SALAAR KHAN

17PWELE5087

SECTION A

8TH SEMESTER

POWER SYSTEM ANALYSIS

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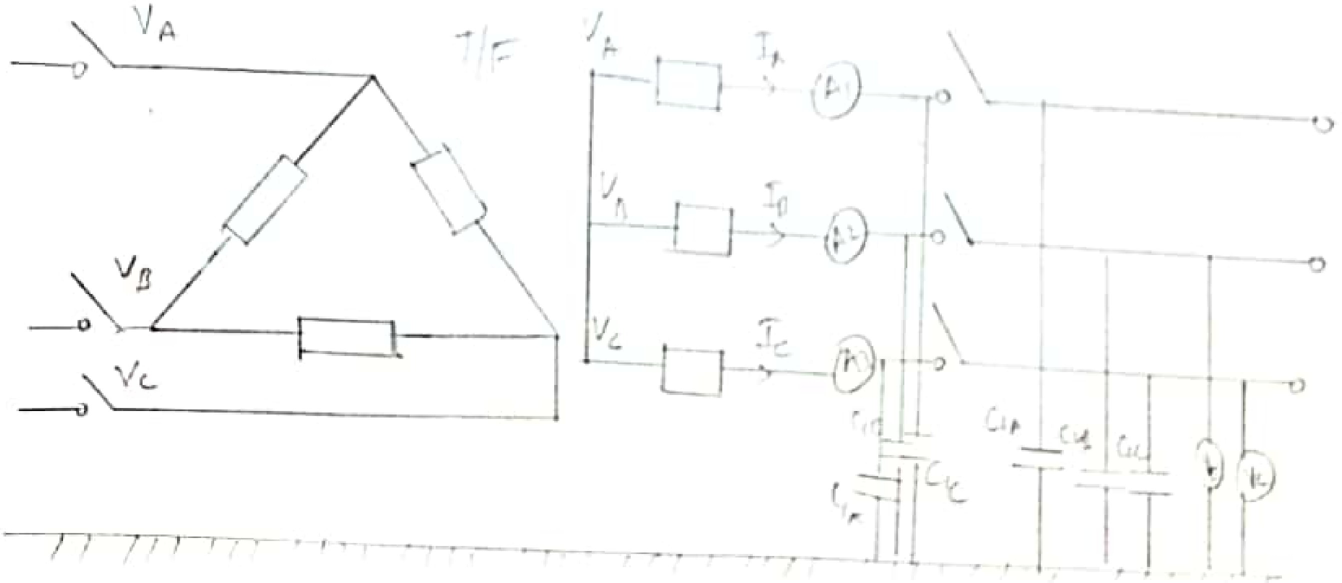
Lab 01

measurment of line current, line voltages, phase voltages and determination of line capacitance on a 3 φ transmission line.

Apparatus

- 3 φ transmission line systems.
- Voltmeters
- 3 pole switches
- Ammeters
- Circuit breakers.
- Transformer.

Circuit diagram



Theory

Line Capacitance

In transmission line when current is passing in a conductor, capacitance is created between the line and ground. This causes Ferranti effect ie the receiving end voltage becomes greater than the sending end voltage.

Procedure

- Connect the 3ϕ transmission system module.
- Now switch ON only the first side connected ie C_1 is switched ON.
- Note down the values of currents, voltages and capacitances.
- Now connect the other side of transmission line with it too ie C_1 and C_2 are both switched ON.
- Measure all the currents, voltages and capacitances again.

Observations

When C_1 is ON.

I_A (A)	I_B (A)	I_C (A)	V_A (V)	V_B (V)	V_C (V)	V_{BC} (V)
0.12	0.03	0.1	90	15	76	73

$C_{1A} = 4.24\mu F$ $C_{1B} = 6.3\mu F$ $C_{1C} = 4.18\mu F$

When both are ON

I_A (A)	I_B (A)	I_C (A)	V_A (V)	V_B (V)	V_C (V)	V_{BC} (V)
0.145	0.03	0.125	90	15	79	80

$C_{12A} = 5.1\mu F$ $C_{12B} = 6.4\mu F$ $C_{12C} = 5.04\mu F$

$C_{2A} = C_{12A} - C_{1A} = 0.86\mu F$

$C_{2B} = C_{12B} - C_{1B} = 0.1\mu F$

$C_{2C} = C_{12C} - C_{1C} = 0.86\mu F$

Conclusion

- The capacitance effect in the transmission line decreases the current and aids in increasing voltage.
- It can be removed by placing a shunt resistor.

Lab 02

Single phase line to ground fault of a 3ϕ transmission line.

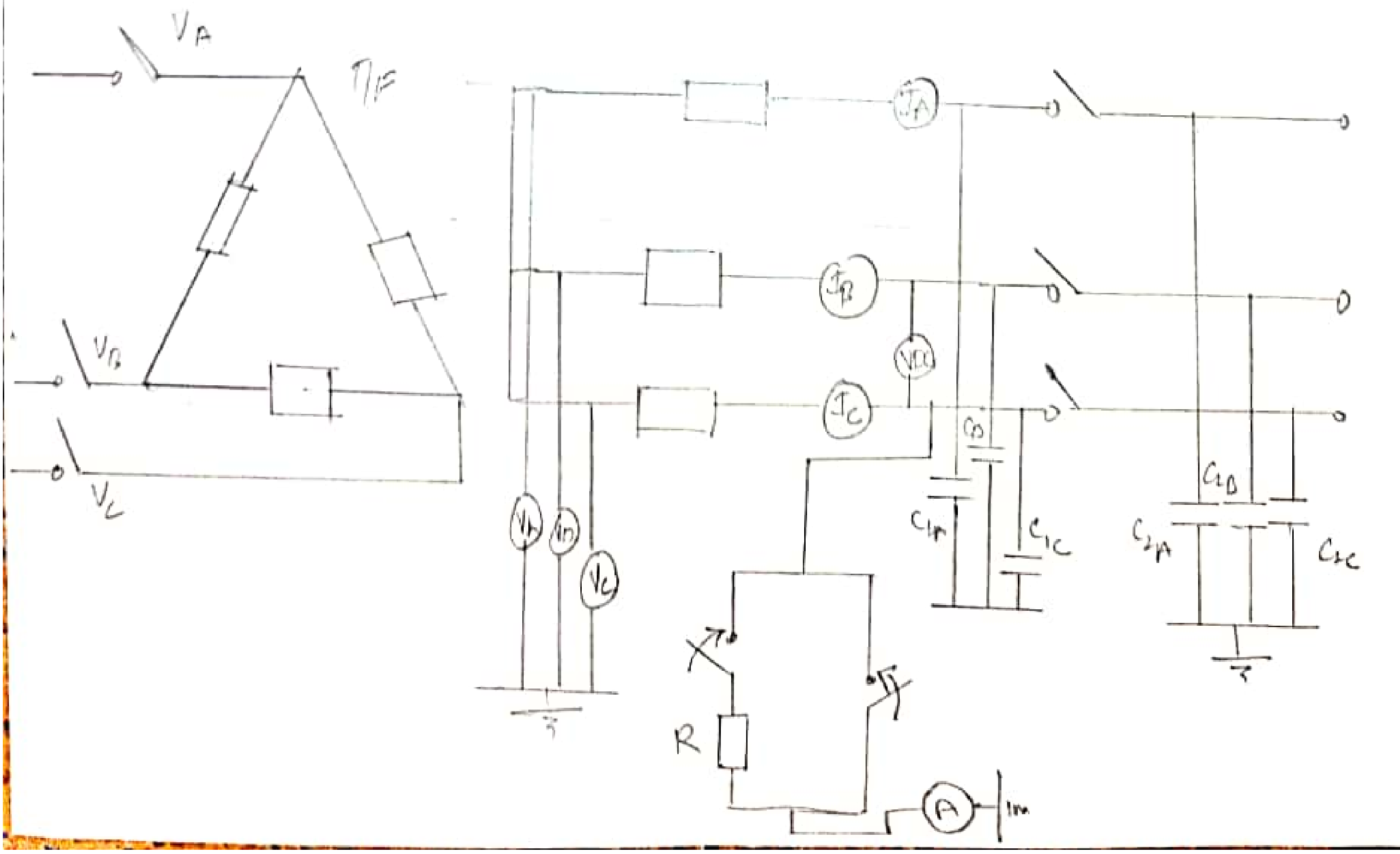
(a) Solid grounding / Resistance free earthing.

