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LCD Extension Board Construction Manual

Dennis Kuschel
dennis_k@freenet.de
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This document describes how the LCD extension board for MyNOR is assembled and mounted on the MyNOR computer board. The LCD extension board adds these features to MyNOR:

➢ LCD display with 4 rows and 20 colums per row
➢ 15 push buttons, one button for hardware-reset or user input (configurable)
➢ Sound output (one voice, rectengular wave form, 261 Hz – 2093 Hz)
➢ Realtime clock with battery backup
➢ Temperature sensor LM75 or TMP100
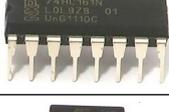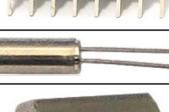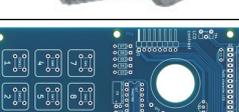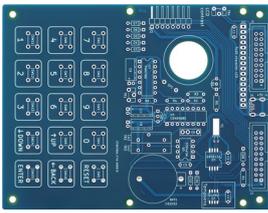➢ Header with exposed I2C and SPI bus
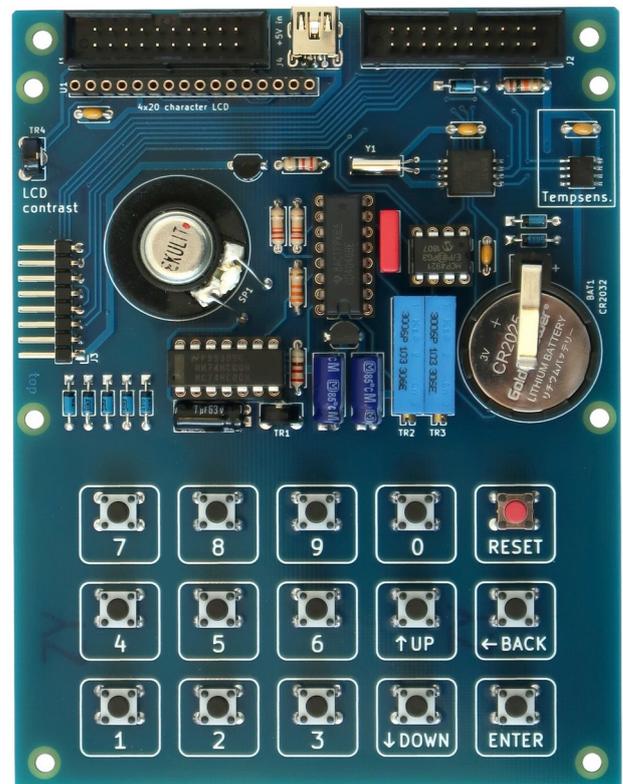
Required Components

The complete bill of material is listed in the table below. Many of the Mouser part numbers can also be used to order the parts at Digikey or other distributors.

Reference	Qty	Picture	Value	Mouser P/N www.mouser.com	Reichelt P/N www.reichelt.de
BAT1	1		for CR2032	122-7520-GR (requires some manual rework so that it fits under the LCD)	KZH 20-1 + CR2032 battery
C1 C2 C4 C5	4		100 nF (X7R / 5 mm)	SR215C104K	X7R-5 100N
C3	1		(used for RTC calibration, see text)		
C6	1		10nF / 5% (foil / 7.5 mm)	FKS3D021002B00JSSD - or - MKS4F021002B00JSSD	FKS3-100 10N
C7 C8	2		10µF / 16V	ESK106M016AC3AA	RAD 10/35
C9	1		1 µF / 16V	ESH105M050AC3AA	RAD 1/63
D1 D2 D3 D4 D5 D6 D7 D8	8		BAT41	BAT41-TAP	BAT 41
J1 J2	2		20 pin header	710-61202021621	WSL 20G
J3	1		8 pin header right-angled	22-28-8083	SL 1X36W 2,54
J4	1		USB_B	XM7D-0512	USB BWM
J5/U1	1		Socket 16 pol. for LCD	801-87-016-10-001101	MPE 115-1-020
Q1	1		BS170	BS170D27Z	BS 170
R1	1		10k	CFR-25JR-5210K	1/4W 10K
R2 R3	2		22k	CFR-25JR-5222K	1/4W 22K
R4	1		33k	CFR-25JR-5233K	1/4W 33K
R5	1		22	CFR-25JR-5222R	1/4W 22
R6	1		220	CFR-25JR-52220R	1/4W 220
SP1	1		Speaker 32 Ohm (8 - 32 Ohm) diameter: 23 - 28 mm	SM230332-1	LSF-23M/N/G

