Aim of the Experiment: Study of signal generation and analysis like voltage sag, swell, harmonics, flicker, and transient in MATLAB.

Test Cases:

Case 1: A pure sinusoidal voltage waveform has a peak amplitude of 1 volt and fundamental frequency of 50 Hz, number of samples per cycle is 64. Plot the waveform for eight cycles when the voltage sag of 30% occurs from the 100th sample to the 200th sample of the waveform.

MATLAB Code:

```
Vm = 1;      % Peak Amplitude
f = 50;      % Fundamental Frequency
Ns = 64;     % Number of Cycles per Cycle
T = 1/f;     %Time Period
w = 2*pi*f; % Angular Frequency in rad/sec
k = 1:8*Ns;
t = k * (0.020/Ns);
V = Vm * sin(w*t);        % Voltage Equation
Vsag = 0.7 * V;           % Voltage Sag of 30%
V(100:200) = Vsag(100:200);
plot(k,V);
xlabel('No of samples');
ylabel('Voltage in Volts');
title('Voltage sag of 30% from 100th sample to 200th sample');
```

Output:

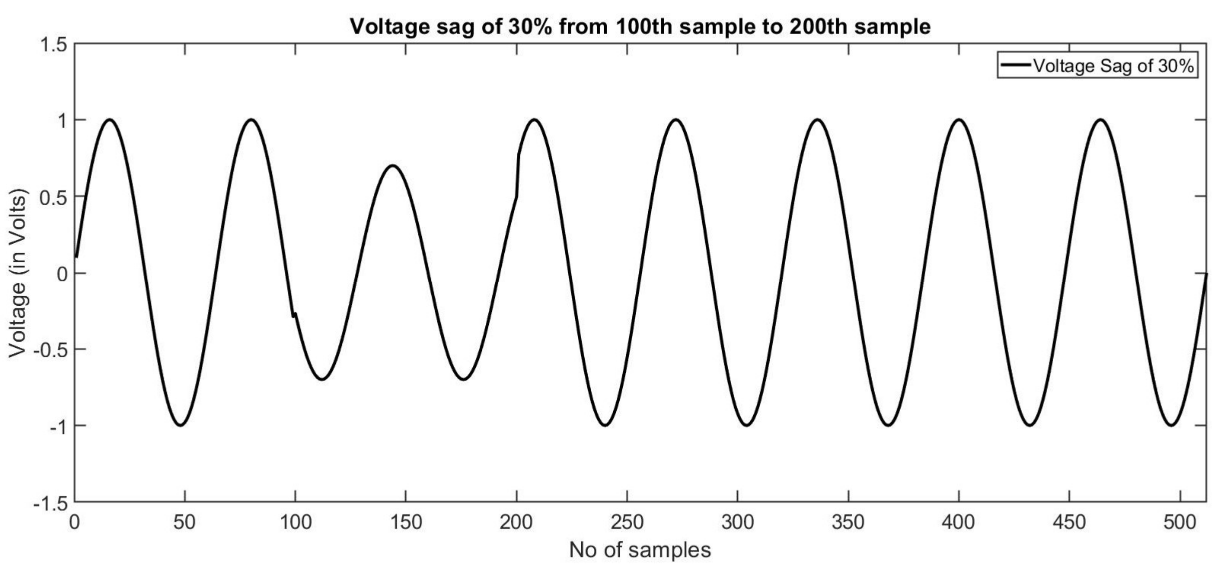

Fig 1. Voltage Waveform for a Voltage sag of 30% from 100th sample to 200th sample of the waveform

