Effective: October 1999

Supersedes I.L. 40-208B, Dated February 1975

(|) Denotes change from superseded issue

Type K-DAR Directional Comparison Blocking Systems

CAUTION

Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely. Inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

1.0 INTRODUCTION

This instruction leaflet describes the over-all functioning of K-DAR directional comparison blocking system using Power-Line Carrier.

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.

2.0 APPLICATION

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

3.0 DIRECTIONAL COMPARISON BLOCKING SYSTEM

3.1 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 circuit(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 1 (page 6).

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 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 remote tripping relays operate.

All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB representative should be contacted.

It is possible for some internal fault conditions to produce operation of the “Carrier start” relay i.e., I_{OS} is non-directional). Also since voice communication or any other function can normally utilize the 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.

3.2 Equipment Complement

These instructions contemplate the use of separate primary and back-up relays. Figure 2 (page 7) shows the details of this arrangement. It is a 4-zone system and contrasts to the 3-zone where the zone-2 phase distance units provide carrier tripping as well as backup. Nevertheless, the underlying principles described here apply whether or not the back-up protection is independent or common with the primary protection.

Table 1 lists the individual components required at each terminal.

Table 1:
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-2	Carrier auxiliary relay	
85CO	W2	Carrier ON-OFF switch	
MA		Millimeter	
85PB		Carrier test push-button	
TRB-2		Blocking Zener	
		Power-Line 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	
67NT	IRD	Ground directional overcurrent relay, dual polarized	Note 3
68	KS-3	Out-of-step blocking relay	
50-2	KC-3	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 KRD-4, (a) Type KRC, current polarizing ground relay, or (b) type KRP, voltage polarizing ground relay.

Note (2) Use type TD-5 timer if 21P is not used for time delay tripping.

Note (3) Alternate to IRD, (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.

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

4.0 OPERATION

When a external fault occurs, as shown in Figure 1 (page 6), 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_0, 21P-ϕϕ + 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-ϕϕ or 21P-3ϕ for phase faults, D_0 and I_0 for ground faults) are permitted to trip. Succeeding paragraphs will explain how this is performed.

4.1 Phase Fault Tripping

Distance units 21P-ϕϕ and 21P-3ϕ, operate only when a fault occurs within their protected zone as shown in Figure 1. They are set to reach beyond the end of the line (overreaching setting), so that phase 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 3 (page 9). For internal faults the RRP contact closes to permit one of the 21P contacts to energize the breaker trip coil, 52TC. The trip path is from positive, through ICS coil, 21P-ϕϕ or 21P-3ϕ and OS contacts, 85-CO contact A11-B11 OI coil, RRP contact, 52a contact, to the trip coil.

Figure 2 (page 7) 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.

4.2 Ground Fault Tripping

Ground directional unit D_0 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 will 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_0, I_0, RRG, 52a, to the trip coil.

4.3 Transmitter Control

Break contacts 21S-ϕϕ, 21S-3ϕ, I_{OS}, and the test push-button 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 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_0 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_0 operates.

A blocking signal is required from breaker B, Figure 1(page 6), 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.

The KA-4 auxiliary relay contains the I_{OS} unit as well as the receiver (polar) unit. For the receiver unit two coils work in opposition to one another. One is identified as RRT (trip) and the other as RRH (holding). If RRT alone is energized contacts RRP and RRG close. If RRH is energized these contacts are held open irrespective of whether or not RRT is energized.

4.4 External Ground Fault

For an external ground fault as in Figure 1(page 6), the RRT coil is energized at A through the generation of the D contact and the CSG contact. Received carrier, however, energizes RRH, which prevents the closing of the RRG contact. Tripping is, then, prevented for this external fault.

4.5 Internal Ground Fault Operation

Refer to Figure 4 (page 10). Operation is the same at both stations. D_O closes, energizing CSG. CSG contacts stop blocking signal transmission and energize 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_0, I_0, RRG and 52a contacts.

