Electrical Level 4

Specialty Transformers 26406-14

Objectives

When trainees have completed this lesson, they should be able to do the following:

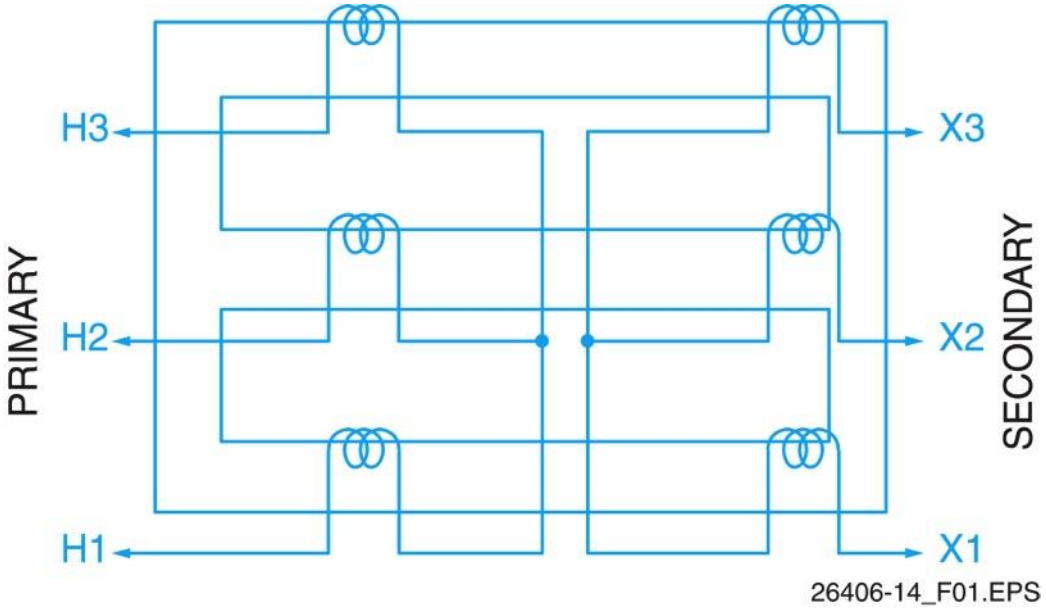
1. Identify three-phase transformer connections.
2. Identify specialty transformer applications.
3. Size and select buck-and-boost transformers.
4. Calculate and install overcurrent protection for specialty transformers.
5. Ground specialty transformers in accordance with *National Electrical Code*® (*NEC*®) requirements.
6. Calculate transformer derating to account for the effects of harmonics.

Performance Tasks

1. Identify various specialty transformers.
2. Using a clamp-on ammeter, demonstrate the principles of a current transformer. Identify the primary winding, then calculate and measure the effects of increasing the number of turns (loops) in the primary winding.
3. Connect a buck-and-boost transformer to a single-phase circuit so that it will first be in the boost mode, and then in the buck mode. Record the voltage increase and decrease for each configuration.

Introduction

- Transformers can be used in either single-phase or three-phase systems to increase or decrease the output voltage based on the ratio of turns between the primary and secondary windings.
- A three-phase transformer has three primary and three secondary windings. Three single-phase transformers can also be used.



Typical Liquid-Filled, Three-Phase Power Transformer

- The large transformers used in distribution systems are known as power transformers and are used to either step the voltage up for transmission or step it down for distribution.
- These transformers are typically liquid-filled and installed outdoors.

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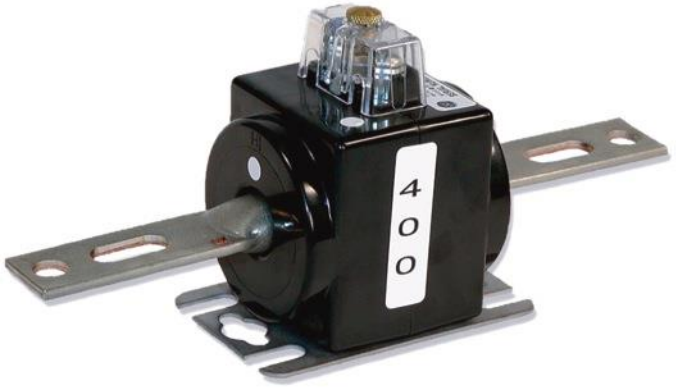
Two Types of Current Transformers

- Instrument transformers are used to step the primary circuit voltage or current down for use in electrical measuring instruments.
- With a toroid current transformer, an insulated conductor passes through the center and proportional current is induced in the toroid winding for a meter application.



