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ME 4405 Section B

Lab Assignment Two

Getting Started with CSS and Reading Spec Sheets

Questions:

Debugging Questions

1. *In the variables window, right click on the Value property of dcoFrequency. Change the number format to hexadecimal. What is the value shown? Confirm that this value is equal to the decimal value displayed (show your work).* ***(10 pts)***

   The decimal value of dcoFrequency displayed is 1000000, while the corresponding number shown in hexadecimal format is 0x000F4240. Confirming that these two values are equal:

   $$000F4240 = (0 * 16^0) + (4 * 16^1) + (2 * 16^2) + (4 * 16^3) + (15 * 16^4)$$
   $$000F4240 = 64 + 512 + 16384 + 983040$$
   $$\mathbf{000F4240 = 1000000}$$

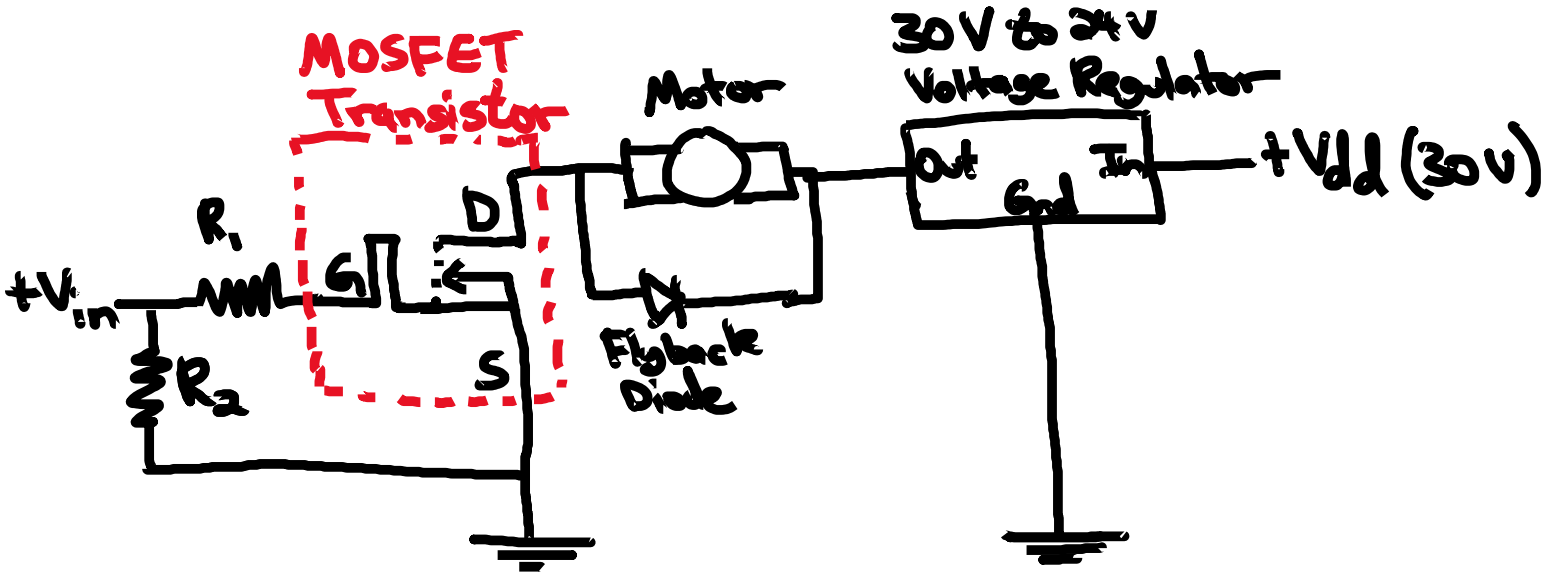
   Hence, the above calculations confirm that the value of dcoFrequency expressed in hexadecimal format is equal to its corresponding decimal value displayed.

2. *You should currently be at line 37 after pressing F8 after starting a new debug session as per the instructions. Now press F5 (Step Into) five times, monitoring the value of i in the Variables window. What is the value of i after pressing F5 five times (repeating the loop)? After changing the displayed format to binary, how many bits are shown? Why is this number of bits displayed (recall data types)?* ***(10 pts)***

   The value of *i* after pressing F5 five times is 30, and its corresponding value expressed in binary is 00000000000000000000000000011110b. As observed, 32 bits are shown because *i* was declared to be an *int*, which is stored by the TI MSP432 launchpad in 32 bits (since this MSP is a 32-bit processor).

