

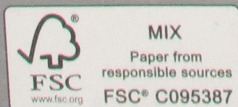
 **studymate**

Name ELECTRICAL TRADES
Subject COLLEGE
Year _____ School _____

96 Page

A4 Botany Book

8mm Feint Ruled / Blank Pages
70gsm Premium Paper



3

EL0025

EL0003

EL0047

EL0020

EL0012

Cluster 1

RE0011+RE0016 (6.3)

UCEELO025

5.2.1 Parallel operation of Transformer

$$Tx A \text{ Load Share} = \frac{Z_B}{Z_A + Z_B} \times \text{Total Load} \quad Z_A = \% \text{ Impedance of Transformer A}$$

$$Tx B \text{ Load Share} = \frac{Z_A}{Z_A + Z_B} \times \text{Total Load} \quad Z_B = \% \text{ Impedance of Transformer B}$$

$$\text{Common base} = \frac{\% Z}{kVA} \quad \% Z = \text{Percentage Impedance of Transformer}$$

$$kVA = kVA \text{ Rating of Transformer}$$

① Total load 160 kVA, Tx A % impedance 5.7%, Tx B % impedance 7.1%

$$Tx A = \frac{Z_B}{Z_A + Z_B} \times \text{Total Load} = \frac{7.1}{5.7 + 7.1} \times 160 = \frac{7.1 \times 160}{12.8} = 88.75 \text{ kVA}$$

$$Tx B = \frac{Z_A}{Z_A + Z_B} \times \text{Total Load} = \frac{5.7}{5.7 + 7.1} \times 160 = \frac{5.7 \times 160}{12.8} = 71.25 \text{ kVA}$$

② Two 3φ 800 kVA ~~11kV/400V~~ Transformer A & B share 640 kVA % Impedance of A = 7.4%, % impedance of B = 6.2%

$$Tx A = \frac{Z_B}{Z_A + Z_B} \times kVA_T = \frac{6.2}{7.4 + 6.2} \times 640 = \frac{6.2}{13.6} \times 640 = 402.25 \text{ kVA}$$

$$Tx B = \frac{Z_A}{Z_A + Z_B} \times kVA_T = \frac{7.4}{7.4 + 6.2} \times 640 = \frac{7.4}{13.6} \times 640 = 437.74 \text{ kVA}$$

$$I_L(A) = \frac{402.25}{\sqrt{3} \times 11} = 21.11 \text{ Amp} \quad I_L(B) = \frac{437.74}{\sqrt{3} \times 11} = 22.9 \text{ A}$$

$$Tx A \text{ kVA} = 402.25$$

$$Tx A \text{ Line Current} = 21.11 \text{ A}$$

$$Tx B \text{ kVA} = 437.74$$

$$Tx B \text{ Line Current} = 22.9 \text{ A}$$

③ Two 3φ 1000 kVA 33kV/11kV Transformer A & B share 1760 kVA

% impedance of A = 6.5%, % impedance of B = 8.5%

$$Tx A = \frac{Z_B}{Z_A + Z_B} \times kVA_T = \frac{8.5}{6.5 + 8.5} \times 1760 = \frac{8.5 \times 1760}{15} = 997.33 \text{ kVA}$$

$$Tx B = \frac{Z_A}{Z_A + Z_B} \times kVA_T = \frac{6.5}{6.5 + 8.5} \times 1760 = \frac{6.5 \times 1760}{15} = 762.66 \text{ kVA}$$

$$I_L(A) = \frac{997.33}{\sqrt{3} \times 33} = 17.44 \text{ A} \quad I_L(B) = \frac{762.66}{\sqrt{3} \times 33} = 13.34 \text{ A}$$

$$Tx A \text{ kVA} = 997.33 \quad I_L(A) = 17.44 \text{ A} \quad Tx B \text{ kVA} = 762.66 \quad I_L(B) = 13.34 \text{ A}$$

Pr 4 Two parallel connected 34 3340/11kV Transformers share a load of 3150kVA, Transformer A is rated at 1500 kVA and has 7% impedance of 11.2%. Transformer B is rated at 2000 kVA and has a percentage impedance of 9.1%.

$$I_{XA} \text{ common base} = \frac{7.2}{kVA} = \frac{11.2}{1500} = 7.46 \times 10^{-3}$$

$$I_{XB} \text{ common base} = \frac{7.2}{kVA} = \frac{9.1}{2000} = 4.55 \times 10^{-3}$$

$$I_{XA} \text{ shared load} = \frac{2.3}{2A+2B} \times kVA_T = \frac{4.55 \times 10^{-3}}{7.46 \times 10^{-3} + 4.55 \times 10^{-3}} \times 3150$$

$$= \frac{4.55 \times 3150}{7.46 + 4.55} = 1181.25 kVA$$

$$I_{XB} \text{ shared load} = \frac{2A}{2A+2B} \times kVA_T = \frac{7.46 \times 10^{-3}}{7.46 \times 10^{-3} + 4.55 \times 10^{-3}} \times 3150$$

$$= \frac{7.46}{12} \times 3150 = 1958.25 kVA$$

$$I_{LA} = \frac{1181.25}{\sqrt{3} \times 33} = 20.66 A$$

$$I_{LB} = \frac{1958.25}{\sqrt{3} \times 33} = 34.25 A$$

Transformer A (kVA) 1181.25 | Transformer B kVA 1958.25
Transformer A line current 20.66A | Transformer B line current 34.25A

① purpose of connecting two transformers in parallel

Less space requirement - Two smaller capacity transformers can supply the load by load sharing

Standardisation - Reduce maintenance cost

Greater reliability - Less likelihood of two transformers failing at the same time.

② Australian Standard identification system for transformer terminals.

H_1, H_2 - High voltage terminals

X_1, X_2 - low voltage terminals

③ Two transformers are connected in parallel with incorrect polarity

- Short circuit can occur.

S.2.2 connect Transformers in parallel

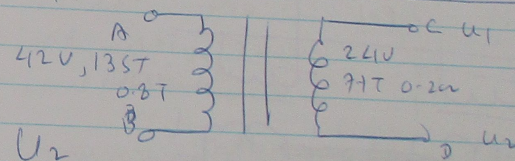
Exposed terminals, Q.H. Test terminals before touching, cover exposed terminals.
Wrong voltage is applied and burnt out of transformer.
A m check transformer voltage before connection.
Wrong polarity causing short circuit. A m check polarity before connection.

continuity Transformer (1)
meter selected - multimeter
Range - 0 ohm

winding Transformer (1)

winding	Terminal
1	A-B ($U_1 - U_2$)
2	C-D ($U_1 - U_2$)

U_1 Winding Arrangement Diagram



Transformer (2)

continuity

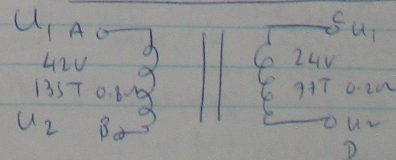
meter selected - multimeter

Range selected - 0 ohm

Transformer (2)

winding	Terminal
1	A-B ($U_1 - U_2$)
2	C-D ($U_1 - U_2$)

