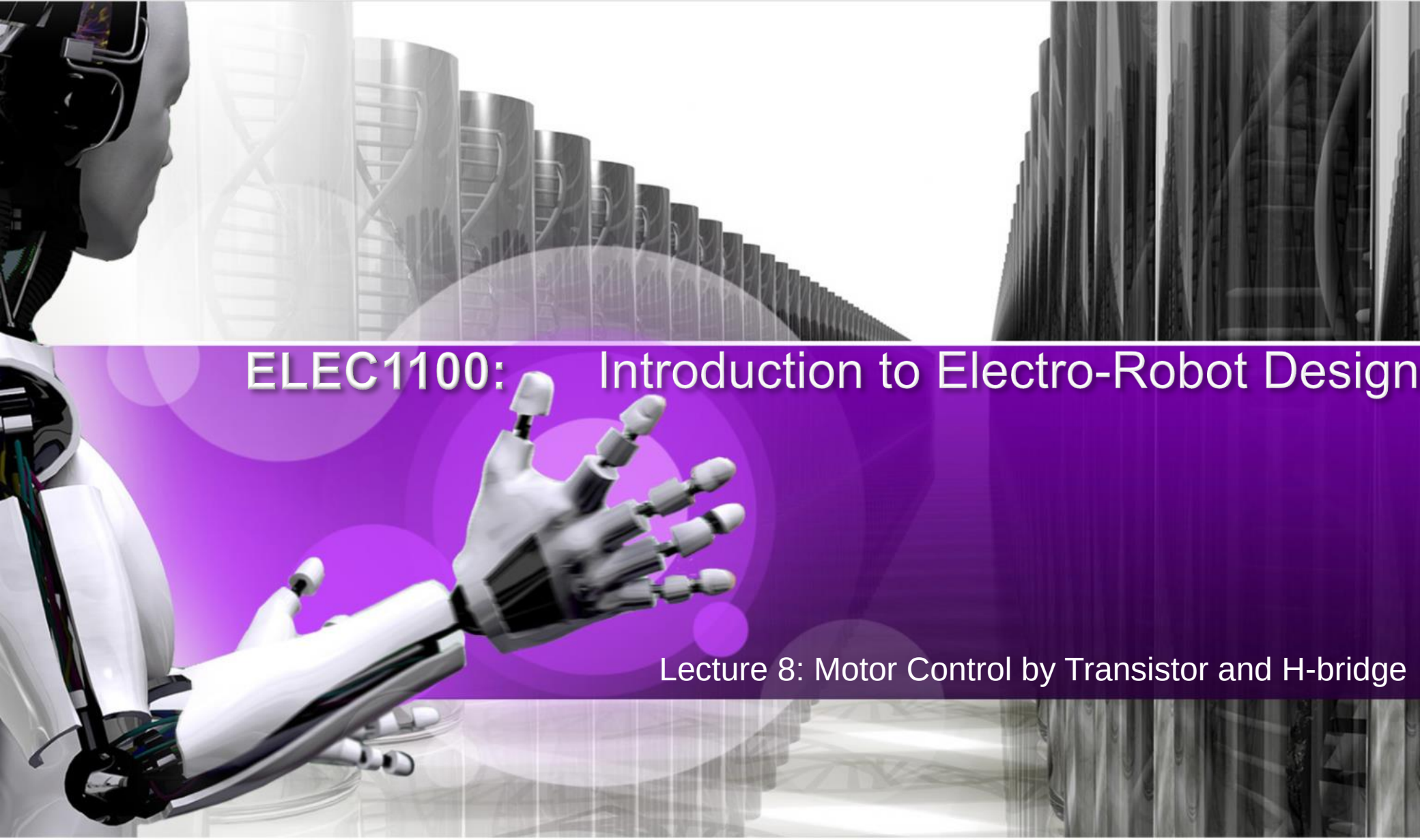
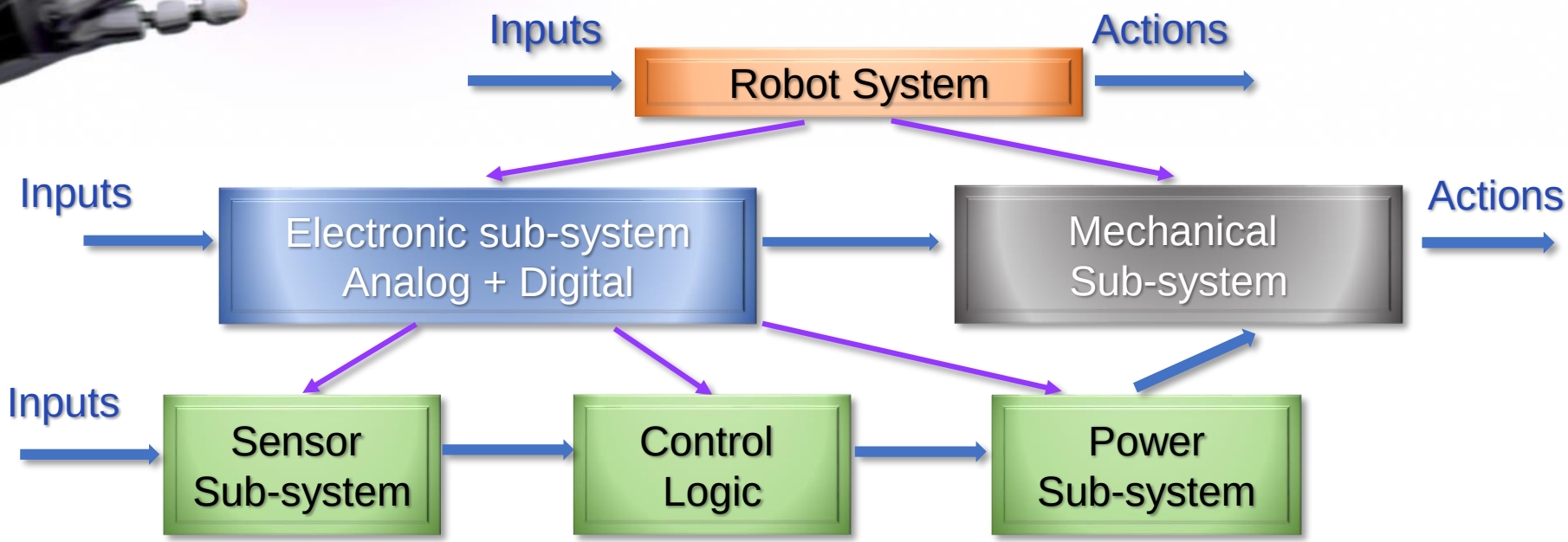


