Electric Machines Laboratory
(EE2P003)

EXPERIMENT-5

PARALLEL OPERATIONS OF SINGLE-PHASE TRANSFORMER

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Aim:

To perform polarity test and parallel operation of two single-phase transformers.

APPARATUS:

INSTRUMENTS / EQUIPMENTS

Sl. No	Instruments / Equipment	Type	Specification	Quantity
1	1- ϕ variac	Iron core	15A, 230V	1 No.
2	1- $\varnothing$ transformer	Iron core	1 kVA 220V / 220V	2 Nos
3	Voltmeter	MI	(0-300V)	2 N.s
4	Voltmeter	MI	(0-600V)	1 No.
5	Ammeter	MI	(0-5A)	2 Nos
6	Ammeter	MI	(0-10A)	1 No
7	Resistive Load		4 kW	1 No.
8	SPST Switch		230V, 15A	1 No.
9	Connecting wires	Cu	1.5 mm^2	As Required

Theory:

Polarity test is performed to determine the terminals having the same instantaneous polarity. The relative polarities of the primary and secondary terminals at any instant must be known per connecting windings of the same transformer in parallel or series or for interconnecting two or more transformers in parallel or for connecting single-phase transformers for polyphase transformation of voltages. Parallel operation of transformers is frequently necessary in the power system network, which consist of a number of a number of transformers installed at generating stations, substations etc. When operating two or more transformers in parallel, their satisfactory performance requires that the following conditions must be satisfied.

(a). For single phase transformers.:

- The same polarity.
- The same voltage ratio.

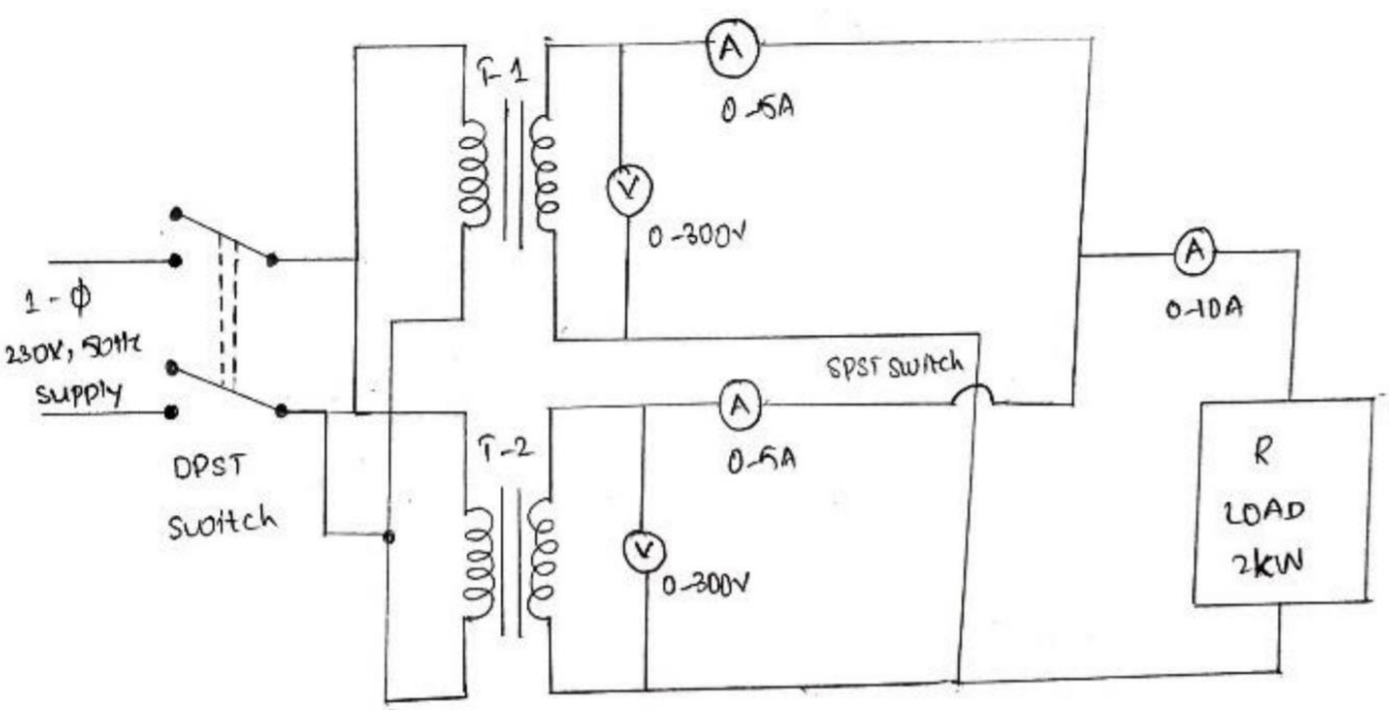
(b)For three phase transformers.

