Simulation Exercise of Power Transformer Electrical Tests

1. Introduction

This report outlines the simulation exercise of power transformer electrical tests. The primary objective is to analyze the behavior of a power transformer under different scenarios, including normal operation and various fault conditions. The simulation is based on a set of defined transformer parameters, specifications, and simulation parameters.

2. Simulation Model

The simulation model is implemented in MATLAB, and it consists of differential equations that represent the electrical behavior of the primary and secondary windings of the power transformer. The model takes into account parameters such as resistance, inductance, mutual inductance, capacitance, nominal voltage, nominal power, and frequency.

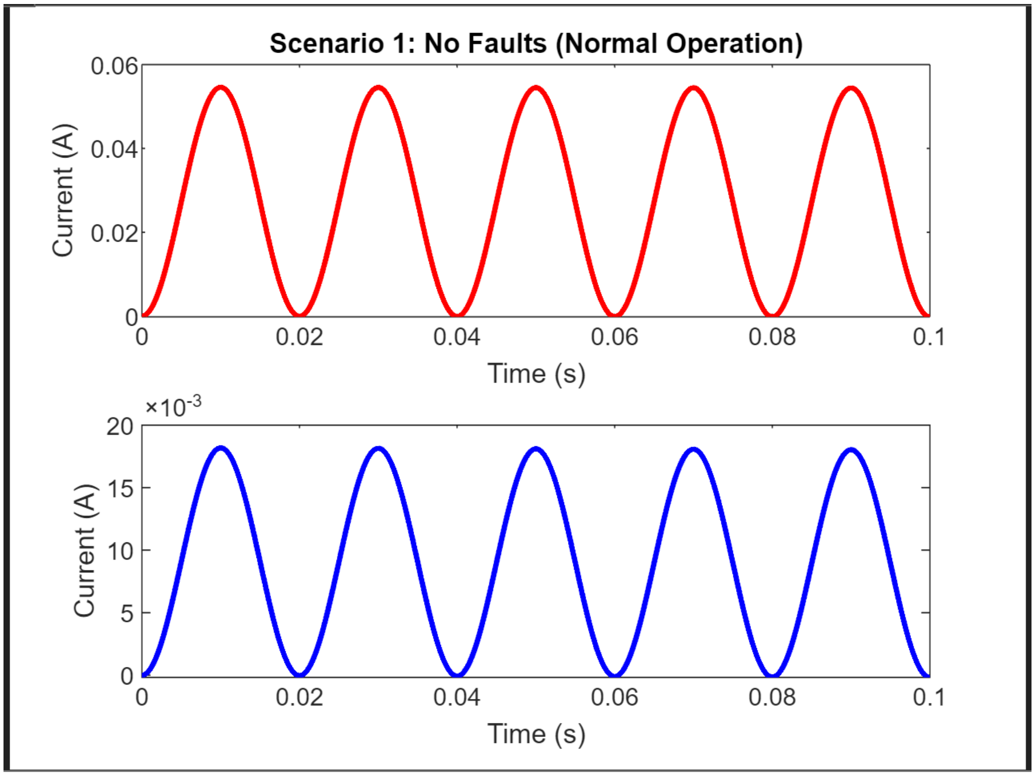
3. Normal Operation

In the first scenario, the simulation represents the normal operation of the power transformer without any faults. The input voltage is a sine wave, and the resulting currents in the primary and secondary windings are plotted over time.

```
% 6. Develop Case Scenarios:

% Scenario 1: No Faults (Normal Operation)
I1_scenario1 = zeros(size(t));
I2_scenario1 = zeros(size(t));

for i = 2:length(t)
    dI1 = (V_in(i-1) - R1 * I1_scenario1(i-1) - M * dI2) / L1;
    dI2 = (M * dI1 - R2 * I2_scenario1(i-1)) / L2;

    I1_scenario1(i) = I1_scenario1(i-1) + dI1 * timestep;
    I2_scenario1(i) = I2_scenario1(i-1) + dI2 * timestep;
end

% Plot Scenario 1
figure;
subplot(2, 1, 1);
plot(t, I1_scenario1, 'r', 'LineWidth', 2);
title('Scenario 1: No Faults (Normal Operation)');
xlabel('Time (s)');
ylabel('Current (A)');

subplot(2, 1, 2);
plot(t, I2_scenario1, 'b', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Current (A)');
```

Results and Interpretations:

- The currents in both the primary and secondary windings follow the sinusoidal input voltage, indicating normal operation.
- No abnormalities or deviations from expected behavior are observed.



