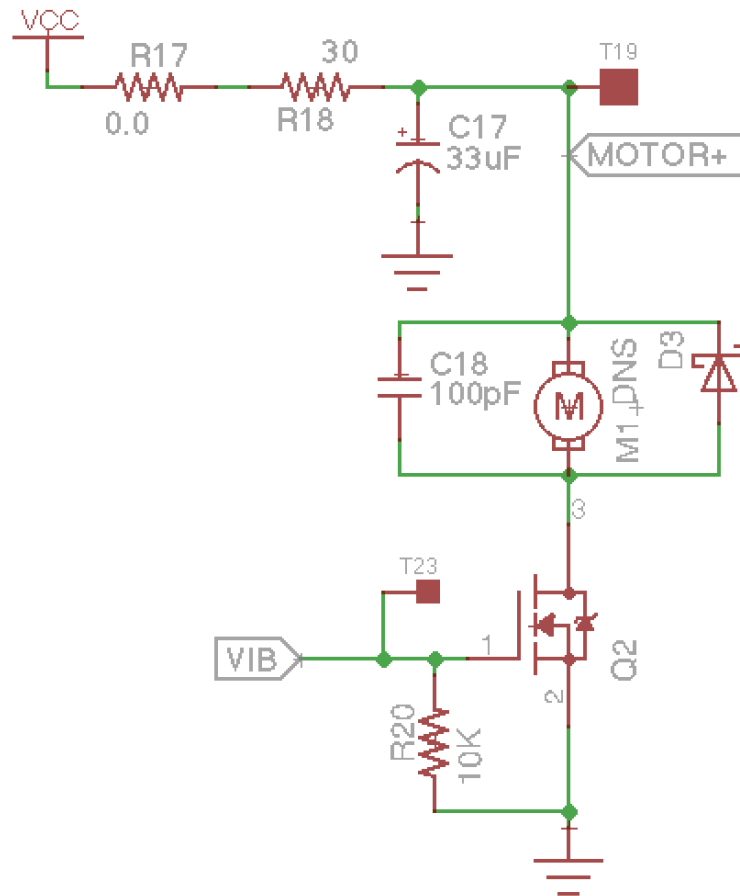


2022 Challenge Puzzle

Problem Statement



A vibration motor (M1) is a common component implemented in consumer electronics to provide haptic feedback. The above analog circuit represents one type of motor implementation. For the following questions, you may assume $VCC = 2.9V$. VIB is sourced from the tri-state output of a microcontroller. VIB is switched to 2.9V for one second, then switched to GND for 20 seconds, and repeated indefinitely.

Further Information:

- If motor leads are connected directly to VCC and GND (motor is separated from the above circuit), average current draw is 100 mA.
- T19 and T23 are test pads
- The term “DNS” may be ignored
- A 70 mAh battery is used to drive both the microcontroller and VCC, through a 2.9V linear regulator.

Tasks

1. Explain the purpose of R18 and C17, C18 and D3, R20 and Q2. Why would R17, a zero ohm resistor, be useful in this circuit?
 - a. Hint - the primary purposes of C17 and R18 are **not** to form a low pass filter. Think of these components independently.
2. How would the circuit be modified to use a p type MOSFET? Provide a circuit drawing to support your explanation (label all components) and explain the required firmware changes.
 - a. What are some benefits of using an n type MOSFET solution vs a p type MOSFET solution?
3. It appears to be easier to drive the motor directly from the microcontroller, so I do not need to use Q2 or R20. Why could this be a problem?
4. It has been decided that the haptic feedback strength is not sufficient. What are some circuit modifications that can be made to increase vibration motor strength? What are some firmware modifications that may be made?
 - a. What are some ways to test that the modifications made leads to an increase in vibration motor strength?
 - b. For one specific circuit modification and one specific firmware modification - include a rough calculation for the new battery life of the product, assuming the full battery supplies current to the vibration motor circuit (i.e. assume MCU and linear regulator are negligible in comparison).
5. It is time to package the circuit in a PCB layout. I need to pick components for the above circuit, to fit in a small area, and would like the PCB assembled with an automated process.
 - Should I use through hole or surface mount technology? Why?
 - Pick out specific parts for R18, C17, D3 and Q2 on Digikey. Explain the most important specifications for each component that you have selected, as it relates to the vibration motor circuit.

Submission

All responses should be submitted electronically in an organized manner. Research is expected to be performed to gain a full understanding of the challenge.