SW1 SW2 SW3 SW4 SW5 SW6 SW7 SW8 SW9 SW10 SW11 SW12 SW13 SW14 SW15	15		SW_Push 6x4.3mm	TL1105BF160Q	TASTER 3301
TR1	1		250	PT6KV-251A2020 -or- PT6KV-221A2020 (220 Ohm, but this is ok)	PT 6-S 250
TR2 TR3	2		10k	M43P103KB40	962-20 10K
TR4	1		10k	PT6KV-103A2020	PT 6-S 10K
U1	1		LCD 20x4	LCD-20x4B	LCD-PM 4X20-5 D
U2	1		PCF8583T	PCF8583T	PCF 8583 T
U3	1		LM75 -or- TMP75	TMP75AID	LM 75 SMD
U4	1		CD4046BE	CD4046BE	MOS 4046
U5	1		MCP4921	MCP4921-E/P	MCP 4921-E/P
U6	1		MCP1702-3302	MCP1702-3302E/TO	MCP 1702-3302
U7	1		74HCT00	SN74HCT00N	74HCT 00
Y1	1		32.768 kHz	LFXTAL002995Bulk	IQD LFXTAL002995
	8		Spacer 10 mm	970100354	DI 10MM
	4		Spacer 15 mm	971150354	DA 15MM
	8		Screw M3 x 8	RM3X8MM-2701	SZK M3X8-200
PCB Raw Card	1		Use provided gerber files (in zip file) and order the PCB at jlcpcb.com		

Board Assembly

The picture below shows the position of each part. Start with soldering the low components, in the following order: SMD ICs U2, U3, then U4 and U7, resistors, diodes and the buttons. After that, continue with Q1 and U6, the trim resistors, capacitors and at last, the connectors.

The speaker can be fixed with some hot glue or 2-component adhesive. For fixing the LCD on the board you can use 15mm spacers with M3 inner thread.
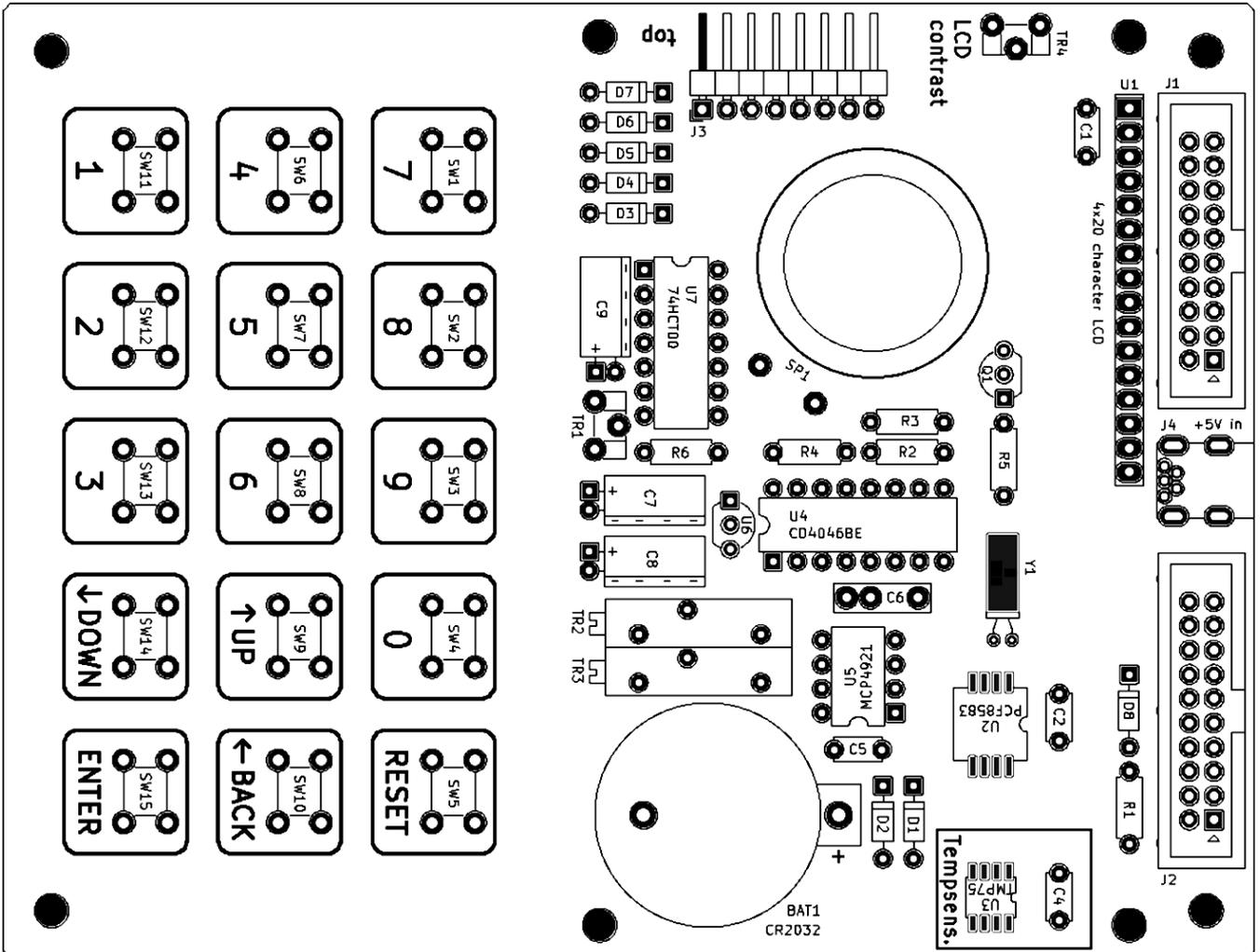
Connecting to MyNOR

