



DesignNews

Exploring Electronic Circuits with Breadboards, AI Circuit Analysis, and Simulators

DAY 3: AI Circuit Analysis – Digraphs and Python Modeling

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Dr. Don Wilcher

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

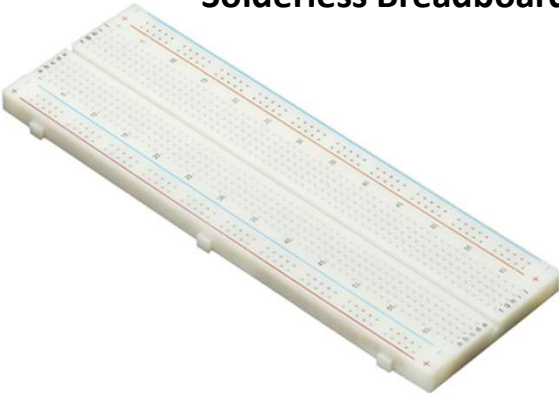
Course Kit and Materials



Adafruit Parts Pal Kit



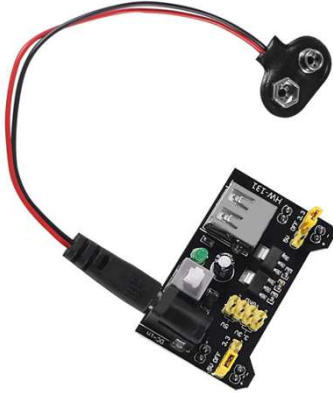
Solderless Breadboard



Jumper Wires: Male to Male



Solderless Breadboard Power Supply



Research Perspective

“Breadboards are widely used in early-stage circuit prototyping since they enable users to rapidly try out different components and to change the connections between them” (Zhu et al., 2020).

Agenda:

- What is a Digraph?
 - a) Definition
 - b) Applications
 - b) Examples
- Creating a Digraph using an AI Large Language Model (LLM)
- Lab: Build a 7 Segment LED Display Dimmer Controller

What is a Digraph?

Definition:

- A digraph or Directed Graph consists of vertices or nodes and a collection of directed edges.
- Each directed edge connects an ordered pair of vertices, pointing from one vertex to another.
- A directed graph "G" is defined as an ordered pair

$$G = (V, A)$$

where:

V is the set of vertices/nodes

A is the set of ordered pairs of vertices, called arcs or directed edges

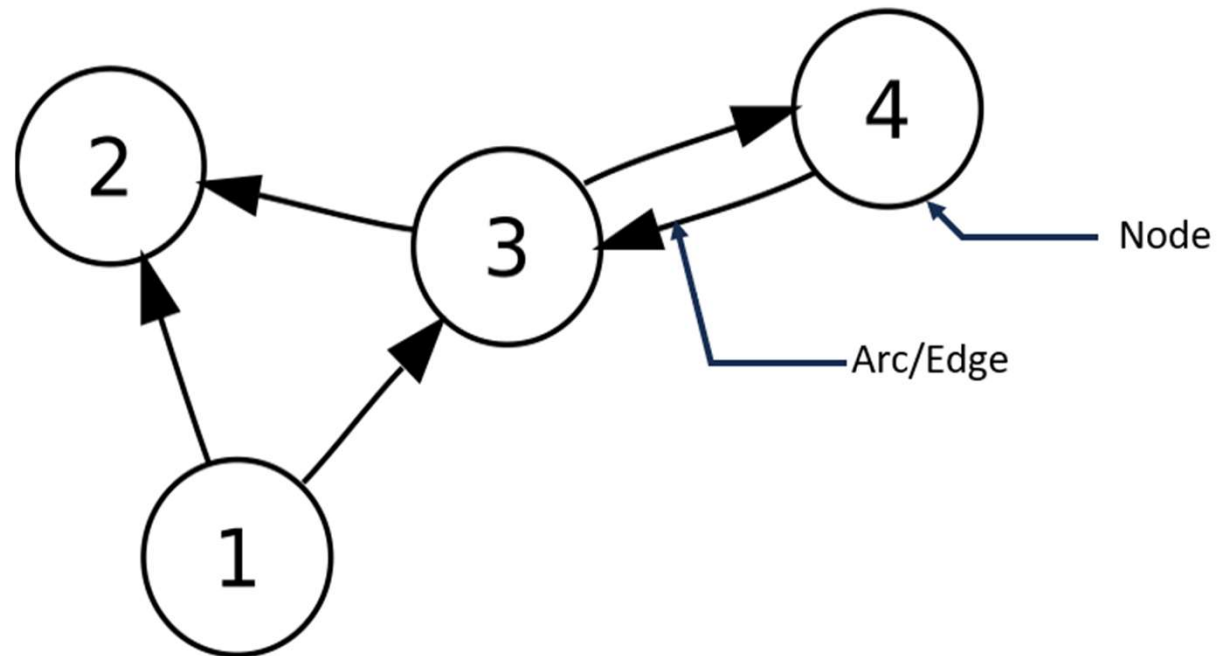


What is a Digraph?...

