INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

K-DAR DIRECTIONAL COMPARISON BLOCKING SYSTEMS

INTRODUCTION

This instruction leaflet describes the over-all functioning of K-DAR directional comparison blocking system using TC carrier. (Refer to L-836600 for K-DAR blocking system using TA-3 tone.)

Detailed description of operation, setting and maintenance of the individual relays are described in their respective instruction leaflets. The description here is intended to supplement these relay instructions.

APPLICATION

By extending the basic principle of differential protection to line relaying, pilot relay systems provide high-speed, simultaneous clearing for all external faults. The pilot channel provides the communication link which enables comparison of current or power flow at all line terminals.

DIRECTIONAL COMPARISON BLOCKING SYSTEM

Basic System Concept

The system described in this instruction leaflet provides high speed detection of transmission line phase and ground faults, initiates tripping, controls reclosing of the circuit breaker (s), controls the breaker failure tripping circuits (s), and refrains from operating for any fault outside of the protected line section.

The tripping relays 21P and 67N are directional and one or both is responsive to all faults internal to the protected line. If fault current flows into all line terminals simultaneously, no blocking carrier is transmitted and high-speed tripping at all terminals of the faulted line takes place.

For faults external to the protected line, 21P and 67N at one terminal will not operate. This prevents tripping at that terminal and permits transmission of a blocking carrier signal to all other terminals. Transmission of carrier is initiated by the 21S relay and/or by I_{OS} (in the 85 relay) which are set to reach beyond the tripping relay at the other terminals as shown in Figure I.

The factor that distinguishes the directional comparison blocking system from other similar pilot systems is that carrier channel is normally in a tripping mode (i.e. the TC carrier is normally off), and that a sustained blocking (trip preventing) carrier signal is transmitted upon the occurrence of any external fault for which the tripping relays operate.

It is possible for some internal fault conditions to produce operation of the "Carrier start" relay (e.g. I_{OS} is non-directional). Also since voice communication or any other function can normally utilize the TC channel in the scheme, there is a possibility that carrier could be on when an internal fault occurs. To avoid any problem due to this, the tripping relays have predominant control and can stop carrier transmission at any time to provide high-speed fault tripping.

The fundamental concept of this system is that tripping takes place only if the tripping relays, which are directional, operate and if carrier is not received.

Equipment Complement

These instructions contemplate the use of separate primary and back-up relays, in line with local back-up philosophies. Figure 2 shows the details of this arrangement. It is a 4-zone system and contrasts to the 3-zone system where the zone-2 phase distance units provide carrier tripping as well as back-up. Nevertheless, the underlying principles described here apply whether or not the back-up protection is independent or common with the primary protection. Of course, the relaying complement may vary from that shown.

Table I lists the schematics for the various K-DAR systems which use TC carrier. Table II shows the equipment complement for the system. (647F381)

TABLE I
SYSTEM SCHEMATICS

Description	Schematic
3-Zone K-DAR relaying with TC & TD-4	647F794
3-Zone K-DAR relaying with TC & TD-52	647F795
4-Zone K-DAR relaying with TC & TD-4	647F790
4-Zone K-DAR relaying with TC & TD-52	647F792 (Fig. 2)

TABLE II
EQUIPMENT COMPLEMENT
(for each terminal)

Number	Type	Description	Remarks
21P	KD-10	Phase distance, pilot trip relay	
21S	KD-11	Phase distance, carrier start relay	
67N	KRD-4	Carrier ground directional over-current relay, dual polarized	(Note 1)
50-1	KC-2	Fault detector to supervise 21-P	
85	KA-4	Carrier auxiliary relay	
85CO	W2	Carrier ON-OFF switch	
MA		0-300 MA milliammeter	
85PB		Carrier test push-button	
TRB-2		Blocking zener	
TC	TC	TC carrier set	

OPTIONS

Number	Type	Description	Remarks
2	TD-52	Z2/Z3 timer	(Note 2)
21-1	KD-10	Zone-1 phase distance	
21-2	KD-10	Zone-2 phase distance	
62NT	1RD	Ground directional overcurrent relay, dual polarized	(Note 3)
68	KS	Out-of-step blocking relay	
50-2	KC-2	Fault detector to supervise 21-1/21-2	
85SD		Reserve Signal Detector	

OPTIONS

Number	Type	Description	Remarks
94T	AR	Trip auxiliary relay for back-up system	(Note 5)
	Resistors	100 ohms and 2 ohms for 94T circuit	(Note 6)
79Z	AR	Double unit in FT-22, for reclose blocking	(Note 4)
62X	AR	Breaker failure initiation, primary	(Note 5)
62Y	AR	Breaker failure initiation, secondary	(Note 5)

Note (1) Alternate to 67N, (a) Type KRC, current polarizing ground relay, or (b) type KRP, Voltage polarizing ground relay.

