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Performance of Power System Installation Tool Kits Electricity 1 ϕ and 3 ϕ As Practicum Kits at the Power Electronics Laboratory

Irwansyah[a,1,*], Nuzuli Fitriadi[b,2], Lindawati[c,3] Mukhsan[d,4], Isma[e,5]

[a,b,d,e] *South Aceh Polytecnic, Jl. Reklamasi Pantai Tapaktuan and 23711, Indonesia*
[c] *Universitas Abulyatama, Jl. Blangbintang Lama, Aceh Besar, Indonesia*

[1] *rasyadoank.id@gmail.com*; [2] nuzuli.fitriadi@gmail.com; [3] lindawati203@gmail.com,*
[4] *mukhsangaki@gmail.com, [5]ismaramlan@gmail.com*

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ABSTRACT

A series circuit is a parallel circuit or a circuit system that connects from a voltage source (V) to a load, while a parallel circuit is a branching circuit that connects from a voltage source to a load. The measurement process in the electric power system is one of the standard procedures that must be carried out. Through the measurement, the required quantities will be obtained following the requirements of PUIL 2000. Three phases by making a series and parallel installation circuit. The method used in this research is to test, measure and calculate the value of voltage (V), current (I), resistance (R) and load power (P) in a series of single-phase and three-phase electrical installations in series and parallel. Based on measurements and calculation results, the maximum total current generated in a single-phase series circuit installation is 82.57 Ampere, which applies equally to L1, L2, L3 and L4. The maximum total current generated in a parallel circuit is 129.35 Amperes at L1 and a minimum current of 96.29 Amperes at L4. The maximum real power (P) generated in a single-phase series installation is 13872 Watts and in parallel circuits is 21523 Watts, for the maximum apparent power (S) generated in a single-phase series installation is 17339 Watts and in parallel circuits is 26904 Watt. Simultaneously, the maximum total current generated in a three-phase series installation is 94.33 Amperes, which applies equally to L1, L2, L3 and L4. The maximum total current generated in a parallel circuit is 150.56 Amperes at L1, and a minimum current of 120.17 Amperes is located at L4. The maximum real power (P) generated in a three-phase series installation is 34637 Watt and, in a parallel circuit, is 54876 Watt. The maximum apparent power (S) generated in a series circuit is 43297 Watt and in a parallel circuit is 68595 Watt.

I. Introduction

The ability to understand testing the characteristics of one-phase and three-phase AC electrical installation circuits based on current and voltage with phases and power in an electrical circuit is one of the main competencies that must be mastered by graduates of the Mechanical Engineering Study Program of the South Aceh Polytechnic. The practical tools are needed to make it easier for students to understand theoretically and practice these competencies. In addition to the existing practicum tools, this tool's availability is expected to be able to practice students in conducting testing because all components have been neatly arranged and designed. Three-phase electrical installations are AC (alternating current) electrical installations that use 3 (three) conductors and have the same voltage but differ in their phase angle by 120 degrees. In general terms, this three-phase system consists of 3 (three) 380 Volt voltage cables and 1 (one) neutral wire notated with "N" or more familiarly known as the R-S-T-N system. There are two kinds of relationships in the three conductor connections: star

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("Y" or star) connection and delta connection. According to the shape, one like the letter "Y" and the other like the symbol "delta." So in this research, a single-phase and three-phase electric power system installation kit will be tested by making a series and parallel installation circuit and taking measurements using an electrical measuring instrument on the installation tool components. So it is hoped that students will be able to know about how to install one-phase three-phase fan electricity and be skilled in using measuring instruments to find out the value of voltage (V), current (I), resistance (R) and load power (P) flowing in a circuit (1).

II. Literature Review

A. Electric Power Installation System (STL)

Electric Power Installation is installing electrical equipment components from generation to consumer to serve the change of electrical energy into mechanical power [3].

