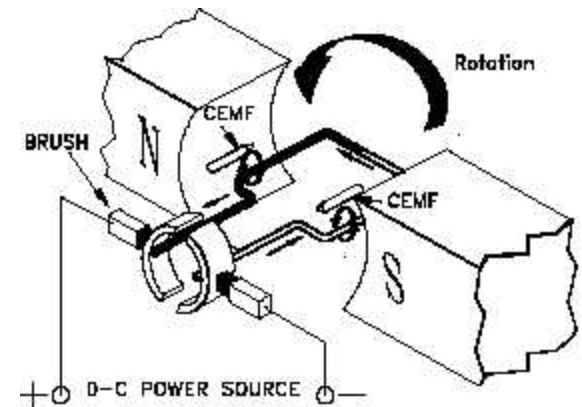


# DC Motors

- Current (ideally) is proportional to the torque produced by the motor
- Direction of current flow determines torque direction

How can a digital input control torque magnitude?



[www.tpub.com](http://www.tpub.com)



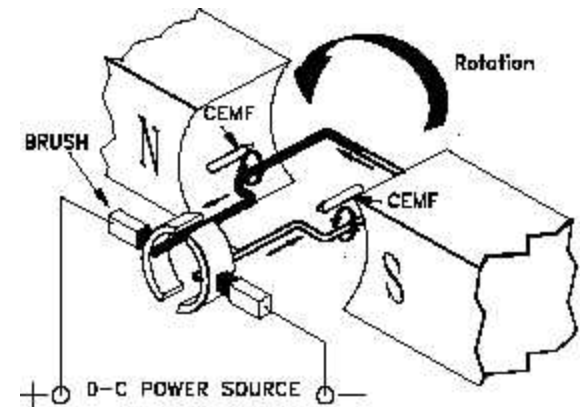
[www.pcgadgets.com](http://www.pcgadgets.com)

# DC Motors

How can a digital input control torque magnitude?

- Use PWM!

How do we handle torque direction?



[www.tpub.com](http://www.tpub.com)

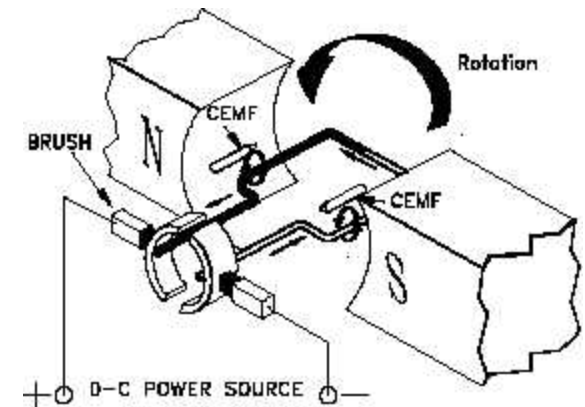


[www.pcgadgets.com](http://www.pcgadgets.com)

# DC Motors

How do we handle torque direction?

- +5V to north 0V to south
- 0V to north +5V to south



[www.tpub.com](http://www.tpub.com)

How would we implement this?



[www.pcgadgets.com](http://www.pcgadgets.com)

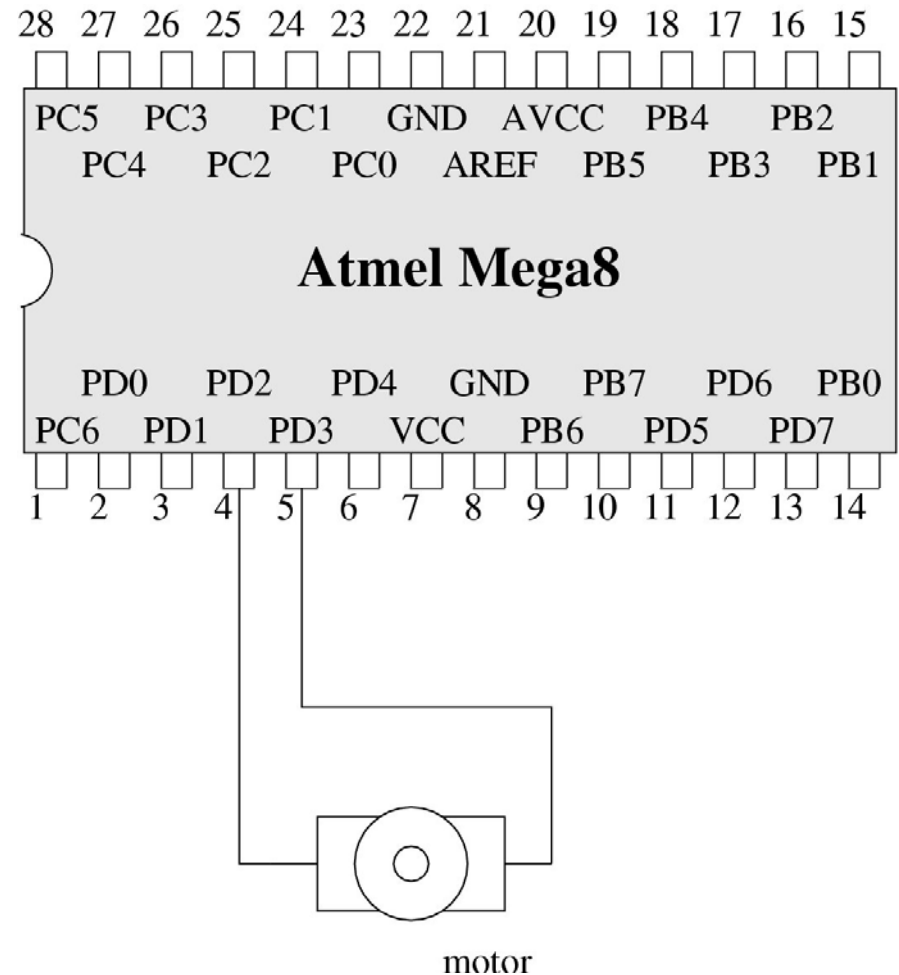
# DC Motor Control

One possibility...

- Connect motor directly to the I/O pins

Two directions:

- PD2: 1; PD3: 0
- PD2: 0; PD3: 1

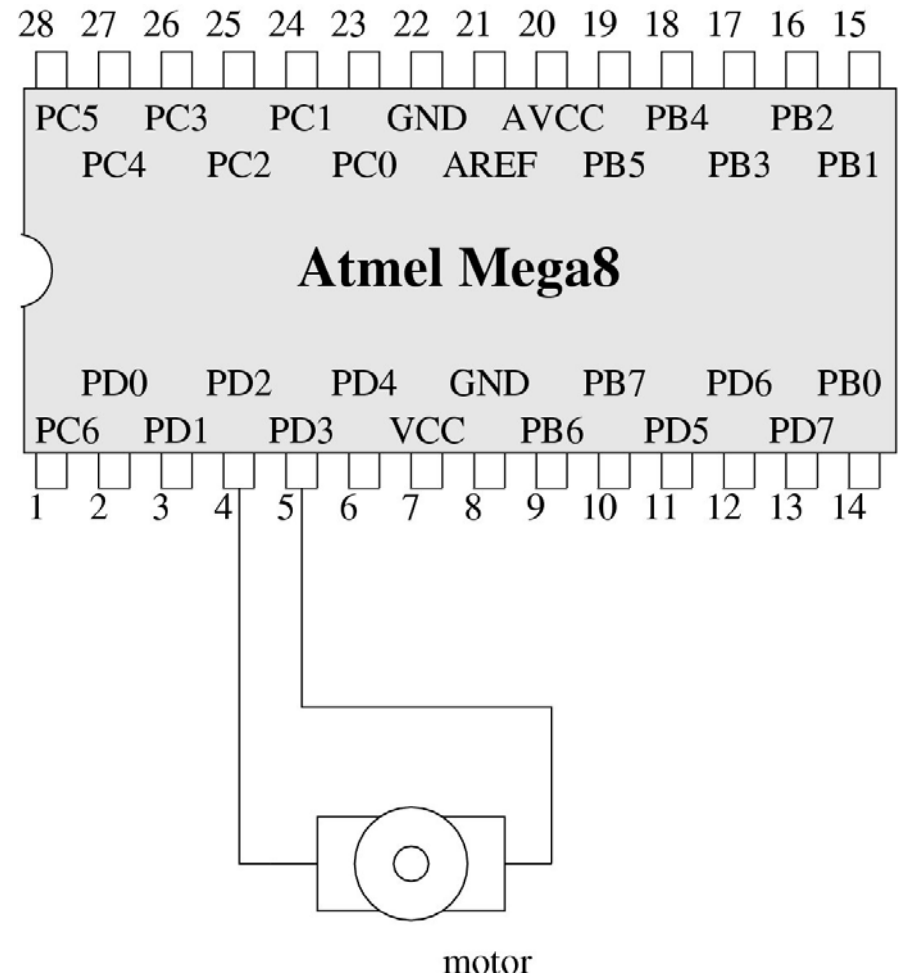


# DC Motor Control

One possibility...

- Connect motor directly to the I/O pins

What is wrong with this implementation?

