GE MULTILIN

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GE Power Management

Power Relays Application Guide

A GUIDE TO THE APPLICATION OF POWER RELAYS FOR THE DETECTION OF OVERPOWER OR REVERSE POWER CONDITIONS ON A POWER SYSTEM

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This guide covers all of our true power relays as distinguished from directional power and directional overcurrent relays. Its purpose is to pinpoint exactly the relay required for any specific application. All power relays from the most sensitive to the highest ever likely to be used are covered. The most sensitive are in the range of the core loss of a power transformer; that is, of the order of one tenth of one percent of full load power. They are used for tripping a bank off when it is no longer supplying power.

The more usual application of a reverse power relay is to protect generators from motoring. This can usually be met with the simplest type of induction disc relay which can also provide the time delay which is generally required. These simpler relays are single phase which is usually acceptable because balanced three phase conditions can be assumed and they range from two per cent up to full load power. The guide gives a table on page 10 listing all the types of generators classified by their prime movers which determine the amount of reverse power when they motor. Three-phase power relays are also listed which have sensitivities from one half of one per cent up to ten per cent of full load. These sensitivities require induction-cylinder type relays which in turn are inherently instantaneous so that separate time delay devices are required. Of course the separate time delay relay can be incorporated in the same case as well as separately resulting in five different types of relays which are shown in the table on the other side of this page.

The guide is designed to be used like an encyclopedia. Table 1 should first be consulted. The introduction spells out the different types listed in the first column and gives their essential differences. Following the introduction the general application of the different types is described after which typical applications are given complete with all the different wiring diagrams and tables listing all the individual ratings of the five different relays.

TABLE - 1

RELAY TYPE	CONNECTIONS		UNITY P-F P.U. RANGES	CONTINUOUS CURRENT RATING	CONTACTS	SPEED OF OPERATION	CASE SIZE	GENERAL APPLICATION
	POTENTIAL	CURRENT	AMPERES △	AMPERES				
ICW51B	1φ L-N 120 VOLTS	1 φ	0.08-0.33 0.21-0.83 0.42-1.67 0.83-3.33	5.0	1 N.O.	ADJUST. TIME DELAY	S1	REVERSE AND/OR OVER POWER
ICW51A	1φ L-L 120 VOLTS OR 208 VOLTS	1 φ	0.07-0.29 0.12-0.48 0.24-0.96 0.48-1.92 0.96-3.84	3.5 5.0 5.0 5.0 5.0	1 N.O.	ADJUST. TIME DELAY	S1	REVERSE AND/OR OVER POWER
GGP53C	3φ L-L 120 VOLTS OR 208 VOLTS	3 φ	0.01-0.04	5.0	1 N.O.	ADJUST. TIME DELAY	M2	REVERSE POWER
CAP 15B	3φ L-L 120 VOLTS OR 208 VOLTS	3 φ	0.025-0.300	5.0	1 N.O. & 1 N.C.	INST.	S2	REVERSE POWER
CCP13D	3φ L-L 120 VOLTS OR 208 VOLTS	3 φ	0.004-0.012 0.008-0.030	5.0	1 N.O. & 1 N.C.	INST.	M2	REVERSE POWER

△ AT RATED VOLTAGE

INTRODUCTION

The relays covered by this guide are listed in Table 1 and are all designed to operate at normal rated voltage to detect reverse power or overpower conditions on a power system. All of these relays with the exception of the ICW51B are suitable for application on three-phase systems only. The ICW51B may be applied on single-phase and two-phase as well as three-phase systems. None of these relays are intended for use as fault protective or regulating devices.

Table 1 compares the salient features and characteristics of the five types of relays. The ICW51A and ICW51B relays are single-phase induction disk devices with inherent time delay; this delay being adjustable as well as the pickup. Because of the band of pick-up ranges that are available, these relays are suitable for the detection of reverse power and/or overpower within their ranges of pickup.

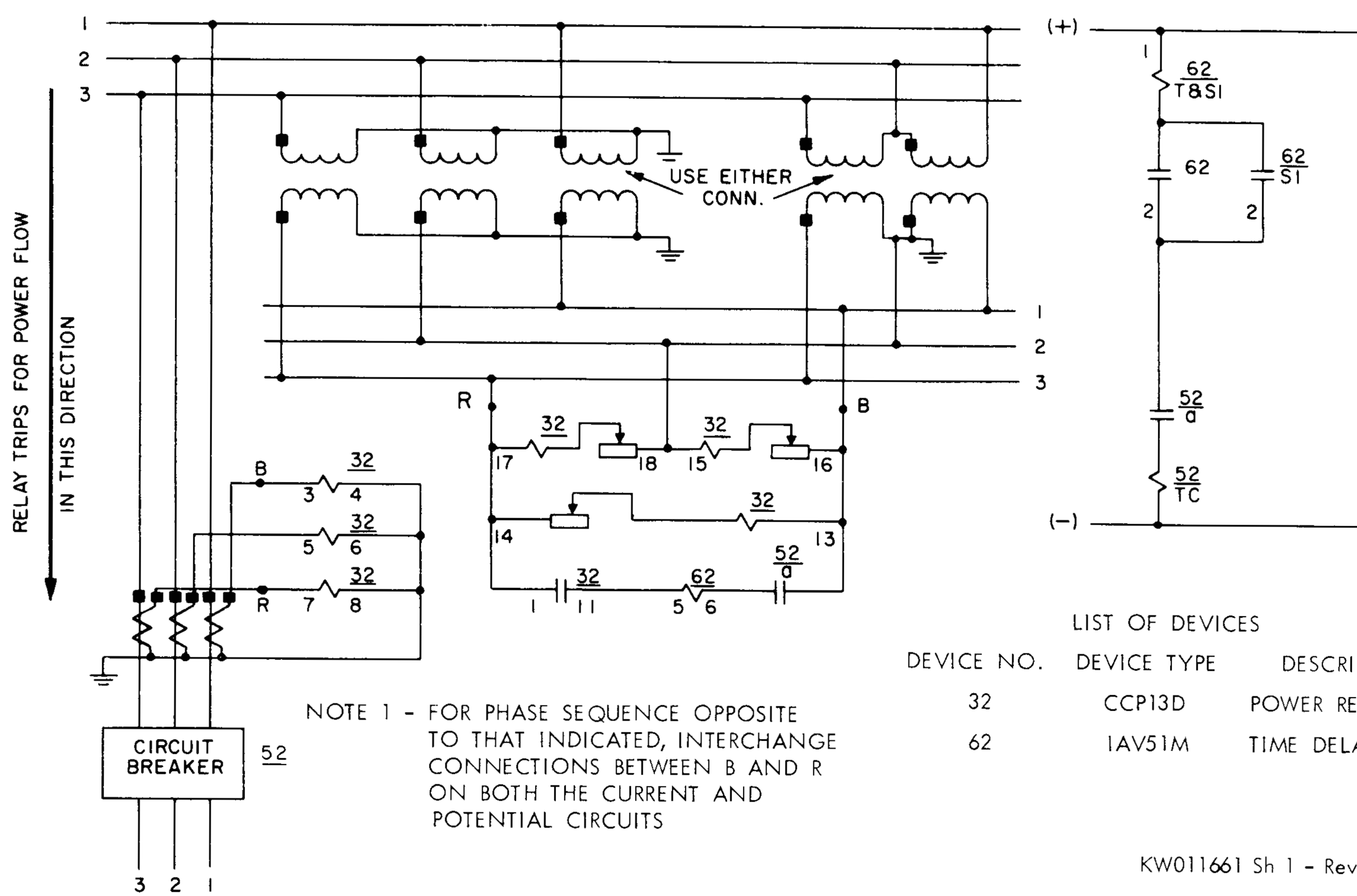
The GGP53C relay is made up of two basic units. The measuring unit is a three-phase, high-speed induction-cup type power unit having a pickup of 0.01-0.04 unity power factor amperes at rated voltage. The second unit is an induction disk, a-c operated, adjustable timing unit. Because of its low pickup, this device is basically a reverse power relay.