BAR-TYPE CURRENT TRANSFORMER

TOROID (DONUT-TYPE)
CURRENT TRANSFORMERS

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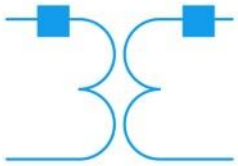
Voltage (Potential) Transformer

- A potential transformer is always connected across the line to be measured.
- In some cases, the polarity of the current must be matched between the instrument and the transformer. Typical polarity marks on electrical drawings include a small black box or a cross.

BASIC SYMBOL



POTENTIAL TRANSFORMER WITH POLARITY MARKS

600V CLASS VOLTAGE TRANSFORMER

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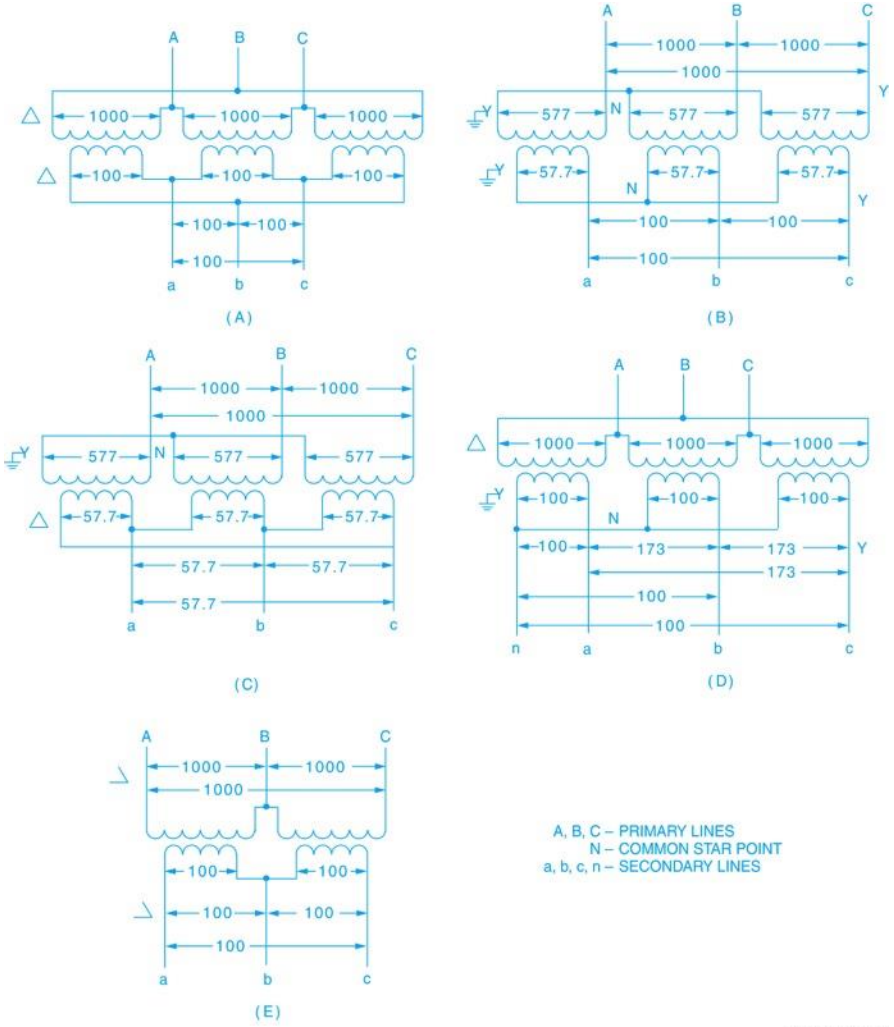
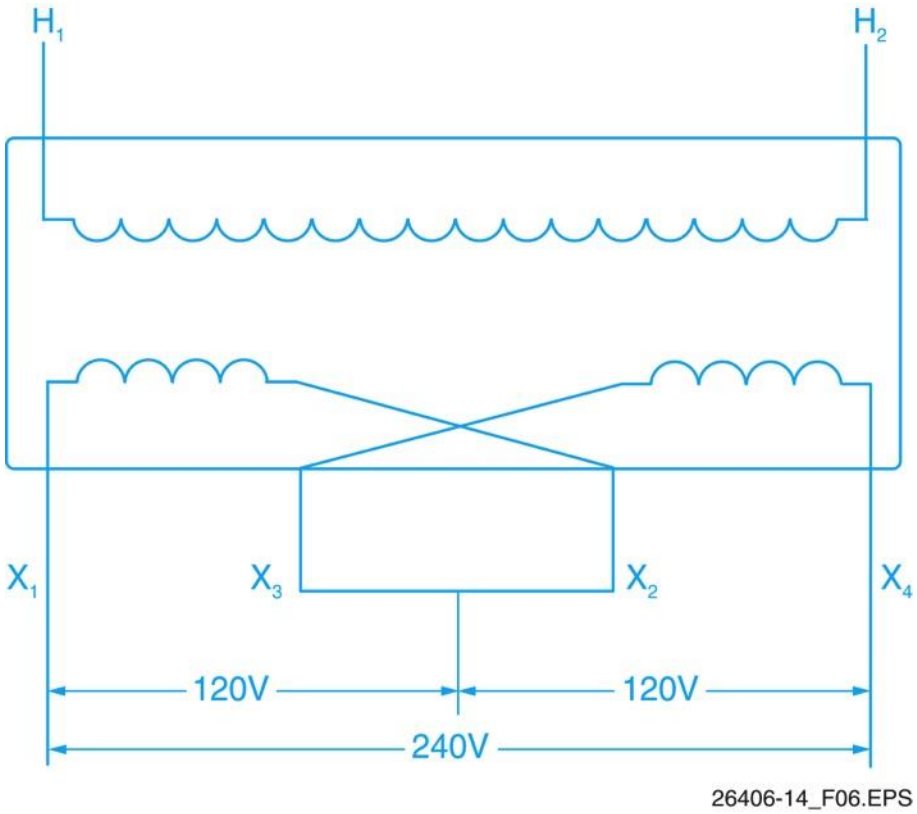
Common Power Transformer Connections