4.6 Out-of-Step Operation

KS-3 relay distance unit, Z_{OS}, is set to include the 21P-3ϕ unit R-X diagram circle as shown in Figure 2 (page 7). When the KS-3 relay operates, the Z_{OS} contact opens. 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 pre-fault value, Z_{Load}, to the fault value, represented by the line O-F in Figure 3 (page 9). 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 2 (page 7), 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 conditions, Z_{OS} contact in Figure 3 (page 9) 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 of 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 3. 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. When the OS contact opens, it is usually used to block tripping.

In come 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.

5.0 SETTINGS

5.1 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 closed 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.

5.2 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 operates. Otherwise, undesired tripping of the remote breaker may occur.

Figure 4 (page 10) summarizes the action for various cases.

5.3 External Phase Fault Operation

Refer to Figure 4 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 Figure 4.

At breaker B, 21S contact opens the 21P contact remains open, so that CSP is not energized: the start lead becomes positive, so the transmitter sends a blocking signal. Tripping does not occur because the 21P contact is open.

At breaker A, 21P contact closes, energizing CSP. CSP contact energizes RRT; however, RRP contact is held open by the RRH current which results from the received carrier signal.

5.4 Internal Phase Fault Operation

Operation is the same at both stations. Refer to Figure 4. 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.

5.5 External Ground Fault Operation

Refer to Figure 4 (page 10). 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} operation is ineffective, since the stop lead is held at negative by CSG. However, at breaker B, CSG does not close, 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.

5.6 Phase Pilot Relays

The 21P relay should be set to substantially overreach the adjacent bus as shown in Figure 1(page 6). 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 line impedance or more.

5.7 Ground Pilot Relays

Carrier starting for ground faults is accomplished with an instantaneous ground overcurrent unit, $I_{OS.}$ 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} or more.

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 will also be necessary to have a higher than normal ratio.

5.8 Carrier Continue Circuit

The “carrier continue” function assures that the relaying system will be secure doing the period following removal of external faults. Components in the KA-4 are committed to carrier transmission for 5 cycles following the opening of any carrier start relay contact for at least 2 cycles.

Sequential tripping for a ground fault on a line that is paralleled to the protected line, can cause the fault to appear to move from “reverse” at one terminal to “reverse” at the opposite terminal. The “carrier continue” function causes carrier transmission to persist for 5 cycles after the CSG contact closes (or the I_{OS} resets) allowing time for the remote ground trip relays to reset. There is no delay in tripping for an internal fault.

5.9 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 circuit failure.