The CAP15B relay is a three-phase, high-speed induction cup power relay that is similar to the power unit of the GGP53C relay. Because of its low pickup, this device is basically a reverse power relay.

The CCP13D relay is a three-phase, high-speed, extremely sensitive power relay. It is made up of three single-phase cup type units all coupled to a common shaft. Because of its very low pick-up range, this device is basically a reverse power relay.

GENERAL APPLICATION

The GGP53C, CAP15B and CCP13D relays are all three-phase devices. Under normal balanced three-phase voltage conditions these relays will develop torques which are directly related to the direction and magnitude of the real component of the three-phase power flowing in the associated circuit. The basic functional differences between the three different relays lies in their sensitivities and their operating times. The GGP53C has a built-in a-c operated timing unit which is adjustable from 1.5 to 30 seconds. Aside from this, it is very much the same as the CAP15B which is an instantaneous device. The CCP13D is more sensitive than both the CAP15B and the GGP53C relays, but like the CAP15B it is an instantaneous device.



NOTE 1 - FOR PHASE SEQUENCE OPPOSITE TO THAT INDICATED, INTERCHANGE CONNECTIONS BETWEEN B AND R ON BOTH THE CURRENT AND POTENTIAL CIRCUITS

LIST OF DEVICES

DEVICE NO.	DEVICE TYPE	DESCRIPTION
32	CCP13D	POWER RELAY
62	IAV51M	TIME DELAY RELAY

KW011661 Sh 1 - Rev. 12/8/61

EXTERNAL CONNECTIONS FOR CCP13D RELAY WHEN USED WITH IAV51M RELAY

FIGURE 1. (KW011661 SH.1)

Because of the sensitivities and high operating speeds of the CAP15B and CCP13D relays, it is strongly suggested that these devices always be used in conjunction with some kind of a time delay relay. This will prevent undesired operations during system disturbances which may momentarily cause the power flow to be reversed from its normal direction of flow. Applied in conjunction with a time delay relay, the CAP15B is functionally similar to the GGP53C. Thus, the CAP15B relay plus a timer need only be considered for application where the timing characteristics or the sensitivity of the GGP53C relay are not suitable. The CCP13D, on the other hand, need only be considered where the CAP15B and GGP53C relays do not have the required sensitivity.

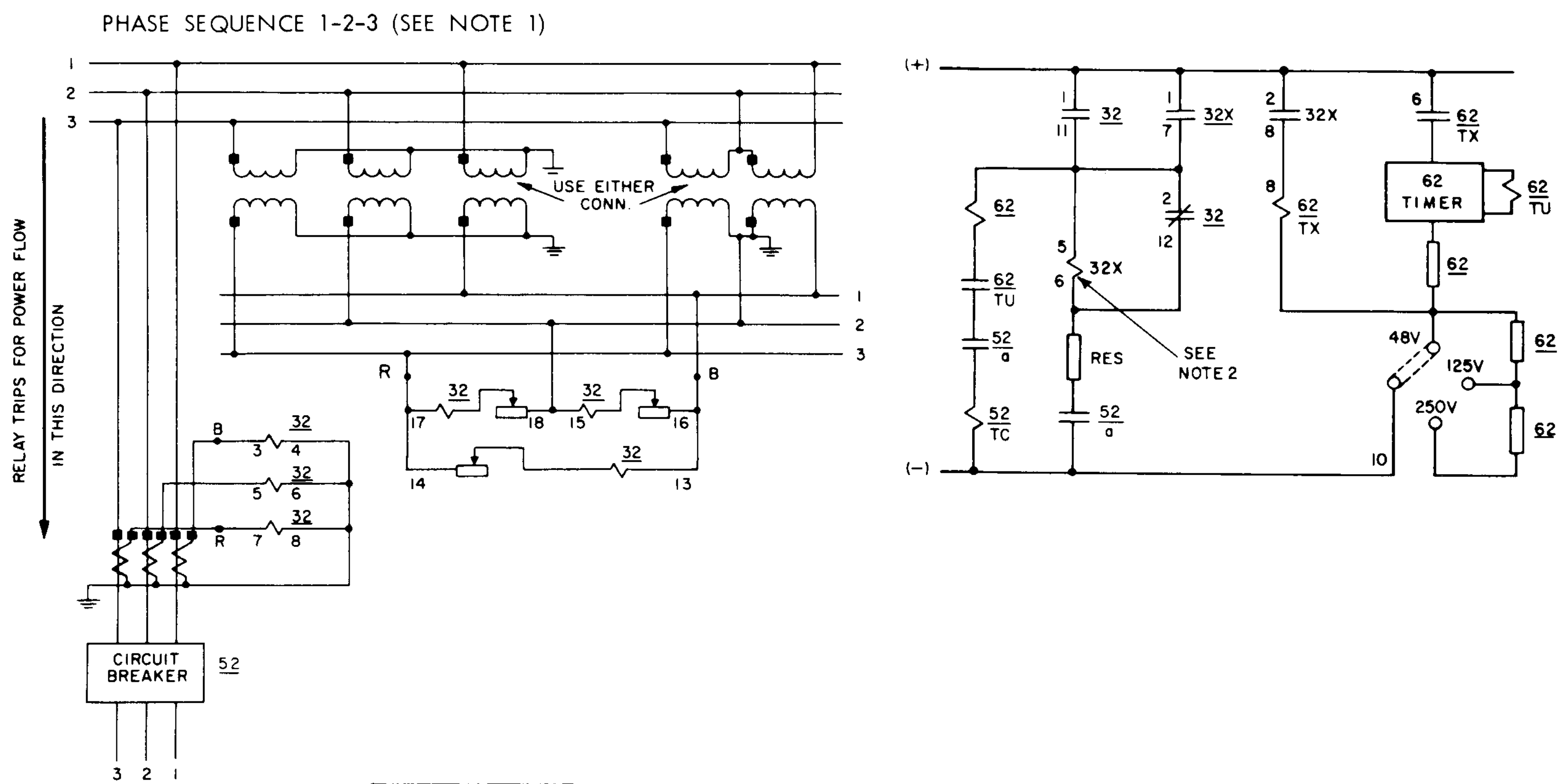
Summarizing, the CAP15B and CCP13D relays should always be used in conjunction with a suitable timing relay and the selection of the proper relay should be based primarily on the sensitivity and timing characteristics that are required for the particular application.

The ICW51A and ICW51B relays are single-phase time delay devices which are not as sensitive as the three-phase relays discussed above. From a functional viewpoint, these two types of relays are essentially the same. The major difference between them lies in the difference in connections. The ICW51A requires a single-phase current and the quadrature phase-to-phase voltage. Under balanced system current and voltage conditions, one ICW51A relay will develop a torque which is directly related to the direction and magnitude of the real component of the three-phase power flowing in the associated circuit. This is true because, for balanced conditions, the power in any one phase is equal to one-third of the total three-phase power. Since the relay gets phase-to-phase voltage and single-phase current, it is conveniently calibrated in terms of three-phase watts. When the ICW51A is applied where balanced three-phase voltages exist but the currents are unbalanced, the relay will develop a torque which is directly related to the direction and magnitude of the real component of the three-phase power that would flow if the three currents were balanced and equal to the current in the phase in which the relay current coil is connected.

