

Transformer Questions & Answers

1. What is a transformer and how does it work?

A transformer is an electrical apparatus designed to convert alternating current from one voltage to another. It can be designed to “step up” or “step down” voltages and works on the magnetic induction principle. A transformer has no moving parts and is a completely static solid state device, which insures, under normal operating conditions, a long and trouble-free life. It consists, in its simplest form, of two or more coils of insulated wire wound on a laminated steel core. When voltage is introduced to one coil, called the primary, it magnetizes the iron core. A voltage is then induced in the other coil, called the secondary or output coil. The change of voltage (or voltage ratio) between the primary and secondary depends on the turns ratio of the two coils.

2. What are taps and when are they used? Taps are provided on some transformers on the high voltage winding to correct for high or low voltage conditions, and still deliver full rated output voltages at the secondary terminals. Standard tap arrangements are at two-and-one-half and five percent of the rated primary voltage for both high and low voltage conditions. For example, if the transformer has a 480 volt primary and the available line voltage is running at 504 volts, the primary should be connected to the 5% tap above normal in order that the secondary voltage be maintained at the proper rating. The standard ASA and NEMA designation for taps are “ANFC” (above normal full capacity) and “BNFC” (below normal full capacity).

3. What is the difference between “Insulating,” “Isolating,” and “Shielded Winding” transformers?

Insulating and isolating transformers are identical. These terms are used to describe the isolation of the primary and secondary windings, or insulation between the two. A shielded transformer is designed with a metallic shield between the primary and secondary windings to attenuate transient noise. This is especially important in critical applications such as computers, process controllers and many other microprocessor controlled devices. All two, three and four winding transformers are of the insulating or isolating types. Only autotransformers, whose primary and secondary are connected to each other electrically, are not of the insulating or isolating variety.

4. Can transformers be operated at voltages other than nameplate voltages? In some cases, transformers can be operated at voltages below the nameplate rated voltage. In **NO** case should a transformer be operated at a voltage in excess of its nameplate rating, unless taps are provided for this purpose. When operating below the rated voltage, the kVA capacity is reduced correspondingly. For example, if a 480 volt primary transformer with a 240 volt secondary is operated at 240 volts, the secondary voltage is reduced to 120 volts. If the transformer was originally rated 10 kVA, the reduced rating would be 5 kVA, or in direct proportion to the applied voltage.

5. Can 60 Hz transformers be operated at 50 Hz?

ACME transformers rated below 1 kVA can be used on 50 Hz service. Transformers 1 kVA and larger, rated at 60 Hz, should not be used on 50 Hz service, due to the higher losses and resultant heat rise. Special designs are required for this service. However, any 50 Hz transformer will operate on a 60 Hz service.

6. Can transformers be used in parallel? Single phase transformers can be used in parallel only when their impedances and voltages are equal. If unequal voltages are used, a circulating current exists in the closed network between the two transformers, which will cause excess heating and result in a shorter life of the transformer. In addition, impedance values of each transformer must be within 7.5% of each other. For example: Transformer A has an impedance of 4%, transformer B which is to be parallel to A must have an impedance between the limits of 3.7% and 4.3%. When paralleling three phase transformers, the same precautions must be observed as listed above, plus the angular displacement and phasing between the two transformers must be identical.

7. Can Acme Transformers be reverse connected?

ACME dry-type distribution transformers can be reverse connected without a loss of kVA rating, but there are certain limitations. Transformers rated 1 kVA and larger single phase, 3 kVA and larger three phase can be reverse connected without any adverse effects or loss in kVA capacity. The reason for this limitation in kVA size is, the turns ratio is the same as the voltage ratio. Example: A transformer with a 480 volt input, 240 volt output— can have the output connected to a 240 volt source and thereby become the primary or input to the transformer, then the original 480 volt primary winding will become the output or 480 volt secondary. On transformers rated below 1 kVA single phase, there is a turns ratio compensation on the low voltage winding. This means the low voltage winding has a greater voltage than the nameplate voltage indicates at no load. For example, a small single phase transformer having a nameplate voltage of 480 volts primary and 240 volts secondary, would actually have a no load voltage of approximately 250 volts, and a full load voltage of 240 volts. If the 240 volt winding were connected to a 240 volt source, then the output voltage would consequently be approximately 460 volts at no load and approximately 442 volts at full load. As the kVA becomes smaller, the compensation is greater— resulting in lower output voltages. When one attempts to use these transformers in reverse, the transformer will not be harmed; however, the output voltage will be lower than is indicated by the nameplate.

