

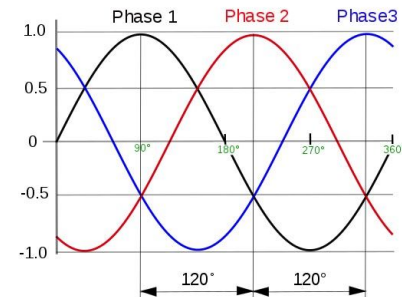
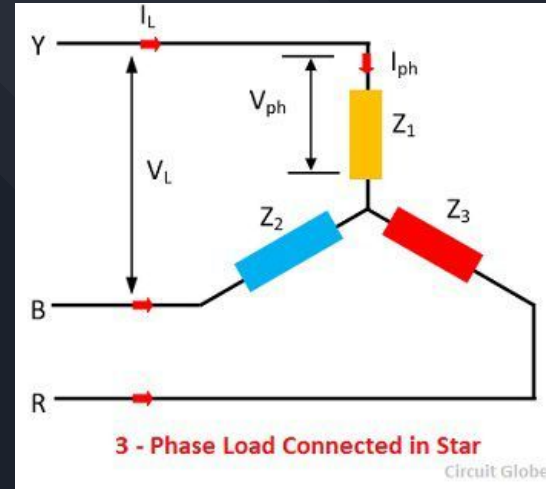


Load Balancing of Kitchens

Aditya Harakare

3 Phase Power

- Common method of AC power transmission
- Used for heavy loads and is more economical
- Constant power transfer to a balanced linear load.
- Can transmit 3 times as much power using just 1.5 times as many wires

