A Appendix – Forms

This Appendix contains forms for photocopying, and recording the configuration and setting of the M-3310 Transformer Protection Relay, and to file the data for future reference. Examples of the suggested use of these forms are illustrated in Chapter 2, **Application** and Chapter 3, **Operation (Front Panel)**.

Page A-2 contains a copy of the Relay Configuration Table (which is also discussed in Section 2.2 Configuration, Functions), and is herein provided to define and record the blocking inputs and output configuration for the relay. For each function, check if **DISABLED** or check the output contacts to be operated by the function. Also check the inputs designated to block the function operation.

The Communication Data & Unit Setup Record Form reproduces the Communication and Setup unit menus. This form records definition of the parameters necessary for communication with the relay, as well as access codes, user logo (identifying) lines, date & time setting, and front panel display operation.

The functional Configuration Record Form reproduces the Configure Relay menus including the Setup Relay submenu which is accessible via M-3820A IPScom® Communication Software or the optional M-3931 HMI front panel module.

For each function or setpoint, refer to the configuration you have defined using the Relay Configuration Table, and circle whether it should be enabled or disabled by the output contacts it will activate, and the inputs that will block its operation.

The Setpoint & Timing Record Form allows recording of the specific values entered for each enabled setpoint or function. The form follows the main menu selections of the relay.

The "**AS SHIPPED**" data forms illustrate the factory settings of the relay.

Examples:

```
81U#1 UNDERFREQUENCY
disable ENABLE
```

```
81U#1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1
```

```
81U#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

FUNCTION	D		O	U	T	P	U	T	S		I	N	P	U	T	S
		8	7	6	5	4	3	2	1		6	5	4	3	2	1
24 DEF TIME #1																
24 DEF TIME #2																
24 INV TIME																
27																
46 DEF TIME																
46 INV TIME																
50W1 #1																
50W1 #2																
50W2 #1																
50W2 #2																
50G																
50BF																
51W1																
51W2																
51G																
51NW1																
51NW2																
59G																
81U#1																
81U#2																
81U#3																
87GD																
87H																
87T																
EXT #1																
EXT #2																
EXT #3																
EXT #4																
EXT #5																
EXT #6																

Table A-1 Relay Configuration

KEY TO INPUT DATA RECORD FORMS

A. All unshaded screens shown on forms require data inputs. Whatever is in that screen when the ENTER button is pressed will be installed in the relay.

B. All shaded screens are either **MENU** screens that have horizontal choices made with right and left arrows.

C. The up and down arrows are for navigating through the menus and adjusting value or letter (lower/upper case) selections.

D. The **ENTER** button records the setting change and moves down within a menu. The operator will notice that after the last menu item, **ENTER** moves to the top of the same menu but does not change menu selections.

E. Pressing **EXIT** at any time will exit from the displayed screen to the preceding menu.

F. The arrow symbols (← →) on the edges of a display indicate additional horizontal menu choices are available in the indicated direction. As previously described, the right and left arrows will move the operator to those additional choices.

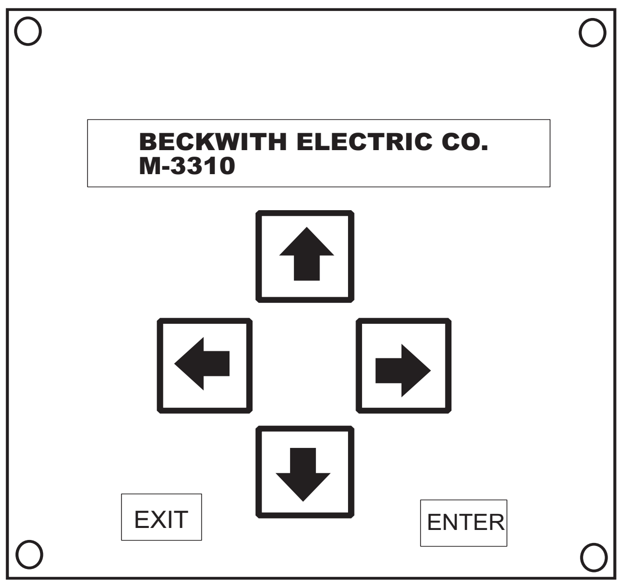


Figure A-1 M-3931 Human-Machine Interface Module

```
CONFIGURE RELAY
←CONFIG sys stat dmd→
```

```
CONFIGURE RELAY
VOLTAGE_RELAY →

27 POSSEQ UNDERVOLTAGE
disable enable

27 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

27 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

59G NEUTRAL OVERVOLTAGE
disable enable

59G BLOCK INPUT
    i6 i5 i4 i3 i2 i1

59G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

CONFIGURE RELAY
← CURRENT_RELAY →

46DT DEF TIME NEGSEQ O/C
disable enable

46DT BLOCK INPUT
    i6 i5 i4 i3 i2 i1

46DT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

46IT INV TIME NEGSEQ O/C
disable enable

46IT BLOCK INPUT
    i6 i5 i4 i3 i2 i1

46IT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
50W1#1 INST PHASE O/C
disable enable

50W1#1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

50W1#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W1#2 INST PHASE O/C
disable ENABLE

50W1#2 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

50W1#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W2#1 INST PHASE O/C
disable ENABLE

50W2#1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

50W2#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W2#2 INST PHASE O/C
disable ENABLE

50W2#2 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

50W2#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51W1 INV TIME O/C
disable ENABLE

51W1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

51W1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51W2 INV TIME O/C
disable ENABLE

51W2 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

51W2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
50G INST GROUND O/C
disable enable

50G BLOCK INPUT
    i6 i5 i4 i3 i2 i1

50G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51G INV TIME GROUND O/C
disable enable

51G BLOCK INPUT
    i6 i5 i4 i3 i2 i1

51G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51NW1 INV TIME RESID O/C
disable enable

51NW1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

51NW1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51NW2 INV TIME RESID O/C
disable enable

51NW2 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

51NW2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

87H HI SET DIFFERENTIAL
disable enable

87H BLOCK INPUT
    i6 i5 i4 i3 i2 i1

87H RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

Figure A-1 Functional Configuration Record Form (Page 1 of 2)

```
87T DIFFERENTIAL CURRENT
disable enable

87T BLOCK INPUT
    i6 i5 i4 i3 i2 i1

87T RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
87GD GROUND DIFFERENTIAL
disable ENABLE

87GD BLOCK INPUT
    i6 i5 i4 i3 i2 i1

87GD RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
50BF BREAKER FAILURE
disable enable

50BF BLOCK INPUT
    i6 i5 i4 i3 i2 i1

50BF RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
CONFIGURE RELAY
← FREQUENCY_RELAY →
```

```
81U#1 UNDERFREQUENCY
disable enable

81U#1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

81U#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

81U#2 UNDERFREQUENCY
disable enable

81U#2 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

81U#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
CONFIGURE RELAY
← CONFIG sys stat dmd →
```

```
81U#3 UNDERFREQUENCY
disable enable

81U#3 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

81U#3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
CONFIGURE RELAY
←VOLTS_PER_HERTZ_RELAY→
```

```
24DT#1 DEF TIME VOLTS/HZ
disable enable

24DT#1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

24DT#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

24DT#2 DEF TIME VOLTS/HZ
disable enable

24DT#2 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

24DT#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2
```

```
24IT INV TIME VOLTS/HZ
disable enable

24IT BLOCK INPUT
    i6 i5 i4 i3 i2 i1

24IT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
CONFIGURE RELAY
←EXTERNAL_RELAY
```

```
EXT#1 EXTERNAL
disable enable

EXT#1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

EXT#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
EXT#2 EXTERNAL
disable enable

EXT#2 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

EXT#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

EXT#3 EXTERNAL
disable enable

EXT#3 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

EXT#3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

EXT#4 EXTERNAL
disable enable

EXT#4 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

EXT#4 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

EXT#5 EXTERNAL
disable enable

EXT#5 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

EXT#5 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

EXT#6 EXTERNAL
disable enable

EXT#6 BLOCK INPUT
    i6 i5 i4 i3 i2 i1

EXT#6 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

Figure A-1 Functional Configuration Record Form (Page 2 of 2)

```
SETUP SYSTEM
← config SYS stat dmd →
```

```
INPUT ACTIVATED PROFILES
IN ap cpy volt curr vt→
```

```
INPUT ACTIVATED PROFILE
disable enable
```

```
ACTIVE SETPOINT PROFILE
in AP cpy volt curr vt→
```

```
ACTIVE SETPOINT PROFILE
 ________
```

```
COPY ACTIVE PROFILE
in ap CPY volt curr vt→
```

```
COPY ACTIVE PROFILE
TO_PROFILE_1 →
```

```
COPY ACTIVE PROFILE
← TO_PROFILE_2 →
```

```
COPY ACTIVE PROFILE
← TO_PROFILE_3 →
```

```
COPY ACTIVE PROFILE
←  TO_PROFILE_4 →
```

```
NOMINAL VOLTAGE
in ap cpy VOLT curr vt→
```

```
NOMINAL VOLTAGE
 ________ VOLTS
```

```
NOMINAL CURRENT
in ap cpy volt CURR vt→
```

```
NOMINAL CURRENT
 ________ AMPS
```

```
V.T. CONFIGURATION
in ap cpy volt curr VT→
```

```
V.T. CONFIGURATION
line_line line_ground →
— — — — — — — — — — — —
← line_gnd_to_line_line
```

```
TRANSFORMER CONNECTION
← XFMR phase seal in →
```

```
TRANSFORMER CONNECTION
 ________
```

```
PHASE ROTATION
← xfmr PHASE seal in →
```

```
PHASE ROTATION
a_c_b   a_b_c
```

```
RELAY SEAL-IN TIME
← xfmr phase SEAL in →
```

```
RELAY SEAL-IN TIME OUT1
 ________ CYCLES
```

```
RELAY SEAL-IN TIME OUT2
 ________ CYCLES
```

```
RELAY SEAL-IN TIME OUT3
 ________ CYCLES
```

```
RELAY SEAL-IN TIME OUT4
 ________ CYCLES
```

```
RELAY SEAL-IN TIME OUT5
 ________ CYCLES
```

```
RELAY SEAL-IN TIME OUT6
 ________ CYCLES
```

```
RELAY SEAL-IN TIME OUT7
 ________ CYCLES
```

```
RELAY SEAL-IN TIME OUT8
 ________ CYCLES
```

```
ACTIVE INPUT STATE
← xfmr phase seal IN→
```

```
ACTIVE INPUT OPEN/CLOSE
    i6 i5 i4 i3 i2 i1
```

```
W2 V.T. PHASE RATIO
← VT_W2 vt_w2g →
```

```
W2 V.T. PHASE RATIO
 ________ :1
```

```
W2 V.T. GROUND RATIO
← vt_w2 VT_W2G →
```

```
W2 V.T. GROUND RATIO
 ________ :1
```

```
W1 C.T. RATIO
← CT_W1 ct_w2 ct_w2→
```

```
W1 C.T. RATIO
 ________ :1
```

```
W2 C.T. RATIO
← ct_w1 CT_W2 ct_w2→
```

```
W2 C.T. RATIO
 ________ :1
```

```
W2 C.T. GROUND RATIO
← ct_w1 ct_w2 CT_W2→
```

```
W1 C.T. GROUND RATIO
 ________ :1
```

Figure A-2   Communication Data & Unit Setup (Page 1 of 2)

COMMUNICATION
← COMM setup exit

COM1 SETUP
com1 com2 com3 com_adr→

COM1 BAUD RATE
← baud_300 baud_600 →
←baud_ 1200 baud_2400 →
←baud_4800 baud_9600

COM2 SETUP
com1 COM2 com3 com_adr→

COM2 BAUD RATE
← baud_300 baud_600 →
←baud_ 1200 baud_2400 →
←baud_4800 baud_9600

COM2 DEAD SYNC TIME
________ MS

COM2 PROTOCOL
beco2200 modbus

COM2 PARITY
none odd even

COM3 SETUP
com1 com2 COM3 com_adr→

COM3 DEAD SYNC TIME
________ MS

COM3 PROTOCOL
beco2200 modbus

COM3 PARITY
none odd even

COMMUNICATION ADDRESS
com1 com2 com3 COM_ADR→

COMMUNICATION ADDRESS
____

COMM ACCESS CODE
← ACCESS

COMM ACCESS CODE
____

SETUP UNIT
← comm SETUP exit

SOFTWARE VERSION
VERS sn access number →

SOFTWARE VERSION
D-0042XXX.XX.XX

SERIAL NUMBER
vers SN access number →

SERIAL NUMBER
____

ALTER ACCESS CODES
vers sn ACCESS number →

ENTER ACCESS CODE
LEVEL#1 level#2 level#3

LEVEL #1
____

ENTER ACCESS CODE
level#1 LEVEL#2 level#3

LEVEL #2
____

ENTER ACCESS CODE
level#1 level#2 LEVEL#3

LEVEL #3
____

USER CONTROL NUMBER
vers sn access NUMBER →

USER CONTROL NUMBER
____

USER LOGO LINE 1
←LOGO1 logo2 out alrm→

USER LOGO LINE 1
____

USER LOGO LINE 2
← logo1 LOGO2 out alrm

USER LOGO LINE 2
____

CLEAR OUTPUT COUNTERS
←logo1 logo2 OUT alrm→

CLEAR OUTPUT COUNTERS
PRESS ENTER KEY TO CLEAR

CLEAR ALARM COUNTER
←logo1 logo2 out ALRM→

CLEAR ALARM COUNTER
PRESS ENTER KEY TO CLEAR

DATE & TIME
← TIME error diag

DATE & TIME
03-JAN-1998 01:00:80

DATE & TIME
________ YEAR

DATE & TIME
jan feb mar apr may →

DATE & TIME
________ DATE

DATE & TIME
sun mon tue wed thu →

DATE & TIME
________ HOUR

DATE & TIME
________ MINUTES

DATE & TIME
Seconds

CLEAR ERROR CODES
← time ERROR diag

CLEAR ERROR CODES
PRESS ENTER KEY TO CLEAR

DIAGNOSTIC MODE
← time error DIAG

PROCESSOR WILL RESET
ENTER KEY TO CONTINUE

Figure A-2 Communication Data & Unit Setup (Page 2 of 2)

VOLTAGE RELAY
VOLT curr freq v/hz ext→

27 POSSEQ UNDERVOLTAGE
VOLT_UNDER n_over

27 PICKUP
________ VOLTS

27 INHIBIT
disable enable

27 INHIBIT
________ VOLTS

27 DELAY
________ CYCLES

59G ZEROSEQ OVERVOLTAGE
volt_under N_OVER

59G PICKUP
________ VOLTS

59G DELAY
________ CYCLES

CURRENT RELAY
volt CURR freq v/hz ext→

46 NEGSEQ OVERCURRENT
NEG_SEQ inst inv

46DT PICKUP
________ AMPS

46DT DELAY
________ CYCLES

46IT PICKUP
________ AMPS

46IT CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

46IT TIME DIAL
____

50 INST OVERCURRENT
neg_seq INST inv

50W1#1 PICKUP
________ AMPS

50W1#2 PICKUP
________ AMPS

51 INV TIME OVERCURRENT
neg_seq inst INV

51W1 PICKUP
________ AMPS

51W1 CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

51W1 TIME DIAL
____

51W2 PICKUP
________ AMPS

51W2 CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

51W2 TIME DIAL
____

50G INST OVERCURRENT
← G_INST g_inv n_inv →

50G PICKUP
________ AMPS

51G INV TIME OVERCURRENT
← g_inst G_INV n_inv →

51G PICKUP
________ AMPS

51G CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

51G TIME DIAL
____

51N RES TIME OVERCURRENT
← g_inst g_inv N_INV →

51NW1 PICKUP
________ AMPS

51NW1 CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

51NW1 TIME DIAL
____

51NW2 PICKUP
________ AMPS

51NW2 CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

51NW2 TIME DIAL
____

87 DIFFERENTIAL OVERCURR
← DIFF g_diff

87H PICKUP
________ PU

87H DELAY
________ CYCLES

87T PICKUP
________ PU

87T SLOPE #1
________ %

87T SLOPE #2
________ %

87T SLOPE BREAKPOINT
________ PU

87T EVEN RESTRAINT
disable enable cross_avg

87T EVEN RESTRAINT
________ %

Figure A-3 Setpoint & Timing Record Form (Page 1 of 2)

87T 5TH RESTRAINT
disable enable cross_avg

87T 5TH RESTRAINT
________ %

87T PICKUP@5TH RESTRAINT
________ PU

87 W1 C.T. TAP
____

87 W2 C.T. TAP
____

87GD GND DIFF OVERCURR
← diff G_DIFF

87GD PICKUP
________ AMPS

87GD DELAY
________ CYCLES

87GD C.T. RATIO CORRECT
____

50BF BREAKER FAILURE
← BRK_FAIL

50BF PICKUP PHASE
________ AMPS

50BF PICKUP RESIDUAL
________ AMPS

50BF INPUT INITIATE
i6 i5 i4 i3 i2 i1

50BF OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1

50BF DELAY
________ CYLES

FREQUENCY RELAY
volt curr FREQ v/hz ext→

81U UNDER FREQUENCY
FREQ_UNDER

81U#1 PICKUP
________ HZ

81U#1 DELAY
________ CYCLES

81U#2 PICKPU
________ HZ

81U#2 DELAY
________ CYCLES

81U#3 PICKUP
________ HZ

81U#3 DELAY
________ CYCLES

VOLTS PER HERTZ RELAY
volt curr freq V/HZ ext→

24 DF TIME VOLTS/HERTZ
DEF_V/HZ inv_v/hz

24DT#1 PICKUP
________ %

24DT#1 DELAY
________ CYCLES

24DT#2 PICKUP
________ %

24DT#2 DELAY
________ CYCLES

24 INV TIME VOLTS/HERTZ
def_v/hz INV_V/HZ

24IT PICKUP
________ %

24IT CURVE
crv#1 crv#2 crv#3 crv#4

24IT TIME DIAL
____

24IT RESET RATE
________ SECONDS

EXTERNAL RELAY
volt curr freq v/hz EXT

EXTERNAL
EXT

EXT#1 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT#1 OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1

EXT#1 DELAY
________ CYCLES

EXT#2 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT#2 OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1

EXT#2 DELAY
________ CYCLES

EXT#3 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT#3 OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1

EXT#3 DELAY
________ CYCLES

EXT#4 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT#4 OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1

EXT#4 DELAY
________ CYCLES

EXT#5 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT#5 OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1

EXT#5 DELAY
________ CYCLES

EXT#6 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT#6 OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1

EXT#6 DELAY
________ CYCLES

Form A-3 Setpoint & Timing Record Form (Page 2 of 2)

CONFIGURE RELAY
←CONFIG sys stat dmd→

CONFIGURE RELAY
VOLTAGE_RELAY →

27 POSSEQ UNDERVOLTAGE
DISABLE enable

59G NEUTRAL OVERVOLTAGE
DISABLE enable

CONFIGURE RELAY
← CURRENT_RELAY →

46DT DEF TIME NEGSEQ O/C
DISABLE enable

50W1#1 INST PHASE O/C
disable ENABLE

50W1#1 BLOCK INPUT
i6 i5 i4 i3 i2 I1

50W1#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1

50W1#2 INST PHASE O/C
DISABLE enable

50W2#1 INST PHASE O/C
disable ENABLE

50W2#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50W2#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W2#2 INST PHASE O/C
DISABLE enable

51W1 INV TIME O/C
disable ENABLE

51W1 BLOCK INPUT
i6 i5 i4 i3 i2 I1

51W1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1

51W2 INV TIME O/C
disable ENABLE

51W2 BLOCK INPUT
i6 i5 i4 i3 i2 I1

51W2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 O2 o1

50G INST GROUND O/C
disable ENABLE

50G BLOCK INPUT
i6 i5 i4 i3 i2 I1

50G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1

51G INV TIME GROUND O/C
disable ENABLE

51G BLOCK INPUT
i6 i5 i4 i3 i2 I1

51G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1

51NW1 INV TIME RESID O/C
disable ENABLE

51NW1 BLOCK INPUT
i6 i5 i4 i3 i2 I1

51NW1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1

51NW2 INV TIME RESID O/C
disable ENABLE

51NW2 BLOCK INPUT
i6 i5 i4 i3 i2 I1

51NW2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 O2 o1

87H HI SET DIFFERENTIAL
disable ENABLE

87H BLOCK INPUT
i6 i5 i4 i3 i2 I1

87H RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1

87T DIFFERENTIAL CURRENT
disable ENABLE

87T BLOCK INPUT
i6 i5 i4 i3 i2 I1

87T RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1

87GD GROUND DIFFERENTIAL
DISABLE enable

50BF BREAKER FAILURE
DISABLE enable

*Figure A-4 Functional Configuration Record Form – **As Shipped** (Page 1 of 2)*

CONFIGURE RELAY
← CONFIG sys stat dmd →

CONFIGURE RELAY
← FREQUENCY_RELAY →

81U#1 UNDERFREQUENCY
DISABLE enable

81U#2 UNDERFREQUENCY
DISABLE enable

81U#3 UNDERFREQUENCY
DISABLE enable

CONFIGURE RELAY
←VOLTS_PER_HERTZ_RELAY→

24DT#1 DEF TIME VOLTS/HZ
DISABLE enable

24DT#2 DEF TIME VOLTS/HZ
DISABLE enable

24IT INV TIME VOLTS/HZ
DISABLE enable

CONFIGURE RELAY
←EXTERNAL_RELAY

EXT#1 EXTERNAL
DISABLE enable

EXT#2 EXTERNAL
DISABLE enable

EXT#3 EXTERNAL
DISABLE enable

EXT#4 EXTERNAL
DISABLE enable

EXT#5 EXTERNAL
DISABLE enable

EXT#6 EXTERNAL
DISABLE enable

*Figure A-4 Functional Configuration Record Form – **As Shipped** (Page 2 of 2)*

```
SETUP SYSTEM
← config SYS stat dmd →
```

```
INPUT ACTIVATED PROFILES
IN ap cpy volt curr vt→
```

```
INPUT ACTIVATED PROFILE
DISABLE enable
```

```
ACTIVE SETPOINT PROFILE
in AP cpy volt curr vt→
```

```
ACTIVE SETPOINT PROFILE
     1
```

```
COPY ACTIVE PROFILE
in ap CPY volt curr vt→
```

```
COPY ACTIVE PROFILE
TO_PROFILE_1 →
```

```
COPY ACTIVE PROFILE
← TO_PROFILE_2 →
```

```
COPY ACTIVE PROFILE
← TO_PROFILE_3 →
```

```
COPY ACTIVE PROFILE
←  TO_PROFILE_4 →
```

```
NOMINAL VOLTAGE
in ap cpy VOLT curr vt→
```

```
NOMINAL VOLTAGE
120 VOLTS
```

```
NOMINAL CURRENT
in ap cpy volt CURR vt→
```

```
NOMINAL CURRENT
5.00 AMPS
```

```
V.T. CONFIGURATION
in ap cpy volt curr VT→
```

```
V.T. CONFIGURATION
LINE_LINE line_ground→
— — — — — — — — — —
←line_gnd_to_line_line
```

