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The Effects of Unbalanced Circuit in Power Losses and Efficieny

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Abstract:- When the voltages and currents in a three-phase power system are not equal, the circuit is called an unbalanced circuit. This problem can occur at any point in the electrical network, and it can occur for many reasons and in the stages of power generation, transmission, and distribution.

I. INTRODUCTION

In general, in electrical power systems, loads are distributed equally as is practical between phases, which means that an unbalanced system is unacceptable and is considered a weak point in the electrical system because the imbalance of voltage and current may have a bad impact on the quality of electrical power in the distribution sector that Deals directly with consumers.

Voltages are usually balanced in power plants where power is generated, as well as in the transportation sectors. Most of the causes of imbalance appear at the usage level in distribution networks due to unequal phase impedances, unequal loads between phases, unequal three-phase equipment and devices (such as three-phase transformers with open delta-star connections), unbalanced faults, poor connections of electrical conductors, Balance is very important and can be used to reduce distribution feed losses and improve system stability and reliability.

If the voltage level is high, unbalanced power quality will not be acceptable. In the system the current unbalance level is several times more than the voltage unbalance level. Such unbalanced line currents can lead to excessive line losses, stator and rotor losses, motor misfiring, and asymmetric meter scaling. Voltage unbalance also affects variable speed AC drive systems where the front end converter consists of three phase rectifier systems

➢ *Current Imbalance Can Occur for Reasons Within the End User's Control or Outside the End User's Control. Some of the Causes of System Imbalance Are:*

- The source voltage from electric utilities at power plants may be unbalanced
- Mismatched adapter taps
- Defective connector, loose connection
- Uneven cross-sections of transmission lines and distribution lines for each phase.
- Connecting heavy three-phase loads to the system increases current and voltage which leads to unbalance of the system.
- Unequal impedances in a power transmission or distribution system result in a three-phase current difference.
- Any large load on one phase, or a number of small loads connected to only one phase, causes more current to flow than that specific phase, resulting in a voltage drop on the line.
- With continuous operation of the motor in different environments causes deterioration of the rotor and stator windings. This degradation typically varies in different phases, affecting both the magnitude and phase angle of the current waveform
- Three-phase equipment such as induction motor and transformer with unbalanced windings. If the reactance of the three phases is not the same, it will cause variable current to flow in three phases and cause the system to be unbalanced, and this condition may be evident in rewinding motors when the repair process is not done according to standards.
- Current leakage from any phase through the bearings or motor body due to damage to the windings, which leads to the formation of a floating ground at times, causing the current to fluctuate.

II. LOSS OF NEUTRALITY IN LOW VOLTAGE DISTRIBUTION NETWORKS

If the neutral conductor is disconnected, its connection points are oxidized, or it is missing from the source (distribution transformer, generator, or from the load side of the consumer’s distribution panel), the neutral conductor of the distribution system will become “floating neutral,” and the network will lose the reference point represented by the ground.

The potential effects of floating the neutral in the power distribution network include an increase in the effective RMS value of the phase voltage relative to the ground due to the imbalance in the loads on the three phases. This may lead to damage to the equipment fed from the network and the creation of a dangerous touch voltage in the structures of the various equipment that are fed from those. the network .

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We will talk here about this case for distribution networks with a TT grounding system, which means the following: First: The network has four buses L1 - L2 - L3 - N:

Second: The neutral point of the transformer is connected directly to the grounding system, which is called operating ground.

Third: The metal parts are connected to another grounded socket or sockets. The first attached figure shows the TT grounding system.

- *** What is Floating Neutral???*

In three-phase systems, the potential of the grounded star point of the transformer remains close to zero volts when there is a balance in the phase currents, and that potential rises when there is an imbalance, but it remains small, not exceeding 3 or 5 volts, depending on the grounding resistance and the imbalance currents.

If the star point of the three-phase unbalanced load is separated from the star point of the grounded supply source (distribution transformer or generator), the phase voltage with the neutral will not remain the same in each phase but will vary depending on the unbalanced load. The loads of the first and second phases will become in series with the voltage between two phases, and thus the voltage at each consumer will change according to the impedances of the equipment used. This is because the potential of this isolated star point or neutral point is always changing, so it is called Floating Neutral.

Kirchhoff's current law states that the resultant of the currents in a node is zero. If the neutral point is the node, in a balanced system, there will be no current through the neutral and any load fault will result in a current through the neutral so that the sum of zero is maintained.

