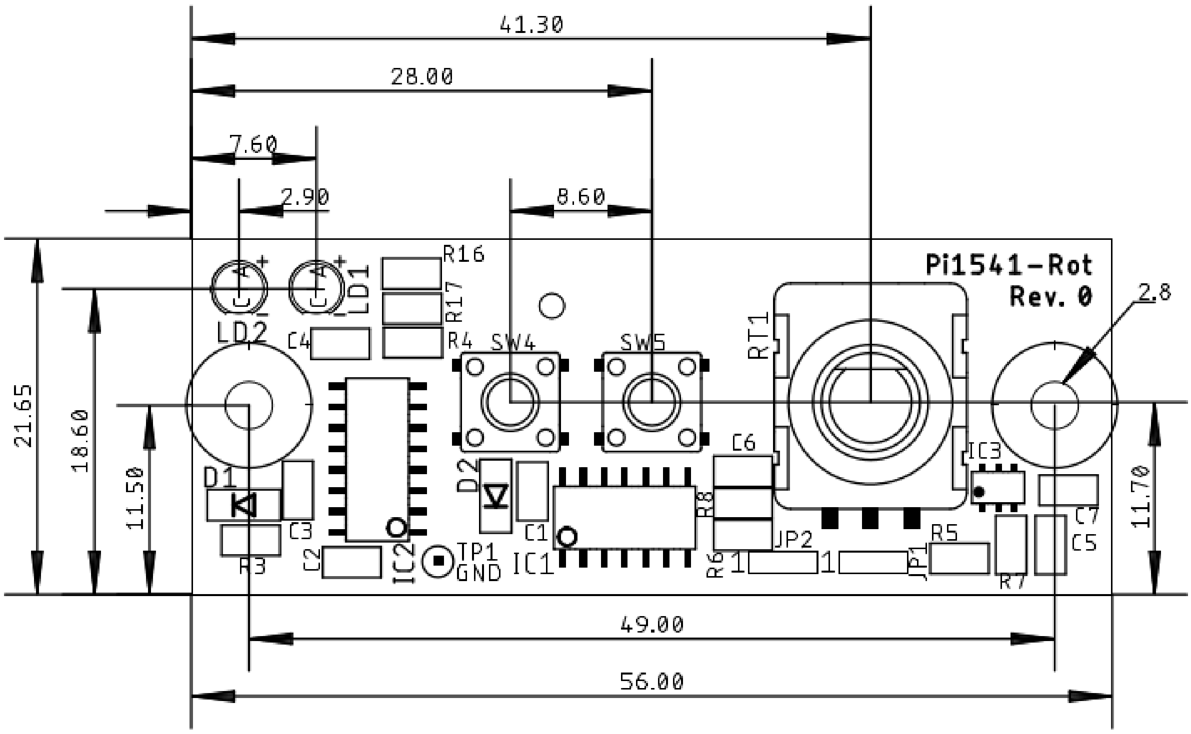


Figure 1: Measures of the Pi1541-Rot Board

Switches Rotary encoder

The switches have functions according to the firmware and configuration, which can be found at this website: https://cbm-pi1541.firebaseapp.com/

The default configuration is:

Switch	Function
SW4	Exit Folder
SW5	Insert Disk

Rotary Enc.	Function
Push	Select/Reset
CCW	Move Up/Previous Disk
CW	Move Down/Next Disk

LEDs

LED	Color	Function
LD2	Green	Power Indicator
LD1	Red	Busy Indicator

Connector

X3: 8p Micro Match, female, THT (Tyco or alternative)

The ribbon cable can also be soldered in directly.

Pin	Signal
1	/SW1 (push)
2	/SW2 (CCW)
3	/SW3 (CW)
4	/SW4
5	/SW5
6	LED_OUT (LD1)
7	+3V3
8	GND

Placement of IC3

IC3 is a dual Schmitt trigger. The case is symmetric (SOT-23-6) and the pin 1 mark is not very visible.