8. Can a Single Phase Transformer be used on a Three Phase source? Yes. Any single phase transformer can be used on a three phase source by connecting the primary leads to any two wires of a three phase system, regardless of whether the source is three phase 3-wire or three phase 4-wire. The transformer output will be single phase.

9. Can Transformers develop Three Phase power from a Single Phase source? No. Phase converters or phase shifting devices such as reactors and capacitors are required to convert single phase power to three phase.

10. How do you select transformers?

- (1) Determine primary voltage and frequency.
- (2) Determine secondary voltage required.
- (3) Determine the capacity required in volt-amperes.

This is done by multiplying the load current (amperes) by the load voltage (volts) for single phase. For example: if the

load is 40 amperes, such as a motor, and the secondary voltage is 240 volts, then 240 x 40 equals 9600 VA. A 10 kVA (10,000 volt-amperes) transformer is required. ALWAYS SELECT THE TRANSFORMER LARGER THAN THE ACTUAL LOAD. This is done for safety purposes and allows for expansion, in case more load is added at a later date. For 3 phase kVA, multiply rated volts x load amps x 1.73 (square root of 3) then divide by 1000.

- (4) Determine whether taps are required. Taps are usually specified on larger transformers.
- (5) Use the selection charts in Section I.

11. What terminations are provided? Primary and Secondary Terminations are provided on ACME Dry-Type Transformers as follows:

- No lugs—lead type connection on
 - 0-25 kVA single phase
 - 0-15 kVA three phase
- Bus-bar terminations
 - (drilled to NEMA standards)
 - 37.5-250 kVA single phase
 - 25-500 kVA three phase

12. Can 60 Hz transformers be used at higher frequencies?

ACME transformers can be used at frequencies above 60 Hz up through 400 Hz with no limitations provided nameplate voltages are not exceeded. However, 60 Hz transformers will have less voltage regulation at 400 Hz than 60 Hz.

13. What is meant by regulation in a transformer?

Voltage regulation in transformers is the difference between the no load voltage and the full load voltage. This is usually expressed in terms of percentage. For example: A transformer delivers 100 volts at no load and the voltage drops to 95 volts at full load, the regulation would be 5%. ACME dry-type distribution transformers generally have regulation from 2% to 4%, depending on the size and the application for which they are used.

14. What is temperature rise in a transformer?

Temperature rise in a transformer is the temperature of the windings and insulation above the existing ambient or surrounding temperature.

15. What is “Class” in insulation? Insulation class was the original method used to distinguish insulating materials operating at different temperature levels. Letters were used for different designations. Letter classifications have been replaced by insulation system temperatures in degrees Celsius. The system temperature is the maximum temperature at the hottest spot in the winding (coil). Graphical representations of six insulation systems recognized by Underwriters’ Laboratories, Inc. are shown in Figure A. These systems are used by Acme for a large part of the product line.

16. Is one insulation system better than another?

Not necessarily. It depends on the application and the cost benefit to be realized. Higher temperature class insulation systems cost more and larger transformers are more expensive to build. Therefore, the more expensive insulation systems are more likely to be found in the larger kVA units.

Referring to Figure A, small fractional kVA transformers use

insulation class 130°C. Compound filled transformers use insulation class 180°C. Larger ventilated transformers are designed to use 220°C insulation. All of these insulation systems will normally have the same number of years operating life. A well designed transformer, observing these temperature limits, will have a life expectancy of 20-25 years.

17. Why should Dry-Type Transformers never be overloaded? Overloading of a transformer results in excessive temperature. This excessive temperature causes overheating which will result in rapid deterioration of the insulation and cause complete failure of the transformer coils.

18. Are temperature rise and actual surface temperature related? No. This can be compared with an ordinary light bulb. The filament temperature of a light bulb can exceed 2000 degrees, yet the surface temperature of the bulb is low enough to permit touching with bare hands.

19. What is meant by “impedance” in transformers?

Impedance is the current limiting characteristic of a transformer and is expressed in percentage.

