Which are the typical applications for transformers?

The typical applications are:

- Distribute power at high voltage
- Eliminate double wiring
- Operate 120 volt equipment from power circuits
- Isolate electrical circuits
- Separately establish branch circuits
- Provide 3 wire secondary circuits
- Buck Boost connexion
- Provide electrostatic shielding for transient noise protection

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 in a distribution network, and still deliver full rated output voltages at the secondary terminals. Standard tap arrangements are at 2.5% and 5% of the rated primary voltage for both high and low voltage conditions. For example, if the transformer has a 600 volts primary and the available line voltage is running at 630 volts, the primary should be connected to the 5% tap above normal in order that the secondary voltage is maintained at the proper rating. The standard ASA and NEMA designation for taps are Full Capacity Above Normal (FCAB) and Full Capacity Below Normal (FCBN).

Can transformers be used in parallel?

Single phase transformers can be used in parallel only when their impedances and voltages are equal, and the connecting cables are identical in gauge and length. 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% and "transformer B", which is to be parallel to "transformer 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.

Can the transformers be combined for redundant (back-up) operation?

The transformers may be paralleled to provide redundant operation, enabling one unit to "stand-in" in the event of a secondary circuit fault on the other connected power supply. As is the case for parallel connections connected to provide increased power capacity, only identical units may be combined, and output voltage settings and load cable gauge and length must match. In addition, the user may elect to connect a diode array at the output terminals of the two units to reduce the likelihood of back-feeding in the event of a unit failure.

Can a single phase transformer be used on a three phase source?

Yes. Single phase transformers may be used in a three phase application in one of the following ways:

- Connect the primary leads to any two wires of the three phase source to obtain a single phase output using a single transformer, regardless of whether the source is three phase 3-wires or three phase 4-wires. The transformer output will be single phase. Care must be used to ensure transformer loading does not create a phase imbalance on the source.
- Bank three single phase transformers to be connected in either a delta-delta or delta-wye configuration for a three phase output. 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 is three times the nameplate rating of each individual single phase transformer. Advantages to banking single phase units are:
  - They are normally available from local stocks
  - Offer greater application flexibility
  - In the event of a failure of one unit in a delta-delta connection, the other transformers can be made to operate in open delta service at 57% of normal bank capacity

While banking two or three single phase transformers in a three phase bank is often expedient, it is more expensive than using one three phase transformer.

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 system to three phase system. Today variable speed drives are used for this application.

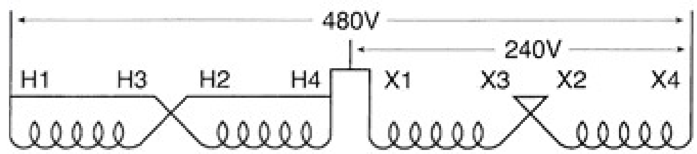
Will a transformer change three phase to single phase?

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.

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 the figure. 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 as follows:



Can a Delta primary (three wire) transformer be used on a Wye (four wire) source?

Yes, any delta primary transformer can be connected to a wye source simply by not using the neutral of the source. This connection will not cause any adverse effects in the operation of the transformer or the source.

What is the difference between "Isolating" and "Shielded Winding" transformers?

These terms are used to describe the isolation between the primary and secondary windings. A shielded transformer is designed with a metallic shield between the primary and secondary windings to attenuate high frequency electrical transient noise. This is especially important in critical applications such as computers, process controllers and many other microprocessors 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.

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.

Are control transformers current limiting?

A control transformer is not current limiting and will allow as much current to pass through as is demanded by the load. As such, a secondary overcurrent device should be utilized.

How and why is grounding of transformers important?

Grounding removes static charges that accumulate within a transformer. Grounding also reduces the chance of static discharge causing personal harm and possible equipment damage in the case of transformer windings accidentally come in contact with the core or enclosure. The actual method of grounding a transformer is simple, defined in NEMA Publication n° ST20: "...grounded means connected to earth or to some extended conducting body which serves instead of the earth, whether the connection is intentional or accidental. Effectively grounded means grounded through a grounding connection of sufficiently low impedance that fault grounds which may occur cannot build up voltages in excess of established limits..."