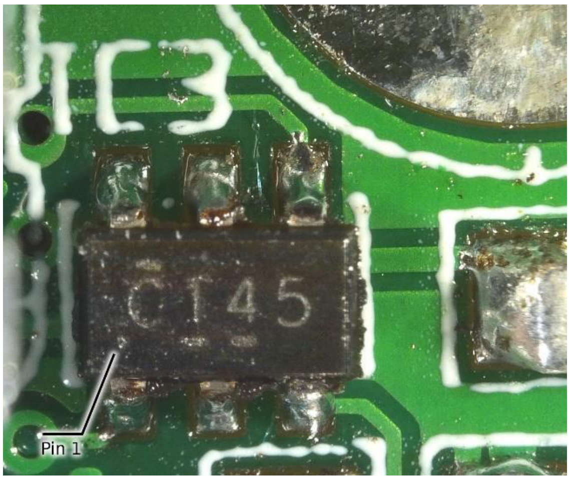
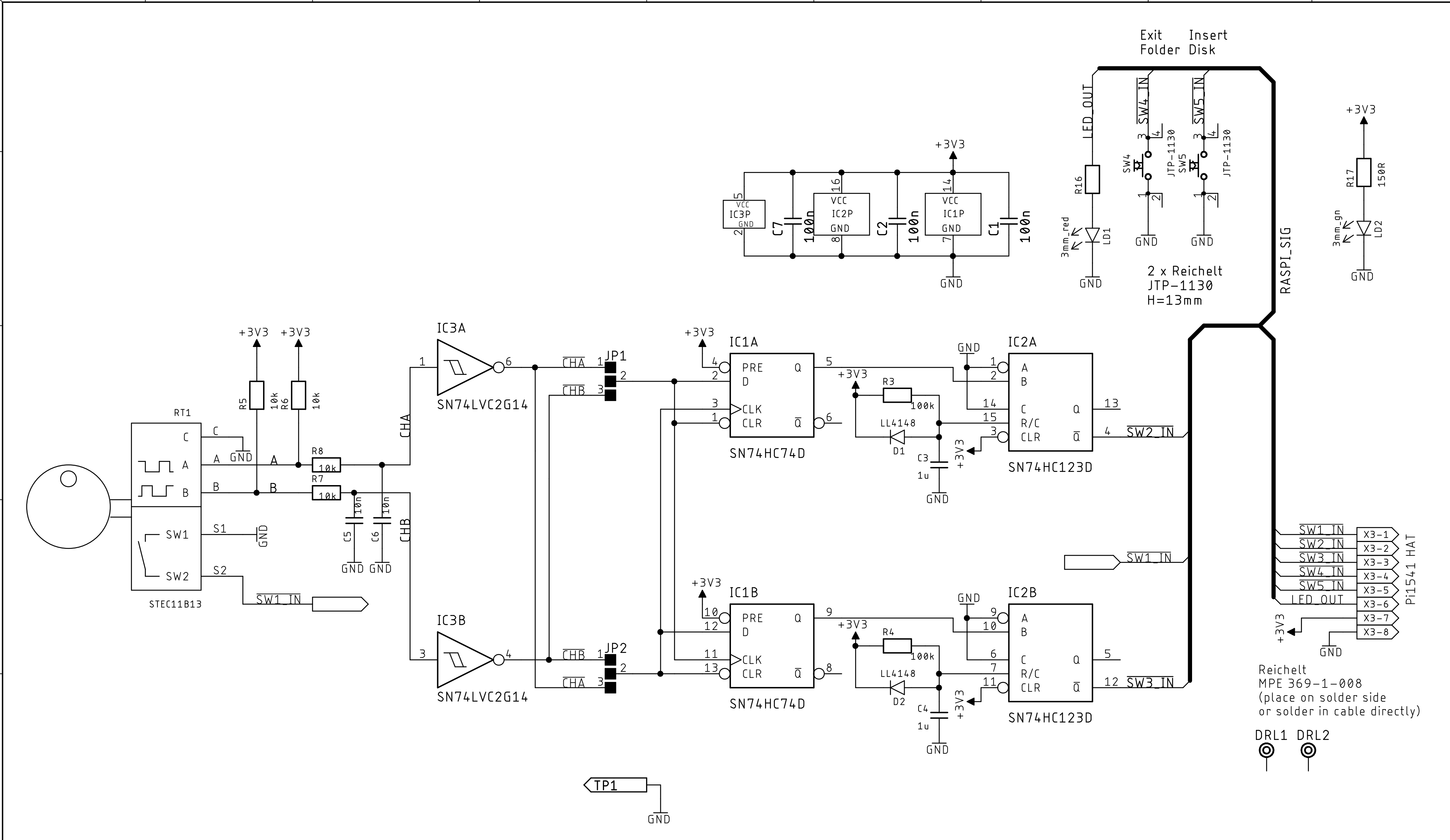


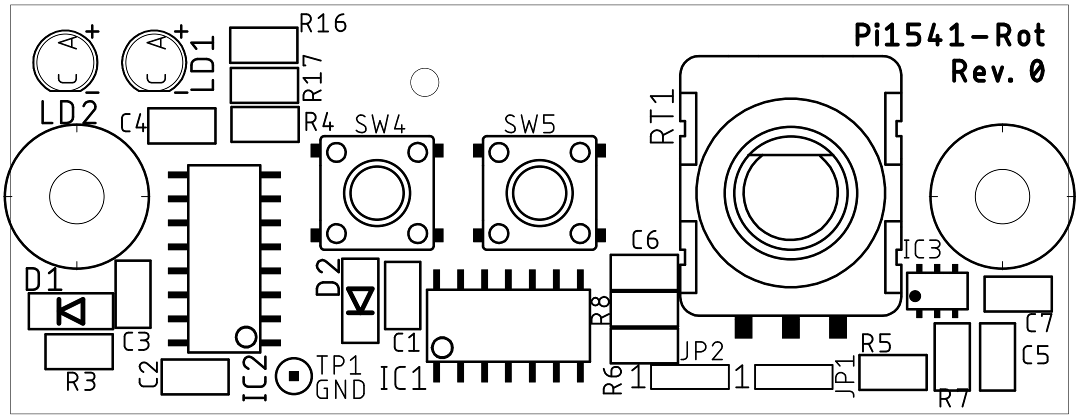
Figure 2: Placement of IC3

If the part marking is upright, pin 1 is at the left lower corner of the part as shown in Figure 2.



