

PSDE4001 assignment 2

by William Young

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HNC ELECTRICAL
PSDE 4001 ELECTRICAL AND ELECTRONIC PRINCIPLES
ASSIGNMENT 2

William Young
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1.0 Task 1

In a team, the ELT171C and ELT171A units were set up as a STAR connected balanced load and connected to a STAR supply respectively. Configured the ELT171C unit as follows:-

Set the variable resistors R_A R_B R_C to 70Ω ,
Switch the L/C switches to L,
Set the variable inductors to 200mH

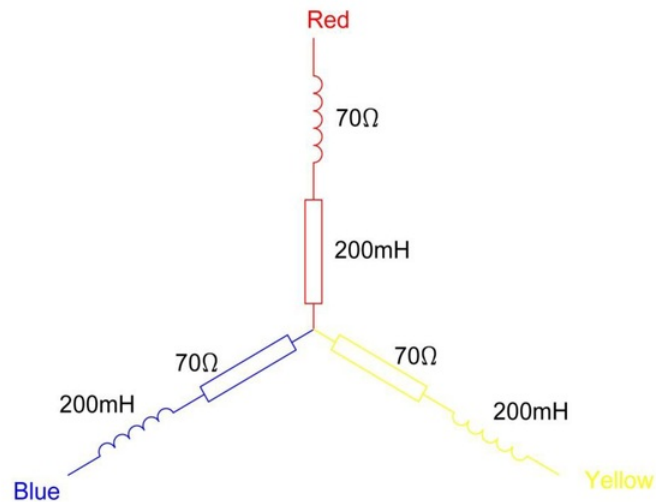


Figure 1 Star Balanced load Configuration

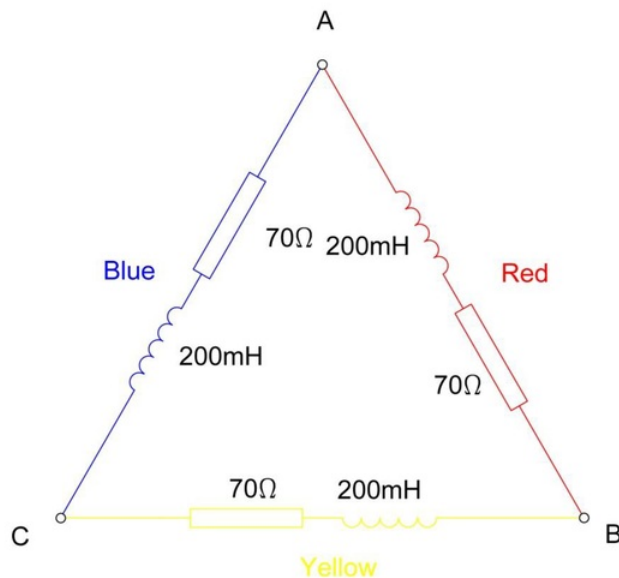


Figure 2 Delta Load balanced Configuration

Good examples for intro to practical task.

