# Pilot Wire Insulation and Protection for HCB and HCB-1 Relaying

Effective: December 1993
Supersedes I.L. 41-971.4J Dated March 1989

( ▌ ) Denotes change since previous issue.

**CAUTION**

**Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.**

## 1.0 APPLICATiON

The insulation and protection equipment shown in Figure 1 is used with the HCB or HCB-1 pilot wire relay. a complete installation for one terminal of a line consists of an insulating transformer, neutralizing reactor, capacitors, mutual drainage reactors and neutralizing reactor with surge voltage protectors.

### 1.1 BYPASS CAPACITOR (C)

The ac bypass capacitor (C) is required only when dc monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Figure 1). Use a 10 uf capacitor for 50/60 Hz applications.

### 1.2 EXCITING CAPACITORS (CG)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use of 1.0 Uf capacitor for 50/60 Hz applications.

For an application using dc monitoring remote-trip relays without the insulating transformer for HCB/ HCB-1 relaying, capacitor C should be connected across the wires to minimize the metallic voltage (wire-wire voltage) generated by the unbalanced impedance of capacitors Cg.

### 1.3 MUTUAL DRAINAGE REACTOR

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station-ground hazard), the remote and station ground are essentially equal, and the joint ground terminal of the two Siemens L2A600 surge protectors should be connected to station ground.

By forcing equal current flow from the two wires into ground, the reactor minimizes metallic voltage (wire-to-wire voltage). The reactor cannot, however, eliminate all metallic voltage even though the longitudinally induced voltages (common mode) are equal and the currents are equal on the two wires unless the wire resistances are identical.

Since it is not practical to make the wire resistances equal, there is a limit to the amount of induced voltage which can be handled without introducing the possibility of relay misoperation due to the generation of spurious metallic voltage. Care must be taken to assure that the resistance unbalance does not generate a metallic voltage greater than 7 volts when the induced voltage is drained. If this value cannot be obtained then use a cable with sufficient insulation to withstand the induced voltage stress or improve the shielding to reduce this voltage.

## 1.4 NEUTRALIZING REACTORS

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Figure 1) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Figure 1) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 uf or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approximately 1 uf total on each wire to ground.

The neutralizing reactor and mutual drainage reactor may be used together as shown or may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

## 1.5 NEUTRALIZING REACTOR SURGE VOLTAGE PROTECTOR

The neutralizing reactor surge protector, type Siemens L2A600, is recommended to minimize wire to wire voltage during a disturbance with one wire accidentally grounded.

## 1.6 SHIELD GROUNDING

In order to be electromagnetically effective, the shield must be grounded at least twice to provide a path for the flow of demagnetizing current the question, though, is where? Should the shield be rounded or insulated from the station mat?

If the shield is grounded to the power station mat, the shield may be damaged by current generated by a rise in station-ground potential during a power-system fault. Unless, the shield has sufficient conductivity to withstand the thermal stress, it should be insulated from station ground. Note that an increase in shield conductivity does not cause a proportional increase in shield current due to the inductance in the loop. If the shield is insulated from station ground (i.e. within 500 ft. of station) it is not effective in reducing induced voltage in the insulated section; if this voltage is large, a high conductivity shield which can thermally withstand the stress of a mat ground is indicated. The “insulated shield” section must be remote grounded to minimize electric-field pickup.

Where the two stations are within about 1500 ft. or less of each other a single shield ground should be used or the shield should be tied to both mats. In such an application it is common to interconnect the two mats via large power cables (in addition to the overhead shield wires); these reduce the 60 Hz mat voltage difference. However, they have a limited effectiveness due to the cable inductance.

