

**NOISE REDUCTION IN CONTROL SIGNALS OF  
INDUSTRIAL SEWING MACHINES USING  
ADAPTIVE FILTERING**

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Degree of Master of Science

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Sri Lanka

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Thesis submitted in partial fulfillment of the requirements for the  
degree Master of Science in Electronics & Automation

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## DECLARATION

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## ABSTRACT

Control signals of a typical industrial sewing machine are distorted when they are connected to the controller. Such distortions due to noise appear at the input port of the control signals and they are, in general, non-stationary signals. Furthermore, access to the controller of an industrial sewing machine is restricted. Therefore, such distortions cannot be attenuated using classical adaptive filters such as Wiener filters. In this dissertation, an adaptive algorithm is developed in order to solve this challenging problem. Here, an additive inverse of the distortion is generated and added to the control signals so that the distortion is significantly attenuated. In order to generate the additive inverse of the distortion, the Normalized Least-Mean Square (NLMS) algorithm is employed as the adaptive algorithm with an external reference signal. In general, the error signal to the filter is the estimation of the signal, However, based on the nature of the adaptive filtering problem, the NLMS algorithm is formulated in a way that, the error signal to the filter is the difference between the noise signal and the estimated noise signal. The experimental results obtained with the control signals of a typical industrial sewing machine confirm that the proposed method effectively attenuates the distortion signal with fast convergence of the NLMS algorithm.

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# TABLE OF CONTENTS

<b>DECLARATION</b>	<b>i</b>
<b>ABSTRACT</b>	<b>ii</b>
<b>ACKNOWLEDGEMENT</b>	<b>iii</b>
<b>LIST OF FIGURES</b>	<b>vi</b>
<b>LIST OF TABLES</b>	<b>vii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>viii</b>
<b>LIST OF MATHEMATICAL OPERATOR NOTATIONS AND SYMBOLS</b>	<b>ix</b>
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 Contribution of the Dissertation . . . . .	2
1.2 Organization of the dissertation . . . . .	2
<b>2 PROBLEM STATEMENT</b>	<b>3</b>
2.1 Preliminaries . . . . .	3
2.2 Main problem . . . . .	4
<b>3 BACKGROUND STUDY</b>	<b>6</b>
3.1 I-O characteristics of the sewing machine . . . . .	6
3.2 Signal measurements . . . . .	7
3.3 Characteristics of signals $x(t)$ and $v(t)$ . . . . .	8

<b>4</b>	<b>MATHEMATICAL MODELING AND SOLUTION</b>	
	<b>APPROACH</b>	<b>11</b>
4.1	Mathematical modeling . . . . .	11
4.2	Solution approach . . . . .	13
4.3	Capturing of $v_1[n]$ and verification for correlation . . . . .	14
4.4	Proposed method . . . . .	17
<b>5</b>	<b>RESULTS</b>	<b>19</b>
<b>6</b>	<b>CONCLUSION AND FUTURE WORK</b>	<b>23</b>
<b>A</b>	<b>STATIONARY CHECK OF THE NOISE SIGNAL</b>	<b>26</b>
A.1	Summary Statics . . . . .	26
A.2	Statistical test . . . . .	27
<b>B</b>	<b>CORRELATION BETWEEN <math>v[n]</math> and <math>v_1[n]</math></b>	<b>28</b>
<b>C</b>	<b>NLMS ALGORITHM</b>	<b>29</b>

## LIST OF FIGURES

2.1	Basic type of input to external controller and sewing machine. . . . .	3
2.2	Coupling External Controller to the Sewing Machine. . . . .	4
2.3	The measured signal $x[n]$ before connecting to the sewing machine and $\tilde{x}[n]$ after connecting to the sewing machine. . . . .	5
3.1	Machine speed vs input signal $x(t)$ . . . . .	6
3.2	FFT of $x[n]$ . . . . .	9
3.3	FFT of $v[n]$ . . . . .	10
4.1	Mathematical modeling of the problem. . . . .	12
4.2	Adaptive noise canceller models. . . . .	14
4.3	Output of the adaptive filter without reference. . . . .	15
4.4	Sensor used to measure $v_1(t)$ . . . . .	15
4.5	Implemented noise sensor. . . . .	16
4.6	Secondary sensor input $v_1[n]$ and $\tilde{x}(t)$ . . . . .	16
4.7	Proposed system configuration. . . . .	18
5.1	$e_p$ vs $p$ curve using proposed adaptive filter for offline data set. . . . .	20
5.2	Optimum Proposed adaptive filter output. . . . .	20
5.3	Optimum proposed adaptive filter output comparison with boundary voltages. . . . .	22
A.1	$\tilde{x}[n] - x[n]$ signal. . . . .	26

## LIST OF TABLES

A.1	Sample mean and sample variance of $\tilde{x}[n] - x[n]$ associated with voltage level of $x[n]$ . . . . .	27
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## LIST OF ABBREVIATIONS

<b>AC</b>	Alternating Current
<b>ECG</b>	Electrocardiogram
<b>EMI</b>	Electromagnetic Interference
<b>EMG</b>	Electromyography
<b>FFT</b>	Fast Fourier Transform
<b>FIR</b>	Finite Impulse Response
<b>I-O</b>	Input-Output
<b>LMS</b>	Least Mean Square
<b>NLMS</b>	Normalized Leas-Mean Square
<b>rpm</b>	Revolution Per Minute
<b>VFD</b>	Variable Frequency Drive

## LIST OF MATHEMATICAL OPERATOR NOTATIONS AND SYMBOLS

$e[n]$	Discrete-time error input signal
$E\{r\}$	Expected value of scalar $r$
$h$	window length of adaptive Wiener filter
$N$	Length of a signal
$p$	Adaptive filter order
$T$	Sampling period
$u[n]$	Discrete-time input signal of the external controller
$\mathbf{v}$	External reference input signal vector
$v(t)$	Continuous-time distortion of the input signal
$v[n]$	Discrete-time distortion of the input signal
$\hat{v}(t)$	Continuous-time estimated distortion of the input signal
$\hat{v}[n]$	Discrete-time estimated distortion of the input signal
$v_1(t)$	Continuous-time external reference input signal of the adaptive filter
$v_1[n]$	Discrete-time external reference input signal of the adaptive filter
$\mathbf{w}$	FIR adaptive filter coefficient vector
$x(t)$	Continuous-time input signal of the sewing machine
$x[n]$	Discrete-time input signal of the sewing machine
$\tilde{x}(t)$	Continuous-time distorted input signal of the sewing machine

$\tilde{x}[n]$	Discrete-time distorted input signal of the sewing machine
$\hat{x}[n]$	Discrete-time estimated input signal of the sewing machine
$\mathbf{x}^T$	Transpose of vector $\mathbf{x}$
$z[n]$	Discrete-time input signal of the sewing machine
$\beta$	Normalized step size of the NLMS adaptive filter
$\Delta v$	Smallest voltage span of the input signal
$\epsilon$	Small positive parameter used in NLMS algorithm
$\nabla \xi[n]$	Gradient of $\xi[n]$ with respect to $\mathbf{w}$
$\xi[n]$	Mean square error
$\mu$	step size of the LMS adaptive filter
$\rho$	Sample correlation coefficient