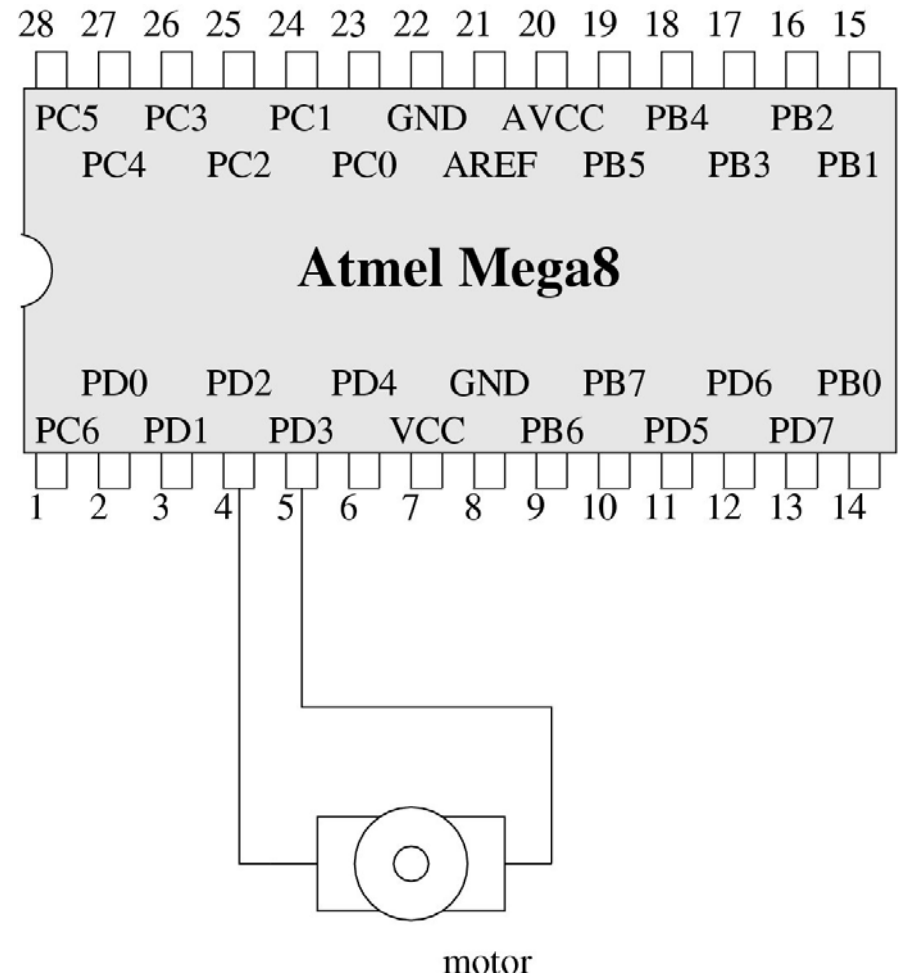


# DC Motor Control

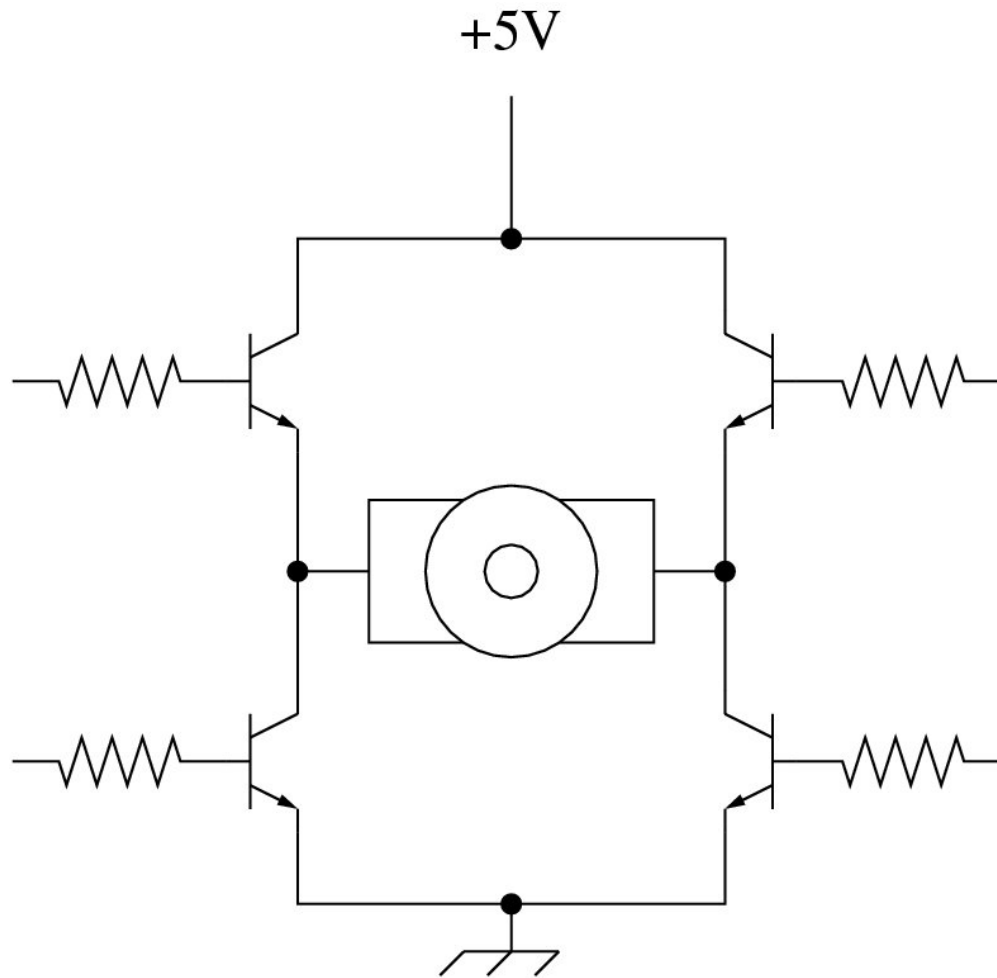
What is wrong with this implementation?

- Our I/O pins can source/sink at most 20 mA of current
- This is not very much when it comes to motors...

How do we fix this?

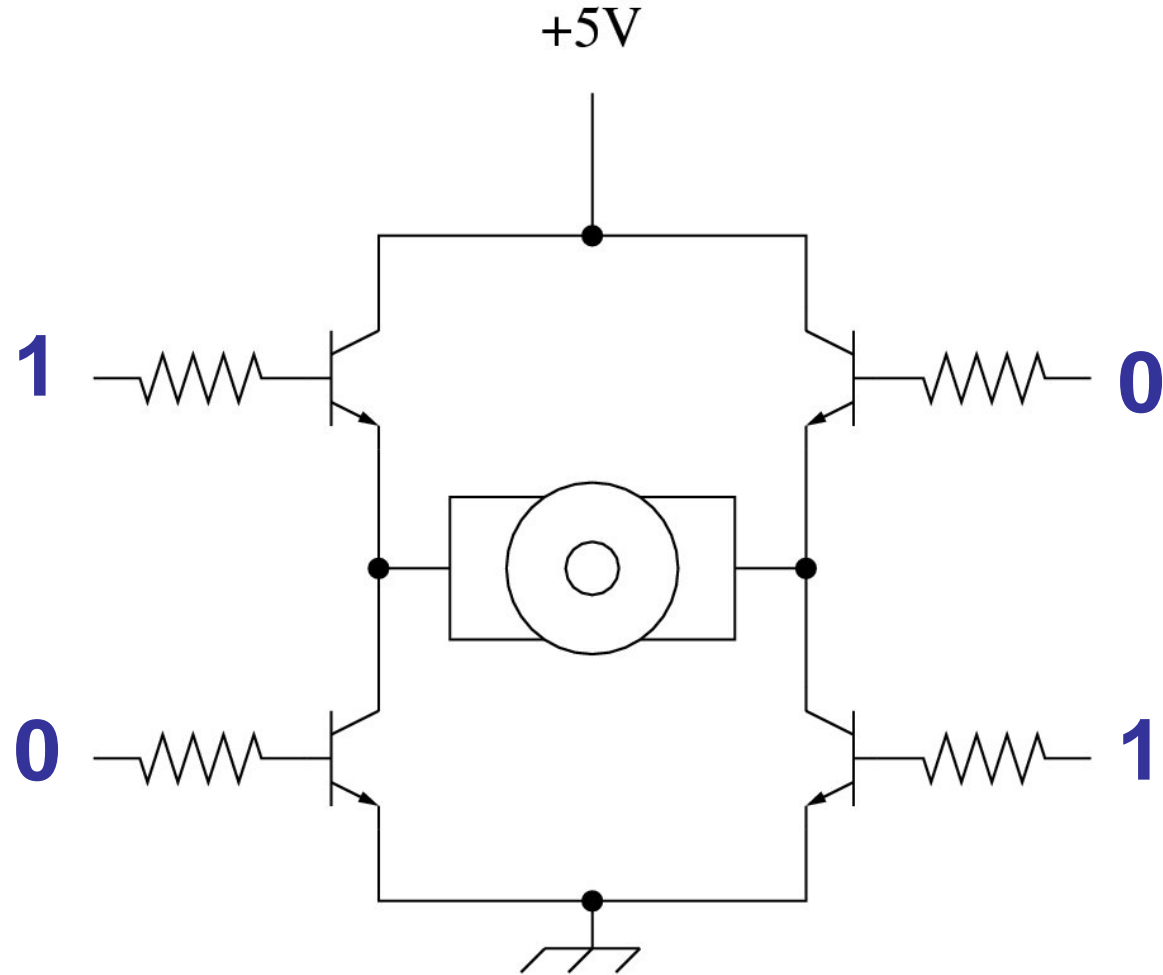


# Simple H-Bridge



# Simple H-Bridge

What happens with these inputs?