Definition:



Anatomy of a Digraph



Question 1

What variable in the Digraph equation " $G = (V, A)$ " is the arc or directed edge?

- a) G**
- b) V**
- c) A**
- d) none of the above**



What is a Digraph? ...

Applications:



Directed graphs are used to model various systems and relationships, including:

- Social networks
- Transportation systems
- Circuit Analysis/Design
- Control Systems
- Computer networks
- Project management dependencies
- Workflow processes

Question 2

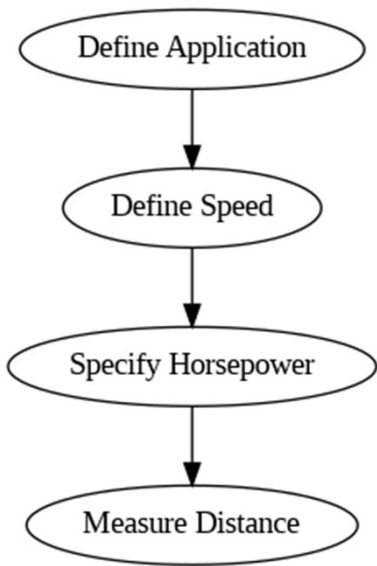
Can a Digraph be used to aid in circuit analysis or design tasks?

- a) False**
- b) True**



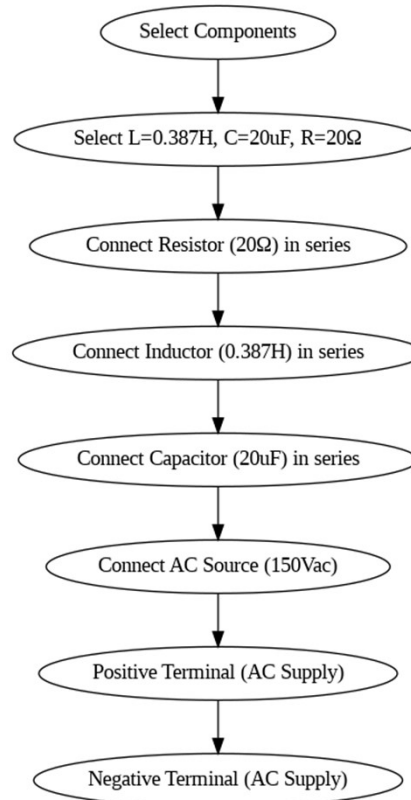
What is a Digraph? ...

Examples:

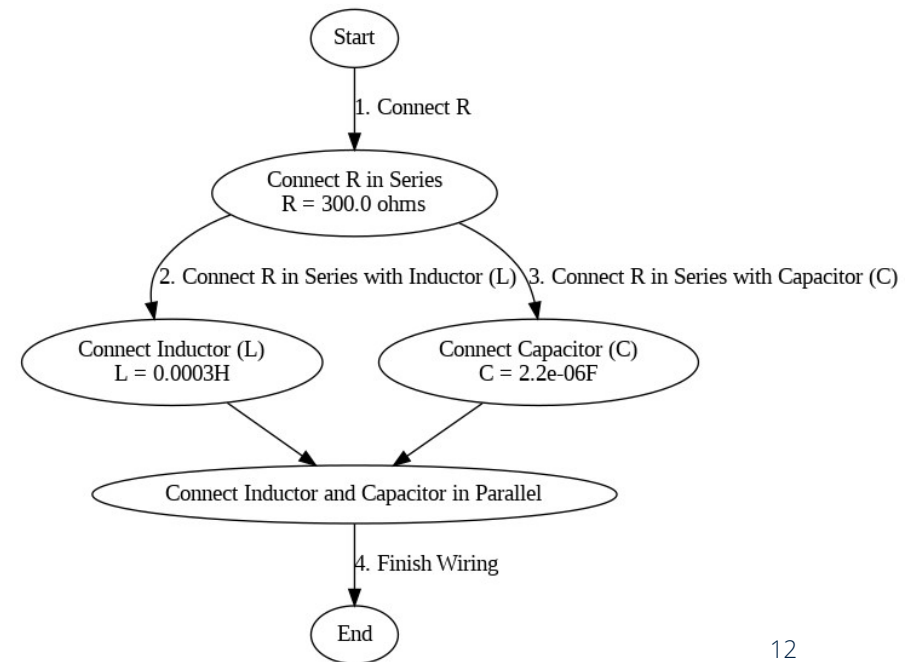


Belt-Drive System Analysis

LCR Circuit Assembly

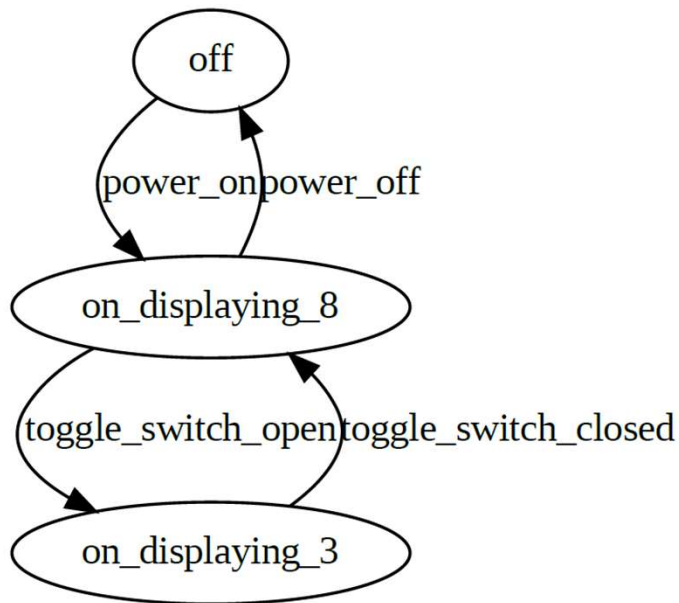


Tuned Circuit Assembly



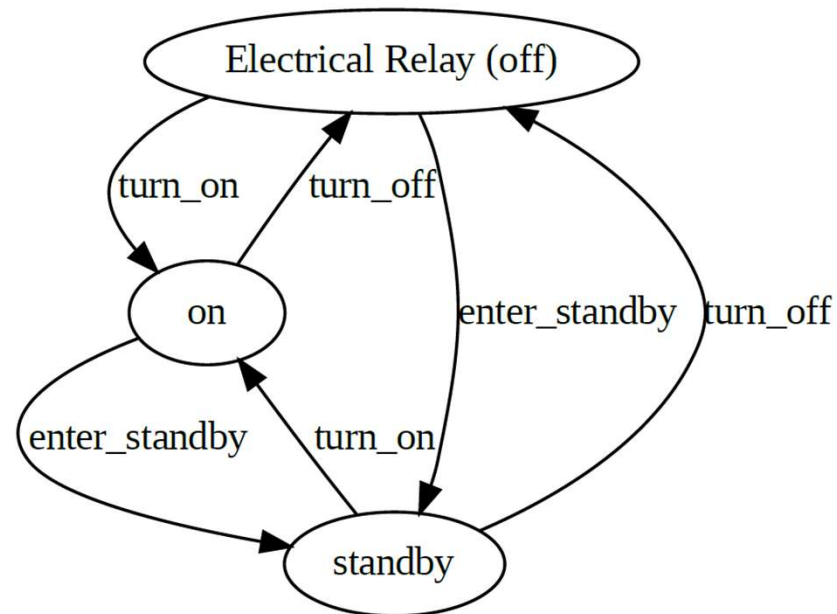
What is a Digraph? ...

Examples:



7-Segment LED Display with Toggle Switch Assembly

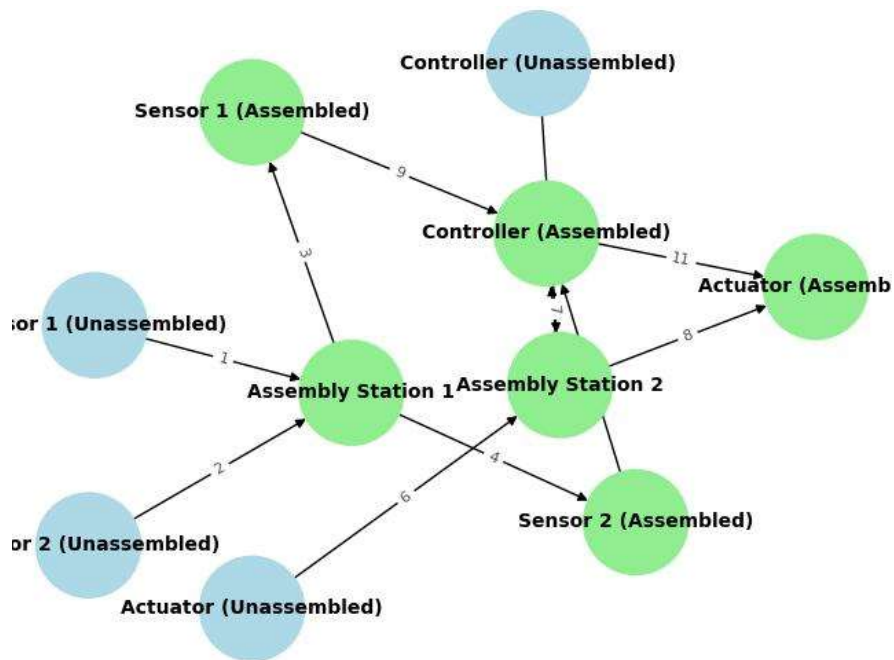
PLC Controlled Relay: Behavior Interaction Priority (BIP) Model



