TEST DATE:	CUSTOMER:	SERIAL NO:

OLTC ACKNOWLEDGE SETUP ☐ **AUTOMATIC or**

☐ **FEEDBACK CONTROL**

PRODUCT/TEST MANUAL

2V162K12

VOLTAGE REGULATOR RELAY

Issue Level	Date	Summary of changes
A	06/01/1997	Initial issue.

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1. BROAD DESCRIPTION

1.1 Basic Functional Operation

The 2Vl62 continuously monitors the transformer output voltage and current. Voltages proportional to the current and having definite phase relationships with it (according to the external wiring configuration and line characteristics) are subtracted from the monitored voltage to give a replica of the Load Centre voltage.

The corrected sensed voltage is rectified and smoothed to give a proportional DC voltage, which is subtracted from a DC reference proportional to the thumbwheel switch "Set Voltage" setting. If the magnitude of the error voltage exceeds a value determined by the "Sensitivity Setting", a "Raise" or "Lower" LED lights, according to the polarity of the error voltage.

The" Initial Raise/Lower" timer is also initiated, and if the error persists for the duration of this timer setting, an operation of the appropriate output relay will occur. If the resultant tap change fails to bring the corrected sensed voltage to the desired value, a "Tap Change Interval" timer is initiated, and after this time has elapsed, a further tap change will take place.

This last cycle will be repeated until the corrected sensed voltage is within the desired bandwidth, when both timers will be reset.

The “Raise” and “Lower” output relays remain energised only in the time interval between initiation of the tap change and subsequent opening of the normally closed Tap Changer auxiliary contacts.

1.2 Line Drop Compensator

The Line Drop Compensator is used to enable the voltage at the source end of the transmission line to be adjusted to compensate for the Line voltage drop, and therefore achieve the required voltage at the load end of the Line, independent of the load current.

2. SPECIFICATION

POWER SUPPLY

Auxiliary Supply Range		40V to 275V AC 40V to 350V DC
Auxiliary Supply Burden (Continuous)		Less than 10VA
Peak Inrush Current		3A at 40V AC
RMS Inrush Current (Fully loaded)		40VA
Ambient Temperature Range		-5” to 55"C
Input Transients		Withstands multiple high energy transients and ring waves in accordance with IEEE28 -ANSI C26.1 category 11, accordingly:
	Ring wave	0.5uS 100KHz 6KV, 500A S/C, 4J
	Surge voltage	1.2/50uS 6KV O/C
	Surge current	8/20uS 3KA S/C, 80J clamped at 1000V
EMI Noise		Mains conducted EMI within limits specified by AS 3584 Class B

2. SPECIFICATION (Cont)

POWER SUPPLY (Cont)

Electrical Isolation	The outputs are isolated from the input in accordance with AS 3260 class 11 Limited Current Circuit, accordingly:

Withstand voltage of 2.5KV RMS 50Hz for one minute.

Creepage and clearance distance greater than 4mm.

Output leakage current less than 0.25mA to earth.

Power Supply Fail Alarm Relay

Normally closed contact rated at 250V AC and isolated as per AS 3260 are energised when both the input auxiliary supply and internal +24V DC rail is within acceptable limits. The relay will drop out causing an alarm output if either supply fails.

VOLTAGE SENSING CIRCUITRY

Nominal Sensing Voltage	450 Volts AC
Sensing Supply Burden	Approximately 1VA
Nominal Sensing Frequency	60Hz $^{+}/_{-}$ 2Hz
Regulated Voltage Setting Range	100 - 129 Volts (0.5V steps)
Precision of Voltage Setting	$^{+}/_{-}$ 0.5 Volts (409 - 527 primary volts) Accuracy of voltage setting is $^{+}/_{-}$ 0.5V for nominal input

LINE DROP COMPENSATION (LDC)

