Developing WiFi IoT ESP8266-Arduino Based Devices

DAY 5: Wireless operated Transistor Driven Electromechanical Relay

Webinar Logistics

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Don Wilcher

Visit 'Lecturer Profile' in your console for more details.
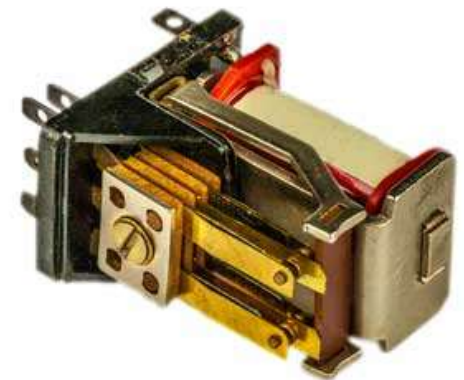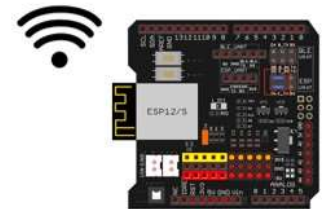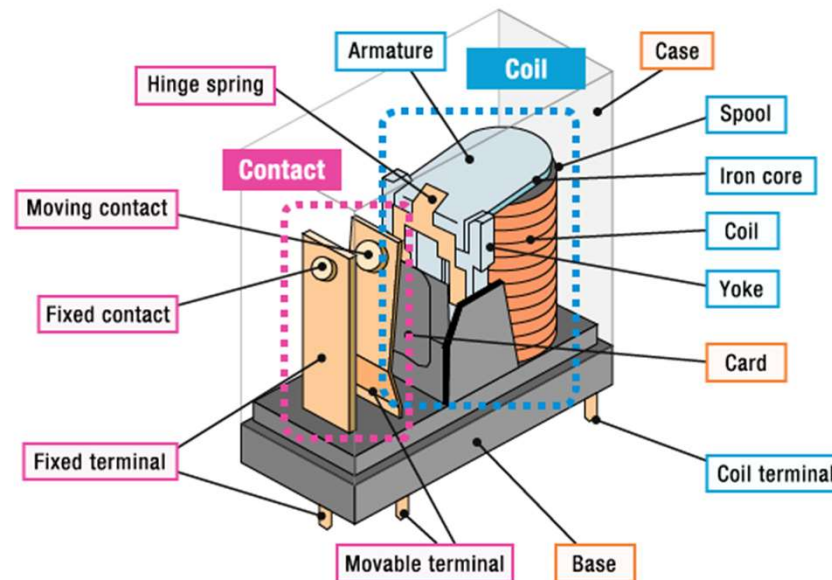
Agenda:

- Electromechanical Relay Construction
- Transistor Relay Driver Circuit
- TinkerCAD Circuits Transistor Driver Circuit model
- Lab: Wireless operated Transistor Driven Electromechanical Relay
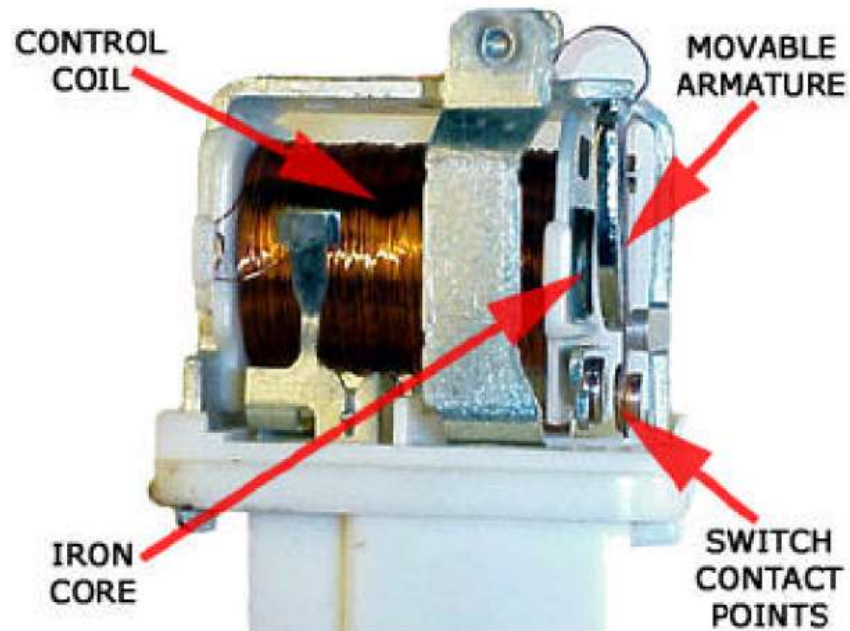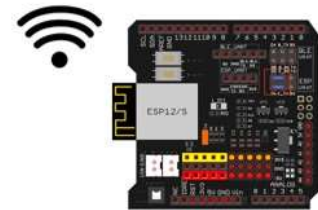
Electromechanical Relay Construction

An electromechanical switch that can be turned ON and OFF by a low current signal is called an electromechanical relay.

Source:

https://www.omron-ecb.co.kr/relay-basics/basic

Electromechanical Relay Construction...

Source:

https://www.circuitstoday.com/working-of-relays

Electromechanical Relay Construction...

How do we take...