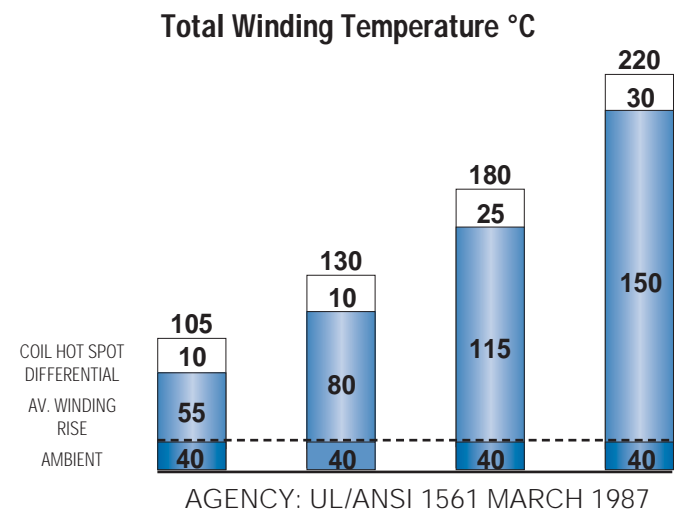


Figure A

20. Why is impedance important? It is used for determining the interrupting capacity of a circuit breaker or fuse employed to protect the primary of a transformer. **Example:** Determine a minimum circuit breaker trip rating and interrupting capacity for a 10 kVA single phase transformer with 4% impedance, to be operated from a 480 volt 60 Hz source.

Calculate as follows:

$$\begin{aligned} \text{Normal Full Load Current} &= \\ \frac{\text{Nameplate Volt Amps}}{\text{Line Volts}} &= \frac{10,000 \text{ VA}}{480 \text{ V}} = \\ &= 20.8 \text{ Amperes} \end{aligned}$$

$$\begin{aligned} \text{Maximum Short Circuit Amps} &= \\ \frac{\text{Full Load Amps}}{4\%} &= \frac{20.8 \text{ Amps}}{4\%} = \\ &= 520 \text{ Amps} \end{aligned}$$

The breaker or fuse would have a minimum interrupting rating of 520 amps at 480 volts.

Example: Determine the interrupting capacity, in amperes, of a circuit breaker or fuse required for a 75 kVA, three phase transformer, with a primary of 480 volts delta and secondary of 208Y/120 volts. The transformer impedance (Z) = 5%. If the secondary is short circuited (faulted), the following capacities are required:

$$\text{Normal Full Load Current} = \frac{\text{Volt Amps}}{\sqrt{3} \times \text{Line Volts}} = \frac{75,000 \text{ VA}}{\sqrt{3} \times 480 \text{ V}} = 90 \text{ Amps}$$

$$\text{Maximum Short Circuit Line Current} = \frac{\text{Full Load Amps}}{5\%} = \frac{90 \text{ Amps}}{5\%} = 1,800 \text{ Amps}$$

The breaker or fuse would have a minimum interrupting rating of 1,800 amps at 480 volts.

NOTE: The secondary voltage is not used in the calculation. The reason is the primary circuit of the transformer is the only winding being interrupted.

21. Can Single Phase Transformers be used for Three Phase applications? Yes. Three phase transformers are sometimes not readily available whereas single phase transformers can generally be found in stock. Three single phase transformers can be used in delta connected primary and wye or delta connected secondary. They should never be connected wye primary to wye secondary, since this will result in unstable secondary voltage. The equivalent three phase capacity when properly connected of three single phase transformers is three times the nameplate rating of each single phase transformer. For example: Three 10 kVA single phase transformers will accommodate a 30 kVA three phase load.

22. Does ACME provide “Zig-Zag” Grounding Transformers? Yes.

Please refer to Page 31 for a special diagram which can be used to connect standard single phase off-the-shelf transformers in a three phase zig-zag manner. This system can be used for either grounding or developing a fourth wire from a three phase neutral. An example would be to change a 480 V — three phase — three wire system to a 480Y/277 V — three phase — four wire system.

23. What color are ACME Dry-Type Transformers?

ASA 61 (NEMA) light gray is used on all enclosed transformers from .050 to 1000 kVA.