Nominal Sensing Current	1 Amp or 5 Amp (tapped CT)
CT Burden	Less than 0.25VA
Maximum Sensing Current	5 x nominal continuous, 19 x nominal for 3 seconds
Resistance Compensation setting Range	0 - 15% of nominal sensing volts
Accuracy	$^{+}/_{-}$ 0.5V for 450V Nom input
Reactance Compensation setting Range	
Accuracy	$^{+}/_{-}$ 0.5V for 450V Nom input
Coarse Raise/Lower Comparator	
Sensitivity	0.5% to 3.0% of nominal (continuously adjustable)
LDC Connection Mode	Pos/Neg X, In-phase/Quad via front panel switch.
Hysteresis	50% of error voltage (Other values may be specified)

2. SPECIFICATION (Cont)

TIMERS & LOGIC

Initial Raise/Lower Timer	20 - 260 seconds $^{+}/_{-}$5% of full scale
Norm/Inverse Mode switch on front panel.	T= Tset x Vsense setting/Verror
Inverse timing curve	True inverse
Tap Change Interval Timer	5 - 65 sec $^{+}/_{-}$ 5% of full scale
"Raise" Output	1 N/O relay contact
"Lower" Output	1 N/O relay contact

ALARMS

Undervoltage Lockout	70% to 88% continuously adjustable. Relay contacts: 1 C/O provided
Overvoltage Alarm	I00% to 118% continuously adjustable.
Tapchanger Fail Alarm Timer	5 min $^{+}/_{-}$ 10%
Auxiliary/Internal Supply Fail	1N/C relay contact

ALARM & CONTROL OUTPUT RELAYS

Type:	Idec RHl B
Contact Ratings	10A 24V DC resistive 0.5A 256V DC L/R 40 ms

INSULATION WITHSTAND

5KV 1/50us Impulse (coil to contacts)
1KV RMS across open contacts

3. TEST EQUIPMENT REQUIRED

500V 60Hz adjustable supply
5A Phase-adjustable current source
50V DC current- limited power supply
Frequency/period counter
Digital Voltmeter (4 1/2 digit preferable)
DC Auxiliary Supply
Electronic Counter
HV Test Equipment

4. ASSOCIATED DRAWINGS

165-162-112	Wiring Diagram
165-162-212	Circuit Schematic Diagram
660-272-306	Main Circuit Loading Diagram
678-028-201	Power Supply Circuit Diagram
678-28-301	Power Supply Loading Diagram

5. HIGH VOLTAGE TESTING

5.1 CLASS III Circuit Tests (5KV 1/50 and 2KV RMS)

a) Apply 2KV RMS 50Hz between terminal groups 1 and 2 in table 1 below for 1 minute.

b) Apply three 5KV 1/50us pulses of each polarity between terminal groups 1 and 2 in Table 1 below.

TABLE 1

TEST	GROUP 1	GROUP 2
A	8,9,22,23,24,25,26,27,28,29,30, (Inputs)	1,2,3,4,5,6,7,10,11,12,13,14,15,16 ,17,18,31,32, (Outputs)
B	All terminals excluding 5,6 & 7 connected together	Earth (Frame)

5.2 CLASS I Circuit Tests (No high voltage applicable) Terminals 5, 6 & 7.

NOTE: POWER SUPPLY LEAKAGE WILL BE 1.5mA DURING 2kV TEST DUE TO NOISE SUPRESSION CAPACITORS.

HIGH VOLTAGE TEST PASS ☐

6. CALIBRATION & TEST PROCEDURE

6.1 POWER SUPPLY

a) Connect 50V DC current limited supply to Auxiliary Supply input terminals 29 and 30.

b) Check that the following supply rail voltages are within limits:
Voltages are measured with respect to SK2-1

	RAIL	MIN	MAX	NOMINAL	ACTUAL
SK2-6	24	23	27	24	
SK2-2	18	17	19	18	
SK2-4	12	11.2	12.8	12	
SK2-3	-12	-11.2	-12.8	-12	

6.2 LINE DROP COMPENSATOR

a) Set LDC rotary switch (on the front panel) to "Pos X in Phase" position, and both LDC pots to the 15% position.

b) Connect a phase meter to monitor the difference between the input sensed current and the compensation voltage waveform appearing at SK2-15.

c) Apply 1 Amp AC ± 5% to the 1 Amp CT input.

d) Adjust trimpot VR2 so that there is a 90 degree phase difference between input current and the SK2-15 waveform.