Title: Pi1541-Rotary Encoder		Doc.-No.: 118-1-01-00	
		Draft.: Petersen	
Date: 08.04.2019 16:16		Rev.: 0	Page 1/1
File: Pi1541_Rot			
			A4

Sven Petersen 2019	Doc.-No.: 118-2-01-00	
	Cu: 35µm	Cu-Layers: 2
Pi1541_Rot		
08.04.2019 16:22		Rev.: 0
placement component side		



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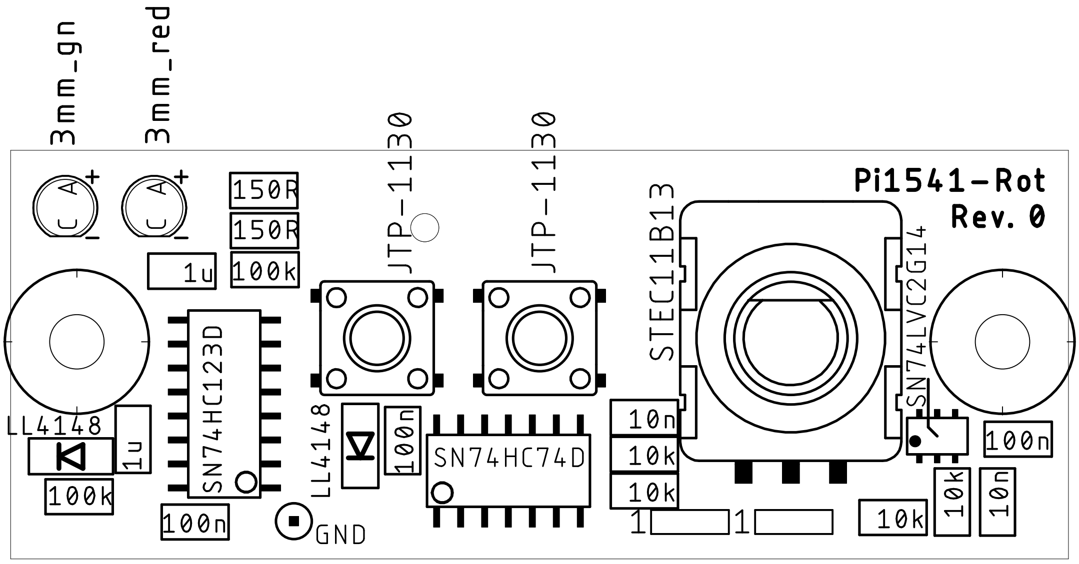

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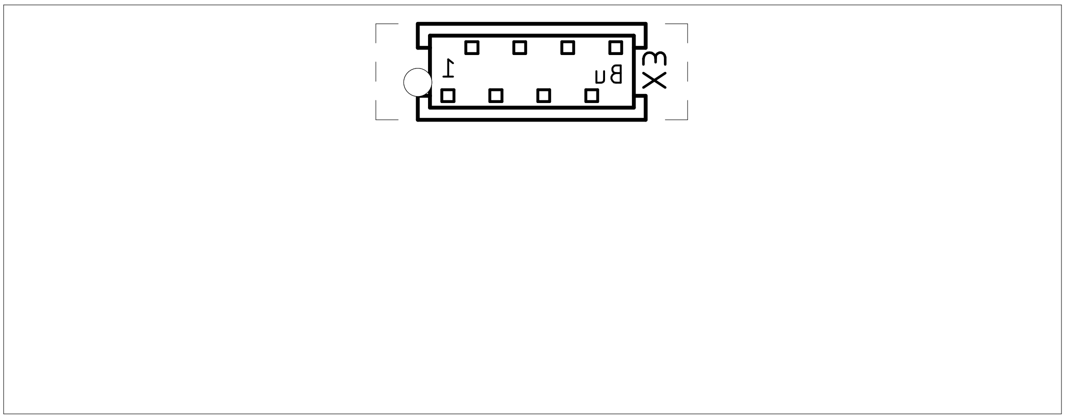

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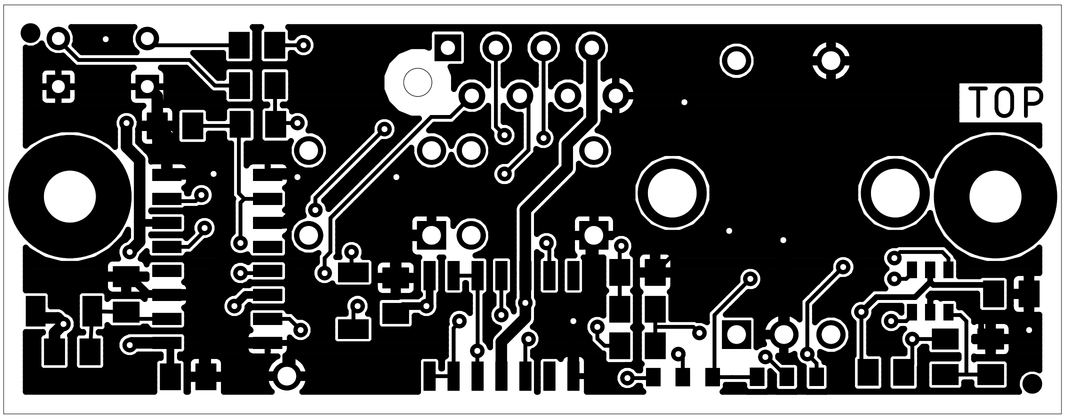

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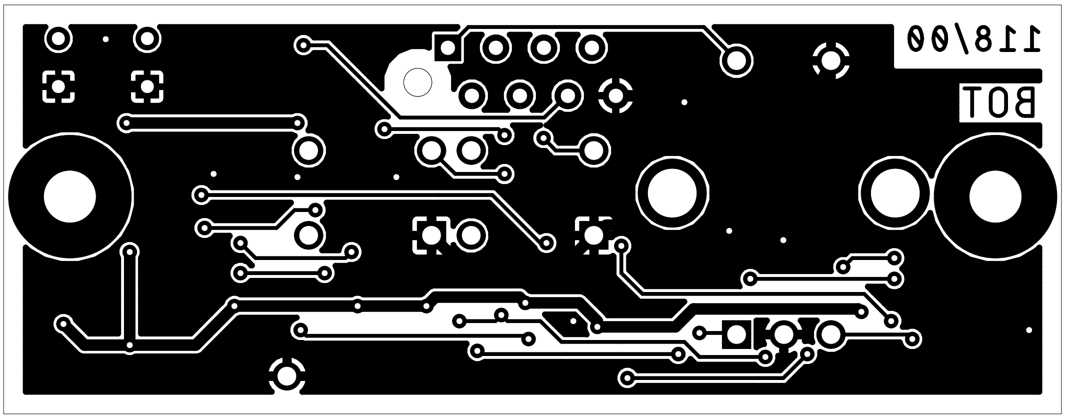

