PROTECTION OF TRANSFORMERS
M-3311A TEST PLAN
Chuck Mozina -- is a Consultant, Protection and Protection Systems for Beckwith Electric and resides in Palm Harbor (near Tampa), Florida. He is a Life Fellow of the IEEE. His consulting practice involves projects relating to protective relay applications, protection system design and coordination. He specializes in generator and power plant protection.

Chuck is an active 20-year member of the IEEE Power System Relay Committee (PSRC) and is the past chairman of the Rotating Machinery Subcommittee. He is active in the IEEE IAS I&CPS, PCIC and PPIC committees, which address industrial system protection. He is a former U.S. representative to the CIGRE Study Committee 34 on System Protection and has chaired a CIGRE working group on generator protection. He also chaired the IEEE task force that produced the tutorial “The Protection of Synchronous Generators,” which won the PSRC’s 1997 Outstanding Working Group Award. Chuck is the 1993 recipient of the Power System Relay Committee’s Career Service Award and he recently received the 2002 IAS I&CPS Ralph Lee Prize Paper Award. His papers have been republished in the IAS Industrial Applications Magazine.

Chuck has a Bachelor of Science in Electrical Engineering from Purdue University and is a graduate of the eight month GE Power System Engineering Course. He has authored a number of papers and magazine articles on protective relaying. He has over 25 years of experience as a protection engineer at Centerior Energy, a major investor-owned utility in Cleveland, Ohio where he was the Manager of the System Protection Section. He is also a former instructor in the Graduate School of Electrical Engineering at Cleveland State University as well as a registered Professional Engineer in the state of Ohio.
Digital Transformer Relay
M-3311A
Three Winding Transformer Relay -- External Connections

- Three Phase Current, plus Two Ground Current Inputs!
- One Voltage Input
This function is available as a standard protective function.

This function is available as an optional protective function.
OVERALL TEST PLAN

1. Relay set-up
2. Simulate full load at unity P.F.
3. Test 87T for Wye-Wye Transformer
4. Test 87T For Delta-Wye Transformer
5. Oscillograph Demo
OVERALL TEST PLAN

1. Relay set-up
2. Simulate full load at unity P.F.
ANSI/IEEE PHASING STANDARD

- H1, H2, H3
  - Primary Bushings
- X1, X2, X3
  - Secondary Bushings

Transformer

- Wye-Wye: H1 and X1 at zero degrees
- Delta-Delta: H1 and X1 at zero degrees
- Delta-Wye: H1 lead X1 by 30 degrees
- Wye-Delta: H1 lead X1 by 30 degrees
M-3311A Typical Connection Diagram
Two Winding Model

- This function is available as a standard protective function.
- This function is available in the Optional Voltage Protection Package

**M-3311A**
- Targets (Optional)
- Integral HMI (Optional)
- Metering
- Sequence Of Events
- Waveform Capture
- IRIG-B
- Front RS232 Communication
- Rear RS-232/485 Communication
- Multiple Setting Groups
- Programmable I/O
- Programmable Logic
- Self Diagnostics
- Dual Power Supply (Optional)

**Two Winding Application**

- Winding 1 (W1)
- Winding 2 (W2)

**Diagram Components**
SOFTWARE DEMO
<table>
<thead>
<tr>
<th>FUNCTION BEING TESTED</th>
<th>24DT</th>
<th>24HT</th>
<th>27</th>
<th>46DT</th>
<th>46IT</th>
<th>49</th>
<th>50W1</th>
<th>50W2</th>
<th>50W3</th>
<th>50GW2</th>
<th>50NW1</th>
<th>50NW2</th>
<th>50NW3</th>
<th>50BFW1</th>
<th>50BFW2</th>
<th>50BFW3</th>
<th>51GW2</th>
<th>51GW3</th>
<th>51NW1</th>
<th>51NW2</th>
<th>51NW3</th>
<th>59G</th>
<th>81OU</th>
<th>87HT</th>
<th>87GDW2</th>
<th>87GDW3</th>
</tr>
</thead>
<tbody>
<tr>
<td>24DT</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>24HT</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td>X</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>46DT</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>46IT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>49</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50W1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50W2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50W3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50GW2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50GW3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50NW1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50NW2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50NW3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50BFW1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50BFW2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50BFW3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51W1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51W2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51W3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51GW2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51GW3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51NW1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51NW2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51NW3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>59G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>81OU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>87HT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>87GD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 6-1 Functions to Disable When Testing
M-3311A CT Connections for Y-Y Transformer – 87T Test Connections
87T SET-UP – M-3311A
87T SET-UP – M-3311A
87T SET-UP – M-3311A
87T SETTINGS