(b) Resistive grounding / Earthing through resistor.

Apparatus

- 3ϕ transmission line system.
- 3 pole switches.
- Voltmeters.
- Circuit breakers.
- Ammeters.
- Transformer.
- 10Ω resistor.

Circuit diagram



Theory

Grounding

When a live wire is connected to the ground and the current passes to the ground without going to the load.

Resistive grounding

When grounding is done via a resistor. i.e. a resistor is placed b/w the live wire and ground.

Procedure

- Connect the 3ϕ transmission system module.
- Now short circuit one of the line and connect directly to the ground (solid grounding).
- Now switch ON the first side of equation only i.e. C_1.
- Note down readings of voltages, currents and capacitances.
- Switch ON C_2 and again take all the readings.
- Now connect the line to ground via a 100Ω resistor when C_1 is switched ON.
- Take all the readings.
- Now connect C_2 and again take all the readings.

Observations

Solid Grounding

I_A(A)	I_B(A)	I_C(A)	V_{OC}(V)	V_A(V)	V_B(V)	V_C(V)	I_g(A)
When C_1 is switched ON							
0.25	0.2	0.4	165	200	165	6	0.72
When C_1 and C_2 both are ON							
0.29	0.27	0.47	175	200	172	6	1

Earth Grounding

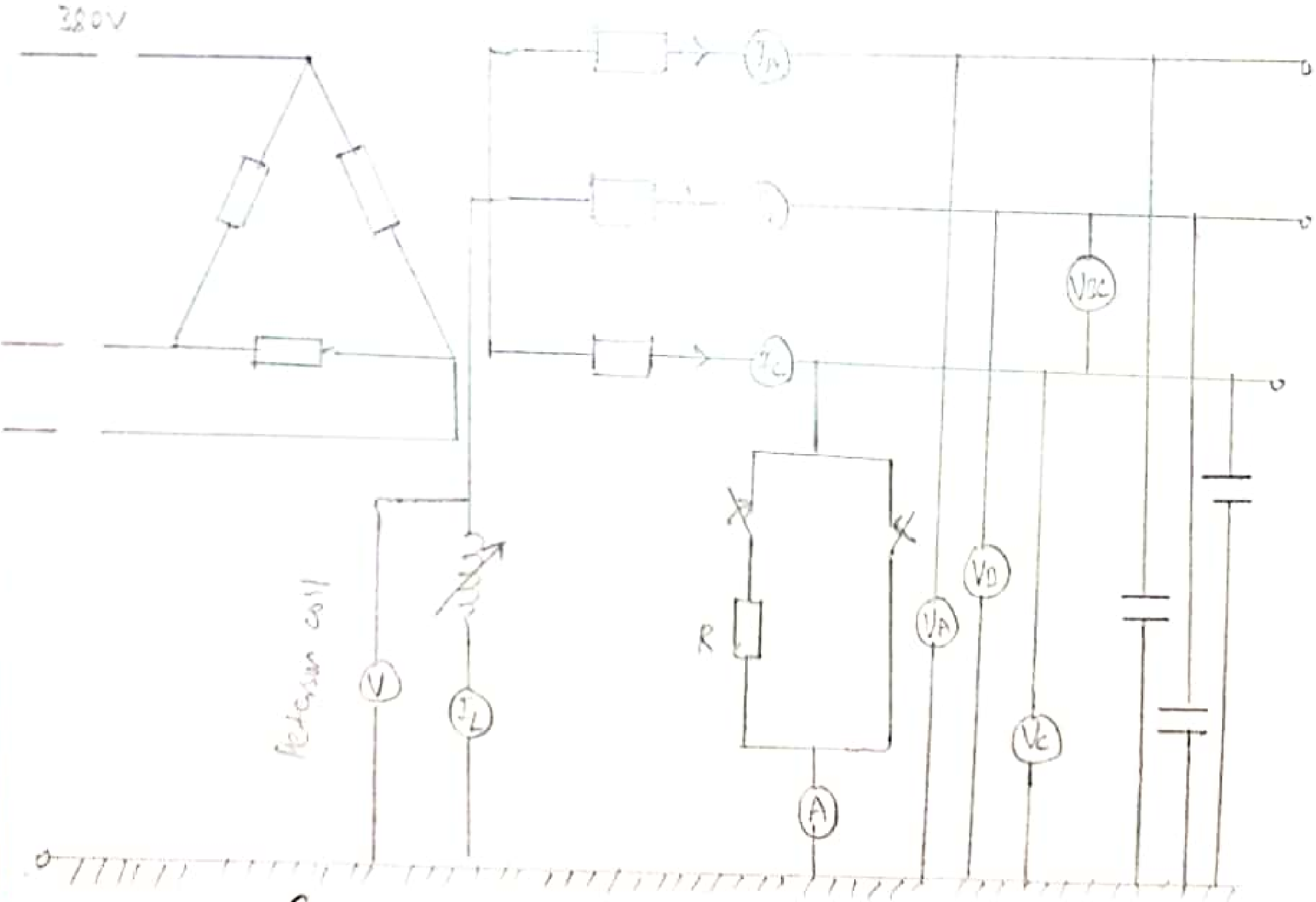
I_A (A)	I_B (A)	I_C (A)	V_{DC} (V)	V_A (V)	V_B (V)	V_C (V)	I_g (A)
When C_1 is switched ON							
0.2	0.24	0.37	168	155	170	33	0.55
When C_1 and C_2 both are ON.							
0.215	0.31	0.43	187	135	190	40	0.8
For normal transmission line							
0.4123	0.03	0.1	73	90	75	75	—

Lab 03

To investigate the effect of peterson coil inductance on single phase line to ground fault in a 3 ϕ network.

Apparatus

- 3 ϕ transmission line system.
- Peterson coil.
- Ammeters
- voltmeters.
- Transformer
- Circuit breaker.



Circuit diagram

Theory

Peterson coil

- It is iron core tapped reactor used for removing effect of ground fault.
- This is a special arrangement and a coil used to minimize the fault current.
- So overall network is saved from short circuit.

Procedure

- Connect the three phase transmission system.
- Now short circuit one of the phase of the system.
- First short circuit via solid grounding.
- Measure all voltages and currents.
- Now connect peterson's coil while being short circuited.
- Again measure all voltages and currents.
- Now changing inductance of peterson coil, record I_L, I_g and V_L.

Observations

I_A (A)	I_B (A)	I_C (A)	V_A (V)	V_B (V)	V_C (V)	I_g (A)
0.13	0.03	0.1	85	17	70	–
0.22	0.24	0.39	198	176	30	0.55

→ Normal

→ Short circuit

Peterson coil

I_L (A)	I_g (A)	V_L (V)
0.29	0.05	60
0.27	0.07	80
0.25	0.14	86
0.22	0.20	75
0.17	0.26	98

Introduction to Power Systems laboratory.

Power systems laboratory consists of different types of advanced, smart and automatically controlled power systems.

It is mainly used for studying, investigating and experimenting different types of faults and observations on a power system.

- It consists of a prototype of each power generation house and power transmission systems.

It consists of:

- Transmission and line fault protection stations.
- Pump storage hydropower plant station.
- Distribution and busbar fault protection system.
- Wind power plant with DFIG.
- Automatic generation and synchronization station.
- Fuel cell technology station.
- Energy magnet station.

Fuell cell Technology Station

A fuel cell is an electrochemical cell that converts chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through a pair of redox reactions.