ELEC1100: Introduction to Electro-Robot Design

Lecture 8: Motor Control by Transistor and H-bridge

SONG Shenghui and MURCH Ross, Dept. of ECE, HKUST

ELEC1100 ROADMAP



Basic electronics:

Wk1: Basic Electronics - Charge/Current/Voltage/Resistor

Wk2: Energy/Power and DC Sources

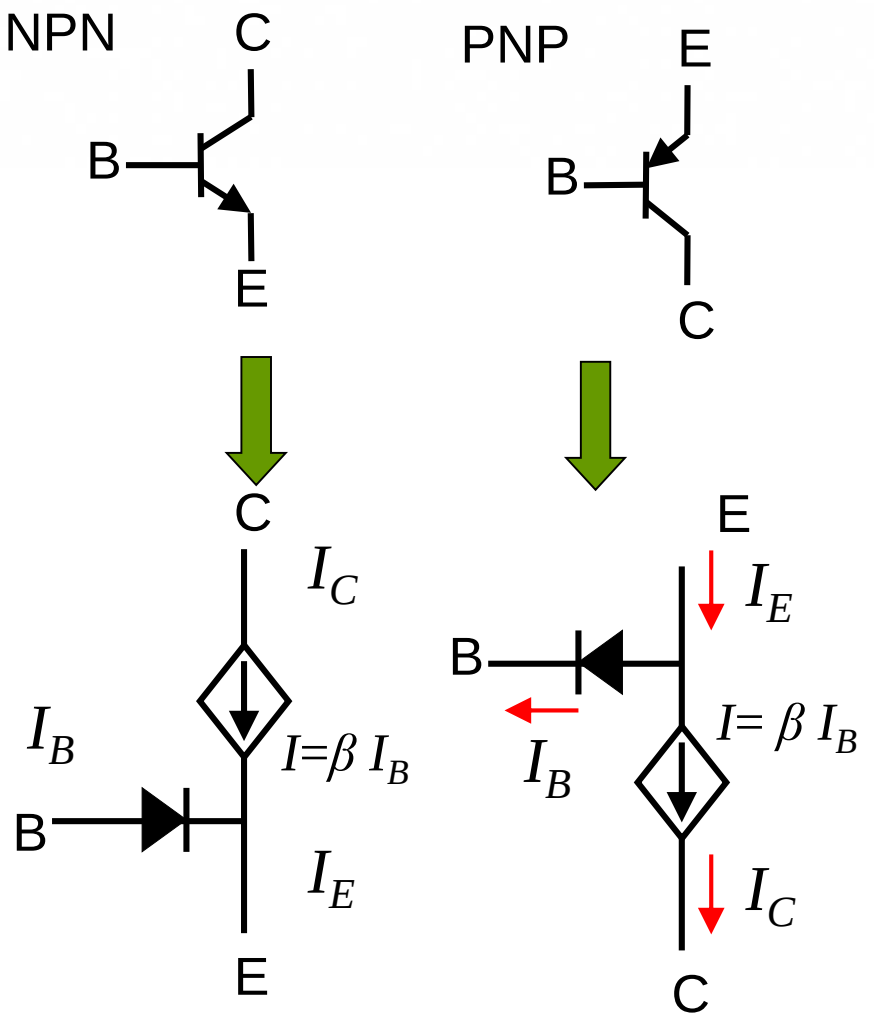
Motor Power Supply:

Wk3: Pulse Signal and PWM Control

Wk4: Transistor and H-Bridge

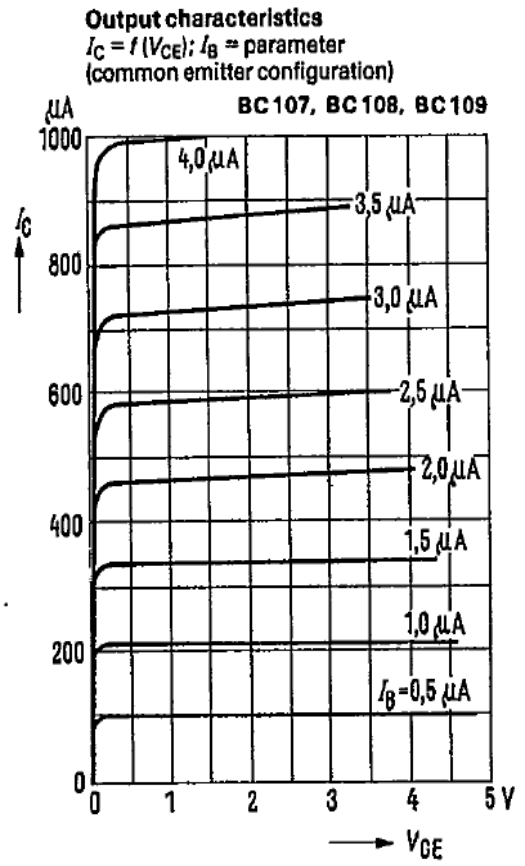
LAST LECTURE

- NPN and PNP transistors and their equivalent circuit
- Calculating diode current by assuming it is either a battery or an open circuit
- Transistors can be used as a switch or an amplifier

