Project #1\aver.m

```
% ID Number: 229,506
% ECE 31033 - Project #1
% aver.m

% The fourth file (aver.m) contains a function you create to compute the average of
% a waveform. Specifically, the function is of the form
%       function av = aver(x,T,dt)
% where x is the waveform to be averaged, T is its period, and dt is the period of time
% between samples. This function must use the last period of the input waveform to
% calculate the average.

function av = aver(x, T, dt)
    location = length(x);
    av = 0;
    time = 0;

    while (time <= T)
        av = av + dt * (x(location));
        time = time + dt;
        location = location - 1;
    end

    av = av / T;
end

```

Project #1\sw.m

```
% ID Number: 229,506
% ECE 31033 - Project #1
% sw.m

% The first file (sw.m) contains a function (sw) that accepts the duty cycle D, and a
% single instant of time as an input, and outputs the state (on/off) of the transistor
% at that time instant as an output. A Fourier series-based triangle wave that you
% create within this function should be compared with the duty cycle D to
% determine the state of the transistor. The output of the function is a 1 if the
% transistor is to be turned on. It is a value of 0 if it is turned off.

function state = sw(D, t)
    T_sw = 1 / 10000;

    w = 2 * pi / T_sw;

    a_k = 0;
    triangle_wave = 0.5;

    N = 200; % Number of Fourier terms.

    k = 1;
    while k <= N
        z = k * w * T_sw; % Temporary variable; to simplify code for the coefficient.

        a_k = (2 * (4 * cos(0.5 * z) - 2 * cos(z) - 2)) / (z^2);
        triangle_wave = triangle_wave + a_k * cos(k * w * t);
        k = k + 1;
    end

    if D >= triangle_wave
        state = 1;
    else
        state = 0;
    end
end
```

Project #1\buck.m

```
% ID Number: 229,506
% ECE 31033 - Project #1
% buck.m

% The file (buck.m) contains the Forward Euler integration algorithm within a while
% loop (FOR LOOPS ARE NOT ALLOWED). buck is not a function. The file buck.m only
% contains a single while loop (i.e. while (t(k)<tend)) to solve for all circuit voltages
% and currents of your buck converter. Within the while loop, you will call the
% function sw at each time instant to determine the value of your transistor gate
% (on or off).  Voltages of currents and voltages of circuit components must be
% determined within the while loop.
while t_vec(k) < tend
    if (ideal_boolean) % If the circuit is ideal.
        switch_state(k) = sw(D, t_vec(k)); % calling sw.m

        % Inductor Current and Load Voltage Calculation
        i_L_vec(k+1) = i_L_vec(k) + dt * ((switch_state(k)) * V_in - V_load_vec(k)) / L;
%i_L
        V_load_vec(k+1) = V_load_vec(k) + dt * ((i_L_vec(k) - (V_load_vec(k) / R_load)) / C);
%V_load

        % Switch 1 and 2: Voltage and Current Calculations
        if(switch_state(k))
            V_switch1(k+1) = V_in;
            i_switch1(k+1) = i_L_vec(k+1) * switch_state(k);

            V_switch2(k+1) = 0;
            i_switch2(k+1) = 0;

            V_L_vec(k+1) = V_in - V_load_avg;
        else
            V_switch1(k+1) = 0;
            i_switch1(k+1) = 0;

            V_switch2(k+1) = -1 * V_in;
            i_switch2(k+1) = i_L_vec(k) * (1 - switch_state(k));

            V_L_vec(k+1) = -1 * V_load_avg;
        end

        % Capacitor: Voltage and Current Calculations
        i_C_vec(k+1) = i_L_vec(k) - (V_load_vec(k) / R_load);
        V_C_vec(k+1) = V_load_vec(k+1);

        % Load: Current Calculation
        i_load_vec(k+1) = V_load_vec(k+1) / R_load;

    else % If the circuit is non ideal.
