Addendum to Instructions for Installation, Operation and Maintenance of Digitrip 3000 Protective Relays

Table of Contents **Page**

CAUTION

COMPLETELY READ AND UNDERSTAND THIS ADDENDUM AND THE DIGITRIP 3000 INSTRUCTION BOOK (I.B. 17555) BEFORE ATTEMPTING INSTALLATION, OPERATION OR APPLICATION OF THE EQUIPMENT. IN ADDITION, ONLY QUALIFIED PERSONS SHOULD BE PERMITTED TO PERFORM ANY WORK ASSOCIATED WITH THE EQUIPMENT. ANY WIRING INSTRUCTIONS PRESENTED IN EITHER DOCUMENT MUST BE FOLLOWED CLOSELY. FAILURE TO DO SO COULD CAUSE PERMANENT EQUIPMENT DAMAGE.

1.0 INTRODUCTION

This addendum describes the Dual-Source Power Supply (DSPS) addition to the Digitrip 3000 Protective Relay.

The conventional Digitrip 3000 relay, style number 4D13120G01, is described in I.B. 17555. Table 1 lists the DSPS–equipped versions.

Description	Cat. No.	Style No.
Digitrip 3000 with 120Vac Dual-Source Power Supply	DT3010	4D13125G01
Digitrip 3000 with 240Vac Dual-Source Power Supply	DT3020	4D13125G02

TABLE 1. ORDERING INFORMATION

2.0 GENERAL DESCRIPTION

The Digitrip 3000 with Dual-Source Power Supply (DSPS) is a microprocessor-based feeder overcurrent protective relay designed for ac auxiliary power applications. The DSPS versions, DT3010 and DT3020, include an integral power supply module which:

- Powers the relay from nominal 120 Vac, 50/60Hz (DT3010 model) or 240 Vac, 50/60Hz (DT3020 model) auxiliary power, which is normally connected and available.
- Operates solely from the main current transformers (cts) during a fault if the normally connected auxiliary ac voltage is not available, like an electromechanical relay or an electronic "self-powered" relay.

The ct powering capability is critical for tripping if the ac auxiliary supply or its fuses fail prior to the fault; or if the fault itself collapses the supply voltage at the critical moment when tripping is needed.

The DT3000 with Dual-Source Power Supply design offers significant performance and reliability benefits over the electromechanical or "self-powered" relays. It provides a full-time metering display, remote communications, and self-monitoring functions. In addition, there is no calibration required. The burden is lower than most electromechanical and solid state self-powered relays.

The DT3000 with DSPS provides long-term, robust, maintenance-free performance, which can't be achieved with an energy-storing uninterruptible power supply (UPS). The DSPS will operate anytime there is a fault even after an extended power outage.

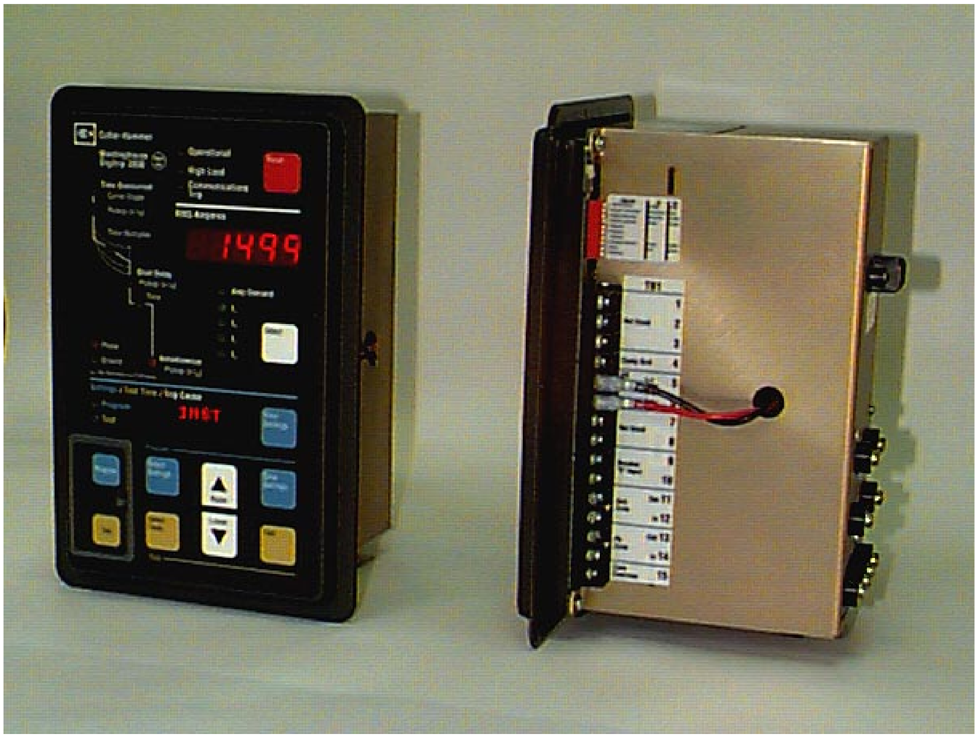

FIGURE 1. DIGITRIP 3000 WITH DSPS

NOTICE

The following material replaces Section 2-3, pages 16 & 17 of I.B. 17555.