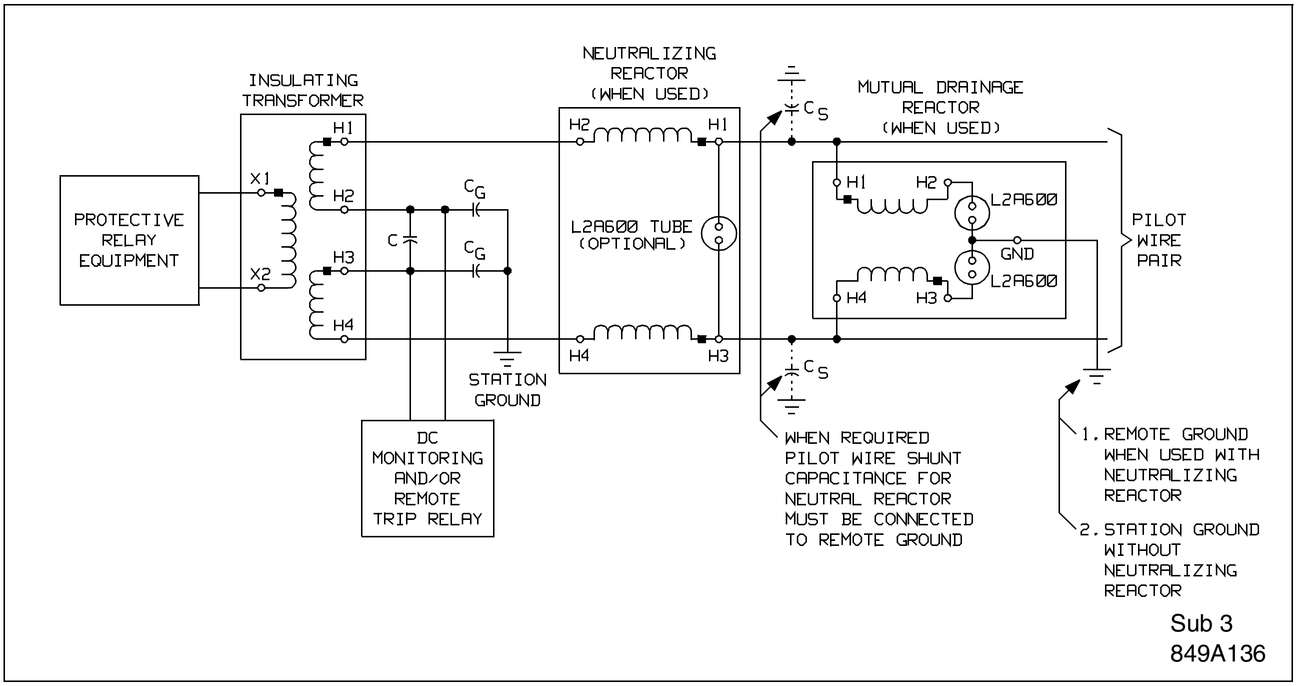