```
TRANSFORMER CONNECTION
← XFMR phase seal in →
```

```
TRANSFORMER CONNECTION
     1
```

```
PHASE ROTATION
← xfmr PHASE seal in →
```

```
PHASE ROTATION
a_c_b   A_B_C
```

```
RELAY SEAL-IN TIME
← xfmr phase SEAL in →
```

```
RELAY SEAL-IN TIME OUT1
30 CYCLES
```

```
RELAY SEAL-IN TIME OUT2
30 CYCLES
```

```
RELAY SEAL-IN TIME OUT3
30 CYCLES
```

```
RELAY SEAL-IN TIME OUT4
30 CYCLES
```

```
RELAY SEAL-IN TIME OUT5
30 CYCLES
```

```
RELAY SEAL-IN TIME OUT6
30 CYCLES
```

```
RELAY SEAL-IN TIME OUT7
30 CYCLES
```

```
RELAY SEAL-IN TIME OUT8
30 CYCLES
```

```
ACTIVE INPUT STATE
← xfmr phase seal IN→
```

```
ACTIVE INPUT OPEN/CLOSE
   i6 i5 i4 i3 i2 i1
```

```
W2 V.T. PHASE RATIO
← VT_W2 vt_w2g →
```

```
W2 V.T. PHASE RATIO
1.0:1
```

```
W2 V.T. GROUND RATIO
← vt_w2 VT_W2G →
```

```
W2 V.T. GROUND RATIO
1.0:1
```

```
W1 C.T. RATIO
← CT_W1 ct_w2 ct_w2g
```

```
W1 C.T. RATIO
10:1
```

```
W2 C.T. RATIO
← ct_w1 CT_W2 ct_w2g
```

```
W2 C.T. RATIO
10:1
```

```
W2 C.T. GROUND RATIO
← ct_w1 ct_w2 CT_W2g
```

```
W1 C.T. GROUND RATIO
10:1
```


*Figure A-2 Communication Data & Unit Setup – **As Shipped** (Page 1 of 2)*

COMMUNICATION
← COMM setup exit

COM1 SETUP
com1 com2 com3 com_adr→

COM1 BAUD RATE
← baud_300 baud_600 →
←baud_ 1200 baud_2400 →
←baud_4800 BAUD_9600

COM2 SETUP
com1 COM2 com3 com_adr→

COM2 BAUD RATE
← baud_300 baud_600 →
←baud_ 1200 baud_2400 →
←baud_4800 BAUD_9600

COM2 DEAD SYNC TIME
50 MS

COM2 PROTOCOL
BECO2200 modbus

COM3 SETUP
com1 com2 COM3 com_adr→

COM3 DEAD SYNC TIME
50 MS

COM3 PROTOCOL
BECO2200 modbus

COMMUNICATION ADDRESS
com1 com2 com3 COM_ADR→

COMMUNICATION ADDRESS
1

COMM ACCESS CODE
← ACCESS

COMM ACCESS CODE
9999

SETUP UNIT
← comm SETUP exit

SOFTWARE VERSION
VERS sn access number →

SOFTWARE VERSION
D-0042V01.02.07

SERIAL NUMBER
vers SN access number →

SERIAL NUMBER
1

ALTER ACCESS CODES
vers sn ACCESS number →

ENTER ACCESS CODE
LEVEL#1 level#2 level#3

LEVEL #1
1111

ENTER ACCESS CODE
level#1 LEVEL#2 level#3

LEVEL #2
2222

ENTER ACCESS CODE
level#1 level#2 LEVEL#3

LEVEL #3
9999

USER CONTROL NUMBER
vers sn access NUMBER →

USER CONTROL NUMBER
1

USER LOGO LINE 1
←LOGO1 logo2 out alrm→

USER LOGO LINE 1
BECKWITH ELECTRIC CO.

USER LOGO LINE 2
← logo1 LOGO2 out alrm

USER LOGO LINE 2
M-3310

CLEAR OUTPUT COUNTERS
←logo1 logo2 OUT alrm→

CLEAR OUTPUT COUNTERS
PRESS ENTER KEY TO CLEAR

CLEAR ALARM COUNTER
←logo1 logo2 out ALRM→

CLEAR ALARM COUNTER
PRESS ENTER KEY TO CLEAR

DATE & TIME
← TIME error diag

DATE & TIME
01-JAN-2000 01:00:80

DATE & TIME
01 YEAR

DATE & TIME
JAN feb mar apr may →

DATE & TIME
01 DATE

DATE & TIME
SUN mon tue wed thu →

DATE & TIME
01 HOUR

DATE & TIME
01 MINUTES

DATE & TIME
01 Seconds

CLEAR ERROR CODES
← time ERROR diag

CLEAR ERROR CODES
PRESS ENTER KEY TO CLEAR

DIAGNOSTIC MODE
← time error DIAG

PROCESSOR WILL RESET
ENTER KEY TO CONTINUE

*Figure A-2 Communication Data & Unit Setup – **As Shipped** (Page 2 of 2)*

VOLTAGE RELAY
VOLT curr freq v/hz ext→

27 POSSEQ UNDERVOLTAGE
VOLT_UNDER n_over

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

59G ZEROSEQ OVERVOLTAGE
volt_under N_OVER

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

CURRENT RELAY
volt CURR freq v/hz ext→

46 NEGSEQ OVERCURRENT
NEG_SEQ inst inv

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

50 INST OVERCURRENT
neg_seq INST inv

50W1#1 PICKUP
1.0 Amps

51 INV TIME OVERCURRENT
neg_seq inst INV

51W1 PICKUP
1.0 AMPS

51W1 CURVE
DEF inv vinv einv →
←ieci iecvi iecei ieclti

51W1 TIME DIAL
5.0

51W2 PICKUP
1.0 AMPS

51W2 CURVE
DEF inv vinv einv →
←ieci iecvi iecei ieclti

51W2 TIME DIAL
5.0

50G INST OVERCURRENT
← G_INST g_inv n_inv →

50G PICKUP
1.0 AMPS

51G INV TIME OVERCURRENT
← g_inst G_INV n_inv →

51G PICKUP
1.0 AMPS

51G CURVE
DEF inv vinv einv →
←ieci iecvi iecei ieclti

51G TIME DIAL
5.0

51N RES TIME OVERCURRENT
← g_inst g_inv N_INV →

51NW1 PICKUP
1.00 AMPS

51NW1 CURVE
DEF inv vinv einv →
←ieci iecvi iecei ieclti

51NW1 TIME DIAL
5.0

51NW2 PICKUP
1.00 AMPS

51NW2 CURVE
DEF inv vinv einv →
←ieci iecvi iecei ieclti

51NW2 TIME DIAL
5.0

87 DIFFERENTIAL OVERCURR
← DIFF g_diff

87H PICKUP
20.0 PU

87H DELAY
2 CYCLES

87T PICKUP
0.50 PU

87T SLOPE #1
25 %

87T SLOPE #2
75 %

87T SLOPE BREAKPOINT
2.0 PU

87T EVEN RESTRAINT
disable enable CROSS_AVG

87T EVEN RESTRAINT
10 %

87T 5TH RESTRAINT
disable enable CROSS_AVG

87T 5TH RESTRAINT
10 %

87T PICKUP@5TH RESTRAINT
0.75 PU

87 W1 C.T. TAP
1.00

87 W2 C.T. TAP
1.00

87GD GND DIFF OVERCURR
← diff G_DIFF

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

50BF BREAKER FAILURE
← BRK_FAIL

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

*Figure A-3 Setpoint & Timing Record Form – **As Shipped** (Page 1 of 2)*

FREQUENCY RELAY
volt curr FREQ v/hz ext→

81U UNDER FREQUENCY
FREQ_UNDER

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

EXTERNAL RELAY
volt curr freq v/hz EXT

EXTERNAL
EXT

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

VOLTS PER HERTZ RELAY
volt curr freq V/HZ ext→

24 DF TIME VOLTS/HERTZ
DEF_V/HZ inv_v/hz

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

24 INV TIME VOLTS/HERTZ
def_v/hz INV_V/HZ

FUNCTION(S) DISABLED
SEE CONFIGURE MENU

*Form A-3 Setpoint & Timing Record Form – **As Shipped** (Page 2 of 2)*

FUNCTION	D		O	U	T	P	U	T	S		I	N	P	U	T	S
		8	7	6	5	4	3	2	1		6	5	4	3	2	1
24 DEF TIME #1	✓															
24 DEF TIME #2	✓															
24 INV TIME	✓															
27	✓															
46 DEF TIME	✓															
46 INV TIME	✓															
50W1 #1									✓							✓
50W1 #2	✓															
50W2 #1	✓															
50W2 #2	✓															
50G									✓							✓
50BF	✓															
51W1									✓							✓
51W2								✓								✓
51G									✓							✓
51NW1									✓							✓
51NW2								✓								✓
59G	✓															
81U#1	✓															
81U#2	✓															
81U#3	✓															
87GD	✓															
87H									✓							✓
87T									✓							✓
EXT #1	✓															
EXT #2	✓															
EXT #3	✓															
EXT #4	✓															
EXT #5	✓															
EXT #6	✓															

*Table A-2 Relay Configuration – **As Shipped***

B Appendix – Communications

The M-3310 Transformer Protection Relay incorporates three serial ports for intelligent, digital communication with external devices. Equipment such as RTUs, data concentrators, modem, or computers can be interfaced for direct, on-line real time data acquisition and control.

Generally, all data available to the operator through the front panel of the relay, with the optional M-3931 HMI module is accessible remotely through the BECO 2200 data exchange protocol. This protocol document and the BECO 2200 relay database specified protocol document are available from the factory or our website at www.beckwithelectric.com.

The M-3820A IPScom® Communication Software package has been supplied for communication to any IBM compatible computer running under Windows 95™ or higher.

The protocol implements serial, byte oriented, asynchronous communication, and can be used to fulfill the following communications functions:

- Real time monitoring of line status.
- Interrogation and modification of setpoints.
- Downloading of recorded oscillograph data.
- Reconfiguration of functions.

■ **NOTE:** The following restrictions apply for MODBUS protocol use:

1. MODBUS protocol is not supported on COM1
2. Parity is supported on COM2 and COM3 only, valid selections are 8,N,2; 8,0,1 or 8,E,1. ASCII mode is not supported (RTU only)
3. Standard baud rates from 300 to 9600 are supported.
4. Only the following MODBUS commands are supported:
   a. Read holding register (function 03)
   b. read input register (function 04)
   c. Force single coil (function 05)
   d. Preset single register (function 06)
6. MODBUS does not support oscillograph record downloading.

For detailed information on communications, refer to Chapter 4, **IPScom Operation.**

Communication Ports

The relay has both front and rear panel RS-232 ports, and a rear RS-485 port. The front and rear panel RS-232 ports are 9-pin (DB9S) connector configured as DTE (Data Terminal Equipment) per the RS-232C standard. Signals are defined in Table B-1.

The RS-485 port is assigned to the rear panel terminal block pins 1 through 4 (see Figure B-2). This can be configured for isolated RS-485 two-wire or non-isolated four-wire operation.

■ **NOTE**: Four-wire operation is only available as a non-isolated RS-485 supplied option.

Each communication port may be configured to operate at any of the standard baud rates (1200, 2400, 4800, and 9600). The RS-485 port shares the same baud rate with COM 2 (or COM 1 – see Section 5.3).

While the RS-232 communication ports do include some Electrostatic Discharge (ESD) protection circuitry, they are excluded from passing ANSI/IEEE C37.90.1 - 1998. Beckwith Electric recommends the use of RS-232 to fiber optic converters to avoid any question of surge-withstand capability.

Figure 5.3 Circuit Board Switches and Jumpers illustrates the placement of an internal terminating resistor jumper that incorporates in the printed circuit board for the RS-485 channel. Otherwise, an external termination resistor can be used

A null modem cable (see Figure B-1) allows direct connection to a personal computer (PC), if desired.

CIRCUIT		SIGNAL	COM 1	COM 2
BB	RX	Receive Data	Pin 2	Pin 2
BA	TX	Transmit Data	Pin 3	Pin 3
CA	RTS	Request to Send	Pin 7	Pin 7
CB	CTS	Clear to Send		Pin 8
CD	DTR	Data Terminal Ready	Pin 4	Pin 4
CF	DCD	Data Carrier Detect		Pin 1
AB	GND	Signal Ground	Pin 5	Pin 5
		+15 V		Pin 1*
		-15 V		Pin 9*
		IRIG-B (+)		Pin 6*

**OPTIONAL - see Section 5.5, Circuit Board Switches and Jumpers*
±15V (±15%) @100 mA max.

Table B-1 Communication Port Signals

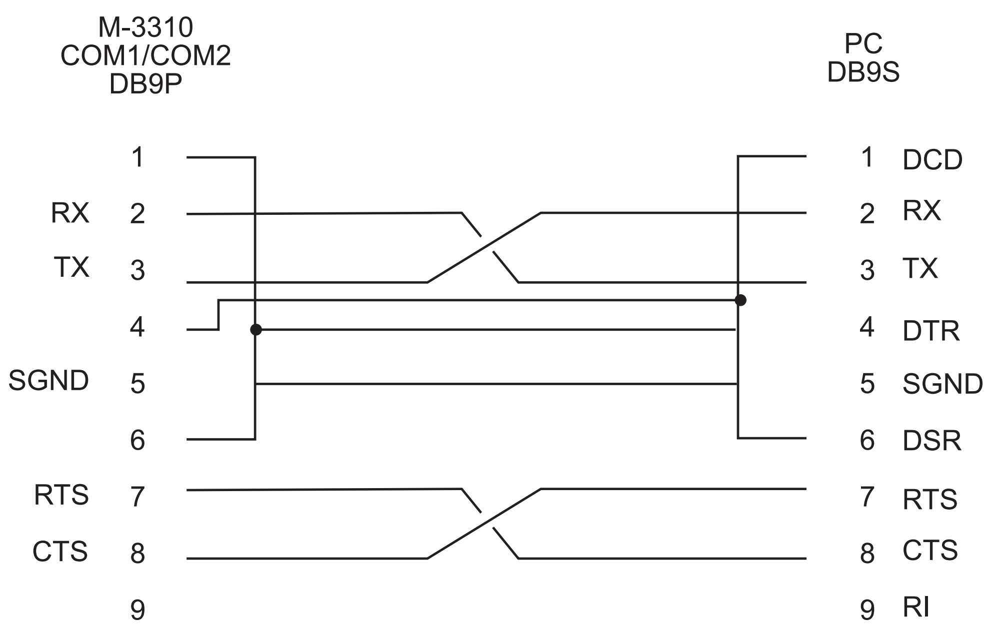


Figure B-1 Null Modem Cable for M-3310

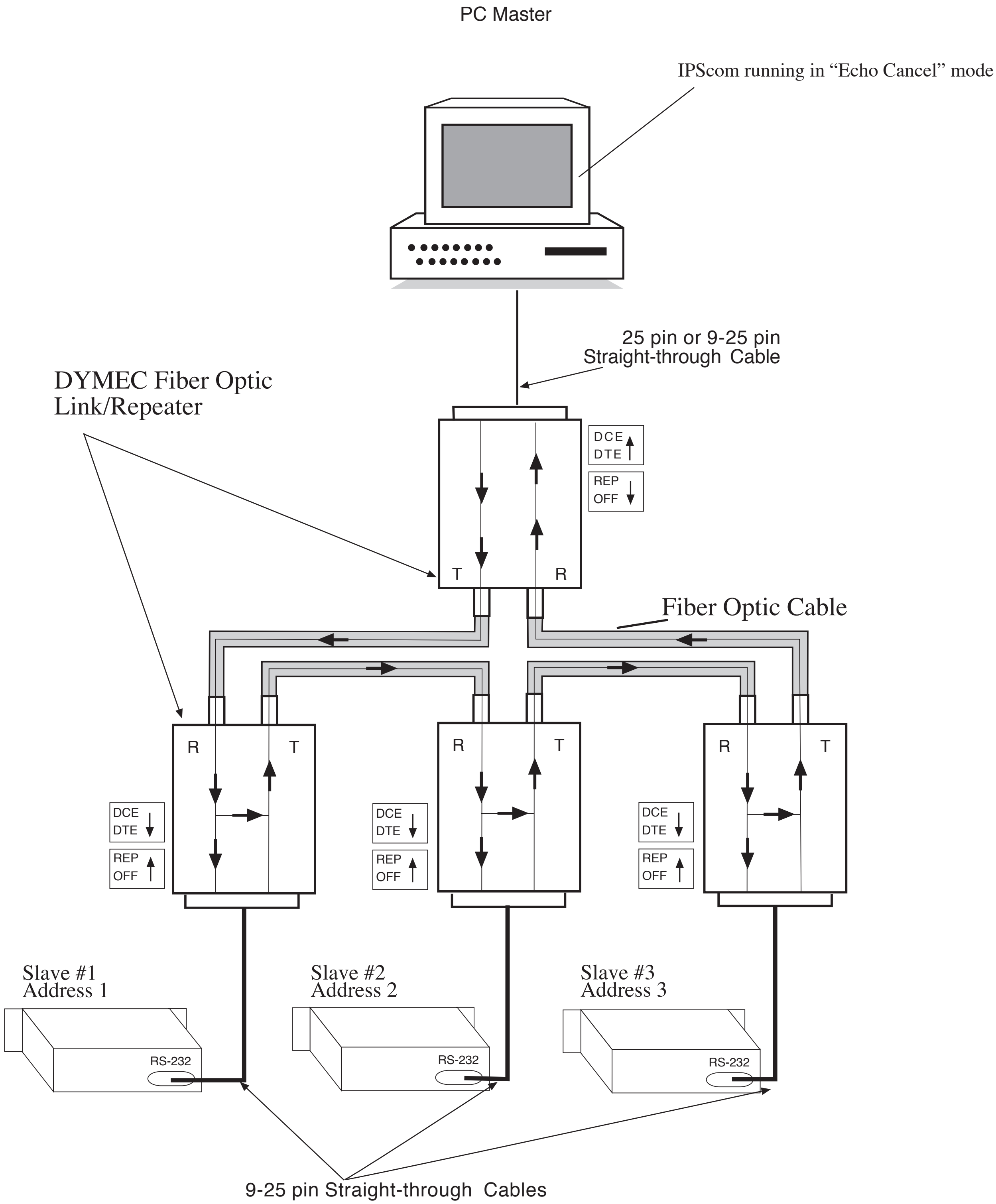
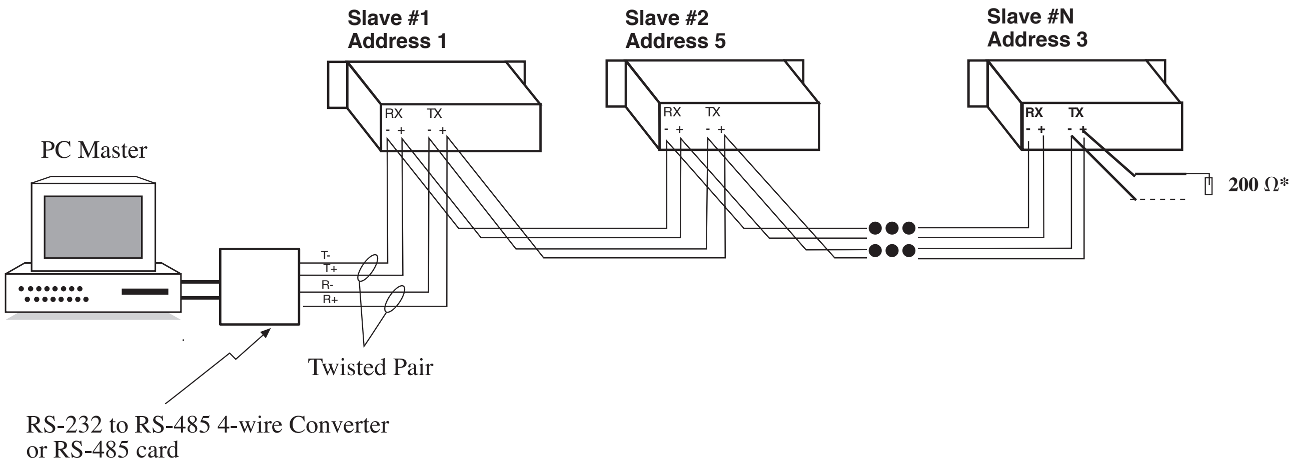
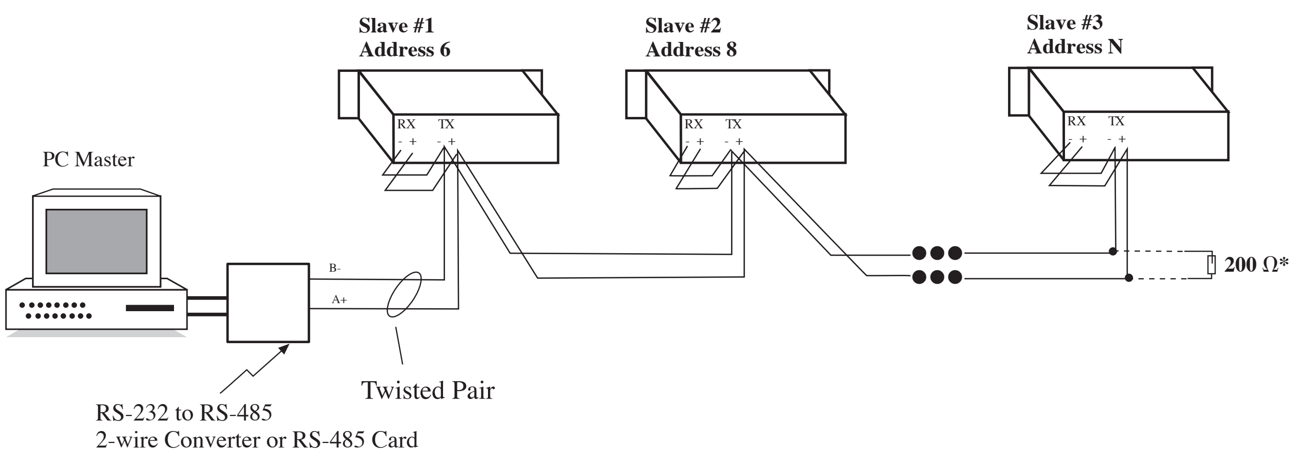


Figure B-2 RS-232 Fiber Optic Network

RS-485 4-Wire Network



RS-485 2-Wire Network



▲ **CAUTION**: Due to the possibility of ground potential difference between units, the units should be mounted in the same rack. If this is not possible, fiber optics with the appropriate converters should be used for isolation. The two-wire topology is preferable to the four-wire, as circuitry within the relay provides some isolation. Four-wire operation is only available when the four-wire RS-485 option is selected at the time of purchase.

■ **NOTE**: Each address on the network must be unique. Only the last physical slave on the network should have the termination resistor installed. This may be completed externally or via a dip jumper internal to the unit. See Section 5.4, **Circuit Board Switches and Jumpers.**

Figure B-3 RS-485 Networks

C Appendix – Error Codes

Error Code	Description
1	
2	Battery backed RAM test fail
3	EEPROM write power-up fail
4	EEPROM read back power-up fail
5	Dual port RAM test fail
6	EEPROM write calibration checksum fail
7	EEPROM write setpoint checksum fail loss of power
8	EEPROM write setpoint checksum fail loss of battery backed RAM
9	DMA checksum/physical block fail
10	
11	DSP external program RAM fail
12	DSP A/D convert fail
13	DSP ground channel fail
14	DSP reference channel fail
15	DSP PGA gain fail
16	DSP DSP <-> Host interrupt 1 fail
17	DSP DSP -> Host interrupt 2 set fail
18	DSP DSP -> Host interrupt 2 reset fail
19	DSP program load fail
20	
21	
22	DSP DPRAM pattern test fail
23	EEPROM write verify error
24	BBRAM test error
25	Uninitialized EEPROM

Table C-1A Self-Test Error Codes (page 1 of 2)

Error Code	Description
26	WARNING calibration checksum mismatch warning
27	WARNING setpoint checksum mismatch warning
28	WARNING low battery (BBRAM) warning
29	Supply/Mux PGA running test fail
30	
31	Unrecognized INT1 interrupt code
32	Values update watchdog fail
33	Abort Error
34	Restart Error
35	Interrupt Error
36	Trap Error
37	Calibration running check fail
38	
39	
40	87 high speed interrupt noise
41	
42	
43	
44	Oscillograph buffer overflow
45	Oscillograph buffer underflow
46	Failure of DSP to calculate calibration phasors
47	Uncalibratable input (gain)
48	Uncalibratable input (phase)
49	
50	Stack overflow

Table C-1B Self-Test Error Codes (pg 2 of 2)

D Appendix – Inverse Time Curves

This Appendix contains two sets of Inverse Time Curve Families. The first set is used for Volts per Hertz functions (Figures D-1 through D-4), and the second set is for the M-3310 functions which utilize the IEC time over current curves (Figures D-5) through D-8).

■ **Note**: Figures D-1 through D-4 are Volts per Hertz curves. Figures D-5 through D-12 are 51, 51N, 51G and 46 functions.

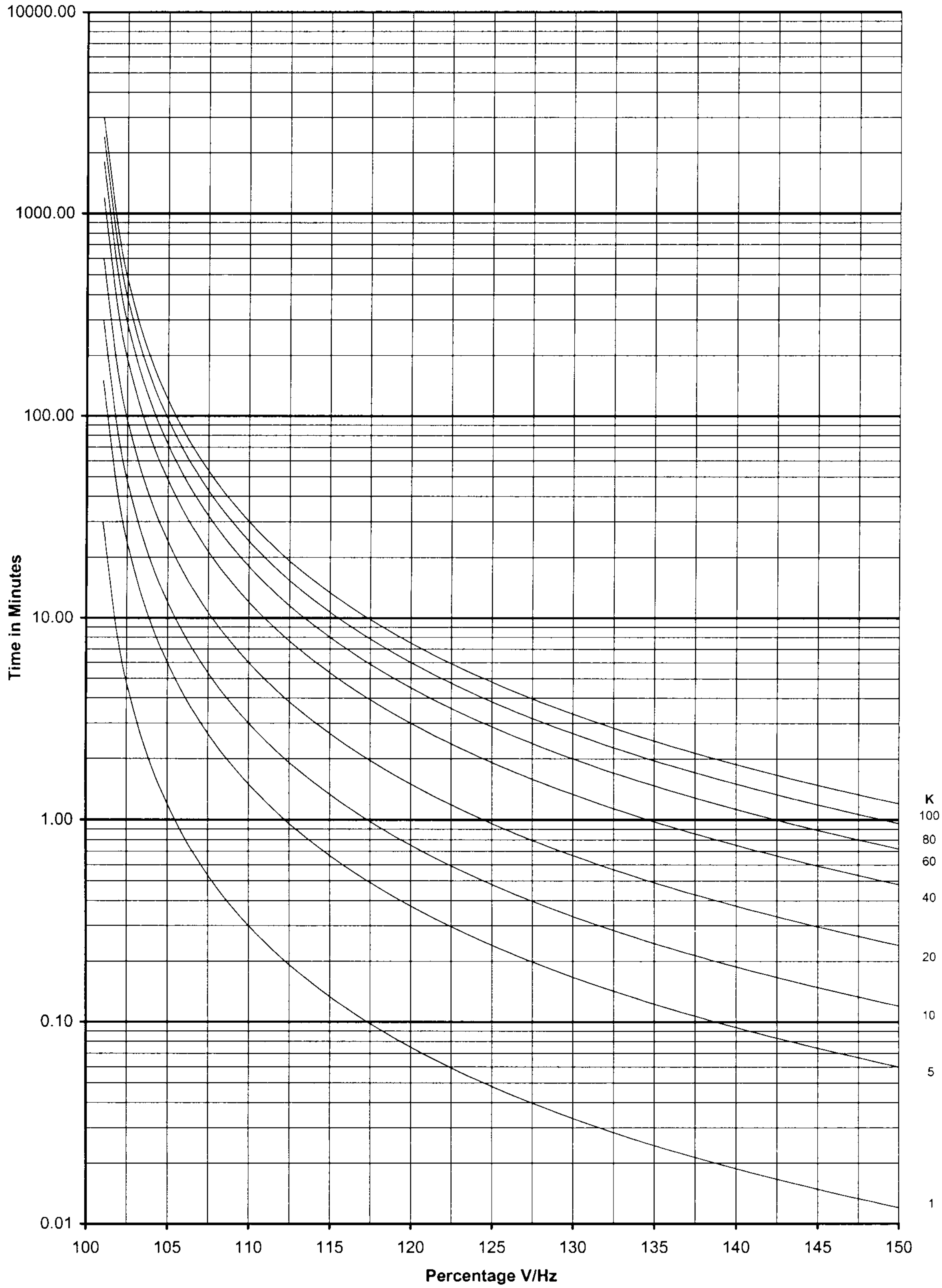


Figure D-1 Volts/Hz (24IT) Inverse Curve Family #1 (Inverse Square)

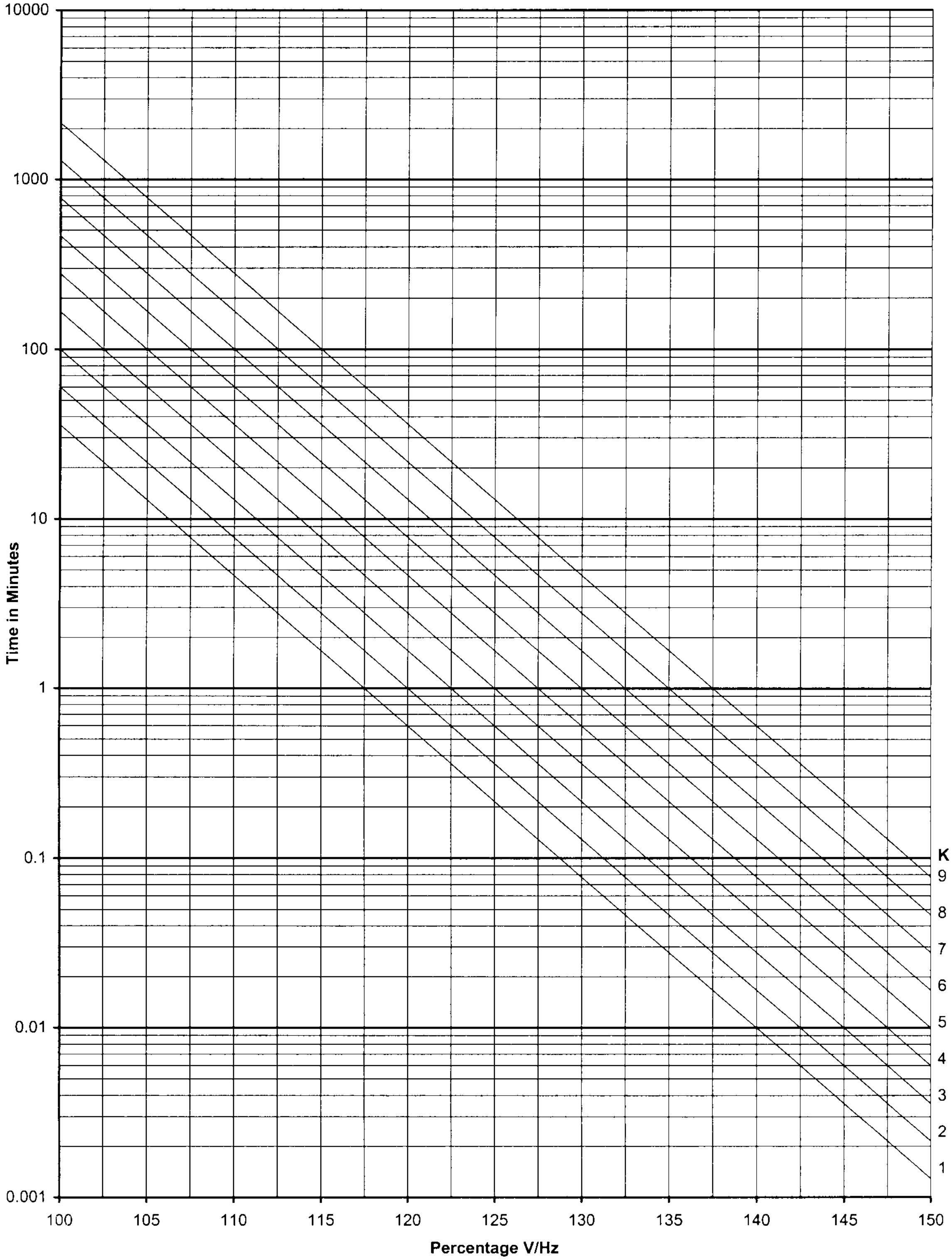


Figure D-2 Volts/Hz (24IT) Inverse Family Curve #2

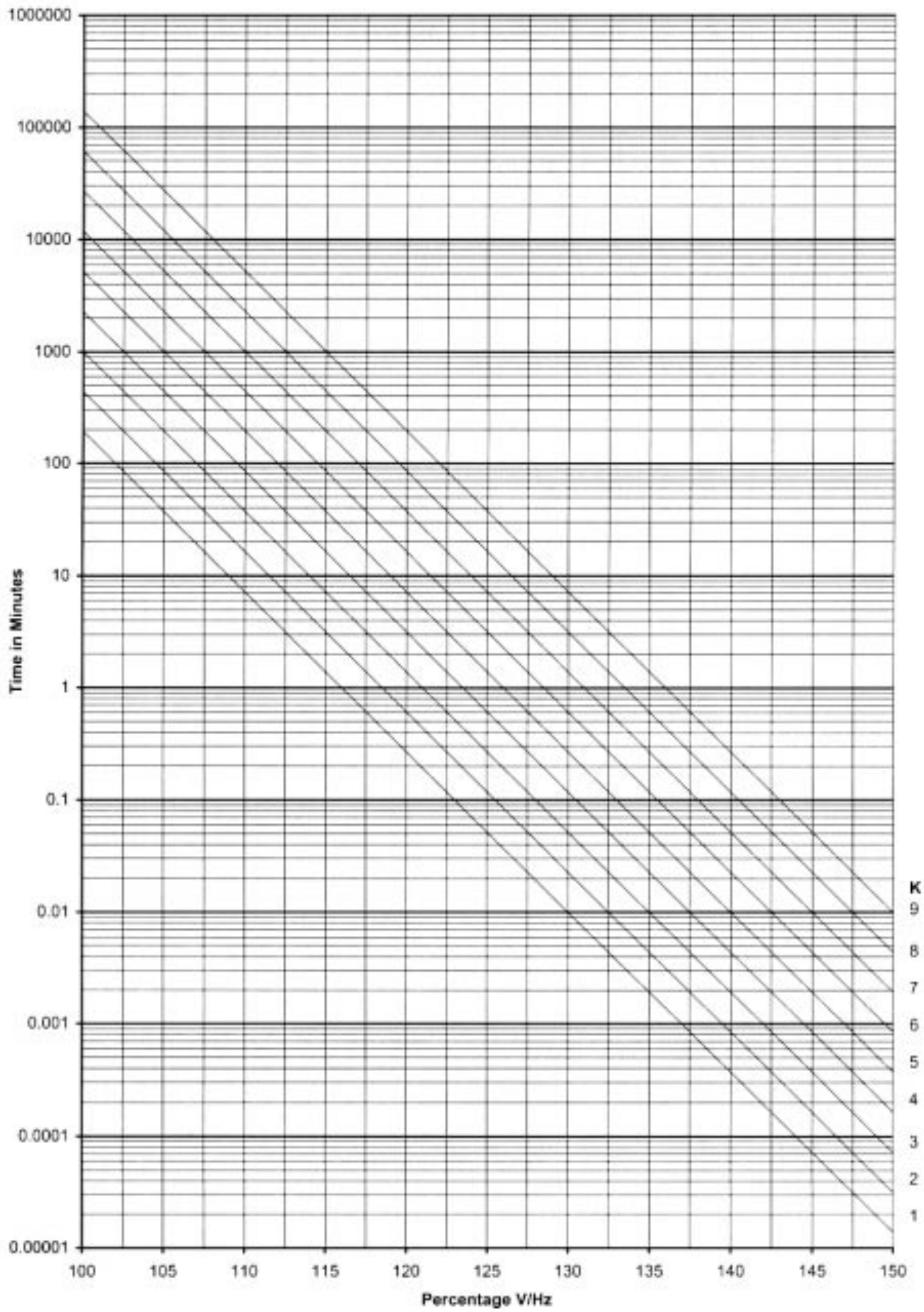


Figure D-3 Volts/Hz (24IT) Inverse Time Curve Family #3

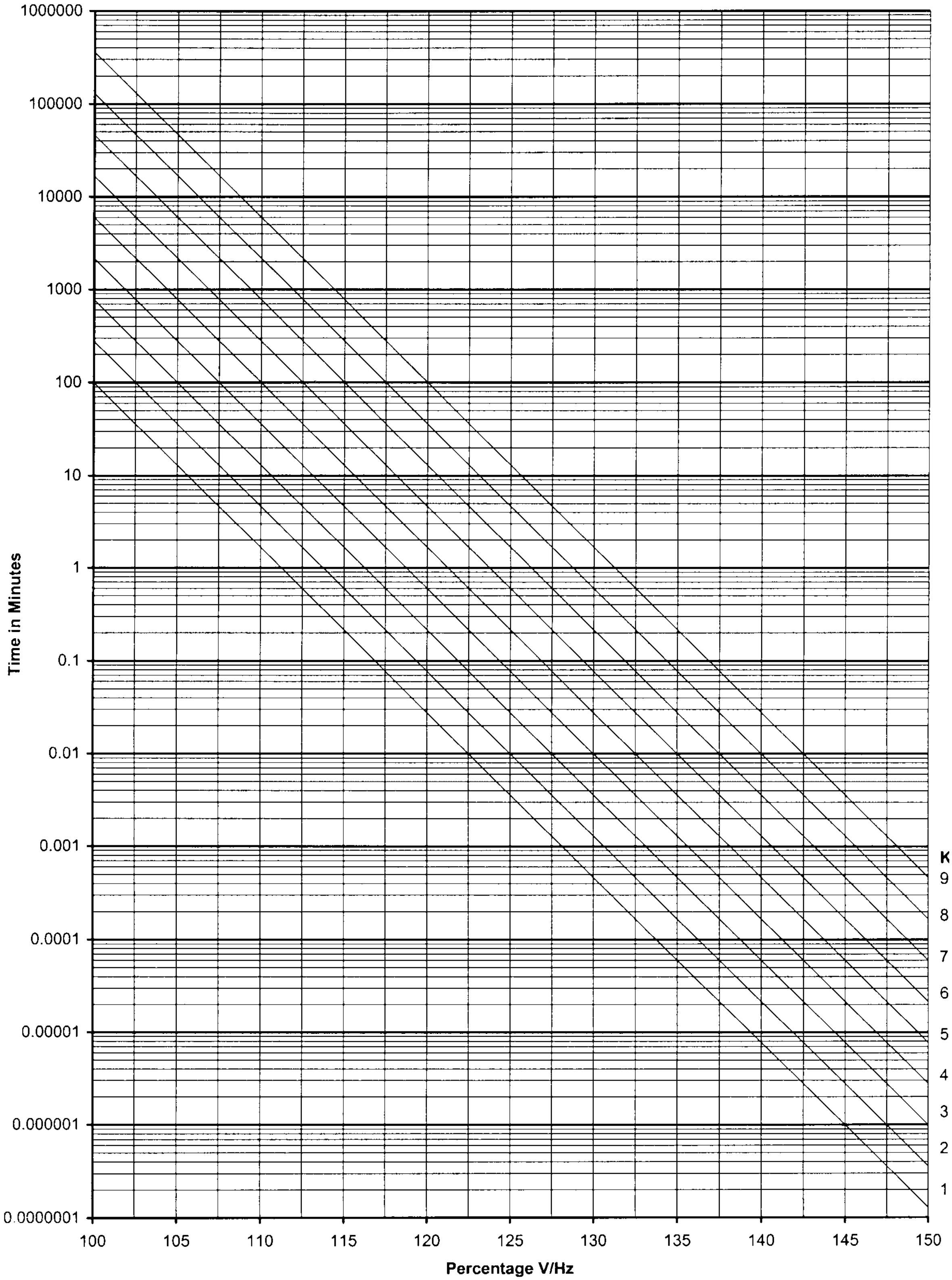


Figure D-4 Volts/Hz (24IT) Inverse Curve Family #4

Multiple of Tap Setting	Definite Time	Inverse Time	Very Inverse Time	Extremely Inverse Time
1.50	0.69899	4.53954	3.46578	4.83520
1.55	0.64862	4.15533	3.11203	4.28747
1.60	0.60539	3.81903	2.81228	3.83562
1.65	0.56803	3.52265	2.55654	3.45706
1.70	0.53558	3.25987	2.33607	3.13573
1.75	0.50725	3.02558	2.14431	2.85994
1.80	0.48245	2.81566	1.97620	2.62094
1.85	0.46068	2.62673	1.82779	2.41208
1.90	0.44156	2.45599	1.69597	2.22822
1.95	0.42477	2.30111	1.57823	2.06529
2.00	0.41006	2.16013	1.47254	1.92006
2.05	0.39721	2.03139	1.37723	1.78994
2.10	0.38606	1.91348	1.29093	1.67278
2.15	0.37648	1.80519	1.21249	1.56686
2.20	0.36554	1.72257	1.12812	1.47820
2.30	0.35293	1.54094	1.01626	1.32268
2.40	0.34115	1.39104	0.92207	1.19250
2.50	0.33018	1.26561	0.84190	1.08221
2.60	0.31999	1.15945	0.77301	0.98780
2.70	0.31057	1.06871	0.71334	0.90626
2.80	0.30189	0.99049	0.66127	0.83527
2.90	0.29392	0.92258	0.61554	0.77303
3.00	0.28666	0.86325	0.57515	0.71811
3.10	0.28007	0.81113	0.53930	0.66939
3.20	0.27415	0.76514	0.50733	0.62593
3.30	0.26889	0.72439	0.47870	0.58700
3.40	0.26427	0.68818	0.45297	0.55196
3.50	0.26030	0.65591	0.42977	0.52032
3.60	0.25697	0.62710	0.40879	0.49163
3.70	0.25429	0.60135	0.38977	0.46554
3.80	0.25229	0.57832	0.37248	0.44175
4.00	0.24975	0.53904	0.34102	0.40129
4.20	0.24572	0.50641	0.31528	0.36564
4.40	0.24197	0.47746	0.29332	0.33460
4.60	0.23852	0.45176	0.27453	0.30741
4.80	0.23541	0.42894	0.25841	0.28346

■ **Note**: The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.

Table D-1A M-3310 Inverse Time Overcurrent Relay Characteristic Curves

Multiple of Tap Setting	Definite Time	Inverse Time	Very Inverse Time	Extremely Inverse Time
5.00	0.23266	0.40871	0.24456	0.26227
5.20	0.23029	0.39078	0.23269	0.24343
5.40	0.22834	0.37495	0.22254	0.22660
5.60	0.22684	0.36102	0.21394	0.21151
5.80	0.22583	0.34884	0.20673	0.19793
6.00	0.22534	0.33828	0.20081	0.18567
6.20	0.22526	0.32771	0.19511	0.17531
6.40	0.22492	0.31939	0.19044	0.16586
6.60	0.22360	0.31150	0.18602	0.15731
6.80	0.22230	0.30402	0.18187	0.14957
7.00	0.22102	0.29695	0.17797	0.14253
7.20	0.21977	0.29027	0.17431	0.13611
7.40	0.21855	0.28398	0.17090	0.13027
7.60	0.21736	0.27807	0.16773	0.12492
7.80	0.21621	0.27253	0.16479	0.12003
8.00	0.21510	0.26734	0.16209	0.11555
8.20	0.21403	0.26251	0.15961	0.11144
8.40	0.21300	0.25803	0.15736	0.10768
8.60	0.21203	0.25388	0.15534	0.10422
8.80	0.21111	0.25007	0.15354	0.10105
9.00	0.21025	0.24660	0.15197	0.09814
9.50	0.20813	0.23935	0.14770	0.09070
10.00	0.20740	0.23422	0.14473	0.08474
10.50	0.20667	0.22923	0.14180	0.07943
11.00	0.20594	0.22442	0.13894	0.07469
11.50	0.20521	0.21979	0.13615	0.07046
12.00	0.20449	0.21536	0.13345	0.06667
12.50	0.20378	0.21115	0.13084	0.06329
13.00	0.20310	0.20716	0.12833	0.06026
13.50	0.20243	0.20341	0.12593	0.05755
14.00	0.20179	0.19991	0.12364	0.05513
14.50	0.20119	0.19666	0.12146	0.05297
15.00	0.20062	0.19367	0.11941	0.05104
15.50	0.20009	0.19095	0.11747	0.04934
16.00	0.19961	0.18851	0.11566	0.04784
16.50	0.19918	0.18635	0.11398	0.04652
17.00	0.19881	0.18449	0.11243	0.04539
17.50	0.19851	0.18294	0.11102	0.04442
18.00	0.19827	0.18171	0.10974	0.04362
18.50	0.19811	0.18082	0.10861	0.04298
19.00	0.19803	0.18029	0.10762	0.04250
19.50	0.19803	0.18014	0.10679	0.04219
20.00	0.19803	0.18014	0.10611	0.04205

■ **Note**: The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.

Table D-1B M-3310 Inverse Time Overcurrent Relay Characteristic Curves

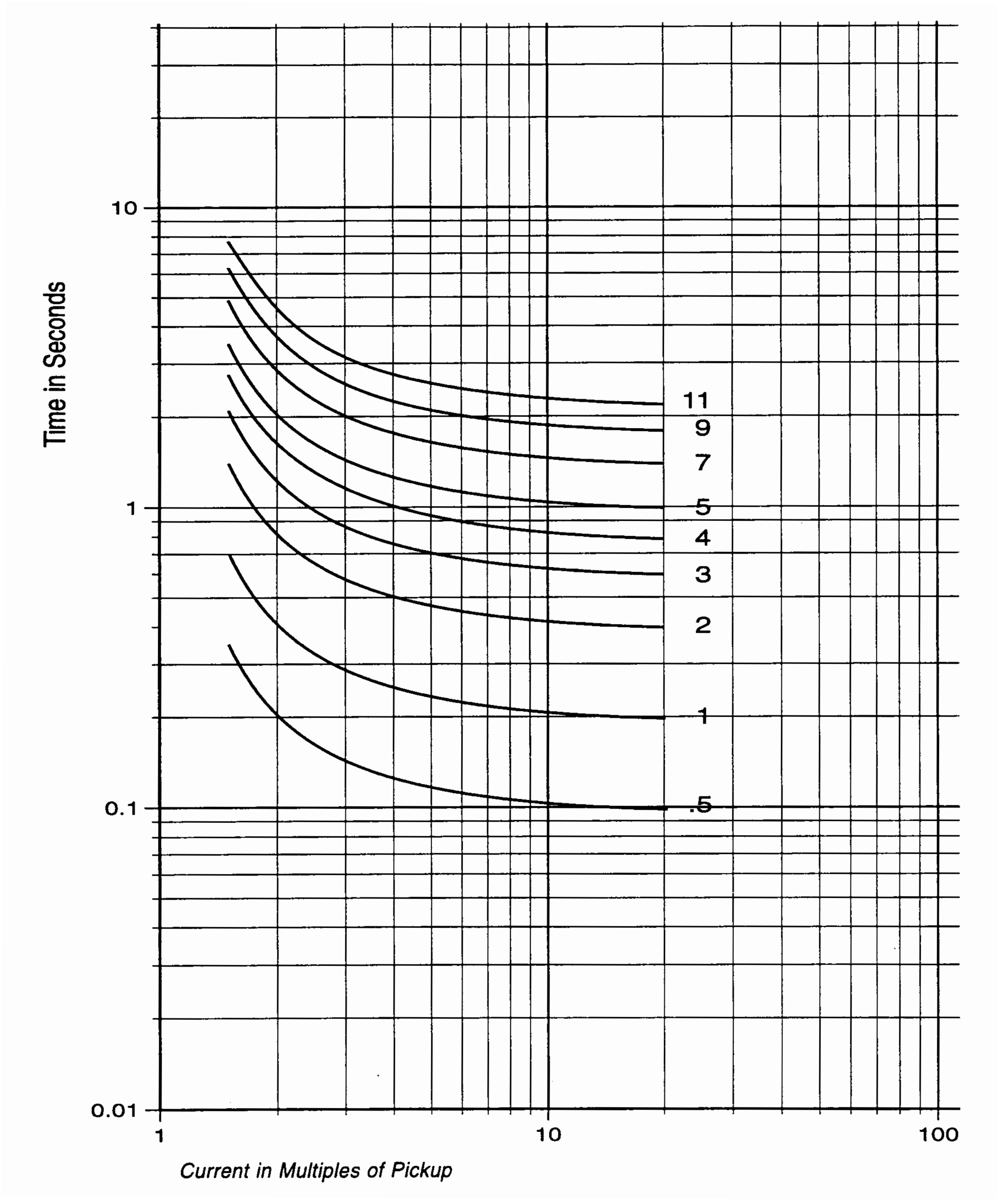


Figure D-5 Definite Time Overcurrent Curve

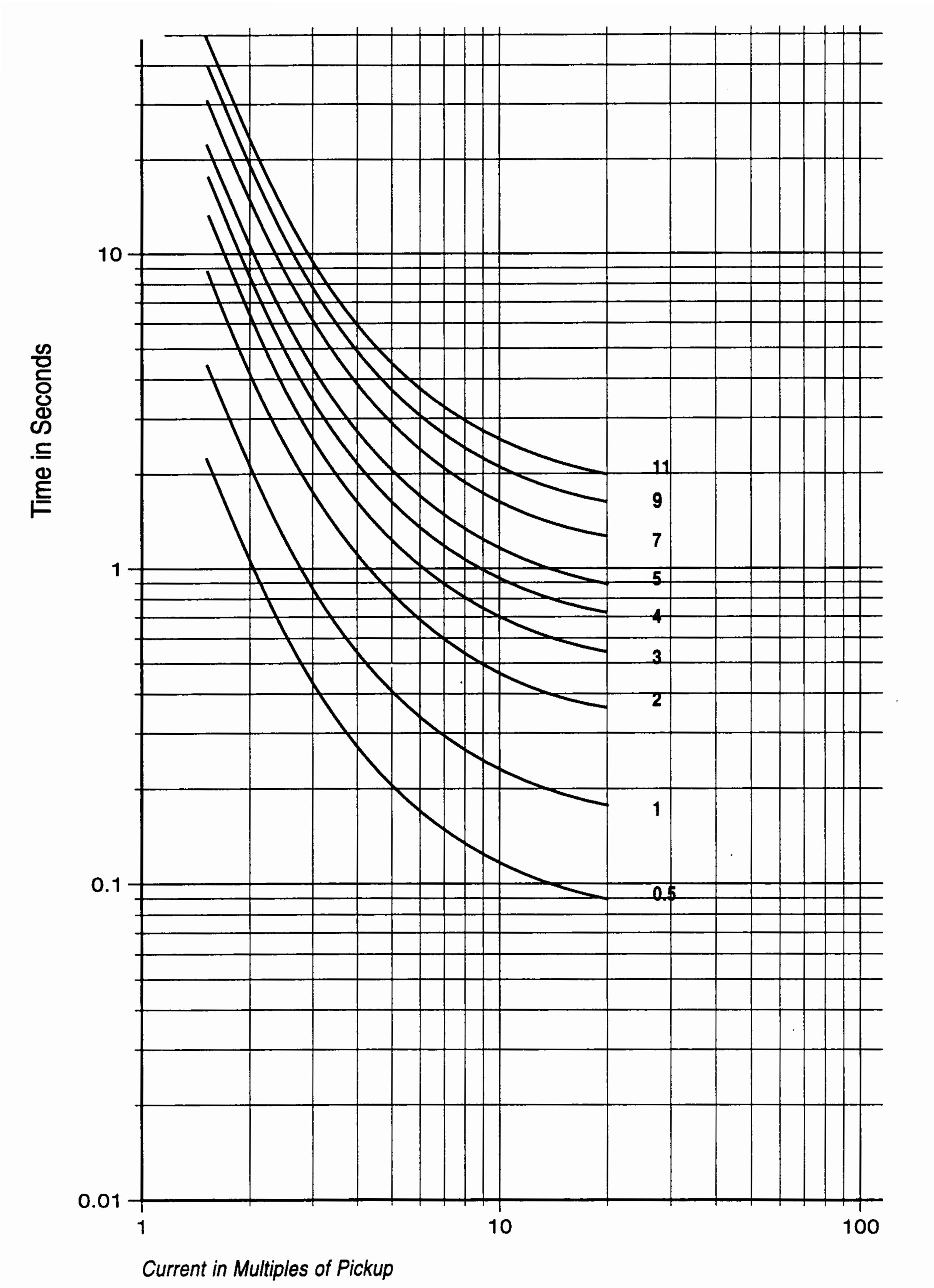


Figure D-6 Inverse Time Overcurrent Curve

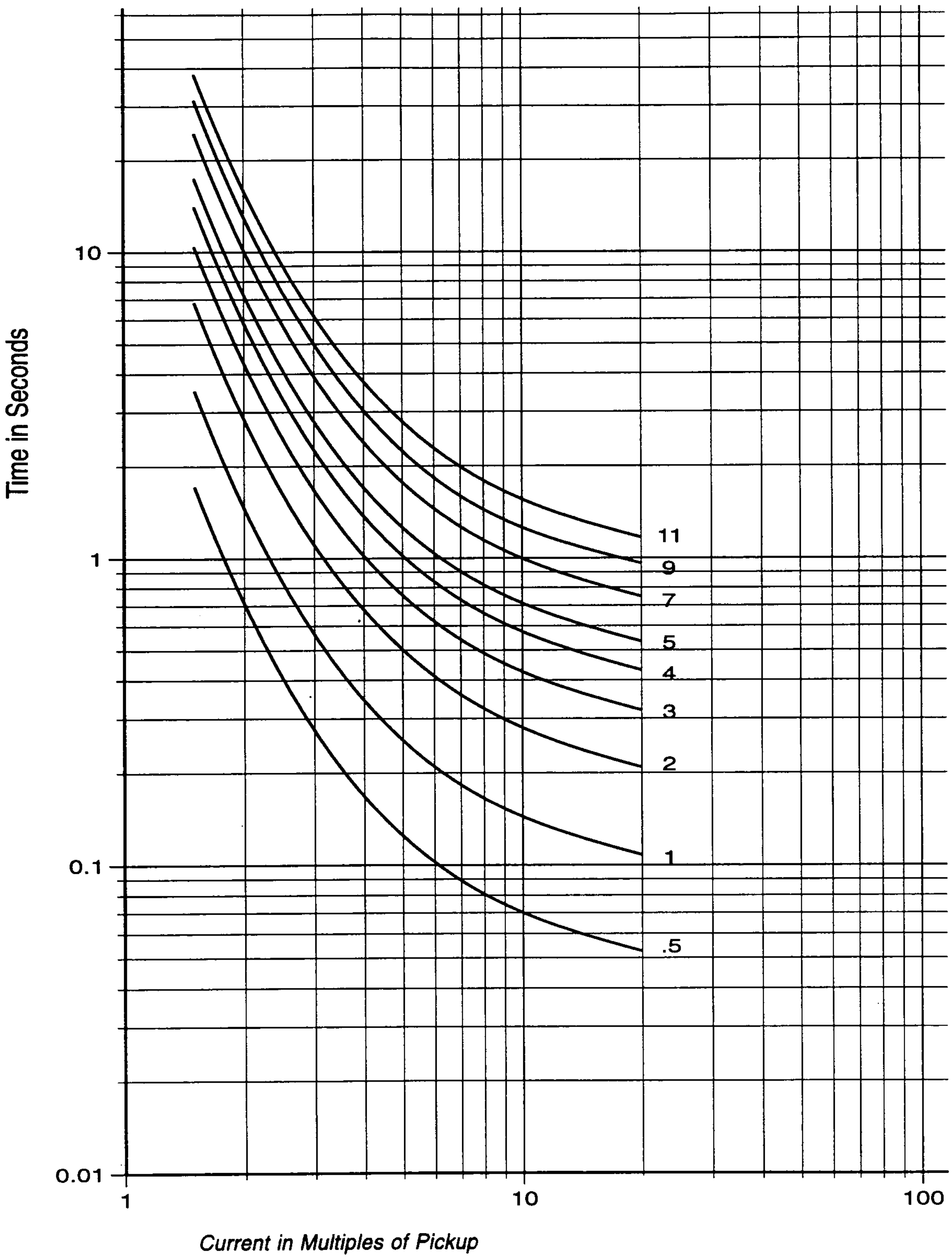


Figure D-7 Very Inverse Time Overcurrent Curve

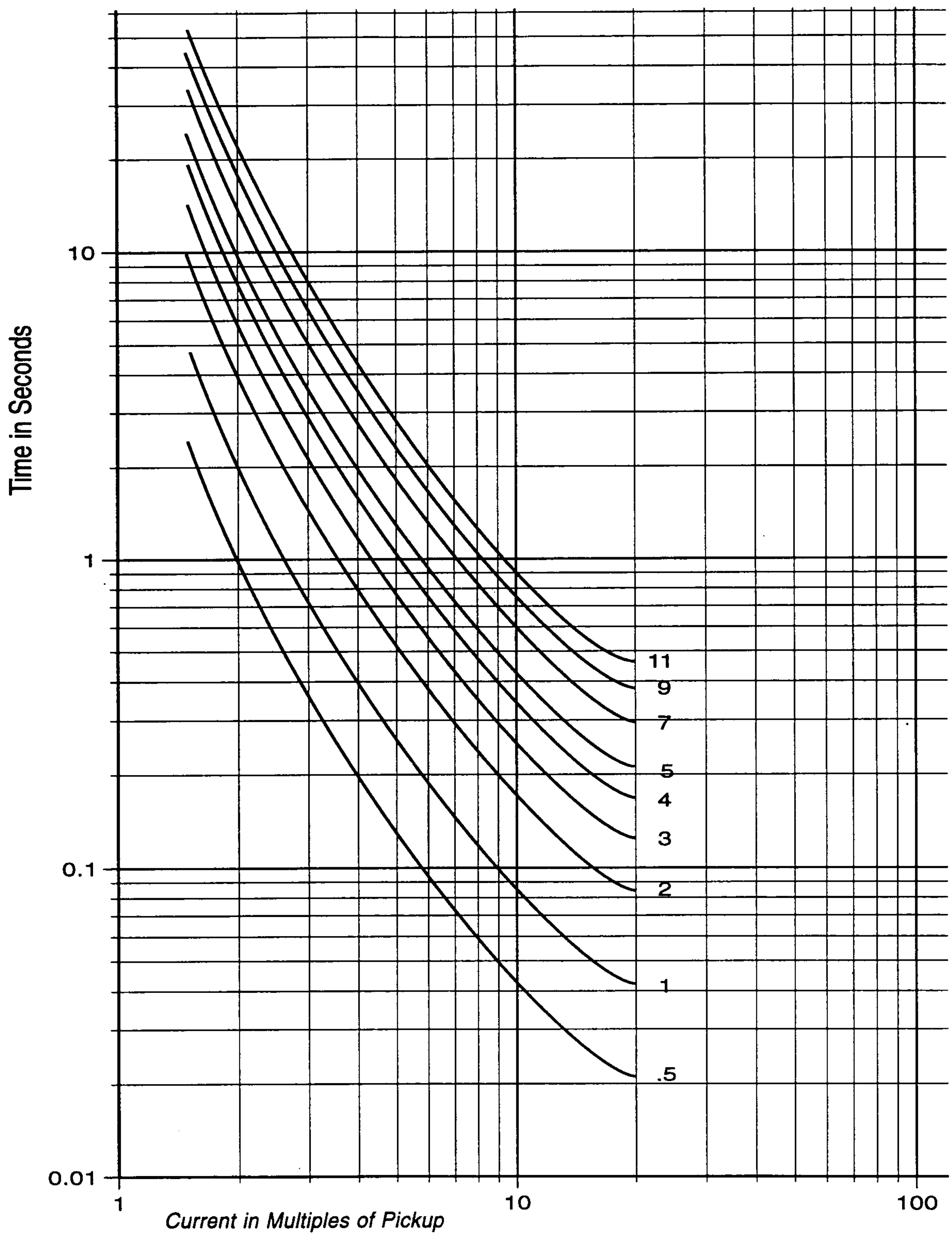


Figure D-8 Extremely Inverse Time Overcurrent Curve

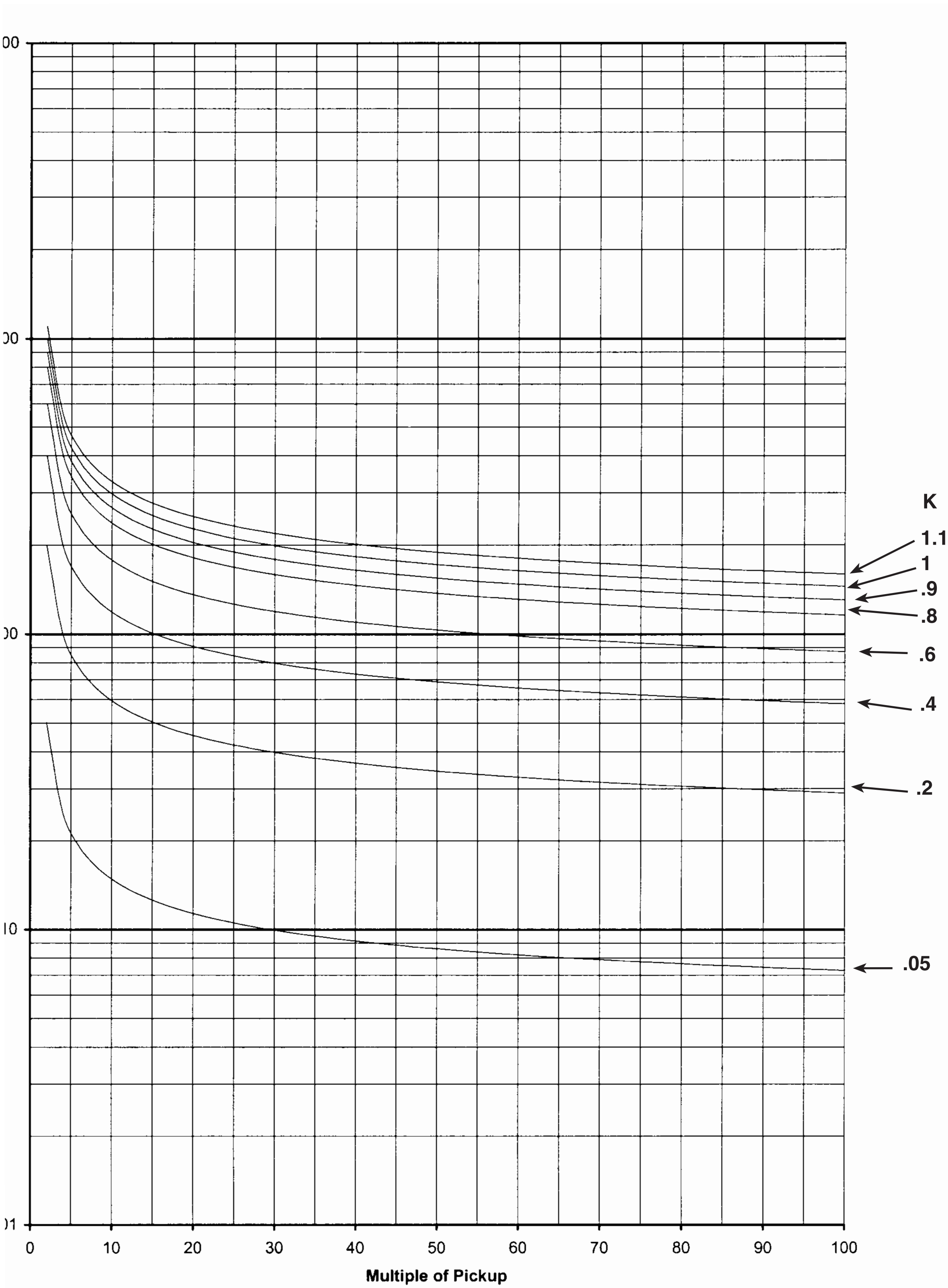


Figure D-9 IEC Curve – Inverse

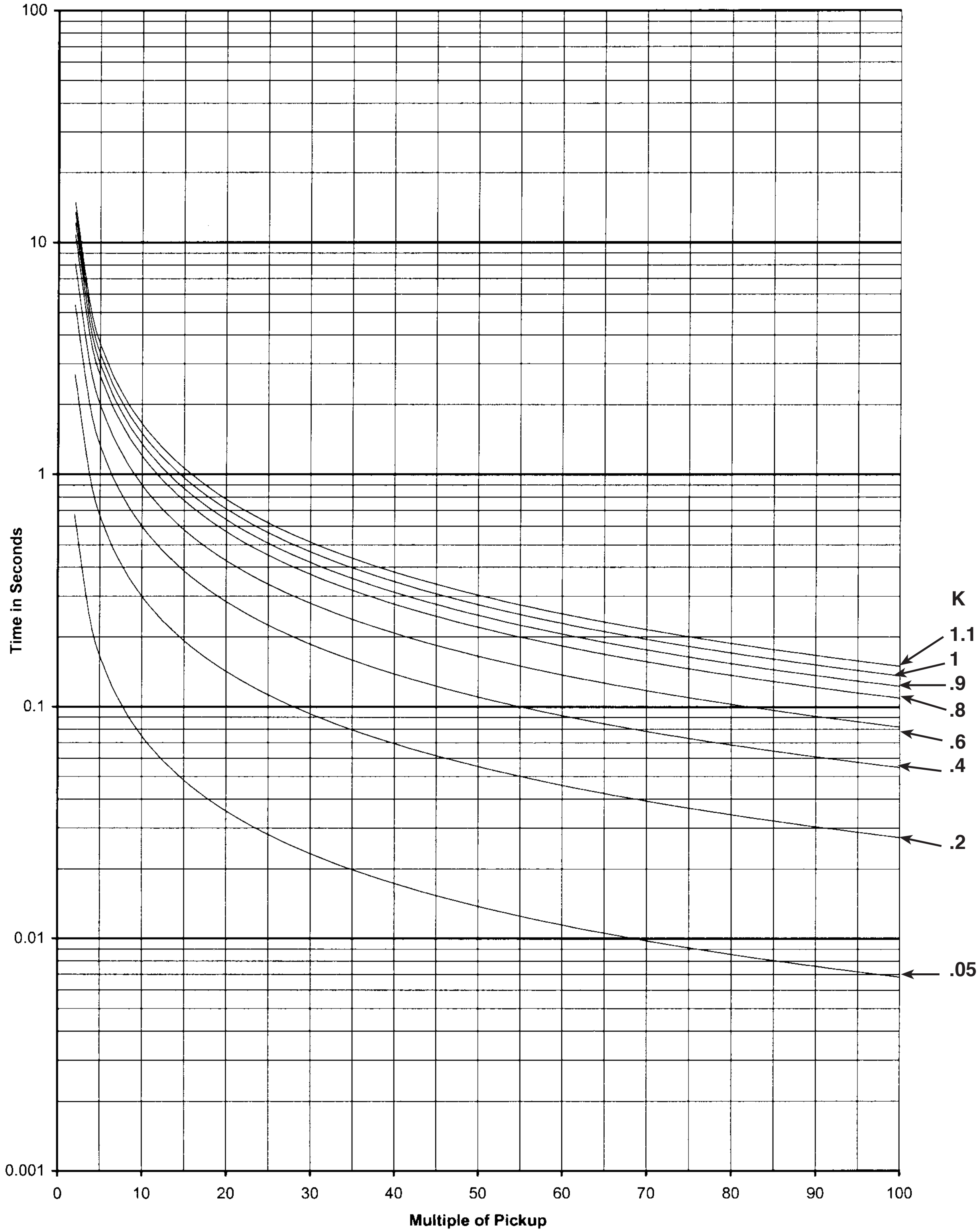


Figure D-10 IEC Curve – Very Inverse

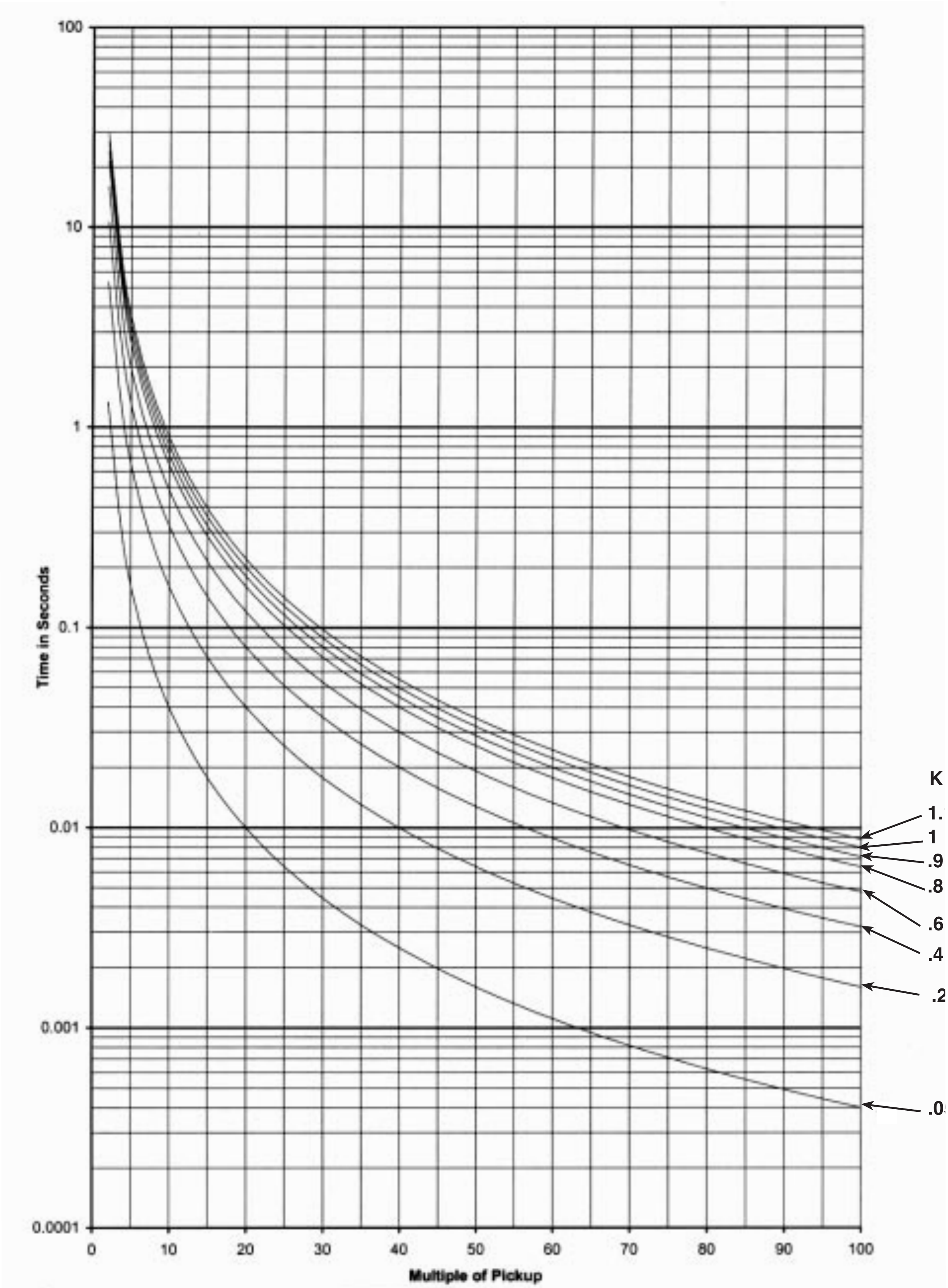


Figure D-11 IEC Curve – Extremely Inverse

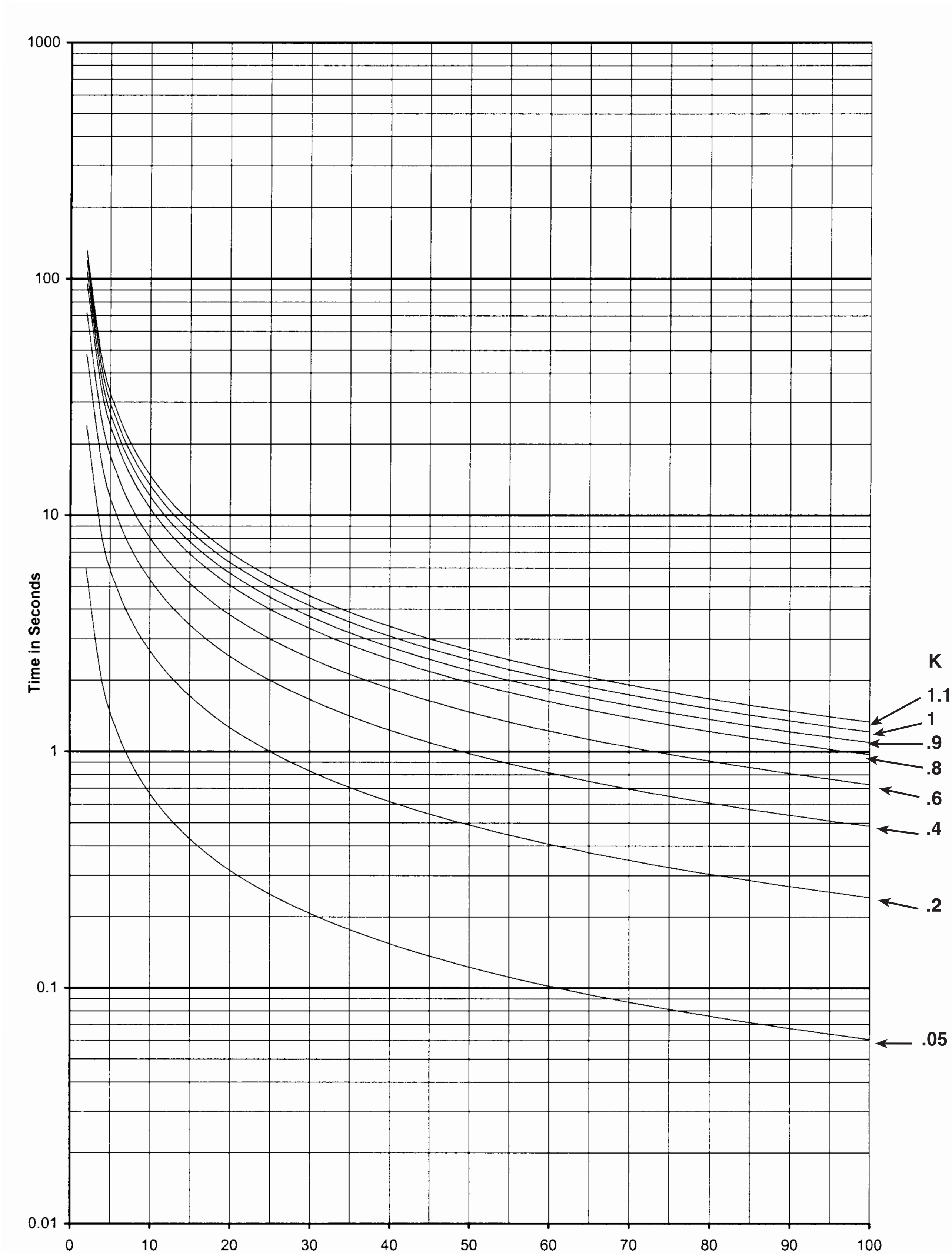


Figure D-12 IEC Curve – Long-Time Inverse

This Page Left Intentionally Blank

1 Introduction

1.1 Instruction Book Contents

This instruction book is divided into six major chapters and four appendices.

Chapter 1: Introduction

Chapter one contains a brief description of the six chapters and four appendices contained in this handbook. It enumerates the functional capabilities of the M-3310 Transformer Protection Relay and provides a list (see Table 1-1) of the device functions. This chapter also describes the accessories that may be used in conjunction with application of the relay.

Chapter 2: Application

Chapter two contains specific information for the person or group responsible for the application of the Transformer Protection Relay. The information provided includes functional diagrams and connection diagrams for typical application of the relay. It describes the configuring of the unit (choosing active functions), and provides output contact assignment and input blocking designation. This chapter also illustrates the definition of system quantities and equipment characteristics required by the relay, and describes the individual function settings and oscillograph recorder setup.

Chapter 3: Operation (Front Panel)

This chapter is designed for the person or group responsible for the operation and direct setting and configuration of the relay and is limited to the installations using the HMI (Human-Machine Interface) Module (M-3931). It includes an introduction to the front panel controls and the function and operation of the keypad, the characteristics of the display, the indicators and Target Module (M-3910), and the communication ports. It further describes the procedures for entering all the required data to the relay.

Included in this chapter is a description of the operations of the monitoring status and metering quantities and of viewing the target history. This chapter also references appropriate forms for recording and communicating the described data to the parties responsible for operation and installation of the relay.

Chapter 4: IPScom® Operation

This chapter provides information for the person or group responsible for the operation and direct setting and configuring of the relay via personal computer, using the IPScom® M-3820A Communications Software package. It includes installation, setup information, and procedures for entering all the data required to operate the relay. Specific descriptions of the monitoring functions, statuses and metering quantities are also provided.

Chapter 5: Installation

This chapter provides all the mechanical information, including dimensions, external connections and equipment ratings required for physical installation of the relay. For reference, the Three-Line Connection Diagram is repeated from Chapter 2. A commissioning checkout procedure is outlined using the HMI option and IPScom® to check the external CT and VT connections. Other tests, which may be desirable at time of installation, are described in Chapter 6.

Chapter 6: Testing

This chapter provides step-by-step test procedures for each function, as well as the diagnostic mode procedures and the auto-calibration procedure for HMI users.

Appendix A: Configuration Record Forms

This appendix supplies a set of forms to record and communicate the inputs required for the proper operation of the relay.

Appendix B: Communications

This appendix describes the communications equipment, the protocol used, the communication ports, and the port signals.

Appendix C: Self-test Error Codes

This appendix lists all error codes and their descriptions.

Appendix D: Inverse Time Curves

This appendix contains a graph of the four families of Inverse Time Curves for V/Hz applications, the four standard and the four IEC overcurrent curves.

1.2 M-3310 Transformer Protection Relay

The M-3310 Transformer Protection Relay (see Figure 1-1), is a microprocessor-based unit that uses digital signal processing technology to protect a high voltage transformer from abnormal voltage and frequency, internal winding faults, system faults, negative sequence current, overloading, and overexcitation (V/Hz) disturbances. The M-3310 also provides system wide protection by implementing breaker failure, load shedding, bus fault and digital feeder relay backup protection capability

The relay provides 17 protective relay functions (see Table 1-1). The nomenclatures of these functions are derived from the standards of ANSI/IEEE C37.2-1991, Standard Electric Power Systems Device Function Numbers.

Six input contacts (located on rear side of unit) can be programmed to block any relay function and/or trigger the oscillograph recorder. Any of the functions or input contacts can be individually programmed to activate one or more of the eight programmable output contacts.

FUNCTION	DESCRIPTION
24	Volts/Hz Overexcitation
27	Phase Undervoltage
46	Negative Sequence Overcurrent
50W1	Inst Phase Overcurrent
50W2	Inst Phase Overcurrent
50BF	Breaker Failure
50G	Inst Neutral Overcurrent
51W1	Inv Time Phase Overcurrent
51W2	Inv Time Phase Overcurrent
51NW1	Inv Time Residual Overcurrent
51NW2	Inv Time Residual Overcurrent
51G	Inv Time Neutral Overcurrent
59G	Neutral Overvoltage
81U	Underfrequency
87	Phase Differential Current
87GD	Ground Differential
EXT‘	External Functions

Table 1-1 M-3310 Device Functions

■ **NOTE:** A certain subset of the listed functions are considered "standard" and shipped with all units. Other functions are "optional" and must be specified at time of purchase. Functions not purchased cannot be enabled.

With the optional M-3931 Human-Machine Interface Module (HMI), all functions can be set or examined via a local, menu-driven 2-line by 24-character display. The HMI also provides the M-3310 with the capability for local metering of various quantities, including phase, neutral, and sequence voltages and currents; power factor, real, reactive, and apparent power measurements.

The relay provides storage of time-tagged target information for the 32 most recent trip events. Also included are self-test, self-calibration and diagnostic capabilities.

The function outputs can provide tripping and/or alarm contacts. Light Emitting Diodes (LEDs) are used for the targets to provide visual indication of a function operation. Three serial I/O ports provide remote communication capability.

A switching mode power supply provides the relay with the various power supply voltages required for operation. (A redundant power supply is available as an option.)

The serial interface ports, COM1 and COM2, are standard 9-pin RS-232C DTE-configured communications ports. The front-panel port, COM1, is used to locally set and interrogate the M-3310 via a portable computer. The second RS-232C port, COM2, is provided at the rear of the unit. An isolated RS-485 communications port, COM3, is also available at the rear terminal block of the relay. Either rear-panel port, COM2 or COM3, can be used to remotely set and interrogate the relay via a modem, network or direct serial connection. Detailed information on the use of the relay communications ports is provided in Appendix B, Communications, as well as Chapter 4, IPScom® Operation.

The unit provides up to 170 cycles of waveform data storage assignable to up to 4 events with selectable post-trigger delay. Once downloaded, the data can be analyzed using the optional M-3821 IPSplot™ Oscillograph Analysis Software package.

1.3 Accessories

Shipped as standard with each M-3310 unit is a copy of IPScom® communications software. The IPScom communications software runs on an IBM PC-compatible computer running under Windows 95 or higher, providing remote access to the relay via either direct serial connection or modem. IPScom provides the following communication functions:

- Setpoint interrogation and modification
- Line status real-time monitoring
- Stored target interrogation
- Recorded oscillograph data downloading
- Real time Phasor display

M-3910 Target Module

The optional target module shown in Figure 1-2 includes 24 individually labeled **TARGET** LEDs (Light Emitting Diodes) to target the operation of the functions on the front panel. Eight individually labeled **OUTPUT** LEDs will be lit as long as any output is picked up.

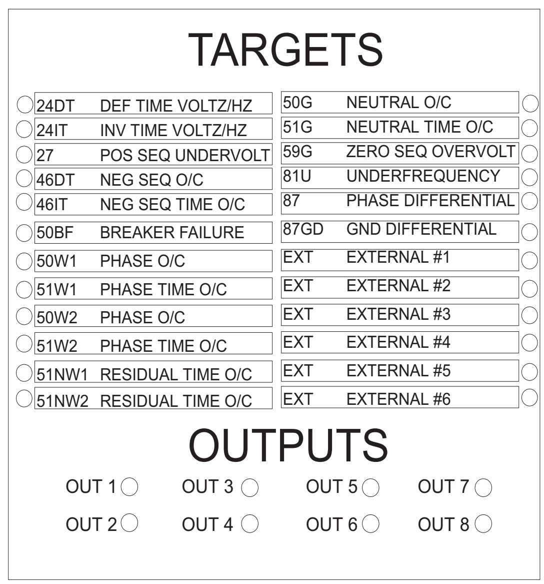


Figure 1-1 M-3910 Target Module

M-3931 Human-Machine Interface (HMI)

The optional HMI module shown in Figure 1-3, provides a means to interrogate the relay and to input settings, access data, etc. directly from the front of the relay. Operation of the module is described in detail in Section 3.1, Front Panel Controls.

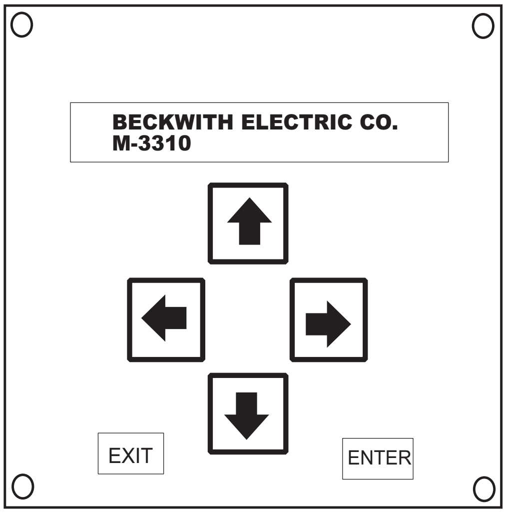


Figure 1-2 M-3931 Human-Machine Interface

M-3821 IPSplot™ Oscillograph Analysis Software Package

The IPSplot Oscillograph Analysis Software runs in conjunction with IPScom software package on any IBM PC-compatible computer running Windows 95 or higher, to enable the plotting and printing of waveform data downloaded from the M-3310 Transformer Protection Relay.

M-3933/M-0423 Serial Communications Cable

The M-3933 cable is a 10-foot RS-232 cable for use between the relay's rear-panel (COM2) port and a modem. This cable has a DB25 (25-pin) connector (modem) and a DB9 (9-pin) at the M-3310 end.

The M-0423 cable is a 10-foot null-modem RS-232 cable for direct connection between a PC and the relay's front-panel COM1 port or the rear COM2 port. This cable has DB9 (9-pin) connectors at each end.

M-3934 Redundant Low Voltage Power Supply

Redundant 24/48 VDC supply.

M-3935 Redundant High Voltage Power Supply

Redundant 110/250 VDC supply.

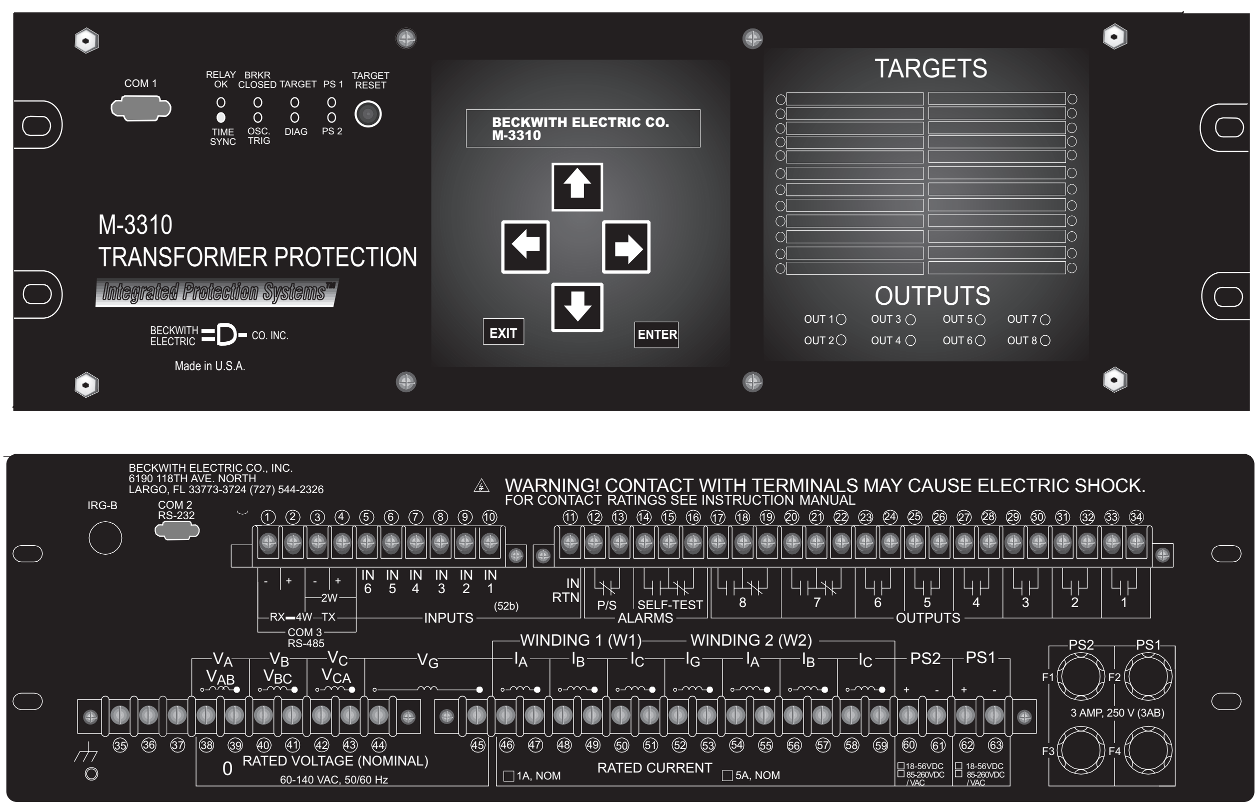


Figure 1-3 M-3310 Transformer Protection Relay

2 Application

2.1 Introduction

This chapter provides information for the person or group responsible for the application of the M-3310 Transformer Protection Relay. Individual relay functions can be programmed to activate any combination of eight output contacts (OUT1–8). Similarly, any relay function can be programmed to be blocked by any of six status inputs (IN1–6). The relay provides programmable setpoints for each relay function. Some relay functions provide two or more setpoints, each with a magnitude setting and associated time delay. Up to four profiles (setpoint groups) may be programmed.

This chapter is designed to assist in the application aspects of the M-3310 Transformer Protection system. Detailed information on the relay functions, configuration, setpoints, functional logic schemes, application to different transformer connections and oscillograph recorder is provided.

This chapter also specifies appropriate forms for recording and communicating the input settings to the parties responsible for operation and installation of the relay.

2.2 Configuration

Profiles

Up to four setpoint profiles may be used. Each profile contains a complete set of function configuration and settings. One of the four profiles may be designated as the Active Profile which will contain the parameters that the relay will actively use. Only the Active Profile may be edited.

The Active Profile may be designated either manually via the HMI interface, by contact input (input activated profiles enabled) or by remote communication.

A copy profile feature is available that copies an image of the Active Profile to any one of the other three profiles. This feature can speed up the configuration process. Consider, for example, a situation where a breaker will be removed from service. Two profiles will be used: an “In Service” profile (Profile 1) and an “Out of Service” profile (Profile 2).

Profile 2 will be identical to the “In Service” profile, with the exception of the overcurrent settings. Profile 1 is set to be the Active profile, and all setpoints entered. An image of Profile 1 will then be copied to Profile 2 with the Copy Active Profile command. Profile 2 is then selected as the Active Profile and the overcurrent setpoints modified.

Following the above procedure not only accelerates the configuration process, but also removes the possibility of errors if all setpoints are reentered manually.

Functions

Configuring the relay consists of enabling the relay functions to be used in a particular application. Once the output contacts (OUT1–8) are designated, each function will be receptive, according to the status inputs designated (IN1–6) to block the function.

Status inputs may also initiate actions, such as Breaker Failure Initiate, Trigger Oscillograph Recorder, switch setpoint profile, or initiate an External function. The status inputs and output contacts need to be chosen *before* configuring the individual functions. Both can be recorded on the **Relay Configuration Table** in Appendix A, **Forms**.

■ **NOTE:** At least one relay output must be selected to enable a function, otherwise the function is disabled.

Special Considerations

Status input IN1 is preassigned to be the 52b breaker contact. IN5 and IN6 may be used to select setpoint profiles.

Outputs 1–6 are form “a” contacts (normally open) and outputs 7 and 8 are form “c” contacts (center tapped “a” and “b” contacts). Output contacts 1–4 contain special circuitry for high-speed operation and pick up 4 ms faster than outputs 5–8. Function 87 outputs are recommended to be directed to OUT1 through OUT4 contacts.

The following functions can be configured using enable/disable output, and status input blocking designations:

- 24 Volts/Hz: Definite Time #1, #2, Inverse Time
- 27 Positive Sequence Undervoltage
- 46 Negative Sequence Overcurrent: Definite Time, Inverse Time
- 50W1 Instantaneous Phase Overcurrent #1,#2
- 50W2 Instantaneous Phase Overcurrent #1,#2
- 50BF Breaker Failure
- 50G Instantaneous Neutral Overcurrent
- 51W1 Inverse Time Phase Overcurrent
- 51W2 Inverse Time Phase Overcurrent
- 51NW1 Inverse Time Residual Overcurrent
- 51NW2 Inverse Time Residual Overcurrent
- 51G Inverse Time Neutral Overcurrent
- 59G Neutral Overvoltage
- 81U Underfrequency: #1,#2,#3
- 87H Phase Differential Overcurrent, High Set
- 87T Phase Differential Overcurrent, Harmonic Restrained Percentage Differential
- 87GD Ground Differential Overcurrent
- External Functions: #1,#2,#3,#4,#5,#6

