1 DIY pulse sensor!

1.1 Background & Preparation

1.1.1 Document history

Created by ELAB - the electrical laboratory of the division of Electrical Engineering at the Royal Institute of Technology, Stockholm, Sweden. ELAB has space and equipment for electronics work. At ELAB, you learn about all things electrical, in part by practical construction, and partly by discussions with members.

ELAB's website https://www.elab.kth.se/

Translated to English by Caroline Dahl, Sven Hedin and Jonas Olson.

1.1.2 Accompanying files

1.1.2.1 PCB design files

PCB made in Eagle Cad 6.60. Accompanying files may be opened in all Eagle versions to date.

Included files:

- N0llELAB_final.brd
- N0llELAB_final.sch

Download Eagle here. https://www.autodesk.com/products/eagle/free-download

1.1.2.2 Documentation

This document is authored in LyX, a wysiwyg LaTex version. Get LyX here.https://www.lyx.org/

Included files:

- DIY_pulsesensor_byELAB.lyx
- DIY_pulsesensor_byELAB.pdf (compiled PDF-version of above)
- instruktioner.pdf (Swedish original instructions)
- Graphics files

1.1.3 Equipment necessary

1. Pulse sensor kit, see Table 1.1
2. Solder iron
3. Solder
4. Solder flux (unless this is part of the solder)

1.2 The exercise

1.2.1 Introduction

In this laboratory session we build a pulse detector. Its function is described in Figure 1.1. A finger is placed in between the light-emitting diode (LED1) and the phototransistor (O1). During the systolic phase of the heart beat, heart muscle pumps blood out into peripheral vessels. Local blood volume increases in the finger and more light is absorbed than under the diastolic phase (the cardiac resting phase). The more light that reaches the photo resistor, the better it conducts. This way, the circuit detects light variations. The signal is later amplified so that it manages to drive the light-emitting diode (LED2) that blinks in phase with the pulse.

Your task is to place and solder the components (Table 1.1) at their correct sites on the circuit board according to the instructions below so that the finished circuit looks like Figure 1.1b.

1.2.2 Soldering

The components of this kit are through-hole mounted. This means that the leads of components are fit through the holes in the circuit board. The components themselves are mounted through the holes of the PCB so that their leads stick out on the side of the PCB that lacks print, and this is the side where they are soldered on. It is appropriate to mount and solder the smallest components first; the circuit board is unstable on the table when tall components are mounted. A good solder joint necessitates sufficient (but not too much) heat, solder and flux to make the solder wet the site, and solder to achieve an electrically conductive joint between components and circuit board, and heat to liquify the solder and activate the flux. If the solder already contains flux, no additional flux is necessary.

Heat is added by pushing the tip of the soldering iron onto the component's leg and the copper trail that it is to be soldered to. Do not push hard. Already prior to this, one may put a very small drop of solder on the tip of the soldering iron in order to achieve better heat conduction. After a second, solder is added by bringing the solder against the site of soldering until it has liquified about the component leg. The amount of solder should be so small that the solder joint appears concave in shape, see Figure 1.2.

Name	Value
R1	82Ω
R2	1,2 MΩ
R3, R4, R8	330 kΩ
R5	10MΩ
R6	22kΩ
R7, R10, R12	1 kΩ
R9, R11	100 kΩ
C1, C2, C5	100 nF
C3, C4	4,7 μF
IC1	MCP6004
O1	using heat-shrink
LED1	Clear
LED2	Matte

Table 1.1: Components of the circuit

When soldering is finished, the remainder component leg is clipped close to the solder joint.