Winding Arrangement Diagram

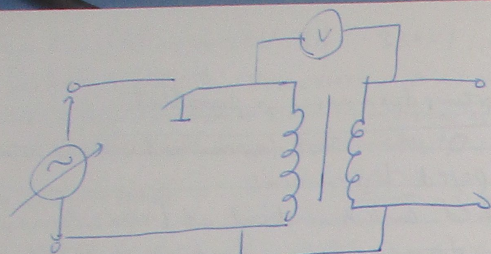


Test Result

A-B 0.2 ohm A-C 0.2 ohm
A-D 0.2 ohm B-C 0.2 ohm
B-D 0.2 ohm C-D 0.2 ohm

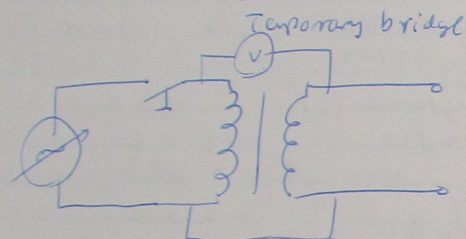
Test Result

A-B 0.2 ohm A-C 0.2 ohm A-D 0.2 ohm
B-C 0.2 ohm B-D 0.2 ohm C-D 0.2 ohm



Transformer 1

Primary voltage	Voltmeter reading
24-34	10.66

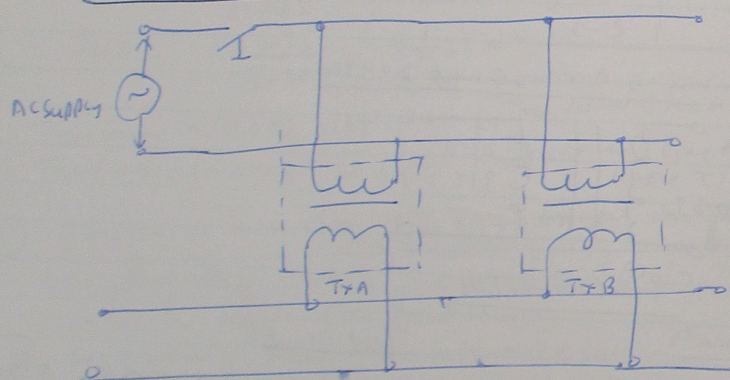


Transformer 2

Primary voltage	Voltmeter reading
24-34	10.66

Temporary bridge

Connect two transformers in parallel



Transformers 1 & 2 in parallel

Primary voltage Reading	Secondary voltage Reading
24-46V	13.9V

- 1/ What would happen if polarity of secondary wdg of Tr 2 was reversed - It will cause short circuit.
- 2/ minimum insulation resistance measured between primary & secondary wdg of transformer - 1MΩ
- 3/ Specifications for paralleling transformers
Polarity, Voltage rating, Regulation, Transformation ratio, Phase Sequence (3φ only) Vector group (3φ only)

6.1 Auto transformer connection and measurements

Exposed Terminals 2 It Test the terminal before touching cover the exposed Terminals

Set the variac voltage at the high point causing high voltage at terminal 2 It Even set the variac voltage at zero ~~measure~~ measure terminal voltage

mmf = NI	Auto Transformer way Resistor		
$\frac{500}{1000} \times \frac{5100}{2} = 650 \Omega$	Primary 71%	57%	43%
	34	34	34
	Variac operation is based on changing resistance at not too different		

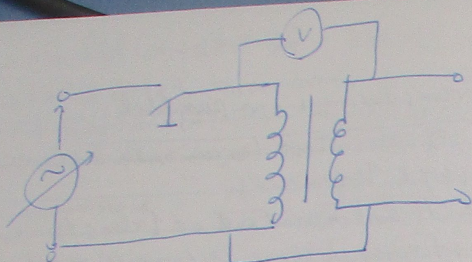
Auto transformer voltage

Primary voltage	71% Tap	57% Tap	43% Tap
calculated value	220	137.1	102.85
measured value	240	199.5	159.4
Supply voltage	240V		
Load Resistance	30Ω		

Auto transformer current

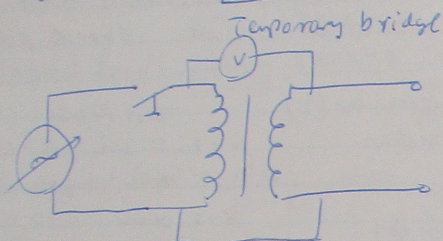
	71% Tap		57% Tap		43% Tap	
	Primary (A)	Secondary (A)	Primary (A)	Sec (A)	Primary (A)	Sec (A)
calculated value	3.8	$\frac{137.1}{30} = 4.57$	$\frac{102.85}{30} = 3.43$ $\frac{102.85}{30} = 3.42$	$\frac{25.7}{30} = 2.85$	1.425	$\frac{25.7}{30} = 2.85$
measured value	5.48	$\frac{197.5}{30} = 6.58$	$\frac{159.4}{30} = 5.31$	$\frac{159.4}{30} = 5.31$	1.99	$\frac{149.4}{30} = 3.98$

	71%	57%	43%
$\frac{I_1}{I_2} = a$	$a = \frac{240}{200} = 1.2$	$a = \frac{240}{160} = 1.5$	$a = \frac{240}{120} = 2$
Calculated	$I_1 = \frac{4.57}{1.2} = 3.8$	$I_1 = \frac{3.43}{1.5} = 2.28$	$I_1 = \frac{2.85}{2} = 1.425$
measured	$I_1 = \frac{6.65}{1.2} = 5.54$	$I_1 = \frac{5.31}{1.5} = 3.54$	$I_1 = \frac{4.98}{2} = 2.49$



Transformer 1

Primary voltage	Voltmeter reading
24-34	10.66

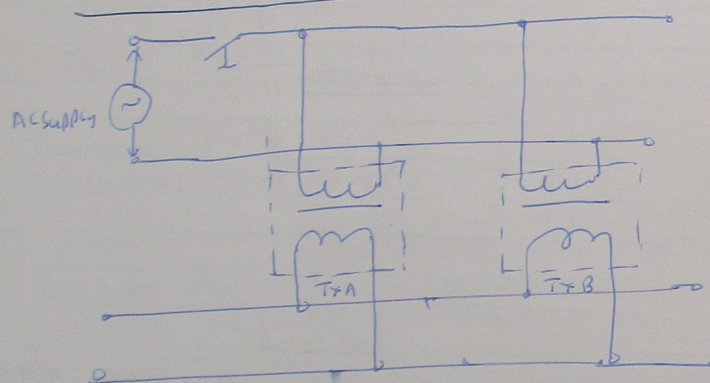


Transformer 2

Primary voltage	Voltmeter reading
24-34	10.66

Temporary bridge

Connect two transformers in parallel



Transformers 1 & 2 in parallel

Primary voltage Reading	Secondary voltage Reading
24-46V	13.9V

- 1) What would happen if polarity of secondary wdg of Tr 2 was reversed - It will cause short circuit.
- 2) minimum insulation resistance measured between primary & secondary wdg of transformer - 1M Ω
- 3) specifications for paralleling transformers
Polarity, voltage regulation, regulation, transformation ratio, phase sequence (3 ϕ only) Vector group (3 ϕ only)

6.1 Auto transformer connection and measurements

Exposed Terminals 2 H Test the terminal before touching cover the exposed Terminals

Set the variac voltage at the high point causing high voltage at terminal 2 H. Ever set the variac voltage at zero ~~measure~~ measure terminal voltage

mmf = NI

Auto Transformer wdg Resistance	
Primary	71% 57% 43%
3 ϕ	34 34 34

variator operation is based on magnetizing resistance is not too different

Autotransformer voltage

	Primary voltage	71% Tap	57% Tap	43% Tap
calculated at value	220	137.1	102.85	95.4
measured value	240	197.5	159.4	119.4
Supply voltage	240V			
Load Resistance	30 Ω			

Auto transformer current

	71% Tap		57% Tap		43% Tap	
	Primary (A)	Secondary (A)	Primary (A)	Sec (A)	Prim (A)	Sec (A)
calculated value	3.6	$\frac{137.1}{30} = 4.57$	$\frac{102.85}{30} = 3.43$ $\frac{2.28}{30} = 0.076$	$\frac{102.85}{30} = 3.43$	1.425	$\frac{85.2}{30} = 2.85$
measured value	5.40	$\frac{197.5}{30} = 6.58$	$\frac{159.4}{30} = 5.31$	$\frac{159.4}{30} = 5.31$	1.99	$\frac{119.4}{30} = 3.98$

	71%	57%	43%
$\frac{I_1}{I_2} = a$	200V	100V	120V
	$a = \frac{240}{200} = 1.2$	$a = \frac{240}{100} = 2.4$	$a = \frac{240}{120} = 2$
Calculated	$I_1 = \frac{4.57}{1.2} = 3.8$	$I_1 = \frac{3.43}{1.5} = 2.28$	$I_1 = \frac{3.18}{2} = 1.59$
measured	$I_1 = \frac{6.58}{1.2} = 5.48$	$I_1 = \frac{5.31}{1.5} = 3.54$	$I_1 = \frac{3.98}{2} = 1.99$

1/ The factors determines the ratio of auto transformer
The ratio of total turns to the number of turns between the secondary taps determines the transformation ratio.

2/ Advantage of auto transformer

Less cost, lower copper loss, Better voltage regulation.