Fuel cells are different from most batteries in requiring a continuous source of fuel and oxygen usually from air to sustain the chemical reaction, whereas in a battery the chemical energy usually comes from metals and their ions as oxides.

This station implements these properties of fuel cells.

Solar Photovoltaic System station.

A solar cell or photovoltaic cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical phenomena.

The photovoltaic effect is the creation of voltage and electric current in a material upon exposure to light. It is a physical and chemical phenomena.

This station implements the photovoltaic effect.

Energy Management Station

An energy management system is a system of computer aided tools used by operators of electric utility grids to monitor, control and optimize the performance of the generation and transmission system. Also it can be used in small scale systems like micro grids.

Synchronization System (with automatic generation)

In an AC power system, synchronization is the process of matching the speed and frequency of a generator or other source to a running network.

An AC generator cannot deliver power to an electrical grid unless it is running at the same frequency as the network.

Their network allows for synchronization of 2 different frequency systems.

Synchronization is important because;

(a) It makes parameters.

(b) It allows power generated at one station to be used at other stations.

Pump Storage hydro power plant

Pump storage hydroelectricity is a type of hydroelectric energy storage used by electric power systems for load balancing.

This method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation. though an open atmosphere, the probability of a fault occuring in it is much higher than that of electrical power transformers or alternators.

This station uses capacitors, resistors and inductors to help limit the fault current.

Wind power plant with DFIG

DFIG : doubly fed induction generator.

It is a popular system in which the power electronic interface controls the rotor current to achieve the variable speed

for maximum energy capture in variable winds.
It offers speed control with reduced cost and power losses.

Lab 05

Synchronization of pump storage hydro power plant with that of WAPDA by manual method.

Apparatus

- Pump storage hydro power plant
- Connecting wires.

Theory

Synchronization

When we want to connect different generating stations together we synchronize them i.e we synchronize their (a) frequency
(b) voltage
(c) Phase angle

Manual Synchronization

In manual synchronization, the frequency, voltage and phase angle of the generating station are monitored and method of bright and dark lamp is used.

Procedure

- Switch ON the pump storage hydro power plant station by connecting it to the main supply.
- Increase the excitation voltage so as in order to increase the output voltage.
- Monitor the frequency of generating station.
- Carefully monitor the synchrometer.

- When the green leads indication is ON; stop increasing the excitation voltage.

- Connect the generating station power/voltage to the main supply.

- Hence both are synchronized.

Lab 06

To investigate ferranti effect and charging current on a transmission line at No load condition.

Apparatus

- Transmission and line fault protection station.
- Connecting wires.

Theory

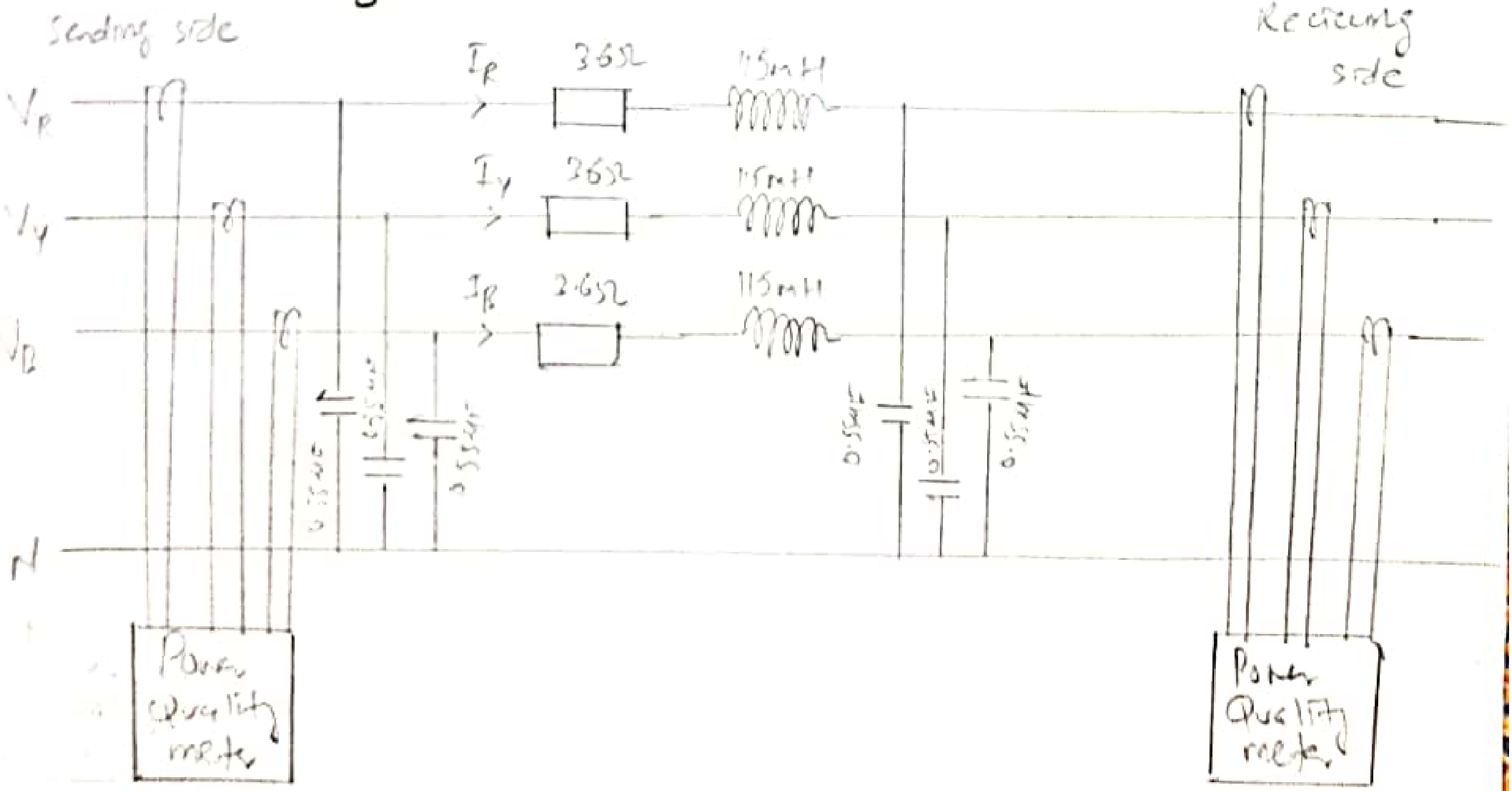
Ferranti effect

Whenever current flow in a conductor due to different polarities on the line conductor and ground, a capacitive effect is observed; due to which the receiving end voltage increases than the sending end voltage; this is called ferranti effect.

Charging current

The current flowing in this so called capacitor created is called as charging current.

Circuit diagram



Procedure

- Make all the connections according to circuit diagram.
- Measure the values of line to line voltages at sending end of the transmission line.
- Now measure the values of line to line voltages at receiving end.
- Measure the values of charging current through the capacitor.
- Record all the values.
- Now change the length of the transmission line from 150 km to 300 km and record all the values again.

