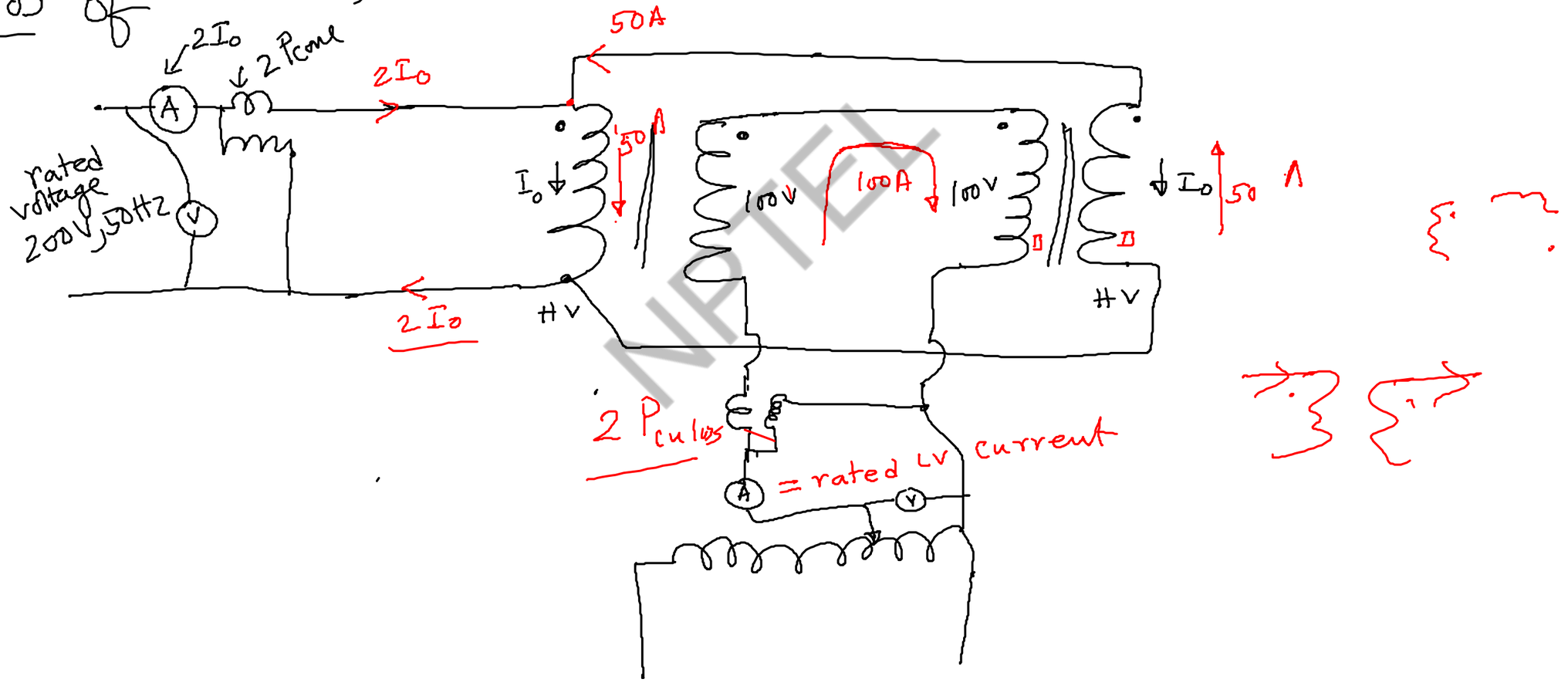
Sumpner's Test
(Back to Back test)

$\frac{10000}{100} = 100A$

2 nos of 10 KVA, 200V/100V, 50 Hz

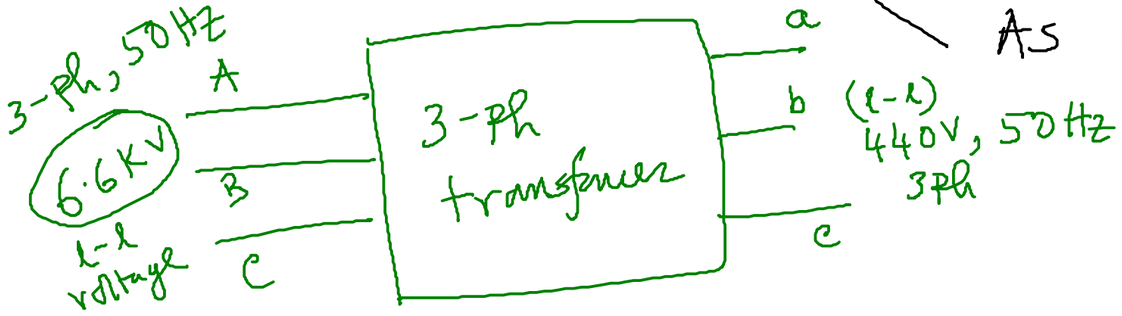


NPTEL

3-Phase transformer

Lec-34

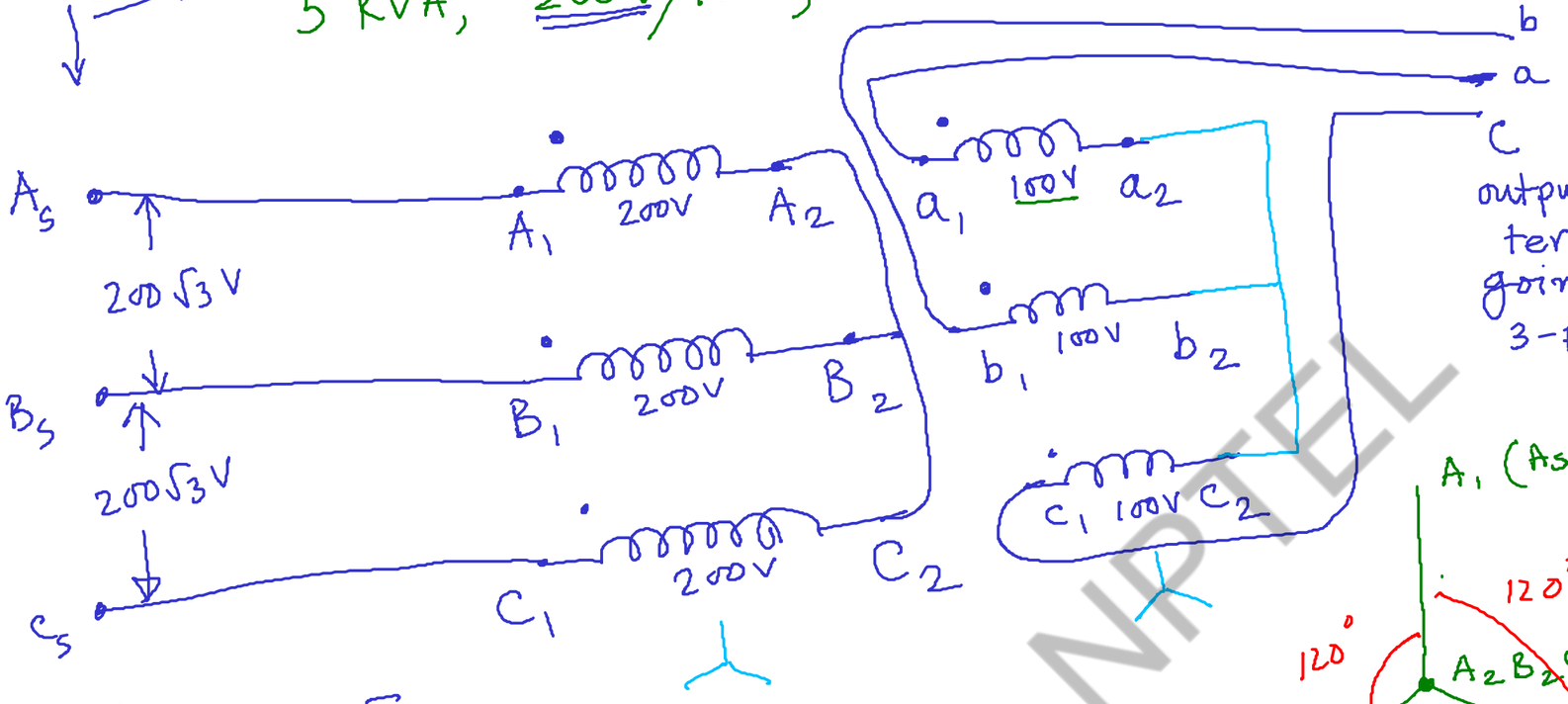
- ✓ use 3 nos. of identical 1-ph transformers (bank of 3-ph. tfs)
- As a single unit



NPTEL

Supply

5 KVA, 200V/100V, 50 Hz 1-ph tfo → 3 such transformers.



$I_{HV\ rated} = \frac{5000}{200} = 25\ A$

$I_{LV\ rated} = 50\ A$

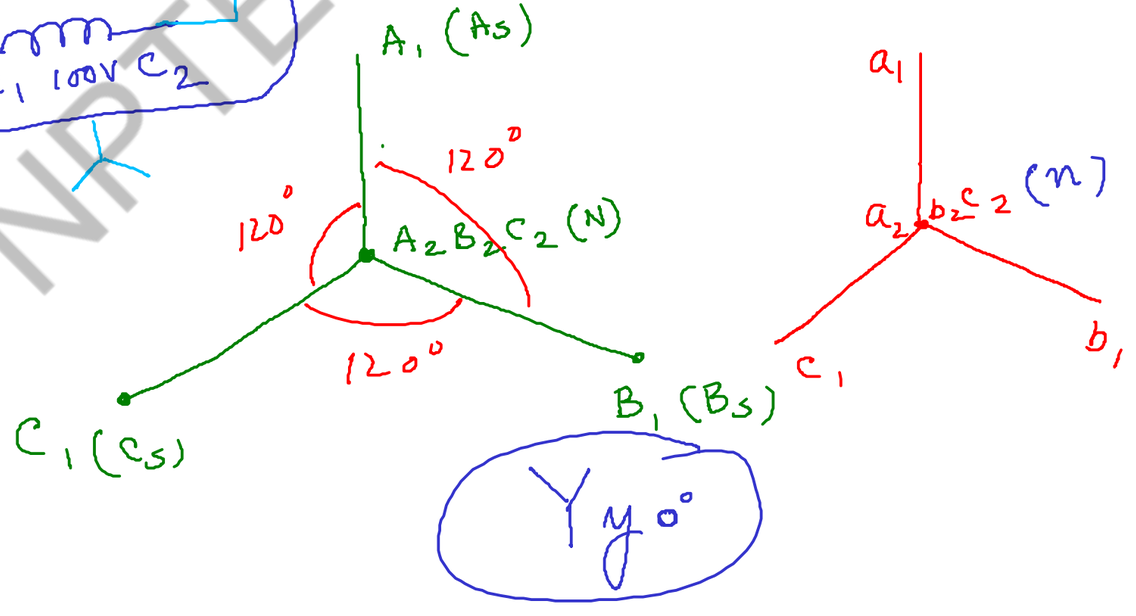
output terminals going to 3-ph. load.

Supply terminals A_s, B_s, C_s

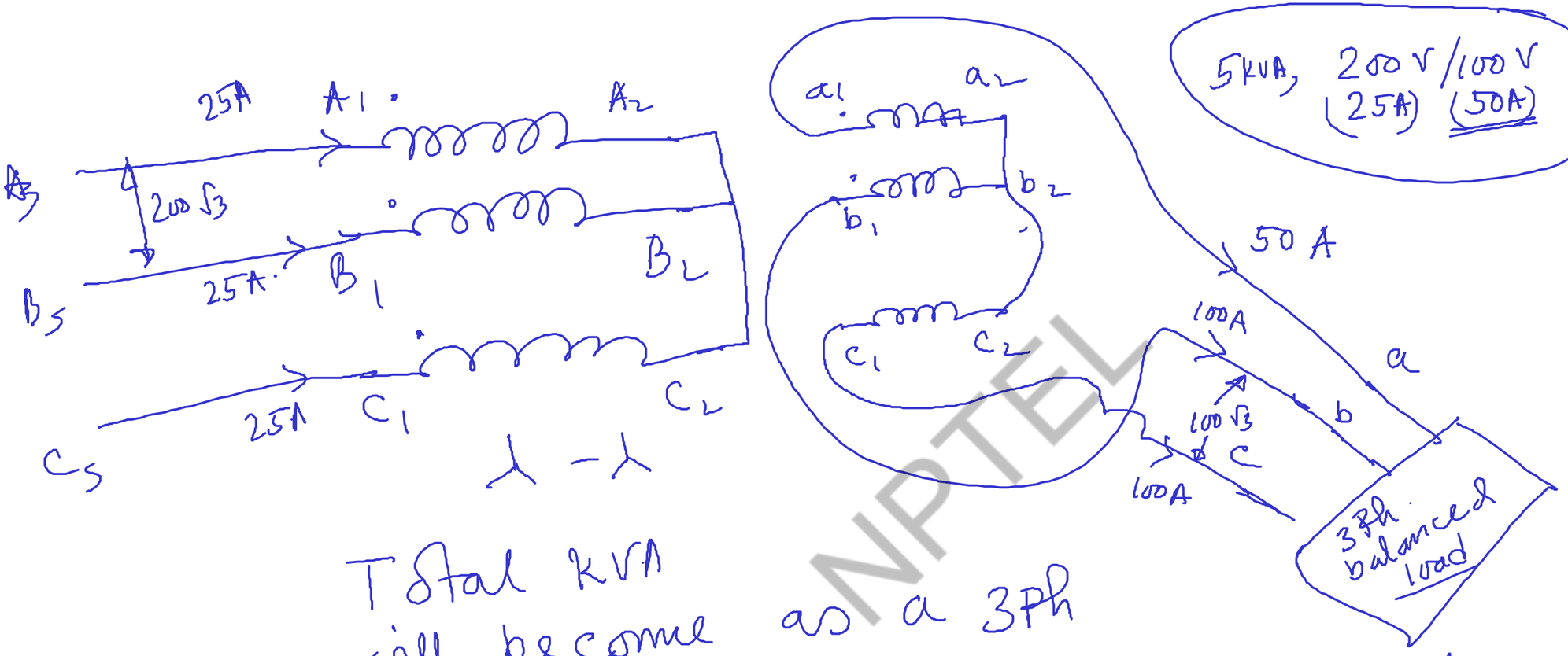
ph. seq. : $A_s B_s C_s$

$V_{1LL} = 200\sqrt{3}$

$V_{2ll} = 100\sqrt{3}$



NPTEL



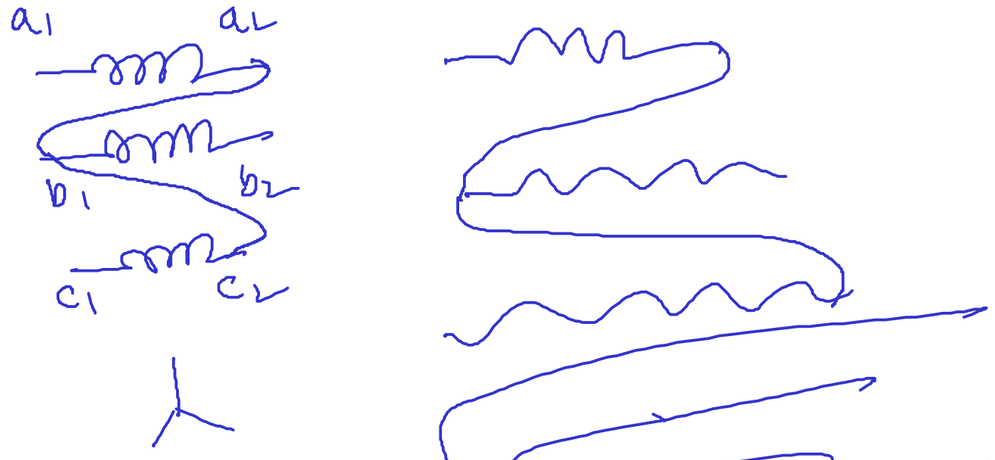
NPTEL

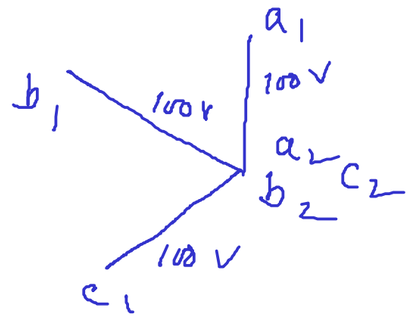
Total KVA will become as a 3ph tfo : $\sqrt{3}\, V_{LL}\, I_L$