3/ Disadvantage of auto transformer

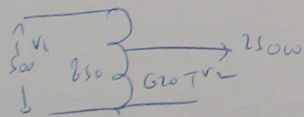
Accidental open circuit occurred in common winding of auto transformer will cause appearance of high voltage across low voltage terminals may damage the load.

Because of no isolation between primary and secondary winding the fault occurred at load side will impact on source side.

4/ AS/NZS clause on Auto Transformer

4.14.4 An auto transformer shall not be used to supply electrical equipment including circuit wiring having a voltage rating of less than the highest input or output voltage of auto transformer.

5/ 500V supply, Autotransformer wdg 850 turns, secondary voltage, and load current of 250W connected to secondary side, which is tapped at 620 turns,

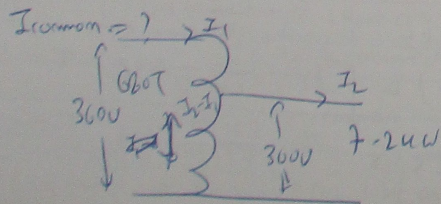


$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \quad V_2 = \frac{500 \times 620}{850}$$

$$\frac{500}{V_2} = \frac{850}{620} \quad = 364.7V$$

$$I_2 = \frac{W}{V_2} = \frac{250}{364.7} = 0.685A$$

6/ Auto transformer step down 360V to supply 7.2W 300V complete wdg got 620 turns, $N_2 = ?$ $I_1 = ?$ $I_2 = ?$



$$I_2 = \frac{7.2 \times 10^3}{300} = \frac{7200}{300} = 24A$$

$$\frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{N_1}{N_2}$$

Q102

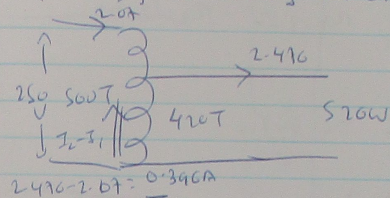
4.15.3.1 capacitor value greater than 0.5μF shall be provided with discharge

$$\frac{360}{300} = \frac{24}{I_1} \rightarrow I_1 = 24 \times \frac{300}{360} = 20A$$

$$\text{common } I_2 - I_1 = 24 - 20 = 4A$$

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \rightarrow \frac{360}{300} = \frac{620}{N_2} \rightarrow N_2 = 620 \times \frac{300}{360} = 507$$

7 Auto transformer, step down 250V to supply 520W complete wdg 500T, secondary 420T, Sec. voltage, primary, secondary current, common part current?



$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{250}{V_2} = \frac{500}{420}$$

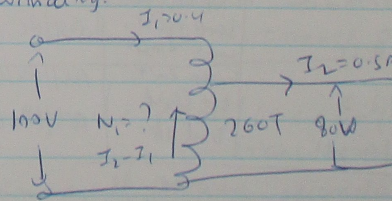
$$V_2 = \frac{250 \times 420}{500} = 210V$$

$$I_2 = \frac{W}{V_2} = \frac{520}{210} = 2.476A$$

$$\frac{I_2}{I_1} = \frac{N_1}{N_2} \rightarrow \frac{2.476}{I_1} = \frac{500}{420}$$

$$I_1 = 2.476 \times \frac{420}{500} = 2.07A$$

8/ Auto transformer, step down 100V to 40W 80V Load. secondary side winding 260 Turns. primary turns? primary current? secondary current? current in common part of winding.



$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{100}{80} = \frac{N_1}{260}$$

$$N_1 = \frac{260 \times 100}{80} = 325 \text{ Turns}$$

$$I_2 = \frac{40W}{80V} = 0.5A$$

$$\frac{N_1}{N_2} = \frac{I_2}{I_1} \rightarrow I_1 = \frac{I_2 \times N_2}{N_1}$$

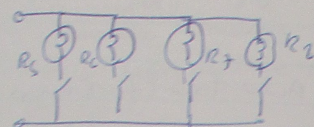
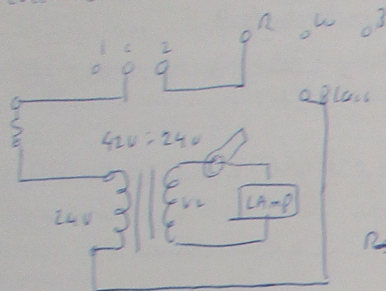
$$= 0.5 \times \frac{260}{325} = 0.4A$$

$$I_2 - I_1 = 0.5 - 0.4 = 0.1A$$

6-3 connect current transformer

Exposed Terminal 2 It Test terminal before touching over exposed terminal

Wrong voltage given to transformer causing burning out of circuit transformer voltage and ratio before energizing.



$$R_5 = 2.8\Omega, R_6 = 3.2\Omega \\ R_7 = 3\Omega, R_8 = 2.7\Omega$$

$$R_5 // R_6 = \frac{2.8 \times 3.2}{2.8 + 3.2} = 1.49\Omega$$

$$R_5 // R_6 // R_7 = \frac{2.8 \times 3.2 \times 3}{2.8 \times 3.2 + 3.2 \times 3 + 2.8 \times 3} = 0.999\Omega$$

$$R_5 // R_6 // R_7 // R_8 = \frac{2.8 \times 3.2 \times 3 \times 2.7}{2.8 \times 3.2 \times 3 + 3.2 \times 3 \times 2.7 + 3.2 \times 2.7 \times 2.8 + 2.7 \times 2.8 \times 3.2} = 0.72\Omega$$

CT value

CT secondary current A	CT primary current		
	calculated value	measured value	
0.50	4.91	measured to R ₅	R ₅
1.2	9.23	Lamp resist. will cause	R ₅ // R ₆
1.8	13.8	when enst	R ₅ // R ₆ // R ₇
2.4	19.11	but it	R ₅ // R ₆ // R ₇ // R ₈

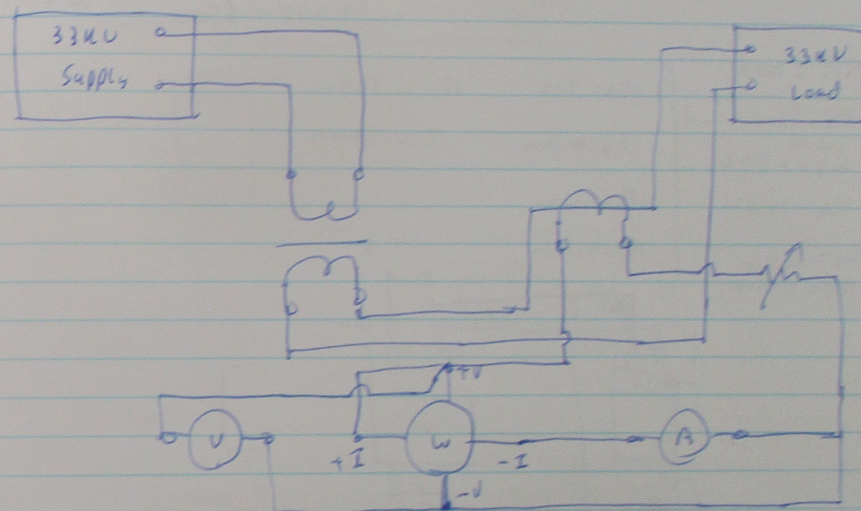
$$I_{primary} = \frac{13.76}{2.8} = 4.91A$$

Compare simulated to CT operation

I secondary

	V	R _t	V/R _t = I _{PR1}	I _{meas}	RATIO
R ₅	13.76	2.8	4.91	0.58	8.44
R ₅ // R ₆	13.76	1.49	9.23	1.2	7.69
R ₅ // R ₆ // R ₇	13.76	0.999	13.8	1.8	7.66
R ₅ // R ₆ // R ₇ // R ₈	13.76	0.72	19.11	2.4	7.96

$$Ratio = \frac{8.44 + 7.69 + 7.66 + 7.96}{4} = 7.92$$



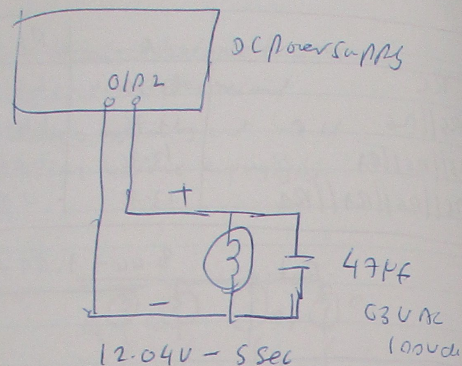
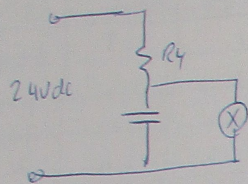
- CT secondary must be short circuited before turning out
Safe procedure to disconnect PT

