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Commissioning of Power Transformer

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بسم الله الرحمن الرحيم

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Dedications

We dedicate this Thesis ...

To our dear parents and to the whole family (BOUSSALEM Karima)...

To all those who are dear to us…

To our friends… To our teachers…

To all who helped us in this thesis…

acknowledgment

First and Foremost praise is to ALLAH, the Almighty, the greatest of all, on whom ultimately we depend for sustenance and guidance. We would like to thank Almighty Allah for giving us the opportunity, determination and strength to do our research and complete it satisfactorily. His continuous grace and mercy was with us throughout our life and ever more during the tenure of our research

The construction of this memory would not have been possible without the conscious intervention of a large number of people. May they find here the expression of our most sincere acknowledgement.

The first person we would like to thank is our supervisor ***Mr MAHBOUB Mohamed Abdelbasset*** *for the guidance, the confidence and the patience which have constituted a considerable contribution without which this work could not have been carried out successfully.*

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Abstract

Commissioning of power transformer

After new power transformer has been set up on site and before it connects with power supply and loading the load, it is must to have to go through numbers of testing procedures for confirming the specifications and performances of a power transformer. The purpose of commissioning tests on transformer is to satisfy, to pre-determined standards, that all the equipment erection is correct and that all the equipment connections or cables have been installed in accordance with the approved erection drawings and diagrams.

Keywords: Power transformer , Commissionning

Résumés

Mise en service du Transformateur de puissance

Une fois le nouveau transformateur de puissance installé sur site et avant qu'il ne se connecte à l'alimentation électrique et ne à la charge, il est nécessaire de passer par un certain nombre de procédures de test pour confirmer les spécifications et les performances d'un transformateur de puissance. Le but des essais de mise en service sur le transformateur est de satisfaire, selon des normes prédéterminées, que tout le montage de l'équipement est correct et que toutes les connexions ou câbles de l'équipement ont été installés conformément aux dessins et schémas de montage approuvés.

Mot-clé : Transformateur, Mise en service

ملخص

اختبار تشغيل محول الطاقة

بعد إعداد محول الطاقة الجديد في الموقع وقبل توصيله بمصدر الطاقة وتحميل الحمولة ، يجب أن يمر بعدد من إجراءات الاختبار لتأكيد مواصفات وأداء محول الطاقة. الغرض من اختبارات التشغيل على المحولات هو الإيفاء ، وفقًا للمعايير المحددة مسبقًا ، بأن جميع تركيب المعدات صحيح وأن جميع توصيلات المعدات أو الكابلات قد تم تركيبها وفقًا لرسومات ومخططات التركيب المعتمدة.

الكلمات المفتاحية محول الطاقة ,اختبار التشغيل

Summary

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GENERAL INTRODUCTION

Nowadays, power transformer is most important equipment in electrical power transmission and power distribution system. Commissioning test for power transformer should to be done to verify the technical suitability for the application and check the healthiness or condition of power transformer before energizing by connecting to the power supply system and loading the load. For confirming that power transformer is follow the specification and performances according customer needs based on the specification set by manufacturer of power transformer, some of testing procedures should to be done.

The pre commissioning test result should to compare with manufacture test result (basically on transformer name plate or manual guideline) and international standard (IEEE STANDARD or INTERPLANT STANDARD-STEEL INDUSTRY, Code Of Practice For Testing And Commissioning Of Power Transformer And Related Switchgears),. The INTERPLANT STANDARD covers guidance on testing and commissioning of power and distribution transformer

The power transformer testing performed before actual commissioning test of the transformer at site is called pre commissioning of the power transformer at site like insulation resistance test, transformer turns ratio test, dc winding resistance test, temperature test and oil test.

The objective of this work is to assess the condition of power transformer after installation, to compare the test results of all the low voltage tests with the manufacturer of transformer test reports. To affect the safe and orderly handover of the power transformer from manufacturer to costumer, guaranteeing its operation in term of performance, reliability, and safe

Our thesis is presented as follows:

- General introduction
- Chapter one : Presentation of SONELGAZ group and GRTE
- Chapter two : General information about transformers
- Chapter three : Commissioning of power transformer
- General conclusion

Chapter 1

PRESENTATION OF SONELGAZ GROUP & GRTE

1.1. **Introduction:**

The Sonelgaz group National Electricity and Gas Company, the first energy operator in Algeria, ensures several missions in the energy field. The latter, ranging from the management of the electrical and gas network to the distribution and marketing of electricity and gas for the benefit of both professionals and individuals, make Sonelgaz a key player in the national economy.

1.2. **Presentation of Sonelgaz:**

The National Electricity and Gas Society (Sonelgaz), created on July 28, 1969, by replacing the previous entity Electricity and gas from Algeria (EGA) responsible for production, distribution, import and Export of electricity and gas [1].

1.3. **Group history:**

- In 1969, the creation of Sonelgaz by replacing the EGA.
- In 1977, the national electrification plan and development of rural areas.
- In 1983, the birth of work companies: six autonomous companies were created:
- Kahrif for electrification; Kahrakib Infrastructures and Dectric Installations; Kanagz-realization of gas networks; Inerga Civil Engineering; ETTERKIB Industrial assembly and the AMC manufacturing company of meters and measures and control devices.
- In 1991, a change in legal nature: Sonelgaz became an industrial and commercial public establishment (EPIC).
- In 1998, the creation of 9 peripheral subsidiaries. In 2002, the transformation of the Epic into a holding company by action.
- In 2004, the creation of three companies "Crafts: SPE for the production of electricity, GRTE for the transport of electricity and GRTG for the transport of gas. In 2005, the creation of the Civil Society of Occupational Medicine (SMT) and a research company and development of electricity and gas (CREDEG).

- In 2006, the emergence of 4 electricity and gas distribution companies (SDA, SDC, SDE and SDO) ER a management company of the national electrical system (OS) [1].

1.4. **Group assignments:**

- The production, transportation, distribution and marketing of electricity in Algeria.
- The transportation of gas for the needs of the national market.
- The distribution and marketing of gas by pipeline[1]

