Instructions for Type SVC Voltage Regulating Relay

Westinghouse Electric Corporation
Power Transformer Division, Sharon, Pa.
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INSTRUCTIONS FOR TYPE SVC VOLTAGE REGULATING RELAY

Introduction

The type SVC voltage Regulating Relay is a factory calibrated control package designed to control load tap changers. It performs the functions of voltage sensing, time delay and line drop compensation with static devices that insure high reliability and low maintenance.

All settings are made by calibrated knobs on the front panel of the relay. The control components do not require warm-up time before making settings. Locking strips secure all continuously adjustable control knobs at the desired settings and all other knobs are on snap-type tap switches which cannot move off position accidentally.

The relay accuracy is better than ASA Standards Class 1.

Description

All of the calibrated control knobs mount on the front of the SVC relay (see figure 1). The following settings can be made:

1. Time Delay - The time delay can be set for raise and lower operation individually. It is continuously adjustable from 0 to 120 seconds with the dial positions marked for 5-15-20 60-90 and 120 seconds. There is also a Test position which has approximately zero time delay, and which can be used to check the bandwidth settings.

2. Balance Voltage - The balance voltage is adjustable from 105 to 134 volts in one volt steps. It is the sum of the values set on the Coarse and Fine control knobs.

3. Bandwidth - The total bandwidth is continuously adjustable from 1 to 6 volts. The dial is calibrated for 1, 1.5, 2, 3, 4 & 6 volts at balance voltages of 105, 110, 115, 120, 125, 130 & 134 volts. The bandwidth is obtained by setting the mark on the control knob in line with the intersection of the bandwidth voltage line and the balance voltage arc.

4. Reactance Reversal - A control switch permits the reversal of the reactance portion of the line drop compensator for parallel operation of load tap changers by the reverse reactance method .

5. Test Rheostat - The test rheostat can be used to provide a continuously adjustable voltage to the relay for testing.

6. Line Drop Compensator

   a. Reactance - Reactance compensation is adjustable in one volt steps from 0 to 24 volts. It is the sum of the values set on the Coarse and Fine control knobs.

   b. Resistance -Resistance compensation is continuously adjustable from 0 to 24 volts. The dial is marked in two-volt increments.

Behind the front panel is a printed circuit board on which most of the static components are mounted. The printed circuit board mounts in a disconnect socket for ease of removal.

Connections to the relay are made at a terminal block under the printed circuit board.

General operating data for the relay on 60 cycles is as follows:

Burden of the potential circuit at 120 volts	5 VA
Separate R & X compensation	24 Volts
100% load compensation current	0.2 Amps
Burden of the current circuit at 100% load	.21 VA

