H-Bridge Design for High-Voltage Application

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July 20, 2020

Task 9: H-Bridge Design for High-Voltage Application

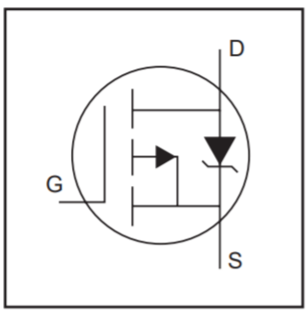
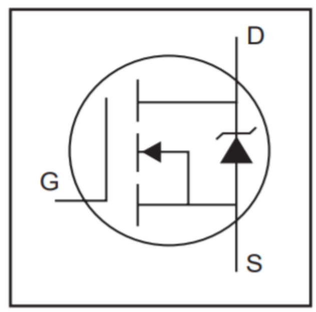
An H-Bridge is an electronic circuit that switches the voltage polarity applied to a load, it contains four switching elements with a load at the center. It's often used in robotic applications in order to move DC motors forwards or backwards. [1]

An H-Bridge circuit was requested to be designed to tolerate more than 3 amperes for a high voltage electronic application. The most suitable transistor was chosen with specifying its advantages and the circuit was designed and built.

Transistor Type

MOSFET transistors were used for their ability to tolerate more current than what BJTs could tolerate. I have chosen an IRF5210 P-Type and an IRFZ44N N-Type power MOSFETs for their high voltage & current tolerances, low Drain-Source On-Resistance for less power loss and heat and high power dissipation. [2] [3]

Table 1: Key MOSFETs' Data Sheet Information

IRF5210 P-Type MOSFET  *Figure 1: IRF5210 Symbolic Diagram [2]*	**IRFZ44N** N-Type MOSFET  *Figure 2: IRFZ44N Symbolic Diagram [3]*
V_{DSS} = -100V	V_{DSS} = 55V
I_D = -40A	I_D = 49A
$R_{DS}(on)$ = 0.06Ω	$R_{DS}(on)$ = 17.5mΩ
Power Dissipation = 200W	Power Dissipation = 94W
TO-220 Package Type	

Other important advantages for both of the MOSFETs are:

- Advanced Process Technology
- Ultra-Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated

H-Bridge Circuit Diagram

Case 1: Motor is OFF

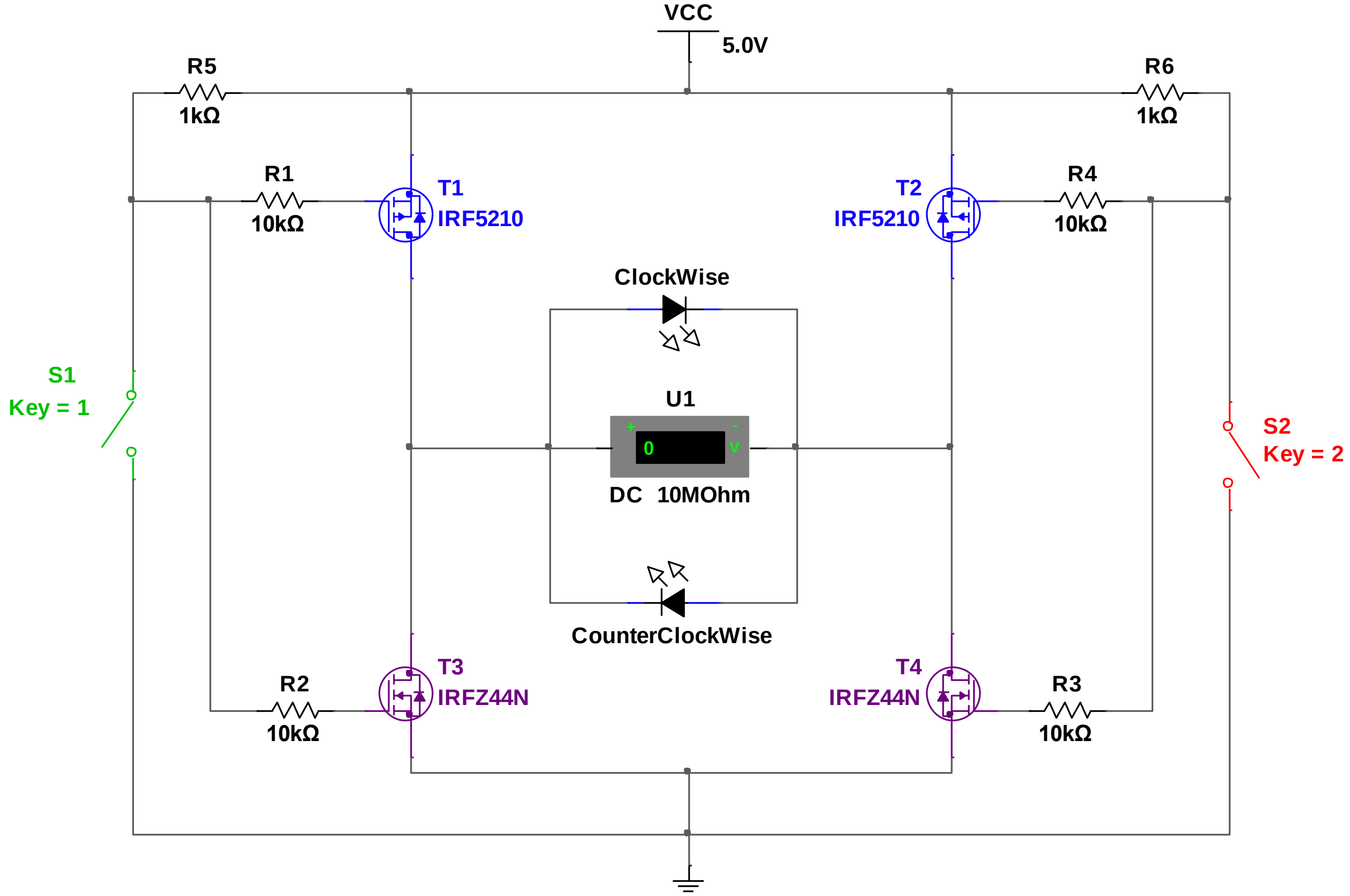


Figure 3: MOSFET's H-Bridge Circuit Diagram using Multisim Case 1

This figure above represents the H-Bridge circuit diagram and it consists of: A DC motor, PNP MOSFETs indicated by blue, NPN MOSFETs indicated by purple, resistors, switches and LEDs for clarification reasons.

In case 1, both switches are OFF. As a result of that, a positive voltage is applied to all MOSFETs' gates because they're connected to VCC, and this turns T1 & T2 OFF because they're p-type MOSFETs, and T3 & T4 ON because they're n-type MOSFETs. This scenario disconnects the DC motor from the power source and turns it OFF as in figure 3.