        switch_state(k) = sw(D_non_ideal, t_vec(k)); % calling sw.m

        if(switch_state(k))
            %i_L_vec(k+1) = i_L_vec(k) + dt * ((V_in - V_T_on - V_load_vec(k) - (R_T_on *
i_L_vec(k)))) / L;    %i_L
```

```
            i_L_vec(k+1) = i_L_vec(k) + dt * ((V_in - V_T_on - V_load_vec(k) - (R_T_on * i_L_vec(k))) / L);    %i_L

            % Switch 1: Voltage and Current Calculations
            V_switch1(k+1) = 0;
            i_switch1(k+1) = i_L_vec(k+1);
            P_switch1(k+1) = (R_T_on * i_L_vec(k+1) + V_T_on) * i_L_vec(k+1);

            % Switch 2: Voltage and Current Calculations
            V_switch2(k+1) = V_D_on + (R_D_on * i_L_vec(k+1)) - V_in;
            i_switch2(k+1) = 0;
        else
            i_L_vec(k+1) = i_L_vec(k) + dt * ((-1 * V_load_vec(k) - V_D_on - (R_D_on * i_L_vec(k)))) / L;

            % Switch 1: Voltage and Current Calculations
            V_switch1(k+1) = V_in + (R_D_on * i_L_vec(k+1)) + V_D_on;
            i_switch1(k+1) = 0;

            % Switch 2: Voltage and Current Calculations
            V_switch2(k+1) = 0;
            i_switch2(k+1) = i_L_vec(k+1);
            P_switch2(k+1) = (R_D_on * i_L_vec(k+1) + V_D_on) * i_L_vec(k+1);
        end

        V_load_vec(k+1) = V_load_vec(k) + dt * ((i_L_vec(k) - (V_load_vec(k) / R_load)) / C);
%V_load
    end

    % Increment the time and index
    t_vec(k + 1) = t_vec(k) + dt;
    k = k + 1;
end
```

Project #1\buckproc.m

```
% ID Number: 229,506
% ECE 31033 - Project #1
% buckproc.m

% The file buckproc.m first contains the circuit parameter values (i.e. L, C, fsw, time
% step, initial conditions etc.). Only the initial value of your circuit voltages and
% currents should be pre-established (i.e. Vload(1)=0). It then invokes buck. Finally,
% it performs your plotting and any post-processing calculations that are done
% using the simulated data (such as computing average values, efficiency, etc.).
%% Ideal - Given Values
V_in = 800;
V_load_avg = 400;
V_load_ripple = 10;
P_load_light = 50000;
P_load_heavy = 250000;
frequency = 10000;

ideal_boolean = 1; % = 0 if non ideal, = 1 if ideal; here, it is ON.

%% Ideal - Calculated Values
T_sw = 1 / frequency;
D = V_load_avg / V_in;  % Duty Cycle

R_load_light = (V_load_avg^2) / P_load_light;
R_load_heavy = (V_load_avg^2) / P_load_heavy;

L_crit = (R_load_light * (1 - D)) / (2 * frequency);
L = L_crit * 1.1;

C = (V_load_avg / V_load_ripple) * (T_sw^2 * (1 - D)) / (8 * L);

I_load_light = V_load_avg / R_load_light;
I_load_heavy = V_load_avg / R_load_heavy;

i_L1_light = (V_load_avg / R_load_light) - (1 - D) * T_sw * V_load_avg / (2 * L);
i_L2_light = (V_load_avg / R_load_light) + (1 - D) * T_sw * V_load_avg / (2 * L);

i_L1_heavy= (V_load_avg / R_load_heavy) - (1 - D) * T_sw * V_load_avg / (2 * L);
i_L2_heavy= (V_load_avg / R_load_heavy) + (1 - D) * T_sw * V_load_avg / (2 * L);

%% Buck Intialization - Heavy Load
% Initializing Values
k = 1;
t = 0;
dt = 1e-7;

tend = 100 * T_sw;

% Zero Vectors (used in buck)
t_vec = [0];
switch_state = [0];

V_L_vec = [0];
```

```
i_L_vec = [0];

V_C_vec = [0];
i_C_vec = [0];

V_load_vec = [0];
i_load_vec = [0];

V_switch1 = [0];
i_switch1 = [0];

V_switch2 = [0];
i_switch2 = [0];

%% Running Buck - Using R_load_heavy
R_load = R_load_heavy;
disp('Running buck for heavy load.');
buck

%% Post-processing Calculations (computing avg values, efficiency, etc)
disp("---------------------")
disp("Heavy Averages:")

V_load_avg_func_H = aver(V_load_vec, T_sw, dt);
disp("  V_load Average: " + V_load_avg_func_H);

