# PRINCIPLES OF TRANSDUCER DEVICES AND COMPONENTS


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Sheroz Khan, International Islamic University Malaysia

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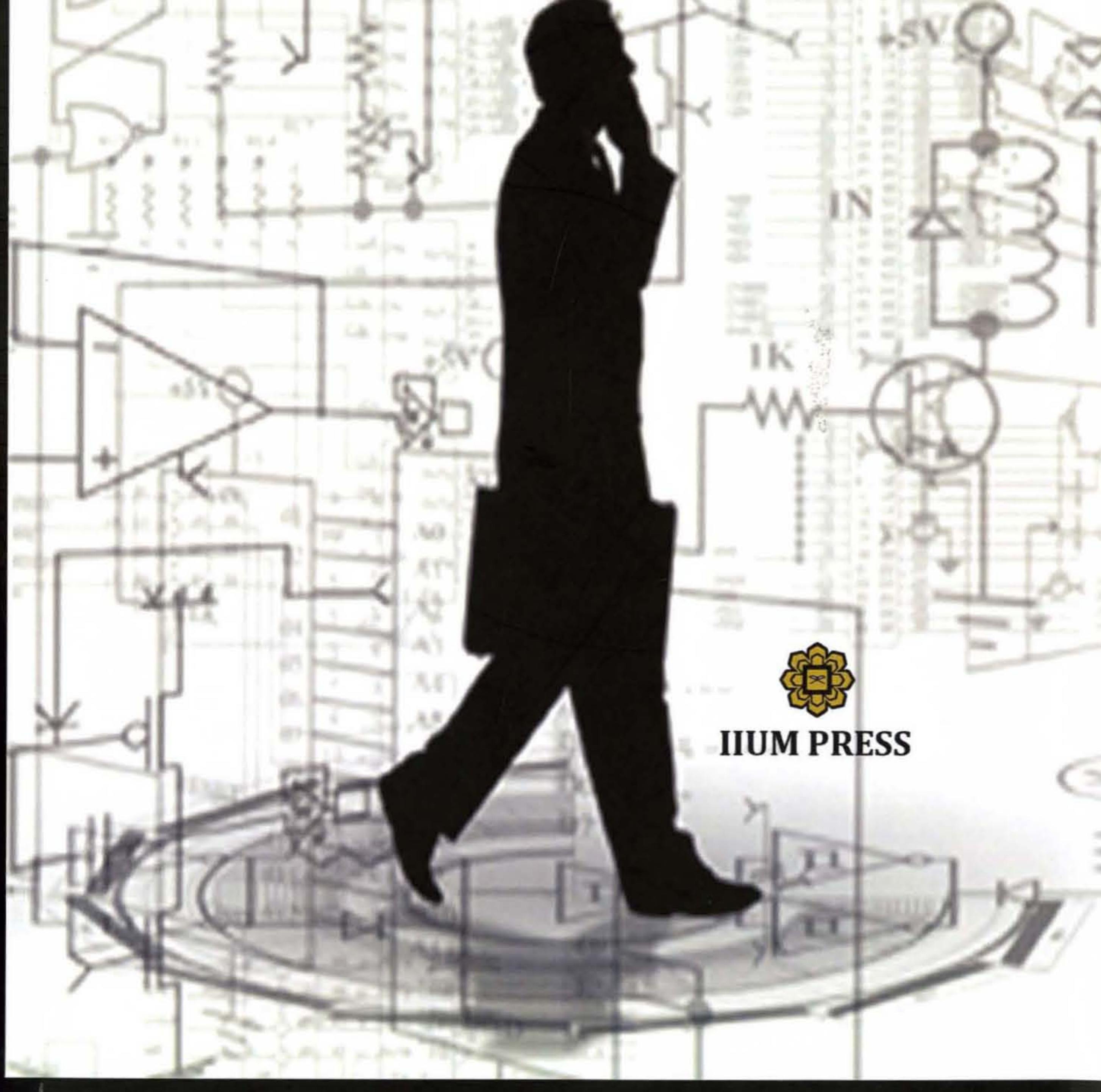


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# CONTENTS

# Chapter 26

# ANALYSIS OF HYBRID STEPPER MOTOR PERFORMANCE UNDER THE INFLUENCE OF VOLTAGE SUPPLY INTERFERENCE

ABDULAZEEZ F. SALAMI, WAHAB A. LAWAL, SHEROZ KHAN, TEDDY SURYA GUNAWAN, SIGIT PUSPITOWIGATI JAROT

## 26.0 INTRODUCTION

This chapter investigates the effects of voltage supply interference on the performance of hybrid stepper motor. MATLAB Simulink is used to model the power supply, sinusoidal interfering signal, stepper motor driver circuit and the hybrid stepper motor. This stepper motor is using a DC Voltage supply of 28 volts and it is a two-phase motor with a step angle of 1.8°. The different simulation scenarios that is explored in this work are for a noiseless power

supply, low frequency-low amplitude noise operating at 50 hertz and 1 volts, low frequency-high amplitude noise operating at 50 hertz and 5 volts, high frequency-low amplitude noise operating at 200 hertz and 1 volts and high frequency-high amplitude noise operating at 200 hertz and 5 volts.