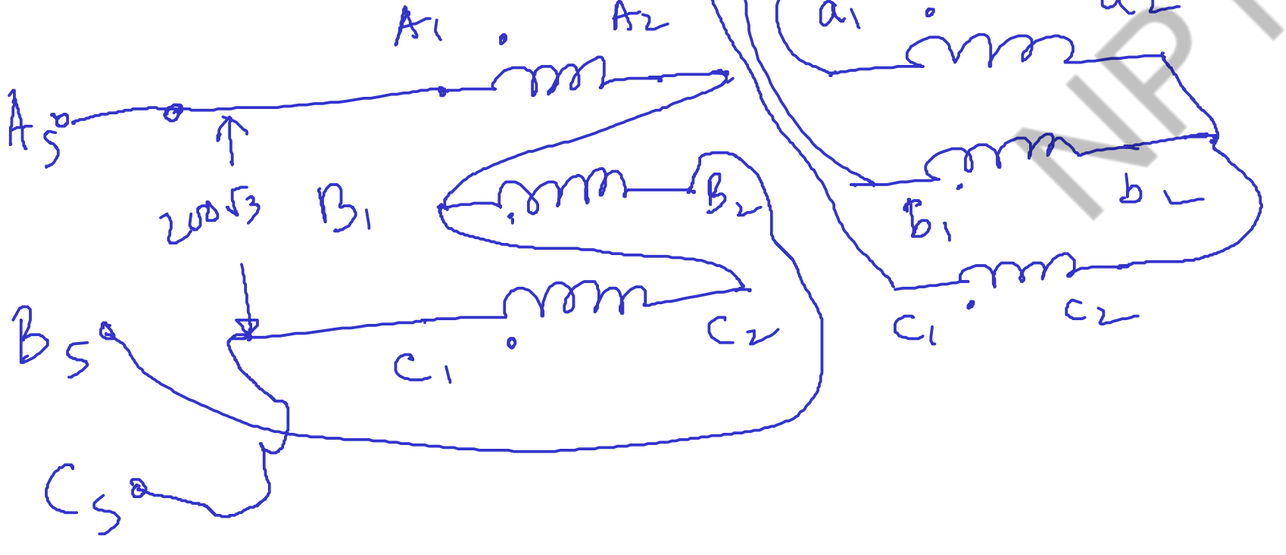
$= \sqrt{3} \times 100\sqrt{3} \times 50$ VA $= 15$ KVA

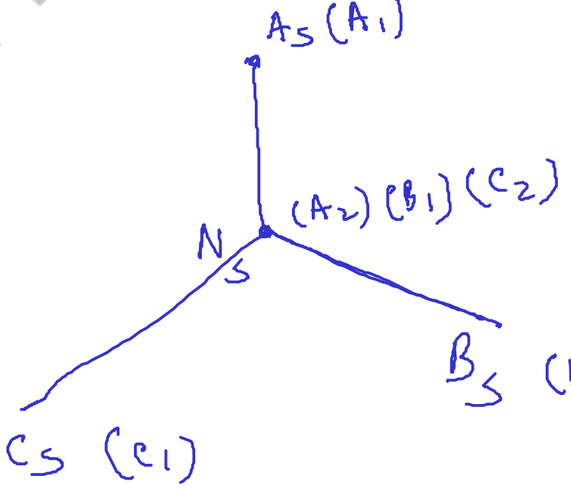
$= \sqrt{3} \times 200\sqrt{3} \times 25$ VA $= 15$ KVA

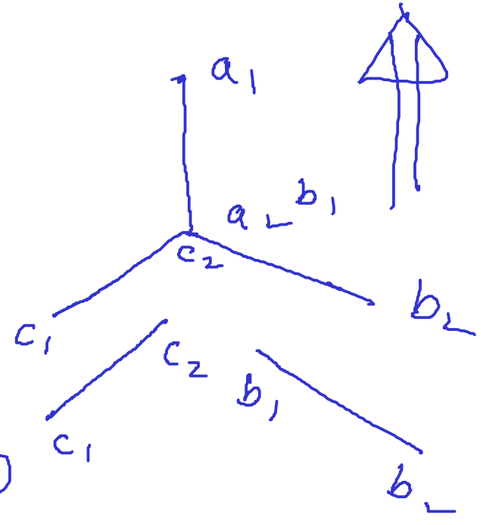
Lec-35


a1
a2
b1
b2
c1
c2

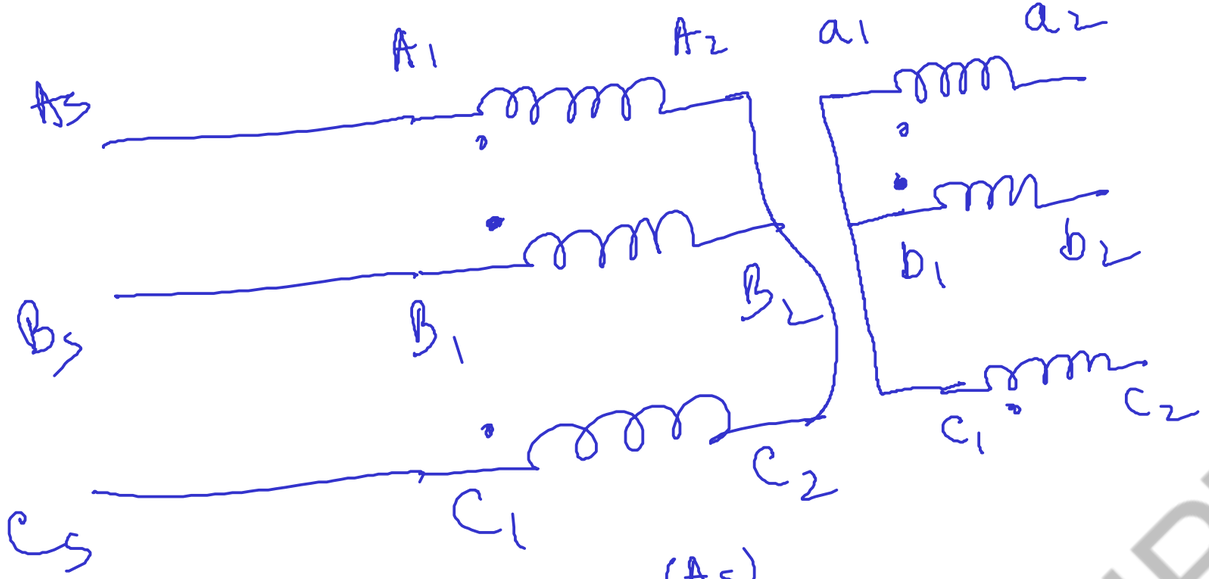

a1
100 V
b1
100 V
a2
c2
b2
100 V
c1

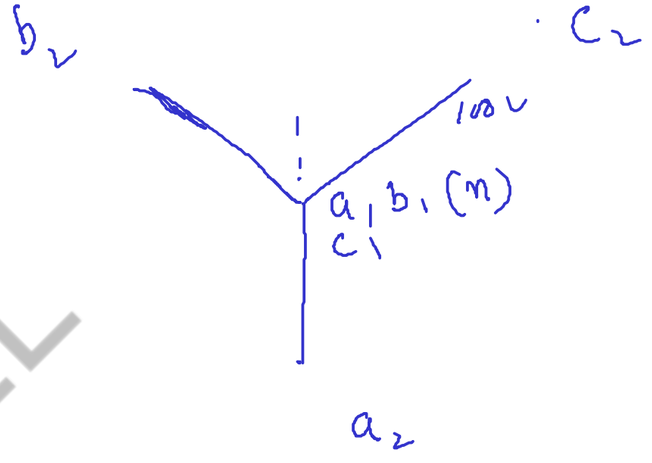

A1
A2
A5
200√3
B1
B2
C1
C2
B5
C5
a1
a2
b1
b2
c1
c2


A5 (A1)
(A2) (B1) (C2)
N5
B5 (B2)
C5 (C1)