Note (2) (a) use type TD-5 timer if 21P is not used for time delay tripping. (b) type TD-4 timer relay for alternative.

Note (3) Alternate to 67NT, (a) type IRC, current polarizing ground relay, or (b) type IRP, voltage polarizing ground relay.

Note (4) Use single unit AR if 21P is not used for time delay tripping (i.e. do not need AR1)

Note (5) 62X, 62Y or 79Z contact also can be used for reclosing initiation. (SGR-52).

Note (6) One additional AR and 100 Ω, 2 Ω resistors are required for trip auxiliary in primary circuit for 2 breaker scheme.

OPERATION

When an external fault occurs, as shown in figure 1, the transmitter at breaker B is keyed by the "start" relays to block tripping at breaker A. Breaker B is not tripped because the fault power flow is not in the proper direction to close the D_O, 21P-$\phi\phi$+ or 21P-3ϕ contacts.

When an internal fault occurs, a blocking signal is transmitted from neither A nor B in figure 1; in the absence of blocking the tripping units at each station (21P-$\phi\phi$ or 21P-3ϕ for phase faults, D_O and I_O for ground faults) are permitted to trip. Succeding paragraphs will explain how this is performed.

Phase Fault Tripping

Distance units 21P-$\phi\phi$ and 21P-3ϕ, operate only when fault power flows into the protected line as shown in figure 1. They are set to reach beyond the end of the line (overreaching setting), so that faults anywhere on the protected line will be detected and cleared at high speed. These units such as at breaker A, figure 1 also operate for faults on the adjacent system; therefore, the 21P contacts must be supervised by a contact which does not close during external faults. This supervising contact is RRP in figure 2. For internal faults the RRP contact closes to permit one of the 21P contacts to energize the breaker trip coil, 52 TC. The trip path is from positive, through ICS coil, 21P-$\phi\phi$ or 21P-3ϕ and OS contacts, 85-CO contact A11-B11 OI coil, RRP contact, 52a contact, to the trip coil.

Figure 2 also shows an optional time delay backup path, through a timer TR contact which bypasses the RRP contact circuit. Operation of 21P starts the timer. If the fault, either internal or external, is not cleared by other means, the breaker will be tripped after time delay, T3, if the fault is within the reach of 21P.

Ground Fault Tripping

Ground directional unit, D_O closes only for ground faults in one direction, as is the case for the phase tripping units, 21P. The instantaneous unit I_O, is set to pickup for a zero sequence current well below the solid ground fault level, to insure high speed tripping even with substantial fault resistance. As with 21P, this overreaching setting results in relay operation for external faults in the "trip direction". To prevent breaker tripping for external faults, the ground trip path must likewise be supervised. RRG is the ground fault supervising contact, which remains open during external faults, but closes during internal faults to permit the ground tripping relay to clear the fault.

Tripping from positive is through 85-CO contact C1-D1, ICS coil, contacts D_O, I_O, RRG, 52a, to the trip coil.

Transmitter Control

Break contacts 21S-$\phi\phi$, 21S-3ϕ, I_{OS}, and the test pushbutton break contact, PB, in figure 2, connect the transmitter "start" lead to minus. When any one of these contacts opens, the "start" lead (i.e. terminal 85/8) is connected to positive through resistor, R2. This positive potential will key the transmitter on (or shift the frequency, when a frequency shift channel is utilized), to block remote breaker tripping, provided that the "stop" lead (i.e. terminal 85/11) is not tied to minus, through contact CSP or CSG. CSP and CSG coils are energized by 21P and D_O contacts, respectively, so that any time a fault is detected in the trip direction the "stop" lead is tied to minus to prevent transmission of a blocking signal. Thus, the stop lead has precedence over the start lead. If, for example, the channel is being used for voice communication at the instant of an internal fault, the stop circuit will interrupt transmission to permit tripping, provided that either 21P or D_O operates.