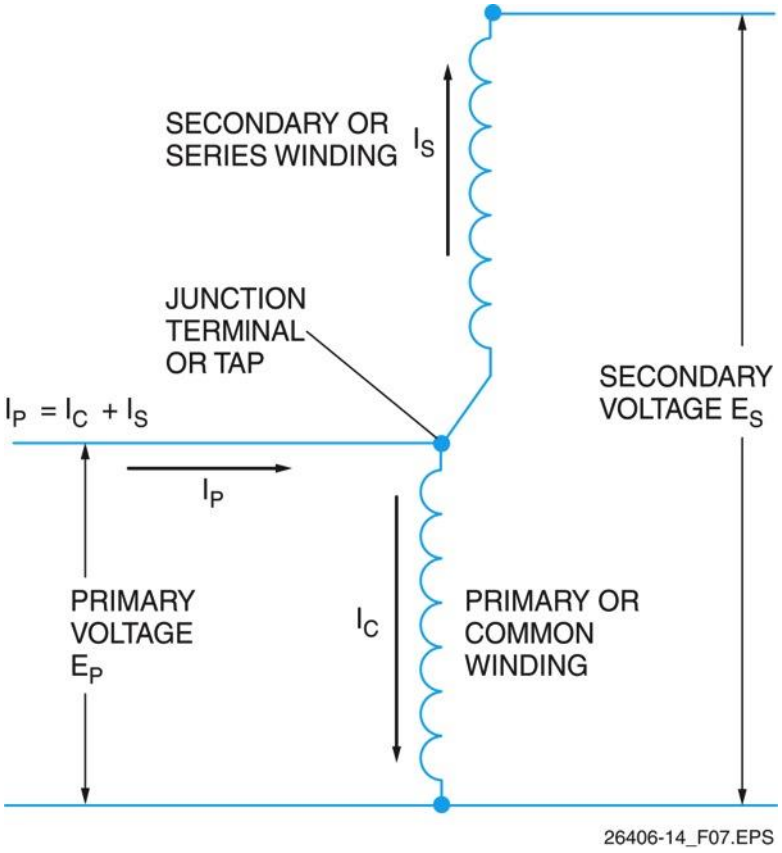


Specialty Transformers

- A single-phase transformer with two secondaries is used to provide two different output voltages, such as 240V for an electric range and dryer and 120V for lighting and appliance circuits.
- These transformers are commonly used where three-wire service is needed from a two-wire, single phase supply.

