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Transformers, Filters, and Surge Protection

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Transformers



A transformer's principal function is to "transform" alternating current (AC) from one voltage to another. Transformers play a critical role in any electrical distribution system and end-use equipment such as industrial control panels. A good example is using control transformers to reduce higher line voltages to lower and safer control voltages.

Because transformers are a fundamental element of most electrical distribution systems, designers must understand what they are, how to use them, and the various styles available for typical industrial applications.

How Transformers Work

Transformers have input (primary) and output (secondary) windings over an iron core (Figure 1). The voltage is transformed by inductively coupling the primary and secondary coils. As the voltage rises and falls in the primary coil, it creates a matching magnetic field that induces a corresponding voltage in the secondary coil.

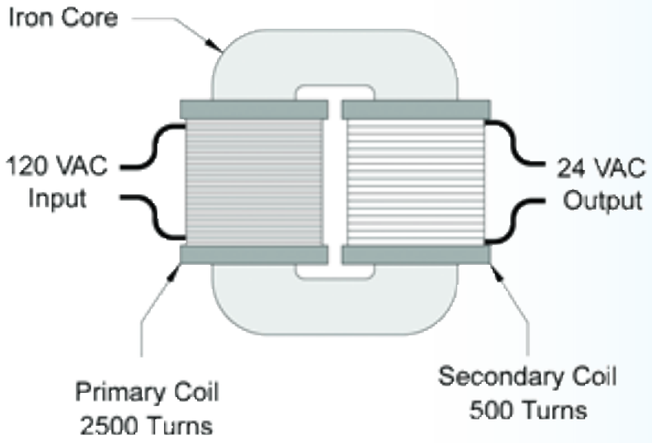


Figure 1: Basic transformer components

This figure illustrates a transformer with a 2500:500 (or 5:1) turns ratio, transforming a 120 VAC input to a 24 VAC output

The relationship between the input and output voltage of a transformer is directly proportional to its turns ratio. The secondary voltage equals the primary voltage divided by the primary-to-secondary turns ratio. If a transformer has 100 turns on the primary and 50 turns on the secondary, it has a 2 to 1 ratio. Therefore, with 240 VAC applied to the primary, the secondary will produce 120 VAC - a "step-down" transformer. The current is inversely proportional to voltage; if this transformer has 2.5 A at 240 VAC on the primary, the secondary will deliver 5 A at 120 VAC. Ignoring losses, the power in equals the power out.

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Transformer Types

Two major types of transformers are isolation transformers and auto-transformers.

Isolation Transformers

An isolation transformer provides two distinct features desirable for most applications:

- The secondary is electrically isolated from the higher and more dangerous input voltage, providing a level of safety essential for most circuits.
- An isolation transformer filters high-voltage transients and high-frequency noise to protect delicate electronics and downstream equipment.

Most transformers are isolation-type transformers, where the primary and secondary coils are physically and electrically separate and isolated, even though they are magnetically coupled.

Isolation Transformers: Multiple Taps

Figure 2 shows a three-phase distribution transformer, which is simply three single-phase transformers built into one unit. It protects downstream equipment and offers additional flexibility with multiple taps for different output voltages.