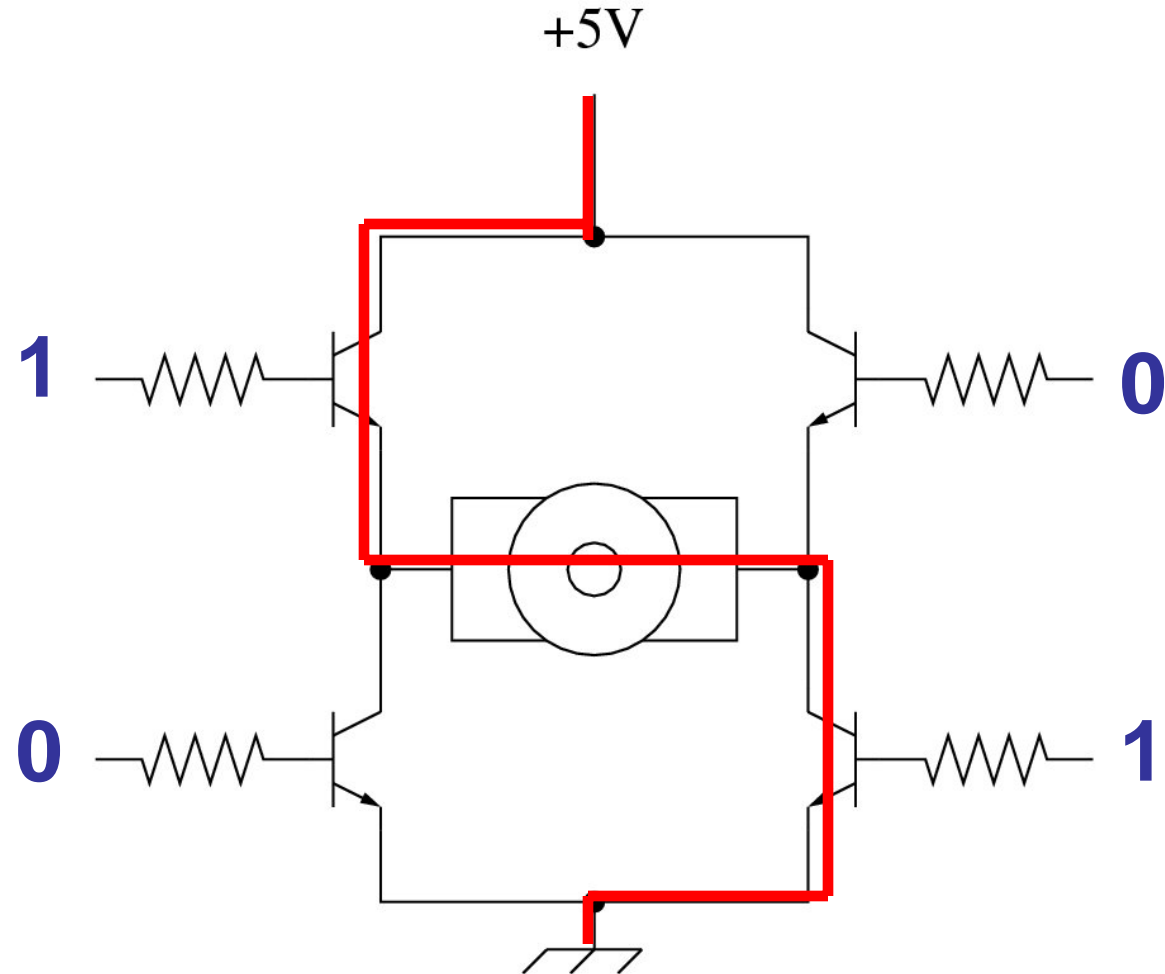




# Simple H-Bridge

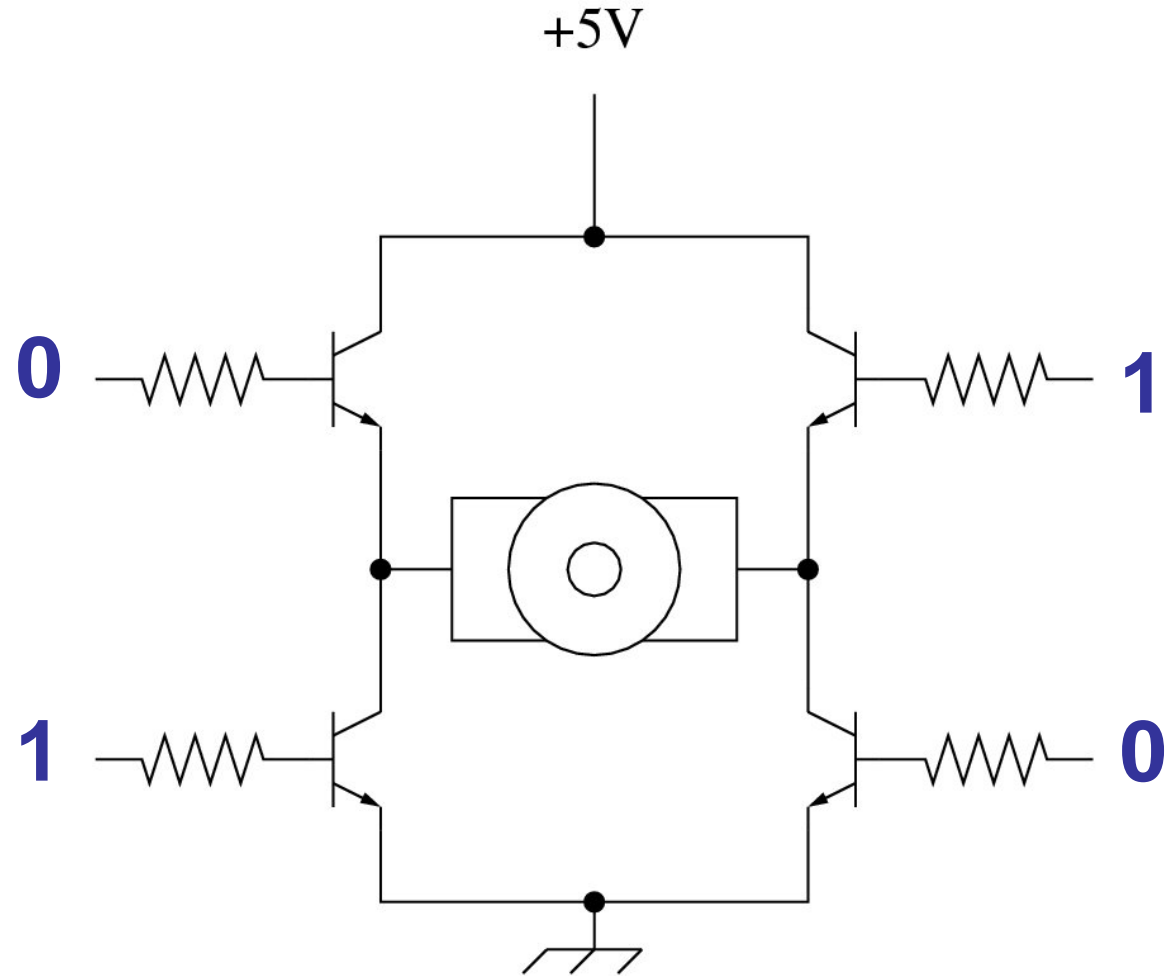
What happens with these inputs?

- Motor turns in one direction



# Simple H-Bridge

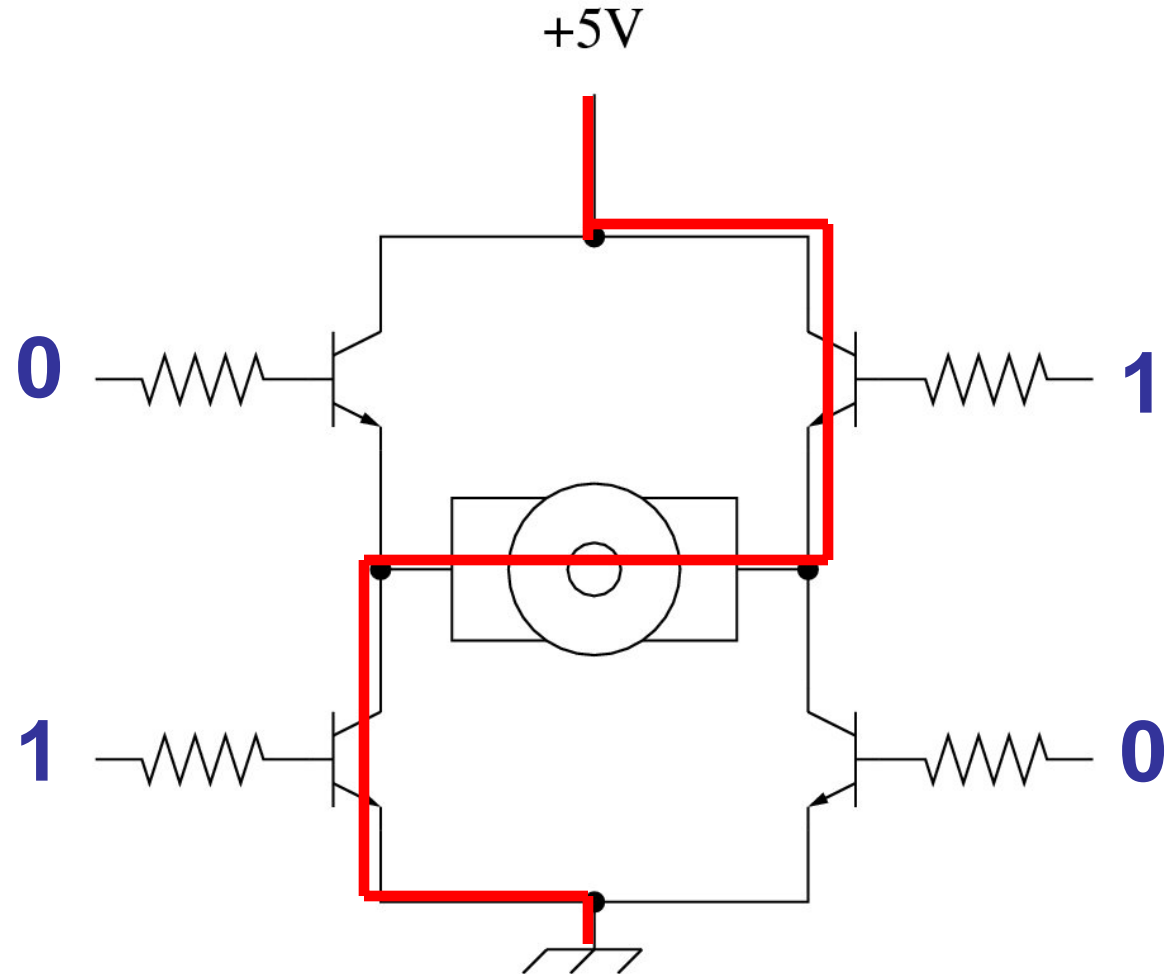
How about  
these  
inputs?



# Simple H-Bridge

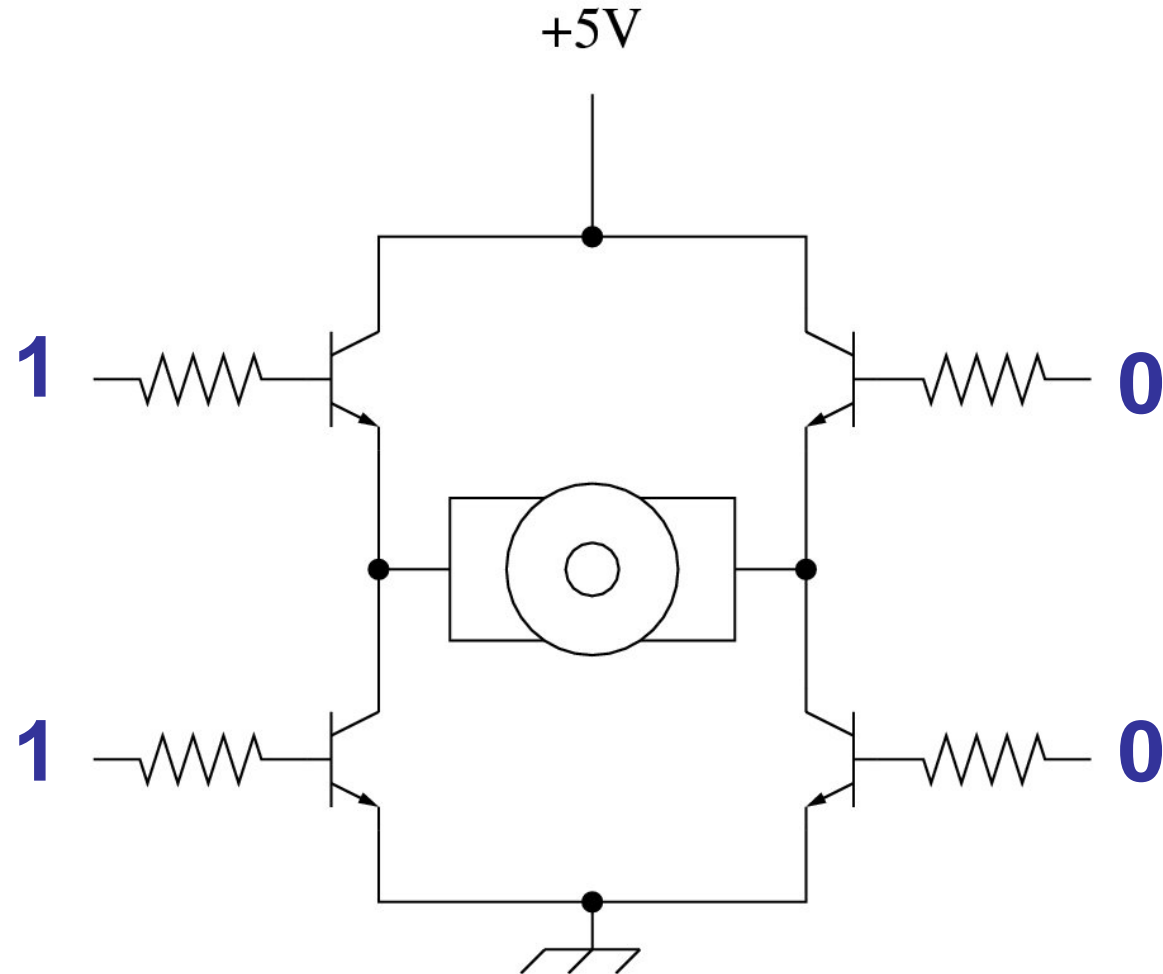
What happens with these inputs?

- Motor turns in the other direction!



# Simple H-Bridge

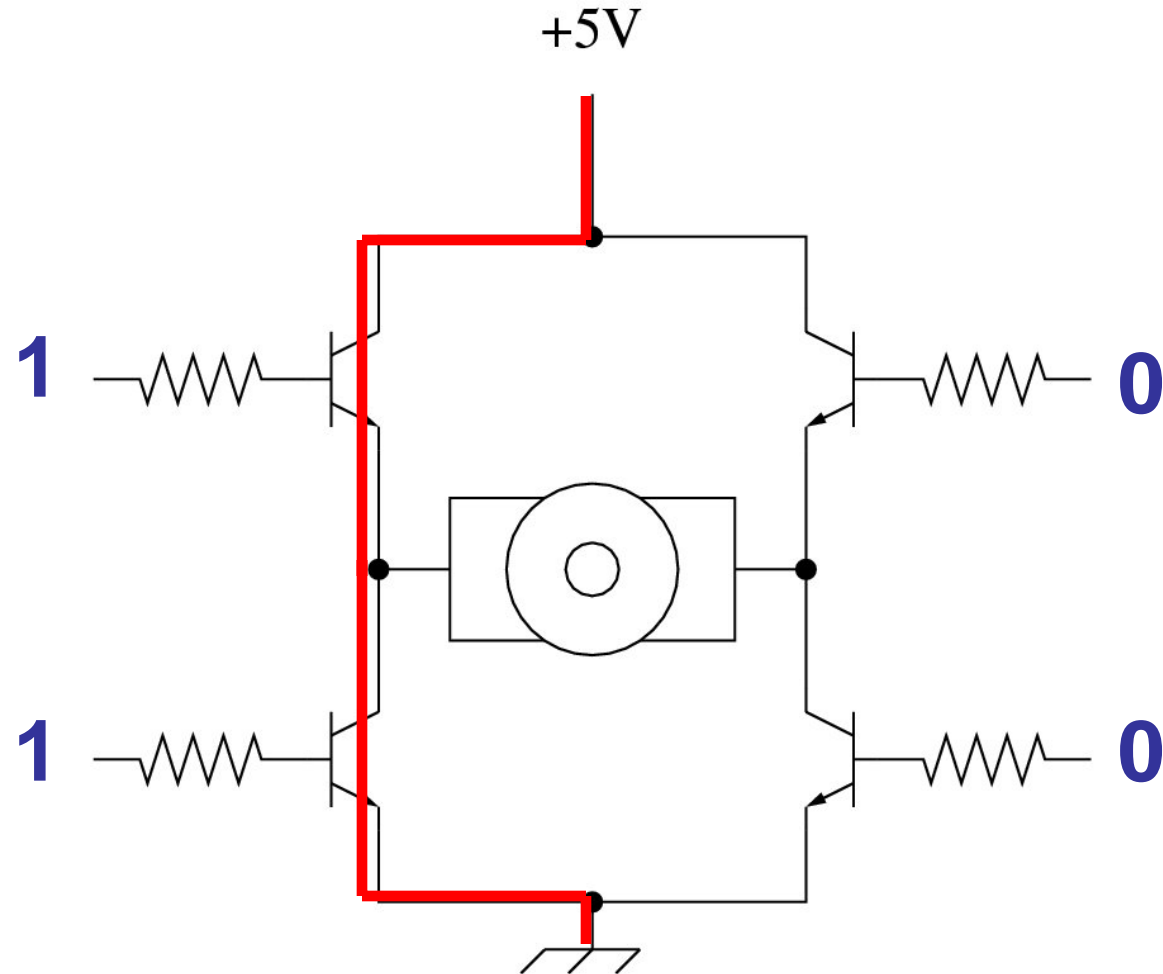
How about  
these  
inputs?