The ICW51B relay is connected to receive phase-to-neutral voltage and the corresponding phase current. Thus, regardless of system conditions, these relays will measure the real power flowing in the particular phase to which the relay is connected. For balanced three-phase conditions, the three-phase watts will always be three times the individual single-phase watts so one ICW51B may be used to measure three-phase watts. Since the relay receives phase-to-neutral voltage and the associated current it is conveniently calibrated in terms of single-phase watts. Also, because of these connections the ICW51B may be used as a power relay on single-phase and two-phase systems.

TYPICAL APPLICATIONS

The following typical applications for the individual relays have been selected to illustrate the important points of consideration in the selection of the proper relay for a given application.



CONTROL VOLTAGE	RESISTOR OHMS
48	200
125	1000
250	4000

DEVICE NO.	LIST OF DEVICES	
	DEVICE TYPE	DESCRIPTION
32	CCP13D	POWER RELAY
62	SAM17G	TIME DELAY RELAY
32X	HGA11A OR J	AUXILIARY RELAY
RES.		CAGE TYPE RESISTOR

EXTERNAL CONNECTIONS FOR CCP13D RELAY WHEN USED WITH SAM17G RELAY

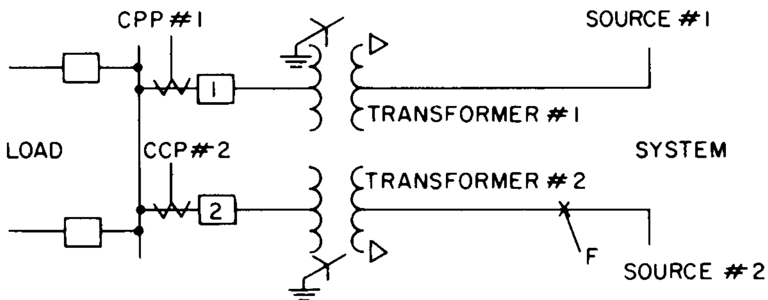
FIGURE 2. (0246A6954)

NOTE 1 – FOR PHASE SEQUENCE OPPOSITE TO THAT INDICATED, INTERCHANGE CONNECTIONS BETWEEN B & R IN BOTH THE POTENTIAL AND CURRENT CIRCUITS.

NOTE 2 – SELECT HGA RELAY WITH CONTINUOUS RATING EQUAL TO 1/2 THE CONTROL VOLTAGE SUPPLY AND SELECT A RESISTOR FROM THE TABLE

CCP13D Relay

Because of its sensitivity and its real power directional characteristics, the CCP13D relay finds application where it is required to detect extremely small reverse power flow. The classical example of such an application is illustrated below.



Consider the section of a system shown above with the normal direction of load flow being from the system to the load. If a single-phase-to-ground fault were to occur at F, it would be cleared at source #2, but not necessarily at breaker #2 because of delta-wye transformer #2. However, it is desirable to open circuit breaker #2 in order to remove the ground fault which could continue to arc. This can be accomplished by the CCP13D relay associated with circuit breaker #2. The CCP13D is generally sensitive enough to operate on the real component of the exciting current (this is the core loss component) taken by the transformer through circuit breaker #2 when source #2 is removed.

Since the CCP13D is very fast and very sensitive, it could operate for system disturbances that result in momentary reversals of power through one or the other of the two banks. For this reason, the CCP13D should be used in conjunction with some time delay when applied as discussed above. Figure 1 shows how this can be done with an a-c operated timing relay while Figure 2 illustrates the connections for a d-c timing relay.

When the CCP13D relay is applied as illustrated in Figures 1 and 2, no holding coil is required. For this reason, a form without a holding coil should be selected, or if a relay with a holding coil is obtained, the holding coil should be by-passed in the relay.

Before the CCP13D is applied, certain calculations should be made to check the sensitivity of the relay against the available core loss component of the associated transformer in order to insure proper operation. In general, the CT's that supply the CCP relay should be selected with the lowest possible ratio without exceeding the 5.0 ampere rating of the relay. A sample calculation is provided below.

Consider the system illustrated above having the following transformer ratings.

10,000 kVA
13,800 Volts wye/138,000 volts delta
Core losses – 15.0 KW at rated voltage.

CCP13D RELAYS

RATINGS				UNITY P-F P.U. RANGE	CONTACTS	TARGET	HOLDING COIL ON N.O. CONTACT	CASE SIZE	MODEL NO.
VOLTS	AMPERES CONT	AMPERES 1 SEC.	FREQ*	AMPERES △		AMPERES	AMPERES		
120	5.0		60	0.008-0.030	1 N.O.& 1 N.C.	1.0	NONE	M2	12CCP13D
120	5.0		60	0.004-0.012	1 N.O.& 1 N.C.	1.0	NONE	M2	12CCP13D
120	5.0		60	0.008-0.030	1 N.O.& 1 N.C.	1.0	1.0	M2	12CCP13D
120	5.0		60	0.004-0.012	1 N.O.& 1 N.C.	1.0	1.0	M2	12CCP13D
120	5.0		60	0.008-0.030	1 N.O.& 1 N.C.	1.0	0.2	M2	12CCP13D
120	5.0		60	0.004-0.012	1 N.O.& 1 N.C.	1.0	0.2	M2	12CCP13D
120	5.0		60	0.008-0.012	1 N.O.& 1 N.C.	1.0	0.2	M2	12CCP13D
120	5.0		60	0.004-0.030	1 N.O.& 1 N.C.	0.2	NONE	M2	12CCP13D
120	5.0		60	0.008-0.012	1 N.O.& 1 N.C.	0.2	NONE	M2	12CCP13D
120	5.0		60	0.004-0.030	1 N.O.& 1 N.C.	0.2	1.0	M2	12CCP13D
120	5.0		60	0.008-0.012	1 N.O.& 1 N.C.	0.2	1.0	M2	12CCP13D
120	5.0		60	0.004-0.030	1 N.O.& 1 N.C.	0.2	0.2	M2	12CCP13D
120	5.0		60	0.008-0.012	1 N.O.& 1 N.C.	0.2	0.2	M2	12CCP13D
208	5.0		60	0.004-0.030	1 N.O.& 1 N.C.	1.0	NONE	M2	12CCP13D
208	5.0		60	0.008-0.012	1 N.O.& 1 N.C.	1.0	NONE	M2	12CCP13D
208	5.0		60	0.004-0.030	1 N.O.& 1 N.C.	1.0	1.0	M2	12CCP13D
208	5.0		60	0.008-0.030	1 N.O.& 1 N.C.	1.0	0.2	M2	12CCP13D
208	5.0		60	0.004-0.012	1 N.O.& 1 N.C.	1.0	0.2	M2	12CCP13D
208	5.0		60	0.008-0.030	1 N.O.& 1 N.C.	0.2	NONE	M2	12CCP13D
208	5.0		60	0.004-0.012	1 N.O.& 1 N.C.	0.2	NONE	M2	12CCP13D
208	5.0		60	0.008-0.030	1 N.O.& 1 N.C.	0.2	1.0	M2	12CCP13D
208	5.0		60	0.004-0.012	1 N.O.& 1 N.C.	0.2	1.0	M2	12CCP13D
208	5.0		60	0.008-0.030	1 N.O.& 1 N.C.	0.2	0.2	M2	12CCP13D
208	5.0		60	0.004-0.012	1 N.O.& 1 N.C.	0.2	0.2	M2	12CCP13D