MIN	MAX	NOMINAL	ACTUAL
86.0	94.0	90.0	

e) Adjust amplitude setting trimpot VR1 so that the SK2-15 voltage is 1.65V RMS when the input current is 1 Amp.

MIN	MAX	NOMINAL	ACTUAL
1.57	1.73	1.65	

f) Connect phase meter to measure phasing of SK2-14 with respect to the input current; they should be in antiphase.

MIN	MAX	NOMINAL	ACTUAL
176	184	180	

g) Adjust trimpot VR3 to give a SK2-14 Voltage of 1.65V at 1 Amp input current.

MIN	MAX	NOMINAL	ACTUAL
1.57	1.73	1.65	

h) Check that the resistive and reactive compensation voltages (all of 1.65V RMS magnitude) have the following phase relationships with the input current:

	Switch Position	Resistive Comp SK2-14	Reactive Comp SK2-15	
1	Pos react - in phase	Antiphase	90 lag	
2	Neg react - in phase	Antiphase	90 lead	
3	Pos react - in quad	90 lead	Antiphase	
4	Neg react - in quad	90 lead	In phase	
5	LDC DISABLED			

i) Record Resistive Compensation voltage (SK2-14) position 1 at the following settings:

SETTING	MIN	MAX	NOMINAL	ACTUAL
5 %	0.47	0.63	0.55	
10 %	1.02	1.18	1.1	

6.2 LINE DROP COMPENSATOR (Cont)

j) Record Reactive Compensation voltage (SK2-15) position 1 at the following settings:

SETTING	MIN	MAX	NOMINAL	ACTUAL
5 %	0.47	0.63	0.55	
10 %	1.02	1.18	1.1	

k) Apply 5.0 Amp input current to the 5 Amp CT input and check that the SK2-14 voltage at 15% "Resistive" is within limits:

MIN	MAX	NOMINAL	ACTUAL
1.57	1.73	1.65	

l) Apply 5.0 Amp input current to the CT and check that the SK2-15 voltage at 15% "Reactive" is within limits:

MIN	MAX	NOMINAL	ACTUAL
1.57	1.73	1.65	

m) Disconnect current source from CT

6.3 INPUT VOLTAGE TRANSFORMER CALIBRATION

Apply 450 V AC 60Hz to sensing input (Term 24 Active and Term 22 Neutral) and select R31/R32 to give 11.0V at SK2-12 with respect to V - (SK2-1).

MIN	MAX	NOMINAL	ACTUAL
10.97	11.03	11.00	

6.4 AVERAGE DETECTOR CALIBRATION

Disable LDC and re-connect 450V sensing input and adjust trimpot VR5 until voltage at SK2-9 is 11.00V.

MIN	MAX	NOMINAL	ACTUAL
10.99	11.01	11.00	

6.5 VOLTAGE INDICATION CIRCUITRY & REFERENCE VOLTAGE CALIBRATION

Note that for this step the 10V reference voltage may not end up exactly at 10.00V, since tolerances on R50/R51/R52/R53 will cause the 10V Reference (SK2-8) to differ from the set voltage at "100.0" Voltage Setting. Optimum setup is for the SK2-5 voltage to be 10.00V at 100.00V "Set Voltage" setting.

6.5 VOLTAGE INDICATION CIRCUITRY & REFERENCE VOLTAGE CALIBRATION (Cont)

a) Set thumbwheel switches to "100.0"V and input voltage to 409.1

b) Adjust trimpot VR4 to give 10.00V at SK2-5.