Science ? → Application

Convert to
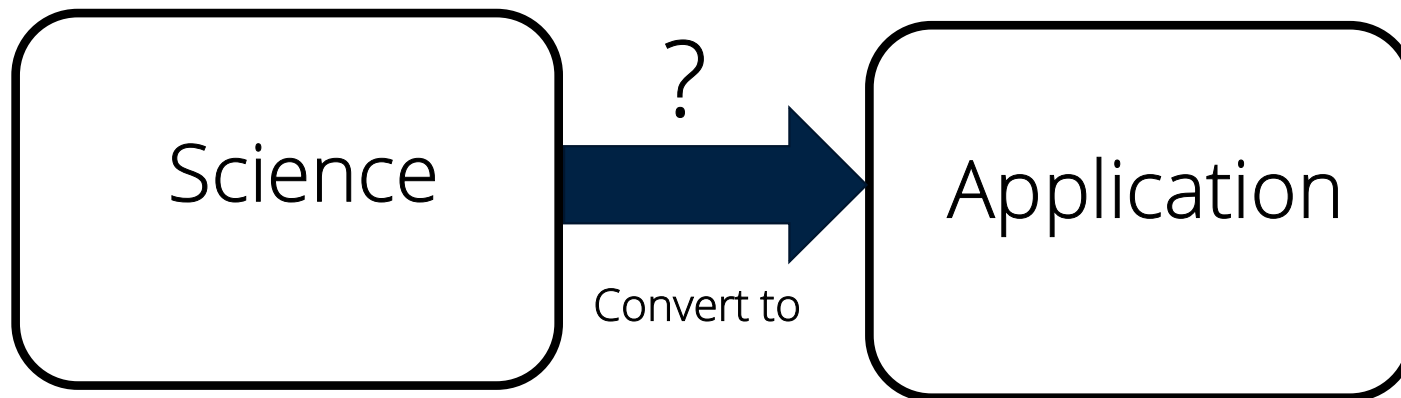
Question 1

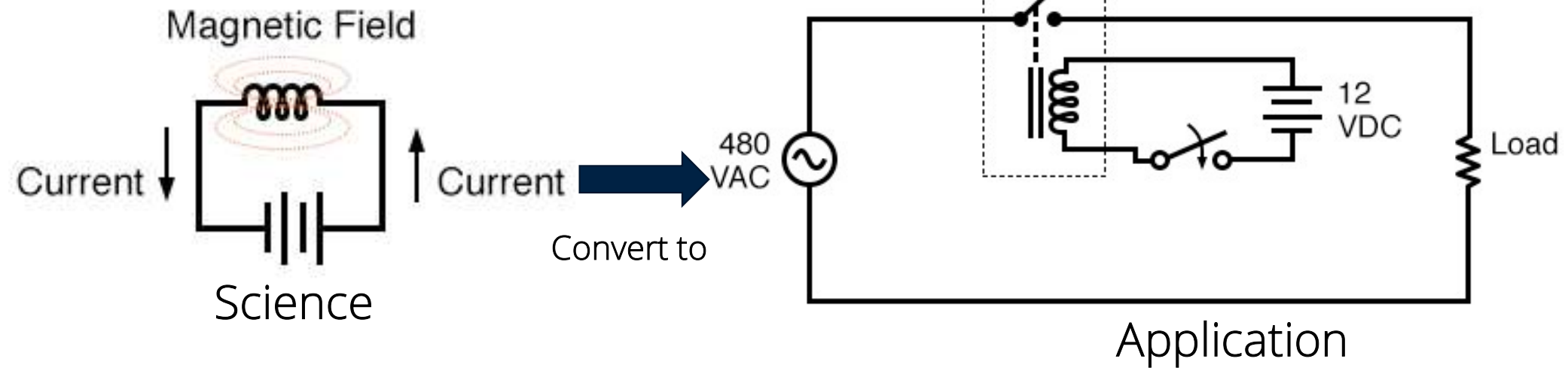**What is the name of the moveable part on an electromechanical relay?**
   a) control coil
   b) iron core
   c) movable armature

Electromechanical Relay Construction...

How do we take...

Magnetic Field

Current ↓   Current ↑

Convert to

Science

Relay

480 VAC

12 VDC

Load

Application

Source:

https://www.allaboutcircuits.com/textbook/digital/chpt-5/relay-construction/
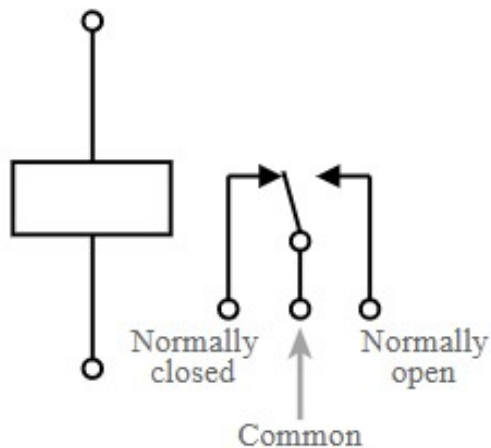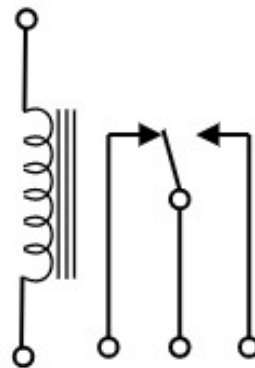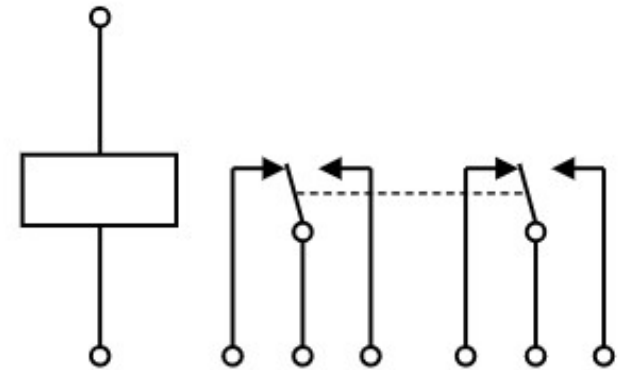
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Electromechanical Relay Construction...

Typical Electromechanical Relay Symbols

New Symbol: SPDT device

Old Symbol: SPDT device

Double Pole-Double Throw (DPDT) device

Source:
https://www.electronics-notes.com/articles/electronic_components/electrical-electronic-relay/what-is-a-relay-basics.php

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Transistor Relay Driver...

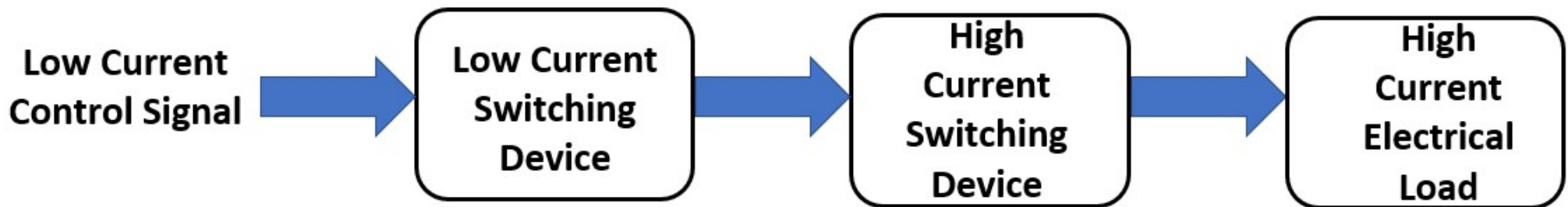## Controlling a High Current Electrical Load...

Low Current Switching Device ≠ High Current Electrical Load

Transistor Relay Driver...
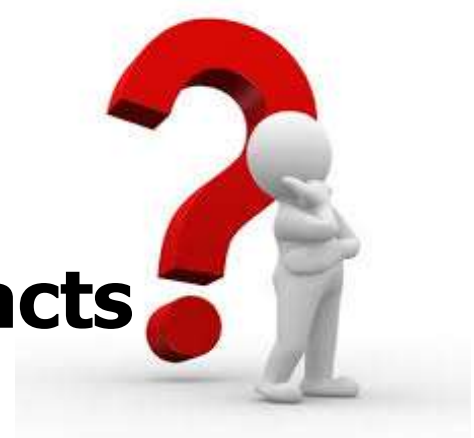
Controlling a High Current Electrical Load...