△ AT RATED VOLTAGE
* SIMILAR RATINGS AVAILABLE FOR 50 CYCLE OPERATION

The full load current at 13,800 volts is

$$\frac{10{,}000}{13.8\sqrt{3}} = 418 \text{ Primary Amperes.}$$

At rated voltage, the core loss component produces an in-phase current of

$$\frac{15.0}{13.8\sqrt{3}} = 0.628 \text{ Primary Amperes.}$$

Since the relay may be called on to operate at lower than normal voltages, the core losses at these lower voltages should be obtained. In the absence of such information, consider that 95 percent of rated voltage is a good figure and since the transformer core losses are roughly proportional to the square of the applied voltage, the minimum core loss component current will be

$$(0.95)\ (0.628) = 0.597 \text{ Primary Amperes.}$$

At reduced voltage, the CCP minimum operating current goes up. Actually, it is inversely proportional to the applied voltage. Thus, the minimum pickup in this case will be the nameplate value divided by 0.95, and the 0.004 ampere setting will yield a minimum pickup of

$$\frac{0.004}{0.95} = 0.00422 \text{ Secondary Amperes.}$$

Based on the maximum full load current, the smallest CT ratio that could be used is 500/5. With this ratio, the core loss component of current would be

$$\frac{0.597}{100} = 0.00597 \text{ Secondary Amperes.}$$

Since the CCP, on the most sensitive setting, will pick up at 0.00422 secondary amperes, this application is satisfactory.

If the main CT's were selected as 800/5, then the core loss component would have been 0.00374 amperes and the relay would not operate. If this were the case, suitable auxiliary CT's could be used to step up the current to the CCP. However, caution should be used in the selection of these auxiliary CT's to insure that no more than 5.0 amperes is supplied to the relay under full load conditions.

GGP53C Relay

While the GGP53C relay may be employed whenever reverse power, time delay operation is required, its major field of application is the protection of generators against motoring. Because of its sensitivity, the GGP53C is almost universally applicable for this function. However, in many instances,

GGP53C RELAYS

RATINGS				PICK UP UNITY P-F	TIME DELAY ADJUSTMENT	CONTACTS	TARGET SEAL-IN	CASE SIZE	MODEL NO.
VOLTS	AMPERES		FREQ						
	CONT	1 SEC		AMPERES △	SECONDS		AMPERES		
120	5.0		60	0.01-0.04	1.5 TO 30.0	1 N.O.	0.2/2.0	M2	12GGP53C1A
208	5.0		60	0.01-0.04	1.5 TO 30.0	1 N.O.	0.2/2.0	M2	12GGP53C2A
120	5.0		50	0.01-0.04	1.5 TO 30.0	1 N.O.	0.2/2.0	M2	12GGP53C3A
208	5.0		50	0.01-0.04	1.5 TO 30.0	1 N.O.	0.2/2.0	M2	12GGP53C4A

△ AT RATED VOLTAGE

CAP15B RELAYS

RATINGS				UNITY P-F P.U. RANGE	CONTACTS	TARGET	HOLDING COIL ON N.O. CONTACT	CASE SIZE	MODEL NO.
VOLTS	AMPERES		FREQ*						
	CONT	1 SEC		AMPERES △		AMPERES	AMPERES		
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	NONE	NONE	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	NONE	1.0	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	NONE	0.2	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	1.0	NONE	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	1.0	1.0	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	1.0	0.2	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	0.2	NONE	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	0.2	1.0	S2	CAP15B
120	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	0.2	0.2	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	NONE	NONE	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	NONE	1.0	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	NONE	0.2	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	1.0	NONE	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	1.0	1.0	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	1.0	0.2	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	0.2	NONE	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	0.2	1.0	S2	CAP15B
208	5.0		60	0.025-0.300	1 N.O.& 1 N.C.	0.2	0.2	S2	CAP15B

△ AT RATED VOLTAGE
* SIMILAR RATINGS AVAILABLE FOR 50 CYCLE OPERATION

the motoring power taken by the generator is so large that the sensitivity of the GGP53C is not required and a less sensitive relay of the ICW type may be applied. (The application of the ICW relays is discussed subsequently under ICW Relays.) The following table lists the approximate motoring power taken by the various different types of generators.

TYPE OF PRIME MOVER	MOTORING POWER IN PERCENT OF UNIT RATING
Gas Turbine – Single Shaft	100
Gas Turbine – Double Shaft	10-15
4 Cycle Diesel	15
2 Cycle Diesel	25
Hydraulic Turbine	2-100*
Steam Turbine (Conventional)	1-4
Steam Turbine (Cond. Cooled)	0.5-1.0

*The larger powers are taken by turbines having submerged impellers.

When the GGP53C relay is used to protect a unit against motoring, the external connections shown in Figure 3 should be employed. In every case, calculations should be made to insure that the motoring power taken by the generator, on loss of the prime mover, exceeds the minimum pickup of the relay. A sample calculation is provided below.

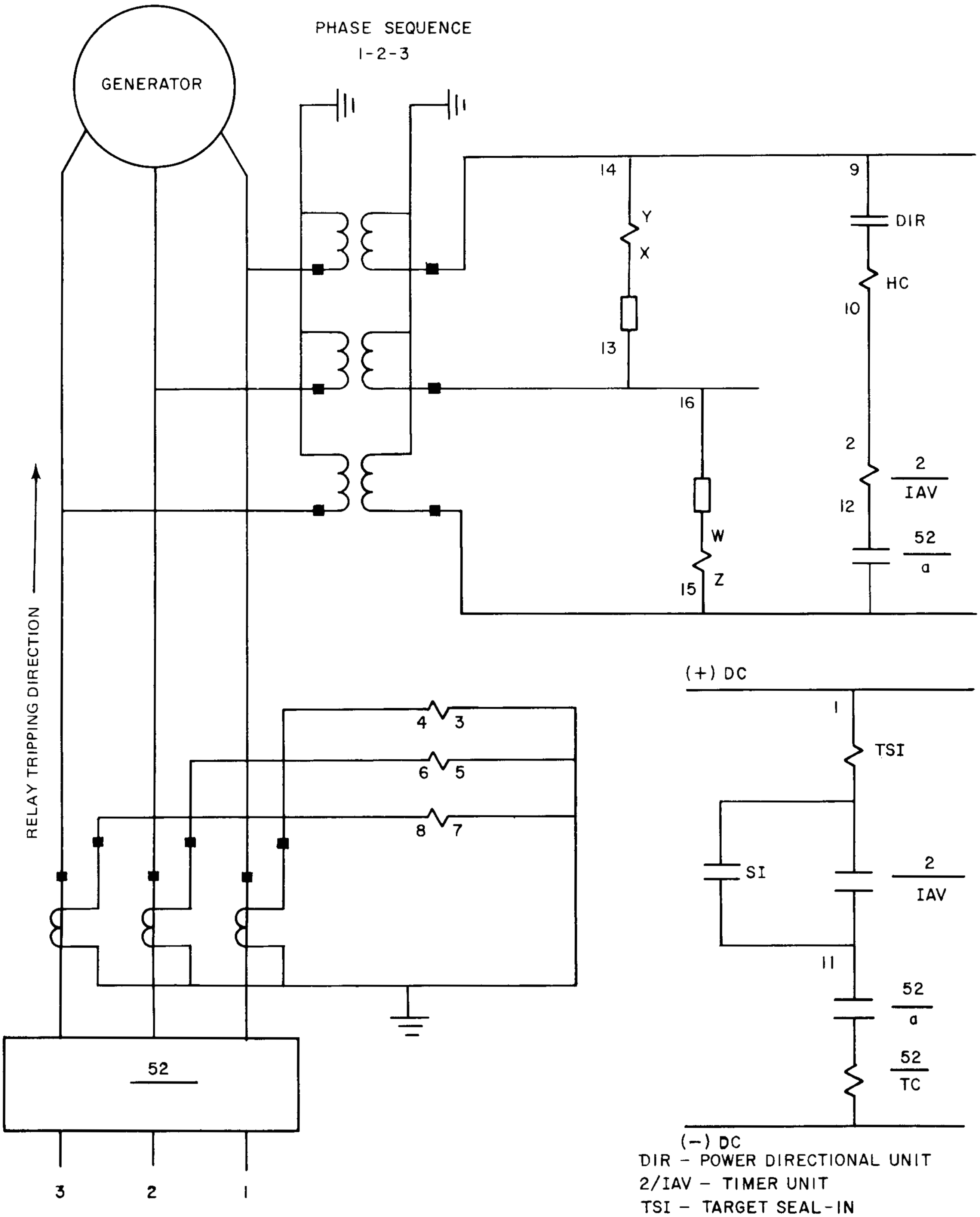
Consider a steam turbine driven generator with the following rating