MIN	MAX	NOMINAL	ACTUAL
9.99	10.01	10.0	

c) Set thumbwheel switches to 120V and input voltage to 490.9

d) Adjust trim pot VR8 to give 12.00V at SK2-5.

MIN	MAX	NOMINAL	ACTUAL
11.99	12.01	12.0	

MIN	MAX	NOMINAL	ACTUAL
12.89	12.91	12.90	

6.6 UNDERVOLTAGE LOCKOUT CALIBRATION

Note: Before performing this calibration, adjust AC sense voltage until a raise or lower signal is detected by the error detector. Switch the inverse/definite time switch to inverse (this reduces the waiting time), and wait for the VRR to output a raise or lower signal as indicated by the output contacts of either the raise or lower relays. Ensure that when the under voltage condition is detected that the raise or lower indication is reset. The only indicator LED"s that should be illuminated in this condition is the Auxiliary supply and the Under voltage indicator.

MIN	MAX	NOMINAL	ACTUAL
392	399.7	396	

The hysteresis voltage (ie. difference between the pickup voltage and dropout voltage measured in step b) above), should be within the following limits:

MIN	MAX	NOMINAL	ACTUAL
16	22.5	18.4	

6.6 UNDERVOLTAGE LOCKOUT CALIBRATION (Cont)

Set U/V blocking control to 70% setting and record the relay dropout and hysteresis voltages:

	MIN	MAX	NOMINAL	ACTUAL
Drop out	306	323	315	
Hysteresis	16	22.5	18.4	

6.7 OVERVOLTAGE ALARM

Note: Before performing the over voltage calibration, increase the sensing voltage until an overvoltage condition is indicated by the "overvoltage LED" becoming illuminated. Ensure that this condition **does not** cause the VRR to go into overvoltage lockout, ie all front panel lamps extinguish with only the "Auxiliary supply" and "Overvoltage" LED on. This test is to ensure that diode D12 has not been fitted.

a) Set overvoltage control to 118% and sensing voltage to 482.73 volts.

b) Adjust VR6 until overvoltage LED comes on.

c) Set overvoltage control to 100% and sensed voltage to 450 volts.

d) Adjust VR11 until overvoltage LED comes on.

e) Repeat steps a) to d) until scale is calibrated.

6.8 ERROR DETECTOR CALIBRATION

a) Set AC Sensing input voltage to 450 V AC.

b) Set bandwidth potentiometer to max (3%) setting.

c) Adjust VR13 for 3.3 volts DC at U10-5

d) Adjust VR12 for a ratio of 6:1 between min and max settings (.5 - 3%)

e) Repeat above steps until scale is calibrated

6.9 INITIAL RAISE/LOWER TIMER CALIBRATION

a) Set AC Sensing input voltage to 450 V AC.

b) Increment the set voltage thumbwheel to give a continuous raise signal and switch the time delay characteristic to definite.

c) Adjust VR15 to achieve a span of 13:1 irrespective of absolute value.

d) Pad C43/C44/C45 to give a waveform period of 507.8ms at the maximum time setting at SK2-11.

e) Check min setting (20 sec) and readjust VR15 for 39mS if necessary.

Note: Check the operate times of the Initial Raise/Lower Timer by measuring the interval between application of AC Sensing Supply and subsequent output relay operation. Note that Auxiliary supply should remain "on" and the sensing voltage should be set about 10V lower than the Reference voltage, to give a "Raise" signal.

Results:

SETTING	MIN	MAX	NOMINAL	ACTUAL
20	10	30	20	

6.10 CALIBRATION OF TAP CHANGE INTERVAL TIMER

a) Adjust AC Sensing voltage until the Bandwidth Error gives continuous “Raise” signal.

b) Connect a frequency counter to SK6-4.

c) Adjust VR17 for a span of 13:1 irrespective of absolute values.

d) Pad C36/C37/C38 until the waveform period is 15.87ms at scale maximum setting (65s).

