Padmounted Switchgear

COOPER Power Systems

Electrical Apparatus

285-10

Kyle® Type VFI Vacuum Fault Interrupter

GENERAL

Kyle® Type VFI Vacuum Fault Interrupter padmounted switchgear (Figure 1) provides superior overcurrent protection through the use of proven, reliable Kyle vacuum interrupters—instead of fuses. The resettable VFI breaker mechanism allows immediate service restoration, eliminating the added downtime and expense associated with replacing conventional fuses.

Deadfront construction provides a high level of safety for both the operator and the general public. Oil insulation offers the further advantage of low maintenance, and permits construction of a compact, low-profile unit that is considerably less obtrusive than a comparable air-insulated design.

VFI Vacuum Fault Interrupter switchgear can be used for both utility and commercial/industrial applications, and can be easily coordinated using field-selectable settings to meet distribution system requirements. Ratings of VFI Vacuum Fault Interrupter padmounted switchgear are shown in Table 1.

911046KM

Figure 1.
Kyle® Type VFI Vacuum Fault Interrupter padmounted switchgear offers a simple approach to protection for 5, 15, 25 and 35kV underground systems, and provides a wide choice of switching combinations to meet specific system requirements without the added cost of custom construction.

TABLE 1
Ratings for VFI Vacuum Fault Interrupter Padmounted Switchgear

Nominal Voltage	5 and 15kV	25kV	35kV
Maximum Design Voltage	15.5	27	38
BIL, kV	95	125	150
1-Minute Withstand, Switch and Terminators, kV	34	40	50
Continuous Current, amps (max.)	600	600	600
Load Switching, amps	600	600	600
Momentary Current, 10 Cycles (asym.), kA	20000	20000	20000
3 Sec., amps (sym.)	12000	12000	12000
3 Shot Make and Latch amps (sym.)	12000	12000	12000
(asym)	20000	20000	20000

FEATURES AND DETAILED DESCRIPTION

VFI Vacuum Fault Interrupter

Kyle's VFI Vacuum Fault Interrupter padmounted switchgear (Figure 2) provides a simple, economical approach to switching requirements for 5, 15, 25 and 35 kV underground systems. The modular design of VFI Vacuum Fault Interrupter switchgear allows the switching system to be tailored to specific requirements without the high cost of custom construction.

The deadfront construction of VFI Vacuum Fault Interrupter padmounted switchgear offers a high safety factor for utility personnel and the general public. Inside, all terminators are covered with insulating rubber. All internal parts are completely sealed in insulating oil to reduce maintenance and eliminate the problems of moisture, dirt and wildlife commonly associated with air-insulated switchgear.

Kyle's oil-insulated, sealed design offers a significant added advantage: an unobtrusive, low-profile appearance that compares favorably with larger, more bulky air-insulated equipment.

VFI Vacuum Fault Interrupter padmounted switchgear is versatile in application. It is suited for utility and commercial/industrial requirements, and a wide selection of TCCs and minimum trip settings make it easily adaptable to standardized distribution systems. VFI Vacuum Fault Interrupter switchgear fits the majority of standard pads, and is compatible with commonly used tools and techniques.

VFI Vacuum Fault Interrupter switchgear and components are a product of Kyle and RTE, proven by years of continuous field experience.

Tri-Phase Control

The Tri-Phase electronic breaker control sets a new standard for ease of time-current-curve coordination. Just like Kyle's time-proven recloser controls, the Tri-Phase offers over 100 minimum trip settings and an assortment of time-current-curves. With standard instantaneous trip and optional ground trip and minimum response TCCs, the Tri-Phase control will satisfy all of your coordination needs.

Three-Phase Ganged Tripping

Most commercial loads consist of large kVA three-phase transformers. Until now, these transformers have been protected with single-phase fuses. Typically, only one of the fuses will open during an overcurrent condition. This "single-phases" three-phase commercial loads, and causes system overvoltage and ferroresonance problems.

The VFI solves this problem by providing three-phase ganged tripping. An overcurrent on any phase automatically opens all three phases simultaneously.

The VFI can be specified with single-phase trip, to provide individual phase protection for single-phase transformer loop applications.

VFI, a Breaker "and" a Switch

The VFI breaker also serves as a vacuum load-break switch. Tap switching has traditionally been accomplished by pulling load-break elbows, or by load-busting fuses. With the VFI, the tap can be switched with a simple push-pull of the operation handle.

Vacuum Load-Break Switch

Source switching is accomplished by three-phase, 600A, vacuum load-break switches. These industry proven switches provide a superior duty cycle, as compared to either oil- or air-break switches, especially in higher voltage applications.

ANSI Padmount Switchgear Standard

The VFI meets ANSI C37.72, which specifies complete deadfront construction. The VFI's vacuum load-break switches also meet the stringent ANSI switching duty cycle, not only at 15kV, but at 25kV and 35kV as well.

