# EXPERIMENT P2: OVERCURRENT PROTECTION

Related course: KIE3009 (Energy Conversion and High Voltage Transmission)

**OBJECTIVES:**
To investigate the inverse current-time characteristics of over current relay under different plug setting and time multiplier setting

**EQUIPMENT:**
Circuit breaker, inverse time relay with built-in current transformer, variable resistor 5A 42Ω, variable voltage supply 0-240V (variac), stop watch, voltmeter, ammeter

**INSTRUCTIONS:**
1. Record all your results and observations in a log book / paper
2. Follow the demonstrator's instructions throughout the experiment

**REFERENCE(S):**
Refer to the main references of KIE3009

**INTRODUCTION:**

Over Current Relays (OCRs) protect distribution and sub-transmission systems from the effect of excessive current due to short circuit or overload conditions. It is also used for the protection of generators, power transformers and electric motors.

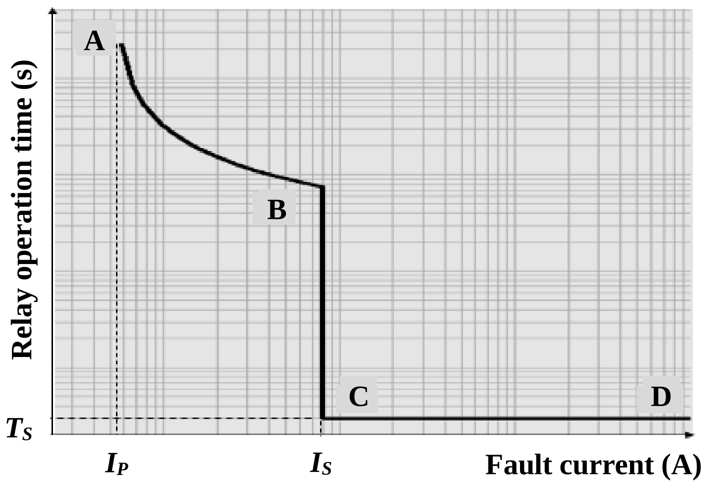


Figure A: Typical current-time characteristic of OCR

**Curve A-B** is the inverse characteristic of the relay and is used to protect apparatus from excessive currents less than severe short circuit fault level. However, if this fault level is allowed to sustain for a certain period, it will damage the apparatus to be protected.

**Curve B-C-D** is meant for instantaneous, high speed clearing of severe short circuits (>$I_S$) by reducing the clearing time to only $T_S$.

**Time multiplier setting (TMS or AT)**: TMS adjusts the relay operation time. The relay operates faster when TMS is lower. E.g. for TMS = 1, if relay operation time is 4 s, then for TMS = 0.2, relay operates at 0.8 s.

**Plug setting (SP)**: SP is also called pick-up current. It is the value of current which the relay operates. E.g., for a 5A relay and current constant of 130%, SP = 1.3x5A = 6.5 A.

**Plug setting multiplier (PSM)**: PSM is the ratio of the fault current to plug setting (SP), **PSM = $I_S$ / SP**, where $I_S$ = fault current from the secondary side of current transformer.

The relationship between relay operation time and PSM is known as relay time graph or PSM graph. From this graph, we can determine the total time taken by the moving parts of an electromechanical relay to complete its total travelling distance for different PSM.

**PROCEDURES:**

Figure 1 shows a block diagram of the experimental setup for the relay to be tested. When an overload current flows through the circuit breaker (CB), the relay and timer will be activated. The relay will send a signal to the CB to trip (open) the circuit.

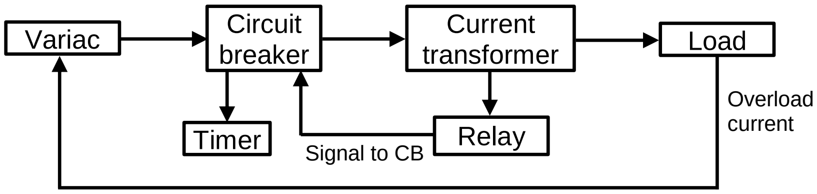



Figure 1: Block diagram of the experimental setup

Following key points are noted before starting the experiment:

- Set the instantaneous current setting (I>>) on the relay as 0.
- The available current transformer (CT) ratio on the relay is 1:2.
- Multiply the Plug Setting (SP) with 0.2.
- Multiply the Time Multiplier Setting (TMS) with 0.01.
- The overload current can be varied using the variac and variable load resistor.

**PRECAUTION: Every time before closing (ON) the circuit breaker, make sure that the variable resistor is at its maximum value (for minimum load current).**

1. Make sure that the circuit connection is as shown in Figure 2. Do not change the circuit connection without permission from the lab demonstrator or technician.
2. For the relay, set the Plug Setting (SP) = 0.8 and Time Multiplier Setting (TMS) = 0.08.
3. Close (press ON) the circuit breaker and quickly adjust the current $I_S$ to 0.5A using variable resistor and variac. The current $I_S$ can be read from the ammeter. Wait for the relay to trip by looking at the stop watch. If the relay does not trip within 90 seconds, it means the relay operating time is infinity for the given SP and TMS. Record the relay tripping time from the stop watch in Table 1. Then, calculate PSM.
4. Repeat step 3 for different current values, TMS and SP according to Table 1.

