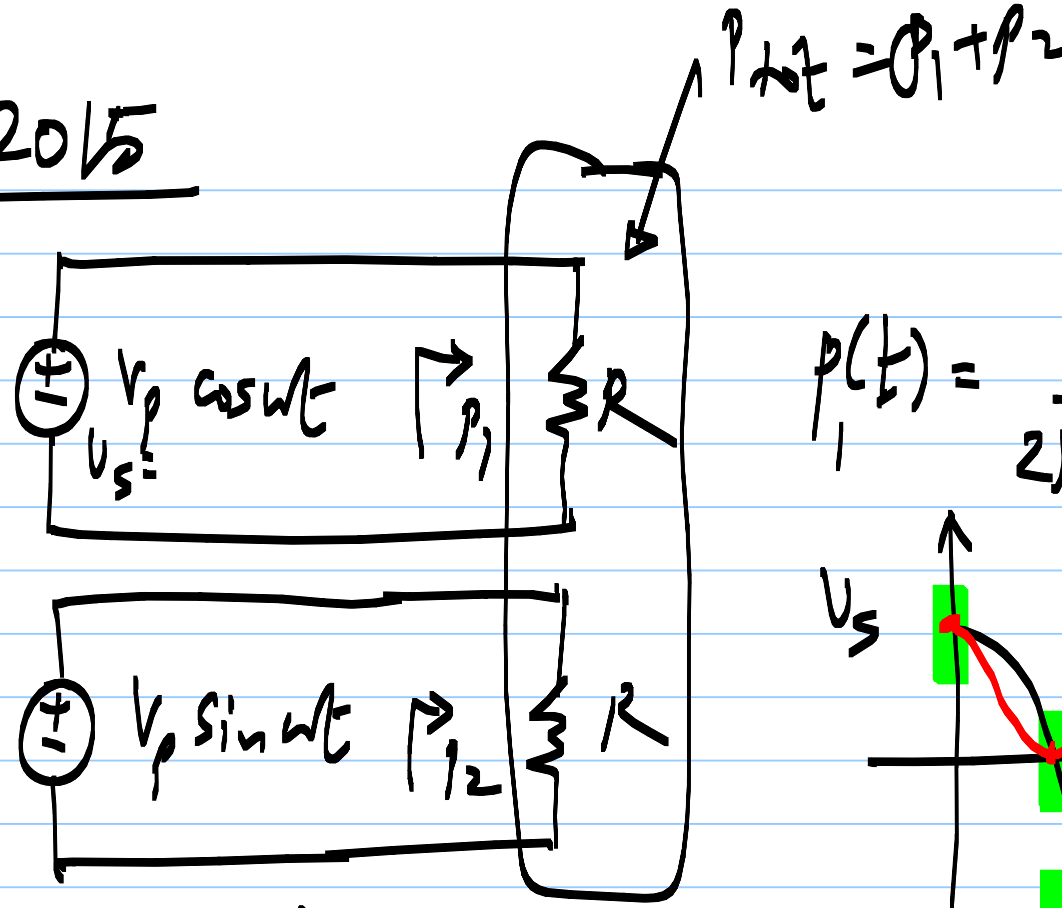
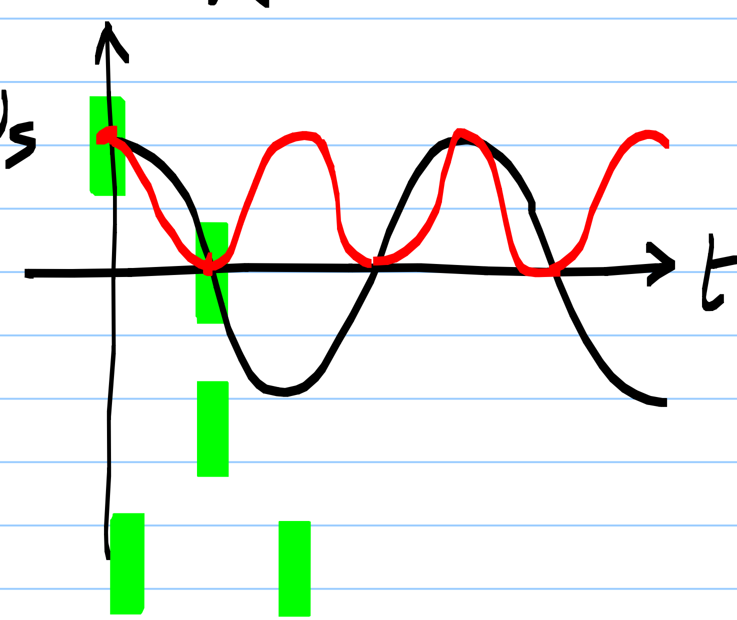
EE 2015