Low Profile Sealed Construction

The VFI features a low-profile cabinet design, with sealed tank construction. This means that the VFI can be used in locations where air-insulated switchgear cannot, such as flood areas or high-contaminant industrial sites.

Low Maintenance

The internal mechanisms and bus work are insulated with mineral oil, or sulfur hexafluoride gas can be specified as the insulation. Either medium provides electrical insulation only, since both load and fault interruption takes place in sealed vacuum interrupters.

Since there are no expulsion fuses or switching by-products to contaminate the insulation medium; maintenance intervals are greatly increased.

Additional Information

Catalog Section 285-50 provides additional information for Kyle® Type RVAC oil- or SF_6-insulated padmounted vacuum switchgear.

Service Information S285-10-1 provides installation instructions, operation information, maintenance procedures and testing information for Kyle® Type VFI oil-insulated padmounted vacuum switchgear.

Service Information S285-10-2 provides installation instructions, operation information, maintenance procedures and testing information for Kyle® Type VFI SF_6-insulated padmounted vacuum switchgear.

Service Information S285-75-1 provides installation instructions, operation information and testing procedures for the Kyle® Tri-Phase™ electronic control.

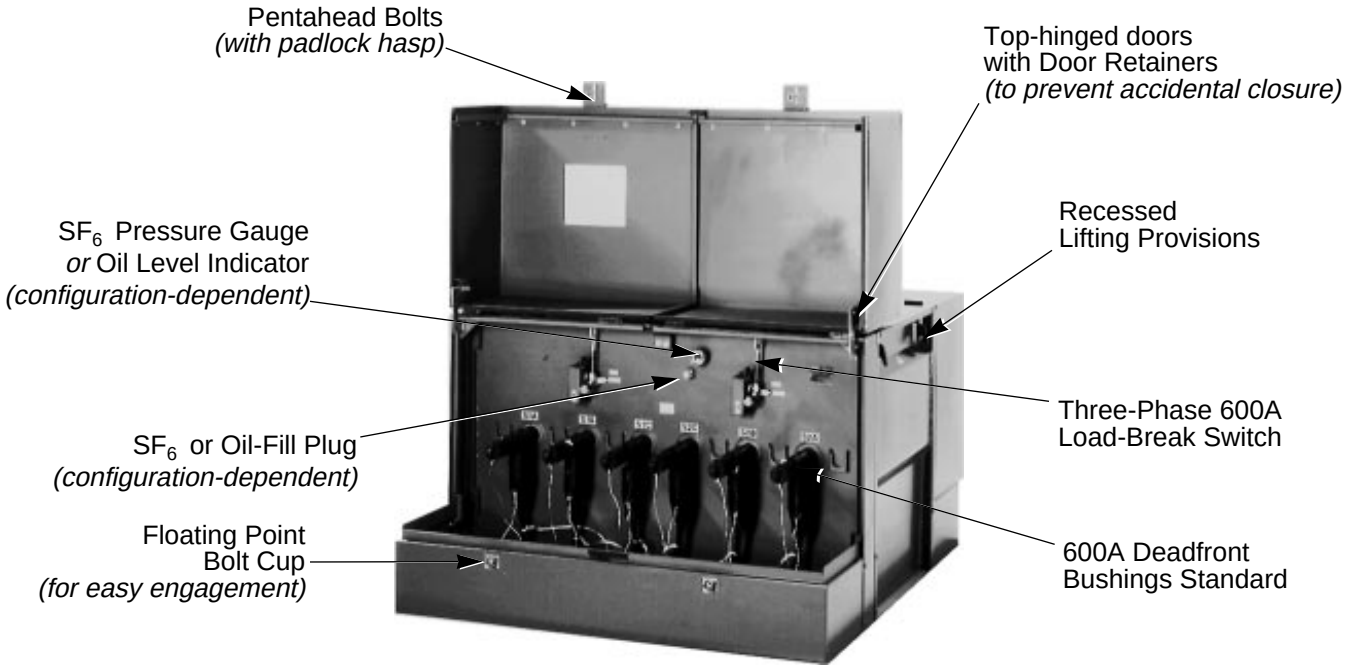


Figure 2.
VFI fault interrupter *source-side* components.