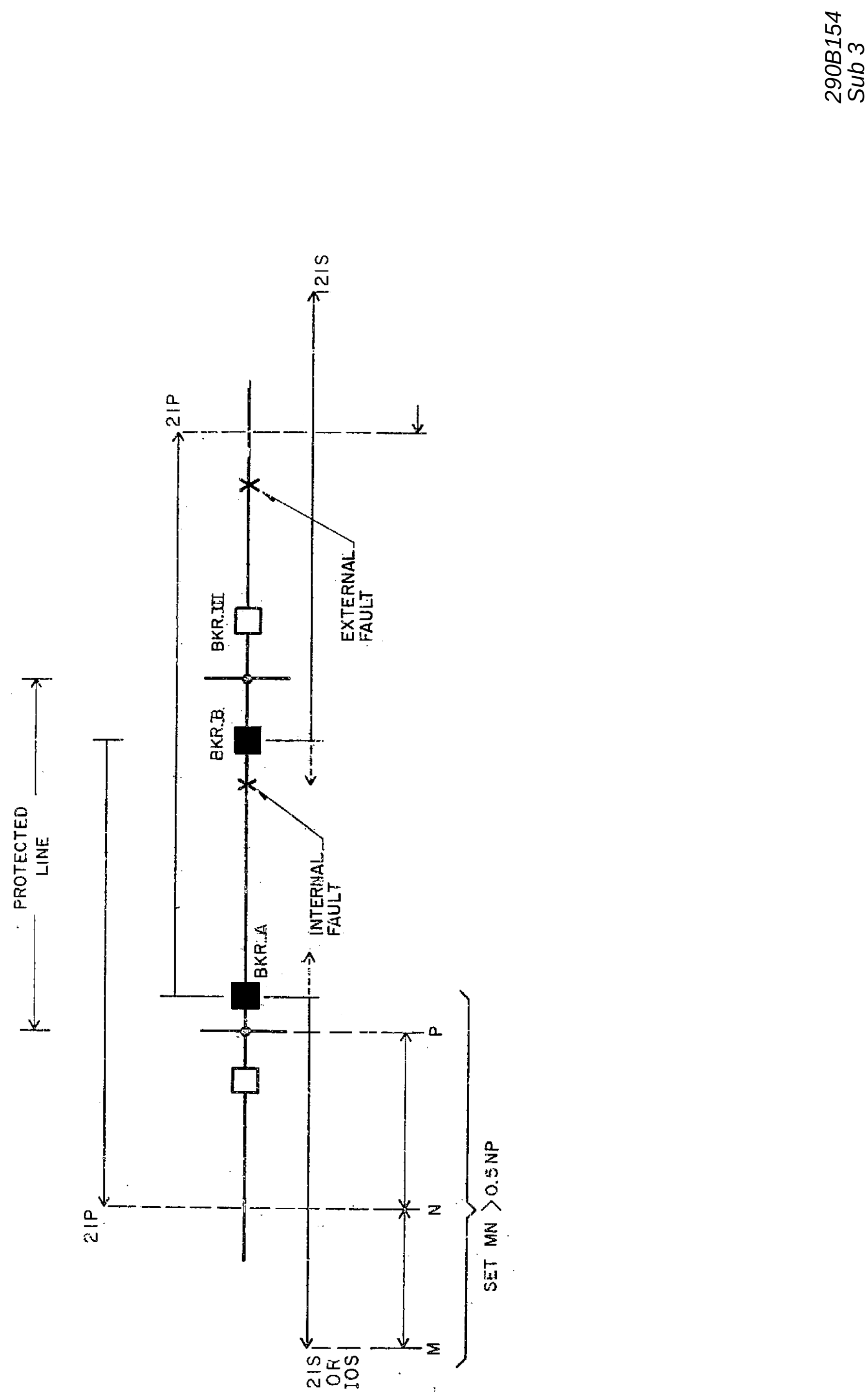


Figure 1: Setting Criteria

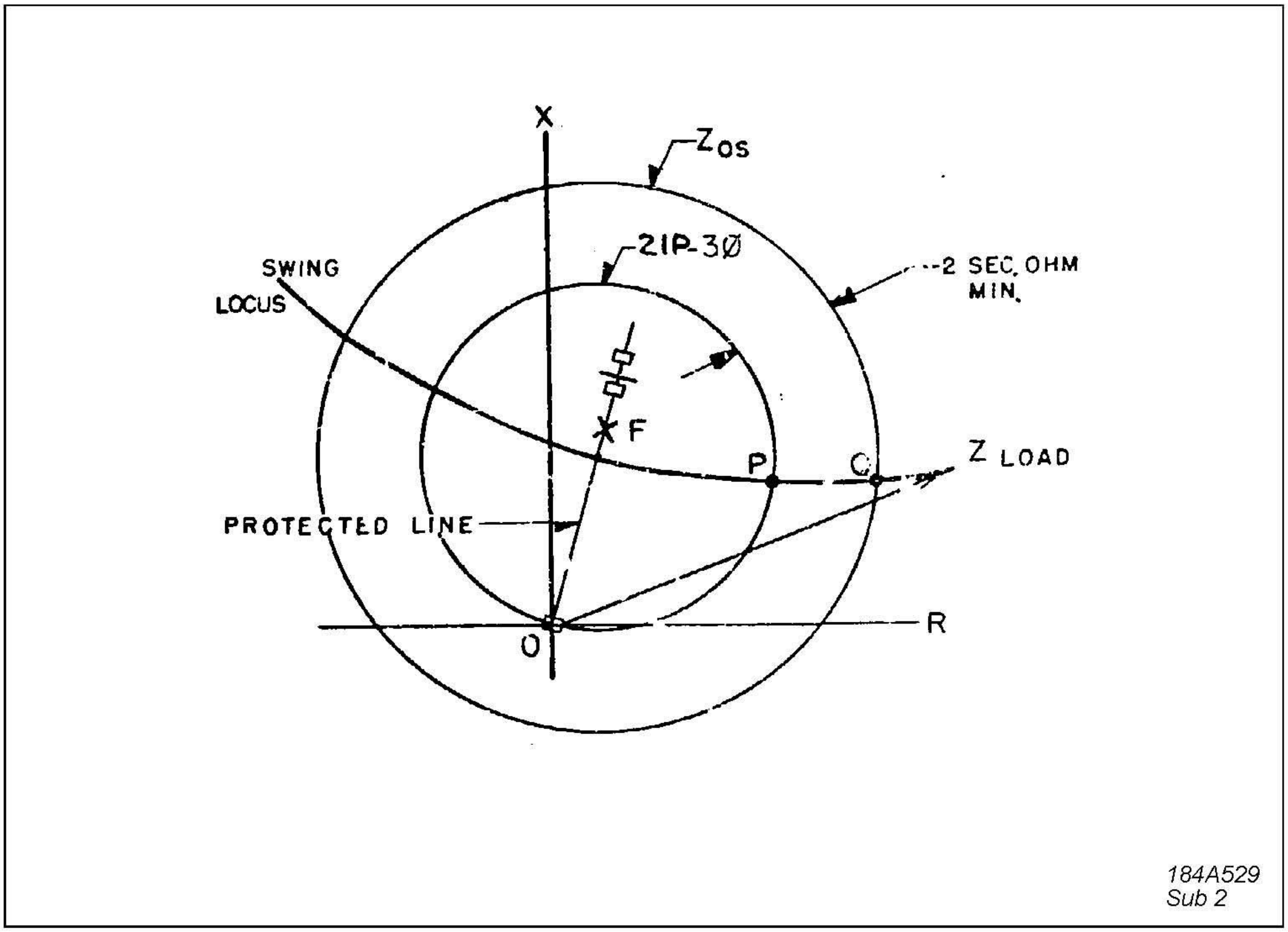