The MATLAB/Simulink model for the system experimented, the stepping pulses and the resulting rotor position waveform is shown in Figure 26.1

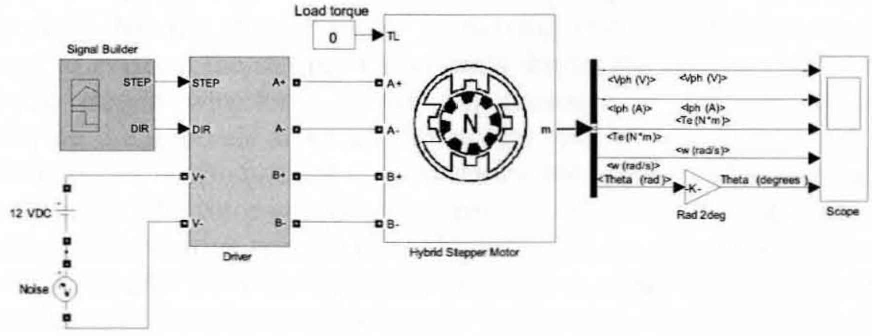
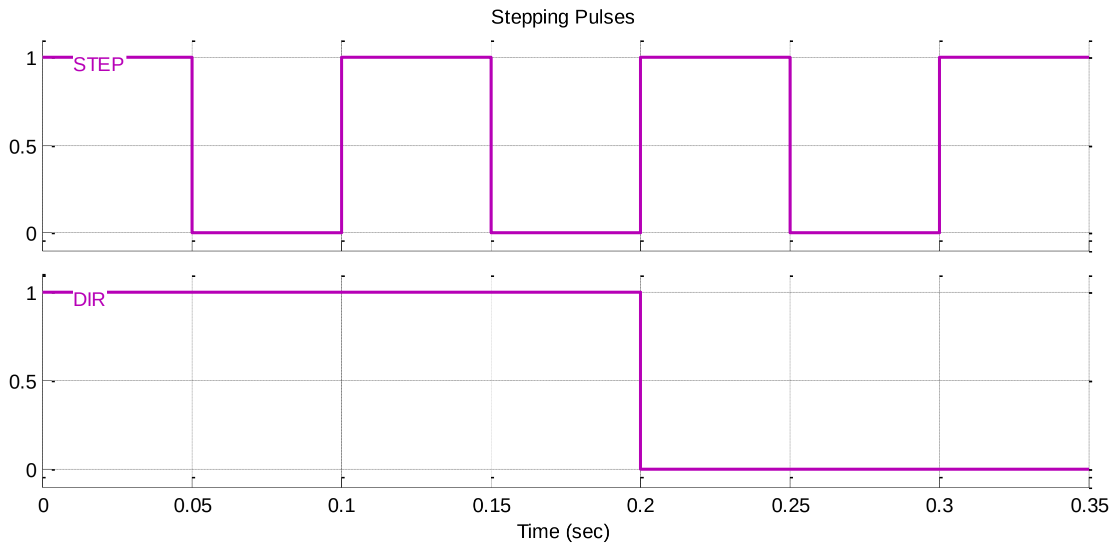
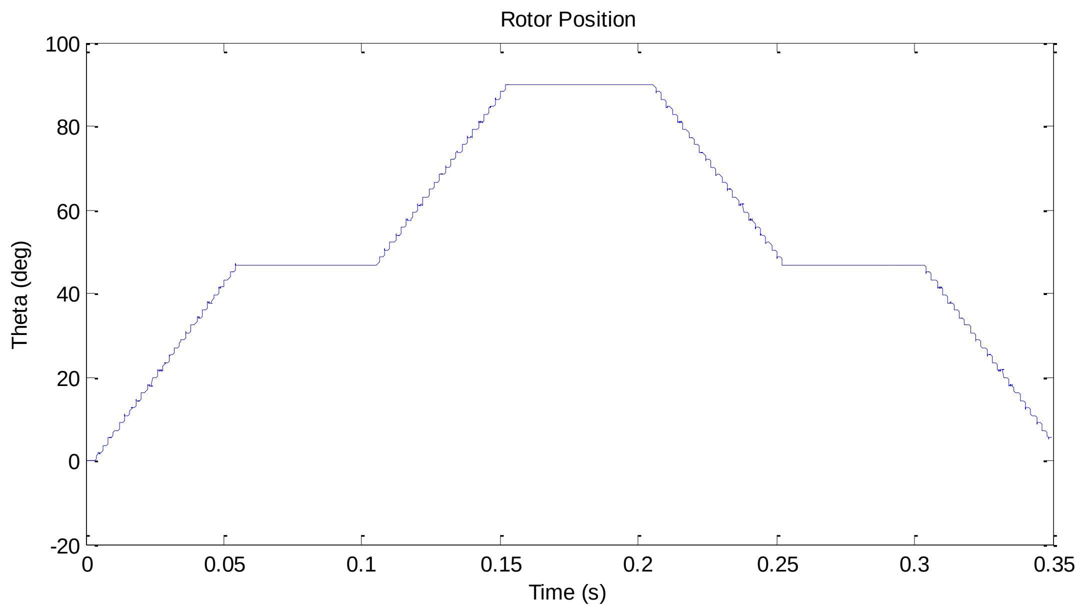
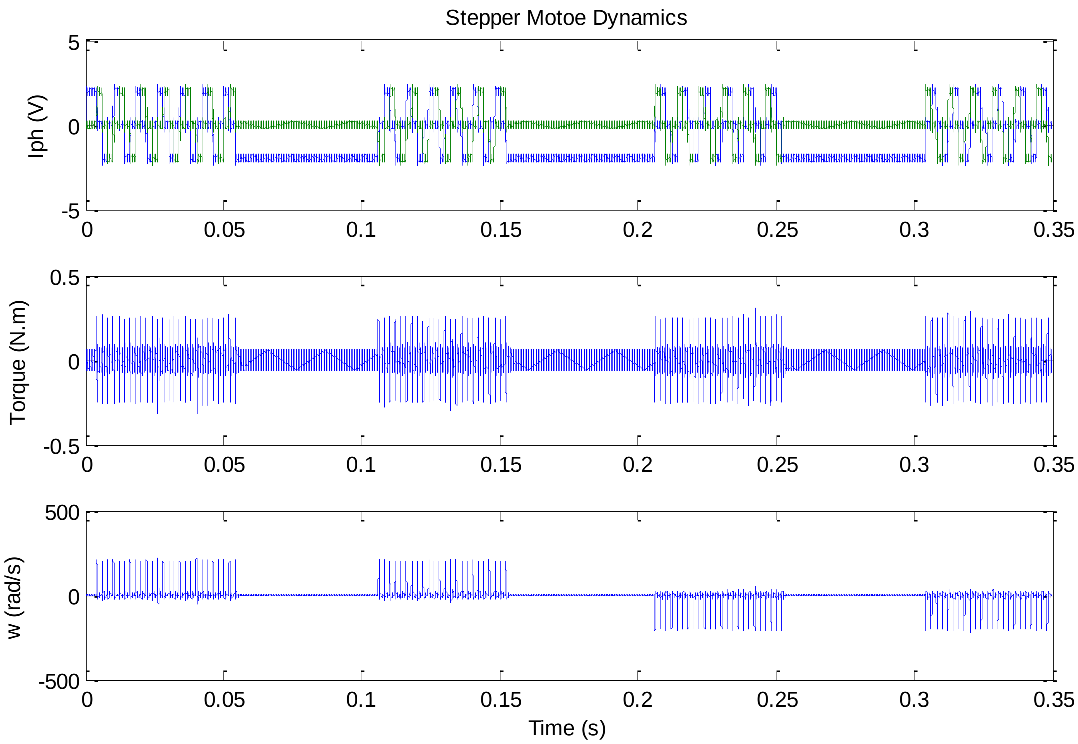