- The same polarity.
- Zero-relative phase displacement.
- Same phase sequence.
- Same voltage ratio.

In addition to the above essential requirements, the transformers operated in parallel should have the following for better load sharing and operating power factor.

- Equal per unit impedances.
- Equal ratio of resistance to reactance.

CIRCUIT DIAGRAM:



Precaution:

- Connection should be right and tight.
- Check the circuit connection thoroughly before switching on the supply.
- Instruments should be connected in proper polarity and range.

- Do not touch any non-insulated part of any instrument or equipment.
- Be ensured the zero setting of the instrument is in the right position. Avoid parallax error.
- Ensure that the two secondaries have been connected properly as per the polarity.

Procedure:

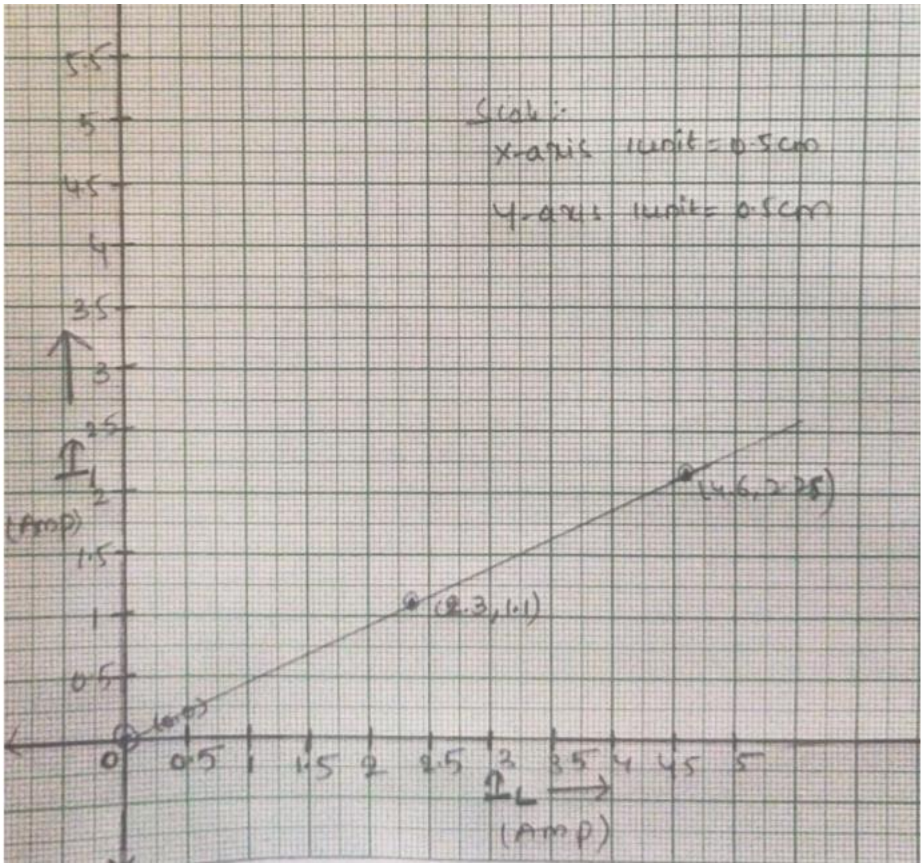
1. Two windings of a transformer the two windings are connected in series across a voltmeter while one of the windings is excited from a suitable ac voltage source when the transformer has a subtractive polarity the voltmeter will read the difference of E1 & E2. If the voltmeter reads E1=E2, the polarity marking of one of the windings must be interchanged.
2. Connect the circuit as per the circuit diagram.
3. Switch on the power supply and adjust the rated voltage across the circuit.
4. Adjust a particular load on the secondaries and note down the readings of all the meters.
5. Repeat step-3 for more readings.
6. Switch off the supply.