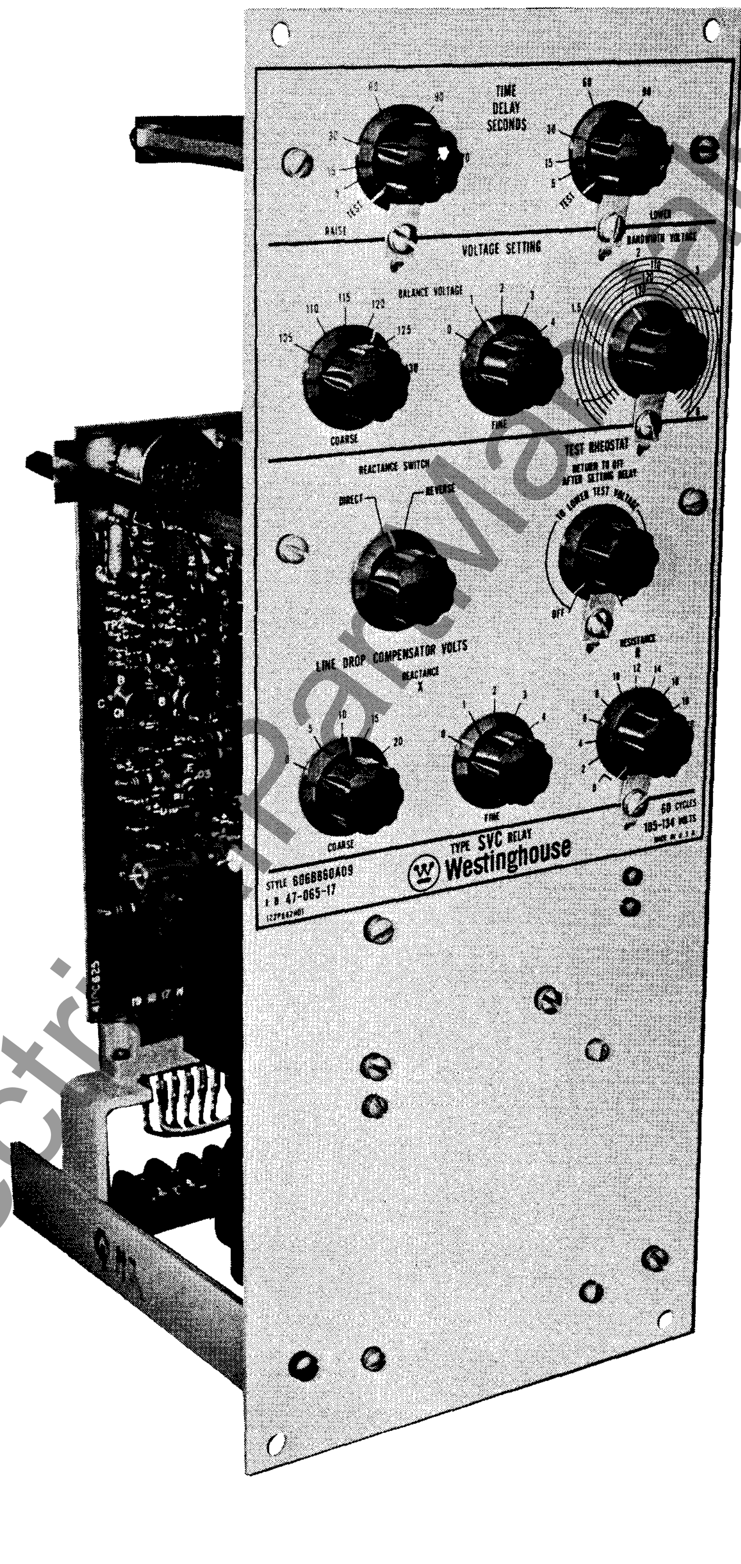


Figure 1 - SVC Relay

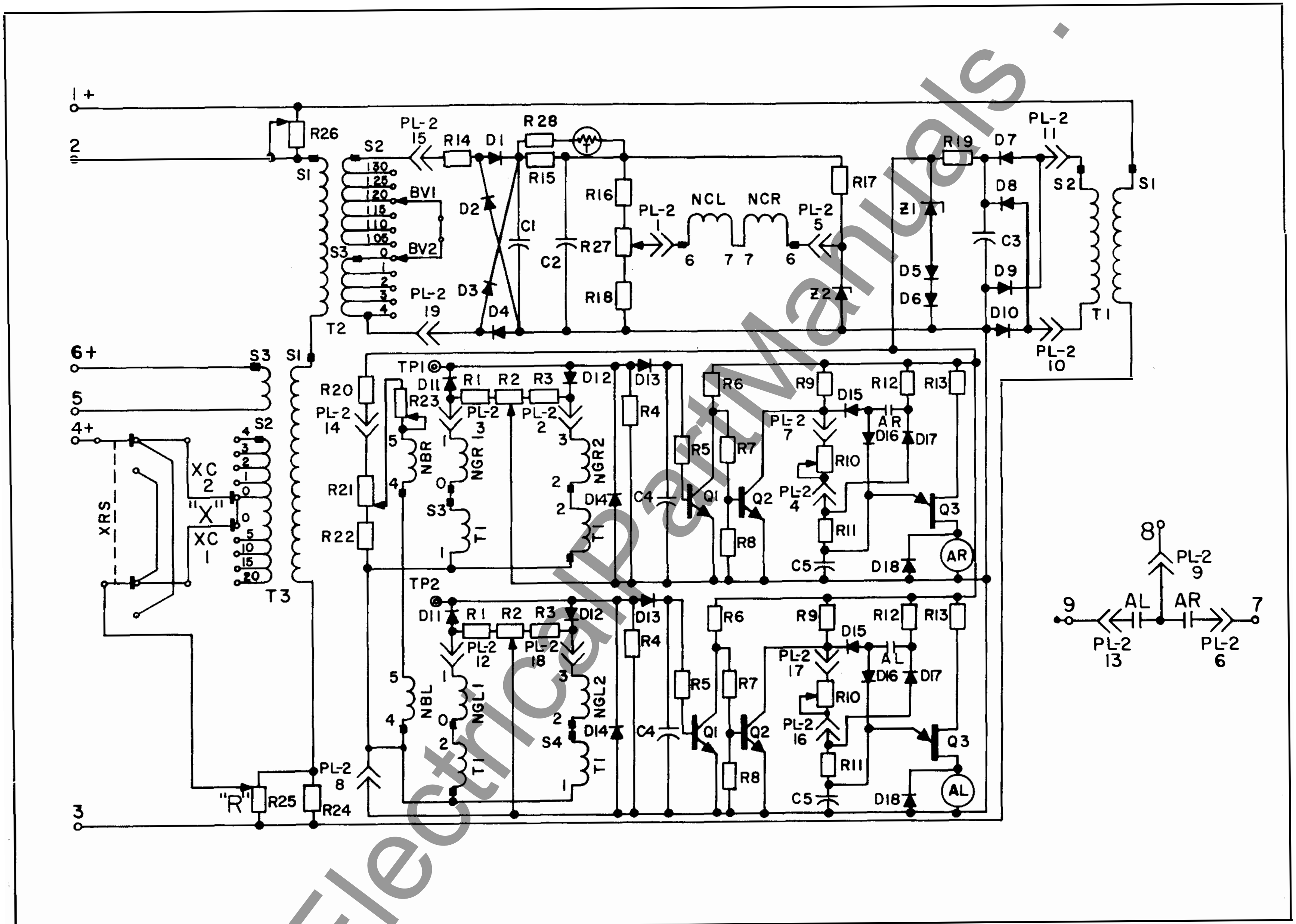
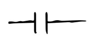
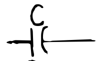
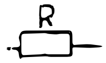


Figure 2 - SVC Internal Schematic

LEGEND FOR FIGURE 2

	THERMISTOR
	NORMALLY OPEN RELAY CONTACT
	CAPACITOR
	DISCONNECT DEVICE
	OPERATING COIL
	RESISTOR
AL, AR	AUXILIARY RELAYS
BV1	BALANCE VOLTAGE ADJUSTMENT - COARSE
BV2	BALANCE VOLTAGE ADJUSTMENT - FINE
D	DIODE
NBL, NBR	MAGAMP BANDWIDTH WINDINGS
NCL, NCR	MAGAMP CONTROL WINDINGS
NGL, NGR	MAGAMP GATE WINDINGS
Q	TRANSISTOR
R	RESISTANCE COMPENSATOR
R10	TIME DELAY ADJUSTMENT RHEOSTATS
R21	BANDWIDTH VOLTAGE ADJUSTMENT
R25	RESISTANCE COMPENSATOR
R26	TEST RHEOSTAT
T	TRANSFORMER
TP	TEST POINT
X	REACTANCE COMPENSATOR
XC1	REACTANCE COMPENSATOR COARSE ADJUSTMENT
XC2	REACTANCE COMPENSATOR FINE ADJUSTMENT
XRS	REACTANCE REVERSING SW.
Z	ZENER DIODE

Operation

The operation of the SVC relay will be described for a relay with the following front panel settings:

1. Time Delay - set at any value.
2. Balance Voltage - Coarse set on 120 volts, Fine set on 0 volts.
3. Bandwidth Voltage - Set for 2 volts.
4. Line Drop Compensator -
   a. Reactance Reversal Switch - Set on Direct.
   b. Reactance "X" - Coarse & Fine both set on 0.
   c. Resistance "R" - Set on 0 .
5. Test Rheostat - Set to off position.

The relay is now set for a balance voltage of 120 volts with a ± 1 volt bandwidth.

Referring to the internal schematic in Figure 2, assume that 120 volts is applied to terminals 1 & 3. This voltage is then applied to the power supply through transformer T1, to the sensing unit through tapped transformer T2 & to the Line Drop Compensator through transformer T3 & rheostat R25. The power supply develops a constant DC voltage at zener diode Z 1, which supplies current to the bandwidth circuit through resistor R20, & which also is the supply for the time delay circuits and the output relays. The tapped sensing transformer T2 and its associated full-wave rectifier circuit applies a DC voltage to tops of resistors R16 and R17, which are the ends of the sensing bridge. Temperature compensated zener diode Z 2 supplies a constant DC reference voltage for the sensing bridge. Rheostat R27 is factory adjusted to produce zero voltage across the magnetic amplifier control windings NCL and NCR, when the supply voltage equals the balance voltage settings. With zero volts across the control winding, there is no output at either test point TP1 or TP2. With no signal into the base of transistor Q1, Q1 will be in the blocking state and transistor Q2 will be in the conducting state, receiving its base drive from zener diode Z1 through resistors R6 and R7. With transistor Q2 conducting, the RC timing circuit of rheostat R10 and capacitor C5 is bypassed through the collector and emitter of transistor Q2. Therefore, the output relays AR and AL remain deenergized.

Now assume that the voltage applied to terminals 1 and 3 drops to 118 volts. The voltage at rheostat R27 of the sensing bridge drops below the value of zener diode Z2 and causes a current to flow into polarity of NCR, the control winding of the raise magnetic amplifier, giving an output at test point TP1. The current in non-polarity of NCL turns the lower magnetic amplifier off more. The output at test point TP1 puts base drive on transistor Q1 of the raise circuit and Q1 switches to the conducting state. With transistor Q1 conducting, the base drive for transistor Q2 is shunted through the collector and emitter of Q1 and Q2 switches to the blocking state. Capacitor C5 is then charged through rheostat R10. When the voltage on C5 reaches the breakdown voltage of the unijunction transistor Q3, Q3 fires and C5 discharges, energizing the output relay AR. The smaller AR contact seals the AR relay in through resistor R12 and diode D16 while the larger AR contact energizes the tap changer motor control circuit through terminals 8 and 9 to initiate a raise in voltage. The AR relay remains energized until the line voltage returns within the bandwidth. Then there is no longer an output at test point TP1 and transistor Q1 returns to the blocking state. Transistor Q2 then returns to the conducting state, shorting out the RC timing circuit and the AR relay.

A raise in voltage applied to terminals 1 and 3 beyond the bandwidth setting would initiate a similar sequence of operations to lower the voltage.

Now, assume that the applied voltage goes up to 122 volts but, returns within the bandwidth before firing the unijunction transistor Q3 and operating relay AL. The voltage going to 122 volts gives an output at test point TP2 causing capacitor C5 to begin charging. When the voltage returns within the bandwidth, transistor Q2 returns to the conducting state and C5 is discharged through resistor R11 and rheostat R10. This provides the same time constant for charging and discharging the timing circuit, or an integrating time delay.

Reactance Reversing Switch. For normal line drop compensation the Reactance Switch (XRS) on the CVC sub-panel is left in the "DIRECT" position. Reversed reactance compensation is obtained by placing it in the "REVERSE" position, which reverses the polarity of the reactance element.