i_load_avg_func_H = aver(i_load_vec, T_sw, dt);
disp("  i_load Average: " + i_load_avg_func_H);

V_L_func_H = aver(V_L_vec, T_sw, dt);
disp("  V_L Average: " + V_L_func_H);

i_L_func_H = aver(i_L_vec, T_sw, dt);
disp("  i_L Average: " + i_L_func_H);

V_C_func_H = aver(V_C_vec, T_sw, dt);
disp("  V_C Average: " + V_C_func_H);

i_C_func_H = aver(i_C_vec, T_sw, dt);
disp("  i_C Average: " + i_C_func_H);

V_sw1_func_H = aver(V_switch1, T_sw, dt);
disp("  V_sw1 Average: " + V_sw1_func_H);

i_sw1_func_H = aver(i_switch1, T_sw, dt);
disp("  i_sw1 Average: " + i_sw1_func_H);

V_sw2_func_H = aver(V_switch2, T_sw, dt);
disp("  V_sw2 Average: " + V_sw2_func_H);

i_sw2_func_H = aver(i_switch2, T_sw, dt);
disp("  i_sw2 Average: " + i_sw2_func_H);

P_out_H = (V_load_avg_func_H^2) / R_load;
P_in_H = V_in * i_sw1_func_H;
eff_H = P_out_H / P_in_H;
```

```
110
111 disp("Efficiency for Light Load: " + (eff_H * 100) + "%.");
112 disp("---------------------")
113
114 %% Plotting - Heavy Load - Transient
115 % Plots for the transient to steady state
116 figure;
117 sgtitle("Heavy Load: Voltage and Current Plots for All Components at Transient State");
118 % Plots for the Load
119 subplot(5,2,1);
120 plot(t_vec, V_load_vec);
121 title('Load Voltage vs Time');
122 xlabel('Time (ms)');
123 ylabel('Voltage (V)');
124
125 subplot(5,2,2);
126 plot(t_vec, i_load_vec);
127 title('Load Current vs Time');
128 xlabel('Time (ms)');
129 ylabel('Current (A)');
130
131 % Plots for the Inductor
132 subplot(5,2,3);
133 plot(t_vec, V_L_vec);
134 title('Inductor Voltage vs Time');
135 xlabel('Time (ms)');
136 ylabel('Voltage (V)');
137
138 subplot(5,2,4);
139 plot(t_vec, i_L_vec);
140 title('Inductor Current vs Time');
141 xlabel('Time (ms)');
142 ylabel('Current (A)');
143
144 % Plots for the Capacitor
145 subplot(5,2,5);
146 plot(t_vec, V_C_vec);
147 title('Capacitor Voltage vs Time');
148 xlabel('Time (ms)');
149 ylabel('Voltage (V)');
150
151 subplot(5,2,6);
152 plot(t_vec, i_C_vec);
153 title('Capacitor Current vs Time');
154 xlabel('Time (ms)');
155 ylabel('Current (A)');
156
157 % Plots for Switch 1
158 subplot(5,2,7);
159 plot(t_vec, V_switch1);
160 title('Transistor Switching Voltage vs Time');
161 xlabel('Time (ms)');
162 ylabel('Voltage (V)');
163
164 subplot(5,2,8);
165 plot(t_vec, i_switch1);
```

```
title('Transistor Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 2
subplot(5,2,9);
plot(t_vec, V_switch2);
title('Diode Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,10);
plot(t_vec, i_switch2);
title('Diode Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

%% Plotting - Heavy Load - Steady State
periods_to_plot = 2;

points_per_period = round(T_sw / dt);  % Points per period
total_periods = floor(tend / T_sw);    % Total number of periods in the simulation

start_index = max(1, (total_periods - periods_to_plot) * points_per_period + 1);
end_index = min(length(t_vec), total_periods * points_per_period);

range_to_plot = start_index:end_index;

%% Plot
figure;
sgtitle("Heavy Load: Voltage and Current Plots for All Components at Steady State");
% Plots for the Load
subplot(5,2,1);
plot(t_vec(range_to_plot), V_load_vec(range_to_plot));
title('Load Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,2);
plot(t_vec(range_to_plot), i_load_vec(range_to_plot));
title('Load Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for the Inductor
subplot(5,2,3);
plot(t_vec(range_to_plot), V_L_vec(range_to_plot));
title('Inductor Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,4);