1.5. **Sonelgaz organization chart**

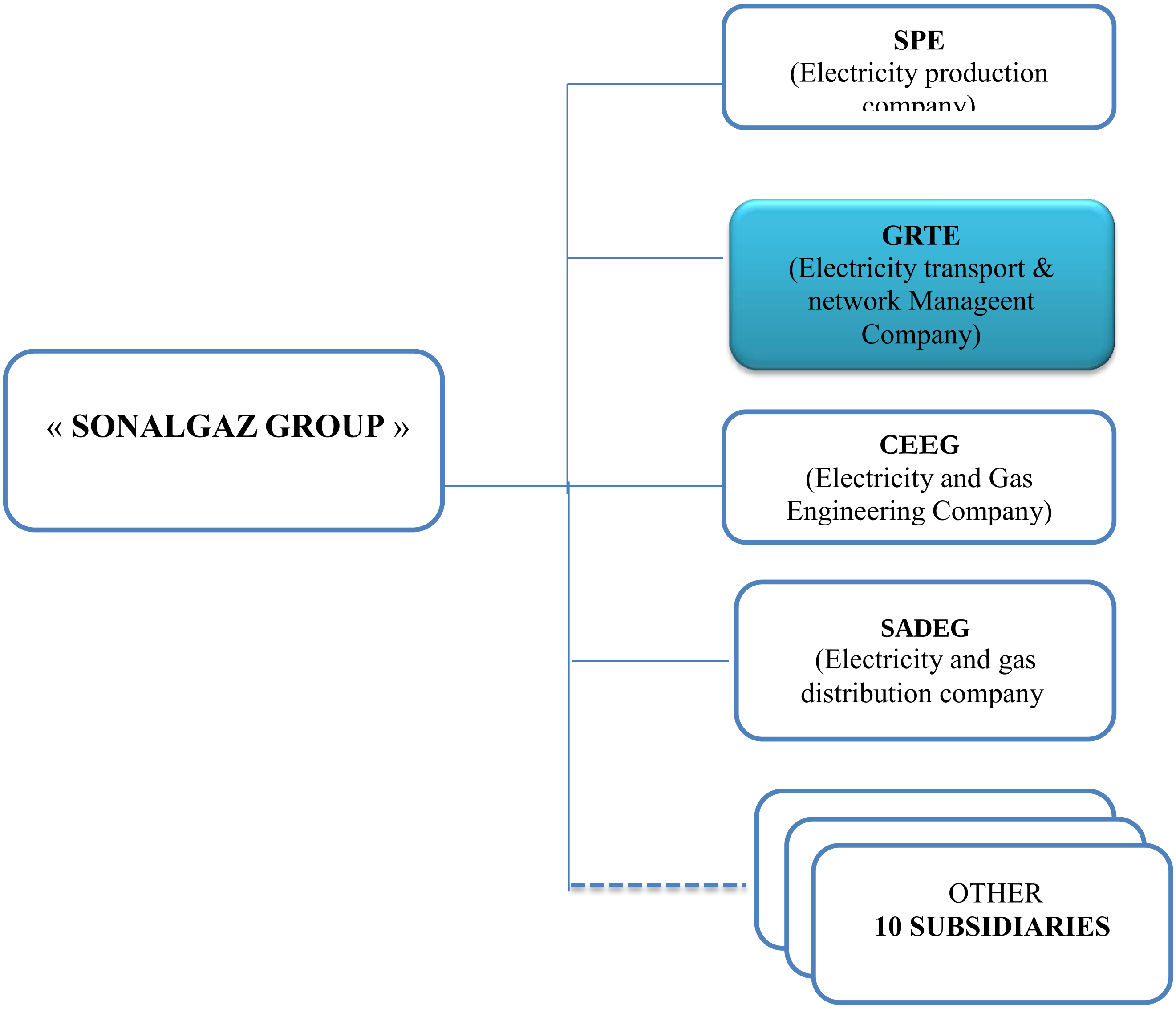

Figure 1.1. Sonelgaz organisation chart

1.6. **Presentation of GRTE Company**

GRTE (La Société Algérienne de Gestion du Réseau de Transport de L'électricité), its mission is to ensure the operation, maintenance and development of the electricity transmission network, in accordance with the legislation and regulations in force and the provisions of Law No. 02-01 of 05/ 02/2002 relating to electricity and the distribution of gas through pipelines, with a view to guaranteeing adequate capacity in relation to transit and reserve needs.

The GRTE Electricity Transmission Network and Manageent, the nerve of the energy transition, is defined as a set of structures made up of overhead lines, underground cables, international interconnection links, transformer stations and their remote control and telecommunications, control, command and measurement equipment used for the transmission of electricity to customers, producers and distribution as well as for the interconnection between power stations and the network electric [2].

- *GRTE operates a grid network composed of*:
  - 32,720 km of high voltage lines including 5,317 km at 400 kV.
  - 373 Substations including 26 Substations in 400kV.
  - 67,598 MVA of transformation power.
  - 73,831 GWh of energy transferred.
  - 21,544 km of fiber optics[2].

Figure 0.2. GRTE Regions

GRTE carries out its activities through central directorates and Six (06) regions of Electricity Transport, namely: Algiers ,center, Oran, Sétif, Annaba and Hassi Messaoud, through 24 transport services spread over the national territory ensuring local maintenance and direct customer relations [2].

Chapter 2

GENERAL INFORMATION ABOUT TRANSFORMERS

2.1. Introduction

In the modern age of digital technology, majority of modern devices such as laptops, smartphones, Internet devices, and other connected systems cannot function without the availability of one essential ingredient, namely electricity.

Flow of power and electricity into our homes and other locations would not be possible without the availability of power transformers. So, what is a power transformer?

2.2. Power Transformer

2.2.1. Definition

The transformer is a static electrical device with electromagnetic induction which makes it possible to transform a voltage or a current of a certain frequency into another voltage or current of the same frequency. It is composed of a magnetic circuit on which are placed two windings at least

As it can be called static induction converter which has two or more fixed windings, inductively coupled and intended for the conversion, through electromagnetic induction, of the parameters(voltage, current intensity, number of phases of the alternating current electrical energy)[3].

Figure 2.1 Power Transformer (GRET OUARGLA)

2.2.2. History of Power Transformers

A transformer refers to a device converts electrical energy from one circuit then onto the next through inductively coupled circuits. A transformer is accustomed to bringing voltage up or down in an AC electrical circuit. A transformer can be utilized to change over AC power to DC power with help of a rectifiers. There are transformers everywhere in each house; they are inside the dark plastic case, which you connect to the socket to energize your mobile phone or different gadgets. These sorts are frequently called "divider warts." They can be substantial, as in national utility systems, or it can be little implanted inside hardware.

The property of induction was found in the 1830's yet it was not until 1886 that William Stanley, working for Westinghouse manufactured the first solid business transformer. His work was based on some simple plans by the Ganz Company in Hungary (ZBD Transformer 1878), and Lucien Gaulard and John Dixon Gibbs in England. Nikola Tesla did not concoct the transformer as a few questionable sources have asserted. The Europeans specified above did the first work in the field. George Westinghouse, Albert Schmid, Oliver Shallenberger and Stanley made the transformer shoddy to create, and simple to modify for conclusive use.

The principal AC power system that utilized the current transformer was as at part of Great Barrington, Massachusetts in 1886. Prior types of the transformer were utilized as a part of Austro-Hungary 1878-1880s and 1882 ahead in England. Lucien Gaulard (Frenchman) utilized his AC system for the progressive Lanzo to Turin electrical piece in 1884 (Northern Italy). In 1891 genius, Mikhail Dobrovsky planned and exhibited his 3 stage transformers in the Electro-Technical Exposition at Frankfurt, Germany[4].

2.2.3.Power Transformer Design

The structure of the power transformer is modeled with metal covered with sheet metal. It is fixed on the shell or core. The structure of the transformer is fixed by winding conductors to make three one-phase or one three-phase transformers. For three single-phase transformers, each bank must be isolated from additional components to ensure continuity of service in the event of a failure of one bank. A single three-phase transformer, whether core or shell type, will not work even if one group is out of service. The three-phase transformer has low manufacturing cost, requires little space, and has relatively high work efficiency.

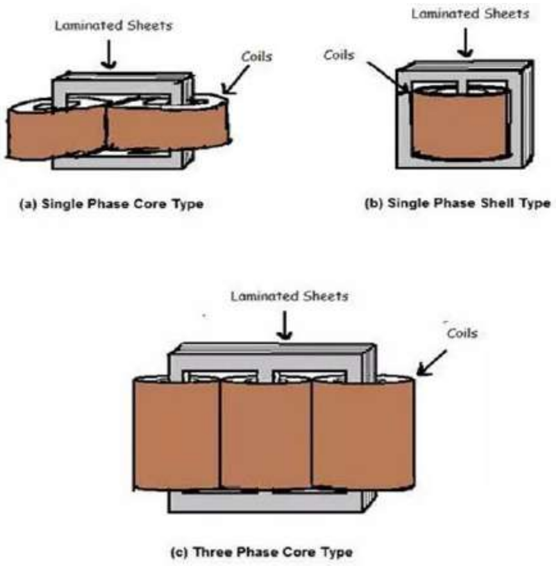

Figure 2.2. Power Transformer Design

2.2.4 Parts of power transformer:

- **Conservator**

  Conservator is a type of tank , used to help oil filling this is situated upper portion of the power transformer . mainly these are cylindrically shaped.

- **Tank**

  Basically this is a container used to keep windings(both) and cooling oil.

- **Buchholz Relay**

  This is a protecting device used to protect our transformer windings . this is a double ended device one end is connect to conservator other is connected to tank. there are two windings inside the relay one for detecting oil level gain to empty and other is connected to a alarm

- **Breather**

  Breather is a device used for absorb the moisture content of a oil and sucked air

- **Silica jell**

  It is a chemical material these are the only one main component inside the breather basically

  silica jell is a brown colour one after the absorbtion silica jel become pink.

- **Oil level scale**

  This is a ordinary part situated on the side of the conservator for proper oil checking oil tank wants a specific amount of oil

- **Primary winding**

  In the case of power transmission primary windings are the main element external connection from the power is connected to winding

- **Secondary winding**

  This is a another winding for reducing power(in the case of step down purpose)

- **Drain valve**

  This valve is used for taking damaged oil from the oil tank for the proper oil collection this valve is situated under the oil tank.

- **Purceline bush**

  This is a outer unit , this is used to prevent unwanted leakage of electricity

- **Radiator**

  This device is used to cooling oil.[6]

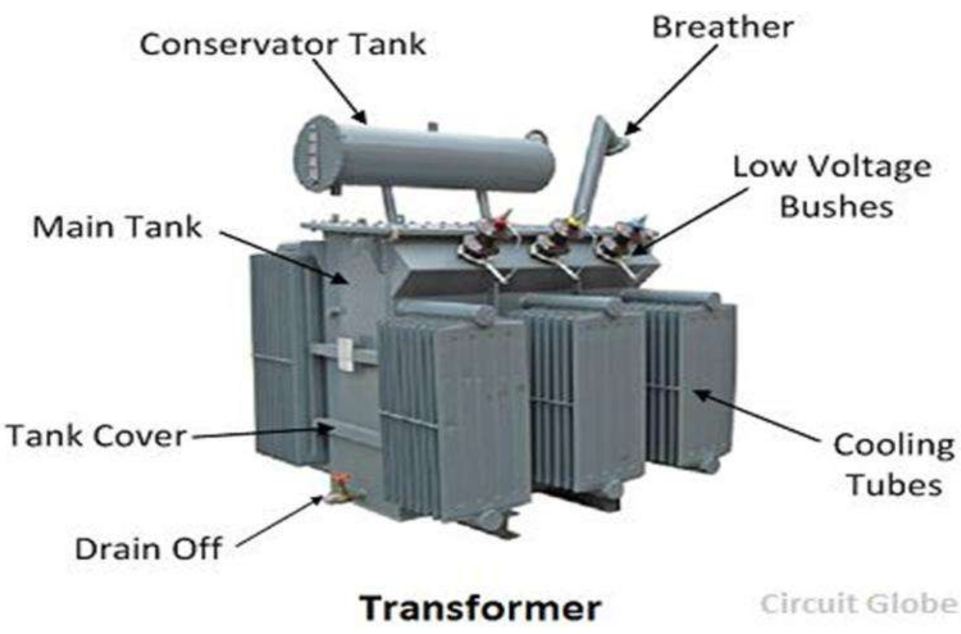

Figure 2.3. Parts of Power Transformer

2.3. Difference between Power Transformer and Distribution Transformer

The power transformer is commonly performed in full load since it is modeled to have high efficiency at 100% load. Otherwise, the distribution transformer has high efficiency once the load stays between 50% and 70%. So, distribution transformers are not desirable to operate at 100% load constantly.