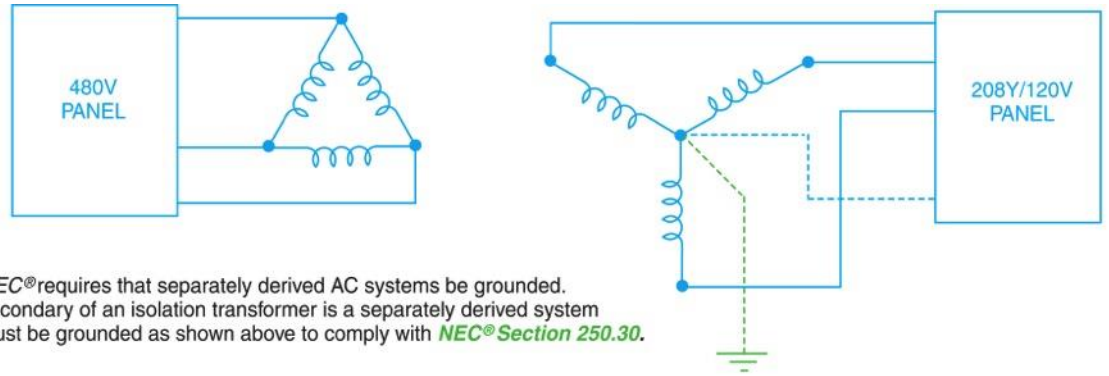


Wiring Diagram of a Typical Autotransformer

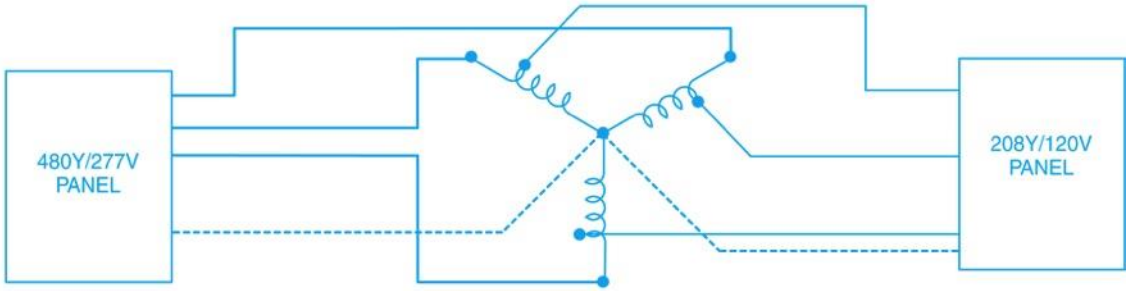


- In an autotransformer, one of the windings is connected in series with the other, forming the equivalent of a single winding.
- Autotransformers are used to make small adjustments to the distribution level, such as an increase from 208V to 240V.

NEC® Grounding Requirements for Isolation and Autotransformers



The *NEC*® requires that separately derived AC systems be grounded. The secondary of an isolation transformer is a separately derived system and must be grounded as shown above to comply with ***NEC*® Section 250.30**.



In the case of autotransformers, the grounded conductor of the supply is connected to the transformer common terminal and the ground is established to satisfy ***NEC*® Section 210.9**.

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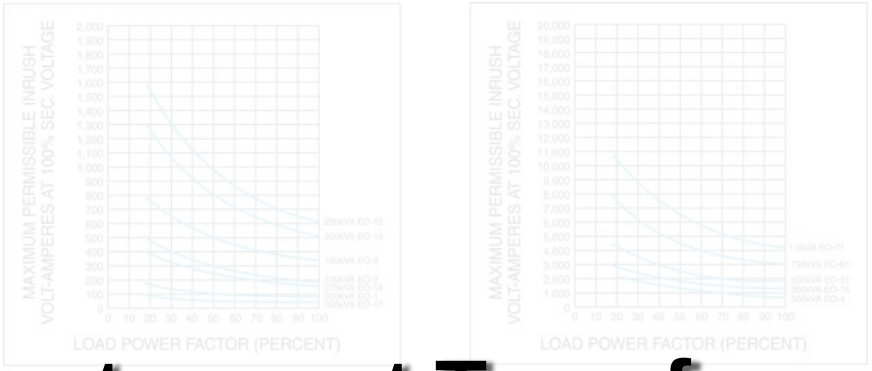
2.0.0 – 2.7.0

Next Session...

