Instructions for Type SVR Voltage Regulating Relay

Westinghouse Electric Corporation

Medium Power Transformer Division, Sharon, Pa.
I. L. 47-065-20A Effective November 1978 Supersedes I. L. 47-065-20, February 1976

Contents

Illustrations

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 his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

Fig. 1 Type SVR Voltage Regulating Relay (Front View)

The Type SVR Voltage Regulating Relay (Figure 1) is a precision factory calibrated control package designed to control load tap changers (LTC). It performs the functions of voltage sensing, line drop compensation, and time delay with static devices. Terminals are available for applying circulating current for parallel operation of transformers, for remote control of voltage reduction (brownout), for operation of the time delay in the non-sequential mode, and for a backup relay responding to load center voltage.

DESCRIPTION:

Characteristics (see Table I, page 2)

All settings are made from the front of the relay by means of marked dials and knobs or switches. The Balance Voltage, Bandwidth and Timer knobs are continuously adjustable and have a locking tab to hold the adjustment in place. All other knobs are on snap type switches which cannot be moved off position accidently.

General Description: The major structural part of the relay is the mounting panel. On the front side are located the calibrated dials with control knobs for setting the desired balance voltage (BV), bandwidth (BW), time delay (T) as well as resistance (R) and reactance (X) line drop compensation (LDC). In addition, raise and lower operation indicating lights signify when the sensing voltage is outside the dead band. A Direct-Test-Reverse switch permits reversing the reactance compensation as well as inserting a test rheostat for varying the input voltage to the sensing circuit for checking calibration. A compensating current by-pass circuit removes any compensation affect when the switch is in the test position.

On the rear of the mounting panel are located the sensing, compensator and power supply transformers as well as the printed circuit module which contains the electronic sensing circuitry in addition to the relay output terminal strip. The thirteen point terminal strip is used to connect: the input sensing voltage (1 and 3), voltmeter test terminals (2 and 3), LDC input (3 and 4), paralleling input (5 and 6), brownout control (11 and 12), non-sequential timer mode (10 and 11), backup relay (1 and 13), Raise relay (7 and 8) and Lower relay (8 and 9). The terminal numbers are identified on the relay and correspond to those shown on the internal schematic, Figure 11.

The panel cutout and drilling plan is shown in Figure 6.

Circuit Description: The circuit can best be described by referring to simplified schematic and internal schematic drawings, Figures 10 and 11. The sensing voltage and power supply

TABLE I. CHARACTERISTICS

Accuracy	ANSI Class 1 (–30°C to +65°C)
Balance Voltage Setting Range	105 to 135 V
Bandwidth Voltage Setting Range	1.0 to 6.0 V
Raise and Lower Time Delay	2 to 120 seconds
Resistance and Reactance Compensation	0 to 24 V at 0.2 A
Paralleling Operation	24 V at 0.2 A
Voltage Reduction Control	0 to 10% (using external resistance).
Dielectric (from terminals to frame)	1500 V 60 Hz (for 1 minute)
Operating Temperature Range	–40°C to +80°C
Reset Time	0.3 seconds maximum
Balance Voltage Calibration Accuracy ± 0.5 V at 25°C.	
Bandwidth Voltage Calibration Accuracy ± 0.25 V at 25°C.	
Timer Accuracy ± 15%	
Reactance Compensation Accuracy ± 0.2 V (below 5 V) ± 1.0 V (5 to 24 V)	
Resistance Compensation Accuracy ± 1.5 V (dial calibration accuracy)	
(Note: resistance compensation is continuously adjustable).	
Parallel Current Circuit Accuracy ± 2 V at 0.2 A input	
Voltage Circuit Rating	160 V maximum at 25°C
Current Circuits Rating	0.32 A maximum continuous 0.64 A maximum for 2 hours
Contact Rating	3 A at 120 V inductive
Voltage Circuit Burden	6 VA at 120 V 60 Hz
Current Circuit Burden	7.6 VA at 0.2 A 60 Hz

circuitry are both connected to terminal 1 and 3.

The power supply is a dual output type (± 15 V dc) and consists of transformer T1 with center tapped secondary feeding two full wave rectifiers. The output of the rectifiers supply a highly stable regulated power supply consisting of integrated circuit operational amplifiers IC-5 and IC-6 along with NPN transistors Q8 and Q9 and PNP transistors Q2 and Q3 as well as filter capacitors C3, C5, C9 and C10. A reference zener Z6 with a low temperature coefficient maintains a constant output voltage in conjunction with trimpot PS. This trimpot is used to set the output voltage for ±15V dc at the factory.

The secondary of the sensing transformer (T2) is connected to a precision full wave rectifier consisting of a dual op-amp IC-1. A capacitor C2, resistor R25 and trimpot P1 constitute a single-pole low pass filter performing an averaging function. The trimpot P1 is factory adjusted for + 7.5 ± 0.25 V dc at test point TP1 with 120 V ac input to the relay. Zener diodes Z1 thru Z4 provide overvoltage protection.

A reference voltage is generated at test point TP3 by means of op-amp IC-3 and the negative regulated power supply. The P2 trimpot is factory adjusted with the balance voltage knob set at 120 and 120 V ac sensing voltage applied for minimum output voltage at TP2. The bandwidth knob is set fully CW for this condition.

Op-amp IC-2 in conjunction with the bandwidth potentiometer knob setting determines the amount of deviation from the balance voltage required to produce an output voltage at test point TP2 to actuate the Raise or Lower op-amps (IC-2 or IC-3). The output voltage can swing negative or positive depending on whether a Raise or Lower operation is required.

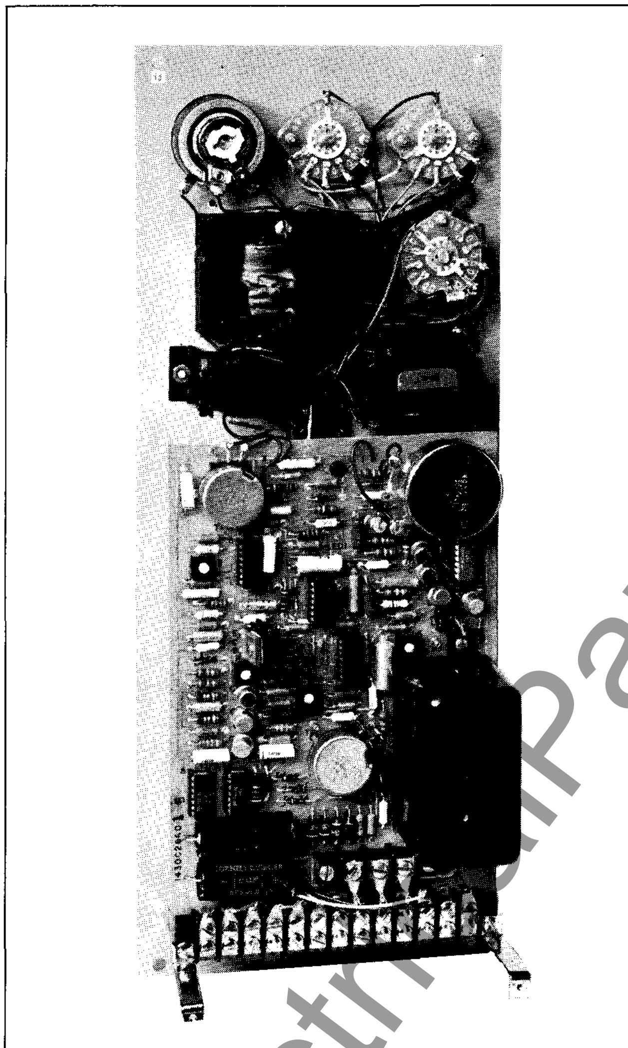


Fig. 2 Type SVR Voltage Regulating Relay (Rear View)