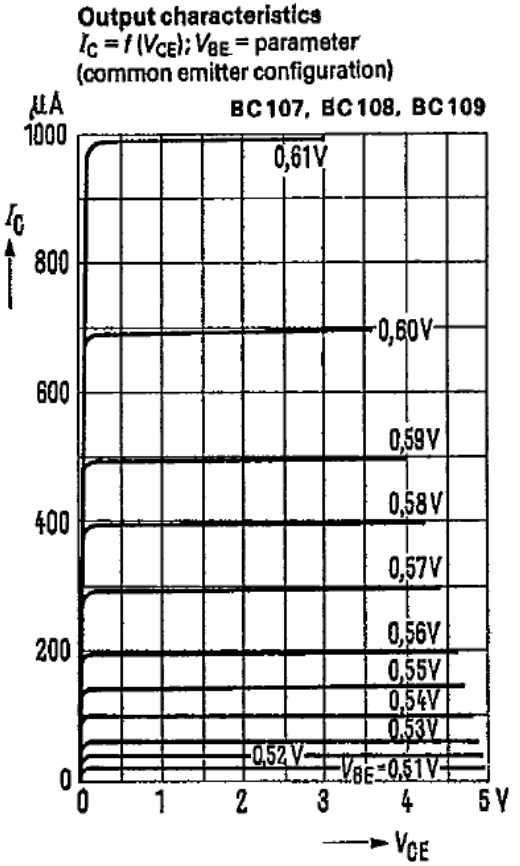


SPECIFICATION OF BJT CHARACTERISTICS

- I_C is more or less proportional to base current
- I_C is non-linearly dependent on V_{BE} and very sensitive to it
- As a result, current control is more easy to perform