Regulation Curves



Instrument Transformers

(C) 60/50 HERTZ

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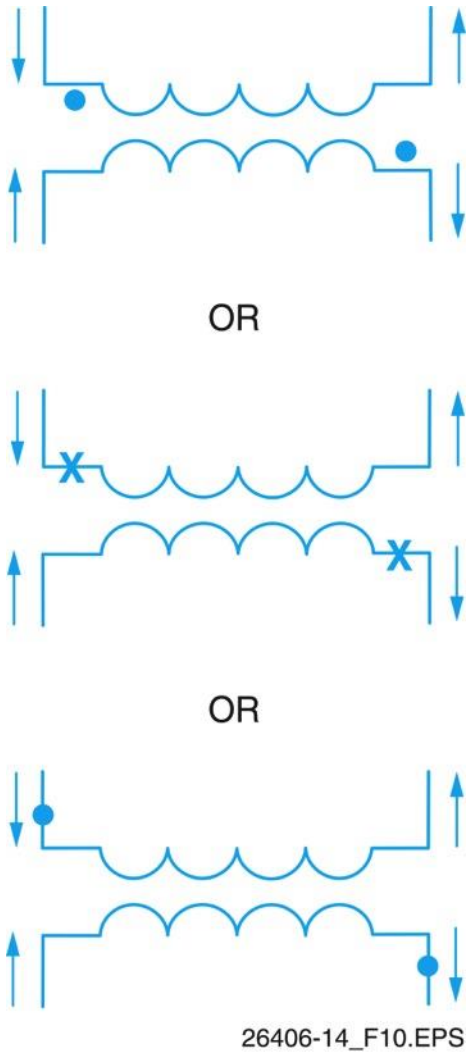
Performance Task

This session will conclude with trainees identifying various specialty transformers.

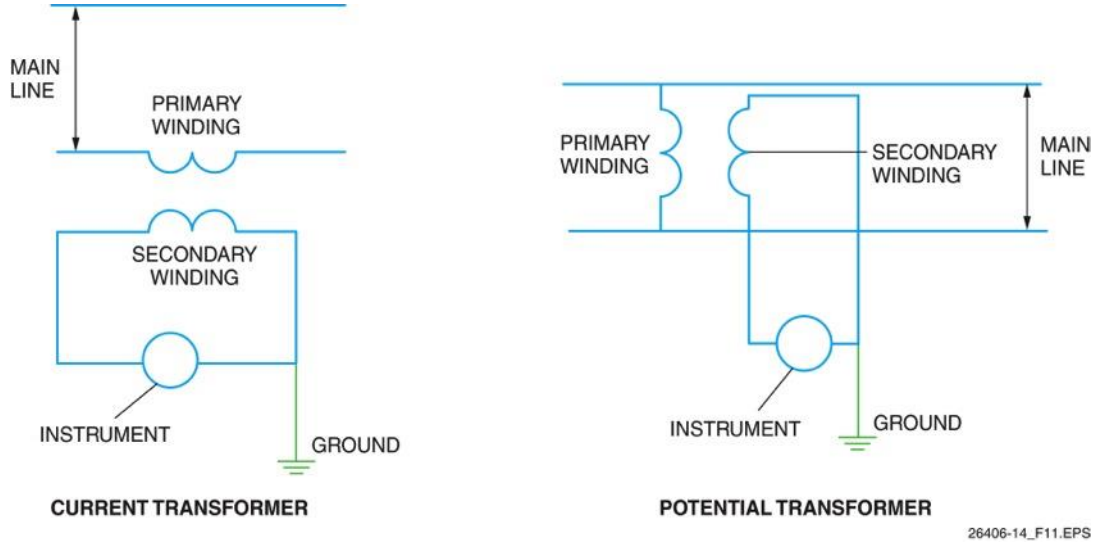


Instrument Transformers

- Instrument transformers are usually connected to an instrument such as an ammeter, voltmeter, wattmeter, or relay.
- When connecting instrument transformers to measure power or power factor, it is necessary to know the polarity of the leads. The polarity is usually indicated by a white mark or dot on the leads.

