الآية

(1)  

ربّ قَدْ آتَيْنِي مِنَ الْمَلْكِ وَغَلَامِي مِنَ تَأْوِيلِ الآخِرَاتِ فَبَاطِنَ السَّمَاءَاتِ والأَرْضِ  

أنَّتِ وَلِيّيّ في الدُّنِيَا واِلْآخِرَةِ وَأَنَّ اللَّهَ عَلِيمَ ﴿وَأَحَدَّ نِسَبَهَا عَلِيمٌ ﴾  

صدق الله العظيم

الآية 101 من سورة يوسف
DEDICATION

To my mother and father, I will always be as you know me, and I will be always searching for new knowledge and science. I love you both as you supported me all the way to this day. I miss you all.

To my wife, I love you so much, and I will be with you for the rest of my life, as you have been supporting me through my studies. It was a tough year for us, but for the best. With all my love.
AKNOWLEDGMENTS

I would like to thank all the people that supported me through my academic way, and helped me to understand the engineering concepts needed that were needed for our engineering life. My special thanks to recommended supervisor Ust Abdalla Salih Ali, as he was beside me in every step throughout my research, and for his great effort to show me the best techniques and sources to solve different problems. I will never forget the great support from my family, from my parents, brothers, sisters and my loved wife, they helped me a lot. I would like to thank you all to be on my side, and for all of your great support, with you I can always succeed.
ABSTRACT

Direct Current motor systems have played an important role in the improvement and development of the industrial revolution, making them the heart of different applications beside Alternating Current motor systems. Therefore, the development of a more efficient control strategy that can be used for the control of a DC servomotor system, and a well defined mathematical model that can be used for off line simulation are essential for this type of systems servomotor systems are known to have nonlinear parameters and dynamic factors, such as backlash, dead zone and Coulomb friction that make the systems hard to control using conventional control methods such as Proportional-Integral-Derivative controllers to evaluation the system performances specifications,theses specifications parameters can be calculated and responses for different inputs can be compared with directly from MATLAB.
منظومات محرك التيار المستمر تلعب دوراً مهماً في مجال تحسين وتطوير الثورة الصناعية وتعتبر القلب النابض في مختلف التطبيقات إلى جانب محركات التيار المتدرد من أجل هذا الغرض فإن التطور والتنمية في معظم استراتيجيات كفاءة التحكم تستخدم محرك التيار المستمر المسمى محرك الأوزار والذي يمكن من استخدام النموذج الرياضي الصحيحة والمحاكاة الجوهيرية والإدارية في مثل هذا النوع من المنظومات. منظومات محرك الأوزار هي منظومات غير خطية لديها ثوابت غير خطية ومعالجات ديناميكية مثل رد الفعل العكسي والمنطقة المبينة والاحتياج والتي تعمل هذه المنظومات الحاجة إلى التحكم المستخدمة في ذلك الطريق التقليدي وما يعرف بالتحكم التناسبي التكامل التفاضلي المستخدم في هذا البحث للمؤشر والاستجابة مثل هذا النوع من المنظومات. حيث تتم مقارنة القيم الحسابية لهذه المؤشرات مع القيم المستخرجة مباشرةً من برامج MATLAB.

LIST OF CONTENTS
# List of Contents

## Chapter One: Introduction

1.1 General ................................................. 1  
1.2 Problem Statement ................................. 2  
1.3 Objectives ............................................. 2  
1.4 Methodology .......................................... 2  
1.5 The Layout ............................................. 3  

## Chapter Two: Previous Works and Control Systems

2.1 Introduction .......................................... 4  
2.2 Control Systems ....................................... 5  
2.2.1 Feedback control .................................. 5  
2.2.2 Feedback control systems ....................... 5  
2.2.3 Open-loop control systems ...................... 6  
2.2.4 Closed-loop control systems .................... 6  
2.2.5 Closed-loop versus open-loop control systems 7  