# Simple H-Bridge

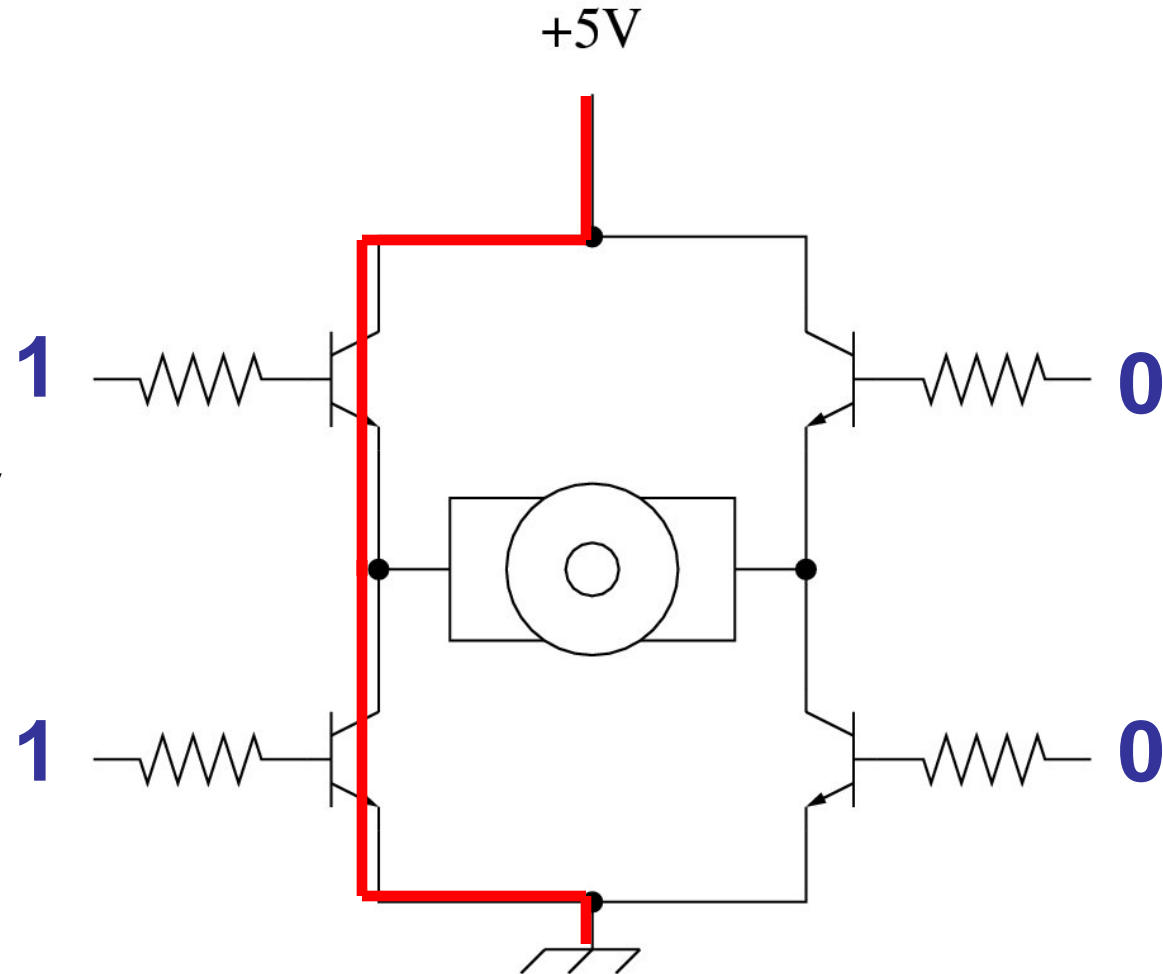
What happens with these inputs?

- We short power to ground
- ... very bad



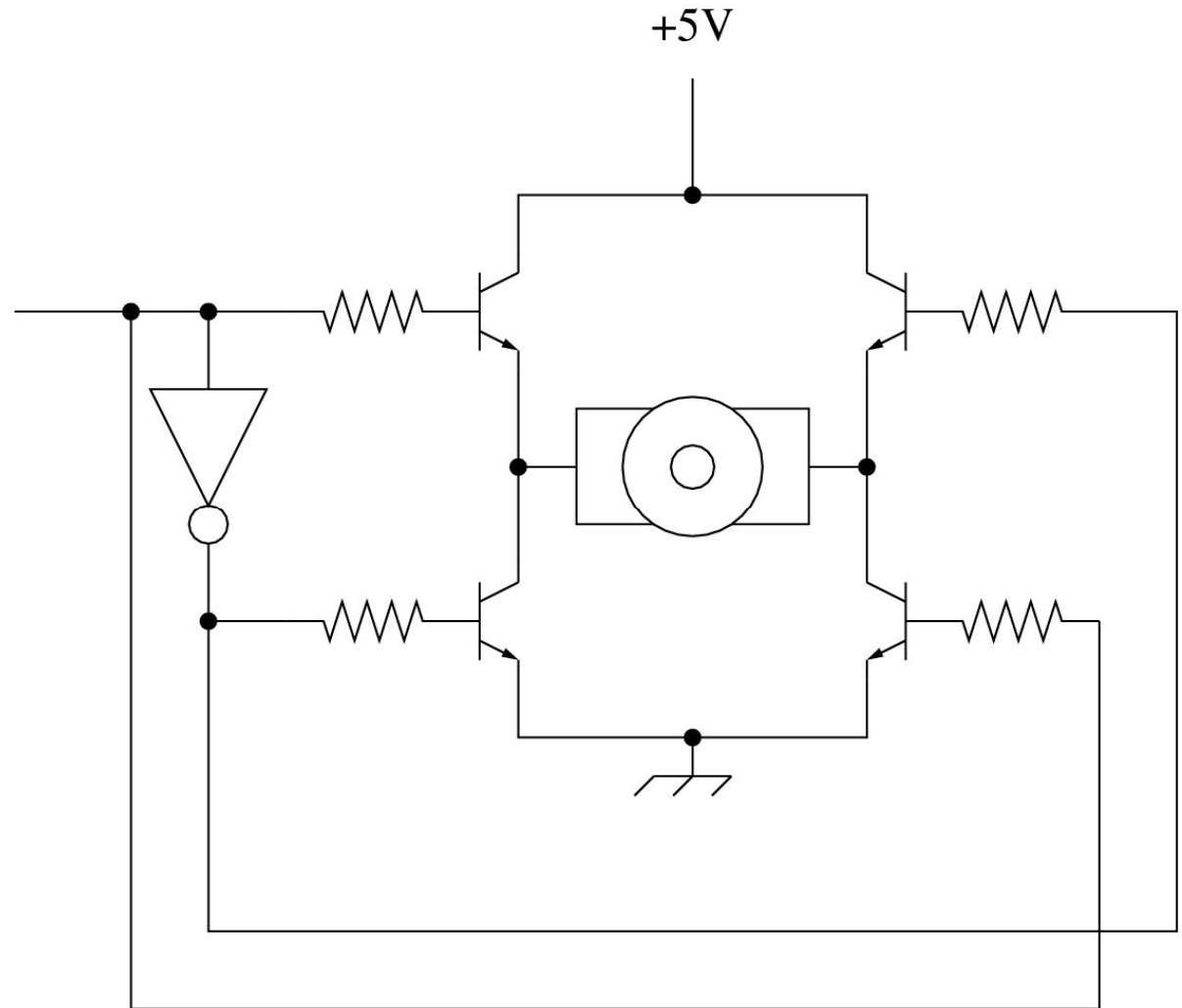
# Simple H-Bridge

How can we prevent a processor from accidentally producing this case?