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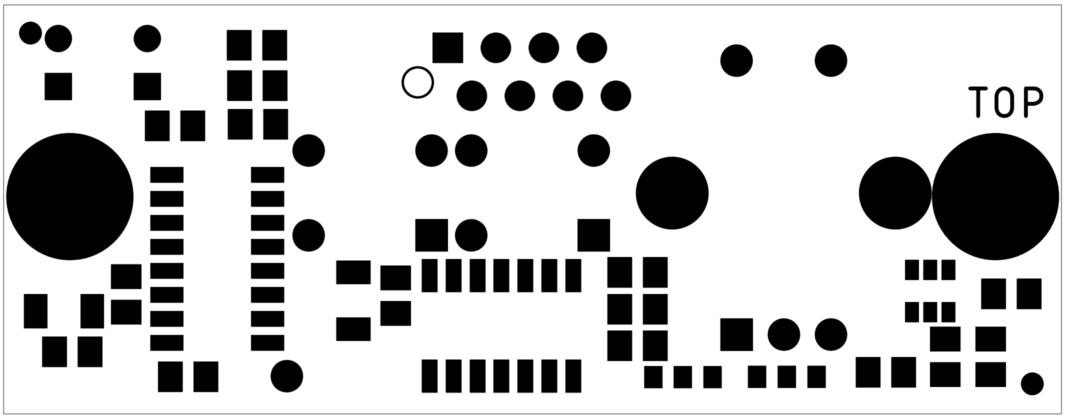
stopmask component side		



Sven Petersen 2019	Doc.-No.: 118-2-01-00	
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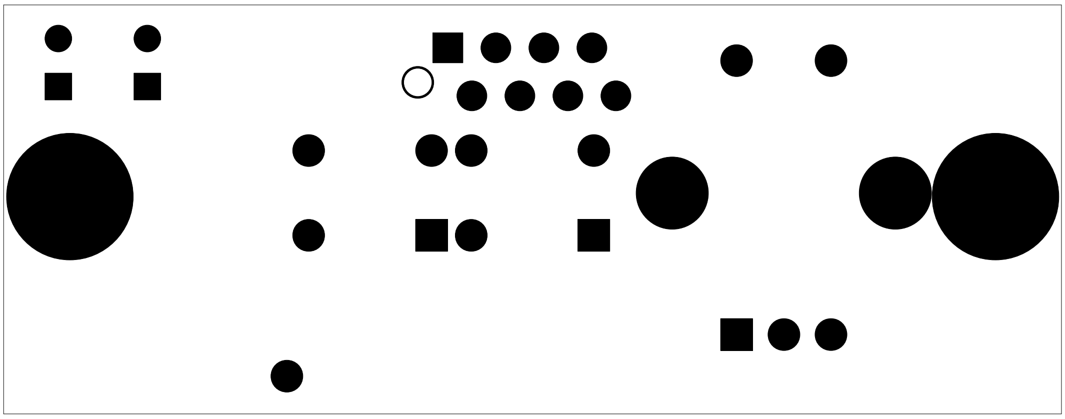

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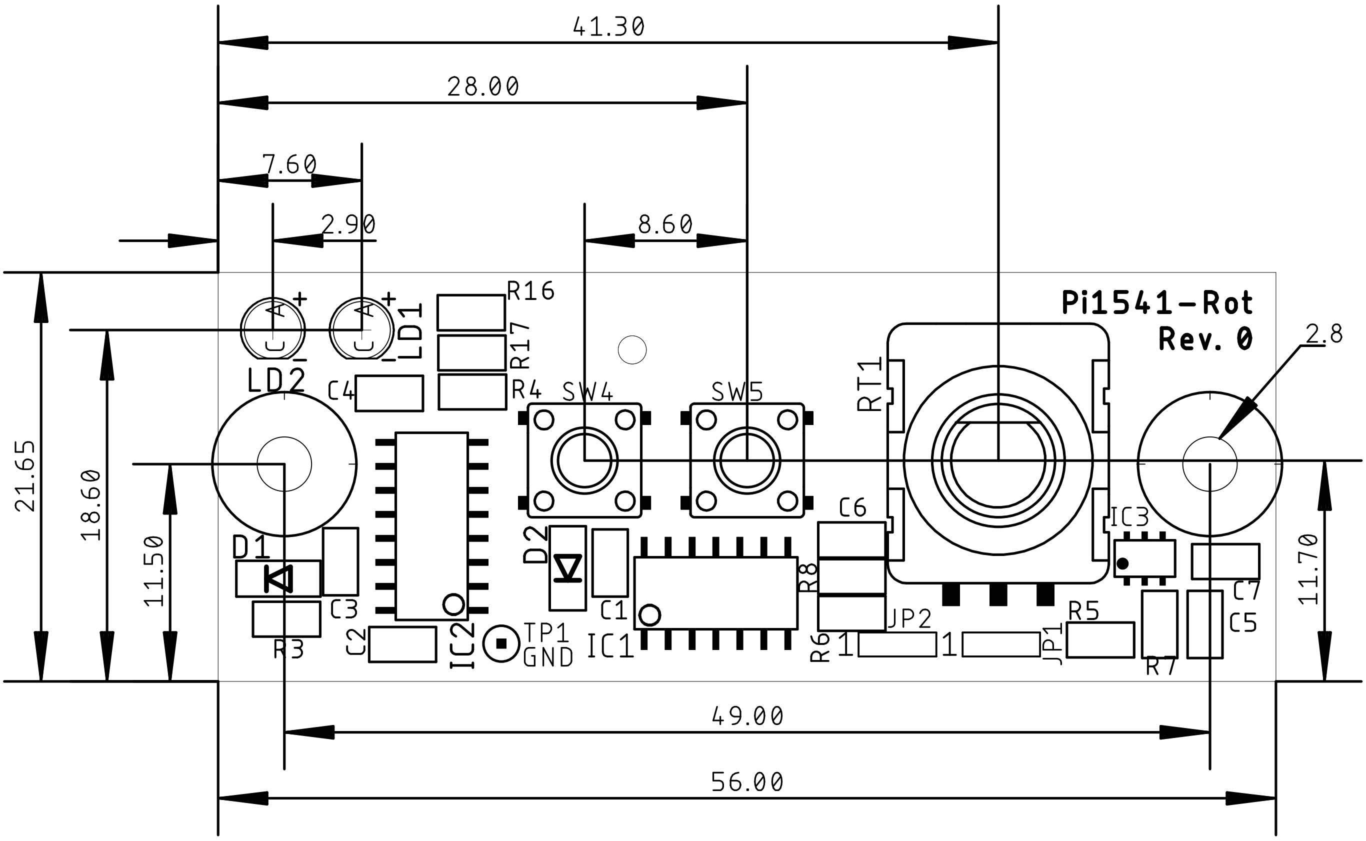
placement component side measures		