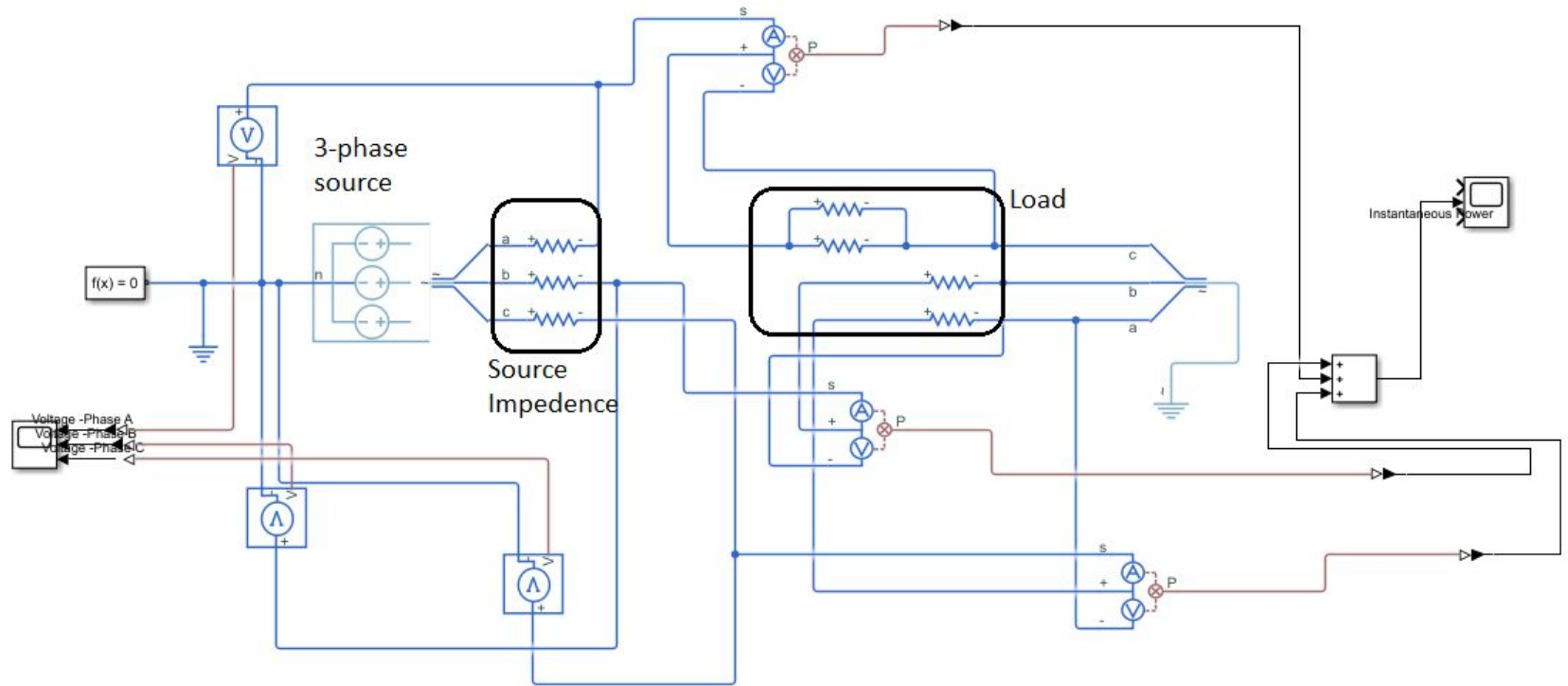


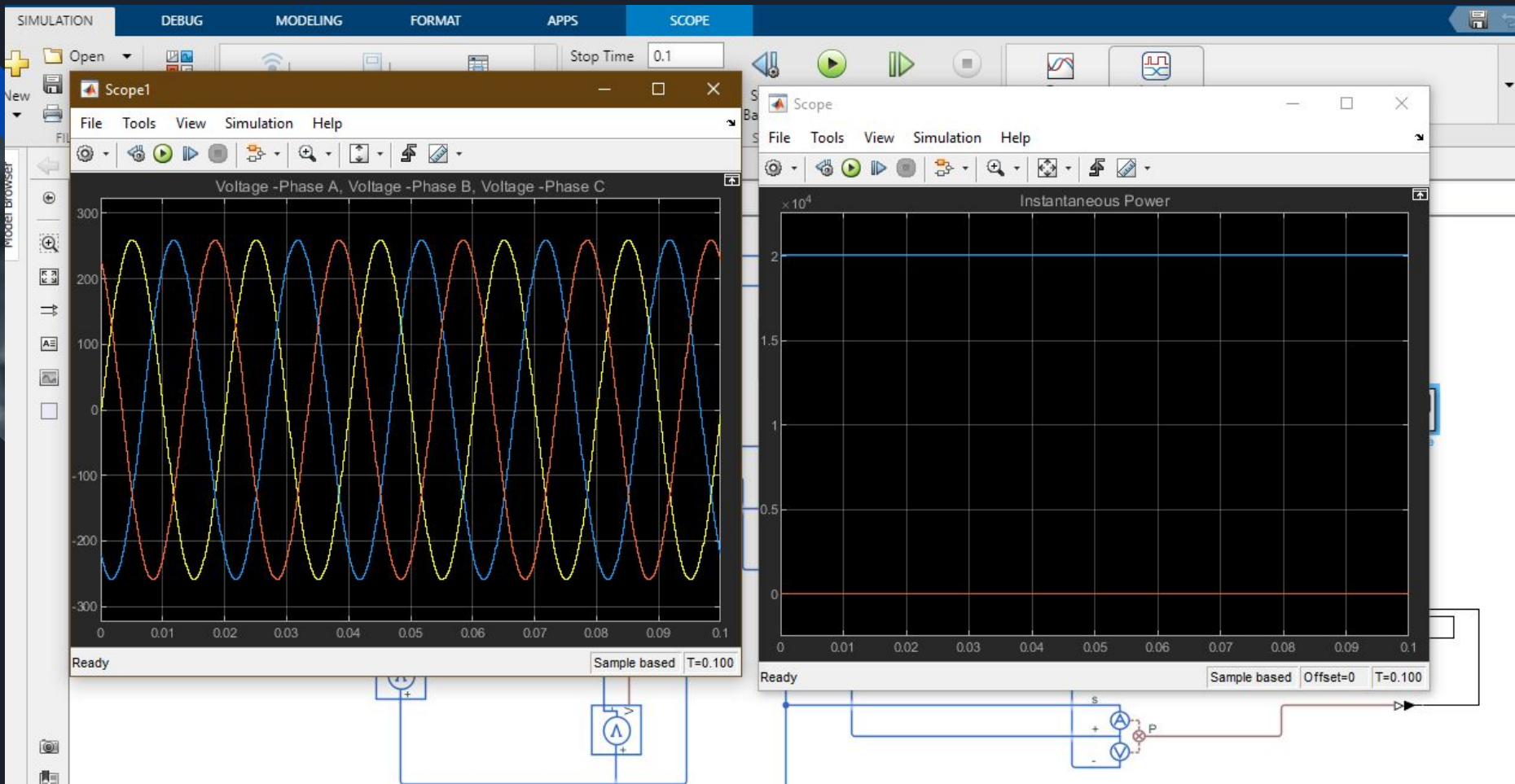


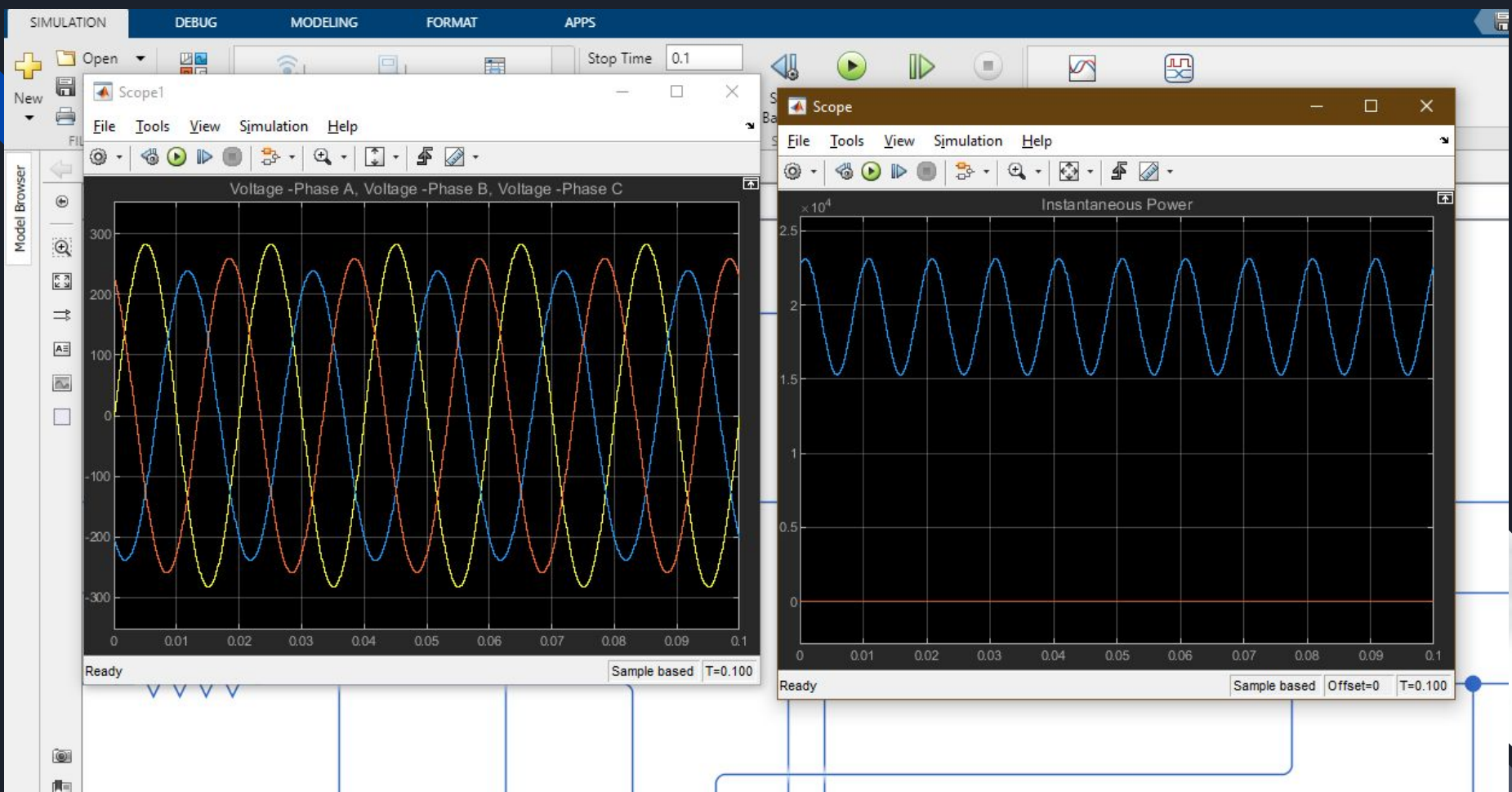
Need for the Balancing of Loads

- Minimize energy loss
- Neutral current = eddy current losses in the upstream transformer
- Ensure equal voltage magnitude and phase at the load side