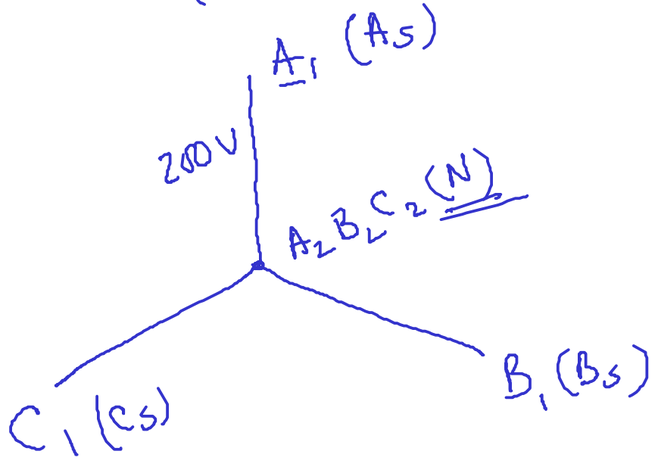

a1
a2
b1
c2
b2
c1
c2
b1
c1
b2

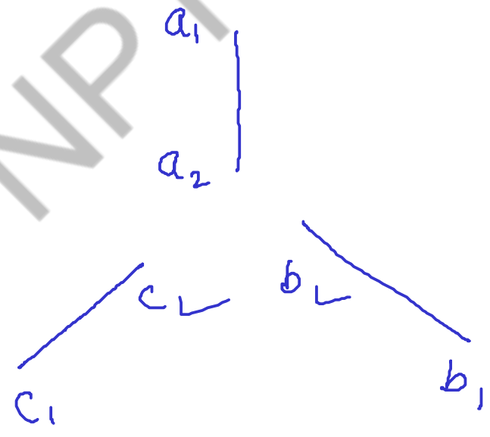
NPTEL





$Y\,y\,180^\circ \equiv Y\,y6$

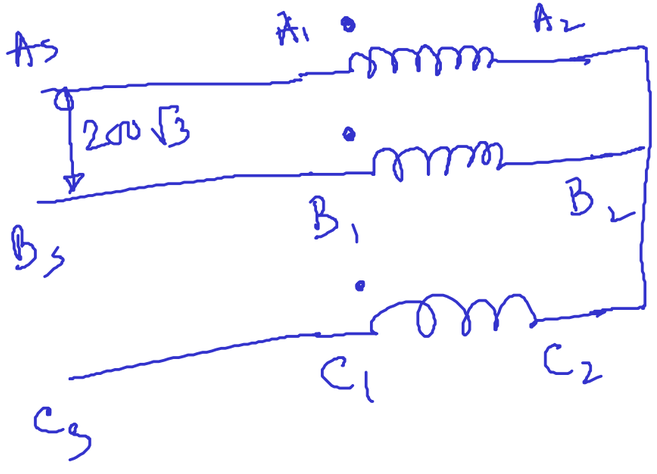


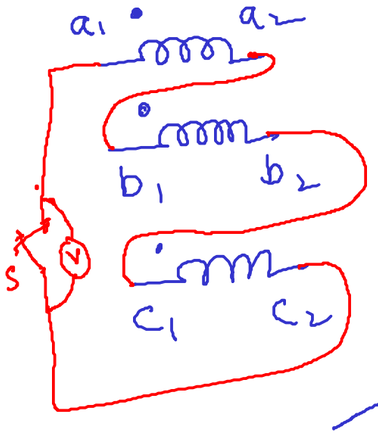


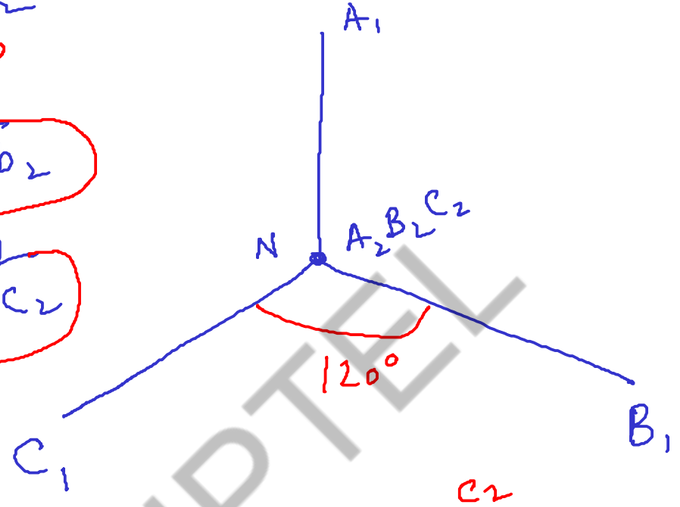
NPTEL

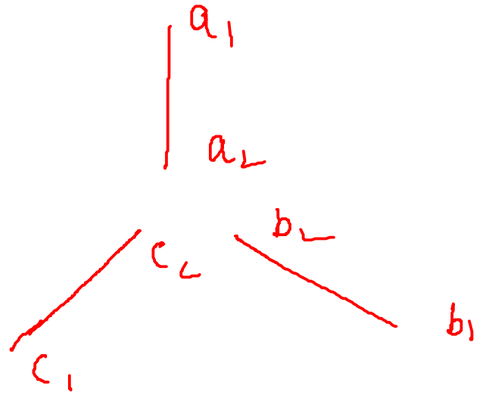
Star – Delta connection :-

3 nos. of 1 ph 200 V / 100 V, 5 KVA, 50 Hz tfo

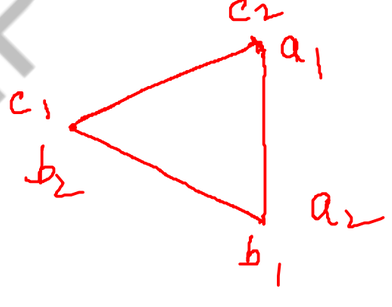






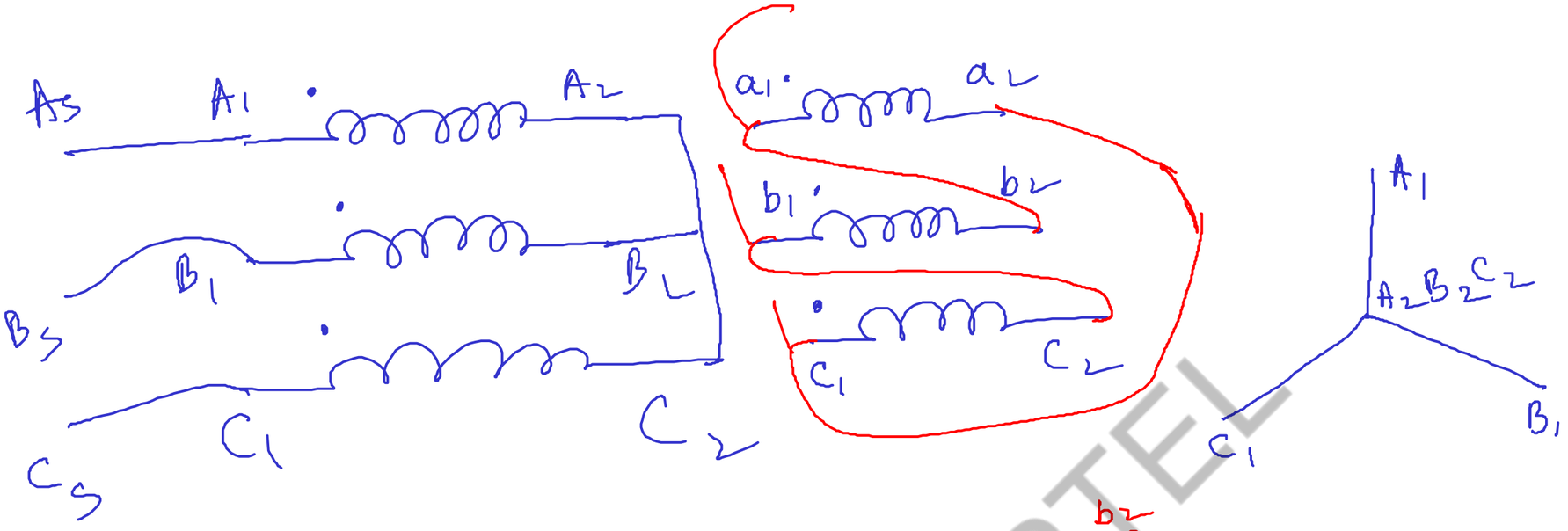


$V_{c_2 a_1} = 0$

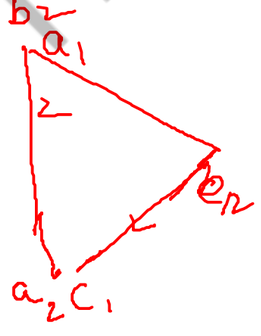


NPTEL

Lec -36

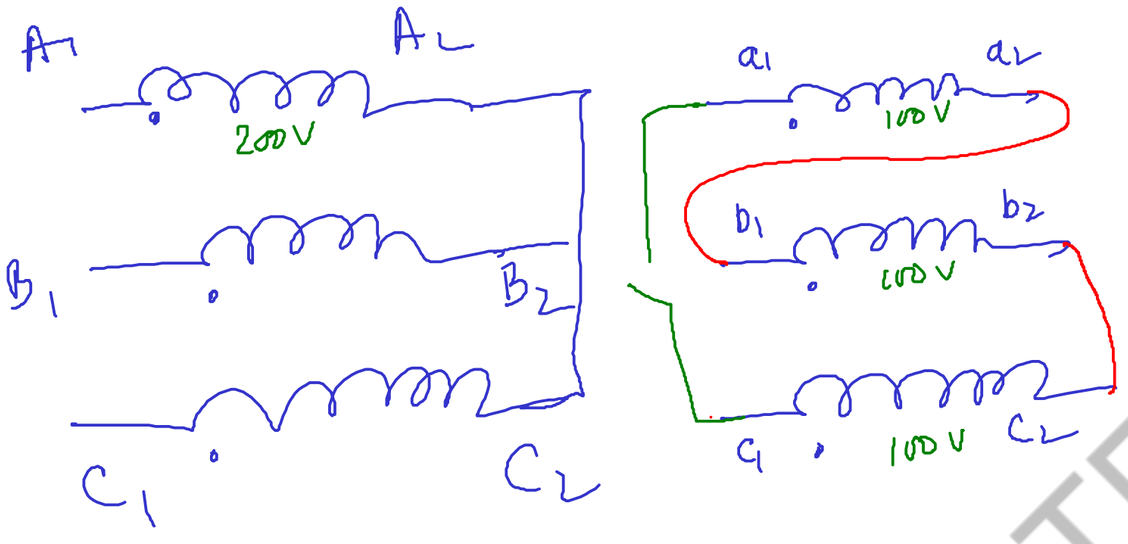

A3
A1
A2
B1
B2
B3
C1
C2
C3
a1
a2
b1
b2
c1
c2

A1
A2B2C2
B1
C1


b2
a1
2
e2
a2C1

a1
a2
b

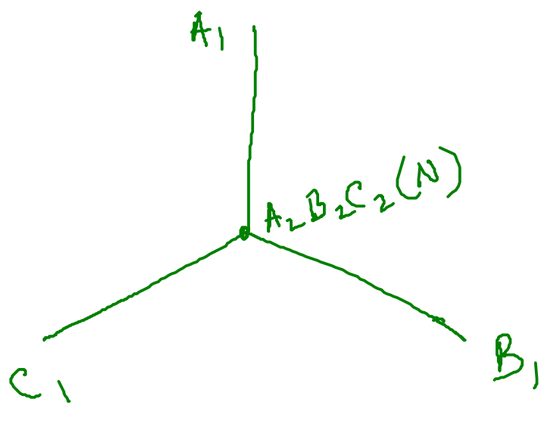
NPTEL

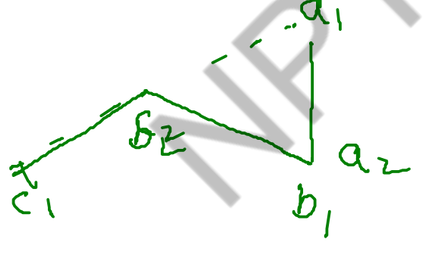


Not proper delta connection.

$V_{a_1 c_1} = 200\,V$

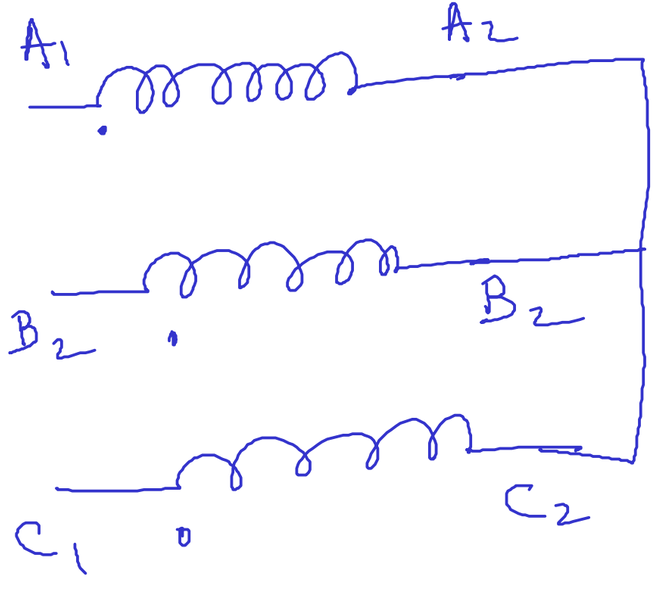
when S is opened



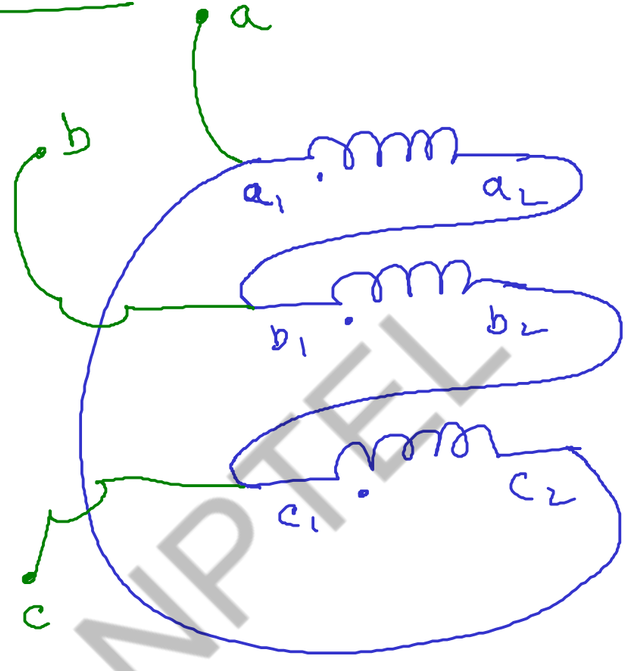


NPTEL

Star-Delta connection :-

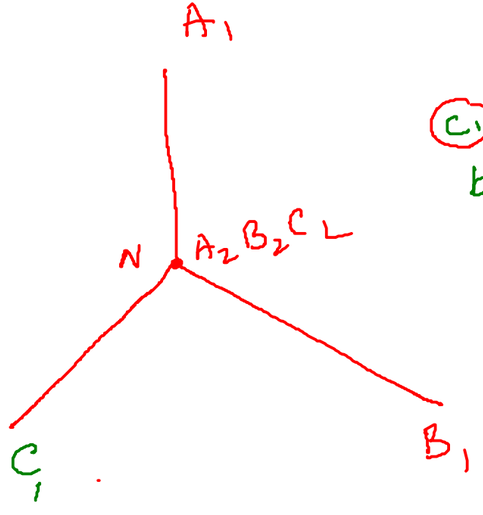


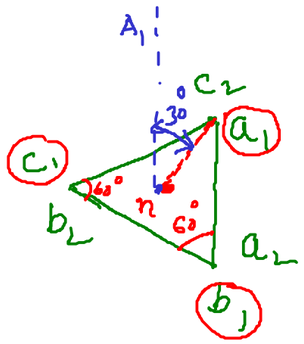
Y



Δ

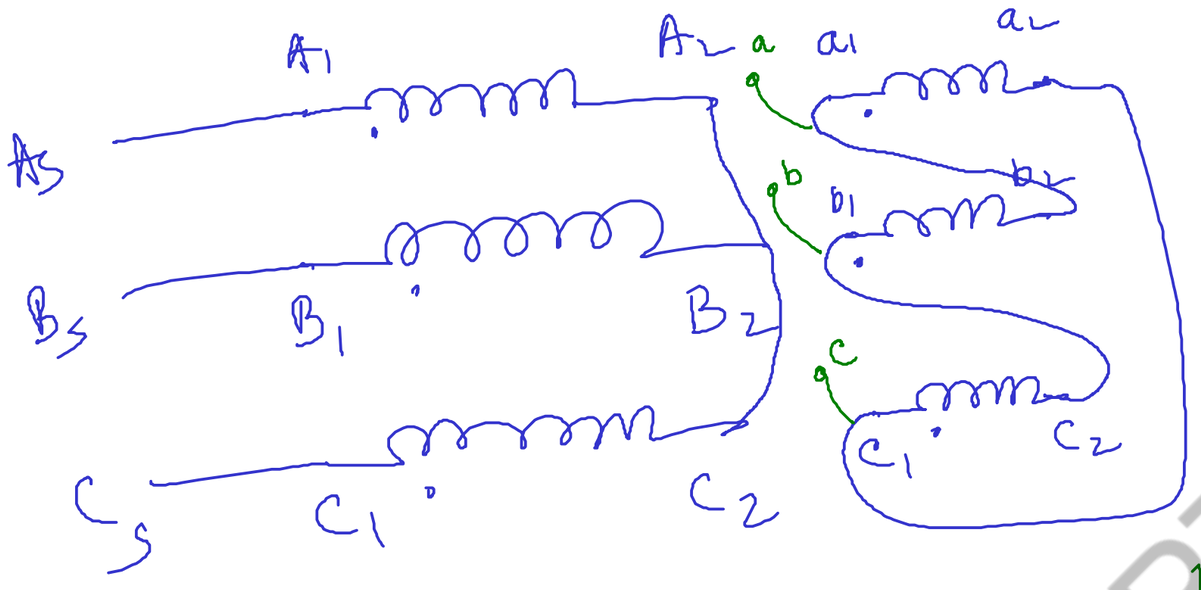
$Y_d(-30^\circ)$

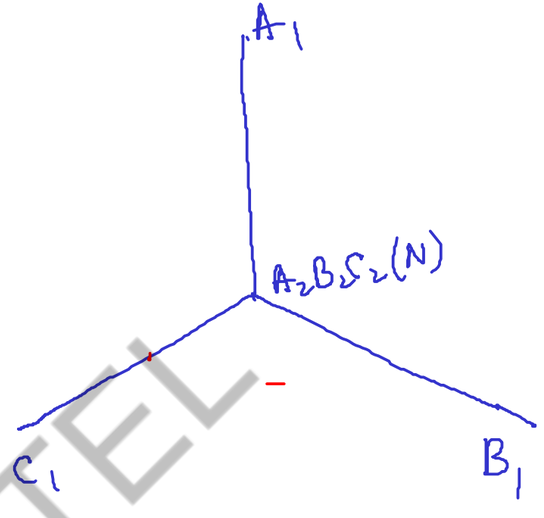


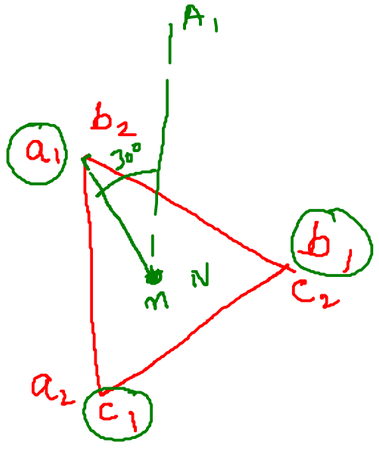


Vector group of 3-ph. tfo

NPTEL



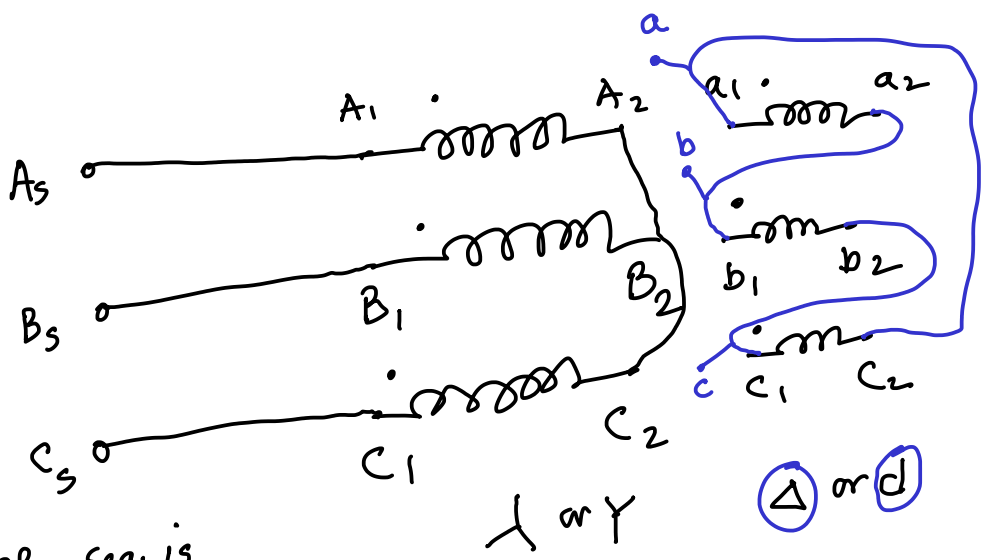




Yd (+30°) → vector group.