"Reverse reactance" compensation is a method used to reduce the circulating current that might flow when two or more transformers are paralleled. It is a requirement of ASA Standards C57.12-37.236.1. Instead of running toward opposite extreme positions, tap changers having "reverse reactance" compensation tend to move toward whatever positions cause the least amount of circulating current to flow. This is accomplished at some sacrifice of normal line drop compensation, but is generally satisfactory when units paralleled are not located in close proximity to each other, or where the supply is from different sources.

Line Drop Compensator Settings. The final settings for the line drop compensator may be made most satisfactorily by field adjustment. Initial settings may be determined from line data by using the curves in Figures 3 and 4 together with the following expressions.

Let

- d = miles from unit to load center
- I_p = main current transformer primary current rating
- E_c = control voltage
- E_p = potential transformer primary voltage
- r = resistance per conductor from unit to load center, in ohms per mile
- x = inductive reactance per conductor from unit to load center, in ohms per mile
- R = resistance dial setting
- X = reactance dial setting

For a single-phase, two-wire circuit:

$$R = \frac{2\ r\ d\ I_p\ E_c}{E_p}$$

$$X = \frac{2\ x\ d\ I_p\ E_c}{E_p}$$

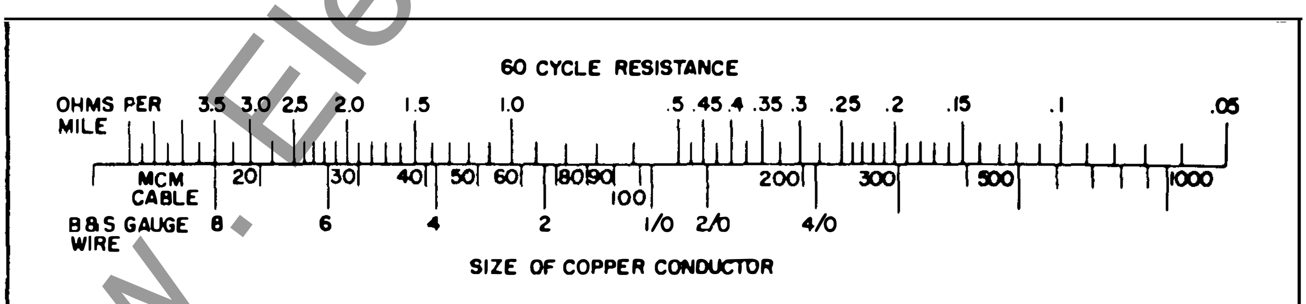
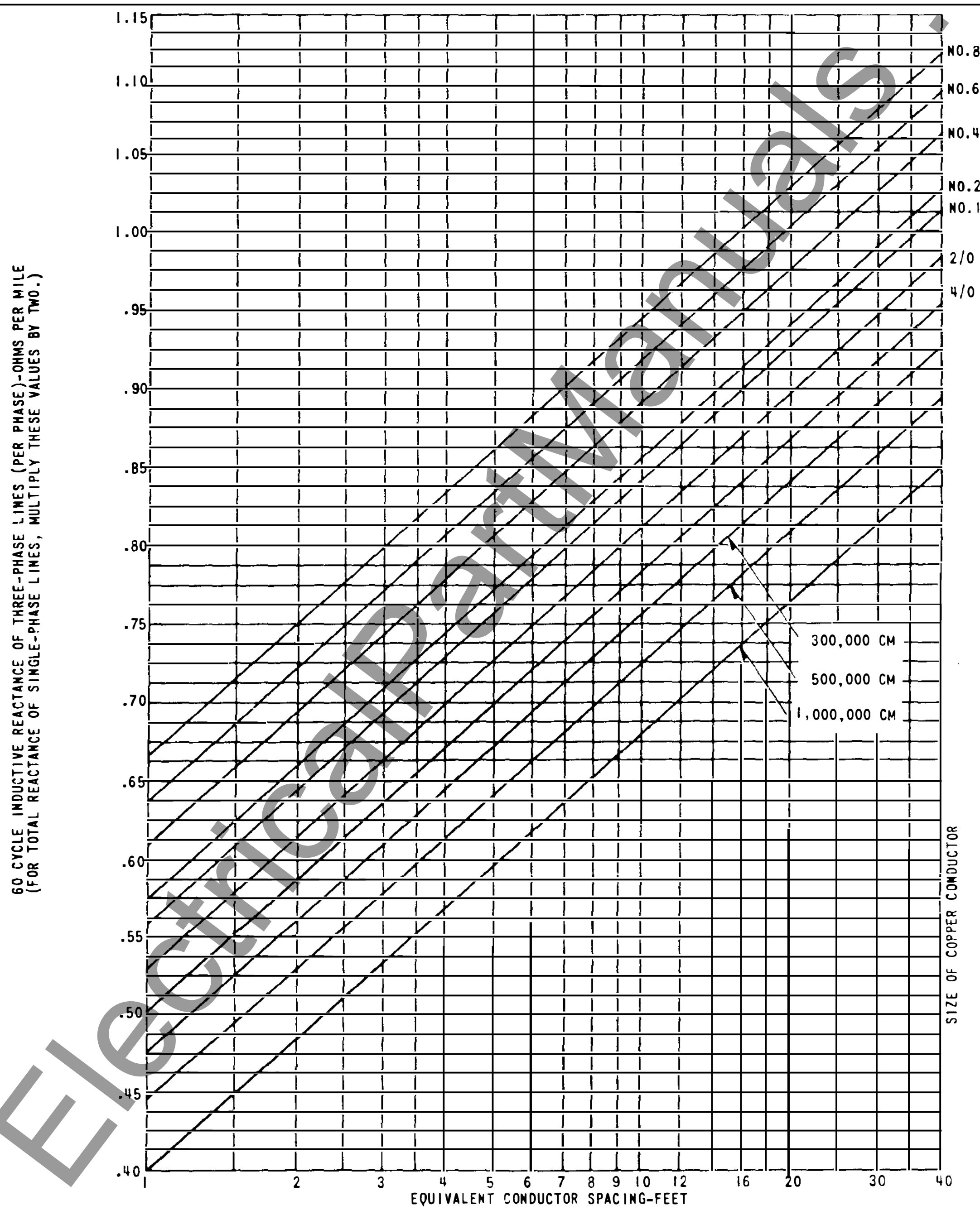


Fig. 3 - *Resistance Chart Showing Ohms per Conductor per Mile 60 Cycle Circuit at 25°C*



EQUIVALENT CONDUCTOR SPACING, D, OF UNSYMMETRICAL THREE PHASE LINES IS GIVEN BY THE EXPRESSION

$D = \sqrt[3]{D_{AB} \times D_{BC} \times D_{CA}}$, WHERE

D_{AB}, D_{BC}, AND D_{CA} ARE THE DISTANCES IN FEET BETWEEN CONDUCTORS DESIGNATED BY THE SUBSCRIPTS.