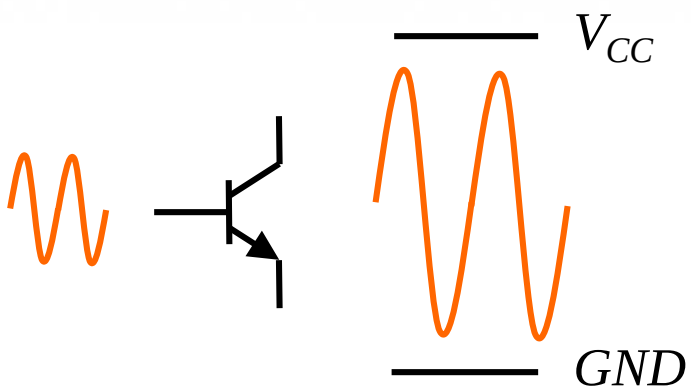
Current Control



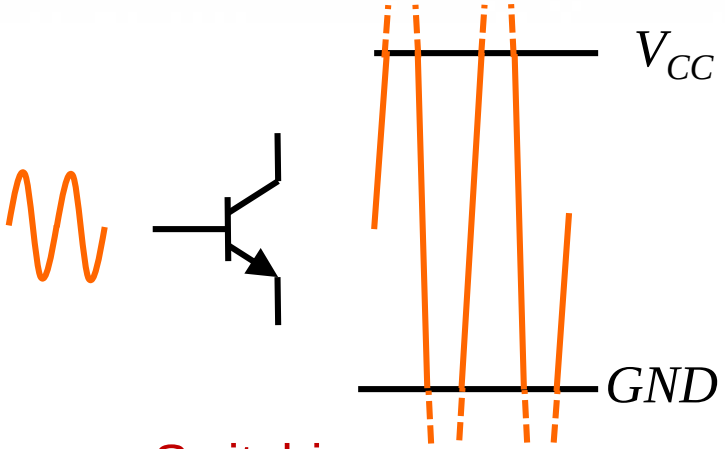
Voltage Control

SWITCH VERSUS AMPLIFIER

- Consider an AC signal input to an amplifier with different gain



Amplification



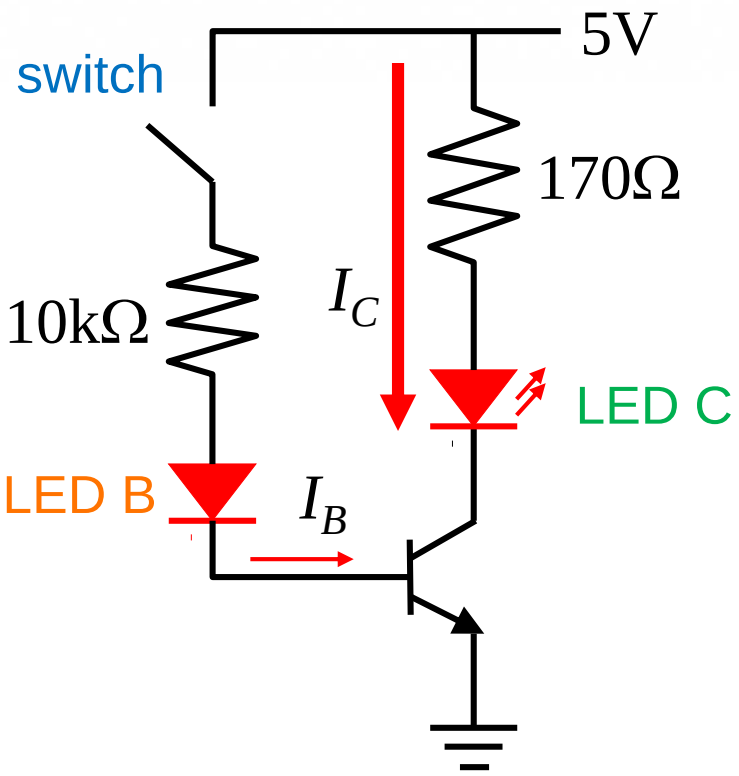
Switching

- For large input signal, an amplifier becomes a switch
- Many applications like audio and sensor signal processing require a transistor to operate in the amplification mode

EXAMPLE OF BJT CIRCUIT

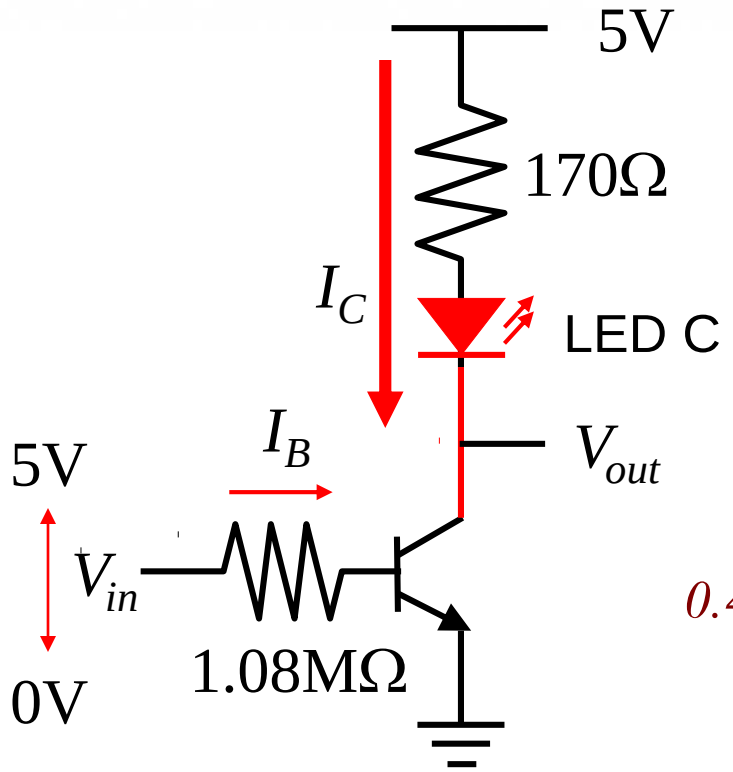
- When the switch is open, there is no collector current
- When the switch is closed, a small current flows into the base of the transistor, which is just enough to make the LED B glow dimly
- The transistor amplifies this small current to allow a large current to flow from its collector to its emitter that makes LED C to light brightly

➢ Question: what is the maximum possible collector current?



MAXIMUM AND ACTUAL COLLECTOR CURRENT

- Consider the following circuit, given the current gain $\beta = 100$



$$I_{Cmax} \approx \frac{5V - 0.7V}{170\Omega} = 25mA$$

$$I_B \approx \frac{V_{in} - 0.7V}{1.08M\Omega}$$

with V_{in}=5V

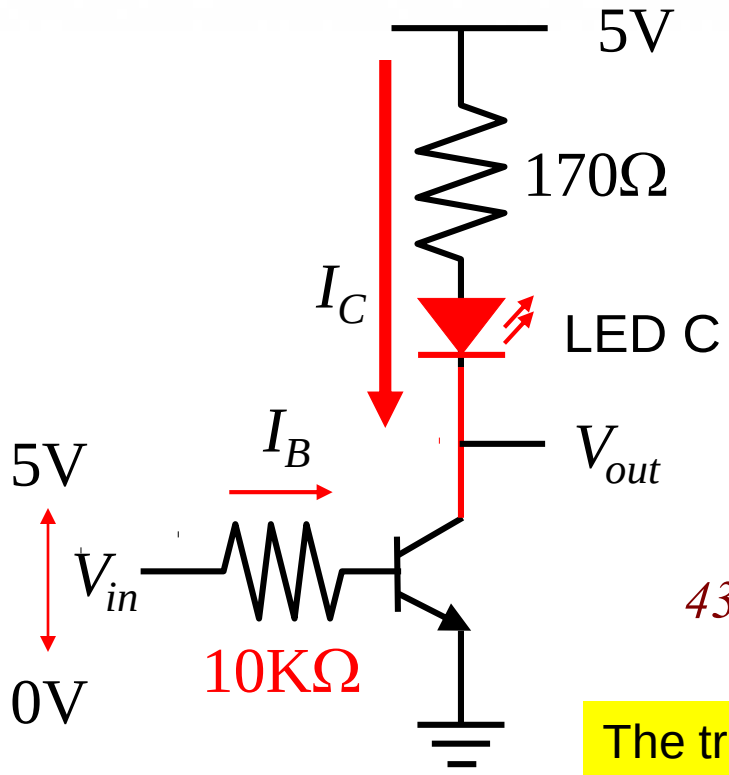
$$I_B \approx \frac{5V - 0.7V}{1.08M\Omega} = 4\mu A$$

