



# ASCEND ELECTRONICS INC.

## 3PH XFRMer BASICS

PN004007

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SIZE

A4

FSCM NO

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004007-230719

REV

1.01

DEPARTMENT: Engineering

SCALE

non

DESIGN REFERENCE

SHEET

1 OF 7

## Brief Explaining 3-Phase Transformer Design Configuration

### Classification of Electrical Services

Alternating current electric power distribution systems can be classified by the following properties:

- Frequency: 50 Hz or 60 Hz
- Number of phases: single or three phase
- Number of wires: 2, 3, or 4 (not counting the safety ground)
- Neutral present:
- Wye connected systems have a neutral
- Delta connected systems typically do not have a neutral
- Voltage classes: (ANSI C84.1-2016)
- Low Voltage: 1000 volts or less
- Medium Voltage: greater than 1000 volts and less than 100 kV
- High Voltage: greater than 100 kV and equal to or less than 230 kV
- Extra-High Voltage: greater than 230 kV but less than 1000 kV
- Ultra-High Voltage: equal to or greater than 1000 kV

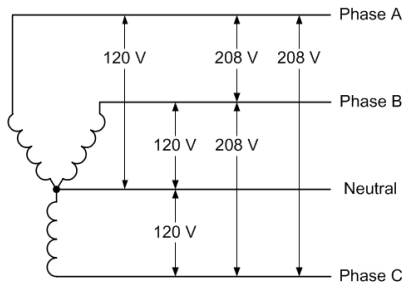
### Standard 3Phase Voltages

Wye Line-to-Neutral Voltage	Wye or Delta Line-to-Line Voltage
120V	208V
230V	400V
240V	415V
277V	480V
347V	600V

Line-to-line voltages in three phase systems are typically 1.732 times the phase-to-neutral voltages:  $\sqrt{3} = 1.732$

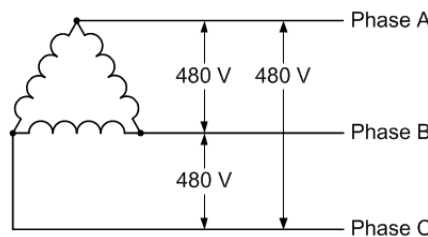
In symmetrical three-phase electrical system, the phase-to-neutral voltages should be equal if the load is balanced.

Three Phase Four Wire Wye



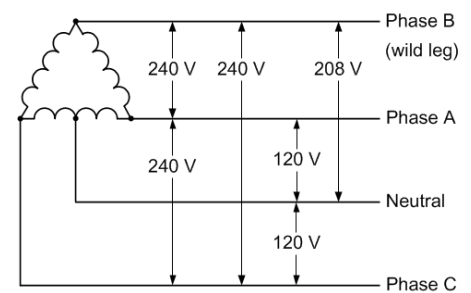
The most common commercial building electric service in North America is 120/208 volt wye, which is used to power 120 volt plug loads, lighting, and smaller HVAC systems. In larger facilities the voltage is 277/480 volt and used to power single phase 277 volt lighting and larger HVAC loads. In western Canada 347/600V is common.

Three Phase Three Wire Delta



Used primarily in industrial facilities to provide power for three-phase motor loads, and in utility power distribution applications. Nominal service voltages of 240, 400, 480, 600, and higher are typical.

Three Phase Four Wire Delta



Also known as a high-leg or wild-leg delta system. Used in older manufacturing facilities with mostly three-phase motor loads and some 120 volt single-phase lighting and plug loads. Similar to the Three Phase Three Wire Delta discussed above but with a center-tap on one of the transformer winding to create neutral for 120 volt single-phase loads. Motors are connected to phase A, B, and C, while single-phase loads are connected to either phase A or C and to neutral. Phase B, the high or wild leg, is not used as the voltage to neutral is 208 volt.