When we analyze the situation with the equations, sin (x + 120) and sin (x + 240), if we are in star mode, where the neutral bus will not have zero current unless the three phases have the same current,

The neutral must not be grounded except at the beginning of the distribution network, that is, at the transformer. Grounding the neutral in a three-phase system helps stabilize the phase voltage.

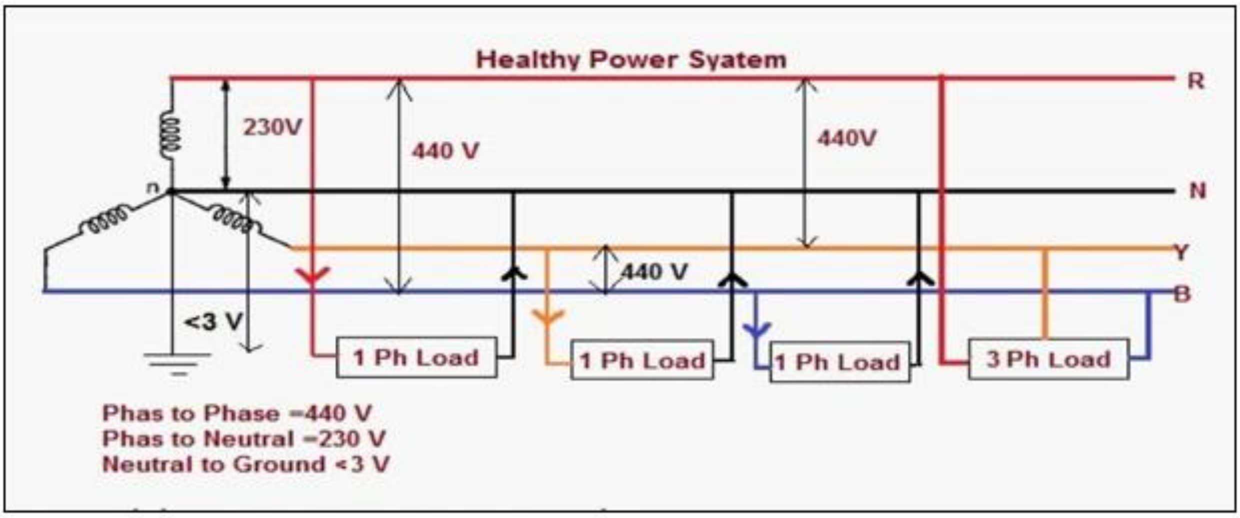

Fig 1 Healthy Load

- *Floating Neutral State:*

Electrical energy flows into and out of subscriber facilities from the distribution network, entering through the phase and leaving through the neutral. If there is a break in the return path through the neutral, the electricity will travel through a different path. The flow of electrical energy that enters one phase returns through the remaining two phases. The neutral point in this case is not the ground potential, but its potential rises to a value that may be large, and this situation may be very dangerous, as the consumer may be exposed to serious electric shocks if he touches the electrical extensions.

Sometimes it is very difficult to detect a floating neutral or a loss of neutrality due to the lack of clear indicators, but a change in flashing in the lighting or the occurrence of simple cases of electricity when touching water pipes and taps may indicate this condition, and electrical shocks here may be fatal in some cases.

Simply put: when we measure the voltage on the phases and on the lines (between two phases), the voltage will be constant between two phases and variable for one phase, and when we measure the voltage between the neutral and the ground point, we will find a high voltage that sometimes exceeds 100 volts.The condition of a floating neutral is an unsafe condition for equipment and individuals because anyone can touch the neutral, considering it safe, and thus be exposed to a shock.Single-phase devices are designed for a certain voltage with a tolerance ratio, so a rise in voltage will lead to their breakdown

➤ *Reasons Leading to Floating Neutrality:*

Firstly - oxidation (or burning) of the connection between the neutral and the subsequent circuits in Bushing, the neutral in the transformer, due to Poor implementation or poor connection, such as connecting copper/aluminum without using the appropriate connection elements.

Second: Collapse or oxidation of the neutral connection points during the connection between cables and aerial networks or during service.

➤ *Third: High Grounding Resistance*

Fourth: Overloading with unbalanced loads in the three-phase system IN = IR <0 + IY <120 + IB <-120

Fourth: Poor implementation of the distribution network between single loads while connecting it to the triple network, as it is possible for more than one load to share the same neutral.

