
PARALLEL OPERATION OF TRANSFORMERS

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Abstract - : *Parallel operation of power transformers is a common practice. Interest is placed on minimizing the reactive current circulation between transformers due to mismatching of electrical properties. Several control schemes have been applied over the years to ensure efficient operation of paralleled transformers with OLTC. These methods rely either on field measurements of circulating currents or on classic Master/Follower approach and usually assume that the paralleled transformers have matching impedances and OLTC positions. On the present work a generalized approach is implemented calculating the circulating current and minimizing losses directly at the System Operation Office and using the distribution system SCADA to control tap position of the paralleled transformers. This permits the determination of optimal tap matching between transformers and calculation of losses under emergency situations where coupling of transformers with slight impedance mismatch might be considered. In the proposed method a map of circulating current is calculated based on the transformer impedance, X/R ratio and OLTC positions, then the optimal tap positions (minimizing losses) under parallel operation are determined.*

1. INTRODUCTION

It is common practice to operate power transformers in parallel and it is usually due to one of the following reasons.

1. Increased Load: If the power of a substation must be increased due to load, one of the economically sound solutions is to add a second transformer in parallel operation.
2. Flexible operation: paralleled transformers can be operated in several ways ensuring reliability, safety, critical load selection and ease of maintenance routine without service outage.
3. High Power: Due to transport size/weight restriction, it may be the only solution to high power requirements. Even so paralleled operation of power transformers has several drawbacks: increasing short-circuit currents that increase necessary breaker capacity, circulating currents that diminish load capability and increased losses.

The present work focuses on reducing circulating current while analyzing parallel operation of transformers with slightly different impedance, ratio or tap positions. Previous works in the area are focused on paralleling schemes applied as automatic control of the on load tap changer at the substation, among the more commonly used are the master/follower and circulating currents method. 2 paralleled operation of power transformer There are several conditions that must be met to operate transformers in parallel, some of these conditions are convenient and some are mandatory. Among the convenient are: same voltage ratio, same short circuit voltage in p.u., and same short circuit power. The mandatory conditions are: same connection index, and same phase sequence. When the convenient conditions are not met paralleled operation is possible but not optimal, not complying with mandatory conditions imply phase to phase failures so operation in parallel is not feasible.

2. LITERATURE SURVEY:

When operating two or more transformers in parallel, their satisfactory performance requires that they have

1. Same voltage ratio and turns ratio (both primary and secondary voltage rating is the same).
2. Same percentage impedance and X/R ratio.
3. Identical position of tap changer.
4. Same MVA ratings.
5. Same phase angle shift (vector group is the same).
6. Same frequency rating.
7. Same polarity.

.Practical Aspects of Instantaneous Magnetization Power Functions of Silicon Iron Laminations particular, it cannot be expected that major text books on magnetism may contain any corresponding data. This is also valid for more recent reviews on transformers like [28,29]. The clear reason for the above is that conventional electronics did not offer the here needed dynamic resolution of data processing. ...

2.1 ANALYSIS, OPTIMIZATION AND CONTROL OF GRID-INTERFACED MATRIX-BASED ISOLATED AC-DC CONVERTERS

Conventional low-frequency transformers or line-frequency transformers (LFTs) have proven to be a robust solution to step-up/step-down the voltage and provide electrical isolation between two networks in the conventional unidirectional power

system, where the power flows from the transmission network to distribution network and the distribution network feeders in turn distribute power to consumers [38].

However, in the modern power system the unidirectional power flow is violated when the DERs' power production exceeds the local demand in the microgrid/nanogrid.

3. COMPONENT SELECTION:

3.1 TRANSFORMER:- The transformer is used for connecting this system directly to 220V AC. It steps down 220V into 12V.

A transformer is an electrical device that transfers electrical energy at one voltage from one circuit to other at a different voltage merely by magnetic coupling; the transfer of energy doesn't involve any kind of motion.

Transformers are analogous to gear box (used to convert torque and hence speed). Transformers step up or step down the voltage and therefore vary the current. As the product of speed and torque remains constant, product of voltage and current also remains constant.

3.2 RECTIFIER:

Single-phase circuits or multi-phase circuit comes under the rectifier circuits. For domestic applications single-phase low power rectifier circuits are used and industrial HVDC applications require three-phase rectification. The most important application of a PN junction diode is rectification and it is the process of converting AC to DC. This project use two rectifier with two diodes and one capacitor of each transformer. In this work bridge rectifier is used due to its merits like full wave rectification and high stability. For a single half of the cycle only two diodes will be in forward bias condition.