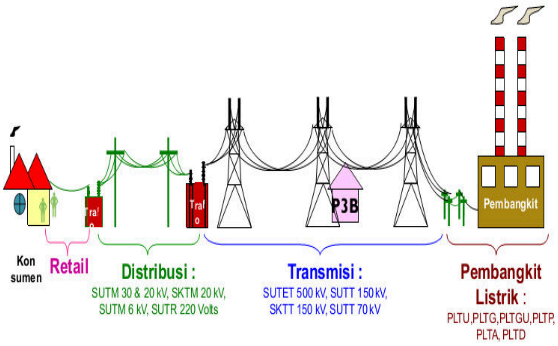

Figure 1. Electric Power System Installation Classification

The electrical energy used needs. It's must be efficient, effective, of good quality and reliable. This means that the generation and distribution of energy must be carried out economically and rationally. To achieve this goal, it turns out that many obstacles must be faced; this is due to the occurrence of events in the electric power system (TL), which are random. Simultaneously, the operating conditions can change if there is a change in load and the discharge of network equipment on the system randomly. This, of course, will cause operating deviation. For this reason, it is necessary to carry out thorough surgical preparation so that the deviation is relatively small.

B. Power System Electrical Installation Requirements

The power system electrical installation can be divided into 3 (three) types, as follows [4]:.

1. Economical Requirements

   Electrical installations must be made in such a way that the price of the entire installation, the installation costs, and the maintenance costs are as cheap as possible. The power losses must be as small as possible. The maximum voltage loss is 5% of the source voltage.

2. Security and Safety Requirements

   Electrical installations must be made in such a way that the possibility of an accident is minimal. Safe, in this case, means not endangering the safety of human life, ensuring the equipment and objects around it from damage due to disturbances such as short circuit failure, overload disturbance, over-voltage interference.

3. Reliability Requirements

   The reliability requirement is that the continuity of providing/flowing electric current to the load/consumers of electricity users must be appropriately guaranteed. So the power installation must be planned so that the possibility of stopping the flow of electricity is minimal.

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C. Definition of Three Phase Electrical Installation

Three-phase electrical installations are electrical installations that use three-phase wires and one 0 wire (neutral) or ground wire. According to the term, three-phase electricity consists of three wires (R-S-T) with electric voltage and one neutral wire (N). Generally, three-phase electricity with a 380V voltage widely used in industries or three-phase power plants is AC (alternating current) electricity, which uses three conductors with the same voltage but differ in a phase angle of 120 degrees. There are two kinds of relationships in the three-conductor connection, namely the star relationship ("Y" or Star) and the delta relationship (Δ). There are two kinds of voltage known in this three-phase system are as follows [4] :

1. The voltage between phases Vpp: phase to phase voltage or some use the term voltage line.
2. Phase voltage to neutral Vpn: phase voltage to neutral or voltage line to neutral.

D. Equations Used in Electrical Installation Calculations

In the design and manufacture of electric power system installation kits, the equations to be used are calculating current, calculating voltage, resistance, and electric power based on ohm's law [7].

Calculate the amount of voltage (volts) equal to the amount of current (I) multiplied by the amount of resistance (R).

$$V = I \, x \, R \quad (1)$$

To calculate the amount of current (I), the amount of voltage (volts) is inversely proportional to the amount of resistance (R).

$$I = \frac{V}{R} \quad (2)$$

Meanwhile, to calculate the amount of resistance (R) is equal to the magnitude of the voltage (volts) is inversely proportional to the amount of current (I).

$$R = \frac{V}{I} \quad (3)$$

Where :

V = The amount of potential difference or voltage (Volt)
I = Amount of Current (Ampere)
R = The amount of resistance (Ohm)

E. Definition and equations of series and parallel electric circuits

Series, parallel and mixed electrical circuits have different characteristics and formulas. For more details, see further discussion of the characteristics of series, parallel, and mixed electrical circuits below [6].

1. Series Electric Circuits

   A series can be straightforward because the series is arranged in a straight line and has no branches. Characteristics of Series Electrical Circuits [8] :

   a. How to arrange a series tends to be practical and straightforward.
   b. All electrical components are arranged in parallel (in a row or sequence).
   c. Connecting cables on all components have no branches along the circuit.
   d. There is only one path for the current to pass, so if there is one path that is lost, then the
   e. the circuit cannot function properly.
   f. The electric current flowing at various points in the circuit is the same.
   g. Each component installed will get the same current.
   h. The potential/voltage difference on each component installed has a different value.
   i. Has a total resistance that is greater than the constituent resistance.