$$I_C = \beta I_B = 0.4mA$$

$0.4mA < 25mA$, I_C is possible

AT HIGH BASE CURRENT

- Change $R_B = 10\text{K}\Omega$, given the current gain $\beta = 100$



$$I_{Cmax} \approx \frac{5V - 0.7V}{170\Omega} = 25mA$$

$$I_B \approx \frac{V_{in} - 0.7V}{10k\Omega}$$

with V_{in}=5V

$$I_B \approx \frac{5V - 0.7V}{10k\Omega} = 0.43mA$$

$$I_C = \beta I_B = 43mA$$

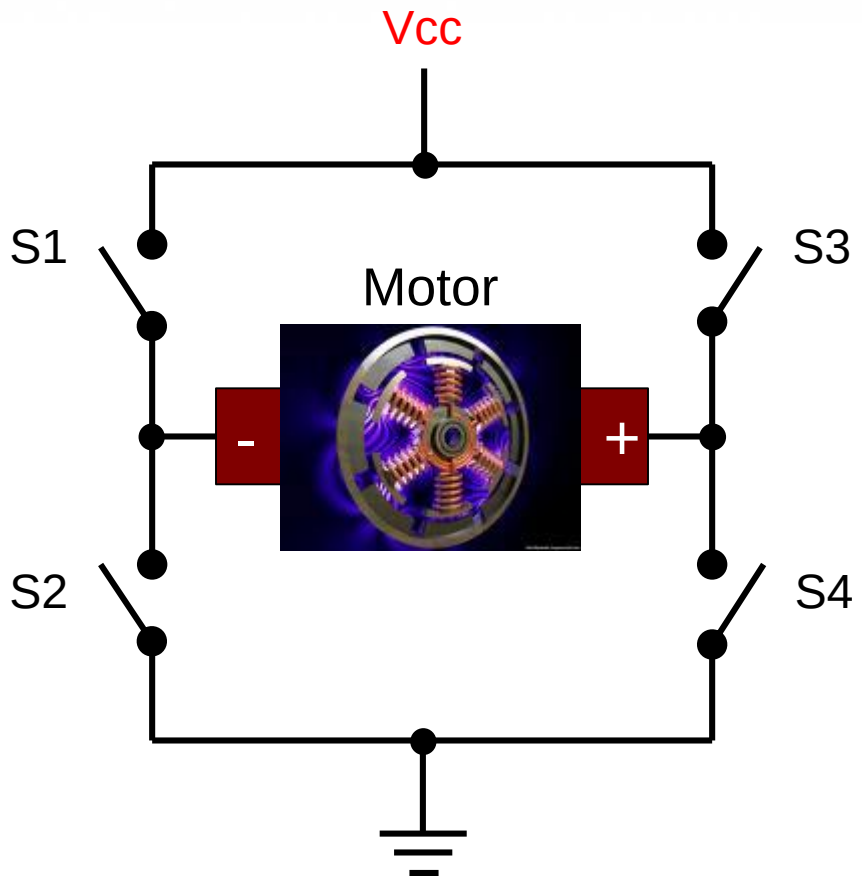
43mA > 25mA, NOT possible

The transistor is saturated (fully on)

The transistor behaviors as a **switch (off/on)**

H-BRIDGE CIRCUIT (SWITCHES)

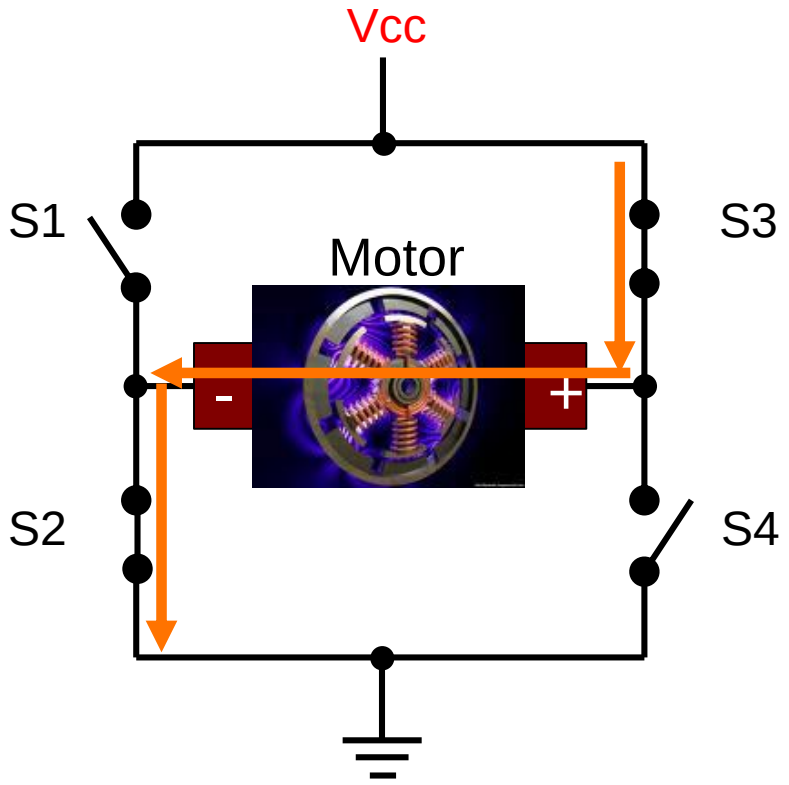
- It is a simple circuit that lets you control a motor to go backward or forward.