- De energize { open power on/off switch, trip CB, Tag out the transformer

- Remove all primary, secondary connected equipment
- Remove transformer

What standard voltage at voltage transformer
100V or 110V { 70V, 100V }

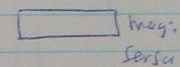
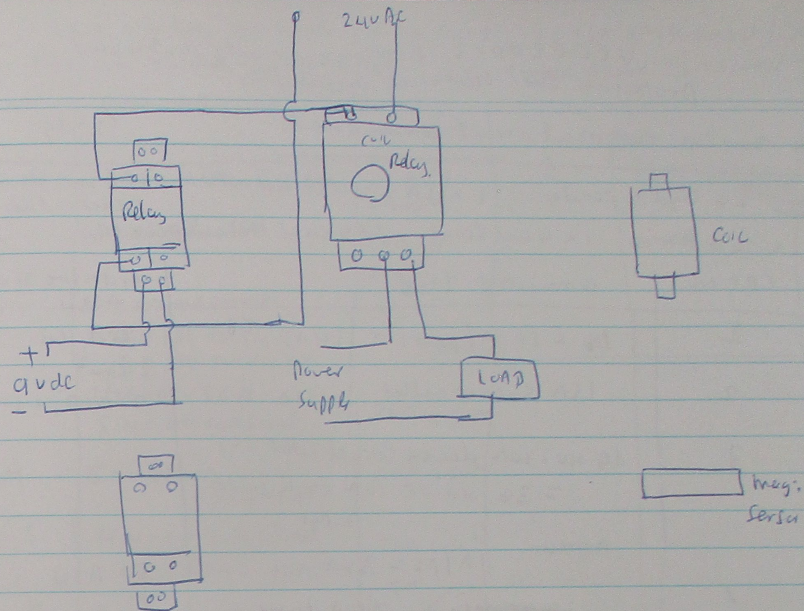
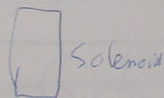
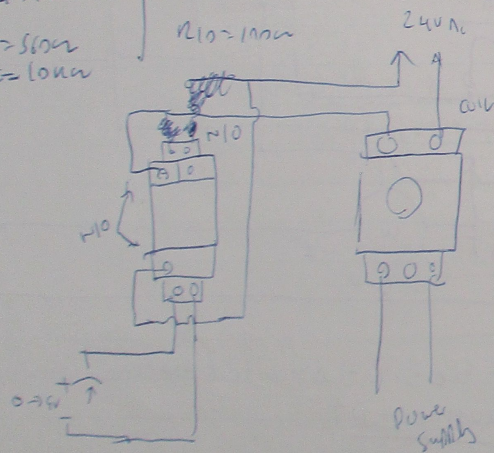
Standard secondary current at current transformer
1 to 5 Amp



$R_1 = 220\Omega$
 $R_2 = 100\Omega$
 $R_3 = 680\Omega$
 $R_4 = 12k\Omega$
 $R_5 = 560\Omega$
 $R_6 = 100\Omega$

$R_7 = 2\Omega$
 $R_8 = 4.7k\Omega$
 $R_9 = 330\Omega$
 $R_{10} = 100\Omega$

$R_{11} = 100k\Omega$
 $R_{12} = 10m\Omega$



UEECL0003 Arrange circuits, control and protection for electrical installations

2.2 Develop electrical circuit arrangements

CS - C9

2.2.1 Lighting points, 1 x 15A single socket outlet, 1 x 10A double socket outlets, 1 x 24A Aircon, 1 x 4kW Stove, 1 x 4.6kW Hot water heater

Ckt No	Connected Load	Protective Device
1	24 x (0.5A / point) = 12A	20A CB, 2.5mm ²
2	15A socket outlet = 12A	20A CB, 2.5mm ²
3	19 no of 10A double socket outlet = 38 no of 10A single socket outlet	20A CB, 2.5mm ²
4	Aircon 1A / pt = 38A	20A CB, 2.5mm ²
5	10 no of 10A double socket = 10 x 2A / pt = 20A	20A CB, 2.5mm ²
6	4kW Stove $\Rightarrow \frac{4000}{230} = 17.39A$	20A CB, 2.5mm ²
7	4.6kW Hot water heater $\frac{4.6 \times 10^3}{230} = 20A$	20A CB 2.5mm ²

2.2.2 56 Lights, 2 x 15A single socket outlet, 36 x 10A double socket outlet, 1 x 30A Aircon

Ckt No	Connected Load	Protective Device
1	56 x 0.5A / pt = 28A	20A CB
2	28 no - 28 x 0.5 = 14A	2.5mm ²
3	28 no - 28 x 0.5 = 14A	2.5mm ²
4	1 x 15A socket outlet (12A)	20A CB 2.5mm ²
5	1 x 15A socket outlet (12A)	20A CB 2.5mm ²
6	36 x 10A double { 20A	20A CB 2.5mm ²
7	36 x 1A / pt = 36A	10A CB 2.5mm ²

2.3.1

12 x High bay mV lights (1.7A each), 1 x 15A single socket outlet, 14 x 10A double socket outlets, 3 x Three phase 32A socket outlet

Ckt No	Connected Load	Protective Device
1	1.7A / pt x 12 = 20.4A	25A CB, 2.5mm ²
2	15A socket outlet	20A CB, 2.5mm ²
3	10A double socket 2A / pt for sig & 4A / pt for down	20A 2.5mm ²
4	14 x 4A = 56A 5 no of 10A socket 5 x 4 = 20A	20A 2.5mm ²
5	5 no of 10A socket 5 x 4 = 20A	20A 2.5mm ²
6	4 no of 10A socket 4 x 4 = 16A	20A 2.5mm ²
7	32A socket x 1	32A 4mm ²
8	32A socket x 1	32A 4mm ²

Q1 When may a socket outlet be counted as lighting pt for ckt loads?