NOTE:- WHERE $D_{CA} = 2\ D_{AB} = 2\ D_{BC}$: $D = 1.26\ D_{AB}$

Fig. 4 - *Reactance in Ohms per Conductor per Mile Versus Spacing for Single Phase or 3 Phase Lines*

For a three-phase unit or for each single-phase unit of a three-phase wye connection:

$$R = \frac{r\ d\ I_p\ E_c}{E_p}$$

$$X = \frac{x\ d\ I_p\ E_c}{E_p}$$

For a three-phase unit with a line-to-line potential transformer and two cross-connected current transformers on a three-phase connection:

$$R = \frac{r\ d\ I_p\ E_c}{\sqrt{3}\ E_p}$$

$$X = \frac{x\ d\ I_p\ E_c}{\sqrt{3}\ E_p}$$

For two single-phase units of an open delta connection:

(a) For the unit in which the current leads the voltage:

$$R = (1.5\ r + .866\ x)\ \frac{d\ I_p\ E_c}{E_p}$$

$$X = (-.866\ r + 1.5\ x)\ \frac{d\ I_p\ E_c}{E_p}$$

(b) For the unit in which the current lags the voltage:

$$R = (1.5\ r - .866\ x)\ \frac{d\ I_p\ E_c}{E_p}$$

$$X = (.866\ r + 1.5\ x)\ \frac{d\ I_p\ E_c}{E_p}$$

For three single-phase units on a delta connection:

Delta connections should be made at the "L" and "SL" terminals of the regulator in order that the potential supply to the voltage regulating relay will measure output line voltage. When this is done, the current transformer supplying the line drop compensator is inside the delta. Basically, therefore, the current in the line drop compensator must be multiplied by $\sqrt{3}$ and shifted 30° to equal the current flowing through the line impedance. This results in the same formulas given above for open delta connections. In the case of the full delta connection, however, the relationship is further modified by the tap changer position, which changes every time the tap changer operates.

Because the three-phase delta connection does not usually permit using the full capability of single-phase voltage regulators, and because the line drop compensation changes with tap changer position, this connection is not usually recommended, the open delta connection being preferred. If full delta must be used, the line drop compensator settings can be approximated by using the open delta formulas.

A typical example is as follows:

Consider two 7620 volt, 100 ampere voltage regulators being operated in open delta on a 4800 volt, three-phase, three-wire line of 2/0 copper with 3 foot conductor spacing and with 4 miles from the regulator to the load center.

r = .45 (from Figure 3)
x = .66 (from Figure 4)
d = 4 miles
I_p = 100 amperes
E_p = 4800 volts
E_C = 120 volts

For the regulator in which the current leads the voltage:

$$R = (1.5 \times .45 + .866 \times .66) \times \frac{4 \times 100 \times 120}{4800} =$$

$$(1.5 \times .45 + .866 \times .66) \times 10 = 12.47$$

$$X = (-\ .866 \times .45 + 1.5 \times .66) \times 10 = 6$$

For the regulator in which the current lags the voltage:

$$R = (1.5 \times .45 - .866 \times .66) \times 10 = 1.03$$

$$X = (.866 \times .45 + 1.5 \times .66) \times 10 = 13.80$$

Therefore, the dials on the control panels of these voltage regulators would be set as follows:

For the regulator with the current leading the voltage:

Polarity Switch = Set for +R, +X
Resistance Volts = Set at 12.5
Reactance Volts = Set at 6

For the regulator with the current lagging the voltage:

Polarity Switch = Set for +R, +X
Resistance Volts = Set at 1.0
Reactance Volts = Set at 14.0

FIELD METHOD FOR DETERMINING THE OPEN DELTA UNIT WITH LEADING OR LAGGING CURRENT WITH RESPECT TO ITS VOLTAGE

To make the proper identification perform the following steps after the regulators are connected in open delta and carrying current.

1. Set the resistance compensator dial of both regulators on zero.

2. Set the reactance compensator dials at 12 on both regulators.

3. Place the control selector switch on "AUTO".

4. The lagging current unit will operate more positions in the raise direction than the leading current unit.

FIELD METHOD FOR DETERMINING WHETHER THE CURRENT IN THE REGULATOR WINDING IS LEADING OR LAGGING THE VOLTAGE IN A CLOSED DELTA BANK OF SINGLE PHASE REGULATORS

The compensator dial setting modifications described for open delta operation will give correct line drop compensation on closed delta connected regulators when they are on neutral position. On other than neutral positions the compensation will be approximately correct. (An error is introduced because the regulator current transformer is connected ahead of the delta connection.)

To determine whether the 3 single phase regulators in a closed delta bank are connected in such manner as to result in the winding current's leading or lagging the voltage of that phase, the following steps may be followed:

1. Set the resistance compensator dials on all regulators on zero.

2. Set the reactance compensator dials on 12 on all 3 units.

3. Place the line drop compensator polarity selector switch for +R +X.

4. Set the control selector switch on "AUTO". The regulators will operate to correct the voltage. Observe the tap changer position.

5. Set the reactance switch to reverse.

If the regulators now operate to raise their output voltage, the regulators are connected as leading units. If the regulators now operate to lower their output voltage, the regulators are connected as lagging units.

6. Obtain revised line drop compensator settings by means of the expressions for open delta operation listed above.

NOTE: The above test for the closed delta regulators is effective for load power factors between 90% lagging and 90% leading. The use of the open delta expressions for the closed delta connections is valid when the delta is closed by connecting the "L" terminals of one regulator to the "SL" terminal of the other regulator.

MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer (with the exception of control settings). Repair work can be most satisfactorily done at the factory. If it is desired to check the adjustment at regular maintenance, the following instructions should be followed:

When contacts require cleaning, they should be cleaned with a fine contact file similar to S#1002110 or a contact burnishing tool. Abrasive material should not be used because any small particles embedded in the contact surface will impair the contact operation.

In the event any of the components become inoperative, they may be replaced with renewal parts ordered from the nearest Westinghouse Sales Office. Give the Style or Shop Order number of the equipment as stamped on the nameplate, together with the description of the parts required.

Instructions for Type SVC Voltage Regulating Relay

Fig. 1 Type SVC Voltage Regulating Relay

The Type SVC Voltage Regulating Relay is a factory calibrated control package designed to control load tap changers. It performs the functions of voltage sensing, time delay and line drop compensation with static devices that insure high reliability and low maintenance.

All settings are made by calibrated knobs on the front panel of the relay. The control components do not require warm-up time before making settings. Locking strips secure all continuously adjustable control knobs at the desired settings and all other knobs are on snap-type switches which cannot move off position accidentally.

The relay accuracy is better than ASA Standards Class 1.

DESCRIPTION

All of the calibrated control knobs mount on the front of the SVC relay (Figure 1). The following settings can be made:

1. Time Delay - The time delay can be set for raise and lower operation individually. It is continuously adjustable from 0 to 120 seconds with the dial positions marked for 5-15-30-60-90 and 120 seconds. There is also a Test position which has approximately zero time delay, and which can be used to check the bandwidth settings.

2. Balance Voltage - The balance voltage is adjustable from 105 to 134 volts in one volt steps. It is the sum of the values set on the Coarse and Fine control knobs.

3. Bandwidth Voltage - The total bandwidth is continuously adjustable from 1 to 6 volts (± .5 to ± 3). The dial is calibrated for 1, 1.5, 2, 3, 4 & 6 volts at balance voltages of 105, 110, 115, 120, 125, 130 and 134 volts. The bandwidth is obtained by setting the mark on the control knob in line with the intersection of the bandwidth voltage line and the balance voltage arc.

4. Reactance Switch - A control switch permits the reversal of the reactance portion of the line drop compensator for parallel operation of load tap changers by the reverse reactance method.

5. Test Rheostat - The test rheostat can be used to provide a continuously adjustable voltage to the relay for testing.

6. Line Drop Compensator Volts

a. Reactance - Reactance compensation is adjustable in one volt steps from 0 to 24 volts. It is the sum of the values set on the Coarse and Fine control knobs.

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b. Resistance - Resistance compensation is continuously adjustable from 0 to 24 volts. The dial is marked in two-volt increments.

Behind the front panel is a printed circuit board on which most of the static components are mounted. The printed circuit board mounts in a disconnect socket for ease of removal.

Connections to the relay are made at a terminal block under the printed circuit board.