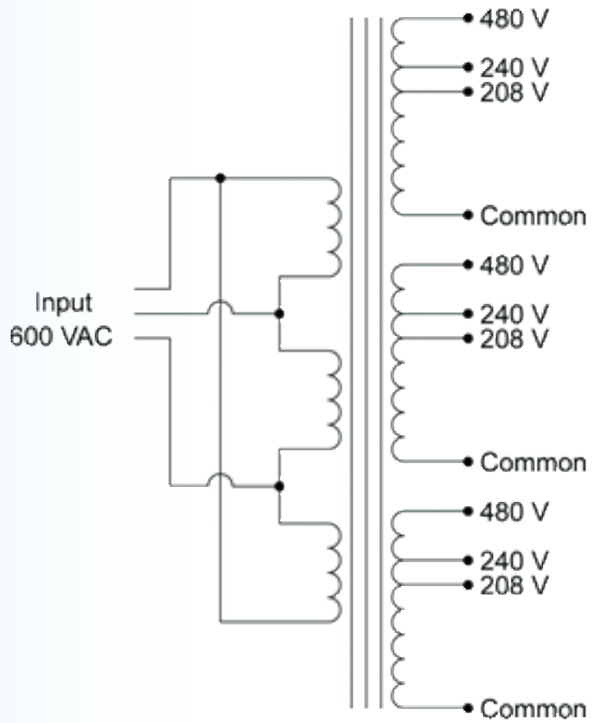


Figure 2: Three-phase tapped power distribution transformer

This figure illustrates a three-phase power distribution transformer's isolated coils and multiple output taps

Auto-transformers

A voltage matching auto-transformer provides an economical solution where isolation is not desired or required (Figure 3). These transformers are used for voltage matching where the supplied equipment requires a different voltage than what is available as standard at the install site.

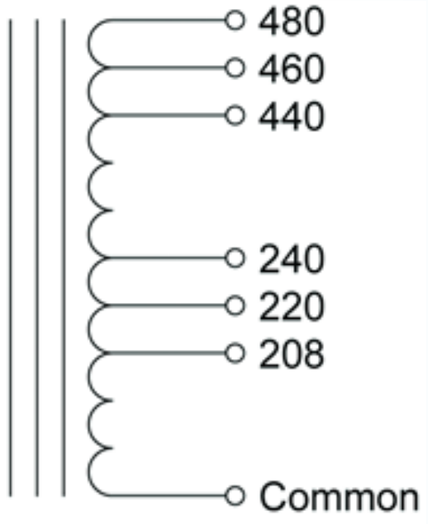


Figure 3: Auto-transformer
This figure depicts an auto-transformer with no electrical isolation between the primary and secondary coils

Auto-transformers: Voltage Matching

A typical voltage-matching example is when equipment designed for a 240 VAC supply is installed in a building with only a 208 VAC service. In this case, the auto-transformer boosts the voltage and solves the problem quickly. Figure 3 shows a schematic of an auto-transformer. The line voltage is connected to the appropriate input terminals, and the adjusted voltages (to boost or step-down the primary) are available at the various output terminals. Consider a buck-boost transformer as your first option if you need a line voltage change of not more than 5-20%.

Transformer Construction

Heat is one of the worst enemies of transformers. As a result, transformer manufacturers design them to dissipate heat, even at maximum capacity. Transformers heat up due to losses caused by eddy currents that form in the conductive material making up the core. Any conductive material placed near rising and falling magnetic fields is subject to eddy current formation and the associated heat rise.

Transformer cores are typically constructed by stacking laminations together to mitigate eddy currents. This stacked core provides an excellent magnetic mass while limiting the electrical path where eddy currents form. Higher efficiency transformers use very thin laminations to achieve good performance, making them significantly smaller than low-efficiency units carrying the same electrical rating.

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Two approaches to dry-type transformer construction are the open core and encapsulated type.



Open Core Transformers

These transformers are the least expensive design; however, they must be installed in an enclosure to protect them from the environment and to protect personnel working close to the unit. Larger transformers can be problematic because safety and protection from the elements requires a large, expensive enclosure.



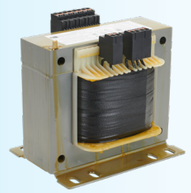
Encapsulated Transformers

Encapsulated transformers address many of the issues associated with an open core transformer. These transformers are made by placing the transformer into a compact enclosure and filling the gaps with a thermally efficient potting compound. This arrangement provides several distinct advantages, including compactness, improved operator safety, superior cooling, better resistance to shock and vibration, available conduit connections, provisions for convenient mounting, and extended life. Encapsulated transformers are typically the best choice for general-purpose, marine, and building distribution applications when considering installation and service life. They are available in standard sizes for single-phase and three-phase applications.



Ventilated Transformers (open core)

Ventilated general-purpose transformers feature high efficiencies and are commonly used in general industrial and commercial applications. Models are rated up to 1000 kVA in single-phase and three-phase configurations. They are installed in enclosures with ventilating louvers to allow air circulation over the windings for cooling. Fans can be installed to increase cooling and, as a result, increase the full-load rating of the transformer.