25/10/2017

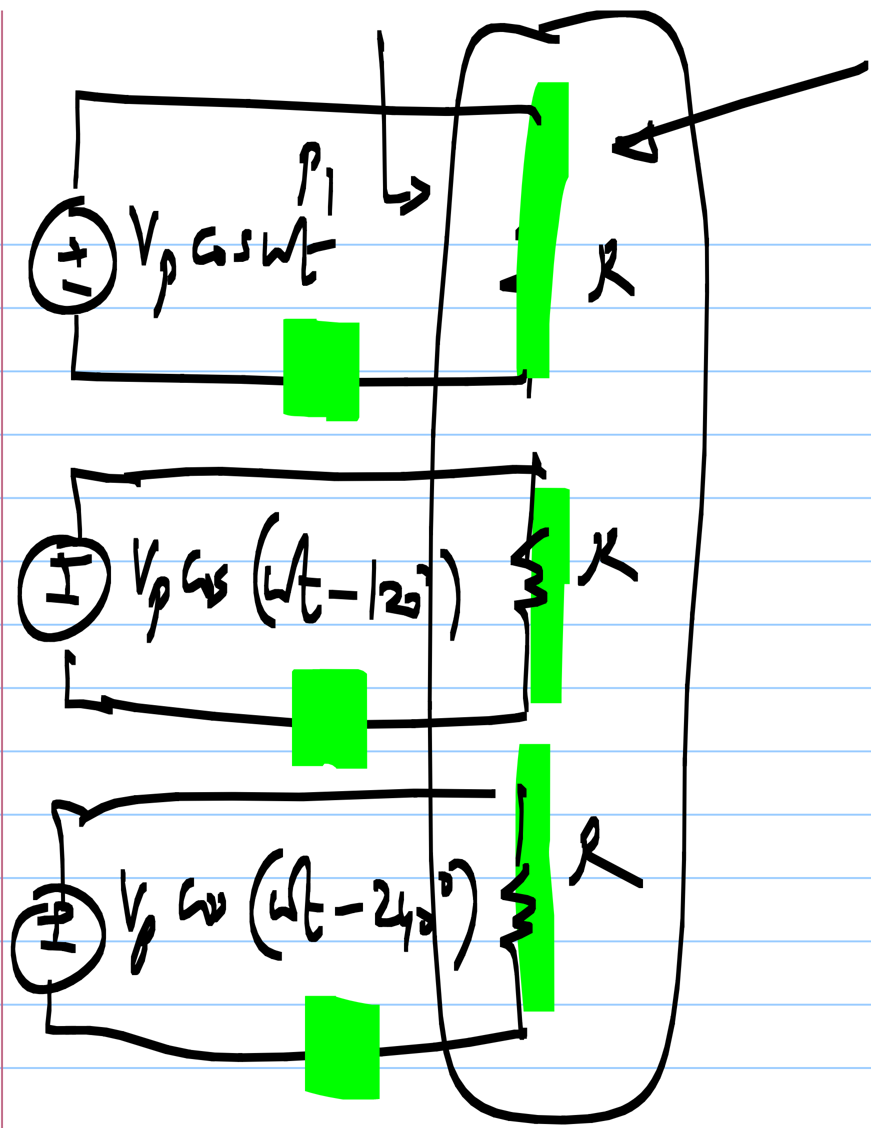
$\bar{V}_s = V_p \angle 0$



$$p_1(t) = \frac{V_p^2}{2R}\left(1 + \cos 2\omega t\right)$$



$$p_2(t) = \frac{V_p^2}{2R}\left(1 - \cos 2\omega t\right)$$

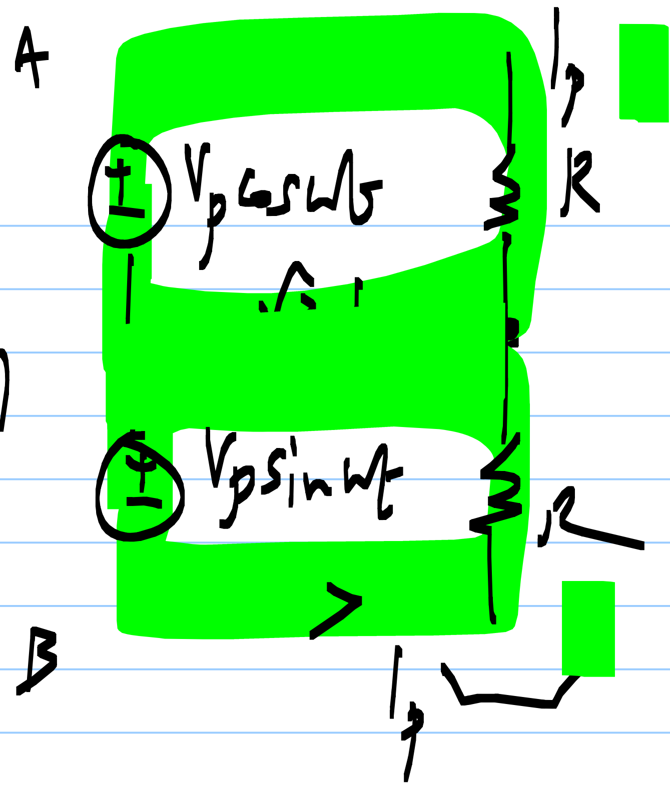


$$P_1 = \frac{V_p^2}{2R}\left(1 + \cos 2\omega t\right)$$

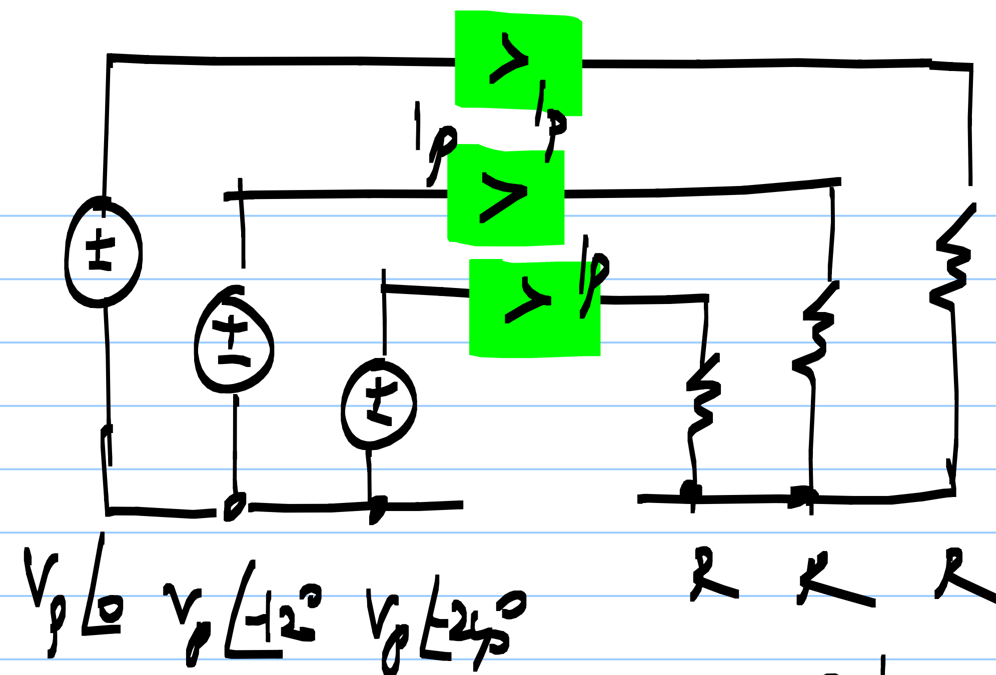
$$P_2 = \frac{V_p^2}{2R}\left(1 + \cos(2\omega t - 240°)\right)$$

