



**Koninklijk Conservatorium**

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# **Microlab Manual**

**(The Microlab Building Pack)**

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## **Contents**

Introduction

<b>1. General description</b>	page 1
<b>2. Building the PCB</b>	page 2
<b>2.1 The resistors</b>	page 2
<b>2.2 Semi-conductors</b>	page 3
<b>2.3 Capacitors</b>	page 3
<b>2.4 Remaining components</b>	page 4
<b>2.5 Microlab extra modifications</b>	page 5
<b>3. Testing the Microlab</b>	page 7
<b>4. Comments and ideas</b>	page 8
<b>5. Microlab MIDI Controller / Note numbers</b>	page 9

Appendices

Appendix A, Schematic Microlab circuit	page 10
Appendix B, Schematic Ultrasonic circuit	page 11
Appendix C, Layout PCB	page 12
Appendix D, Schematic Keyboard matrix	page 13
Appendix E, Layout PCB (with Test Points)	page 14
Appendix F, Top-layer PCB (component side)	page 15
Appendix G, Bottom-layer PCB (soldering side)	page 16
Appendix H Connector overview	page 17

## **Introduction**

The Microlab is developed and designed by J. Scherpenisse and A.J. van den Broek, working at the department of Sonology at the Royal Conservatory in The Hague, Holland. It is especially created for students and teachers from the Sonology Dept, Composition Dept. and the Faculty of Image and Sound.

In these departments a lot of electronic music is composed and performed. Much of the electronic compositions are based upon "self built electronic-instruments", communicating with a computer, sampler or other MIDI-device. To make the communication possible between an instrument and a MIDI-device, you can use an interface like the Microlab.

This manual explains how to build the Microlab your self. It also mentions the important issues for building a good and relatively cheap Microlab, which will function perfectly, when built correctly.

The "Microlab building pack" comes together with a Printed Circuit Board (PCB), manual and the RISC-processor (PIC16C73). This Reduced Instruction Set Computer is fully programmed and ready to go. The only thing you have to do is to assemble the PCB and mount it into a cabinet of your choice.

***Important Note :*** *This is a relatively short technical manual, without explanation of basic "how to built my first circuit board"-techniques. If this is the first time you ever built a PCB and you have never soldered before, get some technical advice first!*

## **1. General description**

The Microlab is an electronic interface, which makes it possible to convert external processes (converted to voltage changes) into MIDI. This creates the possibility for musicians to work with their instrument in the digital domain and communicate with a computer or other MIDI-device.

The Microlab converts incoming voltage changes to serial data (MIDI). When a voltage between 0V and 5V is supplied to one of the inputs, the Microlab generates MIDI-controller out, with a value equivalent to the DC-value. It only sends MIDI when the input-value changes!

Example: a dc-change on input 3 from 0V to 5V results in MIDI-Controller 3, sending values between 0 and 127.

This version of the Microlab (v5.1) contains the following features:

### 32 analog inputs (or 5, see chapter 2)

The microlab can process 32 analog voltage changes at the same time. It will convert these changes into MIDI controller values. More about this in chapter 2.

### Keyboard matrix of 16 keys

To create MIDI note On/Off messages on the Microlab, it is possible to connect 16 keys as shown in [appendix D](#). These keys (or switches) must be connected in combination with the diodes, otherwise it will not function correctly. The velocity of the note on/Off messages is 65. The MIDI note off message is the same as the note On, but the velocity is zero.

### Ultrasonic distance measuring.

The Microlab also makes it possible to use ultrasonic distance measuring. This results in two MIDI-controller numbers. Controller number 52 for the short distance (approx. 0 cm-80 cm) and controller number 53 for the longer distance (approx. 60cm-150cm).

### 4 switch inputs

These are actually some extra inputs only sending on/off information. This means that when a switch is connected, the MIDI-controller value is 0 or 127.

### MIDI LED connection

To check whether the Microlab sends MIDI or not, a LED (Light Emitting Diode) can be connected to the outside of the cabinet (of your choice). See chapter 2.

In the next chapter a full explanation is given of all the components used on the Microlab Printed Circuit Board.

## **2. Building the PCB.**

It is quite easy to build and complete the PCB. Just double-check everything you do before soldering the components onto the PCB. If you are NOT sure, do NOT solder, but first think again. It's a nasty job to remove soldered components! It's also important to check the appendix of this manual. There you will find the layout of the PCB, the schematics (very important!) and the layout of the topside and the bottom-side of the PCB.