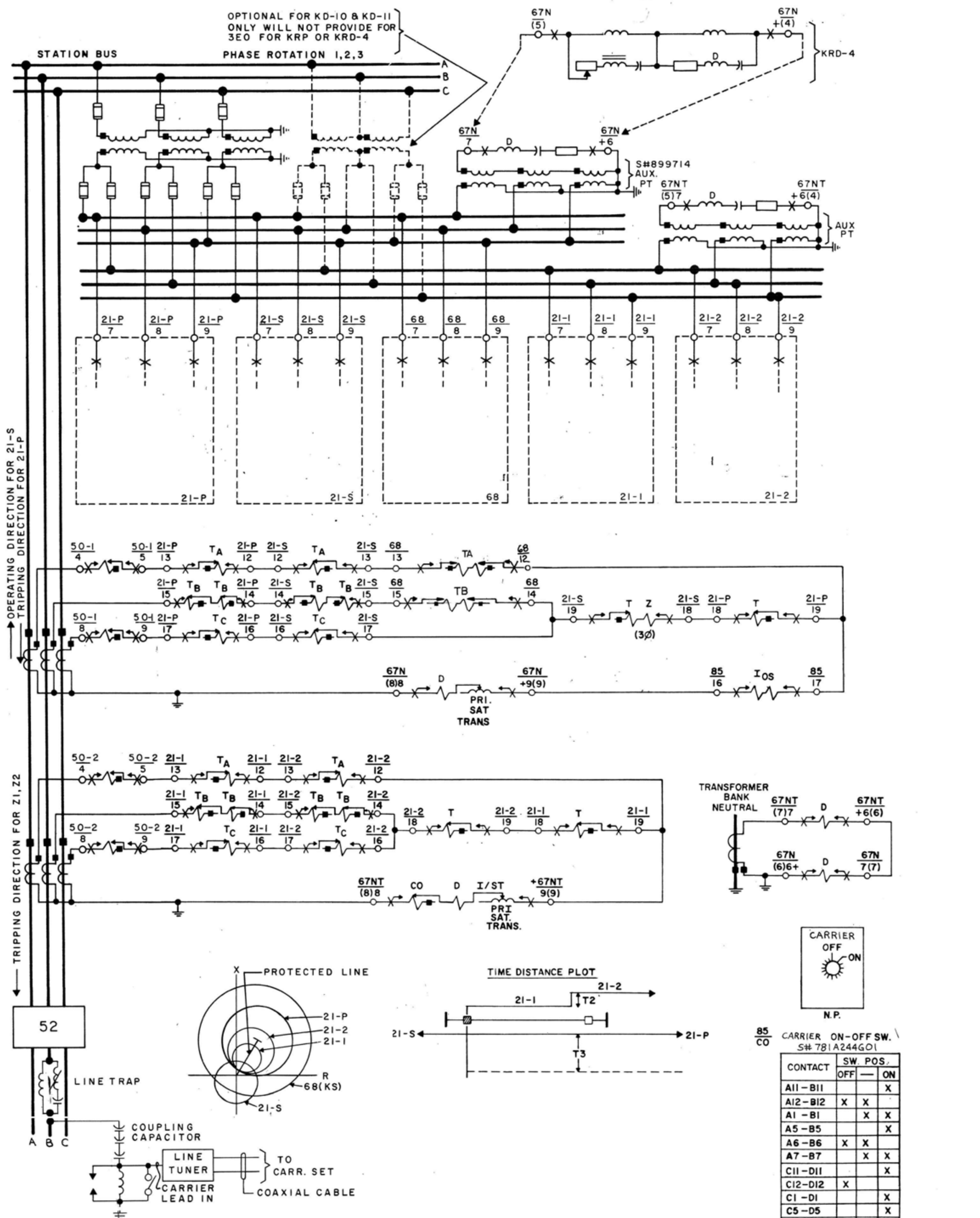