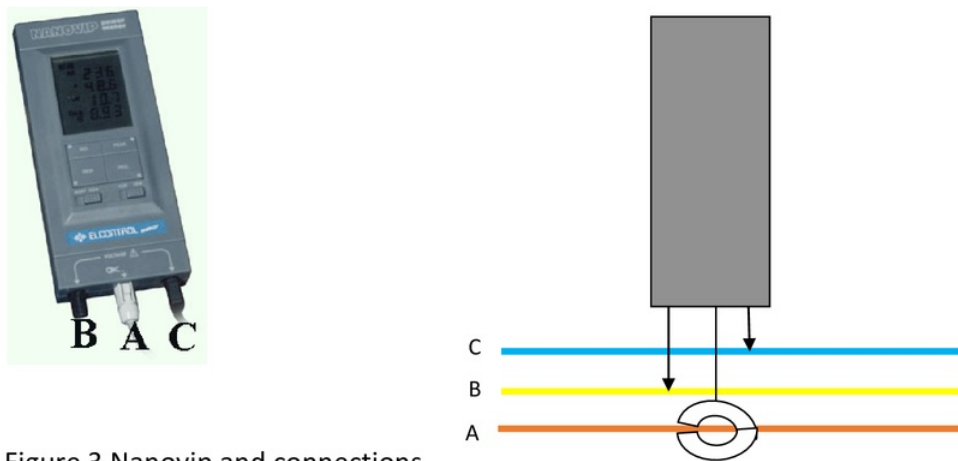


Figure 3 Nanovip and connections

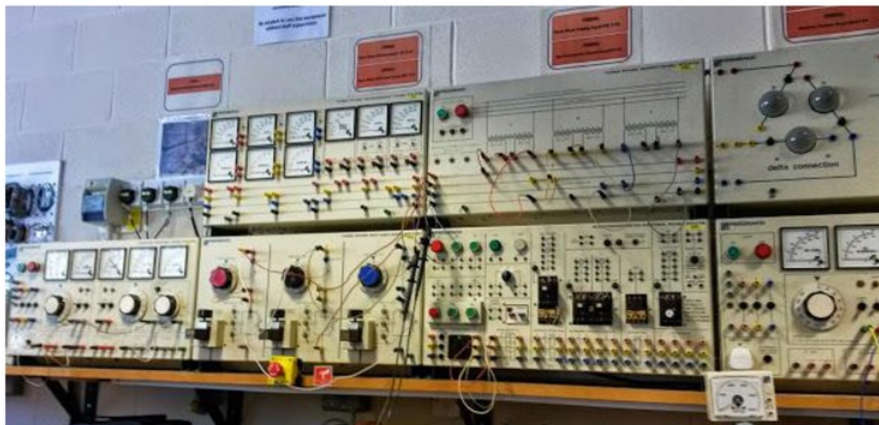


Figure 4 Star Supply-Delta balanced Load



Figure 5 Star Balanced Load

Task 2 Calculations

1.1 Star Load configuration calculations

$$\text{Line voltage} = 213\text{V}$$

$$\text{Phase voltage} = \frac{V_{\text{line}}}{\sqrt{3}} = \frac{213}{\sqrt{3}} = 122.96\text{V}$$

$$x_L = 2\pi fL = 2\pi \times 50 \times 200 \times 10^{-3} = 62.83\Omega$$

$$Z_{\text{PH}} = \sqrt{R^2 + x_L^2} = \sqrt{70^2 + 62.83^2} = 94.06\Omega$$

$$\text{Phase Current } I_{\text{PH}} = \frac{V_{\text{PH}}}{Z_{\text{PH}}} = \frac{123}{94.06} = 1.31\text{mA}$$

The load current in a Star configuration is equal to the line current,

Therefore Line current $I_{\text{line}} = 1.31\text{mA}$

$$\text{Power factor P.F.} = \cos \phi$$

$$\text{Phase } \phi = \tan^{-1} \left[\frac{x_L}{R} \right] = \tan^{-1} \left[\frac{62.83}{70} \right] = 41.911^\circ$$

$$\text{P.F.} = \cos 41.911^\circ = 0.744.$$

2.2 Power Calculations (Star)

This data can now be used to calculate the 'True power P' / 'Apparent power S' and 'Reactive power Q' using the following formulae:-

$$P (\text{W}) = \sqrt{3} (V_L) (I_L) (\cos \phi)$$

$$Q (\text{VAR}) = \sqrt{3} (V_L) (I_L) (\sin \phi)$$

$$S (\text{VA}) = \sqrt{P^2 + Q^2}$$

$$P = \sqrt{3} (213) (1.31) (\cos 41.911) = 359.00\text{W}$$

$$Q = \sqrt{3} (213) (1.31) (\sin 41.911) = 322.25\text{VAR}$$

$$S = \sqrt{359^2 + 322.25^2} = 482.42\text{VA}$$

2.3 Delta Load Configuration Calculations

$$\text{Line Voltage} = 205\text{V}$$

$$\text{Phase Voltage } V_{\text{PH}} = V_{\text{LINE}} \text{ as there is no neutral}$$

$$V_{\text{PH}} = 205\text{V}$$

$$Z_{\text{PH}} \text{ is same as for the 'star load configuration' } = 94.06\Omega$$

$$\text{Phase Current } I_{PH} = \frac{V_{PH}}{Z_{PH}} = \frac{205}{94.06} = 2.18\text{mA}$$

$$I_{LINE} = (\sqrt{3}) \times (I_{PH}) = (\sqrt{3}) \times (2.18) = 3.77\text{A}$$

Power factor and phase angle for Delta and star configurations are the same,

$$\text{P.F.} = 0.744 \text{ and Phase angle} = 41.911^\circ$$

2.4 Power Calculations (Delta)

This data can now be used to calculate the 'True power P' / 'Apparent power S' and 'Reactive power Q' using the same three formulae:-

$$P \text{ (W)} = \sqrt{3} (V_L) (I_L) (\cos \emptyset)$$

$$Q \text{ (VAR)} = \sqrt{3} (V_L) (I_L) (\sin \emptyset)$$

$$S \text{ (VA)} = \sqrt{(P^2 + Q^2)}$$

$$P = \sqrt{3} (205) (3.77) (\cos 41.911) = 997.45\text{W}$$

$$Q = \sqrt{3} (205) (3.77) (\sin 41.911) = 895.3\text{VAR}$$

$$S = \sqrt{(997.45^2 + 895.3^2)} = 1.34\text{kVA}$$

Table 1 Calculated Values for Star and Delta

Good set of results and calculations.