Observations

Phase	Sending voltage (V)	Receiving voltage (V)	Charging current (A)	
	150 km			
L1-2	379	385	0.14	L1
L2-3	381	387	0.14	L2
L-3-4	377	382	0.14	L3
N	–	–	0.01	
	300 km			
L1-2	381	409	0.29	L1
L-23	383	406	0.29	L2
L3-4	379	401	0.29	L3
N	–	–	0.02	

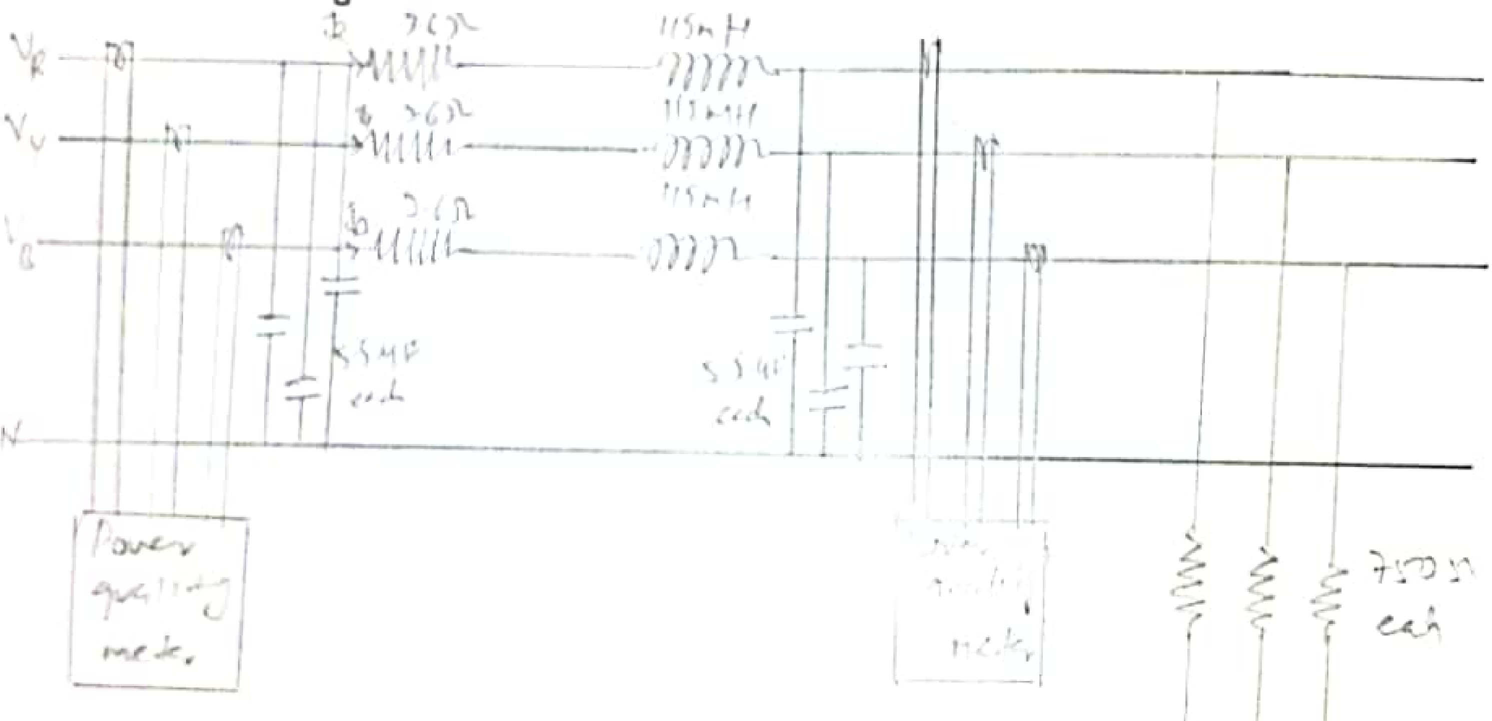
Lab 07

Investigation of resistive load on 3 φ transmission line.

Apparatus

- Transmission and line fault protection system.
- Connecting wires.

Circuit diagram



Procedure

- Make all the connections according to the circuit diagram.
- Connect the main power supply.
- Now connect resistive load on the transmission line.
- Record and measure values of sending end voltages, power and power factor.
- Also measure the values of active power, reactive power,

apparent power and power factor at the receiving end of the transmission line.

- Record all the values.

<u>Observations</u>

Quantity	Sending	Receiving
Voltage (V)	381	387
P (W)	209	207
S (VA)	264	207
Q (VAR)	-161	0
Pf	0.79 ld	1

Lab 08

Investigation of inductive load on a 3ϕ transmission line.

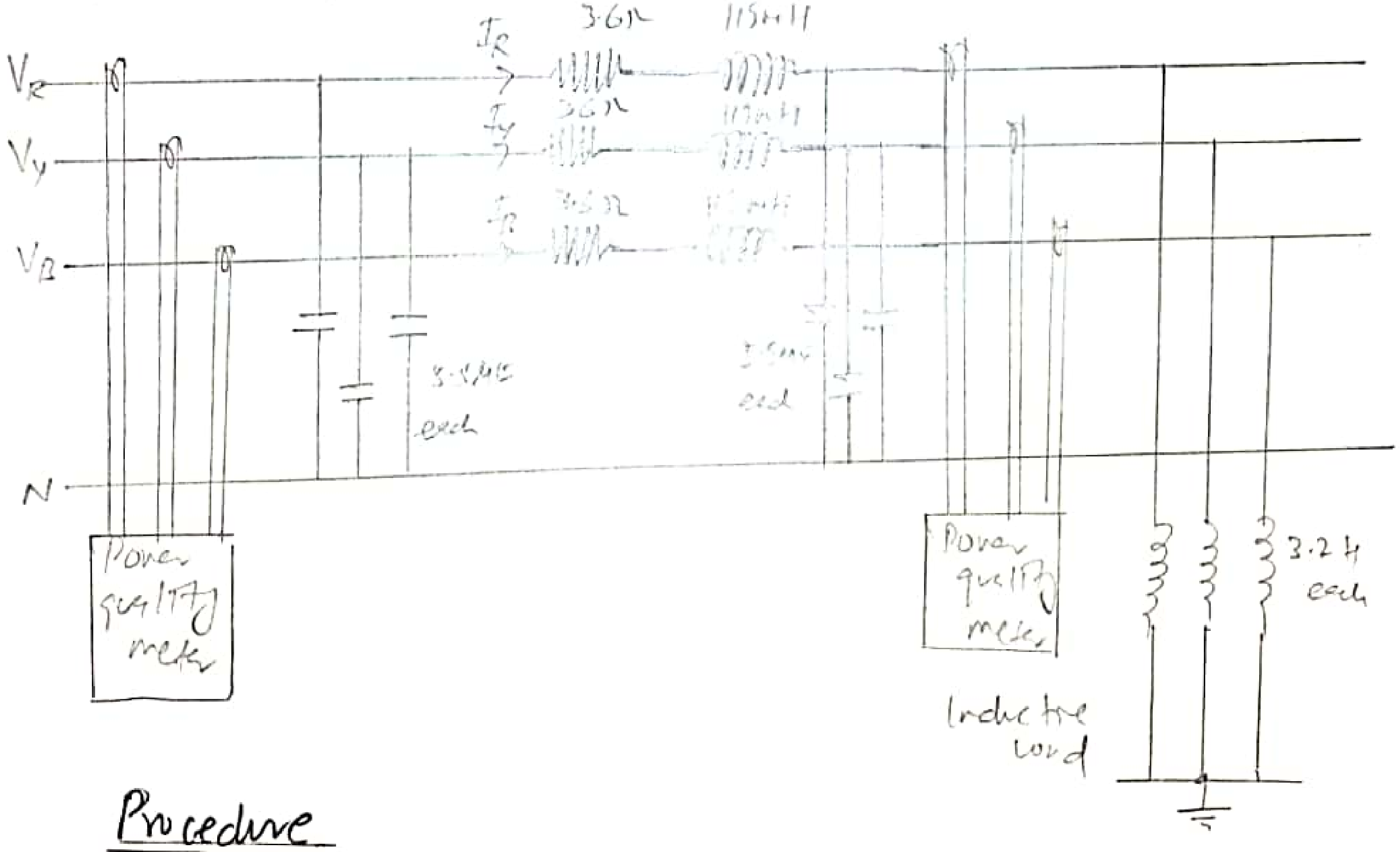
Apparatus

- Transmission and line fault protection station.
- connecting wires.

Theory

Due to purely inductive load on a transmission line, system has a very low / poor power factor and draws a very high current.

Circuit diagram



Procedure

- Make all the connections according to the circuit diagram.
- Connect to the main power supply.