Table 1

| Current $I_S$ (A) | SP = 0.8 A TMS = 0.08 | | SP = 0.8 A TMS = 0.1 | | SP = 0.8 A TMS = 0.12 | | SP = 1.0 A TMS = 0.08 | | SP = 1.2 A TMS = 0.08 | | SP = 1.4 A TMS = 0.08 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time(s) | PSM | Time(s) | PSM | Time(s) | PSM | Time(s) | PSM | Time(s) | PSM | Time(s) | PSM |
| 0.6 | | | | | | | | | | | | |
| 0.8 | | | | | | | | | | | | |
| 1.0 | | | | | | | | | | | | |
| 1.2 | | | | | | | | | | | | |
| 1.4 | | | | | | | | | | | | |
| 1.6 | | | | | | | | | | | | |
| 1.8 | | | | | | | | | | | | |
| 1.9 | | | | | | | | | | | | |
| 2.0 | | | | | | | | | | | | |
| 2.1 | | | | | | | | | | | | |
| 2.2 | | | | | | | | | | | | |
| 2.3 | | | | | | | | | | | | |
| 2.4 | | | | | | | | | | | | |

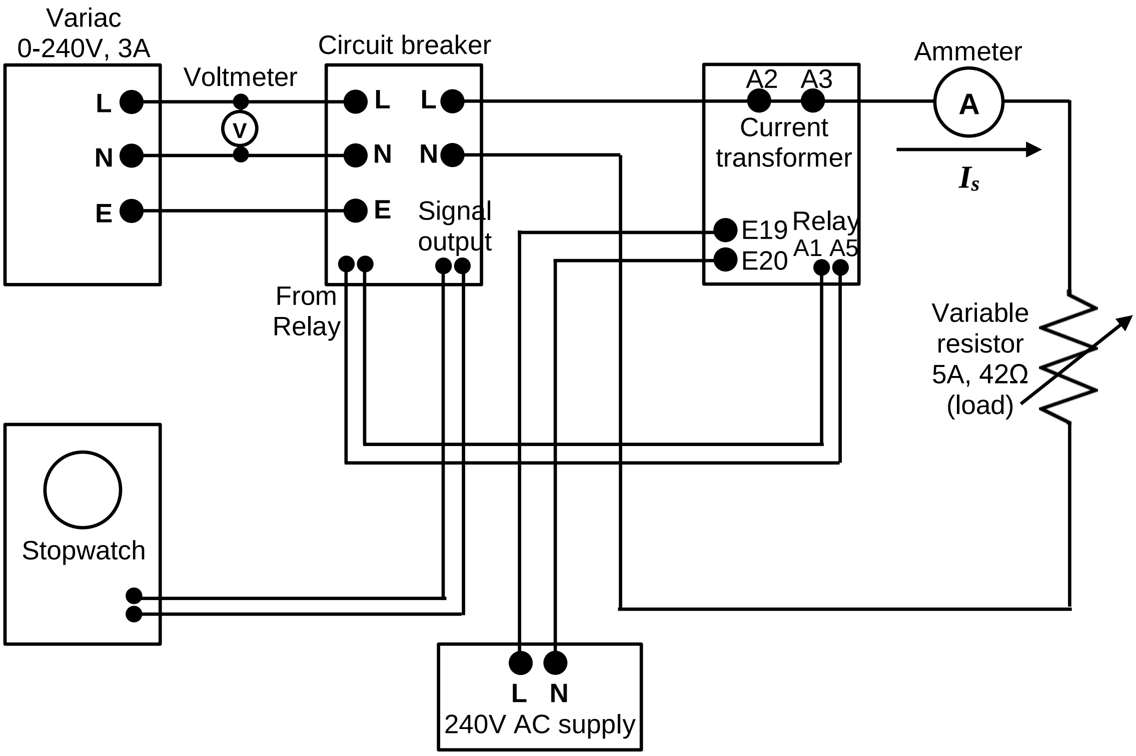



Figure 2: Circuit diagram of experimental setup

**TASKS (Examples are shown in the Appendix):**

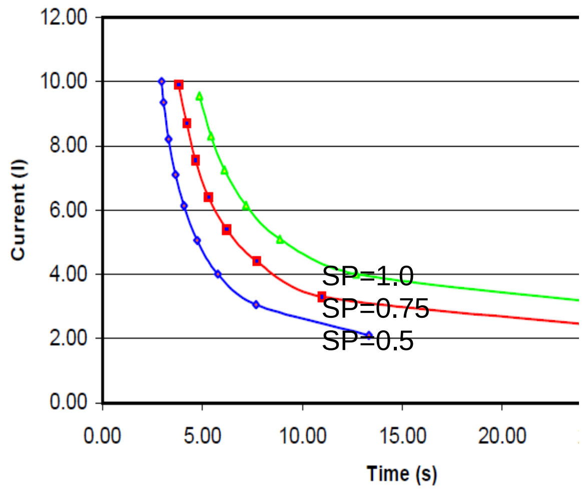
1. From Table 1, when SP = 0.8 A, plot a graph of current $I_S$ (y-axis) vs. relay operation time (x-axis) (plot for TMS = 0.08, 0.1 and 0.12 on the same graph).
2. From Table 1, when TMS = 0.08, plot a graph of current $I_S$ (y-axis) vs. relay operation time (x-axis) (plot for SP = 0.8, 1.2 and 1.4 A on the same graph).
3. From Table 1, when TMS = 0.08, plot a graph of relay operation time (y-axis) vs. PSM (x-axis) (plot for SP = 0.8, 1.2 and 1.4 A on the same graph). This graph represents the standard characteristic of the relay.
4. A 5A relay is supplied via a 200/10 current transformer with a current constant of 175% and a time multiplier setting TMS of 0.2. Find the relay operation time from Task 3 when the fault current is (a) 1.5kA and (b) 2.0 kA.