Because power transformers lead to large voltages during step-down and step-up, the windings have great insulation when compared with distribution types or instrument transformers. Since they apply high-level insulation, they are very massive in size and are also too heavy.

Figure 2. 4. Distribution Power Transformer

Since power transformers are typically not connected to homes straightly, they experience little load fluctuations, while on the other hand, distribution types experience heavy load variations.

These are entirely loaded for 24 hours a day, so iron and copper wastes take place all over the day. The flux density in the power transformer is also greater than the distribution type [5].

2.4. Power transformer working principle

The working principle of the transformer is Faraday's law of electromagnetic induction and mutual induction.

There are usually two coils on the transformer core, the primary coil and the secondary coil. The core laminations are connected in the form of strips. The two coils have high mutual inductance. When alternating current flows through the primary coil, a changing magnetic flux is produced.

According to Faraday's law of electromagnetic induction, this change in magnetic flux induces an electromotive force (electromotive force) in the secondary coil, which is connected to the iron core through the primary coil. This is a mutual induction.

Overall, a transformer carries the below operations:

1) Transfer of electrical energy from circuit to another
2) Transfer of electrical power through electromagnetic induction
3) Electric power transfer without any change in frequency
4) Two circuits are linked with mutual induction [5].

2.5. The role of Power Transformers

An electrical transformer is a converter which makes it possible to modify the values of the voltage and the intensity of the current delivered by an alternative source of electrical energy into a system of voltage and current of different values but of the same frequency and of the same form. Its main components are a ferromagnetic core, on which are coils 2 windings . The conductor of the first winding has a larger diameter than the conductor of the second. Winding made of smaller diameter wire carries alternating current at higher voltage level and lower amperage (HV winding); conversely, in the larger diameter wire the voltage is lower and the current higher (LV winding). Energy is transferred from the primary to the secondary via the magnetic circuit [7].

2.6. Types of Power Transformer

2.6.1. Based on Voltage Levels Commonly

used transformer type, depending upon voltage they are classified as:

- **Step-up Transformer**: They are used between the power generator and the power grid. The secondary output voltage is higher than the input voltage.

- **Step down Transformer**: These transformers are used to convert high voltage primary supply to low voltage secondary output.

2.6.2. Based on the Medium of Core Used

In a transformer, we will find different types of cores that are used.

- **Air core Transformer**: The flux linkage between primary and secondary winding is through the air. The coil or windings wound on the non-magnetic strip.

- **Iron core Transformer**: Windings are wound on multiple iron plates stacked together, which provides a perfect linkage path to generate flux.

2.6.3. Based on the Winding Arrangement

- **Autotransformer**: It will have only one winding wound over a laminated core. The primary and secondary share the same coil. Auto also means "self" in language Greek.

2.6.4. Based on Install Location

- **Power Transformer**: It is used at power generation stations as they are suitable for high voltage application
- **Distribution Transformer**: Mostly used at distribution lanes for domestic purposes. They are designed for carrying low voltages. It is very easy to install and characterized by low magnetic losses.
- **Measurement Transformers**: These are further classified. They are mainly used for measuring voltage, current, power.
- **Protection Transformers**: They are used for component protection purposes. In circuits, some components must be protected from voltage fluctuation etc. Protection transformers ensure component protection [8] .

2.7. Power Transformer Specifications

Power transformers can be modeled as either a three-phase or a single-phase design. There are several important specifications to explore when searching for a power transformer. The specifications of a power transformer contain the maximum power rating, maximum voltage rating, maximum secondary current rating, and o/p type. Power transformer specifications mostly consist of:

- The primary Voltage is 60 kV
- Secondary Voltage is 30 kV
- Frequency if 50Hz.
- Phase is 3Ø
- Vector YNyn0

2.8. Power Transformer Applications.

Power transformers can be used from one voltage type to another at high power ratings. These transformers are employed in various electronic networks and also present in various types and applications.

The applications of the power transformer contain the transmission and distribution of electrical energy. These instruments are broadly used by industrial plants, power plants, and traditional electric utility companies.

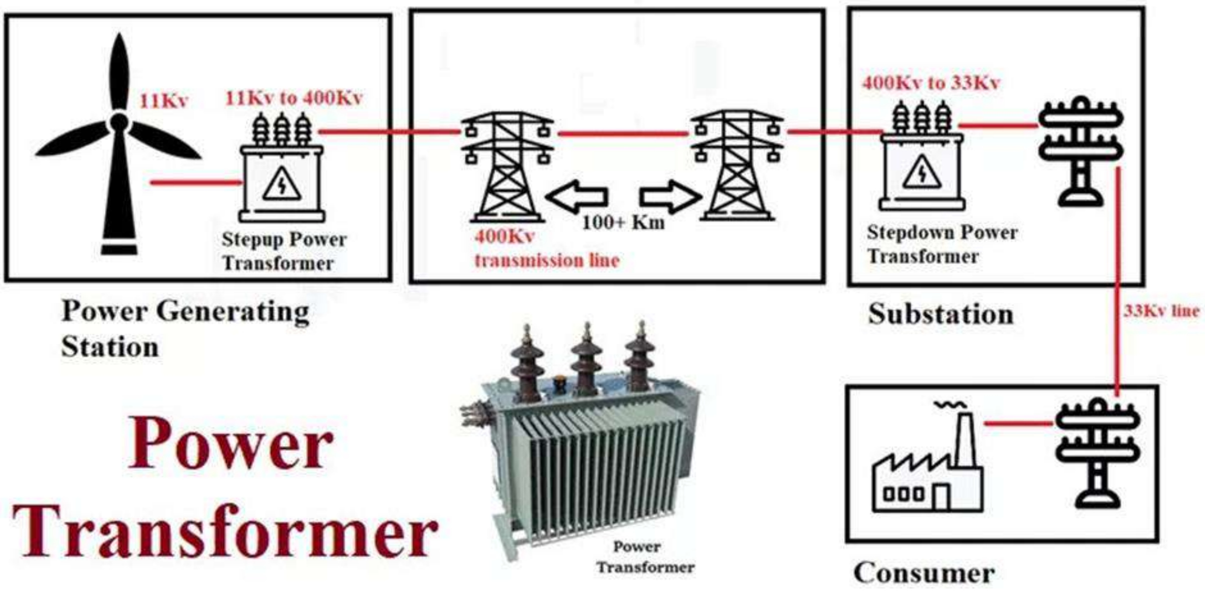

Figure 2.5. Power Transformer applications

Power transformers are applied in the high-voltage transmission lines to step down and step up the voltage. These transformers are typically used for the transmission purpose of heavy loads.

These instruments are massive in size compared to the distribution types that are employed in generating stations and transmission networks. Power transformers are used in the transmission networks, so they are not employed directly for the consumers. So, the load variations of them are less.

These devices are used as a step-up system for transmission so that the I2R waste can be decreased to a determined power flow.

Power transformers are mostly used in electric power production and at distribution stations. They are also used in isolation systems, six pulse and twelve Pulse rectifier transformers, earthing transformers, wind farm transformers, solar PV farm transformers, and autotransformer starters.

Some other applications of a power transformer include:

- Reducing power wastes during electric power transmission
- High voltage step-down and high voltage step-up
- During long-distance consumer applications
- In cases where load runs at full capacity 24×7 [7].

2.9. Conclusion :

Power transformers play an important role in regulating and ensuring the flow of electricity in our everyday life and a number of Power transformer manufacturers are making the best of their efforts to ensure your safety and convenience.

Chapter 3

COMMISIONNING OF POWER TRANSFORMER

3.1. Introduction

After new power transformer has been set up on site and before it connects with power supply and loading the load, it is must to have to go through numbers of testing procedures for confirming the specifications and performances of a power transformer. The purpose of commissioning tests on transformer is to satisfy, to pre-determined standards, that all the equipment erection is correct and that all the equipment connections or cables have been installed in accordance with the approved erection drawings and diagrams.