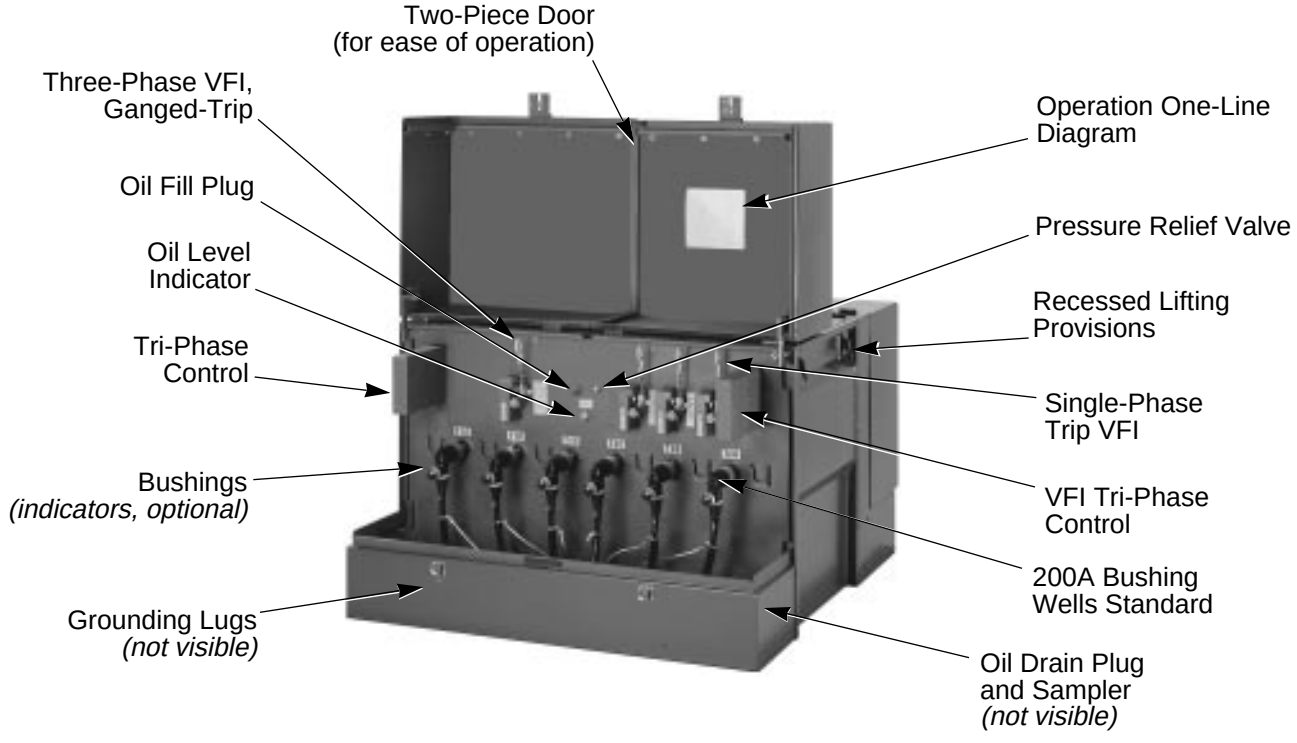


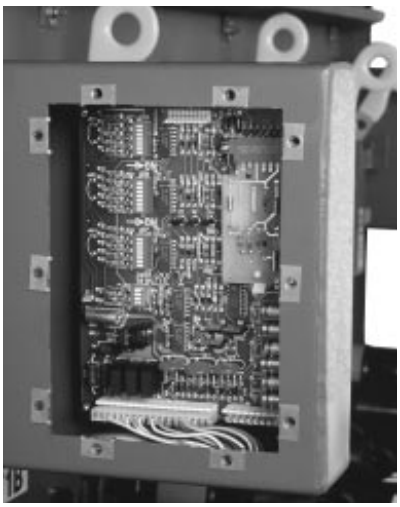
Figure 3.
VFI fault interrupter *tap-side* components.

Tri-Phase Control

The Kyle Tri-Phase control makes use of internally mounted current transformers (CT), one on each phase, to monitor line current levels. If line current, in any phase, exceeds the minimum trip level setting, the control begins a user selectable time-current-curve (TCC) delay sequence. At the completion of the programmed TCC delay, a signal is issued to trip the vacuum fault interrupter mechanism.

CT Circuits

The Tri-Phase control is powered by system current, via the current transformer circuits. It requires no external voltage supply or battery backup. Since the Tri-Phase control is powered by the sensing CT circuits, it is not affected by system voltage conditions, such as overvoltage transients.



911080KMA

Figure 4.
Tri-Phase control.

Control Settings

The minimum-trip setting for each phase is DIP switch selectable. This permits convenient field configuration of the Tri-Phase control, to meet specific application requirements.

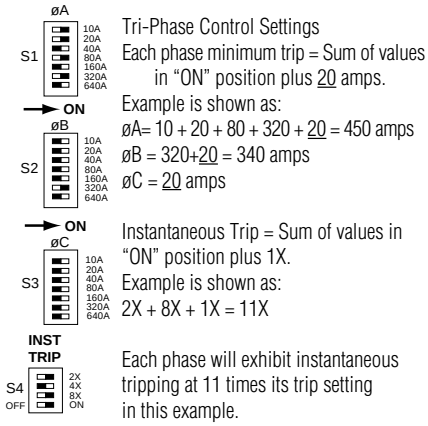
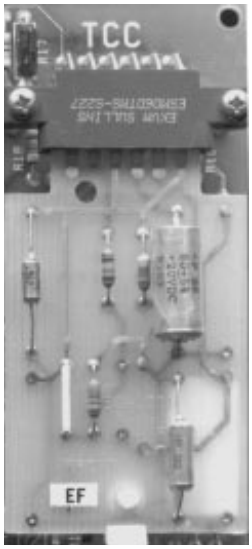


Figure 5

Figure 5.
Tri-phase control settings.

