Lab Notebook

ECE445 Fall 25

YOUR MOST POWERFUL DEBUGGING TOOL

YOUR LEGAL PROTECTION

YOUR INTELLECTUAL PROPERTY PROTECTION

AN INDUSTRY STANDARD

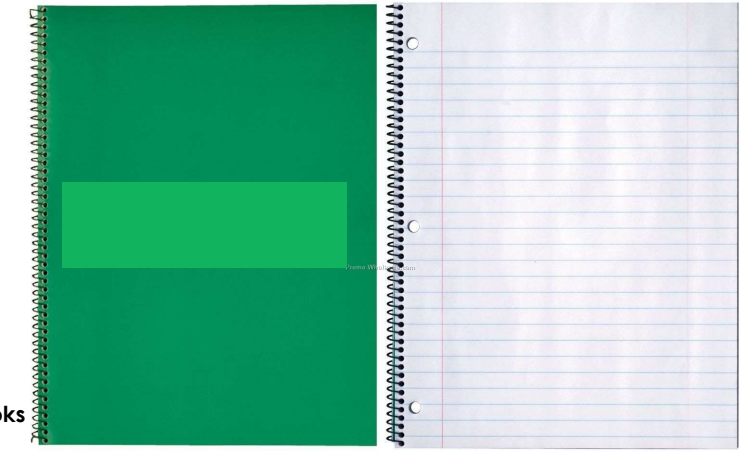
What is an Notebook?

- A record of all of your ideas and your test results
- A record of pertinent portions of datasheets
- A timeline of your project
- A way for your TA to ensure you are on schedule
- A chronicle of your design process, from brainstorming to final implementation.
- The very best reference when writing the final report

Paper Notebook

- Sewn and Numbered Pages
- Carbonless copy is not acceptable
- NOT a spiral bound notebook (pages not sewn)
- NOT a composition book (pages not numbered)

Good!



Bad!

Maintain a Paper Notebook

- Entries are to be written in PEN – preferably with blue or black ink
- **NO PENCIL.**
- Inserts (code snippets, simulation results, etc.) are to be glued in, signed in, and dated in
- **Each** member of the group maintains an individual notebook of individual work – Extensive copying is prohibited
- The notebook should be written legibly
- **The notebook is to be brought to every single TA meeting without exception. We need to see steady and strong progress week to week!**

Electronic notebook

- An alternative to physical paper notebook
- Preferably on GitHub
  - Easy of manage
  - Keep everything together
- Keep digitally as Markdown Documents (.md files)
  - Simple tutorial: https://commonmark.org/help/
  - Example digital notebook: https://gitlab.engr.illinois.edu/ece445/example-project


```
notebooks/
├── alex/
│   ├── README.md
│   └── an_image.png
├── pouya/
│   └── README.md
└── nick/
    ├── README.md
    └── another_image.png
```

What is Written in the Notebook?

- **Everything.**
- The notebook is to be a chronological catalogue of the design process
- Everything, from brainstorming to final testing results, is to be recorded
- This includes all sketches, all proposed designs and their test results, including those that fail, and all calculations
- It is okay to be wrong! The notebook will help you debug!

What should be in each notebook entry?

- Date
- Brief statement of objectives for that session
- Record of what was done
  - Equations
  - Diagrams
  - Figures
- Ultimate goal:
  - *Someone else can follow progress, understand problems, and understand decisions that were made in designing and executing the project*

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The new R_1 value can be calculated as follows:

$$I_B = \frac{I_{C\text{-desired}}}{\beta} = \frac{40\ mA}{65} = 0.616\ mA$$

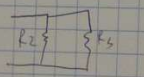
$$R_1 = \frac{V_{TG} - 0.75}{I_B} = 3.65\ k\Omega$$

With this R_1, the current through the LED's was measured as 60 mA. This implies that β is really:

$$\beta = \frac{I_C}{I_B} = \frac{60\ mA}{\left(\frac{3 - 0.75}{3.65}\right)} = 97.3$$

Therefore, R_1 needs to be:

$$R_1 = \frac{(3 - 0.75)}{\frac{40 \times 10^{-3}}{100}} = 5.625\ k\Omega$$



$$R_{eq} = \frac{R_2 R_3}{R_2 + R_3} = 5.625$$

$$R_2 R_3 = 5.625 R_2 + 5.625 R_3$$

$$R_2 = 6$$

$$R_3 = \frac{5.625(6)}{6 - 5.625} = 90$$

With $R_1 = 5.55\ k\Omega$, $I_C = 46\ mA$, $V_{LED} = 3.4\ V$. These are the results we want to see, since these are optimal operating conditions for the LED's. The following table presents the stated results in both forms:

R_1 (k Ω)	I_C (mA)	V_{LED} (V)
1.7	86	3.5
3.65	60	3.4
5.55	46	3.4

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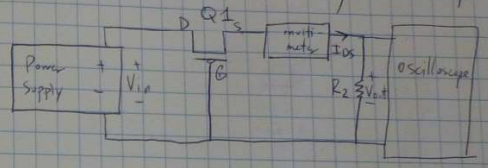
Conclusion: The β value for the BJT given in the datasheet is not correct for the desired operating conditions. The actual β value is 100 (with ~~a~~ 3% tolerance). The reason I had to adjust R_1 more than once is because β is actually a function of I_C (probably a piecewise nearly constant function - e.g. β is fixed for different ranges of I_C). The design needs to be updated to reflect that $R_1 \approx 5.625\ k\Omega$.

Reverse Polarity Protection circuit experimental setup



- Since the Mosfet in our actual design is surface mount, I will be testing the circuit with a different PFET (IRF 5210). The relevant device parameters are given below:

$$R_{DS\text{-}on} = 0.06\ \Omega$$
$$V_{th} = -2 \text{ to } -4\ V$$

- the power supply will deliver a variable voltage (controlled by me)
- the multimeter will measure current through the MOSFET
- the oscilloscope will measure voltage at the output.
- R_2: ~~3~~ 120 Ω

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Selection of Mosfet for reverse polarity protection

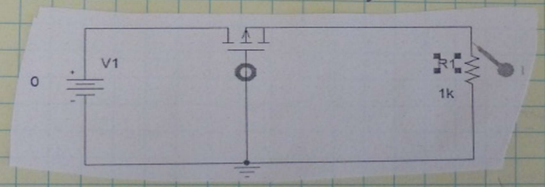
From analysis in the design on Pg. 7, we know that the PFET must have the following properties

1) $V_{th} > -3.5$ V
2) $I_{on,max} > 50$ mA
3) $R_{ds,on}$ must be as small as possible (preferably 0, but realistically in the 0.01 Ohm range)
4) Must be able to block $V_{DS} = -4.5$ V, at least
5) Must be able to handle $V_{GS} = \pm 3.5$ V

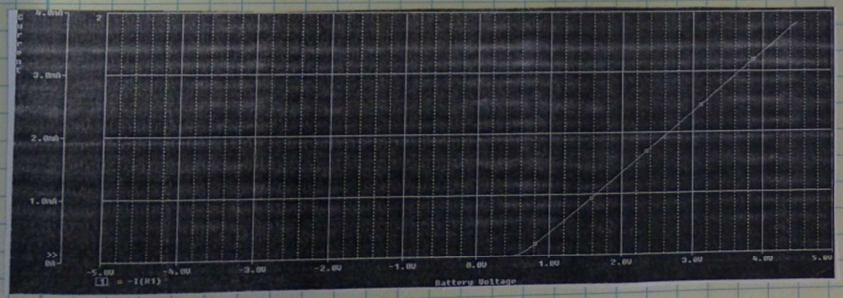
Mosfet chosen:
IRF 7210PBF

Simulation results:

Reverse polarity circuit diagram:



Plot of I vs. V1:



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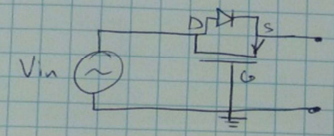
Design Brainstorming of ~~Reverse Polarity/ Amplifier~~ circuits

Objective: come up with a viable design that can be tested in PSPICE.



Source: www.youtube.com/watch?v=IrB-FPcv1Dc
SEDRA & SMITH, Microelectronic circuits

Normal operation: $V_{in} = 4.5$ V

Body diode is on $\Rightarrow$ $V_S \approx 3.5$ V

$V_{GS} = -3.5$ V $< V_t$ (V_t is usually ≈ -1V)
$\Rightarrow$ Transistor is on

Reverse Polarity operation: $V_{in} = -4.5$ V

Assume body diode is on $\Rightarrow$ $V_S = -5.5$ V

$V_{GS} = 5.5 > V_t$
$\rightarrow$ transistor off $\Rightarrow$ assumption contradicted

Reminder: Get help from TA about explanation for Power Mosfet. What allows current to flow from D $\rightarrow$ S? How to analyze power Mosfet circuits?

- tell Ryan about not being able to attend March 5th meeting

Why All the Fuss Over a Notebook?

- The notebook is a chronological record of your work
- Maintaining a professional notebook is a critical skill for industry
- The notebook protects your intellectual property
- The notebook provides legal protection in the event of a lawsuit
- The notebook greatly simplifies the writing of the final report
- The notebook is 10% of your final grade for the course (50 points of 500 points)
- Your TA can help push you in the right direction with the help of your notebooks
- **DO NOT NEGLECT THE INFINITELY IMPORTANT NOTEBOOK!**

Go Build (and Document) Something Cool!