Simulations









Load Balancing Software

Inputs: Equipment Specifications

Output: Load Balancing Schema

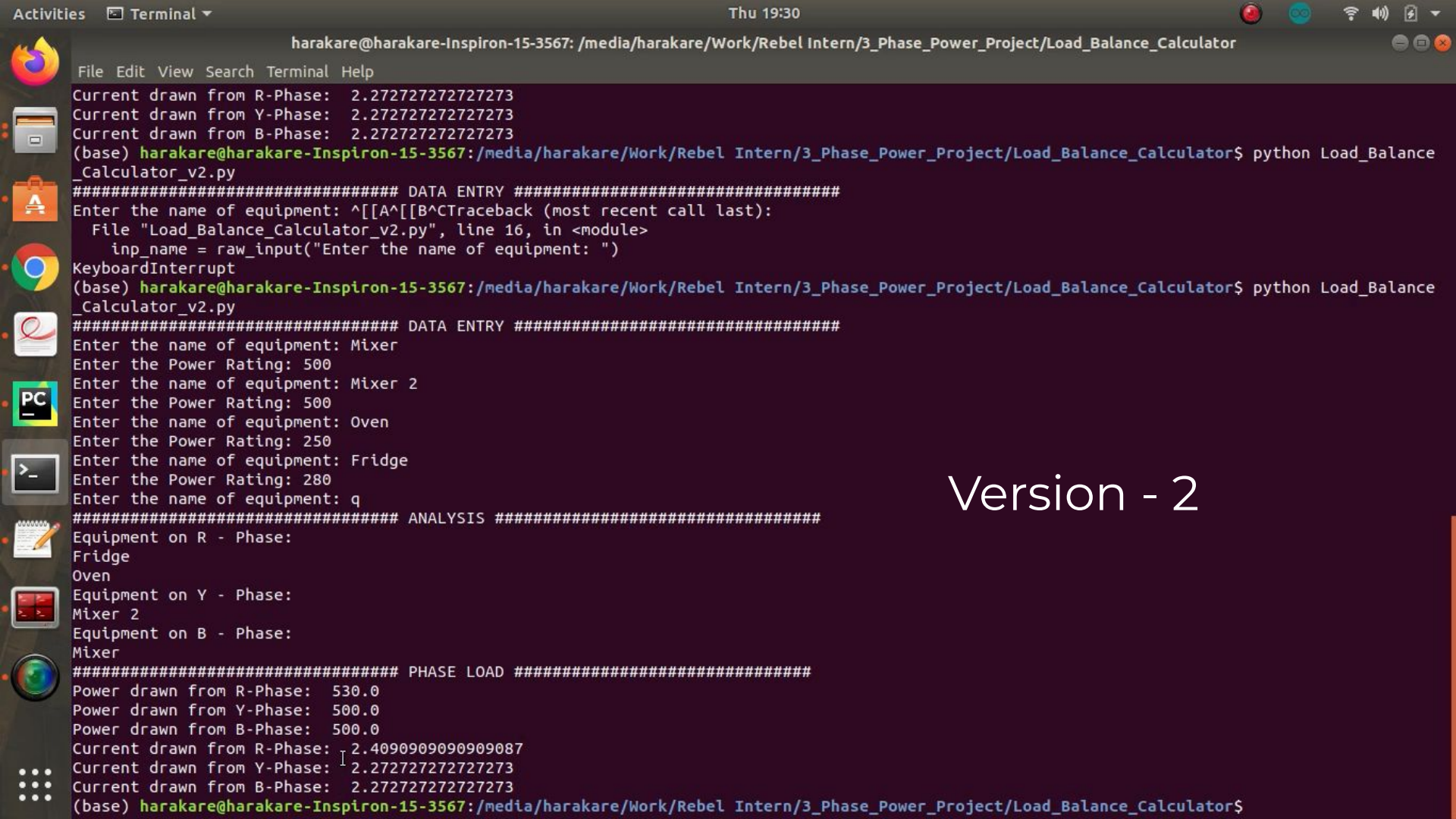
```

# Sort the array of single phase equipments in descending order
single_ph_array = sorted(single_ph_array, key=itemgetter(1), reverse=True)

# Assign each equipment of single phase array either to R/Y/B phase depending on the existing loads
# The equipment with highest power requirement gets assigned first
# The phase with the minimum load gets assigned the next equipment in the sorted array
for i in range(0, len(single_ph_array)):
    sum_r = sum(r_ph_power)      # Maintain Counter for current phase load
    sum_y = sum(y_ph_power)      # Maintain Counter for current phase load
    sum_b = sum(b_ph_power)      # Maintain Counter for current phase load
    if sum_r < sum_y:
        if sum_r < sum_b:
            r_array.append(single_ph_array[i])
            r_ph_power.append(single_ph_array[i][1])
        else:
            b_array.append(single_ph_array[i])
            b_ph_power.append(single_ph_array[i][1])
    elif (sum_y < sum_b):
        y_array.append(single_ph_array[i])
        y_ph_power.append(single_ph_array[i][1])
    else:
        b_array.append(single_ph_array[i])
        b_ph_power.append(single_ph_array[i][1])