The control features an assortment of field replaceable TCC modules, each provides a fixed time-current-curve characteristic. The variety of modules available provide exceptional coordination flexibility between the Tri-Phase control and other protective equipment.



931161KMA

Figure 6.
Typical TCC module.

Normal Load

At normal system current levels, the Tri-Phase control is effectively dormant. Load current is continuously being compared to the selected minimum-trip settings, but the TCC and trip circuits are disabled.

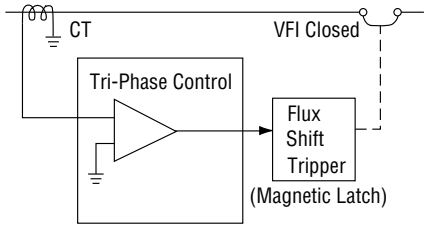


Figure 6

Figure 7.
Normal load diagram.

Overcurrent Protection

The TCC circuit is activated when current above the pre-selected minimum trip value is sensed. Once activated, the TCC circuit uses the magnitude of the overcurrent to establish a time delay. At the completion of the delay, the trip circuit pulses the Flux Shift Tripper, which causes it to trip open the VFI mechanism.

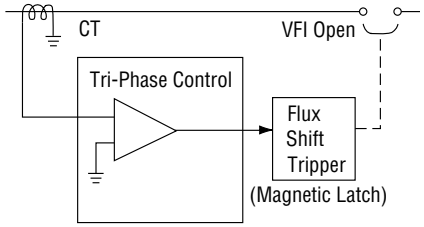
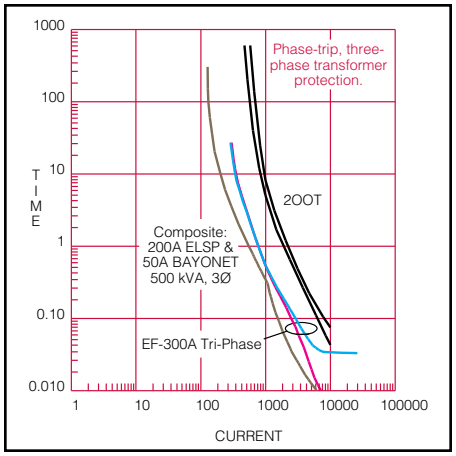


Figure 7

Figure 8.
Overcurrent protection diagram.

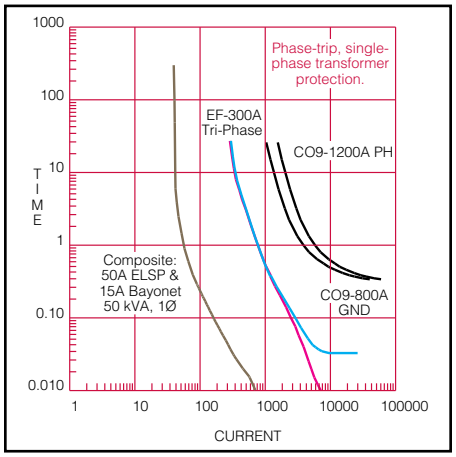
Coordination Flexibility

The E time-current-curve has long been an industry standard for pad-mount switchgear fusing. However, when several protective devices are present on the same line, it can become difficult to obtain proper system coordination. The Tri-Phase control, with the EF TCC installed, combines classic switchgear protection with state-of-the-art VFI technology. The Tri-Phase control eliminates the problems normally associated with fuses, but preserves the familiar E curve.



Coordination and application of the Tri-Phase control is identical to fuse application, but with the benefit of a greatly expanded offering of trip ratings and timing curves.

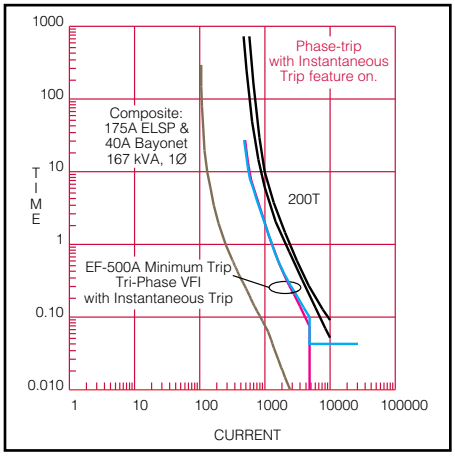
In the following example the EF TCC provides ideal coordination when protecting single-phase distribution transformer loop schemes. The cable can be protected to its rated load with plenty of room between the EF and the substation breaker.