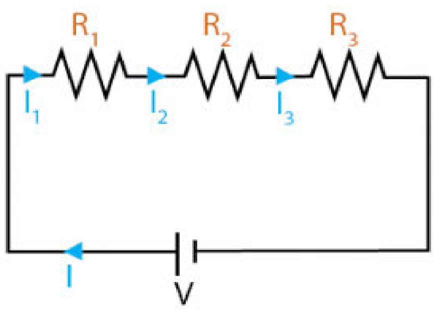

Figure 2. Series Electric Circuits

Based on the ohm law V = I x R, the series circuit can be formulated :

$I = I_1 = I_2 = I_3$ (4)

$V = V_1 = V_2 = V_3$ (5)

$R = R_1 = R_2 = R_3$ (6)

2. Paralel Electric Circuits

Parallel circuits have a recognizable feature; namely the arrangement of the series has branches. Electrical installations in a house usually use a parallel circuit arrangement. Although it is slightly more complicated than a series circuit, parallel circuits have many advantages. Characteristics of Parallel Electrical Circuits [8] :

a. The method of arranging the sequence tends to be more complicated
b. All electrical components are installed in sequence or parallel.
c. The connecting cable in a circuit has branches.
d. Currents can traverse several paths.
e. The current flowing in each branch has a different value.
f. Each component that is installed gets a different current.
g. All components get the same voltage.
h. The total resistance is smaller than the resistance for each constituent component.

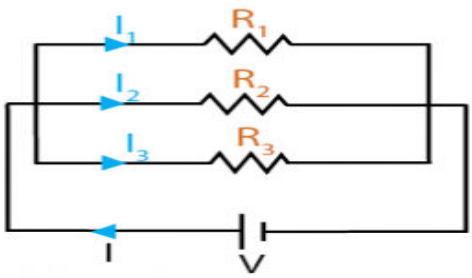

Figure 3. Parallel Electric Circuits

Then the parallel circuit formula used is [8]:

$I = I_1 + I_2 + I_3$ (7)

$V = V_1 = V_2 = V_3$ (8)

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (9)

$I_1 : I_2 : I_3 = \frac{1}{R_1} : \frac{1}{R_2} : \frac{1}{R_3}$ (10)

F. Calculation of Power in Single-Phase and Three-Phase Electrical Circuits

Electrical power is the amount of energy absorbed or generated in a circuit. Energy sources such as electric voltage will produce electric power while the load connected to it will absorb the electric power. In other words, electric power is the level of energy consumption in a circuit or electrical circuit. The formula used to calculate electrical power in an electric circuit is as follows [7]:

$P = V \times I$ (11)

$P = I^2 \times R$ (12)

$P = V^2 / R$ (13)

Where :
P = Electrical Power (Watt)
V = Electrical Voltage (Volt))
I = Electric Current (Ampere)
R = Electrical Resistance (Ohm)

Real power is the electrical power used for electrical installations in a series, either in series or parallel or in the panel kit's electric power system installation *components.*

The line to neutral / three-phase :

$$P = \sqrt{3} \text{ x } V \text{ x } I \text{ x } \text{Cos } Ø \quad (14)$$

$$I = \frac{P}{\sqrt{3}\, x\, V\, x \cos \varphi} \quad (15)$$

Where :
P = Real Power (P)
V = Voltage (V)
I = The current that flows in the conductor (Ampere)
Cos Ø = The power factor, which has a value of 0.8.

Pseudo power is electric power through a transmission or distribution carrier. This power is the product of the voltage and current through the conductor.

The line to neutral / three-phase :

$$S = \sqrt{3} \text{ x } V \text{ x } I \quad (16)$$

Where :
S = Real Power (P)
V = Voltage (Volt)
I = The current that flows in the conductor (Ampere)

III. Research Methods

The methods used in testing the one-phase and three-phase electric power system installation kits are as follows :

1. Looking for literature studies on measurement and electrical installation.
2. Design of single-phase and three-phase installation circuit drawings.
3. Preparation of tools and materials for testing on electric power system installation of panel kits.
4. Testing of electric power system installation kits, measuring the value of voltage (V), current (I), resistance (R) and load power (P) in the installation circuit.
5. Perform installation calculations of single-phase electrical circuits, both series and parallel, based on the electrical installation formulation.
6. Data collection and data analysis.