3.1.1. The instruments of commissioning tests:

3.1.1.1. The Megger Meter

The megger is the instrument uses for measuring the resistance of the insulation. It works on the principle of comparison, i.e., the resistance of the insulation is compared with the known value of resistance. If the resistance of the insulation is high, the pointer of the moving coil deflects towards the infinity, and if it is low, then the pointer indicates zero resistance. The accuracy of the Megger is high as compared to other instruments[9] .

Figure 3.1. Megger Meter

3.1.1.2. CPC100:

CPC 100, in conjunction with its accessories or as a stand-alone unit, is a multipurpose primary test set for commissioning and maintaining substation equipment. It performs current transformer (CT), voltage transformer (VT) and power transformer (TR) tests. Furthermore it is used for contact and winding resistance testing, polarity checks as well as primary and secondary protection relay testing [10].

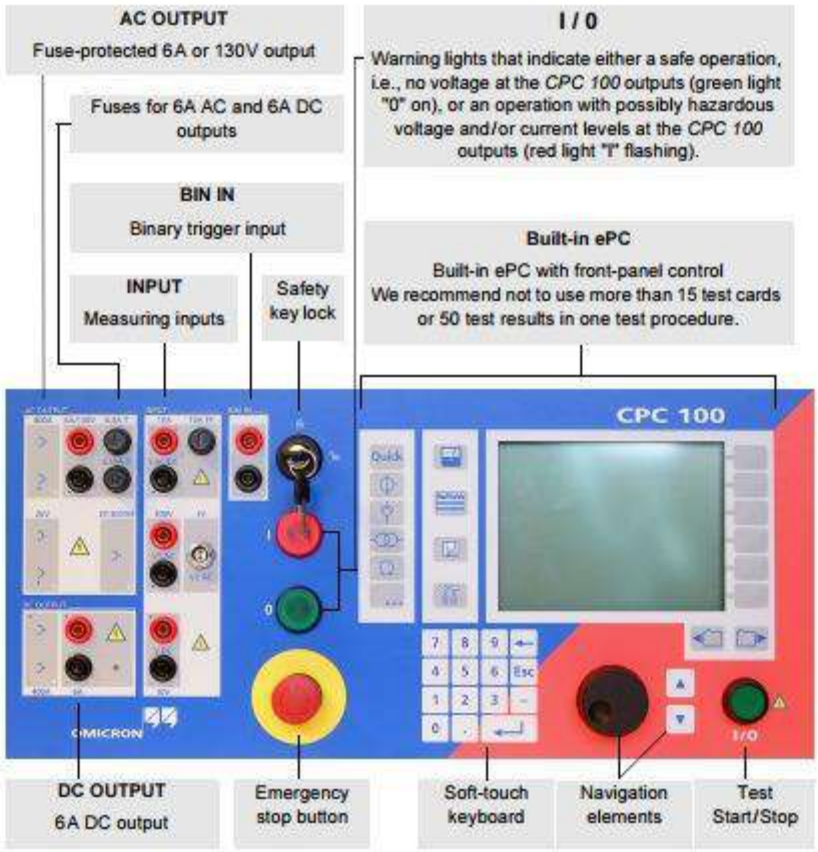

Figure 3.2. Parts of CPC100

3.2. Insulation resistance test :

By measuring the insulation resistance before first energizing of the transformer, the following eventualities are checked:

- possible bad mistakes done during erection or any damages occurred during shipment
- if the procedures performed on the transformer active parts counting from the delivery in the factory till the final works before energizing have had any bad influence on the general insulating properties.

The absolute insulation resistance value depends on the transformer rated power, as well as on the quantity, quality, volume, heat, humidity and other properties, but there are many other factors affecting this value. That is why it is impossible to nominate or define a general allowable minimum insulation resistance value for the transformers of different ratings and particularly of different manufacturers.

In order to make comparisons between insulation resistance values obtained on site and in the factory, it should be necessary to perform the measurement on site in the same conditions which have been present in the factory during the same measurements (relative humidity, bushing cleanliness, same oil, etc.)

However, as it is impossible to achieve the same conditions, an estimate shall be used as described hereunder in the text..

As the law of change in transformer insulation resistance due to temperature variation is known enough..

Insulation resistance values obtained on site may be related to the reference temperature of 20°C for the sake of comparison with the values obtained in the factory. The influence of the other factors is estimated for each case For relating insulation resistance to the reference temperature 20°C, this rule is used: for each 10K of temperature rise or drop, one minute insulation resistance is reduced or raised approximately 1.99 times.

The coefficients may be taken from the following table:

Test Temperature °C	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**
Coefficient k	**.25**	**.36**	**.5**	**.75**	**1**	**1.4**	**1.98**	**2.8**	**3.95**	**5.6**

Table 3.1. Temperature Correction Factor

The value of the coefficient for other temperatures may be calculated by interpolation. However, the other mentioned parameters may have such an influence that even twice reduced insulation resistance obtained in such a way than the resistance measured in the factory may be completely satisfactory.

This is specially the case when the insulation resistance measured in the factory has been extremely high. For these cases, this rule shall be followed: when the insulation resistance obtained in the mentioned way is less than 50% of the value measured in the factory, the manufacturer shall be consulted. In order to get the knowledge about the insulation condition as better as possible, it is convenient to measure insulation resistance value after 15 and 60 seconds counted from the instant of application of test voltage.

It is possible to compare the results obtained by application of the same connection and test voltage only regularly, for this measurement a mega-ohmmeter 2500 or 5000 V with a "guard" terminal should be used. For a two-winding transformer, insulation resistance for the following combinations shall be measured:

- HV - LV (m)
- HV-m (LV)
- LV- m (HV)

For a three-winding transformer, insulation resistance for the following combinations shall be measured:

- HV-MV (LV+m)
- HV-LV (MV+m)
- MV- LV (HV+m)
- HV-m (MV LV)
- MV-m (HV¬+LV)
- LV -m (HV+MV)

The resistance which is to be measured shall be connected between "L" and "E" terminals, while the points given in parenthesis are connected to "guard" terminal.

Legend:

HV-high voltage winding

MV-medium voltage winding

LV-low voltage winding

m-parts at earth potential (tank etc.) [11].

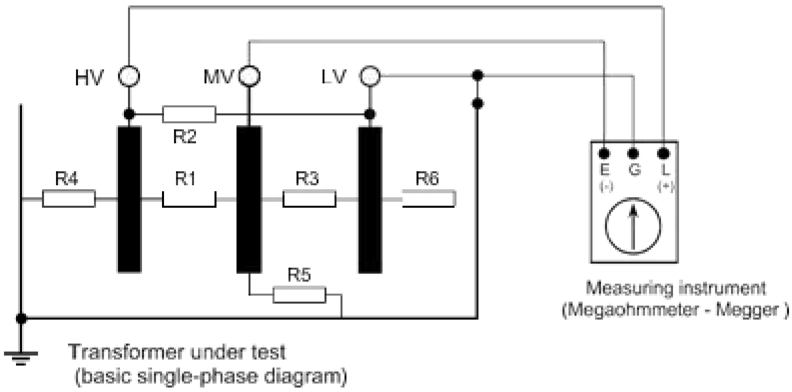

Figure 3.3. circuit for insulation resistance measurement

3.2.1. The objectif of insulation resistance test:

The purpose of this test is to determine the insulation resistance of the high-voltage winding to the ground, low-voltage winding to the ground, and the high-voltage winding to the low voltage winding, also to assess the amount of moisture in transformer insulation.

This test should be done between the windings as follows :

- High Voltage winding to the Earth .
- Low Voltage winding to the Earth same as HV - Earth but the connection will be between LV - Earth .
- The high voltage winding to the low Voltage Windings

3.2.2 Insulation resistance test results:

	Prime/body	sec/body	Prime/sec
Phase 0	5.37 GΩ	8.07 GΩ	7.46 GΩ
Phase 4	6.29 GΩ	7.70 GΩ	6.42 GΩ
Phase 8	6.78 GΩ	6.48 GΩ	7.77 GΩ

Table 3.2. Insulation test results

3.3. Winding resistance measurement

This measurement is normally not performed at site. It shall be performed only if there are some suspects on damage during transportation or upon special requirement.

Winding resistance between corresponding terminals is measured by volta-current (U-I) method.

The measurement is performed in OLTC principal and extreme taps. DC current and voltage drop are measured by using instruments of 0.2 classes according to Figure 4. A ratio between voltage drop and current gives the measured resistance. Temperature is measured by thermometer placed in the transformer pocket on the transformer cover. The required current is obtained from a battery 12 V [11].