### 2.1 The resistors

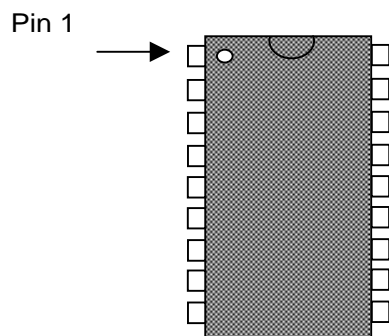
Mount the resistors flat on the PCB. Place the resistors on the component side (see PCB) and solder them on the soldering side!

R1, R40	27 K $\Omega$
R2, R3	220 $\Omega$
AR3 (=R4, R5, R6, R7)	100 $\Omega$ <i>Resistor Array!</i>
AR2 (=R8, R9, R10, R11)	10 K $\Omega$ <i>Resistor Array!</i>
R12, R24, R35, R36, R37, R41	10 K $\Omega$
R13	820 $\Omega$
R14	100 K $\Omega$ ( <i>see chapter 2.5</i> )
AR1 (=R20, R21, R22, R23)	10 K $\Omega$ <i>Resistor Array!</i>
R31	1 K $\Omega$
R32	12 K $\Omega$
R33	560 $\Omega$
R34	56 K $\Omega$
R38	470 $\Omega$
R39	2K2 $\Omega$
R42, R44	3K3 $\Omega$
R43	270 $\Omega$
P1	1 K $\Omega$ <i>Trim potentiometer</i>

## 2.2 Semiconductors

The most important component on the PCB is the processor, the PIC16C73. This is the heart of the Micro-lab. Important is to place this processor in a socket, which is soldered on the PCB. Do NOT solder the processor itself on the PCB!

Very important with mounting Integrated Circuits (IC's) on the PCB is to check pin 1 of the chip. On every chip the counting of the pin numbers is anti-clockwise.



If a chip is connected the wrong way, the circuit will NOT work and you can damage the chip and the total circuit when power is applied!

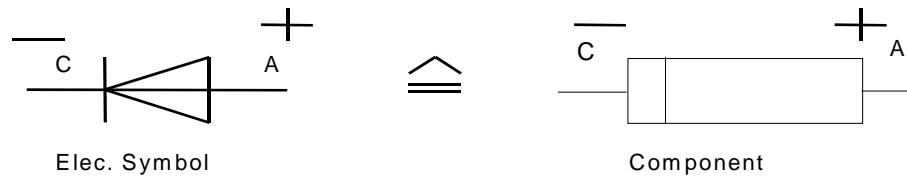
U1 (place in a socket!!)	PIC16C73 (A or B) JW (or OTP-version)
U2	74LS09
U3, U4	HEF4067
U5	74LS04
U6	7805
U8	NE555
U9	TL072
U10	74HC74 (or LS)
U11	74HC04 (or LS)

T1 BC559

Transistor T1 can only be placed on the PCB in one position. Take a close look at the layout and check carefully when you solder.

## 2.2 Semi conductors (continued)

Also diodes only can be mounted one way! They have a positive- (Anode) and a negative side (Cathode). See figure:



D1

LED (MIDI indication)

D2 (=Diode Array)

D9-1A, Common Anode on pin 1

D4 (=Diode Array)

D9-1A, Common Anode on pin 1

D6 (=Diode Array)

D9-1A, Common Anode on pin 1

D9 (=Diode Array)

D9-1A, Common Anode on pin 1

D3 (=Diode Array)

D9-1C, Common Cathode on pin 1

D5 (=Diode Array)

D9-1C, Common Cathode on pin 1

D7 (=Diode Array)

D9-1C, Common Cathode on pin 1

D8 (=Diode Array)

D9-1C, Common Cathode on pin 1

D10

1N4004

D13

1N4148

### **2.3 Capacitors**

With placing and soldering the capacitors you have to check the polarity. All the values smaller than 100nF do not have polarity. Check the layout of the PCB.

C1, C4	3 $\mu$ 3 F (polarity!)
C2, C3, C13	2 $\mu$ 2 F (polarity!)
C14	1 $\mu$ F (polarity!)
C5, C6, C7, C8	100 nF (Blue Siemens)
C9, C10	27 pF
C11, C12, C15, C17	100 nF (MKT)
C16	12 nF

### **2.4 Remaining components**

The last components to be added are the headers. A header on this PCB is a row of pins onto which you can connect wires and/or jumpers.

#### H1, H2, H3, H4 10-pins header (Analog in)

The pins on the outside are connected to the power. The remaining pins are the inputs. This means 8 x 4 inputs in total. From these 32 inputs you can solder wires to a connector of your choice.

#### J1 5-pins header (MIDI out)

The MIDI output is connected with 3 wires. The header-pin, which is directly connected to R3, has to be connected to pin 4 of the MIDI DIN connector. The header-pin, which is directly connected to R2, has to be connected to pin 5 of the MIDI DI connector. Pin 2 of the MIDI-connector is ground (see schematic!).