   Hint:
   - Calculate secondary current from CT [E.g. $I_S$ = 1500x(10/200) = 75 A]
   - Calculate SP = Relay max current x current constant [E.g. SP = 5Ax1.75 = 8.75 A]
   - Calculate PSM = $I_S$ / SP [E.g. = 75/8.75 = 8.57]
   - From the calculated PSM, determine the time $T_1$ from the graph in Task 3
   - Calculate relay operation time = TMSx$T_1$
5. Repeat Task 4 but replace the CT with 200/5 CT and the fault current as (a) 1.5 kA and (b) 2.0 kA.
6. When TMS = 0.08, write down the relay operation time for all available SP values when overload current of 1.2 A is passed through the relay.
7. When SP = 0.8 Amp, write down the relay operation time for all available TMS values when overload current of 1.2 A is passed through the relay.

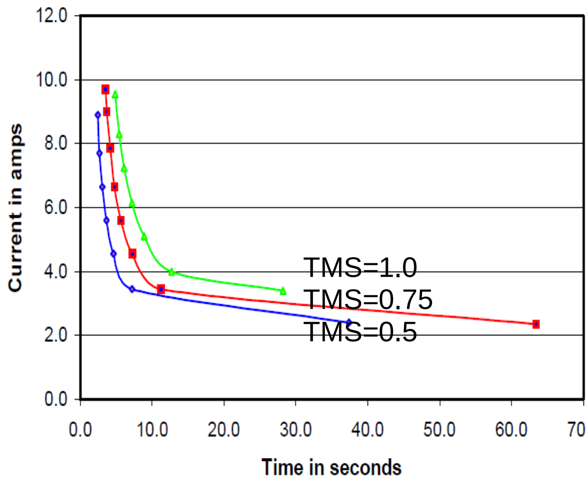
**QUESTIONS:**

1. Explain the theory of electromechanical type over current relay.
2. How does the plug setting (SP) changes the operating current of the relay?
3. How does the time multiplier setting (TMS) change the time of operation of relay?
4. Explain a current transformer having single turn primary winding.
5. Explain how the TMS of the relay adjusts the 'backstop' of the rotating disc.

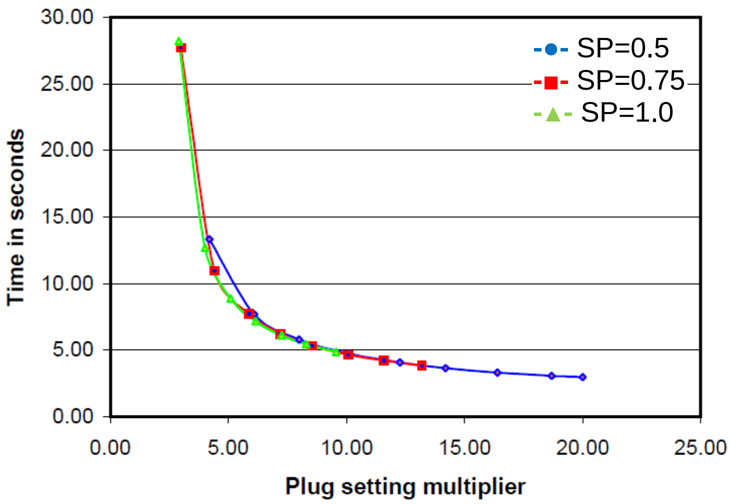
**Appendix (The following graphs are examples only):**




Current vs. time characteristic when TMS = constant




Current vs. time characteristic when SP = constant




Time vs. PSM characteristics when TMS = constant

**END OF EXPERIMENT**