Lab 2 – Notes
Spring 2024

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General Notes

- Make sure to read the “Lab Report How-To-Guide” before doing the first report.

Format and notes on Write-ups

Header

(should include all the important info, including the number and name of experiment, your name and your partner's name, date, section, serial number of the AD2)

- Abstract: 1 abstract per report that summarizes the tasks in the experiment.
    - List of components/equipment: There should be a subsection including the components and equipment used in the experiment.
- Task 1
    - Objective: Should NOT be a copy of the header of the task
    - Procedure: The steps that you have done in building the circuit and taking measurements. Should be simple and preferably in bullets/steps. Should include the circuit diagram for the circuit built in this task. Must NOT be copied from the manual or any one.
    - Results: Present your results in an easy way to understand. Make sure to have the S/N and time stamp of the AD2 on all the screenshots.
    - Conclusion: Make sure to summarize your findings, compute the errors and comment on the potential sources of errors.
- Task 2
    - Objective
    - Procedure
    - Results
    - Conclusion
- Task 3
    - Objective
    - Procedure
    - Results
    - Conclusion

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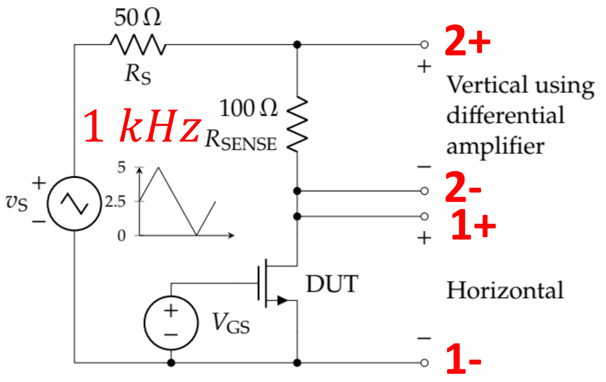
Task 1

Task 2.7.1: RFD3055LE output characteristics

1. *Select* R_{SENSE} for the test set in figure 2.2 to limit the worst case output current to 30 mA. The in lab function generator has a 50 ohm output impedance. The Analog Discovery 2 has a less than 1 ohm output impedance.
2. *Construct* the test set from figure 2.2 using the R_{SENSE} value calculated in step 1. Note that the diff amp circuit is built into the AD2. A prebuilt diffamp circuit is provided in lab. You will use the prebuilt diff amp circuit in lab or the differential inputs when using the AD2 device to measure measure the voltage across R_{SENSE}.
3. *Configure* the oscilloscope to use XY mode and plot the I–V characteristic of the RFD3055LE transistor. On the in lab equipment, use persistence to capture one curve in the cut-off region, one curve in the linear region and two curves in the saturation region. On the AD2, capture the 4 curves as separate screenshots.
4. *Label* the v_{GS} used for each curve.
5. *Estimate* the power consumed by the transistor for each measured curve at the largest v_{DS} by finding the points using the oscilloscope cursors. *Describe* the relationship between the power dissipation and transistor's mode of operation.
6. *Set* V_{GS} = 5 V then *capture* an oscilloscope screenshot showing the measurement. Use the results to estimate $R_{DS(on)}$ in the linear region of operation.
7. *Compare* the computed $R_{DS(on)}$ with the RFD3055LE datasheet $R_{DS(on)}$ value.



1. If you are using the benchtop equipment, then Rs will be 50 Ω (output impedance of the function generator, you don't need to add it externally). If you are using the AD2, then you will need to add extra 50 Ω, or maybe using Rsense to be 150 Ω instead.

2. Please use the AD2 for this task. Hook up ch1 across Vds and ch2 across Rsense. (If you are using the benchtop oscilloscope, you will need to use the diffamp -> Ask a TA)

3. Switch to the mode to the X-Y mode to plot the I-V characteristics. You need to generate 4 curves (1 at cutoff, 2 at saturation, and 1 at the linear region). If you are using the AD2, take screenshots for the 4 curves separately. (If you are using the benchtop oscilloscope, then you will need to use the persistence to show the 4 curves on the same screenshot -> Ask a TA).

5. For each curve, measure VDS and IDS at the very end of each curve, and then compute the power consumption: P = VDS*IDS. Comment on the results.

Note: $I_{DS} = \frac{V_{sense}\ (voltage\ from\ the\ y{-}axis)}{R_{sense}}$

6/7. Set VGS = 5 v, then zoom in (by changing ch1 and ch2 voltage scales). Measure the values of VDS (x-axis) and IDS (y-axis then divide by Rsense). $R_{DS} = \frac{\Delta V_{DS}}{\Delta I_{DS}}$. Compare to the value in the datasheet.

Task 2

Task 2.7.2: PWM speed control with MOSFET switch

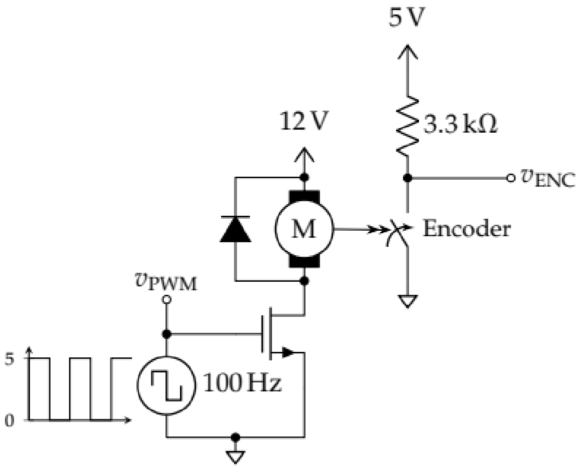


Figure 2.5: PWM motor speed controller.