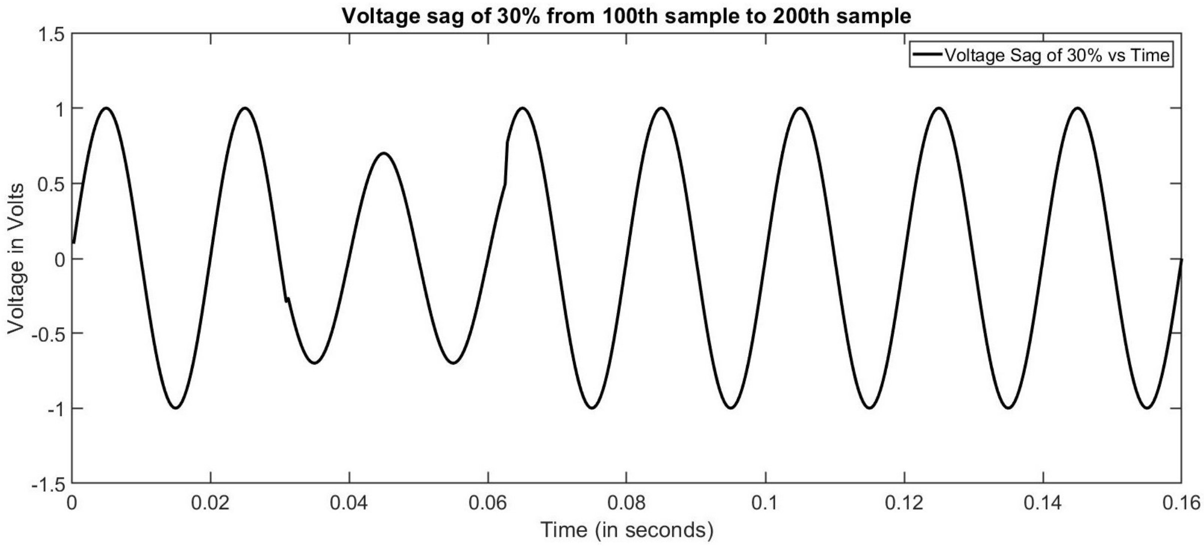

Fig 2. Voltage Waveform for a Voltage sag of 30% from 100^{th} sample (t = 0.03125 sec) to 200^{th} sample (t = 0.0625 sec) of the waveform vs time

Case 2: A pure sinusoidal voltage waveform has a peak amplitude of 1 volt and a fundamental frequency of 50 Hz, number of samples per cycle is 64. Plot the waveform for eight cycles when the voltage swell of 40% occurs from the 150th sample to the 250th sample of the waveform.

MATLAB Code:

```
Vm = 1;     % Peak Amplitude
f = 50;     % Fundamental Frequency
Ns = 64;    % Number of Cycles per Cycle
T = 1/f;    %Time Period
w = 2*pi*f; % Angular Frequency in rad/sec
k = 1:8*Ns;
t = k * (0.020/Ns);
V = Vm * sin(w*t);        % Voltage Equation
Vswell = 1.4 * V;    % Voltage Swell of 40%
V(150:250) = Vswell(150:250);
plot(k,V);
xlabel('No of samples');
ylabel('Voltage in Volts');
title('Voltage Swell of 40% from 150th sample to 250th sample');
```

Output:

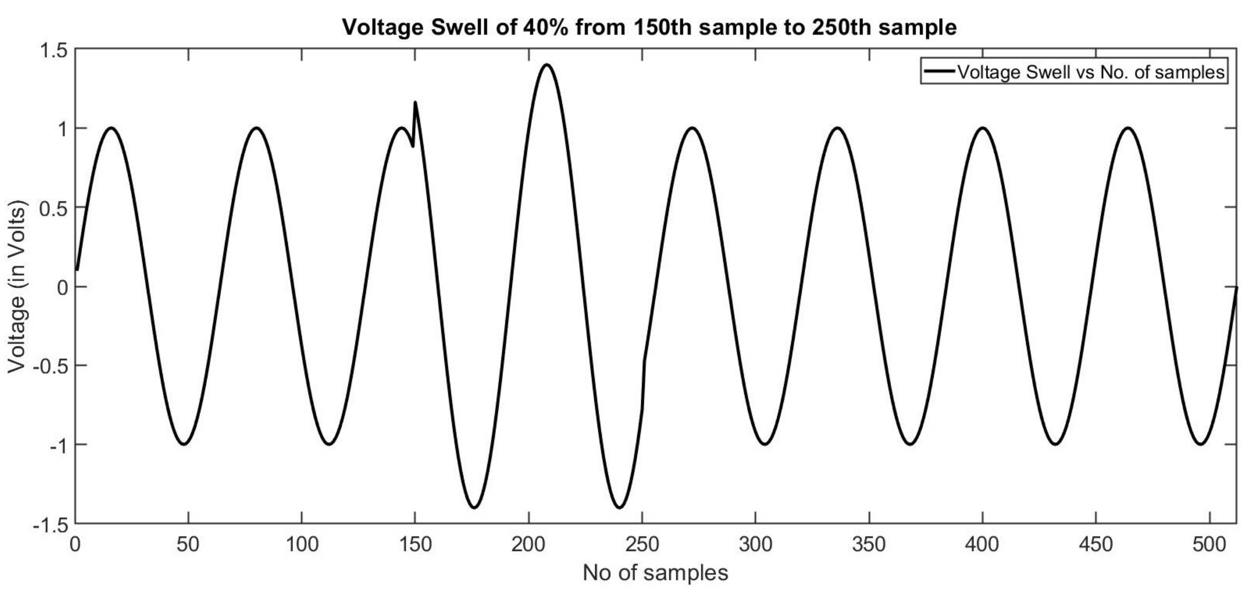

Fig 3. Voltage Waveform for a Voltage swell of 40% from 150th sample to 250th sample of the waveform

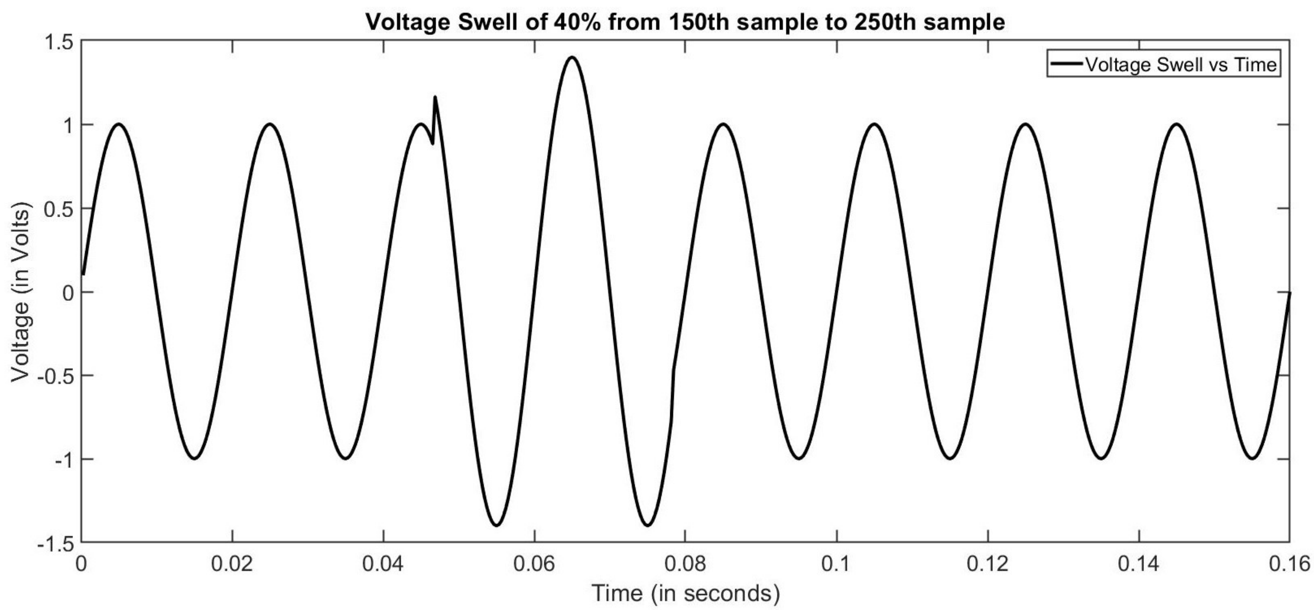

Fig 4. Voltage Waveform for a Voltage swell of 40% from 150th sample (t = 0.046875 sec) to 250th sample (t = 0.078125 sec) of the waveform vs time

