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# E-design 344 Assignment #2

2020

## Objectives

- Design, simulate, implement and test an analogue heart-rate sensor circuit.
- Commit all the circuits to version control.
- Write a report using the template and commit the source files to version control.

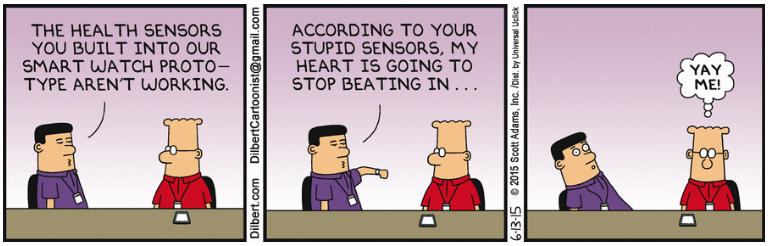


**Table 1:** Change management - History.

| Date | Section | Description | Reason | Person |
|---|---|---|---|---|
| 12 August 2020 | All | – | First issue | MJB |
| 13 August 2002 | All | Corrected small typos. | MJB | |

## Deliverables and checklists

1. Submit your report as a PDF file to https://learn.sun.ac.za for assessment. For the report, ensure you do/include the following:

   - ☐ Make the report filename your surname, student number and the assignment number, e.g.: **Surname_12345678_A1.PDF**.
   - ☐ Add your name and student number to the report, and sign the plagiarism declaration.
   - ☐ Include backgroud, design rationale and calculations, simulations, test results and requisite appendices in the report.
   - ☐ Keep the structure and format supplied in the template – only add and remove content.
   - ☐ Strictly keep to the following page limits
     - System design (for this assignment): **1 page**.
     - Heart rate sensor design: **5 pages**.
     - System and conclusion: **1 pages**.
   - ☐ Screen grab of your version control E344 folder on GitHub as an appendix.

   (a) For the figures:
   - ☐ Preferably use vector data and import directly as PDF into LaTeXreport. I.e. print or save circuit diagrams and signal plots to PDF from LTSpice, and export diagrams from drawing programmes (e.g. www.draw.io, MS Viso, or PowerPoint) to PDF (See video demo on SUNLearn).
   - ☐ Be sure to give labels to your plotted signal in LTSpice (See video on SUNLearn).
   - ☐ Ensure all numbers and text in the figures are clearly legible.
   - ☐ Ensure that each figure has a descriptive caption and that each figure is referenced in the text.
   - ☐ Cite the source in the caption if the image is taken from another source, but add a shortened caption for the 'List of figures' (See template for an example).

2. Submit your circuit design as a **single ASC file** to https://learn.sun.ac.za for auto assessment

   - ☐ Make the ASC filename your surname, student number and the assignment number, e.g.: **Surname_12345678_A1.ASC**.
   - ☐ Please do not modify the LM7805 symbol, it complicates the automatic assessment.
   - ☐ Leave the parts in the blue rectangle untouched – they will be used for the auto-assessment.
   - ☐ Do not change the configuration, library, or any other filenames while developing, since we will add those files to your submitted ASC file when assessing.
   - ☐ Do not give a single net (e.g. '$V_{out}$') two labels in different places (e.g. '$V_{out}$' and '$MyOwnV_{out}$').
   - ☐ You may only use the components listed on SUNLearn, in addition **you may use the built-in LT1018 comparitor and the built-in D-flip-flop (DFLOP)**
   - ☐ Before you submit, remove any additional voltage sources you may have used as part of the development or debug process.

3. Complete the online test at https://learn.sun.ac.za.

## 1 Heart rate monitor conditioning circuit design

**Objective**: Develop the heart rate signal conditioning circuit.

You will find your individualised sensor's specifications on SUNLearn against your student number. The two values describe the DC offset in Volt, and the heart signal's amplitude in mVpk without the noise.

You will also find some `CSV` files that you can use as PWL input files while testing – there is a folder for each. Your circuit will be assessed against similar test input files that meet your individualised specifications. You will also find on SUNLearn some raw, normalised heart beat signals and noise signals with which you can create your own test signals – the AC is normalised to heart signals of 100 mV and the DC component to 1 V, which are also the columns in the `CSV` files. *Note: The assessment will, in addition to testing these nominal levels, also push the boundaries to assess at the extremities of the specifications, and you can emulate this with the normalised test signals.*

Design the signal conditioning circuit according to the following requirements. Your `ASC` file will be assessed according to these. Also demonstrate compliance in your report:

1. The circuit shall work for pulse rate ranges from 50 bpm to 150 bpm
2. The circuit shall generate a 'high' pulse of duration 300 ms for every heart beat
3. The pulse output pulse shall have a 'high' output voltage above 4 $V_{DC}$ and a 'low' below 0.1 $V_{DC}$.
4. The circuit shall give accurate pulses within 2 s of a valid signal being applied at the input. *Clarification: we will only assess the output after 2 seconds of a signal being applied.*
5. Circuit shall use less than 50 mA, which is to be drawn from the linear regulator.
6. You may not modify the symbol files, and have to use the `opamp2` symbol for the op-amps, as shown in the lectures.
7. You are not allowed to use any additional voltage sources in the submitted circuit.
8. The circuit must simulate a 30 second heart signal in under 2 minutes on your own computer.

**Bonus** marks will be given for achieving the following without sacrificing any of the above requirements:

9. The circuit shall be fully compliant despite the presence of the following deviations from your nominal spec: a variation on the DC offset of +/- 0.2 V and a variation of +/- 10% on the transient heartbeat signal (e.g., if you spec was 10 mV for the heartbeat signal, your variation could be +/- 1 $mV_{pk}$.
10. The circuit uses less than 15 mA.
11. Output of the heart rate as an analogue signal that gives a DC output for heart rates from 50 to 150 bpm, with a response time (pulse of less than 1 s for each beat. The range of the output for the specified heart rates must be at least 3.5 $V_{DC}$ from the lowest heart rate to the highest heart rate.

**Guidelines:**

- Start with the template on SUNLearn.
- Design for your individualised spec.
- Analyse your individualised heart signals in the time and frequency domains to decide how to condition the circuit.