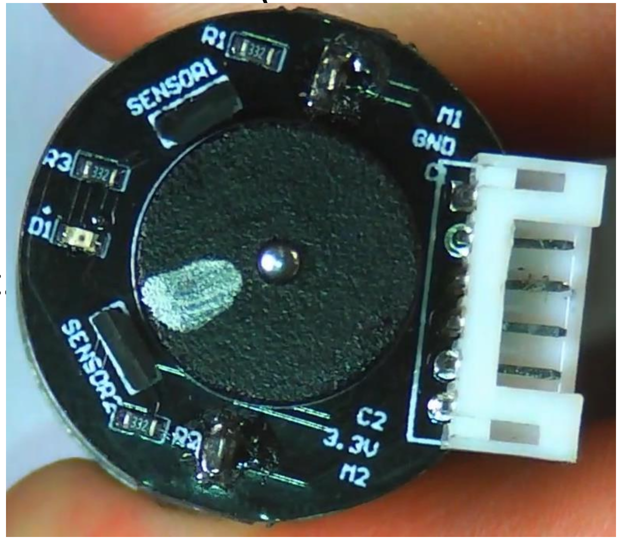
1. *Construct* the circuit in figure 2.5. Use either output of the quadrature encoder for v_{ENC}. Use the 1N5819 diode and RFD3055LE MOSFET.
2. *Configure* the function generator to output a 100 Hz 0 V to 5 V square wave with a duty cycle of 50%.
3. *Capture* an oscilloscope screenshot showing v_{PWM} and v_{ENC}.
4. *Adjust* the function generator duty cycle from 10% to 90%. For each step, *Record* the motor RPM, the encoder frequency, and the average i_D reported by the power supply.
5. *Compute* the total power consumed by the circuit for each step.
6. *Plot* the control duty cycle versus the motor RPM and *describe* the relationship between them.

1. Connect the motor circuit.
   - Make sure to connect M1 to 12v (from benchtop power supply) and M2 to the drain of the Mosfet.
   - Put the diode in the correct orientation.
   - For the encoder part, the 3.3 k is already on the motor (you do not need to add it).
   - Connect the 3.3 v terminal to the power supply (3.3 or 5 v can work), and don't forget to connect the ground terminal. Make sure that a green led lights up.
   - Connect the scope to either C1 or C2 to measure vENC.
2. The input square wave is ranging between 0-5v (make sure to add offset of 2.5v).

4/5. Sweep the duty cycle (at least 10% step), and measure the corresponding encoder freq, motor RPM and ID (current drawn from the power supply).

- Power = 12v * ID
- $RPM = \frac{60f}{p*r}$; (p = 11 and r = 34).

6. Plot RPM vs Duty cycle and comment.



Task 3

Task 2.7.3: LMC555 based PWM generator

In this task, we will create a circuit that can efficiently control the speed of a motor. Note that any load on the motor will still change the speed as this is open loop control. We will explore controls more in experiment 11.

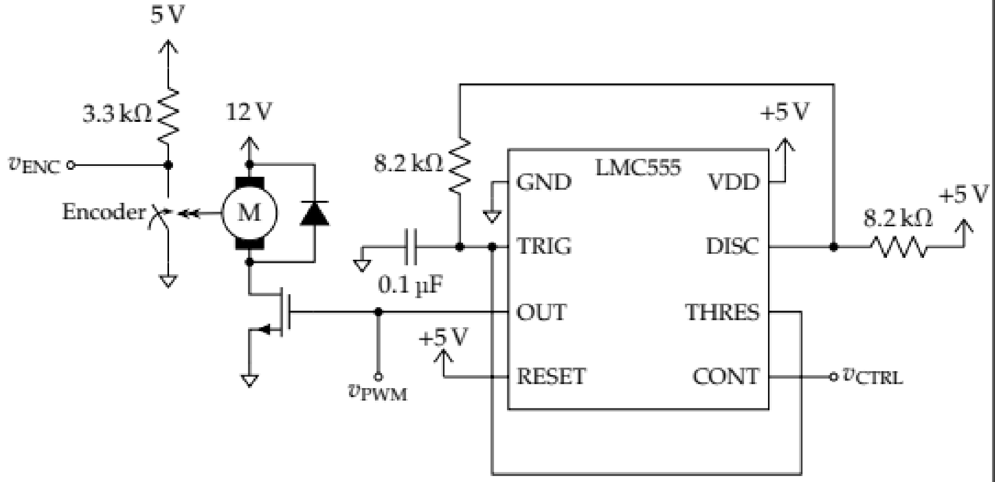


Figure 2.6: PWM Modulation Circuit for Motor Speed Control

1. *Construct* the circuit in figure 11.7. Use the 1N5819 for the diode and the RFD3055LE for the NMOS.
2. *Connect* v_{CTRL} to the function generator and configure the function generator to output DC.
3. *Setup* the oscilloscope to measure v_{PWM} and v_{ENC}.
4. *Adjust* v_{CTRL} from 0 V to 5 V and record the duty cycle of v_{PWM} and the speed of the motor at each step.
5. *Develop* a model for the relationship between v_{CTRL} and the speed of the motor.
6. *Replace* the function generator output with a potentiometer circuit that can adjust v_{CTRL} from 0 V to 5 V. Verify that your circuit is able to control the speed of the motor over its full range.

* Generate the square wave using 555-timer circuit instead of using the function generator.

2. Use the offset voltage in the function generator to change vCTRL.

4. Sweep vCTRL from 0-5v (take at least 10 points), and for each step measure the duty cycle of vPWM and the speed of the motor.

5. Instead of using the function generator with vCTRL, use 5v supply + potentiometer.

To verify that your circuit is working, please report any measurement in your report; show a measured value of vCTRL and its corresponding duty cycle of vPWM and RPM.