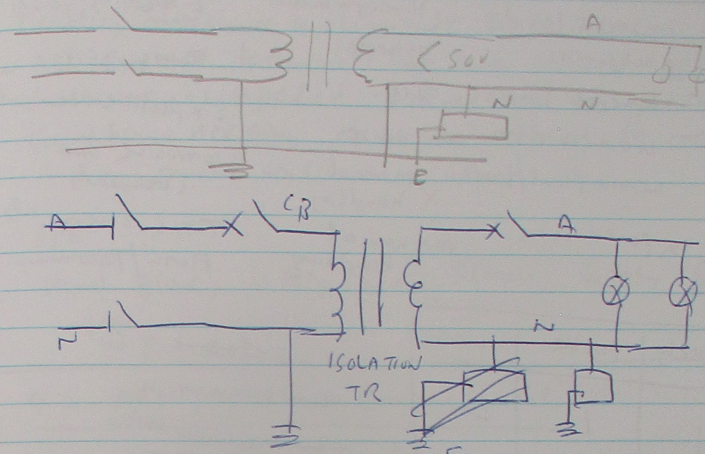
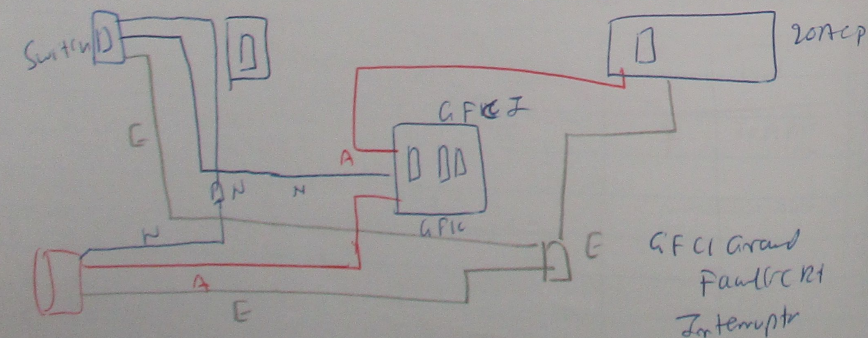
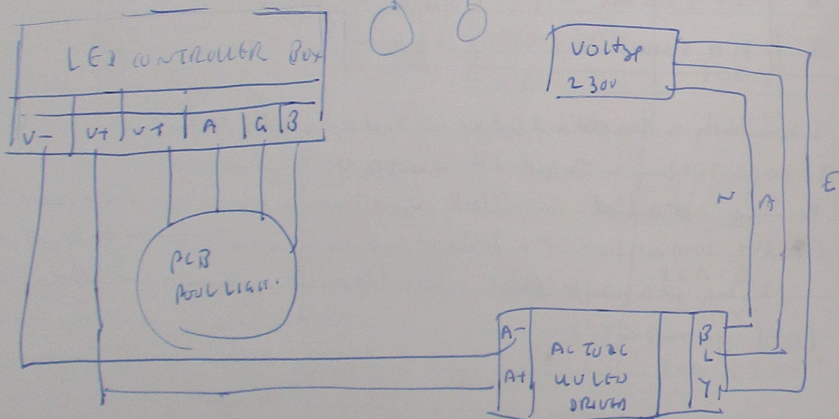
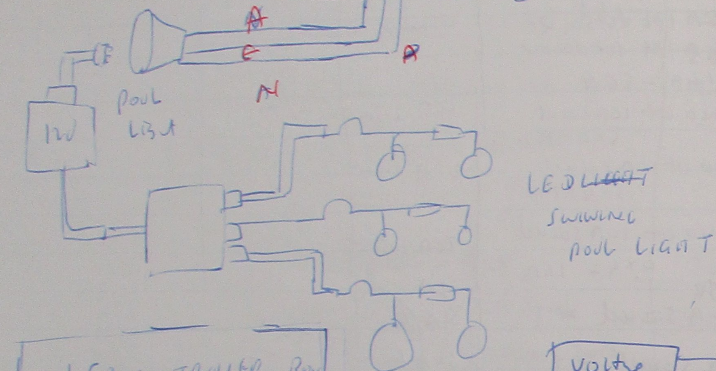
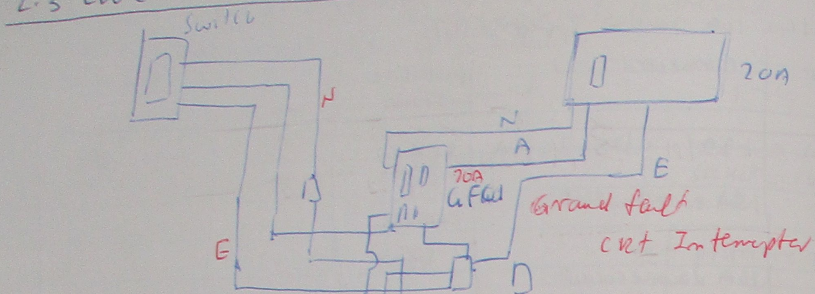
AS 3000-2013 Table C9, Note 6

"A socket outlet installed more than 2.3m above the floor for the connection of a luminaire may be included as a lighting point"

Q2 125W exhaust fan, installed 2.4m above the floor? (Load group a1)

310

2.3 ELV circuit Arrangement



What is the difference between PELV & SELV (configurations)?

SELV 1-4-105, PELV 1-4-96 7-5-6
7-5-5

SELV An extra low voltage system that is electrically separated from earth or from other system in such a way that a single fault live parts of SELV circuits shall not be connected to earth or protective earthing conductors. No part of other circuits or to other live parts.

SELV circuit must not be connected to

- (a) other circuits
- (b) Earth
- (c) Earthing conductors or exposed conductive parts of another system
- (d) Extraneous conductive part

PELV An extra low voltage system that is not electrically separated from earth but that otherwise satisfies all the requirements of SELV.

Basic The following applies to PELV circuits one of conductor of a PELV circuit is earthed.

Basic protection shall be provided by an barrier or enclosure with IPXXB, IP2X (a) Insulation capable withstanding test volt 500V for 1 min

can not give rise to the risk of electric shock

3.3 conduct a job safety / Hazard Analysis

Types of hazard:

High voltage

~~X low voltage~~

X Extra low voltage

High concn

X working 'Live'

- house keeping

x other

Risk matrix

work at height

hot works

confined spaces

UV radiation

white plant / traffic

mobile, for

X power Tools

Forcign books

asbestos

dust

active

noise

X moment handling

mechanical

hand Ling

Explosive gases

Toxic gases

Ex positive chemical

composible ~~non~~
(chemicals)

Toxic chemical,

Flora / fauna

Risk Matrix	Likelihood	Likely	Possible	Unlikely
Severity				
Deathly			1	2
Permanent disability	1			
Serious injury (w/ chronic illness)	1		2	3
Minor injuries requiring first aid	2		3	4

1 - Extreme risk

2 - High risk

3- medium risk

4 - low risk.

Hazards	Associated Risk	Risk Level	Control measure
Exposed Terminals	Electrocution	m	cover all exposed terminals
Heavy motor	Falling on leg	m	Safety boot to be worn, care in handling.
Sharp edge of metallic box	Hand injury	m	Appropriate enclosure
wire and equipment on floor	Trip, slip, fall	L	Good house keeping to maintain
Power, drill grinder	Hand injury cutting	m	Carefully handle any power equipment

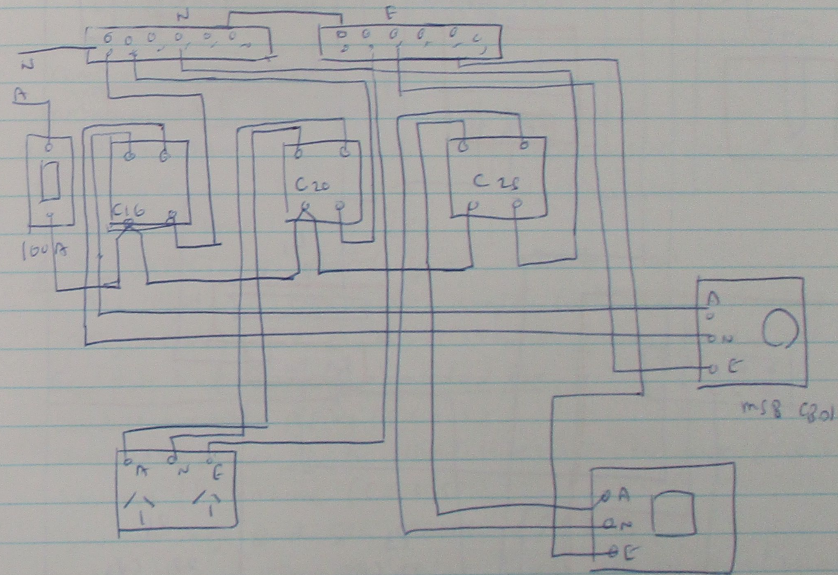
Identify measures to eliminate the identified bias

- All exposed terminals ~~are~~ are covered. Appropriate enclosure is applied to cover all sharp edges.
- Good house keeping & is maintained to remove wire and equipment on floor.