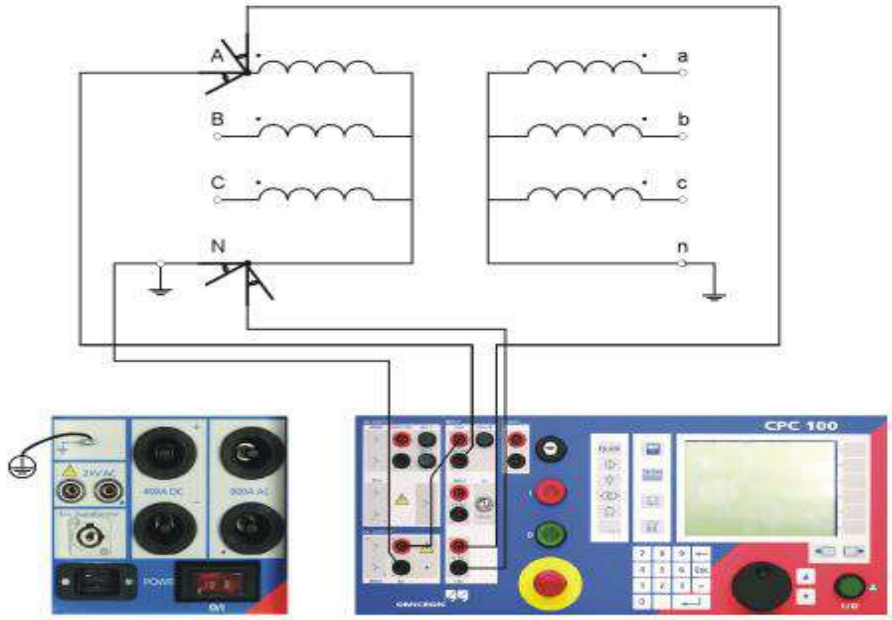

Figure 3.4. setup of a winding resistance test

3.3.1 The objectif of winding resistance

The purpose of this test is to measure the D.C. resistance of the transformer windings , this test can be done by a voltmeter and ammeter method . For low reading values , we connect the voltmeter after the ammeter , but for high resistance values , we connect the voltmeter before the ammeter . A sensitive voltmeter and ammeter will be used with a 100 DC Amp.

3.3.2 Winding resistance test results:

Note: A and B and C Are The phases 0,4, 8

Test Device: CPC 100
Serial Number: FL736J (V1)

Tap	Time	R meas.	Dev.	R ref.	Ripple
C 001	75.000 s	160.30 mΩ	0.00 %	187.52 mΩ	n/a
C 002	45.000 s	157.80 mΩ	0.00 %	184.59 mΩ	1.23 %
C 003	52.000 s	155.21 mΩ	0.00 %	181.56 mΩ	1.49 %
C 004	69.000 s	152.70 mΩ	0.00 %	178.63 mΩ	1.48 %
C 005	48.000 s	150.15 mΩ	0.00 %	175.65 mΩ	1.57 %
C 006	42.000 s	147.64 mΩ	0.00 %	172.71 mΩ	1.62 %
C 007	93.000 s	145.11 mΩ	0.00 %	169.75 mΩ	1.52 %
C 008	74.000 s	142.60 mΩ	0.00 %	166.82 mΩ	1.55 %
C 009	149.000 s	140.08 mΩ	0.00 %	163.87 mΩ	2.9e+2 m%
C 010	55.000 s	137.57 mΩ	0.00 %	160.93 mΩ	1.66 %
C 011	41.000 s	135.03 mΩ	0.00 %	157.96 mΩ	1.62 %
C 012	44.000 s	132.49 mΩ	0.00 %	154.99 mΩ	1.68 %
C 013	49.000 s	130.03 mΩ	0.01 %	152.11 mΩ	1.60 %
C 014	46.000 s	126.52 mΩ	0.00 %	148.00 mΩ	1.77 %
C 015	38.000 s	129.53 mΩ	0.00 %	151.52 mΩ	1.86 %
C 016	41.000 s	132.13 mΩ	0.00 %	154.57 mΩ	1.84 %
C 017	43.000 s	134.66 mΩ	0.00 %	157.53 mΩ	1.75 %
C 018	49.000 s	137.25 mΩ	0.00 %	160.56 mΩ	1.80 %
C 019	36.000 s	139.80 mΩ	0.00 %	163.54 mΩ	1.82 %
C 020	48.000 s	142.39 mΩ	0.00 %	166.57 mΩ	1.90 %
C 021	38.000 s	144.95 mΩ	0.00 %	169.57 mΩ	1.89 %
C 022	89.000 s	147.57 mΩ	0.00 %	172.62 mΩ	4.01 %
C 023	48.000 s	150.13 mΩ	0.00 %	175.62 mΩ	2.53 %
C 024	43.000 s	152.72 mΩ	0.00 %	178.65 mΩ	2.10 %
C 025	38.000 s	155.32 mΩ	0.00 %	181.69 mΩ	2.30 %
C 026	37.000 s	157.90 mΩ	0.00 %	184.71 mΩ	2.12 %
C 027	46.000 s	160.57 mΩ	0.00 %	187.83 mΩ	2.20 %
B 027	98.000 s	161.08 mΩ	0.00 %	188.43 mΩ	n/a
B 026	106.000 s	158.42 mΩ	0.00 %	185.32 mΩ	3.99 %
B 025	49.000 s	155.83 mΩ	0.00 %	182.29 mΩ	4.15 %

B 024	46.000 s	153.20 mΩ	0.00 %	179.22 mΩ	4.13 %
B 023	46.000 s	150.66 mΩ	0.00 %	176.24 mΩ	4.13 %
B 022	43.000 s	148.04 mΩ	0.00 %	173.17 mΩ	4.03 %
B 021	88.000 s	145.51 mΩ	0.00 %	170.21 mΩ	4.13 %
B 020	61.000 s	142.88 mΩ	0.00 %	167.15 mΩ	4.01 %
B 019	46.000 s	140.33 mΩ	0.00 %	164.16 mΩ	3.94 %
B 018	55.000 s	137.76 mΩ	0.00 %	161.15 mΩ	3.84 %
B 017	45.000 s	135.19 mΩ	0.00 %	158.15 mΩ	3.93 %
B 016	49.000 s	132.64 mΩ	0.00 %	155.16 mΩ	3.85 %
B 015	43.000 s	130.05 mΩ	0.00 %	152.13 mΩ	3.85 %
B 014	47.000 s	126.74 mΩ	0.00 %	148.26 mΩ	3.71 %
B 013	46.000 s	130.57 mΩ	0.00 %	152.74 mΩ	3.83 %
B 012	54.000 s	133.05 mΩ	0.00 %	155.65 mΩ	3.65 %
B 011	50.000 s	135.63 mΩ	0.00 %	158.67 mΩ	3.70 %
B 010	50.000 s	138.17 mΩ	0.00 %	161.63 mΩ	3.52 %
B 009	45.000 s	140.74 mΩ	0.00 %	164.64 mΩ	3.56 %
B 008	49.000 s	143.26 mΩ	0.00 %	167.59 mΩ	3.45 %
B 007	43.000 s	145.84 mΩ	0.00 %	170.61 mΩ	3.52 %
B 006	48.000 s	148.38 mΩ	0.00 %	173.58 mΩ	3.38 %
B 005	48.000 s	150.95 mΩ	0.00 %	176.58 mΩ	3.47 %
B 004	91.000 s	153.49 mΩ	0.00 %	179.56 mΩ	3.24 %
B 003	91.000 s	156.06 mΩ	0.00 %	182.57 mΩ	3.35 %
B 002	49.000 s	158.66 mΩ	0.00 %	185.60 mΩ	3.27 %
B 001	44.000 s	161.24 mΩ	0.00 %	188.62 mΩ	3.26 %
A 001	145.000 s	161.72 mΩ	0.00 %	189.18 mΩ	n/a
A 002	43.000 s	159.17 mΩ	0.00 %	186.20 mΩ	1.64 %
A 001	48.000 s	156.55 mΩ	0.00 %	183.14 mΩ	1.67 %
A 003	25.000 s	156.57 mΩ	0.00 %	183.15 mΩ	2.8e+2 m%
A 004	64.000 s	154.02 mΩ	0.00 %	180.17 mΩ	1.57 %
A 005	74.000 s	151.47 mΩ	0.00 %	177.19 mΩ	1.63 %
A 006	113.000 s	148.94 mΩ	0.00 %	174.24 mΩ	1.54 %
A 007	41.000 s	146.40 mΩ	0.00 %	171.26 mΩ	1.66 %
A 008	41.000 s	143.85 mΩ	0.00 %	168.28 mΩ	1.55 %
A 009	70.000 s	141.32 mΩ	0.01 %	165.32 mΩ	1.65 %
A 010	52.000 s	138.78 mΩ	0.01 %	162.35 mΩ	1.64 %
A 011	54.000 s	136.23 mΩ	0.00 %	159.36 mΩ	1.81 %