A blocking signal is required from breaker B. Figure 1, during an external fault because the phase or ground tripping units would otherwise trip at breaker A. At breaker B either the I_{OS} or the 21S contact opens to put positive voltage on the start lead; since neither the CSP nor the CSG contacts close at B the stop lead is not energized, and, therefore, a blocking signal is transmitted.

At breaker A RRT coil is energized when D_O closes to operate CSG; however, tripping is prevented by RRH coil current, which holds RRG open.

Internal Ground Fault Operation

Refer to Table III. Operation is the same at both stations. D_O closes, energizing CSG. CSG contacts stop blocking signal transmission and energize the the RRT coil. Since no blocking signal is received. RRH is not energized; therefore, RRG closes and the breaker trip coil is energized through 85 CO contact C1-D1, D_O, I_O, RRG and 52a contacts.

Out-of-Step Operation

KS relay distance unit, Z_{OS}, is set to include the 21P-3ϕ unit R-X diagram circle as shown in figure 3. A minimum separation of two secondary ohms is recommended between the Z_{OS} and 21P-3ϕ unit circles. This separation provides the means for distinguishing between 3-phase faults and out-of-step conditions. When a fault occurs on the protected line, the impedance seen by the relays changes suddenly from the prefault value, Z_{Load}, to the fault value, represented by the line O-F in figure 3. When a swing or out-of-step condition occurs the impedance seen by Z_{OS} and 21P changes gradually, as the voltage decreases and the current increases. In figure 3 the swing describes an arc which intersects the Z_{OS} circle at point Q and 21P-3ϕ circle, at point P.

During the out-of-step condition the Z_{OS} contact in figure 2 opens before 21P-3ϕ contact closes. OS unit is energized, and after 3 to 4 cycles, an OS contact opens the 21P-3ϕ trip-circuit. All this occurs before the swing reaches point P, in figure 3.

During a fault, the 21P-3ϕ contact closes almost at the same instant that the Z_{OS} contact opens in figure 2. 21P-3ϕ contact short-circuits the OS coil to prevent OS from operating. Thus a fault condition results in a nearly simultaneous operation of Z_{OS} and 21P-3ϕ while an out-of-step condition produces a discrete difference in the operating time of these two distance units.

In some cases it is preferable to block breaker reclosing rather than blocking tripping, when an out-of-step condition occurs. A make contact of OS is available for this purpose. Otherwise, this OS contact may be used for alarm purposes, as shown by the dotted connection in figure 2.

SETTINGS

Carrier

The carrier transmitter and receiver levels and tuning equipment should be adjusted in accordance with the appropriate instruction leaflets. In three terminal applications transmitter frequencies should be chosen 100 Hz apart with all receivers chosen at the center frequency to avoid possible signal cancellation on out-of-phase carrier arrival when there is outfeed at two terminals.

Pilot Relaying Criterion

It is essential that the local start units, which initiate blocking signal transmission, operate for any external fault for which the remote tripping unit also operate. Otherwise, undesired tripping of the remote breaker may occur.

Receiver Relay Comparison Circuits

Receiver relay, RR (in 85) has an RRH holding coil and an RRT tripping coil as shown in figure 2. RRH is energized by the receiver output when a blocking signal is transmitted; RRT coil is energized whenever the local tripping relay contacts close in an attempt to trip the breaker. RRH coil current holds the RRP and RRG contacts open; RRT coil current closes the RRP and RRG contacts in the absence of RRH coil current. This is the key point, which produces the comparison function – the force produced by RRH current is stronger than the opposing forced produced by RRT current, so that the RRP and RRG contacts will be closed by RRT current only when no blocking signal is received.

In figure 1, 21P or D_O and I_O contacts close at breaker A whether the fault is internal or external to the right of breaker B; in either case, CSP or CSG is energized and RRT, in turn, is energized. For the external fault only, the transmitter at B sends a blocking signal, which produces a receiver output at A which energizes the RRH coil to prevent RRP contacts from closing thus preventing tripping. Conversely, for an internal fault, tripping units operate at both stations to close CSP or CSG contacts to prevent transmission of a blocking signal; another set of CSP/CSG contacts energize the RRT coil. Since neither station receives a blocking signal, both RRH coils are deneergized; both RR relays operate to close their RRP and RRG contacts to permit either 21P or D_O and I_O contacts to energize the trip coil.