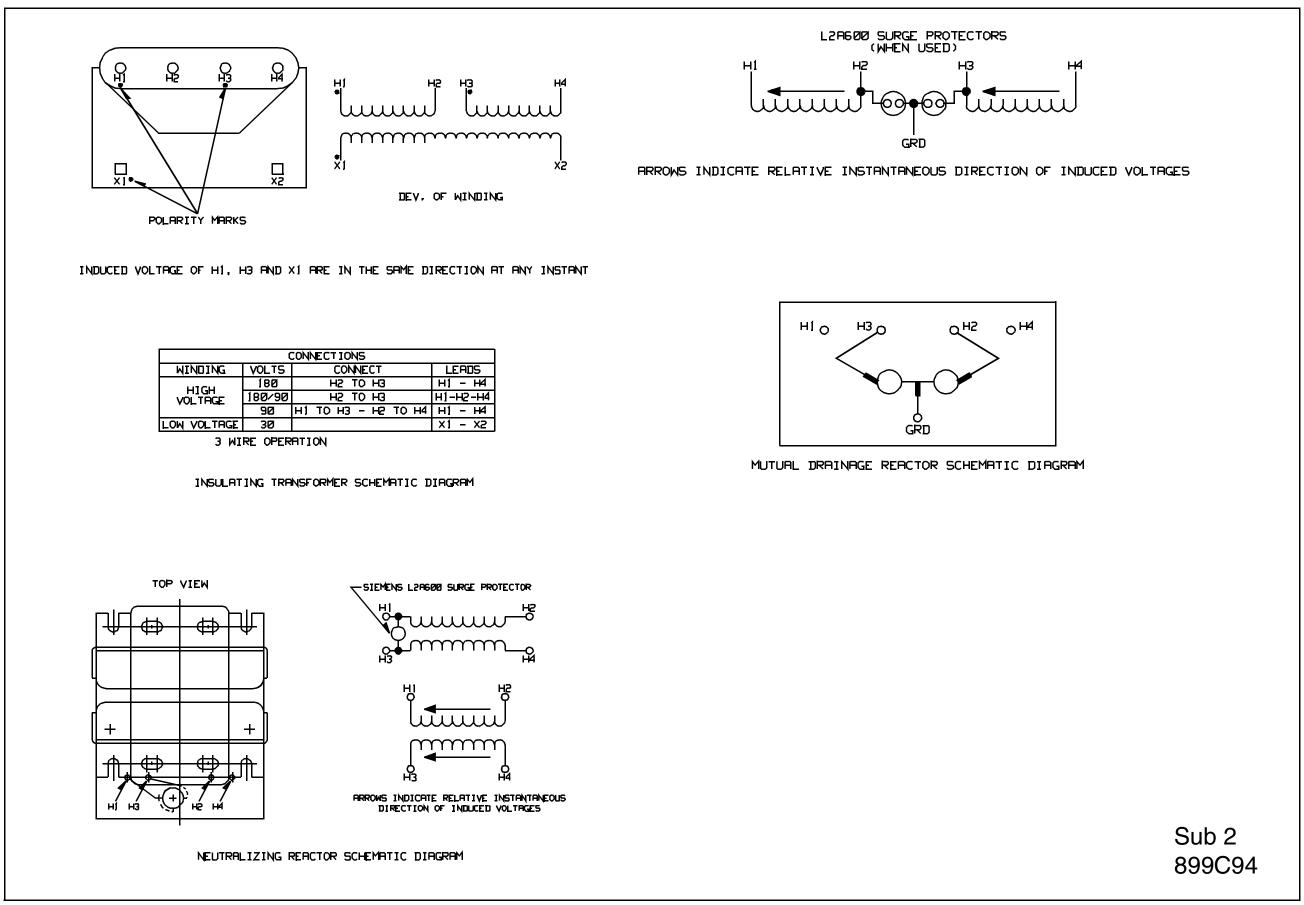