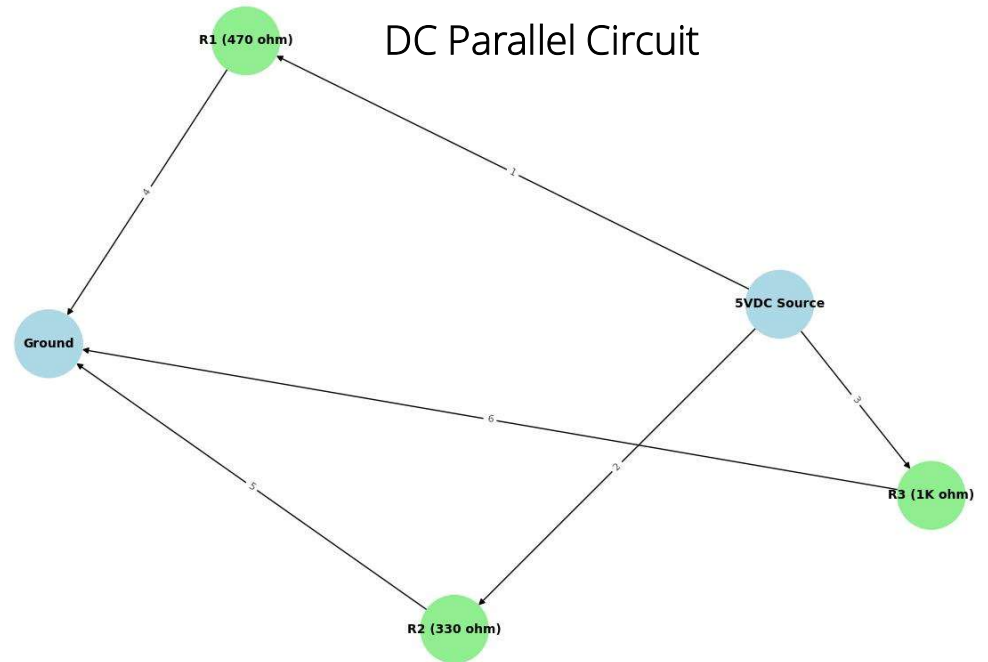
What is a Digraph? ...

Examples:

Controller-Sensor-Actuator Assembly



DC Parallel Circuit



Creating a Digraph Using an AI Large Language Model (LLM)



AI LLM Generated Digraph Model Workflow



Creating a Digraph Using an AI Large Language Model (LLM)...



Create/Enter Prompt

Gemini selected AI LLM



Please create a software agent using Python that will provide instructions on wiring a Tuned LCR circuit. The L (Inductance) value will be 3.2H, the C(Capacitance) value will be 2.2 microfarads (uF) and the R (Resistance) will be 300 ohms. The LC circuit components are wired in parallel. The R is wired in series with the parallel L and C components. The input frequency for the LCR series-parallel circuit is 60Hz. Please provide a digraph showing the assembly steps of the complete circuit.

Creating a Digraph Using an AI Large Language Model (LLM)...

AI LLM Generated Digraph



Digraph for Circuit Assembly

Here's a textual representation of the digraph showing the assembly steps:

```

+-----+      +-----+
| L (3.2H) |-----| C (2.2uF) |
+-----+      +-----+
                |
                v
+-----+      +-----+
| R (300Ω) |-----| (L||C)  | (Combined L and C)
+-----+      +-----+

```

Legend:

|| - Represents parallel connection
 ----- - Represents series connection

This digraph shows the L and C components connected in parallel, followed by the entire parallel combination connected in series with the resistor (R).

Question 3

What AI LLM was used to create the software agent prompt for a Tuned LCR Circuit wiring instructions digraph?

- a) Perplexity.ai**
- b) ChatGPT**
- c) Llama AI**
- d) Gemini**



Creating a Diagraph Using an AI Large Language Model (LLM)

Copy Python Code



Software Partial Code

Python

```
def tune_lcr_circuit_instructions():
    """Provides instructions on wiring a tuned LCR circuit with given parameters.

    Prints instructions for wiring an LCR circuit with
    L = 3.2H, C = 2.2uF, R = 300 ohm in a series-parallel configuration.
    """

    # Define component values
    inductance = 3.2 # Henries
    capacitance = 2.2e-6 # Farads (microfarads converted to Farads)
    resistance = 300 # Ohms

    # Print instructions
    print("Tuning a LCR Circuit")
    print("-" * 30)
    print(f"Component Values:")
    print(f"\tInductance (L): {inductance}H")
    print(f"\tCapacitance (C): {capacitance * 1e6}uF") # Convert Farads to microfarads
    print(f"\tResistance (R): {resistance} ohms")
    print("\nWiring Instructions:")
```

Creating a Digraph Using an AI Large Language Model (LLM)

Paste Code into Python IDE



```
Resonant_Frequency_Digraph.ipynb
File Edit View Insert Runtime Tools Help All changes saved
+ Code + Text

1 def tune_lcr_circuit_instructions():
2     """Provides instructions on wiring a tuned LCR circuit with given parameters.
3
4     Prints instructions for wiring an LCR circuit with
5     L = 3.2H, C = 2.2uF, R = 300 ohm in a series-parallel configuration.
6     """
7
8     # Define component values
9     inductance = 3.2 # Henries
10    capacitance = 2.2e-6 # Farads (microfarads converted to Farads)
11    resistance = 300 # Ohms
12
13    # Print instructions
14    print("Tuning a LCR Circuit")
15    print("-" * 30)
16    print(f"Component Values:")
17    print(f"\tInductance (L): {inductance}H")
18    print(f"\tCapacitance (C): {capacitance * 1e6}uF") # Convert Farads back to microfarads for user display
19    print(f"\tResistance (R): {resistance} ohms")
20    print("\nWiring Instructions:")
21    print(f"1. Connect the inductor ({inductance}H) and capacitor ({capacitance}uF) in parallel.")
22    print(f"2. Connect the resistor ({resistance} ohms) in series with the parallel combination of L and C.")
23    print("\nInput:")
24    print(f"Input Frequency: 60Hz")
25
26 if __name__ == "__main__":
27     tune_lcr_circuit_instructions()
28
```