Fifth: Increase in the value of harmonics in loads, especially triple harmonics and their multiples

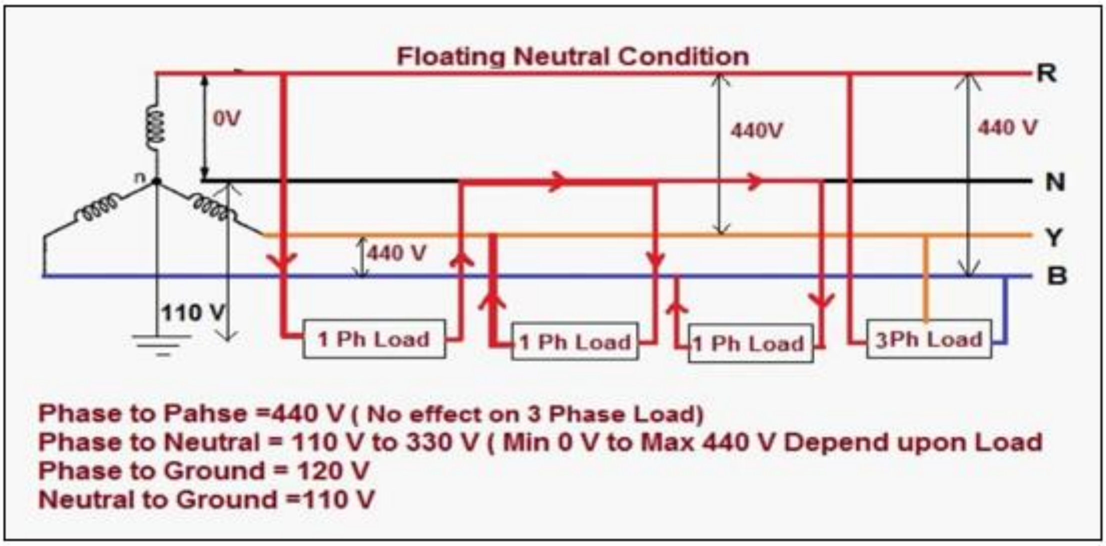

Fig 2 Floating Neutral

According to ohm's law, the electric current that flow in electric circuits in each phases can be expressed by the following formula :Iph = Vph/Zph

From the equation, it is clear that in the three phase lines R, S & T, each phase carries equal current if the phase voltage and impedance of each phase are equal with respect to power and phase difference.

➤ *The Balance Circuit has the following Characteristics.*

- Equal resistance in each phase
- Equal voltage in each phase
- The algebraic sum of the current for all phases is zero.
- When the current in each phase is equal, it indicates that there is no ground current or earth current in a balanced circuit.

Therefore, we can say that the balancing load is the load that draws equal current from the electrical network. In other words, when a three-phase load draws equal current in each phase, it is called a balanced load, and the circuit is said to be a balanced circuit. In balance circuits, the voltage is equal and the phase difference for each phase is 120 degrees. We can prove whether the circuit has a balanced load or not by summing all the phase currents, and if the sum of all the phase currents is zero then the circuit has a balanced load.Let the current flow through the load circuits I1, I2 and I3, the algebraic sum of the current is.

$I1\angle 0+I2\angle 120+I3\angle 240$

$I1=I2+I2+I3=I$

$= I\angle 0+I\angle 120+I\angle 240$

$= I\sin 0+I\sin 120+I\sin 240$

$= 0+0.866-0.866$

$=0$

Hence , I=I2+I2+I3=0

In an electrical circuit, if the sum of the currents of all phases is zero, this means that the circuit is loaded in a balanced manner.

Any deviation in the voltage and current waveform from the ideal sine wave, in terms of size or phase shift, is called an unbalanced electrical circuit.

In an ideal state, the phases of the power supply are spaced 120 degrees apart in terms of phase angle and the magnitude of their peaks should be the same. At the distribution level, load faults cause an imbalance in the current transmitted to the transformer and cause a three-phase voltage imbalance. Even a slight voltage imbalance at the transformer level disturbs the current waveform significantly over all loads connected to it

If the three-phase voltages have the same magnitude and are exactly 120 degrees in phase offset, the three-phase voltage is called balanced, otherwise it is unbalanced. Fig 1

There is no negative or zero series in a balanced system. Rather, there are only positive series components of a three-phase balanced voltage. Conversely, if the system is unbalanced, negative-sequence components, zero-sequence components, or both may be present in the system.