Figure 2 :Out-of-step Blocking Operation

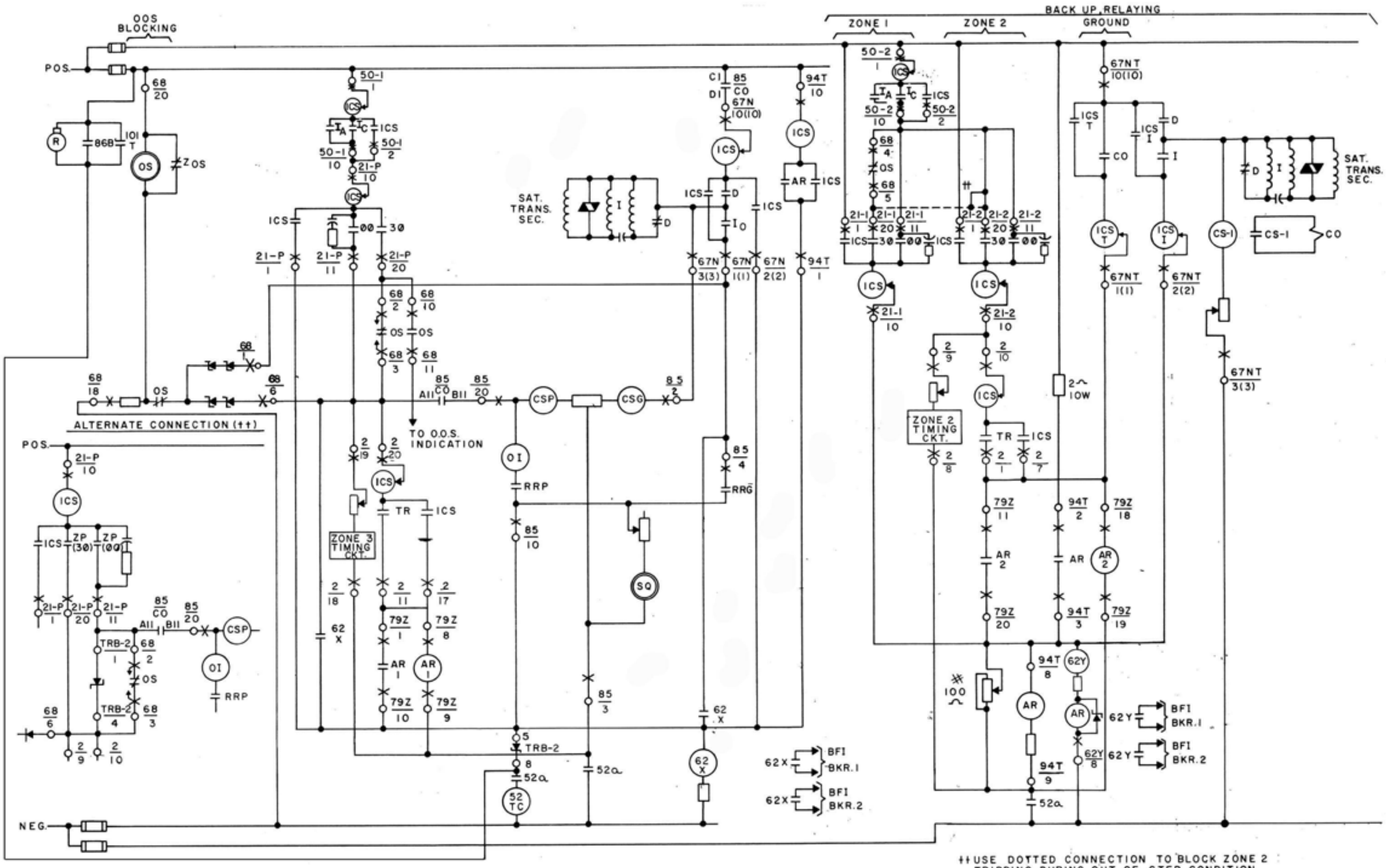


85/CO CARRIER ON-OFF SW. S# 781A244G01

CONTACT	SW. POS. OFF	SW. POS. —	SW. POS. ON
A11 – B11			X
A12 – B12	X	X	
A1 – B1		X	X
A5 – B5			X
A6 – B6	X	X	
A7 – B7		X	X
C11 – D11			X
C12 – D12	X		
C1 – D1			X
C5 – D5			X
C6 – D6	X		
C7 – D7			X