Low Current Control Signal → Low Current Switching Device → High Current Switching Device → High Current Electrical Load

Question 2

What are the common switching contacts on an electromechanical relay?
  a) movable armature
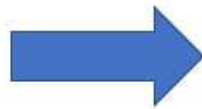 **b) Normally Open**
  c) Normally Closed
  d) b & c

Transistor Relay Driver Circuit...

Controlling a High Current Electrical Load with Low Current Switching

Transistor

Low Current Switching Device

Equation 1: $B = \dfrac{I_C}{I_B}$ or $h_{fe} = \dfrac{I_C}{I_B}$

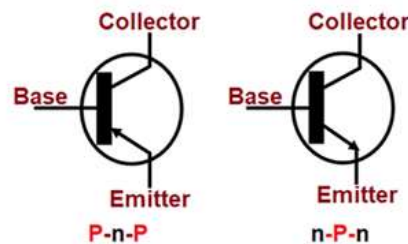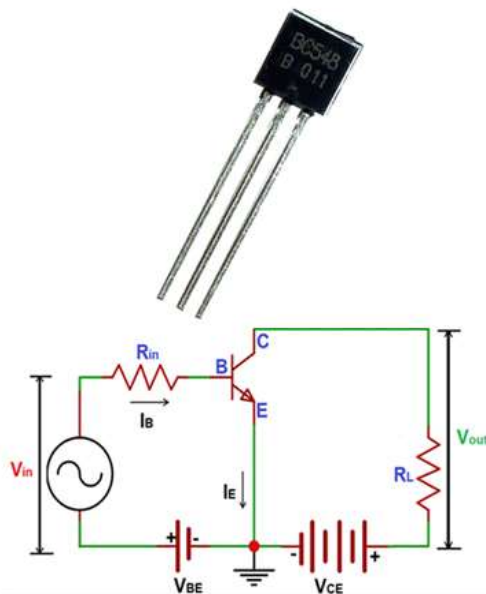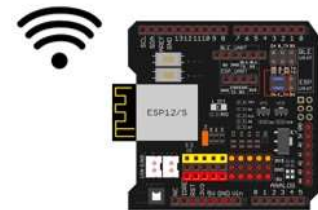**Equation 2**: $I_C = B I_B$

where:
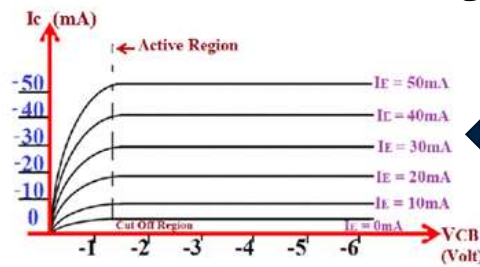
B = Beta

I_c = Collector Current

I_B = Base Current

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Transistor Relay Driver Circuit…

Controlling a High Current Electrical Load with Low Current Switching…

Transistor Family of Curves

Equation 1: $B = \dfrac{I_C}{I_B}$ or $h_{fe} = \dfrac{I_C}{I_B}$

Equation 2: $I_C = B I_B$

where:

$B = \text{Beta}$

$I_c = \text{Collector Current}$

$I_B = \text{Base Current}$

Source:
https://components101.com/articles/understanding-bjt-transistor-and-how-to-use-it-in-your-circuit-designs

Transistor Relay Driver Circuit...

Example of a Partial Transistor Datasheet

ELECTRICAL CHARACTERISTICS (Ta=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Collector-Base Breakdown Voltage	BV$_{CBO}$	Ic=100µA,IE=0	30			V
Collector-Emitter Breakdown Voltage	BV$_{CEO}$	Ic=1mA,IB=0	20			V
Emitter-Base Breakdown Voltage	BV$_{EBO}$	IE=100µA,Ic=0	5			V
Collector Cut-Off Current	I$_{CBO}$	VCB=30V,IE=0			1	µA
Emitter Cut-Off Current	I$_{EBO}$	VEB=5V,Ic=0			100	nA
DC Current Gain(note)	hFE1	VCE=1V,Ic=1mA	100			
	hFE2	VCE=1V,Ic=150 mA	120	110	400	
	hFE3	VCE=1V,Ic=500mA	40			
Collector-Emitter Saturation Voltage	VCE(sat)	Ic=500mA,IB=50mA			0.5	V
Base-Emitter Saturation Voltage	VBE(sat)	Ic=500mA,IB=50mA			1.2	V
Base-Emitter Saturation Voltage	VBE	VCE=1V,Ic=10mA			1.0	V
Current Gain Bandwidth Product	fT	VCE=10V,Ic=50mA	100			MHz
Output Capacitance	Cob	VCB=10V,IE=0 f=1MHz		9.0		pF

Transistor Relay Driver Circuit...

Basic Transistor Switching Analysis

Constant Voltage
Bias circuit scheme
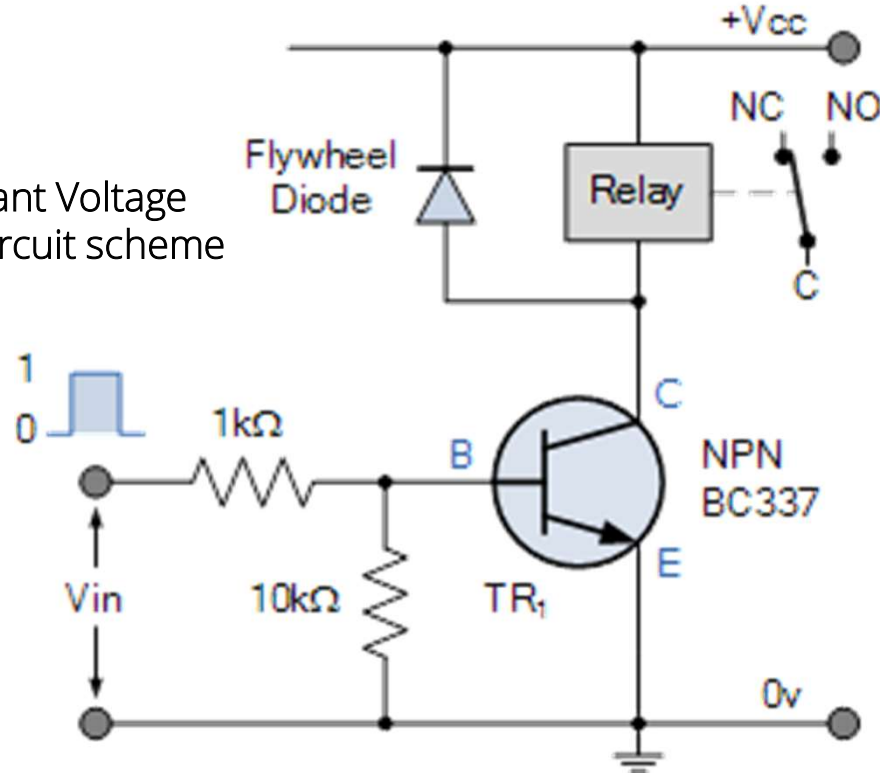
Equation 3: $v_B = \dfrac{v_{IN}R}{R_T}$

$$v_B = \dfrac{5v\,10k\Omega}{11k\Omega}$$

$$v_B = 4.5\text{V}$$
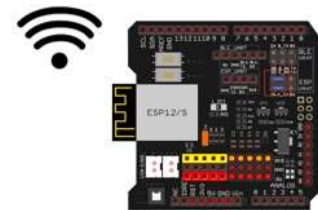
$$v_B > v_{BE}: \; v_{BE} = 0.7v$$