- Apply purely inductive load.
- Measure voltage, current, real apparent and reactive powers at the sending and receiving ends of the transmission line and record it in a table.

Observations

Quantity	Sending	Receiving
Voltage (V)	379	385
P (W)	13	11
S (VA)	70	139
Q (VAR	-43	137
I (A)	0.10	0.21
p.f	0.16 lag	0.06 lag

Lab 09

Investigation of a pure capacitive load on a 3ϕ transmission line.

Apparatus

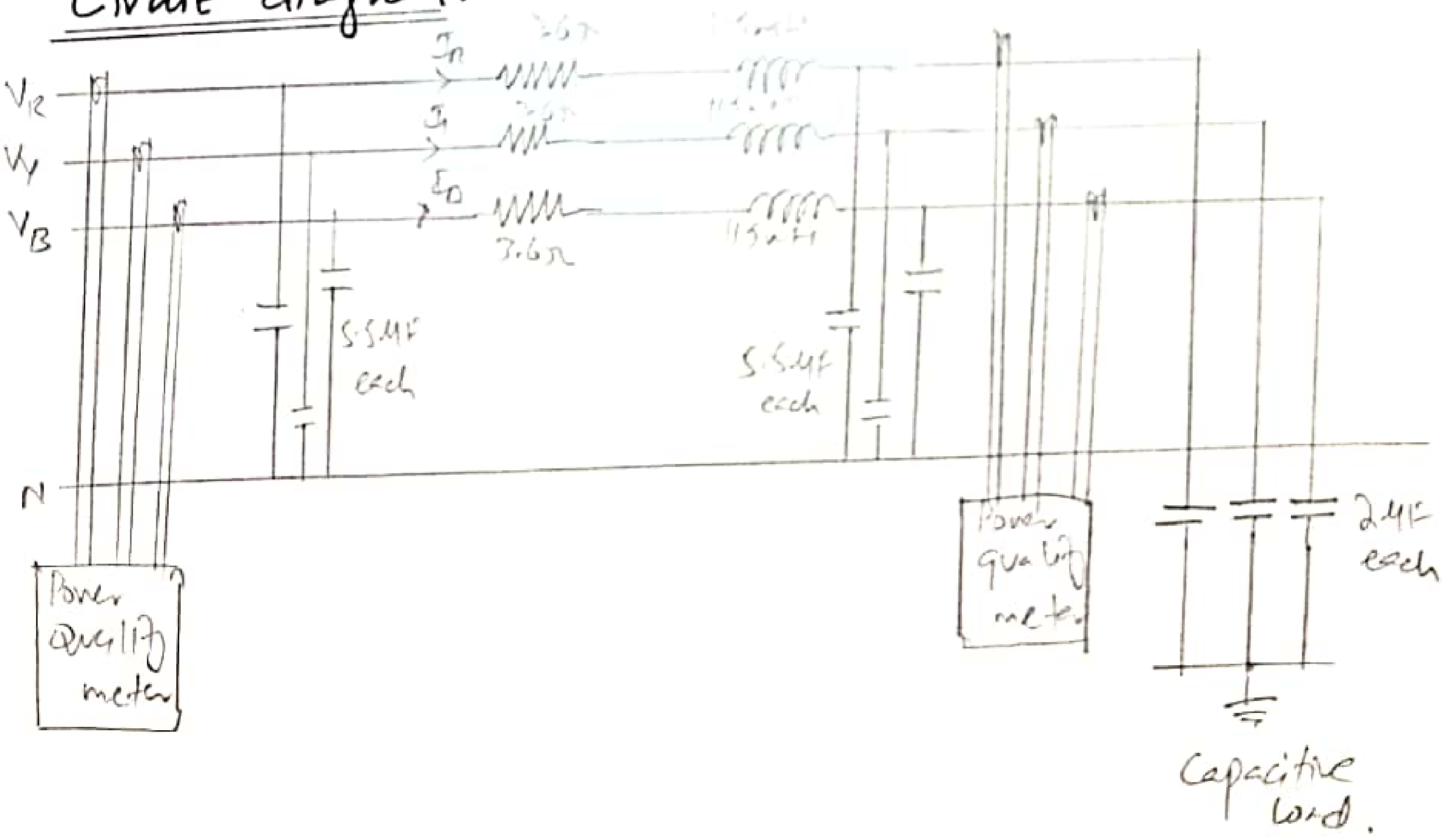
- Transmission and line fault protection station.
- Pure capacitive load.
- Connecting wires.

Theory

Purely capacitive load generates a acts as a source of reactive power.

As capacitive effect is created among the transmission line and the load is also capacitive, so the reactive power increases and ferranti effect is very dominant.

Circuit diagram.



Procedure

- Make the connections according to the circuit diagram.
- Connect the main supply.
- Connect the purely capacitive load on the transmission line.
- Measure the apparent, real and reactive power and voltages at both sending and receiving ends.
- As load is purely capacitive, real power = 0 and only reactive power exists.

Observations

Quantity	Sending end	Receiving end
Voltage (V)	381	425
P (W)	3	0
Q (VAR)	-381	-116
S (VA)	382	117

Scanned with CamScanner

Lab 10

Investigation of R-L load on a 3ϕ transmission line.

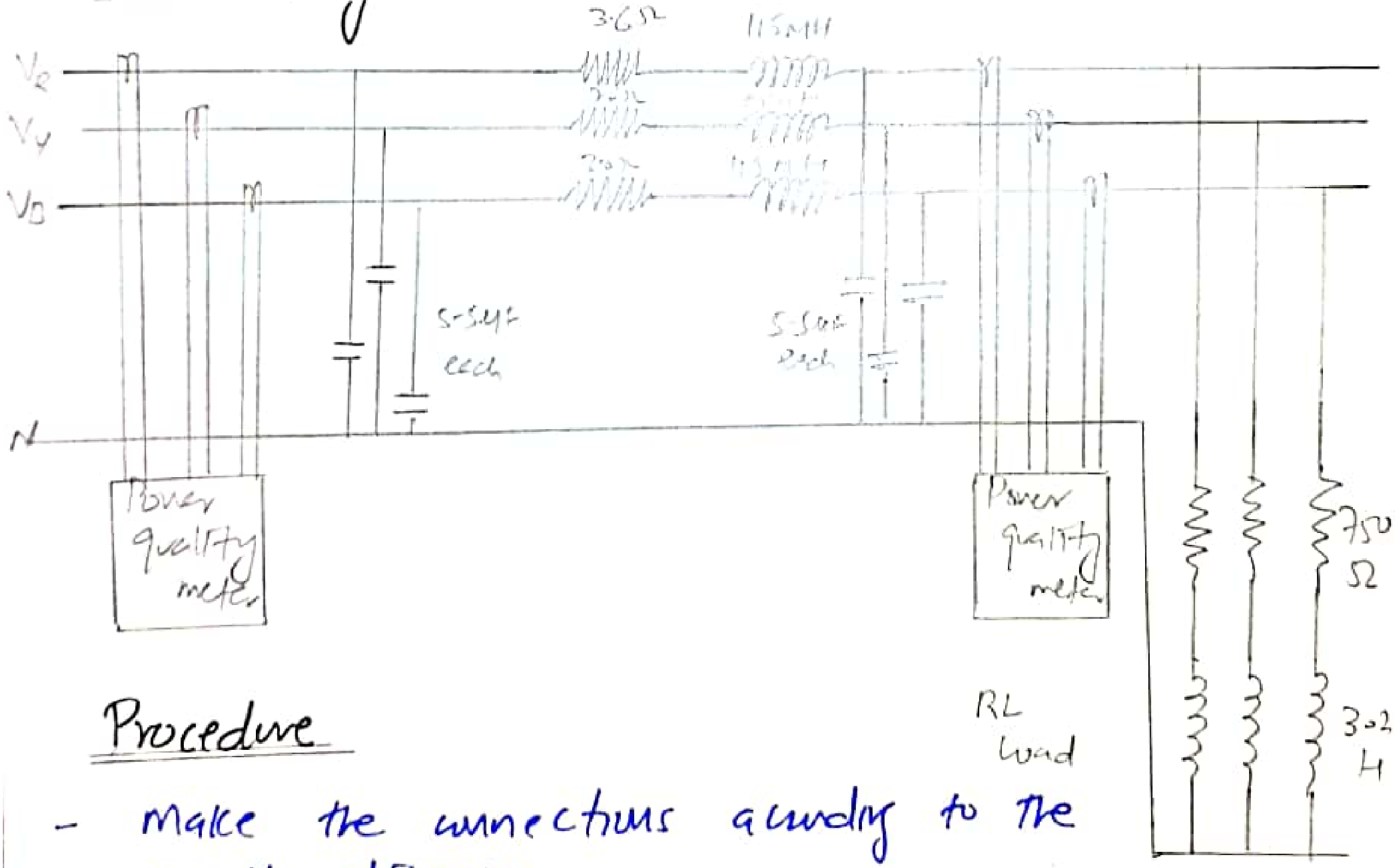
Apparatus

- Transmission and line fault protection station.
- Resistive inductive load.
- Connecting wires.