Load	Voltage (V)		Current (I)		PF	P (W)	Q (VAR)	S (VA)
	Line	Phase	Line	Phase				
Star	213	122.96	1.31	1.31	0.74	359	322.25	482.42
Delta	205	205	3.77	2.18	0.74	997.45	895.3	1340

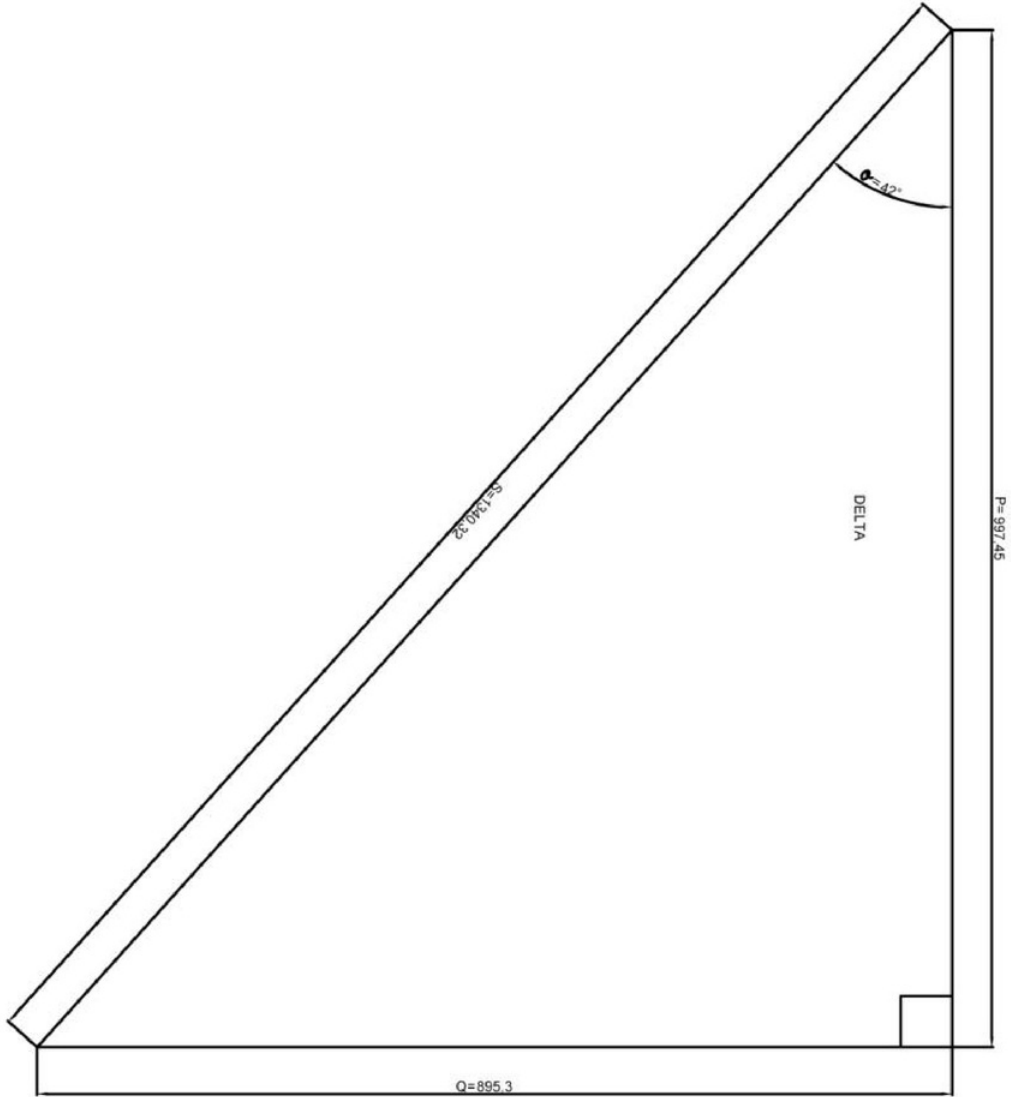
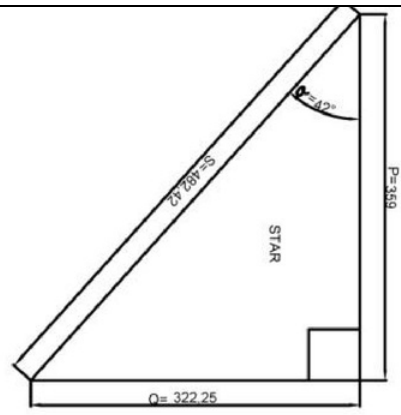
Table 2 Measured Values for Star and Delta (NANOVIP)

Supply	Load	Line Voltages			Phase Voltages			I _A	I _B	I _C	PF	Real Power (W)	Apparent Power (VA)	Reactive Power (VAR)
		V _{AB}	V _{BC}	V _{CA}	V _{RN}	V _{YN}	V _{BN}							
Star	Star	213	212	213	122	122	123	1.17	1.16	1.21	0.65	290	449	338
Star	Delta	206	205	206	206	205	206	3.48	3.42	3.46	0.65	803	1.24k	938

The calculated and measures values are very similar, the minor variance in the current can be accounted for by wire resistances which are not calculated for in the formulae used, poor connections by the test equipment and location the test meter is attached along any wire.