Note: Connect PU/DO time measuring apparatus to measure the time interval between operation of the T/C auxiliary contact and subsequent closure of the “Raise” output relay contacts. Record results:

SETTING	MIN	MAX	NOMINAL	ACTUAL
5	3	7	5	
20	18	22	20	
65	62	68	65	

6.11 CALIBRATION OF AUTO RAISE / LOWER CONTROL PULSE

Note: This test is only performed if the Automatic mode is selected.

a) Set jumpers JI and J2 for auto tap change operation by linking JI and linking J2-2 to J2-3. Set up the voltage and set voltage thumbwheel to give a tap raise or lower.

b) Set initial delay timer to 19 seconds and interval timer to 5 seconds.

c) The lower or raise LED should light after the initial time out. Adjust VR14 so that the LED on time is set as shown below:

MIN	MAX	NOMINAL	ACTUAL
1.8	2.2	2.0	

6.12 TAPCHANGER FAILURE ALARM TIMER

a) Connect a frequency counter to SK7-1.

b) Adjust trimpot VR18 to give a waveform period of 9.15ms.

c) Record operate time of Tap Changer Failure Alarm Timer by generating a “Raise” signal as previously but not simulating operation of the Tapchanger. Record time:

NOMINAL	ACTUAL
300	sec

7. GENERAL & FUNCTIONAL

7.1 Operation of Logic Circuitry

Set Sensitivity to 1%, toggle switch to “Inverse”, Initial Raise/ Lower time to 19s, T/C Interval to 5s, AC sensing voltage to 450V, Thumbwheel to 120V.
Voltage Error Detected “Low” LED should light and IC17 (Initial Raise/Lower Timer) should commence timing. The “Raise” output relay should pick up when IC17 times out, and the output relay LED (Raise Tap Initiate) should also light.
Simulate the opening of the tapchanger Auxiliary contact by operating the temporary pushbutton; the output “Raise” relay should drop out.

Closing of the N/C tapchanger contact removes the reset from the Tap Change Interval Timer, and after this time has elapsed, the “Raise” output relay will again pick up.
The two above steps are repeated until the AC sensed voltage reaches the desired value, when the Bipolar Comparator ceases to give a “Raise” signal and the timers will all be reset.

Operation of the circuit for a “Lower” signal is similar to that for a “Raise”.
If a “Raise” or “Lower” input signal persists, along with failure of the N/C tapchanger contact to open, IC16 timer will time out, operating the Tapchanger Fail Alarm relay and LED. Removal of the “Raise” or “Lower” signal or opening of the N/C tapchanger contact will reset the timer.

7.2 LDC Operational Check

a) Set the Line Drop Compensator controls to the following; PosX in φ, Error detector = 1.5%, Balance setting = 450 volts, 1Amp in 1 Amp CT tap.

b) Adjust the sense voltage source and note when the raise/lower LED extinguishes, this should be as per the table below.

Voltage Phase angle $=0^0$ %R control = 0		Voltage Phase angle to 90^0 %X control = 0	
%X	Balance volts	%R	Balance volts
10	495	10	495