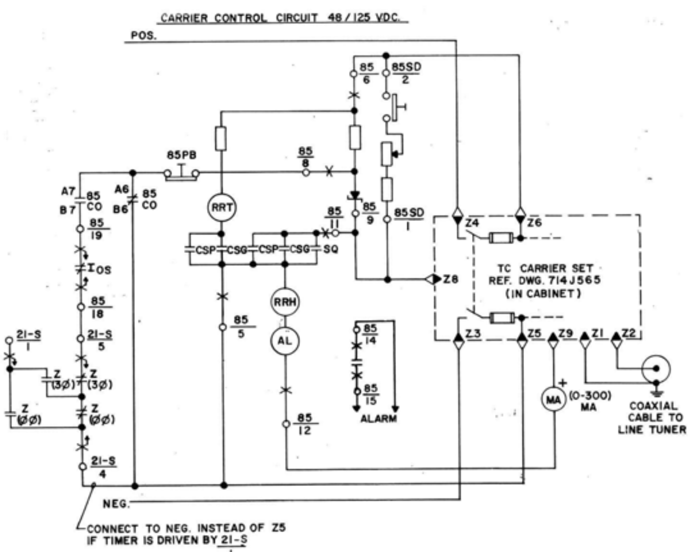
X- DENOTES CONTACT CLOSED

SWITCH SHOWN IN OFF POSITION ON SCHEMATIC.



††USE DOTTED CONNECTION TO BLOCK ZONE 2 TRIPPING DURING OUT-OF-STEP CONDITION. IF ZONE 2 IS BLOCKED, USE ALTERNATE CONNECTION TO PERMIT 21P-30 TRIPPING THROUGH T3 DURING OUT-OF-STEP CONDITION.

※REFER TO 836A753 FOR DETAIL.



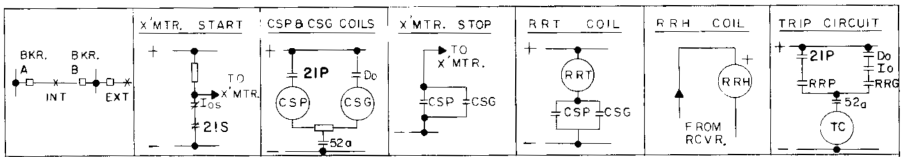
DEVICE NO.	TYPE	FUNCTION	DWG. NO.
2	TD-52	TIMER	762A500
21-1	KD-10	ZONE 1 PHASE	880A988
21-2	KD-10	ZONE 2 PHASE	880A988
21-P	KD-10	PILOT TRIP PHASE	880A988
21-S	KD-11	CARRIER START	880A989
△ 62X	AR	BKR. FAIL AUX.	
△ 62Y	AR	BKR. FAIL AUX.	
67N	KRC	I POL. GRD. PILOT	183A022
† 67N	KRD-4	DUAL POL. GRD. PILOT	629A509
67N	KRP	V. POL. GRD. PILOT	183A025
67NT	IRC	I POL. GRD. BACKUP	184A034
† 67NT	IRD	DUAL POL. GRD. BACK-UP	184A020
67NT	IRP	V POL. GRD. BACK-UP	184A033
68	KS-3	OUT-OF-STEP	3526A98
79Z	AR	REC. BLK. AUX. DOUBLE UNIT FT-22	629A495
85	KA-4	CHANNEL AUX.	3491A17
85/CO	W-2	CARRIER ON-OFF SWITCH	
85/PB		CARRIER TEST PUSH BUTTON	
94T	AR	AUX. TRIP	848A823
TC	TC	CARRIER SET	
TRB-2	TRB-2	BLOCKING ZENER	187A696
50-1	KC-2	FAULT DETECTOR FOR 21-P	837A454
50-2	KC-2	FAULT DETECTOR FOR 21-1;21-2	837A454

†-IRD KRD-4 TERMINAL NUMBERS ARE INDICATED IN PARENTHESIS

△-OPTIONAL FOR BF/RI

Sub 10
647F792

Figure 3. KDAR Relaying with TD-52 (4-Zone Phase Distance)



	X'MTR. START	CSP & CSG COILS	X'MTR. STOP	RRT COIL	RRH COIL	TRIP CIRCUIT
	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 DENERGIZED	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.

407C402
Sub 4

Figure 4: Operation Chart for K-DAR Directional Comparison Blocking Systems

This Page for Notes

IL 40-208 - Revision C

ABB Inc.

4300 Coral Ridge Drive
Coral Springs, Florida 33065

Telephone: +1 954-752-6700
Fax: +1 954-345-5329

www.abb.com/substation automation