Before grounding, make sure all contact surfaces are clean and free of any non-conductive protective coating. Any surface where connections are made must be free of rust, scale and any impediments. Make sure the flexible grounding jumper between the core and coil assembly and case is intact and tight.

The metal enclosure, or frame, of any transformer connected to a circuit operating at more than 30 Volts to ground must be effectively grounded. A grounding conductor for the transformer will have a current carrying capacity in accordance with either the National Electric Code or the National Electrical Safety Code. Make sure grounding or bonding meets NEC and local codes.

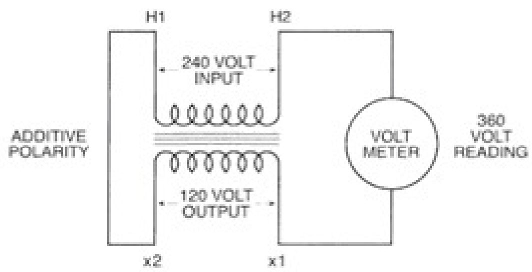
What is a duty cycle?

Duty cycle is the period and duration when a transformer will be loaded. The transformer is designed to run continuously at full load without exceeding the temperature limits. Transformers may also be operated for short time duty. Depending upon the time and cycle of the maximum load, the transformer VA size may be smaller than for continuous duty.

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.



What is balanced loading and why is it important?

Balancing transformer loads means being sure the transformer winding directly feeding a load is not overloaded beyond its capacity. Most single phase transformer applications involve secondary windings rated for 120/240 volts. These are frequently connected for three wire service. Since the transformer has two 120 volt secondary windings, each one is capable of supplying only one-half of the transformer's rated KVA capacity. If care is not taken, it is possible to apply a combination of 120 and 240 volt loads that will, while not exceeding the total nameplate rating, exceed the rating of one of the 120 volt windings.

The same is true of three phase transformers, especially those with 208Y/120 volt or 480Y/277 volt secondaries. Remember, each of the three secondary windings of a three phase transformer has a maximum capacity of one-third the nameplate KVA rating. It is always necessary to distribute the single and three phase loads as evenly as possible across the three secondary windings without exceeding their capacity.

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.

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 60 KVA three phase transformer with a 208Y/120 volt secondary is to service 4 loads at 120 volts single phase each. These loads are 15 KVA, 6 KVA, 10 KVA and 5 KVA.

NOTE: each phase has a 20 KVA capacity (60 KVA three phase gives 20 KVA per phase).

If incorrect method is used, phase A will have a 21 KVA load which is 1 KVA above its normal capacity of 20 KVA, phase B will have a 10 KVA load and phase C will have a 5 KVA load. A failure will result even though we only have a total load of 36 KVA on a 60 KVA transformer

What type of winding material is utilized in transformers?

Transformers are typically wound with copper conductors.

What are the UL enclosure types?

Underwriters Laboratories adopted a system for rating transformer enclosures which differs somewhat from the NEMA system. The UL system lists just three enclosure types:

- UL Type 1 enclosure is intended for indoor service and offers a degree of protection from contact with the device inside the enclosure
- UL Type 2 enclosures are also intended for indoor service and provide protection of the equipment inside the enclosure from limited amounts of falling dirt and water
- UL Type 3R enclosures can be used either indoors or outdoors and provide protection against rain, sleet, snow and ice formation

The proper UL enclosure rating is listed on the transformer nameplate.

What is the effect of encapsulation in control transformers?

Encapsulating the coils of a control transformer will help to protect the unit from moisture, dust, dirt and industrial contaminants. Encapsulation helps to provide maximum protection in hostile environments allowing the unit to run cooler than a non-encapsulated unit.

Is there a quick rule of thumb for determining what transformer K-factor rating is needed for an application?