The differences in the power ratings are different due to the current values being different.

Figure 6 Star and Delta Power Triangles (Approx 1cm =60w/VA/VAR)



3.0 Task 3 Unbalanced Loads

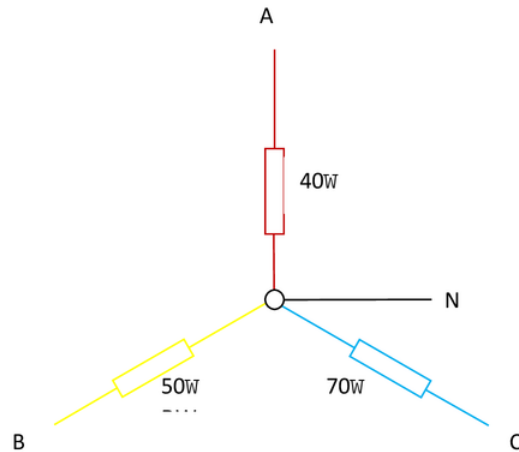


Figure 7 Unbalanced Star load

Load	Line Voltages			Phase Voltages			I_A	I_B	I_C	PF
	V_{AB}	V_{BC}	V_{CA}	V_{RN}	V_{YN}	V_{BN}				
Star	206	208	210	118	118	122	3.37	2.72	1.93	1.0

Table 3 Unbalanced load results

Unbalanced Star (task3)	VAB	VBC	VAC
True power (P)	688W	1.22kW	981W
Apparent power (S)	688VA	1.22Kva	981VA
Reactive power (Q)	0VAR	0VAR	0VAR

Table 4 Un-balanced star power

Should explain the reason for the 0VAR condition.

$$\text{Line Voltage} = 208\text{V}$$

$$\text{Phase voltage } V_{PH} = \frac{V_{LINE}}{\sqrt{3}} = \frac{208}{\sqrt{3}} = 120.09\text{V}$$

$$I_{RED} = \frac{V_{ph}}{R_{APH}} = \frac{120.09}{40} = 3.00\text{A}$$

$$I_{YELLOW} = \frac{V_{ph}}{R_{BPH}} = \frac{120.09}{50} = 2.40\text{A}$$

$$I_{BLUE} = \frac{V_{ph}}{R_{CPH}} = \frac{120.09}{70} = 1.72\text{A}$$

Good results and calcs

PHASE	Measured Current (A)	Calculated Current (A)
I _{RED}	3.37	3.00
I _{YELLOW}	2.72	2.40
I _{BLUE}	1.93	1.72

Table 5 Measured v calculated comparison.

The measured and calculated values for the unbalanced star load are again similar but some discrepancy, this could be due to a number of factors including calibration of the equipment, the setting may not be correct on the test rig and also there is the calibration error of the NANOVIP tester. Either or a combination could change the resultant measured current significantly, each measured current is approximately 11% above; which is a similar error percentage.

Good argument.

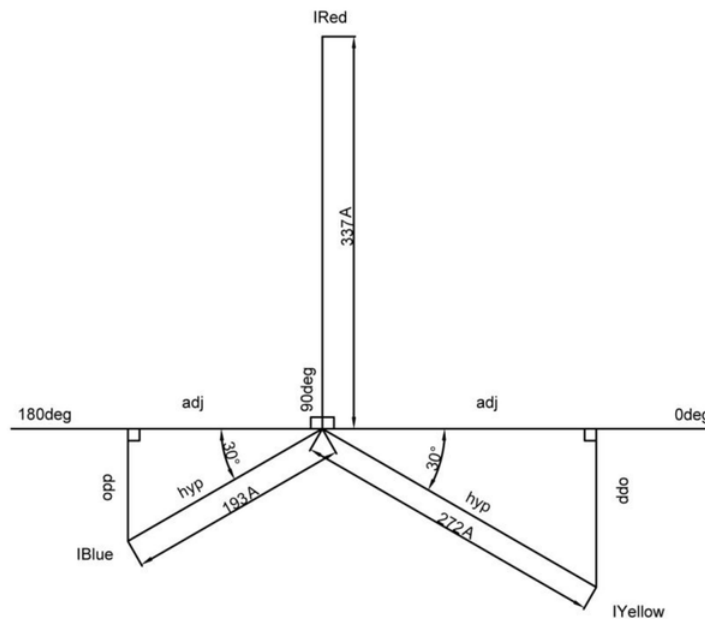


Figure 8 Phase Diagram (Measured Currents) (Scale 100:1)