IV. Results and Discussion

A. Results of Design Drawings of One-Phase and Three-Phase Series and Parallel Electrical Installations Testing Series

Before testing the electrical circuit installation in series and parallel on the panel kit's electric power system installation, it is necessary to design a series of one-phase and three-phase electrical installation circuit drawings so that the drawing design results can be seen in Figure 4 below :

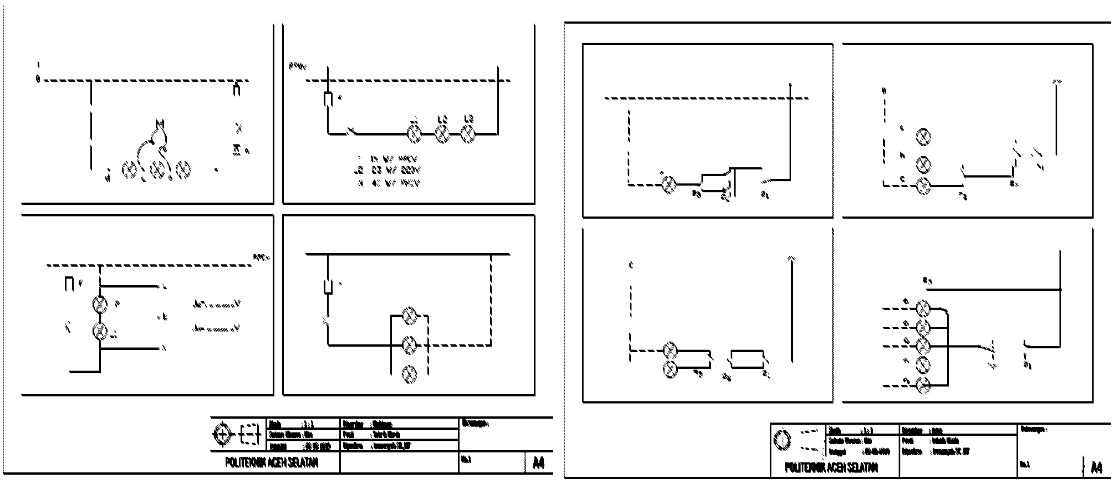

Figure 4. Single-Phase and Three-Phase Electrical Circuit Designs

B. Results of Testing One-Phase Electrical Installations in Series and Parallel Electrical Installations

The tests carried out in this research are stringing the cables on the electric power system panel kits in series and parallel, then measuring the voltage (V), current (I), resistance (R) and load power (P) in a single-phase installation circuit. For testing activities and measurement results can be seen in the Table and Figure below

Table 1. Measurement and Calculation Results in 1-Phase Electrical Circuits in Series

No	Voltage (V)	Current (I)	Resistance (R)	Total Current
1	L1 = 210 Volt	L1 = 3,35 Ampere	L1 = 2,543 Ohm	82,57 Ampere
2	L2 = 210 Volt	L2 = 3,35 Ampere	L2 = 2,543 Ohm	82,57 Ampere
3	L3 = 210 Volt	L3 = 3,35 Ampere	L3 = 2,543 Ohm	82,57 Ampere
4	L4 = 210 Volt	L4 = 3,35 Ampere	L4 = 2,543 Ohm	82,57 Ampere

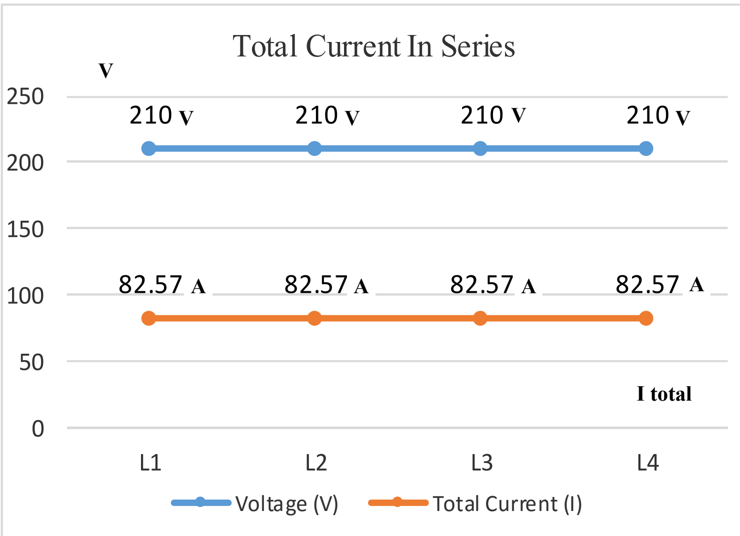

Figure 5. Graph of Total Current Calculation in 1 Phase Electric Circuit in Series

Table 1 and Figure 4 in the graph above show that with the input voltage in the 1-phase circuit of 210 volts, the total current flowing in each lamp (L1, L2, L3 and L4) is 82.57 Ampere.