#### J2 2-pins header (Jumper setting J2)

This jumper (is a direct connection, or shortcut) determines the "base-address" of the MIDI controllers. If J2 has a jumper (shortcut) the controller's numbers starts at 20. If J2 does NOT have a jumper (open), the controller number starts at 0.

#### J4 4-pins header (Jumper setting J4)

A jumper must be connected over the middle two pins (shortcut between pin 2 and 3). This is necessary for the Ultrasonic distance measuring to function ok. The fact that 4 pins header is used, has got to do with former Microlab versions.

## **2.4 Remaining components (continues)**

### J6 \_\_\_\_\_ 8-pins header (key-scan 4x4)

This is the connection for the 16-input key scan. The pins directly connected to pins 25, 26, 27 and 28 are the Matrix Inputs (Mat\_in). The other four are the Matrix Outputs (Mat\_out). The appendix shows a schematic of the keyboard connections.

### J7 \_\_\_\_\_ 4-pins header (switch inputs)

On these 4 pins a switch can be connected. A closed switch generates controller MIDI, value 127. An open switch generates controller MIDI value 0.

### J8, J9 \_\_\_\_\_ 2-pins header (Ultrasonic output)

The Ultrasonic Transmitter has to be connected to these pins (often the S from Sender is written on the Transmitter). There are two headers: one normal 40 kHz signal and one 40 kHz signal inverted. The transmitter has to be connected to both.  
*Always use shielded wire*

### J10 \_\_\_\_\_ 2-pins header (Ultrasonic input)

The Ultrasonic receiver connection : One pin to ground and one pin to the signal. The R from Receiver is written down on the receiver itself (receiver and transmitter look alike!).

*Always use shielded wire.*

### J12 \_\_\_\_\_ 2-pins header (Power/batt connection)

Connection for the power supply or 9V battery. The power-supply at this point has to be between 7V- 12V DC. Check the polarity! The pin closest to the black diode (D10) is the positive (+) connection.

### X1 \_\_\_\_\_ X-tal 18.432 MHz

This is a Crystal Oscillator. This component generates the clock for the processor. Without this component the microlab will NOT work. It's important that the exact frequency is used (18.432 MHz), otherwise the MIDI will not have the right timing! Do not mount the Crystal directly on the board, but leave (1mm) space between the Crystal and the PCB.

### SW1 \_\_\_\_\_ 2-pins header (Reset switch)

Connect a simple switch (make contact) to this header. It generates a total reset for the processor.

### Config \_\_\_\_\_ 7 x wire jumper

The I/O pins of the processor must be connected to the two HEF4067 chips. Check appendix C. Connect the points 1 & 2 of the CONFIG together with a short wire. Do this 6 times.

## **2.5 Microlab extra modifications**

Before you can start with testing and using the Microlab, there are a few important things you should be aware of:

First of all, the resistor R14 is shown in the schematic, but does not exist on the layout of the PCB. Here is the solution: Solder R14 (100k) instead of AR5, between pin 2 of the processor and ground (pin1).

On pin 6 of the processor an extra "pull-up" resistor is needed. A "pull-up" resistor is a resistor, which is connected between the positive power (+5V DC!) and the actual I/O pin. A good value for the resistor is 10 K $\Omega$ .

## **3. Testing the Microlab.**

Before connecting the power to the Microlab PCB, it's better to check the following:

- Take a close look at the solder-side of the PCB and make sure that there are NO Shortcuts.
- Check the polarity of the capacitors.
- Check the "pin 1" of all the IC's
- Check the polarity of all diodes.

When connecting the Microlab for the first time you will need some measuring devices to measure the exact power (+5V) and to adjust the frequency of the Ultrasonic circuit. For measuring the power you will need a simple multimeter. For measuring and adjusting the frequency an oscilloscope or frequency-counter will come in handy. When you are sure everything is correct, connect the power (+7- 15 V DC) on jumper J12.

The testing of the microlab is actually very simple. To make it easier, the circuit has 5 Test Points (TP1 till TP5). Start with TP1 and end with TP5.

TP1 : At this point you should (if power is connected) measure the power-supply. This must be a positive DC-voltage with a value between a minimum +7V and a maximum of +18V. When connecting a battery, you should measure 9V DC. When the value is beneath 7V DC, the circuit will not work correctly (battery empty?).

### **3. Testing the Microlab (continued).**

TP2: This is the power for the circuit and is measured after the voltage regulator (U6). This DC-value must be +5V (4,75 - 5,25). If this value is higher, you must disconnect the power immediately! When the DC-value is lower than 5V it is likely that there is a shortcut somewhere. Disconnect the power (or battery) and check the entire above once more.