Transistor is ON

$$v_B = \dfrac{v_{IN}R}{R_T}$$

$$v_B = \dfrac{0v\,10k\Omega}{11k\Omega}$$

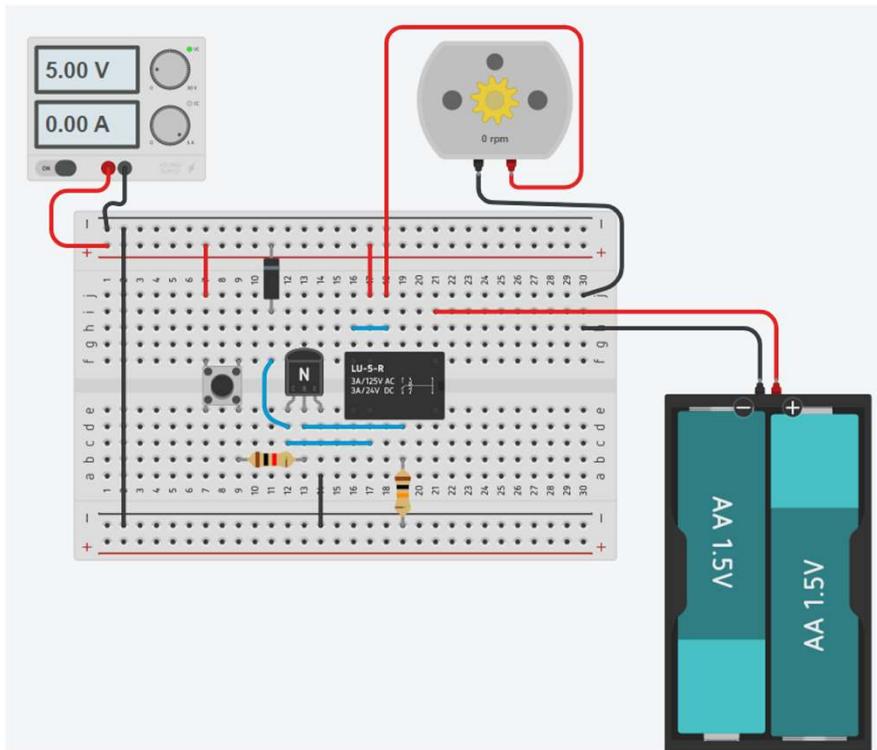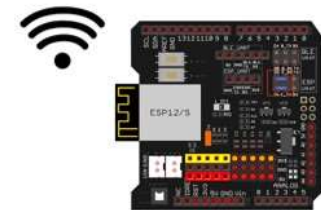$$v_B = 0\text{V}$$

$$v_B < v_{BE:}$$

Transistor is OFF

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Question 3

Using the transistor relay driver circuit on slide 17, determine the base voltage (Vb) with an input control voltage of 3.3V?
   a) 4.5V
   b) 0V
   c) 2.7V

TinkerCAD Circuits Transistor Relay Driver Model. . .

Component List		
Name	**Quantity**	**Component**
T1(2N3904)	1	NPN Transistor (BJT)
R1	1	1 kΩ Resistor
D1(1N4001)	1	Diode
S1	1	Pushbutton
K1(5V)	1	Relay SPDT
M1(3V - 6VDC)	1	DC Motor
Bat1	1	2 batteries, AA, no 1.5V Battery
P1	1	5 , 5 Power Supply
R2	1	10 kΩ Resistor

TinkerCAD Circuits Transistor Relay Driver Model...

Electronic Circuit Schematic Diagram
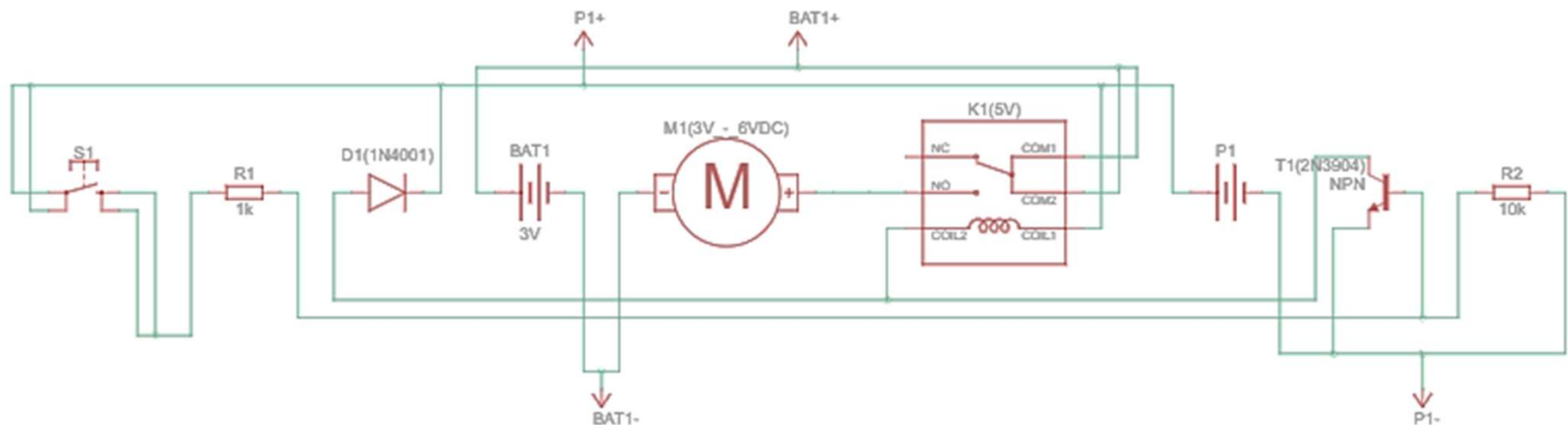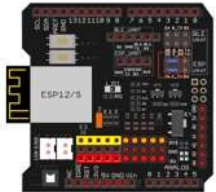
Question 4