$$P_3 = \frac{V_p^2}{2R}\left(1 + \cos(2\omega t - 120°)\right)$$

CoM



$$P_{tot} = \frac{V_p^2}{R}$$

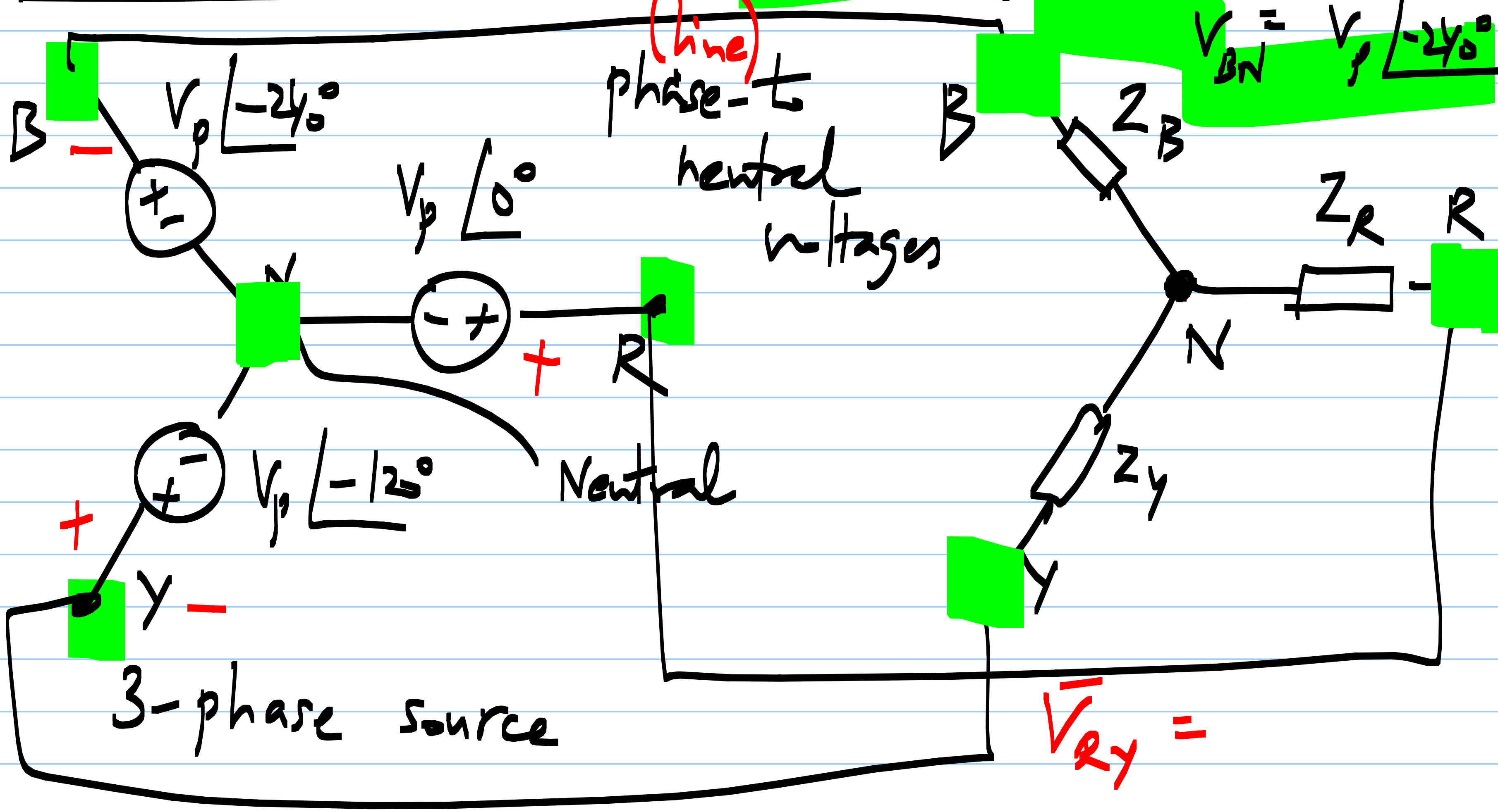


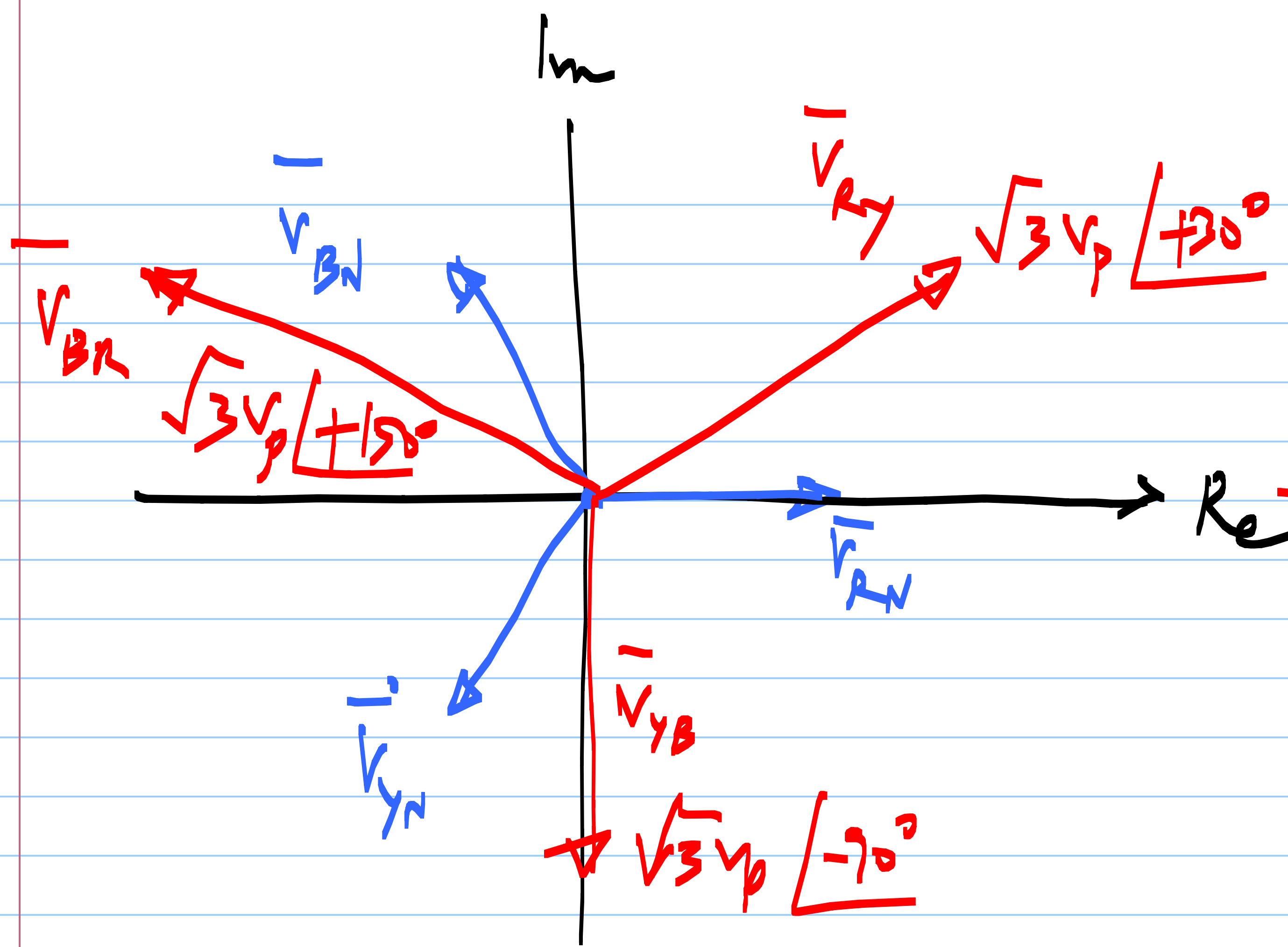
$$P_{tot} = \frac{3}{2} \frac{V_p^2}{R}$$