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3 Design and Compensation of Circuits Systems</td>
<td>8</td>
</tr>
<tr>
<td>2.3.1 Performance specifications</td>
<td>8</td>
</tr>
<tr>
<td>2.3.2 Systems compensation</td>
<td>9</td>
</tr>
<tr>
<td>2.3.3 Design procedures</td>
<td>9</td>
</tr>
<tr>
<td>2.4 Automatic Controllers</td>
<td>10</td>
</tr>
<tr>
<td>2.4.1 Classification of industrial controllers</td>
<td>11</td>
</tr>
<tr>
<td>2.4.2 Two –position or ON-OFF control action</td>
<td>12</td>
</tr>
<tr>
<td>2.4.3 Proportional control action</td>
<td>13</td>
</tr>
<tr>
<td>2.4.4 Integral control action</td>
<td>13</td>
</tr>
<tr>
<td>2.4.5 Derivative control action</td>
<td>14</td>
</tr>
<tr>
<td>2.4.6 Proportional –plus –integral control action</td>
<td>15</td>
</tr>
<tr>
<td>2.4.7 Proportional –plus –derivative control action</td>
<td>15</td>
</tr>
<tr>
<td>2.4.8 Proportional –plus –integral -plus –derivative control action</td>
<td>15</td>
</tr>
<tr>
<td>2.5 Transient and Steady State Response Analyses</td>
<td>16</td>
</tr>
<tr>
<td>2.5.1 Typical test signal</td>
<td>17</td>
</tr>
<tr>
<td>2.5.2 Stability and steady state error</td>
<td>17</td>
</tr>
<tr>
<td>2.6 Steady State Error in Unity Feedback Control Systems</td>
<td>18</td>
</tr>
<tr>
<td>2.6.1 Classification of control systems</td>
<td>19</td>
</tr>
<tr>
<td>2.6.2 Steady state errors</td>
<td>20</td>
</tr>
<tr>
<td>2.6.3 Static position error constant</td>
<td>21</td>
</tr>
</tbody>
</table>

Chapter Three: System Implementation

3.1 Servo System                                                       | 23   |
3.2 Second Order Systems                                               | 28   |
3.2.1 Servo as second order systems                                    | 28   |
3.2.2 Step response second order systems                               | 30   |
3.3 The Transient Response Specifications                              | 36   |
3.3.1 A few comments | 38  
3.3.2 Second order systems specifications | 39  
3.4 Servo System with Velocity Feedback | 42  

Chapter Four: Simulation and Results  
4.1 DC Servo Model | 45  
4.1.1 Proportional control | 49  
4.1.2 PD control implementation | 53  
4.1.3 PI control implementation | 57  
4.1.4 PID control implementation | 60  
4.2 The Final Results | 64  

Chapter Five: Conclusion and Recommendations  
5.1 Conclusion | 66  
5.2 Recommendation | 67  
References | 68  