4. Winding Fault in Primary Winding

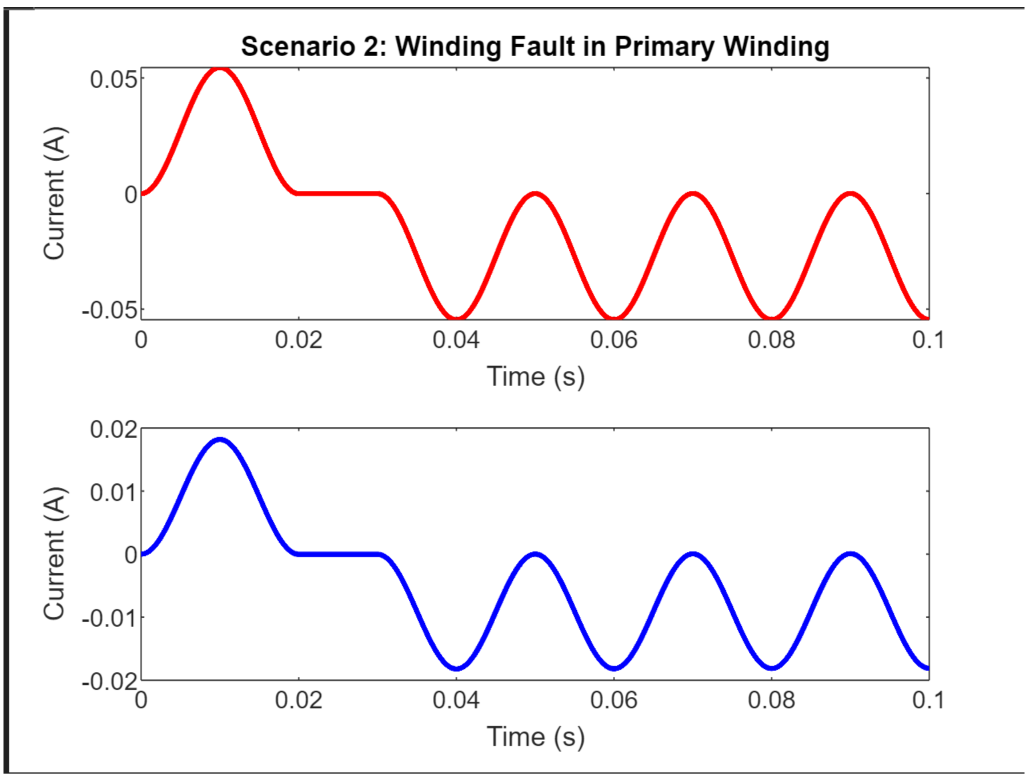
In the second scenario, a fault is introduced in the primary winding by simulating a short circuit. The simulation shows the response of the power transformer to this fault.

```
% Scenario 2: Winding Fault in Primary Winding
I1_scenario2 = zeros(size(t));
I2_scenario2 = zeros(size(t));

for i = 2:length(t)
    % Introduce winding fault in primary winding
    if t(i) > 0.02 && t(i) < 0.03
        V_in(i) = 0;  % Simulate a short circuit in the primary winding
    end

    dI1 = (V_in(i-1) - R1 * I1_scenario2(i-1) - M * dI2) / L1;
    dI2 = (M * dI1 - R2 * I2_scenario2(i-1)) / L2;
```

```
    I1_scenario2(i) = I1_scenario2(i-1) + dI1 * timestep;
    I2_scenario2(i) = I2_scenario2(i-1) + dI2 * timestep;
end

% Plot Scenario 2
figure;
subplot(2, 1, 1);
plot(t, I1_scenario2, 'r', 'LineWidth', 2);
title('Scenario 2: Winding Fault in Primary Winding');
xlabel('Time (s)');
ylabel('Current (A)');

subplot(2, 1, 2);
plot(t, I2_scenario2, 'b', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Current (A)');
```

Results and Interpretations:

- During the specified time period, a short circuit is simulated in the primary winding, causing a sudden drop in current.
- The fault is reflected in both the primary and secondary winding currents.