Case 2: Motor Rotates in a Clock-Wise Direction

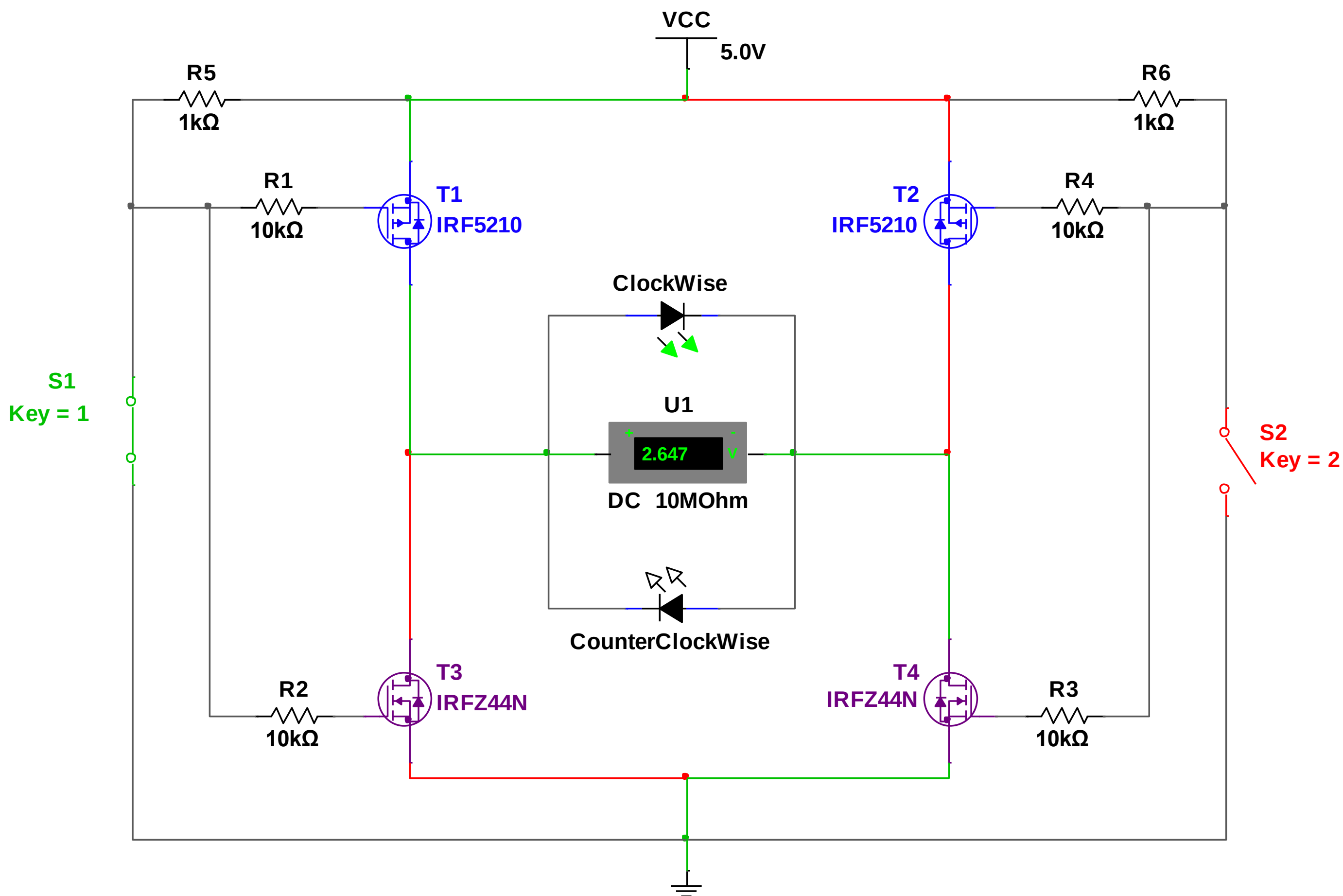


Figure 4: MOSFET's H-Bridge Circuit Diagram using Multisim Case 2

In case 2, where the switch S1 is ON, a negative voltage is applied to T1 & T3 MOSFETs' gates because they're connected to ground, and this turns T1 ON and T3 OFF. On the other side where the switch S2 is OFF, a positive voltage is applied to T2 & T4 MOSFETs' gates because they're connected to VCC, and this turns T2 OFF and T4 ON. This scenario lets the current to flow from VCC to ground through T1, the DC motor and T4, as in the green path in figure 4. As a result of that, the motor rotates in a clock-wise direction indicated by a green LED and justified by its positive voltage.