24 kV
832,000 kVA

Assume that it is desired to provide motoring protection for this unit. On the basis of the above rating, the full load current of this unit would be

$$I_{FL} = \frac{832{,}000}{24\sqrt{3}} = 20{,}000 \text{ primary amperes.}$$

Assume a CT ratio of 30,000/5 and a PT ratio of 25,000/120. Assume further that the manufacturer of the unit advises that the motoring power taken by the machine at rated speed will be 4,000 KW. At rated voltage this represents an in-phase component of current as follows:



EXTERNAL CONNECTIONS FOR GGP53C RELAY PROTECTING A UNIT AGAINST MOTORING

FIGURE 3. (0246A6841-0)

$$I_M = \frac{4{,}000}{24\sqrt{3}} = 96 \text{ primary amperes.}$$

or

$$I_M = \frac{96}{30{,}000} \times 5 = 0.016 \text{ secondary amperes.}$$

The GGP53C relay has a minimum pickup of 0.010 in-phase amperes at 120 volts. Since the rated voltage of the machine (24,000 volts) is somewhat lower than that of the associated PT's (25,000 volts), the PT secondary voltage at rated machine voltage will be

$$\frac{24{,}000}{25{,}000} \times 120 = 115 \text{ volts.}$$

At 115 volts the GGP53C relay will require

$$\frac{120}{115} \times 0.010 = 0.0104 \text{ secondary amperes}$$

to pick up.

Since the in-phase component of the motoring current of the machine exceeds the relay pick-up current, this is a good application.

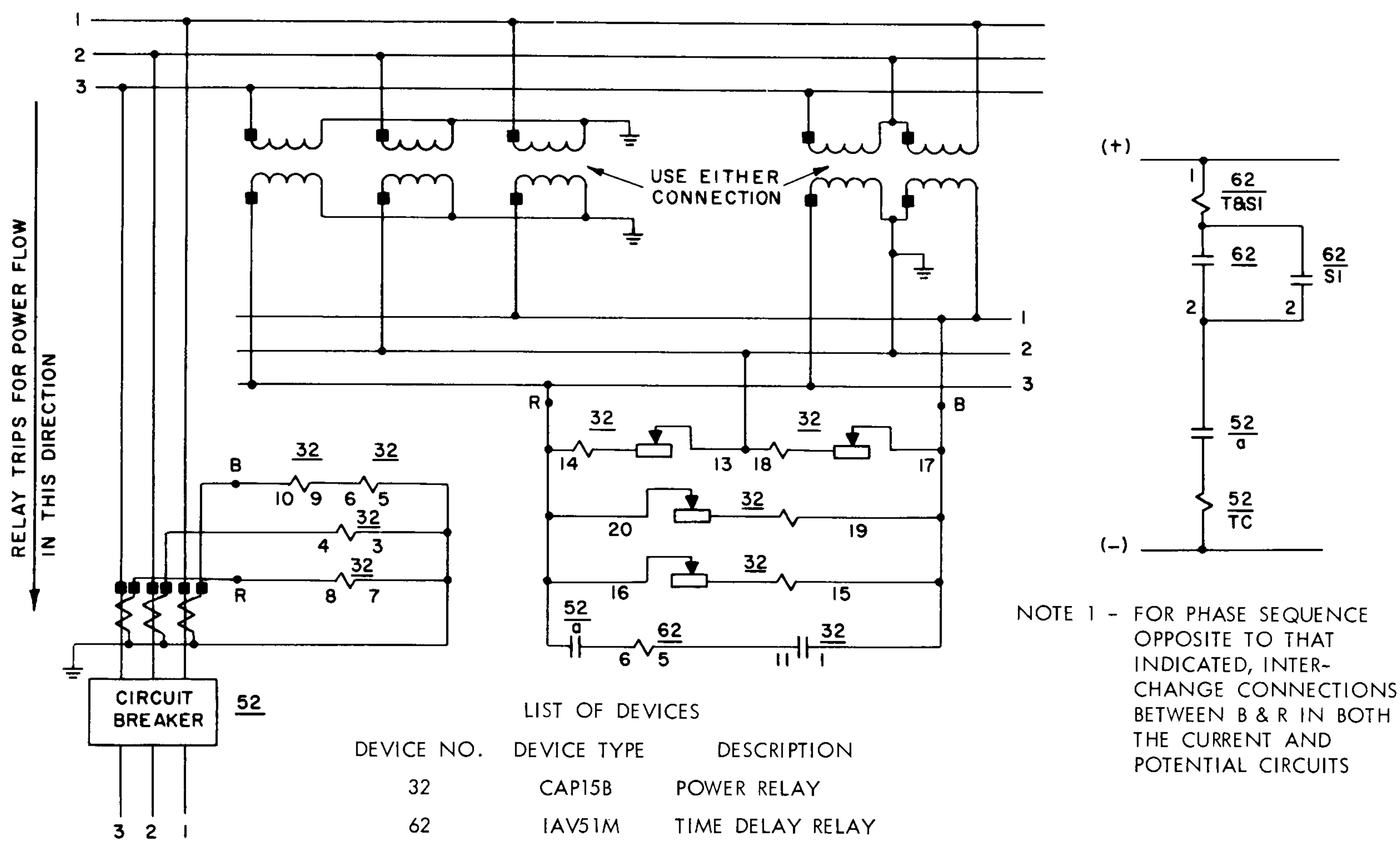
It is important to note that the time delay setting employed should be long enough to override momentary power reversals during synchronizing and system swings.

CAP15B Relay

Because of its sensitivity and real power directional characteristics, the CAP15B is a general purpose reverse power relay. Since this relay is also a high-speed device, it should always be used with a suitable timing relay in order to prevent undesired operations during system disturbances which cause momentary power reversals.

Figure 4 illustrates how the CAP15B may be used in conjunction with an IAV51M a-c timing relay. It should be noted that this combination is similar to the GGP53C relay in terms of sensitivity and timing characteristics. Therefore, the GGP53C should be used unless the timing characteristics or sensitivity are not suitable. If this is the case, some other IAV overvoltage relay may be selected for the timing function or, if a d-c timer is desired, the connections illustrated in Figure 5 may be used.