*Figure 1. External Schematic of Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying*




| CONNECTIONS | | | |
|---|---|---|---|
| WINDING | VOLTS | CONNECT | LEADS |
| HIGH VOLTAGE | 180 | H2 TO H3 | H1 - H4 |
| | 180/90 | H2 TO H3 | H1-H2-H4 |
| | 90 | H1 TO H3 - H2 TO H4 | H1 - H4 |
| LOW VOLTAGE | 30 | | X1 - X2 |

*Figure 2 Schematic Diagram of Protective Equipment for HCB and HCB-1 Relaying*

## TECHNICAL DATA

| INSULATING TRANSFORMER | | | | | |
|---|---|---|---|---|---|
| Style | Rating | Frequency | Schematic | Reference | Outline Reference |
| 7882A26H07<br>7882A26G08 | 4/1<br>6/1 | 50-60 Hz<br>50-60 Hz | 20D1472<br>16D9583 | Fig. 2<br>Fig. 2 | Fig. 3<br>Fig. 3 |

| INSULATING TRANSFORMER | | | | | |
|---|---|---|---|---|---|
| Insulation 60 Sec. Rating | Units | 4/1 | 6/1 | 4/1 | 6/1 |
| | | 60 Hz | | 50 Hz | |
| H to L<br>H to GND<br>L to GND | kV | 12<br>12<br>4 | 12<br>12<br>4 | 12<br>12<br>4 | 12<br>12<br>4 |

| INSULATING TRANSFORMER | | | | | |
|---|---|---|---|---|---|
| General Specifications | Units | 4/1 | 6/1 | 4/1 | 6/1 |
| | | 60 Hz | | 50 Hz | |
| Rated Voltage H1-H2 and H3-H4 | Volts | 60 | 90 | 60 | 90 |
| Rated Voltage X1-X2 | Volts | 30 | 30 | 30 | 30 |
| Continuous Rating H Windings | mA | 12 | 8 | 12 | 8 |
| Resistance of each H Winding | ohms | 20.4 | 46.5 | 20.4 | 46.5 |
| Continuous Rating X Winding | mA | 48 | 48 | 48 | 48 |

| INSULATING TRANSFORMER | | | | | |
|---|---|---|---|---|---|
| General Specifications | Units | 4/1 | 6/1 | 4/1 | 6/1 |
| | | 60 Hz | | 50 Hz | |
| Resistance of X Winding | ohms | 1.7 | 1.7 | 1.7 | 1.7 |
| Exciting Impedance X1-X2 at 30 V | ohms | 850-1250 | 850-1250 | 850-1250 | 790-1030 |
| Approximate Weight | Pounds | 25 | 25 | 25 | 25 |

| SIEMENS L2A600 SURGE VOLTAGE PROTECTOR | |
|---|---|
| ac rms voltage breakdown | 400-450 volts |
| 1 - Second current rating, rms | 40 amperes |
| 11 - Cycle current rating, ms | 200 amperes |

| NEUTRALIZING REACTOR | | | | | |
|---|---|---|---|---|---|
| Style | Freq. | With Siemens L2A600 Tube & Socket | Schematic | Refer-ence | Outline Refer-ence |
| 7882A27G03 | 50-60 | Yes | 899C094 | Fig. 2 | Fig. 4 |
| 7882A27G01 | 50-60 | No | 899C094 | Fig. 2 | Fig. 4 |

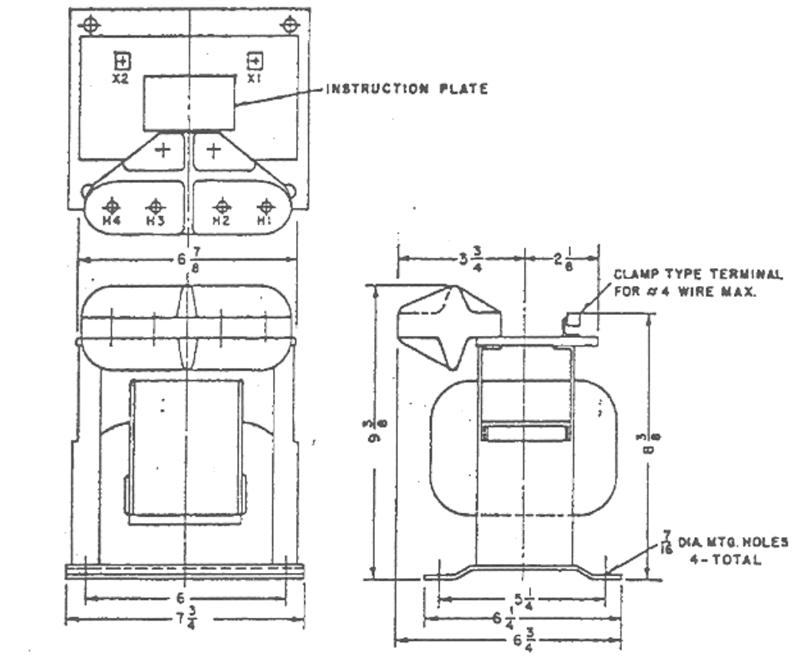
**AUXILIARIES**

Style 949122, Drawing 4C6483
1 uf exciting capacitor - 2 required per 50-60 Hz Neutralizing Reactor

