2014 – 2015 Electronics Design Project 2
Lecture diary

Lecture diary
This diary will document, in highly summarized form, the content of each lecture as it was given. It will be updated as each lecture is presented. It does NOT constitute a set of lecture notes. Please let me know if anything is incorrect or inconsistent.
Dr D Muir

15/1/15 Lecture 1 Introduction to the course

What these lecture are for:
- An accomplishment to the practical project work of the course.
- Some background and theory to illustrate the practical issues.

You will require to have, ‘at your fingertips’, all your other course materials and knowledge because we will need everything.

* Remember the Moodle site for the course where all the reference materials and copies of the handouts will be put.

Project work
- A great and interesting challenge
- Gives experience of design
- Teaches you to analyse the problem and hence break it down into manageable portions.
- Gives an appreciation that planning is important for a successful outcome.

Hopefully it will be great fun, especially when it all works at the end!

This year’s project – A lively display of pulse rate.

Start with the basic project diagram viz. sensor, process, display, PSU.
Break down the processing block further into: signal conditioning and micro.

Take each block in turn and look into its design.

Sensor – use an IR proximity detector.
   Issues – pulse gives only a small signal ~3mv AC.
   Micro needs 2-3 volts for a reliable input => need amplification.
   Also filtering will be needed to remove high frequency noise.

Look at the basic Op Amp circuit.
   Remember the calculation for gain
   Note that the DC blocking, input capacitor forces a high pass on the system.
   To filter out the higher frequency noise we need to include a low pass filter.

The Op Amp needs to work in the ‘single rail’ configuration’ which requires a $V_{ref}$ to be created for the $+Ve$ input to the amp. A potential divider is suitable but a filter capacitor needs to be included.
11/1/15 Lecture 2

Project planning
- The need to identify and plan tasks.
- Tasks depend on each other
- Each task has to be finished on time otherwise later ones get delayed.
- The plan is always being modified and updated to suit developments.
- Example task identification, simplest to work backwards from end point e.g.
  Debug PCB, depends on PCB layout, depends on footprints, depends on final schematic

Example plan as simple table formed of: Task, When, Who

Microprocessor and display boards.
  We will be using the Freedom MBed compatible board plugged into a breakout panel.
  Warning, be aware of the pin connections and the rows.

Display
  8x8 Led array – data sheet
  Multiplexing strategy for such displays, activate columns and drive the rows.
  Noted columns = Cathode, rows = Anode.

Maxim 7221 sheet
  Why device chosen – LED matrix drive capability
  - SPI communication.
  - Does its own multiplexing.
  - Sorts its own current drive.
  Overall function see the block diagram:
  Data word -> internal RAM -> display
  - data word is 16 bits long => 2 x SPI bytes.
  Note the instruction registers, intensity table, power down instructions etc.
  Note the decoupling capacitors required.

Display board
  Notice the 5V power requirement.
  Noted the 3v3 to 5v converter buffer chip.
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29/1/15 Lecture 3
Reminder of project goals viz.
- Stand alone device showing a lively display of pulse rate – either as numerals and or as a ‘scope type’ running display. All on a PCB and running from batteries.

What size for the PCB? – guesstimate it – a tad bigger than the freedom + display board, just enough extra space for the analogue parts.

Decoupling capacitors:
  What are they for:
  - Take noise off power lines
  - Beside every chip and also any analogue ones
  - Values usually 0.1uF and of type multi layer ceramic.

Review of capacitor types, polarized/non polarized.
  Polycarb, polyprop, tantalum, multi layer ceramic, electrolytic.
  Some are good at high frequency performance, some bigger values, some more stable.
ESR – the capacitor equivalent circuit what it implies.

Hence choice of multi layer ceramic types for decouplers, since we don’t care about exact values.
Choose Electrolytic for low frequency decoupling.
Sometime specials needed e.g. Tantalum.
Voltage regulators often need tantalum types.
Note that decouplers are usually placed at every power pin of every digital device.
Remember that the display driver has special requirements.
Lecture 4  Dr J Trinder

The ILOs of today’s lecture were a combination of practical knowledge of the design, construction and debugging of hardware and software and appreciation of the communication problems that can exist between team members with different levels of development knowledge.

Knowledge/Competence Model
Outside of course scope but helps to explain why communication and understanding problems can occur between team members and student/staff and experts/novices

Basic building blocks
- Type of wire to use, solid core for breadboard, mule-strand for flying leads and connections to PSU
- Be consistent with colour coding of wires, especially power supply signal to differentiate different levels. Suggested colours of red for +5 and orange for +3
- Being consistent across the group also makes it easier to help debug each others circuits and reduces the chance of accidentally applying wrong voltages.
- Be consistent with colour coding signal for scope channels as we easily confuse the written colours with the channel colour (noted the Stroop effect)

Safety
- Although low voltage, PSU could potentially supply significant current.
- Do not join cables using crocodile clips, they can easily touch
- Keep jewellery clear of connections.

Hardware Debug Strategies
- Check Power supply voltages
- Split circuit into sections (Divide and conquer)
- Inject a known signal
- Design in an easy way of splitting system into sections
- Once working take and record reference measurements.
- Check the power supply (again)

Software
- General problems of...its easily malleable
- Writing Code
- Be neat and structured
- Split into small understandable sections
- Comments need to be accurate
- Naming things be consistent
- So parts could be designed as hardware or software, you have the decision

Debugging Without a Debugger
- Toggle a pin
- React to an input – switch between features or modes

Useful Resources/General
- Use the change control mechanism of the IDE to track code changes and roll back to working versions.
- The book by “Fast and effective embedded system design” available as ebook
- ByteSplorer and the Character generator application
- Keep a known good reference BINARY that works
- Take a step back. (remember the “we are to too busy to improve” slide)
12/2/15 Lecture 5

Choosing a power supply for the circuit
USB – implies always connected.
Battery means independent and portable.
Suggest, since this is an experimental device, battery life is not important.
Battery life has not been emphasized in this design. Hence choose Cheap and ‘good enough’

Choose the pp3 and looked at pp3 data sheet
Noted: Battery life depends on current draw.
Battery voltage is not constant over its lifetime.
Estimate battery life –
First estimate current used by circuit as:
Display 10mA/Led x 8 = 80mA.
Add 20mA for analogue circuit and Freedom board (wild guess)
=> total 100mA

From pp3 data sheet, we look at line for 100 Ohms load, and find the device ‘should’ last 7 hours or so.

Freedom power circuit
Freedom power circuit is on the user guide.
Identified various power rails viz. USB as incoming 5V and various 3v3 rails.
The Freedom connector pins include 3v3 out, and V5-9V in.
Notice the diodes in the power lines – what are they for – to stop back driving of one voltage source into another.
Determine that display with its 5V will need its own PSU circuit.

Via Farnell WWW and using selection criteria, arrive at the LM2397
Why is it good?
Max input voltage > 9
Current max out 500mA – well big enough for any requirement (including for those who wish to have many displays).
Comes in TO-220 package which is easily soldered.
It has a LDO (low drop out voltage)

Examine the notional circuit of a voltage regulator.
See that is has classic negative feedback and control the pass transistor and hence the output voltage.
In order for the pass transistor to function, it needs voltage headroom and hence to the minimum value for this is called the Drop out voltage.
In our circuit we need LDO so that we can work with lower battery voltages and hence give longer battery life.

Handed out
Pp3 data sheet
Data sheet pages for LM2937
Pages from Freedom board user manual