You need to build two jumper cables to connect the LCD extension board to the MyNOR computer board. The following picture shows how the LCD, the LCD extension board and the MyNOR baseboard are assembled together:
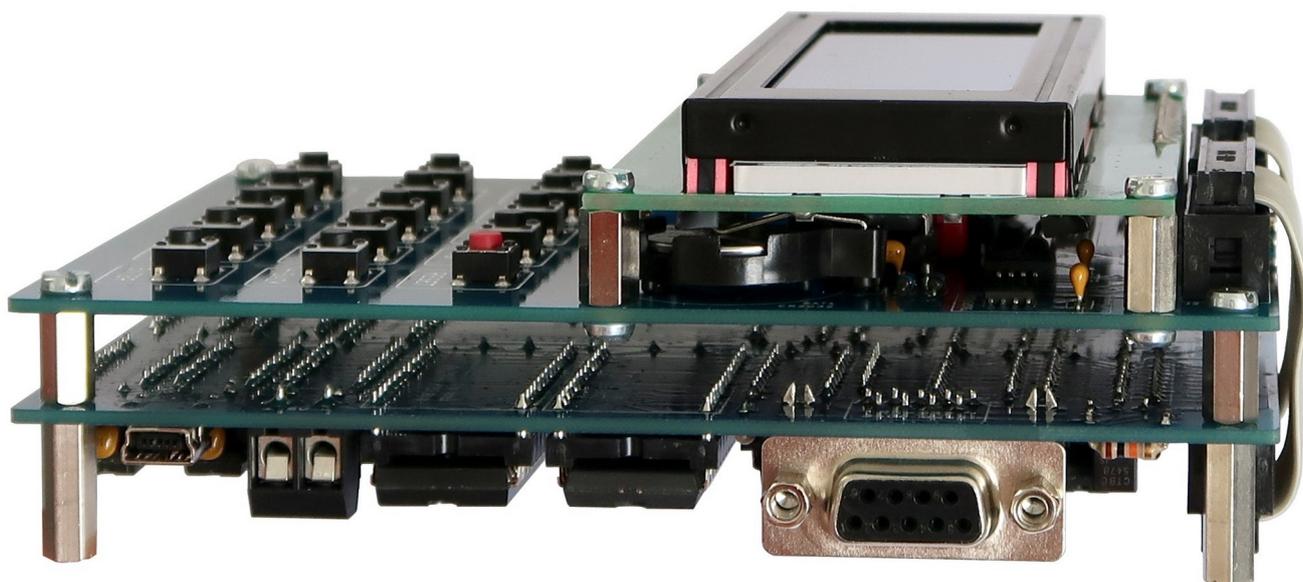
First Test

After you have assembled the boards like shown above, turn on your system and observe the LCD. The LCD should now show the „welcome screen":

BUT to see this screen you have to adjust the LCD contrast. This is done with TR4 at the left side of the LCD extension board.