PP6

Hand glove, safety shoe, apron, safety glass to be worn

4.2 ADS Protection Arrangements

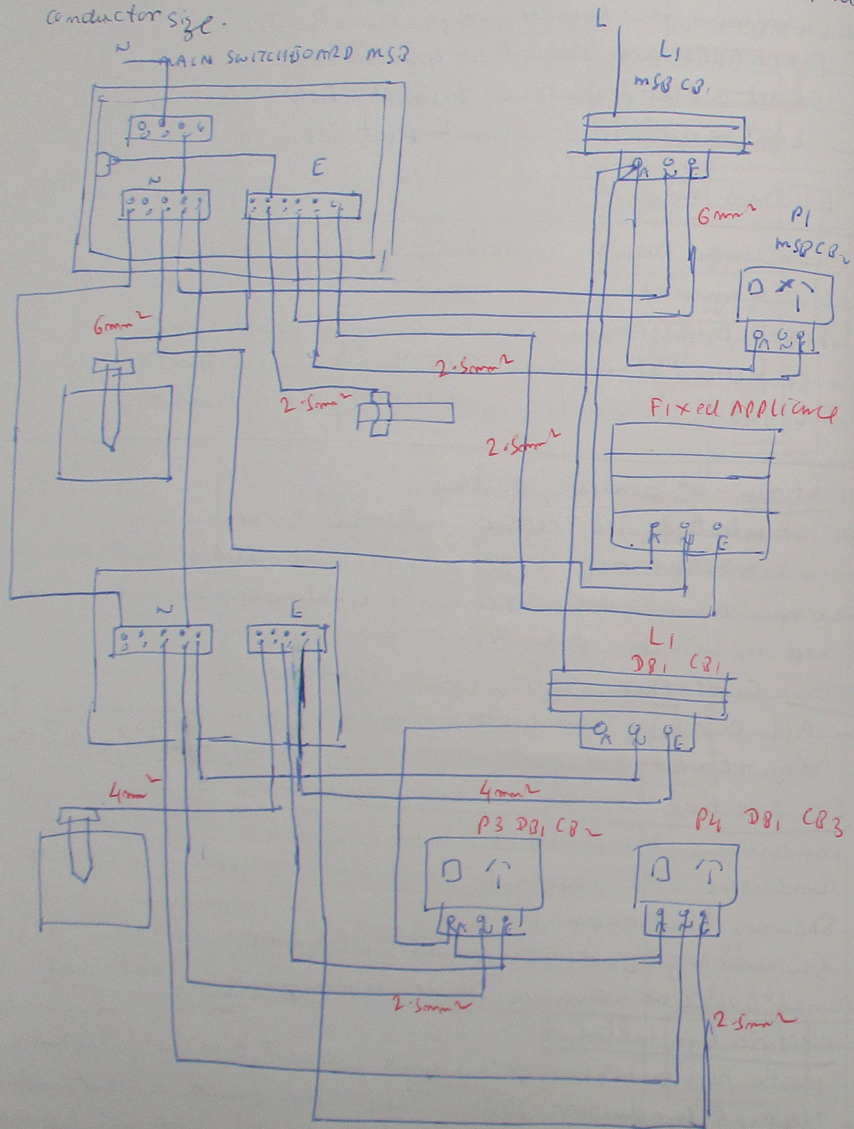


minimum number of RCD required to ^{be given} protect two lighting circuits and two power circuits - Two

RCBO - residual current circuit breaker.

The advantage of having RCBs is that each circuit is a separate device unlike RCD which protects a number of circuits. So in the event of fault, only the faulty circuit would be off.

Draw the necessary earthing connection for a new earthing system consisting of a separate mfn connection at the outboard switch board. Label the diagram to indicate minimum earthing conductor size.

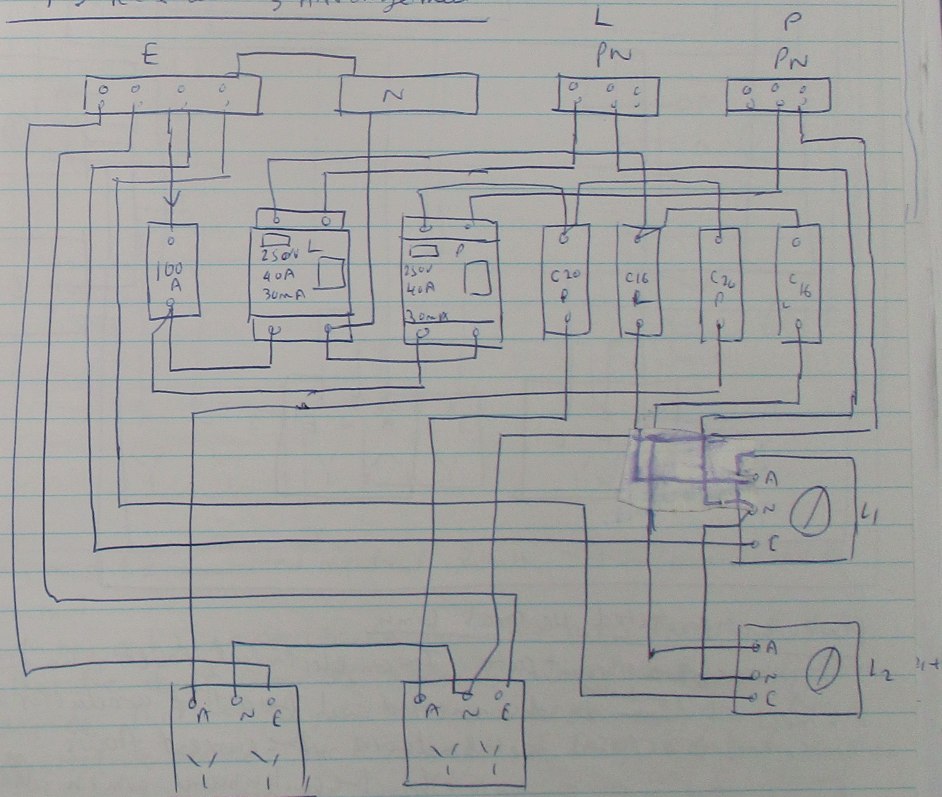


Reference Table S-1 AS3020

Hazards

Exposed conductor & it cover ~~the~~ ^{and} enclosed conductor
 neutral / Earth Reverse polarity & it polarity Test
 mixed circuit & it mixed circuit Test
 open neutral & it properly secured the neutral
 open earth & it Earth continuity Test
 Faulted insulation between wires & it Insulation Resistance Test

7.3 RCD wiring Arrangement



2 poles RCD

7.4 Select and Arrange circuit protection

$$I_n \leq 1.45 I_2$$

All overcurrent
Protection

$$I_B \leq I_n \leq I_2 \quad \text{CB}$$

$$I_B \leq I_n \leq 0.9 I_2 \quad \text{HRC}$$

I_2 = maximum demand of circuit

I_n = Nominal current of protective device

I_2 = continuous current carrying capacity of conductor

I_2 = The current causing operation of the protective device in the required time.

Circuit Breaker	Instantaneous trip current	I_n for 20A CB	Application
B	$4 I_n$	80A	Resistive heating load
C	$7.5 I_n$	150A	Socket outlet lighting
D	$12.5 I_n$	250A	motor

$$I_n = 0.9 I_2$$

I_2 continuous current carrying capacity

Circuit		Conductor		Protective device	
No	Connected load	Size	Current carrying capacity	Type	Nominal current Rating
2	DB 1	36A	6mm ² 41A	C	$36 \times 0.9 = 32.4$ 36A
2	10A Socket outlet	10A	2.5mm ² 23A	C	$23 \times 0.9 = 20.7$ 20A
3	Downlight	12A	1.5mm ² 18A	C	$18 \times 0.9 = 16.2$ 16A
4	Gen lighting Exhaust fan	3A	1.5mm ² 18A	C	$18 \times 0.9 = 16.2$ 16A
5	Store	25A	4mm ² 34A	B	$34 \times 0.9 = 30.6$ 30A
6	Instantaneous water heater	30A	4mm ² 34A	B	$34 \times 0.9 = 30.6$ 30A

$$\frac{I_a}{I_n} = 4 \quad (B)$$

$$\frac{I_a}{I_n} = 7.5 \quad (C)$$

$$\frac{I_a}{I_n} = 12.5 \quad (D)$$

I_a = Instantaneous tripping current

Consumer main

1.4-64
1.4-96
1.4-115

Installation	conductor	main switch	Fault current
max. Demand	Size	current carrying capacity	Breaking capacity
70A	16mm ² 101A	$0.9 I_2 = 0.9 \times 114 = 102.6$ $I_n = 100A$	$I_2 = 145A$ $I_n = 145A$ $I_a = 7.5 I_n = 750A$ $I_a = 145A$

Distribution Board 1

Circuit		Conductor		Protective device	
No	Connected load	Size	Current carrying capacity	Type	Nominal current Rating
1	10A socket outlet	12A	2.5mm ² 23A	C	$23 \times 0.9 = 20.7$ 20A
2	15A socket outlet	15A	2.5mm ² 23A	C	$23 \times 0.9 = 20.7$ 20A
3	20A socket outlet	20A	2.5mm ² 23A	C	$23 \times 0.9 = 20.7$ 20A
4	Fluorescent lighting	2A	1.5mm ² 18A	C	$18 \times 0.9 = 16.2$ 16A

manufacturer's catalogue

TYPE 100 FAULT CURRENT LIMITER, ABB, NHP

Sufficient Breaking capacity

Equipment can be damaged by fault current if it's breaking capacity is too low for fault current.