Theory

The resistive inductive load improves the power factor.

Circuit diagram



Procedure

- Make the connections according to the circuit diagram
- Connect the main supply.
- Connect the resistive inductive load.

- Measure the real, apparent and reactive power on both sending and recieving ends.
- Record all the values.

Observations

Quantity	Sending end	Receiving end
P(W)	190	187
S(VA)	193	228
Q(VAR)	-23	138

Lab 11

Investigation of a 3φ transformer on no load.

Apparatus

- Transmission and line fault protection station.
- connecting wires.

Theory

Transformer

A static device used to step up or step down voltage level.

- It is used for power transformation.
- It works on the principle of mutual induction.
- It has two coils → primary
  ↳ secondary

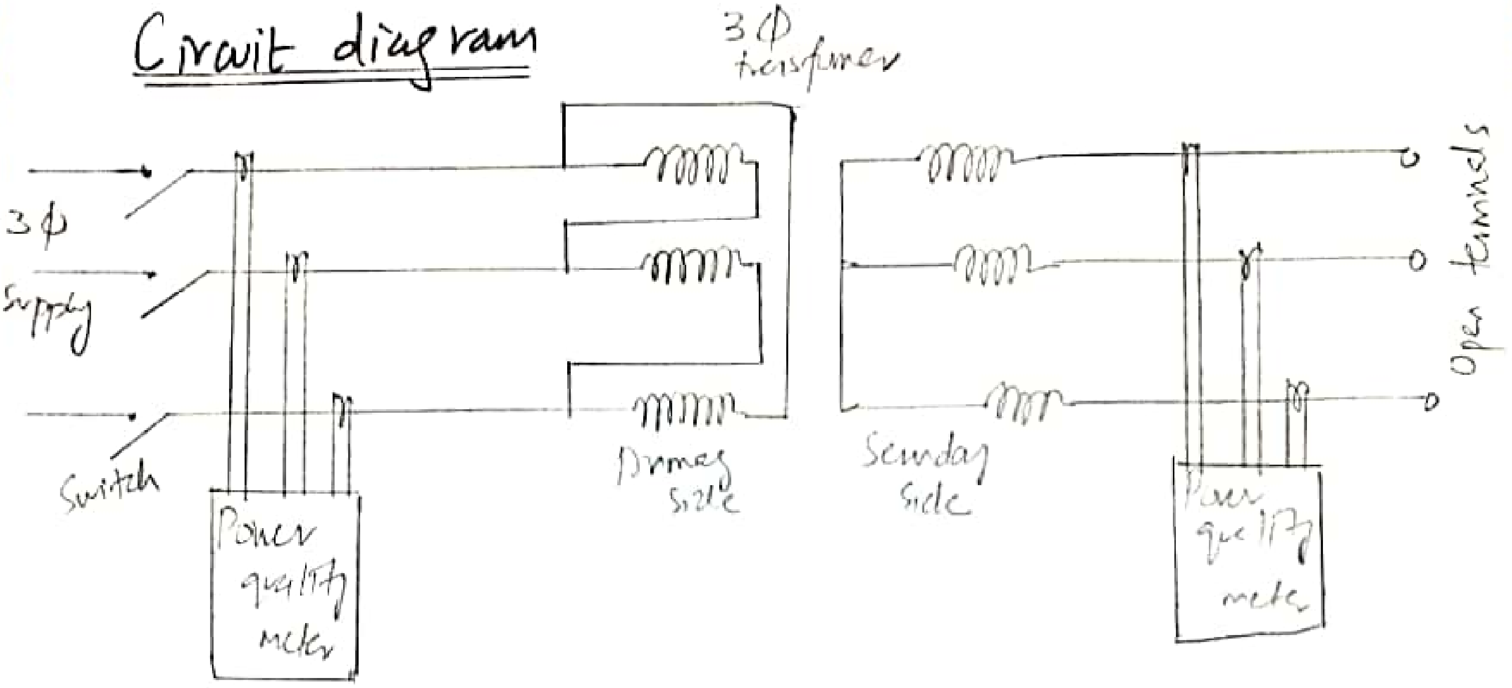
3 φ transformer

The transformer which works on 3 φ supply and has a 3φ winding (star or delta) as primary and secondary windings.

No load

The terminals of secondary windings of transformer are kept open ie no load is connected to it.

Circuit diagram



Procedure

- Connect the main supply to the primary side of transformer.
- Connect the main switches so supply is provided to the primary winding of transformer.
- Measure and record the value of secondary voltage and secondary current.
- Also measure primary current and voltage.
- Record the real, apparent and reactive powers.

Observations.

Primary side

$V_1 = 339\ V$ $\quad I_1 = 0.14\ A$

$$X_m = \frac{V_1^2}{Q_0} = 1492\ \Omega$$

$$R_0 = \frac{V_1^2}{P_0} = 10447.4\ \Omega$$

Secondary side

$V_2 = 424\ V$ $\quad I_2 = 0\ A$

$P_0 = 11\ W$ $\quad Q_0 = 77\ VAR$

$S = 81\ VA$

Transformer rating = 1 kVA

Lab 12

Short Circuit test on a 3ϕ transformer

Apparatus

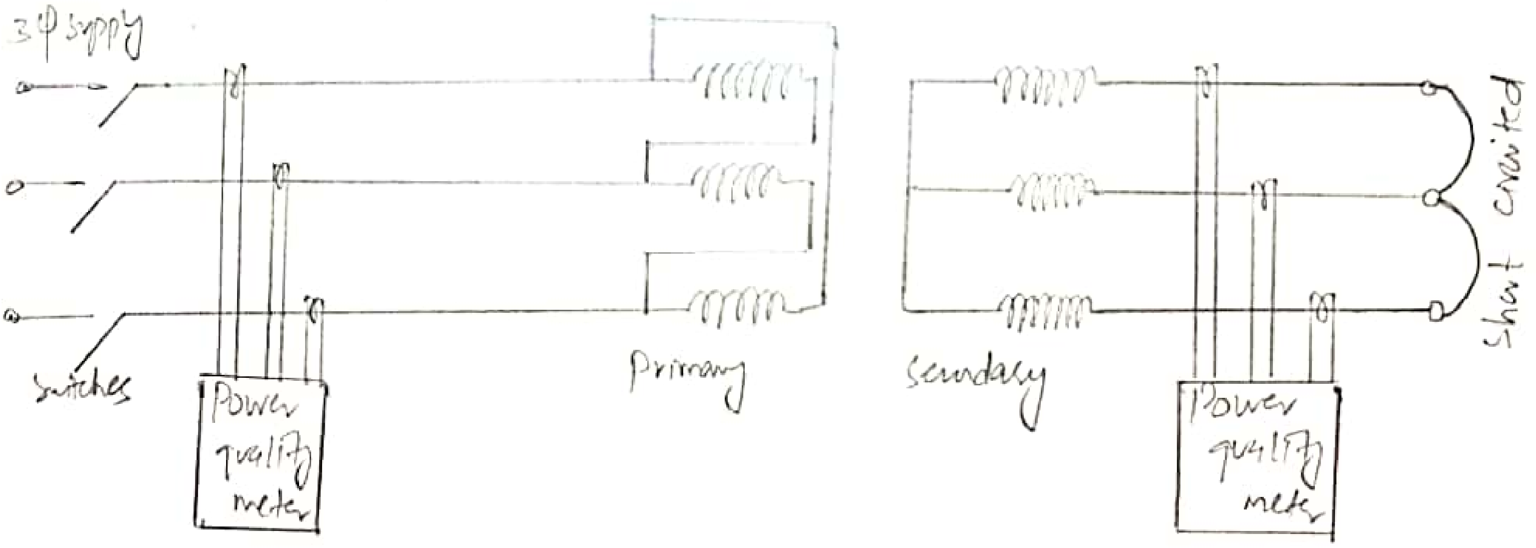
- Transmission and line fault protection station.
- Connecting wires.