Google Colaboratory

Creating a Digraph Using an AI Large Language Model (LLM)



Analyze Digraph Generated Model

```
➔ Tuning a LCR Circuit
-----
Component Values:
  Inductance (L): 3.2H
  Capacitance (C): 2.2uF
  Resistance (R): 300 ohms

Wiring Instructions:
1. Connect the inductor (3.2H) and capacitor (2.2e-06uF) in parallel.
2. Connect the resistor ({resistance} ohms) in series with the parallel combination of L and C.

Input:
Input Frequency: 60Hz
```

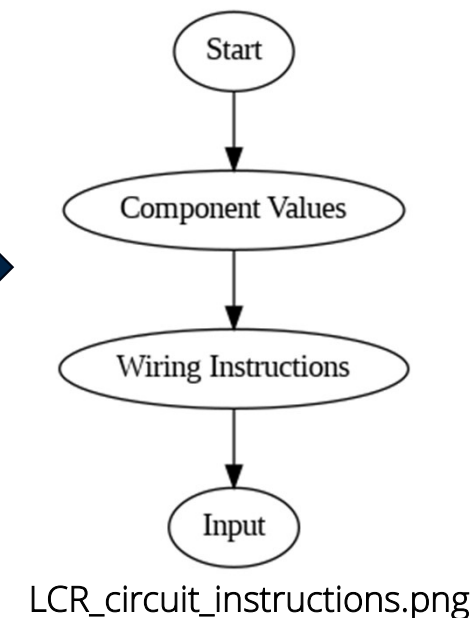
Google Colaboratory

Creating a Digraph Using an AI Large Language Model (LLM)

Improved Digraph Generated Model

```
🔗 Welcome to the Tuned LCR Circuit Wiring Software Agent!  
Please enter the following values:  
Frequency (in Hz): 60  
Inductance (in Henries): 300e-6  
Capacitance (in Farads): 2.2e-6  
Resistance (in Ohms): 300  
  
Instructions for Wiring a Tuned LCR Circuit:  
-----  
1. Connect the resistor (R) in series with the inductor (L) and capacitor (C).  
   Resistance (R): 300.0 ohms  
   Inductance (L): 0.0003H  
   Capacitance (C): 2.2e-06F  
  
2. Connect the inductor (L) and capacitor (C) in parallel.  
  
3. Finish wiring the circuit.  
  
Input Frequency: 60.0Hz  
Resonant Frequency (fr): 6195.10Hz
```

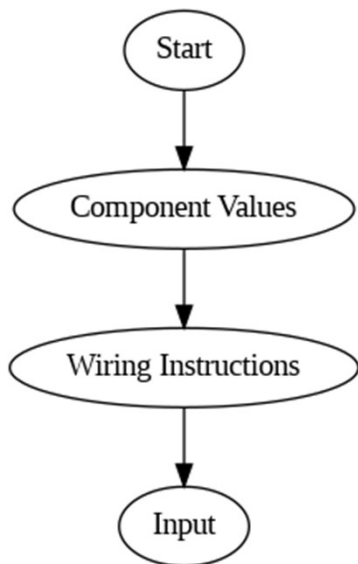
Google Colaboratory



Creating a Digraph Using an AI Large Language Model (LLM)...

Improved Digraph Generated Model

Google Colaboratory



Click Here!

LCR_circuit_instructions.png

```

    58 provide_instructions()
    59
  
```

Welcome to the Tuned LCR Circuit Wiring Software Agent!
Please enter the following values:
Frequency (in Hz): 60
Inductance (in Henries): 300e-6
Capacitance (in Farads): 2.2e-6
Resistance (in Ohms): 300

Instructions for Wiring a Tuned LCR Circuit:

1. Connect the resistor (R) in series with the inductor (L) and capacitor (C).
Resistance (R): 300.0 ohms
Inductance (L): 0.0003H
Capacitance (C): 2.2e-06F
2. Connect the inductor (L) and capacitor (C) in parallel.
3. Finish wiring the circuit.

