

Buck-Boost Transformers - Questions & Answers

1. What is a buck-boost transformer?

Buck-boost transformers are small single phase transformers designed to lower (buck) or raise (boost) line voltage from 5-20%. The most common applications for buck-boost transformers include boosting 208 volts to 230 or 240 volts for air conditioning systems, boosting 110 to 120 volts and 240 to 277 volts for lighting applications, heating systems and induction motors of all types. Many applications exist where supply voltages are frequently above or below nominal.

Buck-boost transformers are conventional low voltage, single phase distribution transformers, with standard primary voltages of 120, 240 or 480 volts, and secondary voltages of 12, 16, 24, 32 or 48 volts. They are available in sizes ranging from 50 VA to 10,000 VA. The primary and secondary are wired together to form a single-winding autotransformer. Utilizing the additive and subtractive polarity, small amounts of voltage are either added or subtracted from a distribution circuit.

2. How does a buck-boost transformer differ from an isolating transformer?

A buck-boost transformer is manufactured as an isolating transformer, with separable primary and secondary, and is shipped from the factory in that configuration. When the end user at site connects it, the primary is connected to the secondary changing the transformer's electrical characteristics to those of an autotransformer. This provides the smaller voltage correction that is typical of buck-boost. The primary and secondary windings are no longer isolated as they are connected together.

3. What is the difference between a buck-boost transformer and an autotransformer?

As noted above, when the primary and secondary are connected together to buck or boost voltage, the transformer becomes an autotransformer. If the connection between the primary and secondary winding is not made, then the unit remains as an isolation transformer.

Applications

4. Why are they used?

A buck-boost transformer is a simple and effective way of correcting off-standard voltages. Electrical and electronic equipment is designed to operate within a standard tolerance of nominal supply voltages. When the supply voltage is consistently too high or low - typically more than 10%, the equipment will operate below peak efficiency.

5. Can buck-boost transformers be used to power low voltage circuits?

Installed as two-winding, isolation transformers, these units can be used to power low voltage circuits including control, lighting circuits, or other low voltage applications that require 12, 16, 24, 32 or 48 volts output, consistent with the secondary of these designs. The unit is connected as an isolating transformer and the nameplate kVA rating is the transformer's capacity.

Operation and Construction

6. Why do buck-boost transformers have 4 windings?

A four winding buck-boost transformer with 2 primary and 2 secondary windings can be connected eight different ways to provide a multitude of voltages and KVA's. This provides the flexibility necessary for the broad variety of applications. A two-winding transformer can only be connected in two different ways.

7. Will a Buck-Boost transformer stabilize voltage?

Buck-boost transformers will not stabilize supply line voltage. The output voltage of a buck-boost is a function of the input voltage. If the input voltage varies, then the output voltage will also vary by the same percentage.

Load Data

8. Are there any restrictions on the type of load that can be operated from a Buck-Boost transformer?

There are no restrictions as to application for Buck-Boost, including single or three-phase motor loads.

9. As an Autotransformer, how can a Buck-Boost transformer supply kVA power?

This is a function of adding voltage - a small amount of voltage is added and a small amount of corresponding power capacity is added as well. For example, if the transformer is connected in such a way that 22 volts is added to a 208 volt primary, a 230 volt output will result.

Using this example, the calculation for autotransformer kVA is as follows:

$$\text{kVA} = \frac{\text{Output Volts} \times \text{Secondary Amps}}{1000}$$

$$\text{kVA} = \frac{230\text{V} \times 41.67 \text{ Amps}}{1000} = 9.58 \text{ KVA}$$

10. How are single phase and three phase load amps and load kVA calculated?

$$\text{Single phase Amps} = \frac{\text{kVA} \times 1000}{\text{Volts}}$$

$$\text{Three phase Amps} = \frac{\text{kVA} \times 1000}{\text{Volts} \times 1.73}$$

$$\text{Single phase kVA} = \frac{\text{Volts} \times \text{Amps}}{1000}$$

$$\text{Three phase kVA} = \frac{\text{Volts} \times \text{Amps} \times 1.73}{1000}$$

Three Phase

11. Can Buck-Boost transformers be used on three phase systems?

Interconnecting two or three single phase units will readily accommodate three phase systems - refer to the corresponding three phase section in this catalog. The number of units to be used in a three phase installation depends on the number of wires in the supply line. If the three phase supply is 4-wire wye, then three buck-boost transformers are required. If the three phase supply is 3-wire wye (neutral not available), two buck-boost transformers are needed.

12. Should Buck-Boost transformers be used to develop three phase 4 wire wye circuits from three phase 3 wire delta circuits?

No - a three-phase "wye" buck-boost transformer connection should be used only on a 4-wire source of supply. A delta to wye connection does not provide adequate current capacity to accommodate unbalanced currents flowing in the neutral wire of the 4-wire circuit.