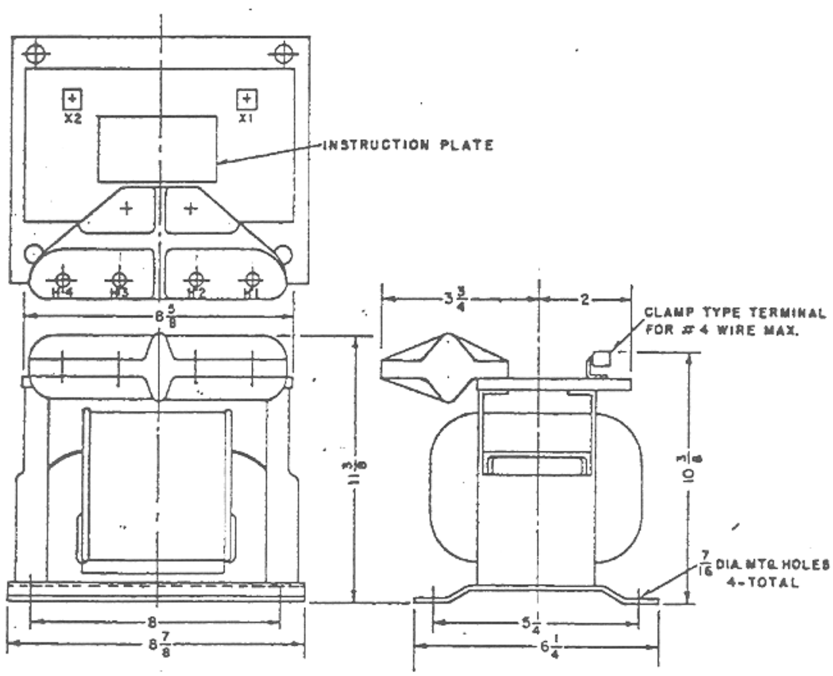
| NEUTRALIZING REACTOR, (continued) | | | |
|---|---|---|---|
| General Specifications | Units | 60 Hz | 50 Hz |
| Voltage Rating between Windings | volts | 500 | 500 |
| Voltage Rating across Windings in Parallel | volts | 4,000 | 4,000 |
| Exciting Impedance - both Windings in Parallel at 4 kV | ohms | 134,000<br>267,000 | 56,750<br>113,500 |
| Leakage Reactance Each Winding | ohms | 65 | 54 |
| Resistance of Each Winding | ohms | 88 | 88 |
| Total Impedance One Reactor Adds to the Pilot Wire Loop | ohms | 219 | 207 |
| Test voltage Windings to Ground | volts | 10,000 | 10,000 |
| Continuous Current Rating Each Winding | mA | 10 | 10 |
| One Second Current Rating Each Winding | mA | 50 | 50 |
| Approximate Weight | pounds | 76 | 76 |

| MUTUAL DRAINAGE REACTORS | | | |
|---|---|---|---|
| General Specifications | Units | 60 Hz | 50 Hz |
| Test voltage Between Windings and Between Windings and Ground for 1 minute | volts | 4,000 | 4,000 |
| Excitation Impedance at 120 volts from H1 to H4 H2 to H3 connect together | ohms | 24,000-48,000 | 17,000-33,000 |
| de Resistance Each Winding | ohms | 8 | 8 |
| Leakage Reactance Each Winding | ohms | 1.5 | 1.2 |
| One Second Rating Each Winding | amperes | 90 | 90 |
| Two Second Rating Each Winding | amperes | 22 | 22 |
| Approximate Weight | pounds | 40 | 40 |
| Saturation Point H1 & H3, to (Winding in Parallel) | volts, rms | 500 | 400 |

