EEL3060

Power Engineering Lab

Transformer Differential Protection Relay

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By:

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I. Objective

To study and understand the operation of a Transformer Differential Protection system and to observe the relay response under various internal fault conditions within the protected zone of a transformer.

II. Apparatus

- Transformer Differential Protection System Trainer (2 KVA, 3-Phase Transformer)
- Numerical Transformer Differential Relay
- CTs (Current Transformers)
- Relay Panel with mimic diagram
- Fault switch
- Start/Stop control switch
- MCB (Miniature Circuit Breaker)
- Measuring meters (for current observation)
- Patch chords (short and long)

III. Theory

Transformer differential protection is a fundamental method to detect internal faults in a transformer by comparing the current entering and leaving the transformer windings. The system uses a differential relay, which operates based on the difference between primary and secondary side currents.

Working Principle:

Under normal or external fault conditions:

- The current entering the transformer (primary side) is nearly equal to the current leaving (secondary side), after adjusting for turns ratio.
- The differential current $I_d = |I_1 - I_2|$ is small, so the relay does not operate.

Under internal fault conditions:

- A significant difference arises between I_1 and I_2 causing the relay to trip.

Harmonic Restraint:

- **Magnetizing Inrush:** Dominated by 2nd harmonic

- **Over-excitation:** Dominated by 5th harmonic
  To avoid false tripping, the relay uses harmonic restraint based on harmonic analysis of the differential current.

CT Ratio & Vector Group Compensation:

- Correction for mismatched CTs and phase shifts is handled in software, preventing nuisance tripping.

IV. Experimental Procedure

Circuit Diagram:

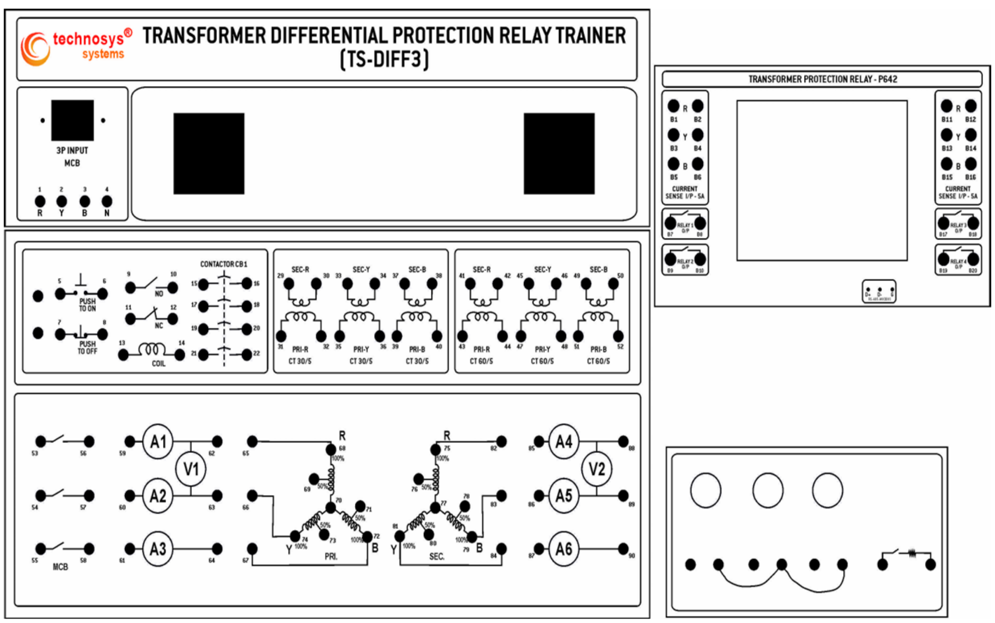

Figure 1: Transformer Differential Protection Relay Kit

Connection Sequence:

S.N.		FROM	TO	S.N.		FROM	TO
SHORT PATCH CHORDS				LONG PATCH CHORDS			
1	Contactor circuit	56	15	1	CT SEC. TERMINALS (PRIMARY WINDING SIDE)	29	B1
2		57	17	2		30	B2
3		58	19	3		33	B3
4		16	59	4		34	B4
5		18	60	5		37	B5
6		20	61	6		38	B6
7	CT PRIMARY TERMINALS (PRIMARY WINDING SIDE)	62	31	7	CT SEC. TERMINALS (SEC. WINDING SIDE)	41	B11
8		32	65	8		42	B12
9		63	35	9		45	B13
10		36	66	10		46	B14
11		64	39	11		49	B15
12		40	67	12		50	B16
13	CT PRIMARY TERMINALS (SEC. WINDING SIDE)	82	43	13	RELAY TRIPPING CONTACTS	9	B17
14		44	85	14		10	B18
15		83	47	15		88	To Bulb Load
16		48	86	16		89	
17		84	51	17		90	
18		52	87	18		78	To Fault Switch
19	Contactor CB1 Control Wiring	15	5	19		79	
20		6	13				
21		14	7				
22		8	11				
23		12	4				
24		16	13				

Figure 2: Connection Sequence

Steps:

1. Connect the trainer circuit as per the wiring chart provided in the manual.
2. Ensure fault switch is OFF.
3. Power ON the system via the MCB.
4. Press the START push-button to energize the transformer windings.
5. Monitor current readings on the metering panel.
6. Introduce faults one by one using the fault switch:
   - R-phase fault
   - Y-phase fault
   - B-phase fault
7. Record the current values displayed on the panel and relay in both healthy and faulty conditions.

Observations Table:

Healthy Conditions-

- **On Panel:**
  - Primary Currents = 0.45 A, 0.45 A, 0.42 A

   - Secondary Currents = 0.60 A, 0.60 A, 0.60 A

- **On Relay:**
   - Primary Currents = 4.2 A, 5.3 A, 4.5 A
   - Secondary Currents = 11.2 A, 11.5 A, 11.3 A

Type of Fault	R-phase Current $I_R(A)$	Y-phase Current $I_Y(A)$	B-phase Current $I_B(A)$
Secondary R-Phase Fault	60	12	9
Secondary B-Phase Fault	7.5	24	9
Secondary Y-Phase Fault	9.9	10.20	17.47

V. Results & Conclusion

Results:

- The differential relay correctly identified internal faults and tripped when fault conditions were introduced in any secondary phase.
- Under healthy and external fault conditions, the relay did not trip due to correct CT ratio and vector group compensation.

Conclusion: The experiment successfully demonstrated the principle of differential protection for transformers. The relay responded accurately to internal faults, validating the importance of harmonic restraint, slope settings, and compensation mechanisms in preventing false trips and ensuring safety of the transformer system.