Operation will now be summarized.

External Phase Fault Operation

Refer to Table III which tabulates external phase fault functioning at the top. The external fault is to the right of breaker B as shown in the upper left of Table III.

At breaker B, 21S contact opens and the 21P contact remains open, so that CSP is not energized; the start lead is at positive and the stop lead is

open, so the transmitter sends a blocking signal. Tripping does not occur because 21P is open.

At breaker A, 21P contact closes, energizing CSP. CSP contact energizes RRT; however, RRP contact is held open by RRH current.

Internal Phase Fault Operation

Operation is the same at both stations. Refer to Table III. 21S does not operate, since it is set to look into the external system. 21P contact closes, energizing CSP, CSP contact closes to apply negative to the stop lead, preventing blocking signal transmission. Another CSP contact energizes RRT; since there is no signal to produce RRH coil current. RRP and RRG contacts close.

External Ground Fault Operation

Refer to Table III. Since the ground overcurrent units I_{OS} in 85 relays are not directional, they operate at both A & B to open their contacts. At breaker A, I_{OS} operatation is ineffective, since the stop lead is energized by CSG. However, at breaker B, CSG and the stop lead are not energized, so that the opening of the I_{OS} contact results in transmission of a blocking signal from B. Tripping at breaker B does not occur because D_O remains open.

Phase Pilot Relays

The 21P relay should be set to substantially overreach the adjacent bus as shown in figure 1. A typical setting is 150% of the line impedance (transformed into relay ohms, of course). Where 21P operates a timer, it must be set to underreach any adjacent line Zone 1 relay. The 21S relay must be set to reach farther than the 21P relay at the remote terminal. It is recommended that distance MN in figure 1 be at least half of distance NP. In general, it is recommended that the 21S setting be made equal to the remote 21P setting.

Ground Pilot Relays

Carrier starting for ground faults is accomplished with an instantaneous ground overcurrent unit, IOS. The I_{OS} unit is factory set for 0.5 amperes. It can be readjusted to any value up to 1 ampere by increasing its spring restraint if the maximum residual load unbalance current in the relays exceeds 0.5 amperes. The I_O unit of 67N relay is customarily set for 1.5 times the I_{OS}.

For long line applications, 100 miles or more, it will be necessary to use a ratio of 2.5 or more rather than the normal 1.5 ratio for I_O/I_{OS}. This is due to the distributed capacitance effect on external ground faults causing a substantially higher zero sequence current to flow in the relays remote from the fault than that which flows in the relays at the terminal close to the fault.

In a 3-terminal application with single terminal infeed and the other two terminals feeding out for an external fault, it may also be necessary to have a higher than normal ratio.

Fault Detectors

I_A and I_C units of 50 relay (s) must be set above maximum load current and below minimum phase fault current if they are to be used to supervise phase distance relays. If they cannot be used for this function, tripping will occur on potential failure.