Connection of Instrument Transformers

Current transformers are single-phase, low kVA devices. The primary of a current transformer is connected in series with one of the main power lines.

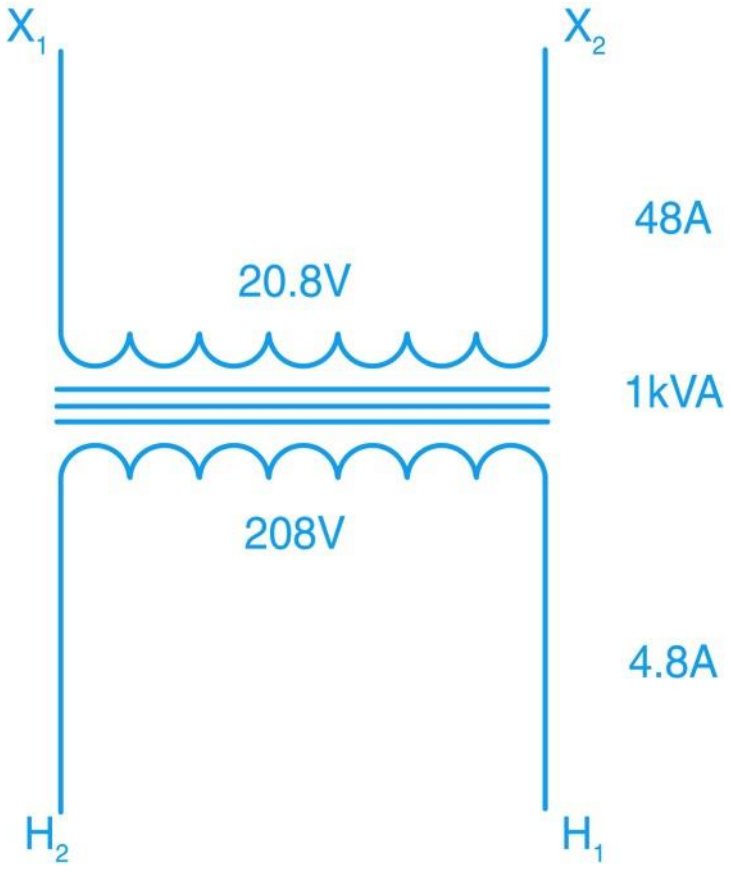


Performance Task

Have the trainees use a clamp-on ammeter to demonstrate the principles of a current transformer.

Sizing Buck-and-Boost Transformers

- Buck-and-boost transformers can handle loads that are much greater than their nameplate ratings.
- This 1kVA isolation transformer is designed to transform 208V to 20.8V, but it can be wired in series to form an autotransformer with a rating of 11kVA.