TABLE 2. ULTesting and Specification Summary (continued on next page)

ANSI C37.90 (Total Compliance to 1989 Revision): (UL Required) ▪ Make and Carry Ratings Sec. 6.7 ▪ Temperature Test Sec. 7 ▪ Dielectric Test Sec. 8 ▪ Surge Withstand Test Sec. 9	**ADDITIONAL TESTS (UL REQUIRED)** ▪ Hot and Cold Calibration of Phase Elements ▪ Meter Readout Accuracy ▪ Zone Interlocking Functionality
UL 1053 (UL REQUIRED) ▪ Current Withstand Test Sec. 27 ▪ Control Power Test Sec. 18 ▪ Output Test Sec. 19 ▪ Temperature Test Sec. 20 ▪ Calibration of Ground Element Sec. 21 ▪ Overvoltage Sec. 22 ▪ Overload Sec. 23 ▪ Endurance – Verify with Calibration Tests Sec. 24 ▪ Dielectric Voltage Withstand Test Sec. 25	**EMC TESTS:** ▪ IEC 255-22-2, Electrostatic Discharge Test (ESD), Rating of 8kV ▪ IEC 255-22-3 (ENV 50140), Radiated RF Immunity ▪ ENV 50141, Conducted RF Immunity ▪ CISPR 11 Class A ▪ CFR 47 FCC Part 15 Subpart b Class A

TABLE 2. ULTesting and Specification Summary (continued from previous page)

CURRENT INPUTS:

- Cts: 5A Secondary
- Ct Burden: See Burden Curves Figures 8 & 9
  <0.04 ohm @ Rated Current(5A)
  <1.0 VA @ Rated Current(5A)
- I_n: 5A(Secondary) or CT(Primary)
- Saturation: 30 x I_n
- Ct Thermal Rating: 10A continuous
  500A for 1 Second

CT(PRIMARY) SETTINGS AVAILABLE:

- Phase & Ground: 10/25/50/75/100/150/200/250/300/400/500/600/630/800/1000/1200/1250/1500/1600/2000/2400/2500/3000/3200/4000/5000

ZONE SELECTIVE INTERLOCKS:

- Phase: Inverse Time Overcurrent and Short Delay
- Ground: Inverse Time Overcurrent and Short Delay

CONTROL POWER:

- Input Voltage:

	Nominal	Operating Range
DT3010:	100-120 Vac	70 – 132 Vac
DT3020:	200-240 Vac	140 – 264 Vac

- Power Consumption: 15VA

OUTPUT TRIP CONTACTS: (Trip OC/Comm, Trip Inst, & Comm Close)

- Momentary: Make 30A ac/dc for 0.25 sec
  Break 0.25A @ 250Vdc
  Break 5A @ 120/240Vac
- Continuous: 5A @ 120/240Vac
  5A @ 30Vdc
- Meets ANSI C37.90 Paragraph 6.7

AUXILIARY RELAYS: (Protection Off Alarm and Trip Alarm)

- Make/Break: 5A @ 120/240Vac & 30Vdc
- Continuous: 5A @ 120/240Vac
  5A @ 30Vdc

ENVIRONMENT:

- Operating temerature: -30 to +55 Degrees Celsius
- Operating Humidity: 0 to 95% Relative Humidity [Non-Condensing]
- Storage Temperature: -40 to +70 Degrees Celsius

OVERCURRENT FUNCTIONS AND PICKUP RANGES:

Long Delay or Inverse Time Overcurrent:
- Phase: (0.2 to 1.0) x I_n [16 settings]
- Ground: (0.1 to 2.0) x I_n [26 settings]

Short Delay:
- Phase: (1 to 11) x In, None[25 settings]
- Ground: (0.1 to 11) x In, None[45 settings]

Instantaneous:
- Phase: (1 to 25) x In, None[30 settings]
- Ground: (0.5 to 11) x In, None[33 settings]

LONG DELAY OR INVERSE TIME OVERCURRENT CURVE CHOICES:

- Thermal: It [Moderately Inverse]
  I2t [Very Inverse]
  I4t [Extremely Inverse]
  Flat [Definite Time]
- ANSI: Moderately Inverse
  Very Inverse
  Extremely Inverse
- IEC: (Per IEC 255-3, 1989) IEC-A [Moderately Inverse]
  IEC-B [Very Inverse]
  IEC-C [Extremely Inverse]
  IEC-D [Definite Time]

TIME DELAY SETTINGS:

- Long Delay or Inverse Time Overcurrent Time Multiplier: It, I^2t, I^4t Curve: 0.2 to 40[47 Settings]
  Flat: 0.2 to 2.0[21 Settings]
  ANSI (all): 0.1 to 5.0[50 Settings]
  IEC (all): 0.05 to 1.00[20 Settings]
- Short Delay Time: 0.05 to 1.5 sec.[22 Settings]

CURRENT MONITORING:

- True RMS Sensing: 3-Phase and Ground
- Display Accuracy: $\pm$1% of Full Scale[I_n] from 0.04xI_n to 1xI_n
  $\pm$2% of Full Scale[I_n] from 1xI_n to 2xI_n
- Amp Demand: Average demand over 5 minute sampling window
- High Load Threshold: 85% of Long Delay or Inverse Time Overcurrent Setting

TIMING ACCURACY:

- Inverse Time Overcurrent Time: $\pm$10% above 1.5 X Pickup
- Short Delay Time: $\pm$50ms

COMMUNICATIONS:

- IMPACC Compatible / Built-in INCOM
- Data Rate is 1200 or 9600 Baud
- Set INCOM address from front panel

NOTES: 1. For Ground Pickup < 0.2pu; Time Tolerance $\pm$ 15%.

3.0 FUNCTIONAL DESCRIPTION

The Dual-Source Power Supply contains 1 ac voltage transformer and 3 ac current transformers. The ac voltage transformer is used to supply nominal ac control power to the unit. The current transformers are used to power the unit from the line current. Normally, the unit will operate from the ac auxiliary power. Since this voltage is usually obtained from the system containing the circuit that the relay is protecting, a fault on the protected line could cause the ac voltage to drop below an acceptable operating level. Below approximately 70 volts for DT3010 or 140 volts for DT3020, the DSPS switches over to current powering. All three current transformer secondaries are connected in series to supply this power. The DSPS will supply enough power to operate the Digitrip 3000 overcurrent relay in the tripped state with currents greater than 1.8 per unit rated secondary current, or 9A, in a single-phase. The DSPS will operate with 3-phase currents in a tripped state with currents greater than 1.2 per unit or 6A rated secondary current.

NOTE: There will be no effect to the DT3000 relay trip time accuracy when the Dual-Source Power Supply switches from normal ac voltage to fault-current power.

4.0 INSTALLATION

NOTICE

The following material replaces Paragraph 5-2 on page 34 of I.B. 17555.