➢ *Voltage and Current Shift*

- In unbalanced circuits, negative-sequence components or zero-sequence components or both may exist in the system due to unequal amount of current and voltage in phases.
- The resistance for negative sequence current is 1/6th of the positive sequence current, which means a small unbalance in voltage waveform will give more current flow and thus losses will be increased.
- The unbalance Voltage always causes extra power loss in the system. The higher the voltage unbalance is the more power is dissipated means higher power bills due high losses.
- The imbalance of current will increase the I2R Losses

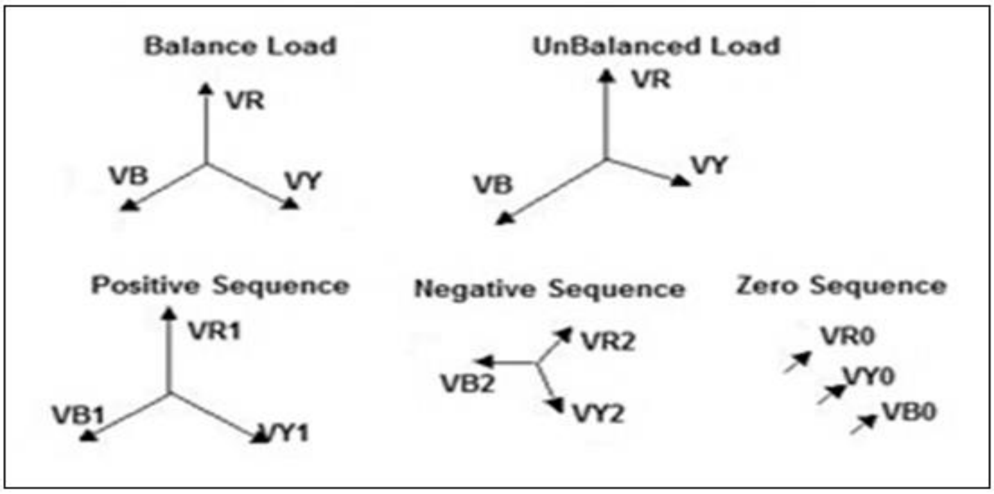

Fig 3 Phase Sequences

➢ *How to Calculate Unbalance*

%voltage unbalance

$$= \frac{\text{maximum deviation from average voltage}}{\text{average voltage}} * 100$$

Example in table 1: phase-to-phase voltages of The System is 11.3kV, 11.4kV, and 10.39kV.

The average Voltage=(11.3+11.4+10.39)/3 = 11.03kV.

The maximum Voltage deviation from Average Voltage=11.03-10.39=0.64 kV %voltageunbalance $= \frac{0.64}{11.03} * 100 = 5.8$ %

In the above result it clear that voltage deviation is above normal and the system is unbalanced. The permissible limit in terms of percentage of negative phase sequence current over positive sequence current is 1.3% ideally but acceptable up to 2%.

Table 1 Unbalanced System Data

Substation name	**Taqtaq/33/11 kV**		
Feeder number	**F4**		
Phases	**R**	**S**	**T**
Voltage/ kV	11.3	11.4	10.39
Current/ A	78.170	85.530	82.496

➢ *Increase Neutral Return Current*

Uneven distribution of loads between the three phases of the system causes unbalanced currents to flow in the system, leading to unbalanced voltage drops on the electrical lines. It is this increase in neutral current that causes losses in the line.

If the system has a balanced load then the neutral current will flow less on the system. We can save thousands of amount of money by reducing losses by reducing the neutral current flow in the system

III. EFFECTS OF VOLTAGE IMBALANCE ON THE SYSTEM AND EQUIPMENT

- Voltage unbalance factors can be classified into two categories:
  Natural factors and unnatural factors.

- *Natural Factors:*

Such as unbalanced single-phase loads, three-phase transformer complexes with open star-delta connections, and defects in the way of properly designing the system and installing appropriate equipment and devices. Voltage imbalances resulting from these factors can generally be reduced through work and daily procedures.

- *Abnormal Factors:*

Include sequencing and switching errors in circuits, poor electrical connections of conductors or switches, asymmetric breakdown of equipment or components, asynchronous burning of three-phase power valves, operation of single-phase motors, etc. The abnormal factors mentioned above may lead to serious damage to systems and equipment and require periodic and accurate follow-up and continuous examination of data in order to reduce the rate of imbalance.