A 012	116.000 s	133.68 mΩ	0.00 %	156.38 mΩ	1.72 %
A 013	58.000 s	131.17 mΩ	0.00 %	153.44 mΩ	1.84 %
A 014	59.000 s	126.95 mΩ	0.00 %	148.51 mΩ	1.64 %
A 015	64.000 s	126.96 mΩ	0.00 %	148.52 mΩ	3.3e+2 m%
A 015	52.000 s	130.74 mΩ	0.01 %	152.95 mΩ	1.86 %
A 016	37.000 s	133.35 mΩ	0.00 %	155.99 mΩ	1.85 %
A 017	50.000 s	135.91 mΩ	0.01 %	158.99 mΩ	1.96 %
A 018	82.000 s	138.52 mΩ	0.00 %	162.05 mΩ	1.78 %
A 019	38.000 s	141.10 mΩ	0.00 %	165.05 mΩ	1.98 %
A 020	37.000 s	143.71 mΩ	0.00 %	168.11 mΩ	1.98 %
A 021	42.000 s	146.31 mΩ	0.00 %	171.15 mΩ	2.06 %
A 022	45.000 s	148.93 mΩ	0.00 %	174.21 mΩ	1.91 %
A 023	55.000 s	151.55 mΩ	0.00 %	177.28 mΩ	2.14 %
A 024	74.000 s	154.15 mΩ	0.00 %	180.33 mΩ	2.01 %
A 025	41.000 s	156.78 mΩ	0.00 %	183.40 mΩ	2.15 %
A 026	38.000 s	159.41 mΩ	0.00 %	186.48 mΩ	2.15 %
A 027	38.000 s	162.11 mΩ	0.00 %	189.63 mΩ	2.20 %

Table 3.3. Winding resistance test results

3.4 Transformation and voltage ratio

Transformation ratio measurement has been performed in the factory and it will be just a check on the site. It is particularly important for regulating transformers to perform this measurement for all tap positions. The check is performed by a voltmeter method, in a way that a three phase or a single-phase voltage of approximately 380/220 V is applied to the high voltage side and on the low voltage side results in all OLTC (on-load tap changer) and OFFCTC (off-circuit tap changer) positions are read of ted and earthed

The measurement is performed by measuring the same phase voltages by voltmeters of 0,2-0,5 classes. The obtained results shall be in accordance with the results given in the factory test report. The testing can be performed as shown in the Figure 5 below [11] .

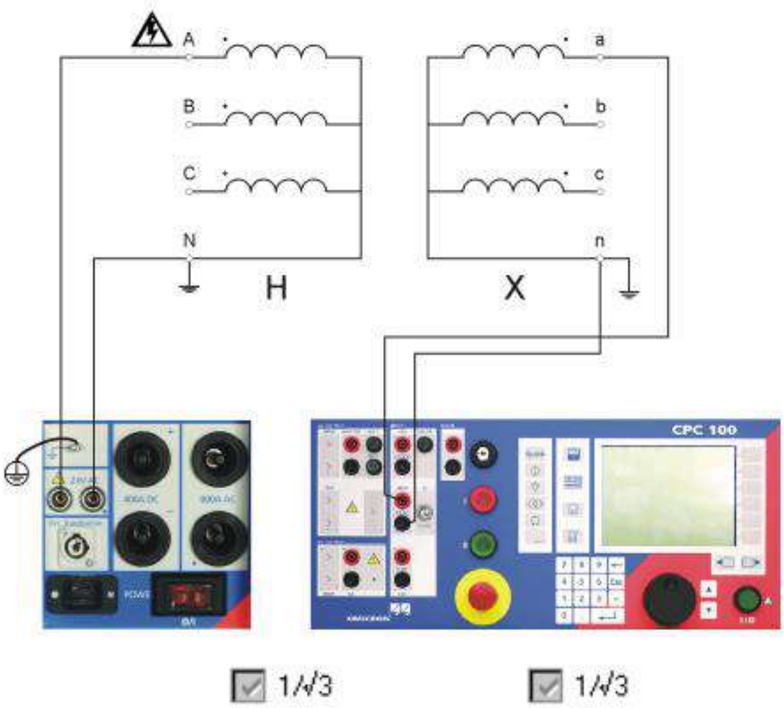

Figure 3.5. Setup for testing a power transformer ratio:

3.4.1 The objectif of transformation ration check

The transformer turns ratio test is used to determine the number of turns in one winding of a transformer in relation to the number of turns in the other windings of the same phase of the transformer.

3.4.2 .Ratio Test Results :

Test Device: CPC 100

Serial Number: FL736J (V1)

Note : A and B and C Are The phases 0,4,8

Tap	HV Reference	LV Reference	Ratio nom.	HV test		LV test		Ratio	
C 027	49200 V	31500.0 V	1.5619 :1	399.89 V	0.00 °	255.88 V	-0.02 °	1.5628 :1	0.06 %
C 026	50031 V	31500.0 V	1.5883 :1	399.91 V	0.00 °	251.65 V	0.00 °	1.5891 :1	0.05 %
025	50862 V	31500.0 V	1.6147 :1	399.90 V	0.00 °	247.55 V	0.01 °	1.6154 :1	0.05 %
C 024	51692 V	31500.0 V	1.6410 :1	399.92 V	0.00 °	243.59 V	0.01 °	1.6418 :1	0.04 %
C 023	52523 V	31500.0 V	1.6674 :1	399.91 V	0.00 °	239.74 V	0.00 °	1.6681 :1	0.04 %

Tap	HV Reference	LV Reference	Ratio nom.	HV test		LV test		Ratio	
C 022	53354 V	31500.0 V	1.6938 :1	399.87 V	0.00 °	236.00 V	0.02 °	1.6944 :1	0.03 %
C 021	54185 V	31500.0 V	1.7202 :1	399.88 V	0.00 °	232.40 V	0.01 °	1.7207 :1	0.03 %
C 020	55015 V	31500.0 V	1.7465 :1	399.94 V	0.00 °	228.93 V	0.00 °	1.7470 :1	0.03 %
C 019	55846 V	31500.0 V	1.7729 :1	399.90 V	0.00 °	225.51 V	0.01 °	1.7733 :1	0.02 %
C 018	56677 V	31500.0 V	1.7993 :1	399.91 V	0.00 °	222.22 V	0.00 °	1.7996 :1	0.02 %
C 017	57508 V	31500.0 V	1.8257 :1	399.92 V	0.00 °	219.03 V	0.01 °	1.8259 :1	0.01 %
C 016	58338 V	31500.0 V	1.8520 :1	399.90 V	0.00 °	215.90 V	0.01 °	1.8522 :1	0.01 %
C 015	59169 V	31500.0 V	1.8784 :1	399.93 V	0.00 °	212.90 V	0.00 °	1.8785 :1	0.01 %
C 014	60000 V	31500.0 V	1.9048 :1	399.92 V	0.00 °	209.95 V	0.00 °	1.9048 :1	0.00 %
C 013	60831 V	31500.0 V	1.9311 :1	399.88 V	0.00 °	207.07 V	0.00 °	1.9311 :1	0.00 %
C 012	61662 V	31500.0 V	1.9575 :1	399.92 V	0.00 °	204.30 V	0.00 °	1.9575 :1	0.00 %
C 011	62492 V	31500.0 V	1.9839 :1	399.92 V	0.00 °	201.60 V	0.00 °	1.9837 :1	-0.01 %
C 010	63323 V	31500.0 V	2.0103 :1	399.89 V	0.00 °	198.94 V	-0.01 °	2.0101 :1	-0.01 %
C 009	64154 V	31500.0 V	2.0366 :1	399.87 V	0.00 °	196.36 V	0.00 °	2.0364 :1	-0.01 %
C 008	64985 V	31500.0 V	2.0630 :1	399.94 V	0.00 °	193.89 V	0.00 °	2.0627 :1	-0.02 %
C 007	65815 V	31500.0 V	2.0894 :1	399.87 V	0.00 °	191.42 V	0.00 °	2.0890 :1	-0.02 %
C 006	66646 V	31500.0 V	2.1157 :1	399.97 V	0.00 °	189.09 V	0.00 °	2.1153 :1	-0.02 %
C 005	67477 V	31500.0 V	2.1421 :1	399.93 V	0.00 °	186.74 V	0.01 °	2.1416 :1	-0.02 %
C 004	68308 V	31500.0 V	2.1685 :1	399.98 V	0.00 °	184.50 V	0.00 °	2.1679 :1	-0.03 %
C 003	69138 V	31500.0 V	2.1949 :1	399.91 V	0.00 °	182.26 V	-0.01 °	2.1942 :1	-0.03 %
C 002	69969 V	31500.0 V	2.2212 :1	399.90 V	0.00 °	180.09 V	0.00 °	2.2206 :1	-0.03 %
C 001	70800 V	31500.0 V	2.2476 :1	399.90 V	0.00 °	177.98 V	0.00 °	2.2469 :1	-0.03 %
B 001	70800 V	31500.0 V	2.2476 :1	399.87 V	0.00 °	177.96 V	0.00 °	2.2469 :1	-0.03 %
B 002	69969 V	31500.0 V	2.2212 :1	399.83 V	0.00 °	180.06 V	0.00 °	2.2206 :1	-0.03 %
B 003	69138 V	31500.0 V	2.1949 :1	399.97 V	0.00 °	182.28 V	0.01 °	2.1943 :1	-0.03 %
B 004	68308 V	31500.0 V	2.1685 :1	399.90 V	0.00 °	184.46 V	0.00 °	2.1680 :1	-0.02 %
B 005	67477 V	31500.0 V	2.1421 :1	399.85 V	0.00 °	186.70 V	0.01 °	2.1416 :1	-0.02 %
B 006	66646 V	31500.0 V	2.1157 :1	399.92 V	0.00 °	189.06 V	0.00 °	2.1154 :1	-0.02 %
B 007	65815 V	31500.0 V	2.0894 :1	399.84 V	0.00 °	191.40 V	0.00 °	2.0890 :1	-0.02 %
B 008	64985 V	31500.0 V	2.0630 :1	399.96 V	0.00 °	193.90 V	0.00 °	2.0627 :1	-0.01 %
B 009	64154 V	31500.0 V	2.0366 :1	399.85 V	0.00 °	196.35 V	0.01 °	2.0364 :1	-0.01 %
B 010	63323 V	31500.0 V	2.0103 :1	399.98 V	0.00 °	198.99 V	0.00 °	2.0101 :1	-0.01 %
B 011	62492 V	31500.0 V	1.9839 :1	399.87 V	0.00 °	201.57 V	0.01 °	1.9838 :1	0.00 %
B 012	61662 V	31500.0 V	1.9575 :1	399.91 V	0.00 °	204.30 V	0.00 °	1.9575 :1	0.00 %