General operating data for the relay on 60 cycles is as follows:

Burden of the potential circuit at 120 volts	5 VA
Separate R and X compensation	24 Volts
100% load compensation current	0.2 Amps
Burden of the current circuit at 100% load	.21 VA

OPERATION

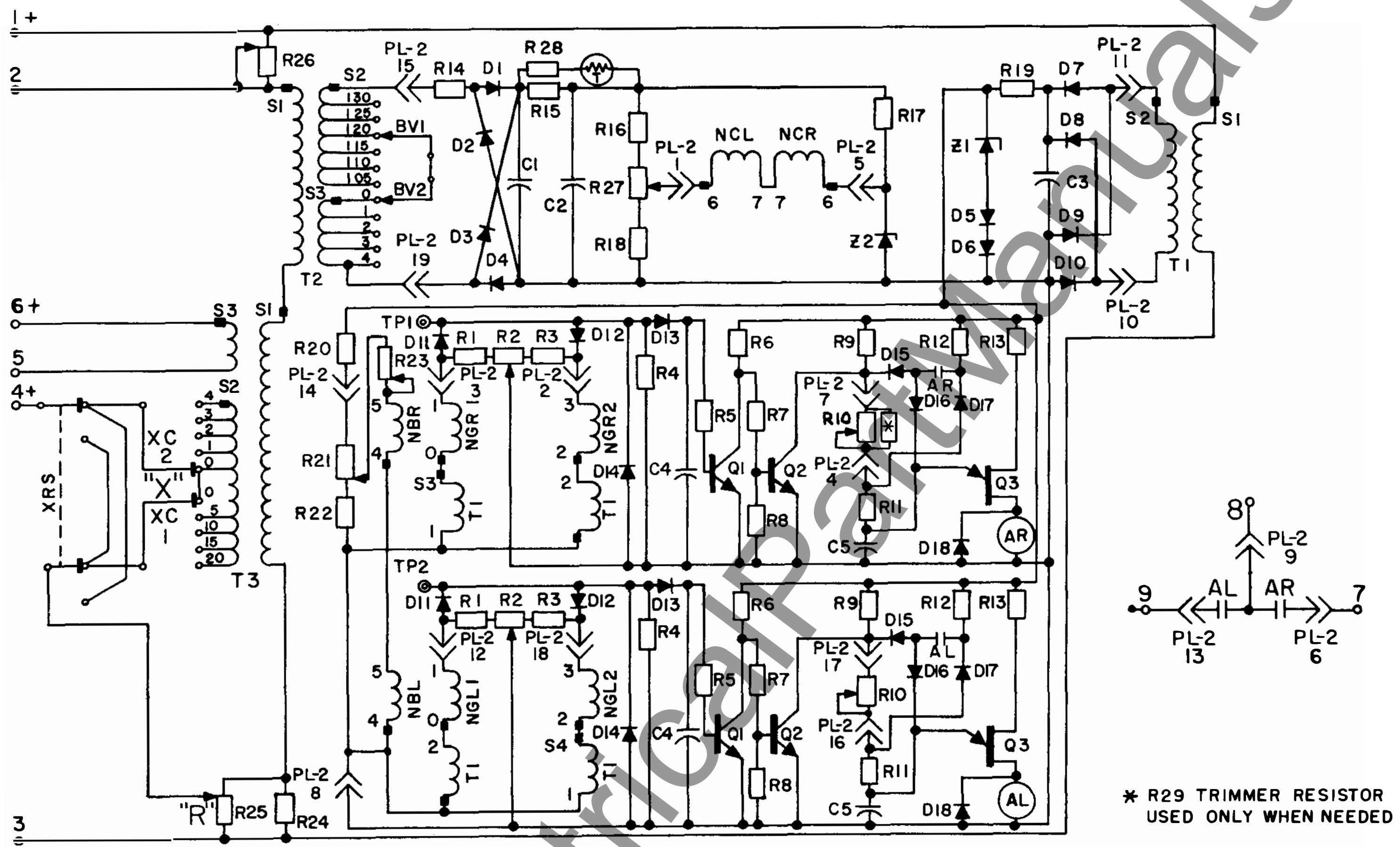
The operation of the SVC relay will be described for a relay with the following front panel setting:

1. Time Delay - Set at any value.
2. Balance Voltage - Coarse set on 120 volts, Fine set on 0 volts.
3. Bandwidth Voltage - Set for 2 volts.
4. Line Drop Compensator -   a. Reactance Reversal Switch - Set on Direct.   b. Reactance "X" - Coarse and Fine both set on O.   c. Resistance "R" - Set on O.
5. Test Rheostat - Set to off position.

The relay is now set for a balance voltage of 120 volts with a ± 1 volt bandwidth.

Referring to the internal schematic in Figure 2, assume that 120 volts is applied to terminals 1 and 3. This voltage is then applied to the power supply through transformer T1, to the sensing unit through tapped transformer T2 and to the Line Drop Compensator through transformer T3 and rheostat R25. The power supply develops a constant DC voltage at zener diode Z 1, which supplies current to the bandwidth circuit through resistor R20, and which also is the supply for the time delay circuits and the output relays. The tapped sensing transformer T2 and its associated full-wave rectifier circuit applies a DC voltage to tops of resistors R16 and R17, which are the ends of the sensing bridge. Temperature compensated zener diode Z 2 supplies a constant DC reference voltage for the sensing bridge. Rheostat R27 is factory adjusted to produce zero voltage across the magnetic amplifier control windings NCL and NCR, when the supply voltage equals the balance voltage settings. With zero volts across the control winding, there is no output at either test point TP1 or TP2. With no signal into the base of transistor Q1, Q1 will be in the blocking state and transistor Q2 will be in the conducting state, receiving its base drive from zener diode Z 1 through resistors R6 and R7. With transistor Q2 conducting, the RC timing circuit of rheostat R10 and capacitor C5 is bypassed through the collector and emitter of transistor Q2. Therefore, the output relays AR and AL remain deenergized.

Now assume that the voltage applied to terminals 1 and 3 drops to 118 volts. The voltage at rheostat R27 of the sensing bridge drops below the value of zener diode Z 2 and causes a current to flow into polarity of NCR, the control winding of the raise magnetic amplifier, giving an output at test point TP1. The current in non-polarity of NCL turns the lower magnetic amplifier off more. The output at test point TP1 puts base drive on transistor Q1 of the raise circuit and Q1 switches to the conducting state. With transistor Q1 conducting, the base drive for transistor Q2 is shunted through the collector and emitter of Q1 and Q2



THERMISTOR

NORMALLY OPEN RELAY CONTACT

CAPACITOR

DISCONNECT DEVICE

OPERATING COIL

RESISTOR

AL,AR	AUXILIARY RELAYS	Q	TRANSISTOR	TP	TEST POINT
BV1	BALANCE VOLTAGE ADJUSTMENT-COARSE	R	RESISTANCE COMPENSATOR	X	REACTANCE COMPENSATOR
BV2	BALANCE VOLTAGE ADJUSTMENT-FINE	R10	TIME DELAY ADJUSTMENT RHEOSTATS	XC1	REACTANCE COMPENSATOR COARSE ADJUSTMENT
D	DIODE	R21	BANDWIDTH VOLTAGE ADJUSTMENT	XC2	REACTANCE COMPENSATOR FINE ADJUSTMENT
NBL,NBR	MAGAMP BANDWIDTH WINDINGS	R25	RESISTANCE COMPENSATOR	XRS	REACTANCE REVERSING SW.
NCL,NCR	MAGAMP CONTROL WINDINGS	R26	TEST RHEOSTAT	Z	ZENER DIODE
NGL,NGR	MAGAMP GATE WINDINGS	T	TRANSFORMER		