Instantaneous Trip

Instantaneous trip, a standard feature of the Tri-Phase control, extends the range of coordination with upstream devices, at higher fault levels. A DIP switch, on the control circuit board, enables the instantaneous trip feature and programs a multiplier that is applied to the standard minimum trip setting. 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; thus eliminating any intentional time delay. For faults below this actuation level, the control operates according to its normal settings.

In the example below, the EF curve coordinates well with the transformer fusing, although instantaneous trip is required to extend coordination with the upstream T-Link.

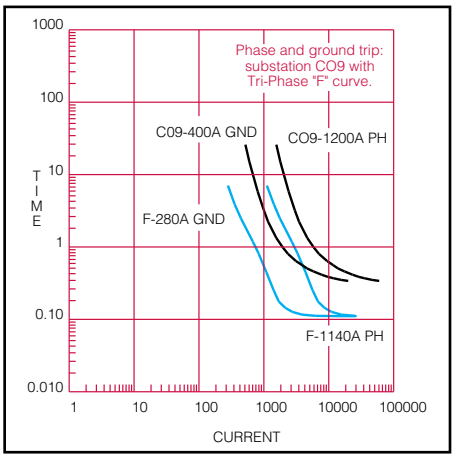


Optional Tri-Phase with Ground Trip (TPG)

The optional Kyle TPG Control operates under the same algorithm as the standard Tri-Phase Control for phase protection. In addition, the TPG Control has a separate zero-sequence circuit and settings for ground protection. Dip switch settings for ground trip vary from 10A to 640A in 10A increments, and are field selectable by the user.

The advantages of Tri-Phase technology are even more apparent when difficult coordination problems arise. The variety of curve options available eliminates curve restrictions presented by fuses. For example, the F-curve was designed to closely match the CO9-relay TCC, ideal for those applications where coordination becomes very tight.

In some applications, such as a switchgear tap that feeds both underground and overhead feeders, the TPG Control accessory is necessary. As shown below, the F curve is tucked closely to the breaker curve. The addition of an F ground fault curve provides complete coordination.



Trip-Free Operation

The VFI mechanism can be quickly and easily reset. However, if a fault is present when the VFI mechanism is closed, the trip-free feature will prevent the mechanism from being held in the closed position.

Advantages of Oil and SF_6 Insulation

- Completely sealed switchgear.
- Eliminates dielectric breakdown due to ambient contaminants.
- Eliminates failures due to contaminated insulators.
- High dielectric strength.
- Permits low profile, compact switchgear designs thru 35kV.
- Extended maintenance cycles.

Oil

- Time-proven, safe, reliable insulation.
- Compatible with existing storage and handling equipment and tools.
- Compatible with existing maintenance practices and procedures.
- Low cost.

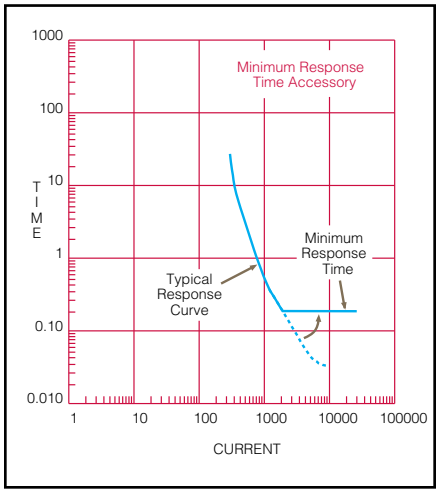
SF_6

- Non-flammable, odorless, colorless, non-toxic.
- Can be located indoors or close to more sensitive outdoor locations.

Tri-Phase Control Accessories

Minimum Response Time

The minimum response time accessory is used to achieve coordination between in-line protective interrupting devices, located where fault-level currents would normally cause simultaneous tripping. The accessory inhibits tripping until a predetermined (user selectable) minimum time has elapsed; available minimum response times are 0.050, 0.100, 0.145, 0.205, 0.260, 0.335, 0.405, 0.495, or 0.580 seconds; time selection is made with a convenient slide switch. Refer to the example shown in the graph following.



Minimum Trip Multiplier

The minimum trip multiplier accessory allows the user to increase the programmed minimum trip setting, to a predetermined alternate setting, by operating a toggle switch. Typical applications for an alternate minimum trip settings include: preplanned or emergency load transfers, maintenance, or other routine switching conditions where line or feeder load temporarily exceeds the normally anticipated levels.

Ground Trip

The TPG Control is a substitute for the standard Tri-Phase control. Operation of the phase-sensing portion of the control is identical to the standard Tri-Phase control. However, TPG measures zero sequence current, which is used for ground fault detection. If a ground-fault is detected the control will begin a user selectable time-current-curve delay sequence. At the completion of the programmed delay, a signal is issued to trip the VFI mechanism.