Tap	HV Reference	LV Reference	Ratio nom.	HV test		LV test		Ratio	
B 013	60831 V	31500.0 V	1.9311 :1	399.90 V	0.00 °	207.07 V	0.02 °	1.9312 :1	0.00 %
B 014	60000 V	31500.0 V	1.9048 :1	399.93 V	0.00 °	209.95 V	0.02 °	1.9049 :1	0.01 %
B 015	59169 V	31500.0 V	1.8784 :1	399.89 V	0.00 °	212.87 V	0.00 °	1.8786 :1	0.01 %
B 016	58338 V	31500.0 V	1.8520 :1	399.92 V	0.00 °	215.91 V	0.00 °	1.8522 :1	0.01 %
B 017	57508 V	31500.0 V	1.8257 :1	399.91 V	0.00 °	219.01 V	0.00 °	1.8260 :1	0.02 %
B 018	56677 V	31500.0 V	1.7993 :1	399.91 V	0.00 °	222.22 V	0.00 °	1.7996 :1	0.02 %
B 019	55846 V	31500.0 V	1.7729 :1	399.90 V	0.00 °	225.51 V	0.00 °	1.7733 :1	0.02 %
B 020	55015 V	31500.0 V	1.7465 :1	399.89 V	0.00 °	228.90 V	0.00 °	1.7470 :1	0.03 %
B 021	54185 V	31500.0 V	1.7202 :1	399.86 V	0.00 °	232.38 V	0.00 °	1.7207 :1	0.03 %
B 022	53354 V	31500.0 V	1.6938 :1	399.86 V	0.00 °	235.99 V	0.00 °	1.6944 :1	0.04 %
B 023	52523 V	31500.0 V	1.6674 :1	399.89 V	0.00 °	239.73 V	0.01 °	1.6681 :1	0.04 %
B 024	51692 V	31500.0 V	1.6410 :1	399.90 V	0.00 °	243.57 V	0.00 °	1.6418 :1	0.05 %
B 025	50862 V	31500.0 V	1.6147 :1	399.90 V	0.00 °	247.54 V	0.00 °	1.6155 :1	0.05 %
B 026	50031 V	31500.0 V	1.5883 :1	399.90 V	0.00 °	251.63 V	0.01 °	1.5892 :1	0.06 %
B 027	49200 V	31500.0 V	1.5619 :1	399.90 V	0.00 °	255.87 V	0.01 °	1.5629 :1	0.06 %
A 027	49200 V	31500.0 V	1.5619 :1	399.90 V	0.00 °	255.87 V	0.01 °	1.5629 :1	0.06 %
A 026	50031 V	31500.0 V	1.5883 :1	399.91 V	0.00 °	251.64 V	0.02 °	1.5892 :1	0.06 %
A 025	50862 V	31500.0 V	1.6147 :1	399.89 V	0.00 °	247.53 V	0.00 °	1.6155 :1	0.05 %
A 024	51692 V	31500.0 V	1.6410 :1	399.92 V	0.00 °	243.59 V	0.00 °	1.6418 :1	0.05 %
A 023	52523 V	31500.0 V	1.6674 :1	399.90 V	0.00 °	239.73 V	0.01 °	1.6681 :1	0.04 %
A 022	53354 V	31500.0 V	1.6938 :1	399.91 V	0.00 °	236.01 V	0.00 °	1.6945 :1	0.04 %
A 021	54185 V	31500.0 V	1.7202 :1	399.91 V	0.00 °	232.41 V	0.00 °	1.7207 :1	0.03 %
A 020	55015 V	31500.0 V	1.7465 :1	399.89 V	0.00 °	228.89 V	0.00 °	1.7471 :1	0.03 %
A 019	55846 V	31500.0 V	1.7729 :1	399.90 V	0.00 °	225.50 V	0.01 °	1.7734 :1	0.03 %
A 018	56677 V	31500.0 V	1.7993 :1	399.90 V	0.00 °	222.20 V	0.01 °	1.7997 :1	0.03 %
A 017	57508 V	31500.0 V	1.8257 :1	399.91 V	0.00 °	219.00 V	0.00 °	1.8260 :1	0.02 %
A 016	58338 V	31500.0 V	1.8520 :1	399.92 V	0.00 °	215.90 V	0.01 °	1.8524 :1	0.02 %
A 015	59169 V	31500.0 V	1.8784 :1	399.90 V	0.00 °	212.87 V	0.01 °	1.8786 :1	0.01 %
A 014	60000 V	31500.0 V	1.9048 :1	399.90 V	0.00 °	209.93 V	0.01 °	1.9049 :1	0.01 %
A 013	60831 V	31500.0 V	1.9311 :1	399.90 V	0.00 °	207.07 V	0.01 °	1.9313 :1	0.01 %
A 012	61662 V	31500.0 V	1.9575 :1	399.89 V	0.00 °	204.28 V	0.00 °	1.9576 :1	0.00 %
A 011	62492 V	31500.0 V	1.9839 :1	399.91 V	0.00 °	201.59 V	0.00 °	1.9838 :1	0.00 %
A 010	63323 V	31500.0 V	2.0103 :1	399.90 V	0.00 °	198.94 V	0.00 °	2.0101 :1	-0.01 %
A 009	64154 V	31500.0 V	2.0366 :1	399.91 V	0.00 °	196.37 V	0.00 °	2.0365 :1	-0.01 %

Tap	HV Reference	LV Reference	Ratio nom.	HV test		LV test		Ratio	
A 008	64985 V	31500.0 V	2.0630 :1	399.88 V	0.00 °	193.85 V	0.00 °	2.0628 :1	-0.01 %
A 007	65815 V	31500.0 V	2.0894 :1	399.89 V	0.00 °	191.42 V	0.00 °	2.0891 :1	-0.01 %
A 006	66646 V	31500.0 V	2.1157 :1	399.92 V	0.00 °	189.05 V	0.00 °	2.1154 :1	-0.02 %
A 005	67477 V	31500.0 V	2.1421 :1	399.89 V	0.00 °	186.72 V	0.00 °	2.1417 :1	-0.02 %
A 004	68308 V	31500.0 V	2.1685 :1	399.92 V	0.00 °	184.46 V	0.00 °	2.1680 :1	-0.02 %
A 003	69138 V	31500.0 V	2.1949 :1	399.92 V	0.00 °	182.25 V	0.00 °	2.1944 :1	-0.02 %
A 002	69969 V	31500.0 V	2.2212 :1	399.96 V	0.00 °	180.11 V	0.00 °	2.2206 :1	-0.03 %
A 001	70800 V	31500.0 V	2.2476 :1	399.87 V	0.00 °	177.96 V	0.00 °	2.2470 :1	-0.03 %

Table.3.4. Ratio test results

3.5. Magnetizing current measurement at 380 v

By magnetizing current measurement at this voltage, it is possible to ascertain bad error in transformer. The measurement is to be performed in each phase of each winding on principal tapping.

The measurement is performed by applying the three-phase/single-phase voltage from the source of approximately 380 V /220 V across ammeters connected in series (universal instruments), Wires by which connections are made shall be well insulated for the test voltage, and instruments shall be placed on the table (case) near the transformer base.