The Raise and Lower op-amp outputs operate the indicator light emitter diodes (LED) as well as actuating the timer circuit and flip-flop (IC4) and the output Nand gates (also IC4). Output resistors R11 and R26 feedback to the bandwidth amplifier to provide a small hysterisis of 0.2 Vac or less.

The Timer circuit is of the single shot multivibrator type incorporating a programmable (PUT) unijunction transistor. Trimpot P3 has been factory adjusted so that the time delay tracks with the Timer Knob setting. The timer is of the "integrating type" which is desirable when the input sensing voltage is fluctuating in and out of the band edge. The timer circuit output consists of a single pulse which switches the output of the flip-flop (IC-4) from approximately zero volts to almost 15 V dc.

The change in the output state of the flip-flop is sensed by the Raise and Lower output Nand gates. Depending on whether a raise or lower signal is also present will determine whether transistor Q4 and Q1 is switched into the conducting state. As a result either the AR or AL auxiliary relay will be energized. Transistor Q1 and Q4 also provide a signal to turn-on the timer capacitor discharge transistor Q12.

If we assume the sensing voltage input is within the deadband (for example 120.5V with the balance voltage setting at 120V and the bandwidth set at 2V) then the voltage out of the bandwidth op-amp (terminal 10 of IC-2) connected to terminal 1 of IC-2 and terminal 2

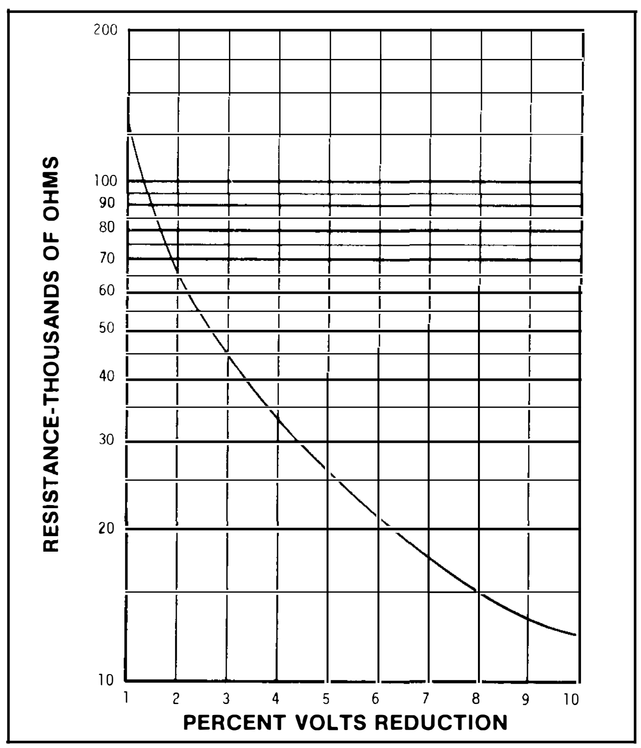


Fig. 3 Percent Balance Voltage Reduction vs Shunt Resistance

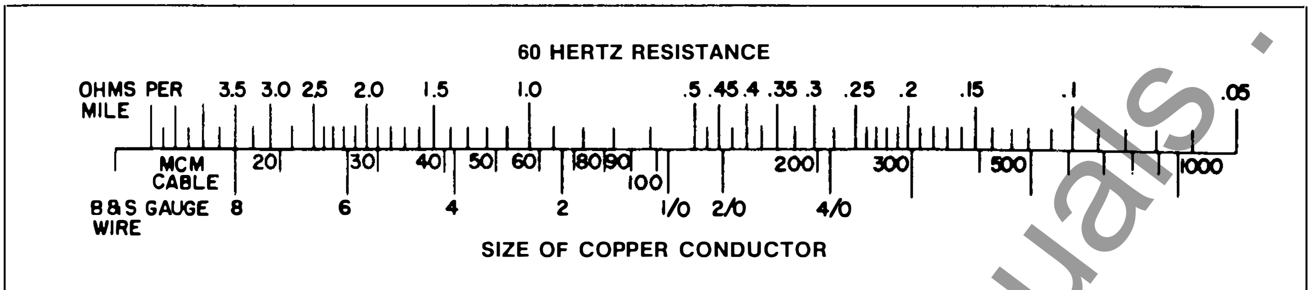


Fig. 4 Resistance Chart Showing Ohms per Conductor per Mile 60 Hertz Circuit at 25°C

of IC-3 will be below the reference voltages connected to terminal 2 of IC-2 and terminal 1 of IC-3. The voltage appearing at terminal 12 of IC-2 and IC-3 will be negative under this condition which designates a non-operate condition.