Pi1541 – Rotary Encoder Board Rev. 0

Functional Description

The rotary encoder RT1 issues two square wave signals on channel A and channel B, depending on the direction of the turn, channel A is ahead of channel B or vice versa.

Since the rotary encoder is working mechanically, the two channels are required to be "debounced". R6/R8/C6 or R5/R7/C7 are serving this purpose, as recommended by the manufacturer of the rotary encoder.

There are two identical circuits for the direction recognition, which consist of a D-flip flop and a mono-flop each. For both directions, channel A and Channel B play an opposite role.

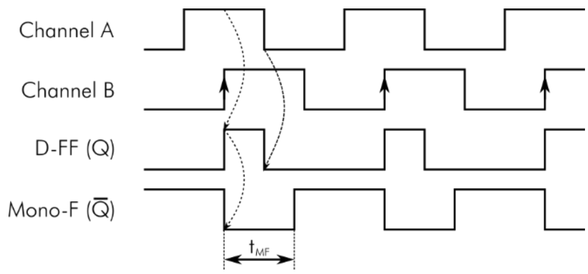


Figure 1: Channel A ahead of channel B

The case shown in Figure 1 describes a turn fitting the detected direction. Here, channel B is driving the clock signal of the D-flipflop (IC1), while channel A is connected to the D-input and the /CLR-signal of that D-FF. A rising edge of channel B will latch the level of channel A (in this case a HIGH) to the output Q. Later in the signal cycle, channel A will get LOW, which resets the D-FF via the /CLR input. The positive pulse generated on the output Q triggers the following mono-flop (IC2). This way, a LOW pulse of a duration t_{MF} will be issued on the /Q output of IC2. t_{MF} is determined by the R/C combination (R3 and C3 or R4 and C4) connected to the mono-flop.

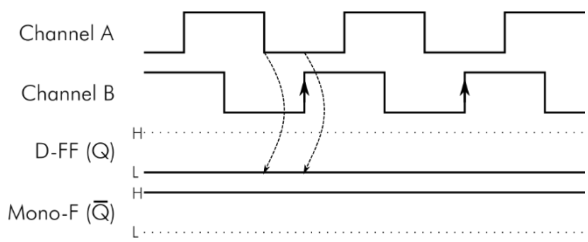


Figure 2: Channel B ahead of channel A

Turning the rotary encoder opposite to the detected direction will result in output signals shown in Figure 2. A LOW level of channel A will reset the D-FF. The output Q of IC1 will be reset. When the rising edge of Channel B latches the level of channel A, which is LOW at that time. The output Q of the D-FF will remain low. No pulses are generated by the mono-flop (IC2).

Pushing the rotary encoder will work as the Select/Reset switch. Pushing SW4 will exit the folder, SW5 will select the disk images for a multi disk game/demo.

Pi1541 – Rotary Encoder Board Rev. 0

Prototype Testing

Test Setup

The Board was connected to the existing Pi1541 setup, replacing the switch board. The software running on the Pi1541 is v1.19 (not modified).

A 4-channel oscilloscope was connected to the two rotary encoder outputs and the outputs for the up and down switch. The latter outputs are active low, that means a pulse is present while low level.