When the CAP15B is used with an IAV timing relay, or a SAM timing relay, as in Figures 4 and 5, no holding coil or target is required. For this reason a form without a holding coil or target should be selected, or if a relay with these devices is obtained, they should be by-passed in the relay.



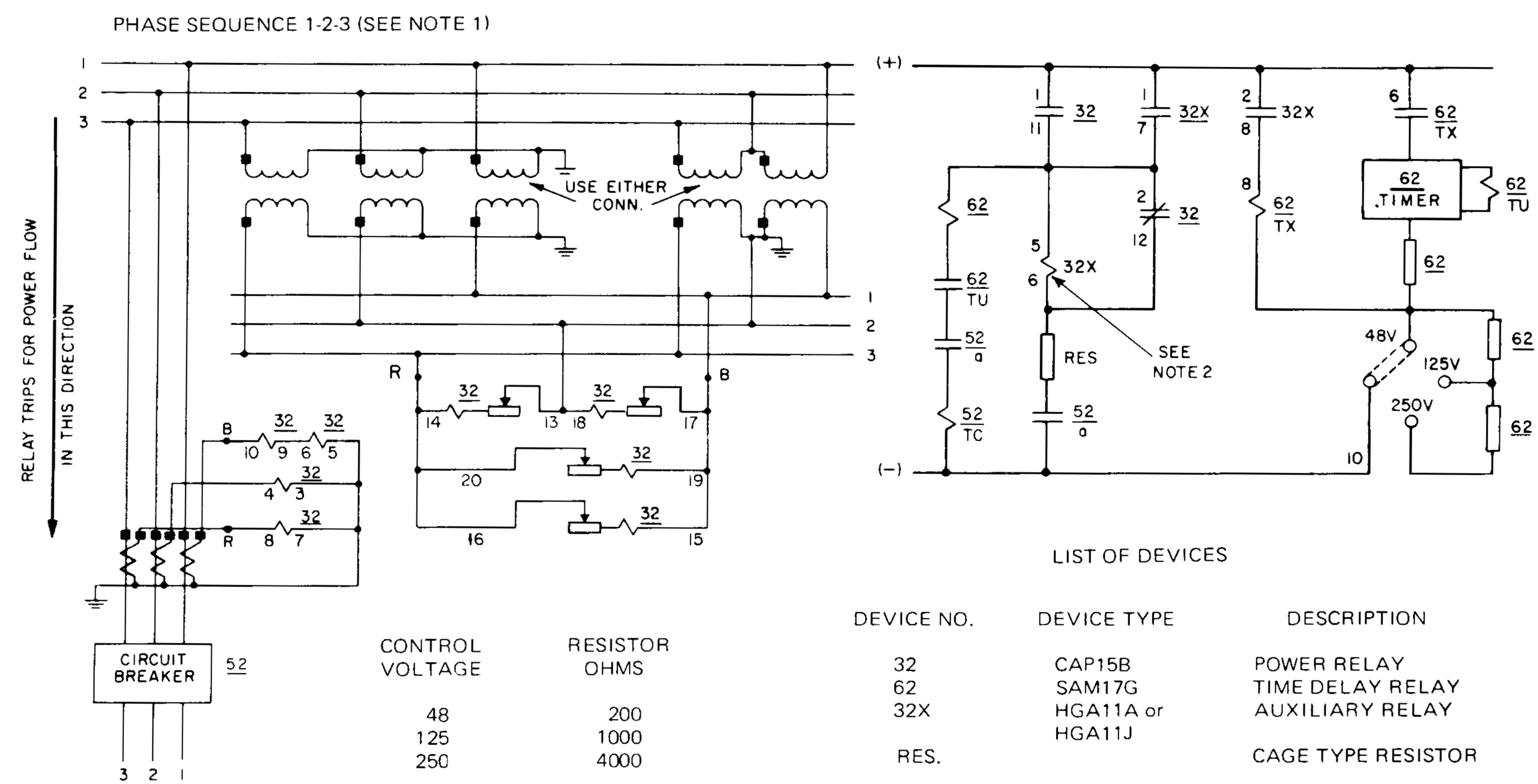
LIST OF DEVICES

DEVICE NO.	DEVICE TYPE	DESCRIPTION
32	CAP15B	POWER RELAY
62	IAV51M	TIME DELAY RELAY

NOTE 1 - FOR PHASE SEQUENCE OPPOSITE TO THAT INDICATED, INTERCHANGE CONNECTIONS BETWEEN B & R IN BOTH THE CURRENT AND POTENTIAL CIRCUITS

EXTERNAL CONNECTIONS FOR CAP15B RELAY WHEN USED WITH IAV51M RELAY

FIGURE 4. (KW011261Sh1)



CONTROL VOLTAGE	RESISTOR OHMS
48	200
125	1000
250	4000

LIST OF DEVICES

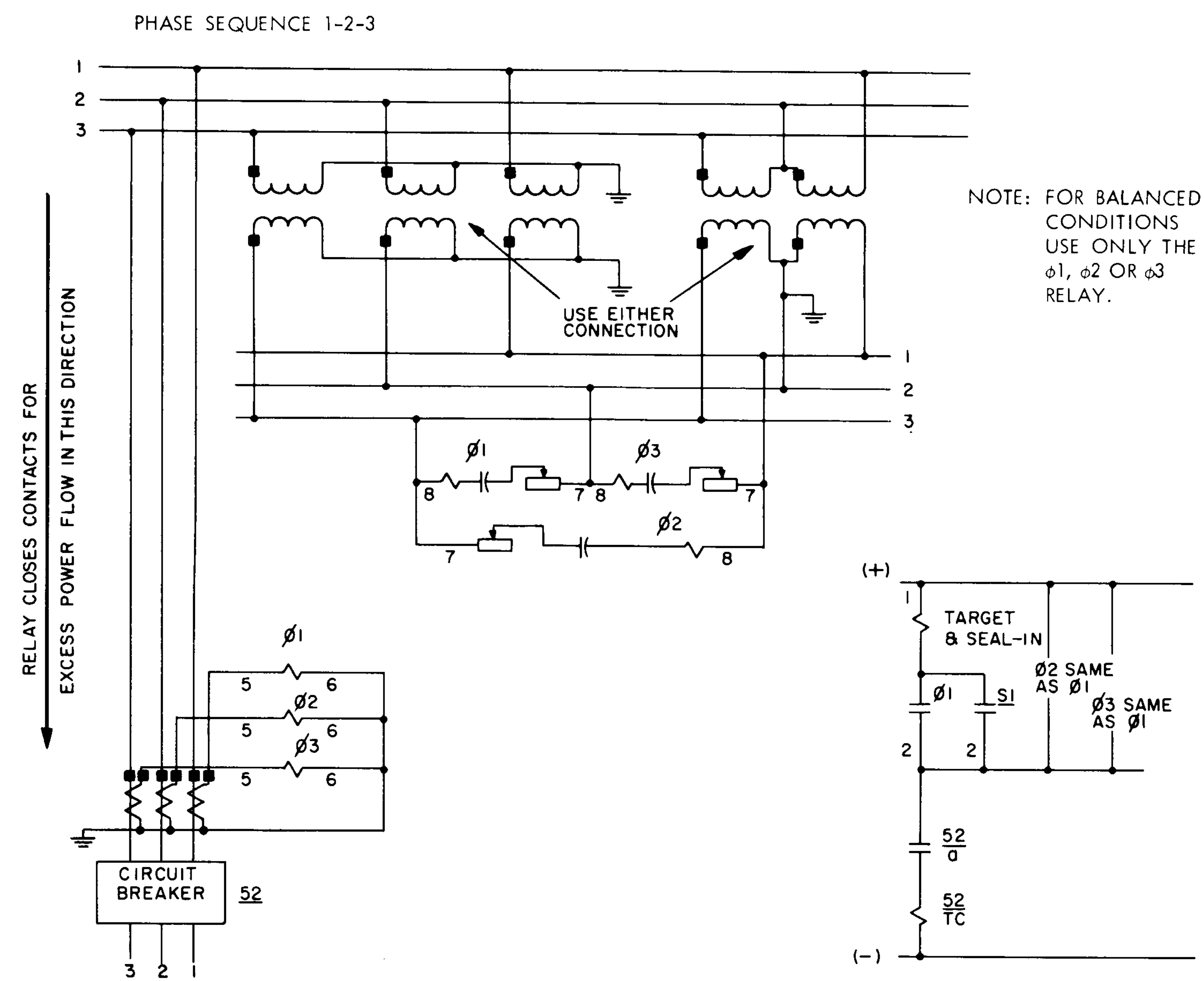
DEVICE NO.	DEVICE TYPE	DESCRIPTION
32	CAP15B	POWER RELAY
62	SAM17G	TIME DELAY RELAY
32X	HGA11A or HGA11J	AUXILIARY RELAY
RES.		CAGE TYPE RESISTOR