Yellow Phase using trigonometry (SOH & CAH),

$$\text{Vertical element} = \sin 30^\circ \times 2.72 = 1.36\text{A}$$

$$\text{Horizontal Element} = \cos 30^\circ \times 2.72 = 2.356\text{A}$$

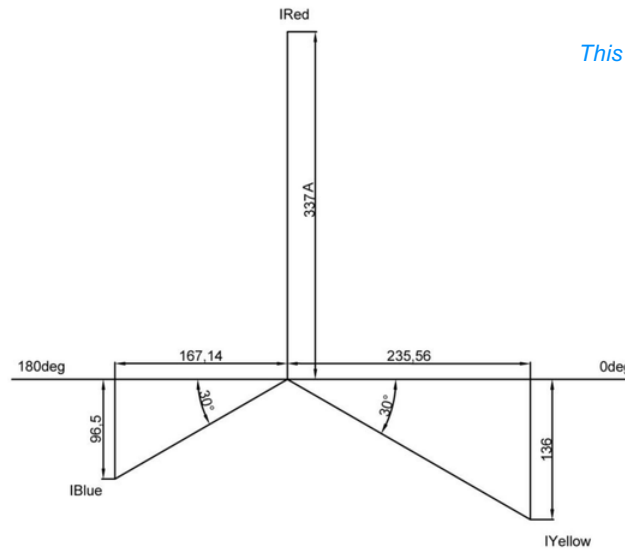
Blue Phase using trigonometry (SOH & CAH),

$$\text{Vertical element} = \sin 30^\circ \times 1.93 = 0.965\text{A}$$

$$\text{Horizontal Element} = \cos 30^\circ \times 1.93 = 1.671\text{A}$$

PHASE	Horizontal	Vertical
I _{RED}	0	3.37
I _{YELLOW}	2.356	1.36
I _{BLUE}	1.671	0.965

Table 6 Horizontal & vertical elements per phase



This is good here.

Figure 9 Phase Diagram (vertical /horizontal) (Scale 100:1)

The combined vertical element = $3.37 - 1.36 - 0.965 = 1.045$

The combined Horizontal element = $2.356 - 1.671 = 0.685$

The Neutral current $I_N = \sqrt{(\text{vertical element})^2 + (\text{horizontal element})^2}$

$$I_N = \sqrt{(1.045)^2 + (0.685)^2}$$

$$I_N = 1.25A$$

Calculation correct.

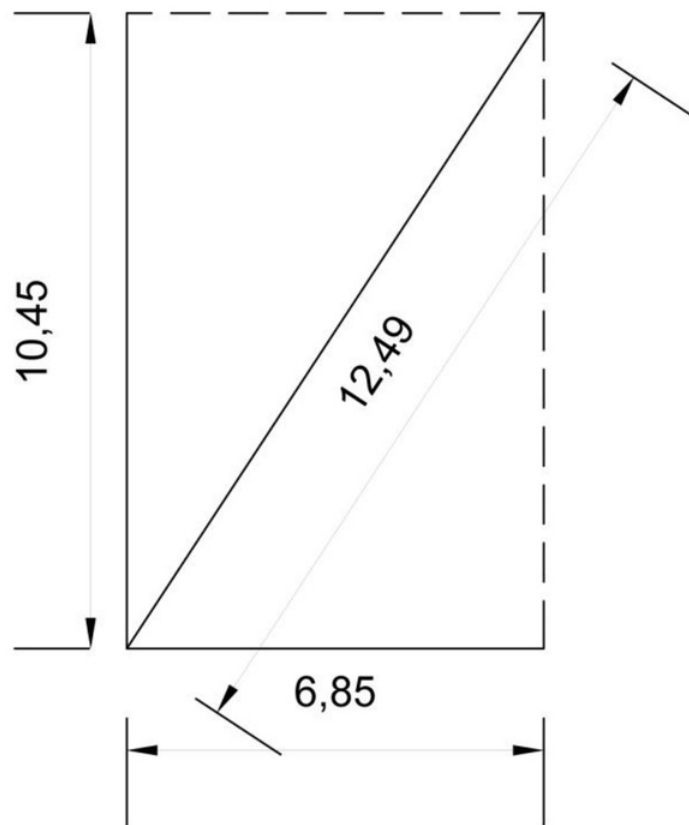


Figure 10 Neutral phasor diagram (scale 10:1/1cm=0.1A)

Being as the unbalanced load had no capacitors or inductors it is a purely resistive load – not leading or lagging, thus the power factor found was measured to be 1.0.

Go
od
sca
led
tria
ngl
e.