LIST OF FIGURES
<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>An automatic controller</td>
<td>11</td>
</tr>
<tr>
<td>2.2</td>
<td>Block diagram of PID controller</td>
<td>16</td>
</tr>
<tr>
<td>2.3</td>
<td>Unity feedback control system</td>
<td>20</td>
</tr>
<tr>
<td>3.1</td>
<td>Schematic diagram of servo system</td>
<td>24</td>
</tr>
<tr>
<td>3.2(a)</td>
<td>Block diagram for the system</td>
<td>27</td>
</tr>
<tr>
<td>3.2(b)</td>
<td>Simplified block diagram for the system</td>
<td>27</td>
</tr>
<tr>
<td>3.3(a)</td>
<td>Servo system</td>
<td>29</td>
</tr>
<tr>
<td>3.3(b)</td>
<td>Block diagram</td>
<td>29</td>
</tr>
<tr>
<td>3.3(c)</td>
<td>Simplified block</td>
<td>30</td>
</tr>
<tr>
<td>3.4</td>
<td>Second order system</td>
<td>31</td>
</tr>
<tr>
<td>3.5</td>
<td>Unit step response curve</td>
<td>38</td>
</tr>
<tr>
<td>3.6</td>
<td>Definition of the angle $\beta$</td>
<td>39</td>
</tr>
<tr>
<td>3.7(a)</td>
<td>Block diagram of the servo system</td>
<td>43</td>
</tr>
<tr>
<td>3.7(b)</td>
<td>Simplified block diagram of the servo system</td>
<td>43</td>
</tr>
<tr>
<td>4.1</td>
<td>Block diagram of the modeling system</td>
<td>47</td>
</tr>
<tr>
<td>4.2</td>
<td>System response without controller</td>
<td>48</td>
</tr>
<tr>
<td>4.3</td>
<td>System simulation without controller</td>
<td>48</td>
</tr>
<tr>
<td>4.4</td>
<td>Block diagram of the system with P controller</td>
<td>49</td>
</tr>
<tr>
<td>4.5</td>
<td>System response for $K_p=2$</td>
<td>51</td>
</tr>
<tr>
<td>4.6</td>
<td>System response for $K_p=5$</td>
<td>51</td>
</tr>
<tr>
<td>4.7</td>
<td>System response for $K_p=10$</td>
<td>52</td>
</tr>
<tr>
<td>4.8</td>
<td>System simulation for $K_p=2$</td>
<td>52</td>
</tr>
<tr>
<td>4.9</td>
<td>System simulation for $K_p=5$</td>
<td>53</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>4.10</td>
<td>System simulation for ( K_p = 10 )</td>
<td>53</td>
</tr>
<tr>
<td>4.11</td>
<td>Block diagram of the system with PD controller</td>
<td>53</td>
</tr>
<tr>
<td>4.12</td>
<td>System response for ( K_d = 0.1 ) and ( K_p = 0.2 )</td>
<td>55</td>
</tr>
<tr>
<td>4.13</td>
<td>System simulation for ( K_d = 0.1 ) and ( K_p = 0.2 )</td>
<td>55</td>
</tr>
<tr>
<td>4.14</td>
<td>System response for ( K_d = 0.15 ) and ( K_p = 0.25 )</td>
<td>56</td>
</tr>
<tr>
<td>4.15</td>
<td>System simulation for ( K_d = 0.15 ) and ( K_p = 0.25 )</td>
<td>57</td>
</tr>
<tr>
<td>4.16</td>
<td>Block diagram of the system with PI controller</td>
<td>57</td>
</tr>
<tr>
<td>4.17</td>
<td>System response for ( K_I = 70 ) and ( K_p = 30 )</td>
<td>58</td>
</tr>
<tr>
<td>4.18</td>
<td>System simulation for ( K_I = 70 ) and ( K_p = 30 )</td>
<td>58</td>
</tr>
<tr>
<td>4.19</td>
<td>System response for ( K_I = 30 ) and ( K_p = 70 )</td>
<td>59</td>
</tr>
<tr>
<td>4.20</td>
<td>System simulation for ( K_I = 30 ) and ( K_p = 70 )</td>
<td>59</td>
</tr>
<tr>
<td>4.21</td>
<td>Block diagram of the system with PID controller</td>
<td>60</td>
</tr>
<tr>
<td>4.22</td>
<td>System response for ( K_I = 30, K_p = 70 ) and ( K_d = 20 )</td>
<td>61</td>
</tr>
<tr>
<td>4.23</td>
<td>System simulation for ( K_I = 30, K_p = 70 ) and ( K_d = 20 )</td>
<td>61</td>
</tr>
<tr>
<td>4.24</td>
<td>System response for ( K_I = 300, K_p = 350 ) and ( K_d = 50 )</td>
<td>62</td>
</tr>
<tr>
<td>4.25</td>
<td>System simulation for ( K_I = 300, K_p = 350 ) and ( K_d = 50 )</td>
<td>62</td>
</tr>
<tr>
<td>4.26</td>
<td>System response for ( K_I = 350, K_p = 400 ) and ( K_d = 50 )</td>
<td>63</td>
</tr>
<tr>
<td>4.27</td>
<td>System simulation for ( K_I = 350, K_p = 400 ) and ( K_d = 50 )</td>
<td>63</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Transient response specifications</td>
<td>42</td>
</tr>
<tr>
<td>4.1</td>
<td>DC servomotor parameters values</td>
<td>45</td>
</tr>
<tr>
<td>4.2</td>
<td>Time response results without controller</td>
<td>48</td>
</tr>
<tr>
<td>4.3</td>
<td>Time response results with P controller</td>
<td>52</td>
</tr>
<tr>
<td>4.4</td>
<td>Time response results with PD controller</td>
<td>57</td>
</tr>
<tr>
<td>4.5</td>
<td>Time response results with PI controller</td>
<td>60</td>
</tr>
<tr>
<td>4.6</td>
<td>Time response results with PID controller</td>
<td>64</td>
</tr>
</tbody>
</table>