plot(t_vec(range_to_plot), i_L_vec(range_to_plot));
title('Inductor Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');
```

```
% Plots for the Capacitor
subplot(5,2,5);
plot(t_vec(range_to_plot), V_C_vec(range_to_plot));
title('Capacitor Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,6);
plot(t_vec(range_to_plot), i_C_vec(range_to_plot));
title('Capacitor Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 1
subplot(5,2,7);
plot(t_vec(range_to_plot), V_switch1(range_to_plot));
title('Transistor Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,8);
plot(t_vec(range_to_plot), i_switch1(range_to_plot));
title('Transistor Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 2
subplot(5,2,9);
plot(t_vec(range_to_plot), V_switch2(range_to_plot));
title('Diode Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,10);
plot(t_vec(range_to_plot), i_switch2(range_to_plot));
title('Diode Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Buck Intialization - Light Load
% Initializing Values
k = 1;
t = 0;
dt = 1e-7;

tend = 250 * T_sw;

% Zero Vectors (used in buck)
t_vec = [0];
switch_state = [0];

V_L_vec = [0];
i_L_vec = [0];

```

```
V_C_vec = [0];
i_C_vec = [0];

V_load_vec = [0];
i_load_vec = [0];

V_switch1 = [0];
i_switch1 = [0];

V_switch2 = [0];
i_switch2 = [0];

%% Running Buck - Using R_load_light
R_load = R_load_light;
disp('Running buck for light load.');
buck

%% Post-processing Calculations (computing avg values, efficiency, etc)
disp("---------------------")
disp("Light Averages:")

V_load_avg_func_L = aver(V_load_vec, T_sw, dt);
disp("  V_load Average: " + V_load_avg_func_L);

i_load_avg_func_L = aver(i_load_vec, T_sw, dt);
disp("  i_load Average: " + i_load_avg_func_L);

V_L_func_L = aver(V_L_vec, T_sw, dt);
disp("  V_L Average: " + V_L_func_L);

i_L_func_L = aver(i_L_vec, T_sw, dt);
disp("  i_L Average: " + i_L_func_L);

V_C_func_L = aver(V_C_vec, T_sw, dt);
disp("  V_C Average: " + V_C_func_L);

i_C_func_L = aver(i_C_vec, T_sw, dt);
disp("  i_C Average: " + i_C_func_L);

V_sw1_func_L = aver(V_switch1, T_sw, dt);
disp("  V_sw1 Average: " + V_sw1_func_L);

i_sw1_func_L = aver(i_switch1, T_sw, dt);
disp("  i_sw1 Average: " + i_sw1_func_L);

V_sw2_func_L = aver(V_switch2, T_sw, dt);
disp("  V_sw2 Average: " + V_sw2_func_L);

i_sw2_func_L = aver(i_switch2, T_sw, dt);
disp("  i_sw2 Average: " + i_sw2_func_L);

P_out_L = (V_load_avg_func_L^2) / R_load;
P_in_L = V_in * i_sw1_func_L;
eff_L = P_out_L / P_in_L;

disp("Efficiency for Light Load: " + (eff_L * 100) + "%.");
```

```
disp("---------------------")
%% Plotting - Light Load - Transient
% Plots for the transient to steady state
figure;
sgtitle("Light Load: Voltage and Current Plots for All Components at Transient State");
% Plots for the Load
subplot(5,2,1);
plot(t_vec, V_load_vec);
title('Load Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,2);
plot(t_vec, i_load_vec);
title('Load Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for the Inductor
subplot(5,2,3);
plot(t_vec, V_L_vec);
title('Inductor Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,4);
plot(t_vec, i_L_vec);
title('Inductor Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for the Capacitor
subplot(5,2,5);
plot(t_vec, V_C_vec);
title('Capacitor Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,6);
plot(t_vec, i_C_vec);
title('Capacitor Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 1
subplot(5,2,7);
plot(t_vec, V_switch1);
title('Transistor Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,8);
plot(t_vec, i_switch1);