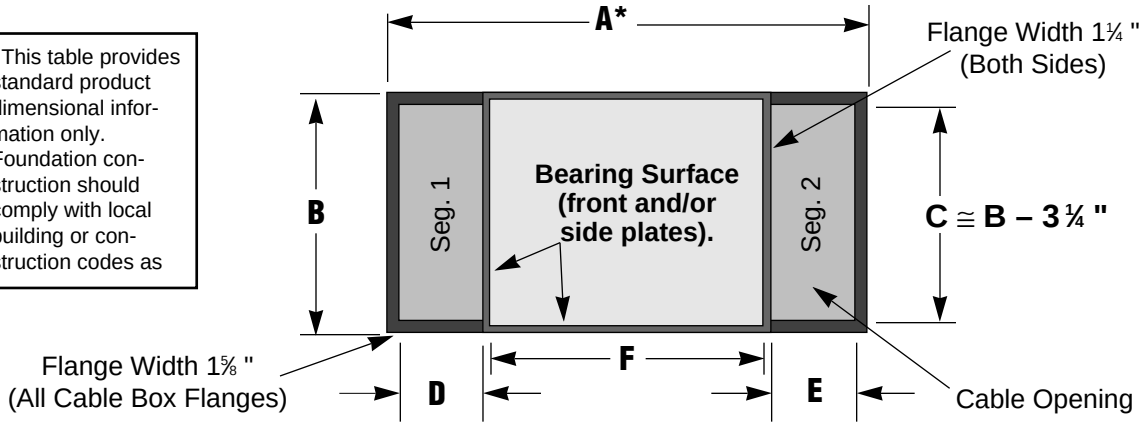
Since the ground-fault curves are more sensitive than the phase curves, they can offer a distinct advantage in those special applications where increased sensitivity and speed in overcurrent protection are required. As a result coordination with upstream devices (i.e. electronic reclosers or breakers) can be improved, in areas where coordination is tight due to limited available fault current, or line and protective device load.

New SCADA Accessory

The VFI vacuum fault interuppter, when ordered with the TPG Tri-Phase with Ground Trip accessory, may also be supplied with an optional SCADA accessory.

Available currently only as a factory-installed option, the SCADA accessory provides the user with remote trip, along with Status and Fault indicatiors, for each TPG-controlled VFI mechanism. In addition, Inrush Restraing and Minimum Trip Multiplier accessories are also provided. Consult your Cooper Power Systems representative for more details.

This table provides standard product dimensional information only. Foundation construction should comply with local building or construction codes as



Standard unit height is 48"

*A ≅ F + 5 ¾" + D + E

kV Class	Dimension	600A Seg 1, 200A Seg. 2						600A Seg. 1, 600A Seg. 2						200A Seg. 1, 200A Seg. 2					
		3 5	6 7 9 11 14	9T	10 13A	10T	12	3 5	6 7 9 11 14	9T	10 13A	10T	12	3 5	6 7 9 11 14	9T	10 13A	10T	12
15	A	60	68	71	68	71	73	66	74	77	74	77	79	54	62	65	62	65	67
	B	40	70	84	70	84	70	40	70	84	70	84	70	40	70	84	70	84	70
	D	18	18	18	18	18	18	18	18	18	18	18	18	12	12	12	12	12	12
	E	12	12	12	12	12	12	18	18	18	18	18	18	12	12	12	12	12	12
	F	24	32	35	32	35	37	24	32	35	32	35	37	24	32	35	32	35	37
25	A	60	68	71	68	71	73	66	74	77	74	77	79	54	62	65	62	65	67
	B	40	70	84	70	84	70	40	70	84	70	84	70	40	70	84	70	84	70
	D	18	18	18	18	18	18	18	18	18	18	18	18	12	12	12	12	12	12
	E	12	12	12	12	12	12	18	18	18	18	18	18	12	12	12	12	12	12
	F	24	32	35	32	35	37	24	32	35	32	35	37	24	32	35	32	35	37
35	A	72	79	81	79	81	87	78	85	87	85	87	93	66	75	77	75	77	81
	B	40	70	84	70	84	70	40	70	84	70	84	70	40	70	84	70	84	70
	D	22	22	22	22	22	22	22	22	22	22	22	22	16	16	16	16	16	16
	E	16	16	16	16	16	16	22	22	22	22	22	22	16	16	16	16	16	16
	F	28	35	37	35	37	43	28	35	37	35	37	43	28	37	39	37	39	43

Figure 9.
VFI Product Dimensions.

HOW TO ORDER

To order a Type VFI Vacuum Fault Interrupter, follow the directions here and on page 10. Use the catalog number noted in Table 1. Modify the last two digits, as required, to adapt the unit to the specific application. Select from Table 3 to specify the control.

1. From Table 1 choose the applicable base model number—select the operating voltage, circuit configuration, and insulation medium.
2. To order a Single-Phase unit, change the second-to-last digit from a 3 to a "1" (i.e. KPOVF915).
3. To identify the required bushing arrangement refer to Table 2. Change the last digit to the number identified in the table (i.e. KPOVF935, the 5 identifies a 25 kV, 600A/200A bushing arrangement).