Fig. 2 Type SVC Relay Internal Schematic

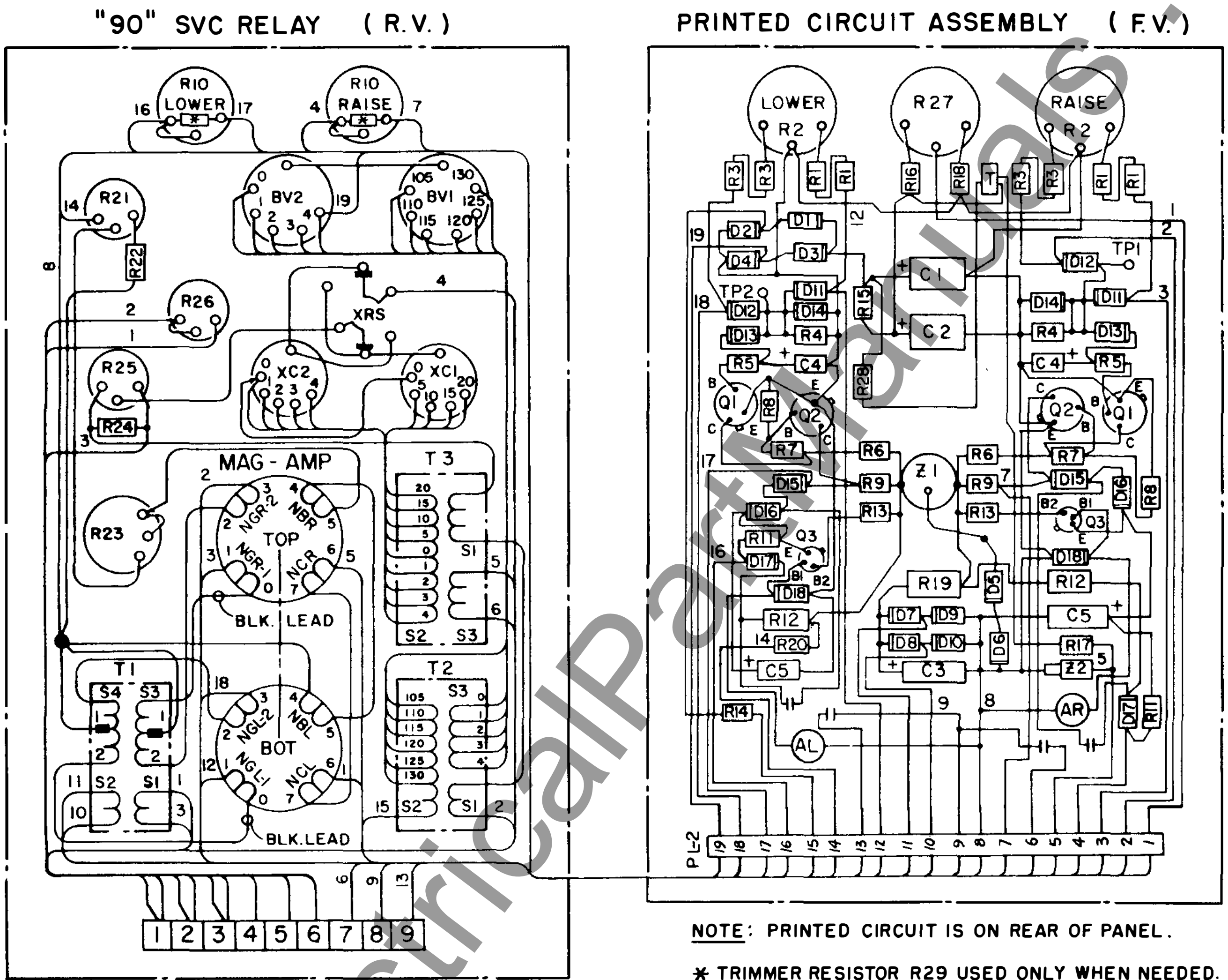


Fig. 3 Type SVC Relay Wiring Diagram

switches to the blocking state. Capacitor C5 is then charged through rheostat R10. When the voltage on C5 reaches the breakdown voltage of the unijunction transistor Q3, Q3 fires and C5 discharges, energizing the output relay AR. The smaller AR contact seals the AR relay in through resistor R12 and diode D16 while the larger AR contact energizes the tap changer motor control circuit through terminals 8 and 7 to initiate a raise in voltage. The AR relay remains energized until the line voltage returns within the bandwidth. Then there is no longer an output at test point TP1 and transistor Q1 returns to the blocking state. Transistor Q2 then returns to the conducting state, shorting out the RC timing circuit and the AR relay.

A raise in voltage applied to terminals 1 and 3 beyond the bandwidth setting would initiate a similar sequence of operations to lower the voltage.

Now, assume that the applied voltage goes up to 122 volts but, returns within the bandwidth before firing the unijunction transistor Q3 and operating relay AL. The voltage going to 122 volts gives an output at test point TP2 causing capacitor C5 to begin charging. When the voltage returns within the bandwidth, transistor Q2 returns to the conducting state and C5 is discharged through resistor R11 and rheostat R10. This provides the same time constant for charging and discharging the timing circuit, or an integrating time delay.

The complete wiring diagram showing the approximate location of the circuit elements and the details of the wiring is given in figure 3.

Reactance Reversing Switch. For normal line drop compensation the Reactance Switch (XRS) on the SVC panel is left in the "DIRECT" position. Reversed reactance compensation is obtained by placing it in the "REVERSE" position, which reverses the polarity of the reactance element.

"Reverse reactance" compensation is a method used to reduce the circulating current that might flow when two or more transformers are paralleled. It is a requirement of ASA Standards C57.12-37.236.1. Instead of running toward opposite extreme positions, tap changers having "reverse reactance" compensation tend to move toward whatever positions cause the least amount of circulating current to flow. This is accomplished at some sacrifice of normal line drop compensation, but is generally satisfactory when units paralleled are not located in close proximity to each other, or where the supply is from different sources.

Line Drop Compensator Settings. The final settings for the line drop compensator may be made most satisfactorily by field adjustment. Initial settings may be determined from line data by using the curves in figures 4 and 5 together with the following expressions.

Let

d = miles from unit to load center

I_p = main current transformer primary current rating

Ec = control voltage

E_p = potential transformer primary voltage

r = resistance per conductor from unit to load center, in ohms per mile

x = inductive reactance per conductor from unit to load center, in ohms per mile

R = resistance dial setting

X = reactance dial setting

For a single-phase, two-wire circuit:

$$R = \frac{2\, r\, d\, I_p\, E_c}{E_p}$$

$$X = \frac{2\, x\, d\, I_p\, E_c}{E_p}$$

For a three-phase unit or for each single-phase unit of a three-phase wye connection:

$$R = \frac{r\, d\, I_p\, E_c}{E_p}$$

$$X = \frac{x\, d\, I_p\, E_c}{E_p}$$

For a three-phase unit with a line-to-line potential transformer and two cross-connected current transformers on a three-phase connection:

$$R = \frac{\sqrt{3}\, r\, d\, I_p\, E_c}{E_p}$$

$$X = \frac{\sqrt{3}\, x\, d\, I_p\, E_c}{E_p}$$

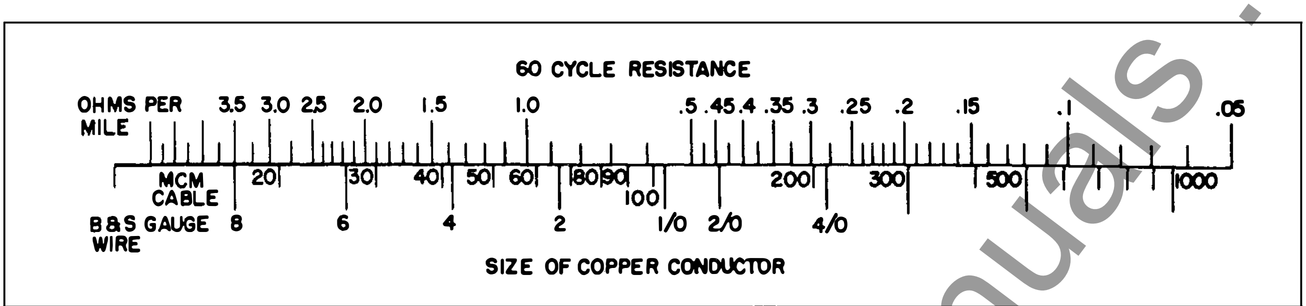


Fig. 4 Resistance Chart Showing Ohms per Conductor per Mile 60 Cycle Circuit at 25°C

ADJUSTMENT

The proper adjustments to insure correct operation of this relay have been made at the factory and should not need readjustment after receipt by the customer (with the exception of control settings). If it is desired to check the adjustment at regular maintenance or following field repairs the following instructions should be followed:

NOTE: If it is impossible to obtain the following values, this is an indication of defective components and the relay should be returned to the factory for repair.