What type of transistor is used to drive the electromechanical relay in the controller project?
** a) FET**
** b) BJT NPN**
** c) BJT PNP**

Osoyoo ESP8266 Arduino Kit Overview
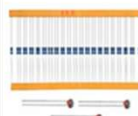
Osoyoo ESP8266 Arduino Kit Overview

OSOYOO WiFi Internet of Things Learning Kit For Arduino
Model:2020003000

|						
OSOYOO ESP8266 WIFI shield	OSOYOO Basic Board with cable	Photoresistor Sensor Module	Water Level Detection Sensor	Sound Detection Sensor Module	Active Buzzer Module	Temperature& Humidity Sensor
Relay Module	Gas Sensor Module	Digital Barometric Pressure Sensor Module	Infrared Sensor Module	Ultrasonic Sensor Module	LED(6 x White, 6×Red, 6×Yellow, 6×Green)	Push Buttons
Servo Motor	Pack of Resistors	40 pin Jumper wires(15cm, Male to male)	8 pin Jumper Wires(20cm, Female to Female)	20 pin Jumper wires(15cm, Male to Female)	Solderless Prototype Breadboard	philips screwdriver

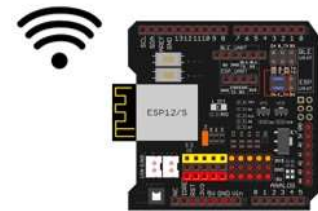https://osoyoo.com/2020/05/30/wifi-iot-learning-kit-for-arduino/
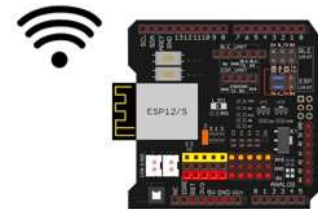
Lab Project: Wireless operated Transistor Driven Electromechanical Relay
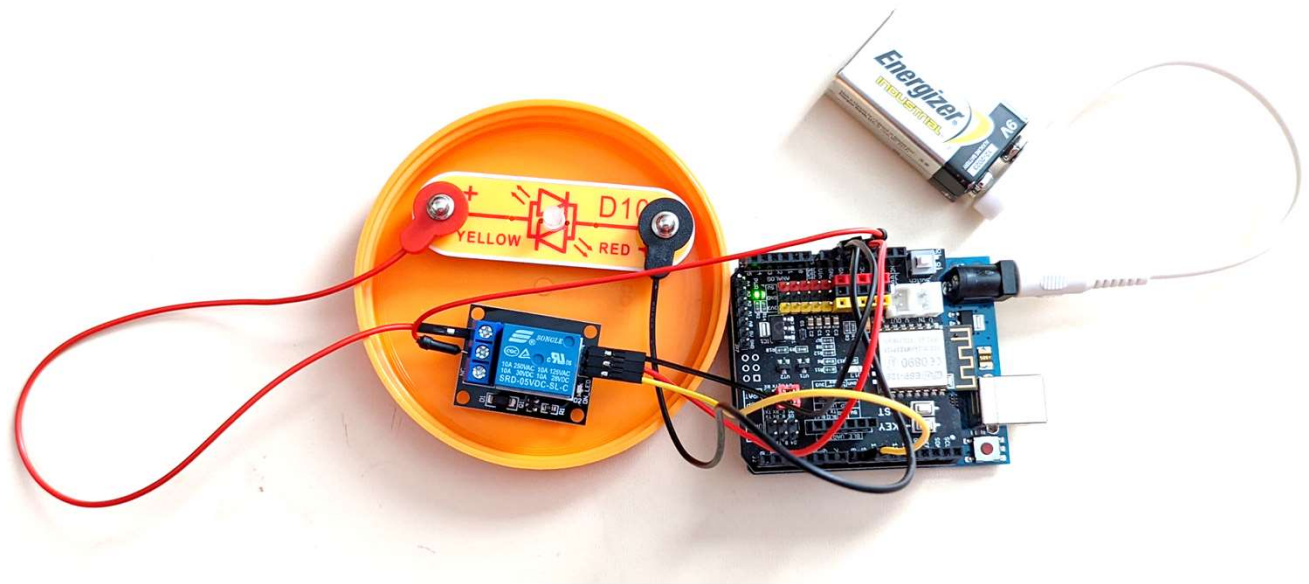
## Lab Project: Wireless operated Transistor Driven Electromechanical Relay

Big IDEAS:

1. Learners will be able to wire a wireless electronic controller using a few off-the-shelf components.
2. Learners will be able to control a solid-state driver for relay control using a mobile app.
3. Learners will be able to make small changes to the code for personalization.
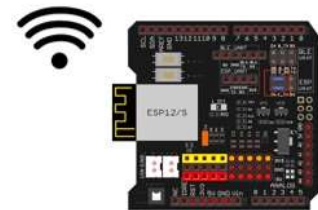
Lab Project: Wireless operated Transistor Driven Electromechanical Relay...