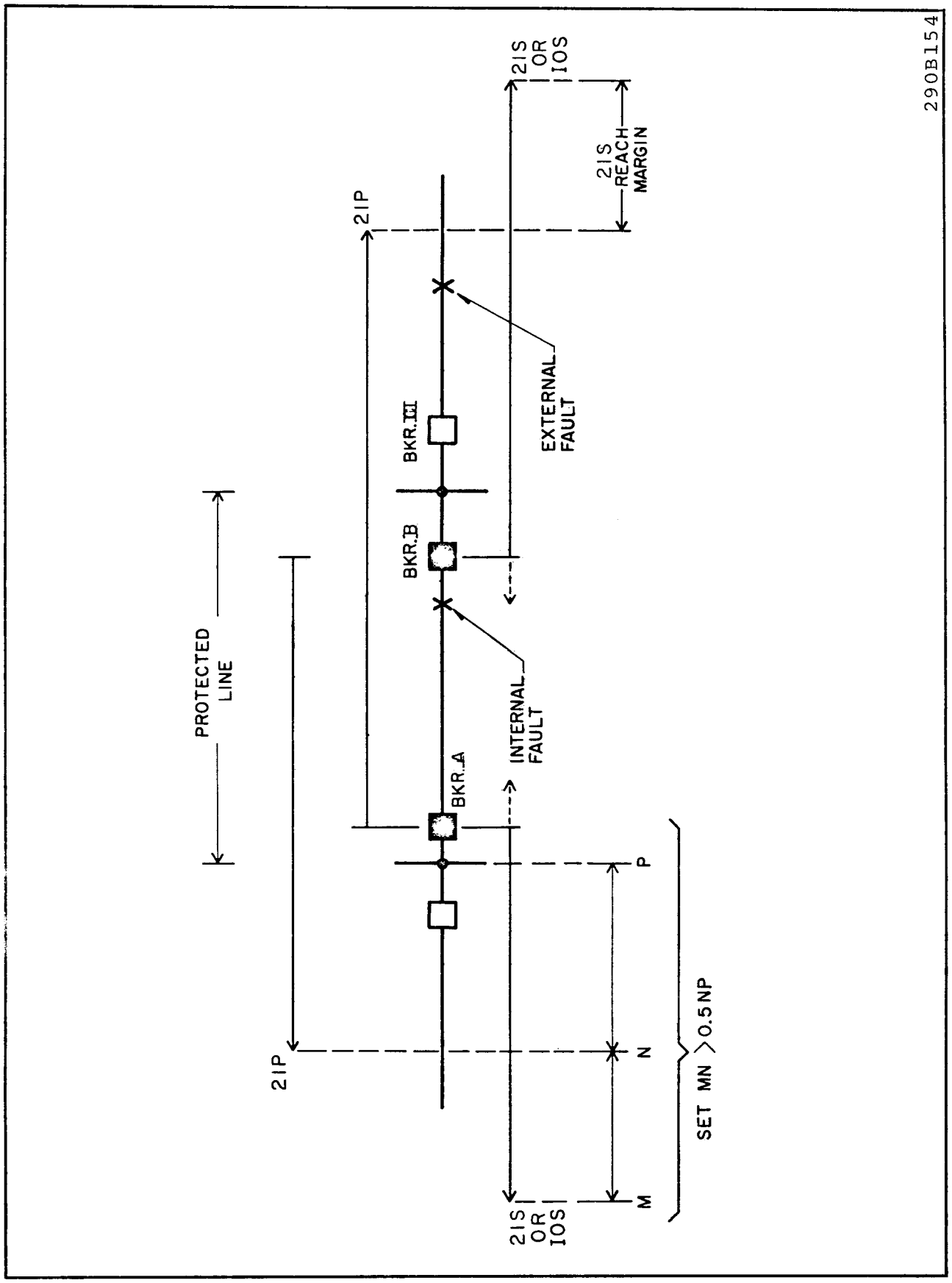

Fig. 1 Setting Criteria

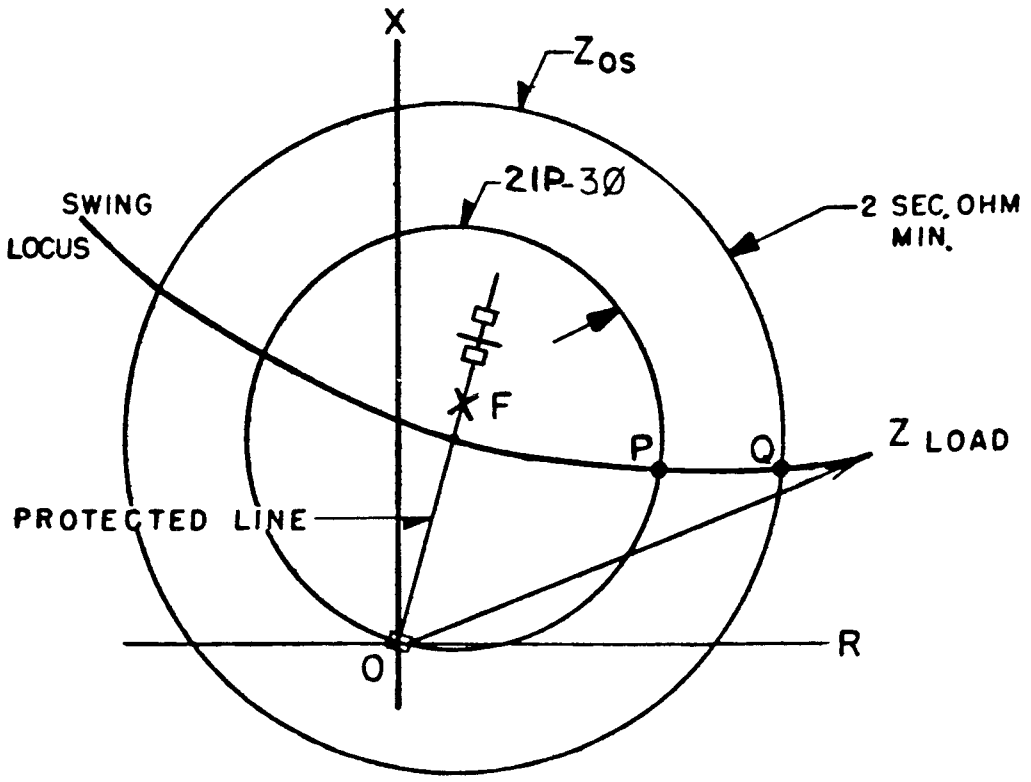

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Fig. 3 Out-of-Step Blocking Operations

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TABLE III

BKR. A / BKR. B — INT / EXT	X'MTR. START — TO X'MTR., I_{os}, 21S	CSP & CSG COILS — 21P, D_o, CSP, CSG, 52a	X'MTR. STOP — TO X'MTR., CSP, CSG	RRT COIL — RRT, CSP, CSG	RRH COIL — RRH, FROM RCVR.	TRIP CIRCUIT — 21P, D_o, I_o, RRP, RRG, 52a, TC
	EXTERNAL		PHASE		FAULT	
BKR. A	21S STAYS CLOSED	21P ENERGIZES CSP	CSP CLOSES	CSP CLOSES	RRH ENERGIZED	RRP & RRG HELD OPEN BY RRH CURRENT
BKR. B	21S OPENS	21P Z_p STAYS OPEN	CSP & CSG STAY OPEN	CSP & CSG STAY OPEN	RRH DE-ENERGIZED (NOTE 1)	RRP & RRG HELD OPEN BY MAGNETIC BIAS (NOTE 1)
	INTERNAL		PHASE		FAULT	
BKR. A	21S STAYS CLOSED	21P ENERGIZES CSP	CSP CLOSES	CSP CLOSES	RRH DE-ENERGIZED	TRIP THROUGH 21P & RRP
