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# AUTHOR REVISION REPORT

*Note: For comments/questions/Answer/Revisions, use the language according to the language used in the manuscript (English or Bahasa Indonesia).*

## I. Manuscript Identity

| | |
|---|---|
| Title | Rotor Speed Analysis of SMC-based IFOC for Low-Speed Induction Motor Control |
| Manuscript number | 67321 |
| Article Type | Research article / ~~Review Article~~ |
| First Submission date | 06 July 2023 |
| Recommendation on First Submission Manuscript | Reviewer 1 (RV1) : Minor Revisions<br>Reviewer 2 (RV2) : Minor Revisions |
| Revision Submission Date | 07 September 2023 |

## II. Reviewer's Comments

### 2.1. General Impression

| | Reviewers (R1 & R2) Comments/Questions | Authors Comments/Answers/Revisions in the Manuscript |
|---|---|---|
| General comprehension of the manuscript | [R 2.1]<br>This article discusses speed regulation with SMC-based IFOC for low speed for Induction Motors, on very low analysis | [R 2.1]<br>- |
| Language/style/ Grammar in general | [R 2.1]<br>still needs to be improved, there are still errors in sentences. | [R 2.1]<br>The language/style/grammar has been improved to meet the requirements of higher quality scientific paper. |
| Structure | [R 2.1]<br>Average | [R 2.1]<br>- |
| Level of enthusiasm | [R 2.1]<br>Still low | [R 2.1]<br>- |

### 2.2. Revision on Major Comments

| | Reviewers (R1 & R2) Major Comments | Authors Answers/Revisions in the Manuscript |
|---|---|---|
| **Abstract** | [R2.1]<br>Insert induction motor prior to the abbreviation of IM.<br><br>[R2.2]<br>What objectives are to be achieved, written explicitly what is the importance / what is the contribution of research results obtained in this field studied? | [R 2.1]<br>........................................................................ Other parameters to be considered are rise time and electromagnetic torque response at low speeds. The addition of the boundary layer of the tanh() function to a first-order SMC can increase induction motor (IM) control up to 175 rpm with a value of Ess = 1.96% compared to the sat() and sign() functions which are only capable of a reference speed of 300 rpm in no-load conditions with a value of Ess = 2% for the sat() function and 1.94% for the sign() function. ....................<br><br>[R2.2] |

| | | |
|---|---|---|
| | | This paper contributed in low-speed control of IM using model based controller (SMC) and IFOC systems.<br><br>Abstract – The control of electric motors, particularly three-phase induction motors, has developed rapidly due to their application in industry. Indirect Field Oriented Control (IFOC) is one of the most widely used control systems due to its ease of application. IFOC controls a three-phase induction motor in the same way as a DC motor. However, IFOC requires a Sliding Mode Control (SMC) controller with Lyapunov stability theory to ensure robustness and stability. In exceptional conditions, such as low-speed settings, the SMC-based IFOC requires unique sets to operate with a steady-state error (Ess) at a speed response of less than 2%. Other parameters to be considered are rise time and electromagnetic torque response at low speeds. The addition of the boundary layer of the tanh() function to a first-order SMC can increase induction motor (IM) control up to 175 rpm with a value of Ess = 1.96% compared to the sat() and sign() functions which are only capable of a reference speed of 300 rpm in no-load conditions with a value of Ess = 2% for the sat() function and 1.94% for the sign() function. ………………………………….............................. |
| **Introduction** | [R2.1]<br>The range (in rpm) of low, medium, and high speeds will be better mentioned.<br><br>[R2.2]<br>On which side is the analysis performed, what is the usefulness obtained? | [R 2.1]<br>Speed range depends on IM nominal speed. This paper classifies the speed range into low, medium and high with a nominal speed of 1500 rpm. Based on this classification, it can be concluded that the low speed range is below 500 rpm.<br><br>[R2.2]<br>This research analysis was carried out on the steady state error in the rotor speed response and torque ripple in the electromagnetic torque response.<br><br>Previous research on low-speed IM discussed independent controller models with various control methods. This paper proposes a model-based controller to achieve low-speed IM control.<br><br>Research on IM speed control using inverters is generally conducted at medium to nominal or high speed rather than low speed. Low-speed control is complicated to achieve [15]-[17]. This research focuses on controlling the IM speed at a low speed. An IFOC equipped with a first-order SMC is used for speed control. The chattering phenomenon in the first-order SMC is overcome using the boundary layer technique [18], [19]. Considering the steady-state error and rise time in the speed response and the ripple in the electromagnetic torque response, the performance analysis is performed on the speed response and the electromagnetic torque under no-load and load conditions. |
| **Methodology** | [R2.1]<br>What is the basis for the author using analysis in this method..? more details to display.<br><br>[R 2.2] | [R 2.1]<br>The proposed system uses IFOC, which comes from IM's electrical and mechanical model. IFOC generally uses a conventional controller such as PID, and a model-free controller, such as a fuzzy controller, to get |