4.1 Panel Preparation

The dimensions for the cutout, along with the location of the 10 mounting holes, are shown in Figure 2. Before actually cutting the panel, be sure that the required 3-dimensional clearances for the relay chassis allow mounting in the desired location. The Digitrip 3000 with DSPS dimensions are shown in Figure 3.

4.2 Mounting the Digitrip 3000 with Dual-Source Power Supply

Once the cutout has been prepared in the panel or switchgear enclosure, according to Figure 2, the Digitrip 3010/3020 can be mounted.

CAUTION

SUPPORT THE PROTECTIVE RELAY FROM THE FRONT SIDE WHEN MOUNTING. WITHOUT SUCH SUPPORT, THE PROTECTIVE RELAY COULD FALL AND CAUSE DAMAGE OR INJURY COULD RESULT.

Do not use a tap on the face of the relay. Use all 10 self-tapping screws included with the relay to mount the unit on the panel.

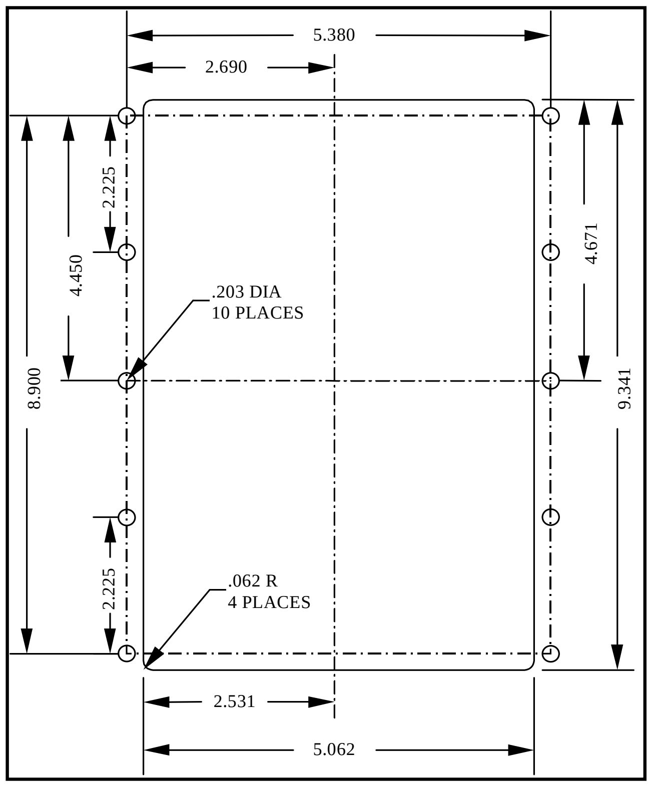

FIGURE 2. PANEL CUTOUT DIMENSIONS (INCHES)

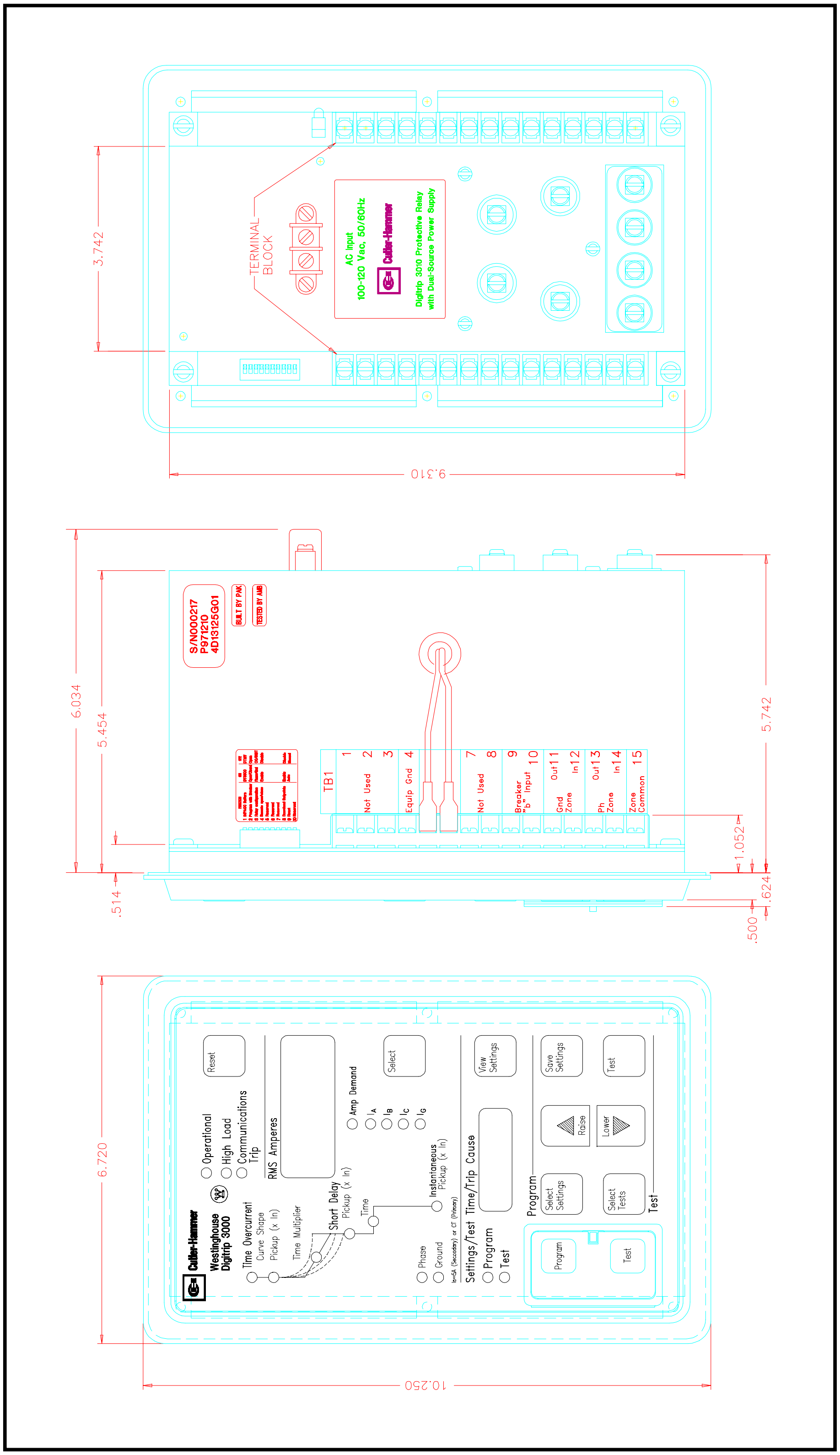

FIGURE 3. DIGITRIP 3010/3020 DIMENSIONS (INCHES)