**Fig. 26.1:** MATLAB/Simulink Model For The System Experimented

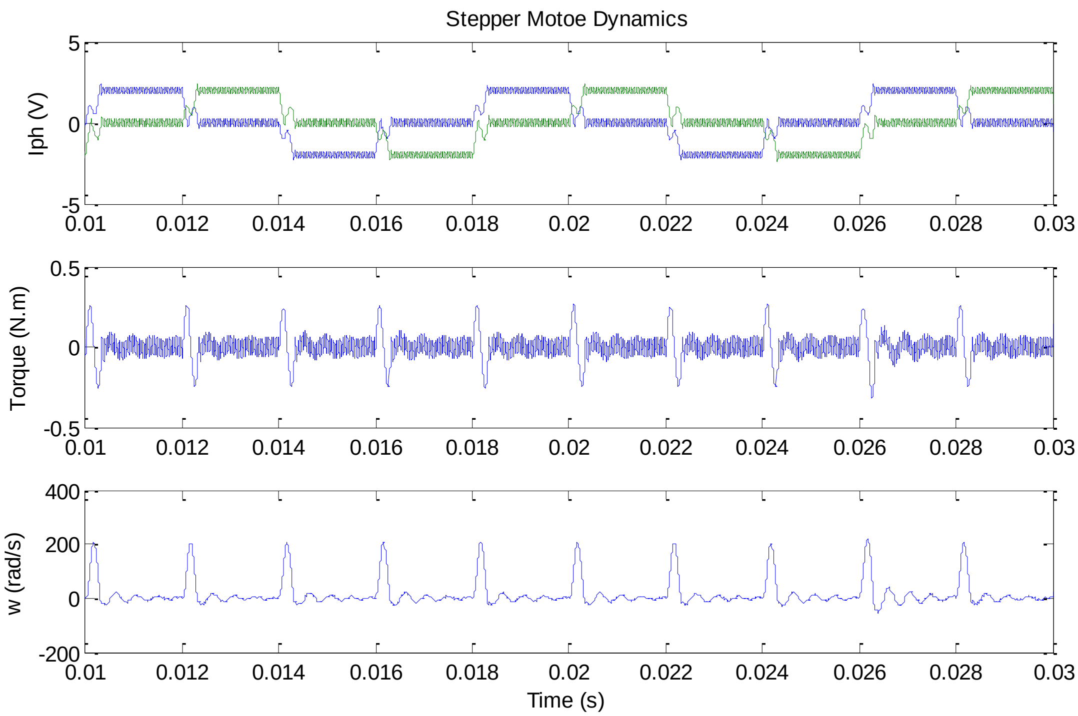


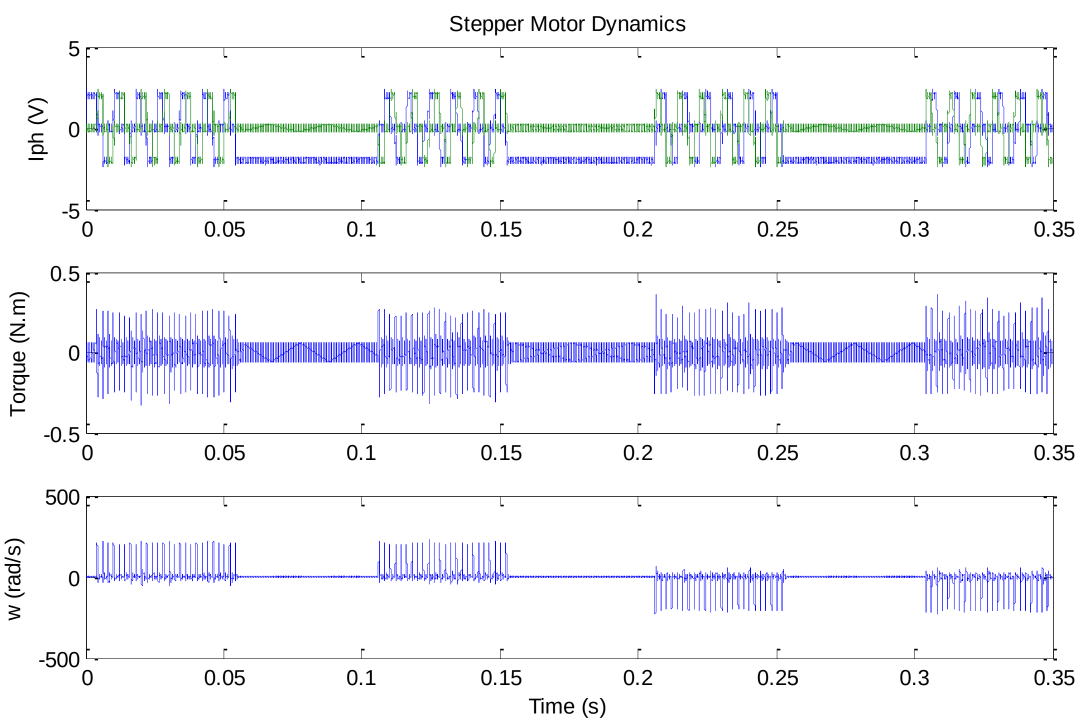

## 26. 1 Noiseless Power Supply




The figure above shows the phase current, electromagnetic torque, and rotor speed of the stepper motor for the time interval of 0.35s. During this interval, the stepper motor moves in set to motion in the following pattern: move in the forward direction (0 – 0.05s) → stop (0.05s – 0.1s) → move in the forward direction (0.1 – 0.15s) → stop (0.15s – 0.2s) → move in the reverse direction (0.2 – 0.25s) → stop (0.25s – 0.3s) → move in the reverse direction (0.3s – 0.35s). The effect of this sequence on the graphs can also be seen clearly. The phase current waveform shows the excitation sequence of the stepper motor coils for the time intervals that the stepper motor is moving. A perfectly constant phase current is seen to exist on the stepper motor coils during the intervals of no motion. The electromagnetic torque waveform shows the presence of a fairly constant torque magnitude during the intervals at which the stepper motor coils are excited. A perfectly zero magnitude torque is also noticed to exist during the intervals of no excitation (stepper motor is stationary). The rotor speed waveform also reflects the changes in the stepper motor operation. The positive speed values shown on the graph represents the intervals at which the stepper motor exhibits a forward movement while the negative speed values represent the intervals the stepper motor moves in the reverse direction. The constant zero regions on the rotor speed waveform represent the intervals at which the stepper motor is stationary. The figure below further shows an expanded view of a section of the waveforms presented in the previous figures.