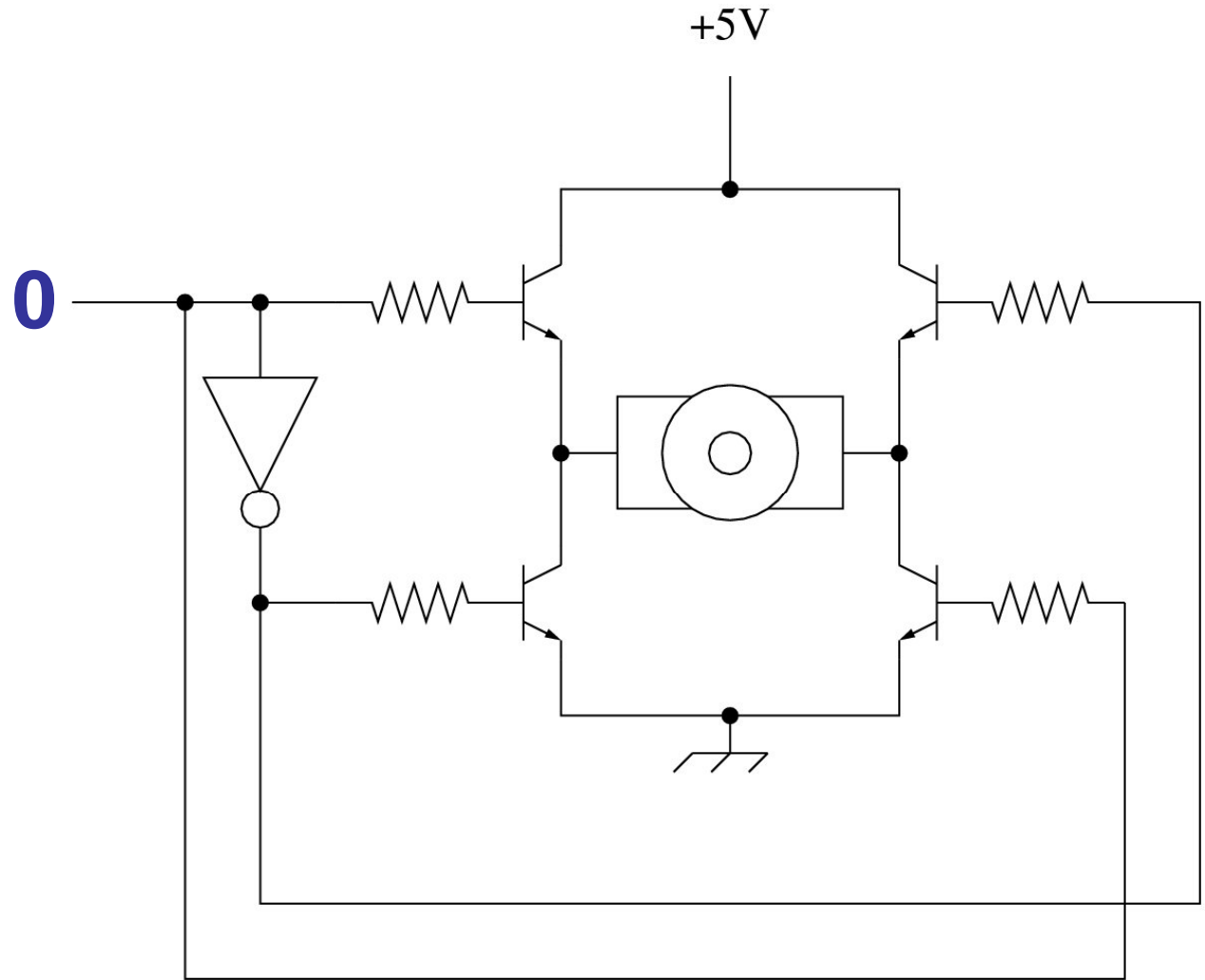
# Modified H-Bridge

We introduce a little logic to ensure the short never occurs



# Modified H-Bridge

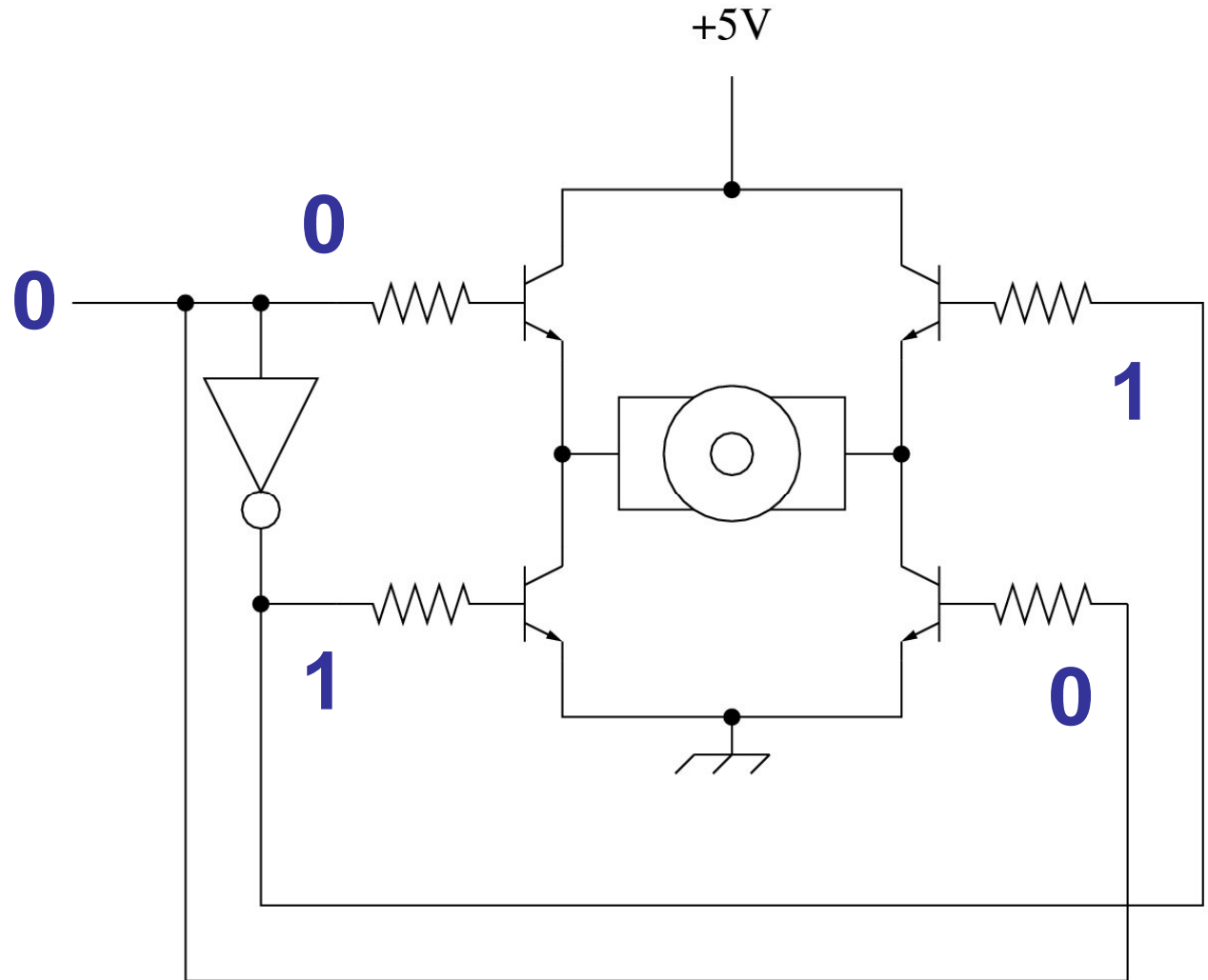
What happens  
with this  
input?





# Modified H-Bridge

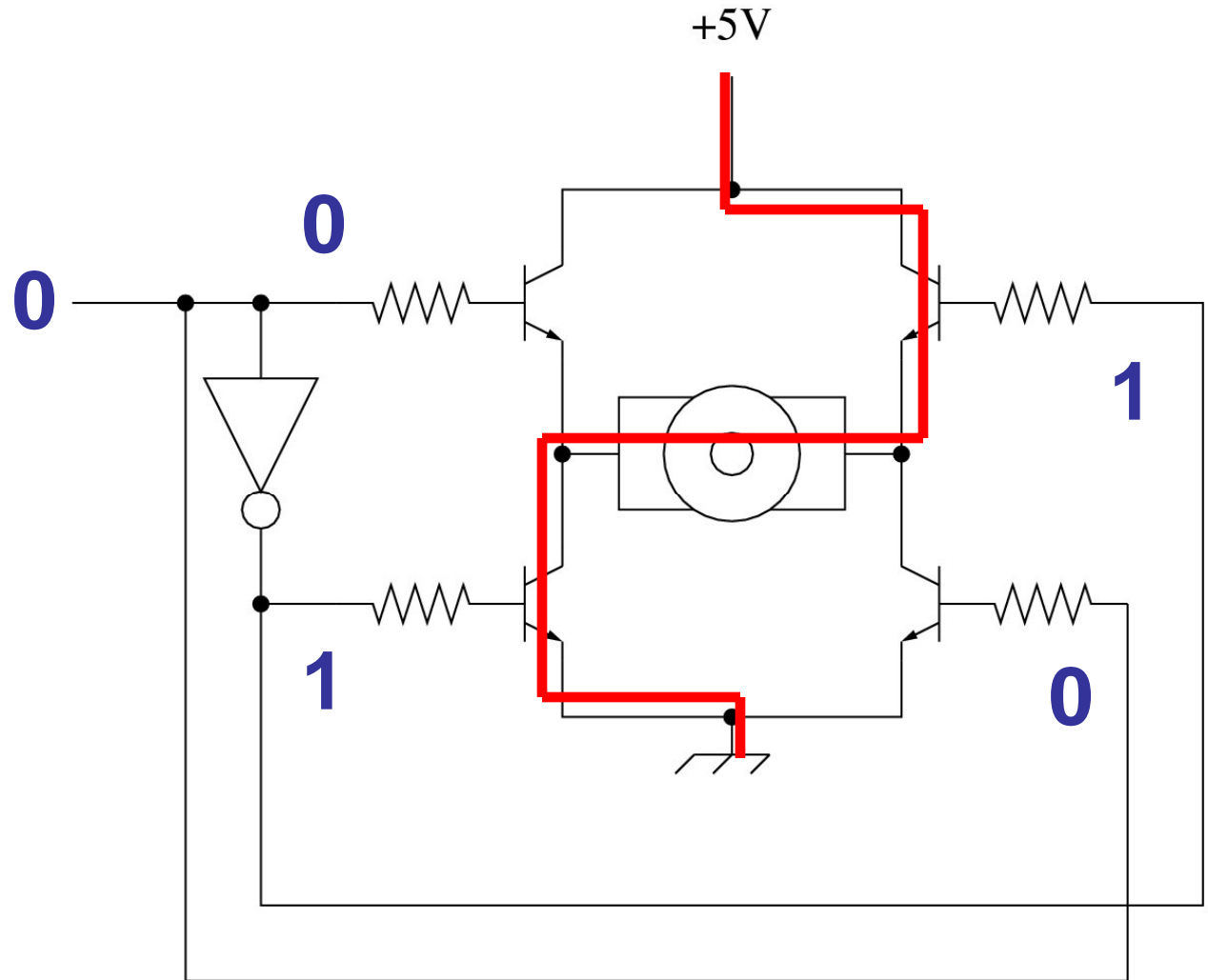
What happens  
with this  
input?



# Modified H-Bridge

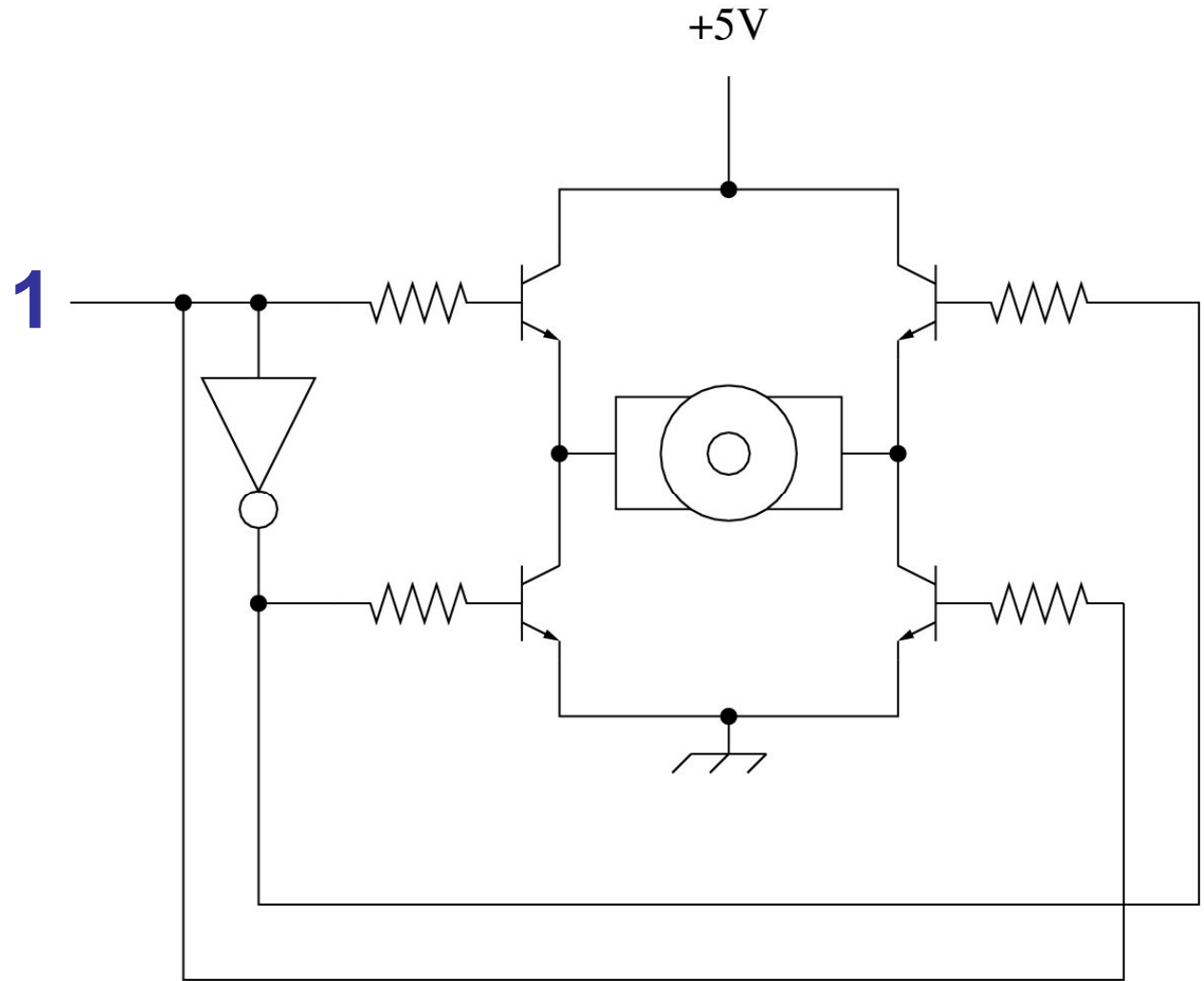
What happens with this input?