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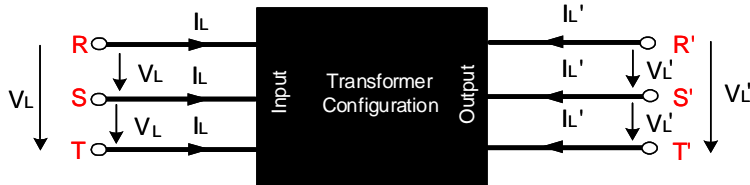
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### Transformer Information

For Symmetrical Load



### Required Information

Primary Voltage:  $V_{prim} = V_L$  [Volt]

Secondary Voltage:  $V_{sec} = V_L'$  [Volt]

Secondary Current:  $I_{sec} = I_L'$  [Ampere]

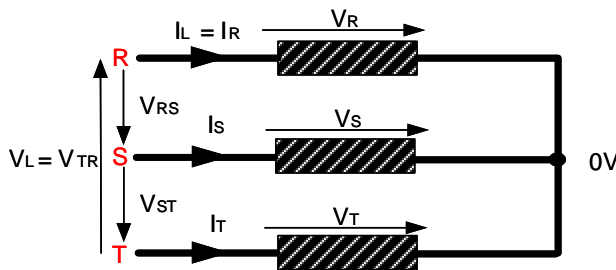
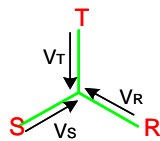
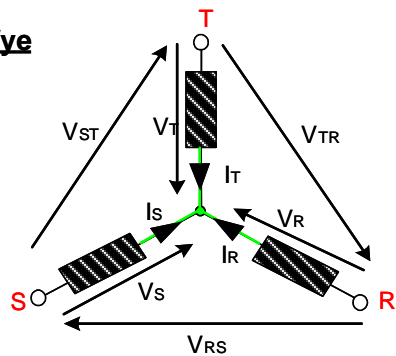
If the total True Power  $P_{TOT}$  [VA (VoltAmpere)] is given then  $I_L'$  calculates to:

$$I_L' = P_{TOT} / (\sqrt{3} * V_L)$$

Primary and Secondary Winding Configuration: Delta or Wye

### Winding Configuration

#### Wye



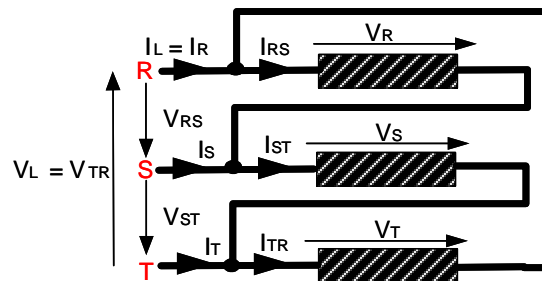
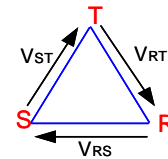
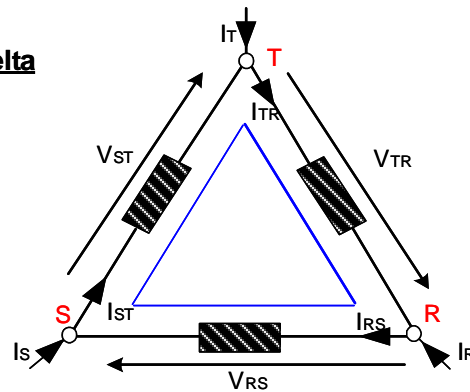
For Symmetrical Load:

$$V_L = V_{RS} = V_{ST} = V_{TR}$$

$$V_R = V_S = V_T = V_L / \sqrt{3}$$

$$I_L = I_R = I_S = I_T$$

#### Delta



For Symmetrical Load:

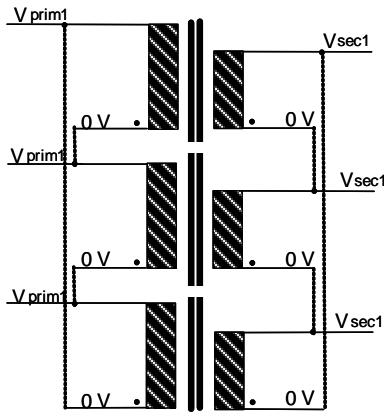
$$V_L = V_{RS} = V_{ST} = V_{TR}$$

$$V_L = V_R = V_S = V_T$$

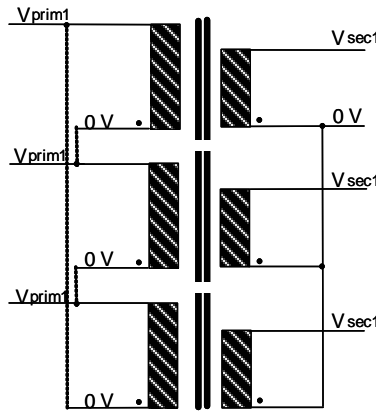
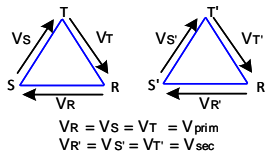
$$I_L = I_R = I_S = I_T$$