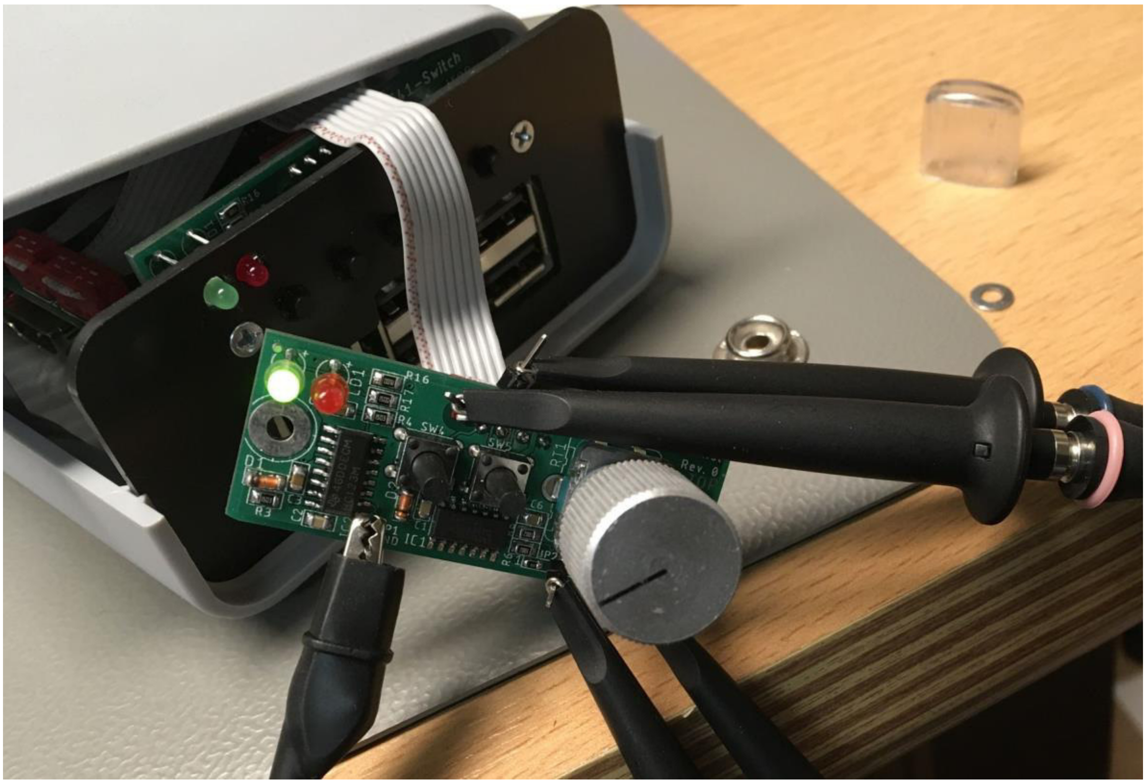


Figure 1: Test setup

Test Results

Test	Result	Testing
Turning the rotary encode CW	Proper function as a down switch (SW3)	Ok
Turning the rotary encoder CCW	Proper function as an up switch (SW2	Ok
Pushing the rotary encode	Proper function as the select switch (SW1)	Ok
Pushing Switch SW4	Proper function as a back switch	Ok
Pushing Switch SW5	Proper function as an insert disk switch	Ok
Turning the rotary encoder fast (in every direction)	Some pulses get lost. It seems that the Pi1541 is not fast enough to follow. The	It does not influence the usability in a bad way. Ok.

Test	Result	Testing
	more to scroll on the display, the more pulses get lost.	
Optimizing the mono-flop timing: R3 and R4 replaced with 47k	Pulses too short for the Pi1541 to detect	Not ok.
Optimizing the mono-flop timing: R3 and R4 replaced with 100k	Pulses are detected by the Pi1541 software. Pulse length 33ms	Ok.
Optimizing the mono-flop timing: R3 and R4 replaced with 75k	Pulses are detected by the Pi1541 software. Pulse length 26ms	Ok.