Case 3: A pure sinusoidal voltage waveform has a peak value of 10 volts and a fundamental frequency of 50 Hz, the number of samples per cycle is 64. Plot the waveform for eight cycles when the voltage wave contains 30% of the third harmonic, 20% of the fifth harmonic, and 10% of the seventh harmonic for the above duration.

MATLAB Code:

```
Vm = 10;           % Peak Amplitude
f = 50;            % Fundamental Frequency
T = 1/f;           % Time Period
w = 2*pi*f;        % Angular Frequency in rad/sec
Ns = 64;           % No. of samples
k = 1:8*Ns;
t = k*(T/Ns);
V1 = Vm * sin(w*t);            % Fundamental Sinusoidal Waveform
V3 = 0.3*Vm*sin(3*w*t);        % 3rd harmonic sinusoidal waveform
V5 = 0.2*Vm*sin(5*w*t);        % 5th harmonic sinusoidal waveform
V7 = 0.1*Vm*sin(7*w*t);        % 7th harmonic sinusoidal waveform
V = V1+V3+V5+V7;               % Expected output Waveform
plot(k, V, 'Linewidth', 2);
grid on;
xlabel('Number of samples');
ylabel('Voltage in Volts');
title('Voltage waveform with different harmonics');
```

Output:

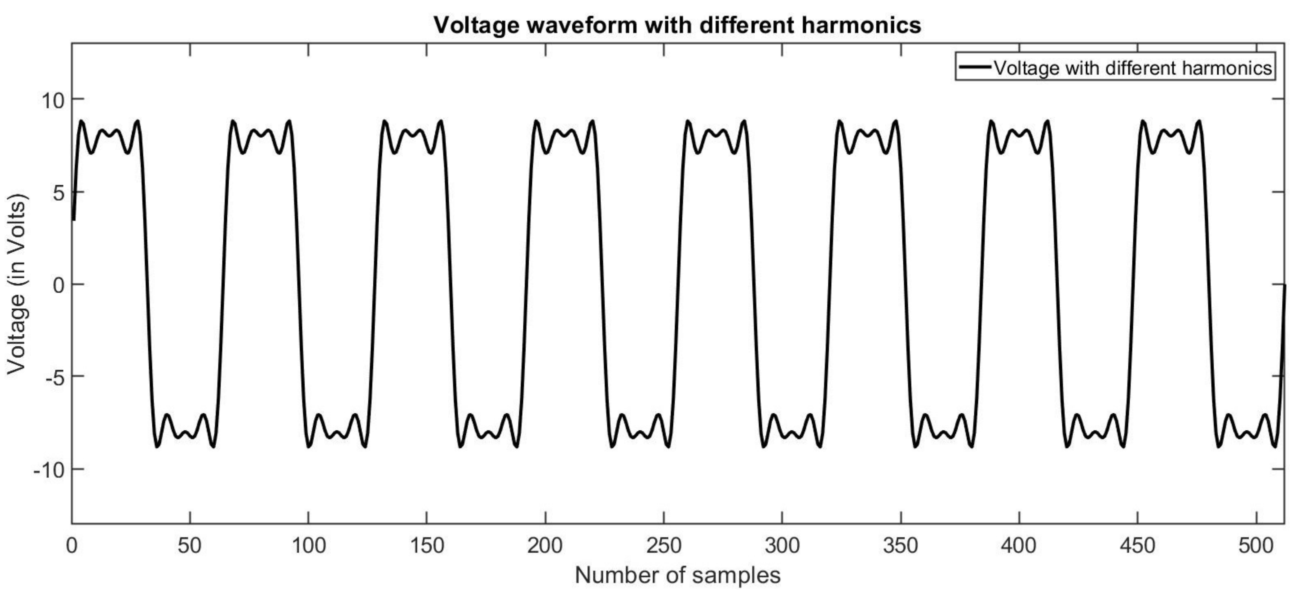

Fig 5. Voltage waveform when the signal contains 3rd, 5th, and 7th harmonics

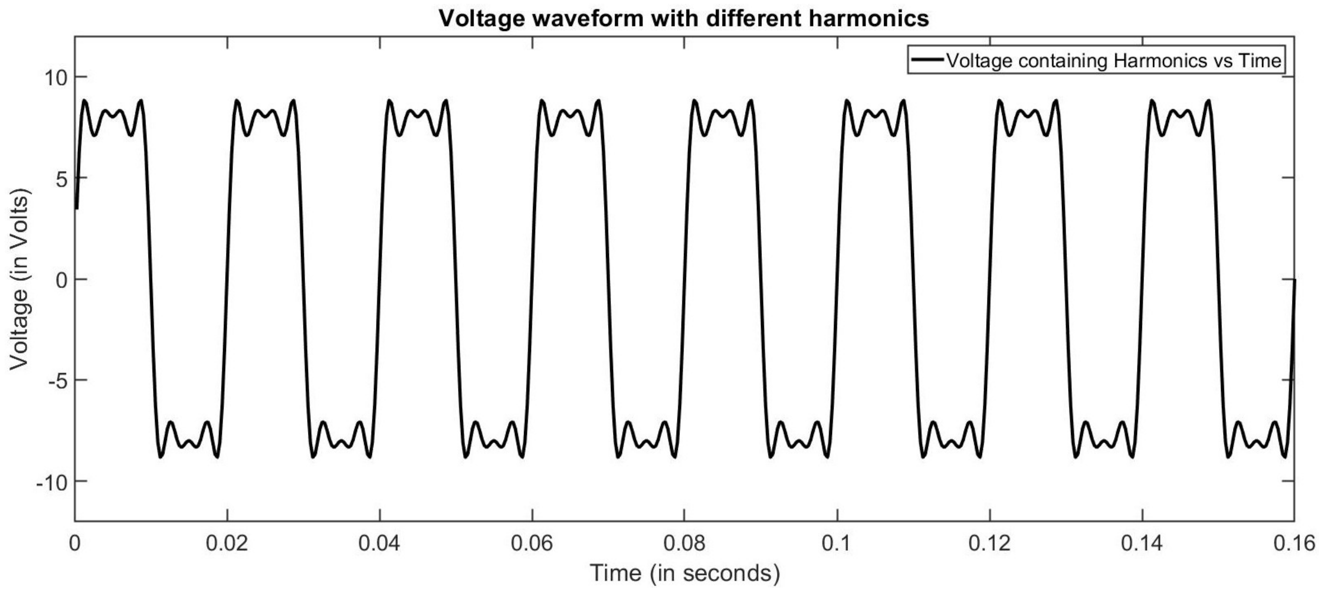

Fig 6. Voltage waveform when the signal contains 3rd, 5th, and 7th harmonics with respect to time

Case 4: A flicker waveform has a flicker coefficient of 0.2; modulating frequency of 10 Hz and fundamental frequency of 50 Hz. Number of samples per cycle is 64. Plot the waveform for eight cycles.

MATLAB Code:

```
a1 = 0.2;            % Flicker Co-efficient
f1 = 10;             % Modulating Frequency
w1 = 2*pi*f1;        % Angular Frequency in rad/sec for f1
f =50;               % Fundamental Frequency
w = 2*pi*f;          % Angular Frequency in rad/sec for f
Ns = 64;             % Number of samples per cycle
k = 1:8*Ns;
t = k*(0.020/Ns);
a = (1 + a1 * sin(w1*t));
b = sin(w*t);
V = a.*b;                      % Flicker Waveform
plot(t, V, 'Linewidth', 2);
grid on;
xlabel('Time (in seconds)');
ylabel('Voltage (in Volts)');
title('Flicker Waveform');
```