7.3 General

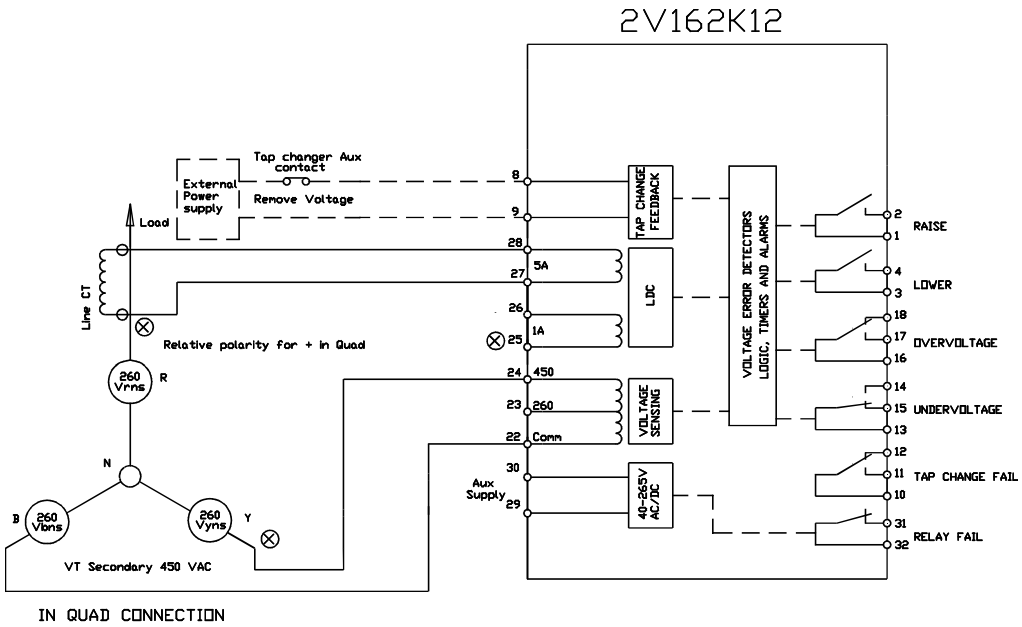
Check operation of all output relays.

Check that the relay is electrically sound and mechanically robust as per Standard Inspection & Test Schedule 903-000-026.

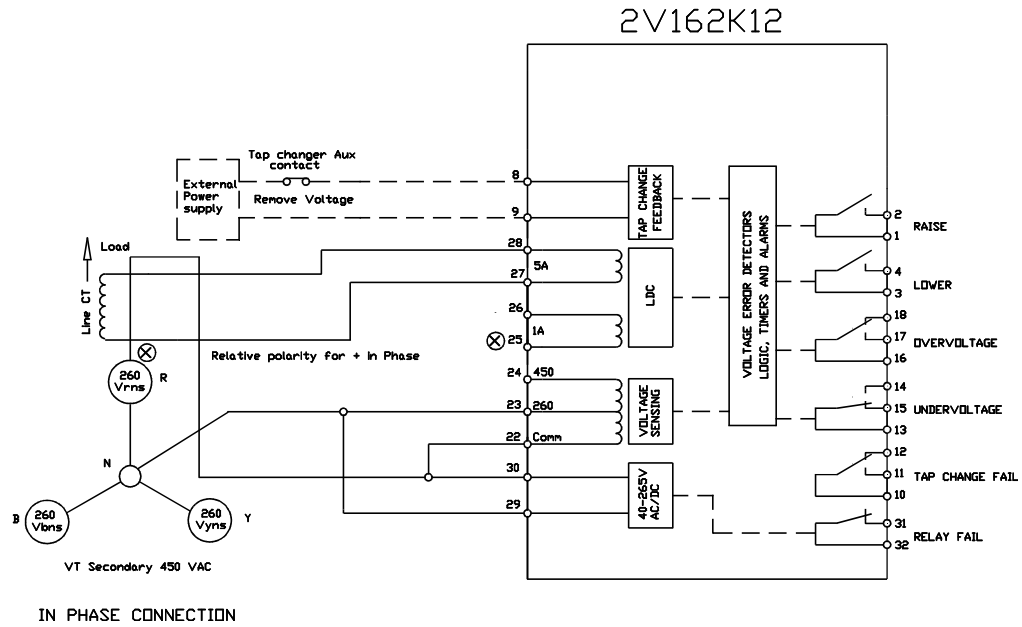
PASS ☐

TESTED BY :_____DATE :_____

8. CONNECTION DIAGRAM



IN QUAD CONNECTION



IN PHASE CONNECTION

9. INSTALLATION GUIDELINES

MOUNTING

The 2Vl62 Voltage Regulator relay is designed for flush, projection or 19 inch rack mounting as shown in the section titled "Mounting Details". It should be installed in an accessible position in the control room or with unmanned substations in a cubicle attached to the transformer main tank.