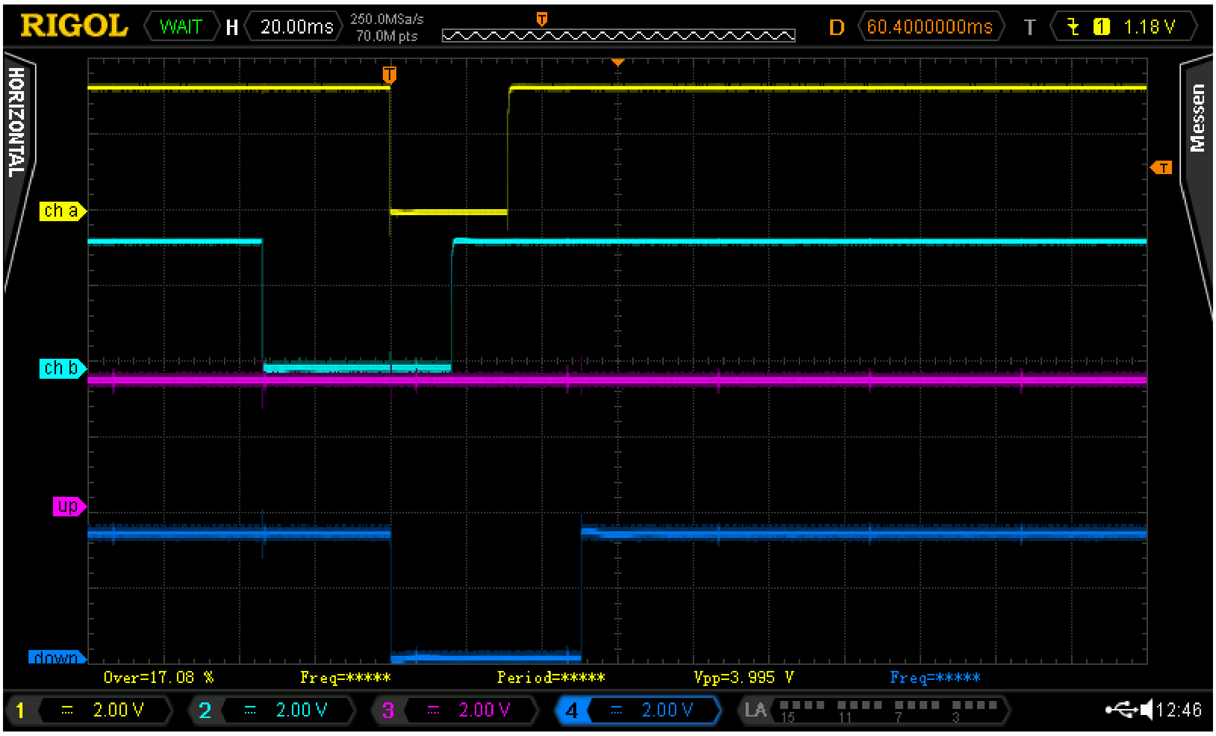


Figure 2: Turning clockwise (R3/4=150k) ⇒ Pulses on the „down-channel" (SW3)

Figure 2 shows the signals of the rotary encode (ch a and ch b) and the output signals issued in the up-switch (SW2) and down-switch channel (SW3). When turning clockwise, the (low) pulse is issued on the "down" channel.

Turning counter-clockwise is shown in Figure 3. The pulse width od the pulses is determined by the capacitors C3 and C4 (both 1u) and the resistors R3 and R4. Turning the rotary encoder too fast is resulting in "wide pulses", the mono-flop is retriggered while the set time is elapsing, thus a pulse is lost. This shown in Figure 4. The first four ticks on the rotary encoder result in one pulse.

To increase the possible speed of the rotary encode, the resistors R3/R4 are modified. A value of 47k instead of the original 150k for these resistors results in the rotary encoder is not recognized by the Pi1541 software at all. In this case the pulse width is approximately 17ms. The resistor values were increased to 100k, the rotary encoder was effective again. The capacitors have a tolerance of 10%. Proving, that the value of 100k is suitable, two 75k resistors were soldered in. The output signals were recognized by the Pi1541 software.

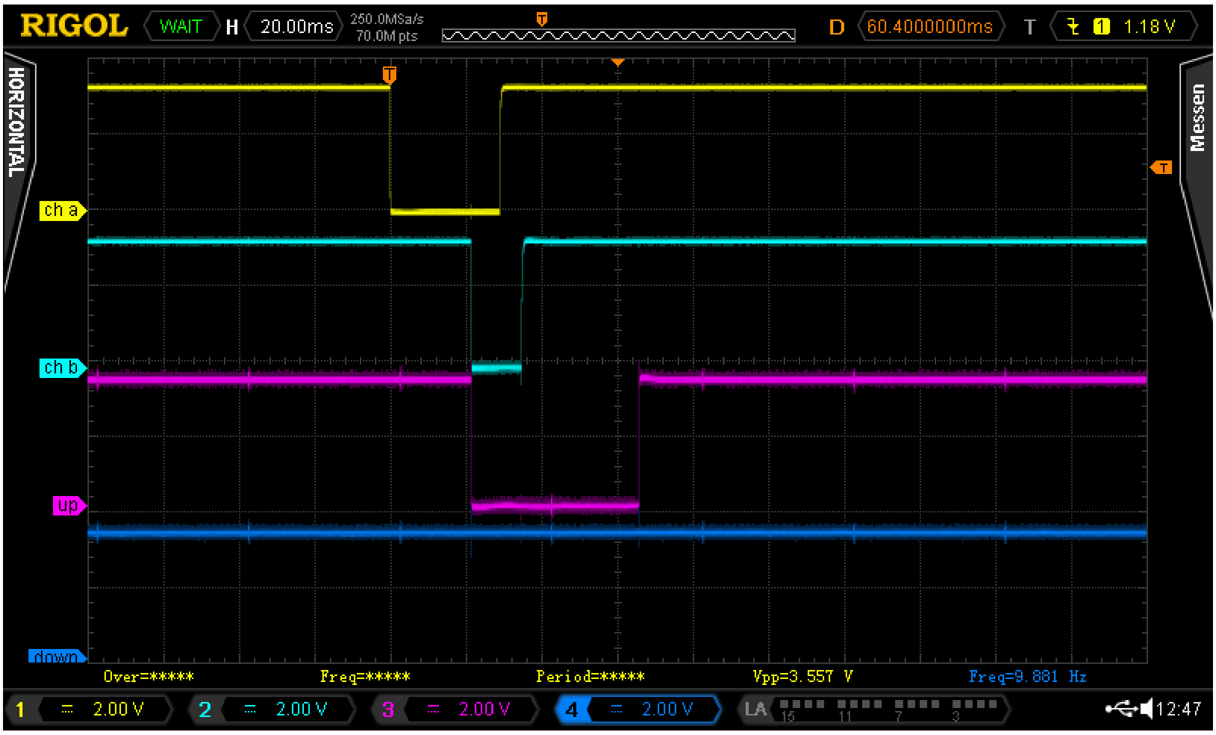


Figure 3: Turning counter-clockwise (R3/4=150k) ⇒ Pulses on the „up-channel" (SW2)