M-3311A —System Setup

- Pickup (pu) – 0.25 pu
- Slope 1 ------ 30%
- Slope 2 ------ 60%
- Breakpoint --- 2.0pu
- 2\textsuperscript{nd} and 4\textsuperscript{th} Harmonics -------- 15%
- 5\textsuperscript{th} Harmonic ----------------- 30%
- Tap W_1 ------------------------- 1.0A
- Tap W_2 ------------------------- 1.0A
87T SETTINGS

87: Phase Differential Current

- Pickup: 10.0
- Time Delay: 1

Outputs:
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8

Blocking Inputs:
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16

Save | Cancel
87T SETTINGS

87: Phase Differential Current

- Winding 1 C.T. Tap: 1.00
- Winding 2 C.T. Tap: 1.00
- Winding 3 C.T. Tap: 5.00
- Winding 4 C.T. Tap: 5.00

Buttons: Save, Cancel
Typical Phase Differential Characteristic – Percentage Slope

\[ I_d = \sum I_{AW1} + I_{AW2} \]

\[ I_R = \sum |I_{AW1}| + |I_{AW2}| \]

I_1 + I_2 = 0

Min. Pickup

Slope 1

Slope 2

TRIP

RESTRAIN

Break Point

UNIT
87T TESTING FOR Y-Y TRANSFORMER CONNECTION

CHECK FOR PROPER CONNECTIONS.

A) APPLY 5A THREE PHASE CURRENTS TO BOTH INPUT 1 and INPUT 2. RELAY SHOULD NOT OPERATE. CHECK PHASE ANGLE METERING SCREEN FOR PROPER PHASING.

MINIMUM PICKUP TEST
A) SET INPUT 1 CURRENTS = 0
B) HOLD DOWN TARGET RESET BUTTON. SLOWLY INCREASE CURRENTS IN INPUT 2 CURRENTS. THE RELAY WILL OPERATE WHEN CURRENT REACHES 0.25A. (1.0A TAP X 0.25 PU).

SLOPE 1 TEST
A) SET BOTH INPUT 1 AND INPUT 2 CURRENTS TO 1.0A.
B) CALCULATE THE VALUE OF INPUT 1 USING THE BELOW EQUATION WHERE S1 IS THE % SLOPE SETTING. FROM OUR SETTINGS: SLOPE 1 = 30%

\[
\text{INPUT 1} = \frac{200 + S1}{200 - S1} \times 1.0A = \frac{200 + 30}{200 - 30} \times 1.35A
\]

C) HOLD DOWN TARGET RESET BUTTON AND SLOWLY INCREASE INPUT 2 CURRENTS. LED SHOULD COME ON AT 1.35A.
87T TESTING FOR Y-Y TRANSFORMER CONNECTION

SLOPE 2 TEST

A) SET BOTH INPUT 1 and INPUT 2 CURRENTS TO 5.0A.

B) CALCULATE THE VALUE OF INPUT 1 USING THE BELOW EQUATION WHERE S1 AND S2 ARE THE SLOPE SETTING. FROM OUR SETTINGS: SLOPE 1 = 30%  SLOPE 2 = 60%  BP (BREAK POINT) = 2.0

\[
\text{INPUT 1} = \left[ \frac{\text{INPUT 2} (1+S2) + \text{BP} (S1 – S2)}{200} \right] \frac{100}{1 - S2 \ 200}
\]

\[
= \left[ \frac{5.0 (1+60) + 2.0 (30-60)}{200} \right] \frac{100}{1 - 60 \ 200}
\]

\[
= 8.43A
\]

C) HOLD DOWN TARGET RESET BUTTON AND SLOWLY INCREASE INPUT 2 CURRENTS. LED SHOULD COME ON AT 8.43A.
87T TESTING FOR Y-Y TRANSFORMER CONNECTION

SECOND HARMONIC RESTRAINT TEST (ENERGIZING INRUSH RESTRAINT)

A) ENSURE THAT EVEN HARMONIC RESTRAINT IS ENABLED

B) APPLY 0 CURRENT TO INPUT 2

C) APPLY 110% OF PU TO INPUT 1 AT 60HZ. PU = 0.25A X 1.10 = 0.275A. RELAY SHOULD OPERATE.