Now you can upload the display board test program to your MyNOR.
Note: This program is primarily intended to set the RTC to the correct time and date.

```
@@@@@@:Set time (LCD-board-test)@@@@@*H6B0]0N1[0J0[0K0Y0D5J1Y0T1V1V0X3D4A0P0P4
Y0L1U1V0D4D4A0L0F5A0M0D4Y0V2K1]0@0[0N0Y0R5J1Y0Z2V1V0X3D4Y0Q0X1U0N0W0A5B4Y0H0]1
Y0M0]1D0Q0Y0U2D4Y0G0D4D0R0Y0U2D4Y0G0D4D0S0Y0U2D4Y0O1K1Y0O1K1Y0A1]1Y0C2L1Y0L0D4
\0N0Y0U2D4Y0L0D4\0N0Y0U2D4Y0Q0X1U0N0W0A5B4Y0Y1K1A0P0N0A0Q0A0Y0L6J1A0P0P4Y0F4U1
V0D4D4Y0_5U1A0P0A0Y0X0L1C0O3Y0[1K1C0C2Y0[1K1Y0O1K1Y0Q0X1S0Q0V0T6B4S0R0V0R2C4S0
S0V0E6B4\0Q0]0@0[0N0O0Q0A0E0H0M0E0U0N0V0^4B4X0C1B4Y0S4J1A0P0J0Y0]3X1Y0J4J1X0C1
B4Y0R5J1Y0V3I1C0B0Y0[0D4F0S0Y0Q0D4Y0Y0D4Y0G7C4A0E0X0Q0E0V0D7B4B0X0P0D0Q0Y0Q0D4
Y0G0D4C0E0Y0[0D4F0S0Y0Q0D4Y0Y0D4Y0G7C4A0E0\1Q0E0V0G0C4B0Y0P0D0Q0Y0Q0D4Y0G0D4C0
E0Y0[0D4F0S0Y0Q0D4Y0Y0D4Y0G7C4A0E0\1Q0E0V0J1C4B0Z0P0D0Q0Y0Q0D4Y0[3I1B0Q0X0B0R0
Y0B0S0Z0Y0Z0W1X0C1B4A0P0J0A0Q0@0Y0L6J1Y0V3I1A0R0D0A0T0@0A0U0@0Y0H4Z1Y0Y0D4F0V0
A0O0@0P0T0F0T0W0[3C4I0U0D0V0Y0Q0D4J0R0U0R0W0G3C4Y0H0]1Y0L0D4C0A0Y0[0D4F0S0Y0Q0
D4Y0Y0D4Y0G7C4U0N0V0W4C4A0E0L0Q0E0V0W4C4[0P0D0Q0Y0Q0D4Y0L0D4C0C0Y0[0D4F0S0Y0Q0
D4Y0Y0D4Y0G7C4U0N0V0^5C4A0E0_0Q0E0V0^5C4B0R0P0D0Q0Y0Q0D4Y0[3I1\0S0Y0A1]1Y0N2W1
X0C1B4[0J0[0K0F0P0F0Q0B0T0S0A0U0@0Y0H4Z1D0T0A0O0@0P0P0F0P0A0O0A0X0Y6[1C0Z1X0[1
K1C0M1X0[1K1A0E0P1N0E0X0[1K1C0I0[0J0[0K0A0E0P0N0E0F0Q0Y0Q0X1S0H0W0X1D4Y0[3I1\0
K0\0J0X0C1B4F0P0A0E0P0M0E0U0N0V0F1D4A0O0A0D0Q0Q0P0W0F1D4C0O0M0P0X0Y6[1[0J0[0K0
F0T0A0U0@0A0V0J0A0W0@0Y0N7Y1C0P1N0T0Y0[1K1C0P1N0V0Y0[1K1X0Y6[1A0L0P4A0M0D4Y0V2
K1X0[7[1A0L0Z4A0M0D4Y0V2K1X0[7[1R2T2C2@1E2R2R2O2R2@0T2M2P2W1U1@1E2R2R2O2R2@0J0
J0Q1Z1S3E3T3@1T3I3M3E3J0R1Z1S3E3T3@1D3A3T3E3@1@1@1@1S1Z1B3E3E3P3@0
```

Use this program to set the RTC to the current time and date. The LCD must now display the correct time (and the seconds must change). You can test the temperature sensor by placing your finger on U3. The temperature displayed should now change. When you press „3", the speaker should emit a tone and the backlight of the display should be switched off for a short time. If the speaker remains silent, continue with the next chapter (sound calibration). TR2 or TR3 may be set to an invalid value.