title('Transistor Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');
```

```
390
391 % Plots for Switch 2
392 subplot(5,2,9);
393 plot(t_vec, V_switch2);
394 title('Diode Switching Voltage vs Time');
395 xlabel('Time (ms)');
396 ylabel('Voltage (V)');
397
398 subplot(5,2,10);
399 plot(t_vec, i_switch2);
400 title('Diode Switching Current vs Time');
401 xlabel('Time (ms)');
402 ylabel('Current (A)');
403
404 %% Plotting - Light Load - Steady State
405 periods_to_plot = 2;
406
407 points_per_period = round(T_sw / dt);  % Points per period
408 total_periods = floor(tend / T_sw);    % Total number of periods in the simulation
409
410 start_index = max(1, (total_periods - periods_to_plot) * points_per_period + 1);
411 end_index = min(length(t_vec), total_periods * points_per_period);
412
413 range_to_plot = start_index:end_index;
414
415 %% Plot
416 figure;
417 sgtitle("Light Load: Voltage and Current Plots for All Components at Steady State");
418 % Plots for the Load
419 subplot(5,2,1);
420 plot(t_vec(range_to_plot), V_load_vec(range_to_plot));
421 title('Load Voltage vs Time');
422 xlabel('Time (ms)');
423 ylabel('Voltage (V)');
424
425 subplot(5,2,2);
426 plot(t_vec(range_to_plot), i_load_vec(range_to_plot));
427 title('Load Current vs Time');
428 xlabel('Time (ms)');
429 ylabel('Current (A)');
430
431 % Plots for the Inductor
432 subplot(5,2,3);
433 plot(t_vec(range_to_plot), V_L_vec(range_to_plot));
434 title('Inductor Voltage vs Time');
435 xlabel('Time (ms)');
436 ylabel('Voltage (V)');
437
438 subplot(5,2,4);
439 plot(t_vec(range_to_plot), i_L_vec(range_to_plot));
440 title('Inductor Current vs Time');
441 xlabel('Time (ms)');
442 ylabel('Current (A)');
443
444 % Plots for the Capacitor
445 subplot(5,2,5);
```

```
plot(t_vec(range_to_plot), V_C_vec(range_to_plot));
title('Capacitor Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,6);
plot(t_vec(range_to_plot), i_C_vec(range_to_plot));
title('Capacitor Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 1
subplot(5,2,7);
plot(t_vec(range_to_plot), V_switch1(range_to_plot));
title('Transistor Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,8);
plot(t_vec(range_to_plot), i_switch1(range_to_plot));
title('Transistor Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 2
subplot(5,2,9);
plot(t_vec(range_to_plot), V_switch2(range_to_plot));
title('Diode Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(5,2,10);
plot(t_vec(range_to_plot), i_switch2(range_to_plot));
title('Diode Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Non Ideal - Given Values
V_T_on = 1;
V_D_on = 1;
R_T_on = 0.01;
R_D_on = 0.01;

ideal_boolean = 0; % = 0 if non ideal, = 1 if ideal; here, it is OFF.

%% Non Ideal - Calculated Values
R_load = R_load_heavy;
D_non_ideal = (V_D_on + V_load_avg + (R_D_on * V_load_avg / R_load));
D_non_ideal = D_non_ideal / (V_in - V_T_on + V_D_on + (R_D_on * V_load_avg / R_load) -
(R_T_on * V_load_avg / R_load));

i_L1_NI = (V_load_avg / R_load) - (((1 - D_non_ideal) * T_sw * V_load_avg) / (2 * L));
i_L2_NI = (V_load_avg / R_load) + (((1 - D_non_ideal) * T_sw * V_load_avg) / (2 * L));

%% Buck Intialization - Heavy Load
```

```
% Initializing Values
k = 1;
t = 0;
dt = 1e-7;

tend = 100 * T_sw;

% Zero Vectors (used in buck)
t_vec = [0];
switch_state = [0];

V_L_vec = [0];
i_L_vec = [0];

V_C_vec = [0];
i_C_vec = [0];

V_load_vec = [0];
i_load_vec = [0];

V_switch1 = [0];
i_switch1 = [0];

V_switch2 = [0];
i_switch2 = [0];

P_switch1 = [0]; % Power loss across the transistor; new for non-ideal calculations.