Note: All configurations are available with 600A Taps. All configurations shown are standard "4-Way" designs, consult factory for "6-Way" designs.

Example: Required unit is to be a 4-way 15kV VFI with two 600-amp, 3-phase vacum source switches, two 200-amp VFI protected 3-phase tap ways with 3-phase trip. The catalog number selected will be **KPOVF932**.

4. From Table 3, select the required control or controls and time-current curve characteristcs (TCCs) cards as required for phase and/or ground trip from Table 4A or Table 4B. See Table 2B to determine the number of controls required per unit.

   Example: For the above unit, KPOVF932, the Tri-Phase control is desired. From Table 2B it is noted that two controls are required for each unit, one for each 3-phase VFI protected tap. From Table 3, the following catalog number is selected for the control: **KTP0111**.

   In addition, we must specify the required TCC. Table 4A is used for the Tri-Phase control. A type EF curve with minimum response time accessory is desired for this unit. From Table 4A, the following catalog number is selected for the TCC cards: **KPA-TCC-EFR**.

5. **Omit this step and go to step 4 if control is to have settings made in the field**—unit will be shipped with factory default settings. If desired, the control(s) settings may be factory set by specifying the following:

   KPA-MT-XXXX; phase min. trip setting (XXXX = 20A – 1290A in 10A increments; *default* 80A).

   KPA-MTG-XXXX (TPG only); grnd. min. trip setting (XXXX = 10A – 640A in 10A increments; *default* 40A).

   KPA-INST-ZZ; phase inst. trip setting (ZZ = 1 – 15 in odd increments, 00 = off, *default*).

   KPA-INSTG-ZZ (TPG only); phase inst. trip setting (same as above).

6. From Tables 5, and 6, respectively, specify the catalog numbers that describe the optional bushings and accessories if they are required.

   Example: For the above unit, inserts are required for the 200A bushing wells on taps T1 and T2. From Table 5, select and enter catalog number KPA-1033 (quantity – 2).

   Example: Also required are copper ground rods, fault indicator mounting provisions, and an operation counter for each source switch and tap VFI operating handle. The following catalog numbers would be selected and entered:

   KPA-1037-7 (copper grnd. rods, enter quantity – 1)

   KPA-FID12 (fault indicator prov., enter quantity – 1)

   KPA-1049V (op. counter, enter quantity – 2)

   KPA-1049S (op. counter, enter quantity – 2)

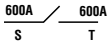
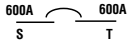
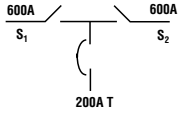
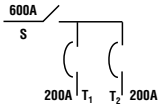
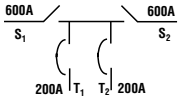
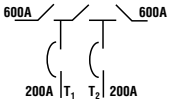
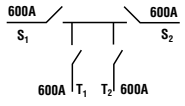
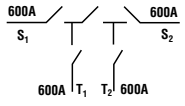
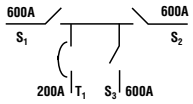
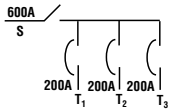
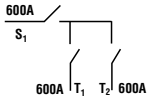
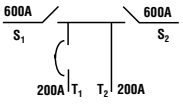
Sample Order

From the foregoing example, the following catalog numbers would be entered to describe the unit that is to be manufactured:

Catalog Number	Qty.
KPOVF932	**1**
KTPO111	**2**
KPA-TCC-EFR	**2**
KPA-1033	**2**
KPA-1037-7	**1**
KPA-FID12	**1**
KPA-1049V	**2**
KPA-1049S	**2**

All control settings will be set at their factory defaults.