```
81U#1 UNDERFREQUENCY
disable ENABLE
```

This designation is required for each relay function. After enabling the function the user is presented with the following two screens.

```
81U#1 BLOCK INPUT
    i6 i5 i4 I3 i2 i1
```

This screen assigns the blocking designations (up to six) for the enabled function. “OR” logic is used if more than one input is selected.

```
81U#1 RELAY OUTPUT
o8 o7 O6 o5 o4 o3 o2 o1
```

This screen assigns the output contacts (up to eight) for the particular relay function. If no output contacts are assigned, the function will be automatically disabled.

2.3 System Diagrams

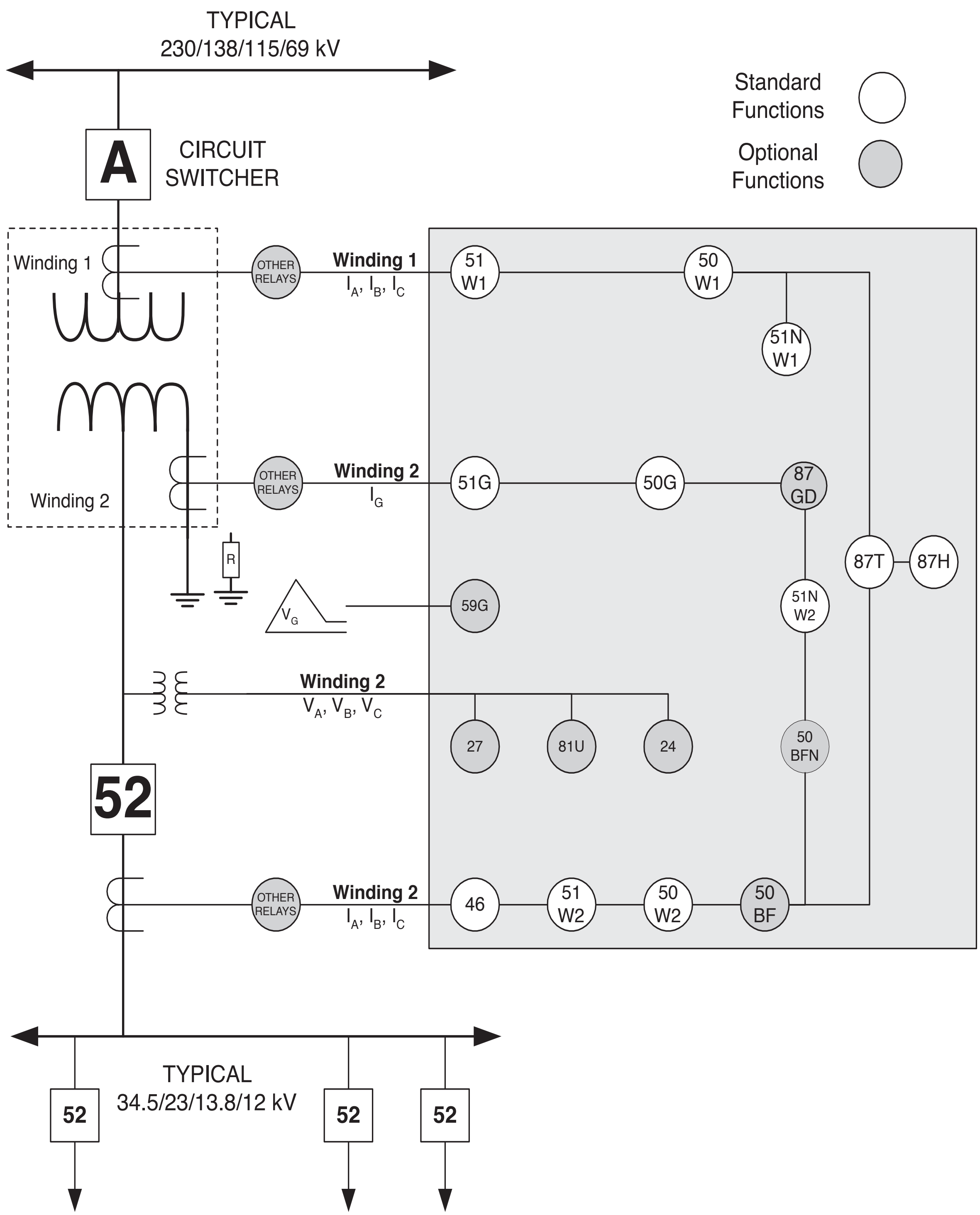


Figure 2-1 One-Line Functional Diagram

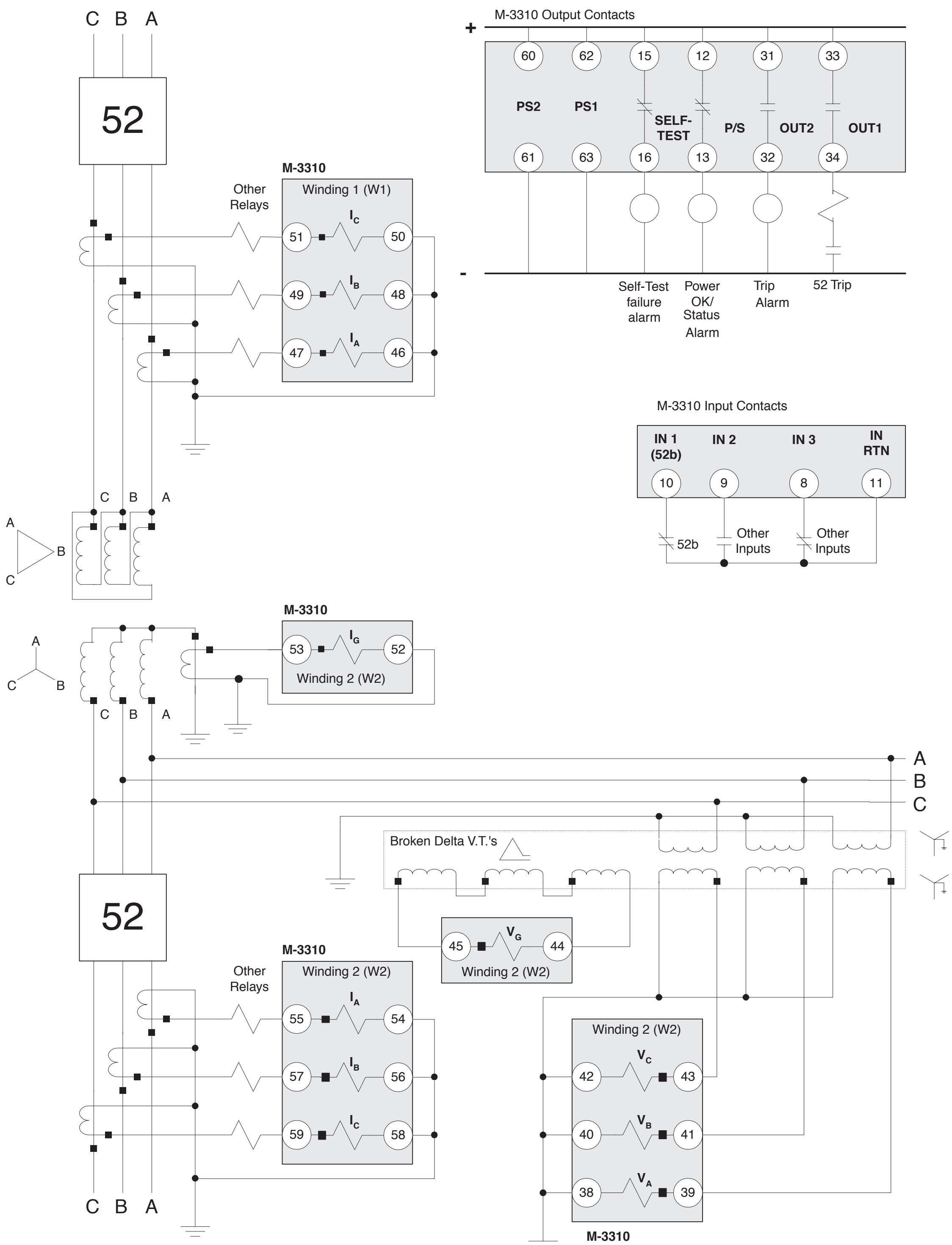


Figure 2-2 Three-Line Connection Diagram

■ **NOTES:**

1. Connection #4, Delta-Wye power transformer shown with Wye-Wye connected CTs.
2. Status Inputs and Relay Output contacts pairs are selected by user.
3. Extra outputs may be designated for control or supervisory operation.

System Setup

The system setup consists of defining common information like CT and VT ratios, nominal voltage and current ratings, transformer connections, and which profile is the Active Profile, etc. Values are entered similar to other setpoints. System setup information is common to all profiles, and should be entered before configuration, setpoint, and time settings.

```
INPUT ACTIVATED PROFILES
disable ENABLE
```

When INPUT ACTIVATED PROFILES are disabled, the Active Profile can be selected via HMI or remote communication. When enabled, the Active profile is selected by the state of Input 5 and 6 (see Table 2-1).

Input 5	Input 6	SELECTION
Open	Open	Profile 1
Closed	Open	Profile 2
Open	Closed	Profile 3
Closed	Closed	Profile 4

Table 2-1 Input Activated Profile Logic

```
ACTIVE SETPOINT PROFILE
    1
```

If INPUT ACTIVATED PROFILES are disabled this screen allows manual selection of the Active Profile. ■ **NOTE:** The above table assumes ACTIVE INPUT STATE set to default setting (close circuit = TRUE).

```
  COPY ACTIVE PROFILE
← TO_PROFILE_2          →
```

This screen initiates a copy of the Active Profile to any one of the other profiles.

```
NOMINAL VOLTAGE
120 Volts
```

The secondary VT voltage when primary voltage is equal to the rated transformer voltage (V trans rated/VT ratio).
Range = 60–140 V; Increment 1 V.

```
NOMINAL CURRENT
5.00 Amps
```

The secondary CT current of the winding 2 phase CTs with the rated transformer current. Range = 0.50–6.00 A (0.1 to 1.2 for 1A), Increment = 0.01 A.

```
V.T. CONFIGURATION
LINE-LINE line-ground
```

Indicates VT connection.

```
TRANSFORMER CONNECTION
    1
```

Indicates one of the 14 different transformer connection configurations.

```
PHASE ROTATION
a-c-b A-B-C
```

Indicates the phase rotation.

```
RELAY SEAL-IN TIME OUT 1
    30 Cycles
```

Seal-in time for output relay #1. Eight individual seal-in delays can be specified, one for each output relay, as specified on subsequent screens (not shown).

```
ACTIVE INPUT OPEN/close
    i6 i5 i4 i3 i2 I1
```

Selects the active state for the six status inputs. When highlighted (upper case), the active state indicates an open circuit. When lowercase, the active state indicates a closed circuit (default).

```
W2 V.T. PHASE RATIO
    1.0:1
```

VT Ratios. Also settable on subsequent screens are W2 ground VT ratio, W1 CT phase, W2 CT phase and W2 CT ground ratios.

2.4 Setpoints and Time Settings

24 Volts/Hz

The Volts-Per-Hertz function (24) provides over-excitation protection for the transformer. This is mainly applied to generator transformers. As voltage rises above the transformer rating, leakage flux increases. The leakage flux induces current in the transformer support structure causing rapid localized heating.

- For power plant applications, over-excitation can occur due to sudden tripping of the generator as a result of faults and other abnormal conditions.
- For EHV applications, an incorrectly switched line can lead to over-excitation at tapped transformers due to combined capacitance.

This function provides two Definite Operating Time setpoints, four families of Inverse Time curves widely used in the industry (see Appendix D, Figures D1–D4), and a linear reset rate programmable to match specific cooling characteristics of the transformer. The V/Hz function provides reliable measurements of V/Hz for a frequency range of 10–80 Hz.

The first task in setting this relay function is to determine the desired protective levels and times. This can be accomplished by combining the V/Hz limit curves of the transformer and the associated generator on one graph and simplifying the result into one curve to coordinate with the protection.

Example of Transformer limits:

- Full Load V/Hz = 1.05 PU (HV terminals)
- No Load V/Hz = 1.10 PU (HV terminals)

■ **NOTE:** The curves must be on the same voltage base to be combined on one graph. An example is shown in Figure 2-3. The manufacturer of the generator and transformer will provide these over-excitation capability limits.

Depending on these characteristics, they can best be matched by one of the four families of inverse time curves, alone or in conjunction with definite time setpoints. Coordination of capabilities and protection is achieved when the time between the relay operation and the capability limit is sufficient for the breakers to open and de-energize the units. This coordination time is read vertically *between* the two curves at any given V/Hz value.

Figure 2-3 illustrates a composite graph of generator limits, transformer limits, a chosen inverse time curve, inverse time pickup, and definite time setpoint. While inverse time curve selection provides closer protection, a traditional two-step protection scheme may be realized by using the two definite time functions (24DT #1 and #2), and disabling the inverse (24IT) element.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Definite Time Volts/Hz (24DT)			
Pickup #1, #2	100 to 200%	1%	± 1%
Time Delay #1, #2	30 to 8160 Cycles	1 Cycle	± 25 Cycles
Inverse Time Volts/Hz (24IT)			
Pickup	100 to 150%	1%	± 1%
Characteristic Curves	#1 to #4		
Time Dial:			
Curve #1 Curve #2 to #4	0 to 9	0.1	
Reset Rate	1 to 999 seconds	1 second	± 3 cycles or 1%

Table 2-2 Volts/Hertz (24) Setpoint Ranges

If this function is enabled, the following settings are applicable:

24DT #1 PICKUP 110%	Definite time setpoint #1 establishes the V/Hz level above which the protection operating time will be fixed at the definite time delay #1 (see Figure 2-3). 100% value is equal to nominal voltage at nominal frequency. Refer to Section 2.3 **System Diagrams**, System Setup.
24DT #1 DELAY 360 Cycles	Delay time #1 establishes the operation time of the protection for all V/Hz values above the level set by definite time setpoint #1. Delay time #1 should be less than the operating time of the selected inverse curve at the definite time setpoint #1 V/Hz level.
24DT #2 PICKUP 110%	Definite time #2 may be programmed to alarm, thereby alerting the operator to take proper control action and possibly avoid tripping (may be used to trip).
24DT #2 DELAY 360 Cycles	Time to operation at any V/Hz value exceeding Definite time setting #2.
24IT PICKUP 105%	As shown in Figure 2-3, the pickup value is the V/Hz value (in %) that the chosen inverse curve begins timing. Typical value is 105%.
24IT CURVE CRV#1 crv#2 crv#3 crv#4	This screen allows user to designate the appropriate curve *family* for this protection application. These curves are shown in Appendix D, Figures D-1 through D-4. Note that the operating times are constant above 150% V/Hz values.
24IT TIME DIAL 9	The appropriate *curve* in the family is designated by the associated "K" value of the curve (see Appendix. D, Figures. D-1 through D-4).
24IT RESET RATE 200 Seconds	After any V/Hz excursion, cooling time must also be taken into account. If the transformer should again be subjected to high V/Hz before it has cooled to normal operating levels, damage could be caused before the V/Hz trip point is reached. For this reason, a linear reset characteristic, adjustable to take into account the cooling rate of the transformer, is provided. If a subsequent V/Hz excursion occurs before the reset characteristic has timed out, the time delay will pick up from the equivalent point (as a %) on the curve. The value entered here should be the time needed for the transformer to cool to normal operating temperature if the V/Hz excursion time was just under the trip time.

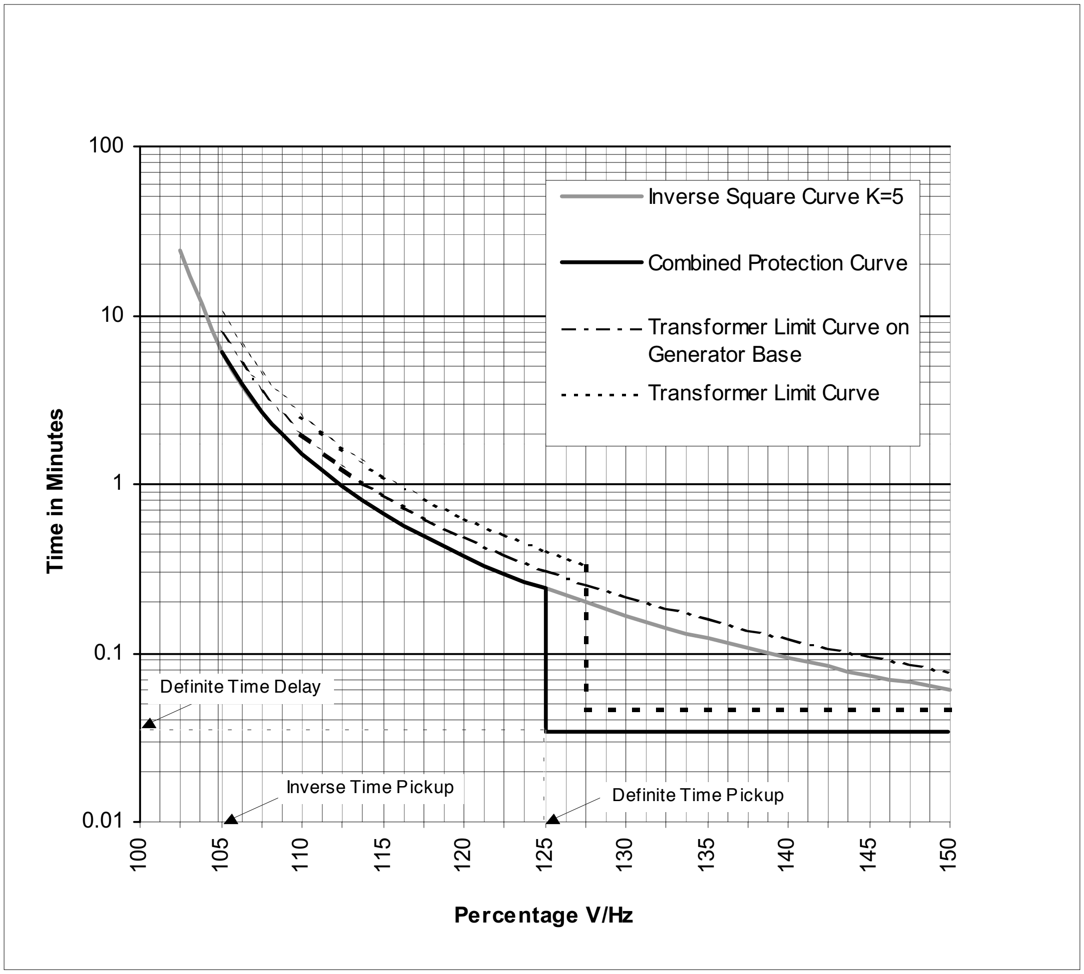


Figure 2-3 Example of Capability and Protection Curves

27 Positive Sequence Undervoltage

The 27 Undervoltage function (see Table 2-3), may be used to detect any condition causing long term undervoltage. It also uses the derived positive sequence voltage from winding 2 VT connections.

This function is used to shed the transformer load when the power system does not have enough reactive support, similar to the Underfrequency (81U) function.

The Inhibit setting of this function prevents it from operating during fault conditions.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Positive Sequence Undervoltage (27)			
Pickup	5.0 to 140 V	1 V	±0.5 V
Inhibit	5.0 to 140 V	1 V	±0.5 V
Time Delay	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ±1

Table 2-3 Positive Sequence Undervoltage (27) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
27 PICKUP
    108 Volts
```

Undervoltage pickup establishes the positive sequence voltage level below which the function timer will start.

```
27 INHIBIT
disable ENABLE
```

Enables or disables the undervoltage inhibit feature.

```
27 INHIBIT
    100 Volts
```

Undervoltage inhibit establishes the positive sequence voltage level below which the function will be disabled.

```
27 DELAY
    30 Cycles
```

The operating time of the function.

46 Negative Sequence Overcurrent

The Negative Sequence Overcurrent function (see Table 2-4), provides protection against possible damage due to unbalanced faults.

The pickup setting of this function can be set below the system load for increased sensitivity for backup of feeder protective relays.

This function has a definite time element and an inverse time element. The definite time pickup value and definite operating time are normally associated with an alarm function. The inverse time element is usually associated with a trip function.

The inverse time function can be selected as one of the eight curve families: definite, inverse, very inverse, extremely inverse, and four IEC curves. The operator selects the pickup and time dial settings.

This protection must *not* operate for system faults that will be cleared by feeder/line relaying. This requires consideration of feeder line protection, bus differential, and breaker failure backup protections.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Negative Sequence Overcurrent Definite Time (46DT)			
Pickup	0.10 to 20.00A (0.02 to 4.00A)	0.01A	±0.1 A or ±3% (±0.02 A or ±3%)
Time Delay	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ±1%
Negative Sequence Overcurrent Inverse Time (46IT)			
Pickup	0.50 to 5.00A (0.10 to 1.00A)	0.01A	±0.1 A or ±3% (±0.02 A or ±3%)
Characteristic Curves	Definite, Inverse, Very Inverse, Extremely Inverse, Four IEC Curves (Inverse, Very Inverse, Extremely Inverse & Longtime Inverse)		
Time Dial:			
Standard Curves #1-4 IEC Curves #5–8	0.5 to 11.0 0.05 to 1.10	0.1 0.01	± ±3 cycles or 5%

Table 2-4 Negative Sequence Overcurrent (46) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
46DT PICKUP
    0.50 Amps
```

Negative sequence overcurrent pickup establishes the negative sequence overcurrent level above which the function timer will start.

```
46DT DELAY
    120 Cycles
```

This setting is the operating time of the function.

```
46IT PICKUP
    1.00 Amps
```

Negative sequence overcurrent pickup establishes the negative sequence overcurrent level above which the function timer will start.

```
46IT CURVE
DEF inv vinv einv →
```

This setting selects one of eight families of curves, as shown in Appendix D, Figures D-5 through D-12.

```
46IT TIME DIAL
    5.0
```

The appropriate curve in the selected family of curves is chosen here.

50BF Breaker Failure

The 50BF function (see Table 2-5), is applicable when a transformer breaker is present. If enabled, the 50BF-Ph phase detector element is used for breaker failure and the 50BF-N provides breaker flashover protection (see Figure 2-4). This provides an additional Breaker Failure Initiate, which is active only when the breaker is open.

50BF-Phase Breaker Failure

When the M-3310 Transformer Protection Relay detects an internal transformer fault or an abnormal operating condition, it closes an output contact to trip the transformer breaker. Protection output contacts must be connected to trip the breakers required to isolate the transformer from the system. The breaker failure condition is detected by the continued presence of current in any one or more phases after the breaker is commanded to trip.

The breaker failure condition is usually detected by the continued presence of current in any one or more of the phases after a breaker has been tripped.

Implementation of the transformer breaker failure function is illustrated in Figure 2-4. The breaker failure timer will be started whenever any one of the designated output contacts or the external programmed breaker failure initiate status input are operated. The timer continues to time if any one of the phase currents is above the 50BF-Ph pickup setting.

50BF-Neutral Element

This overcurrent relay is energized from the transformer winding 2 residual current, see Figure 2-1, One Line Functional Diagram. This function is internally identical to the 50BF-Ph element and operates using residual (winding 2 triple zero sequence) current.

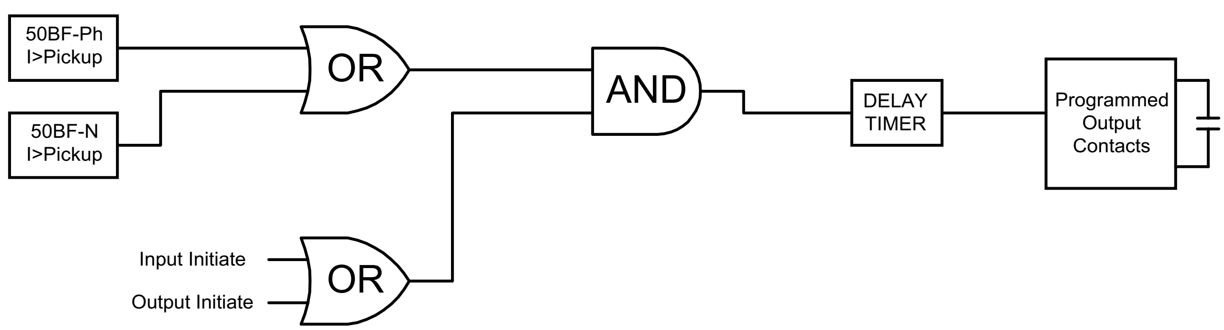


Figure 2-4 Breaker Failure Logic Diagram

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Breaker Failure Phase Element (50BF-Ph)			
Pickup	0.10 to 10.00A (0.02 to 2.00A)	0.01A	±0.1A or ±2% (±0.02A or ±2%)
Time Delay*	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ±2%
Breaker Failure Neutral Element (50BF-N)			
Pickup	0.10 to 10.00A (0.02 to 2.00A)	0.01A	±0.1 A or ±2% (±0.02 A or ±2%)
Time Delay*	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ±2%
** The Delay Timer is shared by both the Phase and Neutral elements*			

Table 2-5 Breaker Failure (50BF) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
50BF PICKUP PHASE
    1.00 Amps
```

Sets 50BF phase current pickup. 0.5A is a typical setting.

```
50BF PICKUP RESIDUAL
    1.00 Amps
```

Sets 50BF residual current pickup. 0.3 A is a typical setting.

```
50BF INPUT INITIATE
    i6 i5 i4 i3 i2 I1
```

Designates the status inputs which will initiate the breaker failure timer.

```
50BF OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 O1
```

Designates the relay outputs which will initiate the breaker failure timer.

```
50 BF DELAY
    30 Cycles
```

For transformer breaker failure use, the time delay should be set to allow for breaker operating time plus margin.

50/50G Instantaneous Overcurrent, Phase & Neutral

The Instantaneous phase (50) and Instantaneous Neutral (50G) overcurrent functions (see Table 2-6), provide fast tripping for high fault currents. The settings of both functions must be set such that they will not pickup for faults or conditions outside the immediate protective zone. Two phase elements (#1 and #2) are available on each winding (W1 and W2). Output is initiated when any individual phase A, B or C exceeds the pickup. These elements also allow the user to program several logic schemes described in Section 2.5, **Functional Logic Schemes.**

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Instantaneous Overcurrent, 3 Phase (50W1 #1, 50W1 #2, 50W2 #1 50W2 #2)			
Pickup	1.0 to 100.0A (0.2 to 20.0A)	0.1A	±0.1A or ±3% (±0.02A or ±3%)
Time Delay	Fixed 2 cycles		±2 cycles
Instantaneous Overcurrent, Neutral (50G)			
Pickup	1.0 to 100.0A (0.2 to 20.0A)	0.1A	±0.1 A or ±3% (±0.02 A or ±3%)
Time Delay	Fixed 2 cycles		±2 cycles

Table 2-6 Instantaneous Overcurrent (50) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
50W1#1 PICKUP
    1.00 Amps
```

Sets phase pickup for instantaneous phase overcurrent.

```
50W1#2 PICKUP
    1.00 Amps
```

```
50W2#1 PICKUP
    1.00 Amps
```

```
50W2#2 PICKUP
    1.00 Amps
```

```
50G PICKUP
    1.0 Amps
```

Sets phase pickup for instantaneous neutral overcurrent.

51 Inverse Time Phase Overcurrent

Time overcurrent relays, one set per winding (see Table 2-7), are used to trip circuits selectively and to time coordinate with up or down stream relays. For this function, eight complete series of inverse time tripping characteristics are included. The eight curve families to be chosen are definite, inverse, very inverse, extremely inverse, and four IEC curves.

The operator selects the time dial within each family setting and tap setting through the relay menu.

The curves available for use are shown in Appendix D, Figures D-5 through D-12. They cover a range from 1.5 to 20 times the tap. For currents beyond 20 times the pickup setting, the relay operating time will remain the same as the time 20 times for pickup setting.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Inverse Time Phase Overcurrent, (51W1, 51W2)			
Pickup	0.50 to 12.00A (0.10 to 2.40A)	0.1A	±0.1A or ±3% (±0.02A or ±3%)
Characteristic Curves	Definite, Inverse, Very Inverse, Extremely Inverse, Four IEC Curves (Inverse, Very Inverse, Extremely Inverse & Longtime Inverse)		
Time Dial: Standard Curves #1-4 IEC Curves #5-8	 0.5 to 11.0 0.05 to 1.10	 0.1 0.01	±3 cycles or ±3%

Table 2-7 Inverse Time Overcurrent (51) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
51W1 PICKUP
    1.00 Amps
```

Sets phase current pickup for 51W1.

```
51W1 CURVE
DEF inv vinv einv          →
```

Selects one of the eight inverse time curves as shown in Appendix D, Figures D-5 through D-12.

```
51W1 TIME DIAL
    5.0
```

The appropriate curve in the selected family of curves is chosen here.

```
51W2 PICKUP
    1.00 Amps
```

Sets phase current pickup for 51W2.

```
51W2 CURVE
DEF inv vinv einv          →
```

Selects one of the eight inverse time curves, as shown in Appendix D, Figures D-5 through D-12.

```
51W2 TIME DIAL
    5.0
```

The appropriate curve in the selected family of curves is chosen here.

51NW1/51NW2 Inverse Time Residual Overcurrent

The Inverse Time Residual Overcurrent (see Table 2-8), provides protection against ground faults. Since normal residual current is usually much lower than the full load phase current, this function can be set more sensitively than the phase overcurrent protection.

The curves available for use are shown in Appendix D, Figures D-5 through D-12. They cover a range from 1.5 to 20 times tap. For currents beyond 20 times the pickup setting, the relay operating time will remain the same as the 20 times pickup setting.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Inverse Time Residual Overcurrent, (51NW1, 51NW2)			
Pickup	0.50 to 6.00A (0.10 to 1.20A)	0.1A	±0.1A or ±3% (±0.02A or ±3%)
Characteristic Curves	Definite, Inverse, Very Inverse, Extremely Inverse, Four IEC Curves (Inverse, Very Inverse, Extremely Inverse & Longtime Inverse)		
Time Dial: Standard Curves #1-4 IEC Curves #5-8	 0.5 to 11.0 0.05 to 1.10	 0.1 0.01	 ±3 cycles or ±5%

Table 2-8 Inverse Time Overcurrent (51NW1, 51NW2) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
51NW1 PICKUP
    1.00 Amps
```

Sets phase current pickup for 51NW1.

```
51NW1 CURVE
DEF inv vinv einv →
```

Selects one of the eight inverse time curves, as shown in Appendix D, Figures D-5 through D-12.

```
51NW1 TIME DIAL
    5.0
```

The appropriate curve in the selected family of curves is chosen here.

```
51NW2 PICKUP
    1.00 Amps
```

```
51NW2 CURVE
DEF inv vinv einv →
```

```
51NW2 TIME DIAL
    5.0
```

51G Inverse Time Neutral Overcurrent

Time overcurrent relay (see Table 2-9) is used to trip circuits selectively and to time coordinate with up or downstream relays. For this function, eight complete series of inverse time neutral tripping characteristics are included. The eight curve families to be chosen are definite, inverse, very inverse, extremely inverse, and four IEC curves. The operator selects the time dial within each family setting and tap setting through the relay menu.

The curves available for use are shown in Appendix D, Figures D-5 through D-12. They cover a range from 1.5 to 20 times the tap. For currents beyond 20 times the pickup setting, the relay operating time will remain the same as the time 20 times for pickup setting.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Inverse Time Neutral Overcurrent (51G)			
Pickup	0.50 to 12.00A (0.10 to 2.40A)	0.1A	±0.1 A or ±3% (±0.02 A or ±3%)
Characteristic Curves	Definite, Time, Inverse, Very Inverse, Extremely Inverse, Four IEC Curves (Inverse, Very Inverse, Extremely Inverse & Longtime Inverse)		
Time Dial: Standard Curves #1-4 IEC Curves #5-8	 0.5 to 11.0 0.05 to 1.10	 0.1 0.01	 ±3 cycles or ±3%

Table 2-9 Inverse Time Overcurrent (51G) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
51G PICKUP
    1.00 Amps
```

Sets phase current pickup for 51G.

```
51G CURVE
DEF inv vinv einv →
```

Selects one of the eight inverse time curves, as shown in Appendix D, **Inverse Time Curves**, Figures D-5 through D-12.

```
51G TIME DIAL
    5.0
```

The appropriate curve in the selected family of curves is chosen here.

```
51G PICKUP
    1.00 Amps
```

Sets phase current pickup for 51G.

```
51G CURVE
DEF inv vinv einv →
```

Selects one of the eight inverse time curves, as shown in Appendix D, Figure D-5 through D-12.

```
51G TIME DIAL
    5.0
```

The appropriate curve in the selected family of curves is chosen here.

59G RMS Overvoltage, Neutral Circuit or Zero Sequence

The Neutral Overvoltage function 59G (see Table 2-10), provides protection for ground faults on the system.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Neutral RMS Overvoltage (59G)			
Pickup	5.0 to 140.0 V	0.1 V	±0.5 V
Time Delay	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ±1%

Table 2-10 Neutral RMS Overvoltage (59G) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
59G PICKUP
    10.0 Volts
```

```
59G DELAY
    30 Cycles
```

Pickup setting for 59G should be set in such a way that it is higher than normal neutral voltage during unbalanced conditions. The time delay should be set to coordinate with downstream ground relaying.

81U Underfrequency

The 81 function (see Table 2-11), provides underfrequency load shedding. This function has three independent pickup and time delay settings to provide a three setpoint load shedding scheme.

The frequency functions are automatically disabled when the input voltage (positive sequence) is less than 5 volts.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Underfrequency (81U #1, 81U #2, 81U #3)			
Pickup	48.00 to 59.99 Hz 38.00 to 49.99 Hz*	0.01 Hz	±0.02 Hz
Time Delay	2 to 65,500 cycles	1 cycle	-1 to +3 cycles or ±1%
** This range applies to 50 Hz nominal frequency models.*			

Table 2-11 Underfrequency (81U) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
81U#1 PICKUP
    59.50 Hz
```

```
81U#1 DELAY
    120 Cycles
```

```
81U#2 PICKUP
    59.00 Hz
```

```
81U#2 DELAY
    60 Cycles
```

```
81U#3 PICKUP
    58.50 Hz
```

```
81U#3 DELAY
    30 Cycles
```

The pickup and time delay setting for load shedding should be selected based on load frequency characteristics of the system.

A time delay of 6 cycles is recommended to prevent relay operation during switching transients.

87H Phase Differential Unrestrained High Set Overcurrent

The 87H function (see Table 2-12), is used to detect transformer internal winding faults with high currents. Unlike the 87T function, the 87H function is not blocked by harmonic restraint. The pickup for this function should be set above the worst case first peak of the inrush current. This prevents misoperation of the function due to magnetizing inrush current during switching on of the transformer. Typical pickup setting is between 8 to 12 pu. The per unit is based on the CT tap setting. The 87H is typically set with no intentional time delay (one cycle time delay setting corresponds to no intentional time delay).

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Differential Overcurrent (87H)			
Pickup	5.0 to 20.0 PU	0.1 pu	±0.1 pu or ±3%
Time Delay	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ±1%

Table 2-12 Phase Differential Current (87H) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
87H PICKUP
    20.0 PU
```

High-set pickup setting.

```
87H DELAY
    2 Cycles
```

87T Phase Differential Restrained Overcurrent

The 87T Phase Differential function (see Table 2-13), is a percentage differential function with dual adjustable slope characteristics (see Figure 2-5). This function provides protection for the transformer from all internal winding faults. This function offers sensitive differential protection at low fault currents and tolerates larger mismatch of currents at high through fault currents.

The 87T minimum pickup setting should be set to prevent operation of the 87T function due to transformer excitation current. Typical setting is 0.2 to 0.4 pu.

Slope 1

The setting of Slope #1 should be set according to various possible errors:

1. Tapchanger operations in the power transformer (worst case ±10%).
2. CT mismatch due to ratio errors. Errors can be as high as ±10%.
3. Transformer excitation current (typical current of 3%).

A typical Slope #1 setting of 30 to 40% prevents misoperation due to above errors.

Slope 2

For heavy faults outside the differential zone, CT saturation can occur. Factors such as residual magnetism in the CT core, CT characteristic mismatch and burden mismatch can contribute large differential currents during this condition. Slope #2 should be set higher than Slope #1. It can provide security against misoperation during high through fault currents. A typical Slope #2 setting is 60 to 100%.

Even Harmonic Restraint

Transformer magnetizing inrush currents contain significant amounts of 2^{nd} and some 4^{th} harmonic currents. This inrush can cause undesirable trips and delay putting a transformer into service. The even harmonic restraint desensitizes the relay and keeps it from operating during a magnetizing inrush condition. Magnetizing inrush current is distinguishable from fault current by harmonic components. The M-3310 Transformer Relay can be set to restrain if the level of even harmonic current is above a set percentage of fundamental.

The harmonic current is calculated from the differential current in the windings. The amount of even harmonic current (Id_{24}) in PU can be found by using the formula: $Id_{24} = \sqrt{Id_2^{\,2} + Id_4^{\,2}}$, where Id_2 and Id_4 are second and fourth harmonic currents in PU, respectively.

The percentage of even harmonics is found by the ratio Id_{24}/Id_1: If this number is above the even harmonic restraint setpoint, function 87T will restrain from operation.

The amount of even harmonics present in the transformer inrush currents depends upon the magnetizing characteristics of the transformer core and residual magnetism present in the core. A setting in the range of 10 to 15% can provide security against misoperations during magnetizing inrush conditions.

Modern transformers tend to have low core losses and very steep magnetizing characteristics. When the relay is applied to this type of transformers, the even harmonic setting should be set around 10% (in some cases, the setting may be lower than 10%). Older transformer designs tend to have higher amounts of even harmonics, where a setting of 15% or greater can provide security against misoperation during magnetizing inrush conditions.

The setting of the even harmonic restraint should be set to a low enough value to provide security against misoperation during transformer magnetizing inrush current and it should not be lower than the amount of even harmonics generated during through fault conditions with CT saturation.

Fifth Harmonic Restraint

Transformer over-excitation produces a high amount of excitation current, which will appear as a differential current to the 87T function. The Fifth Harmonic restraint function can prevent misoperation of the 87T function by shifting the minimum pickup to a higher value (typically set at 150 to 200% of 87T minimum pickup), during transformer over-excitation conditions.

The over-excitation condition is detected by the presence of Fifth Harmonic component as a percentage of fundamental component of differential current above a set value.

The amount of Fifth Harmonic depends on the transformer core magnetizing characteristics. A setting of 30% is adequate to discriminate over-excitation from other conditions.

Cross Phase Averaging

Cross phase averaging is used to average the harmonics of all three phases to provide restraint of phases which may not have enough harmonics. Cross phase average, when enabled, provides security against misoperation during magnetizing inrush. However, it may slightly delay the relay operation for internal faults. The level of cross phase average current may be found using the following equations.

- Even Harmonic Cross Phase Average:

$$Id_{CPA24} = \sqrt{IAd_{24}^{2} + IBd_{24}^{2} + ICd_{24}^{2}}$$

- Fifth Harmonic Cross Phase Average:

$$Id_{CPA5} = \sqrt{IAd_{5}^{2} + IBd_{5}^{2} + ICd_{5}^{2}}$$

When enabled, the above averages are used along with fundamental component of differential current in each of the phases to calculate the harmonic percentages.

It is recommended to enable the cross phase average for even harmonic restraint, and disable the cross phase average for 5^{th} harmonic restraint.

87T W1 and W2 CT Tap Settings

The 87TW1 and 87TW2 CT tap settings are used to convert the W1 and W2 current in terms of P.U. These settings are provided to compensate for CT ratio mismatch for 87T and 87H functions. These should be calculated as follows:

87TW1 CT Tap

For transformer connections 1 to 5 and 10 to 14:

$$\text{87TW1 CT Tap} = \frac{\text{MVA x } 10^{3}}{\sqrt{3} \text{ x } Vw1_{L\text{-}L} \text{ x CTR1}}$$

and for transformer connections 6 to 9:

$$\text{87TW1 CT Tap} = \frac{\text{MVA x } 10^{3}}{Vw1_{L\text{-}L} \text{ x CTR1}}$$

where MVA is the MVA rating of the transformer, $Vw1_{L\text{-}L}$ is the line-to-line rated voltage of the transformer winding 1, and CTR1 is the ratio of phase CT's on transformer winding 1.

87TW2 CT Tap

For transformer connections 1 to 5, 8 to 11, and 14:

$$\text{87TW2 CT Tap} = \frac{\text{MVA x } 10^{3}}{\sqrt{3} \text{ x } Vw2_{L\text{-}L} \text{ x CTR2}}$$

and for connections 6, 7, 12 and 13:

$$\text{87TW2 CT Tap} = \frac{\text{MVA x } 10^{3}}{Vw2_{L\text{-}L} \text{ x CTR2}}$$

where $Vw2_{L\text{-}L}$ is the line-to-line rated voltage of the transformer winding 2, and CTR2 is the ratio of phase CT's on transformer winding 2.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Differential Overcurrent (87T)			
Pickup	0.10 to 1.00 pu	0.01 pu	±0.10 pu or ±5%
Percent Slope #1	5 to 100%	1%	±1%
Percent Slope #2	5 to 200%	1%	±1%
Slope Break Point	1.0 to 4.0 pu	.1 pu	-
Even Harmonic Restraint (2nd and 4th)	5 to 50%	1%	±0.1% or ±1A
5th Harmonic Restraint	5 to 50%	1%	±0.1% or ±1A
Pickup at 5th Harmonic Restraint	0.10 to 2.00 pu	0.01 pu	±0.10 pu or ±5%
Winding 1 CT Tap	1.00 to 10.00:1 (0.20 to 2.00:1)	0.01	-
Winding 2 CT Tap	1.00 to 10.00:1 (0.20 to 2.00:1)	0.01	-

Table 2-13 Phase Differential Current (87T) Setpoint Ranges

If this function is enabled, the following settings are applicable:

See previous pages for more information on these settings.