4.0 Three Phase Electric Supply (use of)

Phase to ground Voltage	Phase to phase voltage				
N	3	6	12	24	36
80	138	80	41	21	14
133	230	133	69	35	23
199	345	199	103	52	35
289	500	289	149	75	50
433	750	433	224	113	75

Table 7 Phase to Phase Voltages (Multiple phases) (**Electrowsky, 2018**)

1. Lower voltage for the same power can be transmitted.
2. Lower phase to phase and phase to ground clearances and shorter towers with narrow right of way
3. Lower phase to phase spacing
4. Lower voltage gradients, resulting smaller conductor size to used.
5. With increasing number of phases, the probability of flashovers' between phases increases. Therefore special attention must be paid to the design of insulation
6. Power transmission with more than three phases, for example six-phases, requires corresponding transformers and circuit breakers, switchgear and bus bars for six poles as well, what is more expensive and results in difficult protection (relaying) when interconnected with three phase lines.
Therefore, the use of multiple phase transmission is presently restricted to some few lines.

(Electrowsky, 2018)

This needs more explaining and what are the applications of 3 phase.

5.0 Task 5 Power factor

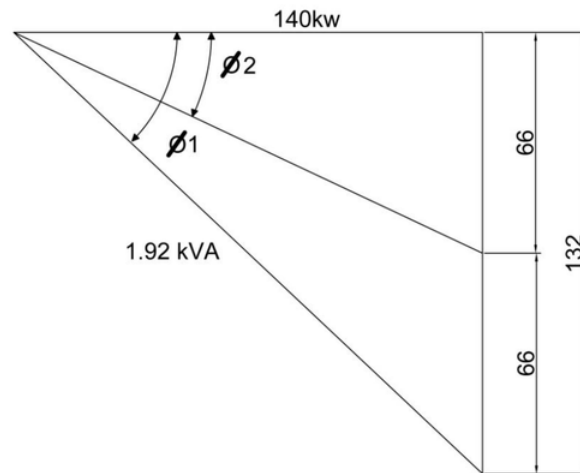


Figure 11 P.F. Triangle A

$$\cos \phi_2 = \frac{140}{192} = 73\% \text{ P.F} = 0.73$$

$$\text{KVAR Correction} = \sqrt{((\text{KVA})^2 - (\text{kw})^2)} - \sqrt{((\text{KVA})^2 - (\text{kw})^2)}$$

(Measured) (Target)

$$65 \text{ KVAR} = \sqrt{((192)^2 - (140)^2)} - \sqrt{((155)^2 - (140)^2)}$$

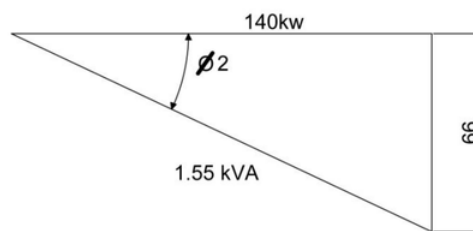


Figure 12 P.F. Triangle B

$$\cos \phi_2 = \frac{140}{155} = 90\% \text{ P.F.} = 0.9$$

In the triangle shown in **Figure 11**

The power $P = 140\text{kw}$

Reactive Power $Q = 132 \text{ KVAR}$

$$\text{Apparent Power } S = \sqrt{(P^2 + Q^2)} = \sqrt{(140^2 + 132^2)} = 1.92\text{KVA}$$

$$\phi = \cos^{-1} \left[\frac{140}{192} \right] = 43^\circ = 0.731$$

In triangle B and ϕ angle $= \cos^{-1} 0.9 = 25.84^\circ$, this is the target ϕ , to increase the power factor this can be achieved by adding capacitor banks in parallel.

6.0 Task 6 Transformer Connection Arrangements

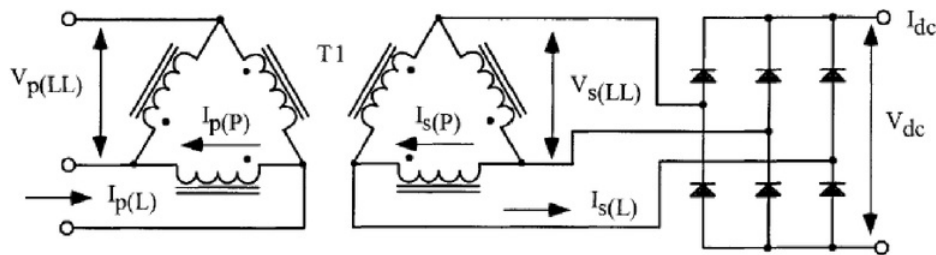


Figure 13 Three phase Delta-Delta full wave bridge (McLyman, 2004)

The delta-delta type transformers shown in **Figure 13** are used for isolating transformers such as the one shown in the schematic shown in **Figure 14**. This is because all the voltages are the same and the current will transfer in the magnetic field.