5.0 WIRING AND SETUP

WARNING

ENSURE THAT THE INCOMING AC POWER SOURCES ARE DISCONNECTED BEFORE PERFORMING ANY WORK ON THE DIGITRIP 3000 PROTECTIVE RELAY OR ITS ASSOCIATED EQUIPMENT. FAILURE TO OBSERVE THIS PRACTICE COULD RESULT IN SERIOUS INJURY, DEATH AND/OR EQUIPMENT DAMAGE.

NOTICE

The following material replaces sections 5-4, on page 35 of I.B. 17555.

Refer to Figures 4, 5, 6, and 7 for the DT3010/DT3020 typical wiring diagrams. Note the following:

1. Direct wire connections to the terminal blocks must not be larger than No. 14 AWG wire. However, larger size wires can be used for the CT connections, with the appropriate ring terminal.
2. All contacts are shown in the de-energized position.

   NOTE: The Protection Off Alarm Relay is energized when ac control power is applied and the DT3000 is operating properly. To obtain a contact that <u>closes when protection is lost</u>, use terminals 9 & 11 of TB2. For a contact that opens when protection is lost, use terminals 9 & 10 of TB2.
3. The Digitrip 3000 comes with the zone interlocking jumpers installed (TB1 terminals 11 to 12 and 13 to 14). Leave these jumpers installed if zone selective interlocking is not used. See I.B. 17555 Section 4 for more information on zone interlocking.

   NOTE: All wiring must conform to applicable federal, state, and local codes.

6.0 APPLICATION CONSIDERATIONS

NOTICE

The following material is an <u>addition</u> to Section 4, on page 31 of I.B. 17555.

6.1 Sensitivity and ct ratios

For scenarios where the relay must trip with loss of ac power, the main-ct secondary current must be greater than 9 amperes for a single-phase-to-ground fault or 6 amperes for a three-phase fault.

For best coverage of faults, the ct ratio should be chosen so that normal full loading of the protected feeder corresponds to a secondary current of approximately one per unit or 5A secondary.

CAUTION

BEWARE OF MISAPPLICATION OF MAIN-CT RATIOS. CONSIDER A CIRCUIT WITH A 400A LOAD THAT NORMALLY REQUIRES A 400:5 CT RATIO, BUT THE CT IS CONNECTED FOR 1200:5. NORMAL LOADS WILL APPEAR AS SMALL CURRENTS, AND EVEN SOME FAULTS MAY HAVE SECONDARY CURRENTS BELOW 1 PER UNIT. THE DSPS WILL NOT BE ABLE TO POWER THE RELAY FOR THESE FAULTS.

6.2 Tripping on facility energization

Normally, the Digitrip 3000 with DSPS will be powered from the auxiliary ac voltage.

If no auxiliary ac control power is present when the breaker closes into a fault or if power is restored to a facility and a fault is present, *the relay will power-up and trip provided the current levels are above the minimum operating level.* In this case, trip times will be approximately 100 ms longer than the case of having normal ac control voltage prior to the fault.

This will also be true if the ac auxiliary power transformer fails or the supply fuses have blown at any time prior to the fault.

Visible front-panel metering displays, and/or network data communications of the relay, comprise a good check on the integrity of the ac supply. In addition, the Protection Off alarm will provide alarm indication if the power is lost or if the relay has failed.