- *Losses*

Table 2 Transformer Data

Transformer capacity	**250 kVA / TaqTaq substation – F1**			
*	**RS**	**ST**	**RT**	
Voltage/ V	413	412	415	
	RN	**SN**	**TN**	
	238	237	237	
Current/ A	**R**	**S**	**T**	**N**
	168	197	205	53

In table 2 , Power in kwh / year= V*I*HOUR* DAY*MONTH

= (168+197+205)*237*24*30*12

= 1,167,177.6 kwh / year

Power losses in N = 53*237*24*30 *12

= 108,527.04 kwh / year

% Losses = (1,167,177.6/1,167,177.6+ 108,527.04) *100

= 8.51 %

In balance System The Load current in R Phase=200A, Y Phase=200A,B Phase=200A and in Unbalance System The Load current in R Phase=300A, Y Phase=200A,B Phase=100A,Consider Resistance of line are same in both case and all phases.

- *In Balanced System:*

Total Load current =R+S+T = 200+200+200=600A

Total Losses =R(I2R)+S(I2R)+T(I2R)

=40000+40000+40000=120,000Watt.

Table 3 / balanced circuit data

*	**RS**	**ST**	**RT**
Voltage/ V	440	440	440
Current/ A	**R**	**S**	**T**
	200	200	200

- *In Unbalanced System:*

Total Load current =R+S+T = 300+100+200 =600 A

Total Losses =R(I2R)+S(I2R)+T(I2R)=90000+40000+10000 =140,000Watt.

In both cases, the total load current is the same in value, but the losses in the unbalanced system greatly exceed the losses in the balanced system.

An imbalance of 1% is acceptable and allowed because it does not affect the cable or the overall performance. But above 1%, it increases linearly and the negative effect begins, and at 4% the rating reduction is 20%. This means that 20% of the current flowing in the cable will be unproductive and will be calculated as losses in the electrical network. Therefore, copper loss in the cable will increase by 25% when the imbalance is 4%.

Table 4 Unbalanced Circuit Data

*	RS	ST	RT
Voltage/ V	440	240	340
Current/ A	**R**	**S**	**T**
	300	100	200

- *Effects On Motor .*

- *Reduce Motor Life By Heating:*

Voltage imbalance leads to excessive losses, which in turn will lead to heating of the motor coils. By increasing the motor operating temperature, it leads to the collapse of the insulating material in the coils and may eventually lead to burning and stopping of the motor. This may also lead to the decomposition of the grease or oil in the bearing, reduce the engine speed and reduce the engine's efficiency. A 3% voltage unbalance results in a 20% increase in heating for an induction motor, and the coil insulation life is halved for every 10°C increase in operating temperature

Table 5 motor temperature rise

Effect of imbalance Voltage on motor T.	
% Voltage imbalance	**% Temperature rise**
2	8
3	18
4	32
5	50

- *Motor Vibration:*

Producing an opposite torque as a result of the negative voltage resulting from a voltage imbalance. This leads to vibration and noise inside the motor, which leads to damage to the bearing and heating of the armature. If the voltage imbalance is high, it may cause the motor to collapse and put it out of service.

- *Reducing The Life of the Motor:*

Unbalanced voltage causes an increase in the temperature of the motor, and over time it may lead to reducing the life of the motor by affecting the motor bearing and its winding.

- *Reduced Efficiency:*

In induction motors connected to unbalanced supplies, negative sequence current flows with positive sequence current resulting in lower output current ratio and poor motor efficiency. Any imbalance greater than 3% hinders engine efficiency. In Table 6, the motor efficiency collapses as the voltage imbalance ratio increases. Any imbalance exceeding 3% hinders the engine's efficiency and affects the desired engine output.

Table 6 Motor efficiency

Motor Efficiency %			
Motor Load % Full	**Voltage Unbalance**		
	Nominal	**1%**	**2.5%**
100	94.4	94.4	93.0
75	95.2	95.1	93.9
50	96.1	95.5	94.1

For example if the 100 HP motor tested were fully loaded and operated for 800 hours per year and supplied by unbalanced voltage of 2.5%. With energy price 36 ID/KWH. The annual calculation of energy and cost savings is The annual power consumption with balanced voltage = 100 HP x 0.746W x800*36 = ID 2,148,480 With unbalanced annual power consumption = 100 HP x 0.746 x 800 x (100/93) x 36 = ID 2,310,193 Annual Cost Savings = 2,310,193-2,148,480 = ID 161,713 The overall savings could be much greater because an imbalanced electric grid could cause effect on multiple motors and other electrical equipment .