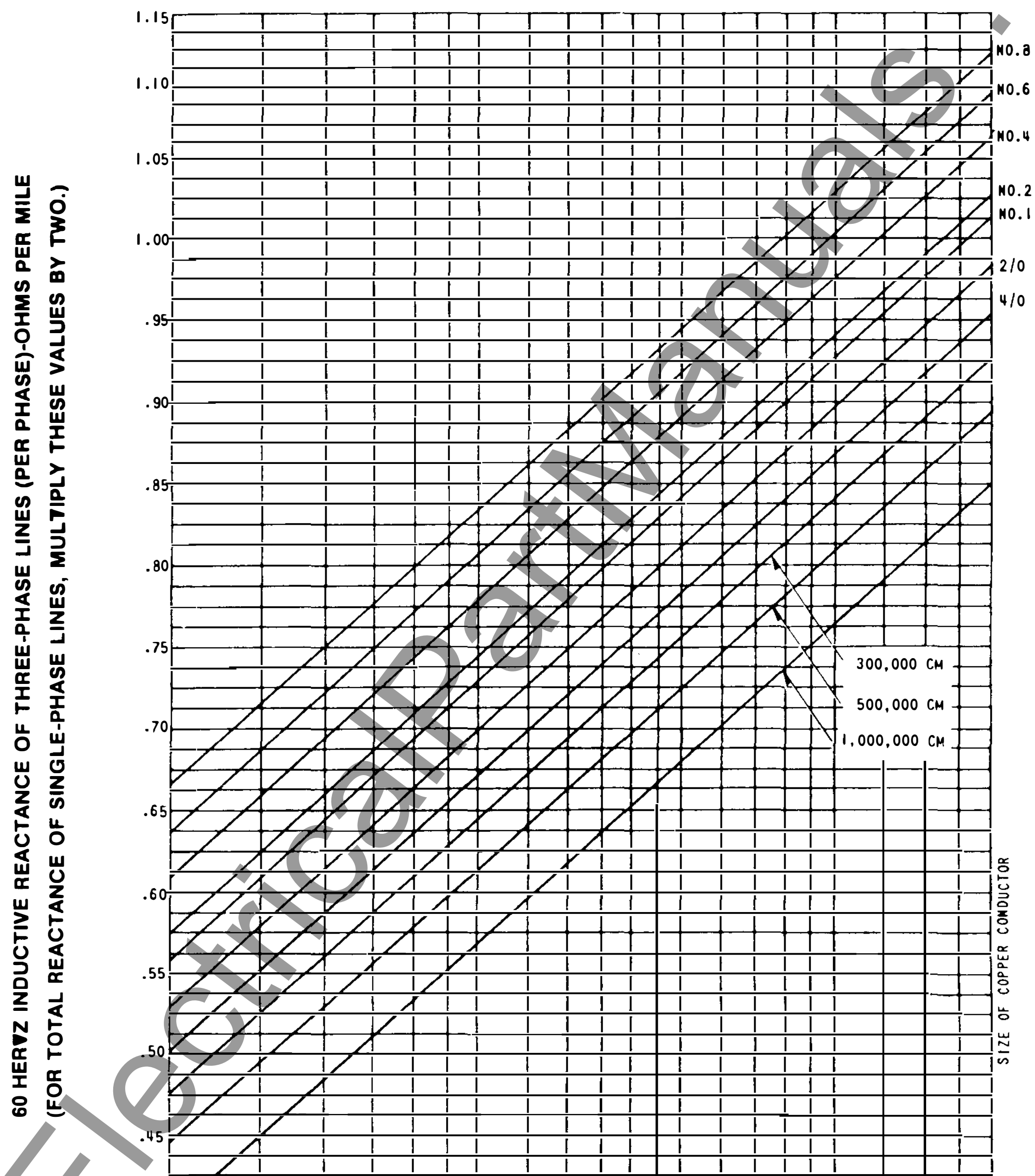
When the sensing voltage input is outside the deadband (either 118.5V or 121.5V with the above relay settings, for example) then the output out of terminal 10 of IC-2 will exceed one or the other of the reference voltage aforementioned (depending on whether the sensing voltage is low or high). As a result, terminal 12 of either IC-2 or IC-3 will go positive to turn on either the Raise or Lower LED light as well as start the timer. In addition, this positive voltage is also applied to either terminal 9 or 13 of IC-4 Nand gate and also terminal 5 of IC-4 for the flip-flop. The timer is started by transistor Q5 turning on and Q7 turning off. This permits the timing capacitor C6 to charge up at a rate determined by the timer pot (T) knob-setting. When the voltage on C6 exceeds the voltage at test point TP7 the unijunction transistor PUT switches on, causing C6 to discharge rapidly through resistor R62. This pulse causes transistor Q6 to momentarily conduct thus causing the flip-flop to change state such that terminal 3 of IC-4 goes from approximately zero to almost +15V dc positive. This voltage is applied to terminal 10 and 12 of IC-4 which will switch the voltage level at terminal 8 or 11 and consequently turn on transistor Q1 or Q4. These transistors control the AR and AL auxiliary relays. This results in an AR or AL contact closure which will operate the tap changer.

When the line drop compensator (LDC) is in use, a voltage proportional to the line current and compensator setting (either reactance or resistance or both) will affect the voltage that appears at the input of the sensing transformer (T2). A reactance reversing switch is provided to take into account leading as well as lagging currents.

A paralleling current input circuit is connected to terminals 5 and 6 to provide compensation when transformers are operated in parallel by the circulating current method. It consists of another primary winding on the reactance transformer.

The voltage reduction control (brownout) is obtained by the user's connecting a 1/2 watt or more resistor externally to terminals 11 and 12. The amount of resistance required to effect a given percent balance voltage reduction is obtained by referring to Figure 3. By connecting an external resistance in this manner, it reduces the reference voltage at test point TP3 and appears to the circuitry as if the balance voltage knob was turned to a lower setting.

By connecting a cam switch to terminals 10 and 11, the user may obtain the non-sequential mode of operation. A momentary closure of the cam switch, while the sensing voltage is outside of the dead band, will reset the flip-flop and the AR or AL contact. A time relay equal to the timer setting will delay the re-energization of the AR or AL relay.