$$I_{RS} = I_{ST} = I_{TR} = I_L / \sqrt{3}$$

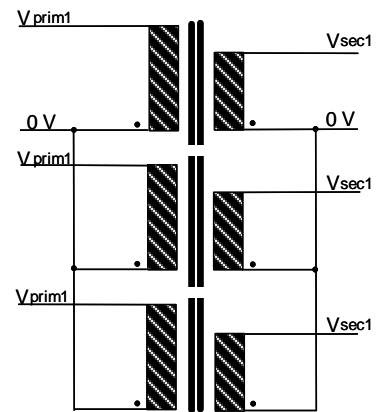
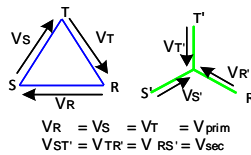
For transformer requirements with unsymmetrical Loads please note in the request form.



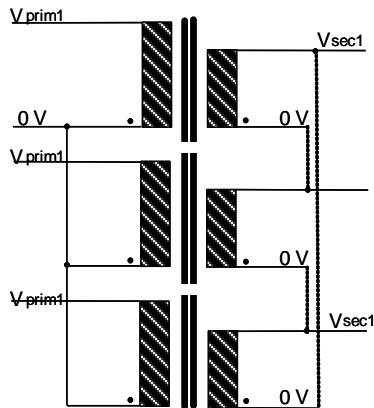
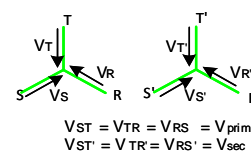
**Configuration A**  
Input Primary Delta  
Output Delta



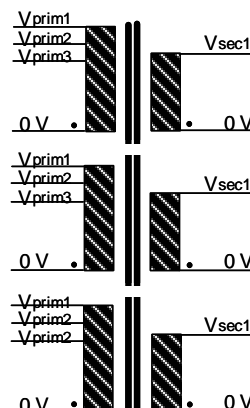
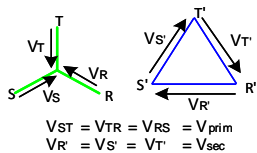
**Configuration B**  
Input Primary Wye  
Output Wye



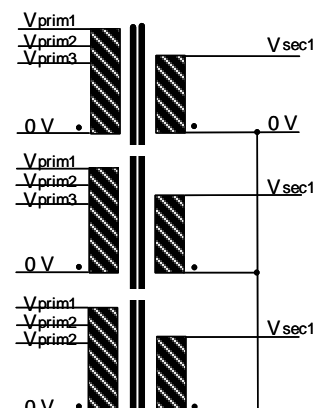
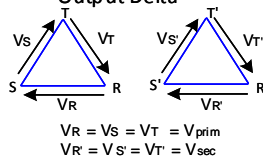
**Configuration C**  
Input Primary Wye  
Output Wye



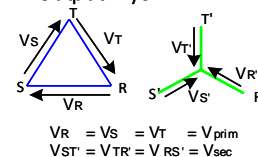
**Configuration D**  
Input Primary Wye  
Output Delta