Although it is not very scientific and may result in a K-factor rating larger than actually needed, there is a quick and easy method to ballpark K-factor. Take a look at all of the loads that will be powered by the transformer. As you examine the loads ask yourself the following questions:

- Which is the amperage draw of this load while it is operating? Be sure to adjust inductive loads for their true power consumption
- Is the load electronic or electrical? Many loads may be a hybrid of the two but try to put it into one classification or another

Once this has been done, add up all of the "electrical" loads that will be on the circuit. Do the same thing for "electronic" loads. When comparing the percentage of "electrical" loads vs. "electronic" loads, if the transformer loading is:

- 0% "electronic", 100% "electrical" - Use a standard (K-1 rated) transformer
- 25% "electronic", 75% "electrical" - Use a K-4 rated transformer
- 50% "electronic", 50% "electrical" - Use a K-9 rated transformer
- 75% "electronic", 25% "electrical" - Use a K-13 rated transformer
- 100% "electronic", 0% "electrical" - Use a K-20 rated transformer

Although "electronic" load will vary in their K-factor rating, by considering all "electronic" loads to be the same, you are assured the sizing is correct and most probably will allow for additional "electronic" loads to be added later.

What transformers should be used for low voltage lighting applications and are there any special considerations?

Buck-boost transformers are ideally suited for handling 12 or 24 volt low voltage lighting. Although normally field connected as an autotransformer and used for voltage correction, buck-boost transformers can also be used as an isolation transformer to go from 120 or 240 volts down to 12 and/or 24 volts. A few tips when using transformers for low voltage lighting applications:

- Be careful about the size of the conductor running to the lights. Resistance in a wire decreases as you increase the cross sectional size of the wire. In other words, the larger the gauge of wire, the lower the resistance. The lower the resistance, the lower the voltage drop. Losing 2 volts due to line resistance can be critical when you're only starting with 12 volts
- Try to limit the length of wire run. Again, the longer the run of wire, the greater the resistance. Many times you are better of using two smaller sized transformers and have two lighting circuits
- If possible, locate the transformer in the middle of the lighting run. In other words, run parallel circuits instead of one long continuous circuit. Be careful when using dimmers for low voltage applications. Locate the dimmer on the low voltage side of the transformer. This will result in a larger dimmer but dimming on the input (high voltage) side will impact the operation of the transformer

How do I determine the correct overcurrent protection for a 600 volts class transformer?

A transformer has all the same component parts as a motor, and like a motor, exhibits an inrush when energized. This inrush current is dependent upon where in the sine wave the transformer was last turned off in relation to the point of the sine wave you are when you energize the transformer. Although transformer inrush could run up to 35 times full load current under no load, it is typically 10 to 15 times normal running current. For this reason it is important to use a dual element slow blow type fuse, the same type of fuse you would use with a motor. If using a circuit breaker, select a breaker with a time delay, again, the same type you would use with a motor. If the time delay is not sufficient, you may experience "nuisance tripping" (a condition where the breaker trips when energizing the transformer but when you try it again, it works fine).

Can general purpose transformers be used to power industrial control devices?

The answer to this question is strictly application related. Industrial control transformers (sometimes referred to as machine tool transformers or control transformers) are specifically designed to meet the demands required to power Industrial control devices such as contactors, solenoids and relays. Industrial control devices typically have two power requirements:

- inrush capacity (the power required to energize or seal the contacts)
- sealed capacity (the power required to keep the contacts sealed)

It is not uncommon for inrush requirements to be 5, 10 or 15 times the sealed requirements.

It is critical that during this period of time requiring the inrush VA requirement that the voltage powering the device remain as steady as possible. Industrial control transformers are designed to provide excellent voltage regulation under inrush conditions. Transformer design engineers accomplish this via a number of different methods. Common methods include

- compensating transformer secondary windings (to offset secondary winding losses)
- using a larger conductor on the secondary windings (to cut winding losses)
- designing a slightly larger (and usually more expensive) transformer

General purpose transformers provide good voltage regulation up to full nameplate load but the output voltage may drop slightly when the transformer is subjected to a momentary overload. This voltage drop may be beyond what the industrial control device can tolerate. Care needs to be taken if industrial control devices are to be powered from a general purpose transformer. It is not recommended to use a general purpose unit if you are powering one or two devices from the transformer or if you have multiple devices that all "turn on" at the same time. A general purpose transformer may be preferable if you have multiple devices to power that do not "turn on" at the same time and space within the motor control panel is at a premium. Normally a general purpose transformer can be located on the outside of the motor control panel.

What effect does a control transformer have on electrical disturbances found on the line?

Because a control transformer has primary and secondary windings, it will provide some degree of "clean-up" with regard to electrical noise, spikes, surges and transients. It will not, however, provide the same degree of power conditioning found in products designed for that purpose.

Why are the 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.