Wireless operated Transistor Driven Electromechanical Relay Block Diagram

WiFi Shield → Arduino Uno → Transistor Relay Driver Circuit → LED
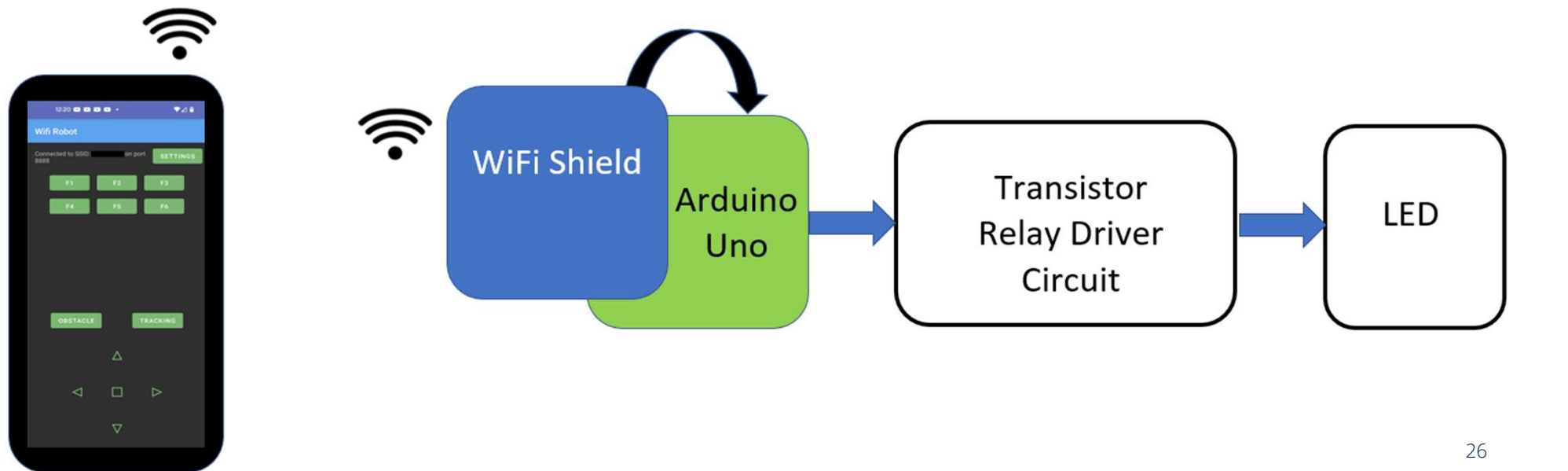
What is an Internet-based Control System?...
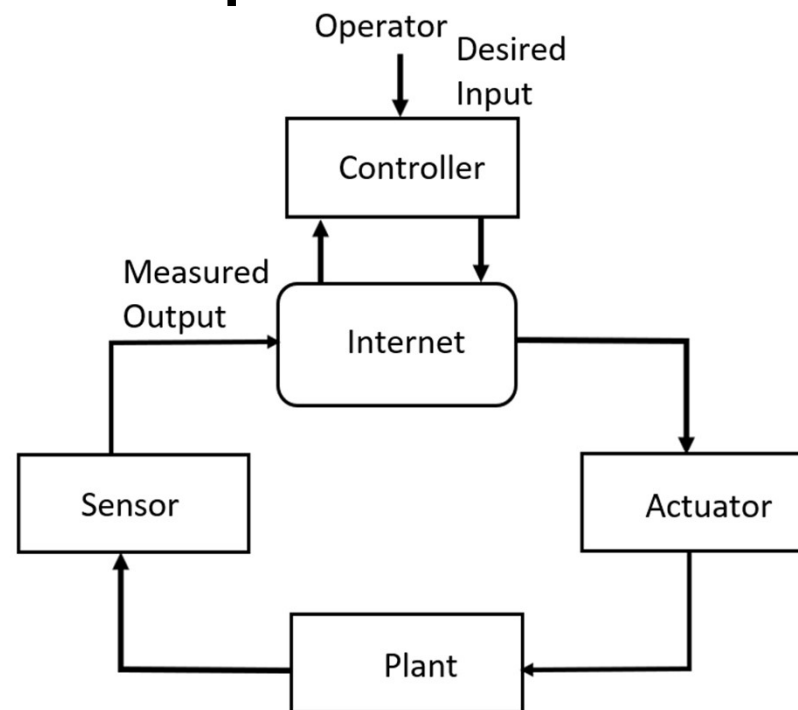## Lab Setup Concept

Control structure with the controller located remotely

Notes:
a) Plant: The combination of an actuator and a process.
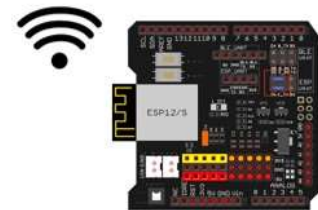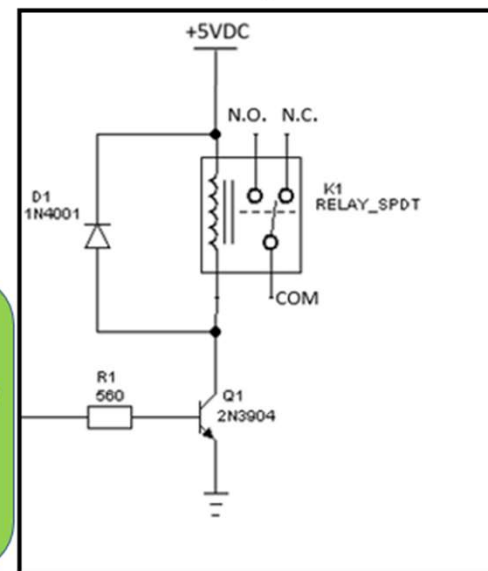b) Inputs and output

Source: Yang, S. (2011). *Internet-based control systems: Designs and applications*. Springer.

Lab Project: Wireless operated Transistor Driven Electromechanical Relay

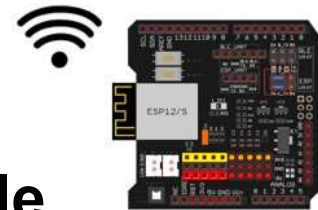**Wireless operated Transistor Driven Electromechanical Relay Functional Block Diagram**
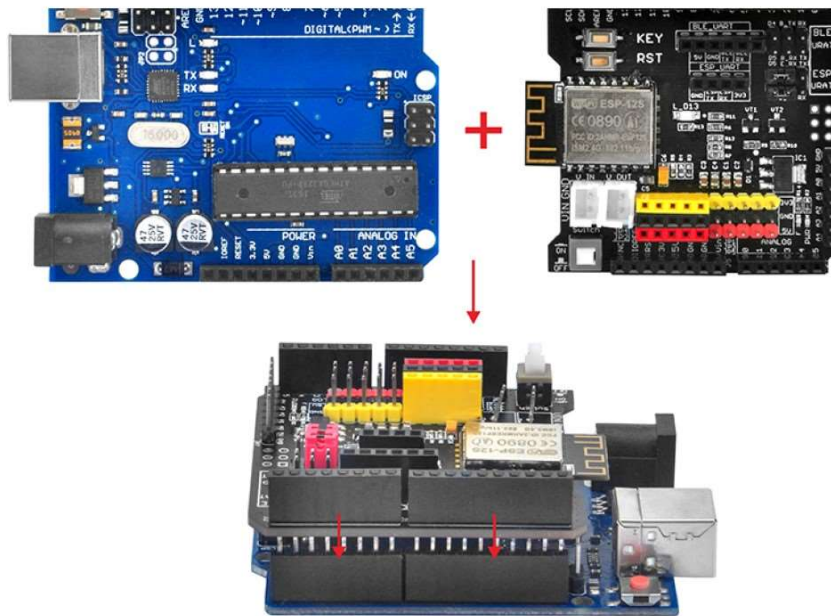

Transistor Driver Relay Circuit

Lab Project: Wireless operated Transistor Driven Electromechanical Relay...