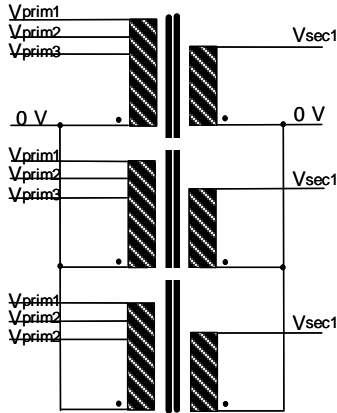


**Configuration E**  
Multiple Input Voltage  
Input Primary Delta  
Output Delta

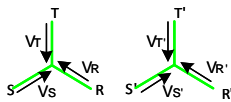


**Configuration F**  
Multiple Input Voltage  
Input Primary Delta  
Output Wye



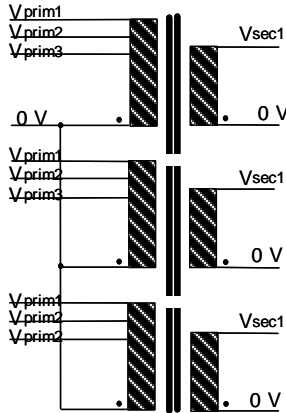


**Configuration G**  
Multiple Input Voltage  
Input Primary Wye  
Output Wye

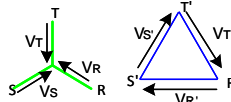


$$V_{ST} = V_{TR} = V_{RS} = V_{prim}$$

$$V_{ST'} = V_{TR'} = V_{RS'} = V_{sec}$$

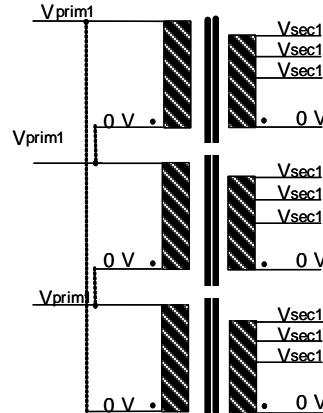


**Configuration H**  
Multiple Input Voltage  
Input Primary Wye  
Output Delta

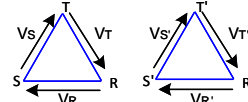


$$V_{ST} = V_{TR} = V_{RS} = V_{prim}$$

$$V_{R'} = V_{S'} = V_{T'} = V_{sec}$$

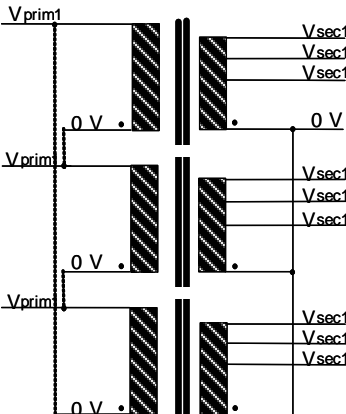


**Configuration J**  
Multiple Output Voltage  
Input Primary Delta  
Output Delta

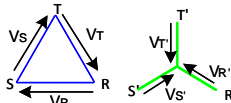


$$V_R = V_S = V_T = V_{prim}$$

$$V_{R'} = V_{S'} = V_{T'} = V_{sec}$$

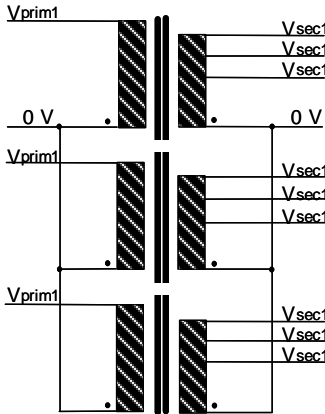


**Configuration K**  
Multiple Output Voltage  