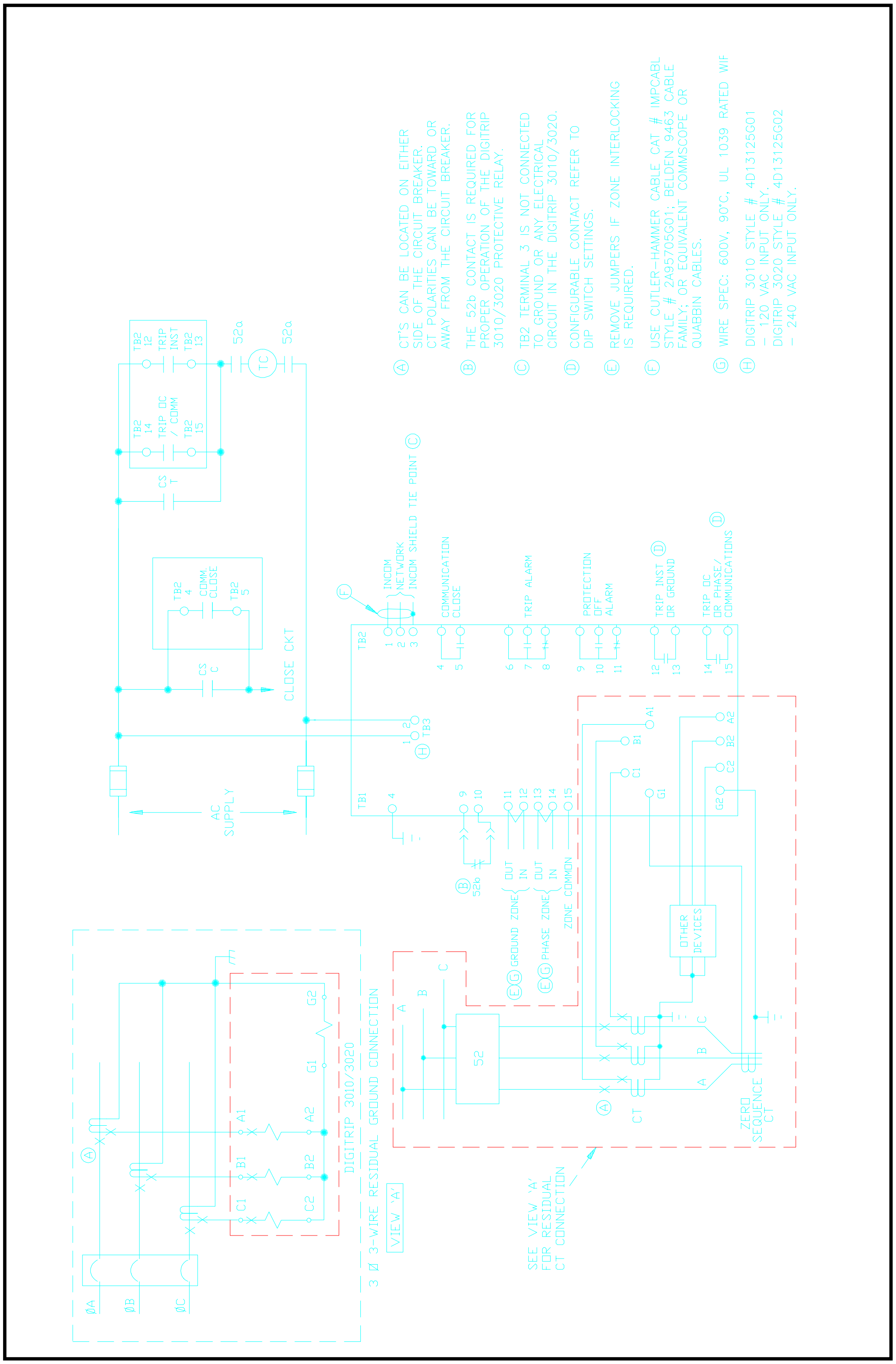

FIGURE 4. DIGITRIP 3010/3020 TYPICAL WIRING DIAGRAM

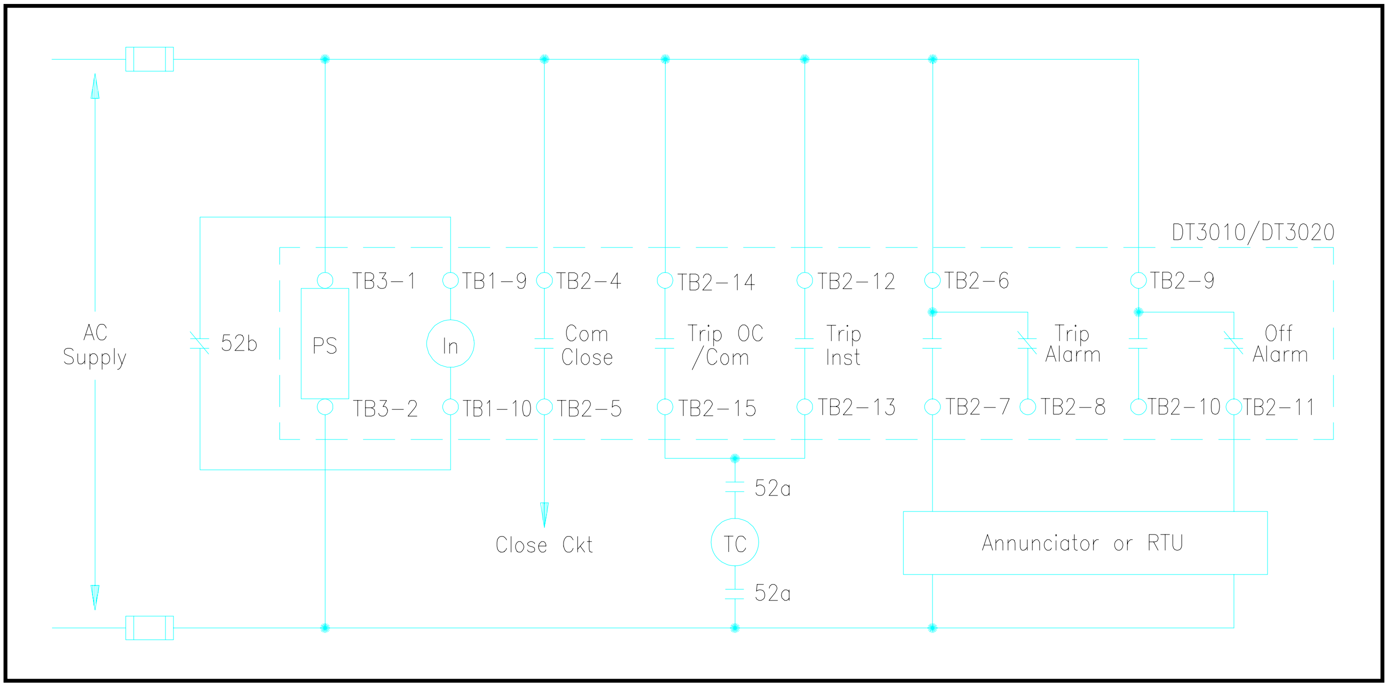

FIGURE 5. DIGITRIP 3010/3020 PROTECTIVE RELAY TYPICAL AC SCHEMATIC

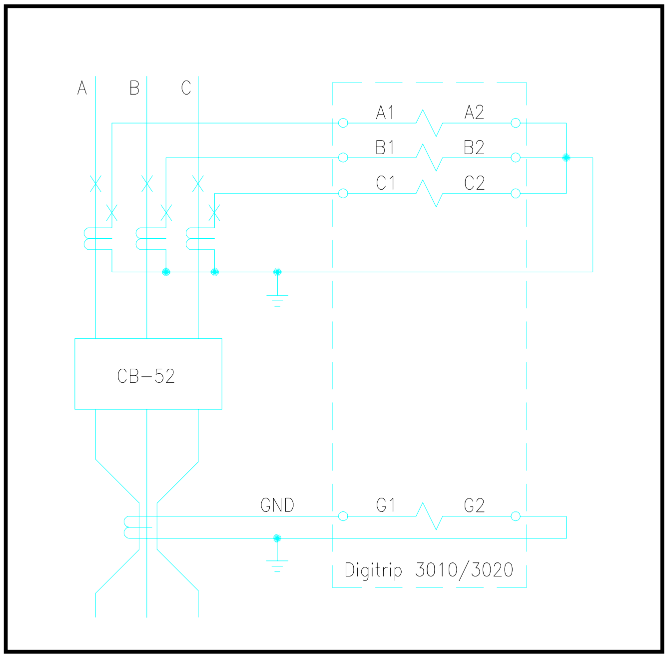

FIGURE 6. DIGITRIP 3010/3020 TYPICAL AC EXTERNAL CURRENT CONNECTION WITH ZERO SEQUENCE GROUND CT

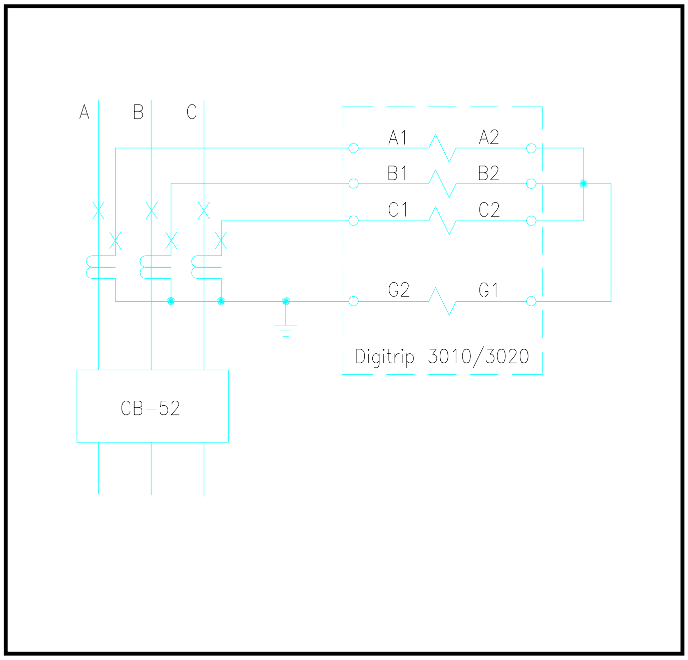

FIGURE 7. DIGITRIP 3010/3020 TYPICAL RESIDUAL GROUND CONNECTION

6.3 Ct Saturation

The DSPS has been designed and extensively tested to assure continued relay powering when the main cts saturate. It powers the relay even for extreme cases in which the ct delivers only a succession of current spikes of 1 to 2 ms each half-cycle.

But pay attention to the standard measuring limitations of any protective relay with saturated cts. The saturated ct is exhibiting serious ratio error, and any connected relay will measure lower current than is actually flowing in the primary circuit. Tripping times will be longer than planned. In extreme cases, the relay may not trip at all.

The Digitrip 3000 is a true RMS measuring device, and will integrate the spikes and dead periods to arrive at a current measurement. The user should follow standard application guidelines of comparing the ct saturation curve with the total connected burden, in light of the maximum fault current. The total burden includes all connected measuring device current windings, plus resistance of the ct secondary winding itself and all interconnecting wiring. Since saturation curves are plotted with RMS-measuring instruments, measurement errors and tripping times can be predicted with good reliability.

The Digitrip 3000 with DSPS can help to reduce ct saturation problems. The current-powering transformers have been designed to present lower burden than most “self-powered” relays, especially for large fault current magnitudes. The burden is much lower than that of an electromechanical relay.

6.4 Burden Data

In normal operating conditions, the burden is <0.08 ohms with 3-phase 1A ct current, or 0.2 per unit, and drops to less than 0.04 ohms at high current levels. Figures 8 and 9 present ct burden data in ohms and volt-amperes. In these cases, the burden shown is the total ct terminal value, which is the DSPS plus the relay measuring circuits, for the indicated operating condition.

Figure 8 shows burden impedance magnitude in ohms. The two lower curves are the values with ac power applied; the upper two are with ct powering only. For each of these pairs, one curve shows the burden for a single-phase current (representing a single-phase-to-ground fault) and the other for three balanced phases with normally arrayed 120-degree phase angle increments. There is no phase sequence sensitivity.

Figure 9 shows the burden in volt-amperes for the same four cases.

The three-phase burden cases assume the normal angular distribution of the phases at 120-degree intervals. If the three-phase current inputs are connected in series to a single current source for a lab-bench test, burden results will be slightly different.