Lab Setup: Attaching WiFi Shield to the Arduino Compatible

Notes:
a) Attach IoT unit to your development machine
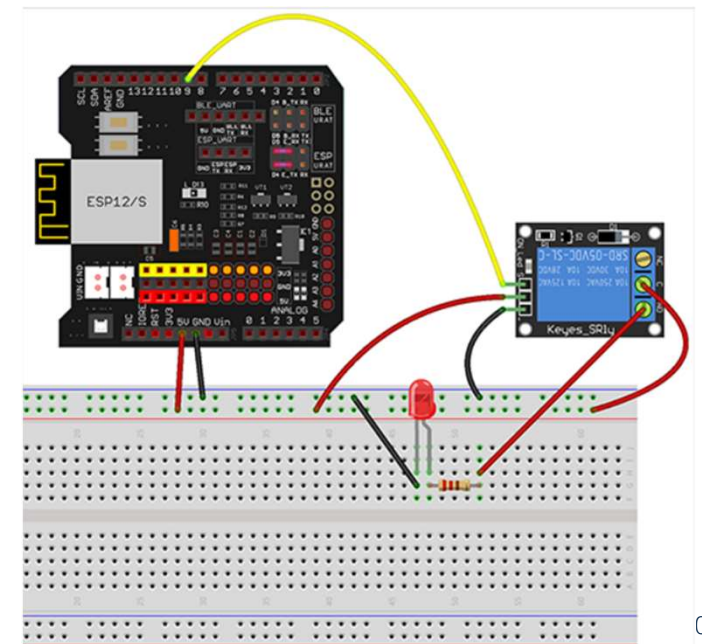b) Connect your Arduino Compatible to the correct COM port

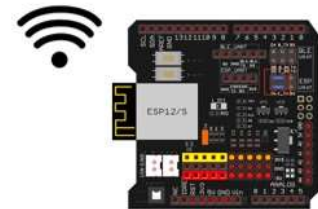# Lab Project: Wireless operated Transistor Driven Electromechanical Relay...

Lab Setup: Wiring the Transistor Relay Module to the IoT unit
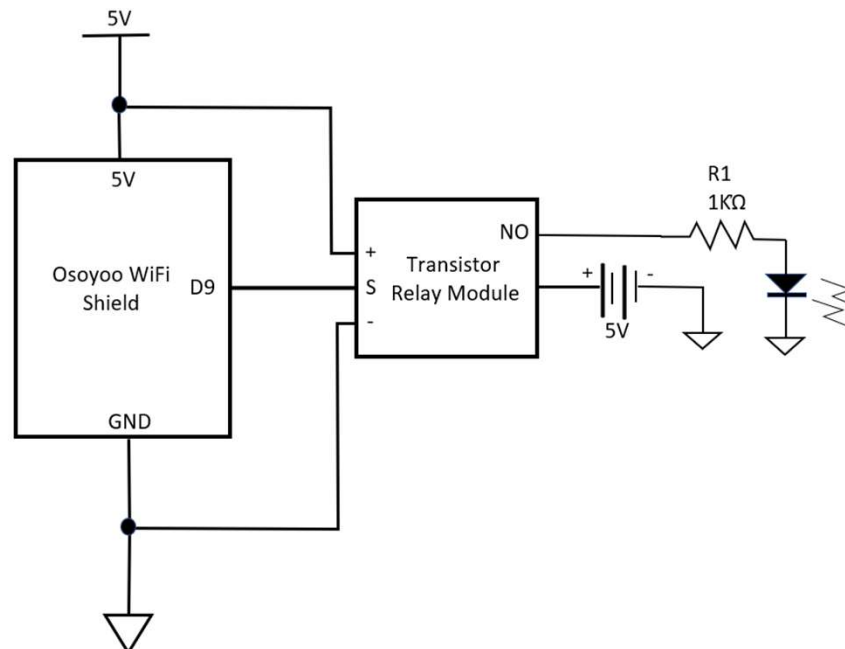
Wiring Chart:

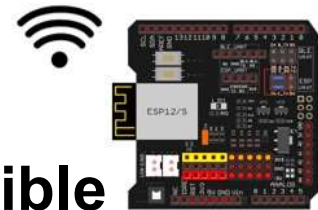| OSOYOO Basic Board	Relay
D9	S
GND	GND
5V	VCC

0

Lab Project: Wireless operated Transistor Driven Electromechanical Relay...

Lab Setup: IoT Receiver – Wireless operated Transistor Driven Electromechanical Relay Electronic Circuit Schematic Diagram

Lab Project: Wireless operated Transistor Driven Electromechanical Relay...
Lab Setup: Upload Lesson 11B code to Arduino Compatible

Download the code from here!

[WiFi Internet of Things Learning Kit for Learn Coding with Arduino IDE 11: Channel Relay « osoyoo.com](#)

📁 esp8266-lesson9	✓	3/5/2022 11:44 PM
📁 esp8266-lesson10	✓	3/5/2022 11:43 PM
📁 esp8266-lesson11B	✓	3/5/2022 11:43 PM

Lab Project: Wireless operated Transistor Driven Electromechanical Relay...
Lab Setup: Mobile App Control

Mobile App:

OSOYOO WiFi UDP
Robot Car APP

Mobile App keys mapped to UDP commands

Button	UDP message	LED response
F1	F	LED turns ON
F2	G	LED turns OFF
F3	H	
F4	I	
F5	J	
F6	K	
▲	A	
▼	B	
▶	R	
◀	L	
square	E	
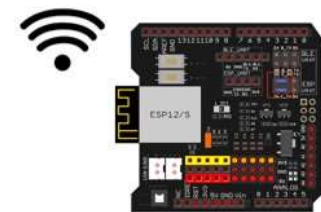
Lab: Wireless Servo Motor Controller . . .

Partial C++ UDP Message Code
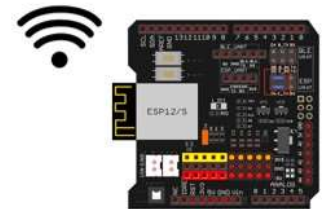
```
82    // read the packet into packetBufffer
83    Udp.read(packetBuffer,UDP_TX_PACKET_MAX_SIZE);
84    if (packetBuffer[0]=='F') digitalWrite(relayPin,HIGH); //F1 pressed
85    if (packetBuffer[0]=='G') digitalWrite(relayPin,LOW);  //F2 pressed
```