Input Primary Delta  
Output Wye

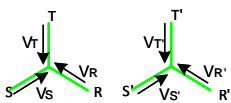


$$V_R = V_S = V_T = V_{prim}$$

$$V_{ST'} = V_{TR'} = V_{RS'} = V_{sec}$$

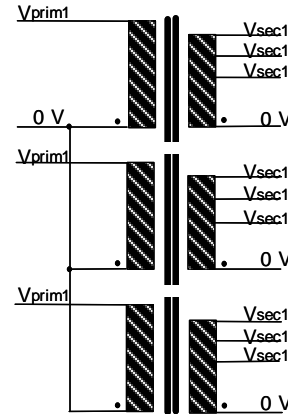


**Configuration L**  
Multiple Output Voltage  
Input Primary Wye  
Output Wye

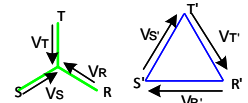


$$V_{ST} = V_{TR} = V_{RS} = V_{prim}$$

$$V_{ST'} = V_{TR'} = V_{RS'} = V_{sec}$$



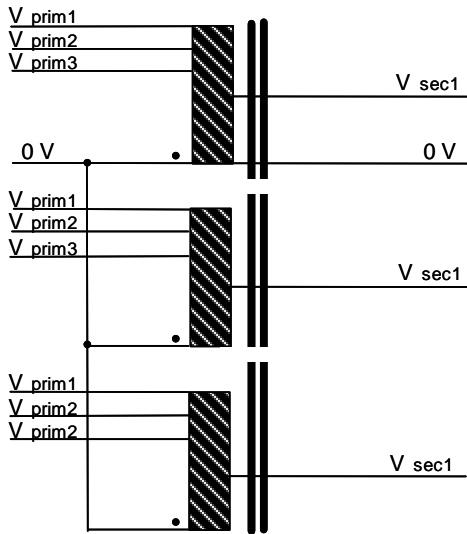
**Configuration M**  
Multiple Output Voltage  
Input Primary Wye  
Output Delta



$$V_{ST} = V_{TR} = V_{RS} = V_{prim}$$

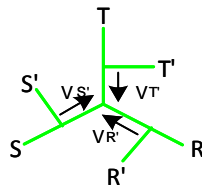
$$V_{R'} = V_{S'} = V_{T'} = V_{sec}$$

### Autotransformer 3Phase



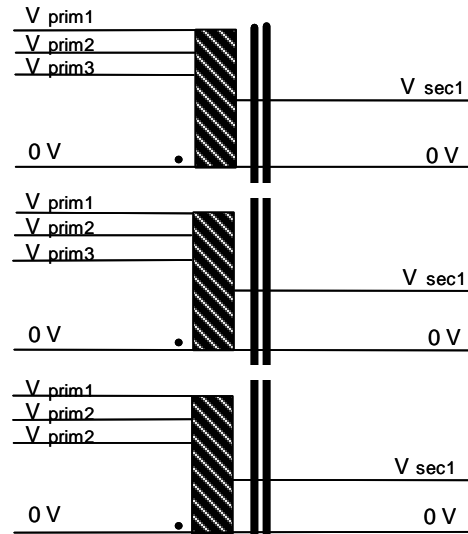
**Configuration 3A1**

One or Multiple Input Voltage  
Input Primary Wye  
Output Wye



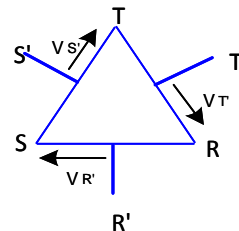
$$V_{ST} = V_{TR} = V_{RS} = V_{prim}$$

$$V_{S'T'} = V_{T'R'} = V_{R'S'} = V_{sec}$$



**Configuration 3A2**

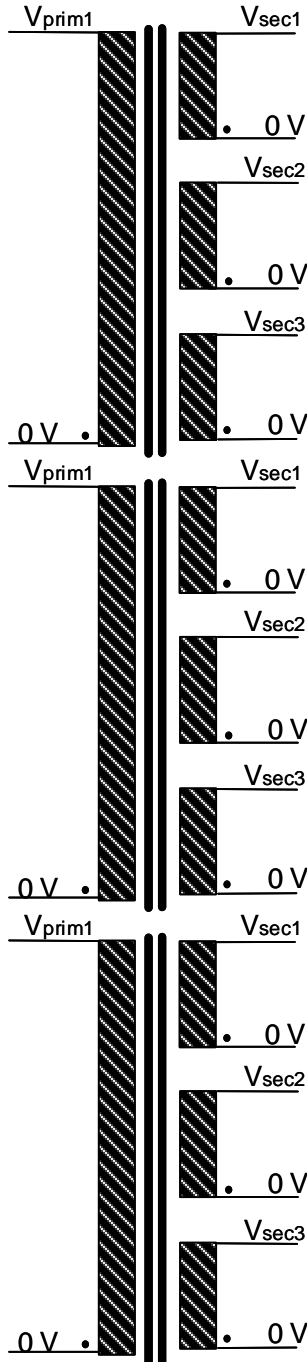
One or Multiple Input Voltage  
Input Primary Delta  
Output Delta