```
87T PICKUP
    0.50 PU
```

```
87T SLOPE #1
    35%
```

```
87T SLOPE #2
    75%
```

```
87T SLOPE BREAKPOINT
    2.0 PU
```

```
87T EVEN RESTRAINT
disable enable CROSS_AVG
```

```
87T EVEN RESTRAINT
    10%
```

```
87T 5TH RESTRAINT
disable enable CROSS_AVG
```

```
87T 5TH RESTRAINT
    30%
```

```
87T PICKUP@5TH RESTRAINT
    30%
```

```
87T W1 C.T.TAP
    1.00
```

```
87T W2 C.T. TAP
    1.00
```

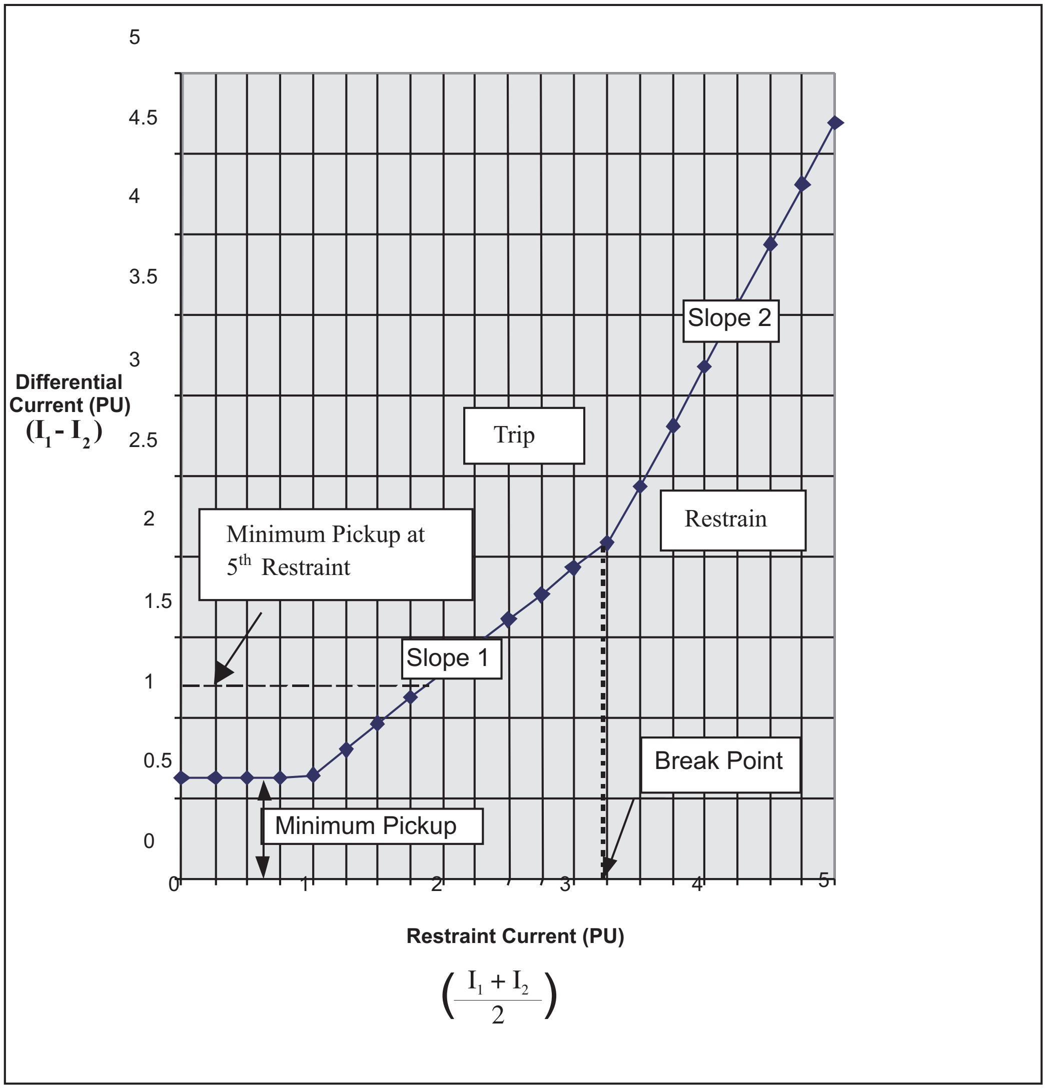


Figure 2-5 87T Programmable Dual Slope Percentage Characteristics

87GD Ground (Zero Sequence) Differential

The zero sequence differential element (see Table 2-14) provides sensitive ground fault protection on the winding 2.

The relay provides a CT Ratio Correction (CT) which removes the need for auxiliary CTs when the phase and neutral CT ratios are different.

The directional element calculates the product ($-3I_0I_G$CosU) for directional indication. The relay will operate only if I_0 (zero sequence current derived from the phase CTs) and I_G (Ground current from the Ground CT) have the opposite polarity, which is the case for internal transformer faults.

The advantage of directional element is that it provides security against ratio errors and CT saturation during faults external to the protected transformer.

The directional element is inoperative if the residual zero sequence current (I_0) is less than 140 mAmps. For this case, the algorithm automatically disables the directional element and the 87GD function becomes non-directional differential. The pickup quantity is calculated as the difference between the corrected triple zero sequence current ($RC3I_0$) and the ground current (I_G). The magnitude of the difference ($RC3I_0$- I_G) is compared to the function pickup setting.

In order to use the 87GD function, the Windings CTs must be connected Y (connections 1–5, 8–11, and 14).

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
Ground Differential (Zero Sequence) Overcurrent (87GD)			
Pickup	0.20 to 10.00 A (0.04 to 2.00 A)	0.01 A	±0.1 A or ±5% (±0.02 A or ±5%)
Time Delay	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ±1%
CT Ratio Correction	0.10 to 7.99	0.01	-

Table 2-14 Ground Differential Current (87GD) Setpoint Ranges

If this function is enabled, the following settings are applicable:

```
87GD PICKUP
    0.20 Amps
```

```
87GD DELAY
    2 Cycles
```

```
87GD C.T. RATIO CORRECT
    1.00
```

■ **NOTE:** For higher values of CT Ratio correction, noise may create substantial differential current making higher settings desirable.

CT Ratio Correction Factor = $\dfrac{Line\_C.T.Ratio}{Ground\_C.T.Ratio}$

EXT (External) Functions

The relay provides six external functions (see Table 2-15), to allow external device contacts to trip through the relay. These functions expand the capability of the relay by providing additional operating logic and target information for external devices. The initiating inputs, any number of external device contacts connected to IN1*—IN6, can be designated to operate the function.

■ **NOTE**: *IN1 is pre-designated as the Breaker contact input.

FUNCTION	SETPOINT RANGE	INCREMENT	ACCURACY
External Functions (EXT#1-EXT#6)			
Input Initiate	IN #1-#6		
Output Initiate	OUT #1-#8		
Time Delay	1 to 8160 cycles	1 cycle	-1 to +3 cycles or ± 1%

Table 2-15 External Functions (EXT) Setpoint Ranges

```
EXT#1 INPUT INITIATE
    i6 i5 i4 i3 i2 i1
```

```
EXT#1 OUTPUT INITIATE
08 o7 o6 o5 o4 o3 o2 o1
```

```
EXT#1 DELAY
    30 Cycles
```

If this function is enabled, the following settings are applicable:

The initiating inputs are user designated for each enabled external function. The activation of one or more of the external contacts will start operation of the external function timer.

The initiating outputs can also be set to start the external functions timer. This aids in setting up special logic schemes as the output contact does not have to be routed back to the input. This also saves inputs as well as speeds up the triggering process as the output contact delay and input de-bounce delay no longer enter the equation.

Complete settings for each of the 5 remaining external contacts (screens not shown).

The following example of how to program an external function (see Figure 2-6):

- Initiating inputs are IN2 or IN5.
- Initiating output is OUT4.
- Blocking input is IN3.
- External function output is OUT6.
- A time delay of 30 cycles.

The only logical limitation is that the same status input cannot be designated as both a initiating input and a blocking input. The connection for the external device to the input contacts is illustrated in Chapter 5, Figure 5-4, **External Connections** and in Chapter 6, Table 6-3, **Input Contacts**.

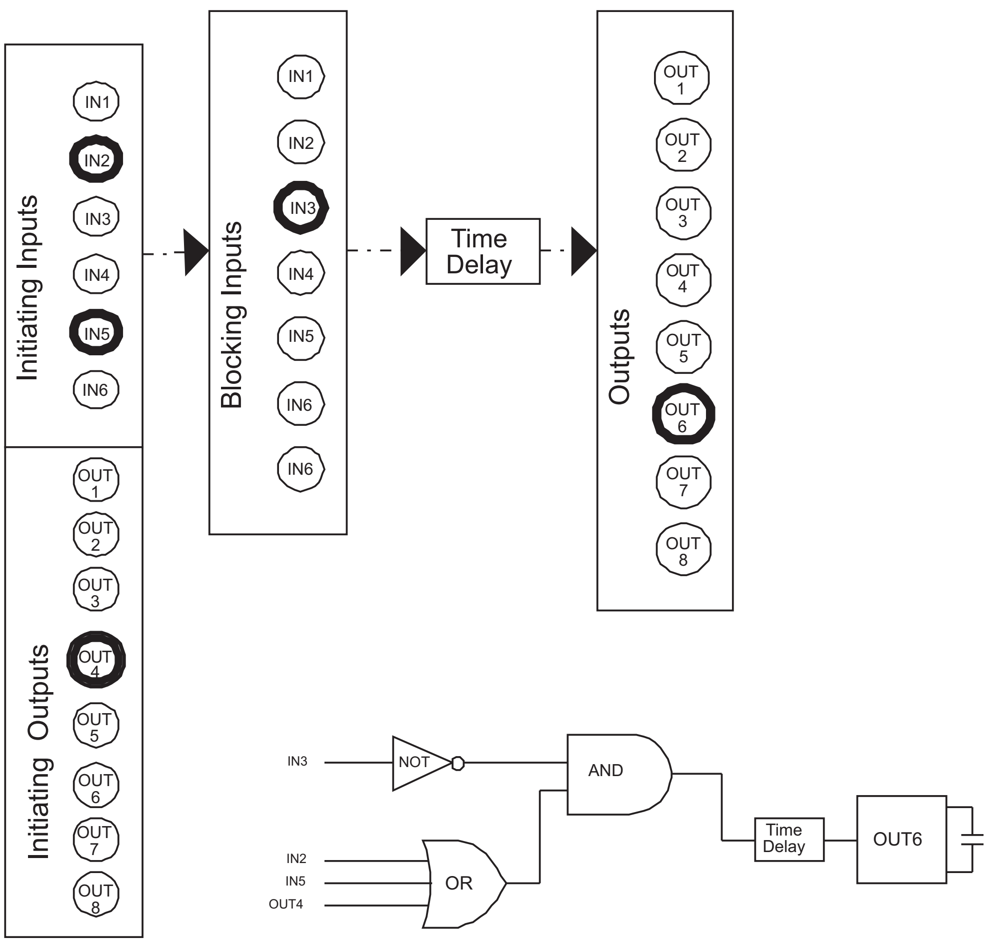


Figure 2-6 External Function Setup

2.5 Functional Logic Scheme

Bus Fault Protection

Digital feeder and transformer protection logic can be combined together to provide high-speed bus fault protection. The designated external function will act as a delayed overcurrent detector within the relay (see Figures 2-7 and 2-8). A fault detected from any feeder relay will activate a programmable input on the relay. This input will block the external function from operating under normal feeder trip conditions. If a fault occurs on the bus connected to winding 2 and none of the feeder relays have been tripped, the external function will then proceed to trip the breaker after the specified time delay.

Example

Function 50W2 #1 is programmed to trip OUT2. External #1 is configured with IN4 to block, OUT 2 to initiate, and OUT3 to trip with a time delay of 7 cycles. In this configuration all feeder relay output contacts will be in parallel on IN4 and OUT3 will act as the relay delayed overcurrent detector which will trip the bus breaker.

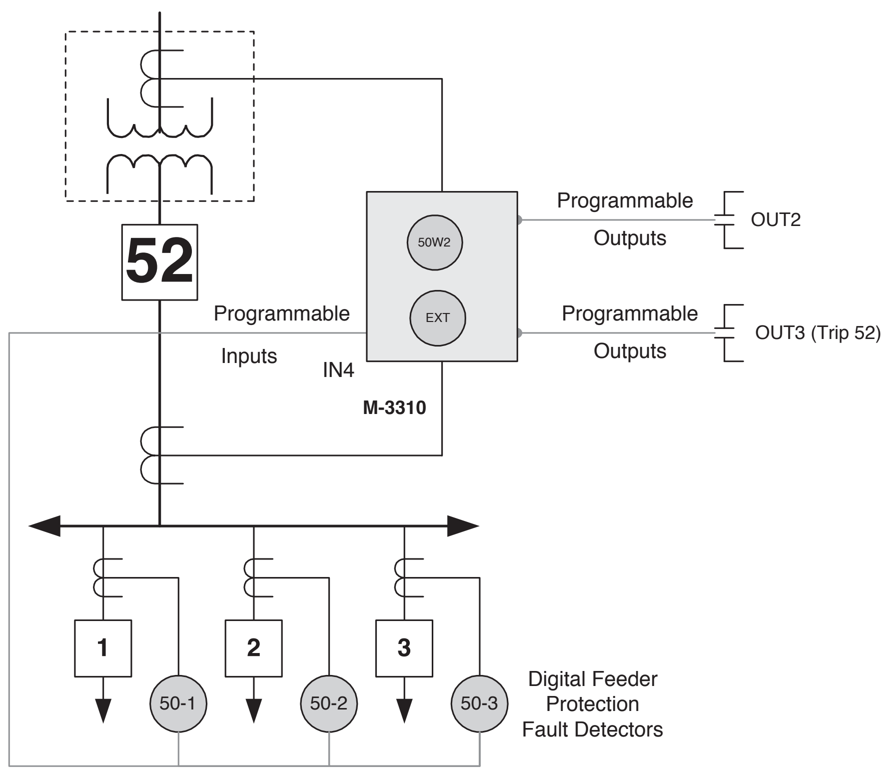


Figure 2-7 Bus Fault Protection Scheme

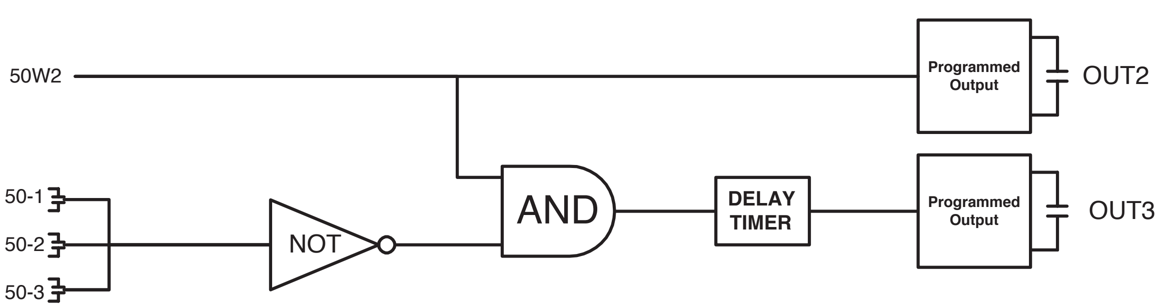


Figure 2-8 Bus Fault Protection Logic

Backup for Digital feeder Relay failure

The M-3310 Transformer Protection Relay can provide backup for digital feeder relays (see Figure 2-9). The backup feature is initiated by the closure of a feeder relay's self-test error contact. This scheme assumes that some sort of contact multiplying is done on the self-test outputs. A multiplied, normally open self-test contact can be paralleled with all feeder relays to initiate the backup feature.

Example

The Negative Sequence Overcurrent (46) function may be utilized to provide the backup protection required. The function is enabled through a user-selected control input, configured such that it is activated by an open contact. The parallel contacts from the feeder relay self-test will be wired to that input (see Figure 2-10). The Negative Sequence function will be set to coordinate with the downstream devices of the feeders on the protected bus.

With no feeder alarms, the paralleled self-test alarm contacts will all be open, and the Negative Sequence Overcurrent function blocked. When a feeder relay fails and its self-test contact closes, the Negative Sequence overcurrent function is enabled (unblocked), and the contact stream establishes a trip path to the failed relay breaker trip circuit. The Negative Sequence relay will then provide backup protection to the failed relay circuit.

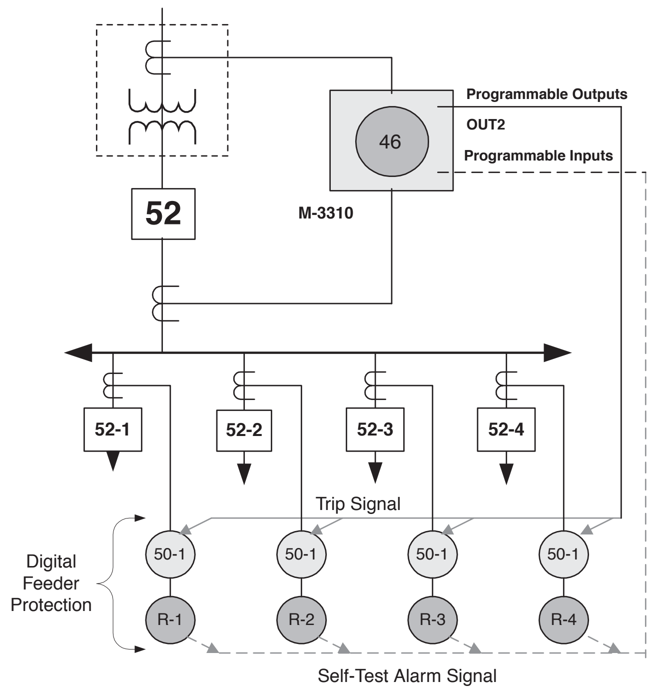


Figure 2-9 Digital Feeder Relay Backup Scheme

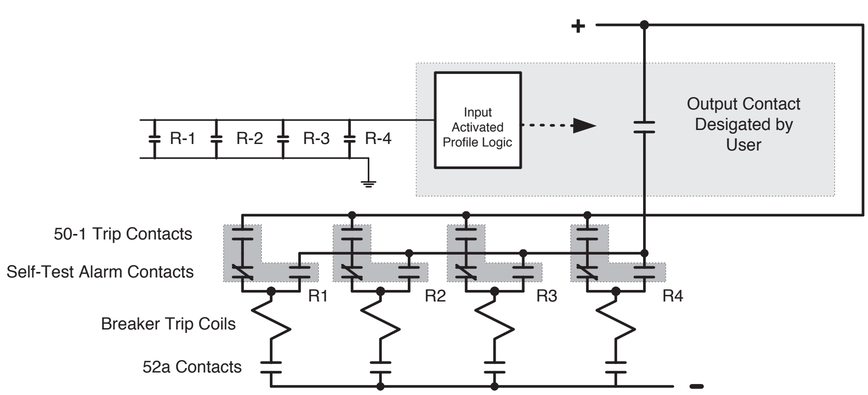


Figure 2-10 Feeder Backup Logic

Load Shedding

Description

In stations where there are two or more transformers (see Figures 2-11 and 2-12), usually there is a normally open tie breaker on the secondary side. If one of the transformers is removed from the system, the tie breaker closes and the remaining transformers will pick up the entire station load. To prevent the remaining transformers from overloading, an overcurrent load shedding is used to remove some of the load if it exceeds a predefined level.

The External functions can provide a cascading time delay feature that can be used for this load shedding configuration. The 52b contact is wired to a relay input, which is programmed to block the 50W2 function. The output of the 50W2 function is programmed to initiate the External functions that are associated with the load shedding configuration. Each External function output is used to trip a corresponding feeder load or initiate voltage reduction.

Example

Function 50W2 #1 is programmed to trip OUT2 and to block on IN2. The 52b contact of the tie breaker and the 52a contacts of the low side transformer breaker are wired to IN2, as shown in Figure 2-12. The EXT #1 function is programmed to use OUT2 to initiate and to trip OUT3 with a small time delay. The EXT #2 function is programmed to use OUT2 to initiate and to trip OUT4 with a longer time delay. The EXT #3 function is programmed to use OUT2 to initiate and to trip OUT5 with an even longer time delay. OUT3 is wired to trip the first load, OUT4 the second load, and so on…

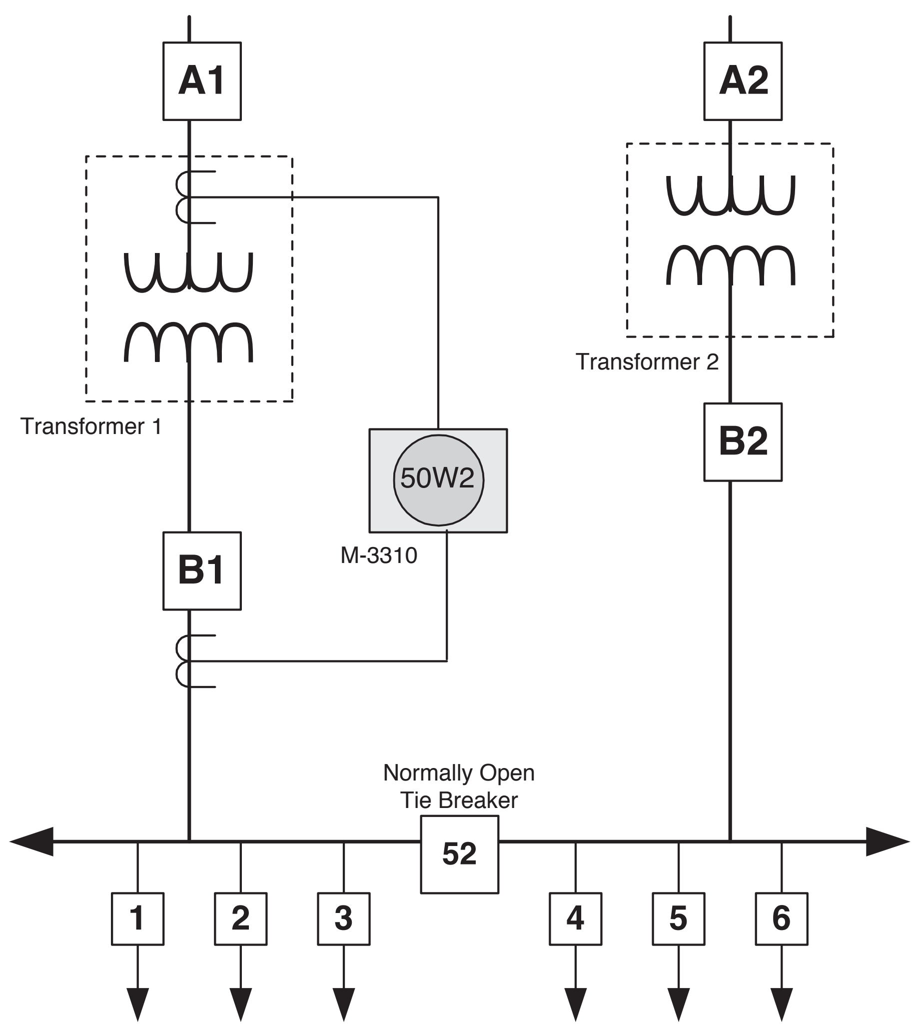


Figure 2-11 Two Bank Load Shedding Scheme

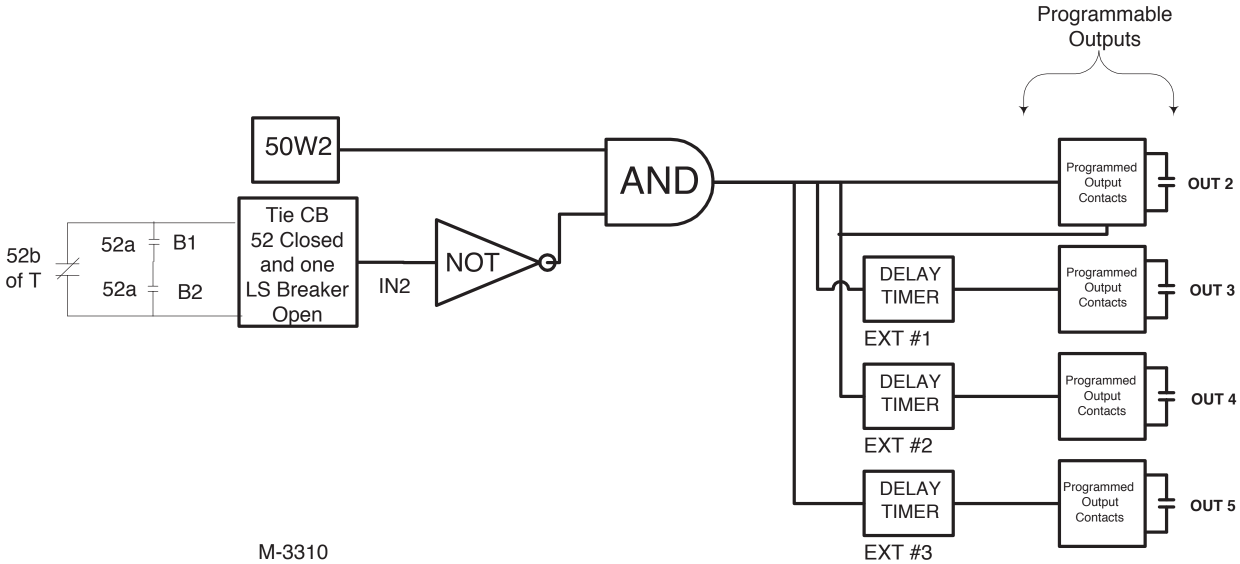


Figure 2-12 Load Shedding Logic

LTC Blocking During Faults

Description

The relay contains logic to block load Tapchangers from operating during feeder fault conditions (see Figure 2-13). Blocking LTC operation during feeder faults can prevent excessive tap changes, reduce contact wear and provide more predictable trip coordination. The blocking contact can be wired to the Auto Disable input (Beckwith M-0270 Tapchanger control, for example) or wired in series with the motor power for the Tapchanger.

Example

Function 50W1 #2 is programmed to trip on OUT7 with a pickup of 2X transformer nameplate rated current. The seal-in delay of OUT7 is programmed to 3000 cycles (50 seconds). The normally closed contact of OUT7 is wired to the Auto Disable input of a Beckwith Electric M-2270/M-2001A Tapchanger control.

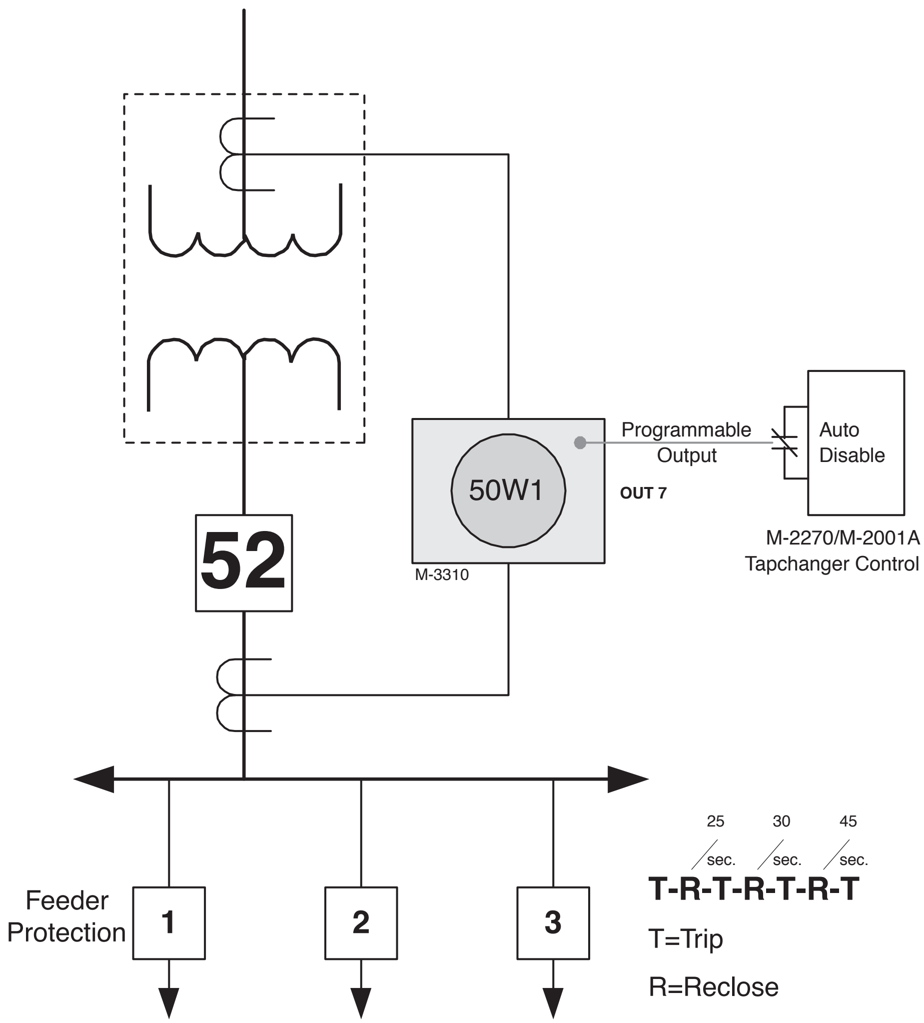


Figure 2-13 LTC Blocking Scheme During Faults

2.6 Transformer Connections

Transformer Connection Settings

The relay is designed to compensate for phase angle shifts imposed by fourteen combinations of power transformer winding connections and current transformer winding connections. The connection types available and the formulas for each are listed in Table 2-16

Setting the Transformer Connection Type

Review the transformer diagrams included (see Figures 2-14 through 2-27) and enter the connection type that matches your transformer.

■ **NOTE**: Connections 1 and 14 are identical except that connection 14 eliminates the zero sequence current in the software.

Connection Type	Transformer Connection Setting	CT Connection Setting
1	YY	yy
2	YDAC	yy
3	YDAB	yy
4	DABY	yy
5	DACY	yy
6	YY	dacdac
7	YY	dabdab
8	YDAC	dacy
9	YDAB	daby
10	DACDAC	yy
11	DABDAB	yy
12	DABY	ydab
13	DACY	ydac
14	YY	yy

D denotes Delta Connection
Y denotes Wye Connection

Table 2-16 Transformer Connections

Type 1: Wye/Wye Power Transformer with Wye/Wye CT Connection

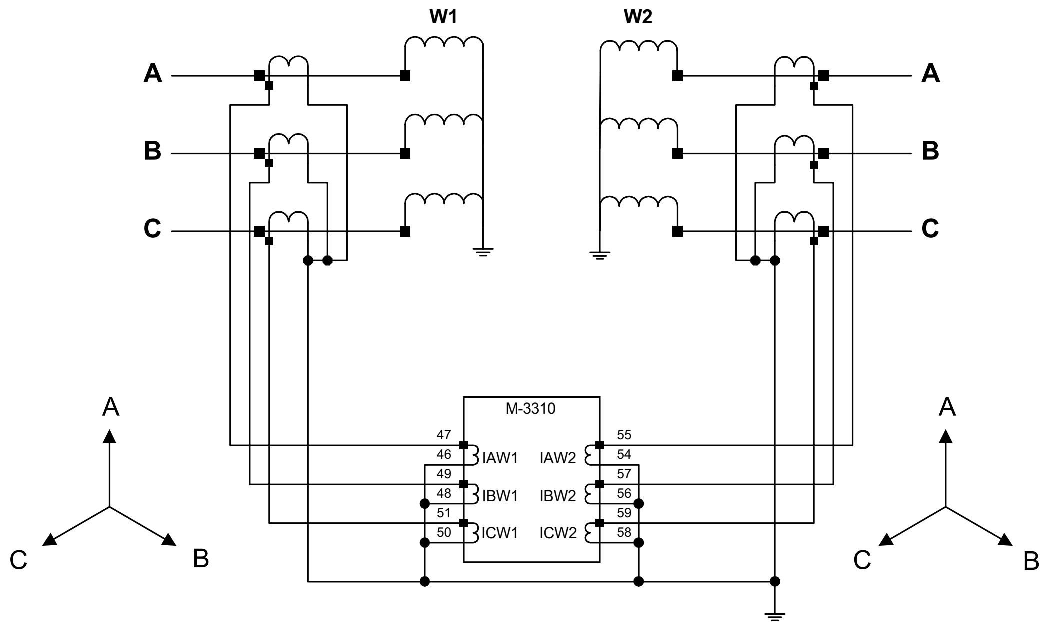


Figure 2-14 Connection Type 1

Type 2: Wye/Delta AC Power Transformer with Wye/Wye CT Connection

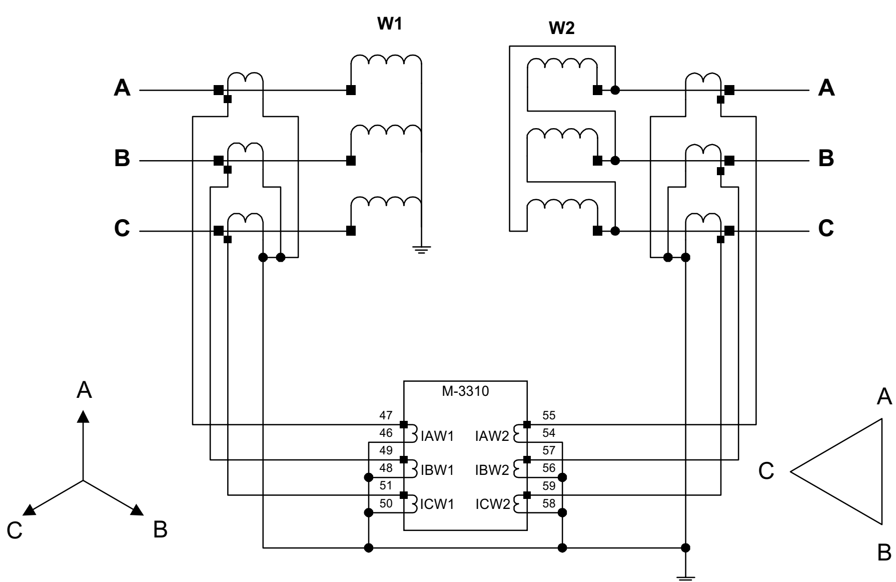


Figure 2-15 Connection Type 2

Type 3: Wye/Delta AB Power Transformer with Wye/Wye CT Connection

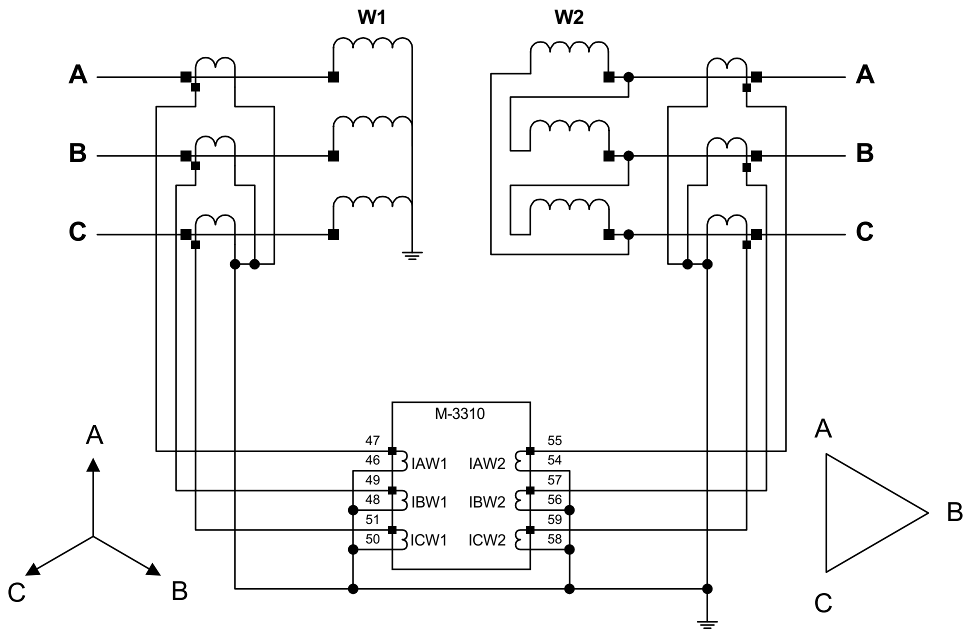


Figure 2-16 Connection Type 3

Type 4: Delta-AB/Wye Power Transformer with Wye/Wye CT Connection

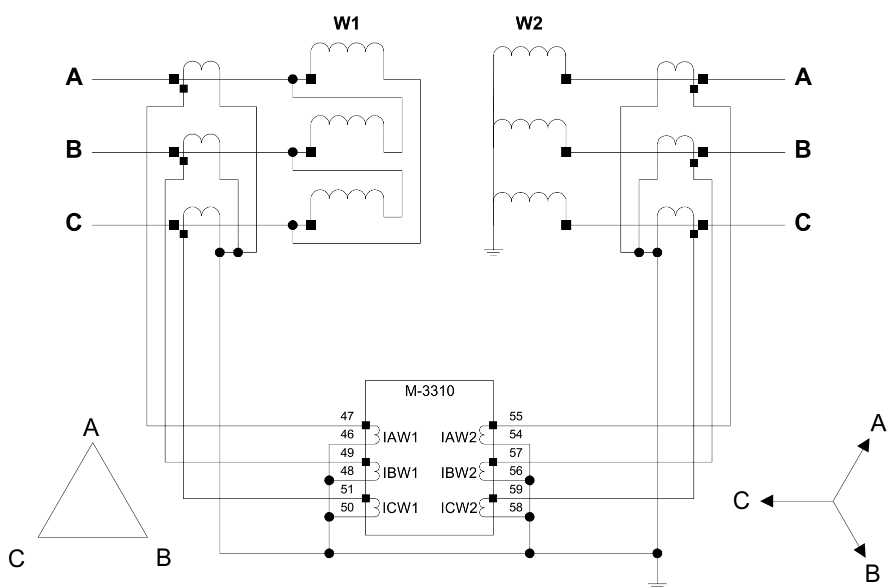


Figure 2-17 Connection Type 4

Type 5: Delta-AC/Wye Power Transformer with Wye/Wye CT Connection

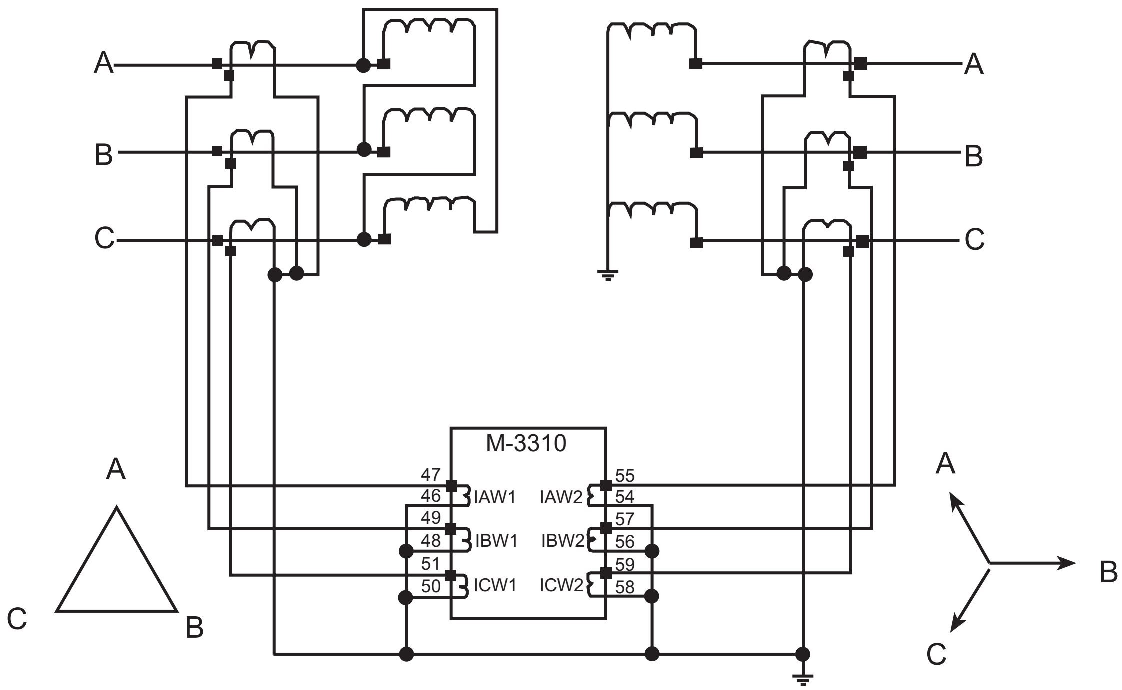


Figure 2-18 Connection Type 5

Type 6: Wye/Wye Power Transformer with Delta-AC/Delta-AC CT Connection

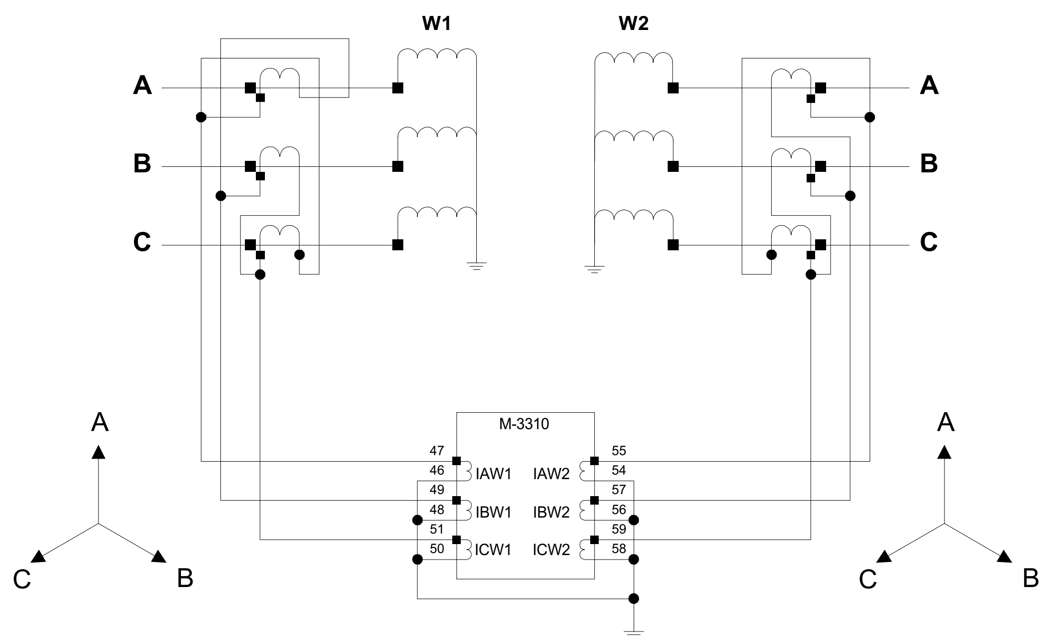


Figure 2-19 Connection Type 6

Type 7: Wye/Wye Power Transformer with Delta-AB/Delta-AB CT Connection

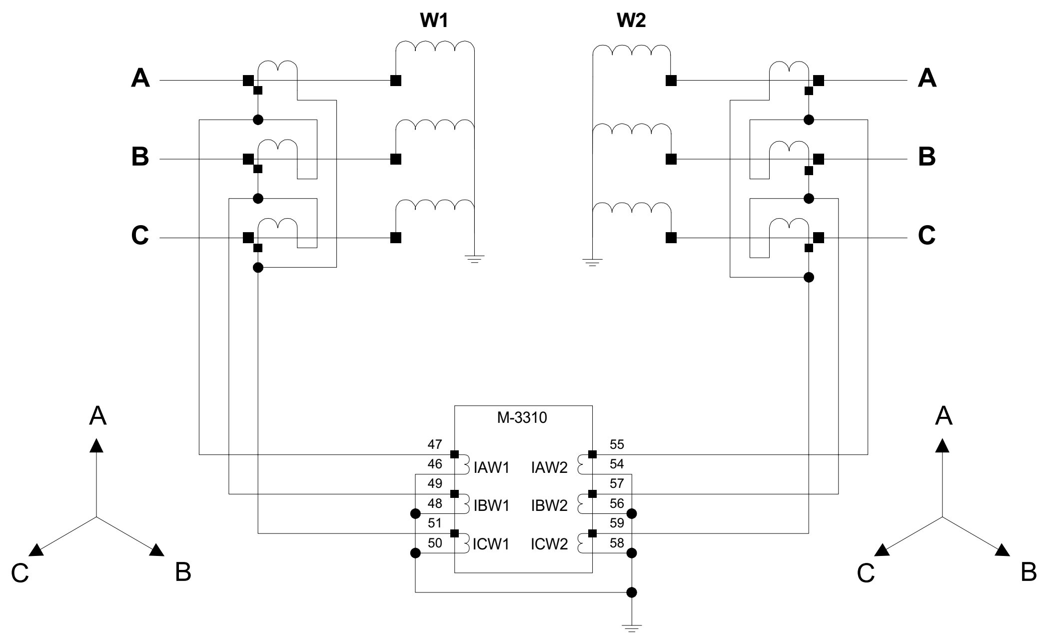


Figure 2-20 Connection Type 7

Type 8: Wye-Delta AC Power Transformer with Delta-AC/Wye CT Connection

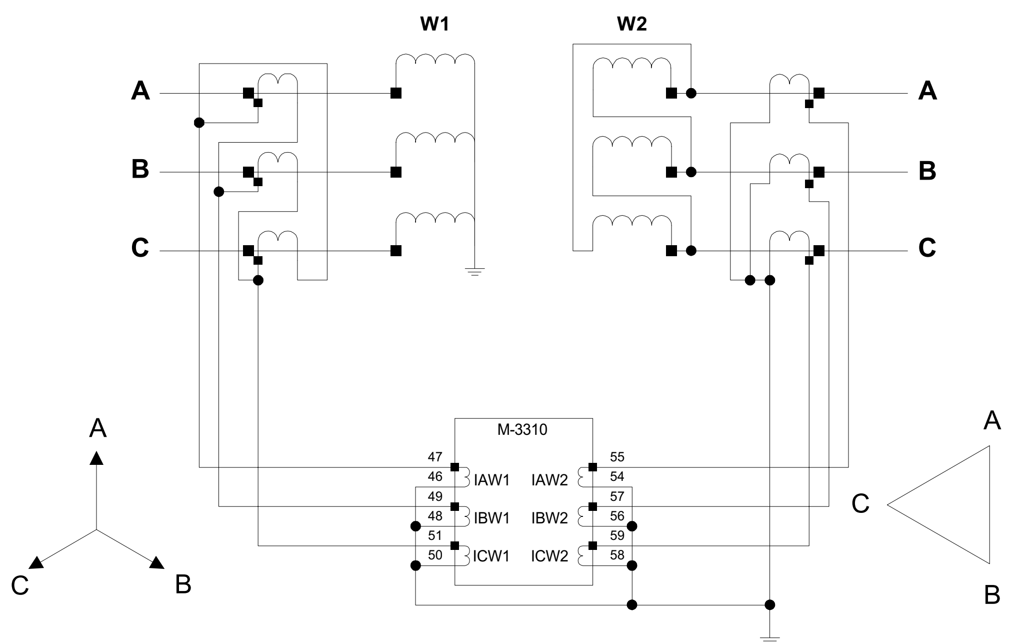


Figure 2-21 Connection Type 8

Type 9: Wye/Delta AB Power Transformer with Delta-AB/Wye CT Connection

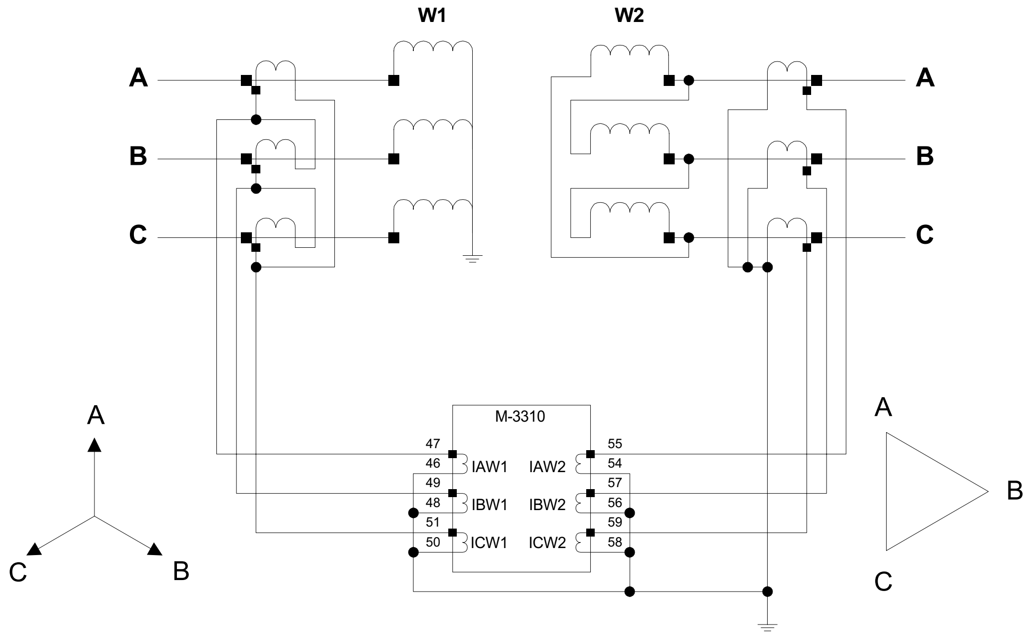


Figure 2-22 Connection Type 9

Type 10: Delta-AC/Delta-AC Power Transformer with Wye/Wye CT Connection

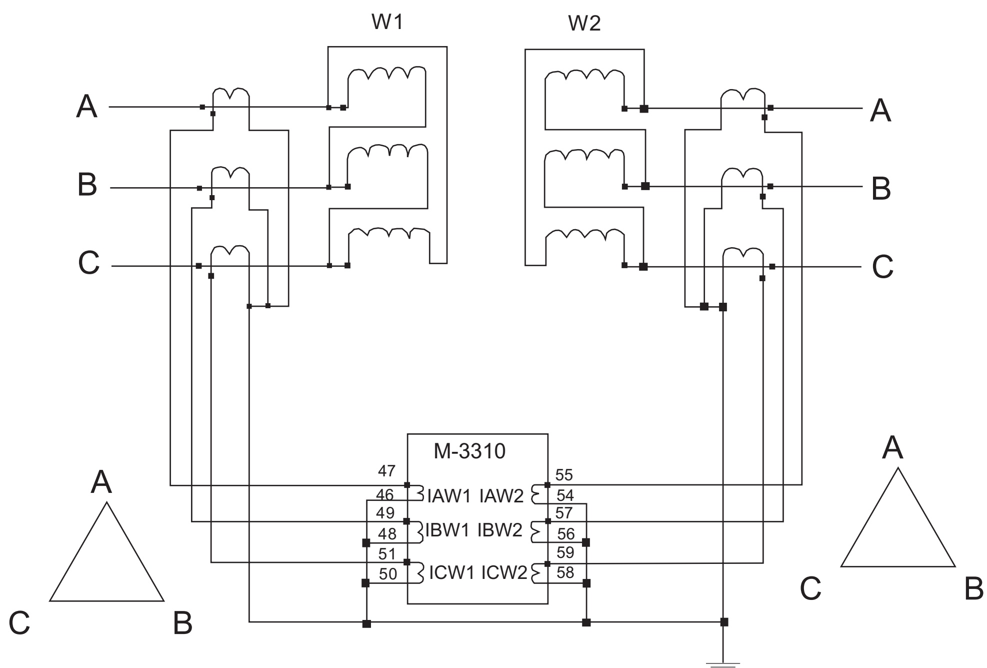


Figure 2-23 Connection Type 10

Type 11: Delta-AB/Delta-AB Power Transformer with Wye/Wye CT Connection

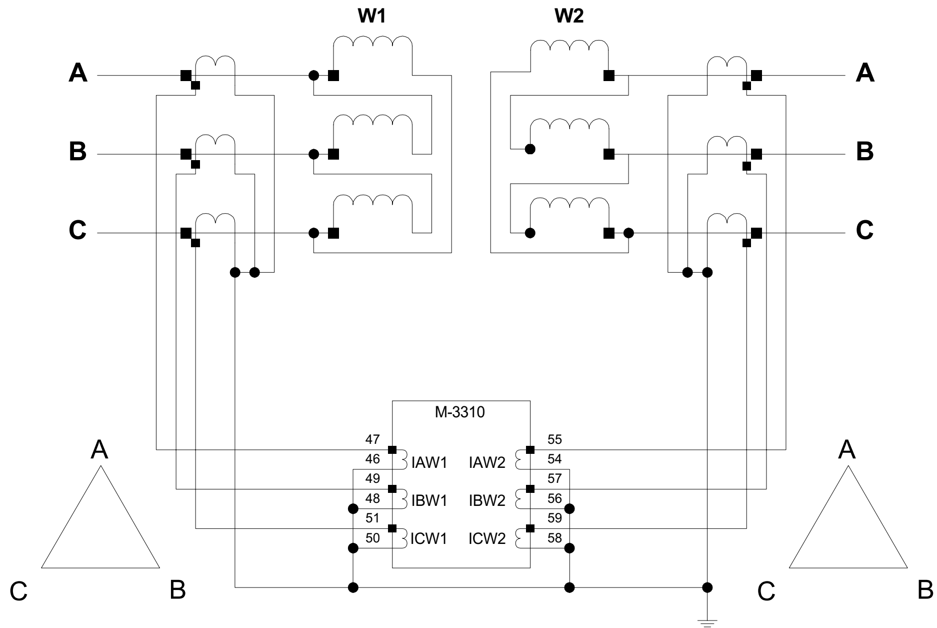


Figure 2-24 Connection Type 11

Type 12: Delta-AB/Wye Power Transformer with Wye/Delta-AB CT Connection

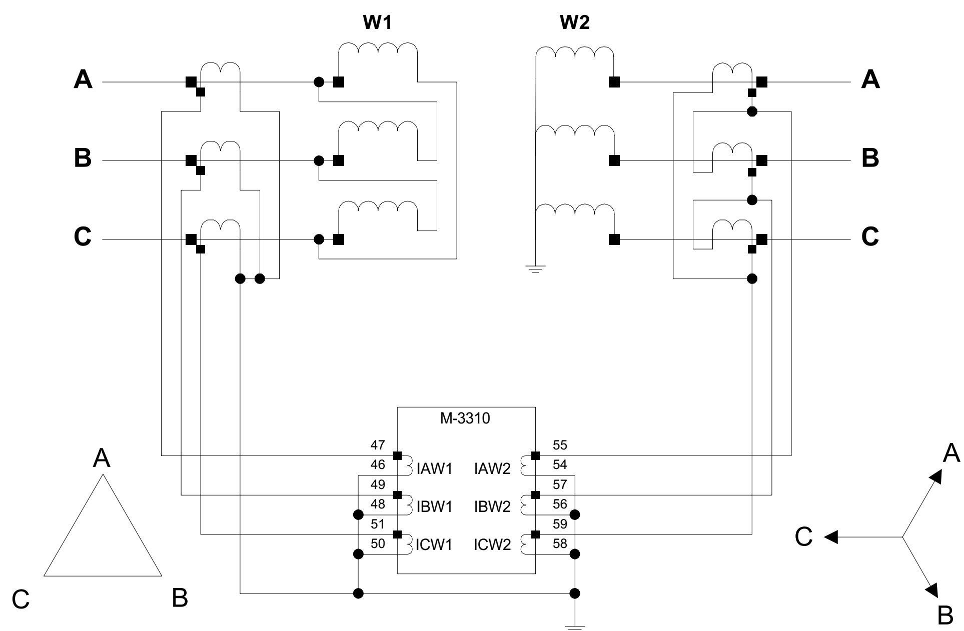


Figure 2-25 Connection Type 12

Type 13: Delta-AC/Wye Power Transformer with Wye/Delta-AC CT Connection

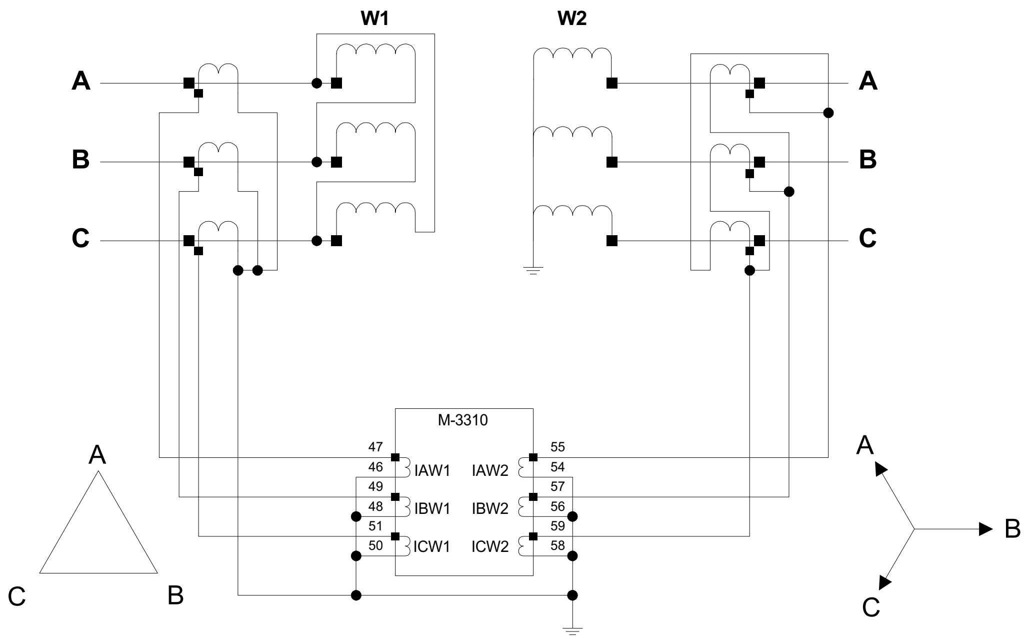


Figure 2-26 Connection Type 13

Type 14: Wye/Wye Power Transformer with Wye/Wye CT Connection (Zero Sequence Current Elimination)

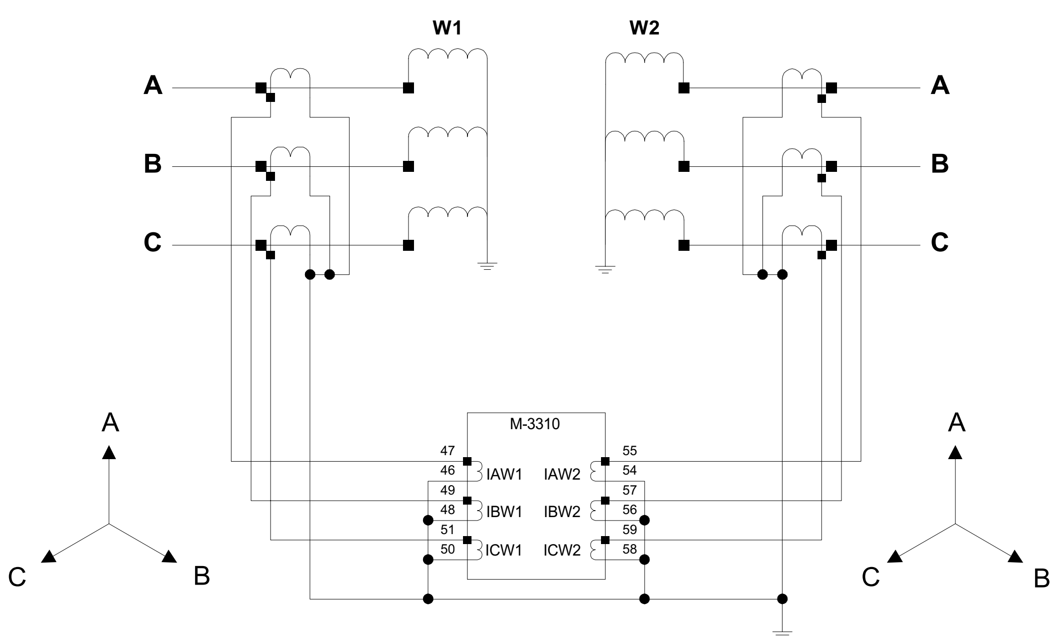


Figure 2-27 Connection Type 14

2.7 Oscillograph Recorder

The oscillograph recorder provides comprehensive data recording of all monitored waveforms (voltage, current, status inputs and output contacts) at 16 samples per cycle. Oscillograph data can be downloaded via the communications ports to any IBM compatible PC running M-3820A IPScom® communications software. Once downloaded, the waveforms can be examined using M-3821 IPSplot® Oscillograph data analysis software.

The recorder can be triggered manually through serial communications using IPScom or automatically using programmed status inputs (IN1–6) or programmed output contact (OUT1–8) operation. When untriggered, the recorder continually records waveform data, keeping the most recent data in memory. The recorders memory may be partitioned into:

- one 170 cycle record,
- two 112 cycle records,
- three 84 cycle records, or
- four 68 cycle records.

When triggered with a specific post trigger delay, the recorder continues recording for the delay period and keeps a snapshot of waveform data in its memory for downloading via IPScom.

■ **NOTE:** If more events or triggers occur before downloading than the number of partitions being used, the oldest record will be overwritten. Records are not retained if power to the relay is interrupted.

A post trigger delay of 5% to 95% may be specified. After triggering, the recorder will continue to store data for the programmed portion of the total record before re-arming for the next record. For example, a setting of 80% will result in a record with 20% pre-trigger and 80% post trigger data.

■ **NOTE:** In most cases, the most desirable data to record will occur before the triggering event, such as a breaker opening or protection operation.

The **OSC TRIG** LED on the front panel will indicate when oscillograph data has been recorded and is available for download.

The setup of the Oscillograph Recorder includes the following settings:

```
RECORDER PARTITIONS
    4
```

This designates the number of partitions that the oscillograph recorder will use. Whenever this number is changed, the post-trigger delay is automatically reset to 5% and all stored records are cleared.