NPTEL

Lec 37

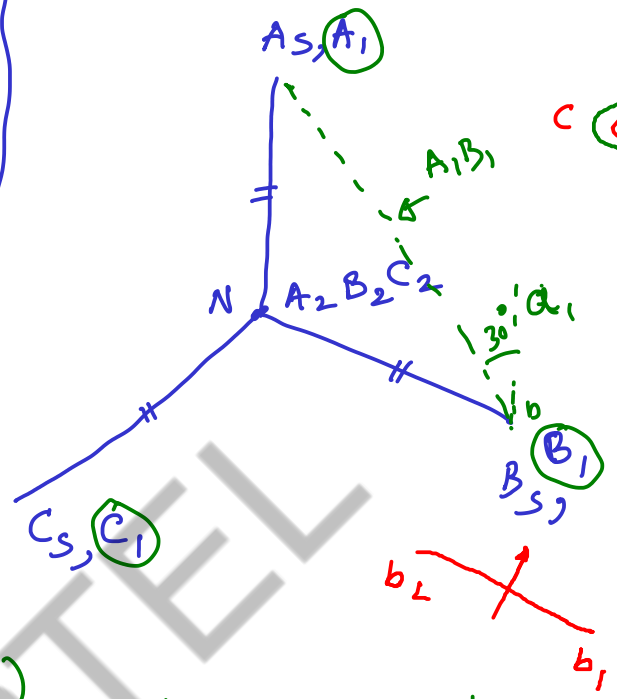


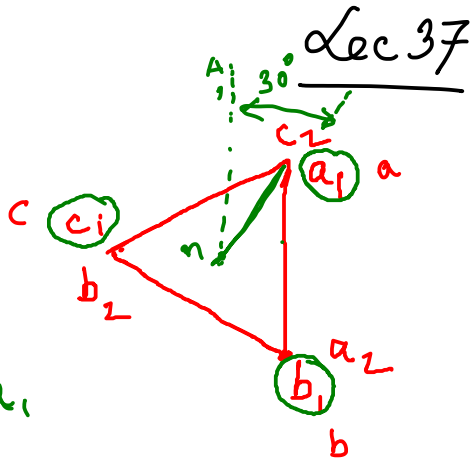
Y or Y

Δ or d

ph. seq is $A_S - B_S - C_S$

supply is balanced



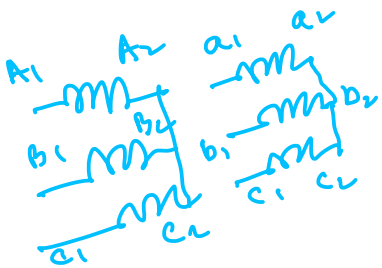


Yd (−30°)

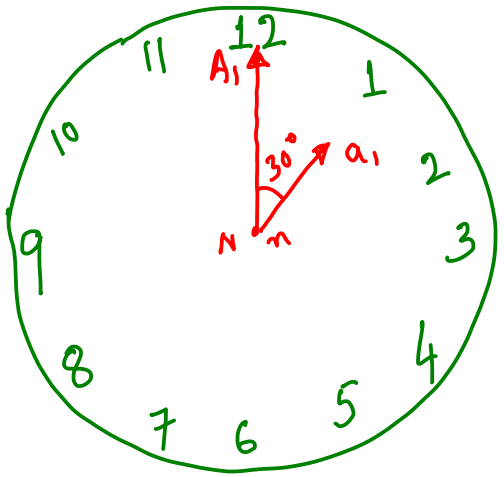
(Vector group) → Clock convention

NPTEL

Clock



$Y_{y0^\circ} \equiv Y_{y12}$



$Y_d(-30^\circ)$

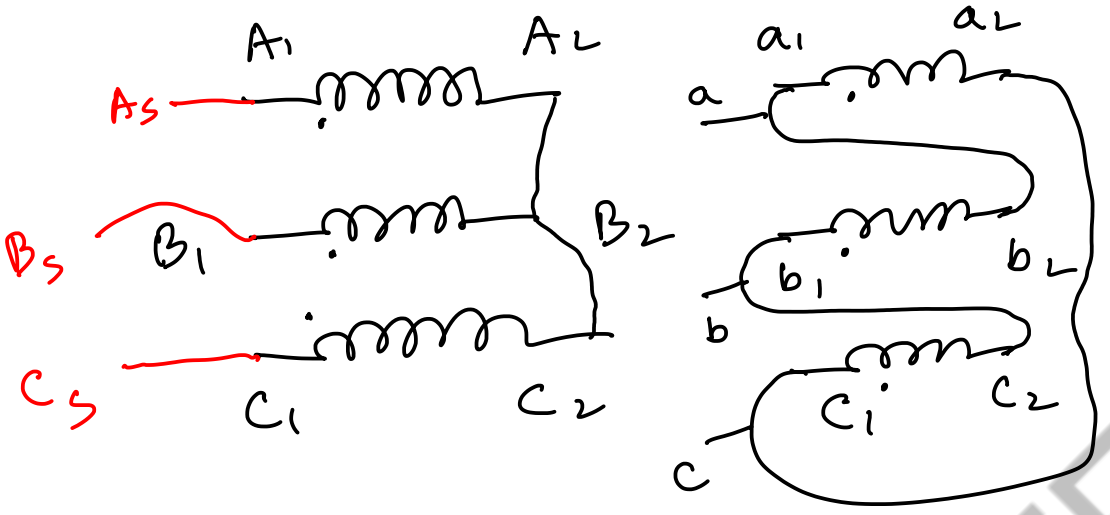
$\Rightarrow Y_d 1$

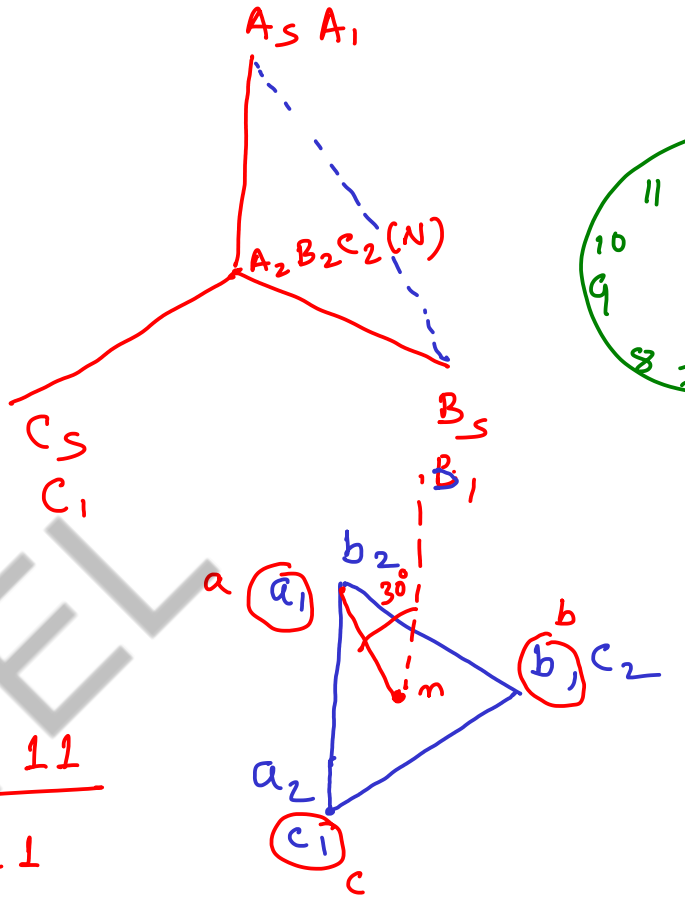
Minute hand is shown at 12 → Primary side A_1 or A_s - ph. voltage wrt neutral (N)

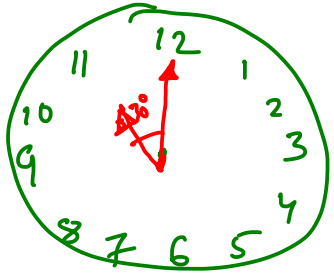
Show the hour hand representing the secondary a or a_1 voltage wrt neutral of the 2ndary side. For delta connection use artificial neutral (n)