24. How do you select a transformer to operate in an ambient higher than 40° centigrade?

When the ambient exceeds 40°C use the following chart for de-rating standard transformers.

Maximum Ambient Temperature	Maximum Percentage of Loading
40°C (104°F)	100%
50°C (122°F)	92%
60°C (140°F)	84%

Instead of ordering custom built transformers to operate in ambients higher than 40°C, it is more economical to use a standard transformer of a larger kVA rating.

25. Can transformers listed in this catalog be reconnected as autotransformers to increase their kVA rating? Several standard single phase transformers listed in this catalog can be connected as autotransformers. The kVA capacity will be greatly increased when used as an autotransformer, in comparison to the nameplate kVA as an insulating transformer. Examples of autotransformer applications are changing 600 volts to 480 volts in either single phase or three phase; changing 480 volts to 240 volts single or three phase or vice versa; or the developing of a fourth wire (neutral) from a 480 volt three phase three wire system for obtaining 277 volts single phase. This voltage is normally used for operating fluorescent lamps or similar devices requiring 277 volts. For further details showing kVA and voltage combinations for various autotransformer connections refer to Page 30 and 31 in this catalog.

26. Are ACME Transformers shown in this catalog U.L. Listed? All of the transformers, with few exceptions, are listed by Underwriters' Laboratories and have met their rigorous requirements. We are also prepared to have transformers, which are not presently listed, submitted for listing to Underwriters' upon the customer's request. Please contact the factory for details.

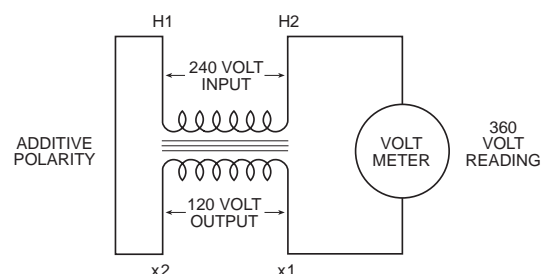
27. Is CSA certification available for transformers shown in this catalog? Most ACME transformers shown in this catalog are certified by Canadian Standards Association. They have been designed and tested in accordance with the latest specifications. Please contact the factory if further details are required.

28. What is BIL and how does it apply to transformers listed in this catalog?

BIL is an abbreviation for Basic Impulse Level. Impulse tests are dielectric tests that consist of the application of a high frequency steep wave front voltage between windings, and between windings and ground. The Basic Impulse Level of a transformer is a method of expressing the voltage surge (lightning, switching surges, etc.) that a transformer will tolerate without breakdown. All transformers manufactured in this catalog, 600 volts and below, will withstand the NEMA standard BIL rating, which is 10 KV. This assures the user that he will not experience breakdowns when his system is properly protected with lightning arrestors or similar surge protection devices.

29. What is polarity, when associated with a transformer?

Polarity is the instantaneous voltage obtained from the primary winding in relation to the secondary winding. Transformers 600 volts and below are normally connected in additive polarity — that is, when tested the terminals of the high voltage and low voltage windings on the left hand side are connected together, refer to diagram below. This leaves one high voltage and



one low voltage terminal unconnected. When the transformer is excited, the resultant voltage appearing across a voltmeter will be the sum of the high and low voltage windings. This is useful when connecting single phase transformers in parallel for three phase operations. Polarity is a term used only with single phase transformers.

30. What is exciting current? Exciting current, when used in connection with transformers, is the current or amperes required for excitation. The exciting current on most lighting and power transformers varies from approximately 10% on small sizes of about 1 kVA and smaller to approximately .5% to 4% on larger sizes of 750 kVA. The exciting current is made up of two components, one of which is a real component and is in the form of losses or referred to as no load watts; the other is in the form of reactive power and is referred to as kVAR.

31. Will a transformer change Three Phase to single phase?

A transformer will not act as a phase changing device when attempting to change three phase to single phase. There is no way that a transformer will take three phase in and deliver single phase out while at the same time presenting a balanced load to the three phase supply system. There are, however, circuits available to change three phase to two phase or vice versa using standard dual wound transformers. Please contact the factory for two phase applications.