1. Set controls on front panel as follows:

   a. Both time delay knobs on "TEST"

   b. Coarse balance voltage knob on "120"

   c. Fine balance voltage knob on "O"

   d. Turn bandwidth voltage knob fully counter-clockwise. The pointer should be opposite the dot just beyond end of scale; if not, adjust knob on its shaft.

   e. Reactance switch on "DIRECT"

   f. Test rheostat on "OFF"

   g. All three line drop compensator knobs on "O"

2. Refer to schematic and detail wiring diagrams, figures 2 and 3, to identify and locate components and test points referenced in the following. Relay should be energized for at least 30 minutes before making adjustments.

3. At disconnect type terminal block (PL2) at bottom of printed circuit board, disconnect wire from point 5 and insert a microammeter having a 50ua scale.

4. Voltage Balance Point Adjustment

   a. Apply a voltage slightly in excess of 123 volts to relay terminals 1 - 3.

   b. Using an expanded scale voltmeter to read the voltage on terminals 2 and 3, turn test rheostat knob clockwise until voltmeter reads exactly 120 volts.

   c. Adjust rheostat R27 at top center of printed circuit board until microammeter reads 0 ± 10ua.

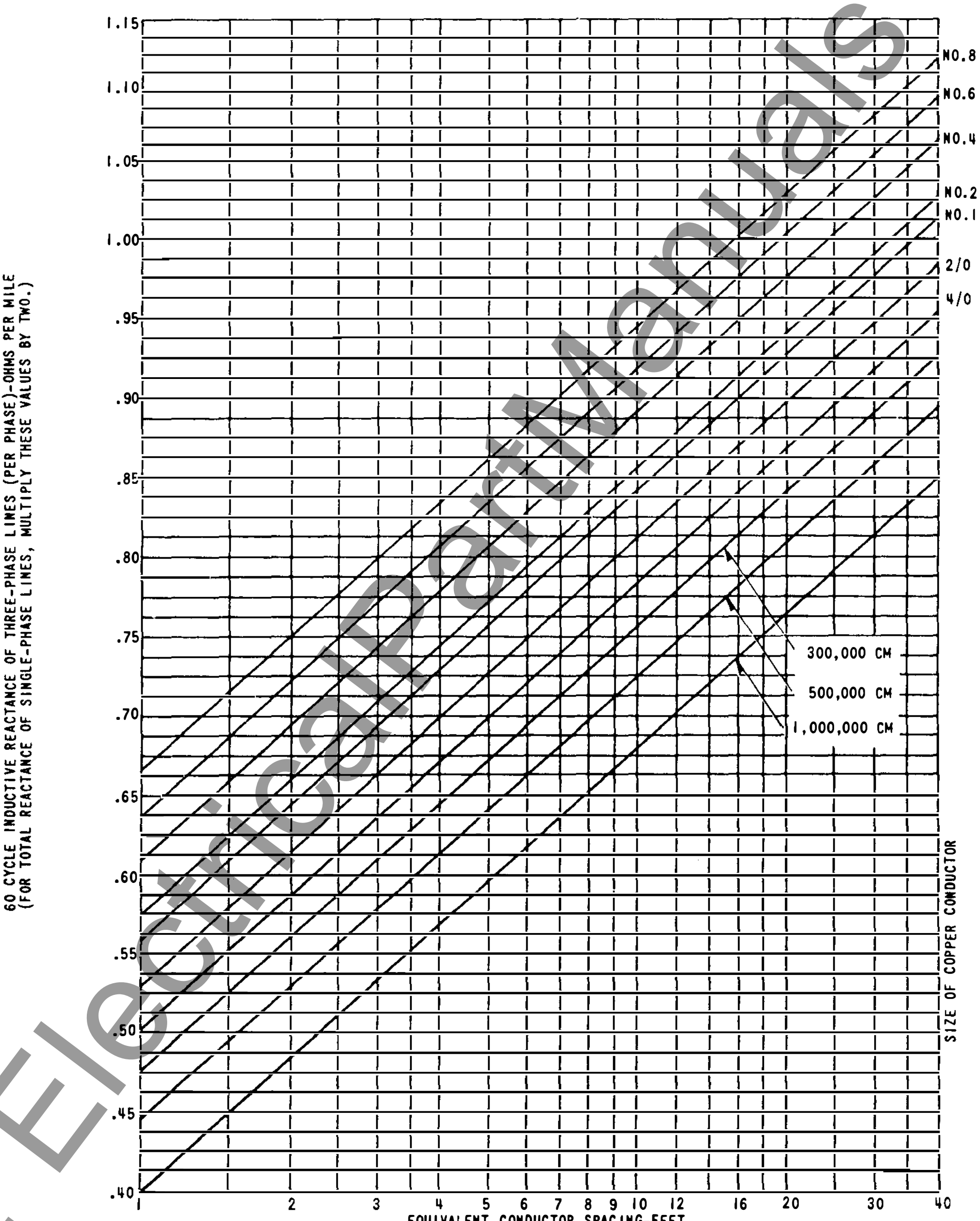
5. Bandwidth Adjustment

   a. Turn R23 (on back of SVC main panel, just below resistance compensation) to its maximum clockwise travel.

   b. Turn test rheostat clockwise (lowering voltage on voltmeter) until the microammeter reads 50ua with positive terminal of meter connected to terminal 5.

   c. Adjust raise R2 (upper right corner of printed circuit board) so that relay AR just operates.

   d. Reverse the microammeter connections and turn test rheostat counter-



EQUIVALENT CONDUCTOR SPACING, D, OF UNSYMMETRICAL THREE PHASE LINES IS GIVEN BY THE EXPRESSION $D = \sqrt[3]{D_{AB} \times D_{BC} \times D_{CA}}$, WHERE

D_{AB}, D_{BC}, AND D_{CA} ARE THE DISTANCES IN FEET BETWEEN CONDUCTORS DESIGNATED BY THE SUBSCRIPTS.

NOTE:- WHERE $D_{CA} = 2\, D_{AB} = 2\, D_{BC}$; $D = 1.26\, D_{AB}$

Fig. 5 Reactance in Ohms per Conductor per Mile Versus Spacing for Single Phase or 3 Phase Lines clockwise (raising voltage on voltmeter) until the microammeter reads 50ua.

e. Adjust lower R2 (upper left corner of printed circuit board) so that relay AL just operates. This completes the initial setting of the R2 potentiometers.

f. Remove the microammeter, and reconnect the wiring to terminal 5 of PL2.

g. Set bandwidth voltage knob clockwise until index mark on the knob points to the intersection of the 6 volt bandwidth line and the 120 volt arc. Turn the test rheostat until the voltmeter connected to terminals 2 and 3 reads 123 volts. Turn R23 fully counter-clockwise and then gradually clockwise until relay AL just operates. Tighten locknut on R23.

h. Check by turning test rheostat clockwise to lower voltage on 2 and 3 until relay AR just operates. This should be 117 ± 0.1 volts. If necessary, readjust the raise R2 slightly.

i. To make the final setting of the R2 potentiometers, set bandwidth voltage knob to 1 volt on the 120 volt arc, and check for operation of AR at 119.5 ± .1 volts and operation of AL at 120.5 ± .1 volts. Lock both R2's.