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

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

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 Liner

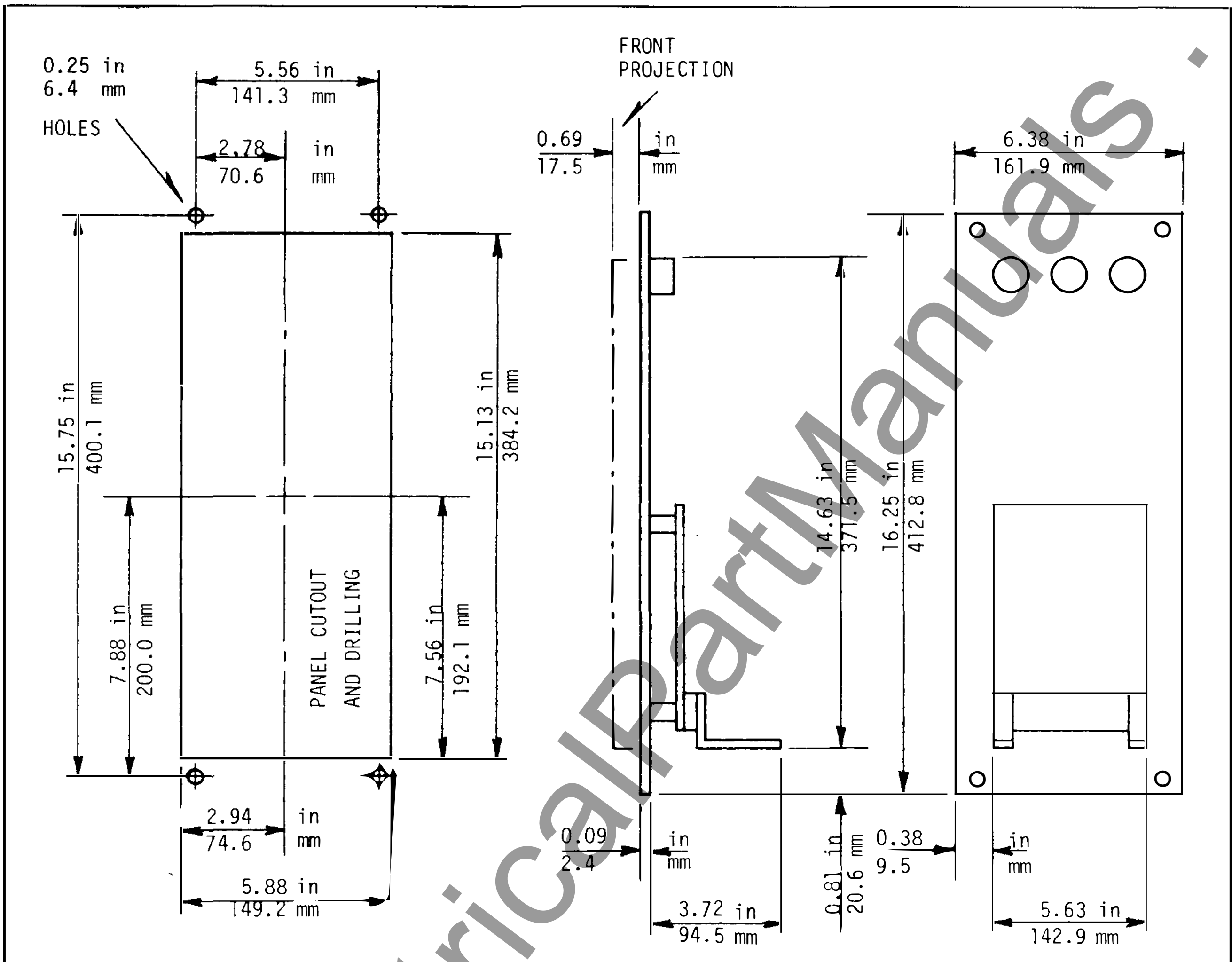


Fig. 6 Outline, Panel Cutout and Drilling for Type SVR Relay

RECEIVING, HANDLING, STORING

When supplied with LTC equipment, the Type SVR Relay will be mounted and connected at the factory. Upon receiving the shipment, the relay should be inspected for shipping damage as part of the general inspection of the complete LTC transformer.

When it is shipped as a separate unit for field installation, the shipping container should be examined for evidence of severe handling and the relay should be examined for shipping damage. If damage is suspected, file a claim with the transportation company and notify the nearest Westinghouse district office.

The Type SVR Relay should be moved and carried using reasonable care to avoid bumping, dropping, or bending and should be held so as to avoid pressure on the printed circuit board components and to avoid accidentally changing the factory adjustments.

If the relay is stored for future use, it should be kept clean and dry. Temperatures during storage should not exceed 80°C (176°F).

INSTALLATION

The Type SVR Relay is intended for use as a part of the control equipment on load tap changing transformers and regulators. As such, it will generally be installed under one of the following conditions:

1. As part of new LTC equipment.
2. As a replacement.
3. To replace some other type voltage regulating relay.
   a. A direct interchange.
   b. A change requiring panel or wiring modification.

These cases will be discussed separately.

1. When supplied as part of new LTC equipment, no installation is required. The relay will be shipped in place and completely wired. There is no temporary blocking. There is a shorting switch in the line drop compensation circuit that must be opened.
2. To replace an existing Type SVR Relay with a new SVR relay:
   a. Deenergize the potential and motor supply circuits and short the LDC current transformer with the shorting switches.

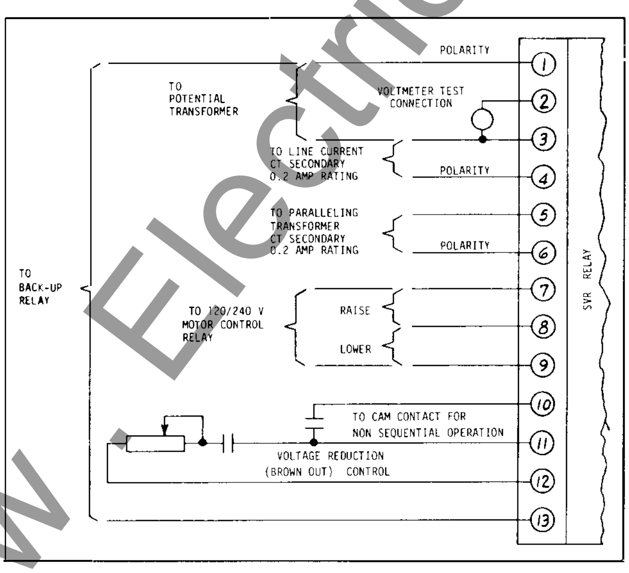


Fig. 7 External Connections for SVR Voltage Regulating Relay

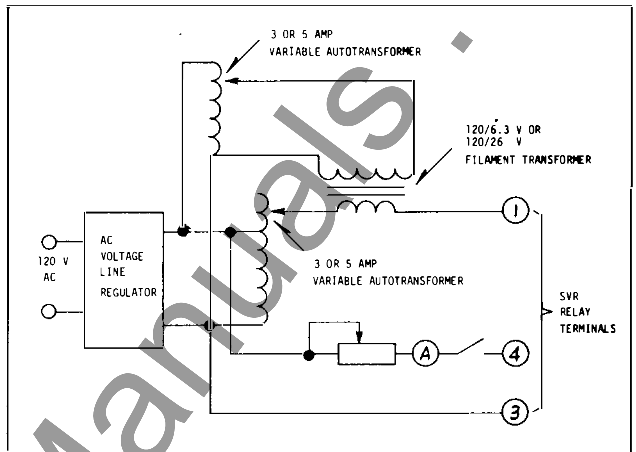


Fig. 8 Typical Test Setup

   b. Disconnect the leads from the terminal block on the back of the panel, noting the lead identification marking on each lead and the terminal point number from which it is removed.
   c. Remove the four mounting screws, one in each corner of the relay front panel and pull the relay forward through the panel.
   d. Push the new relay through the panel cut-out and install and tighten the four mounting screws.
   e. Connect the leads to the terminal block using the connections noted in step a.
3. a. **Condition 3a. is similar to condition 2. Note that the old and new relays may not have the same total number of points on terminal blocks. If only terminals 1 to 9 inclusive were used, connect the leads to the same numbered points on the new relay as they were connected to on the old relay.**
   b. For case 3b., requiring panel and/or wiring changes, Westinghouse will supply a set of conversion drawings showing both the mechanical and electrical changes which must be made.