3 phase system is optimum for delivering power

3-phase system:

- N: Neutral
- $V_{RN} = V_p \angle 0°$
- $V_{YN} = V_p \angle$ [illegible]
- $V_{BN} = V_p \angle -240°$



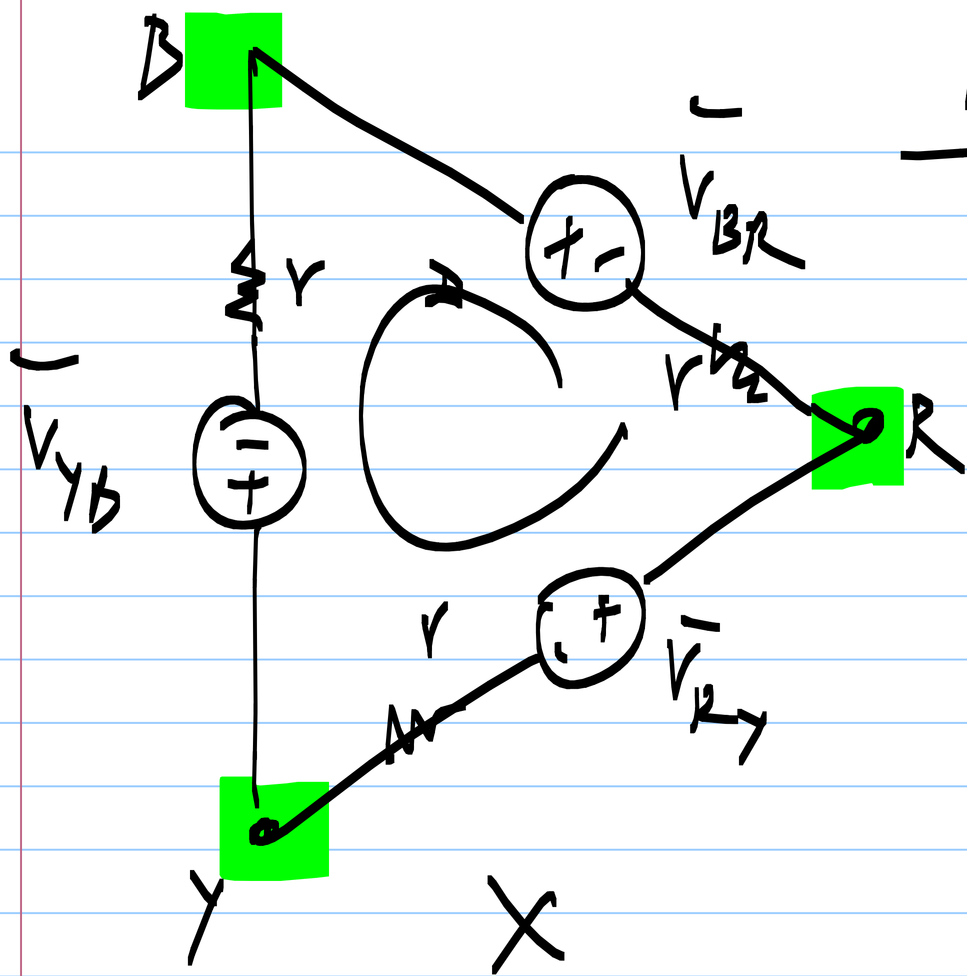


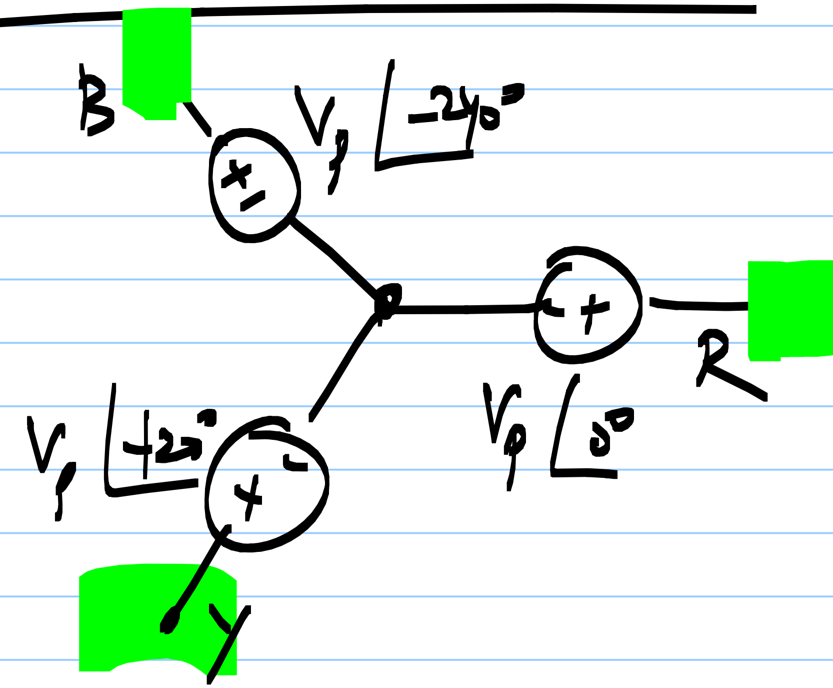
$\bar{V}_{RY}, \bar{V}_{YB}, \bar{V}_{BR}$: line-line voltages
398 V rms

line-neutral voltage:
230 V rms
$230\sqrt{2}$ V peak

Source:

Balanced Source



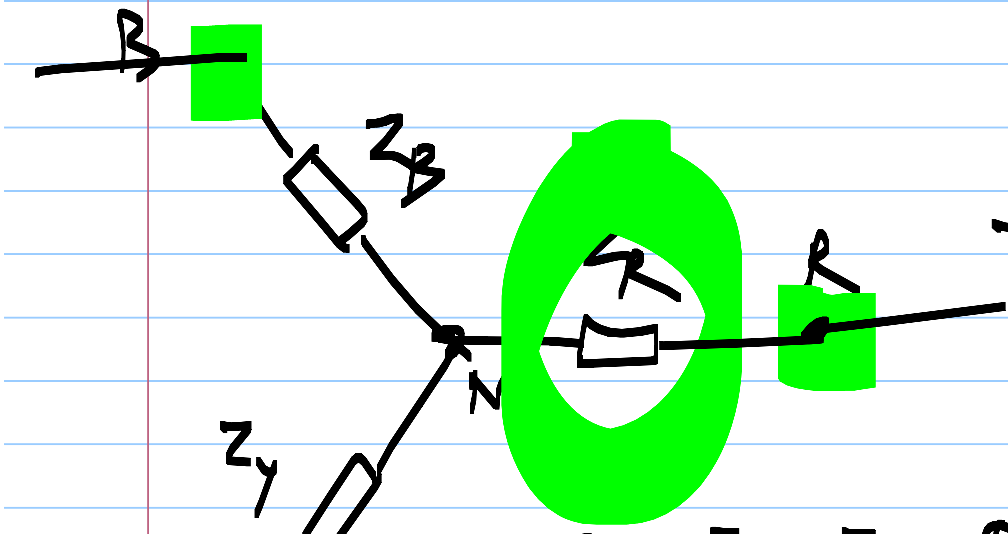


Star Connected

(Y)