- Motor turns in one direction



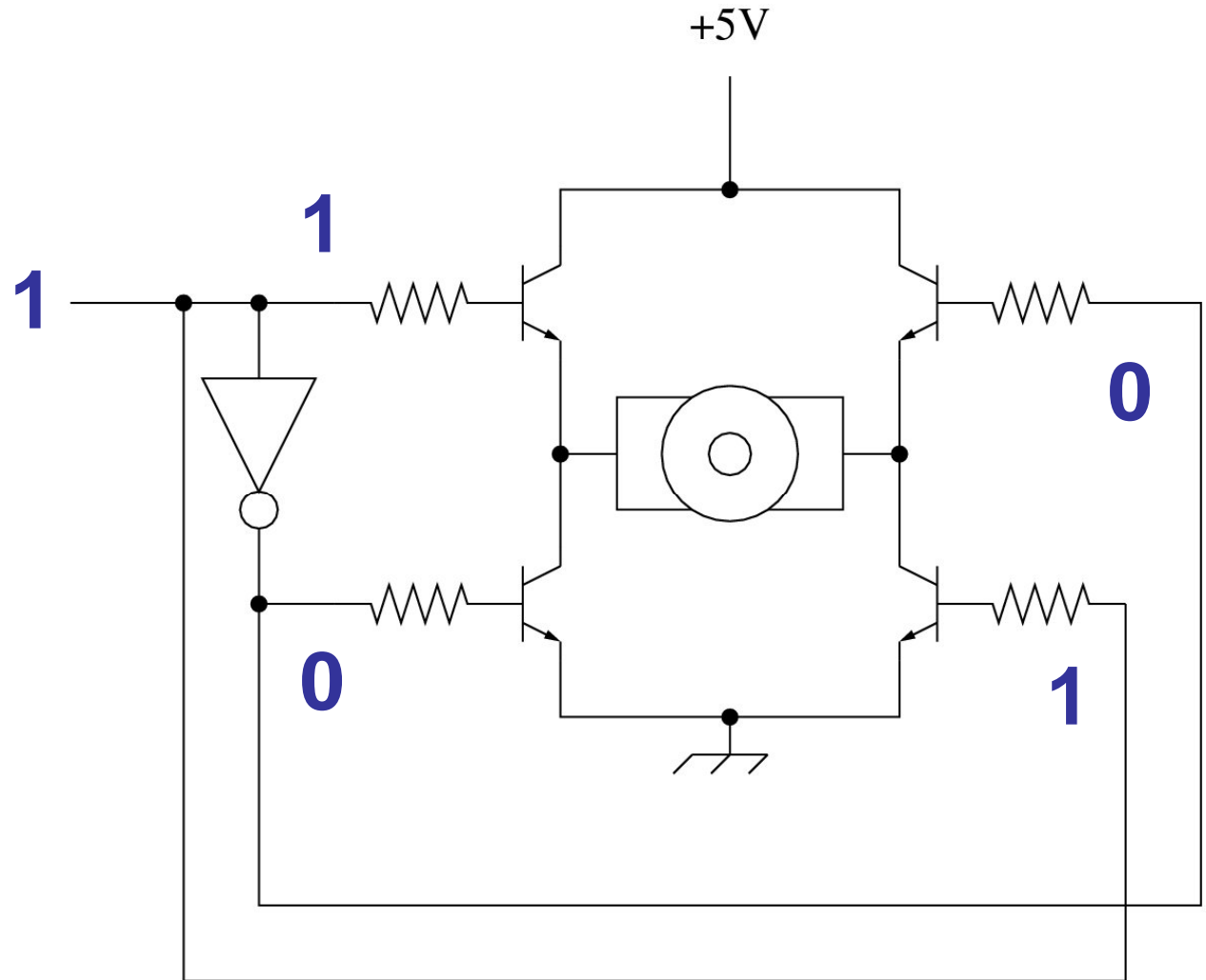
# Modified H-Bridge

How about this  
input?



# Modified H-Bridge

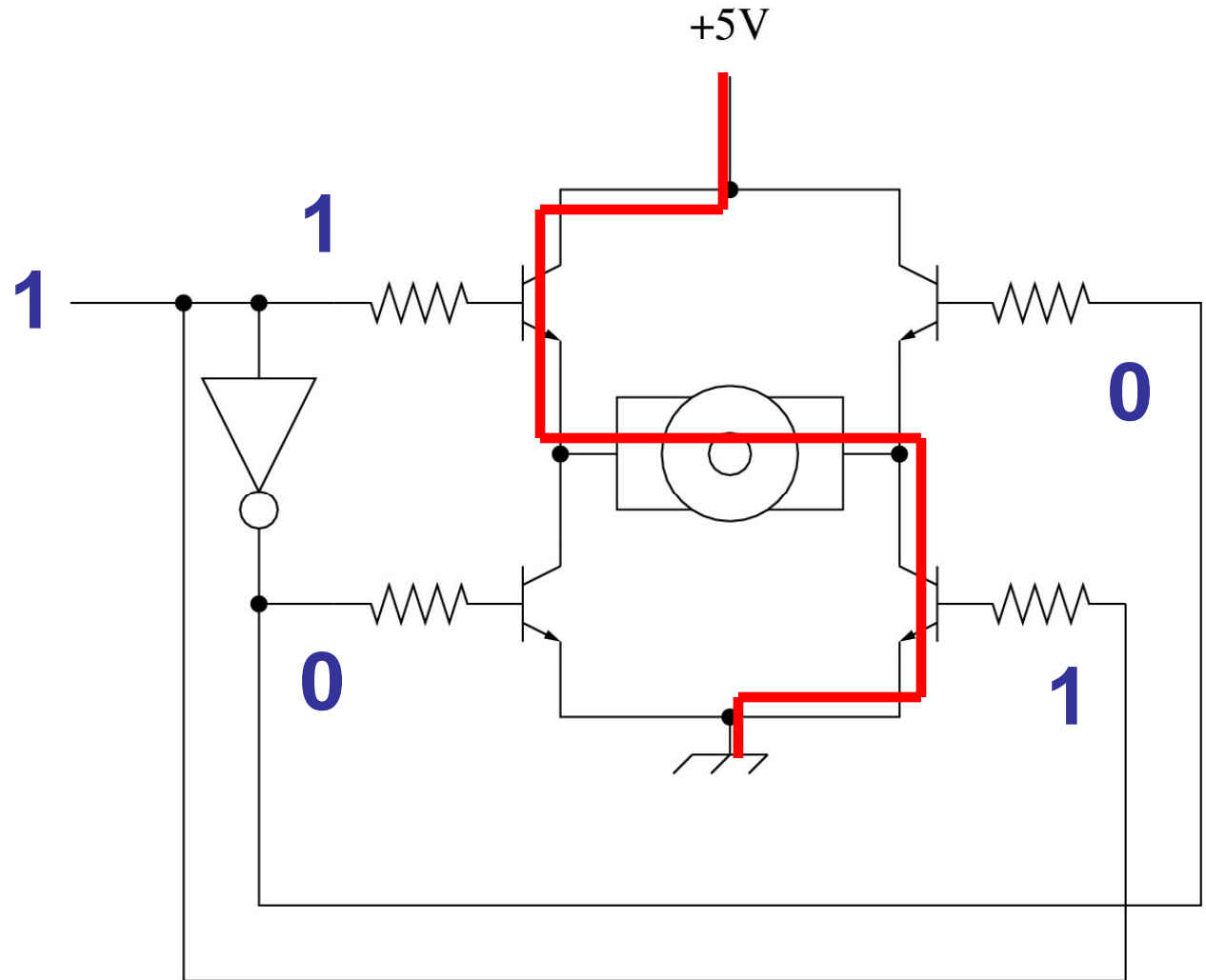
What happens  
with this  
input?



# Modified H-Bridge

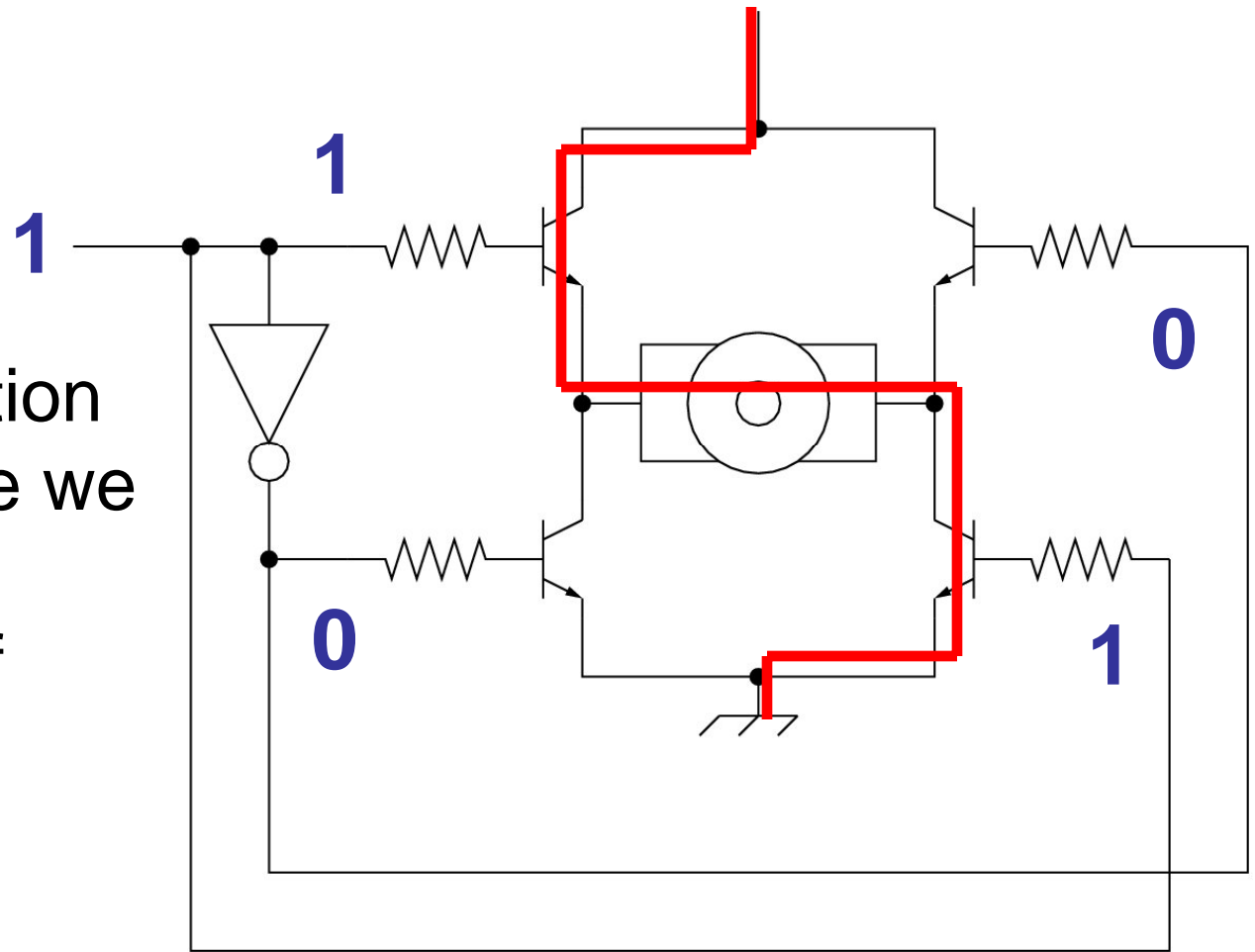
How about this input?

