INSTRUCTIONS

For Installation and Operation

INTRODUCTION

CAUTION: The equipment covered by this publication must be selected for a specific application and it must be installed, operated, and maintained by qualified persons who are thoroughly trained and who understand any hazards that may be involved. This publication is written only for such qualified persons and is not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

The S&C Automatic Control Device—Type UP provides protection of *ungrounded*, wye-connected shunt capacitor banks—including double-wye banks.† It is a solid-state electronic control device of modular construction which detects the loss of individual capacitor units. See Figure 1. As successive individual capacitor units in a series group of a capacitor bank are isolated from the bank by their respective fuses, the surviving capacitor units in the group are protected against cascading voltage overstress by automatic switching—initiated by the Type UP Automatic Control Device—which isolates and locks out

† For applications where the source is a delta-connected tertiary transformer winding, a grounded-wye broken-delta voltage-transformer "bank" with shunt resistor—referred to as a high-impedance grounding transformer (normally required for ground-fault detection)—is required to maintain the stability of phase-to-ground voltage relationships for all but fault conditions. Otherwise spurious signal voltages could appear at the neutral of, and result in isolation of, the capacitor bank. However, if the S&C Type UP Automatic Control Device includes the plug-in unbalance compensation module (connected to compensate for both system voltage unbalance and inherent capacitor-bank unbalance), up to 10% unbalance among system phase-to-ground voltages will be automatically compensated for.

Figure 1. S&C Automatic Control Device—Type UP.

Supersedes Instruction Sheet 531-500 dated 2-16-81

the entire bank when a predetermined neutral-to-ground voltage is exceeded.

The Type UP Automatic Control Device incorporates a *gross overvoltage* circuit which functionally bypasses the lockout-level and timing-control circuits and initiates isolation of the capacitor bank in the event of a flashover of series groups within the capacitor bank. This circuit is activated, after a field-adjustable short-time delay, when the neutral-to-ground voltage exceeds a field-adjustable level.

An optional plug-in alarm module set (catalog number suffix "-H") may be furnished to provide an alarm signal upon loss of a lesser number of capacitor units than that corresponding to the lockout-level setting. For many capacitor banks it is quite feasible to activate the alarm upon loss of a single capacitor unit—a decided advantage since replacement of the failed capacitor unit can be accomplished at a convenient, planned time.

The Type UP Automatic Control Device, with the precision, flexibility, and compactness of solid-state electronics, offers matchless design features and proven circuits that withstand the rigors of power equipment application.

The Type UP Automatic Control Device utilizes plug-in modules featuring glass-reinforced epoxy circuit boards, with all components applied at levels well below MIL-STD guidelines to minimize component stress, power-supply requirements, and internal heating. "Enhanced quality" integrated circuits and gold-over-nickel plated connector pins and receptacle contacts are used throughout for increased reliability. Voltage-sensing input circuits are transformer isolated, and output circuits are relay isolated; these relays have contacts of gold-flashed silver-cadmium oxide to ensure long service life.

Metal-oxide surge protectors at critical points in the control circuits provide the optimum in surge protection. S&C's unique surge-control techniques have been field proven through years of successful application in hostile utility-substation environments. The capability of every S&C electronic device to withstand voltage surges is confirmed by two factory quality-check tests: The ANSI Surge Withstand Capability Test (ANSI Standard C37.90a, 1974); plus a much more severe (5-kv, 3.75-joule) capacitive-discharge test specially developed by S&C to duplicate or exceed voltage surges measured in EHV power substations. The specified surges are applied at all terminals of the device. Additional factory tests include a dielectric test; screening procedures with the device energized—including vibration, temperature-cycling, and maximum-operating-temperature tests; and functional tests (both before and after the screening tests).

The Type UP Automatic Control Device is suitable for mounting in a standard 19-inch relay rack. External control-wiring connections are made to numbered terminal strips at the rear of the device. See Figure 2. Customer-installed fuses and fuse blocks for the control source are provided. For flush-mounting of the control device on switchboards, control consoles, or other enclosures, an optional mounting bezel (catalog number suffix "-L" or "-M") is available.

The Type UP Automatic Control Device may be furnished in a weatherproof enclosure suitable for mounting on a substation structure. In this instance, a prewired, auxiliary, front-access, covered terminal strip is provided, in addition to a space heater suitable for 120-volt ac or 240-volt ac operation. The space heater is controlled by a nonadjustable 90°F thermostat. Factory-installed fuses and fuse blocks for the control source and for the space heater are included. External connections to the automatic control device are made through a conduit-entrance plate located at the bottom of the enclosure.

The Type UP Automatic Control Device may also be furnished in combination with an S&C Automatic Control Device—Type VR, which provides automatic switching of the capacitor bank to regulate system voltage. When this combination is furnished in a weatherproof enclosure, an additional auxiliary, front-access, covered terminal strip is provided, as are additional fuses and fuse blocks. See Figure 3. All necessary interconnections are prewired. Further, if the combination is furnished for 125-volt dc control-source voltage (catalog number suffix "-B"), the weatherproof enclosure is supplied with an exhaust fan controlled by a nonadjustable 120°F thermostat. Refer to S&C Instruction Sheet 531-515 for details on the Type VR Automatic Control Device.

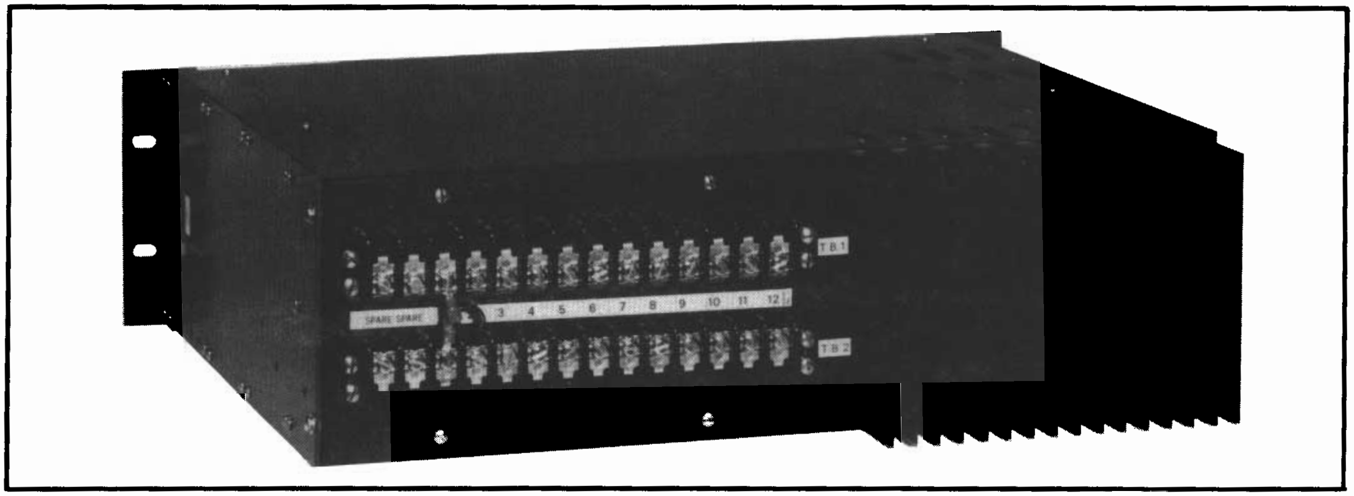

Figure 2. Terminal strips for external control-wiring connections.

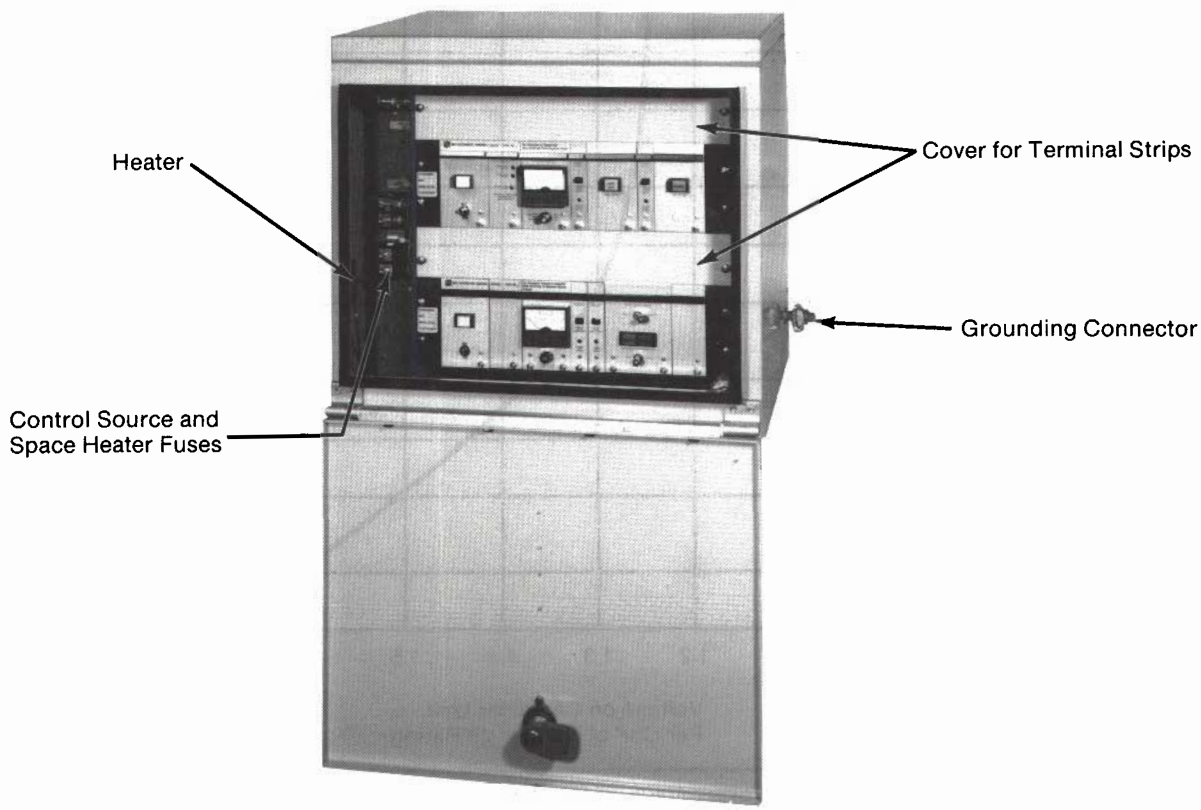

Figure 3. S&C Automatic Control Device—Type UP/VR mounted in weatherproof enclosure.

FUNCTIONAL PERFORMANCE

As failing capacitor units are successively isolated from the same series group by their associated fuses, the voltage applied to the surviving capacitor units in the group increases in discrete steps. Figure 4 indicates permissible capacitor-unit operating time at varying per-unit multiples of capacitor nameplate voltage rating, according to ANSI/IEEE Standard 18-1980, which further states that capacitors shall be capable of continuous operation up to 110% of rated voltage, including harmonics. Most capacitor manufacturers publish similar data, which may permit higher working voltages. When the voltage applied to the surviving capacitor units exceeds the manufacturer's maximum recommended working voltage (or in the absence of such a recommendation, the ANSI/ IEEE data), the entire bank should be removed from service.

The Type UP Automatic Control Device utilizes a voltmeter module which detects the capacitor-bank neutral-to-ground voltage, as monitored by an S&C 15-Volt-Ampere Potential Device. Since predictable discrete increases in capacitor-bank neutral-to-ground voltage result from the isolation of successive capacitor units, a specific value may be selected for adjusting the lockout level module of the Type UP Automatic Control Device.

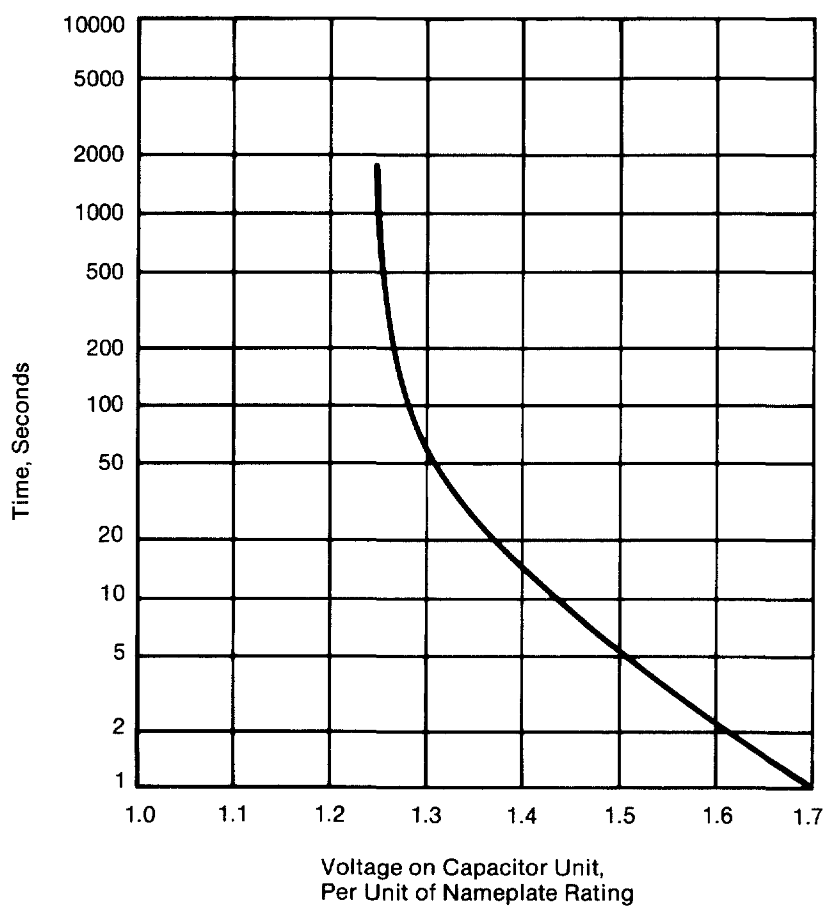

Figure 4. Capacitor-unit power-frequency overvoltage versus time, as permitted by ANSI/IEEE Standard 18-1980, "IEEE Standard for Shunt Power Capacitors," which further states that capacitors shall be capable of continuous operation up to 110% of rated voltage, including harmonics. Note: This curve applies for up to 300 applications of power-frequency overvoltages of the magnitudes and durations illustrated. Capacitor manufacturers may publish different recommendations applicable to their particular units.

A field-adjustable 1- to 30-second§ time delay is incorporated in the lockout level module, to assure operation of the fuse associated with the last-failing capacitor unit before providing a signal to the lockout control module to initiate tripping of the capacitor-bank switching device.

A gross overvoltage circuit responds to faults within the bank producing a neutral-to-ground voltage in excess of a field-adjustable level of 1000 to 5000 volts by initiating isolation and lockout of the capacitor bank after a field-adjustable time delay of 0.5 to 5 seconds.⊕

The Type UP Automatic Control Device may be furnished with an optional alarm module set, which provides an alarm signal upon the loss of a lesser number of capacitor units than that corresponding to the lockout-level setting. The alarm module set, further, responds to loss of control power to the Type UP Automatic Control Device and provides an alarm signal. The 1- to 30-second§ time delay incorporated in the lockout level module is also utilized here to avoid false alarms due to transient disturbances.

The Type UP Automatic Control Device incorporates an auxiliary relay (33X) which is actuated through a "b" contact of the capacitor-bank switch-operator auxiliary switch. This auxiliary relay prevents nuisance lockouts of the automatic control device (as well as nuisance activation of the alarm circuit in installations which include the optional alarm module set) resulting from neutral-to-ground voltages of several kilovolts being induced during periods when the capacitor bank has been routinely de-energized.

When required, an optional plug-in unbalance compensation module may be added (along with required additional voltage-monitoring devices) to detect and compensate for the error voltage appearing between the capacitor-bank neutral and ground caused by system voltage unbalance★ and/or inherent capacitor-bank unbalance resulting from manufacturing-tolerance variations among capacitor units in the bank.

§ Factory-set at 10 seconds.

⊕ Factory-set at 2500 volts, for a time delay of 2 seconds.

★ For proper unbalance compensation, the system-derived voltages monitored by the S&C Automatic Control Device must be obtained by means of S&C 30-Volt-Ampere Potential Devices—or voltage transformers—connected to the segment of station bus to which the capacitor bank is tapped. Connecting circuits from the potential devices or voltage transformers to the S&C Type UP Automatic Control Device must be free of variable loads, variable voltage drops, and ground loops so that the voltages monitored accurately represent the magnitude and phase angle of the bus voltages.

General Installation Requirements

To prevent damage to the Type UP Automatic Control Device in the event that surges which exceed factory-tested levels are encountered, S&C's control-circuit fusing recommendations must be followed. The required fuse blocks and fuses are furnished with the control device. If frequent surges in excess of factory-tested levels are anticipated, S&C should be advised as to the severity of the surges so that special recommendations can be made.

In designing the installation, consideration should be given to provision of adequate ventilation for the control device to limit the temperature adjacent to the unit to 160°F maximum. This is particularly important in instances where the control device is installed in a cabinet or where several control devices are installed in close proximity to each other.

Making the Connections

IMPORTANT: The voltmeter module has been calibrated at the factory to provide direct capacitor-bank neutral-to-ground voltage reading for a specific-voltage-rated S&C 15-Volt-Ampere Potential Device connected between the capacitor-bank neutral and ground—as indicated on the label affixed to the back of the module faceplate.

When the optional unbalance compensation module has been specified, it has been calibrated at the factory for a specific-voltage-rated S&C 15-Volt-Ampere Potential Device connected between the capacitor-bank neutral and ground, and for a specific primary-to-secondary voltage ratio S&C 30-Volt-Ampere Potential Device(s) or voltage transformer(s) connected between the station bus and ground—as indicated on the label affixed to the back of the module faceplate.

If other voltage-monitoring devices are utilized, recalibration is required. Refer to the recalibration instructions contained in S&C Reference Drawing RD-3223 for the voltmeter module, or RD-3224 for the unbalance compensation module. The appropriate drawing(s) is furnished as part of the detailed instruction manual which can be ordered for the Type UP Automatic Control Device.