Load:

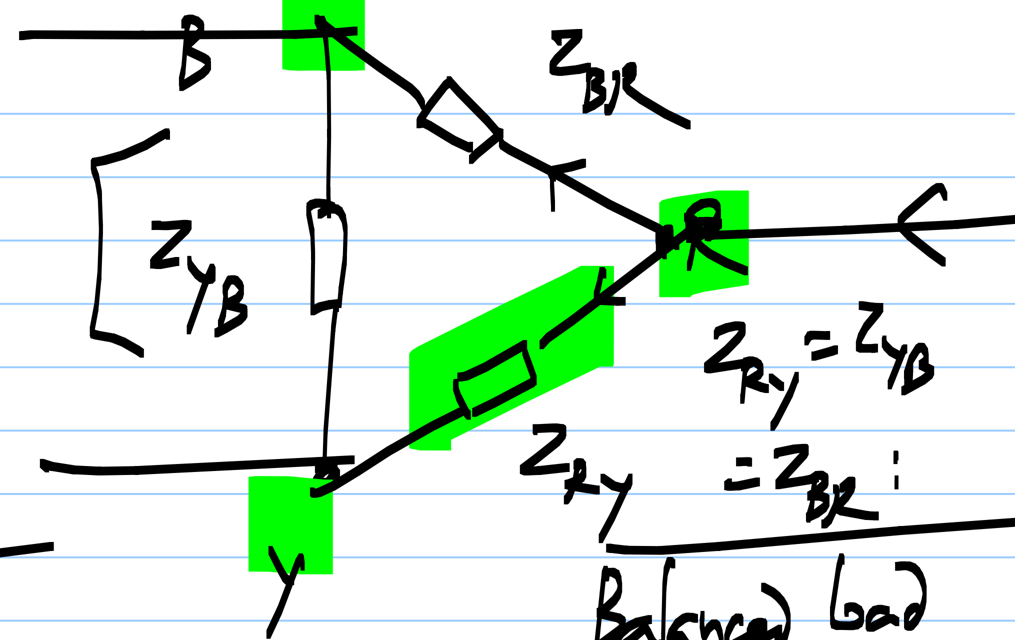
Star-connected



$Z_R = Z_Y = Z_B$: Balanced load

Z_R, Z_Y, Z_B: different: **Unbalanced load**

Delta connected



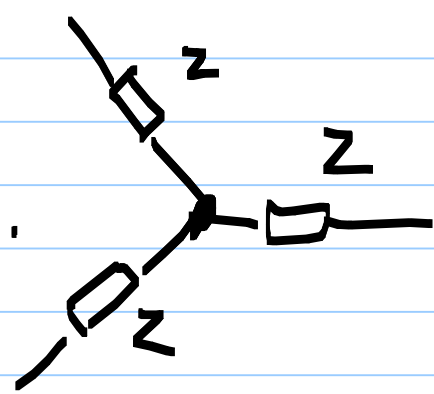
$Z_{RY} = Z_{YB} = Z_{BR}$:

Balanced load

$$Z_R = \frac{Z_{RY} Z_{BR}}{Z_{RY} + Z_{YB} + Z_{BR}}$$

$Z_Y =$

$Z_B =$

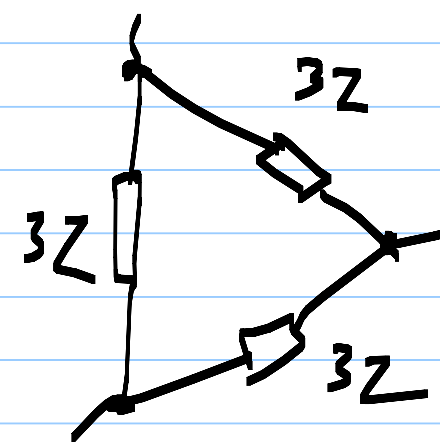


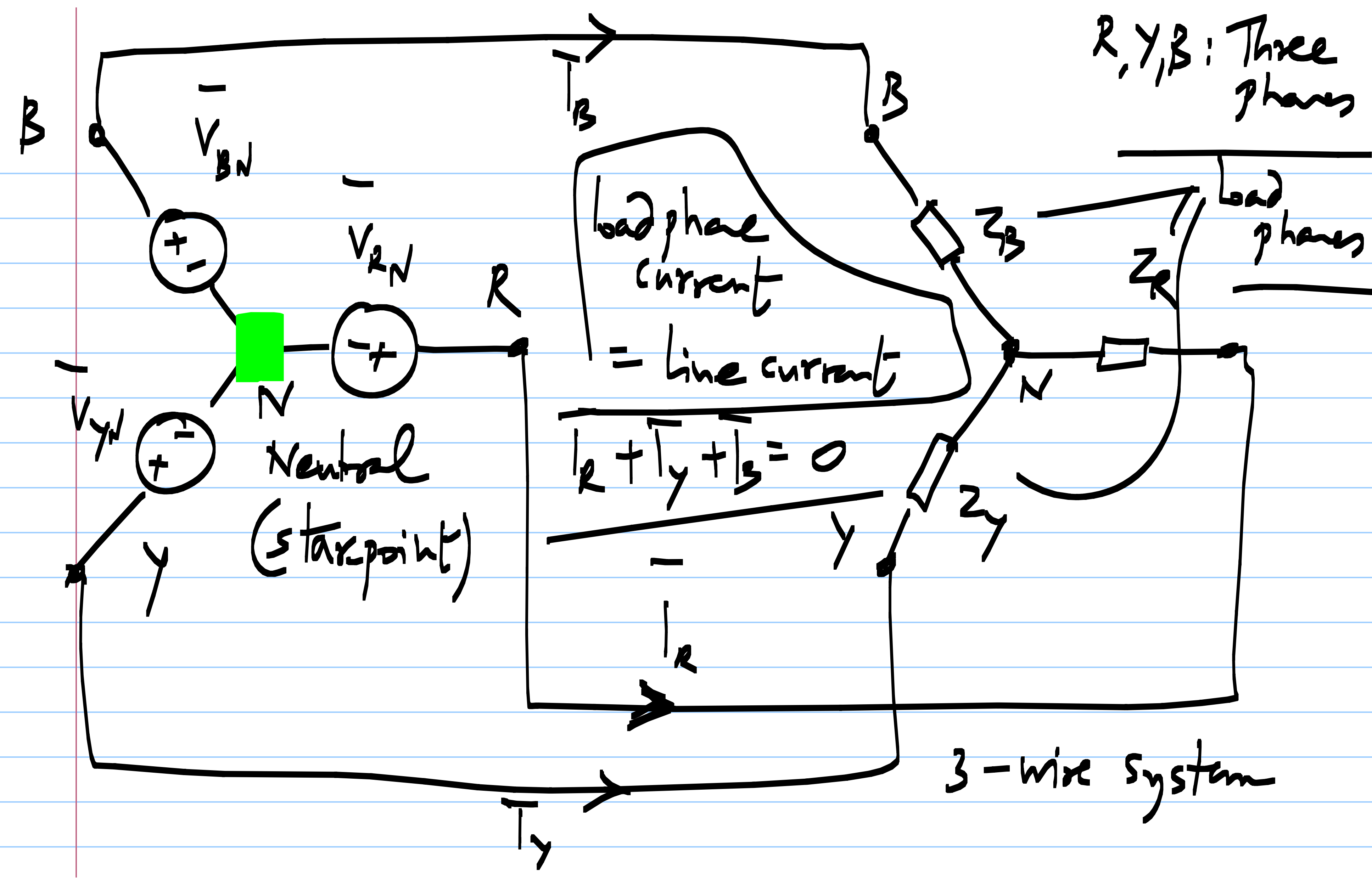
=

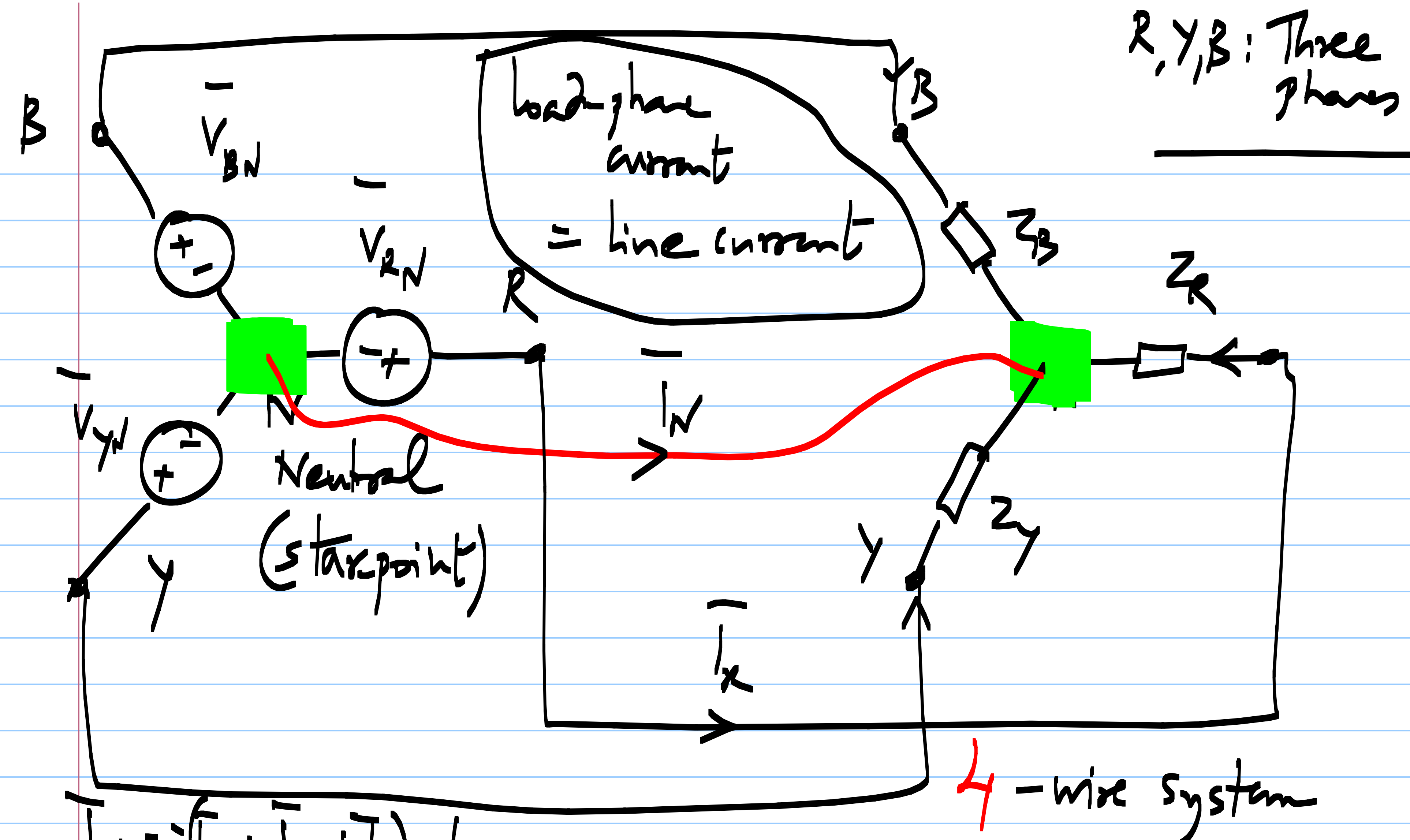
$$Z_{RY} = \frac{Z_R Z_Y + Z_Y Z_B + Z_B Z_R}{Z_B}$$