- Motor turns in the other direction



# Modified H-Bridge

+5V



This implementation is nice because we only need one **direction** bit of control

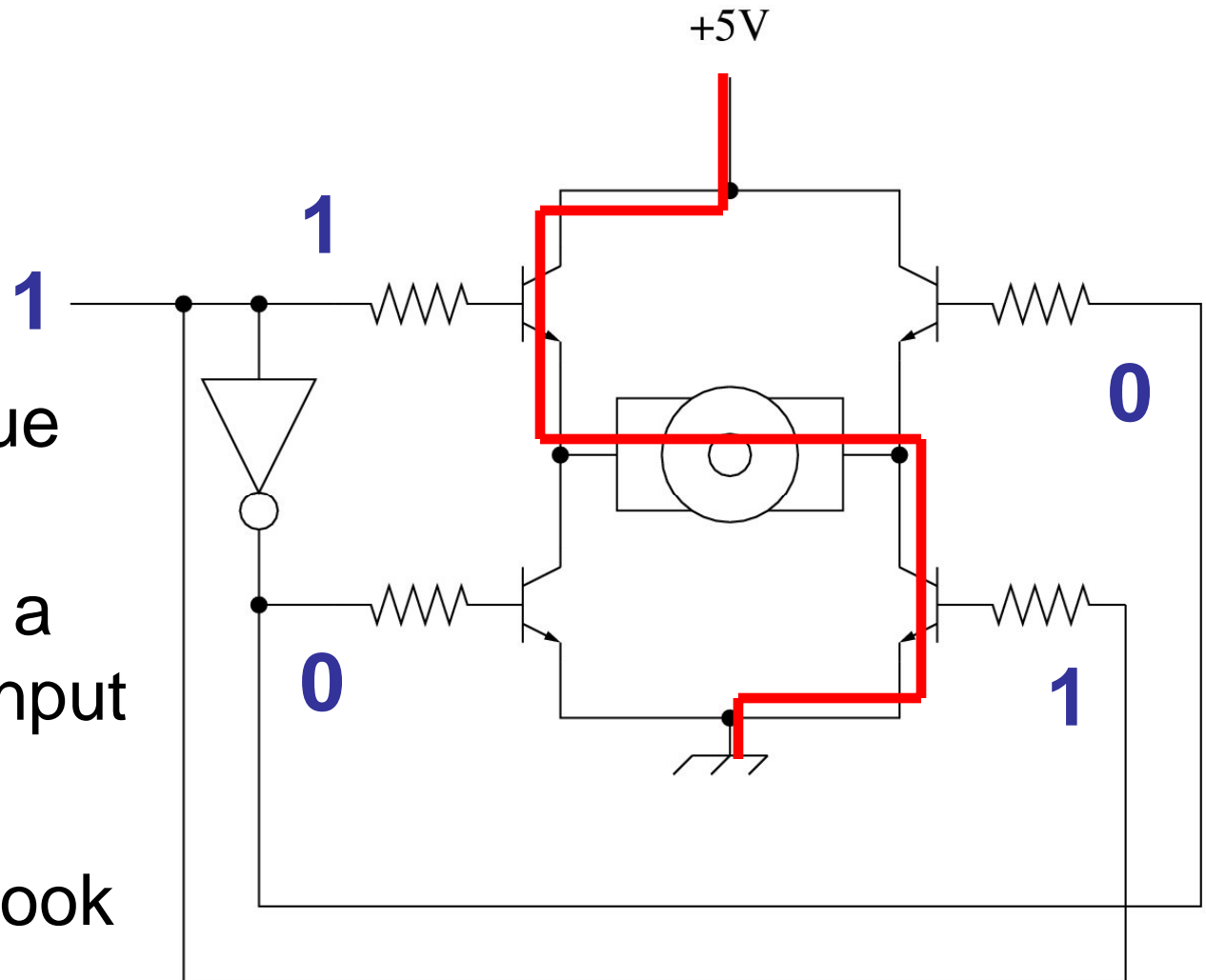
- What are we missing?

# Modified H-Bridge

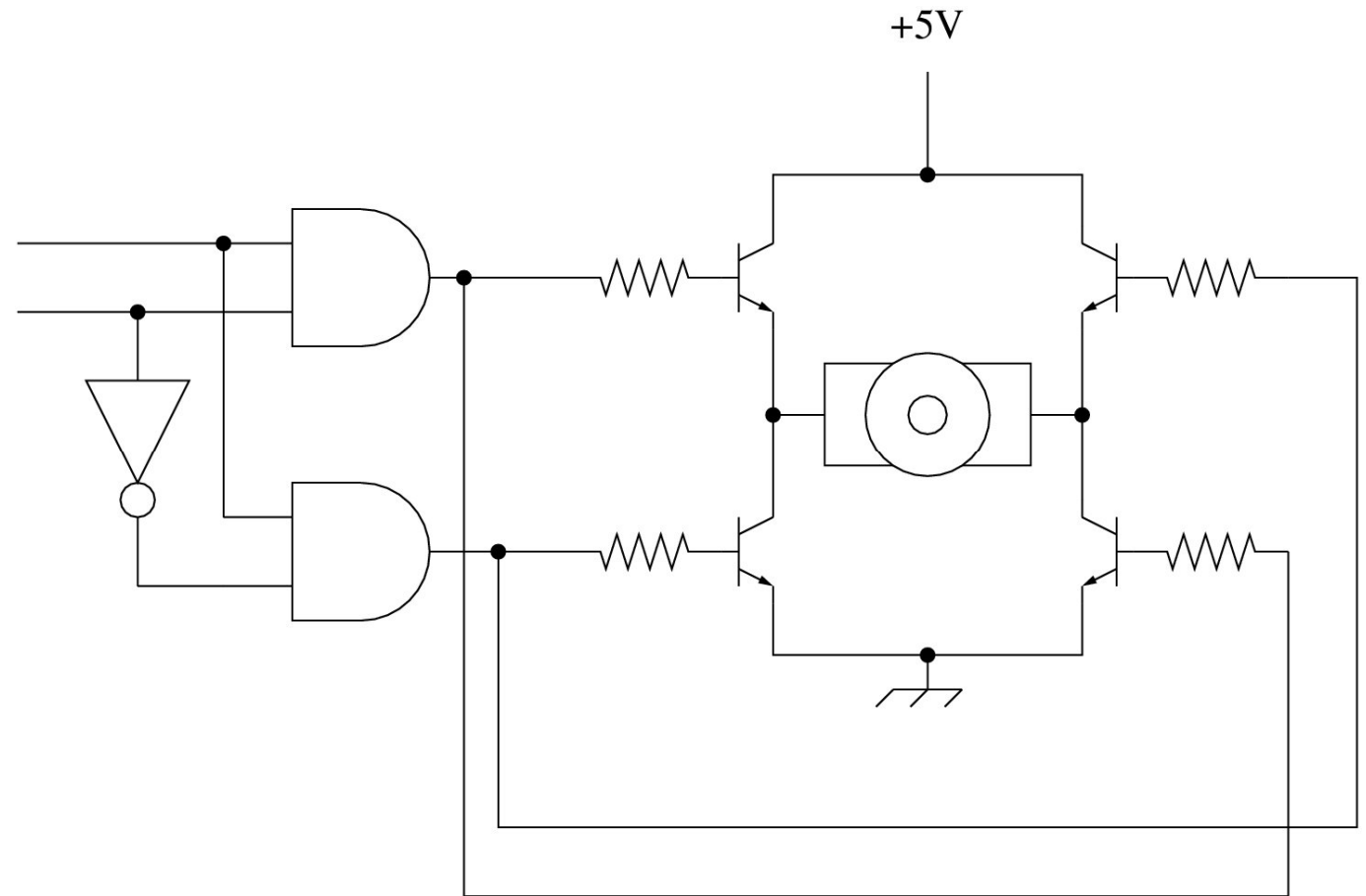
What are we missing?

- Control of torque magnitude
- Let's introduce a second PWM input

What would this look like?