Input Frequency: 60.0Hz
Resonant Frequency (fr): 6195.10Hz

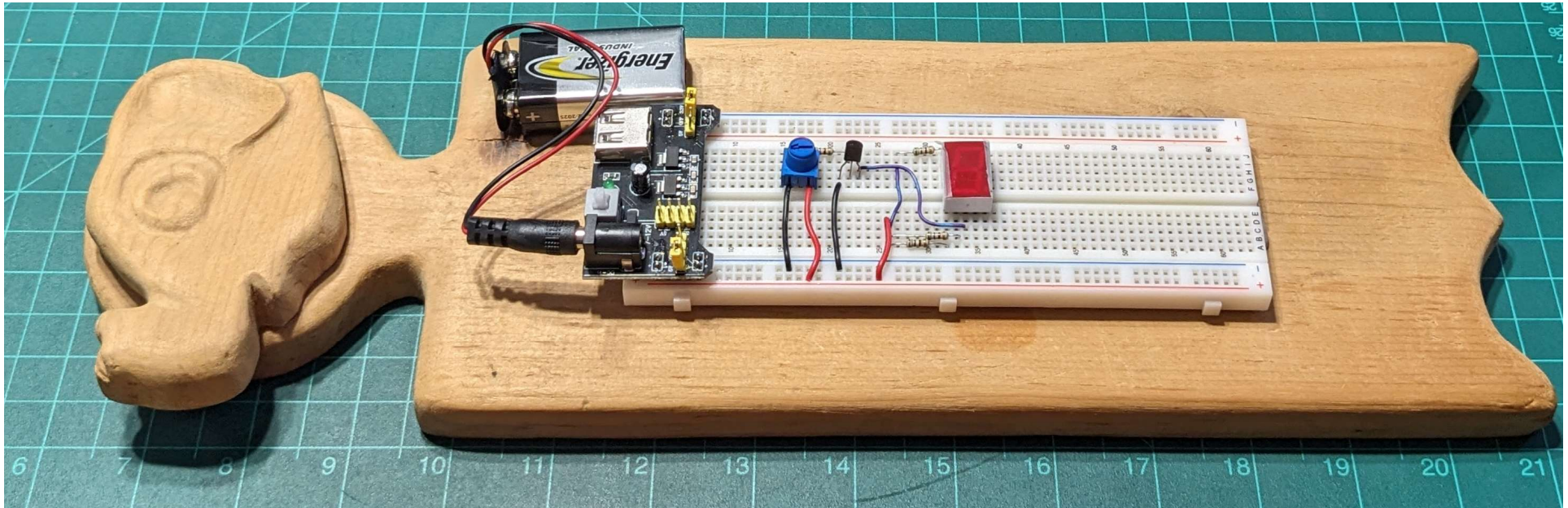
Question 4

What icon on slide 24 allows obtaining the LCR_circuit_instructions.png file?

- a) key**
- b) function symbol**
- c) reply**
- d) folder**



Lab: Build A 7 Segment LED Display Dimmer Controller



Lab: Build A 7 Segment LED Display Dimmer Controller...



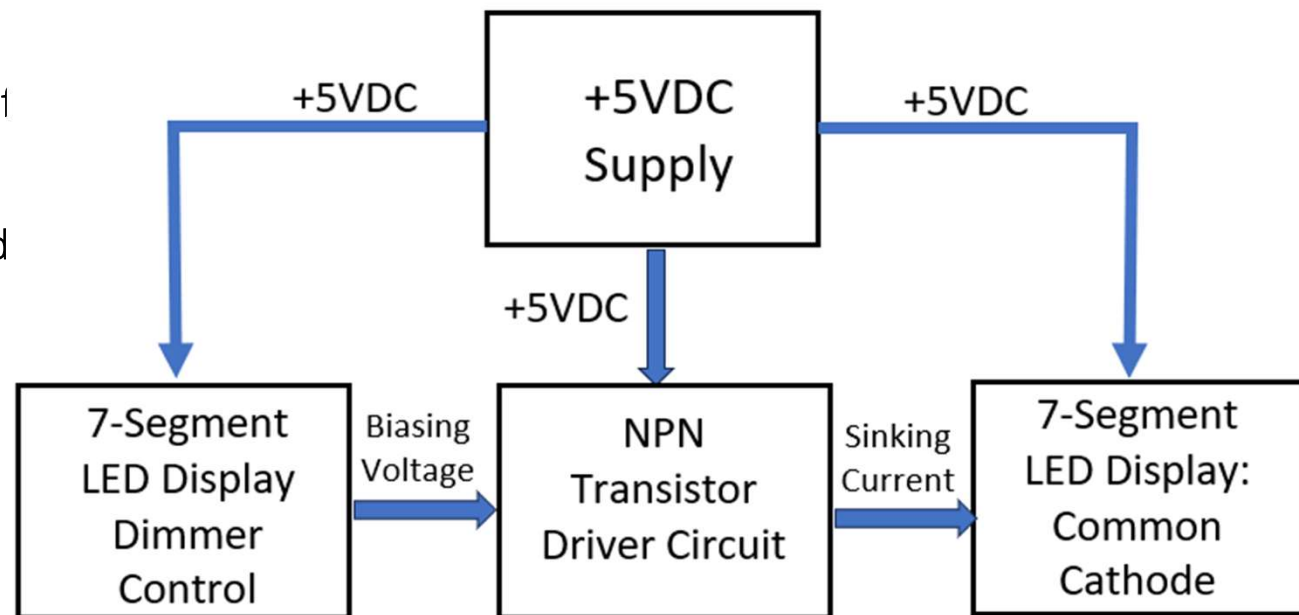
Lab Objectives:

- Participants will learn to capture parts data from a Block Diagram to construct an electronic circuit schematic diagram.
- Participants will learn to organize the wiring tasks in building a 7 Segment LED Display Dimmer Controller on a solderless breadboard.
- Participants will wire and test the 7 Segment LED Display Dimmer Controller on a solderless breadboard.