Control Transformers (open or encapsulated)

Control transformers are an excellent choice for high-inrush applications, such as contactors or solenoid valves, requiring reliable output voltage stability. Most control transformers are specifically designed to handle the high inrush currents required by inductive circuits, then settle back to a lower steady-state current. They are frequently used in machine tool applications, isolating control circuits from power and lighting.

Selecting a Control Transformer

Determine the following three load characteristics to select a transformer: steady-state load (sealed VA), total inrush VA, and inrush load power factor.

- Total steady-state "sealed" VA is the total amount of VA that the transformer must supply to the load circuit for an extended length of time. Calculate this by adding the steady-state VA of all devices in the control circuit. The VA data for the devices should be available from the manufacturers.
- The inrush VA is the VA required for a transformer to simultaneously energize all control circuit components. Obtain this inrush VA data from the device manufacturers. Also, consider starting the devices in sequence to lower the inrush current.
- The inrush load power factor is difficult to determine without a detailed vector analysis of all the control components. In the absence of such information, use a 40% power factor, if possible.

Can a Transformer be Reverse Fed?

Reverse feeding (back-feeding) involves wiring a standard step-down transformer in reverse and using it as a step-up transformer. When a step-up transformer is needed, the best solution is to have it designed for that application. While a standard transformer can be back-fed, several problems can occur. Designers often modify the winding ratios to compensate for voltage drop and inrush current. These modifications can work against the user when the transformer is back-fed, causing large inrush currents and voltage drops. Contact the manufacturer to confirm whether a transformer can be reverse fed. Back-fed transformers may void the standard warranty and not meet local and national electrical codes.

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Transformer Lineup

Ventilated General Purpose Transformers (NEMA Rated)



Hammond Power Solutions Inc.

HPS Sentinel G Series Distribution Transformers starting at $1,600.00

HPS Sentinel G ventilated stand-up distribution transformers meet the latest energy efficiency standards as outlined by DOE and NRCan. These transformers feature higher efficiency which translates into increased profitability due to lower operating costs, decreased cost of ownership over the lifetime of the transformer, and reduced air conditioning costs due to lower heat emissions. HPS Sentinel models are rated up to 75 kVA, and the standard 10 kV BIL rating provides increased reliability and protection against critical equipment failure (including voltage spikes and other line transients).

- Type 3R enclosures
- Integrated wall mounting brackets (up to 45 kVA)
- Factory-installed primary, secondary and neutral lugs (up to 75 kVA)
- Expanded neutral bar for multiple neutral connections
- Factory-installed main grounding lugs
- Separate HV and LV terminal boards for easy cable installation
- 10 kV BIL on all 3-phase LV distribution transformers
- Dual UL and CSA certification
- Standard IBC 2012-OSHPD Seismic ratings (floor mount only)

Ventilated Drive Isolation Transformers (NEMA Rated)



Hammond Power Solutions Inc.

HPS Drive Isolation Transformers starting at $1,293.00

Drive isolation transformers are designed to withstand the mechanical stresses, voltage distortions, and heating associated with motor drives. They provide all of the benefits of a line reactor; the extra reactance reduces harmonics and the effects of voltage and current distortion caused by the variable speed drive. In addition, drive isolation transformers provide the following advantages:

- They provide isolation between the drive system and the power source
- When the wye-connected secondary is grounded, it prevents the transfer of common-mode noise and transients between the voltage source and the drive system
- They localize the effects of drive-induced ground currents and prevent them from being passed upstream to the power system

Features

- Available for 5 to 200 HP drives
- 460 Delta VAC Primary to 460Y VAC Secondary
- Primary taps to compensate for voltage variations
- Winding monitoring thermostat included
- Standard Type 3R enclosure suitable for indoor or outdoor applications
- The windings are designed to withstand over-current of 150% of the rated load for 60 seconds or 200% of the rated load for 30 seconds
- A duty cycle of one start for every two hours is permitted
- 10-year warranty

Encapsulated Core General Purpose Transformers (NEMA Rated)



Hammond Power Solutions Inc.