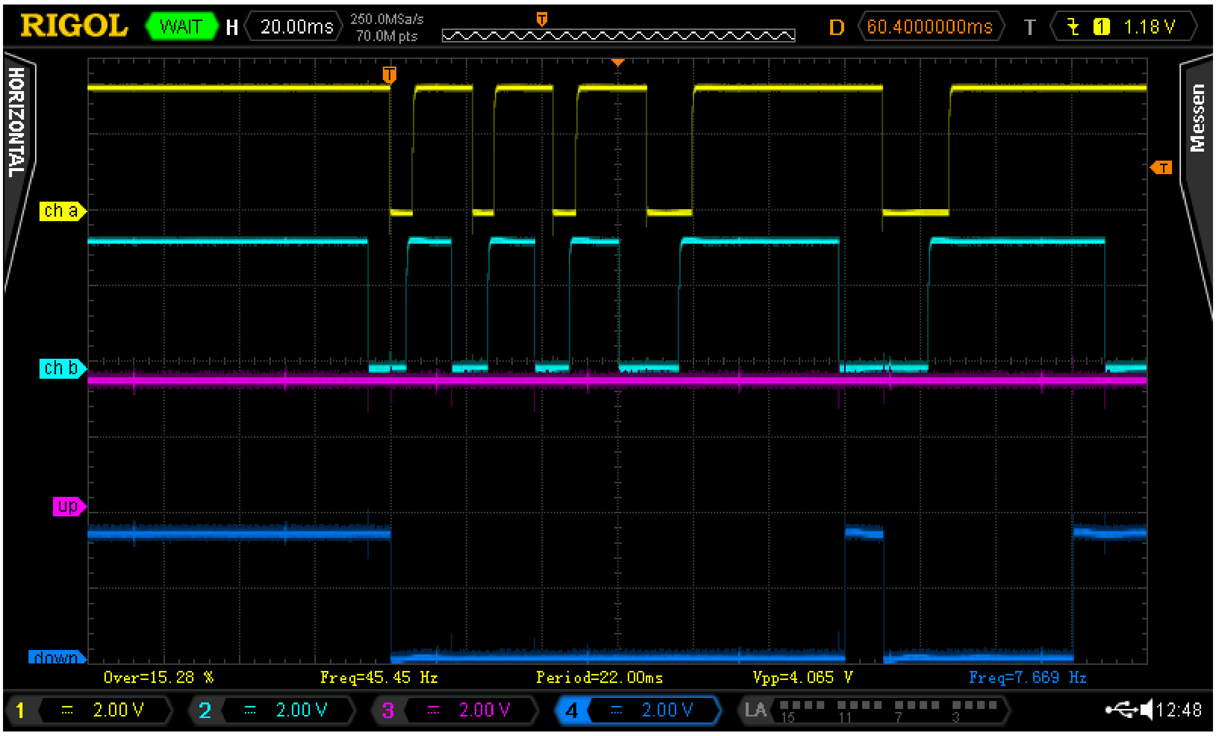


Figure 4: Turning CW too fast

Assembly

The latches at the side of the rotary encoder were a bit tight fit, the component could be installed, though. In future revisions, the size of the holes should be increased from 2.4mm to 2.6mm.

IC3 does not have a Pin 1 mark on the top silk layer, it is only included in the documentation print out (layer 51 tDocu). This can be improved in the library.

Conclusion

The rotary encoder board is fully functional and the lost pulses, when turning too fast are not considered as a problem. A rate of approximately 15 clicks per seconds can be achieved by the hardware. One complete turn of the rotary encoder are 20 clicks. In case the file/directory names are long, the scrolling is slower than if the names to be scrolled are short. The rotary encoder speeds up the navigation a lot compared to navigating with the buttons. It is much more comfortable to use.

Pi1541-Rotary Encoder Board Rev. 0
Bill of Material Rev. 0.1

Pos.	Qty	Value	Footprint	Ref.-No.	Comment
1	1	118-2-01-00	2 Layer	PCB Rev. 0	2 layer, Cu 35μ, HASL, LLL x BBB, 1.6mm FR4
2	1	369-1-008	MICMA08B	X3	MPE Garry, Reichel MPE 369-1-008, Micromatch, female, tht, 8 pin
3	3	100n	0805	C1, C2, C7	cer cap 0805
4	4	10k	0805	R5, R6, R7, R8	resistor 0805, 5% or better
5	2	10n	0805	C5, C6	cer cap 0805
6	2	150R	0805	R16, R17	resistor 0805, 5% or better
7	2	100k	0805	R3, R4	resistor 0805, 5% or better
8	2	1u	0805	C3, C4	cer cap 0805, 10% or better, e.g. Reichelt X5R 0805 CD 1,0U
9	1	3mm_gn	3MM	LD2	LED, 3mm, green, e.g. Reichelt LED 3MM GN
10	1	3mm_red	3MM	LD1	LED, 3mm, red, e.g. Reichelt LED 3MM RT
11	2	JMP_0603	CP3P	JP1, JP2	Jumper (in copper, no sourcable part), 0R resistor (0603) placed 1-2 by default
12	1	0R	603	(JP1), (JP2)	resistor 0603, placed on SMD jumper, e.g. Reichelt RND 0603 0
13	2	JTP-1130	JTP-1130	SW4, SW5	Namae Electronics, Reichelt JTP-1130, H=13mm
14	2	LL4148	SOD80C	D1, D2	Diode, MINIMELF
15	1	SN74HC123D	SO-16	IC2	e.g. TI, Toshiba, etc. Reichelt: SMD HC 123
16	1	SN74HC74D	SO-14	IC1	e.g. NXP, Reichelt: SMD HC 74
17	1	knob for rotary axis 6 mm		(RT1)	e.g. Reichelt KNOPF 10-150B
18	1	STEC11B13	STEC11B13	RT1	Alps, Reichelt: STEC11B13
19	2	n/a	0805	R1, R2	not assembled
20	1	SN74LVC2G14	SOT23-6	IC3	TI, e.g. Reichelt SN 74LVC2G14DBV

Revision History

Pos	v0.0 -> v0.1	
7	Value	R3/4
8	Reichelt P/N	C3/4