Table 2. Measurement and Calculation Results in 3-Phase Electrical Circuits in Series

No	Voltage (V)	Current (I)	Resistance (R)	Total Current
1	L1 = 270 Volt	L1 = 4,50 Ampere	L1 = 2,543 Ohm	94,33 Ampere
2	L2 = 270 Volt	L2 = 4,50 Ampere	L2 = 2,543 Ohm	94,33 Ampere
3	L3 = 270 Volt	L3 = 4,50 Ampere	L3 = 2,543 Ohm	94,33 Ampere
4	L4 = 270 Volt	L4 = 4,50 Ampere	L4 = 2,543 Ohm	94,33 Ampere

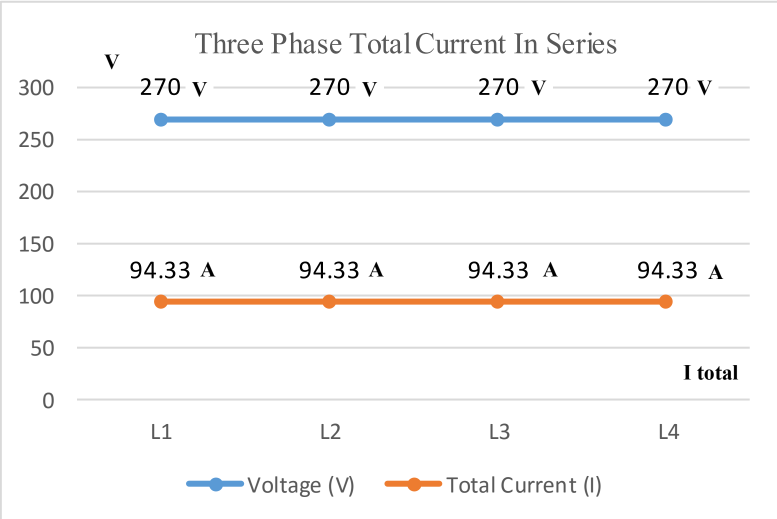

Figure 5. Graph of Total Current Calculation in 3 Phase Electric Circuit in Series

Table 2 and Figure 5 in the graph above show that with the voltage input in the 1-phase circuit of 270 volts, each lamp's total current (L1, L2, L3 and L4) is 94.33 Ampere.

Table 3. Results of Measurements and Calculations in Parallel 1 Phase Electrical Circuits

No	Voltage (V)	Current (I)	Current (R)	Total Current(I)
1	L1 = 208 Volt	L1 = 3,37 Ampere	L1 = 1,608 Ohm	129,35 Ampere
2	L2 = 208 Volt	L2 = 3,37 Ampere	L2 = 1,726 Ohm	120,50 Ampere
3	L3 = 208 Volt	L3 = 3,36 Ampere	L3 = 1,974 Ohm	105,36 Ampere
4	L4 = 208 Volt	L4 = 3,36 Ampere	L4 = 2,160 Ohm	96,29 Ampere

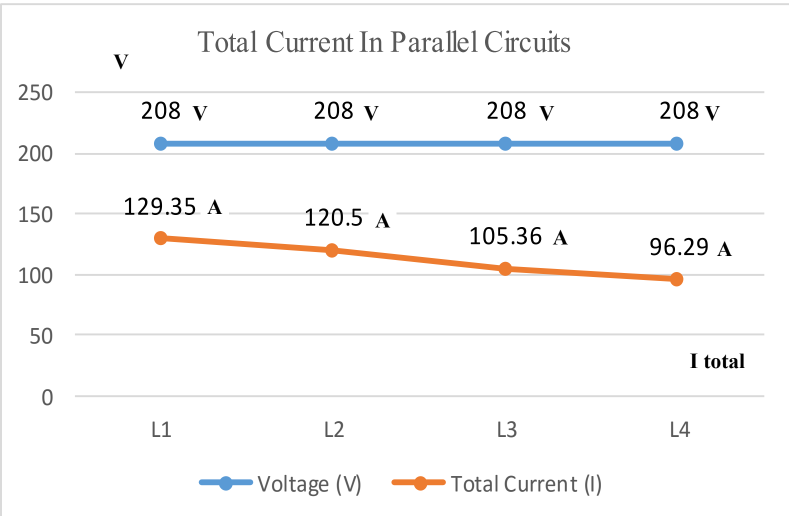

Figure 6. Graph of Calculation of Total Current in Parallel 1 Phase Electrical Circuits

Figure 6 in the graph above shows that with the input voltage in the 3-phase circuit of 208 volts, the total current flowing in each lamp is L1 = 129.35 Ampere, L2 = 10.50 Ampere, L3 = 105.36 Ampere and L4 = 96.29 Amperes.