FAULT SWITCHES

Plate 1 Switch 1/2 Plate 2 Switch 3 ^{beginners} on at the

Circuit Identification		Type of fault	Electrical Test Result	Action
1 2 3 4 5 6 Switch				
1	Stove / Range Switch plate 3 Switch 2	Shortcircuit / minor	11mm Active to Earth On	Re-wire cable check connection
2	Power 2 Switch plate 4 Switch 3	Reverse polarity	Neutral to Earth	Physically connect each conductor to correct terminal
3	HWS Switch plate 4 Switch 4	High Resistance main Earth	500-800	Securely fix each conductor Re-wire damage cable
4	Power 1 & 2 Switch plate 4 Switch 6 Switch plate 2 Switch 3 in off position	Incorrect circuit connection	Intermix Neutral P1 & P2	Identify & correct Neutral to circuit
5	Light 2 Switch plate 3 Switch 3	Open circuit	Open circuit Active	Re-wire cable check connection

Earth ckt	A → A A → N E → E	A → N N → E A → E	Wiring Sockets Wiring Red Black Green Rev polarity	Intermix Power Power A → A N → N E → E	Wrong Polarity
Shortcircuit	Open circuit				

6.1 Test over voltage protected Installation

View over voltage protection device catalogue and installation guide provided by Trainers
see section J page 312

Electrical installation

Type - LV Electrical Installation page 312

Supply 415V / 3 phase supply switchboard
over voltage protective device

page 313

Type - Type SMO

Rating - 50A (6/20) MS

< 2.5kV

Multimeter - Type ANENG 57120

Range max 600V

IR Tester - Type Hioki 3490 ANALOG
meter Tester

Range 250/500/1000V

meter LINK connected

meter - IR Tester

Range 500V A-E d.c.

Insulation Resistance

meter - IR Tester

Range 500V A-E d.c.

Range 250V A-E d.c.

Range 1000V A-E d.c.

View the video provided by Trainers to test over voltage
Protection Device

meter disconnected

continuity

IR Tester 500V A-E d.c.

meter LINK disconnected

Insulation Resistance
meter - IR Tester Range 500V A-E d.c.
250V A-E d.c.
1000V A-E d.c.

- The same result obtained
- The Higher voltage gives more accurate result
- It is working correctly

8.2 over voltage and under voltage Protection Arrangement

<https://www.sollatek.com/medical/>

msb 5
X-ray room - Higher voltage - Increase radiation over/under
2.7.3, 2.6.2 over/under V Installation 1
main switch Board (msb) medical diagnostic

Circuit no.	connected load	over voltage Protection	under Voltage Protection
msb 1	ESB 1 Emergency Service Board 1 - Emergency Evacuation Service	✓	
msb 2	ESB 2 - Emergency Service Board 2 Fire detection service	✓	
msb 3	P1-10A socket outlets circuit 1 Reception & waiting room	✓	
msb 4	P2-10A socket outlet circuit 2 - consultation Room 1-4	✓	✓
msb 5	P3-10A socket outlet circuit 3 X-ray room	✓	✓
msb 6	P4-10A socket outlet circuit 4 MRI Room	✓	✓
msb 7	L1 - Lighting circuit 1 - Reception, waiting room & consult 1/2	✓	✓
msb 8	L2 - Lighting circuit 2 - consult 3/4 X-ray and MRI Room	✓	✓
msb 9	AC1 - GSW ducted A/C system LV 2 plant Room	✓	✓
msb 10	MRI 1 - magnetic Resonance Imaging MRI machine Room - MRI Room	✓	✓
msb 11	X1 - X-ray machine circuit - X-ray Room	✓	✓

over voltage and under voltage Protection

Installation 2 (IT Business)

Circuit Number	connected Load	over voltage Protection Required	under voltage Protection Required
msb 1	ESB 1 - Emergency Service Board 1 - Emergency Evacuation Service	✓	
msb 2	ESB 2 - Emergency Service Board 2 Fire detection service	✓	✓
msb 3	ESB 3 - Emergency Service Board 3 - Lift service	✓	✓
msb 4	P1-10A socket outlet circuit 1 - Reception Area & meeting Room	✓	✓
msb 5	P2-10A socket outlet circuit 2 - work station 1-3	✓	✓
msb 6	P3-10A socket outlet circuit 3 - workstation 4-6	✓	✓
msb 7	P4-10A socket outlet circuit 4 - server Room (mission critical)	✓	✓
msb 8	L1 - Lighting circuit 1 - Office Area 1	✓	
msb 9	L2 - Lighting circuit 2 - Office Area 2	✓	
msb 10	AC1 - HLUW Ducted Air conditioning System LV 2 plant Room	✓	✓

- Suitable protection methods for the circuits requiring over voltage protection
- Surge Protection device (SPD), mercury oxide varistor valve type arrester, gas filled arrester - suppressor diode (solid state)
- Suitable protection method for under voltage protection.

- Under voltage relay
- Automatic voltage regulator
- uninterruptible power supplies (UPS)
- Shunt capacitor / Static Var compensator
- Series capacitor
- ~~and~~ up sizing transformers and / or conductor to reduce impedance.

causes of over voltage

- Nearby switching of high voltage circuit / Heavy load / inductive capacitive circuit
- Lightning (Resonant phenomena)

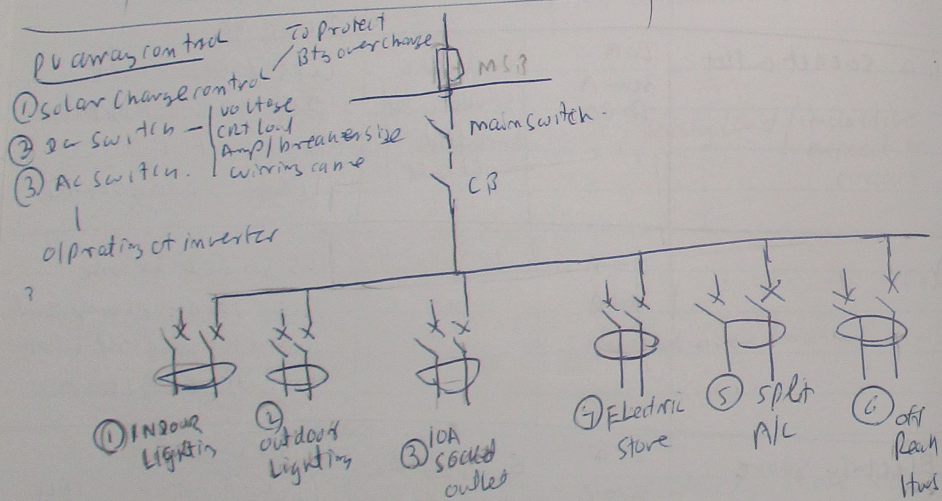
causes of under voltage

- * Power grid over load and fault / general over load (Lightning)
- High impedance of supply conductors
- * Nearby switching of heavy load particularly those requiring large start up current

9.3 Select Electrical Installation Control Equipment

Load	Protection	Note	control device selection
① Indoor lighting	16A 30mA R130	Equipment installed indoor	Standard light switch DETA X6 white single vertical switch 16A, 240V, 2400W Indoor type
② outdoor flood lighting	16A 30mA R180	Equipment installed outside	CLIPSAID WS 226-RG weather proof switch 1 pole 16A 1P66 1 gang, M20 240V AC
③ 16A socket outlet a	20A 30mA R180	includes socket outlet installed outside	CLIPSAID WC 221/2 2 double weather proof power point 16A 1P54, 16A, double
③ (b)	20A 30mA R130	"	MLS 30662 double pole, double power point 16A classic style with socket outlet, 250V AC
④ Electric store	25A 30mA R180	Equipment requires protection against water splashes	25A Single GPO Power point outlet 1P66 250V AC BASIX Series 250V 25A
G6W3 32 AMP single phase 3 phase plug 1P66 250V		water splash +	G6W3 32 Amp socket 14 3rand pin 1P66 250V 5W HPM 1061 3 pin plug side entry 240V 25A 3 pin