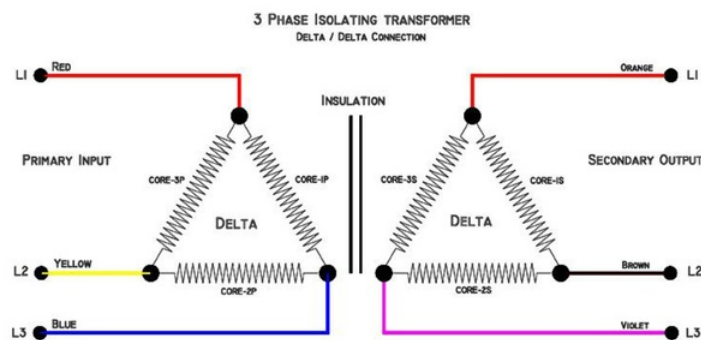


Figure 14 Delta-Delta Isolating Transformer (Anon., 2018)

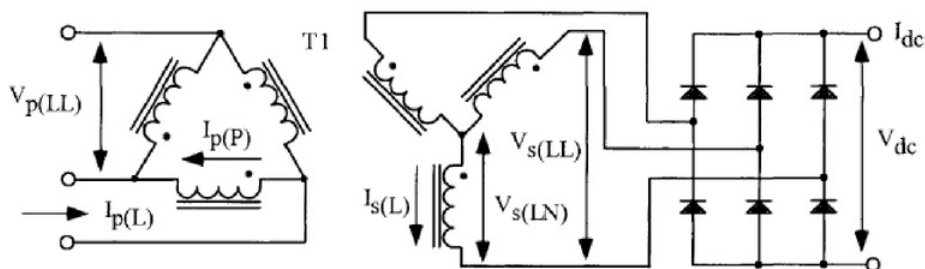


Figure 15 Three Phase Delta-Wye Full Wave circuit (McLyman, 2004)

The Delta-Wye Transformer is commonly used to transform voltages up or down as the combination of the two changes the step up/down ratio. Some of

these voltages can be obtained by selecting a single Live wire and Neutral giving the option to transform down to “single phase” as well; these are shown in **Figure 16**.

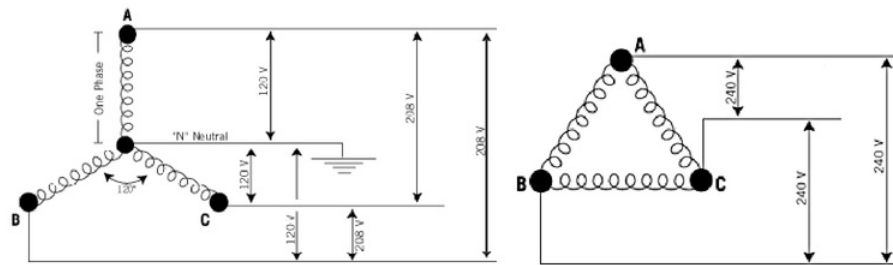


Figure 16 Delta Vs Star Voltages (McLyman, 2004)

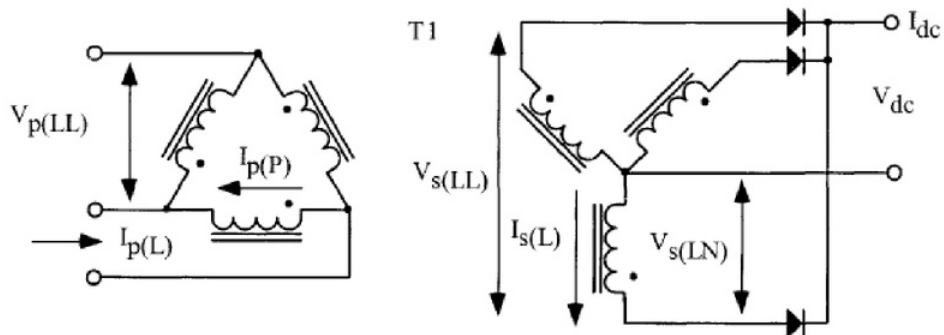


Figure 17 Three Phase Delta-Wye Half Wave Bridge (McLyman, 2004)

A three Phase Delta Wye half wave bridge is a rectifier used to convert the AC sine wave into either DC positive or DC negative and the Neutral would be the opposite DC Negative and Positive respectively. This is achieved using a common output and a “Diodes” to prevent current back flowing, the output graph shows the negative part of the sine wave inverted onto the top doubling the positive, this is shown in **Figure 18**