Lab: Build A 7 Segment LED Display Dimmer Controller...



Level 2 Block Diagram and Bill of Materials (BOM) will help to capture parts and organize the wiring tasks for the project build



Lab: Build A 7 Segment LED Display Dimmer Controller...



Source: E:\DWilcher F\DesignNews\CEC_courses\September_2024\Course_Sessions\Day3\7_Segment_LED_Display_Dimmer_Controller\7_Segment_LED_Display_Dimmer_Controller.kicad
 Date: #####
 Tool: Eeschema (6.0.4)
 Generator: C:\Program Files\KiCad\6.0\bin\scripting\plugins\bom_csv_grouped_by_value.py
 Componer 7

Individual Components:

Item	Qty	Reference	Value	LibPart	Footprint	Datasheet
		DISP1	HDSP-550	Display_C7	Display_7Segment:D1X8K	https://ia800903.us.archive.org/24/items/CTKD1x8K/Cromatek%20D168K.pdf
		Q1	PN2222	Device:Q_NPN_EBC		~
		R1	10K	Device:R_Potentiometer_US		~
		R2	560R	Device:R_US		~
		R3	560R	Device:R_US		~
		R4	560R	Device:R_US		~
		R5	560R	Device:R_US		~

Collated Components:

Item	Qty	Reference	Value	LibPart	Footprint	Datasheet
1	1	DISP1	HDSP-550	Display_C7	Display_7Segment:D1X8K	https://ia800903.us.archive.org/24/items/CTKD1x8K/Cromatek%20D168K.pdf
2	1	Q1	PN2222	Device:Q_NPN_EBC		~
3	1	R1	10K	Device:R_Potentiometer_US		~
4	4	R2, R3, R4, R5	560R	Device:R_US		~



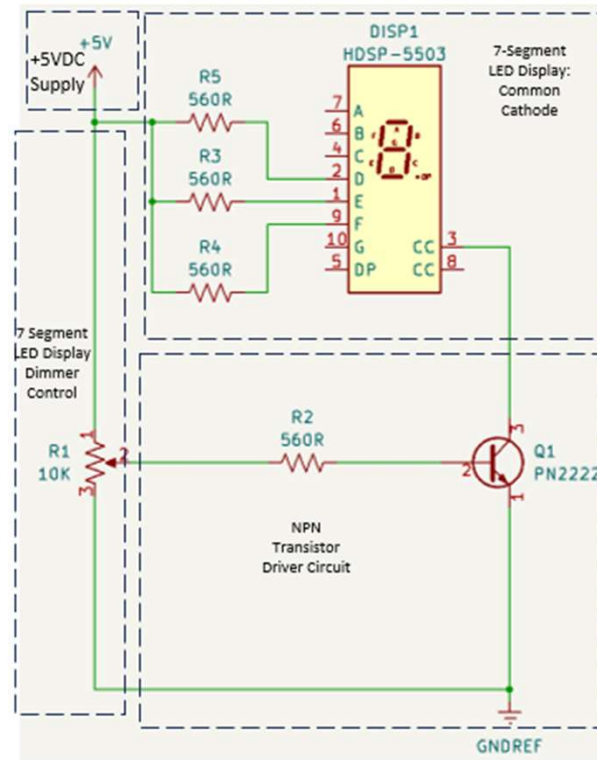
Notice the potentiometer

A Bill of Material (BOM) for the 7 Segment LED Display Dimmer Controller project.

Lab: Build A 7 Segment LED Display Dimmer Controller...