UDP Message Code

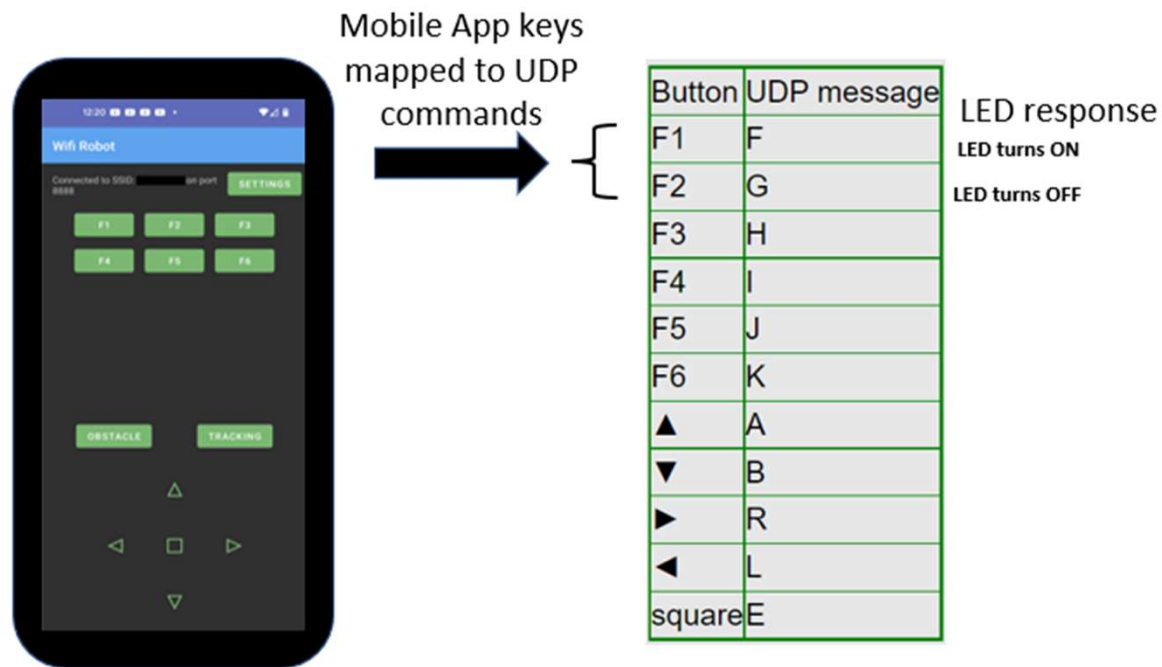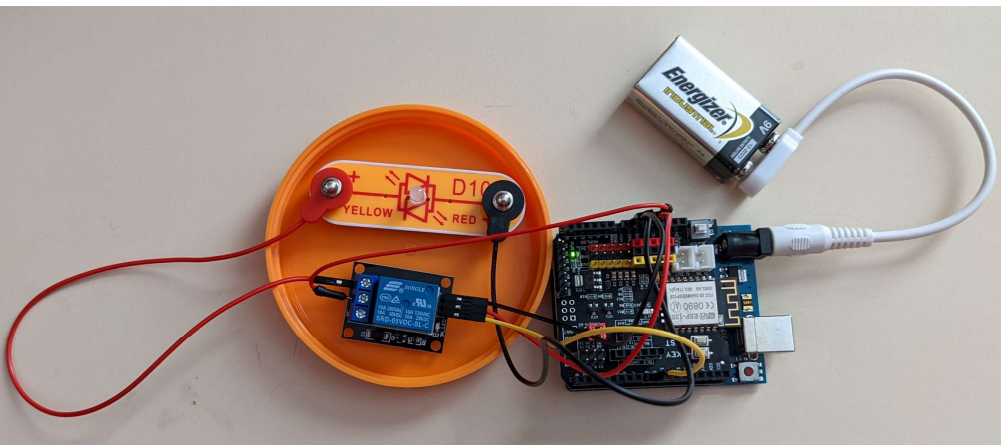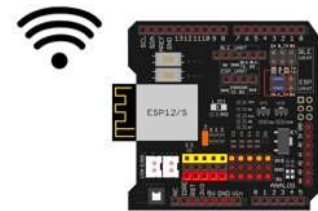# Lab Project: Wireless operated Transistor Driven Electromechanical Relay...
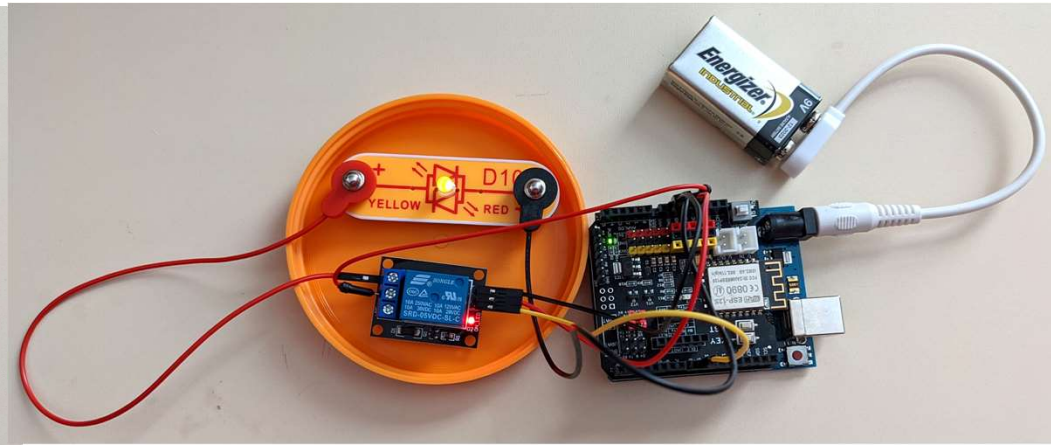
Mobile App:

OSOYOO WiFi UDP
Robot Car APP
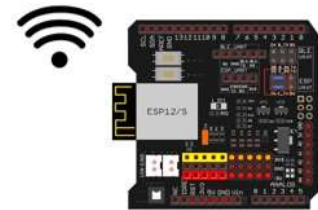
Lab Setup: Mobile App Control

Remote LED OFF

Remote LED ON

Lab Project: Wireless operated Transistor Driven Electromechanical Relay...

Play with the Code!

Line 23:Change the analog Pin or add another relay
int relayPin = 9;   // Digital output that operates the 5VDC relay

Line 84: udp mapped mobile app keys: map another key
if (packetBuffer[0]=='F') digitalWrite(relayPin, HIGH); // udp message F maps to F1 key of mobile app

Line 85: udp mapped mobile app keys: map another key
if (packetBuffer[0]=='G') digitalWrite(relayPin, LOW); // udp message F maps to F2 key of mobile app

Question 5

In reviewing slide 34, what programming construct is used for assigning UDP messages?
a) Bufferpacket[0]
b) packet.Buffer[0]
c) packetBuffer[0]

Thank you for attending

Please consider the resources below:

- Electromechanical Relay Construction
  https://www.omron-ecb.co.kr/relay-basics/basic

- ESP8266 Hardware Design Guidelines (www.expressif.com)

- Multisim Live: Online circuit simulator
  https://www.multisim.com/

- Osoyoo Website.(2022). WiFi iot learning kit.
  https://osoyoo.com/2020/05/30/wifi-iot-learning-kit-for-arduino/

- TinkerCAD Circuits
  https://www.tinkercad.com/learn/circuits

- Wilcher, D. (2012). *Learn electronics with arduino*. Apress

- Yang, S. (2011). *Internet-based control systems: Designs and applications*. Springer.

Thank You

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