This is the „Set time" program.

Sound Calibration

The sound generator is very simple: A 12-bit DAC controls a VCO that generates a square wave. MyNOR's library functions assume that a 12-bit value of 0x000 produces a tone with 261 Hz and that a value of 0xFFF generates a tone with 2093 Hz. But the used PLL chip CD4046 is not designed for a pure VCO function. Thus the output frequency of the VCO is not very reproducable between different chips and it also varies with the ambient temperature and the supply voltage. For this reason you need to calibrate your sound generator.

Note: Since the VCO frequency varies with the supply voltage, you calibrate your sound generator for the currently used power supply. The calibration result can only be reproduced with this supply. If you change the power supply, the output frequency of the VCO changes slightly. Even the on-board 3.3V linear regulator cannot completely prevent this behaviour.

Warning: Use only a Texas Instruments CD4046BE on your board. Only this chip contains a wide-range VCO. Other brands (Phillips) or other types (74HC4046) will not work !!

To calibrate your sound generator, you need to solder a wire bridge on the back side of the LCD extension board. This wire bridge connects the output of the sound generator to the clock input of the RTC chip. The calibration program (see next page) uses the RTC to measure the actual output frequency of the VCO.
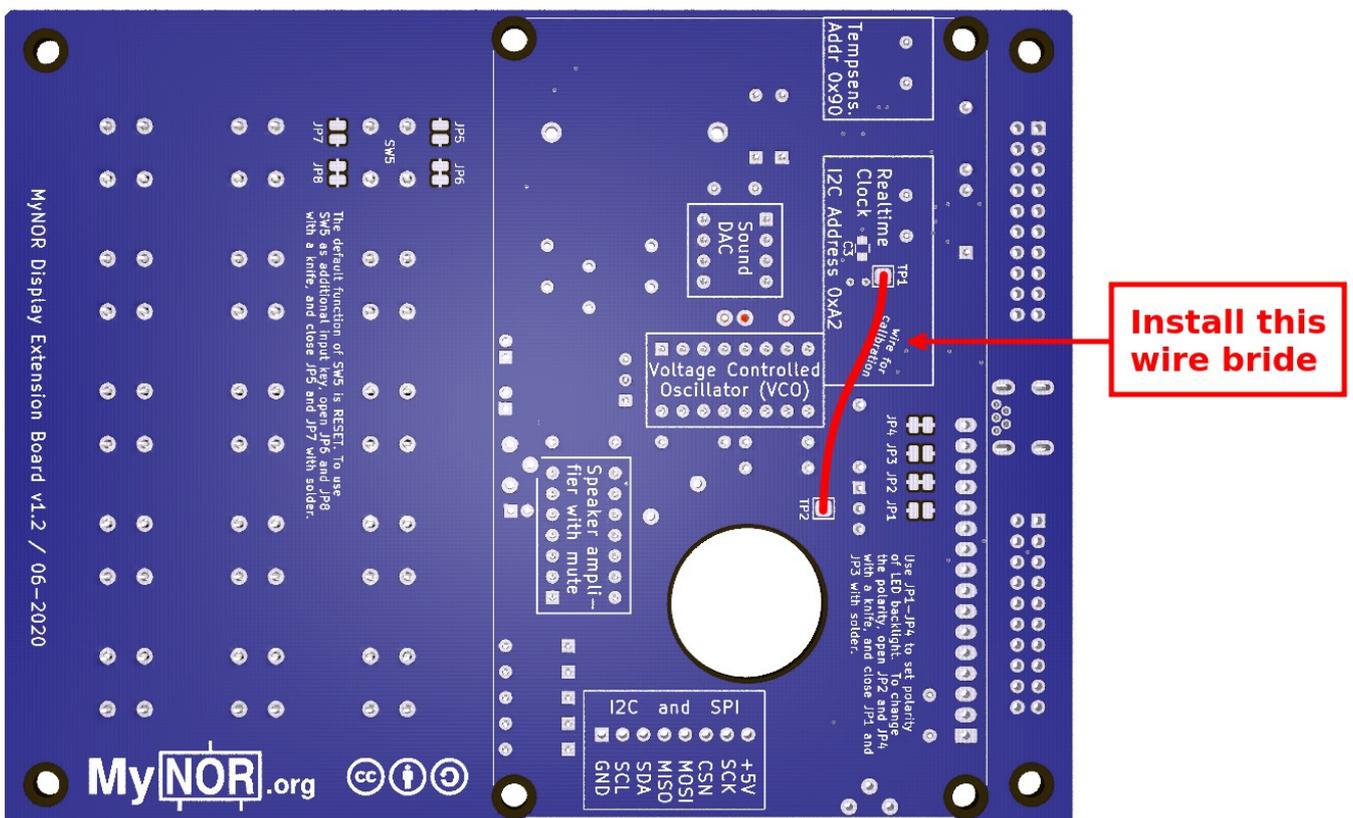
Note:
The installation of the wire bridge modifies the time setting of the RTC. You must reset the RTC to the correct time after you have completed the calibration and removed the wire bridge.