```

Resistive Single Phase Loads Algo



harakare@harakare-Inspiron-15-3567: /media/harakare/Work/Rebel Intern/3_Phase_Power_Project/Load_Balance_Calculator

File Edit View Search Terminal Help

```
(base) harakare@harakare-Inspiron-15-3567: /media/harakare/Work/Rebel Intern/3_Phase_Power_Project/Load_Balance_Calculator$ python Load_Balance_Calculator_v3.py
```

```
##### DATA ENTRY #####
```

```
Enter "q" as the name when data entry is complete
```

```
Enter the name of equipment: Dosa Maker
```

```
Enter no of phases required by equipment (1 or 3): 3
```

```
Enter the Power Rating (Watts): 1200
```

```
Enter the name of equipment: Fan
```

```
Enter no of phases required by equipment (1 or 3): 1
```

```
Enter the Power Rating (Watts): 450
```

```
Enter the name of equipment: Light
```

```
Enter no of phases required by equipment (1 or 3): 1
```

```
Enter the Power Rating (Watts): 550
```

```
Enter the name of equipment: Fridge
```

```
Enter no of phases required by equipment (1 or 3): 1
```

```
Enter the Power Rating (Watts): 500
```

```
Enter the name of equipment: q
```

```
##### ANALYSIS #####
```

```
Equipment on R - Phase:
```

```
Fan
```

```
Dosa Maker (3-phase)
```

```
-----
```

```
Equipment on Y - Phase:
```

```
Fridge
```

```
Dosa Maker (3-phase)
```

```
-----
```

```
Equipment on B - Phase:
```

```
Light
```

```
Dosa Maker (3-phase)
```

```
##### PHASE LOAD #####
```

```
Power drawn from R-Phase: 850.0 Watts
```

```
Power drawn from Y-Phase: 900.0 Watts
```

```
Power drawn from B-Phase: 950.0 Watts
```

```
Current drawn from R-Phase: 3.8636363636363638 A
```

```
Current drawn from Y-Phase: 4.090909090909091 A
```

```
Current drawn from B-Phase: 4.318181818181818 A
```

```
##### END #####
```

```
(base) harakare@harakare-Inspiron-15-3567: /media/harakare/Work/Rebel Intern/3_Phase_Power_Project/Load_Balance_Calculator$
```

Version - 3

Addition of 3-phase loads

Version - 4

1 ##### Load Balance Results #####

2 Equipment on R - Phase:

3 Auto Fryer

4 Auto Fryer_2

5 Bain Marie_3

6 Bain Marie_6

7 Proofer

8 Under Counter Chiller

9 Vertical Chiller

10 Microwave_2

11 Impinger Oven-T98G

12 Mixer Grinder

13 Combi Oven(3-phase)

14 Walk-In Cold

15 -----

16 Equipment on

17 Dosamatic

18 Bain Marie

19 Bain Marie_

20 Idli Steamer

21 Under Count

22 UPS

23 Microwave_4

24 Deep Freezer_2

25 Computer

26 Display

27 Display_2

28 Display_4

29 Combi Oven(3-phase)

30 Walk-In Cold Room(3-phase)

31 -----

32 Equipment on B - Phase:

33 Infra Red Routing Table

34 Bain Marie_2

35 Bain Marie_5

36 Rice Cooker

37 Makeline

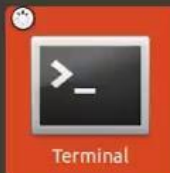
38 Microwave



Text Editor



Files



Terminal



LibreOffice Calc



Simplescreenr...