NPTEL

Star delta connection :-





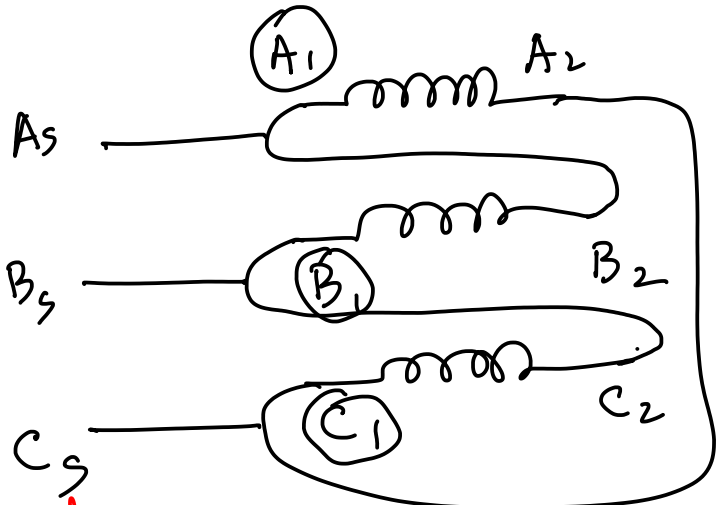


$Y_d(+30^\circ)$ or $Y_d 11$ / $Y_d 1$

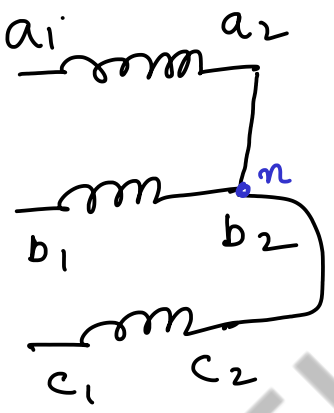
NPTEL

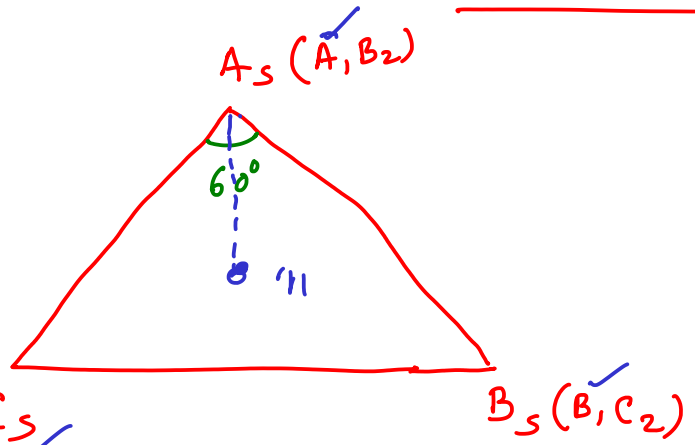
Dy (−30°) or Dy1

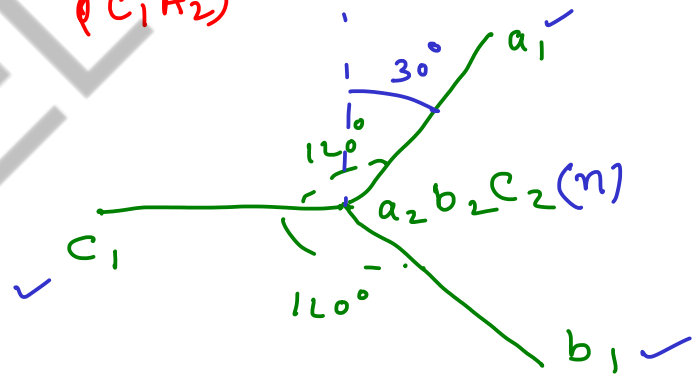
Lec - 38



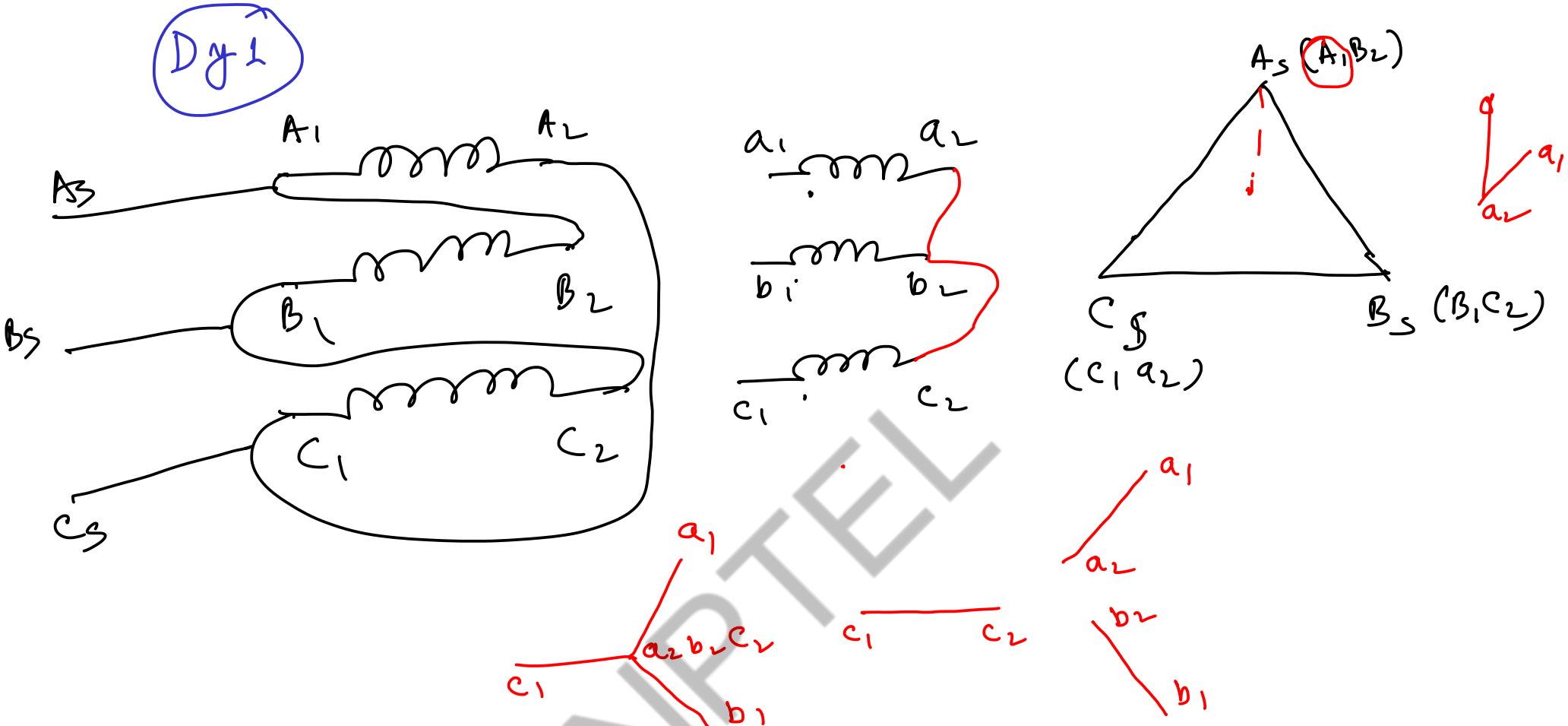
balanced



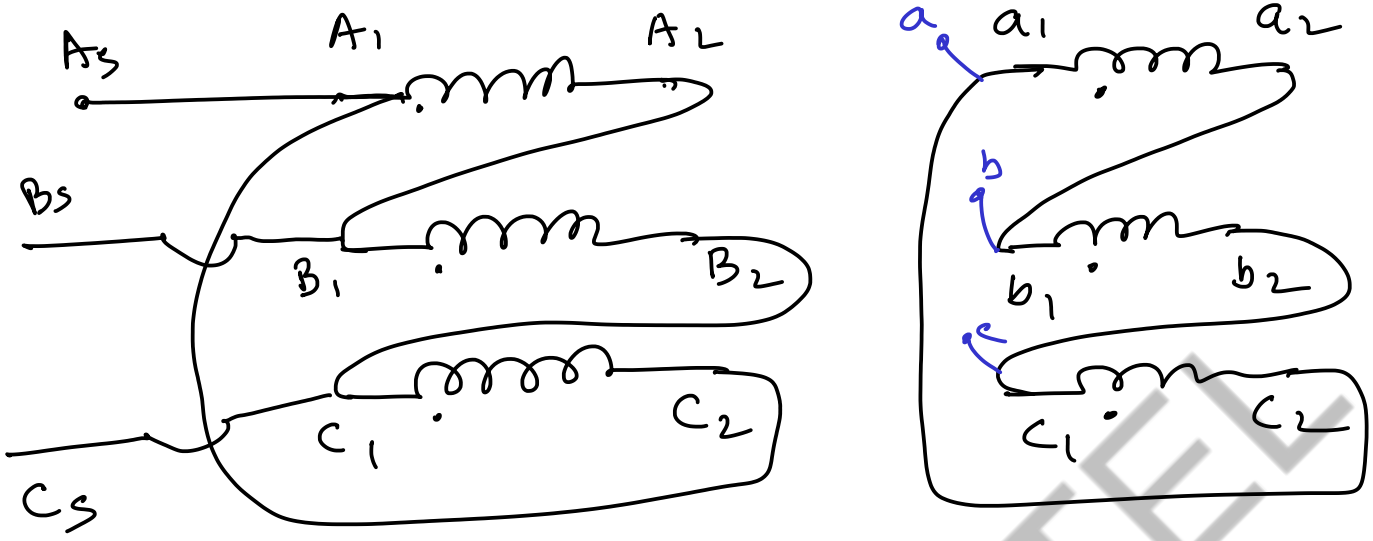




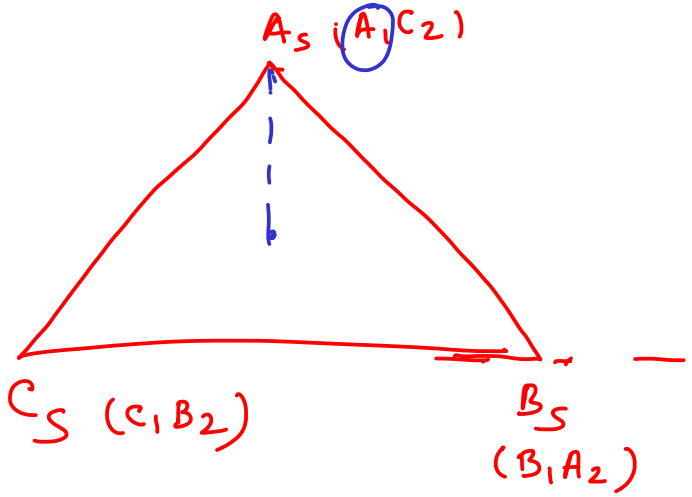
NPTEL

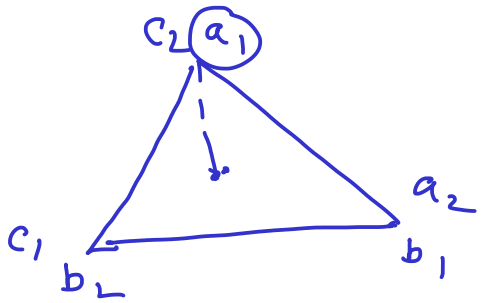

Dy1
A1
A2
A3
B2
B3
B1
C1
C2
C3
a1
a2
b1
b2
c1
c2
A3 (A1 B2)
B3 (B1 C2)
C3
(C1 a2)
a1
a2
a1
a2 b2 c2
c1
b1
c1
c2
a1
a2
b2
b1
NPTEL

Delta-Delta connection :-

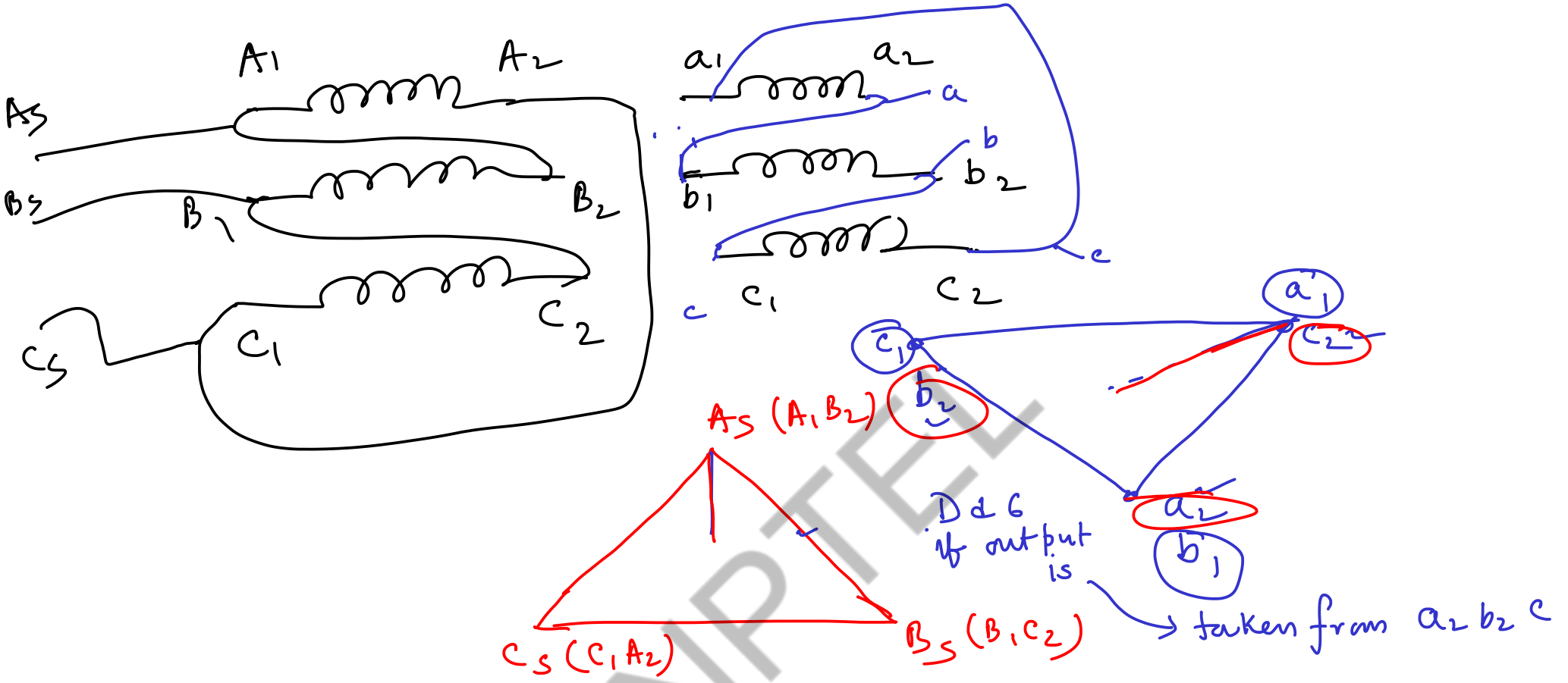


Dd 0°





NPTEL


A1
A2
A3
B3
B1
B2
C3
C1
C2
a1
a2
a
b
b1
b2
c
c
c1
c2
a'1
c'1
c'2
b'2
A3 (A1 B2)
D & G
if output
is
a'2
b'1
taken from a2 b2 c
C3 (C1 A2)
B3 (B1 C2)