Output:

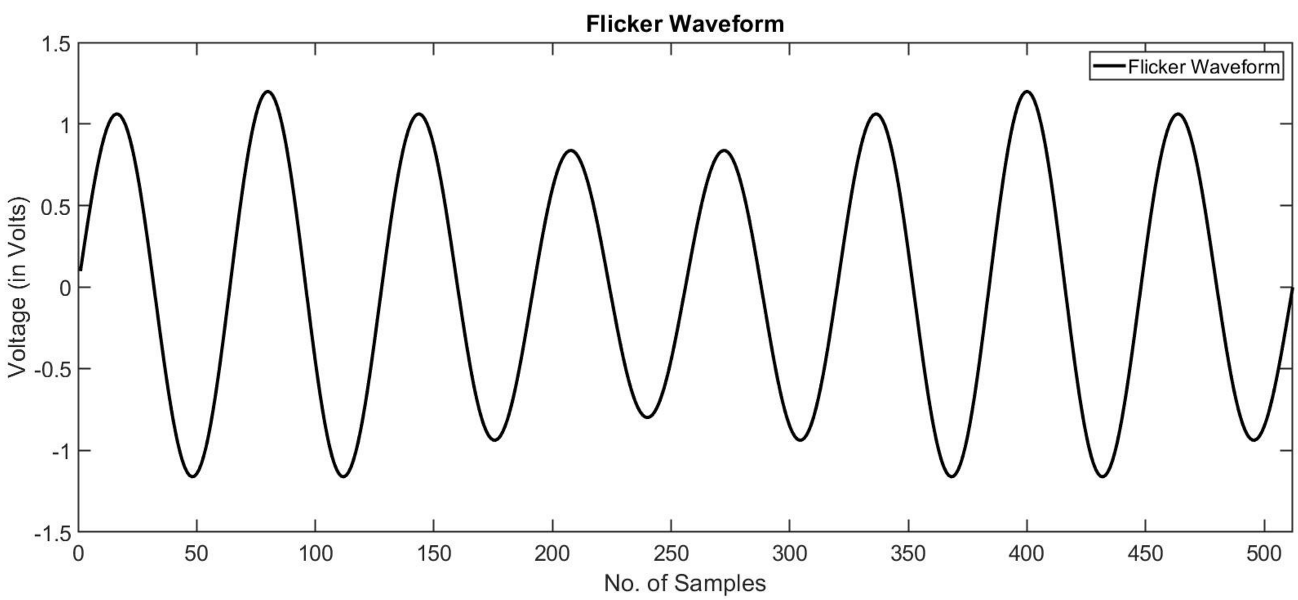

Fig 7. The plot of a Flicker Waveform with a Flicker co-efficient of 0.2 and modulating frequency of 10 Hz.