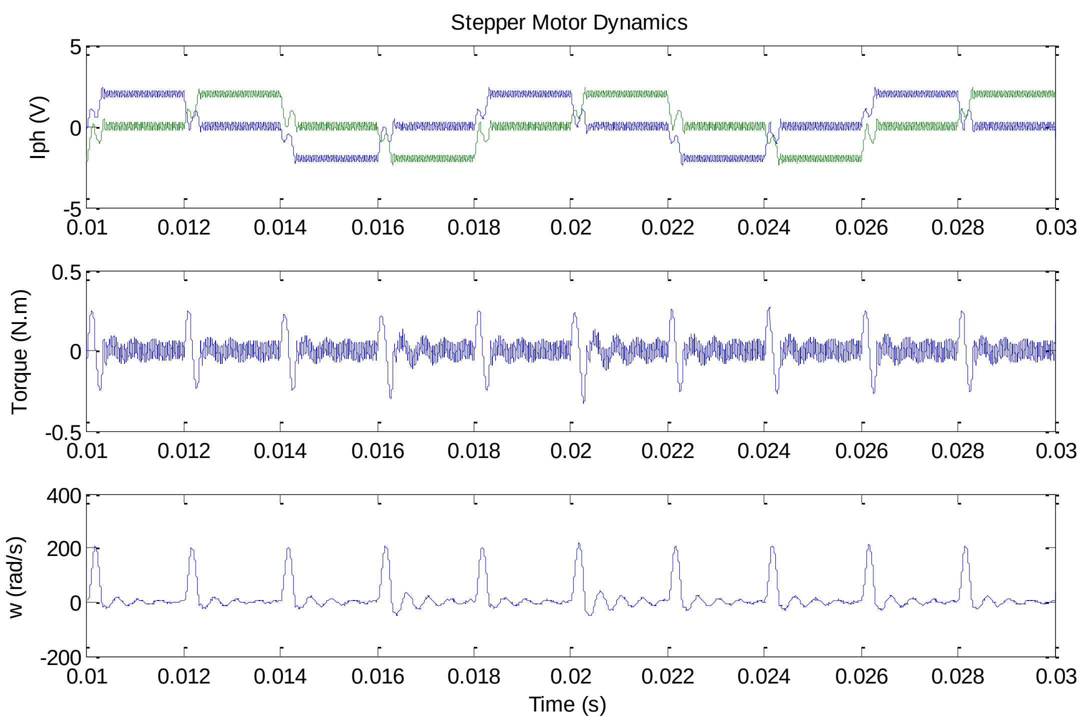



## 26. 2 Effect of Low Frequency-Low Amplitude (LFLA) Interference

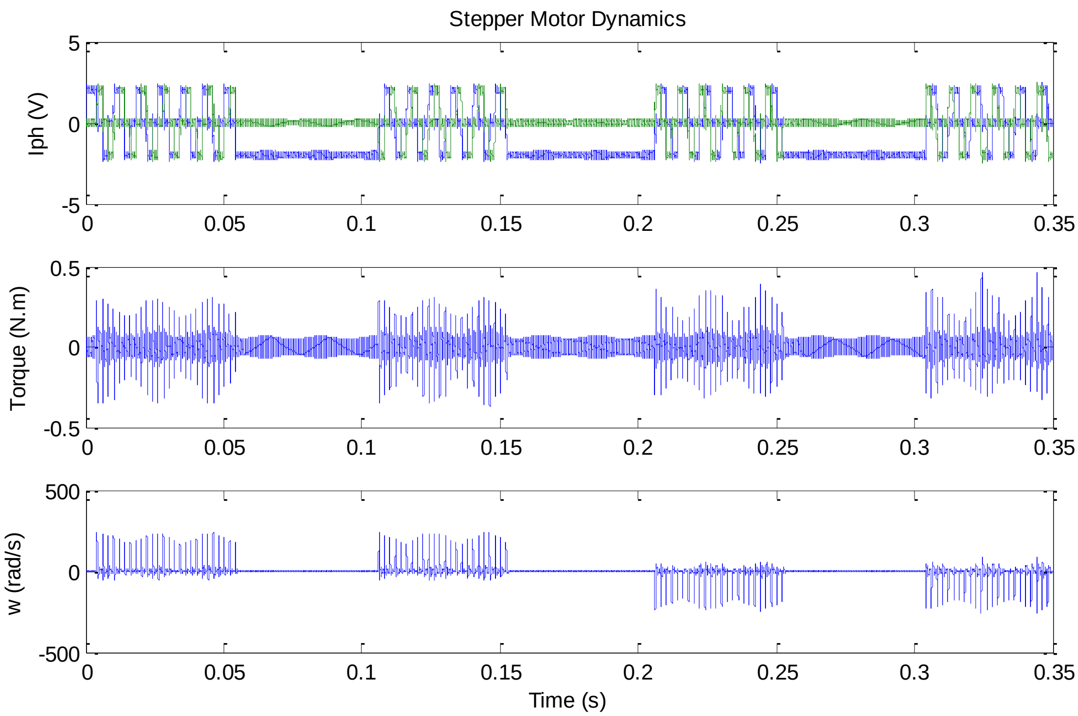



The figure above shows the stepper motor dynamics resulting from mixing the DC voltage supply with an external sinusoidal interference. In this work, this interference is termed a low frequency-low amplitude noise with amplitude and frequency values of 1 volts and 50 hertz respectively. From the plots above it can be noticed that the phase current of the stepper motor shows a low jittery effect during the stationary intervals of the stepper motor. The amplitude and frequency of occurrence of this minor degradation of the phase current signal is proportional to the amplitude and frequency of the interfering signal. It is also observed that the amplitude of the electromagnetic torque and the rotor speed signal are modulated with the noise signal. The effect of this noise modulation is the unstable and uneven signal peaks which is as a result of the superimposition of the sinusoidal-shaped noise on the original signals. The severity of this noise modulation is in a low degree because the amplitude and frequency of the interfering signal are low. Hence, it can be deduced that a low frequency-low amplitude noise signal will result in a minor disruption of the supply voltage and also a minor degradation in the performance of the stepper motor.

The expanded view of the stepper motor dynamics is as shown below:

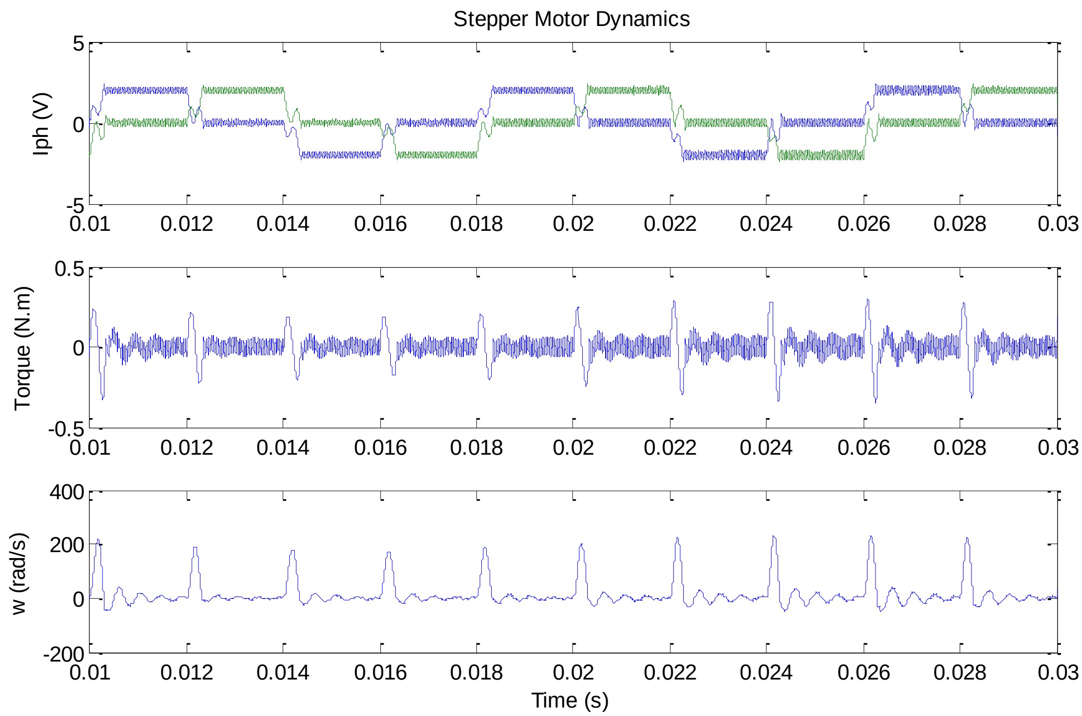



### 26. 3 Effect of Low Frequency-High Amplitude Interference (LFHA) Interference

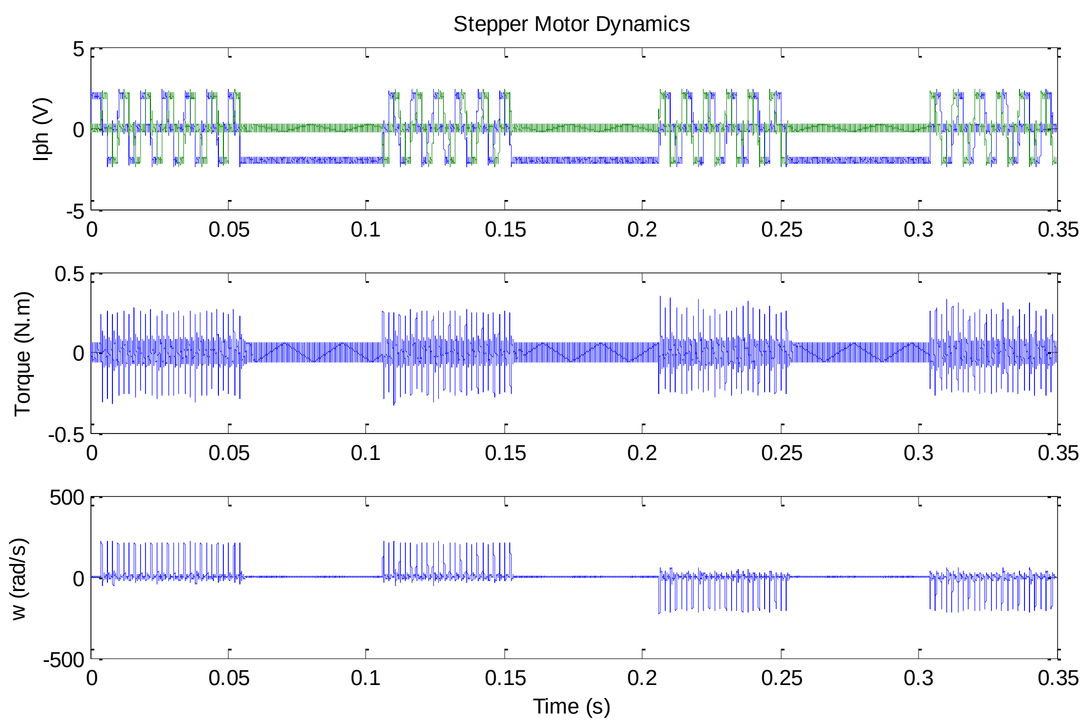



The figure above shows the stepper motor dynamics resulting from mixing the DC voltage supply with a noise signal. In this work, this interference is termed a low frequency-high amplitude noise with amplitude and frequency values of 5 volts and 50 hertz respectively. From the plots above it can be noticed that the phase current of the stepper motor shows a high jittery effect during the stationary intervals of the stepper motor. Hence, it can be deduced that the amplitude and frequency of occurrence of this high degradation of the phase current signal is proportional to the amplitude and frequency of the interfering signal. It is also observed that the amplitude of the electromagnetic torque and the rotor speed signal are modulated with the noise signal. The effect of this noise modulation is the unstable and uneven signal peaks which is as a result of the superimposition of the sinusoidal-shaped noise on the original signals. The severity of this noise modulation is in a high degree because the high amplitude and low frequency of the interfering signal combines to form an average disturbing effect on the stepper motor dynamics. Hence, it can be deduced that a low frequency-high amplitude noise signal will result in an average disruption of the supply voltage and in a high degradation in the performance of the stepper motor.