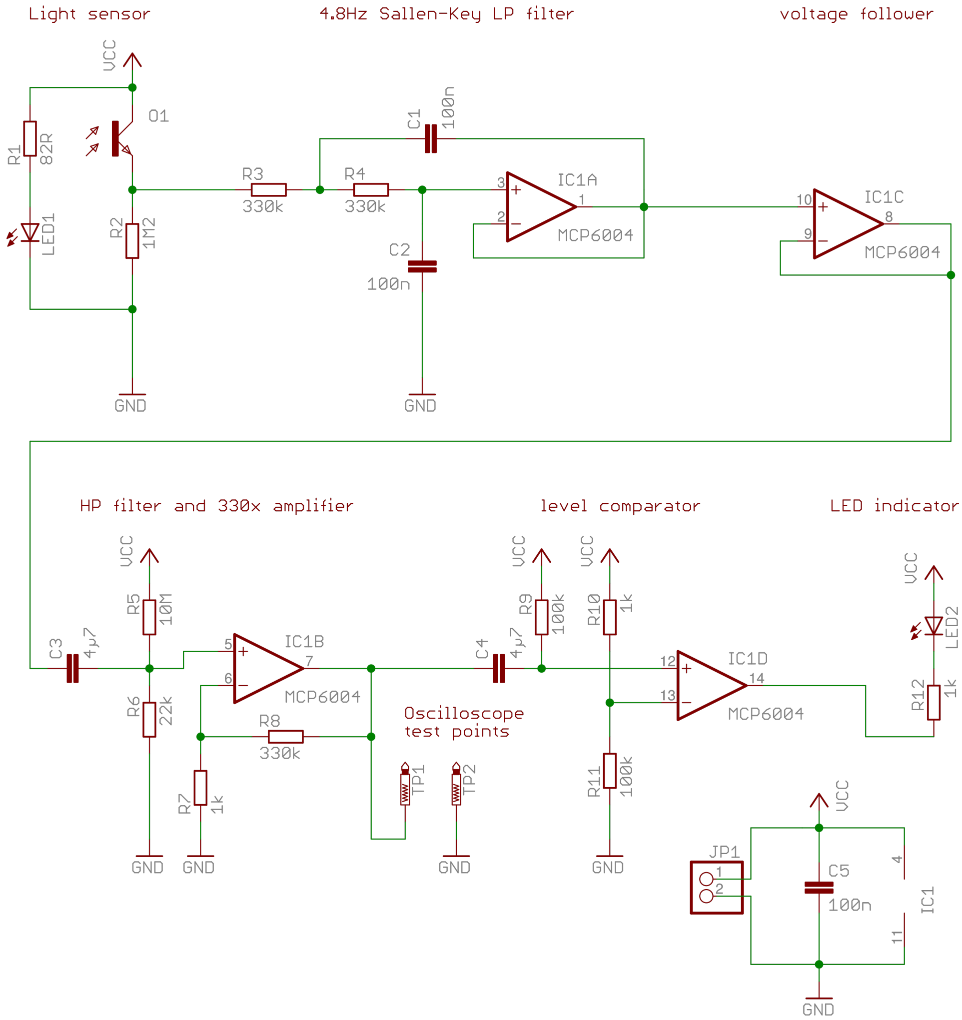
1.3 Components of the circuit

1.3.1 Resistors

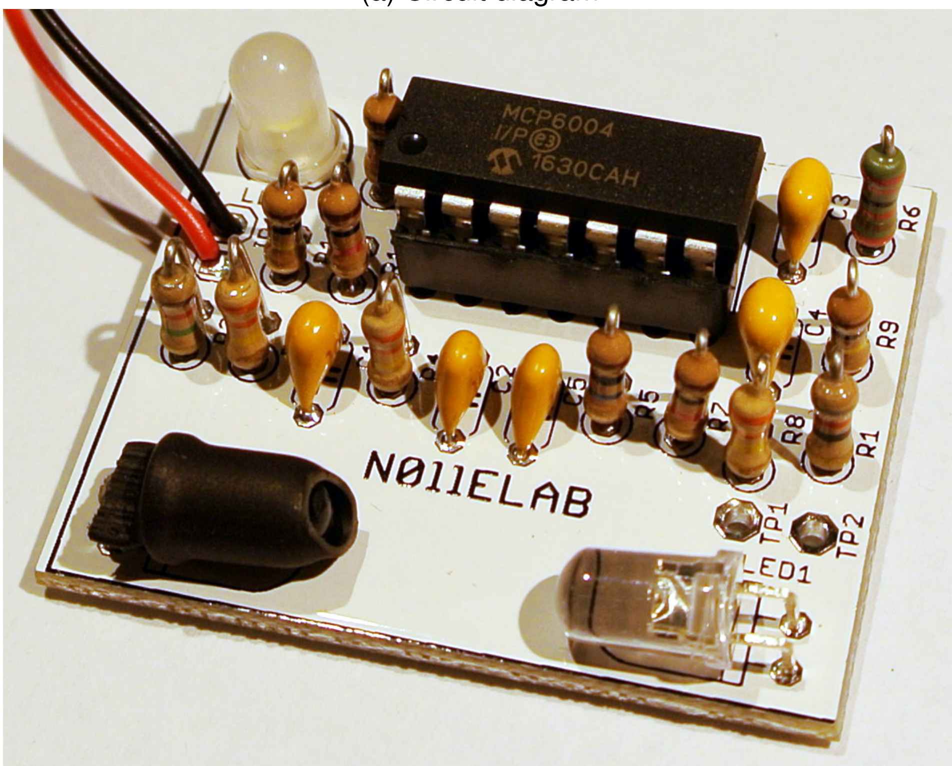
The resistors are cylinder-shaped with a leg at each end. They are non-directional so it doesn't matter how you turn them. In this circuit they are mounted standing up (see Figure 1.1b) in order to save space. All resistors but one has four colour rings. One reads them by starting at the end where the distance between colour ring and component leg is the smallest. The first three rings represent numbers according to the following table:

Silver	Gold	Black	Brown	Red	Orange	Yellow	Green	Blue	Purple	Gray	White
-2	-1	0	1	2	3	4	5	6	7	8	9

These rings denote the resistor's resistance. The two first rings denote significant figures, while the third ring denotes the power of ten to be multiplied by the significant figures. Thus, if the colour of the third ring denotes the value n, the significant figures should be multiplied by 10^n. The unit is Ohm (Ω). As an example, the rings Gray-Red-Orange denotes 8, 2 and ten to the power of 3 (10^3). The result is a resistor with resistance 82,000 Ω, i.e. 82kΩ. The fourth ring denotes manufacturing tolerance and may safely be ignored in this exercise.



(a) Circuit diagram



(b) Completed circuit

Figure 1.1: The circuit

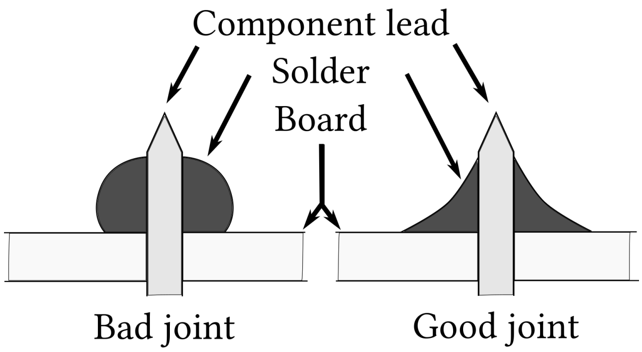


Figure 1.2: Solder joint

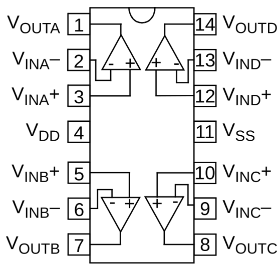


Figure 1.3: Pinout on MCP6004

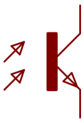
1.3.2 Capacitors

Capacitors in this kit are symmetric so may be turned around at will. Each capacitor is labelled with three numbers - two significant figures and a power of ten. The unit is the picoFarad (1pF). If, for example, it would read “123”, the capacitance is 12*10^3, i.e. 12,000pF = 12nF.

1.3.3 Light emitting diodes (LEDs)

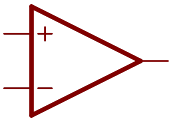
Like all diodes, light emitting diodes (LED1 and LED2) conduct current only in one direction - in through the anode and out through the cathode (the side with the flat spot). So in order to conduct and light up, it has to be mounted in the right direction. How the flat spot should be oriented is shown in the print on the circuit board.

1.3.4 Photo transistors



The photo transistor (O1) is conductive only when illuminated. Just like LEDs, it only works uni-directionally so has to be fit on the PCB the correct way around.

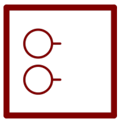
1.3.5 The integrated circuit (IC)



An integrated circuit (IC), that contains four amplifiers, is part of this build. Its socket is soldered to the PCB, and the IC is fitted within. The IC circuit is the black plastic box labelled “MCP6004”. Its 14 leads are numbered anti-clockwise according to Figure 1.3. One starts and ends numbering at the marked end. The IC is fitted in the direction shown on the PCB. The adaptor is fitted similarly, according to its respective mark.

The adaptor is soldered onto the PCB and the IC circuit is pushed into place. The IC may then be removed and exchanged when necessary. The IC circuit is sensitive, so please ensure that the rest of the circuit is correctly soldered before proceeding with pushing the IC circuit into place.

1.3.6 Battery holder



The black wire is soldered onto the negative terminal and the red wire is soldered onto the positive terminal.