The Type UP Automatic Control Device is equipped with numbered terminal strips for external control-wiring connections at the rear of the device. See Figure 2. Using the connection drawing in the instruction manual furnished with the device, make the following connections:

1. Control source (48 volts dc, 125 volts dc, 120 volts 60 hertz, or 240 volts 60 hertz, as appropriate).
2. Output terminals of the S&C 15-Volt-Ampere Potential Device, having a system voltage rating as follows:

Nominal Source Voltage, Kv	Potential-Device System Voltage Rating, Kv, Nominal
below 23	23
23	23
34.5	23
46	23
69	34.5
115	69
138	69
161	138
230	138

3. Opening circuit of the switch operator.
4. Closing circuit of the switch operator.
5. "b" contact of switch-operator auxiliary switch. This contact should be set to open near the fully closed position of the capacitor-bank switching device.
6. Station ground.
7. Space heater source, where applicable (120 volts 60 hertz or 240 volts 60 hertz).
8. Alarm circuit (optional).

Additionally, if the Type UP Automatic Control Device is equipped with the optional plug-in unbalance compensation module, connections are required to the output terminals of other voltage-monitoring devices as follows:

1. *For detection and compensation of inherent capacitor-bank unbalance only, in applications where the source is grounded*, connection must be made to either:
   a. A single, fully system-voltage-rated S&C 30-Volt-Ampere Potential Device equipped with factory-adjusted calibration device (catalog number suffix "-T"), connected to any phase of the station bus from which the capacitor bank is tapped, or

b. A single voltage transformer, connected to the station bus from which the capacitor bank is tapped—either line-to-line across any two phases or line-to-ground on any phase.

2. *For detection and compensation of inherent capacitor-bank unbalance only, in applications where the source is a delta-connected tertiary transformer winding*, connection must be made to a 1:1-ratio voltage transformer which is then to be connected to any secondary of a high-impedance grounding transformer; the voltage transformer should have a voltage rating equal to the secondary voltage rating of the grounding transformer. (The grounding transformer—which should be connected to the station bus from which the capacitor bank is tapped—maintains the stability of phase-to-ground voltage relationships for all but fault conditions.)

3. *For detection and compensation of inherent capacitor-bank unbalance plus detection and compensation of system voltage unbalance, in applications where the source is grounded*, connection must be made to either:

   a. Three fully system-voltage-rated S&C 30-Volt-Ampere Potential Devices equipped with factory-adjusted calibration device (catalog number suffix "-T"), each connected to a phase of the station bus from which the capacitor bank is tapped, or

   b. Three voltage transformers, connected to the station bus, grounded-wye grounded-wye.

4. *For detection and compensation of inherent capacitor-bank unbalance plus detection and compensation of system voltage unbalance, in applications where the source is a delta-connected tertiary transformer winding*, connections must be made to three 1:1-ratio voltage transformers each of which is then to be connected to a secondary of a high-impedance grounding transformer; the voltage transformers should have a voltage rating equal to the secondary voltage rating of the grounding transformer. (The grounding transformer—which should be connected to the station bus from which the capacitor bank is tapped—maintains the stability of phase-to-ground voltage relationships for all but fault conditions.)

When the unbalance compensation module is used to compensate for system voltage unbalance, it is factory-calibrated in accordance with information furnished at the time of ordering. Such information includes the catalog number of the associated S&C 30-Volt-Ampere Potential Devices, the primary- and secondary-voltage ratings and the turns ratio of the associated voltage transformers, or the secondary voltage rating and turns ratio of the associated grounding transformer, as applicable.

Connecting circuits from the voltage-monitoring devices to the Type UP Automatic Control Device must be free of variable loads, variable voltage drops, and ground loops so that the voltages monitored accurately represent the magnitude and phase angle of the bus voltages. Some possible errors affecting unbalance compensation are:

- Differences in effective voltage ratio among the three S&C 30-Volt-Ampere Potential Devices or the three voltage transformers used to obtain system-derived voltages, as applicable.
- Unbalanced or variable loading of the voltage-monitoring devices used to obtain system-derived voltages. (Station-service transformers are thus not suitable sources for this purpose.)
- Control-wiring voltage drops between the voltage-monitoring devices and the automatic control device. (For example, a 1-ampere current flowing through 1000 feet of number 10 AWG wire will result in a 1-volt drop in the voltage-level signal, which may be sufficient to produce undesirable performance of the protection scheme.) Adequately sized dedicated connecting circuits between the voltage-monitoring devices and the automatic control device will minimize voltage drops.
- Induced voltages in control wiring. Proper shielding is important.
- Ground loops caused by differences in voltage between the grounding points for the capacitor-bank neutral-to-ground voltage-monitoring device and those for the voltage-monitoring devices used to obtain system-derived voltages. Preferably, the secondaries of all the voltage-sensing devices should be grounded at one point—at the control house, as per proposed ANSI C57.13.3, "Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases."

ESTABLISHING THE SETTINGS

Two methods of establishing the capacitor-bank lockout level are given on this and succeeding pages—one utilizing graphs and one utilizing formulas.

Determine Incremental Capacitor-Unit Overvoltage and Capacitor-Bank Neutral-to-Ground Voltage Due to Loss of Successive Capacitor Units—Graphical Method

Step-by-step Procedures

1. Collect installation data, including:
   a. Highest anticipated continuous system line-to-neutral voltage, kv
   b. Nameplate capacitor-unit rating, kv
   c. Number of series groups per phase — S
   d. Number of capacitor units in parallel per series group — P.
2. Using the graph, Figure 5, read per-unit values of V_O—the voltage applied to surviving capacitor units—for a series of steps corresponding to increasing values of F—the number of capacitor units isolated—up to

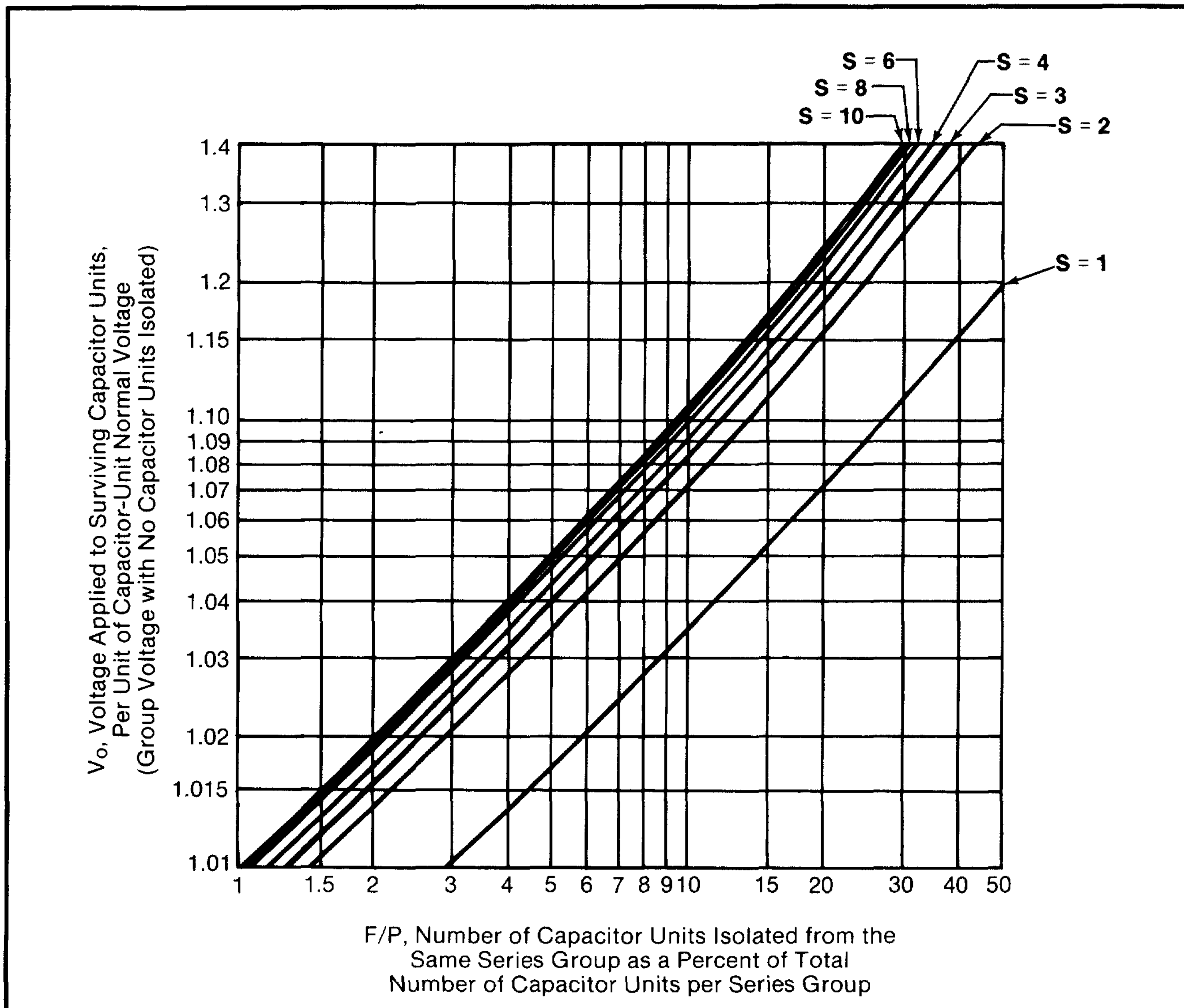

Figure 5. Per-unit voltage applied to surviving capacitor units in a series group versus percentage of capacitor units isolated from the same series group.

and including F_C—the step for which V_O equals or exceeds the capacitor manufacturer's recommended maximum working voltage (generally 1.1 per unit). The step corresponding to F_C will hereafter be referred to as the "critical step."

3. If the capacitor units are operated at other than rated voltage, correct the values read in (2) above by multiplying by the ratio of the "normal" (highest anticipated) applied voltage (all capacitor units operating) to the nameplate voltage rating of the capacitor units.
4. Using the graph, Figure 6, read per-unit values of V_n—capacitor-bank neutral-to-ground voltage—for the same series of steps corresponding to increasing values of F up to and including F_C.
5. Convert the per-unit values of V_n read in (4) above to actual V_n voltage values by multiplying by the highest anticipated system line-to-neutral voltage.

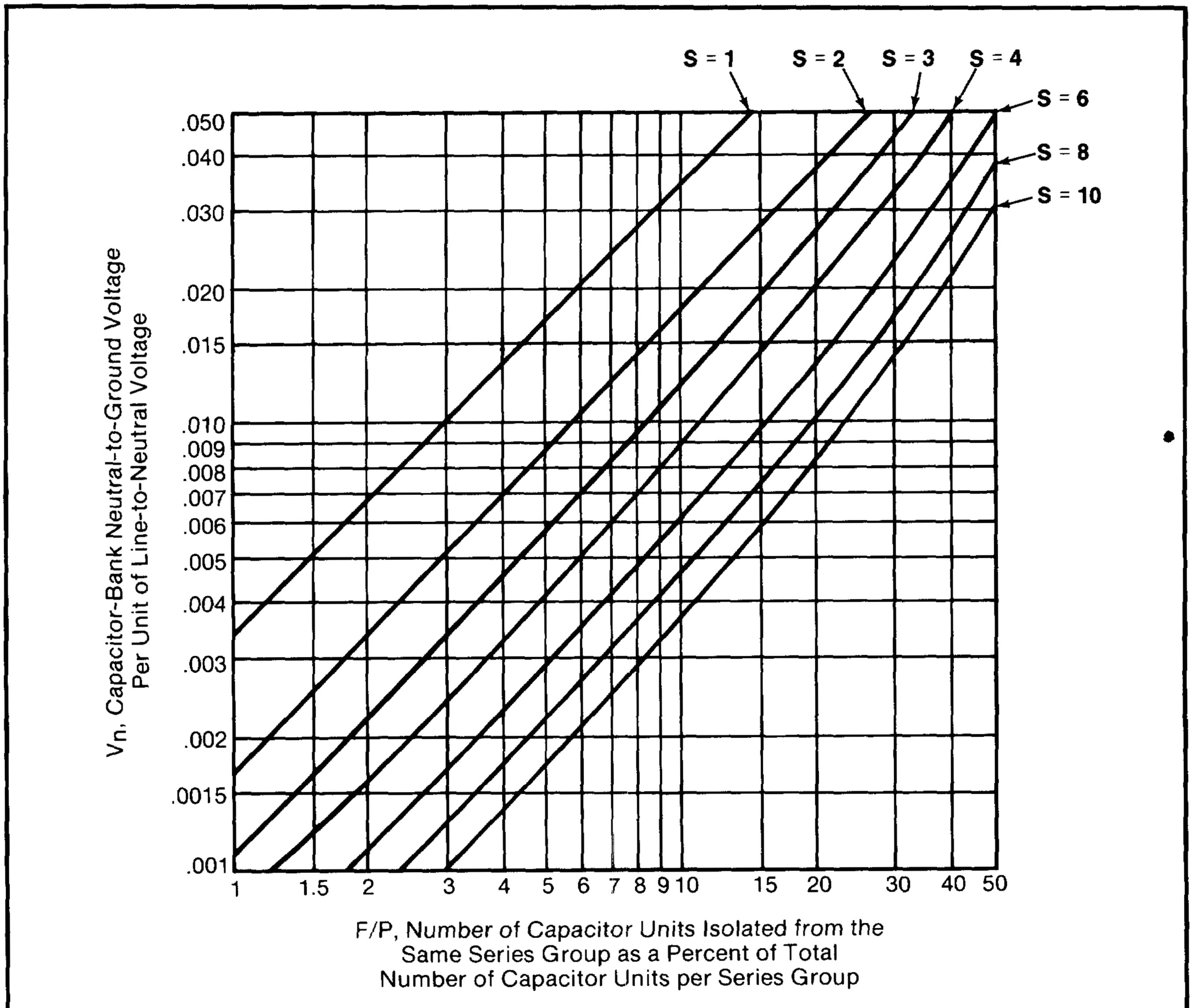

Figure 6. Per-unit capacitor-bank neutral-to-ground voltage versus percentage of capacitor units isolated from the same series group.

6. Determine the desired lockout level—the midpoint between V_n for the critical step, F_c, and V_n for F_{c-1}.

Using the Graphical Method—First Example

1. Installation Data
   a. Highest anticipated continuous system line-to-neutral voltage, kv 20
   b. Nameplate capacitor-unit rating, kv 9.96
   c. Number of series groups per phase 2
   d. Number of capacitor units in parallel per series group 10

2. For F = 1, enter the graph, Figure 5, at 10 on the horizontal scale (1/10 = 10% of capacitor units isolated from a series group). Follow up to a point corresponding to 2 series groups per phase (curve labeled "S = 2") and read V_o = 1.072 per unit on the vertical scale.

   For F = 2, in like manner, enter the graph, Figure 5, at 20 on the horizontal scale (2/10 = 20% of capacitor units isolated from the same series group). Follow up to a point corresponding to 2 series groups per phase (curve labeled "S = 2") and read V_o = 1.16 per unit on the vertical scale. Obviously, F = 2 is the critical step, F_c, if it is desired to limit V_o to 1.1 per unit or less.

3. With an anticipated system line-to-neutral voltage of 20 kv and with 2 series groups per phase, the capacitor units are normally operated at 10 kv. Therefore:

   For F = 1,

   $$V_o = \frac{1.072 \times 10 \text{ kv}}{9.96 \text{ kv}} = 1.076 \text{ per unit}$$

   For F = 2,

   $$V_o = \frac{1.16 \times 10 \text{ kv}}{9.96 \text{ kv}} = 1.16 \text{ per unit}$$

4. For F = 1, enter the graph, Figure 6, at 10 on the horizontal scale (1/10 = 10% of capacitor units isolated from a series group). Follow up to a point corresponding to 2 series groups per phase (curve labeled "S = 2") and read V_n = .018 per unit on the vertical scale.

   For F = 2, in like manner, enter the graph, Figure 6, at 20 on the horizontal scale (2/10 = 20% of capacitor units isolated from the same series group). Follow up to a point corresponding to 2 series groups per phase (curve labeled "S = 2") and read V_n = .038 per unit on the vertical scale.

5. Multiply the values read in (4) above by the system line-to-neutral voltage to convert the per-unit V_n values to actual V_n voltage values. Thus:

   For F = 1,

   V_n = 0.018 X 20,000 volts = 360 volts

   For F = 2,

   V_n = 0.038 X 20,000 volts = 760 volts

6. Determine the lockout level by calculating the midpoint value between V_n for F = 1 and V_n for F = 2, the critical step F_c. Thus, the desired lockout level is

   $$\frac{360 \text{ volts} + 760 \text{ volts}}{2} = 560 \text{ volts}$$

Using the Graphical Method—Second Example

1. Installation Data
   a. Highest anticipated continuous system line-to-neutral voltage, kv 139.44
   b. Nameplate capacitor-unit rating, kv 19.92
   c. Number of series groups per phase 7
   d. Number of capacitor units in parallel per series group 12

2. For F = 1, enter the graph, Figure 5, at 8.33 on the horizontal scale (1/12 = 8.33% of capacitor units isolated from a series group). Follow up to a point corresponding to 7 series groups per phase (interpolate between curves labeled "S = 6" and "S = 8") and read V_o = 1.085 per unit on the vertical scale.

   For F = 2, in like manner, enter the graph, Figure 5, at 16.67 on the horizontal scale (2/12 = 16.67% of capacitor units isolated from the same series group). Follow up to a point corresponding to 7 series groups per phase and read V_o = 1.18 per unit on the vertical scale. Obviously, F = 2 is the critical step, F_c, if it is desired to limit V_o to 1.1 per unit or less.

3. With an anticipated system line-to-neutral voltage of 139.44 kv and with 7 series groups per phase, the capacitor units are normally operated at 19.92 kv, their rated voltage. Therefore, no correction factor need be applied to the values read in (2) above.
4. For F = 1, enter the graph, Figure 6, at 8.33 on the horizontal scale (1/12 = 8.33% of capacitor units isolated from a series group). Follow up to a point corresponding to 7 series groups per phase (interpolate between curves labeled "S = 6" and "S = 8") and read V_n = .0043 on the vertical scale.