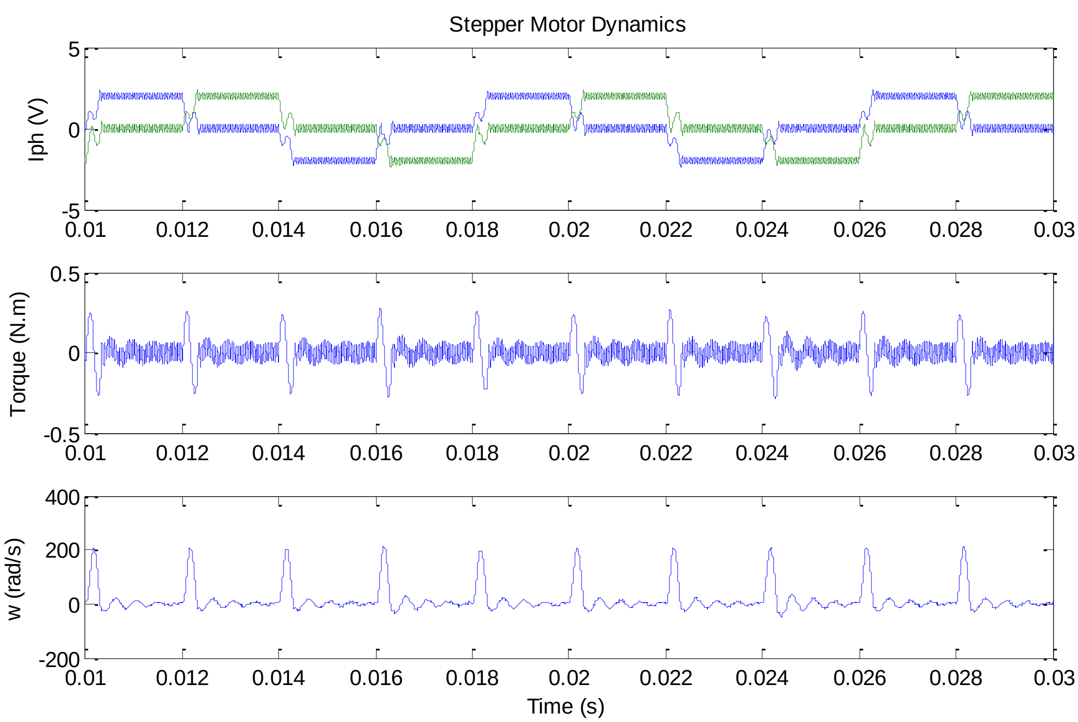
The expanded view of the stepper motor dynamics is as shown below:



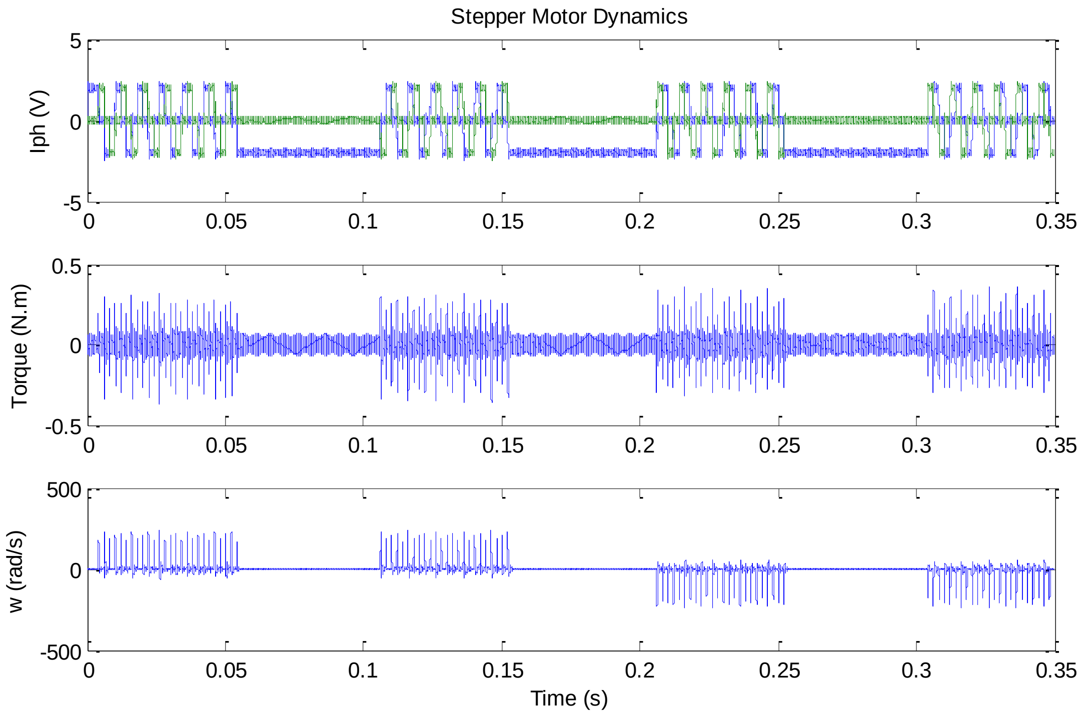

## 26. 4 Effect of High Frequency-Low Amplitude (HFLA) Interference




The figure above shows the stepper motor dynamics resulting from mixing the DC voltage supply with an external sinusoidal interference. In this work, this interference is termed a high frequency-low amplitude noise with amplitude and frequency values of 1 volts and 200 hertz respectively. From the plots above it can be noticed that the phase current of the stepper motor shows an average jittery effect during the stationary intervals of the stepper motor. The amplitude and frequency of occurrence of this medium degradation of the phase current signal is proportional to the amplitude and frequency of the interfering signal. It is also observed that the amplitude of the electromagnetic torque and the rotor speed signal are moderately modulated with the noise signal. The effect of this noise modulation is the unstable and uneven signal peaks which is as a result of the superimposition of the sinusoidal-shaped noise on the original signals. The severity of this noise modulation is to a medium degree because the low amplitude and high frequency of the interfering signal combines to form an average disturbing effect on the stepper motor dynamics. Hence, it can be deduced that a high frequency-low amplitude noise signal will result in an average disruption of the supply voltage and in a medium degradation in the performance of the stepper motor.

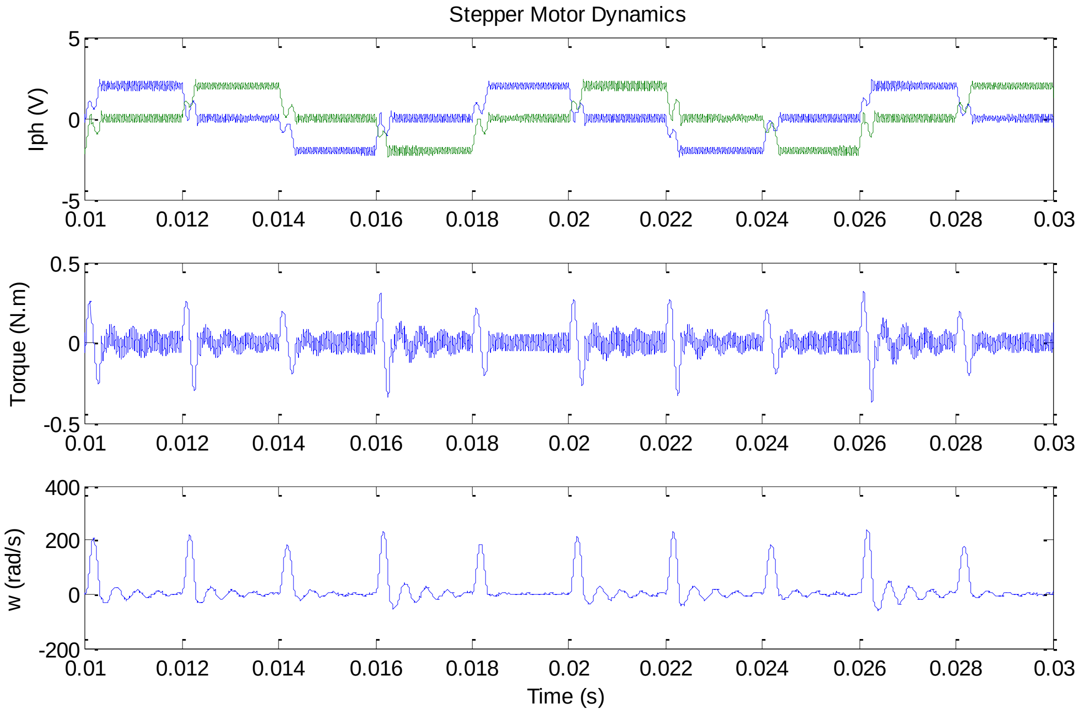



### 26. 5 Effect of High Frequency-High Amplitude (HFHA) Interference




The figure above shows the stepper motor dynamics resulting from mixing the DC voltage supply with a noise signal. In this work, this interference is termed a high frequency-high amplitude noise with amplitude and frequency values of 5 volts and 200 hertz respectively. From the plots above it