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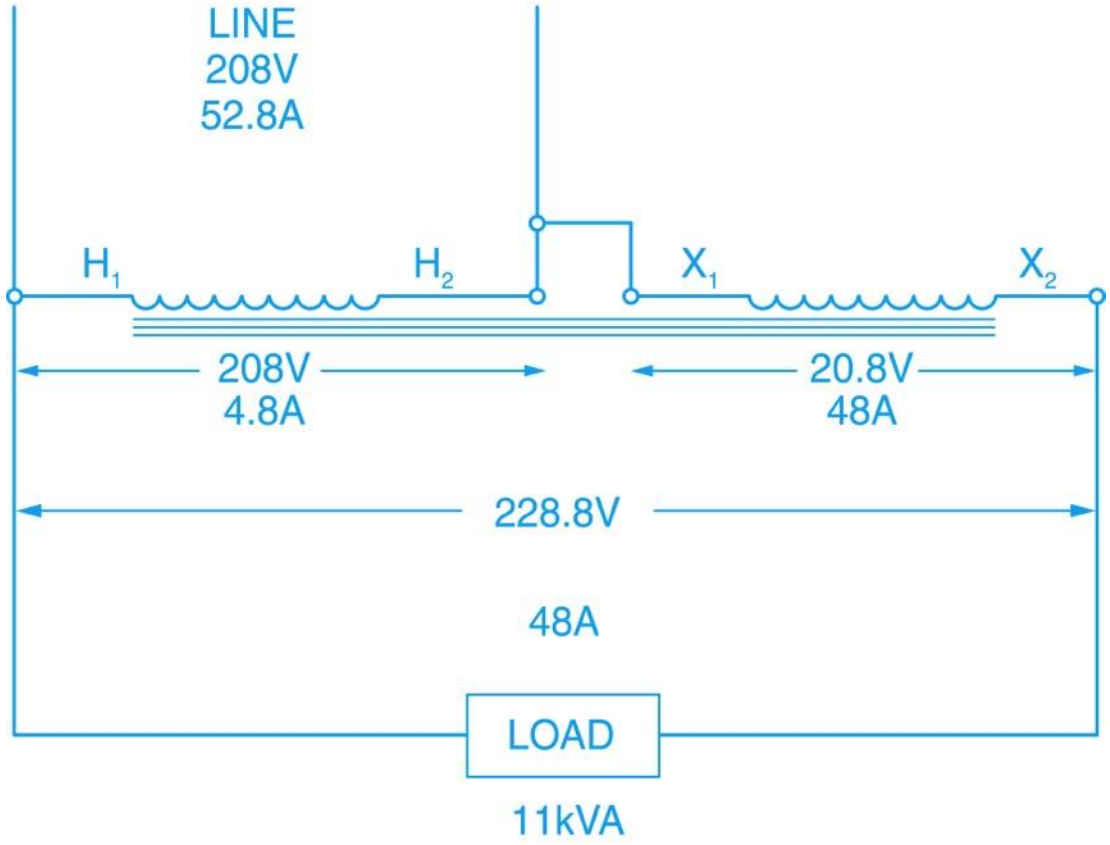
Boost Transformer Connection



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Next Session...

Harmonics

Typical Line Diagram of a Transformer Circuit

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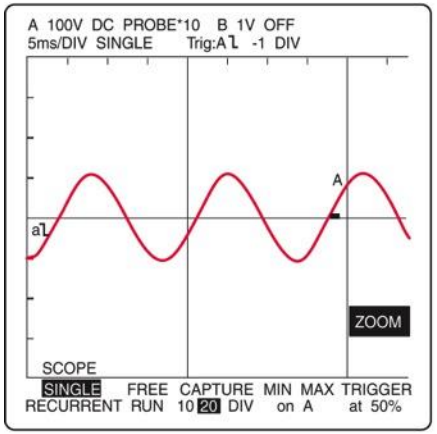
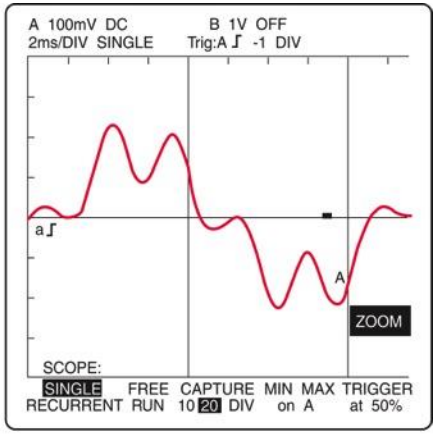
Performance Task

This session will conclude with trainees connecting a buck-and-boost transformer to a single-phase circuit so that it will be first in the boost mode and then in the buck mode.