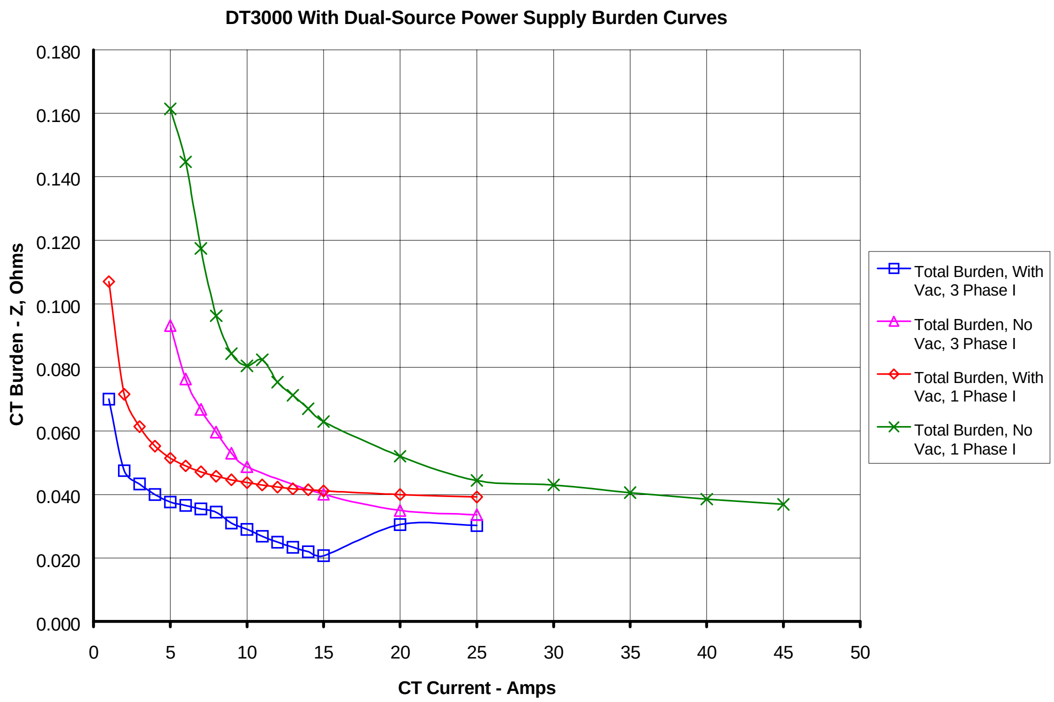

FIGURE 8. DIGITRIP 3010/3020 PROTECTIVE RELAY BURDEN CURVES - OHMS

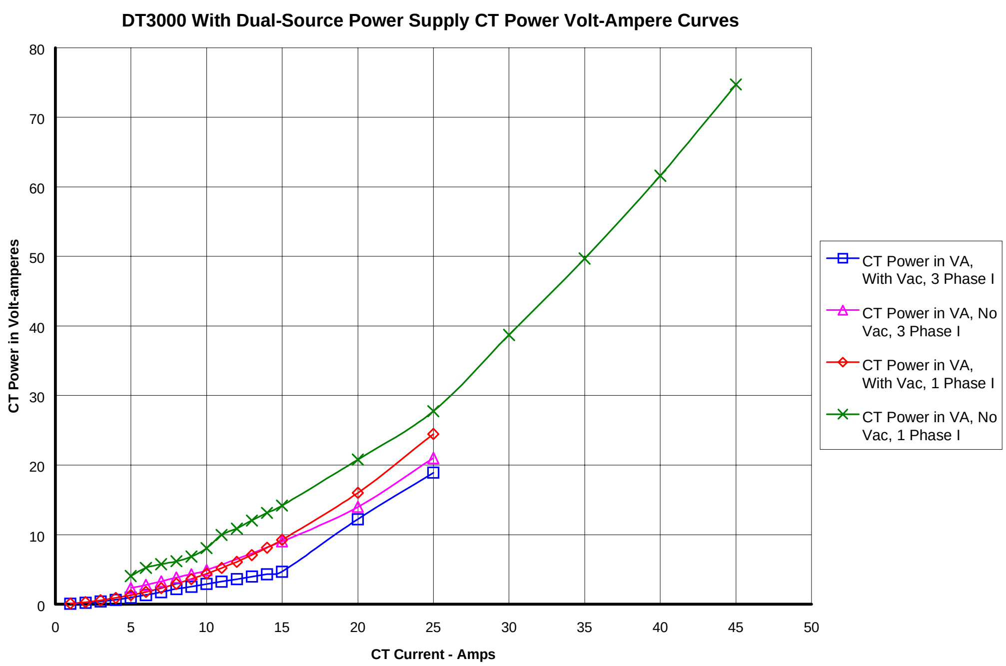

FIGURE 9. DIGITRIP 3010/3020 PROTECTIVE RELAY BURDEN CURVES – POWER IN VA

7.0 TESTING THE DUAL-SOURCE POWER SUPPLY

The DSPS requires no maintenance or adjustment. Use the following procedures to check for proper operation.

First, confirm or test Digitrip 3000 operation with ac power applied, according to the guidelines of I.B. 17555. Then, the following can be used to confirm that the DSPS is functioning correctly.

7.1 In-Service Test

WARNING

THERE MAY BE LIVE VOLTAGES AND CURRENTS PRESENT ON AND AROUND THE DIGITRIP 3000. ONLY QUALIFIED PERSONS SHOULD BE PERMITTED TO PERFORM ANY WORK ASSOCIATED WITH THE EQUIPMENT. FAILURE TO FOLLOW SAFE PRACTICE COULD RESULT IN SERIOUS INJURY, DEATH AND/OR EQUIPMENT DAMAGE.

7.1.1 Some visible load current should be flowing in the protected feeder circuit. It need not be full rated load. Check all three phases.

7.1.2 Consider disconnecting trip circuits during this live testing, although no tripping tests are called for in the following.

7.1.3 Connect a dc voltmeter across Digitrip 3000 terminals 5 & 6 on TB1. This is on the left side of the relay as viewed from the rear.

7.1.4 With ac power applied, this dc meter should read approximately 50 volts.

7.1.5 Connect an isolated ac multimeter across any one phase ct input and observe the voltage drop, which will be less – maybe much less – than 0.25 volt. See Figure 10.

7.1.6 Disconnect ac power from the relay. The front panel and relay data communications may go away if the load current is small.

7.1.7 The ac voltage drop across the ct input should rise to a larger value, at least twice as large as when ac was applied, and maybe approaching 0.5 volt as shown in Figure 10.

7.1.8 The dc voltage on terminals TB1 - 5 & 6 should correspond very roughly to that from the plot in Figure 11, DSPS output voltage as a function of three-phase current.

7.1.9 Disconnect instruments, restore ac power to relay, reconnect trip circuits, and check for resumption of front panel & communications operation.

7.2 Lab Bench Test

7.2.1 With ac control power applied, set the relay to trip well below 9 A – any phase trip function is OK.

7.2.2 Apply more than 9 A to Phase A and confirm tripping. Remove current and reset relay.

7.2.3 Remove ac control voltage – relay turns off.

7.2.4 Apply 9 A to Phase A again. Relay should power up and trip. No need to recheck timing, but it may be observed to be about 100 ms longer than for ac control powered case. If test current is well above 10 A, avoid applying it for a long period.