Table 4. Measurement and Calculation Results in Parallel 3-Phase Electrical Circuits

No	Voltage (V)	Current (I)	Resistance (R)	Total Current
1	L1 = 268 Volt	L1 = 4,59 Ampere	L1 = 1,780 Ohm	150,56 Ampere
2	L2 = 268 Volt	L2 = 4,59 Ampere	L2 = 1,826 Ohm	146,76 Ampere
3	L3 = 268 Volt	L3 = 4,70 Ampere	L3 = 1,978 Ohm	135,50 Ampere
4	L4 = 268 Volt	L4 = 4,70 Ampere	L4 = 2,230 Ohm	120,17 Ampere

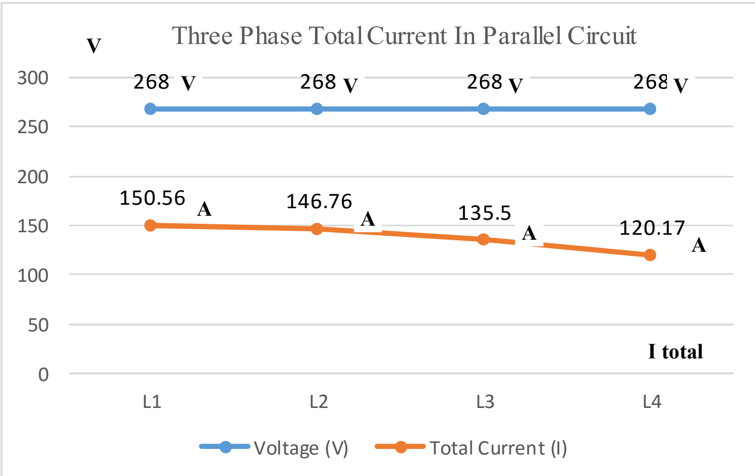

Figure 7. Graph of Calculation of Total Current in Parallel 3 Phase Electrical Circuits

Figure 7 in the graph above shows that with the input voltage in a 3-phase circuit of 268 volts, the total current flowing in each lamp is L1 = 150.56 Ampere, L2 = 146.76 Ampere, L3 = 135.50 Ampere and L4 = 120.17 Ampere.

Figure 8. 1 and 3 phase electrical circuit installation activities in series/parallel

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From the explanation of the electrical installation circuit above, it can be explained that the supply of the voltage source used for one and three phases is 220/240 VAC, so to reduce the voltage from the source, a tool is needed, namely a transformer or power supply. In testing this series, 4 (four) lamps are used, each lamp has 5 watts, 1.5 mm^2 of NYA conductor, 1-phase switch and MCB.

V. Conclusion

From the test results of the one-phase and three-phase electric power system installation kits, the results can be drawn in the following conclusions :

1. The electric power system's measurement process is one of the standard procedures that must be carried out. Through the measurement, the required quantities will be obtained following the requirements of PUIL 2000.
2. Based on measurements and calculation results, the maximum total current generated in a series of 1-phase electric circuits is 82.57 Ampere, which applies equally to L1, L2, L3 and L4. Simultaneously, the maximum total current generated in a parallel circuit is 129.35 Amperes at L1, while the minimum current is 96.29 Amperes at L4.
3. Based on measurements and calculation results, the maximum real power (P) generated in a 1-phase electric circuit in series is 13872 Watts and in a parallel circuit is 21523 Watts.
4. Based on measurements and calculation results, the maximum apparent power (S) generated in a 1-phase electric circuit in series is 17339 Watts and in a parallel circuit is 26904 Watts.
5. Based on measurements and calculation results, the maximum total current generated in a series 3-phase electric circuit is 94.33 Ampere, which applies equally to L1, L2, L3 and L4. Simultaneously, the maximum total current generated in the parallel circuit is 150.56 Ampere located at L1, while the minimum current is 120.17 Ampere at L4.
6. The maximum real power (P) generated in a three-phase circuit in series is 34637 Watt and in a parallel circuit is 54876 Watt
7. based on measurements and calculation results.
8. The maximum apparent power (S) generated in a 3-phase series is 43297 Watt and, in a parallel circuit, is 68595 Watt based on measurements and calculation results.
9.

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