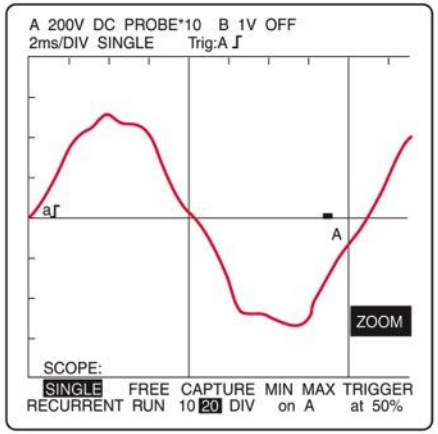
Harmonics



(A) NEAR SINE WAVE



(B) DISTORTED WAVEFORM



(C) DISTORTED WAVEFORM

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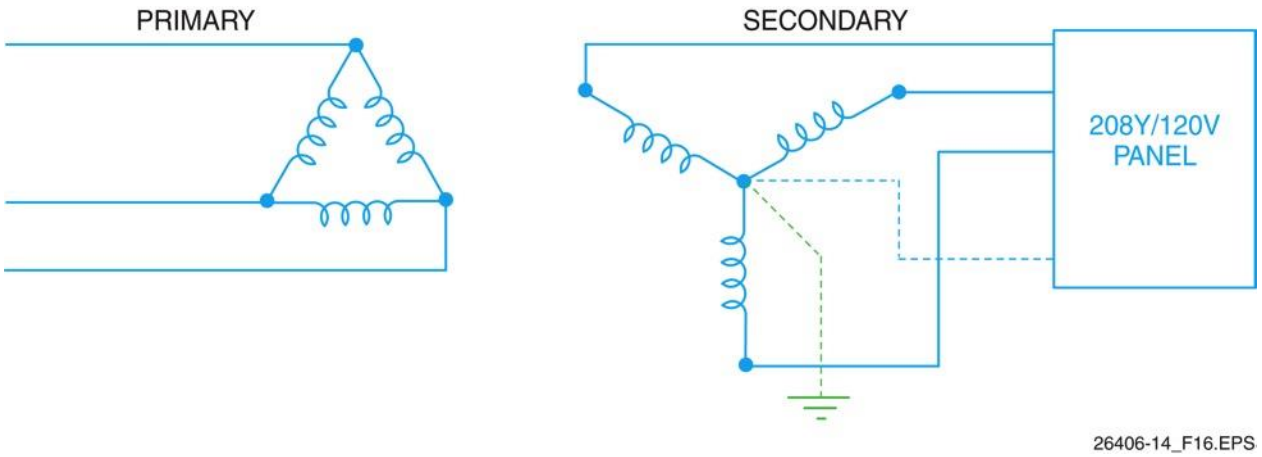
Harmonics Rates and Effects

Name	F	2nd	3rd	4th	5th	6th	7th	8th	9th
Frequency	60	120	180	240	300	360	420	480	540
Sequence	+	—	0	+	—	0	+	—	0

Sequence	Rotation	Effects (skin effect, eddy currents, etc.)
Positive	Forward	Heating of conductors and circuit breakers
Negative	Reverse	Heating as above, plus motor problems
Zero	None	Heating, plus add-in neutral of three-phase, four-wire system

Three-Phase, Delta-Wye Transformer Configuration



- Commercial buildings commonly use a 120V/208V transformer in a delta-wye configuration.
- Single-phase, nonlinear loads connected to the receptacles produce triplen harmonics that algebraically add up in the neutral and may cause the transformer to overheat or fail.

Current Measurements

Conductor Name	Multimeter (true rms)	Average Responding Multimeter	Instantaneous Peak Current
Phase 1	410A	328A	804A
Phase 2	445A	346A	892A
Phase 3	435A	355A	828A
Neutral	548A	537A	762A

- The values shown here indicate why a true rms meter must be used to test for the presence of harmonics.
- The average responding meter consistently shows values that are 20% low on all phases. The transformer should be derated to prevent overheating.

Neutral Loads

- This subpanel supplies branch circuits for the 120V loads in the previous example.
- A check of neutral No. 6 reveals 15A in a conductor rated for 16A. The phase currents of the three circuits sharing this neutral are shown in Table 4.

Neutral Conductor Number	Current (Amps)
01	5.0
02	11.3
03	5.0
04	13.1
05	12.4
06	15.0
07	1.8
08	11.7
09	4.5
10	11.8
11	9.6
12	11.5
13	11.3
14	6.7
15	7.0
16	2.3
17	2.6

Next Session…

Phase Currents and Neutral-to-Ground Voltages

Circuit Number	Phase Current	Neutral-to-Ground Voltage Drop at Receptacle
25	7.8A	3.75V
27	9.7A	4.00V
29		V

Wrap Up

- Each of the three phase currents is less than 15A and the same phase conductors have significant neutral-to-ground voltage drops.
- The neutral conductors could become overheated without tripping any breakers. Additional loads should be avoided, and extra neutrals should be added in the overloaded circuits. In addition, the load currents should be monitored using a true rms meter.

Wrap Up

3-2-1

3 – Write 3 important things learned during class

2 – Write 2 questions you have about the material

1 – Write 1 thought you had about the material

Next Session…

MODULE EXAM

Review the complete module to prepare for the module exam. Complete the Module Review as a study aid.