Theory

Short Circuit test

- This test is used to check electrical losses in a transformer.
- The output terminals of the secondary winding of the transformer are short circuited (connected to each other).

Circuit diagram



Procedure

- Connect the main supply to primary side of transformer.
- Short circuit all terminals of the secondary side.

- Record and measure all the voltages and currents, real, apparent and reactive powers.
- Calculate the electrical losses of transformer.

Observations

$V_1 = 24$ Volts $I_1 = 1.44A$

$P_0 = 55W$ $Q_0 = 11$ VAR

Lab 13

Investigation of a resistive load on 3 ϕ transformer.

Apparatus

- Transmission and line fault protection system.
- Resistive load.
- Connecting wires.

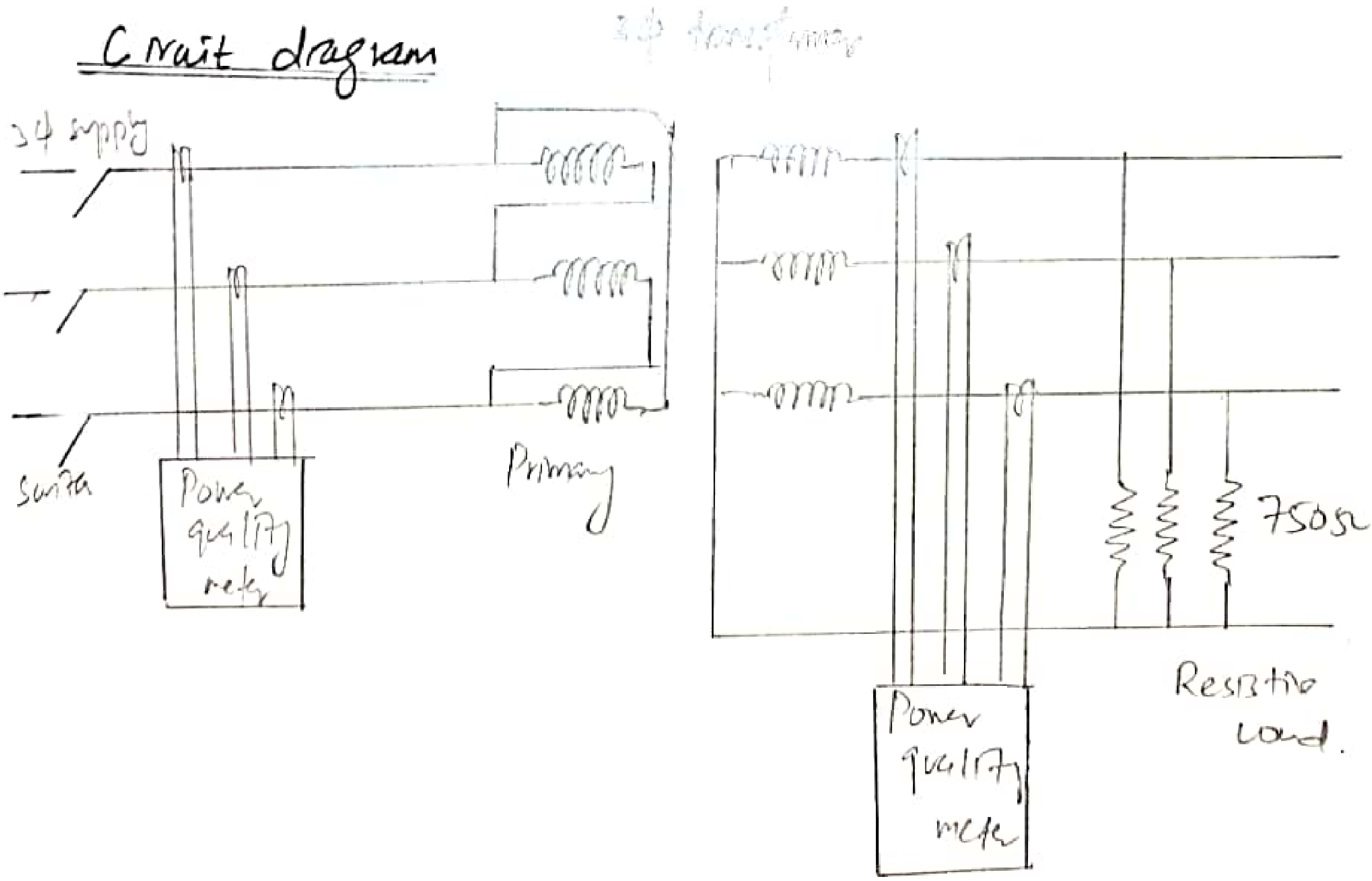
Theory

Resistive load

As there is only resistive load on the 3 ϕ transformer, so there will be only active power.

- In this case reactive power is zero and power factor is 1.

Circuit diagram



Procedure

- Make all the connections according to the circuit diagram.
- Connect primary of the transformer to the main supply.
- connect resistive load to the secondary side of transformer.
- Measure and read the voltages, active power and reactive powers on the primary and secondary side.

Observations.