Case 3: Motor Rotates in a Counter-Clock-Wise Direction

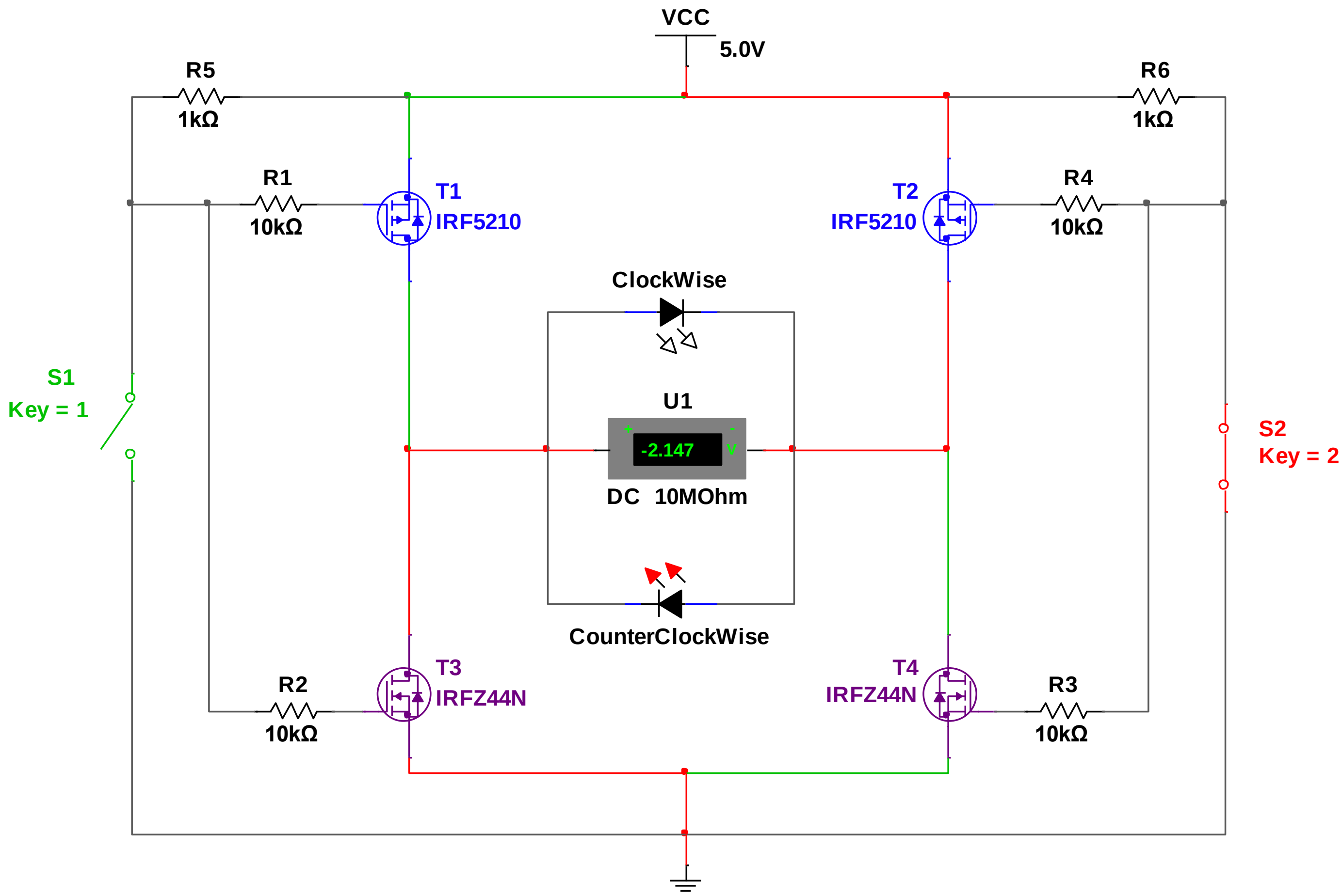


Figure 5: MOSFET's H-Bridge Circuit Diagram using Multisim Case 3

In the third case, where the switch S1 is OFF, a positive voltage is applied to T1 & T3 MOSFETs' gates because they're connected to VCC, and this turns T1 OFF and T3 ON. On the other part of the circuit where the switch S2 is ON, a negative voltage is applied to T2 & T4 MOSFETs' gates because they're connected to ground, and this turns T2 ON and T4 OFF. This lets the current to flow from VCC to ground through T2, the DC motor and T3, as in the red path in figure 5. Consequently, the motor rotates in a counter-clock-wise direction indicated by a red LED and justified by its negative voltage.

References

[1] "What Is an H-Bridge?," Build Electronic Circuits, 05 12 2018. [Online]. Available: https://www.build-electronic-circuits.com/h-bridge/. [Accessed 14 07 2020].

[2] "IRF5210 Datasheet (PDF) - International Rectifier," All Data Sheet, [Online]. Available: https://pdf1.alldatasheet.com/datasheet-pdf/view/68164/IRF/IRF5210.html. [Accessed 16 07 2020].

[3] "IRFZ44N Datasheet (PDF) - International Rectifier," All Data Sheet, [Online]. Available: https://pdf1.alldatasheet.com/datasheet-pdf/view/68619/IRF/IRFZ44N.html. [Accessed 16 07 2020].

[4] "how to simulate in mulitsim ? (H bridge)," ELECTRO AZ YouTube Channel, 14 10 2017. [Online]. Available: https://www.youtube.com/watch?v=Y6gGf6lK6ck. [Accessed 17 07 2020].

[5] "What is MOSFET with Working? MOSFET as a Switch," ElProCus – Electronic Projects for Engineering Students, [Online]. Available: https://www.elprocus.com/mosfet-as-a-switch-circuit-diagram-free-circuits/. [Accessed 19 07 2020].