Google Chrome



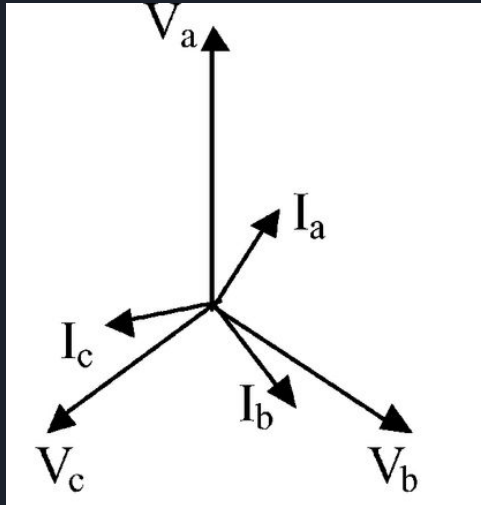
X-terminal-em...

Version - 4

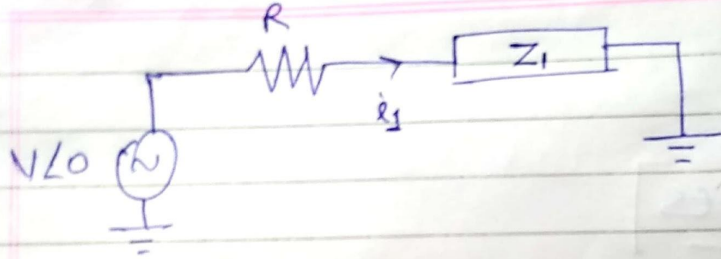


Version - 5

- Addition of inductive and capacitive loads.
- Current is not in phase with the voltage
- Exactly what do we minimize?



Minimize Difference in $|z|$?



Let's say the power line in each phase has a small resistance R .

$$\therefore \text{Voltage across } Z_1 = V_L0 - i_1 R$$
$$\text{where } i_1 = \frac{V_L0}{R + Z_1} \approx \frac{V_L0}{Z_1} \quad (Z_1 \gg R)$$

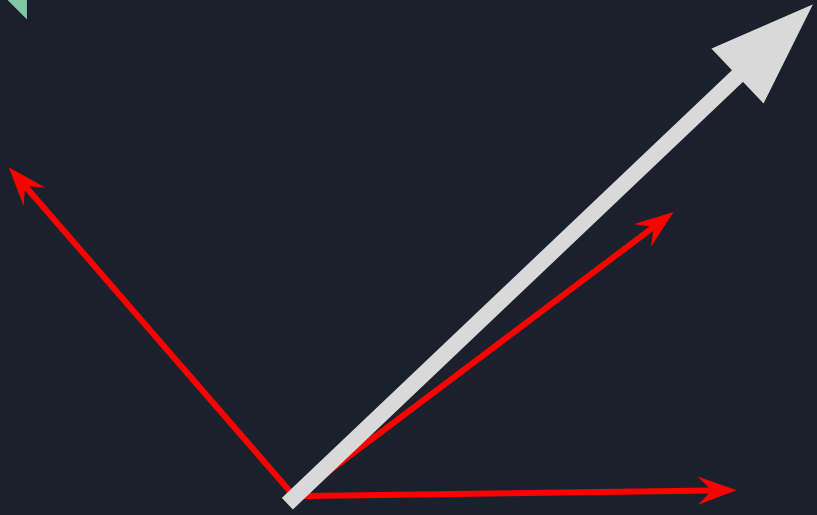
Minimize Difference in $|z|$?

Let's try to make the magnitude of current through each phase equal.

$$\Rightarrow \frac{V}{|Z_1|} = \frac{V}{|Z_2|} = \frac{V}{|Z_3|}$$

$$\Rightarrow |Z_1| = |Z_2| = |Z_3|$$

This will give us the fastest algorithm of first finding $|Z|$ of each device and then arrange them in decreasing order and divide among three phases



Large Neutral Current

Minimize the Neutral Current?

$$\text{Neutral current} = \vec{i}_1 + \vec{i}_2 + \vec{i}_3$$

$$= V \left[\frac{1}{Z_1} + \frac{1}{2Z_2} + \frac{1}{2Z_3} \right] + i \left[\frac{\sqrt{3}}{2Z_2} - \frac{\sqrt{3}}{2Z_3} \right]$$

(We can observe that $Z_1 = Z_2 = Z_3$ makes neutral current = 0)

Hence with all the PnC of Z_1, Z_2 & Z_3 we can compute the above function and find Z_1, Z_2, Z_3 for which function is minimum.