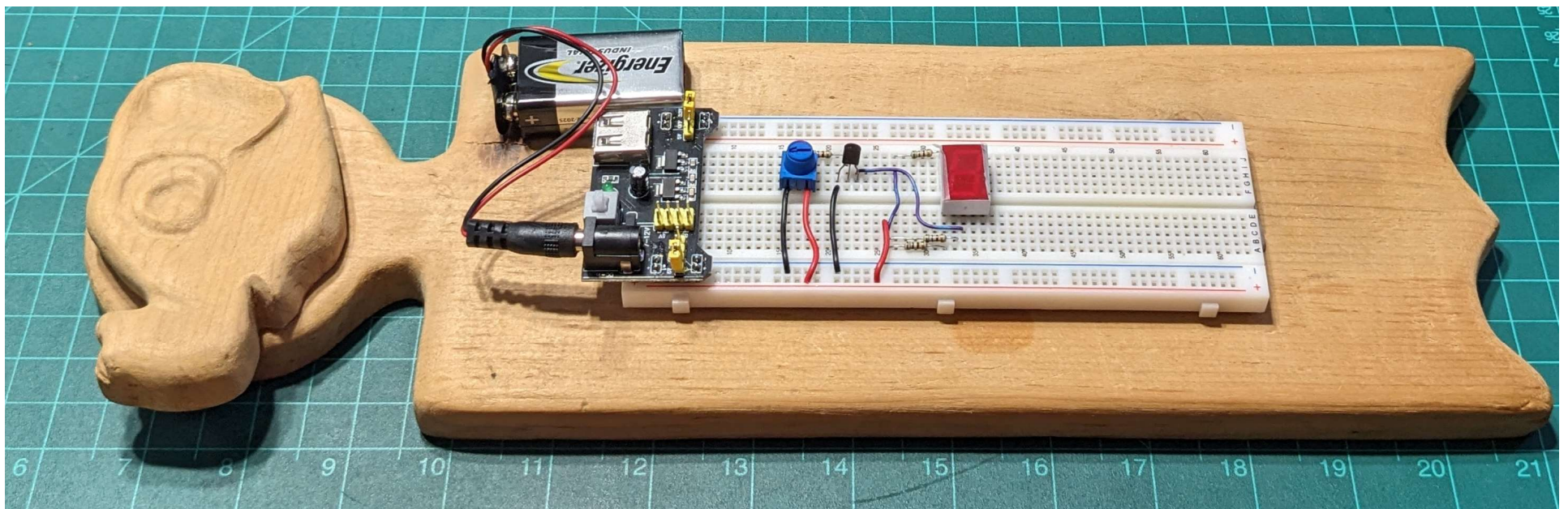
Partitioning the Electronic Circuit Schematic diagram into circuit blocks will aid in the task of electrical wiring on a solderless breadboard.



Lab: Build A 7 Segment LED Display Dimmer Controller...



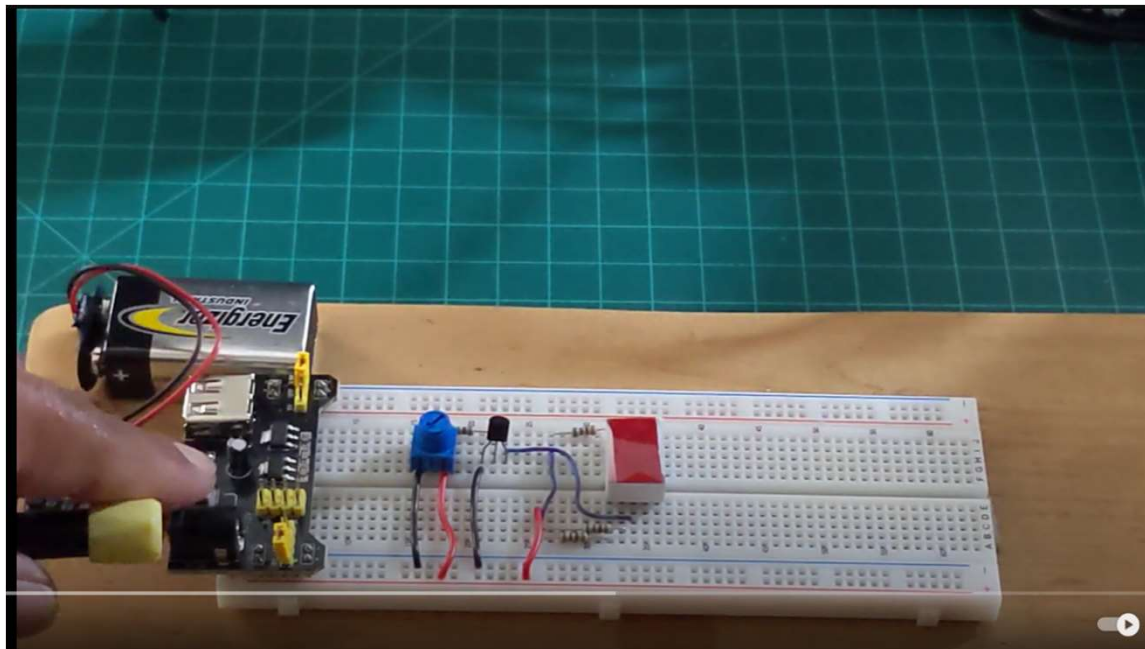
Final Project Build: Solderless Breadboard on an Elephant (E) Breadboard!



Lab: Build A 7 Segment LED Display Dimmer Controller...



Watch the YouTube Video clip for the actual operation of the electronic dimmer controller circuit.



<https://www.youtube.com/watch?v=DU4d2Kd6KJc>

Question 5

What reference designator on the 7 Segment LED Display Dimmer Controller project is used for the potentiometer?

- a) R2**
- b) R3**
- c) R1**
- d) R5**



Thank you for attending

Please consider the resources below:

Wilcher, D. (2024, February 12). *AI allows modeling plc programs at the component level.*
<https://www.designnews.com/artificial-intelligence/ai-allows-modeling-plc-programs-at-the-component-level>



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