Observations:

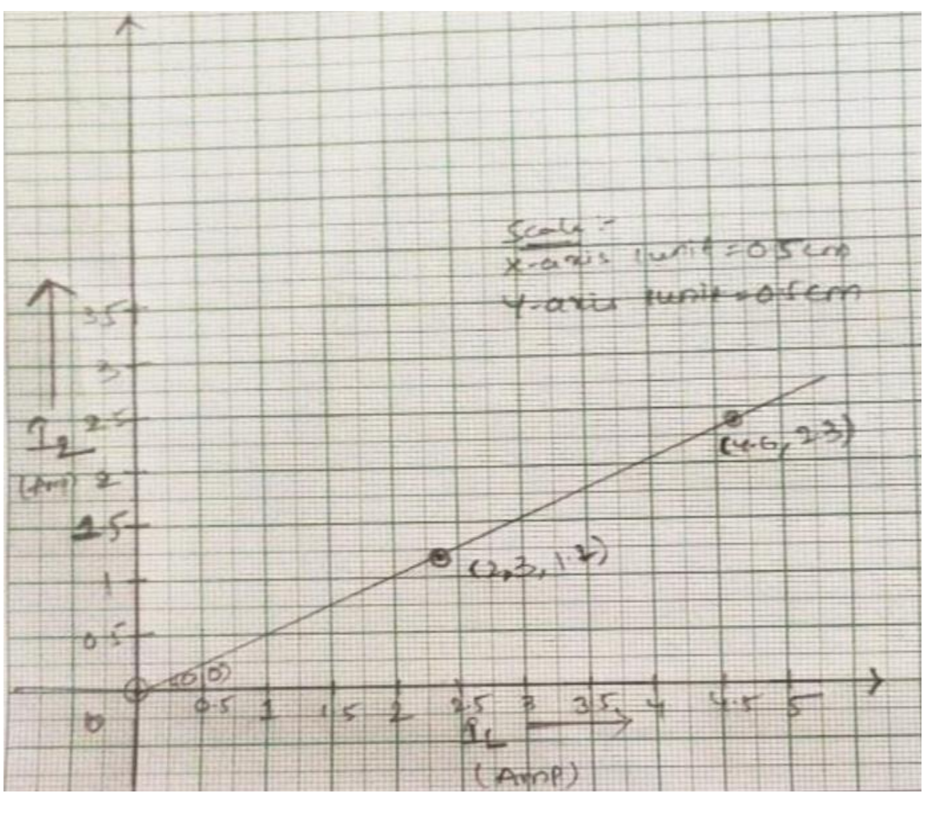
Sl. No	V_L	I_L	W_L	V_1	I_1	W_1	V_2	I_2	W_2
1 (No load)	220 V	0 A	0 W	220 V	0 A	0 W	220.8 V	0 A	0 W
2 (500W)	214 V	2.3 A	492.2 W	213 V	1.1 A	235.4 W	215 V	1.2 A	258 W
3 (1000W)	204 V	4.6 A	938.4 W	208 V	2.2 A	457.6 W	206.5 V	2.3 A	474.5 W

Data Processing & Analysis:

Graph of I_1 v/s I_L



Graph of I_2 v/s I_L



Conclusion

Connections are made carefully and appropriately. All the respective readings are taken without any parallax error. All the appropriate readings of voltmeters and ammeters of both transformers are taken successfully. Plots of I1 v/s IL and I2 v/s IL are drawn. Our aim to perform polarity test and parallel operation of two single-phase transformers is accomplished successfully.

Discussion

1. If two transformers of the same kVA ratings and transformation ratio but of different equivalent impedances are connected in parallel which transformer will be loaded more?

Given that impedances aren't equal, then loading of the transformer will not be proportional to kVA ratings but the current is inversely proportional to internal impedance. So, Lower Impedance transformer will be loaded more.

2. What is meant by circulating current with regard to parallel operation of transformers? How much percentage of circulating connects can be permitted for satisfactory parallel operation? How can it be minimized?

3.

When two substations are connected through a switch, there may be a voltage difference between the sites. When the switch is closed, creating a parallel, it is said that current flows between the sub stations, known as 'circulating current'. A transformer with higher no-load voltage (typically higher tap position) will produce circulating current, while a transformer with lower no-load voltage (typically lower tap position) will receive circulating current. If the transformers connected in parallel have slightly different voltage ratios, then due to the inequality of induced emfs in the secondary windings, a current will flow in the loop formed by the secondary windings under the no-load condition, which may be much greater than the normal no-load current. This current is circulating current. This cannot be more than 10% of full load current. Voltage control of parallel transformers with the circulating current method aims to minimize the circulating current while keeping the voltage at the target value.