Before putting the unit into service the physical layout as well as the test and operating voltages should be checked. To check the operation of the voltage regulator, the PT (Power Transformer) voltage will need to be measured. Reference to sections "Output Terminals" and "Connection Diagram" in this manual should be made.

The 2Vl62K12 Voltage Regulator Relay may be specified with two types of interaction with the on load tap changer (OLTC) as follows.

OLTC ACKNOWLEDGE

After a tap raise or lower command is effected the 2Vl62K12 will wait for a response from the OLTC (momentary removal of signalling voltage) before initiating the interval timer. In this mode of operation the tap change acknowledge input must have a control voltage continuously applied and wired to the OLTC auxiliary contact such that it is momentarily removed when the tap change is in progress.

AUTOMATIC OPERATION

The 2Vl62K12 will effect a tap raise or lower command and automatically initiate the interval timer if the sensed voltage is outside the pre-set bandwidth.

THE TAP CHANGE FEEDBACK OPERATION AND CONTROL VOLTAGE REQUIRED (IF APPLICABLE IS SPECIFIED ON THE FRONT PAGE OF THIS MANUAL)

VOLTAGE REGULATOR (basic settings)

Read the actual voltage (VT sensing voltage) across terminals 22 and 24 on the rear of the unit (450V nominal). Use a voltmeter of sufficient accuracy (class 1 or better)-

Adjust the desired voltage level by manual control of the tap changer until the correct voltage level is displayed on the voltmeter.

Set the voltage level of the 2Vl 62 to the reading measured in b) above.

Fine adjustment of the voltage level (bandwidth centre).

To set the bandwidth to a minimum adjust the error detector to +0.5%. The regulator usually is balanced (no LED signal). When the signal LED”s "Raise" and "Lower" light after incrementing and decrementing by the same amount, then the voltage level is adjusted to the bandwidth centre.

Set the time delay mode switch to "DEFINITE".

Tap Change Interval time delay adjustment = 10 sec. Operate the tap changer manually towards "Raise" by one step, the signal lamp "Lower" must light.

After about 10 seconds the voltage regulator causes the tap changer to return to the original position. The signal lamp extinguishes.

9. INSTALLATION GUIDELINES (Cont)

Repeat the procedure towards direction "Lower", the signal "Raise" must light.
Return the setting to nominal volts as measured in point b) above.
Initial Raise Time adjustment

Set the time delay to the desired value. It may be that the most favourable delay time can only be obtained after a certain operating trial period as it depends on the number of tap changes per day. Therefore we recommend to set the time delay on "l 00 seconds" in order to avoid unnecessary tap change operations. The final time delay will depend on the service conditions of the installation.

Inverselintegrator

If the regulator is to use the inverse-integral method, the inverse timer has to be switched on (position "inv."). In this case the time delay depends on the voltage deviation as is shown in the 2V162 inverse time characteristics curves.

Adjustment of undervoltage blocking

To avoid unnecessary tap changes which could be caused by excessive voltage drops, the undervoltage blocking is recommended to be set to the appropriate value. This value will depend on the network conditions. (ie. line short-circuits, load peaks etc.).
A typical value would be 80% to 85% of nominal volts.

Adjustment of overvoltage alarm

To avoid potentially damaging tap changer runaway conditions an overvoltage alarm function is incorporated. Depending on how this alarm relay is wired into the control system it could be used to initiate a fast tap down operation or simply bring up an alarm on the main panel.

A typical value would be 118% of nominal volts.

LDC Adjustment

The LDC adjustments cater for 0-15% resistive plus 0-15% reactive line impedance. The actual settings of both controls will depend on the characteristics of the transmission line. As these characteristics vary considerably the settings must
be determined by the customer.