D) APPLY ZERO CURRENT TO INPUT 1. CHANGE FREQUENCY TO 120 HZ.

E) HOLD DOWN TARGET RESET BUTTON AND SLOWLY INCREASE INPUT 1 CURRENTS TO 110% OF PICKUP (0.275A).

F) RELAY SHOULD NOT OPERATE (LED LIGHT OFF).
87T TESTING FOR Y-Y TRANSFORMER CONNECTION

FORTH HARMONIC RESTRAINT TEST (ENERGIZING INRUSH RESTRAINT)

A) ENSURE THAT 5TH HARMONIC RESTRAINT IS ENABLED

B) APPLY 0 CURRENT TO INPUT 2.

C) APPLY ZERO CURRENT TO INPUT 1. CHANGE FREQUENCY TO 240 HZ.

E) HOLD DOWN TARGET RESET BUTTON AND SLOWLY INCREASE INPUT 1 CURRENTS TO 110% OF PICKUP (0.275A).

F) RELAY SHOULD NOT OPERATE (LED LIGHT OFF).
87T TESTING FOR Y-Y TRANSFORMER CONNECTION

FIFTH HARMONIC RESTRAINT TEST (OVEREXCITATION RESTRAINT)

A) ENSURE THAT 5TH HARMONIC RESTRAINT IS ENABLED

B) APPLY 0 CURRENT TO INPUT 2

C) APPLY ZERO CURRENT TO INPUT 1. CHANGE FREQUENCY TO 300 HZ.

D) HOLD DOWN TARGET RESET BUTTON AND SLOWLY INCREASE INPUT 1 CURRENTS.

E) RELAY SHOULD NOT OPERATE (LED LIGHT OFF) AT 0.25A PU. CONTINUE TO INCREASE CURRENT. RELAY LED SHOULD BE EXTINGUISH FOR VALUE ABOVE PU (0.25A) TO 0.5A.

F) CONTINUE TO INCREASE CURRENT. THE LED SHOULD LIGHT WHEN THE 5TH HARMONIC PICKUP SETTING OF 0.5A IS REACHED.
DIGITAL TRANSFORMER
DIFFERENTIAL RELAY
SETTING EXAMPLE
(Delta- Wye Transformer)
- H1, H2, H3
  - Primary Bushings
- X1, X2, X3
  - Secondary Bushings

Transformer

- Wye-Wye: H1 and X1 at zero degrees
- Delta-Delta: H1 and X1 at zero degrees
- Delta-Wye: H1 lead X1 by 30 degrees
- Wye-Delta: H1 lead X1 by 30 degrees
Phasing Delta- Wye

- H1 (A) leads X1 (a) by 30
- Currents on “H” bushings are delta quantities
- Can Describe as Delta AB (Ia = Ia - Ib)

Assume 1:1 transformer
Phasing Wye- Delta

- H1 (a) leads X1 (A) by 30
- Currents on “X” bushings are delta quantities
- Can Describe as Delta AC (Ia=IA-IC)

Assume 1:1 transformer
Transformer Phasing – IEC Phasing Standard

Euro-designations use 30° increments of LAG from the X1 bushing to the H1 bushings

**EXAMPLES**

**For Delta Primary Transformers:**
1 = Dy1 = X lags H by 30°
3 = Dy3 = X lags H by 90°
7 = Dy7 = X lags H by 210°

**For Wye Primary Transformers:**
1 = Yd1 = X lags H by 30°
3 = Yd3 = X lags H by 90°
7 = Yd7 = X lags H by 210°
87T SET-UP

M-3311A — System Setup
87T SETTINGS

*M-3311A — System Setup*

- Pickup (pu) – 0.25 pu
- Slope 1 ------ 30%
- Slope 2 ------ 60%
- Breakpoint --- 2.0pu
- 2\textsuperscript{nd} and 4\textsuperscript{th} Harmonics ------ 15%
- 5\textsuperscript{th} Harmonic ------------------- 30%
- Tap W\textsubscript{1} ------------------------------ 1.0A
- Tap W\textsubscript{2} ------------------------------ 1.0A
87T SETTINGS