In the other hand negative phase sequence current flow in the unbalance circuit can cause motor malfunctions, resulting in tripping or permanent damage to electrical equipment and also for motors, a 5% unbalance will result in a 25% capacity reduction. It also causes the breakdown of frequency or variable speed motors connected to an unbalanced system.

- *Solve Unbalancing*

The first data set in Table 7 contains real load data showing the balanced loads recorded by smart meters. Smart meters have recorded the energy consumed by each phase in each household, so the loads are unbalanced in this data set and change randomly over time. Other datasets are generated by processing real load data. More precisely, the data processing is carried out in such a way that the total power consumed by each three-phase load at any given time is maintained in the same amount as in the first data set, i.e. as in the case of real loads. For Dataset 2, all loads are balanced, for Dataset 3 and Dataset 4, all loads follow a certain pattern of imbalance which means the power consumption between phases is not equal and appears different.

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Table 7 Load data

Data set	Phase A	Phase B	Phase C	Total Power	Nature of loads
1	Pa	Pb	Pc	Pa+ Pb+ Pc=3P	real loads
2	P	P	P	3P	balanced loads
3	P	0.87P	1.13P	3P	unbalanced loads
4	P	0.48P	1.52P	3P	unbalanced loads

Programming mixed integers with binary variables solves cases of line switching and click positions. In general, this method can be considered automatic, but failure may occur due to repeated load variations as a result of increases and decreases in the load.

For the purpose of controlling the power flow in the operation phase, several power electronic devices have been proposed that smoothly control the power flow, such as active power filter (APF), distribution static compensator (DSTATCOM), automatic balancing transformer, circuit electric spring, and soft open spots. Through these applications, imbalance problems caused by load variations can be improved in real time. APF and DSTATCOM can be used to compensate for unbalanced loads in distribution systems. The principle of load balancing is achieved by balancing the reference current of the source. The auto-balancing converter, based on multi-level converters, can prevent the voltage and current imbalance arising in the primary side system. A three-phase spring circuit in series can be used with non-critical loads to reduce power imbalance in building electrical power infrastructure. A new method, soft open points (SOPs), can connect different feeders to mitigate three-phase imbalance in the upper level network. Similar to standard operating procedures (SOPs), a railway power conditioner (RPC) can mitigate imbalance caused by two individual phases.

APF and DSTATCOM can balance the current, but the voltage may still be unbalanced if the source is connected to an unbalanced transformer.

One method can produce three single-phase currents to remove the unbalance component through static control. This method differs from APF and DSTATCOM, which rely on instantaneous control, such as a proportional-integral derivative (PID) or fuzzy controller.

Circuit analysis is a simple method that compensates each phase current with the difference between the phase current and the average current. The bus bar voltage, behind the secondary side of the transformer, can become balanced if the total current across the bus bar is balanced over three phases. However, this method is only feasible for Δ–Δ and Y–Y connections, because the transformer impedances are balanced