6. <u>Check Time Delay Calibration</u>

a. Adjust test rheostat so that the voltmeter reads 120 volts. (All knobs remaining as in paragraph 5 i above).

b. Turn both time delay knobs to 30 seconds.

c. Move test rheostat suddenly to raise voltage to at least 122 volts. AL relay should operate after a time delay of not less than 25 seconds nor more than 35 seconds.

d. Move test rheostat suddenly to lower voltage to 118 volts or less. AR relay should operate after a time delay of 25 to 35 seconds.

7. <u>Check Balance Voltage Knob Calibrations</u>

a. Return time delay knobs to "TEST"

b. For any combination of balance voltage and bandwidth voltage knob settings with all line drop compensator knobs set on zero, the "effective balance voltage" is defined as:

Effective balance voltage = 1/2 [(Voltage 2-3 to operate AL) + (Voltage 2-3 to operate AR)]

If the voltage balance knobs are correctly calibrated, the "Effective balance voltage" should be within ± 1 volt of the balance voltage knob settings.

This may be checked at any desired point of the dials by adjusting the knobs to that point, raising and lowering the voltage 2-3 by the test rheostat and/or external voltage adjustments, and noting the voltages, measured on 2-3, at which AR and AL operate.

8. <u>Check Line-Drop Compensator Calibration.</u>

NOTE: This check requires current and voltage sources of known and adjustable phase relationships. (A slight error in phase angle will appreciably affect these tests).

a. Turn time delay knobs to "TEST". Turn test rheostat to "OFF". Set balance voltage knob at 120 volts and bandwidth at 2 volts. Raise variable voltage and note voltage on terminals 2-3 when AL picks up. This will be approximately 121 volts.

b. Connect the current source to terminals 4-3 with its reference polarity on terminal 4.

c. Set the resistance knob, R, on 12. Supply 0.2 amperes from the current source with the current entering terminal 4 in phase with the voltage on terminal 1. Increase the magnitude of voltage 1-3 and note the voltage 2-3 when AL picks up. This should be 12 ± 1 volt higher than measured in part a, or 132 to 134 volts.

d. Return the resistance knob to 0. Turn the reactance knobs to 12 (that is 10 + 2). Adjust the phases so that the 0.2 ampere current entering terminal 4 is 90° lagging the voltage on terminal 1. The AL relay should again pick up at 12 ± 1 volt from the value of part a, or 132 to 134 volts.

e. Turn the reactance switch to "REVERSE" lower the voltage until AL opens, then raise gradually and note when AL picks up. This should be 12 ± 1 volt below part a, or 108 to 110 volts.

f. Move the current supply from terminals 4-3 to terminals 6-5, with polarity on 6. With 90° lag current of 0.2 amperes, in terminal 6, the relay should balance when the voltage is raised so that the voltmeter reading is between 142 and 146 volts. (This should be practically independent of either X or R knob settings).

MAINTENANCE

The type SVC relay requires a minimum of maintenance since it is made up primarily of static devices.

The only moving parts are the AR and AL relays. These are lightly loaded and are selected for long life. Whenever the tap changer is inspected, however, the contacts of these relays should be checked and cleaned if necessary with a fine contact file or burnishing tool.

The remaining parts of the relay require servicing only in case the relay malfunctions.

Any type of intermittent malfunction is probably due to a loose connection. Unless this can be found by visual inspection and easily corrected, it is recommended that the complete relay be returned to the factory for repair.

In case of consistent malfunction, the relay adjustments should first be checked as described under "ADJUSTMENT", page 6. As stated in that section, if the specified adjustments cannot be obtained, it is recommended that the relay be returned to the factory for repair. The following test values, intended for use only under laboratory conditions, are given for reference, and for assistance in locating the trouble, when repairs are to be attempted in the field.

Make set-up as described in section 1 under "ADJUSTMENT". Measure voltages between the points as listed below. The points may be identified by reference to figures 2 and 3. In the case of DC measurements, the positive point is given first:

a. <u>To check power supply:</u>

(PL-2-11) to (PL-2-10) ≅ 46 volts, 60 cycles

(Junction C3-D8-D7-R19) to (PL-2-8) ≅ 53 volts, DC

(Junction Z1-R19-R6 etc.) to (PL-2-8) = 30 ± 1.5 volts, DC

b. <u>To check sensing circuit:</u>

(PL-2-15) to (PL-2-19) ≅ 25 volts, 60 cycles

(Junction C1-R15-etc.) to (PL-2-8) ≅ 18.6 volts DC

(Junction C2 - R15 - etc.) to (PL - 2 -8) ≅ 15 volts DC

(PL-2-5) to (PL-2-8) = 11.7 ± 0.5 volts DC

c. To check the Mag Amp:

(Junction S3 of T1-0 of NGR-1) to (PL-2-8) ≅ 14 volts AC peak

(Junction S4 of T1-2 of NGR-2) to (PL-2-8) ≅ 14 volts AC peak

(Q1 collector) to (PL-2-8) ≅ 8.5 volts when Q1 is off

(Q1 collector) to (PL-2-8) < 1 volt when Q1 is on

(Q2 collector) to (PL-2-8) < 1 volt when Q2 is on

(Q2 collector) to (PL-2-8) ≈ charge with time delay to approx. 18 volts to pick up relay.

AR and AL coils ≅ 2 volts when relay is dropped out

AR and AL coils ≅ 15 volts when relay is picked up

RENEWAL PARTS

Renewal parts for field installation where adequate facilities are available may be ordered from the nearest Westinghouse Sales Office by giving the serial number, type, and S. O. or style number from the transformer nameplate and the part identification shown in figure 3 of this instruction book. In the special case of ordering replacement Mag-Amps or replacement printed circuit boards, follow the special instructions given in figure 6.

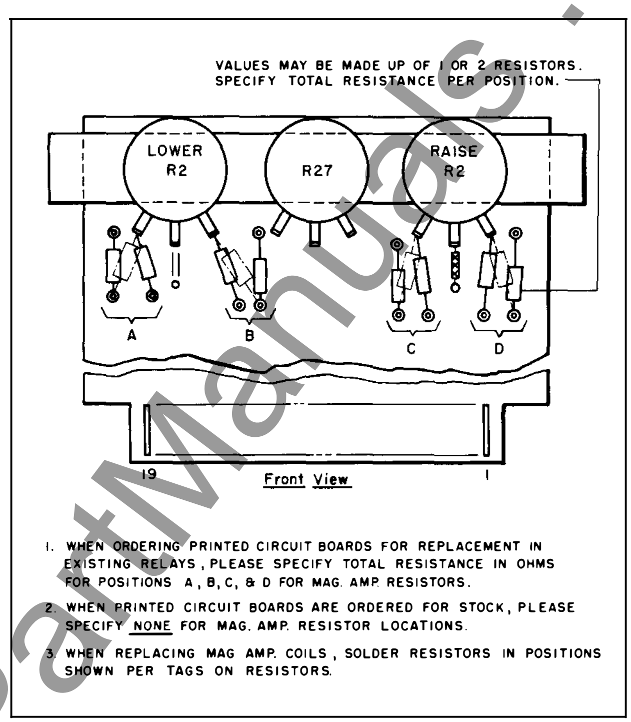


Fig. 6 Type SVC Relay - Magnetic Amplifier Resistor Location