$Z_{YB} =$

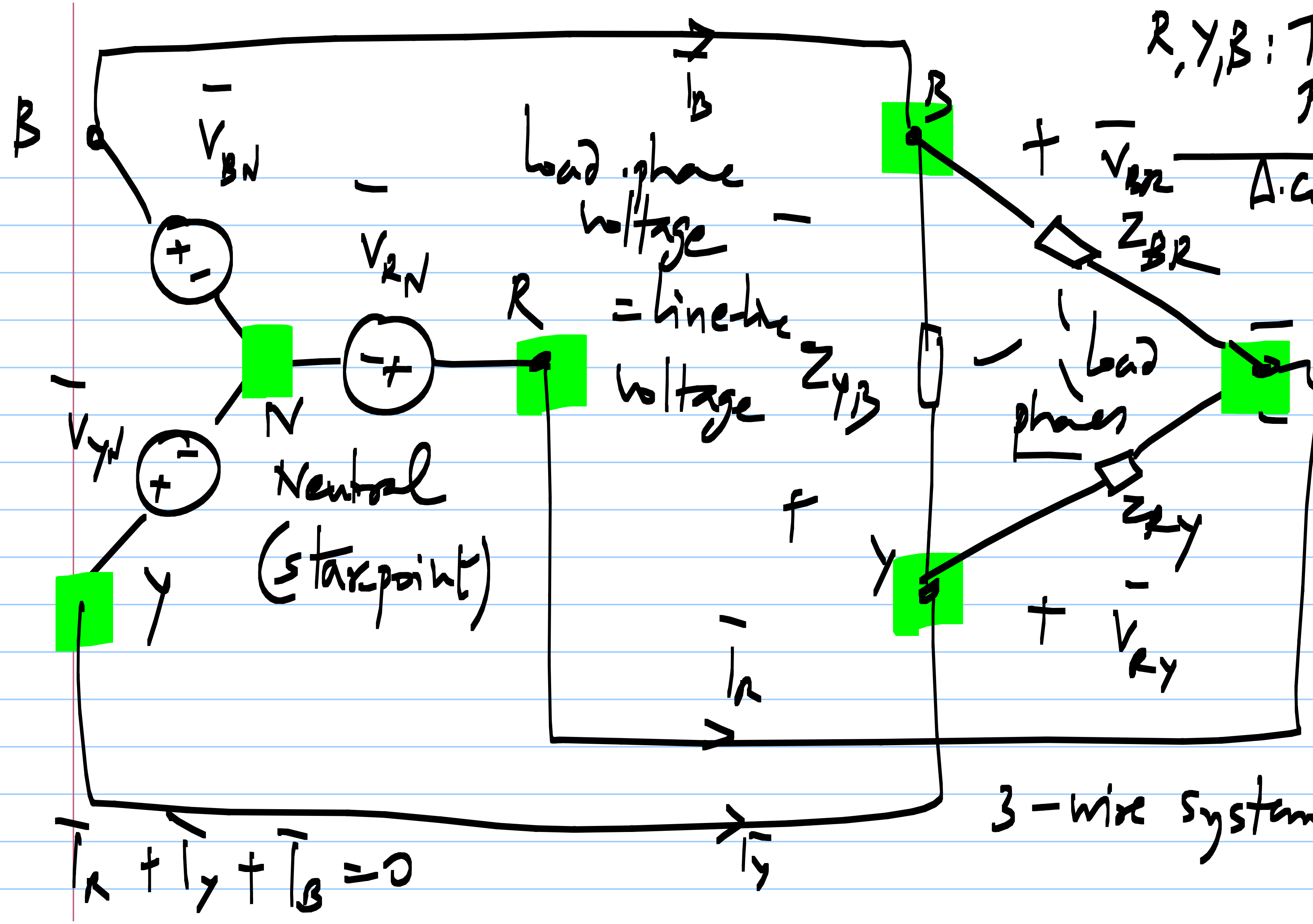
$Z_{BR} =$




B
$\bar{V}_{BN}$
$\bar{V}_{RN}$
$\bar{V}_{YN}$
R
Y
N
Neutral (starpoint)
$\bar{I}_B$
$\bar{I}_R$
$\bar{I}_Y$
Load phase current = Line current
$\bar{I}_R + \bar{I}_Y + \bar{I}_B = 0$
Z_B
Z_R
Z_Y
R, Y, B : Three phases
Load phases
3-wire system