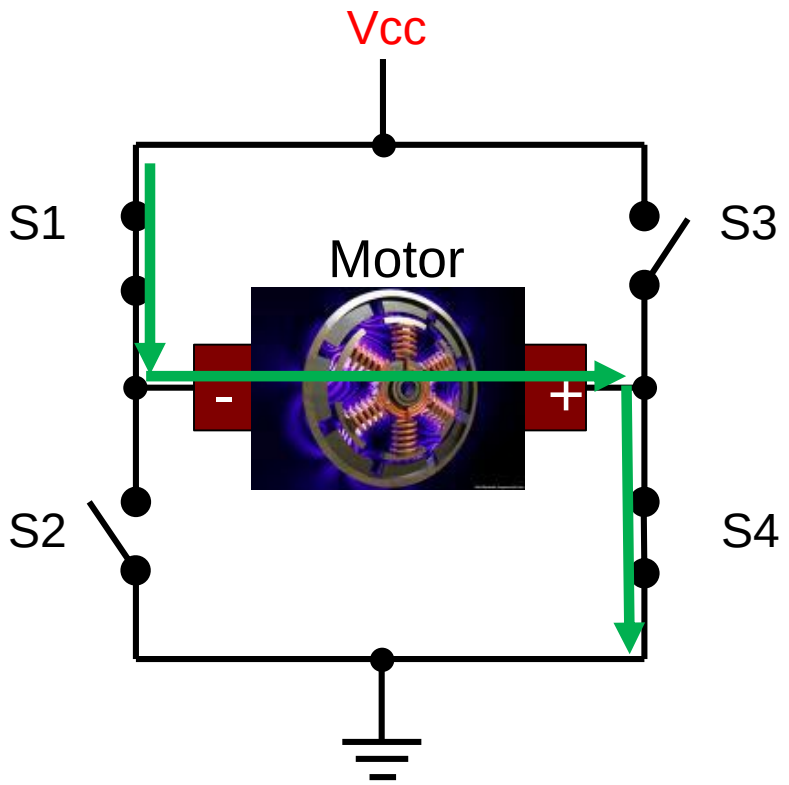
H-BRIDGE CIRCUIT DIRECTION CONTROL

- The motor spins either backward or forward, depending on how you connect its positive (+) and negative (-) terminals.

- Close S2 and S3 (one direction)



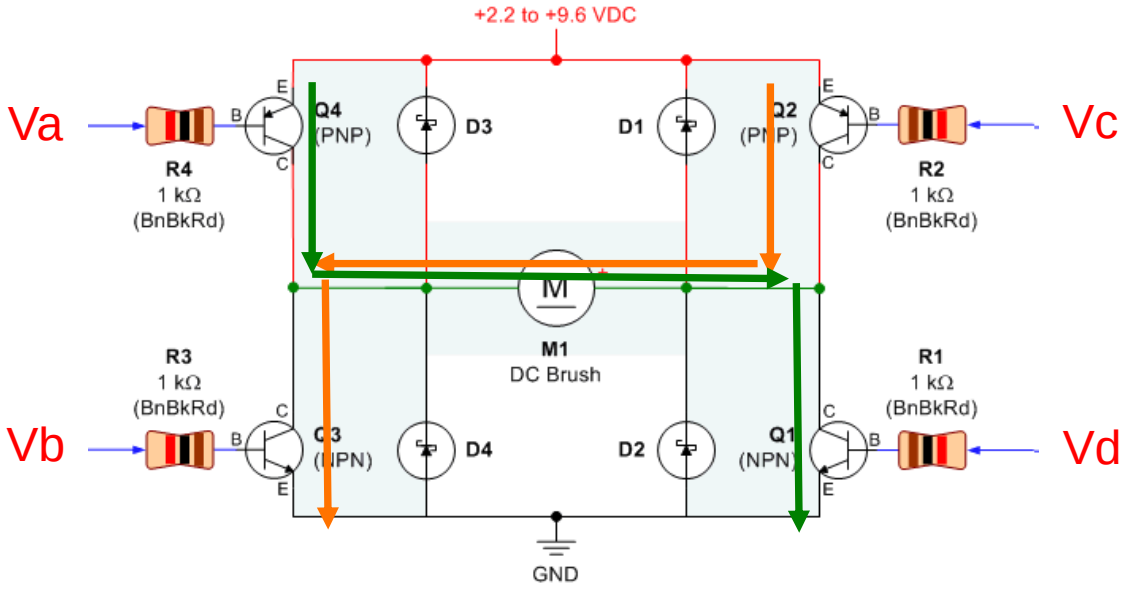
- Close S1 and S4 (opposite direction)



H-BRIDGE OPERATION SUMMARY

- Build H-bridge with four transistors.