7.2.5 Repeat step 3 for Phase B.

7.2.6 Repeat step 3 for Phase C. This time, use an isolated ac multimeter to measure the voltage drop across the Digitrip 3000 current input during the test. Check the value against the “No Vac, 1 Phase I” curve, the highest curve, of Figure 10.

7.2.7 Apply ac control voltage again, with Phase C current still applied, or reapply it. The voltage drop shown on the multimeter should decrease to the value for the “With Vac, 1 Phase I” curve of Figure 10. With ac power applied, this voltage will be roughly half of the value without the ac power applied.

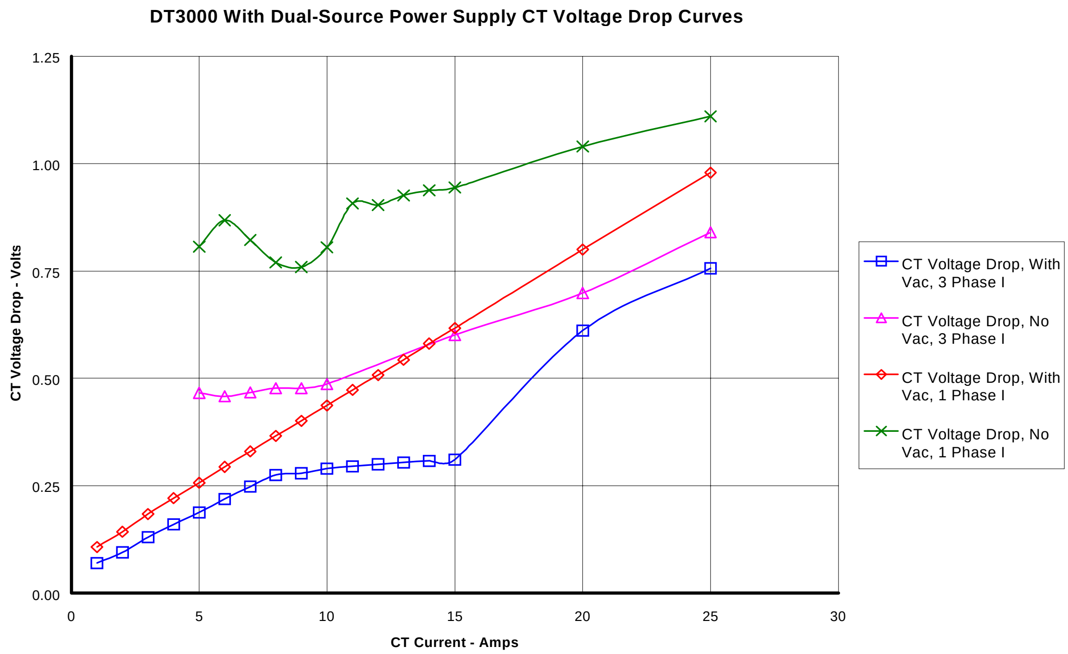

FIGURE 10. Digitrip 3010/3020 protective relay ct voltage drop curves

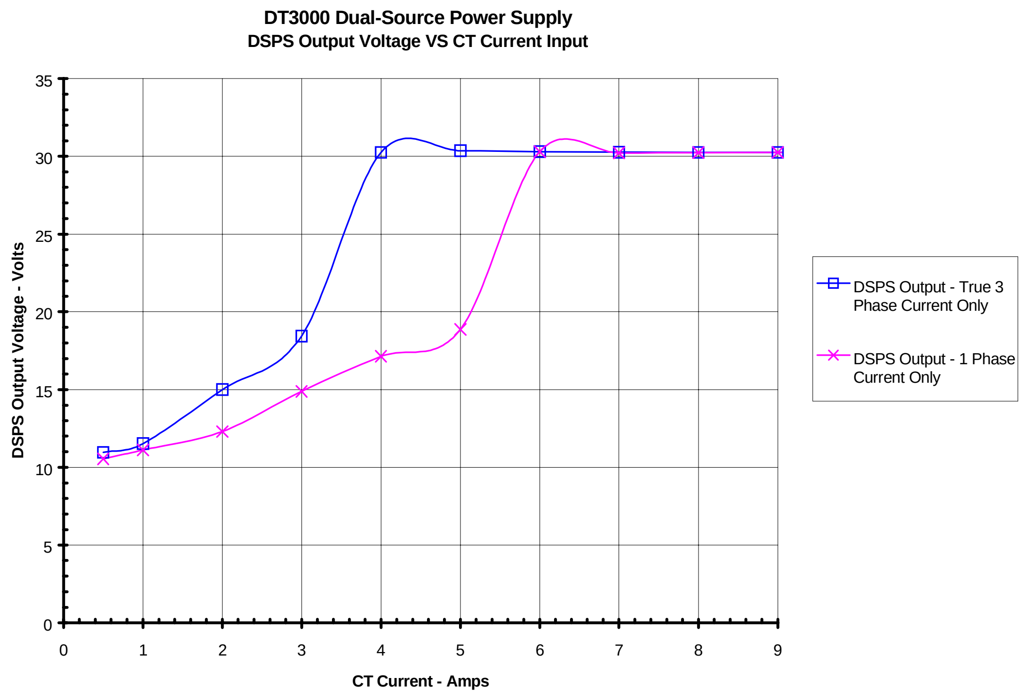

FIGURE 11. DSPS output voltage to relay

8.0 WARRANTY AND LIABILITY INFORMATION

NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OF MERCHANTABILITY, OR WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE ARE MADE REGARDING THE INFORMATION, RECOMMENDATIONS, AND DESCRIPTIONS CONTAINED HEREIN. In no event will Cutler-Hammer be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, otherwise for any special, indirect, incidental, or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information and descriptions contained herein.

9.0 TECHNICAL ASSISTANCE

For additional information, technical assistance, or referral to a local authorized distributor, contact Power Management Applications Support at **1-800-809-2772**.

Cutler-Hammer
Cutler-Hammer Products
Five Parkway Center
Pittsburgh, PA 15220

Style No. 8163A36H01 Effective 3/98
Printed in U.S.A.