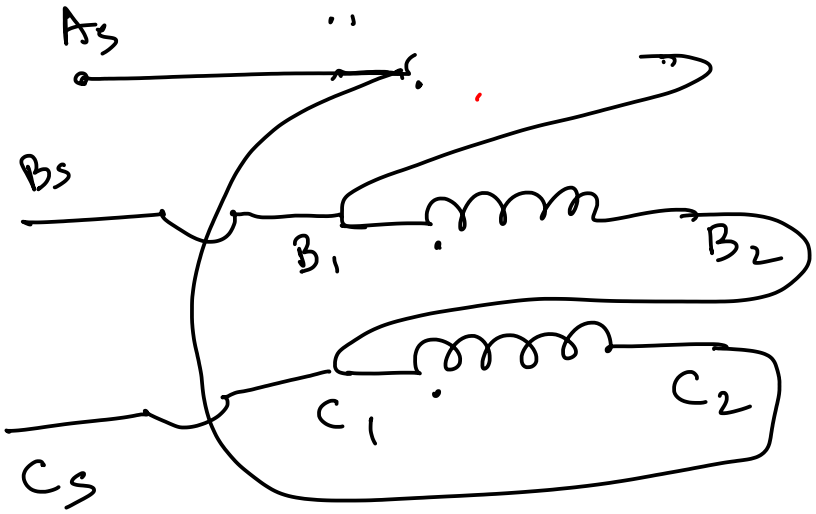
NPTEL

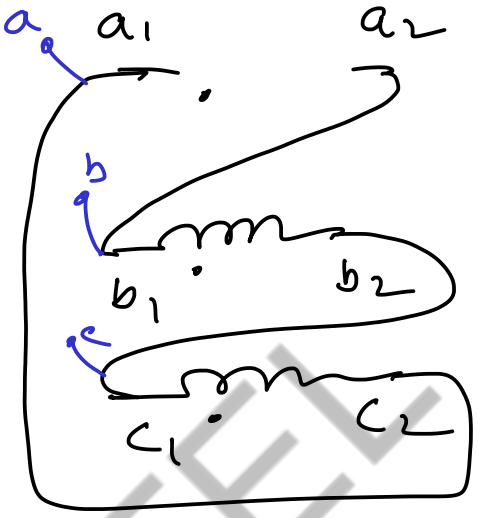
A bank of 3-1ph. tfo

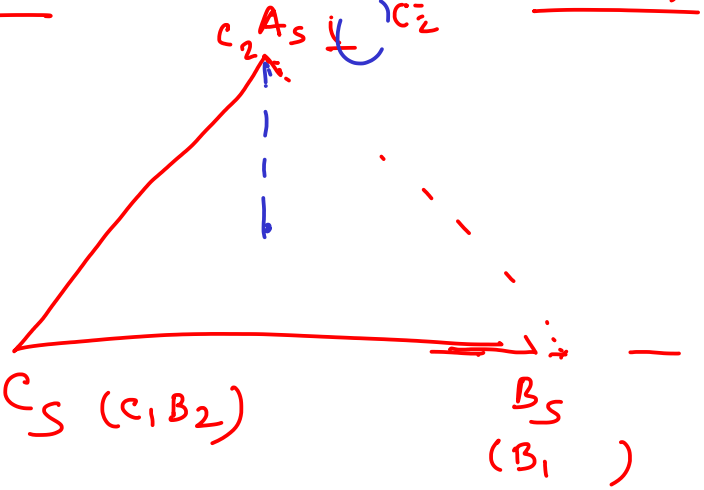
Delta-Delta connection :-

Dd0°

Dec-39

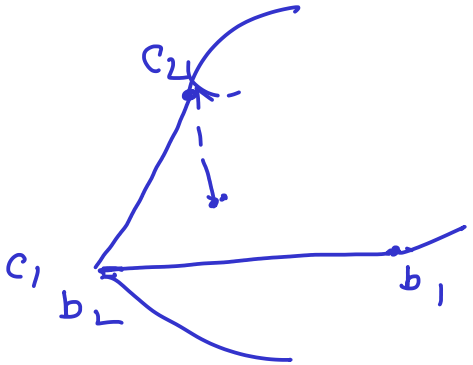




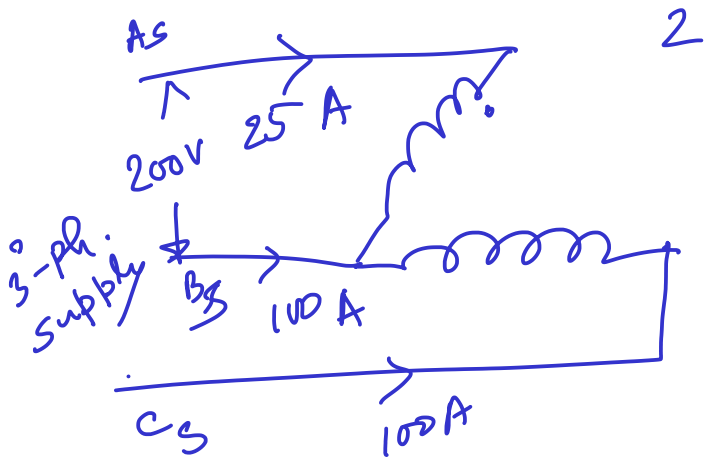


Dd0°

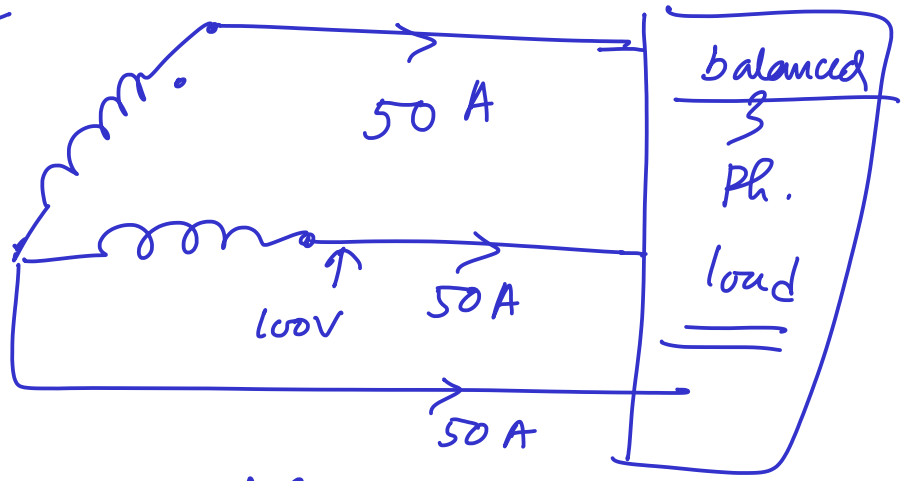
Open delta connection



NPTEL



2 no. of tfo



L L

Open delta Connection

Rating of each tfo.

(5) KVA, 200V/100V 1 ph 5Hz

↓ 50A

25A

$\frac{\sqrt{3} \times 200 \times 25}{10 \times 1000}$

$= \frac{1.732}{2}$

$= \frac{\sqrt{3}}{2}$

$= 0.865$

Total KVA Handled by L L connection

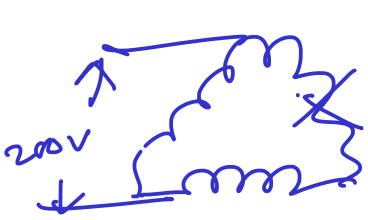
$= \sqrt{3} V_{LL} I_L = \sqrt{3} \times 100 \times 50 = \sqrt{3} \times 200 \times 25$

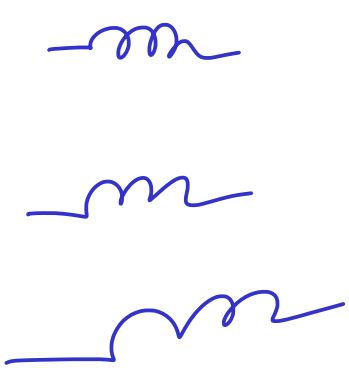
≈ 8.65 KVA

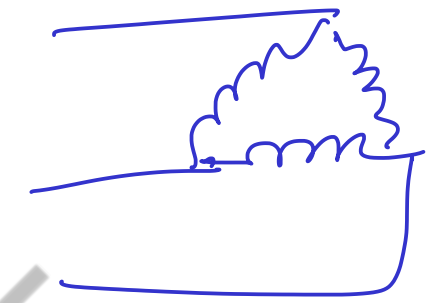
NPTEL

15 KVA

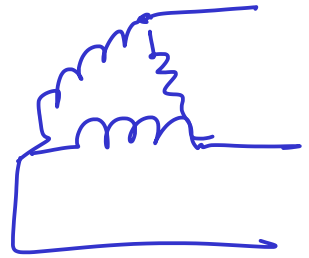
3 x 5KVA







15KVA



4 no.s 5KVA → 1 don't conne
4th spare unit

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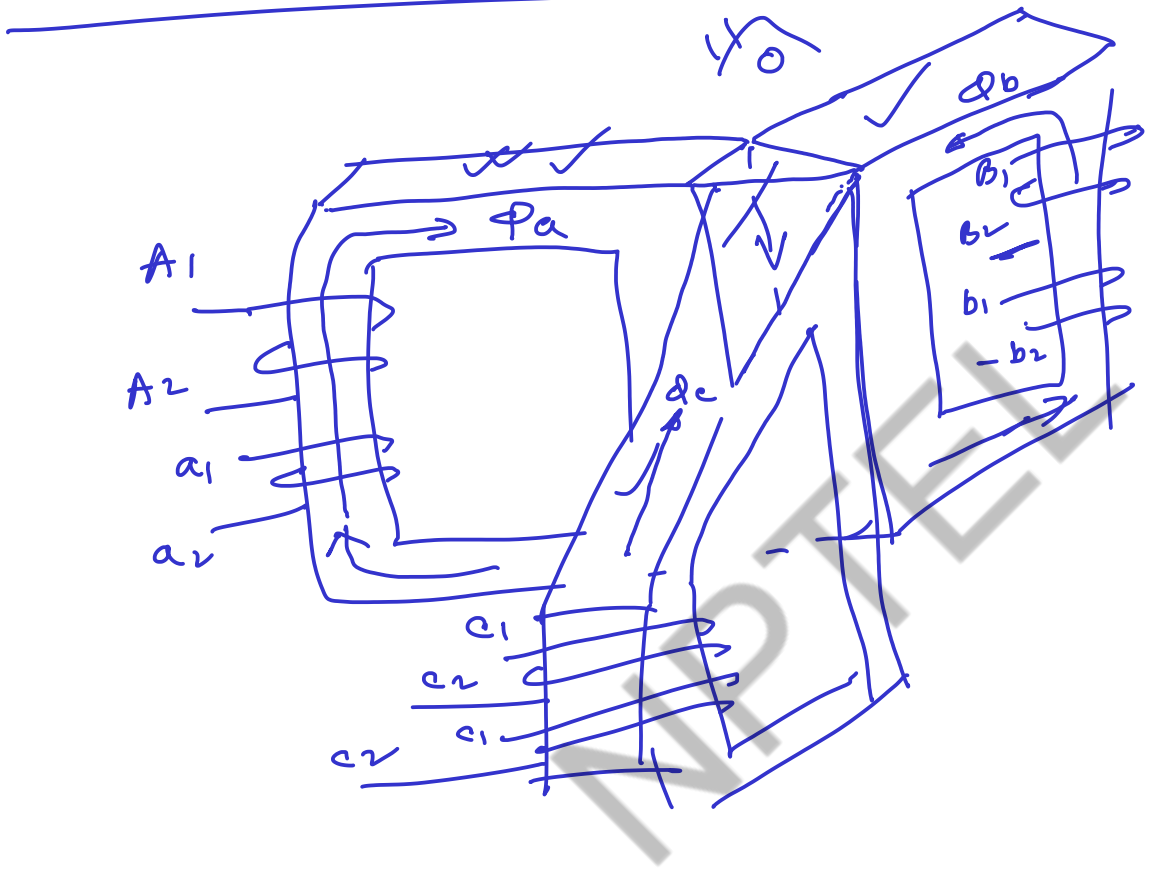
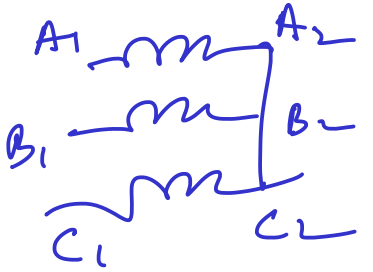
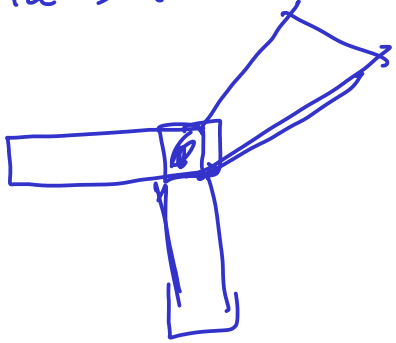
A 3-phase transformer as a single unit.

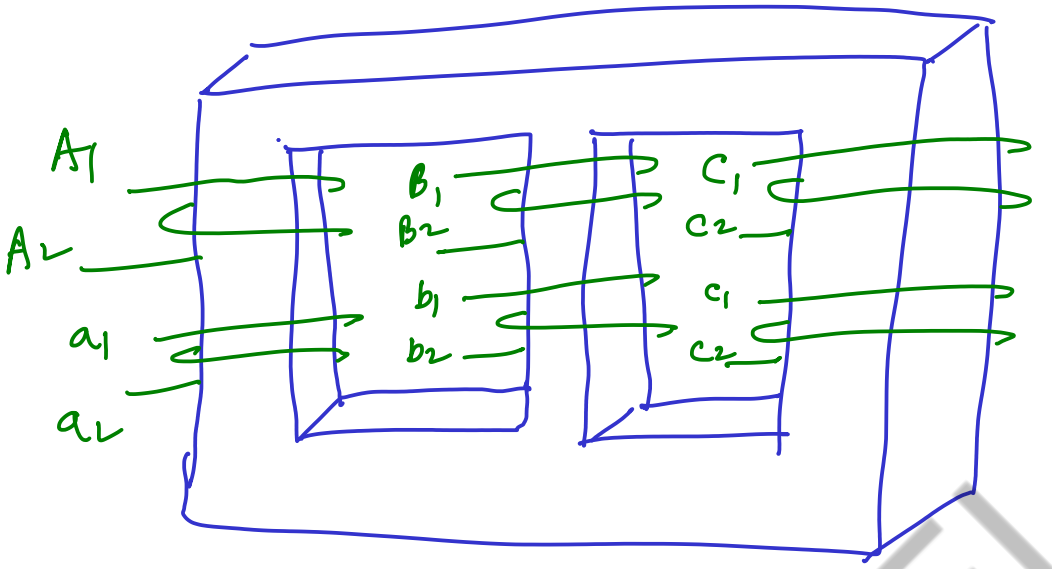




$\Phi_a(t) + \Phi_b(t) + \Phi_c(t)$



NPTEL



Core type

3-phase - Hfo.

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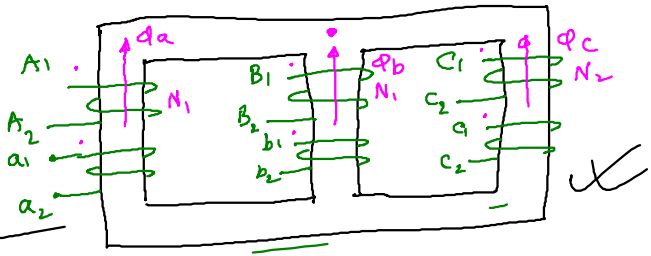
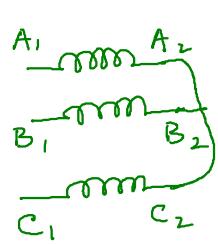
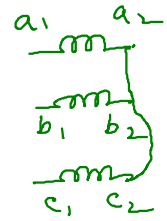
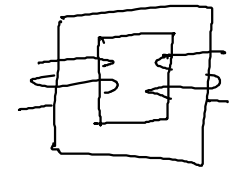
Three Phase transformer as a single unit Core type Lec-40

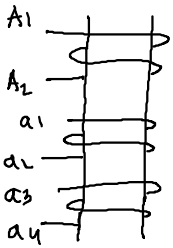


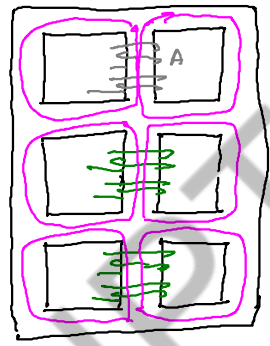




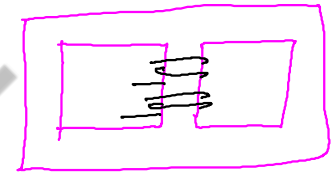


Shell type





Shell Type



1ph Shell Type

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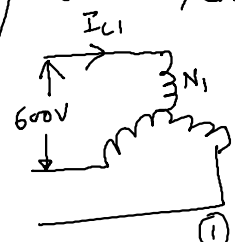
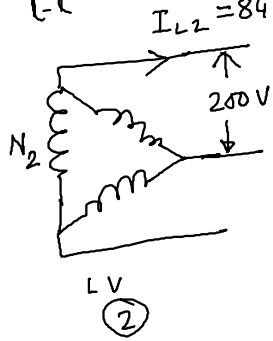
Name plate rating of a 3-phase tfo unit