87: Phase Differential Current

- Winding 1 C.T. Tap: 1.00
- Winding 2 C.T. Tap: 1.00
- Winding 3 C.T. Tap: 5.00
- Winding 4 C.T. Tap: 5.00

Buttons: Save, Cancel
M-3311A CT Connections for DELTA-WYE Transformer – 87T

Current Input 1
- $I_a W_1: -150^0$
- $I_b W_1: +90^0$
- $I_c W_1: -30^0$

Current Input 2
- $I_a W_2: 0^0$
- $I_b W_2: -120^0$
- $I_c W_2: +120^0$
87T TESTING FOR DELTA -WYE TRANSFORMER CONNECTION

CHECK FOR PROPER CONNECTIONS.

A) APPLY THREE PHASE CURRENTS TO BOTH INPUT 1 = 5.0A and INPUT2 = 5.0A. RELAY SHOULD NOT OPERATE. CHECK PHASE ANGLE METERING SCREEN FOR PROPER PHASING.

MINIMUM PICKUP TEST
A) SET INPUT 1 CURRENTS = 0

B) HOLD DOWN TARGET RESET BUTTON. SLOWLY INCREASE CURRENTS IN INPUT 2 CURRENTS. THE RELAY WILL OPERATE WHEN CURRENT REACHES 0.25A. (1.0A TAP X 0.25 PU).

SLOPE 1 TEST
A) SET INPUT 1= 1.00 AND INPUT 2 CURRENTS TO 1.0A.

B) CALCULATE THE VALUE OF INPUT 2 USING THE BELOW EQUATION WHERE S1 IS THE % SLOPE SETTING. FROM OUR SETTINGS: SLOPE 1 = 30%

\[
\text{INPUT 1} = 1.00 \quad \text{INPUT 2} = \frac{200 + S1}{200 - S1} = 1.0A \quad \frac{200 + 30}{200 - 30} = 1.35A
\]

C) HOLD DOWN TARGET RESET BUTTON AND SLOWLY INCREASE INPUT 2 CURRENTS. LED SHOULD COME ON AT 1.35A.
87T TESTING FOR Delta-Wye TRANSFORMER CONNECTION

SLOPE 2 TEST

A) SET BOTH INPUT 1 = 5.00 A and INPUT 2 CURRENTS TO 5.0A.

B) CALCULATE THE VALUE OF INPUT 1 USING THE BELOW EQUATION WHERE S1 AND S2 ARE THE SLOPE SETTING. FROM OUR SETTINGS: SLOPE 1 = 30%  SLOPE 2 = 60%  BP (BREAK POINT) = 2.0

\[
\text{INPUT 2} = \frac{\text{INPUT 2} (1+S2) + \text{BP} (S1 – S2)}{200} \frac{100}{1 - \frac{S2}{200}}
\]

\[
= \frac{5.0 (1 + 60) + 2.0 (30-60)}{200} \frac{100}{1 - \frac{60}{200}}
\]

\[
= 8.43 \text{A}
\]

C) HOLD DOWN TARGET RESET BUTTON AND SLOWLY INCREASE INPUT 2 CURRENTS. LED SHOULD COME ON AT 8.43A.
Oscillograph Demo
IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems

Sponsor
Power Systems Relay Committee of the IEEE Power Engineering Society

Approved 18 March 1999
IEEE-SA Standards Board

Abstract: A common format for data files and exchange medium used for the interchange of various types of fault, test, or simulation data for electrical power systems is defined. Sources of transient data are described, and the case of diskettes as an exchange medium is recommended. Issues of sampling rates, filters, and sample rate conversions for transient data being exchanged are discussed. Files for data exchange are specified, as is the organization of the data. A sample file is given.

Keywords: configuration file, data file, header file, information file, transient data.
Waveform Capture (Phasor)

Phasor diagram with values displayed

Phasor display shown at Marker #1 location

Area of current reversal
3311A TRANSFORMER PROTECTIVE RELAY TEST PLAN

THE END

QUESTION