   For F = 2, in like manner, enter the graph, Figure 6, at 16.67 on the horizontal scale (2/12 = 16.67% of capacitor units isolated from the same series group). Follow up to a point corresponding to 7 series groups per phase and read V_n = .0093 on the vertical scale.
5. Multiply the values read in (4) above by the system line-to-neutral voltage to convert the per-unit V_n values to actual V_n voltage values. Thus:

   For F = 1,

   V_n = .0043 X 139,440 volts = 600 volts

   For F = 2,

   V_n = .0093 X 139,440 volts = 1297 volts
6. Determine the lockout level by calculating the midpoint value between V_n for F = 1 and V_n for F = 2, the critical step F_c. Thus, the desired lockout level is

$$\frac{600 \text{ volts} + 1{,}297 \text{ volts}}{2} = 949 \text{ volts}$$

Determine Incremental Capacitor-Unit Overvoltage and Capacitor-Bank Neutral-to-Ground Voltage Due to Loss of Successive Capacitor Units— Formula Method

Step-by-step Procedures

1. Collect installation data, including:
   a. Highest anticipated continuous system line-to-neutral voltage, kv
   b. Nameplate capacitor-unit rating, kv
   c. Number of series groups per phase
   d. Number of capacitor units in parallel per series group.
2. Calculate per-unit values of V_o—the voltage applied to surviving capacitor units—for a series of steps corresponding to increasing values of F—the number of capacitor units isolated—up to and including F_c—the step for which V_o equals or exceeds the capacitor manufacturer's recommended maximum working voltage (generally 1.1 per unit). The step corresponding to F_c will hereafter be referred to as the "critical step." Use the formulas:

$$V_o\ (\text{volts}) = \frac{(3P)\,(V_{L\text{-}n})}{2F + 3S(P-F)}$$

$$V_o\ (\text{per unit}) = \frac{V_o\ (\text{Volts})}{\text{Nameplate voltage rating of capacitor units}}$$

where $V_{L\text{-}n}$ = Highest anticipated continuous system line-to-neutral voltage

S = Number of series groups per phase

P = Number of capacitor units in parallel per series group

F = Number of capacitor units isolated from bank (and from the same series group)

3. For each value of F used in (2) above, calculate the neutral-to-ground voltage, V_n. Use the formula:

$$V_n = \frac{(F)(V_{L\text{-}n})}{2F + 3S(P-F)}$$

where $V_{L\text{-}n}$, S, P, and F are defined as in (2) above.

4. Determine the lockout level by calculating the midpoint between V_n for F_c, the critical step, and V_n for F_{c-1}.

Using the Formula Method—First Example

1. Installation Data
   a. Highest anticipated continuous system line-to-neutral voltage, kv 20
   b. Nameplate capacitor-unit rating, kv 9.96
   c. Number of series groups per phase 2
   d. Number of capacitor units in parallel per series group 10

2. For F = 1,

$$V_o \text{ (volts)} = \frac{(3)(10)(20{,}000)}{(2)(1) + (3)(2)(10-1)} = 10{,}714 \text{ volts}$$

$$V_o \text{ (per unit)} = \frac{10{,}714}{9{,}960} = 1.0757 \text{ per unit (or 7.57\% overvoltage)}$$

For F = 2,

$$V_o \text{ (volts)} = \frac{(3)(10)(20{,}000)}{(2)(2) + (3)(2)(10-2)} = 11{,}538 \text{ volts}$$

$$V_o \text{ (per unit)} = \frac{11{,}538}{9{,}960} = 1.1585 \text{ per unit (or 15.85\% overvoltage)}$$

Obviously, F = 2 is the critical step, F_c, if it is desired to limit V_o to 1.1 per unit or less.

3. For F = 1,

$$V_n = \frac{(1)(20{,}000)}{(2)(1) + (3)(2)(10-1)} = 357 \text{ volts}$$

For F = 2,

$$V_n = \frac{(2)(20{,}000)}{(2)(2) + (3)(2)(10-2)} = 769 \text{ volts}$$

4. Determine the lockout level by calculating the midpoint between V_n for F = 1 and V_n for F = 2, the critical step F_c. Thus, the desired lockout level is 563 volts.

Using the Formula Method—Second Example

1. Installation Data
   a. Highest anticipated continuous system line-to-neutral voltage, kv 139.44
   b. Nameplate capacitor-unit rating, kv 19.92
   c. Number of series groups per phase 7
   d. Number of capacitor units in parallel per series group 12

2. For F = 1,

$$V_o \text{ (volts)} = \frac{(3)(12)(139{,}440)}{(2)(1) + (3)(7)(12-1)} = 21{,}544 \text{ volts}$$

$$V_o \text{ (per unit)} = \frac{21{,}544}{19{,}920} = 1.0815 \text{ per unit (or 8.15\% overvoltage)}$$

For F = 2,

$$V_o \text{ (volts)} = \frac{(3)(12)(139{,}440)}{(2)(2) + (3)(7)(12-2)} = 23{,}457 \text{ volts}$$

$$V_o \text{ (per unit)} = \frac{23{,}457}{19{,}920} = 1.1776 \text{ per unit (or 17.76\% overvoltage)}$$

Obviously, F = 2 is the critical step, F_C, if it is desired to limit V_O to 1.1 per unit or less.

3. For F = 1,

$$V_n = \frac{(1)(139{,}440)}{(2)(1) + (3)(7)(12-1)} = 598 \text{ volts}$$

For F = 2,

$$V_n = \frac{(2)(139{,}440)}{(2)(2) + (3)(7)(12-2)} = 1303 \text{ volts}$$

4. Determine the lockout level by calculating the midpoint between V_n for F = 1 and V_n for F = 2, the critical step F_C. Thus, the desired lockout level is 951 volts.

Gross Overvoltage Circuit

Calculate the capacitor-bank neutral-to-ground voltage, V_n, resulting from a fault within the capacitor bank which would short out an entire series group. Use the formula:

$$V_n = \left[\frac{1}{3S-2}\right] V_{L\text{-}n}$$

where S = Number of series groups per phase
$V_{L\text{-}n}$ = Highest anticipated continuous system line-to-neutral voltage

For the first example given under "Determine Incremental Capacitor-Unit Overvoltage and Capacitor-Bank Neutral-to-Ground Voltage Due to Loss of Successive Capacitor Units—Formula Method," the desired gross overvoltage lockout level is the midpoint between V_n for F = 2—769 volts—and the value of V_n resulting from shorting out a series group—

$$\left[\frac{1}{(3)(2)-2}\right] 20{,}000 \text{ volts} = 5000 \text{ volts, or}$$

$$\frac{769 \text{ volts} + 5000 \text{ volts}}{2} = 2885 \text{ volts}$$

For the second example given under "Determine Incremental Capacitor-Unit Overvoltage and Capacitor-Bank Neutral-to-Ground Voltage Due to Loss of Successive Capacitor Units—Formula Method," the desired gross overvoltage lockout level is the midpoint between the V_n for F = 2—1303 volts—and the value of V_n resulting from shorting out a series group—

$$\left[\frac{1}{(3)\,(7)-2}\right] 139{,}440 \text{ volts} = 7339 \text{ volts, or}$$

$$\frac{1303 \text{ volts} + 7339 \text{ volts}}{2} = 4321 \text{ volts}$$

Should the calculated gross overvoltage lockout level exceed 5000 volts, the detector should be set at its maximum value.

IS UNBALANCE COMPENSATION NEEDED?

A certain amount of error voltage is always present between the capacitor-bank neutral and ground, due to system voltage unbalance and/or inherent capacitor-bank unbalance resulting from manufacturing-tolerance variations among capacitor units in the bank. Since it is not possible to predict how the two components of the error voltage will combine vectorially, it is important that the magnitude of the error voltage be kept low in relation to the magnitude of the capacitor-bank neutral-to-ground voltage resulting from isolation of one capacitor unit. For example, the error voltage may be additive with respect to the neutral-to-ground voltage resulting from isolation of capacitor units in one phase leg, but subtractive with respect to the neutral-to-ground voltage resulting from isolation of capacitor units in another phase leg.

As a rule, unbalance compensation should be provided if the magnitude of the error voltage approaches 50% of the value of neutral-to-ground voltage calculated for isolation of one capacitor unit. If the capacitor-bank manufacturer can supply an estimate of the per-unit capacitor-bank unbalance between phases, and if the per-unit system voltage unbalance between phases is known, an estimate of the error voltage can be calculated as follows:

$$\text{Error Voltage from Capacitor-Bank Unbalance} = \frac{\begin{pmatrix}\text{Per-unit}\\ \text{Capacitor-Bank}\\ \text{Unbalance}\end{pmatrix}\begin{pmatrix}\text{System Line-}\\ \text{to-Neutral}\\ \text{Voltage}\end{pmatrix}}{3}$$

$$\text{Error Voltage from System Voltage Unbalance} = \frac{\begin{pmatrix}\text{Per-unit}\\ \text{System Voltage}\\ \text{Unbalance}\end{pmatrix}\begin{pmatrix}\text{System Line-}\\ \text{to-Neutral}\\ \text{Voltage}\end{pmatrix}}{3}$$

For the two examples given under "Determine Incremental Capacitor-Unit Overvoltage and Capacitor-Bank Neutral-to-Ground Voltage Due to Loss of Successive Capacitor Units—Formula Method," assume a per-unit capacitor-bank unbalance of 0.01 and a per-unit system voltage unbalance of 0.005.

For the first example:

$$\text{Error Voltage from Capacitor-Bank Unbalance} = \frac{(0.01)(20{,}000\text{ volts})}{3} = 66.7\text{ volts}$$

$$\text{Error Voltage from System Voltage Unbalance} = \frac{(0.005)(20{,}000\text{ volts})}{3} = 33.3\text{ volts}$$

In the event that these error voltages are additive, the total error voltage could be as high as 100 volts—28% of the neutral-to-ground voltage resulting from the isolation of one capacitor unit, 357 volts. Thus, the user should forego inclusion of the unbalance compensation module (and the required additional voltage-monitoring devices) unless the need for unbalance compensation is established through field experience. (See Step 11, page 17.)

For the second example:

$$\text{Error Voltage from Capacitor-Bank Unbalance} = \frac{(0.01)(139{,}440\text{ volts})}{3} = 464.8\text{ volts}$$

$$\text{Error Voltage from System Voltage Unbalance} = \frac{(0.005)(139{,}440\text{ volts})}{3} = 232.4\text{ volts}$$

In the event that these error voltages are additive, the total error voltage could be as high as 697.2 volts—a value requiring unbalance compensation since the netural-to-ground voltage resulting from the isolation of one capacitor unit in this example is 598 volts.

LOCKOUT- AND ALARM-LEVEL ADJUSTMENTS

Step 1

Place the on-off toggle switch on the power supply module in the *on* position. The presence of control-source voltage will be signified by a lighted indicator.

If an alarm indicator or lockout indicator lamp should light, press the appropriate button to reset the circuit.

Step 2

Choose the appropriate scale for the voltmeter by setting its meter range selector so that the predetermined lockout level will fall in the upper half of the voltmeter scale. Thus, for the examples given under the "Formula Method" on pages 12 and 13, the 0-1000 volt scale should be selected in both cases.

Step 3

Adjust the lockout level by pressing the "push-to-read lockout level" button on the lockout level module while turning the "lockout level adjust" screw to attain the required voltmeter reading.

Step 4

If the optional alarm module set is furnished: Adjust the alarm level by pressing the "push-to-read alarm level" button on the alarm level module while turning the "alarm level adjust" screw to attain the required voltmeter reading. Choose the appropriate meter range as noted in Step 2.

The alarm level setting should be approximately half of the value of the capacitor-bank neutral-to-ground voltage resulting from the isolation of one capacitor unit. Thus, using the examples given under the "Formula Method" on pages 12 and 13, the alarm level settings should be 357 volts/2 = 178 volts, and 598 volts/2 = 299 volts, respectively.

Activation of the alarm circuit upon isolation of one capacitor unit enables the user to choose either to continue operating the capacitor bank—deferring replacement of the failed unit until a convenient time—or to replace the failed unit sooner, thus minimizing the time that surviving capacitor units are exposed to overvoltage and thereby reducing the likelihood that marginal units will fail prematurely.

Step 5

Record, for future reference, the lockout-level and alarm-level settings arrived at in the preceding steps, as indicated on the voltmeter. Note also the voltmeter range selected.

Step 6

Adjust the gross overvoltage circuit neutral-to-ground voltage by setting the 1000-5000 volt single-turn potentiometer located on the lockout control module printed circuit board for the required value. For the examples given under "Gross Overvoltage Circuit" on page 13, gross overvoltage settings should be 2885 volts and 4321 volts, respectively.

LOCKOUT-TIMER ADJUSTMENTS

An important consideration in the application of the Type UP Automatic Control Device is that of coordinating capacitor-bank isolation and lockout with operation of the individual capacitor-unit fuses. It is undesirable for the control to initiate lockout before the fuse for the last-failing capacitor unit has had sufficient time to operate—thereby eliminating any indication as to which capacitor unit was in the process of failing. Generally, coordination will be achieved provided:

1. The lockout and alarm levels are set as described in the foregoing example,
2. The lockout time delay is adequate, and
3. A fusing ratio of 1.25 or less is used for individual capacitor-unit fuses.

Step 7

If other than the factory-set lockout time delay is desired (see SPECIFICATIONS, page 19), set the 1-30 second single-turn potentiometer, located on the lockout level module printed circuit board, for the desired value. The scale on the potentiometer is accurate to ±20%.

Step 8

Adjust the gross overvoltage circuit time delay by setting the 0.5-5 second single-turn potentiometer, located on the lockout control module printed circuit board, for the desired value. The scale on the potentiometer is accurate to ±20%.

The gross overvoltage circuit time delay should be a minimum of 0.5 second‡ *plus* the elapsed time between energization of the capacitor-bank switching device opening circuit and closing of the switching device "b" contact (which is coincident with mechanical parting of the disconnect blades, if an S&C Circuit-Switcher is furnished).

For example, if the capacitor-bank switching device is a 230-kv S&C Circuit-Switcher, the minimum gross overvoltage circuit time delay setting should be 0.5 second plus 0.6 second, or 1.1 seconds total. The elapsed time between energization of the opening circuit and mechanical parting of the disconnect blades can be approximated as 40% of the maximum operating time of the particular S&C Circuit-Switcher used.

Step 9

Record, for future reference, the time-delay settings selected in Steps 7 and 8.

‡ Required to prevent gross overvoltage lockout due to transient system voltage.

FIELD DETERMINATION OF NEED FOR UNBALANCE COMPENSATION

Step 10

Close the capacitor-bank switching device to energize the capacitor bank.

Verify that no capacitor units have been isolated from the capacitor bank (check for blown fuses). The voltmeter should read essentially zero or, at most, 50% of the capacitor-bank neutral-to-ground voltage calculated to result from the isolation of one capacitor unit. Record, for future reference, this voltmeter reading. If the voltmeter reading exceeds 50% of the capacitor-bank neutral-to-ground voltage calculated to result from the isolation of one capacitor unit, it will be necessary to either increase the alarm-level setting or to utilize the optional unbalance compensation module, adjusted as described in Step 11.

ADJUSTMENT OF UNBALANCE COMPENSATION

Step 11

If the voltmeter reading taken in Step 10 exceeds 50% of the capacitor-bank neutral-to-ground voltage calculated to result from the isolation of one capacitor unit, unbalance compensation is required. Assuming that the plug-in unbalance compensation module is installed, calibrated,† and connected, proceed as follows: Turn the "amplitude adjust" screw five full turns clockwise from its fully counterclockwise position. Then turn the "phase-fine adjust" screw three full turns clockwise from its fully counterclockwise position. If the voltmeter reading exceeds the full-scale value, temporarily turn the voltmeter range selector switch to the next higher scale. Next, turn the "phase-coarse adjust" screw to operate the four-position rotary switch (at random) to attain a minimum reading on the voltmeter. Turn the "amplitude adjust" screw to further reduce the voltmeter reading. Turn the "phase-fine adjust" screw to attain a minimum reading on the voltmeter. Return the voltmeter range selector switch to the desired scale. Turn the "amplitude adjust" screw to further reduce the voltmeter reading and then turn the "phase-fine adjust" screw to attain a final minimum reading on the voltmeter. Record, for future reference, this voltmeter reading.

† *The unbalance compensation module is factory calibrated in accordance with information furnished by the purchaser at the time of ordering.*

VERIFICATION OF CALCULATED LOCKOUT AND ALARM LEVELS

Lockout level can be checked as follows:

Step 12

Verify that no capacitor units have been isolated from the bank.

Step 13

De-energize the capacitor bank by opening the capacitor-bank switching device. Then ground the bank, observing established operating procedures and safety precautions. Isolate the number of capacitor units—all in the same series group—previously determined as required to lock out the bank, by removing their respective fuses.

Step 14

Remove the temporary grounds, re-energize the bank, and record the voltmeter reading. If the voltmeter deflection exceeds the lockout-level value, an automatic switching operation will occur to isolate the entire capacitor bank after the timer completes its cycle—as indicated by the "Lockout Indicator" lamp. In any event, de-energize the bank by opening the capacitor-bank switching device as soon as the voltmeter reading has been obtained, to avoid shortening the life of the capacitor units. Verify that no other capacitor units have been isolated.

Note: Following automatic lockout of the capacitor bank, the bank can be returned to service *only after pressing* the "Lockout Indicator" button. This permits closing of the capacitor-bank switching device.

Step 15

De-energize and ground the capacitor bank, observing established operating procedures and safety precautions. Reconnect the fuses which were previously removed to isolate the capacitor units.

Step 16

Repeat Steps 13 through 15 for each of the remaining phase legs of the capacitor bank.

Step 17

Verify that the calculated lockout level is lower than the lowest voltmeter reading obtained in Steps 12 through 16. A calculated lockout level higher than one or two of the voltmeter readings obtained in Steps 12 through 16 indicates that system voltage unbalance and/or inherent capacitor-bank unbalance is creating an error voltage appearing between the capacitor-bank neutral and ground, sufficient in magnitude to obscure the neutral-to-ground voltage resulting from the isolation of successive capacitor units. In this event, either of two actions may be taken:

1. Reduce the lockout-level setting to a value lower than the lowest reading obtained in Steps 12 through 16, with the knowledge that lockout may occur with a lesser number of individual capacitor units removed from service.
2. Install the optional plug-in unbalance compensation module and adjust it as indicated under ADJUSTMENT OF UNBALANCE COMPENSATION.

Step 18

To check the alarm level value (if the optional alarm module set is included), proceed in the same manner described in Steps 12 through 16 with regard to checking the lockout-level value.

MAINTENANCE

No routine maintenance is recommended for the Type UP Automatic Control Device other than an occasional exercising (about once per year) to verify that it is operational. This can be done by temporarily adjusting the lockout level downward until lockout of the capacitor bank occurs.

At installations utilizing an S&C Circuit-Switcher as the capacitor-bank switching device, the associated S&C Switch Operator, Type CS-1A or Type CS-2A, may be conveniently decoupled from the Circuit-Switcher. This capability makes it possible to check out the Type UP Automatic Control Device without actually switching the capacitor bank.