<table>
<tr>
<td></td>
<td>Equation (4) doesn't exist. Please insert it.</td>
<td>robustness and stability. The SMC purposed to bring stability and robustness simultaneously.<br>A. IFOC-IM<br>IFOC is one of the vector control methods widely used in IM. IFOC is more readily accepted by industry than Direct Field Oriented Control (DFOC) because the magnetic field in IM is measured by a particular sensor placed in the air gap. DFOC is considered impractical and only suitable for laboratory testing [20]. ……………………………………………………………......<br><br>[R 2.2]<br>Based on Equations (2) and (3), the relationship between rotor speed and electromagnetic torque of IFOC modeling can be expressed in Equation (4).<br>$$\frac{d\omega_r}{dt} = \frac{2}{3\,Pj} m_e - \frac{e_0}{j} \quad (4)$$</td>
</tr>
<tr>
<td>Results and Discussions</td>
<td>[R2.1]<br>Correct this sentence.<br>According to Table 1, a reference speed of less than 200 rpm is only available at 100 rpm, but the tanh() function for torque loads of 1.5 Nm and 0 Nm has Ess values of 3.42% and 3.43%, respectively. These values exceed the tolerance limit of 2%.<br><br>[R2.2]<br>Borders should be given at each reference speed for easy reading.<br><br>[R2.3]<br>Based on this table, the no-load condition (0 N.m.) only exists at reference speeds of 400 rpm, 300 rpm, and 100 rpm.<br>It is necessary to explain the reasons for not carrying out the no-load condition at 350 rpm and 200 rpm.</td>
<td>[R 2.1]<br>……………………………………………………………… The load test with a torque load of 1 Nm shows that only the sign() and tanh() functions can produce Ess values below the tolerance limit of 2%, as shown in Table 1. When tested at a shallow reference speed (200 rpm), the tanh function () can provide Ess values below the 2% tolerance with a torque load of up to 1.5 Nm. On the other hand, the sign() and sat() functions require parameter adjustments through artificial intelligence to obtain optimum values concerning Ess tolerances below 2%. The determination of the parameters of the first-order SMC constants and the boundary layer in the computational test was done intuitively.<br><br>[R 2.2]<br>The table format in is in accordance with the journal template. To make it easier to read the data, color has been added to the table for each data.<br>
<table>
<tr><th rowspan="2">Reference Speed (rpm)</th><th rowspan="2">Torque Load (Nm)</th><th colspan="3">Error Steady-State (%)</th></tr>
<tr><th>Sign()</th><th>Sat()</th><th>Tanh()</th></tr>
<tr><td>400</td><td>0</td><td>1.45</td><td>1.36</td><td>0.84</td></tr>
<tr><td>300</td><td>0</td><td>1.94</td><td>2.02</td><td>1.17</td></tr>
<tr><td></td><td>1</td><td>1.93</td><td>2.53</td><td>1.15</td></tr>
<tr><td>350</td><td>1</td><td>1.59</td><td>2.10</td><td>0.97</td></tr>
<tr><td></td><td>0.5</td><td>1.59</td><td>1.89</td><td>0.97</td></tr>
<tr><td>200</td><td>0.5</td><td>2.91</td><td>3.66</td><td>1.72</td></tr>
<tr><td></td><td>1.5</td><td>2.91</td><td>4.50</td><td>1.72</td></tr>
<tr><td>100</td><td>1.5</td><td>5.80</td><td>9.49</td><td>3.42</td></tr>
<tr><td></td><td>0</td><td>5.83</td><td>6.81</td><td>3.43</td></tr>
</table>
<br>[R 2.3]<br>Table 1 analyzes Figure 3, representing tests of low-speed variations in various torque loads. At the same time, the controller's performance at each low speed and torque load is shown in Figure 4 - 7.</td>
</tr>
<tr>
<td>Conclusions</td>
<td>[R2.1]<br>An analytical conclusion that has not contributed a system to a better method.</td>
<td>[R 2.1]<br>This paper proposes a model-based controller (such as SMC) in an IFOC system to control IM in low-speed references. In comparison, the previous research</td>
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</table>

| | | |
|---|---|---|
| | | discussed the conventional controller (such as PID) and model-free controller (such as fuzzy logic controller). |

### 2.3. Revision on Minor Comments

| | **Reviewers (R1 & R2)** | **Authors** |
|---|---|---|
| | **Minor Comments/Questions** | **Comments/Answers/Revisions in the Manuscript** |
| **Style/Grammar** | | |
| **Consistency/Terminology** | | |
| **References** | | |
| **Tables** | | |
| **Figures** | | |
| **References, tables, and figures** | | |

***** Add a yellow background to the revised/improved manuscript, according to the results of the review.***