EXTERNAL CONNECTIONS FOR CAP15B RELAY WHEN USED WITH SAM17G RELAY

FIGURE 5. (0246A6955)

NOTE 1 - FOR PHASE SEQUENCE OPPOSITE TO THAT INDICATED, INTERCHANGE CONNECTIONS BETWEEN B & R IN BOTH THE POTENTIAL & CURRENT CIRCUITS.

NOTE 2 - SELECT HGA RELAY WITH CONTINUOUS RATING EQUAL TO 1/2 THE CONTROL VOLTAGE SUPPLY & SELECT A RESISTOR FROM THE TABLE.



EXTERNAL CONNECTIONS FOR ICW51A RELAYS

FIGURE 6. (KW010361)

ICW51A Relay

The ICW51A Relay finds application on balanced three-phase systems where time delay reverse power characteristics are required and extreme sensitivity is not essential. A typical application would be on a generator for motoring protection. Reference to the table under the section on the GGP53C relay will indicate that the ICW51A relays may be applied on all gas turbine and diesel units and on some hydraulic and steam driven units. Another application is on tie circuits where it is desired to separate if excess power flows in a reverse direction for more than transient intervals. Figure 6 illustrates the external connections to these relays for both types of applications. This sketch shows the connections to three relays. However, for balanced conditions, one relay is sufficient and the connections to any one of the three relays should be used. Worked examples for each of the two applications appear below.

For the first example assume a 1,000 kVA diesel unit having a rated terminal voltage of 4.16 kV. Assume that three potential transformers are available connected wye-wye with a ratio of 2400/120 volts and that the manufacture gives the motoring power as 200 KW.

Based on the above ratings, the full load current of the unit is

$$I_{FL} = \frac{1{,}000}{4.16\sqrt{3}} = 138 \text{ primary amperes.}$$

Assume that 200/5 CT's are available.

The three-phase secondary watts that the unit will take when it is motoring are

$$P_{sec} = \frac{P_{prim}}{(\text{CT Ratio})\ (\text{PT Ratio})}$$

$$P_{sec} = \frac{200{,}000}{(40)(20)} = 250 \text{ secondary watts.}$$

Since the relay potential connections must be made phase-to-phase, a 208 volt relay should be selected. A range should be selected so that a pick-up setting of 125 watts or less can be made. A suitable time setting should be made so that the relay does not operate to trip the unit on system disturbances and during synchronizing.

For the second example, assume a three-phase interconnection at 13.8 kV where the normal power flow is in a given direction and it is desired to open the interconnection if reverse three-phase power in excess of 500 KW occurs and persists for some short time. Assume a CT ratio of 300/5 and that two 14,400/120 volt PT's are available in open delta connection.

The secondary watts for this condition are

$$P_{sec} = \frac{500,000}{(60)(120)} = 69.5 \text{ watts.}$$

Since the PT's supply 120 volts phase-to-phase, a 120 volt relay should be selected with a range capable of a 69.5 watt setting. This could be either the 25-100 watt relay or the 50-200 watt relay.

ICW51A RELAYS

RATINGS				PICK-UP RANGE		CONTACTS	TARGET SEAL-IN	CASE SIZE	MODEL NO.
VOLTS	AMPERES		FREQ*	3-PHASE WATTS	UNITY P-F AMPERES △		AMPERES		
	CONT	1 SEC							
120	3.5		60	15-60	0.07-0.29	1 N.O.	0.2/2.0	S1	12ICW51A1A
120	5.0		60	25-100	0.012-0.48	1 N.O.	0.2/2.0	S1	12ICW51A2A
120	5.0		60	50-200	0.24-0.96	1 N.O.	0.2/2.0	S1	12ICW51A3A
120	5.0		60	100-400	0.48-1.92	1 N.O.	0.2/2.0	S1	12ICW51A4A
120	5.0		60	200-800	0.96-3.84	1 N.O.	0.2/2.0	S1	12ICW51A5A
208	3.5		60	26-104	0.07-0.29	1 N.O.	0.2/2.0	S1	12ICW51A
208	5.0		60	44-175	0.12-0.48	1 N.O.	0.2/2.0	S1	12ICW51A
208	5.0		60	87-350	0.24-0.96	1 N.O.	0.2/2.0	S1	12ICW51A
208	5.0		60	175-700	0.48-1.92	1 N.O.	0.2/2.0	S1	12ICW51A
208	5.0		60	350-1400	0.96-3.84	1 N.O.	0.2/2.0	S1	12ICW51A

* SIMILAR RATINGS ARE AVAILABLE FOR 50 CYCLE OPERATION
△ AT RATED VOLTAGE

ICW51B RELAYS

RATINGS				PICK-UP RANGE		CONTACTS	TARGET SEAL-IN	CASE SIZE	MODEL NO.
VOLTS	AMPERES		FREQ*	SINGLE-PHASE WATTS	UNITY P-F AMPERES △		AMPERES		
	CONT	1 SEC							
120	5.0		60	10-40	0.08-0.33	1 N.O.	0.2/2.0	S1	12ICW51B1A
120	5.0		60	25-100	0.21-0.83	1 N.O.	0.2/2.0	S1	12ICW51B2A
120	5.0		60	50-200	0.42-1.67	1 N.O.	0.2/2.0	S1	12ICW51B3A
120	5.0		60	100-400	0.83-3.33	1 N.O.	0.2/2.0	S1	12ICW51B4A

* SIMILAR RATINGS ARE AVAILABLE FOR 50 CYCLE OPERATION
△ AT RATED VOLTAGE

ICW51B, Relay

Like the ICW51A, the ICW51B finds application on power systems where time delay reverse power characteristics are required and extreme sensitivity is not essential. The ICW51B may be applied wherever the ICW51A can be applied but only if a phase-to-neutral source of potential is available.

For balanced three-phase conditions one ICW51B is adequate. For balanced voltages but unbalanced currents, one relay may be used but it will only measure the power in the phase to which it is connected. If the three currents are reasonably balanced, this should still suffice. If both the voltages and currents are unbalanced, the ICW51B will measure correctly the power in the phase to which it is connected. If the unbalance is deemed severe though, three such relays may be used; one per phase.