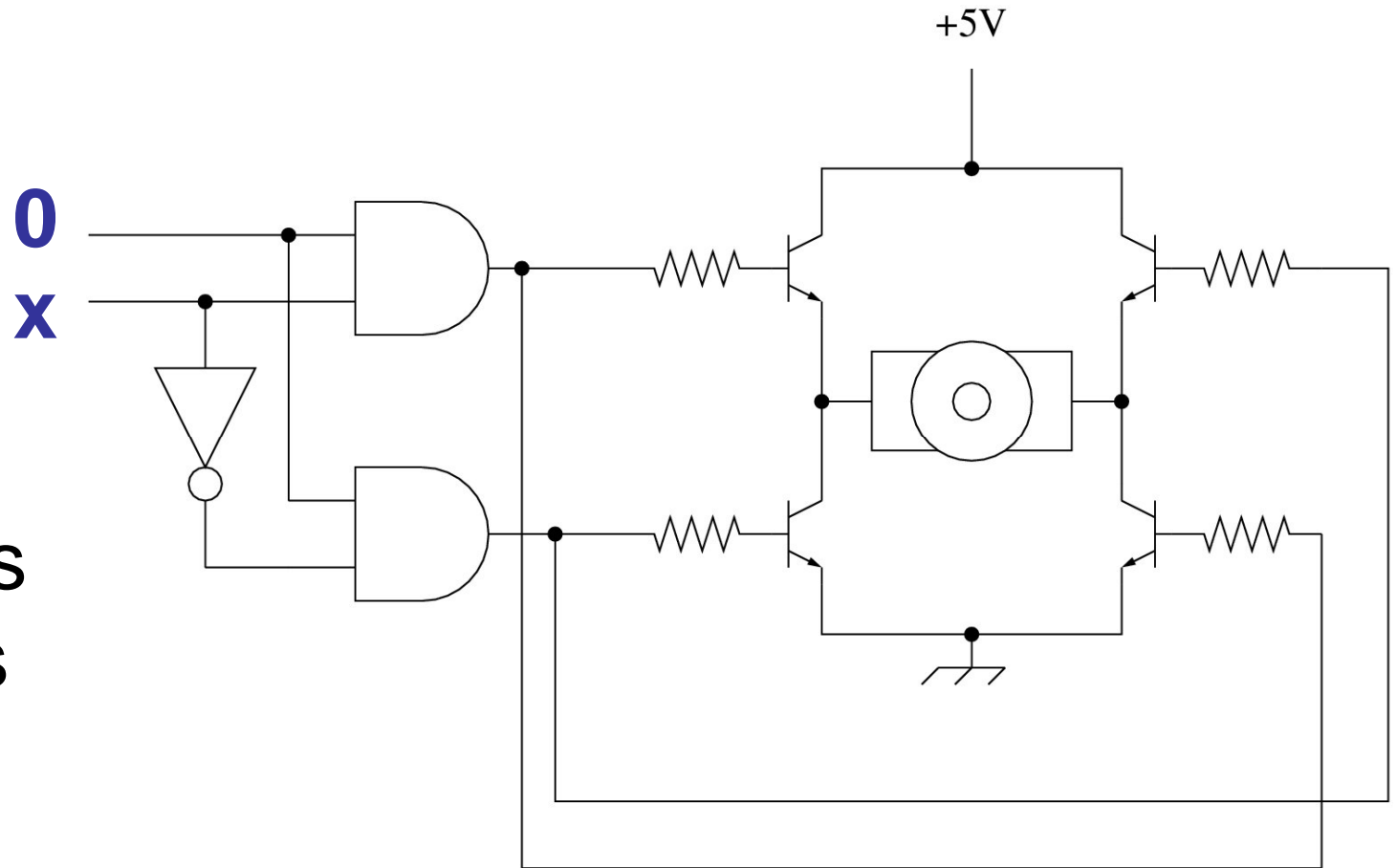
# PWM and Direction Control





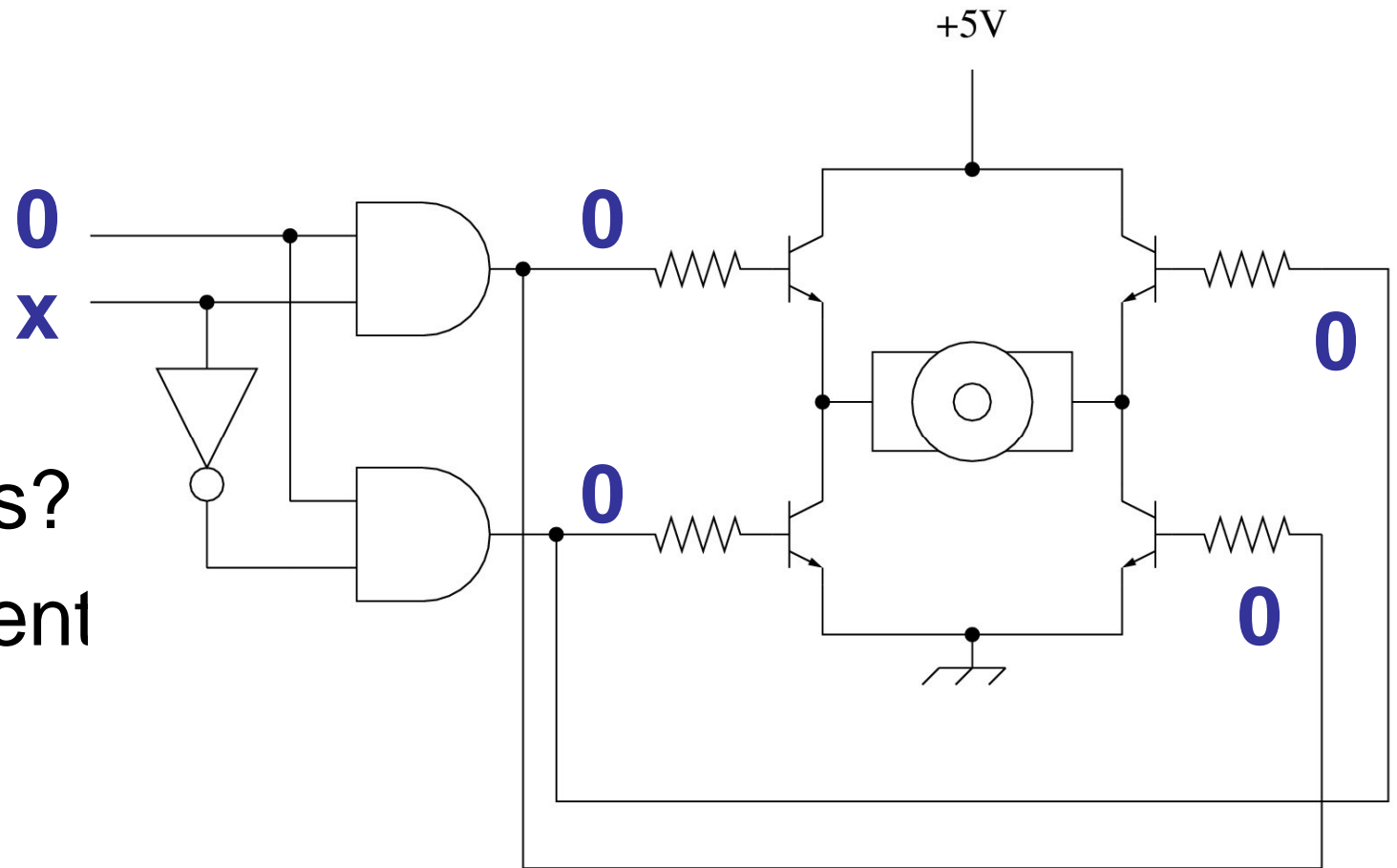
# PWM and Direction Control

What happens with this input?



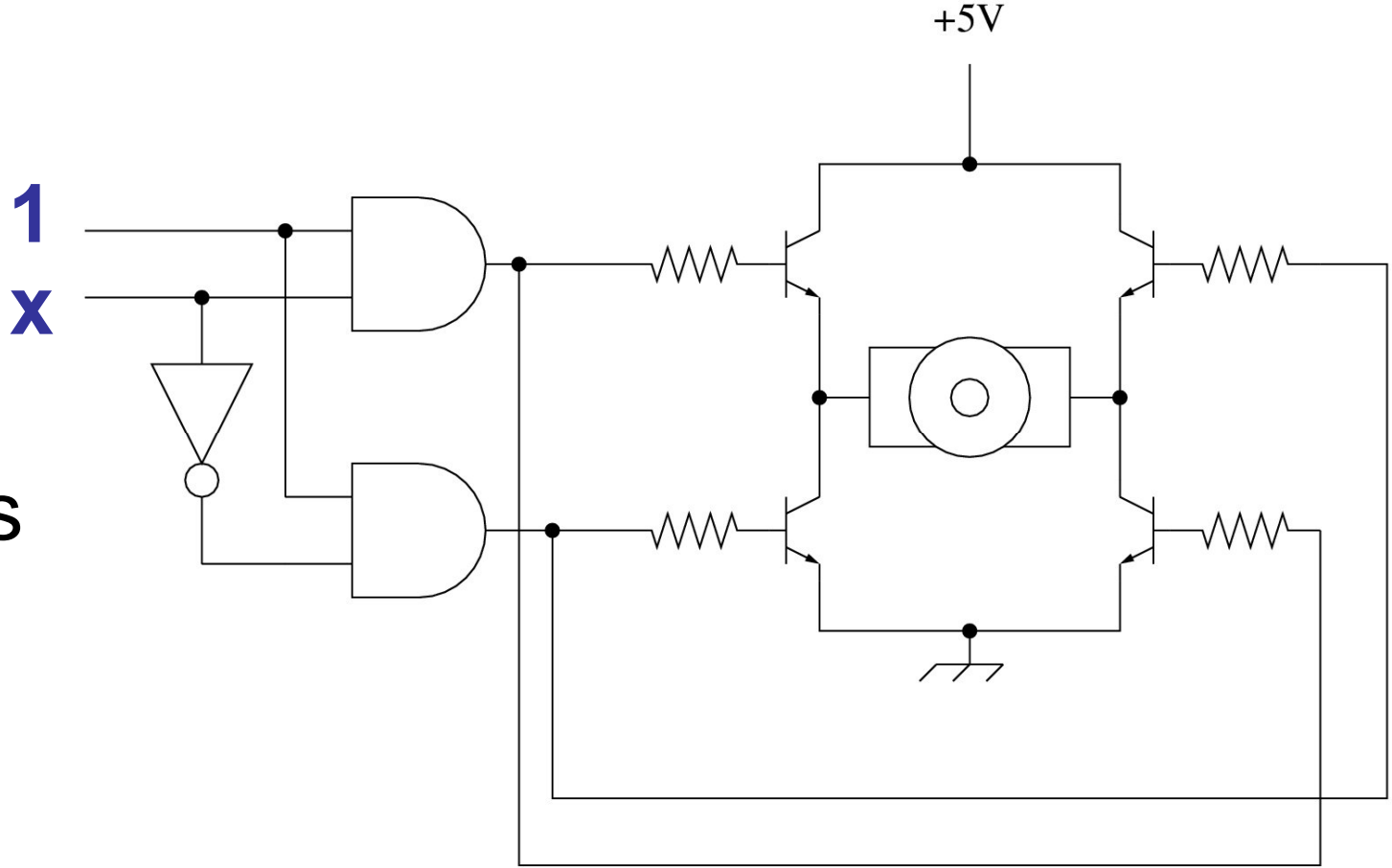
# PWM and Direction Control

- What happens?
- No current flow



# PWM and Direction Control

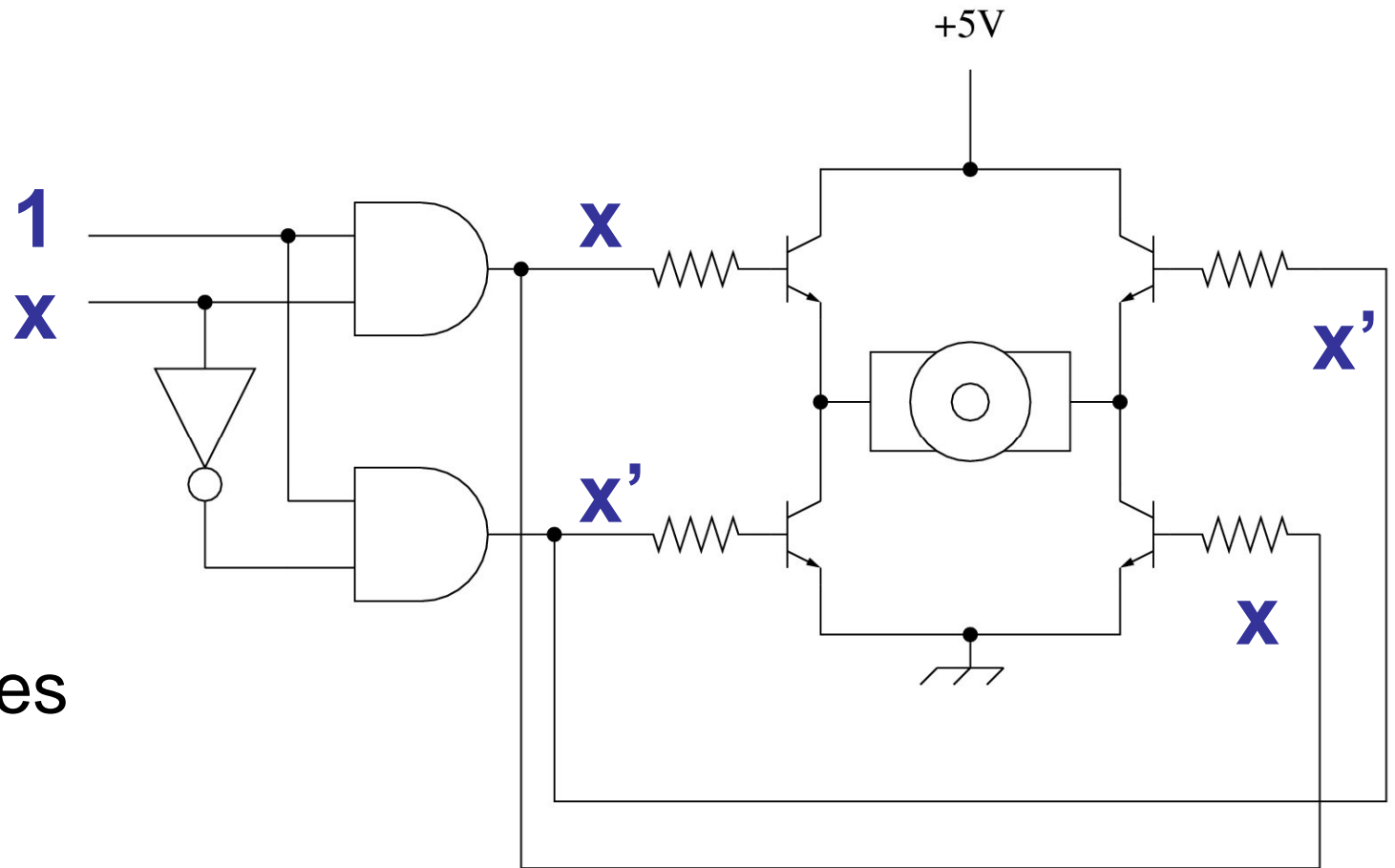
What happens now?



# PWM and Direction Control

What happens now?

- 'x' determines motor direction



# PWM and Direction Control



**Direction**

With the  
PWM input,  
we can  
control the  
magnitude  
of torque