Note this algorithm will require 3^n computations



Minimize the Neutral Current?





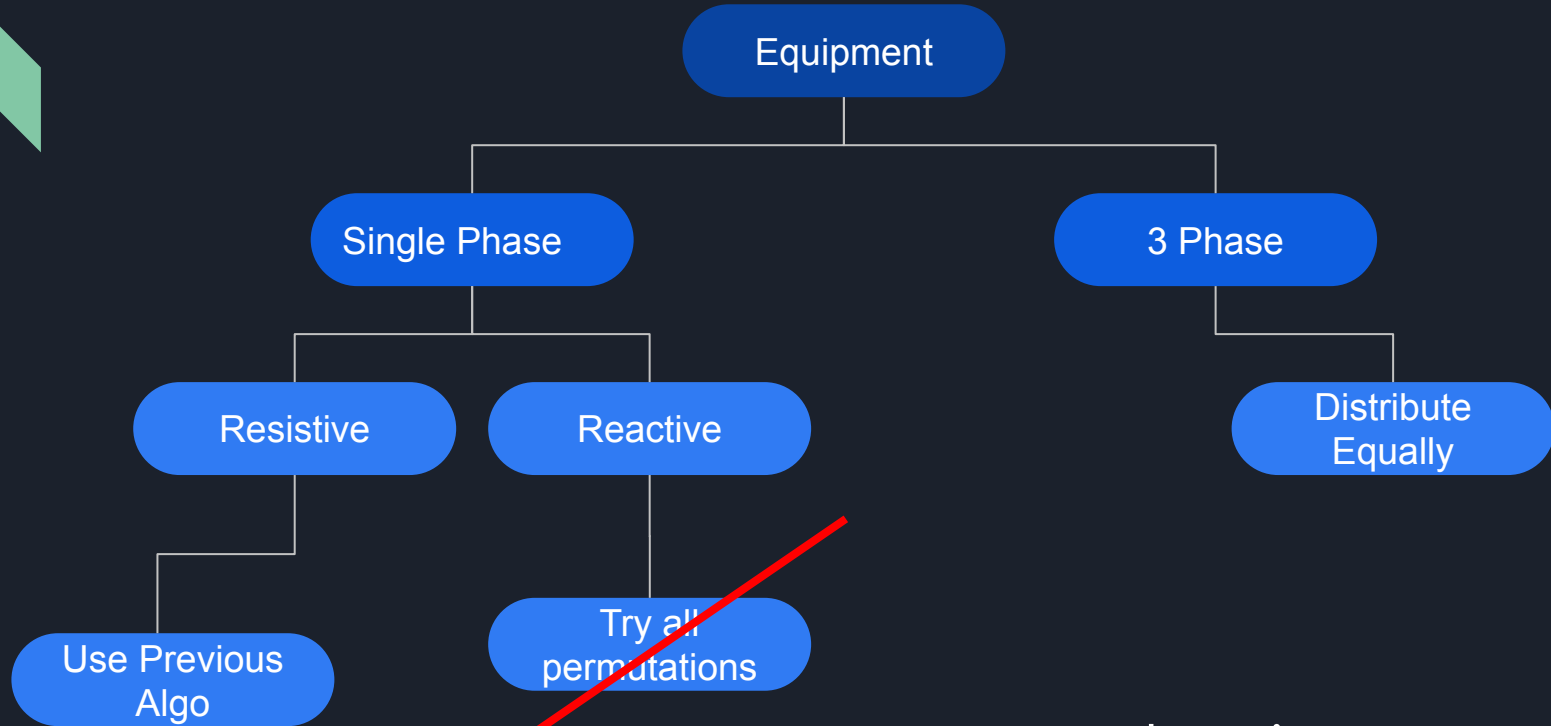
Try to make $Z1 = Z2 = Z3$

Define a loss function:

$$f(Z1, Z2, Z3) = |Z1 - Z2| + |Z2 - Z3|$$

Find $Z1$, $Z2$ and $Z3$ for which f is minimum

Need to try all 3^N combinations
 $3!$ to be precise



~~Try all permutations~~
Just Use prev algo

Works Fine!!!



Questions ??

Thank You!