| MUTUAL DRAINAGE REACTORS | | | | | | |
|---|---|---|---|---|---|---|
| Style | Freq | Inc. Socket for Tube | Inc. L2A600 2 - Tube | Schematic | Reference | Outline |
| 7882A28G03 | 50/60 | Yes | Yes | 899C094 | Fig. 2 | Fig. 5 |




a) INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION




b) INSULATING TRANSFORMER OUTLINE FOR 25 CYCLE OPERATION

Sub 1
899C095

*Figure 3. Insulating Transformer Outlines, 50 and 60 Hz Operation; Protection Equipment for HCB and HCB-1 Relaying*

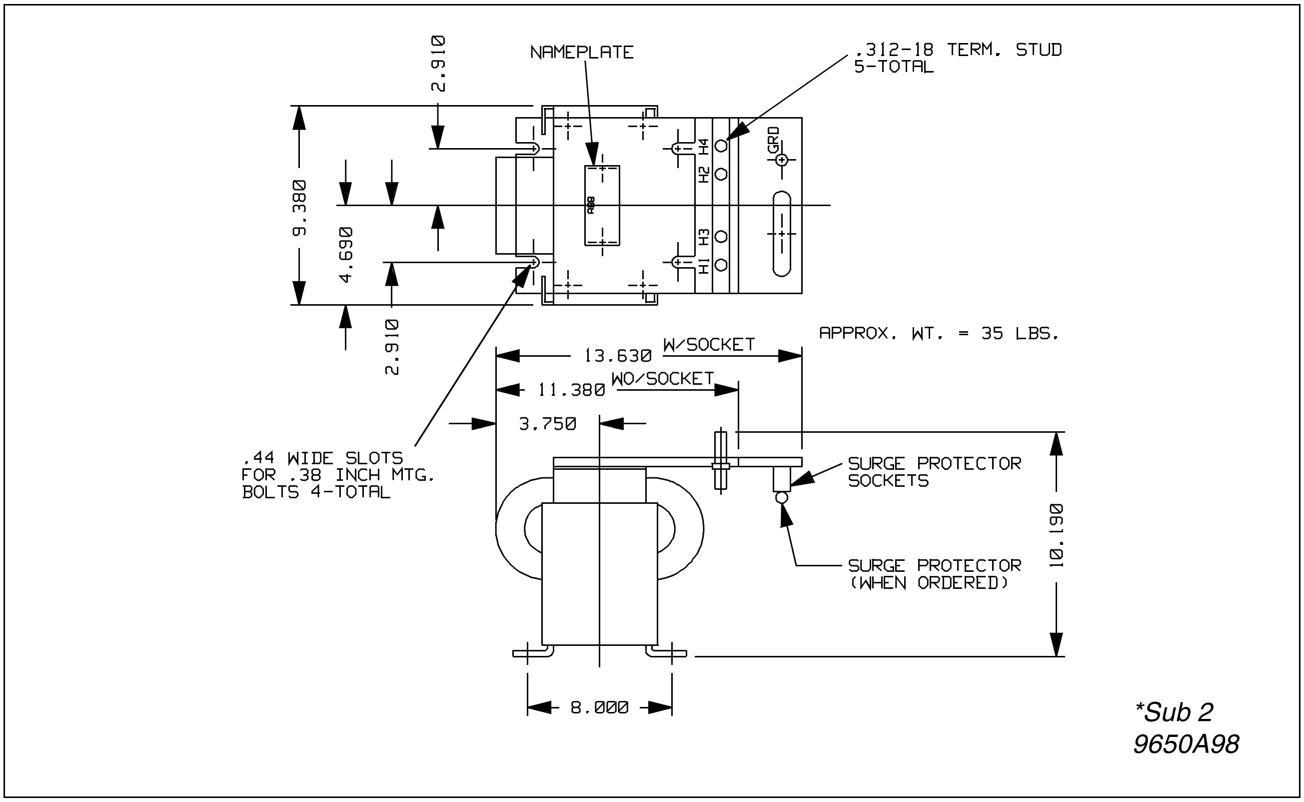



*Figure 4. Neutralizing Reactor Outlines, 50 and 60 Hz Operation; Protective Equipment for HCB and HCB-1 Relaying*