The Type SVR Relay requires both a voltage supply and a current supply. In most cases, the current supply is an integral part of the LTC transformer and is shown on the transformer

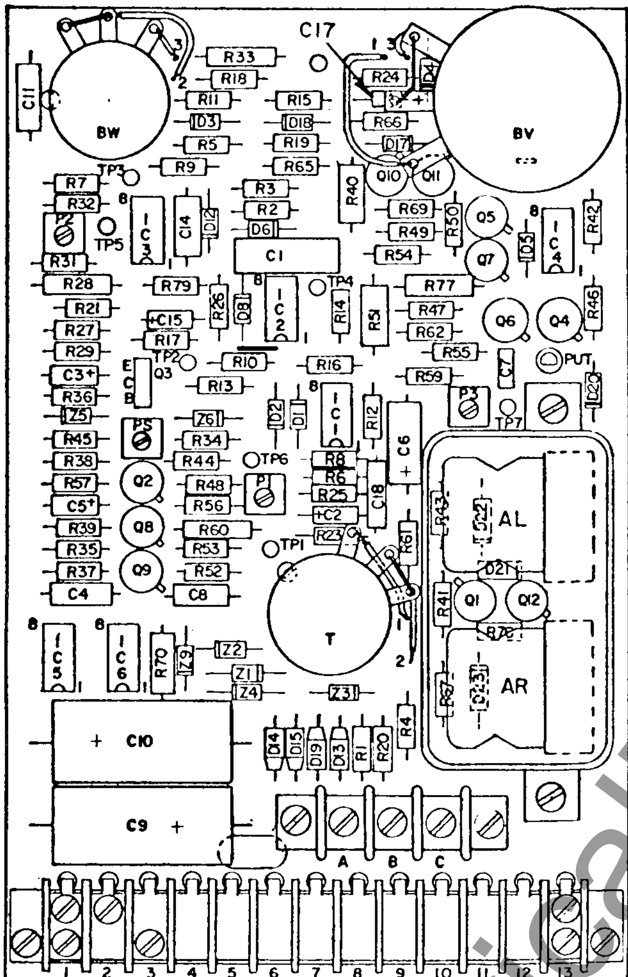


Fig. 9. Type SVR Relay Printed Circuit Component Location.

TABLE II. COMPONENT VALUES

COMPONENT	STYLE	REF.
R1-R13-R20-R54-R79	848A820H16	4.99K 1/4W
R2-R6-R8-R29	848A820H74	20K 1/4W
R3-R21	187A290H26	2.2MEG 1/2W
R4-R23-R65-R66	848A820H62	15K 1/4W
R26-R11	187A290H36	22MEG 1/2W
R5-R17-R27	848A819H81	2.21K 1/4W
R7-R15	848A20H14	4.75K 1/4W
R10-R12-R16-R48-R56-R59-R9-R77	848A820H45	10K 1/4W
R14	862A376H73	5.62K 1/2W
R18	848A821H26	68.1K 1/4W
R24-R67-R19-R47	184A763H58	20K 1/2W
R25	848A20H83	24.9K 1/4W
R28	862A376H25	1.78K 1/2W
R31-R35-R52-R55	848A820H17	5.11K 1/4W
R32	848A819H94	3.01K 1/4W
R33	862A376H88	8.06K 1/2W
R34	848A819H98	3.32K 1/4W
R36	848A819H85	2.43K 1/4W
R37-R53	184A763H21	560 OHMS 1/2W
R39-R57	187A290H31	2.7 OHMS 1/2W
R40-R51	184A636H15	1.5K 3W
R42-R43	184A763H38	3K 1/2W
R44	848A819H44	909 OHMS 1/4W
R45	184A763H34	2K 1/2W
R38-R41-R46	184A763H27	1K 1/2W
R49-R50-R69-R76	184A763H51	10K 1/2W
R60	862A376H01	1K 1/2W
R61	184A763H03	100 OHMS 1/2W
R62	184A763H10	200 OHMS 1/2W
R70	187A643H19	470 OHMS 1W
P1-P3	3502A17H01	5K
P2	3502A17H02	100 OHMS
PS	3502A17H03	2K
BV	184A756H05	5K
T	763A560H18	1 MEG
BW	763A560H19	500K
R80	848A820H27	6.49K 1/4W
C1	188A669H05	.27 MFD
C2	837A241H15	1.0 MFD
C3-C5	187A508H09	1.5 MFD
C4-C8-C11-C14	188A669H03	.1 MFD
C6	184A661H19	100 MFD
C7	763A209H07	20 MMF
C9-C10	837A234H10	250 MFD
C15	184A661H21	6.8 MFD
C16	188A669H01	.47 MFD
C17	837A241H03	.27 MFD
C18	188A669H16	.047 MFD
D1-D2-D4-D5-D6-D8-D22-D23	836A928H06	1N4148
D3-D12-D17-D18-D20-D21	184A855H08	1N459A
D13-D14-D15-D19	188A342H06	1N4818
Z1-Z2-Z3-Z4	186A797H08	1N965B
Z5	186A797H12	1N752A
Z6	837A398H16	1N3157
Z9	185A212H12	1N4749A
LED1-LED2	879A774H02	MV5023
Q1-Q4-Q8-Q9	762A672H10	2N2905A
Q2-Q5-Q6-Q7-Q10-Q11-Q12	762A585H08	2N1711
Q3	3502A22H01	MJE205
PUT	878A289H01	2N6027
AR-AL	408C783H06	RELAY
1C1-1C2-1C3	1443C52H01	CA 747E
1C4	6296D53H05	MC668L
1C5-1C6	6277D61H08	RC741DP
TRANSFORMERS		
T1	3502A31H01	POWER SUPPLY
T2	1423C85G01	SENSING
T3	644B140G01	COMPENSATOR
SWITCH		
S1	3502A30H01	
S2-S3	763A934H01	
POTENTIOMETER		
TR	3502A18H01	10K
RC	17D3532H03	125 OHMS
THERMISTOR		
TH	185A915H07	10K