Figure 7 shows the external connections for three ICW51B relays as applied on a three-phase system. For balanced conditions the same diagram applies except only any one of the three relays need be connected. Figure 8 illustrates the connections for using one ICW51B relay on a single-phase system.

Worked examples of both single-phase and balanced three-phase applications appear below.

Consider first a balanced three-phase interconnection at 13.8 kV where the normal power flow is in a given direction and it is desired to open the interconnection if reverse three-phase power in excess of 500 KW occurs and persists for some short time. Assume a CT ratio of 300/5 and a phase-to-neutral PT with a ratio of 8,400/120 volts.

The secondary <u>single-phase</u> watts for this condition are

$$P_{sec} = \frac{P_{prim}}{3\,(\text{CT Ratio})\,(\text{PT Ratio})} \quad \text{watts per phase}$$

$$P_{sec} = \frac{500{,}000}{3\,(60)\,(70)} = 39.7 \text{ single-phase secondary watts.}$$

In order to obtain this setting, the 25-100 watt relay should be selected.

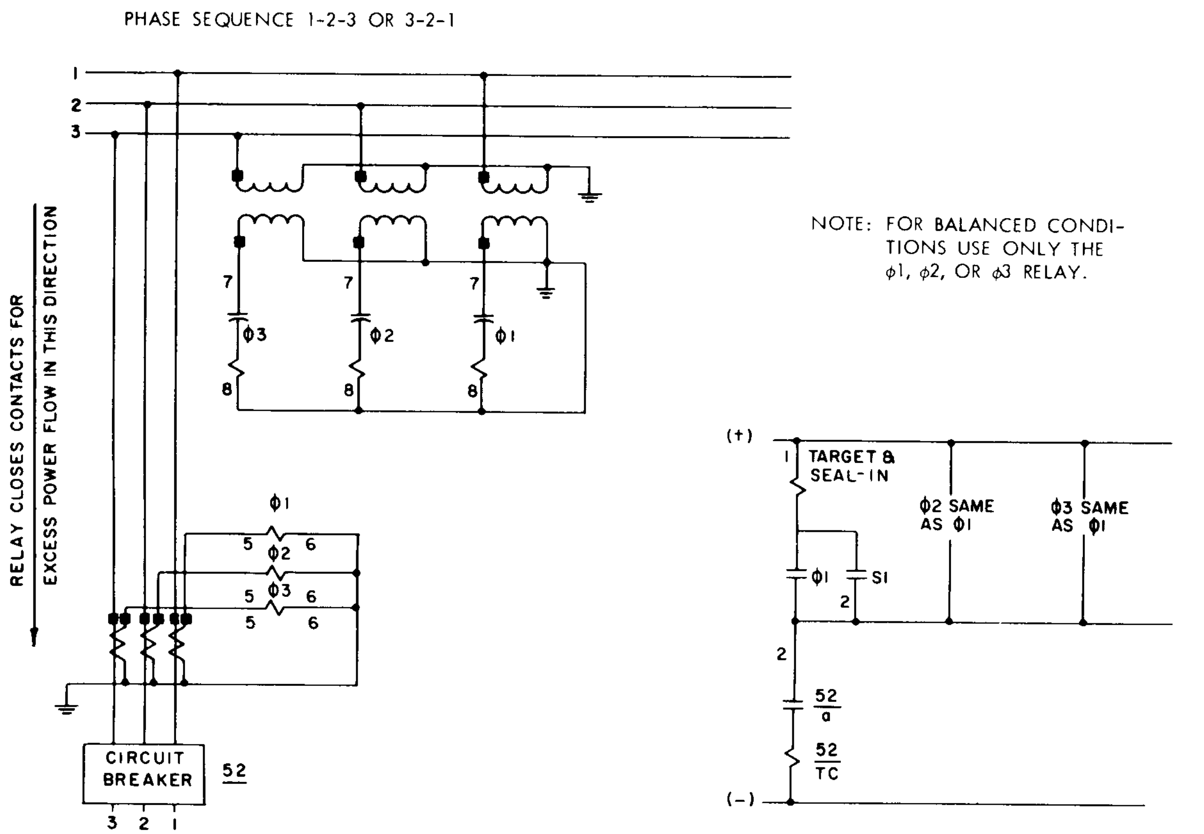
Consider now a single-phase system of 600 volts on which it is desired to detect a reverse power condition in excess of 20 KW. Assume a 100/5 CT and a 600/120 volt PT.

The secondary watts for this condition are

$$P_{sec} = \frac{P_{prim}}{(\text{CT Ratio})\,(\text{PT Ratio})}$$

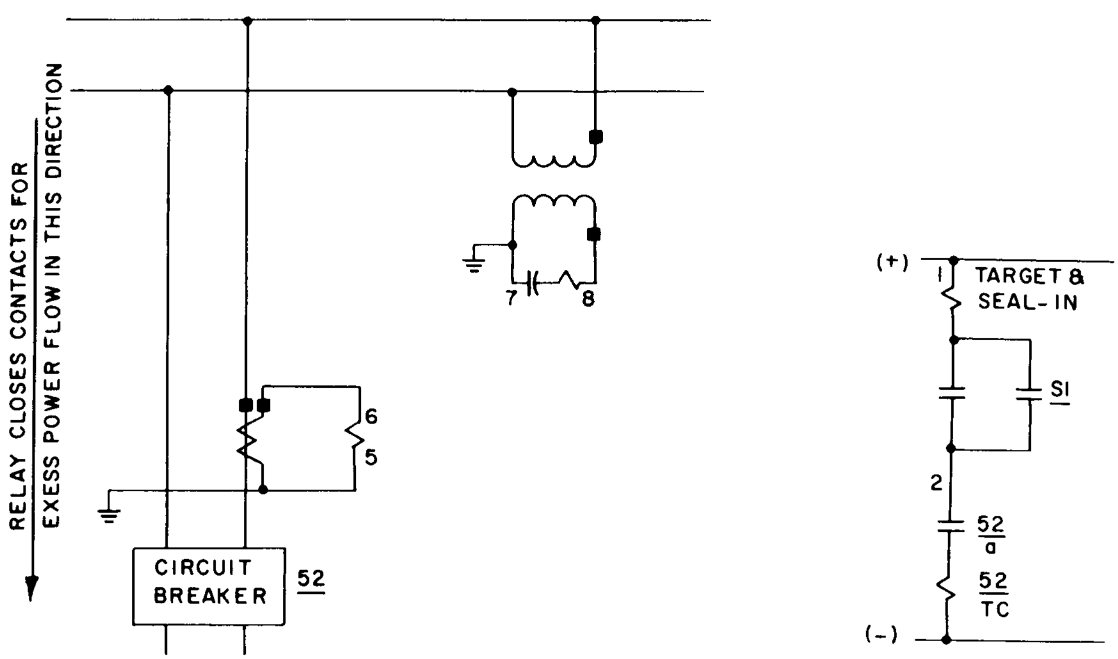
$$P_{sec} = \frac{20{,}000}{(20)(5)} = 200 \text{ secondary watts.}$$

To accommodate this setting select the relay with a 100-400 watt range.



EXTERNAL CONNECTIONS FOR ICW51B RELAY AS USED ON A 3-PHASE SYSTEM

FIGURE 7. (KW010461)



EXTERNAL CONNECTIONS FOR ICW51B RELAY
AS USED ON A SINGLE-PHASE SYSTEM

FIGURE 8. (KW010561)

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