3Ph, 30 KVA (L-L) 600 V/200 V (L-L), 50Hz tfo Ydl





Total KVA

$$I_{L1} = \frac{30\times10^3}{\sqrt{3}\times 600} \text{ A}$$

$$\approx 28 \text{ A}$$

$$\sqrt{3}\times 200\, I_{L2} = 30\times10^3$$

$$\therefore I_{L2} = \frac{30\times10^3}{\sqrt{3}\times200} \text{ A}$$

$$\approx 84 \text{ A}$$

Turns ration of HV & LV windings per phase:-

$$\frac{N_1}{N_2} = \frac{600/\sqrt{3}}{200} = \frac{3}{\sqrt{3}} = \sqrt{3}$$

$\therefore$ Rated currents of windings

$$I_{\substack{LV \\ winding}} = \frac{84}{\sqrt{3}} \text{ A}$$

$$I_{\substack{HV \\ winding}} = 28 \text{ A}$$

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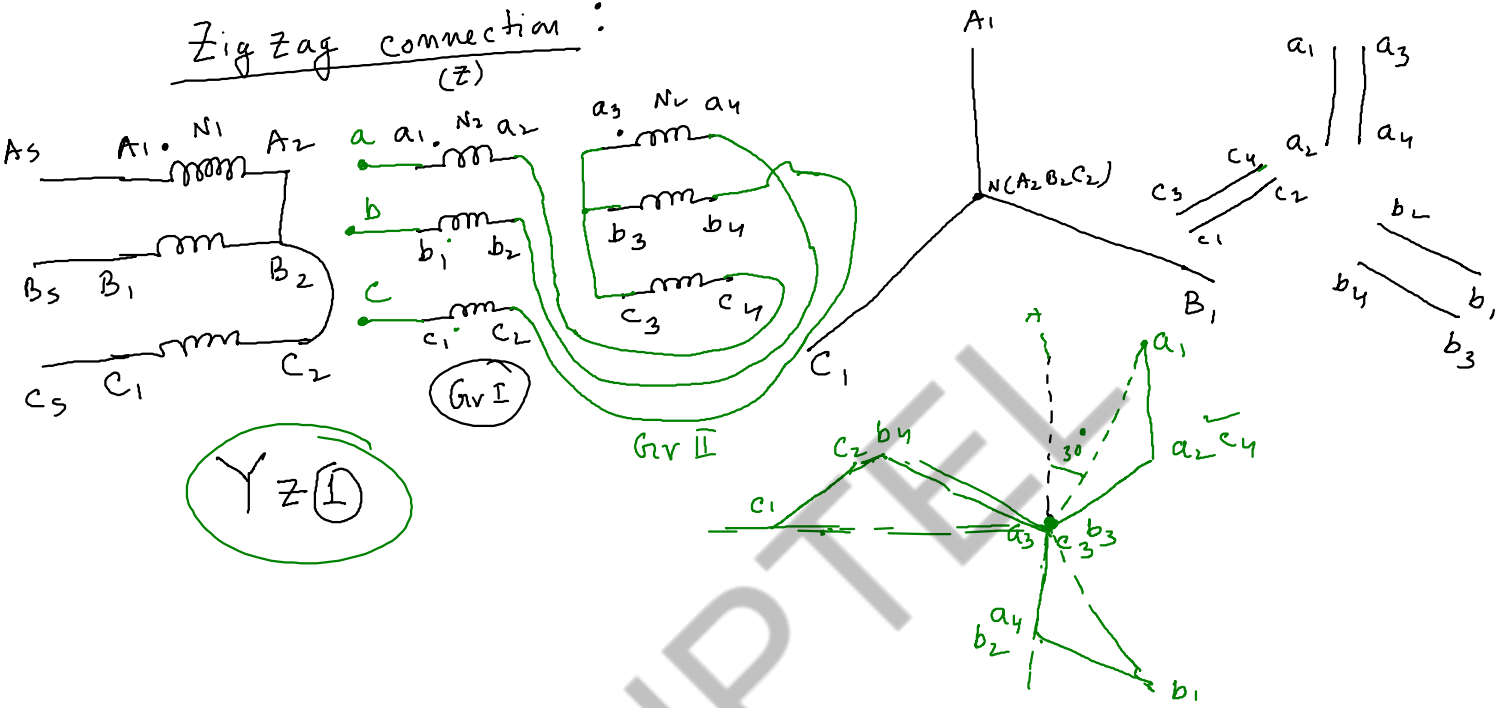
Zig Zag connection :

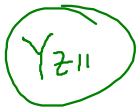
(Z)

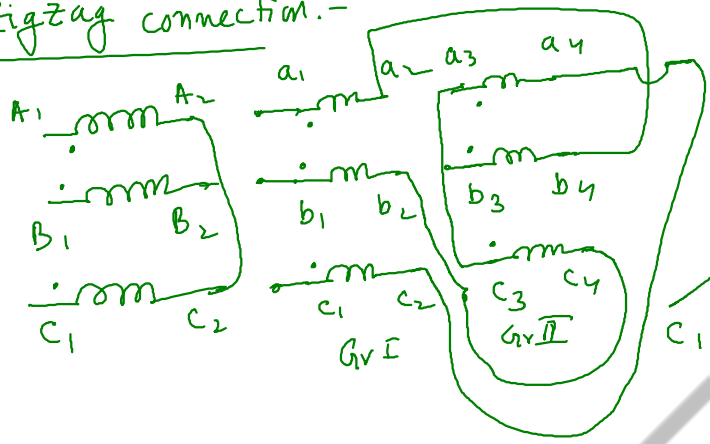


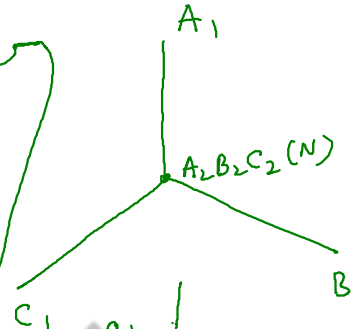
NPTEL

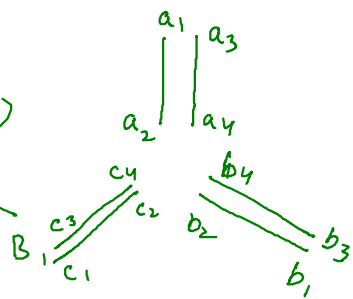
Lec 41

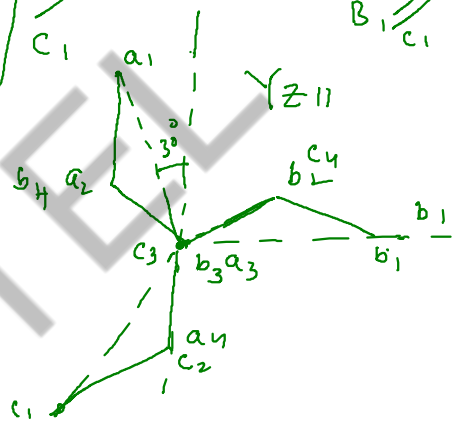
Zigzag connection:-



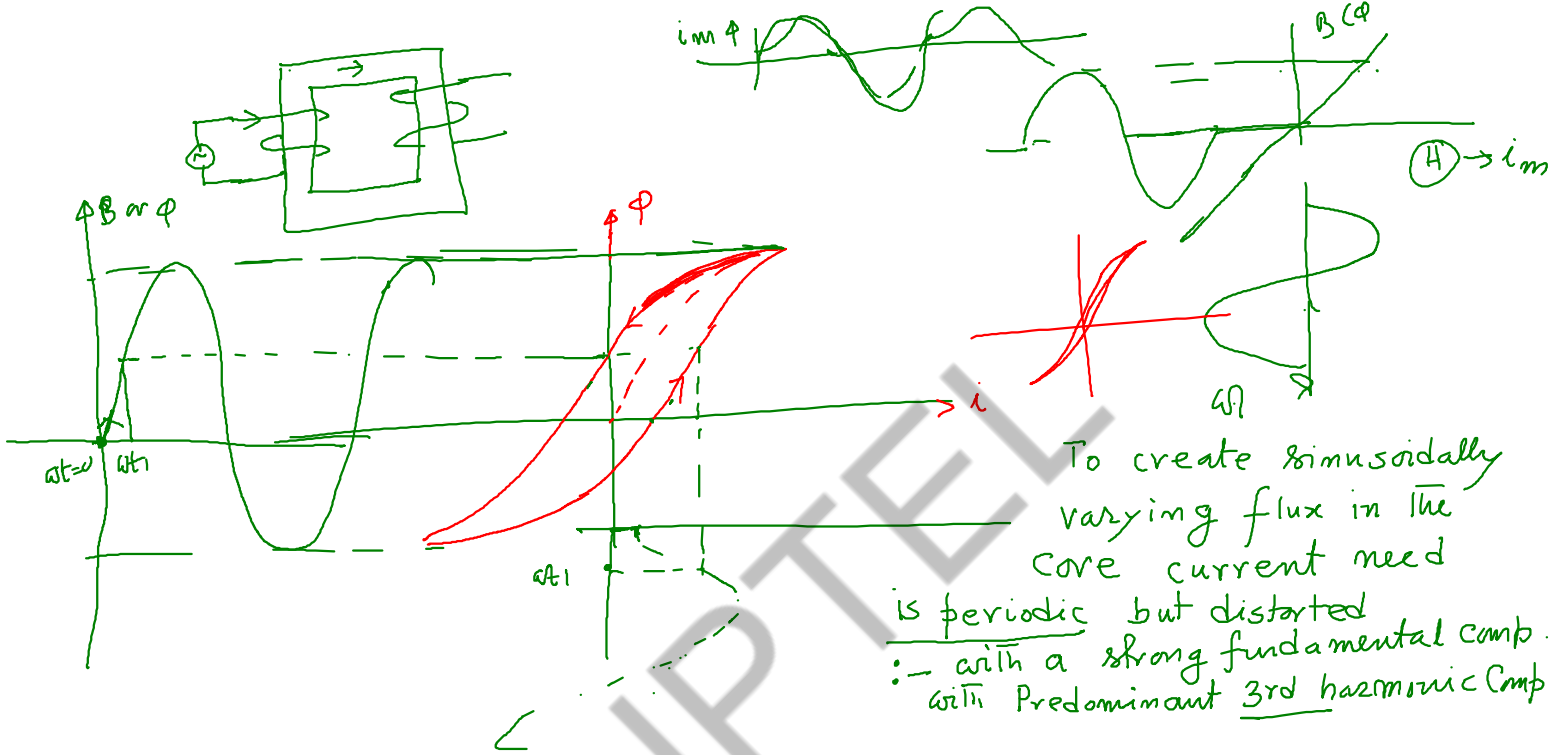








NPTEL

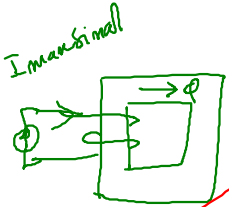


To create sinusoidally varying flux in the core current need is periodic but distorted
:- with a strong fundamental comp.
with Predominant 3rd harmonic Comp.

NPTEL

Reverse problem is :-

Exciting current is suppose sinusoidal (50 Hz)
Then what will be the nature of B or φ ↓ will be distorted but periodic



After Fourier Analysis :-
a strong fundamental (50 Hz) with a predominant 3rd harmonic component

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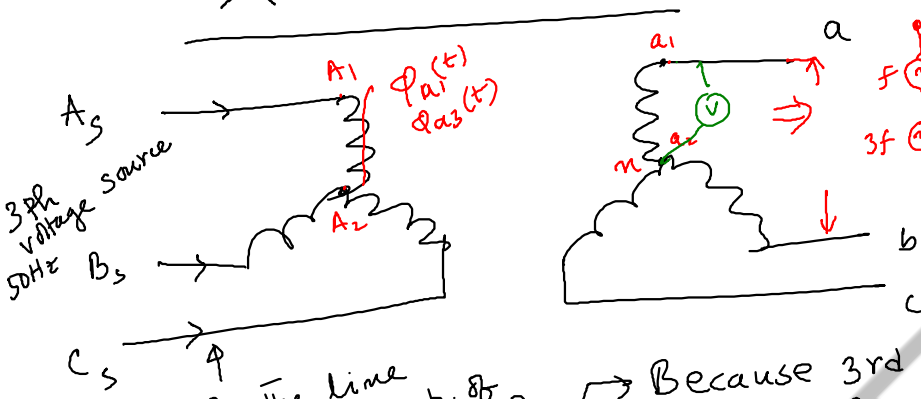
To create 50Hz flux, we require magnetising current having 50Hz + 150 Hz comp

If magnetising current is forced to be sinusoidal, core flux will be a strong fundamental (50Hz) + 150Hz component of flux.

NPTEL

Y - Y connection

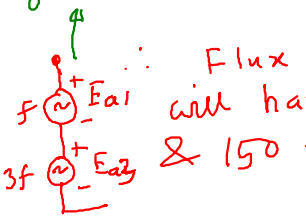


In the line 150Hz comp. of current will not flow.

→ Because 3rd harmonic currents are co-phasal.

So magnetising current will be sinusoidal of 50Hz

Ph voltage will have both 50Hz & 150Hz



∴ Flux in the core will have both 50Hz & 150 Hz component

$$\begin{cases} \sqrt{2}\pi f \phi_{max1} N_1 \rightarrow f \\ \sqrt{2}\pi 3f \phi_{max3} N_1 \rightarrow 3f \end{cases}$$

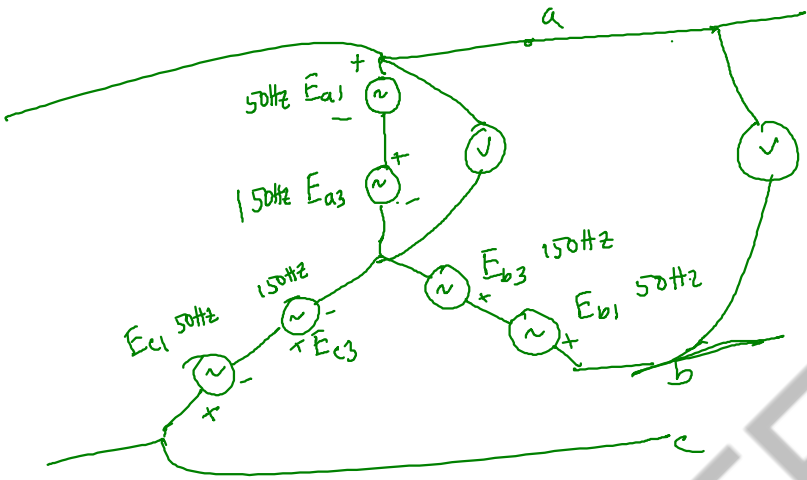
3rd harmonic currents

$i_a = I_{m3} \sin 3\omega t$

$i_b = I_{m3} \sin 3(\omega t - 120^\circ) = I_m \sin \omega t$

$i_c = I_{m3} \sin 3(\omega t + 120^\circ) = I_m \sin \omega t$

NPTEL



In the line-to-line voltage 3rd component will be absent

$$\sqrt{3}|E_{a1}|$$

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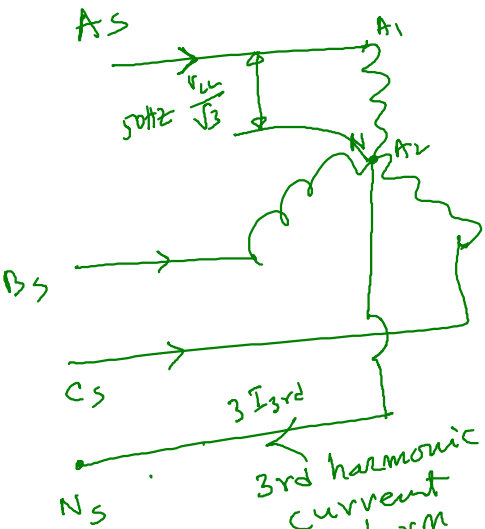
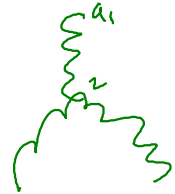


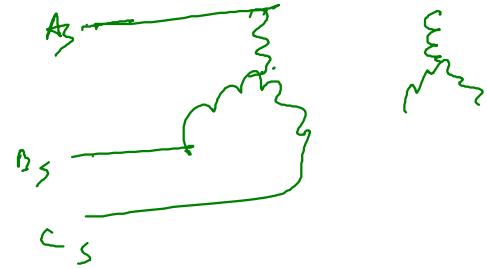
3rd harmonic current will return via this neutral line.