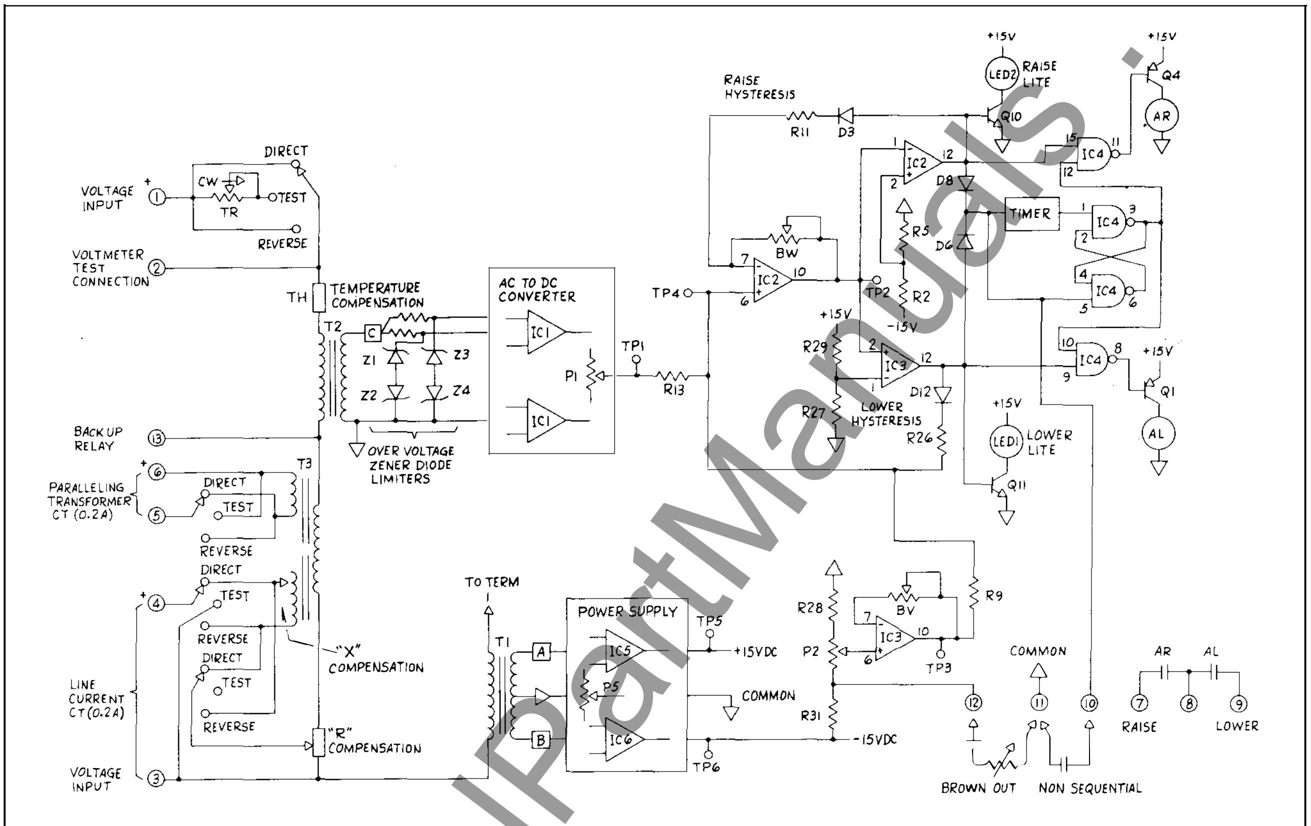


Fig.10. Simplified Schematic of SVR Relay

instruction plate. (If there is a current transformer shorting device, 17, on the control panel, make sure that it is open for operation. Otherwise, there will be no line drop compensation.) The voltage supply must be on the load side of the transformer, must provide voltages within the 105 to 135V adjustment range of the Type SVR Relay, and must be in phase with the current supply at unity power factor load.

CAUTION: Ground and add arresters as necessary so that transient voltages do not exceed the test values of the relay, including on the grounded conductor to terminal 3. These tests are a hipot, to all terminals from ground, of 1500 V 60 Hz for 1 minute and a Surge-Withstand Capability test of 2500 V 1 MHz 6 microsecond "rings" repeated at 50-60 Hz rate for 2 seconds. If the voltage exceeds these values, the relay may be damaged.

The relay should be mounted on a panel in a location free from dirt, moisture, excessive vibration, and heat. See outline and drilling plan, Figure 6 for hole size and location.

A 13 terminal connector strip mounted on the rear of the relay is used to make the various connections to the relay. These are identified elsewhere.

CAUTION: In general, the tapchanger motor must be operated from a different transformer than that used to measure potential. If this is not done, hunting at the upper band edge may result. As soon as the motor starts and before it is sealed in, the motor current can cause the voltage to drop within the band and the control to reset.

OPERATING INSTRUCTIONS

The relays are accurately calibrated at the factory, so no instrumentation is necessary for setting the dials on the front of the relay.

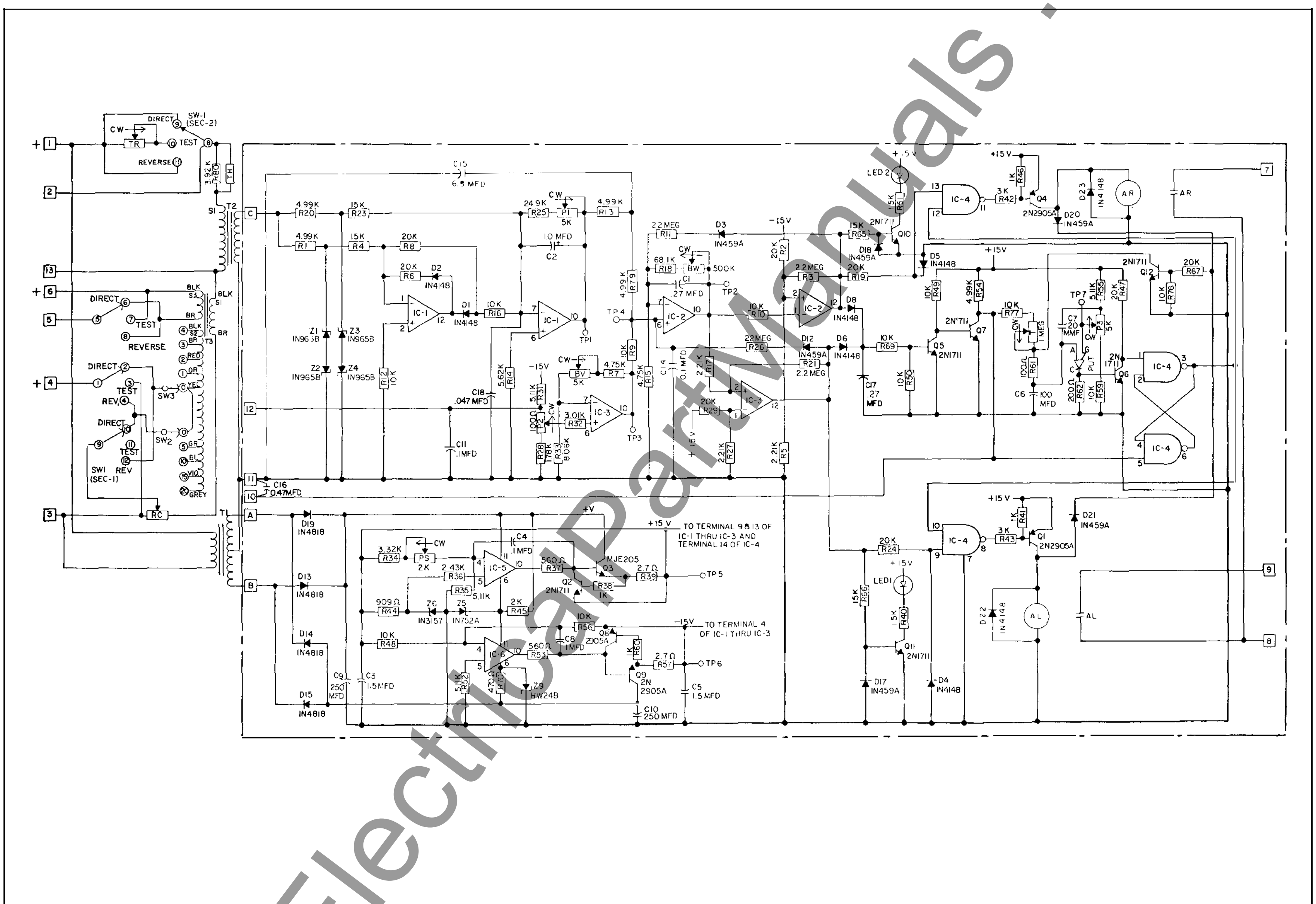


Fig. 11. Type SVR Relay Schematic Diagram

The final settings may be made most satisfactorily by field experience and adjustment. The following instructions give suggested initial or trial setting for cases where there is no history of experience at this or similar locations on the power system. Since nearly every installation has its own set of supply and load characteristics, it is recommended that, when automatic control is started, critical voltage points on the system be temporarily monitored during times of load and/or system changes and the settings modified as required. A few days experience will generally result in satisfactory final settings.