Circuit Design Questions

3. *Design a circuit that uses a solid state (semiconductor) device to switch a DC motor ON or OFF. The circuit should be able to handle high current spikes. The voltage source available is a 30VDC power supply. The motor specifications are given in the "DC motor.pdf" file (use the second motor requiring rated 24VDC supply). Notice the starting current of the motor is a high value. (Hint: Consider using a transistor-based switching circuit such as that shown in Slide 53 of Lecture 2, with appropriate modifications. Assume that the MSP432 GPIO pins will supply the input Vin)* ***(30 pts)***



Rational behind Circuit Design

- The MOSFET transistor is used to switch the DC motor ON or OFF depending on whether the gate-source voltage exceeds the transistor's threshold gate-source voltage.
- The resistors are used to ground the gate terminal of the MOSFET transistor when V_{in} equals zero in order to turn the transistor completely off.
- The flyback diode is utilized to handle large current spikes as it provides an alternative path for the current in the motor coil. Therefore, it assists the circuit as a whole in handling high current spikes.
- A 30 V to 24 V voltage regulator is included in order to convert the 30 V DC power supply to the 24 V DC required to run the motor. The voltage regulator is additionally able to handle high current spikes while still providing a stable output of 24 V.

4. *Find a solid state (semiconductor) switching device on the internet that can be used in the above circuit.* ***Attach the datasheet*** *for this device.* ***Point out the important details*** *in the datasheet of the device that proves the usability of the device.* ***(5 pts)***

   A MOSFET transistor that is able to be used in the above circuit is the IRLB8721PbF HEXFET Power MOSFET:

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{DS}	Drain-to-Source Voltage	30	V
V_{GS}	Gate-to-Source Voltage	± 20	

$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	6.5	8.7	mΩ	V_{GS} = 10V, I_D = 31A ③
		—	13.1	16		V_{GS} = 4.5V, I_D = 25A ③
$V_{GS(th)}$	Gate Threshold Voltage	1.35	1.80	2.35	V	V_{DS} = V_{GS}, I_D = 25μA
$\Delta V_{GS(th)}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	-7.0	—	mV/°C	

As indicated in the above screenshots from the datasheet, this MOSFET transistor has a gate threshold voltage between 1.35 V and 2.35 V, values that are lower than the input voltage values that the MSP432 GPIO pins can supply; hence, the MSP can comfortably supply a sufficiently high voltage necessary to turn the MOSFET transistor on. Furthermore, for this specific MOSFET, a gate-source voltage of 4.5 V corresponds to a drain current as high as 25 A, which is significantly higher than the 780 mA required to start the motor; as a result, this suggests that the input voltage of the MSP432 GPIO pins can easily be adjusted in order for the MOSFET to provide a drain current that is slightly above 780 mA, thereby being able to start the motor. Lastly, 24 V DC is supplied to the motor; because this is less than the maximum drain-to-source voltage that this MOSFET transistor is capable of handling before experiencing any damage, the chances that this transistor would experience any damage due to this specific application is unlikely. Hence, all of the previously mentioned reasons support the fact that this specific MOSFET transistor is suitable for this application.

5. *Find a solid state (semiconductor) switching device on the internet that **cannot** be used in the above circuit. **Attach the datasheet** for this device. **Point out the important details** in the datasheet which show that this component is not suited to this application. **(5 pts)***
   A MOSFET transistor that cannot be used in the above circuit is the Supertex 2N7000:

Electrical Characteristics *(T_A = 25°C unless otherwise specified)*

Sym	Parameter	Min	Typ	Max	Units	Conditions
BV_{DSS}	Drain-to-Source breakdown voltage	60	-	-	V	V_{GS} = 0V, I_D = 10µA
$V_{GS(th)}$	Gate threshold voltage	0.8	-	3.0	V	V_{GS} = V_{DS}, I_D = 1.0mA
I_{GSS}	Gate body leakage current	-	-	10	nA	V_{GS} = ±15V, V_{DS} = 0V
I_{DSS}	Zero Gate voltage drain current	-	-	1.0	µA	V_{GS} = 0V, V_{DS} = 48V
		-	-	1.0	mA	V_{GS} = 0V, V_{DS} = 48V, T_A = 125°C
$I_{D(ON)}$	On-state drain current	75	-	-	mA	V_{GS} = 4.5V, V_{DS} = 10V

Although the V_{GS} that's able to be supplied by the MSP432 GPIO pins exceeds the gate threshold voltage for this transistor, the on-state drain current supplied by this MOSFET is nowhere near as high as the necessary 780 mA current required to start the motor. Hence, this MOSFET is not suitable at all to this application.