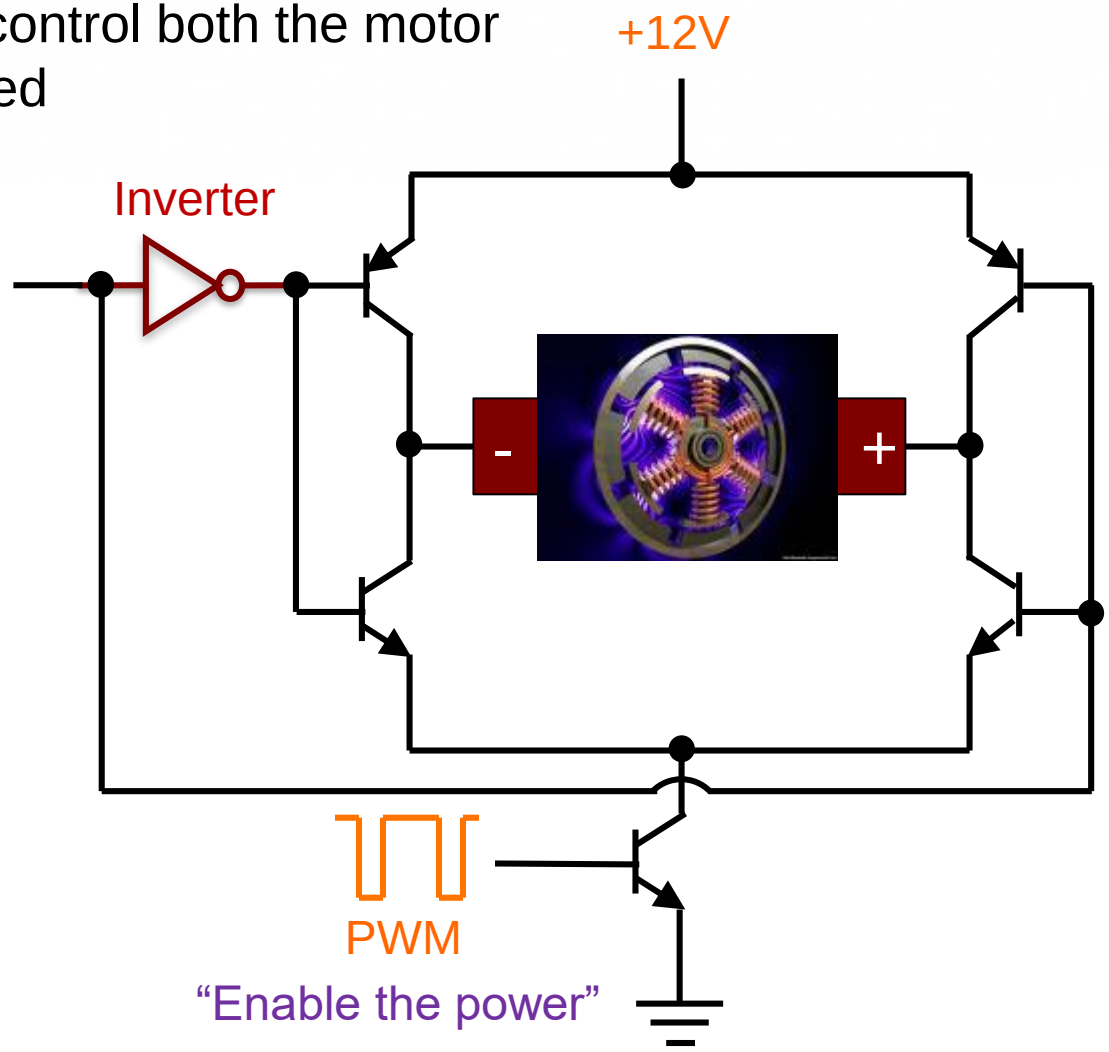
Transistors	Q4 (PNP)	Q3 (NPN)	Q2 (PNP)	Q1 (NPN)
Command	Va	Vb	Vc	Vd
Forward	5V	5V	0V (GND)	0V (GND)
Reverse	0V (GND)	0V (GND)	5V	5V



H-BRIDGE CIRCUIT (TRANSISTORS)

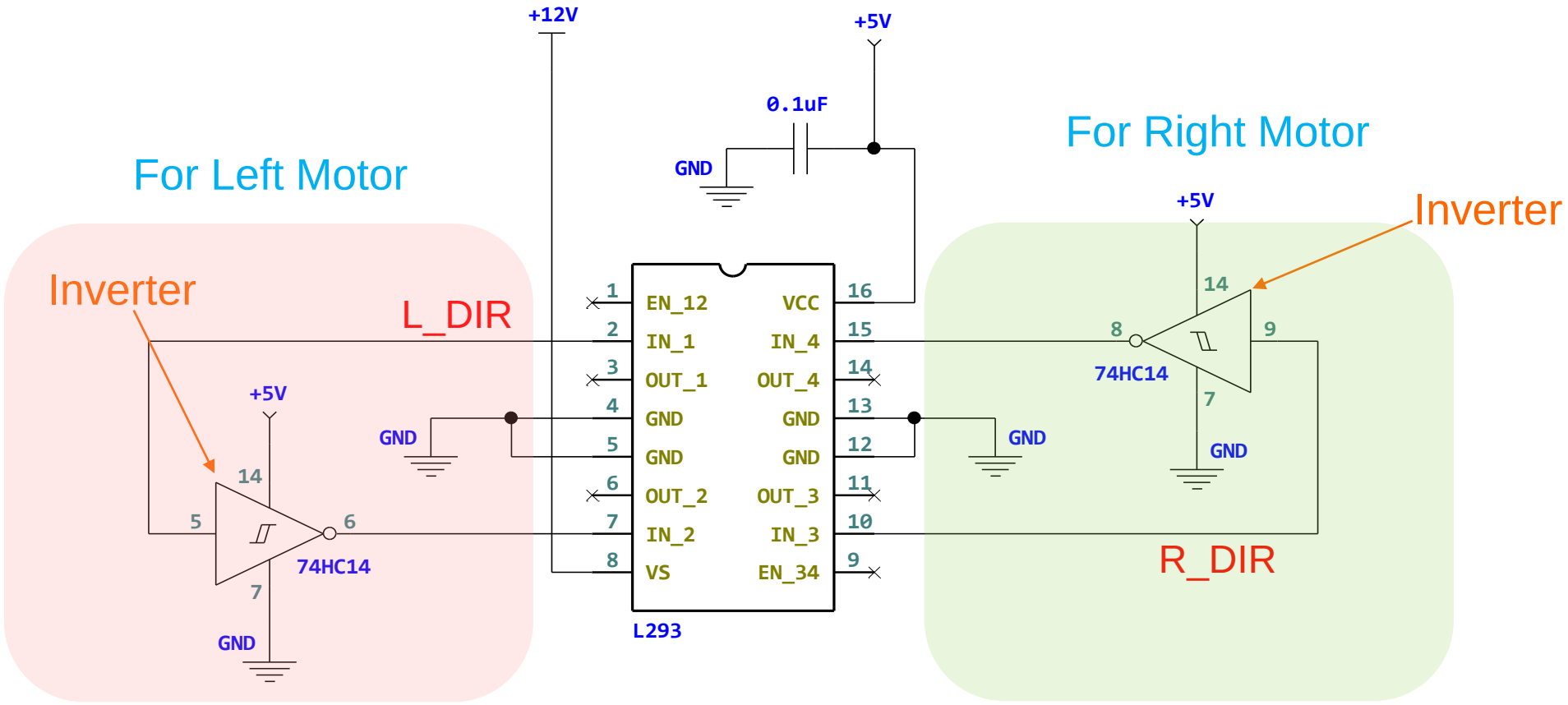
- It is the circuit to control both the motor direction and speed