TABLE 1
Basic Models

Model	One Line Diagram	Voltage (kV)	Insulation Medium: Oil	Insulation Medium: SF_6
3*		15	KPRV3*31*	KPSRV3*31*
		25	KPRV3*34*	KPSRV3*34*
		35	KPRV3*37*	KPSRV3*37*
5		15	KPOVF5*31*	KPSVF5*31*
		25	KPOVF5*34*	KPSVF5*34*
		35	KPOVF5*37*	KPSVF5*37*
6		15	KPOVF6*32*	KPSVF6*32*
		25	KPOVF6*35*	KPSVF6*35*
		35	KPOVF6*38*	KPSVF6*38*
7		15	KPOVF7*32*	KPSVF7*32*
		25	KPOVF7*35*	KPSVF7*35*
		35	KPOVF7*38*	KPSVF7*38*
9		15	KPOVF9*32*	KPSVF9*32*
		25	KPOVF9*35*	KPSVF9*35*
		35	KPOVF9*38*	KPSVF9*38*
9T		15	KPOVF9T*32*	KPSVF9T*32*
		25	KPOVF9T*35*	KPSVF9T*35*
		35	KPOVF9T*38*	KPSVF9T*38*
10*		15	KPRV10*31*	KPSRV10*31*
		25	KPRV10*34*	KPSRV10*34*
		35	KPRV10*37*	KPSRV10*37*
10T*		15	KPRV10T*31*	KPSRV10T*31*
		25	KPRV10T*34*	KPSRV10T*34*
		35	KPRV10T*37*	KPSRV10T*37*
11		15	KPOVF11*32*	KPSVF11*32*
		25	KPOVF11*35*	KPSVF11*35*
		35	KPOVF11*38*	KPSVF11*38*
12		15	KPOVF12*32*	KPSVF12*32*
		25	KPOVF12*35*	KPSVF12*35*
		35	KPOVF12*38*	KPSVF12*38*
13A*		15	KPRV13A*31*	KPSRV13A*31*
		25	KPRV13A*34*	KPSRV13A*34*
		35	KPRV13A*37*	KPSRV13A*37*
14		15	KPOVF14*32*	KPSVF14*32*
		25	KPOVF14*35*	KPSVF14*35*
		35	KPOVF14*38*	KPSVF14*38*

*RVAC models. Special RVAC configurations, also optionally available.
These are switch only, fuseless designs.
See Catalog Section 285-50 for further information.

TABLE 2
Bushing Guide

Voltage Rating	Amperage Rating (Source/Tap)		
	600A / 200A*	600A / 600A	200A* / 200A*
15kV	2	1	3
25kV	5	4	6
35kV	8	7	9

* VFI's ordered with 15 or 25kV voltage rating are equipped with wells only on the 200A side.

Type VFI Vacuum Fault Interrupter

TABLE 3
VFI Control

KTP Basic letters for VFI control

O Control Type

- O = Phase trip **O**nly (Tri-Phase control)
  Note: One TCC, EF supplied as default. See Table 3.
- G = Tri-Phase with **G**round trip (TPG control)
  Note: One TCC, EF supplied as default. See Table 3.
- S = Phase, Gnd, and **S**CADA board (TPG + SCADA board)
  Note: One TCC, EF supplied as default. See Table 3.

111 — Mild steel cabinet

KTP O 111 = Tri-Phase control, mild steel cabinet

*__Note:__ 200A = wells only provided; see Table 5 to order optional bushing inserts if required.

TABLE 4A
Tri-Phase Control TCCs and Settings

Description	Catalog Number
Tri-Phase Control (select Phase TCC only)	KTP011
Phase TCC (X = EF, KF, TF, H, or F)	KPA-TCC-X
Optional Minimum Response TCC Accessory (X = EFR, KFR, TFR, HR, or FR	KPA-TCC-X

Default TCCs and Settings: EF TCC, Min Trip = 80A, Inst Trip = OFF.

TABLE 4B
Optional TPG Control (Tri-Phase Control w/Gnd Trip) TCCs and Settings

Description	Catalog Number
TPG Control (select Phase and Gnd TCC)	KTPG111
Phase TCC (X = EF, KF, or TF)	KPA-TCC-X
Ground TCC (X = EF, KF, or TF)	KPA-TCC-X
Optional Phase Minimum Response TCC Accessory (X = None)	KPA-TCC-X
Optional Ground Minimum Response TCC Accessory (X = None)	KPA-TCC-X
TPG with Optional SCADA Board (Adder for SCADA board); includes Remote Trip, Remote Indication, Inrush Restraint, Fault Targets, and Minimum Trip Multiplier (select Phase and Gnd TCC)	KTPS111

Default TCCs and Settings:
EF TCC supplied for both Phase and Gnd, Phase Min Trip = 80A, Gnd Min Trip = 40A, Phase Inst Trip = OFF, Gnd Inst Trip = OFF, Gnd Trip Block = Disabled.

Type VFI Vacuum Fault Interrupter

TABLE 5
Optional Bushings

Current Rating	Nominal kV Class	Description*	Catalog Number
200-Amp Loadbreak	15	3 Bushing inserts	KPA-1033
200-Amp Loadbreak	15	3 Single-piece bushings	KPA-1041
200-Amp Loadbreak	25	3 Bushing inserts	KPA-1034
200-Amp Loadbreak	25	3 Single-piece bushings	KPA-1042

Cooper Power Systems bushings and bushing wells provided.

TABLE 6
Miscellaneous

Description	Catalog Number
1/2" Copper ground rod (mounts in ANSI stainless steel ground nuts provided as standard)	KPA-1037-7
1” drain valve with 3/8” sampler (in lieu of standard drain plug and sampler)	KPA-1051
Fault indicator provisions, qty 12 (3 provisions in each source and tap door)	KPA-FID12
Operation counter, VFI operator handle	KPA-1049V
Operation counter, switch operator handle	KPA-1049S

COOPER Power Systems

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