can be noticed that the phase current of the stepper motor shows a high jittery effect during the stationary intervals of the stepper motor. Hence, it can be deduced that the amplitude and frequency of occurrence of this high degradation of the phase current signal is proportional to the amplitude and frequency of the interfering signal. It is also observed that the amplitude of the electromagnetic torque and the rotor speed signal are modulated with the noise signal. The effect of this noise modulation is the unstable and uneven signal peaks which is as a result of the superimposition of the sinusoidal-shaped noise on the original signals. The severity of this noise modulation is to a high degree because the high amplitude and high frequency of the interfering signal combines to form a high disturbing effect on the stepper motor dynamics. Hence, it can be deduced that a high frequency-high amplitude noise signal will result in a high disruption of the supply voltage and in a high degradation in the performance of the stepper motor.

The expanded view of the stepper motor dynamics is as shown below:




## 26. 6 Summary of Results and Conclusion

The results obtained form this work shows that the severity of the disturbance on the stepper motor dynamics is proportional to the amplitude of the interfering sinusoidal noise signal. This means that the higher the amplitude of the interfering signal, the greater the effects of the disturbance on the stepper motor dynamics which in turn affects the performance of the stepper motor. The effects of the disturbance can be summarized in the table below:

| | Degree of Degradation | | |
|---|---|---|---|
| | Phase Current | Torque | Speed |
| LFLA | Low | Low | Low |
| LFHA | High | High | High |
| HFLA | Medium | Medium | Medium |
| HFHA | High | High | High |

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