	Load	Protection	Note	Control device
5	Split system AC	25A 30mA RCBO	Equipment installed outside	Weather proof Single switch 16 Amp / IPS3 weather proof TESLA Brand. 240V
6	off Peak HWS	25A 30mA RCBO	Equipment requires protection against ingress or dust in water	35 Amp 2 way Hotwater system Projector blws 35A / 250V double pole



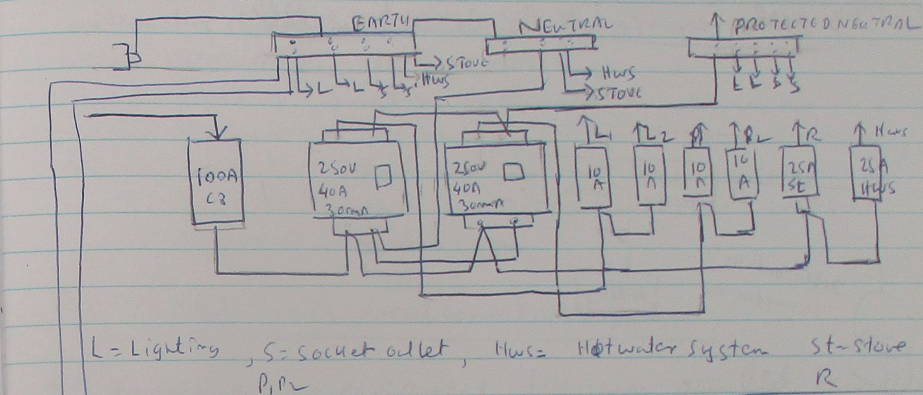
① Identification of main switch 2.3.3.5

- (a) Each main switch shall be marked 'MAIN SWITCH' and shall be readily distinguishable from other switching gear by means of grouping contrasting colouring or other suitable means to provide for prompt operation in an emergency.

② 1 main switch

③ IP rating for electrical control switch outside use (ingress of harmful deposit of dust, strong rain) — IP66

10.3 Draw a switchboard arrangement



NO	Circuit	Circuit Protection	RCD(LN)	connected load
1	L ₁	10A, 4kA Type(C)CB	Y	Lighting
2	L ₂	10A, 4kA Type(C)CB	Y	Lighting
3	P ₁	20A, 4kA Type(C)CB	Y	10A socket outlet
4	P ₂	20A, 4kA Type(C)CB	Y	10A socket outlet
5	R	25A, 4kA, Type(C)CB	N	Electric stove
6	HWS	25A, 4kA, Type(C)CB	N	Off Peak hot water heater

② The same answer

③ How many main switches — one (100A)

④ Orientation of circuit protective devices

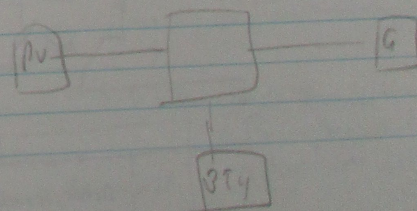
A All circuit breakers must be mounted horizontally

B Listed busway plug-in units are not permitted

C Enclosures for over current devices shall be mounted horizontally

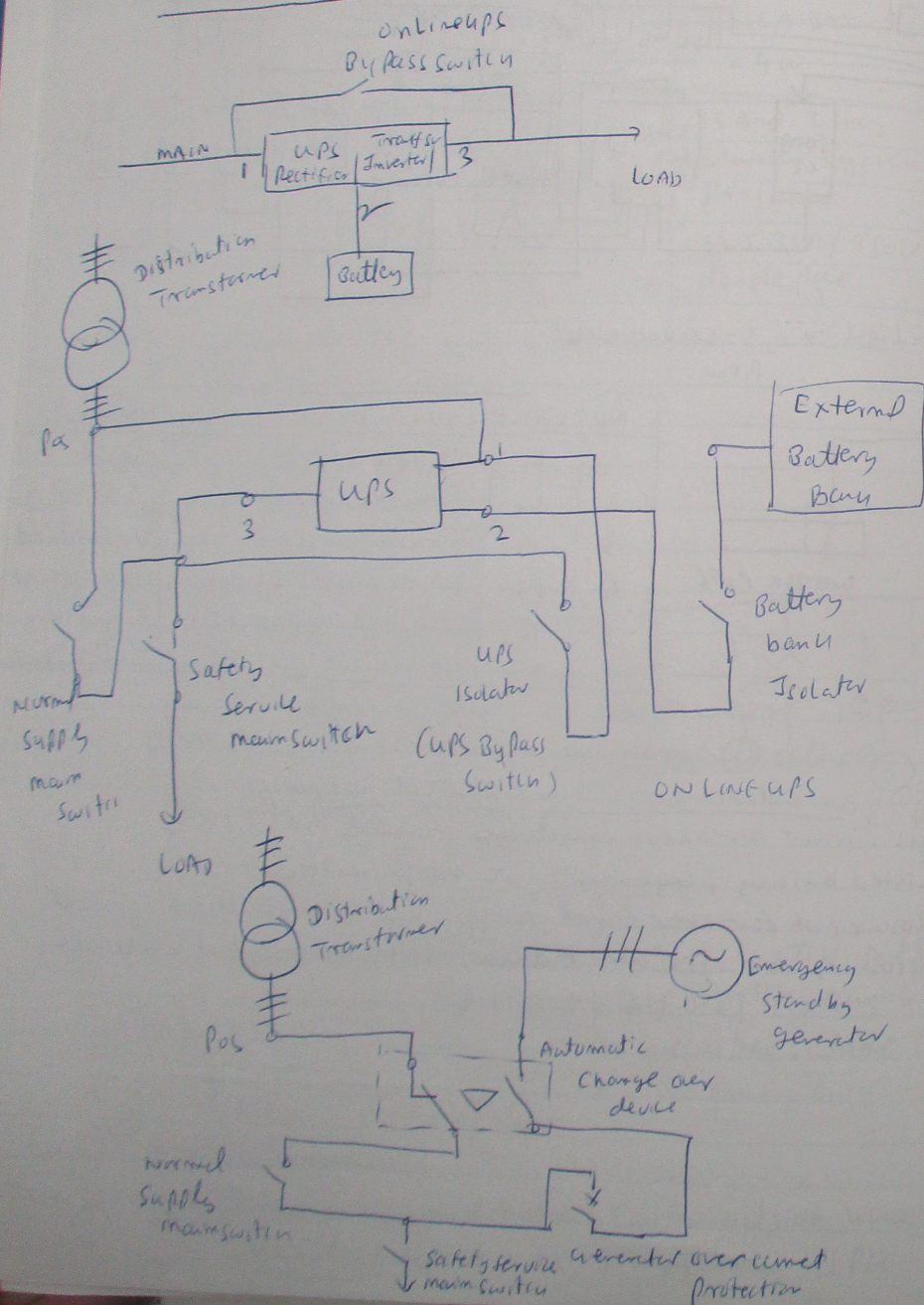
⑤ Enclosures for over current devices shall be mounted vertically.

2.6.2.1 / 2.6.2.4 / 2.3.7.4



UEEE0047 Identify, shutdown and restart systems with alternate supplies

1.3 Apply requirements for Alternative supplies



SIR - Service Installation Rules

① List the clauses in Local SIRs that specify requirements for alternative supplies in consumer installation.

- NSW Electrical Service Rule 2010

9.3.1 Stand by generating equipment must only be used under the conditions agreed to by the electricity distributor. Stand by generating equipment must not be used to parallel with electricity distributor's system unless it complies with clause 9.4 & 9.5.

② Key requirements for alternative supplies

9.3.3 Change over equipment for non parallel operation - manual / automatic change over - only on load side of metering equipment.

9.3.4.1 Normal supply neutral must not be switched

9.4 Requirement for stand by generated close transfer trip

9.5 Requirement for generator parallel operation

9.6.5 metering requirement

9.6.14 Islanding protection Requirement.

A 2.2 Apply generator Requirement

① Stand by generator is not required to provide with overcurrent protection

overcurrent protective device need not be provided where the unexpected interruption of the supply could cause a greater danger than over current 7.3.5.1 (a) Exception.

② Equipotential bonding

7.3.6 Any exposed parts

5.6.3.2 conductive pipe, wire

AS3010

2.5.6.1 Engine frame, generator frame

Exposed conductive part, Earth terminal

enclosure of conductive fixture fittings 5.6.2.6.3