It is advisable, for the first few days after start-up, to compare day-to-day voltmeter readings with those recorded in Step 10 or Step 11. It is possible for changes to occur due to irregularities in the voltage-monitoring devices or to aberrations (developing faults) in the capacitor units themselves. When it has been determined that the capacitor-bank neutral-to-ground voltage is remaining constant, voltmeter readings may be compared at convenient intervals. If a small increase in capacitor-bank neutral-to-ground voltage is then observed, it can be an indication of a failing capacitor unit.

Use the "push-to-read" buttons on the appropriate modules to occasionally check the alarm level (if applicable) and lockout level—as indicated on the voltmeter—against the settings recorded in Step 5.

Finally, it may be prudent to confirm that the time-delay settings, as recorded in Step 9, have not been altered.

SPECIFICATIONS

Automatic Control Device

Catalog Number Suffix	Control-Source Voltage		Current
	Nominal	Operating Range	
A	48 v dc	38.5—56 v dc	1 amp
B	125 v dc	100—140 v dc	1 amp
D	120 v, 60 hz	102—132 v, 60 hz	½ amp
E	240 v, 60 hz	204—264 v, 60 hz	¼ amp

Operating Temperature Range

Ambient adjacent to device ...... -40°F to + 160°F

Neutral-to-Ground Voltage Input Circuit

Normal operating voltage range ..... 0 to 10 v, 60 hz
Frequency range .... 60 ± 0.3 hertz§
Burden .... 1 va maximum

§ For 50-hertz applications, refer to the nearest S&C Sales Office.

‡ For any combination of control-source voltage and ambient temperature within specified range.

System-Voltage Input Circuit (for optional unbalance compensation module)

Voltage range .... 60 to 140 v, 60 hz
Frequency range .... 60 ± 0.3 hertz§
Burden .... 1 va maximum

Neutral-to-Ground Voltmeter

Accuracy .... ± 2% of full-scale reading
Ranges .... 0-500, 0-1000, 0-2000 volts

Lockout Level Module

Level Detector
Adjustment range .... 0 to 2000 volts
Accuracy .... ± 1% of setting‡

Time Delay—To Initiate Lockout
Factory setting .... 10 seconds
Adjustment range .... 1 to 30 seconds
Accuracy .... ± 3% of setting‡

SPECIFICATIONS — Continued

Optional Alarm Module Set

Level Detector
- Adjustment range . . . . 0 to 2000 volts
- Accuracy . . . . ± 1% of setting‡

Time Delay—To Initiate Alarm★
- Factory setting . . . . 10 seconds
- Adjustment range . . . . 1 to 30 seconds
- Accuracy . . . . ± 3% of setting‡

Gross Overvoltage Circuit

Level Detector
- Adjustment range . . . . 1000 to 5000 volts
- Accuracy . . . . ± 5% of setting‡

Time Delay—To Initiate Lockout
- Factory setting . . . . 2 seconds
- Adjustment range . . . . 0.5 to 5 seconds
- Accuracy . . . . ± 5% of setting‡

Output-Relay Contact Ratings

Current Carrying
- Continuous . . . . 10 amperes
- 1-Second . . . . 50 amperes

Interrupting . . . . 1.0 ampere at 48 v dc,
0.5 ampere at 125 v dc,
10 amperes at 120 v, 60 hz,
or 5 amperes at 240 v, 60 hz

Approximate Shipping Weight

Type UP Automatic Control Device only . . . . . 26 lbs.
Type UP Automatic Control Device in Weatherproof Enclosure . . . . 186 lbs.
Type UP/VR Automatic Control Device in Weatherproof Enclosure . . . . 212 lbs.

‡ For any combination of control-source voltage and ambient temperature within specified range.

★ Utilizing lockout level module time delay.

Options

Options which have been included with the Type UP Automatic Control Device are signified by the addition of one or more suffixes to the catalog number of the control device, as indicated in the following table:

Item	Suffix Added to Automatic Control Device Catalog Number
Plug-in alarm module set, consisting of one alarm level module and one alarm control module. Provides an alarm signal upon loss of a lesser number of capacitor units than that corresponding to the lockout-level setting.	-H
Plug-in unbalance compensation module. Compensates for system voltage unbalance plus inherent capacitor-bank unbalance,① or for inherent capacitor-bank unbalance only ②	-K
Mounting bezel for flush mounting of Type UP Automatic Control Device.	-L
Mounting bezel for flush mounting of Type UP/VR Automatic Control Device.	-M
Card extender for Type UP Automatic Control Device. Permits positioning of any module for test. Required for field calibration.	-N
Card extender kit for Type UP/VR Automatic Control Device. Permits positioning of any module for test. Required for field calibration.	-P

① Additional connections are required to output terminals of three S&C 30-Volt-Ampere Potential Devices, each equipped with factory-adjusted calibration device (catalog number suffix "-T") and having a system voltage rating equal to the voltage of the system to which the capacitor bank is connected (or three voltage transformers). Note: When an unbalance compensation module is applied with Type UP/VR, any one of these three potential devices (or voltage transformers) may take the place of the potential device or voltage transformer normally required for sensing bus voltage. Specify catalog number of S&C Potential Devices (or primary voltage rating and turns ratio of voltage transformers, plus nominal voltage of voltage-transformer secondary circuit, i.e., whether 115—120 volts or 65.71—69.3 volts). Alternately, where a high-impedance grounding transformer is used for line-to-ground voltage stabilization, connections may be made to the secondaries of the grounding transformer (specify turns ratio and voltage of secondary circuit of grounding transformer), using three 1:1-ratio voltage transformers (furnished by user).

② Additional connections are required to output terminals of one S&C 30-Volt-Ampere Potential Device equipped with factory-adjusted calibration device (catalog number suffix "-T"), and having a system voltage rating equal to the voltage of the system to which the capacitor bank is connected (or one voltage transformer). Alternately, where a high-impedance grounding transformer is used for line-to-ground voltage stabilization, connections may be made to any secondary of the grounding transformer, using a 1:1-ratio voltage transformer (furnished by the user).

Accessories

Item	Catalog Number
Detailed instruction manual for Type UP Automatic Control Device	RD-3355
Detailed instruction manual for Type UP/VR Automatic Control Device	RD-3360

S&C ELECTRIC COMPANY • Chicago
S&C ELECTRIC CANADA LTD. • Rexdale

GENERAL

This operating description covers the operation of the S&C Automatic Control Device - Type UP for Protection of Ungrounded Wye-Connected Shunt Capacitor Banks.

A block diagram of the Type UP is shown on Drawing #CDR-3109R2, Sheet 1 of 2. An unbalance within the capacitor bank is detected by using an S&C 15 volt-ampere Potential Device to monitor the voltage between the capacitor bank neutral and ground. The Potential Device output is connected to the voltmeter module where the neutral displacement signal is isolated, amplified, filtered and rectified for metering and level detection. Following the voltmeter module are the lockout level module and the optional alarm level module which are used to compare the output of the voltmeter module (neutral displacement signal) against a reference level (the lockout or alarm level setting). When the voltmeter module output exceeds the reference level, the level detector calls for the lockout or alarm timer to start timing. This time is adjustable from 1 to 30 seconds. Upon completion of the lockout timing cycle the lockout control module is activated to energize a latching relay (86). Isolated contacts of the latching relay (1 N.O., 1 N.C.) are provided for connection to the control circuits of the capacitor bank switching device. Upon completion of the alarm timing cycle the alarm control module is activated to energize a latching relay (74). Isolated contacts of the latching relay (1 N.O.) (1 N.C.) are provided for connection to customer's alarm circuits.

A more detailed circuit description follows with reference to the schematic for the S&C Automatic Control Device - Type UP. Drawing number RD-3089 and RD-3150.

48 VDC/125 VDC POWER SUPPLY MODULE (CATALOG NUMBER SUFFIX A OR B)

The function of the power supply module is to convert the customer's control voltage source (48 VDC or 125 VDC) to a $\pm$ 15 volt dc supply. The power supply circuit is a shunt type zener regulator made up of zener diodes D1 and D2 and a series dropping resistor R2. Capacitors C1, C2 and C3 provide high frequency transient suppression. Switch S1 is the "Power ON-OFF" toggle switch and lamp I1 is the illuminated "Power ON" indicator located on the front of the Power-Supply module. The resistor R3 is used to reduce the voltage on lamp I1 and thereby extend operating life. The 33X auxiliary relay designated K-1 is used to eliminate the possibility of Automatic Control Device operation when the capacitor bank switching device is opened. This is accomplished by connecting the K-1 relay and its series dropping resistor R1 in series with a "b" contact from the capacitor bank switch operator such that when the switch operator is in the open position, the K-1 relay is energized to short circuit the voltmeter module output signal.

120 VAC/240 VAC POWER SUPPLY MODULE (CATALOG NUMBER SUFFIX D OR E)

The function of the power supply module is to convert the customer's control voltage source (120 VAC or 240 VAC) to a $\pm$ 15 volt dc supply. A step down transformer (located on the left side plate of the relay rack) transforms 120 or 240 VAC to 40 VAC. The power supply consists of full wave rectifiers DB1 and DB2, series regulators IC1 and IC2, filter capacitors C1, C3, and high frequency noise suppression capacitors C2, C4 and C5. Resistive dividers R1 and R2 allow adjustment of the +15 volt supply. Zener diodes D1 and D2 provide overvoltage protection. Switch S1 is the "Power ON-OFF" toggle switch and lamp I1 is the illuminated "Power ON" indicator located on the front of the power supply module. The 33X auxiliary relay designated K-1 is used to eliminate the possibility of Automatic Control Device operation when the capacitor bank switching device is open. This is accomplished by connecting the K-1 relay in series with the "b" contact from the capacitor bank switch operator such that when the switch operator is in the open position, the K-1 relay is energized to short circuit the voltmeter module output signal.

VOLTMETER MODULE

The function of the voltmeter module is to isolate, amplify, filter and rectify the neutral displacement signal and to provide a meter for the direct reading of capacitor bank neutral-to-ground voltage. Resistor R21 is a switchable fixed burden resistor required to establish the voltage ratio of the neutral Potential Device.* Transformer T1 provides isolation between the Automatic Control Device and the neutral Potential Device and has a 2.67 to 1 stepdown ratio. Resistor R1 is the voltmeter calibration adjust and is used to adjust the neutral displacement signal level to achieve a direct reading of the neutral-to-ground voltage on the voltmeter module panel meter. The calibrated neutral displacement signal is half wave rectified by diode D1 which in turn is connected to the "gross overvoltage" circuit of the lockout control module which will be described later. (Refer to lockout control module.) The calibrated neutral displacement signal is also connected to a combination summing amplifier and 60 Hz narrow bandpass filter, consisting of fixed resistors R3, R4, R5, R6 and R8, capacitors C3, C5 and an operational amplifier IC1 - also variable resistor R10 which is used to adjust zero dc offset of the operational amplifier, and adjustable resistor R17 which is the phase adjust of the bandpass filter (adjusted for a phase shift of zero between input and output of the filter). The signal power level is boosted by means of operation amplifier IC2 and fixed resistors R19 and R20. This amplifier has a gain of 1. The output of the amplifier IC2 drives a step-up transformer which has a ratio of 1 to 20. This voltage is the full wave rectified by means of diode D2 and D3 and filtered by means of resistor R11 and capacitor C4. The output of this RC filter is divided by means of a complex resistor divider and the output of this divider is connected to the inputs of the lockout level module and the alarm level module. The divider output (green test point) is a dc signal which is directly related to the calibrated neutral displacement voltage such that a 5 volt dc level at the output of this divider corresponds to a 2000 volt neutral displacement signal applied to the high side of the neutral Potential Device. Selector switch S1 allows switching of the panel meter to ranges of 500V, 1000V or 2000V full scale. Resistors R13 and R14 are used to maintain a fixed divider ratio independent of the range position of the range selector switch. Relay K-1 is used to switch the meter M1 of the voltmeter module from the output of the voltage divider to the reference level setting of the lockout level module or alarm level module to provide direct reading of alarm and lockout level settings with meter M1. Relay K-1 is energized by depressing the "push-to-read" pushbutton of the alarm level or lockout modules. Since switching out the voltmeter circuit would drastically affect the voltmeter module output divider ratio and thus the output signal level, the voltmeter circuit when switched out is replaced by means of a K-1 relay contact with an equivalent resistor R18.

LOCKOUT LEVEL MODULE

The function of the lockout level module is to compare the output of the voltmeter module (neutral displacement signal) against a dc reference (lockout level setting) and start a timer in the event the neutral displacement signal exceeds the lockout level setting. Upon expiration of the timing cycle, the lockout level module sends an operate command to the lockout control module.

A +5 volt dc supply is derived by means of integrated circuit regulator IC3. An adjustable, low frequency, continuously running oscillator is formed by fixed resistors R3, R4, R5, R6, R8 capacitor C1, comparator IC2 and adjustable resistor R7. R7 is used to adjust the frequency of oscillation and therefore the time delay. The output of the low frequency oscillator (pin 7 of IC2) is connected to the input of the decade counter circuit (IC5, IC6).

A comparator IC1 is used to compare the output of the voltmeter module (neutral displacement signal) against a reference voltage set up by divider R2 (lockout level setting). The reference level is adjustable from 0 - 5 volts dc which directly corresponds to a capacitor bank neutral-to-ground voltage of 0 - 2000 volts ac. When the voltmeter module output signal (pin 3 of IC1) exceeds the reference (pin 2 of IC1), comparator IC1 output (pin 7) will change from a high to a low state to enable the divide-by-80 counter (IC5, IC6). After 80 counts the output of the counter circuit pin 11 of IC6 will change from a low to a high state to bias on transistor Q1 of the lockout control module.

ALARM LEVEL MODULE

The function of the alarm level module is to compare the output of the voltmeter module (neutral displacement signal) against a dc reference (alarm level setting) and start a timer in the event the neutral displacement signal exceeds the alarm level setting. Upon expiration of the timing cycle, the alarm level module sends an operate command to the alarm control module.

A +5 volt dc supply is derived by means of integrated circuit IC2. The output of the low frequency oscillator of the lockout level module is connected to the input of the decade counter circuit (IC4, IC5) of the alarm level module.

LOCKOUT CONTROL MODULE

The function of the lockout control module is to operate a lockout relay (86) in the event an operate command is received from the lockout level module or the gross overvoltage curcuit of the lockout control module.

After the variable timer of the lockout level module has gone through its time cycle, the lockout level module output goes high and turns on transistor Q4 of the lockout control module. This in turn energizes a light-emitting diode within the opto-isolator IC1. The output of the opto-isolator is a photo-transistor. Light from the light-emitting diode turns on the photo-transistor which biases on transistors Q2 and Q3 to energize the latching relay 86 and turn on the lamp I1 through a normally open 86 contact. The latching relay 86 remains pulled in by means of a permanent magnet latch and can be reset manually by means of switch S1. Switch S1 (located on the front of the lockout control module) resets the 86 relay by reversing the voltage on the relay coil).

The voltage unbalance signal, from the voltmeter module, is also brought out to the lockout control module pin 7 to a circuit called the gross overvoltage circuit.

The function of the gross overvoltage circuit is to provide a redundant trip path to the lockout control circuitry bypassing much of the voltmeter module and all of the lockout level module and to provide a fast trip for major faults within the capacitor bank. The gross overvoltage circuit monitors the voltage unbalance signal and is comprised of four functional parts; the detector, buffer, timer and driver. In the event that the voltage unbalance signal exceeds the gross overvoltage trip level setting, as adjusted by a potentiometer, the detector will go active causing the buffer to initiate the timer which after a preselected time delay, adjustable by a potentiometer, causes the driver to activate the lockout circuitry.

The function of the gross overvoltage level detector is to compare the voltage unbalance signal derived from the front end of the voltmeter module to the gross overvoltage trip setting. The detector is composed of a bias resistor, a high pass filter followed by a comparator. The bias resistor is R6, while the filter is a combination of C3 and R10, and the comparator is IC2.

The function of the buffer is to elongate the pulses out of the detector into a dc level capable of activating or deactivating the timer. The IC4A and IC4B comparators, along with resistors R17, R18, R21, R22, R23, R24, R26, R32 and capacitor C6, compare the duration of the positive excursion of the output pulses out of the detector against the time constant as derived from resistors R17, R18 and capacitor C6. Whenever these positive excursions are shorter than 25ms, the output of IC4B will go positive, reverse biasing the clamping diode IC3 (pins 5 and 12) and thus enabling the timer.

The timer's function is to add an adjustable time delay between the detection of a gross overvoltage condition and the activation of the lockout control circuitry. The time delay, as determined by the potentiometer R35 located on lockout control module (labeled time in seconds) and resistor R39, R42 and R43, is adjustable between 0.5 and 4 seconds.

The timer consisting of resistors R19, R20, R31, R35, R37, R39, R42, R43 capacitor C7 and comparator IC4C, is activated when the buffer releases the timing capacitor C7 allowing the capacitor to charge with a time constant determined by resistors R19, R20 and Capacitor C7. When the voltage across the capacitor, corresponding to a specific time delay equals the dc voltage reference as derived from the potentiometer R35 and resistors R31, R37, R39, R42, R43, the timer output will go low enabling the driver.

The function of the driver, consisting of comparator IC4D, resistor R28, R30, R44, R25, R33, transistor Q1 and diodes CR4, IC3 (pins 8 and 9, 3 and 14, 1 and 16, 6 and 11), provides voltage inversion as well as load isolation between the timer circuit and the

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lockout control circuitry. The transistor Q1 diodes D4, D5, D6 D7 and resistor R31, R32, R33 on the output of the comparator IC4D provide sufficient current drive as well as an orderly shutdown of the drive whenever the power supply drops below +12V. The diode IC3 (pins 6 and 11) provides logical isolation between gross overvoltage circuitry and the lockout control circuitry.

ALARM CONTROL MODULE (CATALOG NUMBER SUFFIX H)

The function of the optional alarm control module is to operate the alarm relay in the event an operate command is received from the alarm level module or the dc control voltage source is interrupted.

After the counter of the alarm level module has gone through 80 counts, the alarm level module output goes high and turns on transistor Q1 of the alarm control module. This inturn energizes a light-emitting diode within the opto-isolator IC1. The output of the opto-isolator is a photo-transistor. Light from the light-emitting diode turns on the photo-transistor which biases on transistor Q2 and Q3 to energize the latching relay 74 and turns on the lamp I1 through a normally open 74 contact. The latching relay 74 remains pulled in by means of a permanent magnet latch and can be reset manually by means of switch S1. Switch S1 (located on the front of the alarm control module) resets the 74 relay by reversing the voltage on the relay coil.