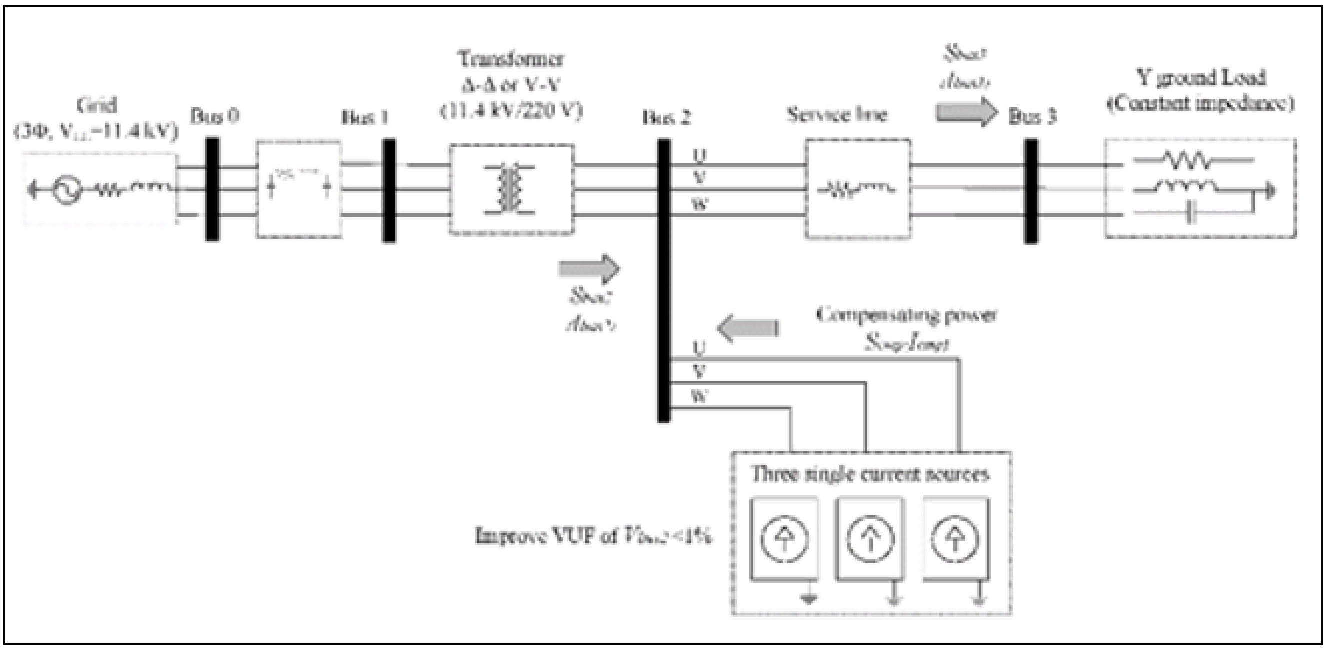

Fig 4 System Balancing

➢ *Impact on Distribution Transformers*

- Under normal operating conditions, the operating voltage of the transformer basically does not change, that is, the no-load loss is constant, but with the three-phase unbalanced load of the power transformer the transformer loss increases. The load loss varies with the operating load of the transformer and is proportional to the square Load current. When the three-phase load is unbalanced, the transformer load loss can be taken as the sum of the single-phase three-phase transformer load loss.

By mathematical theory: Assuming that the numbers a, b, and c are all greater than or equal to 0, then a+b+c≥33√abc. When a=b=c, a+b+c gets the minimum value

Therefore, we can assume that the loss of the three-phase transformer is: QA = Ia2 R, Qb = Ib2 R, QC = Ic2 R. In the formula, IA, Ib and Ic are the phase current of the secondary load of the transformer in series, and R is the phase resistance of the transformer. The expression for transformer loss is as follows: Qa + Qb + qc≥33√ [(Ia2 R) (Ib2 R) (Ic2 R)]

It can be seen that in the case of constant load, when Ia = Ib = Ic, that is, when the three-phase load reaches equilibrium, the transformer loss is minimal.

If the transformer is balanced, the equation is Ia =Ib=Ic=I, Qa+Qb +Qc=3I2R;

In the case of imbalance, the equation is, i.e. Ia = 3I, Ib = Ic = 0, Qa=(3I)2R=9I2R=3(3I2R);

It is clear from the above that the loss of the electrical transformer at maximum unbalance is 3 times its loss at equilibrium.

- Loading the electrical transformer with an unbalanced load causes serious consequences of transformer burnout: Excessive heavy phase current (3 times increased) and overload in the above-mentioned unbalanced condition may cause the temperature of the windings and transformer oil to rise. This leads to an increase in the winding temperature and accelerated aging of the insulation. The transformer oil heats up, causing the oil to deteriorate, which quickly reduces the insulation performance of the transformer, reduces the service life of the transformer (for every 8 °C increase in temperature, the service life will be reduced by half), and even burns the winding.
- The unbalanced load operation of the three-phase power transformer will cause excessive zero sequence current of the transformer and increase the temperature rise of local metal parts: Under the unbalanced operation of the three-phase load, the transformer will inevitably generate zero sequence current, and the presence of zero sequence current in the transformer will generate Zero Sequence In the iron core, this zero sequence flux will form a loop in the wall of the transformer tank or other metal components. However, when designing the distribution transformer, it is not taken into account that these metal components are magnetic conducting parts, so the resulting fatigue and loss of LED current will make these parts hot, resulting in abnormal temperature rise of the local metal parts of the transformer. Transformers, which leads to transformer operating accidents in serious cases.
- In some cases, the phase loads are similar, and the current of each phase is similar, but the neutral current of the line is very large, even more than the maximum phase current, and the reason for this to happen is the different nature of the three-phase load. indicating that the large neutral line current is caused by the presence of different characteristics of three-phase loads.