```
TRIGGER INPUTS
    I6 i5 i4 i3 i2 i1
```

The trigger inputs designate the contact whose operation will trigger the recorder to record an event. Operation is "OR"ed if more than one input is selected.

```
TRIGGER OUTPUTS
o8 o7 o6 o5 o4 o3 o2 o1
```

The trigger outputs are relay output contacts whose operation will trigger the recorder to record an event. Operation is "OR"ed if more than one output is selected.

```
POST TRIGGER DELAY
    5 %
```

The post trigger delay assigns the amount, in percent, of the individual data record occurring after the trigger. The remaining portion consists of pre-trigger data.

This Page Left Intentionally Blank

3 Operation (Front Panel)

This chapter provides general information on the operation of the optional M-3931 Human-Machine Interface Module (HMI) front panel controls to maneuver through the menus, enter values, set and interrogate the M-3310 Transformer Protection Relay.

3.1 Front Panel Controls

The relay has been designed to be set and interrogated locally with the optional M-3931 HMI. An integral part of this design is the layout and function of the front panel indicators and controls; see Figure 3-1.

The indicators and controls consist of a 2 x 24-character display, and a 6-button keypad. These controls are used by the operator to navigate the system menus, and to set or interrogate the unit. Detailed information on using these controls is provided in this chapter.

Alphanumeric Display

To assist the operator in setting and interrogating the relay, the display shows menus, which guide the operator to the desired function or setpoint value. These menus consist of two lines. The bottom line shows lower case abbreviations of each menu selection with the current menu selected and highlighted in uppercase. The top menu line provides a description of the current menu selection (see Figures 3-2 and 3-3).

While the unit is not in use, and has not operated, the user logo lines are displayed. If the unit has operated, the display cycles through a sequence of screens summarizing the operation status conditions (targets) until **ENTER** is pressed, at which time the first-level menu is displayed.

Arrow Buttons

The left and right arrow buttons are used to choose among menu selections shown on the display. When entering values, the left and right arrow buttons are used to select the digit (by moving the cursor) of the displayed setpoint that will be increased or decreased by the use of the up and down arrow buttons.

The up and down arrow buttons *only* increase or decrease input values, or change, between upper and lower case inputs. Upper case inputs are active whereas lower case inputs are inactive. If the up or down arrow button is held in when adjusting numerical values, the speed of the increment or decrement is increased, after a small delay.

EXIT Button

Use the **EXIT** button to exit from a displayed screen to the immediately preceding menu. Any changed setpoint will not be saved if the selection is aborted via the **EXIT** button.

ENTER Button

The **ENTER** button is used to choose a highlighted menu selection, to replace a setpoint or other programmable value with the currently displayed value, or to select one of several displayed options, such as to **ENABLE** or **DISABLE** a function.

Target/Status Indicators and Controls

The target/status indicators and controls consist of the following LEDs: Power Supply (**PSI** and **PS2**) **RELAY OK**, the Oscillograph Recorder (**OSC TRIG**), **BREAKER CLOSED**, **TARGET**, **DIAGNOSTIC** and **TIME SYNC**

Power Supply (PS1 and PS2) LED

The green power LED indicator(s) remains illuminated for the appropriate power supply whenever power is applied to the unit. Power supply PS2 is available as an option.

RELAY OK LED

The green **RELAY OK** LED is controlled by the relay's microprocessor. A flashing **OK** LED indicates proper program cycling. The LED can also be programmed to illuminate continuously.

Oscillograph (OSC TRIG) Recorder LED

The **OSC TRIG** LED illuminates to indicate that oscillograph data has been recorded in the unit's memory.

Breaker (BRKR) CLOSED LED

The red **BRKR CLOSED** LED illuminates when the breaker status input (52b) is open.

Target Indicators and Target Reset

Normally, the 24 **TARGET** LEDs are not illuminated. Upon operation, LEDs corresponding to the cause(s) of the operation will light and stay illuminated until reset. The eight **OUTPUT** LED's will reflect the present state of the **OUT1** - **OUT8** output contacts. Pressing and releasing the **TARGET RESET** button will momentarily light all LEDs (providing a means to test them) and allows resetting of the **TARGET** LEDs if the condition causing the operation has been removed. Detailed information about the cause of the last 32 operations is retained in the unit's memory for access through the alphanumeric display via the **VIEW TARGET HISTORY** menu.

Pressing and holding the **TARGET RESET** button displays the present *pick up* status of the relay functions on the target indicators.

TIME SYNC LED

The green **TIME SYNC** LED illuminates to indicate that the IRIG-B time signal is being received and validated.

Diagnostic LED (DIAG LED)

The diagnostic LED flashes upon occurrence of a detectable self-test error. The LED will flash the Error Code Number. For example, for error code 32, the LED will flash 3 times, followed by a short pause, and then 2 flashes, followed by a long pause, and then repeat. For units equipped with the HMI, the Error Code Number is also displayed on the screen.

Accessing Screens

To prevent unauthorized access to the relay functions, the software has the provision for assigning access codes. If access codes have been assigned, the access code entry screen will be displayed after **ENTER** is pressed from the default message screen. The relay is shipped with the access code feature disabled.

The relay has three levels of access codes. Depending on the access code each level holds, users have varying levels of access to the relay functions.

Level **3** access: provides access to all M-3310 configuration functions and settings.

Level **2** access: provides access to read & change setpoints, monitor status and view target history.

Level **1** access: provides access to read setpoints, monitor status and view target history.

Each access code is a user defined 1 to 4 digit number. If the level 3 access code is set to 9999, the access code feature is disabled. When access codes are disabled, the access screens are bypassed. Access codes are altered by choosing the **ALTER ACCESS CODES** menu under **SETUP UNIT** menu. (These codes can only be altered by a level 3 user).

Default Message Screens

When the M-3310 is powered and unattended, user logo lines are displayed. The display automatically returns to the logo screens after five minutes of unattended operation.

If a function has operated and not been reset, it will display the time and date of the operation and automatically cycle through screens for each applicable target. This sequence is illustrated in Figure 3-2. In either case, pressing **ENTER** will begin local mode operation, thereby displaying the access code entry screen, or if access codes are disabled, the first level menu will be displayed.

Serial Interfaces (COM1, COM2 and COM3)

The serial interface **COM1** port (front) and **COM2** port (rear) are standard 9-pin RS-232C DTE configured communications ports.

The **COM1** port will normally be used for local setting and interrogating of the M-3310 via a portable computer running IPScom®. IPScom only supports communications using BECO 2200 protocol. **COM1** port protocol is fixed at BECO 2200 An additional **COM3** port (RS-485) is available at the rear terminal block. Either the **COM2** port or the **COM3** port will normally be used for remote setting and interrogation of the M-3310 via a network, direct connection or permanently wired modem.

COM2 and **COM3** have the option of setting the protocol to BECO 2200 or MODBUS. **COM1** communicates at a fixed 8 bits, no parity and 2 stop bits (8,N, 2 standard BECO 2200 settings). However, **COM2** and **COM3** have the option of setting parity (none, odd or even), if configured for MODBUS protocol. Detailed information on the use of the communications ports is provided in Appendix B, **Communications**.

The protocol description document and the communication data base document may be requested from the factory or from Beckwith's web site at www.beckwithelectric.com.

Communication Specifications

The following descriptions apply for use of MODBUS protocol:

1. MODBUS protocol is not supported on **COM1**.
2. Parity is supported on **COM2** and **COM3**; valid selections are 8,N, 2; 8,O,1 or 8,E, 1.
3. ASCII mode is not supported (RTU only).
4. Standard baud rates from 300 to 9600 are supported.
5. Only the following MODBUS commands are supported:

a) Read holding register (Function 03).

b) Read input register (function 04)

c) Force single coil (function 05)

d) Preset single register (function 06).

6. MODBUS does not support oscillograph record downloading.

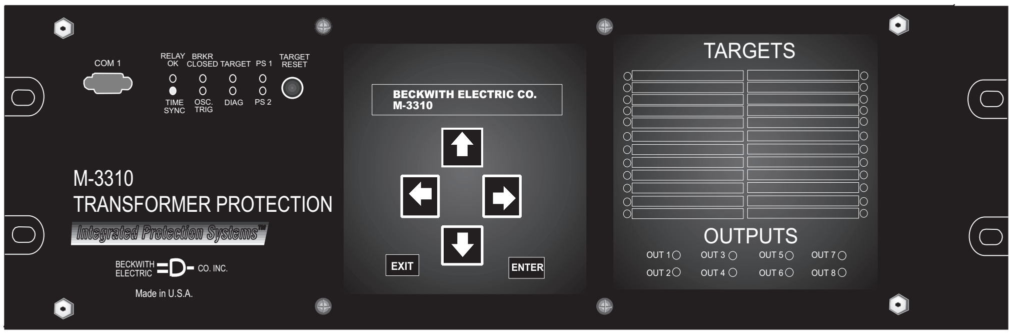


Figure 3-1 M-3310 Front Panel

■ Note: Unit shown with optional HMI and Target Modules

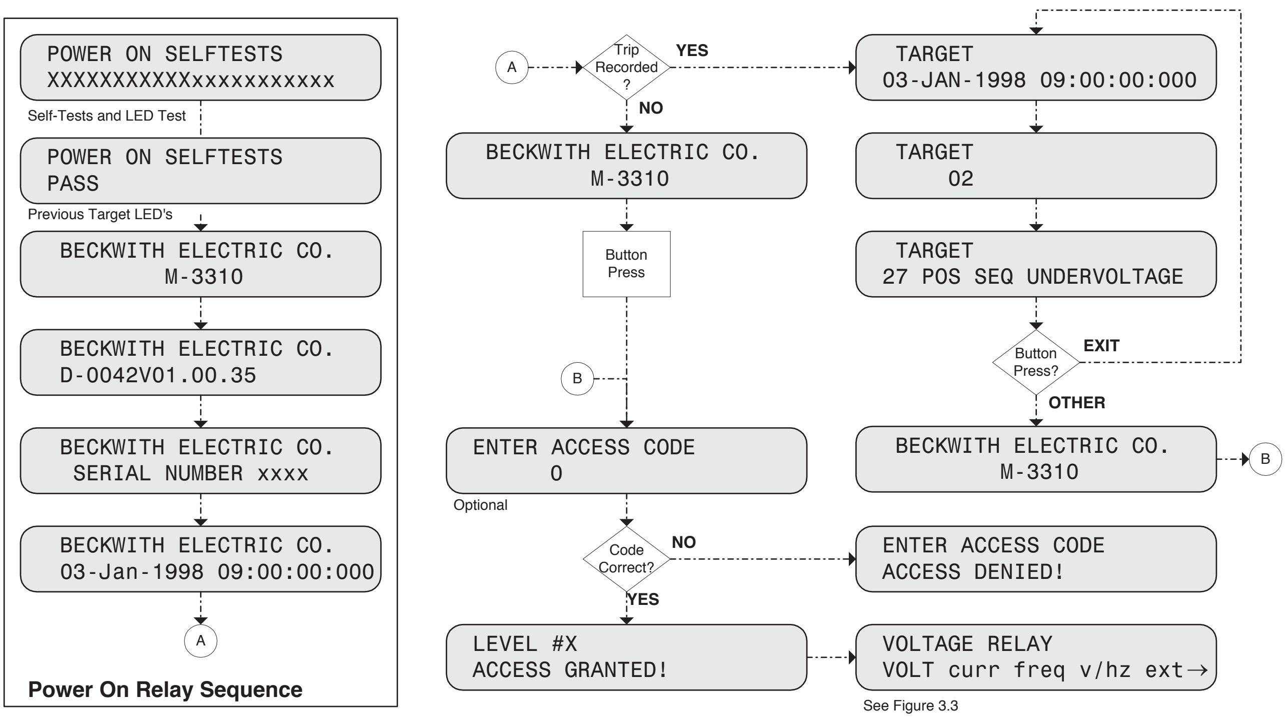


Figure 3-2 Message Flow

```
VOLTAGE RELAY
VOLT curr freq v/hz ext →
```

- 27 Positive Sequence Undervoltage
- 59G Zero Sequence Overvoltage

```
CURRENT RELAY
volt CURR freq v/hz ext →
```

- 46 Negative Sequence Overcurrent
- 50 Instantaneous Overcurrent
- 51 Inverse Time Overcurrent
- 50G Instantaneous Ground Overcurrent
- 51G Inverse Time Ground Overcurrent
- 51N Residual Time Overcurrent
- 87 Phase Differential Overcurrent
- 87GD Ground Differential Overcurrent
- 50BF Breaker Failure

```
FREQUENCY RELAY
volt curr FREQ v/hz ext →
```

- 81 Under Frequency

```
VOLTS PER HERTZ RELAY
volt curr freq V/HZ ext →
```

- 24 Definite Time Volts/Hertz
- 24 Inverse Time Volts/Hertz

```
EXTERNAL RELAY
volt curr freq v/hz EXT →
```

- External Relay

```
CONFIGURE RELAY
← CONFIG sys stat dmd →
```

- Voltage Relay
- Current Relay
- Frequency Relay
- Volts per Hertz Relay
- External Relay

```
SETUP SYSTEM
← config SYS stat dmd →
```

- Input Activated Profiles
- Active Setpoint Profile
- Copy Active Profile
- Nominal Voltage
- Nominal Current
- V.T. Configuration
- Transformer Connection
- Phase Rotation
- Relay Seal-In Time
- Active Input State
- Winding 2 V.T. Phase Ratio
- Winding 2 V.T. Ground Ratio
- W1 C.T. Ratio
- W2 C.T. Ratio
- W2 C.T. Ground Ratio

```
STATUS
← config sys STAT dmd →
```

- Voltage Status
- Current Status
- Frequency Status
- Volts/Hertz Status
- Power Status
- Input/Output Status
- Voltage Timer
- Current Timer
- Frequency Timer
- Volts/Hertz Timer
- External Timer
- Counters
- Time of Last Power Up
- Error Codes

```
DEMAND
← config sys stat DMD →
```

- Demand Status
- Demand Interval
- Maximum Demand Status
- Clear Maximum Demand

```
VIEW TARGET HISTORY
← TARGETS osc_rec →
```

- View Target History
- Clear Target History

```
OSCILLOGRAPH RECORDER
← targets OSC_REC →
```

- View Record Status
- Clear Records
- Recorder Setup

```
COMMUNICATION
← COMM setup exit
```

- COM1 Setup
- COM2 Setup
- COM3 Setup
- Communication Address
- Communication Access Code

```
SETUP UNIT
← comm SETUP exit
```

- Software Version
- Serial Number
- Alter Access Codes
- User Control Number
- User Logo Line 1
- User Logo Line 2
- Clear Output Counters
- Clear Alarm Counter
- Date & Time
- Clear Error Codes
- Diagnostic Mode

```
EXIT LOCAL MODE
← comm setup EXIT
```

Figure 3-3 Main Menu Flow.

3.2 Initial Setup Procedure / Settings

The relay is shipped with the initial configuration settings as listed in Appendix A, and recorded in the Record forms. Selected settings that are unique to the application may be recorded on the appropriate record form as calculated from Chapter 2, **Application.**

Setup Procedure

1. Connect power to the relay's rear power terminals, as marked on the rear panel's power supply label and as shown in Figure 5.4, External Connections.
2. Whenever initially powered up, the M-3310 performs a number of self-tests to ensure its proper operation. During the self-tests, the display shows an "X" for each test successfully executed. If all tests are successful, the unit will briefly display the word **PASS**. Then, a series of status screens, including the model number, software version number, serial number, date and time as set in the system clock, and the user logo screen will be displayed. (Figure 3-2 illustrates this sequence of screens.)
3. If any test should fail, the error LED will flash, an error code will be displayed and the relay will not allow operation to proceed. In such a case, the error code should be noted and the factory contacted. A list of error codes and their descriptions are provided in Appendix C, **Error Codes**. Assuming that various voltage functions are enabled, and there are no voltage inputs connected, various voltage targets will be identified as having operated
4. If remote communication is used, the baud rate, address, and other parameters for the communication ports must be set. Refer to the instructions in Section 3.2, **Communications Data** (located at end of this procedure). Also refer to Chapter 4, **Operation** (Computer), on M-3820A IPScom®Communications Software.
5. To setup the unit with general information required, including altering access codes, clearing output counters, setting date and time, installing user logos, and other adjustments, refer to Section 3.2, **Setup Unit Data**.
6. If desired, calibrate the unit following the calibration procedure described in subsection 6.3, **Auto Calibration**. For units without HMI, refer to Section 5.3, **Circuit Board Switches & Jumpers**.

■ **NOTE:** The relay has been fully calibrated at the factory using very precise and accurate test equipment. There is no need for recalibration before initial installation. Further calibration is only necessary if a component was changed and will be only as accurate as the test equipment used.

7. Finish relay configuration in the **SETUP SYSTEM** menu (see Figure 3-4). This is the general system and equipment information required for the operation of the relay. This includes such items as CT and VT ratios, VT configurations, transformer connections and Nominal values. See Section 3.2, **Setup System**.
8. Enable the desired functions under the **CONFIGURE RELAY** menu. See Section 3.2, **Configure Relay Data** .

■ **NOTE**: Disabling unused functions improves the response time of the indicators and controls.

9. Enter the desired setpoints for the enabled functions. See Section 3.2, **Setpoints and Time Settings**.
10. Enter the desired information for the oscillograph recorder. See Section 3.2, **Oscillograph Recorder Data**.
11. Install the M-3310 and connect external input and output contacts according to the rear panel terminal block markings as shown in Figure 5.4, *External Connections.*

Communication Data

The general information that is required to complete the input data of this section includes:

- baud rate for **COM1** and **COM2** communication ports **COM3** uses the same baud rate as **COM2** (default) or **COM1** (jumper selectable);
- communications address used to access multiple relays via a multi-drop communication line;
- Communications access code (used for communication system security; entering an access code of 9999 disables the communication security feature).
- Communication protocol and dead sync time for **COM2** and **COM3.**
- Parity for **COM3** if MODBUS protocol is used.

Before entering the communication data into the relay, the Communication Data & Unit Setup Record (see Appendix A, Form A.1) should be completed.

Figure 3-5 is a sample of the Communication Data & Unit Setup Record Form. Refer to the column on the left for communication data. It is organized in the same order as in the relay menu.

```
SETUP SYSTEM
← config SYS stat dmd →
```

```
INPUT ACTIVATED PROFILES
IN ap cpy volt curr vt→

INPUT ACTIVATED PROFILE
DISABLE enable
```

```
ACTIVE SETPOINT PROFILE
in AP cpy volt curr vt→

ACTIVE SETPOINT PROFILE
    1
```

```
COPY ACTIVE PROFILE
in ap CPY volt curr vt→

COPY ACTIVE PROFILE
TO_PROFILE_1 →

COPY ACTIVE PROFILE
← TO_PROFILE_2 →

COPY ACTIVE PROFILE
← TO_PROFILE_3 →

COPY ACTIVE PROFILE
← TO_PROFILE_4 →
```

```
NOMINAL VOLTAGE
in ap cpy VOLT curr vt→

NOMINAL VOLTAGE
    120 Volts
```

```
NOMINAL CURRENT
in ap cpy volt CURR vt→

NOMINAL CURRENT
    5.00 Amps
```

```
V.T. CONFIGURATION
in ap cpy volt curr VT→

V.T. CONFIGURATION
LINE-LINE long-ground
```

```
TRANSFORMER CONNECTION
← XFMR phase seal in →

TRANSFORMER CONNECTION
    1
```

```
PHASE ROTATION
← xfmr PHASE seal in →

PHASE ROTATION
a-c-b A_B_C
```

```
RELAY SEAL-IN TIME
← xfmr phase SEAL in →

RELAY SEAL-IN TIME OUT1
    30 Cycles

RELAY SEAL-IN TIME OUT2
    30 Cycles

RELAY SEAL-IN TIME OUT3
    30 Cycles

RELAY SEAL-IN TIME OUT4
    30 Cycles

RELAY SEAL-IN TIME OUT5
    30 Cycles

RELAY SEAL-IN TIME OUT6
    30 Cycles

RELAY SEAL-IN TIME OUT7
    30 Cycles

RELAY SEAL-IN TIME OUT8
    30 Cycles
```

```
ACTIVE INPUT STATE
← xfmr phase seal IN→

ACTIVE INPUT OPEN/CLOSE
    i6 i5 i4 i3 i2 i1
```

```
W2 V.T. PHASE RATIO
← VT_W2 vt_w2g →

W2 V.T. PHASE RATIO
    1.0:1
```

```
W2 V.T. GROUND RATIO
← vt_w2 VT_W2G →

W2 V.T. GROUND RATIO
    1.0:1
```

```
W1 C.T. RATIO
← CT_W1 ct_w2 ct_w2g

W1 C.T. RATIO
    10:1
```

```
W2 C.T. RATIO
← ct_w1 CT_W2 ct_w2g

W2 C.T. RATIO
    10:1
```

```
W2 C.T. GROUND RATIO
← ct_w1 ct_w2 CT_W2G

W1 C.T. GND RATIO
    10:1
```

Figure 3-4 Sample of System Setup Menus

The values shown in the Communication Data column of Figure 3-5 represent the default or "as shipped" values for these setpoints. Communication data for units purchased without the M-3931 HMI module may be altered by using IPSutil™ utility package which is shipped with the IPScom® software package. Establishing communication with the relay using the default parameters is required before other setpoints may be altered.

■ **NOTE**: Communication settings are not considered part of the setpoint profiles. Communication settings are common to all profiles.

Setup Unit Data

The general information that is required to complete the input data in this section includes:

- Access codes
- Control numbers
- Date and time
- User logo
- Diagnostic mode

Before entering the setup data into the M-3310, the Communication Data & Unit Setup Record (see Appendix A, Form A.1) should be completed.

Figure 3-5 is a sample of the Communication Data & Unit Setup Record Form. Refer to the two columns on the right for setup data. It is organized in the same order as in the relay menu.

The relay already contains factory settings for setup data, which can be used to familiarize you with the **SETUP UNIT** menu.

■ **NOTE**: **UNIT SETUP** settings are not considered part of the setpoint profiles. Unit Setup settings are common to all profiles.

Setup System

Information required in this section includes:

- Input Activated Profiles
- Active Setpoint Profile
- Nominal Voltage and Current
- VT Configuration
- Transformer Connection
- Phase Rotation
- Relay Seal-In Time
- Active Input State
- VT Phase and Ground Ratios
- CT Phase and Ground Ratios

See Figure 3-4 for Sample Settings related to input for this Section. The Active Setpoint Profile screen shows the profile presently selected for operation. This profile number can be altered to manually select a different profile, only if the Input Activated Profiles setpoint is set to **DISABLE**. Other settings are self-explanatory, and are required for proper operation of the relay.

■ **NOTE**: Setup System settings are not considered part of the setpoint profiles. Setup System settings are common to all profiles.