The loss-of-dc circuit is made up of resistors R11, R14 and R15, diodes D3 and D5, transistor Q4 will be biased on, which in turn will bias on transistor Q3 and energize the latching relay 74. The energy stored in capacitor C3 is sufficient to pull in lthe alarm relay 74. A permanent magnet holds the relay latched. The 74 relay can be manually reset by means of switch S1(located on the front of the alarm control module).

UNBALANCE COMPENSATION MODULE

The functions of the unbalance compensation module are: 1) to sum and filter the three system-derived voltages to provide a signal voltage proportional to system zero sequence voltage and use to compensate for system voltage unbalance and/or 2) to provide a 0-360° phase shifting network used to compensate for fixed unbalance resulting from variations among capacitor units in the bank.

Transformers T1, T2, T3 and T4 provide isolation between the external control wiring and the electronics. These transformers have a 2.67 to 1 stepdown ratio. Fixed resistors R17, R18, R19 and adjustable resistors R1, R2, R3 form voltage dividers. The adjustable resistors are adjusted such that with an input voltage of 120 volts rms at the transformer primary the voltage between test points TP1, TP2, TP3 and signal ground TP5 is 5 volts rms. The outputs of the voltage dividers are connected to a combination summing amplifier and bandpass filter consisting of fixed resistors R4, R5, R6, R7, R9, capacitors C3, C4 and an operational amplifier IC1 - variable resistor R8 which is the phase adjust of the bandpass filter (adjusted for a phase shift of 180° between input and output of the filter), and variable resistor R11 which is used to zero the dc offset of the operational amplifier. Variable resistor R12

continued . . .

is used to adjust the output voltage of the "Unbalance Compensation Module" to match the neutral signal due to system unbalance that is seen at the input of the Voltmeter Module summing amplifier.

A phase-shifting network is formed by fixed resistor R14, capacitors C5, C6 and variable resistor R15 ("Phase Fine Adjust"). Use of a center tapped secondary (split-phase connection) provide approximately 150° phase angle variation. Switch S1 ("Phase Coarse Adjust") provides for reversal of connection of the phase-shift network to the transformer, as well as means to short circuit capacitor C5 for an additional 90° phase shift required to provide four overlapping ranges covering the full 0-360°. Variable resistor R13 is the "Amplitude Adjust" used to match the magnitude of neutral voltage due to manufacturing tolerance among capacitor units.

* The voltmeter module includes a 500 ohm 7.5 watt burden resistor and a series miniature toggle switch located near the rear of the printed circuit board. The switch is to be positioned as follows:

- When an S&C 15 volt-ampere Potential Device is used for capacitor bank neutral-voltage monitoring, place the toggle switch in the "Burden-OUT" position.

- When an S&C 30 volt-ampere Potential Device is used for capacitor bank neutral-voltage monitoring, place the toggle switch in the "Burden-IN" position.

REVISIONS		
NO.	DATE	NOTICE
1	4-15-83	70392
2	2-11-85	71193
3	6-7-85	71299
4	8-29-85	71510

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DESCRIPTION	DRAWING NO.
OPERATING DESCRIPTION FOR S&C AUTOMATIC CONTROL DEVICE TYPE UP	

SCALE		AUTOMATIC CONTROL	MATERIAL: S & C SPEC. NO.: DESCRIPTION:
DR. BY A.C.	RD-3228	DEVICE TYPE UP	FINISH: S & C SPEC. NO.: DESCRIPTION:
CH. BY J.K.	NEXT ASSEM.	PRODUCT DESCRIPTION	UNLESS OTHERWISE SPECIFIED: DECIMAL DIMS TO BE ± FRACTIONAL DIMS TO BE ± ANGLES TO BE ± BREAK ALL CORNERS REMOVE ALL BURRS
APP. BY	USED ON		
DATE 7-6-78			

REVISIONS

NO.	DATE	NOTICE NO.
1	2-11-85	71193

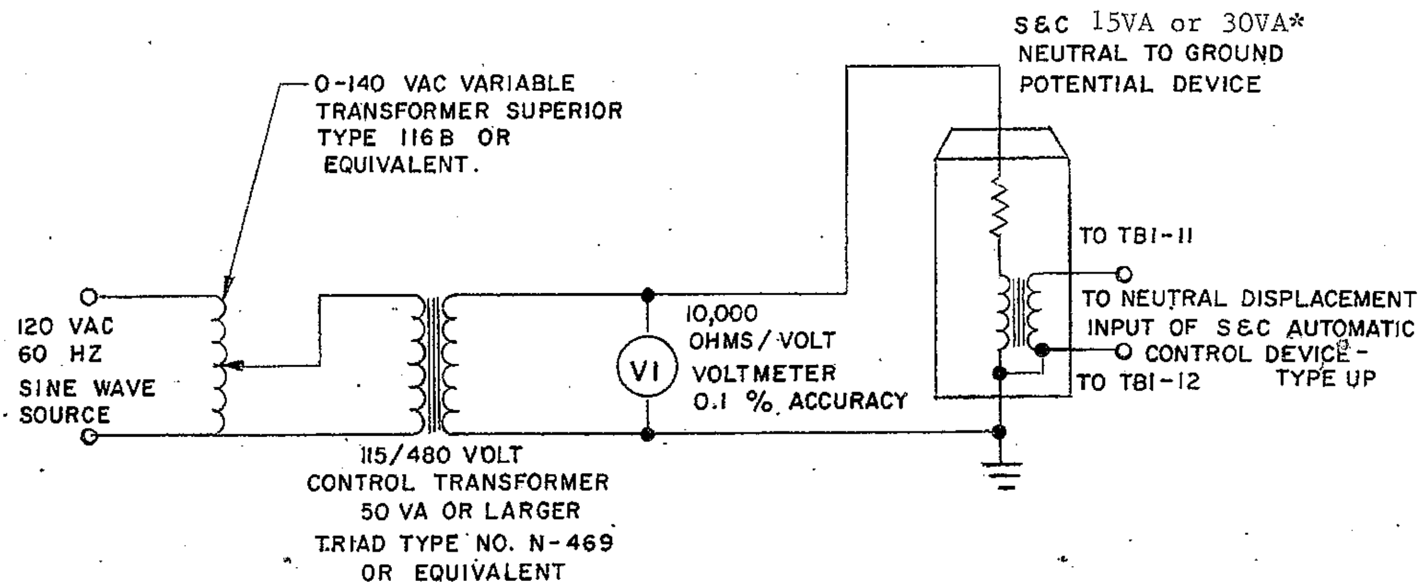

FIGURE 1 VOLTMETER MODULE CALIBRATION, TEST SETUP

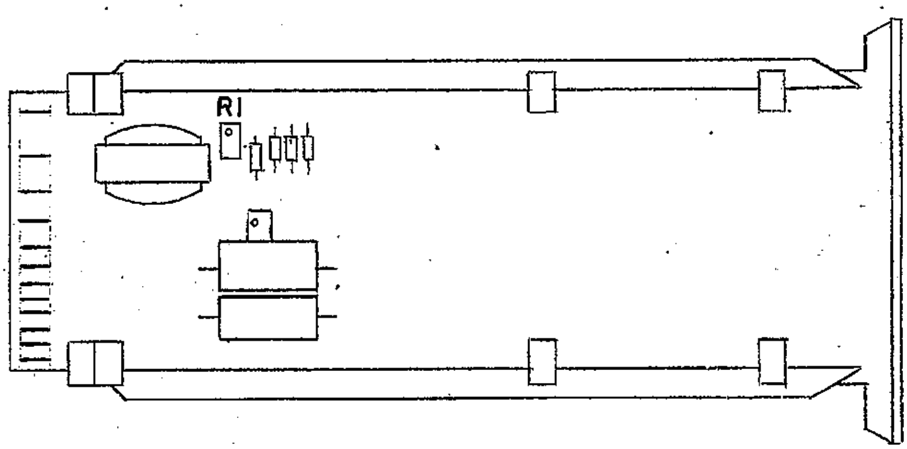

FIGURE 2 POTENTIOMETER LOCATION FOR VOLTMETER MODULE CALIBRATION ADJUST

* See Page Three

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DESCRIPTION
S&C AUTOMATIC CONTROL DEVICE - TYPE UP / FIELD RECALIBRATION OF THE VOLTMETER MODULE

DRAWING NO.
RD-3223 Page 1 OF 3

CAUTION: These instructions are intended only for qualified persons who are thoroughly trained and who understand any hazards that may be involved; and are not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

This voltmeter module has been factory calibrated. Recalibration is required only if the Automatic Control Device/Type UP is used with a Potential Device of a rating other than originally ordered. A calibration label is affixed to the backside of the voltmeter module faceplate at the time of shipment to indicate the voltage rating of the neutral Potential Device used for factory calibration.

1. De-energize and ground the capacitor bank.

2. Disconnect the high side of the neutral Potential Device from the capacitor bank neutral and place the Potential Device ground switch in the grounded position.

3. Disconnect the "b" contact from terminals TB2-6 and TB2-10 of S&C Automatic Control Device/Type UP or decouple the S&C Switch Operator and place the operator in the closed position.

4. Set up test circuit per Figure 1.

5. Withdraw voltmeter module and reinstall it using the card extender, S&C Part No. TA-1012. Place the Potential Device ground switch in the ungrounded position.

6. Place the voltmeter module "Range Selector Switch" on the 500 volt range. Adjust the lockout and alarm level settings for greater than 500 volts to avoid nuisance operations.

7. With variable transformer set at zero, energize the test circuit and then adjust the variable transformer for a voltmeter (V1) reading of 500 Vrms at the high side of the S&C Potential Device.

8. Adjust the voltmeter module "Calibration Adjust" for full scale deflection of 500 Vrms on the voltmeter module meter. This adjustment is labelled "R1" and is located towards the back of the voltmeter module. (See Figure 2 on Page 1.) This is a 23 turn potentiometer.

9. Calibration of the voltmeter module is now complete. De-energize and disconnect the test circuit. (If unbalance compensation is furnished, proceed to RD-3224 for further instructions.) Reconnect "b" contact to Automatic Control Device/Type UP at terminals TB2-6 and TB2-10. Reconnect the high side of the Potential Device to the capacitor bank neutral, remove grounds and restore the bank to service per operating procedures.

* Burden Selector Switch on Voltmeter Module must be set in the "Burden-Out" position when used with a 15VA Potential Device.

Burden Selector Switch on Voltmeter Module must be set in the "Burden-In" position when used with a 30VA Potential Device.

DRAWING NO.
Page 3 of 3
RD-3223

S&C ELECTRIC COMPANY / Specialists in High-Voltage Switching and Protection
GENERAL OFFICES • CHICAGO

DESCRIPTION	DRAWING NO. REV. 2-11-85, EN-71193
S&C AUTOMATIC CONTROL DEVICE/TYPE UP FIELD RECALIBRATION OF THE VOLTMETER MODULE	Page 3 of 3 RD-3223

S & C FORM NO 46-RD 78 (F) 67/87

REV 6-20-78 EN67464

CAUTION: These instructions are intended only for qualified persons who are thoroughly trained and who understand any hazards that may be involved and are not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

IMPORTANT: The unbalance compensation module has been factory calibrated. Recalibration is required only if the Automatic Control Device/Type UP is used with a bus-derived source or a capacitor bank neutral potential device other than what was originally ordered. A calibration label is affixed to the backside of the unbalance compensation module faceplate at the time of shipment, to indicate the primary-to-secondary voltage ratio and the potential device system voltage rating used for factory calibration of the system unbalance compensation circuit. A calibration label is also affixed to the backside of the voltmeter module faceplate to indicate the neutral potential device system voltage rating used for factory calibration of the voltmeter module.

The burden selector switch on the voltmeter module must be set in the "Burden-Out" position when used with a 15 volt-ampere potential device.

The burden selector switch on the voltmeter module must be set in the "Burden-In" position when used with a 30 volt-ampere potential device.

1. De-energize and ground the capacitor bank.

2. Calibrate the voltmeter module per the procedure outlined on S&C Drawing No. RD-3223.

3. Disconnect the line terminal of the capacitor-bank neutral potential device from the capacitor bank neutral and place the potential device ground switch in the grounded position.

4. Disconnect the "b" contact from terminals TB2-6 and TB2-10 (TB2-6 and TB2-7 for ac control-voltage source modules) of S&C Automatic Control Device/Type UP or decouple the S&C Switch Operator and place the operator in the closed position.

5. Remove the bus potential-transformer secondary fuses to isolate the Automatic Control Device/Type UP; if S&C Potential Devices are used to derive bus voltages, place the potential device ground switches in the grounded position.

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DESCRIPTION
S&C AUTOMATIC CONTROL DEVICE/TYPE UP FIELD RECALIBRATION OF UNBALANCE COMPENSATION MODULE

DRAWING NO. RD-3224

S&C FORM NO 46-RD 7A

6. Withdraw the unbalance compensation module and reinstall it using the card extender, S&C Part No. TA-1012.

7. Adjust the "Capacitor Unbalance Amplitude Adjust" fully counterclockwise. You will feel or hear the potentiometer clicking when you are at the full counterclockwise adjustment. This 23-turn potentiometer is accessible from the front of the unbalance compensation module.

<u>Note:</u> If voltage transformers are used to derive bus voltages for system voltage unbalance compensation, proceed to step 8. If S&C Potential Devices are used to derive bus voltages for system voltage unbalance compensation, proceed to step 18.

<u>Calibration For Voltage Transformer Inputs</u>

8. Disconnect wires from terminals TB1-9, TB1-10, TB2-11, and TB2-12 of the Automatic Control Device/Type UP.

9. Set up the test circuit per Figure 1 for connection to terminals TB2-11 and TB2-12 of the automatic control device.

10. Energize the test circuit. The voltmeter module will be pegged past full scale. However, the meter and associated circuitry can withstand this condition continuously without damage.

11. Adjust the variable transformer for a voltmeter V1 reading of 120 volts rms.

12. Adjust voltage-ratio potentiometer "R3" for 5 vac rms ± .1% between test points TP3 (green) and test point TP6 (black). See Figure 3 for potentiometer and test-point locations.

13. De-energize the test circuit. Disconnect the test circuit from terminal TB2-11 and reconnect to terminal TB1-10 on the automatic control device, using the same setup shown in Figure 1.

14. Adjust voltage ratio potentiometer "R2" for 5 vac rms ± .1% between test point TP2 (yellow) and test point TP6 (black).

15. De-energize the test circuit. Disconnect the test circuit from terminal TB1-10 and reconnect to terminal TB1-9 on the automatic control device, using the same setup shown in Figure 1.

16. Adjust voltage ratio potentiometer "R1" for 5 vac rms ± .1% between test point TP1 (red) and test point TP6 (black).

S&C FORM NO 46-RD 7A

17. De-energize the Figure 1 test circuit. Proceed to Step 23.

Calibration For Potential Device Inputs

18. Connect the line terminal of each of the three potential devices to a single phase of the bus.

19. Remove the grounds and re-energize the potential devices. (The potential devices are now connected to same phase.) The voltmeter on the voltmeter module will be pegged past full scale. However, the meter and associated circuitry can withstand this condition continuously without damage.

20. Adjust voltage-ratio potentiometer "R3" for 5* vac rms ± .1% between test point TP3 (green) and test point TP6 (black). See Figure 3 for potentiometer and test-point locations.

21. Adjust voltage-ratio potentiometer "R2" for 5* vac rms ± .1% between test point TP2 (yellow) and test point TP6 (black).

22. Adjust voltage-ratio potentiometer "R1" for 5* vac rms ± .1% between test point TP1 (red) and test point TP6 (black).

*If the bus voltage reading as derived from an independent voltmeter and voltage transformer having metering accuracy, is different from the potential-device system voltage rating, the value of adjust voltage is to be determined by the following formula:

$$(5) \times \frac{\text{Actual Bus Voltage}}{\text{Potential-Device System Voltage Rating}}$$

For example:

If 138 kv potential devices were used to derive bus voltage on a 120 kv system, the voltage-ratio potentiometers are to be adjusted for:

$$5 \times \frac{120}{138} = 4.35 \text{ vac rms}$$

Final Calibration For Voltage Transformer and Potential Device Inputs

23. Disconnect wires from terminals TB1-9, TB1-10, TB2-11 and TB2-12 of the Automatic Control Device Type UP.

24. Set up the new test circuit per Figure 2 for connection between terminals TB1-9 and TB2-12 of the automatic control device.

25. Energize the test circuit.

26. Adjust the variable transformer for a voltmeter V2 reading as indicated in the formula below:

$$V2 = \frac{3V1}{\text{Bus Potential Transformer or Potential Device Ratio}}$$

where V1 is the voltage measured at the line terminal of the capacitor-bank neutral potential device.

If an S&C Potential Device is used to derive bus voltage, use the voltage ratio indicated in Figure 4.

For example: A 69 kv capacitor bank uses bus potential transformers with a ratio of 350:1. If V1 measures 485 volts, adjust V2 as follows:

$$V2 = \frac{3 \text{ X } 485}{350} = 4.16 \text{ volts}$$

27. With the test circuit remaining energized, adjust system unbalance compensation potentiometer "R12" for minimum voltmeter deflection. See Figure 3. (The reading must be less than 100 volts on the voltmeter module with the range selector switch on the 500 volt range.)

28. De-energize the test circuit. Disconnect the test circuit from terminal TB1-9 and reconnect to terminal TB1-10 on the automatic control device, using the same setup shown in Figure 2.

29. With the test circuit energized, adjust voltage-ratio potentiometer "R2" for minimum voltmeter deflection. (The reading must be less than 100 volts on the voltmeter module with the range selector switch on the 500 volt range. If the voltmeter reading is less than 100 volts, no further adjustment is necessary.)

30. De-energize the test circuit. Disconnect the test circuit from terminal TB1-10 and reconnect to terminal TB2-11 on the automatic control device, using the same setup shown in Figure 2.

31. With the test circuit energized, adjust voltage-ratio potentiometer "R3" for minimum voltmeter deflection. (The reading must be less than 100 volts on the voltmeter module with the range selector switch on the 500 volt range. If the voltmeter reading is less than 100 volts, no further adjustment is necessary.)

32. De-energize the test circuit.

33. Reconnect the "b" contact to terminals TB2-6 and TB2-10 (TB2-6 and TB2-7 for ac control-voltage source modules) of the automatic control device.

34. Reconnect the line terminals of the potential device(s), remove grounds from the bank and restore the bank to service per operating procedures.