HPS Fortress™ Single-Phase Encapsulated Power Transformers starting at $164.00

Hammond HPS Fortress industrial power transformers provide an innovative design ideal for commercial applications where quality, ease of installation, and low cost are key. All Fortress units are encapsulated power transformers with electrical-grade silica sand and resin compounds, which completely enclose the core and coil to seal out moisture, airborne contaminants, and eliminate corrosion and deterioration. The NEMA 3R rating allows these potted transformers to be used as indoor/outdoor transformers.

- LE Series 480 x 240 VAC to 240 x 120 VAC
- WE Series 277/240/208/120 VAC to 240 x 120 VAC
- XE Series 480/440/416/400/380 x 240/220/208/200/190 to 240 x 120 VAC

Features

- Single-phase ratings from 0.1 to 25 kVA
- Industry standard sizes
- Easy installation and hook-up
- Rated NEMA 3R for harsh applications
- 10-year limited warranty



Acme Electric®

Single-Phase Encapsulated Core Transformers starting at $1,041.00

Acme Electric encapsulated dry-type distribution transformers are optimized to provide long life in general-purpose applications. A UL Type 3R enclosure makes them suitable for indoor or outdoor service, while encapsulation eliminates corrosion and insulation deterioration.

- Single-phase ratings from 250 VA to 25 kVA
- 240 x 480 VAC to 120 x 240 VAC
- 120/208/240/277 VAC to 120 x 240 VAC
- 600 VAC to 120 x 240 VAC
- 10-year limited warranty



Acme Electric®

Three-Phase Encapsulated Core Transformers starting at $881.00

Acme Electric dry-type encapsulated three-phase distribution transformers are filled with electrical-grade silica and resin compounds that fully enclose the core and coil to seal out moisture. They offer a wide range of primary and secondary voltage configurations, completely enclosed NEMA 3R housings, and are suitable for indoor/outdoor applications.

- 480 VAC Primary to 208Y/120 VAC Secondary
- 480 VAC Primary to 240/120 VAC (center tap) Secondary
- 600 VAC Primary to 480Y/277 VAC Secondary
- 600 VAC Primary to 208Y/120 VAC Secondary

Features

- Three-phase ratings from 3 to 15 kVA
- Fully encapsulated core and coil
- UL Type 3R enclosure
- Grounding studs for use with non-metallic conduit
- Copper lead wire for terminations
- Electrostatic shield standard

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Open Core Industrial Control Transformers



MURR ELEKTRONIK

Open Core/Coil Control Transformers starting at $112.00

Murrelektronik open core control transformers feature a flexible, multi-voltage primary with eleven different input voltage options that can be adapted to different mains voltages using simple quick-connect jumpers.

- Single-phase ratings from 100 to 6300 VA
- 208/230/380/400/420/440/460/480/500/525/550 VAC to 115 x 230 VAC
- 50/60 Hz
- Electrostatic shield standard
- Panel mount (DIN rail options for 100 and 160 VA models)
- IP20 finger-safe terminal connections

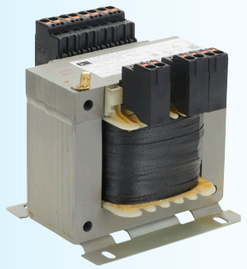


BLOCK

CT Series Open Core/Coil Control Transformers starting at $55.00

BLOCK CT series open core control transformers are ideal for a variety of general purpose and industrial applications. Specifically engineered for isolation, lighting, or signal systems, the CT series provides a cost-effective solution and a rugged design to guarantee uninterrupted power delivery.

- Single-phase ratings from 50 to 2500 VA
- 240/480 or 600 VAC Primary
- 24 or 120 VAC Secondary
- 50/60 Hz
- Fused versions available (on select units)
- Panel mount



BLOCK

USTE Series Open Core/Coil Control Transformers starting at $75.00

BLOCK USTE series open core control transformers offer a versatile solution for a large range of input voltages, allowing OEMs and system integrators to save time and reduce costs by standardizing on a single model. They provide thirteen configurable primary inputs from 208 to 600 VAC. In addition, the 12/24 VAC models comply with safety standards to ensure a safe power supply for SELV (Safety Extra Low Voltage) circuits.