BKR. B	21S STAYS CLOSED	21P ENERGIZES CSP	CSP CLOSES	CSP CLOSES	RRH DE-ENERGIZED	TRIP THROUGH 21P & RRP
	EXTERNAL		GROUND		FAULT	
BKR. A	I_{os} OPENS	D_o ENERGIZES CSP	CSG CLOSES	CSG CLOSES	RRH ENERGIZED	RRP & RRG HELD OPEN BY RRH CURRENT
BKR. B	I_{os} OPENS	D_o STAYS OPEN	CSP & CSG STAY OPEN	CSP & CSG STAY OPEN	RRH DENER-GIZED	RRP & RRG HELD OPEN BY MAGNETIC BIAS
	INTERNAL		GROUND		FAULT	
BKR. A	I_{os} OPENS (NOTE 2)	D_o ENERGIZES CSG	CSG CLOSES	CSG CLOSES	RRH DE-ENERGIZED	TRIP THROUGH D_o, I_o, & RRG
BKR. B	I_{os} OPENS (NOTE 2)	D_o ENERGIZES CSG	CSG CLOSES	CSG CLOSES	RRH DE-ENERGIZED	TRIP THROUGH D_o, I_o, & RRG

NOTE 1 RRH COIL IS ENERGIZED BY ITS OWN TRANSMITTER WHEN CHANNEL USES SINGLE FREQUENCY OPERATION. THIS FEATURE IS NOT ESSENTIAL TO PROPER OPERATION

NOTE 2 I_{os} OPERATION IS INEFFECTIVE SINCE CSG CONTACT CLOSES TO STOP BLOCKING SIGNAL.

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