3.3 REGULATED POWER IC LM7815

Datasheet:

7815 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7815 provides +15V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels

3.4 HEAT SINK:

A heat sink is a piece of metal engineered to dissipate the maximum thermal energy into the ambient surroundings. It assists a component to remain below its maximum operating junction temperature by drawing this energy away, thereby preventing damage through excessive temperatures. All electronic components dissipate heat, and usually their package (body) is sufficient to dissipate it into the surroundings, however voltage regulators such as a 7805, 7812, LM317T, require assistance if they are to operate to their extreme limits.

3.5 RELAY

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

3.6 LED LIGHT

Light emitting diodes (LEDs) are semiconductor light sources. The light emitted from LEDs varies from visible to infrared and ultraviolet regions. They operate on low voltage and power. LEDs are one of the most common electronic components and are mostly used as indicators in circuits. They are also used for luminance and optoelectronic applications. Based on semiconductor diode, LEDs emit photons when electrons recombine with holes on forward biasing. The two terminals of LEDs are anode (+) and cathode (-) and can be identified by their size.

3.7 BC 547 TRANSISTOR

BC547 is an NPN bi-polar junction transistor. A transistor, stands for transfer of resistance, is commonly used to amplify current. A small current at its base controls a larger current at collector & emitter terminals.

BC547 is mainly used for amplification and switching purposes. It has a maximum current gain of 800. Its equivalent transistors are BC548 and BC549.

The transistor terminals require a fixed DC voltage to operate in the desired region of its characteristic curves.

4. SCHEMATIC DIAGRAM:

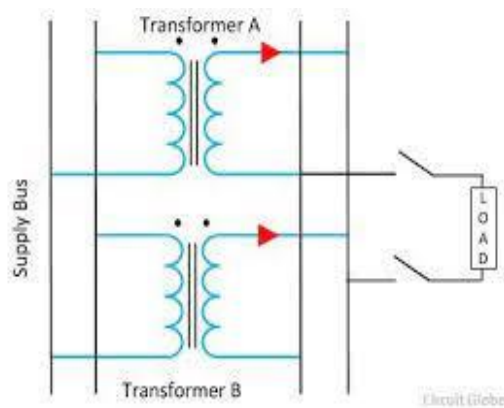


Fig. 5 Real photo while making connections

5. WORKING METHODOLOGY:

For supplying a load in excess of the rating of an existing transformer, two or more transformers may be connected in parallel with the existing transformer. The transformers are connected in parallel when load on one of the transformers is more than its capacity. The reliability is increased with parallel operation than to have single larger unit. The cost associated with maintaining the spares is less when two transformers are connected in parallel.

It is usually economical to install another transformer in parallel instead of replacing the existing transformer by a single larger unit. The cost of a spare unit in the case of two parallel transformers (of equal rating) is also lower than that of a single large transformer. In addition, it is preferable to have a parallel transformer for the reason of reliability. With this at least half the load can be supplied with one transformer out of service.

5.1 CONDITION FOR PARALLEL OPERATION OF TRANSFORMER

For parallel connection of transformers, primary windings of the transformers are connected to source bus-bars and secondary windings are connected to the load bus-bars. Various conditions that must be fulfilled for the successful parallel operation of transformers are

- Same phase angle shift (vector group are same)
- Same frequency rating
- Same polarity

6. PHOTO OF ACTUAL CIRCUIT SETUP:



7. ADVANTAGES AND DISADVANTAGES:

7.1 Advantages :

- Maximize Electrical Power System Efficiency
- Maximize Electrical Power System Stability
- Maximize Electrical Power System Flexibility
- The Availability Of Transformers For Service Can Be Increased By Connecting Two Or More Of Them In Parallel.
- The Parallel Operation Of Transformers Improves The Reliability Of The System.
- The Efficiency Of A Transformer Is Always Maximum At Full Load Conditions.

7.2 Disadvantages;

- Increasing Short-Circuit Currents That Increase Necessary Breaker Capacity.
- The Risk Of Circulating Currents Running From One Transformer To Another Transformer. ...
- The Bus Ratings Could Be Too High.
- Paralleling Transformers Reduces The Transformer Impedance Significantly, I.E. The
- Parallel Transformers May Have Very Low Impedance, Which Creates The High Short
- Circuit Currents

8. CONCLUSION:

A detail explanation of the calculations need to couple power transformers for parallel operation has been deduced, these formulae are later employed to develop an application that analyzes transformer paralleling and determines optimal tap setting by simple multiple function evaluations. This information is then used to remotely control tap changer position of in field transformers trough SCADA to minimize circulating currents and reduce losses.

Also a batch process is applied that yields useful information about transformers feasible of paralleled operation. This information is later used to bias transformer relocation to substations where they have possible paralleling partners

9. REFERENCES

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