Electronics Design Project, for 2nd year.
Building a lively display of pulse rate

Lab 1 – Analogue design

Goals

In this lab you will become familiar with the IR Led sensor and design and prototype the amplifier filter. The goal for this lab is to prototype all the analogue side of your design and be able to document the circuit diagram.

At the end of the lab you need to deliver an outline circuit diagram of the complete analogue section comprising the sensor and the amplifier all with resistor and capacitor specifications and a download from the oscilloscope of signal traces showing the sensor output and the amplified and filtered output ready to the microprocessor.

Information
Data sheets are on Moodle and copies will be available

Take the power voltage to be 3.3V. This is the voltage that can be output by the MBed board (which you will get next week)

Biasing and testing the sensor

The design choices for the sensor are the resistor values required to get it to operate appropriately.

The IR Led is just a normal LED. The forward voltage for it can be read from the data sheet and the typical current is also shown there.

The photo transistor biasing is a bit more obscure. Basically the transistor switches off when there is no light and switches on when there is enough. Our need lies in between but to get maximum voltage swing on the collector, we proceed as follows:

Discover the typical current $I_{CE}$ for the transistor, it can be found on the data sheet. Assume that when the transistor is ‘on’ the voltage from collector to emitter is nil. Hence we get $I_{typ}R_{collector} = V_{supply}$

From this we can calculate a value for $R$. Choose the nearest standard value from stores and wire it up.

Testing the sensor
Use the bench power supply and adjust to 3.3V. Use an Oscilloscope to examine the sensor output (at the collector pin of the sensor). You will need to adjust the scope to its most sensitive setting and fiddle with you finger to get it to work. When you get a pulse trace – record it for your lab books and for your submission.
Designing and testing the amplifier

You should decide on the gain you want then choose resistors and capacitors to suit. Choosing these things can be a bit circular each depends on the other. However, I suggest you do the following:

Choose a gain – that sets the input and feedback resistor ratio.

Design the input filter (high pass). You need to think of the corner frequency you want for this filter and then, using the formula, determine the C and R values. HOWEVER, the challenge is that the R has not to be too big because the other resistor has to be so many times larger. The smaller the R is the larger the C has to be and large capacitors are annoyingly clumsy.

Design the low pass filter. The input resistor determines the feedback resistor via the required gain. The C value for the capacitor can then now be calculated once you have decided on the corner frequency.

Design the Reference voltage for the +ve input for the amp. This is simple, two resistors of the same value. Their values are not critical, but they should not pass too much current (a waste). You also need to add in the bypass capacitor, this should be biggish, say 0.1uF, or 1uF. It can be a polarised type if you want biggest values.

You will likely have to go round your design loop several times to settle on values. Once done, use the prototype board and wire it up.

Test your design using a known signal input and the scope to compare the in and out signals.

Once your amp is running, connect the sensor and get scope traces of your sensor signal filtered and amplified.

Deliverables

When you can demonstrate the full working of the analogue section in this prototype form, fully document your circuit and hand it in. Also hand in copies of the scope traces of the sensor and output from the amplifier. Keep copies of all of those for your lab record and final report.