Core flux is forced to be sinusoidal (50Hz)

and magnetising current 50Hz + 150Hz comp.

is it possible → yes



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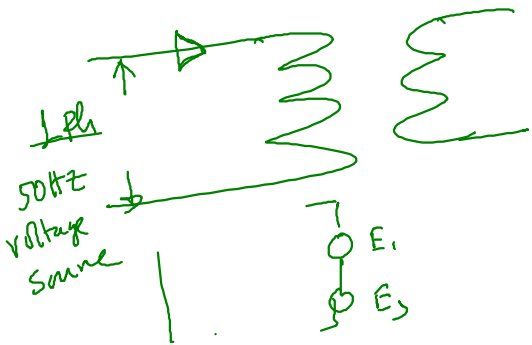
1-ph. tfo



Core flux → 50Hz

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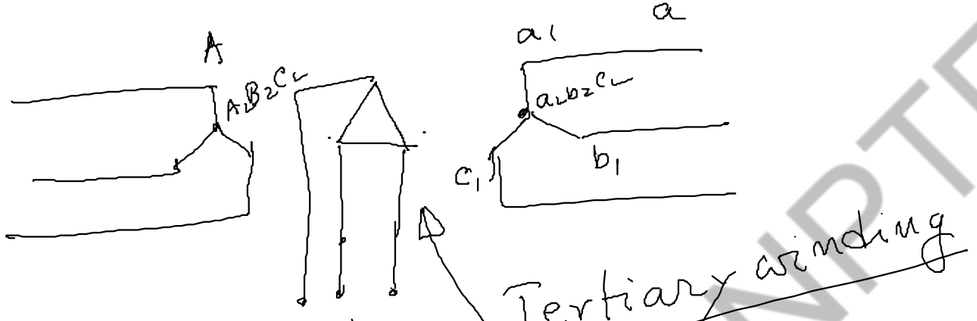
Lec -44

$$I_{3rd} = \frac{3E_{3rd}}{r_2 + j3x_1}$$

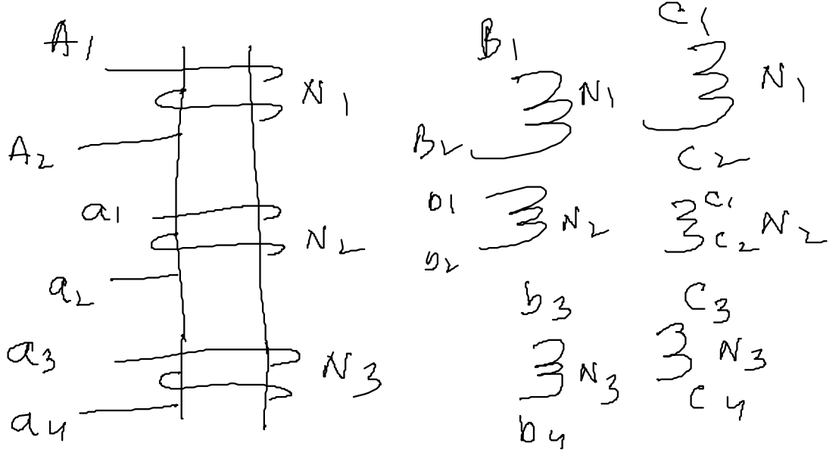
HV → star Y

LV → delta Δ

6.6 KV / 440 V



may or may not be supplied from tertiary winding



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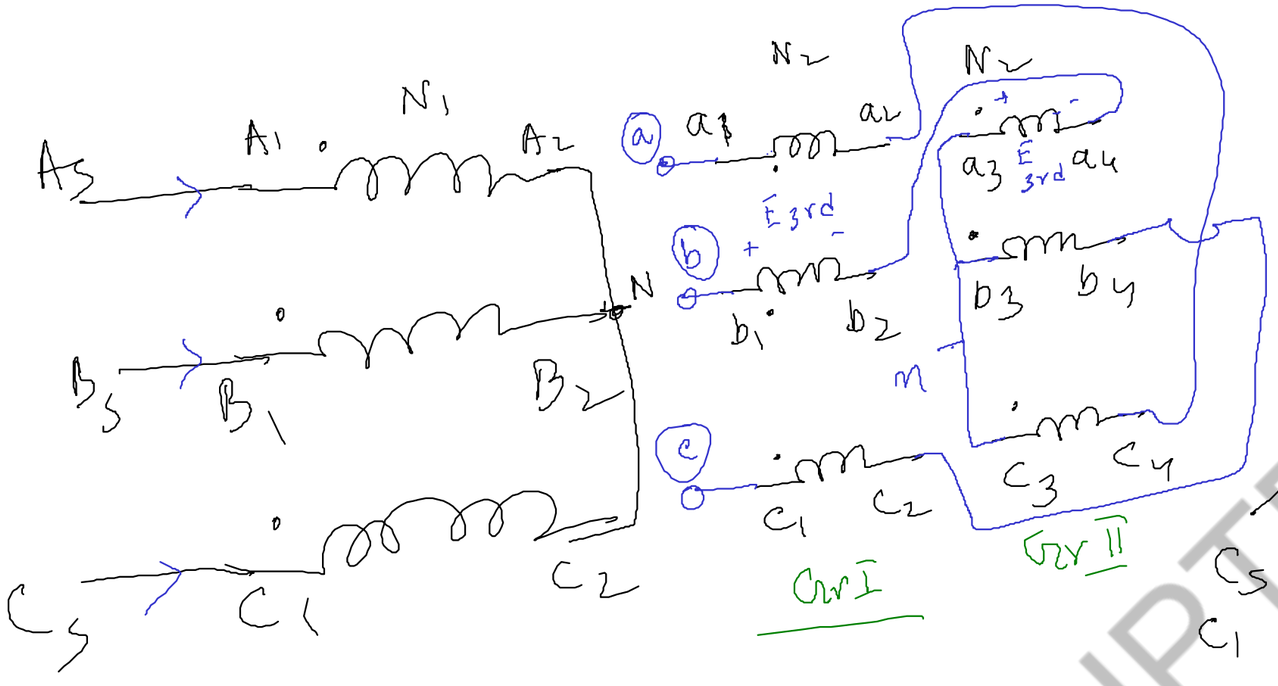
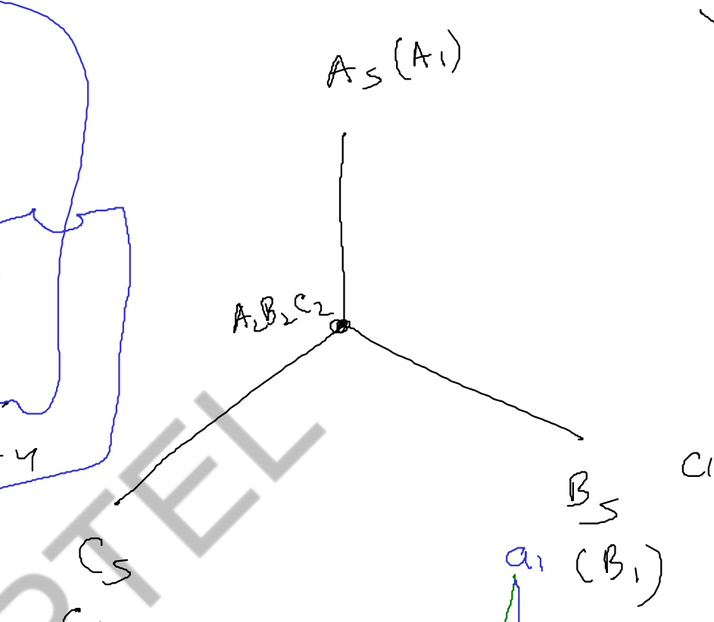
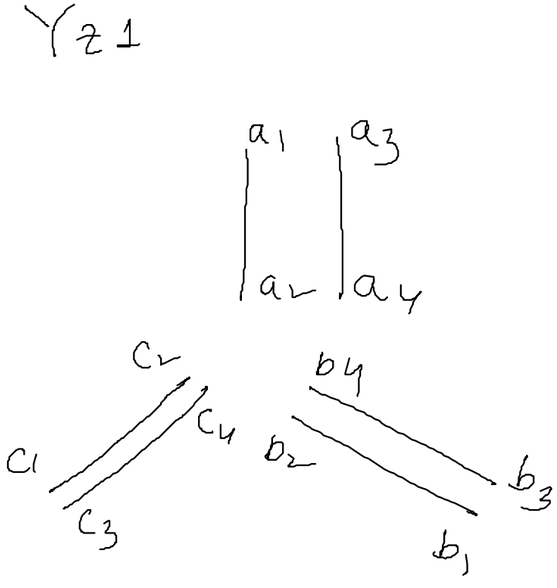
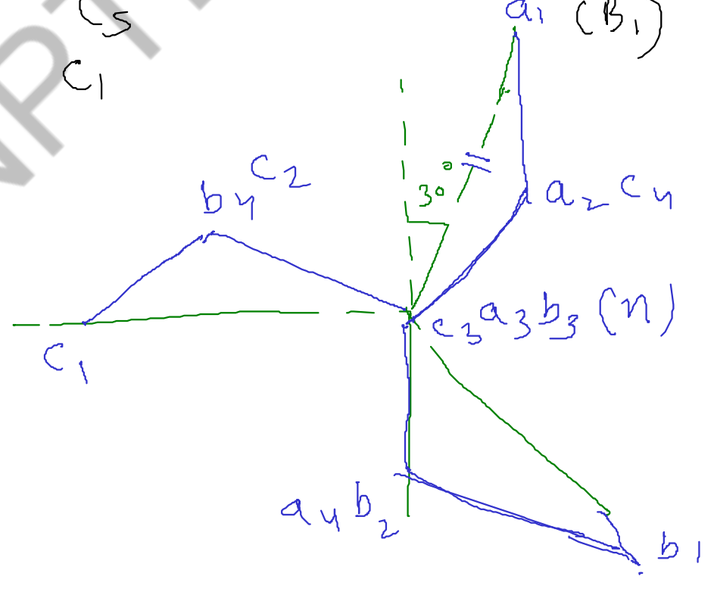
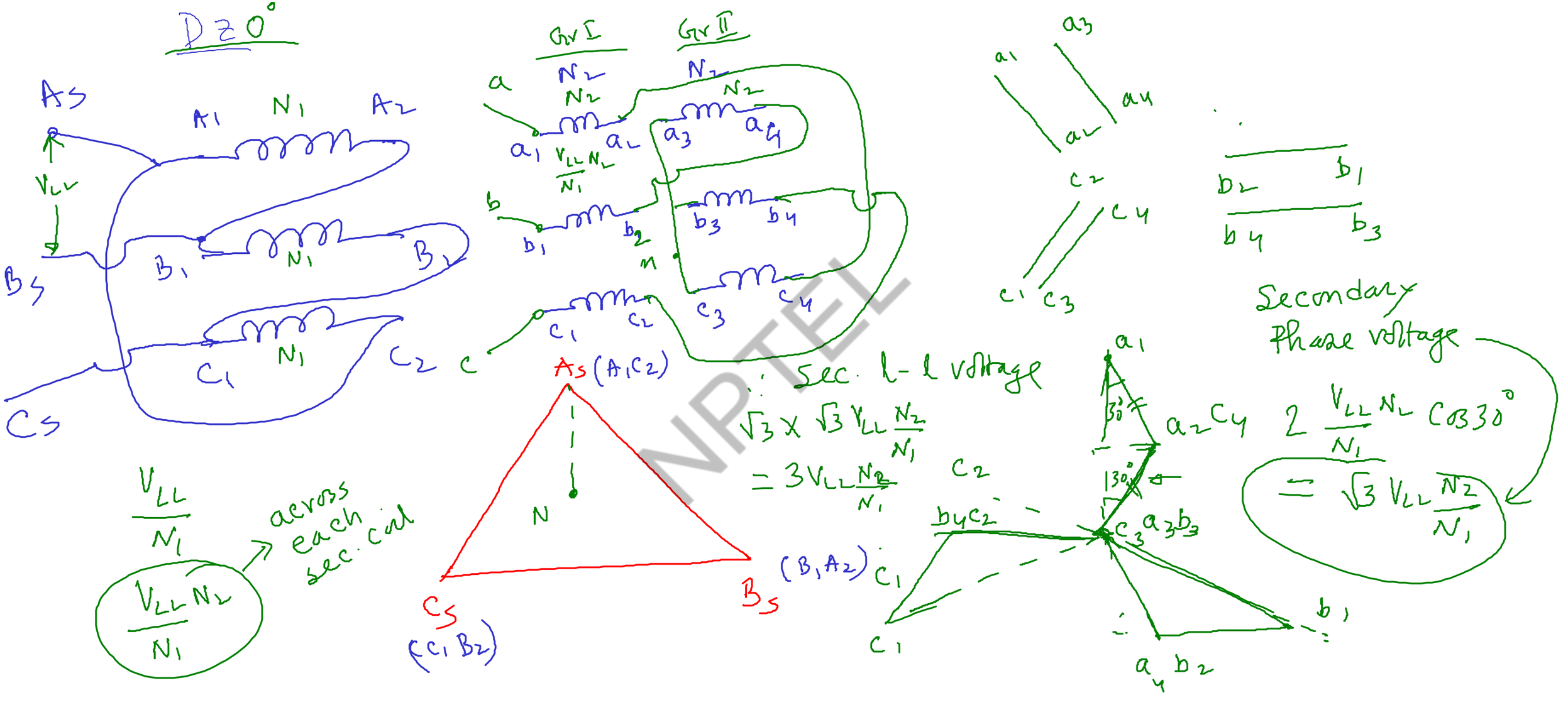

A1
A2
A3
N1
B1
B2
B3
C1
C2
C3
N
N2
N2
a1
a2
a3
a4
b1
b2
b3
b4
c1
c2
c3
c4
E 3rd
E 3rd
m
Grp I
Grp II


A3 (A1)
A2B2C2
B3
C3
C1


Yz1
a1
a3
a2
a4
C2
C4
C1
C3
b4
b2
b3
b1


a1 (B1)
b4 c2
30°
a2 c4
c3 a3 b3 (n)
c1
a4 b2
b1

NPTEL


D z 0°
A5
A1
N1
A2
VLL
B1
N1
B2
B5
C1
N1
C2
C5
Grv I
Grv II
N2
N2
a
a1
a2
VLL N2 / N1
b
b1
b2
n
a3
a4
b3
b4
c
c1
c2
c3
c4
A5 (A1 C2)
N
C5 (C1 B2)
B5 (B1 A2)
VLL / N1
across each sec. coil
VLL N2 / N1
∴ Sec. l-l voltage
√3 x √3 VLL N2/N1
= 3 VLL N2/N1
a1
a3
a4
a2
c2
c4
c1
c3
b2
b1
b4
b3
Secondary Phase voltage
2 VLL/N1 N2 cos30°
= √3 VLL N2/N1
30°
30°
a2 c4
b4 c2
c3 a3 b3
c1
b1
a4 b2
NPTEL