32. Can air cooled transformers be applied to motor loads?

This is an excellent application for air cooled transformers. Even though the inrush or starting current is five to seven times normal running current, the resultant lower voltage caused by this momentary overloading is actually beneficial in that a cushioning effect on motor starting is the result. The tables on Pages 11 and 12 illustrate some typical transformer requirements for use with motor applications.

33. How is an Acme Drive Isolation Transformer (DIT) different than a General Purpose Transformer?

DITs, as the name implies, are designed to be used with motor drives (AC and DC) and to provide isolation from the service line. They are specifically designed to withstand the "short circuit like" duty imposed by the firing of the thyristors. Harmonics generated by drives create added loads on the transformer. Therefore, it is important that a transformer of equal or greater kVA to that recommended by the drive manufacturer be installed for a particular motor application.

34. How are transformers sized to operate Three Phase induction type squirrel cage motors? The minimum transformer kVA rating required to operate a motor is calculated as follows:

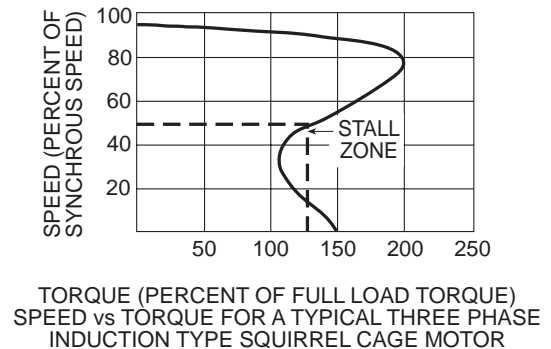
$$\text{Minimum Transformer kVA} = \frac{\text{Running Load Amperes} \times 1.73 \times \text{Motor Operating Voltage}}{1000}$$

NOTE: If motor is to be started more than once per hour add 20% additional kVA.

Care should be exercised in sizing a transformer for an induction type squirrel cage motor as when it is started, the lock rotor amperage is approximately 5 to 7 times the running load amperage. This severe starting overload will result in a drop of the transformer output voltage. When the

voltage is low the torque and the horsepower of the motor will drop proportionately to the square of the voltage. For example: If the voltage were to drop to 70% of nominal, then motor horsepower and torque would drop to 70% squared or 49% of the motor nameplate rating.

If the motor is used for starting a high torque load, the motor may stay at approximately 50% of normal running speed as illustrated by the graph below:



The underlying problem is low voltage at the motor terminals. If the ampere rating of the motor and transformer overcurrent device falls within the motor's 50% RPM draw requirements, a problem is likely to develop. The overcurrent device may not open under intermediate motor ampere loading conditions. Overheating of the motor and/or transformer would occur, possibly causing failure of either component.

This condition is more pronounced when one transformer is used to power one motor and the running amperes of the motor is in the vicinity of the full load ampere rating of the transformer. The following precautions should be followed:

- (1) When one transformer is used to operate one motor, the running amperes of the motor should not exceed 65% of the transformer's full load ampere rating.
- (2) If several motors are being operated from one transformer, avoid having all motors start at the same time. If this is impractical, then size the transformer so that the total running current does not exceed 65% of the transformer's full load ampere rating.

35. Why are Small Distribution Transformers not used for Industrial Control Applications?

Industrial control equipment demands a momentary overload capacity of three to eight times normal capacity. This is most prevalent in solenoid or magnetic contactor applications where inrush currents can be three to eight times as high as normal sealed or holding currents but still maintain normal voltage at this momentary overloaded condition. Distribution transformers are designed for good regulation up to 100 percent loading, but their output voltage will drop rapidly on momentary overloads of this type making them unsuitable for high inrush applications.

Industrial control transformers are designed especially for maintaining a high degree of regulation even at eight times normal load. This results in a larger and generally more expensive transformer. For a complete listing of ACME industrial control transformers, refer to Section V.

36. Can 4-Winding Single Phase Transformer be auto-connected? Yes. There are occasions where 480 volts single phase can be stepped down to 240 volts single phase by autoconnecting a standard 4-winding isolating transformer as shown in Figure 1. If connected in this manner, the nameplate kVA is doubled. For example: A 10 kVA load can be applied to a 5 kVA 4-winding transformer if connected per Figure 1.