When the wire bridge is installed, you can turn on your MyNOR and upload the calibration program:

```
@@@@@@:Sound-tuning@@@@*]6C0_1T5Y0I7H1Y0W4X1Y0D5J1A0L0I3A0M0D4Y0V2K1A0P0A0Y0B0
D4Y0D5J1A0L0Q5A0M0D4Y0O0C4A0L0Z7A0M0D4Y0V7B4A0L0C2A0M0E4Y0O0C4A0L0Y2A0M0E4Y0V7
B4A0L0O3A0M0E4Y0O0C4A0L0E4A0M0E4Y0V2K1A0P0J0A0X0X5A0Y0A0Y0Y4B4W0^3B4A0P0V0A0X0
P3A0Y0C0Y0Y4B4W0^3B4Y0X3Y1A0L0[4A0M0E4Y0V2K1X0J4B4Y0X3Y1A0L0Q5A0M0E4Y0V2K1]0@0
A0E0P3M0E0S0P3V0J4B4X0F0B4[0J0[0K0Y0R0]1Y0B7X1Y0H1C4W0C5B4Y0K1]1D0S0Y0Y5[1F0T0
A0U0@0A0V0D3A0W0@0Y0D4Y1D0R0Y0Y5[1A0O0@0P0T0F0T0W0P6B4I0U0A0O0A0D0T0Q0X0F0T0D0
U0Q0Y0F0U0K0N0W0G7B4Y0S5Z1U0U0W0Y6[1C0D0A0O0A0Q0T0X0Y6[1[0J0[0K0Y0V2K1A0L0P0A0
M0E4Y0V2K1Y0Y7C4Y0D5J1X0Y6[1[0J0[0K0Y0V2K1A0L0G6A0M0D4Y0V2K1Y0_7C4Y0D5J1X0Y6[1
[0J0[0K0D0]0A0E0G0M0E0]0@0[6F0]0]0@0A0E0P3M0E0S0P3W0W1C4A0P0B5Y0H7D1A0P0@0Y0V7D1
A0P0@5Y0V7D1A0P0@0Y0V7D1A0P0@0Y0V7D1A0P0@0Y0V7D1Y0P6D1A0P0B5Y0H7D1
A0P0@0Y0V7D1A0P0@1Y0V7D1Y0P6D1Y0I2\1W0N5C4C0D3F0F0C0H3J0N0U0N0W0Q4C4]0@0A0E0P3
M0E0S0P3W0Y6[1J0F0U0F0W0O4C4X0N6C4C0F6F0F0C0J3J0N0U0N0W0T5C4]0@0A0E0P3M0E0S0P3
W0Y6[1J0F0U0F0W0R5C4A0P0B5Y0H7D1A0P0A0Y0V7D1A0P0C5Y0H7D1A0Q0@0Y0\1E1F0R0A0Q0A0
Y0\1E1F0S0Y0P6D1A0O0A0X0Y6[1A0P0J0X0B0D4A0P0V0[0J0[0K0Y0B7X1Y0L3Y1Y0H1C4W0Y6[1
Y0T1K1D0S0A0Q0@0Y0G1D4D0R0I0Q0Y0G1D4X0L0D4[0J0[0K0[0N0A0O0@0L0N0A0O0@0L0N0A0O0
@0L0N0A0O0@0L0N0U0N0A0E0P1N0E0W0R2D4U0Q0W0R2D4C0@1Y0[1K1\0N0A0E0O0M0E0A0E0P1N0
E0Y0[1K1\0K0\0J0Z0S2T3E3P3@1Q101V1Z1@1U2S3E3@1T2R2R1@1T303J0T3U3N3E3@1F3R3E3Q3
U3E3N3C3Y3@1T303J0R1V1R1@1H2Z3L1@1T3H3E3N3@1A3N3Y3@1K3E3Y3J0@1P1P1P1@1M1^1@1R1
V1R1@0S2T3E3P3@1R101V1Z1@1U2S3E3@1T2R2S1@1T303J0@0T3U3N3E3@1F3R3E3Q3U3E3N3C3Y3
@1T303J0X1X1P1@1H2Z3L1@1T3H3E3N3@1A3N3Y3@1K3E3Y3J0@1P1P1P1@1M1^1@1X1X1P1@0S2T3
E3P3@1S101V1Z1@1U2S3E3@1T2R2R1@1T303J0@0T3U3N3E3@1F3R3E3Q3U3E3N3C3Y3@1T303J0T1
T1P1@1H2Z3L1@1T3H3E3N3@1A3N3Y3@1K3E3Y3J0@1P1P1P1@1M1^1@1T1T1P1@0S2T3E3P3@1T101
V1Z1@1U2S3E3@1T2R2S1@1T303J0@0S2T3E3P3@1U101V1Z1@1U2S3E3@1T2R2R1@1T303J0@0S2T3
E3P3@1V101V1Z1@1U2S3E3@1T2R2S1@1T303J0@0C2H3E3C3K3I3N3G3@1C3A3L3I3B3R3A3T3I303
N3J0@0J0A2L3L3@102K2L1Y303U3@1A3R3E3@1D303N3E3A1@0J0M1^1@1N303T3@103K3L1@1P3R3
E3S3S3@1A3N3Y3J0K3E3Y3@1F303R3@1T3U3N3I3N3G3@1A3G3A3I3N3J0@0
```

