Is it possible to build an H-Bridge with only N-MOSFETs (and these other components)?

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2

I am trying to design an H-bridge circuit and I am only given the following components:

- Opamp
- Zener Diode
- Resistor
- Capacitor
- N-MOSFET
- NPN BJT
- Diode
- 2-input NOR
- 2-input NAND
- Infra-red Detector
- Infra-red Emitter
- D flip-flop

I know that it is easy to design an H-bridge using 2 P-MOSFETs and 2 N-MOSFETs, but I am not given P-MOSFETs.

Is there an equivalent circuit for only N-MOSFETs?

mosfet design h-bridge

edited Nov 3 '15 at 20:26 asked Oct 20 '15 at 3:22

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Greg d'Eon LearningLaSo
2,83521233 616

Think about what a MOSFET is. You can't magically change its chemistry. – Matt Young Oct 20 '15 at 3:25

2 Look up bootstrap circuits. – Matt Young Oct 20 '15 at 3:34

@LearningLaSo - Do you have any idea what Google is all about? You should be able to find a plethora of sample circuits all on your own. – Michael Karas Oct 20 '15 at 3:44

Also fairchildsemi.com/application-notes/AN/AN-6076.pdf is very nice for background on bootstrap drivers for nmos. – Fizz Oct 20 '15 at 3:47

Related: electronics.stackexchange.com/questions/79792/… – Fizz Oct 20 '15 at 3:53

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3 Answers

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If you have a single-output power supply and only NMOS and NPN transistors available, you'll certainly be able to build an "H" bridge, using either, (or both) but you'll not be able to saturate the high side devices so, depending on what your load looks like, they (the high side transistors) may get too hot for comfort and your load probably won't perform the way you want it to.

However, with all the stuff you have available you could easily build a charge pump and use it generate a voltage higher than your supply voltage.

up vote 3 down vote

Once you did that you'd be able to drive either the gates of the high-side MOSFETs or the bases of the high-side BJTs at higher than your supply voltage and get the H bridge to work properly.

answered Oct 20 '15 at 8:05

shareimprove this answer

EM Fields
1

Given all the stuff he's given, I suspect a charge pump might indeed be the solution expected by whoever gave him the assignment. It doesn't look like he took on board anything you've said since he then asked this. So I've decided to basically detail with schematics what you've said. – Fizz Oct 23 '15 at 11:14

add a comment

up Without even considering the concept of bootstrapping it is totally possible to build

vote 3 down vote

an H-Bridge with N-Channel MOSFETs in both the upper and lower switch positions. This is done all the time in high power drivers due to the much larger selection of high performance N-Channel FETs over that for P-Channel FETs.

The key parameter to keep in mind is that the gate drive voltage for the upper FETs needs to be driven above the output voltage positive level by a good amount to ensure that the upper FETs are turned on fully. A starter way to achieve this is to provide a higher voltage supply rail for the gate drivers than what is used for output positive voltage rail.

Once you have learned and understood the concepts of what it takes to drive the upper N-Channel FETs with sufficient gate voltage you can then begin to investigate how to get that higher voltage without having to provide an additional higher voltage power supply. One way to do that is to build a charge pump circuit, with some of your other components, to "double" the positive voltage rail up to near 2X the voltage. To utilize this higher voltage will require a circuit that can swing the upper FET gate up to this 2X voltage and then low. The Op-Amp would be a good candidate to do that for you.

In the industry there is a tendency for engineers to be tasked with designing circuits that cost less but give desired performance and function. There is technique called boot strapping that uses the switching action of the H-Bridge itself to drive a capacitor in a simpler form than the completely separate charge pump circuit. The bootstrap capacitor can achieve almost twice the positive voltage rail level of voltage and again provide the necessary gate drive bias for the upper N-Channel FET. We never get anything for free however and in this case the simpler bootstrap circuit has the requirement that the H-Bridge needs to keep switching all the time to provide the pumping action. This means that a motor drive would need to be switched PWM type drive and never get to full 100% ON drive level.

answered Oct 20 '15 at 3:43

share improve this answer edited Oct 23 '15 at 13:08

Michael Karas
34.1k33368

Since he's given all the other components, I suspect his homework/assignment also requires the use of single supply, but he probably forgot to mention that in his question here. That seems very plausible because he asked a subsequent question of how to create the higher voltage rail. – Fizz Oct 23 '15 at 11:03

@RespawnedFluff - Expanded answer to include more guiding information. – Michael Karas Oct 23 '15 at 13:09

add a comment

up Since this is a school assignment, I suspect the solution is expected to be simple, not

vote 2 down vote

industry grade. The simplest bootstrap that works for the high-side N-channel MOSFETs looks like this (half bridge shown):