$V_1 = 400\ V$ $\quad$ $V_2 = 423\ V$

$P_1 = 269\ W$ $\quad$ $P_2 = 255\ W$

$P.f = 1$ $\quad$ $Q_2 = 0\ VAR$

$I_2 = 0.32\ A.$

Lab 14

Investigation of inductive load as a 3ϕ transformer

Apparatus

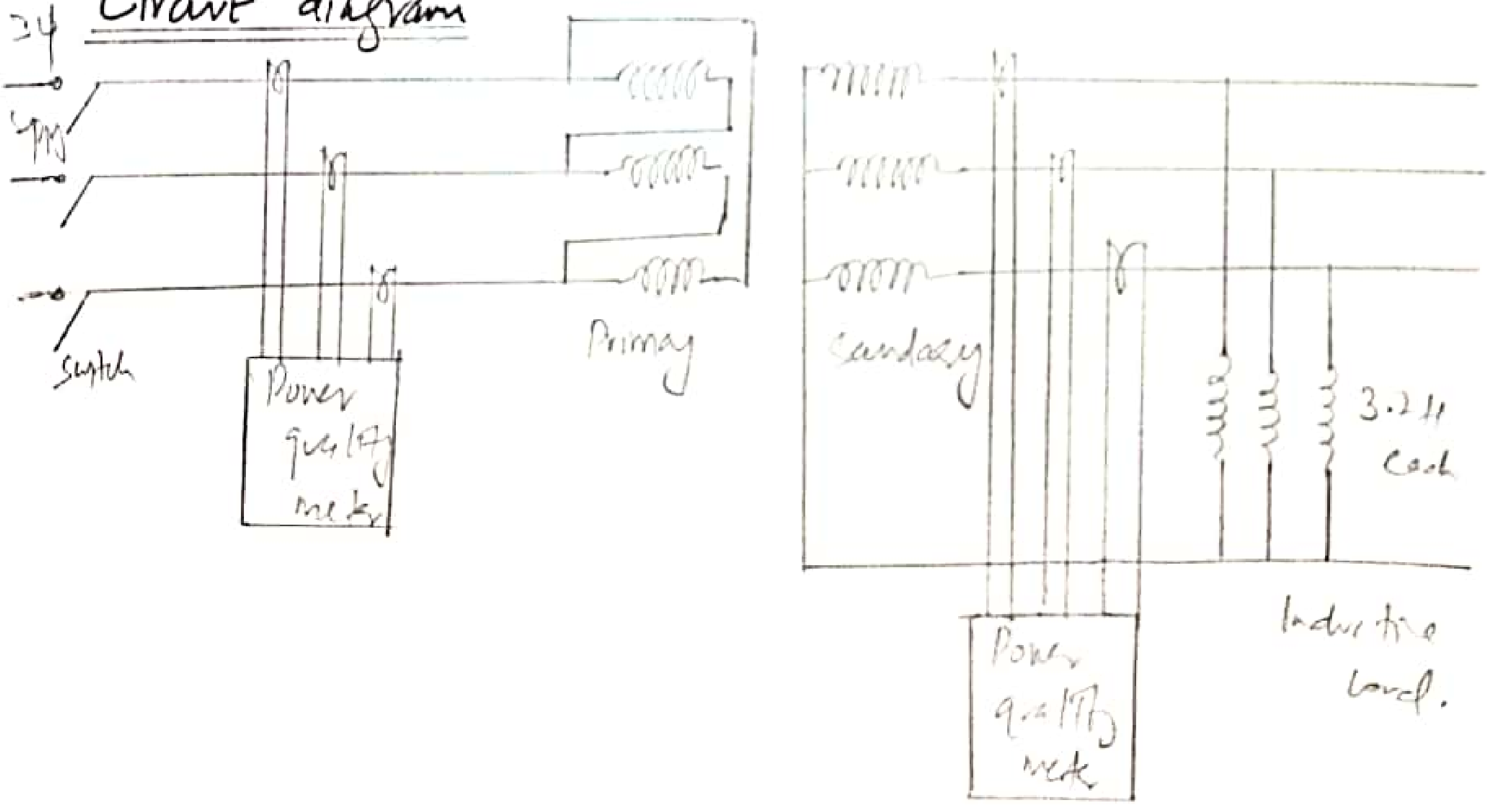
- Transmission and line fault protection system
- Inductive load.
- Connecting wires.

Theory

Inductive load

- Pure inductive load draws extra current from the generating station.
- Inductive load acts as a source of generating reactive power.
- Inductive load implies a very low power factor.

Circuit diagram



Procedure

- Make the connections according to the circuit diagram
- Connect the primary side of transformer to the main supply.
- Connect inductive load on secondary side of transformer.
- Measure and record the voltage, active power, reactive power and power factor at the primary and secondary side of transformer.

Observations

$V_1 = 400V$

$I_1 = 0.40A$

Inductive load = 3.2H

$V_2 = 425V$

$I_2 = 0.24A$

$P = 14$ W

$Q = 174$ VAR

$S = 175$ VA

P.f = 0.08

Lab 15

Investigation of R-L load on a 3ϕ 1KVA transformer.

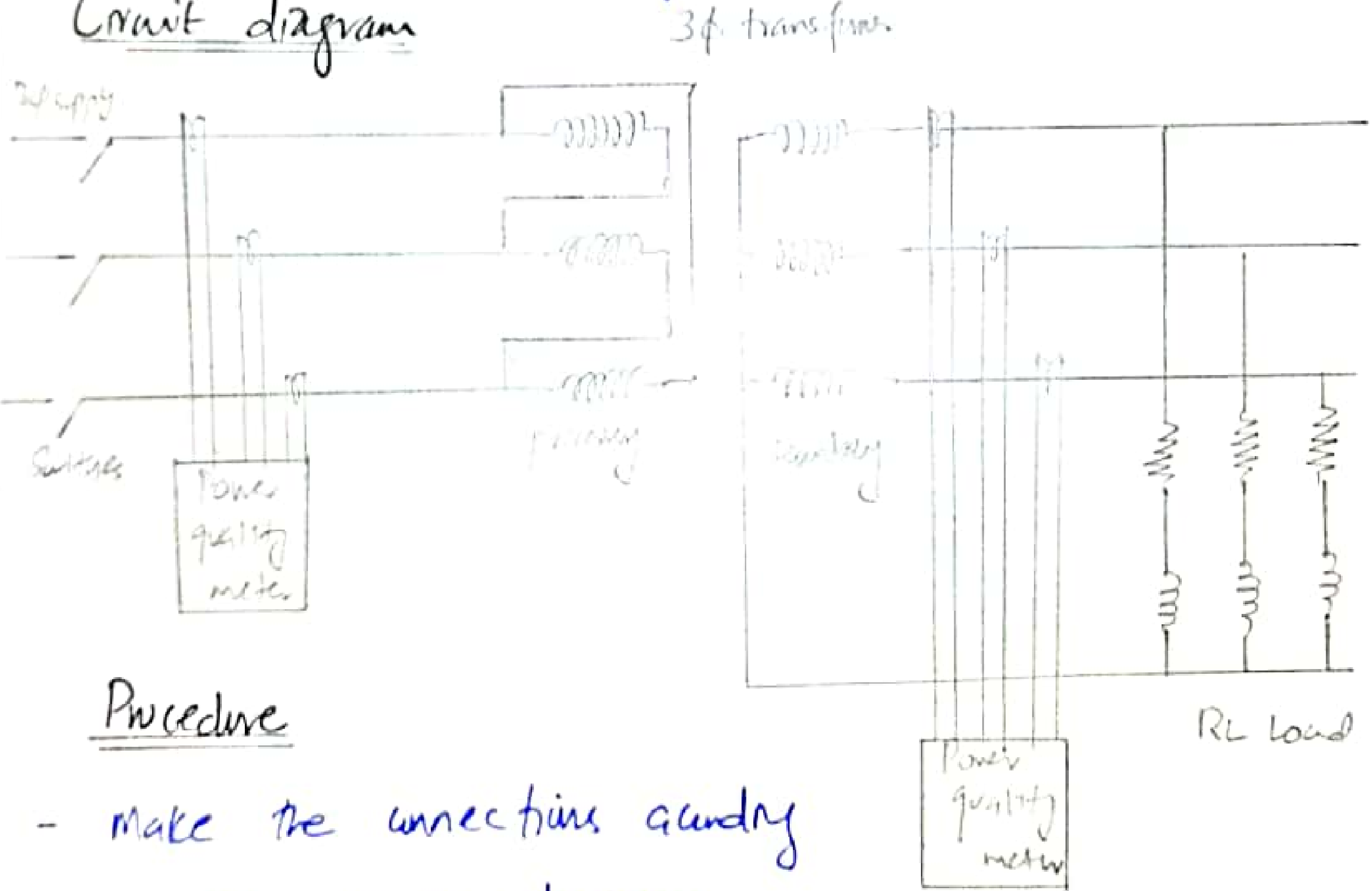
Apparatus

- Transmission and line fault protection system.
- Resistive inductive load ($R = 720\ \Omega$, $L = 3.2\ H$)
- Connecting wires

Theory

The R-L load improves the power factor.

Circuit diagram



Procedure

- Make the connections according to the circuit diagram
- Connect the primary side of 3ϕ transformer to the main supply.
- Connect the RL load to secondary side of the transformer

- Measure and record the voltage, active, and reactive power at primary and secondary sides of the transformer.

Observations

$V_1 = 384\,V$

$I_1 = 0.29\,A$

$V_2 = 421\,V$

$I_2 = 0.41\,A$

$P = 78\,W$

$Q = 95\,VAR$

$S = 123\,VA$

$pf = 0.63$