Balance Voltage

Let P = Potential transformer ratio

Let E_L = Operating voltage of the line

Let E_B = Trial setting of balance voltage dial

$E_B = E_L/P$ (115, 120, 125 are common settings)

Band Width

Let S = Per cent voltage change for one step operation of the load tap changer.

Let BW = Trial setting of band width dial.

$BW = E_B \times 2S/100$ (2 is a common setting).

Time Delay

Suggested trial setting = 30 seconds

Line Drop Compensation: To have the transformer output voltage held constant, set both R and X on zero.

To have the transformer output voltage vary so that the distant load voltage remains constant:

Let P = Potential transformer ratio

Let I_P = Main current transformer primary current rating (For a multi-ratio current transformer, use the rating for which it is connected).

Let d = Length of line, miles, for which line drop compensation is required.

Let r = Resistance per conductor, ohms per mile (from Figure 4)

Let x = Inductive reactance per conductor, ohms per mile (from Figure 5)

Let R = Trial setting of resistance dial

Let X = Trial setting of reactance dial

For a three-phase unit with line-to-neutral potential transformers or for each single-phase unit of a three-phase wye connection:

$$R = \frac{r\ d\ Ip}{P}$$

$$X = \frac{x\ d\ Ip}{P}$$

For a single-phase, two wire line, double the above values of R and X.

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

$$R = \frac{\sqrt{3}\ r\ d\ Ip}{P}$$

$$X = \frac{\sqrt{3}\ x\ d\ Ip}{P}$$

For multiple similar and equally loaded feeders, divide the values of R and X for a three phase unit with line-to-neutral potential transformers by the number of feeders.

NOTE: When current transformers on two lines are cross connected for proper phase relation to line-to-line potential, the tap connection on the ACT transformer (see unit wiring diagram) should be connected to U3 instead of U2, that is for 8.66 amperes instead of 5 amperes.

The reactance line drop compensation may be set in 1 volt increments from 0 to 24 volts. It is the sum of the coarse and fine dial settings. The resistance line drop compensation may be set at any value from 0 to 24 volts. The dial is marked in two volt increments.

Reactance Reversing Switch: The reactance reversing switch should always be on "DIRECT" except when two or more LTC transformers are being paralleled by the reverse reactance method, or when single phase units are being used in open delta on a three wire line by the Wagner method.

"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 ANSI Standards C57.12.30. 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. However, it is generally satisfactory and does allow paralleling transformers that are so far apart that other methods of paralleling are not feasible.

Generalized Effects

While the settings are independent within the Type SVR Relay itself, they mutually react on the system. The following generalized effects may be helpful in changing trial settings to final settings.

Increasing the balance voltage setting increases the voltage level of the entire line at all times.

Increasing the R setting with high power factor loads or the X setting with low power factor loads increases the voltage level of the entire line at times of heavy load with little change in voltage level at light load.

Increasing band width and increasing time delay both tend to reduce the number of tap changer operations. To reduce excessive number of operations resulting from relatively small and smooth voltage changes, increase band width. To reduce excessive number of operations from irregular or spike type short time voltages, increase time delay.

Economically, increased balance voltage tends to increase revenue from the line. Reduced band width tends to increase maximum load which can be connected to the line.

Adjustment Check: The proper adjustments for 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 the control settings). If it is desired to check the adjustment at regular maintenance with the relay on the tap changer control panel and the normal potential supply, the following instructions should be followed:

NOTE: While this procedure should not be expected to have the full precision, convenience, and accuracy of a laboratory setup, it will permit identifying a defective relay. These tests may also be made by opening the potential supply breaker and connecting a controllable regulated voltage to the test terminals PTT1 to PTT2.

CAUTION: Test terminal PTT2 and relay terminal 3 are connected to the control circuit ground. This ground is not disconnected by the potential supply breaker. If an external supply is used for testing the relay, it must be isolated from ground or connected with proper polarity. Otherwise, damage to equipment or injury to someone may result.

If it is preferred that the LTC does not operate during these tests, set the AUTOMATIC-MANUAL switch to MANUAL. Or if the tap changer control panel has a test switch and light to monitor relay operation during test, turn this switch to TEST.

Connect an ac voltmeter with an impedance of at least 100 ohms per volt to test terminals PTT1 to PTT2.

Set the controls on the SVR front panel as follows:

a. Balance voltage at the setting to be checked, for example, the operating voltage level.
b. Bandwidth at the setting to be checked, except that when checking balance voltage, the narrowest setting, fully CCW, may be more convenient.
c. All three line drop compensation dials maybe left at their operating settings. The Test switch position will short and bypass the current away from the compensator.
d. TIME DELAY at the setting to be checked, except that when checking for output of the relay the shortest time, fully CCW may be more convenient.
e. DIRECT-TEST-REVERSE switch to TEST.

Vary the Test rheostat to change the voltage. Note that the RAISE and LOWER indicating lights come on as the voltage just exceeds the set level ± bandwidth voltage. Note that the relay output is delayed for the time set. When checking the delay, the voltage should be changed from definitely in band to definitely out of band, without hesitation or reversal for the full duration of the delay.

Repair and Recalibration: If the relay is not in working order, it is recommended that the relay be returned to the factory for repair and recalibration. However, if the customer feels he has the capability of making his own repairs he may use the trouble shooting chart as a guide. It should be pointed out that replacement of certain parts may affect the relay calibration. A table of parts is listed elsewhere. A component location, Figure 9, is also shown. Westinghouse takes no responsibility for such repairs. Moreover, improper repairs by a customer will affect the warranty.

All dc voltage measurements as listed are made with respect to common (terminal 11). This is also true of the T1, T2 transformer secondary ac voltages.

The Balance Voltage, Bandwidth and Timer control knobs have a mark on the calibrated dial which should line up with the pointer when in the fully CCW position. This can be used to verify that the knob has not slipped on its shaft and if so the knob may be readjusted by means of the knob set screw. Allow approximately .010" clearance between the bottom of the knob and the relay panel to avoid interference with the knob rotation.

The following procedure may be used to recalibrate the relay if necessary.

1. Set the Direct-Test-Reverse switch to direct. Turn the Timer, Resistance and Reactance Knobs fully CCW. Set the Bandwidth Knob fully CW and set the Balance Voltage Knob to 120 V setting.

2. A source of well regulated sinusoidal ac voltage which can be varied is preferable. If however only voltage from local 120 volts is available it may be possible to obtain satisfactory results. A variable autotransformer should be used as shown in the typical test set up drawing, Figure 8.

Since the Reactance Compensation has no calibration and since a three phase supply is not always readily available it is not shown here. If it were, then a phase shifter would be required to obtain current lagging by 90°.