When the program is loaded, the display must show this content:
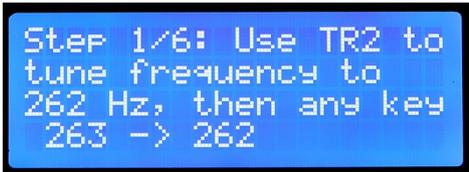
The prorgram guides you step by step through the tuning process. Use the trim resistors TR2 and TR3 to adjust the frequency. Turn the spindle counterclockwise to decrease the frequency and turn it clockwise to increase the frequency. If the measured frequency (the number at bottom left of the display) matches the target frequency by +/- 3 Hz, you can press any key on the board to continue with the next step:
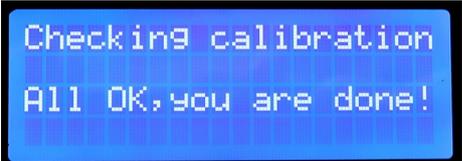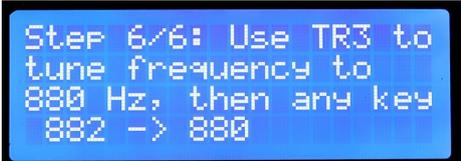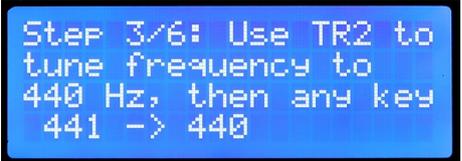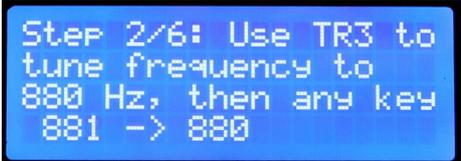
You are now done with the calibration. Turn off the power and remove the wire bridge from the back of the LCD extension board. Run the set-time program again to set the RTC to the correct time.

RTC Calibration

Also the realtime clock needs some calibration. On my prototype boards the RTC ran a bit too fast, so I am assuming that this is a is a behavior desired by the chip manufacturer. However, this allows some tuning by adding a small capacitor between pin 1 and pin 4 of U2. In my case 10 pF was too little and 22 pF was to much. The best value for C3 seems to be 15 pF or 18 pF. You have to find it out yourself.

	15 pF / size 0805	18 pF / size 0805
Reichelt	NPO-G0805 15P	NPO-G0805 18P
Mouser	CC0805JRNPO9BN150	CC0805JRNPO9BN180