13. Why isn't a 'closed delta' Buck-Boost connection recommended?

This connection requires more kVA power than a "wye" or open delta connection and phase shifting occurs on the output. The closed delta connection is more expensive and electrically inferior to other three phase connections.

Connection and Frequency

14. How do you know how to connect a Buck-Boost transformer?

A connection chart is provided with each unit that shows how to make the corresponding connections. These same charts are also shown in this section.

15. Can 60 Hertz Buck-Boost transformers be operated on 50 Hertz?

Due to 'saturation' of the core, 60 Hertz buck-boost transformers should only be operated at 60 Hertz, and not 50 Hertz. Units manufactured as 50 Hertz units will however, operate at 60 Hertz.

Nameplate Data

17. Why are buck-boost transformers shipped from the factory connected as isolating transformers, and not pre-connected autotransformers?

The same 4-winding buck-boost transformer can be connected eight different ways to provide a multitude of voltage combinations. The correct connection can best be determined by the user when assessing the supply voltage at site.

18. Why is the isolation transformer kVA rating shown on the nameplate instead of the autotransformer kVA rating?

Shipped as an isolating transformer, the nameplate is required to show the performance characteristics accordingly. Additionally, as an autotransformer, the eight different combinations of voltages and kVA's would be impractical to list on the nameplate. A connection chart, listing the various connections, is included with each unit.

Sound Levels

19. How does the sound level differ between Buck-Boost and isolation transformers?

Buck-boost transformers, connected as autotransformers, will be quieter than an equivalent isolation transformer capable of handling the same load. The isolation transformer would have to be physically larger than the buck-boost transformer, and smaller transformers are quieter than larger ones. For example, a 10 kVA is 35 dba and a 75 kVA is 50 dba.

Cost and Life Expectancy

20. How does the costs compare between a Buck-Boost transformer and an Isolation transformer handling the same load?

For most buck-boost applications, the savings are about 75% compared to the use of an isolation transformer for the same application.

21. What is the life expectancy of a Buck-Boost transformer?

Buck-boost transformers have exactly the same life expectancy as other dry-type transformers.

22. Buck-Boost transformers are almost always installed as autotransformers. Does the National Electrical Code (NEC) permit the use of autotransformers?

Autotransformers are very common and recognized by all the safety and standard authorities. You can refer to N.E.C. Article 450-4, "Autotransformers 600 Volts, Nominal, or Less", as a reference publication. Item (a) details overcurrent protection for an autotransformer and item (b) covers an isolation transformer being field connected as an autotransformer for a buck-boost application.

23. When a Buck-Boost transformer is connected as an autotransformer, what is the procedure for determining the current rating of the overcurrent protective device, such as the fuse or circuit breaker?

The NEC Article 450-4 outlines overcurrent protection for autotransformers. It is reproduced as follows:
"NEC 450-4 - Autotransformers 600 Volts, Nominal, or Less

(a) Overcurrent Protection. Each autotransformer 600 volts, nominal, or less shall be protected by an individual overcurrent device installed in series with each ungrounded input conductor. Such overcurrent device shall be rated or set at not more than 125 percent of the rated full load input current of the autotransformer. An overcurrent device shall not be installed in series with the shunt winding.

Exception: Where the rated input current of an autotransformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of a fuse or non-adjustable circuit breaker; the next higher standard rating described in our section shall be permitted. When the rated input current is less than 9 amperes, an overcurrent device rated or set at not more than 167 percent of the input current shall be permitted.

(b) Transformer Field-Connected as an autotransformer. A transformer field-connected as autotransformers shall be identified for use at "elevated voltage".

Example: A 1 kVA transformer, Catalog No. Q1C0ERCB, is rated 120 x 240 to 12 x 24 volts. It is to be connected as an autotransformer to raise 208 to 230 volts single phase. When connected as an autotransformer in this application, the kVA rating is increased to 9.58 kVA, or 9,580 VA. This is the rating to be used for determining the full load input amps and the corresponding size of the overcurrent protection device, either a fuse or breaker.

$$\text{Full load input amps} = 9,580 \text{ Volt Amps} = 46 \text{ Amp, } 208 \text{ Volts}$$

When the full load current is greater than 9 amps, the overcurrent protection device - usually a fuse or non-adjustable breaker, the current rating can be up to 125 percent of the full load rating of the autotransformer input current.

$$\text{Max. current rating of the overcurrent device} = 46 \text{ amps} \times 125\% = 57.5 \text{ amps}$$

The National Electrical Code, Article 450-4 (a) Exception, permits the use of the next higher standard ampere rating of the overcurrent device. This is shown in Article 240-6 of the N.E.C.

$$\text{Max. size of the fuse or circuit breaker} = 60 \text{ amps}$$

