

VFI transformer vs switchgear

At issue

A comparison of operating capabilities and costs demonstrates that a transformer equipped with an integral vacuum fault interrupter (VFI) can be a superior alternative to a non-VFI transformer in combination with stand-alone switchgear.

Recommendation

Eaton combines a conventional distribution transformer with the VFI vacuum fault interrupter – the same advanced technology used in VFI pad-mounted switchgear in its Cooper Power™ series VFI transformer. This combination provides both voltage transformation and overcurrent protection in one space-saving, money-saving package.

The VFI transformer is practical for application on all distribution systems—new or existing, outdoor or indoor (Envirotemp™ FR3™ fluid-filled), commercial or industrial. It is vital for installations where conventional protective equipment doesn't provide adequate protection or coordination. It is recommended for sites where aesthetics are particularly important or where real estate is limited. The VFI transformer is available as a three-phase (livefront or deadfront) pad-mounted unit as well as for primary open or secondary unit substation applications. Single-phase units are also available.

Rationale

The VFI transformer provides convenience, safety, and superior overcurrent protection while also reducing the costs and simplifying system installation, maintenance, and operation.

Reduced space requirements

There is only one pad and one enclosure to deal with. As little as half the installation area of conventional transformer/switchgear packages is required.

Simplified installation

Because there is only one piece of low-profile equipment to install, the installation is faster, simpler, cheaper, and more aesthetically pleasing.

Lower operating and maintenance costs

There is one piece of equipment to maintain instead of two. Substation units reduce inventory and maintenance costs associated with insulators or barriers. The sealed tank design protects the oil-immersed VFI breaker so that operation is unimpaired by contaminated or hazardous environments or flood conditions. Breaker maintenance is virtually eliminated.

Transformer or loop overcurrent protection up to 35 kV

When a transformer fault or overload condition occurs, the VFI breaker trips and isolates the transformer, leaving the feeder uninterrupted. When a fault occurs downstream, the VFI breaker trips and isolates the fault, leaving the transformer load uninterrupted.

Extended protection ratings.

Continuous current and interrupting ratings far exceed those of standard fuses, expanding the scope of transformers that can be protected internally instead of with a separate piece of switchgear.

Faster service restoration/fuse change-outs eliminated

The resettable breaker mechanism eliminates the added downtime and expense associated with changing out conventional fuses, allowing immediate service restoration.



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Expanded operating flexibility satisfies all coordination requirements

When current above the predetermined fault level is sensed, the instantaneous trip feature causes the control to bypass the normal TCC delay and trip immediately. This extends the range of coordination with upstream devices at higher fault levels.

The Tri-Phase Ground (TPG) Trip Control provides improved coordination for systems fed by underground as well as overhead feeders. The TPG control provides sensitive ground-fault protection that ensures quick fault interruption when low-level ground fault current is detected.

- Ganged Phase Tripping

The three-phase mechanically ganged trip allows each phase to be set independently.

This provides the necessary coordination with upstream and downstream devices while accommodating the variability of each phase. With all three phases mechanically ganged, a trip signal on one phase will simultaneously open all three phases.

- Loadbreak and Sectionalizing Capability

The breaker can be used as a vacuum loadbreak or sectionalizing switch. With the VFI, the tap or the transformer can be switched with a simple push-pull of the operation handle. The VFI can also be configured with an optional motor operator, enabling the transformer to be incorporated into a distribution automation scheme.

- Added Safety

Trip-free VFI operation provides added safety for field personnel and customers. If a fault condition is present when the VFI breaker is closed, the trip-free feature will prevent the mechanism from being held in the closed position, preventing the operator from closing in on a fault.

The evidence

Total life-cycle costs comparison

Total life-cycle costs include all applicable costs incurred from acquisition to retirement. These costs include elements associated with Warehousing, Transportation, Installation, and Operation.

Customers report that total installed costs for a VFI transformer are half or even less than half of the installed cost of a comparably rated non-VFI transformer with switchgear.

When additional factors of overcurrent and fault protection, safety, coordination and reliability, ease-of-operation, customer acceptance, real estate requirements, and site aesthetics are considered, the VFI Transformer is clearly the best alternative.

The connection

Eaton offers its Cooper Power series three-phase and single-phase substation transformers in the following ratings:

Three-phase pad-mounted VFI transformers

- kVA range through 10,000
- Livefront or deadfront construction
- Primary voltage through 35 kV (150 kV BIL)
- Primary loop feed deadfront construction (200 A or 600 A)
- Secondary voltage 208Y/120 - 24940Y/14400
- Secondary deadfront construction above 480Y/277
- VFI rating 900 A continuous; 12,500 A RMS interrupting (16,000 A also available at 15 kV)
- TCC curves for the Tri-Phase control (can approximate either an S&C™ "E" fuse, an Edison™ "K" or "T" fuse, or resemble a recloser or relay curve)
- Sectionalizing switched on upstream and downstream high voltage feeds.
- Available with Envirotemp™ FR3™ fluid for indoor and restricted outdoor applications (optional)
- Tri-Phase Ground (TPG) Trip Control (standard)
- Motor operator for SCADA control (optional)
- SCADA accessory (optional)

Primary open and secondary unit substation VFI transformer

- kVA range through 10,000 kVA
- Livefront or deadfront construction
- Primary voltage through 35 kV (150 kV BIL)
- Secondary voltage 208Y/120 - 24940Y/14400
- VFI rating 900 A continuous: 12,500 A RMS interrupting (16,000 A also available at 15 kV)
- TCC curves for the Tri-Phase control (can approximate either an S&C™ "E" fuse or resemble a recloser or relay)
- Available with Envirotemp™ FR3™ fluid for indoor applications and restricted outdoor applications (optional)

VFI transformers meet IEEE Std C57.12.00™-2010, IEEE Std C57.12.34™-2009 or C57.12.36™-2007, IEEE Std C57.12.28™-2014, IEEE Std C57.12.90™-2010, and IEEE Std C57.91™-2011 standards for transformer construction. The VFI transformer's vacuum loadbreak switch meets the stringent IEEE Std C37.60™-2012 standard switching duty cycle requirements for all kV classes through 35 kV.

See publications

- 201-20 Single-Phase Pad-Mounted Distribution Transformers
- 210-12 Three-Phase Pad-Mounted Distribution Transformers
- CA202001EN Substation Transformers-Unit and Open Types

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