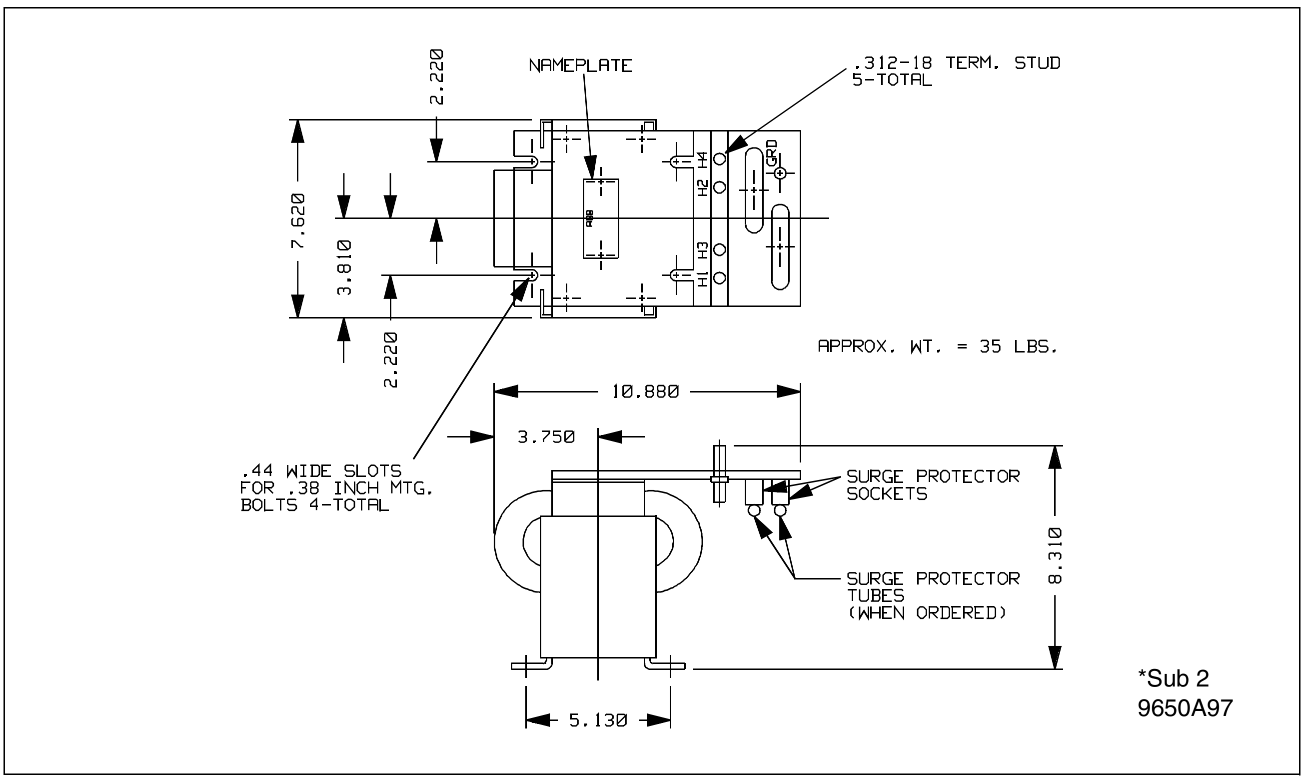



*Figure 5. Mutual Drainage Reactor Outline, 50 and 60 Hz Operation; Protective Equipment for HCB and HCB-1 Relaying*

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