3. Apply 120 V ac to the sensing voltage terminals (1 and 3). Measure voltage at test point TP5. If it is not +15 V dc, then adjust PS for this

value. Check the voltage at TP6 and observe that it is between -14.7 and -15.3 V dc.

4. Check voltage at TP1 for +7.5 V dc. If different, adjust trimpot P1.

5. Check voltage at TP2 to within ± 20 millivolts dc of zero volts. If not, adjust trimpot P2.

6. Change input voltage to 123 V. Slowly reduce bandwidth, bandwidth pot CCW, until Lower light comes on. Leave knob at that position. Reduce voltage to 120 V and slowly increase voltage until Lower light comes on. If lower than 123 V, rotate knob slightly CW and repeat. If higher than 123 V, rotate knob slightly CCW and repeat. When lower light comes on at 123 V, reduce the input voltage until the Raise light comes on. This should be 117 V. If the knob pointer does not line up with the 6 volt marking on the dial, loosen the knob on its shaft and move the knob accordingly and retighten the set screw.

Now move the knob to the 1 volt position and determine the bandwidth by noting the voltage at which first the Lower light comes on and then the Raise light and subtracting the one from the other. The difference should be 1 volt ac ± 0.1 volt.

If outside this value, it may be necessary to readjust the knob position on its shaft such that the Bandwidth at the 6 volt position is within ±3 V ac and is within ±0.1 V ac at the 1 volt position.

7. If the Time knob does not track with its dial, the knob should be first rotated fully CCW to see that the pointer lines up with the calibration mark. If not, reposition knob on the shaft. Then set the pointer at the 30 mark and check the timing. If it still is off, check to see if the voltage at test point TP7 is 9 ± 1.0 V dc. If not, readjust trimpot P3 for 9 V dc. Recheck timing with the knob at the 30 second position. If the time is too long, reduce the voltage at TP7 by adjusting P3 until timing is within 10% of 30 seconds. If the time is too short, increase the voltage at TP7. This should give ±15% accuracy at the other settings. For closer accuracy, the knob may be moved to the desired position on the time scale and trimpot P3 adjusted accordingly.

8. The Resistance compensation dial setting may be checked by first rotating the knob fully CCW and verifying that the pointer lines up with the calibration check line. If not, readjust the knob on the shaft. Then go to the 12 position and apply 0.2A to terminal 3 and 4, observing correct polarity. Verify that the change in the sensing voltage required to operate the indicator light is 12 ± 1.5 V. If outside these limits, go on to the 24 volt dial marking. The change in sensing voltage required to operate the indicator light should be 24 ± 1.5 V ac. If outside these limits, readjust the knob on the shaft so that the relay operates within these limits.

TABLE III TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	SUGGESTED PROCEDURE
A. No contact closure at terminal 7, 8 and 9 with sensing voltage outside of deadband but raise and lower indicator lights operate properly.	1. Relay contacts may be dirty. 2. Logic gate IC-4 may be damaged. 3. Timer circuit may be damaged.	1. Clean relay load contacts (the larger ones) with a burnishing tool S#182A836H01 or similar. 2. Check that IC-4 output at terminal 3 goes from approx. zero to +15 Vdc. 3. Transistor PUT may be defective if an oscilloscope does not show the collector of Q6 take a momentary dip toward zero when the sensing transformer voltage is changed from inside to outside the dead band. Transistor Q5 or Q7 may be defective. Q5 should be conducting and Q7 non-conducting in the operate mode — (outside of the dead band).
B. Indicator lights operate but only the AR or AL output absent.	1. Relay contact may be dirty. 2. Logic gate IC-4 may be damaged. 3. Relay may be damaged. 4. Q1 or Q4 transistor may be non-conducting in operate mode.	1. Clean contact with burnishing tool. 2. Replace IC-4 if voltage at terminal 8 or 11 does not go to approximately zero with relay voltage outside the dead band. 3. Check for relay coil voltage with relay in oerate mode. 4. Check to see if voltage from collector to emitter drops almost to zero with relay in operate mode.
C. Raise or Lower indicator light does not come on but relay has output at terminal 7, 8 and 9.	1. Transistor Q10 or Q11 may be damaged. 2. LED Indicator light may be damaged.	1. Check to see that voltage at the collector of Q10 or Q11 changes from approximately +15 V dc to almost zero with relay in operate mode. This voltage may be measured at the top lead of R40 for Q11 and at the top top lead of R51 for Q10. 2. Replace LED.
D. Raise or Lower indicator light out and no output at either terminal 7 or 9.	1. IC-2 or IC-3 may be damaged. 2. Defective D6 or D8 diode.	1. Check for positive voltage at terminal 12 of IC-2 or IC-3 with relay in operate mode. 2. Check to see if diode is conductive. (may be checked with relay de-energized and an ohm meter).
E. Raise and Lower indicator light out and no output at either terminal 7 or 9.	1. IC-2 may be damaged. 2. IC-1 may be damaged. 3. IC-5 or IC-6 may be damaged. 4. Transformer T1 or T2 may be damaged.	1. Check for minimum of −1.5 V dc at terminal 10 of IC-2 when sensing voltage is reduced below the bottom band-edge. Also check for minimum of +1.5 V dc at terminal 10 when sensing voltage is increased above the top band-edge. 2. With 120 V ac applied to the sensing transformer checked for +7.5 V dc at test point TP1. Move balance voltage knob to 120 setting and check for −7.5 V dc at TP3. 3. Check for −15 V dc at TP6 and +15 V dc at TP5. With 120 V ac applied check for +30 V dc at terminal 11 of IC-5 and −30 V dc at terminal 6 of IC-6. 4. Check for 6 V ac between relay terminal C and 11. Also check for 24 V ac between relay terminal A and 11 and between terminal C and 11.
F. Relay voltage inside the deadband but AR or AL contact closed. Indicator lights off.	1. Relay contact welded closed. 2. Logic Gate IC-4 may be damaged. 3. Transistor Q1 or Q4 may be damaged.	1. Break weld and burnish contacts. 2. Check IC-4 output at terminal 8 or 11 to see that voltage is approximately +15 V dc. 3. Check voltage at AR or AL relay coil which might indicate a shorted Q1 or Q4 transistor.
G. Relay voltage inside the deadband but Raise or Lower indicator light on. AR and AL contact open.	1. Transistor Q10 or Q11 may be damaged.	1. Check for shorted Q10 or Q11 transistor.
H. Relay voltage inside the dead band but Raise Indicator and Raise relay or Lower Indicator and Lower relay picked up.	1. IC-2 or IC-3 may be damaged. 2. If only the RAISE light and the RAISE relay are energized, the −15V dc supply voltage may have changed.	1. Check voltage at terminal 12 of IC-2 or IC-3. Should be approximately zero. 2. Check for a damaged Q9 transistor.

Memorandum

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

Westinghouse · Medium Power Transformer Division · Sharon, Pa.

Printed in U.S.A.
(W.E.)