IV. CONCLUSION

- To make electrical energy available for all uses with high quality and continuity through advanced technologies, several projects must be adopted in order to improve the electrical grid system while providing a new service to subscribers by implementing a system of smart meters and prepaid meters. The future vision for the electricity sector is based on the gradual transformation of the current network from a typical networkف o a smart network characterized by the use of modern technologies and information systems, and contributing in a way It greatly improves the efficiency of energy use and secures electrical supply, with a fault-monitoring mechanismش nd restore power in a fully automatic way and help subscribers follow up, rationalize and controlف heir consumption of electrical energy. In this direction, control centers in transmission and distribution networks must be established and developed Smart networks are the expected hope and promising dream in the present era of transmission, distribution and consumption Electrical energy, which increases the reliability, efficiency, and professional security and safety measures in networks electrical , through smart network Possibility of obtaining technical reports on transformers, including: (transformer loads - maximum load - factor) which lead to he ability to analyze data in network planning
- The major cause of imbalances in the electrical network is wrong division of single-phase customers among the lines in low-voltage distribution systems.. Reaching a point to achieve balance between low voltage distribution systems is difficult and expensive, and it is difficult to achieve 100% balance.
- The electrical energy consumed by single-phase consumers has a significant impact on the results of the balancing process. Predicting the customer's consumption value accurately seems impossible. The existing data on single-phase customers is questionable, and there is always a certain amount of uncertainty. Therefore, there is no kind of approach yet to achieve balancing of low voltage distribution system considering the uncertainty mentioned above.
- In balancing process it important to no depend on number of consumers on each phase because power consumption is different among single phase consumers, therefor balancing should depend on balancing electric current among phases.
- A system balancing by changing feeding phase of single-phase customers.
- To correct the voltage imbalance, the loads must be distributed evenly across the three phases. When one phase becomes more loaded than the other phase, the voltage in that phase will be low, leading to a voltage imbalance. Even distribution of loads helps prevent overloading of one phase.
- Understanding the causes of electrical circuit malfunctions helps technicians look for signs and work to prevent them. Even if there is a slight imbalance

somewhere in the system, testing it now can help detect it before the effects become harmful and the process requires continuous and daily monitoring of loads..

- The other practical way to solve unbalance load is doing through survey of all transformers and registering data of each one and make balancing by moving consumers among phases till reaching balance.
- In order to maintain balancing it is very important to return to transformer data while connecting new consumers by adding to phases that carry lowest load.
- In big industrial loads it is important to distribute single loads among phases equally by observing current meters that connected to each phases in different times by getting balancing while factory operating and in factory off.
- In some times 3phase consumers cause imbalance by distributing loads un equally among phases , to solve this problem should make balancing through internal distribution panels of the consumer .
- Its very important to make periodical maintenance of electric network all over the country in order to fix weak points , because any loosen of connections in electric lines in both sectors transmission lines , distribution transformer and low voltage lines connection lead to losses and distortion in voltage which cause unbalance voltage, in the other hand above defect may cause malfunction of electric equipment.
- Electricity networks in most countries currently rely on technologies and systems that are more than 50 years old, which makes her old daughter an obstacle that prevents her from being able to rely on her to keep pace with the growing demand for energy generation technologies from renewable sources from among a group A variety of sources of electricity generation, such as solar energy, wind energy, and biomass. and other energy sources, in addition to the increasing demand for energy in many countries It is one of the sectors that is becoming more difficult to confront day after day and which requires finding new ways to produce electricity, store it, and deliver it to the consumer.
- Another way to maintain power quality and system performance, it is essential to balance electrical loads in operation. This can be done by monitoring and adjusting the load distribution periodically, based on the actual load conditions and measurements. Methods for balancing electrical loads include switching or relocating the loads, adding or removing loads, replacing or repairing faulty equipment, and using load balancing devices such as phase converters, auto-transformers, or static VAR compensators. Taking these steps not only helps to prevent power quality issues, but also optimizes your electrical design.

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