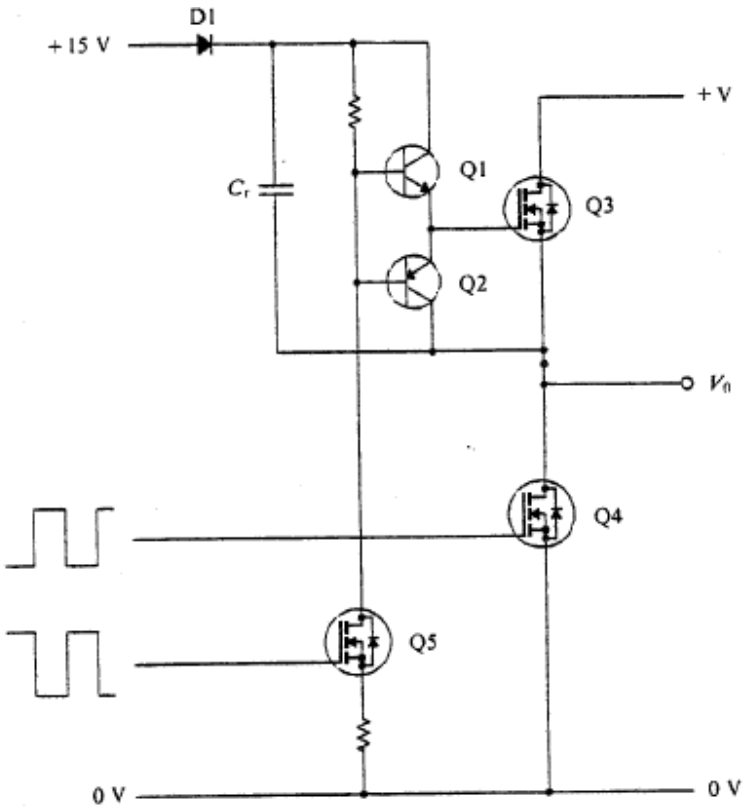

Figure 8.31. H-bridge gate drive circuit with diode-pumped power supply for upper gate drive.

This is from a textbook by Grant and Gowar.

Now since you're not given any PNPs, you can't have the complementary pair drive Q3 there. Instead you have to use a two-NPN totem pole in their place.

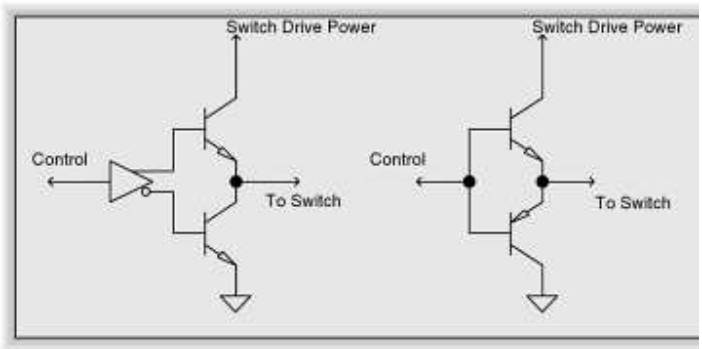

Figure 7-17: Totem-pole output, complementary transist

You seem to be given all the logic gates you want, so this looks like will satisfy your assignment requirements.

A bit more searching even found (in an article referenced by Grant and Gowar) something more economical along the lines I was talking about:

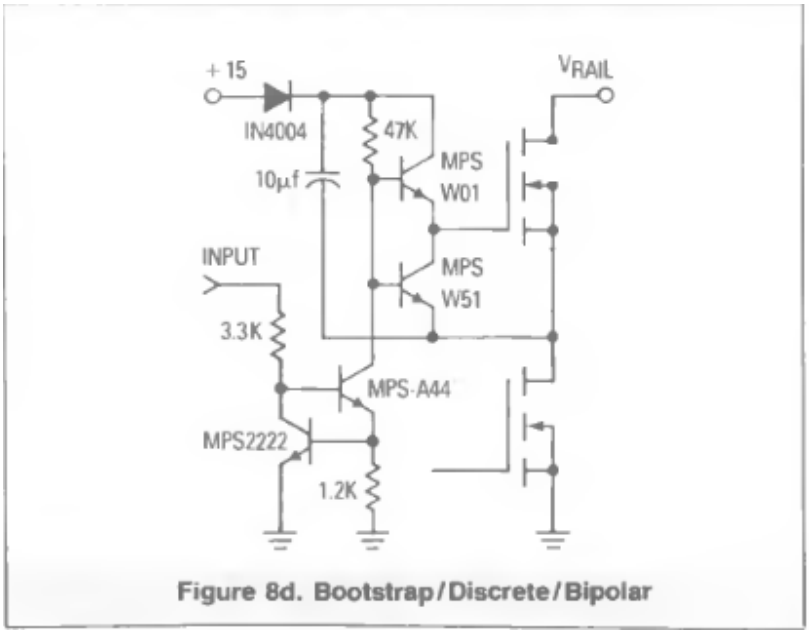

Figure 8d. Bootstrap/Discrete/Bipolar

I have no idea why you're given "Infra-red Detector" and "Infra-red Emitter" but if by any chance that means you're given optocouplers, you could also do this:

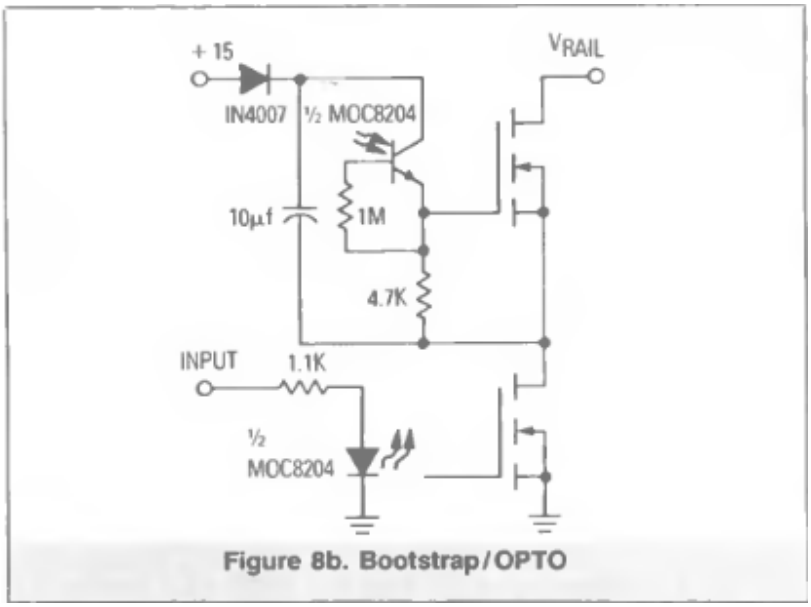

Figure 8b. Bootstrap/OPTO

You're not saying what kind of motor you need this H-bridge to drive. The above circuits are suitable for BLDCs or motors where the on-time of the high-side switches cannot be arbitrarily long because the capacitor can only recharge when the high-side is off (it's shorted while high-side drive is on). If you need arbitrarily long on-time, then a slightly more complex circuit called a charge pump is needed to continuously top off the boostrap/tank capacitor. The textbook-level circuit is (only the high-side driver is shown):

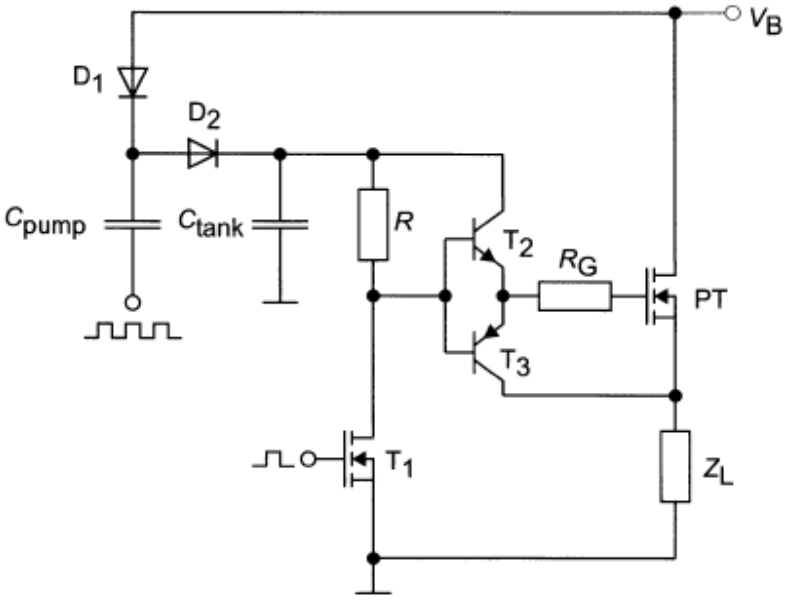

Fig. 2.30. Charge pump circuit

Again you'll have to substitute the complementary pair to meet your design requirement of no-PNPs-allowed. This circuit also requires a clock signal (square wave generator) to drive the pump, which you can make in many ways with what you've got, e.g. op amp. If you don't know how to do that bit (and you need it), you should search the site and/or ask a separate question.

answered Oct 23 '15 at 7:19

shareimprove this answer edited Oct 23 '15 at 10:48

Fizz
11.6k11759

For a video tutorial on bootstrapping see youtube.com/watch?v=ZZDdlAgZfvI – Fizz Oct 28 '15 at 8:01

I'm not sure if circuit "2.30" is correct, because when you turn it on, full voltage from Ctank will be applied to gate of PT. Since Ctank is charged to (Vb+Vpump) it can be really high and PT can be destroyed by gate burn. Correct me if I wrong, but I think that charge pump must be referenced to Vs of PT, but not VB. – eugene Apr 29 at 10:59

1 @eugene: Note that PT is configured as a source follower, with the load connected between source and ground. This means that PT's gate-source voltage will never be substantially greater than its threshold voltage, because as soon as PT starts to conduct, the source voltage rises to "follow" the gate voltage. Note also that the amount by which the voltage on C_tank exceeds V_B is controlled by the peak-to-peak amplitude of the signal driving C_pump, and this should be comfortably less than the Vgs rating of PT. – Dave Tweed