The results obtained shall be near to values given in the factory test report, and if they are missing an -estimation shall be made according to currents measured at no-load

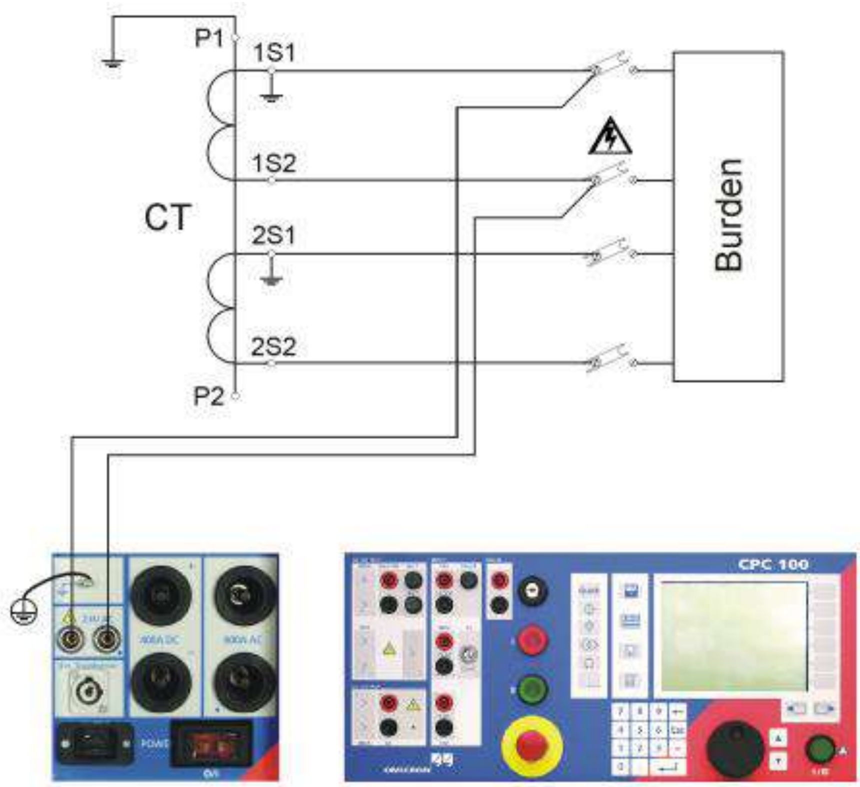

Figure 3.6. . Basic test circuit magnetizing current measurement at 380 V

3.5.1. The objectif of magnetizing current measurement

Magnetizing current test of transformer is performed to locate defects in the magnetic core structure, shifting of windings, failure in between turn insulation or problem in tap changers

3.5.2. Magnetizing current measurement result

MAGN-HT/PH0(PROT):

V	I
797.04 V	340.42 mA
785.53 V	180.85 mA
768.81 V	92.649 mA
746.22 V	55.773 mA
720.53 V	40.828 mA
693.76 V	33.726 mA
666.68 V	29.871 mA
639.34 V	27.411 mA
611.88 V	25.576 mA
584.44 V	24.109 mA
556.95 V	22.862 mA
529.39 V	21.751 mA
501.89 V	20.711 mA
474.31 V	19.742 mA
446.72 V	18.814 mA
419.16 V	17.911 mA
391.62 V	17.017 mA
363.98 V	16.131 mA
336.40 V	15.239 mA
308.80 V	14.338 mA
281.16 V	13.424 mA
253.54 V	12.485 mA
225.95 V	11.513 mA
198.35 V	10.502 mA
170.71 V	9.4300 mA
143.10 V	8.2870 mA
115.48 V	7.0540 mA
87.85 V	5.7070 mA
60.23 V	4.2130 mA
32.61 V	2.5560 mA
4.93 V	618.00 µA

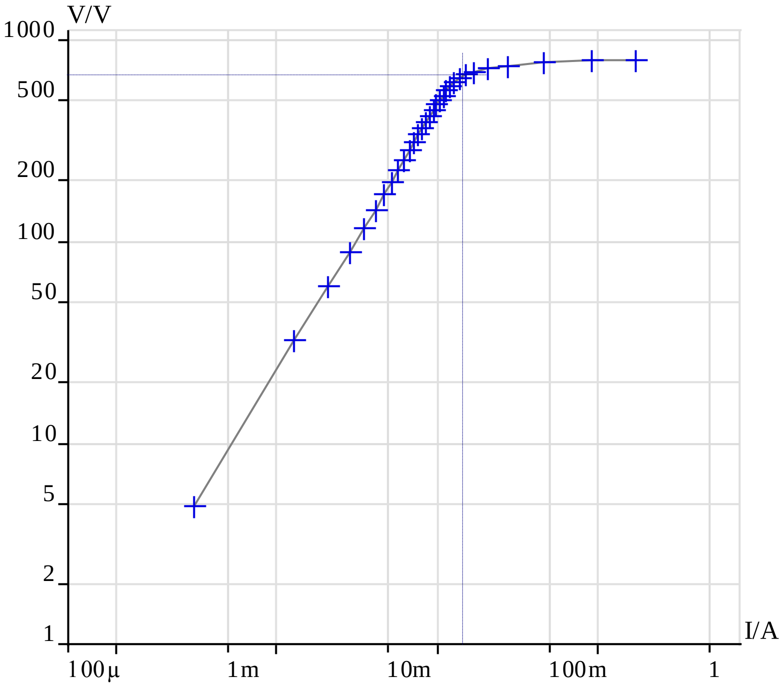

Table.3.5. Magnetizing current measurement result(ph0 protection)

Results MAGN-HT/PH0(MESUR):

V	I
27.79 V	1.0346 A
27.42 V	1.0005 A
26.99 V	0.96633 A
26.67 V	933.08 mA
26.71 V	898.57 mA
26.78 V	864.19 mA
26.79 V	830.37 mA
26.77 V	795.62 mA
26.66 V	761.29 mA
26.45 V	727.62 mA
26.17 V	693.44 mA
25.82 V	659.04 mA
25.90 V	624.97 mA
26.01 V	591.04 mA
26.04 V	556.55 mA
25.92 V	522.79 mA
25.62 V	489.53 mA
25.26 V	455.98 mA
25.32 V	421.75 mA
25.30 V	388.60 mA
24.99 V	355.38 mA
24.70 V	321.69 mA
24.71 V	288.31 mA
24.36 V	255.46 mA
24.28 V	222.75 mA
24.01 V	189.49 mA
23.87 V	157.64 mA
23.67 V	126.09 mA
23.48 V	94.472 mA
23.24 V	64.369 mA
22.79 V	38.484 mA
21.75 V	18.113 mA

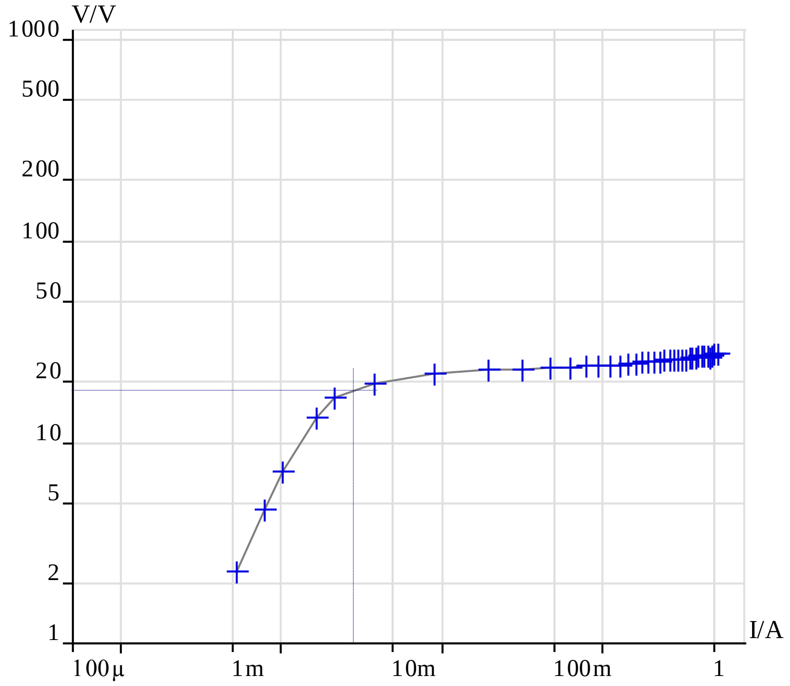

Table.3.6. Magnetizing current measurement result (ph0.measure)

3.6. Conclusion:

The purpose of electric systems commissioning is to increase the reliability of electrical power systems after installation by identifying problems and providing a set of baseline values for comparison with subsequent routine tests.

GENERAL CONCLUSION

To ensure that power transformer is in good condition when operation and according of customer needs, and follow the specification from manufacturer test, most of testing need to be done. Based on the all result, it can be concluded that all of the tests done on the transformer power is follow the specification of manufacturer and able to meet the needs of the industry

This overview of the tasks associated with the transport, installation and commissioning of power transformers highlights that this involves a number of complex tasks which, if not undertaken with due care and diligence, could lead to irreversible damage or loss of service life, or even failure. It is important for users of such services to ensure that the supplier has proven quality, safety and environmental management systems in place and a track record for success in this field.

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