```
COMMUNICATION
← COMM setup exit
```

```
SETUP UNIT
← comm SETUP exit
```

```
COM1 SETUP
COM1 com2 com3 com_adr →
```

```
COM1 BAUD RATE
← baud_4800 BAUD_9600
```

```
COM2 SETUP
com1 COM2 com3 com_adr →
```

```
COM2 BAUD RATE
← baud_4800 BAUD_9600
```

```
COM2 DEAD SYNC TIME
    50 ms
```

```
COM2 PROTOCOL
BECO2200 modbus
```

```
COM3 SETUP
com1 com2 COM3 com_adr→
```

```
COM3 DEAD SYNC TIME
    50 ms
```

```
COM3 PROTOCOL
BECO2200 modbus
```

```
COMMUNICATION ADDRESS
com1 com2 com3 COM_ADR→
```

```
COMMUNICATION ADDRESS
    1
```

```
COMM ACCESS CODE
← ACCESS
```

```
COMM ACCESS CODE
    9999
```

```
SOFTWARE VERSION
VERS sn access number →
```

```
SOFTWARE VERSION
D-0042V0x.xx.xx 3e4d
```

```
SERIAL NUMBER
vers SN access number →
```

```
SERIAL NUMBER
xxxx
```

```
ALTER ACCESS CODES
vers sn ACCESS number →
```

```
ENTER ACCESS CODE
LEVEL#1 level#2 level#3
```

```
LEVEL #1
    1111
```

```
ENTER ACCESS CODE
level#1 LEVEL#2 level#3
```

```
LEVEL #2
    2222
```

```
ENTER ACCESS CODE
level#1 level#2 LEVEL#3
```

```
LEVEL #3
    9999
```

```
USER CONTROL NUMBER
vers sn access NUMBER →
```

```
USER CONTROL NUMBER
    1
```

```
USER LOGO LINE 1
←LOGO1 logo2 out alrm→
```

```
USER LOGO LINE 1
_BECKWITH ELECTRIC CO.
```

```
USER LOGO LINE 2
← logo1 LOGO2 out alrm
```

```
USER LOGO LINE 2
    M-3310
```

```
CLEAR OUTPUT COUNTERS
←logo1 logo2 OUT alrm→
```

```
CLEAR OUTPUT COUNTERS
PRESS ENTER KEY TO CLEAR
```

```
CLEAR ALARM COUNTER
←logo1 logo2 out ALRM→
```

```
CLEAR ALARM COUNTER
PRESS ENTER KEY TO CLEAR
```

```
DATE & TIME
← TIME error diag
```

```
DATE & TIME
03-JAN-1998 01:00:80
```

```
DATE & TIME
    98 Year
```

```
DATE & TIME
JAN feb mar apr may →
```

```
DATE & TIME
    03 Date
```

```
DATE & TIME
SUN mon tue wed thu →
```

```
DATE & TIME
    01 Hour
```

```
DATE & TIME
    00 Minutes
```

```
DATE & TIME
    01 Seconds
```

```
CLEAR ERROR CODES
← time ERROR diag
```

```
CLEAR ERROR CODES
PRESS ENTER KEY TO CLEAR
```

```
DIAGNOSTIC MODE
← time error DIAG
```

```
PROCESSOR WILL RESET
ENTER KEY TO CONTINUE
```

Figure 3-5 Sample of Communication Data & Unit Setup Record

Configure Relay Data

The relay is shipped with a certain group of standard functions, including other optional functions, as purchased. Both of these groups define a configurable set of functions. Only members of this set may be enabled/disabled by the end user. (Optional functions not purchased cannot be enabled.)

Functions designated as **DISABLED** are inactive and will not be available for tripping. All menus associated with inactive functions will be unavailable.

The general information required to complete the input data on this section includes:

- Enable/disable function
- Output choices (OUT1-8)
- Input blocking choices (IN1-6)

Setpoints and Time Settings

The general information that is required to complete the input data in this section includes individual relay function:

- Pickup settings (converted to relay quantities)
- Time delay settings
- Time dials
- Power in PU

Input descriptions are detailed in Section 2.4, **Setpoints and Time Settings**. Make sure to complete the Setpoint & Timing Record Form in Appendix A before entering the setpoint and time setting data into the relay.

The relay already contains factory settings for setpoint and time setting data, which can be used to familiarize you with these menus.

Oscillograph Recorder Data

The oscillograph recorder provides comprehensive data recording of all monitored waveforms, storing up to 170 cycles of data. The total record length is programmable for one (170 cycles), two (113 cycles), or three (85 cycles each) event records. The oscillograph recorder is triggered either remotely or via designated status input signals or relay output operations.

When untriggered, the recorder continuously records waveform data, keeping the data in buffer memory. When triggered, the recorder continues storing data for a period of time, as defined by the user, thereby keeping the most recent records in memory for downloading to a personal computer.

If more events or triggers occur than the number of records (partitions) designated before downloading of data, triggering the recorder overwrites the oldest of the event records. Make sure to complete page two of the Setpoint & Timing Record Form in Appendix A before entering the oscillograph recorder settings into the relay.

■ **NOTE:** Oscillograph recorder settings are not considered part of the Setpoint Profile. Recorder settings are common to all profiles.

The relay already contains factory settings for oscillograph recorder data, which can be used to familiarize you with the **OSCILLOGRAPH RECORDER** menu.

The Oscillograph recorder data can be cleared via the HMI Module to provide a fresh starting point for event triggering.

Demand Metering Data

Setup of the Demand Metering subsystem consists of setting the Demand Interval. Integrating times of 15, 30, or 60 minutes may be set. The maximum Recorded Demand Peaks should also be cleared before commissioning.

3.3 Checkout Status/Metering

The relay has two menu selections concerning monitoring statuses and demand values. This section describes the operation of these selections.

Status/Metering

Access the **STATUS** menu as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **STATUS** appears on the top line of the display.
3. Press **ENTER** to access the **STATUS** submenu and begin the monitoring.

■ **NOTE:** Each category listed below is a submenu item. Pressing the **ENTER** button moves the item down within that menu, allowing monitoring of values within that submenu category. To exit a specific category and continue to the next menu category, press the **EXIT** button.

All metering values in this section are secondary level quantities.

The menu categories for monitored values are:

VOLTAGE STATUS	Phase voltages, neutral voltage, positive sequence voltage, negative sequence voltage, zero sequence voltage
CURRENT STATUS	Winding 1 & 2 Phase currents, W2 ground current, restraint current, differential currents, W2 ground current, ground differential current, W1 & W2 positive sequence current, W1 & W2 negative sequence current, W1 & W2 zero sequence current
FREQUENCY STATUS	Frequency
VOLTS /HZ STATUS	Volts per Hertz
POWER STATUS	real power, reactive power, apparent power, power factor
IN/OUT STATUS	status of input and output contacts

The following timer status can also be monitored:

VOLTAGE TIMER	27, 59G
CURRENT TIMER	46DT, 46IT, 51W1 & W2, 51G, 51N W1 & W2, 87H, 87GD, 50BF
FREQUENCY TIMER	81U#1, 81U#2, 81U#3
VOLTS/HZ TIMER	24DT#1, 24DT#2, 24IT
EXTERNAL FUNCTION TIMER	EXT#1-#6

Timers for the inverse time functions are displayed in percentage where 100% corresponds to the full value of the integrating timer.

If the associated function time setting is less than 2 cycles, the indicated status will be less than actual. The following miscellaneous status can also be monitored:

COUNTERS	OUT1-8 plus alarm
TIME OF LAST POWER UP	Displays DD-MM-YY hours/min/sec
ERROR CODES	Last 3 error code log; reset location, etc.

Demand/Maximum Metering

Time integrated primary metering values, based on the chosen demand integration interval, as well as the time-tagged peak reading are available for viewing.

Monitored values include:

- Winding 1 & 2 Phase Currents
- Ground Current
- Real, Reactive, and Apparent Power
- Power Factor

Maximum values include time-tagged values for all the above quantities.

■ **NOTE**: All metering values in this section are primary level quantities.

View Target History

The **VIEW TARGET HISTORY** menu selection enables the user to review the targets for the previous 32 target conditions. A target is triggered whenever an output is operated or closed. The target history for each operation cycles continuously through a sequence of screens until **EXIT** is pressed. A target includes:

- pickup information which indicates any function which is timing
- an indication whose function or functions have operated and timers expired
- phase and ground currents at the time of trip, and individual phase element information at the time of the trigger, if the operating function was a 3-phase function
- input and output status
- a time tag of the triggered target

The time-tag of the trigger will be in the following format:

HH(Hours); MM(min); SS.xxx(seconds).

The xxx will be 000 if the IRIG-B signal is not connected or not synched. Otherwise, it will give seconds to the nearest thousands of a second.

The final selection allows the user to clear all operation history for further target recording.

■ **NOTE:** If a second function is used in an attempt to operate an output that has already operated, it will not trigger a new target since no new output has been operated or closed. If the second function operation closes a different unoperated output, a new target will be triggered. Targets are captured or recorded only when an output operates.

4 IPScom® Operation

This chapter contains information on configuring and interrogating the M-3310 Transformer Protection Relay via a personal computer running the M-3820A IPScom Communications Software.

4.1 Installation and Setup

The IPScom Communications Software package runs with Microsoft® Windows 95 operating system, or later. This version of IPScom only supports communication via the BECO 2200 protocol.

IPScom is available in the following IBM PC-compatible format: two 3.5" double-sided, high density (DS/HD 1.44 MB) disks.

M-3820A IPScom software is not copy-protected and may be copied to your hard disk. For more information on your specific rights and responsibilities regarding the software, refer to the licensing agreement enclosed with your software, or contact Beckwith Electric Co.

Hardware Requirements

IPScom will run on any IBM PC-compatible computer that provides at least the following:

- 8Mb of RAM
- Microsoft Windows 95 or later
- One 3.5" double-sided, high-density (DS/HD 1.44 MB) disk drive.
- One serial (RS-232) communication port
- VGA monitor
- Mouse or pointing device.
- Windows-compatible printer

The relay is provided with three serial communication ports. Two serial interface ports, COM1 and COM2 are standard 9-pin RS-232 DTE-configured ports. The front panel port, COM1, can be used as a temporary connection to locally set and interrogate the relay by computer. The second RS-232 COM2 port is provided at the rear of the unit.

An RS-485 configured port, COM3 is located at the rear terminal block of the unit. Either COM2 or COM3 can be used to remotely set and interrogate the relay via a modem, whereas all three ports may be used for direct serial connection.

■ **NOTE:** The RS-232 standard specifies a maximum cable length of 50 feet for RS-232 connections. Successful operation cannot be guaranteed for cable lengths exceeding this recommendation. Every effort should be made to keep cabling as short as possible. Low capacitance cable is recommended.

Use of IPScom® and M-3310 Transformer Protection Relay via Modem

In order to use IPScom to communicate with the relay via a modem, the following must be provided for the unit.

- Hayes-compatible external modem; 1200, 2400, 4800, or 9600 baud.
- Serial modem cable with 9-pin connector for the system and the applicable connector for the modem.

Similarly, the computer running IPScom must also have access to a Hayes-compatible internal or external modem. Pin-outs for communication cables are provided in Appendix B, **Communications**.

Use of IPScom and M-3310 Transformer Protection Relay via Direct Serial Connection

In order to use IPScom to communicate with the relay via direct serial connection, a serial "null modem" cable is required. The cable must be provided with a 9-pin connector (DB9P) for the system, and an applicable connector for the computer (usually DB9S or DB25S). Pin-outs for a null modem adapter are provided in Appendix B, **Communications**. A 10-foot, null modem RS-232 cable (part number M-0423) may be purchased from Beckwith Electric Co.

Installation

Before installing the IPScom program, make a copy of the software disks for archive purposes.

Figure 4-1 IPScom Program Icon

IPScom can be run from a hard disk. An installation utility (setup.exe) has been provided to make the process easier.

Installing IPScom

1. Insert the software disk 1 in your drive.
2. Select Run from the Start Menu.
3. In the Run dialog box, specify the file to be installed by typing either *A:\Setup* or *B:\Setup*, depending on the drive in which the software diskette is inserted.
4. The installation utility establishes a program folder (Becoware) and subdirectory (M-3820A). After installation, the IPScom program item icon (see Figure 4-1) is located in the Becoware program folder. The application files are located on drive C, in the new subdirectory named IPScom.

Installing IPSutil™

IPSutil is utility software used to program system-level parameters for units shipped without the M-3931 HMI Module. The IPSutil.exe file is installed in the Becoware folder, along with the IPScom files.

Installing the Modems

Using IPScom to interrogate, set or monitor the relay via a modem requires both a remote modem connected at the relay location and a local modem connected to the computer with IPScom installed.

The local modem can be initialized using IPScom, by connecting the modem to the computer, and selecting the **COMM** menu in IPScom. Select **MODEM**, enter the required information, and select **INITIALIZE** from the expanded Communications dialog box. The following steps outline the initialized modem setup procedure.

Connecting the modem to the computer

1. If the computer has an external modem, use a standard straight-through RS-232 modem cable to connect the computer and modem (M-3933). If the computer has an internal modem, refer to the modem's instruction book to determine which communications port should be selected.

   The Hayes-compatible modem must be attached to (if external) or assigned to (if internal) the same serial port as assigned in IPScom. While IPScom can use any of the four serial ports (**COM1** through **COM 4**), most computers support only **COM1** and **COM2**.

2. Connect the modem to the telephone line and power up.

Connecting the Modem to the Relay

Setup of the modem attached to the M-3310 Transformer Protection Relay may be slightly complicated. It involves programming the parameters (via the AT command set), and storing this profile in the modem's nonvolatile memory.

After programming, the modem will power up in the proper state for communicating with the relay. Programming may be accomplished by using "Hyperterminal" or other terminal software. Refer to your modem manual for further information.

■ **NOTE:** The relay does not issue or understand any modem commands. It will not adjust the baud rate and should be considered a "dumb" peripheral. It communicates with 1 start, 8 data, and 1 stop bit.

1. Connect the unit to an external Hayes-compatible modem by attaching a standard RS-232 modem cable to the appropriate serial communications port on both the unit and the modem.
2. Connect the modem to the telephone line and power up.

The modem attached to the unit must have the following AT command configuration:

E0	No Echo
Q1	Don't return result code
&D3	On to OFF DTR, hang-up and reset
&S0	DSR always on
&C1	DCD ON when detected
S0=2	Answer on second ring

The following commands may also be required at the modem:

&Q6	Constant DTE to DCE
N0	Answer only at specified speed
W	Disable serial data rate adjust
\Q3	Bi-directional RTS/CTS relay
&B1	Fixed serial port rate
S37	Desired line connection speed

There are some variation in the AT commands supported by manufacturers of Hayes-compatible modems. Refer to the hardware user documentation for a list of supported AT commands and direction on issuing these commands.

Setting Up the Relay for Communication

Initial setup of the relay for communication must be completed by the optional M-3931 HMI Module or via direct serial connection using the default "As Shipped" communication parameters. Refer to Communication Data and Unit Setup "AS SHIPPED" form located in Appendix A, **Forms**.

For units shipped without the optional HMI Module, the communication parameters may be altered by first establishing communication using the default parameters and the IPSutil™ program.

IPSutil is an auxiliary program shipped on the same disk with the IPScom program. It is used exclusively for altering communication and setup parameters on units shipped without the M-3931 HMI Module.

■ **NOTE:** Communication is inhibited while the relay is in local mode (being accessed via the HMI). To ensure that the relay is available for remote communication, press **ENTER** at the **EXIT LOCAL MODE** menu item, or press the **EXIT** key several times to back out of the menu tree to the top level screen.

Multiple Systems Setup

The individual addressing capability of IPScom® and the relay allows multiple systems to share a direct or modem connection when connected via a communications-line splitter (see Figure 4-2). One such device enables 2 to 6 units to share one communications line.

▲ **CAUTION:** Units connected to a communications line splitter must have a unique communications address. If two or more units share the same address, corrupted communications will result.

Serial Multidrop Network Setup

Individual remote addressing also allows for communications through a serial multidrop network. Up to 32 relays can be connected using the same 2-wire or optional 4-wire RS-485 communications line. See Appendix B, **Communications**. Figure B-2 illustrates a setup of RS-232 Fiber Optic network, and Figure B-3 illustrates a 2-wire and 4-wire RS-485 network.

Other communication methods are possible using the relay. An Application Note, "*Serial Communication with Beckwith Electric's Integrated Protection System Relays*" is available from the factory, or from our website at www.beckwithelectric.com.

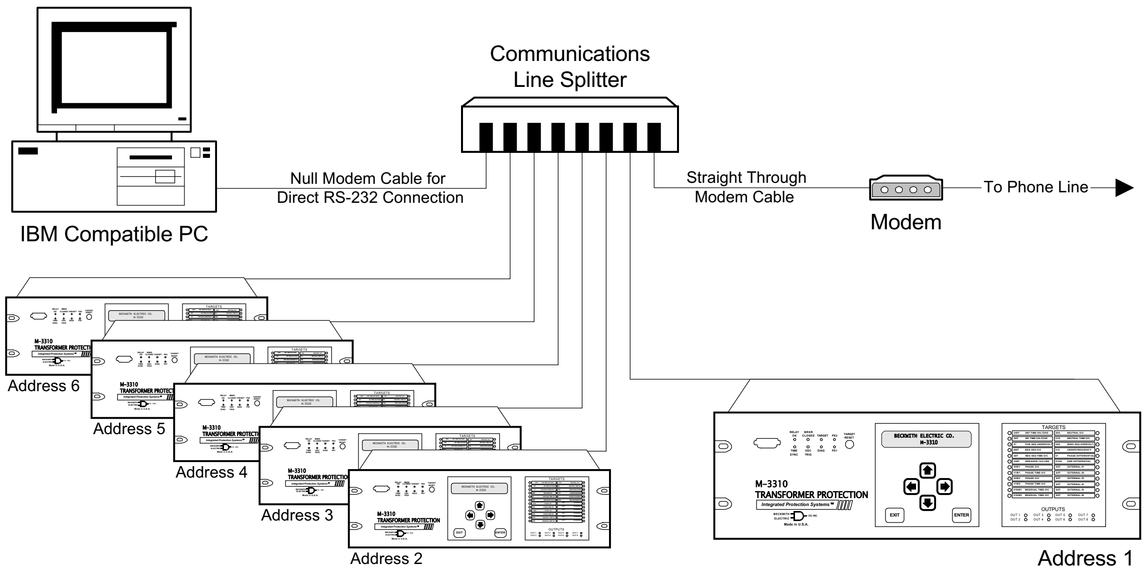


Figure 4-2 Multiple Systems Addressing Using Communications-Line Splitter

4.2 Operation

Activating Communications

After the M-3310 Transformer Protection Relay has been set up, the modems initialized, and IPScom® installed, communication is activated as follows:

1. Choose the IPScom icon from the Becoware group on the Program menu.
2. The **About** IPScom dialog box is displayed briefly, providing the software version number and copyright information.
3. Choose the **COMM** menu. Complete the appropriate information in the window to address the relay.
4. If communication is through a modem, choose the **Modem** command button to expand the communications dialog box. Choose the desired relay location and select **Dial**. This action establishes contact and automatically opens communication to the relay.

   If computer is serially connected through the front port, choose the **Open COM** button. This action establishes communications.
5. Enter any valid IPScom command(s) as desired.
6. To end communication when communicating by modem, choose **Hang Up** from the expanded Communication dialog box.

   To close the communication channel when connected locally, choose the **Close COM** command button.

Overview

When IPScom is run, a menu and status bar is displayed (see Figure 4-3). This section describes each IPScom menu selection and explains each IPScom command in the order they are displayed in the software program. For detailed information on each function dialog box field, refer to Chapter 2, **Application**.

When starting IPScom, the only allowable initial menu choices are the **FILE** menu or the **COMM** menu. The choice specifies whether the operator desires to write to a data file or communicate directly with the relay.

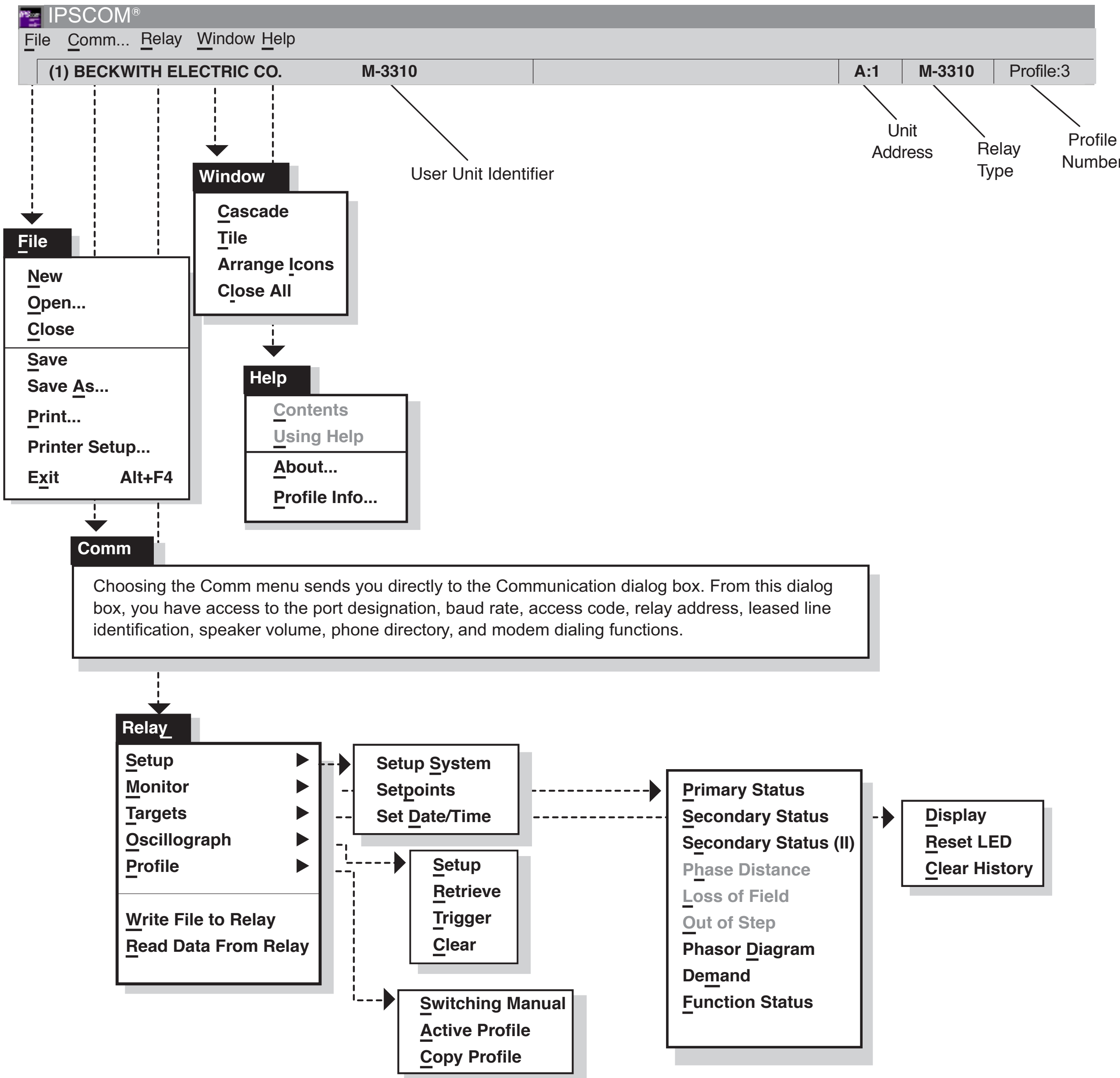


Figure 4-3 IPScom® Menu Selections

■ **NOTE**: Greyed-out menu items are not currently available.

File Menu

The **File** menu enables the user to create a new data file, open a previously created data file, close the current data file, save a file, and exit the program.

Since IPScom® can be used with several Beckwith protection systems in addition to the M-3310 Transformer Protection Relay, the format and contents of a file must be established to reflect which protective system is being addressed. When not connected to one of the protection systems, new files are established with the System Type dialog box (see Figure 4-4). Choosing the **OK** button allows the new data file to be named by using the **Save** or **Save As...** commands.

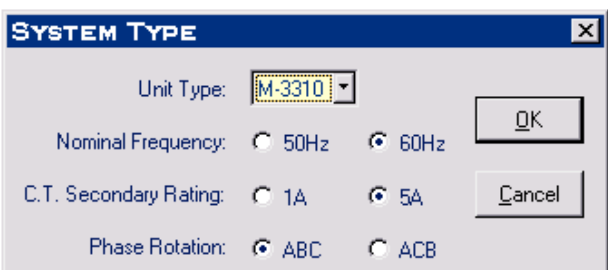


Figure 4-4 System Type Dialog Box

Path: File menu / New command

COMMAND BUTTONS

OK Saves the currently displayed information.

Cancel Returns you to the IPScom main window; any changes to the displayed information are lost.

■ **NOTE:** By choosing the **New** command, unit and setpoint configuration values are based on factory settings specified for the designated protection system.

The **Save** and **Save As...** commands allow re-saving a file or renaming a file, respectively. The **Open** command opens previously created data files. With an opened data file, use the **Relay...Setup...** menu items to access the setpoint windows.

If communication can be established with a relay, it is always safer to use the **Read Data From Relay** command to update the PC's data image with the relay's data. This image now contains the proper system type information, eliminating the need to enter this information manually.

The **Print** and **Printer Setup** commands allow user to select printer options and print out all setpoint data from the data file or directly from relay, if a relay is communicating with PC.

The **Exit** command quits the IPScom program.

Comm Menu

The Communication dialog box (see Figure 4-5) allows setup of the IPScom communication data to coordinate with the relay and by choosing the **Modem** button, to establish contact for remote locations. When communicating by way of a fiber optic loop network, echo cancelling is available by checking the Echo Cancel box. This command masks the sender's returned echo.

If communication is established through the modem, the **Initialize** button should be pressed. If communication cannot be established with the default string, the AT &F may be selected to initialize. Following initialization, select an entry from the modem list and press the **Dial** button to dial out.

If the modem was not used to establish communication (direct connection), press the **Open COM** button to start. If the relay has a default communication access code of 9999, a message window will appear showing access level #3 was granted. Otherwise, another dialog box will appear to prompt the user to enter the access code in order to establish the communication. **Close COM** discontinues communication.

Figure 4-5 Communication Dialog Box

Path: Comm menu

COMMAND BUTTONS

Cancel Returns you to the IPScom main window; any changes to the displayed information are lost.

Open COM Initiates contact with the protective system, either by direct serial or modem communication.

Close COM Breaks communication with the protective system, for both direct serial or modem communication.

Modem Displays the expanded Communication dialog box.

Add Displays the Add/Edit dialog box, allowing you to type a protective system's unit identifier, phone number, and communication address.

Edit Displays the Add/Edit dialog box, allowing you to review and change the user lines (unit identifier), phone number, and communication address of a selected entry.

Delete Deletes a selected entry.

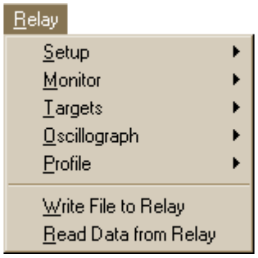
Initialize Allows you to send special setup or other AT commands directly to the modem.

Dial Dials the entry selected from the directory.

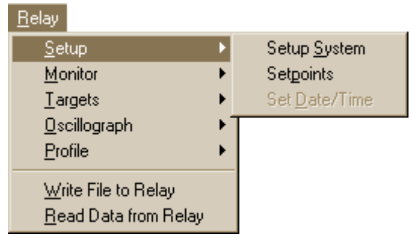
Hang Up Ends modem communication, allowing you to dial again.

Bring Up Terminal Window After Dialing Built-in terminal window allows interactive communication between modem and relay. (This feature is not available under Microsoft® Windows NT.)

Relay Menu



The **Relay** menu provides access to the windows used to set, monitor, and interrogate the relay.



The **Setup** submenu provides three commands: **Setup System**, **Setpoints** and **Set Date/Time**. The **Setup System** dialog box (see Figure 4-6) allows the input of pertinent information regarding the system on which the relay is applied. (See Section 2.2, **Configuration**, System Setup).

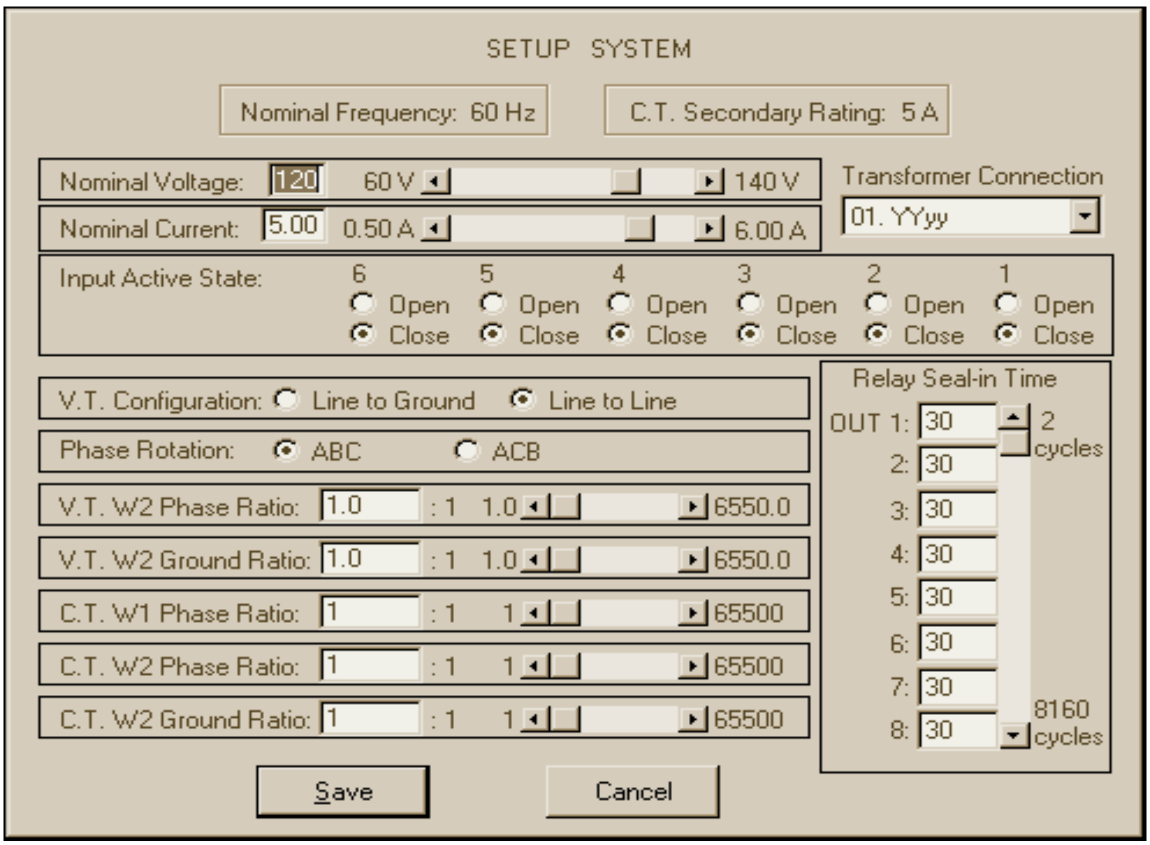


Figure 4-6 Setup System Dialog Box

The **Setpoints** command displays the **Relay Setpoints** dialog box (see Figure 4-7) from which individual relay function dialog boxes may be accessed. The configuration and settings for each function are completed through these Setpoint Configuration dialog boxes. (Function configuration is further described in Section 2.2 **Configuration**, Functions and Section 2.3, **Setpoints and Time Settings**.)

The **Relay Setpoints** dialog box gives access to the **All Setpoints** Table and **Configure** dialog boxes (see Figures 4-8 and 4-9).

Choosing the **Display All** command button displays the **All Setpoints Table** which contains a list of settings for each relay element within a single window.

Choosing the **Configure** command button displays the Configure dialog box (see Figure 4-10) which contains a chart of programmed input and output contacts.

The **All Setpoints** Table and **Configure** dialog boxes feature hotspots which allow user to jump from a scrolling dialog box to a relay configuration dialog box and back again. All available parameters can be reviewed or changed when jumping to a relay configuration dialog box from either scrolling dialog box.

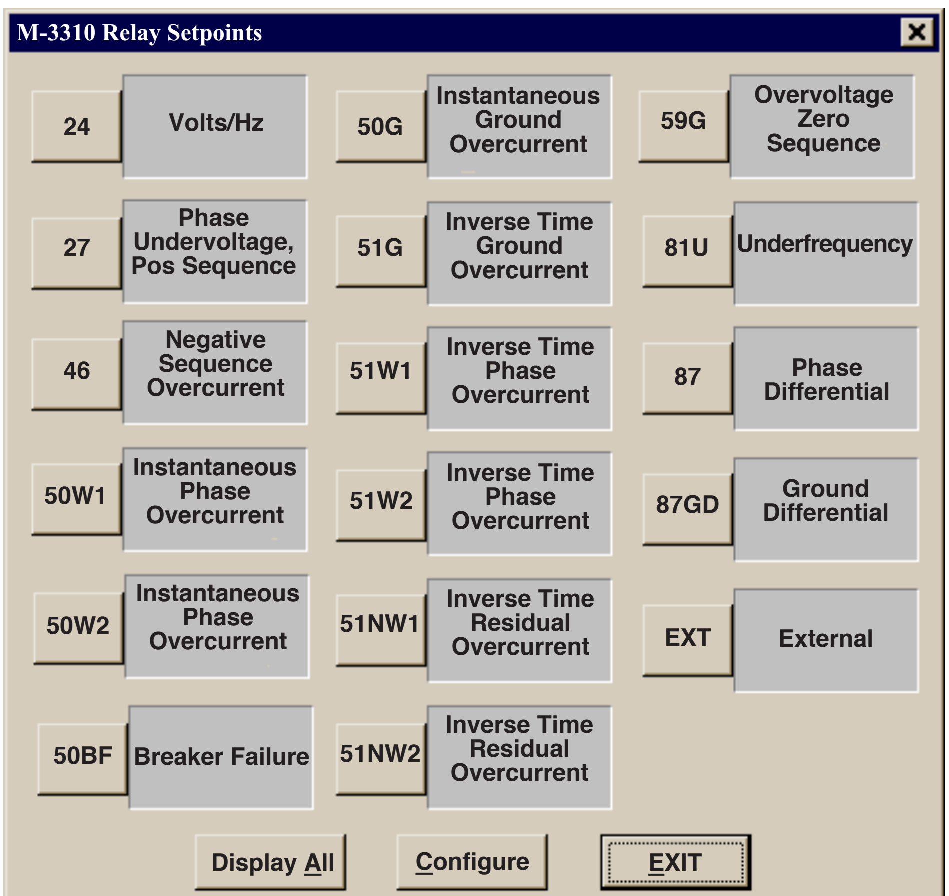


Figure 4-7 Relay Setpoints Dialog Box

Path: Relay menu/Setup submenu/Setpoints command

COMMAND BUTTONS

Display all Opens the All Setpoints Table dialog box.

Configure Opens the Configure dialog box.

Exit Saves the currently displayed information and returns you to the IPScom® main window.

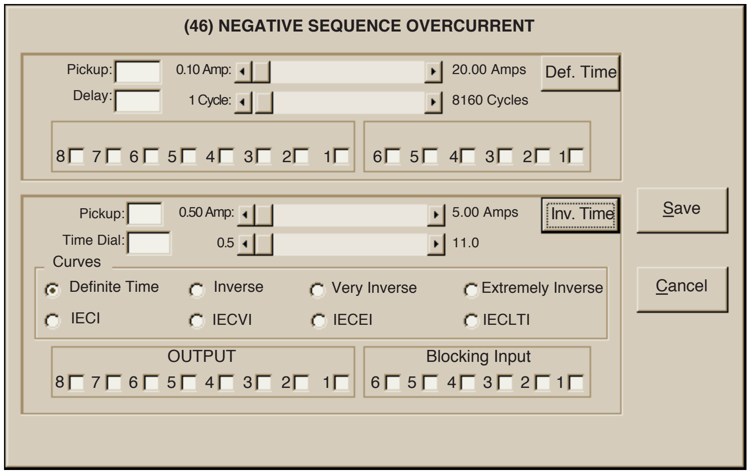


Figure 4-8 Typical Function Configuration Dialog Box

Path: Relay menu/Setup submenu/Setpoints command/46 command button OR 46 jump hotspot within All Setpoints Table or Configure Dialog Box

COMMAND BUTTONS

Save When connected to a protection system, it sends the currently displayed information to the unit. Otherwise, it saves the currently displayed information and returns you to either the Relay Setpoints, All Setpoints Table, or Configure Dialog box.

Cancel Returns you to the Relay Setpoints, All Setpoints Table, or Configure Dialog box; any changes to displayed information are lost.

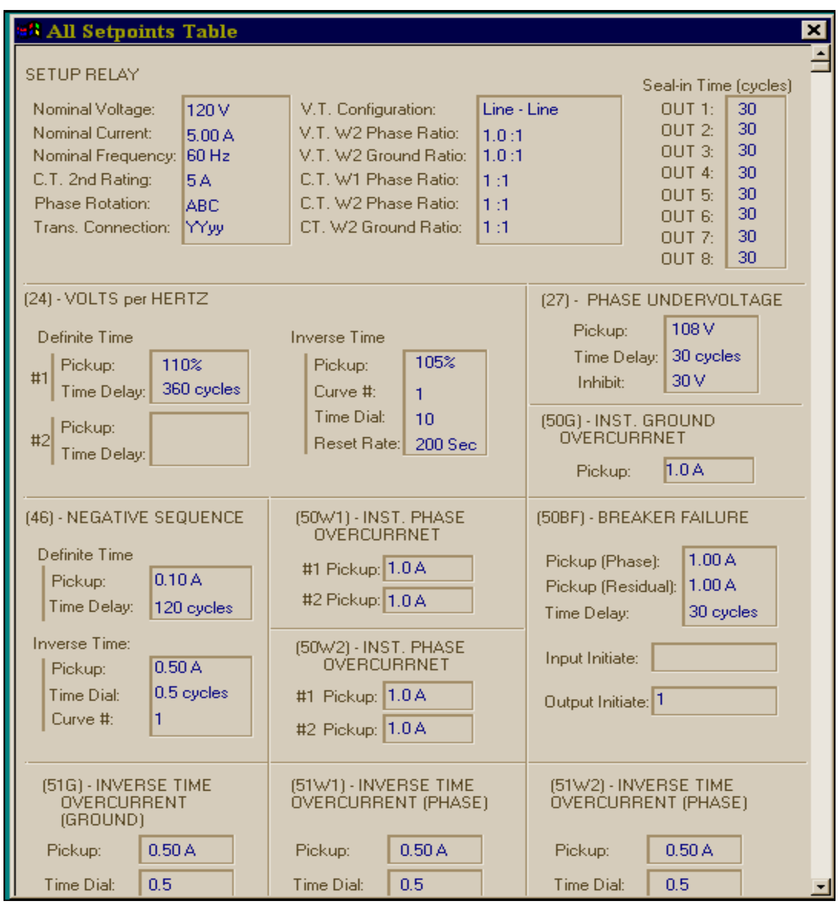


Figure 4-9 All Setpoints Dialog Box

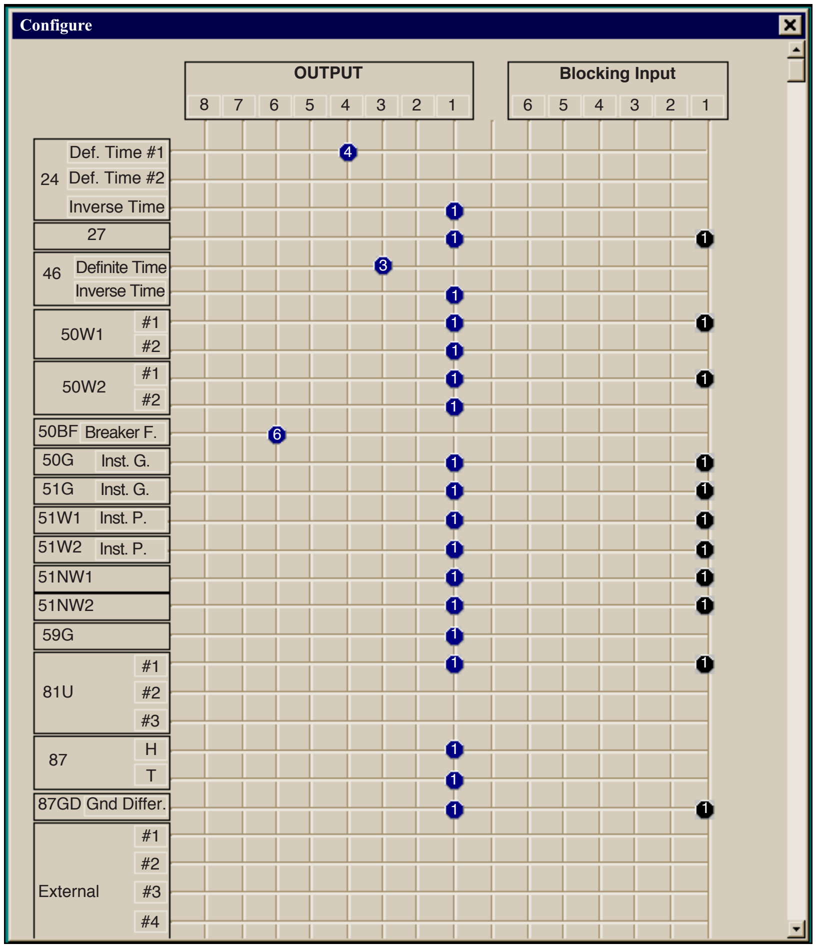
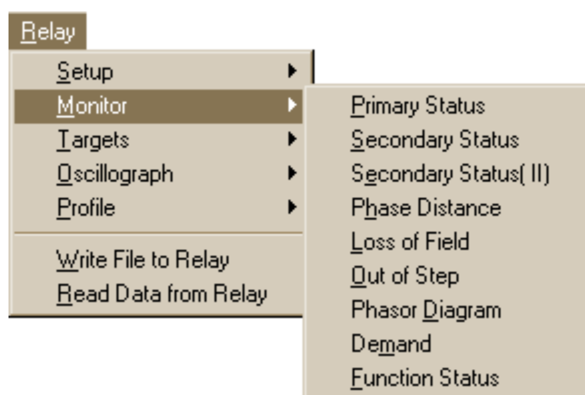


Figure 4-10 Configure Status Box

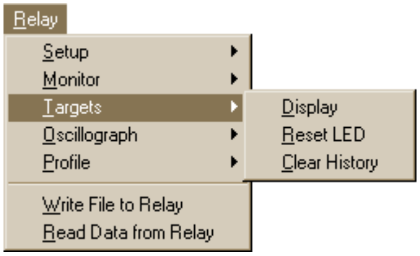
The **Set Date/Time** dialog (see Figure 4-11) allows setup of the relay's date and time clock. If the **Time Sync** indicator is blue, it means valid IRIG-B time information is being received. In this case, only the date fields may be edited; time fields are gray. If the **Time Sync** indicator is gray, both the **Date** and **Time** fields may be edited.

Figure 4-11 Set Unit Date/Time Dialog Box

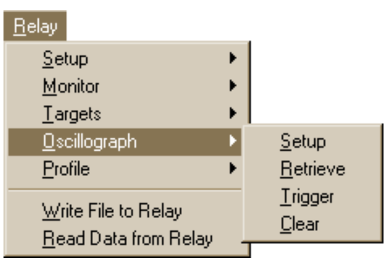


The **Monitor** submenu provides access for reviewing the present status of the relay's measured and calculated values, other real-time parameters and conditions, as well as examining real-time and historical demand metering information (see Section 4.4, **Checkout Status/Metering)**.

■ **NOTE**: The **Monitor** submenu commands **Phase Distance**, **Loss of Field**, and **Out-of-Step** are included for use with the M-3425 Generator Protection Relay, and are unavailable to the M-3310 Transformer Protection Relay.



The **Targets** submenu provides three command options: **Display, Reset**, and **Clear**. The **Display** command displays **Target** dialog (see Figure 4-22, Target Dialog Box). This dialog box provides detailed data on target events including time, date, function status, phase current values, and IN/OUT contact status at the time of trip. Individually recorded events may be selected within the dialog box and saved into a text file, or be printed out with optional added comments. The **Reset** LED is similar to pushing the **Target Reset** button on the relay itself. This command resets current target displayed on the relay. This command does not reset any target history. The **Clear** command clears all stored target history.



The **Oscillograph** submenu allows setting and control over the relay's oscillograph recorder. The **Setup** command allows user to set the number of partitions and triggering designations to be made, retrieves downloads and saves collected data to a file (see Figure 4-12, below). "**Trigger**" sends a command to the relay to capture a waveform. This is the same as issuing a manual oscillograph trigger. "**Clear**" erases all existing records. Run the optional M-3801A IPSplot® Oscillograph Analysis Software program to view the downloaded oscillograph files.

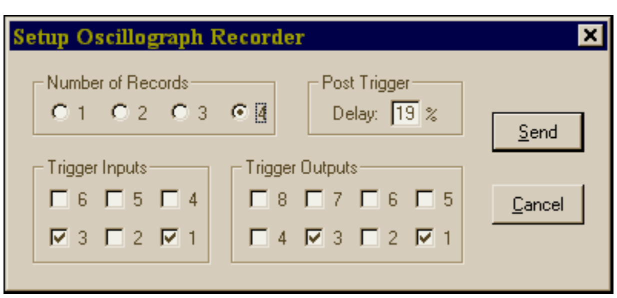
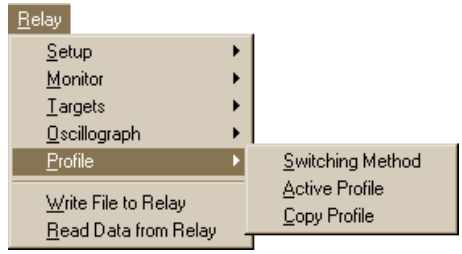


Figure 4-12 Setup Oscillograph Recorder Dialog Box

Profile Menu



The **Profile** submenu provides three command options: **Switching Method, Active Profile**, and **Copy Profile**.

Switching Method command allows selection of either Manual or Input contact. **Active Profile** allows user to designate active profile. **Copy Profile** copies active profile to one of four profiles (user should allow approximately 15 seconds for copying).

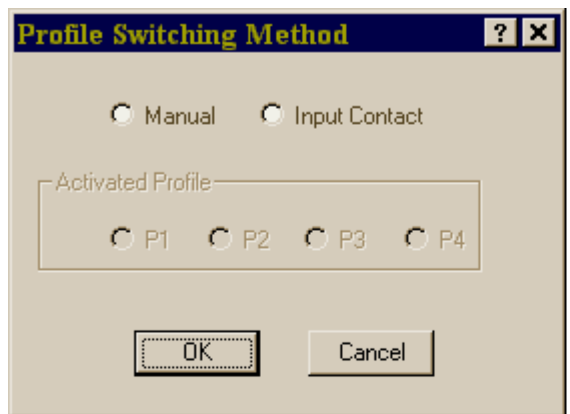
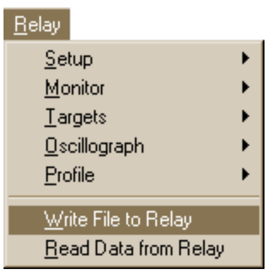


Figure 4-13 Profile Switching Method

Figure 4-14 Select Activated Profile

Figure 4-15 Copy Activated Profile

▲ **CAUTION**: If relay is online, be sure to switch the active profile. If the wrong profile is selected, it may cause unexpected operation.



The **Write File to Relay** command sends pre-defined setpoint data file to the Relay.

The **Read Data from Relay** command updates PC data image with the relay's latest data.

Window Menu/Help Menu

The **Window** menu enables positioning and arrangement of IPScom® windows so that there is better access to available functions. This feature allows the display of several windows at the same time. Clicking on an inactive yet displayed window activates that window.

Though displaying (greyed-out) **Contents** and **Using Help** commands, the Help function is currently unavailable. The **About** command displays IPScom version and development information. **Profile Info** displays user information.

4.3 Checkout Status/Metering

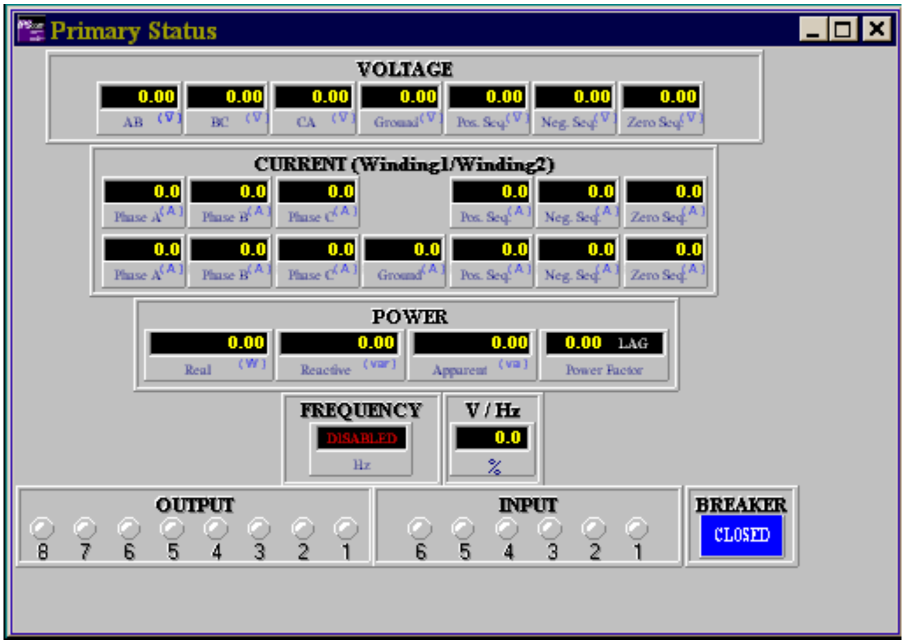


Figure 4-16 Primary Status Dialog Box

Path: Relay menu/Monitor submenu/Primary Status command

This metering window shows voltage status, current status (the first line is for Winding 1 and second line of the current group is for Winding 2), power status, frequency status, Volts/Hz status, IN/OUT status and breaker status in primary level quantities (See Section 3.3 **Checkout/Status/Metering**).

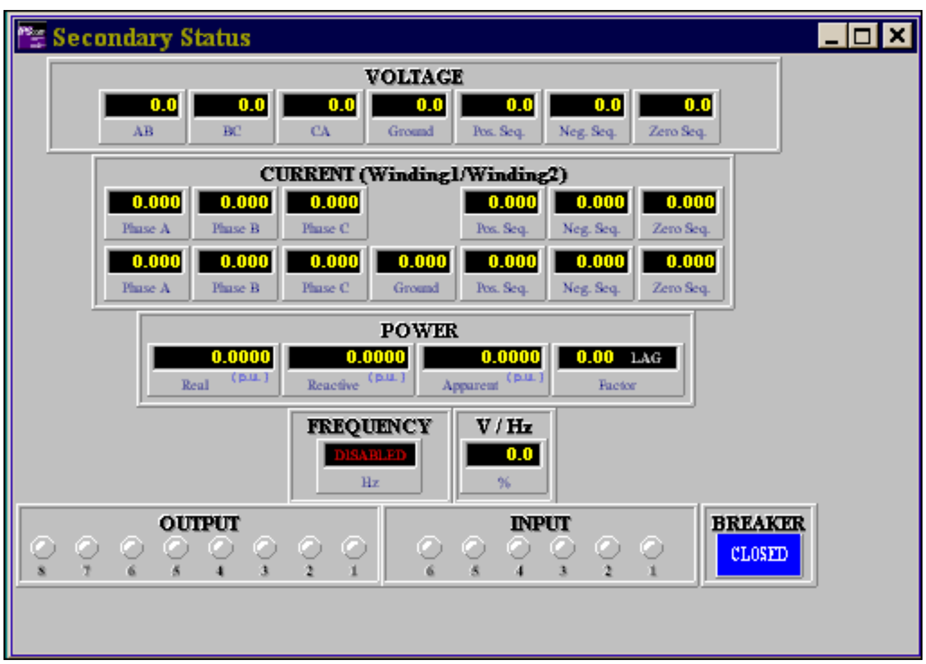


Figure 4-17 Secondary Status Dialog Box

Path: Relay menu/Monitor submenu/Secondary Status command

This metering window shows voltage status, current status (the first line is for Winding 1 and second line of the current group is for Winding 2), power status, frequency status, Volts/Hz status, IN/OUT status and breaker status in secondary level quantities (See Section 3.3 Checkout/ Status/Metering).

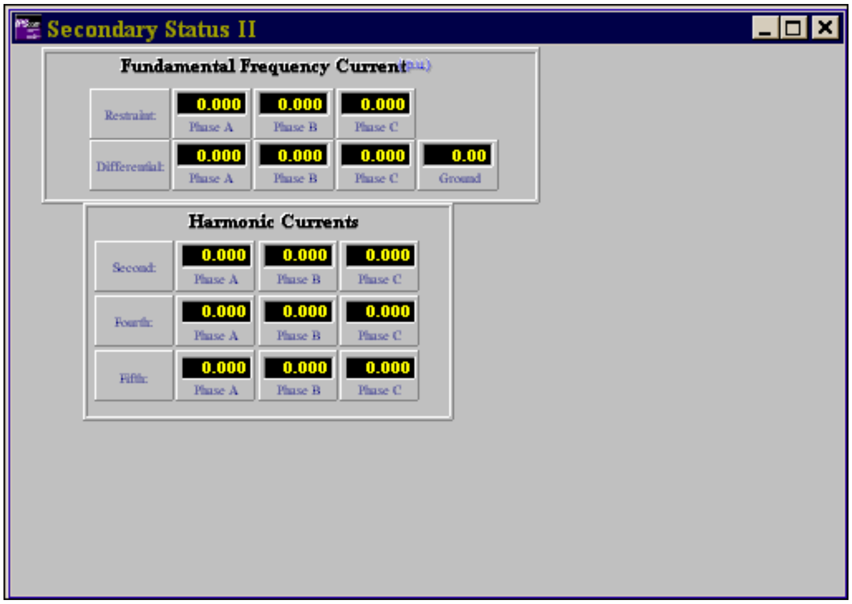


Figure 4-18 Secondary Status Dialog Box (II)

Path: Relay menu/Monitor submenu/Secondary Status (II) command

This metering window shows restraint currents, differential currents, and second, fourth, and fifth harmonic currents in secondary level quantities.

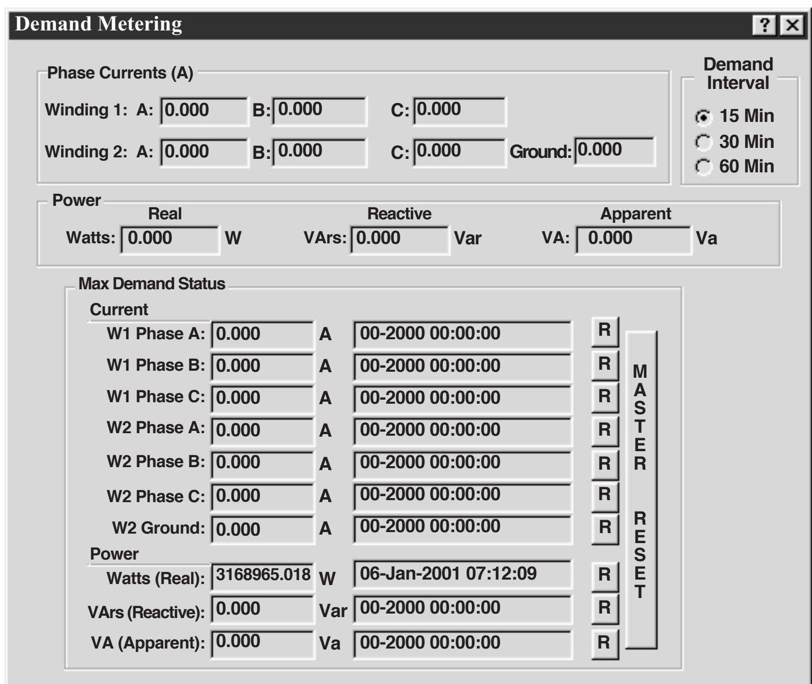


Figure 4-19 Demand Status Window

Path: Relay menu/Monitor submenu/Demand command

COMMAND BUTTONS

Demand Interval	Allows user to interrogate over user-selected period of 15, 30, or 60 minutes
Reset (R)	Reset the addressed Max Demand parameter and Date/Time at which maximum value occured.
Master Reset	Reset all listed Max Demand parameters and their Date/Time at which maximum values occured.

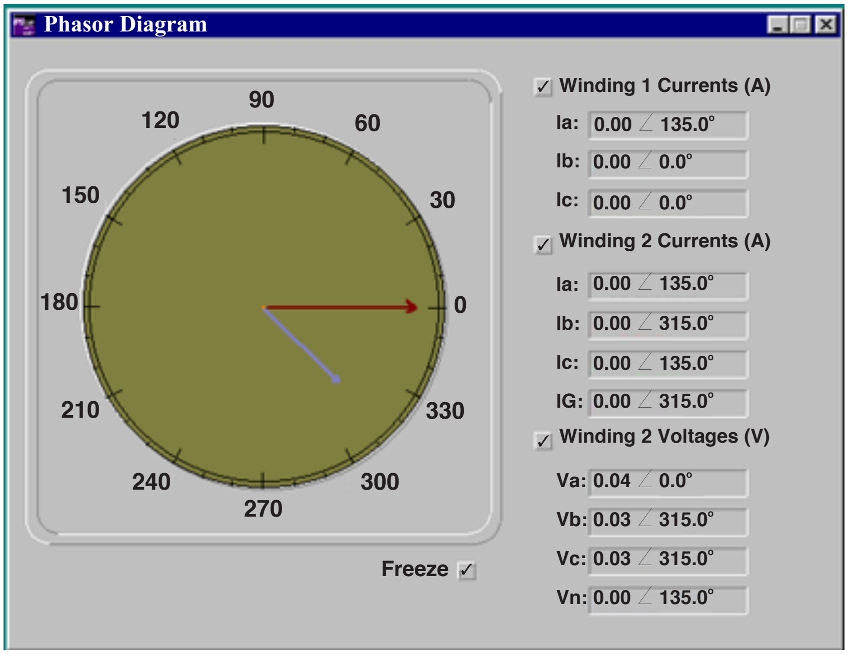


Figure 4-20 Phasor Diagram

Path: Relay menu/Monitor submenu/Phasor Diagram command

COMMAND BUTTONS

Freeze If checked, the Phasor Diagram will display a still picture without updated data. Unchecked, updated data will be displayed automatically.

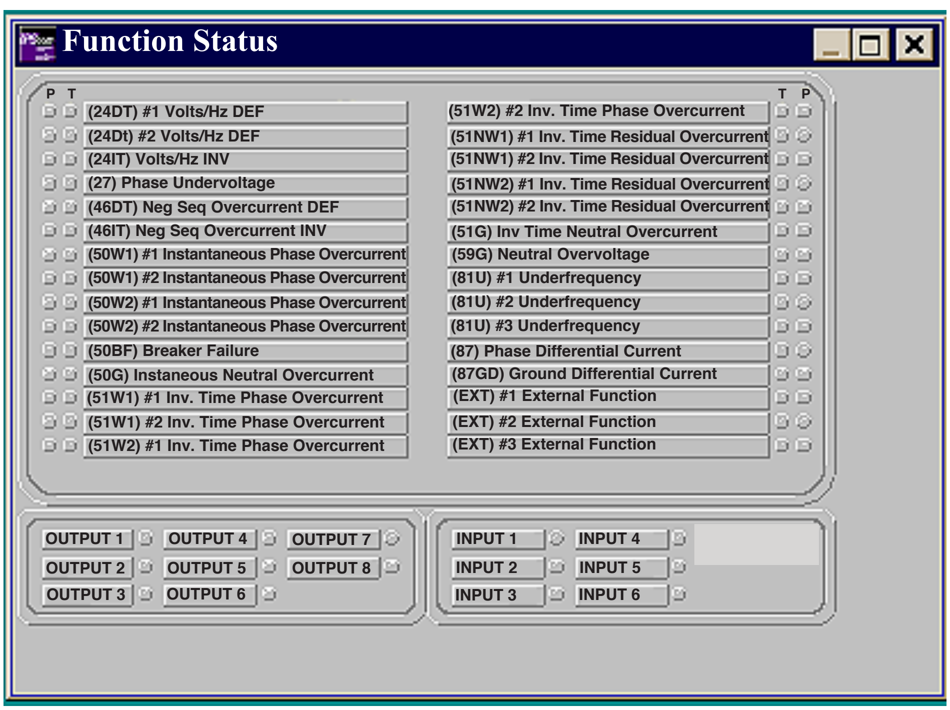


Figure 4-21 Function Status Dialog Box

Path: Relay menu/Monitor submenu/Function Status command

This window shows extended status information of relay functions and INPUT/OUTPUT contact information.

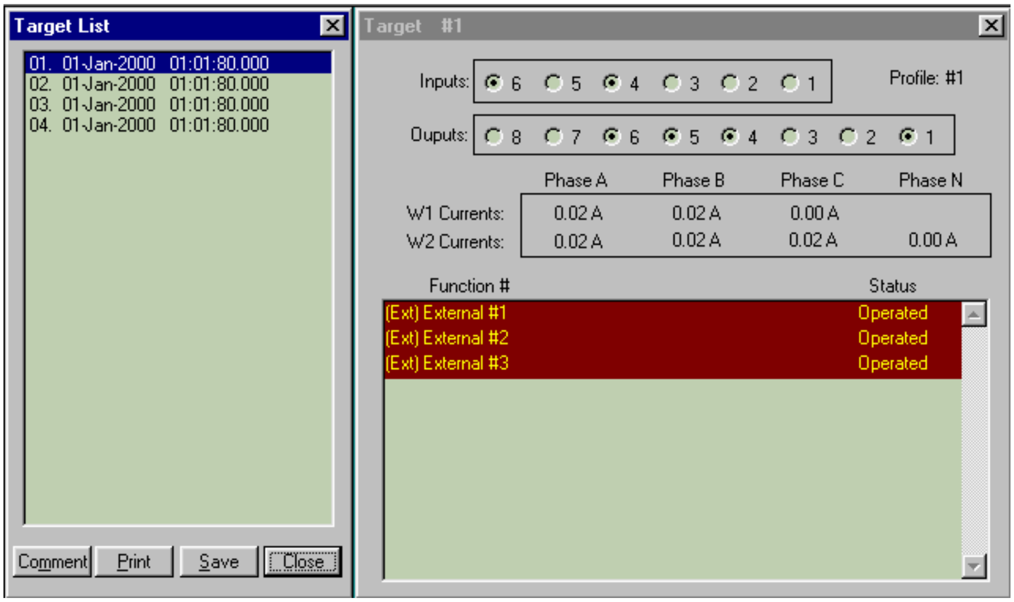


Figure 4-22 Target Dialog Box

Path: Relay menu/Target submenu/Display command

COMMAND BUTTONS

Comment	Opens comment dialog box for annotation.
Print	Prints out selected target information, with comment.
Save	Saves selected target information, with comment, as a text file.
Close	Exits the current displayed dialog box.

4.4 IPSutil™ Communications Software

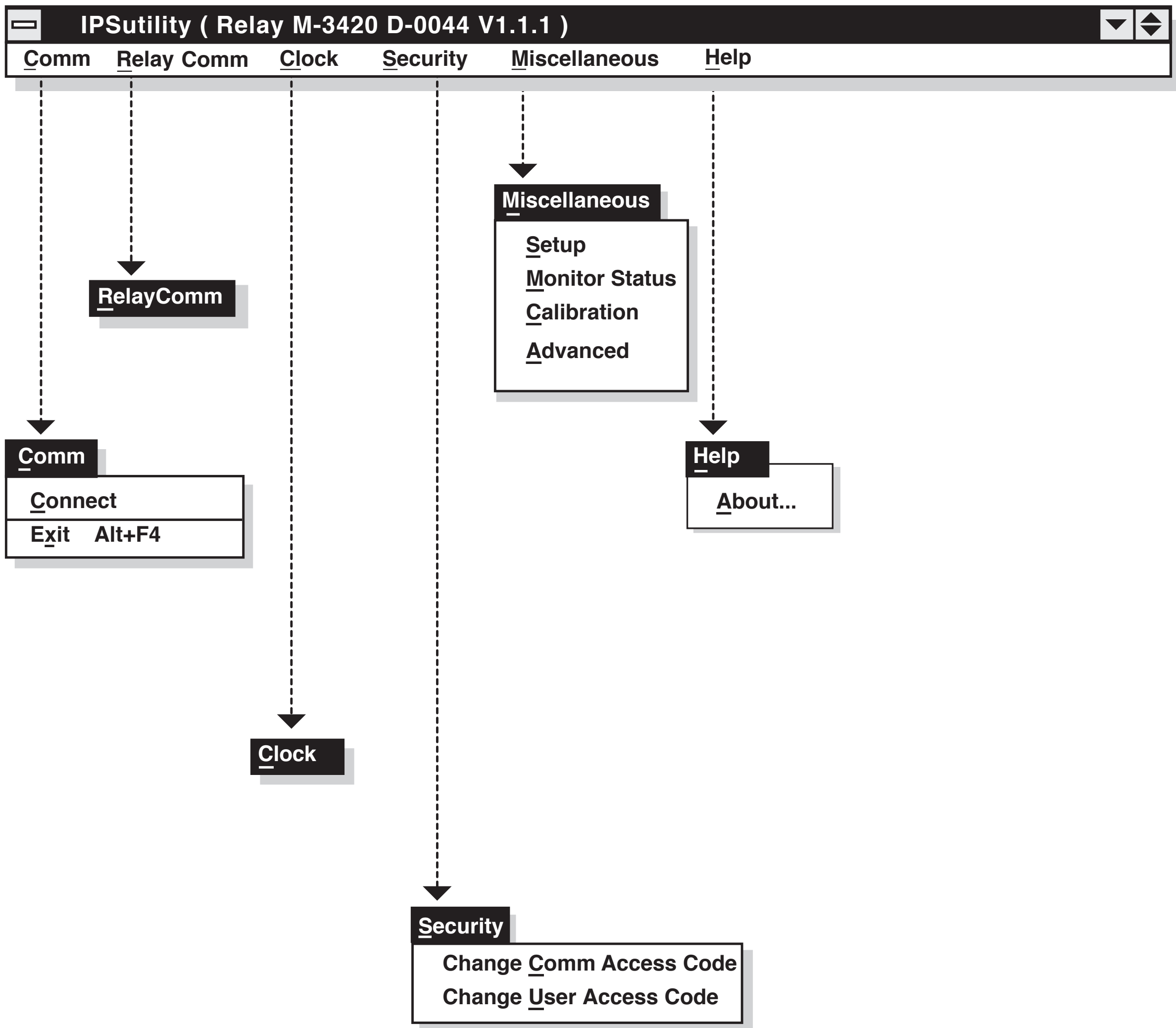


Figure 4-23 Main Menu Flow

M-3890 IPSutil

The M-3890 IPSutil Communication software package provides communication with the Beckwith Integrated Protection System® (IPS) for setting up the relays. Its main purpose is to aid in setting up IPS relays that are ordered without the optional front panel HMI interface.

⬢ WARNING: For convenience, Beckwith Electric distributes both the IPScom® and IPSutil programs on the same disk. The user should be aware, however, that the IPSutil program has the capability of overriding the security parameters set in the relay. It is recommended that you remove the IPSutil program from the IPScom disk and file it separately in a safe place, to be used by authorized people.

Installation and Setup

IPSutil runs with the Microsoft® Windows 95 operating system or above. Hardware requirements are the same as those stated for IPScom®.

Installation

An installation utility has been provided as a part of IPScom® and IPSutil™ programs. After installation, IPSutil can be run from the hard drive by choosing IPSUTIL.EXE.

System Setup

Connect a null modem cable from COM1 of the relay to the PC serial port. IPSutil supports COM1 port direct connection only. Modem connection is not supported. IPSutil is not supported through COM2 or COM3 ports of the relay.

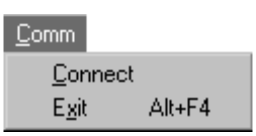
Overview

IPSutil helps in setting up IPS relays which were ordered without the optional front panel HMI interface. Units delivered without HMI's are shipped with a set of factory default settings for various parameters that the end user may wish to change. While the utility program is directed to users that do not have HMI, users of HMI-provided relays can also use IPSutil to set various parameters. When IPSutil is started, a warning window appears:

Figure 4-24 Warning Message

After you accept the warning, you can access the IPSutil main menu. The following sections describe each IPSutil menu items.

Comm Menu

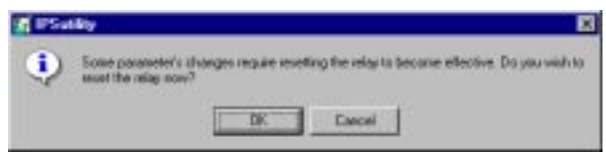


The **Comm** menu allows you to make connections to the relay. This is the first command you must use to access the unit. After you click the **Connect** submenu item, the Communications dialog box appears (See Figure 4-25).

- Select the correct PC communication port where the null modem cable is connected for the relay.
- Select the baud rate of the relay. Factory default is 9600 baud.
- Select the access code resident in the relay. Factory default is 9999.
- Click "Open com" button.

The following message window will appear showing COM opened. Now, the title bar will display the relay model and the software version.

The **Exit** submenu allows you to quit IPSutil. If the relay was connected, this submenu disconnects the relay. When the relay was connected, if you have made any changes for some parameters (for example, baud rate, phase rotation) the following message window appears.



Relay Comm Command

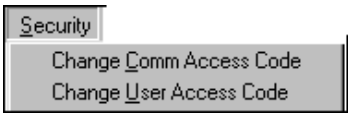
When **Relay Comm** command is selected, the Relay Comm Port Settings dialog box appears (See Figure 4-26). It allows you to set the relay communication ports COM1 or COM2/COM3 baud rate. For COM2/COM3, it allows you to set the protocol and dead synch time. Additionally, for COM2 and COM3, if you select MODBUS protocol, the dialog box allows you to enable the parity option.

■ **NOTE:** If COM1 baud rate is changed and the relay is reset, the new baud rate must be used to communicate with COM1

Clock Command

When the **Clock** command is selected, the "Set Unit Date/Time" dialog box appears (See Figure 4-27). Date and Time can be changed and sent to the relay. This dialog box allows you to start or stop the clock in the relay.

Security Menu



The **Security** Menu allows you to set the communication access code and the level access codes for the relay.

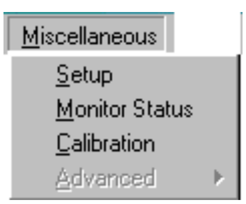
The **Change Comm Access Code** allows you to assign new communication access code to the relay. The range of the access code is 1 to 9999. Note that the access code 9999 is a factory default (See Figure 4-28).

■ **NOTE:** Setting the access code to 9999 disables security.

The **Change User Access Code** allows you to assign three different levels of access code for the relay functions accessibility. The range of the level access code is 1 to 9999 (See Figure 4-29).

▲ **CAUTION**: This submenu allows you to change the relay level access codes.

Miscellaneous Menu



The **Miscellaneous** menu allows you to set and monitor some of the relay parameters.

The **Setup** command allows you to change the users Logo information, test outputs, assign communication address and user control number, phase rotation, **OK** LED flash mode in the relay. Note that the highest number used for the communication address is 255 and the highest control number allowed is 9999 (See Figure 4-30).

The **Monitor Status** command allows you to monitor and clear the error code counters, monitor the check sums, and to view inputs test status. Note that powerloss counter cannot be cleared.

The **Advanced** and **Calibration** commands are reserved for factory use only.

Help Menu

Under **Help**, the **About...** submenu provides you the information on the IPSUtil™ version numbers.

Figure 4-25 Communication Dialog

COMMAND BUTTONS

Open COM Initiates communication with the protective system by direct serial communication.

Close COM Discontinues communication with the protective system.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

Figure 4-26 Relay Comm Port Settings

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

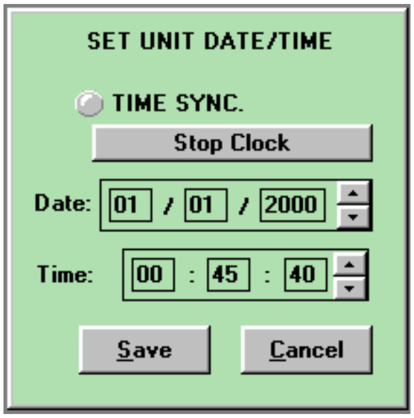


Figure 4-27 Unit Date/Time Dialog Box

COMMAND BUTTONS

Stop Clock This toggles between start/stop the clock of the relay. The 'Stop' stops the clock in the relay. The 'Start' resumes the clock in the relay.

Save When connected to the protection system, the date and time information on the display is sent to the relay.

Cancel Returns you to the IPSutil™ main window. Any changes to the displayed information are lost.

There is a blue Time Sync LED mimic on this dialog box (the LED is displayed as different shading on a monochrome monitor). When this LED is blue, the relay is synchronized with the IRIG-B signal and the Time field is grayed out, indicating that this field can't be changed. But the Date field can be changed (by editing and pressing **Save**). When the LED is *not* blue, the relay is not time-synchronized and therefore, both the Date and Time fields can be changed. The time field in the dialog box is not updated continuously. The time at which the dialog box was opened is the time that is displayed and remains as such. This is true whether the relay is synchronized with the IRIG-B signal or not.

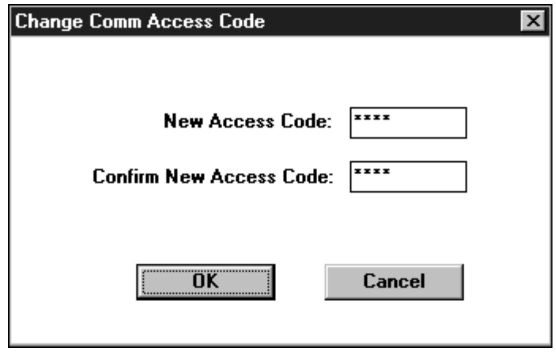


Figure 4-28 Change Communication Access Code Dialog Box

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil™ main window. Any changes to the displayed information are lost.

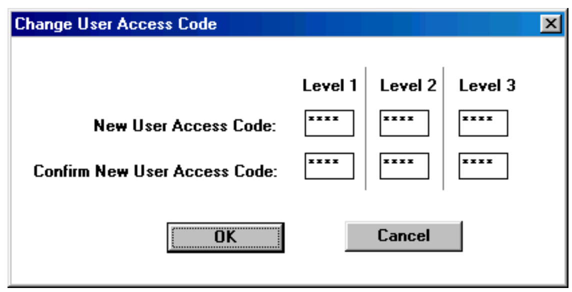


Figure 4-29 Change User Access Code Dialog Box

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

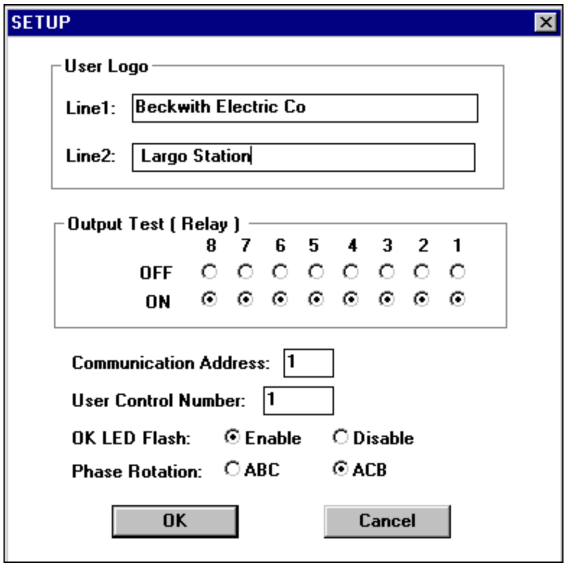


Figure 4-30 Setup Dialog Box

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

■ **NOTE**: Output Test is not available on some versions of the M-3310 Relay.

5 Installation

5.1 General Information

■ **NOTE:** Prior to installation of the equipment, it is essential to review the contents of this manual to locate important data that may be of importance during installation procedures. The following is a quick review of the contents of the chapters of this manual.

It is suggested that terminal connections illustrated herein be transferred to station one-line wiring and three-line connection diagrams, station panel drawings and station DC wiring schematics.

If during the commissioning of the relay, additional tests are desired, refer to Chapter 6**, Testing**.

The operation of the M-3310 Transformer Protection Relay, including the initial setup procedure, is described in Chapter 3, **HMI Operation**. If the relay is provided with a Human-Machine Interface (HMI) module, refer to Chapter 4, **IPScom® Operation.**

Section 3.1, **Front Panel Controls**, describes the front panel controls, and Section 3.2, **Initial Setup Procedure/Settings** describe the HMI setup procedure. The procedures contain specific instructions for entering the communications data, unit setup data, configure relays data, individual setpoints and time settings for each function, and oscillograph recorder setup information.

Section 3.3, **Checkout Status/Metering**, guides the operator through the checkout status procedures including status monitoring and viewing target history.

5.2. Mechanical/Physical Dimensions

Figures 5-1 through 5-4 contain physical dimensions of the relay that may be required for mounting the unit to a rack.

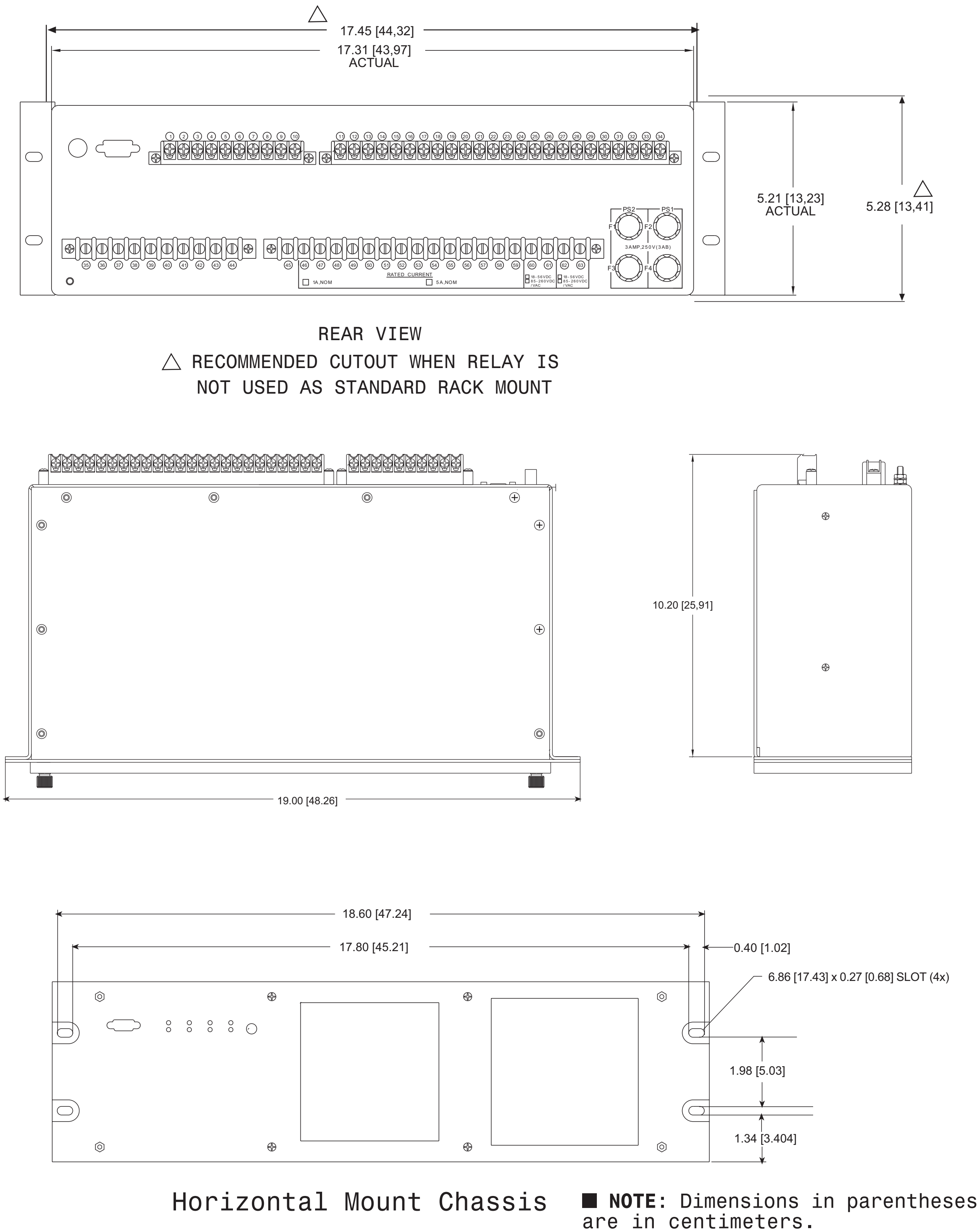


Figure 5-1 M-3310 Mounting Dimensions – Horizontal Chassis

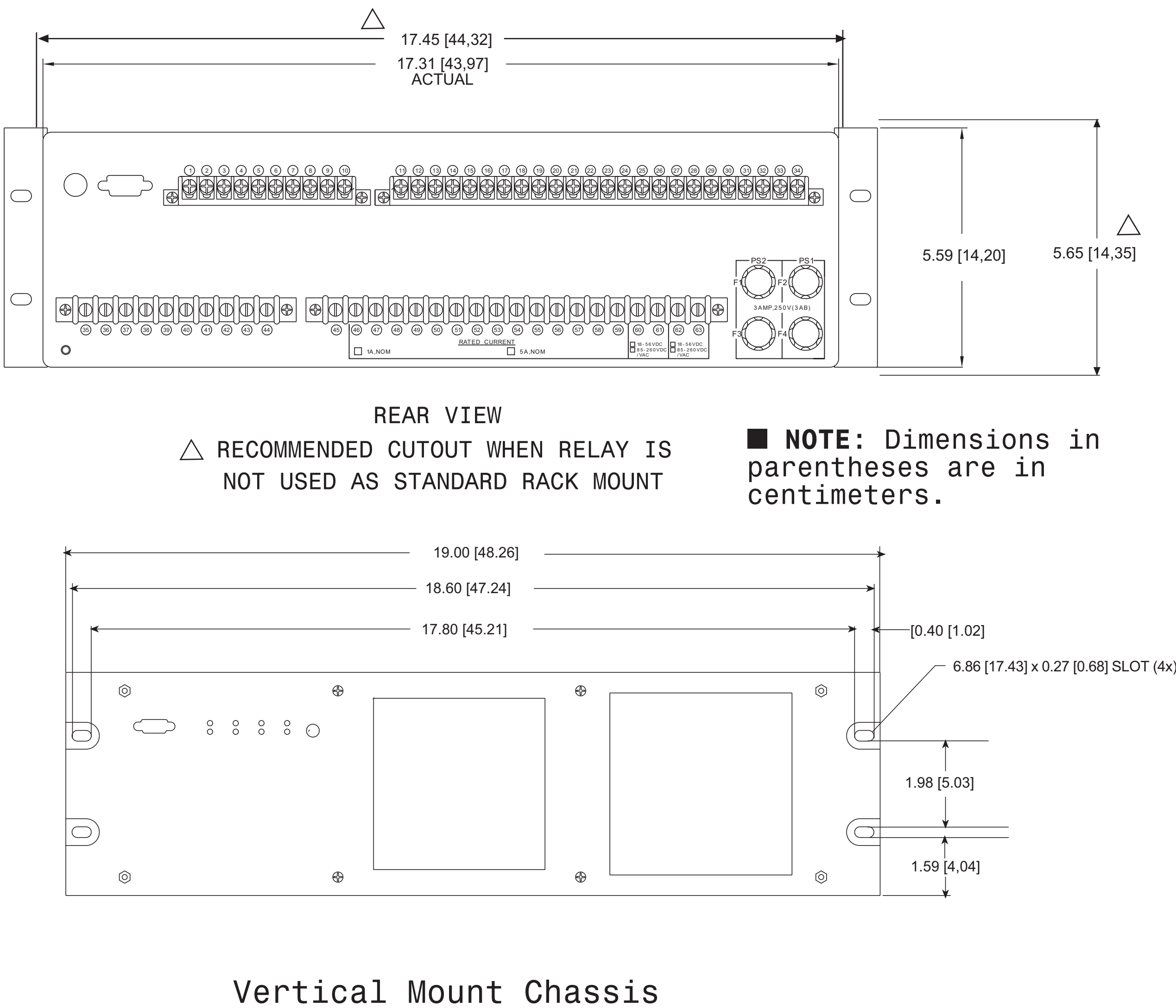


Figure 5-2 M-3310 Mounting Dimensions – Vertical Chassis

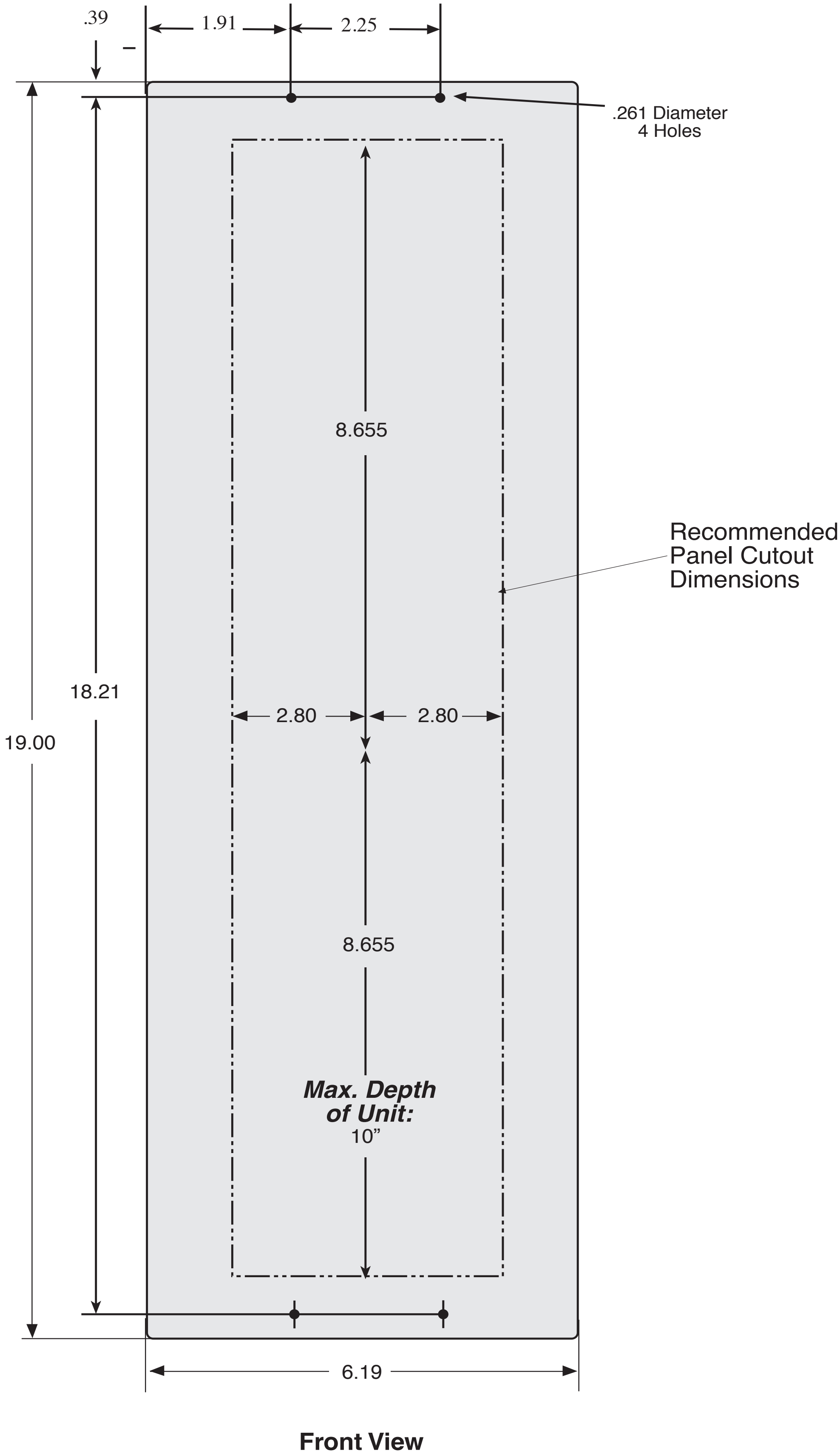


Figure 5-3 (H2) Mounting Dimensions

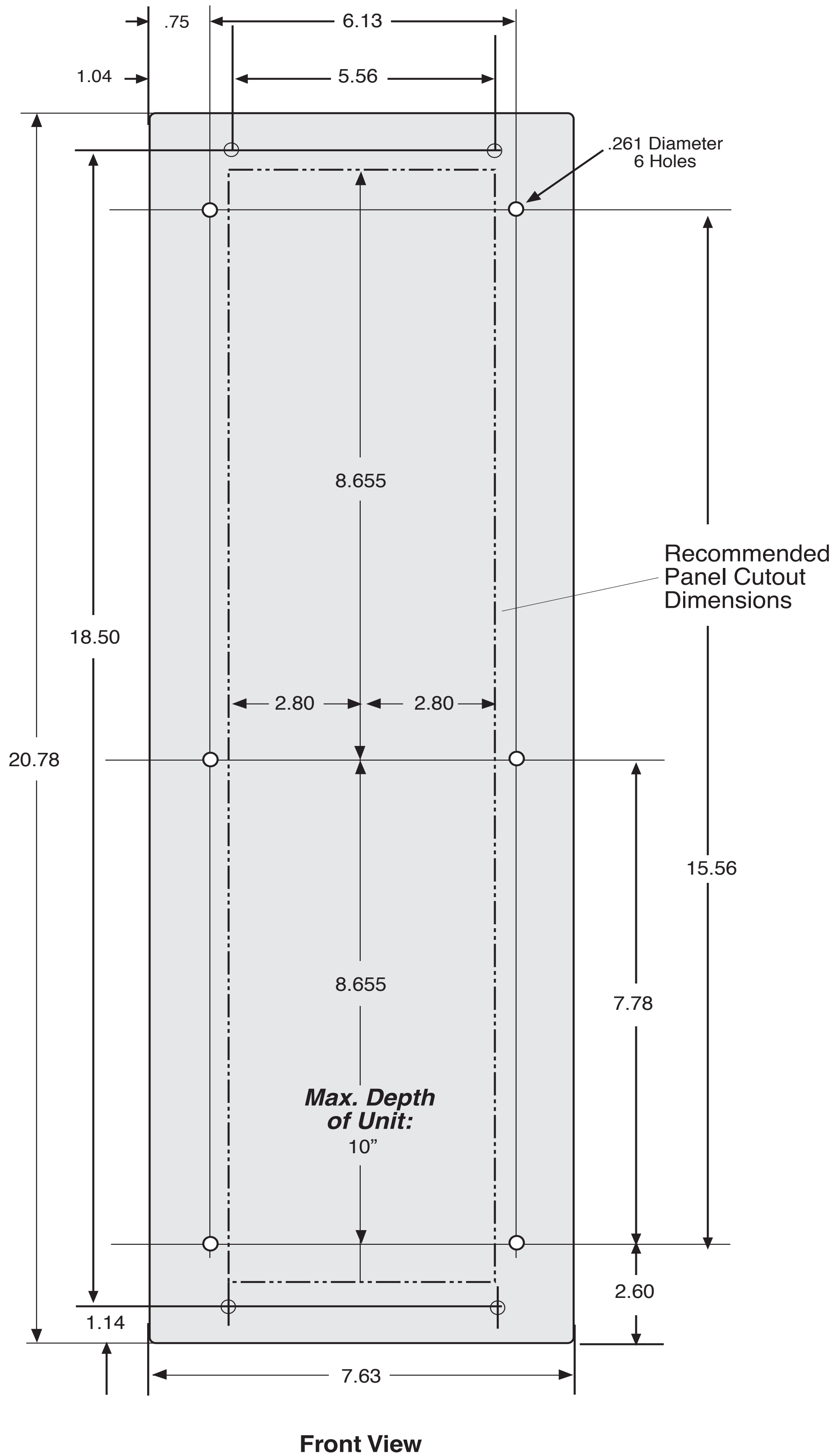


Figure 5-4 (H3) Mounting Dimensions for GE L-2 Cabinet

5.3 External Connections

Figure 5-5 provides an explicit view of all the external contacts, communications points, and power fuses of the M-3310.

■ **NOTE**: Output contacts #1 through #4 are high-speed operation contacts. To fulfill UL and CSA listing requirements, terminal block connections must be made with No. 12 AWG solid or stranded copper wire inserted in an AMP #324915 or equivalent. The screws attaching the connector must be tightened to 8-inch pounds torque. Only dry contacts may be connected to **INPUTS** (terminals 5 through 10, with 11 common), because these contact inputs are internally wetted.

▲ **CAUTION:** Application of external voltages to the INPUTS terminals may result in damage to the unit.

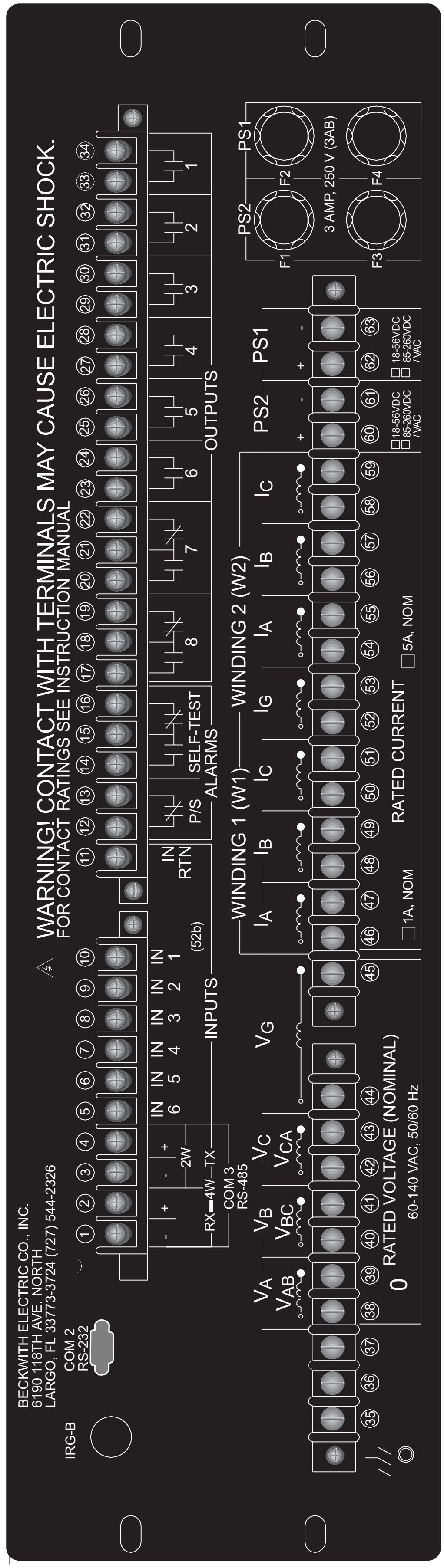


Figure 5-5 M-3310 External Connections

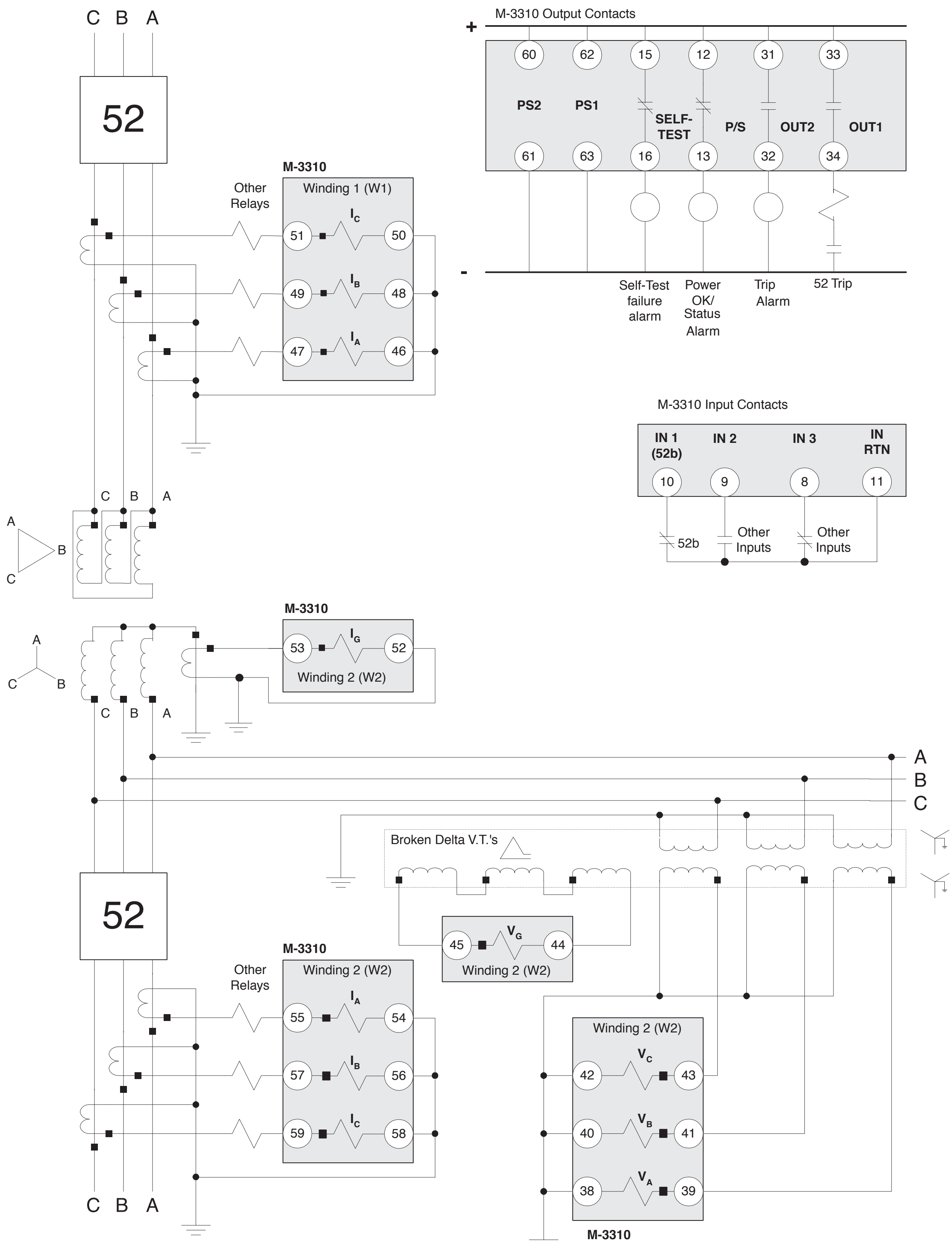


Figure 5-6 Three-Line Connection Diagram with Broken Delta-connected VTs

Transformer Connection #4, Delta-Wye power transformer shown with Wye-Wye connected CT's and Broken Delta connected VT's.

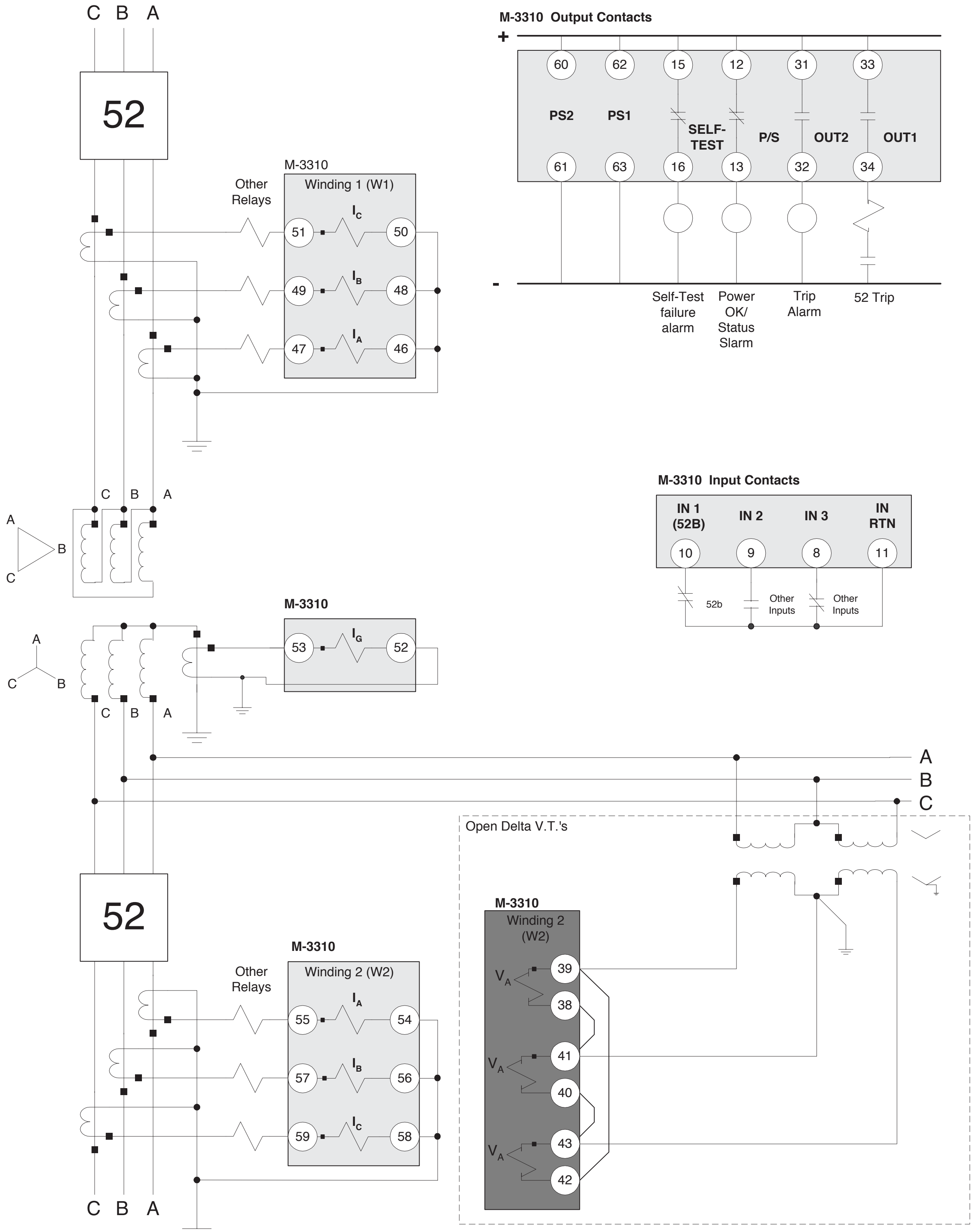


Figure 5-7 Three-Line Connection Diagram with Open Delta-connected VTs

Transformer Connection #4, Delta-Wye power transformer shown with Wye-Wye connected CT's and Open Delta connected VT's.

5.4 Commissioning Checkout

During M-3310 Transformer Protection Relay field commissioning, check the following procedure to ensure that the CT and VT connections are correct.

1. On the keypad, press **ENTER**. After a short delay, the unit should display:

```
VOLTAGE RELAY
VOLT CURR FREQ V/HZ EXT G
```

2. Press the right arrow button until the unit displays:

```
STATUS
← config sys STAT dmd →
```

3. Press **ENTER**. The unit should display:

```
VOLTAGE STATUS
VOLT curr freq v/hz pwr →
```

4. Press **ENTER** to display the phase voltages. The unit should display either V_A V_B, V_C, for line-to-ground connections or $V_{AB,}$ $V_{BC,}$ V_{CA}, for line-to-line connections). Use a voltmeter to compare these actual measurements. If there is a discrepancy, check for loose connections to the rear terminal block of the unit.

```
W2 PHASE VOLTAGE
AB=   BC=   CA=
```

5. Press **ENTER** to display the Neutral voltage. The neutral voltage should be $V_N \approx 0$ volts.

```
W2 NEUTRAL VOLTAGE
0.0 Volts
```

6. Press **ENTER** to display positive sequence voltage. The positive sequence voltage should be V_{POS}y $V_A \approx V_B \approx V_C \approx$ or $V_{AB} \approx V_{BC} \approx V_{CA}$.

```
W2 POS SEQUENCE VOLTAGE
120.0 Volts
```

7. Press **ENTER** to display negative sequence voltage. The negative sequence voltage should be $V_{NEG} \approx 0$

```
W2 NEG SEQUENCE VOLTAGE
0.0 Volts
```

8. Press **ENTER** to display zero sequence voltage. The zero sequence voltage should be $V_{ZERO} \approx 0$.

```
W2 ZERO SEQUENCE VOLTAGE
0.0 Volts
```

■ **NOTE:** If negative sequence voltage shows a high value and positive sequence voltage is close to zero, the phase sequence may be incorrect. Proper phasing must be achieved to obtain proper readings. If phase sequence is incorrect, frequency related functions will not operate properly and the **FREQUENCY STATUS** menu will read **DISABLED**.

If positive, negative and zero sequence voltages are all present, check the polarities of VT connections and correct the connections to obtain proper polarities.

9. Press **EXIT**, the unit displays:

```
VOLTAGE STATUS
VOLT curr freq v/hz pwr →
```

10. Press the right arrow once, the unit displa≈s:

```
CURRENT STATUS
volt CURR freq v/hz pwr →
```

11. Press **ENTER** to display line currents for Winding 1 ($I_AW_{1,}$ $I_BW_{1,}$ I_CW_1). Compare these currents with the measured values using a meter. If there is a discrepancy, check the CT connections to the rear terminal block of the unit. The unit should display:

```
W1 PHASE CURRENT
A= 5.00 B= 5.00 C= 5.00
```

12. Press **ENTER** to display line currents for Winding 2 ($I_AW_{2,}$ $I_BW_{2,}$ I_CW_2). Compare these currents with the measured values using a meter. If there is a discrepancy, check the CT connections to the rear terminal block of the unit. The unit should display:

```
W2 PHASE CURRENT
A= 5.00 B=5.00 C=5.00
```

13. Press **ENTER** for the unit to display ground current. The Ground current should be $I_GW2 \approx 0$ Amps.

```
W2 GROUND CURRENT
0.00 Amps
```

14. Press **ENTER** for the unit to display restraint currents. The restraint currents should be $I_{REST}y\frac{W_1+W_2}{2}$ for each phase.

```
RESTRAINT CURRENT
A=5.000 B=5.000 C=5.000
```

15. Press **ENTER** for the unit to display the fundamental differential currents. The fundamental differential currents should be $I_{DIFF}\approx W_1\text{-}W_2\approx 0$ for each phase. If a significant amount of differential current is present, check the CT polarities.

```
DIFF CURRENT FUND.  (PU)
A=0.000 B=0.000 C=0.000
```

16. Press **ENTER** for the unit to display the second harmonic currents. The second harmonic currents should be $I_{2ND}\approx 0$ for each phase.

```
DIFF CURRENT 2ND H (PU)
A=0.000 B=0.000 C=0.000
```

17. Press **ENTER** for the unit to display the fourth harmonic currents. The fourth harmonic currents should be $I_{4TH}\approx 0$ for each phase.

```
DIFF CURRENT 4TH H (PU)
A=0.000 B=0.000 C=0.000
```

18. Press **ENTER** for the unit to displa≈ the fifth harmonic currents. The fifth harmonic currents should be $I_{5TH}\approx 0$ for each phase.

```
DIFF CURRENT 5TH H (PU)
A=0.000 B=0.000 C=0.000
```

19. Press **ENTER** for the unit to displa≈ the ground differential current. The ground differential current should be $I_{GDIFF}\approx 0$.

```
GND DIFFERENTIAL CURRENT
0.000 Amps
```

20. Press **ENTER** for the unit to displa≈ the positive sequence current for winding 1. The positive sequence current should be $I_{POS}W_1\approx I_AW_{1,}\approx I_BW_{1,}\approx I_CW_1$.

```
W1 POS SEQUENCE CURRENT
5.00 Amps
```

21. Press **ENTER** for the unit to display the negative sequence current for winding 1. The negative sequence current should be $I_{NEG}W_1\approx 0$ Amps.

```
W1 NEG SEQUENCE CURRENT
0.00 Amps
```

22. Press **ENTER** for the unit to display the zero sequence current for winding 1. The zero sequence current should be $I_{ZERO}W_1\approx 0$ Amps. If a significant amount of negative or zero sequence current is present (greater than 25% of $I_AW_{1,}$ $I_BW_{1,}$ I_CW_1), then either the phase sequence or the polarities may be incorrect. Modify connections to obtain the correct phase sequence and polarities.

```
W1 ZERO SEQUENCE CURRENT
0.00 Amps
```

23. Repeat steps 20-22 for winding 2 currents.

24. Press **EXIT**, the unit displays:

```
CURRENT STATUS
volt CURR freq v/hz pwr →
```

25. Press the right arrow button until the unit displays:

```
POWER STATUS
volt curr freq v/hz PWR →
```

26. Press **ENTER** to display real power and verify the correct polarity. The polarity should be positive for forward power and negative for reverse power. If the readings do not agree with actual conditions, check the polarities of the three low end CT's and /or the PT's and the CT and PT ratios.

```
REAL POWER
0.0000 pu    00.000 W
```

27. Repeat step 26 for reactive, apparent, and power factor.

5.5 Circuit Board Switches and Jumpers

DIP JUMPER	POSITION	DESCRIPTION
J60	AB	Connects CD signal to COM 2 pin 1 *
	BC	Connects +15V to COM 2 pin 1
J61	Inserted	Connects -15V to COM 2 pin 9
	Removed	Disconnects COM 2 pin 9 *
J58	AB	Receiver continuously enabled
	BC	Receiver disabled while transmitting*
J10	AB	COM3 Termination Resistor inserted
	BC	COM3 Termination Resistor not inserted*
J46	AB	COM 3 shares Baud rate with COM 1
	BC	COM 3 shares Baud rate with COM2*
J5	AB	Demodulated IRIG-B signal TTL Pin 6
	BC	Modulated IRIG-B signal BNC *

*Default setting

Table 5-1 Circuit Board Jumpers

SWITCH POSITIONS				DESCRIPTION
1	2	3	4	Switches should not be changed while power is applied to unit
U	X	X	X	Up for dual Pwr Supply, down for single
	X			Not functional on M-3310
X	X	U	U	Run Mode
X	X	U	D	Factory Use only
X	X	D	U	Initialize access codes and communication parameters to default values*
X	X	D	D	Calibrate *,**

*Power down, set switch, then power up. After power up, the RELAY OK LED light remains off and DIAG LED will light when the operation has been satisfactorily completed.

**Power down, adjust, connect reference inputs, power up.

Table 5-2 Circuit Board Switches

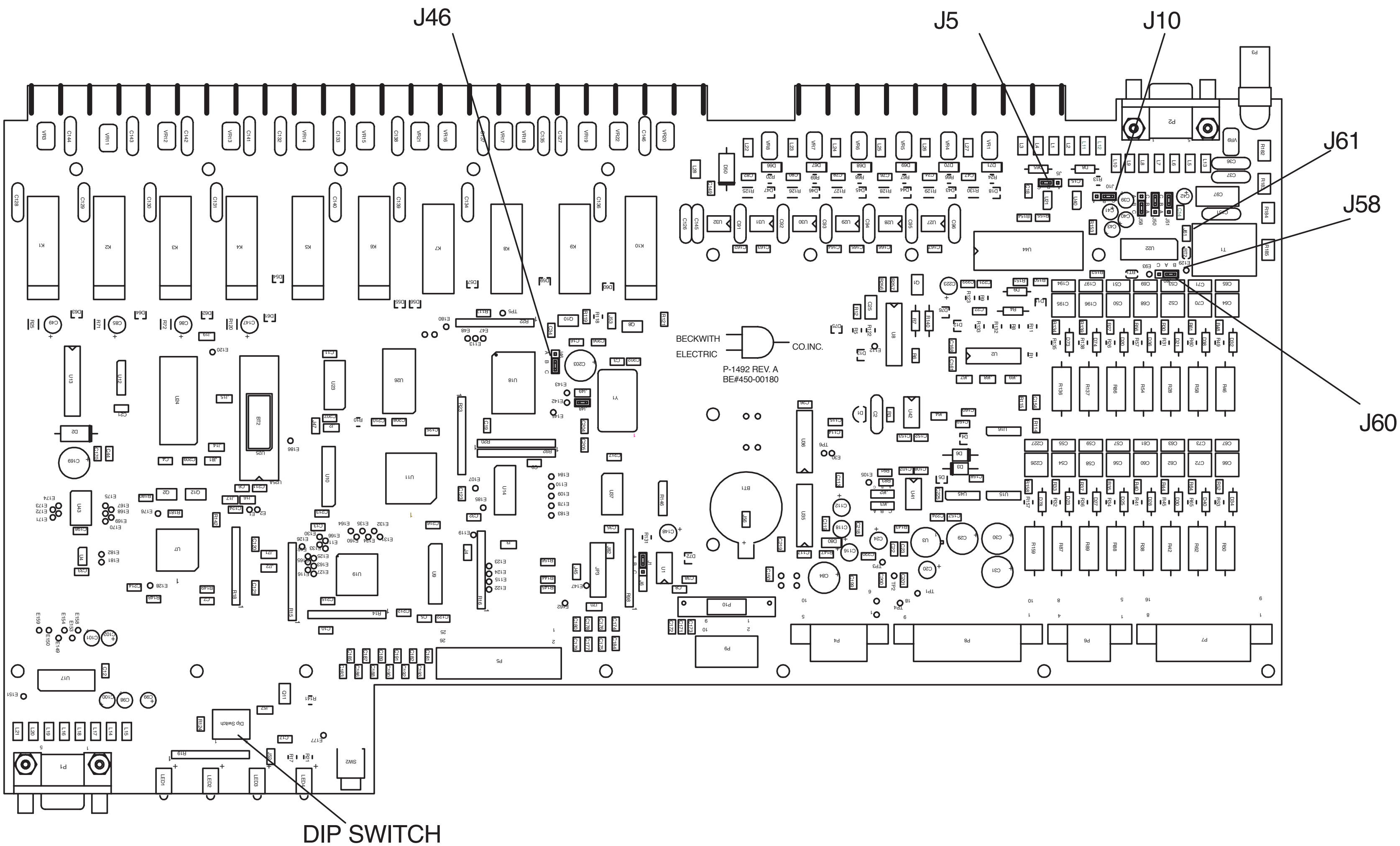


Figure 5-8 M-3310 Circuit Board

6 Testing

6.1 Equipment and Test Setup

The M-3310 Transformer Protection Relay has been calibrated and fully tested at the factory. If calibration is necessary because of component replacement, follow the Autocalibration Procedure described in Section 6.3.

Automatic Calibration

■ **NOTE**: If necessary, refer to Figures 6-2, 6-3, and 5-4 for reference to the HMI, Targets, LEDs, and rear connections.

Required Equipment

The following equipment is required to carry out the test procedures:

- Two Digital Multimeters (DMM) with a 10 Amp current range. These are not required if using a Pulsar Universal Test System.
- One power supply to supply power for the relay, capable of supplying:

  120 Vac or 125 Vdc for units with high voltage power supplies, or 24 Vdc for units with Low Voltage power supplies.
- One 3-phase voltage source capable of 0 to 250 Vac. (Pulsar Universal Test System or equivalent.)
- One 3-phase current source capable of 0 to 25 Amps. (Pulsar Universal Test System or equivalent.)
- Electronic timer with a minimum accuracy of 8 msec. (Pulsar Universal Test System or equivalent.)

■ **NOTE:** A single-phase frequency tester may be used:

48 to 59.99 Hz for 60 Hz units

38 to 49.99 Hz for 50 Hz units

Equipment Setup

▲ **CAUTION**: The proper voltage range for the relay is clearly marked underneath each of the power supply inputs.

1. Connect power to the relay power input terminals 62 and 63. The relay may be configured with a high voltage power supply with a nominal voltage input of 110/120 /230/240 Vac or 110/125/220/250 Vdc. The relay is also available with a low voltage power supply with nominal voltage input of 24/48 Vdc, and a redundant power supply, which is available as an option
2. Connect the voltage and current inputs for each test procedure according to the configuration included with each test description and follow the outlined steps. It is recommended to disable any functions that may operate while performing tests on a particular function.
3. Table 6-1 identifies the functions to disable.

	FUNCTION TO DISABLE																		
FUNCTION BEING TESTED	**24DT**	**24IT**	**27**	**46DT**	**46IT**	**50BF**	**50W1**	**50W2**	**50G**	**51W1**	**51W2**	**51G**	**51NW1**	**51NW2**	**59G**	**81U**	**87H**	**87T**	**87GD**
24DT		X	X													X			
24IT	X		X													X			
27	X	X														X			
46DT					X			X			X						X	X	X
46IT				X				X					X				X	X	X
50BF								X	X		X	X		X			X	X	X
50W1										X			X				X	X	
50W2				X	X	X					X						X	X	X
50G						X						X		X					X
51W1							X						X				X	X	
51W2				X	X	X		X									X	X	X
51G						X			X					X					X
51NW1							X			X							X	X	X
51NW2				X	X	X		X			X						X	X	X
59G																			
81U	X	X	X																
87H				X	X	X	X	X		X	X		X	X				X	X
87T				X	X	X	X	X		X	X		X	X			X		X
87GD				X	X	X		X	X		X	X		X					

Table 6-1 Functions to Disable When Testing

6.2 Diagnostic Test Procedures

The diagnostic procedures perform basic functional tests to verify the operation of the front panel controls, LED's, inputs, outputs, and communication ports. These tests are performed in diagnostic mode, which is entered in the following manner:

■ **NOTE:** The Diagnostic Mode is intended for bench testing the relay only. Do not use the diagnostic mode in relays that are installed in an active protection scheme.

For units with the optional HMI panel:

1. Press **ENTER** to begin main menu.
2. Press the right arrow button until **SETUP UNIT** appears in the top line of the display.
3. Press **ENTER** to access the **SETUP UNIT** menu.
4. Press the right arrow button until **DIAGNOSTIC MODE** appears in the display.
5. Press **ENTER**. A reset warning appears:

```
PROCESSOR WILL RESET!
ENTER KEY TO CONTINUE
```

WARNING: All relay functions and protection will be inoperative while the relay is in diagnostic mode.

6. Press **ENTER**. Unit will now reset and **DIAGNOSTIC MODE** will be temporarily displayed, followed by **OUTPUT TEST** (RELAY). This is the beginning of the diagnostic menu.
7. When testing in **DIAGNOSTIC MODE** is complete, press **EXIT** until the following message appears:

```
PRESS EXIT TO
EXIT DIAGNOSTIC MODE
```

8. Press **EXIT** again to exit **DIAGNOSTIC MODE**. The relay will reset and normal running mode will resume.

■ **NOTE**: Pressing any button other than **EXIT** will return the user to **DIAGNOSTIC MODE.**

Output Test (Relay)

The first step in testing the operation of the function outputs is to confirm the positions of the outputs in the unoperated or **OFF** position. This can be accomplished by connecting a Digital Multimeter (DMM) across the appropriate contacts and confirming open or closed contacts. The de-energized or **OFF** positions for each output is listed in Table 6-2: Output Contacts

RELAY/OUTPUT NUMBER	NORMALLY OPEN CONTACT*		NORMALLY CLOSED CONTACTS*	
1	33	34	N/A	N/A
2	31	32	N/A	N/A
3	39	30	N/A	N/A
4	27	28	N/A	N/A
5	25	26	N/A	N/A
6	23	24	N/A	N/A
7	21	20	21	22
8	18	17	18	19
9 (Self-Test)	15	14	15	16
10 (Power Supply)	13	12	N/A	N/A

*"*Normal" position of the contact corresponds to the OFF or de-energized state of the relay*

Table 6-2 Output Contacts

For units with optional HMI panel:

Enter Diagnostic Mode as previously outlined. Following completion of testing, the output contacts, can be turned **ON** in the following manner:

1. Press **ENTER**. The following is displayed:

```
RELAY NUMBER
      1
```

2. Press **ENTER**. The following is displayed:

```
RELAY NUMBER 1
OFF on
```

3. Use the right button to highlight **ON** in uppercase letters, which signifies selection. The following is displayed:

```
RELAY NUMBER 1
off ON
```

4. Press **ENTER**. **Output Relay #1** will energize. The following is displayed:

```
RELAY NUMBER
      1
```

5. Choose output numbers 2—8 by using the up and down arrow buttons to turn all relays or outputs to the energized or **ON** position. When each output is turned on, the appropriate **OUTPUT** LED turns on and stays on.

6. Use the DMM to verify the position of the output contacts in the "operate" or **ON** position. The readings should be the opposite of the initial reading above. All outputs should be returned to their initial de-energized or **OFF** positions. The **OUTPUT** LEDs will extinguish when each output is turned off.

7. If Output Relay testing is complete, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Input Test (Status)

The **INPUT TEST** menu enables the user to determine the status of the individual status inputs.

For units with optional HMI panel:

Each input can be selected by its number using the up and down buttons. The status of the input will then be displayed.

INPUT NUMBER	RETURN TERMINAL	INPUT NUMBER
1 (52b)	11	10
2	11	9
3	11	8
4	11	7
5	11	6
6	11	5

Table 6-3 Input Contacts

1. When **OUTPUT TEST (RELAY)** is displayed press the right arrow to display the following:

```
INPUT TEST
output INPUT led target →
```

2. Press **ENTER**. The following is displayed:

```
INPUT NUMBER
      1
```

3. Press **ENTER**. The following is displayed:

```
INPUT NUMBER 1
CIRCUIT OPEN
```

4. Connect **IN RTN**, terminal #11, to IN1, terminal #10.

5. Alternatively, if the input in step 4 above is being used in this application and external wiring is complete, the actual external status input contact can be manually closed. This will test the input contact operation *and* the external wiring to the input contacts. The following is immediately displayed:

```
INPUT NUMBER 1
CIRCUIT CLOSED
```

6. Disconnect **IN RTN**, terminal #11, from **IN1**, terminal #10. The following is immediately displayed:

```
INPUT NUMBER 1
CIRCUIT OPEN
```

7. Press **ENTER**. The following is displayed:

```
INPUT NUMBER
      1
```

8. Use the up button to go to the next input. Repeat the procedure using the contacts as shown in Table 6-3: Input Contacts.

9. When finished, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Status LED Test

The **STATUS LED TEST** menu enables the user to check the front panel LED's Individually.

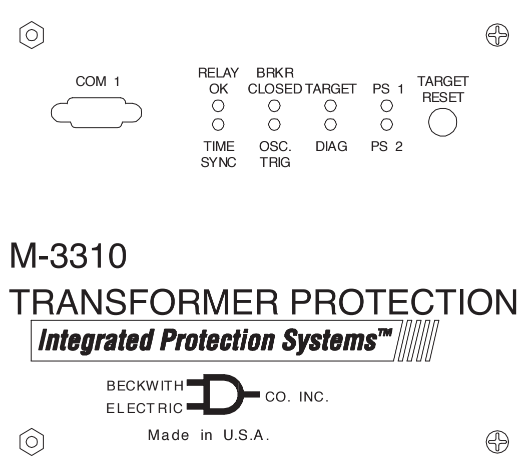


Figure 6-1 Status LED Panel

For units with the optional HMI panel:

1. When **INPUT TESTS (STATUS)** is displayed, press the right arrow button until the following is displayed:

```
STATUS LED TEST
output input LED target →
```

2. Press **ENTER**. LED #1, **RELAY OK**, illuminates and the following is displayed:

```
STATUS LED TEST
LED NUMBER 1 = ON
```

3. Repeat step 2 for each of the 5 remaining LED's shown in Figure 6-1. The PS1 and PS2 LED's are not subject to this test.
4. When **STATUS LED** testing is complete, press **EXIT** to return to **DIAGNOSTIC MODE**.

Target LED Test

■ **NOTE:** This test is not applicable to units that are not equipped with the M-3910 Target Module.

The **TARGET LED TEST** menu allows the user to check the M-3910 Target Module LED's individually.

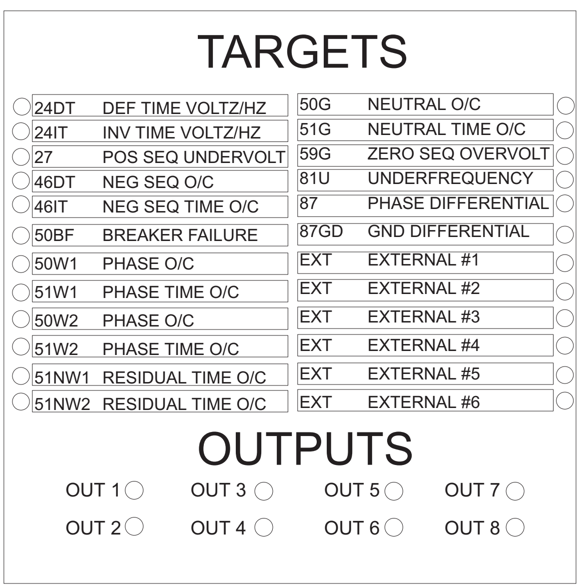


Figure 6-2 M-3910 Target Module

For units with the optional HMI panel:

1. When **STATUS LED TEST** is displayed, press the right button until the following is displayed:

```
TARGET LED TEST
output input LED target →
```

2. Press **ENTER**. Target LED #1, **24DT DEF TIME VOLTS/HZ**, illuminates and the following is displayed:

```
TARGET LED TEST
LED NUMBER 1 = ON
```

3. Repeat step 2 for each of the remaining target and output LED's shown in Figure 6-2.
4. When **TARGET LED** testing is complete, press **EXIT** to return to **DIAGNOSTIC MODE**.

Expanded I/O Test

(This function is not implemented at this time.)

Button Test

■ **NOTE:** This test is only applicable to units that are equipped with the M-3931 HMI Module.

The **BUTTON TEST** menu selection allows the user to check the M-3931 HMI Module Keypad. As each button is pressed, its name is displayed.

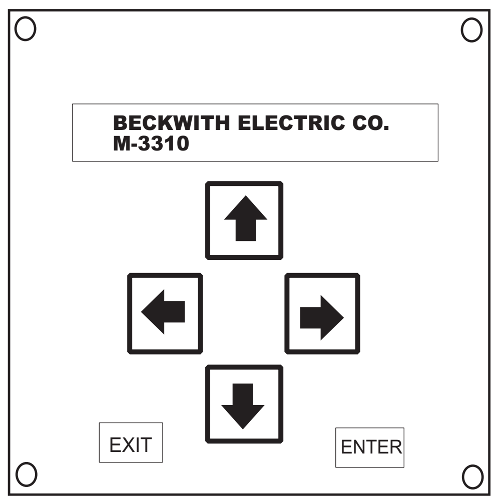


Figure 6-3 M-3931 Human-Machine Interface Module

1. When the **TARGET LED TEST** is displayed, press the right button until the following is displayed:

```
BUTTON TEST
← ex_io BUTTON disp →
```

2. Press and hold **ENTER**. The following is displayed:

```
BUTTON TEST
ENTER
```

3. Release **ENTER**. The following is displayed:

```
BUTTON TEST
     0
```

4. Repeat this test for each of the buttons on the keypad and the **TARGET RESET** button.

■ **NOTE:** Do not press the **EXIT** button until otherwise instructed. Pressing this button will terminate this test and return to **DIAGNOSTIC MODE** menu. Notice the word **EXIT** is displayed temporarily before the test sequence is terminated.

Display Test

■ **NOTE:** This test is only applicable to units that are equipped with the M-3931 HMI Module.

The **DISPLAY TEST** menu selection enables the user to check the alphanumeric display. This test cycles through varying test patterns until the **EXIT** button is pressed.

1. When **BUTTON TEST** is displayed, press the right arrow button until the following is displayed:

```
SCREEN TEST
← ex_io button DISP →
```

2. Press **ENTER**. The unit will display a sequence of test characters until the **EXIT** button is pressed.
3. After the test has cycled completely through the characters, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Communication Tests

■ **NOTE:** These tests are only applicable to units that are equipped with the M-3931 HMI Module.

COM1 and COM2 Test

The **COM1** and **COM2 LOOPBACK TESTS** allow the user to test the front and rear RS-232C ports for proper operation. These tests require the use of a loop-back plug (see Figure 6-4).

The loop-back plug consists of a DB9P connector, with pin 2 connected to pin 3 and pin 7 connected to pin 8.

Figure 6-4 COM1/COM2 Loopback Plug

1. When **DISPLAY TEST** is displayed, press the right arrow button until the following is displayed:

```
COM1 LOOPBACK TEST
← COM1 com2 com3 com3 →
```

2. Press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
CONNECT LOOPBACK PLUG
```

3. Connect the loopback plug to **COM1**.
4. Press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
19200 PASS...
```

5. Press **ENTER** to test each of the baud rates. When all baud rates have been tested, press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
-DONE-
```

6. Press the right arrow until the following is displayed:

```
COM2 LOOPBACK TEST
← com1 COM2 com3 com3 →
```

7. Repeat steps 2-5 to test **COM2**.

COM3 Test (2-Wire)

The **COM3 ECHO TEST 2WIRE** allows the user to test the RS-485 rear terminal connections for proper operation.