$$V_R = V_S = V_T = V_{prim}$$

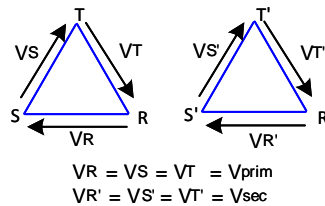
$$V_{R'} = V_{S'} = V_{T'} = V_{sec}$$

### Multi Secondary Winding 3 Phase Transformer

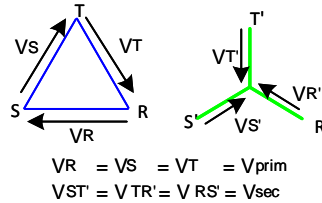


#### Configuration Mx

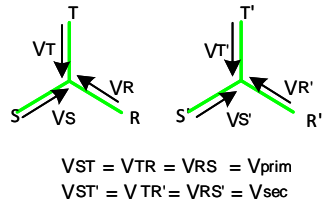
Primary and Secondary can be configured in Delta or Wy



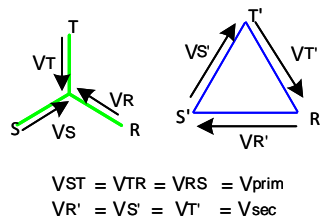
Configuration MA



Configuration MB

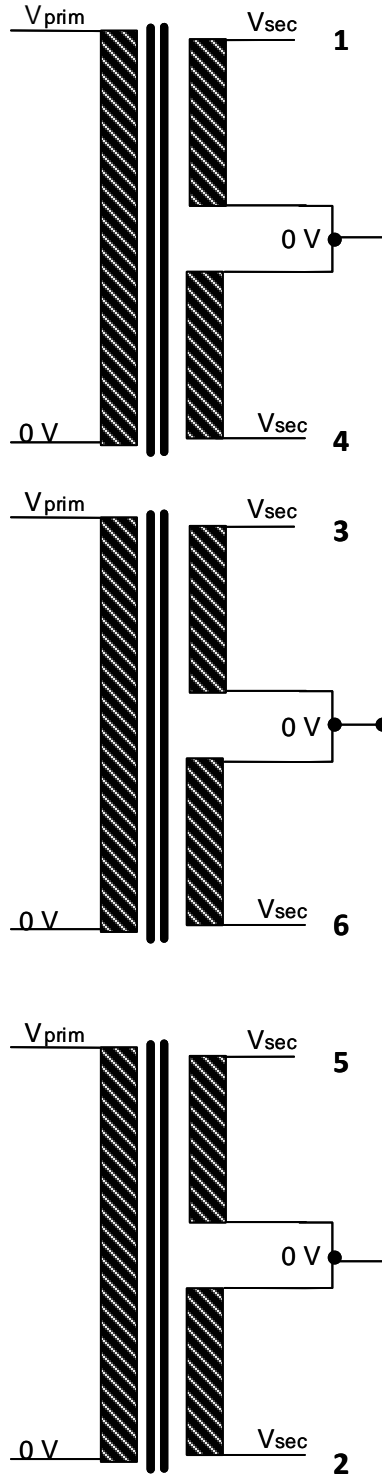


Configuration MC

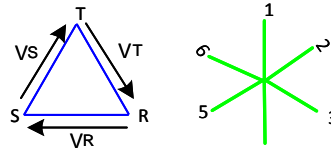


Configuration MD

Note: This drawing shows 3 Output Coils per Phase, more are possible.



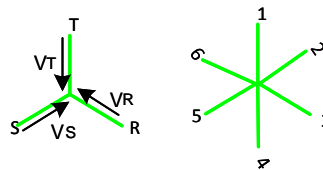
### 6 Phase Half Wave Transformer



Configuration 6A

$$V_R = V_S = V_T = V_{prim}$$

$$V_{12} = V_{23} = V_{34} = V_{45} = V_{56}$$



Configuration 6B

$$V_{ST} = V_{TR} = V_{RS} = V_{prim}$$

$$V_{12} = V_{23} = V_{34} = V_{45} = V_{56}$$

### Secondary Configuration