35. Upon energizing the bank, observe the voltmeter module reading; after verifying that no fuses are blown in the bank, perform the capacitor unbalance compensation adjustments located on the front of the unbalance compensation module, per S&C Instruction Sheet 531-500 to compensate for capacitor manufacturing tolerance unbalance.

36. As a final verification of the compensation calibration, proceed with "Verification of Lockout Level Setting" as outlined in S&C Instruction Sheet 531-500.

FIGURE 1 TEST CIRCUIT

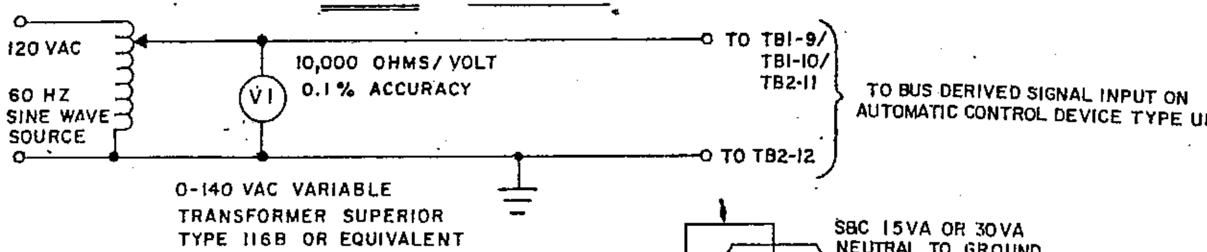


FIGURE 2

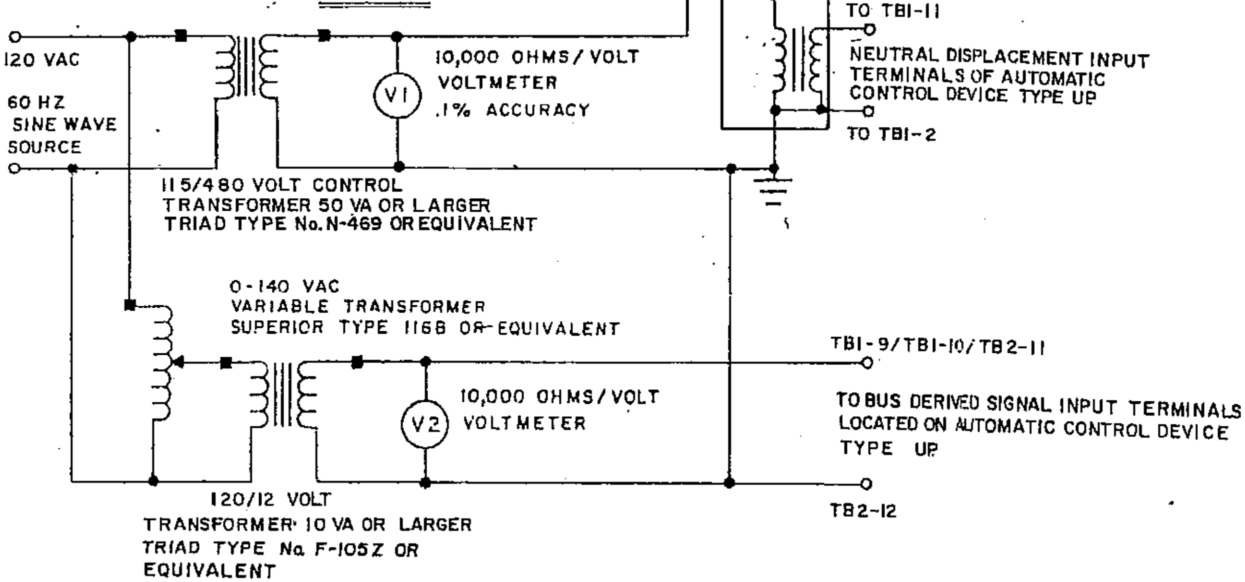
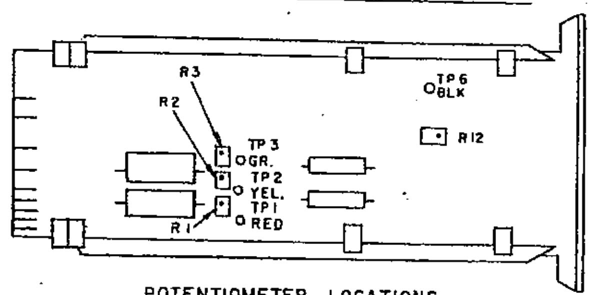


FIGURE 3 UNBALANCE COMPENSATION MODULE



POTENTIOMETER LOCATIONS

FIGURE 4 S & C 30VA BUS VOLTAGE POTENTIAL DEVICE VOLTAGE RATIOS

SYSTEM VOLTAGE RATING, KV	VOLTAGE RATIO
23	111:1
34.5	166:1
46	221:1
69	332:1
115	553:1
138	664:1

* — SEE FIG. 4

NOTICE NO.	DATE	NO.
3991	8-1-90	5
2148	6-16-87	4
193	2-11-85	3
149	5-11-79	2
64	6-20-78	1

REVISIONS

MATERIAL:
S&C SPEC. NO.
DESCRIPTION:

FINISH:
S&C SPEC. NO
DESCRIPTION

PROPRIETARY STATEMENT

RD-3228 AUTOMATIC CONTROL
DEVICE TYPE UP
NEXT ASSEM
PRODUCT DESCRIPTION
USED ON

SCALE
DR BY A.C.
CH BY J.K.
APP BY
DATE 1-11-78

DRAWING NO. RD-3224 PAGE 6 OF 6

S&C ELECTRIC COMPANY
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DESCRIPTION
S&C AUTOMATIC CONTROL DEVICE-TYPE UP
FIELD RECALIBRATION OF
UNBALANCE COMPENSATION MODULE

DRAWING NO. RD-3224 PAGE 6 OF 6

CATALOG NUMBER 38062R2-BHKLN

PARTS INCLUDED WITH ALL CATALOG NUMBERS

(2)	Miniature Lamp	9931-704	☐

PARTS INCLUDED WITH CATALOG NUMBER 38062R2

(2)	FRN-R-2 Fuses (2 Amp)	9931-186	☐
(1)	F3OA2S Fuse Block	9931-245	☐
(3)	FRN-R-5 Fuses (5 Amp) (Included with Catalog No. Suffix "K" Only)	0826-248	☐
(1)	F3OA3S Fuse Block (Included with Catalog No. Suffix "K" Only)	0826-249	☐

REVISIONS

NO.	DATE	NOTICE NO.
7	1-11-96	77165
8	8-8-97	78159
9	12-8-00	80819

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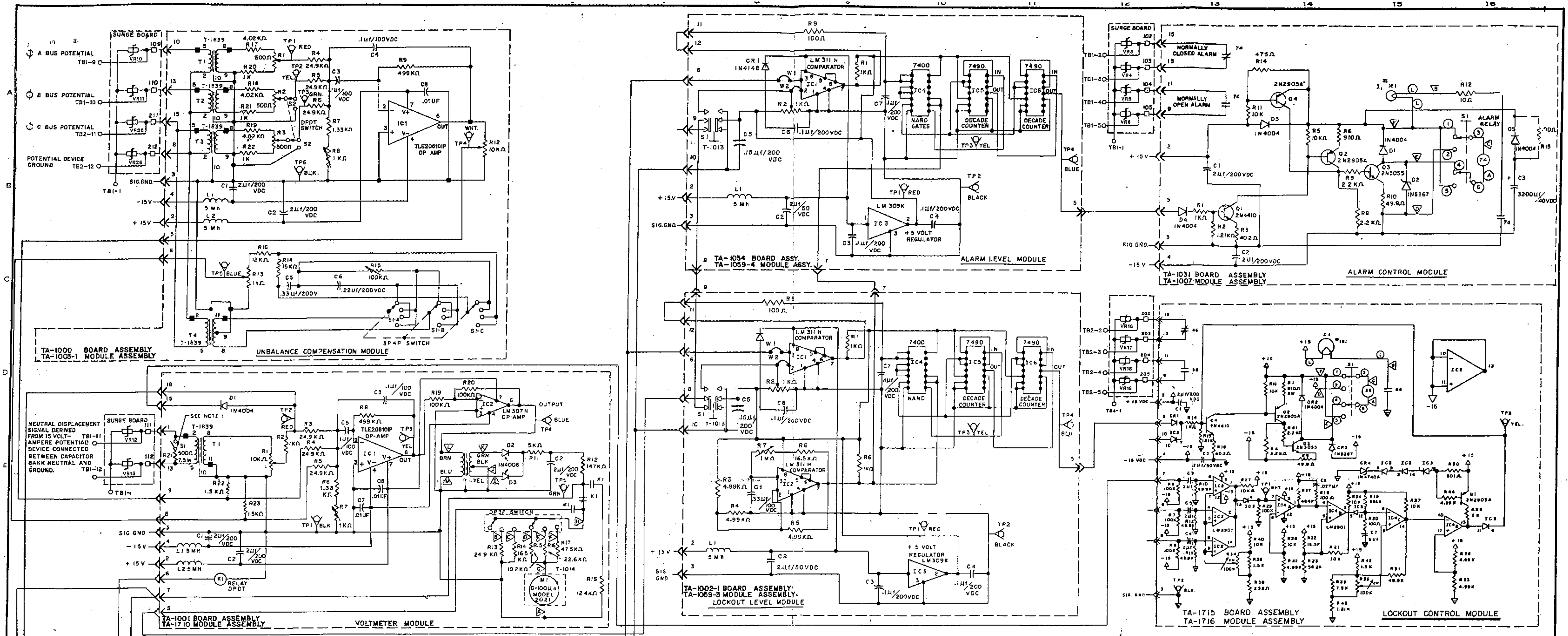
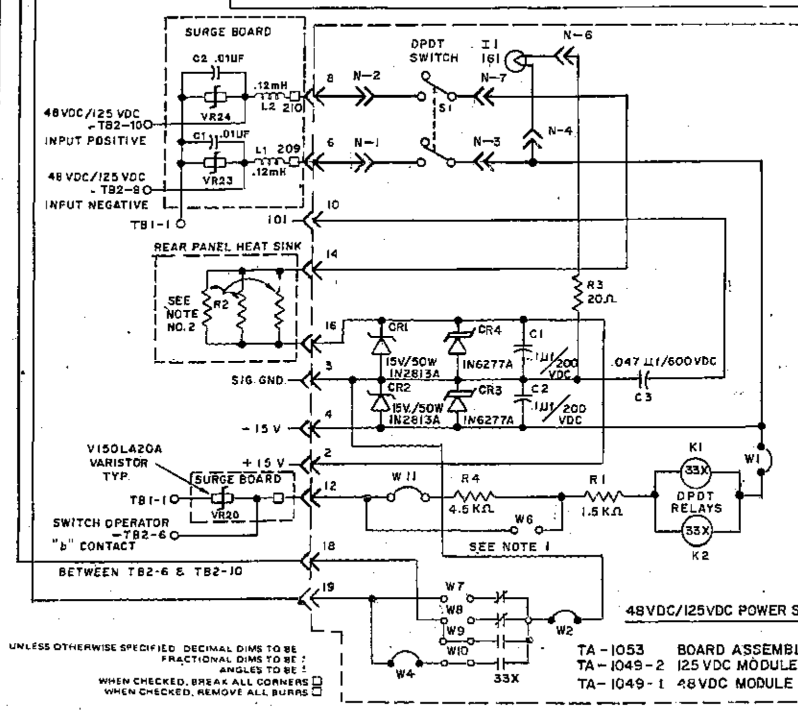
DESCRIPTION
S&C AUTOMATIC CONTROL DEVICE - TYPE UP
STANDARD INSTRUCTION MANUAL - TABLE OF CONTENTS

DRAWING NO. RD-3228 MST

DRAWING NO. RD-3228 MST





NOTES:

NO. 1

FOR 48VDC	PLACE SHUNT IN POSITION 6

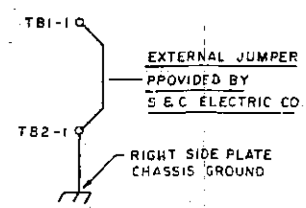
NO. 2

R2	FOR 125 VDC.	375 Ω /50W	3 EACH
R2	FOR 48VDC	50 Ω /50W	2 EACH

NOTE:

1.) BURDEN SELECTOR SWITCH MUST BE SET IN THE "BURDEN OUT" POSITION WHEN USED WITH A 15VA POTENTIAL DEVICE.

BURDEN SELECTOR SWITCH MUST BE SET IN THE "BURDEN IN" POSITION WHEN USED WITH A 30VA POTENTIAL DEVICE

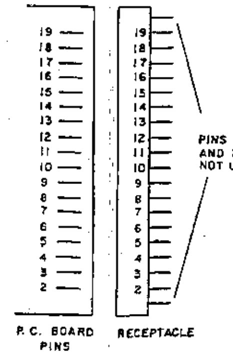


	LOCKOUT CONTROL MODULE
R34	GROSS OVER VOLTAGE TRIP LEVEL ADJUST
R35	GROSS OVER VOLTAGE TIME ADJUST(.5-4 SEC.)
S1	PUSH TO RESET LOCKOUT CONTROL SWITCH

CAUTION: Any installation, operation, inspection or maintenance of the equipment covered by this document must be performed by qualified persons who are thoroughly trained and who understand any hazards that may be involved. This document has been prepared only for such qualified persons and is not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

Before performing the operations described in this document the necessary safety procedures relative to this type of equipment must be carried out.

SWITCH AND POTENTIOMETER LEGEND	
PART NO.	DESCRIPTION
	UNBALANCE COMPENSATION MODULE
R1	PD2 VOLTAGE RATIO ADJUST
R2	PD3 VOLTAGE RATIO ADJUST
R3	PD4 VOLTAGE RATIO ADJUST
R8	BAND PASS FILTER ADJUST
R11	OUTPUT D.C. OFFSET ADJUST
R12	SYSTEM UNBALANCE COMPENSATION ADJUST
R13	CAPACITOR UNBALANCE AMPLITUDE ADJUST
R15	CAPACITOR UNBALANCE PHASE FINE ADJUST
S1	CAPACITOR UNBALANCE PHASE COARSE ADJUST
	VOLTMETER MODULE
R1	VOLTMETER CALIBRATION ADJUST
R7	BAND PASS FILTER ADJUST
R10	OUTPUT D.C. OFFSET ADJUST
S1	VOLTMETER RANGE SELECTOR
	LOCKOUT LEVEL MODULE
R2	LOCKOUT LEVEL ADJUST
R7	ALARM/LOCKOUT TIMING ADJUST
S1	PUSH TO READ LOCKOUT LEVEL SWITCH
	ALARM LEVEL MODULE
R2	ALARM LEVEL ADJUST
S1	PUSH TO READ ALARM LEVEL SWITCH
	ALARM CONTROL MODULE
S1	PUSH TO RESET ALARM CONTROL SWITCH
	POWER SUPPLY MODULE
S1	POWER CONTROL SWITCH



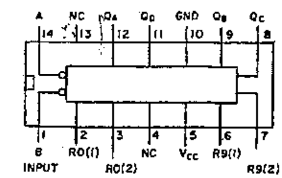
△ — P.C. BOARD WIRE LOCATION

○ — SWITCH TERMINAL

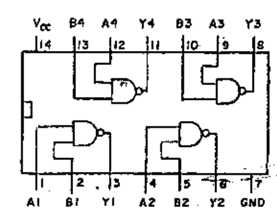
TEST POINT

□ — WIRE WRAP TERMINAL LOCATED ON SURGE BOARD

TB — TERMINAL BLOCKS LOCATED ON REAR PANEL



7490 DECADE COUNTER



7400 QUAD 2-INPUT NAND GATES

UNLESS OTHERWISE SPECIFIED DECIMAL DIMS TO BE ± FRACTIONAL DIMS TO BE ± ANGLES TO BE ± WHEN CHECKED, BREAK ALL CORNERS WHEN CHECKED, REMOVE ALL BURRS

29	9-17-98	78759
28	5-23-97	78034
27	8-17-93	75928
26	6-17-92	75186
25	9-11-91	74693
24	11-1-89	73634
23	3-22-88	72720
22	4-27-87	72303
21	10-3-86	72014
20	2-24-86	71720
19	8-21-85	71510
NO.	DATE	NOTICE No.
REVISIONS		

18	4-8-85	71299
17	8-3-84	70982
16	8-15-83	70553
15	2-9-81	69 45
14	8-2-80	69015
13	4-7-80	68693
12	5-21-79	68156
NO.	DATE	NOTICE No.
REVISIONS		

DRAWING NO. RD-3089

MATERIAL:
S&C SPEC. NO.:
DESCRIPTION:

FINISH:
S&C SPEC. NO.:
DESCRIPTION:

38062R2	S&C AUTOMATIC CONTROL DEVICE	
NEXT ASSEM.	PRODUCT DESCRIPTION	
USED ON		

SCALE —
DR. BY A.C.
CH. BY
APP. BY
DATE 10-3-86

S&C ELECTRIC COMPANY / Specialists in High-Voltage Switching and Protection

GENERAL OFFICES • CHICAGO

DESCRIPTION

S&C AUTOMATIC CONTROL DEVICE-TYPE UP

SCHEMATIC

48VDC/125VDC CONTROL VOLTAGE SOURCE

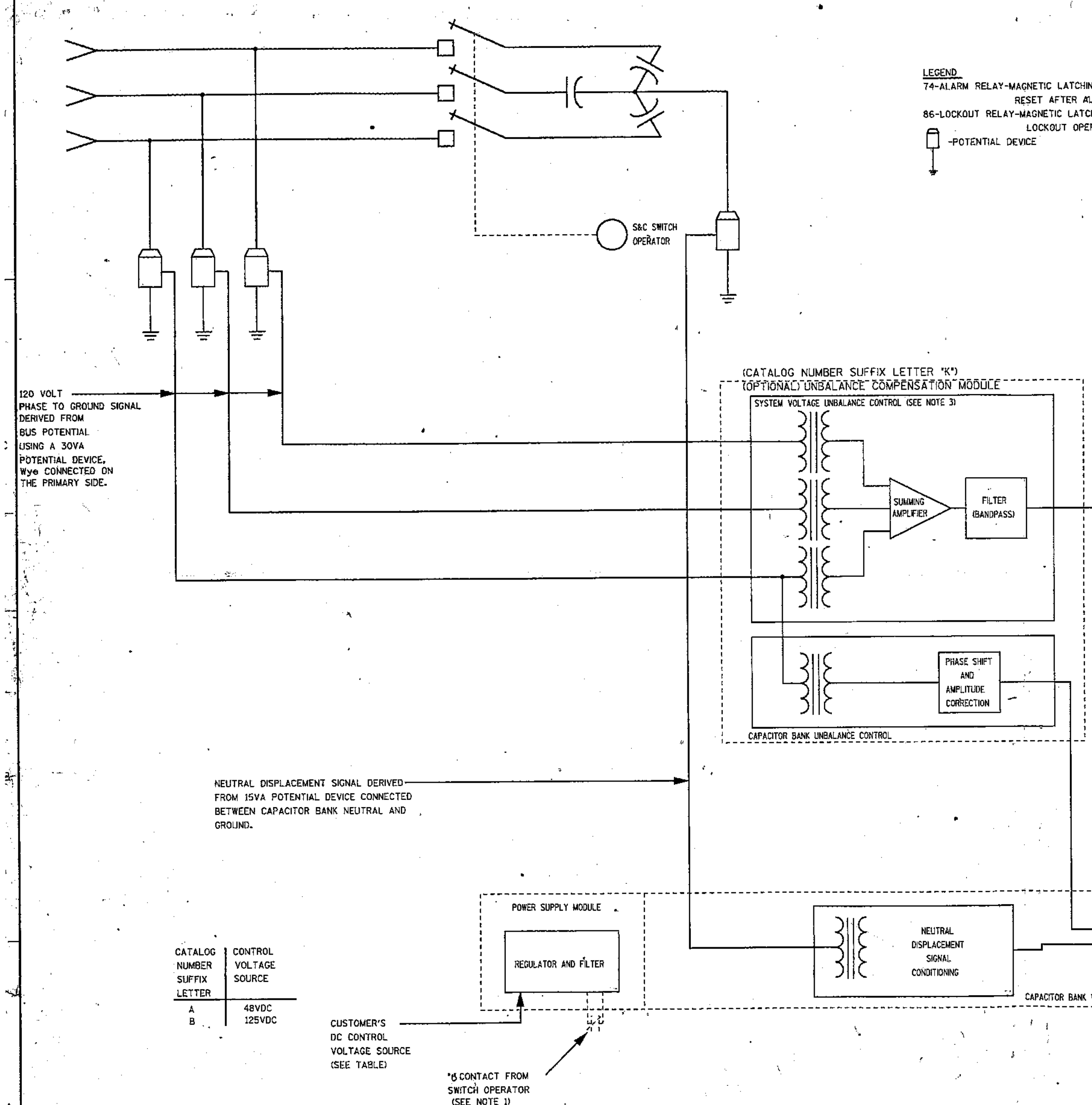
DRAWING NO. RD-3089

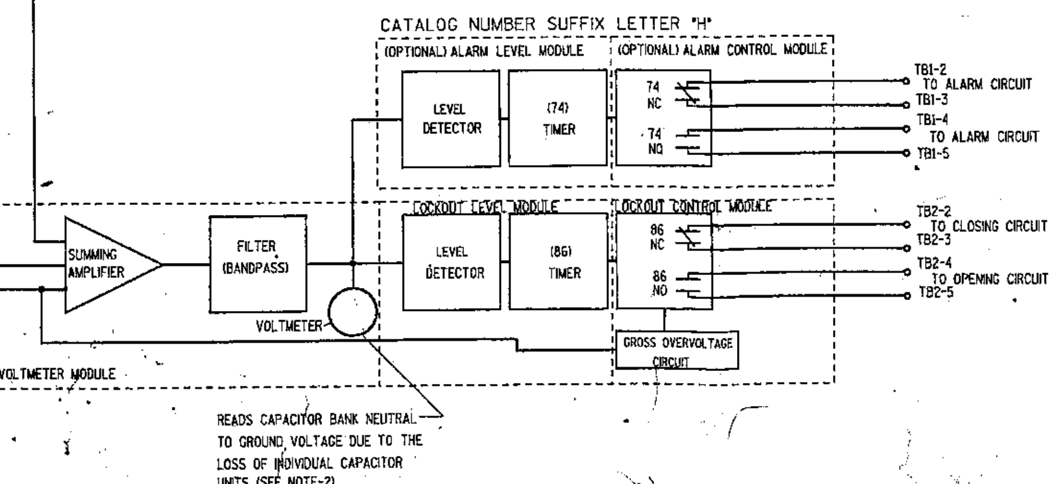
LEGEND

74-ALARM RELAY-MAGNETIC LATCHING TYPE REQUIRES MANUAL RESET AFTER ALARM OPERATION

86-LOCKOUT RELAY-MAGNETIC LATCHING TYPE REQUIRES MANUAL RESET AFTER LOCKOUT OPERATION

-POTENTIAL DEVICE





CATALOG NUMBER SUFFIX LETTER	CONTROL VOLTAGE SOURCE
A	48VDC
B	125VDC

NOTES:

1. THE "b" CONTACT IS USED TO ENERGIZE AN INTERNAL 33X RELAY TO ENSURE THAT THE LEVEL DETECTORS AND VOLTMETER ARE INOPERATIVE WHEN THE CAPACITOR SWITCHING DEVICE IS OPEN.
2. THE NEUTRAL TO GROUND VOLTMETER CIRCUIT IS FACTORY CALIBRATED TO OPERATE WITH A SPECIFIC 15VA NEUTRAL POTENTIAL DEVICE VOLTAGE RATING. A CALIBRATION LABEL IS AFFIXED TO THE BACK SIDE OF THE VOLTMETER MODULE FACEPLATE AT THE TIME OF SHIPMENT TO INDICATE THE VOLTAGE RATING OF NEUTRAL POTENTIAL DEVICE USED FOR FACTORY CALIBRATION.
3. THE SYSTEM UNBALANCE COMPENSATION CIRCUIT IS FACTORY CALIBRATED TO OPERATE WITH THE PRIMARY TO SECONDARY VOLTAGE RATIO SPECIFIED ON THE CUSTOMER ORDER OR THE SYSTEM UNBALANCE COMPENSATION CIRCUIT IS FACTORY CALIBRATED TO OPERATE WITH THE SPECIFIC 30VA POTENTIAL DEVICES WITH CATALOG NUMBER SUFFIX LETTER "T" SUPPLIED WITH THE CONTROL PANEL. A CALIBRATION LABEL IS AFFIXED TO THE BACK SIDE OF THE UNBALANCE COMPENSATION MODULE FACEPLATE AT THE TIME OF SHIPMENT TO INDICATE THE PRIMARY TO SECONDARY VOLTAGE RATIO USED FOR FACTORY CALIBRATION OF THE SYSTEM UNBALANCE COMPENSATION CIRCUIT.
4. ALL S&C AUTOMATIC CONTROL DEVICES ARE FACTORY TESTED TO VERIFY THEIR CAPABILITY TO WITHSTAND WITHOUT MIS-OPERATION OR DAMAGE I.E.E.E. SURGE WITHSTAND CAPABILITY TEST (I.E.E.E. GUIDE NUMBER 472-1974) THIS TEST IS APPLIED TO ALL CONTROL PANEL TERMINATION POINTS. THIS SURGE WITHSTAND CAPABILITY TEST IS SUGGESTED BY THE I.E.E.E. WORKING GROUP AS TYPICAL OF SURGES ENCOUNTERED IN APPLICATION AND USE OF STATIC RELAYS IN A UTILITY ENVIRONMENT.
5. ALL S&C AUTOMATIC CONTROL DEVICES, IN ADDITION, ARE FACTORY TESTED TO VERIFY CAPABILITY TO WITHSTAND WITHOUT MIS-OPERATION OR DAMAGE A 5KV 3.75-JOULE CAPACITIVE DISCHARGE SURGE (0.3 MFD. CAPACITOR CHARGED TO 5KV DC). THIS TEST REPRESENTS A SURGE LEVEL WELL IN EXSCESS OF THOSE NORMALLY ENCOUNTERED IN CONTROL WIRING.
6. CONTROL VOLTAGE FUSING PER THE RECOMMENDATION ON SHEET 2 OF 2 OF THIS CDR DRAWING MUST BE FOLLOWED TO PREVENT DAMAGE TO THE SURGE PROTECTION CIRCUITY IN THE RARE EVENT OF OCCURANCE OF SURGES EXCEEDING FACTORY TESTED LEVELS.
7. IF FREQUENT SURGES IN EXCESS OF FACTORY-TESTED LEVELS ARE EXPECTED, S&C MUST BE ADVISED AS TO THE SEVERITY OF THE SURGE CONDITIONS SO THAT APPROPRIATE SPECIAL RECOMMENDATIONS MAY BE MADE.
8. THE GROSS OVERVOLTAGE CIRCUIT TIME DELAY SHOULD BE A MINIMUM OF 0.5 SECONDS (TO PREVENT GROSS OVERVOLTAGE LOCKOUT DUE TO TRANSIENT VOLTAGES) PLUS THE TIME ELAPSED BETWEEN ENERGIZATION OF THE CAPACITOR-BANK SWITCHING DEVICE OPENING CIRCUIT AND CLOSING OF THE SWITCHING DEVICE "b" CONTACT (WHICH IS COINCIDENTAL WITH MECHANICAL PARTING OF THE DISCONNECT BLADES IF A CIRCUIT-SWITCHER IS FURNISHED).

REFERENCE:

RD-3228 INSTRUCTION MANUAL

81340R5 THRU 81349R5 CATALOG DIMENSION DRAWING (30VA) POTENTIAL DEVICE

581-500 INSTRUCTION SHEET (30VA) POTENTIAL DEVICE

81573 THRU 81576 CATALOG DIMENSION DRAWING (15VA) POTENTIAL DEVICE

581-510 INSTRUCTION SHEET (15VA) POTENTIAL DEVICE

NO.	DATE	NOTICE NO.
14	11-1-88	13107
13	4-8-85	71239
F	3-21-75	64329

REVISIONS

DRAWING NO. CDR-3109R2 SHEET 1 OF 2

UNLESS OTHERWISE SPECIFIED: DECIMAL DIMS TO BE± FRACTIONAL DIMS TO BE± ANGLES TO BE± WHEN CHECKED, BREAK ALL CORNERS ☐ WHEN CHECKED, REMOVE ALL BURRS ☐

DRAWING NO. CDR-3109R2

MATERIAL: S&C SPEC NO. DESCRIPTION:

FINISH: S&C SPEC NO. DESCRIPTION: UNITS (SEE NOTE 2)

PROPRIETARY STATEMENT

NEXT ASSEM. | PRODUCT DESCRIPTION | USED ON

SCALE N.T.S. | DR. BY LPY | DATE 11-1-88

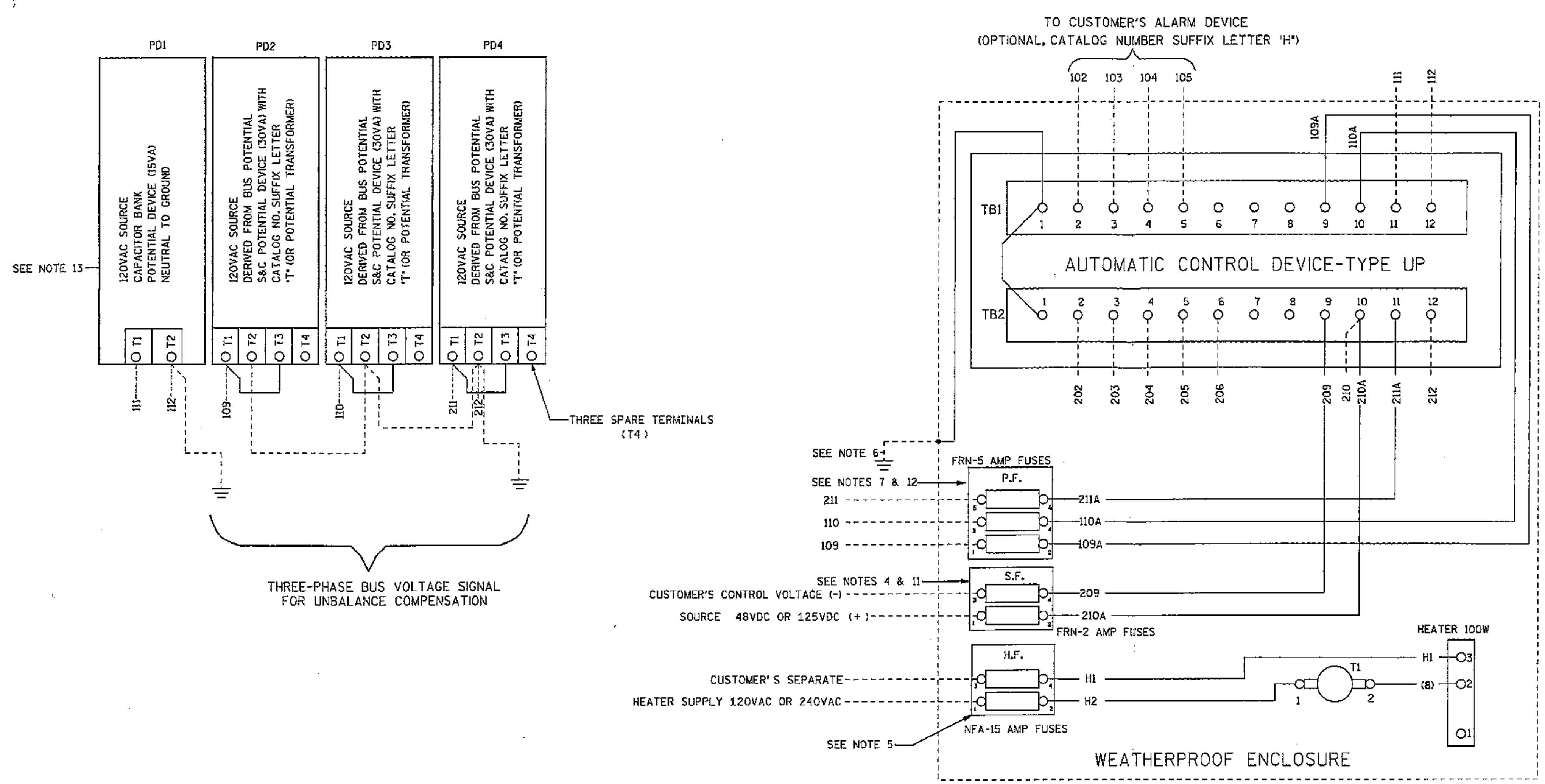
S&C ELECTRIC COMPANY
GENERAL OFFICES • CHICAGO
Specialists in High-Voltage Switching and Protection

DESCRIPTION
BLOCK DIAGRAM
AUTOMATIC CONTROL DEVICE-TYPE UP
(48/125VDC CONTROL VOLTAGE)

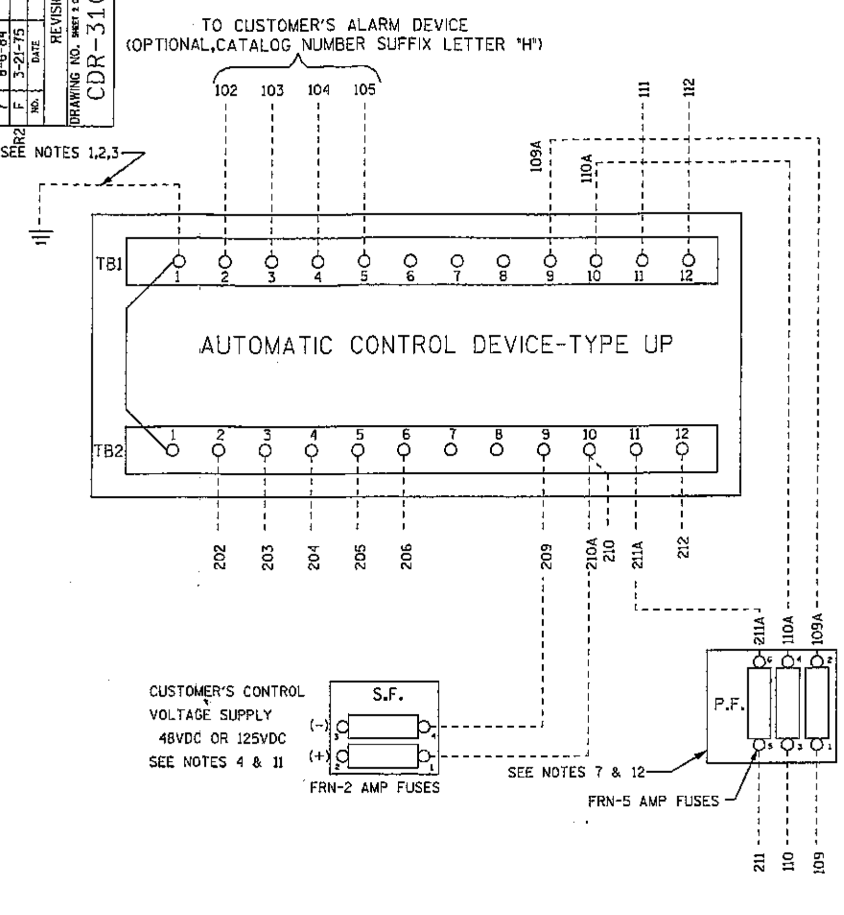
SHEET 1 OF 2

DRAWING NO. CDR-3109R2

REVISED/REDRAWN SAI ... TED 2-12-76



CATALOG NUMBER 38063R2



CATALOG NUMBER 38062R2

NO.	DATE	NOTICE NO.
9	05-23-97	78034
8	11-1-88	73107
7	8-6-84	70982
F	3-21-75	64329

REVISIONS

DRAWING NO. CDR-3109R2

NOTES:

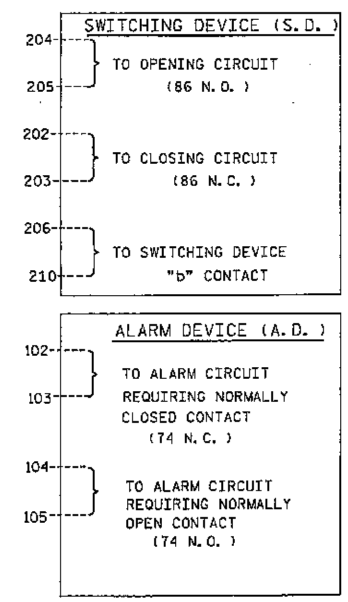
1. THE CUSTOMER IS TO ELECTRICALLY CONNECT TB1-1 OF 38062R2 TO THE GROUNDED METAL STRUCTURE OR DIRECTLY TO THE GROUND BUS WITH A MINIMUM OF NO. 12 AWG. WIRE.
2. IF THE CONNECTION IS MADE THROUGH THE METAL STRUCTURE, THE PAINT AND/OR OTHER NON-CONDUCTIVE COATINGS SHOULD BE REMOVED OR PENETRATED AT POINTS OF CONNECTION.
3. MEANS TO PREVENT POSSIBLE RUST OR CORROSION OF CONNECTION POINTS MUST BE PROVIDED. NO-OXIDE "A" OR A SIMILAR MATERIAL IS TO BE USED.
4. IT IS RECOMMENDED THAT THE PANEL BE FUSED BY USING BUSSMAN TYPE FRN 2 AMPERE FUSES OR EQUIVALENT, PLACED AS CLOSE AS PHYSICALLY POSSIBLE TO THE PANEL AND IN SERIES WITH THE CONTROL VOLTAGE INPUT.
5. THE HEATER AND HEATER FUSES ARE PROVIDED BY S&C ONLY IF CATALOG NUMBER 38063R2 IS ORDERED.
6. CATALOG NUMBER 38063R2 IS SUPPLIED BY S&C WITH TERMINAL TB1-1 CONNECTED TO THE FRAME OF THE WEATHERPROOF ENCLOSURE. THE ENCLOSURE GROUND PAD MUST BE CONNECTED TO A SUITABLE GROUND BY THE CUSTOMER.
7. IF POTENTIAL TRANSFORMERS ARE USED TO DERIVE BUS POTENTIAL IT IS RECOMMENDED THAT TYPE FRN-5 FUSES BE USED IN SERIES WITH EACH POTENTIAL TRANSFORMER SECONDARY CIRCUIT. CATALOG NUMBER 38063R2-K IS SUPPLIED BY S&C WITH A THREE POINT FUSE BLOCK AND THREE TYPE FRN-5 SECONDARY FUSES MOUNTED IN THE WEATHERPROOF ENCLOSURE AND WIRED TO THE CONTROL PANEL. CATALOG NUMBER 38062R2-K IS SUPPLIED BY S&C WITH A THREE POINT FUSE BLOCK AND THREE TYPE FRN-5 SECONDARY FUSES WHICH THE CUSTOMER IS TO MOUNT AND WIRE.
8. WHEN S&C POTENTIAL DEVICES ARE USED AS THE UNBALANCE COMPENSATION SIGNAL SOURCE, S&C 30VA POTENTIAL DEVICE WITH CATALOG NUMBER SUFFIX LETTER "T" MUST BE USED.
9. DASHED LINES INDICATE CUSTOMER WIRING. SOLID LINES INDICATE S&C WIRING.
10. BUSSMAN FUSES TYPE FRN & FRN-R MAY BE USED INTERCHANGEABLY.
11. CATALOG NUMBER 38062R2 IS SUPPLIED BY S&C WITH A TWO POINT FUSE BLOCK AND TYPE FRN-2 CONTROL VOLTAGE FUSES WHICH THE CUSTOMER IS TO MOUNT AND WIRE. CATALOG NUMBER 38063R2 IS SUPPLIED BY S&C WITH A TWO POINT FUSE BLOCK AND TYPE FRN-2 CONTROL VOLTAGE FUSES MOUNTED IN THE WEATHERPROOF ENCLOSURE AND WIRED TO THE CONTROL PANEL.
12. IF 30VA POTENTIAL DEVICES WITH CATALOG NUMBER SUFFIX LETTER "T" ARE USED TO DERIVE BUS POTENTIAL, THE TYPE FRN-5 FUSES MAY BE BY-PASSED AS THERE IS NOT SUFFICIENT SHORT CIRCUIT CURRENT AVAILABLE TO OPERATE THE FUSE.
13. BURDEN SELECTOR SWITCH ON VOLTMETER MODULE MUST BE SET IN THE "BURDEN OUT" POSITION WHEN USED WITH A 15VA POTENTIAL DEVICE. BURDEN SELECTOR SWITCH ON VOLTMETER MODULE MUST BE SET IN THE "BURDEN IN" POSITION WHEN USED WITH A 30VA POTENTIAL DEVICE.

CUSTOMER WIRING

WIRES	BETWEEN	
102	TB1	AD
103	TB1	AD
104	TB1	AD
105	TB1	AD
109	PF	PD2
110	PF	PD3
111	TB1	PD1
112	TB1	PD1
202	TB2	SD
203	TB2	SD
204	TB2	SD
205	TB2	SD
206	TB2	SD
210	TB2	SD
211	PF	PD4
212	TB2	PD4

INTERCONNECTION WIRING --- BY S&C FOR CAT. NO. 38063R2; BY CUSTOMER FOR CAT. NO. 38062R2

WIRES	BETWEEN	
109A	PF	TB1
110A	PF	TB1
209	SF	TB2
210A	SF	TB2
211A	PF	TB2



UNLESS OTHERWISE SPECIFIED:
DECIMAL DIMS TO BE±
FRACTIONAL DIMS TO BE±
ANGLES TO BE±
WHEN CHECKED, BREAK ALL CORNERS ☐
WHEN CHECKED, REMOVE ALL BURRS ☐

DRAWING NO. CDR-3109R2

MATERIAL: S&C SPEC NO. DESCRIPTION:

FINISH: S&C SPEC NO. DESCRIPTION:

NEXT ASSEM.	38063R2 38062R2
PRODUCT DESCRIPTION	S&C AUTO. CONTROL DEVICE
USED ON	
SCALE	N.T.S.
DR. BY	LPY
CK. BY	L.W.
APP. BY	JAZ
DATE	11-1-88

S&C ELECTRIC COMPANY
GENERAL OFFICES • CHICAGO
Specialists in High-Voltage Switching and Protection

DESCRIPTION:
INTERCONNECTION WIRING DIAGRAM
AUTOMATIC CONTROL DEVICE-TYPE UP
(48/125 VDC CONTROL VOLTAGE)

SHEET 2 OF 2

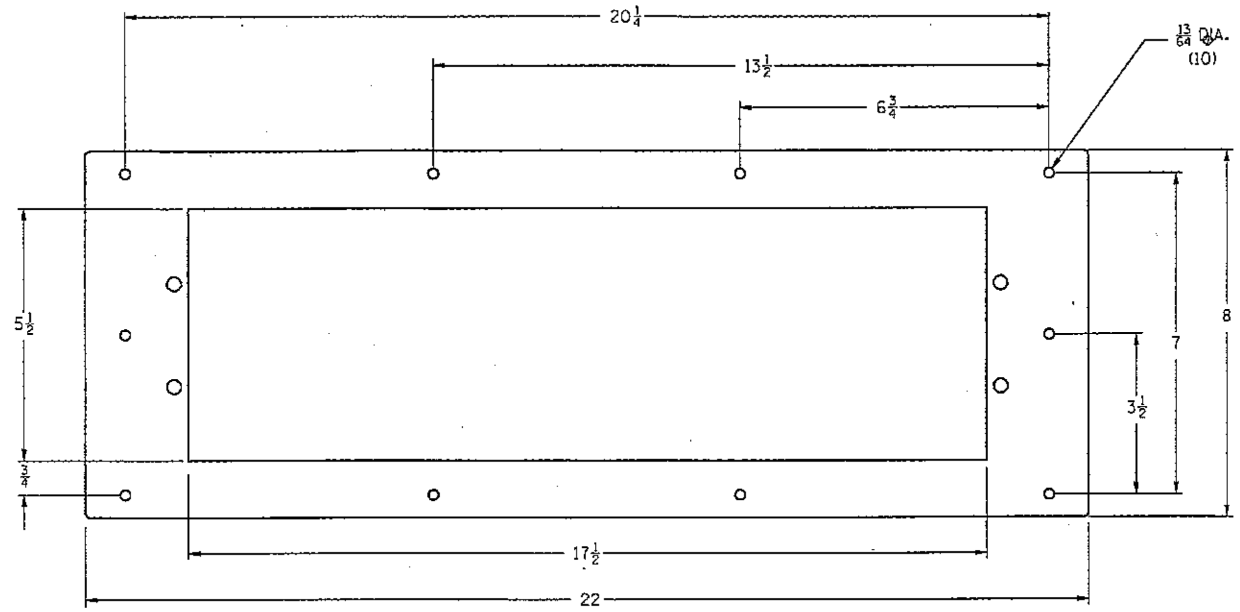
DRAWING NO. CDR-3109R2

REVISED/REDRAWN SAME NUMBER DATED 2-14-75

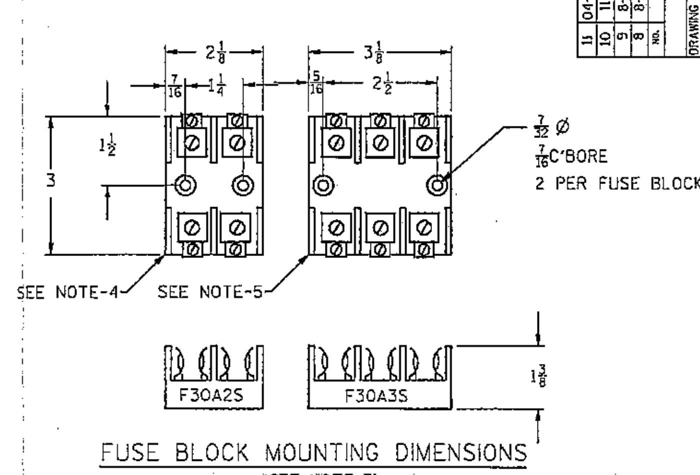
NO.	DATE	NOTICE NO.
11	04-20-94	76385
10	11-1-88	73107
9	8-8-84	70982
8	8-1-79	68289

REVISIONS

DRAWING NO. 38062R2 MST



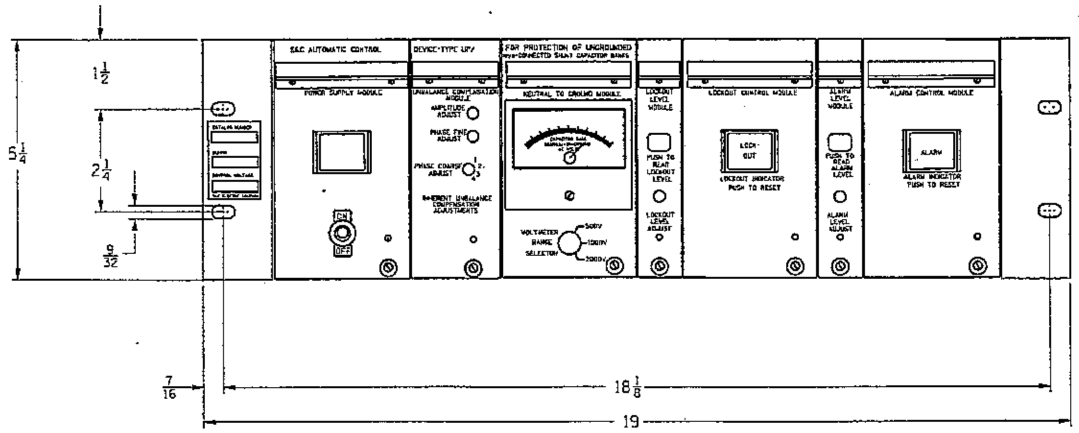
BEZEL FOR MOUNTING OF AUTOMATIC CONTROL DEVICE



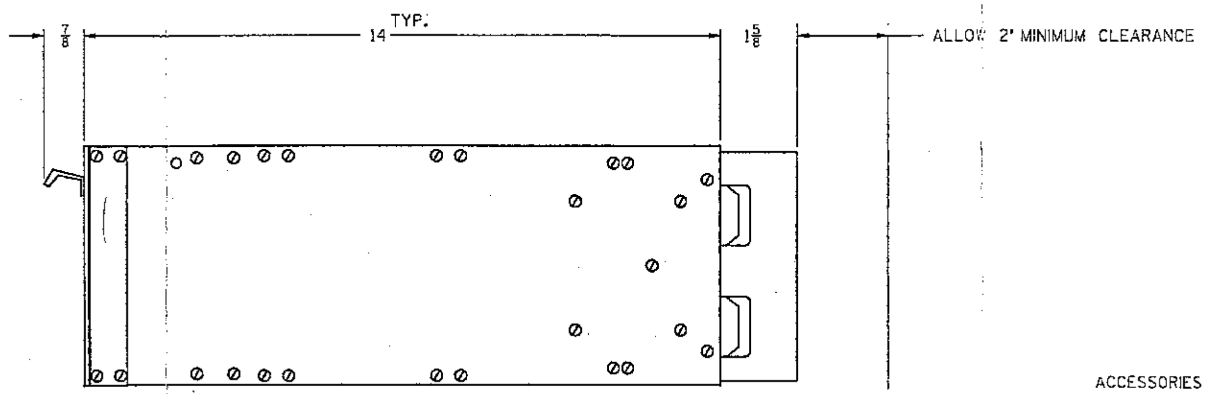
FUSE BLOCK MOUNTING DIMENSIONS
(SEE NOTE-3)

REFERENCE:
RD-3228-STANDARD INSTRUCTION MANUAL
CDR-3109R2-CONNECTION WIRING DIAGRAM (D.C. CONTROL VOLTAGE) 2 SHEETS
CDR-3121R2-CONNECTION WIRING DIAGRAM (A.C. CONTROL VOLTAGE) 2 SHEETS
531-500-INSTRUCTION SHEET
RD-3089-SCHEMATIC (D.C. CONTROL VOLTAGE)
RD-3150-SCHEMATIC (A.C. CONTROL VOLTAGE)

NOTES:
1. WHEN SUFFIX "L" IS SPECIFIED, BEZEL (TND-1000) AND (4) 1/4-20X1/2 R.H.S.S. SCREWS FOR MOUNTING TO CONTROL PANEL WILL BE SHIPPED UN-MOUNTED.
2. MOUNTING HARDWARE FOR ATTACHMENT OF CAPACITOR BANK CONTROL PANEL/TYPE UP FOR PROTECTION OF UNGROUNDED Wye-CONNECTED SHUNT CAPACITOR BANKS AND BEZEL (TND-1000) TO STRUCTURE TO BE SUPPLIED BY CUSTOMER.
3. FUSES AND FUSE BLOCKS ARE PROVIDED WITH REFERENCE DRAWING IN CUSTOMER'S INFORMATION KIT.
4. TWO POINT FUSE BLOCK AND TWO TYPE FRN-2 FUSES ARE PROVIDED BY S&C.
5. THREE POINT FUSE BLOCK AND THREE FRN-5 FUSES ARE PROVIDED BY S&C ONLY IF 38062R2 WITH CATALOG NUMBER SUFFIX LETTER "K" IS ORDERED.



FRONT VIEW
WITH PLUG-IN ALARM MODULES & PLUG-IN UNBALANCE COMPENSATION MODULE (38062R2-HK)



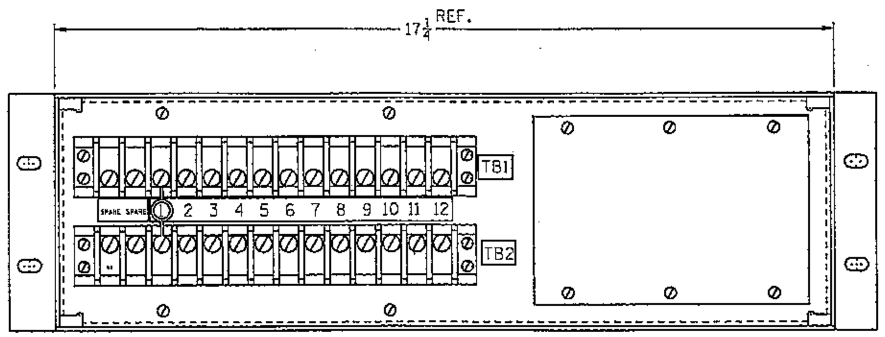
SIDE VIEW

ACCESSORIES

ITEM	NUMBER
DETAILED INSTRUCTION MANUAL	RD-3355

OPTIONS

ITEM	SUFFIX
POWER SUPPLY FOR USE WITH 48VDC CONTROL VOLTAGE SOURCE	-A
POWER SUPPLY FOR USE WITH 125VDC CONTROL VOLTAGE SOURCE	-B
POWER SUPPLY FOR USE WITH 120VAC 60 CYCLE CONTROL VOLTAGE SOURCE	-D
POWER SUPPLY FOR USE WITH 240VAC 60 CYCLE CONTROL VOLTAGE SOURCE	-E
PLUG-IN ALARM FEATURE (CONSISTING OF ONE ALARM LEVEL MODULE AND ONE ALARM CONTROL MODULE) PROVIDES FOR A WARNING SIGNAL UPON LOSS OF A LESSER NUMBER OF CAPACITOR UNITS THAN THAT FOR WHICH THE LOCKOUT LEVEL IS SET	-H
PLUG-IN UNBALANCE COMPENSATION MODULE COMPENSATES FOR SYSTEM VOLTAGE UNBALANCE AND/OR INHERENT CAPACITOR BANK UNBALANCE	-K
MOUNTING BEZEL FOR FLUSH MOUNTING OF CONTROL DEVICE CAT. NUMBER 38062R2 CONSISTS OF (1) PART NUMBER TND-1000	-L
CARD EXTENDER FOR TYPE UP CONTROL DEVICES PERMITS POSITIONING OF ANY MODULE FOR TEST OR CALIBRATION CONSISTS OF (1) PART NUMBER TA-1012	-N



BACK VIEW
(WIRING TERMINALS)

UNLESS OTHERWISE SPECIFIED:
DECIMAL DIMS TO BE ±
FRACTIONAL DIMS TO BE ±
ANGLES TO BE ±
WHEN CHECKED,
BREAK ALL CORNERS ☐
WHEN CHECKED,
REMOVE ALL BURRS ☐

DRAWING NO. 38062R2 MST

MATERIAL:
S&C SPEC NO.
DESCRIPTION:

FINISH:
S&C SPEC NO.
DESCRIPTION:

PROPRIETARY STATEMENT

NEXT ASSEM. | PRODUCT DESCRIPTION
USED ON

SCALE 1:2
DR. BY LPY
CH. BY LW
APP. BY JAZ
DATE 8-15-88

S&C ELECTRIC COMPANY
GENERAL OFFICES - CHICAGO
Specialists in High-Voltage Switching and Protection

DESCRIPTION
S&C AUTOMATIC CONTROL DEVICE TYPE UP
FOR PROTECTION OF UNGROUNDED Wye-CONNECTED SHUNT CAPACITOR BANKS

CATALOG DIMENSIONAL
DRAWING NO. MST
38062R2

REVISED/REDRAWN SAME NO. DATED 7-12-74