■ **NOTE:** This test requires a PC with an RS-485 converter and terminal emulator software installed.

1. When **COM3 LOOPBACK TEST 4WIRE** is displayed, press the right arrow button until the following is displayed:

```
COM3 ECHO TEST 2WIRE
← com1 com2 com3 COM3 →
```

2. Press **ENTER**. The following is displayed:

```
COM3 ECHO TEST 2WIRE
IDLING....9600, N, 8, 1
```

3. On the rear of the unit, connect a PC to the relay at terminals 3 (-) and 4 (+) via RS-485 converter set for 2 wire operation. See Figure 6-5 for diagram.

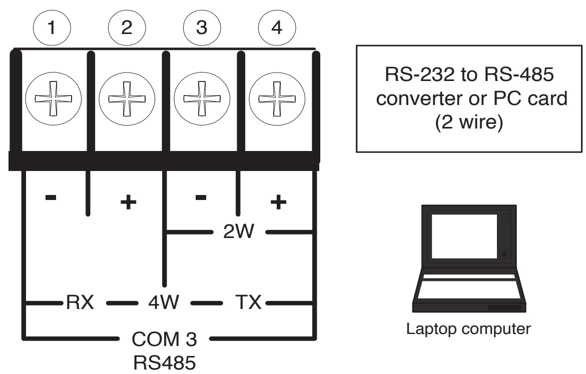


Figure 6-5 RS-485 2-Wire Testing

4. Set the following PC communications parameters:

Baud Rate	9600
Parity	None
Data Bits	8
Stop Bits	1
Duplex	Half

5. Open the terminal emulator program on the PC and open the COM port for the RS-485 converter.
6. Press a key on the PC keyboard. Verify that the character pressed shows temporarily on the display of the relay and appears on the PC monitor.
7. When communications has been verified, press **EXIT**. The following is displayed:

```
COM3 ECHO TEST 2WIRE
-DONE-
```

8. Close the COM port on the PC and exit the terminal emulator program.

COM3 Test (4-Wire)

■ **NOTE:** This test is only applicable to units that have the RS-485 4-Wire option installed.

The **COM3 LOOPBACK TEST 4WIRE** allows the user to test the RS-485 rear terminal connections for proper operation.

1. When **DISPLAY TEST** is displayed, press the right button until the following is displayed:

```
COM3 LOOPBACK TEST 4WIRE
← com1 com2 COM3 com →
```

2. Press **ENTER**. The following is displayed:

```
COM3 LOOPBACK TEST 4 WIRE
CONNECT LOOPBACK PLUG
```

3. On the rear of the unit, connect a jumper from terminal 1 to terminal 3 and from terminal 2 to terminal 4. See Figure 6-6 for diagram.

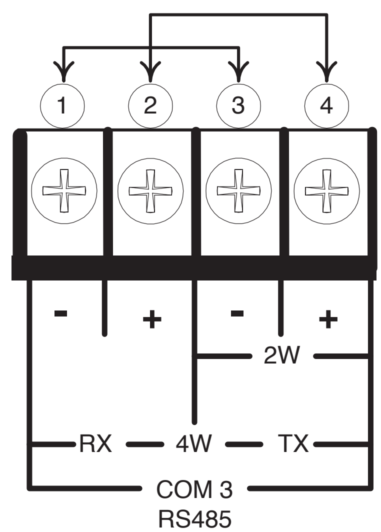


Figure 6-6 RS-485 4-Wire Testing

4. Press **ENTER**. The following is displayed:

```
COM3 LOOPBACK TEST
19200 PASS...
```

5. Press **ENTER** to test each of the baud rates. When all baud rates have been tested, press **ENTER**. The following is displayed:

```
COM3 LOOPBACK TEST
-DONE-
```

Clock Test

1. When **COM3 ECHO TEST 4WIRE** is displayed, press the right arrow button until the following is displayed:

```
CLOCK TEST
← CLOCK led cal factory
```

2. Press **ENTER**. A display similar to the following is shown:

```
CLOCK TEST
03-JAN-1998 09:00:00.000
```

3. Press **ENTER** again to toggle the clock. If the clock is running, it will stop. If clock has stopped, it will start. The clock stop case is shown below.

```
CLOCK TEST
-CLOCK START-
```

4. Press **ENTER** and verify the relay clock is running. A display similar to the following is shown with the seconds counting:

```
CLOCK TEST
03-JAN-1998 09:0035.000
```

5. Press **ENTER** again to stop the clock. The following is displayed:

```
CLOCK TEST
-CLOCK STOP-
```

6. Press **ENTER** and verify the relay clock is stopped. A display similar to the following is shown with the seconds stopped:

```
CLOCK TEST
03-JAN-09:01:80.000
```

■ **NOTE:** When the relay clock is stopped, the seconds will be displayed as 80.

7. Repeat steps 2 and 3 to restart the clock.

■ **NOTE**: If the unit is removed from service or is to be without power for long periods of time, the clock should be stopped to preserve battery life.

Flash Relay OK LED

The **Flash Relay OK LED** function is provided to enabled or disable the flashing of the **Relay OK LED**. This function only has effect while the relay is in normal operating mode and will not be noticed while in **Diagnostic Mode**.

The operation of this function may be tested by completing the following steps:

1. When **CLOCK TEST** is displayed, press the right arrow button until the following is displayed:

```
FLASH RELAY OK LED
← clock LED cal factory
```

2. Press **ENTER**. The following is displayed:

```
FLASH RELAY OK LED
off    ON
```

■ **NOTE:** Please be advised that programming the OK LED to remain on indefinitely is not recommended. It is possible that the LED OK would remain lit even if the relay failed.

Factory Use Only

This function is provided to allow access by factory personnel.

```
FACTORY USE ONLY
← clock led cal FACTORY
```

6.3 Automatic Calibration

The M-3310 Transformer Protection Relay has been fully calibrated at the factory. There is no need to recalibrate the unit prior to installation. Recalibration is only necessary if a component is changed.

For units with the optional M-3931 HMI:

⬣ **WARNING: All relay functions and protection will be inoperative while the relay is in Diagnostic Mode.**

1. Navigate to the **Auto Calibration** function in the **Diagnostic Mode** menu. The following is displayed:

```
AUTO CALIBRATION
← clock led CAL factory
```

2. Press **ENTER**. The following is displayed:

```
CONNECT REFERENCE INPUTS
PRESS ENTER TO CALIBRATE
```

3. Connect all voltage inputs in parallel (V_A= V_B=V_C= V_N) and apply 120.00 (±0.01) VAC ∠0°. See Figure 6-7.
4. Connect all current inputs in series (I_AW_1=I_BW_1=I_CW_1=I_NW_2=I_aW_2=I_bW_2=I_cW_2) and apply 5.00 (±0.01) Amps ∠0°. See Figure 6-8. For 1 Amp CT models, use 1.0 (±0.01) Amps ∠0°.
5. Press **ENTER** to start calibration. This process takes less than 5 seconds. The unit will display the following while the automatic calibration is in progress:

```
AUTO CALIBRATION
-WAIT-
```

6. When the unit has completed calibration, the following will be displayed:

```
AUTO CALIBRATION
-DONE-
```

7. The calibration can be checked by using the **Monitor Status** menu, see Section 3.3, **Checkout Status & Metering**.

For units without the optional M-3931 HMI:

It is possible to autocalibrate M-3310 units that are not equipped with the optional M-3931 HMI. The procedure is similar to HMI equipped units:

1. Power down unit.
2. Refer to Figure 6-8 and place unit in calibrate mode by configuring the proper dip switches.
3. Connect all voltage inputs in parallel.
4. Connect all current inputs in series.
5. Power up unit.
6. **DIAG** LED will light when operation is complete.
7. Power down unit and return dip switches to RUM position.

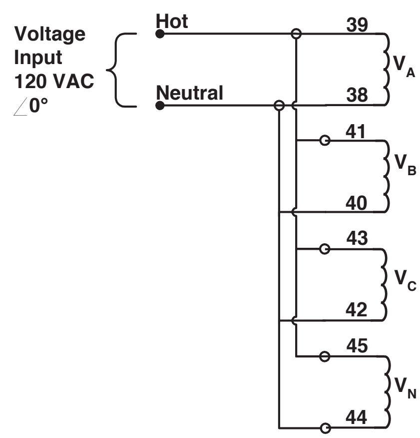


Figure 6-7 Voltage Calibration Configuration

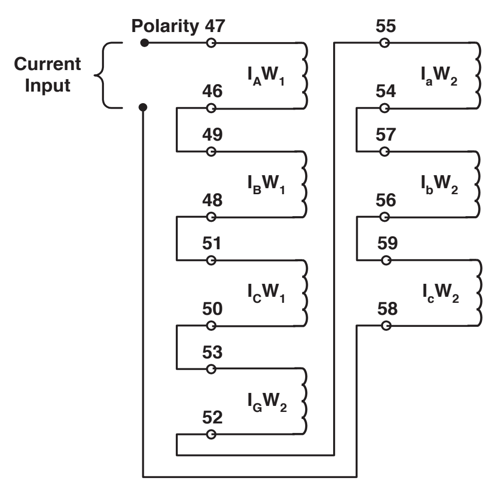


Figure 6-8 Current Calibration Configuration

6.4 Input Configurations

The phase angles shown here represent leading angles as positive and lagging angles as negative. Some manufacturers of test equipment use lagging angles as positive, in which case V_B=120 Vac∠120° and V_C=120 Vac ∠240°. Other voltage and current phase angles should be adjusted in the same manner.

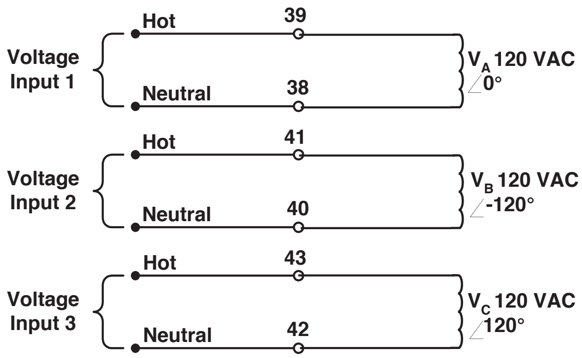


Figure 6-9 Voltage Inputs, Configuration V1

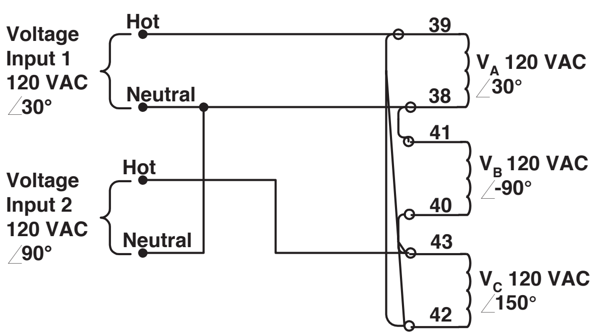


Figure 6-10 Voltage Inputs, Configuration V2

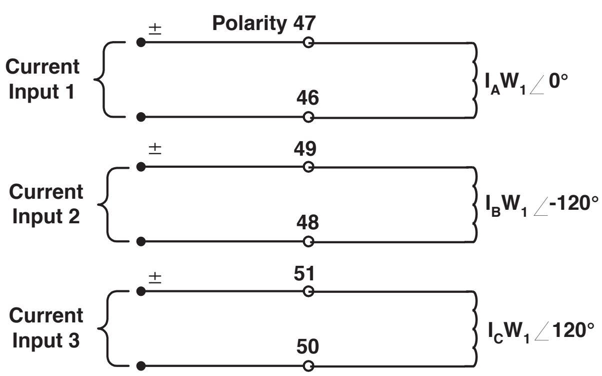


Figure 6-11 Current Inputs, Configuration C1

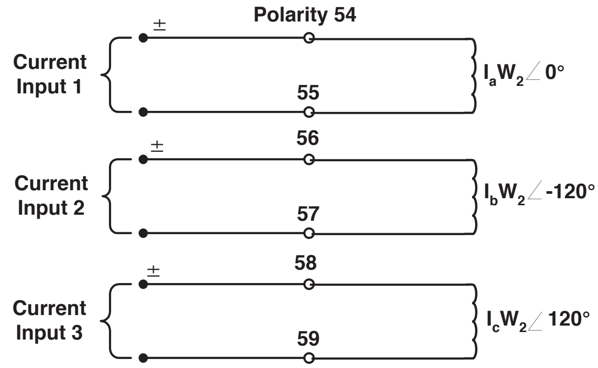


Figure 6-12 Current Inputs, Configuration C2

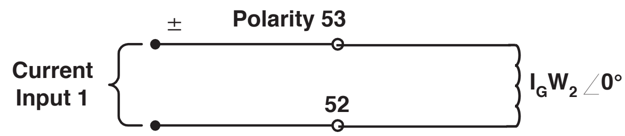


Figure 6-13 Current Inputs, Configuration C3

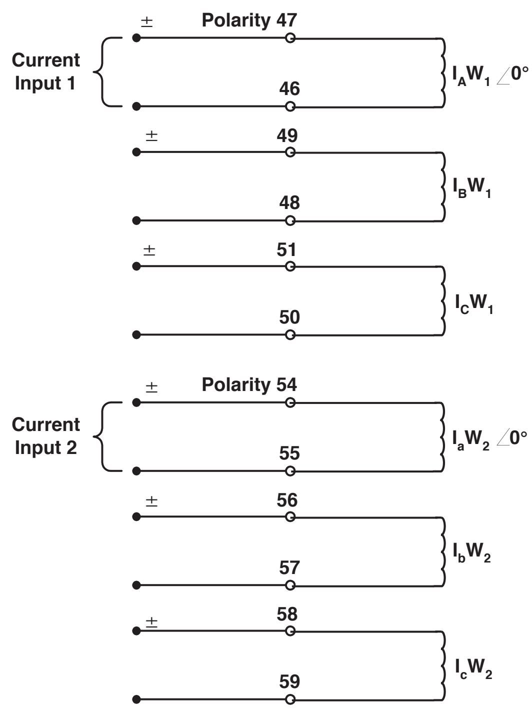


Figure 6-14 Current Inputs, Configuration C4

6.5 Functional Test Procedures

This section details the test quantities, inputs and procedures for testing each function of the relay. The purpose is to confirm the function's designated output operation, the accuracy of the magnitude pickup settings, and the accuracy of time delay settings. Whereas the first test described, "**Power On Self Test,**" does not require electrical quantity inputs, all other functional tests require inputs, and the necessary connection configurations as specified in the test procedure.

In all test descriptions, a process for calculating input quantities to test the actual settings of the function will be given if needed. In many test cases, it will be necessary to disable other functions not being tested at the time. This action is to prevent the operation of multiple functions with one set of input quantities that could cause confusion of operation of outputs or timers. The complete description of the method to disable or enable functions may be found in detail in Section 3.2, **Configure Relay Data** or Chapter 4, **Operation (Computer)**. The complete description of the method to install setting quantities is found in detail in Section 3.2, **Setpoints and Time Settings**.

It is desirable to ***record and confirm*** the actual settings of the individual functions before beginning test procedures. Use the **FUNCTIONAL CONFIGURATION RECORD FORM** and the **SETPOINT AND TIMING RECORD FORM** found in Appendix A for recording settings.

The tests are described in this section in ascending function number order as in Chapter 2, **Application**. Depending on which functions are to be tested at a given time, an order may be determined with the aid of Table 6-1, **Functions to Disable When Testing**. This may result in fewer changes in connections and disable and enable operations.

During the lifetime of the M-3310 Transformer Protection relay, testing of individual functions due to changes in application settings will be more likely than an overall testing routine. An index of the individual test procedures is illustrated at the beginning of this chapter.

■ **NOTE*:*** Care must be taken to reset or re-enable any functions that have been changed from the intended application settings when the test procedures are complete. When a function is re-enabled, both output arrangements and blocking input designations must be reestablished.

It may be desirable to program all test settings in an alternate profile, or to save the relay settings in IPScom® to preserve a desired setup.

Many options for test sequences and methods are possible. As an example, the operation of the output contacts can be tested along with the operation of the LED's in the Diagnostic Test Procedures. The operation of the output contacts may also be confirmed with the LED and function operation during **Functional Test Procedures**, Section 6.5, if desired.

If timer quantities are to be checked, the timer must be activated by the appropriate output contacts. The contact pin numbers are enumerated in Table 6-2 , **Output Contacts**.

It is suggested that copies of the following be made for easy referral during test procedures:

- Input Configurations - page 6-10
- Output Test (Relay)- page 6-3
- Relay Configuration Table - page A-2
- Setpoint & Time Record Form - pages A-8, 9

24DT Volts Per Hertz Definite Time (#1 or #2)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:	Definite Time # Pickup	P %	(100 to 200)
	Time Delay	**D**	**(30 to 8160)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 24DT #1 or 2[1]	**Disable**	
	Function 24IT	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect voltage input in Configuration V1 designated previously. Refer to Section 6.4, **Input Configurations,** for configurations.
4. The volts/Hz pickup level at a percentage setting of nominal frequency (50 or 60Hz) is Definite Time Pickup **P** % ÷ 100 times **Nominal Voltage**, see example below. The Nominal Values have been programmed in the system setup data described in Section 2.2, **Configuration,** and are recorded on the **COMMUNICATION & UNIT SETUP RECORD FORM**. Test voltage levels may be at any percentage of Nominal Voltage. Choose 4 or 5 test levels and calculate the voltage level for each.

150% V/Hz	÷ 100	x 120	=180 volts
Pickup (**P**) setting	divided by 100	times **Nominal Voltage**	equals voltage level

5. *Voltage Pickup Test*:
   - Apply voltage to phase A of the relay at a level 10% lower than pickup level calculated in step 4.
   - Hold the **TARGET RESET** button in and slowly increase the voltage on phase A until the **24DT DEF TIME VOLTS/HZ** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** ±1%.
   - Release the **TARGET RESET** button and decrease phase A voltage to 10% below the pickup voltage and the **OUTPUT** LED will extinguish.
   - Press the **TARGET RESET** button to remove targets. This test may be repeated for each of the other 2 phase voltages.

6. *Frequency Pickup Test:*
   - Apply voltage to phase A of the relay at the Nominal Voltage level.
   - Hold the **TARGET RESET** button in and slowly decrease the frequency of phase A until **the 24DT DEF TIME VOLTS/HZ** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** ±1%.
   - Release the **TARGET RESET** button and increase phase A frequency to 1% above the pickup frequency and the **OUTPUT** LED will extinguish.
   - Press the **TARGET RESET** button to remove targets. This test may be repeated for each of the other 2 phases.

60	÷ 150% V/Hz	X 100	=40Hz
Nominal Frequency	Pickup (**P**) setting	times 100	equals frequency level

7. *Timer Test:* With output contacts connected to the timer, apply the calculated voltage from step 4 on phase A and start timing. The operating time will be **D** cycles within +25 cycles. Repeat this step for all test levels chosen. The tested points verify the operation of the function.
8. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Only the function being tested should be enabled; the other should be disabled.

24IT Volts Per Hertz Inverse Time

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:			
	Inverse Time Pickup	P %	(100 to 150)
	Inverse Time Curve	**C**	**(1 to 4)**
	Time Dial	**TD**	**(1 to 100)**
	Reset Rate	**R**	**(1-999)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 24DT#1 & 2	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect voltage input in Configuration V1 designated previously. Refer to Section 6.4, **Input Configurations,** for configurations.
4. The volts/Hz pickup level at a percentage setting of nominal frequency (50 or 60Hz) is Definite Time Pickup **P** % ÷ 100 times **Nominal Voltage** (see example below). The Nominal Values have been programmed in the system setup data described in Section 2.2, **Configuration,** and are recorded on the **COMMUNICATION & UNIT SETUP RECORD FORM**.

150% V/Hz	÷ 100	x 120	=180 volts
Pickup (**P**) setting	divided by100	times **Nominal Voltage**	equals voltage level

5. Test voltage levels may be at any percentage of Nominal Voltage that are a minimum of 5% higher than the selected pickup percentage, **P** %. It is suggested that 4 or 5 test levels be chosen and voltage level and operating time be calculated for each from the table below.
6. *Time Test*: With output contacts connected to the timer, apply the calculated voltage from step 4 on phase A and start timing. Operating time will be as calculated in step 5, ***<u>±1%.</u>*** Repeat this step for all chosen test levels. The curve portion extending lower than **P**% V/Hz values is inactive and can be ignored.

$t=\dfrac{.003*K}{\left(\left(\dfrac{M}{100}\right)-1\right)^2}$	$t=e^\wedge \dfrac{115+(2.5xTD)=V/Hz}{4.8858}$	$t=e^\wedge \dfrac{113.5+(2.5xTD)=V/Hz}{3.04}$	$t=e^\wedge \dfrac{108.75+(2.5xTD)=V/Hz}{2.4429}$
Curve 1	***Curve 2***	***Curve 3***	***Curve 4***

t = time in minutes TD = Time Dial setting V/Hz in percent (%)

7. *Reset Rate Test:* To test the reset rate, begin timing when the input voltage is reduced below pickup value. Holding the **TARGET RESET** button in, stop timing when **24IT INV. TIME VOLTS/HZ** LED extinguishes. The time will be the Reset Rate (**R**) within ±3 cycles or ±1%.
8. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

■ **NOTE**: If re-testing is required, the unit should be powered down or wait the duration of the programmed Reset of the timer.

27 Positive Sequence Undervoltage

VOLTAGE INPUTS:	Configuration V1		
CURRENT INPUTS:	None		
TEST SETTINGS:	Undervoltage Pickup	P volts	(5 to 140)
	Undervoltage Inhibit	**U volts**	**(5 to 140)**
	Time Delay	**D cycles**	**(1 to 8160)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 81U	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Be sure the Undervoltage Inhibit is set to a lower value than the Undervoltage Pickup to prevent the function from being disabled.
3. Connect voltage input in Configuration V1 designated previously. Refer to Section 6.4, **Input Configurations,** for configurations.
4. Set 3-phase Voltage Inputs at 1.2 x **P** volts at the Nominal Frequency.
5. *Pickup Test:*
   - Hold the **TARGET RESET** button in and slowly decrease 3-phase voltages until the **27 POS SEQ. UNDERVOLT** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** volts ±0.5V or ±5%.
   - Release the **TARGET RESET** button and increase the 3-phase voltages to 1.2 x **P** volts and the **OUTPUT** LED will extinguish.
   - Press **TARGET RESET** button to remove targets.
6. *Undervoltage Inhibit Test*: Slowly decrease the 3-phase voltages until the **27 POS SEQ. UNDERVOLT** LED extinguishes. The level will be **U** volts ±0.5 volts. Steps 6 and 7 may be repeated for each of the other 2 phase voltages.
7. *Time Test*: With output contacts connected to the timer, reduce phase voltages to approximately 50% of **P** volts and start timing. The operating time will be **D** cycles within –1 or +3 cycles or ±1%. Repeat to step 6 if Undervoltage Inhibit testing is desired.
8. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

46DT Negative Sequence Overcurrent Definite Time

VOLTAGE INPUTS:	None		
CURRENT INPUTS:	Configuration C1 (MODIFIED)		
TEST SETTINGS:	Definite Time Pickup	P Amps	(0.1 to 20)
	1 Amp CT Rating		**(0.02 to 4)**
	Time Delay	**D cycles**	**(1 to 8160)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 46 Inverse Time	**Disable**	
	Function 50W2 #1 & #2	**Disable**	
	Function 51W2	**Disable**	
	Function 87H	**Disable**	
	Function 87T	**Disable**	
	Function 87GD	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect inputs in Configuration C1 (MODIFIED) designated previously. Refer to Section 6.4, **Input Configurations** for configurations. The modification to C1 is to exchange Current source 2 and 3 connections. Configuration will be Phase B current from source 3 and Phase C current from source 2.

■ **NOTE**: For proper testing use current below 3 times CT rating.

4. *Pickup Test:*
   - Hold the **TARGET RESET** button in and slowly increase the 3-phase currents until the **NEG. SEQ. O/C** LED illuminates or the pickup indicator operates on the computer screen The level of operation will be equal to Pickup Current **P** ±0.1 Amp or ±3% whichever is higher.
   - Release the **TARGET RESET** button and decrease the 3-phase currents to a level below the Pickup Current **P** and the **OUTPUT** LED will extinguish.
   - Press the **TARGET RESET** button to remove targets.
5. *Time Test*: With output contacts connected to the timer, apply 3-phase current at least 1.1 times **P** and start timing. The operating time will be **D** cycles within –1 or +3 cycles or ±1%. Reduce input currents to 0 Amps
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

46IT Negative Sequence Overcurrent Inverse Time

VOLTAGE INPUTS:	None		
CURRENT INPUTS:	Configuration C1 (MODIFIED)		
TEST SETTINGS:	Inverse Time Pickup	P Amps	(0.5 to 5)
	1 Amp CT Rating		**(0.1 to 1)**
	Standard Inverse Time Curves:[2]		
	Curve	**C**	**(1-4)**
	Time Dial	**TD**	**(0.5 to 11)**
	IEC Inverse Time Curves:[1]		
	IEC Curve	**C**	**(5-8)**
	IEC Time Dial	**TD**	**(0.05 to 1.1)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 46 Inverse Time	**Disable**	
	Function 50W2 #1 & #2	**Disable**	
	Function 51W2	**Disable**	
	Function 87H, 87T, 87GD	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect inputs in Configuration C1 (MODIFIED) designated previously. Refer to Section 6.4, **Input Configurations** for configurations. The modification to C1 is to exchange Current source 2 and 3 connections. Configuration will be Phase B current from source 3, and Phase C current from source 2.

■ **NOTE**: For proper testing use current below 3 times CT rating.

4. *IEC Curve Testing*: Test current level may be chosen as a multiple of any level within the Pickup (**P**) range. Calculate the operating time for the applied current and appropriate Time Dial (**TD**) setting from the table below. Choose 4 or 5 test levels and calculate the operating times for each.

   Standard Curve Testing: The operating time will be read from Appendix D, Negative Sequence Current Inverse Time Curves for the applied current and appropriate Time Dial (**TD**) setting. The curve portions extending to lower than **P** current values are inactive and can be ignored.

5. *Time Test:* With output contacts connected to the timer, apply currents equal to the multiple of the Inverse Time Pickup (**P**) chosen in Step 4, and start timing. The operating time will be as calculated in step 4, ±3 cycles or ±5%.

IEC Standard Inverse	IEC Very Inverse	IEC Extremely Inverse	IEC Long Time Inverse
$t=TD \times \left[\frac{0.14}{M^{0.02}-1}\right]$	$t=TD \times \left[\frac{13.5}{M-1}\right]$	$t=TD \times \left[\frac{80}{M^{2}-1}\right]$	$t=TD \times \left[\frac{120}{M-1}\right]$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Either a Standard Curve or an IEC Curve must be selected.

50BF/50BFN Breaker Failure

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C2 (Modified)

TEST SETTINGS:	50BF-Phase Pickup	P Amps	(0.1 to 10)
	1 Amp CT Rating		**(0.02 to 2)**
	50BF Neutral Pickup	**N Amps**	**(0.1 to 10)**
	1 Amp CT Rating		**(0.02 to 2)**
	Time Delay	**D cycles**	**(1 to 8160)**
	50BF Input Initiate	**IN**	**(1 to 6)**
	50BF Output Initiate	**OUT**	**(1 to 8)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 50W2	**Disable**	
	Function 51W2	**Disable**	
	Function 87H, 87T, 87GD	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect inputs in Configuration C2 designated previously. Refer to Section 6.4, **Input Configurations**, for configurations.

■ **NOTE:** For proper testing use current below 3 times CT rating.

4. Select an input for 50BF Input Initiate (**IN**) and enter the number. Place a jumper from **TB11** (RTN) to the selected Input (**IN**) on the rear of the unit. Make sure that all Output Initiates (**OUT**) are disabled.
5. *Phase Pickup Test:*
   - Hold the **TARGET RESET** button in and slowly increase 3-phase current until the **50BF BREAKER FAILURE** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** Amps ±0.1 Amps or ±2%.
   - Release the **TARGET RESET** button and decrease the 3-phase current and the **OUTPUT** LED's extinguish.
   - Press **TARGET RESET** button to remove targets.
6. *Neutral Pickup Test (Residual Current)*:
   - Set the F50BF neutral to a higher value than the phase pickup to prevent the F50BF phase from tripping.
   - Connect the inputs in configuration C2 (modified), designated previously. The modification to C2 is to set all three currents to phase angle $\angle 0°$. In this configuration, the applied value of I_N is equal to the applied 3-phase currents.
   - Hold the **TARGET RESET** button in and slowly increase winding 2 currents until the **50BF BREAKER FAILURE** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be (**P**) Amps, ±0.1 Amps or ±2%
   - Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish.
   - Press **TARGET RESET** button to remove targets.

■ **NOTE:** It is important to remember when calculating values for residual current functions that phase levels must be added together. For example: $3I_0 = I_A + I_B + I_C$ must be used to calculate pickup level.

7. *Timer Test*[1]*:* With output contacts (**Z**) connected to the timer, input approximately 110% of 50BF Phase Pickup (**P**) Amps and start timing. The operating time will be **D** cycles within –1 or +3 cycles or ±2%. Reduce input currents to 0 Amps.
8. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1] Both the 50BF Phase and Neutral functions use the same timer, therefore, it is necessary only to perform this test once.

50 Instantaneous Phase Overcurrent Winding 1 (#1 or #2)

VOLTAGE INPUTS:	None		
CURRENT INPUTS:	Configuration C1		
TEST SETTINGS:	50W1 Pickup	P Amps	(1 to 100)
	1 Amp CT Rating		**(0.2 to 20)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 50BF		**Disable**
	Function 50 W1 #1 or 2[4]		**Disable**
	Function 51W1		**Disable**
	Function 87H, 87T, 87GD		**Disable**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect inputs in Configuration C1 designated previously. Refer to Section 6.4, **Input Configurations**, for configurations.

■ **NOTE:** Special attention must be taken as to which winding is being tested and which winding is disabled when changing setpoints.

4. *Pickup Test*:
   - Hold the **TARGET RESET** button in and slowly increase the Phase A current until the **50W1 PHASE O/C** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** Amps ±0.1 A or ±2%.
   - Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish.
   - Press **TARGET RESET** button to remove targets. This test may be repeated for each of the other phases. The second 50 function may also be tested in the same manner.
5. *Time Test*: With output contact (**Z**) connected to the timer, apply current 5% above pickup (**P**) and start timing. The operating time will be under 2 cycles.
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Only the winding being tested should be enabled; the other should be disabled.

50 Instantaneous Phase Overcurrent Winding 2 (#1 or #2)

VOLTAGE INPUTS:	None		
CURRENT INPUTS:	Configuration C2		
TEST SETTINGS:	50W2 Pickup	P Amps	(1 to 100)
	1 Amp CT Rating		**(0.2 to 20)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 50BF		**Disable**
	Function 50 W2#1 or 2[5]		**Disable**
	Function 51W2		**Disable**
	Function 87H, 87T, 87GD		**Disable**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect inputs in Configuration C2 designated previously. Refer to Section 6.4, **Input Configurations**, for configurations.

■ **NOTE:** Special attention must be paid as to which winding is being tested and which winding is disabled when changing setpoints.

4. *Pickup Test:*
   - Hold the **TARGET RESET** button in and slowly increase the Phase A current until the **50W2 PHASE O/C** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** Amps ±0.1A or ±2%.
   - Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish.
   - Press **TARGET RESET** button to remove targets. This test may be repeated for each of the other phases. The 2nd 50 function may also be tested in the same manner.
5. *Time Test:* With output contact (**Z**) connected to the timer, apply current 5% above pickup (**P**) and start timing. The operating time will be under 2 cycles.
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Only the winding being tested should be enabled; the other should be disabled.

50G Instantaneous Ground Overcurrent

VOLTAGE INPUTS:	None		
CURRENT INPUTS:	Configuration C3		
TEST SETTINGS:	50G Pickup	P Amps	(1 to 100)
	1 Amp CT Rating		**(0.2 to 20)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 50BF		**Disable**
	Function 51G		**Disable**
	Function 51NW2		**Disable**
	Function 87GD		**Disable**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect the inputs in Configuration C3 designated previously. Refer to Section 6.4, **Input Configurations**, for configurations. The other current phases remain disconnected.
4. *Pickup Test:*
   - Hold the **TARGET RESET** button in and slowly increase the Neutral current until the **50G NEUTRAL O/C** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** Amps ±0.1A or ±3%.
   - Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish.
   - Press **TARGET RESET** button to remove targets.
5. *Time Test:* With output contact (**Z**) connected to the timer, apply current 5% above pickup (**P**) and start timing. The operating time will be under 2 cycles.
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

51 Phase Time Overcurrent (Winding 1 or 2)

VOLTAGE INPUTS: None

CURRENT INPUTS: C1 or C2

TEST SETTINGS:	**51W Pickup**	**P Amps**	**(0.5 to 12)**
	1 Amp CT Rating		**(0.1 to 2.4)**
	Standard Inverse Time Curves:[2]		
	Curve	**C**	**(1-4)**
	Time Dial	**TD**	**(.5 to 11)**
	IEC Inverse Time Curves:[2] **(inverse/very inverse/extremely inverse/long time inverse)**		
	IEC Curve	**C**	
	IEC Time Dial	**TD**	**(.05 to 1.1)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 50BF		**Disable**
	Function 51W1 or W2[1]		**Disable**
	Function 51NW1 or W2[1]		**Disable**
	Function 87		**Disable**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect current inputs in Configuration C1 or C2 designated previously. When connecting current inputs use Configuration C1 for Winding 1, and C2 for Winding 2. See Section 6.4, **Input Configurations**, for configurations.

■ **NOTE**: Special Attention must be paid as to which winding is being tested and which winding is disabled.

4. Refer to Appendix D and Table 6-4. Calculate test times for levels represented on the graphs. It is suggested that 4 or 5 test levels be chosen.
5. *Time Test:* With output contacts connected to the timer, apply input current used in calculations from step 4 and start timing. The operating time will be ±3 cycles or 3% of calculated time. Repeat this step for each test level chosen. The tested points verify the operation of this function.

IEC Standard Inverse	IEC Very Inverse	IEC Extremely Inverse	IEC Long Time Inverse
$t=TD \times \left[\frac{0.14}{M^{0.02} - 1}\right]$	$t=TD \times \left[\frac{13.5}{M - 1}\right]$	$t=TD \times \left[\frac{80}{M^{2} - 1}\right]$	$t=TD \times \left[\frac{120}{M - 1}\right]$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Only the winding being tested should be enabled; the other should be disabled.
[2]Either a Standard Curve or an IEC Curve must be selected.

51G Inverse Time Neutral Overcurrent

VOLTAGE INPUTS:	None		
CURRENT INPUTS:	C3		
TEST SETTINGS:	51G Pickup	P Amps	(0.5 to 12.00)
	1 Amp CT Rating		**(0.1 to 2.4)**
	Standard Inverse Time Curves:[1]		
	Curve	**C**	**(1-4**
	Time Dial	**TD**	**(.5 to 11)**
	IEC Inverse Time Curves:[1] **(inverse/very inverse/extremely inverse/long time inverse)**		
	IEC Curve	**C**	
	IEC Time Dial	**TD**	**(.05 to 1.1)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 50BF		**Disable**
	Function 50G		**Disable**
	Function 51NW2		**Disable**
	Function 87GD		**Disable**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect current inputs in Configuration C3 designated previously. See Section 6.4, **Input Configurations**, for configurations.
4. Refer to Appendix D and Table 6-5. Calculate test times for levels represented on the graphs. Choose 4 or 5 test levels and calculate test times for each.
5. *Time Test:* With output contacts connected to the timer, apply input current used in calculations from step 4 and start timing. The operating time will be within ±3 cycles or 3% of calculated time. Repeat this step for each test level chosen. The tested points verify the operation of this function.

IEC Standard Inverse	IEC Very Inverse	IEC Extremely Inverse	IEC Long Time Inverse
$t=TD \times \left[\frac{0.14}{M^{0.02} - 1}\right]$	$t=TD \times \left[\frac{13.5}{M - 1}\right]$	$t=TD \times \left[\frac{80}{M^{2} - 1}\right]$	$t=TD \times \left[\frac{120}{M - 1}\right]$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Either a Standard Curve or an IEC Curve must be selected.

51N Inverse Time Residual Overcurrent (Winding 1 or 2)

VOLTAGE INPUTS: None

CURRENT INPUTS: C1 or C2 (Modified)

TEST SETTINGS:

51N W Pickup	**P Amps**	**(0.5 to 6)**
1 Amp CT Rating		**(0.1 to 1.2)**
Standard Inverse Time Curves:[1]		
Curve	**C**	**(1-4)**
Time Dial	**TD**	**(.5 to 11)**
IEC Inverse Time Curves:[1] **(inverse/very inverse/extremely inverse/long time inverse)**		
IEC Curve	**C**	
IEC Time Dial	**TD**	**(.05 to 1.1)**
Programmed Outputs	**Z OUT**	**(1 to 8)**
Function 50BF		**Disable**
Function 51N W1 or 2[2]		**Disable**
Function 87H, 87T, 87GD		**Disable**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect current inputs in Configuration C1 or C2 designated previously. When connecting current inputs use Configuration C1 for Winding 1 and C2 for Winding 2. See Section 6.4, **Input Configurations**, for configurations. The modification to C1 or C2 is to set all three currents to phase angle $\angle 0°$. In this configuration, the applied value of IN is equal to the applied 3-phase currents.

■ **NOTE**: Special Attention must be paid to which winding is being tested and which winding is disabled when changing setpoints.

4. Refer to Appendix D and Table 6-6. Calculate test times for levels represented on the graphs. Choose 4 or 5 test levels and calculate test times for each.

■ **NOTE**: It is important to remember when calculating values for residual current functions that phase levels must be added together. For example, it must be used to calculate pickup time.

5. *Time Test:* With output contacts connected to the timer, apply input current used in calculations from step 4 and start timing. The operating time will be ±3 cycles or 3% of calculated time. Repeat this step for each test level chosen. The tested points verify the operation of this function.

IEC Standard Inverse

$$t=TD \times \left[\frac{0.14}{M^{0.02} - 1}\right]$$

IEC Very Inverse

$$t=TD \times \left[\frac{13.5}{M - 1}\right]$$

IEC Extremely Inverse

$$t=TD \times \left[\frac{80}{M^{2} - 1}\right]$$

IEC Long Time Inverse

$$t=TD \times \left[\frac{120}{M - 1}\right]$$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Either a Standard Curve or an IEC Curve must be selected.
[2] Only the winding being tested should be enabled; the other should be disabled.

59G Neutral RMS Overvoltage

VOLTAGE INPUTS:	**See Below**		
CURRENT INPUTS:	**None**		
TEST SETTINGS:	**59G Pickup**	**P volts**	**(5 to 140)**
	Time Delay	**D cycles**	**(1 to 8160)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedure.
2. Confirm settings to be tested.
3. Connect voltage input to terminal numbers 44 and 45.
4. *Pickup Test:*
   - Hold the **TARGET RESET** button in and slowly increase the input Neutral voltage until **59G NEUTRAL OVERVOLT** LED illuminates or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ± 0.5 V
   - Release the **TARGET RESET** button and decrease the input voltage and the **OUTPUT** LED's will extinguish.
   - Press **TARGET RESET** button to remove targets.
5. *Time Test:* With output contacts being connected to the timer, input **P**+1 Volts and start timing. The contacts will close after **D** cycles within –1 to +3 cycles or 1%.
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

81U Under Frequency (#1, #2, or #3)

VOLTAGE INPUTS:	Configuration V1		
CURRENT INPUTS:	None		
TEST SETTINGS:	81U Pickup (#1,#2,#3)	P Hz	(48.00 to 59.99)
	50 Hz Relay		**(38.00 to 49.99)**
	Time Delay #__	**D cycles**	**(2 to 65,500)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 24DT #1 or #2	**Disable**	
	Function 24IT	**Disable**	
	Function 81 (#1, #2, #3)[1]	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated previously. Refer to Section 6.4, **Input Configurations** for configuration.
4. *Pickup Test:*
   - Set the voltages to the Nominal Frequency. Single-phase frequency sources may be used. ■ **NOTE**: When using single-phase frequency sources, connect the source to one voltage input.
   - Hold the **TARGET RESET** button in and slowly decrease the frequency on the input voltage(s) until the **81U UNDERFREQUENCY** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be equal to **P** Hz ±0.02 Hz above 57 Hz and ±0.1 Hz below 57 Hz.
   - Return to nominal input frequency and the **OUTPUT** LED's will extinguish.
   - Press **TARGET RESET** button to remove targets.
5. *Time Test:* With output contacts being connected to the timer, input **P** - 0.5 Hz and start timing. The operating time will be **D** cycles within –1 to +3 cycles or ±1%.
6. Complete the testing for the remaining 81 functions by repeating steps 4 and 5, above.
7. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1] Only the function being tested should be enabled; the other should be disabled.

87H Phase Differential Unrestrained High Set Overcurrent

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C4

TEST SETTINGS:	**Pickup**	**P pu**	**(5.0 to 20.0)**
	Time Delay	**D cycles**	**(1 to 8160)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 46	**Disable**	
	Function 50BF	**Disable**	
	Function 87T	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration C4 as designated previously. Refer to Section 6.4, **Input Configurations** for configuration. For testing purposes it is recommended that the CT Tap Corrections, **CT1** and **CT2**, be set to 1.0. If it is desired to test with other CT Tap settings, the current values must be computed by using the following formulas:

   I_AW_1 (Applied) = I_AW_1 (Calculated) multiplied by CT1.

   I_AW_2 (Applied) = I_AW_2 (Calculated) multiplied by CT2.

■ **NOTE:** It is also important to remember that all values used for this function are measured in *pu*'s. This requires calculating the actual current in Amps to be used for testing: 1 pu = CT Tap.

4. *Minimum Pickup Test:*
   - Set I_AW_1 = 0 Amps (input 1).
   - Hold the **TARGET RESET** button in and slowly increase I_AW_1 (input 2) until the **87 PHASE DIFFERENTIAL** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be equal to **P** pu's ±0.1 pu or ±3%.
   - Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish.
   - Press **TARGET RESET** button to remove targets. This test may be repeated for testing the opposite winding or another phase.
5. *Timer Check:* With output contacts connected to the timer, input at least 10% higher I_AW_1 (input 2) current than the minimum pickup level and start timing. The operating time will be **D** cycles within –1 to +3 cycles or ±1%.
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

87T Phase Differential Restrained Overcurrent

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C4

TEST SETTINGS:	Minimum Pickup	P pu	(0.1 to 1.0)
	Percent Slope #1	**S1 %**	**(5 to 100)**
	Percent Slope #2	**S2 %**	**(5 to 200)**
	Slope Break Point	**BP pu**	**(1.0 to 4.0)**
	Even Harmonic Rest.	**E %**	**(5 to 50)**
	5th Harmonic Rest.	**F %**	**(5 to 50)**
	Pickup at 5 th Harmonic Rest.	**FPpu**	**(0.1 to 2.0)**
	W1 CT Tap Correction	**CT1**	**(1 to 10.00)**
	1 Amp CT Rating		**(0.2 to 2)**
	W2 CT Tap	**CT2**	**(1 to 10.00)**
	1 Amp CT Rating		**(0.2 to 2)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 46DT	**Disable**	
	Function 46IT	**Disable**	
	Function 50BF	**Disable**	
	Function 87H	**Disable**	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration C4 as designated previously. Refer to Section 6.4, **Input Configurations** for configuration. For testing purposes it is recommended that the CT Tap Corrections, **CT1** and **CT2**, be set to 1.0. If it is desired to test with other CT Tap settings, the current values must be computed by using the following formulas:

   I_AW_1 (Applied) = I_AW_1 (Calculated) multiplied by CT1.

   I_AW_2 (Applied) = I_AW_2 (Calculated) multiplied by CT2.

■ **NOTE:** It is also important to remember that all values used for this function are measured in *pu*'s. This requires calculating the actual current in Amps to be used for testing: 1 pu = CT Tap.

4. *Minimum Pickup Test:*
   - Set I_AW_1 (input 1) to 0 Amps. Hold the **TARGET RESET** button in and slowly increase I_AW_2 (input 2) until the **87 PHASE DIFFERENTIAL** LED illuminates, or the pickup indicator operates on the computer target screen. The level of operation will be equal to **P** pu's ±0.1pu or ±5
   - Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish.
   - Press the **TARGET RESET** button again to remove targets. This test may be repeated for testing the opposite winding or another phase.

5. *Slope1 Test:* Define any number of testing points desirable to verify the trip I_AW_2 (Input 2) curve. Choose any values for I_AW_2 (input 2), and calculate the expected operating current I_A (input 2) according to the following:

$I_AW_1 - I_AW_2$	$>$	$(I_AW_1 + I_AW_2)$	x	S1/100	$\div$ 2
Difference in Currents	is greater than	sum of the currents	times	the per unit Slope1	divided by two.

Or $$I_AW_1 = I_AW_2 \left[\frac{(200 + S1)}{(200 - S1)}\right]$$

S1=slope in % from above.

6. Set I_AW_1 (input 1) to the chosen value. Set I_AW_2 to a level 10% lower than the calculated value.
   - Hold the **TARGET RESET** button in and slowly increase I_AW_2 until the **87 PHASE DIFFERENTIAL** LED illuminates, or the pickup indicator operates on the computer target screen. The level of operation will equal to within ±0.1pu or ±1% slope calculation.
   - Release the **TARGET RESET** button and decrease the larger current source and the **OUTPUT** LED will extinguish.
   - Press the **TARGET RESET** button again to remove targets. This test may be repeated for testing the opposite winding or another phase.

■ **NOTE:** The differential current $I_AW_1 - I_AW_2$ must be greater than minimum pickup current (**P**) and less than the Break Point (**BP**) value for proper operation.

7. *Slope2 Test:* Define any number of testing points desirable to verify the trip curve. Choose any values for I_AW_2 (input 2) and calculate the expected operating current I_AW_1 (input 1) according to the following:

$$I_AW_2 = \frac{\left[I_AW_1\left(1 + \frac{S2}{200}\right) + BP\left(\frac{S1-S2}{100}\right)\right]}{\left(1 - \frac{S2}{200}\right)}$$

8. **S1** and **S2** = slope in % from above. The differential current, $I_AW_1 - I_AW_2$ must be greater than both the minimum pickup current (**P**) and the **BP** values.

9. Set I_AW_1 (Input 1) to the chosen value. Set I_AW_2 to a level 10% lower than the calculated pickup.
   - Hold the **TARGET RESET** button in and slowly increase I_AW_2 current until the **87 PHASE DIFFERENTIAL** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will equal to within ±0.1pu or ± 1% slope calculation.
   - Release the **TARGET RESET** button and decrease the larger current and the **OUTPUT** LED's will extinguish.
   - Press the **TARGET RESET** button again to remove targets. This test may be repeated for testing the opposite winding or another phase.

10. *Second Harmonic Restraint Test:*
    - Ensure that Even Harmonic Restraint is enabled with the amplitude of I_AW_1 (input 1) at 60 Hz (or 50 Hz) set to 10% above **P** pu setting and verify the **87 PHASE DIFFERENTIAL** LED is illuminated.
    - Apply 0 Amps at 120 Hz (100 Hz for 50 Hz units) to I_AW_1 (Input 1).
    - Hold the **TARGET RESET** button in and slowly increase the amplitude of I_AW_1 until the **87 PHASE DIFFERENTIAL** LED extinguishes. This level will be **E** times **P** pu, ±1%.

11. *Fourth Harmonic Restraint Test:*
    - Ensure that Even Harmonic Restraint is enabled with the amplitude of I_AW_1 (input 1) at 60 Hz (or 50 Hz) set to 10% above **P** pu setting and verify the **87 PHASE DIFFERENTIAL** LED is illuminated.
    - Apply 0 Amps at 240 Hz (200 Hz for 50 Hz units) to I_AW_1 (Input 1).
    - Hold the **TARGET RESET** button in and slowly increase the amplitude of the 4^{th} Harmonic current I_AW_1 until the **87 PHASE DIFFERENTIAL** LED extinguishes. This level will be **E** times **P** pu, ±1%.
12. *Fifth Harmonic Restraint Test*
    - Ensure that 5th Harmonic Restraint is enabled with the amplitude of I_AW_1 (input 1) at 60 Hz (or 50 Hz) set to above **P**pu, and below **FP**pu and verify the **87 PHASE DIFFERENTIAL** LED is illuminated.
    - Apply **P** times **F** +10% Amps at 300 Hz (250 Hz for 50 Hz units) to I_AW_1 (Input 1), and verify that the Phase Differential LED extinguishes.
    - Hold the **TARGET RESET** button in and slowly decrease the 5^{th} Harmonic amplitude of I_AW_1 until the **87 PHASE DIFFERENTIAL** LED illuminates. This level will be **F** times **P** pu, ±1%.
13. *Elevated Pickup at 5^{th} Harmonic Restraint Test*
    - Ensure that 5^{th} Harmonic Restraint is enabled with 60 Hz (or 50 Hz) set to 10% above **FP** pu, and verify that the **87 Phase Differential** LED is illuminated.
    - Apply **P** times **F** + 10% Amps at 300 Hz (250 Hz for 50 Hz units) to I_AW_1 (input 1).
    - Hold the **TARGET RESET** button in and slowly decrease the 60 Hz (or 50 Hz) amplitude of I_AW_1 until the 87 Phase Differential LED extinguishes. This level will be **FP** pu, ± 0.1 pu or ± 5%.
14. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

87GD Ground Differential

VOLTAGE INPUTS: None

CURRENT INPUTS: C3, C4 (As Described Below)

TEST SETTINGS:	**87GD Pickup**	**P Amps**	**(0.20 to 10)**
	1 Amp CT Rating		**(0.04 to 2)**
	Time Delay	**D cycles**	**(1 to 8160)**
	CT Ratio Correction	**CT**	**(0.10 to 7.99)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Function 46DT		**Disable**
	Function 46IT		**Disable**
	Function 50BFN		**Disable**
	Function 87H		**Disable**
	Function 87T		**Disable**

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedure.
2. Confirm settings to be tested. For testing purposes, it is recommended that the CT Tap Corrections be set to 1.0. Otherwise, current values must be computed by using the following formula:

   I_GW_2 = Applied Current to Winding 2 I_GW_2 divided by CT.
3. *Non-Directional Pickup Tests*:

   A. Standard Test:
   - Connect current input to I_G, terminal numbers 52 and 53, as shown in Figure 6-3.
   - Hold the **TARGET RESET** button in and slowly increase I_G until the **87GD GND DIFFERENTIAL** LED illuminates or the pickup indicator operates on the computer target screen. The level at operation will be equal to **P** Amps ± 0.1 Amps or 5% whichever is greater.
   - Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish. Press **TARGET RESET** button to remove targets.
4. *Directional Pickup Tests*:
   - With I_G connected as above, connect I_AW_2, I_B, or I_C to current Input 1, Figure 6-4. Set I_G to a magnitude equal to ½ **P** Amps. Set I_AW_2, I_B, or I_C to $\angle$180°, and slowly increase phase current until the **87GD GROUND DIFFERENTIAL** LED illuminates or the pickup indicator operates on the computer screen. Operation will occur when the sum of I_G and the applied phase current equal **P** Amps ±0.1 Amps or ±5%. Release the **TARGET RESET** button and decrease the current. The **OUTPUT** LED's will extinguish.
   - Reverse either current (currents now rephase) and re-test. The relay will not operate. The unit will operate regardless of the phase relationship if the phase current is reduced to 140 mAmps or less, and the difference in current between I_G and phase current exceeds the pickup value.
5. *Time Test*: With output contacts being connected to the timer, apply current at least 10% higher than **P** Amps and start timing. The operating time will be **D** cycles within –1 to +3 cycles.
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

External Functions (#1, #2, #3, #4, #5 OR #6)

VOLTAGE INPUTS: None

CURRENT INPUTS: None

TEST SETTINGS:	**Time Delay #__**	**D Cycles**	**(1 to 8160)**
	Programmed Outputs	**Z OUT**	**(1 to 8)**
	Initiating Inputs	**IN**	**(1 to 6)**

1. Confirm initiating input numbers.
2. With output contact(s) **Z** connected to the timer, either jumper out input terminals designated or close external initiating contacts (one at a time) and start timing. The operating time will be **D** cycles within –1 to +3 cycles and the **EXTERNAL #_** LED and the **OUTPUT** LED will illuminate or the pickup indicator operates on the computer target screen.
3. *Blocking Input Test:* To test the designated blocking inputs, hold the **TARGET RESET** button in and short (see step 2) input terminals (one at a time) designated as blocking inputs. The **EXTERNAL #_** LED will extinguish.
4. *Input Test:* Open initiating contact and press **TARGET RESET** button between contact closures to remove targets.
5. Repeat for each designated external triggering contact.
6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

This Page Intentionally Left Blank