$$\bar{I}_N = (\bar{I}_R + \bar{I}_Y + \bar{I}_B) \neq 0$$



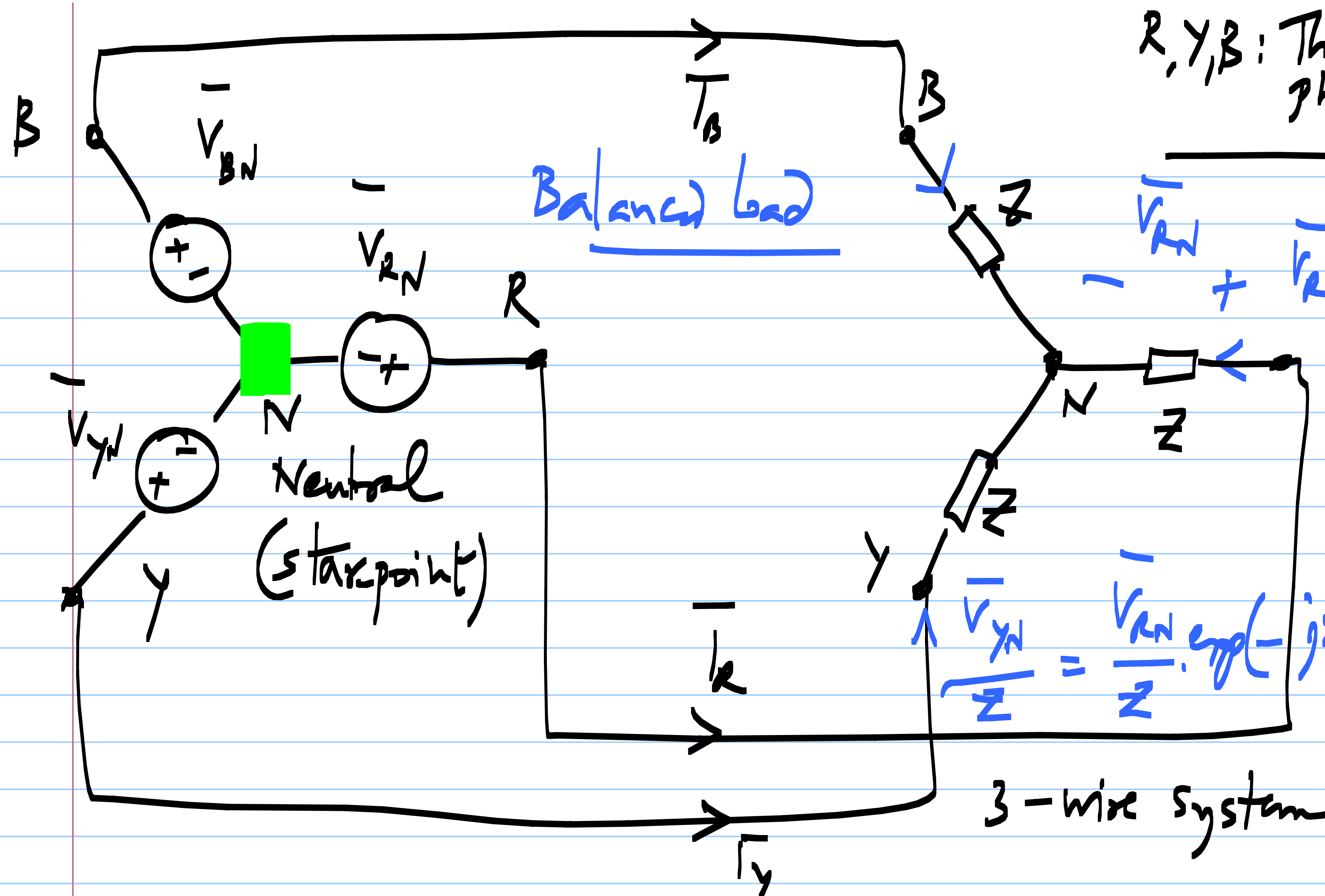
R, Y, B : Three phases

Δ-Connected load

3-wire system

$\bar{I}_R + \bar{I}_Y + \bar{I}_B = 0$

R, Y, B : Three phases

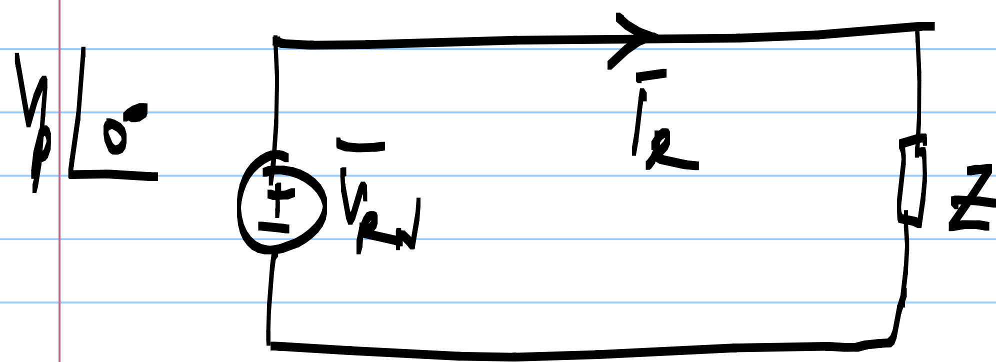


$$-\left(\bar{V}_{RN} + \bar{V}_{RN}\right)/Z$$

$$\frac{\bar{V}_{YN}}{Z} = \frac{\bar{V}_{RN}}{Z} \cdot \exp\left(-j\frac{2\pi}{3}\right)$$

3-wire system

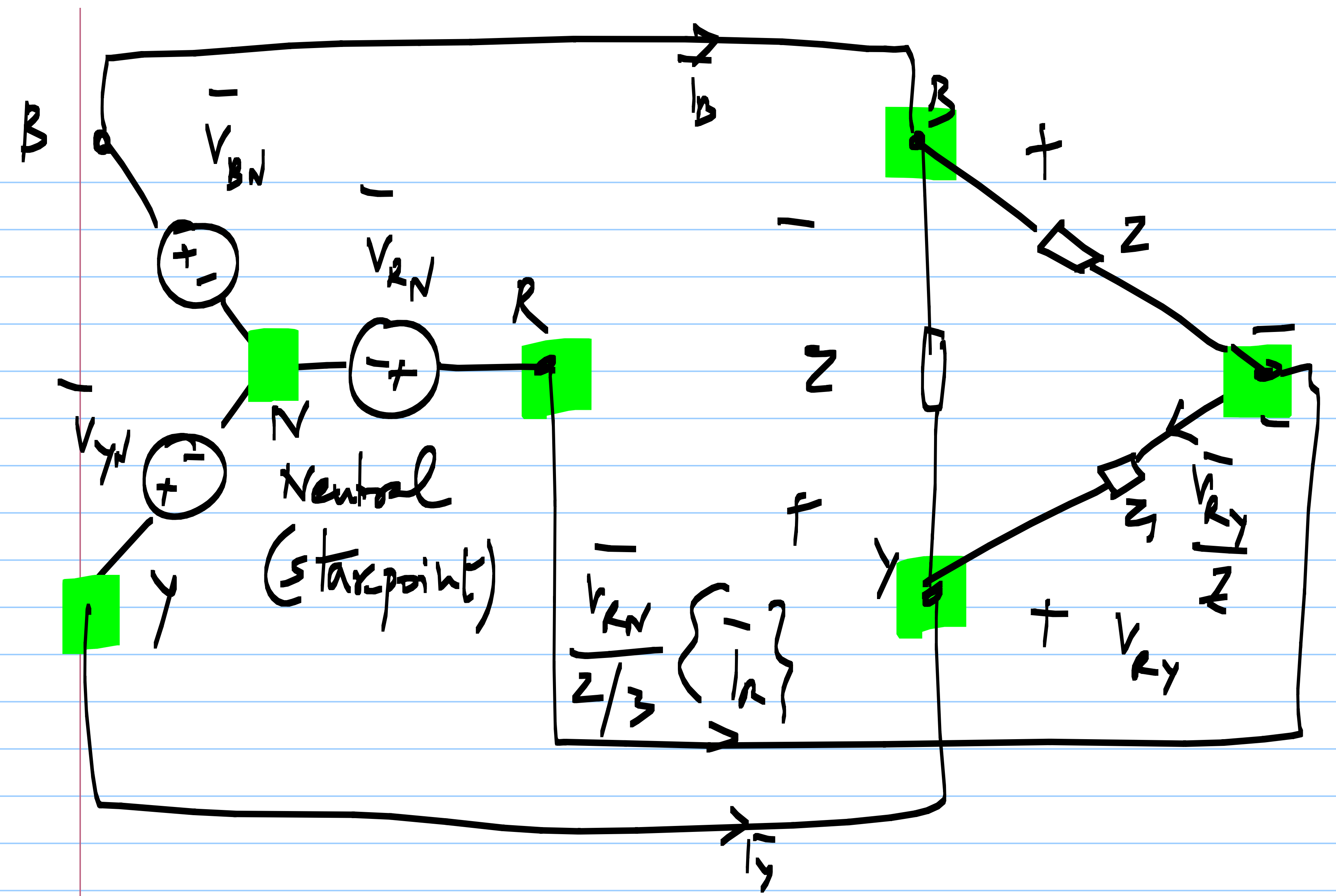
For balanced load: Analyze a single phase



$$\bar{I}_R = \bar{V}_{RN} / Z$$

$$\bar{V}_{YN} = \bar{V}_{RN} \exp\left(-j\, 2\pi/3\right); \quad \bar{V}_{BN} = \bar{V}_{RN} \exp\left(-j\, 4\pi/3\right)$$

$$\bar{I}_{Y} = \bar{I}_R \exp\left(-j\, 2\pi/3\right); \quad \bar{I}_{B} = \bar{I}_R \exp\left(-j\, 4\pi/3\right)$$



B
$\bar{V}_{BN}$
$\bar{V}_{RN}$
R
N
$\bar{V}_{YN}$
Y
Neutral
(starpoint)
$\bar{I}_B$
B
Z
Z
Z
Y
$\bar{V}_{RN}$
Z/3
$\bar{I}_R$
$\bar{V}_{RY}$
Z
$\bar{V}_{RY}$
$\bar{I}_Y$

3-phase power transmission in practice

- Constant instantaneous power (torque) in rotating machinery
- Efficient (in terms of resources to transmit a given power)
- Balanced Source ✓
  - Balanced
  - Unbalanced