- Single-phase ratings from 40 to 3200 VA
- 208/230/380/400/415/440/460/480/500/525/550/575/600 VAC Primary
- 12/24 or 115/230 VAC Secondary
- Low inrush current
- 50/60 Hz
- Tool-free push-in wire terminals
- DIN rail (up to 250 VA) and panel mount

Accessories



Wall Mounting Brackets starting at $133.00

Wall mounting brackets are available for Acme Electric 15 kVA encapsulated 3-phase transformers.

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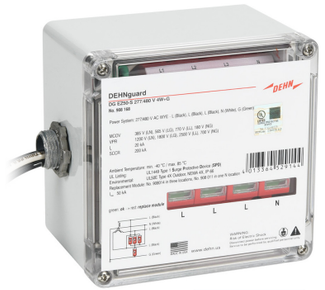
Surge Protective Devices

MERSEN Surge Protective Devices



- Protect equipment and reduce downtime costs
- UL Type 1 rating can be used anywhere downstream of the main transformer including the main service panel
- Compact design for inside or outside panel installation
- Specific voltage configurations provide better protection than generic models
- Mersen's industry-leading TPMOV technology design
- Best-in-class indoor/outdoor use NEMA 4X-rated plastic housing

DEHN EZ50 Surge Protectors



ASSEMBLED IN THE USA FROM FOREIGN & DOMESTIC PARTS

DEHN EZ50-S Surge protectors provide efficient protection for the most challenging outdoor conditions, ensuring uninterrupted performance and system uptime. They are ideal for applications such as electric vehicles, water/wastewater facilities, data centers, mobile phone sites, and a wide range of commercial and industrial environments. By safeguarding critical systems against damaging surges, they help protect your valuable data and infrastructure investment—ensuring maximum reliability and operational continuity.

- Available for 3-phase wye 208Y/120 VAC, 480Y/277 VAC, and 600Y/347 VAC; 3-phase delta 480 VAC; split-phase 120/240 VAC; and single-phase 120 VAC
- Clear and reliable visual indication for each line
- Prewired with 10 AWG, 36-inch-long stranded wires
- Panel or wall mountable, mounting brackets included
- High-performance surge protection with a 50kA I_{MAX} and a 200kA SCCR
- Field-replaceable (hot-swappable) plug-in modules
- NEMA 4X enclosure
- UL 1449 Listed Type 1 SPDs

DEHNguard Surge Protectors - RED/Line



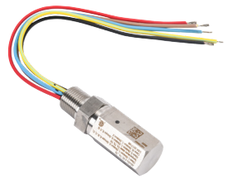
DEHNguard UL 1449 Type 1 surge protectors provide reliable surge protection for a high degree of equipment safety. DEHN DG-MU series modular DIN-rail mount devices are suitable for common electrical systems up to 550 VAC; replacement protection modules are available.



DEHNrail Surge Protectors - RED/Line

The compact DEHNrail UL 1449 Type 4 supplemental surge protection devices for power and controls applications offer modularity and high performance. DG-M-2P series surge arresters provide protection up to 230 VAC, ideal for equipment in industrial environments; replacement protection modules are available.

DEHNpipe Surge Protectors - YELLOW/Line



DEHNpipe DPI series surge protectors for field devices are made of corrosion-resistant stainless steel and connect directly to the device terminals. These units are ideally suited for installation in process environments. These IP67-rated parallel-connection models offer SPD class Type 2 protection, for potentially explosive atmospheres or Class I, Division 2 environments.



DEHNpatch Surge Protectors - YELLOW/Line

DEHNpatch DPA series surge protectors are ideal for Ethernet, Industrial Ethernet, and Power over Ethernet devices, as well as general applications in structured cabling up to the Gbit range. Available are a space-saving DIN-rail mounted model, a NEMA 4/4X-rated unit that can be pole or wall-mounted, and an IP66 model available for outdoor applications.