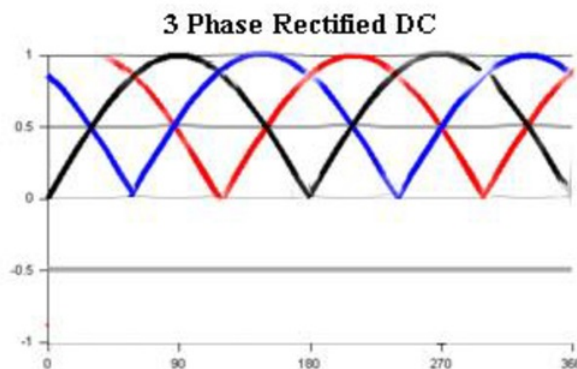


Figure 18 Rectified 3 phase Direct current

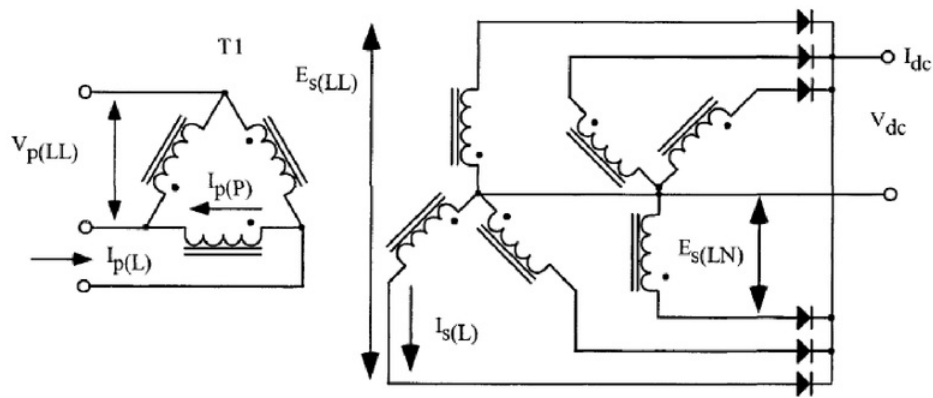


Figure 19 Three Phase Delta-Wye 6-Phase Star (McLyman, 2004)

Three phase Delta-Wye 6 phase create 6 phases from the 3 incoming, this is shown in Figure 19.

“6 phase Induction Motors” are two “3 phase motor” field windings combined but arranged 60 degrees apart to benefit from the magnet wave induced in the motor as the motor turns; by increasing the number of phases in the motor there will be a smoother power flow and a constant torque flow.

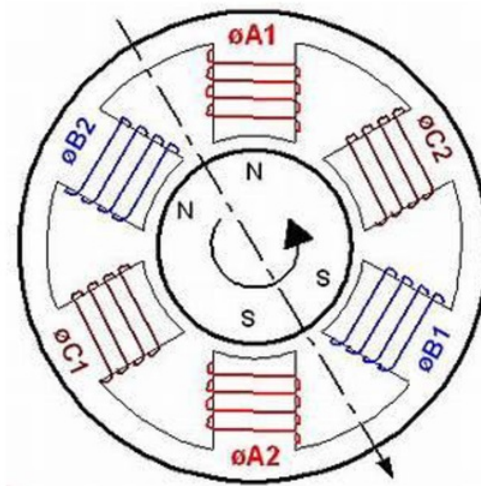


Figure 20 Six Phase Induction Motor

The disadvantages of using this system is that you require 6 cables but smaller, connections are more complicated and the process to reverse the motor required 2 pairs of wires to be changed, 1 pair from each field winding set. You also have many more components which make these motor more costly to produce.

Good
explanation.

PSDE4001 assignment 2

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

58/100

PAGE 1

PAGE 2

PAGE 3

Text Comment. Good examples for intro to practical task.

PAGE 4

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PAGE 6

Text Comment. Good set of results and calculations.

PAGE 7

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PAGE 8

Text Comment. Should explain the reason for the 0VAR condition.

Text Comment. Good results and calcs

PAGE 9

Text Comment. Good argument.

PAGE 10

Text Comment. This is good here.

Text Comment. Calc looks correct.

PAGE 11

Text Comment. Good scaled triangle.

PAGE 12

Text Comment. This needs more explaining and what are the applications of 3 phase.

PAGE 13

Text Comment. Explained well using the calc example.

PAGE 14

PAGE 15

PAGE 16

Text Comment. Good explanation.

GRADING FORM: CSG-RUBIC

WILLIAM YOUNG

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RESEARCH-INFORMED LITERATURE



Research is very good in most parts except for task 4 and no sources listed to backup the findings in the research. 2.5/5 There are plenty of in text refs to relevant sources, but there is no ref list! 2.5/5

5/10

KNOWLEDGE AND UNDERSTANDING



The introduction is for the practical, but no section

for intro exists in report. 2.5/5 Description of procedures is reasonable. 2.5/5 Conclusive discussions are included. 6/10

11/20

ANALYSIS



Testing and results are good. 22/30. Only conclusive discussions exist in report. No section for conclusion has been included. 3/10

25/40

PRACTICAL APPLICATION AND DEP.



description of procedures for practical is reasonable. 2.5/5 results have been discussed and some good arguments are included. Some parts are missing ie. power factor explanation for unbalanced load. 2.5/5 Quality of work is good. 6/10

11/20

SKILLS FOR PROFESSIONAL PRAC.



Report is satisfactory overall. 3/5 team working is good. 3/5

6/10