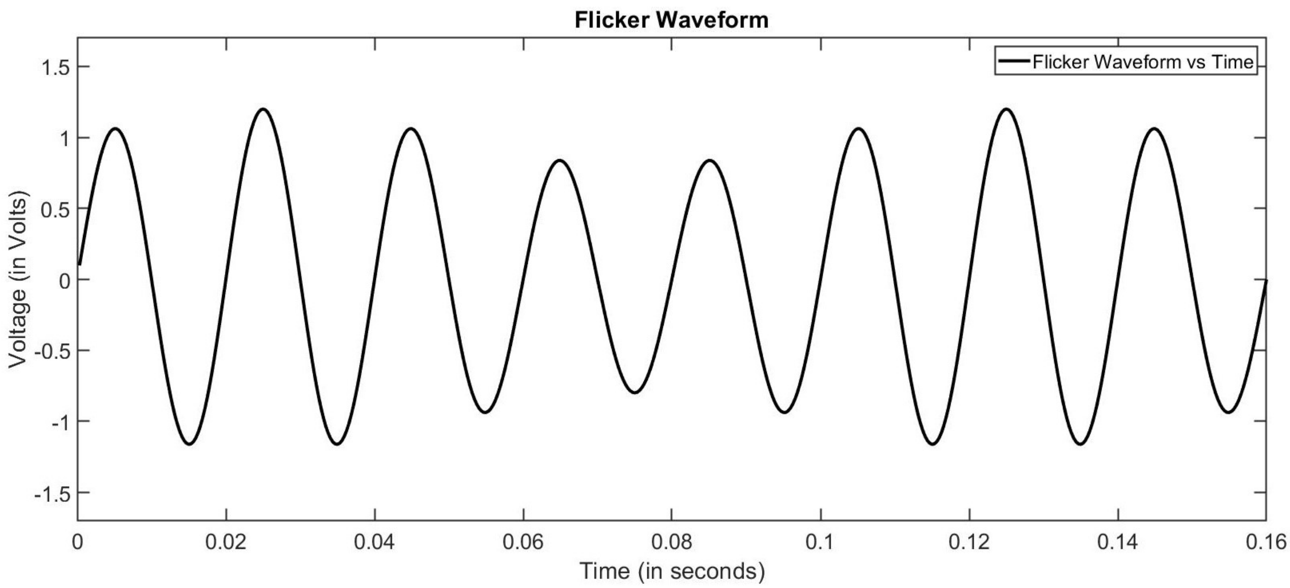

Fig 8. The plot of a Flicker Waveform with a Flicker co-efficient of 0.2 and modulating frequency of 10 Hz. Versus time

Case 5: A voltage waveform with oscillatory transient has the following parameters. a1=2, a2=5, f1=300 Hz, f=60 Hz. of samples per cycle is 64. The oscillatory transient starts at the 100th sample and ends at the 200th sample. Plot the waveform for eight cycles.

MATLAB Code:

```
a1 = 2;          % Constant factor 1
a2 = 5;          % Constant factor 2
f1 = 300;        % Oscillating Frequency
f = 60;          % Fundamental Frequency
Ns = 64;         % No. of samples
w = 2 * pi * f;
w1 = 2 * pi * f1;
k = 1:(8 * Ns); % Adjust the range of k to include 8*Ns
points.
t = k * (0.0167 / Ns);
a = sin(w * t);
b = a1 * exp(-t / a2) .* sin(w1 * t); % Element-wise
multiplication using ".*"
osc_trans_start = 100;
osc_trans_end = 200;
osc_transient = zeros(size(t));
osc_transient(osc_trans_start:osc_trans_end) =
b(osc_trans_start:osc_trans_end);
FL = a + osc_transient;    % Voltage waveform with oscillatory
transient
plot(t, FL, 'Linewidth',2);
xlabel('Time (in seconds)');
ylabel('Voltage (in Volts)');
title('Voltage Waveform with Oscillatory Transient');
grid on;
legend('Voltage Waveform');
```

Output:

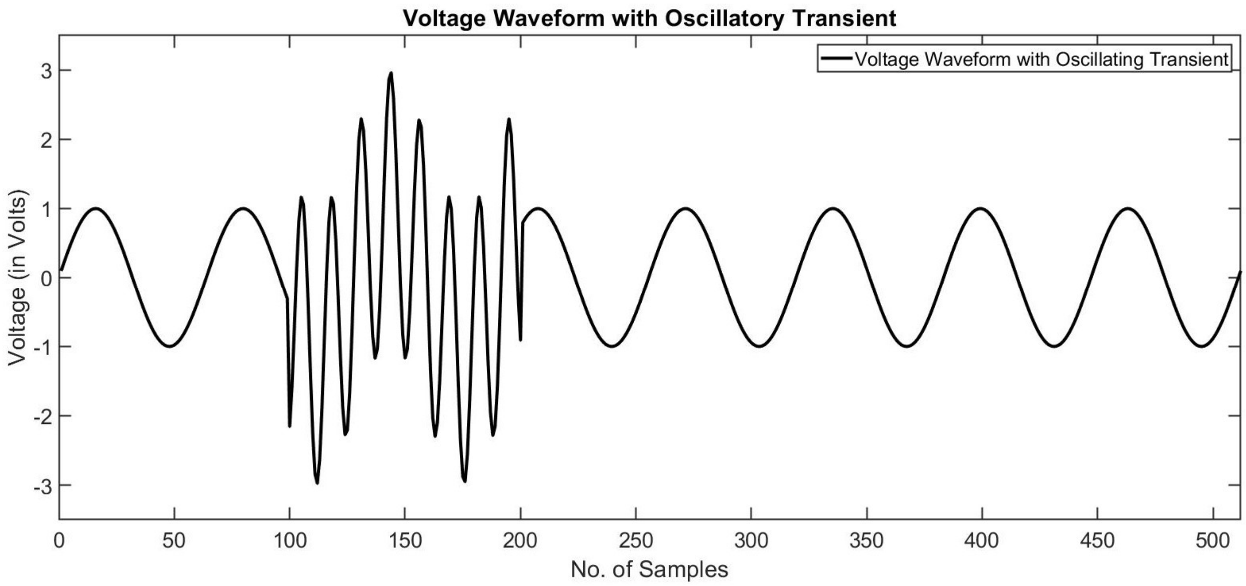

Fig 9. Voltage Waveform with Oscillatory Transient versus No. of Samples

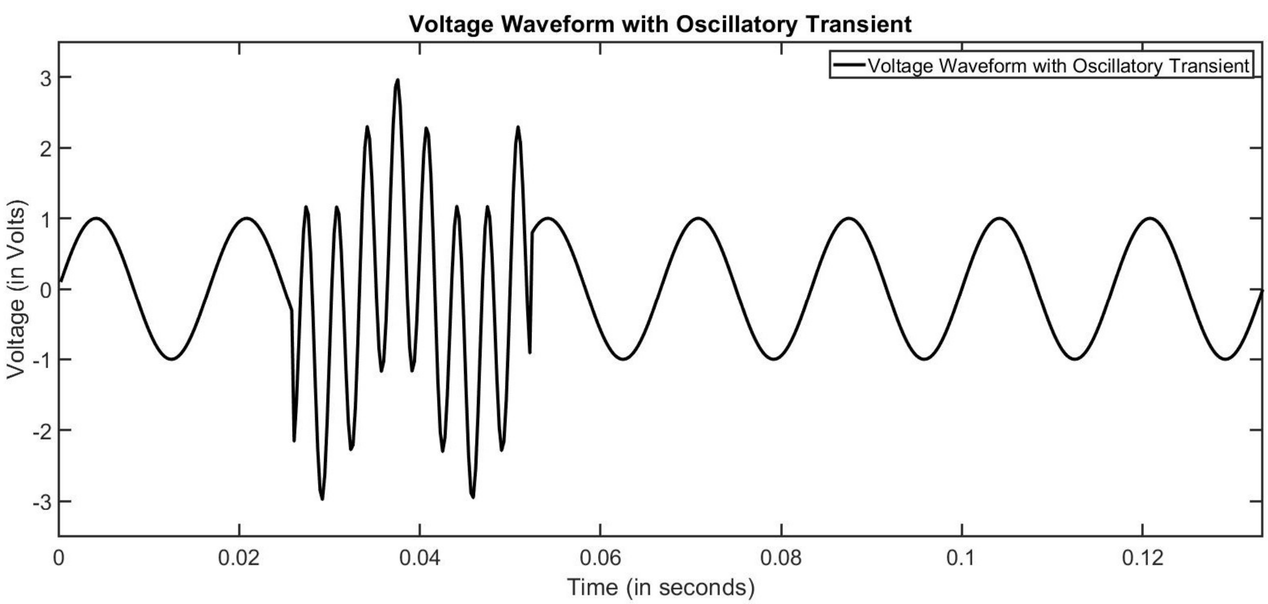

Fig 10. Voltage Waveform with Oscillatory Transient versus time