BLITZDUCTORconnect Compact Data and Signal Surge Protectors - YELLOW/Line

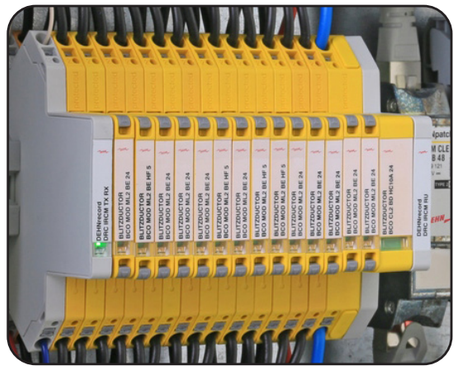
BLITZDUCTORconnect series of combination lightning current and surge arresters feature a modular, compact design for system protection in industrial environments, information technology signal interfaces, and automation or measuring and control systems. The LifeCheck monitoring function helps to continually verify the arrester is able to protect equipment from lightning strikes and surges.

Protection Modules

- 927910 modules protect 120 VAC circuits
- 927924 modules protect 24 VAC/VDC discrete and mA circuits
- 927944 modules protect 4-20mA analog circuits
- 927971 modules protect communication circuits
- 910710 modules use an optical signal to monitor all of the protection modules in a system and open an N.C. monitoring contact if any of the modules have reached end of life

Features

- Universal lightning current and surge arrester
- Slim stackable slice-type design
- High discharge capacity of 3 kA (10/350 µs), 10 kA (8/20 µs)
- LifeCheck and visual status indication integrated in the module
- Low voltage protection level, also capable of protecting terminal equipment
- SPD class Type 1



Surge Suppression Devices

Surge suppressors protect and lengthen the life of motors, contactors, relays, solenoids, and PLC outputs. Contactor and solenoid surge suppressors reduce voltage spikes and electromagnetic noise caused by inductive loads. Motor suppressors protect 3-phase motors up to 575 VAC from damaging line surges.

- Universal surge suppressors
- Motor surge suppressors
- Valve surge suppressors



MURR ELEKTRONIK Universal Surge Suppressors

starting at $9.50

Contactors can produce high-voltage spikes when their coils are de-energized. If unsuppressed, these transient voltages can damage devices in the circuit and affect neighboring electronics. Zener (TVS), Varistor (MOV), and RC surge suppressors are available for contactor coils up to 250 VAC/VDC.



MURR ELEKTRONIK Motor Surge Suppressors

starting at $30.50

Motor surge suppressors protect against the damaging effects of line surges. 3-phase RC filter surge suppressors are available for motors up to 575 VAC at 7.5 kW (10hp). A varistor suppressor, also suitable for VFD applications, will protect 3-phase motor loads up to 575 VAC at 20 kW (26.8hp).

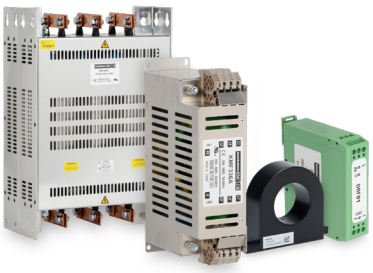


MURR ELEKTRONIK Valve Surge Suppressors

starting at $11.50

Valve surge suppressors mount between the valve base and valve plug to protect against damage caused by voltage spikes from solenoid coils. They are available in 8/9.4mm Form C, 10/11mm Form B, and 18mm Form A plug sizes; in voltages up to 132 VAC/VDC; and in Zener, RC, and varistor types.

Power Line Filters



Roxburgh Power Line Filters and Power Entry Modules

Roxburgh power line EMI (electromagnetic interference) and RF (radio frequency) filters help alleviate transmitted and radiated noise problems in a wide range of applications.

- Three-phase drive-rated power line EMI / RF filters
- Single-phase drive-rated power line EMI / RF filters
- Single-phase power entry modules w/filter
- Ferrite toroids

EATON AEGIS Powerline Filters

- Compact design
- DIN rail mounted (35mm)
- Meets latest UL safety standards for SPD (surge protective device) and EMI filtering protection
- Contains no replaceable parts or items that require periodic maintenance
- 10-year warranty
- UL 1449, 3rd Ed. – Type 2 SPD