- Use a direction (DIR) pin to control the switches



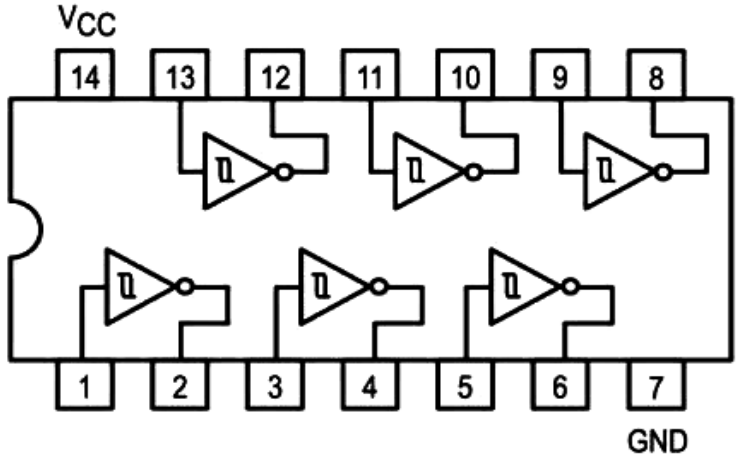
H-BRIDGE IC – L293B

- To simplify your task without using transistors, you may use the H-bridge IC L293B in your lab and project



INVERTER– 74HC14

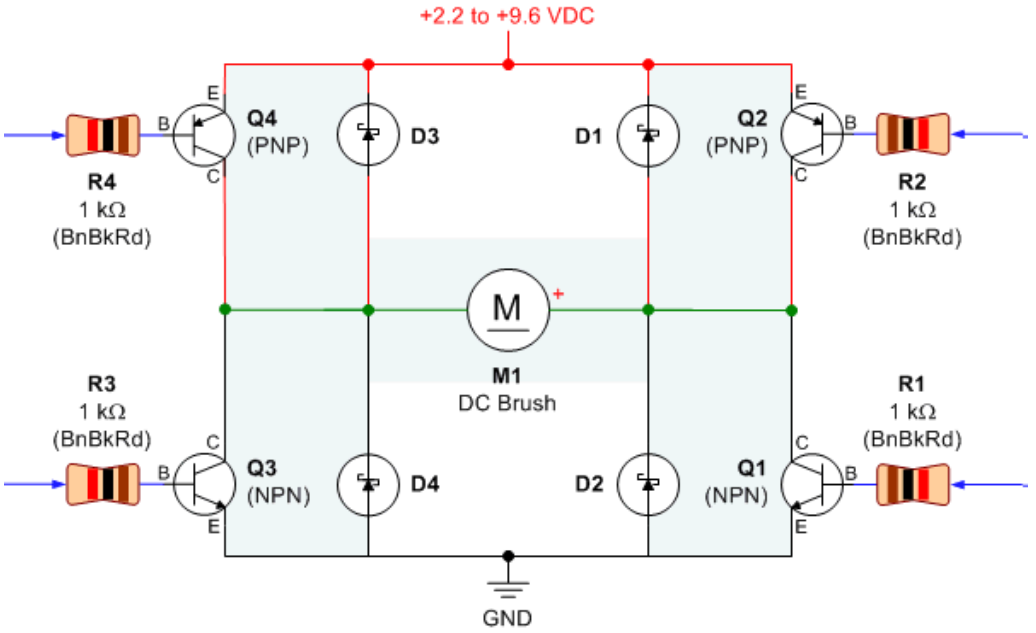
- 74HC14 is the Schmitt-Trigger Inverter you used in Lab#03.
- There are six inverters inside the package and they are independent to each other.
- You may choose whichever is available and convenient according to your breadboard layout.



74HC14 Inverter

LECTURE SUMMARY

- A transistor can work in the switch mode or amplification mode
- A switch mode happens when the input current is very high that saturates the transistor
- Transistors can be used to construct a H-Bridge to drive a motor



NEXT LECTURE

- Kirchhoff's Current Law
- Kirchhoff's Voltage Law

QUESTIONS?