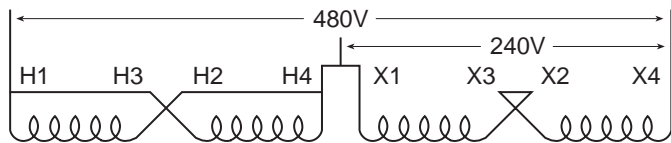


Figure 1

37. What about balanced loading on Three Phases?

Each phase of a three phase transformer must be considered as a single phase transformer when determining loading. For example: A 45 kVA three phase transformer with a 208Y/120 volt secondary is to service 4 loads at 120 volts single phase each. These loads are 10 kVA, 5 kVA, 8 kVA, and 4 kVA.

NOTE: that maximum loading on any phase does not exceed 10 kVA. Each phase has a 15 kVA capacity.

$$\frac{45 \text{ kVA}}{3 \text{ phase}} = 15 \text{ kVA per phase}$$

If incorrect method is used, phase B will have an 18 kVA load which is 3 kVA above its normal capacity of 15 kVA and failure will result even though we only have a total load of 27 kVA on a 45 kVA transformer.

Enclosure Definitions

Type 1 Enclosures — are intended for indoor use, primarily to provide a degree of protection against contact with the enclosed equipment.

Type 2 Enclosures — are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling water and dirt.

Type 3R Enclosures — are intended for outdoor use, primarily to provide a degree of protection against falling rain, sleet and external ice formation.

Definitions Pertaining to Enclosures

Ventilated — means constructed to provide for circulation of external air through the enclosure to remove excess heat, fumes or vapors.

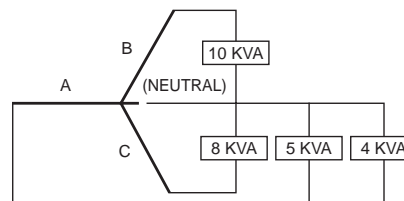
Non-Ventilated — means constructed to provide no intentional circulation of external air through the enclosure.

Indoor Locations — are those areas protected from exposure to the weather.

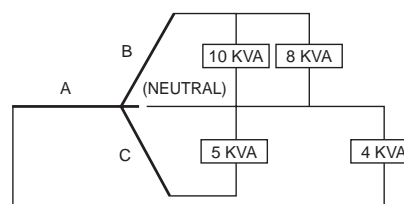
Outdoor Locations — are those areas exposed to the weather.

Hazardous (Classified) Locations — are those areas, which may contain hazardous (classified) materials in sufficient quantity to create an explosion. See Article 500 of The National Electrical Code.

38. What is meant by “Balanced Loading” on Single Phase Transformer applications? Since most single phase transformers have a secondary voltage of 120/240, they will be operated as a three wire system. Care must be taken in properly distributing the load as the transformer secondary consists of 2 separate 120 volt windings. Each 120 volt winding is rated at one-half the nameplate kVA rating. For example: A 10 kVA transformer, 120/240 volt secondary is to service an 8 kVA load at 240 volts and two 1 kVA loads at 120 volts each.

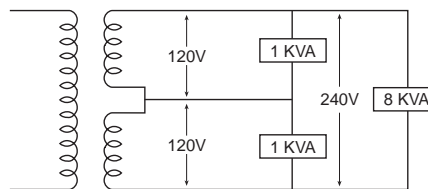


CORRECT WAY:

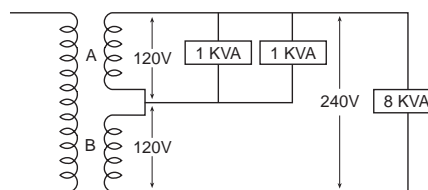


INCORRECT WAY:

If the incorrect method is used, winding A will be loaded at 6 kVA, and winding B will be loaded at 4 kVA. These do total 10 kVA but, since each winding is only rated at 5 kVA (1/2 of nameplate rating), we have an overloaded transformer and a certain failure.



CORRECT WAY:



INCORRECT WAY:

39. What are typical applications for transformers?

ACME transformers should be specified to:

- (1) Distribute power at high voltage.
- (2) Eliminate double wiring.
- (3) Operate 120 volt equipment from power circuits.
- (4) Insulate circuits/establish separately derived circuits.
- (5) Provide 3-wire secondary circuits.
- (6) Buck and Boost (See Section VII).
- (7) Provide electrostatic shielding for transient noise protection.