P_switch2 = [0]; % Power loss across the diode; new for non-ideal calculations.

%% Running Buck - Using R_load_heavy
R_load = R_load_heavy;
disp('Running buck for heavy load and non ideal conditions.');
buck

%% Post-processing Calculations (computing avg values, efficiency, etc)
disp("---------------------")
disp("Non Ideal Averages:")

V_load_avg_func_NI = aver(V_load_vec, T_sw, dt);
disp("  V_load Average: " + V_load_avg_func_NI);

i_L_func_NI = aver(i_L_vec, T_sw, dt);
disp("  i_L Average: " + i_L_func_NI);

V_sw1_func_NI = aver(V_switch1, T_sw, dt);
disp("  V_sw1 Average: " + V_sw1_func_NI);

i_sw1_func_NI = aver(i_switch1, T_sw, dt);
disp("  i_sw1 Average: " + i_sw1_func_NI);

V_sw2_func_NI = aver(V_switch2, T_sw, dt);
disp("  V_sw2 Average: " + V_sw2_func_NI);

i_sw2_func_NI = aver(i_switch2, T_sw, dt);
disp("  i_sw2 Average: " + i_sw2_func_NI);

```

```
P_sw1_func_NI = aver(P_switch1, T_sw, dt);
disp("  P_sw1 Average: " + V_sw2_func_NI);

P_sw2_func_NI = aver(P_switch2, T_sw, dt);
disp("  P_sw2 Average: " + i_sw2_func_NI);

P_out_NI = (V_load_avg_func_NI^2) / R_load;
P_in_NI = V_in * i_sw1_func_NI;
eff_NI = P_out_NI / P_in_NI;

disp("Efficiency for Non-Ideal: " + (eff_NI * 100) + "%.");
disp("Transistor Power Loss: " + P_sw1_func_NI);
disp("Diode Power Loss: " + P_sw2_func_NI);
disp("----------------------")
%% Plotting - Non Ideal Heavy Load - Transient
% Plots for the transient to steady state
figure;
sgtitle("Non Ideal Heavy Load: Voltage and Current Plots for All Components at Transient State");
% Plots for the Load
subplot(3,2,1);
plot(t_vec, V_load_vec);
title('Load Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(3,2,2);
plot(t_vec, i_L_vec);
title('Inductor Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 1
subplot(3,2,3);
plot(t_vec, V_switch1);
title('Transistor Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(3,2,4);
plot(t_vec, i_switch1);
title('Transistor Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 2
subplot(3,2,5);
plot(t_vec, V_switch2);
title('Diode Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(3,2,6);
plot(t_vec, i_switch2);
title('Diode Switching Current vs Time');
xlabel('Time (ms)');
```

```
ylabel('Current (A)');

%% Plotting - Heavy Load - Steady State
periods_to_plot = 2;

points_per_period = round(T_sw / dt);  % Points per period
total_periods = floor(tend / T_sw);    % Total number of periods in the simulation

start_index = max(1, (total_periods - periods_to_plot) * points_per_period + 1);
end_index = min(length(t_vec), total_periods * points_per_period);

range_to_plot = start_index:end_index;

%% Plot
figure;
sgtitle("Non Ideal Heavy Load: Voltage and Current Plots for All Components at Steady State")
;
% Plots for the Load
subplot(3,2,1);
plot(t_vec(range_to_plot), V_load_vec(range_to_plot));
title('Load Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(3,2,2);
plot(t_vec(range_to_plot), i_L_vec(range_to_plot));
title('Inductor Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 1
subplot(3,2,3);
plot(t_vec(range_to_plot), V_switch1(range_to_plot));
title('Transistor Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(3,2,4);
plot(t_vec(range_to_plot), i_switch1(range_to_plot));
title('Transistor Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');

% Plots for Switch 2
subplot(3,2,5);
plot(t_vec(range_to_plot), V_switch2(range_to_plot));
title('Diode Switching Voltage vs Time');
xlabel('Time (ms)');
ylabel('Voltage (V)');

subplot(3,2,6);
plot(t_vec(range_to_plot), i_switch2(range_to_plot));
title('Diode Switching Current vs Time');
xlabel('Time (ms)');
ylabel('Current (A)');
```