TP3 (U1 / pin 21,22,23,24): When you are sure the power-supply is correct, you can connect a probe from a oscilloscope to TP3. At this point you should see a square-wave. If there is NO square-wave, the processor is NOT working. At this point you could measure the DC-value of "pin 1" (reset) from the processor. This pin should be "high"; meaning the value is +5V. If this value is below +5V, the processor is in active (reset-mode) and will not work. Check C1!

If you do see a square-wave, it means that the software inside the processor and the processor itself function ok.

TP4 (U3 / pin 3): If you want to use the ultrasonic distance measuring as well, you have to test / adjust the 80 kHz frequency, generated by the timer chip U8. Make sure (for the testing) that NO jumpers are connected on J4! Connect a probe (from a oscilloscope) to TP4. You should see a square-wave. Take a small screwdriver and adjust the frequency to 80 kHz exact. If the 80 kHz works fine, connect the jumper on J4 in the middle-position.

TP 5 (U1 / pin 17): On pin 17 of the processor you can check whether MIDI is produced. Connect the probe and touch one of the headers H1 till H4 with your finger. This should produce MIDI. If you already connected the LED (D1), the MIDI should also be visual.

#### **4. Microlab MIDI-controller / MIDI-Note numbers**

On this page an overview of the different MIDI controller numbers and note numbers produced by the Microlab:

##### **Analog inputs (32) :**

	<b><u>J2 = open (no jumper)</u></b>	<b><u>J2=closed (jumper)</u></b>
Input 0	MIDI controller number 0	MIDI controller number 20
Input 1	MIDI controller number 1	MIDI controller number 21
..	..	..
Input 31	MIDI controller number 31	MIDI controller number 51

##### **Switch inputs (jumper J7):**

Switch 1	MIDI controller number 64
Switch 2	MIDI controller number 65
Switch 3	MIDI controller number 66
Switch 4	MIDI controller number 67

##### **Keyboard Matrix** (The velocity of the MIDI note on message is 65)

Key 1	MIDI note number 60
Key 2	MIDI note number 61
..	..
Key 16	MIDI note number 76

##### **Ultrasonic :**

Short distance (80 cm)	Midi controller number 52
Longer distance (till 3m.)	Midi controller number 53

## **5. Comments and ideas**

Actually this manual is short, but it should (for the good reader) cover all the technical problems you will encounter during the building of a Microlab. We are still working on new ideas, brought to us by students and others. For example: design a Microlab with a MIDI-input, so you can merge MIDI (maybe from another Microlab).

Or create a new Microlab with USB connections ...

If you have any questions, remarks or new ideas, contact us:

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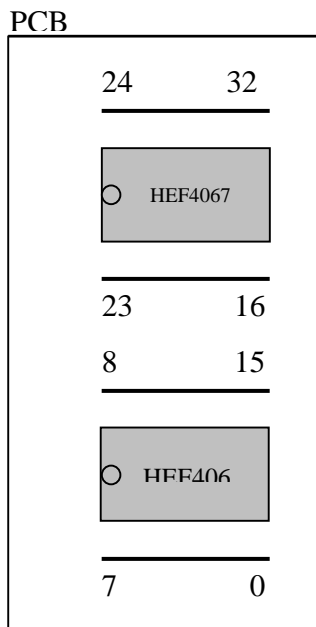
**Microlab D-connector Overview**

Connections 37-pins

Connections 15-pins D-connector :

D-connector:

Pin	Cntrl no	Chip	Pin	Signal
1	1 [20]	A y1	1	Mat_in 4
2	2 [21]	A y2	2	Mat_in 3
3	3 [22]	A y3	3	Mat_in 2
4	4 ..	A y8	4	Mat_in 1
5	5 ..	A y9	5	Mat_out 4
6	6 ..	A y10	6	Mat_out 3
7	7	A y11	7	Mat_out 2
8	8	A y4	8	Mat_out 1
9	9	A y5	9	SW_1
10	10	A y6	10	SW_2
11	11	A y7	11	SW_3
12	12	A y12	12	Ground (0)
13	13	A y13	13	Ultrasonic Receive
14	14	A y14	14	Ultrasonic Send (+)
15	15	A y15	15	Ultrasonic Send (-)
16	16	B y0		
17	17	B y1		
18	18	B y2		
19	19	B y3		
20	20	B y8		
21	21	B y9		
22	22	B y10		
23	23	B y11		
24	24	B y4		
25	25	B y5		
26	26	B y6		
27	27	B y7		
28	28	B y12		
29	29	B y13		
30	30 ..	B y14		
31	31 [51]		B y15	
32	0 [20]		A y0	
33	SW_4			
34	+ 9V (batt or ext power)			
35	Ground (0)			
36	Ground (0)			
37	+ 5			



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