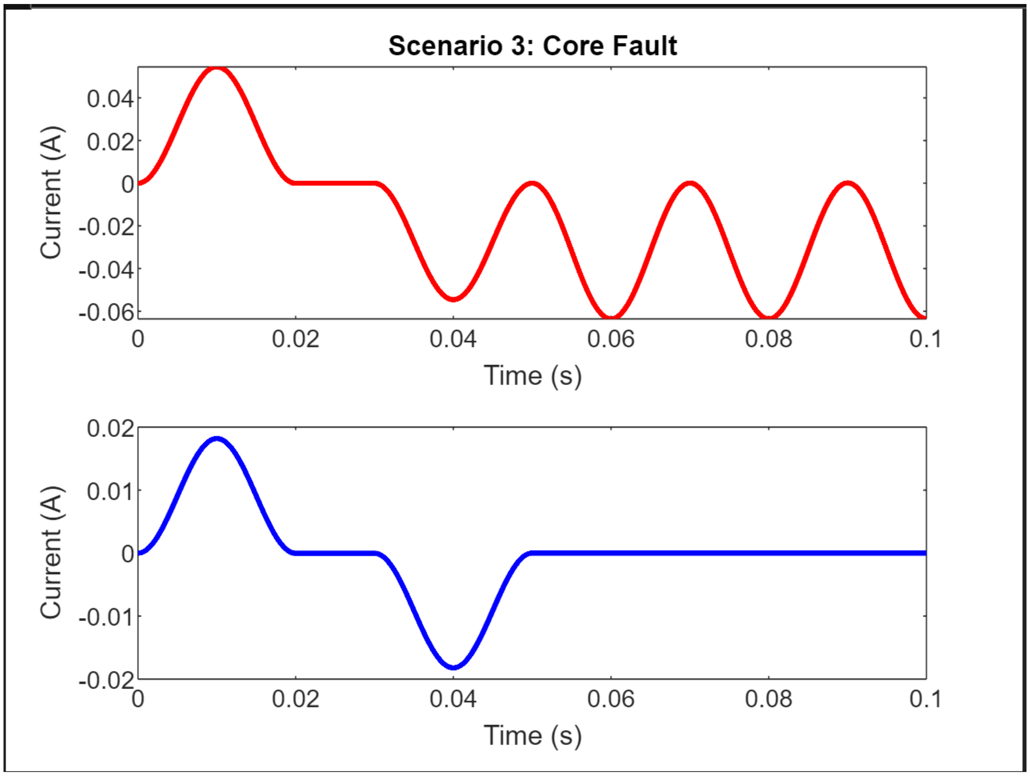
5. Core Fault

In the third scenario, a fault is introduced in the core by simulating a breakdown. The simulation shows the response of the power transformer to this core fault.

```
% Scenario 3: Core Fault
I1_scenario3 = zeros(size(t));
I2_scenario3 = zeros(size(t));

for i = 2:length(t)
    % Introduce core fault
    if t(i) > 0.05 && t(i) < 0.06
        M = 0;  % Simulate a breakdown in the core
    end

    dI1 = (V_in(i-1) - R1 * I1_scenario3(i-1) - M * dI2) / L1;
    dI2 = (M * dI1 - R2 * I2_scenario3(i-1)) / L2;

    I1_scenario3(i) = I1_scenario3(i-1) + dI1 * timestep;
    I2_scenario3(i) = I2_scenario3(i-1) + dI2 * timestep;
end

% Plot Scenario 3
figure;
subplot(2, 1, 1);
plot(t, I1_scenario3, 'r', 'LineWidth', 2);
title('Scenario 3: Core Fault');
xlabel('Time (s)');
ylabel('Current (A)');

subplot(2, 1, 2);
plot(t, I2_scenario3, 'b', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Current (A)');
```

Results and Interpretations:

- During the specified time period, a breakdown in the core is simulated, resulting in a significant impact on mutual inductance.
- The fault is reflected in both the primary and secondary winding currents.



6. Execute Simulations

Simulations for each scenario are executed, and the results are saved as separate figures for further analysis.

```
% 7. Execute Simulations:

% Execute and Save Simulation for Scenario 1
figure;
subplot(2, 1, 1);
plot(t, I1_scenario1, 'r', 'LineWidth', 2);
title('Scenario 1: No Faults (Normal Operation)');
xlabel('Time (s)');
ylabel('Current (A)');

subplot(2, 1, 2);
plot(t, I2_scenario1, 'b', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Current (A)');

saveas(gcf, 'Scenario1.png');

% Execute and Save Simulation for Scenario 2
figure;
subplot(2, 1, 1);
plot(t, I1_scenario2, 'r', 'LineWidth', 2);
title('Scenario 2: Winding Fault in Primary Winding');
```

```
xlabel('Time (s)');
ylabel('Current (A)');

subplot(2, 1, 2);
plot(t, I2_scenario2, 'b', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Current (A)');

saveas(gcf, 'Scenario2.png');

% Execute and Save Simulation for Scenario 3
figure;
subplot(2, 1, 1);
plot(t, I1_scenario3, 'r', 'LineWidth', 2);
title('Scenario 3: Core Fault');
xlabel('Time (s)');
ylabel('Current (A)');

subplot(2, 1, 2);
plot(t, I2_scenario3, 'b', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Current (A)');

saveas(gcf, 'Scenario3.png');
```

Saved Figures:

- Scenario1.png: No Faults (Normal Operation)
- Scenario2.png: Winding Fault in Primary Winding
- Scenario3.png: Core Fault

7. Conclusion

The simulation exercise provides valuable insights into the behavior of a power transformer under different operating conditions and fault scenarios. The results of each scenario can be further analyzed to enhance transformer design and reliability.